W-Series
Automatic Circuit Recloser

Technical Manual

Version 28

Notices

Scope of this Manual

This document describes the features and operation of the W Series Automatic Circuit Recloser (ACR), including the installation and maintenance procedures.

Limitations

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It has been prepared in conjunction with references from sub-assembly suppliers and the collective experience of the manufacturer.

In-service conditions for use of the products may vary between customers and end-users.

Consequently, this Technical Manual is offered as a guide only. It should be used in conjunction with the customers own safety procedures, maintenance program, engineering judgement and training qualifications.

No responsibility, either direct or consequential, for injury or equipment failure can be accepted by Nu-Lec Industries Pty Ltd resulting from the use of this Technical Manual.

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1 Introduction

The W-Series Automatic Circuit Recloser (ACR) is a state-of-the-art electronically controlled outdoor, pole mounted, single phase recloser.

The vacuum interrupter is enclosed in epoxy mouldings eliminating the need for insulants such as oil and gas. Operation is by magnetic actuator which does not rely on the presence of HV supply. The mechanism is enclosed in a stainless steel tank.

A pole mounting bracket is supplied which makes installation quick and easy. Cables are connected to the recloser using parallel groove clamps or cable lugs.

Control electronics are housed in a stainless steel control cubicle designed for harsh environmental conditions. An all-weather user-friendly control panel is provided for a local operator.

Remote monitoring and control can be provided without the addition of a Remote Terminal Unit (RTU).

In this manual, controller events are identified in the text by using ‘single quotes’. See Section 7 (page 25).
Contents of the Operator Control Panel display pages are shown as:

Display Group - Page Title:Text

The control panel is illustrated in Figure 4 (page 25).

Version 28 Features

Version 28 software provides the following new features for the W-Series ACR:

- Operator configurable Quick Keys.
- *Hit and Run* - provides a time delay between a local operator control Trip or Close, and when the recloser operates.
- External Trip Flags - indicates external trips caused by the activation of the Fast Trip Input Module (FTIM) or an IOEX input.
- 600 Baud option for communications port P8.
- Port P9 Configurable Baud Rate - provides the ability to manually configure the baud rate of the CAPM serial port designated as P9.

2 Scope of this Technical Manual

General

This Technical Manual details the specification of the W-Series Circuit Breaker (Recloser), its operation, installation and maintenance.

Whilst every care has been taken in preparation of this manual, no responsibility is taken for loss or damage incurred by the purchaser or user due to any error or omission in the document.

Inevitably, not all details of equipment are provided nor are instructions for every variation or contingency during installation, operation or maintenance.

For additional information on specific problems or requirements, please contact the manufacturer or your distributor.

Equipment Versions Covered by this Manual

This manual applies to the following equipment:

- Pole Top Recloser: Model W27-06
- Pole Top Control Cubicle - Models:PTCC-TEM, PTCC-MOD, PTCC-TRO

The model numbers are shown on the equipment rating plates. If your equipment does not correspond to these numbers then this manual is not applicable. Please contact the manufacturer or your local distributor.

Controller Version Covered by this Manual

The Control and Protection Module (CAPM) is explained in "Control & Protection Module - page 21" .

- Note that this manual applies to both the CAPM 4 and CAPM 5 based controllers.

When the Operator Control Panel is turned on the display will show the controller type. See Section 7 (page 25). If it does not show either “CAPM 4” or “CAPM 5” then this manual does not apply and you should contact the manufacturer or your local distributor for advice on the correct manual required.

Software Identification System

The software loaded into the controller has two important identifiers:

- The Software Version which has the form **XXX-XX.XX**. This identifies the exact software loaded into the program memory on the controller.
- The Configuration Number which has the form **2XXXX**. This identifies the configuration loaded into the database that controls what the software will do. For example, whether the operator text displays are to be in English or another language.

Note that in order to change functionality of the equipment it is sometimes necessary to change the software, sometimes the configuration and sometimes both.

In order to obtain effective technical support from the manufacturer or your distributor it is vital to note down the software version and the configuration number of your equipment and to quote these when making your inquiry. Without this information it is impossible for the manufacturer’s Customer Service to identify the software and provide correct support.

The software version and the configuration number are both shown on the Operator Control Panel page

SYSTEM STATUS-SWITCHGEAR WEAR/GENERAL DETAILS

See Section 7 (page 25) to find out how to use the Operator Control Panel.

A typical example of software version and configuration would be:

Software	**528-03.00**
Configuration	**21186**

Software Version Covered by this Manual

The electronic controller incorporates a microprocessor. The microprocessor software can be configured for different capabilities such as directional protection, a variety of protocols, etc. This is called its “Software Capability”.

The software version and configuration determine the functionality of the controller. (See Software Identification System - page 3) .

To find out if this manual applies to the software/ configuration loaded in the controller it is necessary to display the Software Capability list on the Operator Control Panel found on:

SYSTEM STATUS-CAPABILITY

See Section 7 (page 25) for instructions on using the Operator Control Panel.

Having found this page press SELECT and use the ⮜ ⮞arrow keys to view the capability list.

This manual applies if the capability declarations in the screen below are shown.

If not, contact the manufacturer or your distributor.

```
 - - - - - - - CAPABILITY  - - - - - - -S
W Recloser(Intl)          W01 - 194
WSOS P9 Local             ManualN00-218R05+
WSOS P8 Remote            ManualN00-218R05+
```

The part number for the Recloser manual is shown on the back cover of this publication.

The manual revision is usually stated e.g. R02+ which means revision number 2 or later of the manual. Check the Manual part number on the back cover of the publication.

Related Documents

Not detailed in this document are the following topics that are covered by their own manuals:

- Windows Switchgear Operating System (WSOS) – Used to configure the recloser from a Personal Computer.
- Test and Training Set (TTS) – Used to test control cubicles.
- Specific Telemetry Protocol Implementations - For communications to remote control systems.
- Workshop & Field Test Procedures – A set of instructions on how to test the switchgear.
- Service Procedures – A set of instructions on how to remove and replace the controller electronics.
- External Capacitive Voltage Transformer - an optional accessory to assist with measurement.

For further information on these products refer to the manufacturer or your local distributor.

Year 2000 Compliance Statement

The CAPM controller complies with Rules 1,2,3 and 4 of the British Standards Institute Year 2000 Conformity Requirement (DISC PD2000-1 A Definition of Year 2000 Conformity Requirements). A copy of this statement can be found on the web site (http://www.nulec.com.au/).

Safety Advice Concerning Isolation

The W-Series product is a reclosing circuit-breaker, not an isolator. The product uses vacuum interrupters and therefore does not have isolating properties when in the open position.

Consequently a user must use conventional means to prove the load side of the product is dead before coming within the safe operating distance from the product.

3 Technical Data

This section is the specification of the Recloser. For a complete understanding it is essential to also read the other sections of the manual describing the equipment operation.

Note that where timing, current, voltage or other measurement accuracy is given, it is as a percentage of value unless otherwise stated.

Circuit Breaker

Basic Timings

Contact Close from energisation of close coil[a]	**< 50ms**
Opening Time[a.]	< 35ms
Interrupting Time[a.]	< 45ms
Fault Clearing Time on Instantaneous protection for fault > 4 x Setting Current[a.]	< 70ms
Time to contact part from receipt of trip command by operator, telemetry protocol or IOEX	<150ms

a. The precise definition of these times is given in ANSI C37.60.

Fast Trip Input Module Timings (CAPM 5 Only)

Time until energisation of trip coil from receiving stable signal on input	≤16ms
On state Voltage	18-150V AC/DC
On state Current	≤10mA
Off state Voltage	<3V AC/DC

Ratings

Rated maximum voltage	24kV
Rated Continuous voltage	21kV
Rated Continuous Current	400 Amp
Rated Frequency	50/60Hz
Rated Cable Charging Interrupting Current	25A
Rated Transformer Magnetising Interrupting Current	22A
Rated Symmetrical Interrupting Current	6kA
Rated Asymmetrical Making Current (Peak)	15kA
Rated Symmetrical Making Current (RMS)	6kA
Short Time Current for 3 Seconds	6kA
Short Time Current Recovery Time	180 sec
Rated Impulse Withstand Voltage	125kV
Power Frequency Withstand Phase/Earth across interrupter	60kV
Opening/Closing Mechanism	Latching magnetic actuator

D.C. Resistance Terminal/Terminal	<120 micro-ohm
Tank Construction	Stainless steel
Bushings/VI Housings	Outdoor Cyclo-Aliphatic Epoxy Resin
Maintenance Interval[a]	5 years
Earthing[b]	12mm stud provided
Applicable standards	ANSI C37.60

a. In heavy polluted environments regular checking of insulators should be conducted.
b. You MUST adhere to the instructions in the Installation chapter, section “Earthing” on page 79

Breaking Duty

The duty limits of the circuit breaker are shown in the table below.

Circuit Breaker is rated for ANSI C37.60 duty cycle. Contact wear is automatically calculated for each interrupter by the control cubicle on the basis of fault current and mechanical operations.

The remaining contact life is shown on the operator control panel. See "Contact Life" - page 14 for more detail.

Mechanical operations	10000
Contact wear - 400A	10000
Contact wear - 2kA	1955
Contact wear - 6kA	217

Duty Cycle

Maximum allowable duty cycle at full short current rating:

- Open-0.5s-Close
- Open-2s-Close
- Open-2s-Close
- Open followed by 300 second recovery time.

Terminal Clearance/ Creepage

Insulator Material Type	Outdoor Cyclo-Aliphatic Epoxy Resin
Creepage distance	780mm
Taut String clearance phase/earth	295mm

Current Transformers

There is no access to current transformer connections on the equipment.

This data is supplied for information only.

Ratio	2000:1
Accuracy 2 Amp - 400 Amp	±1%
Accuracy 400 Amp - 6000 Amp	±5%

Environmental

Operating Temperature[a]	-30°C to +50°C
Operating Humidity	0 to 100%

Operating Solar Radiation	1.1kW/m² max
Operating Altitude[b]	3000m max

a. Temperature range depends on control cubicle versions.
b. Altitudes above 1000 meters must be de-rated per ANSI C37.60.

Control Cubicle

General Specifications

Standard control cable length[a]	7m
Maximum vertical separation from circuit breaker with standard control cable.	5m
Maintenance interval[b]	5 years
Auxiliary supply voltage (LV AC mains supply)	As Ordered +10 -20%
Required auxiliary supply rating	50 VA
Battery	2 x 12V 7.2Ah
Battery hold up time from fully charged[c]	5 days
Battery recharge time (new battery to 80% nominal capacity)	10 hours
Battery replacement interval[b.]	5 years
Battery Low Voltage[d]	23V
Battery High Voltage[d.]	32V
Earthing[e]	10mm earth stud
Heater power (where fitted)	120W
Radio/Modem A radio or modem may be fitted by the manufacturer or by the utility, for remote communications. Space, power and data interfaces are provided within the control cubicle.	
Radio/Modem Power Supply Voltage (set by user)	5 - 15V DC
Radio/Modem Power Supply Continuous Current	3A
Radio/Modem Power Supply Max Current	5A for 30 sec with 20% duty cycle
Radio/Modem Space on Radio Panel	See Figure 45 (page 133)
Radio/Modem Interface[f]	V23 or RS232
Radio/Modem Power Shutdown Time	1 - 1440 mins
Timing Accuracy	±10 secs
Control Electronics Thermal Restraints	
Continuous Primary current	800A
Short time primary current	16kA for 3secs
Short time current recovery time	60 sec
Recloser Operations[g]	20 in 1 minute, 1 per minute thereafter
Local Operator Controls Local Operator Control is through the Operator Control Panel, refer to later sections.	

a. Other control cable lengths available-4, 7, 11 and 20 meters.
b. Battery replacement interval is influenced by location. See “Maintenance” on page 85.
c. Assumes no radio/modem power drain or IOEX card connected. At the end of the hold-up period, power is available for a minimum of 10 recloser operations. When exhausted the battery is disconnected.
d. Temperature compensated at 48mV/°C.
e. Earthing Details in "Earthing" - page 79 must be strictly adhered to.
f. See Section 14 (page 65) for more details
g. See "Abnormal Operating Conditions" - page 87

Protection and Auto Reclose functions

The control electronics have in-built protection and auto-reclose relay functions as below.

A setting current is available which applies to all trips in a sequence. However curves, multipliers and other parameters may be set separately for each trip in a sequence.

Multiple sets of protection settings are available. See Section 9 (page 35) for a full description of protection functions.

Inverse Time Protection

Inverse Time Curves available	Refer Appendix A. B and C.
Setting Current Range	3 to 1260 Amps
Setting Current Resolution	1 Amp
Setting Current Accuracy[a]	5% ±1 Amp
Maximum Current for which curve applies	12.5 kA
Maximum Setting Current Multiple for which curve applies	x30
Time Multiplier	0.05 - 2
Time Multiplier Resolution	0.01
Maximum Time to Trip[b]	2 - 180 secs
Maximum Time to Trip Setting Resolution	0.1 sec
Minimum Time to Trip[b.]	0 - 2 sec
Minimum Time to Trip Setting Resolution	0.01 secs
Additional Time to Trip[c]	0 - 2 secs
Additional Time to Trip Setting Resolution	0.01 secs
Threshold Multiplier	1 - 10
Resolution of Multiplier Setting	0.1
Timing Accuracy[d]	5%,±20 ms

a. Current accuracy applies to protection relay function only and excludes accuracy of current transformers.
b. Applies to inverse time and instantaneous protection only.
c. Applies to inverse time protection only.
d. Timing refers to time to initiate operation of circuit breaker (opening and closing times are in addition).

Definite Time Protection

Available as an alternative to inverse time on phase and earth.

Setting Current parameters are as for inverse time protection.

Definite Time range	0.05 - 100 sec
Definite Time resolution	0.1 sec
Timing Accuracy[a]	±50 ms

a. Timing refers to time to initiate operation of circuit breaker (opening and closing times are in addition). See "Inverse Time Protection" - page 8

Instantaneous Protection

Available as an additional element on inverse time or definite time protection or as an alternative without inverse time or definite time.

Instantaneous protection can be applied to phase protection.

Multiplier of Trip Current Setting (applies to both phase and earth)	1 - 30
Resolution of Multiplier Setting	0.1
Maximum Effective Setting	12.5 kA
Trip Current Setting Accuracy[a]	±10%
Transient Overreach for X/R < 10	<5%
Transient Overreach for X/R > 10	<10%

a. Current accuracy applies to protection relay function only and excludes accuracy of current transformers.

Cold Load Pickup

This is an additional protection feature, which operates with inverse time and instantaneous protection.

Cold Load Multiplier Range	1 - 5
Cold Load Multiplier Resolution	0.1
Cold Load Time Constant Range	1 - 480 mins
Cold Load Time Constant Resolution	1 min
Timing Accuracy	±1 min

Inrush Restraint

This is an additional protection feature, which operates with inverse time and instantaneous protection.

Inrush Restraint Multiplier Range	1 - 30
Inrush Restraint Multiplier Resolution	0.1
Inrush Restraint Time Range	0.05 - 30 sec
Inrush Restraint Time Resolution	0.05
Timing Accuracy	±20ms

Under/Over Frequency Protection (CAPM 5 only)

This is an additional protection feature which is only available if the CAPM 5 module is used.

Frequency setting range[a]	45 - 65 Hz
Frequency setting resolution	0.1 Hz
Accuracy (for sinusoidal input)	± 0.05 Hz
Frequency Dead Band (hysteresis)	0.2 Hz
Number of under or over frequency cycles before tripping	2 to 1000
Frequency calculation	Once per cycle averaged over 2 cycles
Low Voltage Inhibit range	4 to 23 kV
Low Voltage Inhibit setting resolution	1V
Normal Frequency Close Time	1 to 1000 secs

a. Under/Over tripping frequencies and normal frequencies are interlocked by software so that only viable settings are possible.

Live Load Blocking

This is an additional protection feature, which operates independently of the protection elements.

Live Load Threshold Voltage	2000V -15000V

High Current Lockout

This is an additional protection feature, which operates in conjunction with the protection elements.

Maximum Effective Setting	12.5kA
Minimum Effective Setting	10 A
Current Setting Resolution	1 A
Accuracy	±15%

Automatic Protection Group selection

This is an additional protection feature.

Auto Change Time	10 - 180 sec
Auto Change Time Resolution	±1 sec

Auto - Reclose

Trips in Sequence to Lockout	1 - 4
Reclose Time After First Trip in Sequence	0.5 - 180 sec
Reclose Time After Second and Third Trips in Sequence	2 - 180 sec
Reclose Time, Timing Resolution	0.1 sec

Reclose Time, Timing Accuracy[a]	±0.1 sec
Single Shot Reset Time	0 - 180 sec
Single Shot Reset, Timing Resolution	1 sec
Single Shot Reset, Timing Accuracy	±1 sec
Sequence Reset Time	3 - 180 sec
Sequence Reset, Timing Resolution	1 sec
Sequence Reset, Timing Accuracy	±1 sec

a. Timing refers to time to initiate operation of circuit breaker (opening and closing times are in addition). See page 5.

Loss of Supply Detection

Live Terminal Threshold Voltage	See "Power System measurements" - page 11
Loss/Restoration of Supply Timeout	0.1 - 100 sec
Loss/Restoration of Supply Timing Accuracy	-0ms/ +150ms

Other Protection features

Fault Reset Time[a]	50 - 800ms
Fault Reset Time Accuracy	±20 ms
Sequence Control	Available

a. Applies to all protection elements.

Power System measurements

Voltage Range (RMS Phase/Earth)[c]	2 - 24kV
Voltage Resolution	1V
Voltage Accuracy[a]	2.5% ±25V
Live Terminal Threshold Voltage range[b]	2 - 24kV
Live Terminal Threshold Voltage setting resolution[b.]	1V
Live Terminal Threshold Voltage accuracy[a.b.]	5% ±250V
Live Terminal Threshold Hysteresis	-20%
Current Range (RMS)[a. c]	1 - 800 Amp
Current Resolution	1 Amp
Current Accuracy[a.]	2.5% ±2 Amp over range 1 - 800 Amp
Apparent Power Range[c]	0 - 12 MVA
Apparent Power Resolution	1 kVA
Apparent Power Accuracy[a.]	±5% over range 20 - 800 Amp
Real Power Range[c d]	-12 - 12 MW

Real Power Accuracy[a.]	±5% of apparent power
Real Power Resolution	1 kW
Reactive Power Range[c.]	0 - 12 MVAR
Reactive Power Resolution	1 kVAR
Reactive Power Accuracy[a.]	±5% of apparent power
Unsigned Power Factor	0.5 - 1.0
Power Factor Resolution	0.01
Power Factor Accuracy	±0.05
Measurement Filter Time Constant (Step Response)	2 sec
Measurement Update Rate	0.5 sec

a. Includes accuracy of switchgear current and voltage transformers.
b. Used for Live/Dead display, Live Load Blocking and Loss Of Supply detection.
c. In database for transmission by a protocol.
d. Used to accumulate kWh reading for weekly maximum demand data.

Demand History

Average Demand Sample Times[a]			5, 15, 30 and 60 minutes	
Storage times for the average/weekly demand default data set				
Sample period (minutes)	5	15	30	60
CAPM 4 - Minimum storage time (days)	26	78	156	312
CAPM 5 - Minimum storage time (days)	78	234	468	936
Event History				
Minimum number of typical events stored in the event history			3,000 events	

a. Configurable history can be accessed via WSOS, thus allowing the operator to select sample period and items stored. This will affect the specified storage times.

Equipment and Crating Dimensions

Equipment Weights	
Part	
Control cable	6kg
Control cubicle	35kg
Pole Mounted Circuit Breaker	62kg
Pole mounting bracket	13kg
Crate	80kg
Dimensions	
Control Cubicle	See Appendix J (page 131)
Circuit Breaker	See Appendix J (page 131)
Crate Dimensions (mm)	
Width	1150mm
Length	1150mm
Height	570mm

4 Construction and Operation

General Description

The circuit breaker uses a vacuum interrupter insulated with cyclo-aliphatic epoxy resin mouldings operated by a single magnetic actuator for both tripping and closing.

The magnetic actuator is operated by capacitors in the control cubicle which are charged and discharged by the electronic controller.

An external pointer, easily visible on the side of the tank, indicates the position of the circuit breaker.

Refer to Figure 1 (page 15) for identification of major features.

Always follow proper safety procedures. This Recloser is not suitable for use as a point of isolation. If work on the electrical system is to be carried out, de-energise the recloser and confirm electrical and mechanical indications.

Any conductors that should be de-energised by the opening of the recloser should be tested and proved dead prior to opening non rated switchgear, or applying earths to the system.

Circuit Breaker Mounting

The mounting bracket is suitable for both timber and concrete poles.

Refer to Figure 30 (page 81) and Appendix J-Dimensions (page 131).

Additional mounting details are provided in "Site Installation" - page 77.

Manual Trip

The manual trip lever is on the side of the tank. Operating this lever downward with a hook stick trips the circuit breaker. This lever should be operated positively through the length of its travel and electrical and mechanical indications confirmed.

The lever remains in the down position until physically returned to the normal position by the operator. Whilst in the down position the circuit breaker is mechanically locked open and electronically interlocked against closing.

Line Connection/ Terminals

High voltage terminals are ∅20mm tin plated copper stems with M10 x 1.5 threaded holes at the end, refer to Figure 28 (page 78).

This means that connections can be either:

- Parallel groove connectors suitable for the cable type. These are readily available in bi-metallic versions suitable for connecting to aluminium cables.
- Standard lugs with 10mm diameter holes. (Generally only suitable for cables up to 70mm^2.)

Surge Arresters

Provision of surge arresters is recommended to protect the circuit breaker from over-voltage.

Control Cubicle Connection

Connection to the control cubicle is by a control cable that plugs into the back of the circuit breaker. The control cable can be orientated to suit the installation.

A current transformer and voltage screen that are embedded in the epoxy resin mouldings send signals to the control electronics which monitors phase current and phase/earth voltage.

The voltage screen is embedded in the “I” side moulding, refer to Figure 1 (page 15).

If the control cable is disconnected (at either end) the CT and voltage screen are automatically shorted by circuitry on the Switchgear Cable Entry Module (SCEM) card mounted inside the tank of the circuit breaker.

Circuit Breaker Memory

The circuit breaker incorporates an electronic memory that is used to record information pertinent to the unit. The following is available on the operator display:

- Serial Number.
- Breaking Rating.
- Continuous Current Rating.
- Number of Mechanical Operations (incremented on close).
- Rated Voltage.
- Contact Life Remaining.

Contact Life

The vacuum interrupter in the circuit breaker has the duty rating given in Section 3 (page 5).

The control electronics measures the interrupted current every time the contacts open.

This measured current is used to calculate the amount of contact wear that each interrupter has suffered and the contact life remaining is reduced accordingly.

The remaining contact life is held in the circuit breaker memory and can be displayed on the Operator Control Panel.

If remaining life reaches zero the circuit breaker should be returned to the manufacturer for refurbishment.[1]

Line Voltage Sensing

The standard W Series ACR senses line voltage on the I-Side terminal.

In normal closed operation this enables voltage and power measurement.

Some automation systems may require voltage sensing on both sides of the ACR when it is open. To satisfy this requirement, an optional Capacitive Voltage Transformer (CVT) may be installed to provide voltage sensing on the X-Side terminal of the ACR.

A brief explanation of the external CVT is given in Appendix K (page 135).

1. Since the actual breaking current is measured and since most faults are considerably lower than the maximum line fault current, a much longer service life is to be expected from this method of monitoring wear compared to a simple operations count method.

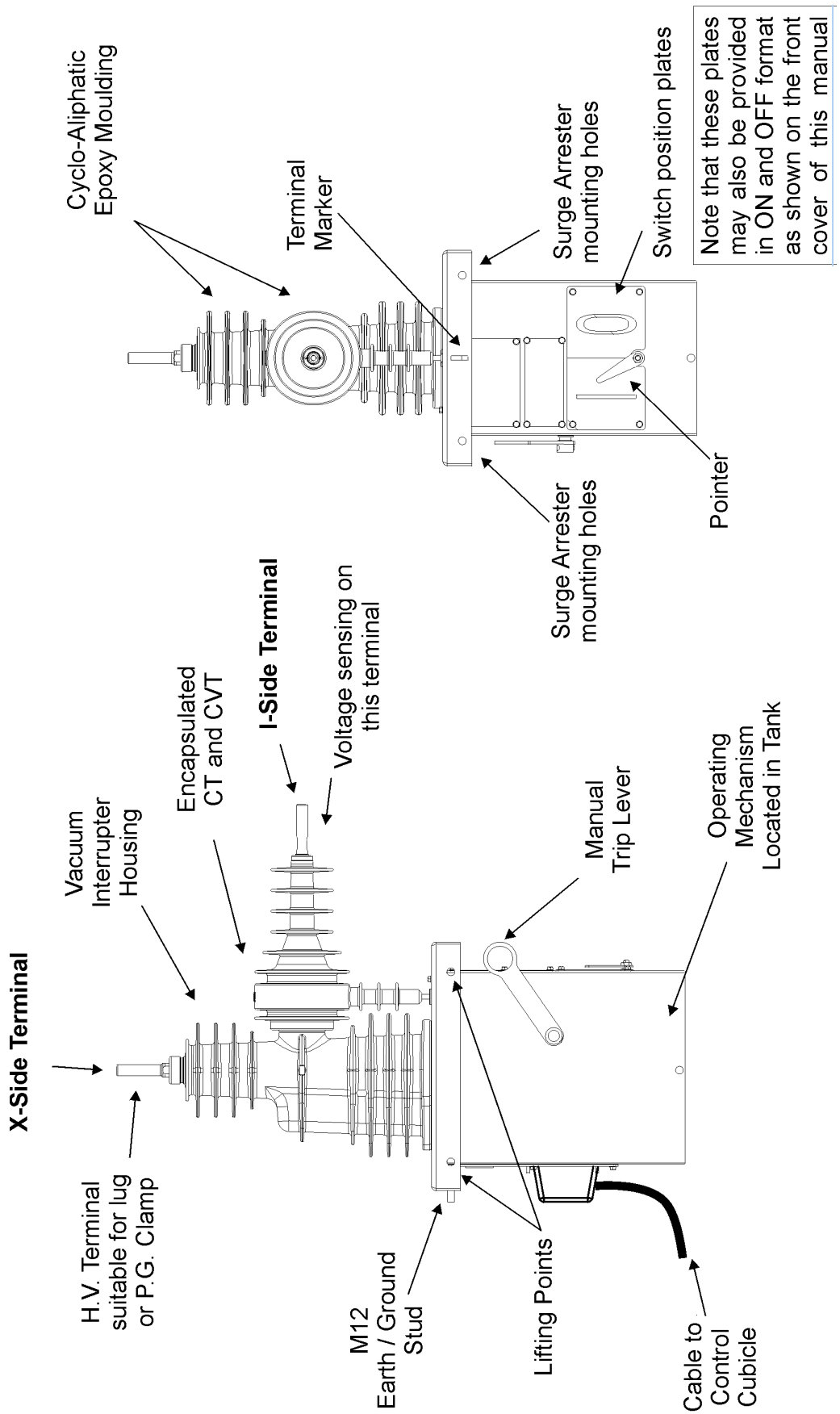


Figure 1: Circuit Breaker Features

5 Control Cubicle

The control cubicle is purposely designed for outdoor pole mounted operation.

It features a hinged hatch for all weather access by operations staff and a door for access by maintenance staff. Both the door and the hatch can be padlocked for security.

Figure 46 (page 134) shows the cubicle's dimensions.

Connection between Cubicle and Circuit Breaker

The circuit breaker is connected to the control cubicle by the control cable. The cable plugs into compatible ports at both the cubicle and the back of the circuit breaker.

Tropical, Moderate and Temperate Versions

Tropical, moderate and temperate climate versions of the control cubicle are available:

- The tropical version is well ventilated and is suitable for climates where the ambient temperature can reach 50°C and only occasionally goes below 0°C, with a lower limit of -10°C.
- The moderate version has reduced ventilation and is used in environments where the temperature rarely goes above 40°C and occasionally goes below -5°C with a lower limit of -15°C.
- The temperate version has reduced ventilation and a heater fitted to the equipment panel. It is suitable for climates where the ambient temperature rarely goes above 40°C but can fall as low as -30°C.

Equipment Panel

Inside the cubicle is an equipment panel with the following key features. See Figure 2 (page 20) and Figure 33 (page 121).

- The **Mains Compartment** houses LV mains transformers (where fitted) and miniature circuit breakers for batteries and auxiliary supply.
- The **Electronics Compartment** houses the Control and Protection Module (CAPM) and the Operator Panel Sub-System (OPS). This compartment is sealed to protect the electronics from airborne pollution.
- The **Battery Compartment** houses two 12Volt batteries.
- The **Radio Mounting Tray** is used to mount the communications radio, modem or IOEX card (where fitted), see Section 15 (page 69). This hinges down to expose the radio/modem and can be detached to allow workshop fitting of the radio/modem.
- The **Control Cable Entry Module** provides termination and filtering for the control cable, this is housed behind a removable panel. The incoming control cable connects to P1 of the CCEM, the internal wiring loom N03-505 connects to P2 of the CCEM.
- A **Heater Compartment** for the control cubicle heater can be fitted.

Running up the centre of the equipment panel is a rubber cable duct used to carry the internal wiring. The equipment panel can be removed by disconnecting external connections and unbolting.

The equipment panel is arranged so the most heat sensitive components, the batteries, are located low down close to the point of air entry. In tropical situations this ensures the batteries stay within a few degrees of ambient at all times thus maximising their life.

Additionally the part which generates the most heat, the mains power supply (where fitted), is located at the top of the cubicle where its heating effect on other parts is minimised.

Sealing & Condensation

All vents are screened against vermin entry and the door is sealed with replaceable foam tape. Complete sealing against water entry under all conditions is not expected e.g. during operation in the rain with the hatch open. Instead, the design is such that if any water does enter, it will run out of the bottom without affecting the electrical or electronic parts.

The well-vented and self-heating nature of the cubicle ensures moisture will dry out rapidly. The extensive use of stainless steel and other corrosion proof materials ensures the presence of moisture has no detrimental effects.

Condensation can be expected to form under some atmospheric conditions such as tropical storms. However, due to the insulated and well-vented design, any condensation will be on metal surfaces where it is of no consequence. The water runs out in the same way as any other water entering the cubicle. Condensation will run out of the bottom and be dried by ventilation and self heating.

The Electronics Compartment, which houses the main electronic modules, is well sealed and is only opened for electronic module replacement.

Mounting & Earthing

The control cubicle is mounted on the pole using either bolts through the pole or strapping around the pole. It is connected to the circuit breaker by the detachable control cable.

WARNING

The control cubicle must be earthed to the circuit breaker to complete the recloser earthing scheme as detailed in Section 17 (page 75).

Radio Mounting Tray Space

The space available on the radio tray to install customer equipment is shown in Figure 45 (page 133).

Auxiliary Power Source

The auxiliary supply is used to maintain charge on the sealed lead-acid batteries that provide standby power when auxiliary power is lost. The controller monitors the status of both the auxiliary and battery supplies.

A low power mode is activated when the batteries are nearly exhausted due to loss of the auxiliary supply. This mode minimises power consumption while still maintaining basic functionality. See Section 18 (page 85) for more information.

Auxiliary power comes from either:

- LV supplies provided by the utility. This connects into the control cubicle and is called an *LV Supply.* In this case the control cubicle is fitted with a suitable transformer and its nameplate indicates the required auxiliary supply voltage.
- HV line supply to a Voltage Transformer (VT) fitted outside the circuit breaker tank. This external VT is connected into the circuit breaker and is called *an Integrated HV Supply.* In this case the rating plate on the transformer indicates its voltage rating.

Section 17 (page 75) gives details of auxiliary supply connection and earthing.

Auxiliary Supply Control Cubicle Options

The control cubicle can be manufactured in a number of different auxiliary supply configurations such as:

- Single Auxiliary Supply from LV
- Single Auxiliary Supply from HV
- Dual Auxiliary Supply from LV
- Dual Auxiliary Supplies, one from LV and one from HV.

Appendix I (page 121) includes the wiring diagrams detailing the connection of auxiliary power supplies. The configuration is indicated on the control cubicle name plate as:

- AUX SUPPLY 240VAC (or other voltage) for LV supply, or
- AUX SUPPLY INTEGRATED for integrated HV supply, with external VT supplied by the manufacturer.

The Miniature Circuit Breakers (MCB) at the top of the control cubicle in the mains compartment protect the battery (centre MCB) and the auxiliary supplies.

When equipped for *Integrated HV Supply* the Aux MCB should always be closed during operation or testing even if the auxiliary supply transformer is not energised. This ensures correct operation of the memory in the circuit breaker.

For a *single LV supply* an AUX OUT socket can be factory fitted as an option to provide a power outlet in the control cubicle. This is shown in Figure 2 (page 20). For dual supplies two AUX supply MCB's are fitted, one for each supply.

Cable Entry

All cables enter the control cubicle from the underside as shown in Figure 46 (page 134). Cable entries are provided for:

- The control cable from the recloser that plugs into connector P1 at the bottom of the battery compartment.
- One or two LV mains supplies (where fitted) which run behind the equipment panel. The two 20mm holes provided for cable entry can also be used for external I/O entry if required.
- Communication Cable/Radio Antenna (where fitted), a 16mm hole is provided for cable entry.

Current Injection Point

A six way connector called the “Current Injection Point” is located on the mains compartment. This is used with the Test and Training Set (TTS) to perform secondary injection while the circuit breaker is connected. This allows injection of equipment in service without disconnection.

Computer Port

A 25 way female D-type connector is located on the electronics compartment cover above the Operator Control Panel. It connects to an RS232 port on the electronic controller for use with the Windows Switchgear Operating System (WSOS) on a portable computer. This port is also used to upgrade electronic controller operating software, including installation of new telemetry protocols.

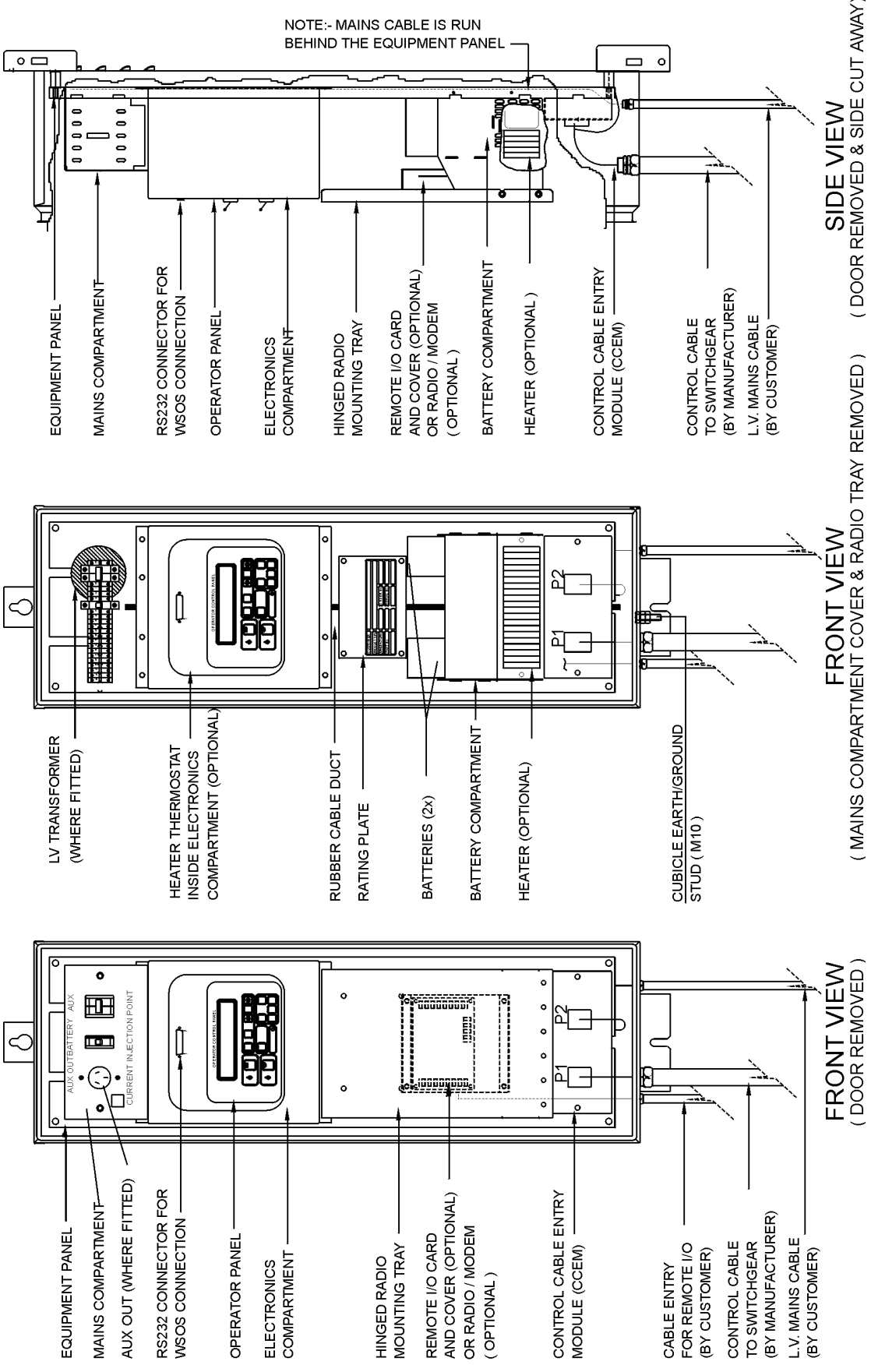


Figure 2: Equipment panel

6 Control Electronics Operation

The control system block diagram is shown in Figure 3 (page 23). The main features are explained below.

Control & Protection Module

The main module of control electronics is the Control and Protection Module (CAPM).

The circuit breaker accompanying this manual uses either module version 4 (CAPM 4) or module version 5 (CAPM 5). It is centred around a microprocessor and carries out the following functions:

- High speed sampling of the line Current Transformer (CT) and calculation of RMS current.
- High speed sampling of the line Capacitive Voltage Transformer (CVT), calculation of RMS phase/earth voltages.
- Calculation of apparent, real and reactive power flows from the above.
- Protection relay functions.
- Auto-reclose relay functions.
- Monitoring of circuit breaker auxiliary switches.
- Charging of the close and trip capacitors.
- Discharging the close and trip capacitors into the magnetic actuator to operate the circuit breaker, either automatically or by local or remote operator command.
- Charging of the battery from the auxiliary supply, changeover to battery on loss of auxiliary supply and disconnection when the battery is exhausted.
- Driving the Operator Panel Sub-system (OPS).
- Driving the external communications interface to allow monitoring and control from a remote computer or operator over a communications link.
- Driving the Windows Switchgear Operating System (WSOS) over an RS232 link. The connector for this link is located on the electronics compartment above the operator control panel.

The CAPM is a replaceable unit.

Operator Panel Subsystem (OPS)

This comprises the electronics compartment cover, an operator control panel with LCD display, a membrane keyboard and its controlling microcomputer.

The OPS is a replaceable unit.

Control Cable Entry Module (CCEM)

This is located at the bottom of the battery compartment and provides termination and filtering for the signals from the circuit breaker.

The CCEM is a replaceable unit.

CAPM Operation

General Overview

The CAPM utilises a Motorola 68332 microprocessor, with non-volatile “Flash” EEPROM and 1Mbyte of volatile read/write static memory.

- Non-volatile Flash memory is used to hold programs, configuration parameters and historical data.
  - CAPM 4 has 2 Mbytes of Flash memory.
  - CAPM 5 has 4 Mbytes of Flash memory.
- Volatile memory is used as run time workspace.

There are no user-adjustable hardware features on the CAPM, no links, no DIL switches and no variable resistors. Re-programming of the microprocessor can be carried out using a built-in loader from a portable computer.

