MiCOM P141, P142, P143
Feeder Management Relays

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ALSTOM

Technical Guide
MiCOM P141, P142, P143
Feeder Management Relays

Volume 1

FEEDER MANAGEMENT RELAYS

MICOM P141, P142, P143

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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 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 of ALSTOM T&D Protection & Control products are immune to the relevant levels of electrostatic discharge when housed in their cases. Do not expose them to the 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 a same electrostatic potential as the equipment by touching the case.

2. Handle the module by its front-plate, frame, or edges of the printed circuit board. Avoid touching the electronic components, printed circuit track or connectors.

3. Do not pass the module to any person without first ensuring that you are both at the same electrostatic potential. Shaking hands achieves equipotential.

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.

More information on safe working procedures for all electronic equipment can be found in BS5783 and IEC 60147-0F.

If you are making measurements on the internal electronic circuitry of an 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 500k – 10M ohms. If a wrist strap is not available you should maintain regular contact with the case to prevent the build up of static. Instrumentation which may be used for making measurements should be earthed to the case whenever possible.

ALSTOM T&D Protection & Control strongly recommends that detailed investigations on the electronic circuitry, or modification work, should be carried out in a Special Handling Area such as described in BS5783 or IEC 60147-0F.

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1. SAFETY SECTION

This Safety Section should be read before commencing any work on the equipment.

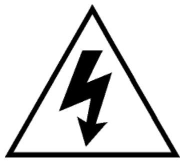
1.1 Health and Safety

The information in the Safety Section of the product documentation is intended to ensure that products are properly installed and handled in order to maintain them in a safe condition. It is assumed that everyone who will be associated with the equipment will be familiar with the contents of the Safety Section.

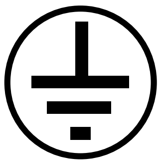
1.2 Explanation of symbols and labels

The meaning of symbols and labels may be used on the equipment or in the product documentation, is given below.

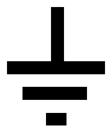
Caution : refer to product documentation



Caution : risk of electric shock



Protective/safety *earth terminal



Functional *earth terminal

Note: This symbol may also be used for a protective/safety earth terminal if that terminal is part of a terminal block or sub-assembly e.g. power supply.

*NOTE: THE TERM EARTH USED THROUGHOUT THE PRODUCT DOCUMENTATION IS THE DIRECT EQUIVALENT OF THE NORTH AMERICAN TERM GROUND.

2. INSTALLING, COMMISSIONING AND SERVICING

Equipment connections

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

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

Voltage and current connections should be made using insulated crimp terminations to ensure that terminal block insulation requirements are maintained for safety. To ensure that wires are correctly terminated, the correct crimp terminal and tool for the wire size should be used.

Before energising the equipment it must be earthed using the protective earth terminal, or the appropriate termination of the supply plug in the case of plug connected equipment. Omitting or disconnecting the equipment earth may cause a safety hazard.

The recommended minimum earth wire size is 2.5mm^2, unless otherwise stated in the technical data section of the product documentation.

Before energising the equipment, the following should be checked:

– Voltage rating and polarity;

– CT circuit rating and integrity of connections;

– Protective fuse rating;

– Integrity of earth connection (where applicable)

3. EQUIPMENT OPERATING CONDITIONS

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

3.1 Current transformer circuits

Do not open the secondary circuit of a live CT since the high level voltage produced may be lethal to personnel and could damage insulation.

3.2 External resistors

Where external resistors are fitted to relays, these may present a risk of electric shock or burns, if touched.

3.3 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.

3.4 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.

3.5 Insertion of modules and pcb cards

These must not be inserted into or withdrawn from equipment whilst it is energised since this may result in damage.

3.6 Fibre optic communication

Where fibre 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.

4. OLDER PRODUCTS

Electrical adjustments

Equipments which require direct physical adjustments to their operating mechanism to change current or voltage settings, should have the electrical power removed before making the change, to avoid any risk of electrical shock.

Mechanical adjustments

The electrical power to the relay contacts should be removed before checking any mechanical settings, to avoid any risk of electric shock.

Draw out case relays

Removal of the cover on equipment incorporating electromechanical operating elements, may expose hazardous live parts such as relay contacts.

Insertion and withdrawal of extender cards

When using an extender card, this should not be inserted or withdrawn from the equipment whilst it is energised. This is to avoid possible shock or damage hazards. Hazardous live voltages may be accessible on the extender card.

Insertion and withdrawal of heavy current test plugs

When using a heavy current test plug, CT shorting links must be in place before insertion or removal, to avoid potentially lethal voltages.

5. DECOMMISSIONING AND DISPOSAL

Decommissioning: The auxiliary supply circuit in the relay may include capacitors across the supply or to earth. To avoid electric shock or energy hazards, after completely isolating the supplies to the relay (both poles of any dc supply), the capacitors should be safely discharged via the external terminals prior to decommissioning.

Disposal: It is recommended that incineration and disposal to water courses is avoided. The product should be disposed of in a safe manner. Any products 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 lithium batteries.

6. TECHNICAL SPECIFICATIONS

Protective fuse rating

The recommended maximum rating of the external protective fuse for this equipment is 16A, Red Spot type or equivalent, unless otherwise stated in the technical data section of the product documentation.

Insulation class:	IEC 61010-1 : 1990/A2 : 2001 Class I EN 61010-1 : 1993/A2 : 2001 Class I	This equipment requires a protective (safety) earth connection to ensure user safety.
Insulation Category (Overvoltage):	IEC 61010-1 : 1990/A2 : 1995 Category III EN 61010-1 : 1993/A2 : 1995 Category III	Distribution level, fixed installation. Equipment in this category is qualification tested at 5kV peak, 1.2/50µs, 500Ω, 0.5J, between all supply circuits and earth and also between independent circuits.
Environment:	IEC 61010-1 : 1990/A2 : 1995 Pollution degree 2 EN 61010-1 : 1993/A2 : 1995 Pollution degree 2	Compliance is demonstrated by reference to generic safety standards.
Product Safety:	72/23/EEC	Compliance with the European Commission Law Voltage Directive.
CE	EN 61010-1 : 2001 EN 60950-1 : 2001	Compliance is demonstrated by reference to generic safety standards.

CHAPTER 1
Introduction

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1. INTRODUCTION TO MICOM

MiCOM is a comprehensive solution capable of meeting all electricity supply requirements. It comprises a range of components, systems and services from ALSTOM T&D Ltd.

Central to the MiCOM concept is flexibility.

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

The components within MiCOM are:

– P range protection relays;

– C range control products;

– M range measurement products for accurate metering and monitoring;

– S range versatile PC support and substation control packages.

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

For up-to-date information on any MiCOM product, refer to the technical publication which can be obtained from:

ALSTOM T&D Protection & Control, or your local sales office. Alternatively visit our web site.

www.alstom.com

2. INTRODUCTION TO MiCOM GUIDES

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

Divided into two volumes, as follows:

Volume 1 – Technical Guide, includes information on the application of the relay and a technical description of its features. It is mainly intended for protection engineers concerned with the selection and application of the relay for the protection of the power system.

Volume 2 – Operation Guide, contains information on the installation and commissioning of the relay, and also a section on fault finding. This volume is intended for site engineers who are responsible for the installation, commissioning and maintenance of the relay.

Note: *May vary according to relay type/model

The chapter content within each volume is summarised below:

Volume 1 Technical Guide

Handling of Electronic Equipment

Safety Section

Chapter 1 Introduction

A guide to the different user interfaces of the protection relay describing how to start using the relay.

Chapter 2 Application Notes (includes a copy of publication P14x/EN BR/Fa)

Comprehensive and detailed description of the features of the relay including both the protection elements and the relay's other functions such as event and disturbance recording, fault location and programmable scheme logic. This chapter includes a description of common power system applications of the relay, calculation of suitable settings, some typical worked examples, and how to apply the settings to the relay.

Chapter 3 Relay Description

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

Chapter 4 Technical Data

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

Chapter 5 Communications and Interface Guide

This chapter provides detailed information regarding the communication interfaces of the relay, including a detailed description of how to access the settings database stored within the relay. The chapter also gives information on each of the communication protocols that can be used with the relay, and is intended to allow the user to design a custom interface to a SCADA system.

Appendix A Relay Menu Database: User interface/Courier/Modbus/
IEC 60870-5-103/DNP 3.0

Listing of all of the settings contained within the relay together with a brief description of each.

Appendix B External Connection Diagrams

All external wiring connections to the relay.

Appendix C Hardware / Software Version History and Compatibility

Appendix D Auto-reclose Logic Diagrams

Volume 2 Operation Guide

Handling of Electronic Equipment

Safety Section

Chapter 1 Introduction

A guide to the different user interfaces of the protection relay describing how to start using the relay.

Note: *May vary according to relay type/model

Chapter 2 Installation (includes a copy of publication P14x/EN BR/Fa)

Recommendations on unpacking, handling, inspection and storage of the relay. A guide to the mechanical and electrical installation of the relay is provided incorporating earthing recommendations.

Chapter 3 Commissioning and Maintenance

Instructions on how to commission the relay, comprising checks on the calibration and functionality of the relay. A general maintenance policy for the relay is outlined.

Chapter 4 Problem Analysis.

Advice on how to recognise failure modes and the recommended course of action.

Appendix A Relay Menu Database: User interface/Courier/Modbus/IEC 60870-5-103/DNP 3.0

Listing of all of the settings contained within the relay together with a brief description of each.

Appendix B External Connection Diagrams

All external wiring connections to the relay.

Appendix C Hardware / Software Version History and Compatibility

Repair Form

3. USER INTERFACES AND MENU STRUCTURE

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

3.1 Introduction to the relay

3.1.1 Front panel

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

Note: *May vary according to relay type/model

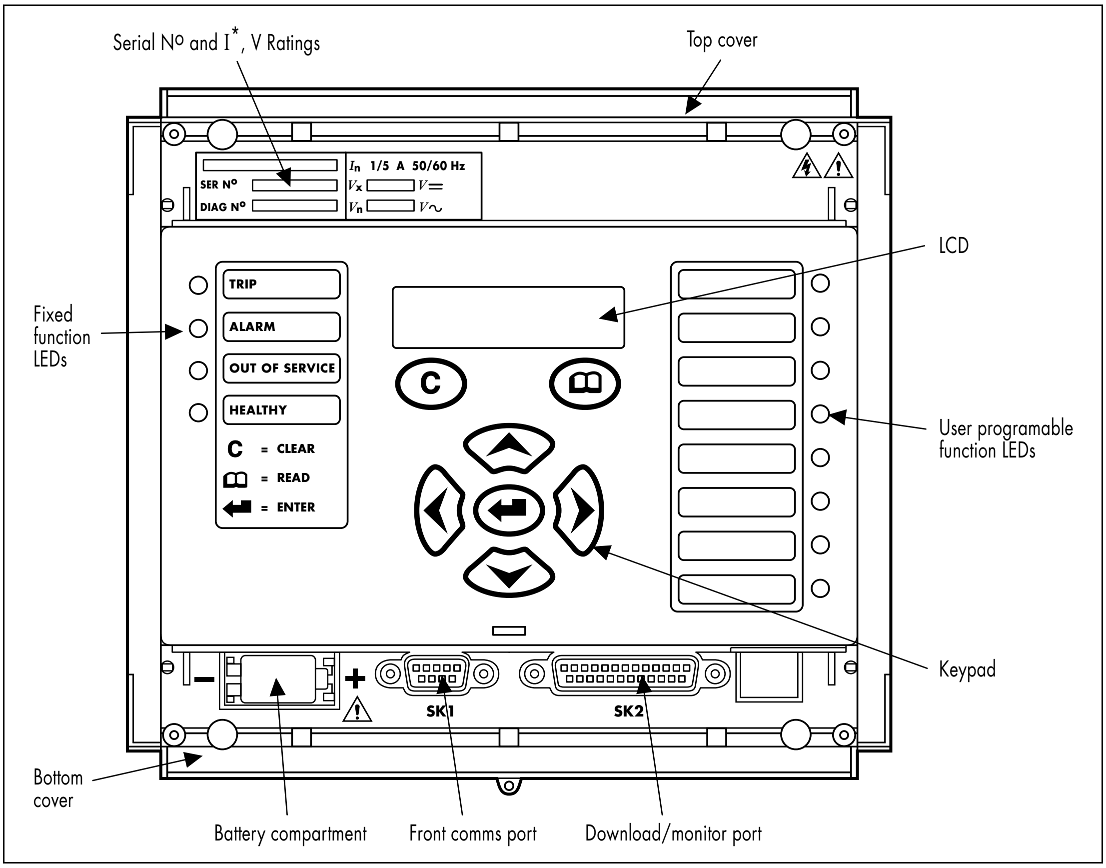


Figure 1: Relay front view

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

– a 16-character by 2-line alphanumeric liquid crystal display (LCD).

– a 7-key keypad comprising 4 arrow keys (⇐, ⇒, ⇑, and ⇓), an enter key (↵), a clear key (C), and a read key (📖).

– 12 LEDs; 4 fixed function LEDs on the left hand side of the front panel and 8 programmable function LEDs on the right hand side.

– Under the top hinged cover:

– the relay serial number, and the relay's current and voltage rating information*.

– Under the bottom hinged cover:

– battery compartment to hold the 1/2 AA size battery which is used for memory back-up for the real time clock, event, fault and disturbance records.

– a 9-pin female D-type front port for communication with a PC locally to the relay (up to 15m distance) via an EIA(RS)232 serial data connection.

– a 25-pin female D-type port providing internal signal monitoring and high speed local downloading of software and language text via a parallel data connection.

Note: *May vary according to relay type/model

The fixed function LEDs on the left hand side of the front panel are used to indicate the following conditions:

Trip (Red) indicates that the relay has issued a trip signal. It is reset when the associated fault record is cleared from the front display. (Alternatively the trip LED can be configured to be self-resetting)*. The trip LED is initiated from relay 3, the protection trip contact.

Alarm (Yellow) flashes to indicate that the relay has registered an alarm. This may be triggered by a fault, event or maintenance record. The LED will flash until the alarms have been accepted (read), after which the LED will change to constant illumination, and will extinguish when the alarms have been cleared.

Out of service (Yellow) indicates that the relay's protection is unavailable.

Healthy (Green) indicates that the relay is in correct working order, and should be on at all times. It will be extinguished if the relay's self-test facilities indicate that there is an error with the relay's hardware or software. The state of the healthy LED is reflected by the watchdog contact at the back of the relay.

3.1.2 Relay rear panel

The rear panel of the relay is shown in Figure 2. All current and voltage signals*, digital logic input signals and output contacts are connected at the rear of the relay. Also connected at the rear is the twisted pair wiring for the rear EIA(RS)485 communication port, the IRIG-B time synchronising input and the optical fibre rear communication port which are both optional.

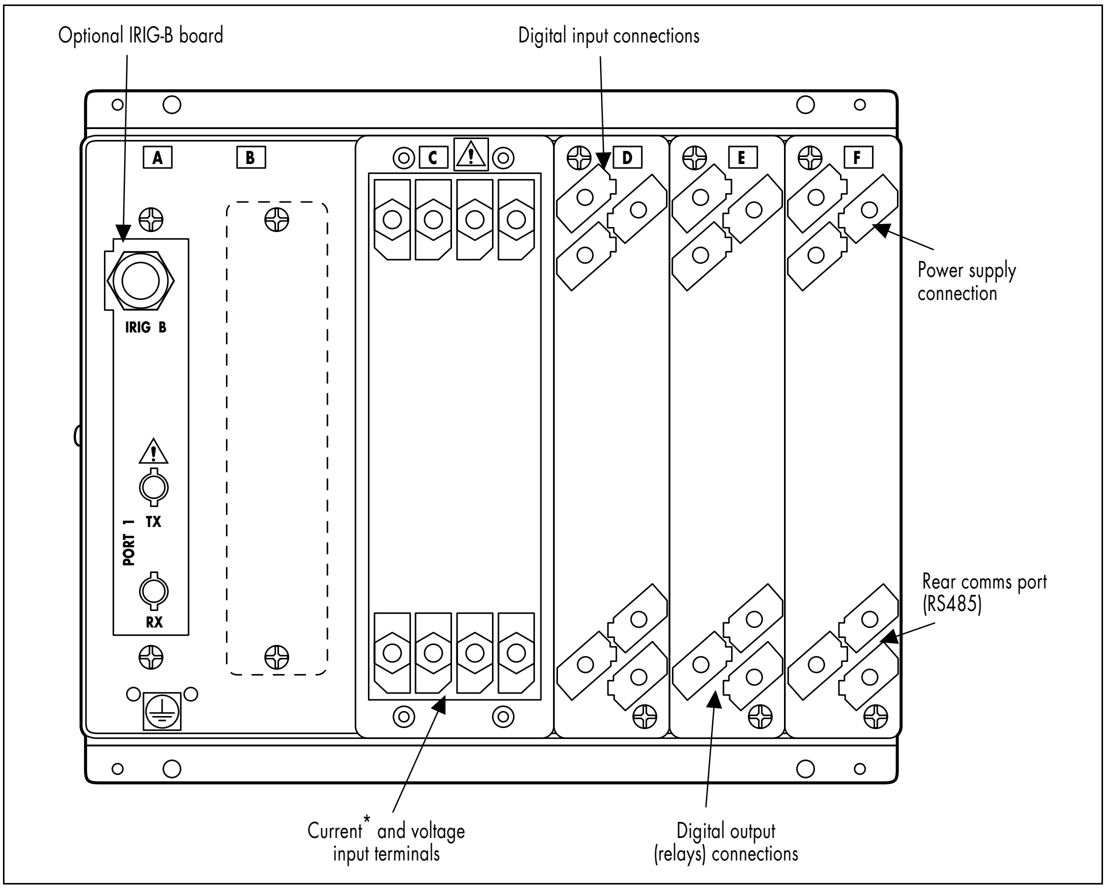


Figure 2: Relay rear view

Refer to the wiring diagram in Appendix B for complete connection details.

Note: *May vary according to relay type/model

3.2 Introduction to the user interfaces and settings options

The relay has three user interfaces:

– the front panel user interface via the LCD and keypad.

– the front port which supports Courier communication.

– the rear port which supports one protocol of either Courier, Modbus, IEC 60870-5-103 or DNP3.0. The protocol for the rear port must be specified when the relay is ordered.

The measurement information and relay settings which can be accessed from the three interfaces are summarised in Table 1.

	Keypad /LCD	Courier	Modbus	IEC60870 -5-103	DNP3.0
Display & modification of all settings	•	•	•		
Digital I/O signal status	•	•	•	•	•
Display/extraction of measurements	•	•	•	•	•
Display/extraction of fault records	•	•	•		
Extraction of disturbance records		•	•		
Programmable scheme logic settings		•			
Reset of fault & alarm records	•	•	•	•	•
Clear event & fault records	•	•	•		•
Time synchronisation		•	•	•	•
Control commands	•	•	•	•	•

Table 1:

3.3 Menu structure

The relay's menu is arranged in a tabular structure. Each setting in the menu is referred to as a cell, and each cell in the menu may be accessed by reference to a row and column address. The settings are arranged so that each column contains related settings, for example all of the disturbance recorder settings are contained within the same column. As shown in Figure 3, the top row of each column contains the heading which describes the settings contained within that column. Movement between the columns of the menu can only be made at the column heading level. A complete list of all of the menu settings is given in Appendix A of the manual.

Note: *May vary according to relay type/model

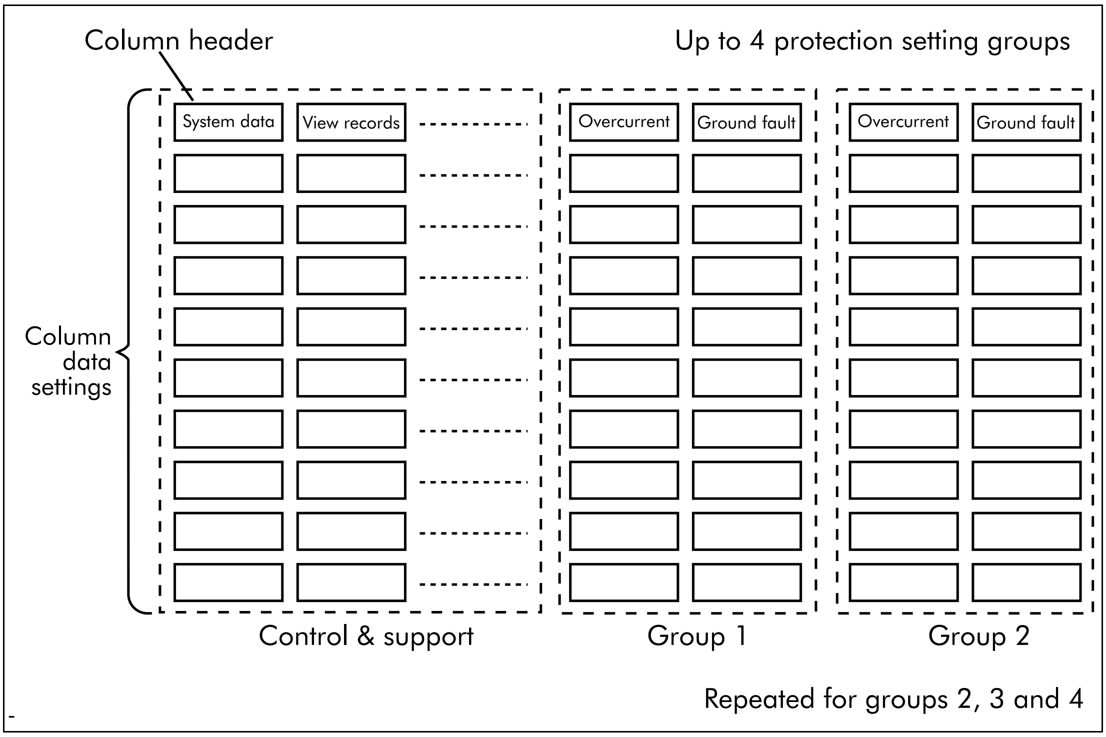


Figure 3: Menu structure

All of the settings in the menu fall into one of three categories: protection settings, disturbance recorder settings, or control and support (C&S) settings. One of two different methods is used to change a setting depending on which category the setting falls into. Control and support settings are stored and used by the relay immediately after they are entered. For either protection settings or disturbance recorder settings, the relay stores the new setting values in a temporary 'scratchpad'. It activates all the new settings together, but only after it has been confirmed that the new settings are to be adopted. This technique is employed to provide extra security, and so that several setting changes that are made within a group of protection settings will all take effect at the same time.

3.3.1 Protection settings

The protection settings include the following items:

- protection element settings
- scheme logic settings
- auto-reclose and check synchronisation settings (where appropriate)*
- fault locator settings (where appropriate)*

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

3.3.2 Disturbance recorder settings

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

Note: *May vary according to relay type/model

3.3.3 Control and support settings

The control and support settings include:

- relay configuration settings
- open/close circuit breaker*
- CT & VT ratio settings*
- reset LEDs
- active protection setting group
- password & language settings
- circuit breaker control & monitoring settings*
- communications settings
- measurement settings
- event & fault record settings
- user interface settings
- commissioning settings

3.4 Password protection

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

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

Table 2:

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

Note: *May vary according to relay type/model

the relay's serial number. The current level of access enabled for an interface can be determined by examining the 'Access level' cell in the 'System data' column, the access level for the front panel User Interface (UI), can also be found as one of the default display options.

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

3.5 Relay configuration

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

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

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

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

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

3.6 Front panel user interface (keypad and LCD)

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

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

Note: *May vary according to relay type/model

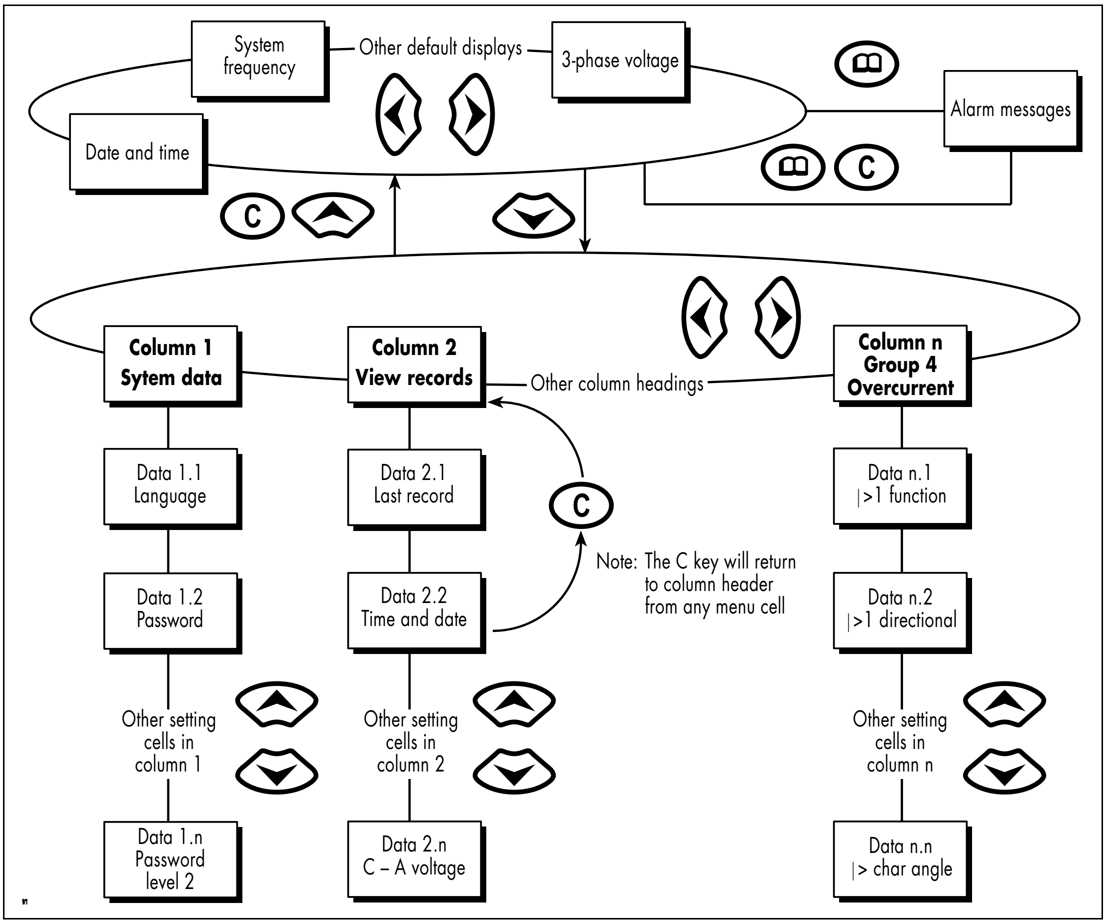


Figure 4: Front panel user interface

3.6.1 Default display and menu time-out

The front panel menu has a selectable default display. The relay will time-out and return to the default display and turn the LCD backlight off after 15 minutes of keypad inactivity. If this happens any setting changes which have not been confirmed will be lost and the original setting values maintained.

The contents of the default display can be selected from the following options: 3-phase and neutral current, 3-phase voltage, power, system frequency, date and time, relay description, or a user-defined plant reference*. The default display is selected with the 'Default display' cell of the 'Measure't setup' column. Also, from the default display the different default display options can be scrolled through using the ⇐ and ⇒ keys. However the menu selected default display will be restored following the menu time-out elapsing. Whenever there is an uncleared alarm present in the relay (e.g. fault record, protection alarm, control alarm etc.) the default display will be replaced by:

Alarms/Faults Present

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

Note: *May vary according to relay type/model

3.6.2 Menu navigation and setting browsing

The menu can be browsed using the four arrow keys, following the structure shown in Figure 4. Thus, starting at the default display the ⇓ key will display the first column heading. To select the required column heading use the ⇐ and ⇒ keys. The setting data contained in the column can then be viewed by using the ⇓ and ⇑ keys. It is possible to return to the column header either by holding the ⇑ key down or by a single press of the clear key C. It is only possible to move across columns at the column heading level. To return to the default display press the ⇑ key or the clear key C from any of the column headings. It is not possible to go straight to the default display from within one of the column cells using the auto-repeat facility of the ⇑ key, as the auto-repeat will stop at the column heading. To move to the default display, the ⇑ key must be released and pressed again.

3.6.3 Password entry

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

Enter password **** Level 1

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

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

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

3.6.4 Reading and clearing of alarm messages and fault records

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

Note: *May vary according to relay type/model

Press clear to reset alarms

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

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

3.6.5 Setting changes

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

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

Update settings? Enter or clear

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

3.7 Front communication port user interface

The front communication port is provided by a 9-pin female D-type connector located under the bottom hinged cover. It provides EIA(RS)232 serial data communication and is intended for use with a PC locally to the relay (up to 15m distance) as shown in Figure 5. This port supports the Courier communication protocol only. Courier is the communication language developed by ALSTOM T&D Protection & Control to allow communication with its range of protection relays. The front port is particularly designed for use with the relay settings program MiCOM S1 which is a Windows NT based software package.

Note: *May vary according to relay type/model

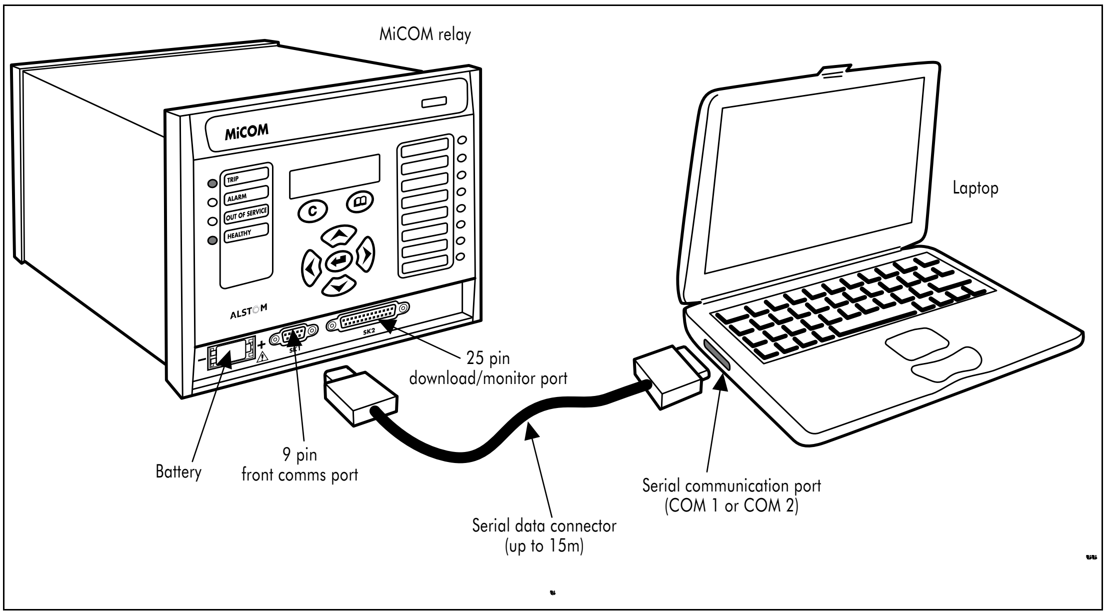


Figure 5: Front port connection

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

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

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

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

For successful data communication, the Tx pin on the relay must be connected to the Rx pin on the PC, and the Rx pin on the relay must be connected to the Tx pin on the PC, as shown in Figure 6. Therefore, providing that the PC is a DTE with pin connections as given above, a 'straight through' serial connector is required, i.e. one that connects pin 2 to pin 2, pin 3 to pin 3, and pin 5 to pin 5. Note that a common cause of difficulty with serial data communication is connecting Tx to Tx and Rx to Rx. This could happen if a 'cross-over' serial connector is used, i.e. one that connects pin 2 to pin 3, and pin 3 to pin 2, or if the PC has the same pin configuration as the relay.

Note: *May vary according to relay type/model

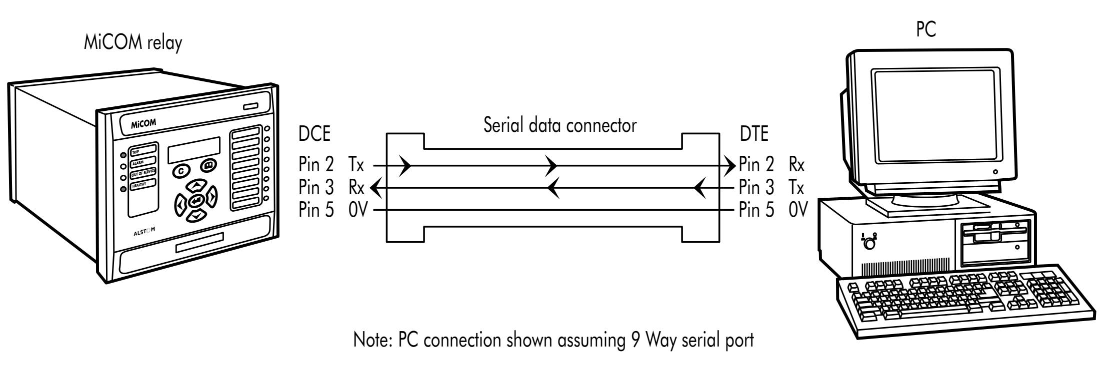


Figure 6: PC – relay signal connection

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

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

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

3.8 Rear communication port user interface

The rear port can support one of four communication protocols (Courier, Modbus, DNP3.0, IEC 60870-5-103), the choice of which must be made when the relay is ordered. The rear communication port is provided by a 3-terminal screw connector located on the back of the relay. See Appendix B for details of the connection terminals. The rear port provides K-Bus/EIA(RS)485 serial data communication and is intended for use with a permanently-wired connection to a remote control centre. Of the three connections, two are for the signal connection, and the other is for the earth shield of the cable. When the K-Bus option is selected for the rear port, the two signal connections are not polarity conscious, however for Modbus, IEC 60870-5-103 and DNP3.0 care must be taken to observe the correct polarity.

The protocol provided by the relay is indicated in the relay menu in the 'Communications' column. Using the keypad and LCD, firstly check that the 'Comms settings' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. The first cell down the column shows the communication protocol being used by the rear port.

3.8.1 Courier communication

Courier is the communication language developed by ALSTOM T&D Protection & Control to allow remote interrogation of its range of protection relays. Courier works on a master/slave basis where the slave units contain information in the form of a database, and respond with information from the database when it is requested by a master unit.

Note: *May vary according to relay type/model

The relay is a slave unit which is designed to be used with a Courier master unit such as MiCOM S1, MiCOM S10, PAS&T or a SCADA system. MiCOM S1 is a Windows NT4.0/95/98/ME/XP compatible software package which is specifically designed for setting changes with the relay.

To use the rear port to communicate with a PC-based master station using Courier, a KITZ K-Bus to EIA(RS)232 protocol converter is required. This unit is available from ALSTOM T&D Protection & Control. A typical connection arrangement is shown in Figure 7. For more detailed information on other possible connection arrangements refer to the manual for the Courier master station software and the manual for the KITZ protocol converter. Each spur of the K-Bus twisted pair wiring can be up to 1000m in length and have up to 32 relays connected to it.

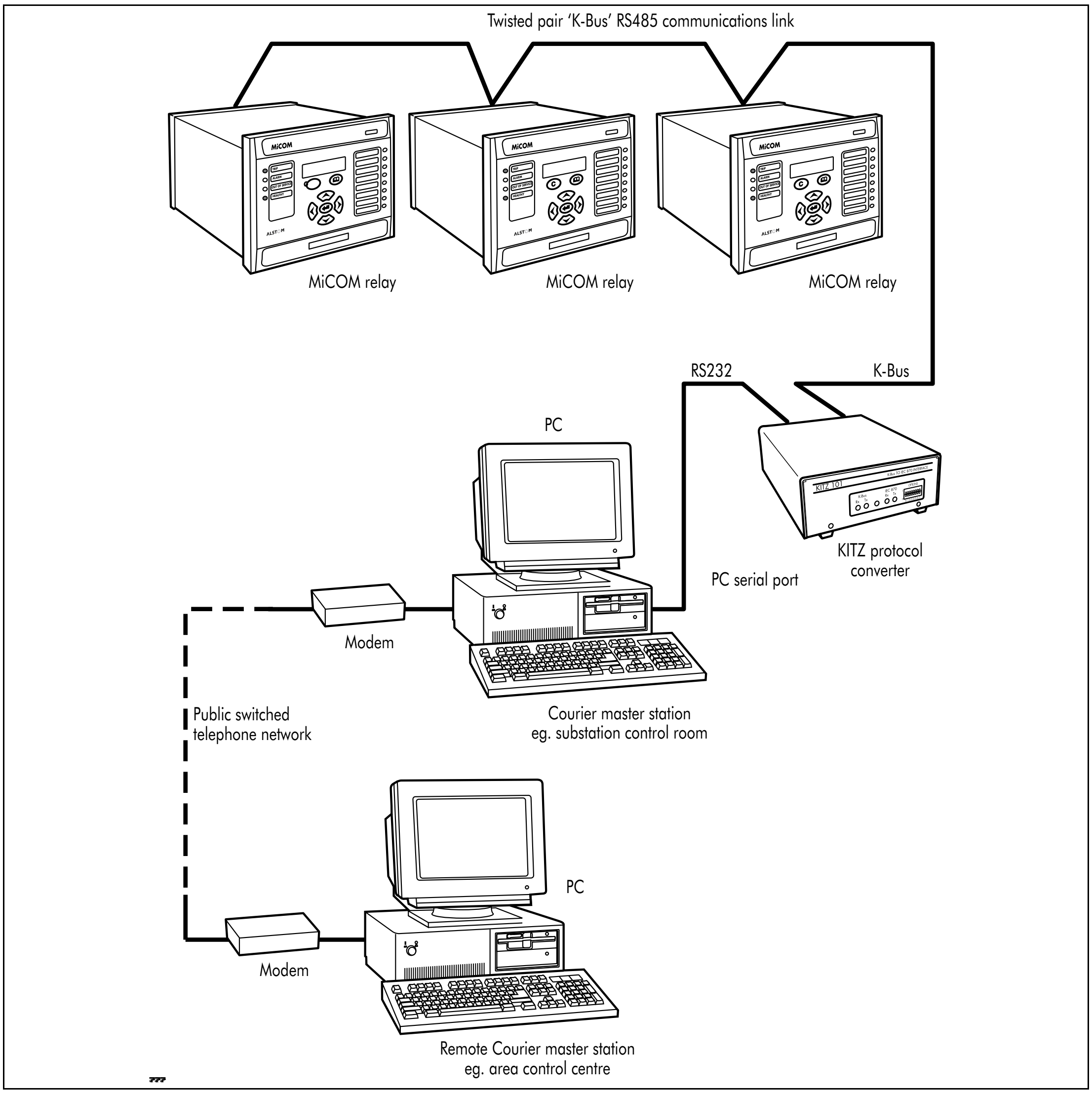


Figure 7: Remote communication connection arrangements

Having made the physical connection to the relay, the relay's communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the 'Comms settings' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. Only two settings apply to the rear port using Courier, the relay's address and the inactivity timer. Synchronous communication is used at a fixed baud rate of 64kbits/s.

Note: *May vary according to relay type/model

Move down the 'Communications' column from the column heading to the first cell down which indicates the communication protocol:

Protocol Courier

The next cell down the column controls the address of the relay:

Remote address 1

Since up to 32 relays can be connected to one K-bus spur, as indicated in Figure 7, it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. Courier uses an integer number between 0 and 254 for the relay address which is set with this cell. It is important that no two relays have the same Courier address. The Courier address is then used by the master station to communicate with the relay.

The next cell down controls the inactivity timer:

Inactivity time 10.00 mins

The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

Note that protection and disturbance recorder settings that are modified using an on-line editor such as PAS&T must be confirmed with a write to the 'Save changes' cell of the 'Configuration' column. Off-line editors such as MiCOM S1 do not require this action for the setting changes to take effect.

3.8.2 Modbus communication

Modbus is a master/slave communication protocol which can be used for network control. In a similar fashion to Courier, the system works by the master device initiating all actions and the slave devices, (the relays), responding to the master by supplying the requested data or by taking the requested action. Modbus communication is achieved via a twisted pair connection to the rear port and can be used over a distance of 1000m with up to 32 slave devices.

To use the rear port with Modbus communication, the relay's communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the 'Comms settings' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. Four settings apply to the rear port using Modbus which are described below. Move down the 'Communications' column from the column heading to the first cell down which indicates the communication protocol:

Protocol Modbus

Note: *May vary according to relay type/model

The next cell down controls the Modbus address of the relay:

Modbus address 23

Up to 32 relays can be connected to one Modbus spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. Modbus uses an integer number between 1 and 247 for the relay address. It is important that no two relays have the same Modbus address. The Modbus address is then used by the master station to communicate with the relay.

The next cell down controls the inactivity timer:

Inactivity timer 10.00 mins

The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

The next cell down the column controls the baud rate to be used:

Baud rate 9600 bits/s

Modbus communication is asynchronous. Three baud rates are supported by the relay, '9600 bits/s', '19200 bits/s' and '38400 bits/s'. It is important that whatever baud rate is selected on the relay is the same as that set on the Modbus master station.

The next cell down controls the parity format used in the data frames:

Parity None

The parity can be set to be one of 'None', 'Odd' or 'Even'. It is important that whatever parity format is selected on the relay is the same as that set on the Modbus master station.

3.8.3 IEC 60870-5 CS 103 communication

The IEC specification IEC 60870-5-103: Telecontrol Equipment and Systems, Part 5: Transmission Protocols Section 103 defines the use of standards IEC 60870-5-1 to IEC 60870-5-5 to perform communication with protection equipment. The standard configuration for the IEC 60870-5-103 protocol is to use a twisted pair connection over distances up to 1000m. As an option for IEC 60870-5-103, the rear port can be specified to use a fibre optic connection for direct connection to a master station. The relay operates as a slave in the system, responding to commands from a master station. The method of communication uses standardised messages which are based on the VDEW communication protocol.

Note: *May vary according to relay type/model

To use the rear port with IEC 60870-5-103 communication, the relay's communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the 'Comms settings' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. Four settings apply to the rear port using IEC 60870-5-103 which are described below. Move down the 'Communications' column from the column heading to the first cell which indicates the communication protocol:

Protocol IEC 60870-5-103

The next cell down controls the IEC 60870-5-103 address of the relay:

Remote address 162

Up to 32 relays can be connected to one IEC 60870-5-103 spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. IEC 60870-5-103 uses an integer number between 0 and 254 for the relay address. It is important that no two relays have the same IEC 60870-5-103 address. The IEC 60870-5-103 address is then used by the master station to communicate with the relay.

The next cell down the column controls the baud rate to be used:

Baud rate 9600 bits/s

IEC 60870-5-103 communication is asynchronous. Two baud rates are supported by the relay, '9600 bits/s' and '19200 bits/s'. It is important that whatever baud rate is selected on the relay is the same as that set on the IEC 60870-5-103 master station.

The next cell down controls the period between IEC 60870-5-103 measurements:

Measure't period 30.00 s

The IEC 60870-5-103 protocol allows the relay to supply measurements at regular intervals. The interval between measurements is controlled by this cell, and can be set between 1 and 60 seconds.

The next cell down the column controls the physical media used for the communication:

Physical link EIA(RS)485

The default setting is to select the electrical EIA(RS)485 connection. If the optional fibre optic connectors are fitted to the relay, then this setting can be changed to 'Fibre optic'.

Note: *May vary according to relay type/model

The next cell down can be used to define the primary function type for this interface, where this is not explicitly defined for the application by the IEC 60870-5-103 protocol*.

Function type 226

3.8.4 DNP 3.0 Communication

The DNP 3.0 protocol is defined and administered by the DNP User Group. Information about the user group, DNP 3.0 in general and protocol specifications can be found on their website: www.dnp.org

The relay operates as a DNP 3.0 slave and supports subset level 2 of the protocol plus some of the features from level 3. DNP 3.0 communication is achieved via a twisted pair connection to the rear port and can be used over a distance of 1000m with up to 32 slave devices.

To use the rear port with DNP 3.0 communication, the relay's communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the 'Comms setting' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. Four settings apply to the rear port using DNP 3.0, which are described below. Move down the 'Communications' column from the column heading to the first cell which indicates the communications protocol:

Protocol DNP 3.0

The next cell controls the DNP 3.0 address of the relay:

DNP 3.0 address 232

Upto 32 relays can be connected to one DNP 3.0 spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by only one relay. DNP 3.0 uses a decimal number between 1 and 65519 for the relay address. It is important that no two relays have the same DNP 3.0 address. The DNP 3.0 address is then used by the master station to communicate with the relay.

The next cell down the column controls the baud rate to be used:

Baud rate 9600 bits/s

DNP 3.0 communication is asynchronous. Six baud rates are supported by the relay '1200bits/s', '2400bits/s', '4800bits/s', '9600bits/s', '19200bits/s' and '38400bits/s'. It is important that whatever baud rate is selected on the relay is the same as that set on the DNP 3.0 master station.

Note: *May vary according to relay type/model

The next cell down the column controls the parity format used in the data frames:

Parity None

The parity can be set to be one of 'None', 'Odd' or 'Even'. It is important that whatever parity format is selected on the relay is the same as that set on the DNP 3.0 master station.

The next cell down the column sets the time synchronisation request from the master by the relay:

Time Synch Enabled

The time synch can be set to either enabled or disabled. If enabled it allows the DNP 3.0 master to synchronise the time.

Note: *May vary according to relay type/model

CHAPTER 2
Application Notes

MiCOM P14x Series
Feeder Management Relays

ALSTOM

T&D
Protection & Control

MiCOM P14x Series
Feeder Management Relays

Introduction

The MiCOM Feeder Management Relays provide flexible and reliable integration of protection, control, monitoring and measurement functions. Extensive functionality is able to provide complete protection and control for a wide range of overhead lines and underground cables from distribution to transmission voltage levels.

Protection

- Directional/non-directional phase overcurrent
- Directional/non-directional earth fault
- Sensitive directional/non-directional earth fault
- Wattmetric earth fault
- I cos ϕ and I sin ϕ earth fault
- Restricted earth fault
- Blocked overcurrent logic
- Selective overcurrent logic
- Cold load pick-up logic
- Voltage controlled overcurrent
- Directional/non-directional negative sequence overcurrent
- RMS thermal overload
- Under/overvoltage
- Residual overvoltage
- Negative sequence overvoltage
- Under/overfrequency
- Broken conductor
- Circuit breaker failure
- Voltage transformer supervision
- Silicon rectifier overload protection
- Current transformer supervision
- Neutral admittance

Control

- Multi-shot autoreclose with check synchronising and external initiation
- Circuit breaker control
- Programmable scheme logic
- Programmable allocation of optically isolated inputs and relay outputs
- Multiple settings groups
- Control inputs

Measurements

- Comprehensive measurement values
  - Instantaneous
  - Integrated

Post fault analysis

- Fault location
- Event and fault records
- Disturbance records

Monitoring

- Trip circuit supervision
- Breaker state monitoring
- Breaker condition monitoring

Communications

- A choice of protocols, IEC 60870, Courier, Modbus and DNP3.0
- Front and rear communication ports

Figure 1: MiCOM P141

Diagnostics

- Power-up diagnostics
- Continuous self monitoring
- Test facilities

User friendly interface

- Liquid crystal display with backlight
- Programmable LED indications
- Password protection
- Optional secondary protective cover
- Fully programmable menu text

Software support

Available in conjunction with MiCOM S1 support software:

- Settings editor
- Programmable scheme logic editor
- Viewing of fault diagnostics and measurements
- Menu text editor
- Disturbance recorder viewer

Models available

- P141 Feeder Management Relay
- P142 with autoreclose
- P143 with autoreclose and check synchronising

Application

The MiCOM P14x series is suitable for all applications where overcurrent protection is required. The integration of many functions provides complete protection for a wide range of overhead lines and underground cables, from distribution to transmission voltage levels. It is suitable for solid earthed, impedance earthed, Petersen coil earthed and isolated systems.

A comprehensive suite of overcurrent protection provides an economic solution to complex protection applications. Figure 2a shows a parallel transformer application where the MiCOM P141 replaces many of the discrete protection elements normally associated with the LV side of the transformer. The protection includes non-directional and directional phase overcurrent and earth fault independently configurable to be either inverse definite minimum time (IDMT) or definite time. Restricted earth fault and circuit breaker failure protection are also included.

Figure 2b shows a MiCOM P143 protecting a plain feeder using phase overcurrent, sensitive earth fault, negative sequence overcurrent, thermal protection and breaker failure protection. The integral autorecloser with check synchronising may be configured to grade with downstream reclosers. A range of communication protocols allows connection with many external devices thus providing remote programming, control and extraction of information.

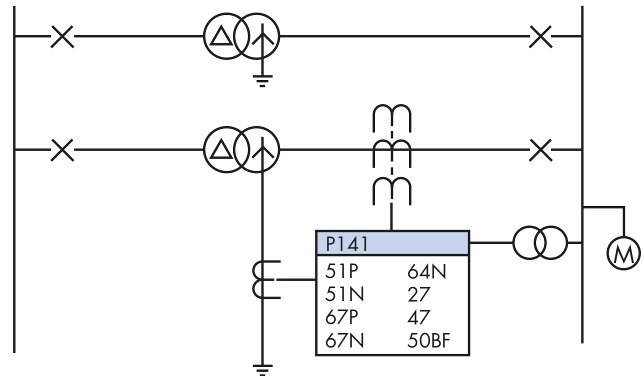


Figure 2a: Typical parallel transformer application

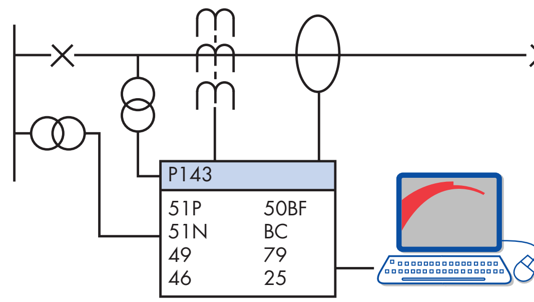


Figure 2b: Typical plain feeder application

ANSI Numbers			
67/50P	Instantaneous phase overcurrent	67	Directional
67/51P	Time delayed phase overcurrent	59	Overvoltage
67/37P	Phase undercurrent	59N	Residual overvoltage
67/50N	Instantaneous neutral overcurrent	27	Undervoltage
67/51N	Time delayed neutral overcurrent	47	Negative sequence overvoltage
37N	Neutral undercurrent	50BF	Breaker failure and backtrip
64N	Restricted earth fault	25	Check synchronising
49	Thermal overload	67/46	Negative sequence overcurrent
79	Autoreclose	BC	Broken conductor detection
67W	Wattmetric	VTS	Voltage transformer supervision
		CTS	Current transformer supervision

Figures 2a and 2b

Protection functions

Three phase tripping with faulted phase indication is provided for all protection functions.

Phase overcurrent

Four independent stages are available for each phase overcurrent element. Each stage may be selected as non-directional or directional (forward/reverse). All stages have definite time delayed characteristics, two of the stages may also be independently set to one of ten IDMT curves (IEC and IEEE). The IDMT stages have a programmable reset timer for grading with electromechanical relays, to reduce autoreclose dead times and to reduce clearance times where intermittent faults occur.

The phase fault directional elements are internally polarised by quadrature phase-phase voltages, and will make a correct directional decision down to:

0.5V (Vn = 100 – 120V) or
2.0V (Vn = 380 – 480V).

A synchronous polarising signal is maintained for 3.2s after voltage collapse to ensure that the instantaneous and time delayed overcurrent elements operate correctly for close-up three phase faults.

Standard earth fault

There are two standard earth fault elements, each with four independent stages.

- The first element operates from measured quantities:
  - earth fault current which is directly measured using a separate CT
  - residual connection of the three line CTs
- The second standard earth fault element operates from a residual current that is derived internally from the summation of the three phase currents.

All earth fault elements have the same directionality and IDMT characteristics as the phase overcurrent element.

Both earth fault elements may be enabled at the same time providing discriminative directional earth fault protection and back-up standby earth fault protection in the same device. The directionality of the earth fault elements is provided by either residual voltage or negative sequence voltage.

Sensitive earth fault

A core balance CT should be used to drive the sensitive earth fault function. The directionality of the sensitive earth fault elements is provided by the residual voltage.

Wattmetric

As an alternative to the directional wattmetric characteristic a directional I cos (ϕ) characteristic can be used for Petersen coil earth fault protection using the sensitive earth fault input. This protection provides discrimination as faulted feeders will have a large component of residual current whilst healthy feeders will have a small value.
A directional I sin (ϕ) characteristic is also available for protection of insulated feeders.

Neutral admittance protection

Neutral admittance protection is provided for the Polish market for earth fault protection. Three single stage elements are provided for non-directional overadmittance, non-directional/directional overconductance and non-directional/directional oversusceptance.

Restricted earth fault

The restricted earth fault protection may be configured as either high impedance or low impedance biased differential.

Blocked overcurrent logic

Each stage of overcurrent and earth fault protection can be blocked by an optically isolated input.
This enables overcurrent and earth fault protection to integrate into a blocked overcurrent busbar protection scheme.

Selective overcurrent logic

Selective overcurrent logic assists with relay co-ordination by allowing the time delay settings of the overcurrent elements to be temporarily modified by energisation of an optically isolated input. This is available using programmable scheme logic.

Cold load pick-up logic

Cold load pick-up temporarily raises the overcurrent settings following closure of the circuit breaker, allowing the protection settings to be set closer to the load profile.

Voltage controlled overcurrent

Voltage controlled overcurrent provides back-up protection for remote phase faults whilst remaining insensitive to load conditions.

Negative sequence overcurrent

Negative sequence overcurrent protection can be set as either non-directional or directional (forward/reverse), and can operate for remote phase-phase and phase-earth faults even with delta-star transformers present.

RMS thermal overload

Thermal characteristics suitable for cables and transformers are available providing both alarm and trip stages. The thermal element may be set with either a single time constant characteristic for the protection of cables or dry transformers, or a dual time constant characteristic to protect oil filled transformers. In the event of loss of auxiliary supply, the thermal state is stored in non-volatile memory.

Under/overvoltage

Under/overvoltage protection may be configured to operate from either phase-phase or phase-neutral quantities. Two independent stages with definite time elements are available, one of the stages can also be configured to an inverse characteristic.

Neutral displacement/residual overvoltage

Residual overvoltage protection is available for detecting earth faults in high impedance earthed or isolated systems. The neutral voltage is derived from the three phase voltage inputs. Two independent measuring elements with definite time characteristics are available, one of the elements can also be configured to have an inverse characteristic.

Negative sequence overvoltage

Negative sequence overvoltage protection provides either a tripping or an interlocking function, upon detection of unbalanced supply voltages

Under/overfrequency

Two independent stages of overfrequency and four of underfrequency are provided. Each stage functions as a definite time element.

Broken conductor

The broken conductor protection detects unbalanced conditions caused by broken conductors, mal-operation of single phase switchgear or by single phasing conditions.

Supervisory functions

Circuit breaker failure protection

Two stage circuit breaker failure protection may be used for tripping upstream circuit breakers and retripping of the local circuit breaker if required. The circuit breaker failure logic may also be initiated externally from other protection devices if required.

Voltage transformer supervision

Voltage transformer supervision is provided to detect loss of one, two or three VT signals, providing indication and inhibition of voltage dependent protection elements. An optically isolated input may also be configured to initiate the voltage transformer supervision alarm and blocking when used with MCBs or other external forms of voltage transformer supervision.

Current transformer supervision

Current transformer supervision is provided to detect loss of phase CT signals and inhibit the operation of current dependent protection elements.

Control

Circuit breaker control

Circuit breaker control is available from the front panel user interface, optically isolated inputs and remotely via the substation communications.

Autoreclose with check synchronising

The P142 provides three pole multi-shot autoreclose. The user may select a single, two, three or four shot autoreclose cycle, with independently settable dead times and reclaim time. Autoreclose can be initiated from the internal protection elements or from external protection via an opto input.

More advanced features of the P143 include check synchronising, live line working and sequence co-ordination (co-ordination with downstream reclosing equipment).

Programmable scheme logic

Programmable scheme logic allows the user to customise the protection and control functions. It is also used to programme the functionality of the optically isolated inputs, relay outputs and LED indications.

The programmable scheme logic comprises gate logic and general purpose timers. The gate logic includes OR, AND and majority gate functions, with the ability to invert the inputs and outputs, and provide feedback. The system is optimised to evaluate changes to the scheme logic signals and thus avoid unnecessary signal processing.

The programmable scheme logic is configured using the graphical MiCOM S1 PC based support software, as illustrated in Figure 3.

The required logic is drawn as shown and is then downloaded directly into the relay. The logic may also be uploaded from the relay and then modified using MiCOM S1 support software.

Independent protection settings groups

The settings are divided into two categories; protection settings, and control and support settings. Four setting groups are provided for the protection settings to allow for different operating conditions and adaptive relaying. All settings are stored in E^2PROM.

Control inputs

The control inputs allow the user to manualy change the status of DDB signals 800 to 831. These signals can be assigned to provide user defined control functions.

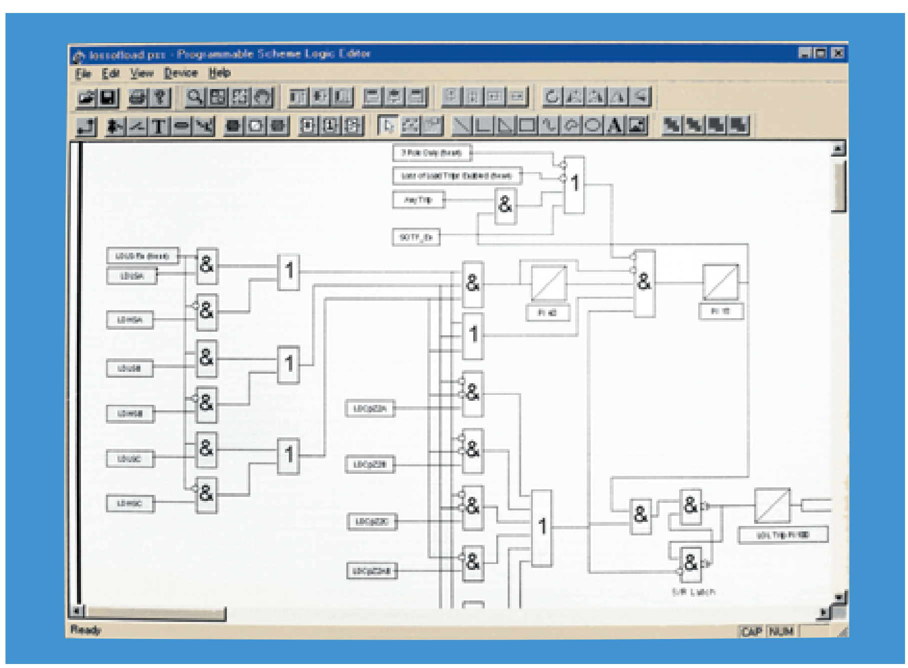


Figure 3: Programmable scheme logic editor (MiCOM S1)

Measurement and recording facilities

The P14x series is capable of measuring and storing the values of a wide range of quantities.
All events, fault and disturbance records are time tagged to a resolution of 1ms using an internal real time clock. An optional IRIG-B port is also provided for accurate time synchronisation.

A lithium battery provides a back-up for the real time clock and all records in the event of supply failure. This battery is supervised and easily replaced from the front of the relay.

Measurements

The measurements provided, which may be viewed in primary or secondary values, can be accessed by the back-lit liquid crystal display, or the communications ports. Phase notation is user definable using the MiCOM S1 text editor.

Instantaneous measurements

Phase voltages	V_{an} V_{bn} V_{cn}
Line voltages	V_{ab} V_{bc} V_{ca}
Neutral voltage	V_n
Phase current	I_a I_b I_c
Neutral currents	I_n I_{SEF}

Sequence currents and voltages

Ratio of I_2/I_1

Frequency

Thermal state

Single and three phase power factor

Active power	W_a W_b W_c W_{total}
Reactive power	VAr_a VAr_b VAr_c VAr_{total}
Apparent power	VA_a VA_b VA_c VA_{total}

Phase currents and phase to neutral voltages are available in true rms and fundamental quantities.

Integrated values

Wh VArh

Peak, average and rolling demand:

- I_a I_b I_c
- W VAr

The P143 provides an additional voltage input for synchronisation and additional measurements:

- Check synchronising voltage
- Slip frequency

Post fault analysis

Fault location

A fault location algorithm provides distance to fault in miles, kilometres, ohms or percentage of line length.

Event records

Up to 250 time-tagged event records are stored in battery backed memory, and can be extracted using the communication ports or viewed on the front panel display.

Fault records

Records of the last 5 faults are stored in battery backed memory. The information provided in the fault record includes:

- Indication of faulted phase
- Protection operation
- Active setting group
- Date and time
- Fault location
- Relay and CB operating time
- Currents, voltages and frequency

Disturbance records

The internal disturbance recorder has 8 analogue channels, 32 digital and 1 time channel. Data is sampled 12 times a cycle and typically 20 disturbance records, each of up to 10.5 seconds duration are stored in battery backed memory. All channels and the trigger source are user configurable. Disturbance records can be extracted from the relay via the remote communications and saved in the COMTRADE format. These records may be examined using MiCOM S1 or any suitable software program.

Plant supervision

Trip circuit supervision

Supervision of the trip circuit in both circuit breaker open and closed states can be realised using the optically isolated inputs and programmable scheme logic.

Circuit breaker state monitoring

An alarm will be generated if there is a discrepancy between the open and closed auxiliary contacts of the circuit breaker.

Circuit breaker condition monitoring

The circuit breaker condition monitoring features include:

- monitoring the number of breaker trip operations
- recording the sum of the broken current quantity ΣI^x, $1.0 \leq x \leq 2.0$
- monitoring the breaker operating time
- fault frequency counter

Local and remote communications

Two communication ports are available; a rear port providing remote communications and a front port providing local communications.

Remote communications

The remote communications are based on RS485 voltage levels. Any of the protocols listed below can be chosen at the time of ordering.

Courier/K-Bus

The Courier language is a protocol which has been developed specifically for the purpose of developing generic PC programmes that will, without modification, communicate with any device using the Courier language.

Modbus

Modbus is a master/slave protocol, whereby the master must have knowledge of the slave's databases and addresses. The Modbus implementation supported by the MiCOM P14x series is RTU mode.

IEC 60870-5-103

The relay is compliant with the transmission protocol defined by the specification IEC 60870-5-103. The standardised messages based on the VDEW communication protocol are supported.

DNP 3.0

The DNP 3.0 protocol is defined and administered by the DNP User Group. The relay operates as a DNP 3.0 slave and supports subset level 2 of the protocol plus some of the features from level 3.

Local communications

The front serial communications port has been designed for use with MiCOM S1, which fully supports functions within the relay by providing the ability to programme the settings off-line, configure the programmable scheme logic, extract and view event, disturbance and fault records, view the measurement information dynamically and perform control functions. PAS&T support software can also be used with the local communications port.

Diagnostics

Automatic tests performed including power-on diagnostics and continuous self-monitoring ensure a high degree of reliability. The results of the self-test functions are stored in battery backed memory.
Test features available on the user interface provide examination of input quantities, states of the digital inputs and relay outputs. A local monitor port providing digital outputs, selected from a prescribed list of signals, including the status of protection elements, may be used in conjunction with test equipment.
These test signals can also be viewed using the Courier and Modbus communications ports and the front panel user interface.

Hardware description

All models within the MiCOM P14x series include:

- A back-lit liquid crystal display
- 12 LEDs
- An optional IRIG-B port
- An RS232 port
- An RS485 port
- A download/monitor port
- A battery (supervised)
- N/O and N/C watchdog contacts
- Supervised +48V field voltage
- 1A/5A dual rated CTs

The hardware variations between the MiCOM P14x series models are:

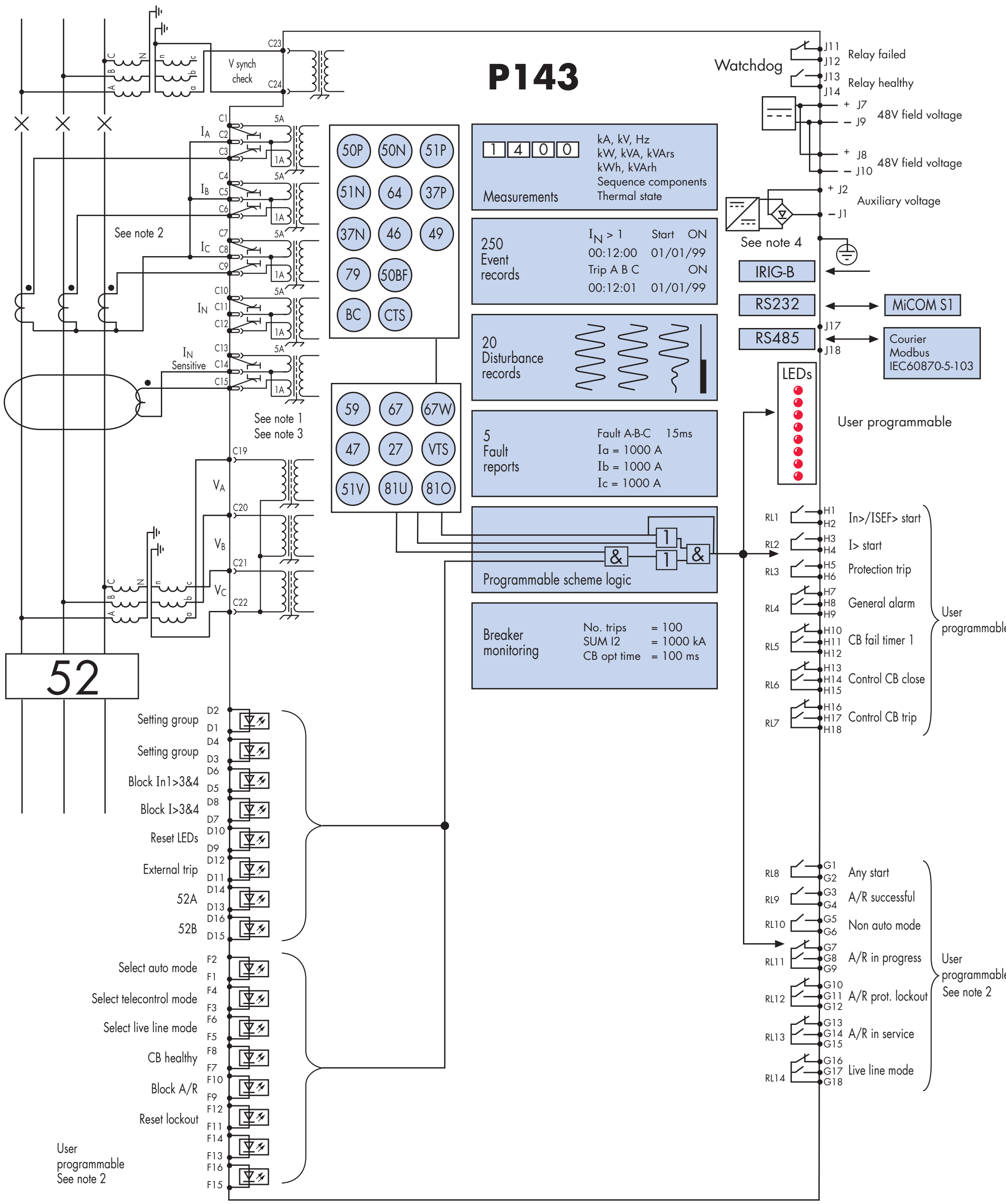
	P141	P142	P143
100 - 120V or 380 - 480V VTs	3	3	4
Optically isolated inputs	8	8	16
Relay outputs	3N/O 4C/O	3N/O 4C/O	6N/O 8C/O

Expansion cards are available to allow further inputs and outputs for the P142 and P143 (see page 16).

N/O – normally open
C/O – change over

The allocation of the optically isolated inputs, relay outputs and 8 of the LEDs are preconfigured as a default, but may be programmed by the user.
The optically isolated inputs are independent and may be powered from the +48V field voltage.
The relay outputs may be configured as latching or self reset.
All CT connections have integral shorting.

A system overview of the MiCOM P143 is shown in Figure 4.



ANSI Numbers

67/50P	Instantaneous phase overcurrent	79	Autoreclose	81O	Overfrequency
67/51P	Time delayed phase overcurrent	67W	Wattmetric	47	Negative sequence overvoltage
37P	Phase undercurrent	51V	Voltage controlled overcurrent	50BF	Breaker failure and backtrip
67/50N	Instantaneous neutral overcurrent	67	Directional	25	Check synchronising
67/51N	Time delayed neutral overcurrent	59	Overvoltage	67/46	Negative sequence overcurrent
37N	Neutral undercurrent	59N	Residual overvoltage	BC	Broken conductor detection
64	Restricted earth fault	27	Undervoltage	VTS	Voltage transformer supervision
49	Thermal overload	81U	Underfrequency	CTS	Current transformer supervision

Note 1: All CT connectors have integral shorting. These contacts are made before the internal CT circuits are disconnected.

Note 2: Additional hardware for P143 only.

Note 3: 5A CT connections shown, 1A CT connections available on the terminal blocks.

Note 4: The bridge rectifier is not present on the 24 – 48V dc version.

Figure 4: MiCOM P143 system overview
(Not intended for wiring purposes, refer to external connection diagram 10 P143 01 for connection details)

Figure 5: User interface

User interface

The front panel user interface comprises:

(1) A 2 x 16 character back-lit liquid crystal display.

(2) Four fixed function LEDs.

(3) Eight user programmable LEDs.

(4) Menu navigation and data entry keys.

(5) "READ" and "CLEAR" keys for viewing and acknowledging alarms.

(6) An upper cover identifying the product name. The cover may be raised to provide access to the product model number, serial number and ratings.

(7) A lower cover concealing the front RS232 port, download/monitor port and battery compartment. The front of the cover can display the name of the product, or any user defined name.

(8) Facility for fitting a security lead seal.

The user interface and menu text are available in English, French, German and Spanish as standard. Labels supplied with the device allow customised descriptions of the LEDs. A user selectable default display provides measurement information, time/date, protection functions and plant reference information. The ability to customise the menu text and alarm descriptions is also supported.

Password protection

Password protection may be independently applied to the front user interface, front communications port and rear communications port. Two levels of password protection are available providing access to the controls and settings respectively.

Protection setting ranges

Phase fault

IDMT/definite time stages	0.08 to 4.0In
Definite time stages	0.08 to 32In
Definite time	0 to 100s

Standard earth fault

IDMT/definite time stages	0.08 to 4.0In
Definite time stages	0.08 to 32In
Definite time	0 to 200s

Sensitive earth fault (SEF/I cos ϕ/I sin ϕ)

IDMT/definite time stages	0.005 to 0.1In
Definite time stages	0.005 to 2.0In
Definite time	0 to 200s

Residual polarising voltage setting Vop> for directional earth fault protection

0.5 to 80V (100 – 120V)

2 to 320V (380 – 440V)

Wattmetric characteristic

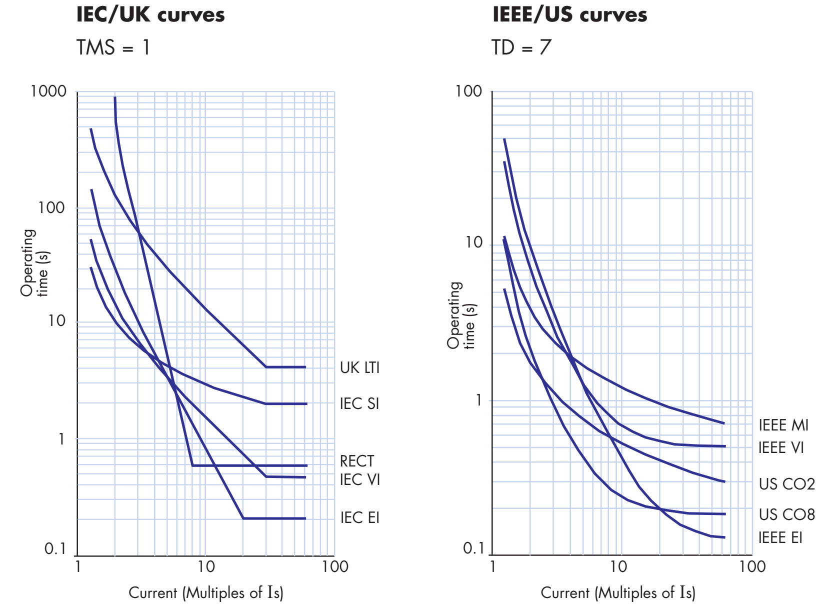
Power threshold (1A)

0 to 20W	(100 – 120V)
0 to 80W	(380 – 480V)

Power threshold (5A)

0 to 100W	(100 – 120V)
0 to 400W	(380 – 480V)

The IEC and IEEE/ANSI IDMT curves for the above protection settings are shown in Figure 6.



TMS 0.025 to 1.2

IEC Standard inverse $$t = TMS \times \frac{0.14}{\left(\frac{I}{Is}\right)^{0.02} - 1}$$

IEC Very inverse $$t = TMS \times \frac{13.5}{\left(\frac{I}{Is}\right) - 1}$$

IEC Extremely inverse $$t = TMS \times \frac{80}{\left(\frac{I}{Is}\right)^{2} - 1}$$

UK Long time inverse $$t = TMS \times \frac{120}{\left(\frac{I}{Is}\right) - 1}$$

Rectifier Curve $$t = TMS \times \frac{45900}{\left(\frac{I}{Is}\right)^{5.6} - 1}$$

TD 0.5 to 15

IEEE Moderately inverse $$t = \frac{TD}{7} \times \left\{\frac{0.0515}{\left(\frac{I}{Is}\right)^{0.02} - 1} + 0.114\right\}$$

IEEE Very inverse $$t = \frac{TD}{7} \times \left\{\frac{19.61}{\left(\frac{I}{Is}\right)^{2} - 1} + 0.491\right\}$$

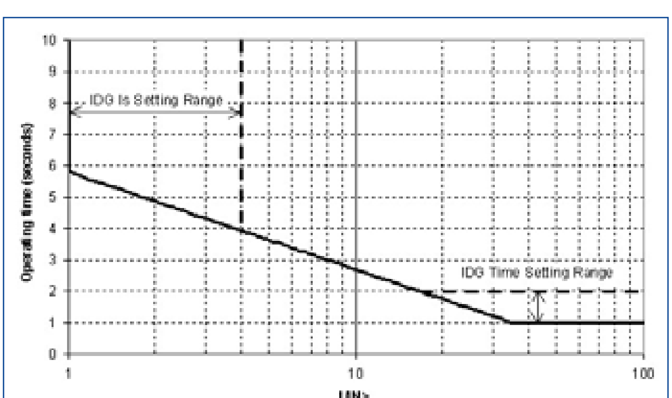
IEEE Extremely inverse $$t = \frac{TD}{7} \times \left\{\frac{28.2}{\left(\frac{I}{Is}\right)^{2} - 1} + 0.1217\right\}$$

US CO8 Inverse $$t = \frac{TD}{7} \times \left\{\frac{5.95}{\left(\frac{I}{Is}\right)^{2} - 1} + 0.18\right\}$$

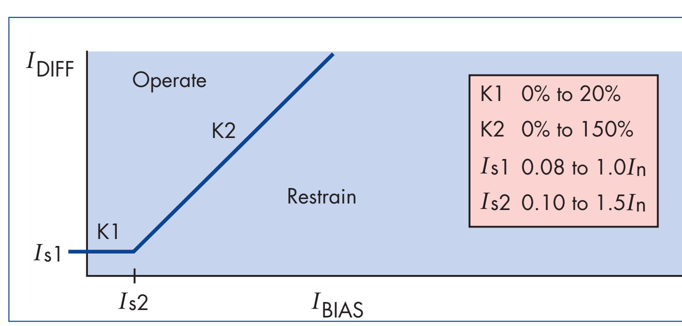
US CO2 Short time inverse $$t = \frac{TD}{7} \times \left\{\frac{0.02394}{\left(\frac{I}{Is}\right)^{0.02} - 1} + 0.01694\right\}$$

Figure 6: IEC and IEEE/ANSI IDMT curves

IDG characteristics



Restricted earth fault



Undercurrent

Phase and neutral

0.02 to 3.2In

ISEF 0.001 to 0.8In

Voltage controlled overcurrent

Voltage control threshold

20 to 120V (100 – 120V)

80 to 480V (380 – 480V)

Overcurrent sensitivity factor

0.25 to 1.0

Negative sequence overcurrent

Threshold	0.08 to 4.0In
Definite time	0 to 100s

Thermal overload

Thermal alarm	50% to 100%

Single time constant characteristic

$$t = -\tau \log_e \left[\frac{(I^2 - kI_{FLC})^2}{I^2 - Ip^2} \right]$$

Where:

t =	time to trip, following application of the overload current, I
τ =	plant heating and cooling time constant (1 to 200 minutes)
I =	largest phase current
I_{FLC} =	thermal trip setting
k =	1.05 constant
I_P =	Steady state pre-load current

Dual time constant characteristic

$$0.4\, e^{\frac{-t}{\tau 1}} + 0.6\, e^{\frac{-t}{\tau 2}} = \frac{[I^2 - (k.I_{FLC})^2]}{I^2 - Ip^2}$$

Where:

τ1, τ2 =	plant heating and cooling time constants (1 to 200 minutes)

Thermal trip current setting
0.08 to 3.2In

Undervoltage

Voltage settings, Vs

10 to 120V	(100 – 120V)
40 to 480V	(380 – 480V)

Time settings

Definite time	0 to 100s
IDMT	t = TMS/(1 – V/Vs)
TMS	0.5 to 100

Overvoltage

Voltage settings, Vs

60 to 185V	(100 – 120V)
240 to 680V	(380 – 480V)

Time settings

Definite time	0 to 100s
IDMT	t = TMS/(V/Vs – 1)
TMS	0.5 to 100

Residual overvoltage

Voltage settings, Vs

1 to 80V	(100 – 120V)
4 to 320V	(380 – 480V)

Time settings

Definite time	0 to 100s
IDMT	t = TMS/(V/Vs – 1)
TMS	0.5 to 100

Negative sequence overvoltage

Voltage settings, Vs

1 to 110V	(100 – 120V)
4 to 440V	(380 – 480V)

Time settings

Definite time	0 to 100s

Under/overfrequency

Frequency settings	45 to 65Hz
Definite time	0 to 100s

Broken conductor

I_2/I_1	0.2 to 1.0
Definite time	0 to 100s

Autoreclose and check synchronising (where appropriate

Main shots	1 to 4
Dead times (1, 2)	0.01 to 300s
Dead times (3, 4)	0.01 to 9999s
Check synchronising	5° to 90°
Slip frequency	0.02 to 1.00Hz

Neutral admittance

Voltage threshold Vn

1 to 40V	(100 – 120V)
4 to 160V	(380 – 480V)

Correction angle

–30° to +30°

Overadmittance settings
YN>/Overconductance settings
GN>/Oversusceptance settings
BN>

25μs to 2.5ms	(SEF input)
250μs to 25ms	(EF input)

Time settings (definite time)

Operating time 0.05 to 100s

Reset time 0 to 100s

Accuracy/operating times (typically)

Phase and earth fault	±5% or 50ms
Wattmetric	±5% or 40ms
Restricted earth fault	±5% or 45ms
Negative sequence overcurrent	±2% or 60ms
Undervoltage	±2% or 50ms
Overvoltage	±2% or 50ms

Measurements

Voltage and amperes	<1%
0.2 – 3.0In	±0.5%
0.2 – 2.0In	±0.5%
Derived value	<2%

Technical data

Ratings

Inputs:

- AC current (In)
  1A/5A dual rated ac rms
- AC voltage (Vn)
  100 – 120V or 380 – 480V rms
  nominal phase-phase

Rated frequency 50/60Hz

Operative range 45Hz to 65Hz

Auxiliary voltage (Vx)

Nominal (V)	Operative range (V)	
dc	dc	ac
24 - 48	19 - 65	-
48 - 110	37 - 150	24 - 110
110 - 250	87 - 300	80 - 265

Additional input/output cards are available for the P142 and P143 (see page 16).

Outputs:

- Field voltage supply
  48V dc (current limit: 112mA)

Burdens

- Auxiliairy voltage
  Size 8 (40 TE), min 11W or 24VA
  Size 16 (60 TE), same
  Minimum is with no optos and no relays energized.

  Each additional opto input
  0.09W (24/27V, 30/34V, 48/54V)
  0.12W (110/125V)
  0.19W (220/250V)

  Each additional output relay
  0,13W
- Nominal voltage circuit
  Vn 100 – 120V < 0.02VA at 110V
  Vn 380 – 480V < 0.02VA at 440V
- Nominal current circuit
  Phase and neutral
  <0.1Ω at 1A
  <0.02Ω at 5A

Thermal withstand

- AC current inputs
  4.0In continuous
  30In for 10s
  100In for 1s
- AC voltage inputs
  2 Vn continuous
  2.6 Vn for10s

Current transformer requirements

The following CT requirements are based on a maximum prospective fault current of 50In and the relay having a maximum high set setting of 25In. The CT requirements are designed to provide operation of:

- Phase and standard earth fault elements
  1A rated currrent circuits
  2.5VA 10P 20
  5A rated current circuits
  7.5VA 10P 20

Digital inputs

Optically isolated inputs may be energised from the supervised 48V field voltage provided or an external battery. The operating voltage is menu selectable (24/27V, 30/34V, 48/54V, 110/125V and 220/225V)

Operating voltage >19.2V dc

Max. input voltage 300V dc

AC immunity 300V rms

Contacts

- Contact ratings:

  Make: 30A and carry for 3s

  Carry: 10A continuous

  Break: dc 50W resistive
  62.5W inductive
  (L/R = 50ms)
  ac 2500VA resistive
  ac 2500VA inductive
  (P.F. = 0.7)

Subject to maxima of 10A and 300V

- Watchdog contact ratings

  dc 30W resistive

  dc 15W inductive
  (L/R = 40ms)

  ac 375VA inductive
  (P.F. = 0.7)
- Durability:

  Loaded contact

  10,000 operations minimum

  Unloaded contact

  100,000 operations minimum

Rear communications port

- Connection

  Multidrop (32 units)
- Cable type

  Screened twisted pair
- Cable length 1000m max
- Connector Screw terminals
- Signal levels RS485
- Isolation SELV
- Remote access

Protocols supported

- Courier
- Modbus
- IEC 60870-5-103
- DNP 3.0

Note: An interface to an optical fibre, type 850nm, BFOC 2.5 connector is available for IEC 60870-5-103.

Front communications port

- Connection Point to point
- Cable type Multi-core
- Cable length 15m max
- Connector RS232 DTE
  9 pin D-type female
- Protocol Courier
- Isolation ELV
- Local access

IRIG-B Port

- Carrier signal

  Amplitude modulated
- Cable type

  50 ohm coaxial cable
- Connection BNC
- Isolation SELV

Internal battery

Battery type: ½AA, 3.6V

Download/monitor port

This is a 25 pin D-type female connector located on the front user interface and is specifically designed for test purposes and software download.

- Isolation ELV
- Local access

High voltage withstand

This is not applicable to the RS232 and download/monitor ports.

- Dielectric withstand

  IEC 60255-5: 1977

  2kV rms for 1 minute between all case terminals connected together and the case earth.

  2kV rms for 1 minute between all terminals of independent circuits with terminals on each independent circuit connected together.

  ANSI/IEEE C37.90-1989 (r1994)

  1kV rms for 1 minute across the open contacts of the watchdog relays.

  1kV rms for 1 minute across open contacts of changeover output relays.

  1.5kV rms for 1 minute across open contacts of normally open output relays.
- High voltage impulse

  IEC 60255-5: 1977

  Three positive and three negative impulses of 5kV peak, 1.2/50µs, 0.5J between all terminals and all terminals and case earth.

Electrical environment

- DC supply interruption

  IEC 60255-11: 1979

  The unit will withstand a 20ms interruption in the auxiliary supply, in its quiescent state, without de-energising.
- AC ripple on dc supply

  IEC 60255-11: 1979

  The unit will withstand a 12% ac ripple on the dc supply.
- AC voltage dips and short interruptions

  IEC 61000-4-11: 1994

  20ms interruptions/dips.
- High frequency disturbance

  IEC 60255-22-1: 1988 Class III

  At 1MHz, for 2s with 200 source impedance:

  2.5kV peak between independent circuits and independent circuits and case earth.

  1.0kV peak across terminals of the same circuit.

This is not applicable to the RS232 and download/monitor ports.

- Fast transient disturbance

  IEC 60255-22-4 : 1992 Class IV

  4kV, 2.5kHz applied directly to auxiliary supply

  4kV, 2.5kHz applied to all inputs.

  This is not applicable to the RS232 and download/monitor ports.
- Surge withstand capability

  IEEE/ANSI C37.90.1 (1989)

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

  C37.90.2: 1995

  25MHz to 1000MHz, zero and 100% square wave modulated. Field strength of 35V/m.
- Electrostatic discharge

  IEC 60255-22-2: 1996 Class 4

  15kV discharge in air to user interface, display and exposed metal work.

  IEC 60255-22-2: 1996 Class 3

  8kV discharge in air to all communication ports. 6kV point contact discharge to any part of the front of the product.
- Surge immunity

  IEC 61000-4-5: 1995 Level 4

  4kV peak, 1.2/50µs between all groups and case earth.

  2kV peak, 1.2/50µs between terminals of each group.

  This is not applicable to the RS232 and download/monitor ports.
- EMC compliance

  CE 89/336/EEC

  Compliance to the European Commission Directive on EMC is claimed via the Technical Construction File route.

  Generic Standards were used to establish conformity:

  EN50081-2: 1994

  EN50082-2: 1995
- Product safety

  CE 73/23/EEC

  Compliance with European Commission Low Voltage Directive.

  Compliance is demonstrated by reference to generic safety standards:

  EN61010-1: 1993/A2: 1995

  EN60950: 1992/A11: 1997

Atmospheric environment

- Temperature

  IEC 60255-6:1988

  Operating –25°C to +55°C

  Storage and transit –25°C to +70°C

  IEC 60068-2-1: 1990/A2:1994

  Cold

  IEC 60068-2-2: 1974/A2:1994

  Dry heat

- Humidity

  IEC 60068-2-3: 1969

  56 days at 93% RH and +40°C

- Enclosure protection

  IEC 60529: 1989

  IP52 Protection (front panel) against dust and dripping water at 15° to the vertical.

Mechanical environment

- Vibration

  IEC 60255-21-1: 1996

  Response Class 2

  Endurance Class 2

- Shock and bump

  IEC 60255-21-2: 1995

  Shock response Class 2

  Shock withstand Class 1

  Bump Class 1

- Seismic

  IEC 60255-21-3: 1995 Class 2

Cases

- P141 & P142 MiCOM 40TE
- P143 MiCOM 60TE
- Weight

  P141/P142 c.7.3 kg

  P143 c.9.2 kg

Additional information

MiCOM P14x Series

Technical Guide	TG8612
Operation Guide	OG8612
Courier Communications	R4113
MiCOM S1 User Manual	R8610
Midos Parts Catalogue and Assembly Instructions	R7012
PAS&T	R8514

Case

The MiCOM P14x series relays are housed in a specially designed case providing a high density of functionality within the product, a customisable user interface, additional functions and information concealed by upper and lower covers. Physical protection of the front panel user interface and prevention of casual access is provided by an optional transparent front cover, which can be fitted or omitted according to choice, since the front panel has been designed to IP52 protection against dust and water. The case is suitable for either rack or panel mounting as shown in Figures 7 and 8.

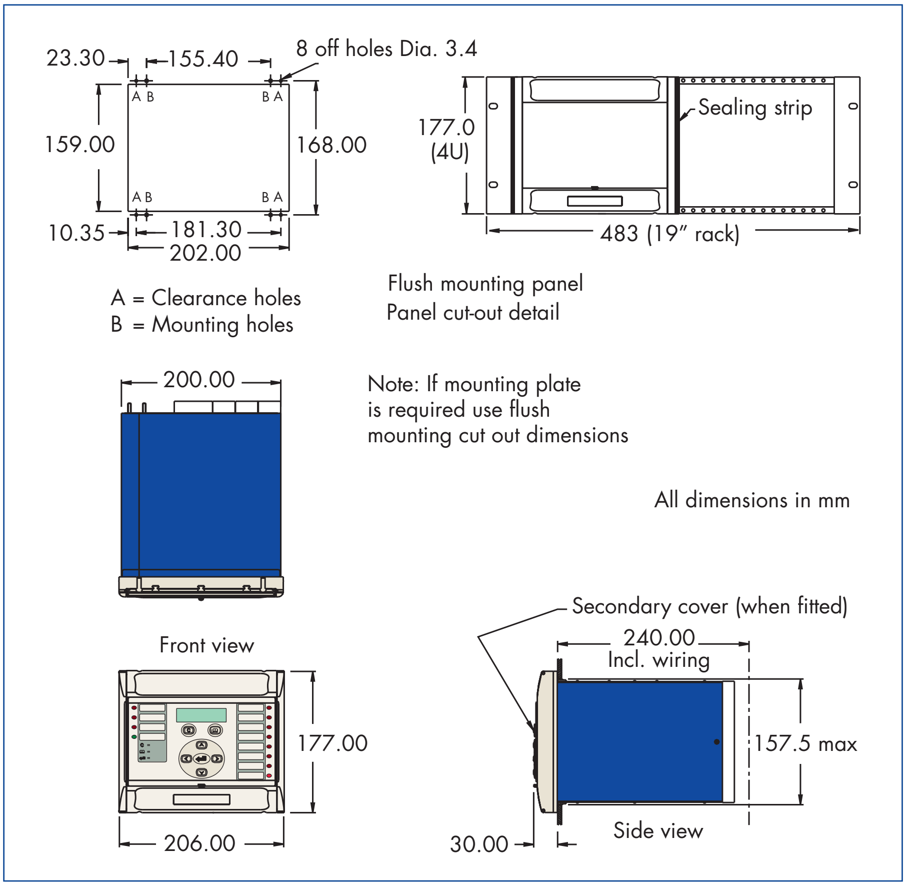


Figure 7: Case sizes P141 and P142 (40TE)

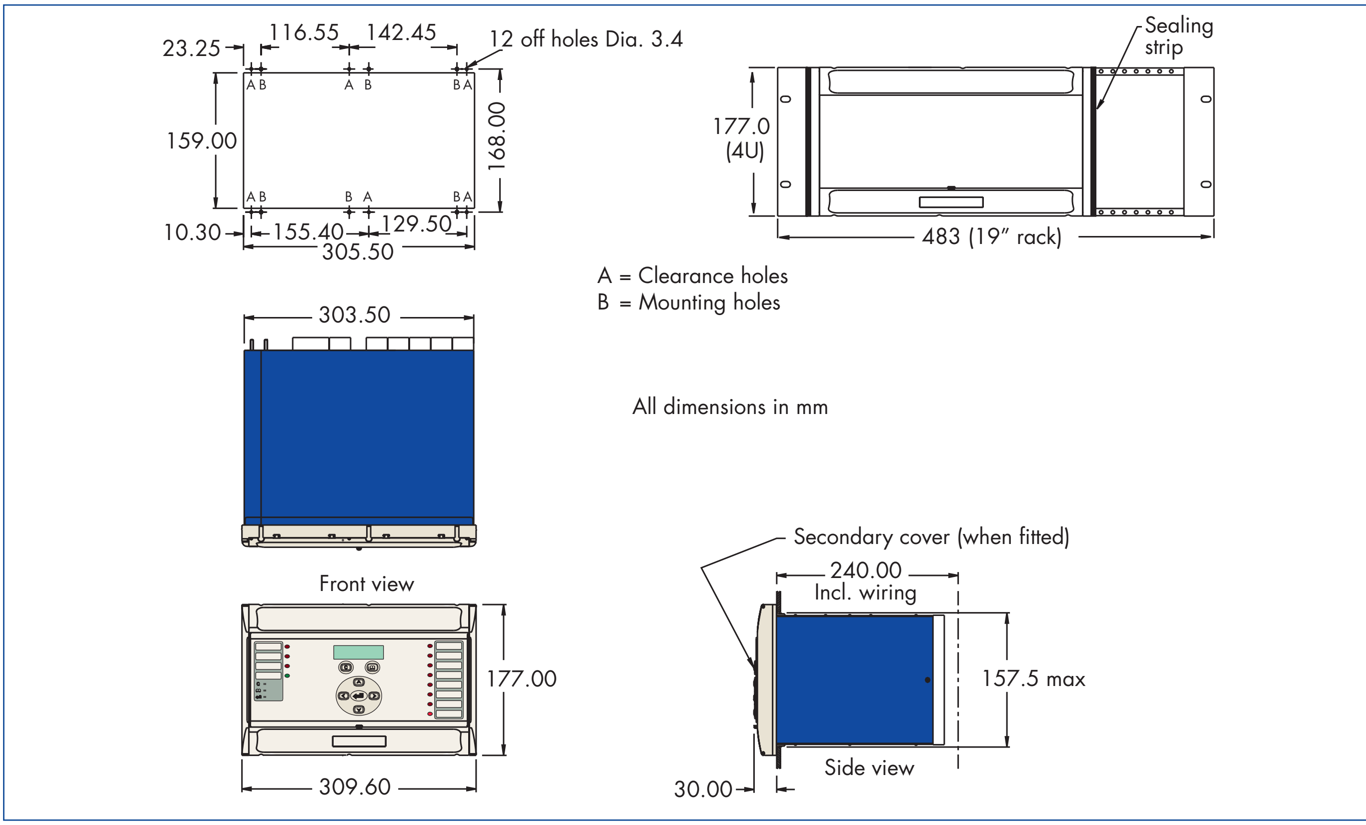


Figure 8: Case size P143 (60TE)

MiCOM P14x Series specification

An integrated feeder protection and autoreclose scheme shall provide 3 phase overcurrent and earth fault protection with faulted phase indication. An integral three pole multi-shot autorecloser shall support check synchronising, live line working and sequence co-ordination.

Five dual rated 1/5A CT inputs shall be available for connection to 3 phase and 2 earth CTs.

Four stages of directional phase overcurrent and earth fault protection shall be provided, with a selection of nine IDMT characteristics for two of the stages. Cold load pick-up logic shall provide co-ordination with upstream devices and allow protection settings to be set closer to the load profile during short term overload conditions. An additional CT shall be provided for sensitive and restricted earth fault protection.

Four independent stages of underfrequency protection and two of overfrequency protection shall be provided.

The device shall be responsive to unbalanced conditions providing alarm and tripping signals. Back-up protection for remote phase-phase and phase-ground faults shall also be available.

Thermal protection with single and dual time constant characteristics suitable for cables and transformers shall be provided. The thermal state shall be stored in non-volatile memory.

Programming of the device shall be possible using a front panel user interface, local and remote communications ports.
A configuration feature shall be provided to enable selection of required functions. This shall allow menu customisation removing unwanted functions and setting groups from the settings display.
The front panel user interface shall provide independent keys for the viewing and acknowledgement of alarms. Fixed and programmable scheme logic shall be provided.

Programmable scheme logic for configuring custom logic schemes shall be uploadable from relay to PC or PC to relay. The relay shall store factory default protection and scheme logic settings for restoration or upload to a PC.

Time-tagged event, fault and disturbance records shall be stored in battery backed memory.

The internal disturbance recorder shall have a capacity to store 20 records, each record shall store sampled data from 8 analogue and 32 digital channels over a period of 10 seconds.

The vendor shall be able to provide software support for local and remote programming, and extraction of records from the device.

A comprehensive range of instantaneous and integrated measurement values shall be available for viewing on the user interface and the communications ports.

Information required with order

Relay type — **MiCOM P 1 4 □ □ □ □ □ □ xxxx □**

Feeder Management Relay

Version

Standard version	1
With integral autoreclose	2
With integral autoreclose and check synchronising	3

Vx aux rating

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

Vn rating

100 – 120V ac	1
380 – 480V ac	2

Hardware options

Standard version	1
IRIG-B input	2
Fibre optic converter (IEC 60870-5-103)	3
IRIG-B input & fibre optic converter (IEC 60870-5-103)	4

Expansion modules fitted

	P141	P142	P143	
No additional hardware	●	●	●	A
4 + 4 card		●		B
Additional 8 optos		●	●	C
Additional 8 relays		●	●	D
Additional 8 optos and 8 relays			●	E
Additional 16 optos			●	F
Additional 16 relays			●	G

Protocol options

K-Bus	1
Modbus	2
IEC 60870-5-103 (VDEW)	3
DNP 3.0	4

Original hardware/software 48V opto inputs only Lower contact rating No I/O expansion available Technical guide reference TG8612C	A
Latest harware/software as described in this publication Technical guide reference P140x/EN T/A22	B

Accessories	**Please quote on order**
Rack frame, (in accordance with IEC 60297)	FX0021 001
Case to rack sealing gaskets are available to improve the overall IP rating of the panel, (10 per order)	GN2044 001
M4 90° pre-insulated ring terminals: Blue - Wire size 1.04 - 2.63mm^2 (100 per order) Red - Wire size 0.25 - 1.65mm^2 (100 per order)	 ZB9124 900 ZB9124 901
Secondary cover: P141, P142 Size 40TE P143 Size 60TE	GN0037 001 GN0038 001
Blanking plates: Size 10TE Size 20TE Size 30TE Size 40TE	GJ2028 002 GJ2028 004 GJ2028 006 GJ2028 008
Stabilising resistors (for high impedance restricted earth fault) METROSILS (for high impedance restricted earth fault)	ZB9016 ZB9411
Resistor box 8 digital inputs - 110V Resistor box 8 digital inputs - 220V	GJ0229 006 GJ0229 007
Push-on tab: 4.8 x 0.8mm converter for 18 way medium duty terminal block (20 per order)	ZA0005 104
Px40 - Monitor/Download port test box	ZA1094 001
2 metre long, 3-wire serial communications cable kit for use with: PC to KITZ or PC to MiCOM relay via front port	ZA0012 001

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1. INTRODUCTION

1.1 Protection of feeders

The secure and reliable transmission and distribution of power within a network is heavily dependent upon the integrity of the overhead lines and underground cables which link the various sections of the network together. As such, the associated protection system must also provide both secure and reliable operation.

The most common fault conditions, on both overhead lines and cables, are short circuit faults. Such faults may occur between phases but will most often involve one or more phases becoming short circuit to earth. Faults of this nature require the fastest possible fault clearance times but at the same time allowing suitable co-ordination with other downstream protection devices.

Fault sensitivity is an issue common to all voltage levels. For transmission systems, tower footing resistance can be high. Also, high resistance faults might be prevalent where lines pass over sandy or rocky terrain. Fast, discriminative fault clearance may still be required for these fault conditions.

The effect of fault resistance is more pronounced on lower voltage systems, resulting in potentially lower fault currents, which in turn increases the difficulty in the detection of high resistance faults. In addition, many distribution systems use earthing arrangements designed to limit the passage of earth fault current. Methods such as resistance earthing, Petersen Coil earthing or insulated systems make the detection of earth faults difficult. Special protection requirements are often used to overcome these problems.

For distribution systems, continuity of supply is of paramount importance. The majority of faults on overhead lines are transient or semi-permanent in nature. Multi-shot autoreclose cycles are therefore commonly used in conjunction with instantaneous tripping elements to increase system availability. For permanent faults it is essential that only the faulted section of plant is isolated. As such, high speed, discriminative fault clearance is often a fundamental requirement of any protection scheme on a distribution network.

Power transformers are encountered at all system voltage levels and will have their own specific requirements with regard to protection. In order to limit the damage incurred by a transformer under fault conditions, fast clearance of winding phase to phase and phase to earth faults is a primary requirement.

Damage to items of plant such as transformers, cables and lines may also be incurred by excessive loading conditions, which leads directly to overheating of the equipment and subsequent degradation of the insulation. To protect against conditions of this nature, protective devices require characteristics which closely match the thermal withstand capability of the item of plant in question.

Uncleared faults, arising from either failure of the associated protection system or of the switchgear itself, must also be given due consideration. As such, the protection devices concerned may well be fitted with logic to deal with breaker failure conditions, in addition to the relays located upstream being required to provide adequate back-up protection for the condition.

Other situations may arise on overhead lines, such as broken phase conductors. Being a series fault condition, it has traditionally been very difficult to detect. However, with numerical technology, it is now possible to design elements which are responsive to such unbalanced system conditions and to subsequently issue alarm/trip signals.

On large networks, time co-ordination of the overcurrent and earth fault relays can often lead to problematic grading situations or, as is often the case, excessive fault clearance times. Such problems can be overcome by relays operating in blocked overcurrent schemes.

1.2 MiCOM feeder relay

MICOM relays are a new range of products from ALSTOM T&D Ltd - Protection & Control. Using the latest numerical technology the range includes devices designed for application to a wide range of power system plant such as motors, generators, feeders, overhead lines and cables.

Each relay is designed around a common hardware and software platform in order to achieve a high degree of commonality between products. One such product in the range is the Feeder Relay. The relay has been designed to cater for the protection of a wide range of overhead lines and underground cables from distribution to transmission voltage levels.

The relay also includes a comprehensive range of non-protection features to aid with power system diagnosis and fault analysis. All these features can be accessed remotely from one of the relays remote serial communications options.

1.2.1 Protection features

The P140 feeder relays contain a wide variety of protection functions. There are 3 separate models available – P141, P142 and P143, to cover a wide range of applications. The protection features of each model are summarised below:

- Three phase overcurrent protection – Four overcurrent measuring stages are provided for each phase and each stage is selectable to be either non-directional, directional forward or directional reverse. Stages 1 and 2 may be set Inverse Definite Minimum Time (IDMT) or Definite Time (DT); stages 3 and 4 may be set DT only.

- Earth fault protection – Three independent earth fault elements are provided; derived, measured and sensitive earth fault protection. Each element is equipped with four stages which are independently selectable to be either non-directional, directional forward or directional reverse. Sensitive Earth Fault can be configured as a Icosϕ or VIcosϕ (Wattmetric) element for application to Petersen Coil Earthed systems, or as a Restricted Earth Fault (REF) element.

- Voltage controlled overcurrent protection – Provides backup protection for remote phase to phase faults by increasing the sensitivity of stages 1 and 2 of the overcurrent protection.

- Negative sequence overcurrent protection – This can be selected to be either non-directional, directional forward or directional reverse and provides remote backup protection for both phase to earth and phase to phase faults.

- Undervoltage protection – Two stage, configurable as either phase to phase or phase to neutral measuring. Stage 1 may be selected as either IDMT or DT and stage 2 is DT only.

- Overvoltage protection – Two stage, configurable as either phase to phase or phase to neutral measuring. Stage 1 may be selected as either IDMT or DT and stage 2 is DT only.

- Negative sequence overvoltage protection – Definite time delayed element to provide either a tripping or interlocking function upon detection of unbalanced supply voltages.

- Neutral admittance protection – operates from either the SEF CT or EF CT to provide single stage admittance, conductance and susceptance elements.
- Residual overvoltage (neutral voltage displacement) protection – Provides an additional method of earth fault detection and has two stages; stage 1 may be selected as either IDMT or DT and stage 2 is DT only.
- Thermal overload protection – Provides thermal characteristics which are suitable for both cables and transformers. Alarm and trip stages are provided.
- Frequency protection – Provides 4 stage underfrequency and 2 stage overfrequency protection.
- Broken conductor detection – To detect open circuit faults.
- Circuit breaker fail protection – Two stage breaker fail protection.
- Autoreclose facility – Integral three phase multi-shot autoreclose with external initiation. (P142/143 only)
- Autoreclose with check synchronisation – Integral three phase multi-shot autoreclose with external initiation and check synchronisation. Includes selectable operating modes such as Auto, Non-Auto, Live-line etc., in addition to Sequence Co-ordination Logic. (P143 only)
- Cold load pick-up logic – May be used to transiently raise the settings, for both phase and earth fault protection, following closure of the circuit breaker.
- Selective overcurrent logic – Provides the capability of temporarily altering the time settings of stages 3 and 4 of the phase overcurrent, earth fault and sensitive earth fault elements.
- Voltage transformer supervision – To prevent mal-operation of voltage dependent protection elements upon loss of a VT input signal.
- Current transformer supervision – To prevent mal-operation of current dependent protection elements upon loss of a CT input signal.
- Programmable scheme logic – Allows user defined protection and control logic to suit particular customer applications.

1.2.2 Non-protection features

- Below is a summary of the P140 relays' non-protection features.
- Measurements – Various measurement values are available for display on the relay or may be accessed via the serial communications.
- Fault /event/disturbance records – Available from the serial communications or on the relay display (fault and event records only).
- Fault locator – Provides distance to fault in km, miles or % of line length.
- Real time clock/time synchronisation - Time synchronisation possible from relay IRIG-B input.
- Four setting groups – Independent setting groups to cater for alternative power system arrangements or customer specific applications.
- Remote serial communications – To allow remote access to the relays. The following communications protocols are supported; Courier, MODBUS, IEC60870-5-103 and DNP3.0.

- Continuous self monitoring – Power on diagnostics and self checking routines to provide maximum relay reliability and availability.
- Circuit breaker state monitoring – Provides indication of discrepancy between circuit breaker auxiliary contacts.
- Circuit breaker control – Control of the breaker can be achieved either locally, via the user interface/opto inputs, or remotely, via serial communications.
- Circuit breaker condition monitoring – Provides records/alarm outputs regarding the number of CB operations, sum of the interrupted current and the breaker operating time.
- Commissioning test facilities.

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.

The P140 relays each include a column in the menu called the configuration column. As this affects the operation of each of the individual protection functions, it is described in the following section.

2.1 Configuration column

The following table shows the configuration column:

Menu Text	Default Setting	Available Settings
CONFIGURATION		
Restore Defaults	No Operation	No Operation All Settings Setting Group 1 Setting Group 2 Setting Group 3 Setting Group 4
Setting Group	Select via Menu	Select via Menu Select via Optos
Active Settings	Group 1	Group 1 Group 2 Group 3 Group 4
Save Changes	No Operation	No Operation Save Abort
Copy from	Group 1	Group 1, 2, 3 or 4
Copy to	No Operation	No Operation Group 1, 2, 3 or 4
Setting Group 1	Enabled	Enabled or Disabled
Setting Group 2	Disabled	Enabled or Disabled
Setting Group 3	Disabled	Enabled or Disabled

Menu Text	Default Setting	Available Settings
Setting Group 4	Disabled	Enabled or Disabled
Overcurrent	Enabled	Enabled or Disabled
Neg Sequence O/C	Disabled	Enabled or Disabled
Broken Conductor	Disabled	Enabled or Disabled
Earth Fault 1	Enabled	Enabled or Disabled
Earth Fault 2	Disabled	Enabled or Disabled
SEF/REF Prot	Disabled	Enabled or Disabled
Residual O/V NVD	Disabled	Enabled or Disabled
Thermal Overload	Disabled	Enabled or Disabled
Neg Sequence O/V	Disabled	Enabled or Disabled
Cold Load Pickup	Disabled	Enabled or Disabled
Selective Logic	Disabled	Enabled or Disabled
Admit Protection	Disabled	Enabled or Disabled
Selective Logic	Disabled	Enabled or Disabled
Volt Protection	Disabled	Enabled or Disabled
Freq Protection	Disabled	Enabled or Disabled
CB Fail	Disabled	Enabled or Disabled
Supervision	Enabled	Enabled or Disabled
Fault Locator	Enabled	Enabled or Disabled
System Checks	Disabled	Enabled or Disabled
Auto Reclose	Disabled	Enabled or Disabled
Input Labels	Visible	Invisible or Visible
Output Labels	Visible	Invisible or Visible
CT & VT Ratios	Visible	Invisible or Visible
Event Recorder	Invisible	Invisible or Visible
Disturb Recorder	Invisible	Invisible or Visible
Measure't Setup	Invisible	Invisible or Visible
Comms Settings	Visible	Invisible or Visible
Commission Tests	Visible	Invisible or Visible
Setting Values	Primary	Primary or Secondary

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

2.2 Overcurrent protection

Overcurrent relays are the most commonly used protective devices in any industrial or distribution power system. They provide main protection to both feeders and busbars when unit protection is not used. They are also commonly applied to provide back-up protection when unit systems, such as pilot wire schemes, are used.

By a suitable combination of time delays and relay pick-up settings, overcurrent relays may be applied to either feeders or power transformers to provide discriminative phase fault protection (and also earth fault protection if system earth fault levels are sufficiently high). In such applications, the various overcurrent relays on the system are co-ordinated with one another such that the relay nearest to the fault operates first. This is referred to as cascade operation because if the relay nearest to the fault does not operate, the next upstream relay will trip in a slightly longer time.

The overcurrent protection included in the P140 relays provides four stage non-directional / directional three phase overcurrent protection with independent time delay characteristics. All overcurrent and directional settings apply to all three phases but are independent for each of the four stages.

The first two stages of overcurrent protection have time delayed characteristics which are selectable between inverse definite minimum time (IDMT), or definite time (DT). The third and fourth stages have definite time characteristics only.

Various methods are available to achieve correct relay co-ordination on a system; by means of time alone, current alone or a combination of both time and current. Grading by means of current is only possible where there is an appreciable difference in fault level between the two relay locations. Grading by time is used by some utilities but can often lead to excessive fault clearance times at or near source substations where the fault level is highest. For these reasons the most commonly applied characteristic in co-ordinating overcurrent relays is the IDMT type.

The following table shows the relay menu for the overcurrent protection, including the available setting ranges and factory defaults:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
OVERCURRENT GROUP 1				
I>1 Function	IEC S Inverse	Disabled, DT, IEC S Inverse, IEC V Inverse, IEC E Inverse, UK LT Inverse, UK Rectifier, RI, IEEE M Inverse, IEEE V Inverse, IEEE E Inverse, US Inverse, US ST Inverse		
I>1 Direction	Non-Directional	Non-Directional Directional Fwd Directional Rev		
I>1 Current Set	1 x In	0.08 x In	4.0 x In	0.01 x In
I>1 Time Delay	1	0	100	0.01
I>1 TMS	1	0.025	1.2	0.025
I>1 Time Dial	1	0.01	100	0.01
I>1 K (RI)	1	0.1	10	0.05

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
OVERCURRENT GROUP 1				
I>1 Reset Char	DT	DT or Inverse		N/A
I>1 tRESET	0	0s	100s	0.01s
I>2 Cells as for I>1 above				
I>3 Status	Disabled	Disabled or Enabled		N/A
I>3 Direction	Non-Directional	Non-Directional Directional Fwd Directional Rev		N/A
I>3 Current Set	20 x In	0.08 x In	32 x In	0.01 x In
I>3 Time Delay	0	0s	100s	0.01s
I>4 Cells as for I>3 above				
I> Char Angle	45	–95°	+95°	1°
I> Blocking	00001111	Bit 0 = VTS Blocks I>1, Bit 1 = VTS Blocks I>2, Bit 2 = VTS Blocks I>3, Bit 3 = VTS Blocks I>4, Bit 4 = A/R Blocks I>3, Bit 5 = A/R Blocks I>4. Bits 6 & 7 are not used.		
V Controlled O/C (refer to Section 2.16)				

Note: VTS Block – When the relevant bit set to 1, operation of the Voltage Transformer Supervision (VTS), will block the stage if directionalised. When set to 0, the stage will revert to Non-Directional upon operation of the VTS.

A/R Block – The autoreclose logic can be set to block instantaneous overcurrent elements after a prescribed number of shots. This is set in the autoreclose column. When a block instantaneous signal is generated then only those overcurrent stages selected to '1' in the I> Function link will be blocked.

The inverse time delayed characteristics listed above, comply with the following formula:

IEC curves

$$t = T \times \left(\frac{\beta}{(M^{\alpha} - 1)} + L \right)$$

or

IEEE curves

$$t = TD \times \left(\frac{\beta}{(M^{\alpha} - 1)} + L \right)$$

where:

t = operation time

β = constant

M = I / Is

K = constant

I = measured current

Is = current threshold setting

α = constant

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

T = Time multiplier setting for IEC curves

TD = Time dial setting for IEEE curves

Curve Description	Standard	β Constant	α Constant	L Constant
Standard Inverse	IEC	0.14	0.02	0
Very Inverse	IEC	13.5	1	0
Extremely Inverse	IEC	80	2	0
Long Time Inverse	UK	120	1	0
Rectifier	UK	45900	5.6	0
Moderately Inverse	IEEE	0.0515	0.02	0.114
Very Inverse	IEEE	19.61	2	0.491
Extremely Inverse	IEEE	28.2	2	0.1217
Inverse	US	5.95	2	0.18
Short Time Inverse	US	0.16758	0.02	0.11858

Note that the IEEE and US curves are set differently to the IEC/UK curves, with regard to the time setting. A time multiplier setting (TMS) is used to adjust the operating time of the IEC curves, whereas a time dial setting is employed for the IEEE/US curves. Both the TMS and time dial settings act as multipliers on the basic characteristics but the scaling of the time dial is approximately 10 times that of the TMS, as shown in the previous menu. The menu is arranged such that if an IEC/UK curve is selected, the "I> Time Dial" cell is not visible and vice versa for the TMS setting.

Note that the IEC/UK inverse characteristics can be used with a definite time reset characteristic, however, the IEEE/US curves may have an inverse or definite time reset characteristic. The following equation can used to calculate the inverse reset time for IEEE/US curves:

$$t_{RESET} = \frac{TD \times S}{(1 - M^2)} \text{ in seconds}$$

where:

TD = Time dial setting for IEEE curves

S = Constant

M = I / Is

Curve Description	Standard	S Constant
Moderately Inverse	IEEE	4.85
Very Inverse	IEEE	21.6
Extremely Inverse	IEEE	29.1
Inverse	US	5.95
Short Time Inverse	US	2.261

2.2.1 RI curve

The RI curve (electromechanical) has been included in the first and second stage characteristic setting options for Phase Overcurrent and both Earth Fault 1 and Earth Fault 2 protections. The curve is represented by the following equation:

$$t = K \times \left(\frac{1}{0.339 - \left({}^{0.236}/_{M} \right)} \right) \text{ in seconds}$$

With K adjustable from 0.1 to 10 in steps of 0.05

2.2.2 Transformer magnetising inrush

When applying overcurrent protection to the HV side of a power transformer it is usual to apply a high set instantaneous overcurrent element in addition to the time delayed low-set, to reduce fault clearance times for HV fault conditions. Typically, this will be set to approximately 1.3 times the LV fault level, such that it will only operate for HV faults. A 30% safety margin is sufficient due to the low transient overreach of the third and fourth overcurrent stages. Transient overreach defines the response of a relay to DC components of fault current and is quoted as a percentage. A relay with a low transient overreach will be largely insensitive to a DC offset and may therefore be set more closely to the steady state AC waveform.

The second requirement for this element is that it should remain inoperative during transformer energisation, when a large primary current flows for a transient period. In most applications, the requirement to set the relay above the LV fault level will automatically result in settings which will be above the level of magnetising inrush current.

All four overcurrent stages operate on the fourier fundamental component. Hence, for the third and fourth overcurrent stages in P140 relays, it is possible to apply settings corresponding to 35% of the peak inrush current, whilst maintaining stability for the condition.

This is important where low-set instantaneous stages are used to initiate autoreclose equipment. In such applications, the instantaneous stage should not operate for inrush conditions, which may arise from small teed-off transformer loads for example. However, the setting must also be sensitive enough to provide fast operation under fault conditions.

Where an instantaneous element is required to accompany the time delayed protection, as described above, the third or fourth overcurrent stage of the P140 relay should be used, as they have wider setting ranges.

2.2.3 Application of timer hold facility

The first two stages of overcurrent protection in the P140 relays are provided with a timer hold facility, which may either be set to zero or to a definite time value. Setting of the timer to zero means that the overcurrent timer for that stage will reset instantaneously once the current falls below 95% of the current setting. Setting of the hold timer to a value other than zero, delays the resetting of the protection element timers for this period. 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 may be experienced. 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 instantaneous, 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 timer hold facility can be found for the first and second overcurrent stages as settings "I>1 tRESET" and "I>2 tRESET", respectively. Note that this cell is not visible for the IEEE/US curves if an inverse time reset characteristic has been selected, as the reset time is then determined by the programmed time dial setting.

2.2.4 Setting guidelines

When applying the overcurrent protection provided in the P140 relays, standard principles should be applied in calculating the necessary current and time settings for co-ordination. The setting example detailed below shows a typical setting calculation and describes how the settings are actually applied to the relay.

Assume the following parameters for a relay feeding an LV switchboard:

CT Ratio = 500/1

Full load current of circuit = 450A

Slowest downstream protection = 100A Fuse

The current setting employed on the P140 relay must account for both the maximum load current and the reset ratio of the relay itself:

I> must be greater than: 450/0.95 = 474A

The P140 relay allows the current settings to be applied to the relay in either primary or secondary quantities. This is done by programming the "Setting Values" cell of the "CONFIGURATION" column to either primary or secondary. When this cell is set to primary, all phase overcurrent setting values are scaled by the programmed CT ratio. This is found in the "VT & CT Ratios" column of the relay menu, where cells "Phase CT Primary" and "Phase CT Secondary" can be programmed with the primary and secondary CT ratings, respectively.

In this example, assuming primary currents are to be used, the ratio should be programmed as 500/1.

The required setting is therefore 0.95A in terms of secondary current or 475A in terms of primary.

A suitable time delayed characteristic will now need to be chosen. When co-ordinating with downstream fuses, the applied relay characteristic should be closely matched to the fuse characteristic. Therefore, assuming IDMT co-ordination is to be used, an Extremely Inverse (EI) characteristic would normally be chosen. As previously described, this is found under "I>1 Function" and should therefore be programmed as "IEC E Inverse".

Finally, a suitable time multiplier setting (TMS) must be calculated and entered in cell "I>1 TMS".

Also note that the final 4 cells in the overcurrent menu refer to the voltage controlled overcurrent (VCO) protection which is separately described in Section 2.16.

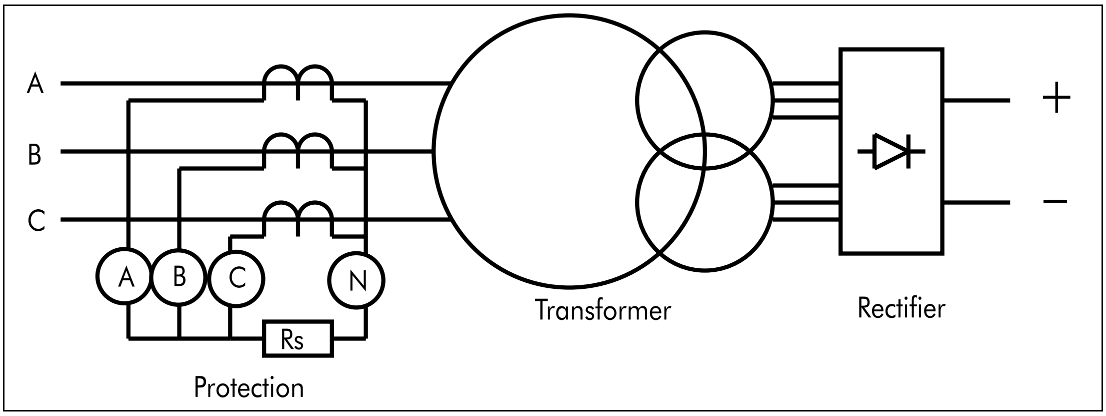


Figure 1: Protection for silicon rectifiers

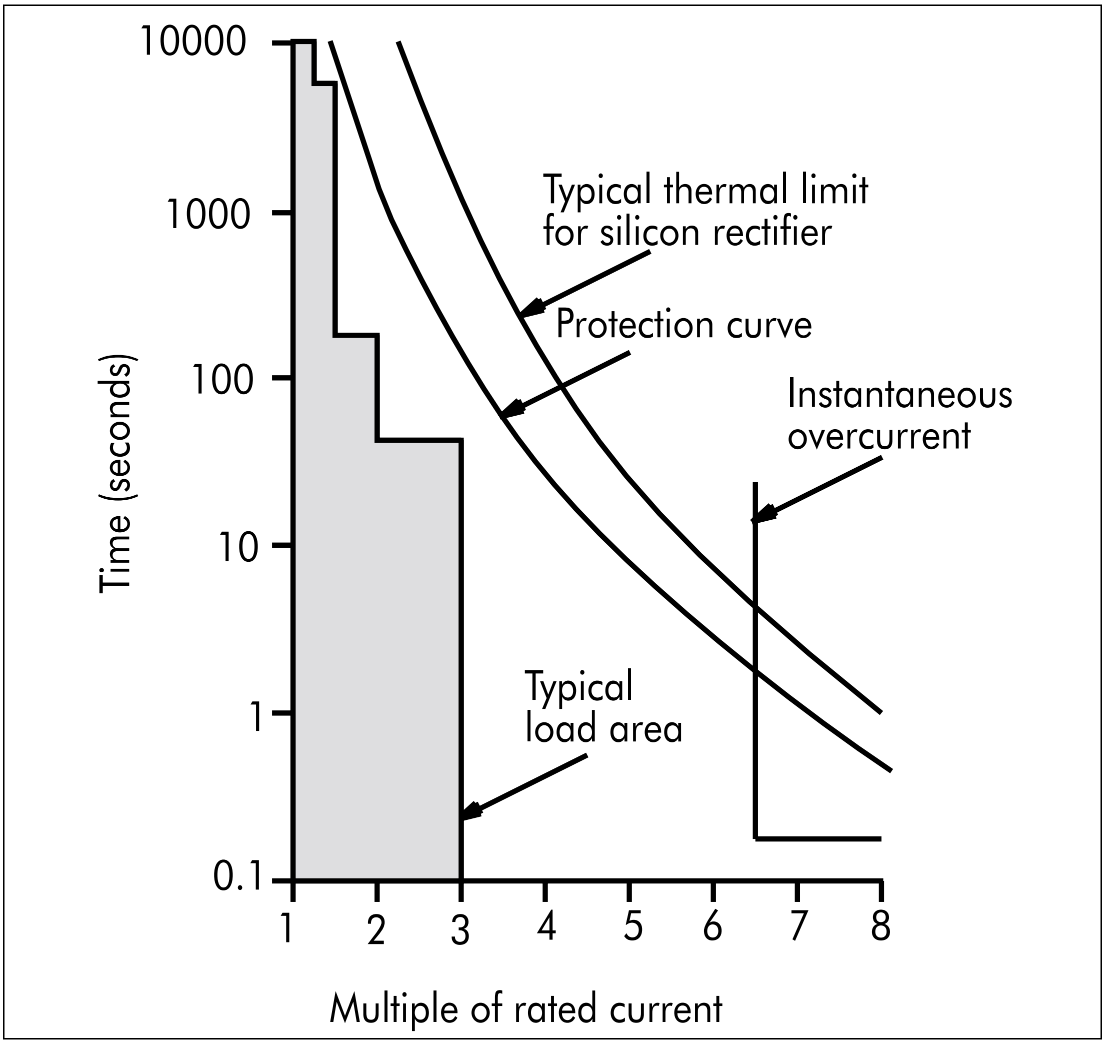


Figure 2: Matching curve to load and thermal limit of rectifier

The rectifier protection feature has been based upon the inverse time/current characteristic as used in the MCTD 01 (Silicon Rectifier Protection Relay) and the above diagram shows a typical application.

The protection of a rectifier differs from the more traditional overcurrent applications in that many rectifiers can withstand relatively long overload periods without damage, typically 150% for 2 hours and 300% for 1 min.

The I> setting should be set to typically 110% of the maximum allowable continuous load of the rectifier. The relay gives start indications when the I> setting has been exceeded, but this is of no consequence, as this function is not used in this application. The rectifier curve should be chosen for the inverse curve as it allows for relatively long overloads even with a 110% I> setting.

Typical settings for the TMS are:

Light industrial service	TMS	=	0.025
Medium duty service	TMS	=	0.1
Heavy duty traction	TMS	=	0.8

The high set is typically set at 8 times rated current as this ensures HV AC protection will discriminate with faults covered by the LV protection. However, it has been known for the high set to be set to 4, or 5 times where there is more confidence in the AC protection.

Use of the thermal element to provide protection between 70% and 160% of rated current could enhance the protection. It is also common practice to provide restricted earth fault protection for the transformer feeding the rectifier. See the appropriate section dealing with restricted earth fault protection.

2.3 Directional overcurrent protection

If fault current can flow in both directions through a relay location, it is necessary to add directionality to the overcurrent relays in order to obtain correct co-ordination. Typical systems which require such protection are parallel feeders (both plain and transformer) and ring main systems, each of which are relatively common in distribution networks.

In order to give directionality to an overcurrent relay, it is necessary to provide it with a suitable reference, or polarising, signal. The reference generally used is the system voltage, as it's angle remains relatively constant under fault conditions. The phase fault elements of the P140 relays are internally polarised by the quadrature phase-phase voltages, as shown in the table below:

Phase of Protection	Operate Current	Polarising Voltage
A Phase	IA	VBC
B Phase	IB	VCA
C Phase	IC	VAB

It is therefore important to ensure the correct phasing of all current and voltage inputs to the relay, in line with the supplied application diagram.

Under system fault conditions, the fault current vector will lag its nominal phase voltage by an angle dependent upon the system X/R ratio. It is therefore a requirement that the relay operates with maximum sensitivity for currents lying in this region. This is achieved by means of the relay characteristic angle (RCA) setting; this defines the angle by which the current applied to the relay must be displaced from the voltage applied to the relay to obtain maximum relay sensitivity. This is set in cell "I>Char Angle" in the overcurrent menu.

Two common applications which require the use of directional relays are considered in the following sections.

2.3.1 Parallel feeders

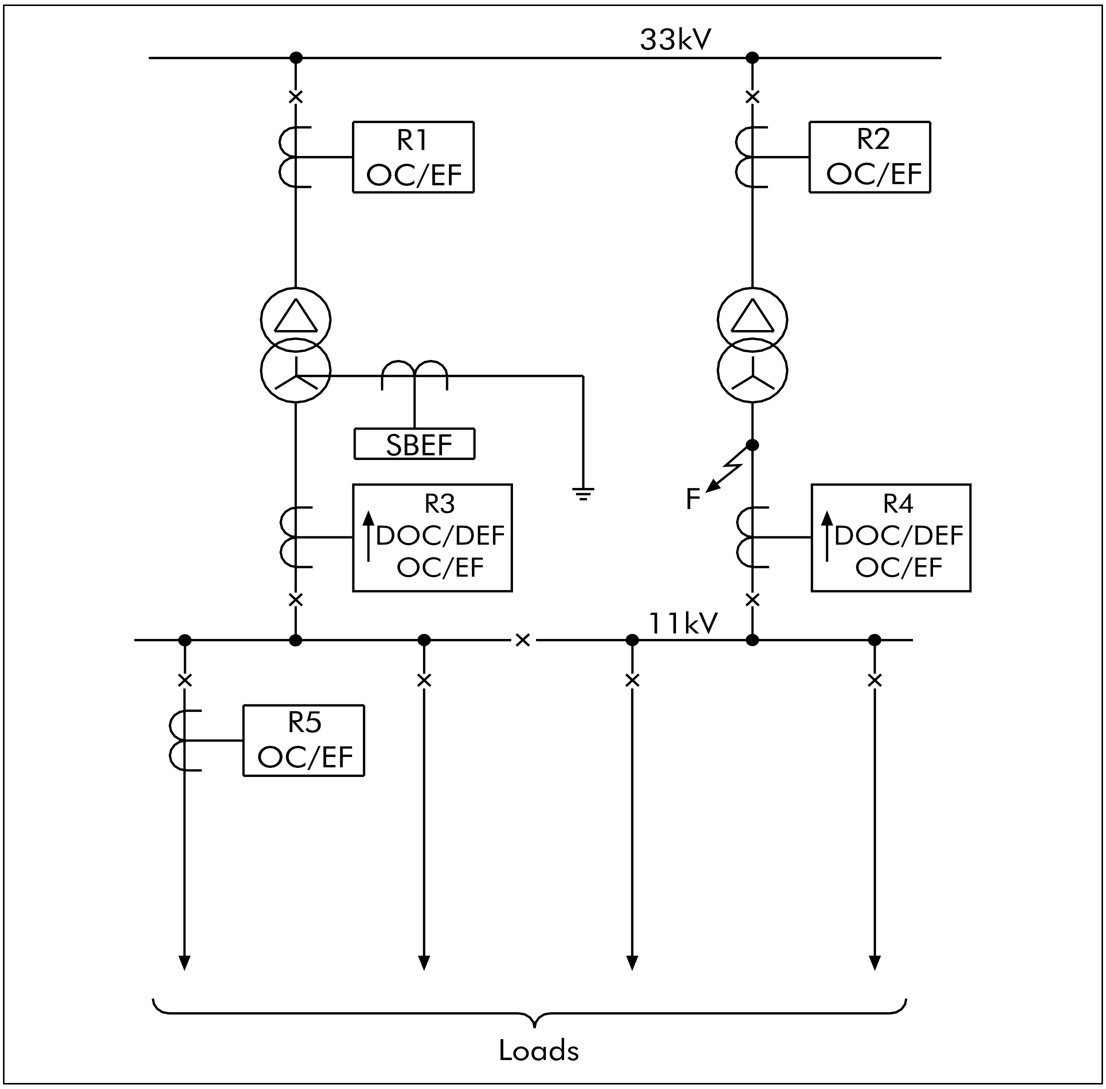


Figure 3: Typical distribution system using parallel transformers

Figure 3 shows a typical distribution system utilising parallel power transformers. In such an application, a fault at 'F' could result in the operation of both R3 and R4 relays and the subsequent loss of supply to the 11kV busbar. Hence, with this system configuration, it is necessary to apply directional relays at these locations set to 'look into' their respective transformers. These relays should co-ordinate with the non-directional relays, R1 and R2; hence ensuring discriminative relay operation during such fault conditions.

In such an application, relays R3 and R4 may commonly require non-directional overcurrent protection elements to provide protection to the 11kV busbar, in addition to providing a back-up function to the overcurrent relays on the outgoing feeders (R5).

When applying the P140 relays in the above application, stage 1 of the overcurrent protection of relays R3 and R4 would be set non-directional and time graded with R5, using an appropriate time delay characteristic. Stage 2 could then be set directional, looking back into the transformer, also having a characteristic which provided correct co-ordination with R1 and R2 IDMT or DT characteristics are selectable for both stages 1 and 2 and directionality of each of the overcurrent stages is set in cell "I> Direction".

Note that the principles previously outlined for the parallel transformer application are equally applicable for plain feeders which are operating in parallel.

2.3.2 Ring main arrangements

A particularly common arrangement within distribution networks is the ring main circuit. The primary reason for its use is to maintain supplies to consumer's in the event of fault conditions occurring on the interconnecting feeders. A typical ring main with associated overcurrent protection is shown in Figure 4.

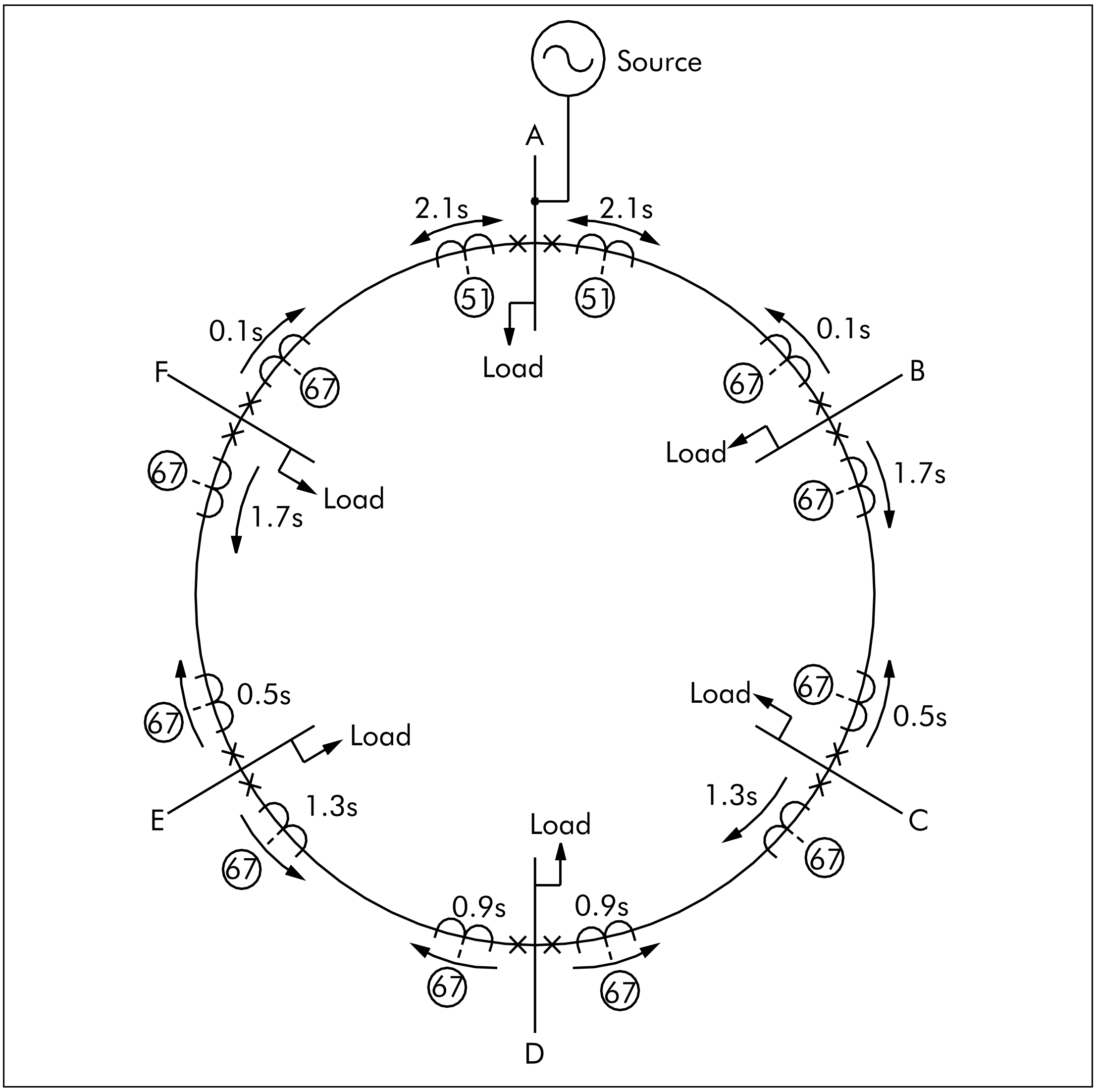


Figure 4: Typical ring main with associated overcurrent protection

As with the previously described parallel feeder arrangement, it can be seen that current may flow in either direction through the various relay locations. Therefore, directional overcurrent relays are again required in order to provide a discriminative protection system.

The normal grading procedure for overcurrent relays protecting a ring main circuit is to open the ring at the supply point and to grade the relays first clockwise and then anti-clockwise. The arrows shown at the various relay locations in Figure 4 depict the direction for forward operation of the respective relays, i.e. in the same way as for parallel feeders, the directional relays are set to look into the feeder that they are protecting. Figure 4 shows typical relay time settings (if definite time co-ordination was employed), from which it can be seen that any faults on the interconnectors between stations are cleared discriminatively by the relays at each end of the feeder.

Again, any of the four overcurrent stages may be configured to be directional and co-ordinated as per the previously outlined grading procedure, noting that IDMT characteristics are only selectable on the first two stages.

2.3.3 Synchronous polarisation

For a fault condition which occurs close to the relaying point, the faulty phase voltage will reduce to a value close to zero volts. For single or double phase faults, there will always be at least one healthy phase voltage present for polarisation of the phase overcurrent elements. For example, a close up A to B fault condition will result in the collapse of the A and B phase voltages. However, the A and B phase elements are polarised from VBC and VCA respectively. As such a polarising signal will be present, allowing correct relay operation.

For a close up three phase fault, all three voltages will collapse to zero and no healthy phase voltages will be present. For this reason, the P140 relays include a synchronous polarisation feature which stores the pre-fault voltage information and continues to apply it to the directional overcurrent elements for a time period of 3.2 seconds. This ensures that either instantaneous or time delayed directional overcurrent elements will be allowed to operate, even with a three phase voltage collapse.

2.3.4 Setting guidelines

The applied current settings for directional overcurrent relays are dependent upon the application in question. In a parallel feeder arrangement, load current is always flowing in the non-operate direction. Hence, the relay current setting may be less than the full load rating of the circuit; typically 50% of In.

Note that the minimum setting that may be applied has to take into account the thermal rating of the relay. Some electro-mechanical directional overcurrent relays have continuous withstand ratings of only twice the applied current setting and hence 50% of rating was the minimum setting that could be applied. With the P140, the continuous current rating is 4 x rated current and so it is possible to apply much more sensitive settings if required. However, there are minimum safe current setting constraints to be observed when applying directional overcurrent protection at the receiving-ends of parallel feeders. The minimum safe settings to ensure that there is no possibility of an unwanted trip during clearance of a source fault are as follows for linear system load:

Parallel plain feeders:

Set>50% Prefault load current

Parallel transformer feeders:

Set>87% Prefault load current

When the above setting constraints are infringed, independent-time protection is more likely to issue an unwanted trip during clearance of a source fault than dependent-time protection.

