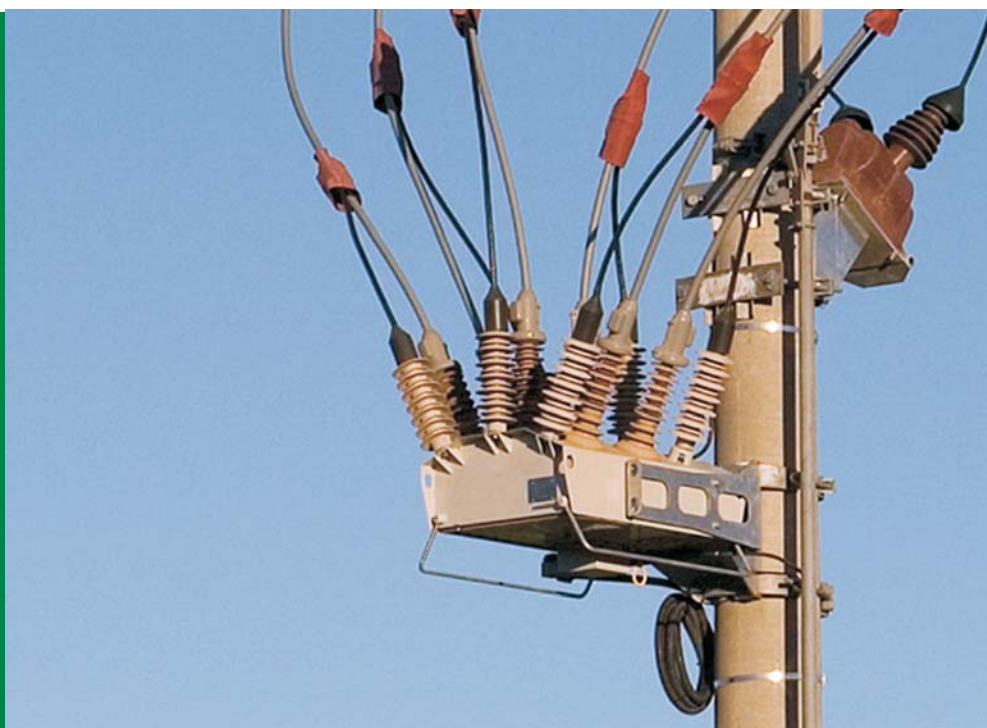


NOJA POWER

User Manual



**OSM Automatic Circuit Recloser
15kV & 27kV Models
With RC01ES Control**

USER MANUAL

NOJA POWER Switchgear

OSM Automatic Circuit Recloser

15kV & 27kV 200 Series

15kV 079 Series

with

RC01ES Control

Revision History

Rev	Author	Date	Comment
1	BOS	8/03/04	First Release
2	BOS	16/04/04	Clarified directional protection sections. Fixed typographical errors.
3	BOS	18-11-04	Added Delayed Close Feature. Corrected directional protection section.
4	BOS	14-4-05	Added minimum bending radius for control cable. Changed PSM input voltage fluctuation from +/-25% to +/-20%. Added OSM coil, sensor and microswitch measurements into troubleshooting section.
5	BOS	17-11-05	Clarified I/O description and wiring diagram. Added palm connector. Added VT to installation drawings.
6	BOS	1-02-06	Added new feature to CO Operation log. Added note to IO Wiring drawing.
7	KL	20-07-2006	Add appendix D, timing details, cable bend radius, minor edits.
8	KL	15-05-2007	Add battery option. Update images. Update Loss of Supply Detector, protection accuracy note, CLP element. Add note to UV alert. Clarify diagnostic warning and caution.
9	BOS	14-05-08	Added new features – External Load Reset Time, Single Shot Timer, SCADA GMT/Local time. Added new IEC60870-5-101 SCADA protocol.

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CONTENTS

1	INTRODUCTION	1
1.1	APPLICABILITY	1
1.1.1	MPM Firmware	1
1.1.2	TELUS Software	1
1.2	SAFETY INFORMATION	1
1.2.1	Personnel Competence	1
1.2.2	Hazard Statements.....	2
1.2.3	Safety Instructions	2
1.3	ACCEPTANCE AND INITIAL INSPECTION	2
2	SPECIFICATIONS	3
2.1	OSM AUTOMATIC CIRCUIT RECLOSER	3
2.1.1	Basic Operating Parameters	3
2.1.2	Ratings.....	3
2.1.3	Sensor Accuracy	3
2.1.4	Breaking Duty.....	4
2.2	RECLOSER CONTROL (RC) CUBICLE	5
2.2.1	Basic Operating Parameters	5
2.2.2	Measurement Accuracy	5
2.2.3	Filtering.....	6
2.2.4	Protection Accuracy	6
2.2.5	Electromagnetic Compatibility (EMC) Performance	7
2.2.6	Power Supply Module (PSM)	7
2.2.7	I/O module.....	8
2.2.8	Rechargeable battery.....	8
3	OSM AUTOMATIC CIRCUIT RECLOSER.....	9
3.1.1	Overview.....	9
3.1.2	Cross Section Diagram: OSM15-200 and OSM 27-203.....	10
3.1.3	Cross Section Diagram: OSM15-079.....	10
3.1.4	Dimensions: OSM15-200 and OSM27-203	11
3.1.5	Dimensions: OSM15-079	12
3.1.6	Main Circuit Bushings.....	13
3.1.7	Current and Voltage Sensing.....	13
3.1.8	Mechanical Trip	13
3.1.9	Position Indicator.....	13
4	RECLOSER CONTROL (RC) CUBICLE.....	14
4.1	OVERVIEW.....	14
4.1.1	Security Cover	15
4.1.2	Functional Diagram	15
4.2	DIMENSIONS.....	16
4.3	MAIN PROCESSOR MODULE	17
4.4	OPERATOR INTERFACE	17
4.4.1	General Control Pushbuttons	18
4.4.2	LCD Control Pushbuttons	18
4.4.3	Fast Keys	19
4.5	TELUS SOFTWARE	20
4.6	AUXILIARY SUPPLY CONNECTION.....	21
4.7	COMMUNICATIONS INTERFACE.....	22
4.7.1	I/O Modules.....	23
4.7.2	RS-485 Connector	24
4.7.3	RS-232 Connector	24
4.7.4	External Load Power Supply Connection for RTU.....	24
4.8	UNINTERRUPTIBLE POWER SUPPLY	25
4.8.1	Power Supply Module.....	25
4.8.2	Settings	25
4.8.3	Operating States	25
4.8.4	Power Management.....	26
4.9	DRIVER MODULE.....	26
5	MEASUREMENT	27

5.1	SAMPLING AND FILTERING	27
5.2	MEASUREMENT SETTINGS	28
6	PROTECTION.....	30
6.1	PHASE AND EARTH OVERCURRENT (OCEF)	30
6.1.1	Phase Overcurrent (OC)	31
6.1.2	Earth Fault (EF)	31
6.1.3	Overcurrent Settings	31
6.1.4	TCC modifiers	34
6.1.5	Directional Overcurrent Elements (DE OC, DE EF)	34
6.1.6	Cold Load Pickup (CLP) Element	35
6.1.7	Inrush Restraint	36
6.1.8	Phase and Earth Overcurrent Reclosing (AR OCEF)	37
6.1.9	Temporary Time Addition (TTA)	39
6.2	SENSITIVE EARTH FAULT (SEF)	40
6.2.1	Sensitive Earth Fault Directional Element (DE SEF)	40
6.2.2	Sensitive Earth Fault Reclosing (AR SEF)	41
6.3	LIVE LINE OVERCURRENT (LL)	42
6.4	UNDER VOLTAGE (UV)	42
6.4.1	Phase Under Voltage (UV1)	43
6.4.2	Line to Line Under Voltage (UV2)	43
6.4.3	Loss of Supply Under Voltage (UV3)	43
6.4.4	Under Voltage Reclosing (AR UV)	43
6.5	UNDER FREQUENCY (UF)	44
6.6	LOSS OF SUPPLY DETECTOR (LSD)	44
6.7	VOLTAGE RECLOSING CONTROL (VRC)	45
6.8	AUTOMATIC BACKFEED RESTORATION (ABR)	46
6.9	PROTECTION STATUS CONTROL (PSC)	46
7	MONITORING	48
7.1	CLOSE OPEN (CO) OPERATIONS	48
7.2	FAULT PROFILE	49
7.3	EVENT LOG	49
7.4	CHANGE MESSAGES	49
7.5	LOAD PROFILE	50
7.6	COUNTERS	50
7.6.1	Lifetime counters	50
7.6.2	Fault counters	50
8	CONTROL AND INDICATION	51
8.1	OPERATOR PANEL SETTINGS	52
8.1.1	Enabling And Disabling Fast Keys	53
8.1.2	Delayed Close	53
8.2	PC CONTROL AND INDICATION	53
8.3	SCADA CONTROL AND INDICATION	54
8.4	DIGITAL INPUTS AND OUTPUTS (I/O)	57
8.4.1	I/O Control	57
8.4.2	I/O Indication	57
8.4.3	I/O settings	58
9	INSTALLATION	60
9.1	DE-CRATING	60
9.1.1	Mechanical Trip Ring	60
9.2	RC CUBICLE PREPARATION	60
9.2.1	Auxiliary Supply Connections	60
9.2.2	RC and OSM Compatibility	61
9.2.3	Initial Checks	61
9.2.4	Control Cable	64
9.2.5	OSM Operation	64
9.2.6	Programming Settings	66
9.3	OSM RECLOSER PREPARATION	66
9.3.1	OSM HV Terminal Connections	66
9.3.2	HV Testing	66
9.3.3	Mounting Bracket	67
9.4	SITE INSTALLATION	67
9.4.1	Transport to Site	67

9.4.2	HV Surge Arrestors	68
9.4.3	Installation: OSM15-200 and OSM27-203.....	68
9.4.4	Installation: OSM15-079.....	69
9.4.5	RC Installation	69
9.4.6	Earthing.....	69
9.4.7	Auxiliary Supply	72
9.4.8	Communications Interface.....	72
10	MAINTENANCE.....	73
10.1	OSM RECLOSER CONTACT WEAR.....	73
10.2	RC CUBICLE	73
10.2.1	Battery Replacement.....	73
10.2.2	Door Seal.....	74
10.3	TROUBLESHOOTING.....	75
10.3.1	RC Cubicle	75
10.3.2	Diagnostic Events.....	76
10.3.3	OSM Recloser.....	80
10.4	SCHEMATICS.....	81
10.4.1	Control Cable.....	81
10.4.2	RC Control Wiring Assembly (WA03)	82
10.4.3	RC Main Wiring Assembly (WA01)	83
10.4.4	Battery Wiring Assembly (WA02).....	84
10.4.5	Auxiliary Supply Wiring Assembly (WA04)	84
10.4.6	RS-485 and External Load.....	85
10.4.7	RS-232	85
10.4.8	TELUS Communications Cable.....	86
10.5	SPARE PARTS LIST.....	86
11	APPENDICES.....	87
11.1	APPENDIX A – PROTECTION ELEMENT STRUCTURE.....	87
11.2	APPENDIX B – DIRECTIONAL PROTECTION	88
11.2.1	Overcurrent directional elements (DE OC, DE EF and DE SEF).....	88
11.3	APPENDIX C – TIME CURRENT CHARACTERISTIC (TCC) CURVES	91
11.3.1	ANSI TCC.....	91
11.3.2	IEC TCC.....	91
11.3.3	User Defined Curves	92
11.4	APPENDIX D – RC-01ES ANSI SUPPORT	94
11.5	APPENDIX E – INDICATION SIGNALS	96
11.6	APPENDIX F – EVENTS.....	100
11.7	APPENDIX G – CHANGE MESSAGES.....	105
11.8	APPENDIX H – CONTROL AND INDICATION OF SETTINGS.....	106
11.9	APPENDIX I – MMI MENU LAYOUT.....	107
INDEX		112

1 Introduction

This manual applies to the range of Automatic Circuit Reclosers and Controls manufactured by NOJA Power.

1.1 Applicability

The following products are covered by this manual:

- OSM-15.5-16/630-079 (Automatic Circuit Recloser rated at 15kV)
- OSM-15.5-16/630-200 (Automatic Circuit Recloser rated at 15kV)
- OSM-27-12.5/630-203 (Automatic Circuit Recloser rated at 27kV)
- RC-01ES (recloser control)

Before Installing and / or operating the recloser or control, read and understand the contents of this manual.

Note that this manual cannot cover all the details or variations in the equipment or process being described. Neither is it expected to address all contingencies associated with installation and operation of this equipment. For any further information please contact your nearest NOJA Power Office or Distributor.

1.1.1 MPM Firmware

This manual applies to firmware versions S02.03.04-xxxx where “xxxx” is the actual build number.

This document applies to MPM firmware versions S02.03.05-6039 and above.

Any newer versions of MPM firmware may have additional features to those described in this manual. These features will be described in the firmware release notes.

1.1.2 TELUS Software

A compatible version of TELUS must be used with the MPM firmware loaded into the device. The current release of MPM firmware requires TELUS version 02.04.05E Rev22 or higher.

1.2 Safety Information

Installation, use and servicing should only be carried out by trained and experienced personnel who are familiar with the equipment and electrical safety requirements.

1.2.1 Personnel Competence

It is the responsibility of the purchaser to ensure the personnel installing, using and maintaining the equipment described in this manual are competent. Minimum personnel competency requirements include:

- Familiarity with this manual and its contents.
- Training in industry accepted safe operating procedures associated with both low and medium voltage equipment.
- Training and appropriate authorisation to energise, de-energise and earth power distribution equipment.
- Training in the care and use of protective equipment associated with low and medium voltage applications.

1.2.2 Hazard Statements

This manual contains three types of hazard statements, as follows:



DANGER: Indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury



WARNING: Indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury



CAUTION: Indicates a potentially hazardous situation that, if not avoided, could result in personal injury or equipment damage

1.2.3 Safety Instructions

General hazard statements used in this manual are described below.



DANGER: Contact with hazardous voltage will cause death or severe personal injury. Contact with Recloser or Control Cubicle terminals should only be undertaken when equipment is isolated from applicable sources of voltage.



WARNING: This equipment is not intended to protect human life. Follow all locally approved safety procedures when installing or operating this equipment. Failure to comply may result in death or severe personal injury.



WARNING: Before working with equipment described in this manual carefully read and understand the contents of this manual. Improper handling, installation, operation or maintenance can result in death, severe personal injury or damage to equipment.



WARNING: Power distribution equipment must be properly selected for the intended operation. It must be installed, used and maintained by competent personnel who have been trained in and understand all relevant safety procedures. Failure to comply can result in death, personal injury or equipment damage.

1.3 Acceptance and Initial Inspection

NOJA Power products are assembled, tested and inspected at the factory before being packaged. Inspect the shipping packaging for any external signs of damage. Also unpack the product and inspect it thoroughly for any signs of transport damage. If transport damage is suspected, file a claim with the carrier.

2 Specifications

2.1 OSM Automatic Circuit Recloser

OSM Automatic Circuit Reclosers comply with the ANSI / IEEE C37.60-2003 standard.

2.1.1 Basic Operating Parameters

	OSM15-079	OSM15-200 - OSM27-203
Current sensing	6 x Rogowski Current Sensors	6 x Rogowski Current Sensors
Voltage sensing	6 x Capacitive Voltage Dividers	6 x Capacitive Voltage Dividers
Ambient temperature	- 40°C to + 55°C	- 40°C to + 55°C
Humidity	0 – 100%	0 – 100%
Altitude ¹	3000m	3000m
Overall dimensions (length x width x height)	720 x 640 x 630 mm	760 x 534 x 750 mm
Weight	62.5kg	85kg

Note: 1. For altitudes above 1000m ratings should be corrected in accordance with ANSI C37.60-2003

2.1.2 Ratings

	OSM15-079	OSM15-200	OSM27-203
Rated maximum voltage	15.5kV	15.5kV	27kV
Rated continuous current	630A	630A	630A
Fault make capacity RMS	16kA	16kA	12.5kA
Fault make capacity Peak	40kA	40kA	31.5kA
Fault break capacity	16kA	16kA	12.5kA
DC component Interruption capacity	20%	20%	20%
Mechanical operations	30000	30000	30000
Full Load Operations	30000	30000	30000
Fault break capacity operations	200	200	200
Short time current withstand 4 seconds	16kA	16kA	12.5kA
Mainly active breaking capacity	630A	630A	630A
Transformer magnetising current	22A	22A	22A
Cable charging current	25A	25A	25A
Line charging current	5A	5A	5A
Impulse withstand phase to earth, phase to phase and across the interrupter	110kV	110kV	125kV ¹
Power frequency withstand phase to Earth and across the interrupter	50kV	50kV	60kV
Closing Time	<60ms	<60ms	<60ms
Opening Time	<30ms	<30ms	<30ms
Breaking / Interrupting Time (including arcing time)	<40ms	<40ms	<40ms

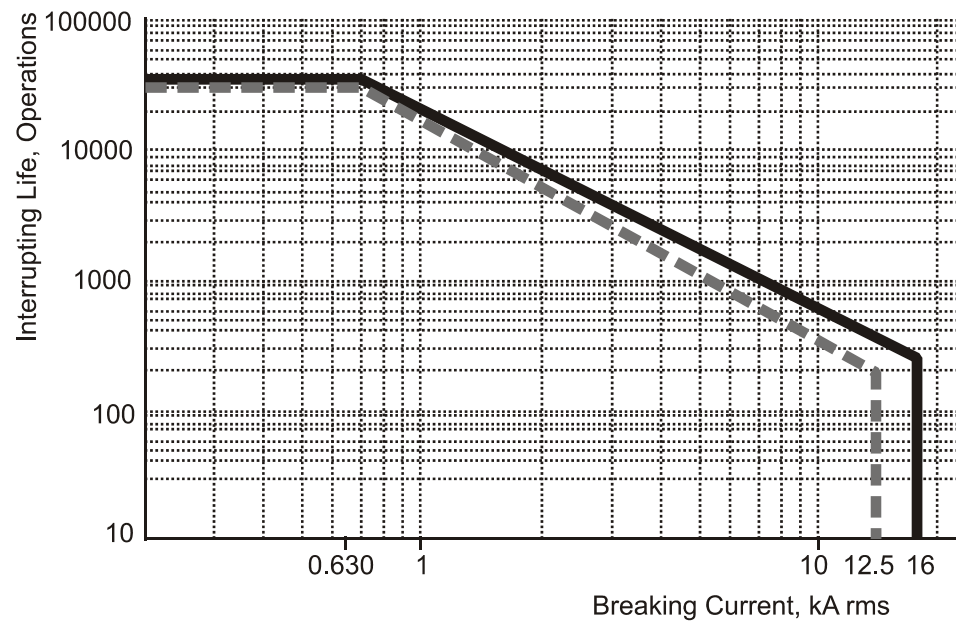
Note: 1. A 150kV BIL option is provided by supplying OSM complete with surge arrestors for each HV terminal and associated mounting brackets.

2.1.3 Sensor Accuracy

Sensor Type	Accuracy
Rogowski coil current sensor	+ / - 0.5%
Capacitively coupled voltage sensor	+ / - 5.0%

2.1.4 Breaking Duty

Vacuum interrupter contact life as a function of interrupting current is illustrated in the graph below.



The high and low current number of operations for each OSM type is summarised in the table below.

	OSM15-079 & 200	OSM27-203
Number of operations at rated continuous current	30,000 ops at 630A	30,000 ops at 630A
Number of operations at rated interrupting current	200 ops at 16kA	200 ops at 12.5kA

Maximum duty cycle is defined as O – 0.1s – CO – 1s – CO – 1s – CO followed by 60 seconds recovery time.

2.2 Recloser Control (RC) Cubicle

The Recloser Control cubicle complies with the following standards:

- ANSI / IEEE C37.60
- ANSI / IEEE C37.61
- IEC 60694.
- As noted in table 2.2.5

2.2.1 Basic Operating Parameters

Rated frequency, Hz	50 / 60
Rated cubicle (auxiliary) AC supply voltage, V	100/127/220
AC (auxiliary) supply circuit breaker	2A
Standard operating duty	O – 0.1s – CO – 1s – CO – 1s – CO – 60s
Degree of protection	IP65
Minimum operating temperature, °C	- 40
Maximum operating temperature, °C	+ 55
Maximum humidity, %	100
Maximum altitude above sea level, m	3000
Operating time after loss of AC supply ¹ , hours	
• at -40°C	12
• at 20°C	48
• at +55°C	48
Weight ² , kg	50
Overall Dimensions, (width x height x depth) mm	400 x 1080 x 309

Notes:

1. Without RTU or other communications device
2. Battery and one I/O module included

2.2.2 Measurement Accuracy

Measured value	Accuracy	Ranges where accuracy guaranteed
Phase to earth voltages	The greater of 1.0% or ± 0.1 kV	0.3 – 16.0 kV
Line to line voltages	The greater of 1.0% or ± 0.1 kV	0.5 – 27.0 kV
Phase currents	The greater of $\pm 1\%$ or ± 4 A	0 – 630 A
Residual Current	The greater of $\pm 5\%$ or ± 0.5 A	0 – 400 A
Active, reactive and total power	$\pm 2\%$	40 – 630 A, 4.5 – 27 kV
Power factor	± 0.02	0 – 1
Active and reactive energy	$\pm 2\%$	40 – 630 A, 4.5 – 27 kV
Frequency		45 – 55 Hz, 55 – 65 Hz
– at $dF/dt < 0.2$ Hz/s	± 0.025 Hz	
– at $dF/dt < 0.5$ Hz/s	± 0.05 Hz	

2.2.3 Filtering

Harmonics rejection rates, not less than

– second	1:100
– third	1:316
– fifth	1:1000

Response delay to a step change in input current or voltage

– at output value changed by 10% of the input step	5 ms
– at output value changed by 20% of the input step	10 ms
– at output value changed by 50% of the input step	18 ms
– at output value changed by 80% of the input step	25 ms
– at output value changed by 90% of the input step	30 ms
– at output value changed by 95% of the input step	35 ms

Note: All protection and measurement is carried out on the basis of fundamental frequency values, ie post filtering.

2.2.4 Protection Accuracy

Parameter	Accuracy	Accuracy Range
Operational pickup current ¹		
– for phase overcurrent elements	the greater of $\pm 2\%$ or $\pm 2A$	10 – 6000A
– for earth overcurrent elements	the greater of $\pm 5\%$ or $\pm 1A$	4 – 1280A
Operational pickup voltage	the greater of $\pm 1\%$ or $\pm 0.1kV$	0.5 – 18kV for UV1 0.5 – 30kV for UV2
Operational pickup frequency	$\pm 0.05Hz$	45 – 55Hz for 50Hz system 55 – 65Hz for 60Hz system
Tripping time for time current characteristics:	the greater of:	
Definite time	+1%; +35ms / –10ms	0 – 120s for all time current characteristics
ANSI / IEC IDMT curve	+3%; +50ms / –10ms	
Reclose time	the greater of $\pm 0.1\%$; +1ms	0.1 – 180s
Reset time	the greater of $\pm 0.1\%$; +1ms	0 – 10s for overcurrent 5 – 180s for reclosing
Restoration time for automatic backfeed restoration element	the greater of $\pm 0.1\%$; $\pm 1ms$	0 – 180s
Angle between voltage and current for phase overcurrent (OC), earth fault (EF) and sensitive earth fault (SEF) directional elements (DE):		
• DE OC	$\pm 2^\circ$	At $U_1 \geq 0.5kV$ and $I_1 \geq 40A$
• DE EF, DE SEF	$\pm 2^\circ$	At $U_0 \geq 0.5kV$ and $I_0 \geq 10A$
• DE EF, DE SEF	$\pm 4^\circ$	At $U_0 \geq 0.5kV$ and $3A \leq I_0 \leq 10A$

Note 1: Pickup is initiated at 100% of pickup current value and drops off at 97.5% (2.5% difference). When a current multiplier is applied to the pickup value the same percentage (2.5%) applies to the new calculated value.