On power-up, or when the circuit breaker is connected, the CAPM reads the data from the memory inside the circuit breaker. The memory data in the circuit breaker includes error check codes enabling the CAPM to validate the data. The status of the data is then displayed on the operator panel.

When a local operator presses buttons on the control panel a character is sent from the Operator Panel Subsystem to the CAPM, which then carries out the required command.

The Recloser operates when the CAPM discharges its trip or close capacitors into the circuit breaker actuator. The CAPM continually monitors the capacitors and will only discharge them into the recloser solenoids if the charge is sufficient for correct recloser operation. In addition, the CAPM will only close the circuit breaker if there is sufficient charge in the trip capacitor to trip the circuit breaker. This ensures

the circuit breaker will always be ready to trip if closed onto a fault.

If a close request occurs when there is insufficient charge in the capacitors it is discarded (this never happens in normal operation).

The CAPM will not attempt to operate the Recloser and any control requests will be discarded if any of the following conditions exist.

- The isolate switches on the operator panel are in the isolate position.
- The circuit breaker is disconnected.
- The circuit breaker memory data cannot be read or is invalid.

The current transformer and voltage screen in the circuit breaker are monitored to provide the protection and measurement functions.

Normal Operations

The circuit breaker, control electronics and power supplies are monitored for correct operation. This data is used to generate a “system healthy” signal which is available either for transmission by a telemetry protocol or as an output on the optional IOEX (Input/Output Expander) module. This can be used for remotely monitoring the health of the circuit breaker.

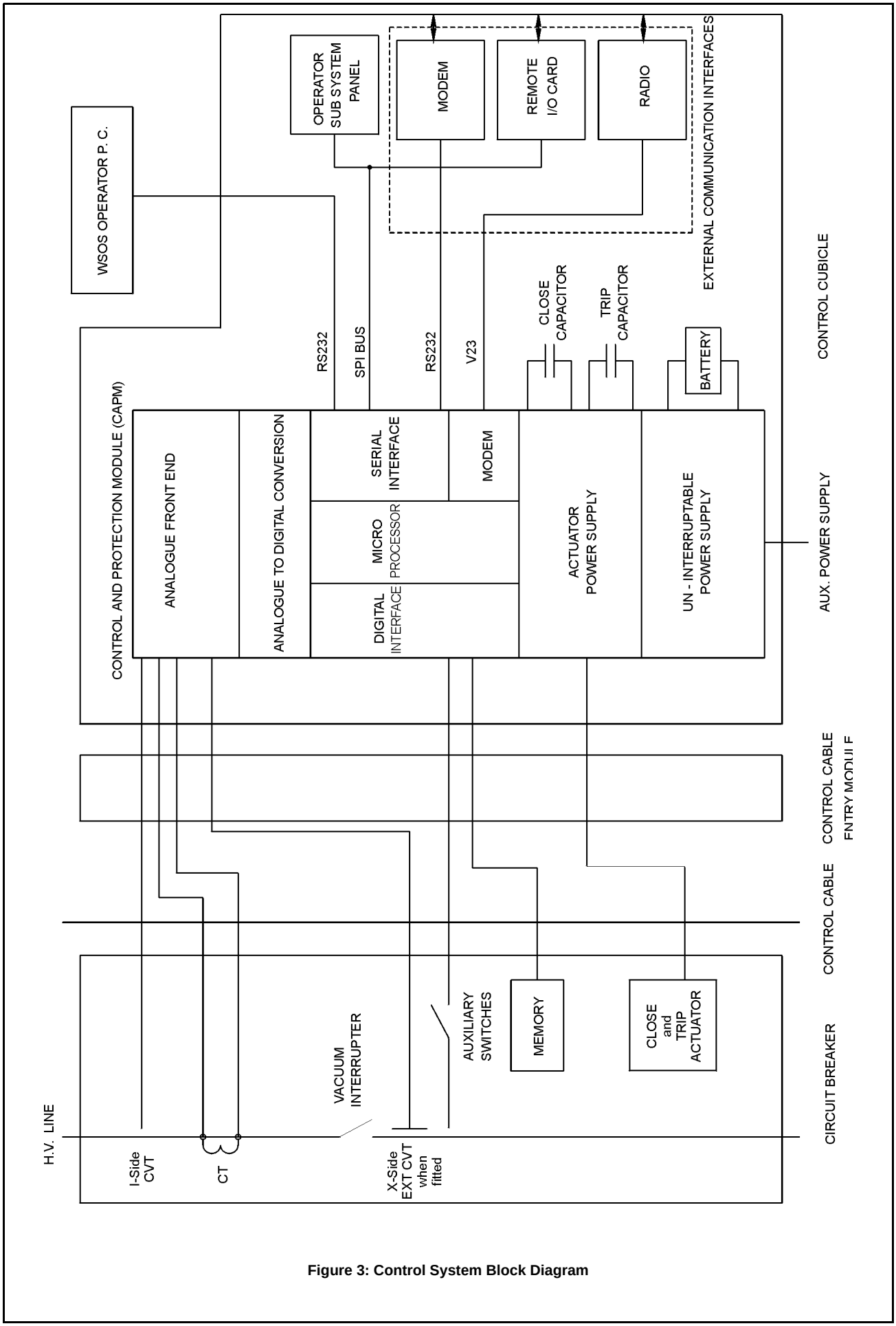


Figure 3: Control System Block Diagram

7 Operator Control Panel

Description

The Operator Control Panel (OCP) is mounted inside the control cubicle on the equipment panel. The OCP consists of a four-line Liquid Crystal Display (LCD) and keypad with switches and Light Emitting Diodes (LEDs), which are used to select and monitor the functionality of the recloser.

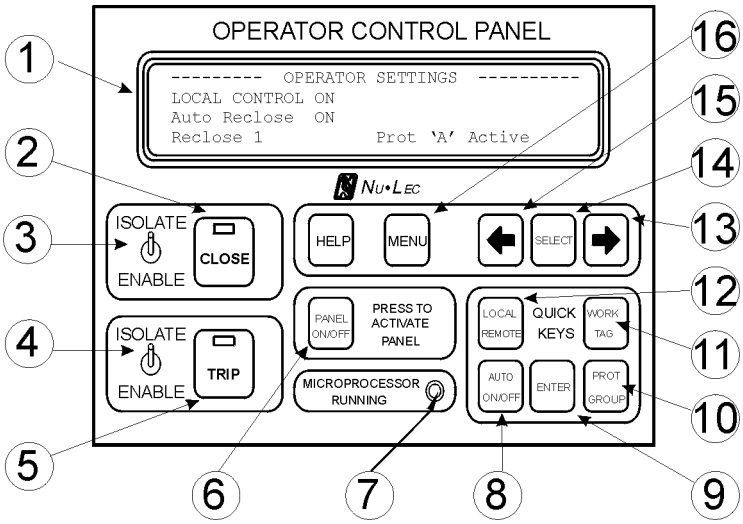


Figure 4: Operator Control Panel

Number	Item	Description
1	Display	Back-lit LCD, 4 line with 40 characters per line.
2	Close key	Generates a Close request to the CAPM when the panel is active. A red LED is embedded in the key. The LED is lit when the recloser is closed.
3	Isolate/Enable Close switch	Isolates the Close key. When the switch is in the Isolate position the close coils in the magnetic actuator are disconnected from the control electronics. Thus the switch provides a physical isolation point for the control circuitry. The recloser cannot be closed and an audible alarm in the panel will sound. The Close key operates normally when the switch is in the Enable position.
4	Isolate/Enable Trip switch	Isolates the Trip key. When the switch is in the Isolate position the trip coils in the magnetic actuator are disconnected from the control electronics. Thus the switch provides a physical isolation point for the control circuitry. The recloser cannot be opened and an audible alarm in the panel will sound. The Trip key operates normally when the switch is in the Enable position.
5	Trip key	Generates a Trip request to the CAPM when the panel is active. A green LED is embedded in the key. The LED is lit when the recloser is open.
6	Panel ON/OFF key	The PANEL ON/OFF key turns the panel on and off.
7	Microprocessor Running LED	The green MICROPROCESSOR RUNNING LED flashes at 2 second intervals to indicate the control electronics are running normally. If the flashing stops or becomes intermittent it indicates a fault condition (e.g. loss of power). The LED flashes at all times, even when the panel is turned off.
8	Quick key[a]	AUTO ON/OFF
9	Enter key	Activates selected Quick key setting, and restores original display.

Operator Control Panel description

Number	Item	Description
10	Quick key[a]	PROTECTION GROUP
11	Quick key[a]	WORK TAG
12	Quick key[a]	LOCAL/REMOTE
13	RIGHT scroll key	➢ - select pages within a group.
14	SELECT key	Press to SELECT Menu item.
15	LEFT scroll key	➢ - select pages within a group.
16	MENU scroll key	Selects the group required.

Operator Control Panel description

a. Default Quick Keys shown.

Organisation of Liquid Crystal Display

The four-line LCD display is typically structured as shown below.

```
- - - - - -  PAGE TITLE - - - - - -
Data Field 1           Data Field 2
Data Field 3           Data Field 4
Data Field 5           Data Field 6
```

Example display pages are shown in Figure 5 (page 29).

Some special display pages are different, these are shown in the relevant sections in this manual. See Appendix D (page 103) and Appendix E (page 109).

Turning on the Control Panel

The **PANEL ON/OFF** key turns the panel on and off. When off, the display is blank and none of the keys work. The panel will turn itself off if no keys are pressed for ten minutes.

When activated the control panel shows a start-up message for 5 seconds then shows the display page.

SYSTEM STATUS - TRIP FLAGS

If the time and date has not been set since the last restart then the operator must set it, by using the **SELECT,** ➢ and pressing the **MENU** key twice before other displays can be selected.

Selecting Displays

The **MENU** key selects the display group. The ➢ keys select pages within the group, this is shown in Figure 5 (page 29).

Therefore to select a particular display page:

1. Press the MENU key to get the desired group on display.
2. Press ➢ to get the page or sub-group required.
3. Press SELECT to get to the sub-page required, where necessary.

Changes can be made to existing program settings using either of two operator controlled methods at the control panel.

The **MENU**, **SELECT**, ➢ **"LEFT ARROW"** and ➢ **"RIGHT ARROW"** keys facilitate manual navigation within the operator panel display pages.

The **QUICK KEYS** are interface keys that facilitate the rapid changing of operator settings.

Using the MENU, SELECT and ARROW Keys

All settings can be changed by the following procedure:

1. Find the page on which the setting is shown as described in Selecting Displays - page 26
2. Press **SELECT** until the required setting starts to flash.
3. Press ➢ keys to change the setting to the new value required. Press **MENU** or **ENTER** to put the new setting into service.

Display Groups

Many different displays are available and are divided into four main groups described below. See Figure 5 (page 29).

System Status

Contains all status information about the recloser and control electronics e.g. battery low, operations count.

Information on this display group is given in Appendix D (page 103).

All System Status displays have the capital letter **'S'** in the top right corner. See Figure 8 (page 30).

Event Log

Shows the event record for the recloser.

More information is given in Section 10 (page 53) and in Appendix G (page 115).

See Figure 5 (page 29).

Measurement

Contains all information about the HV line measurements made e.g. line current, line voltages, maximum demand data.

See Section 12 (page 59) and Appendix F (page 113). All Measurement displays have the capital letter "**M**" in the top right corner. See Figure 6 (page 29).

Protection

Contains all the protection settings currently in use e.g. Trip Current Settings, curves, reclose times.

More information is given in Figure 7 (page 30) and Appendix E (page 109).

All Protection displays have the capital letter **'P'** in the top right corner.

Configurable Quick Keys

Quick Keys provide the capability for the operator to quickly access commonly used programme settings from any screen.

Quick Keys are configurable and can be selected by the operator using the OCPM or WSOS.

Listed in the following table are the operator functions that can be programmed to individual Quick Keys.

A set of stickers is available from the manufacturer that includes the wording for each of the available functions.

The operator can apply the sticker as required to match the selected functionality of the Quick Key. See Appendix H (page 119) for the sticker part numbers.

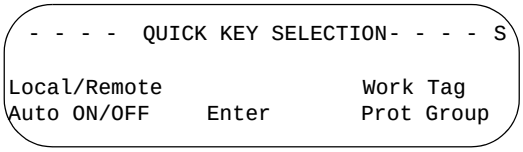
Auto Reclose On / Auto Reclose Off Protection Off
Cold Load On/Off
Live Load Blocking
Local/Remote/Hit and Run Selection
Loop Automation On/Off
Protection Group Selection
Reset Flags
Work Tag On/Off

Quick Key Selection

The Quick Keys can be configured at

SYSTEM STATUS - Quick Key Selection

The following screen is displayed:



To configure a Quick Key press **SELECT** or **ENTER** and the following screen is displayed with the first field flashing.

```
 - -  CHANGE QUICK KEY SELECTION - - S

Local/Remote                Work Tag
Auto ON/OFF     Enter       Prot Group
```

Pressing the **ARROW** keys will scroll the operator through the available functions. See Figure 5 (page 29).

Press **MENU** or **ENTER** when the required function is displayed.

To configure another Quick Key press **SELECT** and repeat the above procedure.

Only one function can be assigned to each Quick Key.

If the operator selects a function that has been assigned to another Quick Key the selection will revert to a blank setting.

When a Quick key is changed an event is generated in the Event Log.

Operation of the Quick Key

A Quick Key may be pressed at any time and will display the relevant page, with the selected field flashing:

- Pressing the Quick Key will continue to cycle the flashing field through the options available.
- Pressing the **ENTER** key activates the newly selected setting and immediately restores the original display.[1]

Whenever a quick key is in use the ⮜ ⮞ and **SELECT** keys are disabled and pressing the **HELP** key displays a special message which details Quick Key operation.

Password Protection

Some settings require passwords to be entered before they can be changed. If a password protected field is selected for change the user is prompted for the password. A password (which can be up to five characters in length) is entered in the following way:

1. The⮜ ⮞ keys are pressed until the first character of the password is displayed.
2. SELECT key is then pressed.
3. This sequence is repeated until the required number of characters has been entered.

Once this is done the password does not need to be entered again while the operator panel is on. However, when the operator panel turns OFF the password will need to be re-entered for further setting changes.

The default factory password is **<CAPM>** but it can be changed by the user with the Windows Switchgear Operator System (WSOS) utility. The factory password does not have to be remembered - the controller prompts the operator for it automatically.

Languages

The OCP language can be changed by selecting[2]

SYSTEM STATUS - OPTIONS 1: Language

The following languages are available:

- English.
- Spanish.
- Portuguese.

1. A particular option may not be available to the operator if it has been disabled on the “SYSTEM STATUS-OPTIONS” page
2. The changing of the language does not generate an event in the Event Log.

Main Display Groups

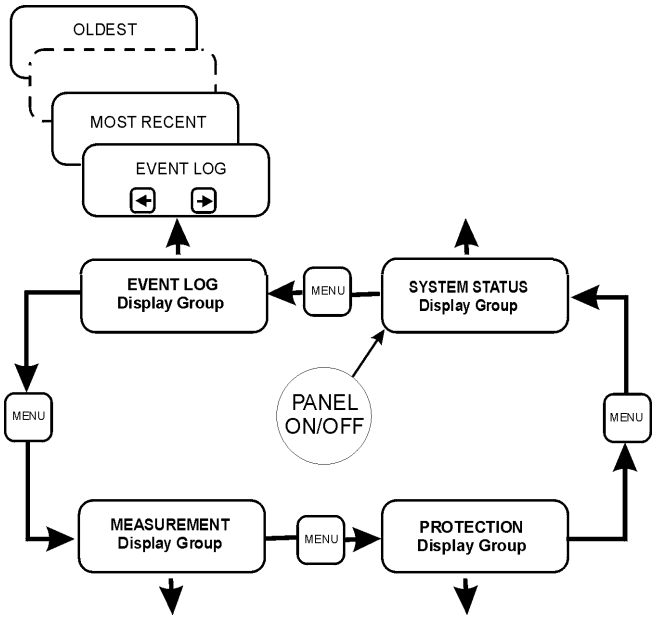


Figure 5: Four main display groups

Measurement Group

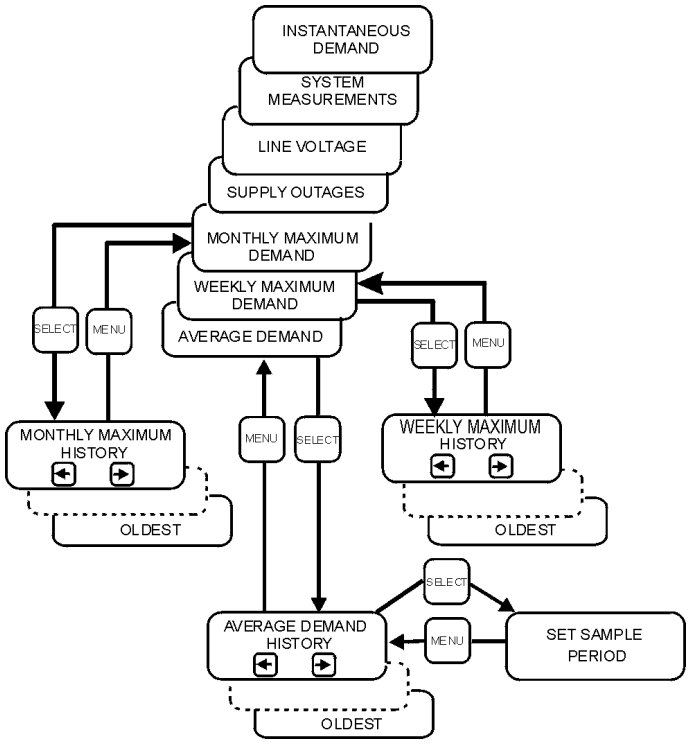


Figure 6: Measurement Group pages

Protection Group

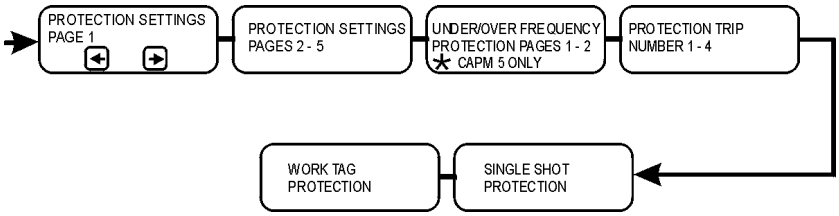


Figure 7: Protection Group pages

System Status Group

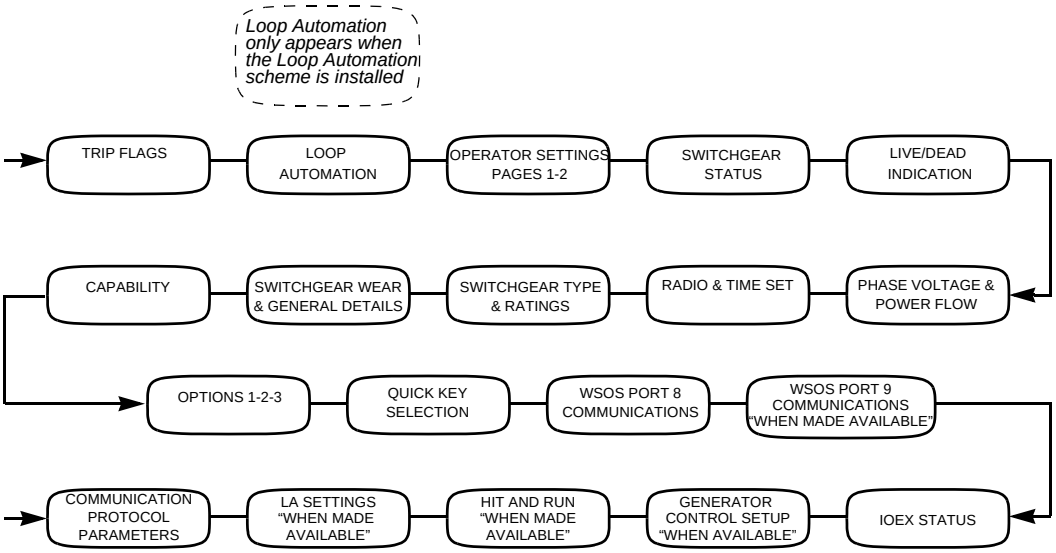


Figure 8: System Status group pages

8 Work Tags and Controller Mode

An important feature of the controller is that it is always in one of two modes, either Local or Remote, and can have a Work Tag applied by Local or Remote operators.

The mode and the tag specify the circumstances under which the circuit breaker can be closed to ensure operational safety.

Definition of Local or Remote User

There are three kinds of local user:

- The Operator Control Panel.
- An IOEX card designated as “Local”. This might apply, for example, to an IOEX card used in a substation to provide control from a panel inside a building.
- A Windows SOS (WSOS) computer plugged into the computer port on the front of the user control panel. See Section 16 (page 73).

There are three kinds of remote user:

- An IOEX card designated as “Remote”. This might apply, for example to an IOEX card used to interface to a SCADA system remote terminal unit. See Section 15 (page 69).
- A remote control protocol. These are almost always designated as remote users. Full information is given in the relevant protocol manual.
- Remote Panel - this panel provides the capability to access a maximum of five reclosers from one location.

An IOEX is designated Local or Remote from the Operator Control Panel page.

SYSTEM STATUS - IOEX Status

Local/Remote Mode

The Local/Remote selection is carried out on

SYSTEM STATUS - OPERATOR SETTINGS 1

There is a quick key on the panel to make this fast and easy. Setting this mode ensures closing and tagging can only be carried out by the designated local or remote users. It is the equivalent of a Local/Remote switch on the front panel.

- Local/Remote does not affect automatic reclosing.

Most importantly the Local/Remote mode can only be set from the Operator Control Panel.

Local Mode

In this mode only a local user can manually close the circuit breaker (it can still close automatically with the auto-reclose function).

This means a user can go to the control cubicle, set local control mode and know that remote closing is disabled.

A remote user can still trip the circuit breaker.

Only a local operator can apply/remove the Work Tag when the controller is in Local Mode.

Remote Mode

In this mode only a remote user can manually close the circuit breaker (the circuit breaker can still close automatically with the Auto-Reclose function).

Only a remote operator can apply/remove the Work Tag when the controller is in Remote Mode.

If the local operator is denied a close operation or a Work Tag due to being in Remote Mode then the operator panel will flash the message.

Not Allowed – Change to Local Control and/or remove Work Tag

Hit and Run

The *Hit and Run* feature provides a time delay between a local operator control **TRIP** or **CLOSE** request and when the ACR operates.

This feature is particularly useful in a Substation because it allows the operator to avoid potential hazards when the recloser operates.

There is no change to the operation of the ACR when *Hit and Run* is turned **OFF**.

Hit and Run is made available via WSOS only. When Hit and Run is Available it is configured at

SYSTEM STATUS - Hit and Run

When Hit and Run has been configured it can be turned on at the LOCAL/Remote field at

SYSTEM STATUS - OPERATOR SETTINGS 1:Hit and Run ON

The following tables show the Hit and Run screen and the field descriptions.

Hit and Run					S
Hit/Run Close Hit/Run Close	OFF 120s	P	Hit/Run Trip Hit/Run Trip	OFF 120s	P

Hit and Run screen

Field	Description
Hit/Run Close OFF Hit/Run Close 10s	Hit and Run Close Time This field is used to delay a local operator panel close request. Range: OFF, 10 to 120 sec (increments of 5 secs). *Factory default is OFF*
Hit/Run Trip OFF Hit/Run Trip 10s	Hit and Run Trip Time This field is used to delay a local operator panel trip request. Range: OFF, 10 to 120 sec (increments of 5 secs). *Factory default is OFF*

Hit and Run field descriptions

When Hit and Run is turned ON the operator has 30 seconds to press either TRIP or CLOSE, otherwise the setting will revert to the setting prior to turning Hit and Run ON.

This will also occur when:

- The panel is turned OFF.
- The countdown period is complete.
- The Hit and Run request is aborted by using the SELECT key.

When Hit and Run is turned ON the following screen is displayed:

```
- - - - - Hit and Run Countdown - -  S
  Press TRIP or CLOSE within 30 sec

    Press the SELECT key to abort
```

When the operator presses TRIP or CLOSE the following screen will be displayed and the countdown will begin:

```
- - - - -Hit and Run Countdown  - - S
     TRIP will occur in 120 sec

   Press the SELECT key to abort
```

The panel will “beep” every two seconds while Hit and Run is on. The beeping will become more rapid during the final ten seconds to action.

An event will be recorded in the Event Log at the start of the Hit and Run period and the end of a Hit and Run countdown or timeout.

Work Tagging

Applying the Work Tag ensures that closing ***cannot*** take place at all, either by a local operator, a remote operator or automatically. Once applied, neither a local user, remote user or the Auto-Reclose function can close the recloser.

Work Tag mode is activated when Work Tag is applied irrespective of Auto Reclose mode status, and is deactivated when the Work Tag is removed.

It is not possible for the operator to close the circuit breaker whilst in Work Tag mode.

If the Work Tag is deactivated whilst Auto Reclose is ON then the Auto Reclose mode will be entered immediately.

The Single Shot timer does not apply to Work Tag mode.

If a trip occurs whilst the Work Tag is applied then an event is logged to identify the Work Tag mode.See Appendix G (page 115).

Work Tags are applied and removed from

SYSTEM STATUS - SWITCHGEAR STATUS: Work Tag OFF

When applied the operator panel flashes the message

Warning - Work Tag Applied

Only a local user can apply/remove the tag when the controller is in Local Mode and only a remote user can apply/remove the tag when the controller is in Remote Mode. This means that a local user *can* remove the Work Tag applied by a remote

user but they must first put the controller into Local Mode.

If the local operator is denied a close operation due to the Work Tag being applied the operator panel will flash the message

Not Allowed – Change to Local Control and/or remove Work Tag

Work Tag Mode Protection Settings

Work Tag Protection settings are used to provide an appropriate protection curve when the Work Tag has been applied.

There is a separate protection page for Work Tag Protection:

```
 - - - WORK TAG PROTECTION TRIP A- - - P
Inv IEC255          Time Multiplier 1.00
No Instantaneous
Minimum 0.00s       Additional 0.00s
```

Section Appendix E (page 109) details all the fields for the Work Tag Protection Trip.

9 Protection

Overview

The controller has many different protection features described in this section. In summary it operates as follows:

- When there is a line fault the circuit breaker is tripped. The Protection Element that may activate is Phase. It may be programmed to cause the trip depending on the relevant setting.
- After a protection trip there will be a delay and then a reclose.
- This trip/close sequence can be repeated a number of times with protection elements programmed to change between each trip in the sequence.
- If the fault cannot be cleared the controller goes to lockout and waits for an operator to initiate the next close. There are a variety of ways the controller can be made to go to lockout without completing the whole reclose sequence.
- The controller can store up to ten groups of operator selected protection settings. These are Protection Groups A to J. Once programmed the protection settings rarely change.
- In addition to the protection settings there are Operator Settings. This group of settings is independent of the protection settings and it changes the main functionality of the recloser.

Fault Flags

Trip Flag Display Page

This is the first System Status page to appear when the panel is turned on, and Protection is on.

The display identifies each protection element that may cause a trip and next to it a ☐ box.

If that particular element caused the most recent protection trip then its corresponding checkbox will be filled in like this ■.

The following display s a typical example of this page which indicates that the most recent trip was caused by an Instantaneous Overcurrent (O/C) fault. There has been a total of three such events.

```
- - - - - - - - TRIP FLAGS - - - - - - - S
O/C   ■ 03  A I    FRQ ☐  00    Ext ☐  00

                                  OPS 0001
```

The counter next to the status indicator shows the number of times each protection element has caused a trip. Each counter has a range of 00 to 99 (cannot count past 99).

- Some elements also display the letter “I” to identify instantaneous trips.

The possible field values are shown below. [1]

TRIP FLAGS			S
O/C ☐■ 00-99 A I	FRQ ☐■ 00-99[a]	Ext ☐■ 00-99	
		OPS	0000

Trip Flags screen

a. This is a CAPM 5 feature only.

Field		Description
O/C	Phase Overcurrent	The letter “A” indicates that the phase is faulted. The letter “I” will also be displayed for instantaneous trip.
FRQ	Frequency Fault[a]	Indicates both under or over frequency conditions.
Ext	External Trip	External trip sources. A trip caused by the activation of a FTIM or an IOEX protection trip input.

Trip Flags - field description

a. This is a CAPM 5 feature only.

1. An Operator Trip does not alter the flags.

The setting of

SYSTEM STATUS-OPERATOR SETTINGS 1: Protection OFF

displays Pickup Flags instead of Trip Flags and more than one element may be set at a time.

Protection OFF must be Allowed at

SYSTEM STATUS-OPTIONS 1: Prot OFF Allowed/Not Allowed

before Protection OFF can be selected.

Resetting theTrip Flags

The Trip Flags will be reset by:

- Any operators close, including remote control commands.
- Start of a new sequence.

The Trip Flags *and* counters will be reset by:

- Pressing the SELECT key twice consecutively within a ten second period whilst the Trip Flags screen is displayed.
- Pressing a Quick Key configured as “Reset Flags” twice within a ten second period.
- Turning Protection OFF, however the flags and counters will not appear until Protection is turned ON.

On the first press of the SELECT key the following display advises the operator what to do next.

```
RESET TRIP FLAGS
Press the key again to reset the
flags. Press the menu key to cancel.
```

Operator Settings

Operator Settings are different from Protection Settings.

They are used by an operator or linesperson on an everyday basis to set the controller into the required mode. For example a linesperson may want to disable Auto-Reclose prior to commencing live line work.

The Operator Settings are all found on at

SYSTEM STATUS - OPERATOR SETTINGS 1

and

SYSTEM STATUS - OPERATOR SETTINGS 2

These are:

- LOCAL/Remote Control selection.
- Auto-Reclose ON/OFF, Protection OFF.
- Operational Cold Load Time and Multiplier. (See Cold Load Pickup (CLP) - page 49).
- Selection of the Active Protection Group.[1]

Protection OFF and Pickup Flags

This command turns all the Protection Features OFF and the circuit breaker will only trip or close in response to a manual operation.[2]

Protection OFF must be Allowed at

SYSTEM STATUS-OPTIONS 1: Prot OFF Allowed/Not Allowed

before Protection can be turned OFF.

A ‘Protection OFF’ event is generated and logged whenever the protection is turned off.

When configured as:

SYSTEM STATUS - OPERATOR SETTINGS 1:Protection OFF

the recloser still logs all pickup and maximum current events and sets the Pickup Flags[3]:

- The circuit breaker will not automatically trip on protection and trip events are not logged.
- If either an Under/Over Frequency condition is detected, the circuit breaker will not trip but the Frequency Pickup Flag is set.[4]

The following display is an example of the Pickup

```
- - - - - - - -PICKUP FLAGS - - - - - - - S
O/C   □ 03  A I    FRQ ■  01

                                   OPS 0001
```

Flag screen indicating an Under Frequency condition with “Protection OFF”.

The “OPS” field indicates the total number of close operations performed by the switchgear. The OPS counter in the previous screen shows one close operation.

The Pickup Flags *and* counters will be reset by:

- Pressing the SELECT key twice within a ten second period whilst the Pickup screen is displayed.
- Pressing a Quick Key configured as “Reset Flags” twice within a ten second period.
- Turning Protection OFF.

On the first press of the SELECT key the following display advises the operator what to do next.

1. Operator settings are not affected by changing the Active Protection Group. For example: if Auto Reclose is in force before the Active Group is changed from A to B then Auto Reclose will also be in force after the change.
2. The Protection OFF command resides in the same field as the Auto Reclose ON or Auto Reclose OFF.
3. External Trips are not shown on the Pickup Flag display.
4. This is a CAPM5 feature only.

```
RESET PICKUP FLAGS

Press the key again to reset the
flags. Press the menu key to cancel.
```

It is possible to configure the controller so the "Protection Off" state cannot be reached. This is set using the

SYSTEM STATUS - OPTIONS 1:Prot OFF Not Allowed

setting. In this case the operator cannot select the "Protection OFF" state, only the active protection groups. Selecting

SYSTEM STATUS - OPTIONS 1:Prot OFF Not Allowed

also has the effect of turning on the protection if it is not already on.[1] Protection is normally switched from OFF to ON by selecting either Auto Reclose ON or Auto Reclose OFF.

Protection Settings and Protection Groups

Protection settings are usually set once by the protection engineer and are not altered unless system conditions change.

A Protection Group is a group of protection settings that defines the protection functionality of the circuit breaker.

These groups are referred to as Protection Groups A to J. The CAPM 4 and CAPM 5 controllers support up to ten completely independent Protection Groups:

- At the Operator Control Panel, the operator selects either Group A, B, C, **…** or J to be Active from

SYSTEM STATUS - OPERATOR SETTINGS 1:Prot 'A'...'J' Active

- The number of protection sets (A-J) available to the operator may also be configured using WSOS.

Whenever a new Protection Group is activated or a protection trip occurs, an event is written to the Event Log indicating which Protection Group is now in operation. The event logged is for example 'Prot Group A Active'; 'Prot Group F Active'; etc.

All the protection parameters are programmed and stored independently for each of the groups. For example, if the Sequence Reset Time is required to be 20 seconds in both A and B groups, then it must be explicitly set to 20 seconds in both groups of protection settings.

Changing Protection Settings

All protection parameters and operator settings are held in non-volatile memory on the CAPM. This ensures they are retained through power interruptions. However, if a different CAPM is installed in a control cubicle, or if the control cubicle is replaced, then the protection parameters need to be re-programmed into the CAPM. This is carried out either through the operator panel or through WSOS.

The ten groups of protection settings are programmed on the protection pages. Passwords are required to make changes.

- Protection Groups should not be changed whilst a protection sequence is in progress.

When programming protection settings, the technician first selects which protection group of parameters to display on

PROTECTION SETTING 1 (A.....J): Group 'A....J' Displayed

This group can then be changed. Selecting a protection group to be displayed ***does not make it active***, that is done by the operator in:

SYSTEM STATUS-OPERATOR SETTINGS 1;Prot 'A...J' Active

Because one protection group can be active and another protection group can be displayed (in the protection pages), care must be taken or confusion will result. However, the title line of the display always shows which protection group is currently being displayed by showing an "**A**", "**B**" or **…** "**J**" suffix, such as:

PROTECTION SETTING 3 E

The operator can change either the active group or the inactive group. When changes are made to the active group they do not go into service immediately. Instead the changes are saved into the internal database in the controller and go into service when:

- The operator moves off the protection group of pages.
- The operator turns off the control panel.
- The control panel turns itself off after the timeout period.
- The controller is powered off and on again.

This allows the operator to edit the active group and then put the new settings into service as a whole. The operator is informed when the changes are going into service.

When the active group is being edited, the page title flashes to indicate the settings being worked on are different to the ones in service.

Changes can also be made by remote operators using WSOS or SCADA systems. If a WSOS operator changes settings, the local operator will see the page title flash to indicate changes are pending. When any user puts their changes into service all pending changes, including those made by other users, go into service.

1. Live Load Blocking still operates even if Protection OFF is selected.

Group Copy

Group Copy is available to facilitate the setting of several protection groups which all have the same or similar settings. It is possible to copy from the displayed protection group to any of the groups available on the CAPM including the active group[1].

This feature is accessed through the protection group at:

PROTECTION SETTING 1 (Copy OFF)

Selecting the field allows the operator to scroll through the available copy options as shown at Appendix E (page 109).

Note: The # symbol indicates which of the Protection Groups (A to J) is currently being displayed by CAPM.

Changes to protection groups are put into service as for any other changes to the active protection group.

Overcurrent Protection

The CAPM continually samples the current flowing in the secondaries of the current transformer. These samples are digitally processed by the CAPM to monitor line current for the purposes of overcurrent protection. Digital filtering algorithms are applied to line currents to minimise transient over-reach.

If the current exceeds the Setting Current, then the relay picks up. Definite Time, Inverse Time and Instantaneous Protection are used to trip the circuit breaker after pickup:

- Definite Time is a protection function that can be set by the user and it causes a trip at a fixed time after pickup. In the case of Definite Time the timing sequence starts immediately after pickup.
- Inverse time is a protection function in which the curve has an inverse time characteristic. (See Inverse Time Protection - page 38).
- Instantaneous Protection is an additional trip element that will trip the recloser if the line current exceeds the Instantaneous Multiplier multiplied by the setting current.

In the case of Inverse Time and Instantaneous Protection the timing sequence initiates when the signal exceeds the Threshold Current. The Threshold Current is calculated from the setting current and Threshold Multiplier. (See Interactions between curve parameters - page 41). If the current falls below the threshold current, the time to trip freezes and will recommence if the current rises back above the threshold current. If the current falls to below 90% of the setting current for longer than the Fault Reset Timer, the protection timer will reset. The setting currents are set once for all trips in a sequence but other protection parameters (e.g. inverse curve type, multipliers and Reclose times) are set separately for each trip in a reclose sequence. This allows, for example, Instantaneous Protection on the first trip in a sequence and inverse time protection on subsequent trips in the sequence.

To do this, a protection setting page for each trip in a sequence is provided. These pages are shown in Appendix E (page 109). The operation of the different protection types is detailed below.

Inverse Time Protection

A variety of inverse time curves are available which cause the circuit breaker to trip faster as the current rises higher.

Inverse time curves are implemented in software in the following way:

- The line current is always monitored.
- When it rises above the Threshold Current, the Time To Trip is calculated and the timing starts. This calculation is repeated every few milliseconds in response to changing line currents.
- When the remaining Time To Trip reaches zero, the trip request is issued. If the current falls below the Threshold Current the timing stops but the protection does not reset immediately. This means the relay will never trip at currents below the Threshold Current under inverse time protection.

The parameters that control inverse time protection are:

- Inverse Curve Type.
- Setting Current.
- Time Multiplier.
- Additional Time.
- Instantaneous Trip Element.
- Minimum Time.
- Maximum Time.
- Threshold Multiplier.

The Inverse Curve type is set independently for each trip, Work Tag and Single Shot. (See Protection Curves - page 40).

1. It is not possible to replicate an existing group to itself i.e.; Protection Group “B” cannot be copied and saved as Protection Group “B”.

Time Multiplier: Set independently for each trip. Multiplies the time to trip.

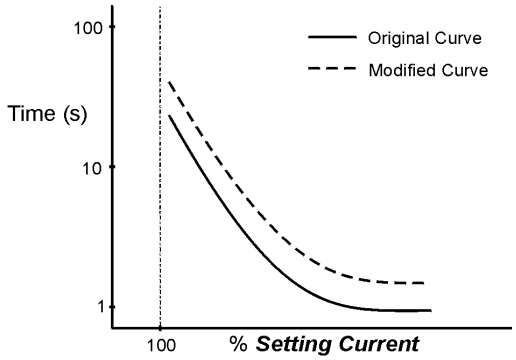


Figure 9: Time multiplier, effects on the inverse curve

Additional Time: Set independently for each trip, sets an Additional Time To Trip which is added to the inverse curve tripping time.

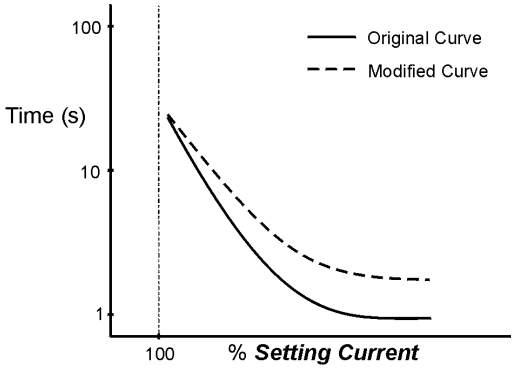


Figure 10: Additional time, effects on the inverse curve

An Instantaneous Trip element can be applied which will trip the circuit breaker if the current rises above a user set multiple of the phase or earth setting currents.