Where the above setting constraints are unavoidably infringed, secure phase fault protection can be provided with relays which have 2-out-of-3 directional protection tripping logic.

A common minimum current setting recommendation (50% relay rated current) would be virtually safe for plain parallel feeder protection as long as the circuit load current does not exceed 100% relay rated current. It would also be safe for parallel transformer feeders, if the system design criterion for two feeders is such that the load on each feeder will never exceed 50% rated current with both feeders in service. For more than two feeders in parallel the 50% relay rated current setting may not be absolutely safe.

In a ring main application, it is possible for load current to flow in either direction through the relaying point. Hence, the current setting must be above the maximum load current, as in a standard non-directional application.

The required characteristic angle settings for directional relays will differ depending on the exact application in which they are used. Recommended characteristic angle settings are as follows:-

- Plain feeders, or applications with an earthing point (zero sequence source) behind the relay location, should utilise a +30° RCA setting.
- Transformer feeders, or applications with a zero sequence source in front of the relay location, should utilise a +45° RCA setting.

On the P140 relays, it is possible to set characteristic angles anywhere in the range –95° to +95°. Whilst it is possible to set the RCA to exactly match the system fault angle, it is recommended that the above guidelines are adhered to, as these settings have been shown to provide satisfactory performance and stability under a wide range of system conditions.

2.4 Thermal overload protection

Thermal overload protection can be used to prevent electrical plant from operating at temperatures in excess of the designed maximum withstand. Prolonged overloading causes excessive heating, which may result in premature ageing of the insulation, or in extreme cases, insulation failure.

The relay incorporates a current based thermal replica, using rms load current to model heating and cooling of the protected plant. The element can be set with both alarm and trip stages.

The heat generated within an item of plant, such as a cable or a transformer, is 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. The relay automatically uses the largest phase current for input to the thermal model.

Equipment is designed to operate continuously at a temperature corresponding to its full load rating, where heat generated is balanced with heat dissipated by radiation etc. Overtemperature 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 following sections will show that different items of plant possess different thermal characteristics, due to the nature of their construction. The relay provides two characteristics which may be selected according to the application.

2.4.1 Single time constant characteristic

This characteristic is used to protect cables, dry type transformers (e.g. type AN), and capacitor banks.

The thermal time characteristic is given by:

$$t = -\tau \log_e \left(\frac{I^2 - (K.I_{FLC})^2}{(I^2 - Ip^2)} \right)$$

where:

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

τ = Heating and cooling time constant of the protected plant;

I = Largest phase current;

I_{FLC} = Full load current rating (relay setting 'Thermal Trip');

k = 1.05 constant, allows continuous operation up to $< 1.05\ I_{FLC}$.

I_P = 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".

The thermal time constant characteristic may be rewritten as:

$$\exp(-t/\tau) = (\theta - \theta_p) / (\theta - 1)$$

where:

$$\theta = I^2/k^2 I_{FLC}^2$$

and

$$\theta_p = I_p^2/k^2 I_{FLC}^2$$

where θ is the thermal state and is θ_p the prefault thermal state.

Note: A current of 105%Is (kI_{FLC}) has to be applied for several time constants to cause a thermal state measurement of 100%

2.4.2 Dual time constant characteristic

This characteristic is used to protect oil-filled transformers with natural air cooling (e.g. type ONAN). The thermal model is similar to that with the single time constant, except that two timer constants must be set.

For marginal overloading, heat will flow from the windings into the bulk of the insulating oil. Thus, at low current, the replica curve is dominated by the long time constant for the oil. This provides protection against a general rise in oil temperature.

For severe overloading, heat accumulates in the transformer windings, with little opportunity for dissipation into the surrounding insulating oil. Thus, at high current, the replica curve is dominated by the short time constant for the windings. This provides protection against hot spots developing within the transformer windings.

Overall, the dual time constant characteristic provided within the relay serves to protect the winding insulation from ageing, and to minimise gas production by overheated oil. Note, however, that the thermal model does not compensate for the effects of ambient temperature change.

The thermal curve is defined as:

$$0.4 \exp(-t/\tau_1) + 0.6 \exp(-t/\tau_2) = (I^2 - (k.I_{FLC})^2) / (I^2 - I_P^2)$$

where:

τ_1 = Heating and cooling time constant of the transformer windings;

τ_2 = Heating and cooling time constant for the insulating oil.

In practice, it is difficult to solve this equation to give the operating time (t), therefore a graphical solution, using a spreadsheet package, is recommended. The spreadsheet can be arranged to calculate the current that will give a chosen operating time. The equation to calculate the current is defined as:

$$I = \sqrt{\frac{0.4Ip^2.\exp\left({}^{-t}/_{\tau 1}\right) + 0.6Ip^2.\exp\left({}^{-t}/_{\tau 2}\right) - k^2.I_{FLC}{}^2}{0.4 \exp\left({}^{-t}/_{\tau 1}\right) + 0.6 \exp\left({}^{-t}/_{\tau 2}\right) - 1}} \quad \text{........ Equation 1}$$

Figure 5 below shows how this equation can be used within a spreadsheet to calculate the relay operating time.

	A	B	C	D	E	F
1						
2	**Time constant 1 =**		**300**	seconds		
3	**Time constant 2 =**		**7200**	seconds		
4	**Pre-overload current Ip =**		**0.9**	per unit		
5	**Full load current =**		**1**	Amps		
6						
7	**OP Time (t)**	**Overload current (I)**				
8	1	14.40852032				
9	1.5	11.7805774				
10	2	10.21617905				
11	2.5	9.150045407				
12	3	8.364131776				
13	3.5	7.754150044				
14	4	7.263123888				
15	4.5	6.856949012				

Figures based upon Equation 1

Figure 5: Spreadsheet calculation for dual time constant thermal characteristic

The results from the spreadsheet can be plotted in a graph of current against time as shown in Figure 6 below:

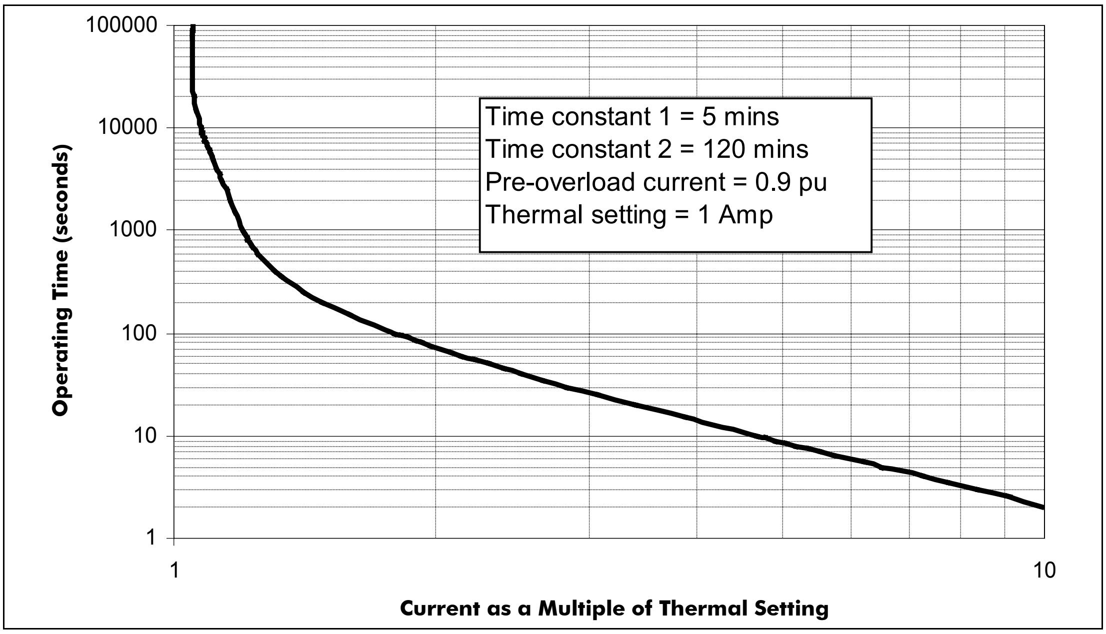


Figure 6: Dual time constant thermal characteristic

The following table shows the menu settings for the thermal protection element:

Menu Text	Default Setting	Setting Range		Step Size
		Max.	Min.	
THERMAL OVERLOAD GROUP 1				
Characteristic	Single	Disabled, Single, Dual		
Thermal Trip	1In	0.08In	3.2In	0.01In
Thermal Alarm	70%	50%	100%	1%
Time Constant 1	10 minutes	1 minutes	200 minutes	1 minutes
Time Constant 2	5 minutes	1 minutes	200 minutes	1 minutes

The thermal protection also provides an indication of the thermal state in the 'MEASUREMENTS 3' column of the relay. The thermal state can be reset by either an opto input (if assigned to this function using the programmable scheme logic) or the relay menu. The reset function in the menu is also found in the 'MEASUREMENTS 3' column with the thermal state.

2.5 Setting guidelines

2.5.1 Single time constant characteristic

The current setting is calculated as:

Thermal Trip = Permissible continuous loading of the plant item/CT ratio.

Typical time constant values are given in the following tables. The relay setting, "Time Constant 1", is in minutes.

Paper insulated lead sheathed cables or polyethylene insulated cables, laid above ground or in conduits. The table shows t 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

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 150mm^2 Al
Busbars	60	

An alarm can be raised on reaching a thermal state corresponding to a percentage of the trip threshold. A typical setting might be "Thermal Alarm" = 70% of thermal capacity.

2.5.2 Dual time constant characteristic

The current setting is calculated as:

Thermal Trip = Permissible continuous loading of the transformer/CT ratio.

Typical time constants:

	τ_1 (Minutes)	τ_2 (Minutes)	Limits
Oil-filled Transformer	5	120	Rating 400 – 1600 kVA

An alarm can be raised on reaching a thermal state corresponding to a percentage of the trip threshold. A typical setting might be "Thermal Alarm" = 70% of thermal capacity.

Note that the thermal time constants given in the above tables are typical only. Reference should always be made to the plant manufacturer for accurate information.

2.6 Earth fault protection

The P140 relays have a total of five input current transformers; one for each of the phase current inputs and two for supplying the earth fault protection elements. With this flexible input arrangement, various combinations of standard, sensitive (SEF) and restricted earth fault (REF) protection may be configured within the relay.

It should be noted that in order to achieve the sensitive setting range that is available in the P140 relays for SEF protection, the input CT is designed specifically to operate at low current magnitudes. This input is common to both the SEF and high impedance REF protection, so these features are treated as mutually exclusive within the relay menu.

2.6.1 Standard earth fault protection elements

The standard earth fault protection elements are duplicated within the P140 relays and are referred to in the relay menu as “Earth Fault 1” (EF1) and “Earth Fault 2” (EF2). EF1 operates from earth fault current which is measured directly from the system; either by means of a separate CT located in a power system earth connection or via a residual connection of the three line CTs. The EF2 element operates from a residual current quantity which is derived internally from the summation of the three phase currents

EF1 and EF2 are identical elements, each having four stages. The first and second stages have selectable IDMT or DT characteristics, whilst the third and fourth stages are DT only. Each stage is selectable to be either non-directional, directional forward or directional reverse. The Timer Hold facility, previously described for the overcurrent elements, is available on each of the first two stages.

The following table shows the relay menu for "Earth Fault 1" protection, including the available setting ranges and factory defaults. The menu for "Earth Fault 2" is identical to that for EF1 and so is not shown here:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
EARTH FAULT 1 GROUP 1				
IN1>1 Function	IEC S Inverse	Disabled, DT, IEC S Inverse, IEC V Inverse, IEC E Inverse, UK LT Inverse, RI, IEEE M Inverse, IEEE V Inverse, IEEE E Inverse, US Inverse, US ST Inverse, IDG		
IN1>1 Direction	Non-directional	Non-directional Directional Fwd Directional Rev		N/A
IN1>1 Current Set	0.2 x In	0.08 x In	4.0 x In	0.01 x In
IN1>1 IDG Is	1.5	1	4	0.1
IN1>1 Time Delay	1	0s	200s	0.01s
IN1>1 TMS	1	0.025	1.2	0.025
IN1>1 Time Dial	1	0.01	100	0.1
IN1>1 K (RI)	1	0.1	10	0.05
IN1>1 IDG Time	1.2	1	2	0.01
IN1>1 Reset Char	DT	DT or Inverse	N/A	
IN1>1 tRESET	0	0s	100s	0.01s
IN1>2 Cells as for IN1>1 Above				
IN1>3 Status	Disabled	Disabled or Enabled		N/A
IN1>3 Direction	Non-directional	Non-directional Directional Fwd Directional Rev		N/A

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
EARTH FAULT 1 GROUP 1				
IN1>3 Current	0.2 x In	0.08 x In	32 x In	0.01 x In
IN1>3 Time Delay	0	0s	200s	0.01s
IN1>4 Cells as for IN1>3 above				
IN1> Blocking	00001111	Bit 0 = VTS Blocks IN>1, Bit 1 = VTS Blocks IN>2, Bit 2 = VTS Blocks IN>3, Bit 3 = VTS Blocks IN>4, Bit 4 = A/R Blocks IN>3, Bit 5 = A/R Blocks IN>4. Bits 6 & 7 are not used.		
IN1> Char Angle	–45°	–95°	+95°	1°
IN1>Pol	Zero Sequence	Zero Sequence or Neg Sequence		N/A
IN1>VNpol Set	5	0.5/2V	80/320V	0.5/2V
IN1>V2pol Set	5	0.5/2V	25/100V	0.5/2V
IN1>I2pol Set	0.08	0.08 x In	1 x In	0.01In

Note: VTS block - When the relevant bit set to 1, operation of Voltage Transformer Supervision (VTS) will block the stage if directionalised. When set to 0, the stage will revert to Non-Directional upon operation of the VTS.

A/R block - The autoreclose logic can be set to block instantaneous overcurrent elements after a prescribed number of shots. This is set in the autoreclose column. When a block instantaneous signal is generated then only those earth fault stages selected to '1' in the IN> Function link will be blocked.

For inverse time delayed characteristics refer to the phase overcurrent elements, Section 2.2.1

The fact that both EF1 and EF2 elements may be enabled in the relay at the same time leads to a number of applications advantages. For example, the parallel transformer application previously shown in Figure 5 requires directional earth fault protection at locations R3 and R4, to provide discriminative protection. However, in order to provide back-up protection for the transformer, busbar and other downstream earth fault devices, Standby Earth Fault (SBEF) protection is also commonly applied. This function has traditionally been fulfilled by a separate earth fault relay, fed from a single CT in the transformer earth connection. The EF1 and EF2 elements of the P140 relay may be used to provide both the directional earth fault (DEF) and SBEF functions, respectively.

Where a Neutral Earthing Resistor (NER) is used to limit the earth fault level to a particular value, it is possible that an earth fault condition could cause a flashover of the NER and hence a dramatic increase in the earth fault current. For this reason, it may be appropriate to apply two stage SBEF protection. The first stage should have suitable current and time characteristics which co-ordinate with downstream earth fault protection. The second stage may then be set with a higher current setting but with zero time delay; hence providing fast clearance of an earth fault which gives rise to an NER flashover.

The remaining two stages are available for customer specific applications.

The previous examples relating to transformer feeders utilise both EF1 and EF2 elements. In a standard feeder application requiring three phase overcurrent and earth fault protection, only one of the earth fault elements would need to be applied. If EF1 were to be used, the connection would be a standard arrangement of the three phase currents feeding into the phase inputs, with the EF1 input connected into the residual path. This is shown in Figure 7. In this application, EF2 should be disabled in the menu. Alternatively, where the EF2 element is used, no residual connection of the CT's will be required.

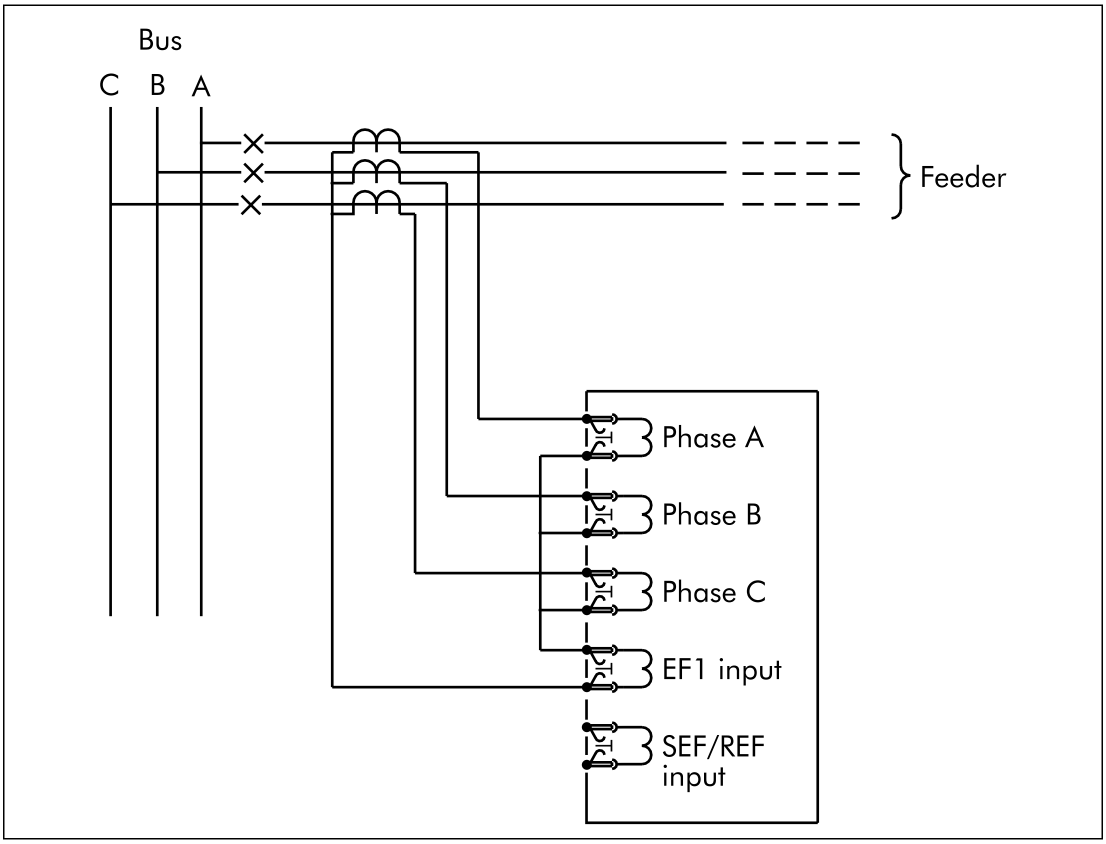


Figure 7: Three phase overcurrent & residually connected earth fault protection

2.6.1.1 IDG curve

The IDG curve is commonly used for time delayed earth fault protection in the Swedish market. This curve is available in stages 1 and 2 of Earth Fault 1, Earth Fault 2 and Sensitive Earth Fault protections.

The IDG curve is represented by the following equation:

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

where:

I = measured current

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

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

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

Figure 8 – illustrates how the IDG characteristic is implemented.

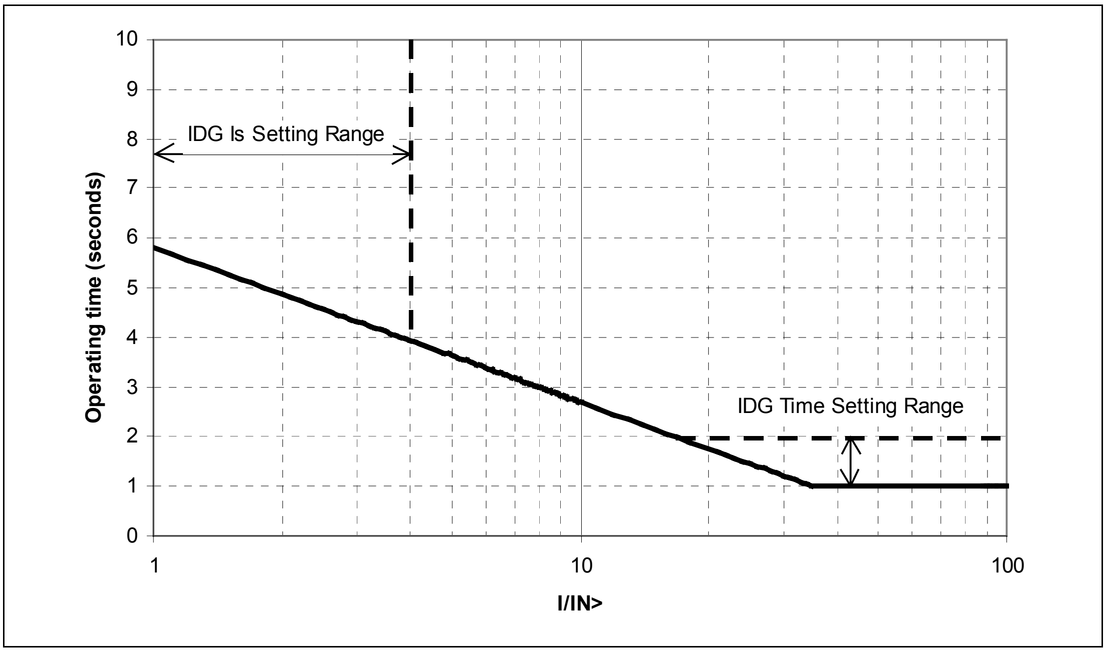


Figure 8: IDG characteristic

2.6.2 Sensitive earth fault protection element (SEF)

If a system is earthed through a high impedance, or is subject to high ground fault resistance, the earth fault level will be severely limited. Consequently, the applied earth fault protection requires both an appropriate characteristic and a suitably sensitive setting range in order to be effective. A separate 4 stage sensitive earth fault element is provided within the P140 relay for this purpose, which has a dedicated input. The SEF protection can be set IN/OUT of service using the DDB 442 'Inhibit SEF' input signal which can be operated from an opto input or control command. This DDB signal blocks the starts and trips of all four stages of SEF protection. DDBs 216-219 'ISEF>1/2/3/4 Timer Blk' can be used to block the four trip stages of SEF protection individually, however, these signals do not block the starts.

The following table shows the relay menu for the "Sensitive Earth Fault" protection, including the available setting ranges and factory defaults.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SEF/REF PROT'N GROUP 1				
SEF/REF Options	SEF	SEF, SEF cos PHI SEF sin PHI Wattmetric, Hi Z REF, Lo Z REF, Lo Z REF + SEF, Lo Z REF + Wattmet		
ISEF>1 Function	DT	Disabled, DT, IEC S Inverse, IEC V Inverse, IEC E inverse, UK LT Inverse IEEE M Inverse, IEEE V Inverse, IEEE E Inverse, US Inverse, US ST Inverse		
ISEF>1 Direction	Non-directional	Non-directional Direction Fwd Direction Rev		N/A
ISEF>1 Current	0.05 x In	0.005 x In	0.1x In	0.00025 x In
ISEF>1 IDG Is	1.5	1	4	0.1
ISEF>1 delay	1	0	200s	0.01s
ISEF>1 TMS	1	0.025	1.2	0.025
ISEF>1 Time Dial	7	0.5	15	0.1
ISEF>1 IDG Time	1.2	1	2	0.1
ISEF>1 Reset Char	DT	DT or inverse		N/A
ISEF>1 tRESET	0	0s	100s	0.01s
ISEF>2 Cells as for ISEF>1 above				
ISEF>3 Status	Disabled	Disabled or Enabled		N/A
ISEF>3 Direction	Non-directional	Non-directional Directional Fwd Directional Rev		N/A
ISEF>3 Current	0.2 x In	0.005 x In	0.8 x In	0.00025 x In
ISEF>3 Time Delay	1	0s	200s	0.01s
ISEF>4 Cells as for ISEF>3 above				
ISEF> Func Link	00001111	Bit 0 = VTS Blocks ISEF>1, Bit 1 = VTS Blocks ISEF>2, Bit 2 = VTS Blocks ISEF>3, Bit 3 = VTS Blocks ISEF>4, Bit 4 = A/R Blocks ISEF>3, Bit 5 = A/R Blocks ISEF>4. Bits 6 & 7 are not used.		

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SEF/REF PROT'N GROUP 1				
ISEF DIRECTIONAL	Sub heading in menu			
ISEF> Char Angle	–45°	–95°	+95°	1°
ISEF>VNpol Set	5	0.5/2V	80/320V	0.5/2V
WATTMETRIC SEF	Sub heading in menu			
PN> Setting	9In/36In W	0 – 20In/80In W		0.05/0.2In W
RESTRICTED E/F	Sub heading in menu (see Section 2.10)			

Note: VTS block - When the relevant bit set to 1, operation of the Voltage Transformer Supervision (VTS) will block the stage if it is directionalised. When set to 0, the stage will revert to Non-Directional upon operation of the VTS.

A/R block - The autoreclose logic can be set to block instantaneous SEF elements after a prescribed number of shots. This is set in the autoreclose column. When a block instantaneous signal is generated then only those SEF stages selected to '1' in the ISEF> Function link will be blocked.

For the range of available inverse time delayed characteristics, refer to those of the phase overcurrent elements, Section 2.2

Note: As can be seen from the menu, the "SEF/REF options" cell has a number of setting options. To enable standard, four stage SEF protection, the SEF option should be selected, which is the default setting. However, if wattmetric, restricted earth fault or a combination of both protections are required, then one of the remaining options should be selected. These are described in more detail in Sections 2.7 to 2.10. The "Wattmetric" and "Restricted E/F" cells will only appear in the menu if the functions have been selected in the option cell.

As shown in the previous menu, each SEF stage is selectable to be either non-directional, directional forward or directional reverse in the "ISEF>Direction" cell. The timer hold facility, previously described for the overcurrent elements in Section 2.2.2 is available on each of the first two stages and is set in the same manner.

Settings related to directionalising the SEF protection are described in detail in the following section.

SEF would normally be fed from a core balance current transformer (CBCT) mounted around the three phases of the feeder cable. However, care must be taken in the positioning of the CT with respect to the earthing of the cable sheath. See Figure 9 below.

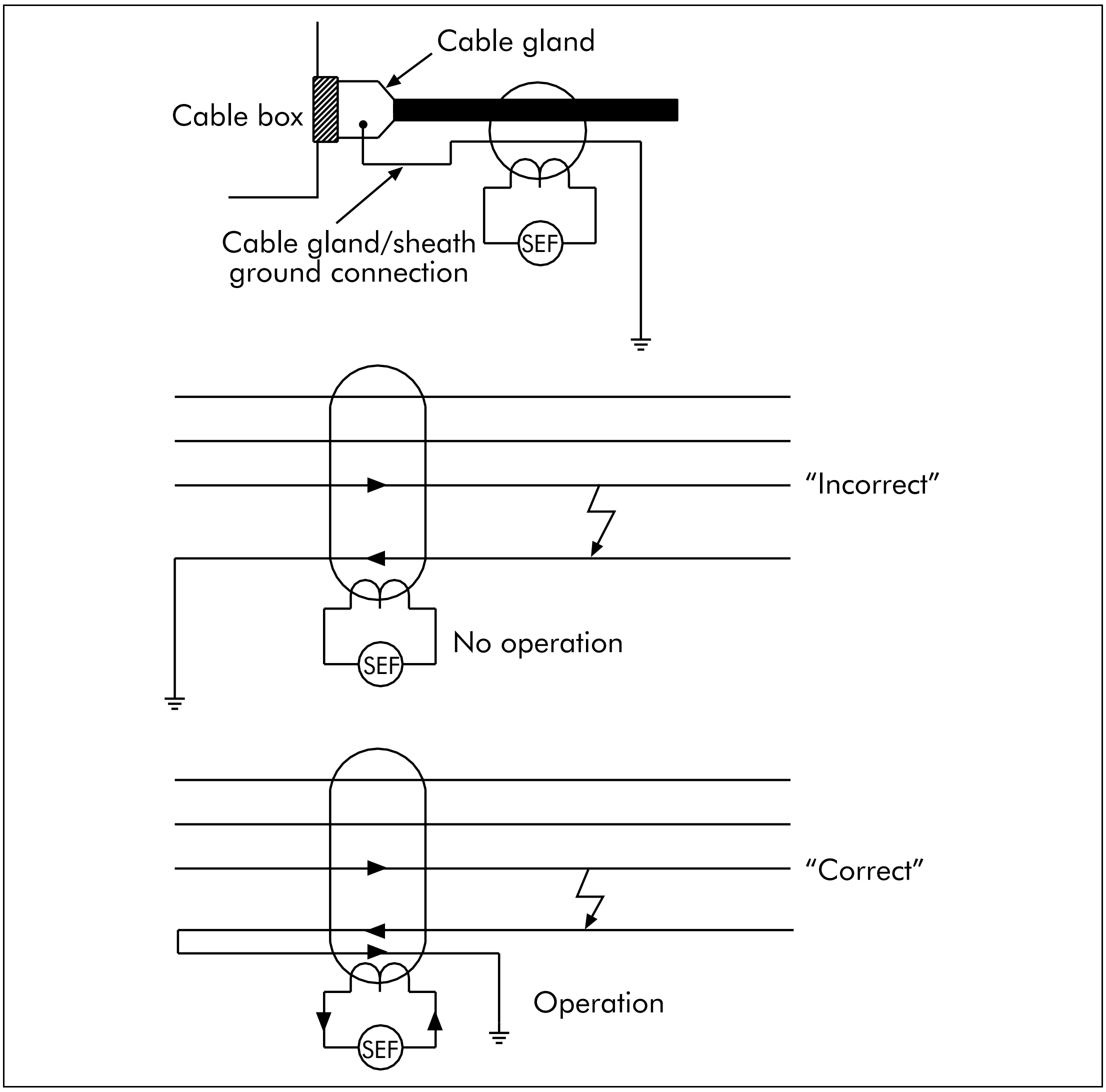


Figure 9: Positioning of core balance current transformers

As can be seen from the diagram, if the cable sheath is terminated at the cable gland and earthed directly at that point, a cable fault (from phase to sheath) will not result in any unbalance current in the core balance CT. Hence, prior to earthing, the connection must be brought back through the CBCT and earthed on the feeder side. This then ensures correct relay operation during earth fault conditions.

2.7 Directional earth fault protection (DEF)

As stated in the previous sections, each of the four stages of EF1, EF2 and SEF protection may be set to be directional if required. Consequently, as with the application of directional overcurrent protection, a suitable voltage supply is required by the relay to provide the necessary polarisation.

With the standard earth fault protection element in the P140 relay, two options are available for polarisation; Residual Voltage or Negative Sequence.

2.7.1 Residual voltage polarisation

With earth fault protection, the polarising signal requires to be representative of the earth fault condition. As residual voltage is generated during earth fault conditions, this quantity is commonly used to polarise DEF elements. The P140 relay internally derives this voltage from the 3 phase voltage input which must be supplied from either a 5-limb or three single phase VTs. These types of VT design allow the passage of residual flux and consequently permit the relay to derive the required residual voltage. In addition, the primary star point of the VT must be earthed. A three limb VT has no path for residual flux and is therefore unsuitable to supply the relay.

It is possible that small levels of residual voltage will be present under normal system conditions due to system imbalances, VT inaccuracies, relay tolerances etc. Hence, the P140 relay includes a user settable threshold (IN>VNPol set) which must be exceeded in order for the DEF function to be operational. The residual voltage measurement provided in the "Measurements 1" column of the menu may assist in determining the required threshold setting during the commissioning stage, as this will indicate the level of standing residual voltage present.

Note that residual voltage is nominally 180° out of phase with residual current. Consequently, the DEF elements are polarised from the "-Vres" quantity. This 180° phase shift is automatically introduced within the P140 relay.

2.7.2 Negative sequence polarisation

In certain applications, the use of residual voltage polarisation of DEF may either be not possible to achieve, or problematic. An example of the former case would be where a suitable type of VT was unavailable, for example if only a three limb VT was fitted. An example of the latter case would be an HV/EHV parallel line application where problems with zero sequence mutual coupling may exist.

In either of these situations, the problem may be solved by the use of negative phase sequence (nps) quantities for polarisation. This method determines the fault direction by comparison of nps voltage with nps current. The operate quantity, however, is still residual current.

This is available for selection on both the derived and measured standard earth fault elements (EF1 and EF2) but not on the SEF protection. It requires a suitable voltage and current threshold to be set in cells "IN>V2pol set" and "IN>I2pol set", respectively.

Negative sequence polarising is not recommended for impedance earthed systems regardless of the type of VT feeding the relay. This is due to the reduced earth fault current limiting the voltage drop across the negative sequence source impedance (V_2pol) to negligible levels. If this voltage is less than 0.5 volts the relay will cease to provide DEF protection.

2.7.3 General setting guidelines for DEF

When setting the Relay Characteristic Angle (RCA) for the directional overcurrent element, a positive angle setting was specified. This was due to the fact that the quadrature polarising voltage lagged the nominal phase current by 90°. i.e. the position of the current under fault conditions was leading the polarising voltage and hence a positive RCA was required. With DEF, the residual current under fault conditions lies at an angle lagging the polarising voltage. Hence, negative RCA settings are required for DEF applications. This is set in cell "I>Char Angle" in the relevant earth fault menu.

The following angle settings are recommended for a residual voltage polarised relay:

Resistance earthed systems → 0°

Distribution systems (solidly earthed) → –45°

Transmission Systems (solidly earthed) → –60°

For negative sequence polarisation, the RCA settings must be based on the angle of the nps source impedance, much the same as for residual polarising. Typical settings would be:

Distribution systems –45°

Transmission Systems –60°

2.7.4 Application to insulated systems

The advantage gained by running a power system which is insulated from earth is the fact that during a single phase to earth fault condition, no earth fault current is allowed to flow. Consequently, it is possible to maintain power flow on the system even when an earth fault condition is present. However, this advantage is offset by the fact that the resultant steady state and transient overvoltages on the sound phases can be very high. It is generally the case, therefore, that insulated systems will only be used in low/medium voltage networks where it does not prove too costly to provide the necessary insulation against such overvoltages. Higher system voltages would normally be solidly earthed or earthed via a low impedance.

Operational advantages may be gained by the use of insulated systems. However, it is still vital that detection of the fault is achieved. This is not possible by means of standard current operated earth fault protection. One possibility for fault detection is by means of a residual overvoltage device. This functionality is included within the P140 relays and is detailed in Section 2.11. However, fully discriminative earth fault protection on this type of system can only be achieved by the application of a sensitive earth fault element. This type of relay is set to detect the resultant imbalance in the system charging currents that occurs under earth fault conditions. It is therefore essential that a core balance CT is used for this application.

This eliminates the possibility of spill current that may arise from slight mismatches between residually connected line CTs. It also enables a much lower CT ratio to be applied, thereby allowing the required protection sensitivity to be more easily achieved.

From Figure 10, it can be seen that the relays on the healthy feeders see the unbalance in the charging currents for their own feeder. The relay on the faulted feeder, however, sees the charging current from the rest of the system (IH1 and IH2 in this case), with it's own feeders charging current (IH3) becoming cancelled out. This is further illustrated by the phasor diagrams shown in Figure 11.

Referring to the phasor diagram, it can be seen that the C phase to earth fault causes the voltages on the healthy phases to rise by a factor of $\sqrt{3}$. The A phase charging current (Ia1), is then shown to be leading the resultant A phase voltage by 90°. Likewise, the B phase charging current leads the resultant Vb by 90°.

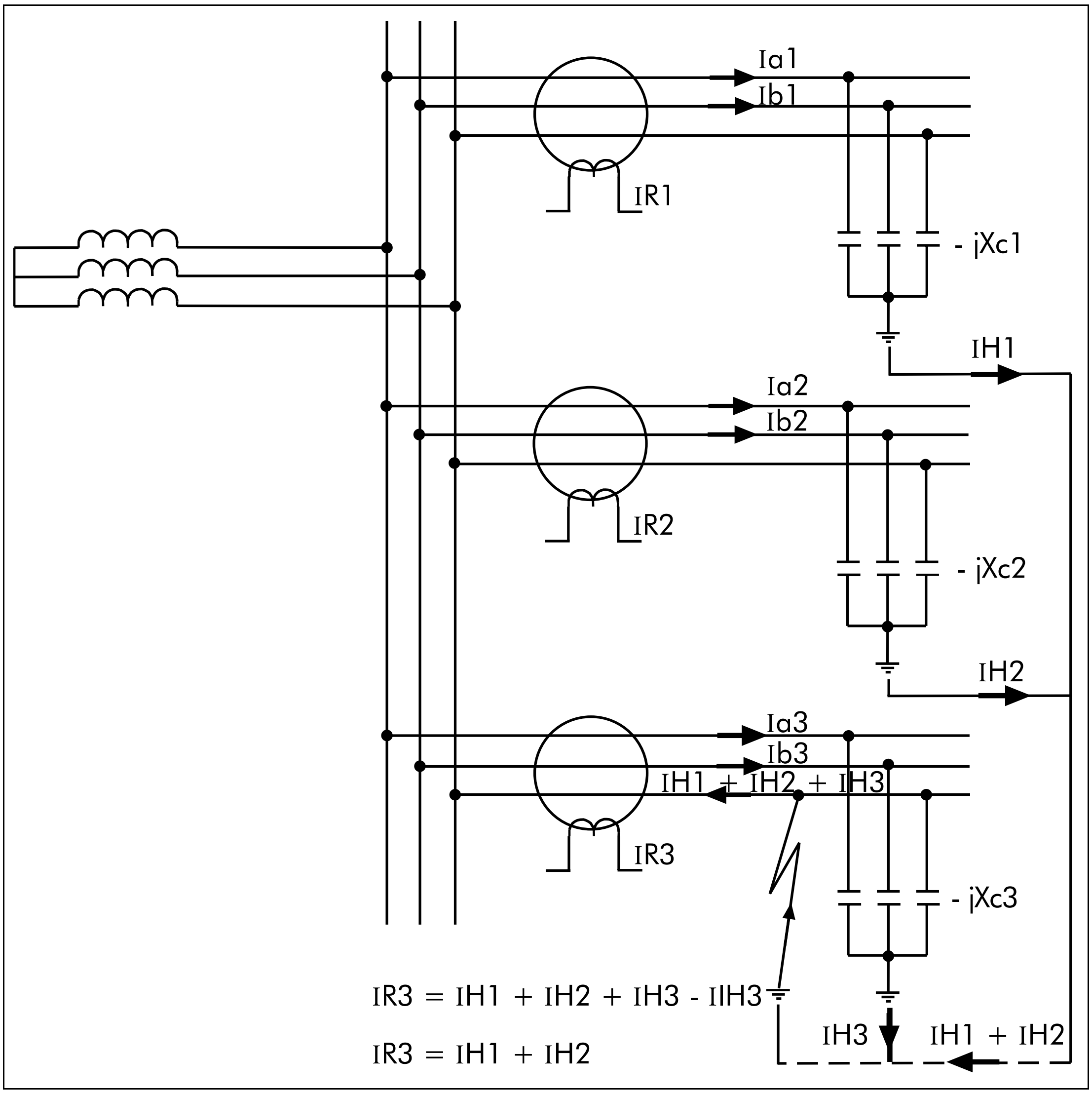


Figure 10: Current distribution in an insulated system with C phase fault

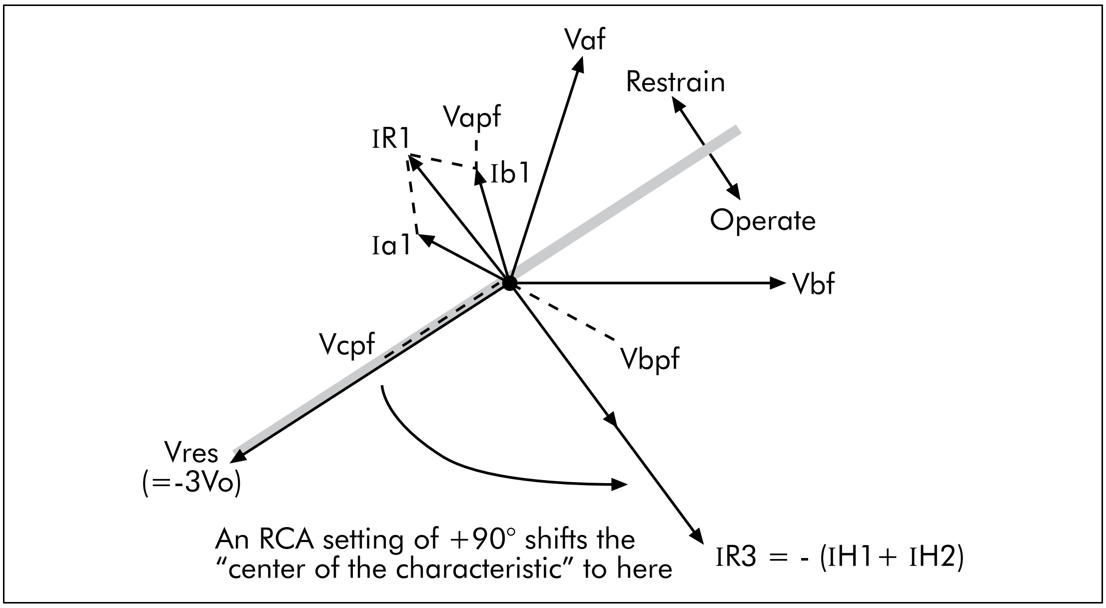


Figure 11: Phasor diagrams for insulated system with C phase fault

The unbalance current detected by a core balance current transformer on the healthy feeders can be seen to be the vector addition of Ia1 and Ib1, giving a residual current which lies at exactly 90° lagging the polarising voltage (–3Vo). As the healthy phase voltages have risen by a factor of √3, the charging currents on these phases will also be √3 times larger than their steady state values. Therefore, the magnitude of residual current, IR1, is equal to 3 x the steady state per phase charging current.

The phasor diagrams indicate that the residual currents on the healthy and faulted feeders, IR1 and IR3 respectively, are in anti-phase. A directional element could therefore be used to provide discriminative earth fault protection.

If the polarising voltage of this element, equal to –3Vo, is shifted through +90°, the residual current seen by the relay on the faulted feeder will lie within the operate region of the directional characteristic and the current on the healthy feeders will fall within the restrain region.

As previously stated, the required characteristic angle setting for the SEF element when applied to insulated systems, is +90°. It should be noted though, that this recommended setting corresponds to the relay being connected such that it's direction of current flow for operation is from the source busbar towards the feeder, as would be the convention for a relay on an earthed system. However, if the forward direction for operation was set as being from the feeder into the busbar, (which some utilities may standardise on), then a –90° RCA would be required. The correct relay connections to give a defined direction for operation are shown on the relay connection diagram.

Note that discrimination can be provided without the need for directional control. This can only be achieved if it is possible to set the relay in excess of the charging current of the protected feeder and below the charging current for the rest of the system.

2.7.5 Setting guidelines - insulated systems

As has been previously shown, the residual current detected by the relay on the faulted feeder is equal to the sum of the charging currents flowing from the rest of the system. Further, the addition of the two healthy phase charging currents on each feeder gives a total charging current which has a magnitude of three times the per phase value. Therefore, the total unbalance current detected by the relay is equal to three times the per phase charging current of the rest of the system. A typical relay setting may therefore be in the order of 30% of this value, i.e. equal to the per phase charging current of the remaining system. Practically though, the required setting may well be determined on site, where suitable settings can be adopted based upon practically obtained results. The use of the P140 relays' comprehensive measurement and fault recording facilities may prove useful in this respect.

2.7.6 Application to Petersen Coil earthed systems

Power systems are usually earthed in order to limit transient overvoltages during arcing faults and also to assist with detection and clearance of earth faults. Impedance earthing has the advantage of limiting damage incurred by plant during earth fault conditions and also limits the risk of explosive failure of switchgear, which is a danger to personnel. In addition, it limits touch and step potentials at a substation or in the vicinity of an earth fault.

If a high impedance device is used for earthing the system, or the system is unearthed, the earth fault current will be reduced but the steady state and transient overvoltages on the sound phases can be very high. Consequently, it is generally the case that high impedance earthing will only be used in low/medium voltage networks in which it does not prove too costly to provide the necessary insulation against such overvoltages. Higher system voltages would normally be solidly earthed or earthed via a low impedance.

A special case of high impedance earthing via a reactor occurs when the inductive earthing reactance is made equal to the total system capacitive reactance to earth at system frequency. This practice is widely referred to as Petersen (or resonant) Coil Earthing. With a correctly tuned system, the steady state earthfault current will be zero, so that arcing earth faults become self extinguishing. Such a system can, if designed to do so, be run with one phase earthed for a long period until the cause of the fault is identified and rectified. With the effectiveness of this method being dependent upon the correct tuning of the coil reactance to the system capacitive reactance, an expansion of the system at any time would clearly necessitate an adjustment of the coil reactance. Such adjustment is sometimes automated.

Petersen coil earthed systems are commonly found in areas where the power system consists mainly of rural overhead lines and can be particularly beneficial in locations which are subject to a high incidence of transient faults. Transient earth faults caused by lightning strikes, for example, can be extinguished by the Petersen Coil without the need for line outages.

Figure 12 shows a source of generation earthed through a Petersen Coil, with an earth fault applied on the A Phase. Under this situation, it can be seen that the A phase shunt capacitance becomes short circuited by the fault. Consequently, the calculations show that if the reactance of the earthing coil is set correctly, the resulting steady state earth fault current will be zero.

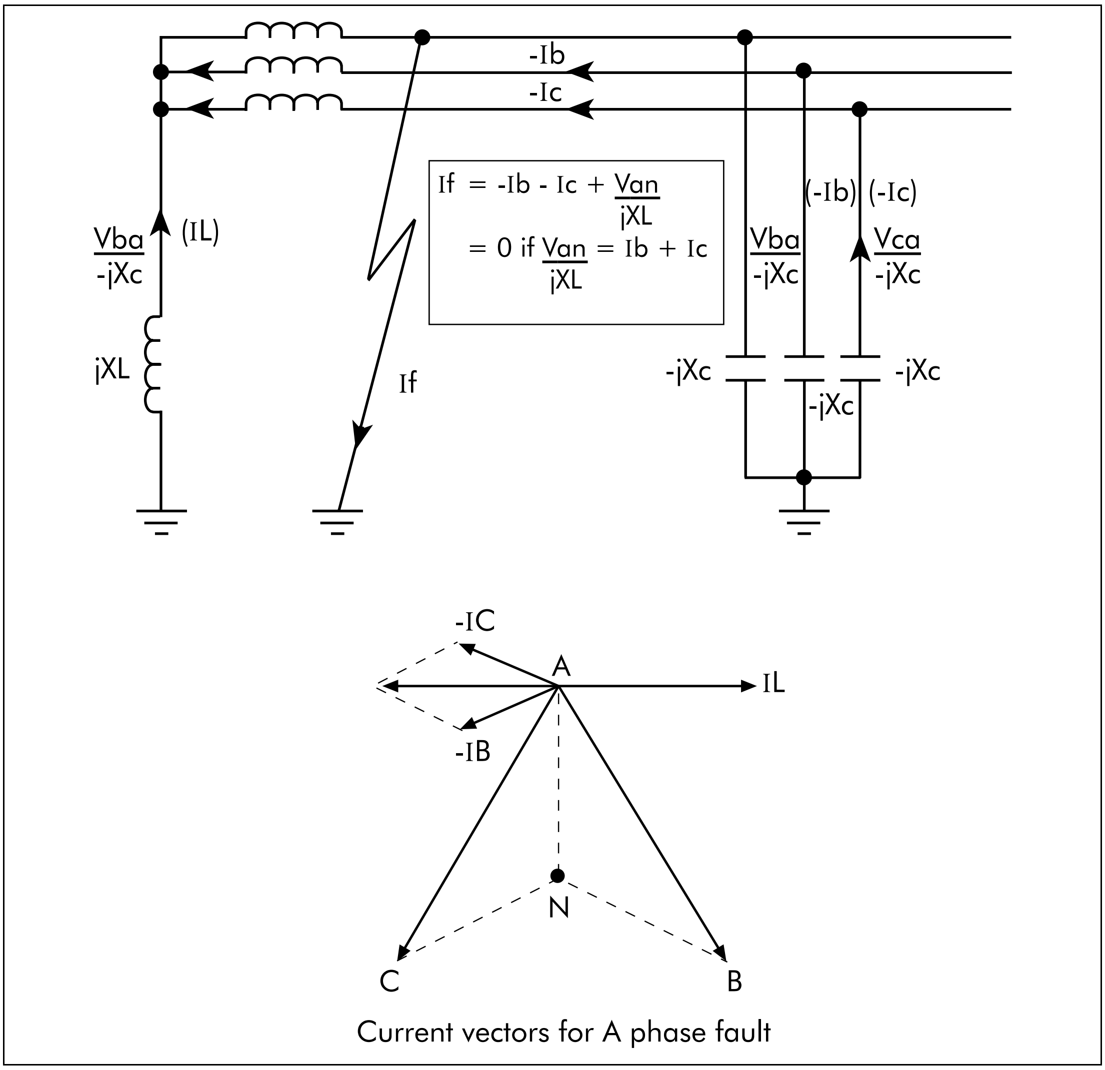


Figure 12: Current distribution in Petersen Coil earthed system

Prior to actually applying protective relays to provide earth fault protection on systems which are earthed via a Petersen Coil, it is imperative to gain an understanding of the current distributions that occur under fault conditions on such systems. With this knowledge, it is then possible to decide on the type of relay that may be applied, ensuring that it is both set and connected correctly.

Figure 13 shows a radial distribution system having a source which is earthed via a Petersen Coil. Three outgoing feeders are present, the lower of which has a phase to earth fault applied on the C phase.

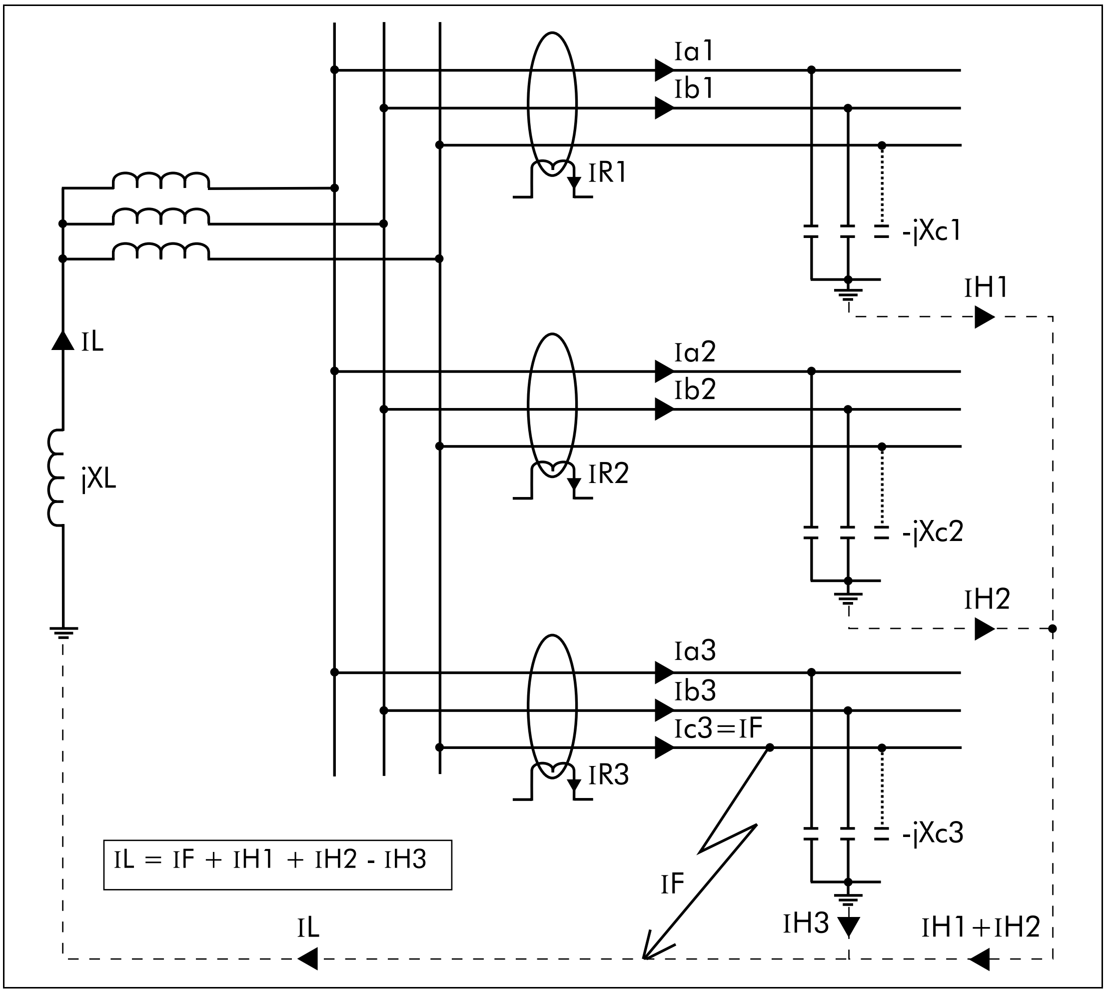


Figure 13: Distribution of currents during a C phase to earth fault

Figures 14 (a, b and c) show vector diagrams for the previous system, assuming that it is fully compensated (i.e. coil reactance fully tuned to system capacitance), in addition to assuming a theoretical situation where no resistance is present either in the earthing coil or in the feeder cables.

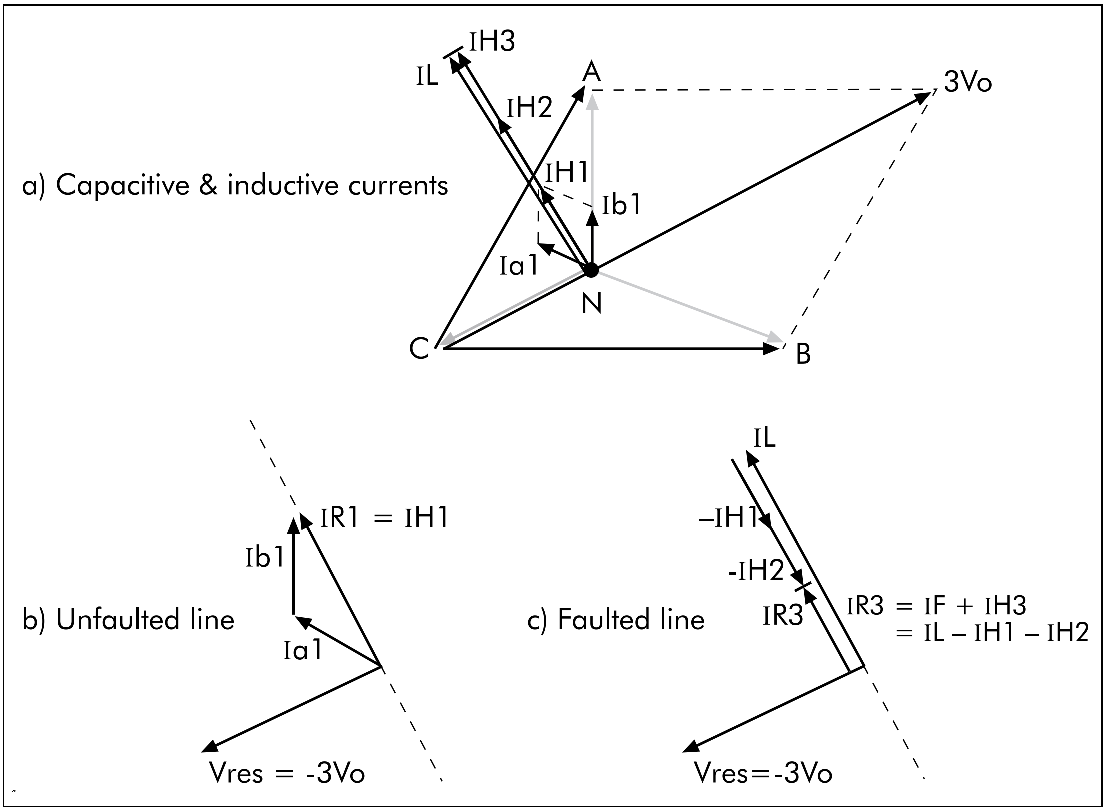


Figure 14: Theoretical case - no resistance present in XL or XC

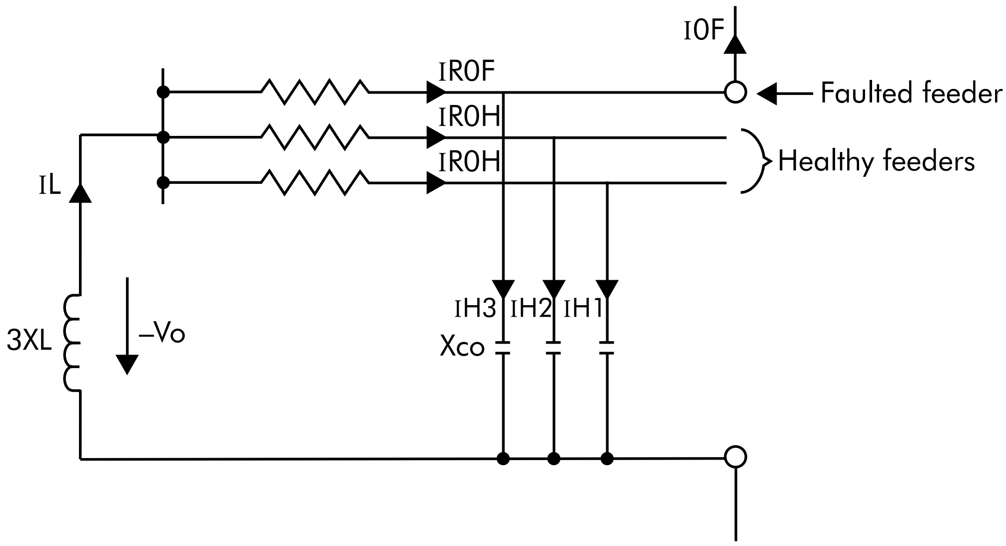
Referring to the vector diagram illustrated in Figure 14a, it can be seen that the C phase to earth fault causes the voltages on the healthy phases to rise by a factor of Ö3. The A phase charging currents (Ia1, Ia2 and Ia3), are then shown to be leading the resultant A phase voltage by 90° and likewise for the B phase charging currents with respect to the resultant Vb.

The unbalance current detected by a core balance current transformer on the healthy feeders can be seen to be a simple vector addition of Ia1 and Ib1, giving a residual current which lies at exactly 90° lagging the residual voltage (Figure 14b). Clearly, as the healthy phase voltages have risen by a factor of √3, the charging currents on these phases will also be √3 times larger than their steady state values. Therefore, the magnitude of residual current, IR1, is equal to 3 x the steady state per phase charging current.

Note: The actual residual voltage used as a reference signal for directional earth fault relays is phase shifted by 180° and is therefore shown as –3Vo in the vector diagrams. This phase shift is automatically introduced within the P140 relays.

On the faulted feeder, the residual current is the addition of the charging current on the healthy phases (IH3) plus the fault current (IF). The net unbalance is therefore equal to IL-IH1-IH2, as shown in Figure 14c.

This situation may be more readily observed by considering the zero sequence network for this fault condition. This is depicted in Figure 15.



Key:

IR0F = Residual current on faulted feeder
IR0H = Residual current on healthy feeder
It can therefore be seen that:-
I0F = IL – IH1 – IH2 – IH3
IR0F = IH3 + I0F
So:
IR0F = IL – IH1 – IH2

Figure 15: Zero sequence network showing residual currents

In comparing the residual currents occurring on the healthy and on the faulted feeders (Figures 14b & 14c), it can be seen that the currents would be similar in both magnitude and phase; hence it would not be possible to apply a relay which could provide discrimination.

However, as previously stated, the scenario of no resistance being present in the coil or feeder cables is purely theoretical. Further consideration therefore needs to be given to a practical application in which the resistive component is no longer ignored – consider Figure 16.

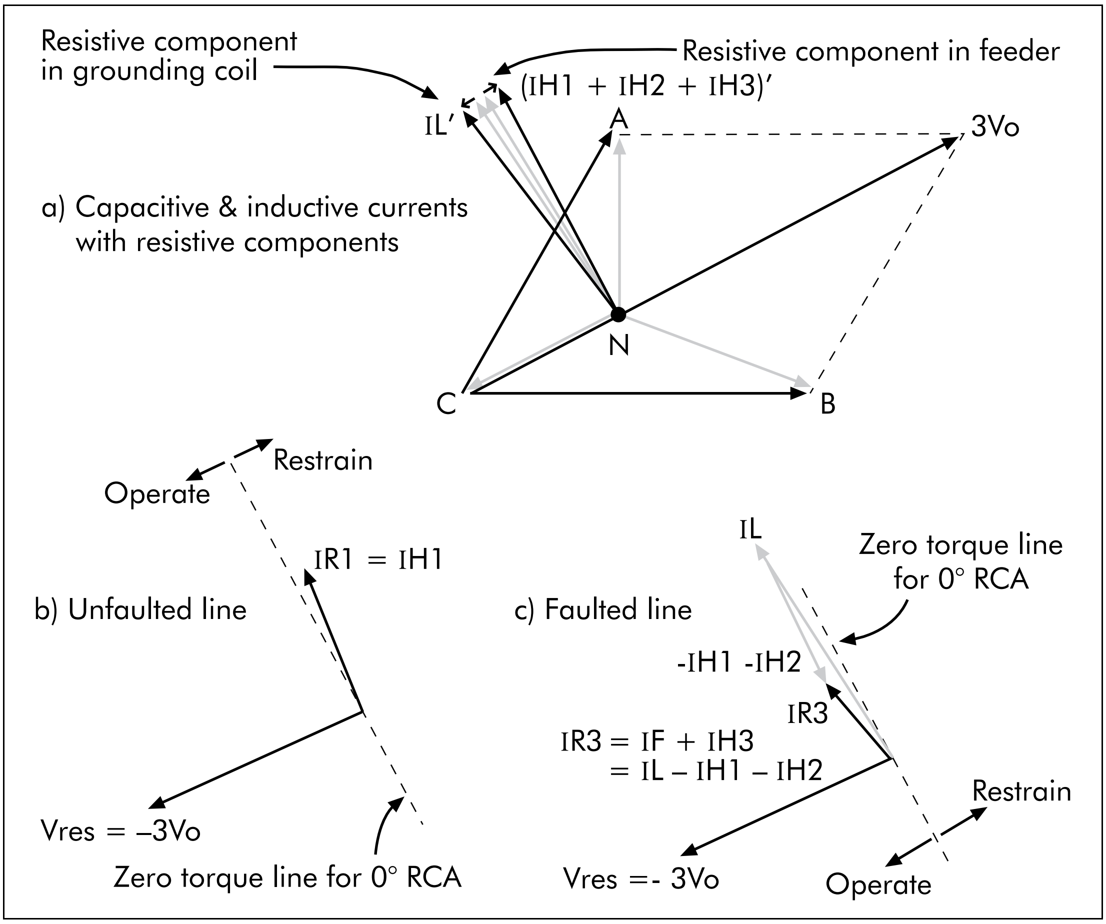


Figure 16: Practical case - resistance present in XL and Xc

Figure 16a again shows the relationship between the capacitive currents, coil current and residual voltage. It can now be seen that due to the presence of resistance in the feeders, the healthy phase charging currents are now leading their respective phase voltages by less than 90°. In a similar manner, the resistance present in the earthing coil has the effect of shifting the current, IL, to an angle less than 90° lagging. The result of these slight shifts in angles can be seen in Figures 16b and 16c.

The residual current now appears at an angle in excess of 90° from the polarising voltage for the unfaulted feeder and less than 90° on the faulted feeder. Hence, a directional relay having a characteristic angle setting of 0° (with respect to the polarising signal of -3Vo) could be applied to provide discrimination. i.e. the healthy feeder residual current would appear within the restrain section of the characteristic but the residual current on the faulted feeder would lie within the operate region - as shown in diagrams 14b and 14c.

In practical systems, it may be found that a value of resistance is purposely inserted in parallel with the earthing coil. This serves two purposes; one is to actually increase the level of earth fault current to a more practically detectable level and the second is to increase the angular difference between the residual signals; again to aid in the application of discriminating protection.

2.8 Operation of sensitive earth fault element

It has been shown that the angular difference between the residual currents on the healthy and faulted feeders allows the application of a directional relay whose zero torque line passes between the two currents. Three possibilities exist for the type of protection element that may consequently be applied for earth fault detection:

1. A suitably sensitive directional earth fault relay having a relay characteristic angle setting (RCA) of zero degrees, with the possibility of fine adjustment about this threshold.

2. A sensitive directional zero sequence wattmetric relay having similar requirements to 1. above with respect to the required RCA settings.

3. 3. A sensitive directional earth fault relay having Icosϕ and Isinϕ characteristics.

All stages of the sensitive earth fault element of the P140 relay are settable down to 0.5% of rated current and would therefore fulfill the requirements of the first method listed above and could therefore be applied successfully. However, many utilities (particularly in central Europe) have standardised on the wattmetric method of earth fault detection, which is described in the following section.

Zero sequence power measurement, as a derivative of Vo and Io, offers improved relay security against false operation with any spurious core balance CT output for non earth fault conditions. This is also the case for a sensitive directional earth fault relay having an adjustable Vo polarising threshold.

Some utilities in Scandinavia prefer to use Icosϕ/Isinϕ for non compensated Peterson Coil or insulated networks.

Wattmetric Characteristic

The previous analysis has shown that a small angular difference exists between the spill current on the healthy and faulted feeders. It can be seen that this angular difference gives rise to active components of current which are in antiphase to one another. This is shown in Figure 17 below:

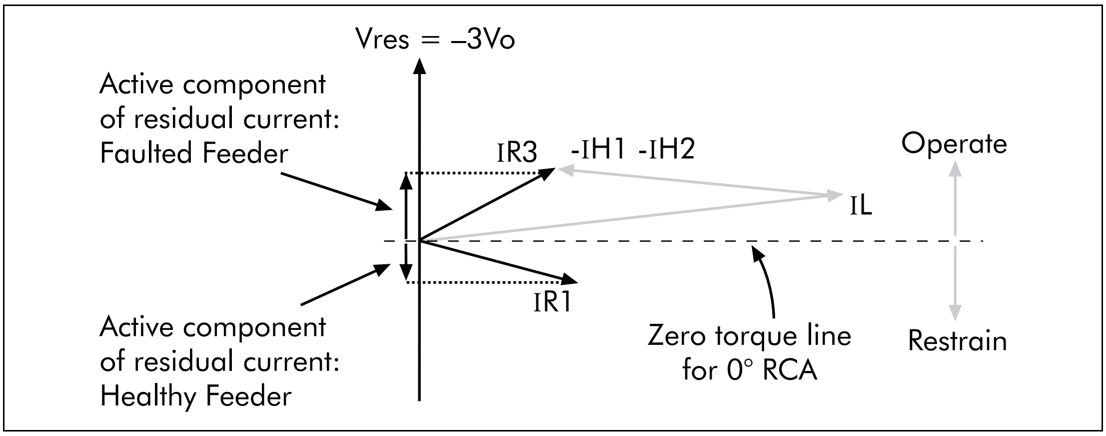


Figure 17: Resistive components of spill current

Consequently, the active components of zero sequence power will also lie in similar planes and so a relay capable of detecting active power would be able to make a discriminatory decision. i.e. if the wattmetric component of zero sequence power was detected in the forward direction, then this would be indicative of a fault on that feeder; if power was detected in the reverse direction, then the fault must be present on an adjacent feeder or at the source.

For operation of the directional earth fault element within the P140 relays, all three of the settable thresholds on the relay must be exceeded; namely the current "ISEF>", the voltage "ISEF>VNpol Set" and the power "PN> Setting".

As can be seen from the following formula, the power setting within the relay menu is called PN> and is therefore calculated using residual rather than zero sequence quantities. Residual quantities are three times their respective zero sequence values and so the complete formula for operation is as shown below:

The PN> setting corresponds to:

$Vres \times Ires \times \cos(\phi - \phi c) = 9 \times Vo \times Io \times \cos(\phi - \phi c)$

where;

ϕ	=	Angle between the Polarising Voltage (-Vres) and the Residual Current
ϕc	=	Relay Characteristic Angle (RCA) Setting (ISEF> Char Angle)
Vres	=	Residual Voltage
Ires	=	Residual Current
Vo	=	Zero Sequence Voltage
Io	=	Zero Sequence Current

The action of setting the PN> threshold to zero would effectively disable the wattmetric function and the relay would operate as a basic, sensitive directional earth fault element. However, if this is required, then the 'SEF' option can be selected from the 'Sens E/F Options' cell in the menu.

A further point to note is that when a power threshold other than zero is selected, a slight alteration is made to the angular boundaries of the directional characteristic. Rather than being ±90° from the RCA, they are made slightly narrower at ±85°.

Icosϕ /Isinϕ Characteristic

In some applications, the residual current on the healthy feeder can lie just inside the operating boundary following a fault condition. The residual current for the faulted feeder lies close to the operating boundary.

In this case, correct discrimination is achieved by means of an Icosϕ characteristic as the faulted feeder will have a large active component of residual current, whilst the healthy feeder will have a small value.

For insulated earth applications, it is common to use the Isinϕ characteristic.

2.9 Application considerations

Required relay current and voltage connections

Referring to the relevant application diagram for the P140 Relay, it should be applied such that it's direction for forward operation is looking down into the protected feeder (away from the busbar), with a 0° RCA setting.

As illustrated in the relay application diagram, it is usual for the earth fault element to be driven from a core balance current transformer (CBCT). This eliminates the possibility of spill current that may arise from slight mismatches between residually connected line CT's. It also enables a much lower CT ratio to be applied, thereby allowing the required protection sensitivity to be more easily achieved.

2.9.1 Calculation of required relay settings

As has been previously shown, for a fully compensated system, the residual current detected by the relay on the faulted feeder is equal to the coil current minus the sum of the charging currents flowing from the rest of the system. Further, as stated in the previous section, the addition of the two healthy phase charging currents on each feeder gives a total charging current which has a magnitude of three times the steady state per phase value. Therefore, for a fully compensated system, the total unbalance current detected by the relay is equal to three times the per phase charging current of the faulted circuit. A typical relay setting may therefore be in the order of 30% of this value, i.e. equal to the per phase charging current of the faulted circuit. Practically though, the required setting may well be determined on site, where system faults can be applied and suitable settings can be adopted based upon practically obtained results.

Also, it should be noted that in most situations, the system will not be fully compensated and consequently a small level of steady state fault current will be allowed to flow. The residual current seen by the relay on the faulted feeder may thus be a larger value, which further emphasises the fact that relay settings should be based upon practical current levels, wherever possible.

The above also holds true regarding the required Relay Characteristic Angle (RCA) setting. As has been shown earlier, a nominal RCA setting of 0º is required. However, fine tuning of this setting will require to be carried out on site in order to obtain the optimum setting in accordance with the levels of coil and feeder resistances present. The loading and performance of the CT will also have an effect in this regard. The effect of CT magnetising current will be to create phase lead of current. Whilst this would assist with operation of faulted feeder relays it would reduce the stability margin of healthy feeder relays. A compromise can therefore be reached through fine adjustment of the RCA. This is adjustable in 1° steps on the P140 relays.

2.9.2 Application of settings to the relay

All of the relevant settings can be found under the SENSITIVE E/F column within the relay menu. Within the Sens E/F Options cell, there are two possibilities for selecting wattmetric earth fault protection; either on it's own or in conjunction with low impedance REF protection, which is described in Section 2.10. The SEF cosϕ and SEF sinϕ options are not available with low impedance REF protection.

Note that the residual power setting, PN>, is scaled by the programmed CT and VT ratios in the relay.

2.10 Restricted earth fault protection

Earth faults occurring on a transformer winding or terminal may be of limited magnitude, either due to the impedance present in the earth path or by the percentage of transformer winding that is involved in the fault. As stated in Section 2.6, it is common to apply standby earth fault protection fed from a single CT in the transformer earth connection - this provides time delayed protection for a transformer winding or terminal fault. In general, particularly as the size of the transformer increases, it becomes unacceptable to rely on time delayed protection to clear winding or terminal faults as this would lead to an increased amount of damage to the transformer. A common requirement is therefore to provide instantaneous phase and earth fault protection. These requirements may be fulfilled by applying differential protection across the transformer. However, an earth fault occurring on the LV winding, particularly if it is of a limited level, may not be detected by the differential relay, as it is only measuring the corresponding HV current. Therefore, instantaneous protection which is restricted to operating for transformer earth faults only, is applied. This is referred to as restricted, or balanced, earthfault protection (REF or BEF). The BEF terminology is usually used when the protection is applied to a delta winding.

When applying differential protection such as REF, some suitable means must be employed to give the protection stability under external fault conditions, thus ensuring that relay operation only occurs for faults on the transformer winding / connections.

Two methods are commonly used; bias or high impedance. The biasing technique operates by measuring the level of through current flowing and altering the relay sensitivity accordingly. The high impedance technique ensures that the relay circuit is of sufficiently high impedance such that the differential voltage that may occur under external fault conditions is less than that required to drive setting current through the relay.

The REF protection in the P140 relays may be configured to operate as either a high impedance or biased element and the following sections describe the application of the relay in each mode.

Note that the high impedance REF element of the relay shares the same CT input as the SEF protection. Hence, only one of these elements may be selected. However, the low impedance REF element does not use the SEF input and so may be selected at the same time.

All of the REF settings can be found at the bottom of the SEF/REF Prot'n column and are shown again below, in addition to the SEF setting options:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SEF/REF PROT'N GROUP 1				
SEF/REF Options	SEF	SEF, Wattmetric, N/A Hi Z REF, Lo Z REF, Lo Z REF + SEF, Lo Z REF + Wattmet		
Restricted E/F	Sub Heading in Menu			
IREF>k1	20%	0.08x In	1.0 x In	0.01x In
IREF>k2	150%	0%	150%	1%
IREF>Is1	0.2	0.05 x In	1 x In	0.01 x In
IREF>Is2	1	0.1 x In	1.5 x In	0.01 x In

Note that CT requirements for REF protection are included in Section 6.

2.10.1 Biased differential protection

In a biased differential relay, the through current is measured and used to increase the setting of the differential element. For heavy through faults, one CT in the scheme can be expected to become more saturated than the other and hence differential current can be produced. However, biasing will increase the relay setting such that the resulting differential current is insufficient to cause operation of the relay.

Figures 18a and 18b show the appropriate relay connections and operating characteristic for the P140 relay applied for biased REF protection, respectively.

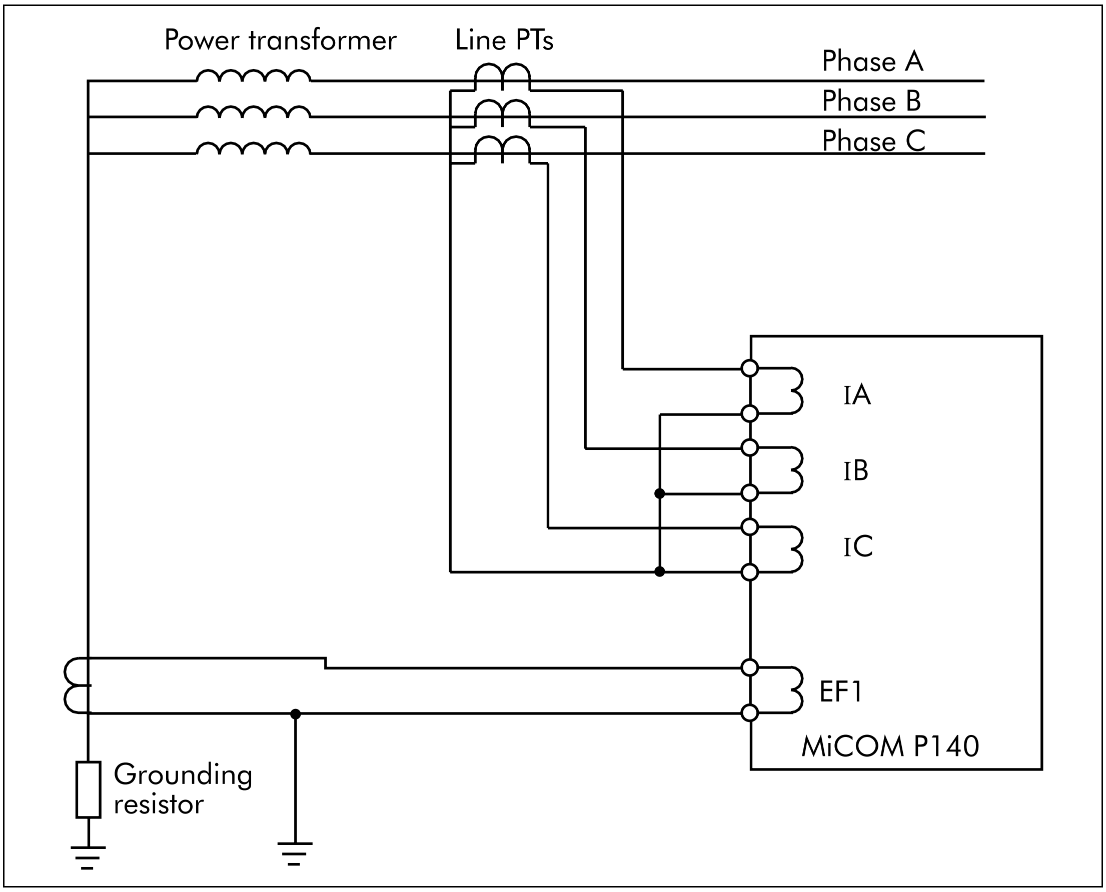


Figure 18a: Relay connections for biased REF protection

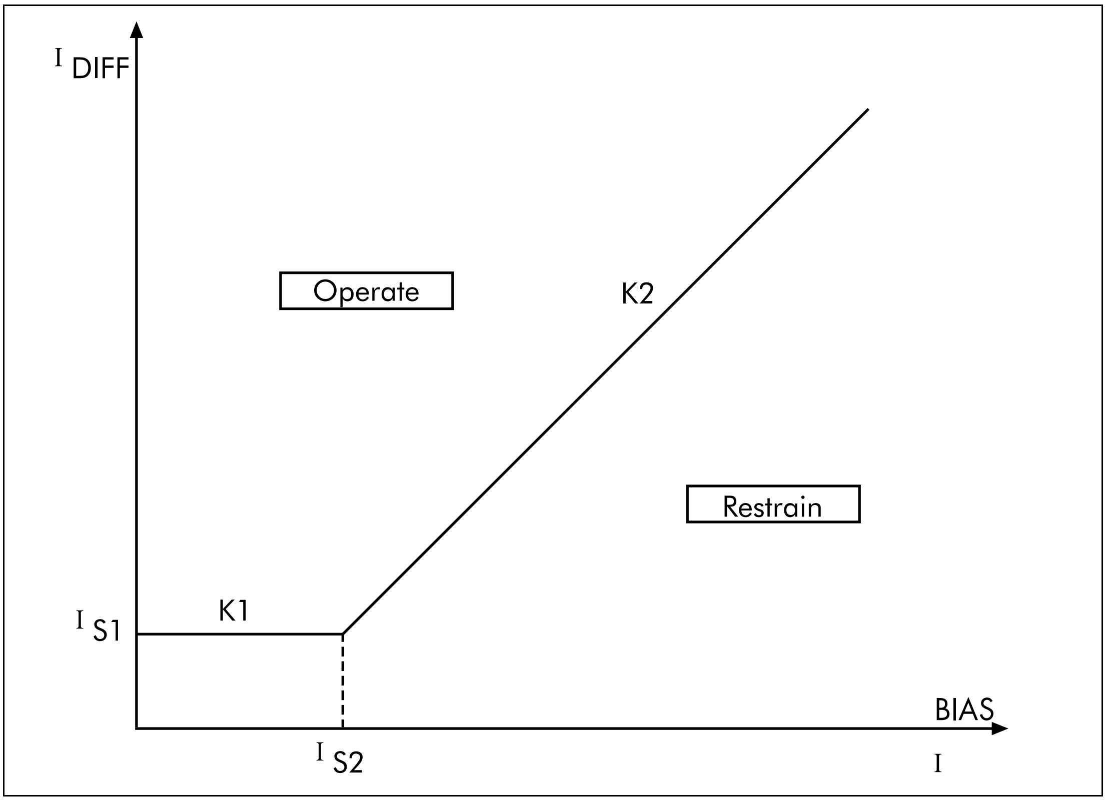


Figure 18b: REF bias characteristic

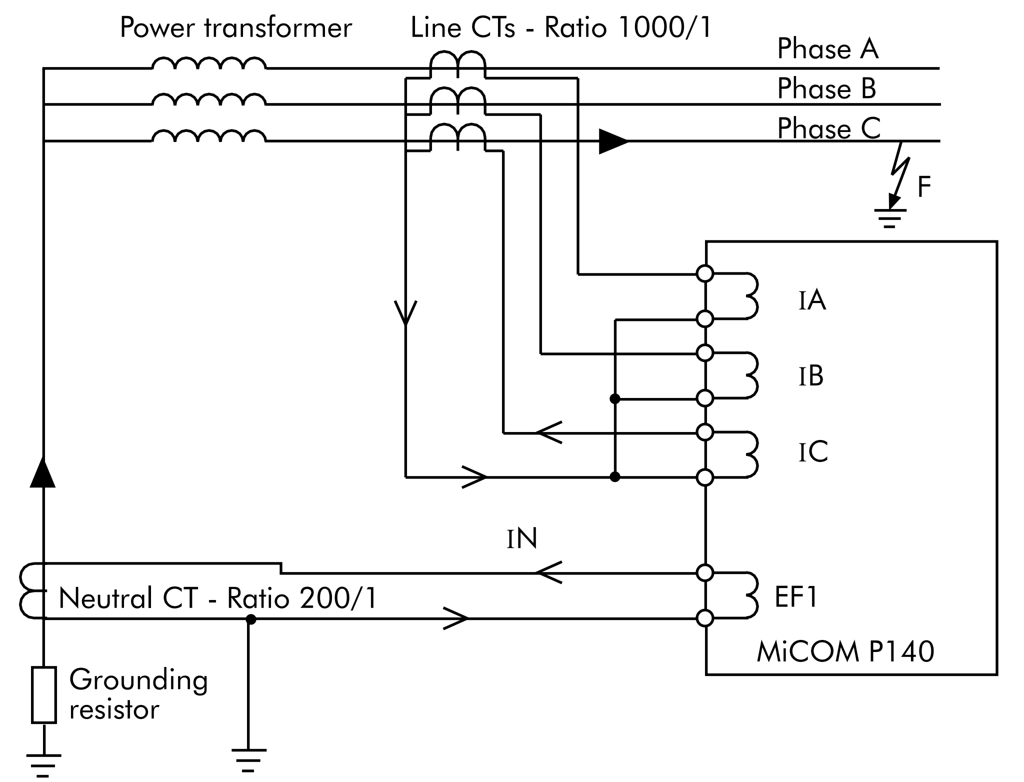
As can be seen in Figure 18a, the three line CTs are connected to the three phase CTs in the normal manner. The neutral CT is then connected to the EF1 CT input. These currents are then used internally to derive both a bias and a differential current quantity for use by the low impedance REF protection. The actual operating characteristic of the element is shown in Figure 18b.

The advantage of this mode of connection is that the line and neutral CT's are not differentially connected and so the neutral CT can also be used to drive the EF1 protection to provide Standby Earth Fault Protection. Also, no external equipment such as stabilising resistors or metrosils are required, as is the case with high impedance protection.

The formulae used by the relay to calculate the required bias quantity is therefore as follows:

Ibias = {(Highest of Ia, Ib or Ic) + (Ineutral x Scaling Factor)}/2

The reason for the scaling factor included on the neutral current is explained by referring to Figure 18c:



$$IBias = \frac{(\text{Highest of } I_A, I_B \text{ or } I_C) + (I_N \times \text{Scaling factor})}{2}$$

$$\text{Where scaling factor} = \frac{\text{Neutral CT ratio}}{\text{Line CT ratio}} \quad \left(= \frac{200}{1000} = 0.2 \text{ in this case} \right)$$

$$IDiff = \overline{I_A} + \overline{I_B} + \overline{I_C} + (\text{Scaling factor} \times \overline{I_N})$$

Figure 18c: REF bias characteristic

Where it is required that the neutral CT also drives the EF1 protection element to provide standby earth fault protection, it may be a requirement that the neutral CT has a lower ratio than the line CTs in order to provide better earth fault sensitivity. If this was not accounted for in the REF protection, the neutral current value used would be incorrect. For this reason, the relay automatically scales the level of neutral current used in the bias calculation by a factor equal to the ratio of the neutral to line CT primary ratings. The use of this scaling factor is shown in Figure 18c, where the formulae for bias and differential currents are given.

2.10.2 Setting guidelines for biased REF protection

As can be seen from Figure 18b, two bias settings are provided in the REF characteristic of the P140. The k1 level of bias is applied up to through currents of Is2, which is normally set to the rated current of the transformer. k1 should normally be set to 0% to give optimum sensitivity for internal faults. However, if any CT mismatch is present under normal conditions, then k1 may be increased accordingly, to compensate.

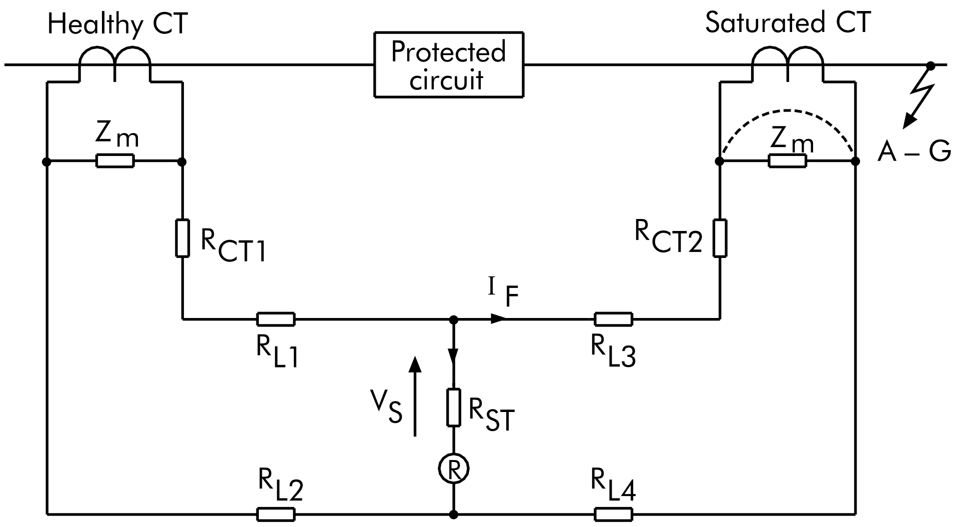
k2 bias is applied for through currents above Is2 and would typically be set to 150%.

The neutral current scaling factor previously described, relies upon the relay having been programmed with line and earth CT ratios. It must therefore be ensured that these ratios are entered into the relay (in the CT & VT RATIOS column) in order for the scheme to operate correctly.

As shown in the previous menu extract, there are three setting options associated with the low impedance biased REF protection. These are "Lo Z REF", "Lo Z REF + SEF" and "Lo Z REF + Wattmet". If the first option is selected, then only the four "Restricted E/F" cells will be present in the menu. The second option will leave all of the SEF stages selectable as well and the third option will provide the optional PN> setting, which is used for Petersen Coil Earthed systems.

2.10.3 High impedance restricted earth fault protection

The high impedance principle is best explained by considering a differential scheme where one CT is saturated for an external fault, as shown in Figure 19.



Voltage across relay circuit

$$V_S = KI_F(R_{CT} + 2R_L) \text{ where } K = 0.5$$

Stabilising resistor R_{ST} limits spill current to I_S (relay setting)

$$R_{ST} = \frac{V_S}{I_S} - R_R$$

I_F	=	Maximum secondary through fault current
Where R_R	=	Relay burden
R_{CT}	=	Current transformer secondary winding resistance
R_L	=	Resistance of a single lead from the relay to the current transformer

Figure 19: High impedance principle

If the relay circuit is considered to be a very high impedance, the secondary current produced by the healthy CT will flow through the saturated CT. If CT magnetising impedance of the saturated CT is considered to be negligible, the maximum voltage across the relay circuit will be equal to the secondary fault current multiplied by the connected impedance, $(R_{L3} + R_{L4} + R_{CT2})$.

The relay can be made stable for this maximum applied voltage by increasing the overall impedance of the relay circuit, such that the resulting current through the relay is less than its current setting. As the impedance of the relay input alone is relatively low, a series connected external resistor is required. The value of this resistor, RST, is calculated by the formula shown in Figure 19. An additional non linear, metrosil, may be required to limit the peak secondary circuit voltage during internal fault conditions.

To ensure that the protection will operate quickly during an internal fault, the CT's used to operate the protection must have a kneepoint voltage of at least 4Vs.

The necessary relay connections for high impedance REF are shown in Figure 20.

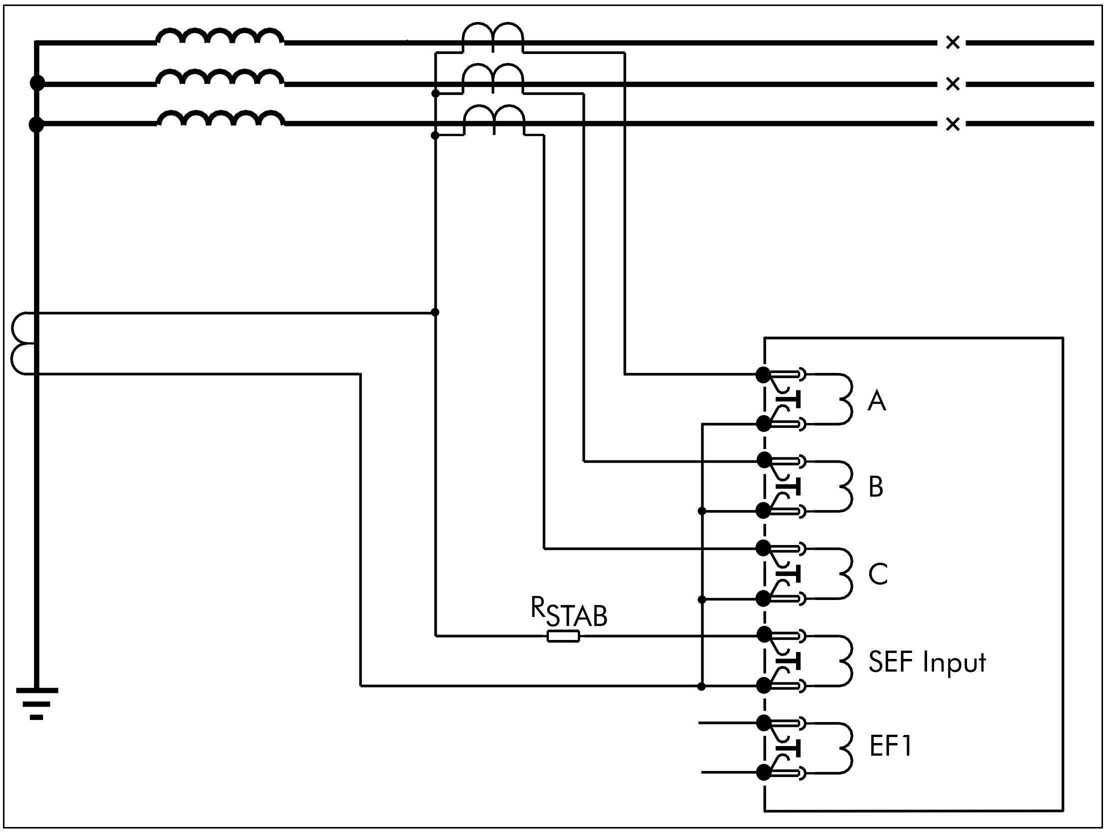


Figure 20: High impedance REF relay/CT connections

As can be seen from Figure 20, the high impedance protection uses an external differential connection between the line CTs and neutral CT. The SEF input is then connected to the differential circuit with a stabilising resistor in series. This leaves the EF1 input free to be connected for standby earth fault protection, if required, either from a residual connection of the line CTs or from a separate neutral CT.

2.10.4 Setting guidelines for high impedance REF

From the "Sens E/F option" cell, "Hi Z REF" must be selected to enable this protection. The only setting cell then visible is "IREF>Is", which may be programmed with the required differential current setting. This would typically be set to give a primary operating current of either 30% of the minimum earth fault level for a resistance earthed system or between 10 and 60% of rated current for a solidly earthed system.

The primary operating current (Iop) will be a function of the current transformer ratio, the relay operating current (IREF>Is1), the number of current transformers in parallel with a relay element (n) and the magnetising current of each current transformer (Ie) at the stability voltage (Vs). This relationship can be expressed in three ways:

1. To determine the maximum current transformer magnetising current to achieve a specific primary operating current with a particular relay operating current:

$$I_e < \frac{1}{n} \times \left(\frac{I_{op}}{\text{CT ratio}} - \text{IREF} > \text{Is} \right)$$

2. To determine the minimum relay current setting to achieve a specific primary operating current with a given current transformer magnetising current.

$$[IREF > Is] < \left(\frac{I_{op}}{CT\ ratio} - nI_e \right)$$

3. To express the protection primary operating current for a particular relay operating current and with a particular level of magnetising current.

$$I_{op} = (CT\ ratio) \times (IREF > Is + nI_c)$$

In order to achieve the required primary operating current with the current transformers that are used, a current setting (IREF>Is) must be selected for the high impedance element, as detailed in expression (ii) above. The setting of the stabilising resistor (RST) must be calculated in the following manner, where the setting is a function of the required stability voltage setting (Vs) and the relay current setting (IREF>Is).

$$\frac{Vs}{IREF>Is} = \frac{1.8\ I_F\ (R_{CT} + 2_{RL})}{I_{REF} > I_s}$$

Note: The above formula assumes negligible relay burden.

The stabilising resistor that can be supplied is continuously adjustable up to its maximum declared resistance.

2.10.5 Use of METROSIL non-linear resistors

Metrosils are used to limit the peak voltage developed by the current transformers under internal fault conditions, to a value below the insulation level of the current transformers, relay and interconnecting leads, which are normally able to withstand 3000V peak.

The following formulae should be used to estimate the peak transient voltage that could be produced for an internal fault. The peak voltage produced during an internal fault will be a function of the current transformer kneepoint voltage and the prospective voltage that would be produced for an internal fault if current transformer saturation did not occur. This prospective voltage will be a function of maximum internal fault secondary current, the current transformer ratio, the current transformer secondary winding resistance, the current transformer lead resistance to the common point, the relay lead resistance and the stabilising resistor value.

$$V_p = \sqrt{2V_k\ (V_f - V_k)}$$

$$V_f = I'_f\ (R_{ct} + 2R_L + R_{ST})$$

Where V_p = peak voltage developed by the CT under internal fault conditions.

V_k = current transformer kneepoint voltage.

V_f = maximum voltage that would be produced if CT saturation did not occur.

I'_f = maximum internal secondary fault current

R_{ct} = current transformer secondary winding resistance.

R_L = maximum lead burden from current transformer to relay.

R_{ST} = relay stabilising resistor.

When the value given by the formulae is greater than 3000V peak, metrosils should be applied. They are connected across the relay circuit and serve the purpose of shunting the secondary current output of the current transformer from the relay in order to prevent very high secondary voltages.

Metrosils are externally mounted and take the form of annular discs. Their operating characteristics follow the expression:

$$V = CI^{0.25}$$

where V = Instantaneous voltage applied to the non-linear resistor (metrosil)

C = Constant of the non-linear resistor (metrosil)

I = Instantaneous current through the non-linear resistor (metrosil)

With a sinusoidal voltage applied across the metrosil, the RMS current would be approximately 0.52 x the peak current. This current value can be calculated as follows:

$$I(rms) = 0.52 \left(\frac{Vs\ (rms) \times \sqrt{2}}{C} \right)^{4}$$

where Vs(rms) = rms value of the sinusoidal voltage applied across the metrosil.

This is due to the fact that the current waveform through the metrosil is not sinusoidal but appreciably distorted.

For satisfactory application of a non-linear resistor (metrosil), it's characteristic should be such that it complies with the following requirements:

1. At the relay voltage setting, the non-linear resistor (metrosil) current should be as low as possible, but no greater than approximately 30mA rms for 1A current transformers and approximately 100mA rms for 5A current transformers.

2. At the maximum secondary current, the non-linear resistor (metrosil) should limit the voltage to 1500V rms or 2120V peak for 0.25 second. At higher relay voltage settings, it is not always possible to limit the fault voltage to 1500V rms, so higher fault voltages may have to be tolerated.

The following tables show the typical Metrosil types that will be required, depending on relay current rating, REF voltage setting etc.

Metrosil Units for Relays with a 1 Amp CT

The Metrosil units with 1 Amp CTs have been designed to comply with the following restrictions:-

1. At the relay voltage setting, the Metrosil current should be less than 30mA rms.

2. At the maximum secondary internal fault current the Metrosil unit should limit the voltage to 1500V rms if possible.

The Metrosil units normally recommended for use with 1Amp CT's are as shown in the following table:

Relay Voltage Setting	Nominal Characteristic		Recommended Metrosil Type	
	C	β	Single Pole Relay	Triple Pole Relay
Up to 125V rms 125 to 300V rms	450 900	0.25 0.25	600A/S1/S256 600A/S1/S1088	600A/S3/1/S802 600A/S3/1/S1195

Note: Single pole Metrosil units are normally supplied without mounting brackets unless otherwise specified by the customer

Metrosil units for relays with a 5 amp CT

These Metrosil units have been designed to comply with the following requirements:

1. At the relay voltage setting, the Metrosil current should be less than 100mA rms (the actual maximum currents passed by the units shown below their type description.

2. At the maximum secondary internal fault current the Metrosil unit should limit the voltage to 1500V rms for 0.25secs. At the higher relay settings, it is not possible to limit the fault voltage to 1500V rms hence higher fault voltages have to be tolerated (indicated by *, **, ***).

3. The Metrosil units normally recommended for use with 5 Amp CTs and single pole relays are as shown in the following table:

Secondary Internal Fault Current	Recommended Metrosil Type			
	Relay Voltage Setting			
Amps rms	Up to 200V rms	250V rms	275V rms	300V rms
50A	600A/S1/S1213 C = 540/640 35mA rms	600A/S1/S1214 C = 670/800 40mA rms	600A/S1/S1214 C =670/800 50mA rms	600A/S1/S1223 C = 740/870* 50mA rms
100A	600A/S2/P/S1217 C = 470/540 70mA rms	600A/S2/P/S1215 C = 570/670 75mA rms	600A/S2/P/S1215 C =570/670 100mA rms	600A/S2/P/S1196 C =620/740* 100mA rms
150A	600A/S3/P/S1219 C = 430/500 100mA rms	600A/S3/P/S1220 C = 520/620 100mA rms	600A/S3/P/S1221 C = 570/670** 100mA rms	600A/S3/P/S1222 C =620/740*** 100mA rm

Note: *2400V peak **2200V peak ***2600V peak

In some situations single disc assemblies may be acceptable, contact ALSTOM T&D Protection & Control for detailed applications.

Note:

1. The Metrosil units recommended for use with 5 Amp CTs can also be applied for use with triple pole relays and consist of three single pole units mounted on the same central stud but electrically insulated for each other. To order these units please specify "Triple pole Metrosil type", followed by the single pole type reference.

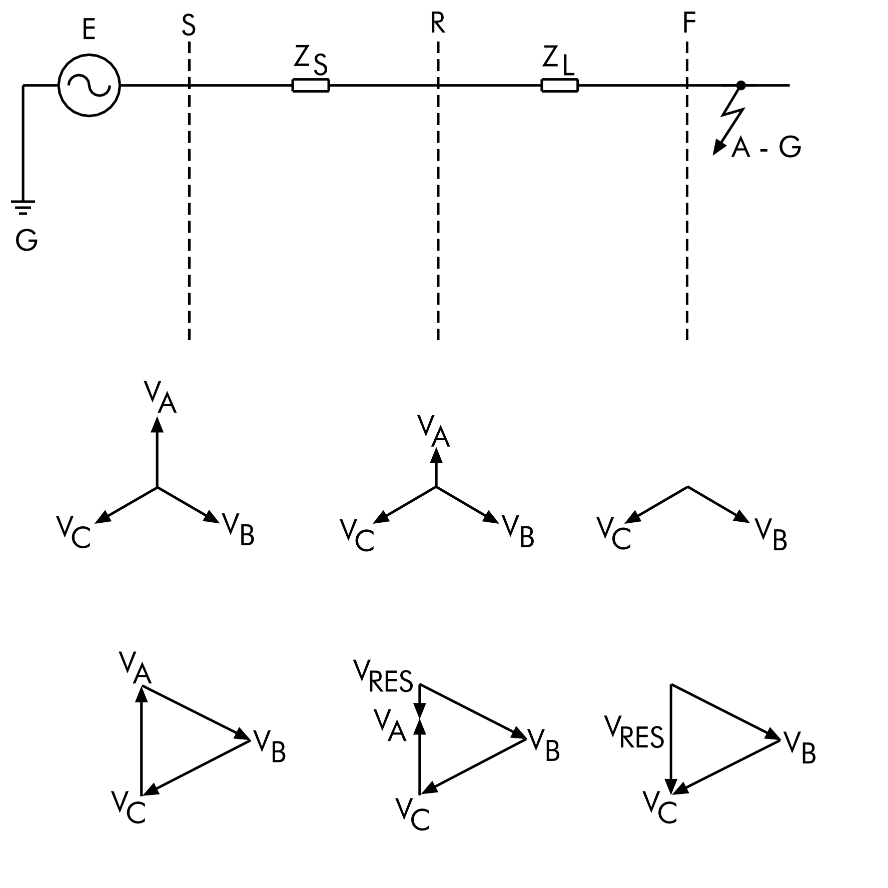
2. Metrosil units for higher relay voltage settings and fault currents can be supplied if required.

3. For further advice and guidance on selecting METROSILS please contact the Applications department at ALSTOM T&D Protection & Control.

2.11 Residual overvoltage (neutral displacement) protection

On a healthy three phase power system, the addition of each of the three phase to earth voltages is nominally zero, as it is the vector addition of three balanced vectors at 120° to one another. However, when an earth fault occurs on the primary system this balance is upset and a 'residual' voltage is produced. This could be measured, for example, at the secondary terminals of a voltage transformer having a "broken delta” secondary connection. Hence, a residual voltage measuring relay can be used to offer earth fault protection on such a system. Note that this condition causes a rise in the neutral voltage with respect to earth which is commonly referred to as “neutral voltage displacement” or NVD.

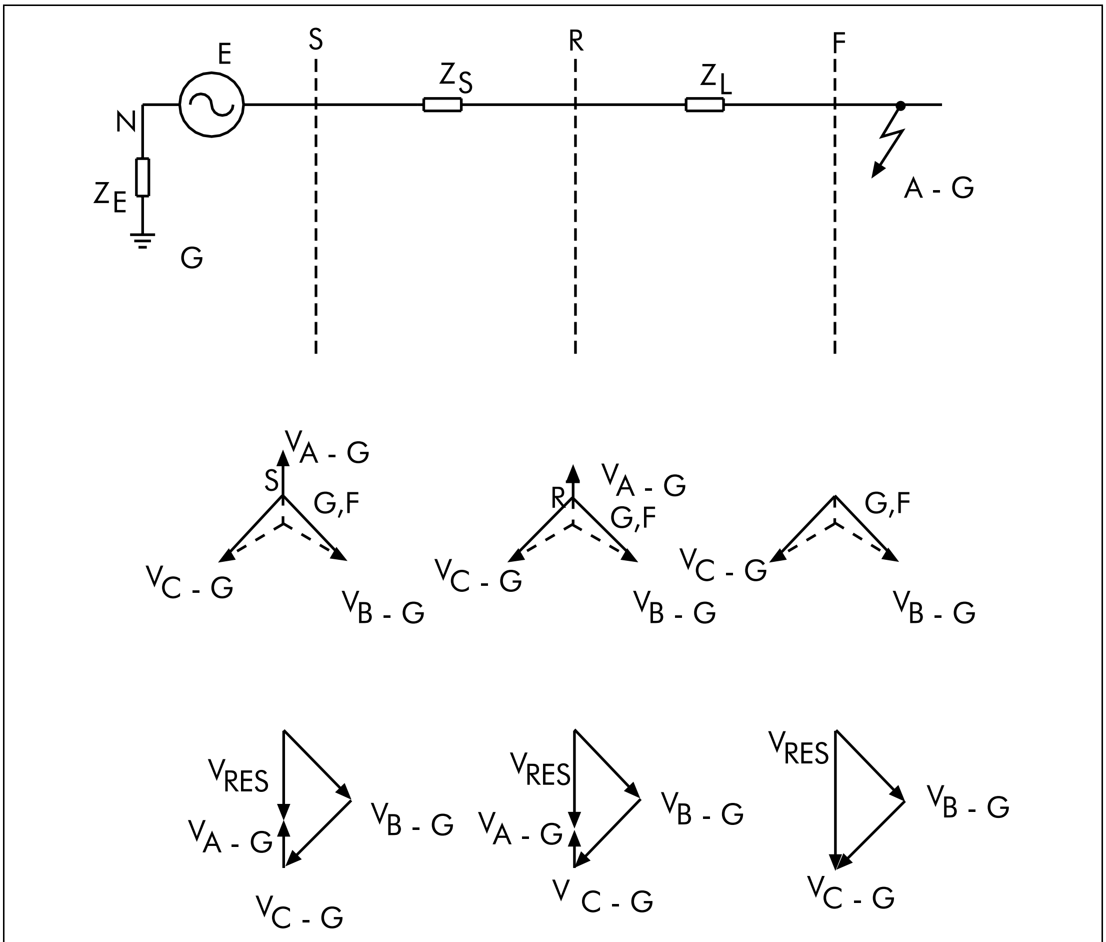
Figures 21a and 21b show the residual voltages that are produced during earth fault conditions occurring on a solid and impedance earthed power system respectively.



$$V_{RES} = \frac{Z_{S0}}{2Z_{S1} + Z_{S0} + 2Z_{L1} + Z_{L0}} \times 3E$$

Figure 21a: Residual voltage, solidly earthed system

As can be seen in Figure 21a, the residual voltage measured by a relay for an earth fault on a solidly earthed system is solely dependent upon the ratio of source impedance behind the relay to line impedance in front of the relay, up to the point of fault. For a remote fault, the Zs/Zl ratio will be small, resulting in a correspondingly small residual voltage. As such, depending upon the relay setting, such a relay would only operate for faults up to a certain distance along the system. The value of residual voltage generated for an earth fault condition is given by the general formula shown in Figure 21a.



$$V_{RES} = \frac{Z_{S0} + 3Z_E}{2Z_{S1} + Z_{S0} + 2Z_{L1} + Z_{L0} + 3Z_E} \times 3E$$

Figure 21b: Residual voltage, resistance earthed system

Figure 21b shows that a resistance earthed system will always generate a relatively large degree of residual voltage, as the zero sequence source impedance now includes the earthing impedance. It follows then, that the residual voltage generated by an earth fault on an insulated system will be the highest possible value (3 x phase-neutral voltage), as the zero sequence source impedance is infinite.

From the previous information it can be seen that the detection of a residual overvoltage condition is an alternative means of earth fault detection, which does not require any measurement of current. This may be particularly advantageous in high impedance earthed or insulated systems, where the provision of core balance CT's on each feeder may be either impractical, or uneconomic.

It must be noted that where residual overvoltage protection is applied, such a voltage will be generated for a fault occurring anywhere on that section of the system and hence the NVD protection must co-ordinate with other earth fault protections.

The NVD element within the P140 relays is of two stage design, each stage having separate voltage and time delay settings. Stage 1 may be set to operate on either an IDMT or DT characteristic, whilst stage 2 may be set to DT only.

Two stages are included for the NVD protection to account for applications which require both alarm and trip stages, for example, an insulated system. It is common in such a case for the system to have been designed to withstand the associated healthy phase overvoltages for a number of hours following an earth fault. In such applications, an alarm is generated soon after the condition is detected, which serves to indicate the presence of an earth fault on the system. This gives time for system operators to locate and isolate the fault. The second stage of the protection can issue a trip signal if the fault condition persists.

The P140 relay internally derives this voltage from the 3 phase voltage input which must be supplied from either a 5-limb or three single phase VT's. These types of VT design allow the passage of residual flux and consequently permit the relay to derive the required residual voltage. In addition, the primary star point of the VT must be earthed. A three limb VT has no path for residual flux and is therefore unsuitable to supply the relay.

The following table shows the relay menu for the "Residual Overvoltage" protection, including the available setting ranges and factory defaults.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
RESIDUAL O/V NVD GROUP 1				
VN>1 Function	DT IDMT	Disabled DT		N/A
VN>1 Voltage Set	5/20V For 110/440V respectively	1/4V For 110/440V respectively	80/320V For 110/440V respectively	1V
VN>1 Time Delay	5s	0	100	0.01s
VN>1 TMS	1	0.5	100	0.5
VN>1 Reset	0	0	100	0.01
VN>2 Status	Disabled	Disabled, Enabled		N/A
VN>2 Voltage Set	10	1/4V (110/440V)	80/320V (110/440V)	1V
VN>2 Time Delay	10s	0	100	0.01s

The IDMT characteristic available on the first stage is defined by the following formula:

$$t = K / (M - 1)$$

where;
- K = Time multiplier setting
- t = Operating time in seconds
- M = Derived residual voltage/relay setting voltage (VN> Voltage Set)

2.11.1 Setting guidelines

The voltage setting applied to the elements is dependent upon the magnitude of residual voltage that is expected to occur during the earth fault condition. This in turn is dependent upon the method of system earthing employed and may be calculated by using the formulae previously given in Figures 20a and 20b. It must also be ensured that the relay is set above any standing level of residual voltage that is present on the system.

Note that IDMT characteristics are selectable on the first stage of NVD in order that elements located at various points on the system may be time graded with one another.

2.12 Undervoltage protection

Undervoltage conditions may occur on a power system for a variety of reasons, some of which are outlined below:

- Increased system loading. Generally, some corrective action would be taken by voltage regulating equipment such as AVR's or On Load Tap Changers, in order to bring the system voltage back to it's nominal value. If the regulating equipment is unsuccessful in restoring healthy system voltage, then tripping by means of an undervoltage relay will be required following a suitable time delay.
- Faults occurring on the power system result in a reduction in voltage of the phases involved in the fault. The proportion by which the voltage decreases is directly dependent upon the type of fault, method of system earthing and it's location with respect to the relaying point. Consequently, co-ordination with other voltage and current-based protection devices is essential in order to achieve correct discrimination.
- Complete loss of busbar voltage. This may occur due to fault conditions present on the incomer or busbar itself, resulting in total isolation of the incoming power supply. For this condition, it may be a requirement for each of the outgoing circuits to be isolated, such that when supply voltage is restored, the load is not connected. Hence, the automatic tripping of a feeder upon detection of complete loss of voltage may be required. This may be achieved by a three phase undervoltage element.
- Where outgoing feeders from a busbar are supplying induction motor loads, excessive dips in the supply may cause the connected motors to stall, and should be tripped for voltage reductions which last longer than a pre-determined time. Such undervoltage protection may be present in the protective device on the motor feeder itself. However, if it is not, the inclusion of this functionality within the feeder protection relay on the incomer may prove beneficial.

Both the under and overvoltage protection functions can be found in the relay menu "Volt Protection". The following table shows the undervoltage section of this menu along with the available setting ranges and factory defaults.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
VOLT PROTECTION GROUP 1				
UNDERVOLTAGE	Sub-Heading			
V< Measur't Mode	Phase-Phase	Phase to Phase Phase to Neutral		N/A
V< Operate Mode	Any Phase	Any Phase Three Phase		N/A
V<1 Function	DT	Disabled DT IDMT		N/A

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
VOLT PROTECTION GROUP 1				
V<1 Voltage Set	80/320V For 110/440V respectively	10/40V For 110/440V respectively	120/480V For 110/440V respectively	1/4V For 110/440V respectively
V<1 Time Delay	10s	0	100	0.01s
V<1 TMS	1	0.5	100	0.5
V<1 Poledead Inh	Enabled	Enabled Disabled		N/A
V<2 Status	Disabled	Enabled Disabled		N/A
V<2 Voltage Set	60/240V For 110/440V respectively	10/40V For 110/440V respectively	120/480V For 110/440V respectively	1/4V For 110/440V respectively
V<2 Time Delay	5s	0	100	0.01s
V<2 Poledead Inh	Enabled	Enabled Disabled		N/A

As can be seen from the menu, the undervoltage protection included within the P140 relays consists of two independent stages. These are configurable as either phase to phase or phase to neutral measuring within the "V<Measur't mode" cell.

Stage 1 may be selected as either IDMT, DT or Disabled, within the "V<1 function" cell. Stage 2 is DT only and is enabled/disabled in the "V<2 status" cell.

Two stages are included to provide both alarm and trip stages, where required. Alternatively, different time settings may be required depending upon the severity of the voltage dip, i.e. motor loads will be able to withstand a small voltage depression for a longer time than if a major voltage excursion were to occur.

Outputs are available for single or three phase conditions via the "V<Operate Mode" cell.

When the protected feeder is de-energised, or the circuit breaker is opened, an undervoltage condition would be detected. Therefore, the "V<Polehead Inh" cell is included for each of the two stages to block the undervoltage protection from operating for this condition. If the cell is enabled, the relevant stage will become inhibited by the inbuilt pole dead logic within the relay. This logic produces an output when it detects either an open circuit breaker via auxiliary contacts feeding the relay opto inputs or it detects a combination of both undercurrent and undervoltage on any one phase.

The IDMT characteristic available on the first stage is defined by the following formula:

$$t = K / (1 - M)$$

Where:

K = Time multiplier setting

t = Operating time in seconds

M = Measured voltage / relay setting voltage (V< Voltage Set)

2.12.1 Setting guidelines

In the majority of applications, undervoltage protection is not required to operate during system earth fault conditions. If this is the case, the element should be selected in the menu to operate from a phase to phase voltage measurement, as this quantity is less affected by single phase voltage depressions due to earth faults.

The voltage threshold setting for the undervoltage protection should be set at some value below the voltage excursions which may be expected under normal system operating conditions. This threshold is dependent upon the system in question but typical healthy system voltage excursions may be in the order of -10% of nominal value.

Similar comments apply with regard to a time setting for this element, i.e. the required time delay is dependent upon the time for which the system is able to withstand a depressed voltage. As mentioned earlier, if motor loads are connected, then a typical time setting may be in the order of 0.5 seconds.

2.13 Overvoltage protection

As previously discussed, undervoltage conditions are relatively common, as they are related to fault conditions etc. However, overvoltage conditions are also a possibility and are generally related to loss of load conditions as described below;

Under conditions of load rejection, the supply voltage will increase in magnitude. This situation would normally be rectified by voltage regulating equipment such as AVR's or on-load tap changers. However, failure of this equipment to bring the system voltage back within prescribed limits leaves the system with an overvoltage condition which must be cleared in order to preserve the life of the system insulation. Hence, overvoltage protection which is suitably time delayed to allow for normal regulator action, may be applied.

During earth fault conditions on a power system there may be an increase in the healthy phase voltages. Ideally, the system should be designed to withstand such overvoltages for a defined period of time. Normally, there will be a primary protection element employed to detect the earth fault condition and to issue a trip command if the fault is uncleared after a nominal time. However, it would be possible to use an overvoltage element as a back-up protection in this instance. A single stage of protection would be sufficient, having a definite time delay.

Both the over and undervoltage protection functions can be found in the relay menu "Volt Protection". The following table shows the overvoltage section of this menu along with the available setting ranges and factory defaults.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
VOLT PROTECTION GROUP 1				
OVERVOLTAGE	Sub-Heading			
V> Measur't Mode	Phase-phase	Phase to Phase Phase to Neutral		N/A
V> Operate Mode	Any Phase	Any Phase Three Phase		N/A

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
V>1 Function	DT	Disabled DT IDMT		N/A
V>1 Voltage Set	130/520V For 110/440V respectively	60/240V For 110/440V respectively	185/740V For 110/440V respectively	1/4V For 110/440V respectively
V>1 Time Delay	10s	0	100	0.01s
V>1 TMS	1	0.5	100	0.5
V>2 Status	Disabled	Enabled Disabled		N/A
V>2 Voltage Set	150/600V For 110/440V respectively	60/240V For 110/440V respectively	185/740V For 110/440V respectively	1/4V For 110/440V respectively
V<2 Time Delay	5s	0	100	0.01s

As can be seen, the setting cells for the overvoltage protection are identical to those previously described for the undervoltage protection in Section 2.12.

The IDMT characteristic available on the first stage is defined by the following formula:

$$t = K / (M - 1)$$

where:

K = Time multiplier setting

t = Operating time in seconds

M = Measured voltage / relay setting voltage (V> Voltage Set)

2.13.1 Setting guidelines

The inclusion of the two stages and their respective operating characteristics allows for a number of possible applications;

- Use of the IDMT characteristic gives the option of a longer time delay if the overvoltage condition is only slight but results in a fast trip for a severe overvoltage. As the voltage settings for both of the stages are independent, the second stage could then be set lower than the first to provide a time delayed alarm stage if required.
- Alternatively, if preferred, both stages could be set to definite time and configured to provide the required alarm and trip stages.
- If only one stage of overvoltage protection is required, or if the element is required to provide an alarm only, the remaining stage may be disabled within the relay menu.

This type of protection must be co-ordinated with any other overvoltage relays at other locations on the system. This should be carried out in a similar manner to that used for grading current operated devices.

2.14 Negative sequence overvoltage protection

Where an incoming feeder is supplying a switchboard which is feeding rotating plant (e.g. induction motors), correct phasing and balance of the ac supply is essential. Incorrect phase rotation will result in any connected motors rotating in the wrong direction. For directionally sensitive applications, such as lifts and conveyor belts, it may be unacceptable to allow this to happen.

Any unbalanced condition occurring on the incoming supply will result in the presence of negative phase sequence (nps) components of voltage. In the event of incorrect phase rotation, the supply voltage would effectively consist of 100% negative phase sequence voltage only.

For such applications the P140 relay includes a negative phase sequence overvoltage element. This element monitors the input voltage rotation and magnitude (normally from a bus connected voltage transformer) and may be interlocked with the motor contactor or circuit breaker to prevent the motor from being energised whilst incorrect phase rotation exists.

The following table shows the relay menu for the negative sequence overvoltage protection, including the available setting ranges and factory defaults.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
NEG SEQUENCE O/V GROUP 1				
V2> status	Enabled	Enabled Disabled		N/A
V2> Voltage Set	15/60V For 110/440V respectively	1/4V For 110/440V respectively	110/440V For 110/440V respectively	1/4V For 110/440V respectively
V2> Time Delay	5s	0	100	0.01

2.14.1 Setting guidelines

As the primary concern is normally the detection of incorrect phase rotation (rather than small unbalances), a sensitive setting is not required. In addition, it must be ensured that the setting is above any standing nps voltage that may be present due to imbalances in the measuring VT, relay tolerances etc. A setting of approximately 15% of rated voltage may be typical.

Note that standing levels of nps voltage (V2) will be displayed in the "Measurements 1" column of the relay menu, labelled "V2 Magnitude". Hence, if more sensitive settings are required, they may be determined during the commissioning stage by viewing the actual level that is present.

The operation time of the element will be highly dependent on the application. A typical setting would be in the region of 5s.

2.15 Negative sequence overcurrent protection (NPS)

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.

The following 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 uncleared asymmetrical faults downstream.
- Where rotating machines are protected by fuses, loss of a 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 and hence an upstream negative phase sequence overcurrent element may be applied to provide back-up protection for dedicated motor protection relays.
- It may be required to simply alarm for the presence of negative phase sequence currents on the system. Operators may then investigate the cause of the unbalance.

The negative phase sequence overcurrent element has a current pick up setting "I2> Current Set", and is time delayed in operation by the adjustable timer "I2> Time Delay". The user may choose to directionalise operation of the element, for either forward or reverse fault protection for which a suitable relay characteristic angle may be set. Alternatively, the element may be set as non-directional.

2.15.1 Setting guidelines

The relay menu for the negative sequence overcurrent element is shown below:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
NEG SEQ O/C GROUP 1				
I2> Status	Disabled	Disabled, Enabled		
I2> Directional	Non- Directional	Non-Directional, Directional Fwd, Directional Rev		
I2> VTS	Block	Block, Non-Directional		
I2> Current Set	0.2In	0.08In	4In	0.01In
I2> Time Delay	10s	0s	100s	0.01s
I2> Char Angle	–60°	–95°	+95°	1°

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
NEG SEQ O/C GROUP 1				
I2> V2pol Set	5/20V For 110/440V respectively	0.5/2V For 110/440V respectively	25/100V For 110/440V respectively	0.5/2V For 110/440V respectively

2.15.2 Negative phase sequence current threshold, 'I2> Current Set'

The current pick-up threshold must be set higher than the negative phase sequence current due to the maximum normal load unbalance on the system. This can be set practically at the commissioning stage, making use of the relay measurement function to display the standing negative phase sequence current, and setting at least 20% above this figure.

Where the negative phase sequence element is required to operate for specific uncleared asymmetric faults, a precise threshold setting would have to be based upon 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 contribution to a specific remote fault condition.

Note that in practice, if the required fault study information is unavailable, the setting must adhere to the minimum threshold previously outlined, employing a suitable time delay for co-ordination with downstream devices. This is vital to prevent unnecessary interruption of the supply resulting from inadvertent operation of this element.

2.15.3 Time delay for the negative phase sequence overcurrent element, 'I2> Time Delay'

As stated above, 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. Hence, in practice, 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

2.15.4 Directionalising the negative phase sequence overcurrent element

Where negative phase sequence current may flow in either direction through a relay location, such as parallel lines or ring main systems, directional control of the element should be employed.

Directionality is achieved by comparison of the angle between the negative phase sequence voltage and the negative phase sequence current and the element may be selected to operate in either the forward or reverse direction. A suitable relay characteristic angle setting (I2> Char Angle) is chosen to provide optimum performance. This setting should be set equal to the phase angle of the negative sequence current with respect to the inverted negative sequence voltage (– V2), in order to be at the centre of the directional characteristic.

The angle that occurs between V2 and I2 under fault conditions is directly dependent upon the negative sequence source impedance of the system. However, typical settings for the element are as follows;

- For a transmission system the RCA should be set equal to –60°.
- For a distribution system the RCA should be set equal to –45°.

For the negative phase sequence directional elements to operate, the relay must detect a polarising voltage above a minimum threshold, "I2> V2pol Set". This must be set in excess of any steady state negative phase sequence voltage. This may be determined during the commissioning stage by viewing the negative phase sequence measurements in the relay.

2.16 Voltage controlled overcurrent protection (51V)

As described in Section 2.2, overcurrent relays are co-ordinated throughout a system such that cascade operation is achieved. This means that the failure of a downstream circuit breaker to trip for a fault condition, whether due to the failure of a protective device, or of the breaker itself, should result in time graded tripping of the next upstream circuit breaker.

However, where long feeders are protected by overcurrent relays, the detection of remote phase to phase faults may prove difficult. This is due to the fact that the current pick up of phase overcurrent elements must be set above the maximum load current, thereby limiting the elements minimum sensitivity. If the current seen by a local relay for a remote fault condition is below it's overcurrent setting, a voltage controlled overcurrent (VCO) element may be used to increase the relay sensitivity to such faults. In this case, a reduction in system voltage will occur; this may then be used to reduce the pick up level of the overcurrent protection.

The VCO function can be selectively enabled on the first two stages of the main overcurrent element, which was described in Section 2.2. When VCO is enabled, the overcurrent setting is modified by the multiplier k when the voltage falls below a threshold as shown in the following table:

Element	Phase to Phase Voltage for Control	Element Pick Up When Control Voltage > Setting	Element Pick Up When Control Voltage < Setting
Ia>	Vab	I>1, I>2	k.I>
Ib>	Vbc	I>1, I>2	k.I>
Ic>	Vca	I>1, I>2	k.I>

The settings for the VCO can be found at the bottom of the "OVERCURRENT" column and are shown in the table below:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
V CONTROLLED O/C				
VCO Status	Disabled	Disabled I>1 I>2 Both I>1 & I>2		N/A
VCO V< Setting	60	20/80V For 110/440V respectively	120/480V For 110/440V respectively	1/4V For 110/440V respectively
VCO k Setting	0.25	0.25	1	0.05

The VCO status cell determines whether or not the VCO function is disabled or, if not, whether the first, second or both of the main overcurrent stages are affected by it.

The VCO V<setting cell determines the voltage threshold at which the current setting of the overcurrent stage/stages becomes reduced, noting that this occurs on a per phase basis.

Note that voltage dependent overcurrent relays are more often applied in generator protection applications in order to give adequate overcurrent relay sensitivity for close up fault conditions. The fault characteristic of this protection must then co-ordinate with any of the downstream overcurrent relays which are responsive to the current decrement condition. It therefore follows that if the P140 relay is to be applied on an outgoing feeder from a generator station, the use of voltage controlled overcurrent protection in the feeder relay may allow better co-ordination with the VCO relay on the generator. The settings in such an application will be directly dependent upon those employed for the generator relay.

2.16.1 Setting guidelines

The "VCO k Setting" should be set low enough to allow operation for remote phase to phase faults, typically:

$$k = \frac{I_F}{I > \times 1.2}$$

where:

If = Minimum fault current expected for the remote fault

I> = Phase current setting for the element to have VCO control

e.g. If the overcurrent relay has a setting of 160% In, but the minimum fault current for the remote fault condition is only 80% In, then the required k factor is given by:

$$k = \frac{0.8}{1.6 \times 1.2} = 0.42$$

The voltage threshold, "VCO V< Setting", would be set below the lowest system voltage that may occur under normal system operating conditions, whilst ensuring correct detection of the remote fault.

2.17 Circuit breaker fail 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 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, breaker failure protection (CBF) 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.

2.18 Breaker failure protection configurations

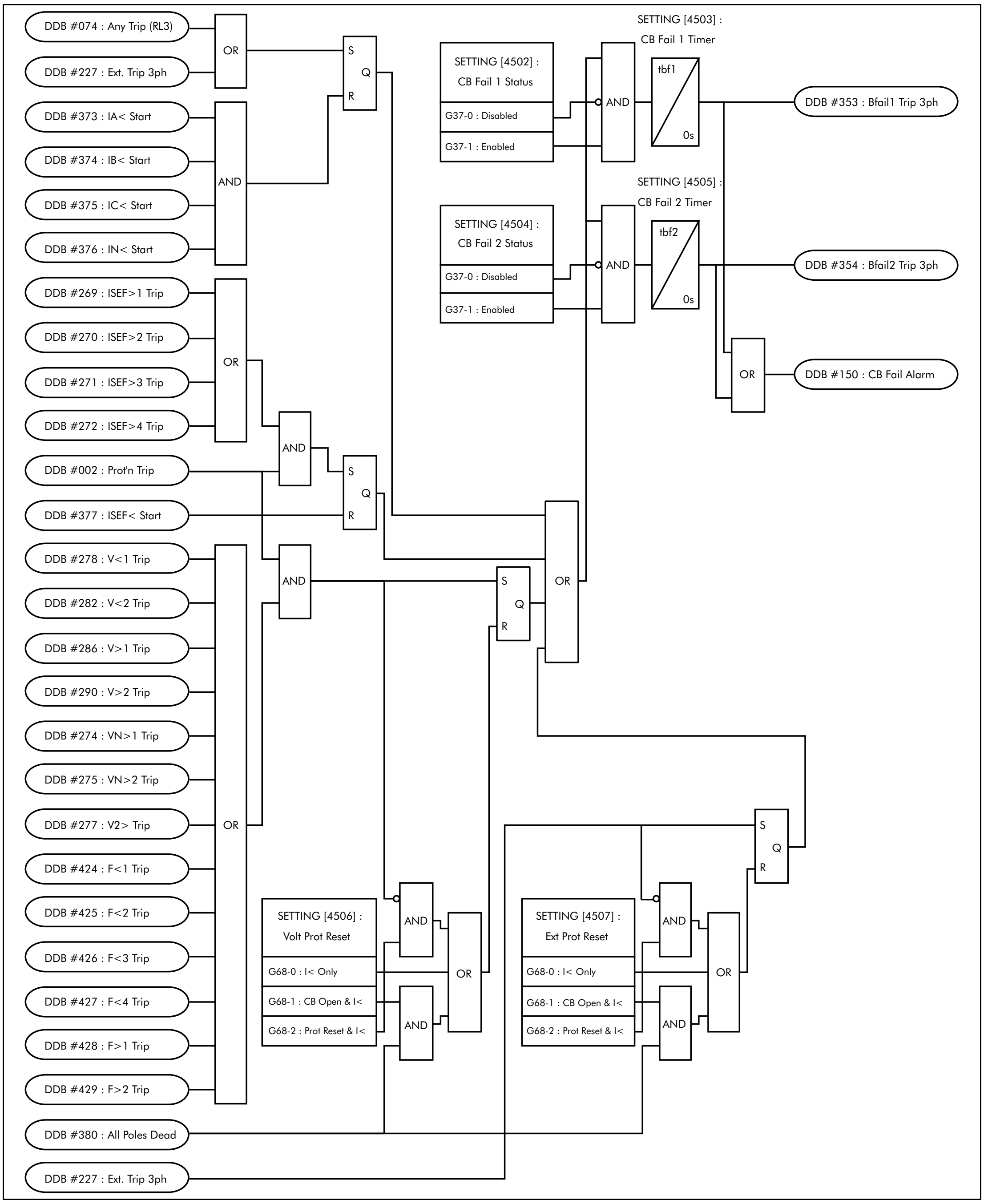


Figure 22: CB fail logic

The circuit breaker failure protection incorporates two timers, "CB Fail 1 Timer" and "CB Fail 2 Timer", allowing configuration for the following scenarios:

- Simple CBF, where only "CB Fail 1 Timer" is enabled. For any protection trip, the "CB Fail 1 Timer" is started, and normally reset when the circuit breaker opens to isolate the fault. If breaker opening is not detected, "CB Fail 1 Timer" times out and closes an output contact assigned to breaker fail (using the programmable scheme logic). This contact is used to backtrip upstream switchgear, generally tripping all infeeds connected to the same busbar section.

- A re-tripping scheme, plus delayed backtripping. Here, "CB Fail 1 Timer" is used to route a trip to a second trip circuit of the same circuit breaker. This requires duplicated circuit breaker trip coils, and is known as re-tripping. Should re-tripping fail to open the circuit breaker, a backtrip may be issued following an additional time delay. The backtrip uses "CB Fail 2 Timer", which is also started at the instant of the initial protection element trip.

CBF elements "CB Fail 1 Timer" and "CB Fail 2 Timer" can be configured to operate for trips triggered by protection elements within the relay or via an external protection trip. The latter is achieved by allocating one of the relay opto-isolated inputs to "External Trip" using the programmable scheme logic.

2.18.1 Reset mechanisms for breaker fail timers

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

- Where circuit breaker auxiliary contacts are defective, or cannot be relied upon to definitely indicate that the breaker has tripped.

- Where a circuit breaker has started to open but has become jammed. This may result in continued arcing at the primary contacts, with an additional arcing resistance in the fault current path. Should this resistance severely limit fault current, the initiating protection element may reset. Thus, reset of the element may not give a reliable indication that the circuit breaker has opened fully.

For any protection function requiring current to operate, the relay uses operation of undercurrent elements (I<) to detect that the necessary circuit breaker poles have tripped and reset the CB fail timers. However, the undercurrent elements may not be reliable methods of resetting circuit breaker fail in all applications. For example:

- Where non-current operated protection, such as under/overvoltage or under/overfrequency, derives measurements from a line connected voltage transformer. Here, I< only gives a reliable reset method if the protected circuit would always have load current flowing. Detecting drop-off of the initiating protection element might be a more reliable method.

- Where non-current operated protection, such as under/overvoltage or under/overfrequency, derives measurements from a busbar connected voltage transformer. Again using I< would rely upon the feeder normally being loaded. Also, tripping the circuit breaker may not remove the initiating condition from the busbar, and hence drop-off of the protection element may not occur. In such cases, the position of the circuit breaker auxiliary contacts may give the best reset method.

Resetting of the CBF is possible from a breaker open indication (from the relay's pole dead logic) or from a protection reset. In these cases resetting is only allowed provided the undercurrent elements have also reset. The resetting options are summarised in the following table.

Initiation (Menu Selectable)	CB Fail Timer Reset Mechanism
Current based protection (e.g. 50/51/46/21/87..)	The resetting mechanism is fixed [IA< operates] & [IB< operates] & [IC< operates] &

Initiation (Menu Selectable)	CB Fail Timer Reset Mechanism
	[IN< operates]
Sensitive earth fault element	The resetting mechanism is fixed. [ISEF< Operates]
Non-current based protection (e.g. 27/59/81/32L..)	Three options are available. The user can Select from the following options. [All I< and IN< elements operate] [Protection element reset] AND [All I< and IN< elements operate] CB open (all 3 poles) AND [All I< and IN< elements operate]
External protection	Three options are available. The user can select any or all of the options. [All I< and IN< elements operate] [External trip reset] AND [All I< and IN< elements operate] CB open (all 3 poles) AND [All I< and IN< elements operate]

The selection in the relay menu is grouped as follows:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CB FAIL & I< GROUP 1				
BREAKER FAIL	{Sub-Heading}			
CB Fail 1 Status	Enabled	Enabled, Disabled		
CB Fail 1 Timer	0.2s	0s	10s	0.01s
CB Fail 2 Status	Disabled	Enabled, Disabled		
CB Fail 2 Timer	0.4s	0s	10s	0.01s
Volt Prot Reset	CB Open & I<	I< Only, CB Open & I<, Prot Reset & I<		
Ext Prot Reset	CB Open & I<	I< Only, CB Open & I<, Prot Reset & I<		
UNDERCURRENT	{Sub-Heading}			
I< Current Set	0.1In	0.02In	3.2In	0.01In
IN< Current Set	0.1In	0.02In	3.2In	0.01In
ISEF< Current	0.02In	0.001In	0.8In	0.0005In
BLOCKED O/C	{Sub-Heading}			
Remove I> Start	Disabled	Enabled, Disabled		
Remove IN> Start	Disabled	Enabled, Disabled		

The "CBF Blocks I>" and "CBF Blocks IN>" settings are used to remove starts issued from the overcurrent and earth elements respectively following a breaker fail time out. The start is removed when the cell is set to Enabled.

2.19 Typical settings

2.19.1 Breaker fail timer settings

Typical timer settings to use are as follows:

CB fail reset mechanism	tBF time delay	Typical delay for 2 cycle circuit breaker
Initiating element reset	CB interrupting time + element reset time (max.) + error in tBF timer + safety margin	50 + 50 + 10 + 50 = 160 ms
CB open	CB auxiliary contacts opening/closing time (max.) + error in tBF timer + safety margin	50 + 10 + 50 = 110 ms
Undercurrent elements	CB interrupting time + undercurrent element (max.) + safety margin operating time	50 + 25 + 50 = 125 ms

Note that all CB Fail resetting involves the operation of the undercurrent elements. Where element reset or CB open resetting is used the undercurrent time setting should still be used if this proves to be the worst case.

The examples above consider direct tripping of a 2 cycle circuit breaker. Note that where auxiliary tripping relays are used, an additional 10-15ms must be added to allow for trip relay operation.

2.19.2 Breaker fail undercurrent settings

The phase undercurrent settings (I<) must be set less than load current, to ensure that I< operation indicates that the circuit breaker pole is open. A typical setting for overhead line or cable circuits is 20% In, with 5% In common for generator circuit breaker CBF.

The sensitive earth fault protection (SEF) and standard earth fault undercurrent elements must be set less than the respective trip setting, typically as follows:

ISEF< = (ISEF> trip) / 2

IN< = (IN> trip) / 2

2.20 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 hence 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, mal-operation 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 relay incorporates an element which measures the ratio of negative to positive phase sequence current (I_2/I_1). 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.

2.20.1 Setting guidelines

The sequence network connection diagram for an open circuit fault is detailed in Figure 23. From this, it can be seen that when a conductor open circuit occurs, current from the positive sequence network will be series injected into the negative and zero sequence networks across the break.

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%.