2.2.5 Electromagnetic Compatibility (EMC) Performance

	Rated value	Applicable standard
Rated power frequency test voltage, (1 min)	2 kV	IEC 60255 – 5
Rated Impulse Voltage, at 0.5J	5 kV	IEC 60255 – 5
Burst Disturbance	1 MHz	IEC 60255 – 22 – 1 (Class III)
Electrostatic Discharge		IEC60255 – 22 – 2 (Class III)
– contact	6 kV	
– air	8 kV	
Radiated Electromagnetic Field	10 V/m	IEC 60255 – 22 – 3
Radiated Electromagnetic Field from portable phones	10 V RMS	IEC 60255 – 22 – 3
Conducted Electromagnetic Field (via external terminals)		
Electrical Fast Transient/Burst Immunity	4 kV	IEC 61000 – 4 – 4 (Level IV)
Surge Immunity (external AC voltage terminals)		IEC 61000 – 4 – 5 (Level IV)
– common	4 kV	
– transverse	2 kV	
Power Frequency Magnetic Field Immunity		IEC 61000 – 4 – 8
– 1 sec	1000 A/m	
– 1 min	100 A/m	
Pulse Magnetic Field Immunity (6.4/16 ms)	1000 A/m	IEC 61000 – 4 – 9
Damped Oscillatory Magnetic Field Immunity	100 A/m	IEC 61000 – 4 – 10
Conducted and Radiated RFI Emissions	Class A	IEC 60255 – 25

2.2.6 Power Supply Module (PSM)

Input AC voltage (depending on power supply links)	220 Vac +/-20% 127 Vac +/-20% 100 Vac +/-20%
Frequency of input voltage	45 – 65 Hz
Maximum power consumption	
– continuous:	
at ambient temperature above -15°C	6 W
at ambient temperature below -15°C	15 W
– within 60s of switching On or execution of the standard operating duty	60 W
Output DC voltage provided for external load	10.2 – 16 V
Ripple content of output DC voltage	20 mV
Maximum external load consumption	
– continuous	15 W
– at 50% duty cycle	30 W
External load short circuit protection level	4 A

2.2.7 I/O module

Basic parameters

Input DC voltage	10.2 – 16 Vdc
Maximum continuous power consumption	1W

Digital inputs

Rated voltages, Vdc	
– for IOM-12/60	12/24/30/48/60 Vdc
– for IOM-100/250	110/125/220 Vdc

Pickup voltage, Vdc	
– for IOM-12/60	above 7 Vdc
– for IOM-100/250	above 100 Vdc

Reset voltage, Vdc	
– for IOM-12/60	below 3 Vdc
– for IOM-100/250	below 30 Vdc

Maximum continuous voltage, Vdc	
– for IOM-12/60	75 Vdc
– for IOM-100/250	275 Vdc

Input resistance	
– for IOM-12/60	3 kΩ
– for IOM-100/250	125 kΩ

Recognition time, ms	20 ms
----------------------	-------

Transmission time, ms	12 – 19 ms
-----------------------	------------

Reset time, ms	20 ms
----------------	-------

Output relay contacts

Rated voltage	
– AC	6 – 230 Vac
– DC	4.5 – 125 Vdc

Rated current	16 A
---------------	------

Maximum breaking power	
– DC at L/R=1ms	30 W
– AC at power factor 0.3	50 VA

Minimum switching power	
– DC	300 mW
– AC	300 mVA

2.2.8 Rechargeable battery

Type	Sealed Lead Acid
Rated Voltage, V	12 Vdc
Rated capacity, Ah	24 Ah

3 OSM Automatic Circuit Recloser

3.1.1 Overview

This manual covers two types of tank. The OSM15-079 is constructed from aluminium while the OSM15-200 and OSM27-203 tank is constructed from 304 grade stainless steel and is arc-fault vented. Both tanks are rated for a 30 year lifetime. All tank types contain three poles, each with its own vacuum interrupter and insulated drive rod contained within a polycarbonate housing. Each pole has its own magnetic actuator contained within a mechanism enclosure; the three poles and single mechanism enclosure are installed within a sealed tank. The enclosure provides an IP65 rating and is fitted with a ceramic breather to prevent build up of condensation.

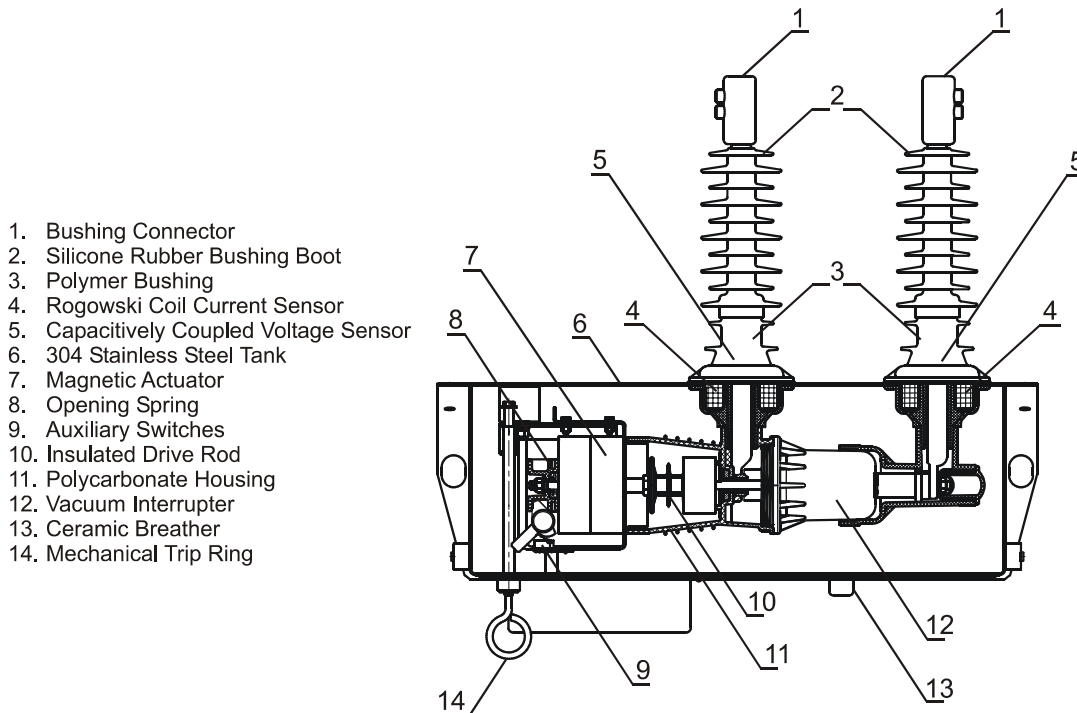
The three magnetic actuators are mechanically interlocked to ensure correct three phase operation and the mechanism is held in the open or closed position by means of magnetic latching. The actuators each have a single solenoid; trip operation is achieved by reversing current direction to generate a driving force in the opposite direction to a close operation. Energy for operation is provided by capacitors located in the Recloser Control (RC) cubicle.

The OSM recloser can be mechanically tripped by using a hook stick to pull the Mechanical Trip Ring to the open position. Position indication is located in the base of the tank and can be viewed by an operator on the ground. Recloser open / close status is detected by the Recloser Control through monitoring the status of parallel connected auxiliary switches that reflect the position of the mechanism.

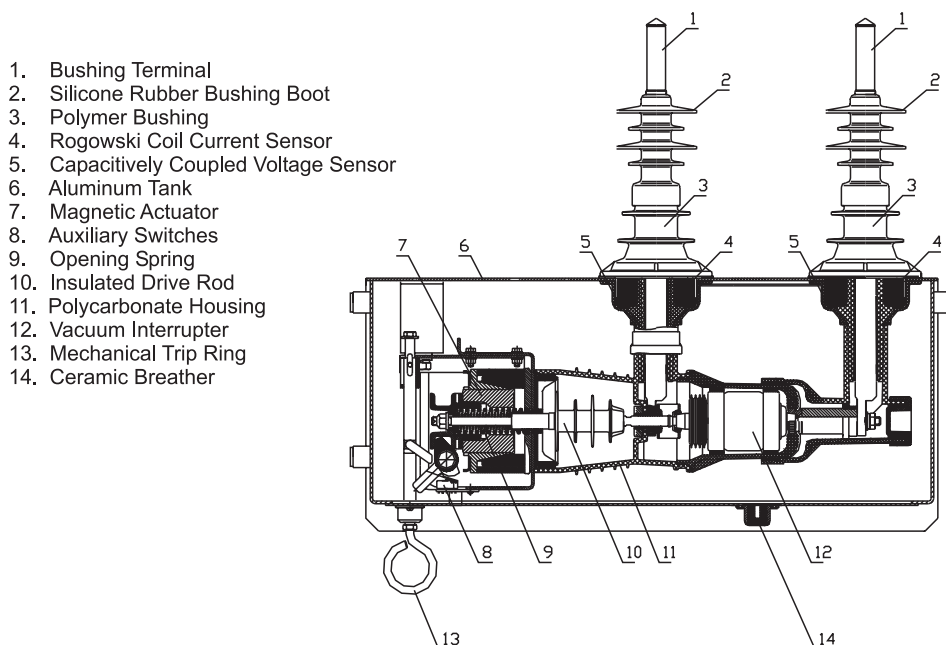
Voltage is measured at all six terminals using conductive rubber screens that are capacitively coupled to the HV terminals. Current is also measured at all six terminals using Rogowski sensors. Three sensors on one side of the vacuum interrupters provide phase current measurement for indication and phase overcurrent protection. The three sensors on the other side of the vacuum interrupters are connected in series and provide residual current measurement for indication and earth overcurrent protection.

The main circuit bushings are manufactured from UV stable polymer and a silicone rubber bushing boot is fitted to provide the required creepage distance. The OSM15-200 and OSM 27/203 have tin plated, aluminium alloy connectors for termination of overhead cables. The OSM/079 has nickel plated copper stems designed for use with PG clamps.

3.1.2 Cross Section Diagram: OSM15-200 and OSM 27-203

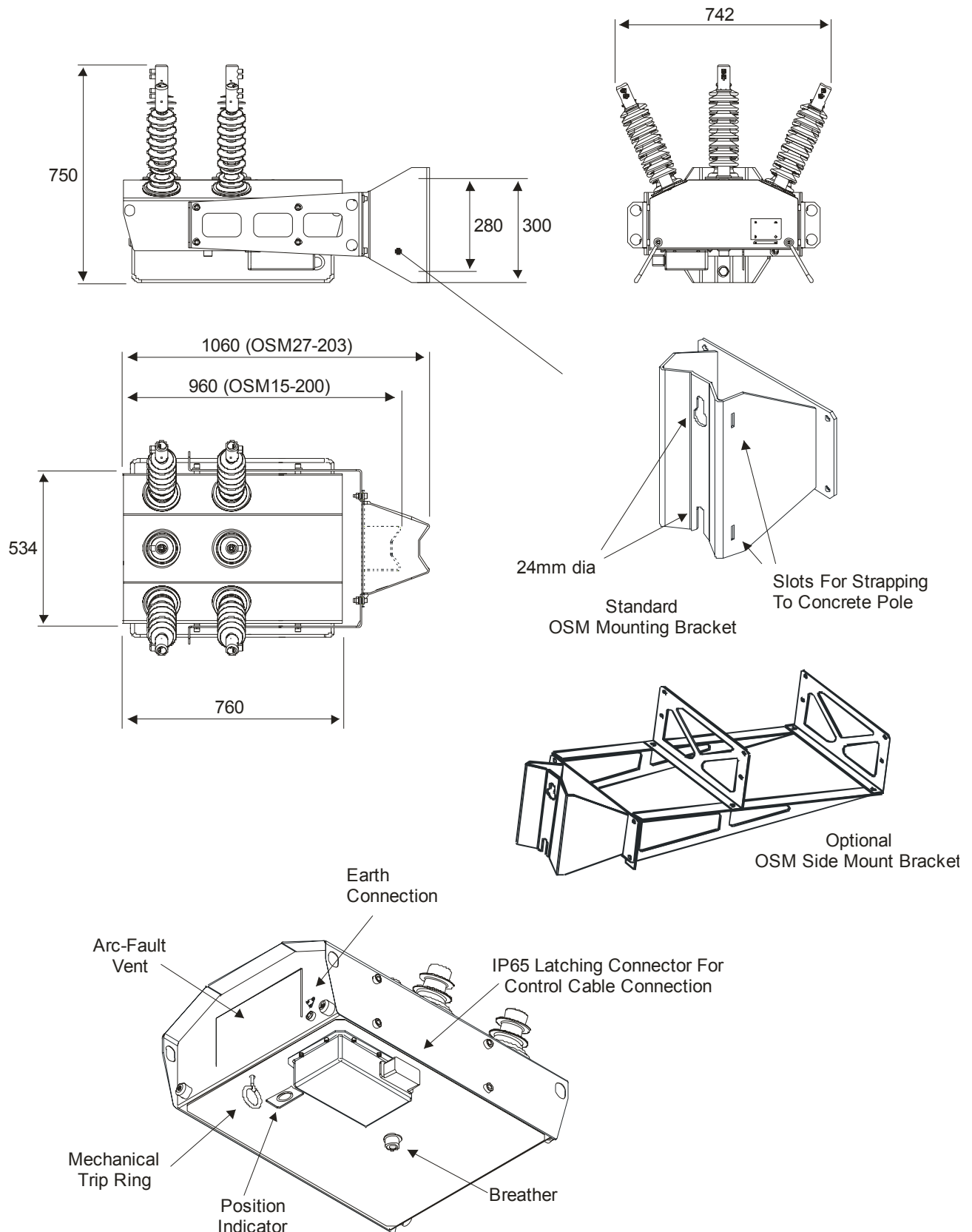


3.1.3 Cross Section Diagram: OSM15-079

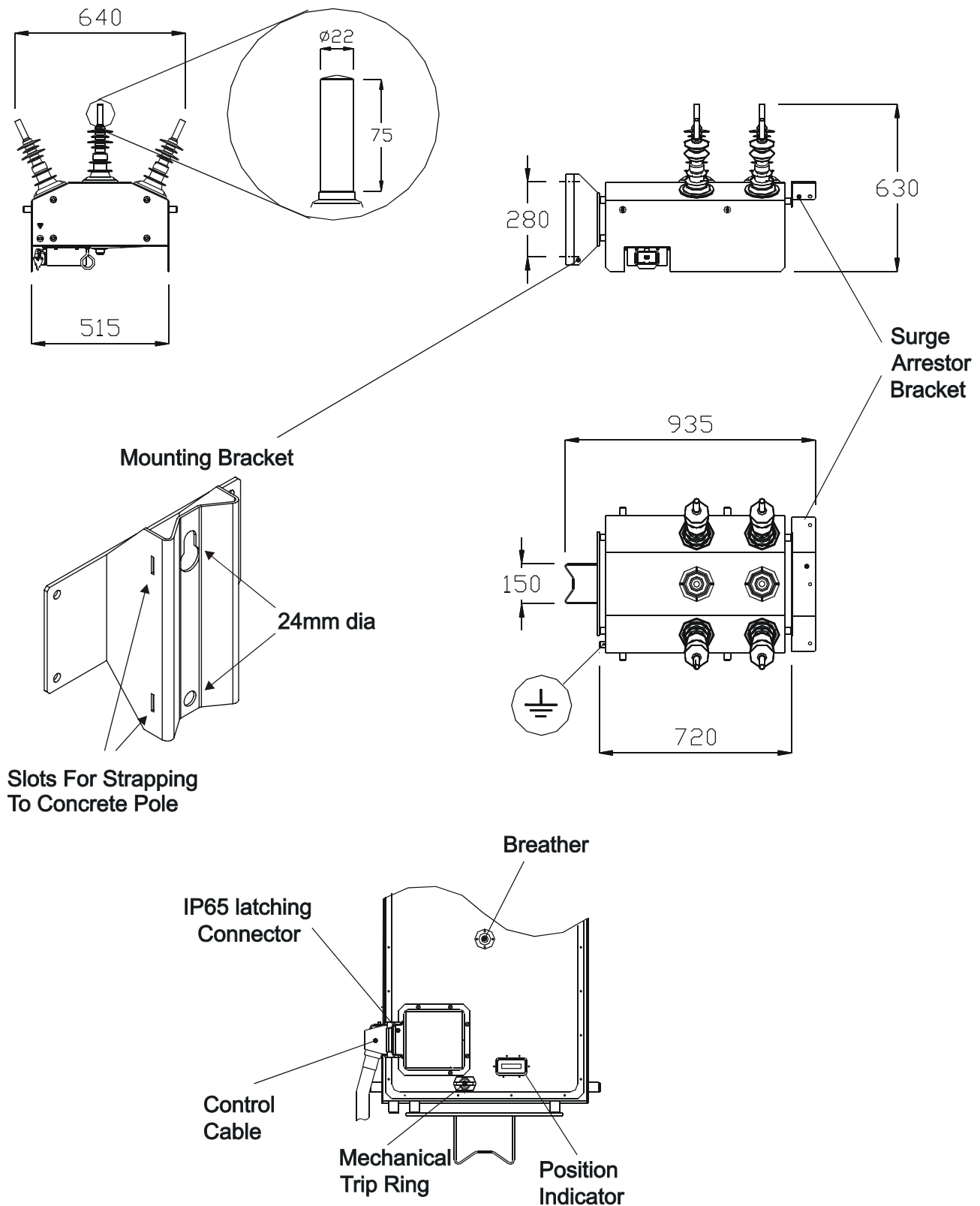


3.1.4 Dimensions: OSM15-200 and OSM27-203

The **OSM15-200** and **OSM27-203** Auto Circuit Recloser is illustrated in the diagram below. The OSM Control Cable are common to both models. Earthing is by an M12 bolt into the tank.



3.1.5 Dimensions: OSM15-079



3.1.6 Main Circuit Bushings

The OSM Auto Circuit Recloser main circuit bushings are manufactured from UV stable polymer and are fitted with silicone rubber bushing boots to provide the following creepage and taut string distances.

Model	Creepage Distance	Taut String Clearance
OSM15-079	485mm	235mm
OSM15-200	485mm	250mm
OSM27-203	842mm	280mm

The OSM15-200 and OSM27-203 HV terminals have a tin-plated, aluminium alloy connector at the end. This connector is suitable for cable sizes from 40mm² to 260mm². Cables are secured in the connector with two hexagonal socket screws. A tin-plated bronze palm connector can be fitted to the bushing instead if required. This has two holes 44.45mm (1.75") apart so a lug can be bolted onto the bushings.

The OSM15-079 has bare HV terminals made from nickel plated copper providing a 75mm stem with a diameter of 22mm. Cables are connected to the stems using PG clamps (not supplied).

The terminals on the (nominal) source side are marked A, B and C. The terminals furthest from the pole are correspondingly marked R, S and T. Since operation is by low voltage magnetic actuators, there is no requirement to have either side terminals energised for operation.

3.1.7 Current and Voltage Sensing

Current Sensing is carried out by six (6) Rogowski sensors, one on each HV terminal. The sensors on the ABC terminals monitor phase currents. The sensors on the RST terminals have secondaries connected in series for monitoring earth currents. A Rogowski sensor is fundamentally an air cored CT and is therefore not prone to saturation when exposed to fault currents. Unlike conventional Current Transformers, Rogowski sensors do not generate potentially hazardous voltages when the secondary is open circuit.

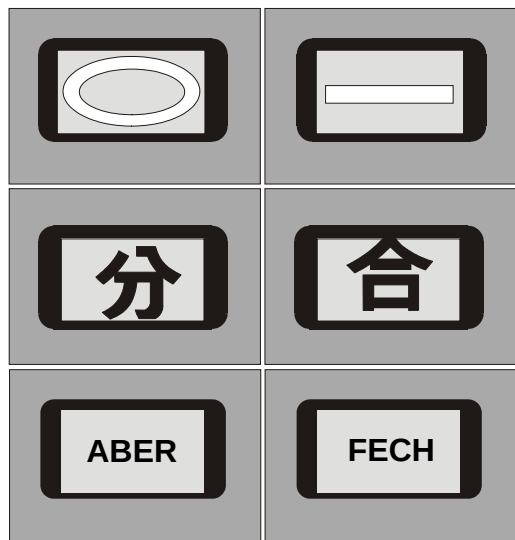
Voltage sensing is carried out by a conductive rubber sheath that is capacitively coupled to the voltage applied to the HV terminals (V_{HV}).

3.1.8 Mechanical Trip

The Mechanical Trip Ring is made of zinc anodised steel and is powder coated yellow. Less than 35kg of downwards force is required to operate the mechanism.

When pulled down, the OSM Auto Circuit Recloser is prevented from operating. An 'OC Coil Isolated' Warning event is generated to provide indication of the locked state, refer section 10.3.2. Pushing the Ring back into the operating position returns the recloser to normal mode.

3.1.9 Position Indicator



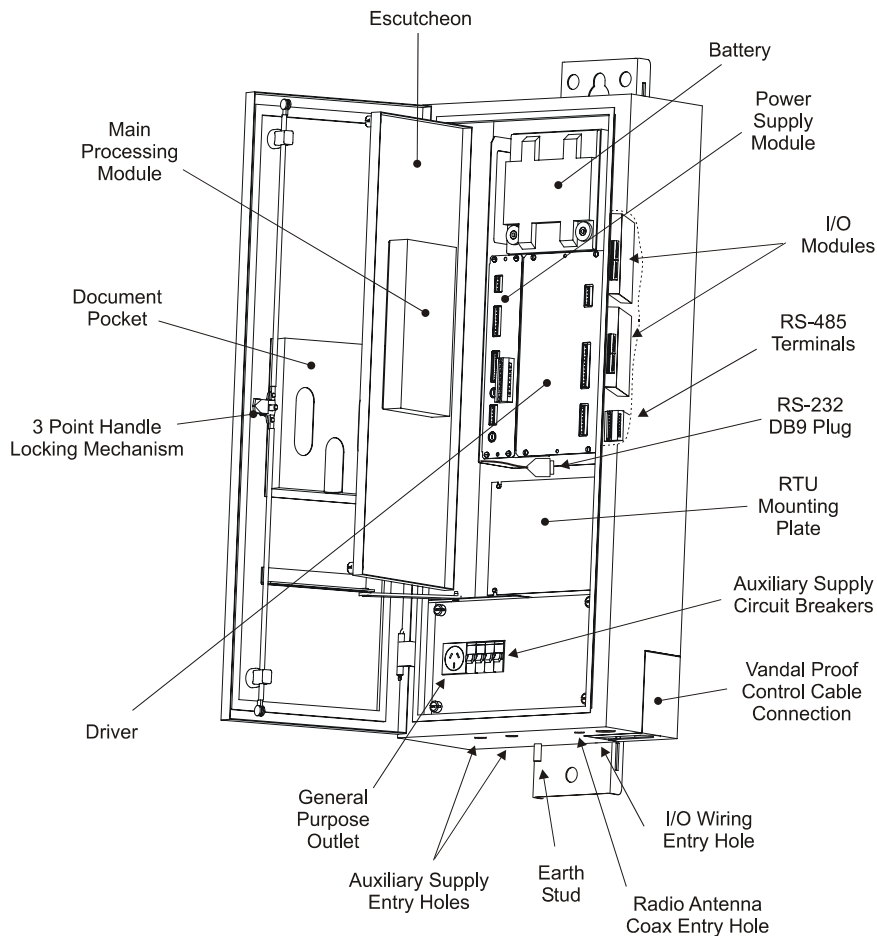
The OSM position indicator is located under a protective cover underneath the tank and is clearly visible from the ground.

