

RL-Series
Load Break Switch
/Sectionaliser

Technical Manual

Notices

Scope of this Manual

This document describes the features and operation of the RL-Series Pole Mounted Load

Break Switch, including the installation and maintenance procedures.

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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.

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1 Introduction

The RL-Series Load Break Switch is a state-of-the-art, pole or pylon mounted, gas insulated, three phase Load Break Switch (LBS)/Sectionalizer optimised for remote control and automation schemes.

Innovative use of a puffer interruption system insulated by SF₆ gas, enclosed in a sealed-for-life stainless steel tank ensures a long, low-maintenance service life. A fully insulated cabling system and a simple pole hanging arrangement all contribute to quick, low cost installation.

Control electronics are housed in a stand-alone stainless steel control cubicle designed to withstand the harshest of environmental

conditions. An all-weather, user-friendly operator control panel is provided to facilitate interface between an operator and the controller module.

Remote monitoring and control can also 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'.

Contents of the Operator Control Panel display pages are shown as:

Display Group - Page Title:Text

The control panel is illustrated in Figure 7 (page 27).

Role of the Sectionalizer

The Load Break Switch (LBS) is equipped with automatic sectionalising logic. The sectionalising logic opens the LBS during the dead time of an upstream recloser after it has tripped and closed a number of times as configured by the user.

The sectionaliser feature can be enabled or disabled by an operator from the operator control panel. When a downstream fault is detected, the sectionaliser uses the Supply Interruption Counter to "count" the trips of an upstream recloser during a reclose sequence. When the counter reaches the user configured value the LBS is automatically tripped. The downstream fault is isolated from the

network and the upstream recloser restores supply to feeders upstream of the LBS.

The following figure of a simple network shows the relative positioning of the LBS downstream of a recloser.

From this figure it can be seen how a fault condition downstream of the LBS can be isolated and supply restored by the recloser to feeders upstream of it.

The fault condition must be rectified before the LBS is manually closed to restore downstream supply.

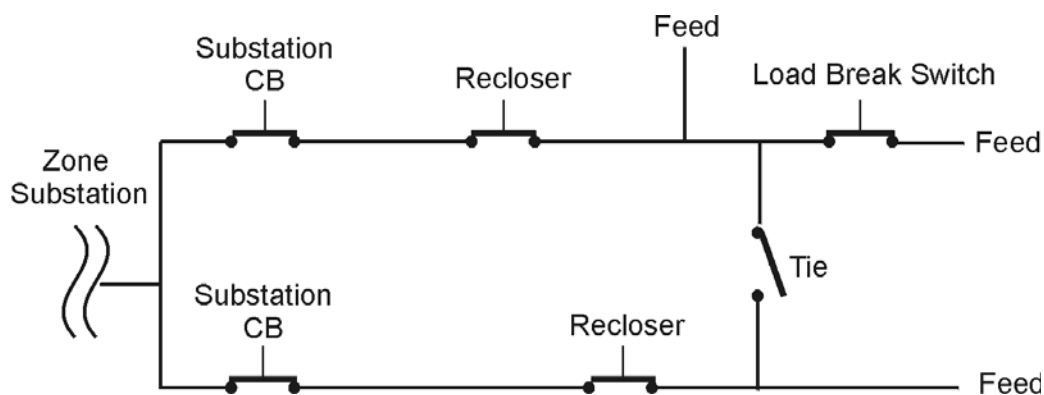


Figure 1: Positioning of the Load Break Switch

Control Cubicle Overview

The cubicle is insulated and designed to minimise any temperature rise resulting from solar heating. An internal equipment panel is used to mount all the equipment, including the batteries, storage capacitors, mains transformer, low voltage circuit breakers, Control And Protection Module (CAPM), operator control panel and radio or modem. These components are carefully located so that the heat generating parts are at the top, while the battery is at the bottom, to keep it cool, in order to maximise battery life.

All weather access is provided to the Operator Control Panel (OCP) through a lockable door on the front of the control cubicle. Vents are screened against vermin entry and the door is sealed

against the outer with a rubber extrusion. All electronic parts are well protected from entry of moisture and condensation ensuring a long lifetime.

Three models of control and communications cubicle are available, Tropical, Moderate and Temperate.

All three cubicles are fitted with the same electronics and incorporate the functions of an overcurrent through-fault detector, a sensitive earth fault relay and a remote terminal unit. Additionally, the electronics measure line current, voltage, real and reactive power, fault currents, and store these for transmission or off-line analysis.

RL-Series Load Break Switch

A unique feature of the RL-Series pole mounted load break switch / sectionaliser is the built in microprocessor controlled power supply. This provides uninterrupted operation of not only the load break switch and fault detector, but also the communications radio or modem. No other power supplies are required for connection into your SCADA or Distribution Automation System.

Due to careful design the efficiency of all parts is extremely high, allowing a battery hold up time of five days after auxiliary supply failure (from fully charged battery, excluding telemetry radio or modem usage). The architecture used has the advantage that the switch operation is

independent of the high voltage supply, relying on a set of batteries charged by the auxiliary supply.

A communications radio or special modem can be mounted within the control and communications cubicle. A V23 FSK modem and two RS232 Ports are included as standard equipment.

The control electronics measures the making/ breaking current every time the LBS operates.

This measured current is then used to calculate the amount of contact wear each interrupter has suffered and the contact life remaining is reduced accordingly. The remaining contact life is held in the switchgear memory and can be displayed on the OCP.

Version 28 Features

Version 28 software provides the following new features for the RL-Series LBS:

- Operator-configurable Quick Keys
- Hit and Run functionality
- 600 baud option for communication port P8
- Communication port P9 configurable baud rate.

2 Scope of this Technical Manual

General

This Technical Manual details the specification of the switchgear, 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 local distributor.

Product Types Covered by this Manual

The Product Type is identified at the equipment rating plate as shown in the following example:

Model	Automation Status	Insulation Medium	System Voltage	Fault Make Capacity	Insulation Level	Cable Rating
RL2-LBS	FA	SF ₆	27	16	150	630

If the identification shown on your switch's rating plate does not correspond to any of the following product types then this manual is not applicable.

Please contact the manufacturer or your local distributor for provision of the correct manual.

RL2-LBS-FA-SF₆-##-##-###

Fully Automatable - This model is fitted with Current Transformers (CT's), Capacitive Voltage Transformers (CVT's), Motor Pack (MP), manual and low gas interlocks, a mechanical operations

counter, and Switchgear Cable Entry Module (SCEM) and supplied with a Pole Top Control Cubicle (PTCC) and Control Cable (CC).

RL2-LBS-A-SF₆-##-##-###

Automatable - fitted with CT's, CVT's, MP, manual and low gas interlocks, a mechanical operations counter, and SCEM. To upgrade to a model FA, please contact your distributor.

Many parts of this manual are specific to the switchgear model FA. However, "Installation" on page 65 and "Maintenance" on page 75 are applicable to model A.

RL2-LBS-MA-SF₆-##-##-###

Manual Automatable - fitted with CT's and CVT's, manual and low gas interlocks, and a mechanical operations counter. To upgrade to models A or FA, please contact your distributor.

Many parts of this manual are specific to the switchgear model FA. However, "Installation" on page 65 and "Maintenance" on page 75 are applicable to model MA.

Controller Version Covered by this Manual

The Control and Protection Module (CAPM) is explained in Section 6 (page 23).

When the Operator Control Panel is turned on the display will show the controller type. See Section 7 (page 27). 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 obtaining 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 exactly identifies the 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 27) to find out how to use the Operator Control Panel.

A typical example of software version and configuration would be:

Software	528-05.00
Configuration	21421

Software Version Covered by this Manual

The electronic controller incorporates a microprocessor. The microprocessor software can be configured for different capabilities such as fault detection, a variety of communication 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 27) 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.

- - - - - CAPABILITY - - - - - S									
RL2	LBS	(Intl)						Manual	RL2-647
WSOS	P8	Remote						Manual	N00-218R05+
WSOS	P9	Local						Manual	N00-218R05+

If not, contact the manufacturer or your distributor.

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 switchgear 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 LBS.
 - Service Procedures – A set of instructions on how to remove and replace the controller electronics.
- For further information on these products refer to the manufacturer or your local distributor.

3 Technical Data

This section details the technical specifications of the Load Break Switch (LBS) and Pole Top Control Cubicle (PTCC).

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

Load Break Switch

Operational Specifications

RL-LBS-## ^a -SF ₆ -## ^b /## ^c /### ^d	15/12/125	15/16/125	27/12/150	27/16/150	38/12/170	38/16/170
Maximum Line Voltage	15.5kV	15.5kV	27kV	27kV	38kV	38kV
Rated Continuous Current (RMS)	630 Amp	630 Amp	630 Amp	630 Amp	630 Amp	630 Amp
Fault Make Capacity (RMS)	12.5kA	16kA	12.5kA	16kA	12.5kA	16kA
Fault Make Capacity (Peak)	31.5kA	40kA	31.5kA	40kA	31.5kA	40kA
No load Mechanical Operations	3000	3000	3000	3000	3000	3000
Rated Full Load Operations	600	600	600	600	400	400
Short Time Current (RMS)	12.5kA 4sec	16kA 4sec	12.5kA 4sec	16kA 4sec	12.5kA 3sec	16kA 3sec
DC Resistance Bushing to Bushing	<120μΩ	<120μΩ	<120μΩ	<120μΩ	<120μΩ	<120μΩ
Fault Make Operations	5	5	5	5	5	5
Frequency	50/60Hz	50/60Hz	50/60Hz	50/60Hz	50/60Hz	50/60Hz
Breaking Capacity						
Mainly Active (0.7pf) Breaking Capacity	630A	630A	630A	630A	630A	630A
Cable Charging Interrupting Current	25A	25A	25A	25A	25A	25A
Impulse Withstand						
Phase to Phase, Phase to Earth	125kV	125kV	150kV	150kV	170kV	170kV
Across Open Contacts	145kV	145kV	170kV	170kV	200kV	200kV
Power Frequency Withstand (wet and dry)						
Phase to Earth	40kV	40kV	60kV	60kV	70kV	70kV
Across Open Contacts	50kV	50kV	60kV	60kV	80kV	80kV

- a. Model Code: MA, A, FA
b. Voltage: 15 (15.5kV), 27kV, 38kV
c. Current (Fault Make Current): 12 (12.5kV), 16kV
d. Basic Impulse Level: 145kV, 170kV, 200kV

General Specifications

Specification	15kV, 27kV, 38kV
Construction	
Tank Construction	316 Grade Stainless Steel

RL-Series Load Break Switch

Specification	15kV, 27kV, 38kV
Insulating Medium	SF ₆ Gas
SF ₆ Nominal Operating Gas Pressure @ 25°C	105kPa Gauge
Mass of SF ₆ required to fill the LBS from vacuum	1.0kg @ 105kPa Gauge
Maintenance Interval ^a	5 years
Earthing ^b	12mm Stud provided
Applicable Standards	IEC 62271-200, IEC 60265-1
SF₆ Gas Pressure Measurement (Model FA)	
Gas Pressure Display Resolution	1kPa
Gas Pressure Display Accuracy	±10kPa
Gas Low Alarm/Interlock setting (temperature compensated)	65kPa Gauge @ 25°C
Gas Low Alarm/Interlock Accuracy	±10kPa
Mechanical SF₆ Gas Interlock (Models: MA, A, FA)	
Gas low interlock setting (temperature compensated)	65kPa Gauge @ 25°C
Gas low interlock setting accuracy	±15kPa
Mechanism Operation	
Closing Mechanism	Spring wound either by DC Motor or Manual Lever
Opening Mechanism	Spring wound either by DC Motor or Manual Lever
Opening arm effort required	Nominal 20kg (Max 25kg)
Basic Timings	
Contact Close - from receipt of close command	<1.2 sec
Contact Open - from receipt of open command	<1.2 sec
Contact Synchronisation time	<5 msec
Current Transformers (Models: MA, A, FA)	
Ratio	2000:1
Accuracy 20 A - 800 A	0.2%
Accuracy 800 A - 16,000 A	1%
Duty Cycle - Maximum allowable duty cycle at rated mainly active load breaking^c	
No Load Close to Open repeated 10 times in 1 minute. Then Close to Open repeated 1 per minute.	
Rated Load - 630 Amp, 0.7 Power Factor Close to Open repeated 1 per minute.	

- a. In heavily polluted environments regular checking/cleaning of insulators should be conducted.
b. Earthing details in Section 16.4 (Page 82) must be strictly adhered to.
c. For application specific operating duty times, please refer to the manufacturer.

Bushings

Type	DIN 47-636-400 with threaded conductor
Phase to Phase centres	250mm

Bushing Boots

The 27/38kV LBS must be fitted with cable tails which are supplied with outdoor elastomeric bushing boots. These boots suit insulated cable sized 16-32mm diameter and achieve an unscreened fully insulated system. The characteristics of the boot are detailed below.

Taut string phase to earth clearance	27kV - 400mm	38kV - 465mm
Creepage If desired, the 38kV boot can be used on the 27kV switch in order to achieve a higher creepage distance.	27kV - 770mm	38kV - 1100mm

Bare Terminals

The standard 15kV Load Break Switch is supplied fitted with bare terminals for cable palm connection. It may also be fitted with cable tails instead of these terminals if required.

Taut string phase to phase clearance	200mm
Taut string phase to earth clearance	200mm
Creepage	500mm

HV Cables^a

Cable is usually provided by the manufacturer pre-cut and terminated to fit the Load break Switch bushings and rated to suit the requirements of the utility. Standard HV cable supplied by the manufacturer is as follows.

Cable Size (mm ²)	Stranding	Material	Rating (Amps)
240	19/4.01	Aluminium	630
185	19/3.5	Aluminium	400
80	7/3.75	Aluminium	250

a. Alternatively, cable can be supplied by the utility if appropriate (e.g. to terminate HV Aerial Bundled Cable). Contact the manufacturer or your local distributor to check cable type for suitability. The manufacturer warrants the equipment only if suitably insulated and water blocked cable and terminations are used.

Environmental

Operating Temperature	-30°C to +50°C
Operating Humidity	0 to 100%
Operating Solar Radiation	1.1kW/m ² max
Operating Altitude ^a	3000m max

a. Altitudes above 1000 metres must be de-rated per ANSI C37.63.

Control Cubicle

General Specifications

Standard control cable length	7m
Maximum vertical separation from LBS with standard control cable.	5m
Maintenance interval	5 years
Auxiliary supply voltage (LV AC mains supply)	As Ordered -20 to +10%
Required auxiliary supply rating	50 VA, 120VA if heater fitted

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Battery	2 x 12V 7.2Ah
Battery hold up time from fully charged	5 days
Battery recharge time (new battery to 80% nominal capacity)	10 hours
Battery replacement interval	5 years
Earthing	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 3 (page 18)
Radio/Modem Interface	V23 or RS232
Radio/Modem Power Shutdown Time	1 - 1440 mins
Control Electronics Thermal Restraints	
Continuous Primary current	800A
Short time primary current	
CAPM 4	16kA for 3 sec
CAPM 5	16kA for 4 sec
Short time current recovery time	60 sec
Local Operator Controls Local Operator Control is through the Operator Control Panel, refer to later sections.	

Fault Detect and Sectionalising Functions

Fault Detect	
Phase Fault Threshold Current Setting Range	10 to 1260 Amps
Earth Fault Threshold Current Setting Range	10 to 1260 Amps
Sensitive Earth Fault Threshold Current Setting Range	4 to 20 Amp
Sensitive Earth Fault Filter Attenuation at 150 Hz	>28dB
Threshold Current Setting Resolution	1 Amp
Threshold Current Setting Accuracy	5%
Definite Time for Fault to Persist Setting Range	0.05 to 100 sec
Setting Resolution	0.01 sec
Definite Time Setting Accuracy	1% of setting, +0, -0.04 sec
Loss of Supply Detection	
Live Line Threshold	2 to 15kV
Live Terminal Threshold Voltage	See Power System Measurements - page 9
Loss/Restoration of Supply Timeout	0.1 to 100 sec

Loss/Restoration of Supply Timing Accuracy	-0.0ms/+150ms
Sectionaliser	
Faults to trip	1 to 4
Sequence reset time	5 to 180 sec
Cold Load Pickup	
Cold Load Multiplier Range	1 - 5
Cold Load Multiplier Resolution	0.1
Cold Load Time Constant Range	1 - 480 mins
Cold Load Constant Resolution	1 minute
Timing Accuracy	+/-1 minute
Inrush Restraint	
Inrush Restraint Multiplier Range	1 - 30
Inrush Restraint Multiplier Resolution	0.1
Inrush Restraint Time Range	0.05 - 30 sec
Inrush Restraint Time Resolution	0.01 sec
Timing Accuracy	±20ms
Live Load Blocking. This is an additional detection feature, which operates independently of the detection elements.	
Live Load Threshold range	See Power System Measurements - page 9
Automatic Detection Group Selection This is an additional detection feature.	
Auto Change time	10 - 180 sec
Auto Change Time Resolution	1 sec
Other Detection features	
Fault Reset Time	50 - 800 ms
Fault Reset Time Accuracy	+20ms

Power System Measurements

Specification	15kV, 27kV	38kV
Voltage Measurement Range (RMS Phase to Earth)	2 to 15kV	2 to 22kV
Voltage Measurement Resolution	±1V	±1V
Voltage Measurement Uncertainty ^a As shipped, operating temp -5°C to +45°C 5 year, operating temp -20°C to +45°C	±1.5% ±2.5%	
Live Line Threshold Phase/Earth user set	2 to 15 kV	2 to 22kV
Phase Current Measurement Range (RMS)	2.5 to 800 Amp	
Phase Current Measurement Resolution	±1 Amp	

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Specification	15kV, 27kV	38kV
Phase Current Measurement Uncertainty ^a As shipped, operating temp -5°C to +45°C 5 year, operating temp -20°C to +45°C	±1% ±1.5%	
Earth Current Measurement Range	1 - 800 Amp	
Earth Current Measurement Resolution	±1 Amp	
Earth Current Measurement Uncertainty ^a As shipped, operating temp -5°C to +45°C 5 year, operating temp -20°C to +45°C	±1.5% ±2.0%	
Power Measurement Range	0-36MW	0 - 52.8MW
Power Measurement Resolution	1 kW	
Power Measurement Uncertainty ^b As shipped, operating temp -5°C to +45°C 5 year, operating temp -20°C to +45°C	±2.0% ±3.0%	
Apparent Power Measurement Range	0-36MVA	0 - 52.8MVA
Apparent Power Measurement Resolution	1 kVA	
Apparent Power Measurement Uncertainty ^b As shipped, operating temp -5°C to +45°C 5 year, operating temp -20°C to +45°C	±2.0% ±3.0%	
Reactive Power Measurement Range	0 - 36MVAR	0 - 52.8MVAR
Reactive Power Measurement Resolution	1 kVAR	
Reactive Power Measurement Uncertainty As shipped, operating temp -5°C to +45°C 5 year, operating temp -20°C to +45°C	±2.0% ±3.0%	
Power Factor Measurement Range	0.5 - 1.0	
Power Factor Measurement Resolution	0.01	
Power Factor Measurement Uncertainty ^c	±0.02	
Measurement Averaging Period	2 sec	
Measurement Update Period	0.5 sec	

a. 95% Confidence Interval, includes CVTs and controller.

b. 95% Confidence Interval, includes CVTs, CTs and controller, Power Factor 0.90 to 1.0

c. 95% Confidence Interval, includes CVTs, CTs and controller.

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. See Section 10 (page 43)

Equipment and Crating Dimensions

Specification	15kV, 27kV		38kV
Equipment Weights			
Part	Weight (kg)		
Control cable	6		
Control cubicle	35		
HV cables (3m long, 180mm ² Al cables, qty 6) complete with bushing boots.	26	29	
Load Break Switch	100		
Pole mounting bracket	20		
Gross weight	185	188	
Dimensions			
Control Cubicle	See Figure 42 (page 107)		
Load Break Switch	See Figure 39 (page 105)		
Crate Dimensions (mm)			
Width	1150mm		
Depth	1200mm		
Height	800mm		

4 Construction and Operation

This section describes the construction and operation of the Load Break Switch (LBS).

Overview

The LBS uses “puffer” interrupters inside a fully welded and sealed stainless steel tank filled with SF₆ gas.

Three interrupters are ganged together on a common shaft that is driven by an over-centring spring mechanism which is given momentum either by:

- Manual rotation of the operating arm using a hookstick from ground level. By pulling downwards on the appropriate side of the arm in a steady, controlled manner, the LBS can be opened or closed. The mechanism is spring based, therefore excessive force or speed in

operation is not necessary and excessive force could cause damage to the motor pack.

- Motor driven rotation of the operating arm using the motor pack (where fitted) mounted at the fixed bracket beneath the tank initiated from the control panel or remotely via SCADA.

Current transformers are installed inside the tank. These are connected to the control electronics to provide fault indication and current measurement.

Moulded epoxy bushings with in-built capacitive voltage transformers are installed inside the tank. These are also connected to the control electronics to provide voltage sensing and measurement.

Control Electronics

The control electronics are located in the manufacturer supplied Pole Top Control Cubicle (PTCC).

The PTCC is connected to the switchgear by the control cable which plugs into the motor pack.

Features

Figure 2 (page 15) details the general assembly and operational features.

These include the following:

- A mounting bracket suitable for mounting to all types of power poles. Optional clamping rings that secure the bracket to circular poles, thereby negating the need for bolts through the pole, are also available from the manufacturer if required.
- Support legs welded to the tank which have the multi-purpose role of protecting the LBS during transportation, securing the surge arrester mounting bracket and enabling the LBS to be mounted onto flat topped surfaces such as pylons or footings.
- Four carry handles welded to the upper portion of the tank. These also provide fixed points for the attachment of slings and shackles during installation.
- Both 27kV and 38kV LBS high voltage connections are made with insulated cable terminated on epoxy bushings. The cable and bushings are covered by a gripping elastomeric boot that is filled with silicone grease to form an insulated system.
- 15kV LBS high voltage connections are made at either the standard bare terminals suited for cable palm connection or the optional cable tail as above.
- Provision is made for the installation of surge arrestors on the frame of the LBS.

CAUTION

If mounted elsewhere they must be earthed to the LBS tank.

- An M12 earth bolt is provided at the top of the tank for earthing the LBS.
- If an internal arc fault condition occurs, a vent at the rear of the LBS tank ruptures to vent the over-pressure. This eliminates the risk of explosion or detachment from the power pole and since the unit is not oil filled, a major fire hazard is eliminated.
- Reflective ON (Closed) / OFF (Open) position indicators are provided on the operating arm and the underside of the tank.
- Operations counter mounted behind the motor pack.
- Mechanical locking of the LBS mechanism is provided by pulling downwards on the yellow Manual Lock handle with a hookstick. When locked, the mechanism cannot be tripped or closed either mechanically or electrically. Pre-drilled holes through the manual lock enable the application of a physical locking device such as a padlock to enable full lock-out condition.
- The status of the mechanical Low Gas Interlock is visible through the viewing port on the underside of the LBS. If the gas pressure is below minimum pressure, a reflective red disc appears in the viewing port. The mechanism is also mechanically locked at the same time so that it cannot trip or close.

RL-Series Load Break Switch

SF₆ Pressure Sensing

The LBS incorporates two pressure sensors that continually monitor the SF₆ gas pressure within the tank.

Pressure Transducer

The pressure transducer is mounted at the Switchgear Cable Entry Module (SCEM) Boss inside the tank. It is monitored by the control electronics through the SCEM to display the SF₆ gas pressure at the operator control panel.

If the gas pressure falls below a pre-set threshold then an SF₆ Pressure Low message is shown on the operator control panel and all electrical operations are electronically locked out. The threshold for the low-pressure detection is temperature compensated.

Low Gas Interlock

The second sensor is mechanical and locks out all operations if the gas pressure reduces below the minimum safe working level. This sensor is temperature compensated.

Triggering of this interlock is indicated when the reflective red disc is visible through the viewing port on the underside of the LBS tank.

Once triggered the interlock can only be reset by the procedure for re-gassing the switch, advised later in this manual.

CAUTION

Always check the gas pressure displayed at the control cubicle and that the red disc is not visible through the viewing port prior to operation of the Load Break Switch.

Switchgear Memory

The Switchgear Cable Entry Module (SCEM) incorporates an electronic memory to store the following information about the LBS:

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

CAUTION

The mechanical operations counter at the underside of the LBS may eventually be out of step with the operations count stored in the memory. This will occur if the LBS is manually operated without the control cubicle connected and powered up. The calculated contact life will be incorrect where manual switching operations are conducted without the control cubicle connected and powered up.

Contact Life

The control electronics measures the making/breaking current every time the LBS operates.

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

- The LBS should be replaced if the remaining life on any phase reaches zero.
- See Section 3 (page 5) for the duty rating of the LBS.