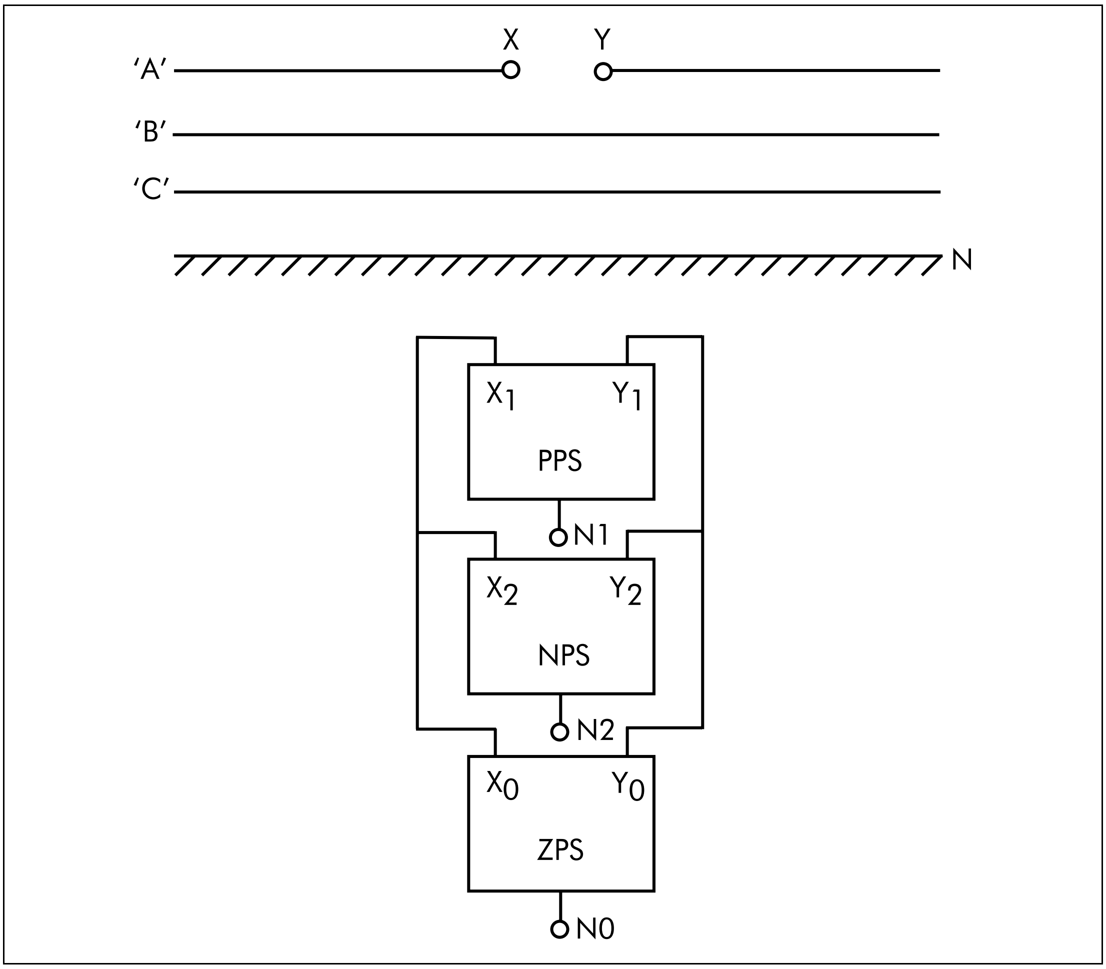


Figure 23: Sequence network connection diagram

It is possible to calculate the ratio of I2/I1 that will occur for varying system impedances, by referring to the following equations:

$$I_{1F} = \frac{Eg\ (Z_2 + Z_0)}{Z_1\ Z_2 + Z_1\ Z_0 + Z_2\ Z_0}$$

$$I_{2F} = \frac{-Eg\ Z_0}{Z_1\ Z_2 + Z_1\ Z_0 + Z_2\ Z_0}$$

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.

Note that a minimum value of 8% negative phase sequence current is required for successful relay operation.

Since sensitive settings have been employed, it can be expected that the element will operate for any unbalance condition occurring on the system (for example, during a single pole autoreclose cycle). Hence, a long time delay is necessary to ensure co-ordination with other protective devices. A 60 second time delay setting may be typical.

The following table shows the relay menu for the Broken Conductor protection, including the available setting ranges and factory defaults:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
BROKEN CONDUCTOR GROUP 1				
Broken Conductor	Disabled	Enabled/Disabled		N/A
I2/I1	0.2	0.2	1	0.01
I2/I1 Time Delay	60s	0s	100s	1s

The example following information was recorded by the relay during commissioning;

$I_{full\ load}$ = 500A

I_2 = 50A

therefore the quiescent I2/I1 ratio is given by;

I_2/I_1 = 50/500 = 0.1

To allow for tolerances and load variations a setting of 200% of this value may be typical: Therefore set I2/I1 = 0.2

Set I2/I1 Time Delay = 60s to allow adequate time for short circuit fault clearance by time delayed protections.

2.21 Frequency protection

The operating frequency of the power system is dependent upon generation capacity and the prevailing load conditions. Where the generation capacity is suddenly reduced or the load is drastically increased, load shedding of non-essential loads based on underfrequency may be employed to allow the power system frequency to recover to nominal. Equally, when the power system conditions recover, load restoration may be employed which is based on overfrequency. Where several loads are being reconnected, it is usual to stage them using a time delay philosophy to reduce the impact of load inrush current.

The Feeder relay includes 4 stages of underfrequency and 2 stages of overfrequency protection to facilitate load shedding and subsequent restoration. The underfrequency stages may be optionally blocked by a pole dead (CB Open) condition.

The following table shows the relay menu for Frequency protection, including the available setting ranges and factory defaults. Note that the frequency settings are based on a default power system frequency of 50Hz.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
FREQ PROTECTION GROUP 1				
UNDERFREQUENCY				
F<1 Status	Enabled	Enabled/Disabled		N/A
F<1 Setting	49.5 Hz	45Hz	65Hz	0.01Hz
F<1 Time Delay	4s	0s	100s	0.01s
F<2 Status	Disabled	Enabled/Disabled		N/A
F<2 Setting	49.0 Hz	45Hz	65Hz	0.01Hz
F<2 Time Delay	3s	0s	100s	0.01s
F<3 Status	Disabled	Enabled/Disabled		N/A
F<3 Setting	48.5 Hz	45Hz	65Hz	0.01Hz
F<3 Time Delay	2s	0s	100s	0.01s
F<4 Status	Disabled	Enabled/Disabled		N/A
F<4 Setting	48.0 Hz	45Hz	65Hz	0.01Hz

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
FREQ PROTECTION GROUP 1				
UNDERFREQUENCY				
F<4 Time Delay	1s	0s	100s	0.01s
F< Function Link	0000			Bit 0 = F<1 Poledead Blk Bit 1 = F<2 Poledead Blk Bit 2 = F<3 Poledead Blk Bit 3 = F<4 Poledead Blk
OVERFREQUENCY				
F>1 Status	Enabled	Enabled/Disabled		N/A
F>1 Setting	50.5 Hz	45Hz	65Hz	0.01Hz
F>1 Time Delay	2s	0s	100s	0.01s
F>2 Status	Disabled	Enabled/Disabled		N/A
F>2 Setting	51.0 Hz	45Hz	65Hz	0.01Hz
F>2 Time Delay	1s	0s	100s	0.01s

2.22 Cold-load pick-up logic

When a feeder circuit breaker is closed in order to energise a load, the current levels that flow for a period of time following energisation may differ greatly from the normal load levels. Consequently, overcurrent settings that have been applied to give short circuit protection may not be suitable during the period of energisation, as they may give incorrect operation.

The Cold Load Pick-Up (CLP) logic included within the P140 relays serves to either inhibit one or more stages of the overcurrent protection for a set duration or, alternatively, to raise the settings of selected stages. This, therefore, allows the protection settings to be set closer to the load profile by automatically increasing them following circuit energisation. The CLP logic thus provides stability, whilst maintaining protection during starting. Note that any of the overcurrent stages that have been disabled in the main relay menu will not appear in the CLP menu.

The following table shows the relay menu for the "Cold Load Pick-up" logic, including the available setting ranges and factory defaults.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
COLD LOAD PICKUP GROUP 1				
tcold Time Delay	7200s	0	14,400s	1s
tclp Time Delay	7200s	0	14,400s	1s
OVERCURRENT		Sub-heading		
I>1 Status	Enable	Block, Enable		N/A
I>1 Current set	1.5 x In	0.08 x In	4 x In	0.01 x In

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
I>1 Time Delay	1s	0	100s	0.01s
I>1 TMS	1	0.025	1.2	0.025
I>1 Time Dial	7	0.5	15	0.1
I>2 Status	Enable	Block, Enable		N/A
I>2 Current Set	1.5 x In	0.08 x In	4 x In	0.01 x In
I>2 Time Delay	1s	0	100s	0.01s
I>2 TMS	1	0.025	1.2	0.025
I>2 Time Delay	7	0.5	15	0.1
I>3 Status	Block	Block, Enable		N/A
I>3 Current Set	25 x In	0.08 x In	32 x In	0.01 x In
I>3 Time Delay	0	0	100s	0.01s
I>4 Status	Block	Block, Enable		N/A
I>4 Current Set	25 x In	0.08 x In	32 x In	0.01 x In
I>4 Time Delay	0	0	100s	0.01s
Stage 1 E/F 1		Sub-heading		
IN1>1 Status	Enable	Block, Enable		N/A
IN1>1 Current	0.2 x In	0.08 x In	4 x In	0.01 x In
IN1>1 Time Delay	1s	0	200s	0.01s
IN1>1 TMS	1	0.025	1.2	0.025
IN1>1 Time Delay	7	0.5	15	0.1
Stage 1 E/F 2		Sub-heading		
IN2>1 Status	Enable	Block, Enable		N/A
IN2>1 Current	0.2 x In	0.08 x In	4 x In	0.01 x In
IN2>1 Time Delay	1s	0	200s	0.01s
IN2>1 TMS	1	0.025	1.2	0.025
IN2>1 Time Dial	7	0.5	15	0.1

As can be seen from the menu, two timer settings are available; "tclp time delay" and "tcold time delay".

"tcold" controls the time that the load must be de-energised for before the new settings are applied. "tclp" then controls the period of time for which the relevant overcurrent and earth fault settings are altered or inhibited following circuit breaker closure. When the set tclp time has elapsed, all of the relevant settings revert back to their original values or become unblocked.

"tcold" and "tclp" are initiated via the CB open and CB closed signals generated within the relay. These signals are produced by connecting auxiliary contacts from the circuit breaker or starting device to the relays opto-inputs. It is important to note that if both an open and closed contact are unavailable, the relay can be configured to be driven from either a single 52a, or 52b contact, as the relay will simply invert one signal to provide the other. This option is available in the "CB control column" in the "CB status input" cell and can be programmed as either "None", 52a, 52b or both 52a and 52b.

As shown in the menu the I> status cells have two setting options, "Enable" and "Block". Selection of "Enable" for a particular stage means that the current and time settings programmed in the following cells will be those that are adopted during the "tclp" time. Selection of "Block" simply blocks the relevant protection stage during the "tclp" time. It also removes the following current and time settings for that stage from the menu.

The CLP logic is included for each of the four overcurrent stages and the first stages of the measured (EF1) and derived (EF2) earth fault protection. Note that the CLP logic is enabled/disabled within the configuration column.

The following sections describe applications where the CLP logic may be useful and the settings that need to be applied.

2.22.1 Air conditioning/resistive heating loads

Where a feeder is being used to supply air conditioning or resistive heating loads there may be a conflict between the ‘steady state’ overcurrent settings and those required following energisation. This is due to the temporary increase in load current that may arise during this period. The CLP logic can be used to alter the applied settings during this time.

In this situation, “Enable” should be selected (from the "I> status" option) and the temporary current and time settings can then be programmed. These settings would be chosen in accordance with the expected load profile. Where it is not necessary to alter the setting of a particular stage, the CLP settings should be set to the required overcurrent settings.

It may not be necessary to alter the protection settings following a short supply interruption. In this case a suitable tcold timer setting can be used.

It should be noted that it is not possible to alter any of the directional settings in the CLP logic.

2.22.2 Motor feeders

In general, feeders supplying motor loads would be protected by a dedicated motor protection device, such as the P240 from the MiCOM range. However, if no specific protection has been applied (possibly due to economic reasons) then the CLP logic in the P140 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 either blocking or raising the settings of the first stage of the standard earth fault protection. This may be useful where instantaneous earth fault protection is required 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 utilise a series stabilising resistor.

The CLP logic may be utilised 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.

2.22.3 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 stabilising resistor is recommended, to ensure transient stability during transformer energisation.

The CLP logic may be utilised 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 stabilising resistor.

2.22.4 Switch onto fault protection (SOTF)

In some feeder applications, fast tripping may be required if a fault is present on the feeder when it is energised. 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 instantaneous operation for a defined period following circuit breaker closure (typically 200ms). Hence, instantaneous fault clearance would be achieved for a switch onto fault (SOTF) condition.

2.23 Selective overcurrent logic

Section 3.1 describes the use of non-cascade protection schemes which make use of start contacts from downstream relays connected to block operation of upstream relays. In the case of Selective Overcurrent Logic (SOL), the start contacts are used to raise the time delays of upstream relays, instead of blocking. This provides an alternative approach to achieving non-cascade types of overcurrent scheme. This may be more familiar to some utilities than the blocked overcurrent arrangement.

The SOL function provides the ability to temporarily increase the time delay settings of the third and fourth stages of phase overcurrent, derived and measured earth fault and sensitive earth fault protection elements. This logic is initiated by energisation of the appropriate opto-isolated input.

To allow time for a start contact to initiate a change of setting, the time settings of the third and fourth stages should include a nominal delay. Guidelines for minimum time settings will be identical to those advised for the blocked overcurrent scheme.

The following table shows the relay menu for the selective logic, including the available setting ranges and factory defaults:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SELECTIVE LOGIC GROUP 1				
OVERCURRENT		Sub-Heading		
I>3 Time Delay	1s	0	100s	0.01s
I>4 Time Delay	1s	0	100s	0.01s
EARTH FAULT 1		Sub-Heading		
IN1>3 Time Delay	2s	0	200s	0.01s
IN1>4 Time Delay	2s	0	200s	0.01s
EARTH FAULT 2		Sub-Heading		
IN2>3 Time Delay	2s	0	200s	0.01s
IN2>4 Time Delay	2s	0	200s	0.01s
SENSITIVE E/F		Sub-Heading		
ISEF>3 Delay	1s	0	200s	0.01s
ISEF>4 Delay	0.5s	0	200s	0.01s

Note that if any of the 3rd and 4th stages are disabled for the phase overcurrent, standard earth fault or sensitive earth fault functions, the corresponding setting will not be displayed in the SOL column.

2.24 Neutral admittance protection

Neutral admittance protection is mandatory for the Polish market, deriving its neutral current input from either the E/F CT or the SEF CT by means of a setting. The neutral voltage is based on the internally derived quantity VN.

Three single stage elements are provided:

- Overadmittance YN> which is non-directional, providing both start and time delayed trip outputs. The trip may be blocked by a logic input.
- Overconductance GN> which is non-directional/directional, providing both start and time delayed trip outputs. The trip may be blocked by a logic input.
- Oversusceptance BN> which is non-directional/directional, providing both start and time delayed trip outputs. The trip may be blocked by a logic input.

The overadmittance elements YN>, GN> and BN> will operate providing the neutral voltage remains above the set level for the set operating time of the element. They are blocked by operation of the fast VTS supervision output.

The overadmittance elements provide measurements of admittance, conductance and susceptance which also appear in the fault record, providing the protection is enabled.

The overadmittance elements are capable of initiating autoreclose, similarly to the earth fault protection, by means of YN>, GN> and BN> settings in the AUTORECLOSE menu column.

The admittance protection settings are given in the table below.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
ADMIT PROTECTION GROUP 1				
VN Threshold	10/40V For 110/440V respectively	1/4V For 110/440V respectively	40/160V For 110/440V respectively	1/4V For 110/440V respectively
CT Input Type	SEF CT	SEF CT/E/F CT		–
Correction Angle	0 degree	–30 degree	30 degree	1 degree
OVER ADMITTANCE				
YN> Status	Disabled	Disabled/Enabled		–
YN> Set (SEF)	5mS/1.25mS For 110/440V respectively	0.1mS/0.025mS For 110/440V respectively	10mS/2.5mS For 110/440V respectively	0.1mS/0.025mS For 110/440V respectively
YN> Set (EF)	50mS/12.5mS For 110/440V respectively	1mS/0.25mS For 110/440V respectively	100mS/25mS For 110/440V respectively	1mS/0.25mS For 110/440V respectively
YN> Time Delay	1 s	0.05 s	100 s	0.01 s
YN> tRESET	0 s	0 s	100 s	0.01 s

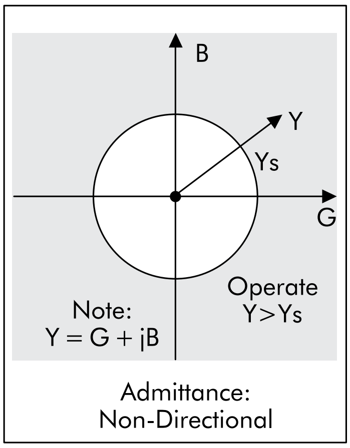
Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
OVER CONDUCTANCE				
GN> Status	Disabled	Disabled/Enabled		
GN> Direction	Non-Directional	Non-Directional/ Directional Fwd/ Directional Rev		
GN> Set (SEF)	0.8mS/0.2mS For 110/440V respectively	0.1mS/0.025mS For 110/440V respectively	5mS/1.25mS For 110/440V respectively	0.1mS/0.025mS For 110/440V respectively
GN> Set (EF)	2mS/0.5mS For 110/440V respectively	1mS/0.25mS For 110/440V respectively	50mS/2.5mS For 110/440V respectively	1mS/0.25mS For 110/440V respectively
GN> Time Delay	1 s	0.05 s	100 s	0.01 s
GN> tRESET	0 s	0 s	100 s	0.01 s
OVER SUSCEPTANCE				
BN> Status	Disabled	Disabled/Enabled		
BN> Direction	Non-Directional	Non-Directional/ Directional Fwd/ Directional Rev		

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
OVER CONDUCTANCE				
BN> Set (SEF)	0.8mS/0.2mS For 110/440V respectively	0.1mS/0.025mS For 110/440V respectively	5mS/1.25mS For 110/440V respectively	0.1mS/0.025mS For 110/440V respectively
BN> Set (EF)	2mS/0.5mS For 110/440V respectively	1mS/0.25mS For 110/440V respectively	50mS/2.5mS For 110/440V respectively	1mS/0.25mS For 110/440V respectively
BN> Time Delay	1 s	0.05 s	100 s	0.01 s
BN> tRESET	0 s	0 s	100 s	0.01 s

Note that YN> Set, GN> Set and BN> Set have units of Siemens (reciprocal Ohms).

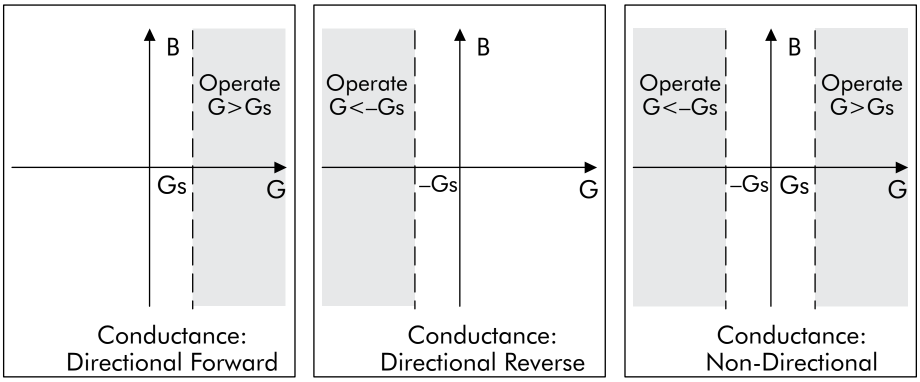
2.24.1 Operation of admittance protection

The admittance protection is non-directional. Hence, provided the magnitude of admittance exceeds the set value YN> Set and the magnitude of neutral voltage exceeds the set value VN Threshold, the relay will operate.



2.24.2 Operation of conductance protection

The conductance protection may be set non-directional, directional forward or directional reverse. Hence, provided the magnitude and the directional criteria are met for conductance and the magnitude of neutral voltage exceeds the set value VN Threshold, the relay will operate. The correction angle causes rotation of the directional boundary for conductance through the set correction angle.



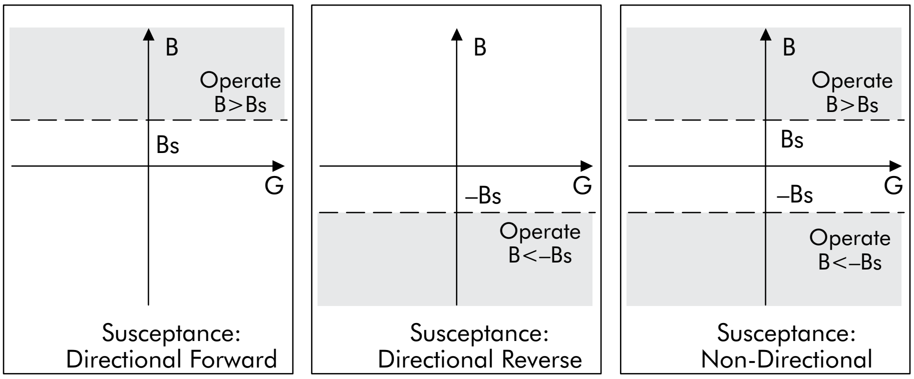
Note the following:

1. Forward operation: Centre of characteristic occurs when IN is in phase with VN.

2. If the correction angle is set to +30º, this rotates the boundary from 90º – 270º to 60º – 240º. It is assumed that the direction of the G axis indicates 0º.

2.24.3 Operation of susceptance protection

The susceptance protection may be set non-directional, directional forward or directional reverse. Hence, provided the magnitude and the directional criteria are met for susceptance and the magnitude of neutral voltage exceeds the set value VN Threshold, the relay will operate. The correction angle causes rotation of the directional boundary for susceptance through the set correction angle.



Note the following :

1. Forward operation : Centre of characteristic occurs when IN leads VN by 90º.

2. If the correction angle is set to +30º, this rotates the boundary from 0º – 180º to 330º – 150º. It is assumed that the direction of the G axis indicates 0º.

3. OTHER PROTECTION CONSIDERATIONS

3.1 Blocked overcurrent protection

Blocked overcurrent protection involves the use of start contacts from downstream relays wired onto blocking inputs of upstream relays. This allows identical current and time settings to be employed on each of the relays involved in the scheme, as the relay nearest to the fault does not receive a blocking signal and hence trips discriminatively. This type of scheme therefore reduces the amount of required grading stages and consequently fault clearance times.

The principle of blocked overcurrent protection may be extended by setting fast acting overcurrent elements on the incoming feeders to a substation which are then arranged to be blocked by start contacts from the relays protecting the outgoing feeders. The fast acting element is thus allowed to trip for a fault condition on the busbar but is stable for external feeder faults by means of the blocking signal. This type of scheme therefore provides much reduced fault clearance times for busbar faults than would be the case with conventional time graded overcurrent protection. The availability of multiple overcurrent and earth fault stages means that back-up time graded overcurrent protection is also provided. This is shown in Figures 24a and 24b.

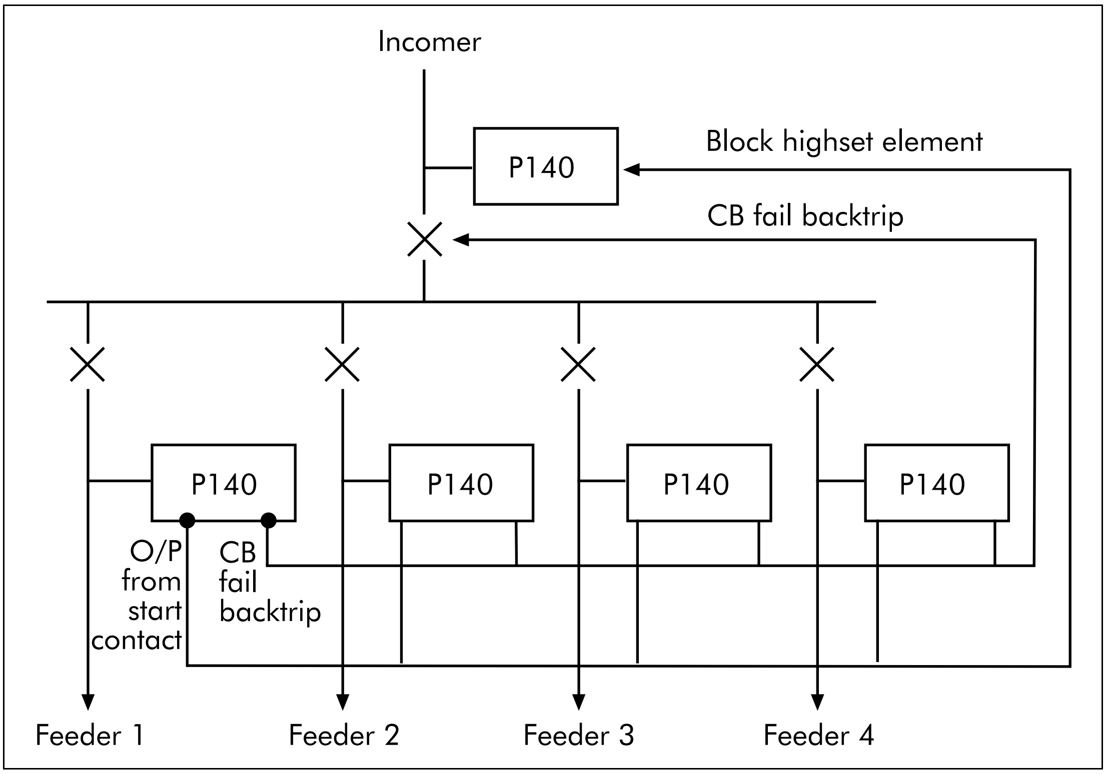


Figure 24a: Simple busbar blocking scheme (single incomer)

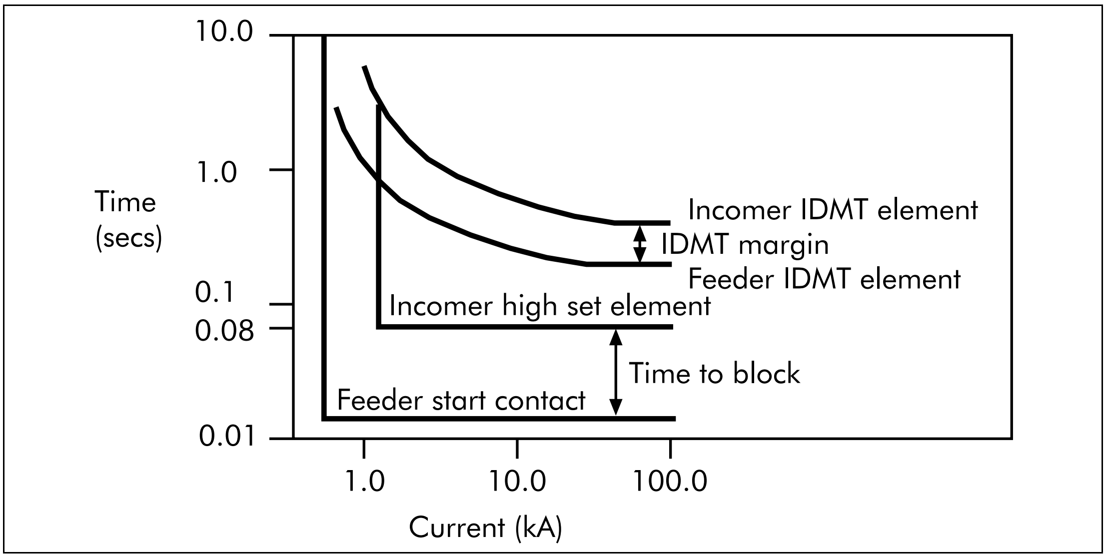


Figure 24b: Simple busbar blocking scheme (single incomer)

The P140 relays have start outputs available from each stage of each of the overcurrent and earth fault elements, including sensitive earth fault. These start signals may then be routed to output contacts by programming accordingly. Each stage is also capable of being blocked by being programmed to the relevant opto-isolated input.

Note that the P140 relays provide a 50V field supply for powering the opto-inputs. Hence, in the unlikely event of the failure of this supply, blocking of that relay would not be possible. For this reason, the field supply is supervised and if a failure is detected, it is possible, via the relays programmable scheme logic, to provide an output alarm contact. This contact can then be used to signal an alarm within the substation. Alternatively, the relays scheme logic could be arranged to block any of the overcurrent/earth fault stages that would operate non-discriminatively due to the blocking signal failure.

For further guidance on the use of blocked overcurrent schemes refer to ALSTOM T&D Protection & Control Ltd.

4. APPLICATION OF NON PROTECTION FUNCTIONS

4.1 Three phase auto-reclosing

An analysis of faults on any overhead line network has shown that 80 – 90% are transient in nature.

A transient fault, such as an insulator flash-over, is a self clearing 'non-damage' fault. This type of fault can be cleared by the immediate tripping of one or more circuit breakers to isolate the fault, and does not recur when the line is re-energised. Lightning is the most common cause of transient faults, other possible causes being clashing conductors and wind blown debris. The remaining 10 – 20% of faults are either semi-permanent or permanent.

A semi-permanent fault could be caused by a small tree branch falling on the line. Here the cause of the fault would not be removed by the immediate tripping of the circuit, but could be burnt away during a time delayed trip.

Permanent faults could be broken conductors, transformer faults, cable faults or machine faults which must be located and repaired before the supply can be restored.

In the majority of fault incidents, if the faulty line is immediately tripped out, and time is allowed for the fault arc to de-ionise, reclosure of the circuit breakers will result in the line being successfully re-energised. Autoreclose schemes are employed to automatically reclose a switching device a set time after it has been opened due to operation of protection where transient and semi-permanent faults are prevalent.

On HV/MV distribution networks, auto-reclosing is applied mainly to radial feeders where system stability problems do not generally arise. The main advantages to be derived from using autoreclose can be summarised as follows:

- Minimises interruptions in supply to the consumer.
- Reduces operating costs - less man hours in repairing fault damage and the possibility of running substations unattended. With autoreclose instantaneous protection can be used which means shorter fault duration's which gives rise to less fault damage and fewer permanent faults.

As 80% of overhead line faults are transient, elimination of loss of supply from such faults, by the introduction of autoreclosing, gives obvious benefits. Furthermore, autoreclosing may allow a particular substation to be run unattended. In the case of unattended substations, the number of visits by personnel to reclose a circuit breaker manually after a fault can be substantially reduced, an important consideration for substations in remote areas.

The introduction of autoreclosing gives an important benefit on circuits using time graded protection, in that it allows the use of instantaneous protection to give a high speed first trip. With fast tripping, the duration of the power arc resulting from an overhead line fault is reduced to a minimum, thus lessening the chance of damage to the line, which might otherwise cause a transient fault to develop into a permanent fault. Using instantaneous protection also prevents blowing of fuses in teed circuits and reduces circuit breaker maintenance by eliminating pre-arc heating when clearing transient faults.

It should be noted that when instantaneous protection is used with autoreclosing, the scheme is normally arranged to block the instantaneous protection after the first trip. Therefore, if the fault persists after reclosure, the time graded protection will give discriminative tripping with fuses or other protection devices, resulting in the isolation of the faulted section. However, for certain applications, where the majority of the faults are likely to be transient, it is not uncommon to allow more than one instantaneous trip before the instantaneous protection is blocked.

Some schemes allow a number of reclosures and time graded trips after the first instantaneous trip, which may result in the burning out and clearance of semi-permanent faults. Such a scheme may also be used to allow fuses to operate in teed feeders where the fault current is low.

When considering feeders which are partly overhead line and partly underground cable, any decision to install autoreclosing would be influenced by any data known on the frequency of transient faults. When a significant proportion of the faults are permanent, the advantages of autoreclosing are small, particularly since reclosing on to a faulty cable is likely to aggravate the damage.

The P143 will initiate autoreclose for fault clearances by the phase overcurrent, earth fault and SEF protections.

The following two tables show the relay settings for the autoreclose function, which include CONFIGURATION, CB CONTROL and AUTORECLOSE settings. The available setting ranges and factory defaults are shown:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CONFIGURATION				
Auto-Reclose	Disabled	Enable / Disable		
CB CONTROL				
CB Status Input	None	None/52A/52B Both 52A & 52B		
AR Telecontrol	No Operation (Control Cell)	Auto/Non Auto/No Operation		
AR Status	(Data)	Auto Mode/Non-auto Mode/Live Line		Indicates AR operating mode
Total Reclosures	(Data)	Total number of AR closures performed by the Relay		
Reset Total A/R	No (Control Cell)	No/Yes		
1 Shot Clearance 2 Shot Clearance 3 Shot Clearance 4 Shot Clearance Persistent Fault	(Data)	Separate "counts" of successful and unsuccessful reclose cycles		

Note that the menu cells AR Telecontrol, AR Status, Total Reclosures and Reset Total A/R are visible only when autoreclose is enabled in the configuration column.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
AUTORECLOSE GROUP 1				
AR Mode Select	Command Mode	Command Mode / Opto Set Mode / User Set Mode / Pulse Set Mode		
Number of Shots	1	1	4	1
Number of SEF Shots	0	0	4	1
Sequence Co-ord	Disabled	Enabled/Disabled		N/A
CS AR Immediate	Disabled	Enabled/Disabled		N/A
Dead Time 1	10s	0.01s	300s	0.01s
Dead Time 2	60s	0.01s	300s	0.01s
Dead Time 3	180s	0.01s	9999s	0.01s
Dead Time 4	180s	0.01s	9999s	0.01s
CB Healthy Time	5s	0.01s	9999s	0.01s
Start Dead t On	Protection Resets	Protection Resets/CB Trips		N/A
tReclaim Extend	No Operation	No Operation/On Prot Start		
Reclaim Time	180s	1s	600s	0.01s
AR Inhibit Time	5s	0.01s	600s	0.01s
AR Lockout	No Block	No Block/Block Inst Prot		N/A
EFF Maint Lock	No Block	No Block/Block Inst Prot		N/A
AR Deselected	No Block	No Block/Block Inst Prot		N/A
Manual Close	No Block	No Block/Block Inst Prot		N/A
Trip 1 Main	No Block	No Block/Block Inst Prot		N/A
Trip 2 Main	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 3 Main	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 4 Main	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 5 Main	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 1 SEF	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 2 SEF	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 3 SEF	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 4 SEF	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 5 SEF	Block Inst Prot	No Block/Block Inst Prot		N/A
Man Close on Flt	Lockout	No Lockout/Lockout		N/A
Trip AR Inactive	No Lockout	No Lockout/Lockout		N/A

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Reset Lockout by	User interface	User Interface/ Select NonAuto		N/A
AR on Man Close	Inhibited	Enabled/Inhibited		N/A
Sys Check Time	5	0.01	9999	0.01
C/S on 1st shot	Enabled	Disabled/Enabled		N/A
AR INITIATION	Sub Heading			
I>1 I>2	Initiate Main AR	No Action/ Initiate Main AR		N/A
I>3 I>4	Initiate Main AR	No Action/ Initiate Main AR/Block AR		N/A
IN1>1 IN1>2	Initiate Main AR	No Action/ Main AR		N/A
IN1>3 IN1>4	Initiate Main AR	No Action/ Initiate Main AR/Block AR		N/A
IN2>1 IN2>2	No Action	No Action/ Initiate Main AR		N/A
IN2>3 IN2>4	No Action	No Action/ Initiate Main AR/Block AR		N/A
ISEF>1 ISEF>2	No Action	No Action/ Initiate Main AR/ Initiate SEF AR/Block AR		N/A
ISEF>3 ISEF>4	No Action	No Action/ Initiate Main AR/ Initiate SEF AR/Block AR		N/A
YN> GN> BN>	No Action	No Action/ Initiate Main AR		N/A
Ext Prot	No Action	No Action/ Initiate Main AR		N/A
SYSTEM CHECKS				
AR with Chk Syn	Disabled	Enabled/Disabled		N/A
AR with Sys Syn	Disabled	Enabled/Disabled		N/A
Live/Dead Ccts	Disabled	Enabled/Disabled		N/A
No System Checks	Disabled	Enabled/Disabled		N/A
Sys Chk on Shot 1	Enabled	Enabled/Disabled		N/A

In addition to these settings, function links in the "OVERCURRENT", "EARTH FAULT1", "EARTH FAULT2" and "SEF/REF PROT'N" columns are also required to fully integrate the autoreclose logic in the relay. Refer to the relevant sections in this manual.

CB Status signals must also be available within the relay, i.e. the default setting for "CB Status Input" should be modified accordingly for the application. The default PSL requires 52A, 52B and CB Healthy logic inputs, so a setting of "Both 52A and 52B" is required for the CB Status Input.

Note that it is possible to initiate the autoreclose by means of an external protection relay.

4.1.1 Logic functions

4.1.1.1 Logic inputs

The autoreclose function has several Digital Data Bus (DDB) logic inputs, which can be mapped in PSL to any of the opto-isolated inputs on the relay or to one or more of the DDB signals generated by the relay logic. The function of these inputs is described below, identified by their signal text.

4.1.1.1.1 CB healthy

The majority of circuit breakers are only capable of providing one trip-close-trip cycle. Following this, it is necessary to re-establish if there is sufficient energy in the circuit breaker (spring charged, gas pressure healthy, etc.) before the CB can be reclosed. The "DDB 230: CB Healthy" input is used to ensure that there is sufficient energy available to close and trip the CB before initiating a CB close command. If on completion of the dead time, the "DDB 230: CB Healthy" input is low, and remains low for a period given by the "CB Healthy Time" timer, lockout will result and the CB will remain open.

This check can be disabled by not allocating an opto input for "DDB 230: CB Healthy". The signal defaults to high if no logic is mapped to DDB 230 within the PSL in the relay.

4.1.1.1.2 BAR

The "DDB 239: Block AR" input will block autoreclose and cause a lockout if autoreclose is in progress. It can be used when protection operation without autoreclose is required. A typical example is on a transformer feeder, where autoreclosing may be initiated from the feeder protection but blocked from the transformer protection.

4.1.1.1.3 Reset lockout

The "DDB 237: Reset Lockout" input can be used to reset the autoreclose function following lockout and reset any autoreclose alarms, provided that the signals which initiated the lockout have been removed.

4.1.1.1.4 Auto mode

The "DDB 241: Auto Mode" input is used to select the Auto operating mode; autoreclose in service. When the "DDB 241: Auto Mode", "DDB 240: Live Line Mode" and "DDB 242: Telecontrol" inputs are off the "Non Auto Mode" of operation is selected; autoreclose out of service.

4.1.1.1.5 Live line mode

The "DDB 240: Live Line Mode" input is used to select the Live Line operating mode where autoreclose is out of service and all blocking of instantaneous protection by autoreclose is disabled. This operating mode takes precedence over all other operating modes for safety reasons.

4.1.1.1.6 Telecontrol mode

The "DDB 242: Telecontrol" input is used to select the Telecontrol operating mode whereby the Auto and Non Auto modes of operation can be selected remotely.

4.1.1.1.7 Live/Dead Ccts OK

DDB 461: "Live/Dead Ccts OK" is an input to the autoreclose logic. When AR is enabled with one or both sides of the CB dead (AUTORECLOSE GROUP 1 – SYSTEM CHECKS setting 49 43 – Live/Dead Ccts: Enabled), DDB 461 should be mapped in PSL to appropriate combinations of Live Line, Dead Line, Live Bus and Dead Bus signals from the system check logic (DDB 443, 444, 445 & 446), as required for the specific application. If setting 49 43 is Disabled, DDB 461 mapping is irrelevant.

4.1.1.1.8 AR SysChecks OK

DDB 403: "AR SysChecks OK" can be mapped in PSL from system checks output DDB 449: "SysChks Inactive", to enable autoreclosing without any system checks, if the system check function is disabled (CONFIGURATION setting 09 23 – System Checks: Disabled). This mapping is not essential, because AUTORECLOSE GROUP 1 – SYSTEM CHECKS setting 49 44 – No System Checks can be set to Enabled to achieve the same effect.

DDB 403 can also be mapped to an opto input, to enable the P142 or P143 to receive a signal from an external system monitoring relay to indicate that system conditions are suitable for CB closing. This should not normally be necessary, since the P143 has comprehensive built in system check functionality. However, it might be used if a P142, which does not have internal synchro check capability, is required to work in conjunction with a separate synchronism check relay.

4.1.1.1.9 Ext AR Prot trip/start

DDB 439: "Ext AR Prot Trip" and/or DDB 440: "Ext AR Prot Start" allow initiation of autoreclosing by a separate protection relay. Please refer to section 4.1.3.2 – Autoreclose Initiation.

4.1.1.1.10 DAR complete

At least one major utility, which uses delayed autoreclosing (DAR) on most of its transmission network, requires a "DAR in Progress" signal from AR initiation up to the application of the CB Close command, but not during the reclaim time following CB reclosure. DDB 453: "DAR Complete" can, if required, be mapped in PSL to be activated for a short pulse when a CB Close command is given at the end of the dead time. If DDB 453: "DAR Complete" is activated during an autoreclose cycle, output DDB 456: "AR in Progress 1" resets, even though the reclaim time may still be running and DDB 360: "AR in Progress" remains set until the end of the reclaim time. For most applications, DDB 453 can be ignored, i.e. not mapped in PSL; in such cases, output DDB 456: AR in Progress 1 operates and resets in parallel with DDB 360: AR in Progress.

4.1.1.1.11 CB in service

One of the interlocks in the autoreclose initiation logic is DDB 454: "CB in Service". This input must be high until the instant of protection operation for an autoreclose cycle to be initiated. For most applications, this DDB can be mapped simply from the "CB Closed" DDB 379. More complex PSL mapping can be programmed if required, e.g. where it is necessary to confirm not only that the CB is closed but also that the line and/or bus VT is actually live up to the instant of protection operation.

4.1.1.1.12 AR restart

In a very small number of applications, it is sometimes necessary to initiate an autoreclose cycle via an external signal to an opto input when the normal interlock conditions are not all satisfied, i.e. the CB is open and the associated feeder is dead. If input DDB 455: "AR Restart" is mapped to an opto input, activation of that opto input will initiate an autoreclose cycle irrespective of the status of the "CB in Service" input, provided the other interlock conditions, such as AR enabled, are still satisfied.

4.1.1.1.13 DT OK to start

This is an optional extra interlock in the dead time initiation logic. In addition to the CB being open and the protection reset, DDB 458: "DT OK to Start" has to be high to enable the dead time function to be "primed" after an AR cycle has started. Once the dead time function is primed, DDB 458 has no further effect – the dead time function stays primed even if DDB 458 subsequently goes low. A typical PSL mapping for this input is from a "Dead Line" signal (DDB 444) from the system check logic, to enable dead time priming only when the feeder has gone dead after CB tripping. If this extra dead time priming interlock is not required, DDB 458 can be left unmapped, and will then default to high.

4.1.1.1.14 Dead time enabled

This is another optional interlock in the dead time logic. In addition to the CB open, protection reset and "dead time primed" signals, DDB 457: "Dead Time Enabled" has to be high to allow the dead time to run. If DDB 457 goes low, the dead time stops and resets, but stays primed, and will restart from zero when DDB 457 goes high again. A typical PSL mapping for DDB 457 is from the CB Healthy input DDB 230, or from selected Live Bus, Dead Line etc signals from the system check logic. It could also be mapped to an opto input to provide a "hold off" function for the follower CB in a "master/follower" application with 2 CBs. If this optional interlock is not required, DDB 457 can be left unmapped, and will then default to high.

4.1.1.1.15 AR Init trip test

If DDB 464: "AR Init Trip Test" is mapped to an opto input, and that input is activated momentarily, the relay logic generates a CB trip output via DDB 372, mapped in default PSL to output R3, and initiates an autoreclose cycle.

4.1.1.2 Autoreclose logic outputs

The following DDB signals can be assigned to a relay contact in the PSL or assigned to a Monitor Bit in "Commissioning Tests", to provide information about the status of the auto Reclose cycle. They can also be applied to other PSL logic as required. The logic output DDBs are described below, identified by their DDB signal text.

4.1.1.2.1 AR in progress

The "DDB 360: AR in Progress" signal is present during the complete reclose cycle from protection initiation to the end of the reclaim time or lockout. DDB 456: "AR in Progress 1" operates with DDB 360 at autoreclose initiation, and, if DDB 453: "DAR Complete" does not operate, remains operated until DDB 360 resets at the end of the cycle. If DDB 453 goes high during the autoreclose cycle, DDB 456 resets (see notes on logic input "DAR Complete" above).

4.1.1.2.2 Sequence counter status

During each autoreclose cycle, a "Sequence Counter" increments by 1 after each fault trip, and resets to zero at the end of the cycle.

DDB 362: "Seq Counter = 0" is set when the counter is at zero;
DDB 363: "Seq Counter = 1" is set when the counter is at 1;
DDB 364: "Seq Counter = 2" is set when the counter is at 2;
DDB 365: "Seq Counter = 3" is set when the counter is at 3;
and
DDB 366: "Seq Counter = 4" is set when the counter is at 4.

4.1.1.2.3 Successful close

The "DDB 367: Successful Close" output indicates that an autoreclose cycle has been successfully completed. A successful autoreclose signal is given after the CB has tripped from the protection and reclosed whereupon the fault has been cleared and the reclaim time has expired resetting the autoreclose cycle. The successful autoreclose output is reset at the next CB trip or from one of the reset lockout methods; see Section 4.1.3.8.1. 'Reset from lockout'.

4.1.1.2.4 AR in service

The "DDB 361: AR in service" output indicates whether the autoreclose is in or out of service. Autoreclose is in service when the relay is in Auto mode and out of service when in the Non Auto and Live Line modes.

4.1.1.2.5 Block main prot

The "DDB 358: Block Main Prot" output indicates that the instantaneous protection "I>3", "I>4", "IN1>3", "IN1>4", "IN2>3", "IN2>4" is being blocked by the autoreclose logic during the autoreclose cycle. Blocking of the instantaneous stages for each trip of the autoreclose cycle is programmed using the Overcurrent and Earth Fault 1/2 function link settings, "I> Function Link", "IN1> Func Link", "IN2> Func Link", and the "Trip 1/2/3/4/5 Main" settings; see Section 4.1.3.3 'Blocking instantaneous protection during an autoreclose cycle'.

4.1.1.2.6 Block SEF prot

The "DDB 359: Block SEF Prot" output indicates that the instantaneous SEF protection "ISEF>3, ISEF>4" is being blocked by the autoreclose logic during the autoreclose cycle. Blocking of the instantaneous SEF stages for each trip of the autoreclose cycle is programmed using the SEF/REF Prot'n function link setting, "ISEF> Func Link", and the "Trip 1/2/3/4/5 SEF" settings; see Section 4.1.3.3 'Blocking instantaneous protection during an autoreclose cycle'.

4.1.1.2.7 Reclose checks

DDB 460: "Reclose Checks" operates when the dead time function is "primed" (see notes on logic input "DT OK to Start", above).

4.1.1.2.8 Dead T in prog

The "DDB 368: Dead T in Prog" output indicates that the dead time is in progress. This signal is set when DDB 460: "Reclose Checks" is set AND input DDB 457: "Dead Time Enabled" is high, and may be useful during relay commissioning to check the operation of the autoreclose cycle.

4.1.1.2.9 DT complete

DDB 459: "DT Complete" operates at the end of the set dead time, and remains operated until either the scheme resets at the end of the reclaim time or a further protection operation/AR initiation occurs. It can be applied purely as an indication, or included in PSL mapping to logic input DDB 453: "DAR Complete" if required (see logic input notes).

4.1.1.2.10 System checks indication

DDB 462: "AR Sync Check" operates when either of the synchro check modules, if selected for autoreclosing, confirms an "in synchronism" condition.

DDB 463: "AR SysChecks OK" operates when any selected system check condition (synchro check, live bus/dead line etc.) is confirmed.

4.1.1.2.11 Auto close

The "DDB 371: Auto Close" output indicates that the autoreclose logic has issued a close signal to the CB. This output feeds a signal to the control close pulse timer and remains on until the CB has closed. This signal may be useful during relay commissioning to check the operation of the autoreclose cycle.

4.1.1.2.12 "Trip when AR blocked" indication

DDB 369: "Protection Lockt" operates if AR lockout is triggered by protection operation either during the inhibit period following a manual CB close (see section 4.1.3.7 – "Autoreclose inhibit following manual close"), or when the relay is in Non Auto or Live Line mode (see section 4.1.3.8 – "AR lockout").

4.1.1.2.13 Reset lockout indication

DDB 370: "Reset Lckout Alm" operates when the relay is in Non Auto mode, if setting 49 22 – "Reset Lockout by" – is set to "Select NonAuto". See section 4.1.3.8.1 – 'Reset from lockout'.

4.1.1.3 Autoreclose alarms

The following DDB signals will produce a relay alarm. These are described below, identified by their DDB signal text.

4.1.1.3.1 AR no checksync (latched)

The "DDB 165: AR No Checksync" alarm indicates that the system voltages were not suitable for autoreclosing at the end of the check synch window time (Sys Check Time), leading to a lockout condition. This alarm can be reset using one of the reset lockout methods; see Section 4.1.3.8.1 'Reset from lockout'.

4.1.1.3.2 AR CB unhealthy (latched)

The "DDB 164: AR CB Unhealthy" alarm indicates that the "DDB 230: CB Healthy" input was not energised at the end of the "CB Healthy Time", leading to a lockout condition. The "DDB 230: CB Healthy" input is used to indicate that there is sufficient energy in the CB operating mechanism to close and trip the CB at the end of the dead time. This alarm can be reset using one of the reset lockout methods; see Section 4.1.3.8.1 'Reset from lockout'.

4.1.1.3.3 AR lockout (self reset)

The "DDB 163: AR Lockout" alarm indicates that the relay is in a lockout status and that further reclose attempts will not be made; see Section 4.1.3.8 'AR Lockout' for more details. This alarm can be reset using one of the reset lockout methods; see Section 4.1.3.8.1 'Reset from lockout'.

4.1.2 Autoreclose logic operating sequence

The autoreclose function provides multi-shot three phase autoreclose control. It can be adjusted to perform a single shot, two shot, three shot or four shot cycle, selectable via "Number of Shots". There is also the option to initiate a separate autoreclose cycle with a different number of shots, "Number of SEF Shots", for the SEF protection. Dead times for all shots (reclose attempts) are independently adjustable. The number of shots is directly related to the type of faults likely to occur on the system and the voltage level of the system. Generally, on medium voltage networks where the percentage of transient and semi-permanent faults is likely to be high, a multi-shot autoreclose device will increase the possibility of the distribution line being successfully re-energised following reclosure of the circuit breaker. For more information, please refer to Section 4.1.4 'Setting guidelines'.

An autoreclose cycle can be internally initiated by operation of a protection element or externally by a separate protection device, provided the circuit breaker is closed until the instant of protection operation. The dead time "Dead Time 1", "Dead Time 2", "Dead Time 3", "Dead Time 4" starts when the circuit breaker has tripped and optionally when the protection has reset, selectable via "Start Dead t On". At the end of the relevant dead time, a CB close signal is given, provided system conditions are suitable. The system conditions to be met for closing are that the system voltages are in synchronism or dead line/live bus or live line/dead bus conditions exist, indicated by the internal check synchronising element and that the circuit breaker closing spring, or other energy source, is fully charged indicated from the "DDB 230: CB Healthy" input. The CB close signal is cut-off when the circuit breaker closes.

When the CB has closed the reclaim time "Reclaim Time" starts. If the circuit breaker does not trip again, the autoreclose function resets at the end of the reclaim time. If the protection operates during the reclaim time the relay either advances to the next shot in the programmed autoreclose cycle, or, if all programmed reclose attempts have been made, goes to lockout.

The total number of autoreclosures is shown in the CB Control menu under "Total Reclosures". This value can be reset to zero with the "Reset Total A/R" command.

4.1.3 Main operating features

4.1.3.1 Operation modes

The autoreclosing function has three operating modes:

1.	AUTO MODE	Autoreclose in service
2.	NON AUTO MODE	Autoreclose out of service – selected protection functions are blocked if setting "AR Deselected" [4914] = Block Inst Prot.
3.	LIVE LINE MODE	Autoreclose out of service – protection functions are NOT blocked, even if setting "AR Deselected" [4914] = Block Inst Prot. LIVE LINE MODE is a functional requirement by some utilities, for maximum safety during live line working on the protected feeder.

For any operating mode to be selected, CONFIGURATION menu setting "Autoreclose" [0924] must first be set to "Enabled". The required operating mode can then be selected by different methods, to suit specific application requirements. The basic method of mode selection is determined by AUTORECLOSE Group n menu setting "AR Mode Select" [4091], as summarised in the following table:

A/R Mode Select Setting	Description
COMMAND MODE	Auto/Non Auto is selected by command cell "AR Telecontrol".
OPTO SET MODE	If DDB 241: Auto Mode input is high Auto operating mode is selected (Autoreclose is in service). If DDB 241: Auto Mode input is low Non Auto operating mode is selected (Autoreclose is out of service and instantaneous protection is blocked)
USER SET MODE	If DDB 242: Telecontrol input is high, the CB Control function A/R Telecontrol is used to select Auto or Non Auto operating mode. If DDB 242: Telecontrol input is low, behaves as OPTO SET setting.
PULSE SET MODE	If DDB 242: Telecontrol input is high, the operating mode is toggled between Auto and Non Auto Mode on the falling edge of DDB 241: Auto Mode input pulses. The pulses are produced by SCADA system. If DDB 242: Telecontrol input is low, behaves as OPTO SET setting.

Note: If "Live Line Mode" input DDB 240 is active, the scheme is forced into LIVE LINE MODE, irrespective of the AR Mode Select setting and Auto Mode and Telecontrol input DDBs.

Live Line Mode input DDB 240 and Telecontrol input DDB 242 are provided to meet the requirements of some utilities who apply a four position selector switch to select AUTO, NON AUTO or LIVE Line operating modes, as shown in Figure 25.

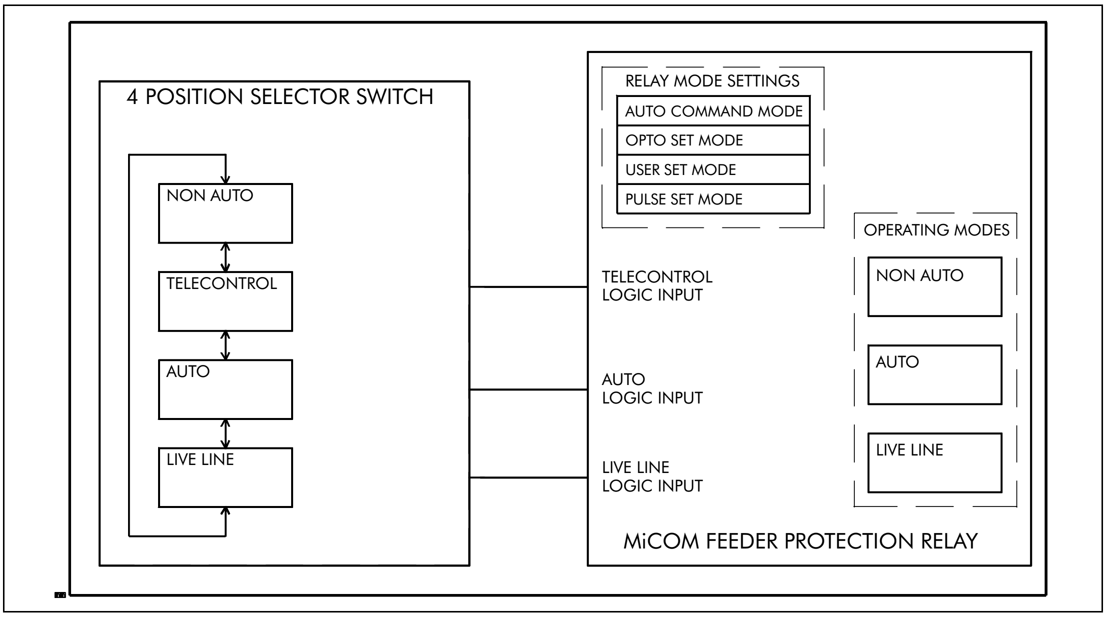


Figure 25: Operating modes

For this application, the four position switch is arranged to activate relay inputs as shown in the table below:

Switch	Input Logic Signals		
Position	Auto	Telecontrol	Live Line
Non Auto	0	0	0
Telecontrol	0 or SCADA Pulse	1	0
Auto	1	0	0
Live Line	0	0	1

Operating mode selection logic is shown in Figure 26.

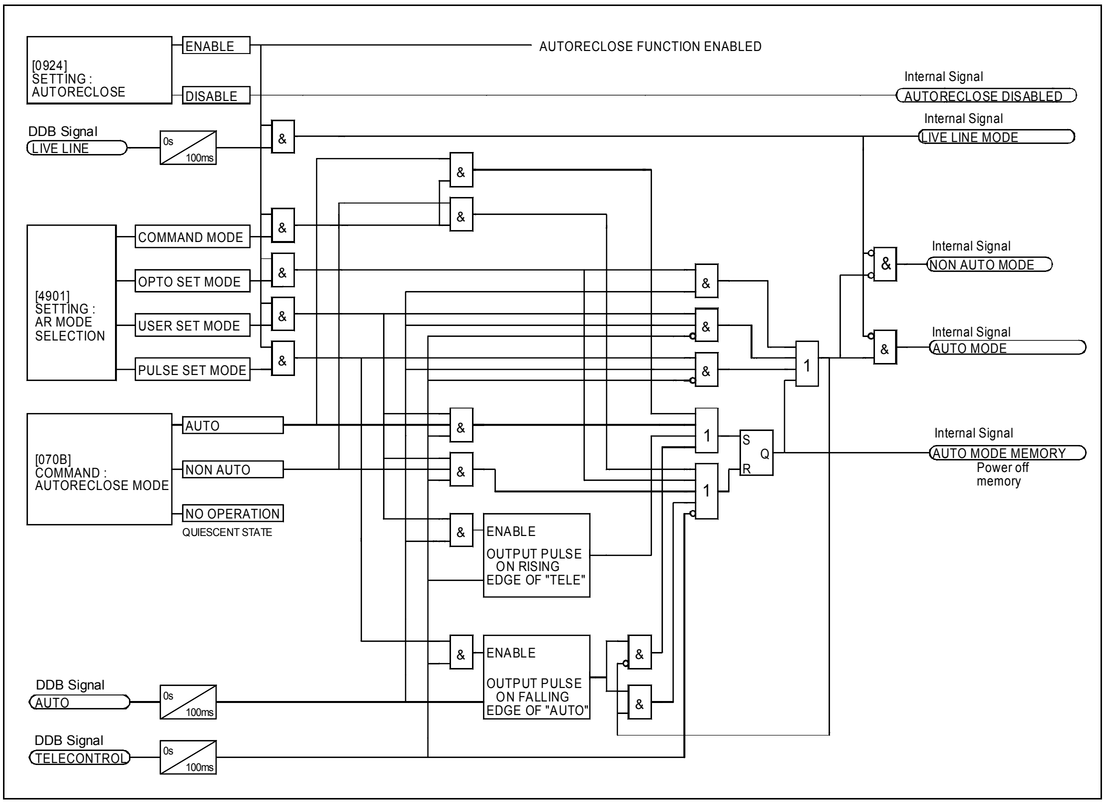


Figure 26: Mode select functional diagram

The mode selection logic includes a 100ms delayed drop off on Auto Mode, Telecontrol and Live Line Mode logic inputs, to ensure a predictable change of operating modes even if the four position switch does not have make-before-break contacts. The logic also ensures that when the switch is moved from Auto or Non Auto position to Telecontrol, the scheme remains in the previously selected mode (Auto or Non Auto) until a different mode is selected by remote control.

The status of the AUTO MODE MEMORY signal is stored in non volatile memory to ensure that the selected operating mode is restored following an auxiliary power interruption.

For applications where live line operating mode and remote selection of Auto/Non-auto modes are not required, a simple two position switch can be arranged to activate Auto Mode input DDB 241, with DDB 240 and DDB 242 being unused.

4.1.3.2 Autoreclose initiation

Autoreclose is usually initiated from the internal protection of the relay. The stages of overcurrent and earth fault protection can be programmed to initiate autoreclose, "Initiate Main AR", not initiate autoreclose, "No Action", or block autoreclose, "Block AR". High set instantaneous protection may be used to indicate a transformer fault on a transformer feeder and so be set to "Block AR". The stages of sensitive earth fault protection can be programmed to initiate autoreclose, "Initiate Main AR", initiate SEF autoreclose, "Initiate SEF AR", not initiate autoreclose, "No Action", or block autoreclose, "Block AR". Normally, SEF protection operation is due to a permanent fault and is set for "No Action". These settings are found under the "AR INITIATION" settings. For example if "I>1" is set to "Initiate Main AR", operation of the "I>1" protection stage will initiate autoreclose; if ISEF>1 is set to "No Action", operation of the ISEF>1 protection stage will lead to a CB trip but no reclose.

A selection must be made for each protection stage that is enabled.

Autoreclose may also be externally initiated by a separate protection device. In this case, the following DDB signals should be mapped to logic inputs:

DDB 439: Ext AR Prot Trip

DDB 440: Ext AR Prot Start (if appropriate)

The setting EXT PROT should be set to "Initiate Main AR".

The autoreclose can be initiated from a protection start, when sequence co-ordination is required, and from a protection trip. Figure 1 of Appendix D illustrates how the start signal is generated and Figure 2, of the same section, demonstrates how the protection trip signal is produced. Figure 2 also shows how the block autoreclose is performed together with external AR initiation. Autoreclose blocking is discussed in detail in section 4.1.3.8.

Although a protection start and a protection trip can initiate an AR cycle, several checks still have to be performed before the initiate signal is given. Some of the checks are listed below:

- Auto mode has been selected (AR in service)
- Live Line mode is disabled
- The number of main protection and SEF shots have not been reached
- Sequence co-ordination enabled (required only for protection start to initiate AR; not necessary for protection trip)
- CB lockout not set
- CB “In Service” (DDB 454 is high)

Figure 3 of Appendix D illustrates how the autoreclose is initiated.

4.1.3.3 Blocking instantaneous protection during an AR cycle

Instantaneous protection may be blocked or not blocked for each trip in an autoreclose cycle. This is selected using the "Trip 1/2/3/4/5 Main" and "Trip 1/2/3/4/5 SEF" settings. These allow the Instantaneous elements of phase, earth fault and SEF protection to be selectively blocked for a CB trip sequence. For example, if "Trip 1 Main" is set to "No Block" and "Trip 2 Main" is set to "Block Inst Prot", the instantaneous elements of the phase and earth fault protection will be available for the first trip but blocked afterwards for the second trip during the autoreclose cycle. This is clearly illustrated in Figure 4 of Appendix D.

Instantaneous protection can also be blocked when the CB maintenance lockout counter or excessive fault frequency lockout has reached its penultimate value. For example, if "No. CB Ops Lock" is set to 100 and the "CB Operations = 99", the instantaneous protection can be blocked to ensure that the last CB trip before lockout will be due to discriminative protection operation.

This is controlled using the "EFF Maint Lock" setting, if this is set to "Block Inst Prot" the instantaneous protection will be blocked for the last CB Trip before lockout occurs.

Instantaneous protection can also be blocked when the relay is locked out, using the "A/R Lockout" setting, "Allow Tripping/Block Tripping". It can also be blocked after a manual close using the "Manual Close" setting, "Allow Tripping/Block Tripping" or when the relay is in the Non Auto mode using the "A/R Deselected" setting "Allow Tripping/Block Tripping". The logic, for these features, is shown in Figure 5 of Appendix D.

Note: The instantaneous protection stages must be identified in the Overcurrent, Earth Fault1, Earth Fault2 and SEF/REF Protn function link settings, "I> Blocking", "IN1> Blocking", "IN2> Blocking" and "ISEF> Blocking" respectively.

External protection may be blocked by mapping DDB 358 "Block Main Prot" or DDB 359 "Block SEF Prot" to appropriate output relay contacts.

4.1.3.4 Dead time control

Dead time is "primed" (DDB 460 – Reclose Checks – set) when:

- the CB has tripped, and
- (optionally via setting "Start Dead t On"), the protection has reset, and
- DDB 458 – DT OK to Start – goes high.

Dead time remains "primed" until the protection re-operates, or the scheme resets at the end of the autoreclose cycle.

Once primed, the dead timer starts to run when DDB 457 – Dead Time Enabled is high.

Setting "CS AR Immediate" Enabled allows immediate re-closure of the circuit breaker provided both sides of the circuit breaker are live and in synchronism at any time after the dead time has started. This allows for quicker load restoration, as it is not necessary to wait for the full dead time.

If "CS AR Immediate" is disabled, or Line and Bus volts are not both live, the dead timer will continue to run, assuming the "DDB#457: Dead Time Enabled" (mapped in PSL) is asserted high. The "Dead Time Enabled" function could be mapped to an opto input to indicate that the circuit breaker is healthy i.e. spring charged etc. Mapping the "Dead Time Enabled" function in PSL increases the flexibility by allowing it, if necessary, to be triggered by other conditions such as "Live Line/Dead Bus" for example. If "Dead Time Enabled" is not mapped in PSL, it defaults to high, so the dead time can run.

The dead time control logic is illustrated in Figure 6 of Appendix D.

Once the dead time is completed or a synchronism check is confirmed, the "Auto-close" signal is given, provided both the "CB Healthy" and the "System Checks" are satisfied. (see section 4.1.3.5 "System Checks"). The "Auto-close" signal triggers a "CB Close" command via the CB Control functionality (see section 4.9).

The "AR CB Close Control" Logic is illustrated in Figure 7 of Appendix D.

4.1.3.5 System checks

The permission to initiate an autoreclose depends upon the following System Check settings :

- **Live/Dead Ccts –** When enabled this setting will give an "AR Check Ok" signal when the "DDB#461 Circuits OK" is asserted high. This logic input DDB would normally be mapped in PSL to appropriate combinations of Line Live, Line Dead, Bus Live and Bus Dead DDB signals. Autoreclose can be initiated once DDB 461 is asserted high.
- **No System Checks** - When enabled this setting completely disables system checks thus allowing autoreclose initiation.
- **Sys Chk on Shot 1** - Can be used to disable system checks on first AR shot.

- **AR with Chk Syn (P143 only)** - Only allows autoreclose when the system satisfies the "Check Synch Stage 1" settings (SYSTEM CHECKS menu).
- **AR with Sys Syn (P143 only)** - Only allows autoreclose when the system satisfies the "Check Synch Stage 2" settings (SYSTEM CHECKS menu)

The "SYSTEM CHECKS" logic can be found in Figure 8 of Appendix D.

4.1.3.6 Reclaim timer initiation

The "tReclaim Extend" setting allows the user to control whether the timer is suspended from the protection start contacts or not. When a setting of "No Operation" is used the Reclaim Timer will operate from the instant that the CB is closed and will continue until the timer expires. The "Reclaim Time" must, therefore, be set in excess of the time delayed protection operating time to ensure that the protection can operate before the autoreclose function is reset. If the autoreclose function resets before the time delayed protection has operated instantaneous protection could be re-enabled and discriminating tripping lost.

For certain applications it is advantageous to set "tReclaim Extend" to "On Prot Start". This facility allows the operation of the reclaim timer to be suspended after CB reclosure by a signal from the main protection start or SEF protection start signals. The main protection start signal is initiated from the start of any protection which has been selected to "Initiate Main AR" (initiate autoreclose) in the "AR Initiation" settings. The SEF protection start signal is initiated from the start of any SEF protection which has been selected to "Initiate SEF AR" (initiate SEF autoreclose) in the "AR Initiation" settings. This feature ensures that the reclaim time cannot time out and reset the autoreclose before the time delayed protection has operated. Since the Reclaim Timer will be suspended, it is unnecessary to use a timer setting in excess of the protection operating time, therefore a short reclaim time can be used. Short reclaim time settings can help to prevent unnecessary lockout for a succession of transient faults in a short period, for example during a thunderstorm. For more information, please refer to Section 4.1.4 'Setting guidelines' or the Reclaim Timer logic in Figure 10 of Appendix D.

4.1.3.7 Autoreclose inhibit following manual close

To ensure that auto-reclosing is not initiated for a manual CB closure on to a pre-existing fault (switch on to fault), AUTO RECLOSE menu setting "A/R on Man Close" can be set to "Inhibited". With this setting, autoreclose initiation is inhibited for a period equal to setting "A/R Inhibit Time" following a manual CB closure. If a protection operation occurs during the inhibit period, auto-reclosing is not initiated. A further option is provided by setting "Man Close on Flt"; if this is set to "Lockout", autoreclose is locked out (DDB#163: AR Lockout – see Section 4.1.1.3.3) for a fault during the inhibit period following manual CB closure. If "Man Close on Flt" is set to "No Lockout", the CB trips without reclosure, but autoreclose is not locked out.

If it is required to block selected fast non-discriminating protection to obtain fully discriminative tripping during the AR initiation inhibit period following CB manual close, setting "Manual Close" can be set to "Block Inst Prot". A "No Block" setting will enable all protection elements immediately on CB closure. (See also section 4.1.1.3.3).

If setting "A/R on Man Close" is set to "Enabled", auto-reclosing can be initiated immediately on CB closure, and settings "A/R Inhibit Time", "Man Close on Flt" and "Manual Close" are irrelevant.

Settings "A/R on Man Close", "A/R Inhibit Time", "Man Close on Flt" and "Manual Close" are all in the AUTO RECLOSE menu.

4.1.3.8 AR lockout

If protection operates during the reclaim time, following the final reclose attempt, the relay will be driven to lockout and the autoreclose function will be disabled until the lockout condition is reset. This will produce an alarm, "DDB 163: AR Lockout". The "DDB 239: Block AR" input will block autoreclose and cause a lockout if autoreclose is in progress.

Autoreclose lockout can also be caused by the CB failing to close because the CB springs are not charged/low gas pressure or there is no synchronism between the system voltages indicated by the "DDB 164: AR CB Unhealthy" and "DDB 165: AR No Checksync" alarms. The functionality, described above, is illustrated in the AR–Lockout logic diagram in Figure 11 of Appendix D.

AR lockout may also be due to a protection operation when the relay is in the Live Line or Non Auto modes when "Trip AR Inactive" is set to "Lockout". autoreclose lockout can also be caused by a protection operation after manual closing during the "AR Inhibit Time" when the "Manual Close on Flt" setting is set to Lockout. Figure 12 of Appendix D shows the logic associated with these functions.

Note: lockout can also be caused by the CB condition monitoring functions, maintenance lockout, excessive fault frequency lockout, broken current lockout, CB failed to trip, CB failed to close, manual close no check synchronism and CB unhealthy.

4.1.3.8.1 Reset from lockout

The "DDB 237: Reset Lockout" input can be used to reset the autoreclose function following lockout and reset any autoreclose alarms, provided that the signals which initiated the lockout have been removed. Lockout can also be reset from the clear key or the "CB CONTROL" command "Lockout Reset".

The "Reset Lockout by" setting, "CB Close/User interface" in "CB CONTROL" (0709) is used to enable/disable reset of lockout automatically from a manual close after the manual close time "AR Inhibit Time". The "Reset Lockout by" setting, "Select Non Auto/User interface" in "AUTO RECLOSE" (4922) is used to enable/disable the resetting of lockout when the relay is in the Non Auto operating mode. The reset lockout methods are summarised in the table below:

Reset Lockout Method	**When Available ?**
User Interface via the “Clear” key. Note - this will also reset all other protection flags	Always
User interface via “CB Control” Command “Lockout Reset	Always
Via opto input “Reset lockout”	Always
Following a successful manual close if “Reset Lockout by” (CB CONTROL menu) is set to “CB Close”	Only when set
By selecting “None Auto” mode, provided “Reset Lockout by” (AUTORECLOSE menu) is set to “Select Non Auto”	Only when set

4.1.3.9 Sequence co-ordination

The autoreclose setting "Sequence Co-ord" can be used to enable the selection of sequence co-ordination with other protection devices, such as downstream pole mounted reclosers. The main protection start or SEF protection start signals indicate to the relay when fault current is present, advance the sequence count by one and start the dead time whether the breaker is open or closed. When the dead time is complete and the protection start inputs are off the reclaim timer will be initiated. This is illustrated in Figure 6 of Appendix D.

Both the upstream and downstream autoreclose relay should be programmed with the same number of shots to lockout and number of instantaneous trips before instantaneous protection is blocked. Thus, for a persistent downstream fault using sequence co-ordination both autoreclose relays will be on the same sequence count and will be blocking instantaneous protection at the same time and so correct discrimination can be obtained. When sequence co-ordination is disabled, the breaker has to be tripped to start the dead time and advance the sequence count by one.

For some applications with downstream pole mounted reclosers when using sequence co-ordination it may be desirable to re-enable instantaneous protection when the recloser has locked out. When the downstream recloser has locked out there is no need for discrimination. This allows the user to have instantaneous then IDMT and then instantaneous trips again during an autoreclose cycle. Instantaneous protection may be blocked or not blocked for each trip in an autoreclose cycle using the " " "Trip 1/2/3/4/5 Main" and "Trip 1/2/3/4/5 SEF" settings, "Block Inst Prot/No Block".

4.1.3.10 Check synchronising for first reclose

The "Sys Chk on Shot 1", (within SYSTEM CHECKS sub menu of AUTO-RECLOSE) setting is used to "Enable/Disable" system checks for the first reclose in an autoreclose cycle. This may be preferred when high speed autoreclose is applied to avoid the extra time for a synchronism check. Subsequent reclose attempts in a multi-shot cycle will still require a synchronism check.

4.1.4 Setting guidelines

4.1.4.1 Number of shots

There are no clear-cut rules for defining the number of shots for a particular application. Generally medium voltage systems utilise only two or three shot autoreclose schemes. However, in certain countries, for specific applications, four shots is not uncommon. Four shots have the advantage that the final dead time can be set sufficiently long to allow any thunderstorms to pass before reclosing for the final time. This arrangement will prevent unnecessary lockout for consecutive transient faults.

Typically, the first trip, and sometimes the second, will result from instantaneous protection - since 80% of faults are transient, the subsequent trips will be time delayed, all with increasing dead times to clear semi-permanent faults.

In order to determine the required number of shots the following factors must be taken into account:

An important consideration is the ability of the circuit breaker to perform several trip-close operations in quick succession and the effect of these operations on the maintenance period.

If statistical information on a particular system shows a moderate percentage of semi-permanent faults which could be burned out, two or more shots are justified. In addition to this, if fused 'tees' are used and the fault level is low, the fusing time may not discriminate with the main IDMT relay and it would then be useful to have several shots. This would warm up the fuse to such an extent that it would eventually blow before the main protection operated.

If statistical information on a particular system shows a moderate percentage of semi-permanent faults which could be burned out during second and/or third shot dead times, two or more shots are justified. In addition to this, if fused 'tees' are used and the fault level is low, the fusing time when starting from normal load current may not initially discriminate with the main IDMT relay and it would then be useful to have several shots. This would warm up the fuse to such an extent that it would eventually blow before the main protection operated.

On EHV transmission circuits with high fault levels, only one reclosure is normally applied, because of the damage which could be caused by multiple reclosures if the fault is permanent.

4.1.4.2 Dead timer setting

The choice of dead time is, very much, system dependent. The main factors which can influence the choice of dead time are:

- Stability and synchronism requirements
- Operational convenience
- Load
- The type of circuit breaker
- Fault de-ionising time
- The protection reset time

4.1.4.2.1 Stability and synchronism requirements

If the power transfer level on a specific feeder is such that the systems at either end of the feeder could quickly fall out of synchronism if the feeder is opened, it is usually required to reclose the feeder as quickly as possible, to prevent loss of synchronism. This is called high speed autoreclosing (HSAR). In this situation, the dead time setting should be adjusted to the minimum time necessary to allow complete de-ionisation of the fault path and restoration of the full voltage withstand level, and comply with the "minimum dead time" limitations imposed by the circuit breaker and protection (see below). For high speed autoreclose the system disturbance time should be minimised by using fast protection, <50 ms, such as distance or feeder differential protection, and fast circuit breakers (fault clearance time <100 ms). Fast fault clearance can reduce the required fault arc de-ionising time. Typical HSAR dead time values are between 0.3 and 0.5 seconds.

On a closely interconnected transmission system, where alternative power transfer paths usually hold the overall system in synchronism even when a specific feeder opens, or on a radial supply system where there are no stability implications, it is often preferred to leave a feeder open for a few seconds after fault clearance. This allows the system to stabilise, and reduces the shock to the system on reclosure. This is called slow or delayed autoreclosing (DAR). The dead time setting for DAR is usually selected for operational convenience (see below).

4.1.4.2.2 Operational convenience

When HSAR is not required, the dead time chosen for the first reclosure (shot) following a fault trip is not critical. It should be long enough to allow any transients resulting from the fault and trip to decay, but not so long as to cause major inconvenience to consumers who are affected by the loss of the feeder. The setting chosen often depends on service experience with the specific feeder.

Typical first shot dead time settings on 11 kV distribution systems are 5 to 10 seconds. In situations where two parallel circuits from one substation are carried on the same towers, it is often arranged for the dead times on the two circuits to be staggered, e.g. one at 5 seconds and the other at 10 seconds, so that the two circuit breakers do not reclose simultaneously following a fault affecting both circuits.

For multi-shot autoreclose cycles, the second and subsequent shot dead times are usually longer than the first shot, to allow time for "semi-permanent" faults to burn clear, and to allow for the CB rated duty cycle and spring charging time. Typical second and third shot dead time settings are 30 seconds and 60 seconds respectively.

4.1.4.2.3 Load requirements

Some types of electrical load might have specific requirements for minimum and/or maximum dead time, to prevent damage and ensure minimum disruption. For example, synchronous motors are only capable of tolerating extremely short interruptions of supply without loss of synchronism. In practice it is desirable to disconnect the motor from the supply in the event of a fault; the dead time would normally be sufficient to allow the motor no-volt device to operate. Induction motors, on the other hand, can withstand supply interruptions up to typically 0.5 seconds and re-accelerate successfully.

Due to the great diversity of load which may exist on a system, it may prove very difficult to arrive at an optimum dead time based upon load alone, so for feeders supplying a mixed load, the dead time is normally chosen for operational convenience.

4.1.4.2.4 Circuit breaker

For high speed autoreclose the minimum dead time of the power system will depend on the minimum time delays imposed by the circuit breaker during a tripping and reclosing operation.

After tripping, time must be allowed for the mechanism to reset before applying a closing pulse; otherwise, the circuit breaker might fail to close correctly. This resetting time will vary depending on the circuit breaker, but is typically 0.1 seconds.

Once the mechanism has reset, a CB Close signal can be applied. The time interval between the energisation of the closing mechanism and the making of the contacts is termed the closing time. Owing to the time constant of a solenoid closing mechanism and the inertia of the plunger, a solenoid closing mechanism may take 0.3s. A spring operated breaker, on the other hand, can close in less than 0.1 seconds.

Where high speed reclosing is required, for the majority of medium voltage applications, the circuit breaker mechanism reset time itself dictates the minimum dead time. The minimum system dead time only considering the CB is the mechanism reset time plus the CB closing time. Thus, a solenoid mechanism will not be suitable for high speed autoreclose as the closing time is generally too long.

For most circuit breakers, after one reclosure, it is necessary to recharge the closing mechanism energy source, (spring, gas pressure etc.) before a further reclosure can take place. Therefore the dead time for second and subsequent shots in a multi-shot sequence must be set longer than the spring or gas pressure recharge time.

4.1.4.2.5 Fault de-ionising time

For high speed autoreclose the fault de-ionising time may be the most important factor when considering the dead time. This is the time required for ionised air to disperse around the fault position so that the insulation level of the air is restored. This time depends on many factors, including system voltage and frequency, line length, nature of fault (Ph-G, Ph-Ph etc.), fault level, fault clearance time and weather conditions. It cannot be accurately predicted. However, it can be approximated from the following formula, based on extensive experience on many transmission and distribution systems throughout the world:

De-ionising time = (10.5 + ((system voltage in kV)/34.5)) / frequency

For 66 kV = 0.25s (50Hz)

For 132 kV = 0.29s (50 Hz)

4.1.4.2.6 Protection reset

It is essential that any time graded protection fully resets during the dead time, so that correct time discrimination will be maintained after reclosure on to a fault. For high speed autoreclose, instantaneous reset of protection is required. However at distribution level, where the protection is predominantly made up of overcurrent and earthfault relays, the protection reset time may not be instantaneous (e.g. induction disk relays). In the event that the circuit breaker re-closes on to a fault and the protection has not fully reset, discrimination may be lost with the downstream protection. To avoid this condition the dead time must be set in excess of the slowest reset time of either the local relay or any downstream protection.

Typical 11/33kV dead time settings in the UK are as follows;

1st dead time = 5 – 10 seconds

2nd dead time = 30 seconds

3rd dead time = 60 – 180 seconds

4th dead time (uncommon in the UK, however used in South Africa) = 1 – 30 minutes

4.1.4.3 Reclaim timer setting

A number of factors influence the choice of the reclaim timer, such as;

- Supply continuity – Large reclaim times can result in unnecessary lockout for transient faults.

- Fault incidence/Past experience – Small reclaim times may be required where there is a high incidence of lightning strikes to prevent unnecessary lockout for transient faults.

- Spring charging time – For high speed autoreclose the reclaim time may be set longer than the spring charging time to ensure there is sufficient energy in the circuit breaker to perform a trip-close-trip cycle. For delayed autoreclose there is no need as the dead time can be extended by an extra CB healthy check window time if there is insufficient energy in the CB. If there is insufficient energy after the check window time the relay will lockout.

- Switchgear Maintenance – Excessive operation resulting from short reclaim times can mean shorter maintenance periods. A minimum reclaim time of >5s may be needed to allow the CB time to recover after a trip and close before it can perform another trip-close-trip cycle. This time will depend on the duty (rating) of the CB.

The reclaim time must be long enough to allow any time delayed protection initiating autoreclose to operate. Failure to do so would result in premature resetting of the autoreclose scheme and re-enabling of instantaneous protection. If this condition arose, a permanent fault would effectively look like a number of transient faults, resulting in continuous autoreclosing unless additional measures were taken to overcome this such as excessive fault frequency lockout protection. It is possible to have short reclaim times by blocking the reclaim time from the protection start signals. If short reclaim times are to be used then the switchgear rating may dictate the minimum reclaim time. The advantage of a short reclaim time is that there are less lockouts of the CB, however, there will be more CB operations and so maintenance periods would be reduced.

Sensitive earth fault protection is applied to detect high resistance earth faults and usually has a long time delay, typically 10 – 15s. This longer time may have to be taken into consideration, if autoreclosing from SEF protection, when deciding on a reclaim time, if the reclaim time is not blocked by an SEF protection start signal. High resistance earth faults, for example, a broken overhead conductor in contact with dry ground or a wood fence, is rarely transient and may be a danger to the public. It is therefore common practice to block autoreclose by operation of sensitive earth fault protection and lockout the circuit breaker.

A typical 11/33kV reclaim time in the UK is 5 – 10 seconds, this prevents unnecessary lockout during thunderstorms. However, times up to 60 – 180 seconds may be used elsewhere in the world.

4.2 Check synchronism (applicable to P143)

4.2.1 Overview

In some situations it is possible for both “bus” and “line” sides of a circuit breaker to be live when the circuit breaker is open, for example at the ends of a feeder which has a power source at each end. Therefore, when closing the circuit breaker, it is normally necessary to check that the network conditions on both sides are suitable, before giving a CB Close command. This applies to both manual circuit breaker closing and auto-reclosure. If a circuit breaker is closed when the line and bus voltages are both live, with a large phase angle, frequency or magnitude difference between them, the system could be subjected to an unacceptable shock, resulting in loss of stability, and possible damage to connected machines.

System checks involve monitoring the voltages on both sides of a circuit breaker, and, if both sides are live, performing a synchronism check to determine whether the phase angle, frequency and voltage magnitude differences between the voltage vectors, are within permitted limits.

The pre-closing system conditions for a given circuit breaker depend on the system configuration and, for auto-reclosing, on the selected auto-reclose program. For example, on a feeder with delayed auto-reclosing, the circuit breakers at the two line ends are normally arranged to close at different times. The first line end to close usually has a live bus and a dead line immediately before reclosing, and charges the line (dead line charge) when the circuit breaker closes. The second line end circuit breaker sees live bus and live line after the first circuit breaker has reclosed. If there is a parallel connection between the ends of the tripped feeder, they are unlikely to go out of synchronism, i.e. the frequencies will be the same, but the increased impedance could cause the phase angle between the two voltages to increase. Therefore the second circuit breaker to close might need a synchronism check, to ensure that the phase angle has not increased to a level which would cause unacceptable shock to the system when the circuit breaker closes.

If there are no parallel interconnections between the ends of the tripped feeder, the two systems could lose synchronism, and the frequency at one end could "slip" relative to the other end. In this situation, the second line end would require a synchronism check comprising both phase angle and slip frequency checks.

If the second line end busbar has no power source other than the feeder which has tripped, the circuit breaker will see a live line and dead bus assuming the first circuit breaker has reclosed. When the second line end circuit breaker closes the bus will charge from the live line (dead bus charge).

4.2.2 VT selection

The P143 has a three phase "Main VT" input and a single phase "Check Sync VT" input. Depending on the primary system arrangement, the main three phase VT for the relay may be located on either the busbar side or the line side of the circuit breaker, with the check sync VT being located on the other side. Hence, the relay has to be programmed with the location of the main VT. This is done via the "Main VT Location" setting in the CT & VT RATIOS menu.

The Check Sync VT may be connected to either a phase to phase or phase to neutral voltage, and for correct synchronism check operation, the relay has to be programmed with the required connection. The "C/S Input" setting in the CT & VT RATIOS menu should be set to A-N, B-N, C-N, A-B, B-C or C-A as appropriate.

4.2.3 Basic functionality

System check logic is collectively enabled or disabled as required, by setting "System Checks" in the CONFIGURATION menu. The associated settings are available in SYSTEM CHECKS, sub-menus VOLTAGE MONITORS, CHECK SYNC and SYSTEM SPLIT. If "System Checks" is selected to Disabled, the associated SYSTEM CHECKS menu becomes invisible, and a **Sys checks Inactive** DDB signal is set.

When enabled, the P143 system check logic sets signals as listed below, according to the status of the monitored voltages.

Line Live – If the Line voltage magnitude is not less than VOLTAGE MONITORS – Live Voltage setting

Line Dead – If the Line voltage magnitude is less than VOLTAGE MONITORS – Dead Voltage setting

Bus Live – If the Bus voltage magnitude is not less than VOLTAGE MONITORS – Live Voltage setting

Bus Dead – If the Bus voltage magnitude is less than VOLTAGE MONITORS – Dead Voltage setting

Check Sync 1 OK – If Check Sync 1 Status is Enabled, the Line and Bus voltages are both live, and the parameters meet the CHECK SYNC – Check Sync 1 ---- settings

Check Sync 2 OK – If Check Sync 2 Status is Enabled, the Line and Bus voltages are both live, and the parameters meet the CHECK SYNC – Check Sync 2 ---- settings

System Split – If SS Status is Enabled, the Line and Bus voltages are both live, and the measured phase angle between the voltage vectors is greater than SYSTEM SPLIT – SS Phase Angle setting

All the above signals are available as DDB signals for mapping in Programmable Scheme Logic (PSL). In addition, the Checksync 1 & 2 signals are "hard coded" into the auto-reclose logic.

In most situations where synchronism check is required, the Check Sync 1 function alone will provide the necessary functionality, and the Check Sync 2 and System Split signals can be ignored.

The "SYSTEM CHECKS" menu contains all of the check synchronism settings for auto and manual reclosure and is shown in the table below along with the relevant default settings:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SYSTEM CHECKS GROUP 1				
Voltage Monitoring	Sub Heading			
Live Voltage	32V	5.5/22V	132/528V	0.5/2V
Dead Voltage	13V	5.5/22V	132/528V	0.5/2V
Check Sync	Sub Heading			
Stage 1	Enabled	Enabled or Disabled		
CS1 Phase Angle	20.00°	5°	90°	1°
CS1 Slip Control	Frequency	Frequency/Both/Timer/None		
CS1 Slip Freq	50mHz	20mHz	1Hz	10mHz
CS1 Slip Timer	1s	0s	99s	0.1s
Stage 2	Enabled	Enabled or Disabled		
CS2 Phase Angle	20.00°	5°	90°	1°
CS2 Slip Control	Frequency	Frequency/Both/Timer/None		
CS2 Slip Freq	50mHz	20mHz	1Hz	10mHz
CS2 Slip Timer	1s	0s	99s	0.1s
CS Undervoltage	54/216V For 110/440V respectively	10/40V For 110/440V respectively	132/528V For 110/440V respectively	0.5/2V For 110/440V respectively
CS Overvoltage	130/520V For 110/440V respectively	50/200V For 110/440V respectively	132/528V For 110/440V respectively	0.5/2V For 110/440V respectively
CS Diff Voltage	6.5/26V For 110/440V respectively	1/4V For 110/440V respectively	132/528V For 110/440V respectively	0.5/2V For 110/440V respectively

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SYSTEM CHECKS GROUP 1				
CS Voltage Block	V<	V< / V> / Vdiff> / V< and V> / V< and Vdiff> / V> and Vdiff> / V< V> and Vdiff> / None		
System Split	Sub-heading			
SS Status	Enabled	Enabled or Disabled		
SS Phase Angle	120°	90°	175°	1°
SS Under V Block	Enabled	Enabled or Disabled		
SS Undervoltage	54/216V For 110/440V respectively	10/40V For 110/440V respectively	132/528V For 110/440V respectively	0.5/2V For 110/440V respectively
SS Timer	1s	0s	99s	0.1s

4.2.4 Check sync 2 and system split

Check Sync 2 and System Split functions are included for situations where the maximum permitted slip frequency and phase angle for synchro check can change according to actual system conditions. A typical application is on a closely interconnected system, where synchronism is normally retained when a given feeder is tripped, but under some circumstances, with parallel interconnections out of service, the feeder ends can drift out of synchronism when the feeder is tripped. Depending on the system and machine characteristics, the conditions for safe circuit breaker closing could be, for example:

Condition 1: for synchronised systems, with zero or very small slip:
slip ≦50 mHz; phase angle <30°

Condition 2: for unsynchronised systems, with significant slip:
slip ≦250 mHz; phase angle <10° and decreasing

By enabling both Check Sync 1, set for condition 1, and Check Sync 2, set for condition 2, the P143 can be configured to allow CB closure if either of the two conditions is detected.

For manual circuit breaker closing with synchro check, some utilities might prefer to arrange the logic to check initially for condition 1 only. However, if a System Split is detected before the condition 1 parameters are satisfied, the relay will switch to checking for condition 2 parameters instead, based upon the assumption that a significant degree of slip must be present when system split conditions are detected. This can be arranged by suitable PSL logic, using the system check DDB signals.

4.2.5 Synchronism check

Check Sync 1 and Check Sync 2 are two synchro check logic modules with almost identical functionality, but independent settings.

For either module to function:

the System Checks setting must be Enabled
AND

the individual Check Sync 1(2) Status setting must be Enabled
AND
the module must be individually "enabled", by activation of DDB signal Check Sync 1(2) Enabled, mapped in PSL.

When enabled, each logic module sets its output signal when:

line volts and bus volts are both live (Line Live and Bus Live signals both set)

AND
measured phase angle is < Check Sync 1(2) Phase Angle setting

AND
(for Check Sync 2 only), the phase angle magnitude is decreasing (Check Sync 1 can operate with increasing or decreasing phase angle provided other conditions are satisfied)
AND
if Check Sync 1(2) Slip Control is set to Frequency or Frequency + Timer, the measured slip frequency is < Check Sync 1(2) Slip Freq setting
AND
if Check Sync Voltage Blocking is set to OV, UV + OV, OV + DiffV or UV + OV + DiffV, both line volts and bus volts magnitudes are < Check Sync Overvoltage setting
AND
if Check Sync Voltage Blocking is set to UV, UV + OV, UV + DiffV or UV + OV + DiffV, both line volts and bus volts magnitudes are > Check Sync Undervoltage setting
AND
if Check Sync Voltage Blocking is set to DiffV, UV + DiffV, OV + DiffV or UV + OV + DiffV, the voltage magnitude difference between line volts and bus volts is < Check Sync Diff Voltage setting
AND
if Check Sync 1(2) Slip Control is set to Timer or Frequency + Timer, the above conditions have been true for a time > or = Check Sync 1(2) Slip Timer setting

4.2.6 Slip control by timer

If Slip Control by Timer or Frequency + Timer is selected, the combination of Phase Angle and Timer settings determines an effective maximum slip frequency, calculated as:

$$\frac{2 \times A}{T \times 360}$$ Hz. for Check Sync 1, or

$$\frac{A}{T \times 360}$$ Hz. for Check Sync 2

where

A = Phase Angle setting (°)
T = Slip Timer setting (seconds)

For example, with Check Sync 1 Phase Angle setting 30° and Timer setting 3.3 sec, the "slipping" vector has to remain within ±30° of the reference vector for at least 3.3 seconds. Therefore a synchro check output will not be given if the slip is greater than 2 x 30° in 3.3 seconds. Using the formula: 2 x 30 ÷ (3.3 x 360) = 0.0505 Hz (50.5 mHz).

For Check Sync 2, with Phase Angle setting 10° and Timer setting 0.1 sec, the slipping vector has to remain within 10° of the reference vector, with the angle decreasing, for 0.1 sec. When the angle passes through zero and starts to increase, the synchro check output is blocked. Therefore an output will not be given if slip is greater than 10° in 0.1 second. Using the formula: $10 \div (0.1 \times 360) = 0.278$ Hz (278 mHz).

Slip control by Timer is not practical for "large slip / small phase angle" applications, because the timer settings required are very small, sometimes < 0.1s. For these situations, slip control by frequency is recommended.

If Slip Control by Frequency + Timer is selected, for an output to be given, the slip frequency must be less than BOTH the set Slip Freq value and the value determined by the Phase Angle and Timer settings.

4.2.7 System split

For the System Split module to function:-

the System Checks setting must be Enabled
AND
the SS Status setting must be Enabled
AND
the module must be individually "enabled", by activation of DDB signal System Split Enabled, mapped in PSL

When enabled, the System Split module sets its output signal when:

line volts and bus volts are both live (Line Live and Bus Live signals both set)
AND
measured phase angle is > SS Phase Angle setting
AND
if SS Volt Blocking is set to Undervoltage, both line volts and bus volts magnitudes are > SS Undervoltage setting

The System Split output remains set for as long as the above conditions are true, or for a minimum period equal to the SS Timer setting, whichever is longer.

The "Check Synch" and "System Synch" functionality is illustrated in Figure 27.

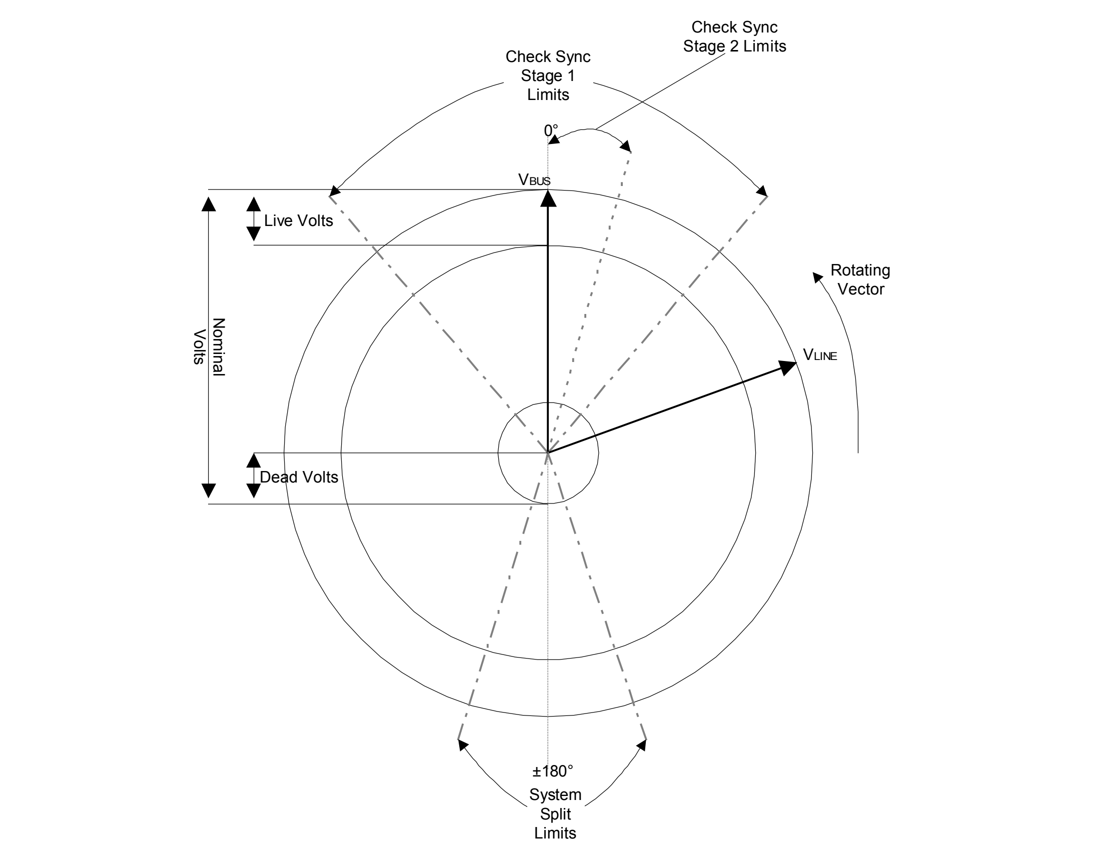


Figure 27: Synchro check and synchro split functionality

4.3 Voltage transformer supervision (VTS)

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

The VTS logic in the relay is designed to detect the voltage failure, and automatically adjust the configuration of protection elements whose stability would otherwise be compromised. A time-delayed alarm output is also available.

There are three main aspects to consider regarding the failure of the VT supply. These are defined below:

1. Loss of one or two phase voltages

2. Loss of all three phase voltages under load conditions

3. Absence of three phase voltages upon line energisation

The VTS feature within the relay operates on detection of negative phase sequence (nps) voltage without the presence of negative phase sequence current. This gives operation for the loss of one or two phase voltages. Stability of the VTS function is assured during system fault conditions, by the presence of nps current. The use of negative sequence quantities ensures correct operation even where three-limb or 'V' connected VT's are used.

Negative Sequence VTS Element:

The negative sequence thresholds used by the element are V_2 = 10V (or 40V on a 380/440V rated relay), and I_2 = 0.05 to 0.5In settable (defaulted to 0.05In).

4.3.1 Loss of all three phase voltages under load conditions

Under the loss of all three phase voltages to the relay, there will be no negative phase sequence quantities present to operate the VTS function. However, under such circumstances, a collapse of the three phase voltages will occur. If this is detected without a corresponding change in any of the phase current signals (which would be indicative of a fault), then a VTS condition will be raised. In practice, the relay detects the presence of superimposed current signals, which are changes in the current applied to the relay. These signals are generated by comparison of the present value of the current with that exactly one cycle previously. Under normal load conditions, the value of superimposed current should therefore be zero. Under a fault condition a superimposed current signal will be generated which will prevent operation of the VTS.

The phase voltage level detectors are fixed and will drop off at 10V (40V on 380/440V relays) and pickup at 30V (120V on 380/440V relays).

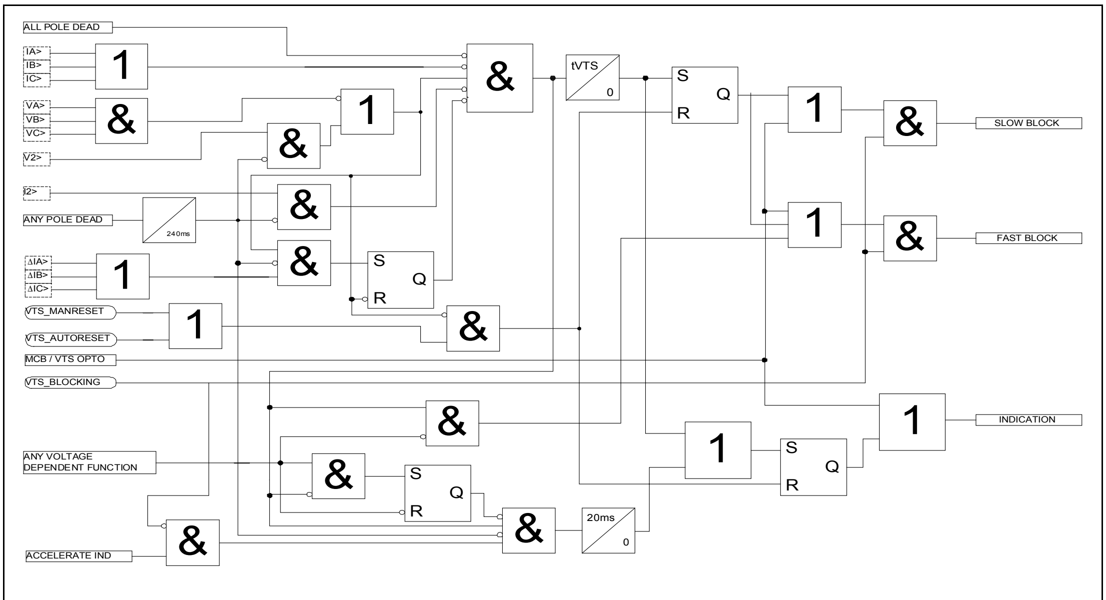
The sensitivity of the superimposed current elements is fixed at 0.1In.

4.3.2 Absence of three phase voltages upon line energisation

If a VT were inadvertently left isolated prior to line energisation, incorrect operation of voltage dependent elements could result. The previous VTS element detected three phase VT failure by absence of all 3 phase voltages with no corresponding change in current. On line energisation there will, however, be a change in current (as a result of load or line charging current for example). An alternative method of detecting 3 phase VT failure is therefore required on line energisation.

The absence of measured voltage on all 3 phases on line energisation can be as a result of 2 conditions. The first is a 3 phase VT failure and the second is a close up three phase fault. The first condition would require blocking of the voltage dependent function and the second would require tripping. To differentiate between these 2 conditions an overcurrent level detector (VTS I> Inhibit) is used which will prevent a VTS block from being issued if it operates. This element should be set in excess of any non-fault based currents on line energisation (load, line charging current, transformer inrush current if applicable) but below the level of current produced by a close up 3 phase fault. If the line is now closed where a 3 phase VT failure is present the overcurrent detector will not operate and a VTS block will be applied. Closing onto a three phase fault will result in operation of the overcurrent detector and prevent a VTS block being applied.

This logic will only be enabled during a live line condition (as indicated by the relays pole dead logic) to prevent operation under dead system conditions i.e. where no voltage will be present and the VTS I> Inhibit overcurrent element will not be picked up.



Note : The Accelerated Ind input is not used in the Feeder Protection.

Figure 28: VTS Logic

Required to drive the VTS logic are a number of dedicated level detectors as follows.

- IA>, IB>, IC> these level detectors shall operate in less than 20ms and their settings should be greater than load current. This setting is specified as VTS current threshold. These level detectors shall pick-up at 100% of setting and drop-off at 95% of setting.

- I2> this level detector operating on negative sequence current and shall have a user setting. This level detector shall pick-up at 100% of setting and drop-off at 95% of setting.

- ΔIIA>, ΔIB>, ΔIC> these are level detectors operating on superimposed phase currents they shall have a fixed setting of 10% of nominal. These level detectors will be subject to a count strategy such that 0.5 cycle of operate decisions must have occured before operation.

- VA>, VB>, VC> these are level detectors operating on phase voltages they shall have a fixed setting Pickup level 30V (Vn 100/120V), 120V (Vn 380/440V), Drop Off level 10V (Vn 100/120V), 40V (Vn 380/440V).

- V2> this level detector operates on negative sequence voltage, it will have a fixed setting of 10V/40V depending on VT ratio (100/120 or 380/440) with pick-up at 100% of setting and drop-off at 95% of setting.

4.3.2.1 Inputs

Signal Name	Description
IA>, IB>, IC>	Phase current levels (Fourier Magnitudes)
I2>	I2 level (Fourier Magnitude).
ΔIA, ΔIB, ΔIC	Phase current samples (current and one cycle previous)
VA>, VB>, VC>	Phase voltage signals (Fourier Magnitudes)
V2>	Negative Sequence voltage (Fourier Magnitude)
ALL POLE DEAD	Breaker is open for all phases (driven from auxiliary contact or pole dead logic).
VTS_MANRESET	A VTS reset performed via front panel or remotely.
VTS_AUTORESET	A setting to allow the VTS to automatically reset after this delay.
MCB/VTS OPTO	To remotely initiate the VTS blocking via an opto.
Any Voltage Dependent Function	Outputs from any function that utilises the system voltage, if any of these elements operate before a VTS is detected the VTS is blocked from operation. The outputs include starts and trips.
Accelerate Ind	Signal from a fast tripping voltage dependent function used to accelerate indications when the indicate only option is selected.
Any Pole Dead	Breaker is open on one or more than one phases (driven from auxiliary contact or pole dead logic).
tVTS	The VTS timer setting for latched operation.

4.3.2.2 Outputs

Signal Name	Description
VTS Fast Block	Used to block voltage dependent functions.
VTS Slow block	Used to block the Any Pole dead signal.
VTS Indication	Signal used to indicate a VTS operation.

4.3.3 Menu settings

The VTS settings are found in the 'SUPERVISION' column of the relay menu. The relevant settings are detailed below.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SUPERVISION GROUP 1				
VT SUPERVISION	Sub Heading			
VTS Status	Blocking	Blocking, Indication		
VTS Reset Mode	Manual	Manual, Auto		
VTS Time Delay	5s	1s	10s	0.1s
VTS I> Inhibit	10In	0.08In	32In	0.01In
VTS I2> Inhibit	0.05In	0.05In	0.5In	0.01In

The relay may respond as follows, on operation of any VTS element:

- VTS set to provide alarm indication only.
- Optional blocking of voltage dependent protection elements.
- Optional conversion of directional overcurrent elements to non-directional protection (available when set to Blocking mode only). These settings are found in the Function Links cell of the relevant protection element columns in the menu.

The VTS I> Inhibit or VTS I2> Inhibit elements are used to override a VTS block in the event of a fault occurring on the system which could trigger the VTS logic. Once the VTS block has been established, however, it would be undesirable for subsequent system faults to override the block. The VTS block will therefore be latched after a user settable time delay 'VTS Time Delay'. Once the signal has latched then two methods of resetting are available. The first is manually via the front panel interface (or remote communications) provided the VTS condition has been removed and secondly, when in 'Auto' mode, by the restoration of the 3 phase voltages above the phase level detector settings mentioned previously.

A VTS indication will be given after the VTS Time Delay has expired. In the case where the VTS is set to indicate only the relay may potentially maloperate, depending on which protection elements are enabled. In this case the VTS indication will be given prior to the VTS time delay expiring if a trip signal is given.

Where a miniature circuit breaker (MCB) is used to protect the voltage transformer ac output circuits, it is common to use MCB auxiliary contacts to indicate a three phase output disconnection. As previously described, it is possible for the VTS logic to operate correctly without this input. However, this facility has been provided for compatibility with various utilities current practices. Energising an opto-isolated input assigned to "MCB Open" on the relay will therefore provide the necessary block.

Where directional overcurrent elements are converted to non-directional protection on VTS operation, it must be ensured that the current pick-up setting of these elements is higher than full load current.

4.4 Current transformer supervision

The current transformer supervision feature is used to detect failure of one or more of the ac phase current inputs to the relay. Failure of a phase CT or an open circuit of the interconnecting wiring can result in incorrect operation of any current operated element. Additionally, interruption in the ac current circuits risks dangerous CT secondary voltages being generated.

4.4.1 The CT supervision feature

The CT supervision feature operates on detection of derived zero sequence current, in the absence of corresponding derived zero sequence voltage that would normally accompany it.

The voltage transformer connection used must be able to refer zero sequence voltages from the primary to the secondary side. Thus, this element should only be enabled where the VT is of five limb construction, or comprises three single phase units, and has the primary star point earthed.

Operation of the element will produce a time-delayed alarm visible on the LCD and event record (plus DDB 149: CT Fail Alarm), with an instantaneous block (DDB 352: CTS Block) for inhibition of protection elements. Protection elements operating from derived quantities (Broken Conductor, Earth Fault2, Neg Seq O/C) are always blocked on operation of the CT supervision element; other protections can be selectively blocked by customising the PSL, integrating DDB 352: CTS Block with the protection function logic.

The following table shows the relay menu for the CT Supervision element, including the available setting ranges and factory defaults:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SUPERVISION GROUP 1				
CT SUPERVISION	Sub Heading			
CTS Status	Disabled	Enabled/Disabled		N/A
CTS VN< Inhibit	5/20V For 110/440V respectively	0.5/2V For 110/440V respectively	22/88V For 110/440V respectively	0.5/2V For 110/440V respectively
CTS IN> Set	0.1In	0.08 x In	4 x In	0.01 x In
CTS Time Delay	5	0s	10s	1s

4.4.2 Setting the CT supervision element

The residual voltage setting, "CTS Vn< Inhibit" and the residual current setting, "CTS In> set", should be set to avoid unwanted operation during healthy system conditions. For example "CTS Vn< Inhibit" should be set to 120% of the maximum steady state residual voltage. The "CTS In> set" will typically be set below minimum load current. The time-delayed alarm, "CTS Time Delay", is generally set to 5 seconds.

Where the magnitude of residual voltage during an earth fault is unpredictable, the element can be disabled to prevent protection elements being blocked during fault conditions.

4.5 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 relay incorporates circuit breaker state monitoring, giving an indication of the position of the circuit breaker, or, if the state is unknown, an alarm is raised.

4.5.1 Circuit breaker state monitoring features

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

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

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

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

If any of the above conditions exist, an alarm will be issued after a 5s time delay. A normally open / normally closed output contact can be assigned to this function via the programmable scheme logic (PSL). The time delay is set to avoid unwanted operation during normal switching duties.

In the CB CONTROL column of the relay menu there is a setting called 'CB Status Input'. This cell can be set at one of the following four options:

None

52A

52B

Both 52A and 52B

Where 'None' is selected no CB status will be available. This will directly affect any function within the relay that requires this signal, for example CB control, autoreclose, etc. Where only 52A is used on its own then the relay will assume a 52B signal from the absence of the 52A signal. Circuit breaker status information will be available in this case but no discrepancy alarm will be available. The above is also true where only a 52B is used. If both 52A and 52B are used then status information will be available and in addition a discrepancy alarm will be possible, according to the following table. 52A and 52B inputs are assigned to relay opto-isolated inputs via the PSL. The CB State Monitoring logic is shown in Figure 29.

Auxiliary Contact Position		CB State Detected	Action
52A	52B		
Open	Closed	Breaker open	Circuit breaker healthy
Closed	Open	Breaker closed	Circuit breaker healthy
Closed	Closed	CB failure	Alarm raised if the condition persists for greater than 5s
Open	Open	State unknown	Alarm raised if the condition persists for greater than 5s

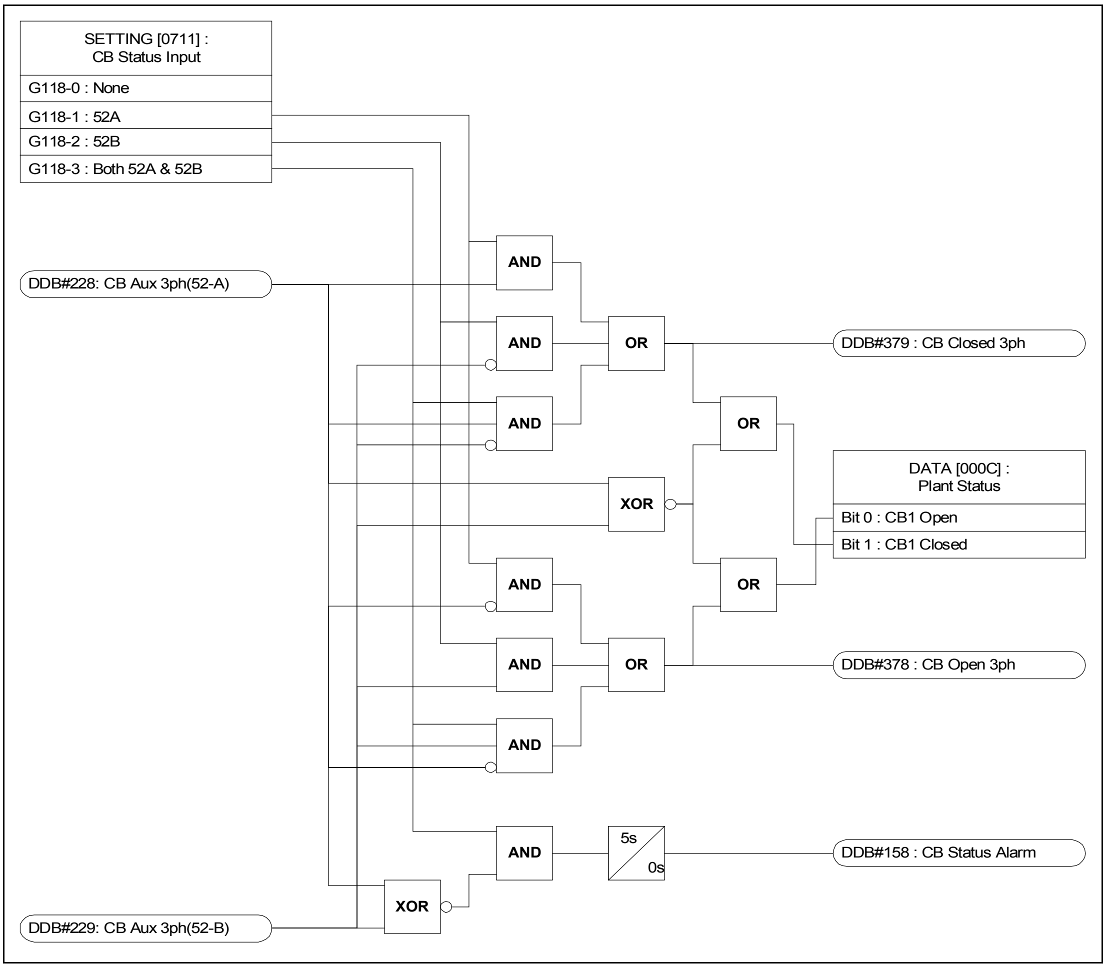


Figure 29: CB state monitoring

4.6 Pole dead logic

The Pole Dead Logic can be used to give an indication if one or more phases of the line are dead. It can also be used to selectively block operation of both the under frequency and under voltage elements. The under voltage protection will be blocked by a pole dead condition provided the "Pole Dead Inhibit" setting is enabled. Any of the four under frequency elements can be blocked by setting the relevant "F< function links".

A pole dead condition can be determined by either monitoring the status of the circuit breaker auxiliary contacts or by measuring the line currents and voltages. The status of the circuit breaker is provided by the "CB State Monitoring" logic. If a "CB Open" signal (DDB#378) is given the relay will automatically initiate a pole dead condition regardless of the current and voltage measurement. Similarly if both the line current and voltage fall below a pre-set threshold the relay will also initiate a pole dead condition. This is necessary so that a pole dead indication is still given even when an upstream breaker is opened. The under voltage (V<) and under current (I<) thresholds have the following, fixed, pickup and drop-off levels:

Settings	Range	Step Size
V< Pick-up and drop off	10V and 30V (100/120V) 40V and 120V (380/440V)	Fixed
I< Pick-up and drop off	0.05 In and 0.055In	Fixed

If one or more poles are dead the relay will indicate which phase is dead and will also assert the ANY POLE DEAD DDB signal (DDB#384). If all phases were dead the ANY POLE DEAD signal would be accompanied by the ALL POLE DEAD DDB signal (DDB#380).

In the event that the VT fails a signal is taken from the VTS logic (DDB#351 – Slow Block) to block the pole dead indications that would be generated by the under voltage and undercurrent thresholds. However, the VTS logic will not block the pole dead indications if they are initiated by a "CB Open" signal (DDB#378).

The pole dead logic diagram is shown below:

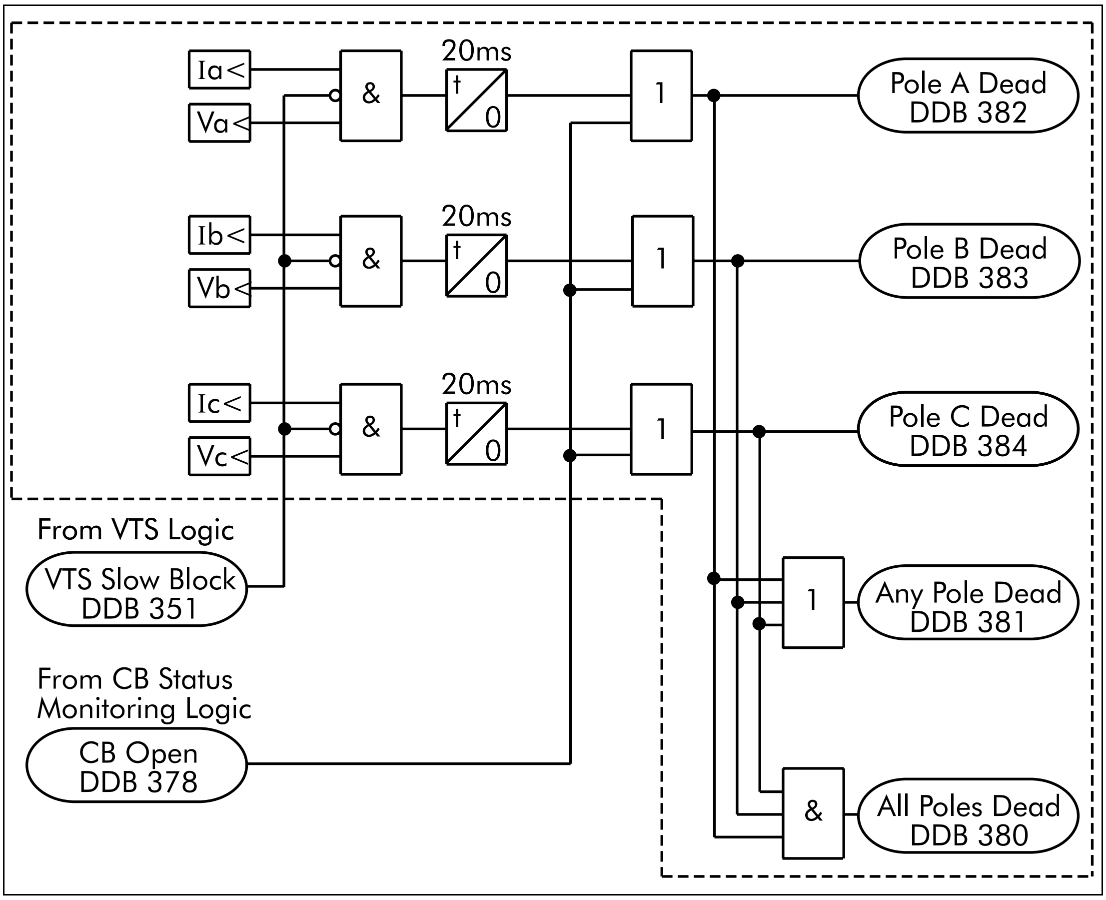


Figure 30: Pole dead logic

4.7 Circuit breaker condition monitoring

Periodic maintenance of circuit breakers is necessary to ensure that the trip circuit and mechanism operate correctly, and also that the interrupting capability has not been compromised due to previous fault interruptions. Generally, such maintenance is based on a fixed time interval, or a fixed number of fault current interruptions. These methods of monitoring circuit breaker condition give a rough guide only and can lead to excessive maintenance.

The P140 relays record 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.

4.7.1 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 menu cells shown are counter values only. The Min/Max values in this case show the range of the counter values. These cells can not be set:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CB CONDITION				
CB operations {3 pole tripping}	0	0	10000	1
Total IA Broken	0	0	25000In^	1
Total IB Broken	0	0	25000In^	1
Total IC Broken	0	0	25000In^	1In^
CB operate time	0	0	0.5s	0.001
Reset CB Data	No		Yes, No	

The above counters may be reset to zero, for example, following a maintenance inspection and overhaul.

The following table, detailing the options available for the CB condition monitoring, is taken from the relay menu. It includes the setup of the current broken facility and those features which can be set to raise an alarm or CB lockout.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CB MONITOR SETUP				
Broken I^	2	1	2	0.1
I^ Maintenance	Alarm disabled	Alarm disabled, Alarm enabled		
I^ Maintenance	1000In^	1In^	25000In^	1In^
I^ Lockout	Alarm disabled	Alarm disabled, Alarm enabled		
I^ Lockout	2000In^	1In^	25000In^	1In^
No CB Ops Maint	Alarm disabled	Alarm disabled, Alarm enabled		
No CB Ops Maint	10	1	10000	1
No CB Ops Lock	Alarm disabled	Alarm disabled, Alarm enabled		
No CB Ops Lock	20	1	10000	1
CB Time Maint	Alarm disabled	Alarm disabled, Alarm enabled		

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CB MONITOR SETUP				
CB Time Maint	0.1s	0.005s	0.5s	0.001s
CB Time Lockout	Alarm disabled	Alarm disabled, Alarm enabled		
CB Time Lockout	0.2s	0.005s	0.5s	0.001s
Fault Freq Lock	Alarm disabled	Alarm disabled, Alarm enabled		
Fault Freq Count	10	1	9999	1
Fault Freq Time	3600s	0	9999s	1s

The circuit breaker condition monitoring counters will be updated every time the relay issues a trip command. In cases where the breaker is tripped by an external protection device it is also possible to update the CB condition monitoring. This is achieved by allocating one of the relays opto-isolated inputs (via the programmable scheme logic) to accept a trigger from an external device. The signal that is mapped to the opto is called 'External Trip'.

Note that when in Commissioning test mode the CB condition monitoring counters will not be updated.

4.8 Setting guidelines

4.8.1 Setting the Σ I^ thresholds

Where overhead lines are prone to frequent faults and are protected by oil circuit breakers (OCB's), 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 Σ I^ 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 OCB's, 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 'Broken I^' = 2.

For other types of circuit breaker, especially those operating on higher voltage systems, practical evidence suggests that the value of 'Broken I^' = 2 may be inappropriate. In such applications 'Broken I^' may be set lower, typically 1.4 or 1.5. An alarm in this instance may be indicative of the need for gas/vacuum interrupter HV pressure testing, for example.

The setting range for 'Broken I^' is variable between 1.0 and 2.0 in 0.1 steps. It is imperative that any maintenance programme must be fully compliant with the switchgear manufacturer's instructions.

4.8.2 Setting the number of operations thresholds

Every operation 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. Should maintenance not be carried out, the relay can be set to lockout the autoreclose function on reaching a second operations threshold. This prevents further reclosure when the circuit breaker has not been maintained to the standard demanded by the switchgear manufacturer's maintenance instructions.

Certain circuit breakers, such as oil circuit breakers (OCB's) can only perform a certain number of fault interruptions before requiring maintenance attention. This is because each fault interruption causes carbonising of the oil, degrading its dielectric properties. The maintenance alarm threshold "No CB Ops Maint" may be set to indicate the requirement for oil sampling for dielectric testing, or for more comprehensive maintenance. Again, the lockout threshold "No CB Ops Lock" may be set to disable autoreclosure when repeated further fault interruptions could not be guaranteed. This minimises the risk of oil fires or explosion.

4.8.3 Setting the operating time thresholds

Slow CB operation is also indicative of the need for mechanism maintenance. Therefore, alarm and lockout thresholds (CB Time Maint/CB Time Lockout) are provided and are settable in the range of 5 to 500ms. This time is set in relation to the specified interrupting time of the circuit breaker.

4.8.4 Setting the excessive fault frequency thresholds

A circuit breaker may be rated to break fault current a set number of times before maintenance is required. However, successive circuit breaker operations in a short period of time may result in the need for increased maintenance. For this reason it is possible to set a frequent operations counter on the relay which allows the number of operations "Fault Freq Count" over a set time period "Fault Freq Time" to be monitored. A separate alarm and lockout threshold can be set.

4.9 Circuit breaker control

The relay includes the following options for control of a single circuit breaker:

- Local tripping and closing, via the relay menu
- Local tripping and closing, via relay opto-isolated inputs
- Remote tripping and closing, using the relay communications

It is recommended that separate relay output contacts are allocated for remote circuit breaker control and protection tripping. This enables the control outputs to be selected via a local/remote selector switch as shown in Figure 31. Where this feature is not required the same output contact(s) can be used for both protection and remote tripping.

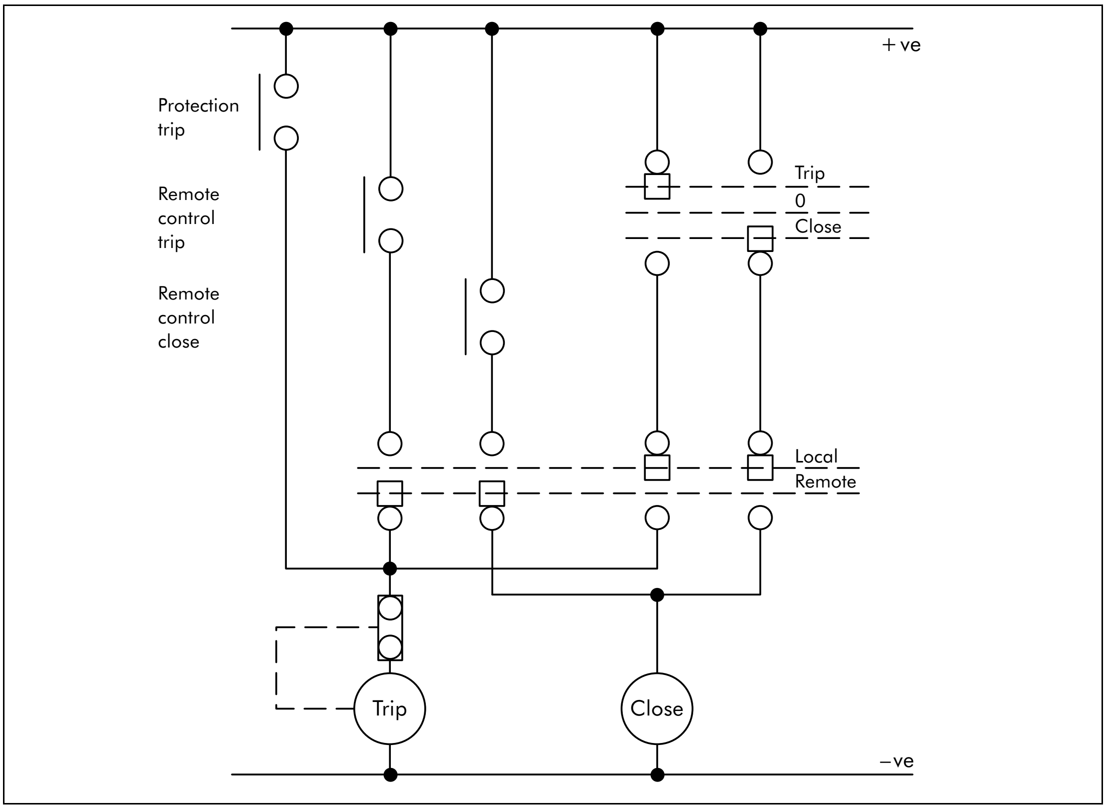


Figure 31: Remote control of circuit breaker

The following table is taken from the relay menu and shows the available settings and commands associated with circuit breaker control. Depending on the relay model some of the cells may not be visible:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CB CONTROL				
CB control by	Disabled	Disabled, Local, Remote, Local+Remote, Opto, Opto+local, Opto+Remote, Opto+Rem+local		
Close Pulse Time	0.5s	0.01s	10s	0.01s
Trip Pulse Time	0.5s	0.01s	5s	0.01s
Man Close Delay	10s	0.01s	600s	0.01s
CB Healthy Time	5s	0.01s	9999s	0.01s
Check Sync Time	5s	0.01s	9999s	0.01s
Lockout Reset	No	No, Yes		
Reset Lockout By	CB Close	User Interface, CB Close		
Man Close RstDly	5s	0.01s	600s	0.01s
A/R Telecontrol	No Operation	No operation, auto, non-auto {refer to autoreclose notes for further information}		

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CB CONTROL				
A/R Status {Indication of current mode only}	Auto Mode	Auto mode, non-auto mode, live line {refer to autoreclose notes for further information}		
Total Reclosures	0	0	10000	1
Reset Total A/R	No	No, Yes		
CB Status Input	None	None, 52A, 52B, Both 52A and 52B		

A manual trip will be permitted provided that the circuit breaker is initially closed. Likewise, a close command can only be issued if the CB is initially open. To confirm these states it will be necessary to use the breaker 52A and/or 52B contacts (the different selection options are given from the 'CB Status Input' cell above). If no CB auxiliary contacts are available then this cell should be set to None. Under these circumstances no CB control (manual or auto) will be possible.

Once a CB Close command is initiated the output contact can be set to operate following a user defined time delay ('Man Close Delay'). This would give personnel time to move away from the circuit breaker following the close command. This time delay will apply to all manual CB Close commands.

The length of the trip or close control pulse can be set via the 'Trip Pulse Time' and 'Close Pulse Time' settings respectively. These should be set long enough to ensure the breaker has completed its open or close cycle before the pulse has elapsed.

Note that the manual close commands are found in the SYSTEM DATA column of the menu.

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.

Where the check synchronism function is set, this can be enabled to supervise manual circuit breaker close commands. A circuit breaker close output will only be issued if the check synchronism criteria are satisfied. A user settable time delay is included ('C/S Window') for manual closure with check synchronising. If the checksynch criteria are not satisfied in this time period following a close command the relay will lockout and alarm.

In addition to a synchronism check before manual reclosure there is also a CB Healthy check if required. This facility accepts an input to one of the relays opto-isolators to indicate that the breaker is capable of closing (circuit breaker energy for example). A user settable time delay is included "CB Healthy Time" for manual closure with this check. If the CB does not indicate a healthy condition in this time period following a close command then the relay will lockout and alarm.

Where autoreclose is used it may be desirable to block its operation when performing a manual close. In general, the majority of faults following a manual closure will be permanent faults and it will be undesirable to autoreclose. The "Man Close RstDly" timer setting is the time for which autoreclose will be disabled following a manual closure of the breaker.

If the CB fails to respond to the control command (indicated by no change in the state of CB Status inputs) a "CB Failed to Trip" or "CB Failed to Close" alarm will be generated after the relevant trip or close pulses have expired. These alarms can be viewed on the relay LCD display, remotely via the relay communications, or can be assigned to operate output contacts for annunciation using the relays programmable scheme logic (PSL).

Note that the "CB Healthy Time" timer and "Check Sync Time" timer set under this menu section are applicable to manual circuit breaker operations only. These settings are duplicated in the autoreclose menu for autoreclose applications.

The "Lockout Reset" and "Reset Lockout by" setting cells in the menu are applicable to CB Lockouts associated with manual circuit breaker closure, CB Condition monitoring (Number of circuit breaker operations, for example) and autoreclose lockouts.

The CB Control logic is illustrated in Figure 9 of Appendix D.

4.10 Trip circuit supervision (TCS)

The trip circuit, in most protective schemes, extends beyond the relay enclosure and passes through components such as fuses, links, relay contacts, auxiliary switches and other terminal boards. This complex arrangement, coupled with the importance of the trip circuit, has led to dedicated schemes for its supervision.

Several trip circuit supervision schemes with various features can be produced with the P140 range. Although there are no dedicated settings for TCS, in the P140, the following schemes can be produced using the programmable scheme logic (PSL). A user alarm is used in the PSL to issue an alarm message on the relay front display. If necessary, the user alarm can be re-named using the menu text editor to indicate that there is a fault with the trip circuit.

4.10.1 TCS scheme 1

4.10.1.1 Scheme description

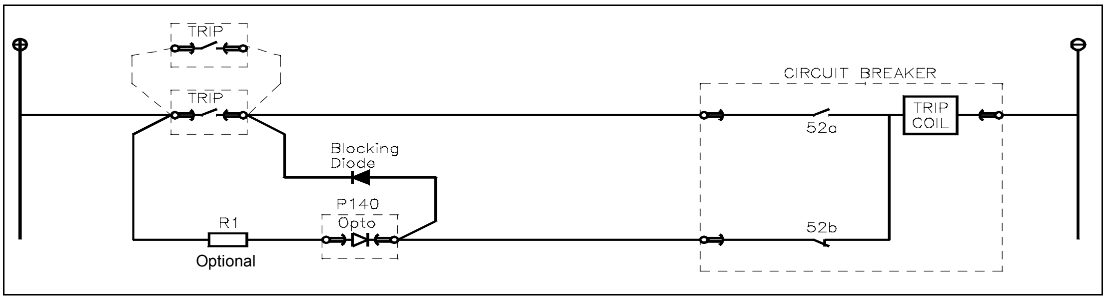


Figure 32: TCS scheme 1

This scheme provides supervision of the trip coil with the breaker open or closed, however, pre-closing supervision is not provided. This scheme is also incompatible with latched trip contacts, as a latched contact will short out the opto for greater than the recommended DDO timer setting of 400ms. If breaker status monitoring is required a further 1 or 2 opto inputs must be used. Note, a 52a CB auxiliary contact follows the CB position and a 52b contact is the opposite.

When the breaker is closed, supervision current passes through the opto input, blocking diode and trip coil. When the breaker is open current still flows through the opto input and into the trip coil via the 52b auxiliary contact. Hence, no supervision of the trip path is provided whilst the breaker is open. Any fault in the trip path will only be detected on CB closing, after a 400ms delay.

Resistor R1 is an optional resistor that can be fitted to prevent mal-operation of the circuit breaker if the opto input is inadvertently shorted, by limiting the current to <60mA. The resistor should not be fitted for auxiliary voltage ranges of 30/34 volts or less, as satisfactory operation can no longer be guaranteed. The table below shows the appropriate resistor value and voltage setting (OPTO CONFIG menu) for this scheme.

This TCS scheme will function correctly even without resistor R1, since the opto input automatically limits the supervision current to less that 10mA. However, if the opto is accidentally shorted the circuit breaker may trip.

Auxiliary Voltage (Vx)	Resistor R1 (ohms)	Opto Voltage Setting with R1 Fitted
24/27	-	-
30/34	-	-
48/54	1.2k	24/27
110/250	2.5k	48/54
220/250	5.0k	110/125

Note: When R1 is not fitted the opto voltage setting must be set equal to supply voltage of the supervision circuit.

4.10.2 Scheme 1 PSL

Figure 33 shows the scheme logic diagram for the TCS scheme 1. Any of the available opto inputs can be used to indicate whether or not the trip circuit is healthy. The delay on drop off timer operates as soon as the opto is energised, but will take 400ms to drop off / reset in the event of a trip circuit failure. The 400ms delay prevents a false alarm due to voltage dips caused by faults in other circuits or during normal tripping operation when the opto input is shorted by a self-reset trip contact. When the timer is operated the NC (normally closed) output relay opens and the LED and user alarms are reset.

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

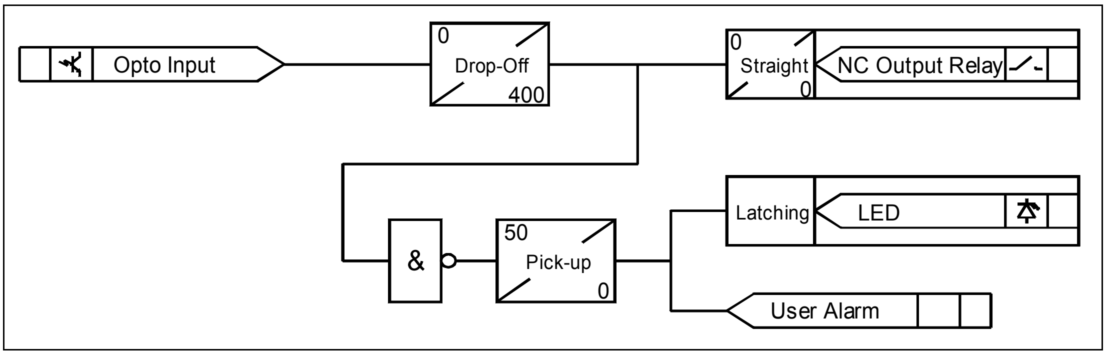


Figure 33: PSL for TCS schemes 1 and 3

4.10.3 TCS scheme 2

4.10.3.1 Scheme description

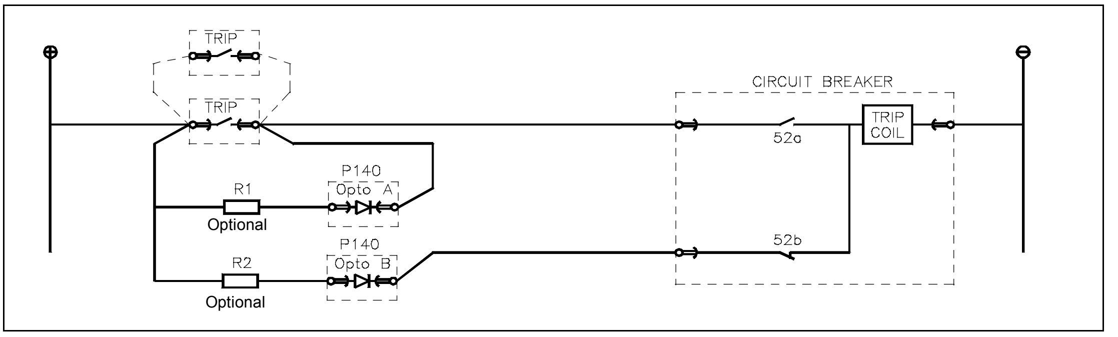


Figure 34: TCS scheme 2

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

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

As with scheme 1, optional resistors R1 and R2 can be added to prevent tripping of the CB if either opto is shorted. The resistor values of R1 and R2 are equal and can be set the same as R1 in scheme 1.