Indicator colour is RED when closed and GREEN when open. Two choices of indicator are available at time of order, as depicted opposite; IEC standard I and O, Chinese characters or Portuguese ABER (ABERTO - Open) and FECH (FECHADO - Close).

4 Recloser Control (RC) Cubicle

4.1 Overview

The Recloser Control (RC) cubicle is manufactured from powder coated 304 grade stainless steel. The cubicle provides IP65 protection for the equipment it houses.



RC cubicle features include

- User Interface (MMI)
- Provision for a padlock with 12mm hasp
- Space for radio, modem, RTU or other communications equipment (300 wide x 165 high x 180 deep)
- Miniature Circuit Breaker for auxiliary supply
- General Purpose Power Outlet (GPO)
- Door stay to hold the door at an angle of 110°
- Document pocket
- Vandal proof entry for control cable
- Dust proof drainage filter
- M12 Earthing stud

Electro–Magnetic Compliance (EMC) requires potential sources of Electro–Magnetic Interference (EMI) to be housed within a magnetically permeable material to ‘soak up’ energy associated with the EMI. Mild steel is ideal for this application and all NOJA Power modules with EMI generating capacity are housed within zinc plated mild steel to provide the best compromise between EMC requirements and long service life.

The RC Cubicle has been tested to stringent EMC standards, refer section 2.2.5 for details. To achieve its high level of EMC the RC Cubicle features screened wiring where appropriate.

The **Power Supply Module** (PSM) manages the power requirements for all the other modules. Auxiliary voltage inputs are protected by 1A, 250V fuses on the PSM. Together with a 12V sealed lead acid battery the PSM provides Uninterruptible Power Supply (UPS) supported operation.

The **Main Processing Module** (MPM) contains the microprocessor control and a User Interface (MMI) for operator control. It is fitted with a 9 pin male RS–232 connector to allow connection of a PC by means of the TELUS software package.

The **Driver** module is responsible for generating the current pulses for trip / close operation and monitoring the health of the operating circuits.

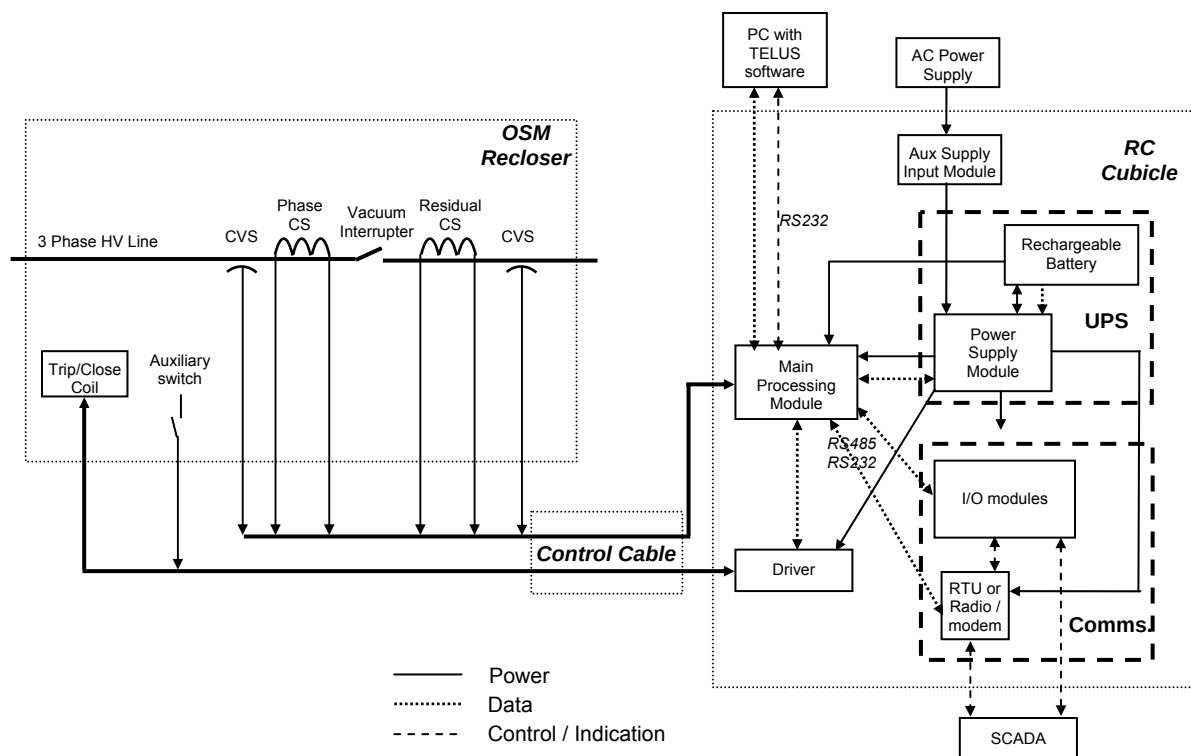
RS-485/RS-232 ports and **I/O Modules** provide external control and indication functions for SCADA or other remote control applications. The RC cubicle can be fitted with two I/O Modules to provide a total of 12 inputs and 12 outputs.

4.1.1 Security Cover

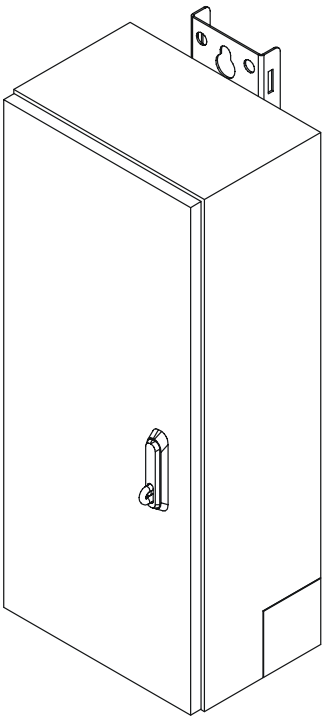
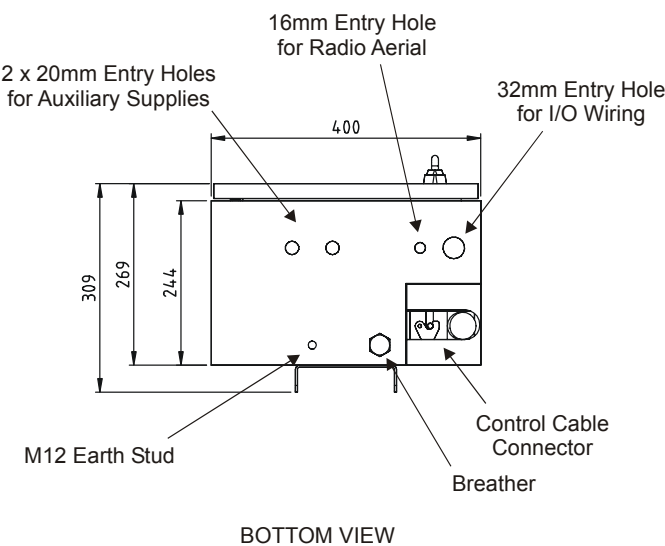
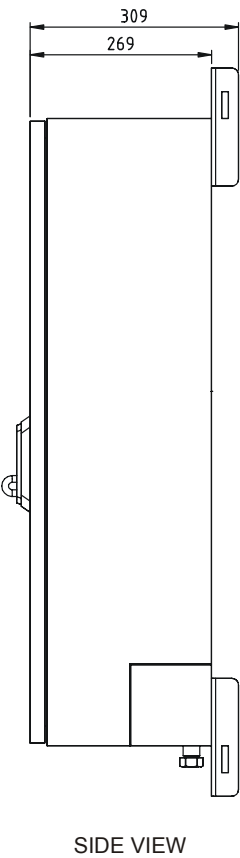
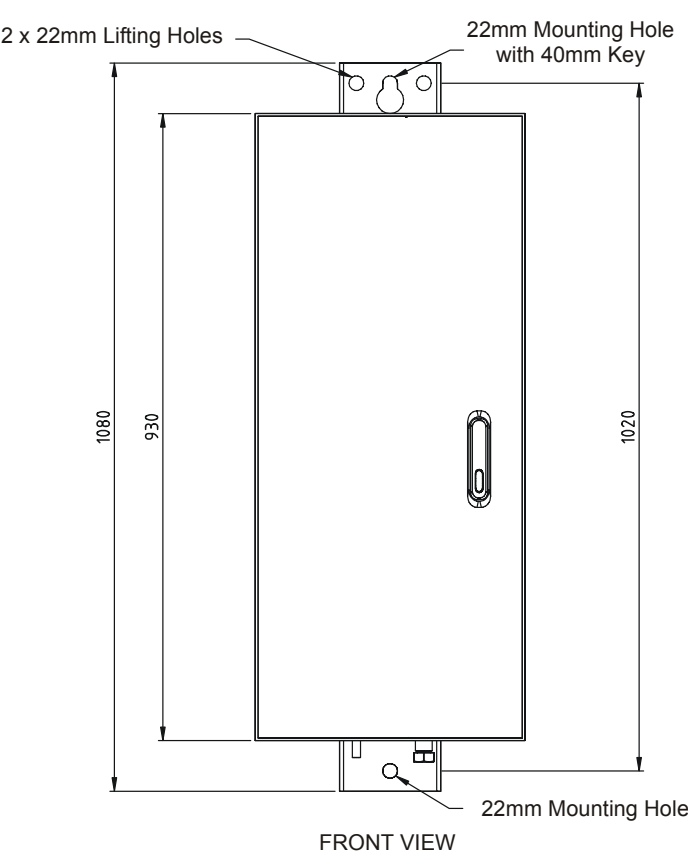
Control and Auxiliary Supply connections are secured by means of a protective cover fastened from within the RC Cubicle by three wing nuts.

4.1.2 Functional Diagram

The functional structure of the OSM Recloser with RC cubicle is illustrated in the block diagram below.



4.2 Dimensions



4.3 Main Processor Module

The Main Processor Module (MPM) is responsible for all the functionality available in the RC Control through interaction with the OSM recloser, UPS and Driver module. The MPM has an integrated operator panel with a DE9M serial connection for TELUS software.

The Main Processing Module provides the following functions:

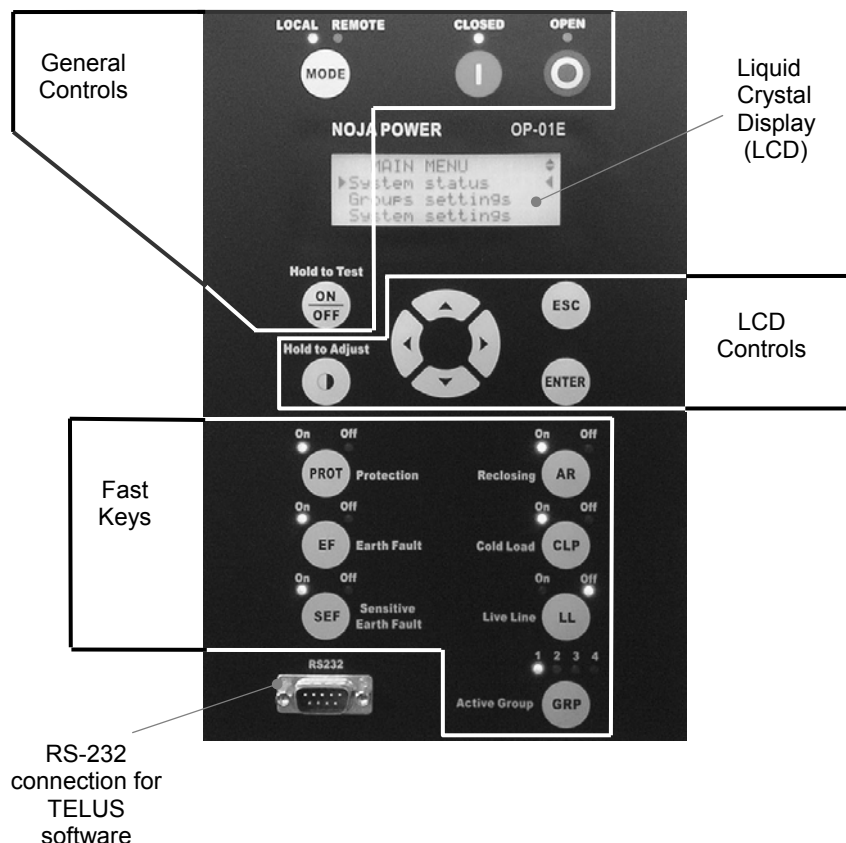
- Measurement
- Protection
- Monitoring
- Control and Indication

4.4 Operator Interface

The operator interface for the Recloser Control (RC) Cubicle is called the MMI (Man Machine Interface). The MMI consists of a sealed membrane keypad featuring push button controls with Light Emitting Diode (LED) indication together with a four line, 20 character Liquid Crystal Display (LCD) and navigation push buttons.

The MMI is used to access the following information: (refer to section 7 for further information)

- Recloser Control and Indication
- Close/Open operation details
- View and change system and protection settings
- View all counters (Lifetime and Fault counters)
- Erase stored information (Energy meter, Event log, Change messages, Load profile, CO operations, Fault counters).



The layout of the MMI is illustrated opposite, each of the pushbutton groups are explained in the following section.

LED's embedded within the panel indicate status. When executing a control the 'new status' LED blinks to indicate the change has been accepted and is being processed. Once the change of status has been confirmed, the 'old status' LED is extinguished and the 'new status' LED is continually lit. This should not take longer than one second.

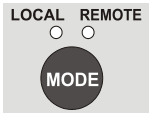
4.4.1 General Control Pushbuttons



ON / OFF

The MMI must be turned on before a user can use it for control and indication. The MMI will automatically turn itself off again if no operator activity is detected for 5 minutes.

The ON / OFF pushbutton also provides a means of testing the LCD and all indicating diodes. Pressing and holding will cause all the LED's to blink and the message "TEST" to cycle through the four lines on the LCD. Holding any pushbutton and subsequently releasing ON / OFF will cause the test to continue (provided the pushbutton under test is healthy).



Control Mode

The Control mode pushbutton allows the Recloser Control to be set to either Local Control or Remote Control mode.

When in Local control mode, indication is available to both local and remote applications but controls can only be executed locally. When in Remote control mode, indication is available to both local and remote applications but controls can only be executed by Remote applications. MPM data can still be viewed locally on the LCD panel.

The exception to this is an Open control, which can be executed locally or remotely, independent of Control mode.



'I' (Close)

The red pushbutton labelled 'I' is used to close the recloser contacts. The control is only executed if the MMI is set to Local control mode. If the MMI is set to Remote control mode the control will not be accepted and the LED will not blink.

A delayed close can be programmed into the MMI to allow an operator time to move away from the recloser if required. A message is displayed on the LCD Panel when the Close button is pushed and the Closed LED starts blinking. Pressing the ESC key will cancel the close operation otherwise the device will close after the time delay has expired. Refer to section 8.1.



'O' (Open)

The green pushbutton labelled 'O' is used to open the recloser contacts. An Open control can be executed in either Local or Remote mode.

4.4.2 LCD Control Pushbuttons



LCD Contrast pushbutton

Adjusting LCD contrast is carried out by holding or repeatedly pressing this pushbutton to cycle through the available range of contrast settings. Once released, the LCD will retain the last contrast setting.



Navigation pushbuttons

These pushbuttons allow movement through the MMI menu structure and changes to setting values.

Each screen has one of two navigation symbols in the top right hand corner; “” indicates vertical scrolling, ie the up and down pushbuttons can be used to access information, “” indicates four way scrolling, ie up, down, right and left pushbuttons can be used to access information.

Once a field has been selected for editing, the up and down pushbuttons are used to change the value. Where the value being changed is a number, right and left arrow are used to select each digit, up and down arrows are used to change the value of that digit only.



The ENTER pushbutton is used to access a field within the data menu once it has been selected, (fields that are unable to be changed, ie indication only, are bracketed by arrows, → ←)

On pressing ENTER, the LCD will either display the next level screen or surround the selected field with brackets. Triangular brackets ►◄ indicate another screen is available by pressing enter. Square brackets [] indicate the value is able to be changed via the arrow push buttons.

All settings are password protected except for those accessible using the Fast Keys, refer section 4.4.3. A request to enter the password is automatically generated when the user tries to edit protected parameters for the first time after switching the MMI ON.

MMI passwords have the format AAAA, where A can be a digit (from 1 to 9) or a letter (from A to Z). Refer to section 9.2.3 for an example of how to enter the password.



The ESC pushbutton is used to either move the user back one screen or de-select a variable.

LCD control pushbuttons provide access to the following functions within the MMI menu structure:

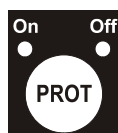
- view system status: date, time, recloser state (Open/Closed/Lockout), malfunction and warnings signals, “protection initiated” indication signals. Measurements, I/O status. UPS status, Prot status
- view Close/Open (CO) operations record, lifetime and fault counters, protection group settings, system settings
- change protection status, all settings except for protection Group names and PC baud rate
- view MPM identification: serial number & software version
- test operability of digital input / output (I/O) relays
- switch external load voltage On/Off, MMI power Off
- erase records, energy meter and fault counters readings

Refer Appendix I – MMI Menu Layout for further information on location of settings and information.

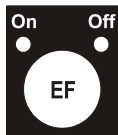
4.4.3 Fast Keys

Fast keys allow the status of protection elements and the active protection group to be set by an operator using a single push button. Each fast key can be enabled or disabled as required. When enabled they can only be used when the MMI is set to Local control mode. Refer to section 8.1.

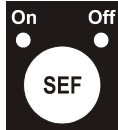
Repeated pressing of a Fast Key will cycle through the available options, the last option selected will become active (with the exception of the GRP key, see below).



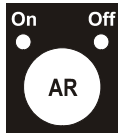
The Protection Fast Key is used to turn Protection ON or OFF. When set to OFF, all protection elements for all groups are disabled.



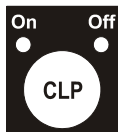
The Earth Fault Fast Key is used to disable or enable all Earth Fault overcurrent elements for all groups. When set to OFF, all EF elements are disabled.



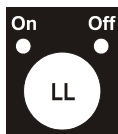
The Sensitive Earth Fault Fast Key is used to disable or enable all Sensitive Earth Fault overcurrent elements for all groups.



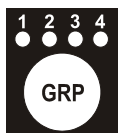
The Reclosing Fast Key is used to disable or enable all Auto Reclose elements for all groups.



The Cold Load Fast Key is used to disable or enable Cold Load Pickup for all groups.



The Live Line Fast Key is used to enable or disable all Live Line elements for all groups.



The Active Group Fast Key is used to select which of the four Protection Groups is active. Once the appropriate group has been chosen (indicated by flashing LED), press ENTER to make it active.

The Active Protection group cannot be changed if a protection element pickup occurs. Where this happens subsequent to pressing ENTER, the new group will become active once all protection elements have reset.

4.5 TELUS Software

The TELUS software package provides configuration and control of the MPM features and functionality. It is a comprehensive device configuration tool and allows the user to;

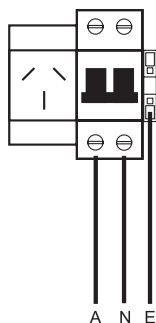
- Configure all RC settings
- Download all settings from PC to MPM
- Upload all settings, operations log, event log, fault profile, load profile, change log, fault counters, lifetime counters from MPM to PC
- Go On-Line and view all measurements, operate the OSM, configure Protection Status Control elements, synchronise time/date to PC clock, erase data from MPM memory, reset MPM password.
- Filter logs and profile information to assist in analysis of data
- Print settings and all MPM historical data
- Generate graphical representations of fault and load profile data
- Import and export configuration files for use by other personnel
- Maintain a library of OSM profile files
- Configure User Defined curves and standard Time Current Characteristics using a graphical interface.
- Ensure relay co-ordination by importing co-ordinating device characteristics from a library of protection curves.
- Configure DNP3, IEC60870-5-101 and MODBUS protocol settings for SCADA control.

4.6 Auxiliary Supply Connection

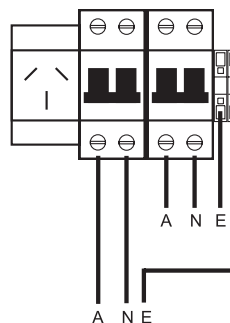
The RC Cubicle auxiliary supply can be 100Vac, 127Vac or 220Vac and can be supplied from one or two separate AC supplies. Standard RC configuration is for a single, phase to earth, AC supply. The number of auxiliary supplies must be specified at time of purchase so an extra circuit breaker can be supplied.

Auxiliary supply is connected to the RC Cubicle through a double-pole miniature circuit breaker as shown in the diagram below.

Single Auxiliary Supply



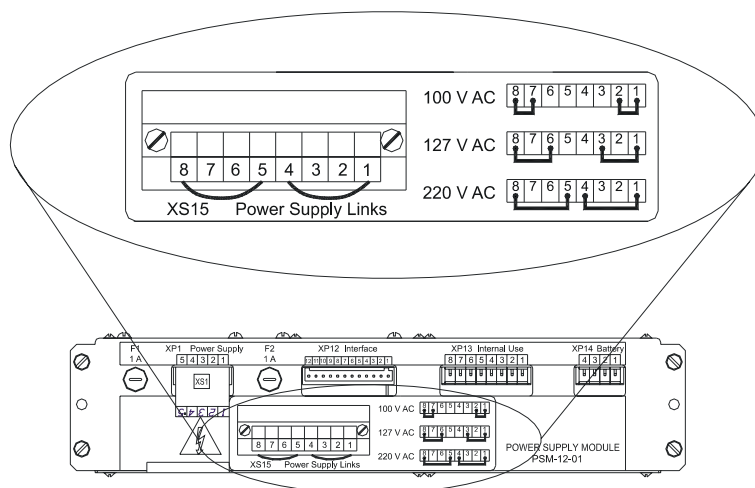
Dual Auxiliary Supplies



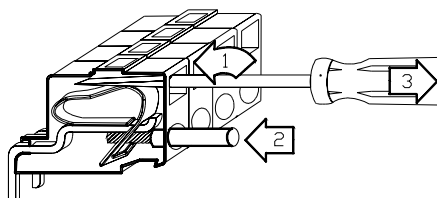
WARNING: The earth wire **MUST** be connected, even if in a workshop/testing environment. Failure to comply may result in damage to equipment or personal injury.

The pre set auxiliary supply voltage can be determined by referring to the advisory information that appears next to the PSM XS15 connector and comparing that to the actual link configuration.

The diagram below shows links installed for a 220Vac auxiliary supply.