If the Instantaneous Multiplier is set below the Threshold Current Multiplier then an Instantaneous Trip will only occur after the line current exceeds the Threshold Current. See figure opposite

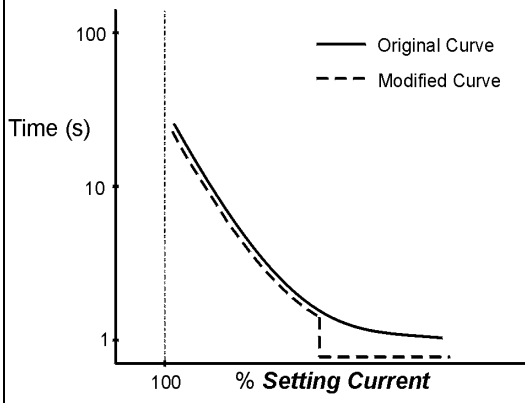


Figure 11: Instantaneous, effects on the Inverse curve.

Minimum Time: Set independently for each trip, sets the Minimum Time To Trip.

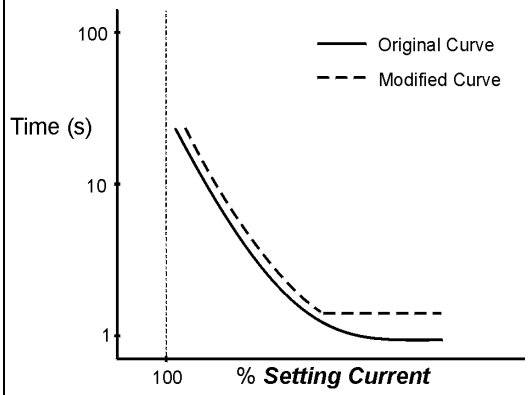


Figure 12: Minimum time, effects on the inverse curve

Maximum Time: Sets the Maximum Time To Trip if the time exceeds the preset limit.

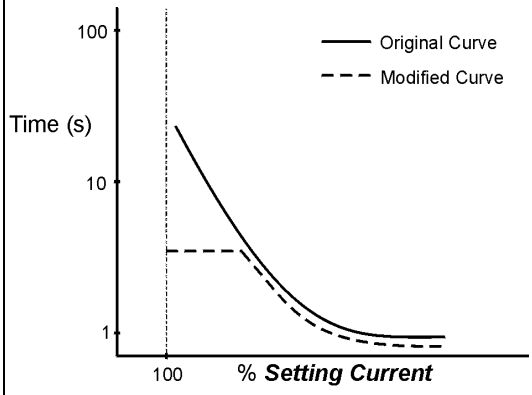


Figure 13: Maximum time, effects on the inverse curve

Threshold Multiplier: The Threshold Multiplier is used to prevent tripping if the line current is below the Threshold Current.

The Threshold Current is the setting current multiplied by the Threshold Multiplier. See figure opposite.

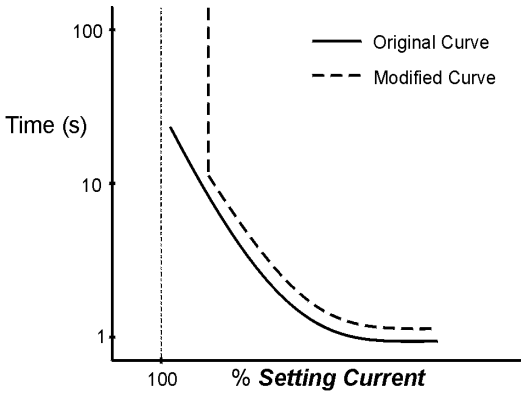


Figure 14: Threshold element, effects on the inverse curve

Protection Curves

In total there are 48 inverse protection curves stored in the controller's non-volatile memory.

The available curves are defined in the following Appendices:

- 3 Standard IEC255 curves are defined in Appendix A (page 89).
- 3 Standard IEEE Std C37.112 curves are defined in Appendix B (page 91).
- 42 non-standard Curves are defined in Appendix C (page 93).

Any one of the 48 curves can be selected for the phase protection trips 1 to 4, Single Shot and Work Tag trips.

User Defined Curves

Up to 5 (five) User Defined Curves may also be selected in the same way as a Protection Curve.

- User Defined Curves are configured using the Windows Switchgear Operating System.
- If no User Defined Curves have been defined, or previously defined curves have been deleted, then the text display will show[1]

PROTECTION TRIP NUMBER 1 A: User Curves Not Set

1. When instantaneous only protection parameters are selected, Minimum Time To Trip and the Threshold multipliers apply but the Additional and Maximum times to trip do not.

This is simply to indicate to the user that the User Defined Curves are available but have not been defined or down loaded [1].

Interactions between curve parameters

This section describes some of the interactions that can occur between the user selectable inverse curve parameters. In order to understand the interactions between the curve settings it is important to know the way the curves are constructed. The curve settings are applied in the following order:

- Curve Selected.
- Time Multiplier.
- Additional Time.
- Instantaneous Element.
- Maximum Time.
- Threshold Current.
- Minimum Time.

The figure opposite is an example of a protection curve modified by the instantaneous element and maximum, minimum times.

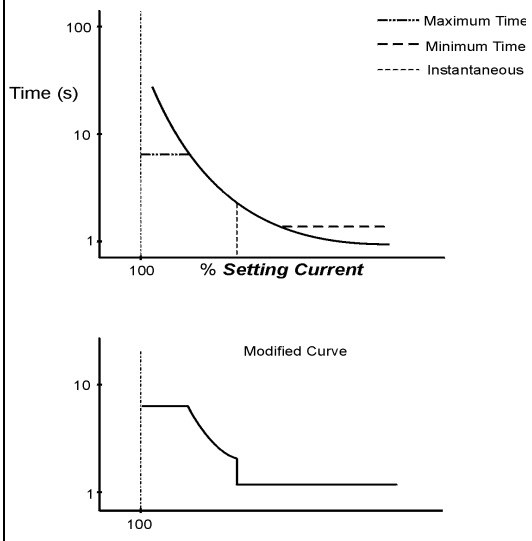


Figure 15: Protection curve modified by minimum, maximum times and instantaneous element

The figure opposite is an example of using Maximum Time, Instantaneous and Threshold Current multipliers. The Maximum Time is set to 2s, the Instantaneous Multiplier is set to x10, and the Threshold Current Multiplier is set to x2. In this example, pickup will occur at the setting current, the timing sequence will begin at 2 times the setting current, and the instantaneous trip will occur at 10 times the setting current.

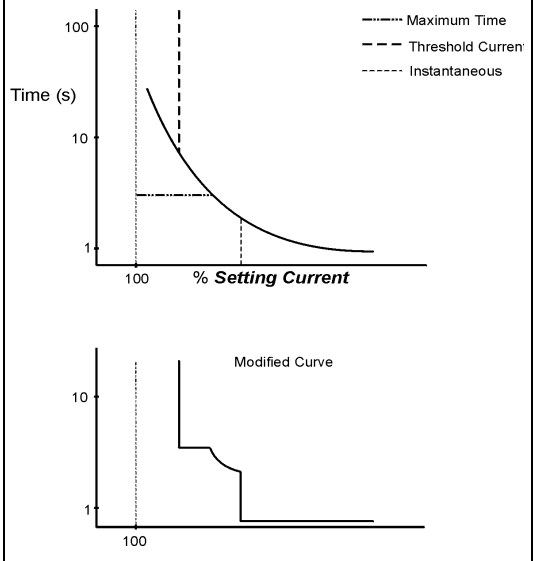


Figure 16: Interaction between Instantaneous threshold current and Maximum Time.

1. Only one instance of this text will be displayed even though there are potentially five curves available.

The figure opposite shows an example of where the Threshold Current may be used.

Here the coordination is lost at currents to the left of where the two curves (fuse and IEC_255 inv) cross. The Threshold Current changes the curve so that at currents less than, for example, 3 times the pickup level, the device does not trip.

This allows coordination with the fuse to be maintained.

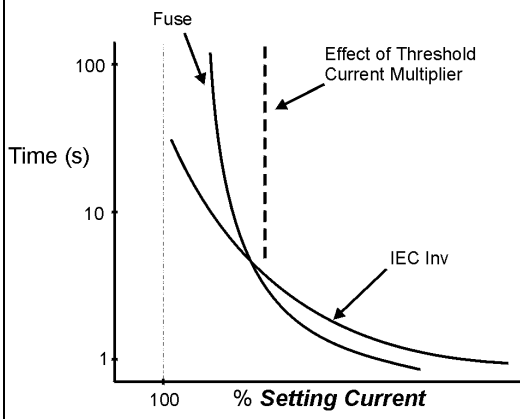


Figure 17: Co-ordination between fuse and IEC 255 inverse curve using the threshold current multiplier

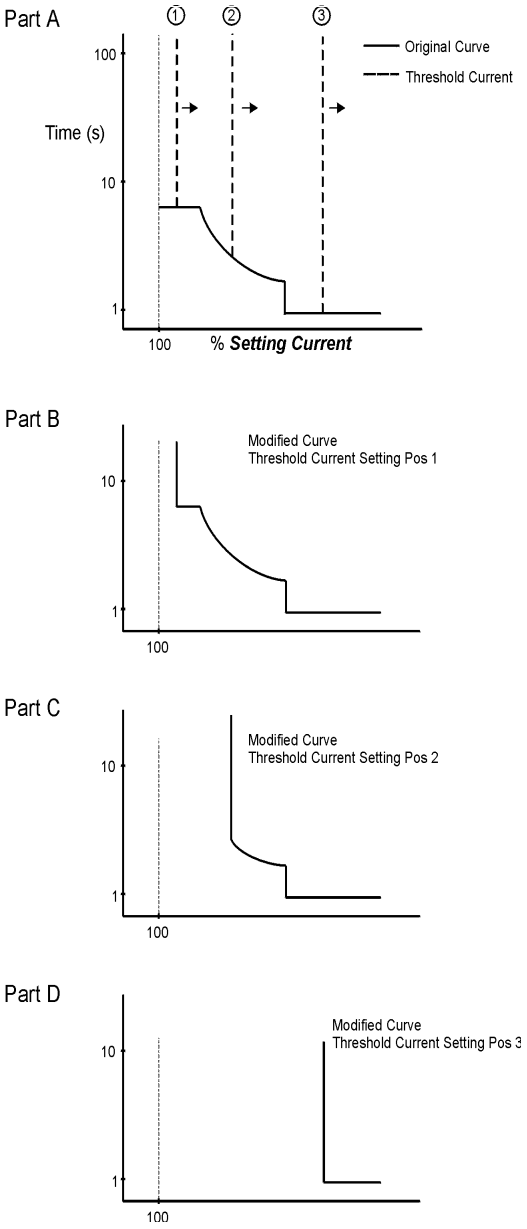


Figure 18: Composite curve changes due to different settings of threshold current multiplier

The figure opposite is an example of the effects on a composite curve due to an increase in the setting of the Threshold Current Multiplier.

Part A shows a composite curve which has an inverse time characteristic modified by Maximum Time and Instantaneous protection. Also shown in part A is an example of 3 different levels of Threshold Current Multiplier, settings: 1, 2 and 3.

Parts B, C and D are the curves resulting from the Threshold Current Multiplier settings 1, 2, and 3.

Threshold Current has a significant effect on the protection characteristics and at any one time is determined by the:

PROTECTION SETTINGS 1 (A....J): Multi Threshold

page and

- Cold Load Pickup. (See Single Shot Mode - page 47)
- Inrush Restraint. (See Lockout Conditions - page 47)

Definite Time Protection

This is available as an **alternative** to inverse time Trip Current Settings. Definite Time trips the circuit breaker at a fixed time after pickup. The Threshold Multipliers (including inrush and cold load), as well as the Minimum, Additional and Maximum times do not apply.

Under/Over Frequency Protection (CAPM 5 only)

Frequency Measurement

Frequency is measured using successive zero crossings of the “I” side terminal Phase to Earth voltage.

The voltage signal is first passed through a Low Pass Filter to remove harmonics.

A typical measurement display looks like this:

The frequency value is updated every 0.5 seconds and averaged over 2.0 seconds. The displayed value is the measured frequency and is valid whenever the voltage on the “I” Terminal is above

```
- - - - - - SYSTEM MEASUREMENTS - - - - M
Frequency 50.6 Hz      Power (P)      2479kW
                       Power (Q)     200kVAR
                       Power Factor     0.93
```

or equal to the Low Voltage Inhibit Threshold (LVIT).

When the voltage of the “I” side Terminal is below the LVIT the display will show “Freq Unavailable” like this:

```
- - - - - - SYSTEM MEASUREMENTS - - - - M
Freq Unavailable       Power (P)      2479kW
                       Power (Q)     200kVAR
                       Power Factor     0.93
```

The measured frequency is displayed on the Measurement Pages. See Appendix F (page 113).

Under/Over Frequency Tripping

When the measured frequency equals or exceeds the under or over frequency trip threshold an Under or Over Frequency Pickup event is generated and a Trip Delay Counter (TDC) is started.

The Trip Delay Counter is reset and an Under or Over Frequency Reset event is generated each time the measured frequency equals or goes below the threshold plus the dead band for any period of time. The Frequency dead band is used to prevent a frequency value that is fluctuating around the threshold from causing excessive pickup/reset events.

If the frequency remains equal to or greater than the Under or Over Frequency Threshold for the specified number of cycles, the TDC counts out and an Under or Over Frequency Trip event is generated and a Trip Request is issued.

Figure 19 (page 44) shows the method of Tripping and “Normal Frequency Closing” for Over Frequency. The same method applies to Under Frequency only mirrored about the Nominal frequency axis.

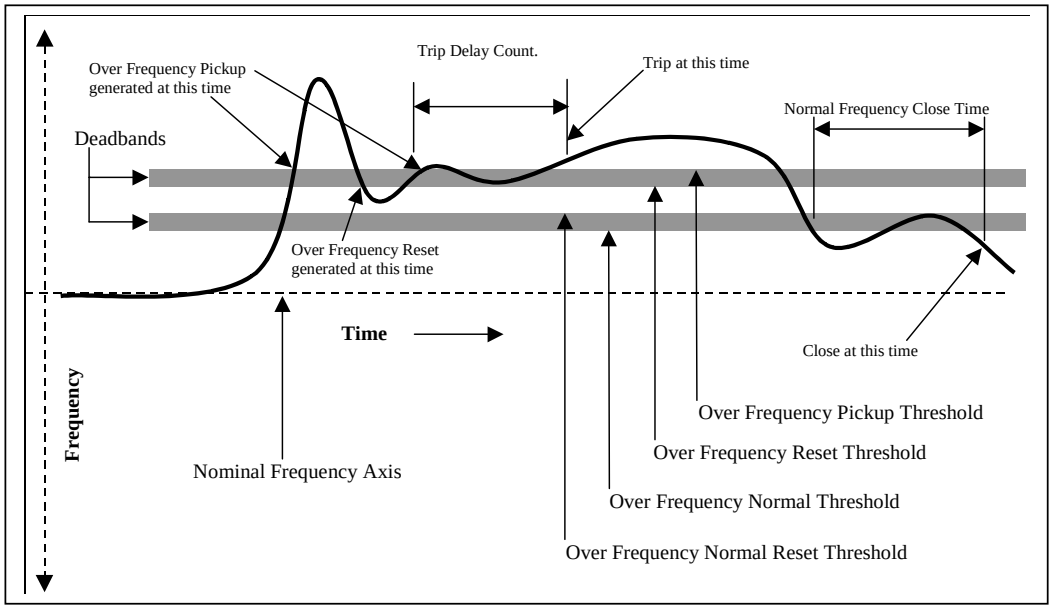


Figure 19: Over Frequency Detection

If the “Normal Frequency Close” function is switched OFF a “Lockout” event is generated after the trip and the Operator Settings Display shows a “Lockout” Status.

Auto-Reclose does NOT occur after an Under or Over Frequency Trip.

Normal Frequency Close

The “Normal Frequency Close” function closes the ACR automatically after an Under or Over Frequency trip when the frequency has returned to normal. For this function to work, the source side must be connected to the “I” side terminal.

The automatic close occurs when:

- The ACR tripped due to Under or Over Frequency Protection.
- “Normal Frequency Close” was ON before the trip occurred and is still ON.
- The frequency has returned to be less than or equal to the Frequency Normal threshold and remained less than this threshold plus the dead band ***AND*** the voltage on the “I’ Side terminal has remained ***above*** the LVIT, for the “Normal Frequency Close Time”.

The Normal Frequency Close Timing is aborted every time that the frequency exceeds the Normal Frequency threshold plus the dead band or the voltage on the source side bushing has fallen equal to or below the LVIT.

A "Lockout" event is ***not*** generated when a Normal Frequency Close is ON and the ACR trips on Under or Over Frequency Protection.

- The Operator Settings display does not show "Lockout". It remains blank.

Whilst waiting for the frequency to return to normal, a special title will be flashing on the top line of the operator display:

```
ACR will auto-reclose when frequency normal
```

When the frequency returns to normal status the flashing title becomes:

```
Freq Normal-ACR will close in xxxx secs
```

The "XXXX" denotes the period of time remaining before closing occurs. In the final 10 seconds before actually closing the panel will "beep" to warn the operator.

The Normal Frequency Close ON/OFF setting may be controlled either via telemetry protocol or the configuration page.

A "Lockout" event will be generated if any of the following occur whilst the controller is waiting for the frequency to become normal:

- Normal Frequency Close is turned OFF.
- Under Frequency Normal setting is changed.
- Over Frequency Normal setting is changed.
- Normal Frequency Close setting is changed.
- Low Voltage Inhibit Threshold setting is changed.[1]

Configuration

This section details the Under / Over Frequency configuration pages on the Operator Control panel display. They are displayed on

PROTECTION-UNDER/OVER FREQUENCY PROTECTION

within the Protection display group.

Two configuration pages are available within the group.

Configuration Page One

The default settings at this page are displayed at the right:

```
 - - - - UNDER/OVERFREQUENCYPROTECTION 1  -P
U/F Trip        OFF        O/FTrip          OFF
U/F Trip at     49.0Hz     after         4cycles
O/F Trip at     52.0Hz     after        50cycles
```

The following table explains each of the above settings:

UNDER / OVER FREQUENCY PROTECTION 1	
Field	**Explanation**
U / F Trip ON/OFF	This field allows the Under Frequency protection to be enabled (ON) or disabled (OFF). Under Frequency tripping will not occur whilst set to OFF.
U / F Trip at 49.0Hz	The frequency value at and below which an Under Frequency Pickup will occur.
After 4 cycles	The number of continuous cycles at and below the Under Frequency Threshold required before an Under Frequency Trip will occur. Maximum 1000 – Minimum 2.
O / F Trip ON/OFF	This field allows the Over Frequency protection to be enabled (ON) or disabled (OFF). Over Frequency tripping will not occur whilst set to OFF.
O / F Trip at 52.0Hz	The frequency value at and above which an Over Frequency Pickup will occur.
After 50 cycles	The number of continuous cycles at and above the Over Frequency Threshold required before an Over Frequency Trip will occur. Maximum 1000 – Minimum 2.

Under/Over Frequency Protection 1 field descriptions

1. The Operator Settings page will display "Lockout" and the special titles will be removed if any of the above occur.

Configuration Page Two

The default settings at this page are displayed as shown at right:

```
 - - - UNDER/OVER FREQUENCY PROTECTION 2  -P
U/F    Normal    49.5Hz    O/F Normal    50.5Hz
Low V Inhibit 5000V
Normal Freq Close OFF
```

The following table explains each of the settings:

UNDER / OVER FREQUENCY PROTECTION 2	
Field	**Explanation**
U / F Normal 49.5Hz	The frequency at or **above** which the Frequency is deemed to be Normal. Maximum 65Hz – Minimum 45Hz.
O / F Normal 50.5Hz	The frequency at or **below** which the Frequency is deemed to be Normal. Maximum 65Hz – Minimum 45Hz.
Low V Inhibit	The voltage at or below which the Under / Over Frequency protection will be disabled. Maximum 15KV – Minimum 2 KV.
Normal Freq Close ON/OFF	This field controls the use of the Normal Frequency Close feature.
After 60 secs	The time that the source voltage must have returned to normal before auto closing takes place. Maximum 1000 – Minimum 1 seconds.

Under/Over Frequency Protection 2 field descriptions

Live Load Blocking

When

PROTECTION SETTING 3 (A...J):Live Load Block ON

is selected, all close requests will be disregarded if the load side terminal is live.

To enable Live Load Blocking on a standard W-Series ACR, the circuit breaker must be installed with the load side connected to the "I" -Side Terminal of the circuit breaker. The "Power Flow Direction" must be set to "Source X, Load I". This requirement is due to the CVT being fitted only to the "I" -Side Terminal.

If the optional External CVT has been fitted to the "X"-Side Terminal, then the circuit breaker can be installed with the load side on either the X or I Terminal.

Live Load Blocking is selected from:

PROTECTION SETTING 3 (A...J):Live Load Block OFF/ ON

Live Load Blocking uses the Live Terminal Threshold set on:

SYSTEM STATUS-PHASE VOLTAGE and POWER FLOW:"LIVE" if 2000V

Auto-Reclose

When

SYSTEM STATUS-OPERATOR SETTINGS 1:Auto-Reclose ON

is selected, the controller will automatically reclose following a protection trip.

The user set delay between trip and reclose is called the reclose time and can be set differently for each trip in a sequence. If the fault persists the circuit breaker will trip again under protection. This will happen a number of times, until the fault is cleared or the protection relay reaches the end of the defined reclose sequence. At this point the circuit breaker remains open and will not reclose automatically. This is known as lockout and the circuit breaker can only be closed by local or remote operator command, which clears the lockout condition.

When Auto-Reclose is off, no reclose takes place and the controller goes directly to lockout after a protection trip. (See Single Shot Mode - page 47).

To control the number of trips in a reclose sequence, the total protection trips to Lockout must be set:

All protection trips in a sequence increment a Protection Trip Counter (PTC**)** which causes the protection to go to lockout once the "*total protection trips to lockout"* value is reached.

The bottom left field on the

SYSTEM STATUS-OPERATOR SETTINGS 1

page shows what is happening during a reclose sequence.

The display is normally blank when the circuit breaker is closed but when a reclose sequence is in progress it shows "Reclose 1"after the first reclose, "Reclose 2"after the second reclose etc. In other words, this display shows the status of the protection trip counter.

When the circuit breaker is open and the protection is in lockout it shows "lockout". When the circuit breaker is closed by an operator the display blanks to show that lockout is cleared. This

display is very useful when performing current injection testing.

Sequence Reset

A Sequence Reset Timer is used to reset the reclose sequence counters to zero so the next fault starts again at Trip 1. It starts timing when the circuit breaker is closed automatically. This means the sequence reset time usually starts at the end of the reclose time after an Auto-Reclose.

However, if the fault is still present the protection will pick-up again and hold the sequence reset timer at zero. The timer restarts when the fault has been cleared. The sequence reset timer “expires” when it reaches the user set sequence reset time. A ‘Sequence Reset’ event is then logged.

The Sequence Reset Time (also known as Reclaim Time) is set on:

PROTECTION SETTING 2 (A...J):Seq Reset Time 30s

Lockout Conditions

Lockout is set by any kind of manual trip, either by using the TRIP button on the operator control panel, the mechanical trip lever on the side of the circuit breaker or by remote operator trip.

Lockout will also occur after the following events:

- After a trip, when the controller is in Single Shot mode.(See Single Shot Mode - page 47).
- After a trip, if Work Tag is applied.
- When the protection trip counter reaches the preset number of trips in Auto-Reclose Mode.
- When High Current Lockout has occurred. (See High Current Lockout - page 47).
- Under/Over Frequency[1] protection trip. (See Normal Frequency Close - page 44).
- After a trip when controller is in low power mode.
- Mechanism failed in an open position.

High Current Lockout

If a trip occurs and the measured maximum fault current exceeds the “High Current Lockout” setting, the controller goes directly to lockout and will not reclose. A High Current Lockout will only occur when the setting is equal to, or higher than, the Pickup Current.

High Current Lockout is enabled on:

PROTECTION SETTING 4 (A...J):High Current LO OFF/ ON

and only applies during the preset

PROTECTION SETTING 4 (A...J):Activation Trip 1

or one of the subsequent trips in a sequence.

High Current Lockout can occur when Single Shot Mode is active or when closing onto a fault by an operator. In both of these situations the controller would have gone to lockout anyway without high current lockout being triggered. The difference is that if High Current Lockout was triggered an event will be recorded in the event log as extra information for fault analysis.

Dead Lockout

This protection function may be selected via:

SYSTEM STATUS-OPTIONS 2:Dead Lockout ON/OFF

When Dead Lockout is ON the circuit breaker will not re-close unless the source side terminal is live at the instant of auto-reclose. If the terminal is dead, the controller goes to lockout.

When the optional external CVT is not fitted:

- Dead Lockout cannot be set to ON whilst Source Side X - Load Side I is set.
- Source Side X - Load Side I cannot be set whilst configured as:

SYSTEM STATUS-OPTIONS 2:Dead Lockout ON/OFF

Single Shot Mode

Single Shot Mode is used to provide an appropriate protection curve when non-reclosing operation is required, for example, when closing onto a fault.

In Single Shot Mode the controller goes directly to lockout after one trip and will not Auto-Reclose.

Single Shot Mode is *activated* when:

- Auto-Reclose is turned off, and Work Tag is not applied.
- The circuit breaker is closed by operator command irrespective of the state of Auto-Reclose.

Single Shot Mode is *de-activated* when:

- Auto-Reclose is turned back on,
- Work Tag is not active, and the Single Shot Timer expires without a protection pickup occurring (see below).

1. This is a CAPM 5 feature only

When Single Shot Mode is active, it is displayed in

SYSTEM STATUS-OPERATOR SETTINGS 1:Single Shot Active

Single Shot protection trip settings can be selected individually via separate protection pages. Each page is similar to the protection trip page.

When Single Shot Mode de-activates, protection reverts to the fully programmed sequence.[1]

A trip in Single Shot Mode generates a 'single shot' event. The Single Shot Trip number and the Single Shot reset time is set on:

PROTECTION SETTING 2 (A...J)

Single Shot Timer

This timer starts when the circuit breaker closes and runs for the preset number of seconds:

PROTECTION SETTING 2 (A...J):SS Reset Time 1s

This may be disabled by setting the Single Shot reset time to zero.

Single Shot remains active while the timer is counting i.e.; a protection trip will result in a lockout without reclosing. The "time to trip setting" may be longer than the Single Shot Reset Time.

If a protection pickup occurs whilst timing, the timer is reset to zero and held there while pickup is active. A protection reset will restart the timer provided it has not already timed out.

When set to zero, auto-reclosing will always be enabled while the operator command:

SYSTEM STATUS-OPERATOR SETTINGS 1:Auto-Reclose ON

is set. This means that Single Shot Mode does not activate after an operator or automation close command.

- This feature is of most benefit when grading by numbers of protection operations.

Inrush Restraint

When closing onto a typical load there is always a short lived inrush current caused by, for example, transformer magnetisation currents, low resistance lamp filaments and motors starting. The purpose of Inrush Restraint is to prevent the circuit breaker from tripping when inrush current occurs.

Inrush restraint works by raising the Threshold Currents for a short period of time to allow the inrush to flow. The inrush time and multiplier settings are specified on:

PROTECTION SETTING 5 (A...J)

Typical values would be 200ms with a multiplier of 5.

Inrush Restraint is **armed** for operation whenever the load current goes to zero (zero current is defined as when the phase current is less than 2.5 Amp). For example, when the load is dropped either by the circuit breaker itself, or by an upstream or downstream circuit breaker.

When the load current at a later time becomes non-zero (either through the circuit breaker being closed or some upstream or downstream device being closed) the Inrush Restraint is **activated** and the Inrush Multiplier is used in place of the Threshold Current Multiplier for the required time.

For Inrush Restraint to be effective, the Inrush Multiplier must be larger than the Threshold Current Multiplier.The figure opposite shows an example of the inrush settings applied to an inverse curve. In this example, the Threshold Current Multiplier is set to x1.1, the Instantaneous Multiplier is set to x10, the Inrush Multiplier is set to x5 and the Inrush Time is set to 0.5 second. After a close, for the first 0.5 of a second, the Threshold Current increases to 5 times "setting current". It then drops back to the original setting of 1.1 times the setting current once the Inrush Time is complete.

Under these circumstances the instantaneous trip current value does not change. If, on the other hand, the Instantaneous Multiplier was set to x4 then during the Inrush Time an instantaneous trip would not have occurred until the line current exceeded 5 times the setting current.

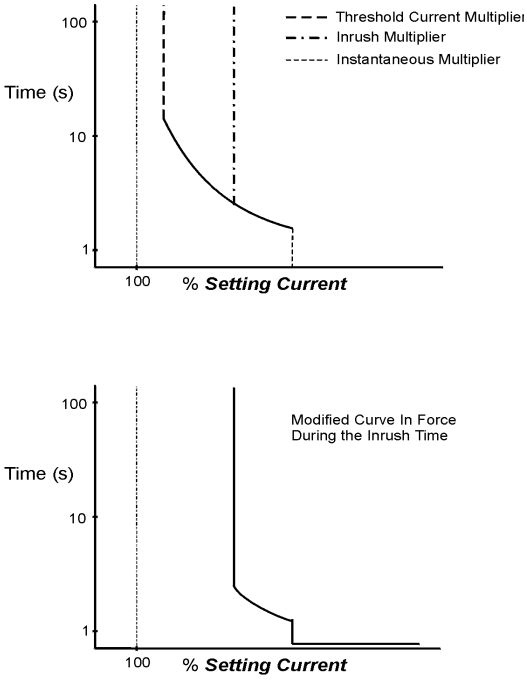


Figure 20: Effect of inrush current settings on a protection curve

1. The circuit breaker can be closed or Auto-Reclose can be turned on/off by a number of sources (from the Control Panel, by a telemetry command, by WSOS command or by IOEX command). Single Shot is activated/de-activated irrespective of the source of the control.

When cold load protection is turned on the multiplier used for inrush will always be the higher of the Inrush Multiplier and the Cold Load Multiplier.

Inrush Restraint does not apply to Definite Time.

If normal currents are expected to drop below 2.5A then Inrush Restraint cannot be used. In this case Inrush Restraint should be turned off.

Inrush Restraint parameters are set on:

PROTECTION SETTING 5 (A...J)

Cold Load Pickup (CLP)

When a typical load has been without supply for a period of time (hours) it loses its diversity.

When power is restored the load is higher than usual because all the heater, refrigerator or air conditioner thermostats have turned on. The longer the period without supply the greater the loss of diversity and the higher the load current when supply is restored.

The purpose of the Cold Load Pickup feature is to allow for this loss of diversity automatically and hold the load without tripping. It works by timing the loss of supply to the load and then raising the threshold current accordingly.

The user specifies a multiplier and a time. The controller detects when load current is zero (see Inrush Restraint) and starts a timer called the Operational Cold Load Time. Using this timer, an Operational Cold Load Multiplier is calculated using the following formula:

$$\text{Operational Cold Load Mult'} = 1 + \left[\frac{\text{Operational Cold Load Time}}{\text{User Set Cold Load Time}} \text{ x } (\text{User Set Cold Load Mult'} - 1) \right]$$

The Operational Cold Load Multiplier is used to modify the Threshold Current Multiplier.

Therefore the protection threshold will increase at a rate specified by the customer when the load is turned off – but only up to the User Set Cold Load Multiplier. The controller calculates the new thresholds every minute.

For example, if the User Set Cold Load Time is 2 hours, the User Set Cold Load Multiplier is x2 and the current has been off for 1 hour, then the Operational Cold Load Time is 1 hour. Consequently the phase threshold is increased to equal the Operational Cold Load Multiplier of 1.5.

Once load current is restored the Operational Cold Load Timer starts to count down. This means that the Operational Cold Load Multiplier reduces back to 1 and hence the threshold current also reduces back to its original value. Note that the rate of increase and decrease of threshold current is the same.

In this way, lost load diversity is automatically compensated for. It doesn't matter where the current was turned off (e.g. at the substation or at the recloser) the compensation will still work.

- The User Set Cold Load Time and the User Set Cold Load Multiplier are set on:

PROTECTION SETTING 5 (A...J)

- The Operational Cold Load Multiplier will not go above the user set Cold Load Multiplier or below the user set thresholds on:

PROTECTION SETTING 1 (A...J)

- On power up the load is assumed to be diverse, i.e. the Operational Cold Load Time is zeroed and “Cold Load IDLE” will be displayed.
- Cold Load affects the current threshold including instantaneous.
- High Current Lockout and Definite Time settings are not affected.
- Cold Load Pickup cannot be used if normal currents are expected to drop below 2.5A and should be turned off.

Cold Load Pickup Example

The figure opposite is an example of the Cold Load settings applied to an inverse curve. In this example, the Threshold Current Multiplier is set to x1.1, the Instantaneous Multiplier is set to x1.75, the Cold Load Multiplier is set to x2 and the Cold Load time is set to 2 hours.

Part A indicates how the Current Multiplier will vary according to the length of time the line current is turned off and then restored.

Part B indicates the original protection curve.

Part C indicates the protection curve that is constructed for use when the line current is first restored and the Current Multiplier corresponds to 2 times the setting current. Note that in this case an Instantaneous Trip will not occur until the line current exceeds 2 times the “setting current”.

Part D indicates the protection curve that is constructed for use when the line current has been restored for 1 hour. This corresponds to a Current Multiplier of 1.5 times the setting current. Note that an Instantaneous Trip will now occur at the set value of 1.75 times the setting current. After the power has been restored for 1.8 hours the Cold Load Multiplier will revert back to the original Threshold Multiplier settings and the protection curve will be as in Part B.

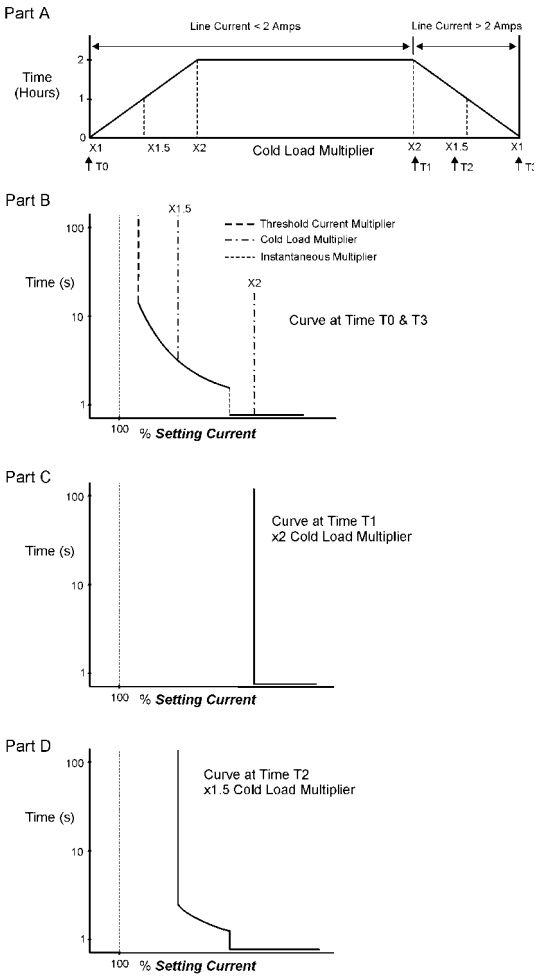


Figure 21: Cold Load multiplier (CLM) settings applied to protection curves

Cold Load Pickup Status Display

The operational status of the cold load pickup is shown in:

SYSTEM STATUS-OPERATOR SETTINGS 2:Cold Load

This can show the following states:

- Cold Load OFF: Cold load pickup has been configured OFF in the currently active protection group, no operator control of Cold Load Pickup is possible.
- Cold Load IDLE: Cold Load Pickup is configured ON but Cold Load Pickup is not affecting the thresholds. This is probably because the load current is on and the Operational Cold Load Time is zero. This is the normal condition.
- Cold Load NO CHANGE.
- Cold Load MAX.
- CLP 60min X1.5mult (for example). The display shows the Operational Cold Load Time and Multiplier. This affects the protection thresholds. In this example the Operational Cold Load Time is 60mins and the Multiplier is 1.5.

Operator Control of Cold Load Pickup

When Cold Load Pickup is configured ON at the currently active protection group it can be further controlled by using **SELECT**, and the ⮜ ⮞ keys.

SELECT, and the ⮜ ⮞ keys enable the following:

- Zero the Operational Cold Load Time. Note that if the load current is off the Operational Cold Load Time will start to increase.
- Set the Operational Cold Load Time and Multiplier to a desired value. Note that the Operational Cold Load Time will then increase or decrease depending on whether the load current is OFF or ON.

Sequence Control

Sequence control causes the circuit breaker to step to the next count in the reclose sequence on reset of all protection elements whether or not the circuit breaker tripped. The sequence will only advance if Auto Reclose is on and the Single Shot Timer has timed out.

Consider a situation where there are two circuit breakers in a feeder. Both are programmed for fast tripping on the first trip and slow tripping on the second trip in order to co-ordinate with fuses on the spur lines. Suppose there is a fault downstream of the second circuit breaker which is big enough to be picked up by the first circuit breaker as well. The circuit breaker closest to the fault trips, steps onto the second set of protection settings which is a slow trip and then recloses. If the fault has not been cleared the circuit breaker nearest to the substation is still on its fast trip settings and will now trip. This situation would result in unnecessary loss of supply to the load connected to the first recloser.

This problem is overcome by setting Sequence control on in the circuit breaker nearest to the primary substation. When Sequence control is on, the circuit breaker steps onto the next stage in the protection trip sequence after it has seen a fault whether it tripped or not. In this way an upstream circuit breaker will keep its sequence co-ordinated with a downstream circuit breaker. If the fault is cleared the trip count will reset back to zero after the sequence reset time in the normal way.

Automatic Protection Group Selection

Sometimes a circuit breaker is used at a location in a supply network where the power flow can be in either direction depending on the configuration of the rest of the network.

One example of this is a network tie point where the operator may have to select a different group of protection settings to compensate for a change in power flow when changing the network configuration. Emergency switching configurations may require more than one pair of Protection Groups.

Enabling Automatic Selection

Automatic Protection Group Selection (APGS) allows the appropriate Protection Group to be selected automatically without the need for operator intervention. It works by automatically changing between Protection Groups depending on the direction of power flow.

- APGS is made available by setting:

SYSTEM STATUS-OPTIONS 3:APGS Allowed

- Either the Primary or Alternate Group required is selected.
- APGS is then enabled by selecting:

SYSTEM STATUS-OPERATOR SETTINGS 1:Protection Auto

- The operator display will indicate the currently active set by displaying:

SYSTEM STATUS-OPERATOR SETTINGS 1:Auto “A” to “J” Active

On power down, the controller saves the current status of Protection Auto and uses that status to determine the active Protection Group on power up.

Disabling Automatic Selection

APGS is turned OFF (disabled) either by:

- A change of power flow configuration.
- Selecting a Protection Group other than

SYSTEM STATUS-OPERATOR SETTINGS 1:Protection Auto

- Setting:

SYSTEM STATUS-OPTIONS 3:APGS Not Allowed

Note

This feature is not the same as Directional Blocking.

Selection Rules

When the APGS feature is enabled, the active Protection Group is automatically selected in accordance with the following rules:

- There may be a maximum of five pairs of APGS Protection Groups: A&B, C&D, E&F, G&H and I&J. Each pair comprises a Primary Protection Group and Alternate Protection Group respectively.
- The number of APGS pairs depends on how many protection sets are selected to be available. Where an odd number of Protection Groups have been selected the last group does not participate in APGS. Protection Auto can not be selected if this last group is active.
- When the power flow is in the **positive** direction (source to load) Primary Protection Group A, C, E, G or I is used.
- When the power flow is in the **negative** direction (load to source) Alternate Protection Group B, D, F, H or J is used.