4.10.4 Scheme 2 PSL

The PSL for this scheme (Figure 35) is practically the same as that of scheme 1. The main difference being that both opto inputs must be off before a trip circuit fail alarm is given.

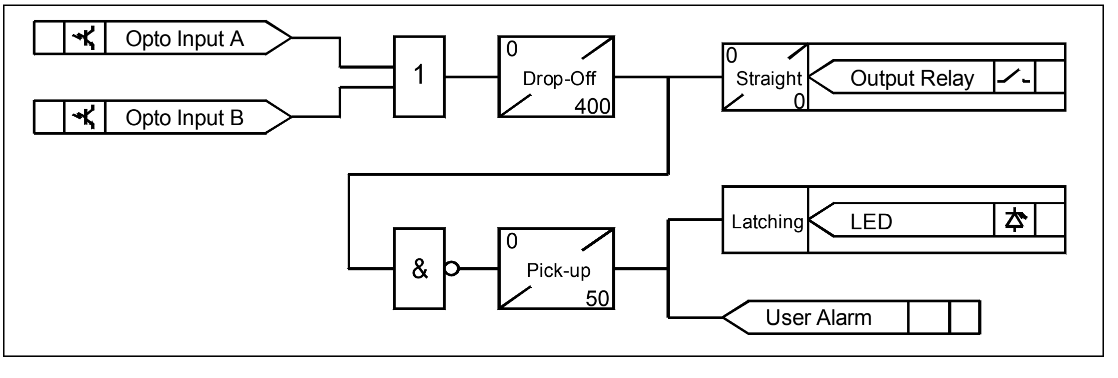


Figure 35: PSL for TCS scheme 2

4.10.5 TCS scheme 3

4.10.5.1 Scheme description

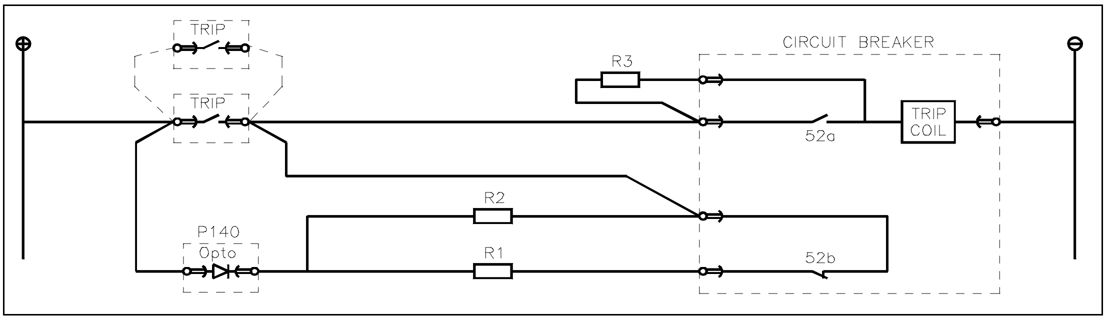


Figure 36: TCS scheme 2

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

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

As with schemes 1 and 2, resistors R1 and R2 are used to prevent false tripping, if the opto-input is accidentally shorted. However, unlike the other two schemes, this scheme is dependent upon the position and value of these resistors. Removing them would result in incomplete trip circuit monitoring. The table below shows the resistor values and voltage settings required for satisfactory operation.

Auxiliary Voltage (Vx)	Resistor R1 & R2 (ohms)	Resistor R3 (ohms)	Opto Voltage Setting
24/27	-	-	-
30/34	-	-	-
48/54	1.2k	0.6k	24/27
110/250	2.5k	1.2k	48/54
220/250	5.0k	2.5k	110/125

Note: Scheme 3 is not compatible with auxiliary supply voltages of 30/34 volts and below.

4.10.6 Scheme 3 PSL

The PSL for scheme 3 is identical to that of scheme 1 (see Figure 33).

4.11 Fault locator

4.11.1 Introduction

The relay has an integral fault locator that uses information from the current and voltage inputs to provide a distance to fault location feature. The sampled data from the analog input circuits is written to a cyclic buffer until a fault condition is detected. The data in the input buffer is then held to allow the fault calculation to be made.

When the fault calculation is complete the fault location information is available in the relay fault record.

4.11.2 Basic theory for ground faults

A two-machine equivalent circuit of a faulted power system is shown in Figure 37.

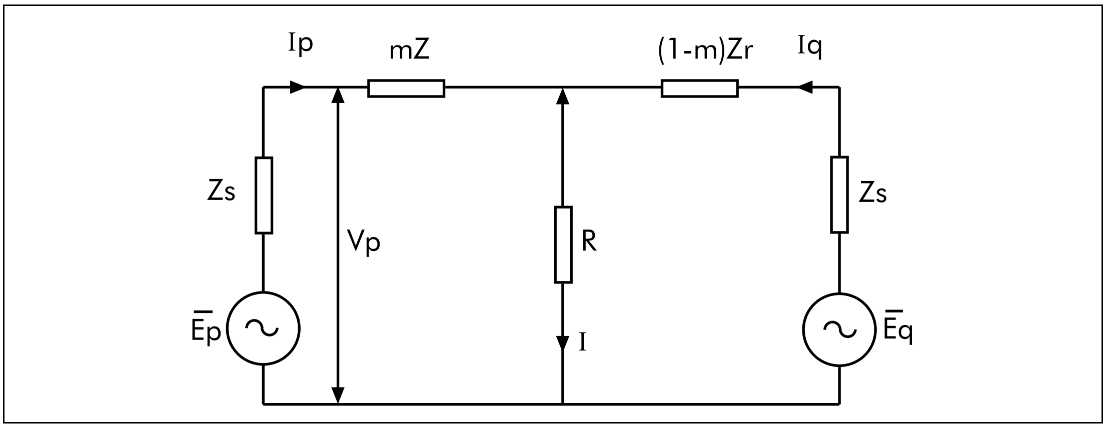


Figure 37: Two machine equivalent circuit

From this diagram :

$$Vp = mIpZr + IfRf \quad \text{(equ.1)}$$

The fault location, m, can be found if If can be estimated allowing equation 1 to be solved.

4.11.3 Data acquisition and buffer processing

The fault locator stores the sampled data within a 12 cycle cyclic buffer at a resolution of 24 samples per cycle. When the fault recorder is triggered the data in the buffer is frozen such that the buffer contains 6 cycles of pre-trigger data and 6 cycles of post-trigger data. Fault calculation commences shortly after this trigger point.

The trigger for the fault locator is user selectable via the programmable scheme logic.

The fault locator can store data for up to four faults. This ensures that fault location can be calculated for all shots on a typical multiple reclose sequence.

4.11.4 Faulted phase selection

Selection of the faulted phase(s) is performed by comparing the magnitude of the pre-fault and post fault values of the three phase-to-phase currents. A single phase-to-ground fault produces the same change on two of these signals and zero on the third. A phase-to-phase or double phase-to-ground fault produces one signal which is larger than the other two. A three phase fault produces the same change on all 3 currents.

Current changes are considered to be the same if they are within 20% of each other. Phase selection and fault location calculation can only be made if the current change exceeds 5%In.

4.11.5 The fault location calculation

This works by:

a) First obtaining the vectors.

b) Selecting the faulted phase(s).

c) Estimating the phase of the fault current, If, for the faulted phase(s).

d) Solving equation 1 for the fault location m at the instant of time where If = 0.

4.11.5.1 Obtaining the vectors

Different sets of vectors are chosen depending on the type of fault identified by the phase selection algorithm. The calculation using equation 1 is applied for either a phase to ground fault or a phase to phase fault.

thus for an A phase to ground fault:-

IpZr = Ia (Zline /THETA line) + In (Zresidual /THETA residual) (equation 2)

and Vp = VA

and for an A phase to B phase fault:-

IpZr = Ia (Zline /THETA line) – Ib (Zresidual /THETA residual) (equation 3)

and Vp = VA – VB

4.11.5.2 Solving the equation for the fault location

As the sine wave of If passes through zero, the instantaneous values of the sine waves Vp and Ip can be used to solve equation (1) for the fault location m. (The term IfRf being zero.)

This is determined by shifting the calculated vectors of Vp and IpZr by the angle (90° – angle of fault current) and then dividing the real component of Vp by the real component of IpZr. See Figure 38 below.

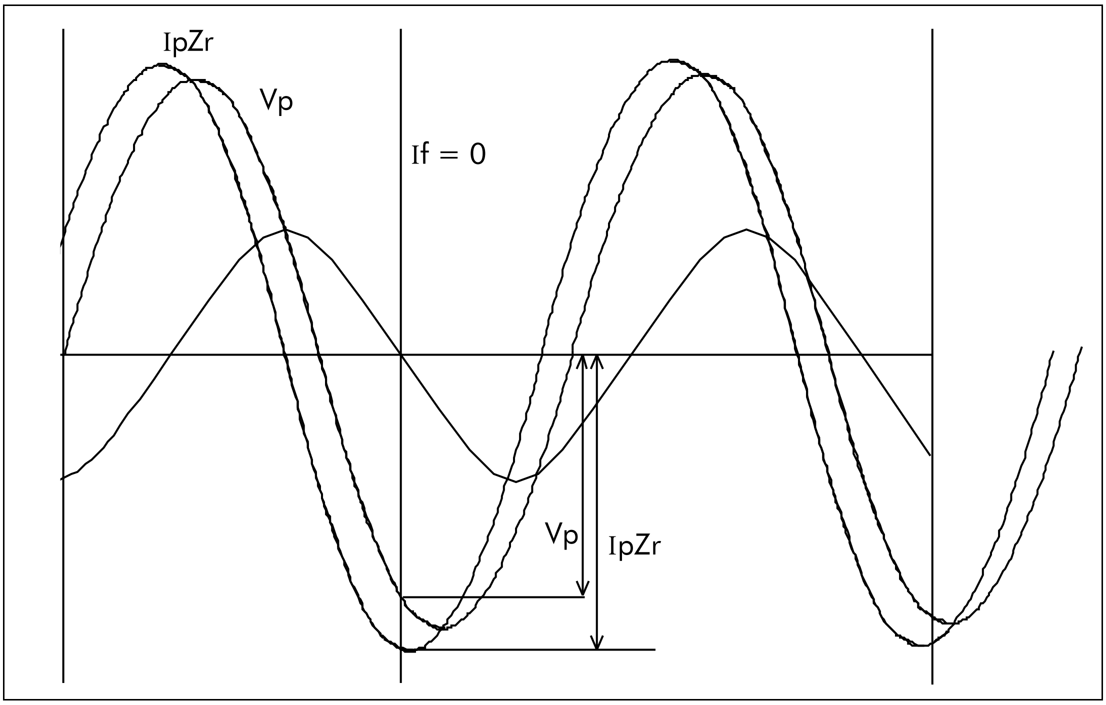


Figure 38: Fault locator selection of fault current zero

i.e.:

Phase advanced vector Vp

= °Vp°(cos(s) + jsin(s)) * (sin(d) + jcos(d))

= °Vp°[- sin(s-d) + jcos(s-d)]

Phase advanced vector IpZr

= °IpZr°(cos (e) + jsin (e)) * (sin (d) + jcos (d))

= °IpZr°[- sin(e-d) + jcos(e-d)]

therefore from equation 1

m = Vp ÷ (Ip * Zr) at If = 0

= Vpsin(s-d) / (IpZr * sin(e-d))

where

d = angle of fault current If

s = angle of Vp

e = angle of IpZr

Thus the relay evaluates m which is the fault location as a percentage of the fault locator line impedance setting and then calculates the output fault location by multiplying this by the line length setting.

When calculated, the fault location can be found in the fault record under the "VIEW RECORDS" column in the "**Fault Location**" cells. Distance to fault is available in metres, miles, impedance or percentage of line length.

4.11.6 Fault locator settings

The following table shows the relay menu for the fault locator, including the available setting ranges and factory defaults:-

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
VIEW RECORDS				
Fault Location	x metres	Distance to fault in metres		
Fault Location	x miles	Distance to fault in miles		
Fault Location	x Ω	Distance to fault in impedance		
Fault Location	x %	Distance to fault in % of line length		
FAULT LOCATOR GROUP 1				
Line Length (metres)	16000	10	1E6	10
Line Length (miles)	10	0.005	600	0.005
Line Impedance	6	0.1	250	0.01

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Line Angle	70	20	85	1
KZN Residual	1	0	7	0.01
KZN Res Angle	0	–90	90	1

4.11.7 Fault locator trigger

Fault location is part of the data included within the relay fault record and therefore the fault locator is triggered whenever a fault record is generated. This is controlled by DDB 144: Fault REC TRIG; in the default PSL this signal is energised from operation of any protection trip.

4.11.8 Setting example

Assuming the following data for the protected line

230kV transmission line

CT ratio = 1200/5

VT ratio = 230,000/115

Line length = 10Km

Positive sequence line impedance ZL1 = 0.089+j0.476 Ohms/Km

Zero sequence line impedance ZL0 = 0.34+j1.03 ohms/Km

Zero sequence mutual impedance ZM0 = 0.1068+j0.5712 Ohms/Km

The line length can be set in either metres or miles.

Therefore for this example set line length = 10Km.

The line impedance magnitude and angle settings are calculated as follows:

Ratio of secondary to primary impedance = CT ratio/VT ratio = 0.12

Positive sequence line impedance ZL1 = 0.12 x 10(0.484∠79.4°) = 0.58 ∠79.4°

Therefore set line length = 0.58

line angle = 79°

The residual impedance compensation magnitude and angle are calculated using the following formula;

$$KZn = \frac{ZL0 - ZL1}{3\ ZL1}$$

$$= \frac{(0.34 + j1.03) - (0.089 + j0.476)}{3 \times (0.48479.4¼)}$$

$$= \frac{0.6065.\ 23}{1.4579.4}$$

$$= 0.41 - 14.17$$

Therefore set kZn Residual = 0.48

kZn Res Angle = ∠14°

4.12 Event & fault records

The relay records and time tags up to 250 events and stores them in non-volatile (battery backed up) memory. This enables the system operator to establish the sequence of events that occurred within the relay following a particular power system condition, switching sequence etc. When the available space is exhausted, the oldest event is automatically overwritten by the new one.

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

The event records are available for viewing either via the frontplate LCD or remotely, via the communications ports.

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

VIEW RECORDS	
LCD Reference	Description
Select Event	Setting range from 0 to 249. This selects the required event record from the possible 250 that may be stored. A value of 0 corresponds to the latest event and so on.
Time & Date	Time & Date Stamp for the event given by the internal Real Time Clock.
Event Text	Up to 32 Character description of the Event refer to following sections).
Event Value	Up to 32 Bit Binary Flag or integer representative of the Event (refer to following sections).
Select Fault	Setting range from 0 to 4. This selects the required fault record from the possible 5 that may be stored. A value of 0 corresponds to the latest fault and so on.
	The following cells show all the fault flags, protection starts, protection trips, fault location, measurements etc. associated with the fault, i.e. the complete fault record.
Select Maint	Setting range from 0 to 4. This selects the required maintenance report from the possible 5 that may be stored. A value of 0 corresponds to the latest report and so on.
Maint Text	Up to 32 Character description of the occurrence (refer to following sections).
Maint Type	These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence to Report Data.
Reset Indication	Either Yes or No. This serves to reset the trip LED indications provided that the relevant protection element has reset.

For extraction from a remote source via communications, refer to Chapter 5, where the procedure is fully explained.

Note that a full list of all the event types and the meaning of their values is given in Appendix A.

4.12.1 Types of event

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

4.12.1.1 Change of state of opto-isolated inputs

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

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

The Event Value is an 8 or 16 bit word showing the status of the opto inputs, where the least significant bit (extreme right) corresponds to opto input 1 etc. The same information is present if the event is extracted and viewed via PC.

4.12.1.2 Change of state of one or more output relay contacts

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

Time & date of event
"OUTPUT CONTACTS"
"Event Value 010101010101010101010"

The Event Value is a 7, 14 or 21 bit word showing the status of the output contacts, where the least significant bit (extreme right) corresponds to output contact 1 etc. The same information is present if the event is extracted and viewed via PC.

4.12.1.3 Relay alarm conditions

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

Alarm Condition	Event Text	Event Value
Battery Fail	Battery Fail ON/OFF	Bit position 0 in 32 bit field
Field Voltage Fail	Field V Fail ON/OFF	Bit position 1 in 32 bit field
Setting Group via Opto Invalid	Setting Grp Invalid ON/OFF	Bit position 2 in 32 bit field
Protection Disabled	Prot'n Disabled ON/OFF	Bit position 3 in 32 bit field
Frequency out of Range	Freq out of Range ON/OFF	Bit position 4 in 32 bit field
VTS Alarm	VT Fail Alarm ON/OFF	Bit position 5 in 32 bit field
CB Trip Fail Protection	CB Fail ON/OFF	Bit position 6 in 32 bit field

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

4.12.1.4 Protection element starts and trips

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

4.12.1.5 General events

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

Nature of Event	Displayed Text in Event Record	Displayed Value
Level 1 password modified, either from user interface, front or rear port	PW1 edited UI, F or R	0

A complete list of the 'General Events' is given in Appendix A.

4.12.1.6 Fault records

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

Note that viewing of the actual fault record is carried out in the "Select Fault'" cell further down the "VIEW RECORDS" column, which is selectable from up to 5 records. These records consist of fault flags, fault location, fault measurements etc. Also note that the time stamp given in the fault record itself will be more accurate than the corresponding stamp given in the event record as the event is logged some time after the actual fault record is generated.

The fault record is triggered from the 'Fault REC TRIG' signal assigned in the default programmable scheme logic to relay 3, protection trip. Note, the fault measurements in the fault record are given at the time of the protection start. Also, the fault recorder does not stop recording until any start or relay 3 (protection trip) resets in order to record all the protection flags during the fault.

It is recommended that the triggering contact (relay 3 for example) be 'self reset' and not latching. If a latching contact was chosen the fault record would not be generated until the contact had fully reset.

4.12.1.7 Maintenance reports

Internal failures detected by the self monitoring circuitry, such as watchdog failure, field voltage failure etc. are logged into a maintenance report. The maintenance report holds up to 5 such 'events' and is accessed from the "Select Report" cell at the bottom of the "VIEW RECORDS" column.

Each entry consists of a self explanatory text string and a 'Type' and 'Data' cell, which are explained in the menu extract at the beginning of this section and in further detail in Appendix 1.

Each time a Maintenance Report is generated, an event is also created. The event simply states that a report was generated, with a corresponding time stamp.

4.12.1.8 Setting changes

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

Type of Setting Change	Displayed Text in Event Record	Displayed Value
Control/Support Setting	C & S Changed	0
Group 1 Change	Group 1 Changed	1

Note: Control/Support settings are communications, measurement, CT/VT ratio settings etc, which are not duplicated within the four setting groups. When any of these settings are changed, the event record is created simultaneously. However, changes to protection or disturbance recorder settings will only generate an event once the settings have been confirmed at the 'setting trap'.

4.12.2 Resetting of event/fault records

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

4.12.3 Viewing event records via MiCOM S1 support software

When the event records are extracted and viewed on a PC they look slightly different than when viewed on the LCD. The following shows an example of how various events appear when displayed using MiCOM S1:-

- Monday 03 November 1998 15:32:49 GMT I>1 Start ON

ALSTOM : MiCOM P143

Model Number: P143111A1A0040A

Address: 001 Column: of Row: 23

Event Type: Setting event

- Monday 03 November 1998 15:32:52 GMT Fault Recorded

  ALSTOM : MiCOM P143

  Model Number: P143111A1A0040A

  Address: 001 Column: 01 Row: 00

  Event Type: Fault record

- Monday 03 November 1998 15:33:11 GMT Logic Inputs

  ALSTOM : MiCOM P143

  Model Number: P143111A1A0040A

  Address: 001 Column: 00 Row: 20

  Event Type: Logic input changed state

- Monday 03 November 1998 15:34:54 GMT Output Contacts

  ALSTOM : MiCOM P143

  Model Number: P143111A1A0040A

  Address: 001 Column: 00 Row: 21

  Event Type: Relay output changed state

- Monday 03 November 1998 15:35:55 GMT A/R Lockout ON

  ALSTOM : MiCOM P143

  Model Number: P143111A1A0040A

  Address: 001 Column: 00 Row: 22

  Event Type: Alarm event

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

For further information regarding events and their specific meaning, refer to Appendix A.

4.12.4 Event filtering

It is possible to disable the reporting of events from any user interface that supports setting changes. The settings which control the various types of events are in the Record Control column. The effect of setting each to disabled is as follows:

Alarm Event	None of the occurrences that produce an alarm will result in an event being generated. The presence of any alarms is still reported by the alarm LED flashing and the alarm bit being set in the communications status byte. Alarms can still be read using the Read key on the relay front panel.
Relay O/P Event	No event will be generated for any change in relay output state.

Opto Input Event	No event will be generated for any change in logic input state.
General Event	No General Events will be generated.
Fault Rec Event	No event will be generated for any fault that produces a fault record. The fault records can still be viewed by operating the "Select Fault" setting in column 0100.
Maint Rec Event	No event will be generated for any occurrence that produces a maintenance record. The maintenance records can still be viewed by operating the "Select Maint" setting in column 0100.
Protection Event	Any operation of protection elements will not be logged as an event.

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

If the Protection Event setting is Enabled a further set of settings is revealed which allow the event generation by individual DDB signals to be enabled or disabled.

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

For further information regarding events and their specific meaning, refer to Appendix A.

4.13 Disturbance recorder

The integral disturbance recorder has an area of memory specifically set aside for record storage. The number of records that may be stored is dependent upon the selected recording duration but the relays typically have the capability of storing a minimum of 20 records, each of 10.5 second duration. Disturbance records continue to be recorded until the available memory is exhausted, at which time the oldest record(s) are overwritten to make space for the newest one.

The recorder stores actual samples which are taken at a rate of 12 samples per cycle.

Each disturbance record consists of eight analog data channels and thirty-two digital data channels. The relevant CT and VT ratios for the analog channels are also extracted to enable scaling to primary quantities. Note that if a CT ratio is set less than unity, the relay will choose a scaling factor of zero for the appropriate channel.

The "DISTURBANCE RECORDER" menu column is shown in the following table:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
DISTURB RECORDER				
Duration	1.5s	0.1s	10.5s	0.01s
Trigger Position	33.3%	0	100%	0.1%
Trigger Mode	Single	Single or Extended		
Analog Channel 1	VAN	VAN, VBN, VCN, VCHECKSYNC, IA, IB, IC, IN, IN SEF		

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Analog Channel 2	VBN	As above		
Analog Channel 3	VCN	As above		
Analog Channel 4	IA	As above		
Analog Channel 5	IB	As above		
Analog Channel 6	IC	As above		
Analog Channel 7	IN	As above		
Analog Channel 8	IN SEF	As above		
Digital Inputs 1 to 32	Relays 1 to 7/14 and Opto's 1 to 8/16	Any of 7 or 14 O/P Contacts or Any of 8 or 16 Opto Inputs or Internal Digital Signals		
Inputs 1 to 32 Trigger	No Trigger except Dedicated Trip Relay O/P's which are set to Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		

Note: The available analogue and digital signals will differ between relay types and models and so the individual courier database in Chapter 5 should be referred to when determining default settings etc.

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

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

As can be seen from the menu, each of the analog channels is selectable from the available analog inputs to the relay. The digital channels may be mapped to any of the opto isolated inputs or output contacts, in addition to a number of internal relay digital signals, such as protection starts, LED's etc. The complete list of these signals may be found by viewing the available settings in the relay menu or via a setting file in MiCOM S1. Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition, via the "Input Trigger" cell. The default trigger settings are that any dedicated trip output contacts (e.g. relay 3) will trigger the recorder.

It is not possible to view the disturbance records locally via the LCD; they must be extracted using suitable software such as MiCOM S1. This process is fully explained in Chapter 5.

4.14 Measurements

The relay produces a variety of both directly measured and calculated power system quantities. These measurement values are updated on a per second basis and are summarised below:

Phase Voltages and Currents

Phase to Phase Voltage and Currents

Sequence Voltages and Currents

Power and Energy Quantities

Rms. Voltages and Currents

Peak, Fixed and Rolling Demand Values

There are also measured values from the protection functions, which are also displayed under the measurement columns of the menu; these are described in the section on the relevant protection function.

4.14.1 Measured voltages and currents

The relay produces both phase to ground and phase to phase voltage and current values. They are produced directly from the DFT (Discrete Fourier Transform) used by the relay protection functions and present both magnitude and phase angle measurement.

4.14.2 Sequence voltages and currents

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

4.14.3 Power and energy quantities

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

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

In addition to the measured power quantities the relay calculates the power factor on a phase by phase basis in addition to a three-phase power factor.

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

4.14.4 Rms. voltages and currents

Rms. Phase voltage and current values are calculated by the relay using the sum of the samples squared over a cycle of sampled data.

4.14.5 Demand values

The relay produces fixed, rolling and peak demand values, using the Reset Demand menu cell it is possible to reset these quantities via the User Interface or the remote communications.

Fixed demand values

The fixed demand value is the average value of a quantity over the specified interval; values are produced for each phase current and for three phase real and reactive power. The fixed demand values displayed by the relay are those for the previous interval, the values are updated at the end of the fixed demand period.

Rolling demand values

The rolling demand values are similar to the fixed demand values, the difference being that a sliding window is used. The rolling demand window consists of a number of smaller sub-periods. The resolution of the sliding window is the sub-period length, with the displayed values being updated at the end of each of the sub-periods.

Peak demand values

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

4.14.6 Settings

The following settings under the heading Measurement Setup can be used to configure the relay measurement function.

MEASUREMENT SETUP	Default Value	Options/Limits
Default Display	Description	Description/Plant Reference/ Frequency/Access Level/3Ph + N Current/3Ph Voltage/Power/Date and time
Local Values	Primary	Primary/Secondary
Remote Values	Primary	Primary/Secondary
Measurement Ref	VA	VA/VB/VC/IA/IB/IC
Measurement Mode	0	0 to 3 step 1
Fix Dem Period	30 minutes	1 to 99 minutes step 1 minute
Roll Sub Period	30 minutes	1 to 99 minutes step 1 minute
Num Sub Periods	1	1 to 15 step 1
Distance Unit*	Km	Km/miles
Fault Location*	Distance	Distance/Ohms/% of Line

* Note: These settings are available for products with integral fault location.

Default display

This setting can be used to select the default display from a range of options, note that it is also possible to view the other default displays whilst at the default level using the ⟨ and ⟩ keys. However once the 15 minute timeout elapses the default display will revert to that selected by this setting.

Local values

This setting controls whether measured values via the front panel user interface and the front Courier port are displayed as primary or secondary quantities.

Remote values

This setting controls whether measured values via the rear communication port are displayed as primary or secondary quantities.

Measurement ref

Using this setting the phase reference for all angular measurements by the relay can be selected.

Measurement mode

This setting is used to control the signing of the real and reactive power quantities; the signing convention used is defined in Section 4.14.3.

Fixed demand period

This setting defines the length of the fixed demand window.

Rolling sub-period and number of sub-periods

These two settings are used to set the length of the window used for the calculation of rolling demand quantities and the resolution of the slide for this window.

Distance unit

This setting is used to select the unit of distance for fault location purposes, note that the length of the line is preserved when converting from km to miles and vice versa.

Fault location

The calculated fault location can be displayed using one of several options selected using this setting.

4.15 Changing setting groups

The setting groups can be changed either via opto inputs or via a menu selection. In the Configuration column if 'Setting Group- select via optos' is selected then optos 1 and 2, which are dedicated for setting group selection, can be used to select the setting group as shown in the table below. If 'Setting Group- select via menu' is selected then in the Configuration column the 'Active Settings - Group1/2/3/4' can be used to select the setting group. If this option is used then opto inputs 1 and 2 can be used for other functions in the programmable scheme logic.

OPTO 1	**OPTO 2**	**Selected Setting Group**
0	0	1
1	0	2
0	1	3
1	1	4

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

4.16 Control inputs

Menu Text	Default Setting	Setting Range	Step Size
CONTROL INPUTS			
Ctrl I/P Status	00000000000000000000000000000000		
Control Input 1	No Operation	No Operation, Set, Reset	
Control Input 2 to 32	No Operation	No Operation, Set, Reset	

The Control Input commands can be found in the 'Control Input' menu. In the 'Ctrl I/P status' menu cell there is a 32 bit word which represent the 32 control input commands. The status of the 32 control inputs can be read from this 32 bit word. The 32 control inputs can also be set and reset from this cell by setting a 1 to set or 0 to reset a particular control input. Alternatively, each of the 32 Control Inputs can can be set and reset using the individual menu setting cells 'Control Input 1, 2, 3' etc.

The Control Inputs are available through the relay menu as described above and also via the rear communications.

In the programmable scheme logic editor 32 Control Input signals, DDB 800-831, which can be set to a logic 1 or On state, as described above, are available to perform control functions defined by the user.

4.17 VT Connections

4.17.1 Open delta (vee connected) VT's

The P140 range can be used with vee connected VTs by connecting the VT secondaries to C19, C20 and C21 input terminals, with the C22 input left unconnected.

This type of VT arrangement cannot pass zero-sequence (residual) voltage to the relay, or provide any phase to neutral voltage quantities. Therefore any protection that is dependent upon phase to neutral voltage measurements should be disabled.

The under and over voltage protection can be set as phase-to-phase measurement with vee connected VTs. The voltage dependent overcurrent use phase-phase voltages anyway, therefore the accuracy should not be affected. Directional earth fault and sensitive directional earth fault protection should be disabled as the neutral voltage will always be zero, even in the event of an earth fault. CT supervision should also be disabled as this is also dependent upon the measurement of zero sequence voltage.

The accuracy of single phase voltage measurements can be impaired when using vee connected VT's. The relay attempts to derive the phase to neutral voltages from the phase to phase voltage vectors. If the impedance of the voltage inputs were perfectly matched the phase to neutral voltage measurements would be correct, provided the phase to phase voltage vectors were balanced. However, in practice there are small differences in the impedance of the voltage inputs, which can cause small errors in the phase to neutral voltage measurements. This may give rise to an apparent residual voltage. This problem also extends to single phase power measurements that are also dependent upon their respective single phase voltages.

The phase to neutral voltage measurement accuracy can be improved by connecting 3, well matched, load resistors between the phase voltage inputs (C19, C20, C21) and neutral C22, thus creating a 'virtual' neutral point. The load resistor values must be chosen so that their power consumption is within the limits of the VT. It is recommended that 10kΩ ±1% (6W) resistors are used for the 110V (Vn) rated relay, assuming the VT can supply this burden.

4.17.2 VT single point earthing

The P140 range will function correctly with conventional 3 phase VT's earthed at any one point on the VT secondary circuit. Typical earthing examples being neutral earthing and yellow phase earthing.

5. PROGRAMMABLE SCHEME LOGIC DEFAULT SETTINGS

The relay includes programmable scheme logic (PSL). The purpose of this logic is multi-functional and includes the following:

- Enables the mapping of opto-isolated inputs, relay output contacts and the programmable LED's.
- Provides relay output conditioning (delay on pick-up/drop-off, dwell time, latching or self-reset).

- Fault Recorder start mapping, i.e. which internal signals initiate a fault record.
- Enables customer specific scheme logic to be generated through the use of the PSL editor inbuilt into the MiCOM S1 support software.

The following section details the default settings of the PSL. Note that changes to these defaults can only be carried out using the PSL editor and not via the relay front-plate.

5.1 Logic input mapping

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

Opto-Input Number	P141 Relay Text	P142 Relay Text	P143 Relay Text
1	L1 Setting Group	L1 Setting Group L1	L1 Setting Group
2	L2 Setting Group	L2 Setting Group L2	L2 Setting Group
3	L3 Block IN1>3 & 4	L3 Block IN1>3 & 4	L3 Block IN1>3 & 4
4	L4 Block I>3 & 4	L4 Block I>3 & 4	L4 Block I>3 & 4
5	L5 Rst LEDs/Lckt	L5 Rst LEDs/Lckt	L5 Reset LEDs
6	L6 External Trip	L6 External Trip	L6 External Trip
7	L7 52-A	L7 CB Healthy	L7 52-A
8	L8 52-B	L8 52-B	L8 52-B
9			L9 Select Auto
10			L10 Sel Telecntl
11			L11 Select Live Line
12			L12 CB Healthy
13			L13 Block AR
14			L14 Reset Lockout
15			L15 Not Mapped
16			L16 Not Mapped

Note: If the "Setting Group" cell in the "CONFIGURATION" column is set to "Select via Opto", the opto's that are used for changing setting groups are always opto's 1 and 2. This mapping is effectively hardwired and does not therefore need to be mapped within the PSL.

5.2 Relay output contact mapping

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

Relay Contact Number	P141 Relay Text	P142 Relay Text	P143 Relay Text
1	R1 IN>/ISEF> Start	R1 IN>/ISEF> Start	R1 IN>/ISEF> Start
2	R2 I> Start	R2 I> Start	R2 I> Start
3	R3 Protn Trip	R3 Protn Trip	R3 Protn Trip
4	R4 General Alarm	R4 General Alarm	R4 General Alarm
5	R5 CB Fail Tmr 1	R5 CB Fail Tmr 1	R5 CB Fail Tmr 1
6	R6 Cntl CB Close	R6 Cntl CB Close	R6 Cntl CB Close
7	R7 Cntl CB Trip	R7 Cntl CB Trip	R7 Cntl CB Trip
8			R8 Any Start
9			R9 AR Successful
10			R10 Non Auto
11			R11 AR In Prog
12			R12 AR Lockout
13			R13 AR In Service
14			R14 Liveline

Note: It is important that the Relay 3 is used for tripping purposes as only this output drives the trip LED on the frontplate. It also feeds into other logic sections that require CB trip information such as the CB fail, autoreclose, condition monitoring etc.

A fault record can be generated by connecting one or a number of contacts to the "Fault Record Trigger" in PSL. It is recommended that the triggering contact be 'self reset' and not a latching. If a latching contact was chosen the fault record would not be generated until the contact had fully reset.

5.3 Relay output conditioning

The default conditioning of each of the output contacts is as shown in the following table:

Relay Contact Number	P141 Relay	P142 Relay	P143 Relay
1	Straight	Straight	Straight
2	Straight	Straight	Straight
3	Dwell 100ms	Dwell 100ms	Dwell 100ms
4	Dwell 500ms	Dwell 500ms	Dwell 500ms
5	Dwell 100ms	Dwell 100ms	Dwell 100ms
6	Straight	Straight	Straight

Relay Contact Number	P141 Relay	P142 Relay	P143 Relay
7	Straight	Straight	Straight
8			Straight
9			Straight
10			Straight
11			Straight
12			Straight
13			Straight
14			Straight

5.4 Programmable LED output mapping

The default mappings for each of the programmable LED's are as shown in the following table:

LED Number	P141 Relay	P142 Relay	P143 Relay
1	E/F Trip	E/F Trip	E/F Trip
2	I>1/2 Trip	I>1/2 Trip	I>1/2 Trip
3	I>3/4 Trip	I>3/4 Trip	I>3/4 Trip
4	Thermal Alarm	A/R In Progress	A/R In Progress
5	Thermal Trip	A/R Lockout	A/R Lockout
6	Any Start	Any Start	Any Start
7	CB Open	CB Open	CB Open
8	CB Closed	CB Closed	CB Closed

5.5 Fault recorder start mapping

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

P141 Relay	P142 Relay	P143 Relay
R3 Protn Trip	R3 Protn Trip	R3 Protn Trip

6. CT/VT REQUIREMENTS

The CT requirements for the Feeder Relays are as shown below.

The current transformer requirements are based on a maximum prospective fault current of 50 times the relay rated current (In) and the relay having an instantaneous setting of 25 times rated current (In). The current transformer requirements are designed to provide operation of all protection elements.

Where the criteria for a specific application are in excess of those detailed above, or the actual lead resistance exceeds the limiting value quoted, the CT requirements may need to be increased according to the formulae in the following sections.

Nominal Rating	Nominal Output	Accuracy Class	Accuracy Limited Factor	Limiting Lead Resistance
1A	2.5VA	10P	20	1.3 ohms
5A	7.5VA	10P	20	0.11 ohms

Separate requirements for Restricted Earth Fault are given in Section 6.6 and 6.7.

6.1 Non-directional definite time/IDMT overcurrent & earth fault protection

6.1.1 Time-delayed phase overcurrent elements

$$V_K \geq I_{cp}/2 * (R_{CT} + R_L + R_{rp})$$

6.1.2 Time-delayed earth fault overcurrent elements

$$V_K \geq I_{cn}/2 * (R_{CT} + 2R_L + R_{rp} + R_{rn})$$

6.2 Non-directional instantaneous overcurrent & earth fault protection

6.2.1 CT requirements for instantaneous phase overcurrent elements

$$V_K \geq I_{sp} \text{ x } (R_{CT} + R_L + R_{rp})$$

6.2.2 CT requirements for instantaneous earth fault overcurrent elements

$$V_K \geq I_{sn} \text{ x } (R_{CT} + 2R_L + R_{rp} + R_{rn})$$

6.3 Directional definite time/IDMT overcurrent & earth fault protection

6.3.1 Time-delayed phase overcurrent elements

$$V_K \geq I_{cp}/2 * (R_{CT} + R_L + R_{rp})$$

6.3.2 Time-delayed earth fault overcurrent elements

$$V_K \geq I_{cn}/2 * (R_{CT} + 2R_L + R_{rp} + R_{rn})$$

6.4 Directional instantaneous overcurrent & earth fault protection

6.4.1 CT requirements for instantaneous phase overcurrent elements

$$V_K \geq I_{fp}/2 * (R_{CT} + R_L + R_{rp})$$

6.4.2 CT requirements for instantaneous earth fault overcurrent elements

$$V_K \geq I_{fn}/2 * (R_{CT} + 2R_L + R_{rp} + R_{rn})$$

6.5 Non-directional/directional definite time/IDMT sensitive earth fault (SEF) protection

6.5.1 Non-directional time delayed SEF protection (residually connected)

$$V_K \geq I_{cn}/2 * (R_{CT} + 2R_L + R_{rp} + R_{rn})$$

6.5.2 Non-directional instantaneous SEF protection (residually connected)

$$V_K \geq I_{sn} \text{ x } (R_{CT} + 2R_L + R_{rp} + R_{rn})$$

6.5.3 Directional time delayed SEF protection (residually connected)

$$V_K \geq I_{cn}/2 \text{ x } (R_{CT} + 2R_L + R_{rp} + R_{rn})$$

6.5.4 Directional instantaneous SEF protection (residually connected)

$$V_K \geq I_{fn}/2 * (R_{CT} + 2R_L + R_{rp} + R_{rn})$$

6.5.5 SEF protection - as fed from a core-balance CT

Core balance current transformers of metering class accuracy are required and should have a limiting secondary voltage satisfying the formulae given below:

Directional/non-directional time delayed element:

$$V_K \geq I_{cn}/2 * (R_{CT} + 2R_L + R_{rn})$$

Directional instantaneous element:

$$V_K \geq I_{fn}/2 * (R_{CT} + 2R_L + R_{rn})$$

Non-directional element:

$$V_K \geq I_{sn} \times (R_{CT} + 2R_L + R_{rn})$$

Note that, in addition, it should be ensured that the phase error of the applied core balance current transformer is less than 90 minutes at 10% of rated current and less than 150 minutes at 1% of rated current.

Abbreviations used in the previous formulae are explained below:-

where

V_K = Required CT knee-point voltage (volts)

I_{fn} = Maximum prospective secondary earth fault current (amps)

I_{fp} = Maximum prospective secondary phase fault current (amps)

I_{cn} = Maximum prospective secondary earth fault current or 31 times I> setting (whichever is lower) (amps)

I_{cp} = Maximum prospective secondary phase fault current or 31 times I> setting (whichever is lower) (amps)

I_{sn} = Stage 2 & 3 earth fault setting (amps)

I_{sp} = Stage 2 and 3 setting (amps)

R_{CT} = Resistance of current transformer secondary winding (ohms)

R_L = Resistance of a single lead from relay to current transformer (ohms)

R_{rp} = Impedance of relay phase current input at 30In (ohms)

R_{rn} = Impedance of the relay neutral current input at 30In (ohms)

6.6 Low impedance restricted earth fault protection

$V_K \geq 24 * In * (R_{CT} + 2R_L)$ for $X/R < 40$ and if $< 15In$

$V_K \geq 48 * In * (R_{CT} + 2R_L)$ for $X/R < 40$, $15In < If < 40In$ and $40 < X/R < 120$, $If < 15In$

where

V_K = Required CT knee point voltage (volts)

I_n = rated secondary current (amps)

R_{CT} = Resistance of current transformer secondary winding (ohms)

R_L = Resistance of a single lead from relay to current transformer (ohms)

If = Maximum through fault current level (amps)

6.7 High impedance restricted earth fault protection

The high impedance restricted earth fault element shall maintain stability for through faults and operate in less than 40ms for internal faults provided the following equations are met:

$$R_{st} = \frac{1.8 \times I_F \; (R_{CT} + 2R_L)}{I_S}$$

$$V_K \geq 4 * I_s * R_{st}$$

where

V_K = Required CT knee-point voltage (volts)

R_{st} = Value of stabilising resistor (ohms)

If = Maximum secondary through fault current level (amps)

V_K = CT knee point voltage (volts)

I_S = Current setting of REF element (amps), (IREF>I_s)

R_{CT} = Resistance of current transformer secondary winding (ohms)

R_L = Resistance of a single lead from relay to current transformer (ohms).

7. COMMISSIONING TEST MENU

To help minimise the time required to test MiCOM relays the relay provides several test facilities under the 'COMMISSION TESTS' menu heading. There are menu cells which allow the status of the opto-isolated inputs, output relay contacts, internal digital data bus (DDB) signals and user-programmable LEDs to be monitored. Additionally there are cells to test the operation of the output contacts, user-programmable LEDs and, where available, the autoreclose cycles.

The following table shows the relay menu of commissioning tests, including the available setting ranges and factory defaults:

Menu Text	Default Setting	Settings
COMMISSION TESTS		
Opto I/P Status	–	–
Relay O/P Status	–	–
Test Port Status	–	–
LED Status	–	–
Monitor Bit 1	64 (LED 1)	0 to 511 See Appendix A for details of Digital data bus signals
Monitor Bit 2	65 (LED 2)	0 to 511

Menu Text	Default Setting	Settings
COMMISSION TESTS		
Monitor Bit 3	66 (LED 3)	0 to 511
Monitor Bit 4	67 (LED 4)	0 to 511
Monitor Bit 5	68 (LED 5)	0 to 511
Monitor Bit 6	69 (LED 6)	0 to 511
Monitor Bit 7	70 (LED 7)	0 to 511
Monitor Bit 8	71 (LED 8)	0 to 511
Test Mode	Disabled	Disabled Test Mode Contacts Blocked
Test Pattern	All bits set to 0	0 = Not Operated 1 = Operated
Contact Test	No Operation	No Operation Apply Test Remove Test
Test LEDs	No Operation	No Operation Apply Test
Test Autoreclose	No Operation	No Operation 3 Pole Test

7.1 Opto I/P status

This menu cell displays the status of the relay's opto-isolated inputs as a binary string, a '1' indicating an energised opto-isolated input and a '0' a de-energised one. If the cursor is moved along the binary numbers the corresponding label text will be displayed for each logic input.

It can be used during commissioning or routine testing to monitor the status of the opto-isolated inputs whilst they are sequentially energised with a suitable dc voltage.

7.2 Relay O/P status

This menu cell displays the status of the digital data bus (DDB) signals that result in energisation of the output relays as a binary string, a '1' indicating an operated state and '0' a non-operated state. If the cursor is moved along the binary numbers the corresponding label text will be displayed for each relay output.

The information displayed can be used during commissioning or routine testing to indicate the status of the output relays when the relay is 'in service'. Additionally fault finding for output relay damage can be performed by comparing the status of the output contact under investigation with it's associated bit.

Note: When the 'Test Mode' cell is set to 'Enabled' this cell will continue to indicate which contacts would operate if the relay was in-service, it does not show the actual status of the output relays.

7.3 Test port status

This menu cell displays the status of the eight digital data bus (DDB) signals that have been allocated in the 'Monitor Bit' cells. If the cursor is moved along the binary numbers the corresponding DDB signal text string will be displayed for each monitor bit.

By using this cell with suitable monitor bit settings, the state of the DDB signals can be displayed as various operating conditions or sequences are applied to the relay. Thus the programmable scheme logic can be tested.

As an alternative to using this cell, the optional monitor/download port test box can be plugged into the monitor/download port located behind the bottom access cover. Details of the monitor/download port test box can be found in section 7.11 of this chapter.

7.4 LED status

The 'LED Status' cell is an eight bit binary string that indicates which of the user-programmable LEDs on the relay are illuminated when accessing the relay from a remote location, a '1' indicating a particular LED is lit and a '0' not lit.

7.5 Monitor bits 1 to 8

The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.

Each 'Monitor Bit' is set by entering the required digital data bus (DDB) signal number (0 – 511) from the list of available DDB signals in Appendix A of this guide. The pins of the monitor/download port used for monitor bits are given in the table below. The signal ground is available on pins 18, 19, 22 and 25.

Monitor bit	1	2	3	4	5	6	7	8
Monitor/download port pin	11	12	15	13	20	21	23	24

THE MONITOR/DOWNLOAD PORT DOES NOT HAVE ELECTRICAL ISOLATED AGAINST INDUCED VOLTAGES ON THE COMMUNICATIONS CHANNEL. IT SHOULD THEREFORE ONLY BE USED FOR LOCAL COMMUNICATIONS.

7.6 Test mode

This menu cell is to allow secondary injection testing to be performed on the relay. It also enables a facility to directly test the output contacts by applying menu controlled test signals. To select test mode the option 'Test Mode' should be selected. This takes the relay out of service causing an alarm condition to be recorded and the yellow 'Out of Service' LED to illuminate. This also freezes any information stored in the CB CONDITION column and in IEC60870-5-103 builds changes the Cause of Transmission, COT, to Test Mode. However the output contacts are still active in this mode. To disable the output contacts in addition to the above select 'Blocked'. Once testing is complete the cell must be set back to 'Disabled' to restore the relay back to service. Test mode can also be selected by energising an opto mapped to the Test Mode signal.

7.7 Test pattern

The 'Test Pattern' cell is used to select the output relay contacts that will be tested when the 'Contact Test' cell is set to 'Apply Test'. The cell has a binary string with one bit for each user-configurable output contact which can be set to '1' to operate the output under test conditions and '0' to not operate it.

7.8 Contact test

When the 'Apply Test' command in this cell is issued the contacts set for operation (set to '1') in the 'Test Pattern' cell change state. After the test has been applied the command text on the LCD will change to 'No Operation' and the contacts will remain in the Test State until reset issuing the 'Remove Test' command. The command text on the LCD will again revert to 'No Operation' after the 'Remove Test' command has been issued.

Note: When the 'Test Mode' cell is set to 'Enabled' the 'Relay O/P Status' cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.

7.9 Test LEDs

When the 'Apply Test' command in this cell is issued the eight user-programmable LEDs will illuminate for approximately 2 seconds before they extinguish and the command text on the LCD reverts to 'No Operation'.

7.10 Test autoreclose

Where the relay provides an autoreclose function, this cell will be available for testing the sequence of circuit breaker trip and autoreclose cycles with the settings applied.

Issuing the command '3 Pole Trip' will cause the relay to perform the first three phase trip/reclose cycle so that associated output contacts can be checked for operation at the correct times during the cycle. Once the trip output has operated the command text will revert to 'No Operation' whilst the rest of the autoreclose cycle is performed. To test subsequent three phase autoreclose cycles repeat the '3 Pole Trip' command.

Note: The factory settings for the relay's programmable scheme logic has the 'AR Trip Test' signal mapped to relay 3. If the programmable scheme logic has been changed, it is essential that this signal remains mapped to relay 3 for the 'Test Autoreclose' facility to work.

7.11 Using a monitor/download port test box

A monitor/download port test box containing 8 LED's and a switchable audible indicator is available from ALSTOM T&D Protection & Control Ltd., or one of their regional sales offices. It is housed in a small plastic box with a 25-pin male D-connector that plugs directly into the relay's monitor/download port. There is also a 25-pin female D-connector which allows other connections to be made to the monitor/download port whilst the monitor/download port test box is in place.

Each LED corresponds to one of the monitor bit pins on the monitor/download port with 'Monitor Bit 1' being on the left hand side when viewing from the front of the relay. The audible indicator can either be selected to sound if a voltage appears on any of the eight monitor pins or remain silent so that indication of state is by LED alone.

CHAPTER 3
Relay Description

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1. RELAY SYSTEM OVERVIEW

1.1 Hardware overview

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

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

1.1.1 Processor board

The processor board performs all calculations for the relay and controls the operation of all other modules within the relay. The processor board also contains and controls the user interfaces (LCD, LEDs, keypad and communication interfaces).

1.1.2 Input module

The input module converts the information contained in the analog and digital input signals into a format suitable for processing by the processor board. The standard input module consists of two boards: a transformer board to provide electrical isolation and a main input board which provides analog to digital conversion and the isolated digital inputs.

1.1.3 Power supply module

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

1.1.4 IRIG-B board

This board, which is optional, can be used where an IRIG-B signal is available to provide an accurate time reference for the relay. There is also an option on this board to specify a fibre optic rear communication port, for use with IEC 60870 communication only.

All modules are connected by a parallel data and address bus which allows the processor board to send and receive information to and from the other modules as required. There is also a separate serial data bus for conveying sample data from the input module to the processor. Figure 1 shows the modules of the relay and the flow of information between them.

1.2 Software overview

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

1.2.1 Real-time operating system

The real time operating system is used to provide a framework for the different parts of the relay's software to operate within. To this end the software is split into tasks.

The real-time operating system is responsible for scheduling the processing of these tasks such that they are carried out in the time available and in the desired order of

Priority. The operating system is also responsible for the exchange of information between tasks, in the form of messages.

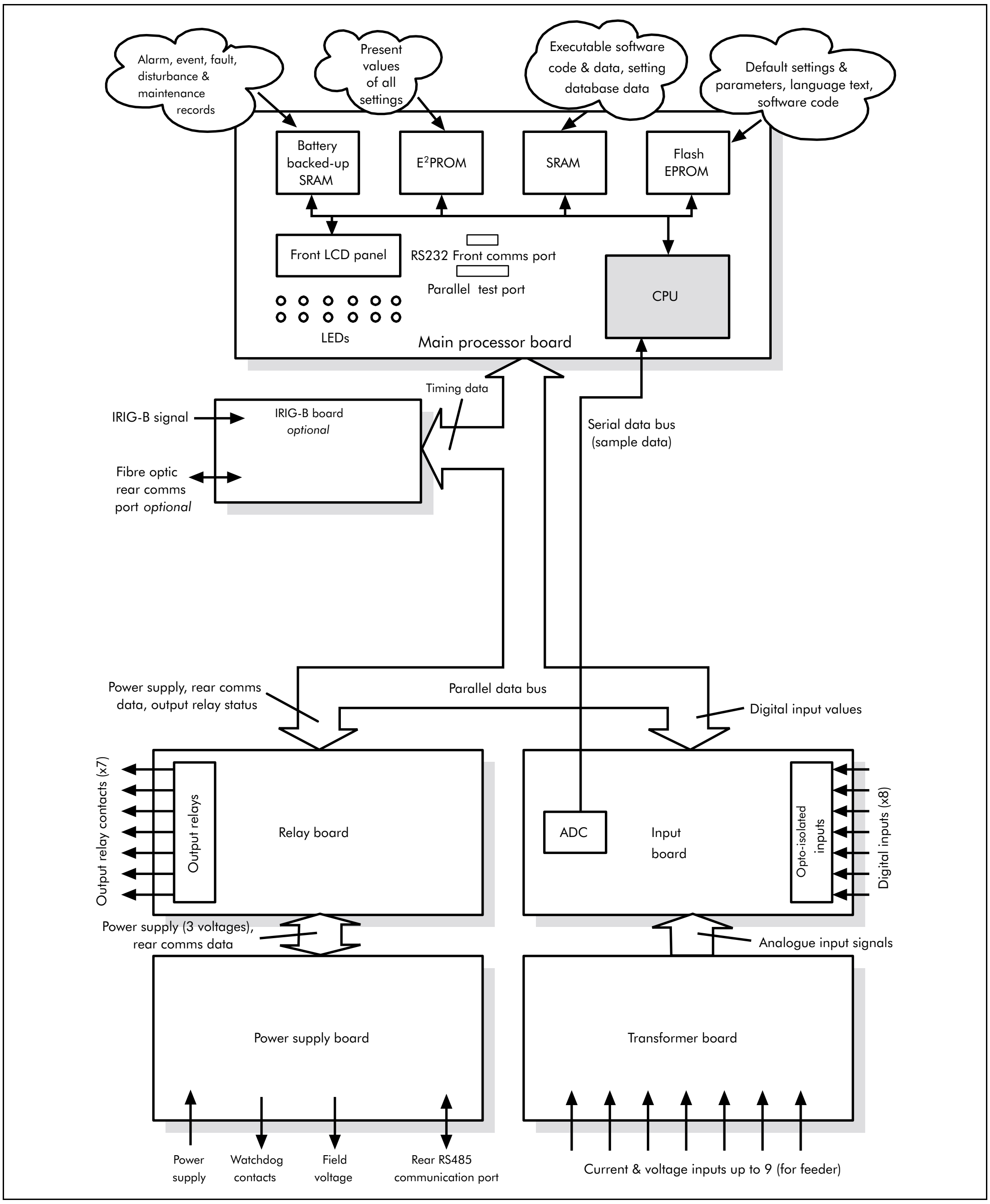

Figure 1: Relay modules and information flow

1.2.2 System services software

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

1.2.3 Platform software

The platform software deals with the management of the relay settings, the user interfaces and logging of event, alarm, fault and maintenance records. All of the relay settings are stored in a database within the relay which provides direct compatibility with Courier communications. For all other interfaces (i.e. the front panel keypad and LCD interface, Modbus and IEC60870-5-103 and DNP3.0) the platform software converts the information from the database into the format required. The platform software notifies the protection & control software of all settings changes and logs data as specified by the protection & control software.

1.2.4 Protection & control software

The protection and control software performs the calculations for all of the protection algorithms of the relay. This includes digital signal processing such as Fourier filtering and ancillary tasks such as the measurements. The protection & control software interfaces with the platform software for settings changes and logging of records, and with the system services software for acquisition of sample data and access to output relays and digital opto-isolated inputs.

1.2.5 Disturbance recorder

The analog values and logic signals are routed from the protection and control software to the disturbance recorder software. This software compresses the data to allow a greater number of records to be stored. The platform software interfaces to the disturbance recorder to allow extraction of the stored records.

2. HARDWARE MODULES

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

2.1 Processor board

The relay is based around a TMS320C32 floating point, 32-bit digital signal processor (DSP) operating at a clock frequency of 20MHz. This processor performs all of the calculations for the relay, including the protection functions, control of the data communication and user interfaces including the operation of the LCD, keypad and LEDs.

The processor board is located directly behind the relay's front panel which allows the LCD and LEDs to be mounted on the processor board along with the front panel communication ports. These comprise the 9-pin D-connector for EIA(RS)232 serial communications (e.g. using MiCOM S1 and Courier communications) and the 25-pin D-connector relay test port for parallel communication. All serial communication is handled using a two-channel 85C30 serial communications controller (SCC).

The memory provided on the main processor board is split into two categories, volatile and non-volatile: the volatile memory is fast access (zero wait state) SRAM which is used for the storage and execution of the processor software, and data storage as required during the processor's calculations. The non-volatile memory is sub-divided into 3 groups: 2MB of flash memory for non-volatile storage of software code and text together with default settings, 256kB of battery backed-up SRAM for the storage of disturbance, event, fault and maintenance record data, and 32kB of E^2PROM memory for the storage of configuration data, including the present setting values.

2.2 Internal communication buses

The relay has two internal buses for the communication of data between different modules. The main bus is a parallel link which is part of a 64-way ribbon cable. The ribbon cable carries the data and address bus signals in addition to control signals and all power supply lines. Operation of the bus is driven by the main processor board which operates as a master while all other modules within the relay are slaves.

The second bus is a serial link which is used exclusively for communicating the digital sample values from the input module to the main processor board. The DSP processor has a built-in serial port which is used to read the sample data from the serial bus. The serial bus is also carried on the 64-way ribbon cable.

2.3 Input module

The input module provides the interface between the relay processor board and the analog and digital signals coming into the relay. The input module consists of two PCBs; the main input board and a transformer board. The P141 and P142 relays provide three voltage inputs and four current inputs. The P143 relay provides an additional voltage input for the check sync function.

2.3.1 Transformer board

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

2.3.2 Input board

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

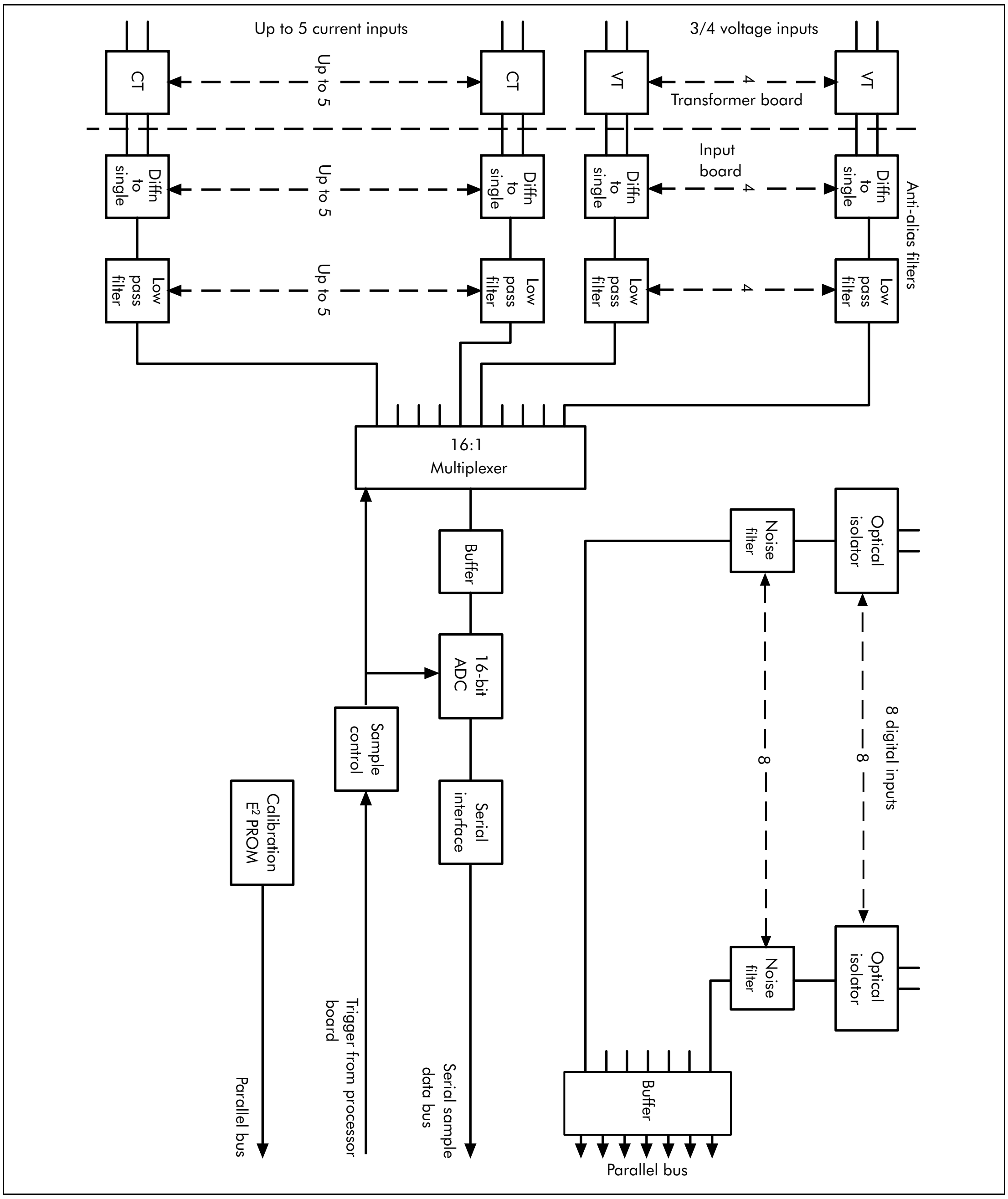

Figure 2: Main input board

The signal multiplexing arrangement provides for 16 analog channels to be sampled. The P140 range of products provide 5 current inputs and either 3 or 4 voltage inputs. 3 spare channels are used to sample 3 different reference voltages for the purpose of continually checking the operation of the multiplexer and the accuracy of the A-D converter. The sample rate is maintained at 24 samples per cycle of the power waveform by a logic control circuit which is driven by the frequency tracking function on the main processor board. The calibration E²PROM holds the calibration coefficients which are used by the processor board to correct for any amplitude or phase errors introduced by the transformers and analog circuitry.

The other function of the input board is to read the state of the signals present on the digital inputs and present this to the parallel data bus for processing. The input board holds 8 optical isolators for the connection of up to eight digital input signals. The opto-isolators are used with the digital signals for the same reason as the transformers with the analog signals; to isolate the relay's electronics from the power system environment. A 48V 'field voltage' supply is provided at the back of the relay for use in driving the digital opto-inputs. The input board provides some hardware filtering of the digital signals to remove unwanted noise before buffering the signals for reading on the parallel data bus. Depending on the relay model, more than 8 digital input signals can be accepted by the relay. This is achieved by the use of an additional opto-board which contains the same provision for 8 isolated digital inputs as the main input board, but does not contain any of the circuits for analog signals which are provided on the main input board.

For the P140 feeder protection relay, the protection task is executed twice per cycle, i.e. after every 12 samples for the sample rate of 24 samples per power cycle used by the relay. Therefore, the time taken to register a change in the state of an opto input can vary between a half to one cycle. The time to register the change of state will depend on if the opto input changes state at the start or end of a protection task cycle with the additional half cycle filtering time.

2.3.3 Universal opto isolated logic inputs

The P140 series relays are fitted with universal opto isolated logic inputs that can be programmed for the nominal battery voltage of the circuit of which they are a part. They nominally provide a Logic 1 or On value for Voltages ≥80% of the set lower nominal voltage and a Logic 0 or Off value for the voltages ≤60% of the set higher nominal voltage. This lower value eliminates fleeting pickups that may occur during a battery earth fault, when stray capacitance may present up to 50% of battery voltage across an input. Each input also has a pre-set filter of ½ cycle which renders the input immune to induced noise on the wiring: although this method is secure it can be slow, particularly for intertripping.

In the Opto Config menu the nominal battery voltage can be selected for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.

The P142 can have an optional expansion card that will increase the number of opto inputs to 16. The P143 can have up to 2 expansion cards that will increase the number of opto inputs to 32.

The P142 can be fitted with an optional expansion card that will give a further 4 inputs and 4 relay outputs (4 I/O Card). This card is not compatible with the P143.

Menu Text	Default Setting	Setting Range		Step Size
		Min	Max	
OPTO CONFIG				
Global Nominal V	24-27	24-27, 30-34, 48-54, 110-125, 220-250, Custom		
Opto Input 1	24-27	24-27, 30-34, 48-54, 110-125, 220-250		
Opto Input 2-32	24-27	24-27, 30-34, 48-54, 110-125, 220-250		

Each opto input also has a pre-set filter of ½ cycle which renders the input immune to induced noise on the wiring; although this method is secure it can be slow, particularly for intertripping.

For the P140 feeder protection relay, the protection task is executed twice per cycle, i.e. after every 12 samples for the sample rate of 24 samples per power cycle used by the relay. Therefore, the time taken to register a change in the state of an opto input can vary between a half to one cycle. The time to register the change of state will depend on if the opto input changes state at the start or end of a protection task cycle with the additional half cycle filtering time.

2.4 Power supply module (including output relays)

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

2.4.1 Power supply board (including EIA(RS)485 communication interface)

One of three different configurations of the power supply board can be fitted to the relay. This will be specified at the time of order and depends on the nature of the supply voltage that will be connected to the relay. The three options are shown in table 1 below.

Nominal dc Range	Nominal ac Range
24/54 V	Dc only
48/125 V	30/1 00 Vrms
110/250 V	100/240 Vrms

Table 1: Power supply options

The output from all versions of the power supply module are used to provide isolated power supply rails to all of the other modules within the relay. Three voltage levels are used within the relay, 5.1V for all of the digital circuits, ±16V for the analog electronics, e.g. on the input board, and 22V for driving the output relay coils. All power supply voltages including the 0V earth line are distributed around the relay via the 64-way ribbon cable. One further voltage level is provided by the power supply board which is the field voltage of 48V. This is brought out to terminals on the back of the relay so that it can be used to drive the optically isolated digital inputs.

The two other functions provided by the power supply board are the EIA(RS)485 communications interface and the watchdog contacts for the relay. The EIA(RS)485 interface is used with the relay's rear communication port to provide communication using one of either Courier, Modbus or IEC60870-5-103 protocols. The EIA(RS)485 hardware supports half-duplex communication and provides optical isolation of the serial data being transmitted and received. All internal communication of data from the power supply board is conducted via the output relay board which is connected to the parallel bus.

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

2.4.2 Output relay board

The output relay board holds seven relays, three with normally open contacts and four with changeover contacts. The relays are driven from the 22V power supply line. The relays' state is written to or read from using the parallel data bus. Depending on the relay model seven additional output contacts may be provided, through the use of up to three extra relay boards.

For relay models with suffix A hardware, only the 7 output relay boards were available. For equivalent relay models in suffix B hardware or greater the base numbers of output contacts is being maintained for compatibility. The 8 output relay board is only used for new relay models or existing relay models available in new case sizes or to provide additional output contacts to existing models for suffix issue B or greater hardware. Note, the model number suffix letter refers to the hardware version.

The relays are driven from the 22V power supply line. The relays' state is written to or read from using the parallel data bus. Depending on the relay model seven additional output contacts may be provided, through the use of up to three extra relay boards.

The P142 can have an optional expansion card that will increase the number of relay outputs to 15. The P143 can have up to 2 expansion cards that will increase the number of relay outputs to 30.

The P142 can be fitted with an optional expansion card that will give a further 4 inputs and 4 relay outputs (4 I/O Card). This card is not compatible with the P143.

2.5 IRIG-B board

The IRIG-B board is an order option which can be fitted to provide an accurate timing reference for the relay. This can be used wherever an IRIG-B signal is available. The IRIG-B signal is connected to the board via a BNC connector on the back of the relay. The timing information is used to synchronise the relay's internal real-time clock to an accuracy of 1ms. The internal clock is then used for the time tagging of the event, fault maintenance and disturbance records.

The IRIG-B board can also be specified with a fibre optic transmitter/receiver which can be used for the rear communication port instead of the EIA(RS)485 electrical connection (IEC60870 only).

2.6 Mechanical layout

The case materials of the relay are constructed from pre-finished steel which has a conductive covering of aluminium and zinc. This provides good earthing at all joints giving a low impedance path to earth which is essential for performance in the presence of external noise. The boards and modules use a multi-point earthing strategy to improve the immunity to external noise and minimise the effect of circuit noise. Ground planes are used on boards to reduce impedance paths and spring clips are used to ground the module metalwork.

Heavy duty terminal blocks are used at the rear of the relay for the current and voltage signal connections. Medium duty terminal blocks are used for the digital logic input signals, the output relay contacts, the power supply and the rear communication port. A BNC connector is used for the optional IRIG-B signal. 9-pin and 25-pin female D-connectors are used at the front of the relay for data communication.

Inside the relay the PCBs plug into the connector blocks at the rear, and can be removed from the front of the relay only. The connector blocks to the relay's CT inputs are provided with internal shorting links inside the relay which will automatically short the current transformer circuits before they are broken when the board is removed.

The front panel consists of a membrane keypad with tactile dome keys, an LCD and 12 LEDs mounted on an aluminium backing plate.

3. RELAY SOFTWARE

The relay software was introduced in the overview of the relay at the start of this chapter. The software can be considered to be made up of four sections:

- the real-time operating system
- the system services software
- the platform software
- the protection & control software

This section describes in detail the latter two of these, the platform software and the protection & control software, which between them control the functional behaviour of the relay. Figure 3 shows the structure of the relay software.

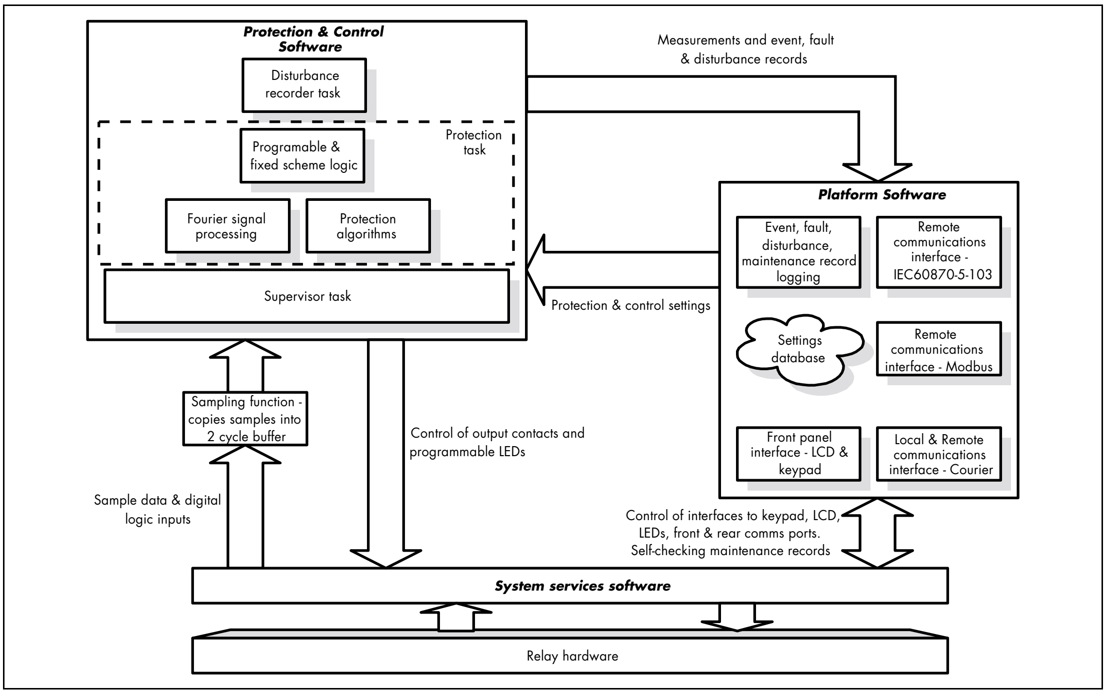

Figure 3: Relay software structure

3.1 Real-time operating system

The software is split into tasks; the real-time operating system is used to schedule the processing of the tasks to ensure that they are processed in the time available and in the desired order of priority. The operating system is also responsible in part for controlling the communication between the software tasks through the use of operating system messages.

3.2 System services software

As shown in figure 3, the system services software provides the interface between the relay's hardware and the higher-level functionality of the platform software and the protection & control software. For example, the system services software provides drivers for items such as the LCD display, the keypad and the remote communication ports, and controls the boot of the processor and downloading of the processor code into SRAM from non-volatile flash EPROM at power up.

3.3 Platform software

The platform software has three main functions:

- to control the logging of records that are generated by the protection software, including alarms and event, fault, and maintenance records.
- to store and maintain a database of all of the relay's settings in non-volatile memory.
- to provide the internal interface between the settings database and each of the relay's user interfaces, i.e. the front panel interface and the front and rear communication ports, using whichever communication protocol has been specified (Courier, Modbus, IEC 60870-5-103 and DNP3.0).

3.3.1 Record logging

The logging function is provided to store all alarms, events, faults and maintenance records. The records for all of these incidents are logged in battery backed-up SRAM in order to provide a non-volatile log of what has happened. The relay maintains four logs: one each for up to 32 alarms, 250 event records, 5 fault records and 5 maintenance records. The logs are maintained such that the oldest record is overwritten with the newest record. The logging function can be initiated from the protection software or the platform software is responsible for logging of a maintenance record in the event of a relay failure. This includes errors that have been detected by the platform software itself or error that are detected by either the system services or the protection software function. See also the section on supervision and diagnostics later in this chapter.

3.3.2 Settings database

The settings database contains all of the settings and data for the relay, including the protection, disturbance recorder and control & support settings. The settings are maintained in non-volatile E^2PROM memory. The platform software's management of the settings database includes the responsibility of ensuring that only one user interface modifies the settings of the database at any one time. This feature is employed to avoid conflict between different parts of the software during a setting change. For changes to protection settings and disturbance recorder settings, the platform software operates a 'scratchpad' in SRAM memory. This allows a number of setting changes to be applied to the protection elements, disturbance recorder and saved in the database in E^2PROM. (See also chapter 1 on the user interface). If a setting change affects the protection & control task, the database advises it of the new values.

3.3.3 Database interface

The other function of the platform software is to implement the relay's internal interface between the database and each of the relay's user interfaces. The database of settings and measurements must be accessible from all of the relay's user interfaces to allow read and modify operations. The platform software presents the data in the appropriate format for each user interface.

3.4 Protection and control software

The protection and control software task is responsible for processing all of the protection elements and measurement functions of the relay. To achieve this it has to communicate with both the system services software and the platform software as well as organise its own operations. The protection software has the highest priority of any of the software tasks in the relay in order to provide the fastest possible protection response. The protection & control software has a supervisor task which controls the start-up of the task and deals with the exchange of messages between the task and the platform software.

3.4.1 Overview - protection and control scheduling

After initialisation at start-up, the protection and control task is suspended until there are sufficient samples available for it to process. The acquisition of samples is controlled by a 'sampling function' which is called by the system services software and takes each set of new samples from the input module and stores them in a two-cycle buffer. The protection and control software resumes execution when the number of unprocessed samples in the buffer reaches a certain number. For the P140 feeder protection relay, the protection task is executed twice per cycle, i.e. after every 12 samples for the sample rate of 24 samples per power cycle used by the relay. The protection and control software is suspended again when all of its processing on a set of samples is complete. This allows operations by other software tasks to take place.

3.4.2 Signal processing

The sampling function provides filtering of the digital input signals from the opto-isolators and frequency tracking of the analog signals. The digital inputs are checked against their previous value over a period of half a cycle. Hence a change in the state of one of the inputs must be maintained over at least half a cycle before it is registered with the protection and control software.

The frequency tracking of the analog input signals is achieved by a recursive Fourier algorithm which is applied to one of the input signals, and works by detecting a change in the measured signal's phase angle. The calculated value of the frequency is used to modify the sample rate being used by the input module so as to achieve a constant sample rate of 24 samples per cycle of the power waveform. The value of the frequency is also stored for use by the protection and control task.

When the protection and control task is re-started by the sampling function, it calculates the Fourier components for the analog signals. The Fourier components are calculated using a one-cycle, 24-sample Discrete Fourier Transform (DFT). The DFT is always calculated using the last cycle of samples from the 2-cycle buffer, i.e. the most recent data is used. The DFT used in this way extracts the power frequency fundamental component from the signal and produces the magnitude and phase angle of the fundamental in rectangular component format. The DFT provides an accurate measurement of the fundamental frequency component, and effective filtering of harmonic frequencies and noise. This performance is achieved in conjunction with the relay input module which provides hardware anti-alias filtering to attenuate frequencies above the half sample rate, and frequency tracking to maintain a sample rate of 24 samples per cycle. The Fourier components of the input current and voltage signals are stored in memory so that they can be accessed by all of the protection elements' algorithms. The samples from the input module are also used in an unprocessed form by the disturbance recorder for waveform recording and to calculate true rms values of current, voltage and power for metering purposes.

3.4.3 Programmable scheme logic

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

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

The execution of the PSL logic is event driven; the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals or a trip output from a protection element. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL. The protection and control software updates the logic delay timers and checks for a change in the PSL input signals every time it runs.

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

3.4.4 Event and fault recording

A change in any digital input signal or protection element output signal causes an event record to be created. When this happens, the protection and control task sends a message to the supervisor task to indicate that an event is available to be processed and writes the event data to a fast buffer in SRAM which is controlled by the supervisor task. When the supervisor task receives either an event or fault record message, it instructs the platform software to create the appropriate log in battery backed-up SRAM. The operation of the record logging to battery backed-up SRAM is slower than the supervisor's buffer. This means that the protection software is not delayed waiting for the records to be logged by the platform software. However, in the rare case when a large number of records to be logged are created in a short period of time, it is possible that some will be lost if the supervisor's buffer is full before the platform software is able to create a new log in battery backed-up SRAM. If this occurs then an event is logged to indicate this loss of information.

3.4.5 Disturbance recorder

The disturbance recorder operates as a separate task from the protection and control task. It can record the waveforms for up to 8 analog channels and the values of up to 32 digital signals. The recording time is user selectable up to a maximum of 10 seconds. The disturbance recorder is supplied with data by the protection and control task once per cycle. The disturbance recorder collates the data that it receives into the required length disturbance record. It attempts to limit the demands it places on memory space by saving the analog data in compressed format whenever possible. This is done by detecting changes in the analog input signals and compressing the recording of the waveform when it is in a steady-state condition. The compressed disturbance records can be decompressed by MiCOM S1 which can also store the data in COMTRADE format, thus allowing the use of other packages to view the recorded data.

3.4.6 Fault locator

The fault locator task is also separate from the protection and control task. The fault locator is invoked by the protection and control task when a fault is detected. The fault locator uses a 12-cycle buffer of the analog input signals and returns the calculated location of the fault to the protection and control task which includes it in the fault record for the fault. When the fault record is complete (i.e. includes the fault location), the protection and control task can send a message to the supervisor task to log the fault record.

4. SELF TESTING & DIAGNOSTICS

The relay includes a number of self-monitoring functions to check the operation of its hardware and software when it is in service. These are included so that if an error or fault occurs within the relay's hardware or software, the relay is able to detect and report the problem and attempt to resolve it by performing a re-boot. This involves the relay being out of service for a short period of time which is indicated by the 'Healthy' LED on the front of the relay being extinguished and the watchdog contact at the rear operating. If the restart fails to resolve the problem, then the relay will take itself permanently out of service. Again this will be indicated by the LED and watchdog contact.

If a problem is detected by the self-monitoring functions, the relay attempts to store a maintenance record in battery backed-up SRAM to allow the nature of the problem to be notified to the user.

The self-monitoring is implemented in two stages: firstly a thorough diagnostic check which is performed when the relay is booted-up, e.g. at power-on, and secondly a continuous self-checking operation which checks the operation of the relay's critical functions whilst it is in service.

4.1 Start-up self-testing

The self-testing which is carried out when the relay is started takes a few seconds to complete, during which time the relay's protection is unavailable. This is signalled by the 'Healthy' LED on the front of the relay which will illuminate when the relay has passed all of the tests and entered operation. If the testing detects a problem, the relay will remain out of service until it is manually restored to working order.

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

4.1.1 System boot

The integrity of the flash EPROM memory is verified using a checksum before the program code and data stored in it is copied into SRAM to be used for execution by the processor. When the copy has been completed the data then held in SRAM is compared to that in the flash EPROM to ensure that the two are the same and that no errors have occurred in the transfer of data from flash EPROM to SRAM. The entry point of the software code in SRAM is then called which is the relay initialisation code.

4.1.2 Initialisation software

The initialisation process includes the operations of initialising the processor registers and interrupts, starting the watchdog timers (used by the hardware to determine whether the software is still running), starting the real-time operating system and creating and starting the supervisor task. In the course of the initialisation process the relay checks:

- the status of the battery.
- the integrity of the battery backed-up SRAM that is used to store event, fault and disturbance records.
- the voltage level of the field voltage supply which is used to drive the opto-isolated inputs.

- the operation of the LCD controller.
- the watchdog operation.

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

4.1.3 Platform software initialisation & monitoring

In starting the platform software, the relay checks the integrity of the data held in E^2PROM with a checksum, the operation of the real-time clock, and the IRIG-B board if fitted. The final test that is made concerns the input and output of data; the presence and healthy condition of the input board is checked and the analog data acquisition system is checked through sampling the reference voltage.

At the successful conclusion of all of these tests the relay is entered into service and the protection started-up.

4.2 Continuous self-testing

When the relay is in service, it continually checks the operation of the critical parts of its hardware and software. The checking is carried out by the system services software (see section on relay software earlier in this chapter) and the results reported to the platform software. The functions that are checked are as follows:

- the flash EPROM containing all program code and language text is verified by a checksum.
- the code and constant data held in SRAM is checked against the corresponding data in flash EPROM to check for data corruption.
- the SRAM containing all data other than the code and constant data is verified with a checksum.
- the E^2PROM containing setting values is verified by a checksum.
- the battery status.
- the level of the field voltage.
- the integrity of the digital signal I/O data from the opto-isolated inputs and the relay contacts is checked by the data acquisition function every time it is executed. The operation of the analog data acquisition system is continuously checked by the acquisition function every time it is executed, by means of sampling the reference voltages.
- the operation of the IRIG-B board is checked, where it is fitted, by the software that reads the time and date from the board.

In the unlikely event that one of the checks detects an error within the relay's subsystems, the platform software is notified and it will attempt to log a maintenance record in battery backed-up SRAM. If the problem is with the battery status or the IRIG-B board, the relay will continue in operation. However, for problems detected in any other area the relay will initiate a shutdown and re-boot. This will result in a period of up to 5 seconds when the protection is unavailable, but the complete restart of the relay including all initialisations should clear most problems that could occur. As described above, an integral part of the start-up procedure is a thorough diagnostic self-check. If this detects the same problem that caused the relay to restart, i.e. the restart has not cleared the problem, then the relay will take itself permanently out of service. This is indicated by the 'Healthy' LED on the front of the relay, which will extinguish, and the watchdog contact which will operate.

CHAPTER 4
Technical Data

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1. RATINGS

1.1 Currents

f_n = 1A or 5A ac rms.

Separate terminals are provided for the 1A and 5A windings, with the neutral input of each winding sharing one terminal.

CT Type	Linear Range
Standard	0 to 64fn
Sensitive	0 to 2fn

Duration	Withstand
Continuous rating	4 In
10 minutes	4.5 In
5 minutes	5 In
3 minutes	6 In
2 minutes	7 In
10 seconds	30 In
3 seconds	50 In
1 second	100 In

1.2 Voltages

Maximum rated voltage relate to earth 300Vdc or 300Vrms.

Nominal Voltage Vn	Short Term Above Vn
100 – 120$V_{ph\text{ - }ph}$ rms	0 to 200$V_{ph\text{ - }ph}$ rms
380 – 480$V_{ph\text{ - }ph}$ rms	0 to 800$V_{ph\text{ - }ph}$ rms

Duration	Withstand (Vn = 100/120V)	Withstand (Vn = 380/480V)
Continuous (2Vn)	240$V_{ph\text{ - }ph}$ rms	880$V_{ph\text{ - }ph}$ rms
10 seconds (2.6Vn)	312$V_{ph\text{ - }ph}$ rms	1144$V_{ph\text{ - }ph}$ rms

1.3 Auxiliary voltage

The relay is available in three auxiliary voltage versions, these are specified in the table below:

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

** rated for ac or dc operation.

1.4 Frequency

The nominal frequency (Fn) is dual rated at 50 – 60Hz, the operate range is 45Hz – 65Hz.

1.5 'Universal' logic inputs (P140 range)

The P140 series relays are fitted with universal opto isolated logic inputs that can be programmed for the nominal battery voltage of the circuit of which they are a part. They nominally provide a Logic 1 or On value for Voltages ≥80% of the set lower nominal voltage and a Logic 0 or Off value for the voltages ≤60% of the set higher nominal voltage. This lower value eliminates fleeting pickups that may occur during a battery earth fault, when stray capacitance may present up to 50% of battery voltage across an input. Each input also has a pre-set filter of ½ cycle which renders the input immune to induced noise on the wiring.

In the "Opto Config" menu the nominal battery voltage can be selected for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can be individually set to a nominal voltage value.

Menu Text	Default Setting	Setting Range		Step Size
		Min	Max	
OPTO CONFIG				
Global Nominal V	24-27	24-27, 30-34, 48-54, 110-125, 220-250, Custom		
Opto Input 1	24-27	24-27, 30-34, 48-54, 110-125, 220-250		
Opto Input 2-32	24-27	24-27, 30-34, 48-54, 110-125, 220-250		

Battery Voltage (V dc)	Logical "off" (V dc)	Logical "on" (V dc)
24/27	<16.2	>19.2
30/34	<20.4	>24
48/54	<32.4	>38.4
110/125	<75	>88
220/250	<150	>176

All the logic inputs are independent and isolated. Relay types P141 and P142 have a base number of 8 opto inputs and relay type P143 has a base number of 16 opto inputs. One optional board can be added to the P142 to increase its number of opto inputs, the boards available are the 8 opto input board or 8 output contact board or 4 opto input+4 output contact board. Two optional boards can be added to the P143 to increase its number of opto inputs, the boards available are the 8 opto input board or 8 output contact board.

1.6 Output relay contacts

There are 2 versions of the output relay board one with seven relays, three normally open contacts and four changeover contacts and one with eight relays, two normally open contacts and six changeover contacts.

For relay models with suffix A hardware, only the 7 output relay boards were available. For equivalent relay models in suffix B hardware or greater the base numbers of output contacts is being maintained for compatibility. The 8 output relay board is only used for new relay models or existing relay models available in new case sizes or to provide additional output contacts to existing models for suffix issue B or greater hardware. Note, the model number suffix letter refers to the hardware version.

Relay types P141 and P142 have a base number of 7 relay contacts. Relay type P143 has a base number of 14 relay output contacts. One optional board can be added to the P142 to increase its number of output contacts, the boards available are the 8 opto input board or 8 output contact board or 4 opto input+4 output contact board. Two optional boards can be added to the P143 to increase its number of output contacts, the boards available are the 8 opto input board or 8 output contact board.

Make & Carry	30A for 3s
Carry	250A for 30ms 10A continuous
Break	dc: 50W resistive dc: 62.5W inductive (L/R = 50ms) ac: 2500VA resistive (pf=1) ac: 2500VA inductive (pf=0.7)
Maxima:	10A and 300V
Loaded Contact:	10,000 operation minimum
Unloaded Contact:	100,000 operations minimum

Watchdog Contact	
Break	dc: 30W resistive dc: 15W inductive (L/R = 40ms) ac: 375VA inductive (P.F. = 0.7)

1.7 Field voltage

The field voltage provided by the relay is nominally 48V dc with a current limit of 112mA. The operating range shall be 40V to 60V with an alarm raised at <35V (±5%).

1.8 Loop through connections

Terminals D17 – D18 are internally connected together for convenience when wiring, maxima 5A and 300V.

1.9 Wiring requirements

The requirements for the wiring of the relay and cable specifications are detailed in the installation section of the Operation Guide (Volume 2 Chapter 2).

2. BURDENS

2.1 Current circuit

CT burden (At Nominal Current)	
Phase	<0.15 VA
Earth	<0.2VA

2.2 Voltage circuit

Reference Voltage (Vn)	
Vn = 100 – 120V	<0.02VA rms at 110V
Vn = 380 – 480V	<0.02VA rms at 440V

2.3 Auxiliary supply

Case Size	Minimum*
Size 8 /40TE	11W or 24 VA
Size 12 /60TE	11W or 24 VA

* no output contacts or optos energised

Each additional energised opto input	0.09W (24/27, 30/34, 48/54V)
Each additional energised opto input	0.12W (110/125V)
Each additional energised opto input	0.19W (220/250V)
Each additional energised output relay	0.13W

2.4 Optically-isolated inputs

Peak current of opto input when energised is 3.5mA (0→300V) maximum input voltage 300Vdc (any setting).

3. ACCURACY

For all accuracy's specified, the repeatability is ±2.5% unless otherwise specified.

If no range is specified for the validity of the accuracy, then the specified accuracy is valid over the full setting range.

3.1 Reference conditions

Quantity	Reference Conditions	Test Tolerance
General		
Ambient temperature	20 °C	±2°C
Atmospheric pressure	86kPa to 106kPa	–
Relative humidity	45 to 75 %	–
Input energising quantity		
Current	In	±5%
Voltage	Vn	±5%
Frequency	50 or 60Hz	±0.5%
Auxiliary supply	DC 48V or 110V AC 63.5V or 110V	±5%
Settings	Reference value	
Time multiplier setting	1.0	
Time dial	7	
Phase angle	0°	

3.2 Influencing quantities

No additional errors will be incurred for any of the following influencing quantities:

Quantity	Operative Range (Typical Only)
Environmental	
Temperature	–25°C to +55°C
Mechanical (Vibration, Shock, Bump, Seismic)	According to IEC 60255-21-1:198 IEC 60255-21-2:1988 IEC 60255-21-3:1995
Quantity	Operative range
Electrical	
Frequency	45 Hz to 65 Hz
Harmonics (single)	5% over the range 2nd to 17th
Auxiliary voltage range	0.8 LV to 1.2 HV (dc) 0.8 LV to 1.1 HV (ac)
Aux. supply ripple	12% Vn with a frequency of 2.fn
Point on wave of fault waveform	0 to 360°
DC offset of fault waveform	No offset to fully offset
Phase angle	–90° to + 90°
Magnetising inrush	No operation with OC elements set to 35% of peak anticipated inrush level.

4. HIGH VOLTAGE WITHSTAND

4.1 Dielectric withstand

IEC60255-5: 2000

2.0kVrms for one minute between all terminals and case earth.

2.0kVrms for one minute between all terminals of each independent circuit grouped together, and all other terminals. This includes the output contacts and loop through connections D17/D18.

1.5kVrms for one minute across dedicated normally open contacts of output relays.

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

4.2 Impulse

IEC60255-5:1997

The product will withstand without damage impulses of 5kV peak, 1.2/50μs, 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.

4.3 Insulation resistance

IEC60255-5:1997

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

4.4 ANSI dielectric withstand

ANSI/IEEE C37.90. (1989) (Reaff. 1994)

1kV rms. for 1 minute across open contacts of the watchdog contacts.

1kV rms. for 1 minute across open contacts of changeover output contacts.

1.5kV rms. for 1 minute across normally open output contacts.

5. ELECTRICAL ENVIRONMENT

5.1 Performance criteria

The following three classes of performance criteria are used within sections 4.2 to 4.12 (where applicable) 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.

5.1.1 Class A

During the testing the relay will not maloperate, upon completion of the testing the relay will function as specified. A maloperation will include a transient operation of the output contacts, operation of the watchdog contacts, reset of any of the relays microprocessors or an alarm indication.

The relay communications and IRIG-B signal must continue uncorrupted via the communications ports and IRIG-B port respectively during the test, however relay communications and the IRIG-B signal may be momentarily interrupted during the tests, provided that they recover with no external intervention.

5.1.2 Class B

During the testing the relay will not maloperate, upon completion of the testing the relay will function as specified. A maloperation will include a transient operation of the output contacts, operation of the watchdog contacts, reset of any of the relays microprocessors or an alarm indication. A transitory operation of the output LEDs is acceptable provided no permanent false indications are recorded.

The relay communications and IRIG-B signal must continue uncorrupted via the communications ports and IRIG-B port respectively during the test, however relay communications and the IRIG-B signal may be momentarily interrupted during the tests, provided that they recover with no external intervention.

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

5.2 Auxiliary supply tests, dc interruption, etc.

5.2.1 DC voltage interruptions

IEC 60255-11:1979.

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

Performance criteria - Class A.

DC Auxiliary Supply Interruptions 50, 100, 200ms, 40s.

Performance criteria - Class C.

5.2.2 DC voltage fluctuations

IEC 60255-11:1979.

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

Performance criteria - Class A.

5.3 AC voltage dips and short interruptions

5.3.1 AC voltage short interruptions

IEC 61000-4-11:1994.

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

Performance criteria - Class A.

AC Auxiliary Supply Interruptions 50, 100, 200ms, 1s, 40s.

Performance criteria - Class C.

5.3.2 AC voltage dips

IEC 61000-4-11:1994

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

Performance criteria –Class A.

AC Auxiliary Supply 100% Voltage Dips 50, 100, 200ms, 1s, 40s.

Performance criteria - Class C.

AC Auxiliary Supply 60% Voltage Dips 2, 5, 10, 20ms.

Performance criteria - Class A.

AC Auxiliary Supply 60% Voltage Dips 50, 100, 200ms, 1s, 40s.

Performance criteria - Class C.

AC Auxiliary Supply 30% Voltage Dips 2, 5, 10, 20ms.

Performance criteria - Class A.

AC Auxiliary Supply 30% Voltage Dips 50, 100, 200ms, 1s, 40s.

Performance criteria - Class C.

5.4 High frequency disturbance

IEC 60255-22-1:1988 Class III.

1MHz burst disturbance test.

2.5kV common mode.

Power supply, field voltage, CTs, VTs, opto inputs, output contacts, IRIG-B and terminal block communications connections.

1kV differential mode.

Power supply, field voltage, CTs, VTs, opto inputs and output contacts.

Performance criteria Class A.

5.5 Fast transients

IEC 60255-22-4:1992 (EN 61000-4-4:1995), Class III and Class IV.

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

Power supply, field voltage, opto inputs, output contacts, CTs, VTs.

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

IRIG-B and terminal block communications connections.

Performance criteria Class A.

5.6 Conducted/radiated emissions

5.6.1 Conducted emissions

EN 55011:1998 Class A, EN 55022:1994 Class A.

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

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

5.6.2 Radiated emissions

EN 55011:1998 Class A, EN 55022:1994 Class A.

30 - 230MHz, 40dBµV/m at 10m measurement distance.
230 - 1000MHz, 47dBµV/m at 10m measurement distance.

5.7 Conducted/radiated immunity

5.7.1 Conducted immunity

EN 61000-4-6:1996 Level 3.

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

Performance criteria Class A.

5.7.2 Radiated immunity

IEC 60255-22-3:1989 Class III (EN 61000-4-3: 1997 Level 3).

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

Spot tests at 80MHz, 160MHz, 450MHz, 900MHz.

Performance criteria Class A.

5.7.3 Radiated immunity from digital radio telephones

ENV 50204:1995

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

Performance criteria Class A.

5.8 Electrostatic discharge

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

Class 4: 15kV air discharge.
Class 3: 6kV contact discharge.
Tests carried out both with and without cover fitted.

Performance criteria Class A.

5.9 Surge immunity

IEC 61000-4-5:1995 Level 4.

4kV common mode 12Ω source impedance, 2kV differential mode 2Ω source impedance.

Power supply, field voltage, VTs.

The CT inputs are immune to all levels of common mode surge as per IEC 61000-4-5: 1995 Level 4. Total immunity to differential surges to Level 4 can be achieved by adding a time delay of at least 20ms. Note, routing the CT wires as a pair reduces the likelihood of a differential surge.

4kV common mode 42Ω source impedance, 2kV differential mode 42Ω source impedance.

Opto inputs, output contacts.

4kV common mode 2Ω source impedance applied to cable screen.

Terminal block communications connections and IRIG-B.

Performance criteria Class A under reference conditions.

5.10 Power frequency magnetic field

IEC 61000-4-8:1994 Level 5.

100A/m field applied continuously in all planes for the EUT in a quiescent state and tripping state

1000A/m field applied for 3s in all planes for the EUT in a quiescent state and tripping state

Performance criteria Class A.

5.11 Power frequency interference

NGTS* 2.13 Issue 3 April 1998, section 5.5.6.9.

500V rms. common mode.
250V rms. differential mode.

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

Performance criteria Class A.

* National Grid Technical Specification

5.12 Surge withstand capability (SWC)

ANSI/IEEE C37.90.1 (1990) (Reaff. 1994)

Oscillatory SWC Test

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

Fast Transient SWC Tests

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

Performance criteria Class A

5.13 Radiated immunity

ANSI/IEEE C37.90.2 1995

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

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

Performance criteria Class A.

6. ATMOSPHERIC ENVIRONMENT

6.1 Temperature

IEC 60068-2-1:1990/A2:1994 - Cold

IEC 60068-2-2:1974/A2:1994 - Dry heat

IEC 60255-6:1988

Operating Temperature Range °C (Time Period in Hours)		Storage Temperature Range °C (Time Period in Hours)	
Cold Temperature	Dry Heat Temperature	Cold Temperature	Dry Heat Temperature
-25 (96)	55 (96)	-25 (96)	70 (96)

6.2 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.

6.3 Enclosure protection

IEC 60529:1989

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 3mm/minute for 2.5 minutes.

7. MECHANICAL ENVIRONMENT

7.1 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.

7.1.1 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.

7.1.2 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 (g_n)	Number of Sweeps in Each Axis	Frequency Range (Hz)
2	0.075	1	1	10 – 150

Vibration endurance

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

7.1.3 Shock and bump

IEC 60255-21-2:1988

IEC 60255-21-2:1988

Type of Test	Severity Class	Peak Acceleration (g_n)	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

7.1.4 Seismic

IEC 60255-21-3:1995

Cross over frequency - 8 to 9Hz

x = horizontal axis, y = vertical axis

Severity Class	Peak Displacement Below Cross Over Frequency (mm)		Peak Acceleration Above Cross Over Frequency (g_n)		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

8. EC EMC COMPLIANCE

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

The Competent Body has issued a Technical Certificate and a Declaration of Conformity has been completed.

The following Generic Standards used to establish conformity:

EN 50081-2:1994

EN 50082-2:1995

9. EC LVD COMPLIANCE

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

EN 61010-1:1993/A2: 1995

EN 60950:1992/A11: 1997

10. PROTECTION FUNCTIONS

The following functional claims are applicable to the P140 range of feeder management relays. Note however that not all the protection functions listed below are applicable to every relay.

10.1 Three phase non-directional/directional overcurrent protection (50/51) (67)

10.1.1 Setting ranges

Setting	Stage	Range	Step Size
I>1 Current Set	1st Stage	0.08 - 4.0In	0.01In
I>2 Current Set	2nd Stage	0.08 - 4.0IIn	0.01In
I>3 Current Set	3rd Stage	0.08 - 32In	0.01In
I>4 Current Set	4th Stage	0.08 - 32In	0.01In

Directional overcurrent settings:

	Range	Step Size
Relay characteristic angle	-95° to +95°	1

The directional elements polarising is fixed and uses a cross polarised quantity, if the polarising voltage falls to less than 0.5V synchronous memory polarising is available for 3.2s.

10.1.2 Time delay settings

Each overcurrent element has an independent time setting and each time delay is capable of being blocked by an optically isolated input:

Element	Time Delay Type
1st Stage	Definite Time (DT) or IDMT
2nd Stage	DT or IDMT
3rd Stage	DT
4th Stage	DT

Curve Type	Reset Time Delay
IEC / UK curves	DT only
All other	IDMT or DT

10.1.3 Transient overreach and overshoot

10.1.3.1 Accuracy

Additional tolerance due to increasing X/R ratios	±5% over the X/R ratio of 1 to 90
Overshoot of overcurrent elements	<30ms

10.2 Inverse time (IDMT) characteristic

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

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

$$t = T \times \left(\frac{\beta}{(M^{\alpha} - 1)} + L \right)$$

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

$$t = TD \times \left(\frac{\beta}{(M^{\alpha} - 1)} + L \right)$$

where

t = operation time

β = constant

K = constant

I = measured current

I_S = current threshold setting

α = constant

L = ANSI/IEEE constant (zero for IEC/UK curves)

T = Time multiplier setting for IEC/UK curves

TD = Time dial setting for IEEE/US curves

IDMT characteristics

IDMT Curve Description	Standard	β Constant	α Constant	L Constant
Standard inverse	IEC	0.14	0.02	0
Very inverse	IEC	13.5	1	0
Extremely inverse	IEC	80	2	0
Long time inverse	UK	120	1	0
Rectifier	UK	45900	5.6	0
Moderately inverse	IEEE	0.0515	0.02	0.114
Very inverse	IEEE	19.61	2	0.491
Extremely inverse	IEEE	28.2	2	0.1217
Inverse	US-C08	5.95	2	0.18
Short time inverse	US-C02	0.16758	0.02	0.11858

The IEC extremely inverse curve becomes definite time at currents greater than 20 x setting. The IEC standard, very and long time inverse curves become definite time at currents greater than 30 x setting. The rectifier curve becomes definite time at currents greater than 8 x setting.

10.2.1 Time multiplier settings for IEC/UK curves

Name	Range	Step Size
TMS	0.025 to 1.2	0.025

10.2.2 Time dial settings for IEEE/US curves

Name	Range	Step Size
TD	0.01 to 100	100

10.2.3 Definite time characteristic

Element	Range	Step Size
All stages	0 to 100s	10ms

10.2.4 Reset characteristics

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

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

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

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

All inverse reset curves conform to the following formula:

$$tRESET = \frac{TD \times S}{(1 - M^2)} \text{ in seconds}$$

Where

S = Constant

M = I / Is

TD = Time Dial Setting (Same setting as that employed by IDMT curve)

Curve Description	Standard	S Constant
Moderately Inverse	IEEE	4.85
Very Inverse	IEEE	21.6
Extremely Inverse	IEEE	29.1
Inverse	US	5.95
Short Time Inverse	US	2.261

Inverse Reset Characteristics

10.2.5 RI curve

The RI curve (electromechanical) has been included in the first and second stage characteristic setting options for Phase Overcurrent and both Earth Fault 1 and Earth Fault 2 protections. The curve is represented by the following equation:

$$t = K \times \left(\frac{1}{0.339 - \left(0.236/_{M} \right)} \right) \text{ in seconds}$$

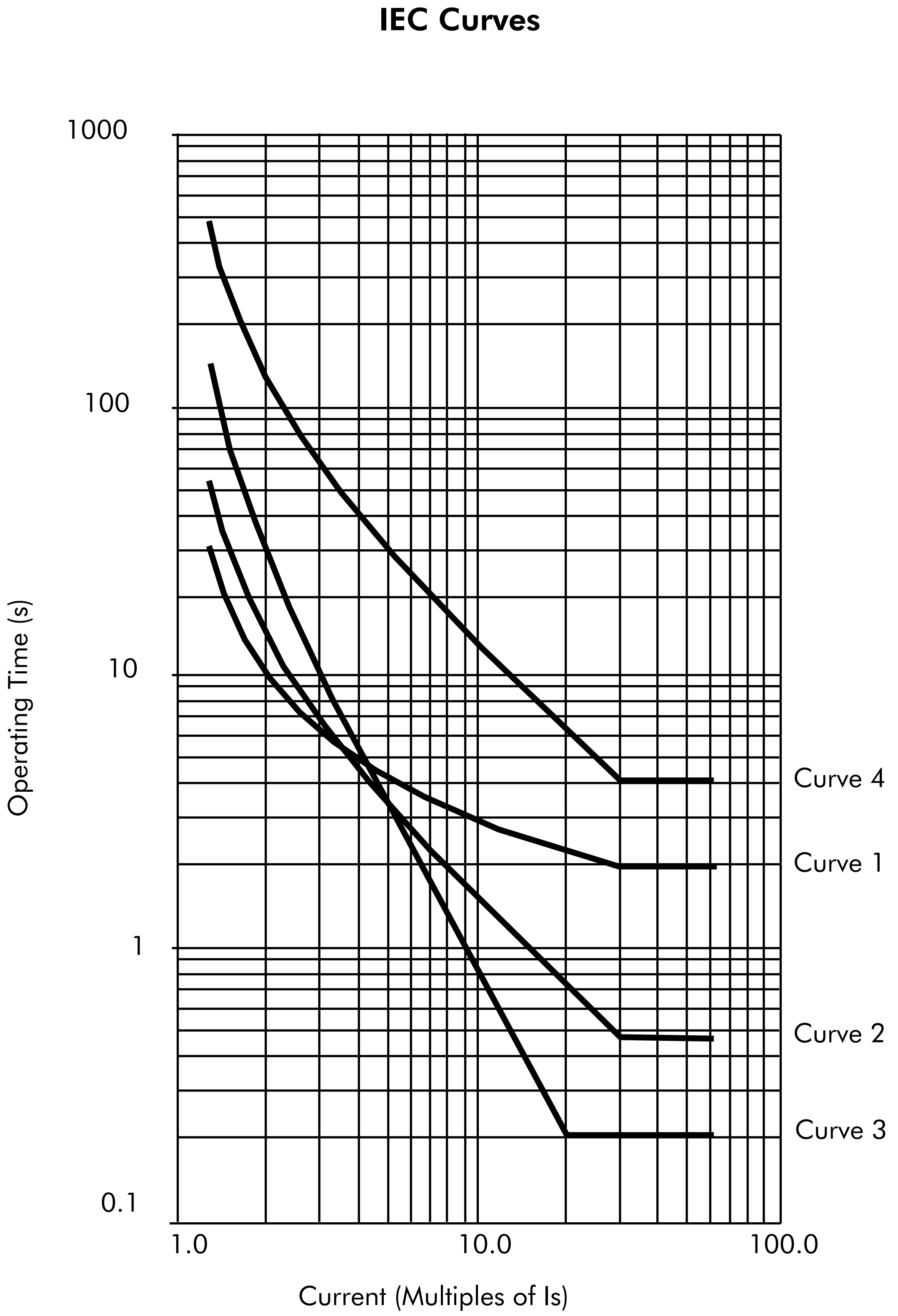
With K adjustable from 0.1 to 10 in steps of 0.05

10.2.6 Accuracy

Pick-up		Setting ±5%
Drop-off		0.95 x Setting ±5%
Minimum trip level of IDMT elements		1.05 x Setting ±5%
IDMT characteristic shape		±5% or 40ms whichever is greater (under reference conditions)*
IEEE reset		±5% or 40ms whichever is greater
DT operation		±2% or 40ms whichever is greater
DT reset		±5%
Directional boundary accuracy (RCA ±90°)		±2° hysteresis 2°
Characteristic	UK curves	IEC 60255-3 – 1998
	US curves	IEEE C37.112 – 1996

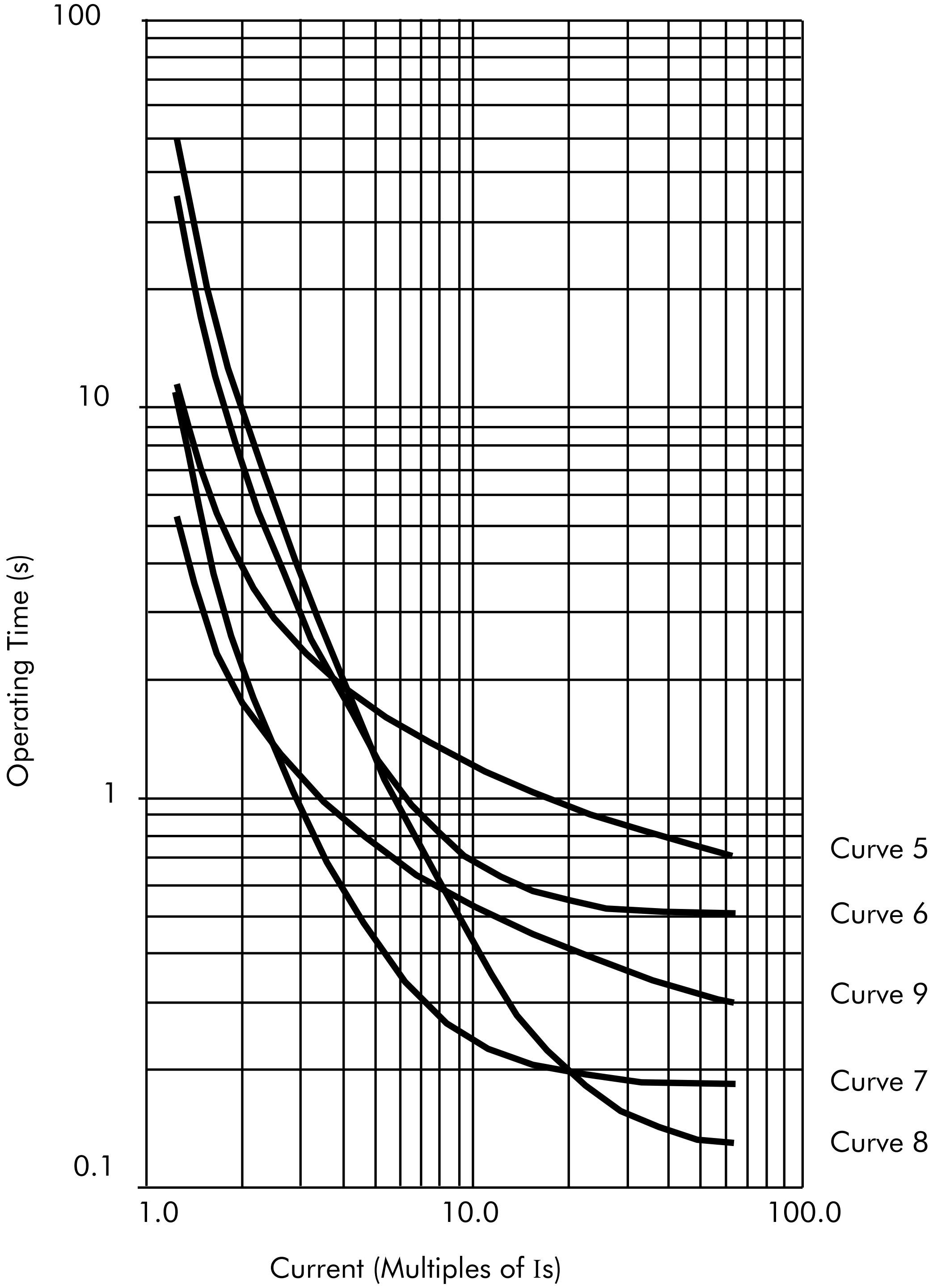
Reference conditions TMS=1, TD=7 and I> setting of 1A, operating range 2-20In

10.2.7 IEC curves



Curve 1	Standard inverse
Curve 2	Very inverse
Curve 3	Extremely inverse
Curve 4	UK long time inverse

Amercian Curves



Curve 5	IEEE moderately inverse
Curve 6	IEEE very inverse
Curve 7	IEEE extremely inverse
Curve 8	US inverse
Curve 9	US short time inverse

10.3 Earth fault & sensitive earth fault protection (50N/51N) (67N) (64)

There are two standard earth fault elements, Earth Fault 1 uses measured quantities, Earth Fault 2 uses derived quantities.

10.3.1 Setting ranges

10.3.1.1 Earth fault, sensitive earth fault

		Range	Step Size
Earth Fault 1	IN1>1 Current Set	0.08 - 4.0In	0.01In
(Measured)	IN1>2 Current Set	0.08 - 4.0In	0.01In
	IN1>3 Current Set	0.08 - 32In	0.01In
	IN1>4 Current Set	0.08 - 32In	0.01In
Earth Fault 2	IN2>1 Current Set	0.08 - 4.0In	0.01In
(Derived)	IN2>2 Current Set	0.08 - 4.0In	0.01In
	IN2>3 Current Set	0.08 - 32In	0.01In
	IN2>4 Current Set	0.08 - 32In	0.01In
Sensitive Earth Fault	ISEF>1 Current Set	0.005 - 0.1In	0.00025In
(Measured)	ISEF>2 Current Set	0.005 - 0.1In	0.00025In
	ISEF>3 Current Set	0.005 - 0.8In	0.001In
	ISEF>4 Current Set	0.005 - 0.8In	0.001In

10.3.1.2 Polarising quantities for earth fault measuring elements

The polarising quantity for earth fault elements can be either zero sequence or negative sequence values. This can be set independently set for Earth Fault 1 and Earth Fault 2.

Characteristic angle settings

Setting	Range	Step Size
IN1> Char angle	-95° to +95°	1°
IN2> Char angle	-95° to +95°	1°
ISEF> Char angle	-95° to +95°	1°

Zero sequence voltage polarisation

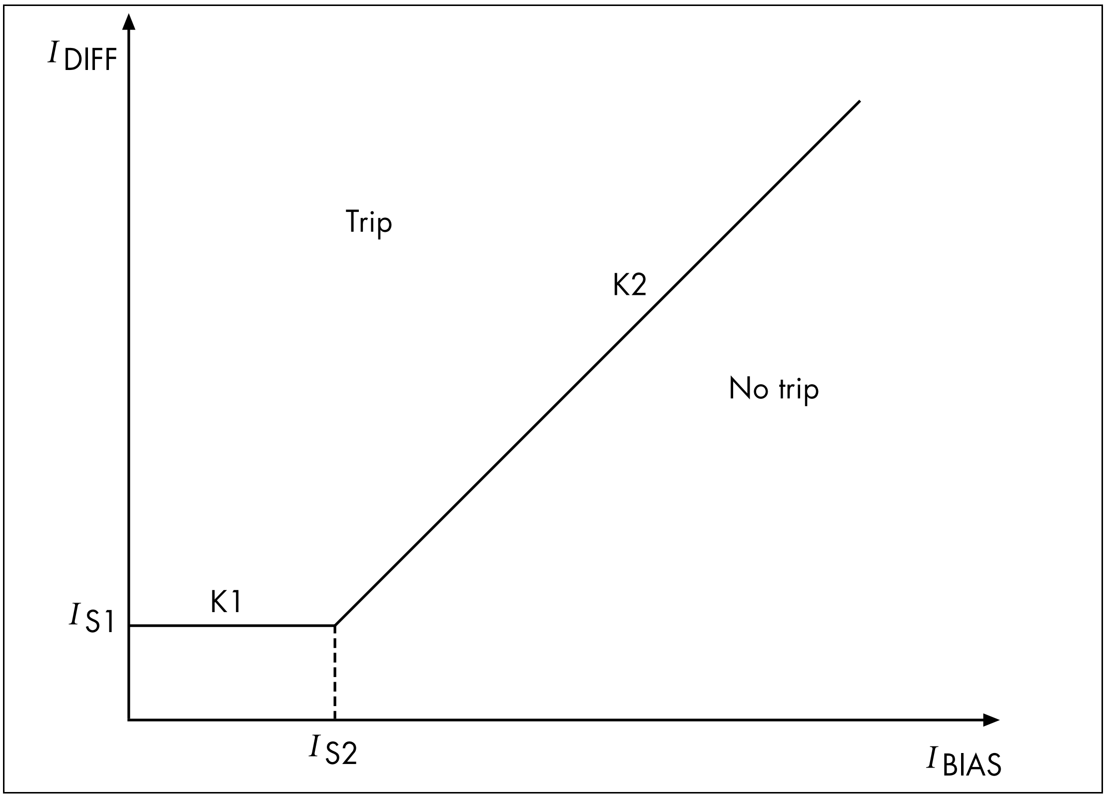
Setting	Range	Step Size
IN1>VNpol Set (Vn = 100/120 V)	0.5 – 80V	0.5V
IN1>VNpol Set (Vn = 380/480 V)	2.0 – 320V	2V

Negative sequence polarisation

Setting	Range	Step Size
IN1>I2pol Set	0.08 - 1.0In	0.01In
IN1>V2pol Set (Vn = 100/120 V)	0.5 – 25V	0.5V
IN1>V2pol Set (Vn = 380/480 V)	2.0 – 100V	2V

10.3.1.3 Restricted earth fault (low impedance)

Setting	Range	Step Size
IREF> K1	0% to 20%	1% (minimum)
IREF> K2	0% to 150%	1% (minimum)
IREF> Is1	8% to 100% In	1% In
IREF> Is2	10% to 150% In	1% In



10.3.1.4 Restricted earth fault (high impedance)

The High Impedance Restricted Earth Fault protection is mutually exclusive with the Sensitive Earth Fault protection as the same sensitive current input is used. This element should be used in conjunction with an external stabilising resistor.

Setting	Range	Step Size
IREF> K1	0% to 20%	1% (minimum)

10.3.2 EF and SEF time delay characteristics

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

10.3.3 IDG curve

The IDG curve is available in stages 1 and 2 of Earth Fault 1, Earth Fault 2 and Sensitive Earth Fault protections.

The IDG curve is represented by the following equation:

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

where:

I = measured current

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

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

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

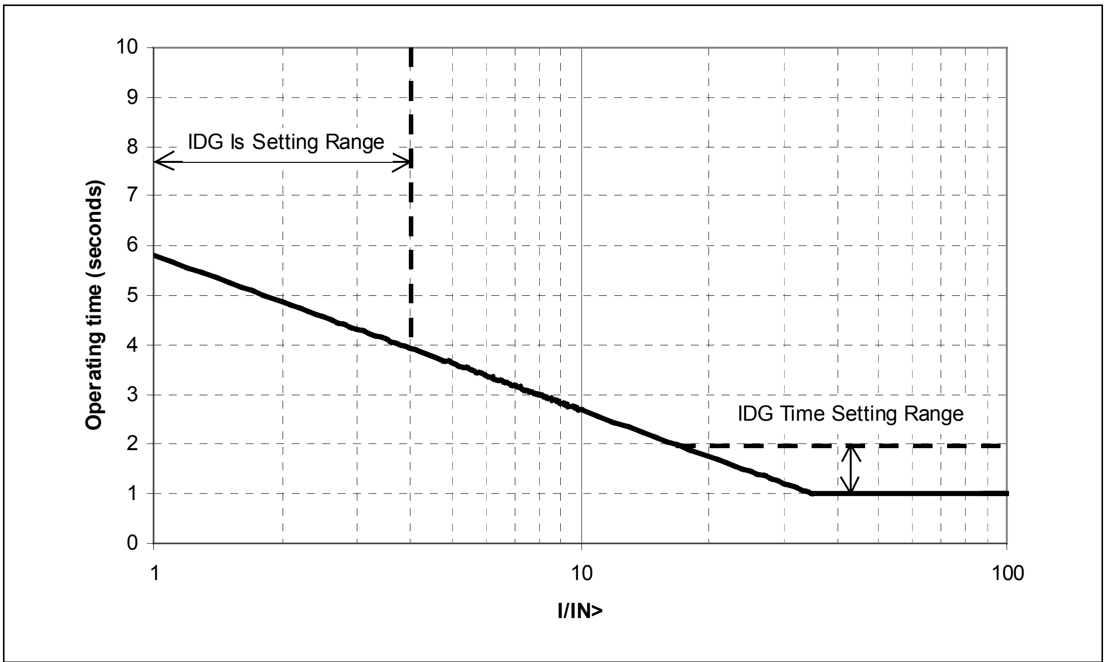


Figure 1: Illustrates how the IDG characteristic is implemented

10.3.4 Wattmetric SEF settings (zero sequence power settings)

If Wattmetric SEF is selected an additional zero sequence power threshold is applied, this is settable according to the following table.

Name	Range	Step Size
P_N> Setting	0 - 20W (Rating = 1A, 100/120V)	0.05W
	0 - 100W (Rating = 5A, 100/120V)	0.25W
	0 - 80W (Rating = 1A, 380/440V)	0.20W
	0 - 400W (Rating = 5A, 380/440V)	1W

10.3.5 Accuracy

10.3.5.1 Earth fault 1

Pick-up	For DT Start	Setting ±5%
Drop-off	For IDMT Start	1.05 x Setting ±5%
Minimum trip level of IDMT elements		1.05 x Setting ±5%
IDMT characteristic shape		±5% or 40ms whichever is greater (under reference conditions)*
IEEE reset		±5% or 40ms whichever is greater
DT operation		±2% or 50ms whichever is greater
DT reset		±5%
Repeatability		2.5%

* Reference conditions TMS=1, TD=7 and IN> setting of 1A, operating range 2-20In

10.3.5.2 Earth fault 2

Pick-up	For DT Start	Setting ±5%
Drop-off	For IDMT Start	1.05 x Setting ±5%
Minimum trip level of IDMT elements		1.05 x Setting ±5%
IDMT characteristic shape		±5% or 40ms whichever is greater (under reference conditions)*
IEEE reset		±10% or 40ms whichever is greater
DT operation		±2% or 50ms whichever is greater
DT reset		±2% or 50ms whichever is greater
Repeatability		5%

* Reference conditions TMS=1, TD=7 and IN> setting of 1A, operating range 2-20In

10.3.5.3 SEF

Pick-up	For DT Start	Setting ±5%
Drop-off	For IDMT Start	1.05 x Setting ±5%
Minimum trip level of IDMT elements		1.05 x Setting ±5%
IDMT characteristic shape		±5% or 40ms whichever is greater (under reference conditions)*
IEEE reset		±7.5% or 60ms whichever is greater
DT operation		±2% or 50ms whichever is greater
DT reset		±5%
Repeatability		5%

* Reference conditions TMS=1, TD=7 and IN> setting of 100mA, operating range 2-20Is

10.3.5.4 REF

Pick-up	Setting formula ±5%
Drop-off	0.80 x Setting formula ±5%
Low impedance operating time	<60ms
High impedance pick-up	Setting ±5%
High impedance operating time	<30ms
Repeatability	<15%

10.3.5.5 Wattmetric SEF

Pick-up	For P=0W	ISEF> ±5%
	For P>0W	P> ±5%
Drop-off	For P=0W	(0.95 x I_{SEF}>) ±5%
	For P>0W	0.9 x P> ±5%
Boundary accuracy		±5% with 1° hysteresis
Repeatability		5%

10.3.5.6 Polarising quantities

Zero sequence polarising

Operating boundary pick-up	±2°of RCA ±90°
Hysteresis	<3°
VN> Pick-up	Setting ±10%
VN> Drop-off	0.9 x Setting ±10%

Negative sequence polarising

Operating boundary pick-up	±2°of RCA ±90°
Hysteresis	<3°
V2> Pick-up	Setting ±10%
V2> Drop-off	0.9 x Setting ±10%
I2> Pick-up	Setting ±10%
I2> Drop-off	0.9 x Setting ±10%

10.4 Negative sequence overcurrent

10.4.1 Setting ranges

Name	Range	Step Size
I2> Current Set	0.08 - 4.0In	0.01In
I2> Time Delay	0 - 100s	0.1s
I2> Char Angle	-95° to +95°	1°
I2> V2pol Set (100 – 110V)	0.5 to 25	0.5
I2> V2pol Set (380 – 480V)	2 to 100	2

10.4.2 Accuracy

I2> Pick-up	Setting ±5%
I2> Drop-off	0.95 x Setting ±5%
Operating boundary Pick-up	±2°of RCA ±90°
Operating boundary hysteresis	<1°
DT Operation	±2% or 60ms whichever is the greater
Reset	<35ms
Repeatability	1%
Instantaneous operating time	<70ms

10.5 Under voltage protection

10.5.1 Level settings

Name	Range	Step Size
V<1 & V<2 Voltage Set (V_n = 100/120V)	10 - 120V	1V
V<1 & V<2 Voltage Set (Vn = 380/440V)	40 - 480V	4V

10.5.2 Under voltage protection time delay characteristics

Under voltage measuring elements are followed by an independently selectable time delay.

The first element has delay characteristics selectable as either Inverse Time or Definite Time. The remaining element has an associated Definite Time delay setting.

Each measuring element time delay is capable of being blocked by the operation of a user defined logic (optical isolated) input.

The inverse characteristic is given by the following formula:

$$t = \frac{K}{(1 - M)}$$

where

K = Time multiplier setting

t = Operating time in seconds

M = Applied input voltage/relay setting voltage (Vs)

Definite time and TMS setting ranges

Name	Range	Step Size
DT setting	0 - 100s	0.01s
TMS Setting (K)	0.5 – 100	0.5

10.5.3 Accuracy

Pick-up	For DT Start	Setting ±5%
	For IDMT Start	1.05 x Setting ±5%
Drop-off		0.95 x Setting ±5%
IDMT characteristic shape		±2% or 50ms whichever is greater
DT operation		±2% or 50ms whichever is greater
Reset		<75ms
Repeatability		<1%

10.6 Over voltage protection

10.6.1 Level settings

Name	Range	Step Size
V>1 & V>2 Voltage Set (V_n = 100/120V)	60 - 185V	1V
V>1 & V>2 Voltage Set (V_n = 380/440V)	240 - 740V	4V

10.6.2 Over voltage protection time delay characteristics

Over voltage measuring elements are followed by an independently selectable time delay.

The first elements have time delay characteristics selectable as either Inverse Time or Definite Time. The remaining element has an associated Definite Time delay setting.

Each measuring element time delay is capable of being blocked by the operation of a user defined logic (optical isolated) input.

The inverse characteristics shall be given by the following formula:

$$t = \frac{K}{(M - 1)}$$

where

K = Time multiplier setting

t = Operating time in seconds

M = Applied input voltage/relay setting voltage (Vs)

Definite time and TMS setting ranges.

Name	Range	Step Size
DT setting	0 – 100s	0.01s
TMS Setting (K)	0.5 – 100s	0.5

10.6.3 Accuracy

Pick-up	For DT Start	Setting ±1%
	For IDMT Start	1.05 x Setting ±5%
Drop-off		0.95 x Setting ±5%
IDMT characteristic shape		±2% or 50ms whichever is greater
DT operation		±2% or 50ms whichever is greater
Reset		<75ms
Repeatability		<1%

10.7 Neutral displacement/residual over voltage

10.7.1 Setting ranges

Name	Range	Step Size
V_N>1 Voltage Set (V_n 100/120V) V_N>2 Voltage Set (V_n 100/120V)	1 – 80V 1 – 80V	1V 1V
V_N>1 Voltage Set (V_n 380/440V) V_N>2 Voltage Set (V_n 380/440V)	4 – 320V 4 – 320V	4V 4V

10.7.2 Neutral displacement/residual overvoltage protection time delay characteristics

Neutral overvoltage measuring elements are followed by an independently selectable time delay.

The first element has a time delay characteristics selectable as either Inverse Time or Definite Time. The second element has an associated Definite Time delay setting.

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

Each measuring element time delay is capable of being blocked by the operation of a user defined logic (optical isolated) input.

The inverse characteristic is given by the following formula:

$$t = \frac{K}{(M - 1)}$$

where

K = Time multiplier setting

t = Operating time in seconds

M = Applied input voltage/relay setting voltage (Vs)

Definite time and TMS setting ranges.

Name	Range	Step Size
DT setting	0 – 100s	0.01s
TMS Setting (K)	0.5 – 100	0.5
DT reset setting	0 – 100s	0.01s

10.7.3 Accuracy

Pick-up	For DT Start	Setting ±5%
	For IDMT Start	1.05 x Setting ±5%
Drop-off		0.95 x Setting ±5%
IDMT characteristic shape		±5% or 65ms whichever is greater
DT operation		±2% or 20ms whichever is greater Instantaneous operation <55ms
Reset		<35ms
Repeatability		<10%

10.8 Under-frequency protection

10.8.1 Level settings

All four stages of under-frequency protection have identical settings. Only the first under frequency element (F<1) is shown.

Name	Range	Step Size
F<1 Setting	45 - 65Hz	0.01Hz
F<1 time delay	0 - 100s	0.01s

10.8.2 Accuracy

Pick-up	Setting ±0.025Hz
Drop-off	1.05 x Setting ±0.025Hz
DT operation	±2% or 50ms whichever is greater*

* The operating will also include a time for the relay to frequency track (20Hz/second)

10.9 Over-frequency protection

10.9.1 Level settings

Name	Range	Step Size
F>1 Setting	45 - 65Hz	0.01Hz
F>1 time delay	0 - 100s	0.01s
F>2 Setting	45 - 65Hz	0.01Hz
F>2 time delay	0 - 100s	0.01s

10.9.2 Accuracy

Pick-up	Setting ±0.025Hz
Drop-off	0.95 x Setting ±0.025Hz
DT operation	±2% or 50ms whichever is greater*

* The operating will also include a time for the relay to frequency track (20Hz/second)

10.10 Broken conductor logic

10.10.1 Setting ranges

Settings	Range	Step Size
I2/I1 Setting	0.2 - 1.0	0.01
I2/I1 Time delay	0 – 100s	0.1s

10.10.2 Accuracy

Pick-up	Setting ±2.5%
Drop-off	0.95 x Setting ±2.5%
DT operation	±2% or 40ms whichever is greater

10.11 Thermal overload

The thermal overload element can use either a single or a dual time constant equation, these are defined below:

1. Single time constant characteristic

$$t = -\tau_1 \ln\left(\frac{I^2 - (1.05.\ ITH)^2}{(I^2 - Ip^2)}\right)$$

2. Dual time constant characteristic

$$0.4.\ \exp\left(\frac{-t}{\tau_1}\right) + 0.6.\ \exp\left(\frac{-t}{\tau_2}\right) = \left(\frac{I^2 - (1.05.\ ITH)^2}{(I^2 - Ip^2)}\right)$$

The thermal state is stored in the relay non-volatile memory and will be retained during loss of auxiliary voltage to the relay.

Ip is the pre-fault steady state load

I is the overload current

t is the time to trip

ITH is the thermal trip current level

10.11.1 Setting ranges

Name	Setting Range	Step Size
Time constant	Single or Dual	-
Thermal trip current I_θ>>	0.08 - 3.2I_N	0.01I_N
Thermal alarm θ>	50 - 100% of I_θ>>	1% of I_θ>>
Time constant τ_1	1 - 200 minutes	1 minute
Time constant τ_2	1 - 200 minutes	1 minute

10.11.2 Accuracy

Pick-up	Thermal alarm	Calculated trip time ±10%*
	Thermal overload	Calculated trip time ±10%*
Cooling time accuracy		±15% of theoretical
Repeatability		<10%

* Operating time measured with applied current of 20% above thermal setting.

10.12 Voltage controlled overcurrent

10.12.1 Setting range

	Setting Range	Step Size
Voltage Control threshold VCO < Setting	20 - 120V (100/120V) 80 - 480V (380/440V)	1V 4V
VCO k Setting	0.25 – 1.00	0.05

10.12.2 Accuracy

Pick-up	VCO threshold	Setting ±5%
	Overcurrent	(K factor x Setting) ±5%
Drop-off	VCO threshold	1.05 x Setting ±5%
	Overcurrent	0.95 x (K factor x Setting) ±5%
Operating time		±5% or 60ms whichever is greater
Repeatability		<5%

10.13 Cold load pick-up settings

10.13.1 Setting range

The cold load pick-up function allows the following phase overcurrent and earth fault to be adjusted.

Setting	Range	Step Size
tcold Time Delay	0 to 14 400s	1s
tclp Time Delay	0 to 14 400s	1s
I>1 Status	Enabled/Disabled	-
I>1 Current Set	0.08 to 4.0In	0.01In

Setting	Range	Step Size
I>1 Current Set	0.08 to 4.0In	0.01In
I>1 Time Delay	0 to 100s	0.01
I>1 TMS	0.025 to 1.2	0.025
I>1 Time Dial	0.5 to 15	0.1
I>2 Status	Enabled/Disabled	-
I>2 Current Set	0.08 to 4.0In	0.01In

10.13.2 Accuracy

Pick-up	For I> stage 1 and 2	Setting ±1.5%
	For I> stage 3 and 4	Setting ±2.5%
	For IN>	Setting ±1.5%
Drop-off	For I> stage 1 and 2	0.95 x Setting ±1.5%
	For I> stage 3 and 4	0.95 x Setting ±2.5%
	For IN>	0.9 x Setting ±1.5%
DT operation		±0.5% or 40ms whichever is greater
Repeatability		<1%

10.14 Negative sequence overvoltage protection

10.14.1 Setting range

Name	Setting Range	Step Size
Voltage threshold V2> Voltage Set	1V - 110V (100/120V) 4V - 440V (380/440V)	1V 4V
V2> Time Delay	0 – 100s	0.01s

10.14.2 Accuracy

Pick-up	Setting ±5%
Drop-off	0.95 x Setting ±5%
DT operation	±2% or 50ms whichever is greater
Repeatability	<5%

10.15 Admittance, conductance and susceptance

10.15.1 Setting range

Name	Setting Range	Step Size
Voltage threshold (Vn)	1V – 40V (100/120V) 4V – 160V (380/440V)	1V 4V
Correction angle	-30 - 30°	1°
YN> Set	25µS – 2.5mS (SEF CT) 250µS – 25mS (E/F CT)	25µS 250µS

Name	Setting Range	Step Size
YN> time delay	0.05s – 100s	0.01s
YN> tRESET	0s – 100s	0.01s
GN> Set	25µS – 2.5mS (SEF CT) 250µS – 25mS (E/F CT)	25µS 250µS
GN> time delay	0.05s – 100s	0.01s
GN> tRESET	0s – 100s	0.01s
BN> Set	25µS – 2.5mS (SEF CT) 250µS – 25mS (E/F CT)	25µS 250µS
BN> time delay	0.05s – 100s	0.01s
BN> tRESET	0s – 100s	0.01s

10.15.2 Accuracy

YN, BN and BN measurements	±5%
YN, GN, BN pick-up	Setting ±5%
YN, GN, BN drop-off	> 0.85 x Setting
Operating time	Start <100ms Trip Setting ±2% or 50ms
Operating boundary	±2°
VN	Setting ±5%

10.16 Selective overcurrent protection

The selective logic function allows the following definite time delayed stages to be modified on energisation of a user definable logic input.

10.16.1 Setting range

Name	Setting Range	Step Size
I>3 Time Delay I>4 Time Delay	0 to 100s 0 to 100s	10ms 10ms
IN1>3 Time Delay IN1>4 Time Delay	0 to 200s 0 to 200s	10ms 10ms
IN2>3 Time Delay IN2>4 Time Delay	0 to 200s 0 to 200s	10ms 10ms
ISEF>3 Time Delay ISEF>4 Time Delay	0 to 200s 0 to 200s	10ms 10ms

10.16.2 Accuracy

Fast block operation	<25ms
Fast block reset	<30ms
Time delay	Setting ±2% or 20ms whichever is greater

11. SUPERVISORY FUNCTIONS

11.1 Voltage transformer supervision

Name	Range	Step Size
Negative phase sequence voltage threshold (V2)	10V (100/120V) 40V (380/480V)	Fixed
Phase overvoltage	P.U. 30V, D.O. 10V (100/120V) P.U.120V, D.O.40V (380/480V)	Fixed
Superimposed current	0.1 In	Fixed
VTS I2> Inhibit	0.05 In to 0.5 In	0.01 In
VTS I> Inhibit	0.08 In to 32 In	0.01 In
VTS Time Delay	1.0 – 10s	0.1s

11.1.1 Accuracy

Fast block operation	<25ms
Fast block reset	<30ms
Time delay	Setting ±2% or 20ms whichever is greater

11.2 Current transformer supervision

The I_N and V_N thresholds take the same values as set for the directional earth fault element.