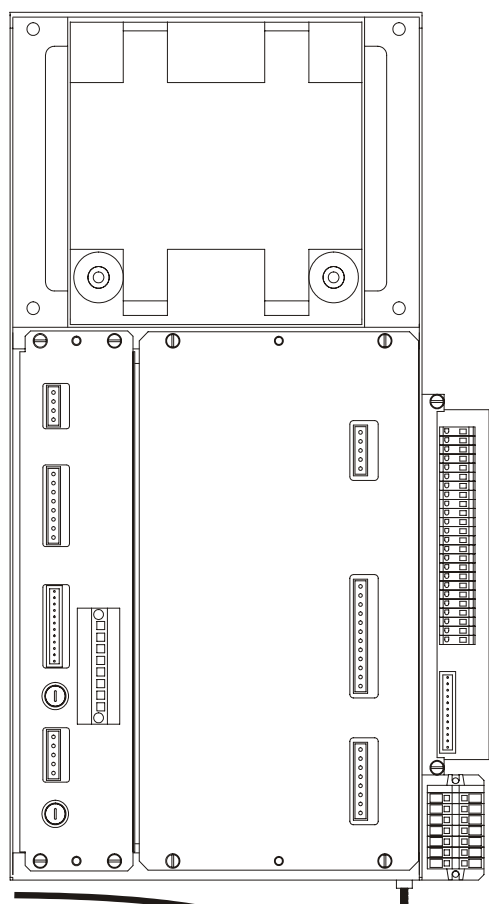
All RC Cubicle connectors, with the exception of the auxiliary supply active and neutral connections, utilise cage clamps which will accept solid or multi-stranded cable with cross section up to 2.5mm². The cage clamp installation method is illustrated in the diagram below.



4.7 Communications Interface

Remote communications with the Recloser Control can be achieved by using the optional I/O Modules or by connecting to either the RS-485 or RS-232 interface. In either case, all communications wiring must be by means of screened cable with the screens earthed to the RC cubicle earth at one end only. Where cabling exits the RC cubicle, it should be fitted with an appropriate RFI ferrite filter, located as close as possible to the (inside) floor of the cubicle. Where an antenna is required, a bulk head mounting surge arrestor must be fitted to the floor of the cubicle.

The RC cubicle is supplied with an RTU mounting plate for installation of equipment with dimensions not greater than 300w x 165h x 180d mm. The RTU mounting plate is fitted with wing nuts and the user can drill mounting holes to accommodate a suitable RTU.



IOM-XP1

Contact	Signal	Designation
1	COM1	Common for Inputs
2	In1	Input 1
3	IN2	Input 2
4	IN3	Input 3
5	IN4	Input 4
6	IN5	Input 5
7	IN6	Input 6
10	COM2	Common for Outputs 1 - 5
11	K1-12	Output 1.1
12	K1-14	Output 1.2
13	K2-12	Output 2.1
14	K2-14	Output 2.2
15	K3-12	Output 3.1
16	K3-14	Output 3.2
17	K4-12	Output 4.1
18	K4-14	Output 4.2
19	K5-12	Output 5.1
20	K5-14	Output 5.2
22	K6-12	Output 6.1
23	K6-14	Output 6.2
24	COM3	Common for Output 6

RS485 connector-XS1

Contact	Signal	Designation
1	+12V_EXT	+12V for RTU
2	GND	GROUND
3	TX+	TRANSMITTER 1.1
4	TX-	TRANSMITTER 1.2
5	RX+	RECEIVER 1.1
6	RX-	RECEIVER 1.2
7	EARTH	EARTH

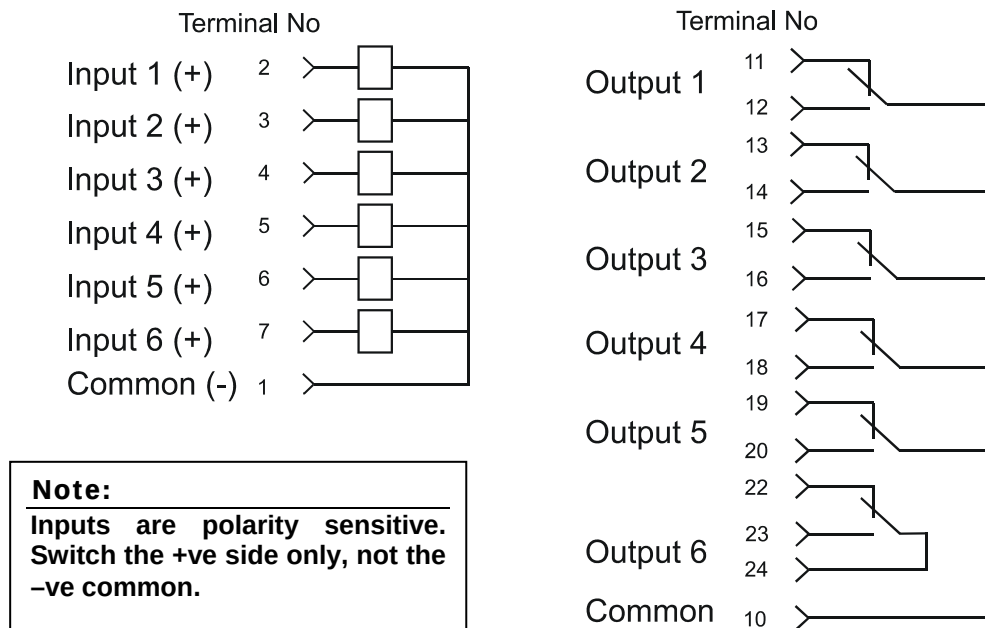
RS232 connector-X9

Pin	Signal
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

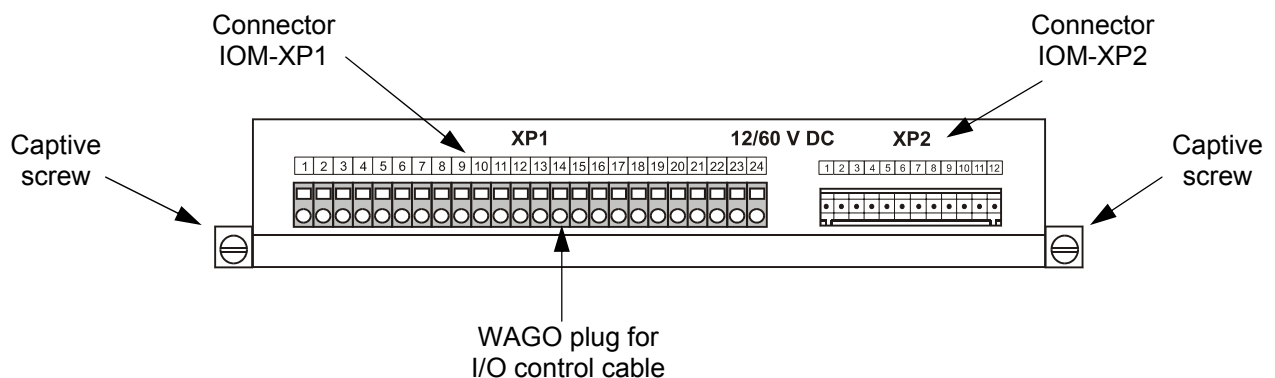
4.7.1 I/O Modules

Up to two Input Output Modules can be supplied with the RC cubicle as an option. Each I/O module has six opto-coupled inputs and six voltage free contact outputs. This means up to 12 control connections (inputs) and 12 indication connections (outputs) can be wired out to an RTU.

Input and output wiring on each of the I/O modules connects to the terminal block designated IOM – XP1 as illustrated in the diagram below.



Using TELUS software, any available control can be programmed for each input, refer to section 8 for a complete list of controls available for the IOM. Any combination of eight available indications can be programmed for each output, refer section 11.4 for a complete list of available indications. Default control and indication settings for the two modules are listed in section 8.4



The IOM-XP1 connector has terminals for user installed input and output wiring.

The IOM-XP2 connector carries control and indication signals from the Main Processing Module and connects to the RC wiring loom.

4.7.2 RS-485 Connector

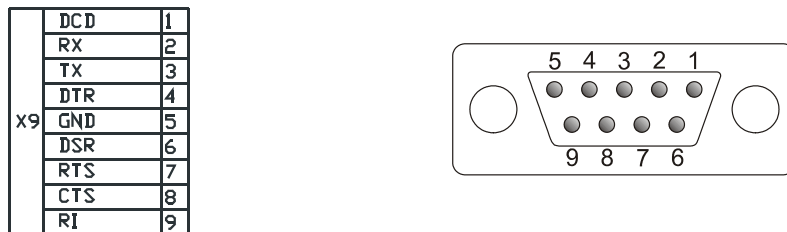
Another option for remote control is to connect a Remote Terminal Unit (RTU) to the RS485 connector supplied with the Recloser Control cubicle. Where wiring exits the cubicle an RS485 to RS485 converter (as appropriate) must be installed to provide impulse immunity for the RC electronics.

Signals provided on the connector are described in the table below.

Terminal	Signal	Description
1	+12V_EXT	+12Vdc supply (External Load supply, originating from PSM)
2	GND	External Load 0V
3	TX+	Transmitter 1
4	TX-	Transmitter 2
5	RX+	RECEIVER 1
6	RX-	RECEIVER 2
7	EARTH	RC cubicle earth

4.7.3 RS-232 Connector

An RS232 port is available inside the cubicle for connection to an RTU. Connection is via a DE9M plug located behind the escutcheon panel.

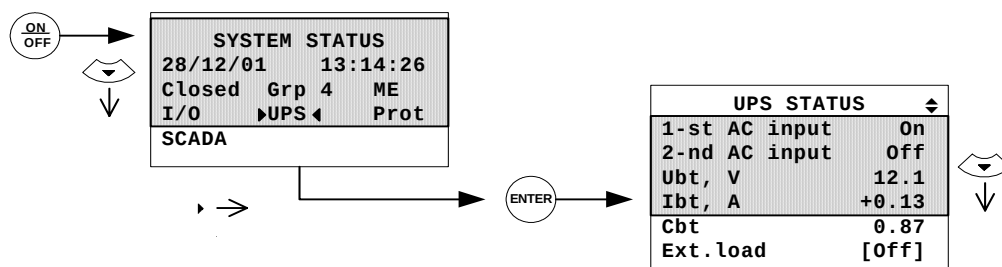


RS232 DE9 PLUG

4.7.4 External Load Power Supply Connection for RTU

A 12Vdc power supply is located on terminals 1 and 2 of the RS485 connector. It is turned on using the MMI or TELUS software and is rated at 15W continuous duty or 30W with a 50% duty cycle. A software fuse automatically disables the supply in the event of a short circuit. Once the short has been fixed the supply can be turned back on by an operator.

The following diagram illustrates how to access the External Load ON/OFF setting from the MMI.



4.8 Uninterruptible Power Supply

The Uninterruptible Power Supply (UPS) provides power management for the Recloser Control from an AC supply with a 12Vdc battery for backup.

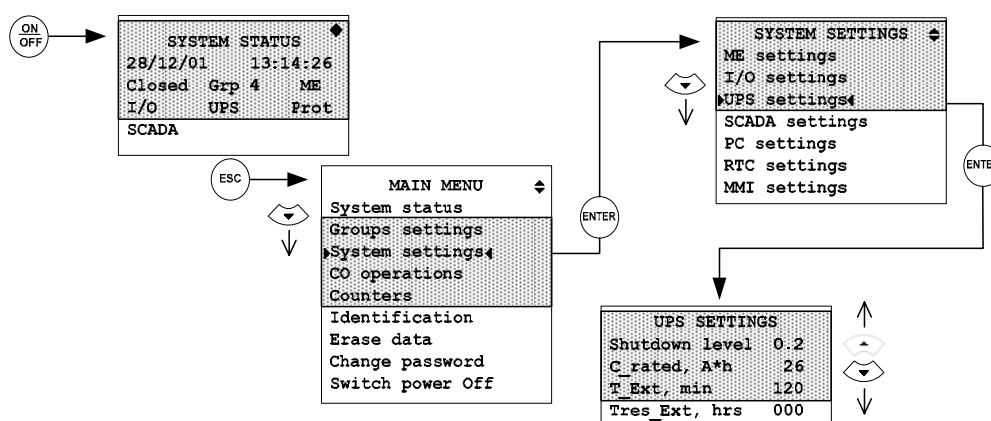
4.8.1 Power Supply Module

Battery temperature is monitored by the Power Supply Module (PSM) and charging current is adjusted to ensure optimum charging. An external load (eg radio or modem) can be supplied for a user configurable time of up to 720 minutes after loss of AC supply before automatically shutting down to conserve batteries.

The PSM controls the operating voltage for the Main Processing Module (MPM), Driver and External Load and will shut these down in an orderly fashion in the case of a prolonged loss of auxiliary supply. On restoration of auxiliary supply, the UPS will automatically restore them to their normal operating condition.

4.8.2 Settings

Title	Designation	Range	Resolution	Factory Default
Shutdown level	Shutdown level	0.1 – 0.8	0.1	0.2
Rated battery capacity	C _{rated}	10 – 50Ah	1Ah	26
External load time	T _{ext}	1 – 720 min	1 min	120
External Load Reset Time	Tres _{ext}	0 – 720 hr	1 hour	0



4.8.3 Operating States

The UPS has eight operating states as described in the table below.

State	Description
Normal supply	During normal conditions the battery voltage and PSM output voltages are kept at an optimum voltage depending on battery temperature. During transient conditions (eg due to temperature changes or change of battery voltage caused by its replacement) the battery is charged until the optimum battery voltage is achieved. In both cases external power is derived from input AC voltages with the battery utilised only as a back up supply. Battery charging current varies from 0 to 0.26 A in order to restore the total battery charge in less than 12 hours (where ambient temperature is +20°C, operator panel switched Off and no CO operations generated). During charging, the PSM output voltage equals the battery voltage (to a shutdown level of 10.2V) to ensure reliable supply for external devices.
AC supply	In this mode the AC input is used as the sole supply due to detection of an abnormal battery voltage. If the battery voltage exceeds 16V or is less than 2V, the battery is switched Off.

State	Description
	If the battery voltage exceeds 2V and is less than 10.2V, battery trickle charging is provided. Trickle charging draws less than 100mA and will take much longer than in normal charging mode. If unsuccessful the battery leakage current may be exceeding the trickle charge current, indicating the battery should be replaced. PSM output voltages in this mode are equal to the battery optimum voltage.
Battery supply	In this mode the battery is used as the sole power supply when the AC inputs are switched Off. The battery is discharging but exceeds 10.2V, providing reliable supply for external devices.
DS1	This temporary state exists for less than 3 minutes after activation of a Power Off control signal. During this time data is saved to non-volatile memory. Output voltage is provided for all relevant modules.
DS2	This temporary state exists for less than 3 minutes after residual battery charge drops below the shutdown level or after expiry of the shutdown timer. During this time data is saved to non-volatile memory. Output voltage is provided for all relevant modules.
Shutdown	This state appears after the DS2 state. It exists until AC supply is restored ¹ or a Power On control signal is activated.
Off	This state appears after the DS1 state and exists until activation of a Power On control signal.
Standby	This temporary state appears after activation of a Power On control signal while the UPS is in the Shutdown state. It exists until expiration of the shutdown timer or restoration of AC supply ¹ . Unless AC is restored, the PSM automatically returns to shutdown mode 5 minutes after the last control via MMI, PC, SCADA or IO. Output voltage is provided for all relevant modules.

Note: 1. AC supply is switched off if either of the AC1, AC2 input voltages exceeds the maximum operating level or if both of them fall below the minimum operating level, refer section 2.2.6.

4.8.4 Power Management

The UPS provides power for all components of the RC Cubicle when in the “Normal supply”, “AC supply”, “Battery supply”, “DS1”, “DS2” and “Standby” states.

In “Shutdown” or “Off” states, output voltage is only provided for the Real Time Clock and the wake up circuit (activated by restoration of AC supplies).

External Load Supply

The external load timer (T_ext) starts to time down when “Battery supply” state is activated due to a loss of AC supply. The External Load voltage is switched off when the timer expires.

External load voltage is automatically restored on re-establishment of AC supply.

The external load supply can be cycled off then on again at regular intervals (Tres_ext) to reset connected communications equipment if required. If Tres_ext is set to zero then the power will remain on constantly (no reset will occur).

4.9 Driver Module

The Driver module converts Trip/Close control signals from the Main Processing Module (MPM) into current pulses applied to the magnetic actuator coil to drive the contacts into the open or closed position. It also converts the OSM auxiliary switch status into a logical position signal for use by protection and indication elements of the MPM.

The health of the OSM coil circuit and the driver’s own readiness to execute the next Trip/Close operation is monitored by the Driver module. Depending on the problem, an ‘OSM Coil SC’ (Short Circuit) Malfunction, ‘Driver Not Ready’ or ‘OSM Coil Isolated’ warning event will be logged by the MPM.

The Driver module Trip and Close capacitors have the capacity to provide a complete rated duty cycle equal to O – 0.1s – CO – 1s – CO – 1s – CO. The capacitors are charged within 60s of initial auxiliary power application or execution of the above duty cycle.

During capacitor charging, the Driver activates the “Driver not ready” (DNR) signal indicating it cannot execute the next control operation (Trip/Close). Once capacitors are sufficiently charged the DNR signal is deactivated.

5 Measurement

The Main Processing Module (MPM) converts analogue signals originating at the OSM into data as indicated in the table below. The measurement data is filtered for harmonic content and the RMS value of the fundamental signal is used by Protection and Indication applications as shown in the table.

Measured value	Designation	Measured range	Resolution	Applicability	
				Protection	Indication
Phase currents	Ia, Ib, Ic	0 – 7000A	1A	✓	✓
Residual current ¹	In	0 – 6000A	1A	✓	✓
Phase to earth voltages	Ua, Ub, Uc, Ur, Us, Ut	0 – 18kV	0.1kV	✓	✓
Line to line voltages	Uab, Ubc, Uca	0 – 30kV	0.1kV	✓	–
Positive sequence current	I1	0 – 7000A	1A	✓	–
Positive sequence voltage	U1	0 – 18kV	0.1kV	✓	–
Residual voltage ²	Un	0 – 18kV	0.1kV	✓	–
Phase shift between positive sequence voltage and current	A1	0 – 359°	1°	✓	–
Phase shift between residual voltage and current	An	0 – 359°	1°	✓	–
Single and three phase total, active and reactive power	A, B & C kVA / kW / kVA 3 phase kVA / kVA / kW	0 – 65535	1	–	✓
Single and three phase total and reactive energy related to forward and reverse power flow directions	A, B & C +/- kVAh A, B & C +/- kVAhr, 3 phase +/- kVAh 3 phase +/- kVAhr	0 – 999999999	1	–	✓
Frequency ³ from ABC and RST recloser sides	Fabc, Frst	45 – 65 Hz	0.01Hz	✓	✓
Phase sequence from ABC and RST sides	Phase seq.	ABC / ACB / ? ⁴ RST / RTS / ? ⁴	NA	–	✓
Single phase and three phase power factor	Power factor: 3phase, A phase, B phase, C phase	0 – 1	0.01	–	✓

Notes:

1. Residual Current is equal to three times the zero sequence current
2. Residual voltage is equal to three times the zero sequence voltage
3. When all three phase to earth voltages on any one side drop below approximately 0.5kV, prior frequency is 'remembered' by the measurement element.
4. "?" is displayed when any phase voltage drops below 50% of the rated voltage.

5.1 Sampling and Filtering

An analogue second order low pass filter is applied to each measurement channel to block signals with frequency above 800Hz.

Current and voltage channels are sampled 16 times during each power frequency cycle by the Analogue to Digital Converter (ADC). Each measurement has a low and high coefficient applied and the measurement algorithm selects the appropriate value to provide best resolution for each sample.

First harmonic RMS values for phase and residual currents together with zero, negative and positive sequence voltages are calculated 16 times per cycle by application of digital filtering algorithms using the last 32 samples. The resultant fundamental RMS values are utilised by protection and indication elements.

RMS values for active and reactive power / energy values, power frequency, power direction and phase sequence are calculated once per cycle.

Metering and display values are updated every 16 cycles.

5.2 Measurement Settings

The rated frequency must be entered by the user for correct operation at either 50 or 60Hz. Voltage measurement is expressed in terms of rated phase to phase system voltage, also entered by the user.

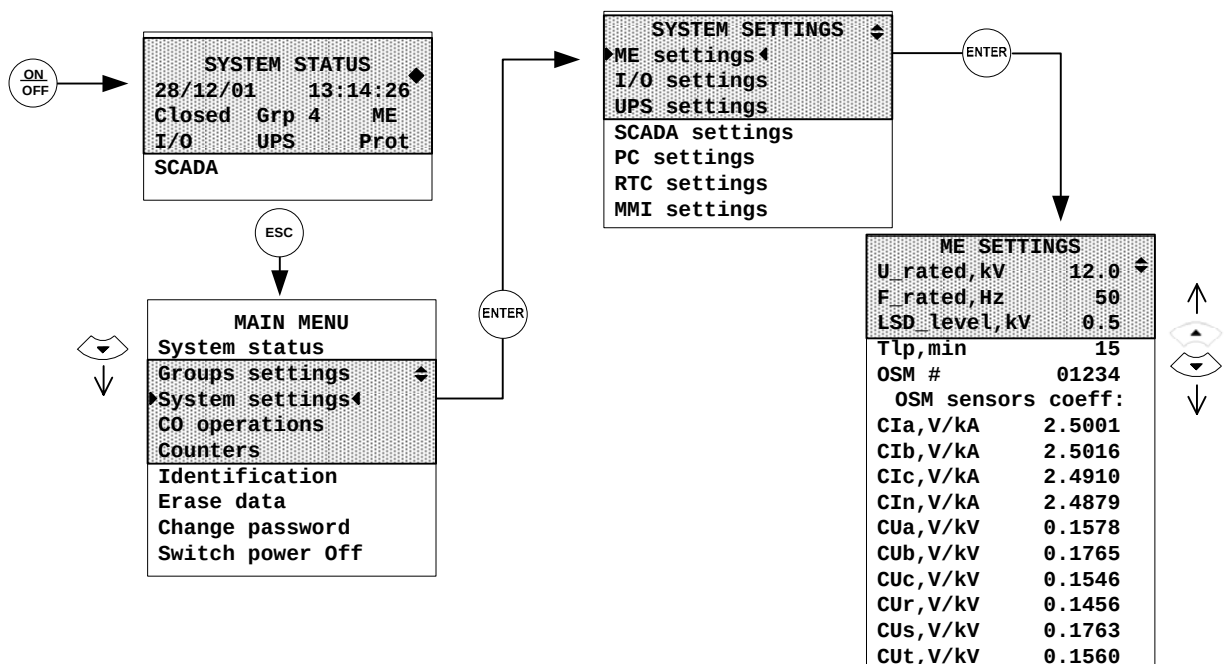
Current sensing is carried out by Rogowski sensors. Voltage sensing is by means of Capacitive Voltage Dividers. An individual calibration coefficient is determined for each of the four current channels and six voltage channels received from the OSM. These ten measurement coefficients and the OSM serial number are also entered by the user.