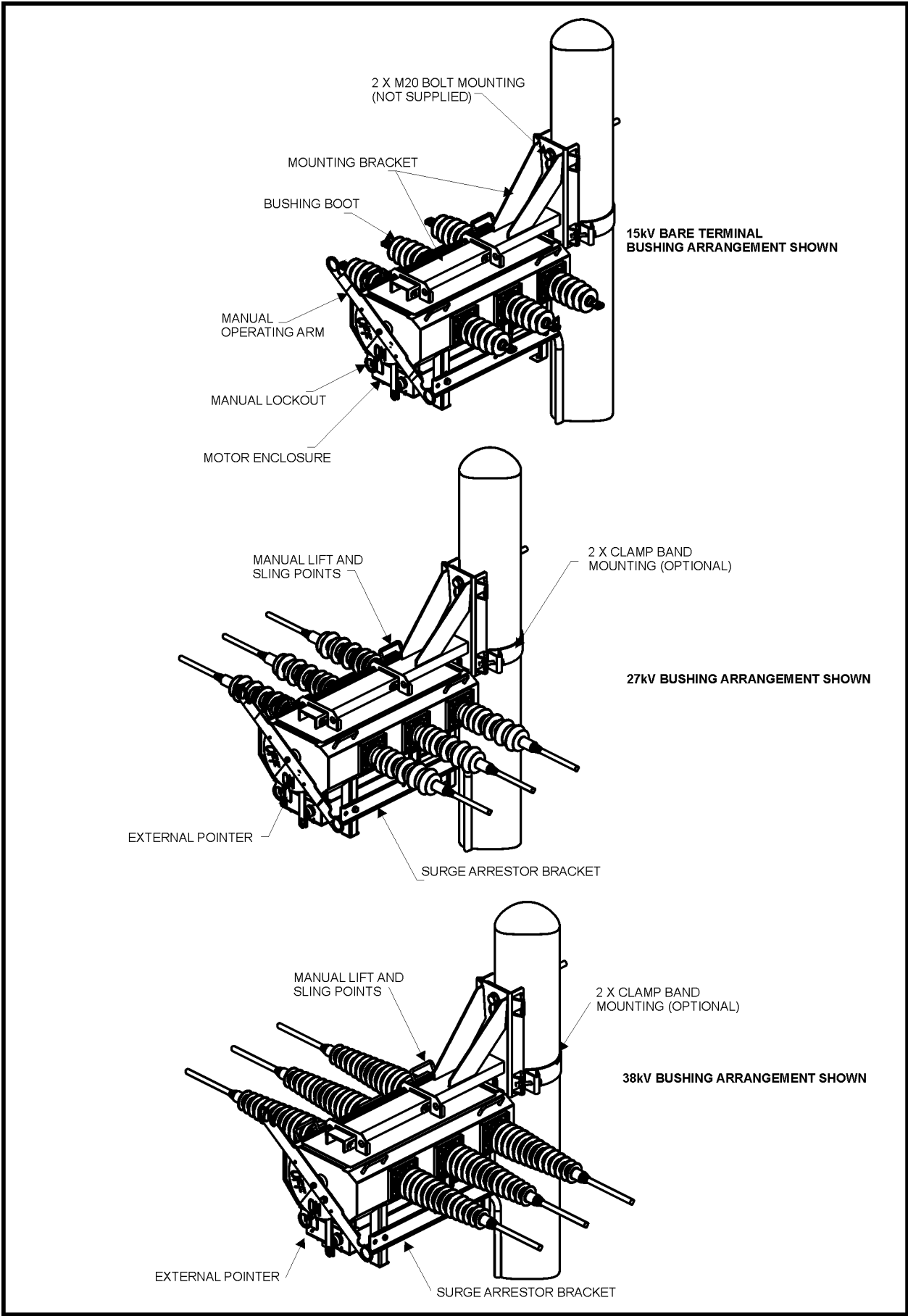


Figure 2: Load Break Switch Assembly

5 Control Cubicle

The control cubicle supplied with the Load Break Switch 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 4 (page 20) shows the cubicle's dimensions.

Connection to LBS

The Load Break Switch is connected to the control cubicle by the control cable. The cable plugs into compatible ports at both the cubicle and underside of the switch.

The control cable carries the following connections:

- Motor Operating Signals.
- Travel switches that monitor the position of the contacts (one switch indicating CLOSE and

the other OPEN) and the position of the gas interlock/mechanical interlock.

- Current transformers and voltage screens embedded in the bushings. These send signals to the control electronics to monitor line current, earth current and phase to earth voltages. If the control cable is disconnected (at either end) these signals are automatically shorted by circuitry inside the Load Break Switch.
- Signals to read and write the switch memory.

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 5 (page 21).

- 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 (where fitted), see Section 15 (page 59). 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 (CCEM)** 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** for the control cubicle 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.

RL-Series Load Break Switch

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 LBS by the detachable control cable.

WARNING

The control cubicle must be earthed to the LBS to complete the earthing scheme as detailed in "Earthing" - page 70

Radio Mounting Tray Space

The space available on the radio tray to install customer equipment is shown below.

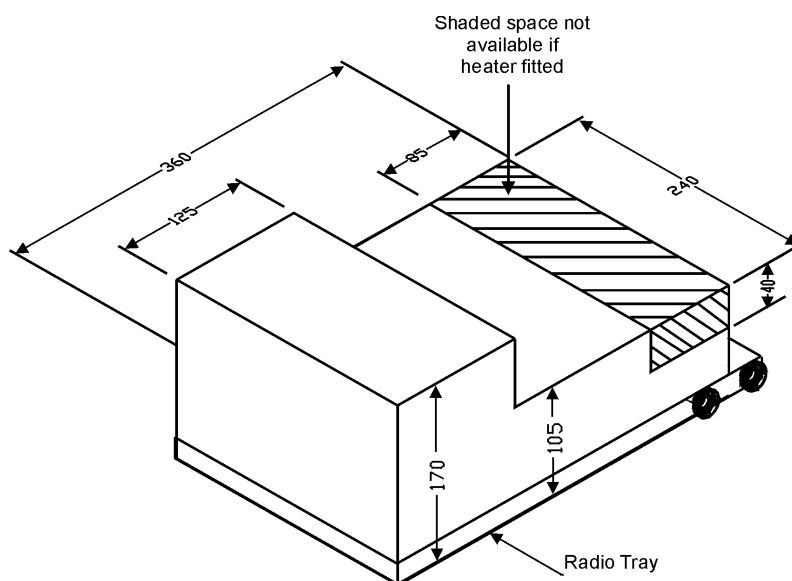


Figure 3: Radio mounting space

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. (See "Low Power Mode" - page 78) .

Auxiliary power comes from one of two sources:

- 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 LBS tank¹. This external VT is connected to the LBS and is called an *Integrated HV Supply*. In this case the rating plate on the transformer indicates its voltage rating.

"Connection of Auxiliary Power" - page 71 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:

- Supply from an external 110V or 240V AC source.

- Supply from an external voltage transformer supplied by the manufacturer.
- Dual 110/240V AC supply from an external source.

1. The VT is designed only for the manufacturer's control cubicle and cannot provide power for any other purpose.

- Dual supply from an external 110/240V AC source and external voltage transformer supplied by the manufacturer.

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 LBS.

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 5 (page 21). 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 5 (page 21). Cable entries are provided for:

- The control cable from the LBS 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 Aerial (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 LBS 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.

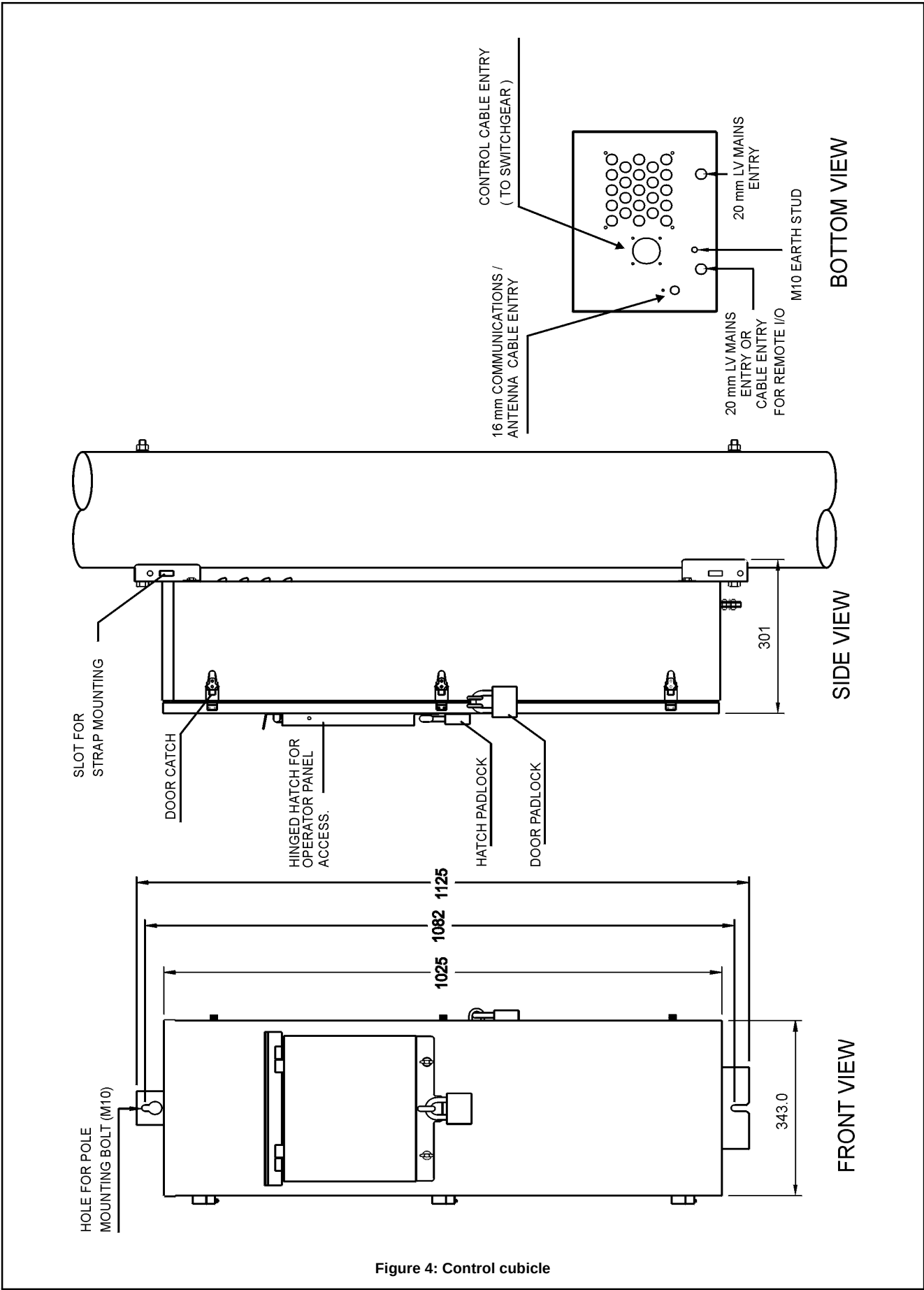


Figure 4: Control cubicle

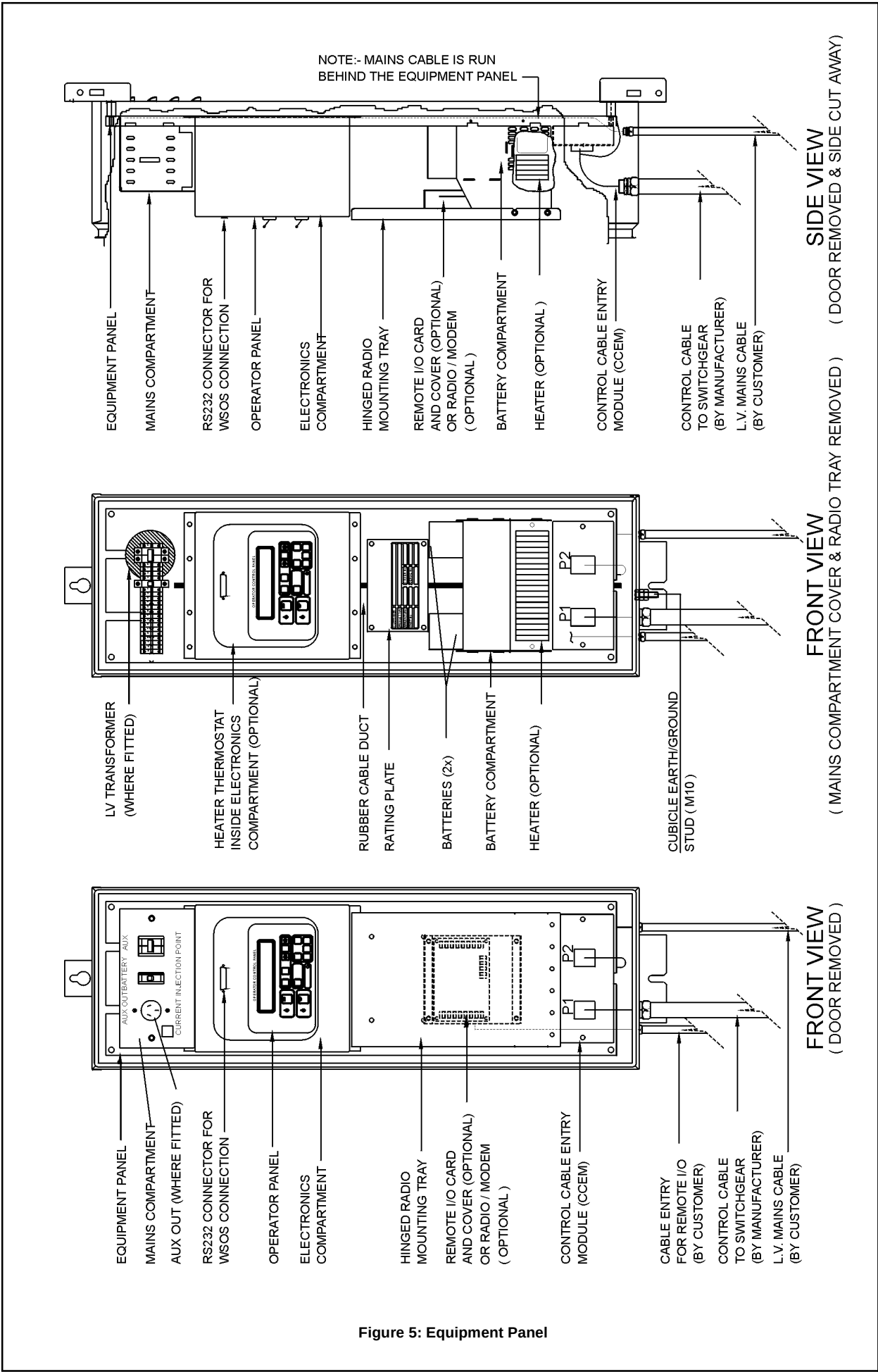


Figure 5: Equipment Panel

6 Control Electronics Operation

The control system block diagram is shown in Figure 6 (page 25). The main features are explained below.

Control & Protection Module

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

The LBS 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 Transformers (CTs), calculation of RMS phase current and earth spill current.
- High speed sampling of the line Capacitive Voltage Transformers (CVTs), calculation of RMS phase/earth voltages.
- Calculation of apparent, real and reactive power flows from the above.
- Fault Detection functions.
- Sectionaliser functions.
- Monitoring of LBS auxiliary switches.

- Monitoring of LBS insulant gas pressure through the pressure transducer and position of the low gas interlock micro-switch.
- Controlling the DC motor to trip or close the LBS.
- 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 Operator Panel Subsystem 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 LBS.

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 memory is used to hold programs, configuration parameters and historical data.
- CAPM 4 has 2Mbytes of memory.
- CAPM 5 has 4Mbytes of 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, when the LBS is connected, the CAPM reads the data from the Switch Cable Entry Module (SCEM) memory inside the LBS¹. The memory data includes error check codes enabling the CAPM to validate the data. The status of the data is 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 LBS operates when the CAPM activates the DC motor in the motor compartment to drive the mechanism. If the LBS fails to operate, the failure is recorded in the event log.

1. Applies to RL-Series FA.

RL-Series Load Break Switch

Normal Operations	The LBS, electronics and power supplies are monitored for correct operation. Data is then 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 module. This data can be used for remotely monitoring the health of the LBS.
Gas Low Lockout	The SF₆ gas pressure inside the LBS is monitored by the CAPM using the built-in pressure transducer. The actual pressure¹ is displayed on the operator control panel page e. g.: SYSTEM STATUS - SWITCHGEAR STATUS: SF6 Pressure Normal 105kPag In the event of a low gas pressure fault condition the same display will read: SYSTEM STATUS - SWITCHGEAR STATUS: SF6 Pressure Low and an SF₆ PRESSURE LOW event is generated. When the gas low condition is detected all electrical operations of the switchgear are locked out.	The RL-Series also features an in-built mechanical Low Gas Interlock. If operation of the interlock is initiated the mechanism is locked and cannot be operated. This action also generates a “MECHANISM LOCKED” event within the Event Log and is shown on:the page: SYSTEM STATUS - SWITCHGEAR STATUS: Mechanism Locked Restoration of the gas pressure and resetting the low gas interlock sensor unlocks the mechanism generating a Mechanism Unlocked event and normalising the status display at the operator control panel.
Event Log	Whenever the status of the control electronics or the switchgear changes, events are generated which are then recorded in an Event Log for display to the operator. Examples of such events are: AUXILIARY SUPPLY FAIL	SF6 PRESSURE LOW Events are viewed on the Event Log pages and can also be uploaded using WSOS. See Section 12 (page 51) for further explanation of the Event Log and Operator Displays.
Manual Lockout	When the manual lockout is in the down position the mechanism is mechanically locked and cannot be operated. This generates a Mechanism Locked event in the event log and may be seen at the operator control panel as a flashing title: Switchgear Mechanically Interlocked	Unlocking the mechanism generates a “Mechanism Unlocked” event and clears the status display on the operator control panel.

1. Note that the “Pressure Normal” range varies according to the LBS model.

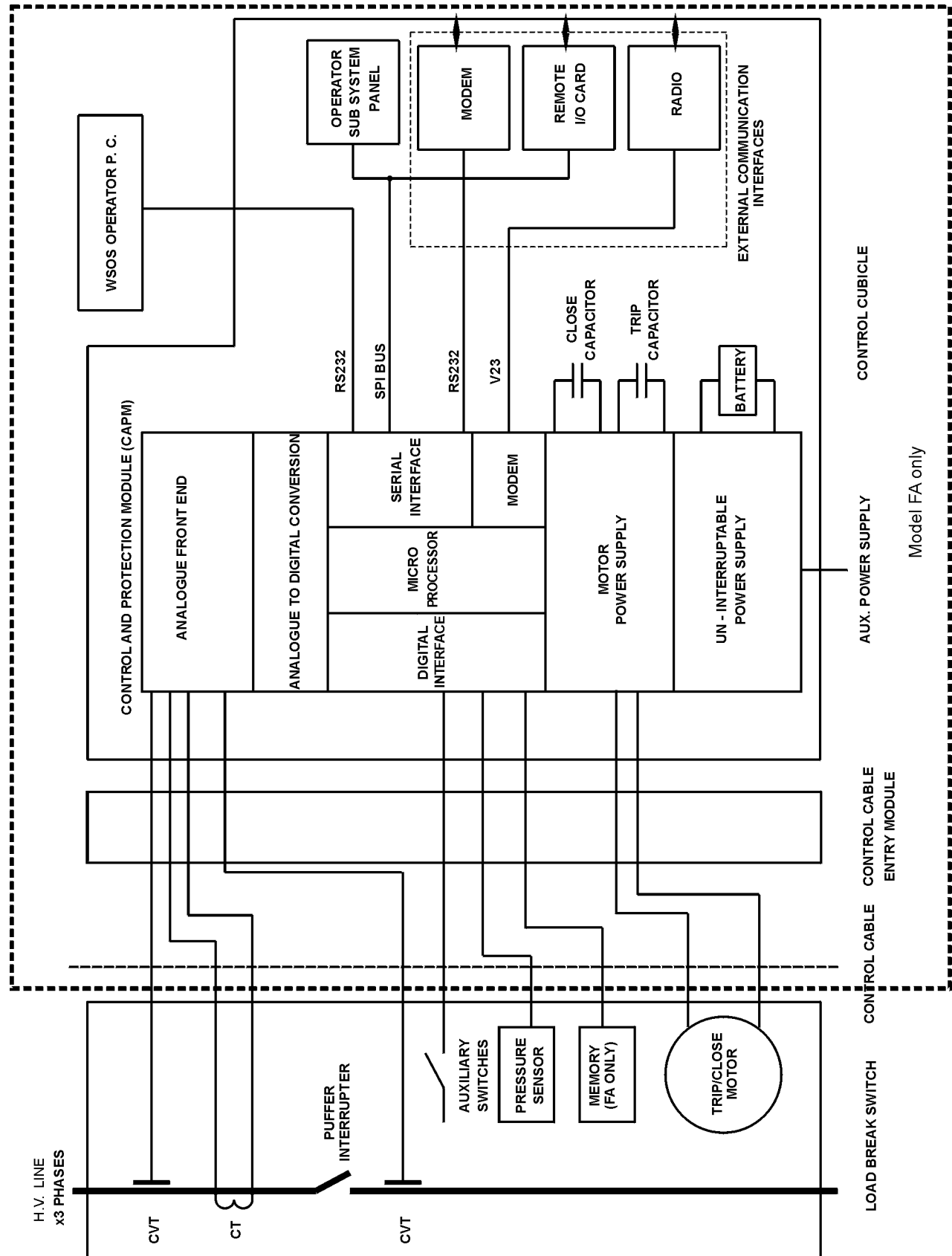


Figure 6: Control System Block Diagram

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 LBS.

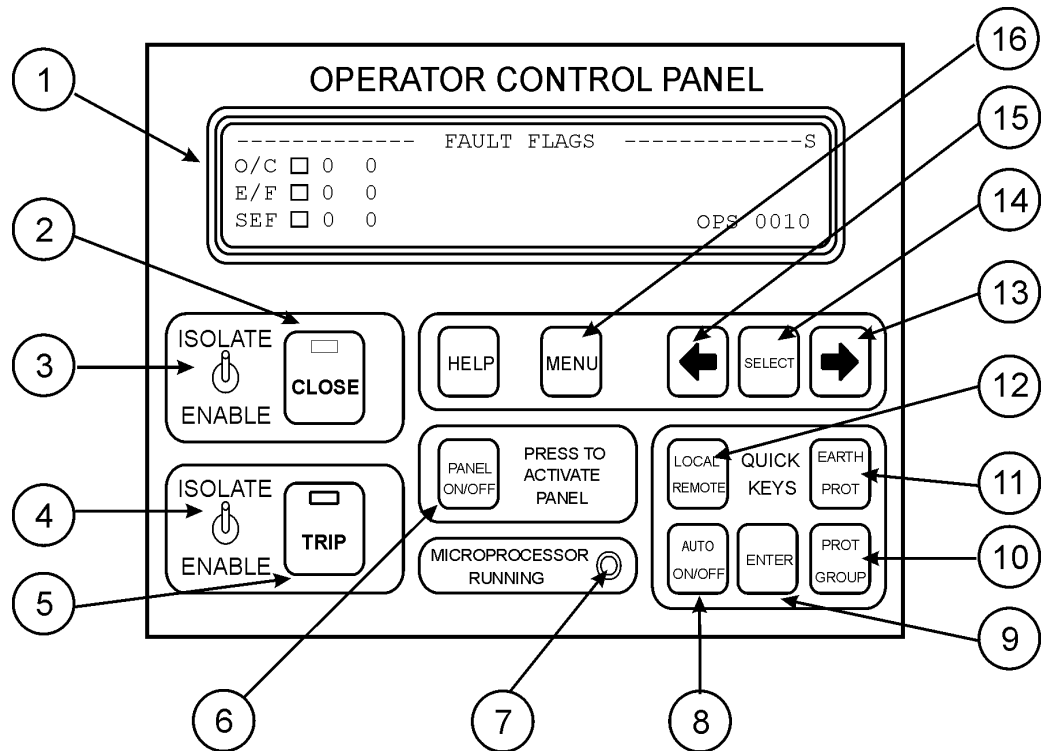


Figure 7: Operator Control Panel

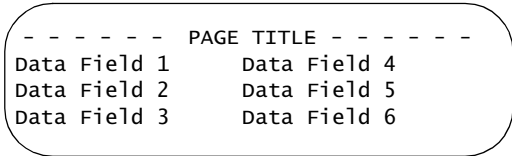
Number	Item	Description
1	Display	Back-lit LCD, 4 line with 40 characters per line.
2	Close key	Generates a Close request to the CAPM when the panel is active. A red LED is embedded in the key. The LED is lit when the LBS is closed.
3	Isolate/Enable Close switch	Isolates the Close key. When the switch is in the Isolate position the motor is disconnected from the control electronics. Thus the switch provides a physical isolation point for the control circuitry. The LBS 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 motor is disconnected from the control electronics. Thus the switch provides a physical isolation point for the control circuitry. The LBS 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 red LED is embedded in the key. The LED is lit when the LBS is open.
6	Panel ON/OFF key	The PANEL ON/OFF key turns the panel on and off.

Number	Item	Description
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	Labelled: AUTO ON/OFF Factory Default Configuration: BLANK
9	Enter key	Activates selected Quick key setting, and restores original display.
10	Quick key ^a	Labelled: PROT GROUP Factory Default Configuration: BLANK
11	Quick key ^a	Labelled: EARTH PROT Factory Default Configuration: BLANK
12	Quick key ^a	Labelled: LOCAL REMOTE Factory Default Configuration: BLANK
13	RIGHT scroll key	➤ - select pages within a display group. Select fields within a page. Increment the value within a field.
14	SELECT key	Press to SELECT Menu item.
15	LEFT scroll key	➤ - select pages within a display group. Select fields within a page. Increment the value within a field.
16	MENU scroll key	Selects the group required.

a. NOTE that the quick key label does not match the its factory default configuration. Reconfigure the quick key (See “Configurable Quick Keys” on page 29.) and apply the relevant sticker to the key while commissioning the unit.

Organisation of Liquid Crystal Display

The display area consists of four lines, each forty characters long.



The top line of the display is the page title. To the right of the title is a letter, indicating the display group to which the page belongs:

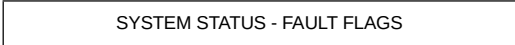
- S System Status Display Group
- E Event Log
- M Measurement Display Group
- D Detection Display Group

The next three lines are the data on display. Pages may not display data in all of the six data fields.

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.



If the time and date has not been set since the last restart then the operator must set it.

Selecting Displays

The **MENU** key selects the display group. The ➤ keys select pages within the group, this is shown in Figure 9 (page 31).

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.

Using the MENU, SELECT and ARROW Keys

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

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 28.
2. Press **SELECT** until the required setting starts to flash.

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

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. Multiple pages

within each group display different data as shown in Figure 9 (page 31).

System Status

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

Information on this display group is given in Appendix A (page 79). All System Status displays have the capital letter 'S' in the top right corner.

Event Log

Shows the event record for the LBS. More information is given in Section 12 (page 51) and in Appendix D (page 89).