- For AGPS to generate a change, from Primary to Alternate Protection Group, the power flow must be greater than 50kW in the **negative** direction (load to source) for longer than the period set on

SYSTEM STATUS-OPTIONS 3:Auto Change Time 60s

- To revert to the Primary Protection Group the power flow must be greater than 50 kW in the **positive** direction (source to load) for longer than the period set on

SYSTEM STATUS-OPTIONS 3:Auto Change Time 60s

Fail to Operate Under Protection

If the circuit breaker fails to trip under protection, a 'mechanism fail' will be logged in the event record and no further trip attempts will occur until all the protection elements have reset. When the next pickup/protection trip sequence occurs the circuit breaker will then attempt another trip.

If the recloser fails to Auto Reclose then the relay goes to lockout.

10 Event Log

When the status of the control electronics or switchgear changes, *events* are generated which are recorded in an *Event Log* for display to the operator. Examples of such events are ‘Load Supply On’ or ‘Lockout’.

Events are viewed on the Event Log pages and can also be up-loaded and viewed with the Windows Switchgear Operating System.

The event log display looks like this:

```
 - - - - - - - EVENT LOG - - - - - - - -
10/01/01 12:09:02.06Close Coil Connect
10/01/01 12:09:03.95Panel Close Req
10/01/01 12:09:37.95Load Supply ON
```

Events are dated, time stamped to a 10ms resolution and displayed in the order in which they occurred.

The ⩤ key scrolls the display *downward* to show older events, the ⩥ key scrolls the display *upward* to show more recent events. Pressing the ⩤ key removes the title of the display to make more room for events. The title will only be restored when the event log is selected again from the top level menu.

Appendix G (page 115) lists all the events in alphabetical order and explains when they are generated.

Display Updating

The event log display will update automatically with new events provided the most recent event is on the bottom line of the screen. When new events occur they are entered at the bottom of the screen and the older events are scrolled up.

Protection Generated Events

The circuit breaker generates events to aid the user in analysis of faults or in testing. Events are generated which indicate the following things:

- Protection ‘Pickup’ occurs when any of the enabled protection elements pick up (this event is particularly useful when current injection testing).
- Circuit Breaker trip under protection. A series of events indicate the active protection setting, type of protection and the number of the trip, either single shot or trips 1, 2, 3 or 4.
- The maximum value of the protection elements involved in the trip detected by the protection relay. Some faults will cause pickup of more than one element and events are generated for these as well. These events are not generated until all elements have fallen back to their normal values. This means they will be time stamped after the Protection Trip in the event log.
- Automatic reclose of the circuit breaker.
- Expiration of the sequence reset timer. This indicates the protection relay has reset back to the beginning of the reclose sequence.

Loss of Supply Events

The control electronics monitors voltage screens embedded in the epoxy moulding of the “I” side terminal to determine if the terminal is live.

Live/Dead indication is shown on real time displays (see later) when the phase/earth voltage exceeds a user configured threshold, in page

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW:“LIVE”if > 2000V

A terminal is designated as Dead when the voltage falls 20% below the live threshold. The live/dead status is used to generate events when source supply is lost. To determine if supply is ON, the live status must be sustained on the source side terminal for the time set by the user in page.

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: Supply Timeout 5.0s

If this occurs then a 'Source Supply ON’ event is generated.

When supply is lost on all three phases for the Supply Timeout, a 'Source Supply OFF' event is generated.

The load side is also monitored to generate 'Load Supply ON' and 'Load Supply OFF' events.

The designated Source and Load sides can be swapped in relation to the circuit breaker terminals. See “Power Flow Direction” on page 55.

Typical Event Log Displays

A typical sequence of events for a fault which had instantaneous protection on the first trip and inverse time protection on the second trip with two trips to lockout, may result in the sequence shown in Figure 22 (page 54).

However, if the fault was cleared after the first trip has occurred, the controller will generate a ‘Sequence Reset’ event once the Sequence Reset Time has expired, as shown in Figure 23 (page 54).

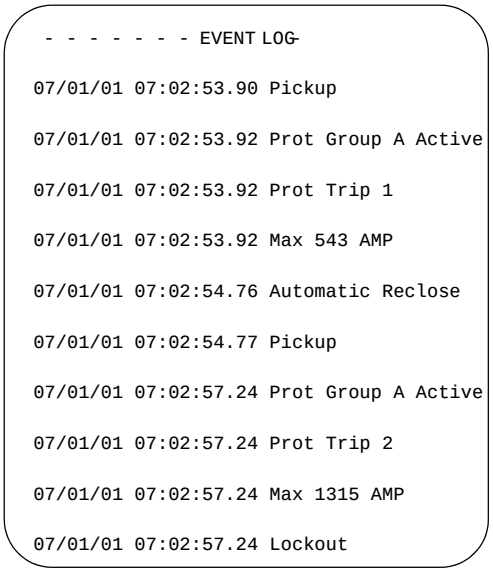


Figure 22: Event Log auto reclose example

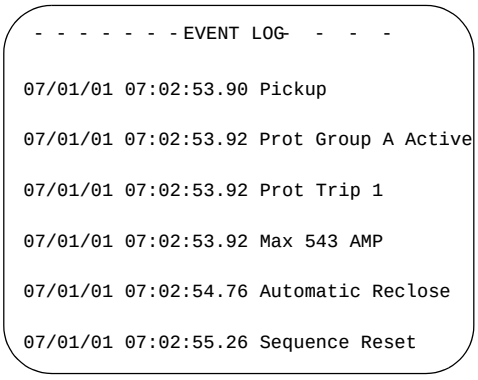


Figure 23: Sequence Reset Example

11 Power System Measurements

The Control and Protection Module (CAPM) digitises the current transformer (CT) signals and voltage screen (CVT) signals from the recloser.

These are used to provide a variety of data for the operator.

Power System Frequency

The controller must be set for the correct power system frequency – either 50 or 60 Hz. This is set on the page:

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: System Freq 50/60 Hz

Power Flow Direction

The circuit breaker can physically be connected into the HV lines either way. Consequently the controller must be configured for the correct direction of power flow. The direction of power flow is defined as being positive from Source to Load.

The two terminals on the circuit breaker are labelled I and X. The engineer can configure which terminal corresponds to the source and load.

The power flow direction is configured on pages

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: Source X, Load I

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: Source I, Load X

Power flow direction setting is used to determine:

- Whether the source or load corresponds to (I) or (X) on the voltage measurement displays.
- Which direction is positive power flow for use on the kWh totals in the Maximum Weekly display.
- Which is the source or load for Live Load Blocking.

Real Time Displays

The CT and CVT signals are digitally processed to measure data, which is displayed on the Operator Control Panel in real time. Data displayed is as follows:

- Line Current.
- Real Power (kW), this is a signed quantity unless Power Flow Unsigned has been selected on page

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: Power Flow Signed/Unsigned

- Power Factor (PF), this is an unsigned quantity.
- Line voltage on the terminals.
- Live terminal indication on the “I” side of the circuit breaker.

Measurement pages 2 and 3 will be displayed differently according to the (Source I - Load X) or (Source X - Load I) power flow selection made at

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: Source I, Load X

The displayed data looks like this:

```
 - - - - INSTANTANEOUS DEMAND  - - - M
Current  123 Amp
```

```
 - - - - System Measurements - - - - M
Freq    UnavailablePower(P)2479 kW
                   Power(Q)200 kVAR
                   Power Factor0.93
```

Source I/Load X - Phase to Earth V Disp - no ext CVT

Without an optional External CVT and if the Source I / Load X power flow direction is selected the Measurement Page will look as follows:

```
 - - - - - -LINE VOLTAGE - - - - - - M
I (Source) phase to earth 19100 Volt
X (Load) phase to earth Unavailable
```

If the Source X/Load I power flow direction is set then the Measurement will look as follows:

```
 - - - - - -LINE VOLTAGE - - - - - - M
X (Source) phase to earth 19100 Volt
I (Load) phase to earth Unavailable
```

Source I/Load X - Phase to Earth V Disp - with ext CVT

With an external CVT fitted and the Source I/Load X power flow direction is selected the page appears as follows:

```
 - - - - - -LINE VOLTAGE - - - - - - M
I (Source) phase to earth 19100 Volt
X (Load) phase to earth 19100 Volt
```

If the Source X/Load I power flow direction is set then the Measurement will look as follows:

```
 - - - - - -LINE VOLTAGE - - - - - - M
X (Source) phase to earth 19100 Volt
I (Load) phase to earth 19100 Volt
```

Terminal Live/ Dead Indication - no external CVT

SYSTEM STATUS - LIVE/DEAD INDICATION

displays the terminal live/dead indication.

Without an optional External CVT fitted, and the Source I/Load X power flow direction selected, the page appears as follows:

```
 - - - - - -LIVE/DEAD INDICATION - - S
I Live                X Unavailable
```

Terminal Live/ Dead Indication - with external CVT

With an external CVT fitted and the Source I/Load X power flow direction the page appears as follows:

```
 - - - - - -LIVE/DEAD INDICATION - - S
I Live                X Live
```

Maximum Demand Data Displays

Monthly Maximum

For each calendar month, the period with the greater average Real Power is recorded and displayed on the Operator Control Panel. Data displayed is as follows (each value is reset on power up):

- The month/year for the peak period on display.
- The time at the end of the peak averaging period.
- The Real Power (kW) during the peak period. This is a signed quantity unless Power Flow Unsigned has been selected on:

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: Power Flow Signed/Unsigned

- The Power Factor (PF) during the peak period.
- The total integrated real power flow (kWh) during the month. In a system where power can flow both ways this quantity will show either the net energy flow (i.e.: zero if equal energy had flowed both ways) or the total power flow irrespective of the direction depending on page.

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: Power Flow Signed/Unsigned

The displayed data looks like this:

```
 - - - - -  MONTHLY DEMAND  - - - - -M
Jan/2001      Total            28565kWh
Peak Period   12/01/2001       17:15:00
Peak Demand   1235kW             0.93PF
```

If there is no Monthly Demand data available the display will look like this:

```
 - - - - - -MONTHLY DEMAND - - - - -M

       NO MONTHLY DATA AVAILABLE
```

Weekly Maximum

For each week, the period with the greater average Real Power is recorded and displayed on the Operator Control Panel. Demand Data displayed is as follows (each value is reset on power up):

- The date of the last day of the week for the peak period on display.
- The time of the end of the peak averaging period.
- The Real Power (kW) during the peak period. This is a signed quantity unless Power Flow Unsigned has been selected on:

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: Power Flow Signed/Unsigned

- The Power Factor (PF) during the peak period.
- The total Integrated Real Power flow (kWh) during the week. In a system where power can

flow both ways this quantity will show either the net energy flow (i.e.: zero if equal energy had flowed both ways) or the total power flow irrespective of the direction depending on page.

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: Power Flow Signed/Unsigned

- The displayed data looks like this:

```
 - - - - WEEKLY MAXIMUM DEMAND - - - M
week ending  10/01/2001  total 7565kWh
peakperiod   07/01/2001  17:15:00
peakdemand   31141kW     0.93 PF
```

If there is no Weekly Demand data available the display will look like this:

```
 - - - - WEEKLY MAXIMUM DEMAND - - M

       NO WEEKLY DATA AVAILABLE
```

Average Demand Data Displays - Default

The real time data is averaged over a user set period to provide average demand data that is then displayed on the control panel.

To set the average demand period press the **SELECT** key from the

MEASUREMENT: AVERAGE DEMAND HISTORY

screen to access the

MEASUREMENT: SAMPLE PERIOD

page. Press **SELECT** again and use the ⮜ ⮞ keys to vary the displayed period. Press **MENU** to return to page.

MEASUREMENT: AVERAGE DEMAND

Average Demand - Default

Data displayed is as follows:

- Date and time of the end of the averaging period.
- Currents averaged over the period.
- Real Power (kW) averaged over the period. This is a signed quantity unless Power Flow Unsigned has been selected on:

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW: Power Flow Signed/Unsigned

- Power Factor (PF) averaged over the period.

The displayed data looks like this:

```
 - - - - - AVERAGE DEMAND  - - - - -M
12/01/2001 13:45:00Current 123Amp
2749 kW
0.93 PF
```

When first selected, the average demand display shows the most recent period.

To view older periods press the **SELECT** key and then the ⮜ ⮞ keys. To return to the most recent period press the **MENU** key.

Average Demand - Configurable

Average Demand data may be customised using WSOS.

Customised data is not available on the screen if this option is selected. However, the customised data can be retrieved and viewed through WSOS.

This operator message indicates that the Average Demand is no longer available at the control panel.

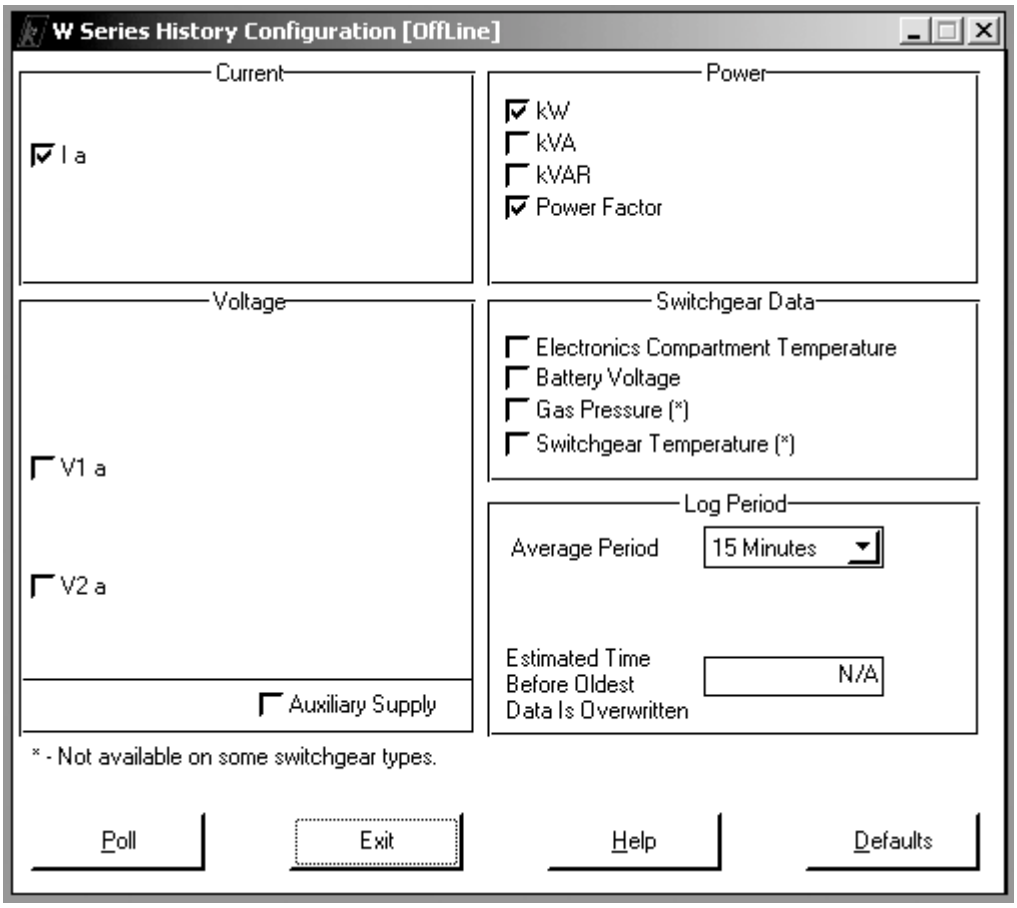
```
 - - - - - AVERAGE DEMAND  - - - - M

        CUSTOMISED DATA LOGGING
         WSOS DISPLAY ONLY
```

The following illustration shows the data that may be configured and displayed through WSOS.

Note: The data storage time is calculated from the parameters selected in these fields.

All Data is averaged over the logging period.



12 Supply Outage Measurement

Many Utilities analyse the supply outages to measure the quality of supply to their customers. The average duration and frequency of outages are key indicators in this process and they are commonly defined as:

- System Average Interruption Duration Index (SAIDI). This is equal to the average minutes lost per customer per year. Each utility has its own definition of lost customer minutes. For example, it may not include outages of one minute or less or outages resulting from transmission grid failures or major storms.
- System Average Interruption Frequency Index (SAIFI). This is equal to the average number of outages per customer per year. Once again each utility may define an outage in a different way.

The Supply Outage Measurement[1] feature utilises built-in recloser features to record the number and duration of outages. These statistics are recorded in the controller and are available to the Utility to help calculate SAIDI and SAIFI. The controller records the:

- cumulative total number of outages,
- cumulative total outage duration, and
- the time and duration of each outage event in the Event Log.

These records are accessible to the user and can be retrieved using the operator control panel, WSOS or a SCADA System.

Determination of Supply Outage

The controller monitors the circuit breaker terminal voltages to determine when there is an outage. A loss of supply voltage for a user-set time is defined as the start of the outage and when voltage is restored for the same user-set time it is the end of the outage. The reported outage duration is the actual time without voltage.

- A standard W Series circuit breaker cannot detect voltage on the X-Side terminal when the circuit breaker is open so Supply Outage measurement is not available for that side of the network.
- If an optional External CVT is fitted, outages on both source and load side network segments are monitored. See Appendix K (page 135) for a brief description of the External CVT.

The circuit breaker logs the number of, duration of and the start and finish time of each outage on the network connected to the I-Side terminal. When an outage is detected on the network segment connected to the I-Side terminal it is timed and the data stored in the database for later analysis.

If the circuit breaker is disconnected from the controller or the controller is powered down during an outage then the controller cannot determine the outage duration. In such cases the outage duration data for the specific outage is discarded. The outage counter is maintained.

Configuration and Display

Supply Outage Measurement is configured and displayed on:

MEASUREMENT – SUPPLY OUTAGES

The top line of the display is the page title and the letter “M” to the right indicates that this page is located in the Measurement Display Group. The next three lines are the data on display. To the right of the data field column is a small column showing the type of data displayed, these have significance as follows:

P - Password Protected (i.e. can only be changed if the password is known)

R - Operator Controlled Reset of the counter and timer values

SUPPLY OUTAGE					**M**
Measure Outages OFF Measure Outages ON		P	Out. Duration	60 s	P
Source outages	2	R	Duration Unavailable	4h14m56s	R
Load outages	3	R	Duration Unavailable	6h23m24s	R

Supply Outages screen

1. Supply Outage Measurement is the subject of a patent application.

Field	Description
Measure Outages ON/OFF	Supply Outage Measurement [a]function enabled/disabled. *Default is Measure Outages OFF.*
Outage Duration	User-defined minimum time, in seconds, for terminals without voltage to be counted as supply outage. Also used as the minimum time for restored voltage before an outage is considered finished. *Range: 1 to 3600 sec.* *Default is 60s.*
Source Outages	Number of supply outages on the source terminal
Load Outages	Number of supply outages on the load terminal
Duration	Total duration of supply outages in hours, minutes and seconds for both source and load-side terminals. *Maximum: 9999 hours, 59 mins, 59 sec.*

Supply Outages - field descriptions

a. Different default values may be factory loaded.

The displayed data looks like this.

```
- - - - -  SUPPLY OUTAGES - - - - -M
Measure OutagesON   Out.Duration 60s
Source Outages  3   Duration4h14m56s
Load Outages    3   Duration6h23m24s
```

Resetting the Counters and Timers

To reset the counters find:

MEASUREMENT – SUPPLY OUTAGES

- Press the **SELECT** key until a counter field flashes.
- Press ⮜or ⮞ keys to reset the counter.
- Press the **MENU** key to continue.

This resets both counters and both timers.

Event Record

A supply outage event is logged in the event record when the supply outage ends. Events are also logged when the operator turns this function ON or OFF, resets the counters and changes the source and load terminals.

The Supply Outage events are listed in the table below.

Event Text	Explanation
Load Out 59 m 59 s	The circuit breaker load terminal experienced a supply outage up to 59 minutes 59 seconds.
Load Out 99 h 59 m	The circuit breaker load terminal experienced a supply outage up to 99 hours 59 minutes.
Load Out 9999 h	The circuit breaker load terminal experienced a supply outage > 100 hours.
Outages ON Outages OFF	The operator has turned ON or OFF the supply outage measurement functions.
Outages reset	The operator has reset the four outage counters.
Source Out 59 m 59 s	The circuit breaker source terminal experienced a supply outage up to 59 minutes 59 seconds.
Source Out 99 h 59 m	The circuit breaker source terminal experienced a supply outage up to 99 hours 59 minutes.
Source Out 9999 h	The circuit breaker source terminal experienced a supply outage > 100 hours

Supply Outage events

The following example shows a typical sequence of events where a circuit breaker has lost supply due to an upstream fault:

```
 - - - - - - - EVENT LOG  - - - - -

07/01/01 22:47:48.00 Source Supply OFF
07/01/01 22:47:48.00 Load Supply OFF

07/01/01 22:52:17.90 Source Supply ON
07/01/01 22:52:17.90 Load Supply ON

07/01/01 22:52:23.90 Source Out 4m 29s
07/01/01 22:52:23.90 Load Out 4m 29s
```

Loss of supply detected on both Source and Load sides.

Restored supply detected on both sides of the ACR.

Supply outage is logged for source and load sides.

13 Generator Control

Operation

The Generator Control option allows a generator to be operated by an IOEX output in response to the loss of supply, which is sensed by the line side terminal.

After a preset time period (HV Dead Time) the CAPM will trip the ACR to isolate the load.

When the ACR opens, the CAPM, via a set of IOEX contacts will turn the generator on. The generator will stay on until the supply is restored.

When supply is restored to the system, and after the expiration of a preset time (HV Live Time) the generator is turned off and the CAPM will close the ACR to restore supply to the load.

Closing is prevented when supplying the load via the generator. This is a safety feature to prevent closing onto unsynchronised supplies.

This feature requires an External CVT to be fitted to the X side of the recloser. Appendix K (page 135) has more information about the External CVT option.

Configuration and Display

This option can be made available or unavailable in

SYSTEM STATUS - OPTIONS 2-Generator Control

OPTIONS 2			S
	P	Loop Auto Avail Loop Auto Not Avail	P
		Dead Lockout OFF Dead Lockout ON	P
Lang English (Intl) Idioma Espanol Lingua Portugesa	P	GenCtrl Not Avail GenCtrl Available	P

Options 2 screen

Field	Description
GenCtrl Not Avail GenCtrl Available	Generator Control Availability This field is used to make Generator Control option available or not available to operators. *Factory default is not available.*

Options 2-Field descriptions

To configure the IOEX mapping for Generator Control, the “Generator Control” and “Generator Run request” outputs should be assigned. See Section 15 (page 69).

With **“Generator Control On”** and the recloser in the open position it is impossible to close if the load side bushings are energised.

The actual contents of the data rows and the field descriptions are shown in the following tables.

The screen shown below will be displayed at the end of the existing status screen if Generator Control is available.

Generator Control				S
GenCtrl OFF GenCtrl ON				
HV Dead Time 5s		HV Live Time 5s		
Control State: GenCtrl OFF Control State: Switch Closed Control State: Line Dead Check Control State: Wait Switch Open Control State: Wait Generator Live Control State: Generator Running Control State: Line Live Check Control State: Wait Generator Off Control State: Wait Switch Closed				D

Generator Control screen

Field	Description
GenCtrl ON GenCtrl OFF	Generator Control This field is used to turn on or off the Generator Control option. *Factory default is OFF.*
HV Dead Time	Amount of time the line side terminal is dead before any action performed by Generator Control. Also used to detect when a generator is stopped. Range: 1 to 600 sec *Factory default is 5 sec.*
HV Live Time	Amount of time the line side terminal is “live” before any action performed by Generator Control. Also used to detect when a generator is running. Range: 1 to 600 sec *Factory default is 5 sec.*
Control State	Control State Shows what Generator Control is doing.

Generator Control-field descriptions

14 Communications Interfaces

The Control and Protection Module (CAPM) provides an external communications interface for connection into a communications system.

This interface can be used by a remote computer to monitor and control the recloser. Typical applications would be connection into a SCADA system for remote operator control or connection into a distribution automation system for automatic control by a supervising computer.

Two physical interfaces are provided on the CAPM, either interface can be used:

- V23 FSK modem with radio interface signals.
- RS232 interface.

These are detailed below. In addition, a switch mode power supply is provided to power the radio/ modem.

RS232 Ports P8 and P9 and V23 Port P10 are not isolated from each other or the controller electronics.

Consequently, they should only be connected to devices inside the PTCC that are powered by the PTCC radio supply, including Modems, optical isolators, and radios.

Use of the serial ports to connect directly to other devices outside the PTCC may cause damage and voids any warranty.

If V23 connection to devices outside the PTCC is essential, the manufacturers 600 ohm interface accessory is recommended.

V23 Interface

An in-built FSK modem provides half duplex V23 signalling at 1200 bits per second. This interface is primarily designed for use with voice frequency radio systems and provides additional signals for this purpose.This interface is available on CAPM plug P10 which is a 16 way ribbon header, or a factory fitted cable may have been supplied to connect direct to the radio.

Unless a particular radio cable is ordered, a standard cable (part number N03-530) with a female 15 way "D" connector is fitted. The cable is run to the bottom of the radio panel. This cable allows a simple "personalised" cable to connect from the standard cable to a particular radio type. The "personalised" cable can be fitted in the field without the need to open the electronics compartment. Contact the manufacturer for the supply of "personalised" cables suitable for particular radio types required.

Signals provided are:

Cable (N03-530)	P10 Pin	Direction	Use
5	5	-	0 Volts (ground/earth)
4	4	To CAPM	Receive, 10 kOhm impedance Sensitivity 0.1 – 2V pk-pk
15	15	From CAPM	Press to talk (PTT)
11	11	From CAPM	Transmit, 600 Ohm impedance Level 2.5V pk-pk
6	6	To CAPM	Busy, 10 kOhm impedance

The Press to Talk (PTT) signal is used to key up a radio transmitter. PTT is implemented using a Field Effect Transistor (FET) with an on resistance of less than 1 ohm. When PTT is asserted the transistor is turned on and connects the PTT signal to 0V. (i.e. the equivalent of a relay contact to earth).

A busy signal can be provided by the radio to indicate receive channel busy. High level is +4.5 to +5V, low level 0V to +0.5V.

Caution

Levels in excess of ±13V should not be applied. The FET is rated for a maximum of +32V and negative voltages are not permitted.
Transmit and receive are unbalanced signals relative to 0 volts and are not isolated. If a DC level is imposed by the radio on the transmit line then this should be less than 2.5 VDC.

A 600 ohm line isolator accessory (TERM1) is available from the manufacturer.

RS232 Interface

An RS232 interface is available on CAPM plug P8 which is a standard D25 male or a factory fitted cable may have been provided to connect directly to the modem. This interface is provided to connect to conventional modems which provide the correct signalling for the communications

network used, e.g. optical fibre modem or telephone dial up modem, as follows:

P8 Pin No:	Direction	Use when connected	Not connected	Internal Use Do Not Connect
1		0V (ground/earth)		
2	From CAPM	Tx Data (TxD)		
3	To CAPM	Rx Data (RxD)		
4	From CAPM	Request To Send (RTS)		
5	To CAPM	Clear To Send (CTS)		
6			X	
7		0V (ground/earth)		
8	To CAPM	Data Carrier Detect (DCD)		
9				X
10				X
11				X
12			X	
13			X	
14				X
15			X	
16				X
17			X	
18				X
19			X	
20	From CAPM	Data Terminal Ready (DTR)		
21			X	
22			X	
23			X	
24			X	
25				X

P9 Configurable Baud Rate

The CAPM Port P9 defaults to fixed 19200 baud, Local mode. If made available to the operator via WSOS, the baud rate and mode can be configured in the CAPM. When WSOS goes online it attempts to communicate at 19.2k baud. If unsuccessful it cycles through 9600, 2400, 1200 and back to 19.2k baud until successful.

Operation

WSOS provides the capability for the operator to designate the mode of operation of the P9 port.

Port P9 can be configured by the operator when made available via WSOS. This allows the operator to:

- Set a fixed or configurable baud rate.
- Designate P9 as Local or Remote.[1]

Port P9 can be configured using WSOS or the OCPM.

1. The default setting is Local.

The actual contents of the data rows and the field descriptions are shown in the following table.

WSOS Port P9 Communications			S
Baud19200 Selection in the range 1200, 2400, 9600 and 19200.	P	P9 Mode Local P9 Mode Remote	P

WSOS Port P9 Communications screen and description

The following screen shows P9 set to a Baud rate of 19200 and Local mode of operation:

Changes to the P9 settings will generate an event in the Event Log.

```
 - - - -WSOS PORT P9 Communications  S
Baud      19200  P9 Mode      Local
```

Radio/Modem Power

A switched mode power supply for a radio/modem is built into the CAPM and draws its power from the auxiliary supply and/or the battery.[1]

The supply is available on plug P3 of the CAPM via a disconnect type terminal block. A factory fitted cable to connect directly to the radio/modem may have been provided. Connections are as follows:

Standard Cable Type N03-530, 15 Way D Female	P3 Pin	Direction	Use
8	AUX +	FROM CAPM	RADIO/MODEM POWER SUPPLY POSITIVE
1	EARTH	FROM CAPM	0V (EARTH)

The radio/modem power supply voltage is set by the user from the Operator Control Panel in the

SYSTEM STATUS -RADIO and TIME SET: Radio Supply 12 Volts

page. This is a password protected parameter.

If the auxiliary power fails, battery power can be conserved by automatically shutting down the radio/modem power supply. The shutdown takes place after the radio holdup time, set on the

SYSTEM STATUS -RADIO and TIME SET: Radio Hold 60 min

page by the user, has elapsed. If the Radio Hold time is set to zero then the radio supply will not shutdown, except under special circumstances. See "LV Auxiliary Power from Mains" - page 80 . The radio/modem power supply is restored when the auxiliary supply returns to normal.

The radio/modem power supply can be turned on and off by the operator for radio maintenance without passwords in the

SYSTEM STATUS -RADIO and TIME SET: Radio Supply ON

page. If the radio supply has shutdown it will be indicated on page:

SYSTEM STATUS -RADIO and TIME SET

Connections Into Electronics Compartment

Connections to the CAPM (if not factory fitted) must be run through the rubber cable ducting in the middle of the equipment panel. This ducting provides a sealed entry into the electronics compartment thus keeping out airborne pollution.

It should not normally be necessary to run additional cables into the electronics compartment. However, if cables must be run, slots in the ducting have been left free for the purpose of connecting radio/modem data and power. If these cables were not factory fitted the slots will have been sealed with rubber cord.

To run cables into the electronics compartment, remove the rubber cord and use the slots.

All such cables must be round, sheathed and between 9 and 10.5mm in diameter to ensure a good seal.

Use heatshrink sleeving to increase the diameter of a cable. See "Replacement of Cables" - page 87 for instructions on removing the electronics compartment cover to gain access to the CAPM.

1. The power supply is not isolated.

15 Input Output Expander Card

The optional Input Output Expander (IOEX) card provides optically isolated input contacts and voltage free output contacts to allow connection of an external Remote Terminal Unit (RTU). It is installed in a die cast, sealed enclosure mounted on the radio tray and earthed to an equipment panel mounting bolt. See "IOEX Cabling" - page 80 for external wiring recommendations.

A “mapping” held in the CAPM database controls the function of the IOEX. It specifies what database information is “mapped” into the IOEX outputs and which controls are “mapped” into the IOEX inputs.

The bottom line of the IOEX Status display page identifies the mapping loaded:

- The standard mapping for inputs and outputs are shown in See "Inputs - Standard Mapping" - page 70 and "Outputs - Standard Mapping" - page 70 respectively.
- Some equipment may be supplied with alternative mappings.

Field Excitation

The field excitation for IOEX inputs/outputs MUST NOT be provided from the control cubicle battery nor the radio power supply. Doing so will breach the isolation barriers and introduce serious risk of damage or interference to the control electronics.

IOEX as Local/ Remote User

An IOEX can be designated from the IOEX Status Page as either Local or Remote User. See Section 8 (page 31) for further information on Local and Remote Users.

IOEX Status Page

The

SYSTEM STATUS-IOEX Status

page displays the status of the IOEX inputs and outputs to assist debugging during installation and maintenance.

The top line of the display is the page title and the letter “**S**” to the right indicates that this page is located in the System Status Display Group. The next three lines are the data on display, consisting of one selection from each data cell. To the right of each data cell in the table is a small column containing a letter indicating the type of data. These letters, which *are not* shown on the display, indicate:

P - Password Protected (i.e. can only be changed if the password is known)

D – Display Only (i.e. Cannot be changed).

IOEX Status				S
Inputs	1 – – – – * – – – – – – – 12	D	Local Remote	P
Outputs	1 – * – – – – – * 8	D	IOEX OK Invalid Map Initialising Unplugged Wrong Type	D
Standard IOEX Mapping.				D

IOEX Status screen

The fields are described as follows:

Field	Explanation
Inputs 1 - - - - * - - - - - - - 12	This indicates the current state of the inputs. A dash – represents the OFF state and an asterisk * the ON state.
Outputs 1 - * - - - - - * 8	This indicates the current state of the outputs. A dash – represents the OFF state and an asterisk * the ON state.
Local Remote	Designates the IOEX to be either a local or a remote user. See "Definition of Local or Remote User" - page 31 .
IOEX OK	Shows the status of the IOEX: “IOEX OK” means that the mapping is valid and in service.

IOEX Status screen descriptions

Field	Explanation
Invalid Map	“Invalid Map” means there is a problem with the IOEX mapping in the database. Contact the manufacturer.
Unplugged	“Unplugged” is displayed if the CAPM is not receiving data from the IOEX, check the cabling.
Wrong Type	“Wrong Type” is displayed if the IOEX hardware is detected as being different to the mapping, contact the manufacturer.
Initialising	“Initialising” is displayed while the IOEX is being initialised.

IOEX Status screen descriptions

When the IOEX configuration is invalid or has some other problems such as wrong hardware type, the IOEX driver stops and flashes the message

IOEX Configuration Corrupt or Invalid

at the top of the screen.

The displayed data looks like this.

```
 - - - - - - - IOEX STATUS - - - - - - -S
Inputs     1------------12             Local
Outputs    1*--*----8               Unplugged
Standard IOEX Mapping
```

Inputs - Standard Mapping

The IOEX has12 independent, optically isolated inputs, each with Metal Oxide Varistor (MOV) protection. DC in either polarity or AC input signals are accepted. Input Voltage range is 60 – 130 VAC or 18 – 150 VDC.

Input Number	Terminal Number	Inputs ON
		Recloser
1	1-2	Trip the circuit breaker, set lockout and inhibit all close operations
2	3-4	Close the circuit breaker
3	5-6	
4	7-8	
5	9-10	Auto Reclose ON
6	11-12	Auto Reclose OFF
7	13-14	Protection Set A Selected
8	15-16	Protection Set B Selected

- The recloser “close” input will only function when the controller is set to the designated IOEX mode and the Work Tag is off. For example, if the IOEX card is designated as local then the IOEX close input will only operate when the controller is in the Local mode of operation and the Work Tag is turned off. See Section 8 (page 31).
- Tripping and controlling all other settings works in Local and Remote modes and is independent of the Work Tag status.
- If the IOEX Trip input is held on while either the IOEX close or manual close input is activated, the recloser will not close. This is indicated in the event log by a ‘Close Blocking ON’ and ‘Close Blocking OFF’ event whenever the IOEX Trip input changes state.
- If both Auto Reclose ON and OFF inputs are on, the default is Auto Reclose ON.

Outputs - Standard Mapping

The IOEX has 8 independent voltage free relay contact outputs, each with MOV protection. The contacts are rated for 150 VAC, 2A or 150 VDC, 1A non-inductive.

Output Number[a]	Terminal Number	Output On (relay closed)	Output Off (relay open)
1	25-26	Tripped	Closed
2	27-28	Closed	Tripped

Output Number[a]	Terminal Number	Output On (relay closed)	Output Off (relay open)
3	29-30	Flag A, Overcurrent Protection Trip indication.	
4	31-32	Lockout	Not in lockout
5	33-34		
6	35-36	Auto Reclose ON	Auto Reclose OFF
7	37-38	Flag B, Overcurrent Protection Trip indication.	
8	39-40	System Healthy See "System Healthy Indicator" - page 71	Other conditions

a. The IOEX contacts are not guaranteed to change during fast Auto Reclose sequences but will indicate the final steady state condition within 150ms.

Trip Source[a]	Flag A, Trip indication	Flag B, Trip indication
Reset, Set to this state on Recloser Close.	Off	Off
Prot Trip	On	On

a. The Trip Source outputs do not indicate other causes of a trip such as Loss of Phase.

System Healthy Indicator

The IOEX system healthy indicator is present when all of the following are true:

- Aux Supply OK.
- Battery Supply OK.
- SCEM Data Valid.
- CAPM Electronics OK.
- Contact Life greater than 20% .
- IOEX to CAPM communications OK.
- Mechanism OK

Failure of any of these will cause the system healthy flag to be extinguished.

Power Consumption

If an IOEX card is fitted to the control cubicle, the battery holdup time can be affected.

This is due to the current drawn by the IOEX card and its relay coils. An IOEX card draws 10mA without any relays turned on. The relays draw approximately 20mA each for an IOEX Rev 1 and 10mA each for an IOEX Rev 2. There can be up to four relays energised at once with at least one relay energised at all times.

Therefore an IOEX Rev 1 draws a minimum of 30mA and a maximum of 90mA while an IOEX Rev 2 will draw a minimum of 20mA and maximum of 50mA. The manufacturer's battery holdup time rating is based on a recloser installation without the IOEX card fitted.

Configurable IOEX

WSOS incorporates the Configurable IOEX tool that allows users to generate custom I/O mappings for an IOEX card.

Logic can be applied to each point with up to five sets of logic or "actions" for each input and one trigger action for each output.

This tool can be launched from within WSOS and used to individually define each of the twelve inputs and eight outputs for an IOEX map.

Scope

The Configurable IOEX tool can only create mappings that are compatible with CAPM software versions 027-07.xx (CAPM 4) and 527-07.xx (CAPM 5), and all later versions.

The tool can be used to read mappings from previous versions of software but can only create files for use with the specified software versions.

The manufacturers WSOS Version 4.12 or higher is also required to use the Configurable IOEX tool.

Overview

Custom maps can now be created for an IOEX and loaded into a CAPM directly from WSOS. The types of actions that can be mapped to each input or output is dependent on the software version loaded into the CAPM.

When the tool is started the user is asked to input the software version.This is then used to retrieve a valid set of points to use when constructing logic within the tool.

The mappings and I/O logic are created using the tool and saved to an IOEX mapping file on the WSOS computer. Once a valid file has been created it is linked to the switchgear device configuration in WSOS and written into the CAPM.

The IOEX Configuration tool is intended to be used Off-Line only. Mappings are created, saved and linked to a WSOS switchgear device configuration while disconnected from the switchgear. Once these tasks have been completed the user connects to the device and writes the new mapping into the CAPM along with the switchgear device configuration.

When this tool is installed, a technical manual describing its operation and use is available through its Help menu.

16 Accessories

Test and Training Set (TTS)

For simplified testing in the field or in the workshop a purpose built test set called a Test and Training Set (TTS) is available.

The TTS is a briefcase sized test set which connects to the control cubicle and allows a standard secondary injection test set to be connected to inject currents into the control cubicle. The TTS will also simulate the circuit breaker and allow comprehensive testing of the control electronics. The TTS is highly suited to train staff in maintenance and operations.

The test and training set is purchased as a separate item. For further information refer to your distributor.

Windows Switchgear Operating System (WSOS)

Section 7 (page 25) describes the built-in operator control panel. An alternative interface to the operator panel is the *Windows Switchgear Operating System (WSOS*). This is a software package for a Personal Computer (PC) that allows management, control and monitoring of a population of reclosers. WSOS is purchased as an additional item. For pricing information refer to your distributor.

WSOS provides facilities for:

- Online and Offline management of all protection settings.
- Tripping and Closing of the switchgear and other operator control functions.
- Up-loading of historical data (e.g. event record or demand measurements) into the computer, which can be taken away and processed elsewhere.
- Automatic dial-back from the controller to the WSOS PC on change of state.

Embedded in the circuit breaker controller is server software for the WSOS package. The server provides two interfaces for connection to WSOS as described below.