General settings

Title	Designation	Range	Resolution
Rated voltage	Umax	3 – 27kV	0.1kV
Rated frequency	F_rated_	50/60 Hz	NA
Loss of Supply Detector Level	LSD_level	0.5 – 6.0kV	0.1kV
Load Profile time	Tlp	5/10/15/30/60 min	NA
OSM serial number	OSM #	00000 – 99999	1
Ia calibration coefficient	Cla	2 – 3 V/kA	0.0001 V/kA
Ib calibration coefficient	Cib	2 – 3 V/kA	0.0001 V/kA
Ic calibration coefficient	Cic	2 – 3 V/kA	0.0001 V/kA
In calibration coefficient	CIn	2 – 3 V/kA	0.0001 V/kA
Ua calibration coefficient	CUa	0.1 – 0.2 V/kV	0.0001 V/kV
Ub calibration coefficient	CUb	0.1 – 0.2 V/kV	0.0001 V/kV
Uc calibration coefficient	CUC	0.1 – 0.2 V/kV	0.0001 V/kV
Ur calibration coefficient	CUR	0.1 – 0.2 V/kV	0.0001 V/kV
Us calibration coefficient	CUS	0.1 – 0.2 V/kV	0.0001 V/kV
Ut calibration coefficient	CUT	0.1 – 0.2 V/kV	0.0001 V/kV

Note: OSM sensor settings programmed into the RC when sent from the factory will be correct for the OSM whose serial number is also programmed.

Accessing the Measurement settings using the MMI operator panel is illustrated below



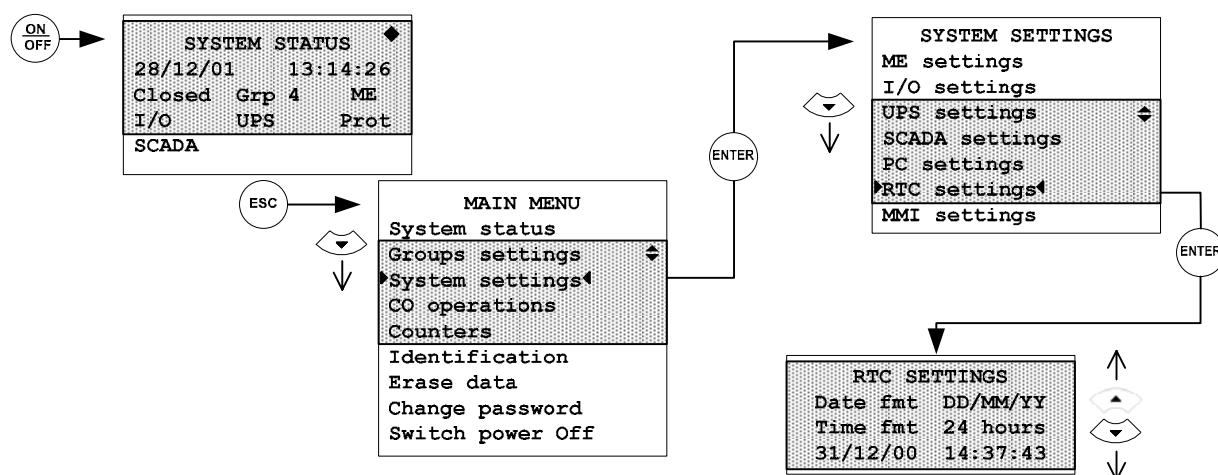
Real Time Clock (RTC) settings

The Real Time Clock provides measurement of real date/time for all elements with 1ms resolution. The clock is powered directly from the battery and, once set, date and time only requires adjustment if the battery has been removed with no auxiliary supply connected to the RC cubicle.

Title	Designation	Settings	Factory Default
Date format	Date fmt	DD/MM/YY or MM/DD/YY	DD/MM/YY
Time format	Time fmt	12 hours/24 hours ¹	12 hours
Date	Date	In accordance with selected format	NA ²
Time	Time	In accordance with selected format	NA ²

Note: 1. 12 hour format displays (eg) 09:12:14pm; 24 hour format displays (eg) 21:12:14

2. Correct date and time (GMT +10 hrs) are applied at the factory. Time may require adjusting for a different time zone or will need to be set if the battery has become fully discharged during transit or subsequent storage.



All user settings can be changed from the Man Machine Interface (MMI). Alternatively they can be transferred using the TELUS software package (except for the LSD Level which is only programmable through the MMI).

6 Protection

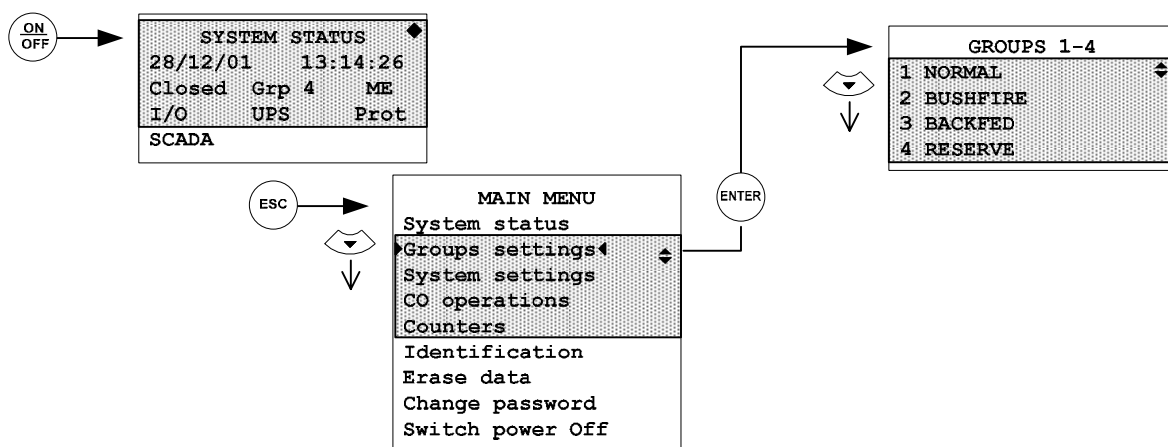
Four individual groups of Protection Settings are available. Each group has the following protection functions:

- Phase and Earth Overcurrent (OCEF)
- Sensitive Earth Fault (SEF)
- Live Line Overcurrent (LL)
- Under Voltage (UV)
- Under Frequency (UF)
- Loss of Supply Detection (LSD)
- Voltage Reclosing Control (VRC)
- Automatic Backfeed Restoration (ABR)

Descriptions with up to 50 characters or numbers can be assigned for each of the protection groups using the TELUS software package.

Group 1 – 4 settings

Title	Designation	Range
Group name	Grp name	Up to 10 English alphabet letters or digits from 0 to 9



6.1 Phase and Earth Overcurrent (OCEF)

Individual phase currents are monitored for Phase Overcurrent protection (OC) and residual current is monitored for Earth Fault protection (EF). Both OC and EF have three overcurrent protection elements for each of the forward and reverse powerflow directions. These allow time current characteristics to be matched across three zones of protection to meet co-ordination requirements.

A Directional Element provides effective protection in ring feed or back feed situations while maintaining good co-ordination.

Zone Sequence co-ordination, the duration of reclose times and duration of reset times are global settings for Auto Reclose Phase and Earth Overcurrent (AR OCEF). Independent OC and EF parameters are used to define the maximum number of operations in a reclose sequence and to either Disable, set to trip and Reclose or set to Alarm (with no operation) for each of the remaining trips in the sequence. Once the master

parameters are determined for OC and EF, low set and high set elements can be set to Disable, Lockout or Reclose for each of the remaining protection trips in a sequence.

Cold Load Pickup and Inrush Restraint elements allow effective customising of protection to match system characteristics.

The Temporary Time Adder provides a way to achieve fault clearing where a series of reclosers on a feeder have the same Time Current Characteristic by automatically applying a grading margin time on auto reclose.

6.1.1 Phase Overcurrent (OC)

Phase Overcurrent protection uses phase currents measured by the Rogowski sensors on the ABC terminals of the OSM. OC protection consists of six individual overcurrent elements providing three stages of protection in both forward and reverse powerflow directions.

- OC1 Sequence Master time delayed elements, for forward powerflow direction (OC1+) and for reverse powerflow direction (OC1-). Used to set the maximum number of operations to lockout and provide time delayed protection operations in a reclose sequence.
- OC2 Low set elements, for forward powerflow direction (OC2+) and for reverse powerflow direction (OC2-). Can be used to provide a fast fuse clearing first operation or a first stage Time Current Characteristic (TCC) element. Low set elements are equipped with Maximum current modification mode to allow a fuse burning strategy to be implemented.
- OC3 High set elements, for forward powerflow direction (OC3+) and for reverse powerflow direction (OC3-). Used to minimise exposure of downstream equipment to high fault currents.
- DE OC Phase overcurrent directional element provides a means of enabling or disabling directional protection for each of the six OC elements.

6.1.2 Earth Fault (EF)

Earth Fault protection uses residual currents measured by the Rogowski sensors on the RST terminals of the OSM. EF protection consists of six individual overcurrent elements providing three stages of protection in both forward and reverse powerflow directions.

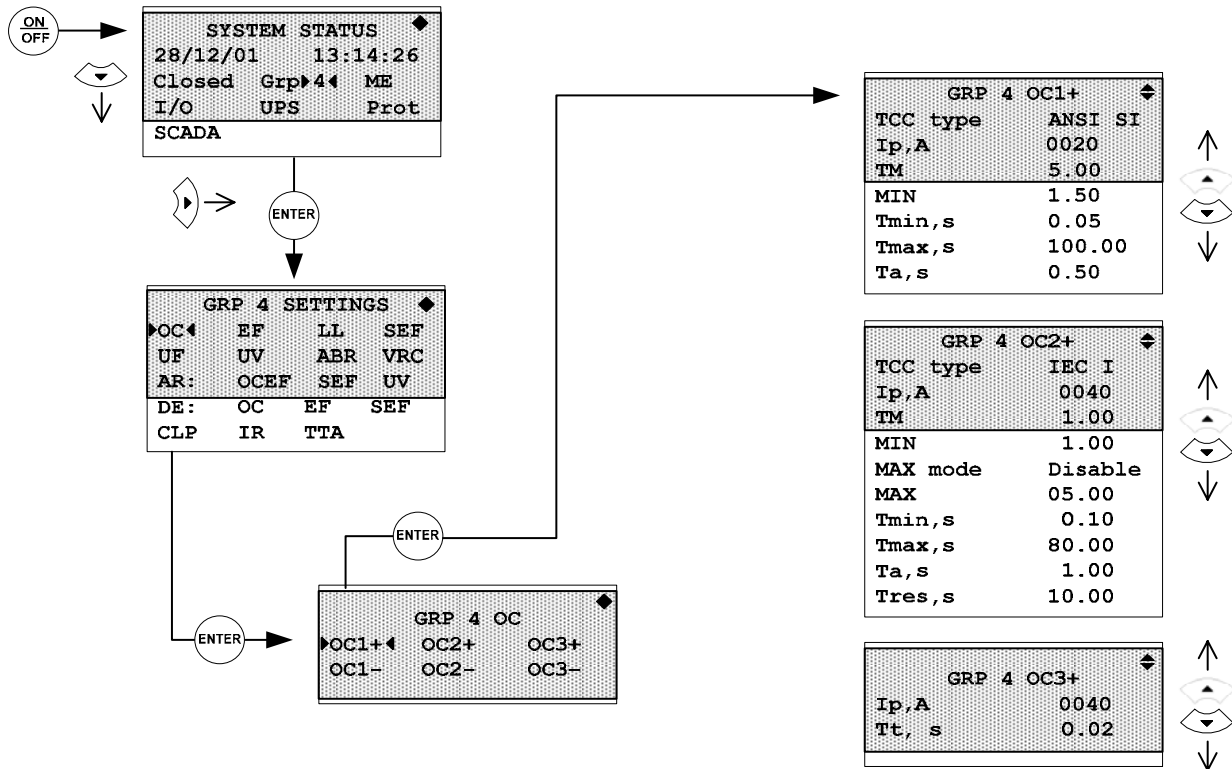
- EF1 Sequence Master time delayed elements, for forward powerflow direction (EF1+) and for reverse powerflow direction (EF1-). Used to set the maximum number of operations to lockout and to provide time delayed protection operations in a reclose sequence.
- EF2 Low set elements, for forward powerflow direction (EF2+) and for reverse powerflow direction (EF2-). Can be used to provide a fast fuse clearing first operation or a first stage TCC element. Low set elements are equipped with Maximum current modification mode to allow a fuse burning strategy to be implemented.
- EF3 High set elements, for forward powerflow direction (EF3+) and for reverse powerflow direction (EF3-). Used to minimise exposure of downstream equipment to high fault currents.
- DE EF Earth overcurrent directional element provides a means of enabling or disabling directional control for each of the six EF elements.

6.1.3 Overcurrent Settings

The forward and reverse Low set elements (OC1+, OC1-, EF1+, EF1-, OC2+, OC2-, EF2+, EF2-) can be set with an Inverse Delayed Minimum Time (IDMT) or definite time (TD) Time Current Characteristic (TCC). Curves are selected for the OC elements and the EF elements independently.

Standard IDMT curves and their abbreviations are defined in Section 11.3.1

MMI Setting layout for forward and reverse direction OC and EF elements is identical and is illustrated below for the OC1+ element.



Time current characteristic (TCC) types

Title	Designation	Range	Factory Default
Time current characteristic	TCC Type	ANSI: EI / VI / I / STI / STEI / LTEI / LTVI / LTI IEC: EI / VI / I / LTI TD, UD1 ¹ , UD2 ²	IEC I

Notes: 1. UD1 (User Defined, type 1) is only applicable for master elements; OC1+, OC1-, EF1+ and EF1-
2. UD2 (User Defined, type 2) is only applicable for low set elements; OC2+, OC2-, EF2+ and EF2-

Definite time (TD) TCC settings

Title	Designation	Range	Resolution
Pickup current	Ip	10 – 1280A	1A
Tripping time	Tt	0 – 120s	0.01s
Reset time	Tres	0 – 10s	0.01s

ANSI and IEC TCC settings

Title	Designation	Range	Resolution	Factory Default
Pickup current	Ip	10 – 1280A	1A	0300
Time multiplier	TM	0.01 – 15	0.01	0.50
Minimum current multiplier ¹	MIN	1 – 5	0.01	1.00
Definite minimum time	Tmin	0 – 10s	0.01s	00.00
Maximum tripping time	Tmax	1 – 120s	0.01s	120.00
Additional time	Ta	0 – 2s	0.01s	0.00
Reset time ²	Tres	0 – 1s	0.01s	0.05

Notes: 1. set as a multiple of the pickup current (Ip) setting.
2. not applicable for ANSI TCC whose reset timer simulates a rotating disk reset characteristic.

User defined (UD1 and UD2) TCC settings

User defined curves allow customisation of TCC operating characteristics. UD1 can be applied to the master elements (OC1+, OC1-, EF1+, EF1-) and consists of up to three IDMT sections. UD2 can be applied to the low set elements (OC2+, OC2-, EF2+, EF2-) and consists of up to 4 definite time sections.

Configuration of UD1 settings must be done using TELUS software. Refer to section 11.3 for more information on User Defined curves.

Title	Designation	Range	Resolution
Number of protection stages ¹	N	1 – 3	1
i – th characteristic point operating current ²	I(i)	10 – 6000A	1A
i – th characteristic point operating time ²	T(i)	0 – 120s	0.01s
Current multiplier ¹	CM	1.00 – 2.00	0.01
Additional time ¹	Ta	0 – 2s	0.01s
Reset time	Tres	0 – 10s	0.01s

Notes:

1. applicable for UD1 only
2. For UD1 the number of points varies $i=1 - 3$ if $N=1$, $1 - 5$ if $N=2$, $1 - 7$ if $N=3$. For UD2 the maximum number of points is 4.

Maximum Current Modification Mode Settings

Maximum current mode is designed to allow a fuse burning strategy to be implemented. When current exceeds a user set maximum the trip operation timer freezes until current drops back below that level. This extends the tripping time to avoid nuisance tripping during operation of downstream fuses.

Maximum Current modification mode is only available on the low set elements (OC2+, OC2-, EF2+, EF2-). Each element can be independently set for maximum current modifying mode.

For ANSI and IEC TCC's the maximum current is calculated using a multiplier applied to the pickup current. For UD2, the maximum current is set in Amps.

Title	Designation	Range	Resolution	Factory Default
Maximum Current modification Mode	MAX mode	Enable / Disable	NA	D
Maximum Current Multiplier ¹	MAX	1.1 – 10	0.01	5.00
Maximum Operating Current ²	I _{max}	10 – 6000A	1A	0500

Notes: 1. Applies to ANSI or IEC TCC's only

2. Applies to UD2 TCC only

High Set Element Settings

The High set elements (OC3+, OC3-, EF3+, EF3-) can be set independently for OC and EF to a definite time characteristic using the settings below

Title	Designation	Range	Resolution	Factory Default
Pickup current	I _p	20 – 6000A	1A	1000
Tripping time	T _t	0 – 2s	0.01s	0.10

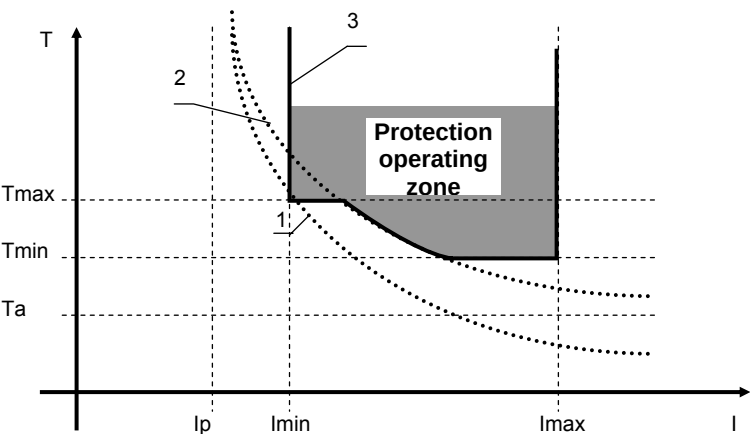
Note: OC3 elements are equipped with an instantaneous reset timer.

6.1.4 TCC modifiers

Each ANSI or IEC Time Current Characteristic can be modified with the aid of the following operators:

- definite minimum time (Tmin)
- maximum tripping time (Tmax)
- minimum current multiplier (MIN)
- maximum current multiplier (MAX)¹
- additional time (Ta).

The figure below illustrates the effect of the modifying operators on a TCC curve.



where:
Ip Pickup current
Imax = MAX*Ip
Imin = MIN*Ip
1 Original TCC (without modifications)
2 TCC additional time (Ta) only
3 TCC with all modifications applied¹.

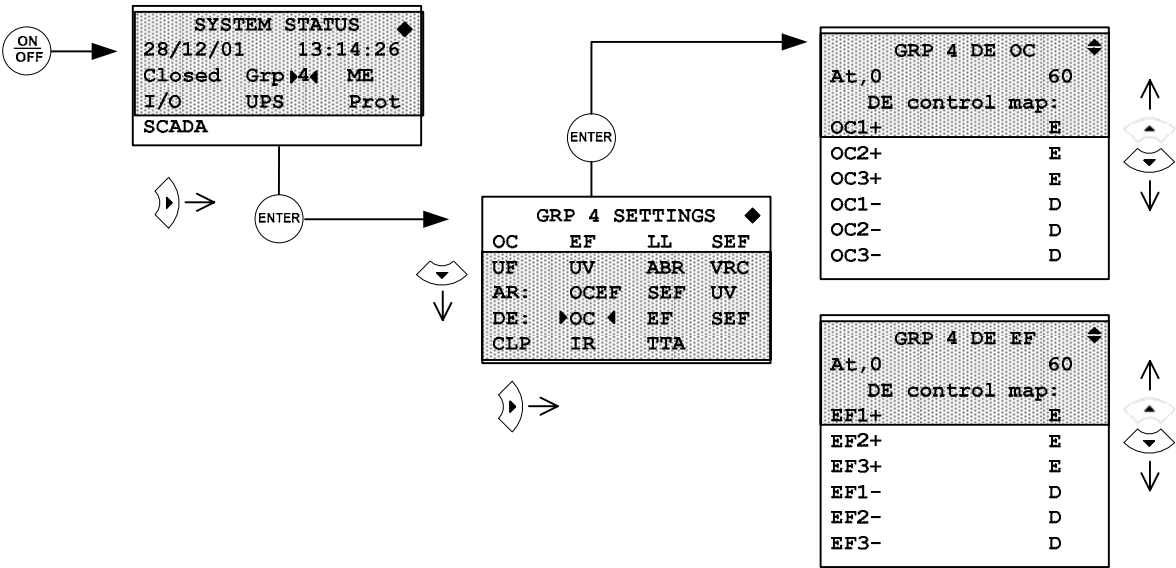
Note 1: maximum current modification is only applicable for the low set overcurrent elements (OC2+, OC2-, EF2+, EF2-).

6.1.5 Directional Overcurrent Elements (DE OC, DE EF)

The Directional function for Phase Overcurrent and Earth Fault protection is provided by two directional elements, DE OC and DE EF.

Note: DE OC and DE EF use different methods to determine direction during a fault. DE OC uses Positive sequence voltage and current while DE EF uses zero sequence voltage and current. For a detailed description of Directional Protection refer to Appendix B – Directional Protection.

The directional elements (DE OC and DE EF) can be set independently and the MMI menu layout is illustrated below



Torque angle setting

Title	Designation	Range	Resolution	Factory Default
Torque angle	At	0 – 359°	1°	000

Directional control map

Element	Directional control	Factory Default	Element	Directional control	Factory Default
OC1+	Enable/Disable	D	EF1+	Enable/Disable	D
OC2+	Enable/Disable	D	EF2+	Enable/Disable	D
OC3+	Enable/Disable	D	EF3+	Enable/Disable	D
OC1-	Enable/Disable	D	EF1-	Enable/Disable	D
OC2-	Enable/Disable	D	EF2-	Enable/Disable	D
OC3-	Enable/Disable	D	EF3-	Enable/Disable	D

6.1.6 Cold Load Pickup (CLP) Element

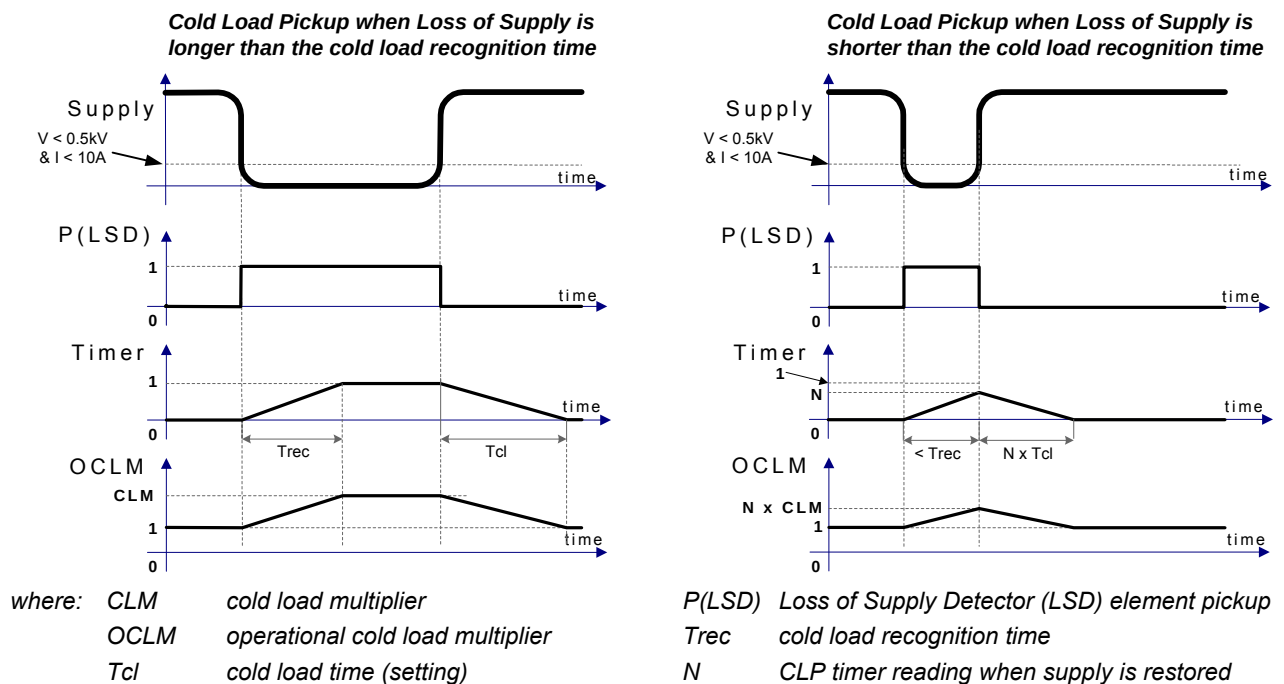
Restoring supply to a feeder after an extended outage will often result in a higher than normal load as thermostat controlled loads (heaters, air-conditioners, refrigerators, etc) will all come on at the same time. The extent and duration of the increased demand will depend on the characteristics of the feeder load.