Measurement

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

See Section 11 (page 47) and Appendix C (page 87). All Measurement displays have the capital letter 'M' in the top right corner.

Detection

Displays all the fault detection settings currently in use e.g. Fault Settings and Sectionalising.

All Detection displays have the capital letter 'D' in the top right corner.

Configurable Quick Keys

Quick Keys give you quick access to particular settings from any screen.

The fields containing settings that you will frequently change can each be linked to a Quick Key. You use a Quick Key for instant display and selection of the linked field which, otherwise, you would have to find by navigation.

NOTE: The factory default configuration for each Quick Key is BLANK regardless of the label on the key. Configure each Quick Key and apply the relevant sticker while commissioning the unit.

You can configure the Quick Keys using either the operator control panel or WSOS.

Any one of the following fields can be linked to one of the four Quick Keys.

A set of stickers containing labels appropriately worded for each of the available functions is

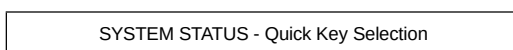
provided with each LBS. (See Appendix E (page 93) for part numbers.) Apply the sticker as required to match the selected functionality of the Quick Key.

ACO On/Off
Cold Load On/Off
Live Load Blocking
Local/Remote/Hit and Run Selection
Sectionalise On/Off
Detection Group Selection
Reset Flags
Work Tag On/Off
Blank

Figure 8: Available Quick Key functions

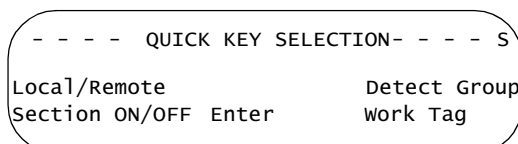
Configurable Quick Key Selection

The Quick Keys can be configured at

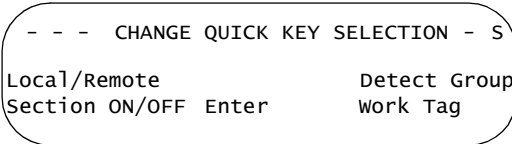


The following screen is displayed:

To configure a Quick Key press **SELECT** or



ENTER and the following screen is displayed with the first field flashing.



Pressing the **ARROW** keys will scroll the operator through the available functions. See Figure 8 (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 you select a function that has been already assigned to another Quick Key, the later selection attempt will be ineffective and that Quick Key will remain configured BLANK.

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. Appendix B (page 85) details this.

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.

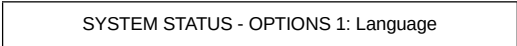
3. This sequence is repeated until the required number of characters has been entered.

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 WSOS utility. The factory password does not have to be remembered - the controller prompts the operator for it automatically.

Languages

The OCPM language can be changed by selecting²



The following languages are available:

- English (International and USA).
- Spanish.
- Portugese.

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

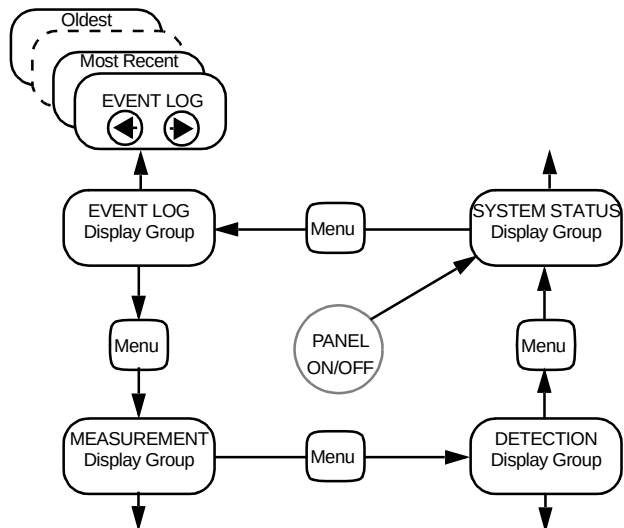


Figure 9: Four main display groups

Measurement Group

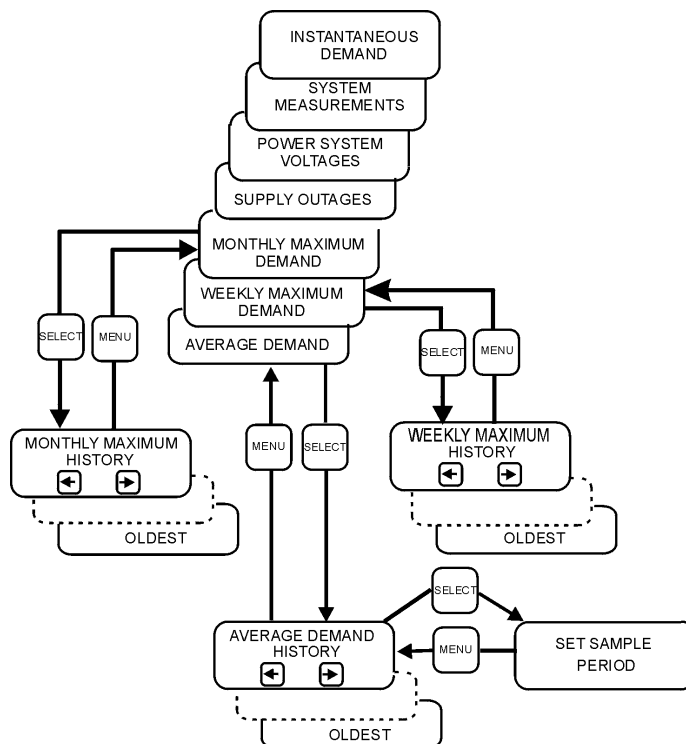


Figure 10: Measurement Group pages

Detection
Group



Figure 11: Detection Group pages

System Status
Group

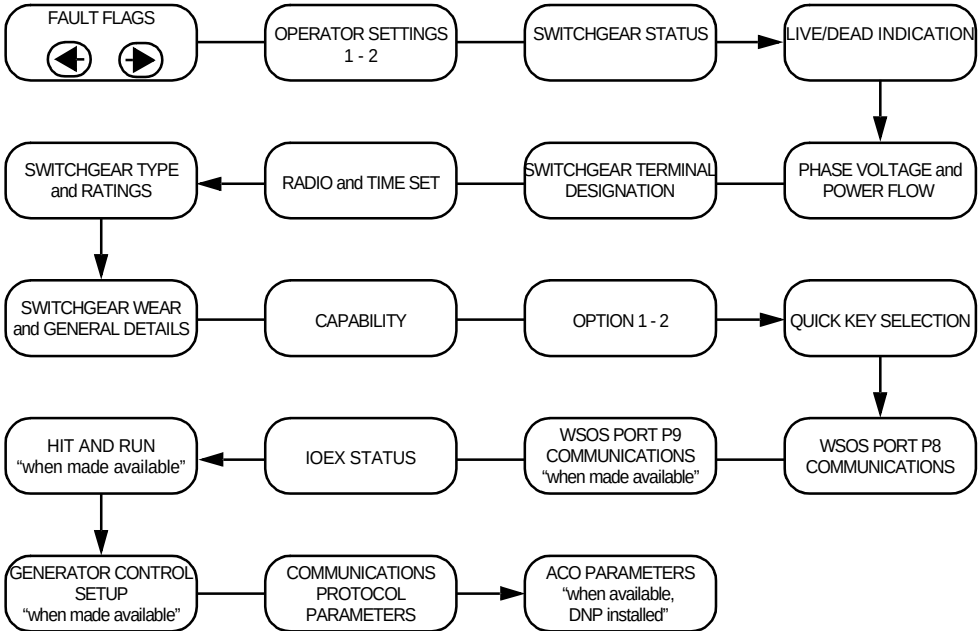


Figure 12: System Status Group pages

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 LBS can be closed to ensure operational safety.

Definition of Local or Remote User

There are four 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 WSOS computer plugged into the computer port on the front of the user control panel.
- Auxiliary Panel - this panel may be configured either local or remote. It provides the capability to access a maximum of five PTCC from one location.

There are four 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.
- A SCADA control protocol. These are always designated as remote users. Full information is given in the relevant protocol manual.
- Auxiliary Panel - this panel may be configured either local or remote. It provides the capability to access a maximum of five PTCC from one location.
- A WSOS computer plugged into the telemetry port.

Local/Remote Mode

The Local Control/Remote Control selection¹ is carried out on

SYSTEM STATUS - OPERATOR SETTINGS

There is a quick key on the panel to make this fast and easy. Setting this mode ensures closing can

only be carried out by the designated local or remote users.

Local/Remote does not affect automatic sectionalising or automatic change-over.

Local Mode

In this mode only a local user can manually close the LBS from the controller panel.

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

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 LBS.

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 LBS operates.

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

There is no change to the operation of the LBS 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 made available through WSOS, it can be turned on at:

SYSTEM STATUS - OPERATOR SETTINGS 1: Hit and Run ON/Local Control ON/Remote Control ON

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

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

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

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 count-down 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 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. Applying and removing tags is password protected.

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

9 Fault Detection

Overview

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

- The fault Detection Elements are Phase, Earth, and Sensitive Earth Fault (SEF). Each individual element can be programmed to log a fault detection depending on the relevant setting.
- The controller stores up to ten groups of Detection Settings that can be selected by the operator, these are Detection Groups A to J.
- In addition to the Detection Settings there are Operator Settings. This group of settings is independent of the Detection Settings and it changes the main functionality of the Load Break Switch.

Basic Fault Detection

The phase, earth and SEF fault detection elements are monitored with independent definite time and fault current settings.

A pickup event is generated for each element if the current exceeds the fault current setting for that element.

A pickup normally initiates a timer which runs for the definite time setting for that element. When this timer expires a fault is said to have occurred and is reported in the Event Log.

The current level at which the definite time timer starts can be modified by a multiplier in the case of Inrush Restraint or Cold Load Pickup.

When all pickups have reset, a peak current event is generated for each element that have picked up. A peak current event is a record of the maximum current measured between fault pickup and fault reset.

The Phase, Earth and SEF fault detection thresholds and definite times are found on:

DETECTION SETTINGS - 2

See Appendix B (page 85)

Upstream Recloser Operation

The LBS can be configured to automatically trip in order to isolate a downstream fault. This action is referred to as sectionalising and is explained more fully in Chapter 1 'Role of the Sectionaliser'. To enable this feature, Sectionaliser Auto must be selected at:

SYSTEM STATUS- OPERATOR SETTINGS

Sectionalising depends on the ability of the LBS to count the operations (trips) of an upstream recloser.

An upstream trip at the recloser is detected by a fault followed by no current and no voltage. This condition is called a *Supply Interruption*.

A supply interrupt detect occurs when the current drops from above the fault threshold to zero within one second and the other phases also reduce to zero current¹.

Interruption of supply is confirmed by ensuring that the source and load side voltages fall below the "Live If" threshold. This causes the Supply Interrupt Count to increment.

The supply interrupt count is displayed at:

SYSTEM STATUS- OPERATOR SETTINGS

A Sequence Reset Timer is used which is triggered each time the supply interrupt counter increments. When the timer expires, the supply interrupt count is cleared.

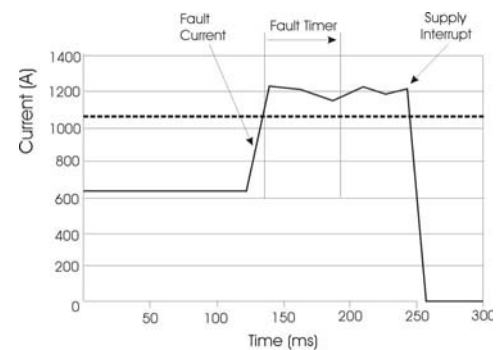


Figure 13: Supply Interruption Detection

Fault Flags

Fault Flag Display Page

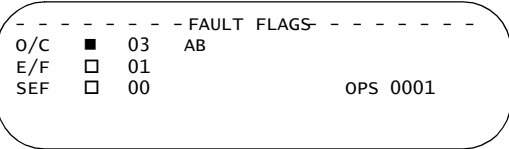
This is the first page in the System Status menu to appear when the panel is turned on. The display identifies each detection element that could detect

a fault and information on the fault history of that element.

1. Zero current is defined as all three phase currents less than 2.5 Amp.

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Each element has an associated fault flag ☐ and a counter. If the fault flag is set thus ☒ it indicates that the element detected a fault during the most recent fault sequence. If the overcurrent flag is set it will also display the phases between which the fault occurred. The counter indicates the number of faults that element has detected since the counter was last reset.



The previous display is a typical example of this page.
The page as shown indicates:

- The Overcurrent element was the only one to detect a fault during the last fault sequence. There have been three overcurrent fault detections since this counter was last reset. They may not have all occurred during the last sequence. The last overcurrent fault detected involved A and B phases.
- The Earth Fault element has detected one fault since the last time its counter was reset. This fault did not occur during the most recent fault sequence.
- There have not been any SEF faults detected since the counters were last reset.

Each counter has a range of 00 to 99. Faults in excess of 99 will not be recorded until the counters have been reset.
Only the overcurrent element displays the letters A, B, C to identify the phase.

FAULT FLAGS			
O/C	☒	03	AB
E/F	☐	01	
SEF	☐	00	
		OPS	0001

Fault Flags screen

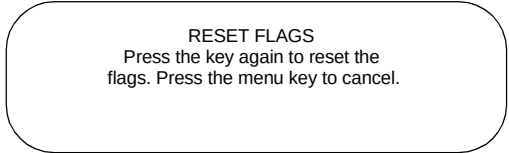
Field		Description
O/C	Phase Overcurrent	The letters to the right of the O/C field identifies the phase or phases faulted.
E/F	Earth Fault	
SEF	Sensitive Earth Fault	This field is not displayed when SEF is unavailable.
OPS	Operations Counter	The "OPS" field indicates the total number of operations performed by the LBS.

Fault Flags - field description

Resetting the Fault Flags

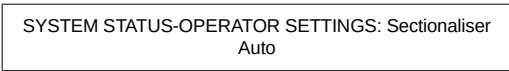
The fault flags may be manually reset using the SELECT key at the operator control panel.
Pressing the SELECT key twice within a ten second period resets the flags and clears all of the counters and phase indications.
On the first press, the following display appears providing the operator with the option to abort the reset operation.

The fault flags can also be reset by an operator trip or close but this does not reset the counters.



Higher Level Settings

The LBS can be configured as a sectionaliser that trips during the dead time of an upstream recloser after a configurable number of supply interrupts. Sectionalising occurs when:



is selected and the number of supply interrupts counted exceeds the "Trip After" setting at:



The supply interrupt count is displayed on:



When sectionalising is enabled, the upstream recloser reclose time must exceed 1.2 seconds to allow for the opening time of the LBS.

Operator Settings

Operator Settings are different from Detection Settings.

They are used by an operator, on an everyday basis, to set the controller into the required mode. For example an operator may want to disable Sectionalising and Sensitive Earth Fault prior to commencing live line work.

The Operator Settings are all found at:

SYSTEM STATUS - OPERATOR SETTINGS

These are:

- Local/Remote Control selection.
- Sectionaliser ON/OFF.
- Operational Cold Load Time and Multiplier.
- Selection of the Active Detection Group or Detection OFF

These operator settings are not affected by changing the Active Detection Group.

For example; if Sectionaliser ON is in force before the Active Group is changed from A to B then Sectionaliser ON will also be in force after the change.

Fault Reset Time

The fault reset time setting determines the amount of time taken for a pickup to reset after the over-current that caused the pickup has gone.

The fault reset time timer starts running after a pickup when the current falls to 90% of the fault current setting. If the current is still below 90% of the fault current setting when this timer expires, the fault is reset. If the current returns to above the 90% level before the fault reset timer expires, the definite time timer continues uninterrupted.

If the current drops below the fault current setting after a pickup but remains above the 90% level, the definite time timer that started at pickup will continue to run. However even if this timer expires, a fault will not be detected unless the current rises back above the fault current setting.

This setting is found on:

DETECTION SETTING - 3: Flt Reset Time ##ms

Sequence Reset

A sequence reset timer is used to reset the supply interrupt counters to zero so that the next supply interrupt count starts again at one.

It starts timing when the Supply Interrupt count is incremented. However, if the fault returns the detection will pick-up again and hold the sequence reset timer at zero. The sequence reset timer

“expires” when it reaches the user set sequence reset time at which a “Sequence Reset” event is then logged.

The Sequence Reset Time is set on:

FAULT DETECT: Seq Reset Time 30s

Detection Settings and Detection Groups

Detection settings are normally applied when a LBS is first put into service and don't need to be changed unless significant changes to network conditions occur.

A detection group is a group of settings which determines when a pickup or fault is detected for each of the detection elements.

The CAPM4/5 controller supports up to ten completely independent detection groups referred to as detection groups A to J.

At the Operator Control Panel, the operator selects either Group A, B, C, ... or J to be Active on:

SYSTEM STATUS-OPERATOR SETTINGS: Det 'A' ... 'J'
Active

The number of detection sets (A-J) available to the operator may also be configured using the Windows Switchgear Operating System (WSOS) program.

Whenever a new Detection Group is activated or a fault detection occurs, an event is written to the Event Log indicating which Detection Group is now in operation. The following are examples of logged events:

Det Group A Active

Det Group B Active

All timers associated with the new setting are reset.

All the detection 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 detection settings.

Changing Detection Settings

All detection 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 detection parameters need to be re-pro-

grammed into the CAPM. This is carried out either through the operator panel or through Windows Switchgear Operator System (WSOS).

The ten groups of detection settings are programmed on the detection pages and passwords

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are required to make changes. Detection Groups should not be changed whilst a detection sequence is in progress.

When programming detection settings the technician first selects which detection group of parameters to display on:

DETECTION SETTING 1 (A - J): Group A - J Displayed

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

OPERATOR SETTINGS: Det 'A' ... 'J' Active

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

DETECTION 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 fault detection 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.

Whilst 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. 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.

Group Copy

Group Copy is available to facilitate the setting of several detection groups which all have the same or similar settings.

It is possible to copy from the displayed detection group to any of the groups available on the CAPM including the active group¹.

This feature is accessed through the detection group at:

DETECTION SETTING 3 (A-J Copy OFF)

Selecting the field allows the operator to scroll through the available copy options as shown at Appendix B (page 85).

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

Live Load Blocking

When:

DETECTION SETTING 3: Live Load Block ON

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

- Live Load Blocking is selected from:

OPTIONS: Live Load OFF/ON

- Live Load Blocking uses the Live Terminal Threshold on:

PHASE VOLTAGE and POWER FLOW: LIVE if > 2000V

Inrush and Upstream Recloser Operation

Purpose of 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. Inrush Restraint inhibits fault detection when inrush current occurs.

Inrush restraint² works by raising the phase and earth Threshold Currents for a short period of time to allow the inrush to flow. The inrush time and multiplier settings are specified on:

DETECTION SETTINGS 4 (A ... J

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

2. Inrush Restraint functionality does not apply to SEF

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

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

When the measured current at a later time becomes non-zero (either through the LBS or an upstream device being closed), inrush restraint is activated for the duration of the inrush restraint time setting. During this time, the phase, earth and SEF elements will still pickup at their respective fault current settings, but the level required for phase and earth fault detection is raised to a new threshold by the inrush restraint multiplier setting.

Operation of Inrush

Whenever the current goes from zero to non zero, the inrush restraint timer is started. While this timer is running the current threshold that must be exceeded in order to start the phase or earth definite time timers becomes the fault current setting for those elements multiplied by the inrush restraint multiplier setting. The inrush restraint time and multiplier settings should be selected in order to mask the inrush current as shown in Figure 14 (page 39).

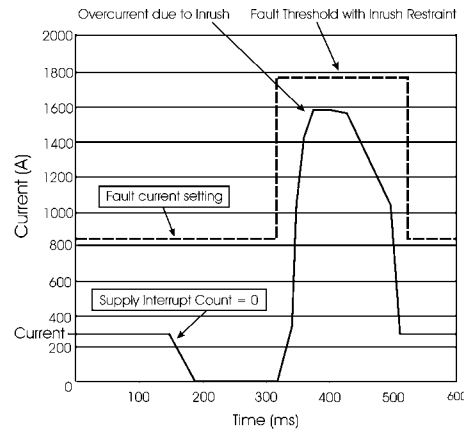


Figure 14: Fault Detection and Inrush

In Figure 14 (page 39), the inrush current has subsided and normal load current is present when the inrush restraint timer expires. Consequently no fault has been detected. However because the measured current exceeded the fault current setting, a pickup and max current events will be logged.

If the measured current had been still higher than the fault current setting when the inrush restraint timer expired, the definite time timer for that element would have started. If the current remained above the fault current setting for the definite time setting, a fault for that element would be detected.

Inrush restraint is disabled if the supply interrupt count is greater than zero.

In other words, if the current is zero due to the protection trip of an upstream recloser, the LBS should have also seen the fault and its supply interrupt count will be at least one. In this case as shown in Figure 15 (page 39), the inrush restraint will be disabled and the multiplier will not apply if the current goes to non-zero when the upstream recloser closes.

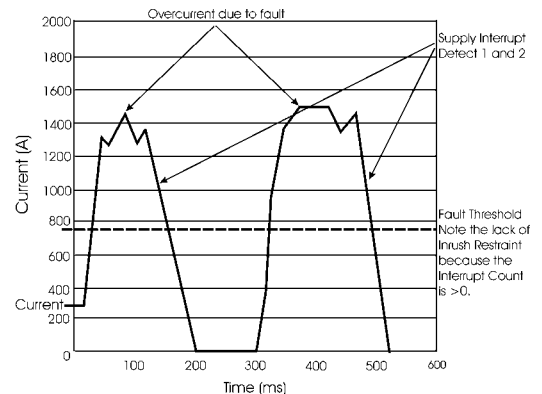


Figure 15: Downstream fault detection

Inrush will not work with currents of less than 2.5 amps.

Cold Load Pickup

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

The load is higher than usual when power is restored 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 (CLP) feature is to allow for this loss of diversity automatically and inhibit fault detection. 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 (OCLM) is calculated using the formula shown in Figure 16 (page 40). The Operational Cold Load Multiplier is used to modify the phase and earth Threshold Current Multipliers.

Cold Load Pickup functionality does not apply to SEF.

Therefore the phase and earth detection thresholds 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 and earth thresholds are 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 one (1) and hence the phase and earth threshold currents also reduce back to their values. Note that the rate of increase and decrease of threshold currents 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 LBS) the compensation will still work.

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

DETECTION SETTINGS 4

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

DETECTION SETTINGS 4

- 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 phase and earth detection thresholds but not SEF.

Cold Load Pickup cannot be used if normal currents are expected to drop below 2.5A and should be turned off.

Cold Load Pickup Status Display

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

SYSTEM STATUS - OPERATOR SETTINGS: Cold Load

This can show the following states:

- Cold Load OFF: Cold load pickup has been configured OFF in the currently active detection 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 (probably because the load current is on and Operational Cold Load Time is zero). This is the normal condition.
- CLP 60min X1.5mult (for example). The display shows the Operational Cold Load Time and Multiplier. This affects the detection 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 detection group it can be further controlled by using the **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.

$$M_1 = 1 + \left[\frac{T_1}{T_2} \times (M_2 - 1) \right]$$

M₁ - Operational Cold Load Multiplier
M₂ - User Set Cold Load Multiplier
T₁ - Operational Cold Load Time
T₂ - User Set Cold Load Time

Figure 16: OCLM Formula

Automatic Detection Group Selection

Sometimes a Load Break Switch is used at a location within a supply network where the power flow may be in either direction depending on the configuration of the rest of the network.

One example of this is at a network tie point.

In this situation the operator may have to select a different group of detection settings to compensate for a change in power flow when changing the network configuration. In other situations, emergency switching configurations may require more than one pair of Detection Groups.

Enabling Automatic Selection

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

- ADGS is made available by setting:

SYSTEM STATUS - OPTIONS 1: ADGS Allowed

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

SYSTEM STATUS - OPERATOR SETTINGS: Detection
Auto

- The display will show the currently active detection group set by displaying:

SYSTEM STATUS - OPERATOR SETTINGS: Auto 'A' to 'J'
Active

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

Disabling Automatic Selection

ADGS is turned OFF (disabled) either by:

- An operator change in power flow direction on the following page (e.g. changing from Source I and Load X to Source X and Load I).

SYSTEM STATUS - PHASE VOLTAGE and POWER FLOW

- Selecting a Detection Group other than

SYSTEM STATUS - OPERATOR SETTINGS: Detection
Auto

- Setting

SYSTEM STATUS - OPTIONS 1: ADGS Not Allowed

Selection Rules

Once the ADGS function is enabled the active Detection Group is automatically selected according to the following rules:

- There are a maximum of five pairs of ADGS Detection Groups: A & B, C & D, E & F, G & H and I & J. Each pair consists of a primary Detection Group and Alternate Detection Group respectively.
- The number of ADGS pairs depends on how many detection sets are selected to be available. Where an odd number of Detection Groups have been selected, the last group does not participate in ADGS. Detection Auto cannot be selected with this last group active.
- Primary Detection Group A, C, E, G or I is used when the power flow is in the positive direction (source to load).

- Alternate Detection Group B, D, F, H or J is used when the power flow is in the negative direction (load to source).

- For ADGS to generate a change from Primary to Alternate Detection 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: Auto Change Time 60s

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

SYSTEM STATUS - OPTIONS: Auto Change Time 60s

10 Power System Measurements

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

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

Switchgear Terminal Designation

The six bushings on the Load Break Switch (LBS) are labelled I, II, III and X, XX, XXX.

Bushings must have the correct power system phase assigned at time of installation, a process called "setting the phasing". Setting the phasing affects all the displays, events, etc., concerned with switchgear terminals, for example: voltage measurements, live/dead terminal displays and maximum current events.

Phasing is set from page.

SYSTEM STATUS - SWITCHGEAR TERMINAL
DESIGNATION

The first line of the display allows the operator to cycle between the six possible phase combinations (ABC, ACB, BAC, BCA, CAB, CBA). When the operator presses the **ENTER** key, the controller then orientates the currents and voltages to match the selection.

After the phasing has been set, the operator should record the details on the Operating Instructions label affixed to the rear of the control cubicle door to indicate the relationship between the bushings and phases.