Settings	Range	Step Size
VN <	0.5 - 22V (for Vn = 100/120V) 2 - 88V (for Vn = 380 / 440V)	0.5V 2V
IN>	0.08In - 4In	0.01In
Time delay t	0 - 10s	1s
CTS Time Delay	0 - 10s	1s

11.2.1 Accuracy

Pick-up	IN>	Setting ±5%
	VN <	Setting ±5%
Drop-off	IN>	0.9 x Setting ±5%
	VN <	(1.05 x Setting) ±5% or 1V whichever is greater
Time delay operation		Setting ±2% or 20ms whichever is greater
CTS block operation		< 1 cycle
CTS reset		< 35ms

12. CONTROL FUNCTION SETTINGS

12.1 Communications settings

Front port	Communication Parameters (Fixed)
Protocol	Courier
Address	1
Message format	IEC 60870FT1.2
Baud rate	19200 bits/s

Rear Port Settings	Setting Options	Setting Available For:
Physical link	RS485 or Fibre optic	IEC only
Remote address	0 – 255 (step 1)	IEC/Courier
Modbus address	1 – 247 (step 1)	Modbus only
Baud rate	9 600 or 19 200 bits/s	IEC only
Baud rate	9 600, 19 200 or 38 400 bits/s	Modbus only
Inactivity timer	1 – 30 minutes (step 1)	All
Parity	"Odd", "Even" or "None"	Modbus only
Measurement	1 – 60 minutes (step 1) period	IEC only

12.2 Autoreclose

12.2.1 Options

The autorecloser in the feeder protection is three pole only. There are two schemes available, scheme 1 is fitted to P142 and scheme 2 is fitted to P143. Due to the complexity of the logic the application notes should be referred to. The main facilities provided by the two schemes are described in the following table:

Function	Scheme 1	Scheme 2
Autoreclose In/Out Of Service Selection	•	•
Operating Modes	•	•
Sequence Co-ordination	•	•
Protection Monitor	•	•
Initiate Autoreclose Sequence	•	•
Dead Times	•	•
System Check		•
Auto Close	•	•
Reclaim Time	•	•
Block Protection	•	•
Autoreclose Lockout	•	•
Protection Lockout	•	•
Reset Lockout	•	•

Function	Scheme 1	Scheme 2
Autoreclose Inhibit	•	•

12.2.2 Settings

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CONFIGURATION				
Auto-Reclose	Disabled	Enable / Disable		
CB CONTROL				
CB Status Input	None	None/52A/52B Both 52A & 52B		
AR Telecontrol	No Operation (Control Cell)	Auto/Non Auto		
AR Status	Auto	Auto/Non Auto/ Live Line		Indicates AR operating mode
Total Reclosures	x (Data)	Total number of AR closures performed by the Relay		
Reset Total A/R	No (Control Cell)	No/Yes		

Note that the menu cells AR Telecontrol, AR Status, Total Reclosures and Reset Total A/R are visible only when autoreclose is enabled in the configuration column.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
AUTORECLOSE GROUP 1				
AR Mode Select	Auto	Command Mode/ Opto Set Mode / User Set Mode / Pulse Set Mode		
Number of Shots	1	1	4	1
Number of SEF Shots	0	0	4	1
Sequence Co-ord	Disabled	Enabled/Disabled		N/A
CS AR Immediate	Disabled	Enabled/Disabled		N/A
Dead Time 1	10s	0.01s	300s	0.01s
Dead Time 2	60s	0.01s	300s	0.01s
Dead Time 3	180s	0.01s	9999s	0.01s
Dead Time 4	180s	0.01s	9999s	0.01s
CB Healthy Time	5s	0.01s	9999s	0.01s
Start Dead t On	Protection Resets	Protection Resets/ CB Trips		N/A

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
tReclaim Extend	No Operation	No Operation/On Prot Start		
Reclaim Time	180s	1s	600s	0.01s
AR Inhibit Time	5s	0.01s	600s	0.01s
AR Lockout	No Block	No Block/Block Inst Prot		N/A
EFF Maint Lock	No Block	No Block/Block Inst Prot		N/A
AR Deselected	No Block	No Block/Block Inst Prot		N/A
Manual Close	No Block	No Block/Block Inst Prot		N/A
Trip 1 Main	No Block	No Block/Block Inst Prot		N/A
Trip 2 Main	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 3 Main	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 4 Main	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 5 Main	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 1 SEF	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 2 SEF	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 3 SEF	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 4 SEF	Block Inst Prot	No Block/Block Inst Prot		N/A
Trip 5 SEF	Block Inst Prot	No Block/Block Inst Prot		N/A
Man Close on Flt	Lockout	No Lockout/Lockout		N/A
Trip AR Inactive	No Lockout	No Lockout/Lockout		N/A
Reset Lockout by	User interface	User Interface/ Select Non-Auto		N/A
AR on Man Close	Inhibited	Enabled/Inhibited		N/A
Sys Check Time	5	0.01	9999	0.01
AR INITIATION (Sub Heading)				
I>1 I>2	Initiate Main AR	No Action/ Initiate Main AR		N/A
I>3 I>4	Initiate Main AR	No Action/ Initiate Main AR/ Block AR		N/A
IN1>1 IN1>2	Initiate Main AR	No Action/ Main AR		N/A
IN1>3 IN1>4	Initiate Main AR	No Action/ Initiate Main AR/ Block AR		N/A
IN2>1 IN2>2	No Action	No Action/ Initiate Main AR		N/A

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
IN2>3 IN2>4	No Action	No Action/ Initiate Main AR/ Block AR		N/A
ISEF>1 ISEF>2	No Action	No Action/ Initiate Main AR/ Initiate SEF AR/Block AR		N/A
ISEF>3 ISEF>4	No Action	No Action/ Initiate Main AR/ Initiate SEF AR/Block AR		N/A
YN> GN> BN>	No Action	No Action/ Initiate Main AR		N/A
Ext Prot	No Action	No Action/ Initiate Main AR		N/A
SYSTEM CHECKS				
AR with ChkSyn	Disabled	Enabled/Disabled		N/A
AR with SysSyn	Disabled	Enabled/Disabled		N/A
Live/Dead Ccts	Disabled	Enabled/Disabled		N/A
No System Checks	Disabled	Enabled/Disabled		N/A
SysChk on Shot 1	Enabled	Enabled/Disabled		N/A

13. PROGRAMMABLE SCHEME LOGIC

13.1 Level settings

Settings	Range	Step Size
Time delay t	0-14400000ms (4 hrs)	1ms

13.2 Accuracy

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

14. MEASUREMENTS AND RECORDING FACILITIES

14.1 Measurements

Typically ±1.0% , but ±0.5% between 0.2 – 2In / VnAccuracy under reference conditions.

Measurand	Range	Accuracy
Current	0.05 to 3 In	±1.0% of reading
Voltage	0.05 to 2 Vn	±1.0% of reading
Power (W)	0.2 to 2 Vn 0.05 to 3 In	±5.0% of reading at unity power factor
Reactive Power (VArs)	0.2 to 2 Vn 0.05 to 3 In	±5.0% of reading at zero power factor
Apparent Power (VA)	0.2 to 2 Vn 0.05 to 3 In	±5.0% of reading
Energy (Wh)	0.2 to 2 Vn 0.2 to 3 In	±5% of reading at zero power factor
Energy (Varh)	0.2 to 2 Vn 0.2 to 3 In	±5% of reading at zero power factor
Phase accuracy	0° to 360°	±0.5°
Frequency	45 to 65Hz	±0.025Hz

14.2 IRIG-B and real time clock

14.2.1 Features

Real time 24 hour clock settable in hours, minutes and seconds
Calendar settable from January 1994 to December 2092
Clock and calendar maintained via battery after loss of auxiliary supply
Internal clock synchronisation using IRIG-B
Interface for IRIG-B signal is BNC

14.2.2 Performance

Year 2000	Compliant
Real time clock accuracy	< ±2 seconds / day
Modulation ratio	1/3 or 1/6
Input signal peak-peak amplitude	200 mV to 20 V
Input impedance at 1000 Hz	6000 Ω
External clock synchronisation	Conforms to IRIG standard 200-98, format B

15. DISTURBANCE RECORDS

15.1 Level settings

Setting	Range	Step
Record length	0 to 10.5s	0.1s
Trigger position	0 to 100%	0.1%
Trigger mode	Single/Extended	
Sample rate	12 Samples/Cycle	Fixed
Digital signals	Selectable from logic inputs and outputs and internal signals	
Trigger logic	Each of the digital inputs can be selected to trigger a record	

15.2 Accuracy

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

Setting	Range	Step Size
Line length	0.01 to 1000km **	0.01km **
Line impedance (100/110V)	0.1/In to 250/In ý	0.01/In ý
Line impedance (380/480V)	0.4/In to 1000/In ý	0.04/In ý
Line angle	20° to 85°	1°
KZN residual	0 to 7.00	0.01
KZN res angle	–90° to +90°	1°

16. PLANT SUPERVISION

16.1 CB state monitoring control and condition monitoring

16.1.1 CB monitor settings

Setting	Range	Step
Broken I^ (mult)	1 – 2	0.1
I^ Maintenance	1 – 25000 (x (CT ratio^mult)) A	1 (x (CT ratio^mult)) A
I^ Lockout	1 – 25000 (x (CT ratio^mult)) A	1 (x (CT ratio^mult)) A
No CB Ops maintenance	1 – 10000	1
No CB Ops lockout	1 – 10000	1
CB time maintenance	0.005 – 0.5s	0.001s
CB time lockout	0.005 – 0.5s	0.001s
Fault frequency count	0 – 9999	1
Fault frequency time	0 – 9999	1

16.1.2 CB control settings

Name	Range	Step Size
CB control by	Disabled/Local/ Remote/Local+Remote/ Opto/ Opto+local/ Opto+Remote/ Opto+Rem+local	
Close pulse time	0.1 to 5s	0.1s
Trip pulse time	0.1 to 5s	0.1s
Man close delay	0 to 60s	1s
Healthy window	0.01 to 9999	0.01
C/S window	0.01 to 9999	0.01

16.1.3 Accuracy

Timers	±2% or 20ms whichever is greater
Broken current accuracy	±5%

16.2 CB fail and backtrip breaker fail

16.2.1 Timer settings

Setting	Range	Step
CB fail 1 timer	0 – 10s	0.01s
CB fail 2 timer	0 – 10s	0.01s

The timers are reset by:

- undercurrent elements operating, or
- initiating element drop-off (loss of external initiating signal), or
- circuit breaker open auxiliary contact. (If current operation/external device is not applicable)

16.2.2 Timer accuracy

Timers	±2% or 40ms whichever is greater
Reset time	<30ms

16.2.3 Undercurrent settings

Name	Range	Step Size
Phase I<	0.02 - 3.2 In	0.01 In
Earth IN<	0.02 - 3.2 In	0.01 In
Sensitive Earth ISEF<	0.001 - 0.8 In	0.0005 In

16.2.4 Undercurrent accuracy

Pick-up	±10% or 25mA whichever is the greater
Operating time	<20ms
Reset	<25ms

17. INPUT AND OUTPUT SETTING RANGES

17.1 CT and VT ratio settings

The primary and secondary rating can be independently set for each set of CT or VT inputs, for example the earth fault CT ratio can be different to that used for the phase currents. Note, VT primary and secondary values are phase-phase rms values.

	Primary Range	Secondary Range
Current transformer	1 to 30000 Amps step size 1A	1 or 5 Amps
Voltage transformer	100V to 1000 kV step size 1V	80 to 140V (Vn = 100/120V) 320 to 560V (Vn = 380/480V)

18. BATTERY LIFE

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

19. FREQUENCY RESPONSE

With the exception of the RMS measurements all other measurements and protection functions are based on the Fourier derived fundamental component. The fundamental component is extracted by using a 24 sample Discrete Fourier Transform (DFT). This gives good harmonic rejection for frequencies up to the 23rd harmonic. The 23rd is the first predominant harmonic that is not attenuated by the Fourier filter and this is known as an 'Alias'. However, the Alias is attenuated by approximately 85% by an additional, analogue, 'anti-aliasing' filter (low pass filter). The combined affect of the anti-aliasing and Fourier filters is shown below:

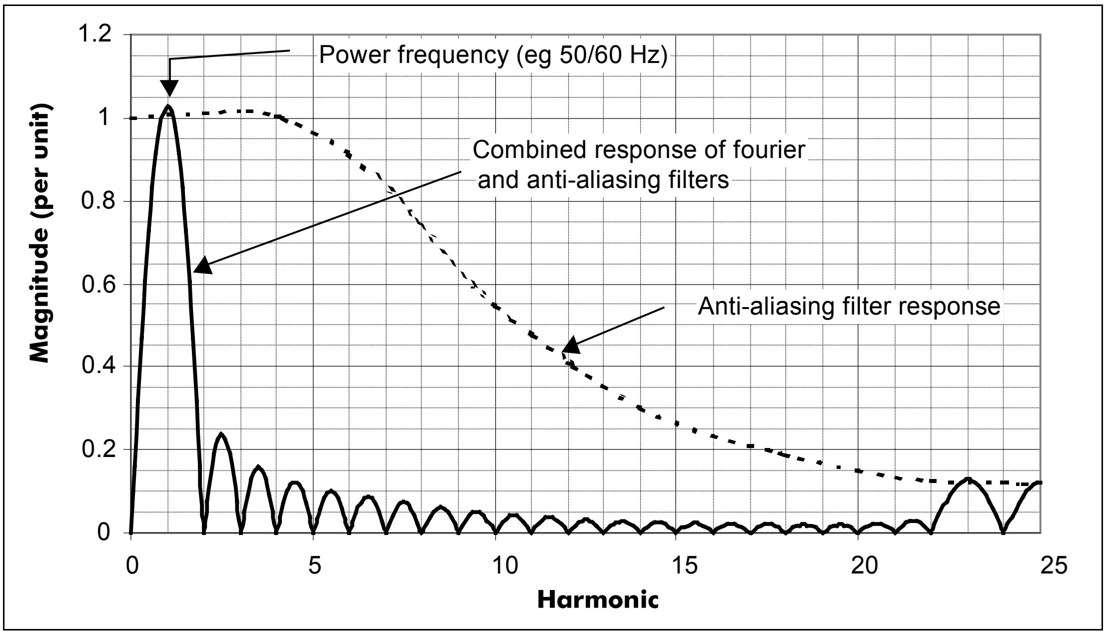


Figure 2: Frequency response

For power frequencies that are not equal to the selected rated frequency the harmonics would not be attenuated to zero amplitude. For small deviations of ±1Hz, this is not a problem but to allow for larger deviations, an improvement is obtained by the addition of frequency tracking.

With frequency tracking the sampling rate of the analogue / digital conversion is automatically adjusted to match the applied signal. In the absence of a suitable signal to amplitude track, the sample rate defaults to the selected rated frequency (Fn). In the presence of a signal within the tracking range (45 to 65Hz), the relay will lock on to the signal and the measured frequency will coincide with the power frequency as labelled in the diagram above. The resulting outputs for harmonics up to the 23rd will be zero.

CHAPTER 5
SCADA Communications

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1. INTRODUCTION

This chapter describes the remote interfaces of the MiCOM relay in enough detail to allow integration within a substation communication network. As has been outlined in earlier chapters the relay supports a choice of one of three protocols via the rear communication interface. This is in addition to the front serial interface which supports the Courier protocol.

The rear EIA(RS)485 interface is isolated and is suitable for permanent connection whichever protocol is selected. The advantage of this type of connection is that up to 32 relays can be 'daisy chained' together using a simple twisted pair electrical connection.

For each of the three protocol options the supported functions/commands will be listed together with the database definition. The operation of standard procedures such as extraction of event, fault and disturbance records or setting changes will also be described.

It should be noted that the descriptions contained within this chapter do not aim to fully detail the protocol itself. The relevant documentation for the protocol should be referred to for this information. This chapter serves to describe the specific implementation of the protocol on the relay.

2. COURIER INTERFACE

2.1 Courier protocol

Courier is an ALSTOM Protection and Control communication protocol. The concept of the protocol is that a standard set of commands are used to access a database of settings/data within the relay. This allows a generic master to be able to communicate with different slave devices. The application specific aspects are contained, within the database itself rather than the commands used to interrogate it. i.e. the master station does not need to be pre-configured. The same protocol can be used via two physical links K-Bus or EIA(RS)232; K-Bus is based on EIA(RS)485 voltage levels and is synchronous, the EIA(RS)232 interface uses IEC60870 FT1.2 (IEC60870) frame format. The relay supports an IEC60870 connection on the front, for one to one connection, this is not suitable for permanent connection. This interface uses a fixed baud rate, 11 bit frame and a fixed device address. The rear EIA(RS)485 interface is used to provide a permanent connection for K-Bus and allows multi-drop connection. It should be noted that although K-Bus is based on EIA(RS)485 voltage levels it is a synchronous protocol using FM0 encoding. It is not possible to use a standard EIA(RS)232 to EIA(RS)485 converter to convert IEC60870 to K-Bus.

The following documentation should be referred to for a detailed description of the Courier protocol, command set and link description.

R6509 K-Bus Interface Guide

R6510 IEC60870 Interface Guide

R6511 Courier Protocol

R6512 Courier User Guide

2.2 Front courier port

The front EIA(RS)232 port supports the Courier protocol for one to one communication. It is designed for use during installation and commissioning/maintenance and is not suitable for permanent connection. Since this interface will not be used to link the relay to a substation communication system some of the features of Courier are not implemented. These are as follows:

Automatic extraction of Event Records:

Courier Status byte does not support the Event flag

Sent Event/Accept Event commands are not implemented

Automatic extraction of Disturbance records:

Courier Status byte does not support the Disturbance flag

Busy Response Layer:

Courier Status byte does not support the Busy flag, the only response to a request will be the final data

Fixed Address:

The address of the front Courier port is always 1, the Change Device address command is not supported.

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

2.3 Supported command set

The following Courier commands are supported by the relay:

Protocol Layer

Reset Remote Link

Poll Status

Poll Buffer*

Low Level Commands

Send Event*

Accept Event*

Send Block

Store Block Identifier

Store Block Footer

Menu Browsing

Get Column Headings

Get Column Text

Get Column Values

Get Strings

Get Text

Get Value

Get Column Setting Limits

Setting Changes

Enter Setting Mode

Preload Setting

Abort Setting

Execute Setting

Reset Menu Cell

Set Value

Control Commands

Select Setting Group

Change Device Address*

Set Real Time

Note: Commands indicated with a * are not supported via the front Courier port.

2.4 Relay courier database

The Courier database is two dimensional structure with each cell in the database being referenced by a row and column address. Both the column and the row can take a range from 0 to 255. Addresses in the database are specified as hexadecimal values, e.g. 0A02 is column 0A (10 decimal) row 02. Associated settings/data will be part of the same column, row zero of the column contains a text string to identify the contents of the column.

Appendix A contains the complete database definition for the relay for each cell location the following information is stated:

- Cell Text
- Cell Datatype
- Cell value
- Whether if the cell is settable, if so
- Minimum value
- Maximum value
- Step size
- Password Level required to allow setting changes
- String information (for Indexed String or Binary flag cells)

2.5 Setting changes

(See Courier User Guide Chapter 9)

Courier provides two mechanisms for making setting changes, both of these are supported by the relay. Either method can be used for editing any of the settings within the relay database.

2.5.1 Method 1

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

Enter Setting Mode - checks that the cell is settable and returns the limits

Preload Setting - Places a new value to the cell, this value is echoed to ensure that setting corruption has not taken place, the validity of the setting is not checked by this action.

Execute Setting - Confirms the setting change, if the change is valid then a positive response will be returned, if the setting change fails then an error response will be returned.

Abort Setting - This command can be used to abandon the setting change.

This is the most secure method and is ideally suited to on-line editors as the setting limits are taken from the relay before the setting change is made. However this method can be slow if many settings are being changed as three commands are required for each change.

2.5.2 Method 2

The Set Value command can be used to directly change a setting, the response to this command will be either a positive confirm or an error code to indicate the nature of a failure. This command can be used to implement a setting more rapidly then the previous method, however the limits are not extracted from the relay. This method is most suitable for off-line setting editors such as MiCOM S1.

2.5.3 Relay settings

There are three categories of settings within the relay database

- Control and Support
- Disturbance Recorder
- Protection Settings Group

Setting changes made to the control and support settings are implemented immediately and stored in non-volatile memory. Settings made to either the Disturbance recorder settings or the Protection Settings Groups are stored in scratchpad memory only and are not immediately implemented by the relay.

To action setting changes made to these areas of the relay database the Save Changes cell in the Configuration column must be written to. This allows the changes to either be confirmed and stored within non-volatile memory or the setting changes to be aborted.

2.5.4 Setting transfer mode

If it is necessary to transfer all of the relay settings to or from the relay a cell within the Communication System Data column can be used. This cell (location BF03) when set to 1 makes all of the relay settings visible. Any setting changes made with the relay set in this mode are stored in scratchpad memory (including control and support settings). When the value of BF03 is set back to 0 any setting changes are confirmed and stored in non-volatile memory.

2.6 Event extraction

Events can be extracted either automatically (rear port only) or manually (either Courier port). For automatic extraction all events are extracted in sequential order using the standard Courier mechanism, this includes fault/maintenance data if appropriate. The manual approach allows the user to select events, faults or maintenance data at random from the stored records.

2.6.1 Automatic event extraction

(See Chapter X Courier User Guide)

This method is intended for continuous extraction of event and fault information as it is produced, it is only supported via the rear Courier port.

When new event information is created the Event bit is set within the Status byte, this indicates to the Master device that event information is available. The oldest, unextracted event can be extracted from the relay using the Send Event command. The relay will respond with the event data, which will be either a Courier Type 0 or Type 3 event. The Type 3 event is used for fault records and maintenance records.

Once an event has been extracted from the relay the Accept Event can be used to confirm that the event has been successfully extracted. If all events have been extracted then the event bit will reset, if there are more events still to be extracted the next event can be accessed using the Send Event command as before.

2.6.2 Event types

Events will be created by the relay under the following circumstances:

- Change of state of output contact
- Change of state of opto input
- Protection element operation
- Alarm condition
- Setting Change
- Password entered/timed-out
- Fault Record (Type 3 Courier Event)
- Maintenance record (Type 3 Courier Event)

2.6.3 Event format

The Send Event command results in the following fields being returned by the relay:

- Cell Reference
- Timestamp
- Cell Text
- Cell Value

Appendix B contains a table of the events created by the relay and indicates how the contents of the above fields are interpreted. Fault records and Maintenance records will return a Courier Type 3 event which contains the above fields together with two additional fields:

- Event extraction column
- Event number

These events contain additional information which is extracted from the relay using the referenced extraction column. Row 01 of the extraction column contains a setting which allows the fault/maintenance record to be selected. This setting should be set to the event number value returned within the record, the extended data can be extracted from the relay by uploading the text and data from the column.

2.6.4 Manual event record extraction

Column 01 of the database can be used for manual viewing of event, fault and maintenance records. The contents of this column will depend of the nature of the record selected. It is possible to select by event number, or to directly select a fault record or maintenance record.

Event Record selection (Row 01) - This cell can be set to a value between 0 to 249 to select which of the 250 stored events is selected, 0 will select the most recent record; 249 the oldest stored record. For simple event records (Type 0) cells 0102 to 0105 contain the event details. A single cell is used to represent each of the event fields. If the event selected is a fault or maintenance record (Type 3) then the remainder of the column will contain the additional information.

Fault Record Selection (Row 05) - This cell can be used to directly select a fault record using a value between 0 and 4 to select one of up to five stored fault records (0 will be the most recent fault and 4 will be the oldest). The column will then contain the details of the fault record selected.

Maintenance Record Selection (Row F0) - This cell can be used to select a maintenance record using a value between 0 and 4 and operates in a similar way to the fault record selection.

It should be noted that if this column is used to extract event information from the relay the number associated with a particular record will change when a new event or fault occurs.

2.7 Disturbance record extraction

The stored disturbance records within the relay are accessible in a compressed format via the Courier interface. The records are extracted using column B4, it should be noted that cells required for extraction of uncompressed disturbance records are not supported.

Select Record Number (Row 01) - This cell can be used to select the record to be extracted. Record 0 will be the oldest unextracted record, older records will be assigned positive values, and negative values will be used for more recent records. To facilitate automatic extraction via the rear port the Disturbance bit of the Status byte is set by the relay whenever there are unextracted disturbance records.

Once a record has been selected, using the above cell, the time and date of the record can be read from cell 02. The disturbance record itself can be extracted using the block transfer mechanism from cell B00B. It should be noted that the file extracted from the relay is in a compressed format, it will be necessary to use MiCOM S1 to de-compress this file and save the disturbance record in the COMTRADE format.

As has been stated the rear Courier port can be used to automatically extract disturbance records as they occur. This operates using the standard Courier mechanism defined in Chapter 8 of the Courier User Guide. The front Courier port does not support automatic extraction although disturbance record data can be extracted manually from this port.

2.8 Programmable logic settings

The programmable logic settings can be uploaded from and downloaded to the relay using the block transfer mechanism defined in Chapter 12 of the Courier User Guide. The following cells are used to perform the extraction

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

The Programmable scheme logic settings can be uploaded and downloaded to and from the relay using this mechanism. If it is necessary to edit the settings MiCOM S1 must be used as the data format is compressed. MiCOM S1 also performs checks on the validity of the settings before they are downloaded to the relay.

3. MODBUS INTERFACE

The Modbus interface is a master/slave protocol, it is defined by MODICON Inc. by the following document:

Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev. E

3.1 Communication link

This interface also uses the rear EIA(RS)485 port for communication using RTU mode communication rather than ASCII mode as this provides more efficient use of the communication bandwidth. This mode of communication is defined in page 7 of the Modbus Guide.

The following parameters can be configured for this port using either the front panel interface or the front Courier port:

Baud Rate

Device Address

Parity

Inactivity Time

3.2 Modbus functions

The following Modbus function codes are supported by the relay:

01 Read Coil Status

02 Read Input Status

03 Read Holding Registers

04 Read Input Registers

06 Preset Single Register

07 Read Exception Status

08 Diagnostics

11 Fetch Communication Event Counter

12 Fetch Communication Event Log

16 Preset Multiple Registers 127 max

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

01 Read status of output contacts (0xxxx addresses)

02 Read status of opto inputs (1xxxx addresses)

03 Read Setting values (4xxxx addresses)

04 Read Measured values (3xxxx addresses

06 Write single setting value (4xxxx addresses)

16 Write multiple setting values (4xxxx addresses)

3.3 Response codes

Code	Modbus Description	MiCOM Interpretation
01	Illegal Function Code	The function code transmitted is not supported by the slave
02	Illegal Data Address	The start data address in the request is not an allowable value. If any of the cells in the range to be written to cannot be accessed due to password protection then all changes within the request are discarded and this error response will be returned. Note: If the start address is correct but the range includes non-implemented addresses this response is not produced
03	Illegal Value	A value referenced in the data field transmitted by the master is not within range. Other values transmitted within the same packet will be executed if inside range
06	Slave Device Busy	The write command cannot be implemented due to the database being locked by another interface. This response is also produced if the relay software is busy executing a previous request.

3.4 Register mapping

The relay supports the following memory page references:-

Memory Page	Interpretation
0xxxx	Read and write access of the Output Relays.
1xxxx	Read only access of the Opto Inputs.
3xxxx	Read only access of Data.
4xxxx	Read and write access of Settings.

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

Note that the "extended memory file" (6xxxx) is not supported.

A complete map of the Modbus addresses supported by the relay is contained in Appendix 1 of this service manual.

3.5 Event extraction

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

3.5.1 Manual selection

The following registers can be read to indicate the numbers of the various types of record stored.

30100 - Number of stored records

30101 - Number of stored fault records

30102 - Number of stored maintenance records

There are three registers available to manually select stored records.

40100 - Select Event, 0 to 249

40101 - Select Fault, 0 to 4

40102 - Select Maintenance Record, 0 to 4

For each of the above registers a value of 0 represents the most recent stored record.

Each fault or maintenance record logged causes an event record to be created by the relay. If this event record is selected the additional registers allowing the fault or maintenance record details will also become populated. (see 3.5.3 for details)

3.5.2 Automatic extraction

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

The Modbus master can determine whether the relay has any events stored that have not yet been extracted. This is performed by reading the relay status register 30001 (G26 data type). If the event bit of this register is set then the relay has unextracted events available. To select the next event for sequential extraction the master station writes a value of 1 to the record selection register 40400 (G18 data type). The event data together with any fault/maintenance data can be read from the registers specified below. Once the data has been read the event record can be marked as having been read by writing a value of 2 to register 40400. The process can then be repeated until all events have been extracted.

3.5.3 Record data

The location and format of the registers used to access the record data is the same whether they have been selected using either of the two mechanisms detailed above.

Event Description	Modbus Address	Length	Comments
Time and Date	30103	4	See G12 data type.
Event Type	30107	1	See G13 data type. Indicates type of event.
Event Value	30108	2	Nature of Value depends on Event Type. This will contain the status as a binary flag for Contact, Opto, Alarm and protection events.
Modbus Address	30110	1	This indicates the Modbus Register address where the change occurred. Alarm 30011 Relays 30723 Optos 30725 Protection events – Like the Relay and Opto addresses this will map onto the Modbus address of the appropriate DDB status register, depending on which bit of the DDB the changed. These will range from 30727 to 30753. For Platform events, Fault events and Maintenance events the default is 0.
Event Index	30111	1	This register will contain the DDB No for protection events or the bit No for alarm events. The direction of the change will be indicated by the MSB.
Additional Data Present	30112	1	0 Means that there is no additional data. 1 Means fault record data can be read from 30113 to 30199 (number of registers depends on the product). 2 Means maintenance record data can be read from 30036 to 30039.

If a fault record or maintenance record is directly selected using the manual mechanism then the data can be read from the register ranges specified above, the event record data in cells 30103 to 30111 will not be available.

It is possible using register 40401(G6 data type) to clear independently the stored relay event/fault and maintenance records. This register also provides an option to reset the relay indications, this has the same effect on the relay as pressing the clear key within the alarm viewer using the front panel menu.

3.6 Disturbance record extraction

The relay provides facilities for both manual and automatic extraction of disturbance records. The two methods differ only in the mechanism for selecting a disturbance record, the method for extracting the data and the format of the data are identical.

3.6.1 Manual selection

Each disturbance record has a unique identifier which increments for each stored record and resets at a value of 65535. The following registers can be used to determine the identifiers for the stored records

30800 - The number of stored disturbance records

30801 - The identifier for the oldest stored record

A record can be selected by writing the required record identifier to register 40250. It is possible to read the timestamp of the selected record and in this way produce a list of all the stored records.

3.6.2 Automatic extraction

The Modbus master station can determine the presence of unread disturbance records by polling register 30001 (G26 data type). When the disturbance bit of this register is set disturbance records are available for extraction. To select the next disturbance record write a value of 0 x 0004 to cell 40400 (G18 data type). Once the disturbance record data has been read by the master station this record can be marked as having been read by writing a value of 0 x 0008 to register 40400.

3.6.3 Record data

The timestamp for a record selected using either of the above means can be read from registers 30930 to 30933. The disturbance record data itself is stored in a compressed format, due to the size of the disturbance record it must be read using a paging system. The number of pages required to extract a record will depend on the configured size of the record.

When a record is first selected the first page of data will be available in registers 30803 to 30929 (the number of registers required for the current page can be read from register 30802, this will be 127 for all but the last page in the record). Once the first page has been read the next page can be selected by writing a value of 0x0010 to register 40400. If this action is performed on the last page for the disturbance record an illegal value error response will be returned. This error response can be used by the Modbus master to indicate that the last page of the disturbance record has been read.

3.7 Setting changes

The relay settings can be split into two categories:

- control and support settings
- disturbance record settings and protection setting groups

Changes to settings within the control and support area are executed immediately. Changes to either the protection setting groups or the disturbance recorder are stored in a temporary area and must be confirmed before they are implemented. All the relay settings are edited via Modbus using 4xxxx addresses. The following points should be noted when settings are being edited:

- Settings implemented using multiple registers must be written to using a multi-register write operation.
- The first address for a multi-register write must be a valid address, if there are unmapped addresses within the range being written to then the data associated with these addresses will be discarded.

- If a write operation is performed with values that are out of range then the illegal data response will be produced. Valid setting values within the same write operation will be executed.
- If a write operation is performed attempting to change registers that require a higher level of password access than is currently enabled then all setting changes in the write operation will be discarded.

3.7.1 Password protection

As described in the introduction to this service manual the relay settings can be subject to Password protection. The level of password protection required to edit a setting is indicated in relay setting database (Appendix A). Level 2 is the highest level of password access, level 0 indicates that no password is required for editing.

The following registers are available to control Password protection:

40001&40002	Password Entry
40022	Default Password Level
40023&40024	Setting to Change password level 1
40025&40026	Setting to Change password level 2
30010	Can be read to indicate current access level

3.7.2 Control and support settings

Control and support settings are executed immediately on the write operation.

3.7.3 Protection and disturbance recorder settings

Setting changes to either of these areas are stored in a scratchpad area and will not be used by the relay unless a confirm or to abort operation is performed. Register 40405 can be used to either to confirm or abort the setting changes within the scratchpad area. It should be noted that the relay supports four groups of protection settings. The Modbus addresses for each of the four groups are repeated within the following address ranges:

Group 1	41000-42999
Group 2	43000-44999
Group 3	45000-46999
Group 4	47000-48999

In addition to the basic editing of the protection setting groups the following functions are provided.

- Default values can be restored to a setting group or to all of the relay settings by writing to register 40402.
- It is possible to copy the contents of one setting group to another by writing the source group to register 40406 and the target group to 40407.

It should be noted that the setting changes performed by either of the two operations defined above are made to the scratchpad area. These changes must be confirmed by writing to register 40405.

The active protection setting groups can be selected by writing to register 40404. An illegal data response will be returned if an attempt is made to set the active group to one that has been disabled.

4. IEC60870-5-103 INTERFACE

The IEC60870-5-103 interface is a master/slave interface with the relay as the slave device. This protocol is based on the VDEW communication protocol. The relay conforms to compatibility level 2, compatibility level 3 is not supported.

The following IEC60870-5-103 facilities are supported by this interface:

- Initialisation (Reset)
- Time Synchronisation
- Event Record Extraction
- General Interrogation
- Cyclic Measurements
- General Commands

4.1 Physical connection and link layer

Two connection options are available for IEC60870-5-103, either the rear EIA(RS)485 port or an optional rear fibre optic port. Should the fibre optic port be fitted the selection of the active port can be made via the front panel menu or the front Courier port, however the selection will only be effective following the next relay power up.

For either of the two modes of connection it is possible to select both the relay address and baud rate using the front panel menu/front Courier. Following a change to either of these two settings a reset command is required to re-establish communications.

4.2 Initialisation

Whenever the relay has been powered up, or if the communication parameters have been changed a reset command is required to initialise the communications. The relay will respond to either of the two reset commands (Reset CU or Reset FCB), the difference being that the Reset CU will clear any unsent messages in the relay's transmit buffer.

The relay will respond to the reset command with an identification message ASDU 5, the Cause Of Transmission COT of this response will be either Reset CU or Reset FCB depending on the nature of the reset command. The following information will be contained in the data section of this ASDU:

Manufacturer Name: ALSTOM

The Software Identification Section will contain the first four characters of the relay model number to identify the type of relay, e.g. P141.

In addition to the above identification message, if the relay has been powered up it will also produce a power up event.

4.3 Time synchronisation

The relay time and date can be set using the time synchronisation feature of the IEC60870-5-103 protocol. The relay will correct for the transmission delay as specified in IEC60870-5-103. If the time synchronisation message is sent as a send/confirm message then the relay will respond with a confirm. Whether the time synchronisation message is sent as a send confirm or a broadcast (send/no reply) message, a time synchronisation message will be returned as Class 1 data.

If the relay clock is being synchronised using the IRIG-B input then it will not be possible to set the relay time using the IEC60870-5-103 interface. An attempt to set the time via the interface will cause the relay to create an event with the current date and time taken from the IRIG-B synchronised internal clock.

4.4 Spontaneous events

The events created by the relay will be passed using the standard function type/information numbers to the IEC60870-5-103 master station. Private codes are not used, thus any events that cannot be passed using the standardised messages will not be sent.

Events are categorised using the following information:

Common Address

Function Type

Information number

Appendix 1 contains a complete listing of all events produced by the relay. The common address is used to differentiate in circumstances where the relay produces more events of a certain type than can be passed using the standardised messages. For example if the relay produces starts and trips for four stages of overcurrent only two stages can be passed using the standardised messages.

Using the different common address for two of the overcurrent stages allows each stage to be indicated. The table in Appendix 1 shows the common address as an offset value.

The common address offset will be added to the station address in order to pass these events.

4.5 General interrogation

The GI request can be used to read the status of the relay, the function numbers, information numbers and common address offsets that will be returned during the GI cycle are indicated in Appendix 1.

4.6 Cyclic measurements

The relay will produce measured values using ASDU 9 on a cyclical basis, this can be read from the relay using a Class 2 poll (note ADSU 3 is not used). The rate at which the relay produces new measured values can be controlled using the Measurement Period setting. This setting can be edited from the front panel menu/front Courier port and is active immediately following a change.

It should be noted that the measurands transmitted by the relay are sent as a proportion of either 1.2 or 2.4 times the rated value of the analog value. The selection of either 1.2 or 2.4 for a particular value is indicated in Appendix 1.

4.7 Commands

A list of the supported commands is contained in Appendix 1. The relay will respond to other commands with an ASDU 1, with a cause of transmission (COT) of negative acknowledgement of a command.

4.8 Test mode

It is possible using either the front panel menu or the front Courier port to disable the relay output contacts to allow secondary injection testing to be performed. This is interpreted as test mode by the IEC60870-5-103 standard. An event will be produced to indicate both entry to and exit from test mode. Spontaneous events and cyclic measured data transmitted whilst the relay is in test mode will have a COT of test mode.

4.9 Disturbance records

The disturbance records stored by the relay cannot be extracted using the mechanism defined in the IEC60870-5-103 standard. The relay maintains compatibility with the VDEW control system by transmitting an ASDU 23 with no disturbance records at the start of every GI cycle.

Any attempt to extract disturbance record data from the relay (using ASDU 24) will result in the relay responding with ASDU 31 end of transmission of disturbance record with a Type of Order of abortion by the protection equipment.

4.10 Blocking of monitor direction

The relay does not support a facility to block messages in the Monitor direction.

5. DNP3 INTERFACE

5.1 DNP3 protocol

The DNP3 protocol is defined and administered by the DNP Users Group. Information about the user group, DNP3 in general and the protocol specifications can be found on their website:

www.dnp.org

The descriptions given here are intended to accompany the device profile document which is included in Appendix A. The DNP3 protocol is not described here, please refer to the documentation available from the user group. The device profile document specifies the full details of the DNP3 implementation for the relay. This is the standard format DNP3 document which specifies which objects, variations and qualifiers are supported. The device profile document also specifies what data is available from the relay via DNP3. The relay operates as a DNP3 slave and supports subset level 2 of the protocol, plus some of the features from level 3.

DNP3 communication uses the EIA(RS)485 communication port at the rear of the relay. The data format is 8 data bits, 1 start bit and 1 stop bit. Parity is configurable (see menu settings below).

5.2 DNP3 menu settings

The settings shown below are available in the menu for DNP3 in the 'Communications' column.

Setting	Range	Description
Remote Address	0 – 65534	DNP3 address of relay (decimal)
Baud Rate	1200, 2400, 4800, 9600, 19200, 38400	Selectable baud rate for DNP3 communication
Parity	None, Odd, Even	Parity setting
Time Sync	Enabled, Disabled	Enables or disables the relay requesting time sync from the master via IIN bit 4 word 1

5.3 Object 1 binary inputs

Object 1, binary inputs, contains information describing the state of signals within the relay which mostly form part of the digital data bus (DDB). In general these include the state of the output contacts and input optos, alarm signals and protection start and trip signals. The 'DDB number' column in the device profile document provides the DDB numbers for the DNP3 point data. These can be used to cross-reference to the DDB definition list which is also found in Appendix A. The binary input points can also be read as change events via object 2 and object 60.

5.4 Object 10 binary outputs

Object 10, binary outputs, contains commands which can be operated via DNP3. As such all points accept commands of type pulse on and latch on and execute the command once for either command. Pulse off and latch off are also accepted but result in no action being taken. The other fields ignored (queue, clear, trip/close, in time and off time). A read of object 10 will give a value of zero at all times since the commands do not have a data value. Due to that fact that many of the relay's functions are configurable, it may be the case that some of the object 10 commands are not available for operation. For example a 'test auto-reclose' command when the auto-reclose function is disabled. I the case of a read from object 10 this will result in the point being reported as off-line and for an operate command to object 12 will generate an error response.

5.5 Object 20 binary counters

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

5.6 Object 30 analogue input

Object 30, analogue inputs, contains information from the relay's measurements columns in the menu. All object 30 points are reported via DNP3 as fixed point values although they are stored inside the relay in floating point format. The conversion to fixed point format requires the use of a scaling factor, which differs for the various types of data within the relay e.g. current, voltage, phase angle etc. The data types supported are listed at the end of the device profile document with each type allocated a 'D number', i.e. D1, D2, etc. In the object 30 point list each data point has a D number data type assigned to it which defines the scaling factor, default deadband setting and the range and resolution of the deadband setting. The deadband is the setting used to determine whether a change event should be generated for each point. The change events can be read via object 32 or object 60 and will be generated for any point whose value has changed by more than the deadband setting since the last time the data value was reported.

Any analogue measurement that is unavailable at the time it is read will be reported as offline, e.g. the thermal state when the thermal protection is disabled in the configuration column. Note that all object 30 points are reported as secondary values in DNP3 (with respect to CT and VT ratios).

5.7 DNP3 configuration using MiCOM S1

A PC support package for DNP3 is available as part of the Settings and Records module of MiCOM S1. The S1 module allows configuration of the relay's DNP3 response. The PC is connected to the relay via a serial cable to the 9-pin front part of the relay – see chapter 1, Introduction. The configuration data is uploaded from the relay to the PC in a block of compressed format data and downloaded to the relay in a similar manner after modification. The new DNP3 configuration takes effect in the relay after the download is complete. The default configuration can be restored at any time by choosing 'All Settings' from the 'Restore Defaults' cell in the menu 'Configuration' column. In S1 the DNP3 data is displayed on three tabbed screen, one for each object1, 20 and 30. Object 10 is not configurable.

5.7.1 Object 1

For every point included in the device profile document there is a check box for membership of class 0 and ration buttons for class 1, 2 or 3 membership. Any point which is in class 0 must be a member of one of the change event classes, 1, 2 or 3. Points which are configured out of class 0 are by default not capable of generating change events. Furthermore, points that are not part of class 0 are effectively removed from the DNP3 response by renumbering the points that are in class 0 into a contiguous list starting at point number 0. The renumbered point numbers are shown at the left hand side of the screen in S1 and can be printed out to form a revised device profile for the relay. This mechanism allows best use of available bandwidth by only reporting the data points required by the user when a poll for all points is made.

5.7.2 Object 20

The running counter value of object 20 points can be configured to be in or out of class 0. Any running counter that is in class 0 can have its frozen value selected to be in or out of the DNP3 response, but a frozen counter cannot be included without the corresponding running counter. As with object 1, the class 0 response will be renumbered into a contiguous list of points based on the selection of running counters. The frozen counters will also be renumbered based on the selection; note that if some of the counters that are selected as running are not also selected as frozen then the renumbering will result in the frozen counters having different point numbers to their running counterparts. For example, object 20 point 3 (running counter) might have its frozen value reported as object 21 point 1.

5.7.3 Object 30

For the analogue inputs, object 30, the same selection options for classes 0, 1, 2 and 3 are available as for object 1. In addition to these options, which behave in exactly the same way as for object 1, it is possible to change the deadband setting for each point. The minimum and maximum values and the resolution of the deadband settings are defined in the device profile document; MiCOM S1 will allow the deadband to be set to any value within these constraints.

APPENDIX A
Relay Menu Database

APPENDIX A

This Appendix is split into several sections, these are as follows:

- Menu Database for Courier, User Interface and Modbus
- Menu Datatype Definition
- Event Data for Courier, User Interface and Modbus
- IEC60870-5-103 Interoperability Guide
- Internal Digital Signals
- DNP3.0 Device Profile Document
- Default Programmable Logic

Menu database

This database defines the structure of the relay menu for the courier interface, the front panel user interface and the Modbus interface. This includes all the relay settings and measurements. Datatypes for Modbus and indexed strings for Courier and the user interface are cross-referenced to the Menu Datatype Definition section (using a G Number). For all settable cells the setting limits and default value are also defined within this database.

Note: The following labels are used within the database

Label	Description	Value
V1	Main VT Rating	1 (100/110V)
V2	Checksynch VT Rating	1 (100/110V)
V3	NVD VT Rating	1 (100/110V)
I1	Phase CT Rating	1 or 5 (Setting 0A08)
I2	Earth Fault CT Rating	1 or 5 (Setting 0A0A)
I3	Sensitive CT Rating	1 or 5 (Setting 0A0C)
I4	Mutual CT Rating	1 or 5 (Setting 0A0E)

Menu datatype definition

This table defines the datatypes used for Modbus (the datatypes for the Courier and user interface are defined within the Menu Database itself using the standard Courier Datatypes). This section also defines the indexed string setting options for all interfaces. The datatypes defined within this section are cross-referenced to from the menu Database using a G number.

Event data

This section of the appendix specifies all the event information that can be produced by the relay. It details exactly how each event will be presented via the Courier, User and Modbus interfaces.

IEC60870-5-103 Interoperability guide

This table fully defines the operation of the IEC60870-5-103 (VDEW) interface for the relay it should be read in conjunction with the relevant section of the Communications Chapter of this Manual (Volume 1 Chapter 5).

Internal digital signals

This table defines all of the relay internal digital signals (opto inputs, output contacts and protection inputs and outputs). A relay may have up to 512 internal signals each referenced by a numeric index as shown in this table. This numeric index is used to select a signal for the commissioning monitor port. It is also used to explicitly define protection events produced by the relay (see the Event Data section of this Appendix).

DNP3.0 Device Profile Document

This table defines all of the objects, functions and/or qualifiers supported.

Default programmable logic

This section documents the default programmable logic for the various models of the relay. This default logic for each model of the relay is supplied with the MiCOM S1 Scheme Logic Editor PC support software.

References

Chapter 1 Introduction: User Interface operation and connections to the relay

Chapter 5 Communications: Overview of communication interfaces

Courier User Guide R6512

Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev E

IEC60870-5-103 Telecontrol Equipment and Systems – Transmission Protocols – Companion Standard for the informative interface of Protection Equipment

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
SYSTEM DATA		00	00												*	*	*	
Language		00	01	Indexed String	G19			G19	English	Setting	0	3	1	2	*	*	*	Setting applies only to interface being used
Password		00	02	ASCII Password (4 chars)	G20	40001	40002	G20	AAAA	Setting	65	90	1	0	*	*	*	Setting applies only to interface being used
Sys Fn Links		00	03	Binary Flag (8 bits)	G95	40003		G95	0	Setting	1	1	1	2	*	*	*	
				Indexed String														
Description		00	04	ASCII Text (16 chars)		40004	40011	G3	MiCOM P141	Setting	32	163	1	2	*			
									MiCOM P142							*		
									MiCOM P143								*	
Plant Reference		00	05	ASCII Text (16 chars)		40012	40019	G3	ALSTOM	Setting	32	163	1	2	*	*	*	
Model Number		00	06	ASCII Text (16 chars)		30020	30035	G3		Data					*	*	*	
Serial Number		00	08	ASCII Text (7 chars)		30044	30051	G3		Data					*	*	*	
Frequency		00	09	Unsigned Integer (16 bits)		40020		G1	50	Setting	50	60	10	2	*	*	*	
Comms Level		00	0A	Unsigned Integer (16 bits)					1	Data					*	*	*	
Relay Address		00	0B	Unsigned Integer (16 bits)					255	Setting	0	255	1	1	*	*	*	Build = Courier
																		Rear port address available via LCD
Relay Address		00	0B	Unsigned Integer (16 bits)					1	Setting	1	247	1	1	*	*	*	Build = Modbus
																		Rear port address available via LCD
Relay Address		00	0B	Unsigned Integer (16 bits)					1	Setting	0	254	1	1	*	*	*	Build = IEC60870-5-103
																		Rear port address available via LCD
Relay Address		00	0B	Unsigned Integer (16 bits)					1	Setting	0	65534	1	1	*	*	*	Build = DNP3.0
																		Rear port address available via LCD
	N/A			Binary Flag (16 bits)		30001		G26		Data					*	*	*	Modbus only (Relay status)
Plant Status		00	0C	Binary Flag (16 bits)		30002		G4		Data					*	*	*	
Control Status		00	0D	Binary Flag (16 bits)		30004		G5		Data					*	*	*	
Active Group		00	0E	Unsigned Integer (16 bits)		30006		G1		Data					*	*	*	
CB Trip/Close		00	10	Indexed String	G55				No Operation	Command	0	2	1	1	*	*	*	Visible to LCD+Front Port
CB Trip/Close	N/A	00	10	Indexed String	G55	40021		G55	No Operation	Command	0	2	1	1	*	*	*	Visible to Rear Port
Software Ref. 1		00	11	ASCII Text (16 chars)		30052	30059	G3		Data					*	*	*	
Opto I/P Status		00	20	Binary Flag (32 bits)		30007		G8		Data					*	*	*	
				Indexed String														
Relay O/P Status		00	21	Binary Flag (32 bits)		30008	30009	G9		Data					*	*	*	
				Indexed String														
Alarm Status 1		00	22	Binary Flag (32 bits)		30011	30012	G96-1		Data					*	*	*	
				Indexed String														
Alarm Status 1		00	50	Binary Flag (32 bits)		30013	30014	G96-1		Data					*	*	*	
				Indexed String														
Alarm Status 2		00	51	Binary Flag (32 bits)		30015	30016	G96-2		Data					*	*	*	
				Indexed String														
Access Level		00	D0	Unsigned Integer (16 bits)	G1	30010		G1		Data					*	*	*	
Password Control		00	D1	Unsigned Integer (16 bits)	G22	40022		G22	2	Setting	0	2	1	2	*	*	*	
Password Level 1		00	D2	ASCII Password (4 chars)	G20	40023	40024	G20	AAAA	Setting	65	90	1	1	*	*	*	
Password Level 2		00	D3	ASCII Password (4 chars)	G20	40025	40026	G20	AAAA	Setting	65	90	1	2	*	*	*	
VIEW RECORDS		01	00												*	*	*	
						30100		G1										No of event records stored
						30101		G1										No of fault records stored
						30102		G1										No of maintenance records stored

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
Select Event		01	01	Unsigned Integer (16 bits)		40100			0	Setting	0	249	1	0	*	*	*	Max value is oldest record
[0...n]																		n is last event record
Menu Cell Ref	N/A	01	02	Cell Reference		30107		G13	(From Record)	Data					*	*	*	Indicates type of event
																		See Event sheet
Time & Date		01	03	IEC870 Date & Time		30103	30106	G12	(From Record)	Data					*	*	*	
Event Text		01	04	ASCII Text (32 chars)						Data					*	*	*	See Event sheet
Event Value		01	05	Unsigned Integer (32 bits)		30108	30109	G27		Data					*	*	*	Note DTL depends on event type
Select Fault		01	06	Unsigned Integer (16 bits)		40101		G1	0	Setting	0	4	1	0	*	*	*	Allows Fault Record to be selected
[0...n]																		n is last fault record
						30110		G1		Data					*	*	*	Modbus change address
																		Alarm 30011, Relay 30723, Opto 30725
						30111		G1		Data					*	*	*	Status of current 16 ddb elements
						30112		G1		Data					*	*	*	Additional data present
Started Phase		N/A								Data					*	*	*	
A B C N																		A/B/C/N Visible if Start A/B/C/N
Tripped Phase		N/A								Data					*	*	*	
A B C N																		A/B/C/N Visible if Trip A/B/C/N
Overcurrent		N/A								Data					*	*	*	
Start I> 1234																		1/2/3/4 Visible if Start I>1/2/3/4
Overcurrent		N/A								Data					*	*	*	
Trip I> 1234																		1/2/3/4 Visible if Trip I>1/2/3/4
Neg Seq O/C		N/A								Data					*	*	*	
I2> Start Trip																		
Broken Conductor		N/A								Data					*	*	*	
Trip																		
Earth Fault 1		N/A								Data					*	*	*	
Start IN1> 1234																		1/2/3/4 visible if Start IN1>1/2/3/4
Earth Fault 1		N/A								Data					*	*	*	
Trip IN1> 1234																		1/2/3/4 visible if Trip IN1>1/2/3/4
Earth Fault 2		N/A								Data					*	*	*	
Start IN2> 1234																		1/2/3/4 visible if Start IN2>1/2/3/4
Earth Fault 2		N/A								Data					*	*	*	
Trip IN2> 1234																		1/2/3/4 visible if Trip IN2>1/2/3/4
Sensitive E/F		N/A								Data					*	*	*	
Start ISEF> 1234																		1/2/3/4 visible if Start ISEF>1/2/3/4
Sensitive E/F		N/A								Data					*	*	*	
Trip ISEF> 1234																		1/2/3/4 visible if Trip ISEF>1/2/3/4
Restricted E/F		N/A								Data					*	*	*	
Trip IREF>																		
Residual O/V NVD		N/A								Data					*	*	*	
Start VN> 1 2																		1/2 visible if Start VN>1/2
Residual O/V NVD		N/A								Data					*	*	*	
Trip VN> 1 2																		1/2 visible if Trip VN>1/2
Thermal Overload		N/A								Data					*	*	*	
Alarm Trip																		
Neg Seq O/V		N/A								Data					*	*	*	
V2> Start Trip																		
U/Voltage Start		N/A								Data					*	*	*	
V< 1 2 AB BC CA																		1/2/AB/BC/CA visible if Start V<1/2
U/Voltage Trip		N/A								Data					*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
V< 1 2 AB BC CA																		1/2/AB/BC/CA visible if Trip V<1/2
O/Voltage Start		N/A								Data					*	*	*	
V> 1 2 AB BC CA																		1/2/AB/BC/CA visible if Start V>1/2
O/Voltage Trip		N/A								Data					*	*	*	
V> 1 2 AB BC CA																		1/2/AB/BC/CA visible if Trip V>1/2
Underfrequency		N/A								Data					*	*	*	
Start F< 1234																		1/2/3/4 visible if Start F<1/2/3/4
Underfrequency		N/A								Data					*	*	*	
Trip F< 1234																		1/2/3/4 visible if Trip F<1/2/3/4
Overfrequency		N/A								Data					*	*	*	
Start F> 1 2																		1/2 visible if Start F>1/2
Overfrequency		N/A								Data					*	*	*	
Trip F> 1 2																		1/2 visible if Trip F>1/2
Overadmittance		N/A								Data					*	*	*	
YN> Start Trip																		Visible if Start YN> / Trip YN>
Overconductance		N/A								Data					*	*	*	
GN> Start Trip																		Visible if Start GN> / Trip GN>
Oversusceptance		N/A								Data					*	*	*	
BN> Start Trip																		Visible if Start BN> / Trip BN>
Breaker Fail		N/A								Data					*	*	*	
CB Fail 1 2																		1/2 visible if CB Fail 1/2
Supervision		N/A								Data					*	*	*	VTS/CTS/VCO/CLP visible if
VTS CTS VCO CLP																		Alarm VTS/CTS/VCO/CLP
A/R State		N/A								Data						*	*	
Trip 1 2 3 4 5																		1/2/3/4 visible if SC:Count 1/2/3/4
Faulted Phase	N/A	01	07	Binary Flag (8 bits)	G16	30113		G16		Data					*	*	*	Started phases + tripped phases
Start Elements 1	N/A	01	08	Binary Flag (32 bits)	G84	30114	30115	G84		Data					*	*	*	Started main elements
				Indexed String														
Start Elements 2	N/A	01	09	Binary Flag (32 bits)	G107	30116	30117	G107		Data					*	*	*	Started secondary elements
				Indexed String														
Trip Elements 1	N/A	01	0A	Binary Flag (32 bits)	G85	30118	30119	G85		Data					*	*	*	Tripped main elements
				Indexed String														
Trip Elements 2	N/A	01	0B	Binary Flag (32 bits)	G86	30120	30121	G86		Data					*	*	*	Tripped secondary elements
				Indexed String														
Fault Alarms	N/A	01	0C	Binary Flag (32 bits)	G87	30122	30123	G87		Data					*	*	*	Faullt Alarms/Warnings
				Indexed String														
Fault Time		01	0D	IEC870 Date & Time		30124	30127	G12		Data					*	*	*	Fault Record Time Stamp
Active Group		01	0E	Unsigned Integer (16 bits)		30128		G1		Data					*	*	*	
System Frequency		01	0F	Courier Number (frequency)		30129		G30		Data					*	*	*	
Fault Duration		01	10	Courier Number (time)		30130	30131	G24		Data					*	*	*	
CB Operate Time		01	11	Courier Number (time)		30132		G25		Data					*	*	*	
Relay Trip Time		01	12	Courier Number (time)		30133	30134	G24		Data					*	*	*	
Fault Location		01	13	Courier Number (metres)		30135	30136	G125		Data					*	*	*	
Fault Location		01	14	Courier Number (miles)		30137	30138	G125		Data					*	*	*	
Fault Location		01	15	Courier Number (impedance)		30139	30140	G125		Data					*	*	*	
Fault Location		01	16	Courier Number (percentage)		30141	30142	G125		Data					*	*	*	
IA		01	17	Courier Number (current)		30143	30144	G24		Data					*	*	*	
IB		01	18	Courier Number (current)		30145	30146	G24		Data					*	*	*	
IC		01	19	Courier Number (current)		30147	30148	G24		Data					*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
VAB		01	1A	Courier Number (voltage)		30149	30150	G24		Data					*	*	*	
VBC		01	1B	Courier Number (voltage)		30151	30152	G24		Data					*	*	*	
VCA		01	1C	Courier Number (voltage)		30153	30154	G24		Data					*	*	*	
IN Measured		01	1D	Courier Number (current)		30155	30156	G24		Data					*	*	*	
IN Derived		01	1E	Courier Number (current)		30157	30158	G24		Data					*	*	*	
IN Sensitive		01	1F	Courier Number (current)		30159	30160	G24		Data					*	*	*	
IREF Diff		01	20	Courier Number (current)		30161	30162	G24		Data					*	*	*	Visible if low imp REF protection enabled
IREF Bias		01	21	Courier Number (current)		30163	30164	G24		Data					*	*	*	Visible if low imp REF protection enabled
VAN		01	22	Courier Number (voltage)		30165	30166	G24		Data					*	*	*	
VBN		01	23	Courier Number (voltage)		30167	30168	G24		Data					*	*	*	
VCN		01	24	Courier Number (voltage)		30169	30170	G24		Data					*	*	*	
VN Derived		01	25	Courier Number (voltage)		30171	30172	G24		Data					*	*	*	
Admittance		01	26	Courier Number (inverse ohms)		30173	30174	G125		Data					*	*	*	Visible if admittance prot enabled (ISEF)
Conductance		01	27	Courier Number (inverse ohms)		30175	30176	G125		Data					*	*	*	Visible if admittance prot enabled (ISEF)
Susceptance		01	28	Courier Number (inverse ohms)		30177	30178	G125		Data					*	*	*	Visible if admittance prot enabled (ISEF)
Admittance		01	29	Courier Number (inverse ohms)		30179	30180	G125		Data					*	*	*	Visible if admittance prot enabled (IN)
Conductance		01	2A	Courier Number (inverse ohms)		30181	30182	G125		Data					*	*	*	Visible if admittance prot enabled (IN)
Susceptance		01	2B	Courier Number (inverse ohms)		30183	30184	G125		Data					*	*	*	Visible if admittance prot enabled (IN)
Select Maint		01	F0	Unsigned Integer (16 bits)		40102		G1	Manual override to select a fault record	Setting	0	4	1	2	*	*	*	Allows Self Test Report to be selected
[0...n]																		n is last maintenance record
Maint Text		01	F1	ASCII Text (32 chars)						Data					*	*	*	
Maint Type		01	F2	Unsigned Integer (32 bits)		30036	30037	G27		Data					*	*	*	
Maint Data		01	F3	Unsigned Integer (32 bits)		30038	30039	G27		Data					*	*	*	
Reset Indication		01	FF	Indexed String	G11				No	Command	0	1	1	1	*	*	*	
MEASUREMENTS 1		02	00												*	*	*	
IA Magnitude		02	01	Courier Number (current)		30200	30201	G24		Data					*	*	*	
IA Phase Angle		02	02	Courier Number (angle)		30202		G30		Data					*	*	*	
IB Magnitude		02	03	Courier Number (current)		30203	30204	G24		Data					*	*	*	
IB Phase Angle		02	04	Courier Number (angle)		30205		G30		Data					*	*	*	
IC Magnitude		02	05	Courier Number (current)		30206	30207	G24		Data					*	*	*	
IC Phase Angle		02	06	Courier Number (angle)		30208		G30		Data					*	*	*	
IN Measured Mag		02	07	Courier Number (current)		30209	30210	G24		Data					*	*	*	
IN Measured Ang		02	08	Courier Number (angle)		30211		G30		Data					*	*	*	
IN Derived Mag		02	09	Courier Number (current)		30212	30213	G24		Data					*	*	*	
IN Derived Angle		02	0A	Courier Number (angle)		30214		G30		Data					*	*	*	
ISEF Magnitude		02	0B	Courier Number (current)		30215	30216	G24		Data					*	*	*	
ISEF Angle		02	0C	Courier Number (angle)		30217		G30		Data					*	*	*	
I1 Magnitude		02	0D	Courier Number (current)		30218	30219	G24		Data					*	*	*	
I2 Magnitude		02	0E	Courier Number (current)		30220	30221	G24		Data					*	*	*	
I0 Magnitude		02	0F	Courier Number (current)		30222	30223	G24		Data					*	*	*	
IA RMS		02	10	Courier Number (current)		30224	30225	G24		Data					*	*	*	
IB RMS		02	11	Courier Number (current)		30226	30227	G24		Data					*	*	*	
IC RMS		02	12	Courier Number (current)		30228	30229	G24		Data					*	*	*	

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	P141	P142	P143	Comment
VAB Magnitude		02	14	Courier Number (voltage)		30230	30231	G24		Data					*	*	*	
VAB Phase Angle		02	15	Courier Number (angle)		30232		G30		Data					*	*	*	
VBC Magnitude		02	16	Courier Number (voltage)		30233	30234	G24		Data					*	*	*	
VBC Phase Angle		02	17	Courier Number (angle)		30235		G30		Data					*	*	*	
VCA Magnitude		02	18	Courier Number (voltage)		30236	30237	G24		Data					*	*	*	
VCA Phase Angle		02	19	Courier Number (angle)		30238		G30		Data					*	*	*	
VAN Magnitude		02	1A	Courier Number (voltage)		30239	30240	G24		Data					*	*	*	
VAN Phase Angle		02	1B	Courier Number (angle)		30241		G30		Data					*	*	*	
VBN Magnitude		02	1C	Courier Number (voltage)		30242	30243	G24		Data					*	*	*	
VBN Phase Angle		02	1D	Courier Number (angle)		30244		G30		Data					*	*	*	
VCN Magnitude		02	1E	Courier Number (voltage)		30245	30246	G24		Data					*	*	*	
VCN Phase Angle		02	1F	Courier Number (angle)		30247		G30		Data					*	*	*	
VN Derived Mag		02	22	Courier Number (voltage)		30248	30249	G24		Data					*	*	*	
VN Derived Ang		02	23	Courier Number (angle)		30250		G30		Data					*	*	*	
V1 Magnitude		02	24	Courier Number (voltage)		30251	30252	G24		Data					*	*	*	
V2 Magnitude		02	25	Courier Number (voltage)		30253	30254	G24		Data					*	*	*	
V0 Magnitude		02	26	Courier Number (voltage)		30255	30256	G24		Data					*	*	*	
VAN RMS		02	27	Courier Number (voltage)		30257	30258	G24		Data					*	*	*	
VBN RMS		02	28	Courier Number (voltage)		30259	30260	G24		Data					*	*	*	
VCN RMS		02	29	Courier Number (voltage)		30261	30262	G24		Data					*	*	*	
Frequency		02	2D	Courier Number (frequency)		30263		G30		Data					*	*	*	Visible if frequency is valid (40-70Hz)
C/S Voltage Mag		02	2E	Courier Number (voltage)		30264	30265	G24		Data							*	Visible if System Checks enabled
C/S Voltage Ang		02	2F	Courier Number (angle)		30266		G30		Data							*	Visible if System Checks enabled
C/S Bus-Line Ang		02	30	Courier Number (angle)		30267		G30		Data							*	Visible if System Checks enabled
Slip Frequency		02	31	Courier Number (frequency)		30268		G30		Data							*	Visible if System Checks enabled
I1 Magnitude		02	40	Courier Number (current)				G24		Data					*	*	*	
I1 Phase Angle		02	41	Courier Number (angle)		30269		G30		Data					*	*	*	
I2 Magnitude		02	42	Courier Number (current)				G24		Data					*	*	*	
I2 Phase Angle		02	43	Courier Number (angle)		30270		G30		Data					*	*	*	
I0 Magnitude		02	44	Courier Number (current)				G24		Data					*	*	*	
I0 Phase Angle		02	45	Courier Number (angle)		30271		G30		Data					*	*	*	
V1 Magnitude		02	46	Courier Number (voltage)				G24		Data					*	*	*	
V1 Phase Angle		02	47	Courier Number (angle)		30272		G30		Data					*	*	*	
V2 Magnitude		02	48	Courier Number (voltage)				G24		Data					*	*	*	
V2 Phase Angle		02	49	Courier Number (angle)		30273		G30		Data					*	*	*	
V0 Magnitude		02	4A	Courier Number (voltage)				G24		Data					*	*	*	
V0 Phase Angle		02	4B	Courier Number (angle)		30274		G30		Data					*	*	*	
MEASUREMENTS 2		03	00												*	*	*	
A Phase Watts		03	01	Courier Number (power)		30300	30302	G29		Data					*	*	*	
B Phase Watts		03	02	Courier Number (power)		30303	30305	G29		Data					*	*	*	
C Phase Watts		03	03	Courier Number (power)		30306	30308	G29		Data					*	*	*	
A Phase VArs		03	04	Courier Number (VAr)		30309	30311	G29		Data					*	*	*	
B Phase VArs		03	05	Courier Number (VAr)		30312	30314	G29		Data					*	*	*	
C Phase VArs		03	06	Courier Number (VAr)		30315	30317	G29		Data					*	*	*	
A Phase VA		03	07	Courier Number (VA)		30318	30320	G29		Data					*	*	*	
B Phase VA		03	08	Courier Number (VA)		30321	30323	G29		Data					*	*	*	
C Phase VA		03	09	Courier Number (VA)		30324	30326	G29		Data					*	*	*	
3 Phase Watts		03	0A	Courier Number (power)		30327	30329	G29		Data					*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
3 Phase VArs		03	0B	Courier Number (VAr)		30330	30332	G29		Data					*	*	*	
3 Phase VA		03	0C	Courier Number (VA)		30333	30335	G29		Data					*	*	*	
3Ph Power Factor		03	0E	Courier Number (decimal)		30336		G30		Data					*	*	*	
APh Power Factor		03	0F	Courier Number (decimal)		30337		G30		Data					*	*	*	
BPh Power Factor		03	10	Courier Number (decimal)		30338		G30		Data					*	*	*	
CPh Power Factor		03	11	Courier Number (decimal)		30339		G30		Data					*	*	*	
3Ph WHours Fwd		03	12	Courier Number (Wh)		30340	30342	G29		Data					*	*	*	3 Phase Watt - Hours (Forward)
3Ph WHours Rev		03	13	Courier Number (Wh)		30343	30345	G29		Data					*	*	*	3 Phase Watts - Hours (Reverse)
3Ph VArHours Fwd		03	14	Courier Number (VArh)		30346	30348	G29		Data					*	*	*	3 Phase VAr - Hours (Forward)
3Ph VArHours Rev		03	15	Courier Number (VArh)		30349	30351	G29		Data					*	*	*	3 Phase VAr - Hours (Reverse)
3Ph W Fix Demand		03	16	Courier Number (power)		30352	30354	G29		Data					*	*	*	3 Phase Watts - Fixed Demand
3Ph VArs Fix Dem		03	17	Courier Number (VAr)		30355	30357	G29		Data					*	*	*	3 Phase VArs - Fixed Demand
IA Fixed Demand		03	18	Courier Number (current)		30358	30359	G24		Data					*	*	*	
IB Fixed Demand		03	19	Courier Number (current)		30360	30361	G24		Data					*	*	*	
IC Fixed Demand		03	1A	Courier Number (current)		30362	30363	G24		Data					*	*	*	
3 Ph W Roll Dem		03	1B	Courier Number (power)		30364	30366	G29		Data					*	*	*	3 Phase Watts - Rolling Demand
3Ph VArs RollDem		03	1C	Courier Number (VAr)		30367	30369	G29		Data					*	*	*	3 Phase VArs - Rolling Demand
IA Roll Demand		03	1D	Courier Number (current)		30370	30371	G24		Data					*	*	*	
IB Roll Demand		03	1E	Courier Number (current)		30372	30373	G24		Data					*	*	*	
IC Roll Demand		03	1F	Courier Number (current)		30374	30375	G24		Data					*	*	*	
3Ph W Peak Dem		03	20	Courier Number (power)		30376	30378	G29		Data					*	*	*	3 Phase Watts - Peak Demand
3Ph VAr Peak Dem		03	21	Courier Number (VAr)		30379	30381	G29		Data					*	*	*	3 Phase VArs - Peak Demand
IA Peak Demand		03	22	Courier Number (current)		30382	30383	G24		Data					*	*	*	
IB Peak Demand		03	23	Courier Number (current)		30384	30385	G24		Data					*	*	*	
IC Peak Demand		03	24	Courier Number (current)		30386	30387	G24		Data					*	*	*	
Reset Demand		03	25	Indexed String	G11	40103		G11	No	Command	0	1	1	1	*	*	*	
																		South Pars Modifications - 2
	N/A					30388	30389	G125		Data					*	*	*	A Phase Watts (see [0301])
	N/A					30390	30391	G125		Data					*	*	*	B Phase Watts (see [0302])
	N/A					30392	30393	G125		Data					*	*	*	C Phase Watts (see [0303])
	N/A					30394	30395	G125		Data					*	*	*	A Phase VArs (see [0304])
	N/A					30396	30397	G125		Data					*	*	*	B Phase VArs (see [0305])
	N/A					30398	30399	G125		Data					*	*	*	C Phase VArs (see [0306])
	N/A					30400	30401	G125		Data					*	*	*	A Phase VA (see [0307])
	N/A					30402	30403	G125		Data					*	*	*	B Phase VA (see [0308])
	N/A					30404	30405	G125		Data					*	*	*	C Phase VA (see [0309])
	N/A					30406	30407	G125		Data					*	*	*	3 Phase Watts (see [030A])
	N/A					30408	30409	G125		Data					*	*	*	3 Phase VArs (see [030B])
	N/A					30410	30411	G125		Data					*	*	*	3 Phase VA (see [030C])
	N/A					30412	30413	G125		Data					*	*	*	3 Phase WHours Fwd (see [0312])
	N/A					30414	30415	G125		Data					*	*	*	3 Phase WHours Rev (see [0313])
	N/A					30416	30417	G125		Data					*	*	*	3 Phase VArHours Fwd (see [0314])
	N/A					30418	30419	G125		Data					*	*	*	3 Phase VArHours Rev (see [0315])
	N/A					30420	30421	G125		Data					*	*	*	3 Phase W Fix Demand (see [0316])
	N/A					30422	30423	G125		Data					*	*	*	3 Phase VArs Fix Demand (see [0317])
	N/A					30424	30425	G125		Data					*	*	*	3 Phase W Roll Demand (see [031B])
	N/A					30426	30427	G125		Data					*	*	*	3 Phase VArs Roll Demand (see [031C])
	N/A					30428	30429	G125		Data					*	*	*	3 Phase W Peak Demand (see [0320])

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
	N/A					30430	30431	G125		Data					*	*	*	3 Phase VArs Peak Demand (see [0321])
MEASUREMENTS 3		04	00												*	*	*	
Highest Phase I		04	01	Courier Number (current)		30432	30433	G24		Data					*	*	*	
Thermal State		04	02	Courier Number (percentage)		30434		G30		Data					*	*	*	Visible if thermal overload prot enabled
Reset Thermal		04	03	Indexed String	G11	40104		G11		Command	0	1	1	1	*	*	*	Visible if thermal overload prot enabled
IREF Diff		04	04	Courier Number (current)		30435	30436	G24		Data					*	*	*	Visible if low imp REF protection enabled
IREF Bias		04	05	Courier Number (current)		30437	30438	G24		Data					*	*	*	Visible if low imp REF protection enabled
Admittance		04	06	Courier Number (inverse ohms)		30439	30440	G125		Data					*	*	*	Visible if admittance prot enabled (ISEF)
Conductance		04	07	Courier Number (inverse ohms)		30441	30442	G125		Data					*	*	*	Visible if admittance prot enabled (ISEF)
Susceptance		04	08	Courier Number (inverse ohms)		30443	30444	G125		Data					*	*	*	Visible if admittance prot enabled (ISEF)
Admittance		04	09	Courier Number (inverse ohms)		30445	30446	G125		Data					*	*	*	Visible if admittance prot enabled (IN)
Conductance		04	0A	Courier Number (inverse ohms)		30447	30448	G125		Data					*	*	*	Visible if admittance prot enabled (IN)
Susceptance		04	0B	Courier Number (inverse ohms)		30449	30450	G125		Data					*	*	*	Visible if admittance prot enabled (IN)
I2/I1 Ratio		04	0C	Courier Number (inverse ohms)		30451		G30		Data					*	*	*	
CB CONDITION		06	00												*	*	*	CB CONDITION MONITORING
CB Operations		06	01	Unsigned Integer (16 bits)		30600		G1		Data					*	*	*	Number of Circuit Breaker Operations
Total IA Broken		06	02	Courier Number (current)		30601	30602	G24		Data	NM1				*	*	*	Broken Current A Phase
Total IB Broken		06	03	Courier Number (current)		30603	30604	G24		Data	NM1				*	*	*	Broken Current B Phase
Total IC Broken		06	04	Courier Number (current)		30605	30606	G24		Data	NM1				*	*	*	Broken Current C Phase
CB Operate Time		06	05	Courier Number (time)		30607		G25		Data					*	*	*	Circuit Breaker operating time
Reset CB Data		06	06	Indexed String	G11	40150		G11	No	Command	0	1	1	1	*	*	*	Reset All Values
CB CONTROL		07	00												*	*	*	
CB Control by		07	01	Indexed String	G99	40200		G99	Disabled	Setting	0	7	1	2	*	*	*	
Close Pulse Time		07	02	Courier Number (time)		40201		G2	0.5	Setting	0.1	10	0.01	2	*	*	*	
Trip Pulse Time		07	03	Courier Number (time)		40202		G2	0.5	Setting	0.1	5	0.01	2	*	*	*	
Man Close Delay		07	05	Courier Number (time)		40203		G2	10	Setting	0.01	600	0.01	2	*	*	*	
CB Healthy Time		07	06	Courier Number (time)		40204	40205	G35	5	Setting	0.01	9999	0.01	2	*	*	*	
Sys Check Time		07	07	Courier Number (time)		40206	40207	G35	5	Setting	0.01	9999	0.01	2			*	
Lockout Reset		07	08	Indexed String	G11	40208		G11	No	Command	0	1	1	2	*	*	*	
Reset Lockout by		07	09	Indexed String	G81	40209		G81	CB Close	Setting	0	1	1	2	*	*	*	
Man Close RstDly		07	0A	Courier Number (time)		40210		G2	5	Setting	0.1	600	0.01	2	*	*	*	
A/R Telecontrol		07	0B	Indexed String	G78	40211		G78	No Operation	Command	0	2	1	2		*	*	
A/R Status		07	0E	Indexed String	G83	30608		G83		Data						*	*	
Total Reclosures		07	0F	Unsigned Integer (16 bits)		30609		G1		Data						*	*	No of Autoreclosures
Reset Total A/R		07	10	Indexed String	G11	40212		G11	No	Command	0	1	1	2		*	*	Reset No of Autoreclosures
CB Status Input		07	11	Indexed String	G118	40213		G118	None	Setting	0	3	1	2	*	*	*	52A and 52B Logic Input Assignment
1 Shot Clearance		07	12	Unsigned Integer (16 bits)		30610		G1		Data						*	*	
2 Shot Clearance		07	13	Unsigned Integer (16 bits)		30611		G1		Data						*	*	
3 Shot Clearance		07	14	Unsigned Integer (16 bits)		30612		G1		Data						*	*	
4 Shot Clearance		07	15	Unsigned Integer (16 bits)		30613		G1		Data						*	*	
Persistent Fault		07	16	Unsigned Integer (16 bits)		30614		G1		Data						*	*	
DATE AND TIME		08	00												*	*	*	
Date/Time	N/A	08	01	IEC870 Date & Time		40300	40303	G12		Setting				0	*	*	*	
Date			N/A															Front Panel Menu only

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
12-Jan-98																		
Time			N/A															Front Panel Menu only
12:00																		
IRIG-B Sync		08	04	Indexed String	G37	40304		G37	Disabled	Setting	0	1	1	2	*	*	*	
IRIG-B Status		08	05	Indexed String	G17	30090		G17		Data					*	*	*	
Battery Status		08	06	Indexed String	G59	30091		G59		Data					*	*	*	
Battery Alarm		08	07	Indexed String	G37	40305		G37	Enabled	Setting	0	1	1	2	*	*	*	
CONFIGURATION		09	00												*	*	*	
Restore Defaults		09	01	Indexed String	G53	40402		G53	No Operation	Command	0	5	1	2	*	*	*	
Setting Group		09	02	Indexed String	G61	40403		G61	Select via Menu	Setting	0	1	1	2	*	*	*	
Active Settings		09	03	Indexed String	G90	40404		G90	Group 1	Setting	0	3	1	1	*	*	*	
Save Changes		09	04	Indexed String	G62	40405		G62	No Operation	Command	0	2	1	2	*	*	*	
Copy From		09	05	Indexed String	G90	40406		G90	Group 1	Setting	0	3	1	2	*	*	*	
Copy To		09	06	Indexed String	G98	40407		G98	No Operation	Command	0	3	1	2	*	*	*	
Setting Group 1		09	07	Indexed String	G37	40408		G37	Enabled	Setting	0	1	1	2	*	*	*	
Setting Group 2		09	08	Indexed String	G37	40409		G37	Disabled	Setting	0	1	1	2	*	*	*	
Setting Group 3		09	09	Indexed String	G37	40410		G37	Disabled	Setting	0	1	1	2	*	*	*	
Setting Group 4		09	0A	Indexed String	G37	40411		G37	Disabled	Setting	0	1	1	2	*	*	*	
															*	*	*	
Overcurrent		09	10	Indexed String	G37	40412		G37	Enabled	Setting	0	1	1	2	*	*	*	
Neg Sequence O/C		09	11	Indexed String	G37	40413		G37	Disabled	Setting	0	1	1	2	*	*	*	
Broken Conductor		09	12	Indexed String	G37	40414		G37	Disabled	Setting	0	1	1	2	*	*	*	
Earth Fault 1		09	13	Indexed String	G37	40415		G37	Enabled	Setting	0	1	1	2	*	*	*	
Earth Fault 2		09	14	Indexed String	G37	40416		G37	Disabled	Setting	0	1	1	2	*	*	*	
SEF/REF Prot'n		09	15	Indexed String	G37	40417		G37	Disabled	Setting	0	1	1	2	*	*	*	
Residual O/V NVD		09	16	Indexed String	G37	40418		G37	Disabled	Setting	0	1	1	2	*	*	*	
Thermal Overload		09	17	Indexed String	G37	40419		G37	Disabled	Setting	0	1	1	2	*	*	*	
Neg Sequence O/V		09	18	Indexed String	G37	40420		G37	Disabled	Setting	0	1	1	2	*	*	*	
Cold Load Pickup		09	19	Indexed String	G37	40421		G37	Disabled	Setting	0	1	1	2	*	*	*	
Selective Logic		09	1A	Indexed String	G37	40422		G37	Disabled	Setting	0	1	1	2	*	*	*	
Admit Protection		09	1B	Indexed String	G37	40423		G37	Disabled	Setting	0	1	1	2	*	*	*	
Volt Protection		09	1D	Indexed String	G37	40424		G37	Disabled	Setting	0	1	1	2	*	*	*	
Freq Protection		09	1E	Indexed String	G37	40425		G37	Disabled	Setting	0	1	1	2	*	*	*	
CB Fail		09	20	Indexed String	G37	40426		G37	Disabled	Setting	0	1	1	2	*	*	*	
Supervision		09	21	Indexed String	G37	40427		G37	Enabled	Setting	0	1	1	2	*	*	*	
Fault Locator		09	22	Indexed String	G37	40428		G37	Enabled	Setting	0	1	1	2	*	*	*	
System Checks		09	23	Indexed String	G37	40429		G37	Disabled	Setting	0	1	1	2			*	
Auto-Reclose		09	24	Indexed String	G37	40430		G37	Disabled	Setting	0	1	1	2		*	*	
Input Labels		09	25	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	
Output Labels		09	26	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	
CT & VT Ratios		09	28	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	
Recorder Control		09	29	Indexed String	G80				Invisible	Setting	0	1	1	1	*	*	*	
Disturb Recorder		09	2A	Indexed String	G80				Invisible	Setting	0	1	1	1	*	*	*	
Measure't Setup		09	2B	Indexed String	G80				Invisible	Setting	0	1	1	1	*	*	*	
Comms Settings		09	2C	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	
Commission Tests		09	2D	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	
Setting Values		09	2E	Indexed String	G54				Primary	Setting	0	1	1	1	*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
Control Inputs		09	2F	Indexed String	G80				Visible	Setting	0	1	1	2	*	*	*	
						40400		G18										Record Selection Command register
						40401		G6										Record Control Command register
CT AND VT RATIOS		0A	00												*	*	*	Values for multiplier see mult column
Main VT Primary		0A	01	Courier Number (voltage)		40500	40501	G35	110	Setting	100	1000000	1	2	*	*	*	Label V1=Main VT Rating/110
Main VT Sec'y		0A	02	Courier Number (voltage)		40502		G2	110	Setting	80*V1	140*V1	1*V1	2	*	*	*	
C/S VT Primary		0A	03	Courier Number (voltage)		40503	40504	G35	110	Setting	100	1000000	1	2			*	Label V2=C/S VT Rating/110
C/S VT Secondary		0A	04	Courier Number (voltage)		40505		G2	110	Setting	80*V2	140*V2	1*V2	2			*	Check Sync VT Secondary
Phase CT Primary		0A	07	Courier Number (current)		40506		G2	1	Setting	1	30000	1	2	*	*	*	I1=Phase CT secondary rating
Phase CT Sec'y		0A	08	Courier Number (current)		40507		G2	1	Setting	1	5	4	2	*	*	*	
E/F CT Primary		0A	09	Courier Number (current)		40508		G2	1	Setting	1	30000	1	2	*	*	*	Label I2=E/F CT secondary rating
E/F CT Secondary		0A	0A	Courier Number (current)		40509		G2	1	Setting	1	5	4	2	*	*	*	
SEF CT Primary		0A	0B	Courier Number (current)		40510		G2	1	Setting	1	30000	1	2	*	*	*	Label I3=SEF CT secondary rating
SEF CT Secondary		0A	0C	Courier Number (current)		40511		G2	1	Setting	1	5	4	2	*	*	*	
C/S Input		0A	0F	Indexed String	G40	40512		G40	A-N	Setting	0	5	1	2			*	Phasing of C/S input
Main VT Location			10	Indexed String	G89	40513		G89	Line	Setting	0	1	1	2			*	Line or Bus VT
RECORD CONTROL		0B	00												*	*	*	
Clear Events		0B	01	Indexed String	G11				No	Command	0	1	1	1	*	*	*	
Clear Faults		0B	02	Indexed String	G11				No	Command	0	1	1	1	*	*	*	
Clear Maint		0B	03	Indexed String	G11				No	Command	0	1	1	1	*	*	*	
Alarm Event		0B	04	Indexed String	G37	40520		G37	Enabled	Setting	0	1	1	2	*	*	*	
Relay O/P Event		0B	05	Indexed String	G37	40521		G37	Enabled	Setting	0	1	1	2	*	*	*	
Opto Input Event		0B	06	Indexed String	G37	40522		G37	Enabled	Setting	0	1	1	2	*	*	*	
System Event		0B	07	Indexed String	G37	40523		G37	Enabled	Setting	0	1	1	2	*	*	*	
Fault Rec Event		0B	08	Indexed String	G37	40524		G37	Enabled	Setting	0	1	1	2	*	*	*	
Maint Rec Event		0B	09	Indexed String	G37	40525		G37	Enabled	Setting	0	1	1	2	*	*	*	
Protection Event		0B	0A	Indexed String	G37	40526		G37	Enabled	Setting	0	1	1	2	*	*	*	
DDB 31 - 0		0B	0B	Binary Flag (32 bits)	G27	40527	40528	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 63 - 32		0B	0C	Binary Flag (32 bits)	G27	40529	40530	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 95 - 64		0B	0D	Binary Flag (32 bits)	G27	40531	40532	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 127 - 96		0B	0E	Binary Flag (32 bits)	G27	40533	40534	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 159 - 128		0B	0F	Binary Flag (32 bits)	G27	40535	40536	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 191 - 160		0B	10	Binary Flag (32 bits)	G27	40537	40538	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 223 - 192		0B	11	Binary Flag (32 bits)	G27	40539	40540	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 255 - 224		0B	12	Binary Flag (32 bits)	G27	40541	40542	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 287 - 256		0B	13	Binary Flag (32 bits)	G27	40543	40544	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 319 - 288		0B	14	Binary Flag (32 bits)	G27	40545	40546	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 351 - 320		0B	15	Binary Flag (32 bits)	G27	40547	40548	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 383 - 352		0B	16	Binary Flag (32 bits)	G27	40549	40550	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 415 - 384		0B	17	Binary Flag (32 bits)	G27	40551	40552	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 447 - 416		0B	18	Binary Flag (32 bits)	G27	40553	40554	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 479 - 448		0B	19	Binary Flag (32 bits)	G27	40555	40556	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 511 - 480		0B	1A	Binary Flag (32 bits)	G27	40557	40558	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 543 - 512		0B	1B	Binary Flag (32 bits)	G27	40559	40560	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 575 - 544		0B	1C	Binary Flag (32 bits)	G27	40561	40562	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 607 - 576		0B	1D	Binary Flag (32 bits)	G27	40563	40564	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 639 - 608		0B	1E	Binary Flag (32 bits)	G27	40565	40566	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 671 - 640		0B	1F	Binary Flag (32 bits)	G27	40567	40568	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
DDB 703 - 672		0B	20	Binary Flag (32 bits)	G27	40569	40570	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 735 - 704		0B	21	Binary Flag (32 bits)	G27	40571	40572	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 767 - 736		0B	22	Binary Flag (32 bits)	G27	40573	40574	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 799 - 768		0B	23	Binary Flag (32 bits)	G27	40575	40576	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 831 - 800		0B	24	Binary Flag (32 bits)	G27	40577	40578	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 863 - 832		0B	25	Binary Flag (32 bits)	G27	40579	40580	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 895 - 864		0B	26	Binary Flag (32 bits)	G27	40581	40582	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 927 - 896		0B	27	Binary Flag (32 bits)	G27	40583	40584	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 959 - 928		0B	28	Binary Flag (32 bits)	G27	40585	40586	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 991 - 960		0B	29	Binary Flag (32 bits)	G27	40587	40588	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DDB 1022 - 992		0B	2A	Binary Flag (32 bits)	G27	40589	40590	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	
DISTURB RECORDER		0C	00												*	*	*	DISTURBANCE RECORDER
Duration		0C	01	Courier Number (time)		40600		G2	1.5	Setting	0.1	10.5	0.01	2	*	*	*	
Trigger Position		0C	02	Courier Number (percentage)		40601		G2	33.3	Setting	0	100	0.1	2	*	*	*	
Trigger Mode		0C	03	Indexed String	G34	40602		G34	Single		0	1	1	2	*	*	*	
Analog Channel 1		0C	04	Indexed String	G31	40603		G31	VA	Setting	0	7	1	2	*	*		
												8					*	
Analog Channel 2		0C	05	Indexed String	G31	40604		G31	VB	Setting	0	7	1	2	*	*		
												8					*	
Analog Channel 3		0C	06	Indexed String	G31	40605		G31	VC	Setting	0	7	1	2	*	*		
												8					*	
Analog Channel 4		0C	07	Indexed String	G31	40606		G31	IA	Setting	0	7	1	2	*	*		
												8					*	
Analog Channel 5		0C	08	Indexed String	G31	40607		G31	IB	Setting	0	7	1	2	*	*		
												8					*	
Analog Channel 6		0C	09	Indexed String	G31	40608		G31	IC	Setting	0	7	1	2	*	*		
												8					*	
Analog Channel 7		0C	0A	Indexed String	G31	40609		G31	IN	Setting	0	7	1	2	*	*		
												8					*	
Analog Channel 8		0C	0B	Indexed String	G31	40610		G31	IN Sensitive	Setting	0	7	1	2	*	*		
												8					*	
Digital Input 1		0C	0C	Indexed String	G32	40611		G32	Relay 1	Setting	0	DDB Size	1	2	*	*	*	DDB Size different for each model
Input 1 Trigger		0C	0D	Indexed String	G66	40612		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 2		0C	0E	Indexed String	G32	40613		G32	Relay 2	Setting	0	DDB Size	1	2	*	*	*	DDB Size different for each model
Input 2 Trigger		0C	0F	Indexed String	G66	40614		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 3		0C	10	Indexed String	G32	40615		G32	Relay 3	Setting	0	DDB Size	1	2	*	*	*	DDB Size different for each model
Input 3 Trigger		0C	11	Indexed String	G66	40616		G66	Trigger L/H	Setting	0	2	1	2	*	*	*	
Digital Input 4		0C	12	Indexed String	G32	40617		G32	Relay 4	Setting	0	DDB Size	1	2	*	*	*	DDB Size different for each model
Input 4 Trigger		0C	13	Indexed String	G66	40618		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 5		0C	14	Indexed String	G32	40619		G32	Relay 5	Setting	0	DDB Size	1	2	*	*	*	DDB Size different for each model
Input 5 Trigger		0C	15	Indexed String	G66	40620		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 6		0C	16	Indexed String	G32	40621		G32	Relay 6	Setting	0	DDB Size	1	2	*	*	*	DDB Size different for each model
Input 6 Trigger		0C	17	Indexed String	G66	40622		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 7		0C	18	Indexed String	G32	40623		G32	Relay 7	Setting	0	DDB Size	1	2	*	*	*	DDB Size different for each model
Input 7 Trigger		0C	19	Indexed String	G66	40624		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 8		0C	1A	Indexed String	G32	40625		G32	Opto Input 1	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Relay 8								*	
Input 8 Trigger		0C	1B	Indexed String	G66	40626		G66	No Trigger	Setting	0	2	1	2	*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
Digital Input 9		0C	1C	Indexed String	G32	40627		G32	Opto Input 2	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Relay 9								*	
Input 9 Trigger		0C	1D	Indexed String	G66	40628		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 10		0C	1E	Indexed String	G32	40629		G32	Opto Input 3	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Relay 10								*	
Input 10 Trigger		0C	1F	Indexed String	G66	40630		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 11		0C	20	Indexed String	G32	40631		G32	Opto Input 4	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Relay 11								*	
Input 11 Trigger		0C	21	Indexed String	G66	40632		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 12		0C	22	Indexed String	G32	40633		G32	Opto Input 5	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Relay 12								*	
Input 12 Trigger		0C	23	Indexed String	G66	40634		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 13		0C	24	Indexed String	G32	40635		G32	Opto Input 6	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Relay 13								*	
Input 13 Trigger		0C	25	Indexed String	G66	40636		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 14		0C	26	Indexed String	G32	40637		G32	Opto Input 7	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Relay 14								*	
Input 14 Trigger		0C	27	Indexed String	G66	40638		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 15		0C	28	Indexed String	G32	40639		G32	Opto Input 8	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 1								*	
Input 15 Trigger		0C	29	Indexed String	G66	40640		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 16		0C	2A	Indexed String	G32	40641		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 2								*	
Input 16 Trigger		0C	2B	Indexed String	G66	40642		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 17		0C	2C	Indexed String	G32	40643		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 3								*	
Input 17 Trigger		0C	2D	Indexed String	G66	40644		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 18		0C	2E	Indexed String	G32	40645		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 4								*	
Input 18 Trigger		0C	2F	Indexed String	G66	40646		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 19		0C	30	Indexed String	G32	40647		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 5								*	
Input 19 Trigger		0C	31	Indexed String	G66	40648		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 20		0C	32	Indexed String	G32	40649		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 6								*	
Input 20 Trigger		0C	33	Indexed String	G66	40650		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 21		0C	34	Indexed String	G32	40651		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 7								*	
Input 21 Trigger		0C	35	Indexed String	G66	40652		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 22		0C	36	Indexed String	G32	40653		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 8								*	
Input 22 Trigger		0C	37	Indexed String	G66	40654		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 23		0C	38	Indexed String	G32	40655		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 9								*	
Input 23 Trigger		0C	39	Indexed String	G66	40656		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 24		0C	3A	Indexed String	G32	40657		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 10								*	
Input 24 Trigger		0C	3B	Indexed String	G66	40658		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 25		0C	3C	Indexed String	G32	40659		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 11								*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
Input 25 Trigger		0C	3D	Indexed String	G66	40660		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 26		0C	3E	Indexed String	G32	40661		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 12								*	
Input 26 Trigger		0C	3F	Indexed String	G66	40662		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 27		0C	40	Indexed String	G32	40663		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 13								*	
Input 27 Trigger		0C	41	Indexed String	G66	40664		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 28		0C	42	Indexed String	G32	40665		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 14								*	
Input 28 Trigger		0C	43	Indexed String	G66	40666		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 29		0C	44	Indexed String	G32	40667		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 15								*	
Input 29 Trigger		0C	45	Indexed String	G66	40668		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 30		0C	46	Indexed String	G32	40669		G32	Not Used	Setting	0	DDB Size	1	2	*	*		DDB Size different for each model
									Opto Input 16								*	
Input 30 Trigger		0C	47	Indexed String	G66	40670		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 31		0C	48	Indexed String	G32	40671		G32	Not Used	Setting	0	DDB Size	1	2	*	*	*	DDB Size different for each model
Input 31 Trigger		0C	49	Indexed String	G66	40672		G66	No Trigger	Setting	0	2	1	2	*	*	*	
Digital Input 32		0C	4A	Indexed String	G32	40673		G32	Not Used	Setting	0	DDB Size	1	2	*	*	*	DDB Size different for each model
Input 32 Trigger		0C	4B	Indexed String	G66	40674		G66	No Trigger	Setting	0	2	1	2	*	*	*	
MEASURE'T SETUP		0D	00												*	*	*	MEASUREMENT SETTINGS
Default Display		0D	01	Indexed String	G52	40700		G52	Description	Setting	0	7	1	2	*	*	*	
Local Values		0D	02	Indexed String	G54	40701		G54	Primary	Setting	0	1	1	1	*	*	*	Local Measurement Values
Remote Values		0D	03	Indexed String	G54	40702		G54	Primary	Setting	0	1	1	1	*	*	*	Remote Measurement Values
Measurement Ref		0D	04	Indexed String	G56	40703		G56	VA	Setting	0	5	1	1	*	*	*	Measurement Phase Reference
Measurement Mode		0D	05	Unsigned Integer (16 bits)		40705		G1	0	Setting	0	3	1	1	*	*	*	
Fix Dem Period		0D	06	Courier Number (time-minutes)		40706		G2	30	Setting	1	99	1	2	*	*	*	Fixed Demand Interval
Roll Sub Period		0D	07	Courier Number (time-minutes)		40707		G2	30	Setting	1	99	1	2	*	*	*	Rolling demand sub period
Num Sub Periods		0D	08	Unsigned Integer (16 bits)		40708		G1	1	Setting	1	15	1	2	*	*	*	Number of rolling sub periods
Distance Unit		0D	09	Indexed String	G97	40709		G97	Miles	Setting	0	1	1	2	*	*	*	
Fault Location		0D	0A	Indexed String	G51	40710		G51	Distance	Setting	0	2	1	2	*	*	*	
COMMUNICATIONS		0E	00												*	*	*	
Rear Protocol		0E	01	Indexed String	G71					Data					*	*	*	
Remote Address		0E	02	Unsigned Integer (16 bits)					255	Setting	0	255	1	1	*	*	*	Build = Courier
																		Available on LCD
Remote Address		0E	02	Unsigned Integer (16 bits)					1	Setting	1	247	1	1	*	*	*	Build = Modbus
																		Available on LCD
Remote Address		0E	02	Unsigned Integer (16 bits)					1	Setting	0	254	1	1	*	*	*	Build = IEC60870-5-103
																		Available on LCD
Remote Address		0E	02	Unsigned Integer (16 bits)					1	Setting	0	65534	1	1	*	*	*	Build = DNP3.0
																		Available on LCD
Inactivity Timer		0E	03	Courier Number (time-minutes)					15	Setting	1	30	1	2	*	*	*	Build = Courier
Inactivity Timer		0E	03	Courier Number (time-minutes)					15	Setting	1	30	1	2	*	*	*	Build = Modbus
Inactivity Timer		0E	03	Courier Number (time-minutes)					15	Setting	1	30	1	2	*	*	*	Build - IEC60870-5-103
Baud Rate		0E	04	Indexed String	G38m				19200 bits/s	Setting	0	2	1	2	*	*	*	Build = Modbus

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
Baud Rate		0E	04	Indexed String	G38v				19200 bits/s	Setting	0	1	1	2	*	*	*	Build = IEC60870-5-103
Baud Rate		0E	04	Indexed String	G38d				19200 bits/s	Setting	0	5	1	2	*	*	*	Build = DNP3.0
Parity		0E	05	Indexed String	G39				None	Setting	0	2	1	2	*	*	*	Build = Modbus
Parity		0E	05	Indexed String	G39				None	Setting	0	2	1	2	*	*	*	Build = DNP3.0
Measure't Period		0E	06	Courier Number (time)					10	Setting	1	60	1	2	*	*	*	Build = IEC60870-5-103
Physical Link		0E	07	Indexed String	G21				RS485	Setting	0	1	1	1	*	*	*	Build = IEC60870-5-103
																		and Fibre Optic board fitted
Time Sync		0E	08	Indexed String	G37				Disabled	Setting	0	1	1	1	*	*	*	Build = DNP3.0
COMMISSION TESTS		0F	00												*	*	*	
Opto I/P Status		0F	01	Binary Flag (16 bits)				G8		Data					*	*	*	
				Indexed String														
Relay O/P Status		0F	02	Binary Flag (32 bits)				G9		Data					*	*	*	
				Indexed String														
Test Port Status		0F	03	Binary Flag (8 bits)				0-7		Data					*	*	*	
				Indexed String														
LED Status		0F	04	Binary Flag (8 bits)	0-7			0-7		Data					*	*	*	
Monitor Bit 1		0F	05	Unsigned Integer (16 bits)		40850		G1	64	Setting	0	511	1	2	*	*	*	Default LED 1
Monitor Bit 2		0F	06	Unsigned Integer (16 bits)		40851		G1	65	Setting	0	511	1	2	*	*	*	Default LED 2
Monitor Bit 3		0F	07	Unsigned Integer (16 bits)		40852		G1	66	Setting	0	511	1	2	*	*	*	Default LED 3
Monitor Bit 4		0F	08	Unsigned Integer (16 bits)		40853		G1	67	Setting	0	511	1	2	*	*	*	Default LED 4
Monitor Bit 5		0F	09	Unsigned Integer (16 bits)		40854		G1	68	Setting	0	511	1	2	*	*	*	Default LED 5
Monitor Bit 6		0F	0A	Unsigned Integer (16 bits)		40855		G1	69	Setting	0	511	1	2	*	*	*	Default LED 6
Monitor Bit 7		0F	0B	Unsigned Integer (16 bits)		40856		G1	70	Setting	0	511	1	2	*	*	*	Default LED 7
Monitor Bit 8		0F	0C	Unsigned Integer (16 bits)		40857		G1	71	Setting	0	511	1	2	*	*	*	Default LED 8
Test Mode		0F	0D	Indexed String	G119	40858		G119	Disabled	Setting	0	2	1	2	*	*	*	
Test Pattern		0F	0E	Binary Flag (32 bits)	G9	40859	40860	G9	0	Setting	0	6	1	2	*	*		
				Indexed String							0	13	1	2			*	
Contact Test		0F	0F	Indexed String	G93	40861		G93	No Operation	Command	0	2	1	2	*	*	*	
Test LEDs		0F	10	Indexed String	G94	40862		G94	No Operation	Command	0	1	1	2	*	*	*	
Test Autoreclose		0F	11	Indexed String	G36	40863		G36	No Operation	Command	0	1	1	2		*	*	
																		South Pars Modifications - 1
	N/A			Binary Flag(16)		30701		G1		Data					*	*	*	Relay Status (repeat of Courier status)
	N/A			Courier Number (current)		30702	30703	G24		Data					*	*	*	IA Magnitude
	N/A			Courier Number (current)		30704	30705	G24		Data					*	*	*	IB Magnitude
	N/A			Courier Number (current)		30706	30707	G24		Data					*	*	*	IC Magnitude
	N/A			Courier Number (voltage)		30708	30709	G24		Data					*	*	*	VAB Magnitude
	N/A			Courier Number (voltage)		30710	30711	G24		Data					*	*	*	VBC Magnitude
	N/A			Courier Number (voltage)		30712	30713	G24		Data					*	*	*	VCA Magnitude
	N/A			Courier Number (power)		30714	30716	G29		Data					*	*	*	3 Phase Watts
	N/A			Courier Number (power)		30717	30719	G29		Data					*	*	*	3 Phase VArs
	N/A			Courier Number (decimal)		30720		G30		Data					*	*	*	3 Phase Power Factor
	N/A			Courier Number (frequency)		30721		G30		Data					*	*	*	Frequency
	N/A			Binary Flag(8)		30722		G1		Data					*	*	*	Relay Test Port Status
DDB 0 - 31	N/A	0F	20	Binary Flag (32 bits)		30723	30724	G27		Data					*	*	*	DDB Elements 0-31
DDB 32 - 63	N/A	0F	21	Binary Flag (32 bits)		30725	30726	G27		Data					*	*	*	
DDB 64 - 95	N/A	0F	22	Binary Flag (32 bits)		30727	30728	G27		Data					*	*	*	
DDB 96 - 127	N/A	0F	23	Binary Flag (32 bits)		30729	30730	G27		Data					*	*	*	
DDB 128 - 159	N/A	0F	24	Binary Flag (32 bits)		30731	30732	G27		Data					*	*	*	

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
DDB 160 - 191	N/A	0F	25	Binary Flag (32 bits)		30733	30734	G27		Data					*	*	*	
DDB 192 - 223	N/A	0F	26	Binary Flag (32 bits)		30735	30736	G27		Data					*	*	*	
DDB 224 - 255	N/A	0F	27	Binary Flag (32 bits)		30737	30738	G27		Data					*	*	*	
DDB 256 - 287	N/A	0F	28	Binary Flag (32 bits)		30739	30740	G27		Data					*	*	*	
DDB 288 - 319	N/A	0F	29	Binary Flag (32 bits)		30741	30742	G27		Data					*	*	*	
DDB 320 - 351	N/A	0F	2A	Binary Flag (32 bits)		30743	30744	G27		Data					*	*	*	
DDB 352 - 383	N/A	0F	2B	Binary Flag (32 bits)		30745	30746	G27		Data					*	*	*	
DDB 384 - 415	N/A	0F	2C	Binary Flag (32 bits)		30747	30748	G27		Data					*	*	*	
DDB 416 - 447	N/A	0F	2D	Binary Flag (32 bits)		30749	30750	G27		Data					*	*	*	
DDB 448 - 479	N/A	0F	2E	Binary Flag (32 bits)		30751	30752	G27		Data					*	*	*	
DDB 480 - 511	N/A	0F	2F	Binary Flag (32 bits)		30753	30754	G27		Data					*	*	*	
DDB 543 - 512	N/A	0B	30	Binary Flag (32 bits)		30755	30756	G27		Data					*	*	*	
DDB 575 - 544	N/A	0B	31	Binary Flag (32 bits)		30757	30758	G27		Data					*	*	*	
DDB 607 - 576	N/A	0B	32	Binary Flag (32 bits)		30759	30760	G27		Data					*	*	*	
DDB 639 - 608	N/A	0B	33	Binary Flag (32 bits)		30761	30762	G27		Data					*	*	*	
DDB 671 - 640	N/A	0B	34	Binary Flag (32 bits)		30763	30764	G27		Data					*	*	*	
DDB 703 - 672	N/A	0B	35	Binary Flag (32 bits)		30765	30766	G27		Data					*	*	*	
DDB 735 - 704	N/A	0B	36	Binary Flag (32 bits)		30767	30768	G27		Data					*	*	*	
DDB 767 - 736	N/A	0B	37	Binary Flag (32 bits)		30769	30770	G27		Data					*	*	*	
DDB 799 - 768	N/A	0B	38	Binary Flag (32 bits)		30771	30772	G27		Data					*	*	*	
DDB 831 - 800	N/A	0B	39	Binary Flag (32 bits)		30773	30774	G27		Data					*	*	*	
DDB 863 - 832	N/A	0B	3A	Binary Flag (32 bits)		30775	30776	G27		Data					*	*	*	
DDB 895 - 864	N/A	0B	3B	Binary Flag (32 bits)		30777	30778	G27		Data					*	*	*	
DDB 927 - 896	N/A	0B	3C	Binary Flag (32 bits)		30779	30780	G27		Data					*	*	*	
DDB 959 - 928	N/A	0B	3D	Binary Flag (32 bits)		30781	30782	G27		Data					*	*	*	
DDB 991 - 960	N/A	0B	3E	Binary Flag (32 bits)		30783	30784	G27		Data					*	*	*	
DDB 1022 - 992	N/A	0B	3F	Binary Flag (32 bits)		30785	30786	G27		Data					*	*	*	
CB MONITOR SETUP		10	00												*	*	*	
Broken I^		10	01	Courier Number (decimal)		40151		G2	2	Setting	1	2	0.1	2	*	*	*	Broken Current Index
I^ Maintenance		10	02	Indexed String	G88	40152		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*	Broken Current to cause maintenance alarm
I^ Maintenance		10	03	Courier Number (current)		40153	40154	G35	1000	Setting	1 * NM1	25000	1 * NM1	2	*	*	*	IX Maintenance Alarm
I^ Lockout		10	04	Indexed String	G88	40155		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*	Broken Current to cause lockout alarm
I^ Lockout		10	05	Courier Number (current)		40156	40157	G35	2000	Setting	1 * NM1	25000	1 * NM1	2	*	*	*	IX Maintenance Lockout
No. CB Ops Maint		10	06	Indexed String	G88	40158		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*	No of CB Trips to cause maintenance alarm
No. CB Ops Maint		10	07	Unsigned Integer (16 bits)		40159		G1	10	Setting	1	10000	1	2	*	*	*	No of CB Trips for maintenance alarm
No. CB Ops Lock		10	08	Indexed String	G88	40160		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*	No of CB Trips to cause lockout alarm
No. CB Ops Lock		10	09	Unsigned Integer (16 bits)		40161		G1	20	Setting	1	10000	1	2	*	*	*	No of CB Trips for lockout alarm
CB Time Maint		10	0A	Indexed String	G88	40162		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*	CB Operating Time to cause maintenance alarm
CB Time Maint		10	0B	Courier Number (time)		40163	40164	G35	0.1	Setting	0.005	0.5	0.001	2	*	*	*	CB Operating Time for maintenance alarm
CB Time Lockout		10	0C	Indexed String	G88	40165		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*	CB Operating Time to cause lockout alarm
CB Time Lockout		10	0D	Courier Number (time)		40166	40167	G35	0.2	Setting	0.005	0.5	0.001	2	*	*	*	CB Operating time for lockout alarm
Fault Freq Lock		10	0E	Indexed String	G88	40168		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*	Excessive fault frequency
Fault Freq Count		10	0F	Unsigned Integer (16 bits)		40169		G1	10	Setting	1	9999	1	2	*	*	*	Excessive Fault Frequency Counter
Fault Freq Time		10	10	Courier Number (time)		40170	40171	G35	3600	Setting	0	9999	1	2	*	*	*	Excessive Fault Frequency Time

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
OPTO CONFIG		11	00												*	*	*	
Global Nominal V		11	01	Indexed String	G200	40900		G200	48/54V	Setting	0	5	1	2	*	*	*	Global Opto Input Voltage
Opto Input 1		11	02	Indexed String	G201	40901		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 2		11	03	Indexed String	G201	40902		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 3		11	04	Indexed String	G201	40903		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 4		11	05	Indexed String	G201	40904		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 5		11	06	Indexed String	G201	40905		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 6		11	07	Indexed String	G201	40906		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 7		11	08	Indexed String	G201	40907		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 8		11	09	Indexed String	G201	40908		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 9		11	0A	Indexed String	G201	40909		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 10		11	0B	Indexed String	G201	40910		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 11		11	0C	Indexed String	G201	40911		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 12		11	0D	Indexed String	G201	40912		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 13		11	0E	Indexed String	G201	40913		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 14		11	0F	Indexed String	G201	40914		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 15		11	10	Indexed String	G201	40915		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 16		11	11	Indexed String	G201	40916		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 17		11	12	Indexed String	G201	40917		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 18		11	13	Indexed String	G201	40918		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 19		11	14	Indexed String	G201	40919		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 20		11	15	Indexed String	G201	40920		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 21		11	16	Indexed String	G201	40921		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 22		11	17	Indexed String	G201	40922		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 23		11	18	Indexed String	G201	40923		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 24		11	19	Indexed String	G201	40924		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 25		11	1A	Indexed String	G201	40925		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 26		11	1B	Indexed String	G201	40926		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 27		11	1C	Indexed String	G201	40927		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 28		11	1D	Indexed String	G201	40928		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 29		11	1E	Indexed String	G201	40929		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 30		11	1F	Indexed String	G201	40930		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 31		11	20	Indexed String	G201	40931		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
Opto Input 32		11	21	Indexed String	G201	40932		G201	48/54V	Setting	0	4	1	2	*	*	*	Individual Opto Input Voltage
CONTROL INPUTS		12	00												*	*	*	
Ctrl I/P Status		12	01	Binary Flag(32 bits)	G202	40950	40951	G202	0x00000000	Setting	0xFFFFFFFF	32	1	2	*	*	*	Control Input Status
				Indexed String														
Control Input 1		12	02	Indexed String	G203	40952		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 2		12	03	Indexed String	G203	40953		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 3		12	04	Indexed String	G203	40954		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 4		12	05	Indexed String	G203	40955		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 5		12	06	Indexed String	G203	40956		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 6		12	07	Indexed String	G203	40957		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 7		12	08	Indexed String	G203	40958		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 8		12	09	Indexed String	G203	40959		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 9		12	0A	Indexed String	G203	40960		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 10		12	0B	Indexed String	G203	40961		G203	No Operation	Command	0	2	1	2	*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
Control Input 11		12	0C	Indexed String	G203	40962		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 12		12	0D	Indexed String	G203	40963		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 13		12	0E	Indexed String	G203	40964		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 14		12	0F	Indexed String	G203	40965		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 15		12	10	Indexed String	G203	40966		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 16		12	11	Indexed String	G203	40967		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 17		12	12	Indexed String	G203	40968		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 18		12	13	Indexed String	G203	40969		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 19		12	14	Indexed String	G203	40970		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 20		12	15	Indexed String	G203	40971		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 21		12	16	Indexed String	G203	40972		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 22		12	17	Indexed String	G203	40973		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 23		12	18	Indexed String	G203	40974		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 24		12	19	Indexed String	G203	40975		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 25		12	1A	Indexed String	G203	40976		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 26		12	1B	Indexed String	G203	40977		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 27		12	1C	Indexed String	G203	40978		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 28		12	1D	Indexed String	G203	40979		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 29		12	1E	Indexed String	G203	40980		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 30		12	1F	Indexed String	G203	40981		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 31		12	20	Indexed String	G203	40982		G203	No Operation	Command	0	2	1	2	*	*	*	
Control Input 32		12	21	Indexed String	G203	40983		G203	No Operation	Command	0	2	1	2	*	*	*	
OVERCURRENT		35	00												*	*	*	
GROUP 1																		
I>1 Function		35	23	Indexed String	G150	41250		G150	IEC S Inverse	Setting	0	12	1	2	*	*	*	
I>1 Direction		35	24	Indexed String	G44	41251		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
I>1 Current Set		35	27	Courier Number (current)		41252		G2	1	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	
I>1 Time Delay		35	29	Courier Number (time)		41253		G2	1	Setting	0	100	0.01	2	*	*	*	
I>1 TMS		35	2A	Courier Number (decimal)		41254		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
I>1 Time Dial		35	2B	Courier Number (decimal)		41255		G2	1	Setting	0.01	100	0.01	2	*	*	*	
I>1 k(RI)		35	2C	Courier Number (decimal)		41256		G2	1	Setting	0.1	10	0.05	2	*	*	*	
I>1 Reset Char		35	2E	Indexed String	G60	41257		G60	DT	Setting	0	1	1	2	*	*	*	
I>1 tRESET		35	2F	Courier Number (time)		41258		G2	0	Setting	0	100	0.01	2	*	*	*	
I>2 Function		35	32	Indexed String	G150	41259		G150	Disabled	Setting	0	12	1	2	*	*	*	
I>2 Direction		35	33	Indexed String	G44	41260		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
I>2 Current Set		35	36	Courier Number (current)		41261		G2	1	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	
I>2 Time Delay		35	38	Courier Number (time)		41262		G2	1	Setting	0	100	0.01	2	*	*	*	
I>2 TMS		35	39	Courier Number (decimal)		41263		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
I>2 Time Dial		35	3A	Courier Number (decimal)		41264		G2	1	Setting	0.01	100	0.01	2	*	*	*	
I>2 k(RI)		35	3B	Courier Number (decimal)		41265		G2	1	Setting	0.1	10	0.05	2	*	*	*	
I>2 Reset Char		35	3D	Indexed String	G60	41266		G60	DT	Setting	0	1	1	2	*	*	*	
I>2 tRESET		35	3E	Courier Number (time)		41267		G2	0	Setting	0	100	0.01	2	*	*	*	
I>3 Status		35	40	Indexed String	G37	41268		G37	Disabled	Setting	0	1	1	2	*	*	*	
I>3 Direction		35	41	Indexed String	G44	41269		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
I>3 Current Set		35	44	Courier Number (current)		41270		G2	20	Setting	0.08*I1	32*I1	0.01*I1	2	*	*	*	
I>3 Time Delay		35	45	Courier Number (time)		41271		G2	0	Setting	0	100	0.01	2	*	*	*	
I>4 Status		35	47	Indexed String	G37	41272		G37	Disabled	Setting	0	1	1	2	*	*	*	

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
I>4 Direction		35	48	Indexed String	G44	41273		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
I>4 Time Delay		35	4C	Courier Number (time)		41275		G2	0	Setting	0	100	0.01	2	*	*	*	
I> Blocking		35	4E	Binary Flag (8 bits)	G14	41276		G14	15	Setting	15	4	1	2	*			VTS Block/AR Block
									15		63	6	1	2		*	*	per stage
I> Char Angle		35	4F	Courier Number (angle)		41277		G2	45	Setting	-95	95	1	2	*	*	*	I> Characteristic Angle
V CONTROLLED O/C		35	51	(Sub-heading)											*	*	*	
VCO Status		35	52	Indexed String	G100	41278		G100	Disabled	Setting	0	3	1	2	*	*	*	VCO applies to I>1 & I>2 only
VCO V< Setting		35	53	Courier Number (voltage)		41279		G2	60	Setting	20*V1	120*V1	1*V1	2	*	*	*	
VCO k Setting		35	54	Courier Number (decimal)		41280		G2	0.25	Setting	0.25	1	0.05	2	*	*	*	
NEG SEQ O/C		36	00												*	*	*	
GROUP 1																		
I2> Status		36	01	Indexed String	G37	41300		G37	Disabled	Setting	0	1	1	2	*	*	*	
I2> Directional		36	02	Indexed String	G44	41301		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
I2> VTS		36	03	Indexed String	G45	41302		G45	Block	Setting	0	1	1	2	*	*	*	
I2> Current Set		36	04	Courier Number (current)		41303		G2	0.2	Setting	0.08*I1	4*I1	0.01*I1	2	*	*	*	
I2> Time Delay		36	05	Courier Number (time)		41304		G2	10	Setting	0	100	0.01	2	*	*	*	
I2> Char Angle		36	06	Courier Number (angle)		41305		G2	-60	Setting	-95	95	1	2	*	*	*	
I2> V2pol Set		36	07	Courier Number (voltage)		41306		G2	5	Setting	0.5*V1	25*V1	0.5*V1	2	*	*	*	
BROKEN CONDUCTOR		37	00												*	*	*	
GROUP 1																		
Broken Conductor		37	01	Indexed String	G37	41350		G37	Enabled	Setting	0	1	1	2	*	*	*	
I2/I1 Setting		37	02	Courier Number (decimal)		41351		G2	0.2	Setting	0.2	1	0.01	2	*	*	*	
I2/I1 Time Delay		37	03	Courier Number (time)		41352		G2	60	Setting	0	100	0.1	2	*	*	*	
EARTH FAULT 1		38	00												*	*	*	
GROUP 1																		
IN1> Input		38	01	Indexed String	G49			G49	Measured	Data					*	*	*	Measured EF current input
IN1>1 Function		38	25	Indexed String	G151	41400		G151	IEC S Inverse	Setting	0	12	1	2	*	*	*	
IN1>1 Direction		38	26	Indexed String	G44	41401		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
IN1>1 Current		38	29	Courier Number (current)		41402		G2	0.2	Setting	0.08*I2	4.0*I2	0.01*I2	2	*	*	*	
IN1>1 IDG Is		38	2A	Courier Number (decimal)		41403		G2	1.5	Setting	1	4	0.1	2	*	*	*	
IN1>1 Time Delay		38	2C	Courier Number (time)		41404		G2	1	Setting	0	200	0.01	2	*	*	*	
IN1>1 TMS		38	2D	Courier Number (decimal)		41405		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
IN1>1 Time Dial		38	2E	Courier Number (decimal)		41406		G2	1	Setting	0.01	100	0.01	2	*	*	*	
IN1>1 k(RI)		38	2F	Courier Number (decimal)		41407		G2	1	Setting	0.1	10	0.05	2	*	*	*	
IN1>1 IDG Time		38	30	Courier Number (time)		41408		G2	1.2	Setting	1	2	0.01	2	*	*	*	
IN1>1 Reset Char		38	32	Indexed String	G60	41409		G60	DT	Setting	0	1	1	2	*	*	*	
IN1>1 tRESET		38	33	Courier Number (time)		41410		G2	0	Setting	0	100	0.01	2	*	*	*	
IN1>2 Function		38	36	Indexed String	G151	41411		G151	Disabled	Setting	0	12	1	2	*	*	*	
IN1>2 Direction		38	37	Indexed String	G44	41412		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
IN1>2 Current		38	3A	Courier Number (current)		41413		G2	0.2	Setting	0.08*I2	4.0*I2	0.01*I2	2	*	*	*	
IN1>2 IDG Is		38	3B	Courier Number (decimal)		41414		G2	1.5	Setting	1	4	0.1	2	*	*	*	
IN1>2 Time Delay		38	3D	Courier Number (time)		41415		G2	1	Setting	0	200	0.01	2	*	*	*	
IN1>2 TMS		38	3E	Courier Number (decimal)		41416		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
IN1>2 Time Dial		38	3F	Courier Number (decimal)		41417		G2	1	Setting	0.01	100	0.01	2	*	*	*	
IN1>2 k(RI)		38	40	Courier Number (decimal)		41418		G2	1	Setting	0.1	10	0.05	2	*	*	*	
IN1>2 IDG Time		38	41	Courier Number (time)		41419		G2	1.2	Setting	1	2	0.01	2	*	*	*	
IN1>2 Reset Char		38	43	Indexed String	G60	41420		G60	DT	Setting	0	1	1	2	*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
IN1>2 tRESET		38	44	Courier Number (time)		41421		G2	0	Setting	0	100	0.01	2	*	*	*	
IN1>3 Status		38	46	Indexed String	G37	41422		G37	Disabled	Setting	0	1	1	2	*	*	*	
IN1>3 Direction		38	47	Indexed String	G44	41423		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
IN1>3 Current		38	4A	Courier Number (current)		41424		G2	0.2	Setting	0.08*I2	32*I2	0.01*I2	2	*	*	*	
IN1>3 Time Delay		38	4B	Courier Number (time)		41425		G2	1	Setting	0	200	0.01	2	*	*	*	
IN1>4 Status		38	4D	Indexed String	G37	41426		G37	Disabled	Setting	0	1	1	2	*	*	*	
IN1>4 Direction		38	4E	Indexed String	G44	41427		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
IN1>4 Current		38	51	Courier Number (current)		41428		G2	0.2	Setting	0.08*I2	32*I2	0.01*I2	2	*	*	*	
IN1>4 Time Delay		38	52	Courier Number (time)		41429		G2	1	Setting	0	200	0.01	2	*	*	*	
IN1> Blocking		38	54	Binary Flag (8 bits)	G63	41430		G63	15	Setting	15	4	1	2	*			
									15		63	6	1	2		*	*	
IN1> POL		38	55	(Sub Heading)										2	*	*	*	
IN1> Char Angle		38	56	Courier Number (angle)		41431		G2	-45	Setting	-95	95	1	2	*	*	*	
IN1> Pol		38	57	Indexed String	G46	41432		G46	Zero Sequence	Setting	0	1	1	2	*	*	*	Zero Seq or Neg Seq
IN1> VNpol Set		38	59	Courier Number (voltage)		41433		G2	5	Setting	0.5*V1	80*V1	0.5*V1	2	*	*	*	
IN1> V2pol Set		38	5A	Courier Number (voltage)		41434		G2	5	Setting	0.5*V1	25*V1	0.5*V1	2	*	*	*	
IN1> I2pol Set		38	5B	Courier Number (current)		41435		G2	0.08	Setting	0.08*I1	1.0*I1	0.01*I1	2	*	*	*	
EARTH FAULT 2		39	00												*	*	*	
GROUP 1																		
IN2> Input		39	01	Indexed String	G49			G49	Derived	Data					*	*	*	Derived EF current input
IN2>1 Function		39	25	Indexed String	G151	41450		G151	IEC S Inverse	Setting	0	12	1	2	*	*	*	
IN2>1 Direction		39	26	Indexed String	G44	41451		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
IN2>1 Current		39	29	Courier Number (current)		41452		G2	0.2	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	
IN2>1 IDG Is		39	2A	Courier Number (decimal)		41453		G2	1.5	Setting	1	4	0.1	2	*	*	*	
IN2>1 Time Delay		39	2C	Courier Number (time)		41454		G2	1	Setting	0	200	0.01	2	*	*	*	
IN2>1 TMS		39	2D	Courier Number (decimal)		41455		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
IN2>1 Time Dial		39	2E	Courier Number (decimal)		41456		G2	1	Setting	0.01	100	0.05	2	*	*	*	
IN2>1 k(RI)		39	2F	Courier Number (decimal)		41457		G2	1	Setting	0.1	10	0.05	2	*	*	*	
IN2>1 IDG Time		39	30	Courier Number (time)		41458		G2	1.2	Setting	1	2	0.01	2	*	*	*	
IN2>1 Reset Char		39	32	Indexed String	G60	41459		G60	DT	Setting	0	1	1	2	*	*	*	
IN2>1 tRESET		39	33	Courier Number (time)		41460		G2	0	Setting	0	100	0.01	2	*	*	*	
IN2>2 Function		39	36	Indexed String	G151	41461		G151	Disabled	Setting	0	12	1	2	*	*	*	
IN2>2 Direction		39	37	Indexed String	G44	41462		G44	Directional Fwd	Setting	0	2	1	2	*	*	*	
IN2>2 Current		39	3A	Courier Number (current)		41463		G2	0.2	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	
IN2>2 IDG Is		39	3B	Courier Number (decimal)		41464		G2	1.5	Setting	1	4	0.1	2	*	*	*	
IN2>2 Time Delay		39	3D	Courier Number (time)		41465		G2	1	Setting	0	200	0.01	2	*	*	*	
IN2>2 TMS		39	3E	Courier Number (decimal)		41466		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
IN2>2 Time Dial		39	3F	Courier Number (decimal)		41467		G2	1	Setting	0.01	100	0.01	2	*	*	*	
IN2>2 k(RI)		39	40	Courier Number (decimal)		41468		G2	1	Setting	0.1	10	0.05	2	*	*	*	
IN2>2 IDG Time		39	41	Courier Number (time)		41469		G2	1.2	Setting	1	2	0.01	2	*	*	*	
IN2>2 Reset Char		39	43	Indexed String	G60	41470		G60	DT	Setting	0	1	1	2	*	*	*	
IN2>2 tRESET		39	44	Courier Number (time)		41471		G2	0	Setting	0	100	0.01	2	*	*	*	
IN2>3 Status		39	46	Indexed String	G37	41472		G37	Disabled	Setting	0	1	1	2	*	*	*	
IN2>3 Direction		39	47	Indexed String	G44	41473		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
IN2>3 Current		39	4A	Courier Number (current)		41474		G2	0.2	Setting	0.08*I1	32*I1	0.01*I1	2	*	*	*	
IN2>3 Time Delay		39	4B	Courier Number (time)		41475		G2	1	Setting	0	200	0.01	2	*	*	*	
IN2>4 Status		39	4D	Indexed String	G37	41476		G37	Disabled	Setting	0	1	1	2	*	*	*	

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
IN2>4 Direction		39	4E	Indexed String	G44	41477		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
IN2>4 Current		39	51	Courier Number (current)		41478		G2	0.2	Setting	0.08*I1	32*I1	0.01*I1	2	*	*	*	
IN2>4 Time Delay		39	52	Courier Number (time)		41479		G2	1	Setting	0	200	0.01	2	*	*	*	
IN2> Blocking		39	54	Binary Flag (8 bits)	G63	41480		G63	15	Setting	15	4	1	2	*			
									15		63	6	1	2		*	*	
IN2> POL		39	55	(Sub Heading)										2	*	*	*	
IN2> Char Angle		39	56	Courier Number (angle)		41481		G2	-45	Setting	-95	95	1	2	*	*	*	
IN2> Pol		39	57	Indexed String	G46	41482		G46	Zero Sequence	Setting	0	1	1	2	*	*	*	Zero seq or neg seq
IN2> VNpol Set		39	59	Courier Number (voltage)		41483		G2	5	Setting	0.5*V1	80*V1	0.5*V1	2	*	*	*	
IN2> V2pol Set		39	5A	Courier Number (voltage)		41484		G2	5	Setting	0.5*V1	25*V1	0.5*V1	2	*	*	*	
IN2> I2pol Set		39	5B	Courier Number (current)		41485		G2	0.08	Setting	0.08*I1	1.0*I1	0.01*I1	2	*	*	*	
SEF/REF PROT'N		3A	00												*	*	*	GROUP 1 - SENSITIVE EARTH FAULT
GROUP 1																		
SEF/REF Options		3A	01	Indexed String	G58	41500		G58	SEF	Setting	0	7	1	2	*	*	*	Sensitive Earth Fault Options
ISEF>1 Function		3A	2A	Indexed String	G152	41501		G152	DT	Setting	0	11	1	2	*	*	*	
ISEF>1 Direction		3A	2B	Indexed String	G44	41502		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
ISEF>1 Current		3A	2E	Courier Number (current)		41503		G2	0.05	Setting	0.005*I3	0.1*I3	0.00025*I3	2	*	*	*	
ISEF>1 IDG Is		3A	2F	Courier Number (decimal)		41504		G2	1.5	Setting	1	4	0.1	2	*	*	*	
ISEF>1 Delay		3A	31	Courier Number (time)		41505		G2	1	Setting	0	200	0.01	2	*	*	*	
ISEF>1 TMS		3A	32	Courier Number (decimal)		41506		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
ISEF>1 Time Dial		3A	33	Courier Number (decimal)		41507		G2	1	Setting	0.01	100	0.01	2	*	*	*	
ISEF>1 IDG Time		3A	34	Courier Number (time)		41508		G2	1.2	Setting	1	2	0.01	2	*	*	*	
ISEF>1 Reset Chr		3A	36	Indexed String	G60	41509		G60	DT	Setting	0	1	1	2	*	*	*	
ISEF>1 tRESET		3A	37	Courier Number (time)		41510		G2	0	Setting	0	100	0.01	2	*	*	*	
ISEF>2 Function		3A	3A	Indexed String	G152	41511		G152	Disabled	Setting	0	11	1	2	*	*	*	
ISEF>2 Direction		3A	3B	Indexed String	G44	41512		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
ISEF>2 Current		3A	3E	Courier Number (current)		41513		G2	0.05	Setting	0.005*I3	0.1*I3	0.00025*I3	2	*	*	*	
ISEF>2 IDG Is		3A	3F	Courier Number (decimal)		41514		G2	1.5	Setting	1	4	0.1	2	*	*	*	
ISEF>2 Delay		3A	41	Courier Number (time)		41515		G2	1	Setting	0	200	0.01	2	*	*	*	
ISEF>2 TMS		3A	42	Courier Number (decimal)		41516		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
ISEF>2 Time Dial		3A	43	Courier Number (decimal)		41517		G2	1	Setting	0.01	100	0.01	2	*	*	*	
ISEF>2 IDG Time		3A	44	Courier Number (time)		41518		G2	1.2	Setting	1	2	0.01	2	*	*	*	
ISEF>2 Reset Chr		3A	46	Indexed String	G60	41519		G60	DT	Setting	0	1	1	2	*	*	*	
ISEF>2 tRESET		3A	47	Courier Number (time)		41520		G2	0	Setting	0	100	0.01	2	*	*	*	
ISEF>3 Status		3A	49	Indexed String	G37	41521		G37	Disabled	Setting	0	1	1	2	*	*	*	
ISEF>3 Direction		3A	4A	Indexed String	G44	41522		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
ISEF>3 Current		3A	4D	Courier Number (current)		41523		G2	0.4	Setting	0.005*I3	2.0*I3	0.001*I3	2	*	*	*	
ISEF>3 Delay		3A	4E	Courier Number (time)		41524		G2	0.5	Setting	0	200	0.01	2	*	*	*	
ISEF>4 Status		3A	50	Indexed String	G37	41525		G37	Disabled	Setting	0	1	1	2	*	*	*	
ISEF>4 Direction		3A	51	Indexed String	G44	41526		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
ISEF>4 Current		3A	54	Courier Number (current)		41527		G2	0.6	Setting	0.005*I3	2.0*I3	0.001*I3	2	*	*	*	
ISEF>4 Delay		3A	55	Courier Number (time)		41528		G2	0.25	Setting	0	200	0.01	2	*	*	*	
ISEF> Blocking		3A	57	Binary Flag (8 bits)	G64	41529		G64	15	Setting	15	4	1	2	*			
									15		63	6	1	2		*	*	
ISEF POL		3A	58	(Sub Heading)										2	*	*	*	
ISEF> Char Angle		3A	59	Courier Number (angle)		41530		G2	90	Setting	-95	95	1	2	*	*	*	
ISEF> VNpol Set		3A	5B	Courier Number (voltage)		41531		G2	5	Setting	0.5*V1	80*V1	0.5*V1	2	*	*	*	

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
WATTMETRIC SEF		3A	5D	(Sub Heading)											*	*	*	
PN> Setting		3A	5E	Courier Number (power)		41532		G2	9	Setting	0.0*V1*I3	20*V1*I3	0.05*V1*I3	2	*	*	*	
RESTRICTED E/F		3A	60	(Sub Heading)											*	*	*	Low/High Imp Restricted Earth Fault
IREF> k1		3A	61	Courier Number (percentage)		41533		G2	20	Setting	0	20	1	2	*	*	*	Low impedance REF k1
IREF> k2		3A	62	Courier Number (percentage)		41534		G2	150	Setting	0	150	1	2	*	*	*	Low impedance REF k2
IREF> Is1		3A	63	Courier Number (current)		41535		G2	0.2	Setting	0.08*I1	1.0*I1	0.01*I1	2	*	*	*	Low impedance REF Is1
IREF> Is2		3A	64	Courier Number (current)		41536		G2	1	Setting	0.1*I1	1.5*I1	0.01*I1	2	*	*	*	Low impedance REF Is2
IREF> Is		3A	65	Courier Number (current)		41537		G2	0.2	Setting	0.05*I3	1.0*I3	0.01*I3	2	*	*	*	High impedance REF Is
RESIDUAL O/V NVD		3B	00												*	*	*	
GROUP 1																		
VN Input		3B	01	Indexed String	G49			G49	Derived	Data					*	*	*	Derived VN Input only
VN>1 Function		3B	02	Indexed String	G23	41550		G23	DT	Setting	0	2	1	2	*	*	*	
VN>1 Voltage Set		3B	03	Courier Number (voltage)		41551		G2	5	Setting	1*V1	80*V1	1*V1	2	*	*	*	
VN>1 Time Delay		3B	04	Courier Number (time)		41552		G2	5	Setting	0	100	0.01	2	*	*	*	
VN>1 TMS		3B	05	Courier Number (decimal)		41553		G2	1	Setting	0.5	100	0.5	2	*	*	*	
VN>1 tReset		3B	06	Courier Number (time)		41554		G2	0	Setting	0	100	0.01	2	*	*	*	
VN>2 Status		3B	07	Indexed String	G37	41555		G37	Disabled	Setting	0	1	1	2	*	*	*	
VN>2 Voltage Set		3B	08	Courier Number (voltage)		41556		G2	10	Setting	1*V1	80*V1	1*V1	2	*	*	*	
VN>2 Time Delay		3B	09	Courier Number (time)		41557		G2	10	Setting	0	100	0.01	2	*	*	*	
THERMAL OVERLOAD		3C	00												*	*	*	
GROUP 1																		
Characteristic		3C	01	Indexed String	G67	41600		G67	Single	Setting	0	1	2	2	*	*	*	Thermal overload options
Thermal Trip		3C	02	Courier Number (current)		41601		G2	1	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	
Thermal Alarm		3C	03	Courier Number (percentage)		41602		G2	70	Setting	50	100	1	2	*	*	*	
Time Constant 1		3C	04	Courier Number (time-minutes)		41603		G2	10	Setting	1	200	1	2	*	*	*	
Time Constant 2		3C	05	Courier Number (time-minutes)		41604		G2	5	Setting	1	200	1	2	*	*	*	
NEG SEQUENCE O/V		3D	00												*	*	*	
GROUP 1																		
V2> Status		3D	01	Indexed String	G37	41650		G37	Enabled	Setting	0	1	1	2	*	*	*	
V2> Voltage Set		3D	02	Courier Number (voltage)		41651		G2	15	Setting	1*V1	110*V1	1*V1	2	*	*	*	
V2> Time Delay		3D	03	Courier Number (time)		41652		G2	5	Setting	0	100	0.01	2	*	*	*	
COLD LOAD PICKUP		3E	00												*	*	*	
GROUP 1																		
tcold Time Delay		3E	01	Courier Number (time)		41700		G2	7200	Setting	0	14400	1	2	*	*	*	CB open time for load to become cold
tclp Time Delay		3E	02	Courier Number (time)		41701		G2	7200	Setting	0	14400	1	2	*	*	*	CB closed time after which load is warm
OVERCURRENT		3E	20	(Sub Heading)											*	*	*	
I>1 Status		3E	21	Indexed String	G106	41702		G106	Enable	Setting	0	1	1	2	*	*	*	Visible if I>1 enabled
I>1 Current Set		3E	22	Courier Number (current)		41703		G2	1.5	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	
I>1 Time Delay		3E	24	Courier Number (time)		41704		G2	1	Setting	0	100	0.01	2	*	*	*	
I>1 TMS		3E	25	Courier Number (decimal)		41705		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
I>1 Time Dial		3E	26	Courier Number (decimal)		41706		G2	1	Setting	0.01	100	0.01	2	*	*	*	
I>1 k(RI)		3E	27	Courier Number (decimal)		41707		G2	1	Setting	0.1	10	0.05	2	*	*	*	
I>2 Status		3E	29	Indexed String	G106	41708		G106	Enable	Setting	0	1	1	2	*	*	*	Visible if I>2 enabled
I>2 Current Set		3E	2A	Courier Number (current)		41709		G2	1.5	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	
I>2 Time Delay		3E	2C	Courier Number (time)		41710		G2	1	Setting	0	100	0.01	2	*	*	*	
I>2 TMS		3E	2D	Courier Number (decimal)		41711		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
I>2 Time Dial		3E	2E	Courier Number (decimal)		41712		G2	1	Setting	0.01	100	0.01	2	*	*	*	
I>2 k(RI)		3E	2F	Courier Number (decimal)		41713		G2	1	Setting	0.1	10	0.05	2	*	*	*	
I>3 Status		3E	31	Indexed String	G106	41714		G106	Block	Setting	0	1	1	2	*	*	*	Visible if I>3 enabled
I>3 Current Set		3E	32	Courier Number (current)		41715		G2	25	Setting	0.08*I1	32*I1	0.01*I1	2	*	*	*	
I>3 Time Delay		3E	33	Courier Number (time)		41716		G2	0	Setting	0	100	0.01	2	*	*	*	
I>4 Status		3E	35	Indexed String	G106	41717		G106	Block	Setting	0	1	1	2	*	*	*	Visible if I>4 enabled
I>4 Current Set		3E	36	Courier Number (current)		41718		G2	25	Setting	0.08*I1	32*I1	0.01*I1	2	*	*	*	
I>4 Time Delay		3E	37	Courier Number (time)		41719		G2	0	Setting	0	100	0.01	2	*	*	*	
STAGE 1 E/F 1		3E	39	(Sub Heading)											*	*	*	
IN1>1 Status		3E	3A	Indexed String	G106	41720		G106	Enable	Setting	0	1	1	2	*	*	*	Visible if IN>1 enabled
IN1>1 Current		3E	3B	Courier Number (current)		41721		G2	0.2	Setting	0.08*I2	4.0*I2	0.01*I2	2	*	*	*	
IN1>1 IDG Is		3E	3C	Courier Number (decimal)		41722		G2	1.5	Setting	1	4	0.1	2	*	*	*	
IN1>1 Time Delay		3E	3E	Courier Number (time)		41723		G2	1	Setting	0	200	0.01	2	*	*	*	
IN1>1 TMS		3E	3F	Courier Number (decimal)		41724		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
IN1>1 Time Dial		3E	40	Courier Number (decimal)		41725		G2	7	Setting	0.5	15	0.1	2	*	*	*	
IN1>1 k(RI)		3E	41	Courier Number (decimal)		41726		G2	1	Setting	0.1	10	0.05	2	*	*	*	
STAGE 1 E/F 2		3E	43	(Sub Heading)											*	*	*	
IN2>1 Status		3E	44	Indexed String	G106	41727		G106	Enable	Setting	0	1	1	2	*	*	*	Visible if IN>2 enabled
IN2>1 Current		3E	45	Courier Number (current)		41728		G2	0.2	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	
IN2>1 IDG Is		3E	46	Courier Number (decimal)		41729		G2	1.5	Setting	1	4	0.1	2	*	*	*	
IN2>1 Time Delay		3E	48	Courier Number (time)		41730		G2	1	Setting	0	200	0.01	2	*	*	*	
IN2>1 TMS		3E	49	Courier Number (decimal)		41731		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	
IN2>1 Time Dial		3E	4A	Courier Number (decimal)		41732		G2	7	Setting	0.5	15	0.1	2	*	*	*	
IN2>1 k(RI)		3E	4B	Courier Number (decimal)		41726		G2	1	Setting	0.1	10	0.05	2	*	*	*	
SELECTIVE LOGIC		3F	00												*	*	*	
GROUP 1																		
OVERCURRENT		3F	01	(Sub Heading)											*	*	*	
I>3 Time Delay		3F	02	Courier Number (time)		41750		G2	1	Setting	0	100	0.01	2	*	*	*	Visible if I>3 enabled
I>4 Time Delay		3F	03	Courier Number (time)		41751		G2	1	Setting	0	100	0.01	2	*	*	*	Visible if I>4 enabled
EARTH FAULT 1		3F	04	(Sub Heading)											*	*	*	
IN1>3 Time Delay		3F	05	Courier Number (time)		41752		G2	2	Setting	0	200	0.01	2	*	*	*	Visible if IN1>3 enabled
IN1>4 Time Delay		3F	06	Courier Number (time)		41753		G2	2	Setting	0	200	0.01	2	*	*	*	Visible if IN1>4 enabled
EARTH FAULT 2		3F	07	(Sub Heading)											*	*	*	
IN2>3 Time Delay		3F	08	Courier Number (time)		41754		G2	2	Setting	0	200	0.01	2	*	*	*	Visible if IN2>3 enabled
IN2>4 Time Delay		3F	09	Courier Number (time)		41755		G2	2	Setting	0	200	0.01	2	*	*	*	Visible if IN2>4 enabled
SENSITIVE E/F		3F	0A	(Sub Heading)											*	*	*	
ISEF>3 Delay		3F	0B	Courier Number (time)		41756		G2	1	Setting	0	200	0.01	2	*	*	*	Visible if ISEF>3 enabled
ISEF>4 Delay		3F	0C	Courier Number (time)		41757		G2	0.5	Setting	0	200	0.01	2	*	*	*	Visible if ISEF>4 enabled
ADMIT PROTECTION		40	00												*	*	*	
GROUP 1																		
VN Threshold		40	01	Courier Number (voltage)		41800		G2	10*V1	Setting	1*V1	40*V1	1*V1	2	*	*	*	
CT Input Type		40	02	Indexed String	G120	41801		G120	SEF CT	Setting	0	1	1	2	*	*	*	
Correction Angle		40	03	Courier Number (angle)		41802		G2	0	Setting	-30	30	1	2	*	*	*	
OVER ADMITTANCE		40	04	(Sub Heading)											*	*	*	
YN> Status		40	05	Indexed String	G37	41803		G37	Disabled	Setting	0	1	1	2	*	*	*	
YN> Set		40	06	Courier Number (inverse ohms)		41804		G2	0.005	Setting	0.0001*I3/V1	0.01*I3/V1	0.0001*I3/V1	2	*	*	*	ISEF