Cold Load Pickup caters for loss of load diversity due to an extended outage by increasing the Operational Cold Load Multiplier (OCLM) from 1 to a user set value (cold load multiplier) over a user set period of time (Cold Load recognition time). Once supply is restored the OCLM returns to one over a second user set time (Cold Load Time). OCLM is recalculated every cycle and is not applicable for OC3 (high set) or EF (Earth Fault) elements.

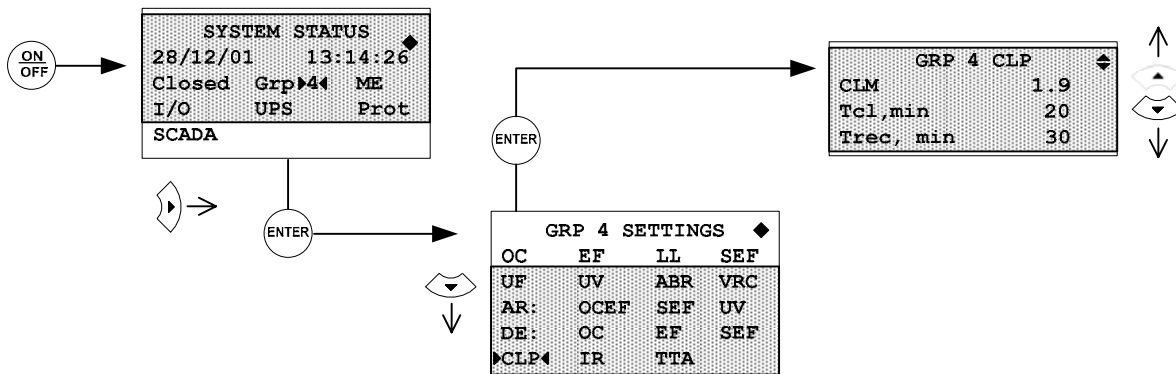
Provision of variable ramp rates for increase and decrease of the Operational Cold Load Multiplier provides flexibility for differing system characteristics.

The CLP element is initiated by Loss of Supply, a condition defined by volts less than 0.5kV on all three phases and current less than 10A on all three phases. Loss of supply generates pickup of the Loss of Supply Detector element (refer section 6.6).

Operation of the Cold Load Pickup element is illustrated in the diagrams below.



MMI menu layout for Cold Load Protection settings is as follows.



Cold Load Pickup Settings

Title	Designation	Range	Resolution	Factory Default
Cold load multiplier	CLM	1 – 5	0.1	1.0
Cold load time	Tcl	1 – 400 min	1 min	15
Cold load recognition time	Trec	0 – 60 min	1 min	15

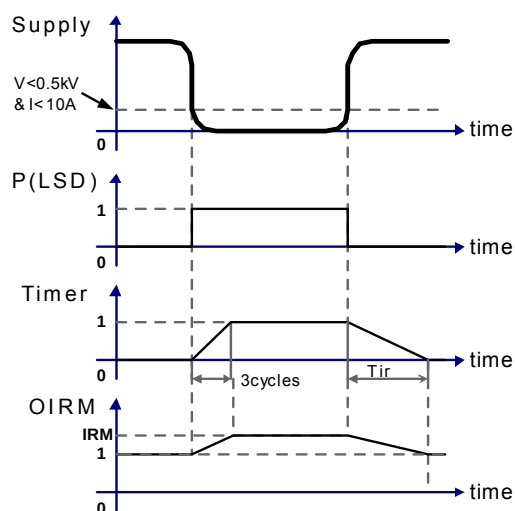
6.1.7 Inrush Restraint

Whenever a feeder is energised, even after a short outage caused by an auto reclose, there are inrush currents associated with certain types of load causing higher than normal loading. Examples are transformer excitation current and motor start current.

The inrush element applies a temporary multiplier to the level of pickup current on detection of loss of supply (refer Section 6.6) and is not applicable for OC3 (high set phase overcurrent), EF (Earth Fault) or SEF (Sensitive Earth Fault) protection elements.

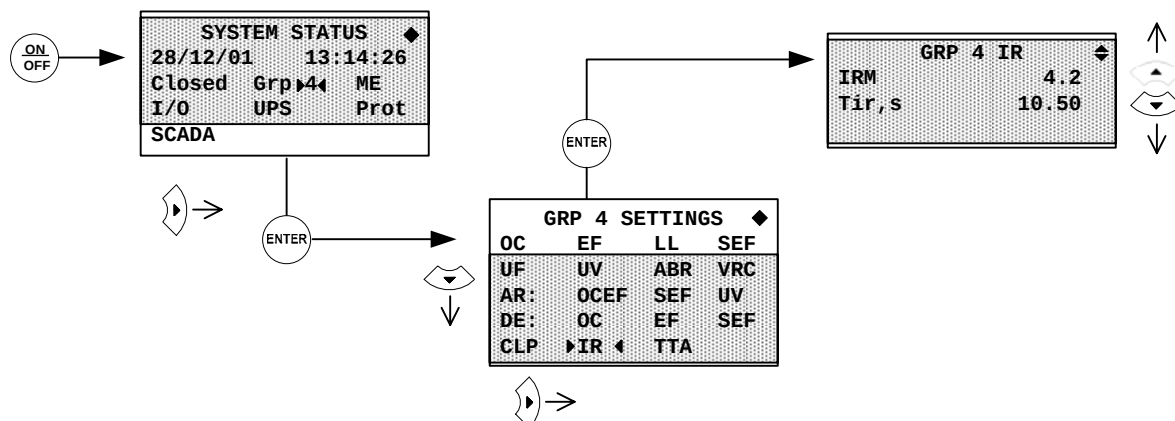
Appropriate application of Inrush Restraint allows protection co-ordination the flexibility to cope with transient increases in load current caused by inrush without compromising protection sensitivity.

Operation of the Inrush element is illustrated in the diagram below.



where *IRM* – inrush restraint multiplier
OIRM – operational inrush restraint multiplier
P(LSD) – pickup signal derived from LSD element
Tir – inrush restraint time

MMI menu layout for Inrush Restraint settings is illustrated below.



Inrush Restraint settings

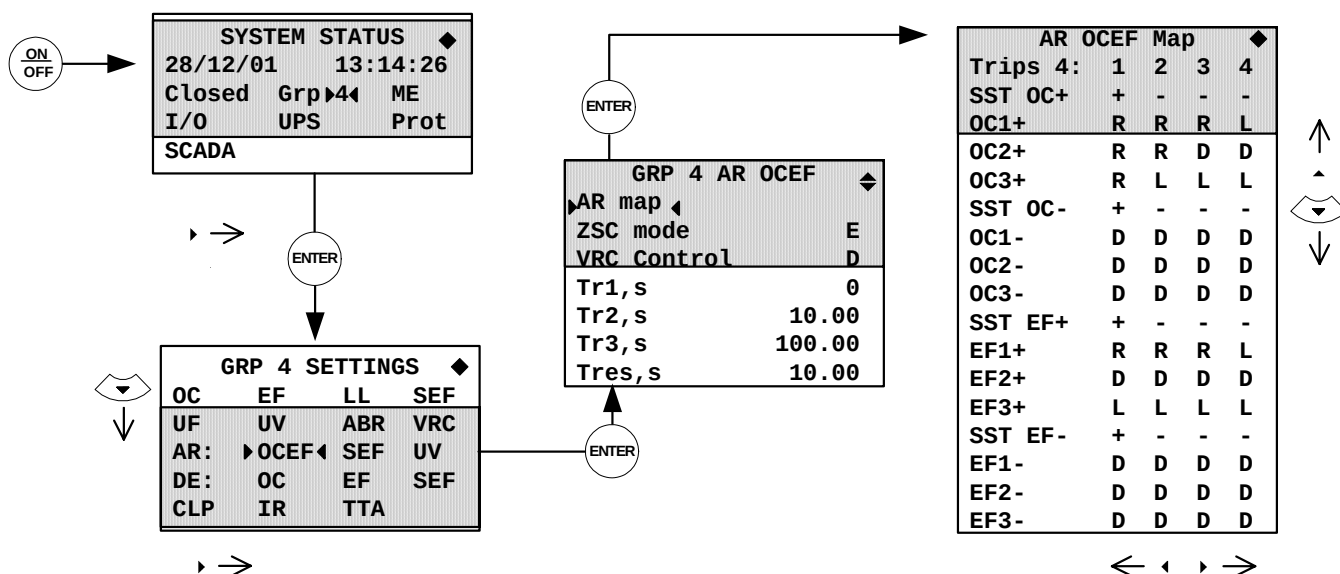
Title	Designation	Range	Resolution	Factory Default
Inrush restraint multiplier	IRM	1 – 20	0.1	05.0
Inrush restraint time	Tir	0.01 – 10s	0.01s	0.10

6.1.8 Phase and Earth Overcurrent Reclosing (AR OCEF)

The Reclosing element is responsible for reclosing sequences associated with the Phase and Earth Overcurrent protection element, application of Zone Sequence Co-ordination and applying the 12 overcurrent elements in accordance with the selected operating mode for each.

Reset time refers to the period of time subsequent to a reclose after which the trip counter is set to zero. If a protection trip occurs after a manual close operation as a result of a pickup during the reset time, the recloser will operate to lockout on the characteristics of the first trip.

MMI menu layout for AR OCEF is illustrated below



Reclose sequence settings

Title	Designation	Range	Resolution	Factory Default
Zone sequence co-ordination mode	ZSC Mode	Enable / Disable	–	D
Voltage reclosing control element	VRC Control	Enable/Disable	–	D
First reclose time	Tr ₁	0.1 – 180s	0.01s	010.00
Second reclose time	Tr ₂	1 – 180s	0.01s	020.00
Third reclose time	Tr ₃	1 – 180s	0.01s	020.00
Reset time	Tres	5 – 180s	0.01s	030.00

Available operating modes for each of the master elements (OC1+, OC1- , EF1+ and EF1-) are;

trip and Reclose

trip and Lockout

Alarm only

Disable.

The maximum number of operations to lockout is defined by applying master element settings. Eg if 3 operations are required, the appropriate OC1 and EF1 elements have an L for the 3rd trip.

Available operating modes for each of the low and high set elements (OC2/3+, OC2/3-, EF2/3+ and EF2/3-) are

trip and Reclose

trip and Lockout

Disable

Fuse saving or burning regimes can be implemented through application of an appropriate operating mode to the stage 2 and 3 protection elements.

Single Shot Trip (SST)

Single Shot Trip determines which trip sequence settings are active when Auto Reclosing is OFF. Any trip in a sequence can be selected (trip 1, 2, 3 or 4) as the single shot trip time/current settings.

The Single Shot Trip can be set independently for OC+, OC-, EF+ and EF- elements.

Note: Live Line protection settings are the priority protection trip settings when LL is ON.

OCEF element Operating Mode Settings

Note: Factory defaults are in the column on the right hand side of each field.

Element	1 st trip		2 nd trip		3 rd trip		4 th trip	
SST OC+		+						
OC1+	R/L/A/D	R	R/L/A/D	R	R/L/A/D	L	L/A/D	L
OC2+	R/L/D	D	R/L/D	D	R/L/D	D	L/D	D
OC3+	R/L/D	L	R/L/D	L	R/L/D	L	L/D	L
SST EF+		+						
EF1+	R/L/A/D	R	R/L/A/D	R	R/L/A/D	L	L/A/D	L
EF2+	R/L/D	D	R/L/D	D	R/L/D	D	L/D	D
EF3+	R/L/D	L	R/L/D	L	R/L/D	L	L/D	L
SST OC-		+						
OC1-	R/L/A/D	D	R/L/A/D	D	R/L/A/D	D	L/A/D	D
OC2-	R/L/D	D	R/L/D	D	R/L/D	D	L/D	D
OC3-	R/L/D	D	R/L/D	D	R/L/D	D	L/D	D
SST EF-		+						
EF1-	R/L/A/D	D	R/L/A/D	D	R/L/A/D	D	L/A/D	D
EF2-	R/L/D	D	R/L/D	D	R/L/D	D	L/D	D
EF3-	R/L/D	D	R/L/D	D	R/L/D	D	L/D	D

where: R = trip and Reclose A = Alarm only L = trip and Lockout D = Disable + = SST Set to this Trip

Zone Sequence Co-ordination (ZSC)

Enabling Zone Sequence Co-ordination makes the RC move its trip counter forward by one if it detects a downstream protection device has operated. This allows co-ordination with downstream devices with fast times for initial operations and slow times for subsequent operations.

6.1.9 Temporary Time Addition (TTA)

The Temporary Time Addition element can be used to achieve fault isolation with series reclosers programmed with the same Time Current Characteristic (TCC).

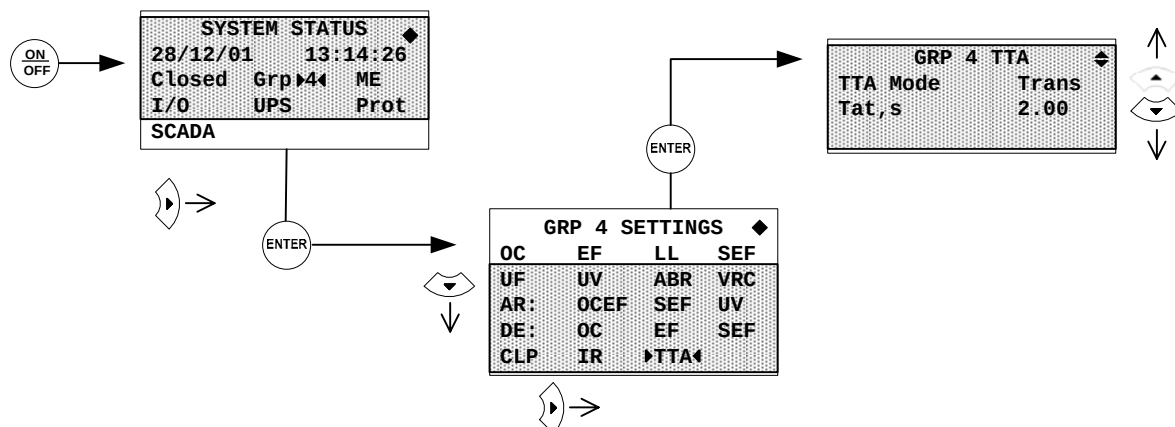
The principle of operation is that each recloser opens in response to any downstream fault and Voltage Reclosing Control (refer section 6.7) inhibits reclose operations of successive devices until the upstream device has operated in each case. Each device that closes onto a healthy section of feeder has additional time added onto the TCC low set instantaneous element (OC2) only. The device that closes onto the fault has no additional time applied and will subsequently operate to lockout and clear the fault.

TTA can be selected to operate in continuous or transient modes, and is not applicable for OC or EF elements mapped for disable (D) within a reclose sequence.

Transient mode is used to inhibit the application of additional time if any pickups are detected within 3 cycles of closing the device. If this situation occurs the additional time will not be applied at all. If no pickup is detected after closing the device then the additional time is applied.

Continuous mode is used to delay the application of additional time until after any protection pickup events have finished. The pickup must have occurred within 3 cycles of closing the device. This mode always applies additional time even if the fault has been isolated by a downstream device.

MMI menu layout for TTA settings is illustrated below



TTA settings

Title	Designation	Range	Resolution	Factory Default
Time addition mode	TTA mode	Trans/Cont	NA	Trans
Transient additional time	Tat	0 – 1s	0.01s	0.00

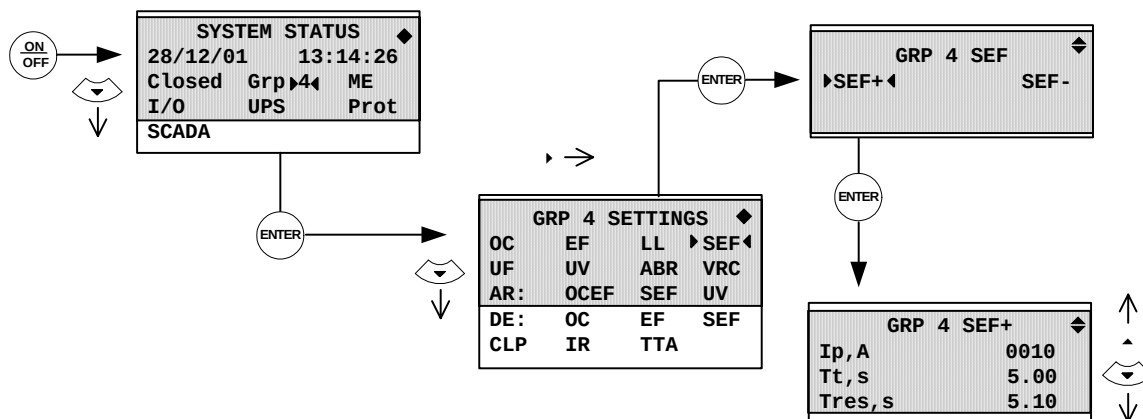
Note: Voltage Reclosing Control (VRC) must be enabled for the TTA feature to work. Refer to section 6.7.

6.2 Sensitive Earth Fault (SEF)

Sensitive Earth Fault protection monitors residual current measured by the second set of Rogowski sensors in the OSM. SEF protection comprises two Overcurrent elements, a Directional element and an Auto Reclose element.

One overcurrent element is for forward power flow direction (SEF+) and the other for reverse power flow direction (SEF–). Each element can be programmed with an independent Definite time TCC and the Directional Element allows enabling or disabling of SEF+ and SEF– as required.

MMI menu layout for SEF settings is as illustrated below for the SEF+ element.



SEF+, SEF– settings

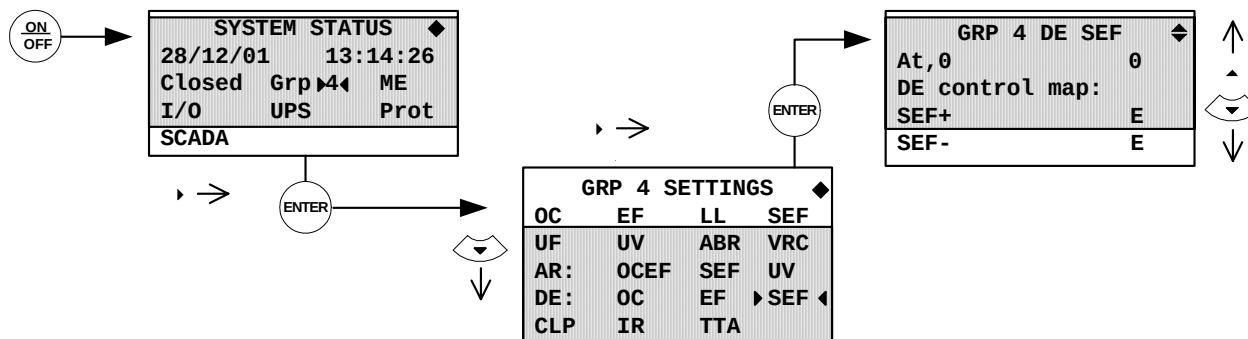
Title	Designation	Range	Resolution	Factory Default
Pickup current	Ip	4 – 80A	1A	15
Tripping time	Tt	0 – 120s	0.01s	010.00
Reset time	Tres	0 – 10s	0.01	0.05

6.2.1 Sensitive Earth Fault Directional Element (DE SEF)

The directional element DE SEF supervises SEF+ and SEF– elements.

Note: DE SEF uses zero sequence voltages and currents to determine direction during a fault. Directional elements are described in more detail in Appendix B – Directional Protection.

MMI menu layout for DE SEF settings is illustrated below.



DE SEF settings

Title	Designation	Range	Resolution	Factory Default
Torque angle	At	0 – 359°	1°	000

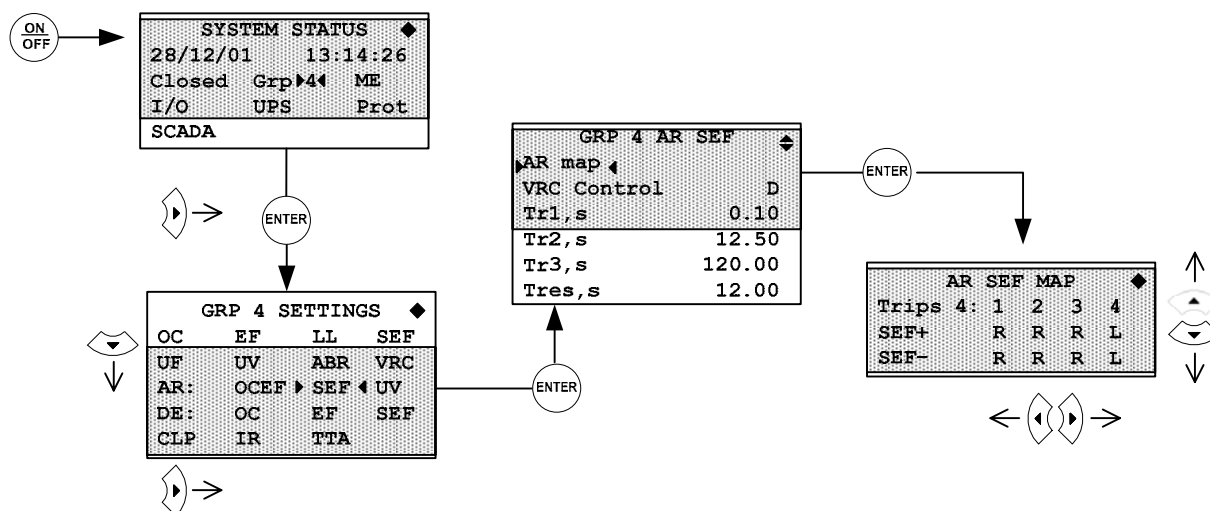
DE SEF control map:

Element	DE control mode	Factory Default
SEF+	Enable/Disable	D
SEF –	Enable/Disable	D

6.2.2 Sensitive Earth Fault Reclosing (AR SEF)

This element determines the reclosing functionality when a SEF protection operation occurs. Operation of this element is identical to AR OCEF with the exception that zone sequence co-ordination is not applicable.