SWITCHGEAR TERMINAL DESIGNATION			S
I / X	Terminals	A Phase ^a	P
II / XX	Terminals	B Phase	P
III / XXX	Terminals	C Phase	P

Switchgear Terminal Designation screen

a. The phase designations can be rotated from this field by pressing the arrow key (ABC, ACB, BAC, BCA, CAB, CBA).

Power Flow Direction

The switch is a symmetrical device meaning that either side can be connected to the power source.

Consequently, after installation, the controller must be configured to designate source side. This is done by configuring the direction of power flow so that *positive* power flows from source to load. The engineer can configure which set of bushings corresponds to the source and load.

The power flow direction is configured on

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

When changed, this reverses the power flow direction but not the phasing. See "Switchgear Terminal Designation" - page 43).

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 Demand display and ADGS.
- Which is the source or load for Live Load Blocking.

RL-Series Load Break Switch

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:

- Currents in each phase and to earth.
- 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.
- Voltage on the source side terminals. The voltages can be either phase to phase or phase to earth. This is a selectable item from:

SYSTEM STATUS - PHASE VOLTAGE and POWER
FLOW: Display Ph-Ph Volt

- Live/Dead indication on all six terminals.

The displayed data looks like this:

```
- - - - INSTANTANEOUS DEMAND - - - - M
Earth  0 Amp      A Phase  123 Amp
        2749kw    B Phase  128 Amp
        0.93PF    C Phase  121 Amp
```

```
- - - - System Measurements - - - - M
Power(P) 2479 kW
Power(Q) 200 kVAR
Power Factor 0.93
```

If phase to phase voltages are selected rather than phase to earth then the measurement page 2 and 3 text will change.

```
- - - - SOURCE SIDE VOLTAGES - - - - M
Ai phase to earth 12700 volt
Bi phase to earth 12700 volt
Ci phase to earth 12700 volt
```

```
- - - - LOAD SIDE VOLTAGES - - - - M
Ax phase to earth 12700 volt
Bx phase to earth 12700 volt
Cx phase to earth 12700 volt
```

An example of the new text is as follows:

```
- - - - SOURCE SIDE VOLTAGES - - - - M
Ai-Bi phase to phase 22000 volt
Bi-Ci phase to phase 22000 volt
Ci-Ai phase to phase 22000 volt
```

```
- - - - LOAD SIDE VOLTAGES - - - - M
Ax-Bx phase to phase 22000 volt
Ax-Bx phase to phase 22000 volt
Ax-Bx phase to phase 22000 volt
```

The page

SYSTEM STATUS - LIVE/DEAD INDICATION

displays the terminal live/dead indication as follows:

```
- - - - LIVE/DEAD INDICATION - - - - S
Ai Live      Ax Live
Bi Live      Bx Live
Ci Live      Cx Live
```

Maximum Demand Data Displays

Monthly Maximum

For each calendar month, the period with the greatest 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 greatest 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
weekending 10/01/2001 total 17565kwh
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 in each phase 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 13:45:00A Phase 123Amp
2749 kw B Phase 128Amp
0.93 PF C Phase 121Amp
    
```

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 the Windows Switchgear Operating System (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
    
```

Figure 17 (page 46) shows the WSOS screen with the data that may be selected and displayed through WSOS¹.

1. The Data Storage Time is calculated from the parameters selected from the above table and then displayed at the WSOS screen. All data is averaged over the logging period.

RL FA Series History Configuration [OffLine]

Current

☐ Mean I abc
 ☒ I a
 ☒ I b
 ☒ I c
 ☐ I g

Power

☒ kW
 ☐ kVA
 ☐ kVAR
 ☒ Power Factor

Voltage

☒ Phase To Ground
 ☐ Phase To Phase

☐ Mean Vi abc
 ☐ Mean Vi ph-ph
 ☐ Mean Vx abc
 ☐ Mean Vx ph-ph
 ☐ Vi a
 ☐ Vi a-b
 ☐ Vi b
 ☐ Vi b-c
 ☐ Vi c
 ☐ Vi c-a
 ☐ Vx a
 ☐ Vx a-b
 ☐ Vx b
 ☐ Vx b-c
 ☐ Vx c
 ☐ Vx c-a

☐ Auxiliary Supply

Switchgear Data

☐ Electronics Compartment Temperature
 ☐ Battery Voltage
 ☐ Gas Pressure (*)
 ☐ Switchgear Temperature (*)

Log Period

Average Period

15 Minutes

Estimated Time Before Oldest Data Is Overwritten

N/A

* - Not available on some switchgear types

Poll

Exit

Help

Defaults

Figure 17: WSOS Configuration data

11 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 feature utilises built-in LBS 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 LBS terminal voltages to determine when there is an outage.

- A loss of supply voltage on one or more phases for a user-set time is defined as the start of the outage.
- When voltage is restored to all three phases for the same user-set time it is defined as the end of the outage.
- The reported outage duration is the actual time without voltage.

Due to the LBS measuring voltages on both the source and load terminals, outages on source side

and load side network segments are monitored separately. The LBS logs the start and end time of each outage, the total duration and the number of outages on each network segment. When an outage is detected on either segment it is timed and the data is held in the database for future analysis.

If the LBS 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 that specific outage is discarded. The outage counter is maintained.

Configuration and Display

Supply Outage Measurement is configured and displayed on the page.

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. See Appendix A (page 79).

The following tables show the Supply Outages screen and describe each field.

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

Supply Outages screen

RL-Series Load Break Switch

Field	Description
Measure Outages ON/OFF	Supply Outage Measurement function enabled/disabled. <i>Default is Measure Outages OFF.^a</i>
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. <i>Range: 1 to 3600 sec. Default is 60s.</i>
Source Outages	Number of supply outages on the source terminals
Load Outages	Number of supply outages on the load terminals
Duration	Total duration of supply outages in hours, minutes and seconds for both source and load-side terminals. <i>Maximum: 9999 hours, 59 mins, 59 sec.</i>

Supply Outages-field descriptions

a. Different default values may be factory loaded.

The displayed data looks like this.

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

Resetting the Counters and Timers

To reset the counters find the page:

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.

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 LBS load terminals experienced a supply outage up to 59 minutes 59 seconds.
Load Out 99 h 59 m	The LBS load terminals experienced a supply outage up to 99 hours 59 minutes.
Load Out 9999 h	The LBS load terminals experienced a supply outage above 100 hours.
Outages ON	The operator has turned ON or OFF the supply outage measurement functions.
Outages OFF	
Outages reset	The operator has reset the four outage counters.
Source Out 59 m 59 s	The LBS source terminals experienced a supply outage up to 59 minutes 59 seconds.
Source Out 99 h 59 m	The LBS source terminals experienced a supply outage up to 99 hours 59 minutes.
Source Out 9999 h	The LBS source terminals experienced a supply outage above 100 hours.

Supply Outage events

The following example shows a typical sequence of events where a LBS 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 LBS.

Supply outage is logged for source and load sides.

12 Event Log

When the status of the control electronics or LBS 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 12:09:02.06	Close Coil Connect	
10/01/01 12:09:03.95	Panel close req	
10/01/01 12:09:37.95	Load 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 D (page 89) 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 if 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.

Detection Generated Events

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

- Detection 'Pickup' occurs when any of the enabled detection elements picks up (this event is particularly useful when current injection testing).
- Switchgear fault detect. A series of events indicate the active detection setting, whether the fault was caused by phase, earth or SEF detection elements.

- The magnitude of the maximum RMS fault currents detected by the 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 below the setting current (i.e. reset). *This means they will be time stamped after the fault detection in the event log.*
- Expiration of the sequence reset timer.
- Supply Interruption count.

Loss of Supply Events

The control electronics monitors voltage screens embedded in the H.V. bushings to determine if the terminals are 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
--

Terminals are 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 all three source side terminals 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.

If¹ individual phases change from LIVE to DEAD or vice-versa for the Supply Timeout then events are generated for these phases e.g. 'Bi Live', 'Bx Dead'.

In situations where large numbers of Auxiliary Supply Events are generated it may be preferable to stop the display of those events in the Event Log. Change the setting in page:.

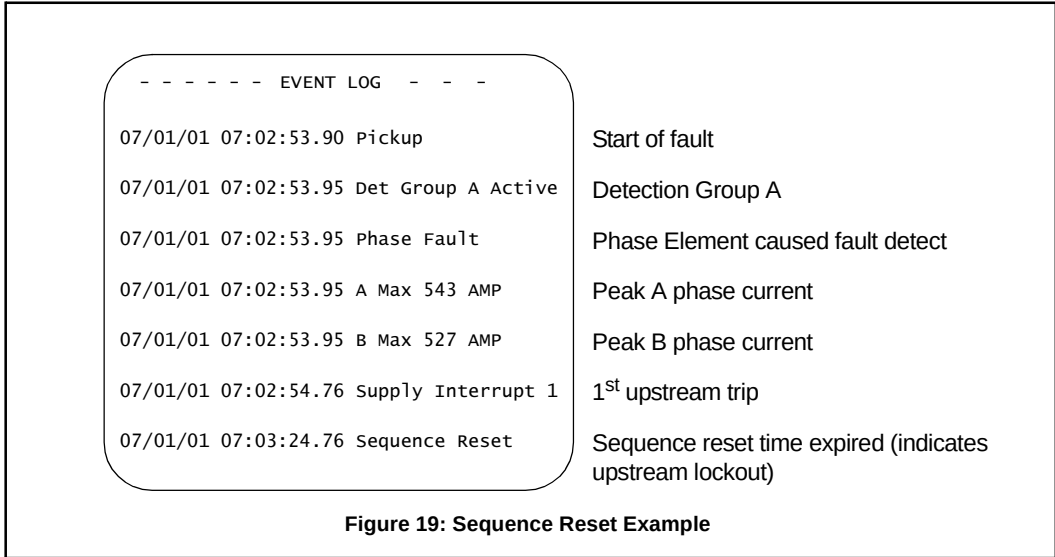
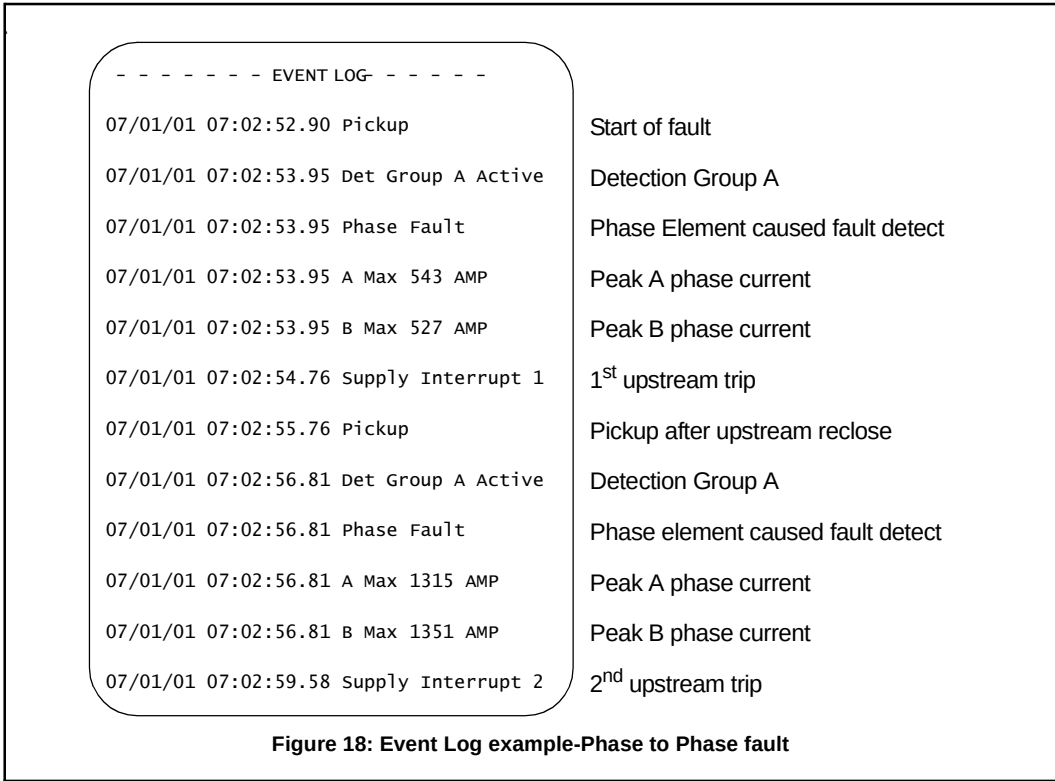
SYSTEM STATUS - OPTIONS 3: Aux Supply Evts ON

1. The designated Source and Load sides can be swapped in relation to the switchgear terminals, refer to Section 9 (page 35).

Typical Event Log Displays

A typical sequence of events for a phase/phase fault, where an upstream recloser had instantaneous protection on the first trip and inverse time detection on the second trip with two trips to lock-out, may result in the sequence shown in Figure 18.

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 19



13 Generator Control

Operation

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

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

When the LBS 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 LBS 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.

Configuration and Display

This option can be turned ON or OFF in

SYSTEM STATUS - OPTIONS 1-Generator Control

The displayed screen is shown and described in the following tables.

With “**Generator Control On**” and the LBS in the open position, close is inhibited if the load side bushings are energised.

OPTIONS 1					S
ADGS Allowed APGS Not Allowed		P	ADGS Change	60 s	
Lang English (Intl)			GenCtrl Not Avail GenCtrl Available		P

Options 1 screen

Field	Description
GenCtrl Not Avail GenCtrl Available	Generator Control Availability This field is used to make Generator Control available or not available. Not Available means that the Generator Control page is not displayed and Generator Control is Off. <i>Factory default is not available.</i>

Options 1-field descriptions

The screen shown below will be displayed after the IOEX Status page 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

RL-Series Load Break Switch

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

Generator Control-field descriptions

To reconfigure the IOEX mapping for Generator Control, the “Generator Control” and “Generator

Run Request” outputs should be assigned to IOEX outputs.

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 LBS. 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 $\pm 13V$ 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

RL-Series Load Break Switch

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

Exact use of signals depends on the protocol software installed.

WARNING

When connection a radio or modem to Port 8 ensure that there is no power to the PTCC.

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, 600 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 600,1200, 2400, 9600 and 19200.	P	ModeLocal ModeRemote	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 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 No:	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 "Connection of Auxiliary Power" - page 71 . 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
  
```

It is possible to configure the system to cycle power to the modem periodically. The relevant setting is on page