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
YN> Set		40	07	Courier Number (inverse ohms)		41805		G2	0.05	Setting	0.001*I2/V1	0.1*I2/V1	0.001*I2/V1	2	*	*	*	IN
YN> Time Delay		40	08	Courier Number (time)		41806		G2	1	Setting	0.05	100	0.01	2	*	*	*	
YN> tRESET		40	09	Courier Number (time)		41807		G2	0	Setting	0	100	0.01	2	*	*	*	
OVER CONDUCTANCE		40	0A	(Sub Heading)											*	*	*	
GN> Status		40	0B	Indexed String	G37	41808		G37	Disabled	Setting	0	1	1	2	*	*	*	
GN> Direction		40	0C	Indexed String	G44	41809		G44	Non-Directional	Setting	0	1	2	2	*	*	*	
GN> Set		40	0D	Courier Number (inverse ohms)		41810		G2	0.0008	Setting	0.0001*I3/V1	0.005*I3/V1	0.0001*I3/V1		*	*	*	ISEF
GN> Set		40	0E	Courier Number (inverse ohms)		41811		G2	0.002	Setting	0.001*I2/V1	0.05*I2/V1	0.001*I2/V1	2	*	*	*	IN
GN> Time Delay		40	0F	Courier Number (time)		41812		G2	1	Setting	0.05	100	0.01	2	*	*	*	
GN> tRESET		40	10	Courier Number (time)		41813		G2	0	Setting	0	100	0.01	2	*	*	*	
OVER SUSCEPTANCE		40	11	(Sub Heading)											*	*	*	
BN> Status		40	12	Indexed String	G37	41814		G37	Disabled	Setting	0	1	1	2	*	*	*	
BN> Direction		40	13	Indexed String	G44	41815		G44	Non-Directional	Setting	0	2	1	2	*	*	*	
BN> Set		40	14	Courier Number (inverse ohms)		41816		G2	0.0008	Setting	0.0001*I3/V1	0.005*I3/V1	0.0001*I3/V1	2	*	*	*	ISEF
BN> Set		40	15	Courier Number (inverse ohms)		41817		G2	0.002	Setting	0.001*I2/V1	0.05*I2/V1	0.001*I2/V1	2	*	*	*	IN
BN> Time Delay		40	16	Courier Number (time)		41818		G2	1	Setting	0.05	100	0.01	2	*	*	*	
BN> tRESET		40	17	Courier Number (time)		41819		G2	0	Setting	0	100	0.01	2	*	*	*	
VOLT PROTECTION		42	00												*	*	*	
GROUP 1																		
UNDER VOLTAGE		42	01	(Sub Heading)											*	*	*	
V< Measur't Mode		42	02	Indexed String	G47	41950		G47	Phase-Phase	Setting	0	1	1	2	*	*	*	
V< Operate Mode		42	03	Indexed String	G48	41951		G48	Any Phase	Setting	0	1	1	2	*	*	*	
V<1 Function		42	04	Indexed String	G23	41952		G23	DT	Setting	0	2	1	2	*	*	*	
V<1 Voltage Set		42	05	Courier Number (voltage)		41953		G2	80	Setting	10*V1	120*V1	1*V1	2	*	*	*	Range covers Ph-N & Ph-Ph
V<1 Time Delay		42	06	Courier Number (time)		41954		G2	10	Setting	0	100	0.01	2	*	*	*	
V<1 TMS		42	07	Courier Number (decimal)		41955		G2	1	Setting	0.5	100	0.5	2	*	*	*	
V<1 Poledead Inh		42	08	Indexed String	G37	41956		G37	Enabled	Setting	0	1	1	2	*	*	*	
V<2 Status		42	09	Indexed String	G37	41957		G37	Disabled	Setting	0	1	1	2	*	*	*	
V<2 Voltage Set		42	0A	Courier Number (voltage)		41958		G2	60	Setting	10*V1	120*V1	1*V1	2	*	*	*	
V<2 Time Delay		42	0B	Courier Number (time)		41959		G2	5	Setting	0	100	0.01	2	*	*	*	
V<2 Poledead Inh		42	0C	Indexed String	G37	41960		G37	Enabled	Setting	0	1	1	2	*	*	*	
OVERVOLTAGE		42	0D	(Sub Heading)											*	*	*	
V> Measur't Mode		42	0E	Indexed String	G47	41961		G47	Phase-Phase	Setting	0	1	1	2	*	*	*	
V> Operate Mode		42	0F	Indexed String	G48	41962		G48	Any Phase	Setting	0	1	1	2	*	*	*	
V>1 Function		42	10	Indexed String	G23	41963		G23	DT	Setting	0	2	1	2	*	*	*	
V>1 Voltage Set		42	11	Courier Number (voltage)		41964		G2	130	Setting	60*V1	185*V1	1*V1	2	*	*	*	
V>1 Time Delay		42	12	Courier Number (time)		41965		G2	10	Setting	0	100	0.01	2	*	*	*	
V>1 TMS		42	13	Courier Number (decimal)		41966		G2	1	Setting	0.5	100	0.5	2	*	*	*	
V>2 Status		42	14	Indexed String	G37	41967		G37	Disabled	Setting	0	1	1	2	*	*	*	
V>2 Voltage Set		42	15	Courier Number (voltage)		41968		G2	150	Setting	60*V1	185*V1	1*V1	2	*	*	*	
V>2 Time Delay		42	16	Courier Number (time)		41969		G2	0.5	Setting	0	100	0.01	2	*	*	*	
FREQ PROTECTION		43	00															
GROUP 1																		
UNDER FREQUENCY		43	01	(Sub Heading)											*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
F<1 Status		43	02	Indexed String	G37	42000		G37	Enabled	Setting	0	1	1	2	*	*	*	
F<1 Setting		43	03	Courier Number (Frequency)		42001		G2	49.5	Setting	45	65	0.01	2	*	*	*	
F<1 Time Delay		43	04	Courier Number (Time)		42002		G2	4	Setting	0	100	0.01	2	*	*	*	
F<2 Status		43	05	Indexed String	G37	42003		G37	Disabled	Setting	0	1	1	2	*	*	*	
F<2 Setting		43	06	Courier Number (Frequency)		42004		G2	49	Setting	45	65	0.01	2	*	*	*	
F<2 Time Delay		43	07	Courier Number (Time)		42005		G2	3	Setting	0	100	0.01	2	*	*	*	
F<3 Status		43	08	Indexed String	G37	42006		G37	Disabled	Setting	0	1	1	2	*	*	*	
F<3 Setting		43	09	Courier Number (Frequency)		42007		G2	48.5	Setting	45	65	0.01	2	*	*	*	
F<3 Time Delay		43	0A	Courier Number (Time)		42008		G2	2	Setting	0	100	0.01	2	*	*	*	
F<4 Status		43	0B	Indexed String	G37	42009		G37	Disabled	Setting	0	1	1	2	*	*	*	
F<4 Setting		43	0C	Courier Number (Frequency)		42010		G2	48	Setting	45	65	0.01	2	*	*	*	
F<4 Time Delay		43	0D	Courier Number (Time)		42011		G2	1	Setting	0	100	0.01	2	*	*	*	
F< Function Link		43	0E	Binary Flag (4 bits)	G65	42012		G65	16	Setting	15	4	1	2	*	*	*	Pole dead inhibit of F<1 to F<4
OVER FREQUENCY		43	0F	(Sub Heading)											*	*	*	
F>1 Status		43	10	Indexed String	G37	42013		G37	Enabled	Setting	0	1	1	2	*	*	*	
F>1 Setting		43	11	Courier Number (Frequency)		42014		G2	50.5	Setting	45	65	0.01	2	*	*	*	
F>1 Time Delay		43	12	Courier Number (Time)		42015		G2	2	Setting	0	100	0.01	2	*	*	*	
F>2 Status		43	13	Indexed String	G37	42016		G37	Disabled	Setting	0	1	1	2	*	*	*	
F>2 Setting		43	14	Courier Number (Frequency)		42017		G2	51	Setting	45	65	0.01	2	*	*	*	
F>2 Time Delay		43	15	Courier Number (Time)		42018		G2	1	Setting	0	100	0.01	2	*	*	*	
	N/A			IEC870 Date & Time		42049	42052	G12		Setting				0	*	*	*	Repeat of [0801]
CB FAIL & I<		45	00												*	*	*	
GROUP 1																		
BREAKER FAIL		45	01	(Sub Heading)											*	*	*	
CB Fail 1 Status		45	02	Indexed String	G37	42100		G37	Enabled	Setting	0	1	1	2	*	*	*	
CB Fail 1 Timer		45	03	Courier Number (time)		42101		G2	0.2	Setting	0	10	0.01	2	*	*	*	
CB Fail 2 Status		45	04	Indexed String	G37	42102		G37	Disabled	Setting	0	1	1	2	*	*	*	
CB Fail 2 Timer		45	05	Courier Number (time)		42103		G2	0.4	Setting	0	10	0.01	2	*	*	*	
Volt Prot Reset		45	06	Indexed String	G68	42104		G68	CB Open & I<	Setting	0	2	1	2	*	*	*	
Ext Prot Reset		45	07	Indexed String	G68	42105		G68	CB Open & I<	Setting	0	2	1	2	*	*	*	
UNDER CURRENT		45	08	(Sub Heading)											*	*	*	
I< Current Set		45	09	Courier Number (current)		42106		G2	0.1	Setting	0.02*I1	3.2*I1	0.01*I1	2	*	*	*	
IN< Current Set		45	0A	Courier Number (current)		42107		G2	0.1	Setting	0.02*I2	3.2*I2	0.01*I2	2	*	*	*	
ISEF< Current		45	0B	Courier Number (current)		42108		G2	0.02	Setting	0.001*I3	0.8*I3	0.0005*I3	2	*	*	*	
BLOCKED O/C		45	0C	(Sub Heading)											*	*	*	Blocked Overcurrent Schemes
Remove I> Start		45	0D	Indexed String	G37	42109		G37	Disabled	Setting	0	1	1	2	*	*	*	CBF condition removes start
Remove IN> Start		45	0E	Indexed String	G37	42110		G37	Disabled	Setting	0	1	1	2	*	*	*	CBF condition removes start
SUPERVISION		46	00												*	*	*	
GROUP 1																		
VT SUPERVISION		46	01	(Sub Heading)											*	*	*	
VTS Status		46	02	Indexed String	G7	42150		G7	Blocking	Setting	0	1	1	2	*	*	*	
VTS Reset Mode		46	03	Indexed String	G69	42151		G69	Manual	Setting	0	1	1	2	*	*	*	
VTS Time Delay		46	04	Courier Number (time)		42152		G2	5	Setting	1	10	0.1	2	*	*	*	
VTS I> Inhibit		46	05	Courier Number (current)		42153		G2	10	Setting	0.08*I1	32*I1	0.01*I1	2	*	*	*	
VTS I2> Inhibit		46	06	Courier Number (current)		42154		G2	0.05	Setting	0.05*I1	0.5*I1	0.01*I1	2	*	*	*	
CT SUPERVISION		46	07	(Sub Heading)											*	*	*	
CTS Status		46	08	Indexed String	G37	42155		G37	Disabled	Setting	0	1	1	2	*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
CTS VN< Inhibit		46	09	Courier Number (voltage)		42156		G2	5	Setting	0.5*V1	22*V1	0.5*V1	2	*	*	*	
CTS IN> Set		46	0A	Courier Number (current)		42157		G2	0.1	Setting	0.08*I1	4*I1	0.01*I1	2	*	*	*	
CTS Time Delay		46	0B	Courier Number (time)		42158		G2	5	Setting	0	10	1	2	*	*	*	
FAULT LOCATOR		47	00												*	*	*	
GROUP 1																		
Line Length		47	01	Courier Number (metres)		42200	42201	G35	16000	Setting	10	1000000	1	2	*	*	*	Length in km
Line Length		47	02	Courier Number (miles)		42202	42203	G35	10	Setting	0.005	621	0.005	2	*	*	*	Length in miles
Line Impedance		47	03	Courier Number (impedance)		42204		G2	6	Setting	0.1*V1/I1	250*V1/I1	0.01*V1/I1	2	*	*	*	
Line Angle		47	04	Courier Number (angle)		42205		G2	70	Setting	20	85	1	2	*	*	*	
KZN Residual		47	05	Courier Number (decimal)		42206		G2	1	Setting	0	7	0.01	2	*	*	*	Multiplier
KZN Res Angle		47	06	Courier Number (angle)		42207		G2	0	Setting	-90	90	1	2	*	*	*	
SYSTEM CHECKS		48	00														*	
GROUP 1																		
VOLTAGE MONITORS		48	14	(Sub Heading)														
Live Voltage		48	15	Courier Number (voltage)		42250		G2	32	Setting	1*V1	132*V1	0.5*V1	2		*	*	
Dead Voltage		48	16	Courier Number (voltage)		42251		G2	13	Setting	1*V1	132*V1	0.5*V1	2		*	*	
CHECK SYNCH		48	17	(Sub Heading)														
CS1 Status		48	18	Indexed String	G37	42252		G37	Enabled	Setting	0	1	1	2			*	
CS1 Phase Angle		48	19	Courier Number (angle)		42253		G2	20	Setting	5	90	1	2			*	
CS1 Slip Control		48	1A	Indexed String	G42	42254		G42	Frequency	Setting	1	3	1	2			*	
CS1 Slip Freq		48	1B	Courier Number (frequency)		42255		G2	0.05	Setting	0.02	1	0.01	2			*	
CS1 Slip Timer		48	1C	Courier Number (time)		42256		G2	1	Setting	0	99	0.1	2			*	
CS2 Status		48	1D	Indexed String	G37	42257		G37	Disabled	Setting	0	1	1	2			*	
CS2 Phase Angle		48	1E	Courier Number (angle)		42258		G2	20	Setting	5	90	1	2			*	
CS2 Slip Control		48	1F	Indexed String	G42	42259		G42	Frequency	Setting	1	3	1	2			*	
CS2 Slip Freq		48	20	Courier Number (frequency)		42260		G2	0.05	Setting	0.02	1	0.01	2			*	
CS2 Slip Timer		48	21	Courier Number (time)		42261		G2	1	Setting	0	99	0.1	2			*	
CS Undervoltage		48	22	Courier Number (voltage)		42262		G2	54	Setting	10*V1	132*V1	0.5V1	2			*	
CS Overvoltage		48	23	Courier Number (voltage)		42263		G2	130	Setting	60*V1	132*V1	0.5V1	2			*	
CS Diff Voltage		48	24	Courier Number (voltage)		42264		G2	6.5	Setting	1*V1	132*V1	0.5V1	2			*	
CS Volt Blocking		48	25	Indexed String	G41	42265		G41	V<	Setting	0	7	1	2			*	
SYSTEM SPLIT		48	26	(Sub Heading)														
SS Status		48	27	Indexed String	G37	42266		G37	Enabled	Setting	0	1	1	2			*	
SS Phase Angle		48	28	Courier Number (angle)		42267		G2	120	Setting	90	175	1	2			*	
SS Under V Block		48	29	Indexed String	G37	42268		G37	Enabled	Setting	0	1	1	2			*	
SS Undervoltage		48	2A	Courier Number (voltage)		42269		G2	54	Setting	10*V1	132*V1	0.5V1	2			*	
SS Timer		48	2B	Courier Number (time)		42270		G2	1	Setting	0	99	0.1	2			*	
AUTORECLOSE		49	00													*	*	
GROUP 1																		
A/R Mode Select		49	01	Indexed String	G70	42300		G70	Command Mode	Setting	0	3	1	2		*	*	
Number of Shots		49	02	Unsigned Integer (16 bits)		42301		G1	1	Setting	1	4	1	2		*	*	
Number SEF Shots		49	03	Unsigned Integer (16 bits)		42302		G1	0	Setting	0	4	1	2		*	*	Visible if SEF enabled
Sequence Co-ord		49	04	Indexed String	G37	42303		G37	Disabled	Setting	0	1	1	2		*	*	
CS AR Immediate		49	05	Indexed String	G37	42304		G37	Disabled	Setting	0	1	1	2			*	
Dead Time 1		49	08	Courier Number (time)		42305		G2	10	Setting	0.01	300	0.01	2		*	*	
Dead Time 2		49	09	Courier Number (time)		42306		G2	60	Setting	0.01	300	0.01	2		*	*	
Dead Time 3		49	0A	Courier Number (time)		42307	42308	G35	180	Setting	0.01	9999	0.01	2		*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
Dead Time 4		49	0B	Courier Number (time)		42309	42310	G35	180	Setting	0.01	9999	0.01	2		*	*	
CB Healthy Time		49	0C	Courier Number (time)		42311	42312	G35	5	Setting	0.01	9999	0.01	2		*	*	
Start Dead t On		49	0D	Indexed String	G72	42313		G72	Protection Reset	Setting	0	1	1	2		*	*	
tReclaim Extend		49	0E	Indexed String	G73	42314		G73	No Operation	Setting	0	1	1	2		*	*	
Reclaim Time		49	0F	Courier Number (time)		42315		G2	180	Setting	1	600	0.01	2		*	*	
AR Inhibit Time		49	10	Courier Number (time)		42316		G2	5	Setting	0.01	600	0.01	2		*	*	AR Inhibit Time Delay
AR Lockout		49	12	Indexed String	G91	42317		G91	No Block	Setting	0	1	1	2		*	*	Block Trips on Lockout
EFF Maint Lock		49	13	Indexed String	G91	42318		G91	No Block	Setting	0	1	1	2		*	*	Block Protection Trips when Maint/EFF Locked Out
AR Deselected		49	14	Indexed String	G91	42319		G91	No Block	Setting	0	1	1	2		*	*	Block Protection Trips if Auto Mode Deselected
Manual Close		49	15	Indexed String	G91	42320		G91	No Block	Setting	0	1	1	2		*	*	Block Protection Trips after Control Close
Trip 1 Main		49	16	Indexed String	G82	42321		G82	No Block	Setting	0	1	1	2		*	*	Block Main Prot for 1st Trip
Trip 2 Main		49	17	Indexed String	G82	42322		G82	Block Inst Prot	Setting	0	1	1	2		*	*	Block Main Prot for 2nd Trip
Trip 3 Main		49	18	Indexed String	G82	42323		G82	Block Inst Prot	Setting	0	1	1	2		*	*	Block Main Prot for 3rd Trip
Trip 4 Main		49	19	Indexed String	G82	42324		G82	Block Inst Prot	Setting	0	1	1	2		*	*	Block Main Prot for 4th Trip
Trip 5 Main		49	1A	Indexed String	G82	42325		G82	Block Inst Prot	Setting	0	1	1	2		*	*	Block Main Prot for 5th Trip
Trip 1 SEF		49	1B	Indexed String	G82	42326		G82	Block Inst Prot	Setting	0	1	1	2		*	*	Block SEF Prot for 1st Trip
Trip 2 SEF		49	1C	Indexed String	G82	42327		G82	Block Inst Prot	Setting	0	1	1	2		*	*	Block SEF Prot for 2nd Trip
Trip 3 SEF		49	1D	Indexed String	G82	42328		G82	Block Inst Prot	Setting	0	1	1	2		*	*	Block SEF Prot for 3rd Trip
Trip 4 SEF		49	1E	Indexed String	G82	42329		G82	Block Inst Prot	Setting	0	1	1	2		*	*	Block SEF Prot for 4th Trip
Trip 5 SEF		49	1F	Indexed String	G82	42330		G82	Block Inst Prot	Setting	0	1	1	2		*	*	Block SEF Prot for 5th Trip
Man Close on Flt		49	20	Indexed String	G92	42331		G92	Lockout	Setting	0	1	1	2		*	*	Lockout for Control Close onto Fault
Trip AR Inactive		49	21	Indexed String	G92	42332		G92	No Lockout	Setting	0	1	1	2		*	*	Lockout for Non Auto or Liveline modes
Reset Lockout by		49	22	Indexed String	G74	42333		G74	User Interface	Setting	0	1	1	2		*	*	Reset Lockout
AR on Man Close		49	24	Indexed String	G75	42334		G75	Inhibited	Setting	0	1	1	2		*	*	Auto-Reclose after Control Close
Sys Check Time		49	25	Courier Number (time)		42335	42336	G35	5	Setting	0.01	9999	0.01	2		*	*	Check Sync Window
AR INITIATION		49	28	(Sub Heading)												*	*	
I>1 AR		49	29	Indexed String	G101	42337		G101	Initiate Main AR	Setting	0	1	1	2		*	*	Visible if I>1 enabled
I>2 AR		49	2A	Indexed String	G101	42338		G101	Initiate Main AR	Setting	0	1	1	2		*	*	Visible if I>2 enabled
I>3 AR		49	2B	Indexed String	G102	42339		G102	Initiate Main AR	Setting	0	2	1	2		*	*	Visible if I>3 enabled
I>4 AR		49	2C	Indexed String	G102	42340		G102	Initiate Main AR	Setting	0	2	1	2		*	*	Visible if I>4 enabled
IN1>1 AR		49	2D	Indexed String	G101	42341		G101	Initiate Main AR	Setting	0	1	1	2		*	*	Visible if IN1>1 enabled
IN1>2 AR		49	2E	Indexed String	G101	42342		G101	Initiate Main AR	Setting	0	1	1	2		*	*	Visible if IN1>2 enabled
IN1>3 AR		49	2F	Indexed String	G102	42343		G102	Initiate Main AR	Setting	0	2	1	2		*	*	Visible if IN1>3 enabled
IN1>4 AR		49	30	Indexed String	G102	42344		G102	Initiate Main AR	Setting	0	2	1	2		*	*	Visible if IN1>4 enabled
IN2>1 AR		49	31	Indexed String	G101	42345		G101	No Action	Setting	0	1	1	2		*	*	Visible if IN2>1 enabled
IN2>2 AR		49	32	Indexed String	G101	42346		G101	No Action	Setting	0	1	1	2		*	*	Visible if IN2>2 enabled
IN2>3 AR		49	33	Indexed String	G102	42347		G102	No Action	Setting	0	2	1	2		*	*	Visible if IN2>3 enabled
IN2>4 AR		49	34	Indexed String	G102	42348		G102	No Action	Setting	0	2	1	2		*	*	Visible if IN2>4 enabled
ISEF>1 AR		49	35	Indexed String	G103	42349		G103	No Action	Setting	0	2	1	2		*		Visible if ISEF>1 enabled
ISEF>2 AR		49	36	Indexed String	G103	42350		G103	No Action	Setting	0	3	1	2			*	
ISEF>3 AR		49	37	Indexed String	G103	42351		G103	No Action	Setting	0	2	1	2		*		Visible if ISEF>3 enabled
ISEF>4 AR		49	38	Indexed String	G103	42352		G103	No Action	Setting	0	2	1	2		*		Visible if ISEF>4 enabled
YN> AR		49	39	Indexed String	G101	42353		G101	No Action	Setting	0	1	1	2		*	*	Visible if YN> enabled
GN> AR		49	3A	Indexed String	G101	42354		G101	No Action	Setting	0	1	1	2		*	*	Visible if GN> enabled
BN> AR		49	3B	Indexed String	G101	42355		G101	No Action	Setting	0	1	1	2		*	*	Visible if BN> enabled

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
Ext Prot		49	3C	Indexed String	G101	42356		G101	No Action	Setting	0	1	1	2		*	*	
SYSTEM CHECKS		49	40	(Sub Heading)														
AR with ChkSyn		49	41	Indexed String	G37	42357		G37	Disabled	Setting	0	1	1	2		*	*	
AR with SysSyn		49	42	Indexed String	G37	42358		G37	Disabled	Setting	0	1	1	2			*	
Live/Dead Ccts		49	43	Indexed String	G37	42359		G37	Disabled	Setting	0	1	1	2			*	
No System Checks		49	44	Indexed String	G37	42360		G37	Enabled	Setting	0	1	1	2		*	*	
SysChk on Shot 1		49	45	Indexed String	G37	42361		G101	Enabled	Setting	0	1	1	2		*	*	
INPUT LABELS		4A	00												*	*	*	
GROUP 1																		
Opto Input 1		4A	01	ASCII Text (16 chars)		42400	42407	G3	L1 Setting Group	Setting	32	163	1	2	*	*	*	
Opto Input 2		4A	02	ASCII Text (16 chars)		42408	42415	G3	L2 Setting Group	Setting	32	163	1	2	*	*	*	
Opto Input 3		4A	03	ASCII Text (16 chars)		42416	42423	G3	L3 Block IN1>3&4	Setting	32	163	1	2	*	*	*	
Opto Input 4		4A	04	ASCII Text (16 chars)		42424	42431	G3	L4 Block I>3&4	Setting	32	163	1	2	*	*	*	
Opto Input 5		4A	05	ASCII Text (16 chars)		42432	42439	G3	L5 Rst LEDs/Lckt	Setting	32	163	1	2	*	*		
									L5 Reset LEDs								*	
Opto Input 6		4A	06	ASCII Text (16 chars)		42440	42447	G3	L6 External Trip	Setting	32	163	1	2	*	*	*	
Opto Input 7		4A	07	ASCII Text (16 chars)		42448	42455	G3	L7 52-A	Setting	32	163	1	2	*		*	
									L7 CB Healthy							*		
Opto Input 8		4A	08	ASCII Text (16 chars)		42456	42463	G3	L8 52-B	Setting	32	163	1	2	*	*	*	
Opto Input 9		4A	09	ASCII Text (16 chars)		42464	42471	G3	L9 Select Auto	Setting	32	163	1	2			*	
									L9 Not Used	Setting	32	163	1	2		*BC		
Opto Input 10		4A	0A	ASCII Text (16 chars)		42472	42479	G3	L10 Sel Telecntl	Setting	32	163	1	2			*	
									L10 Not Used	Setting	32	163	1	2		*BC		
Opto Input 11		4A	0B	ASCII Text (16 chars)		42480	42487	G3	L11 Sel LiveLine	Setting	32	163	1	2			*	
									L11 Not Used	Setting	32	163	1	2		*BC		
Opto Input 12		4A	0C	ASCII Text (16 chars)		42488	42495	G3	L12 CB Healthy	Setting	32	163	1	2			*	
									L12 Not Used	Setting	32	163	1	2		*BC		
Opto Input 13		4A	0D	ASCII Text (16 chars)		42496	42503	G3	L13 Block AR	Setting	32	163	1	2			*	
									L13 Not Used	Setting	32	163	1	2		*C		
Opto Input 14		4A	0E	ASCII Text (16 chars)		42504	42511	G3	L14 Reset Lckout	Setting	32	163	1	2			*	
									L14 Not Used	Setting	32	163	1	2		*C		
Opto Input 15		4A	0F	ASCII Text (16 chars)		42512	42519	G3	L15 Not Used	Setting	32	163	1	2		*C	*	
Opto Input 16		4A	10	ASCII Text (16 chars)		42520	42527	G3	L16 Not Used	Setting	32	163	1	2		*C	*	
Opto Input 17		4A	11	ASCII Text (16 chars)		42528	42535	G3	L17 Not Used	Setting	32	163	1	2			*CEF	
Opto Input 18		4A	12	ASCII Text (16 chars)		42536	42543	G3	L18 Not Used	Setting	32	163	1	2			*CEF	
Opto Input 19		4A	13	ASCII Text (16 chars)		42544	42551	G3	L19 Not Used	Setting	32	163	1	2			*CEF	
Opto Input 20		4A	14	ASCII Text (16 chars)		42552	42559	G3	L20 Not Used	Setting	32	163	1	2			*CEF	
Opto Input 21		4A	15	ASCII Text (16 chars)		42560	42567	G3	L21 Not Used	Setting	32	163	1	2			*CEF	
Opto Input 22		4A	16	ASCII Text (16 chars)		42568	42575	G3	L22 Not Used	Setting	32	163	1	2			*CEF	
Opto Input 23		4A	17	ASCII Text (16 chars)		42576	42583	G3	L23 Not Used	Setting	32	163	1	2			*CEF	
Opto Input 24		4A	18	ASCII Text (16 chars)		42584	42591	G3	L24 Not Used	Setting	32	163	1	2			*CEF	
Opto Input 25		4A	19	ASCII Text (16 chars)		42592	42599	G3	L25 Not Used	Setting	32	163	1	2			*F	
Opto Input 26		4A	1A	ASCII Text (16 chars)		42600	42607	G3	L26 Not Used	Setting	32	163	1	2			*F	
Opto Input 27		4A	1B	ASCII Text (16 chars)		42608	42615	G3	L27 Not Used	Setting	32	163	1	2			*F	
Opto Input 28		4A	1C	ASCII Text (16 chars)		42616	42623	G3	L28 Not Used	Setting	32	163	1	2			*F	
Opto Input 29		4A	1D	ASCII Text (16 chars)		42624	42631	G3	L29 Not Used	Setting	32	163	1	2			*F	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
Opto Input 30		4A	1E	ASCII Text (16 chars)		42632	42639	G3	L30 Not Used	Setting	32	163	1	2			*F	
Opto Input 31		4A	1F	ASCII Text (16 chars)		42640	42647	G3	L31 Not Used	Setting	32	163	1	2			*F	
Opto Input 32		4A	20	ASCII Text (16 chars)		42648	42655	G3	L32 Not Used	Setting	32	163	1	2			*F	
OUTPUT LABELS		4B	00												*	*	*	
GROUP 1																		
Relay 1		4B	01	ASCII Text (16 chars)		42700	42707	G3	R1 IN/ISEF>Start	Setting	32	163	1	2	*	*	*	
Relay 2		4B	02	ASCII Text (16 chars)		42708	42715	G3	R2 I>Start	Setting	32	163	1	2	*	*	*	
Relay 3		4B	03	ASCII Text (16 chars)		42716	42723	G3	R3 Prot'n Trip	Setting	32	163	1	2	*	*	*	
Relay 4		4B	04	ASCII Text (16 chars)		42724	42731	G3	R4 General Alarm	Setting	32	163	1	2	*	*	*	
Relay 5		4B	05	ASCII Text (16 chars)		42732	42739	G3	R5 CB Fail Tmr 1	Setting	32	163	1	2	*	*	*	
Relay 6		4B	06	ASCII Text (16 chars)		42740	42747	G3	R6 Cntl CB Close	Setting	32	163	1	2	*	*	*	
Relay 7		4B	07	ASCII Text (16 chars)		42748	42755	G3	R7 Cntl CB Trip	Setting	32	163	1	2	*	*	*	
Relay 8		4B	08	ASCII Text (16 chars)		42756	42763	G3	R8 Any Start	Setting	32	163	1	2			*	
									R8 Not Used	Setting	32	163	1	2		*BD		
Relay 9		4B	09	ASCII Text (16 chars)		42764	42771	G3	R9 AR Successful	Setting	32	163	1	2			*	
									R9 Not Used	Setting	32	163	1	2		*BD		
Relay 10		4B	0A	ASCII Text (16 chars)		42772	42779	G3	R10 Non Auto	Setting	32	163	1	2			*	
									R10 Not Used	Setting	32	163	1	2		*BD		
Relay 11		4B	0B	ASCII Text (16 chars)		42780	42787	G3	R11 AR In Prog	Setting	32	163	1	2			*	
									R11 Not Used	Setting	32	163	1	2		*BD		
Relay 12		4B	0C	ASCII Text (16 chars)		42788	42795	G3	R12 AR Lockout	Setting	32	163	1	2			*	
									R12 Not Used	Setting	32	163	1	2		*D		
Relay 13		4B	0D	ASCII Text (16 chars)		42796	42803	G3	R13 AR InService	Setting	32	163	1	2			*	
									R13 Not Used	Setting	32	163	1	2		*D		
Relay 14		4A	0E	ASCII Text (16 chars)		42804	42811	G3	R14 Live Line	Setting	32	163	1	2			*	
									R14 Not Used	Setting	32	163	1	2		*D		
Relay 15		4A	0F	ASCII Text (16 chars)		42812	42819	G3	R15 Not Used	Setting	32	163	1	2		*D	*DEG	
Relay 16		4A	10	ASCII Text (16 chars)		42820	42827	G3	R16 Not Used	Setting	32	163	1	2			*DEG	
Relay 17		4A	11	ASCII Text (16 chars)		42828	42835	G3	R17 Not Used	Setting	32	163	1	2			*DEG	
Relay 18		4A	12	ASCII Text (16 chars)		42836	42843	G3	R18 Not Used	Setting	32	163	1	2			*DEG	
Relay 19		4A	13	ASCII Text (16 chars)		42844	42851	G3	R19 Not Used	Setting	32	163	1	2			*DEG	
Relay 20		4A	14	ASCII Text (16 chars)		42852	42859	G3	R20 Not Used	Setting	32	163	1	2			*DEG	
Relay 21		4A	15	ASCII Text (16 chars)		42860	42867	G3	R21 Not Used	Setting	32	163	1	2			*DEG	
Relay 22		4A	16	ASCII Text (16 chars)		42868	42875	G3	R22 Not Used	Setting	32	163	1	2			*DEG	
Relay 23		4A	17	ASCII Text (16 chars)		42876	42883	G3	R23 Not Used	Setting	32	163	1	2			*G	
Relay 24		4A	18	ASCII Text (16 chars)		42884	42891	G3	R24 Not Used	Setting	32	163	1	2			*G	
Relay 25		4A	19	ASCII Text (16 chars)		42892	42899	G3	R25 Not Used	Setting	32	163	1	2			*G	
Relay 26		4A	1A	ASCII Text (16 chars)		42900	42907	G3	R26 Not Used	Setting	32	163	1	2			*G	
Relay 27		4A	1B	ASCII Text (16 chars)		42908	42915	G3	R27 Not Used	Setting	32	163	1	2			*G	
Relay 28		4A	1C	ASCII Text (16 chars)		42916	42923	G3	R28 Not Used	Setting	32	163	1	2			*G	
Relay 29		4A	1D	ASCII Text (16 chars)		42924	42931	G3	R29 Not Used	Setting	32	163	1	2			*G	

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
Relay 30		4A	1E	ASCII Text (16 chars)		42932	42939	G3	R32 Not Used	Setting	32	163	1	2			*G	
GROUP 2 PROTECTION SETTINGS															*	*	*	
Repeat of Group 1 cols/rows		50	00			*43000	44999								*	*	*	
GROUP 3 PROTECTION SETTINGS															*	*	*	
Repeat of Group 1 cols/rows		70	00			*45000	46999								*	*	*	
GROUP 4 PROTECTION SETTINGS																		
Repeat of Group 1 cols/rows		90	00			*47000	48999								*	*	*	
															*	*	*	
(No Header)	N/A	B0	00												*	*	*	Auto-extraction of Fault Records
Select Record		B0	01	Unsigned Integer (16 bits)						Setting	0	65535	1		*	*	*	Unique cyclical fault number(from event)
Faulted Phase		B0	02	Binary Flag (8 bits) Indexed String	G16					Data					*	*	*	
Start Elements 1		B0	03	Binary Flag (32 bits) Indexed String	G84					Data					*	*	*	
Start Elements 2		B0	04	Binary Flag (32 bits) Indexed String	G107					Data					*	*	*	
Trip Elements 1		B0	05	Binary Flag (32 bits) Indexed String	G85					Data					*	*	*	
Trip Elements 2		B0	06	Binary Flag (32 bits) Indexed String	G86					Data					*	*	*	
Fault Alarms		B0	07	Binary Flag (32 bits) Indexed String	G87					Data					*	*	*	
Fault Time		B0	08	IEC870 Date & Time						Data					*	*	*	
Active Group		B0	09	Unsigned Integer (16 bits)						Data					*	*	*	
System Frequency		B0	0A	Courier Number (frequency)						Data					*	*	*	
Fault Duration		B0	0B	Courier Number (time)						Data					*	*	*	
CB Operate Time		B0	0C	Courier Number (time)						Data					*	*	*	
Relay Trip Time		B0	0D	Courier Number (time)						Data					*	*	*	
Fault Location		B0	0E	Courier Number (metres)						Data					*	*	*	
Fault Location		B0	0F	Courier Number (miles)						Data					*	*	*	
Fault Location		B0	10	Courier Number (impedance)						Data					*	*	*	
Fault Location		B0	11	Courier Number (percentage)						Data					*	*	*	
IA		B0	12	Courier Number (current)						Data					*	*	*	
IB		B0	13	Courier Number (current)						Data					*	*	*	
IC		B0	14	Courier Number (current)						Data					*	*	*	
VAB		B0	15	Courier Number (voltage)						Data					*	*	*	
VBC		B0	16	Courier Number (voltage)						Data					*	*	*	
VCA		B0	17	Courier Number (voltage)						Data					*	*	*	
IN Measured		B0	18	Courier Number (current)						Data					*	*	*	
IN Derived		B0	19	Courier Number (current)						Data					*	*	*	
IN Sensitive		B0	1A	Courier Number (current)						Data					*	*	*	
IREF Diff		B0	1B	Courier Number (current)						Data					*	*	*	
IREF Bias		B0	1C	Courier Number (current)						Data					*	*	*	
VAN		B0	1D	Courier Number (voltage)						Data					*	*	*	
VBN		B0	1E	Courier Number (voltage)						Data					*	*	*	
VCN		B0	1F	Courier Number (voltage)						Data					*	*	*	
VN Derived		B0	20	Courier Number (voltage)						Data					*	*	*	
Admittance		B0	21	Courier Number (inverse ohms)						Data					*	*	*	

Courier Text	UI	Courier Col	Courier Row	Data Type	Strings	Modbus Address Start	Modbus Address End	Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model P141	Model P142	Model P143	Comment
Conductance		B0	22	Courier Number (inverse ohms)						Data					*	*	*	
Susceptance		B0	23	Courier Number (inverse ohms)						Data					*	*	*	
Admittance		B0	24	Courier Number (inverse ohms)						Data					*	*	*	
Conductance		B0	25	Courier Number (inverse ohms)						Data					*	*	*	
Susceptance		B0	26	Courier Number (inverse ohms)						Data					*	*	*	
(No Header)	N/A	B1	00												*	*	*	Event Records
Select Record		B1	01	Unsigned Integer (16 bits)						Setting	0	65535	1		*	*	*	
Time and Date		B1	02	IEC870 Date & Time						Data					*	*	*	
Record Text		B1	03	ASCII Text (32 chars)						Data					*	*	*	
Record Type		B1	04	Unsigned Integer (32 bits)						Data					*	*	*	
Record Data		B1	05	Unsigned Integer (32 bits)						Data					*	*	*	
(No Header)	N/A	B2	00												*	*	*	Data Transfer
Domain		B2	04	Indexed String				G57	PSL Settings	Setting	0	1	1	2	*	*	*	
Sub-Domain		B2	08	Indexed String				G90	Group 1	Setting	0	3	1	2	*	*	*	
Version		B2	0C	Unsigned Integer (16 bits)					256	Setting	0	65535	1	2	*	*	*	
Start		B2	10	Not Used											*	*	*	
Length		B2	14	Not Used											*	*	*	
Reference		B2	18	Not Used											*	*	*	
Transfer Mode		B2	1C	Indexed String	G76			G76	6	Setting	0	7	1	2	*	*	*	
Data Transfer		B2	20	Repeated groups of Unsigned Integers						Setting					*	*	*	Only settable if Domain = PSL Settings
(No Header)	N/A	B3	00												*	*	*	Disturbance Recorder Control
UNUSED		B3	01												*	*	*	
Recorder Source		B3	02	Indexed String	0			0	Samples	Data					*	*	*	
Reserved for future use		B3	03-1F												*	*	*	
(No Header)	N/A	B4	00												*	*	*	Disturbance Record Extraction
Select Record Number - n		B4	01	Unsigned Integer					0	Setting	-199	199	1	0	*	*	*	
Trigger Time		B4	02	IEC870 Date & Time						Data					*	*	*	
UNUSED		B4	03												*	*	*	
UNUSED		B4	04												*	*	*	
UNUSED		B4	05												*	*	*	
UNUSED		B4	06												*	*	*	
UNUSED		B4	07												*	*	*	
UNUSED		B4	08												*	*	*	
UNUSED		B4	09												*	*	*	
Compression Format		B4	0A	Unsigned Integer (16 bits)					1	Data					*	*	*	
Upload Compression Record		B4	0B	Unsigned Integer (16 bits)						Data					*	*	*	
UNUSED		B4	0C-0F												*	*	*	
UNUSED		B4	10												*	*	*	
UNUSED		B4	11												*	*	*	
UNUSED		B4	12												*	*	*	
UNUSED		B4	13												*	*	*	
UNUSED		B4	14												*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
UNUSED		B4	15-1F												*	*	*	
UNUSED		B4	20												*	*	*	
UNUSED		B4	21												*	*	*	
UNUSED		B4	22												*	*	*	
UNUSED		B4	23												*	*	*	
UNUSED		B4	24												*	*	*	
UNUSED		B4	25												*	*	*	
UNUSED		B4	26												*	*	*	
UNUSED		B4	27												*	*	*	
UNUSED		B4	28												*	*	*	
UNUSED		B4	29												*	*	*	
						30800		G1		Data								Number of Disturbance Records (0 to 200)
						30801		G1		Data								Oldest Stored Disturb. Record (1 to 65535)
						30802		G1		Data								Number of Registers in Current Page
						30803	30929	G1		Data								Disturbance Recorder Page (0 to 65535)
						40250		G1		Setting	1	65535	1	2				Select Disturbance Record
						30930	30933	G12		Data								Timestamp of selected record
(No Header)	N/A	B5	00															Calibration Coefficients - Hidden
Cal Software Version		B5	01	ASCII Text (16 chars)											*	*	*	
Cal Date and Time		B5	02	IEC870 Date & Time											*	*	*	
Channel Types		B5	03	Repeated Group 16 * Binary Flag 8 bits											*	*	*	
Cal Coeffs		B5	04	Block transfer Repeated Group of UINT32 (4 coeffs voltage channel, 8 coeffs current channel)											*	*	*	
(No Header)	N/A	B6	00												*	*	*	Comms Diagnostics - Hidden
Bus Comms Err Count Front		B6	01	Unsigned Integer (32 bits)											*	*	*	
Bus Message Count Front		B6	02	Unsigned Integer (32 bits)											*	*	*	
Protocol Err Count Front		B6	03	Unsigned Integer (32 bits)											*	*	*	
Busy Count Front		B6	04	Unsigned Integer (32 bits)											*	*	*	
Reset front count		B6	05	(Reset Menu Cell cmd only)											*	*	*	
Bus Comms Err Count Rear		B6	06	Unsigned Integer (32 bits)											*	*	*	
Bus Message Count Rear		B6	07	Unsigned Integer (32 bits)											*	*	*	
Protocol Err Count Rear		B6	08	Unsigned Integer (32 bits)											*	*	*	
Busy Count Rear		B6	09	Unsigned Integer (32 bits)											*	*	*	
Reset rear count		B6	0A	(Reset Menu Cell cmd only)											*	*	*	
PSL DATA		B7	00												*	*	*	
Grp1 PSL Ref		B7	01	ASCII Text (32 chars)		31000	31015	G3		Data					*	*	*	"Model Number" Default PSL
Date/Time		B7	02	IEC870 Date & Time		31016	31019	G12		Data					*	*	*	
Grp1 PSL ID		B7	03	Unsigned Integer (32 bits)		31020	31021	G27		Data					*	*	*	
Grp2 PSL Ref		B7	11	ASCII Text (32 chars)		31022	31037	G3		Data					*	*	*	"Model Number" Default PSL
Date/Time		B7	12	IEC870 Date & Time		31038	31041	G12		Data					*	*	*	
Grp2 PSL ID		B7	13	Unsigned Integer (32 bits)		31042	31043	G27		Data					*	*	*	
Grp3 PSL Ref		B7	21	ASCII Text (32 chars)		31044	31059	G3		Data					*	*	*	"Model Number" Default PSL
Date/Time		B7	22	IEC870 Date & Time		31060	31063	G12		Data					*	*	*	

Courier Text	UI	Courier		Data Type	Strings	Modbus Address		Modbus Database	Default Setting	Cell Type	Min	Max	Step	Password Level	Model			Comment
		Col	Row			Start	End								P141	P142	P143	
Grp3 PSL ID		B7	23	Unsigned Integer (32 bits)		31064	31065	G27		Data					*	*	*	
Grp4 PSL Ref		B7	31	ASCII Text (32 chars)		31066	31081	G3		Data					*	*	*	"Model Number" Default PSL
Date/Time		B7	32	IEC870 Date & Time		31082	31085	G12		Data					*	*	*	
Grp4 PSL ID		B7	33	Unsigned Integer (32 bits)		31086	31087	G27		Data					*	*	*	
COMMS SYS DATA	N/A	BF	00												*	*	*	
Dist Record Cntrl Ref			01	Menu Cell(2)					B300	Data					*	*	*	
Dist Record Extract Ref			02	Menu Cell(2)					B400	Data					*	*	*	
Setting Transfer			03	Unsigned Integer (16 bits)						Setting					*	*	*	
Reset Demand Timers			04	None (Reset Menu Cell)						Data(but supports Reset Menu cell)					*	*	*	
UNUSED			05												*	*	*	
Block Transfer Ref			06	Menu Cell(2)					B200	Data					*	*	*	

Data Types

TYPE	VALUE/BIT MASK	DESCRIPTION		
G1		UNSIGNED INTEGER		
		eg. 5678 stored as 5678		
G2		NUMERIC SETTING		
		See 50300.3110.004		
G3		ASCII TEXT CHARACTERS		
	0x00FF	Second character		
	0xFF00	First character		
G4		PLANT STATUS (1 REGISTER)		
	0x0001	CB1 Open (0 = Off, 1 = On)		
	0x0002	CB1 Closed (0 = Off, 1 = On)		
	0x0004	Not Used (0 = Off, 1 = On)		
	0x0008	Not Used 4 (0 = Off, 1 = On)		
	0x0010	Not Used (0 = Off, 1 = On)		
	0x0020	Not Used (0 = Off, 1 = On)		
	0x0040	Not Used (0 = Off, 1 = On)		
	0x0080	Not Used (0 = Off, 1 = On)		
	0x0100	Not Used (0 = Off, 1 = On)		
	0x0200	Not Used (0 = Off, 1 = On)		
	0x0400	Not Used (0 = Off, 1 = On)		
	0x0800	Not Used (0 = Off, 1 = On)		
	0x1000	Not Used (0 = Off, 1 = On)		
	0x2000	Not Used (0 = Off, 1 = On)		
	0x4000	Not Used (0 = Off, 1 = On)		
	0x8000	Not Used (0 = Off, 1 = On)		
G5		CONTROL STATUS (1 REGISTER)		
	0x0001	Not Used (0 = Off, 1 = On)		
	0x0002	Not Used (0 = Off, 1 = On)		
	0x0004	Not Used (0 = Off, 1 = On)		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x0008	Not Used (0 = Off, 1 = On)		
	0x0010	Not Used (0 = Off, 1 = On)		
	0x0020	Not Used (0 = Off, 1 = On)		
	0x0040	Not Used (0 = Off, 1 = On)		
	0x0080	Not Used (0 = Off, 1 = On)		
	0x0100	Not Used (0 = Off, 1 = On)		
	0x0200	Not Used (0 = Off, 1 = On)		
	0x0400	Not Used (0 = Off, 1 = On)		
	0x0800	Not Used (0 = Off, 1 = On)		
	0x1000	Not Used (0 = Off, 1 = On)		
	0x2000	Not Used (0 = Off, 1 = On)		
	0x4000	Not Used (0 = Off, 1 = On)		
	0x8000	Not Used (0 = Off, 1 = On)		
G6		RECORD CONTROL COMMAND REGISTER		
	0	No Operation		
	1	Clear Event Records		
	2	Clear Fault Record		
	3	Clear Maintenance Records		
	4	Reset Indications		
G7		VTS INDICATE/BLOCK		
	0	Blocking		
	1	Indication		
G8		LOGIC INPUT STATUS		
	(2nd Reg, 1st Reg)	P141	P142	P143
	0x0000,0x0001	Opto 1 Input State (0=Off, 1=On) All	Opto 1 Input State (0=Off, 1=On) All	Opto 1 Input State (0=Off, 1=On) All
	0x0000,0x0002	Opto 2 Input State (0=Off, 1=On) All	Opto 2 Input State (0=Off, 1=On) All	Opto 2 Input State (0=Off, 1=On) All
	0x0000,0x0004	Opto 3 Input State (0=Off, 1=On) All	Opto 3 Input State (0=Off, 1=On) All	Opto 3 Input State (0=Off, 1=On) All
	0x0000,0x0008	Opto 4 Input State (0=Off, 1=On) All	Opto 4 Input State (0=Off, 1=On) All	Opto 4 Input State (0=Off, 1=On) All
	0x0000,0x0010	Opto 5 Input State (0=Off, 1=On) All	Opto 5 Input State (0=Off, 1=On) All	Opto 5 Input State (0=Off, 1=On) All
	0x0000,0x0020	Opto 6 Input State (0=Off, 1=On) All	Opto 6 Input State (0=Off, 1=On) All	Opto 6 Input State (0=Off, 1=On) All
	0x0000,0x0040	Opto 7 Input State (0=Off, 1=On) All	Opto 7 Input State (0=Off, 1=On) All	Opto 7 Input State (0=Off, 1=On) All

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x0000,0x0080	Opto 8 Input State (0=Off, 1=On) All	Opto 8 Input State (0=Off, 1=On) All	Opto 8 Input State (0=Off, 1=On) All
	0x0000,0x0100	Not Used	Opto 9 Input State (0=Off, 1=On) BC	Opto 9 Input State (0=Off, 1=On) All
	0x0000,0x0200	Not Used	Opto 10 Input State (0=Off, 1=On) BC	Opto 10 Input State (0=Off, 1=On) All
	0x0000,0x0400	Not Used	Opto 11 Input State (0=Off, 1=On) BC	Opto 11 Input State (0=Off, 1=On) All
	0x0000,0x0800	Not Used	Opto 12 Input State (0=Off, 1=On) BC	Opto 12 Input State (0=Off, 1=On) All
	0x0000,0x1000	Not Used	Opto 13 Input State (0=Off, 1=On) C	Opto 13 Input State (0=Off, 1=On) All
	0x0000,0x2000	Not Used	Opto 14 Input State (0=Off, 1=On) C	Opto 14 Input State (0=Off, 1=On) All
	0x0000,0x4000	Not Used	Opto 15 Input State (0=Off, 1=On) C	Opto 15 Input State (0=Off, 1=On) All
	0x0000,0x8000	Not Used	Opto 16 Input State (0=Off, 1=On) C	Opto 16 Input State (0=Off, 1=On) All
	0x0001,0x0000	Not Used	Not Used	Opto 17 Input State (0=Off, 1=On) CEF
	0x0002,0x0000	Not Used	Not Used	Opto 18 Input State (0=Off, 1=On) CEF
	0x0004,0x0000	Not Used	Not Used	Opto 19 Input State (0=Off, 1=On) CEF
	0x0008,0x0000	Not Used	Not Used	Opto 20 Input State (0=Off, 1=On) CEF
	0x0010,0x0000	Not Used	Not Used	Opto 21 Input State (0=Off, 1=On) CEF
	0x0020,0x0000	Not Used	Not Used	Opto 22 Input State (0=Off, 1=On) CEF
	0x0040,0x0000	Not Used	Not Used	Opto 23 Input State (0=Off, 1=On) CEF
	0x0080,0x0000	Not Used	Not Used	Opto 24 Input State (0=Off, 1=On) CEF
	0x0100,0x0000	Not Used	Not Used	Opto 25 Input State (0=Off, 1=On) F
	0x0200,0x0000	Not Used	Not Used	Opto 26 Input State (0=Off, 1=On) F
	0x0400,0x0000	Not Used	Not Used	Opto 27 Input State (0=Off, 1=On) F
	0x0800,0x0000	Not Used	Not Used	Opto 28 Input State (0=Off, 1=On) F
	0x1000,0x0000	Not Used	Not Used	Opto 29 Input State (0=Off, 1=On) F
	0x2000,0x0000	Not Used	Not Used	Opto 30 Input State (0=Off, 1=On) F
	0x4000,0x0000	Not Used	Not Used	Opto 31 Input State (0=Off, 1=On) F
	0x8000,0x0000	Not Used	Not Used	Opto 32 Input State (0=Off, 1=On) F
G9		RELAY OUTPUT STATUS		
	(2nd Reg, 1st Reg)	P141	P142	P143
	0x0000,0x0001	Relay 1 (0=Off, 1=On) All	Relay 1 (0=Off, 1=On) All	Relay 1 (0=Off, 1=On) All
	0x0000,0x0002	Relay 2 (0=Off, 1=On) All	Relay 2 (0=Off, 1=On) All	Relay 2 (0=Off, 1=On) All
	0x0000,0x0004	Relay 3 (0=Off, 1=On) All	Relay 3 (0=Off, 1=On) All	Relay 3 (0=Off, 1=On) All
	0x0000,0x0008	Relay 4 (0=Off, 1=On) All	Relay 4 (0=Off, 1=On) All	Relay 4 (0=Off, 1=On) All

TYPE	VALUE/BIT MASK	DESCRIPTION					
	0x0000,0x0010	Relay 5 (0=Off, 1=On)	All	Relay 5 (0=Off, 1=On)	All	Relay 5 (0=Off, 1=On)	All
	0x0000,0x0020	Relay 6 (0=Off, 1=On)	All	Relay 6 (0=Off, 1=On)	All	Relay 6 (0=Off, 1=On)	All
	0x0000,0x0040	Relay 7 (0=Off, 1=On)	All	Relay 7 (0=Off, 1=On)	All	Relay 7 (0=Off, 1=On)	All
	0x0000,0x0080	Not Used		Relay 8 (0=Off, 1=On)	BD	Relay 8 (0=Off, 1=On)	All
	0x0000,0x0100	Not Used		Relay 9 (0=Off, 1=On)	BD	Relay 9 (0=Off, 1=On)	All
	0x0000,0x0200	Not Used		Relay 10 (0=Off, 1=On)	BD	Relay 10 (0=Off, 1=On)	All
	0x0000,0x0400	Not Used		Relay 11 (0=Off, 1=On)	BD	Relay 11 (0=Off, 1=On)	All
	0x0000,0x0800	Not Used		Relay 12 (0=Off, 1=On)	D	Relay 12 (0=Off, 1=On)	All
	0x0000,0x1000	Not Used		Relay 13 (0=Off, 1=On)	D	Relay 13 (0=Off, 1=On)	All
	0x0000,0x2000	Not Used		Relay 14 (0=Off, 1=On)	D	Relay 14 (0=Off, 1=On)	All
	0x0000,0x4000	Not Used		Relay 15 (0=Off, 1=On)	D	Relay 15 (0=Off, 1=On)	DEG
	0x0000,0x8000	Not Used		Not Used		Relay 16 (0=Off, 1=On)	DEG
	0x0001,0x0000	Not Used		Not Used		Relay 17 (0=Off, 1=On)	DEG
	0x0002,0x0000	Not Used		Not Used		Relay 18 (0=Off, 1=On)	DEG
	0x0004,0x0000	Not Used		Not Used		Relay 19 (0=Off, 1=On)	DEG
	0x0008,0x0000	Not Used		Not Used		Relay 20 (0=Off, 1=On)	DEG
	0x0010,0x0000	Not Used		Not Used		Relay 21 (0=Off, 1=On)	DEG
	0x0020,0x0000	Not Used		Not Used		Relay 22 (0=Off, 1=On)	DEG
	0x0040,0x0000	Not Used		Not Used		Relay 23 (0=Off, 1=On)	G
	0x0080,0x0000	Not Used		Not Used		Relay 24 (0=Off, 1=On)	G
	0x0100,0x0000	Not Used		Not Used		Relay 25 (0=Off, 1=On)	G
	0x0200,0x0000	Not Used		Not Used		Relay 26 (0=Off, 1=On)	G
	0x0400,0x0000	Not Used		Not Used		Relay 27 (0=Off, 1=On)	G
	0x0800,0x0000	Not Used		Not Used		Relay 28 (0=Off, 1=On)	G
	0x1000,0x0000	Not Used		Not Used		Relay 29 (0=Off, 1=On)	G
	0x2000,0x0000	Not Used		Not Used		Relay 30 (0=Off, 1=On)	G
	0x4000,0x0000	Not Used		Not Used		Not Used	
	0x8000,0x0000	Not Used		Not Used		Not Used	
G10		SIGNED FIXED POINT NUMBER - 1 DECIMAL PLACE					
		-3276.8 to 3276.7 e.g. display of temperature					

TYPE	VALUE/BIT MASK	DESCRIPTION		
G11		YES/NO		
	0	No		
	1	Yes		
G12		TIME AND DATE (4 REGISTERS - IEC870 FORMAT)		
	0x007F	First register - Years		
	0x0FFF	Second register - Month of year / Day of month / Day of week		
	0x9FBF	Third Register - Summertime and hours / Validity and minutes		
	0xFFFF	Fourth Register - Milli-seconds		
G13		EVENT RECORD TYPE		
	0	Latched alarm active		
	1	Latched alarm inactive		
	2	Self reset alarm active		
	3	Self reset alarm inactive		
	4	Relay event		
	5	Opto event		
	6	Protection event		
	7	Platform event		
	8	Fault logged event		
	9	Maintenance record logged event		
G14		I> FUNCTION LINK		
		P141	P142	P143
	Bit 0	VTS Blocks I>1 (1=Blk; 0=Non-dir)	VTS Blocks I>1 (1=Blk; 0=Non-dir)	VTS Blocks I>1 (1=Blk; 0=Non-dir)
	Bit 1	VTS Blocks I>2 (1=Blk; 0=Non-dir)	VTS Blocks I>2 (1=Blk; 0=Non-dir)	VTS Blocks I>2 (1=Blk; 0=Non-dir)
	Bit 2	VTS Blocks I>3 (1=Blk; 0=Non-dir)	VTS Blocks I>3 (1=Blk; 0=Non-dir)	VTS Blocks I>3 (1=Blk; 0=Non-dir)
	Bit 3	VTS Blocks I>4 (1=Blk; 0=Non-dir)	VTS Blocks I>4 (1=Blk; 0=Non-dir)	VTS Blocks I>4 (1=Blk; 0=Non-dir)
	Bit 4	Not Used	A/R Blocks I>3	A/R Blocks I>3
	Bit 5	Not Used	A/R Blocks I>4	A/R Blocks I>4
	Bit 6	Not Used	Not Used	Not Used
	Bit 7	Not Used	Not Used	Not Used
G15		DISTURBANCE RECORD INDEX STATUS		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0	No Record		
	1	Un-extracted		
	2	Extracted		
G16		FAULTED PHASE		
	0x0001	Start A		
	0x0002	Start B		
	0x0004	Start C		
	0x0008	Start N		
	0x0010	Trip A		
	0x0020	Trip B		
	0x0040	Trip C		
	0x0080	Trip N		
G17		IRIG-B STATUS		
	0	Card not fitted		
	1	Card failed		
	2	Signal Healthy		
	3	No Signal		
G18		RECORD SELECTION COMMAND REGISTER		
	0x0000	No Operation		
	0x0001	Select Next Event		
	0x0002	Accept Event		
	0x0004	Select Next Disturbance Record		
	0x0008	Accept Disturbance Record		
	0x0010	Select Next Disturbance Record Page		
		NOTE THAT THE RELAY SUPPORTS THE COMBINED SETTING 0x0003		
		I.E ACCEPT EVENT AND SELECT NEXT EVENT		
G19		LANGUAGE		
	0	English		
	1	Francais		
	2	Deutsch		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	3	Espanol		
G20	(2nd Reg, 1st Reg)	PASSWORD (2 REGISTERS)		
	0x0000, 0x00FF	First password character		
	0x0000, 0xFF00	Second password character		
	0x00FF, 0x0000	Third password character		
	0xFF00, 0x0000	Fourth password character		
		NOTE THAT WHEN REGISTERS OF THIS TYPE ARE READ THE SLAVE WILL		
		ALWAYS INDICATE AN "*" IN EACH CHARACTER POSITION TO PRESERVE		
		THE PASSWORD SECURITY.		
G21		IEC870 INTERFACE		
	0	RS485		
	1	Fibre Optic		
G22		PASSWORD CONTROL ACCESS LEVEL		
	0	Level 0 - Passwords required for levels 1 & 2.		
	1	Level 1 - Password required for level 2.		
	2	Level 2 - No passwords required.		
G23		VOLTAGE CURVE SELECTION		
	0	Disabled		
	1	DT		
	2	IDMT		
G24	2 REGISTERS	UNSIGNED LONG VALUE, 3 DECIMAL PLACES		
		High order word of long stored in 1st register		
		Low order word of long stored in 2nd register		
		Example 123456.789 stored as 123456789		
G25	1 REGISTER	UNSIGNED VALUE, 3 DECIMAL PLACES		
		Example 50.050 stored as 50050		
G26		RELAY STATUS		
	0x0001	Out Of Service (0=Out; 1=In Service)		
	0x0002	Minor Self Test Failure		
	0x0004	Event		
	0x0008	Time Synchronisation		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x0010	Disturbance		
	0x0020	Fault		
	0x0040	Unused		
	0x0080	Unused		
	0x0100	Unused		
	0x0200	Unused		
	0x0400	Unused		
	0x0800	Unused		
	0x1000	Unused		
	0x2000	Unused		
	0x4000	Unused		
	0x8000	Unused		
G27	2 REGISTERS	UNSIGNED LONG VALUE		
		High order word of long stored in 1st register		
		Low order word of long stored in 2nd register		
		Example 123456 stored as 123456		
G28	1 REGISTER	SIGNED VALUE POWER & WATT-HOURS		
		Power = (Secondary power/CT secondary) * (110/VT secondary)		
G29	3 REGISTER	POWER MULTIPLIER		
		All power measurments use a signed value of type G28 and a		
		2 register unsigned long multiplier of type G27		
		Value = Real Value*110/(CTsecondary*VTsecondary)		
		For Primary Power Multipler = CTprimary * VTprimary/110		
		For Secondary Power Multipler = CTsecondary * VTsecondary/110		
G30	1 REGISTER	SIGNED VALUE, 2 DECIMAL PLACES		
G31		ANALOGUE CHANNEL ASSIGNMENT SELECTION		
		P141	P142	P143
	0	VA	VA	VA
	1	VB	VB	VB

TYPE	VALUE/BIT MASK	DESCRIPTION		
	2	VC	VC	VC
	3	IA	IA	V Checksync
	4	IB	IB	IA
	5	IC	IC	IB
	6	IN	IN	IC
	7	IN Sensitive	IN Sensitive	IN
	8	Not Used	Not Used	IN Sensitive
G32		DISTURBANCE RECORDER DIGITAL CHANNEL ASSIGNMENT		
		P141	P142	P143
	0	Unused	Unused	Unused
	1	R1 IN/ISEF>Start	R1 IN/ISEF>Start	R1 IN/ISEF>Start
	2	R2 I>Start	R2 I>Start	R2 I>Start
	3	R3 Prot'n Trip	R3 Prot'n Trip	R3 Prot'n Trip
	4	R4 General Alarm	R4 General Alarm	R4 General Alarm
	5	R5 CB Fail Tmr 1	R5 CB Fail Tmr 1	R5 CB Fail Tmr 1
	6	R6 Cntl CB Close	R6 Cntl CB Close	R6 Cntl CB Close
	7	R7 Cntl CB Trip	R7 Cntl CB Trip	R7 Cntl CB Trip
	8	L1 Setting Group	R8 Not Used BD	R8 Any Start
	9	L2 Setting Group	R9 Not Used BD	R9 AR Successful
	10	L3 Block IN1>3&4	R10 Not Used BD	R10 Non Auto
	11	L4 Block I>3&4	R11 Not Used BD	R11 AR In Prog
	12	L5 Rst LEDs/Lckt	R12 Not Used D	R12 AR Lockout
	13	L6 External Trip	R13 Not Used D	R13 AR InService
	14	L7 52-A	R14 Not Used D	R14 Live Line
	15	L8 52-B	R15 Not Used D	R15 Not Used DEG
	16	LED 1	L1 Setting Group	R16 Not Used DEG
	17	LED 2	L2 Setting Group	R17 Not Used DEG
	18	LED 3	L3 Block IN1>3&4	R18 Not Used DEG
	19	LED 4	L4 Block I>3&4	R19 Not Used DEG
	20	LED 5	L5 Rst LEDs/Lckt	R20 Not Used DEG
	21	LED 6	L6 External Trip	R21 Not Used DEG

TYPE	VALUE/BIT MASK	DESCRIPTION		
	22	LED 7	L7 CB Healthy	R22 Not Used DEG
	23	LED 8	L8 52-B	R23 Not Used G
	24	SG-opto Invalid	L9 Not Used BC	R24 Not Used G
	25	Prot'n Disabled	L10 Not Used BC	R25 Not Used G
	26	F out of Range	L11 Not Used BC	R26 Not Used G
	27	VT Fail Alarm	L12 Not Used BC	R27 Not Used G
	28	CT Fail Alarm	L13 Not Used C	R28 Not Used G
	29	CB Fail Alarm	L14 Not Used C	R29 Not Used G
	30	I^ Maint Alarm	L15 Not Used C	R30 Not Used G
	31	I^ Lockout Alarm	L16 Not Used C	L1 Setting group
	32	CB Ops Maint	LED 1	L2 Setting group
	33	CB Ops Lockout	LED 2	L3 Block IN1>3&4
	34	CB Op Time Maint	LED 3	L4 Block I>3&4
	35	CB Op Time Lock	LED 4	L5 Reset LEDs
	36	Fault Freq Lock	LED 5	L6 External Trip
	37	CB Status Alarm	LED 6	L7 52-A
	38	Man CB Trip Fail	LED 7	L8 52-B
	39	Man CB Cls Fail	LED 8	L9 Select Auto
	40	Man CB Unhealthy	SG-opto Invalid	L10 Sel Telecntl
	41	SR User Alarm 1	Prot'n Disabled	L11 Sel LiveLine
	42	SR User Alarm 2	F out of Range	L12 CB Healthy
	43	SR User Alarm 3	VT Fail Alarm	L13 Block AR
	44	SR User Alarm 4	CT Fail Alarm	L14 Reset Lckout
	45	SR User Alarm 5	CB Fail Alarm	L15 Not Used
	46	SR User Alarm 6	I^ Maint Alarm	L16 Not Used
	47	SR User Alarm 7	I^ Lockout Alarm	L17 Not Used CEF
	48	SR User Alarm 8	CB Ops Maint	L18 Not Used CEF
	49	SR User Alarm 9	CB Ops Lockout	L19 Not Used CEF
	50	SR User Alarm 10	CB Op Time Maint	L20 Not Used CEF
	51	SR User Alarm 11	CB Op Time Lock	L21 Not Used CEF
	52	SR User Alarm 12	Fault Freq Lock	L22 Not Used CEF

TYPE	VALUE/BIT MASK	DESCRIPTION			
	53	SR User Alarm 13	CB Status Alarm	L23 Not Used	CEF
	54	SR User Alarm 14	Man CB Trip Fail	L24 Not Used	CEF
	55	SR User Alarm 15	Man CB Cls Fail	L25 Not Used	F
	56	SR User Alarm 16	Man CB Unhealthy	L26 Not Used	F
	57	SR User Alarm 17	AR Lockout	L27 Not Used	F
	58	SR User Alarm 18	AR CB Unhealthy	L28 Not Used	F
	59	MR User Alarm 19	AR No Sys Check	L29 Not Used	F
	60	MR User Alarm 20	SR User Alarm 1	L30 Not Used	F
	61	MR User Alarm 21	SR User Alarm 2	L31 Not Used	F
	62	MR User Alarm 22	SR User Alarm 3	L32 Not Used	F
	63	MR User Alarm 23	SR User Alarm 4	LED 1	
	64	MR User Alarm 24	SR User Alarm 5	LED 2	
	65	MR User Alarm 25	SR User Alarm 6	LED 3	
	66	MR User Alarm 26	SR User Alarm 7	LED 4	
	67	MR User Alarm 27	SR User Alarm 8	LED 5	
	68	MR User Alarm 28	SR User Alarm 9	LED 6	
	69	MR User Alarm 29	SR User Alarm 10	LED 7	
	70	MR User Alarm 30	SR User Alarm 11	LED 8	
	71	MR User Alarm 31	SR User Alarm 12	SG-opto Invalid	
	72	MR User Alarm 32	SR User Alarm 13	Prot'n Disabled	
	73	MR User Alarm 33	SR User Alarm 14	F out of Range	
	74	MR User Alarm 34	SR User Alarm 15	VT Fail Alarm	
	75	MR User Alarm 35	SR User Alarm 16	CT Fail Alarm	
	76	MR User Alarm 36	SR User Alarm 17	CB Fail Alarm	
	77	I>1 Trip	SR User Alarm 18	I^ Maint Alarm	
	78	I>1 Trip A	MR User Alarm 19	I^ Lockout Alarm	
	79	I>1 Trip B	MR User Alarm 20	CB Ops Maint	
	80	I>1 Trip C	MR User Alarm 21	CB Ops Lockout	
	81	I>2 Trip	MR User Alarm 22	CB Op Time Maint	
	82	I>2 Trip A	MR User Alarm 23	CB Op Time Lock	
	83	I>2 Trip B	MR User Alarm 24	Fault Freq Lock	

TYPE	VALUE/BIT MASK	DESCRIPTION		
	84	I>2 Trip C	MR User Alarm 25	CB Status Alarm
	85	I>3 Trip	MR User Alarm 26	Man CB Trip Fail
	86	I>3 Trip A	MR User Alarm 27	Man CB Cls Fail
	87	I>3 Trip B	MR User Alarm 28	Man CB Unhealthy
	88	I>3 Trip C	MR User Alarm 29	Man No Checksync
	89	I>4 Trip	MR User Alarm 30	AR Lockout
	90	I>4 Trip A	MR User Alarm 31	AR CB Unhealthy
	91	I>4 Trip B	MR User Alarm 32	AR No Sys Check
	92	I>4 Trip C	MR User Alarm 33	System Split
	93	I2> Trip	MR User Alarm 34	SR User Alarm 1
	94	Broken Line Trip	MR User Alarm 35	SR User Alarm 2
	95	IN1>1 Trip	MR User Alarm 36	SR User Alarm 3
	96	IN1>2 Trip	I>1 Trip	SR User Alarm 4
	97	IN1>3 Trip	I>1 Trip A	SR User Alarm 5
	98	IN1>4 Trip	I>1 Trip B	SR User Alarm 6
	99	IN2>1 Trip	I>1 Trip C	SR User Alarm 7
	100	IN2>2 Trip	I>2 Trip	SR User Alarm 8
	101	IN2>3 Trip	I>2 Trip A	SR User Alarm 9
	102	IN2>4 Trip	I>2 Trip B	SR User Alarm 10
	103	ISEF>1 Trip	I>2 Trip C	SR User Alarm 11
	104	ISEF>2 Trip	I>3 Trip	SR User Alarm 12
	105	ISEF>3 Trip	I>3 Trip A	SR User Alarm 13
	106	ISEF>4 Trip	I>3 Trip B	SR User Alarm 14
	107	IREF> Trip	I>3 Trip C	SR User Alarm 15
	108	VN>1 Trip	I>4 Trip	SR User Alarm 16
	109	VN>2 Trip	I>4 Trip A	SR User Alarm 17
	110	Thermal Trip	I>4 Trip B	SR User Alarm 18
	111	V2> Trip	I>4 Trip C	MR User Alarm 19
	112	V<1 Trip	I2> Trip	MR User Alarm 20
	113	V<1 Trip A/AB	Broken Line Trip	MR User Alarm 21
	114	V<1 Trip B/BC	IN1>1 Trip	MR User Alarm 22

TYPE	VALUE/BIT MASK	DESCRIPTION		
	115	V<1 Trip C/CA	IN1>2 Trip	MR User Alarm 23
	116	V<2 Trip	IN1>3 Trip	MR User Alarm 24
	117	V<2 Trip A/AB	IN1>4 Trip	MR User Alarm 25
	118	V<2 Trip B/BC	IN2>1 Trip	MR User Alarm 26
	119	V<2 Trip C/CA	IN2>2 Trip	MR User Alarm 27
	120	V>1 Trip	IN2>3 Trip	MR User Alarm 28
	121	V>1 Trip A/AB	IN2>4 Trip	MR User Alarm 29
	122	V>1 Trip B/BC	ISEF>1 Trip	MR User Alarm 30
	123	V>1 Trip C/CA	ISEF>2 Trip	MR User Alarm 31
	124	V>2 Trip	ISEF>3 Trip	MR User Alarm 32
	125	V>2 Trip A/AB	ISEF>4 Trip	MR User Alarm 33
	126	V>2 Trip B/BC	IREF> Trip	MR User Alarm 34
	127	V>2 Trip C/CA	VN>1 Trip	MR User Alarm 35
	128	Any Start	VN>2 Trip	MR User Alarm 36
	129	I>1 Start	Thermal Trip	I>1 Trip
	130	I>1 Start A	V2> Trip	I>1 Trip A
	131	I>1 Start B	V<1 Trip	I>1 Trip B
	132	I>1 Start C	V<1 Trip A/AB	I>1 Trip C
	133	I>2 Start	V<1 Trip B/BC	I>2 Trip
	134	I>2 Start A	V<1 Trip C/CA	I>2 Trip A
	135	I>2 Start B	V<2 Trip	I>2 Trip B
	136	I>2 Start C	V<2 Trip A/AB	I>2 Trip C
	137	I>3 Start	V<2 Trip B/BC	I>3 Trip
	138	I>3 Start A	V<2 Trip C/CA	I>3 Trip A
	139	I>3 Start B	V>1 Trip	I>3 Trip B
	140	I>3 Start C	V>1 Trip A/AB	I>3 Trip C
	141	I>4 Start	V>1 Trip B/BC	I>4 Trip
	142	I>4 Start A	V>1 Trip C/CA	I>4 Trip A
	143	I>4 Start B	V>2 Trip	I>4 Trip B
	144	I>4 Start C	V>2 Trip A/AB	I>4 Trip C
	145	VCO Start AB	V>2 Trip B/BC	I2> Trip

TYPE	VALUE/BIT MASK	DESCRIPTION		
	146	VCO Start BC	V>2 Trip C/CA	Broken Line Trip
	147	VCO Start CA	Any Start	IN1>1 Trip
	148	I2> Start	I>1 Start	IN1>2 Trip
	149	IN1>1 Start	I>1 Start A	IN1>3 Trip
	150	IN1>2 Start	I>1 Start B	IN1>4 Trip
	151	IN1>3 Start	I>1 Start C	IN2>1 Trip
	152	IN1>4 Start	I>2 Start	IN2>2 Trip
	153	IN2>1 Start	I>2 Start A	IN2>3 Trip
	154	IN2>2 Start	I>2 Start B	IN2>4 Trip
	155	IN2>3 Start	I>2 Start C	ISEF>1 Trip
	156	IN2>4 Start	I>3 Start	ISEF>2 Trip
	157	ISEF>1 Start	I>3 Start A	ISEF>3 Trip
	158	ISEF>2 Start	I>3 Start B	ISEF>4 Trip
	159	ISEF>3 Start	I>3 Start C	IREF> Trip
	160	ISEF>4 Start	I>4 Start	VN>1 Trip
	161	VN>1 Start	I>4 Start A	VN>2 Trip
	162	VN>2 Start	I>4 Start B	Thermal Trip
	163	Thermal Alarm	I>4 Start C	V2> Trip
	164	V2> Start	VCO Start AB	V<1 Trip
	165	V<1 Start	VCO Start BC	V<1 Trip A/AB
	166	V<1 Start A/AB	VCO Start CA	V<1 Trip B/BC
	167	V<1 Start B/BC	I2> Start	V<1 Trip C/CA
	168	V<1 Start C/CA	IN1>1 Start	V<2 Trip
	169	V<2 Start	IN1>2 Start	V<2 Trip A/AB
	170	V<2 Start A/AB	IN1>3 Start	V<2 Trip B/BC
	171	V<2 Start B/BC	IN1>4 Start	V<2 Trip C/CA
	172	V<2 Start C/CA	IN2>1 Start	V>1 Trip
	173	V>1 Start	IN2>2 Start	V>1 Trip A/AB
	174	V>1 Start A/AB	IN2>3 Start	V>1 Trip B/BC
	175	V>1 Start B/BC	IN2>4 Start	V>1 Trip C/CA
	176	V>1 Start C/CA	ISEF>1 Start	V>2 Trip

TYPE	VALUE/BIT MASK	DESCRIPTION		
	177	V>2 Start	ISEF>2 Start	V>2 Trip A/AB
	178	V>2 Start A/AB	ISEF>3 Start	V>2 Trip B/BC
	179	V>2 Start B/BC	ISEF>4 Start	V>2 Trip C/CA
	180	V>2 Start C/CA	VN>1 Start	Any Start
	181	CLP Operation	VN>2 Start	I>1 Start
	182	I> BlockStart	Thermal Alarm	I>1 Start A
	183	IN/ISEF>Blk Start	V2> Start	I>1 Start B
	184	VTS Fast Block	V<1 Start	I>1 Start C
	185	VTS Slow Block	V<1 Start A/AB	I>2 Start
	186	CTS Block	V<1 Start B/BC	I>2 Start A
	187	Bfail1 Trip 3ph	V<1 Start C/CA	I>2 Start B
	188	Bfail2 Trip 3ph	V<2 Start	I>2 Start C
	189	Control Trip	V<2 Start A/AB	I>3 Start
	190	Control Close	V<2 Start B/BC	I>3 Start A
	191	Close in Prog	V<2 Start C/CA	I>3 Start B
	192	IA< Start	V>1 Start	I>3 Start C
	193	IB< Start	V>1 Start A/AB	I>4 Start
	194	IC< Start	V>1 Start B/BC	I>4 Start A
	195	IN< Start	V>1 Start C/CA	I>4 Start B
	196	ISEF< Start	V>2 Start	I>4 Start C
	197	CB Open 3 ph	V>2 Start A/AB	VCO Start AB
	198	CB Closed 3 ph	V>2 Start B/BC	VCO Start BC
	199	All Poles Dead	V>2 Start C/CA	VCO Start CA
	200	Any Pole Dead	CLP Operation	I2> Start
	201	Lockout Alarm	I> BlockStart	IN1>1 Start
	202	Field volts fail	IN/ISEF>Blk Start	IN1>2 Start
	203	F<1 Start	VTS Fast Block	IN1>3 Start
	204	F<2 Start	VTS Slow Block	IN1>4 Start
	205	F<3 Start	CTS Block	IN2>1 Start
	206	F<4 Start	Bfail1 Trip 3ph	IN2>2 Start
	207	F>1 Start	Bfail2 Trip 3ph	IN2>3 Start

TYPE	VALUE/BIT MASK	DESCRIPTION		
	208	F>2 Start	Control Trip	IN2>4 Start
	209	F<1 Trip	Control Close	ISEF>1 Start
	210	F<2 Trip	Close in Prog	ISEF>2 Start
	211	F<3 Trip	Block Main Prot	ISEF>3 Start
	212	F<4 Trip	Block SEF Prot	ISEF>4 Start
	213	F>1 Trip	AR In Progress	VN>1 Start
	214	F>2 Trip	AR In Service	VN>2 Start
	215	YN> Start	Seq Counter = 0	Thermal Alarm
	216	GN> Start	Seq Counter = 1	V2> Start
	217	BN> Start	Seq Counter = 2	V<1 Start
	218	YN> Trip	Seq Counter = 3	V<1 Start A/AB
	219	GN>Trip	Seq Counter = 4	V<1 Start B/BC
	220	BN> Trip	Successful Close	V<1 Start C/CA
	221		Dead T in Prog	V<2 Start
	222		Auto Close	V<2 Start A/AB
	223		AR Trip Test	V<2 Start B/BC
	224		IA< Start	V<2 Start C/CA
	225		IB< Start	V>1 Start
	226		IC< Start	V>1 Start A/AB
	227		IN< Start	V>1 Start B/BC
	228		ISEF< Start	V>1 Start C/CA
	229		CB Open 3 ph	V>2 Start
	230		CB Closed 3 ph	V>2 Start A/AB
	231		All Poles Dead	V>2 Start B/BC
	232		Any Pole Dead	V>2 Start C/CA
	233		Lockout Alarm	CLP Operation
	234		Field volts fail	I> BlockStart
	235		F<1 Start	IN/ISEF>Blk Start
	236		F<2 Start	VTS Fast Block
	237		F<3 Start	VTS Slow Block
	238		F<4 Start	CTS Block

TYPE	VALUE/BIT MASK	DESCRIPTION		
	239		F>1 Start	Bfail1 Trip 3ph
	240		F>2 Start	Bfail2 Trip 3ph
	241		F<1 Trip	Control Trip
	242		F<2 Trip	Control Close
	243		F<3 Trip	Close in Prog
	244		F<4 Trip	Block Main Prot
	245		F>1 Trip	Block SEF Prot
	246		F>2 Trip	AR In Progress
	247		YN> Start	AR In Service
	248		GN> Start	Seq Counter = 0
	249		BN> Start	Seq Counter = 1
	250		YN> Trip	Seq Counter = 2
	251		GN>Trip	Seq Counter = 3
	252		BN> Trip	Seq Counter = 4
	253			Successful Close
	254			Dead T in Prog
	255			Auto Close
	256			A/R Trip Test
	257			IA< Start
	258			IB< Start
	259			IC< Start
	260			IN< Start
	261			ISEF< Start
	262			CB Open 3 ph
	263			CB Closed 3 ph
	264			All Poles Dead
	265			Any Pole Dead
	266			Man Check Synch
	267			A/R Check Synch
	268			Lockout Alarm
	269			Field volts fail

TYPE	VALUE/BIT MASK	DESCRIPTION		
	270			F<1 Start
	271			F<2 Start
	272			F<3 Start
	273			F<4 Start
	274			F>1 Start
	275			F>2 Start
	276			F<1 Trip
	277			F<2 Trip
	278			F<3 Trip
	279			F<4 Trip
	280			F>1 Trip
	281			F>2 Trip
	282			YN> Start
	283			GN> Start
	284			BN> Start
	285			YN> Trip
	286			GN> Trip
	287			BN> Trip
G33		DISTURBANCE RECORDER TRIGGERING (2 REGISTERS, 32 BINARY FLAGS)		
	(2nd Reg, 1st Reg)			
	0x0000,0x0001	Digital Channel 1 Bit 0 (0 = No Trigger, 1= Trigger)		
	0x0000,0x0002	Digital Channel 1 Bit 1 (0 = No Trigger, 1= Trigger)		
	0x0000,0x0004	Digital Channel 1 Bit 2 (0 = No Trigger, 1= Trigger)		
	0x0000,0x0008	Digital Channel 1 Bit 3 (0 = No Trigger, 1= Trigger)		
	0x0000,0x0010	Digital Channel 1 Bit 4 (0 = No Trigger, 1= Trigger)		
	0x0000,0x0020	Digital Channel 1 Bit 5 (0 = No Trigger, 1= Trigger)		
	0x0000,0x0040	Digital Channel 1 Bit 6 (0 = No Trigger, 1= Trigger)		
	0x0000,0x0080	Digital Channel 1 Bit 7 (0 = No Trigger, 1= Trigger)		
	0x0000,0x0100	Digital Channel 1 Bit 8 (0 = No Trigger, 1= Trigger)		
	0x0000,0x0200	Digital Channel 1 Bit 9 (0 = No Trigger, 1= Trigger)		
	0x0000,0x0400	Digital Channel 1 Bit 10 (0 = No Trigger, 1= Trigger)		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x0000,0x0800	Digital Channel 1 Bit 11 (0 = No Trigger, 1= Trigger)		
	0x0000,0x1000	Digital Channel 1 Bit 12 (0 = No Trigger, 1= Trigger)		
	0x0000,0x2000	Digital Channel 1 Bit 13 (0 = No Trigger, 1= Trigger)		
	0x0000,0x4000	Digital Channel 1 Bit 14 (0 = No Trigger, 1= Trigger)		
	0x0000,0x8000	Digital Channel 1 Bit 15 (0 = No Trigger, 1= Trigger)		
	0x0001,0x0000	Digital Channel 2 Bit 0 (0 = No Trigger, 1= Trigger)		
	0x0002,0x0000	Digital Channel 2 Bit 1 (0 = No Trigger, 1= Trigger)		
	0x0004,0x0000	Digital Channel 2 Bit 2 (0 = No Trigger, 1= Trigger)		
	0x0008,0x0000	Digital Channel 2 Bit 3 (0 = No Trigger, 1= Trigger)		
	0x0010,0x0000	Digital Channel 2 Bit 4 (0 = No Trigger, 1= Trigger)		
	0x0020,0x0000	Digital Channel 2 Bit 5 (0 = No Trigger, 1= Trigger)		
	0x0040,0x0000	Digital Channel 2 Bit 6 (0 = No Trigger, 1= Trigger)		
	0x0080,0x0000	Digital Channel 2 Bit 7 (0 = No Trigger, 1= Trigger)		
	0x0100,0x0000	Digital Channel 2 Bit 8 (0 = No Trigger, 1= Trigger)		
	0x0200,0x0000	Digital Channel 2 Bit 9 (0 = No Trigger, 1= Trigger)		
	0x0400,0x0000	Digital Channel 2 Bit 10 (0 = No Trigger, 1= Trigger)		
	0x0800,0x0000	Digital Channel 2 Bit 11 (0 = No Trigger, 1= Trigger)		
	0x1000,0x0000	Digital Channel 2 Bit 12 (0 = No Trigger, 1= Trigger)		
	0x2000,0x0000	Digital Channel 2 Bit 13 (0 = No Trigger, 1= Trigger)		
	0x4000,0x0000	Digital Channel 2 Bit 14 (0 = No Trigger, 1= Trigger)		
	0x8000,0x0000	Digital Channel 2 Bit 15 (0 = No Trigger, 1= Trigger)		
G34		DISTURBANCE RECORDER TRIGGER MODE		
	0	Single		
	1	Extended		
G35		NUMERIC SETTING (AS G2 BUT 2 REGISTERS)		
		Number of steps from minimum value		
		expressed as 2 register 32 bit unsigned int		
G36		AUTORECLOSE TEST		
	0	No Operation		
	1	3 Pole Test		
G37		ENABLED / DISABLED		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0	Disabled		
	1	Enabled		
G38m		COMMUNICATION BAUD RATE (MODBUS)		
	0	9600 bits/s		
	1	19200 bits/s		
	2	38400 bits/s		
G38v		COMMUNICATION BAUD RATE (IEC60870)		
	0	9600 bits/s		
	1	19200 bits/s		
G38d		COMMUNICATION BAUD RATE (DNP 3.0)		
	0	1200 bits/s		
	1	2400 bits/s		
	2	4800 bits/s		
	3	9600 bits/s		
	4	19200 bits/s		
	5	38400 bits/s		
G39		COMMUNICATIONS PARITY		
	0	Odd		
	1	Even		
	2	None		
G40		CHECK SYNC INPUT SELECTION		
	0	A-N		
	1	B-N		
	2	C-N		
	3	A-B		
	4	B-C		
	5	C-A		
G41		CHECK SYNC VOLTAGE BLOCKING		
	0	None		
	1	V<		
	2	V>		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	3	Vdiff>		
	4	V< and V>		
	5	V< and Vdiff>		
	6	V> and Vdiff>		
	7	V<, V> and Vdiff>		
G42		CHECK SYNC SLIP CONTROL		
	0	None		
	1	Timer		
	2	Frequency		
	3	Both		
G43		IDMT CURVE TYPE		
	0	Disabled		
	1	DT		
	2	IEC S Inverse		
	3	IEC V Inverse		
	4	IEC E Inverse		
	5	UK LT Inverse		
	6	IEEE M Inverse		
	7	IEEE V Inverse		
	8	IEEE E Inverse		
	9	US Inverse		
	10	US ST Inverse		
G44		DIRECTION		
	0	Non-Directional		
	1	Directional Fwd		
	2	Directional Rev		
G45		VTS BLOCK		
	0	Block		
	1	Non-Directional		
G46		POLARISATION		
	0	Zero Sequence		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	1	Neg Sequence		
G47		MEASURING MODE		
	0	Phase-Phase		
	1	Phase-Neutral		
G48		OPERATION MODE		
	0	Any Phase		
	1	Three Phase		
G49		VN or IN INPUT		
	0	Measured		
	1	Derived		
G50		RTD SELECT		
	0x0001	RTD Input #1		
	0x0002	RTD Input #2		
	0x0004	RTD Input #3		
	0x0008	RTD Input #4		
	0x0010	RTD Input #5		
	0x0020	RTD Input #6		
	0x0040	RTD Input #7		
	0x0080	RTD Input #8		
	0x0100	RTD Input #9		
	0x0200	RTD Input #10		
G51		FAULT LOCATION		
	0	Distance		
	1	Ohms		
	2	% of Line		
G52		DEFAULT DISPLAY		
	0	3Ph + N Current		
	1	3Ph Voltage		
	2	Power		
	3	Date and Time		
	4	Description		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	5	Plant Reference		
	6	Frequency		
	7	Access Level		
G53		SELECT FACTORY DEFAULTS		
	0	No Operation		
	1	All Settings		
	2	Setting Group 1		
	3	Setting Group 2		
	4	Setting Group 3		
	5	Setting Group 4		
G54		SELECT PRIMARY SECONDARY MEASUREMENTS		
	0	Primary		
	1	Secondary		
G55		CIRCUIT BREAKER CONTROL		
	0	No Operation		
	1	Trip		
	2	Close		
G56		PHASE MEASUREMENT REFERENCE		
	0	VA		
	1	VB		
	2	VC		
	3	IA		
	4	IB		
	5	IC		
G57		DATA TRANSFER DOMAIN		
	0	PSL Settings		
	1	PSL Configuration		
G58		SEF/REF SELECTION		
	0	SEF		
	1	SEF cos(PHI)		
	2	SEF sin(PHI)		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	3	Wattmetric		
	4	Hi Z REF		
	5	Lo Z REF		
	6	Lo Z REF+SEF		
	7	Lo Z REF+Wattmet		
G59		BATTERY STATUS		
	0	Dead		
	1	Healthy		
G60		IDMT CURVE TYPE		
	0	DT		
	1	Inverse		
G61		ACTIVE GROUP CONTROL		
	0	Select via Menu		
	1	Select via Opto		
G62		SAVE AS		
	0	No Operation		
	1	Save		
	2	Abort		
G63		IN> FUNCTION LINK		
		P141	P142	P143
	Bit 0	VTS Blocks IN>1 (1=Blk; 0=Non-dir)	VTS Blocks IN>1 (1=Blk; 0=Non-dir)	VTS Blocks IN>1 (1=Blk; 0=Non-dir)
	Bit 1	VTS Blocks IN>2 (1=Blk; 0=Non-dir)	VTS Blocks IN>2 (1=Blk; 0=Non-dir)	VTS Blocks IN>2 (1=Blk; 0=Non-dir)
	Bit 2	VTS Blocks IN>3 (1=Blk; 0=Non-dir)	VTS Blocks IN>3 (1=Blk; 0=Non-dir)	VTS Blocks IN>3 (1=Blk; 0=Non-dir)
	Bit 3	VTS Blocks IN>4 (1=Blk; 0=Non-dir)	VTS Blocks IN>4 (1=Blk; 0=Non-dir)	VTS Blocks IN>4 (1=Blk; 0=Non-dir)
	Bit 4	Not Used	A/R Blocks IN>3	A/R Blocks IN>3
	Bit 5	Not Used	A/R Blocks IN>4	A/R Blocks IN>4
	Bit 6	Not Used	Not Used	Not Used
	Bit 7	Not Used	Not Used	Not Used
G64		ISEF> FUNCTION LINK		
		P141	P142	P143
	Bit 0	VTS Blocks ISEF>1 (1=Blk; 0=Non-dir)	VTS Blocks ISEF>1 (1=Blk; 0=Non-dir)	VTS Blocks ISEF>1 (1=Blk; 0=Non-dir)

TYPE	VALUE/BIT MASK	DESCRIPTION		
	Bit 1	VTS Blocks ISEF>2 (1=Blk; 0=Non-dir)	VTS Blocks ISEF>2 (1=Blk; 0=Non-dir)	VTS Blocks ISEF>2 (1=Blk; 0=Non-dir)
	Bit 2	VTS Blocks ISEF>3 (1=Blk; 0=Non-dir)	VTS Blocks ISEF>3 (1=Blk; 0=Non-dir)	VTS Blocks ISEF>3 (1=Blk; 0=Non-dir)
	Bit 3	VTS Blocks ISEF>4 (1=Blk; 0=Non-dir)	VTS Blocks ISEF>4 (1=Blk; 0=Non-dir)	VTS Blocks ISEF>4 (1=Blk; 0=Non-dir)
	Bit 4	Not Used	A/R Blocks ISEF>3	A/R Blocks ISEF>3
	Bit 5	Not Used	A/R Blocks ISEF>4	A/R Blocks ISEF>4
	Bit 6	Not Used	Not Used	Not Used
	Bit 7	Not Used	Not Used	Not Used
G65		F< FUNCTION LINK		
	Bit 0	F<1 Poledead Blk		
	Bit 1	F<2 Poledead Blk		
	Bit 2	F<3 Poledead Blk		
	Bit 3	F<4 Poledead Blk		
	Bit 4	Not Used		
	Bit 5	Not Used		
	Bit 6	Not Used		
	Bit 7	Not Used		
G66		MESSAGE FORMAT		
	0	No Trigger		
	1	Trigger L/H		
	2	Trigger H/L		
G67		THERMAL OVERLOAD CHARACTERISTICS		
	0	Disabled		
	1	Single		
	2	Dual		
G68		CB FAIL RESET OPTIONS		
	0	I< Only		
	1	CB Open & I<		
	2	Prot Reset & I<		
G69		VTS RESET MODE		
	0	Manual		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	1	Auto		
G70		AUTORECLOSE MODE		
	0	Command Mode		
	1	Opto Set Mode		
	2	User Set Mode		
	3	Pulse Set Mode		
G71		PROTOCOL		
	0	Courier		
	1	IEC870-5-103		
	2	Modbus		
	3	DNP 3.0		
G72		START DEAD TIME		
	0	Protection Reset		
	1	CB Trips		
G73		AUTORECLOSE RECLAIM TIME EXTENSION		
	0	On Prot Start		
	1	No Operation		
G74		RESET LOCKOUT		
	0	User Interface		
	1	Select NonAuto		
G75		AUTORECLOSE AFTER MANUAL CLOSE		
	0	Enabled		
	1	Inhibited		
G76		TRANSFER MODE		
	0	Prepare Rx		
	1	Complete Rx		
	2	Prepare Tx		
	3	Complete Tx		
	4	Rx Prepared		
	5	Tx Prepared		
	6	OK		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	7	Error		
G77		AUTORECLOSE IN SERVICE		
	0	Out of Service		
	1	In Service		
G78		AUTORECLOSE TELECEONTROL COMMANDS		
	0	No Operation		
	1	Auto		
	2	Non-auto		
G79		CUSTOM SETTINGS		
	0	Disabled		
	1	Basic		
	2	Complete		
G80		VISIBILITY		
	0	Invisible		
	1	Visible		
G81		RESET LOCKOUT OPTIONS		
	0	User Interface		
	1	CB Close		
G82		AUTORECLOSE PROTECTION BLOCKING OPTIONS		
	0	No Block		
	1	Block Inst Prot		
G83		AUTORECLOSE STATUS		
	0	Auto Mode		
	1	Non-auto Mode		
	2	Live Line		
G84	Modbus value+bit pos	STARTED ELEMENTS - 1		
	(2nd Reg, 1st Reg)			
	0x0000,0x0001	General Start		
	0x0000,0x0002	Start I>1		
	0x0000,0x0004	Start I>2		
	0x0000,0x0008	Start I>3		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x0000,0x0010	Start I>4		
	0x0000,0x0020	Start I2>		
	0x0000,0x0040	Start IN1>1		
	0x0000,0x0080	Start IN1>2		
	0x0000,0x0100	Start IN1>3		
	0x0000,0x0200	Start IN1>4		
	0x0000,0x0400	Start IN2>1		
	0x0000,0x0800	Start IN2>2		
	0x0000,0x1000	Start IN2>3		
	0x0000,0x2000	Start IN2>4		
	0x0000,0x4000	Start ISEF>1		
	0x0000,0x8000	Start ISEF>2		
	0x0001,0x0000	Start ISEF>3		
	0x0002,0x0000	Start ISEF>4		
	0x0004,0x0000	Start NVD VN>1		
	0x0008,0x0000	Start NVD VN>2		
	0x0010,0x0000	Thermal Alarm		
	0x0020,0x0000	Start V2>		
	0x0040,0x0000	Start V<1		
	0x0080,0x0000	Start V<2		
	0x0100,0x0000	Start V< A/AB		
	0x0200,0x0000	Start V< B/BC		
	0x0400,0x0000	Start V< C/CA		
	0x0800,0x0000	Start V>1		
	0x1000,0x0000	Start V>2		
	0x2000,0x0000	Start V> A/AB		
	0x4000,0x0000	Start V> B/BC		
	0x8000,0x0000	Start V> C/CA		
G85	Modbus value+bit pos	TRIPPED ELEMENTS - 1		
	(2nd Reg, 1st Reg)			
	0x0000,0x0001	Any Trip		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x0000,0x0002	Trip I>1		
	0x0000,0x0004	Trip I>2		
	0x0000,0x0008	Trip I>3		
	0x0000,0x0010	Trip I>4		
	0x0000,0x0020	Trip I2>		
	0x0000,0x0040	Trip Broken Line		
	0x0000,0x0080	Trip IN1>1		
	0x0000,0x0100	Trip IN1>2		
	0x0000,0x0200	Trip IN1>3		
	0x0000,0x0400	Trip IN1>4		
	0x0000,0x0800	Trip IN2>1		
	0x0000,0x1000	Trip IN2>2		
	0x0000,0x2000	Trip IN2>3		
	0x0000,0x4000	Trip IN2>4		
	0x0000,0x8000	Trip ISEF>1		
	0x0001,0x0000	Trip ISEF>2		
	0x0002,0x0000	Trip ISEF>3		
	0x0004,0x0000	Trip ISEF>4		
	0x0008,0x0000	Trip IREF>		
	0x0010,0x0000	Trip NVD VN>1		
	0x0020,0x0000	Trip NVD VN>2		
	0x0040,0x0000	Trip Thermal		
	0x0080,0x0000	Trip V2>		
	0x0100,0x0000			
	0x0200,0x0000			
	0x0400,0x0000			
	0x0800,0x0000			
	0x1000,0x0000			
	0x2000,0x0000			
	0x4000,0x0000			

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x8000,0x0000			
G86	(Courier/IEC870 Bit Position)	TRIPPED ELEMENTS - 2		
	(2nd Reg,1st Reg)			
	0x0000,0x0001	Trip V<1		
	0x0000,0x0002	Trip V<2		
	0x0000,0x0004	Trip V< A/AB		
	0x0000,0x0008	Trip V< B/BC		
	0x0000,0x0010	Trip V< C/CA		
	0x0000,0x0020	Trip V>1		
	0x0000,0x0040	Trip V>2		
	0x0000,0x0080	Trip V> A/AB		
	0x0000,0x0100	Trip V> B/BC		
	0x0000,0x0200	Trip V> C/CA		
	0x0000,0x0400	Trip F<1		
	0x0000,0x0800	Trip F<2		
	0x0000,0x1000	Trip F<3		
	0x0000,0x2000	Trip F<4		
	0x0000,0x4000	Trip F>1		
	0x0000,0x8000	Trip F>2		
	0x0001,0x0000	Trip YN>		
	0x0002,0x0000	Trip GN>		
	0x0004,0x0000	Trip BN>		
	0x0008,0x0000			
	0x0010,0x0000			
	0x0020,0x0000			
	0x0040,0x0000			
	0x0080,0x0000			
	0x0100,0x0000			
	0x0200,0x0000			
	0x0400,0x0000			
	0x0800,0x0000			

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x1000,0x0000			
	0x2000,0x0000			
	0x4000,0x0000			
	0x8000,0x0000			
G87	(Courier/IEC870 Bit Position)	FAULT ALARMS		
	(2nd Reg,1st Reg)	P141	P142	P143
	0x0000,0x0001	CB Fail 1	CB Fail 1	CB Fail 1
	0x0000,0x0002	CB Fail 2	CB Fail 2	CB Fail 2
	0x0000,0x0004	VTS	VTS	VTS
	0x0000,0x0008	CTS	CTS	CTS
	0x0000,0x0010	VCO	VCO	VCO
	0x0000,0x0020	CLP	CLP	CLP
	0x0000,0x0040		A/R Trip 1	A/R Trip 1
	0x0000,0x0080		A/R Trip 2	A/R Trip 2
	0x0000,0x0100		A/R Trip 3	A/R Trip 3
	0x0000,0x0200		A/R Trip 4	A/R Trip 4
	0x0000,0x0400		A/R Trip 5	A/R Trip 5
	0x0000,0x0800			
	0x0000,0x1000			
	0x0000,0x2000			
	0x0000,0x4000			
	0x0000,0x8000			
	0x0001,0x0000			
	0x0002,0x0000			
	0x0004,0x0000			
	0x0008,0x0000			
	0x0010,0x0000			
	0x0020,0x0000			
	0x0040,0x0000			
	0x0080,0x0000			
	0x0100,0x0000			

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x0200,0x0000			
	0x0400,0x0000			
	0x0800,0x0000			
	0x1000,0x0000			
	0x2000,0x0000			
	0x4000,0x0000			
	0x8000,0x0000			
G88		ALARMS		
	0	Alarm Disabled		
	1	Alarm Enabled		
G89		MAIN VT LOCATION		
	0	Line		
	1	Bus		
G90		SETTING GROUP SELECTION		
	0	Group 1		
	1	Group 2		
	2	Group 3		
	3	Group 4		
G91		AUTORECLOSE PROTECTION BLOCKING		
	0	No Block		
	1	Block Inst Prot		
G92		LOCKOUT		
	0	No Lockout		
	1	Lockout		
G93		COMMISSION TEST		
	0	No Operation		
	1	Apply Test		
	2	Remove Test		
G94		COMMISSION TEST		
	0	No Operation		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	1	Apply Test		
G95		SYSTEM FUNCTION LINKS		
	Bit 0	Trip led self reset (1 = enable self reset)		
	Bit 1	Not Used		
	Bit 2	Not Used		
	Bit 3	Not used		
	Bit 4	Not Used		
	Bit 5	Not Used		
	Bit 6	Not Used		
	Bit 7	Not Used		
G96-1	Bit Position	ALARM STATUS 1 - INDEXED STRINGS		
		P141	P142	P143
	0	Battery Fail	Battery Fail	Battery Fail
	1	Field Volt Fail	Field Volt Fail	Field Volt Fail
	2	SG-opto Invalid	SG-opto Invalid	SG-opto Invalid
	3	Prot'n Disabled	Prot'n Disabled	Prot'n Disabled
	4	F out of Range	F out of Range	F out of Range
	5	VT Fail Alarm	VT Fail Alarm	VT Fail Alarm
	6	CT Fail Alarm	CT Fail Alarm	CT Fail Alarm
	7	CB Fail Alarm	CB Fail Alarm	CB Fail Alarm
	8	I^ Maint Alarm	I^ Maint Alarm	I^ Maint Alarm
	9	I^ Lockout Alarm	I^ Lockout Alarm	I^ Lockout Alarm
	10	CB Ops Maint	CB Ops Maint	CB Ops Maint
	11	CB Ops Lockout	CB Ops Lockout	CB Ops Lockout
	12	CB Op Time Maint	CB Op Time Maint	CB Op Time Maint
	13	CB Op Time Lock	CB Op Time Lock	CB Op Time Lock
	14	Fault Freq Lock	Fault Freq Lock	Fault Freq Lock
	15	CB Status Alarm	CB Status Alarm	CB Status Alarm
	16	Man CB Trip Fail	Man CB Trip Fail	Man CB Trip Fail
	17	Man CB Cls Fail	Man CB Cls Fail	Man CB Cls Fail
	18	Man CB Unhealthy	Man CB Unhealthy	Man CB Unhealthy

TYPE	VALUE/BIT MASK	DESCRIPTION		
	19	Not Used	Not Used	Man No Checksync
	20	Not Used	AR Lockout	AR Lockout
	21	Not Used	AR CB Unhealthy	AR CB Unhealthy
	22	Not Used	AR No Sys Checks	AR No Sys Checks
	23	Not Used	Not Used	System Split
	24	SR User Alarm 1	SR User Alarm 1	SR User Alarm 1
	25	SR User Alarm 2	SR User Alarm 2	SR User Alarm 2
	26	SR User Alarm 3	SR User Alarm 3	SR User Alarm 3
	27	SR User Alarm 4	SR User Alarm 4	SR User Alarm 4
	28	SR User Alarm 5	SR User Alarm 5	SR User Alarm 5
	29	SR User Alarm 6	SR User Alarm 6	SR User Alarm 6
	30	SR User Alarm 7	SR User Alarm 7	SR User Alarm 7
	31	SR User Alarm 8	SR User Alarm 8	SR User Alarm 8
G96-2	Bit Position	ALARM STATUS 2 - INDEXED STRINGS		
		P141	P142	P143
	0	Not Used	Not Used	Not Used
	1	Not Used	Not Used	Not Used
	2	Not Used	Not Used	Not Used
	3	Not Used	Not Used	Not Used
	4	SR User Alarm 9	SR User Alarm 9	SR User Alarm 9
	5	SR User Alarm 10	SR User Alarm 10	SR User Alarm 10
	6	SR User Alarm 11	SR User Alarm 11	SR User Alarm 11
	7	SR User Alarm 12	SR User Alarm 12	SR User Alarm 12
	8	SR User Alarm 13	SR User Alarm 13	SR User Alarm 13
	9	SR User Alarm 14	SR User Alarm 14	SR User Alarm 14
	10	SR User Alarm 15	SR User Alarm 15	SR User Alarm 15
	11	SR User Alarm 16	SR User Alarm 16	SR User Alarm 16
	12	SR User Alarm 17	SR User Alarm 17	SR User Alarm 17
	13	SR User Alarm 18	SR User Alarm 18	SR User Alarm 18
	14	MR User Alarm 19	MR User Alarm 19	MR User Alarm 19
	15	MR User Alarm 20	MR User Alarm 20	MR User Alarm 20

TYPE	VALUE/BIT MASK	DESCRIPTION		
	16	MR User Alarm 21	MR User Alarm 21	MR User Alarm 21
	17	MR User Alarm 22	MR User Alarm 22	MR User Alarm 22
	18	MR User Alarm 23	MR User Alarm 23	MR User Alarm 23
	19	MR User Alarm 24	MR User Alarm 24	MR User Alarm 24
	20	MR User Alarm 25	MR User Alarm 25	MR User Alarm 25
	21	MR User Alarm 26	MR User Alarm 26	MR User Alarm 26
	22	MR User Alarm 27	MR User Alarm 27	MR User Alarm 27
	23	MR User Alarm 28	MR User Alarm 28	MR User Alarm 28
	24	MR User Alarm 29	MR User Alarm 29	MR User Alarm 29
	25	MR User Alarm 30	MR User Alarm 30	MR User Alarm 30
	26	MR User Alarm 31	MR User Alarm 31	MR User Alarm 31
	27	MR User Alarm 32	MR User Alarm 32	MR User Alarm 32
	28	MR User Alarm 33	MR User Alarm 33	MR User Alarm 33
	29	MR User Alarm 34	MR User Alarm 34	MR User Alarm 34
	30	MR User Alarm 35	MR User Alarm 35	MR User Alarm 35
	31	MR User Alarm 36	MR User Alarm 36	MR User Alarm 36
G97		DISTANCE UNIT		
	0	Kilometres		
	1	Miles		
G98		COPY TO		
	0	No Operation		
	1	Group 1		
	2	Group 2		
	3	Group 3		
	4	Group 4		
G99		CB CONTROL		
	0	Disabled		
	1	Local		
	2	Remote		
	3	Local+Remote		
	4	Opto		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	5	Opto+local		
	6	Opto+Remote		
	7	Opto+Rem+local		
G100		VCO OPTIONS		
	0	Disabled		
	1	I>1		
	2	I>2		
	3	Both I>1 & I>2		
G101		PROTECTION-A/R INTERFACE (I>/IN> Stages 1/2)		
	0	No Action		
	1	Initiate Main AR		
G102		PROTECTION-A/R INTERFACE (I>/IN> Stages 3/4) (P142 - SEF Stages 1/2/3/4)		
	0	No Action		
	1	Initiate Main AR		
	2	Block AR		
G103		PROTECTION-A/R INTERFACE (ISEF> Stages 1/2/3/4 - P143)		
	0	No Action		
	1	Initiate Main AR		
	2	Initiate SEF AR		
	3	Block AR		
G104		PROTECTION-A/R INTERFACE		
	0	No Action		
	1	Block AR		
G106		COLD LOAD PICKUP		
	0	Block		
	1	Enable		
G107	Modbus value+bit pos	STARTED ELEMENTS - 2		
	(2nd Reg, 1st Reg)			
	0x0000,0x0001	Start F<1		
	0x0000,0x0002	Start F<2		
	0x0000,0x0004	Start F<3		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x0000,0x0008	Start F<4		
	0x0000,0x0010	Start F>1		
	0x0000,0x0020	Start F>2		
	0x0000,0x0040	Start YN>		
	0x0000,0x0080	Start GN>		
	0x0000,0x0100	Start BN>		
	0x0000,0x0200			
	0x0000,0x0400			
	0x0000,0x0800			
	0x0000,0x1000			
	0x0000,0x2000			
	0x0000,0x4000			
	0x0000,0x8000			
	0x0001,0x0000			
	0x0002,0x0000			
	0x0004,0x0000			
	0x0008,0x0000			
	0x0010,0x0000			
	0x0020,0x0000			
	0x0040,0x0000			
	0x0080,0x0000			
	0x0100,0x0000			
	0x0200,0x0000			
	0x0400,0x0000			
	0x0800,0x0000			
	0x1000,0x0000			
	0x2000,0x0000			
	0x4000,0x0000			
	0x8000,0x0000			
G118		CB CONTROL LOGIC INPUT ASSIGNMENT		
	0	None		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	1	52A		
	2	52B		
	3	Both 52A and 52B		
G119		TEST MODE		
	0	Disabled		
	1	Test Mode		
	2	Blocked		
G120		CT INPUT TYPE (ADMITTANCE)		
	0	SEF CT		
	1	E/F CT		
G125	2 REGISTERS	IEEE FLOATING POINT FORMAT		
		Bit 31 = sign		
		Bits 30-23 = e7 - e0		
		Implicit 1.		
		Bits 22-0 = f22 - f0		
G150		POC IDMT CURVE TYPE		
	0	Disabled		
	1	DT		
	2	IEC S Inverse		
	3	IEC V Inverse		
	4	IEC E Inverse		
	5	UK LT Inverse		
	6	Rectifier		
	7	RI		
	8	IEEE M Inverse		
	9	IEEE V Inverse		
	10	IEEE E Inverse		
	11	US Inverse		
	12	US ST Inverse		
G151		EF IDMT CURVE TYPE		
	0	Disabled		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	1	DT		
	2	IEC S Inverse		
	3	IEC V Inverse		
	4	IEC E Inverse		
	5	UK LT Inverse		
	6	RI		
	7	IEEE M Inverse		
	8	IEEE V Inverse		
	9	IEEE E Inverse		
	10	US Inverse		
	11	US ST Inverse		
	12	IDG		
G152		SEF IDMT CURVE TYPE		
	0	Disabled		
	1	DT		
	2	IEC S Inverse		
	3	IEC V Inverse		
	4	IEC E Inverse		
	5	UK LT Inverse		
	6	IEEE M Inverse		
	7	IEEE V Inverse		
	8	IEEE E Inverse		
	9	US Inverse		
	10	US ST Inverse		
	11	IDG		
G200		OPTO INPUT CONFIGURATION - GLOBAL		
	0	24/27V		
	1	30/34V		
	2	48/54V		
	3	110/125V		
	4	220/250V		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	5	Custom		
G201		OPTO INPUT CONFIGURATION - INDIVIDUAL		
	0	24/27V		
	1	30/34V		
	2	48/54V		
	3	110/125V		
	4	220/250V		
G202		CONTROL INPUT STATUS		
	(2nd Reg, 1st Reg)			
	0x0000,0x0001	Control Input 1 (0=Reset; 1=Set)		
	0x0000,0x0002	Control Input 2 (0=Reset; 1=Set)		
	0x0000,0x0004	Control Input 3 (0=Reset; 1=Set)		
	0x0000,0x0008	Control Input 4 (0=Reset; 1=Set)		
	0x0000,0x0010	Control Input 5 (0=Reset; 1=Set)		
	0x0000,0x0020	Control Input 6 (0=Reset; 1=Set)		
	0x0000,0x0040	Control Input 7 (0=Reset; 1=Set)		
	0x0000,0x0080	Control Input 8 (0=Reset; 1=Set)		
	0x0000,0x0100	Control Input 9 (0=Reset; 1=Set)		
	0x0000,0x0200	Control Input 10 (0=Reset; 1=Set)		
	0x0000,0x0400	Control Input 11 (0=Reset; 1=Set)		
	0x0000,0x0800	Control Input 12 (0=Reset; 1=Set)		
	0x0000,0x1000	Control Input 13 (0=Reset; 1=Set)		
	0x0000,0x2000	Control Input 14 (0=Reset; 1=Set)		
	0x0000,0x4000	Control Input 15 (0=Reset; 1=Set)		
	0x0000,0x8000	Control Input 16 (0=Reset; 1=Set)		
	0x0001,0x0000	Control Input 17 (0=Reset; 1=Set)		
	0x0002,0x0000	Control Input 18 (0=Reset; 1=Set)		
	0x0004,0x0000	Control Input 19 (0=Reset; 1=Set)		
	0x0008,0x0000	Control Input 20 (0=Reset; 1=Set)		
	0x0010,0x0000	Control Input 21 (0=Reset; 1=Set)		
	0x0020,0x0000	Control Input 22 (0=Reset; 1=Set)		

TYPE	VALUE/BIT MASK	DESCRIPTION		
	0x0040,0x0000	Control Input 23 (0=Reset; 1=Set)		
	0x0080,0x0000	Control Input 24 (0=Reset; 1=Set)		
	0x0100,0x0000	Control Input 25 (0=Reset; 1=Set)		
	0x0200,0x0000	Control Input 26 (0=Reset; 1=Set)		
	0x0400,0x0000	Control Input 27 (0=Reset; 1=Set)		
	0x0800,0x0000	Control Input 28 (0=Reset; 1=Set)		
	0x1000,0x0000	Control Input 29 (0=Reset; 1=Set)		
	0x2000,0x0000	Control Input 30 (0=Reset; 1=Set)		
	0x4000,0x0000	Control Input 31 (0=Reset; 1=Set)		
	0x8000,0x0000	Control Input 32 (0=Reset; 1=Set)		
G203		CONTROL INPUT COMMAND		
	0	No Operation		
	1	Set		
	2	Reset		

IEC870-5-103: Interoperability					**Compatibility Level 2**					
Physical Layer										
Electrical Interface: EIA RS-485										
Number of loads = 1 for one protection equipment										
Optical Interface (Order option)										
Plastic Fibre BFOC/2.5 type connector)										
Transmission speed										
User Setting: 9600 or 19200										
Application Layer										
More than one COMMON ADDRESS OF ASDU = LINK ADDRESS										
Standard Information numbers in monitor direction										
ASDU TYPE	**COT**	**FUN**	**INF NO.**	**Description**	**GI**	**Model Number**			**Address***	**Interpretation**
						P141	P142	P143		
System Functions(Monitor)										
8	10	255	0	End of General Interrogration		*	*	*	0	
6	8	255	0	Time Syncronisation		*	*	*	0	
5	3	160	2	Reset FCB		*	*	*	0	
5	4	160	3	Reset CU		*	*	*	0	
5	5	160	4	Start/Restart		*	*	*	0	
5	6	160	5	Power On		*	*	*	0	
Note: Identification message in ASDU 5: ALSTOM, Software Ref P14x.										
Status Indications										
1	1,7,9,11,12,20,21	160	16	Auto-recloser active	*		*	*	0	Autoreclose In Service
1	1,7,9,11,12,20,21		17	Tele-protection active						
1	1,7,9,11,12,20,21		18	Protection active						
1	1,11,12,20,21	160	19	LED Reset		*	*	*	0	Reset Indication
1	9,11		20	Monitor direction blocked						
1	9,11	160	21	Test mode	*	*	*	*	0	Protection Disabled
1	9,11		22	Local parameter setting						
1	1,7,9,11,12,20,21	160	23	Characteristic 1	*	*	*	*	0	Group 1 Active
1	1,7,9,11,12,20,21	160	24	Characteristic 2	*	*	*	*	0	Group 2 Active
1	1,7,9,11,12,20,21	160	25	Characteristic 3	*	*	*	*	0	Group 3 Active
1	1,7,9,11,12,20,21	160	26	Characteristic 4	*	*	*	*	0	Group 4 Active
1	1,7,9,11	160	27	Auxillary input 1	*	*	*	*	0	Opto Input 1
1	1,7,9,11	160	28	Auxillary input 2	*	*	*	*	0	Opto Input 2
1	1,7,9,11	160	29	Auxillary input 3	*	*	*	*	0	Opto Input 3

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Model Number			Address*	Interpretation
1	1,7,9,11	160	30	Auxillary input 4	*	*	*	*	0	Opto Input 4
1	1,7,9,11	160	27	Auxillary input 1	*	*	*	*	1	Opto Input 5
1	1,7,9,11	160	28	Auxillary input 2	*	*	*	*	1	Opto Input 6
1	1,7,9,11	160	29	Auxillary input 3	*	*	*	*	1	Opto Input 7
1	1,7,9,11	160	30	Auxillary input 4	*	*	*	*	1	Opto Input 8
1	1,7,9,11	160	27	Auxillary input 1	*		*BC	*	2	Opto Input 9
1	1,7,9,11	160	28	Auxillary input 2	*		*BC	*	2	Opto Input 10
1	1,7,9,11	160	29	Auxillary input 3	*		*BC	*	2	Opto Input 11
1	1,7,9,11	160	30	Auxillary input 4	*		*BC	*	2	Opto Input 12
1	1,7,9,11	160	27	Auxillary input 1	*		*C	*	3	Opto Input 13
1	1,7,9,11	160	28	Auxillary input 2	*		*C	*	3	Opto Input 14
1	1,7,9,11	160	29	Auxillary input 3	*		*C	*	3	Opto Input 15
1	1,7,9,11	160	30	Auxillary input 4	*		*C	*	3	Opto Input 16
1	1,7,9,11	160	27	Auxillary input 1	*			*CEF	4	Opto Input 17
1	1,7,9,11	160	28	Auxillary input 2	*			*CEF	4	Opto Input 18
1	1,7,9,11	160	29	Auxillary input 3	*			*CEF	4	Opto Input 19
1	1,7,9,11	160	30	Auxillary input 4	*			*CEF	4	Opto Input 20
1	1,7,9,11	160	27	Auxillary input 1	*			*CEF	5	Opto Input 21
1	1,7,9,11	160	28	Auxillary input 2	*			*CEF	5	Opto Input 22
1	1,7,9,11	160	29	Auxillary input 3	*			*CEF	5	Opto Input 23
1	1,7,9,11	160	30	Auxillary input 4	*			*CEF	5	Opto Input 24
1	1,7,9,11	160	27	Auxillary input 1	*			*F	6	Opto Input 25
1	1,7,9,11	160	28	Auxillary input 2	*			*F	6	Opto Input 26
1	1,7,9,11	160	29	Auxillary input 3	*			*F	6	Opto Input 27
1	1,7,9,11	160	30	Auxillary input 4	*			*F	6	Opto Input 28
1	1,7,9,11	160	27	Auxillary input 1	*			*F	7	Opto Input 29
1	1,7,9,11	160	28	Auxillary input 2	*			*F	7	Opto Input 30
1	1,7,9,11	160	29	Auxillary input 3	*			*F	7	Opto Input 31
1	1,7,9,11	160	30	Auxillary input 4	*			*F	7	Opto Input 32
Supervision Indications										
1	1,7,9		32	Measurand supervision I						
1	1,7,9		33	Measurand supervision V						
1	1,7,9		35	Phase sequence supervision						
1	1,7,9		36	Trip circuit supervision						
1	1,7,9		37	I>> back-up supervision						

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Model Number			Address*	Interpretation
1	1,7,9	160	38	VT fuse failure	*	*	*	*		VT Supervision Indication
1	1,7,9		39	Teleprotection disturbed						
1	1,7,9		46	Group warning						
1	1,7,9		47	Group alarm						
Earth Fault Indications										
1	1,7,9		48	Earth Fault L1						
1	1,7,9		49	Earth Fault L2						
1	1,7,9		50	Earth Fault L3						
1	1,7,9		51	Earth Fault Fwd						
1	1,7,9		52	Earth Fault Rev						
Fault Indications										
2	1,7,9	160	64	Start /pickup L1	*	*	*	*	0	I>1 Start A Phase
2	1,7,9	160	65	Start /pickup L2	*	*	*	*	0	I>1 Start B Phase
2	1,7,9	160	66	Start /pickup L3	*	*	*	*	0	I>1 Start C Phase
2	1,7,9	160	64	Start /pickup L1	*	*	*	*	1	I>2 Start A Phase
2	1,7,9	160	65	Start /pickup L2	*	*	*	*	1	I>2 Start B Phase
2	1,7,9	160	66	Start /pickup L3	*	*	*	*	1	I>2 Start C Phase
2	1,7,9	160	64	Start /pickup L1	*	*	*	*	2	I>3 Start A Phase
2	1,7,9	160	65	Start /pickup L2	*	*	*	*	2	I>3 Start B Phase
2	1,7,9	160	66	Start /pickup L3	*	*	*	*	2	I>3 Start C Phase
2	1,7,9	160	64	Start /pickup L1	*	*	*	*	3	I>4 Start A Phase
2	1,7,9	160	65	Start /pickup L2	*	*	*	*	3	I>4 Start B Phase
2	1,7,9	160	66	Start /pickup L3	*	*	*	*	3	I>4 Start C Phase
2	1,7,9	160	67	Start /pickup N	*	*	*	*	0	Start N
2	1,7,9	160	67	Start /pickup N	*	*	*	*	1	IN1>1 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	2	IN1>2 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	3	IN1>3 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	4	IN1>4 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	5	IN2>1 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	6	IN2>2 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	7	IN2>3 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	8	IN2>4 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	9	ISEF>1 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	10	ISEF>2 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	11	ISEF>3 Start

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Model Number			Address*	Interpretation
2	1,7,9	160	67	Start /pickup N	*	*	*	*	12	ISEF>4 Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	13	YN> Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	14	GN> Start
2	1,7,9	160	67	Start /pickup N	*	*	*	*	15	BN> Start
2	1,7	160	68	General Trip		*	*	*	0	Any Trip (Relay 3)
2	1,7	160	68	General Trip		*	*	*	1	IREF> Trip
2	1,7	160	68	General Trip		*	*	*	2	I2> Trip
2	1,7	160	68	General Trip		*	*	*	3	Broken Line Trip
2	1,7	160	68	General Trip		*	*	*	4	Thermal Trip
2	1,7	160	68	General Trip		*	*	*	5	VN>1 Trip
2	1,7	160	68	General Trip		*	*	*	6	VN>2 Trip
2	1,7	160	68	General Trip		*	*	*	7	V<1 Trip
2	1,7	160	68	General Trip		*	*	*	8	V<2 Trip
2	1,7	160	68	General Trip		*	*	*	9	V>1 Trip
2	1,7	160	68	General Trip		*	*	*	10	V>2 Trip
2	1,7	160	68	General Trip		*	*	*	11	V2> Trip
2	1,7	160	68	General Trip		*	*	*	12	F<1 Trip
2	1,7	160	68	General Trip		*	*	*	13	F<2 Trip
2	1,7	160	68	General Trip		*	*	*	14	F<3 Trip
2	1,7	160	68	General Trip		*	*	*	15	F<4 Trip
2	1,7	160	68	General Trip		*	*	*	16	F>1 Trip
2	1,7	160	68	General Trip		*	*	*	17	F>2 Trip
2	1,7	160	69	Trip L1		*	*	*	0	I>1 Trip A Phase
2	1,7	160	70	Trip L2		*	*	*	0	I>1 Trip B Phase
2	1,7	160	71	Trip L3		*	*	*	0	I>1 Trip C Phase
2	1,7	160	69	Trip L1		*	*	*	1	I>2 Trip A Phase
2	1,7	160	70	Trip L2		*	*	*	1	I>2 Trip B Phase
2	1,7	160	71	Trip L3		*	*	*	1	I>2 Trip C Phase
2	1,7	160	69	Trip L1		*	*	*	2	I>3 Trip A Phase
2	1,7	160	70	Trip L2		*	*	*	2	I>3 Trip B Phase
2	1,7	160	71	Trip L3		*	*	*	2	I>3 Trip C Phase
2	1,7	160	69	Trip L1		*	*	*	3	I>4 Trip A Phase
2	1,7	160	70	Trip L2		*	*	*	3	I>4 Trip B Phase
2	1,7	160	71	Trip L3		*	*	*	3	I>4 Trip C Phase
2	1,7		72	Trip I>> (backup)						

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Model Number			Address*	Interpretation
4	1,7		73	Fault Location in ohms						
2	1,7		74	Fault forward						
2	1,7		75	Fault reverse						
2	1,7		76	Teleprotection signal sent						
2	1,7		77	Teleprotection signal received						
2	1,7		78	Zone 1						
2	1,7		79	Zone 2						
2	1,7		80	Zone 3						
2	1,7		81	Zone 4						
2	1,7		82	Zone 5						
2	1,7		83	Zone 6						
2	1,7,9	160	84	General Start	*	*	*	*	0	Any Start
2	1,7,9	160	84	General Start	*	*	*	*	1	I2> Start
2	1,7,9	160	84	General Start	*	*	*	*	2	Thermal Alarm
2	1,7,9	160	84	General Start	*	*	*	*	3	VN>1 Start
2	1,7,9	160	84	General Start	*	*	*	*	4	VN>2 Start
2	1,7,9	160	84	General Start	*	*	*	*	5	V<1 Start
2	1,7,9	160	84	General Start	*	*	*	*	6	V<2 Start
2	1,7,9	160	84	General Start	*	*	*	*	7	V>1 Start
2	1,7,9	160	84	General Start	*	*	*	*	8	V>2 Start
2	1,7,9	160	84	General Start	*	*	*	*	9	V2> Start
2	1,7,9	160	84	General Start	*	*	*	*	10	F<1 Start
2	1,7,9	160	84	General Start	*	*	*	*	11	F<2 Start
2	1,7,9	160	84	General Start	*	*	*	*	12	F<3 Start
2	1,7,9	160	84	General Start	*	*	*	*	13	F<4 Start
2	1,7,9	160	84	General Start	*	*	*	*	14	F>1 Start
2	1,7,9	160	84	General Start	*	*	*	*	15	F>2 Start
2	1,7	160	85	Breaker Failure		*	*	*	0	CB Fail Alarm
2	1,7		86	Trip measuring system L1						
2	1,7		87	Trip measuring system L2						

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Model Number			Address*	Interpretation
2	1,7		88	Trip measuring system L3						
2	1,7		89	Trip measuring system E						
2	1,7	160	90	Trip I>		*	*	*	0	I>1 Trip
2	1,7	160	91	Trip I>>		*	*	*	0	I>3 Trip
2	1,7	160	90	Trip I>		*	*	*	1	I>2 Trip
2	1,7	160	91	Trip I>>		*	*	*	1	I>4 Trip
2	1,7	160	92	Trip IN>		*	*	*	0	IN1>1 Trip
2	1,7	160	93	Trip IN>>		*	*	*	0	IN1>3 Trip
2	1,7	160	92	Trip IN>		*	*	*	1	IN1>2 Trip
2	1,7	160	93	Trip IN>>		*	*	*	1	IN1>4 Trip
2	1,7	160	92	Trip IN>		*	*	*	2	IN2>1 Trip
2	1,7	160	93	Trip IN>>		*	*	*	2	IN2>3 Trip
2	1,7	160	92	Trip IN>		*	*	*	3	IN2>2 Trip
2	1,7	160	93	Trip IN>>		*	*	*	3	IN2>4 Trip
2	1,7	160	92	Trip IN>		*	*	*	4	ISEF>1 Trip
2	1,7	160	93	Trip IN>>		*	*	*	4	ISEF>3 Trip
2	1,7	160	92	Trip IN>		*	*	*	5	ISEF>2 Trip
2	1,7	160	93	Trip IN>>		*	*	*	5	ISEF>4 Trip
2	1,7	160	92	Trip IN>		*	*	*	6	YN> Trip
2	1,7	160	92	Trip IN>		*	*	*	7	GN> Trip
2	1,7	160	92	Trip IN>		*	*	*	8	BN> Trip
Auto-Reclose Indications (Monitor)										
1	1,7	160	128	CB 'on' by A/R			*	*	0	Autoreclose Close Signal
1	1,7		129	CB 'on' by long time A/R						
1	1,7,9	160	130	AR blocked	*		*	*	0	Autoreclose Lockout
Measurands (Monitor)										
3.1	2,7		144	Measurand I						
3.2	2,7		145	Measurands I,V						
3.3	2,7		146	Measurands I,V,P,Q						
3.4	2,7		147	Measurands IN,VEN						
9	2,7		148	Measurands IL1,2,3,VL1,2,3,P,Q,f		*	*	*	0	
Generic Functions(Monitor)										
10	42,43		240	Read Headings						
10	42,43		241	Read attributes of all entries of a group						

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Model Number			Address*	Interpretation
10	42,43		243	Read directory of entry						
10	1,2,7,9,11,12,42,43		244	Real attribute of entry						
10	10		245	End of GGI						
10	41,44		249	Write entry with confirm						
10	40,41		250	Write entry with execute						
10	40		251	Write entry aborted						
Standard Information Numbers in control direction										
System Functions (Control)										
7	9	255	0	Init General Interrogation		*	*	*	0	
6	8	255	0	Time Syncronisation		*	*	*	255	
General Commands										
20	20	160	16	Auto-recloser on/off			*	*	0	
20	20		17	Teleprotection on/off						
20	20		18	Protection on/off						
20	20	160	19	LED Reset		*	*	*	0	Reset LEDs
20	20	160	23	Activate characteristic 1		*	*	*	0	Group 1 Active
20	20	160	24	Activate characteristic 2		*	*	*	0	Group 2 Active
20	20	160	25	Activate characteristic 3		*	*	*	0	Group 3 Active
20	20	160	26	Activate characteristic 4		*	*	*	0	Group 4 Active
Generic Functions										
21	42		240	Read headings of all defined groups						
21	42		241	Read single attribute of all entries of a group						
21	42		243	Read directory of single entry						
21	42		244	Read attribute of sngle entry						
21	9		245	Generic General Interrogation (GGI)						
10	40		248	Write entry						
10	40		249	Write with confirm						
10	40		250	Write with execute						
10	40		251	Write entry abort						
***Note that the value in this column is added to the station address to produce the common address of the ASDU**										
Basic Application Functions										
Test Mode			y							
Blocking of monitor direction			x							
Disturbance data			x							
Generic services			x							

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Model Number			Address*	Interpretation
Private data			x							
Miscellaneous										
					Max .MVAL = times rated value					
Measurand					1.2		2.4			
Current L1							*			
Current L2							*			
Current L3							*			
Voltage L1-E					*					
Voltage L2-E					*					
Voltage L3-E					*					
Active Power P							*			
Reactive Power Q							*			
Frequency f					*					
Voltage L1-L2										