MMI menu layout for AR SEF settings is illustrated below.



Reclosing sequence settings

Title	Designation	Range	Resolution	Factory Default
First reclose time	Tr1	0.1 – 180s	0.01s	010.00
Second reclose time	Tr2	1 – 180s	0.01s	020.00
Third reclose time	Tr3	1 – 180s	0.01s	020.00
Reset time	Tres	5 – 180s	0.01s	030.00

Up to four SEF protection trips can be programmed in a reclose sequence. The number of SEF trips to lockout is independent of OCEF. Four options can be chosen for each trip:

- Alarm
- trip to Lockout
- trip to Reclose
- Disable.

Reclosing map

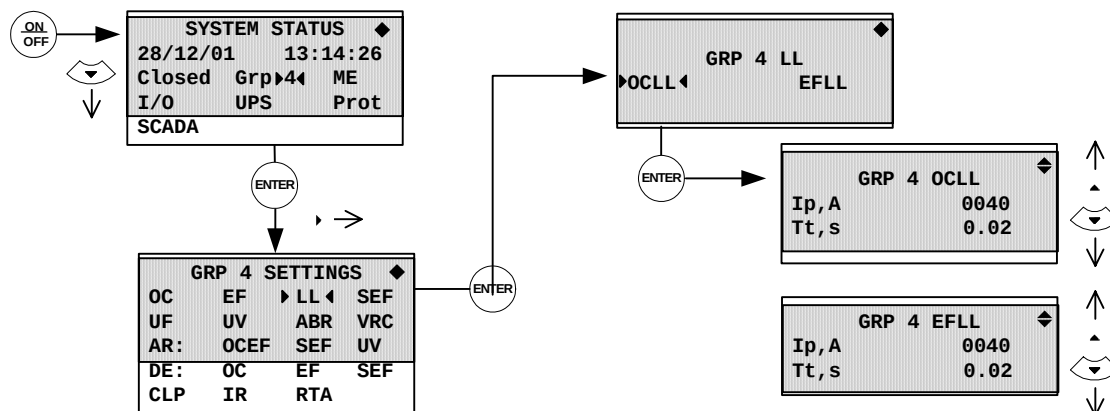
Element	1 st trip		2 nd trip		3 rd trip		4 th trip	
SEF+	R/L/A/D	L	R/L/A/D	L	R/L/A/D	L	L/A/D	L
SEF –	R/L/A/D	D	R/L/A/D	D	R/L/A/D	D	L/A/D	D

where:

- R trip and Reclose
- A Alarm only
- L trip and Lockout
- D Disable

6.3 Live Line Overcurrent (LL)

Live Line Overcurrent protection consists of two non directional Overcurrent elements, one for Earth Fault (EFLL) and one for Phase Overcurrent (OCLL). Operation of either element results in a trip to Lockout and an independent Definite Time can be selected for each. Enabling the LL element automatically disables any automatic closing from any source. MMI settings for LL elements are illustrated below



OCLL settings

Title	Designation	Range	Resolution	Factory Default
Pickup current	Ip	10 – 1280A	1A	1000
Tripping time	Tt	0 – 2s	0.01s	0.20

EFL settings

Title	Designation	Range	Resolution	Factory Default
Pickup current	Ip	4 – 1280A	1A	1000
Tripping time	Tt	0 – 2s	0.01s	0.20

OCLL, EFL elements are equipped with an instantaneous reset timer.

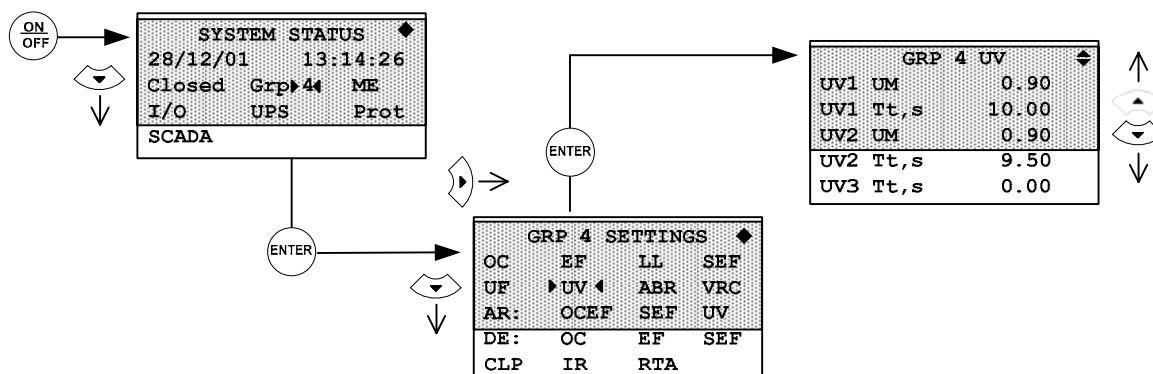
Note: When LL is active it overrides the SST Trip Settings. Refer to section 6.1.8.

6.4 Under Voltage (UV)

Under voltage protection allows protection to operate in response to dips in three phase voltage, phase imbalance or loss of phase and for loss of three phase supply. There are three Under Voltage elements (UV1, UV2 and UV3) and an Auto Reclosing element (AR UV).

The Auto Reclosing element allows one reclose operation if the recloser has operated in response to any Under Voltage element. Under voltage protection Reclose time and the operating mode for each elements protection are user set.

MMI menu layout for UV settings is illustrated below



6.4.1 Phase Under Voltage (UV1)

Phase Under Voltage is mainly used for load shedding. It responds to three phase positive sequence voltage falling below a user set level.

UV1 settings

Title	Designation	Range	Resolution	Factory Default
Voltage multiplier	UM	0.6 – 1	0.01	0.85
Tripping time	Tt	0 – 180s	0.01s	010.00

Note: for UV1 pickup voltage equals $UM \times U_{rated} / \sqrt{3}$; where U_{rated} is the rated system voltage entered in the measurement settings (refer to section 5.2).

6.4.2 Line to Line Under Voltage (UV2)

Line to Line Under Voltage is used to protect downstream loads sensitive to voltage imbalance or dips in voltage. It responds to a voltage drop across any two phases.

UV2 Settings

Title	Designation	Range	Resolution	Factory Default
Voltage multiplier	UM	0.6 – 1	0.01	0.80
Tripping time	Tt	0 – 180s	0.01s	010.00

Note: for UV2 element pickup voltage Up equals $UM \times U_{rated}$; where U_{rated} is the rated system voltage entered in the measurement settings (refer to section 5.2).

6.4.3 Loss of Supply Under Voltage (UV3)

Loss of Supply Under Voltage allows the recloser to open in response to a loss of three phase supply. This element monitors the output of the Loss of Supply Detector (LSD) and responds to a loss of current on all three phases plus a loss of voltage on either the ABC or RST side terminals (or all six HV terminals). Refer to section 6.6 for a description of LSD.

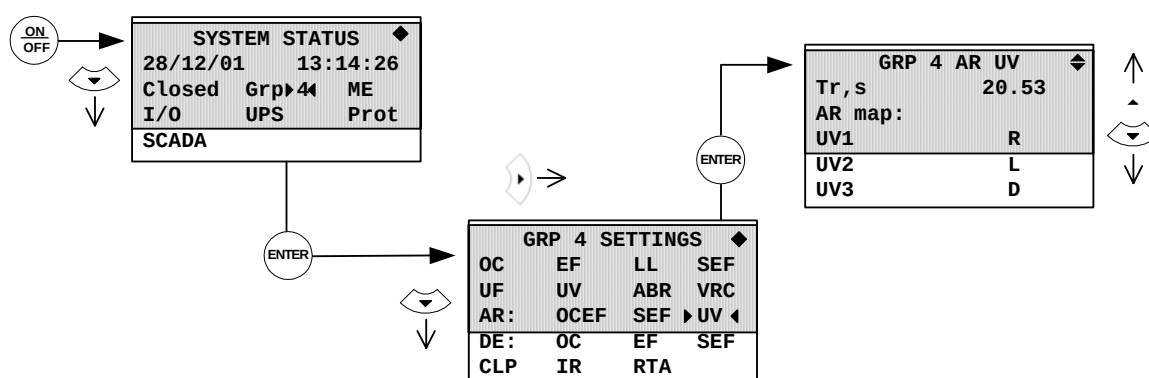
UV3 settings

Title	Designation	Range	Resolution	Factory Default
Tripping time	Tt	0 – 180s	0.01s	060.00

6.4.4 Under Voltage Reclosing (AR UV)

Under Voltage reclosing is activated by a protection operation initiated by any one of UV1, UV2 or UV3 and provides for a single Auto Reclose operation. Under voltage protection Reclose time and the operating mode for each UV element can be user set.

If none of the UV1, UV2 or UV3 elements are mapped for Trip to Reclose then AR UV is disabled. MMI menu layout for Under Voltage Auto Reclosing is illustrated in the following diagram.



Reclose sequence settings

Title	Designation	Range	Resolution	Factory Default
Reclose time	Tr	0 – 180s	0.01s	010.00

Reclosing map

Element	Settings	Factory Default
UV1	R/L/A/D	D
UV2	R/L/A/D	D
UV3	R/L/A/D	D

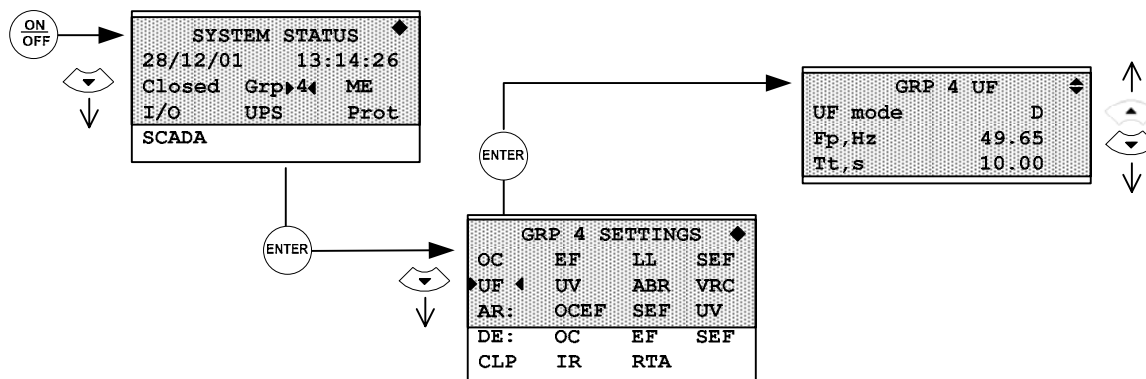
where:

R trip and Reclose
 L trip and Lockout
 A Alarm only
 D Disable

Note: When set to alarm, the alarm will be activated only when recloser is closed. Applies to UV1, UV2, UV3.

6.5 Under Frequency (UF)

Under Frequency Protection monitors measurement of HV supply frequency and responds to a sustained reduction in system frequency. The UF element operating mode can be set to Alarm, Disable or trip to Lockout. Auto Reclose is not available for Under Frequency protection.

UF settings

Title	Designation	Range	Resolution	Factory Default
Operating mode	Mode	Lockout / Alarm / Disable	–	D
Pickup frequency	Fp	45 – 50 Hz (for rated freq. 50Hz), 55 – 60 Hz (for rated freq. 60Hz)	0.01 Hz	49.50
Tripping time	Tt	0 – 120 s	0.01s	10.00

6.6 Loss of Supply Detector (LSD)

The Loss of Supply Detector detects loss of voltage and current on all three phases.

Uabc< activates when voltage < LSD_level on each of the A,B and C terminals

Urst< activates when voltage < LSD_level on each of the R,S and T terminals

Iabc< activates when current < 10 A on all three phases

The first two elements (Uabc< and Urst<) are used by Voltage Reclosing Control (VRC) and Automatic Backfeed Restoration (ABR) elements as inputs.

The LSD element indicates to other protection elements that supply has been lost. To provide validation of loss of supply both voltage and current are monitored, activation of the Loss of Supply Detector output requires ((Uabc< OR Urst< OR (Uabc< AND Urst<)) AND Iabc<).

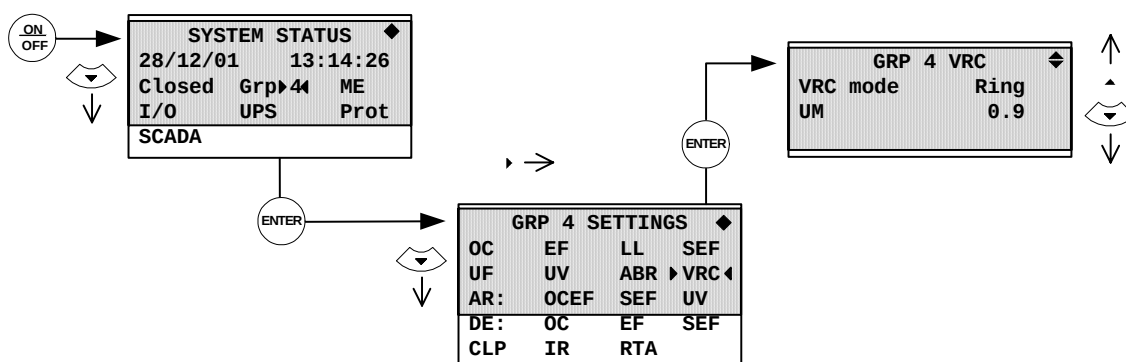
The LSD_level is configurable between 0.5kV and 6.0kV and is set from the ME settings screen on the MMI. Refer to section 5.2 for details on how to change the LSD_level setting.

6.7 Voltage Reclosing Control (VRC)

Voltage Reclosing Control inhibits an auto reclose operation by any of AR OCEF, AR SEF, AR UV and ABR elements when voltage on the source side falls below a user set threshold. Correct application of VRC prevents potentially hazardous backfeed situations from arising by isolating the source on perceived loss of upstream supply during an operation to clear a downstream fault.

VRC has three operating modes; two related to designation of source in radial protection applications and a third for use in ring feed situations.

- ABC** The recloser A,B,C terminals are connected to the source side in a radial feed situation. In ABC mode an auto reclose is blocked if the A, B, and C terminals each see voltage below the VRC threshold.
- RST** The recloser R,S,T terminals are connected to the source side in a radial feed situation. In RST mode an auto reclose is blocked if the R, S, and T terminals each see voltage below the VRC threshold.
- Ring** In Ring Operating Mode, source and load cannot be determined and an auto reclose is allowed if only one side of the open recloser sees voltage above the VRC threshold.



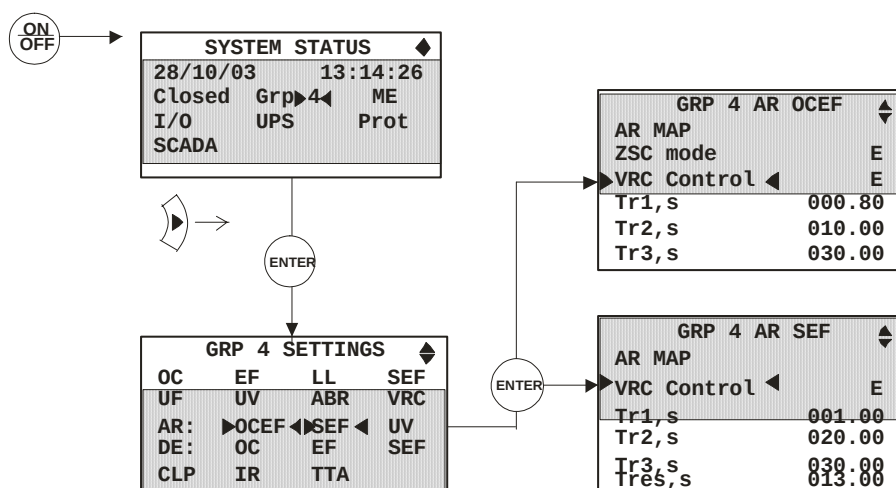
VRC settings

Title	Designation	Range	Resolution	Factory Default
Reclosing control mode	VRC mode	ABC/RST/Ring	NA	ABC
Voltage multiplier	UM	0.6 – 0.95	0.01	0.80

Note 1: VRC threshold equals $UM \times U_{rated} / \sqrt{3}$; where U_{rated} is the rated system voltage entered in the measurement settings (refer page 28).

Note 2: If the source side voltage remains below the threshold for longer than 200s then the recloser will go to lockout and will not continue the reclose sequence.

VRC can be independently disabled or enabled for AR OCEF and AR SEF:



6.8 Automatic Backfeed Restoration (ABR)

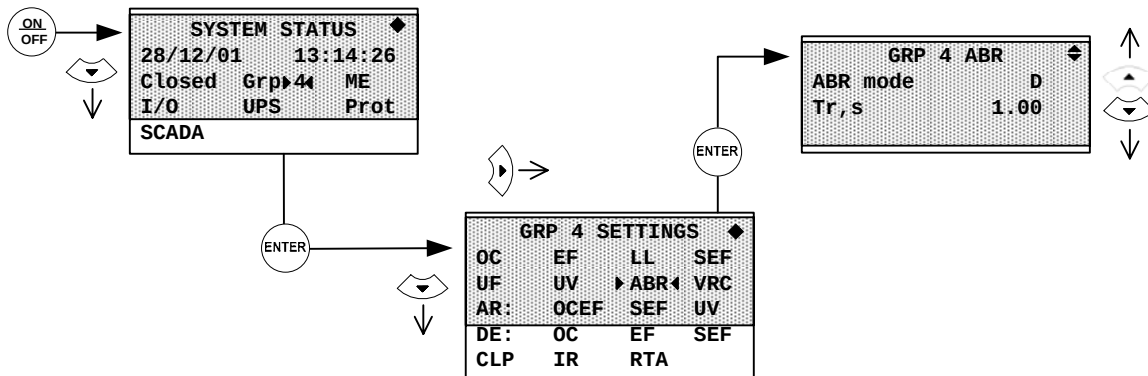
When enabled, Automatic Backfeed Restoration generates an automatic close if supply is restored to the source side of a normally open recloser. Source side is determined by setting the VRC mode, refer section 6.7, where Ring modes is selected, ABR will operate on restoration of voltage to either (but not both) sides of an open switch.

Note that enabling Live Line or disabling Protection or Auto Reclose automatically disables ABR. Closing the recloser by any means also disables ABR. ABR can only be turned on if the OSM is in the open position, Protection is enabled, Auto Reclose is enabled and Live Line is disabled.

ABR settings

Title	Designation	Range	Resolution	Factory Default
Operating mode	ABR Mode	Enable/Disable	NA	D
Restoration time	Tr	0 – 180s	0.01s	100.00

MMI Layout for ABR settings is illustrated below



6.9 Protection Status Control (PSC)

Protection Status Control allows global changes to protection status from a variety of sources. Changes to PSC status can be done from the Man Machine Interface (MMI), Supervisory Control and Data Acquisition (SCADA) systems, digital input and output (I/O) interface or Personal Computer (PC) running the TELUS software program.

The table below lists the available PSC elements. Setting an element to the indicated state causes the PSC to change all associated protection elements as shown.

Note that Live Line is unique in that it causes elements to be disabled when turned ON or OFF. Setting any other element to ON simply enables all affected elements.

PSC Element	Effect on associated protection elements	Factory Default
S(Group i)=On ^{1 2}	All protection elements for the identified group are enabled. All protection elements for all other groups are disabled.	Active grp 1
S(Prot)=Off ²	All protection elements for all groups are disabled.	Prot. Off
S(AR)=Off ²	AR OCEF, AR SEF, AR UV, ABR for all groups are disabled	AR Off
S(LL)=Off ²	OCLL, EFLL for all groups are disabled	LL Off
S(LL)=On ²	OC1+, OC2+, OC3+, OC1-, OC2-, OC3-, EF1+, EF2+, EF3+, EF1-, EF2-, EF3-, SEF+, SEF-, AR OCEF, AR SEF, AR UV, ABR, CLP, IR for all groups are disabled	
S(EF)=Off ²	EF1-, EF2-, EF3-, EF1+, EF2+, EF3+ for all groups are disabled	Off
S(SEF)=Off ²	SEF+, SEF- for all groups are disabled	Off

PSC Element	Effect on associated protection elements	Factory Default
S(UV)=Off	UV1, UV2, UV3 for all groups are disabled	Off
S(UF)=Off	UF for all groups is disabled	Off
S(ABR)=Off	ABR for all groups is disabled	Off
S(CLP)=Off ²	CLP for all groups is disabled	Off

Notes: 1 When Group *i* is switched ON, other Groups are automatically switched OFF.

2 ON / OFF control available from the MMI fast keys

7

Monitoring

The RC Cubicle generates and maintains the following records:

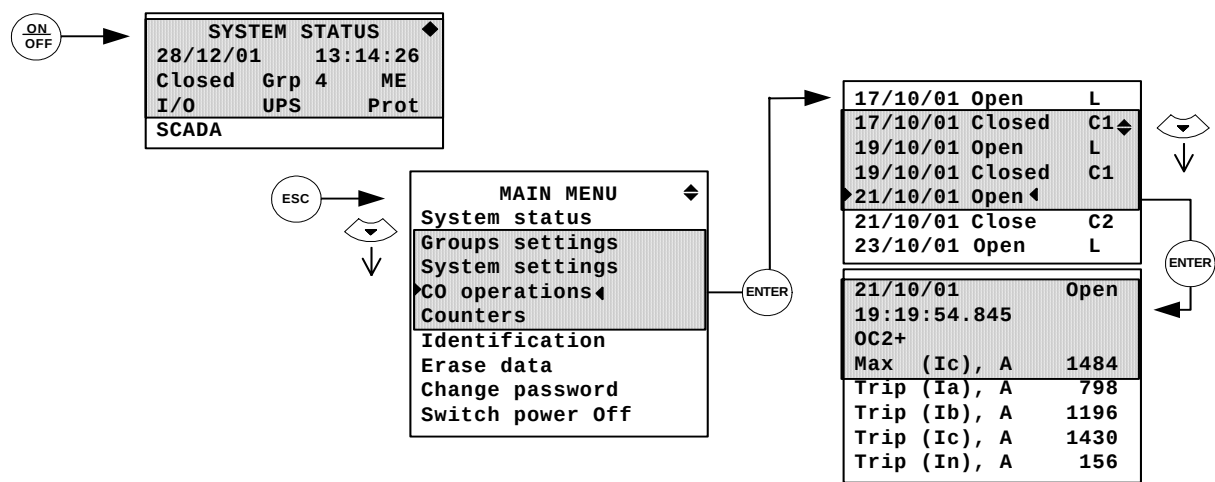
- Close / Open (CO) operations OSM operation data
- Fault Profile Fault episode data
- Event log Event data
- Change messages Setting and status change data
- Load profile Real, Reactive and Active Power profile data
- Lifetime and Fault counters

Monitoring records and counters can be downloaded to a laptop by means of TELUS software and can be erased from the Main Processing Module (MPM) memory.

7.1

Close Open (CO) Operations

This record registers at least the last 50 Closed/Open events associated with changes in OSM position¹.
The CO Operations log is accessible via the MMI screen or can be captured using TELUS software.



Each event is described by the following characteristics.

- Date and time event registered
- Event title (Open/Closed)
- Source of event
- Relevant state
- Critical parameter
- Phase and residual currents at time of initiation of trip command.