Connection can be made from a PC to the WSOS server at either port but only one port can be used at any one time.

Electronics Compartment Computer Port (P9)

This is the computer port on the front of the electronics compartment also known as the P9 port.

It is a standard RS232 connection running at 19.2 kBaud unless otherwise configured. See Section 14 (page 65) .

The port is normally used to connect a portable notebook PC for maintenance purposes such as downloading settings or uploading the event records using WSOS. This port is designated a Local User, as defined in "Local/Remote Mode" - page 31, and may be configured as remote. See Section 14 (page 65).

Telemetry Port (P8)

This is a standard RS232 port and provides remote access to a PC running WSOS located elsewhere such as in an office or a workshop. For details of the hardware interface. See "RS232 Interface" - page 65 .

To gain remote access a modem must be installed in the control cubicle allowing the PC to control the recloser from another location. Typically the modem is connected to a telephone line or is itself a digital cellular telephone modem.

The modem allows an engineer or operator to dial into the controller and check on the event record or make protection setting changes.

In addition the controller can be configured to dial the PC automatically when events occur such as trip to lockout. This is called Change of State (COS) reporting and allows a WSOS computer to be used as a monitoring system for a population of circuit breakers. More information is provided in the WSOS Technical Supplement Manual N00-402.

This port is designated as a Remote User, as defined in "Local/Remote Mode" - page 31.

"RS232 Interface" - page 65 gives details of the hardware interface. In some software configurations this port is used by other protocols, in which case it cannot be used for WSOS connection at the same time.

The port is configured on

SYSTEM STATUS - WSOS Port P8 Communications

and requires:

- The baud rate must be set to match the modem interface to allow dial-in access to WSOS (this is not necessarily the same as the modem signalling speed, refer to the modem manual)
- CAPM 4 possible range is 300 baud to 9.6 kBaud.
- CAPM 5 possible range is 300 baud to 19.2 kBaud.
- “COS On” if Change of State Reporting is required. In this case a telephone number is also required.

Outline of Operation

The WSOS manual supplement document number N00-402 gives more details on the operation of P8 as a remote WSOS port. In summary it:

- Operates as a RS232 interface.
- Supports TXD, RXD and DCD and in turn requires these signals to be supported by the modem or otherwise correctly wired.
- If communication to a WSOS PC has occurred in the last 10 seconds or DCD is asserted then "Online" is displayed on

SYSTEM STATUS - WSOS Port P8 Communications

- If Change of State is ON, the port uses the Hayes command set to make the dialup connection and therefore this must be supported by the modem. Whilst dialling "Dialling" is displayed as the status. If dialling does not result in a connection then retries are made and if they do not succeed then the modem is powered down and up again before further attempts to connect are made.
- Once connected the controller waits for WSOS to interrogate (poll) it. Provided successful polls take place the controller then resets it change flags so that it will not call again until there is another change. If at any time there is no poll from the WSOS PC for 60 seconds then the controller will terminate the connection using the Hayes hang-up command, or if that fails by powering down the modem.

Manual Operation Set

The manual operation set allows a user to manually trip or close the circuit breaker when a control cubicle is either not available or not working. It operates the actuator inside the circuit breaker from its own trip/close capacitor using its own batteries. No external power source is needed.

The Manual Operation Set is purchased as an additional item, for further information refer to your distributor.

Remote Control Panel

The remote control panel provides dual control for the manufacturer's Reclosers installed in Sub-Station applications. The remote control panel duplicates the Operator Control Panel to provide almost identical functionality to that provided at the Control Cubicle.

The Remote Control Panel is purchased as an additional item, for further information refer to your distributor.

Secondary Voltage Injection Interface Set

The Secondary Voltage Injection Interface Set (SVIIS) enables the direct injection of low voltage for testing of the control cubicle protection or Distribution System Automation functions.

It may be used to:

- Inject voltage signals when connected to a Test and Training Set.
- Simulate loss of voltage on an energised recloser.
- Confirm the Pole Top Control Cubicle (PTCC) and control cable connections on all the manufacturer's Pole Top Circuit Breakers.
- The SVIIS is provided with a separate Technical Manual N05-633. This manual describes the configurations that the SVIIS may be used within.
- Test procedures using the SVIIS are described in detail within the manufacturer's "Workshop and Field Test" Manual. Refer to the manufacturer or your local distributor.

External Capacitive Voltage Transformer

The External Capacitive Voltage Transformer (CVT) provides voltage measurement on the circuit breaker X-Side terminal and may be purchased separately an additional item.

For further information, refer to your Nu-Lec Industries distributor.

A brief description of the External CVT is provided at Appendix K (page 135).

Fast Trip Input Module

A Fast Trip Input Module (FTIM) is available as an accessory.

This provides an optically isolated input to unconditionally trip the circuit breaker within 60ms of activation (including debounce and breaker operating time).

The FTIM is purchased as an additional item, for further information refer to your distributor.

17 Installation

Unpacking & Checking

Contents of Crate

Each crate includes the following:

- W-Series pole top circuit breaker.
- Pole mounting bracket. This will be bolted to the floor of the crate and be fitted with the necessary nuts and bolts to attach it to the circuit breaker.
- Control Cubicle.
- Control cable.

Optional extras, which may have been purchased, include:

- Clamp bands to attach the mounting bracket to circular poles which cannot be drilled (there are different clamp bands to suit different pole diameters).
- Cable clamps to connect the HV cables to the circuit breaker.

On receipt the unit should be checked for completeness and shipping damage. If any is found, contact the manufacturer or your local distributor immediately.

Unpacking Procedure

Tools required:

- Wrecking bar to remove nails.
- Four D shackles, two slings and crane with a safe working load of 100kg to lift the circuit breaker.
- Screwdriver or Battery Drill with 8mm socket.
- 16mm Spanner or Socket.

Procedure:

- Remove top of crate and lift out the control cable and bushing boots. Store carefully in a clean dry place.
- Unscrew and remove the four (4) screws located on the wall of the crate. The mounting bracket, mounting kit and the two pieces of wood that the screws have just been removed from are all secured together. Lift the complete mounting bracket out of the crate.

Caution
Take great care not to drop the mounting bracket, which weighs 13kg, onto the circuit breaker.

- Fit D-shackles to the lifting points on the circuit breaker and lift out of the crate onto the ground using the crane.
- Lay the crate down on its side and remove the HV cables.
- Remove the two bolts securing the control cubicle and slide the unit from the crate.

WARNING
The control cubicle weighs approximately 35 kg

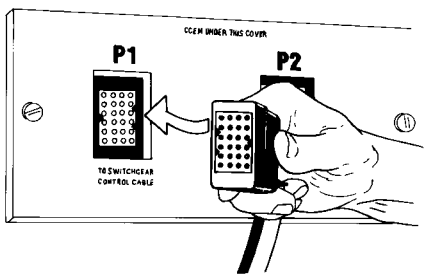
Control Cable Connection

When installing or testing the circuit breaker it is necessary to connect and disconnect the control cable.

To do this successfully requires the correct technique that is explained below with reference to Figure 24 (page 75) and Figure 25 (page 76).

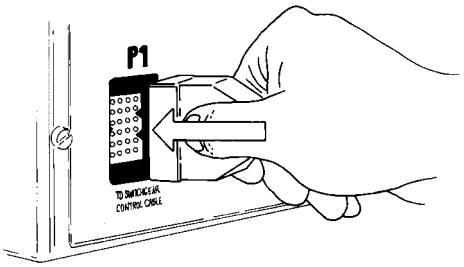
- Power down the control cubicle by switching off all MCB's. This should be done whenever connecting or disconnecting the control cable from the control cubicle.
- To connect: hold the plug by the long sides, check orientation, gently locate it on the socket and push firmly home. Check it has locked by wriggling the plug. If the plug cannot be pushed on with moderate force then it has not been located properly. Heavy force is never required.
- To disconnect: hold the plug by the short sides and grip hard to release the clips inside the plug (not visible). Wriggle to allow the clips to release and then pull the plug out.

Caution
Never pull the plug out by the cable.



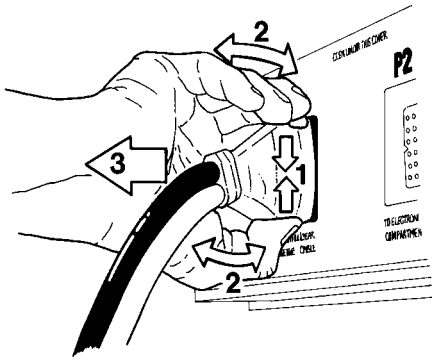
Check orientation

Figure 24: Connecting the control cable (1)



Locate and push home. then wriggle to check locking.

Figure 25: Connecting the control cable (2)



1. Grip and squeeze to open locking clips.
2. Wriggle to release.
3. Pull.

Figure 26: Disconnecting the control cable

Testing & Configuring

The tests can be carried out on site or in the workshop as preferred.

Unpack the crate as above and put the control cubicle in a clean safe place where they will not be damaged or soiled. Make a temporary earth connection between the control cubicle, the circuit breaker and earth. This need only be 1mm² copper wire.

Unbolt the blanking plate from the bottom of the circuit breaker and connect the cover end of the control cable to plug P1 on the Switch Cable Entry Module (SCEM) located inside the compartment. See "Control Cable Connection" - page 75 for the correct way to plug in the control cable.

Do not bolt the cover onto the tank unless this is the final installation since the sealing gasket on the cover cannot be re-used once it has been fully compressed.

Then connect the other end of the control cable into connector P1 on the Control Cable Entry Module (CCEM). See Figure 24 (page 75)and Figure 26 (page 76).

Turn on the battery and aux supply circuit breakers at the top of the control cubicle and carry out the following tests:

1. Trip and close the circuit breaker from the control cubicle.

2. Insulation test the high voltage connections to earth to check for shipping damage to the high voltage components of the circuit breaker. The test voltage should not exceed 54kV for 60 seconds (90% of the factory test voltage).

3. Configure the protection settings.

4. Perform primary current injection as required.

5. Perform secondary current injection as required using a Test and Training Set (TTS).

6. The radio/modem plate can be unscrewed and a radio or modem fitted, connected and tested as required.

WARNING

If testing is carried out substantially above the rated line/earth voltage then X-rays may be emitted from the vacuum interrupters. In this case all personnel must be shielded from the X-rays.

Important Notes:

When a circuit breaker is connected to a control cubicle the controller reads the circuit breaker memory. Five minutes after an operation occurs, the control cubicle writes the circuit breaker memory with the latest operations count and contact wear data. During the writing process the control cubicle “beeps”. Always wait 5 minutes after an operation before turning off the control cubicle so the changed data can be written to the circuit breaker. Do not turn off or unplug the control cubicle during the writing process.

Attend to the battery using the care instructions given in "Battery Care" - page 85. Note that fitting the batteries with reverse polarity will cause damage to the electronic systems.

- An application note detailing workshop and field test procedures is available. Contact the manufacturer’s agent or distributor**.**

Transport to Site

If the unpacking and testing was carried out in the workshop then the circuit breaker and control cubicle must be transported safely to site. It is important the following steps are carried out:

- Turn off all control cubicle circuit breakers and disconnect all auxiliary power supplies.
- Disconnect the control cable from both circuit breaker and control cubicle and put back the blanking plate on the bottom of the circuit breaker where the control cubicle is connected.

- Either remove the batteries from the control cubicle and safely transport separately or secure the batteries in the control cubicle.
- Transport the circuit breaker, control cubicle and all parts in a safe and secure manner to site.The recommended way to do this is to re-pack the equipment into the original crating.
- Transport the circuit breaker, control cubicle and all parts in a safe and secure manner to site.

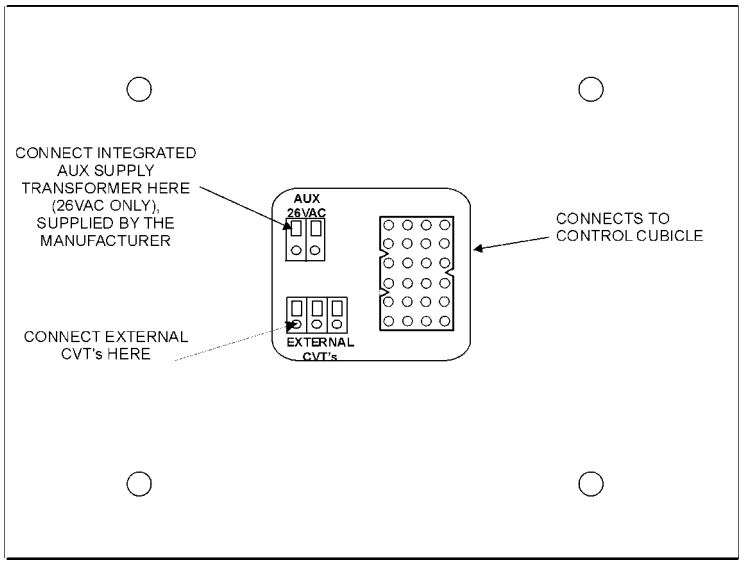


Figure 27: SCEM Compartment

Site Installation

Tools Required

- Torque wrench and metric socket set, normal engineers tools.
- Tools to prepare pole as required.
- Crane or other lift device for the circuit breaker and control cubicle, four D shackles and slings.

Parts Required (Not supplied by the manufacturer)

- Two 20mm galvanised or stainless steel bolts with washers and nuts etc. to bolt mounting bracket to power pole. See Figure 28 (page 78). If the optional pole clamp has been purchased this is not required.
- Mounting parts for control cubicle. Either 20mm steel strapping or 10mm galvanised or stainless steel bolts, nuts, etc. See Figure 2 (page 20).
- Fixing hardware for control cable. This is standard 25mm sheathed conduit and can be fixed to the pole with ties, straps, P-clips or saddles.
- Earth wire and lugs for the earthing scheme and parts for LV mains auxiliary power connection. See Figure 29 (page 80), Figure 33 (page 121) and "Earthing" - page 79.
- 20mm sealing cable entry glands to suit auxiliary supply mains cables, 16mm sealing cable entry glands to suit aerial or communications cable as required.
- Aerial, aerial feeder cable and surge arrester as required if a radio is fitted (unless supplied by the manufacturer).
- Cable ferrites for IOEX cables (If IOEX is fitted).

Site Procedure

Complete the following sequential steps to erect and test the circuit breaker. Refer to mounting details provided at Figure 29 (page 80), Figure 30 (page 81), Figure 31 (page 82) and Figure 32 (page 83).

- Transport to site and carry out testing prior to erection as required.
- Ensure that the pole is of sufficient strength to support the circuit breaker. A structural engineer may be required to calculate the stresses involved.
- Securely mount the circuit breaker mounting bracket on the power pole.
- Lift the circuit breaker into position, complete with any surge arrester brackets and surge arresters. Lower it onto the mounting bracket and fix with the four 16mm nuts and bolts provided. Tighten to 100 Nm.
- Complete the high voltage connections and note the terminal wiring on the Operating Instructions label affixed to the inside of the control cubicle door.
- Lift the control cubicle into position and bolt or strap to the power pole. Note that the control cubicle mounts are provided with key holes so it can be lifted onto the mounting bolt and simply slid into position.

- Run the earth connections as shown in Figure 33 (page 121), refer also to "Earthing" - page 79.

WARNING
It is vital that the earthing scheme described is carried out.

- For LV mains supply run auxiliary wiring as shown in Figure 33 (page 121).
- It is vital that the scheme described is carried out.
- Carry out the wiring connections inside the control cubicle as shown in Figure 29 (page 80).

Caution
Make sure the LV mains cable is run behind the equipment panel.

- For LV supply from a dedicated transformer supplied by the utility, connect as shown in Figure 32 (page 83).
- For Integrated supply from an external transformer, connect as shown in Figure 32 (page 83). Refer to "LV Auxiliary Power from Dedicated Utility Transformer" - page 80.
- Remove the cover plate from the bottom of the circuit breaker tank and connect the control cable to plug P1 on the Switch Cable Entry Module (SCEM) located inside the tank. Refer to "Control Cable Connection" - page 75 for the correct way to plug in. Then bolt up the cover.

The cover can be fitted in different orientations to best suit the installation.

- Run the control cable down from the circuit breaker to the control cubicle.
- Power down the control cubicle by switching off all MCB's. Note that this should be done whenever connecting or disconnecting the control cable from the control cubicle. Remove the blanking plate of the control cubicle and feed the control cable through the bottom of the control cubicle and plug into connector P1 on the control cable entry module (CCEM), as shown in Figure 2 (page 20).
- Fit batteries to control cubicle.

Caution
Fitting the batteries with reverse polarity will cause damage to the electronic systems.

- Power up control cubicle and test operation of circuit breaker.
- Mount aerial and run aerial feed to control cubicle or run external communications cable to control cubicle. Use the cable entry shown in Figure 2 (page 20) with a sealing 16mm gland.

The circuit breaker is now ready for energising and commissioning. This should include setting the frequency, power flow direction and the phasing. Refer also Section 11 (page 55).

HV Connections

The HV terminals are ∅20mm tin plated copper stems with M10 x 1.5 tapped holes in the ends.

Connections are made to the circuit breaker terminals using one of the methods below, See Figure 29 (page 80).

- Parallel Groove clamps which grip both the cable and the stem. These are standard line equipment available in bimetallic versions to connect to aluminium conductors. These are suitable for all cable sizes.

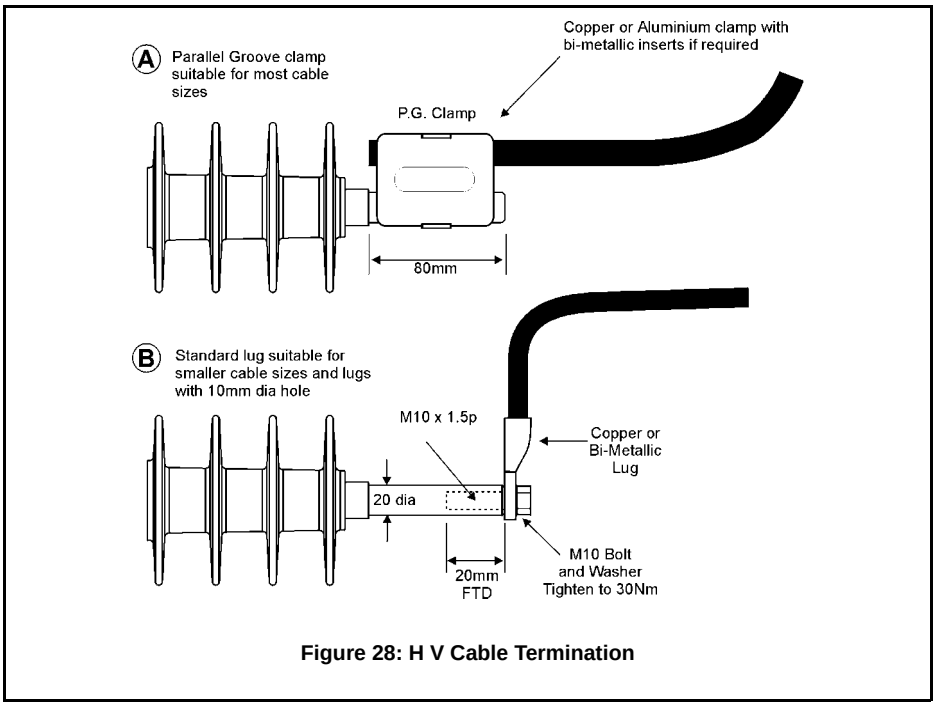


Figure 28: H V Cable Termination

- Crimp lugs with holes for M10 bolts. These are suitable for cable sizes up to approximately 70mm^2 and are available in bimetallic versions

Surge Arrester Mounting and Terminating

Surge arrester brackets may be fitted to the circuit breaker tank top. See Figure 30 (page 81) and Figure 31 (page 82).

These provide a single 14mm ∅ hole for mounting surge arresters and automatically earth the surge arrester via the tank top.

When the circuit breaker is end mounted, surge arrester brackets can be fitted to both sides of the recloser. When centre mounted a single surge arrester bracket can be fitted to the “I” -Side of the circuit breaker, and the “X” -Side surge arresters can be fitted to a cross arm.

When surge arresters are fitted to a cross-arm it is essential that the earth for the surge arresters is connected to the earth terminal on the ACR.

WARNING
If this is not done it may invalidate warranty.

Surge arresters should be connected to the cables from the circuit breaker terminals to the lines. Connecting closer to the circuit breaker is better than further away.

It is usually easiest to fit the surge arresters brackets and surge arresters to the circuit breaker when it is on the ground before lifting onto the pole. In this case fit the surge arrester brackets to the circuit breaker with the two bolts provided but make sure that they are not in the holes used by the mounting bracket. Then, when the circuit breaker is lifted into position, the correct holes will be free for fitting the circuit breaker to the mounting bracket.

The circuit breaker mounting bolts fix the surge arrester brackets to the circuit breaker and the circuit breaker to the bracket.

Earthing

Figure 31 (page 82) shows the earthing common to all installations.

This arrangement earths the circuit breaker frame and the surge arresters directly to earth through a *main* earth *bond* consisting of a copper conductor of at least 70mm^2. Any surges will flow down this path.

Caution
Do not earth surge arresters by a different path, doing this may cause damage to the control electronics or circuit breaker. Also, any aerial should be bonded to the circuit breaker or the *main* earth *bond*.

The control cubicle is connected to this *main* earth *bond* by a tee-off. The control cubicle electronics are internally protected from potential differences which may occur between the circuit breaker frame and control cubicle frame whilst surge currents are flowing down *the main* earth *bond*. No other connections to earth from the control cubicle are allowed since surge currents will also flow in those paths. Follow this arrangement on both conducting and insulating power poles.

Keep the *main* earth *bond* physically separated from the control cable, as they run down the power pole, by the maximum spacing available. This should be at least 200mm for wood and concrete poles and 100mm for steel poles.

Protection of Radio Equipment

It is highly advisable to connect a gas discharge type of surge arrester in the aerial feed to the radio. Failure to do so will result in loss of radio and control electronics protection which could lead to complete electronic failure due to lightning activity.

Caution
A failure of this nature is not covered by the products general warranty arrangements.

A feed-through or bulkhead type arrester fitted to the bottom to the bottom of the control cubicle is ideal. If fitted internally the surge arrester should be earthed to an equipment panel mounting stud by the shortest possible wire. Holes are provided for a Polyphasor, IS-B50 type bulkhead surge arrester. See Figure 2 (page 20). A suitable type of bulkhead mount surge arrester is specified in Appendix H (page 119).

If a surge arrester is not fitted then the co-ax earth screen should be earthed to an equipment panel mounting stud by the shortest possible wire.

IOEX Cabling

Turn off the controller before connecting the IOEX to the CAPM.

To ensure electromagnetic compatibility compliance is maintained, ferrite filters should be fitted to all input/output IOEX cables. A suitable type of ferrite is specified in Appendix H- Replaceable Parts & Tools (page 119).

The wiring to the IOEX must be shielded with the shield bonded to the control cubicle stud only. The manufacturer recommends shielded 12 pair data cable with a separate common for inputs and outputs. Insulation must withstand a minimum of 150 V DC.

Separate the CAPM - IOEX cable from input/ output wiring as much as possible.

LV Auxiliary Power from Mains

Where LV mains are connected to the control cubicle to provide auxiliary power the connection **must** connect the neutral of the LV system to a tee-off from the *main* earth *bond* as shown in Figure 31 (page 82). An LV surge arrester **must** also be fitted from the LV phase connection to this tee-off.

This connection scheme bonds the LV and HV earths and so protects the primary insulation of the auxiliary supply transformer in the control cubicle when surge currents are flowing.Fit additional LV surge arresters to all the other LV phases (if they exist), to balance the supply for other users connected to the LV system.

If local conditions or wiring rules prohibit bonding the HV and LV systems in this way, providing the auxiliary supply to the control cubicle from the LV mains system is not possible. Instead, use one of the alternative arrangements detailed below.

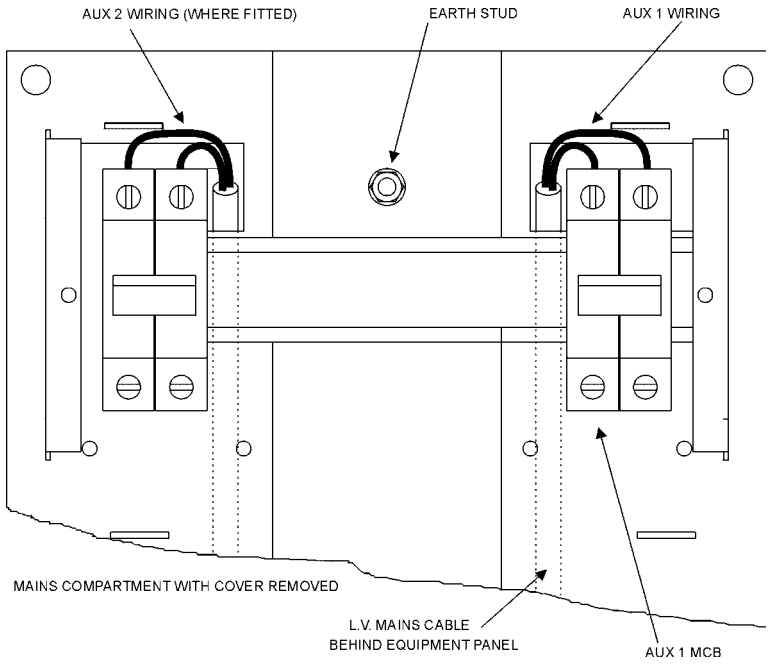


Figure 29: LV Auxiliary Supply Connection

LV Auxiliary Power from Dedicated Utility Transformer

Figure 32 (page 83) shows wiring and earthing if a dedicated transformer is supplied by the utility. Note that this should not be used to supply any other equipment without consulting the manufacturer to ensure that no hazard is caused to the control cubicle electronics.

Figure 32 (page 83) shows that the transformer and any steelwork is earthed to the switchgear tank and that one side of the transformer secondary is earthed to the earth stud on the equipment panel inside the control cubicle.

Auxiliary Power from Integrated Transformer

The manufacturer can provide a dedicated voltage transformer outside the circuit breaker tank which connects directly into the control electronics. This is called an *Integrated Auxiliary Supply*.

An external transformer is mounted on the front of the tank as shown in Figure 32 (page 83) which also shows suggested HV connections. The secondary of the external transformer connects into the SCEM on the side of the circuit breaker. To connect the transformer secondary remove the SCEM compartment cover plate, pass the cable, which is pre-fitted with a cable gland at the correct length, through the hole, secure the gland, connect the auxiliary supply to the screw 2-terminal plug on the SCEM and replace the compartment cover.

No additional earthing for Integrated Auxiliary Supply is required in addition to the common earthing shown in Figure 31 (page 82).

Transformer Switching

If the circuit breaker application involves switching unloaded transformers, ensure that the system configuration is not prone to repetitive re-strike. Check with the manufacturer representative if further advice is required.

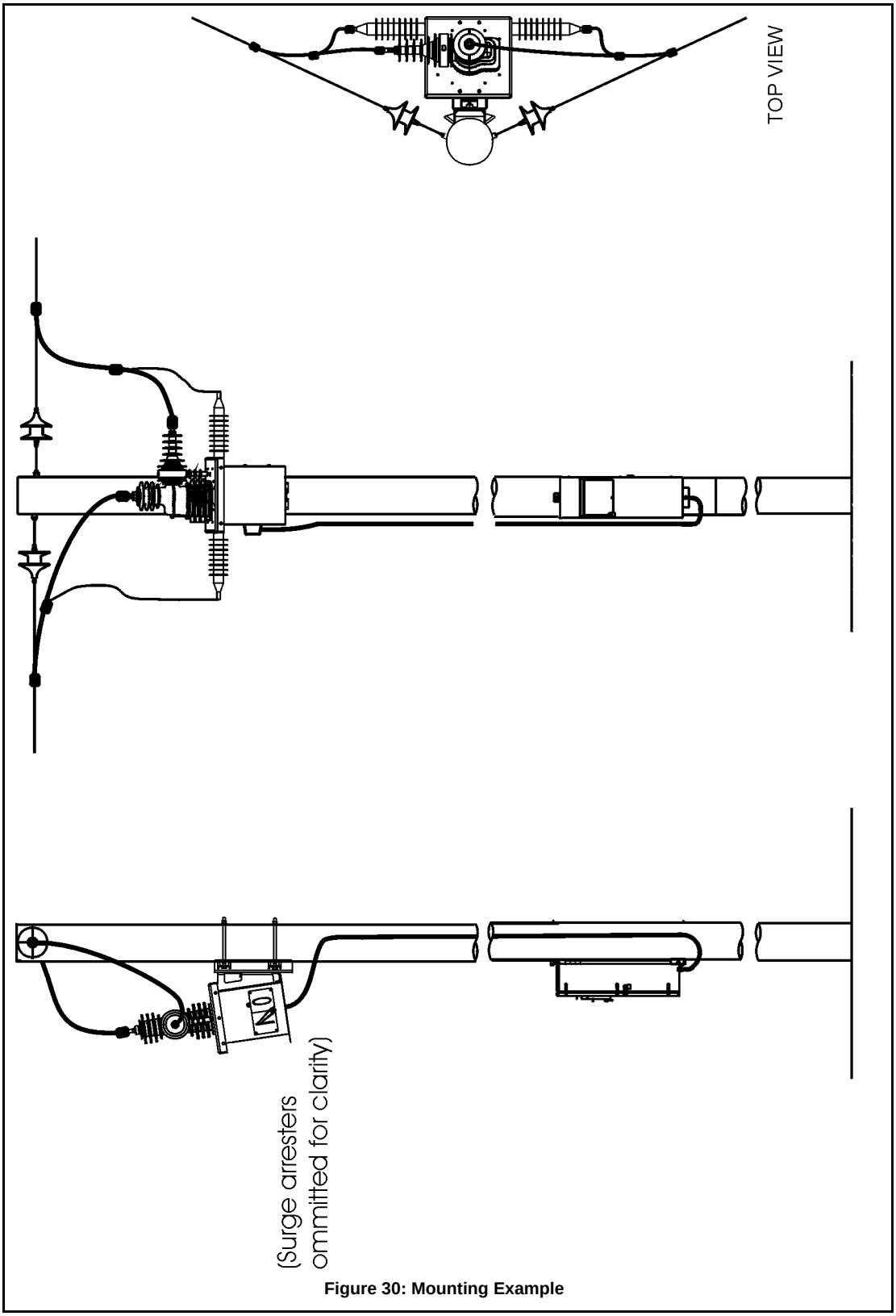


Figure 30: Mounting Example

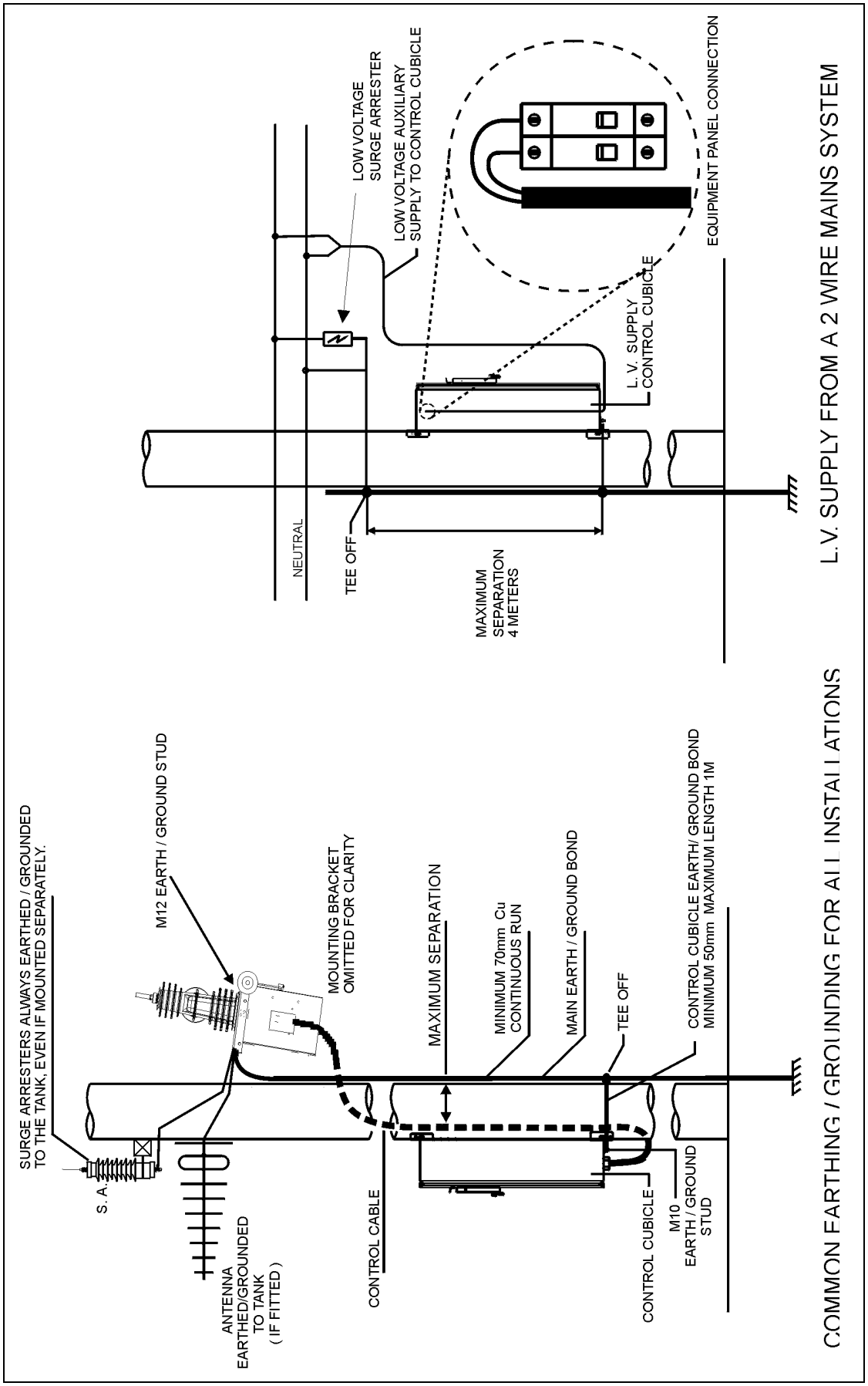


Figure 31: Common Earthing and LV Supply

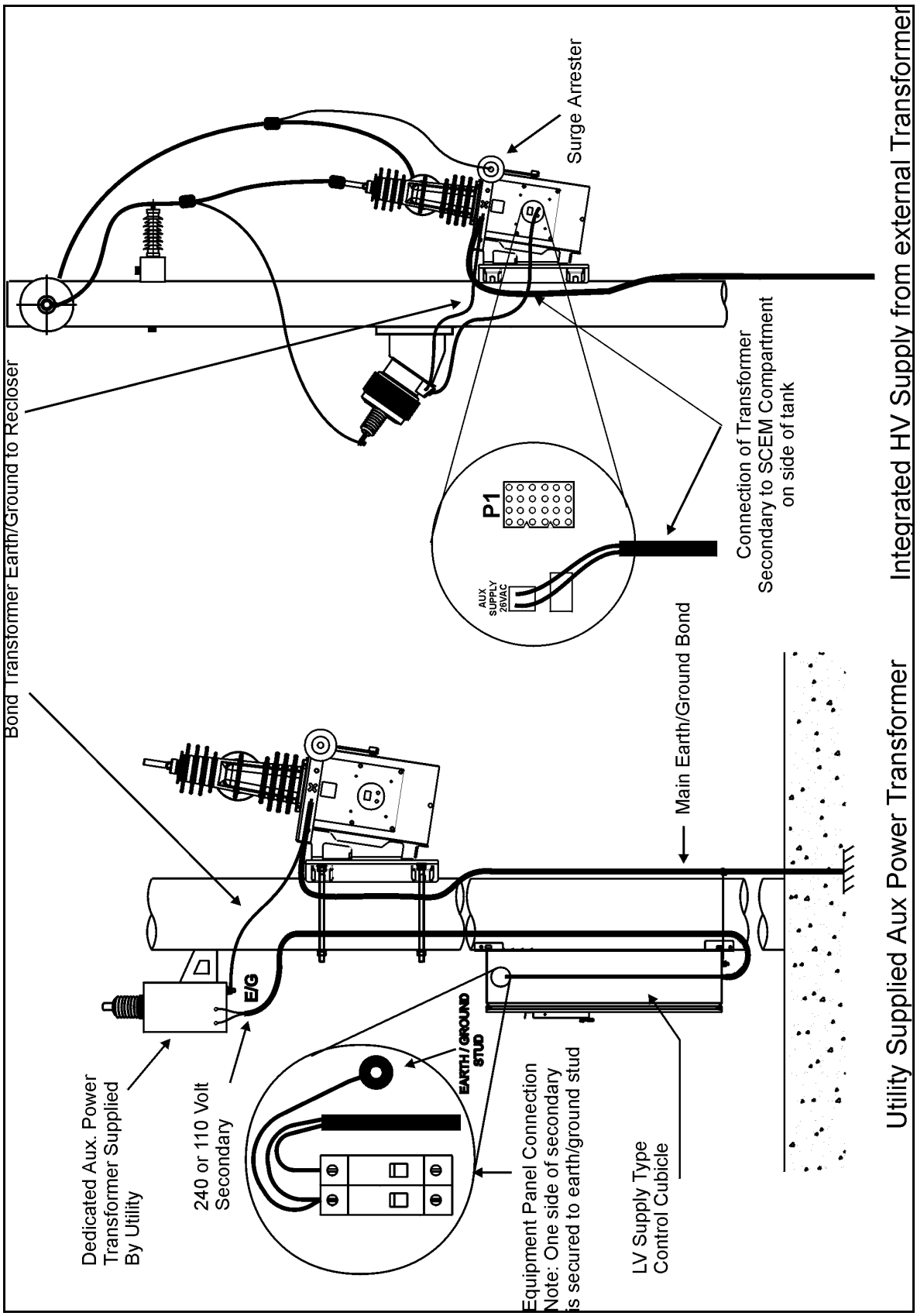


Figure 32: Utility Aux Transformer and Integrated External Transformer

18 Maintenance

Maintenance is carried out using standard electricians' and mechanics' tools.

Circuit Breaker Maintenance

No user maintenance of the circuit breaker mechanism is required.

The circuit breaker should be returned to the manufacturer for refurbishment if the mechanical duty or breaking duty is exceeded. This is checked by examining the remaining contact life on the Operator Control Panel. When the remaining contact life approaches zero, the circuit breaker is worn out.

Every five years the bushings should be checked, cleaned if necessary and the pointer checked to ensure it is free from mechanical obstructions. In areas of high atmospheric pollution more frequent cleaning may be appropriate.

Control Cubicle Maintenance

Maintenance of the control cubicle is required every five years to carry out the work given below.

Control Cubicle Cleaning

Check for excessive dirt on the cubicle, particularly the roof, and clean off.

Ensure the louvres are not blocked and that air vents and water drainage holes in the base are open.

Battery Replacement

Battery replacement is recommended after a period of five years. See "Battery Care" - page 85 .

The procedure is:

- Turn off the battery circuit breaker.
- Unplug batteries and replace with new batteries.

Caution
Ensure that polarity is correct.

- Turn on the battery circuit breaker and ensure that “Battery Normal status”, is restored on

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Protection and Operation Check

Bypass the circuit breaker and carry out primary injection testing to check circuit breaker protection and operation.

Alternatively use a Test and Training Set to perform secondary injection. The Test and Training Set manual gives procedures for in-service and bypassed testing of both the control cubicle and the circuit breaker.

Door Seal

Check the door sealing rubber for perishing or undue hardening. If necessary renew the seal.

Battery Care

The battery is predicted to provide good performance for the recommended five year service period. This is based on the battery manufacturer's data. No battery warranty is given by the manufacturer. In some environments, an exceptionally high control cubicle temperature can mean a shorter battery replacement period. Consult the manufacturer if you suspect your environment to be excessively hot.