```

SYSTEM STATUS -RADIO and TIME SET: Modem Pwr
Cyc OFF
  
```

The default for this setting is OFF, otherwise you can enter a numeric in the range 1 to 48 causing power to the modem to be cycled every *n* hours.

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 cords and use their slots.

1. The power supply is not isolated.

RL-Series Load Break Switch

All cables running into the electronics compartment must be round, sheathed and between 9 and 10.5mm in diameter to ensure a good seal.

Heatshrink sleeving can be used to increase the diameter of a cable. See "Replacement of Electronic Modules" - page 78 for instructions on removing the electronics compartment cover to gain access to the CAPM.

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 70 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 "Inputs - Standard Mapping" - page - 60 and "Outputs - Standard Mapping" - page - 60 respectively.
- Some equipment may be supplied with customised 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

"Definition of Local or Remote User" - page 33 for further information on Local and Remote Users.

IOEX Status Page

The following page

SYSTEM STATUS - IOEX Status

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. See Appendix A (page 79).

The following tables show the IOEX Status screen and field descriptions.

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

IOEX Status screen

Field	Description
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.
IOEX Local IOEX Remote	Designates the IOEX to be either a local or a remote user. Refer to See "Definition of Local or Remote User" - page 33 .
IOEX OK	Shows the status of the IOEX: "IOEX OK" means that the mapping is valid and in service.
Invalid Map	"Invalid Map" means there is a problem with the IOEX mapping in the database. Contact the manufacturer.

IOEX Status-field descriptions

RL-Series Load Break Switch

Field	Description
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 Nu-Lec Industries.
Initialising	"Initialising" is displayed while the IOEX is being initialised.
LBS Standard Mapping	See "Inputs - Standard Mapping" - page - 60 This is the title of the IOEX map loaded and may be altered via the Configurable IOEX tool.

IOEX Status-field 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

Inputs - Standard Mapping

The IOEX has 12 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
		Load Break Switch
1	1-2	Trip the LBS
2	3-4	Close the LBS
3	5-6	Reset Fault Indicator (and other flags)
4	7-8	Not used
5	9-10	Sectionaliser ON
6	11-12	Sectionaliser OFF
7	13-14	Detection Set A Selected
8	15-16	Detection Set B Selected

- The LBS "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 33).
- 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 LBS 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 Sectionalise ON and OFF inputs are on, the default is Sectionalise 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
3	29-30	Flag A. See table below.	
4	31-32	Fault Indicator ON	Fault Indicator OFF

Output Number ^a	Terminal Number	Output On (relay closed)	Output Off (relay open)
5	33-34	Not used	Not used
6	35-36	Sectionaliser ON	Sectionaliser OFF
7	37-38	Flag B. See table below.	
8	39-40	System Healthy	System not healthy

a. The IOEX contacts are not guaranteed during a fast upstream auto-reclose sequence but will indicate the final steady state condition within 150ms.

Trip Source ^a	Flag A, Trip indication	Flag B, Trip indication
Faults Reset	Off	Off
Phase Fault	On	On
Earth Fault	Off	On
SEF Fault	On	Off

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.

- Gas pressure normal.
- Contact Life greater than 20% on all phases.
- 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. The manufacturer's battery holdup time rating is based on an LBS 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) or higher.

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 4.13 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.

RL-Series Load Break Switch

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 LBS 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 27) 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 Sectionalisers. WSOS is purchased as an additional item. For pricing information refer to your distributor.

WSOS provides facilities for:

- Online and Offline management of all detection 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 LBS 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. See Figure 2 (page 15).

It is a standard RS232 connection running at 19.2 kBaud unless otherwise configured. See Section 14 (page 55).

The port is normally used to connect a portable notebook PC for maintenance purposes such as downloading settings or uploading the event record. This port is designated a Local User, as defined in Section 8 (page 33), and may be configured as remote.

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, please refer to "Communications Interfaces" on page 55.

To gain remote access a modem must be installed in the control cubicle allowing the PC to control the sectionaliser 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 detection 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 LBSs. More information is provided in the WSOS Technical Supplement Manual N00-402.

This port is designated as a Remote User, as defined in Section 8 (page 33). Section 14

(page 55) 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 the

SYSTEM STATUS - WSOS Port P8 Communications

page 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 N00-218 gives more details on the opera-

tion 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 the page.

SYSTEM STATUS - WSOS Port P8 Communications
--

- 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 its 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.

Remote Control Panel

The remote control panel provides dual control for the manufacturer's Sectionalisers 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. This panel can be used to select and monitor up to five LBS.

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 detection 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 sectionaliser.

- Confirm the Pole Top Control Cubicle (PTCC) and control cable connections on all the manufacturers Pole Top LBSS.

- 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.

17 Installation

Unpacking & Checking

Contents of Crate

Each crate includes:

- Pole top LBS.
- Pole mounting bracket.
- A mounting kit containing nuts and bolts for bolting the mounting bracket to the LBS, pole clamps and bolts if purchased.
- Control cubicle (which will normally contain two batteries unless arrangements have been made to ship batteries separately).
- Control cable.
- Six cable tails (where supplied by the manufacturer) pre-terminated to fit into the LBS bushings.

- Surge arrestor brackets.

Additionally, for 27kV and 38kV units:

- Six bushing boots with clamping rings attached.
- Six tubes of electrical silicone grease to fill the bushing boots.
- One clamping ring spanner to fit boots to the bushings.

On receipt, the contents should be checked for shipping damage and the manufacturer informed immediately if any is found.

Unpacking Procedure

Tools required:

- Wrecking bar to remove nails.
- Four D shackles, two slings and crane with a safe working load of 300kg to lift the LBS.
- Screwdriver or battery drill with 8mm socket.

Procedure:

1. Remove the top of the crate and lift out the HV cables.
2. Unscrew and remove the four (4) screws located on the outside walls of the crate and remove the two (2) pieces of wood that sit across the top of the LBS.
3. Lift the zipper bag and cardboard box out of the crate.
4. Unscrew and remove the four (4) screws that secure the LBS to the base of the crate.
5. Fit D-shackles to the lifting points on the LBS and carefully lift it out of the crate onto the ground using a crane.
6. Remove the control cable and other accessories.

7. Unscrew and remove the two (2) screws located on the outside wall of the crate that secures the wood block on top of the mounting bracket. Unscrew and remove the screw securing the mounting bracket to the base of the crate and remove the bracket and bushing boots from the crate.

CAUTION

Take great care not to drop the bracket, which weighs 20kg, onto the LBS.

8. Unscrew and remove the screws that secure the surge arrestor brackets to the base of the crate and remove the brackets from the crate.
9. Unscrew and remove the two (2) screws that secure the top and bottom of the control cubicle to the base of the crate and lift the control cubicle out of the crate.

WARNING

The control cubicle weighs approx. 35kg.

Control Cable Connection

When installing or testing the LBS 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 20 (page 66) and Figure 21 (page 66) and Figure 22 (page 66)

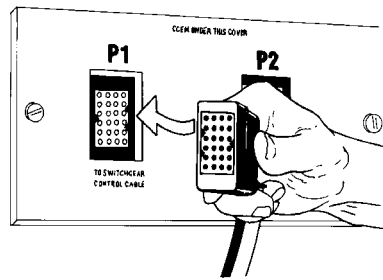
- Power down the control cubicle by switching off all MCB's. This should be done whenever connecting or disconnecting the control cable from the control cubicle
- *To connect:* hold the plug by the long sides, check orientation, gently locate it on the socket and push firmly home. Check it has locked by wiggling 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.

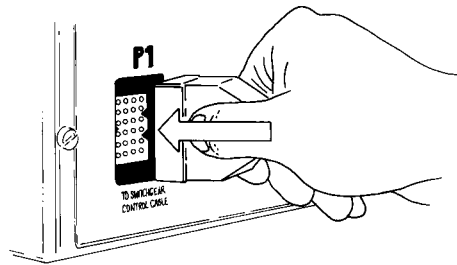
CAUTION

Never pull the plug out by the cable.



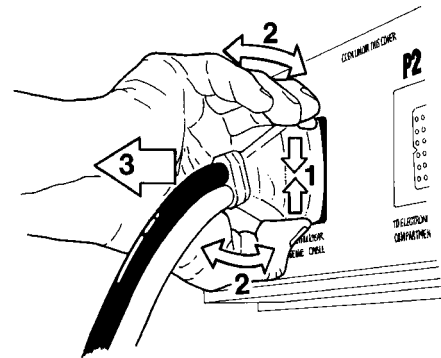
Check orientation

Figure 20: Connecting the control cable (1)



Locate and push home

Figure 21: Connecting the control cable (2)



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

Figure 22: 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 HV cables, boots and the control cable in a clean safe place where they will not be damaged or soiled. Make a temporary earth connection between the control cubicle and the LBS, this need only be 1mm² copper wire.

Unbolt one of the compartment cover plates from the bottom of the LBS and connect the control cable to plug P1 on the Switch Cable Entry Module (SCEM) located inside the compartment. See "Control Cable Connection" - page 65 for the correct way to connect the control cable.

■ If desired the LV auxiliary supply (if applicable) can be connected as shown in Figure 24 (page 70).

If the LBS has an integrated power transformer then a temporary auxiliary supply can be made by connecting a fused and isolated twenty-four Volt AC or thirty-six Volt DC (24VAC or 36VDC) supply between terminals 2 and 3 of the terminal block in the mains compartment. A fused, *isolated*, 36 Volt battery is a good way to do this.¹

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

1. Manual trip and close of the LBS.
2. Insulation test the high voltage connections to earth to check for shipping damage on the high voltage side of the LBS.
3. Configure the fault detection 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.

CAUTION

Once the LBS has been connected to a powered-up control cubicle, do not disconnect or turn off the control cubicle for at least ten minutes after the last trip or close.

■ Attend to the battery using the care instructions given in "Battery Care" - page 77 .

CAUTION

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

■ An application note detailing workshop and field test procedures is available. Contact your agent or distributor.

It may be desirable at this time to fit the cable tails and surge arrestors to the LBS. See "Surge Arrestor Mounting and Terminating" - page 69 .

1. This supply connects directly to the CAPM and cannot be turned off by the control cubicle miniature circuit breakers.

Transport to Site

If the unpacking and testing was carried out in the workshop then the LBS 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 LBS

and control cubicle and put back the cover plate on the bottom of the LBS.

- Either remove the batteries from the control cubicle and safely transport them separately or secure the batteries in the control cubicle.
- Transport the LBS, control cubicle and all parts in a safe and secure manner to site.

Site Installation

Tools Required

- Torque wrench and metric socket set, standard engineer's tools.
- Standard 300gm cartridge applicator. (Caulking Gun).
- Bushing boot clamping spanner. (supplied by the manufacturer).

- Tools to prepare pole and HV connections as required.
- Crane or other lift for LBS 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 2 (page 15). 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 4 (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 26 (page 73), Figure 24 (page 70), and "LV Auxiliary Power from Mains" - page 71 .
- 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

WARNING

It is vital that the earthing scheme described is carried out

To erect and test the LBS carry out the following steps. Mounting details are given in Figure 39 (page 105) and Figure 26 (page 73):

1. Transport to site and carry out testing prior to erection as required.
2. Connect cable tails and surge arrestors, if required, before elevating or raising the LBS. See "HV Cable Tail Connections" - page 68 .
3. Ensure that the pole is of sufficient strength to support the LBS. A structural engineer may be needed to calculate the stresses involved.
4. Securely mount the LBS mounting bracket on the power pole.
5. Lift the LBS into position and slide it on to the mounting bracket so that it hangs from the mounting bracket. Figure 2 (page 15).
6. Bolt the LBS to the mounting bracket with the two 12mm nuts and bolts provided. Tighten to 40 Nm.
7. Complete the high voltage connections as shown in Figure 25 (page 72) or as appropriate for the site installation.

8. 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 10mm bolt and simply slid into position.

9. Run the earth connections as shown in Figure 26 (page 73). See "Earthing" - page 70 .
10. For LV mains supply run auxiliary wiring as shown in Figure 27 (page 74). See "LV Auxiliary Power from Mains" - page 71 . Make connection inside control cubicle as shown in See Figure 24 (page 70). **Make sure the LV mains cable is run behind the equipment panel.**

CAUTION

It is vital that the scheme described above is carried out.

11. For LV supply from a dedicated transformer supplied by the utility, connect as shown in Figure 27 (page 74).