Digital Data Bus

DDB No.	Source	Description	English Text	P141	P142	P143
0	Output Conditioner	Output Relay 1	Output Label 1 (Setting)	*	*	*
1	Output Conditioner	Output Relay 2	Output Label 2 (Setting)	*	*	*
2	Output Conditioner	Output Relay 3	Output Label 3 (Setting)	*	*	*
3	Output Conditioner	Output Relay 4	Output Label 4 (Setting)	*	*	*
4	Output Conditioner	Output Relay 5	Output Label 5 (Setting)	*	*	*
5	Output Conditioner	Output Relay 6	Output Label 6 (Setting)	*	*	*
6	Output Conditioner	Output Relay 7	Output Label 7 (Setting)	*	*	*
7	Output Conditioner	Output Relay 8	Output Label 8 (Setting)		*DG	*
8	Output Conditioner	Output Relay 9	Output Label 9 (Setting)		*DG	*
9	Output Conditioner	Output Relay 10	Output Label 10 (Setting)		*DG	*
10	Output Conditioner	Output Relay 11	Output Label 11 (Setting)		*DG	*
11	Output Conditioner	Output Relay 12	Output Label 12 (Setting)		*D	*
12	Output Conditioner	Output Relay 13	Output Label 13 (Setting)		*D	*
13	Output Conditioner	Output Relay 14	Output Label 14 (Setting)		*D	*
14	Output Conditioner	Output Relay 15	Output Label 15 (Setting)		*D	*DEG
15	Output Conditioner	Output Relay 16	Output Label 16 (Setting)			*DEG
16	Output Conditioner	Output Relay 17	Output Label 17 (Setting)			*DEG
17	Output Conditioner	Output Relay 18	Output Label 18 (Setting)			*DEG
18	Output Conditioner	Output Relay 19	Output Label 19 (Setting)			*DEG
19	Output Conditioner	Output Relay 20	Output Label 20 (Setting)			*DEG
20	Output Conditioner	Output Relay 21	Output Label 21 (Setting)			*DEG
21	Output Conditioner	Output Relay 22	Output Label 22 (Setting)			*DEG
22	Output Conditioner	Output Relay 23	Output Label 23 (Setting)			*G
23	Output Conditioner	Output Relay 24	Output Label 24 (Setting)			*G
24	Output Conditioner	Output Relay 25	Output Label 25 (Setting)			*G
25	Output Conditioner	Output Relay 26	Output Label 26 (Setting)			*G
26	Output Conditioner	Output Relay 27	Output Label 27 (Setting)			*G
27	Output Conditioner	Output Relay 28	Output Label 28 (Setting)			*G
28	Output Conditioner	Output Relay 29	Output Label 27 (Setting)			*G
29	Output Conditioner	Output Relay 30	Output Label 28 (Setting)			*G
30		Unused				
31		Unused				
32	Opto Input	Opto Input 1	Opto Label 1 (Setting)	*	*	*
33	Opto Input	Opto Input 2	Opto Label 2 (Setting)	*	*	*
34	Opto Input	Opto Input 3	Opto Label 3 (Setting)	*	*	*
35	Opto Input	Opto Input 4	Opto Label 4 (Setting)	*	*	*
36	Opto Input	Opto Input 5	Opto Label 5 (Setting)	*	*	*
37	Opto Input	Opto Input 6	Opto Label 6 (Setting)	*	*	*
38	Opto Input	Opto Input 7	Opto Label 7 (Setting)	*	*	*
39	Opto Input	Opto Input 8	Opto Label 8 (Setting)	*	*	*
40	Opto Input	Opto Input 9	Opto Label 9 (Setting)		*BC	*
41	Opto Input	Opto Input 10	Opto Label 10 (Setting)		*BC	*
42	Opto Input	Opto Input 11	Opto Label 11 (Setting)		*BC	*
43	Opto Input	Opto Input 12	Opto Label 12 (Setting)		*BC	*
44	Opto Input	Opto Input 13	Opto Label 13 (Setting)		*C	*
45	Opto Input	Opto Input 14	Opto Label 14 (Setting)		*C	*
46	Opto Input	Opto Input 15	Opto Label 15 (Setting)		*C	*
47	Opto Input	Opto Input 16	Opto Label 16 (Setting)		*C	*
48	Opto Input	Opto Input 17	Opto Label 17 (Setting)			*CEF

DDB No.	Source	Description	English Text	P141	P142	P143
49	Opto Input	Opto Input 18	Opto Label 18 (Setting)			*CEF
50	Opto Input	Opto Input 19	Opto Label 19 (Setting)			*CEF
51	Opto Input	Opto Input 20	Opto Label 20 (Setting)			*CEF
52	Opto Input	Opto Input 21	Opto Label 21 (Setting)			*CEF
53	Opto Input	Opto Input 22	Opto Label 22 (Setting)			*CEF
54	Opto Input	Opto Input 23	Opto Label 23 (Setting)			*CEF
55	Opto Input	Opto Input 24	Opto Label 24 (Setting)			*CEF
56	Opto Input	Opto Input 25	Opto Label 25 (Setting)			*F
57	Opto Input	Opto Input 26	Opto Label 26 (Setting)			*F
58	Opto Input	Opto Input 27	Opto Label 27 (Setting)			*F
59	Opto Input	Opto Input 28	Opto Label 28 (Setting)			*F
60	Opto Input	Opto Input 29	Opto Label 29 (Setting)			*F
61	Opto Input	Opto Input 30	Opto Label 30 (Setting)			*F
62	Opto Input	Opto Input 31	Opto Label 31 (Setting)			*F
63	Opto Input	Opto Input 32	Opto Label 32 (Setting)			*F
64	Output Conditioner	Programmable LED 1	LED 1	*	*	*
65	Output Conditioner	Programmable LED 2	LED 2	*	*	*
66	Output Conditioner	Programmable LED 3	LED 3	*	*	*
67	Output Conditioner	Programmable LED 4	LED 4	*	*	*
68	Output Conditioner	Programmable LED 5	LED 5	*	*	*
69	Output Conditioner	Programmable LED 6	LED 6	*	*	*
70	Output Conditioner	Programmable LED 7	LED 7	*	*	*
71	Output Conditioner	Programmable LED 8	LED 8	*	*	*
72	PSL	Input to Relay Output Conditioner	Relay Cond 1	*	*	*
73	PSL	Input to Relay Output Conditioner	Relay Cond 2	*	*	*
74	PSL	Input to Relay Output Conditioner	Any Trip	*	*	*
75	PSL	Input to Relay Output Conditioner	Relay Cond 4	*	*	*
76	PSL	Input to Relay Output Conditioner	Relay Cond 5	*	*	*
77	PSL	Input to Relay Output Conditioner	Relay Cond 6	*	*	*
78	PSL	Input to Relay Output Conditioner	Relay Cond 7	*	*	*
79	PSL	Input to Relay Output Conditioner	Relay Cond 8		*DG	*
80	PSL	Input to Relay Output Conditioner	Relay Cond 9		*DG	*
81	PSL	Input to Relay Output Conditioner	Relay Cond 10		*DG	*
82	PSL	Input to Relay Output Conditioner	Relay Cond 11		*DG	*
83	PSL	Input to Relay Output Conditioner	Relay Cond 12		*D	*
84	PSL	Input to Relay Output Conditioner	Relay Cond 13		*D	*
85	PSL	Input to Relay Output Conditioner	Relay Cond 14		*D	*
86	PSL	Input to Relay Output Conditioner	Relay Cond 15		*D	*DEG
87	PSL	Input to Relay Output Conditioner	Relay Cond 16			*DEG
88	PSL	Input to Relay Output Conditioner	Relay Cond 17			*DEG
89	PSL	Input to Relay Output Conditioner	Relay Cond 18			*DEG
90	PSL	Input to Relay Output Conditioner	Relay Cond 19			*DEG
91	PSL	Input to Relay Output Conditioner	Relay Cond 20			*DEG
92	PSL	Input to Relay Output Conditioner	Relay Cond 21			*DEG
93	PSL	Input to Relay Output Conditioner	Relay Cond 22			*DEG
94	PSL	Input to Relay Output Conditioner	Relay Cond 23			*G
95	PSL	Input to Relay Output Conditioner	Relay Cond 24			*G
96	PSL	Input to Relay Output Conditioner	Relay Cond 25			*G
97	PSL	Input to Relay Output Conditioner	Relay Cond 26			*G
98	PSL	Input to Relay Output Conditioner	Relay Cond 27			*G
99	PSL	Input to Relay Output Conditioner	Relay Cond 28			*G

DDB No.	Source	Description	English Text	P141	P142	P143
100	PSL	Input to Relay Output Conditioner	Relay Cond 29			*G
101	PSL	Input to Relay Output Conditioner	Relay Cond 30			*G
102	PSL					
103	PSL					
104	PSL	Input to LED Output Conditioner	LED Cond IN 1	*	*	*
105	PSL	Input to LED Output Conditioner	LED Cond IN 2	*	*	*
106	PSL	Input to LED Output Conditioner	LED Cond IN 3	*	*	*
107	PSL	Input to LED Output Conditioner	LED Cond IN 4	*	*	*
108	PSL	Input to LED Output Conditioner	LED Cond IN 5	*	*	*
109	PSL	Input to LED Output Conditioner	LED Cond IN 6	*	*	*
110	PSL	Input to LED Output Conditioner	LED Cond IN 7	*	*	*
111	PSL	Input to LED Output Conditioner	LED Cond IN 8	*	*	*
112	PSL	Input to Auxiliary Timer 1	Timer in 1	*	*	*
113	PSL	Input to Auxiliary Timer 2	Timer in 2	*	*	*
114	PSL	Input to Auxiliary Timer 3	Timer in 3	*	*	*
115	PSL	Input to Auxiliary Timer 4	Timer in 4	*	*	*
116	PSL	Input to Auxiliary Timer 5	Timer in 5	*	*	*
117	PSL	Input to Auxiliary Timer 6	Timer in 6	*	*	*
118	PSL	Input to Auxiliary Timer 7	Timer in 7	*	*	*
119	PSL	Input to Auxiliary Timer 8	Timer in 8	*	*	*
120	PSL	Input to Auxiliary Timer 9	Timer in 9	*	*	*
121	PSL	Input to Auxiliary Timer 10	Timer in 10	*	*	*
122	PSL	Input to Auxiliary Timer 11	Timer in 11	*	*	*
123	PSL	Input to Auxiliary Timer 12	Timer in 12	*	*	*
124	PSL	Input to Auxiliary Timer 13	Timer in 13	*	*	*
125	PSL	Input to Auxiliary Timer 14	Timer in 14	*	*	*
126	PSL	Input to Auxiliary Timer 15	Timer in 15	*	*	*
127	PSL	Input to Auxiliary Timer 16	Timer in 16	*	*	*
128	Auxiliary Timer	Output from Auxiliary Timer 1	Timer out 1	*	*	*
129	Auxiliary Timer	Output from Auxiliary Timer 2	Timer out 2	*	*	*
130	Auxiliary Timer	Output from Auxiliary Timer 3	Timer out 3	*	*	*
131	Auxiliary Timer	Output from Auxiliary Timer 4	Timer out 4	*	*	*
132	Auxiliary Timer	Output from Auxiliary Timer 5	Timer out 5	*	*	*
133	Auxiliary Timer	Output from Auxiliary Timer 6	Timer out 6	*	*	*
134	Auxiliary Timer	Output from Auxiliary Timer 7	Timer out 7	*	*	*
135	Auxiliary Timer	Output from Auxiliary Timer 8	Timer out 8	*	*	*
136	Auxiliary Timer	Output from Auxiliary Timer 9	Timer out 9	*	*	*
137	Auxiliary Timer	Output from Auxiliary Timer 10	Timer out 10	*	*	*
138	Auxiliary Timer	Output from Auxiliary Timer 11	Timer out 11	*	*	*
139	Auxiliary Timer	Output from Auxiliary Timer 12	Timer out 12	*	*	*
140	Auxiliary Timer	Output from Auxiliary Timer 13	Timer out 13	*	*	*
141	Auxiliary Timer	Output from Auxiliary Timer 14	Timer out 14	*	*	*
142	Auxiliary Timer	Output from Auxiliary Timer 15	Timer out 15	*	*	*
143	Auxiliary Timer	Output from Auxiliary Timer 16	Timer out 16	*	*	*
144	PSL	Trigger for Fault Recorder	Fault REC TRIG	*	*	*
145	Group Selection	Setting Group via opto invalid	SG-opto Invalid	*	*	*
146	Commissioning Test	Test Mode Enabled Alarm	Prot'n Disabled	*	*	*
147	Frequency Tracking	Frequency Out Of Range Alarm	F out of Range	*	*	*
148	VT Supervision	VTS Indication Alarm	VT Fail Alarm	*	*	*
149	CT Supervision	CTS Indication Alarm	CT Fail Alarm	*	*	*
150	CB Fail	Breaker Fail Any Trip Alarm	CB Fail Alarm	*	*	*

DDB No.	Source	Description	English Text	P141	P142	P143
151	CB Monitoring	Broken Current Maintenance Alarm	I^ Maint Alarm	*	*	*
152	CB Monitoring	Broken Current Lockout Alarm	I^ Lockout Alarm	*	*	*
153	CB Monitoring	No of CB Ops Maintenance Alarm	CB Ops Maint	*	*	*
154	CB Monitoring	No of CB Ops Maintenance Lockout	CB Ops Lockout	*	*	*
155	CB Monitoring	Excessive CB Op Time Maintenance Alarm	CB Op Time Maint	*	*	*
156	CB Monitoring	Excessive CB Op Time Lockout Alarm	CB Op Time Lock	*	*	*
157	CB Monitoring	EFF Lockout Alarm	Fault Freq Lock	*	*	*
158	CB Status	CB Status Alarm	CB Status Alarm	*	*	*
159	CB Control	CB Failed to Trip	Man CB Trip Fail	*	*	*
160	CB Control	CB Failed to Close	Man CB Cls Fail	*	*	*
161	CB Control	Manual CB Unhealthy	Man CB Unhealthy	*	*	*
162	CB Control	Manual No Check Sync	Man No Checksync			*
163	Autoreclose	Autoclose Lockout/RLY BAR	AR Lockout		*	*
164	Autoreclose	AR CB Unhealthy	AR CB Unhealthy		*	*
165	Autoreclose	AR No System Checks	AR No Sys Checks		*	*
166	Check Synch	System Split Alarm	System Split			*
167	PSL	User definable Alarm 1 (Self Reset)	SR User Alarm 1	*	*	*
168	PSL	User definable Alarm 2 (Self Reset)	SR User Alarm 2	*	*	*
169	PSL	User definable Alarm 3 (Self Reset)	SR User Alarm 3	*	*	*
170	PSL	User definable Alarm 4 (Self Reset)	SR User Alarm 4	*	*	*
171	PSL	User definable Alarm 5 (Self Reset)	SR User Alarm 5	*	*	*
172	PSL	User definable Alarm 6 (Self Reset)	SR User Alarm 6	*	*	*
173	PSL	User definable Alarm 7 (Self Reset)	SR User Alarm 7	*	*	*
174	PSL	User definable Alarm 8 (Self Reset)	SR User Alarm 8	*	*	*
175	PSL	User definable Alarm 9 (Self Reset)	SR User Alarm 9	*	*	*
176	PSL	User definable Alarm 10 (Self Reset)	SR User Alarm 10	*	*	*
177	PSL	User definable Alarm 11 (Self Reset)	SR User Alarm 11	*	*	*
178	PSL	User definable Alarm 12 (Self Reset)	SR User Alarm 12	*	*	*
179	PSL	User definable Alarm 13 (Self Reset)	SR User Alarm 13	*	*	*
180	PSL	User definable Alarm 14 (Self Reset)	SR User Alarm 14	*	*	*
181	PSL	User definable Alarm 15 (Self Reset)	SR User Alarm 15	*	*	*
182	PSL	User definable Alarm 16 (Self Reset)	SR User Alarm 16	*	*	*
183	PSL	User definable Alarm 17 (Self Reset)	SR User Alarm 17	*	*	*
184	PSL	User definable Alarm 18 (Self Reset)	SR User Alarm 18	*	*	*
185	PSL	User definable Alarm 19 (Manual Reset)	MR User Alarm 19	*	*	*
186	PSL	User definable Alarm 20 (Manual Reset)	MR User Alarm 20	*	*	*
187	PSL	User definable Alarm 21 (Manual Reset)	MR User Alarm 21	*	*	*
188	PSL	User definable Alarm 22 (Manual Reset)	MR User Alarm 22	*	*	*
189	PSL	User definable Alarm 23 (Manual Reset)	MR User Alarm 23	*	*	*
190	PSL	User definable Alarm 24 (Manual Reset)	MR User Alarm 24	*	*	*
191	PSL	User definable Alarm 25 (Manual Reset)	MR User Alarm 25	*	*	*
192	PSL	User definable Alarm 26 (Manual Reset)	MR User Alarm 26	*	*	*
193	PSL	User definable Alarm 27 (Manual Reset)	MR User Alarm 27	*	*	*
194	PSL	User definable Alarm 28 (Manual Reset)	MR User Alarm 28	*	*	*
195	PSL	User definable Alarm 29 (Manual Reset)	MR User Alarm 29	*	*	*
196	PSL	User definable Alarm 30 (Manual Reset)	MR User Alarm 30	*	*	*
197	PSL	User definable Alarm 31 (Manual Reset)	MR User Alarm 31	*	*	*
198	PSL	User definable Alarm 32 (Manual Reset)	MR User Alarm 32	*	*	*
199	PSL	User definable Alarm 33 (Manual Reset)	MR User Alarm 33	*	*	*
200	PSL	User definable Alarm 34 (Manual Reset)	MR User Alarm 34	*	*	*
201	PSL	User definable Alarm 35 (Manual Reset)	MR User Alarm 35	*	*	*

DDB No.	Source	Description	English Text	P141	P142	P143
202	PSL	User definable Alarm 36 (Manual Reset)	MR User Alarm 36	*	*	*
203	PSL	Block Phase Overcurrent Stage 1 Time Delay	I>1 Timer Block	*	*	*
204	PSL	Block Phase Overcurrent Stage 2 Time Delay	I>2 Timer Block	*	*	*
205	PSL	Block Phase Overcurrent Stage 3 Time Delay	I>3 Timer Block	*	*	*
206	PSL	Block Phase Overcurrent Stage 4 Time Delay	I>4 Timer Block	*	*	*
207	PSL	Block Negative Sequence O/C Time Delay	I2> Timer Block	*	*	*
208	PSL	Block Earth Fault #1 Stage 1 Time Delay	IN1>1 Timer Blk	*	*	*
209	PSL	Block Earth Fault #1 Stage 2 Time Delay	IN1>2 Timer Blk	*	*	*
210	PSL	Block Earth Fault #1 Stage 3 Time Delay	IN1>3 Timer Blk	*	*	*
211	PSL	Block Earth Fault #1 Stage 4 Time Delay	IN1>4 Timer Blk	*	*	*
212	PSL	Block Earth Fault #2 Stage 1 Time Delay	IN2>1 Timer Blk	*	*	*
213	PSL	Block Earth Fault #2 Stage 2 Time Delay	IN2>2 Timer Blk	*	*	*
214	PSL	Block Earth Fault #2 Stage 3 Time Delay	IN2>3 Timer Blk	*	*	*
215	PSL	Block Earth Fault #2 Stage 4 Time Delay	IN2>4 Timer Blk	*	*	*
216	PSL	Block SEF Stage 1 Time Delay	ISEF>1 Timer Blk	*	*	*
217	PSL	Block SEF Stage 2 Time Delay	ISEF>2 Timer Blk	*	*	*
218	PSL	Block SEF Stage 3 Time Delay	ISEF>3 Timer Blk	*	*	*
219	PSL	Block SEF Stage 4 Time Delay	ISEF>4 Timer Blk	*	*	*
220	PSL	Block Residual Overvoltage Stage 1 Time Delay	VN>1 Timer Blk	*	*	*
221	PSL	Block Residual Overvoltage Stage 2 Time Delay	VN>2 Timer Blk	*	*	*
222	PSL	Block Phase Undervoltage Stage 1 Time Delay	V<1 Timer Block	*	*	*
223	PSL	Block Phase Undervoltage Stage 2 Time Delay	V<2 Timer Block	*	*	*
224	PSL	Block Phase Overvoltage Stage 1 Time Delay	V>1 Timer Block	*	*	*
225	PSL	Block Phase Overvoltage Stage 2 Time Delay	V>2 Timer Block	*	*	*
226	PSL	Initiate Cold Load Pickup	CLP Initiate	*	*	*
227	PSL	External Trip 3ph	Ext.Trip 3ph	*	*	*
228	PSL	52-A CB Auxiliary Input (3 phase)	CB Aux 3ph(52-A)	*	*	*
229	PSL	52-B CB Auxiliary Input (3 phase)	CB Aux 3ph(52-B)	*	*	*
230	PSL	CB Healthy Input	CB Healthy	*	*	*
231	PSL	MCB/VTS opto	MCB/VTS	*	*	*
232	PSL	Opto Input Trip CB	Init Trip CB	*	*	*
233	PSL	Opto Input Close CB	Init Close CB	*	*	*
234	PSL	Reset Manual CB Close Time Delay	Reset Close Dly	*	*	*
235	PSL	Reset Latched Relays & LED's	Reset Relays/LED	*	*	*
236	PSL	Reset Thermal State	Reset Thermal	*	*	*
237	PSL	Reset Lockout Opto Input	Reset Lockout	*	*	*
238	PSL	Reset CB Maintenance Values	Reset CB Data	*	*	*
239	PSL	Block Autoreclose / BAR	Block A/R		*	*
240	PSL	Live Line Operation	Live Line Mode		*	*
241	PSL	Auto Mode Operation	Auto Mode		*	*
242	PSL	Telecontrol Mode Operation	Telecontrol Mode		*	*
243	Phase Overcurrent	1st Stage O/C Trip 3ph	I>1 Trip	*	*	*
244	Phase Overcurrent	1st Stage O/C Trip A	I>1 Trip A	*	*	*
245	Phase Overcurrent	1st Stage O/C Trip B	I>1 Trip B	*	*	*
246	Phase Overcurrent	1st Stage O/C Trip C	I>1 Trip C	*	*	*
247	Phase Overcurrent	2nd Stage O/C Trip 3ph	I>2 Trip	*	*	*
248	Phase Overcurrent	2nd Stage O/C Trip A	I>2 Trip A	*	*	*
249	Phase Overcurrent	2nd Stage O/C Trip B	I>2 Trip B	*	*	*
250	Phase Overcurrent	2nd Stage O/C Trip C	I>2 Trip C	*	*	*
251	Phase Overcurrent	3rd Stage O/C Trip 3ph	I>3 Trip	*	*	*
252	Phase Overcurrent	3rd Stage O/C Trip A	I>3 Trip A	*	*	*

DDB No.	Source	Description	English Text	P141	P142	P143
253	Phase Overcurrent	3rd Stage O/C Trip B	I>3 Trip B	*	*	*
254	Phase Overcurrent	3rd Stage O/C Trip C	I>3 Trip C	*	*	*
255	Phase Overcurrent	4th Stage O/C Trip 3ph	I>4 Trip	*	*	*
256	Phase Overcurrent	4th Stage O/C Trip A	I>4 Trip A	*	*	*
257	Phase Overcurrent	4th Stage O/C Trip B	I>4 Trip B	*	*	*
258	Phase Overcurrent	4th Stage O/C Trip C	I>4 Trip C	*	*	*
259	Neg Sequence O/C	Negative Sequence O/C Trip	I2> Trip	*	*	*
260	Broken Conductor	Broken Conductor Trip	Broken Line Trip	*	*	*
261	Earth Fault 1	1st Stage EF#1 Trip	IN1>1 Trip	*	*	*
262	Earth Fault 1	2nd Stage EF#1 Trip	IN1>2 Trip	*	*	*
263	Earth Fault 1	3rd Stage EF#1 Trip	IN1>3 Trip	*	*	*
264	Earth Fault 1	4th Stage EF#1 Trip	IN1>4 Trip	*	*	*
265	Earth Fault 2	1st Stage EF#2 Trip	IN2>1 Trip	*	*	*
266	Earth Fault 2	2nd Stage EF#2 Trip	IN2>2 Trip	*	*	*
267	Earth Fault 2	3rd Stage EF#2 Trip	IN2>3 Trip	*	*	*
268	Earth Fault 2	4th Stage EF#2 Trip	IN2>4 Trip	*	*	*
269	Sensitive Earth Fault	1st Stage SEF Trip	ISEF>1 Trip	*	*	*
270	Sensitive Earth Fault	2nd Stage SEF Trip	ISEF>2 Trip	*	*	*
271	Sensitive Earth Fault	3rd Stage SEF Trip	ISEF>3 Trip	*	*	*
272	Sensitive Earth Fault	4th Stage SEF Trip	ISEF>4 Trip	*	*	*
273	Restricted Earth Fault	REF Trip	IREF> Trip	*	*	*
274	Residual Overvoltage	1st Stage Residual O/V Trip	VN>1 Trip	*	*	*
275	Residual Overvoltage	2nd Stage Residual O/V Trip	VN>2 Trip	*	*	*
276	Thermal Overload	Thermal Overload Trip	Thermal Trip	*	*	*
277	Neg Sequence O/V	Negative Sequence O/V Trip	V2> Trip	*	*	*
278	Undervoltage	1st Stage Phase U/V Trip 3ph	V<1 Trip	*	*	*
279	Undervoltage	1st Stage Phase U/V Trip A/AB	V<1 Trip A/AB	*	*	*
280	Undervoltage	1st Stage Phase U/V Trip B/BC	V<1 Trip B/BC	*	*	*
281	Undervoltage	1st Stage Phase U/V Trip C/CA	V<1 Trip C/CA	*	*	*
282	Undervoltage	2nd Stage Phase U/V Trip 3ph	V<2 Trip	*	*	*
283	Undervoltage	2nd Stage Phase U/V Trip A/AB	V<2 Trip A/AB	*	*	*
284	Undervoltage	2nd Stage Phase U/V Trip B/BC	V<2 Trip B/BC	*	*	*
285	Undervoltage	2nd Stage Phase U/V Trip C/CA	V<2 Trip C/CA	*	*	*
286	Overvoltage	1st Stage Phase O/V Trip 3ph	V>1 Trip	*	*	*
287	Overvoltage	1st Stage Phase O/V Trip A/AB	V>1 Trip A/AB	*	*	*
288	Overvoltage	1st Stage Phase O/V Trip B/BC	V>1 Trip B/BC	*	*	*
289	Overvoltage	1st Stage Phase O/V Trip C/CA	V>1 Trip C/CA	*	*	*
290	Overvoltage	2nd Stage Phase O/V Trip 3ph	V>2 Trip	*	*	*
291	Overvoltage	2nd Stage Phase O/V Trip A/AB	V>2 Trip A/AB	*	*	*
292	Overvoltage	2nd Stage Phase O/V Trip B/BC	V>2 Trip B/BC	*	*	*
293	Overvoltage	2nd Stage Phase O/V Trip C/CA	V>2 Trip C/CA	*	*	*
294	All protection	Any Start	Any Start	*	*	*
295	Phase Overcurrent	1st Stage O/C Start 3ph	I>1 Start	*	*	*
296	Phase Overcurrent	1st Stage O/C Start A	I>1 Start A	*	*	*
297	Phase Overcurrent	1st Stage O/C Start B	I>1 Start B	*	*	*
298	Phase Overcurrent	1st Stage O/C Start C	I>1 Start C	*	*	*
299	Phase Overcurrent	2nd Stage O/C Start 3ph	I>2 Start	*	*	*
300	Phase Overcurrent	2nd Stage O/C Start A	I>2 Start A	*	*	*
301	Phase Overcurrent	2nd Stage O/C Start B	I>2 Start B	*	*	*
302	Phase Overcurrent	2nd Stage O/C Start C	I>2 Start C	*	*	*
303	Phase Overcurrent	3rd Stage O/C Start 3ph	I>3 Start	*	*	*

DDB No.	Source	Description	English Text	P141	P142	P143
304	Phase Overcurrent	3rd Stage O/C Start A	I>3 Start A	*	*	*
305	Phase Overcurrent	3rd Stage O/C Start B	I>3 Start B	*	*	*
306	Phase Overcurrent	3rd Stage O/C Start C	I>3 Start C	*	*	*
307	Phase Overcurrent	4th Stage O/C Start 3ph	I>4 Start	*	*	*
308	Phase Overcurrent	4th Stage O/C Start A	I>4 Start A	*	*	*
309	Phase Overcurrent	4th Stage O/C Start B	I>4 Start B	*	*	*
310	Phase Overcurrent	4th Stage O/C Start C	I>4 Start C	*	*	*
311	Voltage Controlled O/C	Voltage Controlled O/C Start AB	VCO Start AB	*	*	*
312	Voltage Controlled O/C	Voltage Controlled O/C Start BC	VCO Start BC	*	*	*
313	Voltage Controlled O/C	Voltage Controlled O/C Start CA	VCO Start CA	*	*	*
314	Neg Sequence O/C	Negative Sequence O/C Start	I2> Start	*	*	*
315	Earth Fault 1	1st Stage EF#1 Start	IN1>1 Start	*	*	*
316	Earth Fault 1	2nd Stage EF#1 Start	IN1>2 Start	*	*	*
317	Earth Fault 1	3rd Stage EF#1 Start	IN1>3 Start	*	*	*
318	Earth Fault 1	4th Stage EF#1 Start	IN1>4 Start	*	*	*
319	Earth Fault 2	1st Stage EF#2 Start	IN2>1 Start	*	*	*
320	Earth Fault 2	2nd Stage EF#2 Start	IN2>2 Start	*	*	*
321	Earth Fault 2	3rd Stage EF#2 Start	IN2>3 Start	*	*	*
322	Earth Fault 2	4th Stage EF#2 Start	IN2>4 Start	*	*	*
323	Sensitive Earth Fault	1st Stage SEF Start	ISEF>1 Start	*	*	*
324	Sensitive Earth Fault	2nd Stage SEF Start	ISEF>2 Start	*	*	*
325	Sensitive Earth Fault	3rd Stage SEF Start	ISEF>3 Start	*	*	*
326	Sensitive Earth Fault	4th Stage SEF Start	ISEF>4 Start	*	*	*
327	Residual Overvoltage	1st Stage Residual O/V Start	VN>1 Start	*	*	*
328	Residual Overvoltage	2nd Stage Residual O/V Start	VN>2 Start	*	*	*
329	Thermal Overload	Thermal Overload Alarm	Thermal Alarm	*	*	*
330	Neg Sequence O/V	Negative Sequence O/V Start	V2> Start	*	*	*
331	Undervoltage	1st Stage Phase U/V Start 3ph	V<1 Start	*	*	*
332	Undervoltage	1st Stage Phase U/V Start A/AB	V<1 Start A/AB	*	*	*
333	Undervoltage	1st Stage Phase U/V Start B/BC	V<1 Start B/BC	*	*	*
334	Undervoltage	1st Stage Phase U/V Start C/CA	V<1 Start C/CA	*	*	*
335	Undervoltage	2nd Stage Phase U/V Start 3ph	V<2 Start	*	*	*
336	Undervoltage	2nd Stage Phase U/V Start A/AB	V<2 Start A/AB	*	*	*
337	Undervoltage	2nd Stage Phase U/V Start B/BC	V<2 Start B/BC	*	*	*
338	Undervoltage	2nd Stage Phase U/V Start C/CA	V<2 Start C/CA	*	*	*
339	Overvoltage	1st Stage Phase O/V Start 3ph	V>1 Start	*	*	*
340	Overvoltage	1st Stage Phase O/V Start A/AB	V>1 Start A/AB	*	*	*
341	Overvoltage	1st Stage Phase O/V Start B/BC	V>1 Start B/BC	*	*	*
342	Overvoltage	1st Stage Phase O/V Start C/CA	V>1 Start C/CA	*	*	*
343	Overvoltage	2nd Stage Phase O/V Start 3ph	V>2 Start	*	*	*
344	Overvoltage	2nd Stage Phase O/V Start A/AB	V>2 Start A/AB	*	*	*
345	Overvoltage	2nd Stage Phase O/V Start B/BC	V>2 Start B/BC	*	*	*
346	Overvoltage	2nd Stage Phase O/V Start C/CA	V>2 Start C/CA	*	*	*
347	Cold Load Pickup	Cold Load Pickup Operation	CLP Operation	*	*	*
348	CBF & POC	I> Blocked O/C Start	I> BlockStart	*	*	*
349	CBF & IN1/IN2/SEF	IN/ISEF> Blocked O/C Start	IN/SEF>Blk Start	*	*	*
350	VT Supervision	VTS Fast Block	VTS Fast Block	*	*	*
351	VT Supervision	VTS Slow Block	VTS Slow Block	*	*	*
352	CT Supervision	CTS Block	CTS Block	*	*	*
353	CB Fail	tBF1 Trip 3Ph	Bfail1 Trip 3ph	*	*	*
354	CB Fail	tBF2 Trip 3Ph	Bfail2 Trip 3ph	*	*	*

DDB No.	Source	Description	English Text	P141	P142	P143
355	CB Control	Control Trip	Control Trip	*	*	*
356	CB Control	Control Close	Control Close	*	*	*
357	CB Control	Control Close in Progress	Close in Prog	*	*	*
358	Autoreclose	AR Block Main Protection	Block Main Prot		*	*
359	Autoreclose	AR Block SEF Protection	Block SEF Prot		*	*
360	Autoreclose	Autoreclose In Progress	AR In Progress		*	*
361	Autoreclose	Autoreclose In/Out of service	AR In Service		*	*
362	Autoreclose	Seq Counter = 0	Seq Counter = 0		*	*
363	Autoreclose	Seq Counter = 1	Seq Counter = 1		*	*
364	Autoreclose	Seq Counter = 2	Seq Counter = 2		*	*
365	Autoreclose	Seq Counter = 3	Seq Counter = 3		*	*
366	Autoreclose	Seq Counter = 4	Seq Counter = 4		*	*
367	Autoreclose	Successful Reclosure	Successful Close		*	*
368	Autoreclose	Dead Time in Progress	Dead T in Prog		*	*
369	Autoreclose	Protection Lockout of AR	Protection Lockt		*	*
370	Autoreclose	AR Reset Lockout Alarm	Reset Lckout Alm		*	*
371	Autoreclose	Auto Close/ AR Close	Auto Close		*	*
372	Autoreclose	Autoreclose trip test	A/R Trip Test		*	*
373	Undercurrent	IA< operate	IA< Start	*	*	*
374	Undercurrent	IB< operate	IB< Start	*	*	*
375	Undercurrent	IC< operate	IC< Start	*	*	*
376	Undercurrent	IN< operate	IN< Start	*	*	*
377	Undercurrent	ISEF< operate	ISEF< Start	*	*	*
378	CB Status	3 ph CB Open	CB Open 3 ph	*	*	*
379	CB Status	3 ph CB Closed	CB Closed 3 ph	*	*	*
380	Poledead	All Poles Dead	All Poles Dead	*	*	*
381	Poledead	Any Pole Dead	Any Pole Dead	*	*	*
382	Poledead	Phase A Pole Dead	Pole Dead A	*	*	*
383	Poledead	Phase B Pole Dead	Pole Dead B	*	*	*
384	Poledead	Phase C Pole Dead	Pole Dead C	*	*	*
385	VT Supervision	Accelerate Ind	VTS Acc Ind	*	*	*
386	VT Supervision	Any Voltage Dependent	VTS Volt Dep	*	*	*
387	VT Supervision	Ia over threshold	VTS Ia>	*	*	*
388	VT Supervision	Ib over threshold	VTS Ib>	*	*	*
389	VT Supervision	Ic over threshold	VTS Ic>	*	*	*
390	VT Supervision	Va over threshold	VTS Va>	*	*	*
391	VT Supervision	Vb over threshold	VTS Vb>	*	*	*
392	VT Supervision	Vc over threshold	VTS Vc>	*	*	*
393	VT Supervision	I2 over threshold	VTS I2>	*	*	*
394	VT Supervision	V2 over threshold	VTS V2>	*	*	*
395	VT Supervision	Superimposed Ia over threshold	VTS Ia delta>	*	*	*
396	VT Supervision	Superimposed Ib over threshold	VTS Ib delta>	*	*	*
397	VT Supervision	Superimposed Ic over threshold	VTS Ic delta >	*	*	*
398	Fixed Logic	CBF Current Prot SEF Trip	CBF SEF Trip	*	*	*
399	Fixed Logic	CBF Non Current Prot Trip	CBF Non I Trip	*	*	*
400	Fixed Logic	Fixed Logic CBF SEF Stage Trip	CBF SEF Trip-1	*	*	*
401	Fixed Logic	Fixed Logic CBF Non Current Protection Stage Trip	CBF Non I Trip-1	*	*	*
402	PSL	Control System Check OK	Man Check Synch			*
403	PSL	AR System Check OK/SYNC	AR SysChecks OK		*	*
404	CB Monitoring	Composite Lockout Alarm	Lockout Alarm	*	*	*
405	CB Monitoring	Pre-Lockout	Pre-Lockout		*	*

DDB No.	Source	Description	English Text	P141	P142	P143
406	Frequency Tracking	Freq High	Freq High	*	*	*
407	Frequency Tracking	Freq Low	Freq Low	*	*	*
408	Fixed Logic	Stop Freq Track	Stop Freq Track	*	*	*
409	EF1/EF2/SEF/VN/YN	Composite EF Start	Start N	*	*	*
410	Field Voltage Monitor	Field Voltage Failure	Field Volts Fail	*	*	*
411	Frequency Tracking	Freq Not Found	Freq Not Found	*	*	*
412	PSL	Block Underfrequency Stage 1 Timer	F<1 Timer Block	*	*	*
413	PSL	Block Underfrequency Stage 2 Timer	F<2 Timer Block	*	*	*
414	PSL	Block Underfrequency Stage 3 Timer	F<3 Timer Block	*	*	*
415	PSL	Block Underfrequency Stage 4 Timer	F<4 Timer Block	*	*	*
416	PSL	Block Overfrequency Stage 1 Timer	F>1 Timer Block	*	*	*
417	PSL	Block Overfrequency Stage 2 Timer	F>2 Timer Block	*	*	*
418	Frequency Protection	Under frequency Stage 1 Start	F<1 Start	*	*	*
419	Frequency Protection	Under frequency Stage 2 Start	F<2 Start	*	*	*
420	Frequency Protection	Under frequency Stage 3 Start	F<3 Start	*	*	*
421	Frequency Protection	Under frequency Stage 4 Start	F<4 Start	*	*	*
422	Frequency Protection	Over frequency Stage 1 Start	F>1 Start	*	*	*
423	Frequency Protection	Over frequency Stage 2 Start	F>2 Start	*	*	*
424	Frequency Protection	Under frequency Stage 1 Trip	F<1 Trip	*	*	*
425	Frequency Protection	Under frequency Stage 2 Trip	F<2 Trip	*	*	*
426	Frequency Protection	Under frequency Stage 3 Trip	F<3 Trip	*	*	*
427	Frequency Protection	Under frequency Stage 4 Trip	F<4 Trip	*	*	*
428	Frequency Protection	Over frequency Stage 1 Trip	F>1 Trip	*	*	*
429	Frequency Protection	Over frequency Stage 2 Trip	F>2 Trip	*	*	*
430	PSL	Block Overadmittance Timer	YN> Timer Block	*	*	*
431	PSL	Block Overconductance	GN> Timer Block	*	*	*
432	PSL	Block Oversusceptance Timer	BN> Timer Block	*	*	*
433	Admittance Protection	Overadmittance Start	YN> Start	*	*	*
434	Admittance Protection	Overconductance Start	GN> Start	*	*	*
435	Admittance Protection	Oversusceptance Start	BN> Start	*	*	*
436	Admittance Protection	Overadmittance Trip	YN> Trip	*	*	*
437	Admittance Protection	Overconductance Trip	GN> Trip	*	*	*
438	Admittance Protection	Oversusceptance Trip	BN> Trip	*	*	*
439	PSL	External Initiate AR Protection Trip	Ext AR Prot Trip		*	*
440	PSL	External Initiate AR Protection Start	Ext AR Prot Strt		*	*
441	PSL	Initiate Test Mode	Test Mode	*	*	*
442	PSL	Inhibit SEF Protection - All Stages	Inhibit SEF	*	*	*
443	Voltage Monitors	Live Line	Live Line		*	*
444	Voltage Monitors	Dead Line	Dead Line		*	*
445	Voltage Monitors	Live Bus	Live Bus			*
446	Voltage Monitors	Dead Bus	Dead Bus			*
447	Check Synchronisation	Check Sync Stage 1 OK	Check Sync 1 OK			*
448	Check Synchronisation	Check Sync Stage 2 OK	Check Sync 2 OK			*
449	Check Synchronisation	System Checks Inactive	SysChks Inactive			*
450	PSL	CS Stage 1 Enabled	CS1 Enabled			*
451	PSL	CS Stage 2 Enabled	CS2 Enabled			*
452	PSL	System Split Enabled	SysSplit Enabled			*
453	PSL	Delayed Autoreclose Complete	DAR Complete		*	*
454	PSL	CB In Service	CB In Service		*	*
455	PSL	Autoreclose Restart	AR Restart		*	*
456	Autoreclose	Autoreclose In Progress 1	AR In Progress 1		*	*

DDB No.	Source	Description	English Text	P141	P142	P143
457	PSL	Dead Time Enabled	DeadTime Enabled		*	*
458	PSL	Dead Time OK To Start	DT OK To Start		*	*
459	Autoreclose	Dead Time Complete	DT Complete		*	*
460	Autoreclose	Reclose Checks In Progress	Reclose Checks		*	*
461	PSL	Live/Dead Circuits OK	Circuits OK		*	*
462	Autoreclose	Autoreclose Sync Check	AR Sync Check			*
463	Autoreclose	Autoreclose System Checks OK	AR SysChecksOK		*	*
464	PSL	AR Initiate Trip Test	AR Init TripTest		*	*
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DDB No.	Source	Description	English Text	P141	P142	P143
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800	Virtual Input Command	Control Input 1	Control Input 1	*	*	*
801	Virtual Input Command	Control Input 2	Control Input 2	*	*	*
802	Virtual Input Command	Control Input 3	Control Input 3	*	*	*
803	Virtual Input Command	Control Input 4	Control Input 4	*	*	*
804	Virtual Input Command	Control Input 5	Control Input 5	*	*	*
805	Virtual Input Command	Control Input 6	Control Input 6	*	*	*
806	Virtual Input Command	Control Input 7	Control Input 7	*	*	*
807	Virtual Input Command	Control Input 8	Control Input 8	*	*	*
808	Virtual Input Command	Control Input 9	Control Input 9	*	*	*
809	Virtual Input Command	Control Input 10	Control Input 10	*	*	*
810	Virtual Input Command	Control Input 11	Control Input 11	*	*	*
811	Virtual Input Command	Control Input 12	Control Input 12	*	*	*
812	Virtual Input Command	Control Input 13	Control Input 13	*	*	*
813	Virtual Input Command	Control Input 14	Control Input 14	*	*	*

DDB No.	Source	Description	English Text	P141	P142	P143
814	Virtual Input Command	Control Input 15	Control Input 15	*	*	*
815	Virtual Input Command	Control Input 16	Control Input 16	*	*	*
816	Virtual Input Command	Control Input 17	Control Input 17	*	*	*
817	Virtual Input Command	Control Input 18	Control Input 18	*	*	*
818	Virtual Input Command	Control Input 19	Control Input 19	*	*	*
819	Virtual Input Command	Control Input 20	Control Input 20	*	*	*
820	Virtual Input Command	Control Input 21	Control Input 21	*	*	*
821	Virtual Input Command	Control Input 22	Control Input 22	*	*	*
822	Virtual Input Command	Control Input 23	Control Input 23	*	*	*
823	Virtual Input Command	Control Input 24	Control Input 24	*	*	*
824	Virtual Input Command	Control Input 25	Control Input 25	*	*	*
825	Virtual Input Command	Control Input 26	Control Input 26	*	*	*
826	Virtual Input Command	Control Input 27	Control Input 27	*	*	*
827	Virtual Input Command	Control Input 28	Control Input 28	*	*	*
828	Virtual Input Command	Control Input 29	Control Input 29	*	*	*
829	Virtual Input Command	Control Input 30	Control Input 30	*	*	*
830	Virtual Input Command	Control Input 31	Control Input 31	*	*	*
831	Virtual Input Command	Control Input 32	Control Input 32	*	*	*
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DDB No.	Source	Description	English Text	P141	P142	P143
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DDB No.	Source	Description	English Text	P141	P142	P143
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919		Unused				
920		Unused				
921		Unused				
922	Disturbance Recorder	Unused				
923	PSL	PSL Internal Node 1		*	*	*
924	PSL	PSL Internal Node 2		*	*	*
925	PSL	PSL Internal Node 3		*	*	*
926	PSL	PSL Internal Node 4		*	*	*
927	PSL	PSL Internal Node 5		*	*	*
928	PSL	PSL Internal Node 6		*	*	*
929	PSL	PSL Internal Node 7		*	*	*
930	PSL	PSL Internal Node 8		*	*	*
931	PSL	PSL Internal Node 9		*	*	*
932	PSL	PSL Internal Node 10		*	*	*
933	PSL	PSL Internal Node 11		*	*	*
934	PSL	PSL Internal Node 12		*	*	*
935	PSL	PSL Internal Node 13		*	*	*
936	PSL	PSL Internal Node 14		*	*	*
937	PSL	PSL Internal Node 15		*	*	*
938	PSL	PSL Internal Node 16		*	*	*
939	PSL	PSL Internal Node 17		*	*	*
940	PSL	PSL Internal Node 18		*	*	*
941	PSL	PSL Internal Node 19		*	*	*
942	PSL	PSL Internal Node 20		*	*	*
943	PSL	PSL Internal Node 21		*	*	*
944	PSL	PSL Internal Node 22		*	*	*
945	PSL	PSL Internal Node 23		*	*	*
946	PSL	PSL Internal Node 24		*	*	*
947	PSL	PSL Internal Node 25		*	*	*
948	PSL	PSL Internal Node 26		*	*	*
949	PSL	PSL Internal Node 27		*	*	*
950	PSL	PSL Internal Node 28		*	*	*
951	PSL	PSL Internal Node 29		*	*	*
952	PSL	PSL Internal Node 30		*	*	*
953	PSL	PSL Internal Node 31		*	*	*
954	PSL	PSL Internal Node 32		*	*	*
955	PSL	PSL Internal Node 33		*	*	*
956	PSL	PSL Internal Node 34		*	*	*
957	PSL	PSL Internal Node 35		*	*	*
958	PSL	PSL Internal Node 36		*	*	*
959	PSL	PSL Internal Node 37		*	*	*
960	PSL	PSL Internal Node 38		*	*	*
961	PSL	PSL Internal Node 39		*	*	*
962	PSL	PSL Internal Node 40		*	*	*
963	PSL	PSL Internal Node 41		*	*	*
964	PSL	PSL Internal Node 42		*	*	*
965	PSL	PSL Internal Node 43		*	*	*
966	PSL	PSL Internal Node 44		*	*	*

DDB No.	Source	Description	English Text	P141	P142	P143
967	PSL	PSL Internal Node 45		*	*	*
968	PSL	PSL Internal Node 46		*	*	*
969	PSL	PSL Internal Node 47		*	*	*
970	PSL	PSL Internal Node 48		*	*	*
971	PSL	PSL Internal Node 49		*	*	*
972	PSL	PSL Internal Node 50		*	*	*
973	PSL	PSL Internal Node 51		*	*	*
974	PSL	PSL Internal Node 52		*	*	*
975	PSL	PSL Internal Node 53		*	*	*
976	PSL	PSL Internal Node 54		*	*	*
977	PSL	PSL Internal Node 55		*	*	*
978	PSL	PSL Internal Node 56		*	*	*
979	PSL	PSL Internal Node 57		*	*	*
980	PSL	PSL Internal Node 58		*	*	*
981	PSL	PSL Internal Node 59		*	*	*
982	PSL	PSL Internal Node 60		*	*	*
983	PSL	PSL Internal Node 61		*	*	*
984	PSL	PSL Internal Node 62		*	*	*
985	PSL	PSL Internal Node 63		*	*	*
986	PSL	PSL Internal Node 64		*	*	*
987	PSL	PSL Internal Node 65		*	*	*
988	PSL	PSL Internal Node 66		*	*	*
989	PSL	PSL Internal Node 67		*	*	*
990	PSL	PSL Internal Node 68		*	*	*
991	PSL	PSL Internal Node 69		*	*	*
992	PSL	PSL Internal Node 70		*	*	*
993	PSL	PSL Internal Node 71		*	*	*
994	PSL	PSL Internal Node 72		*	*	*
995	PSL	PSL Internal Node 73		*	*	*
996	PSL	PSL Internal Node 74		*	*	*
997	PSL	PSL Internal Node 75		*	*	*
998	PSL	PSL Internal Node 76		*	*	*
999	PSL	PSL Internal Node 77		*	*	*
1000	PSL	PSL Internal Node 78		*	*	*
1001	PSL	PSL Internal Node 79		*	*	*
1002	PSL	PSL Internal Node 80		*	*	*
1003	PSL	PSL Internal Node 81		*	*	*
1004	PSL	PSL Internal Node 82		*	*	*
1005	PSL	PSL Internal Node 83		*	*	*
1006	PSL	PSL Internal Node 84		*	*	*
1007	PSL	PSL Internal Node 85		*	*	*
1008	PSL	PSL Internal Node 86		*	*	*
1009	PSL	PSL Internal Node 87		*	*	*
1010	PSL	PSL Internal Node 88		*	*	*
1011	PSL	PSL Internal Node 89		*	*	*
1012	PSL	PSL Internal Node 90		*	*	*
1013	PSL	PSL Internal Node 91		*	*	*
1014	PSL	PSL Internal Node 92		*	*	*
1015	PSL	PSL Internal Node 93		*	*	*
1016	PSL	PSL Internal Node 94		*	*	*
1017	PSL	PSL Internal Node 95		*	*	*

DDB No.	Source	Description	English Text	P141	P142	P143
1018	PSL	PSL Internal Node 96		*	*	*
1019	PSL	PSL Internal Node 97		*	*	*
1020	PSL	PSL Internal Node 98		*	*	*
1021	PSL	PSL Internal Node 99		*	*	*
1022	PSL	PSL Internal Node 100		*	*	*

Event Record Data Format

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
Logic Inputs		**Changes in opto input status**	5	0020	Binary Flag (8 bits)		*A		
					Binary Flag (8 bits)			*A	
					Binary Flag (12 bits)			*B	
					Binary Flag (16 bits)			*C	
					Binary Flag (8 bits)			*D	
					Binary Flag (16 bits)				*A
					Binary Flag (24 bits)				*C
					Binary Flag (16 bits)				*D
					Binary Flag (24 bits)				*E
					Binary Flag (32 bits)				*F
					Binary Flag (16 bits)				*G
					Value contains new opto input status				
Output Contacts		**Changes in output contact status**	4	0021	Binary Flag (7 bits)		*A		
					Binary Flag (7 bits)			*A	
					Binary Flag (11 bits)			*B	
					Binary Flag (7 bits)			*C	
					Binary Flag (15 bits)			*D	
					Binary Flag (14 bits)				*A
					Binary Flag (14 bits)				*C
					Binary Flag (22 bits)				*D
					Binary Flag (22 bits)				*E
					Binary Flag (14 bits)				*F
					Binary Flag (30 bits)				*G

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
					Value contains new output contact status				
		Alarm Events:			Unsigned integer (32 bits) MSB (Bit 31) : Direction 1=ON, 0=OFF				
					32 bit offset				
Battery Fail	ON/OFF	Battery Fail	2/3	0022	0		*	*	*
Field Volt Fail	ON/OFF	Field Voltage Fail	2/3	0022	1		*	*	*
SG-opto Invalid	ON/OFF	Setting group via opto invalid	2/3	0022	2		*	*	*
Prot'n Disabled	ON/OFF	Protection Disabled	2/3	0022	3		*	*	*
F out of Range	ON/OFF	Frequency out of range	2/3	0022	4		*	*	*
VT Fail Alarm	ON/OFF	VTS Alarm	2/3	0022	5		*	*	*
CT Fail Alarm	ON/OFF	CTS Alarm	2/3	0022	6		*	*	*
CB Fail Alarm	ON/OFF	CB Trip Fail Protection (Latched)	0/1	0022	7		*	*	*
I^ Maint Alarm	ON/OFF	Broken current Maintenance Alarm	2/3	0022	8		*	*	*
I^ Lockout Alarm	ON/OFF	Broken current Lockout Alarm	2/3	0022	9		*	*	*
CB Ops Maint	ON/OFF	No of CB Ops Maintenance Alarm	2/3	0022	10		*	*	*
CB Ops Lockout	ON/OFF	No of CB Ops Lockout Alarm	2/3	0022	11		*	*	*
CB Op Time Maint	ON/OFF	CB Op Time Maintenance Alarm	2/3	0022	12		*	*	*
CB Op Time Lock	ON/OFF	CB Op Time Lockout Alarm	2/3	0022	13		*	*	*
Fault Freq Lock	ON/OFF	Excessive Fault Frequency Lockout Alarm	2/3	0022	14		*	*	*
CB Status Alarm	ON/OFF	CB Status Alarm (Latched)	0/1	0022	15		*	*	*
Man CB Trip Fail	ON/OFF	CB Fail Trip Control (Latched)	0/1	0022	16		*	*	*
Man CB Cls Fail	ON/OFF	CB Fail Close Control (Latched)	0/1	0022	17		*	*	*
Man CB Unhealthy	ON/OFF	No Healthy Control Close (Latched)	0/1	0022	18		*	*	*
Man No Checksync	ON/OFF	No C/S Control Close (Latched)	0/1	0022	19				*
AR Lockout	ON/OFF	AR Lockout	2/3	0022	20			*	*

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
AR CB Unhealthy	ON/OFF	AR CB Not Healthy (Latched)	0/1	0022	21			*	*
AR No Sys Checks	ON/OFF	AR No Sys Checks (Latched)	0/1	0022	22				*
System Split	ON/OFF	System Split	2/3	0022	23				*
SR User Alarm 1	ON/OFF	User Definable Alarm 1 (Self Reset)	2/3	0022	24		*	*	*
SR User Alarm 2	ON/OFF	User Definable Alarm 2 (Self Reset)	2/3	0022	25		*	*	*
SR User Alarm 3	ON/OFF	User Definable Alarm 3 (Self Reset)	2/3	0022	26		*	*	*
SR User Alarm 4	ON/OFF	User Definable Alarm 4 (Self Reset)	2/3	0022	27		*	*	*
SR User Alarm 5	ON/OFF	User Definable Alarm 5 (Self Reset)	2/3	0022	28		*	*	*
SR User Alarm 6	ON/OFF	User Definable Alarm 6 (Self Reset)	2/3	0022	29		*	*	*
SR User Alarm 7	ON/OFF	User Definable Alarm 7 (Self Reset)	2/3	0022	30		*	*	*
SR User Alarm 8	ON/OFF	User Definable Alarm 8 (Self Reset)	2/3	0022	31		*	*	*
					32 bit offset				
Unused		Reserved for Px40 Platform		0032	0		*	*	*
Unused		Reserved for Px40 Platform		0032	1		*	*	*
Unused		Reserved for Px40 Platform		0032	2		*	*	*
Unused		Reserved for Px40 Platform		0032	3		*	*	*
SR User Alarm 9	ON/OFF	User Definable Alarm 9 (Self Reset)	2/3	0032	4		*	*	*
SR User Alarm 10	ON/OFF	User Definable Alarm 10 (Self Reset)	2/3	0032	5		*	*	*
SR User Alarm 11	ON/OFF	User Definable Alarm 11 (Self Reset)	2/3	0032	6		*	*	*
SR User Alarm 12	ON/OFF	User Definable Alarm 12 (Self Reset)	2/3	0032	7		*	*	*
SR User Alarm 13	ON/OFF	User Definable Alarm 13 (Self Reset)	2/3	0032	8		*	*	*
SR User Alarm 14	ON/OFF	User Definable Alarm 14 (Self Reset)	2/3	0032	9		*	*	*
SR User Alarm 15	ON/OFF	User Definable Alarm 15 (Self Reset)	2/3	0032	10		*	*	*
SR User Alarm 16	ON/OFF	User Definable Alarm 16 (Self Reset)	2/3	0032	11		*	*	*
SR User Alarm 17	ON/OFF	User Definable Alarm 17 (Self Reset)	2/3	0032	12		*	*	*

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
SR User Alarm 18	ON/OFF	User Definable Alarm 18 (Self Reset)	2/3	0032	13		*	*	*
MR User Alarm 19	ON/OFF	User Definable Alarm 19 (Manual Reset)	0/1	0032	14		*	*	*
MR User Alarm 20	ON/OFF	User Definable Alarm 20 (Manual Reset)	0/1	0032	15		*	*	*
MR User Alarm 21	ON/OFF	User Definable Alarm 21 (Manual Reset)	0/1	0032	16		*	*	*
MR User Alarm 22	ON/OFF	User Definable Alarm 22 (Manual Reset)	0/1	0032	17		*	*	*
MR User Alarm 23	ON/OFF	User Definable Alarm 23 (Manual Reset)	0/1	0032	18		*	*	*
MR User Alarm 24	ON/OFF	User Definable Alarm 24 (Manual Reset)	0/1	0032	19		*	*	*
MR User Alarm 25	ON/OFF	User Definable Alarm 25 (Manual Reset)	0/1	0032	20		*	*	*
MR User Alarm 26	ON/OFF	User Definable Alarm 26 (Manual Reset)	0/1	0032	21		*	*	*
MR User Alarm 27	ON/OFF	User Definable Alarm 27 (Manual Reset)	0/1	0032	22		*	*	*
MR User Alarm 28	ON/OFF	User Definable Alarm 28 (Manual Reset)	0/1	0032	23		*	*	*
MR User Alarm 29	ON/OFF	User Definable Alarm 29 (Manual Reset)	0/1	0032	24		*	*	*
MR User Alarm 30	ON/OFF	User Definable Alarm 30 (Manual Reset)	0/1	0032	25		*	*	*
MR User Alarm 31	ON/OFF	User Definable Alarm 31 (Manual Reset)	0/1	0032	26		*	*	*
MR User Alarm 32	ON/OFF	User Definable Alarm 32 (Manual Reset)	0/1	0032	27		*	*	*
MR User Alarm 33	ON/OFF	User Definable Alarm 33 (Manual Reset)	0/1	0032	28		*	*	*
MR User Alarm 34	ON/OFF	User Definable Alarm 34 (Manual Reset)	0/1	0032	29		*	*	*
MR User Alarm 35	ON/OFF	User Definable Alarm 35 (Manual Reset)	0/1	0032	30		*	*	*
MR User Alarm 36	ON/OFF	User Definable Alarm 36 (Manual Reset)	0/1	0032	31		*	*	*
		Protection Events:			Unsigned integer (32 bits) MSB (Bit 31) : Direction 1=ON, 0=OFF				
					32 bit offset				
Any Trip	ON/OFF	Any Trip	6	0F22	10	74	*	*	*
I>1 Trip	ON/OFF	1st Stage O/C Trip 3ph	6	0F27	19	243	*	*	*
I>1 Trip A	ON/OFF	1st Stage O/C Trip A	6	0F27	20	244	*	*	*

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
I>1 Trip B	ON/OFF	1st Stage O/C Trip B	6	0F27	21	245	*	*	*
I>1 Trip C	ON/OFF	1st Stage O/C Trip C	6	0F27	22	246	*	*	*
I>2 Trip	ON/OFF	2nd Stage O/C Trip 3ph	6	0F27	23	247	*	*	*
I>2 Trip A	ON/OFF	2nd Stage O/C Trip A	6	0F27	24	248	*	*	*
I>2 Trip B	ON/OFF	2nd Stage O/C Trip B	6	0F27	25	249	*	*	*
I>2 Trip C	ON/OFF	2nd Stage O/C Trip C	6	0F27	26	250	*	*	*
I>3 Trip	ON/OFF	3rd Stage O/C Trip 3ph	6	0F27	27	251	*	*	*
I>3 Trip A	ON/OFF	3rd Stage O/C Trip A	6	0F27	28	252	*	*	*
I>3 Trip B	ON/OFF	3rd Stage O/C Trip B	6	0F27	29	253	*	*	*
I>3 Trip C	ON/OFF	3rd Stage O/C Trip C	6	0F27	30	254	*	*	*
I>4 Trip	ON/OFF	4th Stage O/C Trip 3ph	6	0F27	31	255	*	*	*
I>4 Trip A	ON/OFF	4th Stage O/C Trip A	6	0F28	0	256	*	*	*
I>4 Trip B	ON/OFF	4th Stage O/C Trip B	6	0F28	1	257	*	*	*
I>4 Trip C	ON/OFF	4th Stage O/C Trip C	6	0F28	2	258	*	*	*
I2> Trip	ON/OFF	Negative Sequence O/C Trip	6	0F28	3	259	*	*	*
Broken Line Trip	ON/OFF	Broken Conductor Trip	6	0F28	4	260	*	*	*
IN1>1 Trip	ON/OFF	1st Stage EF#1 Trip	6	0F28	5	261	*	*	*
IN1>2 Trip	ON/OFF	2nd Stage EF#1 Trip	6	0F28	6	262	*	*	*
IN1>3 Trip	ON/OFF	3rd Stage EF#1 Trip	6	0F28	7	263	*	*	*
IN1>4 Trip	ON/OFF	4th Stage EF#1 Trip	6	0F28	8	264	*	*	*
IN2>1 Trip	ON/OFF	1st Stage EF#2 Trip	6	0F28	9	265	*	*	*
IN2>2 Trip	ON/OFF	2nd Stage EF#2 Trip	6	0F28	10	266	*	*	*
IN2>3 Trip	ON/OFF	3rd Stage EF#2 Trip	6	0F28	11	267	*	*	*
IN2>4 Trip	ON/OFF	4th Stage EF#2 Trip	6	0F28	12	268	*	*	*
ISEF>1 Trip	ON/OFF	1st Stage SEF Trip	6	0F28	13	269	*	*	*

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
ISEF>2 Trip	ON/OFF	2nd Stage SEF Trip	6	0F28	14	270	*	*	*
ISEF>3 Trip	ON/OFF	3rd Stage SEF Trip	6	0F28	15	271	*	*	*
ISEF>4 Trip	ON/OFF	4th Stage SEF Trip	6	0F28	16	272	*	*	*
IREF> Trip	ON/OFF	REF Trip	6	0F28	17	273	*	*	*
VN>1 Trip	ON/OFF	1st Stage Residual O/V Trip	6	0F28	18	274	*	*	*
VN>2 Trip	ON/OFF	2nd Stage Residual O/V Trip	6	0F28	19	275	*	*	*
Thermal Trip	ON/OFF	Thermal Overload Trip	6	0F28	20	276	*	*	*
V2> Trip	ON/OFF	Negative Sequence O/V Trip	6	0F28	21	277	*	*	*
V<1 Trip	ON/OFF	1st Stage Phase U/V Trip 3ph	6	0F28	22	278	*	*	*
V<1 Trip A/AB	ON/OFF	1st Stage Phase U/V Trip A/AB	6	0F28	23	279	*	*	*
V<1 Trip B/BC	ON/OFF	1st Stage Phase U/V Trip B/BC	6	0F28	24	280	*	*	*
V<1 Trip C/CA	ON/OFF	1st Stage Phase U/V Trip C/CA	6	0F28	25	281	*	*	*
V<2 Trip	ON/OFF	2nd Stage Phase U/V Trip 3ph	6	0F28	26	282	*	*	*
V<2 Trip A/AB	ON/OFF	2nd Stage Phase U/V Trip A/AB	6	0F28	27	283	*	*	*
V<2 Trip B/BC	ON/OFF	2nd Stage Phase U/V Trip B/BC	6	0F28	28	284	*	*	*
V<2 Trip C/CA	ON/OFF	2nd Stage Phase U/V Trip C/CA	6	0F28	29	285	*	*	*
V>1 Trip	ON/OFF	1st Stage Phase O/V Trip 3ph	6	0F28	30	286	*	*	*
V>1 Trip A/AB	ON/OFF	1st Stage Phase O/V Trip A/AB	6	0F28	31	287	*	*	*
V>1 Trip B/BC	ON/OFF	1st Stage Phase O/V Trip B/BC	6	0F29	0	288	*	*	*
V>1 Trip C/CA	ON/OFF	1st Stage Phase O/V Trip C/CA	6	0F29	1	289	*	*	*
V>2 Trip	ON/OFF	2nd Stage Phase O/V Trip 3ph	6	0F29	2	290	*	*	*
V>2 Trip A/AB	ON/OFF	2nd Stage Phase O/V Trip A/AB	6	0F29	3	291	*	*	*
V>2 Trip B/BC	ON/OFF	2nd Stage Phase O/V Trip B/BC	6	0F29	4	292	*	*	*
V>2 Trip C/CA	ON/OFF	2nd Stage Phase O/V Trip C/CA	6	0F29	5	293	*	*	*
Any Start	ON/OFF	Any Start	6	0F29	6	294	*	*	*

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
I>1 Start	ON/OFF	1st Stage O/C Start 3ph	6	0F29	7	295	*	*	*
I>1 Start A	ON/OFF	1st Stage O/C Start A	6	0F29	8	296	*	*	*
I>1 Start B	ON/OFF	1st Stage O/C Start B	6	0F29	9	297	*	*	*
I>1 Start C	ON/OFF	1st Stage O/C Start C	6	0F29	10	298	*	*	*
I>2 Start	ON/OFF	2nd Stage O/C Start 3ph	6	0F29	11	299	*	*	*
I>2 Start A	ON/OFF	2nd Stage O/C Start A	6	0F29	12	300	*	*	*
I>2 Start B	ON/OFF	2nd Stage O/C Start B	6	0F29	13	301	*	*	*
I>2 Start C	ON/OFF	2nd Stage O/C Start C	6	0F29	14	302	*	*	*
I>3 Start	ON/OFF	3rd Stage O/C Start 3ph	6	0F29	15	303	*	*	*
I>3 Start A	ON/OFF	3rd Stage O/C Start A	6	0F29	16	304	*	*	*
I>3 Start B	ON/OFF	3rd Stage O/C Start B	6	0F29	17	305	*	*	*
I>3 Start C	ON/OFF	3rd Stage O/C Start C	6	0F29	18	306	*	*	*
I>4 Start	ON/OFF	4th Stage O/C Start 3ph	6	0F29	19	307	*	*	*
I>4 Start A	ON/OFF	4th Stage O/C Start A	6	0F29	20	308	*	*	*
I>4 Start B	ON/OFF	4th Stage O/C Start B	6	0F29	21	309	*	*	*
I>4 Start C	ON/OFF	4th Stage O/C Start C	6	0F29	22	310	*	*	*
VCO Start AB	ON/OFF	Voltage Controlled O/C Start AB	6	0F29	23	311	*	*	*
VCO Start BC	ON/OFF	Voltage Controlled O/C Start BC	6	0F29	24	312	*	*	*
VCO Start CA	ON/OFF	Voltage Controlled O/C Start CA	6	0F29	25	313	*	*	*
I2> Start	ON/OFF	Negative Sequence O/C Start	6	0F29	26	314	*	*	*
IN1>1 Start	ON/OFF	1st Stage EF#1 Start	6	0F29	27	315	*	*	*
IN1>2 Start	ON/OFF	2nd Stage EF#1 Start	6	0F29	28	316	*	*	*
IN1>3 Start	ON/OFF	3rd Stage EF#1 Start	6	0F29	29	317	*	*	*
IN1>4 Start	ON/OFF	4th Stage EF#1 Start	6	0F29	30	318	*	*	*
IN2>1 Start	ON/OFF	1st Stage EF#2 Start	6	0F29	31	319	*	*	*

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
IN2>2 Start	ON/OFF	2nd Stage EF#2 Start	6	0F2A	0	320	*	*	*
IN2>3 Start	ON/OFF	3rd Stage EF#2 Start	6	0F2A	1	321	*	*	*
IN2>4 Start	ON/OFF	4th Stage EF#2 Start	6	0F2A	2	322	*	*	*
ISEF>1 Start	ON/OFF	1st Stage SEF Start	6	0F2A	3	323	*	*	*
ISEF>2 Start	ON/OFF	2nd Stage SEF Start	6	0F2A	4	324	*	*	*
ISEF>3 Start	ON/OFF	3rd Stage SEF Start	6	0F2A	5	325	*	*	*
ISEF>4 Start	ON/OFF	4th Stage SEF Start	6	0F2A	6	326	*	*	*
VN>1 Start	ON/OFF	1st Stage Residual O/V Start	6	0F2A	7	327	*	*	*
VN>2 Start	ON/OFF	2nd Stage Residual O/V Start	6	0F2A	8	328	*	*	*
Thermal Alarm	ON/OFF	Thermal Overload Alarm	6	0F2A	9	329	*	*	*
V2> Start	ON/OFF	Negative Sequence O/V Start	6	0F2A	10	330	*	*	*
V<1 Start	ON/OFF	1st Stage Phase U/V Start 3ph	6	0F2A	11	331	*	*	*
V<1 Start A/AB	ON/OFF	1st Stage Phase U/V Start A/AB	6	0F2A	12	332	*	*	*
V<1 Start B/BC	ON/OFF	1st Stage Phase U/V Start B/BC	6	0F2A	13	333	*	*	*
V<1 Start C/CA	ON/OFF	1st Stage Phase U/V Start C/CA	6	0F2A	14	334	*	*	*
V<2 Start	ON/OFF	2nd Stage Phase U/V Start 3ph	6	0F2A	15	335	*	*	*
V<2 Start A/AB	ON/OFF	2nd Stage Phase U/V Start A/AB	6	0F2A	16	336	*	*	*
V<2 Start B/BC	ON/OFF	2nd Stage Phase U/V Start B/BC	6	0F2A	17	337	*	*	*
V<2 Start C/CA	ON/OFF	2nd Stage Phase U/V Start C/CA	6	0F2A	18	338	*	*	*
V>1 Start	ON/OFF	1st Stage Phase O/V Start 3ph	6	0F2A	19	339	*	*	*
V>1 Start A/AB	ON/OFF	1st Stage Phase O/V Start A/AB	6	0F2A	20	340	*	*	*
V>1 Start B/BC	ON/OFF	1st Stage Phase O/V Start B/BC	6	0F2A	21	341	*	*	*
V>1 Start C/CA	ON/OFF	1st Stage Phase O/V Start C/CA	6	0F2A	22	342	*	*	*
V>2 Start	ON/OFF	2nd Stage Phase O/V Start 3ph	6	0F2A	23	343	*	*	*
V>2 Start A/AB	ON/OFF	2nd Stage Phase O/V Start A/AB	6	0F2A	24	344	*	*	*

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
V>2 Start B/BC	ON/OFF	2nd Stage Phase O/V Start B/BC	6	0F2A	25	345	*	*	*
V>2 Start C/CA	ON/OFF	2nd Stage Phase O/V Start C/CA	6	0F2A	26	346	*	*	*
CLP Operation	ON/OFF	Cold Load Pickup Operation	6	0F2A	27	347	*	*	*
Bfail1 Trip 3ph	ON/OFF	tBF1 Trip 3Ph	6	0F2B	1	353	*	*	*
Bfail2 Trip 3ph	ON/OFF	tBF2 Trip 3Ph	6	0F2B	2	354	*	*	*
Control Trip	ON/OFF	Control Trip	6	0F2B	3	355	*	*	*
Control Close	ON/OFF	Control Close	6	0F2B	4	356	*	*	*
Close in Prog	ON/OFF	Control Close in Progress	6	0F2B	5	357	*	*	*
Block Main Prot	ON/OFF	AR Block Main Protection	6	0F2B	6	358		*	*
Block SEF Prot	ON/OFF	AR Block SEF Protection	6	0F2B	7	359		*	*
AR In Progress	ON/OFF	Autoreclose In Progress	6	0F2B	8	360		*	*
AR In Service	ON/OFF	Autoreclose In/Out of service	6	0F2B	9	361		*	*
Seq Counter = 1	ON/OFF	Seq Counter = 1	6	0F2B	11	363		*	*
Seq Counter = 2	ON/OFF	Seq Counter = 2	6	0F2B	12	364		*	*
Seq Counter = 3	ON/OFF	Seq Counter = 3	6	0F2B	13	365		*	*
Seq Counter = 4	ON/OFF	Seq Counter = 4	6	0F2B	14	366		*	*
Successful Close	ON/OFF	Successful Reclosure	6	0F2B	15	367		*	*
Dead T in Prog	ON/OFF	Dead Time in Progress	6	0F2B	16	368		*	*
Protection Lockt	ON/OFF	Protection Lockout of AR	6	0F2B	17	369		*	*
Reset Lckout Alm	ON/OFF	AR Reset Lockout Alarm	6	0F2B	18	370		*	*
Auto Close	ON/OFF	Auto Close/ AR Close	6	0F2B	19	371		*	*
A/R Trip Test	ON/OFF	Autoreclose trip test	6	0F2B	20	372		*	*
CB Open 3 ph	ON/OFF	3 ph CB Open	6	0F2B	26	378	*	*	*
CB Closed 3 ph	ON/OFF	3 ph CB Closed	6	0F2B	27	379	*	*	*
Stop Freq Track	ON/OFF	Stop Freq Track	6	0F2A	26	346	*	*	*

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
Start N	ON/OFF	Composite EF Start	6	0F2C	25	409	*	*	*
F<1 Start	ON/OFF	Under frequency Stage 1 Start	6	0F2D	2	418	*	*	*
F<2 Start	ON/OFF	Under frequency Stage 2 Start	6	0F2D	3	419	*	*	*
F<3 Start	ON/OFF	Under frequency Stage 3 Start	6	0F2D	4	420	*	*	*
F<4 Start	ON/OFF	Under frequency Stage 4 Start	6	0F2D	5	421	*	*	*
F>1 Start	ON/OFF	Over frequency Stage 1 Start	6	0F2D	6	422	*	*	*
F>2 Start	ON/OFF	Over frequency Stage 2 Start	6	0F2D	7	423	*	*	*
F<1 Trip	ON/OFF	Under frequency Stage 1 Trip	6	0F2D	8	424	*	*	*
F<2 Trip	ON/OFF	Under frequency Stage 2 Trip	6	0F2D	9	425	*	*	*
F<3 Trip	ON/OFF	Under frequency Stage 3 Trip	6	0F2D	10	426	*	*	*
F<4 Trip	ON/OFF	Under frequency Stage 4 Trip	6	0F2D	11	427	*	*	*
F>1 Trip	ON/OFF	Over frequency Stage 1 Trip	6	0F2D	12	428	*	*	*
F>2 Trip	ON/OFF	Over frequency Stage 2 Trip	6	0F2D	13	429	*	*	*
YN> Start	ON/OFF	Over admittance Start	6	0F2D	17	433	*	*	*
GN> Start	ON/OFF	Over conductance Start	6	0F2D	18	434	*	*	*
BN> Start	ON/OFF	Over susceptance Start	6	0F2D	19	435	*	*	*
YN> Trip	ON/OFF	Over admittance Trip	6	0F2D	20	436	*	*	*
GN> Trip	ON/OFF	Over conductance Trip	6	0F2D	21	437	*	*	*
BN> Trip	ON/OFF	Over susceptance Trip	6	0F2D	22	438	*	*	*
		General Events			Unsigned Integer (32 bits)				
Alarms Cleared		Relay Alarms Cleared	7	FFFF	0		*	*	*
Events Cleared		Relay Event Records Cleared	7	0B01	1		*	*	*
Faults Cleared		Relay Fault Records Cleared	7	0B02	2		*	*	*
Maint Cleared		Relay Maintenance Records Cleared	7	0B03	3		*	*	*
PW Unlocked UI		Password Unlocked via User Interface	7	0002	4		*	*	*

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
PW Invalid UI		Invalid Password entered on User Interface	7	0002	5		*	*	*
PW1 Modified UI		Password Level 1 Modified on User Interface	7	0002	6		*	*	*
PW2 Modified UI		Password Level 2 Modified on User Interface	7	0002	7		*	*	*
PW Expired UI		Password unlock expired User Interface	7	0002	8		*	*	*
PW Unlocked F		Password Unlocked via Front Port	7	0002	9		*	*	*
PW Invalid F		Invalid Password entered on Front Port	7	0002	10		*	*	*
PW1 Modified F		Password Level 1 Modified on Front Port	7	0002	11		*	*	*
PW2 Modified F		Password Level 2 Modified on Front Port	7	0002	12		*	*	*
PW Expired F		Password unlock expired Front Port	7	0002	13		*	*	*
PW Unlocked R		Password Unlocked via Rear Port	7	0002	14		*	*	*
PW Invalid R		Invalid Password entered on Rear Port	7	0002	15		*	*	*
PW1 Modified R		Password Level 1 Modified on Rear Port	7	0002	16		*	*	*
PW2 Modified R		Password Level 2 Modified on Rear Port	7	0002	17		*	*	*
PW Expired R		Password unlock expired Rear Port	7	0002	18		*	*	*
IRIG-B Active		IRIG-B Timesync Active (Valid Signal)	7	0805	19		*	*	*
IRIG-B Inactive		IRIG-B Timesync Inactive (No Signal)	7	0805	20		*	*	*
Time Synch		Relay Clock Adjusted	7	0801	21		*	*	*
C&S Changed		Control and Support Settings Changed	7	FFFF	22		*	*	*
Dist Changed		Disturbance Recorder Settings Changed	7	0904	23		*	*	*
Group 1 Changed		Change to Protection Setting Group 1	7	0904	24		*	*	*
Group 2 Changed		Change to Protection Setting Group 2	7	0904	25		*	*	*
Group 3 Changed		Change to Protection Setting Group 3	7	0904	26		*	*	*
Group 4 Changed		Change to Protection Setting Group 4	7	0904	27		*	*	*
ActGrp Changed		Active Group Selection Changed	7	0903	28		*	*	*
Indication Reset		Relay Indications Reset	7	01FF	29		*	*	*

Event Text	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	DDB No.	P141	P142	P143
Power On		Relay Powered Up	7	FFFF	30		*	*	*
Text		**Fault Recorder**		**Cell Ref**	**Value**	**Extraction Column**		**Record No.**	
Fault Recorded		Fault Records	8	0100	0	B000	16bit UINT		
Text		**Self Monitoring**		**Cell Ref**	**Value**	**Extraction Column**		**Record No.**	
Maint Recorded		Maintenance Records	9	FFFF	0	B100	16bit UINT		
Maintenance Record Text		**Description**			**Continuous**		**P141**	**P142**	**P143**
Fast W'dog Error		Fast Watchdog Error					*	*	*
Battery Failure		Battery Failure			*		*	*	*
BBRAM Failure		Battery Backed RAM Failure			*		*	*	*
Field Volt Fail		Field Voltage Failure			*		*	*	*
Bus Reset Error		Bus Error					*	*	*
Slow W'Dog Error		Slow Watchdog Error					*	*	*
SRAM Failure Bus		SRAM Bus Failure			*		*	*	*
SRAM Failure Blk		SRAM Block Failure			*		*	*	*
Flash Failure		Flash Checksum Error			*		*	*	*
Code Verify Fail		Software Code Verification Failure			*		*	*	*
EEPROM Failure		EEPROM Failure			*		*	*	*
Software Failure		Software Error			*		*	*	*
Hard Verify Fail		Hardware Verification Error					*	*	*
Non Standard		General Error			*		*	*	*

DNP 3.0
DEVICE PROFILE DOCUMENT

Vendor Name: **Alstom T&D Ltd Protection & Control**
Device Name: **P140 FEEDER PROTECTION Relay**, Model numbers: **P141xxxx4xx10xA and B**
P142xxxx4xx10xA and B
P143xxxx4xx10xA and B

Highest DNP Level Supported:	Device Function:
For Requests: Level 2	Master
For Responses: Level 2	✓ Slave

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the DNP V3.0 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 request qualifier code 06 (no range).

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):	Maximum Application Fragment Size (octets):
Transmitted: **292**	Transmitted: **2048**
Received: **292**	Received: **249**

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
None	✓ **None**
✓ **Fixed at 2**	Configurable
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:

Inter-character Delay:	**4 character times at selected baud rate.**
Select/Operate Arm Timeout:	**default 10s.**
Need Time Interval:	**configurable, 0 or 30min.**

DNP 3.0

DEVICE PROFILE DOCUMENT

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
Count > 1	✔ **Never**	Always	Sometimes	Configurable
Pulse On	Never	✔ **Always**	Sometimes	Configurable
Pulse Off	✔ **Never**	Always	Sometimes	Configurable
Latch On	Never	✔ **Always**	Sometimes	Configurable
Latch Off	Never	✔ **Always**	Sometimes	Configurable
Queue	✔ **Never**	Never	Sometimes	Configurable
Clear Queue	✔ **Never**	Never	Sometimes	Configurable

Reports Binary Input Change Events when no specific variation requested:

- Never
- ✔ **Only time-tagged, var 2**
- 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
- Only certain Objects
- Sometimes
- ENABLE/DISABLE UNSOLICITED Function codes supported

Sends Static Data in Unsolicited Responses:

- ✔ **Never**
- When Device Restarts
- When Status Flags Change

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

Object			REQUEST		RESPONSE	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
1	0	Binary Input - Any Variation	1	00,01,06,07, 08,17,28		
1	1	Binary Input	1	00,01,06,07, 08,17,28	129	00,01,17,28
1	2	Binary Input with Status	1	00,01,06,07, 08,17,28	129	00,01,17,28
2	0	Binary Input Change - Any Variation	1	06,07,08	129	
2	1	Binary Input Change without Time	1	06,07,08	129	17,28
2	2	Binary Input Change with Time	1	06,07,08	129	17,28
10	0	Binary Output - All Variations	1	00,01,06,07, 08,17,28		
10	2	Binary Output Status	1	00,01,06,07, 08,17,28	129	00,01,17,28
12	1	Control Relay Output Block	3,4,5,6	00,01,07,08, 17,28	129	echo
20	0	Binary Counter	1,7,8,9,10	00,01,06,07, 08,17,28		
20	1	32-Bit Binary Counter with Flag	1,7,8,9,10	00,01,06,07, 08,17,28	129	00,01,17,28
20	2	16-Bit Bianry Counter with Flag	1,7,8,9,10	00,01,06,07, 08,17,28	129	00,01,17,28
20	5	32-Bit Binary Counter without Flag	1,7,8,9,10	00,01,06,07, 08,17,28	129	00,01,17,28
20	6	16-Bit Binary Counter Without Flag	1,7,8,9,10	00,01,06,07, 08,17,28	129	00,01,17,28
21	0	Frozen Counter	1	00,01,06,07, 08,17,28		
21	1	32-Bit Frozen Counter with Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
21	2	16-Bit Frozen Counter with Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
21	9	32-Bit Frozen Counter without Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
21	10	16-Bit Frozen Counter without Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
30	0	Analog Input - All Variations	1	00,01,06,07, 08,17,28		
30	1	32-Bit Analog Input	1	00,01,06,07, 08,17,28	129	00,01,17,28
30	2	16-Bit Analog Input	1	00,01,06,07, 08,17,28	129	00,01,17,28
30	3	32-Bit Analog Input without Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
30	4	16-Bit Analog Input without Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
32	0	Analog Change Event - All Variations	1	06,07,08		
32	1	32-Bit Analog Change Event without Time	1	06,07,08	129	17,28
32	2	16-Bit Analog Change Event without Time	1	06,07,08	129	17,28

Object			REQUEST		RESPONSE	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
32	3	32-Bit Analog Change Event with Time	1	06,07,08	129	17,28
32	4	16-Bit Analog Change Event with Time	1	06,07,08	129	17,28
50	0	Time and Date - All Variations	1	00,01,06,07, 08,17,28		00,01,17,28
50	1	Time and Date	1,2	00,01,06,07, 08,17,28	129	00,01,17,28
52	2	Time Delay Fine			129	7
60	0	Class 0,1,2,3 Data	1	06		
60	1	Class 0 Data	1	06	129	00,01
60	2	Class 1 Data	1	06,07,08	129	17, 28
60	3	Class 2 Data	1	06,07,08	129	17,28
60	4	Class 3 Data	1	06,07,08	129	17,28
80	1	Internal Indications	2	00 (index = 7)		
		No Object (function code only)	13			
		No Object (function code only)	14			
		No Object (function code only)	23			

Binary Input Points
Static (Steady State) Object Number: **1**
Change Event Object Number: **2**
Request Function Code 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)**

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
			Output Relay Status			
0	0	0	Output Relay 1	0	2	FALSE
1	1	1	Output Relay 2	1	2	FALSE
2	2	2	Output Relay 3	2	2	FALSE
3	3	3	Output Relay 4	3	2	FALSE
4	4	4	Output Relay 5	4	2	FALSE
5	5	5	Output Relay 6	5	2	FALSE
6	6	6	Output Relay 7	6	2	FALSE
	7	7	Output Relay 8	7	2	FALSE
	8	8	Output Relay 9	8	2	FALSE
	9	9	Output Relay 10	9	2	FALSE
	10	10	Output Relay 11	10	2	FALSE
	11	11	Output Relay 12	11	2	FALSE
	12	12	Output Relay 13	12	2	FALSE
	13	13	Output Relay 14	13	2	FALSE
	14	14	Output Relay 15	14	2	FALSE
		15	Output Relay 16	15	2	FALSE
		16	Output Relay 17	16	2	FALSE
		17	Output Relay 18	17	2	FALSE
		18	Output Relay 19	18	2	FALSE
		19	Output Relay 20	19	2	FALSE
		20	Output Relay 21	20	2	FALSE
		21	Output Relay 22	21	2	FALSE
		22	Output Relay 23	22	2	FALSE
		23	Output Relay 24	23	2	FALSE

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
		24	Output Relay 25	24	2	FALSE
		25	Output Relay 26	25	2	FALSE
		26	Output Relay 27	26	2	FALSE
		27	Output Relay 28	27	2	FALSE
		28	Output Relay 29	28	2	FALSE
		29	Output Relay 30	29	2	FALSE
			Opto Isolator Status			
7	15	30	Opto Isolator 1	32	2	FALSE
8	16	31	Opto Isolator 2	33	2	FALSE
9	17	32	Opto Isolator 3	34	2	FALSE
10	18	33	Opto Isolator 4	35	2	FALSE
11	19	34	Opto Isolator 5	36	2	FALSE
12	20	35	Opto Isolator 6	37	2	FALSE
13	21	36	Opto Isolator 7	38	2	FALSE
14	22	37	Opto Isolator 8	39	2	FALSE
	23	38	Opto Isolator 9	40	2	FALSE
	24	39	Opto Isolator 10	41	2	FALSE
	25	40	Opto Isolator 11	42	2	FALSE
	26	41	Opto Isolator 12	43	2	FALSE
	27	42	Opto Isolator 13	44	2	FALSE
	28	43	Opto Isolator 14	45	2	FALSE
	29	44	Opto Isolator 15	46	2	FALSE
	30	45	Opto Isolator 16	47	2	FALSE
		46	Opto Isolator 17	48	2	FALSE
		47	Opto Isolator 18	49	2	FALSE
		48	Opto Isolator 19	50	2	FALSE
		49	Opto Isolator 20	51	2	FALSE
		50	Opto Isolator 21	52	2	FALSE

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
		51	Opto Isolator 22	53	2	FALSE
		52	Opto Isolator 23	54	2	FALSE
		53	Opto Isolator 24	55	2	FALSE
		54	Opto Isolator 25	56	2	FALSE
		55	Opto Isolator 26	57	2	FALSE
		56	Opto Isolator 27	58	2	FALSE
		57	Opto Isolator 28	59	2	FALSE
		58	Opto Isolator 29	60	2	FALSE
		59	Opto Isolator 30	61	2	FALSE
		60	Opto Isolator 31	62	2	FALSE
		61	Opto Isolator 32	63	2	FALSE
			Alarm Indications			
15	31	62	Field Voltage Fail	410	2	FALSE
16	32	63	Setting Group Via Opto Invalid	145	2	FALSE
17	33	64	Protection Disabled	146	2	FALSE
18	34	65	Frequency Out Of Range	147	2	FALSE
19	35	66	VT Fail Alarm	148	2	FALSE
20	36	67	CT Fail Alarm	149	2	FALSE
21	37	68	CB Fail Alarm	150	2	FALSE
22	38	69	Broken Current Maintenance Alarm	151	2	FALSE
23	39	70	Broken Current Lockout Alarm	152	2	FALSE
24	40	71	Number of CB Operations Maintenance Alarm	153	2	FALSE
25	41	72	Number of CB Operations Lockout Alarm	154	2	FALSE
26	42	73	CB Operation Time Maintenance Alarm	155	2	FALSE
27	43	74	CB Operation Time Lockout Alarm	156	2	FALSE
28	44	75	Excessive Fault Frequency Lockout Alarm	157	2	FALSE
29	45	76	CB Status Alarm	158	2	FALSE
30	46	77	Manual CB Failed to Trip	159	2	FALSE

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
31	47	78	Manual CB Failed to Close	160	2	FALSE
32	48	79	CB Not Healthy for Manual Close	161	2	FALSE
		80	CB No Check Sync for Manual Close	162	2	FALSE
	49	81	Auto Recloser Lockout	163	2	FALSE
	50	82	CB Not Healthy for A/R Close	164	2	FALSE
		83	CB No Check Sync for A/R Close	165	2	FALSE
		84	System Split Alarm (Self Reset)	166	2	FALSE
33	51	85	User Definable Alarm 1 (Self Reset)	167	2	FALSE
34	52	86	User Definable Alarm 2 (Self Reset)	168	2	FALSE
35	53	87	User Definable Alarm 3 (Self Reset)	169	2	FALSE
36	54	88	User Definable Alarm 4 (Self Reset)	170	2	FALSE
37	55	89	User Definable Alarm 5 (Self Reset)	171	2	FALSE
38	56	90	User Definable Alarm 6 (Self Reset)	172	2	FALSE
39	57	91	User Definable Alarm 7 (Self Reset)	173	2	FALSE
40	58	92	User Definable Alarm 8 (Self Reset)	174	2	FALSE
41	59	93	User Definable Alarm 9 (Self Reset)	175	2	FALSE
42	60	94	User Definable Alarm 10 (Self Reset)	176	2	FALSE
43	61	95	User Definable Alarm 11 (Self Reset)	177	2	FALSE
44	62	96	User Definable Alarm 12 (Self Reset)	178	2	FALSE
45	63	97	User Definable Alarm 13 (Self Reset)	179	2	FALSE
46	64	98	User Definable Alarm 14 (Self Reset)	180	2	FALSE
47	65	99	User Definable Alarm 15 (Self Reset)	181	2	FALSE
48	66	100	User Definable Alarm 16 (Self Reset)	182	2	FALSE
49	67	101	User Definable Alarm 17 (Self Reset)	183	2	FALSE
50	68	102	User Definable Alarm 18 (Self Reset)	184	2	FALSE
51	69	103	User Definable Alarm 19 (Latched)	185	2	FALSE
52	70	104	User Definable Alarm 20 (Latched)	186	2	FALSE
53	71	105	User Definable Alarm 21 (Latched)	187	2	FALSE

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
54	72	106	User Definable Alarm 22 (Latched)	188	2	FALSE
55	73	107	User Definable Alarm 23 (Latched)	189	2	FALSE
56	74	108	User Definable Alarm 24 (Latched)	190	2	FALSE
57	75	109	User Definable Alarm 25 (Latched)	191	2	FALSE
58	76	110	User Definable Alarm 26 (Latched)	192	2	FALSE
59	77	111	User Definable Alarm 27 (Latched)	193	2	FALSE
60	78	112	User Definable Alarm 28 (Latched)	194	2	FALSE
61	79	113	User Definable Alarm 29 (Latched)	195	2	FALSE
62	80	114	User Definable Alarm 30 (Latched)	196	2	FALSE
63	81	115	User Definable Alarm 31 (Latched)	197	2	FALSE
64	82	116	User Definable Alarm 32 (Latched)	198	2	FALSE
65	83	117	User Definable Alarm 33 (Latched)	199	2	FALSE
66	84	118	User Definable Alarm 34 (Latched)	200	2	FALSE
67	85	119	User Definable Alarm 35 (Latched)	201	2	FALSE
68	86	120	User Definable Alarm 36 (Latched)	202	2	FALSE
			Miscellaneous Indications			
69	87	121	Battery Status	N/A	2	FALSE
70	88	122	IRIG-B Status	N/A	2	FALSE
			Protection Events (Digital Databus Signals)			
71	89	123	Any Trip	74	2	FALSE
72	90	124	Phase Overcurrent Stage 1 3 Phase Trip	243	2	FALSE
73	91	125	Phase Overcurrent Stage 1 Phase A Trip	244	2	FALSE
74	92	126	Phase Overcurrent Stage 1 Phase B Trip	245	2	FALSE
75	93	127	Phase Overcurrent Stage 1 Phase C Trip	246	2	FALSE
76	94	128	Phase Overcurrent Stage 2 3 Phase Trip	247	2	FALSE
77	95	129	Phase Overcurrent Stage 2 Phase A Trip	248	2	FALSE
78	96	130	Phase Overcurrent Stage 2 Phase B Trip	249	2	FALSE
79	97	131	Phase Overcurrent Stage 2 Phase C Trip	250	2	FALSE

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
80	98	132	Phase Overcurrent Stage 3 3Phase Trip	251	2	FALSE
81	99	133	Phase Overcurrent Stage 3 Phase A Trip	252	2	FALSE
82	100	134	Phase Overcurrent Stage 3 Phase B Trip	253	2	FALSE
83	101	135	Phase Overcurrent Stage 3 Phase C Trip	254	2	FALSE
84	102	136	Phase Overcurrent Stage 4 3Phase Trip	255	2	FALSE
85	103	137	Phase Overcurrent Stage 4 Phase A Trip	256	2	FALSE
86	104	138	Phase Overcurrent Stage 4 Phase B Trip	257	2	FALSE
87	105	139	Phase Overcurrent Stage 4 Phase C Trip	258	2	FALSE
88	106	140	Negative Sequence Overcurrent Trip	259	2	FALSE
89	107	141	Broken Conductor Trip	260	2	FALSE
90	108	142	Earth Fault 1 Stage 1 Trip	261	2	FALSE
91	109	143	Earth Fault 1 Stage 2 Trip	262	2	FALSE
92	110	144	Earth Fault 1 Stage 3 Trip	263	2	FALSE
93	111	145	Earth Fault 1 Stage 4 Trip	264	2	FALSE
94	112	146	Earth Fault 2 Stage 1 Trip	265	2	FALSE
95	113	147	Earth Fault 2 Stage 2 Trip	266	2	FALSE
96	114	148	Earth Fault 2 Stage 3 Trip	267	2	FALSE
97	115	149	Earth Fault 2 Stage 4 Trip	268	2	FALSE
98	116	150	Sensitive Earth Fault Stage 1 Trip	269	2	FALSE
99	117	151	Sensitive Earth Fault Stage 2 Trip	270	2	FALSE
100	118	152	Sensitive Earth Fault Stage 3 Trip	271	2	FALSE
101	119	153	Sensitive Earth Fault Stage 4 Trip	272	2	FALSE
102	120	154	Restricted Earth Fault Trip	273	2	FALSE
103	121	155	Residual Over Voltage Stage 1 Trip	274	2	FALSE
104	122	156	Residual Over Voltage Stage 2 Trip	275	2	FALSE
105	123	157	Thermal Trip	276	2	FALSE
106	124	158	Negative Sequence Over Voltage Trip	277	2	FALSE
107	125	159	Phase Under Voltage Stage 1 3 Phase Trip	278	2	FALSE

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
108	126	160	Phase Under Voltage Stage 1 Phase A Trip	279	2	FALSE
109	127	161	Phase Under Voltage Stage 1 Phase B Trip	280	2	FALSE
110	128	162	Phase Under Voltage Stage 1 Phase C Trip	281	2	FALSE
111	129	163	Phase Under Voltage Stage 2 3 Phase Trip	282	2	FALSE
112	130	164	Phase Under Voltage Stage 2 Phase A Trip	283	2	FALSE
113	131	165	Phase Under Voltage Stage 2 Phase B Trip	284	2	FALSE
114	132	166	Phase Under Voltage Stage 2 Phase C Trip	285	2	FALSE
115	133	167	Phase Over Voltage Stage 1 3 Phase Trip	286	2	FALSE
116	134	168	Phase Over Voltage Stage 1 Phase A Trip	287	2	FALSE
117	135	169	Phase Over Voltage Stage 1 Phase B Trip	288	2	FALSE
118	136	170	Phase Over Voltage Stage 1 Phase C Trip	289	2	FALSE
119	137	171	Phase Over Voltage Stage 2 3 Phase Trip	290	2	FALSE
120	138	172	Phase Over Voltage Stage 2 Phase A Trip	291	2	FALSE
121	139	173	Phase Over Voltage Stage 2 Phase B Trip	292	2	FALSE
122	140	174	Phase Over Voltage Stage 2 Phase C Trip	293	2	FALSE
123	141	175	Any Start	294	2	FALSE
124	142	176	Phase Overcurrent Stage 1 3 Phase Start	295	2	FALSE
125	143	177	Phase Overcurrent Stage 1 Phase A Start	296	2	FALSE
126	144	178	Phase Overcurrent Stage 1 Phase B Start	297	2	FALSE
127	145	179	Phase Overcurrent Stage 1 Phase C Start	298	2	FALSE
128	146	180	Phase Overcurrent Stage 2 3 Phase Start	299	2	FALSE
129	147	181	Phase Overcurrent Stage 2 Phase A Start	300	2	FALSE
130	148	182	Phase Overcurrent Stage 2 Phase B Start	301	2	FALSE
131	149	183	Phase Overcurrent Stage 2 Phase C Start	302	2	FALSE
132	150	184	Phase Overcurrent Stage 3 3 Phase Start	303	2	FALSE
133	151	185	Phase Overcurrent Stage 3 Phase A Start	304	2	FALSE
134	152	186	Phase Overcurrent Stage 3 Phase B Start	305	2	FALSE
135	153	187	Phase Overcurrent Stage 3 Phase C Start	306	2	FALSE

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
136	154	188	Phase Overcurrent Stage 4 3 Phase Start	307	2	FALSE
137	155	189	Phase Overcurrent Stage 4 Phase A Start	308	2	FALSE
138	156	190	Phase Overcurrent Stage 4 Phase B Start	309	2	FALSE
139	157	191	Phase Overcurrent Stage 4 Phase C Start	310	2	FALSE
140	158	192	Voltage Controlled Overcurrent Phase AB Start	311	2	FALSE
141	159	193	Voltage Controlled Overcurrent Phase BC Start	312	2	FALSE
142	160	194	Voltage Controlled Overcurrent Phase CA Start	313	2	FALSE
143	161	195	Negative Sequence Over Current Start	314	2	FALSE
144	162	196	Earth Fault 1 Stage 1 Start	315	2	FALSE
145	163	197	Earth Fault 1 Stage 2 Start	316	2	FALSE
146	164	198	Earth Fault 1 Stage 3 Start	317	2	FALSE
147	165	199	Earth Fault 1 Stage 4 Start	318	2	FALSE
148	166	200	Earth Fault 2 Stage 1 Start	319	2	FALSE
149	167	201	Earth Fault 2 Stage 2 Start	320	2	FALSE
150	168	202	Earth Fault 2 Stage 3 Start	321	2	FALSE
151	169	203	Earth Fault 2 Stage 4 Start	322	2	FALSE
152	170	204	Sensitive Earth Fault Stage 1 Start	323	2	FALSE
153	171	205	Sensitive Earth Fault Stage 2 Start	324	2	FALSE
154	172	206	Sensitive Earth Fault Stage 3 Start	325	2	FALSE
155	173	207	Sensitive Earth Fault Stage 4 Start	326	2	FALSE
156	174	208	Residual Over Voltage Stage 1 Start	327	2	FALSE
157	175	209	Residual Over Voltage Stage 2 Start	328	2	FALSE
158	176	210	Thermal Alarm	329	2	FALSE
159	177	211	Negative Sequence Over Voltage Start	330	2	FALSE
160	178	212	Phase Under Voltage Stage 1 3 Phase Start	331	2	FALSE
161	179	213	Phase Under Voltage Stage 1 Phase A Start	332	2	FALSE
162	180	214	Phase Under Voltage Stage 1 Phase B Start	333	2	FALSE
163	181	215	Phase Under Voltage Stage 1 Phase C Start	334	2	FALSE

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
164	182	216	Phase Under Voltage Stage 2 3 Phase Start	335	2	FALSE
165	183	217	Phase Under Voltage Stage 2 Phase A Start	336	2	FALSE
166	184	218	Phase Under Voltage Stage 2 Phase B Start	337	2	FALSE
167	185	219	Phase Under Voltage Stage 2 Phase C Start	338	2	FALSE
168	186	220	Phase Over Voltage Stage 1 3 Phase Start	339	2	FALSE
169	187	221	Phase Over Voltage Stage 1 Phase A Start	340	2	FALSE
170	188	222	Phase Over Voltage Stage 1 Phase B Start	341	2	FALSE
171	189	223	Phase Over Voltage Stage 1 Phase C Start	342	2	FALSE
172	190	224	Phase Over Voltage Stage 2 3 Phase Start	343	2	FALSE
173	191	225	Phase Over Voltage Stage 2 Phase A Start	344	2	FALSE
174	192	226	Phase Over Voltage Stage 2 Phase B Start	345	2	FALSE
175	193	227	Phase Over Voltage Stage 2 Phase C Start	346	2	FALSE
176	194	228	Cold Load Pickup Operation	347	2	FALSE
177	195	229	Circuit Breaker Fail 1 Trip 3Phase	353	2	FALSE
178	196	230	Circuit Breaker Fail 2 Trip 3 Phase	354	2	FALSE
179	197	231	Control Trip	355	2	FALSE
180	198	232	Control Close	356	2	FALSE
181	199	233	Control Close in Progress	357	2	FALSE
	200	234	Auto Reclose Block Main Protection	358	2	FALSE
	201	235	Auto Reclose Block Sensitive Earth Fault Protection	359	2	FALSE
	202	236	Auto Reclose 3 Pole in Progress	360	2	FALSE
	203	237	Auto Reclose in Service	361	2	FALSE
	204	238	Auto Reclose Sequence Count 1	363	2	FALSE
	205	239	Auto Reclose Sequence Count 2	364	2	FALSE
	206	240	Auto Reclose Sequence Count 3	365	2	FALSE
	207	241	Auto Reclose Sequence Count 4	366	2	FALSE
	208	242	Auto Reclose Successful Reclose	367	2	FALSE
	209	243	Auto Reclose Dead Time in Progress	368	2	FALSE

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
	210	244	Auto Reclose Protection Lockout	369	2	FALSE
	211	245	Auto Reclose Reset Lockout Alarm	370	2	FALSE
	212	246	Auto Close	371	2	FALSE
	213	247	Auto Reclose Trip Test	372	2	FALSE
182	214	248	Earth Fault Start	409	2	FALSE
183	215	249	Underfrequency Stage 1 Start	418	2	FALSE
184	216	250	Underfrequency Stage 2 Start	419	2	FALSE
185	217	251	Underfrequency Stage 3 Start	420	2	FALSE
186	218	252	Underfrequency Stage 4 Start	421	2	FALSE
187	219	253	Overfrequency Stage 1 Start	422	2	FALSE
188	220	254	Overfrequency Stage 2 Start	423	2	FALSE
189	221	255	Underfrequency Stage 1 Trip	424	2	FALSE
190	222	256	Underfrequency Stage 2 Trip	425	2	FALSE
191	223	257	Underfrequency Stage 3 Trip	426	2	FALSE
192	224	258	Underfrequency Stage 4 Trip	427	2	FALSE
193	225	259	Overfrequency Stage 1 Trip	428	2	FALSE
194	226	260	Overfrequency Stage 2 Trip	429	2	FALSE
195	227	261	Overadmittance Start	433	2	FALSE
196	228	262	Overconductance Start	434	2	FALSE
197	229	263	Oversusceptance Start	435	2	FALSE
198	230	264	Overadmittance Trip	436	2	FALSE
199	231	265	Overconductance Trip	437	2	FALSE
200	232	266	Oversusceptance Trip	438	2	FALSE
			CB Status			
201	233	267	3 Phase CB Open	378	2	FALSE
202	234	268	3 Phase CB Closed	379	2	FALSE
203	235	269	Phase A Undercurrent	373	2	FALSE
204	236	270	Phase B Undercurrent	374	2	FALSE

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	DDB Number	Change Event Assigned Class (1,2,3)	Initial Value
205	237	271	Phase C Undercurrent	375	2	FALSE
206	238	272	Eath Fault Undercurrent	376	2	FALSE
207	239	273	Sensitive Earth Fault Undercurrent	377	2	FALSE
208	240	274	All Poles Dead	380	2	FALSE
209	241	275	Any Pole Dead	381	2	FALSE
210	242	276	Phase A Pole Dead	382	2	FALSE
211	243	277	Phase B Pole Dead	383	2	FALSE
212	244	278	Phase C Pole Dead	384	2	FALSE

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

Object Number: **12**

Request Function Code supported: **3 (select), 4 (operate), 5 (direct operate), 6 (direct operate, noack)**

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	Supported Control Relay Output Block Fields
			Activate Setting Groups	
0	0	0	Activate Setting Group 1	Note 1
1	1	1	Activate Setting Group 2	Note 1
2	2	2	Activate Setting Group 3	Note 1
3	3	3	Activate Setting Group 4	Note 1
			Controls	
4	4	4	CB Trip	Note 1
5	5	5	CB Close	Note 1
6	6	6	Reset Indication	Note 1
7	7	7	Reset Demand Measurements	Note 1
8	8	8	Reset Thermal Measurements	Note 1
9	9	9	Clear Event Log	Note 1
10	10	10	Clear Fault Log	Note 1
11	11	11	Clear Maintenance Log	Note 1
12	12	12	Test LEDs	Note 1
	13	13	Test Autoreclose	Note 1
13	14	14	Reset CB Maintenance Lockout	Note 1
	15	15	Reset Total Autoreclosures	Note 1
14	16	16	Reset Circuit Breaker Data	Note 1
	17	17	AR Telecontrol Auto	Note 1
	18	18	AR Telecontrol Non-Auto	Note 1
			Virtual Input Controls	
15	19	19	Control Input 1	Note 1
16	20	20	Control Input 2	Note 1

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	Supported Control Relay Output Block Fields
17	21	21	Control Input 3	Note 1
18	22	22	Control Input 4	Note 1
19	23	23	Control Input 5	Note 1
20	24	24	Control Input 6	Note 1
21	25	25	Control Input 7	Note 1
22	26	26	Control Input 8	Note 1
23	27	27	Control Input 9	Note 1
24	28	28	Control Input 10	Note 1
25	29	29	Control Input 11	Note 1
26	30	30	Control Input 12	Note 1
27	31	31	Control Input 13	Note 1
28	32	32	Control Input 14	Note 1
29	33	33	Control Input 15	Note 1
30	34	34	Control Input 16	Note 1
31	35	35	Control Input 17	Note 1
32	36	36	Control Input 18	Note 1
33	37	37	Control Input 19	Note 1
34	38	38	Control Input 20	Note 1
35	39	39	Control Input 21	Note 1
36	40	40	Control Input 22	Note 1
37	41	41	Control Input 23	Note 1
38	42	42	Control Input 24	Note 1
39	43	43	Control Input 25	Note 1
40	44	44	Control Input 26	Note 1
41	45	45	Control Input 27	Note 1
42	46	46	Control Input 28	Note 1
43	47	47	Control Input 29	Note 1
44	48	48	Control Input 30	Note 1
45	49	49	Control Input 31	Note 1

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	Supported Control Relay Output Block Fields
46	50	50	Control Input 32	Note 1

Note 1 - LATCH_ON and PULSE_ON operations are supported, although both have the same effect for these data points; the operation is carried out once. The queue, clear, trip/close, on time and off time fields are ignored. A read of these points through object 10 will always return zero.

Binary Counter Points

Static (Steady-State) Object Number: **20**

Request Function Code 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 Counter Points

Static (Steady State) Object Number: **21**

Request Function Code supported: **1 (read)**

Static Variation reported when variation 0 requested: 9 **(32-Bit Binary Counter without Flag)**

Change Event Variation reported when variation 0 requested: none-not supported

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	Data Type
0	0	0	3Ph WHours Fwd	D10
1	1	1	3Ph WHours Rev	D10
2	2	2	3Ph VArHours Fwd	D10
3	3	3	3Ph VArHours Rev	D10
4	4	4	CB Operations	
	5	5	Total Reclosures	
	6	6	1 Shot Clearance	
	7	7	2 Shot Clearance	
	8	8	3 Shot Clearance	
	9	9	4 Shot Clearance	
	10	10	Persistent Fault	

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)

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	Data Type	Valid Range	Change Event Deadband	Changed Event Assigned Class	Initial Value
0	0	0	Active Group	D9	1 … 4	Note 1	3	1
			Measurements 1					
1	1	1	IA Magnitude	D1	0.000…65.534	Note 1	3	0
2	2	2	IA Phase Angle	D4	-180.00…+180.00	Note 1	3	0
3	3	3	IB Magnitude	D1	0.000…65.534	Note 1	3	0
4	4	4	IB Phase Angle	D4	-180.00…+180.00	Note 1	3	0
5	5	5	IC Magnitude	D1	0.000…65.534	Note 1	3	0
6	6	6	IC Phase Angle	D4	-180.00…+180.00	Note 1	3	0
7	7	7	IN Measured Magnitude	D1	0.000…65.534	Note 1	3	0
8	8	8	IN Measured Angle	D4	-180.00…+180.00	Note 1	3	0
9	9	9	IN Derived Magnitude	D1	0.000…65.534	Note 1	3	0
10	10	10	IN Derived Angle	D4	-180.00…+180.00	Note 1	3	0
11	11	11	ISEF Magnitude	D2	0.0000…2.0000	Note 1	3	0
12	12	12	ISEF Angle	D4	-180.00…+180.00	Note 1	3	0
13	13	13	I1 Magnitude	D1	0.000…65.534	Note 1	3	0
14	14	14	I2 Magnitude	D1	0.000…65.534	Note 1	3	0
15	15	15	I0 Magnitude	D1	0.000…65.534	Note 1	3	0
16	16	16	IA RMS	D1	0.000…65.534	Note 1	3	0
17	17	17	IB RMS	D1	0.000…65.534	Note 1	3	0
18	18	18	IC RMS	D1	0.000…65.534	Note 1	3	0
19	19	19	VAB Magnitude	D3	0.00…220.00	Note 1	3	0
20	20	20	VAB Phase Angle	D4	-180.00…+180.00	Note 1	3	0
21	21	21	VBC Magnitude	D3	0.00…220.00	Note 1	3	0
22	22	22	VBC Phase Angle	D4	-180.00…+180.00	Note 1	3	0
23	23	23	VCA Magnitude	D3	0.00…220.00	Note 1	3	0

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	Data Type	Valid Range	Change Event Deadband	Changed Event Assigned Class	Initial Value
24	24	24	VCA Phase Angle	D4	-180.00…+180.00	Note 1	3	0
25	25	25	VAN Magnitude	D3	0.00…220.00	Note 1	3	0
26	26	26	VAN Phase Angle	D4	-180.00…+180.00	Note 1	3	0
27	27	27	VBN Magnitude	D3	0.00…220.00	Note 1	3	0
28	28	28	VBN Phase Angle	D4	-180.00…+180.00	Note 1	3	0
29	29	29	VCN Magnitude	D3	0.00…220.00	Note 1	3	0
30	30	30	VCN Phase Angle	D4	-180.00…+180.00	Note 1	3	0
31	31	31	VN Derived Magnitude	D3	0.00…220.00	Note 1	3	0
32	32	32	VN Derived Angle	D4	-180.00…+180.00	Note 1	3	0
33	33	33	V1 Magnitude	D3	0.00…220.00	Note 1	3	0
34	34	34	V2 Magnitude	D3	0.00…220.00	Note 1	3	0
35	35	35	V0 Magnitude	D3	0.00…220.00	Note 1	3	0
36	36	36	VAN RMS	D3	0.00…220.00	Note 1	3	0
37	37	37	VBN RMS	D3	0.00…220.00	Note 1	3	0
38	38	38	VCN RMS	D3	0.00…220.00	Note 1	3	0
39	39	39	Frequency	D5	40.00…70.00	Note 1	3	0
		40	C/S Voltage Magnitude	D3	0.00…220.00	Note 1	3	0
		41	C/S Voltage Angle	D4	-180.00…+180.00	Note 1	3	0
		42	C/S Bus-Line Angle	D4	-180.00…+180.00	Note 1	3	0
		43	Slip Frequency	D5	-70.00…+70.00	Note 1	3	0
			Measurements 2					
40	40	44	A Phase Watts	D6	-10,500…+10,500	Note 1	3	0
41	41	45	B Phase Watts	D6	-10,500…+10,500	Note 1	3	0
42	42	46	C Phase Watts	D6	-10,500…+10,500	Note 1	3	0
43	43	47	A Phase VArs	D6	-10,500…+10,500	Note 1	3	0
44	44	48	B Phase VArs	D6	-10,500…+10,500	Note 1	3	0
45	45	49	C Phase VArs	D6	-10,500…+10,500	Note 1	3	0
46	46	50	A Phase VA	D6	-10,500…+10,500	Note 1	3	0
47	47	51	B Phase VA	D6	-10,500…+10,500	Note 1	3	0

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	Data Type	Valid Range	Change Event Deadband	Changed Event Assigned Class	Initial Value
48	48	52	C Phase VA	D6	-10,500…+10,500	Note 1	3	0
49	49	53	3 Phase Watts	D6	-31,500…+31,500	Note 1	3	0
50	50	54	3 Phase VArs	D6	-31,500…+31,500	Note 1	3	0
51	51	55	3 Phase VA	D6	-31,500…+31,500	Note 1	3	0
52	52	56	3Ph Power Factor	D8	0.000…1.000	Note 1	3	0
53	53	57	APh Power Factor	D8	0.000…1.000	Note 1	3	0
54	54	58	BPh Power Factor	D8	0.000…1.000	Note 1	3	0
55	55	59	CPh Power Factor	D8	0.000…1.000	Note 1	3	0
56	56	60	3Ph W Fix Demand	D6	-31,500…+31,500	Note 1	3	0
57	57	61	3Ph VArs Fix Demand	D6	-31,500…+31,500	Note 1	3	0
58	58	62	IA Fixed Demand	D1	0.000…65.534	Note 1	3	0
59	59	63	IB Fixed Demand	D1	0.000…65.534	Note 1	3	0
60	60	64	IC Fixed Demand	D1	0.000…65.534	Note 1	3	0
61	61	65	3 Ph W Roll Demand	D6	-31,500…+31,500	Note 1	3	0
62	62	66	3 Ph VArs Roll Demand	D6	-31,500…+31,500	Note 1	3	0
63	63	67	IA Roll Demand	D1	0.000…65.534	Note 1	3	0
64	64	68	IB Roll Demand	D1	0.000…65.534	Note 1	3	0
65	65	69	IC Roll Demand	D1	0.000…65.534	Note 1	3	0
66	66	70	3Ph W Peak Demand	D6	-31,500…+31,500	Note 1	3	0
67	67	71	3Ph VAr Peak Demand	D6	-31,500…+31,500	Note 1	3	0
68	68	72	IA Peak Demand	D1	0.000…65.534	Note 1	3	0
69	69	73	IB Peak Demand	D1	0.000…65.534	Note 1	3	0
70	70	74	IC Peak Demand	D1	0.000…65.534	Note 1	3	0
			Measurements 3					
71	71	75	Highest Phase Current	D1	0.000…65.534	Note 1	3	0
72	72	76	Thermal State	D7	0.00…200.00	Note 1	3	0
73	73	77	IREF Diff	D1	0.000…65.534	Note 1	3	0
74	74	78	IREF Bias	D1	0.000…65.534	Note 1	3	0
75	75	79	Neutral Admittance	D11	-31,500…+31,500	Note 1	3	0

P141 Point Index	P142 Point Index	P143 Point Index	Name/Description	Data Type	Valid Range	Change Event Deadband	Changed Event Assigned Class	Initial Value
76	76	80	Neutral Conductance	D11	-31,500…+31,500	Note 1	3	0
77	77	81	Neutral Susceptance	D11	-31,500…+31,500	Note 1	3	0
78	78	82	Sensitive Admittance	D12	-31,500…+31,500	Note 1	3	0
79	79	83	Sensitive Conductance	D12	-31,500…+31,500	Note 1	3	0
80	80	84	Sensitive Susceptance	D12	-31,500…+31,500	Note 1	3	0
81	81	85	I2/I1 Ratio	D7	0.00…200.00	Note 1	3	0
			Addendum To Measurements 1					
82	82	86	I1 Phase Angle	D4	-180.00…+180.00	Note 1	3	0
83	83	87	I2 Phase Angle	D4	-180.00…+180.00	Note 1	3	0
84	84	88	I0 Phase Angle	D4	-180.00…+180.00	Note 1	3	0
85	85	89	V1 Phase Angle	D4	-180.00…+180.00	Note 1	3	0
86	86	90	V2 Phase Angle	D4	-180.00…+180.00	Note 1	3	0
87	87	91	V0 Phase Angle	D4	-180.00…+180.00	Note 1	3	0

Note 1 - the default deadband defined for the data type is used.

Data Types

Notes:

1 Type D6 can represent Watts, VArs or VA; the exact unit applied depends on the description of the item.

2 The default change event deadband is used unless specified otherwise in the point list.

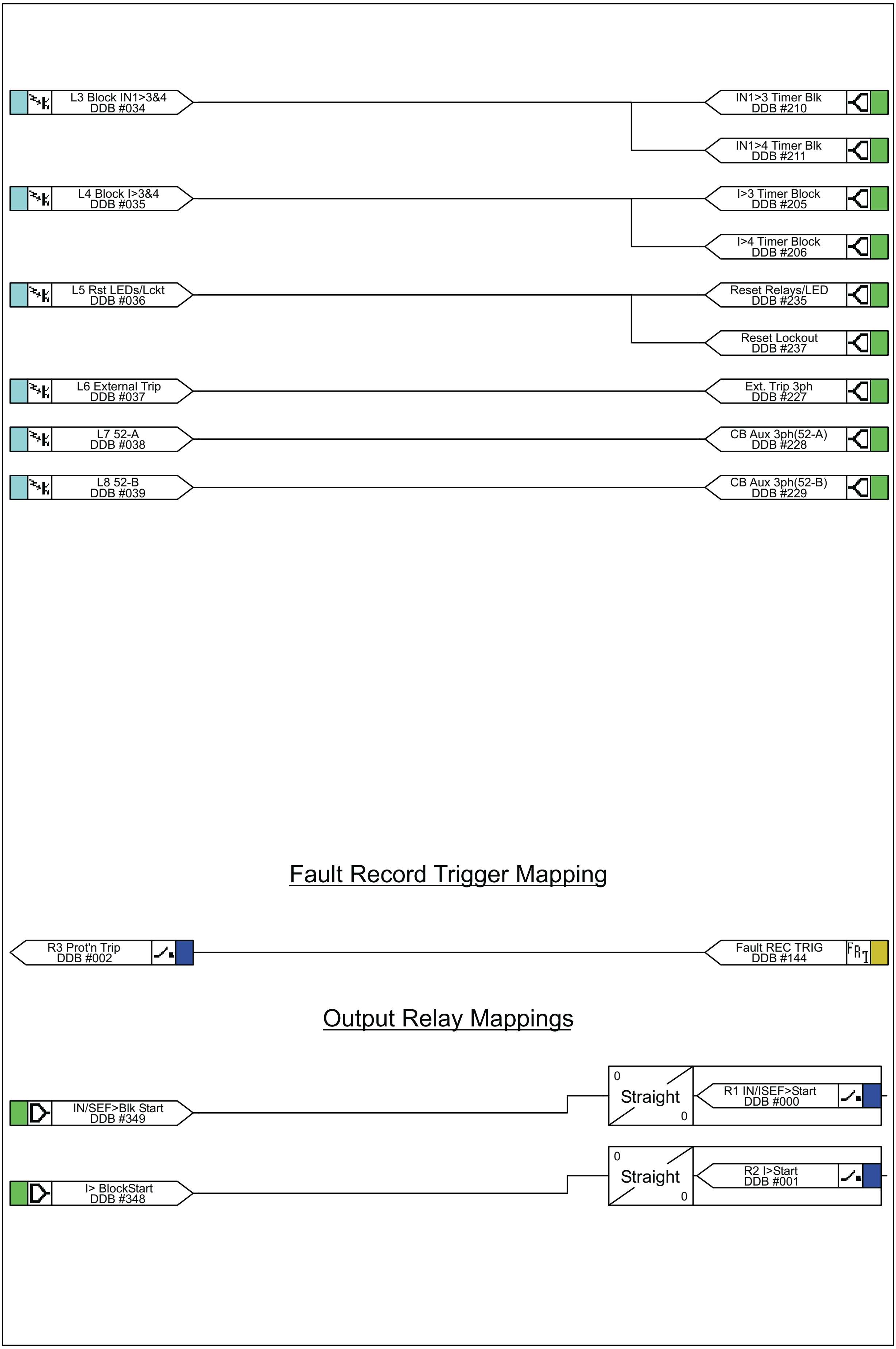
3 The scaling value represents the multiplier required at the master station.