Once in service, batteries need little care. Procedures for storage and other contingencies are as follows:

- Batteries should be stored at a temperature of between -10°C to 30°C and cycled every six months. Batteries should be stored for a maximum of one year.
- Batteries should be cycled prior to putting into service if they have not been cycled within three months. When shipped by the manufacturer the batteries will have been cycled within the previous 30 days.
- If the batteries become exhausted in service and are left for more than two weeks without auxiliary supply being restored to the control cubicle they should be taken out, cycled and have their capacity checked before being returned to service.

To cycle a battery, discharge with a 10 Ohm 15 Watt resistor to a terminal voltage of 10V. Next, recharge it with a voltage regulated DC supply set to 13.8V. A 3A current limited supply is appropriate.

Battery type is given in Appendix H (page 119). More information on the battery care is available from the battery manufacturer.

Caution

These batteries are capable of supplying very high currents. Always turn off the battery circuit breaker before connecting or disconnecting the batteries in the cubicle. Never leave flying leads connected to the battery.

Fault Finding

If there is a problem it may be explained in "Abnormal Operating Conditions" - page 87. If not, the fault must be traced as follows.

Faults can only arise in one of the following:

- Circuit Breaker.
- Control Cable.
- Control Cubicle.

The best way to determine which part is faulty is to use a Test and Training Set to isolate the faulty part.

If a Test and Training Set is not available then use the circuit breaker check suggested below and employ substitution techniques to determine where the fault lies:

- Faulty circuit breaker units may be returned for factory repair.
- Faulty control cables should be replaced.
- Faulty control cubicles can be checked and repaired as indicated below.

Control Cable Check

The control cable is a one-to-one cable. This means a direct end-to-end test of all the connections in the control cable can be made with a DMM set to resistance.

All pins should show a one-to-one connection less than 0.2 Ohms with no shorts between pins.

Circuit Breaker Check

Connections to the circuit breaker are available on the underside of the circuit breaker and/or on the control cable connector where it plugs into P1 on the Control Cable Entry Module (CCEM) at the bottom of the control cubicle. Some (but not all) of these connections can be simply tested with a hand held DMM. This can show up some circuit breaker faults with a simple test.

The procedure is to test the resistance between the pins on the control cable.

Caution

Do not apply any tests to the circuit breaker other than those shown in the following table

Pins	Test	Use	Expected Result
1 to 5	Resistance	Trip solenoid.	1.5 Ohm +/- 0.5 Ohm
2 to 5	DC Voltage	Auxiliary supply transformer (if fitted). This has been rectified internally so a DC full wave rectified signal is present.	25 to 45 VDC measured with a true RMS meter **when the transformer primary is energised.**
3 to 5	Resistance	Close solenoid.	2 Ohm +/- 0.5 Ohm
20 to 24	Resistance	U phase CT	7 Ohm +/- 4 Ohm
21 to 11	Resistance	Auxiliary travel switch, closed indicates the circuit breaker is tripped.	< 5 Ohm when circuit breaker is tripped. >100k Ohm when circuit breaker is closed
22 to 11	Resistance	Auxiliary travel switch, closed indicates the circuit breaker is closed.	< 5 Ohm when circuit breaker is closed. >100kOhm when circuit breaker is tripped
23 to 11	Resistance	Indicates when the Manual Trip Ring is down in the locked position.	< 5 Ohm when Manual Trip Ring is in the normal position. > 100k Ohm when circuit breaker is tripped and the mechanism is locked open.

Circuit Breaker test

Control Cubicle Check

Fault finding within the control cubicle involves determining whether the fault lies in the electronic modules, the wiring or elsewhere. The electronic modules are user replaceable items. Other faults require the equipment panel or the control cubicle to be returned to the factory. Appendix I (page 121) gives the control cubicle wiring schematics to assist in re-assembly of the control cubicle wiring.

A suggested fault finding approach is as follows:

- If the microprocessor running LED on the operator panel is blinking then the CAPM micro and the Operator Panel Sub-system (OPS) microprocessor are running. If the operator display does not operate there is a problem with the display itself and the OPS should be replaced.
- If the display is operating, check the

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page for an indication of any power supply problems (Aux Supply Fail and/or Battery OFF) which can be traced and rectified.
- If the display indicates switchgear disconnected or if there are operating problems then the control cable and the CCEM should be inspected and replaced as required.
- If the microprocessor running LED is not blinking, the most likely problem is loss of power. Check the presence of battery voltage on the battery circuit breaker and the presence of aux supply on the aux supply circuit breaker and rectify as required.
- If power supply is present then attempt to go on-line with WSOS to determine whether the CAPM is functioning correctly. Replace the CAPM or Operator Panel Sub-system as required.
- If this does not rectify the problem then the equipment panel should be returned for factory repair.

Replacement of Electronic Modules

Electronic modules are user replaceable as detailed below. These modules can be damaged by static electricity, water, dirt and mishandling. Therefore replacement should only be carried out in a suitable place such as in a workshop and carried out by competent personnel.

Access to the Control Cable Entry Module (CCEM) is by removing its cover plate held in place by fixing screws. To remove the CCEM, hold the ¼ inch spacer underneath the board with a spanner and remove the four M4 screws.

The electronics compartment houses the Control and Protection Module (CAPM) and the trip and close capacitors. The compartment cover itself forms part of the Operator Panel Subsystem (OPS). For access to these parts refer CAPM Replacement Procedure in the service manual.

See Appendix I (page 121) for control cubicle wiring schematics.

Replacement of Cables

It is easier to fit and remove cables from the cable duct if they are lightly greased with silicone grease.

Fitting or Replacing Heater

For models fitted with a control cubicle heater, Figure 41 (page 129) shows the wiring. The thermostat is located inside the electronics compartment and is set to +15°C for correct operation.

Abnormal Operating Conditions

The operation of the capacitor charging inverter can be affected under abnormal conditions such as when the battery capacity is very low. The following features are used to protect the controller in this situation while still allowing the circuit breaker to keep operating.

Low Power Mode

When the batteries are nearly exhausted, the controller will change its capacitor charging mode from normal to low power. In low power mode the controller takes longer to charge the capacitors and the radio supply is shut down. A ‘Low Power Mode’ event is logged whenever this happens.

When a trip occurs in low power mode, the recloser will go to lockout if the capacitors cannot be recharged quickly enough. Operator close and trip operations can be performed, but at a longer time interval than normal. If an operator trip or close request is denied, a ‘Cap Chrg’ event will be logged.

To return to normal power mode, either replace the batteries or re-establish the auxiliary supply for a minimum of 15 minutes.

Excess Close Operations

During testing it is possible to carry out so many trip/close operations that the capacitor charging inverter shuts itself down before it overheats. It takes more than 20 operations within a minute to do this and is not going to happen while in service (it only happens during excessive testing).

When this happens the inverter shuts down for 5 minutes and a ‘Cap Excess Closes’ event is logged. During this time all trip/close requests will be denied.

Appendix A IEC255 Inv Time Prot Tables

The Inverse time protection curves in this appendices are as defined by IEC255 standard where “I” is the actual current expressed as a multiple of the trip current set by the user:

- Type A - Inverse, for which equation is:
  Time to Trip = $0.14 / (I^{0.02} - 1)$
- Type B - Very Inverse, for which equation is:
  Time to Trip = $13.5 / (I-1)$
- Type C - Extremely Inverse, for which equation is:
  Time to Trip = $80 / (I^2 - 1)$

Tables for the times to trip for each of these curves are given below.

Setting Current Multiple	Inverse Time (secs)	Very Inverse Time (secs)	Extremely Inverse Time (secs)
1.10	73.37	135.00	380.95
1.50	17.19	27.00	64.00
2.00	10.03	13.50	26.67
2.50	7.57	9.00	15.24
3.00	6.30	6.75	10.00
3.50	5.52	5.40	7.11
4.00	4.98	4.50	5.33
4.50	4.58	3.86	4.16
5.00	4.28	3.38	3.33
5.50	4.04	3.00	2.74
6.00	3.84	2.70	2.29
6.50	3.67	2.45	1.94
7.00	3.53	2.25	1.67
7.50	3.40	2.08	1.45
8.00	3.30	1.93	1.27
8.50	3.20	1.80	1.12
9.00	3.12	1.69	1.00
9.50	3.04	1.59	0.90
10.00	2.97	1.50	0.81
10.50	2.91	1.42	0.73
11.00	2.85	1.35	0.67
11.50	2.80	1.29	0.61
12.00	2.75	1.23	0.56
12.50	2.70	1.17	0.52
13.00	2.66	1.13	0.48
13.50	2.62	1.08	0.44
14.00	2.58	1.04	0.41
14.50	2.55	1.00	0.38
15.00	2.52	0.96	0.36
15.50	2.48	0.93	0.33
16.00	2.46	0.90	0.31
16.50	2.43	0.87	0.29
17.00	2.40	0.84	0.28
17.50	2.38	0.82	0.26
18.00	2.35	0.79	0.25
18.50	2.33	0.77	0.23
19.00	2.31	0.75	0.22
19.50	2.29	0.73	0.21

Setting Current Multiple	Inverse Time (secs)	Very Inverse Time (secs)	Extremely Inverse Time (secs)
20.00	2.27	0.71	0.20
20.50	2.24	0.69	0.19
21.00	2.23	0.68	0.18
21.50	2.21	0.66	0.17
22.00	2.20	0.64	0.17
22.50	2.18	0.63	0.16
23.00	2.16	0.61	0.15
23.50	2.15	0.60	0.15
24.00	2.13	0.59	0.14
24.50	2.12	0.57	0.13
25.00	2.11	0.56	0.13
25.50	2.09	0.55	0.12
26.00	2.08	0.54	0.12
26.50	2.07	0.53	0.11
27.00	2.05	0.52	0.11
27.50	2.04	0.51	0.11
28.00	2.03	0.50	0.10
28.50	2.02	0.49	0.10
29.00	2.01	0.48	0.10
29.50	2.00	0.47	0.09
30.00	1.99	0.47	0.09

Appendix B IEEE Inv Time Prot Tables

The Inverse time protection curves in this appendices are as defined by IEEE Std C37.112-1996 standard where "I" is the actual current expressed as a multiple of the trip current set by the user:

- Std Moderately inverse, for which the equation is:

  Time to Trip = $(0.0515 / (I^{0.02} - 1)) + 0.114$

- Std Very inverse, for which the equation is:

  Time to Trip = $(19.61 / (I^2 - 1)) + 0.491$

- Std Extremely Inverse, for which the equation is:

  Time to Trip = $(28.2 / (I^2 - 1)) + 0.1217$

Tables for the times to trip for each of these curves are given below.

Setting Current Multiple	Std Moderately Inverse Time (secs)	Std Very Inverse Time (secs)	Std Extremely Inverse Time (secs)
1.10	27.11	93.87	134.41
1.50	6.44	16.18	22.68
2.00	3.80	7.03	9.52
2.50	2.90	4.23	5.49
3.00	2.43	2.94	3.65
3.50	2.14	2.23	2.63
4.00	1.95	1.80	2.00
4.50	1.80	1.51	1.59
5.00	1.69	1.31	1.30
5.50	1.60	1.16	1.09
6.00	1.53	1.05	0.93
6.50	1.46	0.97	0.81
7.00	1.41	0.90	0.71
7.50	1.37	0.85	0.63
8.00	1.33	0.80	0.57
8.50	1.29	0.77	0.52
9.00	1.26	0.74	0.47
9.50	1.23	0.71	0.44
10.00	1.21	0.69	0.41
10.50	1.18	0.67	0.38
11.00	1.16	0.65	0.36
11.50	1.14	0.64	0.34
12.00	1.12	0.63	0.32
12.50	1.11	0.62	0.30
13.00	1.09	0.61	0.29
13.50	1.08	0.60	0.28
14.00	1.06	0.59	0.27
14.50	1.05	0.58	0.26
15.00	1.04	0.58	0.25
15.50	1.03	0.57	0.24
16.00	1.02	0.57	0.23
16.50	1.01	0.56	0.23
17.00	1.00	0.56	0.22
17.50	0.99	0.56	0.21
18.00	0.98	0.55	0.21
18.50	0.97	0.55	0.20
19.00	0.96	0.55	0.20
19.50	0.96	0.54	0.20

Setting Current Multiple	Std Moderately Inverse Time (secs)	Std Very Inverse Time (secs)	Std Extremely Inverse Time (secs)
20.00	0.95	0.54	0.19
20.50	0.94	0.54	0.19
21.00	0.93	0.54	0.19
21.50	0.93	0.53	0.18
22.00	0.92	0.53	0.18
22.50	0.92	0.53	0.18
23.00	0.91	0.53	0.18
23.50	0.90	0.53	0.17
24.00	0.90	0.53	0.17
24.50	0.89	0.52	0.17
25.00	0.89	0.52	0.17
25.50	0.88	0.52	0.17
26.00	0.88	0.52	0.16
26.50	0.87	0.52	0.16
27.00	0.87	0.52	0.16
27.50	0.87	0.52	0.16
28.00	0.86	0.52	0.16
28.50	0.86	0.52	0.16
29.00	0.85	0.51	0.16
29.50	0.85	0.51	0.15
30.00	0.85	0.51	0.15

Appendix C Non-Std Invd Time Prot Curves

The 42 Inverse time protection curves in this appendix are non-standard inverse curves. Tables for the times to trip for each of these curves are given below.

Setting Multiple Current	TCC 010	TCC 101	TCC 102	TCC 103	TCC 104	TCC 105	TCC 106	TCC 107	TCC 111
1.10	0.145	0.100	0.214	0.301	0.445	0.705	1.015	1.218	2.589
1.50	0.100	0.036	0.065	0.128	0.252	0.351	0.396	0.597	1.121
2.00	0.080	0.022	0.028	0.075	0.155	0.232	0.203	0.291	0.651
2.50	0.069	0.019	0.022	0.052	0.107	0.171	0.117	0.159	0.443
3.00	0.060	0.017	0.019	0.040	0.067	0.137	0.073	0.095	0.325
3.50	0.056	0.016	0.017	0.033	0.040	0.113	0.046	0.055	0.250
4.00	0.053	0.016	0.016	0.029	0.028	0.097	0.030	0.034	0.201
4.50	0.050	0.015	0.016	0.025	0.022	0.085	0.022	0.024	0.169
5.00	0.048	0.015	0.016	0.022	0.019	0.076	0.019	0.020	0.146
5.50	0.046	0.015	0.016	0.020	0.017	0.068	0.016	0.017	0.127
6.00	0.045	0.015	0.016	0.019	0.016	0.059	0.015	0.016	0.113
6.50	0.044	0.015	0.016	0.018	0.015	0.053	0.013	0.015	0.101
7.00	0.043	0.015	0.016	0.017	0.014	0.048	0.013	0.014	0.091
7.50	0.042	0.015	0.016	0.016	0.013	0.043	0.012	0.013	0.083
8.00	0.041	0.015	0.016	0.016	0.012	0.038	0.011	0.013	0.076
8.50	0.041	0.015	0.016	0.015	0.012	0.033	0.011	0.013	0.069
9.00	0.040	0.015	0.016	0.015	0.011	0.030	0.011	0.012	0.063
9.50	0.040	0.015	0.016	0.015	0.011	0.027	0.011	0.012	0.057
10.00	0.039	0.015	0.016	0.015	0.011	0.025	0.011	0.012	0.053
10.50	0.039	0.015	0.016	0.014	0.011	0.024	0.011	0.012	0.049
11.00	0.039	0.015	0.016	0.014	0.011	0.022	0.011	0.011	0.045
11.50	0.039	0.015	0.016	0.014	0.011	0.021	0.011	0.011	0.041
12.00	0.038	0.015	0.016	0.014	0.011	0.020	0.011	0.011	0.038
12.50	0.038	0.015	0.016	0.014	0.011	0.019	0.011	0.011	0.036
13.00	0.038	0.015	0.016	0.014	0.011	0.018	0.011	0.011	0.033
13.50	0.037	0.015	0.016	0.014	0.011	0.017	0.011	0.011	0.031
14.00	0.037	0.015	0.016	0.014	0.011	0.016	0.011	0.011	0.030
14.50	0.037	0.015	0.016	0.014	0.011	0.016	0.011	0.011	0.029
15.00	0.037	0.015	0.016	0.014	0.011	0.015	0.011	0.011	0.027
15.50	0.037	0.015	0.016	0.014	0.011	0.015	0.011	0.011	0.026
16.00	0.036	0.015	0.016	0.014	0.011	0.014	0.011	0.011	0.025
16.50	0.036	0.015	0.016	0.014	0.011	0.014	0.011	0.011	0.024
17.00	0.036	0.015	0.016	0.014	0.011	0.014	0.011	0.011	0.023
17.50	0.036	0.015	0.016	0.014	0.011	0.014	0.011	0.011	0.023
18.00	0.035	0.015	0.016	0.014	0.011	0.013	0.011	0.011	0.022
18.50	0.035	0.015	0.016	0.014	0.011	0.013	0.011	0.011	0.022
19.00	0.035	0.015	0.016	0.014	0.011	0.013	0.011	0.011	0.021
19.50	0.035	0.015	0.016	0.014	0.011	0.013	0.011	0.011	0.021
20.00	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.020
20.50	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.020
21.00	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.019

Setting Multiple Current	TCC 010	TCC 101	TCC 102	TCC 103	TCC 104	TCC 105	TCC 106	TCC 107	TCC 111
21.50	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.019
22.00	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.019
22.50	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.018
23.00	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.018
23.50	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.018
24.00	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.017
24.50	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.017
25.00	0.035	0.015	0.016	0.014	0.011	0.012	0.011	0.011	0.017
25.50	0.035	0.015	0.016	0.014	0.011	0.011	0.011	0.011	0.017
26.00	0.035	0.015	0.016	0.014	0.011	0.011	0.011	0.011	0.016
26.50	0.035	0.015	0.016	0.014	0.011	0.011	0.011	0.011	0.016
27.00	0.035	0.015	0.016	0.014	0.011	0.011	0.011	0.011	0.016
27.50	0.035	0.015	0.016	0.014	0.011	0.011	0.011	0.011	0.016
28.00	0.035	0.015	0.016	0.014	0.011	0.011	0.011	0.011	0.016
28.50	0.035	0.015	0.016	0.014	0.011	0.011	0.011	0.011	0.016
29.00	0.035	0.015	0.016	0.014	0.011	0.011	0.011	0.011	0.016
29.50	0.035	0.015	0.016	0.014	0.011	0.011	0.011	0.011	0.016
30.00	0.035	0.015	0.016	0.014	0.011	0.011	0.011	0.011	0.016

Setting Multiple Current	TCC 112	TCC 113	TCC 114	TCC 115	TCC 116	TCC 117	TCC 118	TCC 119	TCC 120
1.10	2.415	2.954	6.054	4.692	5.752	5.396	6.949	6.401	9.354
1.50	1.024	1.264	2.376	1.792	2.301	2.291	2.511	2.505	3.755
2.00	0.563	0.704	1.398	0.726	1.216	1.396	1.248	1.518	2.013
2.50	0.356	0.467	0.952	0.374	0.748	0.920	0.754	1.145	1.302
3.00	0.257	0.358	0.699	0.219	0.499	0.649	0.523	0.940	0.925
3.50	0.198	0.293	0.532	0.141	0.351	0.489	0.384	0.809	0.696
4.00	0.158	0.259	0.420	0.096	0.259	0.391	0.295	0.716	0.549
4.50	0.132	0.233	0.334	0.067	0.200	0.321	0.234	0.652	0.462
5.00	0.113	0.215	0.261	0.049	0.159	0.270	0.193	0.602	0.398
5.50	0.099	0.203	0.206	0.038	0.129	0.231	0.162	0.572	0.348
6.00	0.088	0.196	0.164	0.030	0.107	0.200	0.139	0.549	0.311
6.50	0.079	0.189	0.127	0.025	0.090	0.176	0.121	0.529	0.281
7.00	0.073	0.185	0.098	0.021	0.078	0.156	0.107	0.512	0.257
7.50	0.068	0.182	0.076	0.019	0.068	0.140	0.096	0.499	0.236
8.00	0.063	0.180	0.053	0.018	0.060	0.126	0.087	0.487	0.220
8.50	0.059	0.179	0.038	0.017	0.053	0.115	0.078	0.477	0.207
9.00	0.056	0.177	0.032	0.016	0.048	0.105	0.071	0.468	0.195
9.50	0.053	0.176	0.028	0.015	0.043	0.097	0.066	0.461	0.185
10.00	0.050	0.175	0.025	0.014	0.039	0.089	0.060	0.455	0.175
10.50	0.048	0.174	0.024	0.014	0.036	0.083	0.056	0.452	0.167
11.00	0.046	0.174	0.022	0.014	0.034	0.078	0.051	0.448	0.161
11.50	0.044	0.173	0.021	0.014	0.031	0.073	0.048	0.445	0.155
12.00	0.043	0.172	0.020	0.014	0.029	0.068	0.045	0.441	0.150
12.50	0.041	0.172	0.019	0.014	0.027	0.064	0.042	0.439	0.145
13.00	0.040	0.172	0.018	0.014	0.026	0.059	0.040	0.436	0.141
13.50	0.039	0.171	0.018	0.014	0.024	0.055	0.037	0.434	0.137
14.00	0.038	0.171	0.017	0.014	0.023	0.052	0.035	0.432	0.134
14.50	0.037	0.171	0.017	0.014	0.022	0.048	0.034	0.431	0.130
15.00	0.036	0.170	0.016	0.014	0.020	0.044	0.032	0.429	0.128
15.50	0.035	0.170	0.016	0.014	0.019	0.041	0.031	0.429	0.126
16.00	0.034	0.170	0.016	0.014	0.019	0.039	0.030	0.428	0.124
16.50	0.033	0.170	0.015	0.014	0.018	0.037	0.029	0.427	0.122
17.00	0.032	0.169	0.015	0.014	0.017	0.035	0.028	0.427	0.121
17.50	0.032	0.169	0.015	0.014	0.016	0.033	0.026	0.426	0.119
18.00	0.031	0.169	0.014	0.014	0.016	0.031	0.025	0.426	0.117
18.50	0.031	0.169	0.014	0.014	0.015	0.030	0.025	0.425	0.115
19.00	0.030	0.168	0.014	0.014	0.015	0.029	0.024	0.425	0.114
19.50	0.030	0.168	0.014	0.014	0.014	0.028	0.023	0.424	0.113
20.00	0.029	0.168	0.014	0.014	0.014	0.027	0.022	0.424	0.111
20.50	0.029	0.168	0.014	0.014	0.014	0.026	0.022	0.423	0.110
21.00	0.028	0.167	0.013	0.014	0.013	0.026	0.021	0.423	0.109
21.50	0.028	0.167	0.013	0.014	0.013	0.025	0.020	0.422	0.108
22.00	0.028	0.167	0.013	0.014	0.013	0.025	0.020	0.422	0.106
22.50	0.027	0.167	0.013	0.014	0.013	0.024	0.019	0.422	0.105
23.00	0.027	0.167	0.013	0.014	0.012	0.024	0.019	0.421	0.104
23.50	0.027	0.166	0.013	0.014	0.012	0.023	0.019	0.421	0.103
24.00	0.026	0.166	0.013	0.014	0.012	0.023	0.018	0.421	0.102

Setting Multiple Current	TCC 112	TCC 113	TCC 114	TCC 115	TCC 116	TCC 117	TCC 118	TCC 119	TCC 120
24.50	0.026	0.166	0.013	0.014	0.012	0.023	0.018	0.421	0.102
25.00	0.026	0.166	0.012	0.014	0.012	0.022	0.018	0.421	0.101
25.50	0.026	0.166	0.012	0.014	0.012	0.022	0.017	0.421	0.100
26.00	0.026	0.166	0.012	0.014	0.012	0.021	0.017	0.421	0.099
26.50	0.025	0.166	0.012	0.014	0.011	0.021	0.017	0.421	0.098
27.00	0.025	0.166	0.012	0.014	0.011	0.021	0.017	0.421	0.098
27.50	0.025	0.166	0.012	0.014	0.011	0.020	0.016	0.421	0.097
28.00	0.025	0.166	0.012	0.014	0.011	0.020	0.016	0.421	0.096
28.50	0.025	0.166	0.012	0.014	0.011	0.020	0.016	0.421	0.096
29.00	0.025	0.166	0.012	0.014	0.011	0.020	0.016	0.421	0.095
29.50	0.025	0.166	0.012	0.014	0.011	0.020	0.016	0.421	0.095
30.00	0.025	0.166	0.012	0.014	0.011	0.020	0.016	0.421	0.095

Setting Multiple Current	TCC 121	TCC 122	TCC 131	TCC 132	TCC 133	TCC 134	TCC 135	TCC 136	TCC 137
1.10	8.877	8.219	10.610	13.732	13.716	11.367	13.660	15.655	19.198
1.50	1.145	4.430	8.306	4.460	5.602	4.790	6.369	4.658	10.162
2.00	0.019	2.616	7.106	2.586	3.020	2.387	3.677	2.781	6.495
2.50	0.014	1.689	6.425	1.571	1.920	1.507	2.566	1.884	4.756
3.00	0.012	1.102	6.101	1.002	1.329	1.079	1.969	1.339	3.667
3.50	0.011	0.653	5.901	0.722	0.973	0.847	1.616	1.024	2.933
4.00	0.011	0.347	5.730	0.552	0.754	0.698	1.367	0.833	2.416
4.50	0.011	0.114	5.624	0.438	0.613	0.617	1.197	0.686	2.006
5.00	0.011	0.037	5.537	0.353	0.511	0.553	1.072	0.550	1.694
5.50	0.011	0.022	5.460	0.287	0.432	0.508	0.974	0.448	1.464
6.00	0.011	0.019	5.398	0.236	0.371	0.484	0.900	0.367	1.287
6.50	0.011	0.017	5.359	0.198	0.323	0.463	0.849	0.304	1.155
7.00	0.011	0.016	5.334	0.169	0.284	0.446	0.805	0.252	1.062
7.50	0.011	0.015	5.312	0.146	0.253	0.436	0.767	0.210	0.990
8.00	0.011	0.014	5.290	0.127	0.227	0.432	0.735	0.172	0.928
8.50	0.011	0.013	5.269	0.110	0.205	0.427	0.711	0.142	0.873
9.00	0.011	0.013	5.251	0.097	0.186	0.423	0.689	0.116	0.824
9.50	0.011	0.012	5.233	0.086	0.170	0.419	0.670	0.087	0.786
10.00	0.011	0.012	5.216	0.077	0.157	0.416	0.651	0.064	0.753
10.50	0.011	0.012	5.210	0.070	0.146	0.415	0.635	0.049	0.730
11.00	0.011	0.011	5.208	0.064	0.137	0.415	0.619	0.038	0.714
11.50	0.011	0.011	5.208	0.058	0.128	0.415	0.607	0.032	0.699
12.00	0.011	0.011	5.208	0.053	0.121	0.415	0.599	0.029	0.685
12.50	0.011	0.011	5.208	0.049	0.115	0.415	0.591	0.026	0.671
13.00	0.011	0.011	5.208	0.046	0.109	0.415	0.584	0.024	0.662
13.50	0.011	0.011	5.208	0.043	0.103	0.415	0.577	0.022	0.653
14.00	0.011	0.011	5.208	0.040	0.098	0.415	0.571	0.021	0.645
14.50	0.011	0.011	5.207	0.037	0.093	0.415	0.566	0.020	0.640
15.00	0.011	0.011	5.207	0.035	0.089	0.415	0.561	0.019	0.635
15.50	0.011	0.011	5.207	0.033	0.085	0.415	0.556	0.018	0.629
16.00	0.011	0.011	5.207	0.032	0.082	0.415	0.553	0.017	0.626
16.50	0.011	0.011	5.207	0.030	0.078	0.415	0.551	0.017	0.622
17.00	0.011	0.011	5.207	0.029	0.076	0.415	0.549	0.017	0.619
17.50	0.011	0.011	5.207	0.027	0.074	0.415	0.548	0.016	0.616
18.00	0.011	0.011	5.207	0.026	0.072	0.415	0.546	0.016	0.614
18.50	0.011	0.011	5.207	0.025	0.070	0.415	0.544	0.015	0.612
19.00	0.011	0.011	5.207	0.023	0.068	0.415	0.543	0.015	0.610
19.50	0.011	0.011	5.207	0.023	0.066	0.415	0.541	0.015	0.608
20.00	0.011	0.011	5.207	0.022	0.065	0.415	0.539	0.015	0.606
20.50	0.011	0.011	5.207	0.022	0.063	0.415	0.538	0.015	0.605
21.00	0.011	0.011	5.207	0.021	0.061	0.415	0.537	0.015	0.603
21.50	0.011	0.011	5.207	0.021	0.060	0.415	0.535	0.015	0.602
22.00	0.011	0.011	5.207	0.020	0.058	0.415	0.534	0.015	0.602
22.50	0.011	0.011	5.207	0.020	0.057	0.415	0.533	0.015	0.602
23.00	0.011	0.011	5.207	0.019	0.056	0.415	0.531	0.015	0.602
23.50	0.011	0.011	5.207	0.019	0.054	0.415	0.530	0.015	0.602
24.00	0.011	0.011	5.207	0.018	0.054	0.415	0.529	0.015	0.602

Setting Multiple Current	TCC 121	TCC 122	TCC 131	TCC 132	TCC 133	TCC 134	TCC 135	TCC 136	TCC 137
24.50	0.011	0.011	5.207	0.018	0.053	0.415	0.528	0.015	0.602
25.00	0.011	0.011	5.207	0.018	0.052	0.415	0.528	0.015	0.602
25.50	0.011	0.011	5.207	0.018	0.051	0.415	0.528	0.015	0.602
26.00	0.011	0.011	5.207	0.017	0.051	0.415	0.528	0.015	0.602
26.50	0.011	0.011	5.207	0.017	0.050	0.415	0.528	0.015	0.602
27.00	0.011	0.011	5.207	0.017	0.049	0.415	0.528	0.015	0.602
27.50	0.011	0.011	5.207	0.017	0.049	0.415	0.528	0.015	0.602
28.00	0.011	0.011	5.207	0.017	0.048	0.415	0.528	0.015	0.602
28.50	0.011	0.011	5.207	0.017	0.047	0.415	0.528	0.015	0.602
29.00	0.011	0.011	5.207	0.017	0.047	0.415	0.528	0.015	0.602
29.50	0.011	0.011	5.207	0.017	0.046	0.415	0.528	0.015	0.602
30.00	0.011	0.011	5.207	0.017	0.046	0.415	0.528	0.015	0.602

Setting Multiple Current	TCC 138	TCC 139	TCC 140	TCC 141	TCC 142	TCC 151	TCC 152	TCC 161	TCC 162
1.10	20.647	15.250	25.082	19.763	36.299	38.923	72.701	19.879	27.549
1.50	9.741	5.097	10.141	15.227	16.543	11.551	45.263	3.860	8.109
2.00	5.905	2.889	5.802	13.159	9.181	5.848	39.251	1.688	3.793
2.50	4.115	1.943	4.122	12.159	5.868	3.688	36.458	1.002	2.331
3.00	3.117	1.446	3.254	11.511	3.711	2.545	35.035	0.686	1.570
3.50	2.493	1.139	2.708	11.095	2.372	1.888	33.905	0.494	1.117
4.00	1.949	0.929	2.323	10.860	1.507	1.489	32.987	0.371	0.819
4.50	1.583	0.776	2.057	10.655	1.101	1.244	32.235	0.299	0.615
5.00	1.299	0.661	1.857	10.486	0.849	1.068	31.587	0.248	0.486
5.50	1.085	0.564	1.695	10.419	0.701	0.973	31.014	0.209	0.394
6.00	0.925	0.486	1.590	10.383	0.595	0.894	30.568	0.180	0.325
6.50	0.802	0.423	1.506	10.351	0.511	0.828	30.234	0.158	0.274
7.00	0.703	0.373	1.434	10.321	0.445	0.773	29.955	0.140	0.235
7.50	0.625	0.332	1.372	10.293	0.391	0.728	29.690	0.126	0.206
8.00	0.561	0.297	1.315	10.267	0.346	0.687	29.441	0.114	0.182
8.50	0.508	0.268	1.268	10.243	0.310	0.652	29.226	0.105	0.162
9.00	0.462	0.242	1.226	10.220	0.279	0.622	29.021	0.097	0.145
9.50	0.422	0.221	1.197	10.199	0.253	0.600	28.880	0.091	0.130
10.00	0.388	0.202	1.168	10.180	0.231	0.579	28.768	0.085	0.117
10.50	0.360	0.185	1.144	10.175	0.211	0.565	28.661	0.079	0.106
11.00	0.337	0.171	1.119	10.175	0.194	0.551	28.564	0.075	0.097
11.50	0.315	0.158	1.098	10.175	0.179	0.539	28.463	0.071	0.089
12.00	0.297	0.146	1.079	10.175	0.166	0.529	28.376	0.067	0.082
12.50	0.280	0.135	1.060	10.175	0.154	0.518	28.290	0.064	0.076
13.00	0.265	0.126	1.053	10.175	0.144	0.514	28.201	0.061	0.071
13.50	0.253	0.117	1.046	10.175	0.132	0.509	28.135	0.059	0.067
14.00	0.242	0.110	1.038	10.175	0.121	0.504	28.068	0.057	0.063
14.50	0.232	0.103	1.032	10.175	0.112	0.499	27.998	0.054	0.060
15.00	0.224	0.096	1.026	10.175	0.103	0.495	27.971	0.052	0.056
15.50	0.216	0.090	1.020	10.175	0.095	0.491	27.955	0.051	0.053
16.00	0.208	0.085	1.014	10.175	0.088	0.487	27.939	0.049	0.050
16.50	0.201	0.080	1.009	10.175	0.081	0.485	27.924	0.047	0.048
17.00	0.195	0.074	1.003	10.175	0.076	0.482	27.910	0.046	0.045
17.50	0.190	0.070	0.998	10.175	0.070	0.479	27.897	0.045	0.042
18.00	0.184	0.065	0.996	10.175	0.066	0.477	27.883	0.043	0.040
18.50	0.197	0.062	0.995	10.175	0.062	0.475	27.869	0.043	0.038
19.00	0.175	0.058	0.994	10.175	0.059	0.472	27.857	0.042	0.036
19.50	0.171	0.055	0.993	10.175	0.056	0.470	27.845	0.041	0.034
20.00	0.168	0.051	0.992	10.175	0.053	0.469	27.833	0.040	0.033
20.50	0.154	0.049	0.991	10.175	0.050	0.468	27.821	0.040	0.031
21.00	0.161	0.046	0.990	10.175	0.048	0.468	27.809	0.039	0.030
21.50	0.158	0.043	0.990	10.175	0.046	0.468	27.799	0.038	0.029
22.00	0.155	0.041	0.989	10.175	0.045	0.467	27.788	0.038	0.028
22.50	0.152	0.039	0.988	10.175	0.043	0.467	27.777	0.037	0.027
23.00	0.149	0.037	0.988	10.175	0.042	0.467	27.766	0.036	0.026
23.50	0.146	0.035	0.987	10.175	0.040	0.467	27.757	0.036	0.026
24.00	0.144	0.033	0.986	10.175	0.039	0.466	27.751	0.035	0.025

Setting Multiple Current	TCC 138	TCC 139	TCC 140	TCC 141	TCC 142	TCC 151	TCC 152	TCC 161	TCC 162
24.50	0.142	0.031	0.986	10.175	0.038	0.466	27.746	0.035	0.024
25.00	0.140	0.030	0.985	10.175	0.037	0.466	27.740	0.034	0.024
25.50	0.137	0.028	0.985	10.175	0.037	0.466	27.735	0.033	0.023
26.00	0.135	0.027	0.985	10.175	0.036	0.465	27.729	0.033	0.023
26.50	0.134	0.026	0.985	10.175	0.035	0.465	27.725	0.033	0.022
27.00	0.133	0.025	0.984	10.175	0.034	0.465	27.722	0.032	0.022
27.50	0.132	0.024	0.984	10.175	0.034	0.464	27.720	0.032	0.021
28.00	0.131	0.023	0.984	10.175	0.033	0.464	27.717	0.031	0.021
28.50	0.131	0.022	0.984	10.175	0.033	0.464	27.714	0.031	0.020
29.00	0.130	0.022	0.984	10.175	0.032	0.464	27.711	0.031	0.020
29.50	0.129	0.021	0.984	10.175	0.032	0.464	27.709	0.031	0.020
30.00	0.129	0.021	0.984	10.175	0.032	0.464	27.709	0.031	0.020

Setting Multiple Current	TCC 163	TCC 164	TCC 165	TCC 200	TCC 201	TCC 202
1.10	33.228	53.091	84.512	74.687	122.30	125.06
1.50	3.747	18.503	31.451	17.354	27.161	64.047
2.00	1.356	7.916	12.916	10.039	13.506	26.654
2.50	0.720	4.318	5.994	7.583	9.012	15.234
3.00	0.482	2.596	3.199	6.323	6.770	10.004
3.50	0.356	1.715	2.051	5.530	5.410	7.109
4.00	0.276	1.162	1.463	4.985	4.505	5.335
4.50	0.222	0.787	1.102	4.588	3.860	4.154
5.00	0.187	0.556	0.866	4.286	3.380	3.333
5.50	0.161	0.420	0.714	4.044	3.006	2.735
6.00	0.140	0.333	0.602	3.844	2.705	2.286
6.50	0.123	0.272	0.515	3.671	2.456	1.940
7.00	0.109	0.228	0.450	3.533	2.254	1.667
7.50	0.097	0.197	0.397	3.409	2.081	1.448
8.00	0.087	0.174	0.352	3.300	1.931	1.270
8.50	0.078	0.155	0.317	3.206	1.804	1.123
9.00	0.070	0.140	0.287	3.119	1.690	1.000
9.50	0.064	0.127	0.262	3.044	1.591	0.897
10.00	0.058	0.116	0.240	2.974	1.502	0.808
10.50	0.054	0.106	0.221	2.910	1.422	0.732
11.00	0.049	0.098	0.205	2.854	1.353	0.667
11.50	0.046	0.090	0.190	2.797	1.286	0.610
12.00	0.042	0.085	0.178	2.751	1.229	0.560
12.50	0.040	0.080	0.166	2.705	1.176	0.516
13.00	0.037	0.075	0.156	2.660	1.125	0.476
13.50	0.035	0.071	0.145	2.623	1.082	0.441
14.00	0.033	0.068	0.135	2.586	1.040	0.410
14.50	0.031	0.065	0.126	2.549	1.001	0.382
15.00	0.030	0.062	0.117	2.518	0.966	0.357
15.50	0.028	0.059	0.110	2.488	0.933	0.335
16.00	0.027	0.057	0.103	2.458	0.901	0.314
16.50	0.026	0.055	0.096	2.429	0.871	0.295
17.00	0.025	0.053	0.091	2.404	0.845	0.278
17.50	0.023	0.051	0.086	2.380	0.820	0.262
18.00	0.022	0.049	0.081	2.355	0.795	0.248
18.50	0.022	0.048	0.077	2.330	0.772	0.234
19.00	0.021	0.047	0.072	2.310	0.751	0.222
19.50	0.020	0.045	0.069	2.290	0.731	0.211
20.00	0.019	0.044	0.065	2.270	0.712	0.200
20.50	0.019	0.043	0.062	2.249	0.693	0.191
21.00	0.018	0.042	0.059	2.231	0.676	0.182
21.50	0.018	0.040	0.057	2.214	0.660	0.173
22.00	0.018	0.039	0.055	2.198	0.644	0.166
22.50	0.017	0.038	0.053	2.181	0.629	0.159
23.00	0.017	0.037	0.051	2.164	0.614	0.152

Setting Multiple Current	TCC 163	TCC 164	TCC 165	TCC 200	TCC 201	TCC 202
23.50	0.017	0.036	0.049	2.149	0.601	0.145
24.00	0.017	0.036	0.047	2.135	0.588	0.139
24.50	0.016	0.035	0.046	2.122	0.576	0.134
25.00	0.016	0.034	0.044	2.108	0.564	0.129
25.50	0.016	0.033	0.043	2.094	0.552	0.124
26.00	0.016	0.033	0.042	2.080	0.541	0.119
26.50	0.015	0.032	0.041	2.068	0.530	0.114
27.00	0.015	0.031	0.040	2.056	0.520	0.110
27.50	0.015	0.031	0.040	2.045	0.510	0.106
28.00	0.014	0.030	0.039	2.034	0.501	0.103
28.50	0.014	0.030	0.039	2.022	0.492	0.099
29.00	0.014	0.029	0.038	2.011	0.482	0.096
29.50	0.014	0.029	0.038	2.001	0.475	0.093
30.00	0.014	0.029	0.038	2.001	0.475	0.093

Appendix D System Status Pages

This appendix shows all the System Status group of pages on the Operator Control Panel display.