12. For Integrated supply from an external transformer, connect as shown in Figure 27 (page 74).
13. Unbolt and remove the cover plate from the bottom of the motor enclosure. Connect the control cable to plug P1. See "Control Cable Connection" - page 65 for the correct way to

connect/disconnect the control cable. Then bolt up the cover. The cover can be fitted in different orientations, to best suit the installation.

14. Run the control cable from the LBS down to the control cubicle.

15. 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 cover of the control cubicle and feed the control cable through the bottom of the control cubicle. Connect the control cable to port P1 on the Control Cable Entry Module (CCEM), as shown in Figure 5 (page 21).

16. Fit batteries to the control cubicle.

CAUTION

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

17. Power up control cubicle by switching on all MCB's (batteries, auxiliary supply circuit breakers) and test operation of LBS by using the Trip and Close buttons to trip and close the switch.

18. Mount the aerial and run aerial feed to control cubicle or run external communications cable to control cubicle. Use the cable entry shown in Figure 4 (page 20) with a sealing 16mm gland.

19. The LBS is now ready for energising and commissioning. This should include setting the frequency, power flow direction and the phasing. See Section 10 (page 43).

Additional Component Installations

HV Bare Terminal

This is a factory fitted option as an alternative to insulated cable tails which enables the rapid connection of HV cables to the bushings.

The terminal and shorter boot are fitted to the LBS during assembly at the factory and require no further installation actions other than making and securing the connection between the palm and the

HV cable. Silicone grease is not required for use with bare terminals.

Refer to Figure 23 (page 69) for identification of cable palm connection point. This figure may also be used if the terminal is to be removed and then re-installed during its service life.

HV Cable Tail Connections

HV cables are supplied in one of two forms:

- Fitted with a lug to be bolted to a factory fitted palm on the end of the bushing (250 or 400A).

- Fitted with a threaded termination that is screwed into the bushing (630A).

In both cases the procedure is to attach the cable to the bushing and then cover with the bushing boot as detailed in the following sections, refer to Figure 23 (page 69).

- The bushing is supplied clean and protected with a plastic cap. Ensure this is undisturbed and the bushing body and tin plated central conductor or palm are clean and undamaged. If the bushing has become soiled then clean with methylated spirits. Sand or brush the aluminium palm to remove oxide.

- Grease the bushing and the conductor with the silicone grease provided (part number 990000350).

- Unpack the cable tail and bushing boots. Check that the cable termination and the boot are clean and undamaged. If necessary, clean with methylated spirits.

- Push the boot down the cable to a distance approx. 1 metre from the termination (place a small amount of grease on the closed end of the boot to assist the boot to slide down the cable). Fill the bushing boot with the silicone grease provided. Start at the closed end and finish approx. 60mm from the open end of the

boot. **Hint** - as you fill the boot with grease, keep sliding it down the cable as this pushes the grease up into the boot.

- For cables terminated with a screw thread, ensure the thread, locknut and bushing surfaces are clean and dry. Ensure the brass locknut is screwed to the end of the thread. Screw the tail into the bushing by turning the whole cable tail until there is a gap of 1-2mm between the bushing and the brass locknut. Tighten the brass locknut to 50 Nm using a torque wrench. Take care to apply only twisting forces to the terminal (no shear force).

- For cables terminated with a lug, smear with aluminium jointing paste and bolt the lug to the bushing palm with the bolts provided. Tighten to 44Nm.

- Grease the surface of the bushing, and slide the bushing boot down over the bushing while rotating the boot to and fro. Fix into place using the clamping ring and spanner provided. The bottom of the boot should be firmly seated on the top of the LBS tank.

- During the clamping process silicone may bleed from the top of the boot where the cable tail comes out. This is quite normal and can be assisted by sliding a small screwdriver into the boot alongside the cable tail. Silicone grease will also come out around the bottom of the bushing. This is quite normal. Wipe off excess silicone grease with a clean cloth.

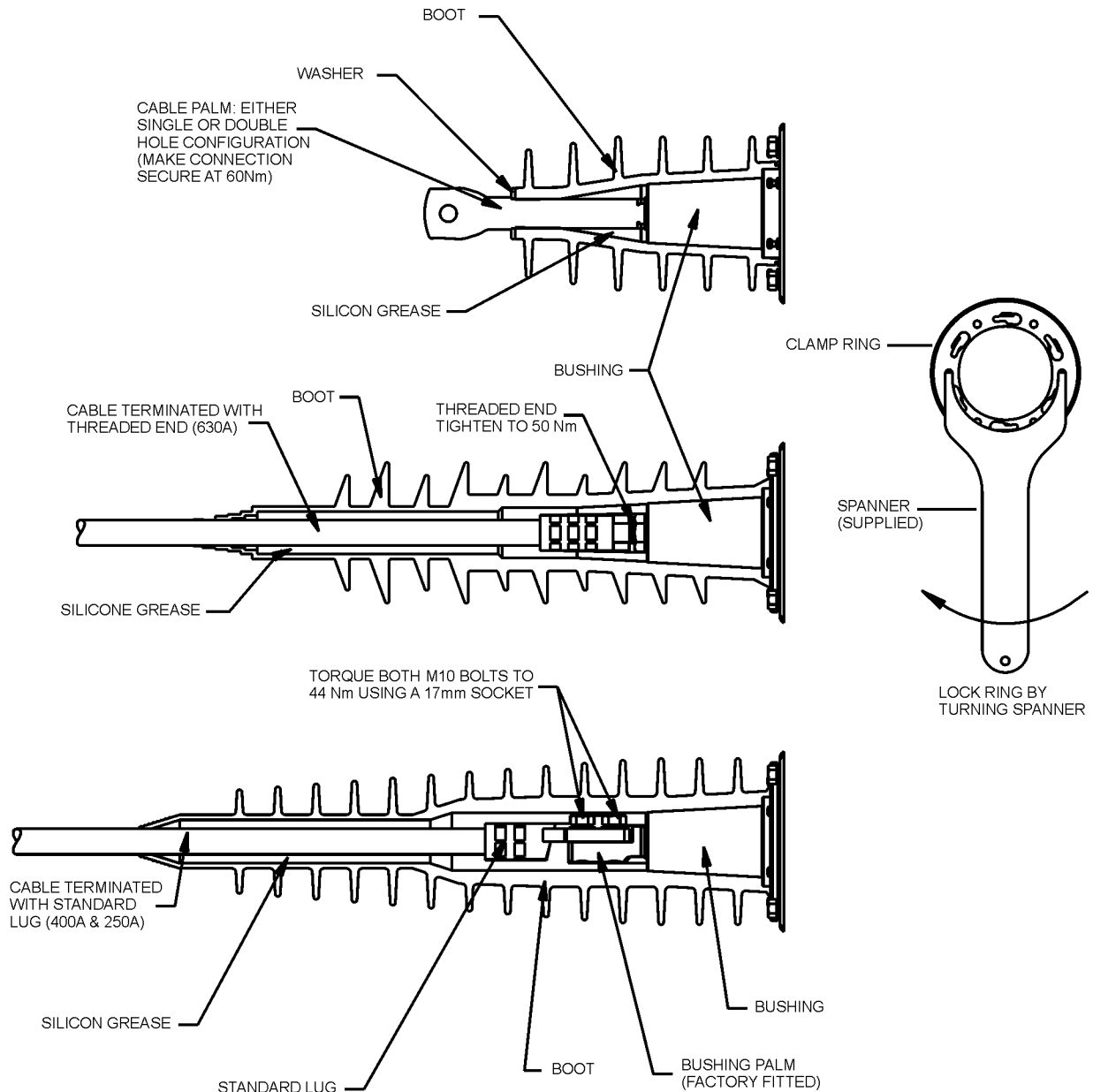


Figure 23: Cable tail installation

Surge Arrestor Mounting and Terminating

Purpose designed mounting brackets are provided for the installation of surge arrestors.

Note

Each surge arrestor fitted to the 38kV model recloser must not exceed a maximum front length of 578mm and a maximum weight of 7.0kg.

The brackets are secured to the support legs welded to the LBS tank. The brackets are secured using bolts through pre-drilled holes. The bolts are provided with the brackets and arresters. Connections from the surge arrestors to the cable tails can be made by stripping off the cable tail insulation and using a parallel or "T" type clamp to make the

connection to the cable tail. The connection should be made far enough up the tail so that phase/phase and phase/earth clearances are maintained. A distance of 200mm above the bushing boot is suggested.

CAUTION

For the 38kV version, the bracket must be installed with the arrows pointing up.

The cable tail is watertight, hence additional water blocking where the insulation has been removed is not required, however it is good practice to tape the joint to maintain the cabling system insulation.

RL-Series Load Break Switch

Protection of Radio Equipment

It is highly advisable to connect a gas discharge type of surge arrester in the aerial feed to the radio.

CAUTION

Failure to protect the aerial feed in this way could result in complete radio and control electronics failure due to lightning activity. Damage of this nature is not covered by the product's general warranty arrangements.

A feed-through or bulkhead type arrester fitted 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 Poly-phasor, IS-B50 type bulkhead surge arrester. See Figure 4 (page 20). A suitable type of bulkhead mount surge arrester is specified in Appendix E (page 93).

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.

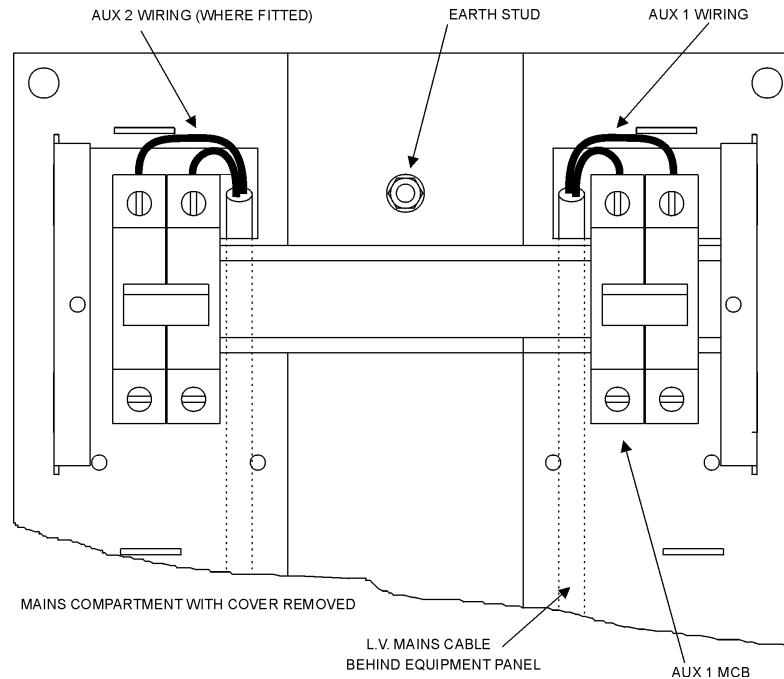


Figure 24: LV Auxiliary Supply connection

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 E (page 93).

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 cable from input/output wiring as much as possible.

Earthing

Figure 26 (page 73) shows the earthing common to all installations.

This arrangement earths the Load Break Switch frame and the surge arrestors directly to earth through a *main earth bond* consisting of a copper conductor of at least 70mm². Any surges will flow down this path. Do not earth surge arrestors by a different path, doing this may cause damage to the control electronics or Load Break Switch. Also any aerial should be bonded to the Load Break Switch 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 Load Break Switch 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. This arrangement should be followed on both conducting and insulating power poles.

The *main earth bond* should be 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.

Connection of Auxiliary Power

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 26 (page 73). 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 arrestors 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.

LV Auxiliary Power from Dedicated Utility Transformer

Figure 27 (page 74) 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 27 (page 74) shows how the transformer and any steelwork must be earthed to the switchgear tank and one side of the transformer secondary earthed to the earth stud on the equipment panel inside the control cubicle.

Auxiliary Power from Integrated Transformer

The manufacturer can also provide an external dedicated voltage transformer that connects directly into the control electronics. This is called an *Integrated Auxiliary Supply*.

An external transformer is mounted on the pole as shown in Figure 27 (page 74) which also shows the suggested HV connections.

The secondary of the external transformer connects into the SCEM on the underside of the LBS.

To connect the transformer secondary remove the SCEM compartment cover plate, pass the cable which is pre-fitted with a cable gland through the hole, secure the gland, connect the auxiliary supply to the screw terminal block on the SCEM and replace the compartment cover.

The earthing required for an Integrated Auxiliary Supply, in addition to the common earthing, is shown in Figure 27 (page 74).

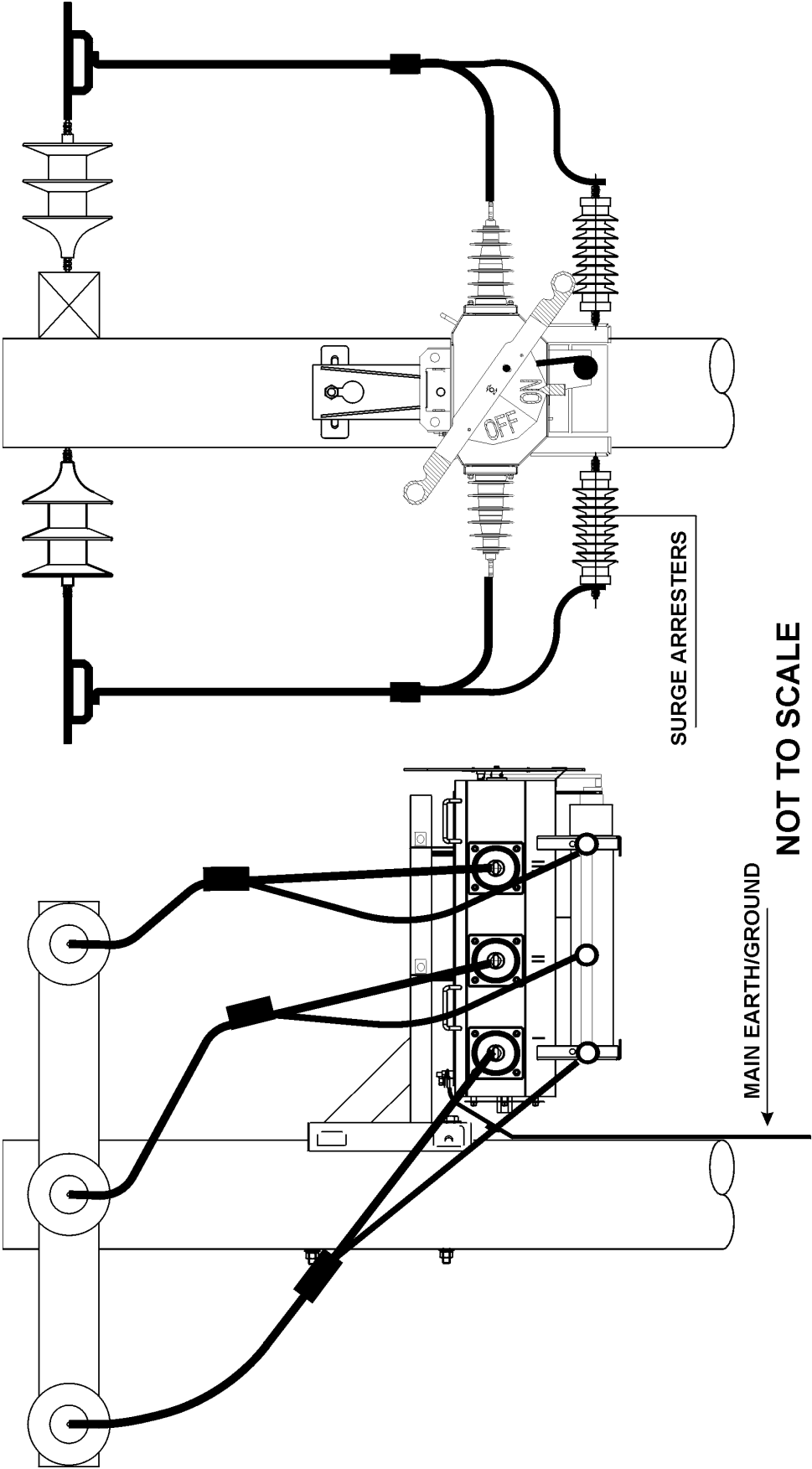
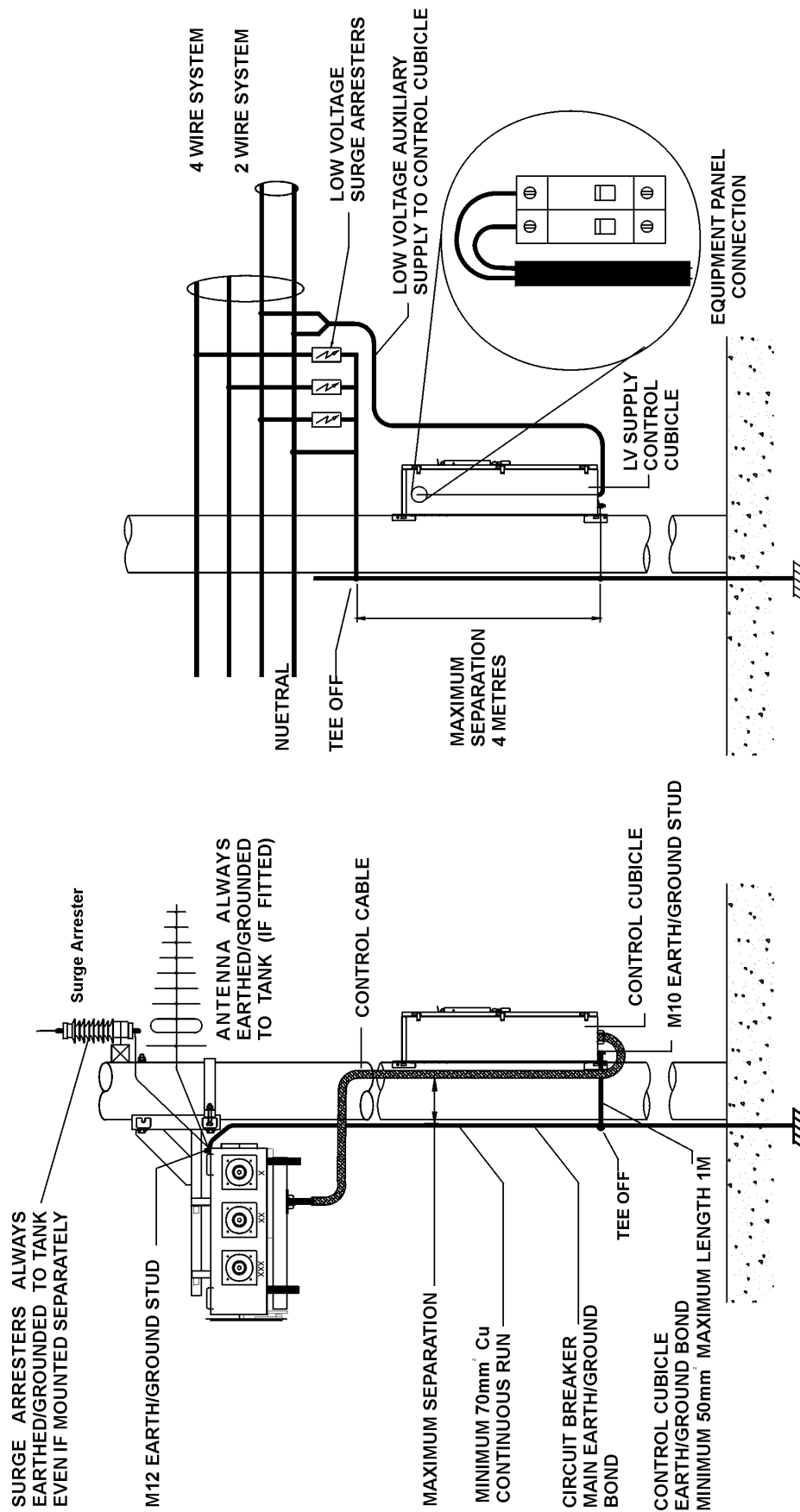


Figure 25: HV Termination



COMMON EARTHING FOR ALL INSTALLATIONS

L.V. SUPPLY FROM 2 WIRE OR 4 WIRE MAINS SYSTEM

NOT TO SCALE
DRAWING IS INDICATIVE OF INSTALLATION ONLY

Figure 26: Common earthing and LV supply

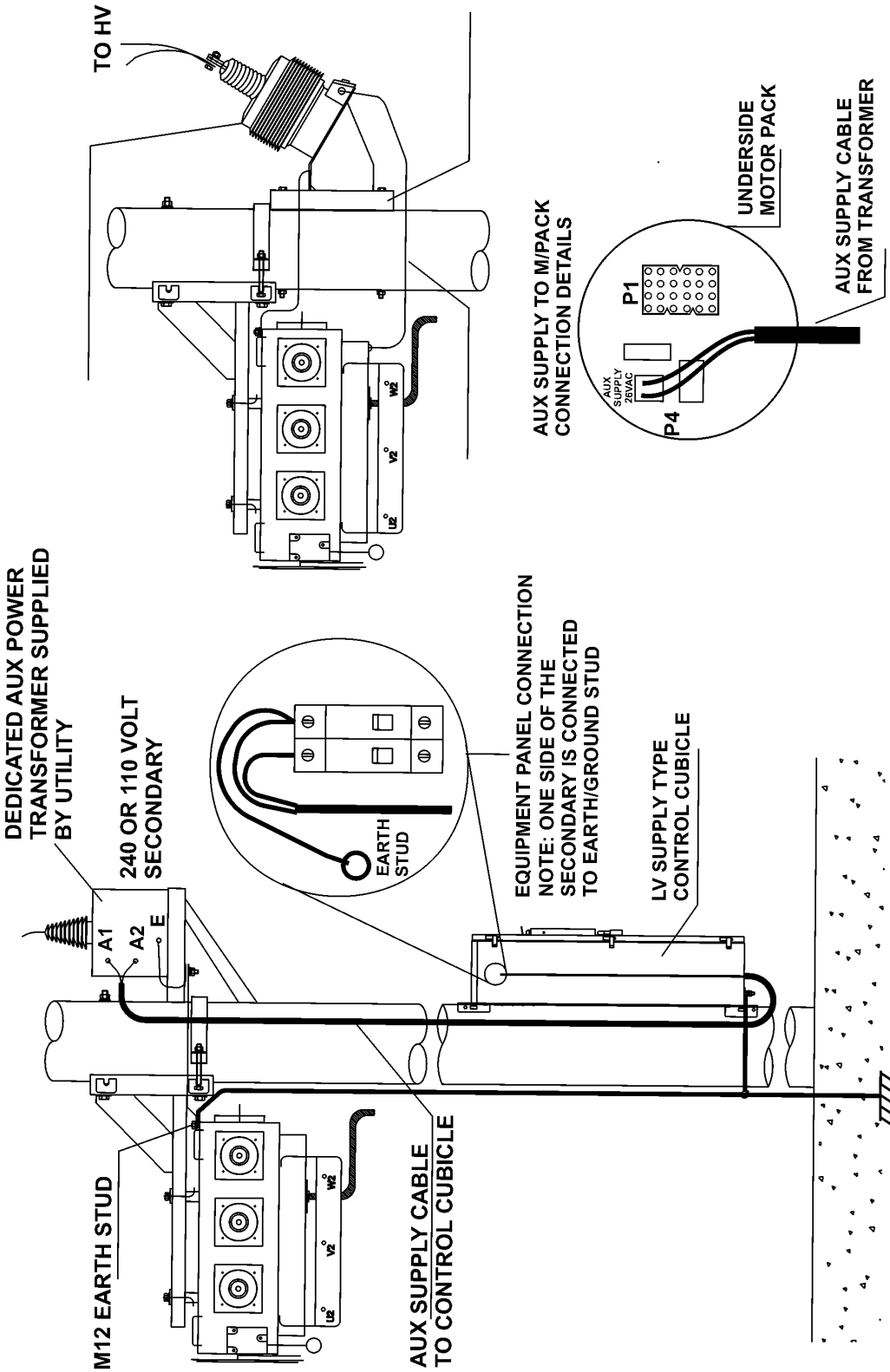


Figure 27: Utility aux transformer and integrated external transformer

18 Maintenance

Maintenance is carried out using standard electricians' and mechanics' tools.

Fault Finding

If there is a problem it may be explained in "Control Cubicle Electronics Check" - page 76 . If not, the fault must be traced as follows.

Faults can only arise in one of the following:

- Load Break Switch.
- 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 switchgear check suggested below and employ substitution techniques to determine where the fault lies.

Faulty units can be returned for factory repair. Faulty control cables should be replaced. Faulty control cubicles can be checked and repaired as indicated below.

Control Cubicle Maintenance

Maintenance of the control cubicle is required every five years and is detailed below.

Part	Maintenance Requirements
Door Seal	Check the door sealing rubber for perishing or undue hardening. Renew the seal if unserviceable.
Control Cubicle Cleaning	Check for excessive dirt on the cubicle, particularly the roof, and clean off. Ensure the louvres are not blocked and that all cooling and water drainage holes in the base are open.
Control Cable	The control cable is a "1-1" cable. This means a direct end-to-end test of all the connections in the control cable can be made with a DVM set to resistance. All pins should show a 1-1 resistance less than 0.2 Ohms with no shorts between pins.
Fitting or Replacing Heater	For models fitted with a control cubicle heater Control Cubicle Schematic Figure 37 (page 103) shows the wiring. The thermostat is located inside the electronics compartment and is set to +15°C for correct operation.

PTCC Maintenance

Fault Detection and Operation Check

Bypass the LBS and carry out primary injection testing to check LBS detection 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 LBS.

Load Break Switch Check

Connections to the LBS are available on the underside of the LBS 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 DVM. This can show up some LBS faults with a simple test.

The procedure is to test the resistance between the pins on the control cable as detailed in the following table.

CAUTION

Do not apply any tests to the LBS other than those shown below.

Pins	Test	Use	Expected Result
1 to 5	Resistance	Motor Relay	1 to 2 kOhm when LBS closed >100kOhm when LBS open.
2 to 5	DC Voltage	Integrated 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	Motor Relay	1 to 2 kOhm when LBS open >100kOhm when LBS closed
4 to 8	Resistance	I Phase CT	13 Ohm +/- 3 Ohm
12 to 16	Resistance	II Phase CT	13 Ohm +/- 3 Ohm
20 to 24	Resistance	III Phase CT	13 Ohm +/- 3 Ohm
21 to 5 ^a	Resistance	Auxiliary travel switch, closed indicates the LBS is tripped	< 10 Ohm when LBS is tripped. >100kOhm when LBS is closed
22 to 5 ^a	Resistance	Auxiliary travel switch, closed indicates the LBS is closed	< 10 Ohm when LBS is closed. >100kOhm when LBS is tripped
23 to 5 ^a	Resistance	Aux travel switch, closed indicates LBS is mechanically locked.	< 10 Ohm when LBS is mechanically locked. >100kOhm when LBS is mechanically unlocked.

Control cable test

a. Note: Pin 11 is not connected. All measurements are to be done to Pin 5.

Control Cubicle Electronics 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 F (page 95) 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:

SYSTEM STATUS-SWITCHGEAR STATUS

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.

Load Break Switch Maintenance

No user maintenance of the LBS mechanism is required.

The LBS should be replaced 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 in any phase approaches zero, the LBS 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.

At suitable intervals:

- Check that the red Low Gas Interlock disc is not visible through the view port.
- Check that the gas low alarm is not showing on the operator control panel.

If either low gas pressure indicator is active, recharge the LBS SF₆ using the gas fill adaptor (see next section).

LBS SF₆ Recharging

LBS SF₆ recharging is carried out using a Gas Fill Adaptor (GFA) and Tool, and a standard size-D SF₆ cylinder. See Appendix E (page 93) for these part numbers.

The 15/27/38kV LBS is refilled to a pressure of 105kPa on the gauge, corrected by +0.68kPa for every degree Celsius above 25°C and -0.68kPa for every degree below 25°C. For altitudes above 1000m it is recommended that you increase the gauge pressure for altitude by 9.6kPa / 1000m above sea level.

The recharging procedure is as follows:

1. Calculate the required pressure to suit the ambient conditions (see above).
2. Check that the gas fill point on the LBS has the spring washer and plug fitted before you connect the Gas Fill Tool to the unit.
3. Retract the locking pin on the gas fill tool and slide the housing over the gas fill boss on the tank. Allow the locking pin to spring into the groove. Gently check that the tool cannot be pulled off the boss.