4 I_n and V_n represent the rated current and rated voltage respectively.

Data Type	Name/Description	Scaling	DEFAULT Change Event Deadband	Change Event Deadband MIN	Change Event Deadband MAX	Change Event Deadband STEP	Units
D1	Phase, RMS, & sequence currents	x I_n / 500	0.1 I_n	0.05 I_n	64 I_n	0.01 I_n	A
D2	Sensitive neutral currents	x I_n / 10,000	0.01 I_n	0.01 I_n	2 I_n	0.001 I_n	A
D3	Voltages	x V_n /(110 x 100)	5 V_n / 110	0.1 V_n / 110	220 V_n / 110	0.1 V_n / 110	V
D4	Angles	x 0.01	1	0.1	180	0.1	°
D5	Frequency	x 0.01	0.5	0.1	70	0.1	Hz
D6	Power	x 0.1I_n .V_n / 110	I_n .V_n / 110	0.1I_n .V_n / 110	3200 I_n .V_n / 110	0.1I_n .V_n / 110	W/Var/VA
D7	Percentage	x 0.01	10	0.1	320	0.1	%
D8	Power Factor	x 0.001	0.10	0.01	1	0.01	[None]
D9	Setting Group	x 1	1	1	4	1	[None]
D10	Energy	x I_n .V_n / 110	n/a	I_n .V_n / 110	32000 I_n .V_n / 110	I_n .V_n / 110	Whr/Varhr/VAhr
D11	Admittance (I Earth Fault)	x (I_n / 1000).(110 / V_n)	(0.1 I_n).(110 / V_n)	(0.01 I_n).(110 / V_n)	32 I_n .(110 / V_n)	(0.01 I_n).(110 / V_n)	S
D12	Admittance (I SEF)	x (I_n / 10000).(110 / V_n)	(0.01 I_n).(110 / V_n)	(0.001 I_n).(110 / V_n)	2 I_n .(110 / V_n)	(0.001 I_n).(110 / V_n)	S
D13	Time (minutes)	x 0.01	5	1	30	0.5	Minutes
D14	Temperature	x 0.1	1	0.1	300	0.1	C
D15	Time (ms)	x 0.01	1	0.1	30	0.1	ms

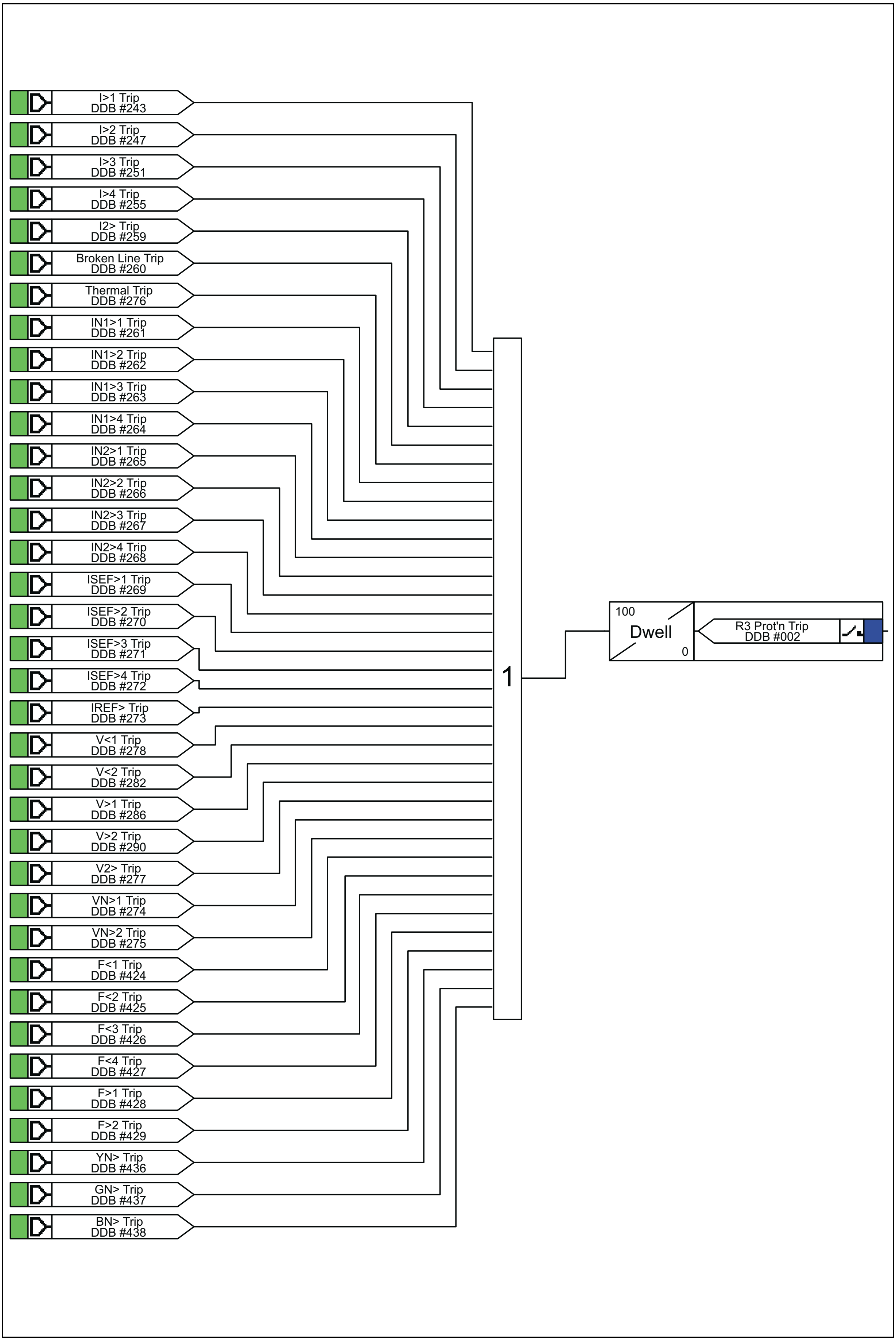
MiCOM P141 PROGRAMMABLE SCHEME LOGIC

Opto Input Mappings



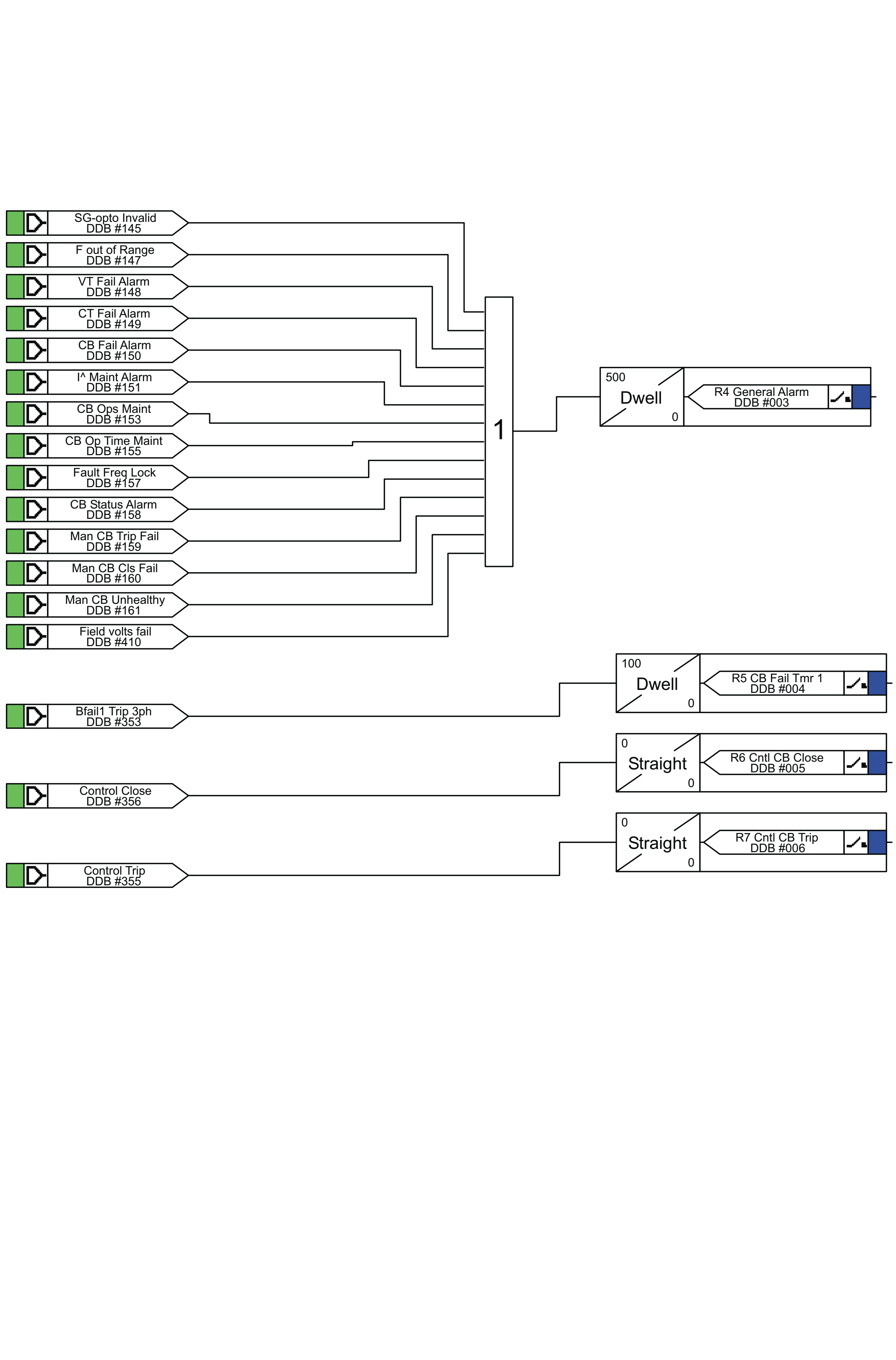
MiCOM P141 PROGRAMMABLE SCHEME LOGIC

Output Relay Mappings



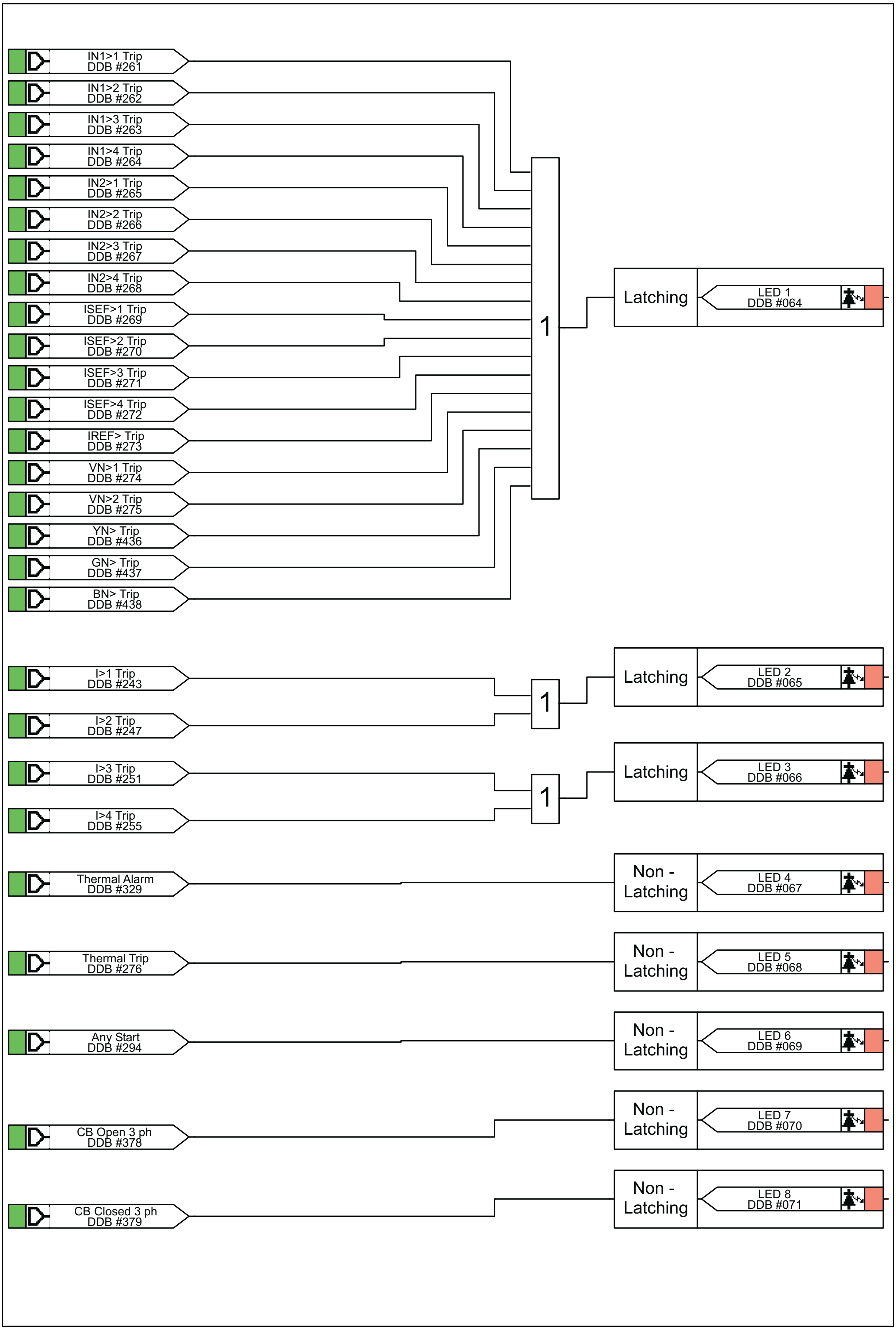
MiCOM P141 PROGRAMMABLE SCHEME LOGIC

Output Relay Mappings



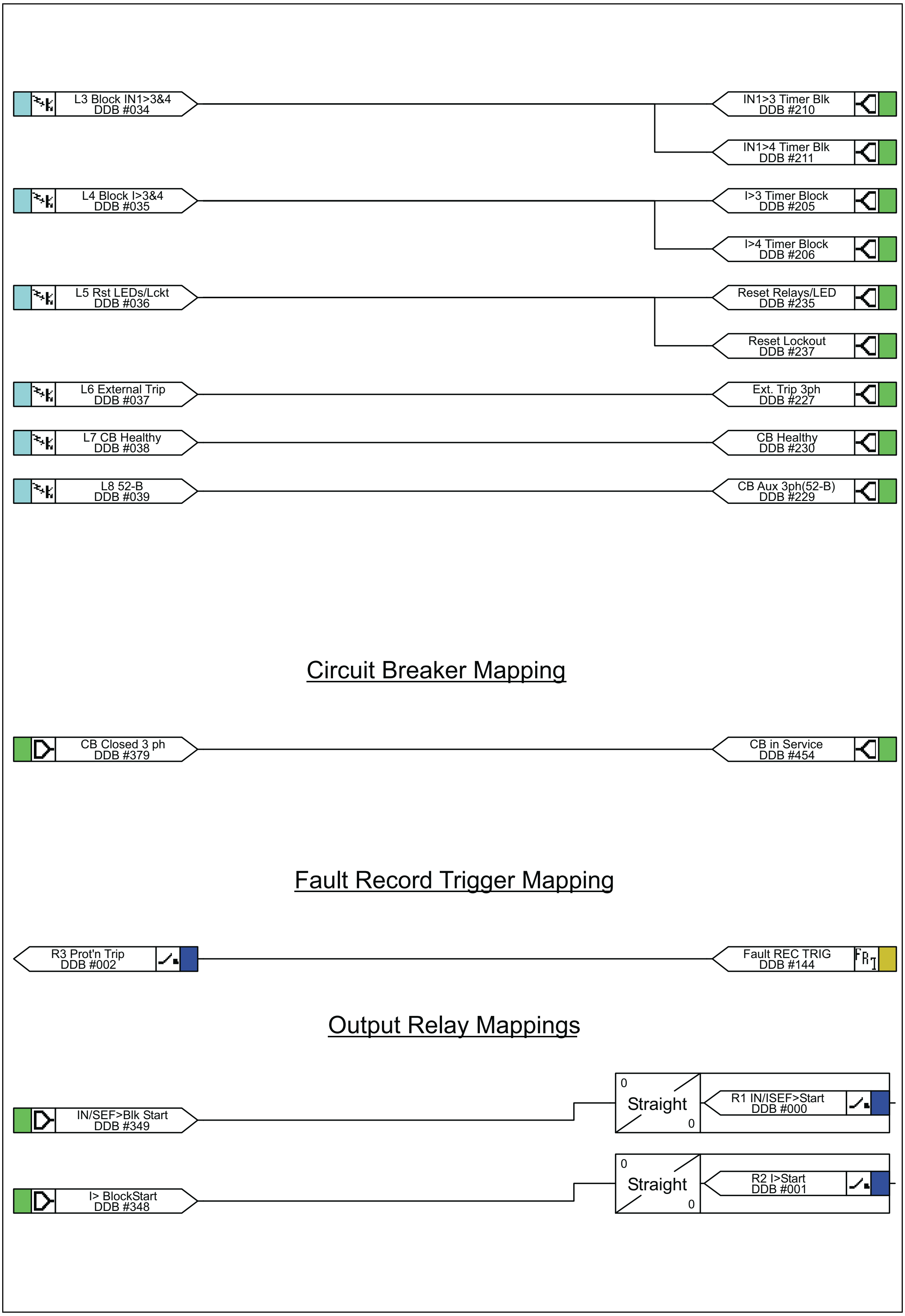
MiCOM P141 PROGRAMMABLE SCHEME LOGIC

LED Mappings



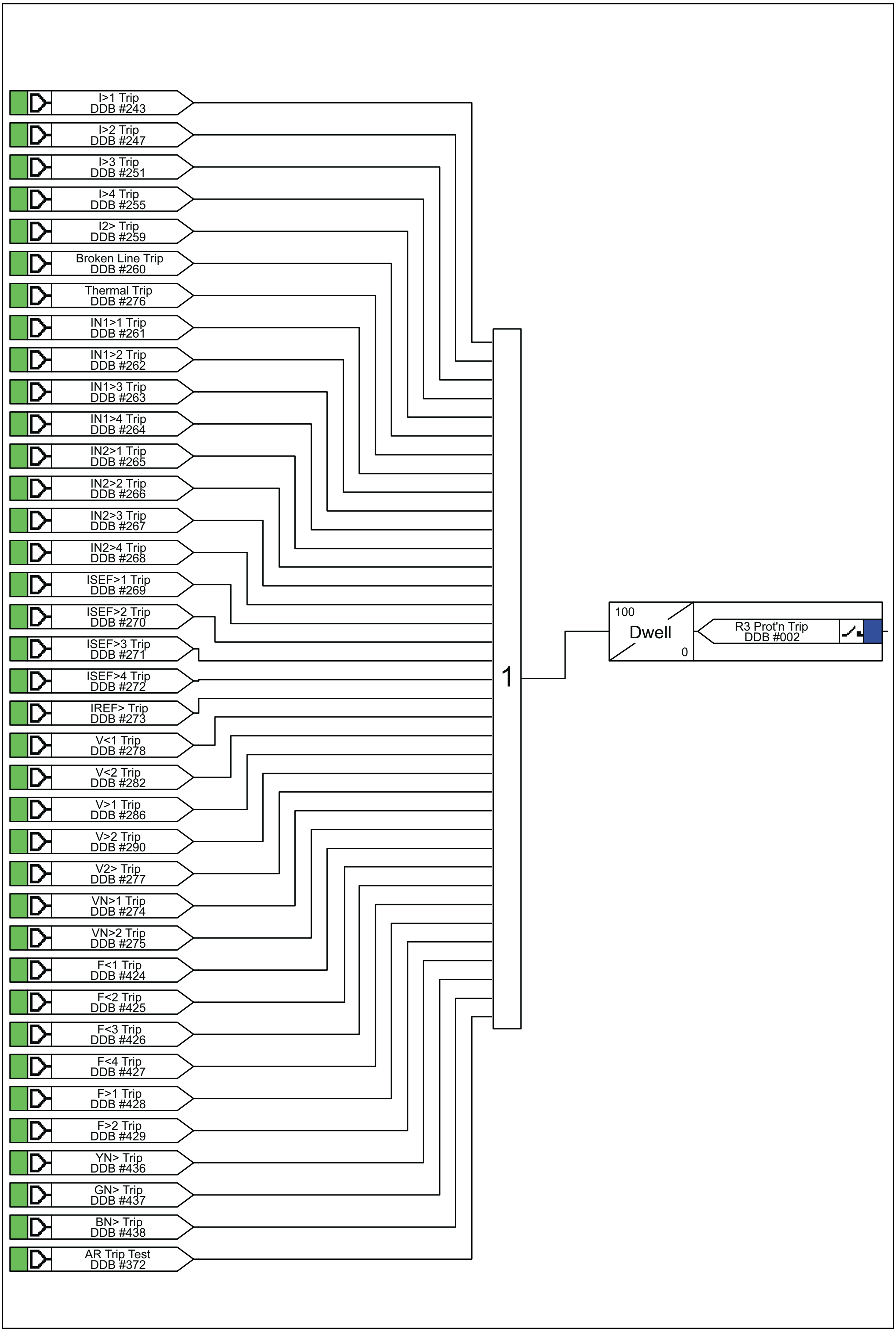
MiCOM P142 PROGRAMMABLE SCHEME LOGIC

Opto Input Mappings



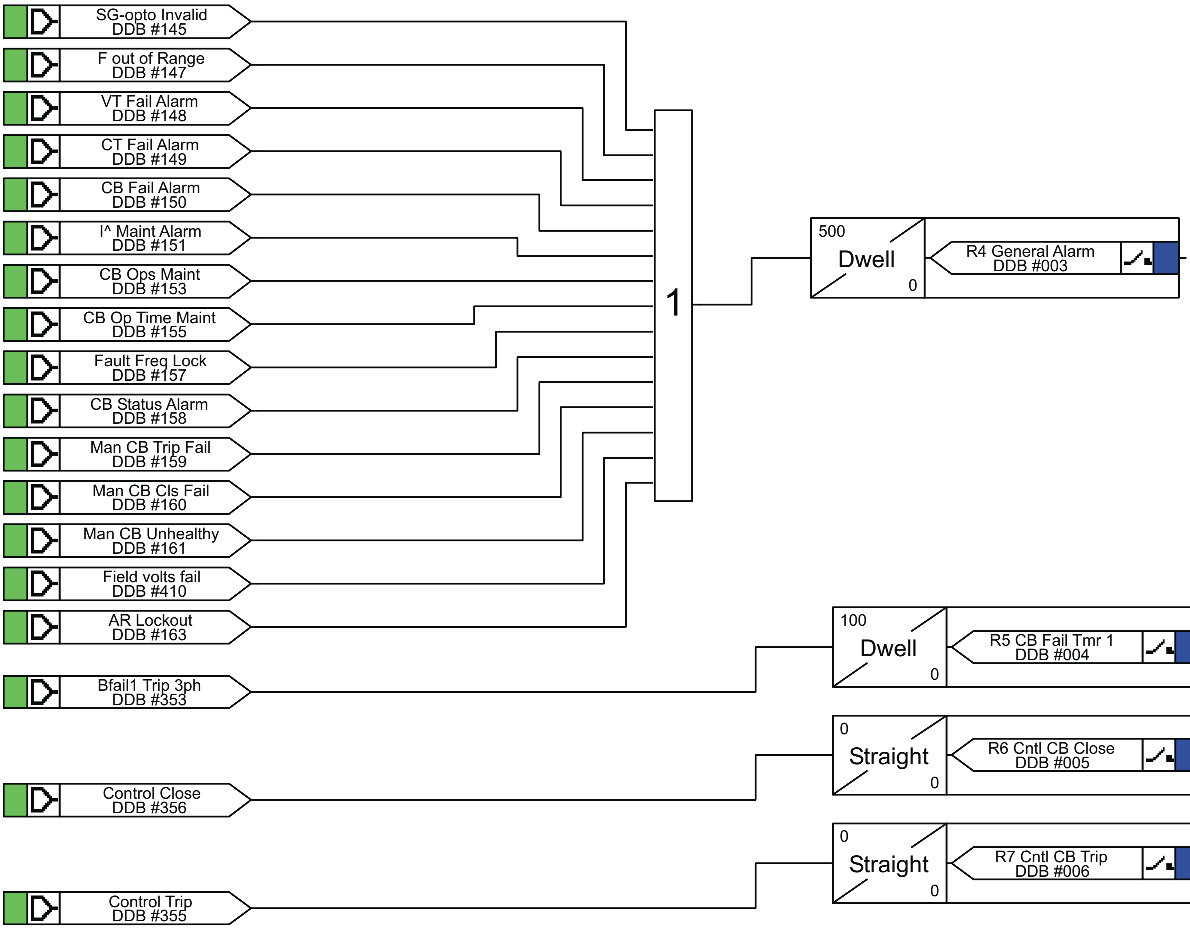
MiCOM P142 PROGRAMMABLE SCHEME LOGIC

Output Relay Mappings



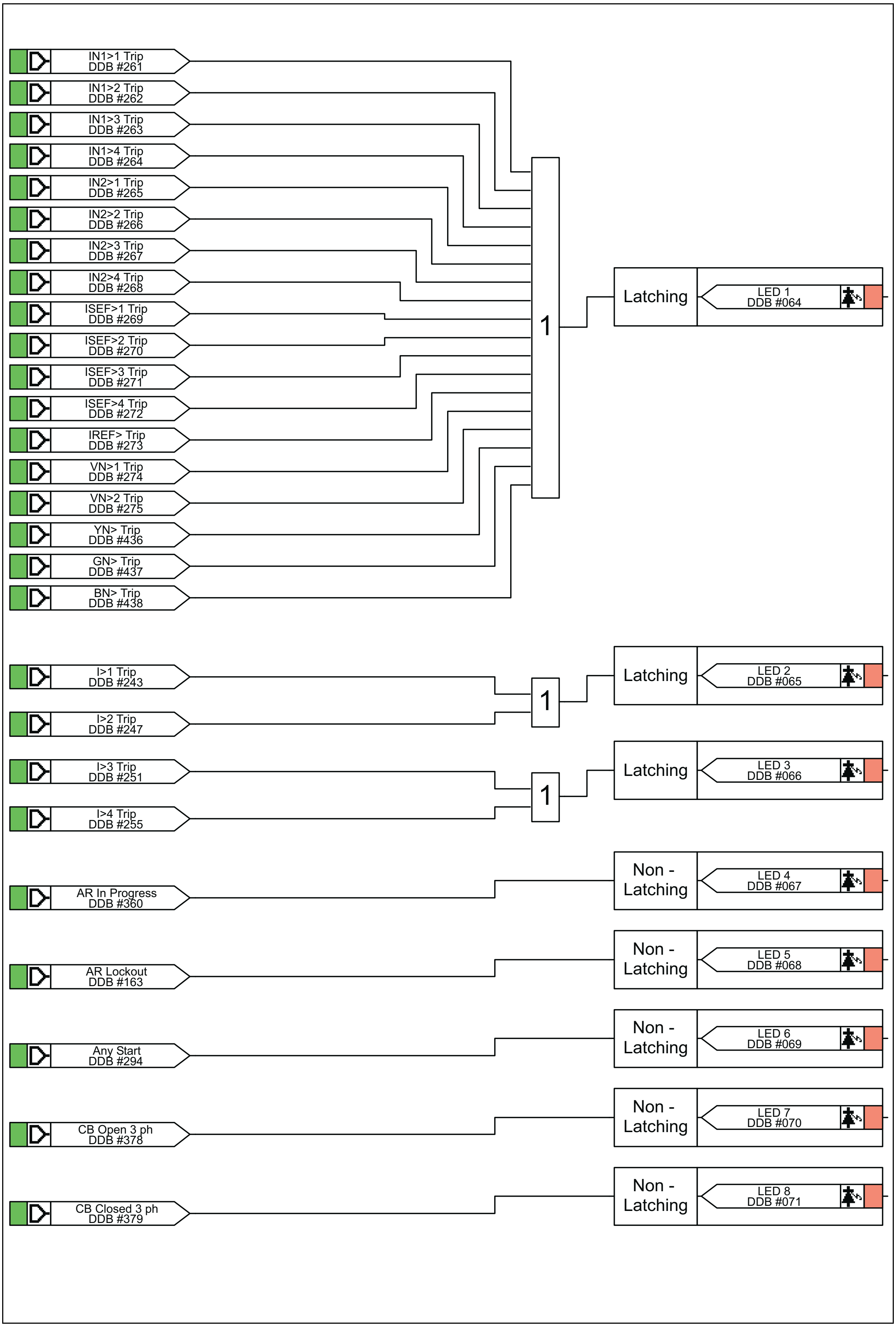
MiCOM P142 PROGRAMMABLE SCHEME LOGIC

Output Relay Mappings



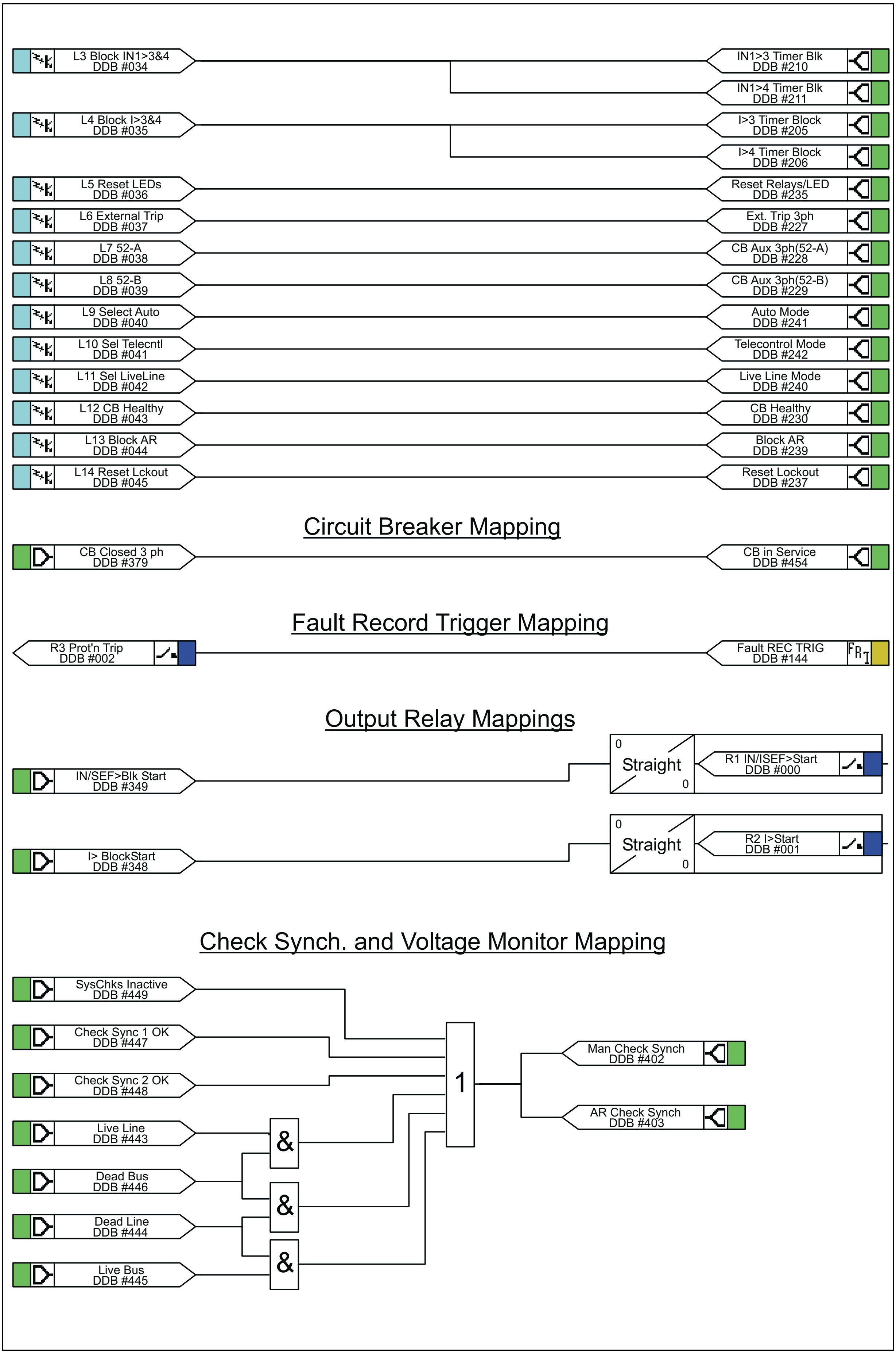
MiCOM P142 PROGRAMMABLE SCHEME LOGIC

LED Mappings



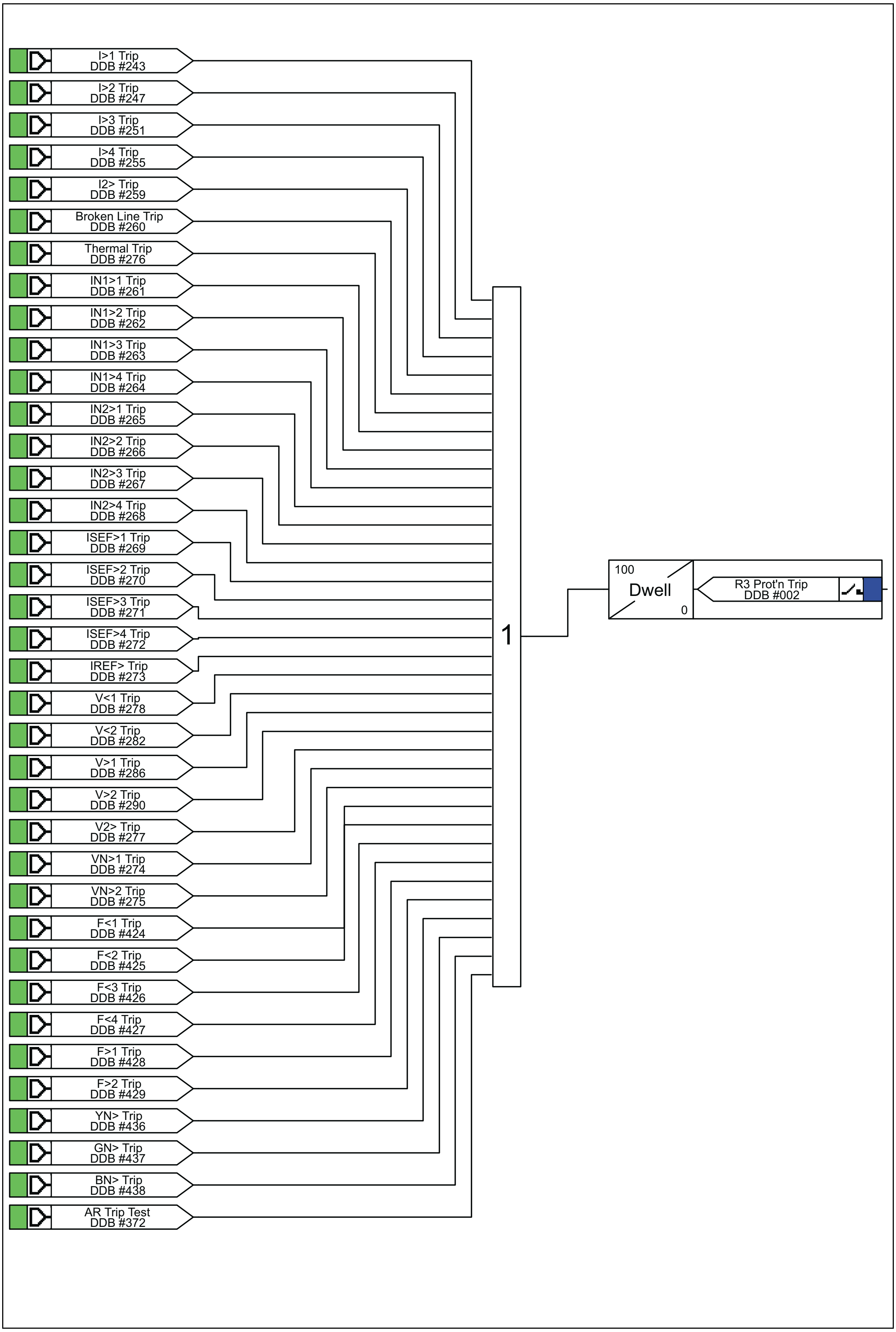
MiCOM P143 PROGRAMMABLE SCHEME LOGIC

Opto Input Mappings



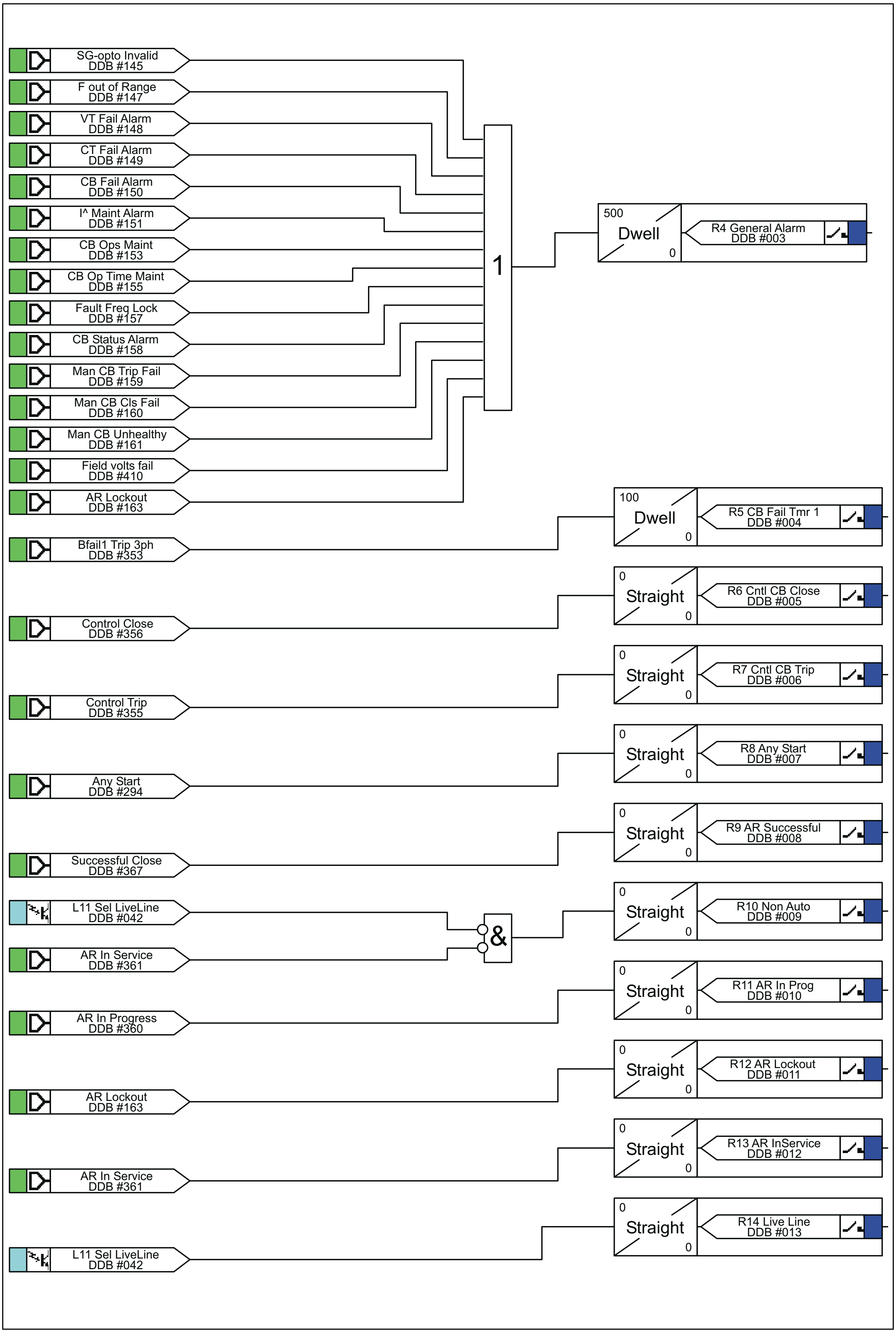
MiCOM P143 PROGRAMMABLE SCHEME LOGIC

Output Relay Mappings



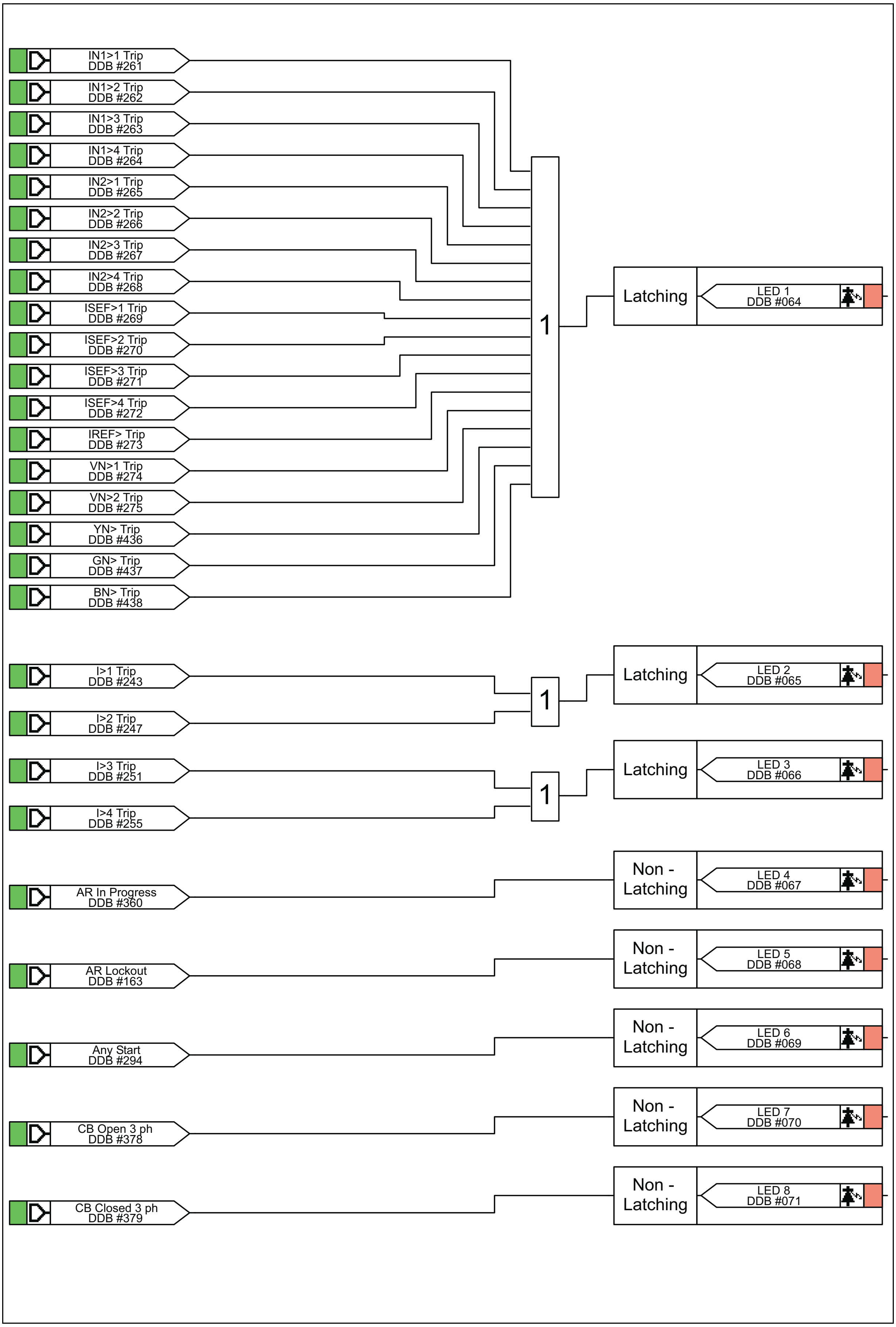
MiCOM P143 PROGRAMMABLE SCHEME LOGIC

Output Relay Mappings



MiCOM P143 PROGRAMMABLE SCHEME LOGIC

LED Mappings



APPENDIX B
External Connection Diagrams

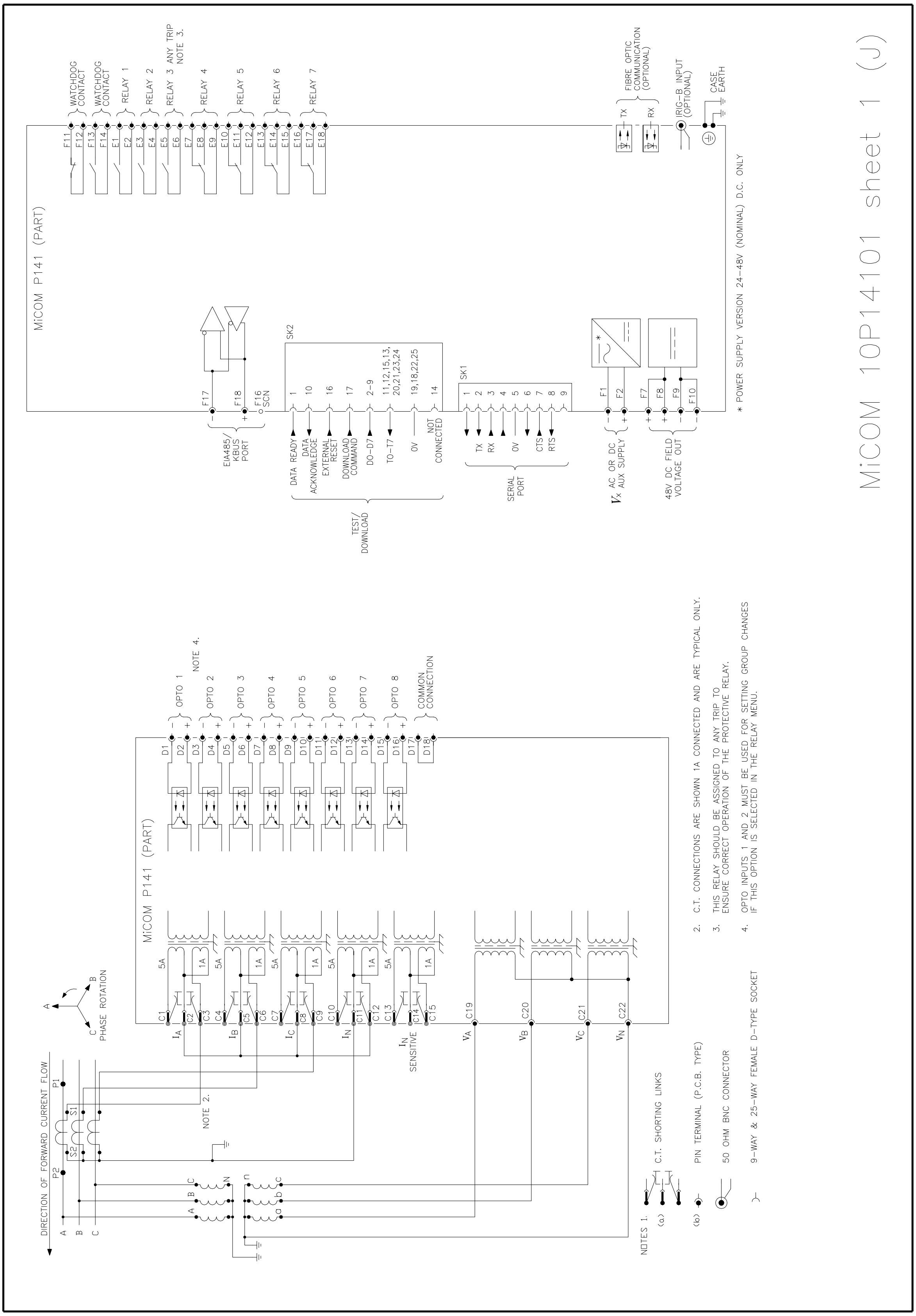


Figure 1: P141

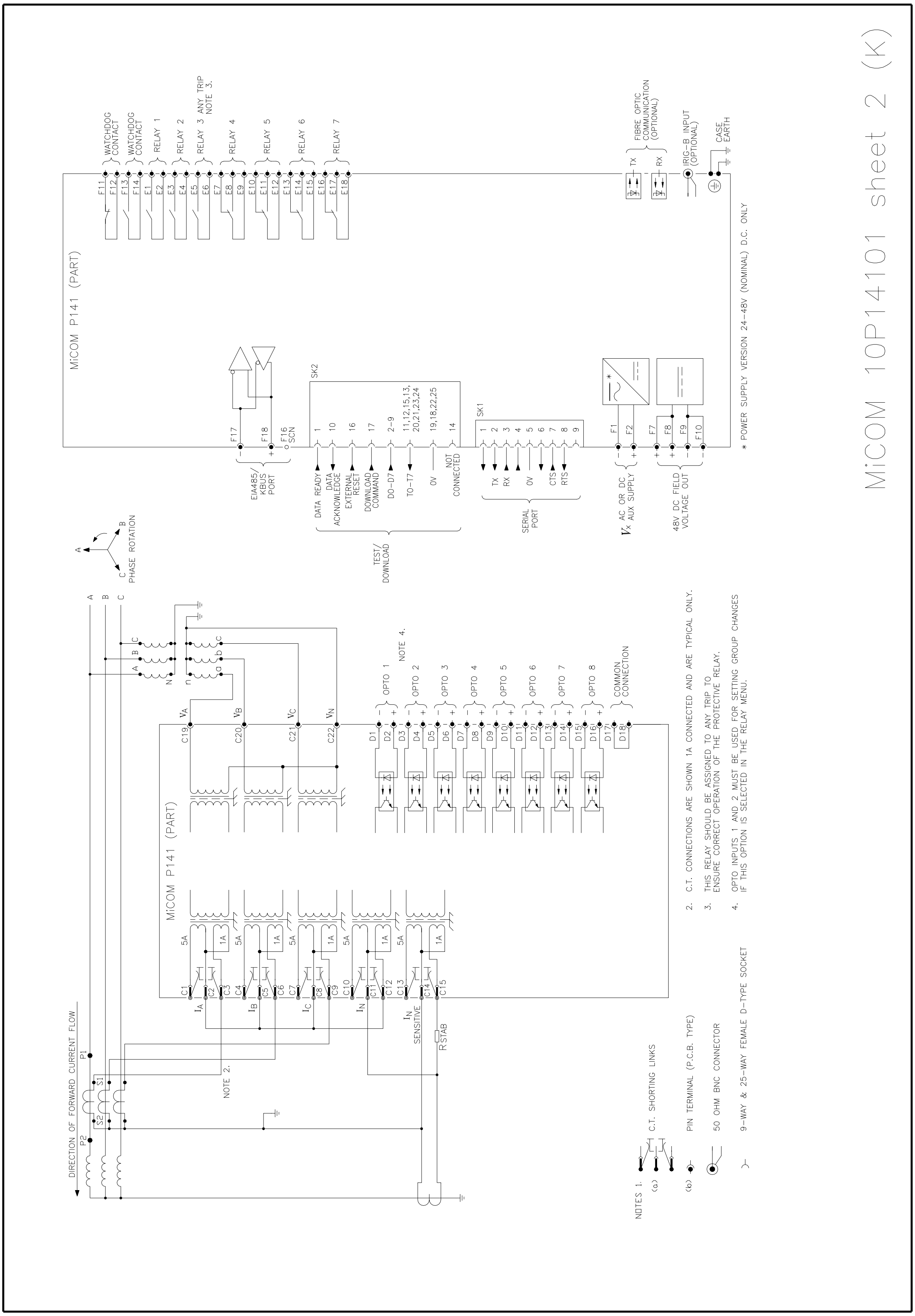


Figure 2: P141

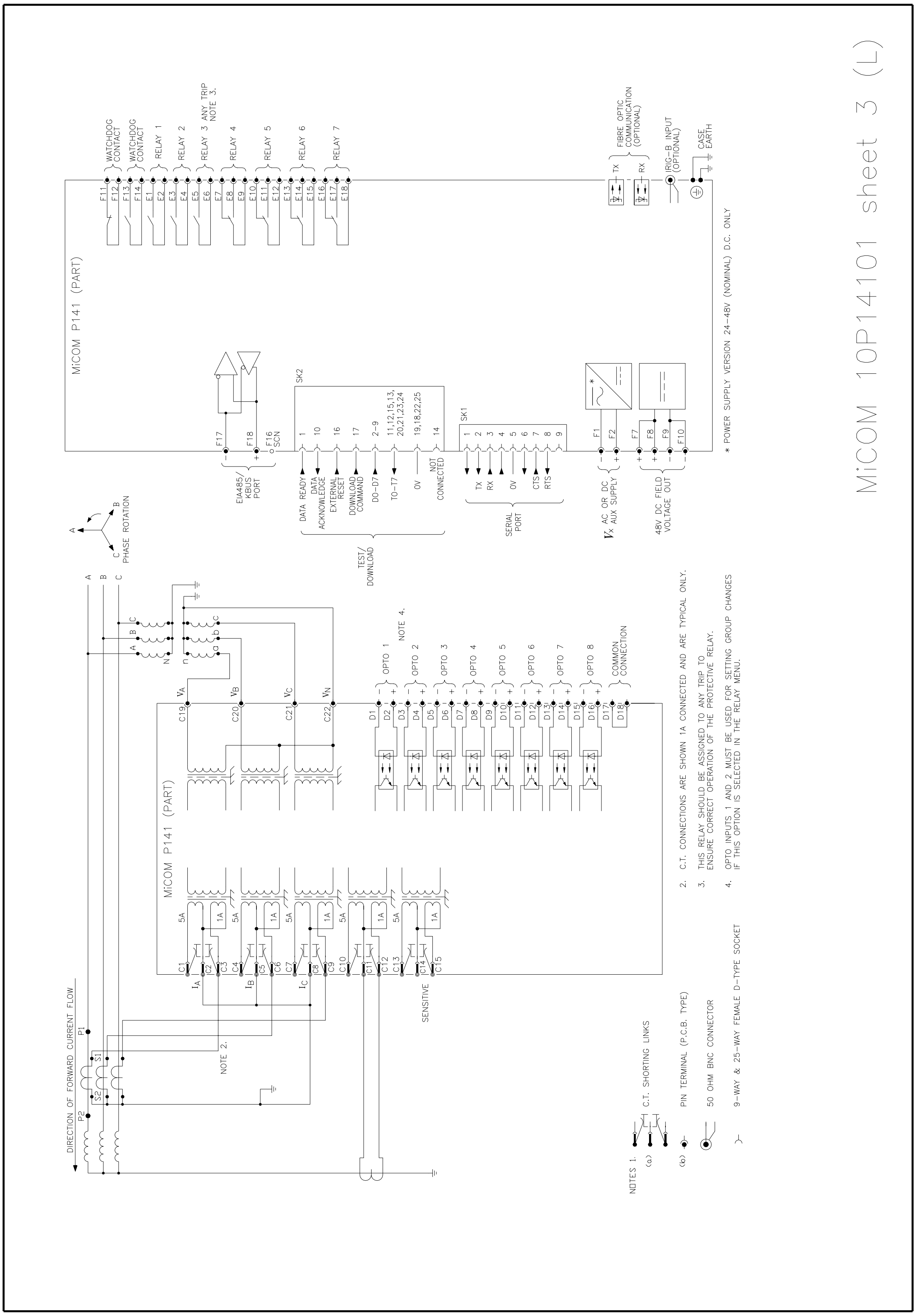


Figure 3: P141

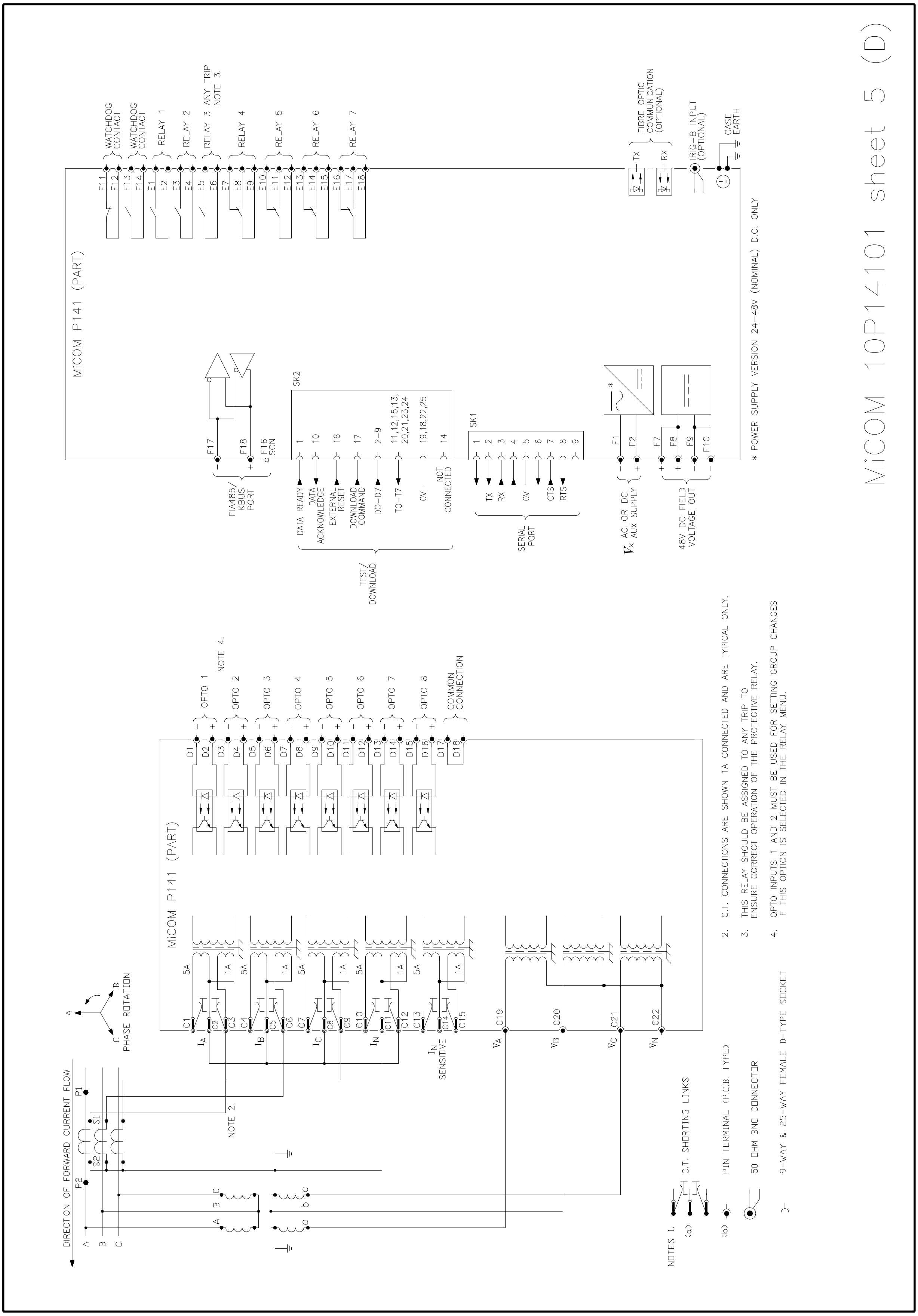


Figure 4: P141

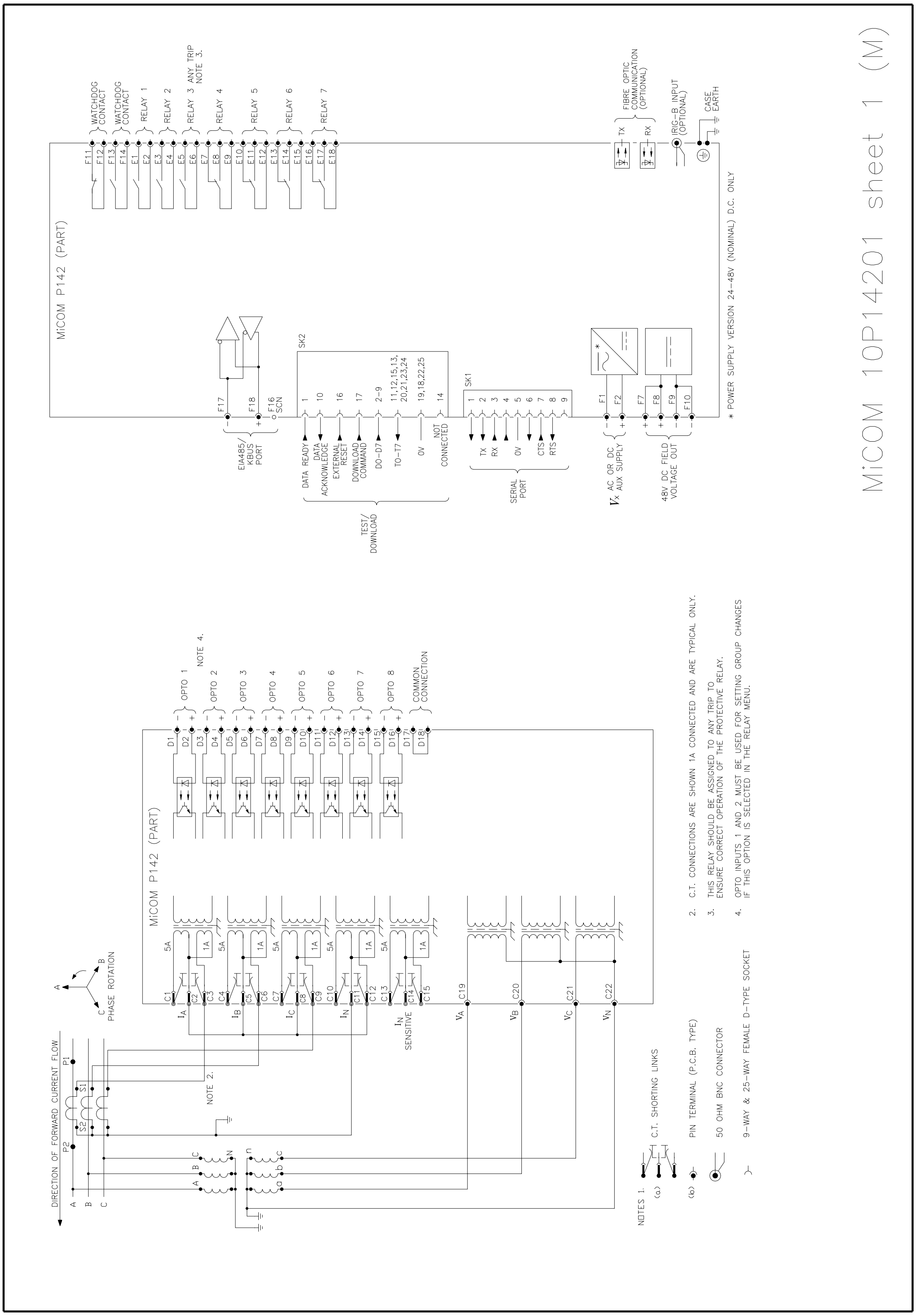


Figure 5: P142

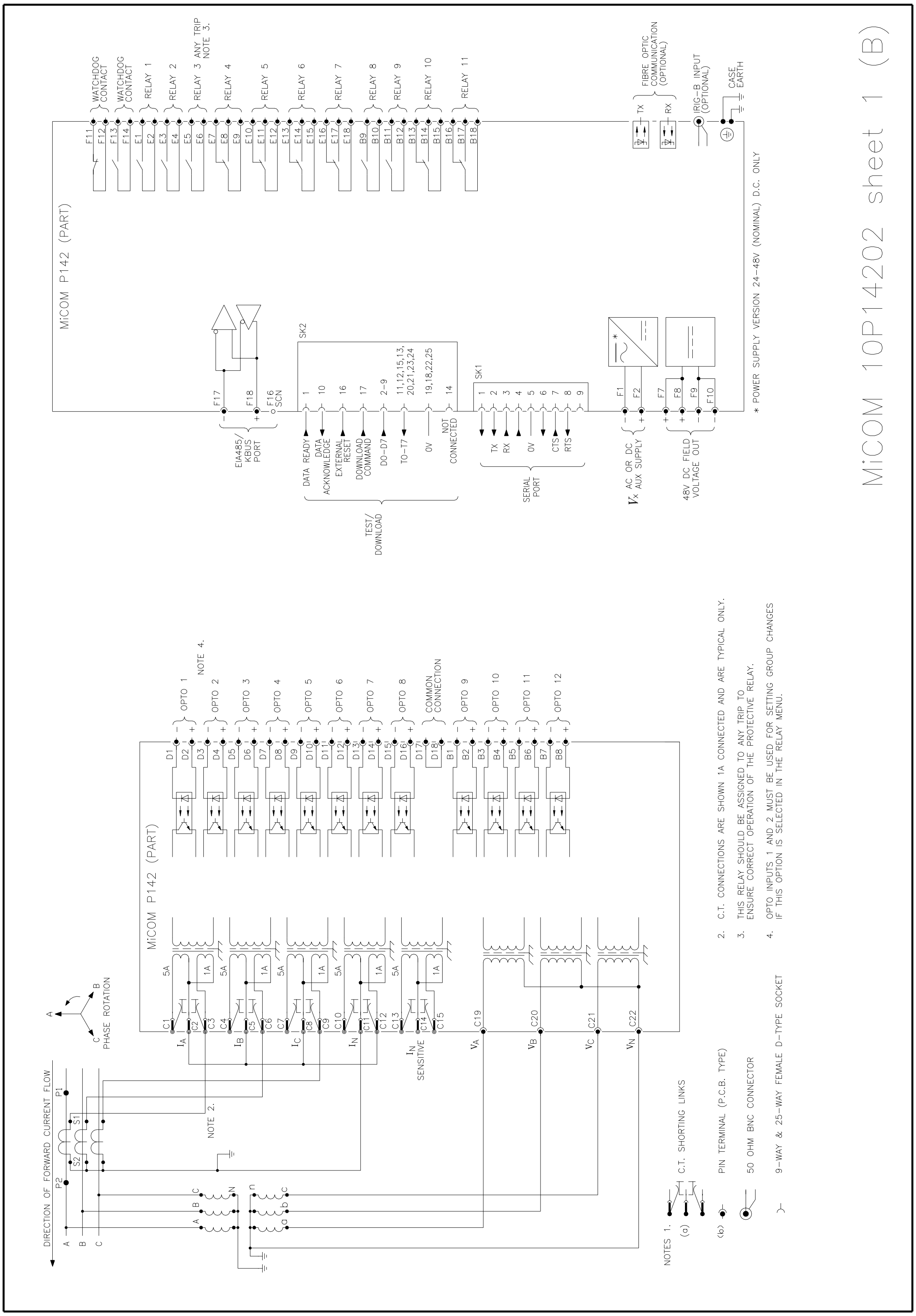


Figure 6: P142

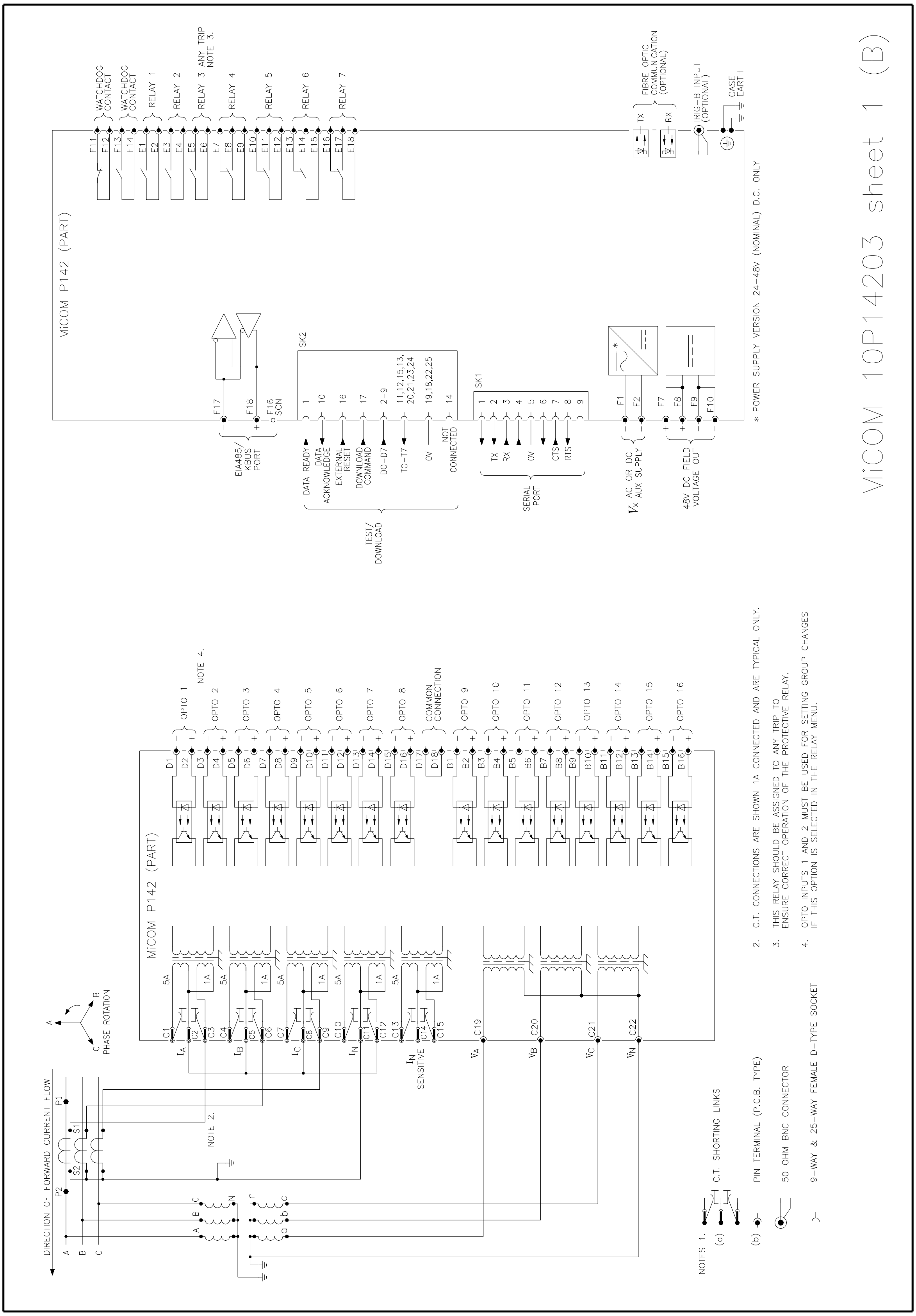


Figure 7: P142

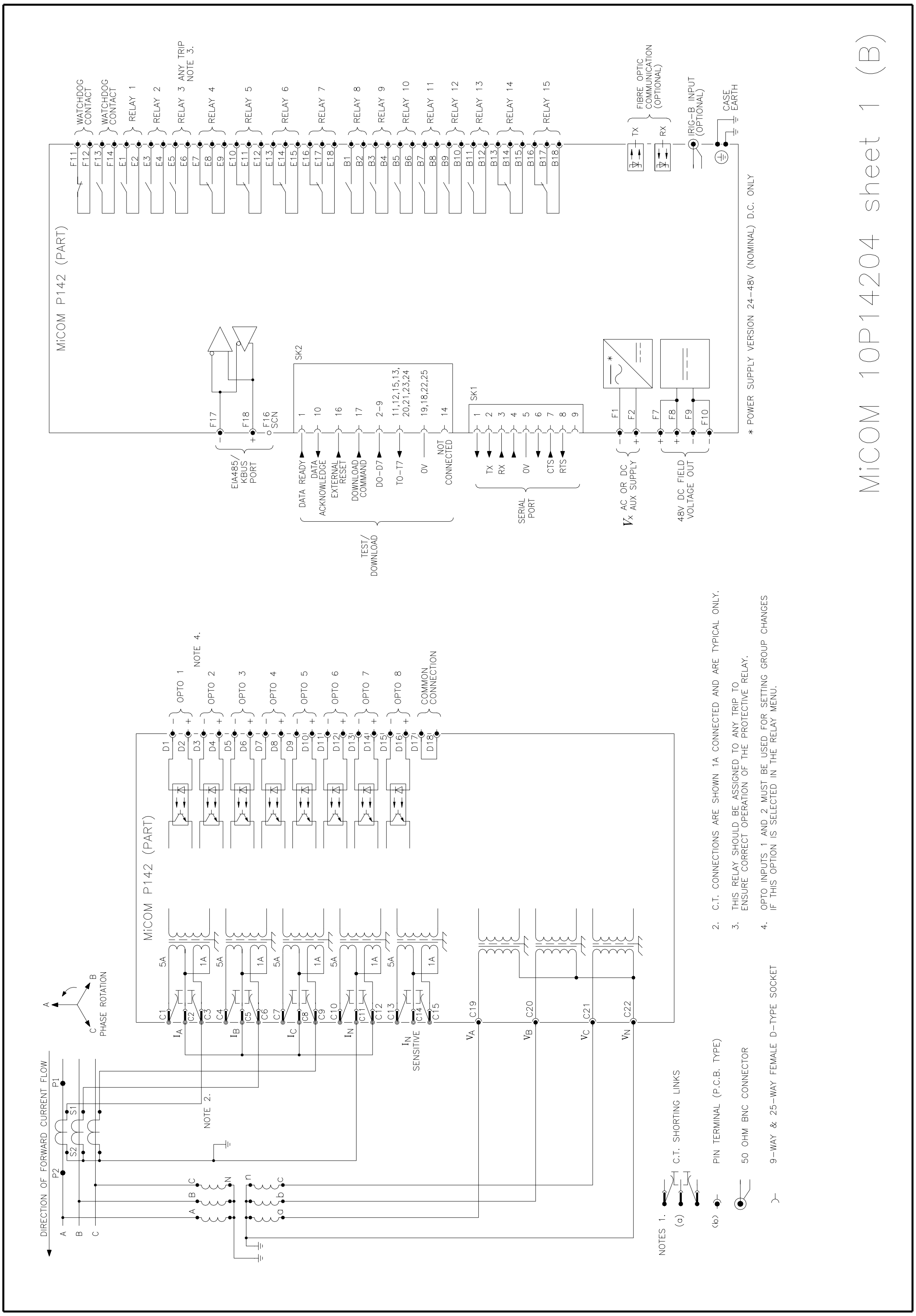


Figure 8: P142

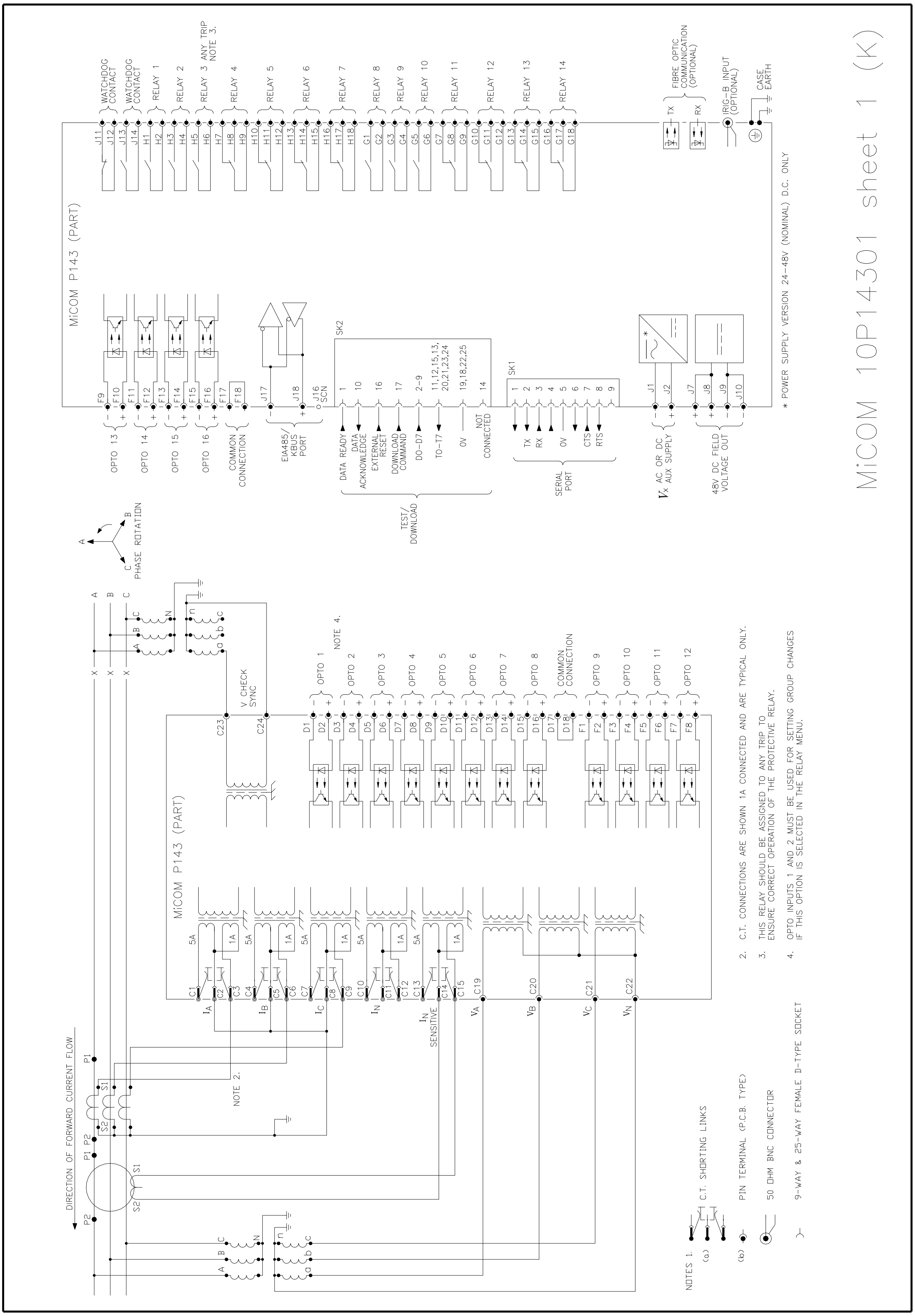


Figure 9: P143

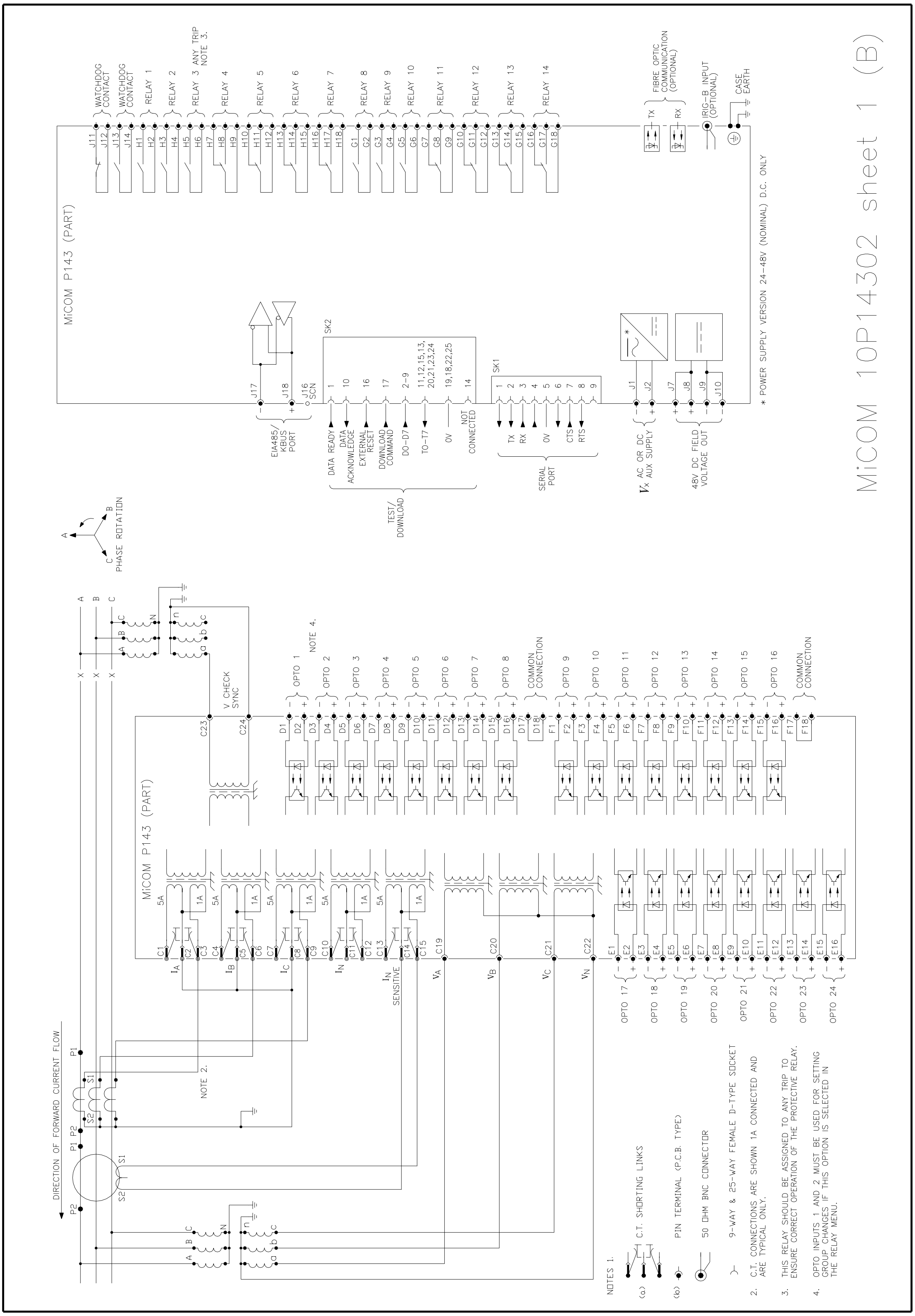


Figure 10: P143

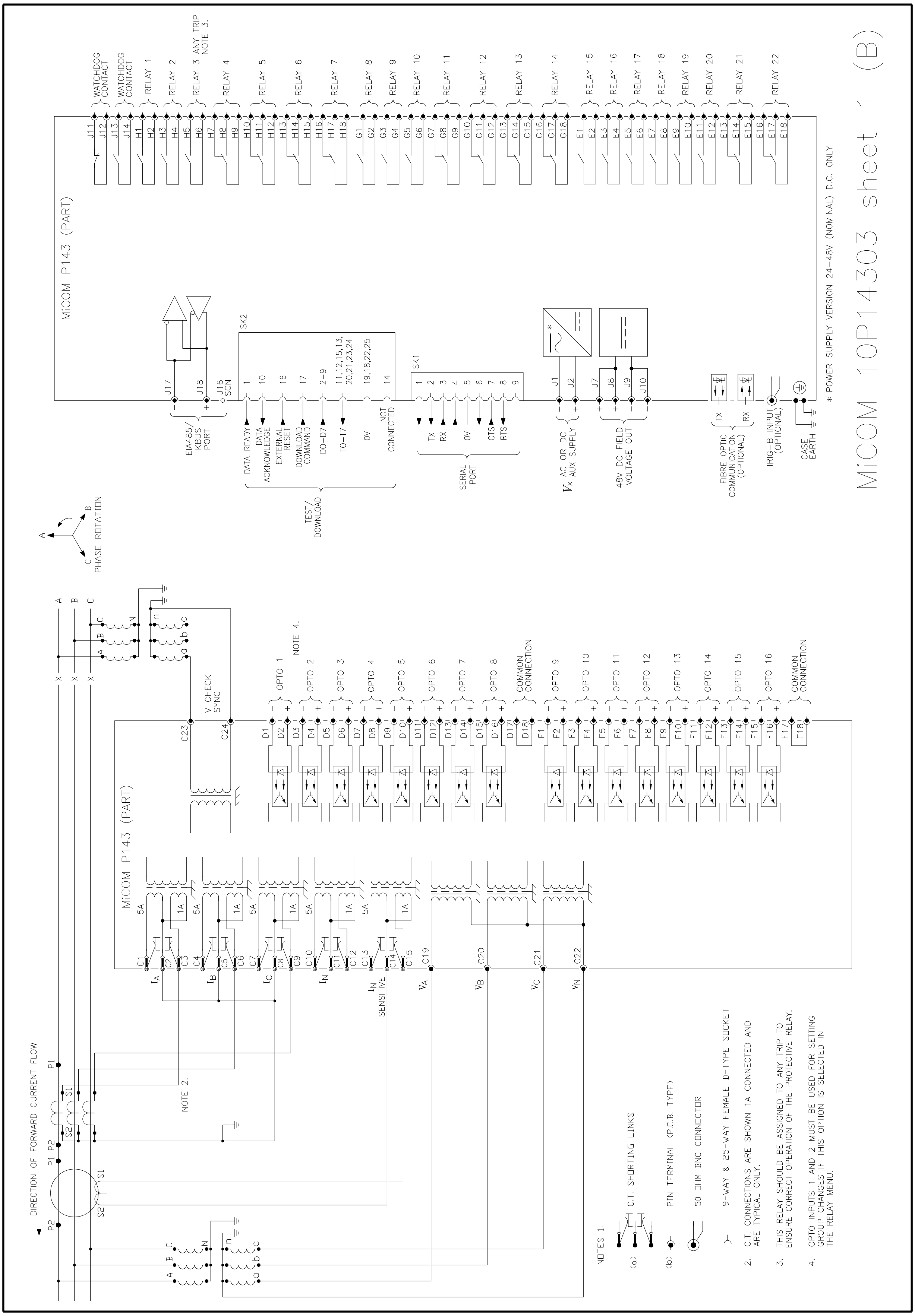


Figure 11: P143

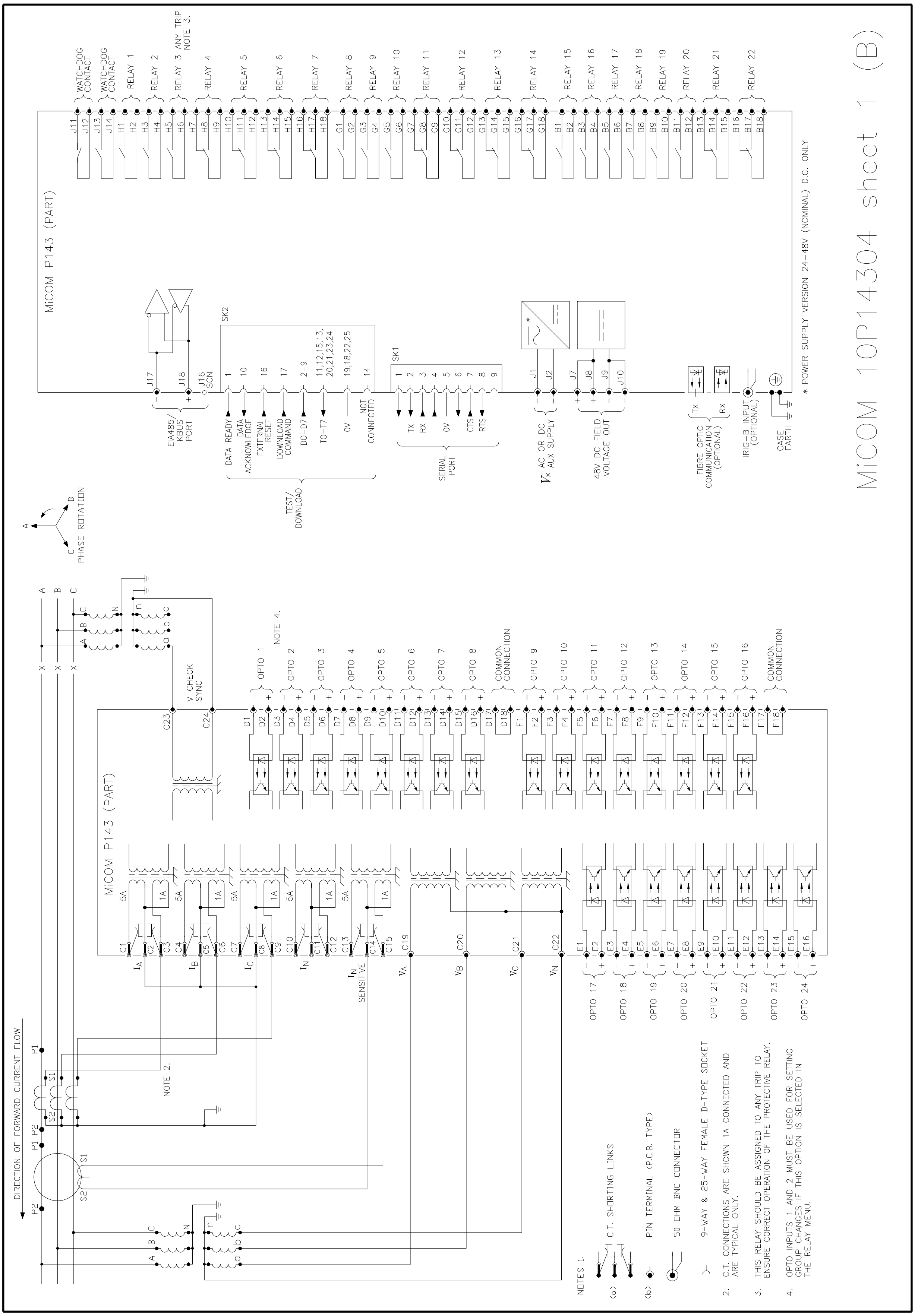


Figure 12: P143

ALSTOM

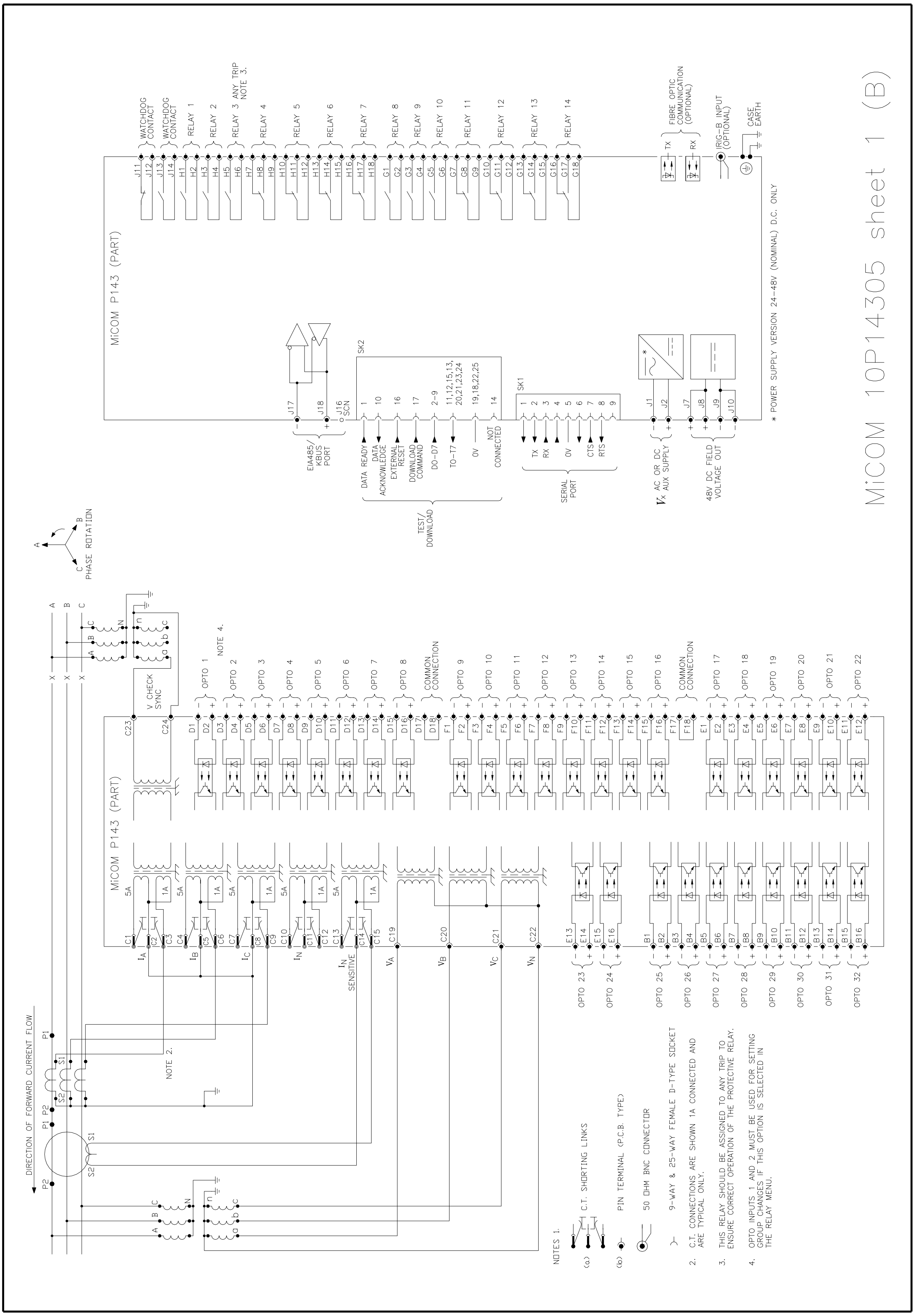


Figure 13: P143

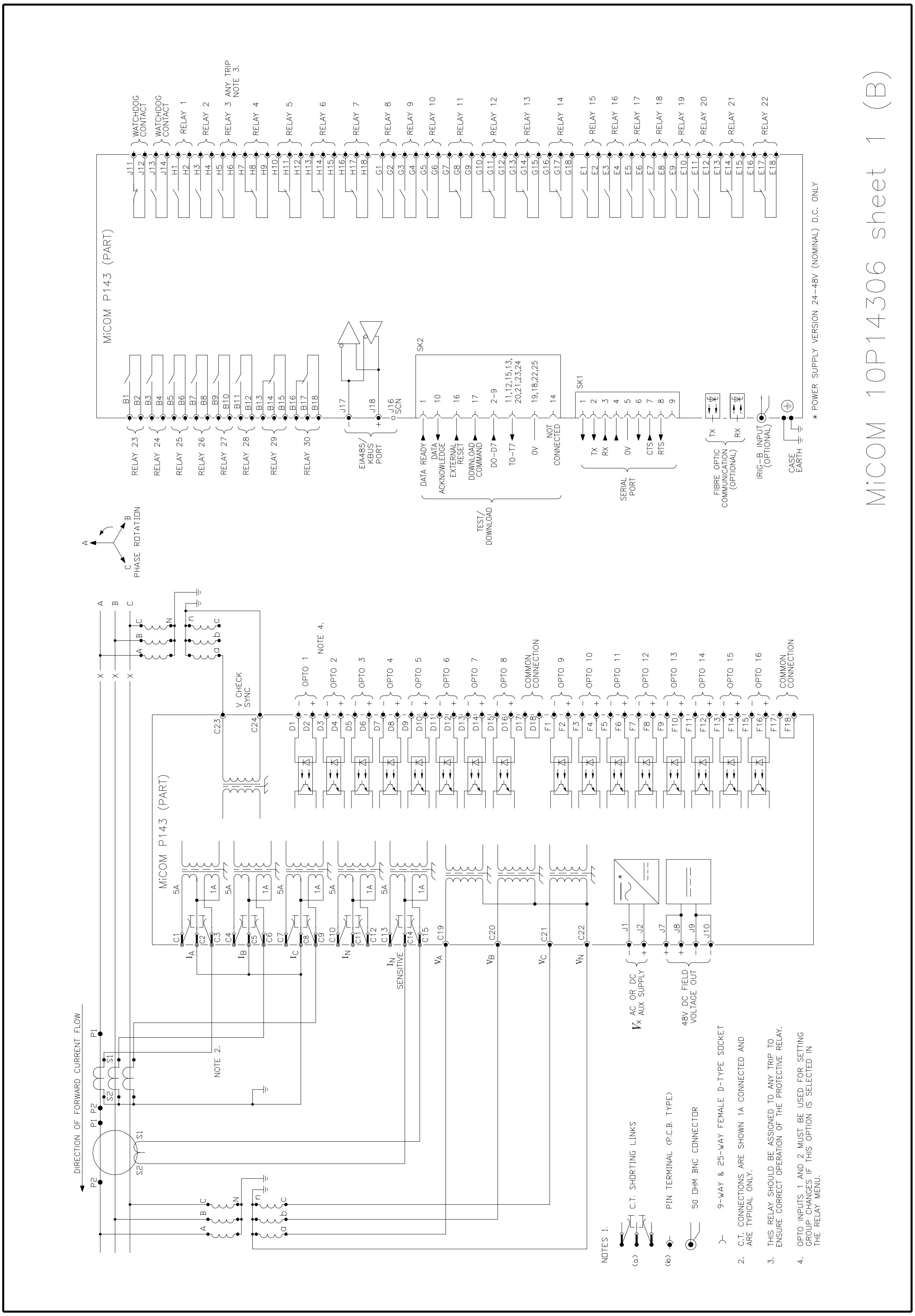


Figure 14: P143

APPENDIX C
Hardware / Software Version History and Compatibility

(Note: Includes versions released and supplied to customers only)

Relay type: P141, P142, P143…..						
Software Version	Date of Issue	Full Description of Changes	S1 Compatibility	Backward Compatibility		
				PSL	Setting Files	Menu Text Files

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Relay type: P141, P142, P143.....						
Software Version	Date of Issue	Full Description of Changes	S1 Compatibility	Backward Compatibility		
				PSL	Setting Files	Menu Text Files

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1. P140 PHASE 2.1 ENHANCEMENTS

The P140 Phase 2.1 enhancements comprise hardware and software enhancements.

1.1 Hardware enhancements

The hardware enhancements provide increased i/o variants as follows:

- P141xxxAxA0100B	Base unit with 8 logic inputs and 7 output relays

- P142xxxAxA0100B	Base unit with 8 logic inputs and 7 output relays
- P142xxxBxA0100B	Expanded unit with 12 logic inputs and 11 output relays
- P142xxxCxA0100B	Expanded unit with 16 logic inputs and 7 output relays
- P142xxxDxA0100B	Expanded unit with 8 logic inputs and 15 output relays

Expansion is provided by means of an appropriate terminal block in position B

- P143xxxAxB0100B	Base unit with 16 logic inputs and 14 output relays
- P143xxxCxB0100B	Expanded unit with 24 logic inputs and 14 output relays
- P143xxxDxB0100B	Expanded unit with 16 logic inputs and 22 output relays
- P143xxxExB0100B	Expanded unit with 24 logic inputs and 22 output relays
- P143xxxFxB0100B	Expanded unit with 32 logic inputs and 14 output relays
- P143xxxGxB0100B	Expanded unit with 16 logic inputs and 30 output relays

Expansion is provided by means of appropriate terminal blocks in positions B and E

The case sizes remain the same as Phase 1 for all variants:

- P141xxxxxA0100B	Size 8 (40TE)
- P142xxxxxA0100B	Size 8 (40TE)
- P143xxxxxB0100B	Size 12 (60TE)

Notes:

1. It is noted that the contact rating of the relay contacts has been increased to 10A.
2. The optically isolated logic inputs may be used in conjunction with the standard dc battery supply voltages from 24Vdc to 250Vdc. The operate threshold for each opto input is a menu setting.
3. The i/o expansion is provided by means of additional 8 relay, 8 logic input or 4input/4 output cards as appropriate.

1.2 Software enhancements

1.2.1 DDB/PSL enhancements

- The DDB width has been increased in size from 512 to 1023 signals.
- The number of auxiliary timers has been increased from 8 to 16.
- It is now possible to name the PSL in each setting group with a 32 character reference. The PSL also has a unique identifier.
- 32 Control inputs have been added which are commands which set/reset prescribed DDB signals. The commands may be initiated via the user interface or via comms.
- The total number of alarms has been increased from 32 to 64. This provides 18 user programmable self reset alarms and 18 latched alarms (reset via UI clear key).

1.2.2 Additional sequence measurements

- Sequence angle measurements have been included for I0, I1, I2, V0, V1, V2 in the Measurements 1 menu column.
- The ratio I_2 / I_1 has been included in the Measurements 3 menu column.

1.2.3 Thermal overload

- The maximum setting has been increased from 3.2 to 4x In.
- The element now operates from rms current, rather than Fourier.
- The displayed measurement of the highest of the 3 phase currents in the Measurements 3 column is based on rms current.

1.2.4 IDMT characteristics

1.2.4.1 Correction to IEEE/US characteristics

The following formulae, obtained from IEEE Standard C37.112-1996, are now employed for the operate and reset characteristics:

IEEE moderately inverse characteristic

- Trip characteristic $t = TD \times (0.114 + 0.0515 / (M^{0.02} - 1))$
- Reset characteristic $t = TD \times 4.85 / (1 - M^2)$

IEEE very inverse characteristic

- Trip characteristic $t = TD \times (0.491 + 19.61 / (M^2 - 1))$
- Reset characteristic $t = TD \times 21.6 / (1 - M^2)$

IEEE extremely inverse characteristic

- Trip characteristic $t = TD \times (0.1217 + 28.2 / (M^2 - 1))$
- Reset characteristic $t = TD \times 29.1 / (1 - M^2)$

US Inverse Curve Type CO-8

- Trip characteristic $t = TD \times (0.18 + 5.95 / (M^2 - 1))$
- Reset characteristic $t = TD \times 5.95 / (1 - M^2)$

US Short Time Inverse Curve Type CO-2

- Trip characteristic $t = TD \times (0.11858 + 0.16758 / (M^{0.02} - 1))$
- Reset characteristic $t = TD \times 2.261 / (1 - M^2)$

The required setting range for TD is 0.01 – 100 in steps of 0.01. (The main change is that the previous time multiplier of TD/7 is now TD and the TD setting range has been expanded).

Note: M = I/Is (i.e. the multiple of current setting which has been applied to the relay).

1.2.4.2 Rectifier

The rectifier curve has been included in the first and second stage characteristic setting options for Phase Overcurrent protection.

The Rectifier Characteristic is given by:

$t = TMS . (45900 / (M^{5.6} - 1)$

where TMS = 0.025 - 1.2 in steps of 0.025 and M = I/Is.

1.2.4.3 RI

The RI curve has been included in the first and second stage characteristic setting options for Phase Overcurrent and Earth Fault 1 and Earth Fault 2 protections.

The RI curve is given by the following formula:

$t = K . (1/ (0.339 - 0.236/M)$

The time multiplier K has setting values between 0.10 to 10 in steps of 0.05.

1.2.4.4 IDG

This curve has been included in the first and second stage characteristic setting options for Earth Fault 1, Earth Fault 2 and Sensitive Earth Fault protection.

The IDG characteristic is given by the following formula:

$t = 5.8 - 1.35 \log_e (I/Ia)$ in seconds

Ia is an adjustable setting which defines the start point on the curve, where:

Ia = 0.005 – 0.1 x In in steps of 0.00025 x In (where In = 1A or 5A) - SEF prot'n.

Ia = 0.08 – 4 x In in steps of 0.01 x In (where In = 1A or 5A) - EF1 and EF2 prot'n.

The pickup level of the relay is set by means of a further adjustable setting Is, where:

Is = 1 – 4 x Ia in steps of 0.1x Ia.

For high fault current levels, the time characteristic shall become definite time with a value to, where to is an adjustable setting.

to = 1 – 2 s in steps of 0.01 s

The default setting for to = 1.2 s.

1.2.5 SEF protection enhancements

- The current setting ranges for ISEF>3 and ISEF>4 have been extended to 0.005 – 2 In.
- The 4 SEF stages may be inhibited by a single logic input to provide SEF in/out of service.

1.2.6 System checks (voltage monitors and check synch)

Voltage monitor DDB signals are provided for:

- Live line (P142/P143)
- Dead line (P142/P143)
- Live bus (P143 only)
- Dead bus (P143 only)

Check Synchronism has been provided in the P143 with the following features:

- 2 independent stages of check synchronism where each stage is enabled by a logic signal.
- The 2nd stage of check synchronism operates only for decreasing difference angle.
- System split detection, enabled by a logic signal.
- Overvoltage blocking setting option for the 2 check synch stages.

(See section 2 for more details).

1.2.7 Autoreclose

The following enhancements have been provided:

Complete rationalisation of the autoreclose functionality in the P142 and P143, including:

- Autoreclose mode selection.
- Sequence co-ordination for radial feeder applications.

Extra interlock options in initiation and dead time logic for both the P142 and P143.

Additional counters for:

- Number of transient faults cleared by 1 successful reclosure
- Number of transient faults cleared by 2 successful reclosures
- Number of transient faults cleared by 3 successful reclosures

- Number of transient faults cleared by 4 successful reclosures
- Number of persistent faults which have taken autoreclose to lockout

The ability to initiate AR trip test with a logic input signal.

(See section 2 for more details).

2. P142 AND P143 AUTO-RECLOSE AND SYNC CHECK CHANGES FOR SOFTWARE VERSION 10

The auto-reclose functionality in both the P142 and P143 is now identical, so the P142 now has the same auto-reclose functions as the P143, including the more comprehensive mode selection and sequence co-ordination. The only difference between the two schemes is that the P142 does not have a Check Sync VT input, and so cannot perform synchronism check or Line/Bus voltage comparisons.

Most of the changes and extra functions in the latest P143 auto-reclose and synchronism check functionality were added so that the relay can be configured to meet the auto-reclose and synchronism check specifications of a major national transmission utility. The relay can still be configured to act in the same way as the previous scheme, for applications on typical distribution systems.

2.1 Auto-reclose functions (P142 and P143)

- "CB Closed" interlock in the AR initiation logic is replaced by a "CB In Service" interlock (DDB 454, which can be mapped in PSL). This can be mapped simply from the "CB Closed" DDB to retain the previous functionality, but extra "AR initation enable" conditions can be mapped in if required, such as "Line and Bus both initially live immediately before protection operation".
- New "AR Restart" input (DDB 455) enables AR initiation without the usual CB Closed or CB In Service interlocks, for special situations. This input can normally be ignored.
- There are now two slightly different "AR in Progress" signals, and a new "DAR Complete" signal.
  "AR in Progress" (DDB 360) is the same as before, i.e. it operates from AR initiation until the scheme resets at the end of the reclaim time.
  "AR in Progress 1" (DDB 456) also operates from AR initiation until scheme reset, but will reset if "DAR Complete" operates before scheme reset.
  "DAR Complete" (DDB 453) can be mapped in PSL to operate when a CB Close command is given, so allowing "AR in Progress 1" to reset, and providing an external signal, if required.
- Two extra interlocks are added in the dead time control logic.
  "DT OK to Start" (DDB 458, mapped in PSL) has to be high to enable the dead time function to be "primed" after an AR cycle has started. Once the dead time function is "primed", this input has no further effect; dead time remains primed even if "DT OK to Start" goes low. A typical use for this input is to prevent dead time starting until the line voltage has definitely gone dead after CB tripping. If not mapped in PSL, input "DT OK to Start" defaults to high, so dead time starting is enabled.
  "Dead Time Enabled" (DDB 457, mapped in PSL) has to be high to allow the dead time to run after it has been "primed"; if this input goes low, the dead time stops and resets, but remains primed, and will re-start from zero when the "Dead

Time Enabled" input goes high again. A typical use for this input is to prevent the dead time from running if the "CB Healthy" input is low, or if selected live bus/dead line or similar conditions are not satisfied. If not mapped in PSL, input "Dead Time Enabled" defaults to high, so dead time running is enabled.

- Separate "shots" counters are provided in the CB CONTROL menu, to count separately:
  - number of successful reclosures at first shot (0712 – 1 Shot Clearance);
  - number of successful reclosures at second shot (0713 – 2 Shot Clearance);
  - number of successful reclosures at third shot (0714 – 3 Shot Clearance);
  - number of successful reclosures at fourth shot (0715 – 4 Shot Clearance);
  - number of unsuccessful reclose cycles (0716 – Persistent Fault).

2.2 System Check functions (P143 only)

- An extra synchronism check function has been added, so the scheme now has two independent synchro checks, CS1 and CS2, each with independently adjustable phase angle and slip frequency settings. CS1 operates in exactly the same manner as the previous scheme, but with an extra option for blocking by an overvoltage condition. CS2 is very similar, but can operate only while the phase angle magnitude is decreasing. Either or both synchro check functions can be mapped in PSL to interlock with auto-reclose logic and manual CB close logic. In most situations only one synchro check function is required, and either CS1 or CS2 can be enabled. However, in a few situations a combination of two SC functions is necessary. For example, one major transmission utility allows synchro check with phase angle up to typically 20° if the measured slip frequency is less than say 50 mHz, or with a phase angle less than 10° and decreasing in magnitude, if the slip frequency is between 50 mHz and 250 mHz.

- A new function, "System Split" (DDB 166), has been added, which operates if the magnitude of the measured phase angle between the Main VT and Ch Sync VT inputs is greater than a set value (4828 – SS Phase Angle, range 90° to 175°). In many applications, this can be ignored, but it is required by at least one major transmission utility.

- Live/dead Line, live/dead Bus, CS1 OK, CS2 OK and System Split signals, as well as "System Checks Inactive" (i.e. not enabled), are now available on the P143 as DDB signals (DDB 166 and DDB 443 – 449) for mapping in PSL. They were previously used only in the fixed logic and not available for use in PSL.

Live line and dead line signals are available on the P142.

- "Phase Angle", "Slip Frequency" etc settings in SYSTEM CHECKS Gr 1 4801 to 4809 have been deleted, and replaced by a new set of settings in cells 4814 to 482B.

- System check option settings for manual CB closing, previously 480A to 480E, are deleted. The options for manual CB closing are now determined by PSL mapping to DDB 402 – Man Check Synch.

- System check option settings for auto-reclosing, previously 480F to 4813, are deleted. The options for auto-reclosing are now determined by Auto-reclose SYSTEM CHECKS settings 4941 to 4945 and PSL mapping to DDB 461 – Live/Dead Ccts OK.

APPENDIX D
Autoreclose Diagrams

MiCOM P141, P142, P143

Feeder Management Relays

Appendix D

Autoreclose Diagrams

Scheme 1 - refers to P142 autoreclose logic

Scheme 2 - refers to P143 autoreclose logic

CONTENT

Figure 1: “Protection Start” signals 3

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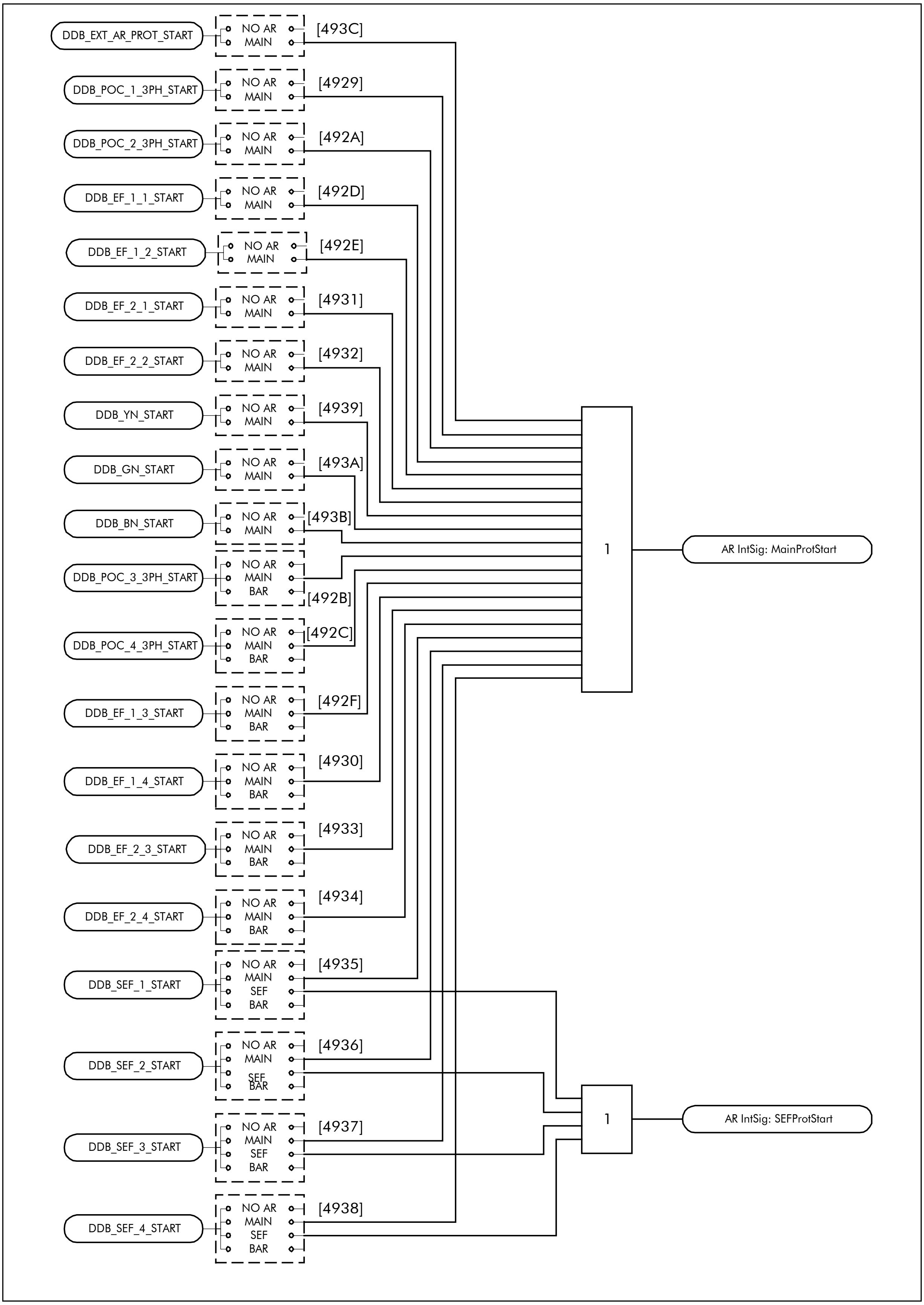

Figure 1: "Protection Start" signals

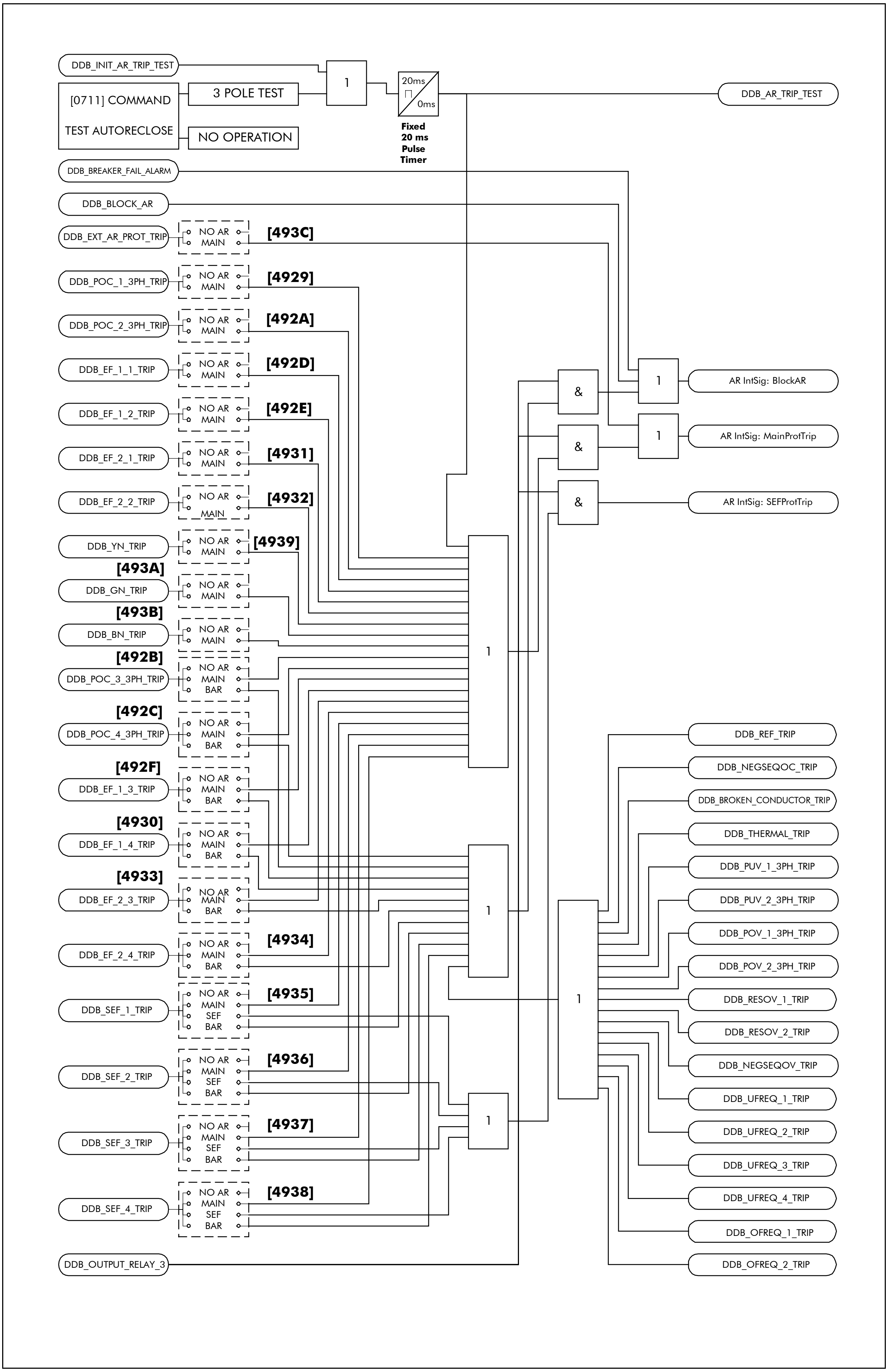

Figure 2: “Protection Trip” and “Block AR” signals

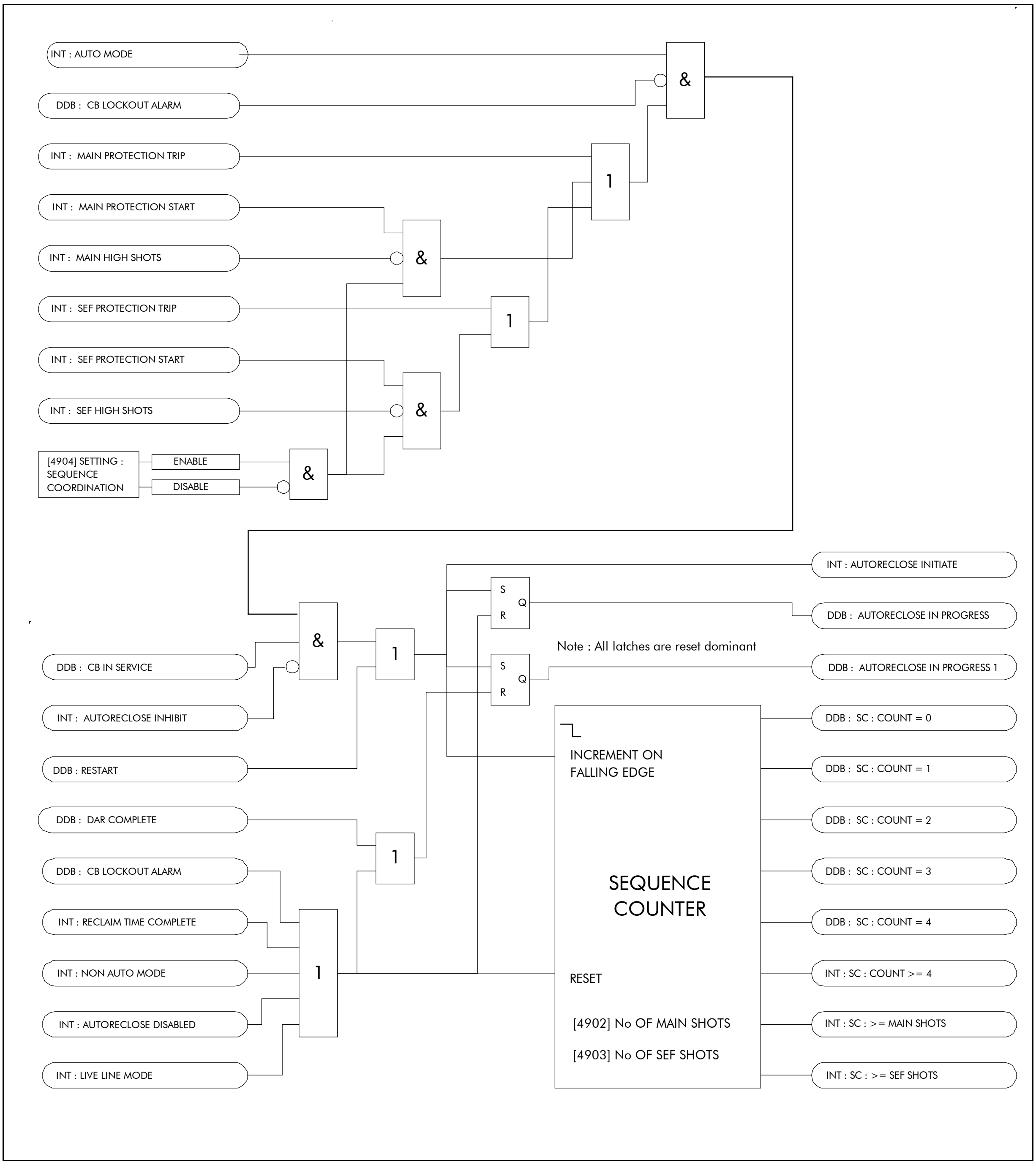

Figure 3: AR Initiation and Sequence Counter

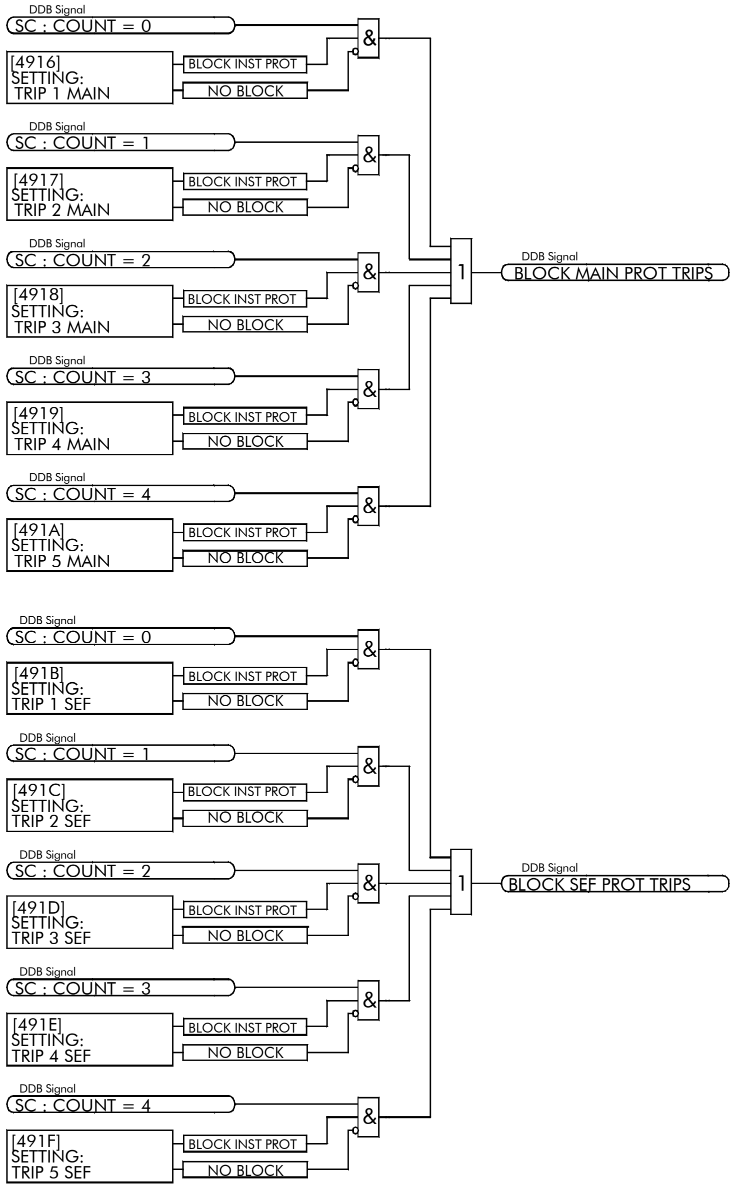

Figure 4: “Block Instantaneous Protection” for selected trips

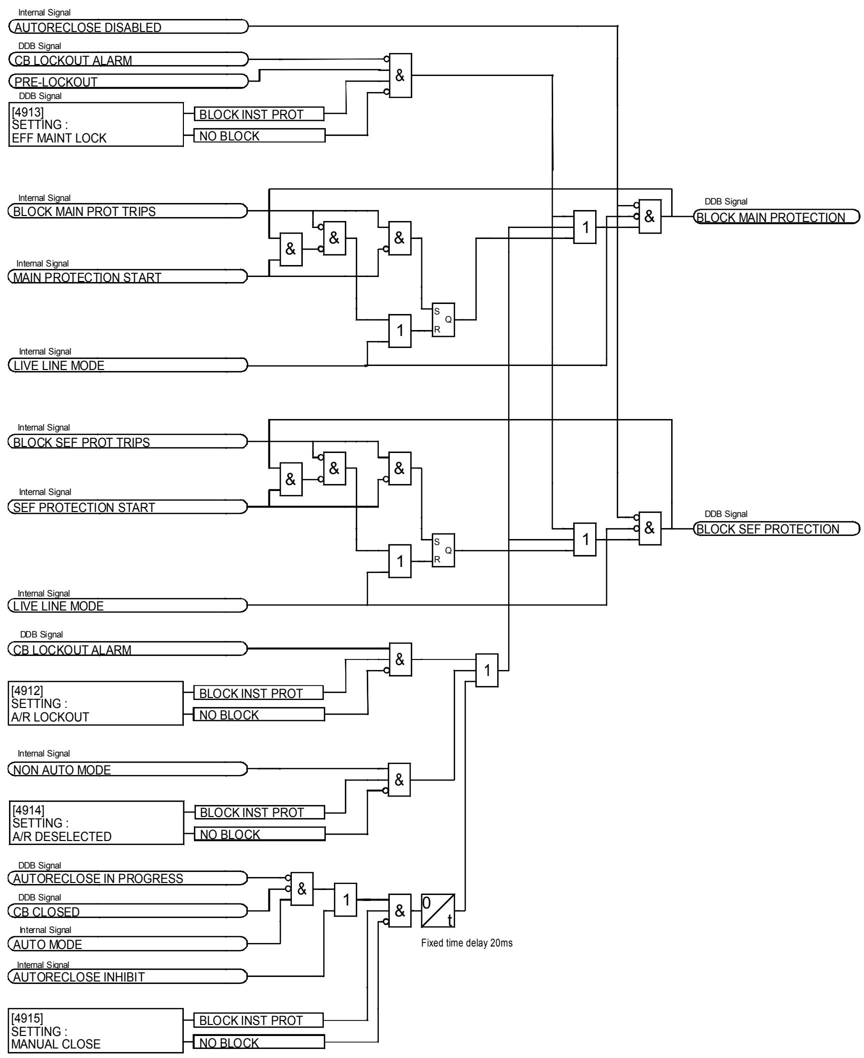

Figure 5: "Block Instantaneous Protection" for AR unavailable or maintenance / EFF lockout

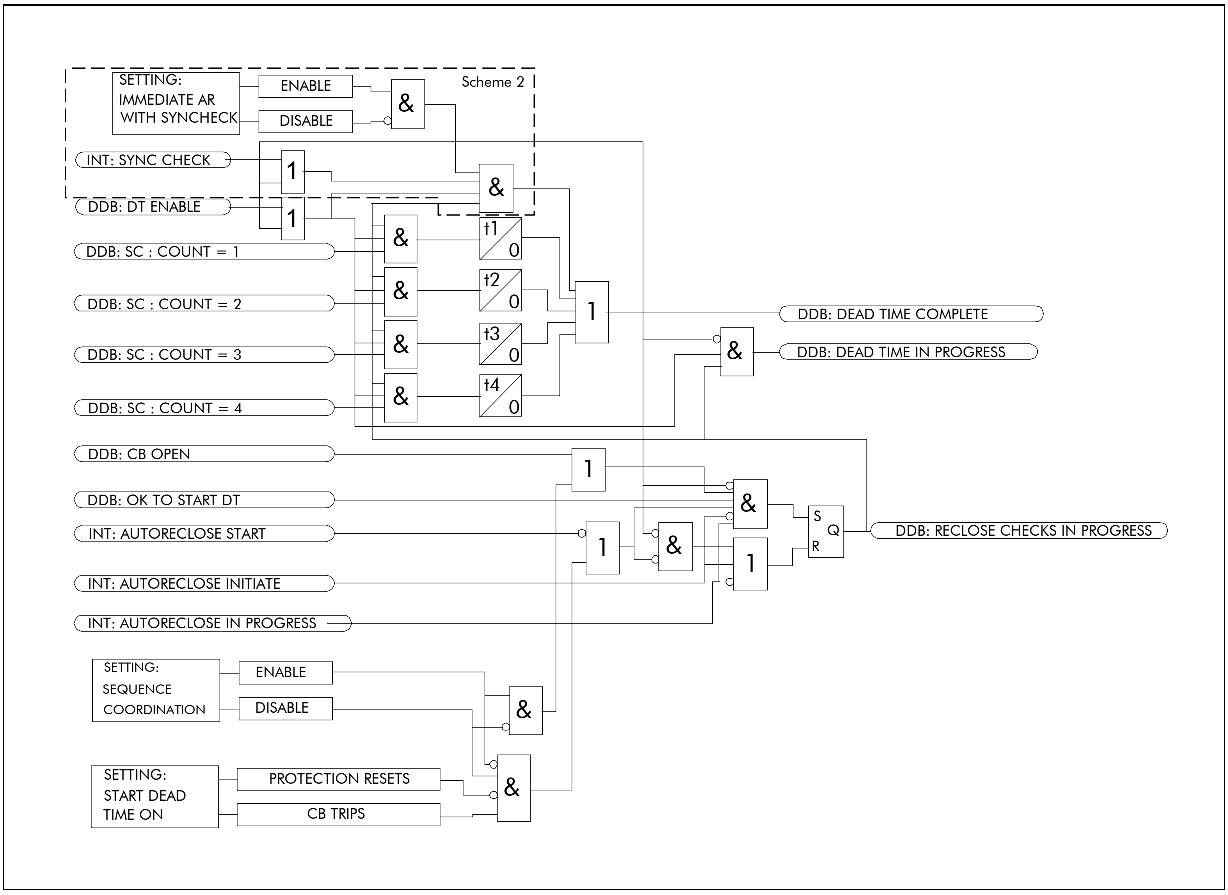

Figure 6: Dead time control

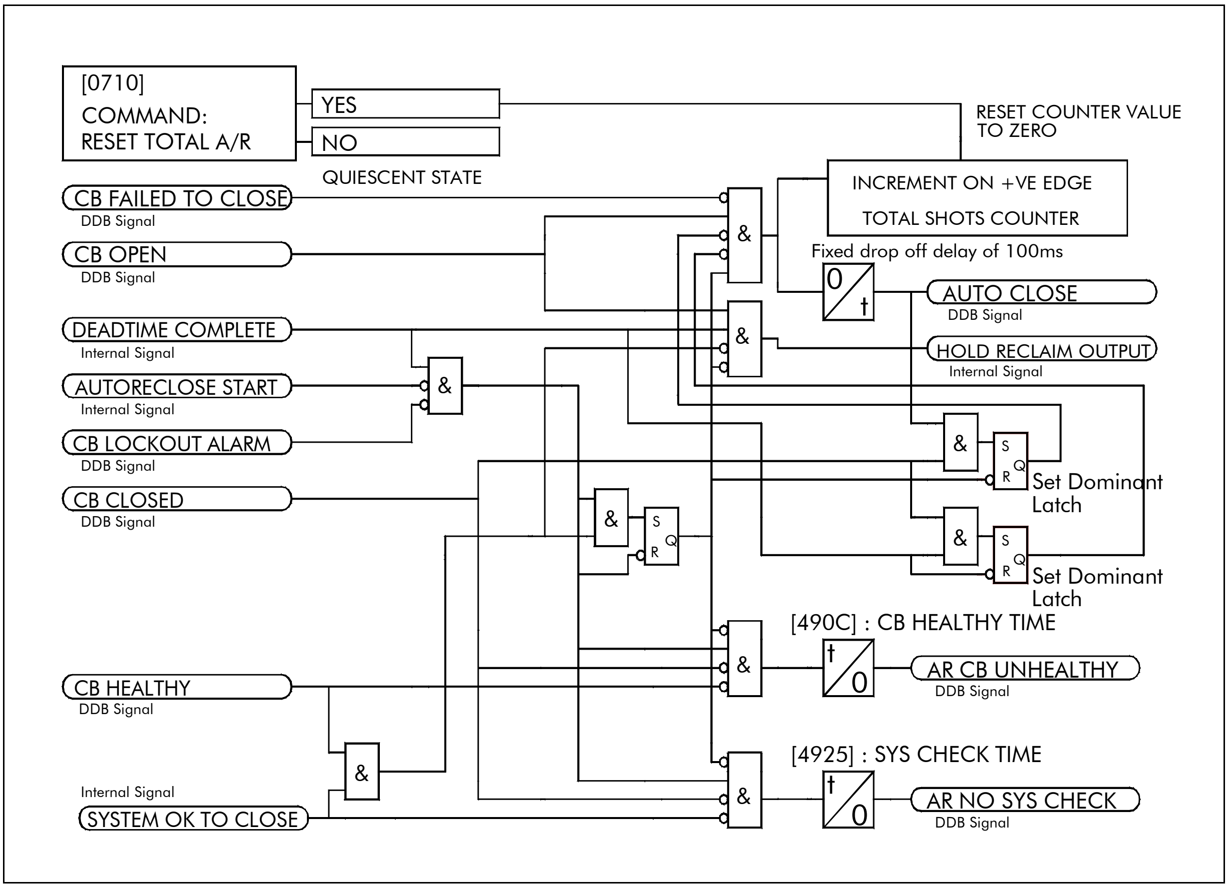

Figure 7: AR CB close control

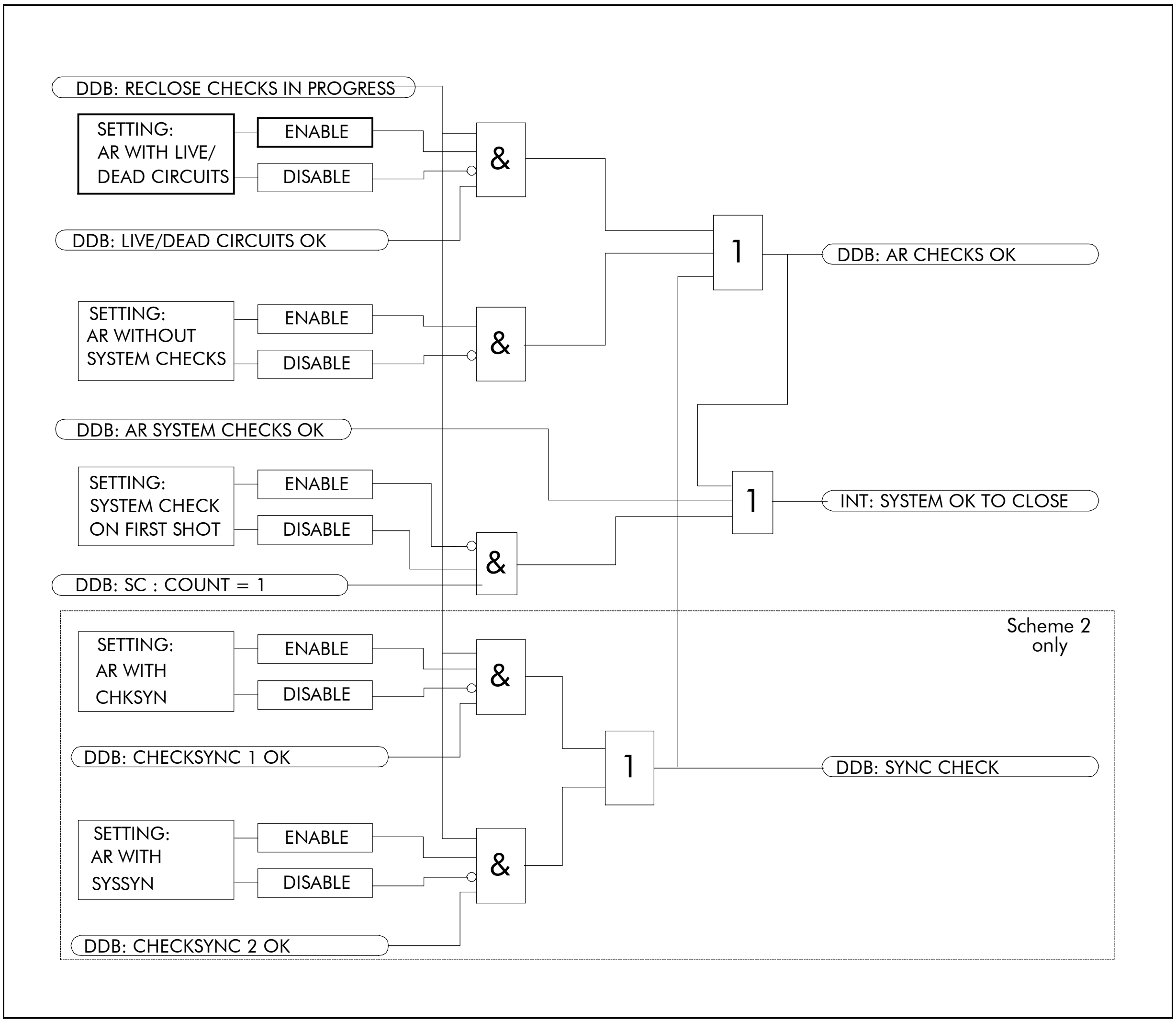

Figure 8: System checks

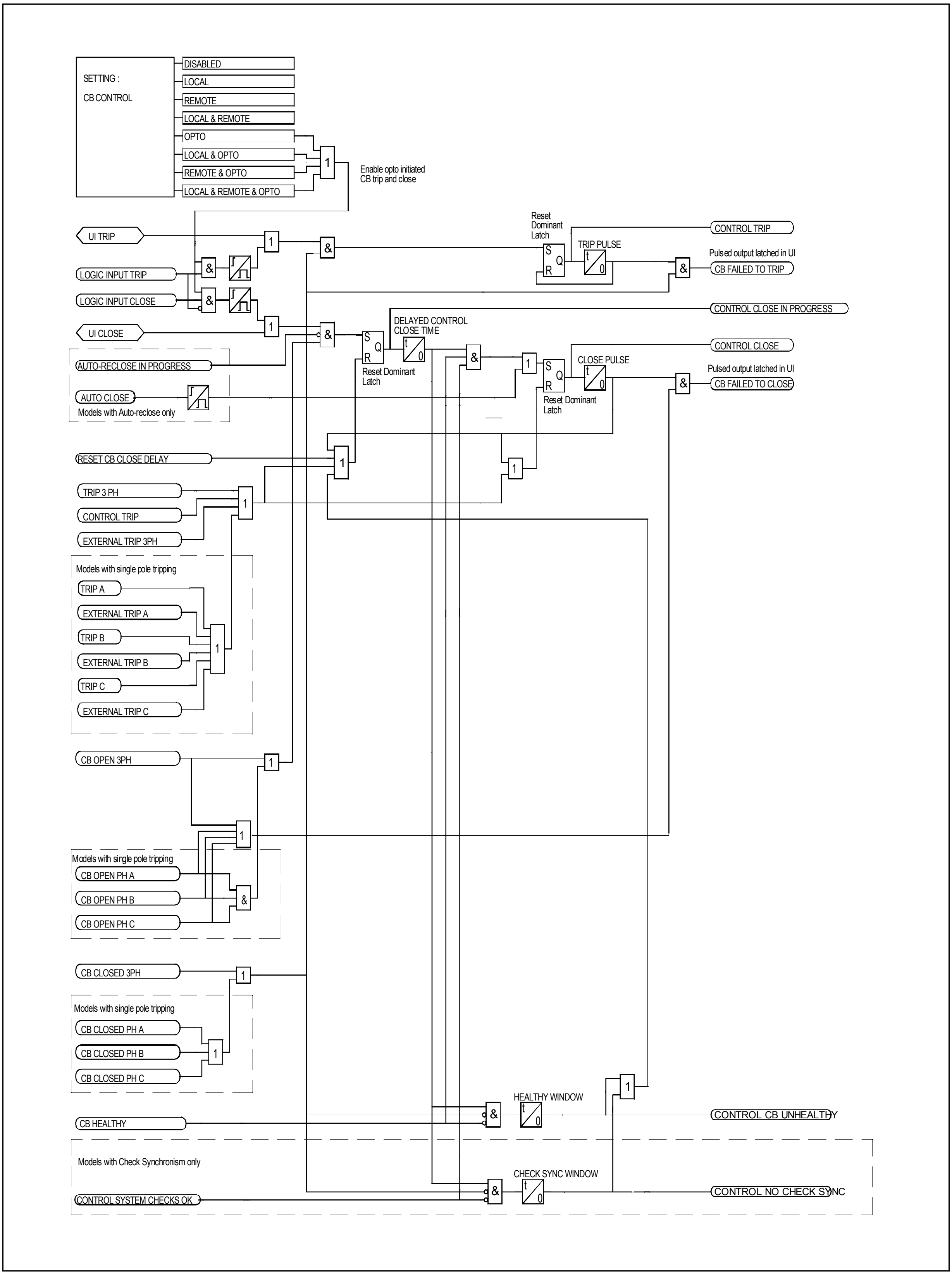

Figure 9: Circuit breaker control

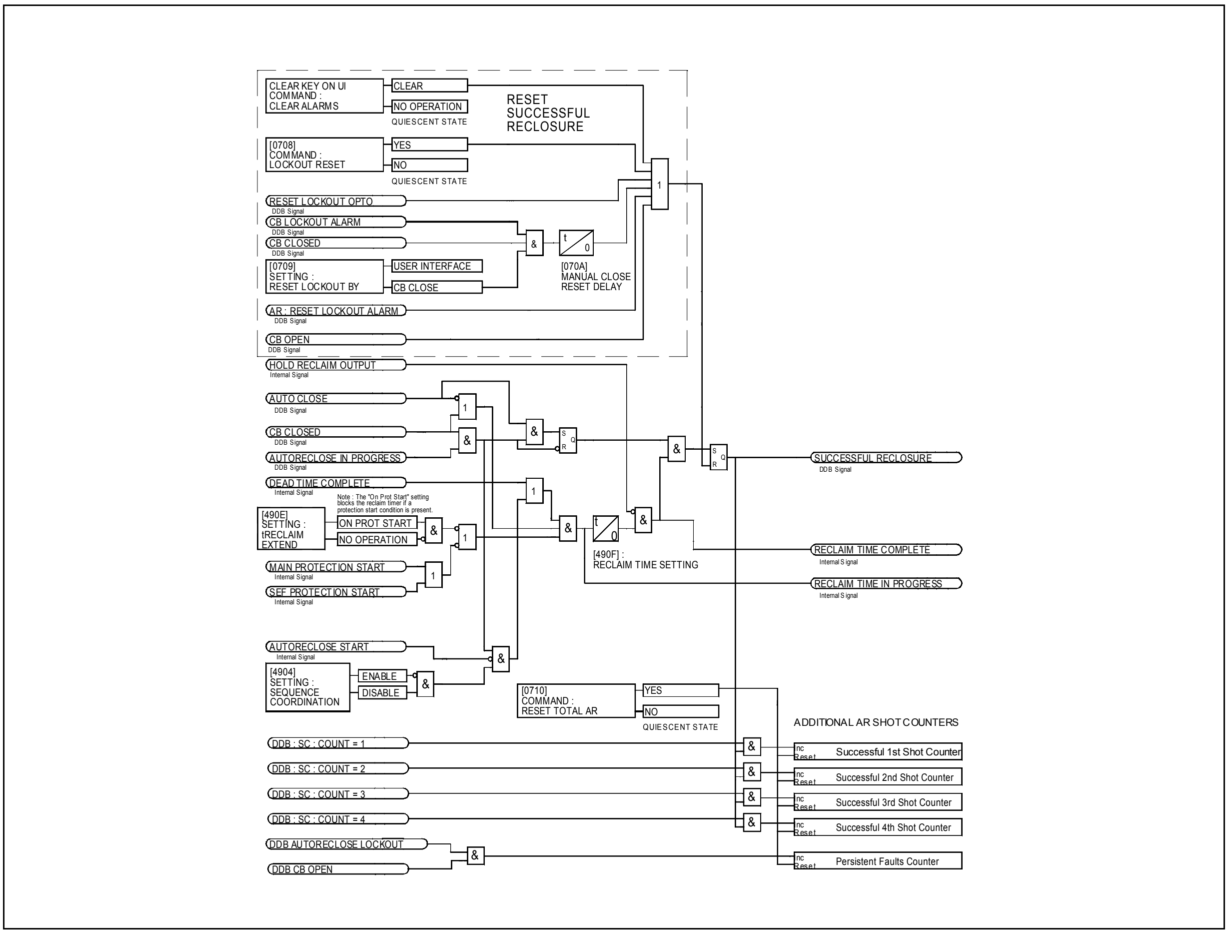

Figure 10: Reclaim time / AR successful logic

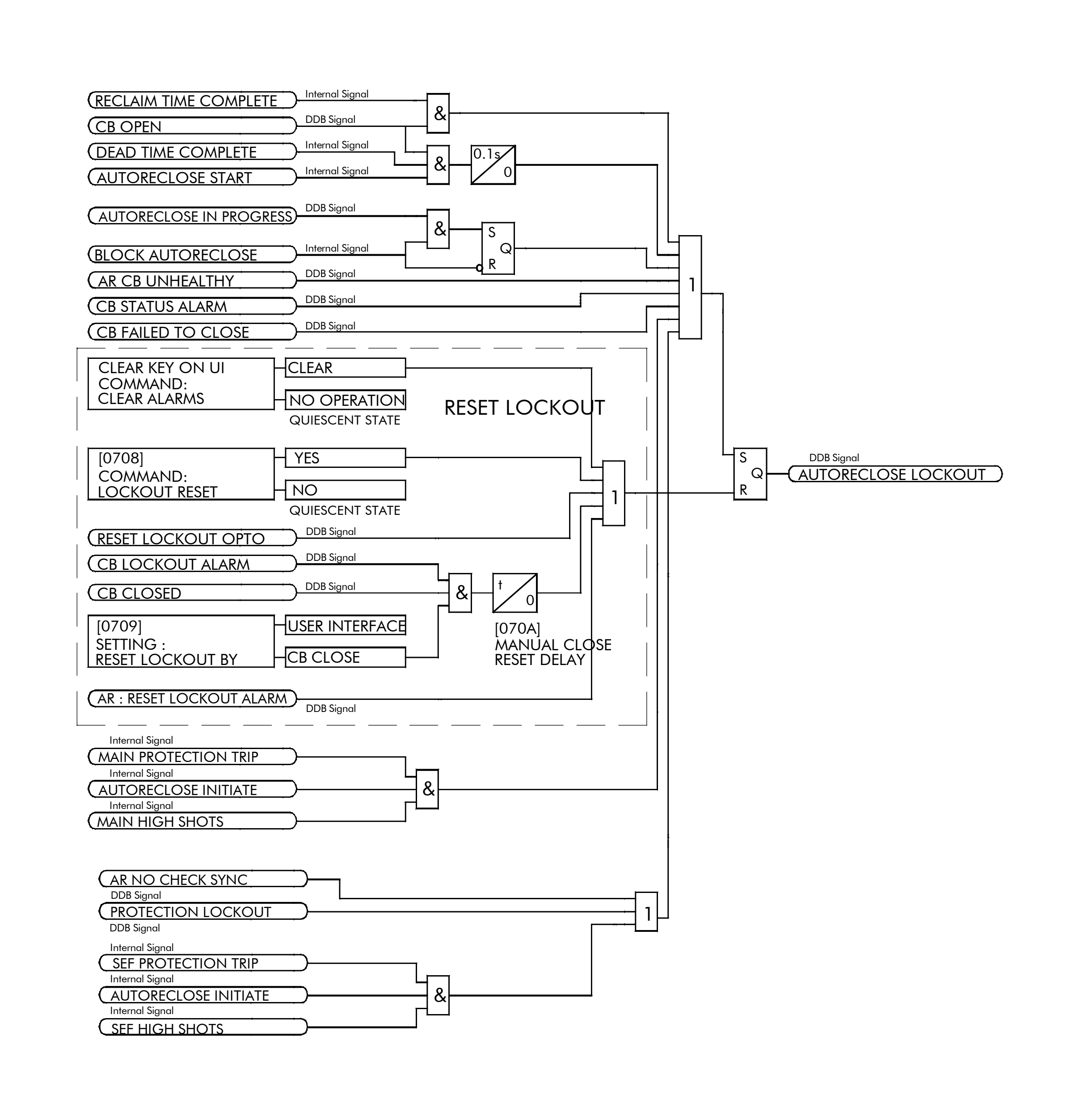

Figure 11: Overall AR lockout logic

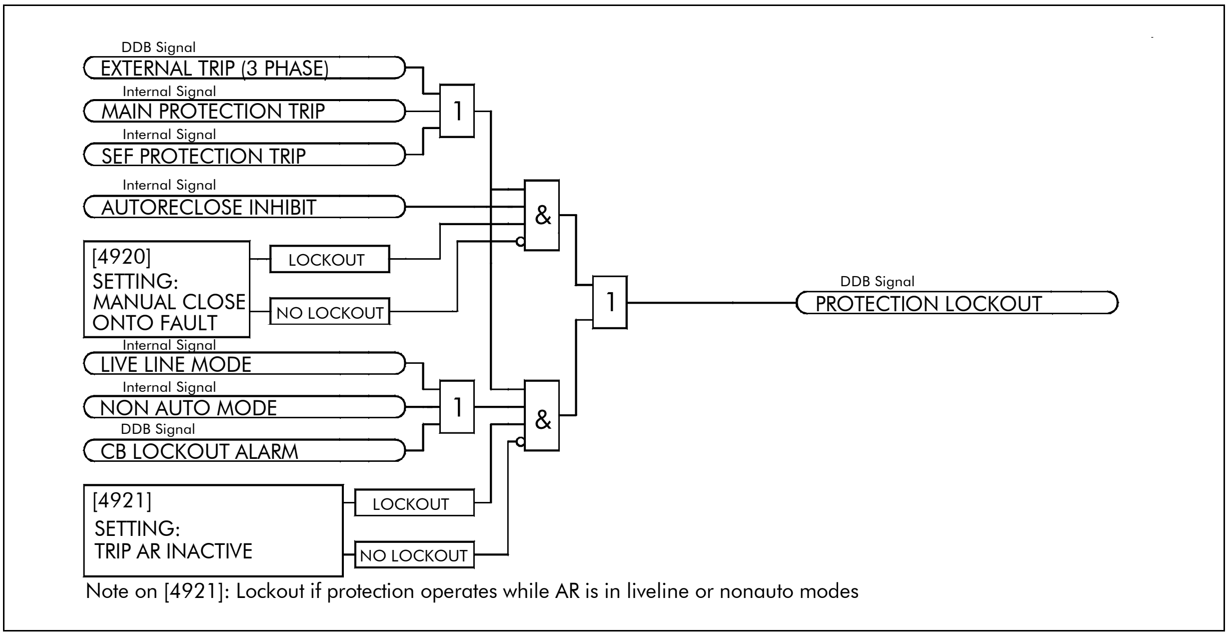

Figure 12: Lockout for protection trip when AR not available

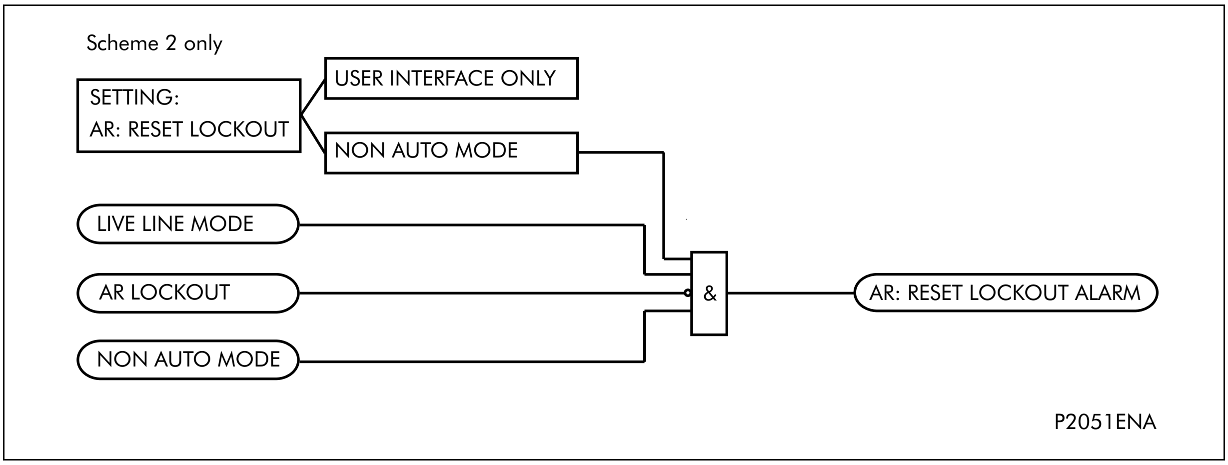

Figure 13: AR reset lockout

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