- See Section 6 (page 21) to Section 9 (page 35) for more information on the data.

The top line of the display is the page title. To the right of the title is a letter, these have significance as follows:

S System Status Display Group

P Protection Display Group

M Measurement Display Group

The next three lines are the data on display. Most displays have six data fields. These lines are shown in the following tables.

Typical or default values are shown in the tables. For example **Reclose Time 0.5 sec** is shown for the reclose time setting. When the user views display it would show the actual setting, e.g. **Reclose Time 3.0 sec**.[1]

Where the display field can have alternative text, all the possible text displays are shown, one below the other. For example, in the table overleaf for the page

SYSTEM STATUS - OPERATOR SETTINGS

the first data field can be either:

- LOCAL CONTROL ON, or
- Remote Control ON

The letters in the small columns to the right of each display text column indicate the type of data displayed. These have significance as follows[2]

O Operator Controlled

D Display Only (i.e. cannot be changed)

P Password Protected (i.e. can only be changed if the password is known)

R Operator Controlled Reset (i.e. resets a field or group of fields)

Fault Flags

Trip Flags

TRIP FLAGS									S
O/C	☐■	00-99	A	I	R	FRQ ☐■ 00-99[a]	R	Ext ☐■ 00-99	R
								OPS 0001	

a. This is a CAPM 5 feature only.

Pickup Flags

PICKUP FLAGS									S
O/C	☐■	00-99	A	I	R	FRQ ☐■ 00-99[a]	R		
								OPS 0001	R

a. This is a CAPM 5 feature only.

1. Different default values from those shown may be factory loaded.
2. These letters do not appear on the actual display

Operator Settings 1

OPERATOR SETTINGS 1			S
LOCAL CONTROL ON Remote Control On Hit and Run ON Hit and Run OFF	O		
Auto Reclose OFF Auto Reclose ON Protection OFF[a]	O		
Lockout Single Shot Active (blank in normal operation) Reclose 1 Reclose 2 Reclose 3	D	Protection Auto[b c] Auto ‘A’, ‘B’, **… ,** ‘J’ Active[c, d] . . .	O O

a. If {SYSTEM STATUS-OPTIONS 1:Prot OFF Not Allowed} is configured then this option is not shown.
b. Navigation of this field starts with “Protection Auto” (when configured) to minimise key presses.
c. If {SYSTEN STATUS-OPTIONS 1:APGS Not Allowed} is configured then this option is not shown.
d. One of ten different Protection Groups (A-J) can be active. Foe example, if Protection Group D is active the display will read {Prot ‘D’ Active}.

Operator settings 2

OPERATOR SETTINGS 2			S
Cold Load OFF Cold Load IDLE Cold Load NO CHANGE Cold Load MAX CLP120min x 2.3 mult[a]	O		

a. This field is “display only” when configured as Cold Load OFF.

Switchgear Status

SWITCHGEAR STATUS			S
Work Tag OFF Work Tag Applied	O		
Aux Supply Normal Aux Supply Fail	D	BtyNormal X.XV Bty Off X.XV Bty Low Volts X.XV Bty Overvolt X.XV	D
ACR Connected ACR Unplugged	D	ACR Data Valid ACR Data Invalid	D

Live/Dead Indication

LIVE/DEAD INDICATION			S
I Unavailable I Live I Dead	D	X Unavailable X Dead X Live	D

Phase Voltage and Power Flow

PHASE VOLTAGE and POWER FLOW			S
“LIVE” if > 2000V	P	Supply Timeout 4.0s	P
Power Flow Signed Power Flow Unsigned	P	Source I, Load X Source X, Load I	P
		System Freq 50Hz System Freq 60Hz	P

Radio and Time Set

RADIO and TIME SET			S
Radio Supply OFF Radio Supply ON Radio ShutDown See "Radio/Modem Power" - page 67 for further details.	O	Radio Supply 12V	P
Radio Hold 60 min	P		
Date/Time 10/01/2001 10:55:12			O

Switchgear Type and Ratings

SWITCHGEAR TYPE and RATINGS			S
Recloser	D	S/N NP-101005	D
6000A Interruption	D	Rated 21000 Volts	D
400A Continuous	D	1292 Operations	D

Switchgear Wear/General Details

SWITCHGEAR WEAR/GENERAL DETAILS			S
Contact 75.6%	D	CAPM S/N NP-101234	D
		Software 528-03.00	D
		Configuration 21186	D

Capability

CAPABILITY[a]		S
W28 Recloser (Inter’)	Manual W01-194[b]	D
WSOS P9 Local	Manual N00-218 R05+	D
WSOS P8 Remote [c]	Manual N00-402 R05+	D

a. Additional lines can be viewed by pressing the SELECT key.
b. Refer to back cover of this publication.
c. Some software configurations will support another protocol on Port P8 as an alternative to WSOS.

Options 1

OPTIONS 1			S
Prot OFF Allowed Prot OFF Not Allowed	P		

Options 2

OPTIONS 2			S
		Loop Auto Not Avail Loop Auto Available	P
		Dead Lockout OFF Dead Lockout ON	P
Language English (Intl) Idioma Espanol Lingua Portugesa	P	GenCtrl Not Avail GenCtrl Available	

Options 3

OPTIONS 3			S
APGS Allowed APGS Not Allowed	P	APGS Change 60s	P

Quick Key selection

QUICK KEY SELECTION			S
Text Description of QK1	P	Text Description of QK3	P
Text Description of QK2	P	Text Description of QK4	P

WSOS Port P8 Comms

WSOS Port P8 Communications			S
Change-Of-State OFF Change-Of-State ON	P	Baud 9600 Selection in the range 600, 1200, 2400, 9600, 19200	P
P8 Not Available Offline Dialling Online	D		
Dialup Number		Default 0, max 18 digits	P

WSOS Port P9 Comms

WSOS Port P9 Communications			S
Baud 9600 Selection in the range 1200, 2400, 9600, 19200	P	Mode Local Mode Remote[a]	P

a. The default may not be **LOCAL** if the CAPM database is configured differently.

IOEX Status

IOEX Status			S
Inputs 1 – – – – * – – – – – – – 12	D	Local Remote	P
Outputs 1 – * – – – – – * 8	D	IOEX OK Invalid Map Initialising Unplugged Wrong Type	D
Standard IOEX Mapping.[a]			D

a. Any Custom Mapping will be detailed in this text field.

Generator Control

Generator Control				S
GenCtrl OFF GenCtrl ON	O			
HV Dead Time 5s	O	HV Live Time 5s		O
Control State: GenCtrl OFF Control State: Switch Closed Control State: Line Dead Check Control State: Wait Switch Open Control State: Wait Generator Live Control State: Generator Running Control State: Line Live Check Control State: Wait Generator Off Control State: Wait Switch Closed				D

Hit and Run

Hit and Run				S
Hit/Run Close OFF Hit/Run Close 120s	P	Hit/Run Trip OFF Hit/Run Trip 120s		P

Appendix E Protection Pages

This appendix shows all the Protection Group of pages on the Operator Control Panel display. See Section 9 (page 35) for more information on protection operation.

Protection Setting 1 (A-J)

PROTECTION SETTING 1 (A – J)			P
Group A – J Displayed	P	Copy OFF[a] Copy from # to A Copy from # to B Copy from # to C Copy from # to D Copy from # to E Copy from # to F Copy from # to G Copy from # to H Copy from # to I Copy from # to J Copy from # to ALL Copy # Incomplete Copy ALL Incomplete	P
Trip 200 Amp	P		
Threshold Multi 1.1	P		

a. Use Select key to scroll through the options. When either the Menu or Enter key is pressed, the copy is performed and the field defaults to the “Copy OFF” display.

Protection Setting 2 (A-J)

PROTECTION SETTING 2 (A – J)			P
		Seq Reset Time 30s	P
		Flt Reset Time 50ms	P
		SS Reset Time 1s	P

Protection Setting 3 (A-J)

PROTECTION SETTING 3 (A – J)			P
		Live Load Block OFF Live Load Block ON	P
		Maximum Time OFF Maximum Time 5.0s	P
Trips to Lockout 4	P	Sequence Control OFF Sequence Control ON	P

Protection Setting 4 (A-J)

PROTECTION SETTING 4 (A – J)			P
High Lockout OFF High Lockout ON	P		
High Lockout 5000A	P		
Activation Trip 1 Activation Trip 2 Activation Trip 3 Activation Trip 4	P		

Protection Setting 5 (A-J)

PROTECTION SETTING 5 (A – J)	P		P
Inrush OFF Inrush ON	P	Cold Load OFF Cold Load ON	P
Inrush Time 0.10s	P	Cold Load Time 120m	P
Inrush Mult x 4.0	P	Cold Load Mult x 2.0	P

Under/Over Frequency Protection 1

UNDER / OVER FREQUENCY PROTECTION 1[a] (A - J)				P
U / F Trip U / F Trip	OFF ON	P	O / F Trip O / F Trip	OFF ON	P
U / F Trip at	49.0Hz	P	After	4 cycles	P
O / F Trip at	52.0Hz	P	After	50 cycles	P

a. CAPM 5 feature only.

Under/Over Frequency 2

UNDER / OVER FREQUENCY PROTECTION 2[a] (A - J)				P
U / F Normal	49.5Hz	P	O / F Normal	50.5Hz	P
Low V Inhibit	5000V	P			
Normal Freq Close OFF Normal Freq Close ON		P	After 60 secs This display only appears if the Normal Frequency Close is ON.		D

a. CAPM 5 feature only.

Protection Trip

PROTECTION TRIP NUMBER 1, 2, 3, 4 (A – J)	P		P
IEC255 Curves (1, 2 or 3) Definite Time Instantaneous Only IEEE Curves (1, 2 or 3) User Defined Curve (1, 2, 3, 4 or 5) User Defined Curves Not Set Additional Curve Selection[a]	P	Time Multiplier 1.00 1.00s Time Multiplier 1.00 Time Multiplier 1.00	P
No Instantaneous Instant Mult x 1.0	P	Reclose Time 1.0s Reclose time not available on trip 4	P
Minimum 0.00s	P	Additional 0.00s	P

a. See Appendices for the available curves.

Single Shot Protection Trip

SINGLE SHOT PROTECTION TRIP (A – J)	P		P
IEC255 Curves (1, 2 or 3) Definite Time Instantaneous Only IEEE Curves (1, 2 or 3) User Defined Curve (1, 2, 3, 4 or 5) User Defined Curves Not Set Additional Curve Selection[a]	P	Time Multiplier 1.00 1.00s Time Multiplier 1.00 Time Multiplier 1.00	P
No Instantaneous Instant Mult x 1.0	P		
Minimum 0.00s	P	Additional 0.00s	P

a. See Appendices for the available curves.

Work Tag Protection Trip

WORK TAG PROTECTION TRIP (A – J)			P
IEC255 Curves (1, 2 or 3) Definite Time Instantaneous Only IEEE Curves (1, 2 or 3) User Defined Curve (1, 2, 3, 4 or 5) User Defined Curves Not Set Additional Curve Selection[a]	P	Time Multiplier 1.00 1.00s Time Multiplier 1.00 Time Multiplier 1.00	P
No Instantaneous Instant Mult x 1.0	P		
Minimum 0.00s	P	Additional 0.00s	P

a. See Appendices for the available curves.

Appendix F Measurement Pages

This appendix shows the Measurement Group of pages on the Operator Control Panel display.

See Section 11 (page 55) for more information on measurement functionality.

Instantaneous Demand

INSTANTANEOUS DEMAND		M
Current	123 Amp	D
		D
		D

System Measurements

SYSTEM MEASUREMENTS				M
Frequency 50.0 HZ Freq Unavailable	D	Power (P)	2479 kW	D
		Power (Q)	200 kVAR	D
		Power Factor	0.93	D

Source Side Voltages

When Source side is I and Load side is X.

SOURCE SIDE VOLTAGES		M
I (Source) phase to earth	19100 Volt	D
X (Load) phase to earth	Unavailable	D

Load Side Voltages

When Source side is X and Load side is I.

LOAD SIDE VOLTAGES		M
X (Source) phase to earth	Unavailable	D
I (Load) phase to earth	19100 Volt	D

Supply Outages

SUPPLY OUTAGES					M
Measure Outages OFF Measure Outages ON		P	Outage Duration	60 s	P
Source outages	2	R	Duration Unavailable[a]	4h14m56s	R
Load outages	3	R	Duration Unavailable[b]	6h23m24s	R

a. Standard W Series with Source side network segment connected to X Side terminal and no external cvt.
b. Standard W Series with Load side network segment connected to X Side terminal and no external cvt.

Monthly Maximum Demand

MONTHLY MAXIMUM DEMAND				M
Jan/2001		total	28865 kWh	D
peak period	07 / 01 / 2001	17:15:00		D
peak demand	2000 kW	0.93 PF		D

Weekly Maximum Demand

WEEKLY MAXIMUM DEMAND				M
Week ending	10 / 01 / 2001	total	7565 kWh	D
peak period	07 / 01 / 2001	17:15:00		D
peak demand	2000 kW	0.93 PF		D

Average Demand

AVERAGE DEMAND				M
10 / 01 / 2001	13:45:00	A phase	123 Amp	D
2749 kW				D
0.93 PF				D

Appendix G List of Events

The following table lists the events that can appear in the Event Log, in alphabetical order.

Event Text	Explanation
ACR Open ACR Closed	On power up and switch re-connection the circuit breaker is either open or closed.
Automatic Reclose	The circuit breaker was automatically re-closed following a protection trip. See "Auto-Reclose" - page 46.
Auto Reclose OFF	Auto Reclose has been turned OFF by a local or remote operator. See “Auto-Reclose” on page 46.
Auto Reclose ON	Auto Reclose has been turned ON by a local or remote operator. See “Auto-Reclose” on page 46.
Aux Supply Fail	The auxiliary power supply has failed.
Aux Supply Normal	The auxiliary power supply has become normal. See "Auxiliary Power Source" - page 18. .
Battery Low Volts	The battery voltage is below the low battery threshold.
Battery Normal	The battery is in the normal range
Battery Off	The battery is not connected.
Battery Overvolt	The battery voltage is too high. This will only occur if there is a battery charger hardware failure.[a]
Cap Chrg *status*	Logged if a trip/close request is denied due to a capacitor inverter problem. Where *status* is the current status of the inverter, for example “Cap Chrg Resting”. See "Abnormal Operating Conditions" - page 87. .
CAP *failure mode*	Trip and/or close capacitors did not charge correctly. Where *failure mode*, is the cause of the failure. For example, “CAP Excess Closes”.
Capmload Reset	The electronic controller has been reset after loading new software.
Close Blocking ON	The circuit breaker is prevented from closing. See "Inputs - Standard Mapping" - page 70. .
Close Blocking OFF	Close blocking has been disabled. The circuit breaker will now close when requested. See "Inputs - Standard Mapping" - page 70. .
Close Coil Connect Close Coil Isolate	The Close solenoid isolate switch on the operator control panel was changed to the Enable/Isolate position. See "Operator Control Panel" - page 25.
I Contact <20%	Less than 20% contact life remaining in vacuum interrupter
Current >= 5000A	The circuit breaker tripped with a current above the High Current Lockout setting whilst the High Current Lockout was effective, the event shows the value of setting at the time the event occurred. See "High Current Lockout" - page 47. .
Denied Wrong Mode	When the switch is in a different mode (Local, Remote or Work Tag Applied) to the device which attempted the close. See Section 8 (page 31).
Det Group A - J Active	Detection group A - J is active. Written to the event log whenever an active group changes. See "Protection Settings and Protection Groups" - page 37.
Disconnected	The circuit breaker has been disconnected.
Generator Start Req	Request generator start
Generator Stop Req	Request generator stop
Generator Running	Generator running.
Generator Stopped	Generator has stopped running.
GenCtrl Trip Req	Generator control opening recloser in preparation for starting the generator.
GenCtrl Close Req	Generator control closing recloser to restore line supply.
GenCtrl ON	Switching Generator Control On.
GenCtrl OFF	Switching Generator Control Off.
Hit and Run ON	Start of Hit and Run period.
Hit and Run OFF	End of Hit and Run request countdown, or timeout.
IOEX InputXX On	IOEX Input XX has changed from the Off state to the On state (where XX is from 01 to 12).
IOEX InputXX Off	IOEX Input XX has changed from the On state to the Off state (where XX is from 01 to 12).
IOEX OutputXX On	IOEX Output XX has changed from the Off state to the On state (where XX is from 01 to 08).
IOEX OutputXX Off	IOEX Output XX has changed from the On state to the Off state (where XX is from 01 to 08).
Live Load Blocking	A close request was disregarded due to a load side terminal being alive. See "Protection" - page 35. .
Load out 59 m 59 s Load out 99 h 59 m Load out 9999 h	The circuit breaker load terminal experienced a supply outage up to 59 minutes 59 seconds. The circuit breaker load terminal experienced a supply outage up to 99 hours 59 minutes. The circuit breaker load terminal experienced a supply outage >10,000 hours. See Section 12 (page 59).
Load Supply OFF/ON	All three load side voltages are OFF/ON.

Event Text	Explanation
Loader: Close Iso Loader: Trip Iso	The close/trip isolate needs to be activated to allow a new program to be transferred to the controller.
LOCAL CONTROL ON	A local operator has put the controller in local mode.
Lockout	The protection went to lockout and will not perform any more automatic recloses, See "Lockout Conditions" - page 47. and "Protection Generated Events" - page 53 .
Low Power Mode	If the power supply voltage reduces below a threshold for a certain time, the radio supply is turned off immediately. The recloser will still operate but will go to lockout if the capacitors cannot be charged quickly enough. See "Abnormal Operating Conditions" - page 87. .
Max NN Amp	Following pickup of overcurrent protection, the maximum fault current recorded was NN amps. This event is logged only after the current has fallen back below the phase setting current.
Mech Locked Mech Unlocked	Switchgear has been manually locked/unlocked using the manual trip lever.
Mechanical Trip Mechanical Close	Switchgear was tripped or closed using the manual mechanical trip lever.
Mechanism Fail	The switchgear has failed to close or trip manually.
Normal Freq Close (CAPM 5 only)	The Source frequency has returned to normal and a Close request has been issued. See “Under/Over Frequency Protection (CAPM 5 only)” on page 43.
New SCEM Data	New SCEM data was written to the SCEM with the operation count and wear updated from the new SCEM data.
Normal Power Mode	If the power supply voltage returns to normal then the power mode will return to normal after 15 min. See "Abnormal Operating Conditions" - page 87. .
NP-xxxxxx Connected	Circuit breaker with serial number xxxxxx has been connected.
OCPM Door Opened	PTCC door has been opened.
OCPM Door Closed	PTCC door has been closed. CPTCC door sensing is an option.
Outages ON Outages OFF	The operator (local or remote) has turned ON or OFF the supply outage measurement functions. See Section 12 (page 59).
Outages Reset	The operator (local or remote) has reset the four outage counters. See Section 12 (page 59).
Over Freq Pickup (CAPM 5 only)	The Source frequency has been equal to or above the Over Frequency trip threshold. See “Under/Over Frequency Protection (CAPM 5 only)” on page 43.
Over Freq Reset (CAPM 5 only)	The Source frequency has fallen to equal or above the Over Frequency trip threshold plus the dead band. See “Under/Over Frequency Protection (CAPM 5 only)” on page 43.
Over Freq Trip (CAPM 5 only)	The Source frequency has been equal to or above the Over Frequency threshold for the Trip Delay count and a trip request has been issued. See “Under/Over Frequency Protection (CAPM 5 only)” on page 43.
Pickup	
Power Up	The electronics just had power applied or had a power up reset or watchdog reset. The time displayed will be approximately the time that power down occurred plus 1 sec.
Power Down	The electronics was powered down.
Protection OFF	All of the protection features have been turned off. The circuit breaker will only perform a manual trip or close. See "Protection OFF and Pickup Flags" - page 36. .
Protection ON	Protection has been turned back on. See "Protection OFF and Pickup Flags" - page 36. .
Prot Group A – J Active	Protection group A – J is active. Written to event whenever the active groups change or a trip occurs. See "Protection Settings and Protection Groups" - page 37. .
Prot Trip NN	Trip NN in the reclose sequence
P9 Baud xxxxx	The operator has altered the baud rate of P9, via the panel or WSOS, to be the value shown. Where xxxxx is one of 19200, 9600, 2400 or 1200.
P9 Mode yyyyy	The operator has altered P9’s mode, via the panel or WSOS, to be that shown. Where yyyyy is either **Local** or **Remote**.
QKx <function>	Quick Key X has been mapped to the function. Thus pressing this Quick Key will now allow alteration of the <function> setting. Eg. **“QK1 Local/Remote”**[b]
Radio Supply Failed	The built-in radio supply has failed.
Remote Control On	A local operator has put the controller in remote mode.
SCEM Corrupted	The SCEM records are corrupted.
SCEM *type* Fail	Where *type* can be Memory or Write.
SCEM Type *type*	The control cable has been connected to a different type of SCEM where *type* can be SCEM 9, 93C46 or Unknown.
Sequence Reset	The sequence reset timer has expired. This causes the protection relay to reset to the start of the circuit breaker sequence for the next fault. See "Sequence Reset" - page 47. and "Event Log" - page 53 .

Event Text	Explanation
Sequence Advance	When sequence control is ON this event is generated when the sequence counter is advanced due to a downstream fault which did not cause a protection trip. See "Sequence Reset" - page 47. .
Single Shot	A trip occurred whilst in Single Shot Mode. See "Single Shot Mode" - page 47. .
Source out 59 m 59 s Source out 99 h 59 m Source out 9999 h	The circuit breaker source terminal experienced a supply outage up to 59 minutes 59 seconds. The circuit breaker source terminal experienced a supply outage up to 99 hours 59 minutes. The circuit breaker source terminal experienced a supply outage >10,000 hours. See Section 12 (page 59).
Source Dead	Circuit breaker cannot close due to operation of Dead Lockout.
Source I, Load X Source X, Load I	The operator (local or remote) has changed the power flow direction. See Section 11 (page 55).
Source Supply OFF/ON	All three source side voltages are OFF/ON. See "Event Log" - page 53. .
Source Trip Req *Source* Close Req	A trip/close request was issued from the source. Where source can be one of, Panel, WSOS, IOEX, Protocol, etc. Panel = Operator Control Panel. GenCtrl = Generator Control WSOS = Windows Switchgear Operating System IOEX = Input Output Expander Card. Protocol = This is a communications protocol such as DNP3.
Trip Coil Connect Trip Coil Isolate	The Trip solenoid isolate switch on the operator control panel was changed to the Enable/Isolate position. See Section 7 (page 25).
Under Freq Pickup (CAPM 5 only)	The Source frequency has been equal to or below the Under Frequency trip threshold. See “Under/Over Frequency Protection (CAPM 5 only)” on page 43.
Under Freq Reset (CAPM 5 only)	The Source frequency has risen to equal or above the Under Frequency trip threshold. See “Under/Over Frequency Protection (CAPM 5 only)” on page 43.
Under Freq Trip (CAPM 5 only)	The Source frequency has been equal to or below the Under Frequency threshold for the Trip Delay count and a trip request has been issued. See “Under/Over Frequency Protection (CAPM 5 only)” on page 43.
Work Tag	A trip occurred whilst the Work Tag was applied.
Work Tag Applied Work Tag OFF	The Work Tag has been applied/turned off. See "Work Tags and Controller Mode" - page 31.
Wrong Switch No *n*	This version of software and the connected switch type are incompatible. “n” is the switchgear type. The controller will have to be loaded with the correct software.
<Time/Date>	A new time/date has been set.

a. If this event occurs the equipment may require maintenance. Contact the manufacturer or Distributor for advice.
b. This event will be logged if the Quick Key configuration is changed via the panel or WSOS.

Appendix H Replaceable Parts & Tools

All replacement parts listed in the following table are available from the manufacturer, special purpose tools are also listed.

Part	Part Number
Antenna Surge Arrester	ELCMIS0211
Batteries - Panasonic No LCR12V7.2P 12 Volt	BAT8250012
Circuit Breaker cable entry compartment cover gasket	N01-008
Control and Protection Module: CAPM 4 CAPM 5	 ELCCAPM 4 ELCCAPM 5
Control Cable 7m long (Also available in 3.5,4,8,10,11and 20 metre lengths)	N03-602
Control Cubicle: • Tropical version • Moderate version • Temperate version	 PTCC-TRO PTCC-MOD PTCC-TEM
Control Cubicle - temperate version heater 240 VAC	ELCM1S0140
Control Cubicle - temperate version thermostat	ELCM1S0142
Control Cubicle heater 120 VAC	ELCM150143
Control Cubicle Door Seal • TESA tape DF50604/1224	NEO0910082
Control Cubicle Entry Module (CCEM)	ELCCCEM1
Electronics Compartment Cover Gasket	N03-036
Ferrite Filters (ID = 10mm) for incoming cable.	ELCIND0030 (two reqd)
Manual Operation Set	N07-600
Operator Panel Subsystem Backlit Display & Quick Keys	N03-622
Quick Key Stickers - International English	N03-682
Quick Key Stickers - Portuguese	N03-684
Quick Key Stickers - Spanish	N03-685
Radio Cable (intermediate) V23	N03-530
Test and Training Set (TTS)	TTS1-02
Windows Switchgear Operating System (WSOS)	Refer to distributor