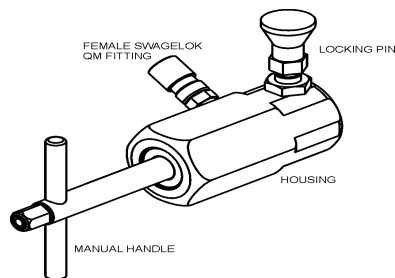


Figure 28: Gas Fill Tool

4. Push the handle into the plug and rotate anticlockwise until the bayonets drop into the slots. Continue to rotate the handle until the head of the plug bottoms out. This will be indicated by the handle becoming difficult to turn any further. NOTE: DO NOT FORCE THE HANDLE FURTHER.

5. Connect the gas fill adaptor to the SF₆ cylinder and slowly open the valve on the cylinder to bleed gas into the hose. Close the valve on the gauge assembly when the air in the hose has been flushed.
6. Check that the regulator output pressure is between 50-150kPa. If it needs to be reduced, wind anti-clockwise and release a small amount of gas to check the setting.
7. Connect the hose from the gas fill adaptor to the female Swagelok QM fitting on the gas fill adaptor tool. The LBS gas pressure should now be visible on the pressure gauge.
8. Open the valve on the gauge assembly to bleed gas into the LBS. This operation must be carried out slowly and you must take care not to over-pressurise the LBS. A relief valve is fitted to the gas fill adaptor for safety purposes, but it will not protect the LBS from overpressure. If excess gas is put into the LBS it can be released by disconnecting the gas fill adaptor from the gas cylinder.
9. The gauge reads high while gas is flowing, so you will have to monitor the pressure during the filling process. Do this by turning off the valve on the gauge assembly at regular intervals to get the correct pressure reading.
10. At correct pressure, turn off the gauge assembly valve and then the cylinder valve.
11. Rotate the handle of the gas fill tool clockwise to close the valve. Torque the handle to 16 Nm.
12. Retract the locking pin on the gas fill tool and slide the housing away from the gas fill boss on the tank to detach the tool from the tank.
13. Disconnect the gas fill adaptor from the SF₆ cylinder.

CAUTION

Only the Gas Fill Adaptor and Gas Fill Tool can be used for recharging SF₆.

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 LBS 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 E (page 93). 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

RL-Series Load Break Switch

	or disconnecting the batteries in the cubicle. Never leave flying leads connected to the battery.	
Battery Replacement	Battery replacement is recommended after a period of five years. See "Battery Replacement" - page 78 . The procedure is: 1. Turn off the battery LBS.	2. Unplug batteries and replace with new batteries. Ensure that polarity is correct. 3. Turn on the battery LBS and ensure that "Battery Normal status", is restored on the: SYSTEM STATUS-SWITCHGEAR STATUS display page.
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 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 to CAPM Replacement Procedure in the service manual. See Appendix F (page 95) 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.	
Abnormal Operating Conditions	The operation of the CAPM 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.
Low Power Mode	When the batteries are nearly exhausted, the controller will change its mode from normal to low power. A 'Low Power Mode' event is logged whenever this happens. In low power mode the radio supply is shut down. and close and trip operations can not be per-	formed. If an operator trip or close request is denied, a "Denied Battery Low" 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.

Appendix A System Status Pages

This appendix shows all the System Status group of pages on the Operator Control Panel display.

- For more information on the data refer to Section 7 (page 27).

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
D	Detection Display Group
M	Measurement Display Group

The next three lines are the data on display. Most displays have six data fields. These are shown in the following tables

Where a display field contains a numeric value, the table gives a typical value or the default value if applicable.

For example **Seq Reset Time 30.0 sec** is shown for the sequence time setting. When the user comes to the display it would show **Seq Reset Time 25.0 sec** if that was the actual setting¹.

Where the display field can show alternative text, all the different text displays are shown in the table, one below the other.

This is illustrated in the table below, which shows the page.

SYSTEM STATUS - OPERATOR SETTINGS

Here the first data field can be either:

- Local Control ON, or
- Remote Control ON

To the right of the data field column is a small column showing the type of data displayed, these have significance as follows:

- 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

FAULT FLAGS				S
O/C ☐ 00 ABC I	R			
E/F ☐ 00 I	R			
SEF ☐ 00	R	OPS	0000 - 9999	R

Operator Settings

OPERATOR SETTINGS 1				S
LOCAL CONTROL ON Remote Control On Hit and Run ON Hit and Run OFF	O			O
Sectionaliser OFF Sectionaliser Auto	O	Aux Supply Events ON Aux Supply Events OFF		
<blank in normal operation> Supply Interrupt 1 Supply Interrupt 2 etc. Supply Interrupt 4 Sectionaliser Trip	D	Det Auto Auto 'A' Active Auto 'B' Active etc. Auto 'J' Active Det 'A', 'B', ..., 'J' Active		O

1. Different default values may be factory loaded.

RL-Series Load Break Switch

OPERATOR SETTINGS 2			S
Cold Load OFF Cold Load IDLE CLP 120min x2.3mult	O		

Switchgear Status

SWITCHGEAR STATUS				S
Work Tag OFF Work Tag Applied	O	SF6 Normal 105kPag (15/27/38kV) SF6 Low 55kPag (15/27/38kV) SF6 Pressure Invalid (15/27/38kV)		D
Aux Supply Normal Aux Supply Fail	D	Battery Normal Battery Off Battery Low Volts Battery Overvolt	X.XV X.XV X.XV X.XV	D
LBS Connected LBS Unplugged	D	LBS Data Valid LBS Data Invalid		D

Live/Dead Indication

LIVE/DEAD INDICATION				S
Ai Live Ai Dead	D	Ax Live Ax Dead		D
Bi Live Bi Dead	D	Bx Live Bx Dead		D
Ci Live Ci Dead	D	Cx Live Cx Dead		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
Display Ph/Ph Volt Display Ph/Earth Volt	P	System Freq 50Hz System Freq 60Hz		P

Switchgear Terminal Designation

SWITCHGEAR TERMINAL DESIGNATION			S
I / X Terminals	A Phase ^a		P
II / XX Terminals	B Phase		P
III / XXX Terminals	C Phase		P

a. The phase designations can be rotated from this field by pressing the arrow key (ABC, ACB, BAC, BCA, CAB, CBA).

Radio and Time Set

RADIO and TIME SET				S
Radio Supply OFF Radio Supply ON Radio ShutDown See "Radio/Modem Power" - page 57 for further details.	O	Radio Supply 12V		P
Radio Hold 60 min	P	Modem Pwr Cyc OFF Modem Pwr Cyc 1 hr - 48 hr		
Date/Time		10/01/2001 10:55:12		O

Switchgear Type and

SWITCHGEAR TYPE and RATINGS				S
Load Break Switch	D	S/N NP-101005		D
630A Interruption	D	Rated 27000 Volts		D
630A Continuous	D	1292 Operations		D

Switchgear Wear/General

SWITCHGEAR WEAR/GENERAL DETAILS				S
I Contact 75.6%	D	CAPM S/N NP-101234		D
II Contact 75.6%	D	Software S28-05.00		D
III Contact 74.5%	D	Configuration 21421		D

Capability

CAPABILITY				S
RL-Series -FA Series (Intl)		Manual RL2-647		D
WSOS P8 Remote ^a		Manual N00-218		D
WSOS P9 Local		Manual N00-218		D

a. Some software configurations will support another protocol on Port P8 as an alternative to WSOS.

Options

OPTIONS 1				S
ADGS Allowed ADGS Not Allowed	P	ADGS Change 60s		P
Lang English (Intl) Idioma Espanol Lingua Portugesa	P			

OPTIONS 2				S
Gen Ctrl Available Gen Ctrl Not Available	P			
ACO Not Available ACO Available	P			
Aux Evts Available Aux Evts Not Avail	P			

RL-Series Load Break Switch

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

WSOS Port P9 Communications				S
Baud 9600 Selection in the range 600, 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
LBS STANDARD 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 B Fault Detection Pages

This appendix shows all the Detection Group of pages on the Operator Control Panel display.

Detection

DETECTION SETTINGS 1 (A – J)			D
Group A – J Displayed	P	Copy OFF 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 (except #) ^a Copy # Incomplete ^b Copy ALL Incomplete	P
Seq Reset Time 30 s	P	Trip on count 1 Trip on count 2 Trip on count 3 Trip on count 4	P

a. Use the select key to scroll through these options. When either the ENTER or MENU key is pressed, the copy is performed and the field defaults to the "Copy OFF" display.

b. Advises failure of the copy feature.

DETECTION SETTINGS 2 (A – J)			D
Phase Fault 200 Amp Phase Fault OFF	P	Definite Time 0.05 s	P
Earth Fault 40 Amp Earth Fault OFF	P	Definite Time 0.05 s	P
SEF Fault 4 Amp SEF Fault OFF	P	Definite Time 5.00 s	P

DETECTION SETTINGS 3 (A – J)			D
Flt Reset Time 50ms	P	Live Load Block OFF Live Load Block ON	P

DETECTION SETTINGS 4 (A – J)			D
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

Appendix C Measurement Pages

This appendix shows the Measurement Group of pages on the Operator Control Panel display.

Refer to Section 11 (page 47) for more information on measurement functionality.

Instantaneous Demand

INSTANTANEOUS DEMAND					M
Earth	0 Amp	D	A Phase	123 Amp	D
			B Phase	128 Amp	D
			C Phase	121 Amp	D

System Measurements

SYSTEM MEASUREMENTS				M
	Power (P)	2479 kw		D
	Power (Q)	200 kVAR		D
	Power Factor	0.93		D

Source Side Voltages

SOURCE SIDE VOLTAGES ^a				M
Ai phase to earth 12700 Volt				D
Bi phase to earth 12700 Volt				D
Ci phase to earth 12700 Volt				D

a. Phase to earth.

Load Side Voltages

LOAD SIDE VOLTAGES ^a				M
Ax phase to earth 12700 Volt				D
Bx phase to earth 12700 Volt				D
Cx phase to earth 12700 Volt				D

a. Phase to earth.

Source Side Voltages

SOURCE SIDE VOLTAGES ^a				M
Ai – Bi phase to phase 22000 Volt				D
Bi – Ci phase to phase 22000 Volt				D
Ci – Ai phase to phase 22000 Volt				D

a. Phase to phase.

RL-Series Load Break Switch

Load Side Voltages

LOAD SIDE VOLTAGES ^a			M
Ax – Bx phase to phase 22000 Volt			D
Bx – Cx phase to phase 22000 Volt			D
Cx – Ax phase to phase 22000 Volt			D

a. Phase to phase.

Supply Outages

SUPPLY OUTAGES					M
Measure Outages OFF	P	Outage Duration	60 s	P	
Measure Outages ON					
Source outages	2	R	Duration	4h14m56s	R
Load outages	3	R	Duration	6h23m24s	R

Monthly Maximum Demand

MONTHLY MAXIMUM DEMAND				M
JAN/2001	Total		28865 kWh	D
Peak period	07 / 01 / 2001	17:15:00		D
Peak demand	31141 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	31141 kW	0.93 PF		D

Average Demand

AVERAGE DEMAND				M
10 / 01 / 2001	13:45:00	A phase	123 Amp	D
2749 kW		B phase	128 Amp	D
0.93 PF		C phase	121 Amp	D

Appendix D Event Log

The following table lists the events that can appear in the Event Log, in alphabetical order.

Event Text	Explanation
<Time/Date>	A new time/date has been set.
A/B/C i/x Live A/B/C i/x Dead	A terminal has changed from dead to live. See "Loss of Supply Events" on page 51.
A/B/C Phase Fault	The indicated element has exceeded its fault threshold for its set amount of time.
A Max NN Amp B Max NN Amp C Max NN Amp	Following pickup of the overcurrent detection element on A, B or C phase, the maximum fault current recorded was NN Amps. This event is logged only after the current has fallen back below the phase setting current.
Aux Supply Fail	The auxiliary power supply has failed.
Aux Supply Normal	The auxiliary power supply has become normal.
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.
CAP <i>message</i>	Charge Failed Charge OK Excess Closes Excess Trips Q5 Fail ^a The above events may be generated if there is a problem with the on-board capacitor charging circuit or if there has been a large number of operations in a short period of time, e.g. 10 operations within 60 seconds. Chrg Charge OK Chrg Charging Chrg Disable Chrg Full Chrg OFF Chrg Resting Chrg Run-up The above events may be logged if the CAPM fails to trip or close when the internal logic expects it to.
Capmload Reset	The electronic controller has been reset after loading new software.
Close Blocking ON	The LBS is prevented from closing.
Close Blocking OFF	The LBS will now close when requested.
Close Coil Connect Close Coil Isolate	The Close/Trip isolate switch on the operator control panel was changed to the Enable/Isolate position.
Denied Battery Low	Operation denied if either a Trip or Close request is made when the CAPM is in 'Low Power Mode'
Denied Gas Low	This event is recorded if an operation is attempted with SF ₆ pressure low.
Denied wrong Mode	When the switch is in a different mode (Local, Remote or Work Tag Applied) to the device which attempted the close.
Det Group # Active	Indicated the detection group that is in service when a new group is selected or just before logging a pickup. # may be A to J.
Disconnected	The LBS has been disconnected.
E Max NN Amp	Following pickup of the overcurrent detection element on earth or SEF, the maximum fault current recorded was NN Amps. This event is logged only after the current has fallen back below the earth setting current.
Earth Fault	The indicated element has exceeded its fault threshold for its set amount of time.
Excess Motor Ops	Indicates that a Trip or Close request has been made: § After there has been 10 or more operations within a 60 second period and more than 1 operation per 60 seconds for 600 seconds thereafter.
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 switch in preparation for starting the generator.
GenCtrl Close Req	Generator control closing switch to restore line supply.

RL-Series Load Break Switch

Event Text	Explanation
GenCtrl ON	Switching generator control ON.
GenCtrl OFF	Switching generator control OFF.
Hit and Run On Hit and Run Off	Start of Hit and Run period End of Hit and Run period 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).
LBS Open LBS Closed	On power up and switch re-connection the LBS is either open or closed.
Live Load Blocking	A close request was disregarded due to a load side terminal being alive.
Load out 59 m 59 s Load out 99 h 59 m Load out 9999 h	The LBS load terminals experienced a supply outage up to 59 minutes 59 seconds. The LBS load terminals experienced a supply outage up to 99 hours 59 minutes. The LBS load terminals experienced a supply outage above 100 hours.
Load Supply OFF/ON	All three load side voltages are OFF/ON.
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.
Low Power Mode	If the power supply voltage reduces below a threshold for a certain time, the radio supply is turned off immediately. The LBS will still operate but will go to lockout if the capacitors cannot be charged quickly enough.
Mech Locked / Unlocked	The LBS mechanism has been locked or unlocked.
Mechanical Close	The LBS was closed using the mechanical close lever.
Mechanical Trip	The LBS was tripped using the manual mechanical trip lever.
Mechanism Fail	The LBS has failed to close or trip electrically.
Normal Power Mode	If the power supply voltage returns to normal then the power mode will return to normal after 15 min.
NP-xxxxxx Connected	LBS with serial number xxxxxx has been connected.
OCPM Door Closed OCPM Door Open	This message is only ever logged if the control cubicle is equipped with a door switch.
Outages ON Outages OFF	The operator (local or remote) has turned ON or OFF the supply outage measurement functions.
Outages Reset	The operator (local or remote) has reset the four outage counters.
Phasing <i>order</i>	The Terminal Designation has been changed where <i>order</i> is one of the following – ABC, ACB, BAC, BCA, CAB, CBA.
Pickup	One of the detection elements picked up (phase, earth or SEF). This event is generated by the first element to pick up, if more elements pick up subsequently then no more pickup events are generated until all the elements have reset.
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.
Power Shutdown	The power supply on the CAPM has failed.
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 yyyy	The operator has altered P9's mode, via the panel or WSOS, to be that shown. Where yyyy 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. E.g. “ QK1 Local/Remote ” ^b
Radio Supply Failed Radio Supply OK	This message indicates a radio power supply fault. This message indicates that the fault has been rectified and power supply has been returned to normal. Radio supply faults may occur when the batteries are depleted.
SCEM Corrupted	The SCEM records are corrupted.
SCEM <i>type</i> Fail	Where <i>type</i> can be Memory or Write.
SCEM Type <i>type</i>	The control cable has been connected to a different type of SCEM where <i>type</i> can be SCEM 9, 93C46 or Unknown. ^a
Sectionalizer Trip	The sectionalising logic has issued a trip request.
SEF Fault	The indicated element has exceeded its fault threshold for its set amount of time.
Sequence Reset	The sequence reset timer has expired. The supply interrupts count will start again.

Event Text	Explanation
SF ₆ Pressure Normal SF ₆ Pressure Low Pressure Invalid	The SF ₆ pressure status has changed state.
Source I Load X Source X Load I	The operator (local or remote) has changed the power flow direction.
Source Fault	The element (as indicated by source) has exceeded its fault threshold for its set amount of time. Source may be any one of the following: A Phase B Phase C Phase Earth SEF
Source Supply OFF/ON	All three source side voltages are OFF/ON.
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. WSOS = Windows Switchgear Operating System IOEX = Input Output Expander Card. Protocol = A communications protocol such as DNP3.
Supply Interrupt NN	All currents fell to zero within one second of a fault. This indicates upstream device operating. This was the NNth interruption since the sequence reset timer started timing.
Switch Connected	The LBS has been connected to the control cubicle.
Switch/SCEM Mismatch	The LBS has been installed with the wrong SCEM.
I contact < 20% II contact < 20% III contact < 20%	Less than 20% contact life remaining in the I-X, II-XX or III-XXX puffer interrupter.
Work Tag Applied Work Tag OFF	The Work Tag has been applied/turned off.
Wrong Switch No <i>n</i>	This version of software and the connected switch type are incompatible. " <i>n</i> " is the switchgear type. The controller will have to be loaded with correct software. ^a .

- a. If this event occurs, the equipment may require maintenance. Contact the manufacturer or your local distributor for advice.
b. This event will be logged if the Quick Key configuration is changed via the panel or WSOS.

Appendix E Replaceable Parts & Tools

All replacement parts are available from the LBS manufacturer.
Listed below are the parts that may be required for replacement following customer maintenance.
Also listed are special purpose tools

Part	Part Number
Bare HV Terminal Kit Bare Terminal Kit 2-hole Terminal Kit ANSI 2-hole	994000010 994000030 994000060
Panasonic Batteries: • LCR12V7.2P 12 Volt Battery (set of 2)	997000000
1100mm Bushing Boot Silicone (38kV)	990000305
770mm Bushing Boot Silicone (27kV)	990000330
Boot Clamping Ring	990000315
Boot Clamping Ring Spanner	990000320
Bushing Boot Installation Tool (For use in cold climates)	990000310
Cable Tail Kit: Quantity 1 of 400 Amp, 3m cable fitted with lug	990000640
Cable Tail Kit: Quantity 1 of 630 Amp, 3m cable fitted with screw termination	990000110
Control and Protection Module: CAPM 5	999900015
Control Cable 7m long (Also available in 3.5,4,8,10,11and 20 metre lengths)	992000030
Control Cubicle: Tropical Version Moderate Version Temperate Version	PTCC-TRO PTCC-MOD PTCC-TEM
Control Cubicle Heater Kit 220/240 VAC, includes thermostat	997000025
Control Cubicle Heater Kit 110/120 VAC, includes thermostat	997000020
Control Cubicle Entry Module (CCEM)	999900020
Ferrite Filters (ID = 10mm) for incoming cable.	997000210
Gas Fill Adapter Includes cylinder adapter	990003050
Quick Key Map English	99700110
Radio Cable (Standard)	997100090
Secondary Voltage Injection Interface Set	990003065
Silicone electrical grease tube	990000350
Test and Training Set (TTS)	990003000
Windows Switchgear Operating System (WSOS)	Refer Distributor

Appendix F Control Cubicle Schematics

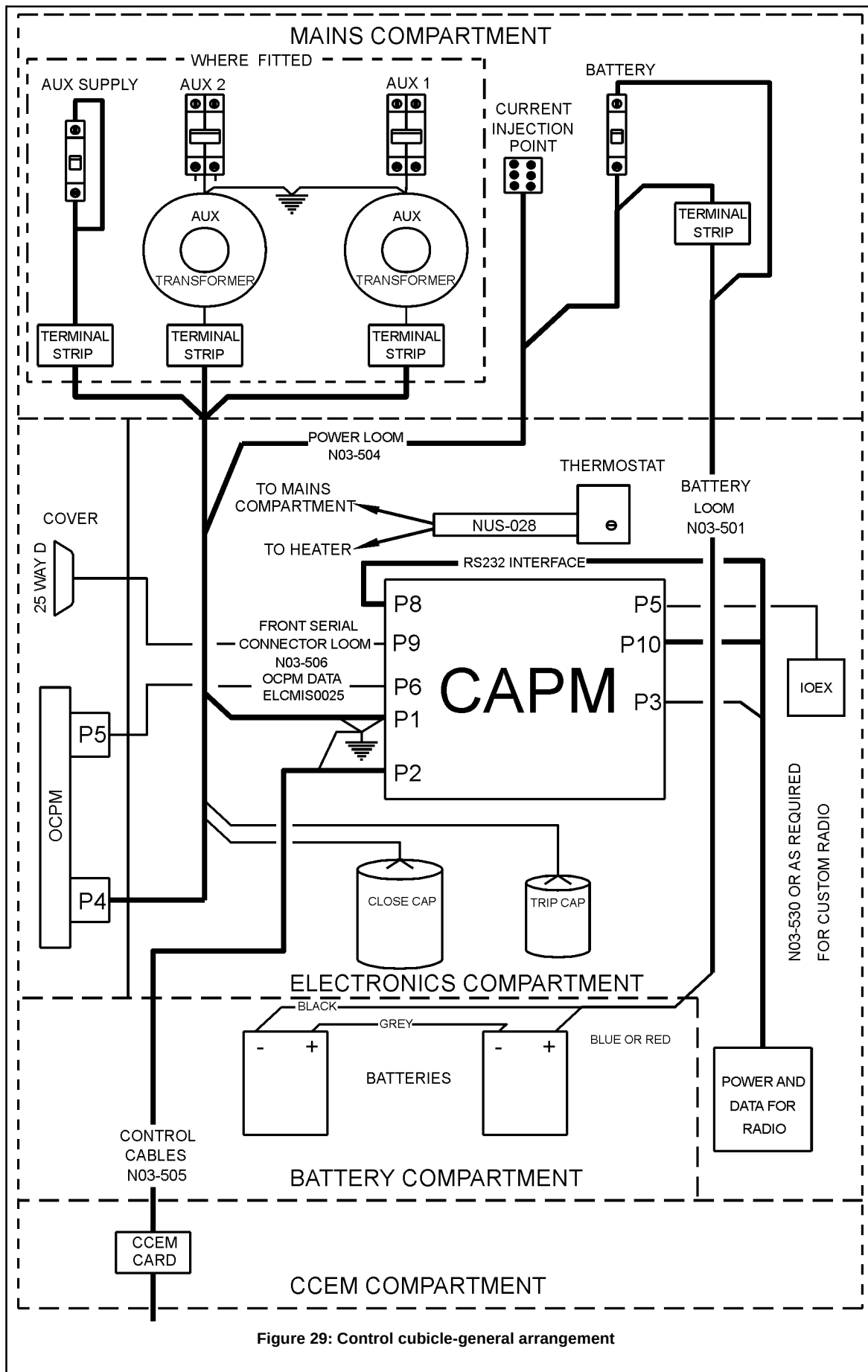


Figure 29: Control cubicle-general arrangement

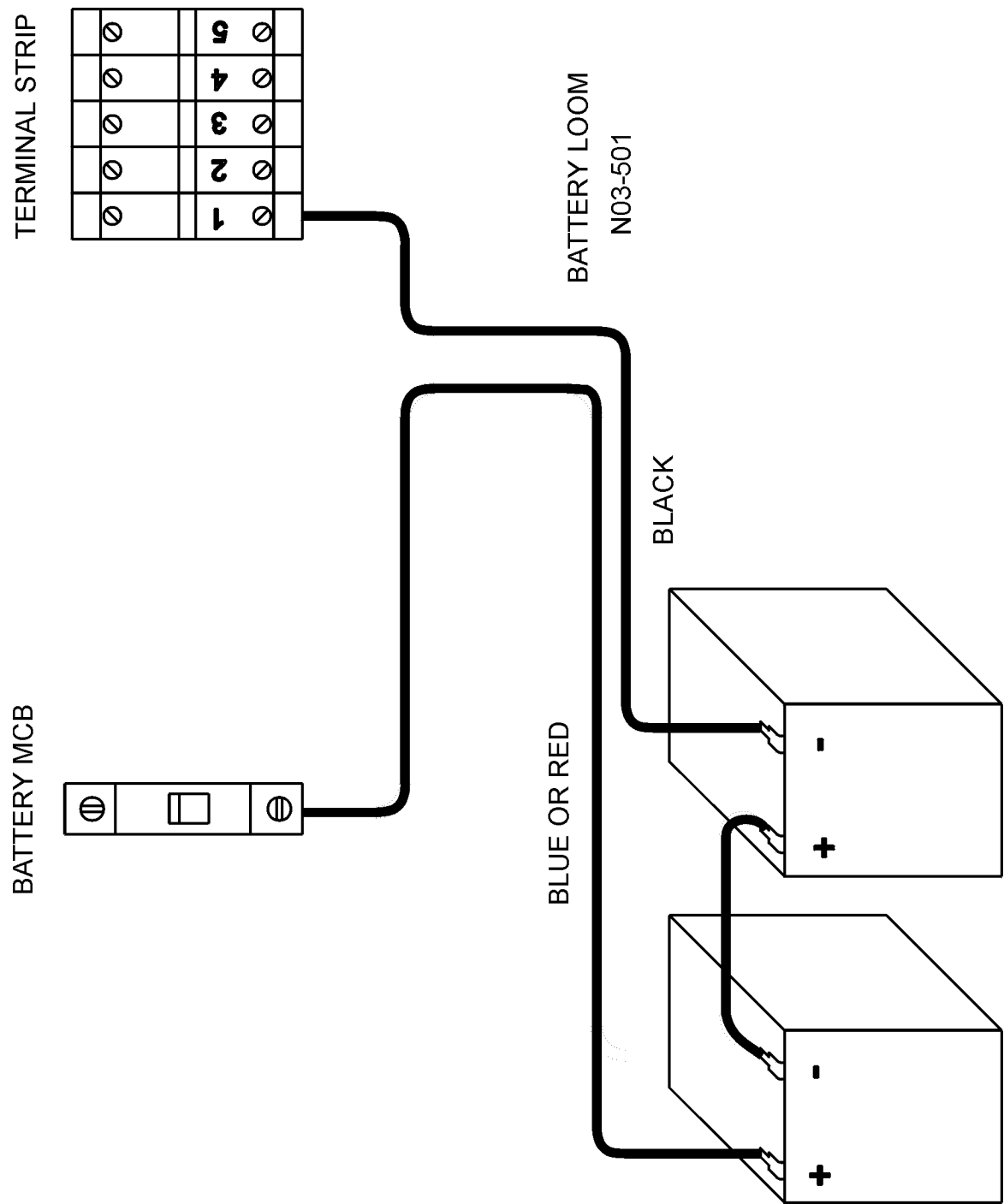


Figure 30: Control cubicle-battery loom

BATTERY
AUX. SUPPLY
MCB

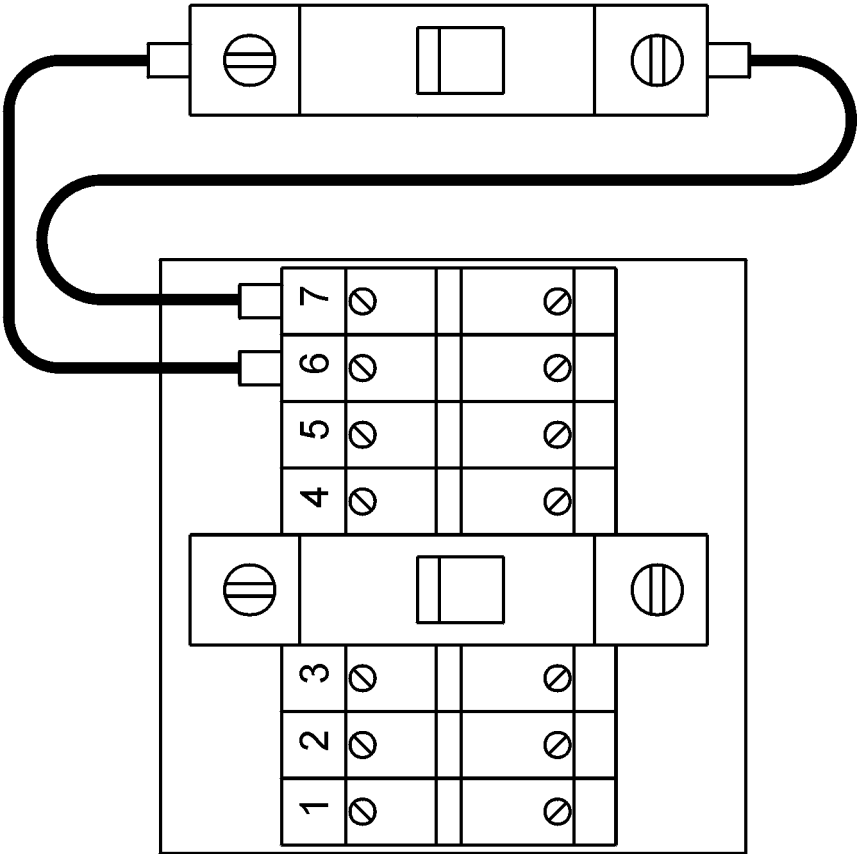


Figure 32: Control cubicle-Single integrated aux power supply

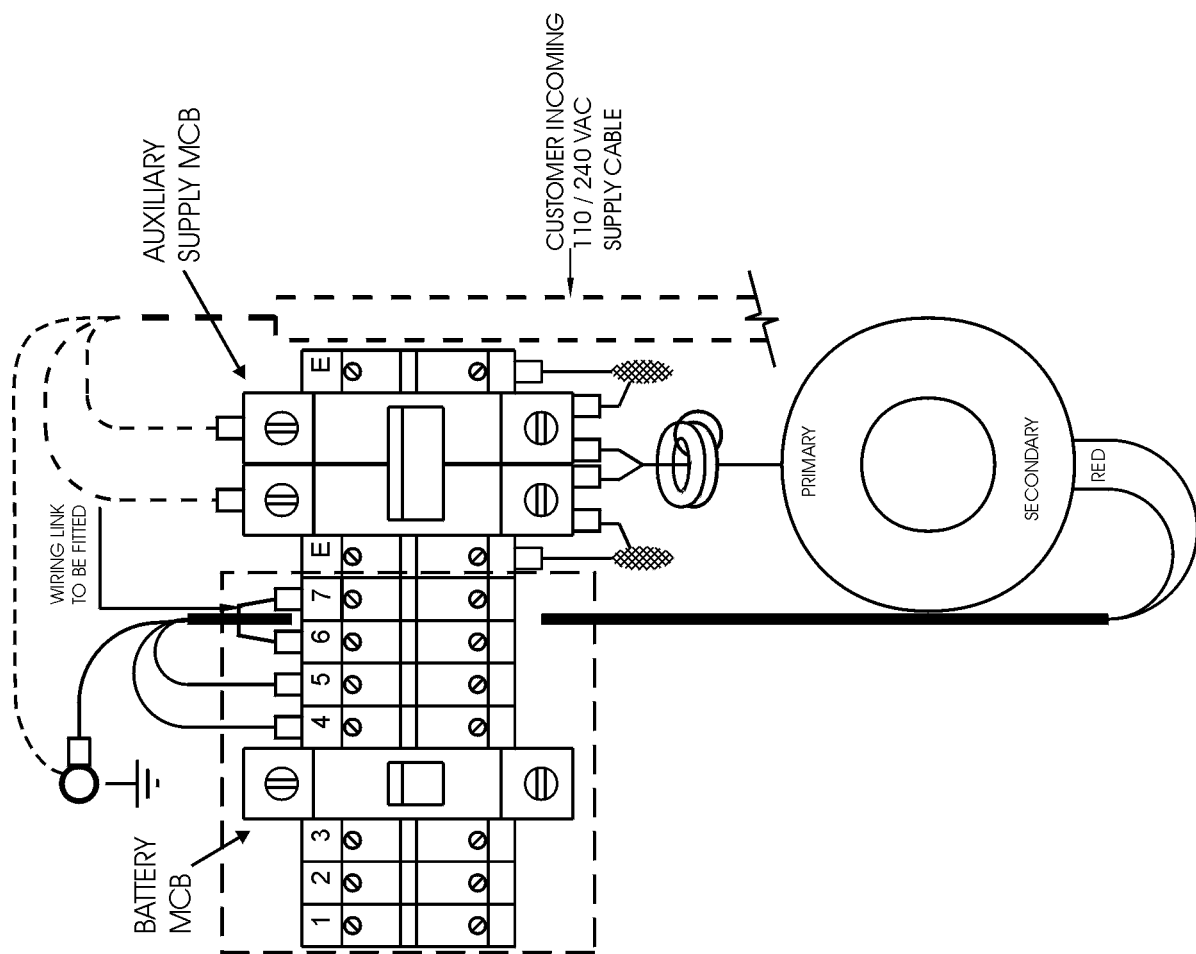


Figure 33: Control cubicle-Single LV aux power supply

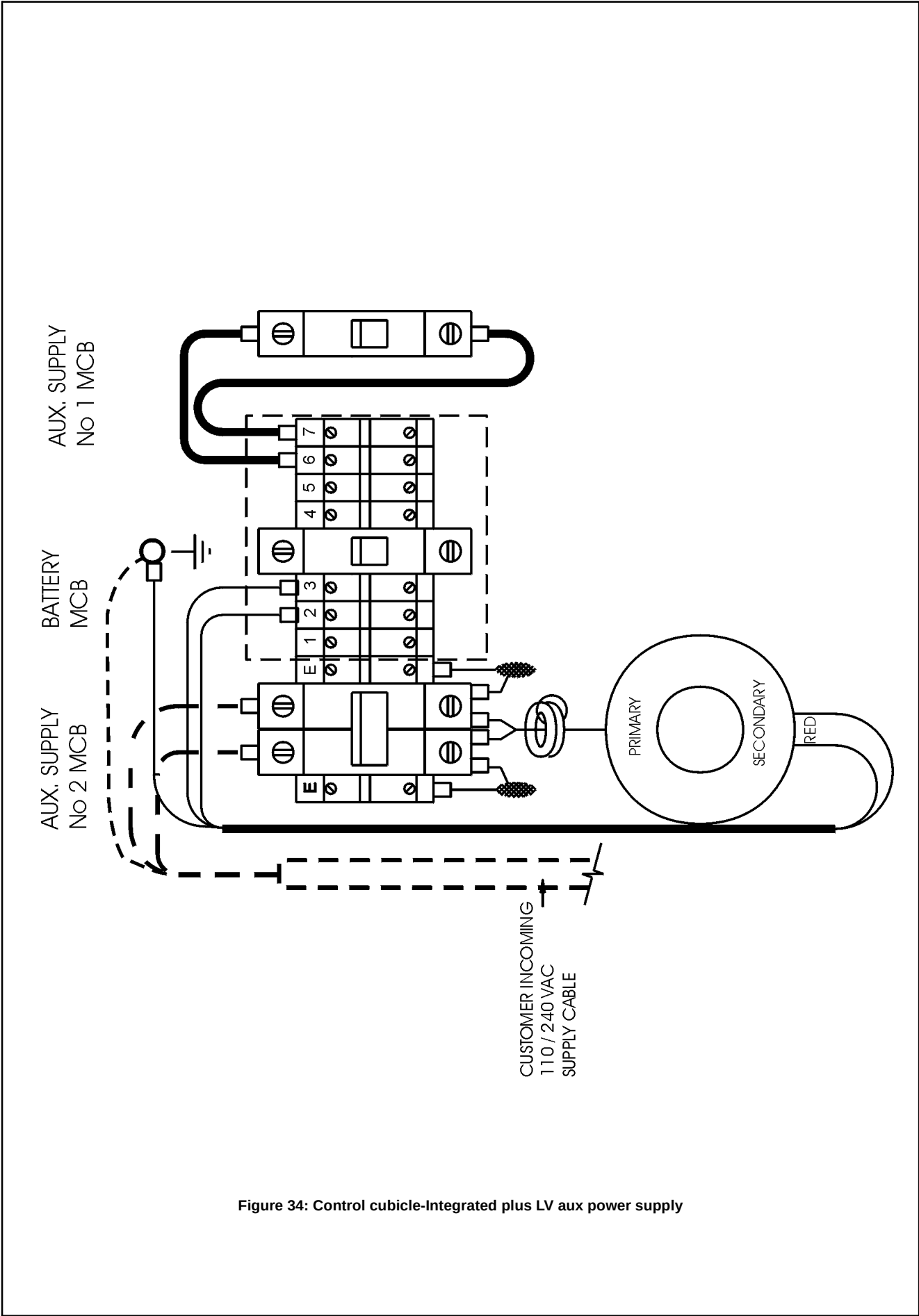


Figure 34: Control cubicle-Integrated plus LV aux power supply

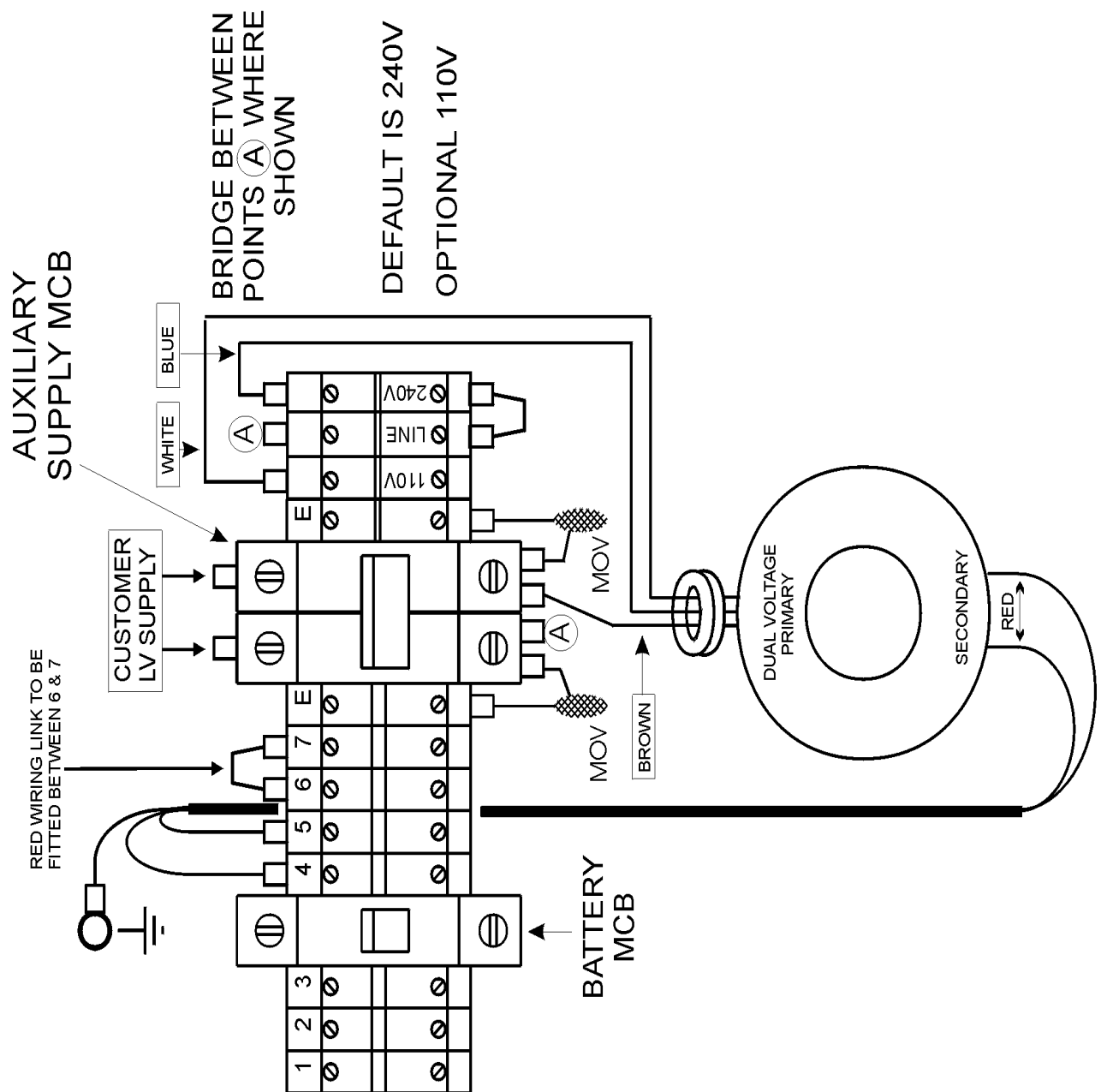


Figure 35: Control cubicle - Dual low voltage auxiliary supply -110/240 Volts

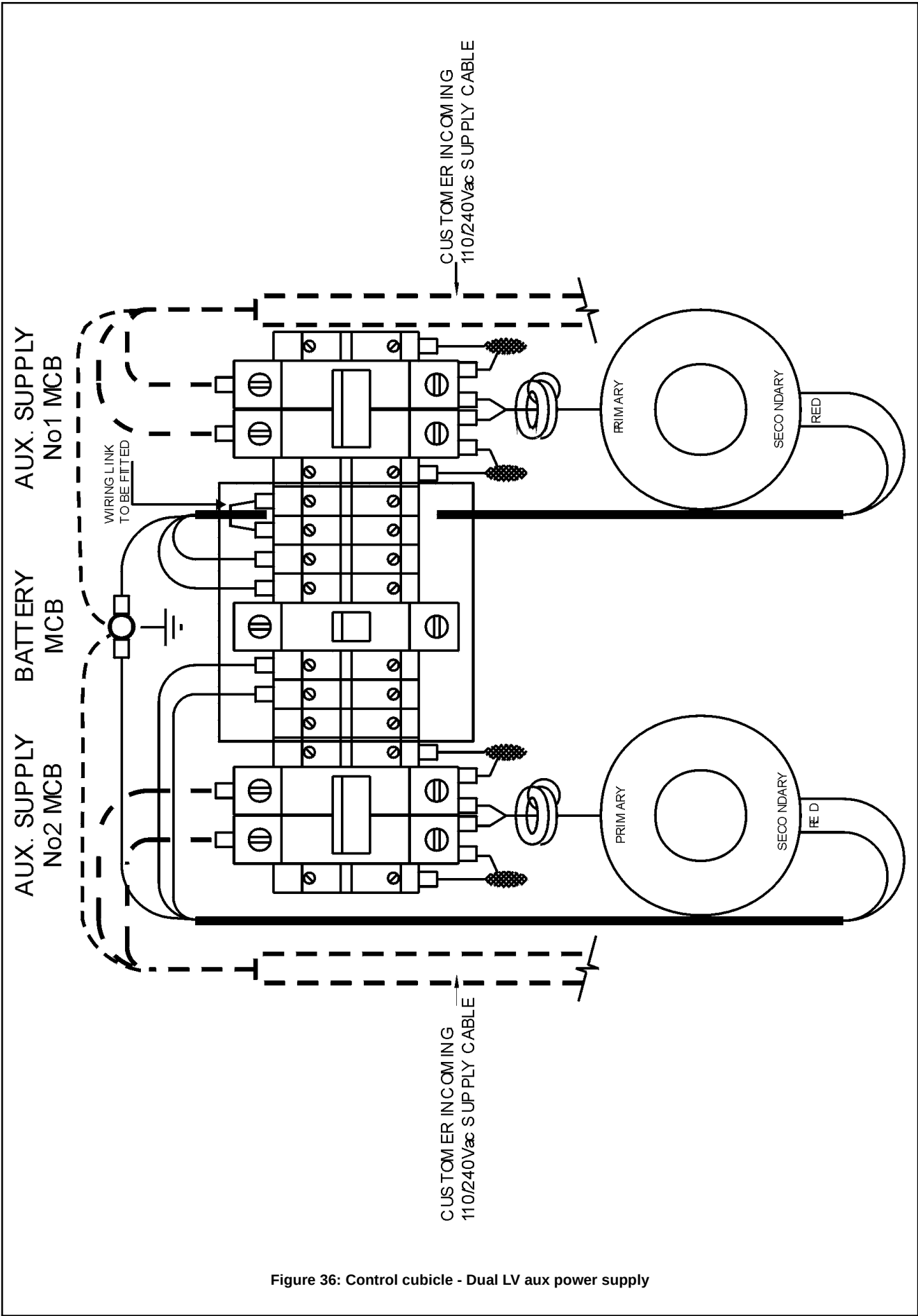


Figure 36: Control cubicle - Dual LV aux power supply

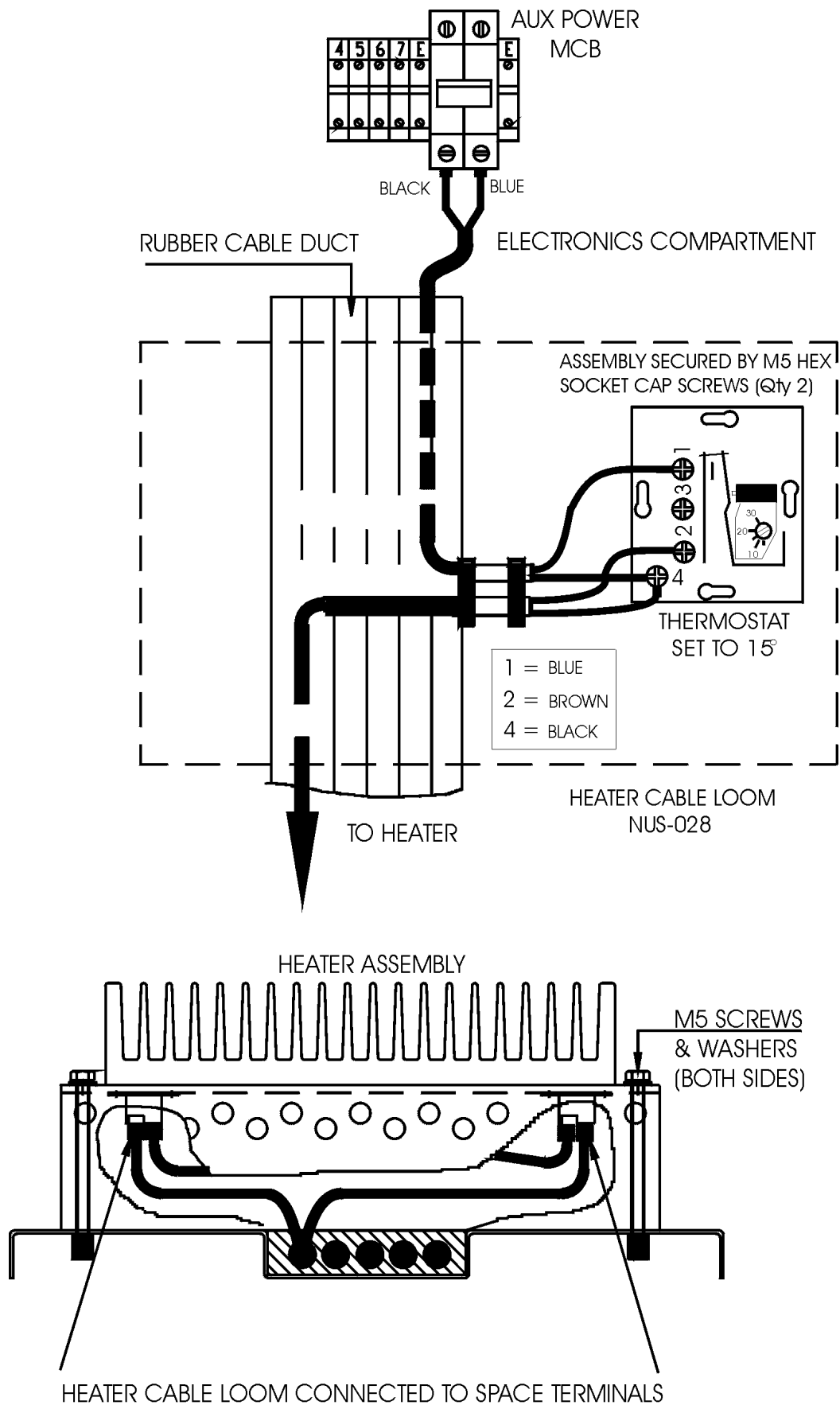


Figure 37: Control cubicle - heater / thermostat connection

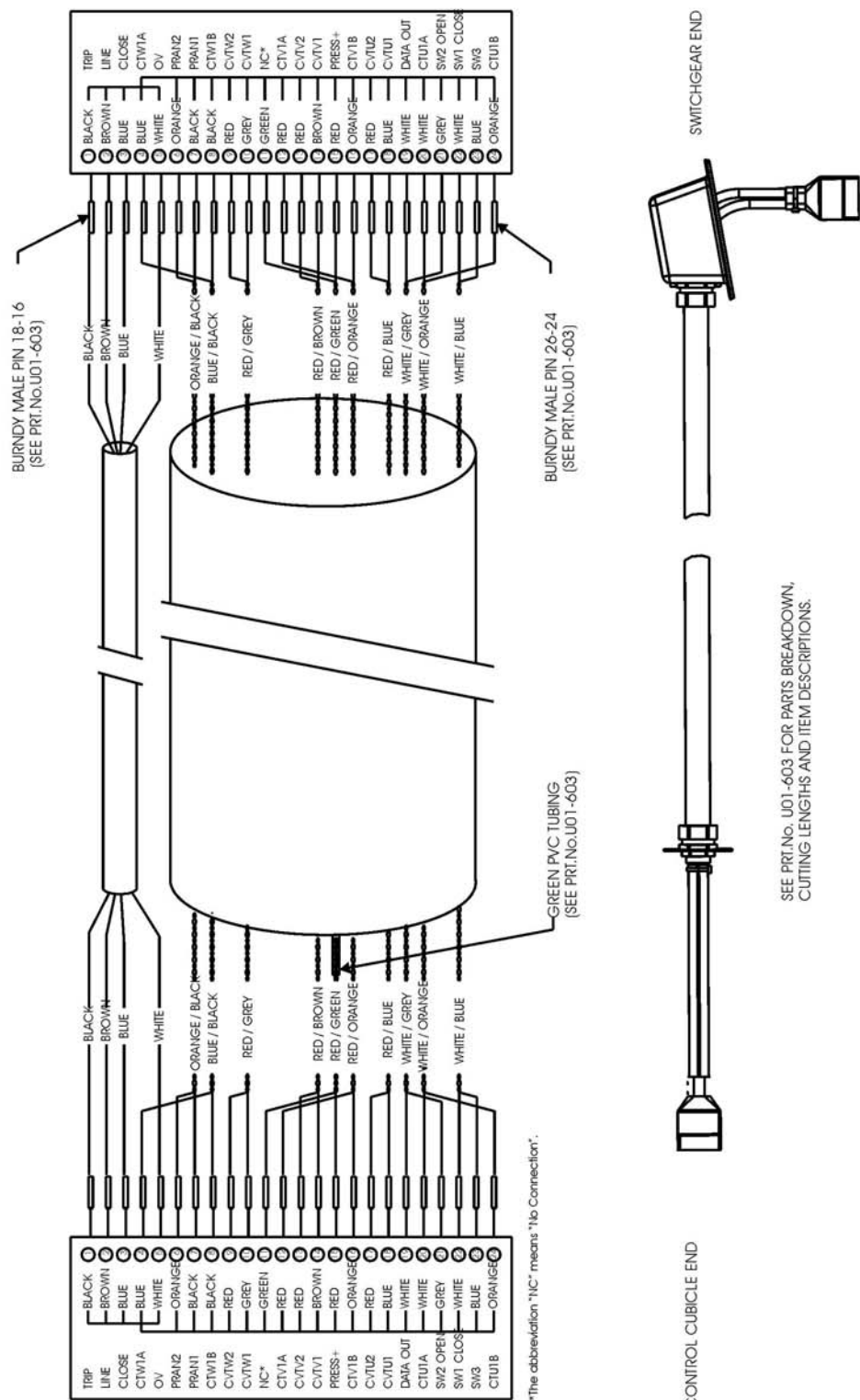


Figure 38: Control cubicle - Control cable service drawing

Appendix G Dimensions

Load Break Switch

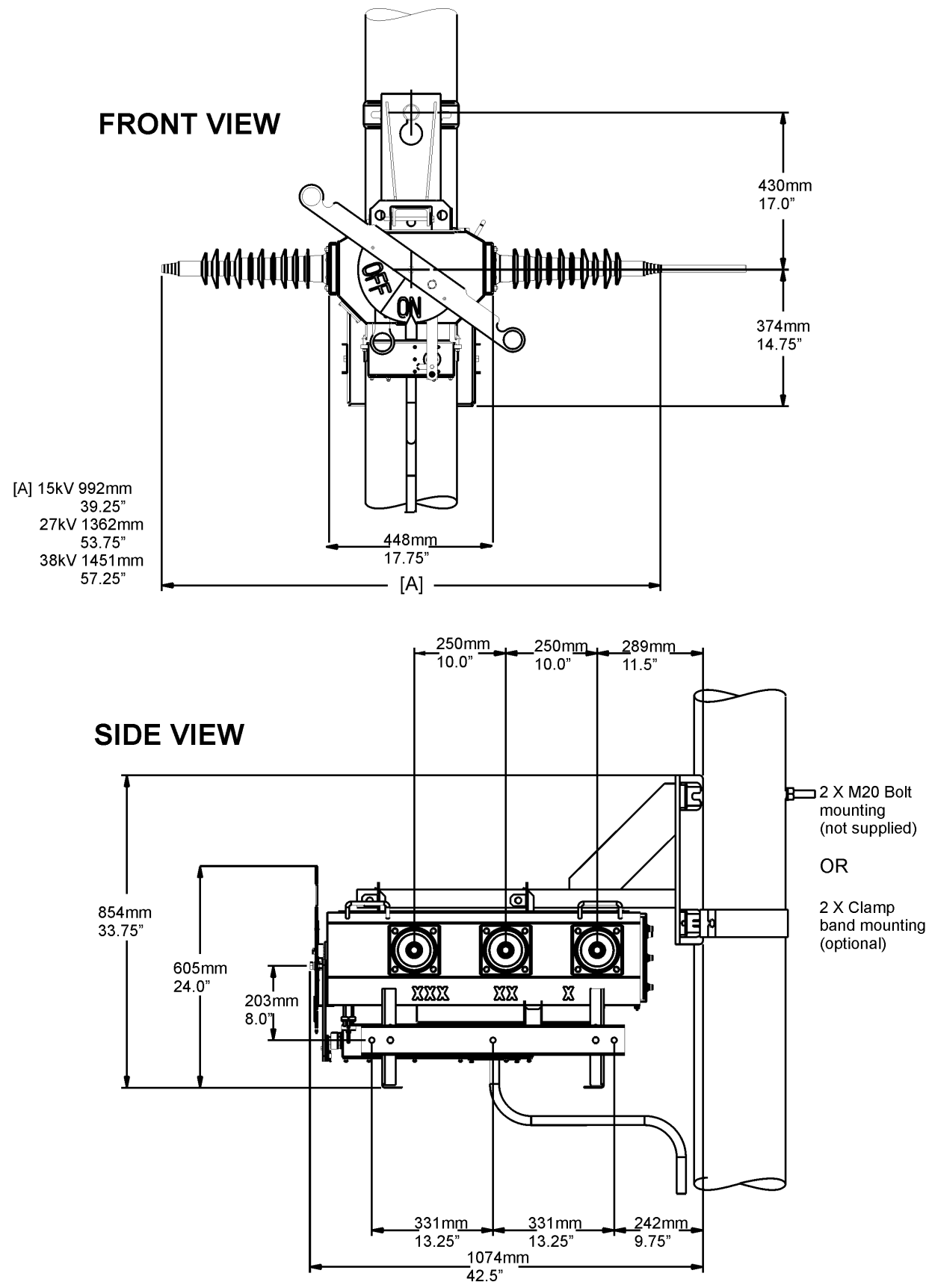


Figure 39: Load Break Switch dimensions

Pole Mounting Bracket

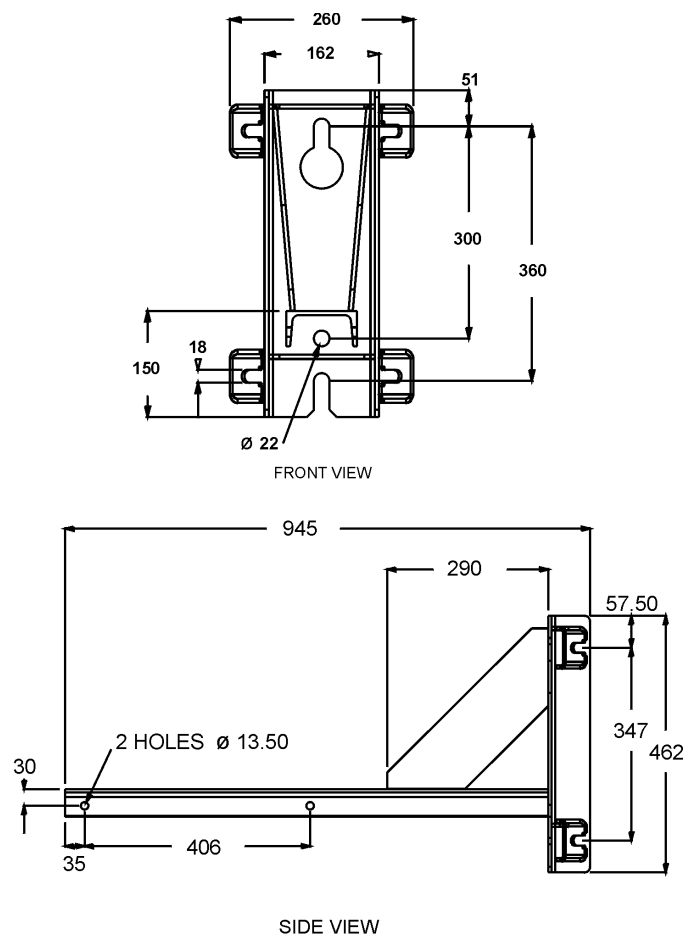


Figure 40: Mounting Bracket dimensions

Radio Mounting Space

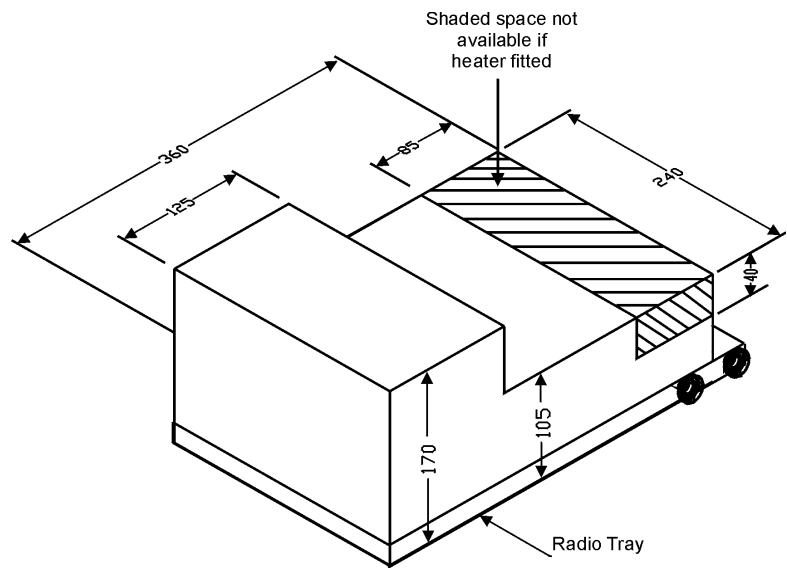


Figure 41: Radio mounting space

**Control
Cubicle**

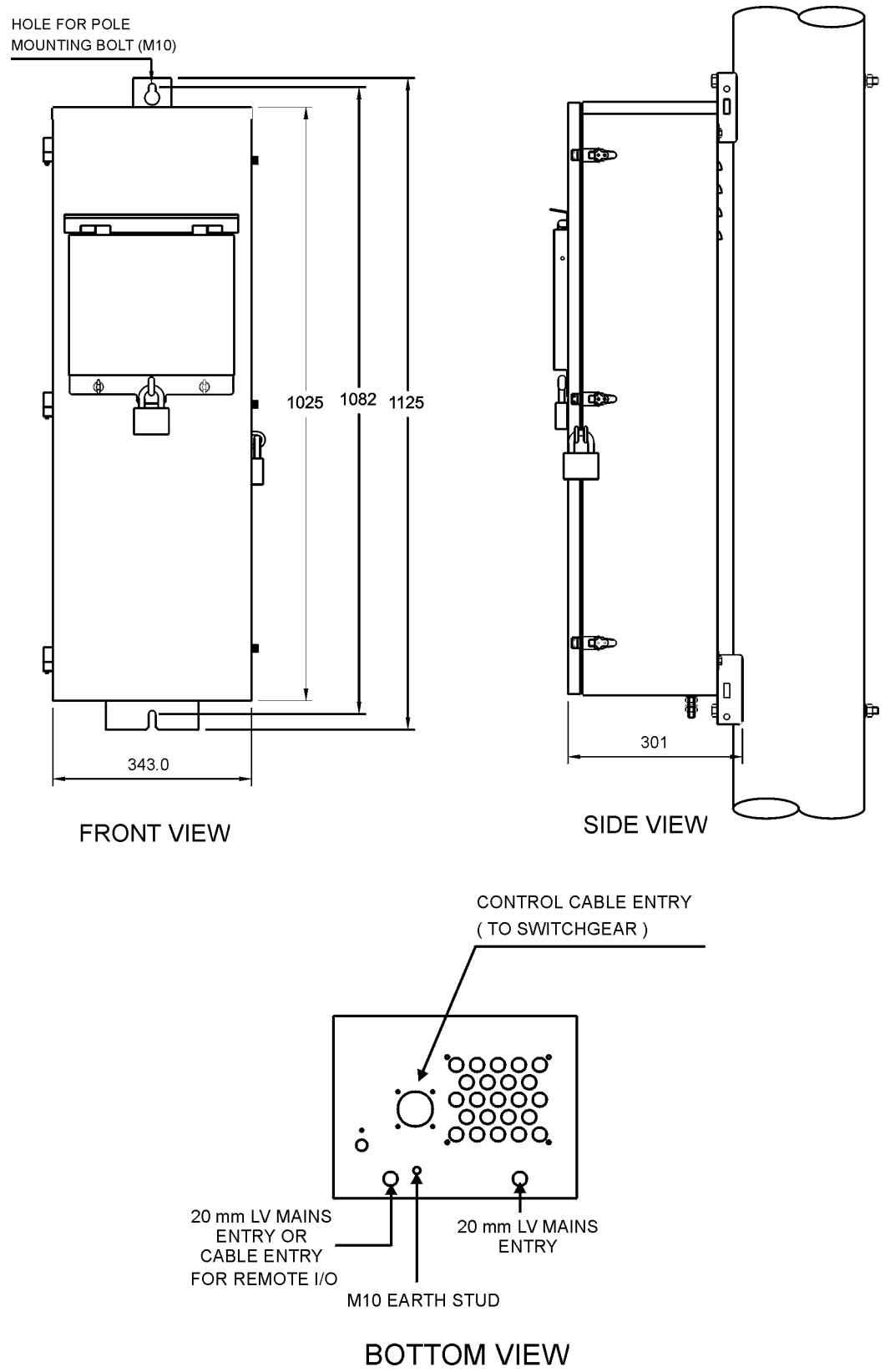
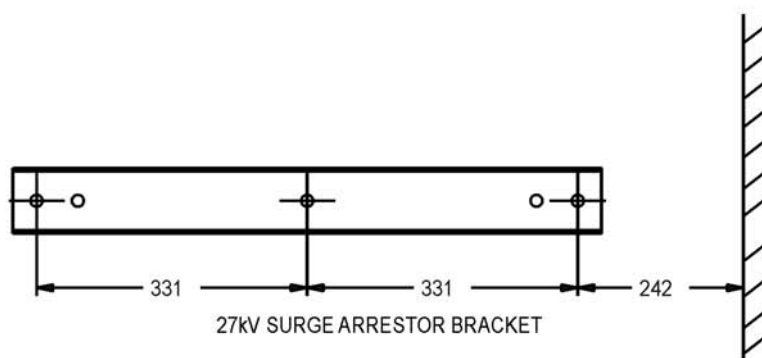
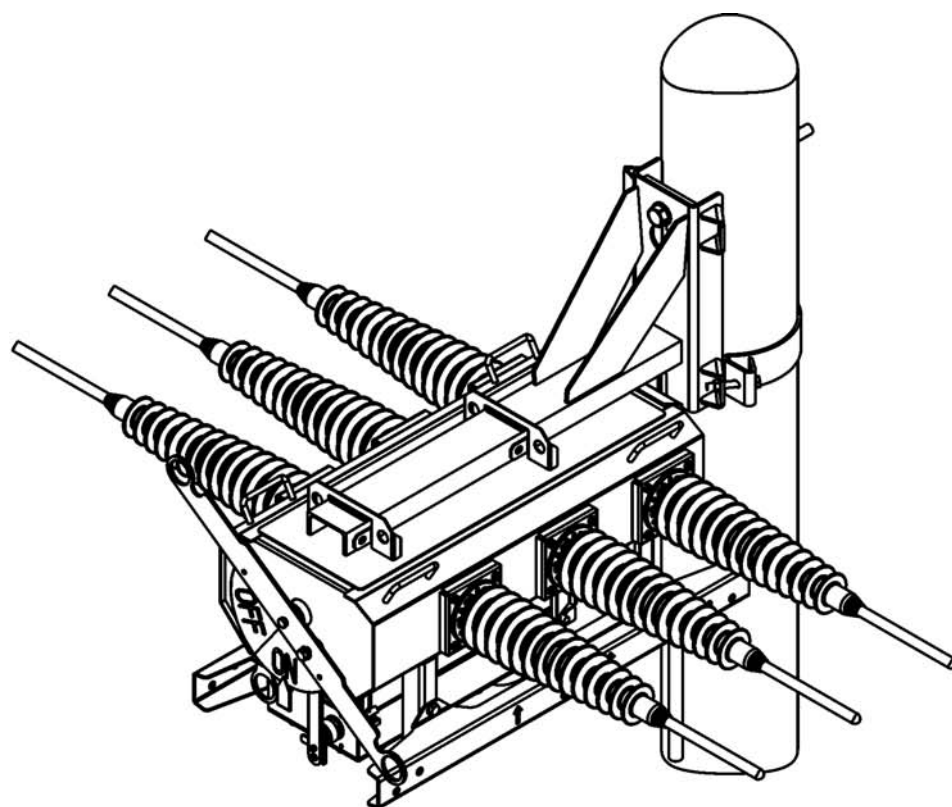
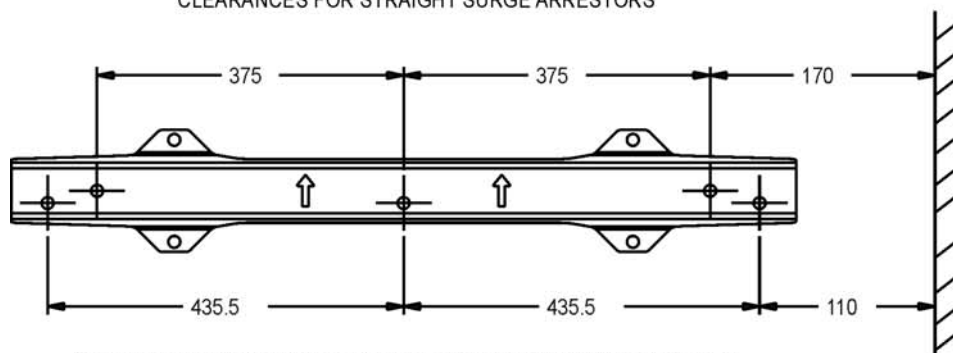


Figure 42: Control Cubicle dimensions

Surge Arrestor Mounting Brackets



CLEARANCES FOR STRAIGHT SURGE ARRESTORS



CLEARANCES FOR SURGE ARRESTORS WITH INSULATING BRACKETS

38kV SURGE ARRESTOR BRACKET

Figure 43: Surge Arrester Bracket dimensions

Appendix H Silicone Grease Hazard Data

Silicone grease type LUB058044 is supplied by the manufacturer for filling the bushing boot cavities. This product is supplied to the manufacturer as Gensil Paste 12.

The following is reproduced from the original document provided by Rhodia Australia.

Release date of original document: March, 2003.

MATERIAL SAFETY DATA SHEET GENSIL PASTE 12 INFOSAFE No: 2RHOT

Not Classified as Hazardous according to criteria of NOHSC.

COMPANY DETAILS

Company Name

Rhodia Australia Pty Ltd
(ABN 24050029000)

Address

352 Ferntree Gully Road, NOTTINGHILL 3168,
Australia

Emergency Phone (Aust)

1800 033 111

Tel / Fax

Ph: +6103 9541 1000 Fax: +6103 9548 8686

IDENTIFICATION

Product Code

GS 12

Product Name

GENSIL PASTE 12

Proper Shipping Name

None Allocated

Other Names

None listed

UN Number

None Allocated

DG Class

None Allocated

Packing Group

None Allocated

Hazchem Code

None Allocated

Poisons Schedule

Not Scheduled

Product Use

Silicone Grease

PHYSICAL DATA

Appearance

Translucent, light grey paste

Specific Gravity

1 (Water = 1)

Flash Point

> 200°C

Flammable Limit LEL

Non-flammable

Solubility in water

Insoluble

OTHER PROPERTIES

pH Value

Neutral

Solubility in Organic Solvents

Dispersible in aromatic and chlorinated hydrocarbon solvents

Odour

None

Form

Liquid

Decomposition Temperature

> 300°C

Stability

Stable under normal conditions of use and storage

Hazardous Polymerization

Will not occur

INGREDIENTS

Information on composition

Dimethylpolysiloxane based compound with inert fillers

HEALTH EFFECTS

Acute - Swallowed

Will not generally cause irritation to mouth, throat and stomach.

Acute - Eye

Considered to be non-irritant.

RL-Series Load Break Switch

Acute - Skin	Considered to be non-irritant.
Acute - Inhaled	Extremely low volatility. Not considered to be hazardous.
Chronic	No chronic effects have been observed under normal conditions of use and handling. To our knowledge there have been no reports in the literature of health effects in workers arising from long term exposure to this substance.
FIRST AID	
Swallowed	Give water or milk to drink.
Eye	Irrigate with copious quantity of water for 15 minutes.
Skin	Wash with plenty of soap and water.
Inhaled	No significant risk of inhalation.
First Aid Facilities	Eye wash fountain.
ADVICE TO DOCTOR	
Advice to Doctor	All treatments should be based on observed signs and symptoms of distress of the patient. Consideration should be given to the possibility that over-exposure to materials other than this may have occurred. Treat symptomatically. No specific antidote available.
PRECAUTIONS FOR USE	
Exposure Limits	See below.
Other Exposure Information	No exposure limit assigned to this substance.
Engineering Controls	No special ventilation required.
PERSONAL PROTECTION	
Protective Equipment	General safe work practice provides adequate protection.
Work/Hygienic Practices	Personal hygiene is an important work practice exposure control measure and the following general measures should be undertaken when working with or handling this material: (1) Do not store, use and/or consume foods, beverages, tobacco products or cosmetics in areas where this material is stored (2) Wash hands and face carefully before eating, drinking, using tobacco, applying cosmetics or using toilets. (3) Wash exposed skin promptly to remove accidental splashes of contact with this material.
FLAMMABILITY	
Fire Hazards	Non-flammable. Combustible. Will burn if involved in a fire but not considered to be a significant fire risk. The main combustion products are silica, carbon dioxide and carbon monoxide.
Other Precautions	Safe working practice and good hygiene should be observed.
STORAGE and TRANSPORT	
Storage Precautions	No special conditions apply. Avoid spillage.
Other Storage Information	General safe working practice should be adequate.
Proper Shipping Name	None allocated.
SPILLS and DISPOSAL	
Spills and Disposal	Presents slipping hazard on floors. Wipe or soak up in inert material for disposal. Wash walking surfaces with detergent and water.

FIRE / EXPLOSION HAZARD**Fire / Explosion Hazard**

Low hazard. Non-flammable liquid. Forms essentially amorphous silica, carbon dioxide and carbon monoxide on combustion. Fire can be extinguished by carbon dioxide, powder or a water type extinguisher.

Hazardous Reaction

The product is considered stable under normal handling conditions. Reaction with strong alkalis at temperatures above 120°C will form flammable, volatile siloxanes.

Hazchem Code

None allocated

OTHER INFORMATION**Toxicology**

Not considered to be toxic under normal conditions of use and handling. No exposure standards are allocated to this substance.

Environmental Protection

Non-biodegradable. No negative ecological effects are known.

Packaging and Labelling

Keep in original container, ensure product name and code is marked on the container.

Regulatory Information

All ingredients are listed in the Australian Inventory of Chemical Substances.

Technical Data

A Technical Data Sheet for this product is available upon request.

References

- (1) Australian Health Ministers Advisory Council, "Standard for the uniform scheduling of drugs and poisons" No: 11. AGPS, Canberra 1996.
- (2) National Occupational Health and Safety Commission, "National Code of Practice for the Preparation of Material Safety Data Sheets" (NOHSC:2011-1994) AGPS, Canberra 1994.
- (3) National Occupational Health and Safety Commission, "List of Designated Hazardous Substances" (NOHSC:10005-1994) AGPS, Canberra 1994.
- (4) National Occupational Health and Safety Commission, "Exposure Standards for Atmospheric Contaminants in the Occupational Environment", NOHSC:1003-1995) AGPS, Canberra 1995.
- (5) National Occupational Health and Safety Commission, "Approved Criteria for Classifying Hazardous Substances" (NOHSC:1008-1994) AGPS, Canberra 1994.
- (6) Commonwealth of Australia, "Australian Code for the Transport of Dangerous Goods by Road and Rail", 6th Edition, AGPS, Canberra, 1998
- (7) Rhodia internal data.

CONTACT POINT**Contact**

Plant Chemist, Rhodia Australia.

Further Advice to the User:

This material safety data sheet should be used in conjunction with the technical data sheets. It does not replace them. The information given is based on our knowledge of the health and safety data of this product at the time of publication. It is given in good faith. The attention of the user is drawn to the possible risks incurred by using the product for any purpose other than that for which it was intended. If clarification or further information is needed to

enable appropriate risk assessment, the user should contact Rhodia Australia. Our responsibility for products sold is subject to our standard terms and conditions sent to customers. No liability whatsoever can be accepted with regard to the handling, processing or use of the product concerned which, in all cases, shall be in accordance with the appropriate regulations and/or legislation.

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