Appendix I Control Cubicle Schematics

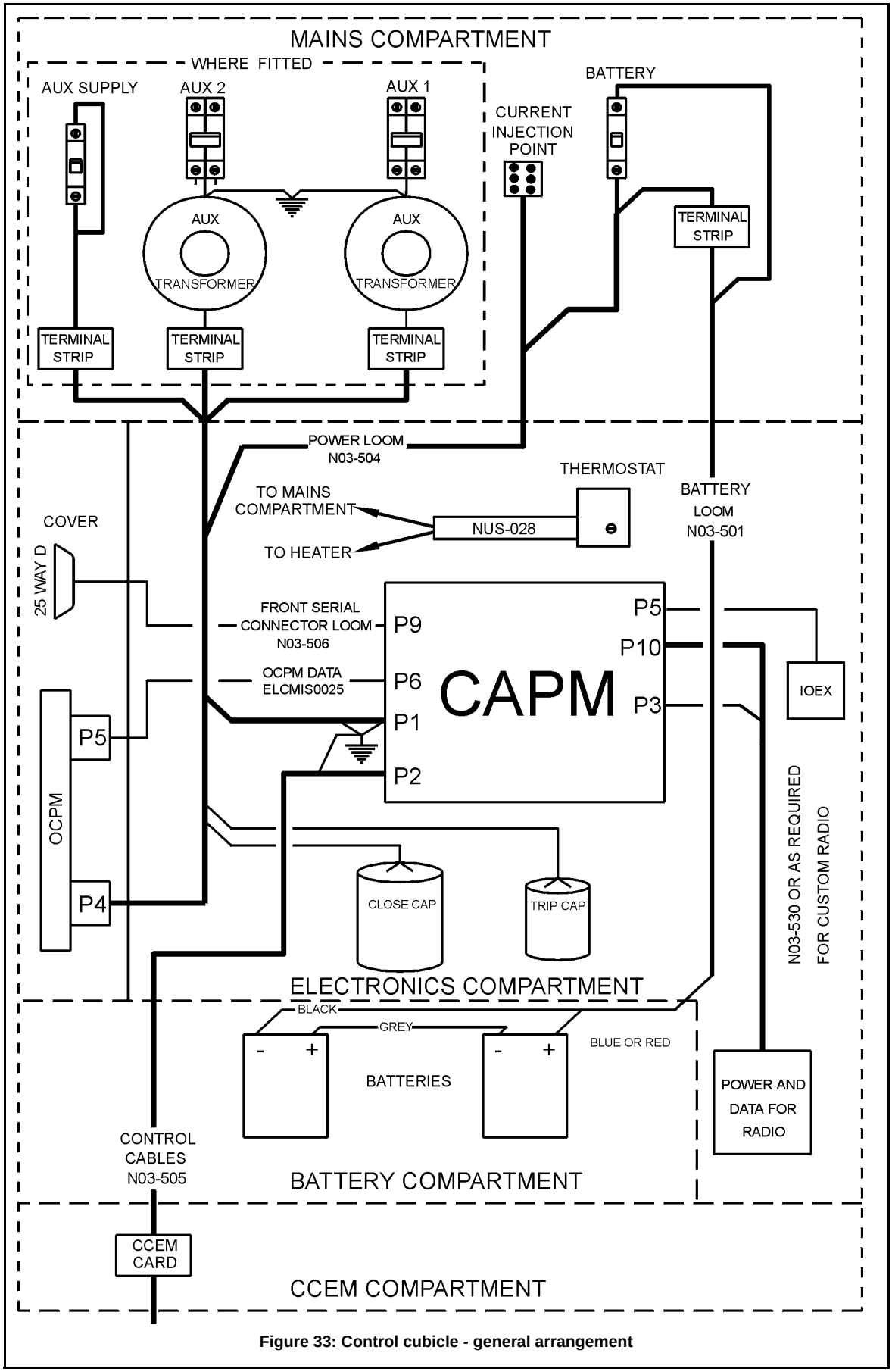


Figure 33: Control cubicle - general arrangement

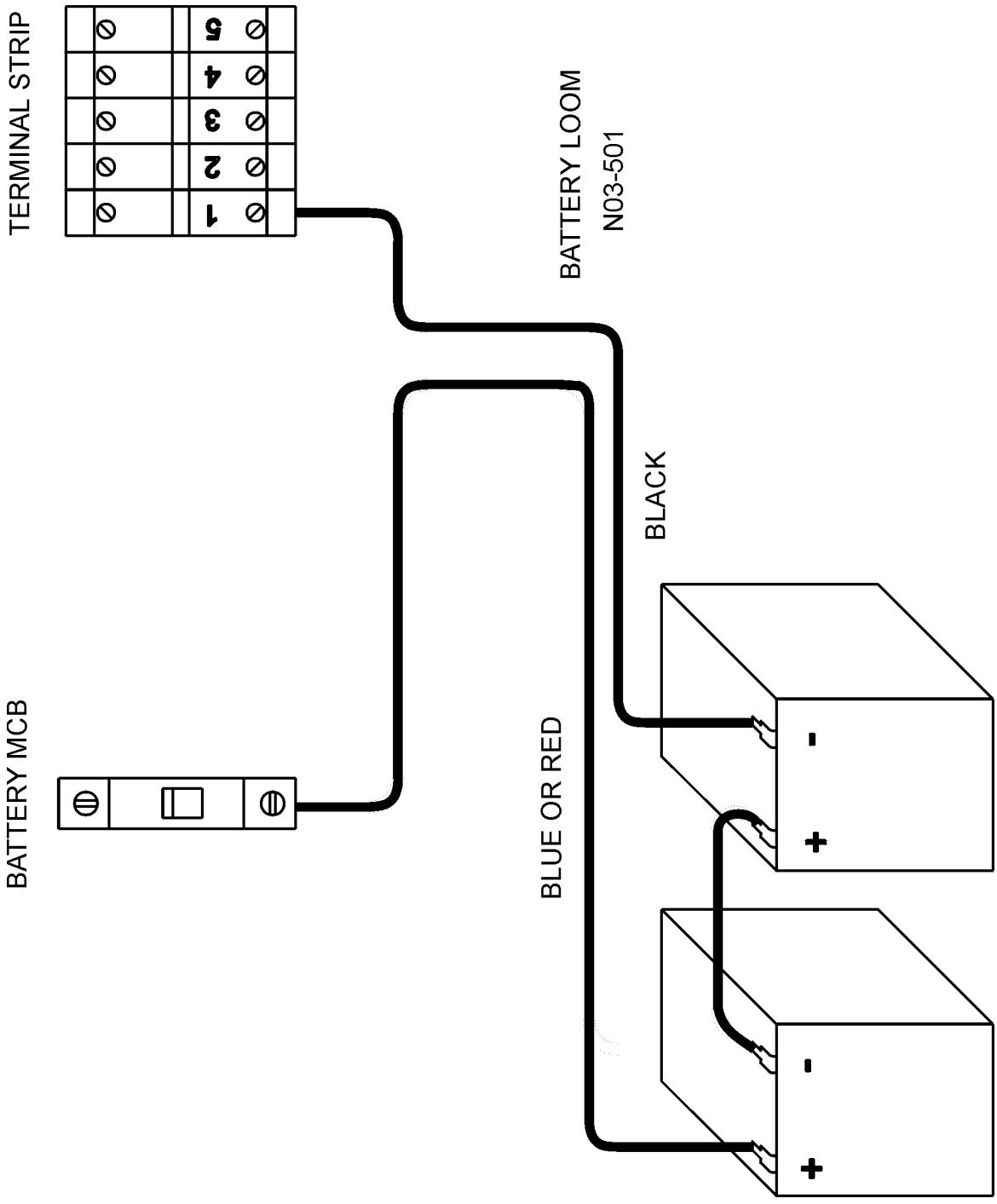


Figure 34: Control cubicle - battery loom

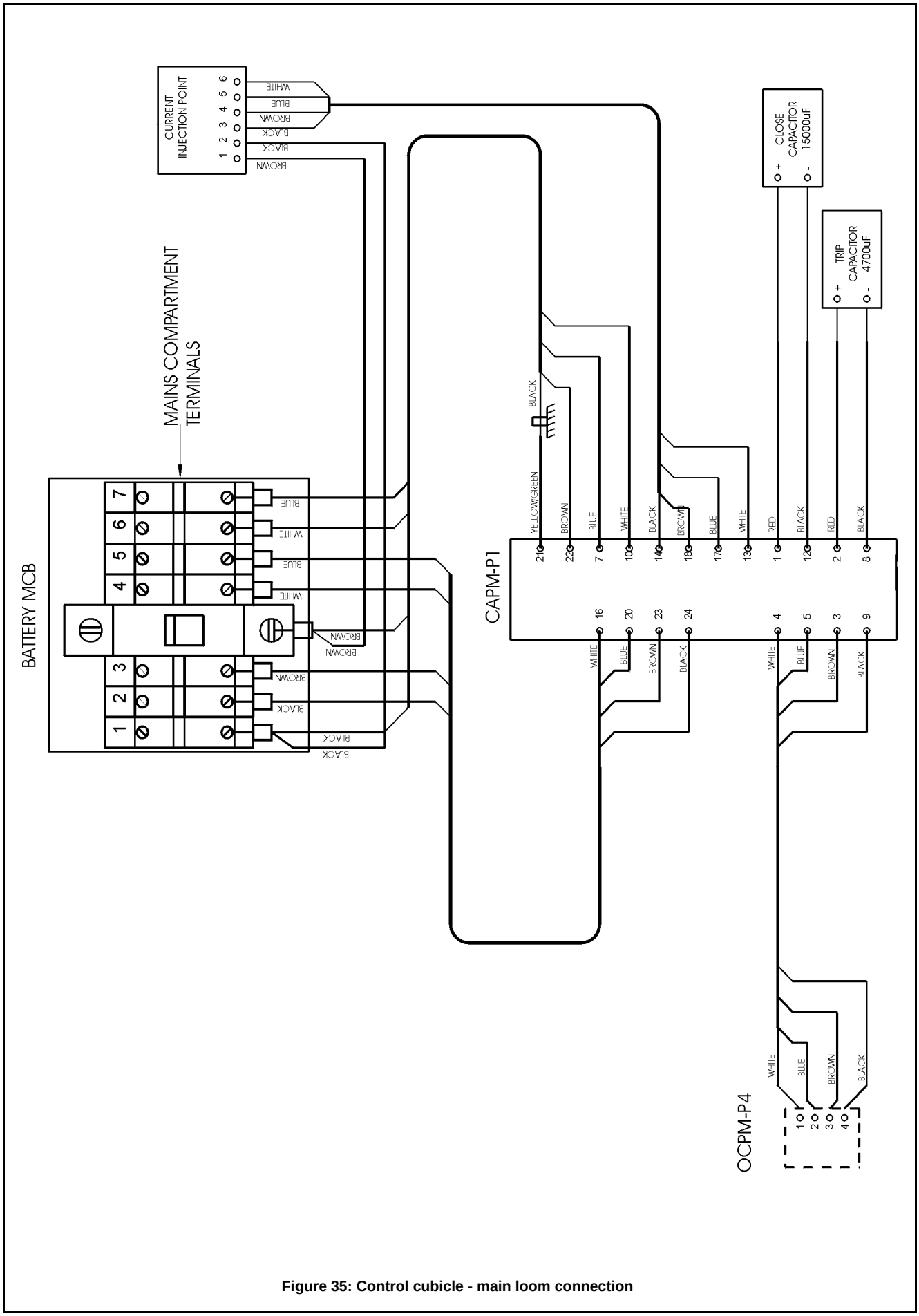


Figure 35: Control cubicle - main loom connection

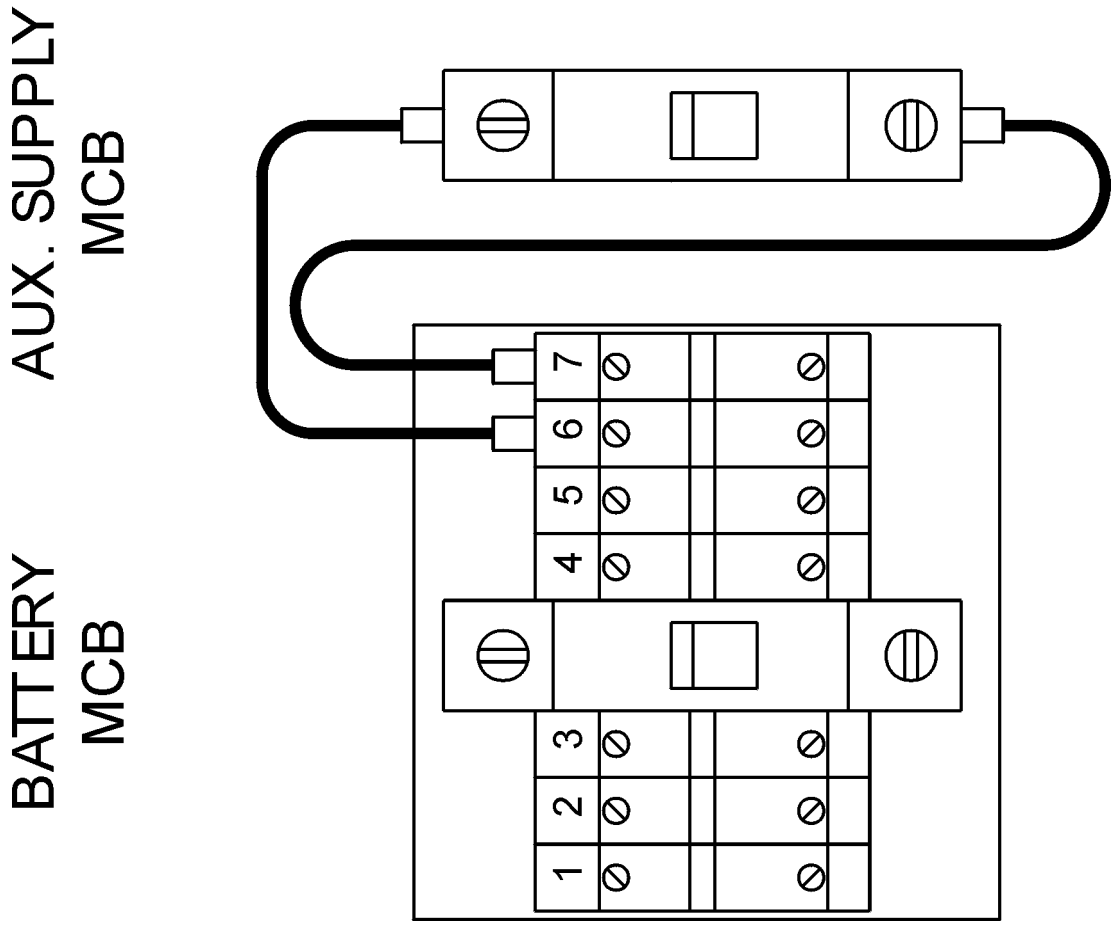


Figure 36: Control cubicle - Single integrated aux power supply

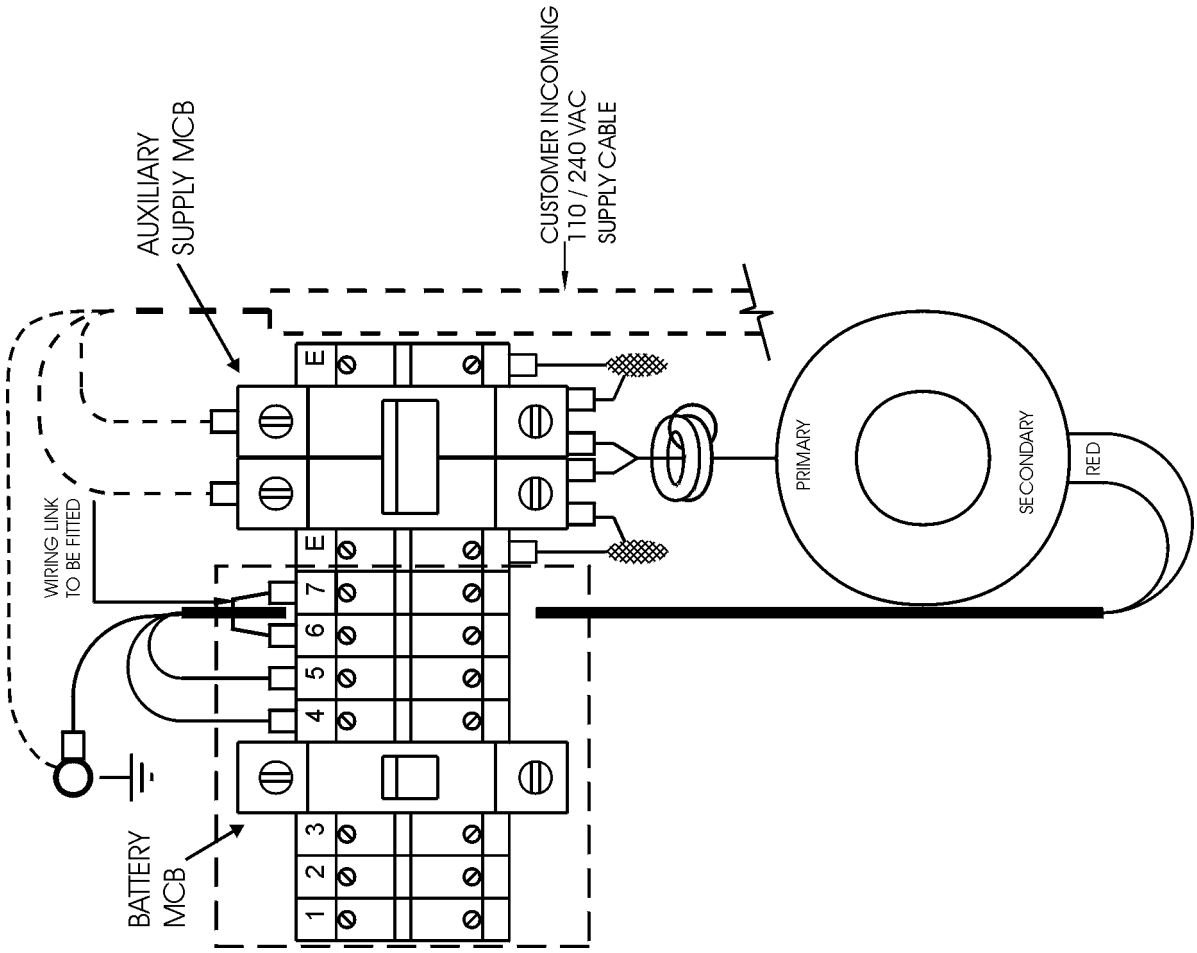


Figure 37: Control cubicle - Single LV aux power supply

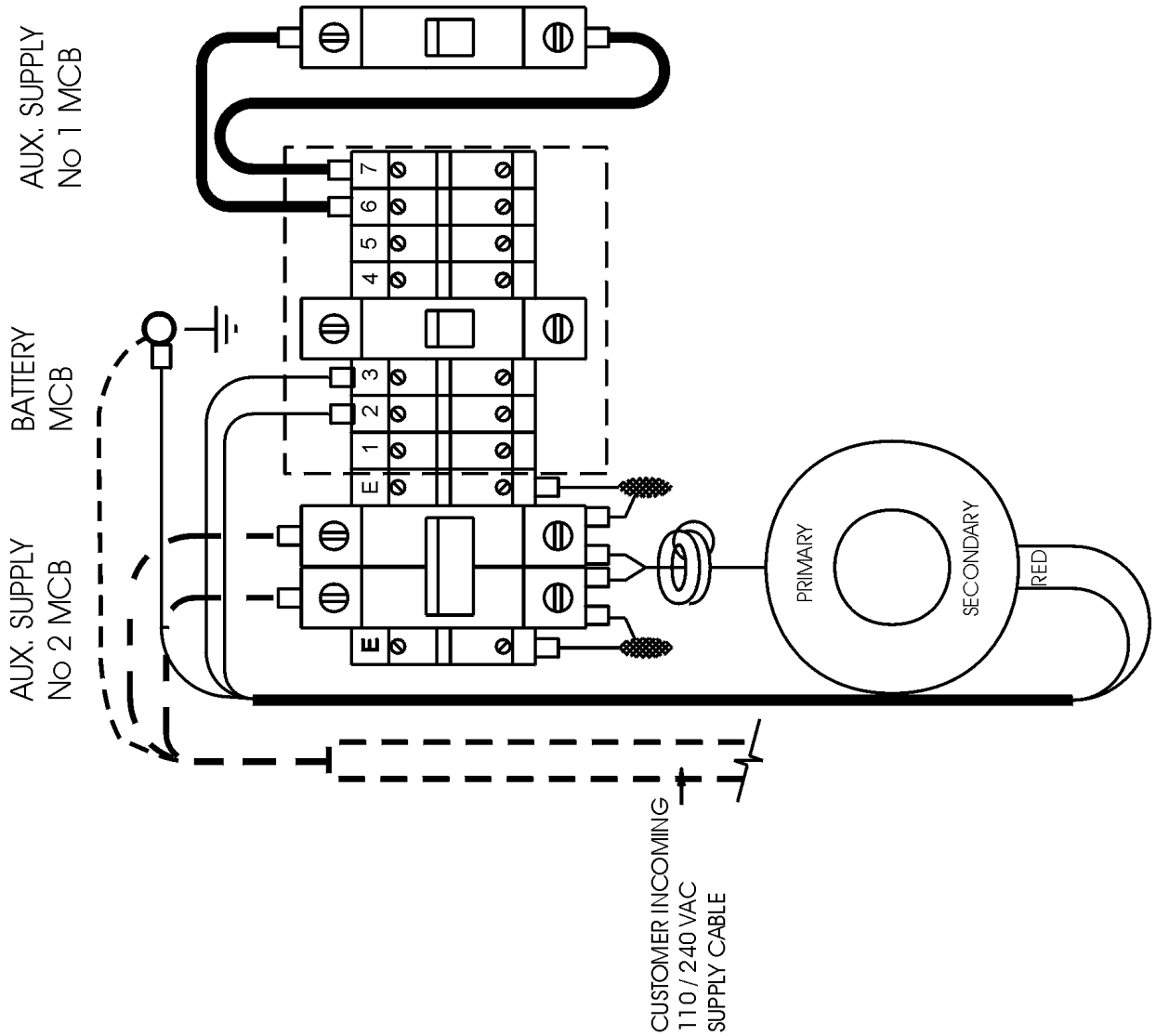


Figure 38: Control cubicle - Integrated plus LV aux power supply

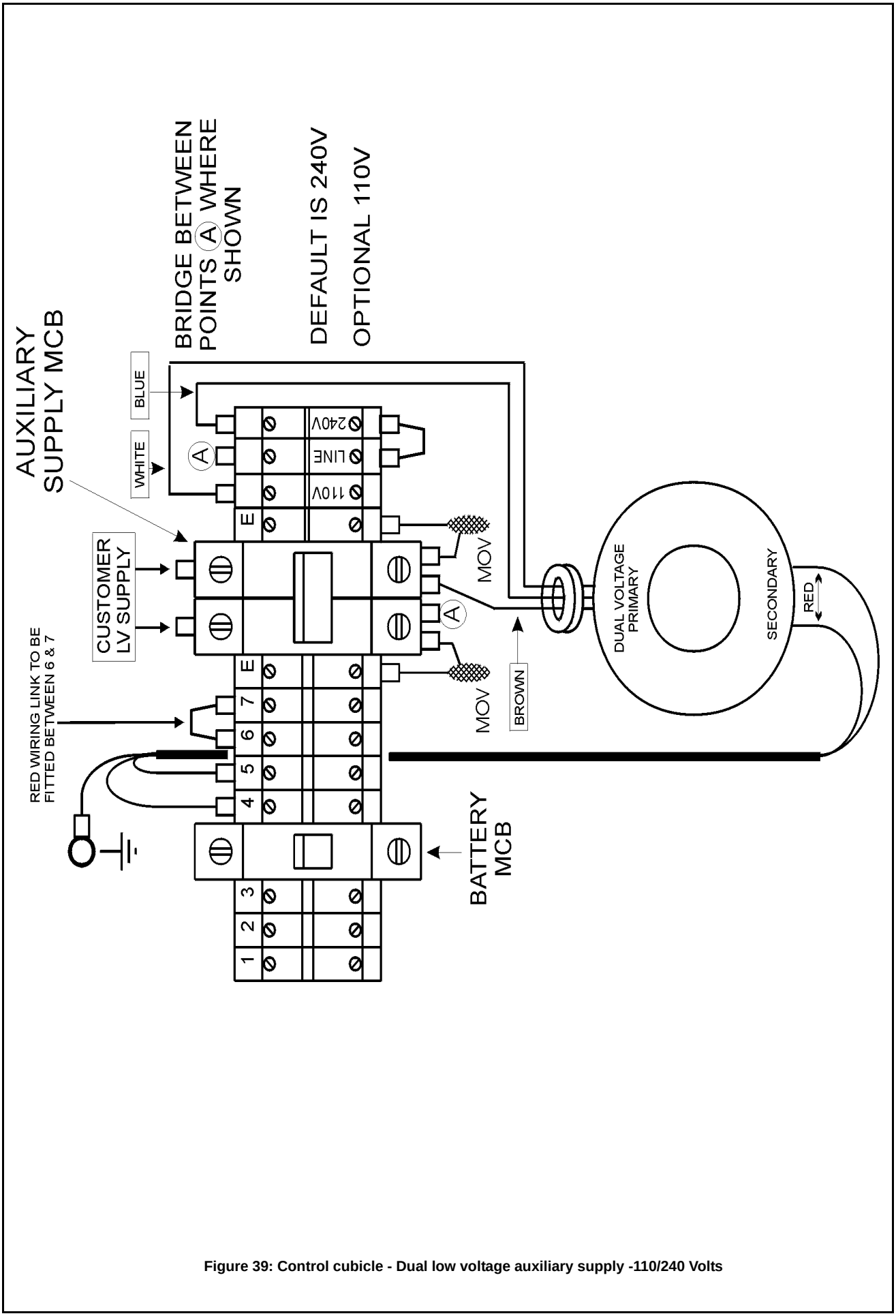


Figure 39: Control cubicle - Dual low voltage auxiliary supply -110/240 Volts

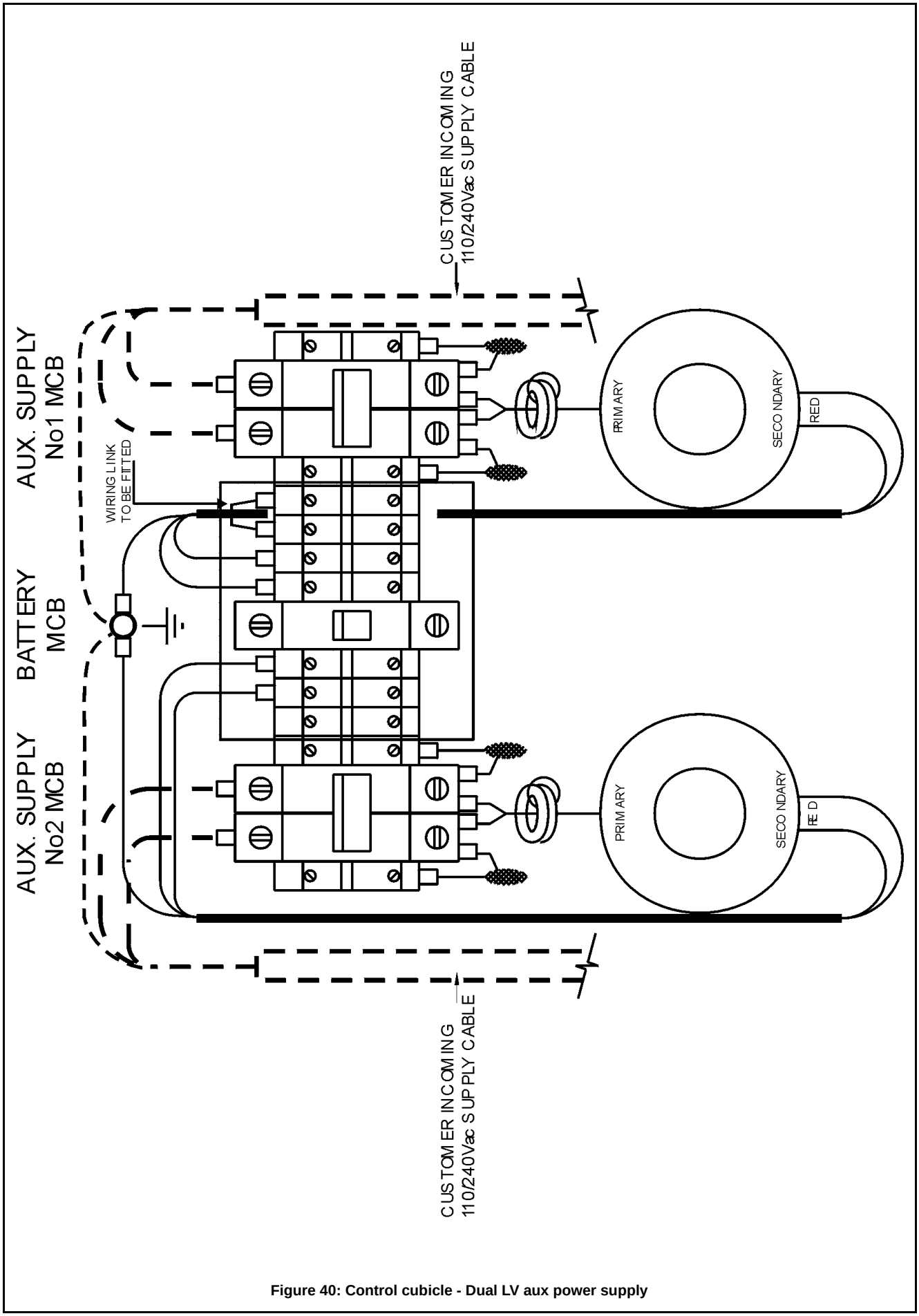


Figure 40: Control cubicle - Dual LV aux power supply

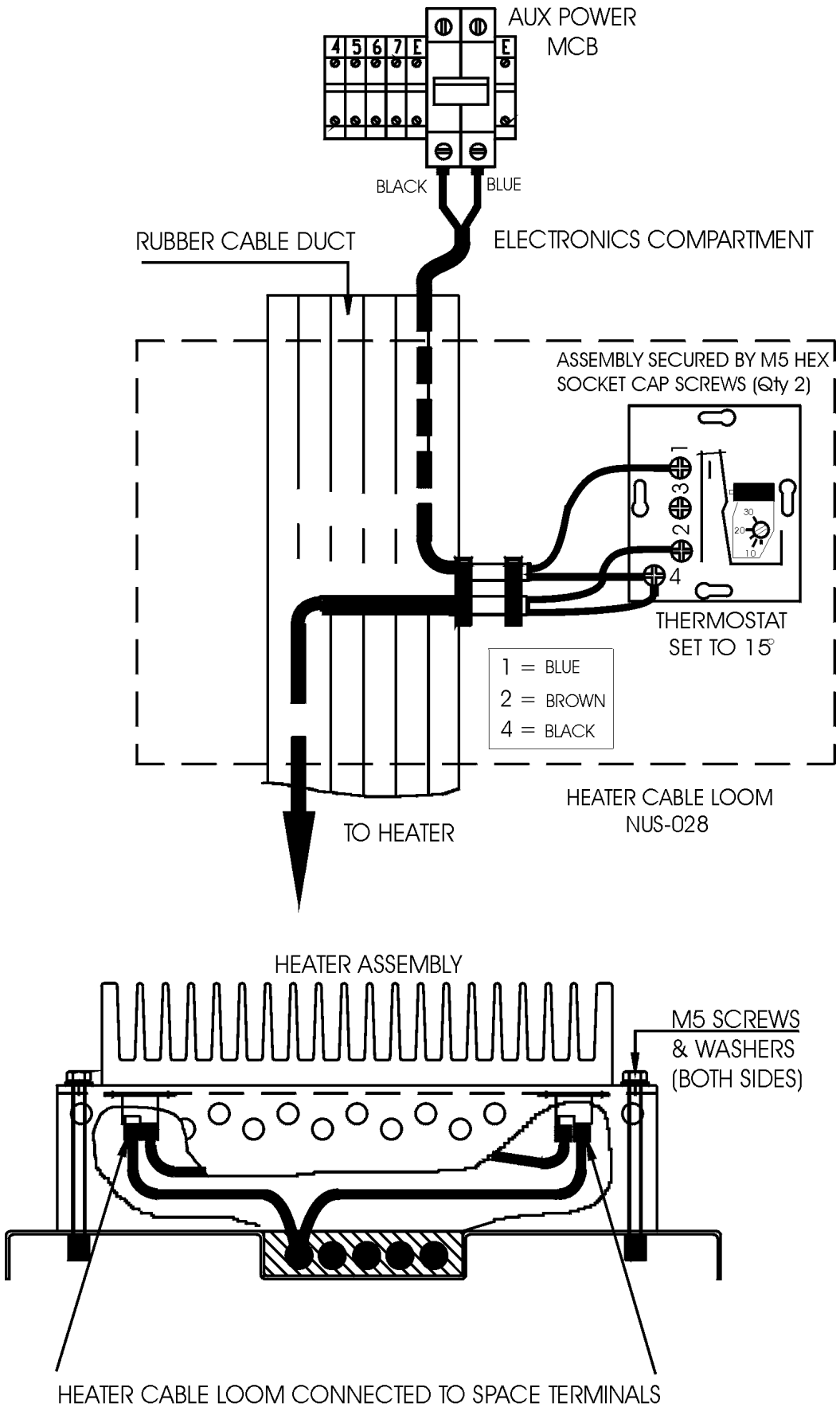


Figure 41: Control cubicle - Heater/thermostat connection

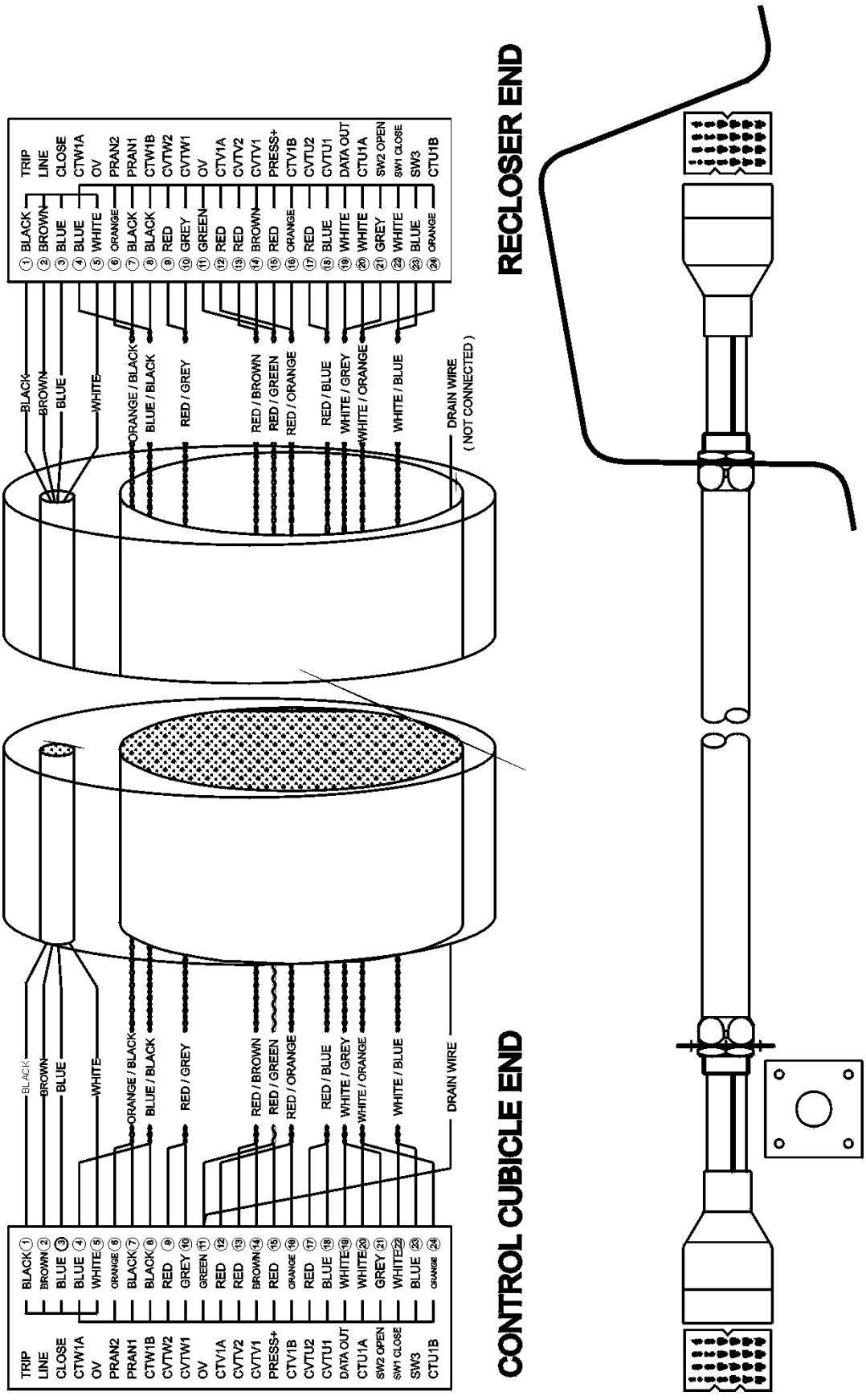
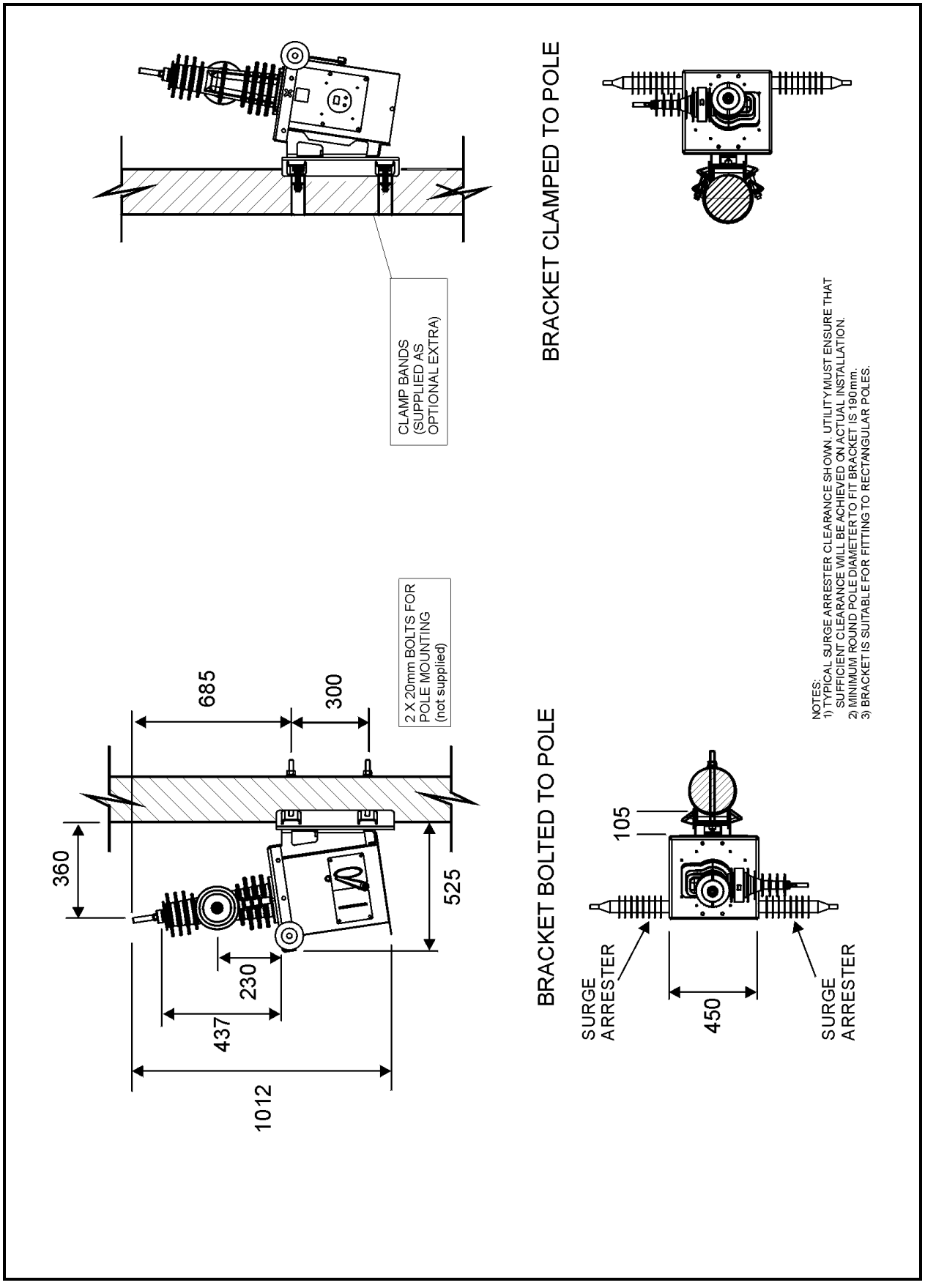


Figure 42: Control cubicle - Control cable service drawing

Appendix J Dimensions

Circuit Breaker



Centre Mounting Bracket

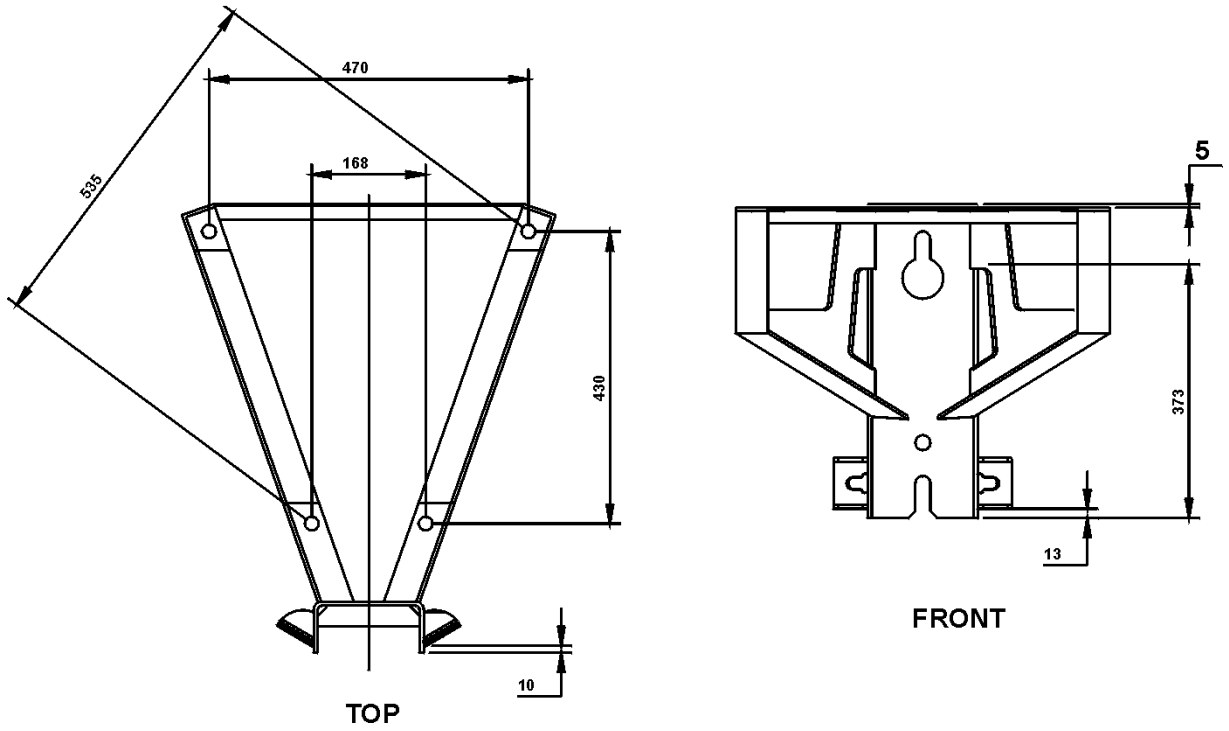


Figure 43: Centre Mounting Bracket

End Mounting Bracket

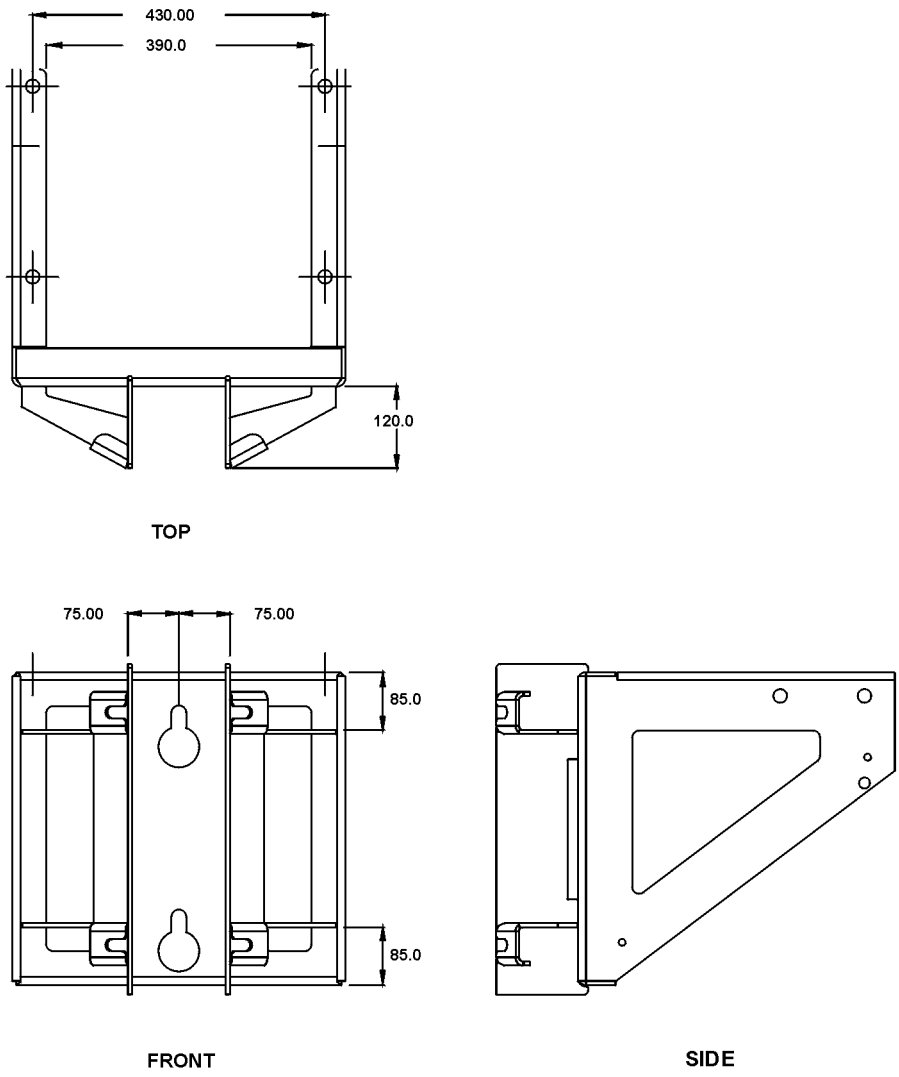


Figure 44: End Mounting Bracket

Radio Mounting Space

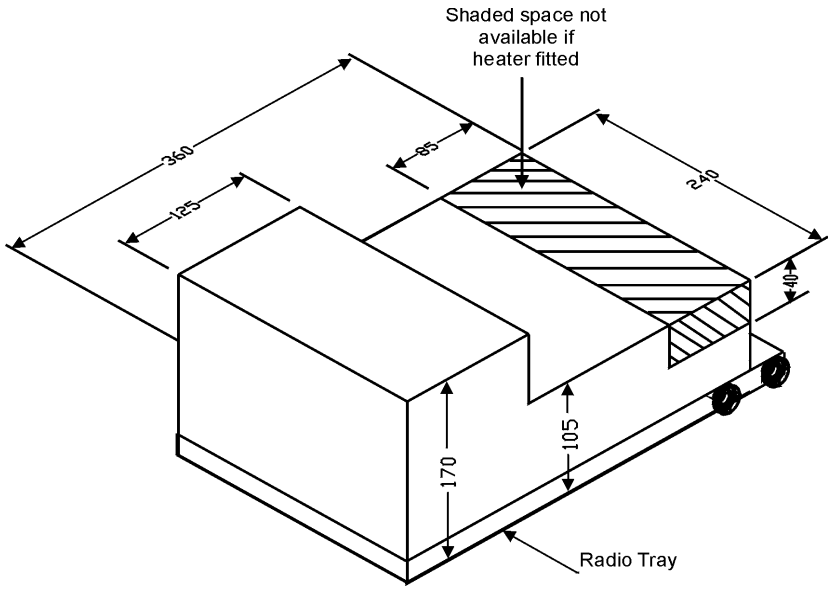


Figure 45: Radio mounting space

PTCC

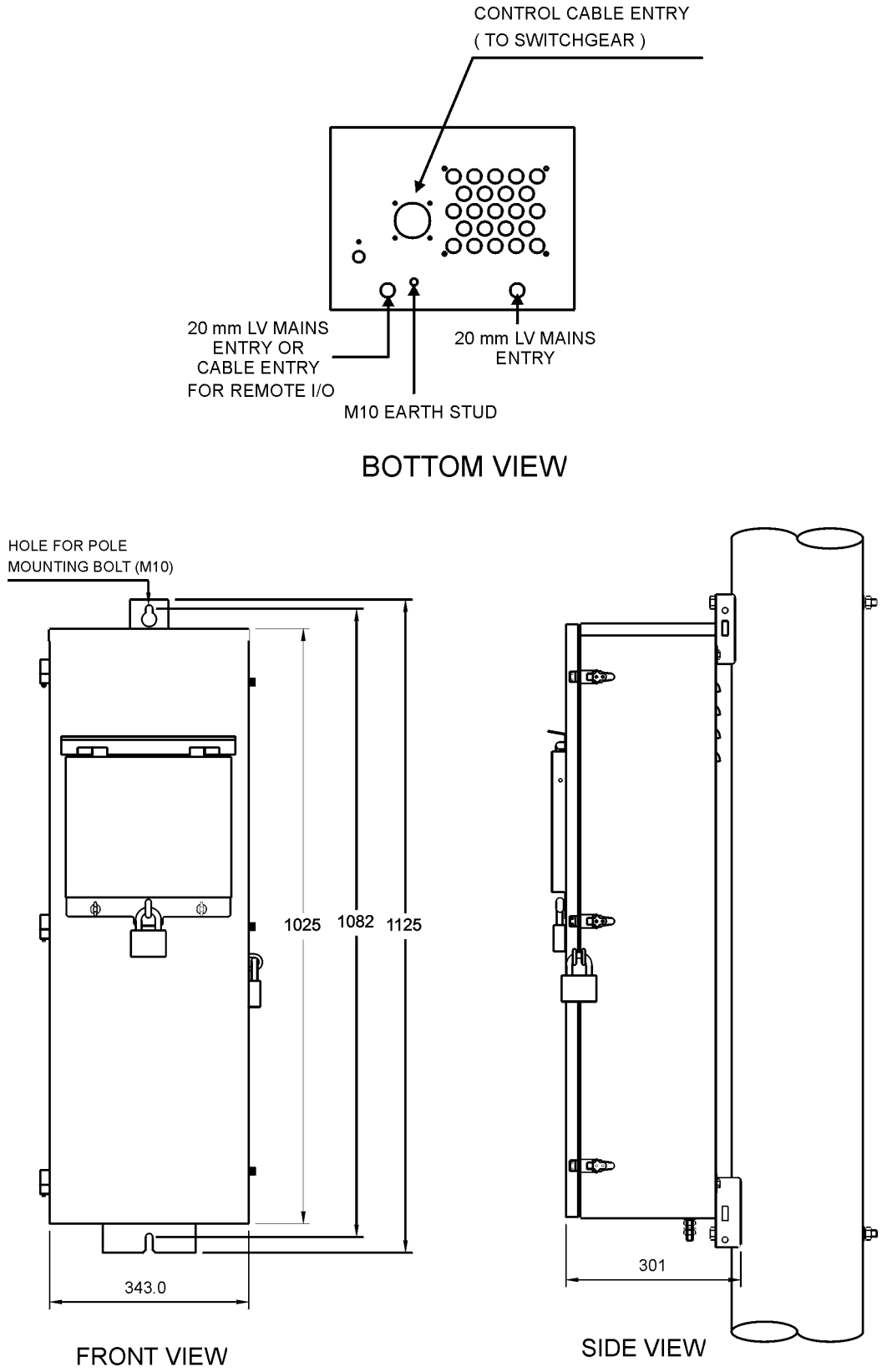


Figure 46: PTCC dimensions

Appendix K Ext CVT Opt Accessory

General Description

The CVT27X is an external Capacitor Voltage Transformer (CVT) designed for use with W Series circuit breakers.

Purpose

Although voltage measurement on the I-Side terminal is a standard feature of the W Series circuit breaker, X-Side terminal voltage measurement is not included. Voltage measurement at the I-Side terminal is provided by a CVT built into the I-Side terminal bushing. Other applications, such as Loop Automation, can be optimised by using the CVT27X to measure the X-Side terminal voltage.

Integration into Existing System

It is a simple task to integrate the CVT27X into an existing installation and no changes are required to either the circuit breaker or the control cubicle, to enable the load side voltage measurement.

After installation, the CVT27X calibration software is used once to calibrate the external CVT using the internal CVT as the reference.

Reference Material

Technical Manual No: N00-425 is supplied with each CVT order. This manual should be fully read before commencing installation or system reconfiguration.

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