The table below provides further information on CO Operation events

Event	Applicable sources of event	Relevant state ²	Critical parameter
Open	Any protection element Operator by means of MMI, PC, I/O, SCADA or mechanical trip ring	O1 (Lockout) or O2 / O3 / O4 (waiting to reclose)	Values registered between pickup start and open events Maximum phase current (Max(Ia) / Max(Ib) / Max(Ic)) for OC elements Maximum residual current (Max(In)) for EF elements Minimum positive sequence voltage (Min(U1)) for UV1 Minimum line to line voltage (Min(Uab) / Min(Ubc) / Min(Uca)) for UV2 Minimum frequency (Min(F)) for UF
Closed	Any Auto Reclose element, ABR, MMI, SCADA, PC, I/O	C2 / C3 / C4 for AR OCEF, AR SEF C0 or C1 for others	NA

Note: 1. The CO operations record can be erased from the MPM memory.

7.2 Fault profile

The Fault profile is made up of records related to each of the last 4 protection trip operations caused by any protection element. The fault profile is not visible on the MMI and can be captured using TELUS software.

Each record includes Ia, Ib, Ic, Ua, Ub, Uc, Uab, Ubc, Uca, U1 and F values logged for each cycle of power frequency for up to 1 second prior to trip operation. The values for each cycle are identified by a sequential number from 1 to 50. The record with the highest sequential number is the time at which the OSM tripped.

7.3 Event log

The Event log registers up to 1300 events associated with changes of particular signals or parameters; Appendix F – Events describes all events registered in the event log. The Event Log is not visible on the MMI but can be captured using TELUS software. Each event is described by the following characteristics:

- Date and time registered
- Event title
- Source of event
- Relevant phase
- Critical parameter.

7.4 Change Messages

The Change Messages record contains up to 50 events associated with changes of settings, protection status, ext. load status, control mode or erasing energy meter readings, fault counters readings, CO Operations, event log, load profile or change messages; refer Appendix G – Change Messages. The Change Messages log is not visible on the MMI but can be captured using TELUS software. Each event is described by the following:

- Date and Time of change
- Changed parameter
- Old value
- New value
- Source of change (MMI, PC, SCADA, I/O)

7.5 Load profile

This record registers up to 3840 readings of three phase power (kVA, kW, kVar); and single phase power (A kVA, A kW, A kVar, B kVA, B kW, B kVar, C kVA, C kW, C kVar). The readings are averaged over a preset time interval 5/10/15/30/60 min. Consequently, the load profile record covers a time interval between 13.3 to 160 days. Each load profile reading is provided with a date and time stamp. The Load profile is not visible on the MMI but can be captured using TELUS software.

If the UPS enters Off or Shutdown mode only the last 96 readings are saved to non-volatile memory.

7.6 Counters

The MPM monitors the number of operations and energy throughput during a fault and calculates the percentage of contact wear remaining after each Close – Open operation.

Two lifetime counters are maintained, one for mechanism wear and the other for contact wear.

Fault counters provide indication of the number and type of each fault the OSM has operated for.

7.6.1 Lifetime counters

Lifetime counters calculate and record the total number of Close Open (CO) Operations and the mechanical and contact wear. They are accessible via the MMI or can be captured using TELUS software.

- Total CO Operations – A close operation and the subsequent open operation are treated as a CO Operation.
- Mechanical wear – The value is calculated as a ratio of the total number of CO operations to the rated OSM mechanical life (30000) and expressed as a percentage.
- Contact wear – The value is calculated for each phase using a recurrent formula to calculate the total contact wear consumed after each interruption.

The Maximum recalculated wear on any of the three phases is recorded as a percentage

Values are calculated and updated after each Close Open (CO) Operation.

7.6.2 Fault counters

Fault counters record the number of protection trips provided by each of the following

Phase Overcurrent (OC)

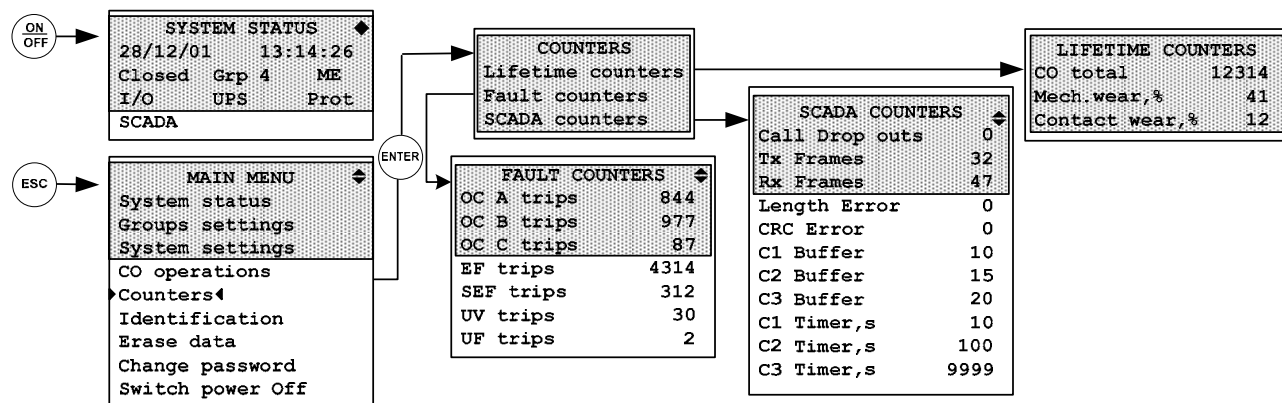
Earth Fault (EF)

Sensitive Earth Fault (SEF)

Under Voltage (UV)

Under frequency (UF)

Records are calculated and updated after each protection trip. They are accessible via the MMI or can be captured using TELUS software.



8 Control and Indication

Recloser Control and Indication capabilities are handled by four independent Control and Indication Elements

- Man Machine Interface (MMI)
- Personal Computer (PC) with TELUS software installed
- Supervisory Control and Data Acquisition (SCADA)
- Digital Input and Output (I/O)

The Control and Indication capabilities for each element are illustrated in the diagrams below.

Control Capabilities

		MMI	PC	SCADA	I/O
Control data					
	Date	✓	✓	✓	-
	Time	✓	✓	✓	-
	Life time counters readings	-	✓	✓	-
	Settings				
	System settings				
	ME settings	✓	✓	-	-
	UPS settings	✓	✓	-	-
	RTC settings	✓	✓	-	-
	MMI settings	✓	✓	-	-
	PC settings	✓	✓	-	-
	SCADA settings	✓	✓	-	-
	I/O settings	✓	✓	-	-
	Group 1 settings	✓	✓	-	-
	Group 2 settings	✓	✓	-	-
	Group 3 settings	✓	✓	-	-
	Group 4 settings	✓	✓	-	-
	Control signals				
	Remote Off	✓	-	-	-
	Trip/Close	✓	✓	✓	✓
	On(Prot)/Off(Prot)	✓	✓	✓	✓
	On(Grp1)	✓	✓	✓	✓
	On(Grp2)	✓	✓	✓	✓
	On(Grp4)	✓	✓	✓	✓
	On(AR)/Off(AR)	✓	✓	✓	✓
	On(EF)/Off(EF)	✓	✓	✓	✓
	On(SEF)/Off(SEF)	✓	✓	✓	✓
	On(LL)/Off(LL)	✓	✓	✓	✓
	On(CLP)/Off(CLP)	✓	✓	✓	✓
	On(UV)/Off(UV)	✓	✓	✓	✓
	On(ABR)/Off(ABR)	✓	✓	✓	✓
	On(UF)/Off(UF)	✓	✓	✓	✓
	On(Power)	✓	-	-	✓
	Off(Power)	✓	✓	✓	✓
	On(Ext)/Off(Ext)	✓	✓	✓	✓
	Reset password	-	✓	-	-
	Erase fault counters	✓	✓	✓	-
	Erase energy meters	✓	✓	✓	-
	Erase CO operations	✓	✓	✓	-
	Erase event log	✓	✓	✓	-
	Erase change messages	✓	✓	✓	-
	Erase load profile	✓	✓	✓	-

Key:

ME	Measurement Elements
UPS	Uninterruptible Power Supply
RTC	Real Time Clock
MMI	Man Machine Interface
I/O	Input/Output module
Remote	Remote Control mode
Grp	Protection group
AR	Auto Reclose
LL	Live Line
CLP	Cold Load Pickup
UV	Under Voltage protection
ABR	Auto Backfeed Restoration
UF	Under frequency
Ext	External load power supply

Notes: Refer Appendix H – Control and Indication of Settings for further information regarding Group settings.

Indication Capabilities

Key:
UPS Uninterruptible Power Supply
AR Auto Reclose
Prot Protection

Refer to section 1 for details on Measured date

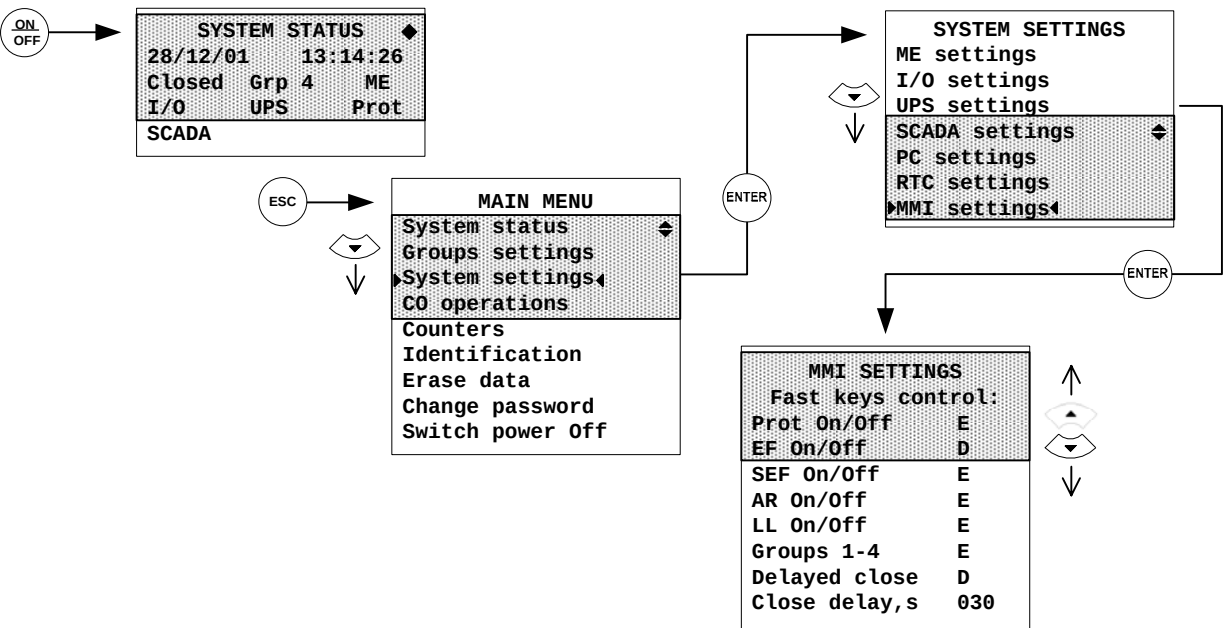
Refer to section 11.4 for details of Indication Signals

Refer to section 6.9 for details on Prot Status signals.

	MMI	PC	SCADA	I/O
Indication data				
System status				
Date, time	✓	✓	✓	-
Measured data	✓	✓	✓	-
UPS status	✓	✓	✓	-
Indication signals				
Local mode	✓	✓	✓	✓
Lockout	✓	✓	✓	✓
AR initiated	-	-	✓	✓
Prot initiated	✓	✓	✓	✓
Pickup signals	-	-	✓	-
Alarm signals	-	-	✓	✓
Open signals	-	-	✓	✓
Closed signals	-	-	✓	✓
Prot status signals	✓	✓	✓	✓
Malfunctions	✓	✓	✓	✓
Warnings	✓	✓	✓	✓
Counter readings				
Lifetime counters	✓	✓	✓	-
Fault counters	✓	✓	✓	-
Records				
CO operations	✓	✓	-	-
Fault profile	-	✓	-	-
Event log	-	✓	-	-
Change messages	-	✓	-	-
Load profile	-	✓	-	-
Settings	✓	✓	-	-

8.1 Operator Panel Settings

The keys on the operator panel can be programmed to control which fast keys are active and to activate a delayed close function as required by local operating procedures.



MMI settings

Title	Designation	Settings	Factory Default
Prot On/Off pushbutton control mode	Prot On/Off mode	Enable/Disable	E
EF On/Off pushbutton control mode	EF On/Off mode	Enable/Disable	E
SEF On/Off pushbutton control mode	SEF On/Off mode	Enable/Disable	E
CLP On/Off pushbutton control mode	CLP On/Off mode	Enable/Disable	E
AR On/Off pushbutton control mode	AR On/Off mode	Enable/Disable	E
LL On/Off pushbutton control mode	LL On/Off mode	Enable/Disable	E
Delayed Close	Delayed Close	Enable/Disable	D
Delayed Close Delay Time	Close Delay,s	0-300 seconds	30

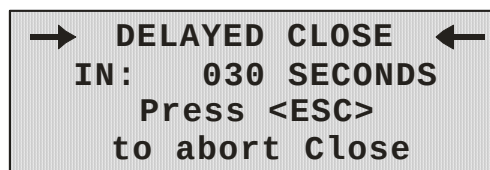
8.1.1 Enabling And Disabling Fast Keys

The MMI fast keys can be programmed to be available or not available according to local operating practice. If a fast key is disabled, pushing it will have no effect.

8.1.2 Delayed Close

This feature inserts a delay before closing the recloser when the “Close” button is pressed on the operator panel. The delay can be set from 0 – 300 seconds. This allows an operator time to move away from the recloser before the close operation occurs.

A message is displayed on the LCD Panel when the Close button is pushed and the Closed LED starts blinking:



Pressing the ESC key will cancel the close operation otherwise the device will close after the time delay has expired.

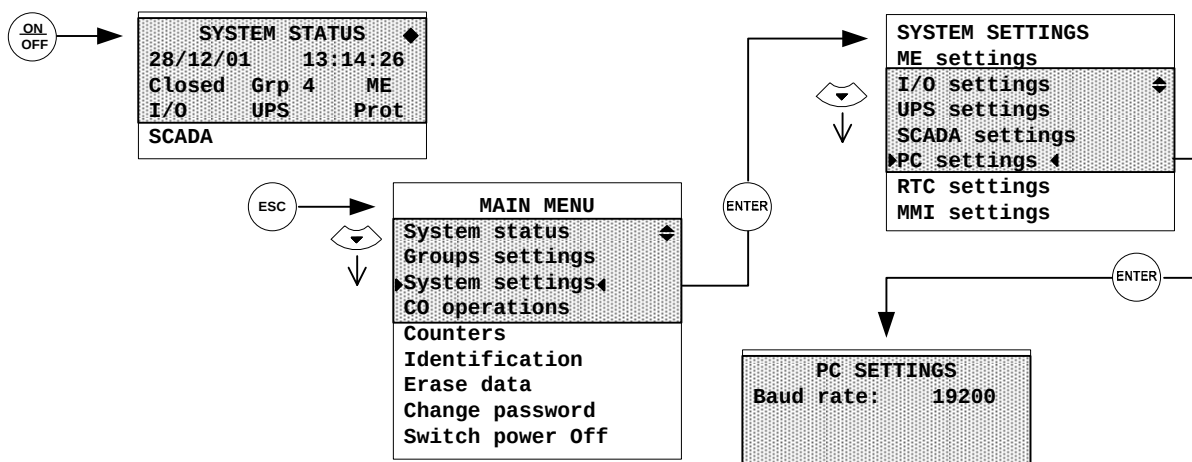
8.2 PC Control and indication

This element provides control and indication functions via an external PC using TELUS software.

For indication data, control signals and applicable settings refer to the description of each control and indication element. Activation of control signals and settings via PC is possible only when the control mode is set to local. Indication via PC is possible in both Local and Remote control modes.

PC settings

Title	Designation	Range	Resolution	Factory Default
Baud rate	Baud rate	2400/4800/9600/19200	NA	19200



8.3 SCADA Control and Indication

Control and indication functions can be provided via SCADA using an embedded communications protocol such as Modbus, DNP3 or IEC60870-5-101.

Activation of control signals via SCADA is possible only when control mode is set to Remote. Indication via SCADA is possible in both Local and Remote control modes.

SCADA functionality is determined by the applicable communications protocol. Please refer to one of the following documents for more information:

- NOJA-519 – DNP3 Protocol Implementation
- NOJA-546 – IEC60870-5-101 Protocol Implementation
- NOJA-508 – Modbus Protocol Implementation

The settings listed below are all available from the MMI menu system. Additional advanced settings are available from TELUS only. These advanced settings are described in the following document:

- NOJA-520 – SCADA Interface Description

Note: DNP3 and IEC60870-5-101 are not available together in the same MPM firmware.

General Settings

Title	Designation	Range	Resolution	Factory Default
Communications Device	Comm device	Direct/Radio/Modem	NA	Direct
Protocol	Protocol	DNP3/Modbus/D or; IEC/Modbus/D	NA	DNP3/IEC
SCADA time	SCADA time	Local/GMT	NA	Local

Port Settings

Title	Designation	Range	Resolution	Factory Default
Port Type	Port type	RS232/RS485	NA	RS232
Baud Rate	Baud rate	300/600/1200/2400/ 4800/9600/19200	NA	19200
Duplex Type	Duplex type	Half/Full	NA	Half
Parity	Parity	None/Even/Odd	NA	None

DNP3 Settings

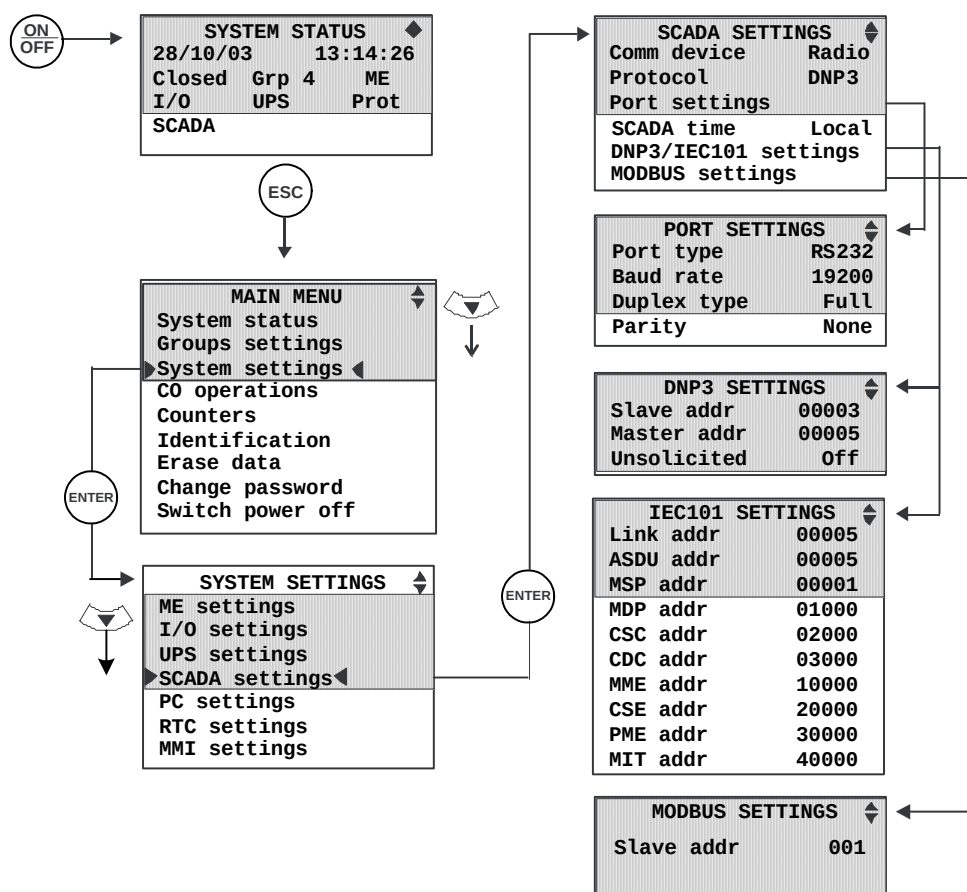
Title	Designation	Range	Resolution	Factory Default
Slave Address	Slave addr	0 - 65534	1	5
Master Address	Master addr	0 - 65534	1	3
Unsolicited	Unsolicited	On/Off	NA	Off

IEC Settings

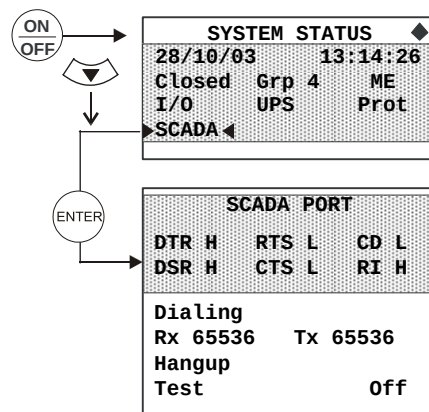
Title	Designation	Range	Resolution	Factory Default
Link Address	Link addr	0 - 65534	1	5
ASDU Address (MPM)	ASDU addr	0 - 65534	1	5
Single Point Base Address	MSP addr	0 – 65534	1	1
Double Point Base Address	MDP addr	0 – 65534	1	1,000
Single Point Command Base Address	CSC addr	0 – 65534	1	2,000
Double Point Command Base Address	CDC addr	0 – 65534	1	3,000
Measured Value Base Address	MME addr	0 – 65534	1	10,000
Setpoint Command Base Address	CSE addr	0 – 65534	1	20,000
Parameter Command Base Address	PME addr	0 – 65534	1	30,000
Integrated Total Base Address	MIT addr	0 - 65534	1	40,000

Modbus Settings

Title	Designation	Range	Resolution	Factory Default
Slave Address	Slave addr	1 - 247	1	1



A SCADA port monitoring screen can be viewed on the MPM under System Status:



This screen can be used to monitor the pin status, connection status, amount of packets received and transmitted, hangup the connection and conduct tests.

Item	Description	Range	RS232	RS485
DTR, RTS, CD, DSR, CTS, RI	RS232 Port Pins	H = Pin High L = Pin Low I = Ignore Pin	Yes	-
Connection Status	Displays port connection status	Disconnected Connected Dialing Redialing Autodialing	Yes	Yes
Rx	Displays amount of packets received. Count can be reset to zero by pressing enter.	0 - 65535	Yes	Yes
Tx	Displays amount of packets transmitted. Count can be reset to zero by pressing enter.	0 - 65535	Yes	Yes
Hangup	Hangs up the modem.	N/A	Yes	Yes
Test	Sends ASCII String "RCTEL TEST" out port. Message continues to send until turned off.	Off On	Yes	Yes

Note: The "Modem is powered from external load" setting available only in TELUS can affect when the communications protocol is running. Please refer to the SCADA Interface Description document (NOJA-520) for a detailed description of this feature.

8.4 Digital Inputs and Outputs (I/O)

This element provides control and indication function via digital input and output (I/O) modules. For a complete range of I/O Module indication and control signals, refer to section 8.

Activation of control signals via I/O is possible only when control mode is set Remote. Indication via I/O is possible in either Local or Remote control modes. For wiring details, refer to section 4.7.1.

Up to two I/O modules can be fitted to the RC control cubicle. The modules must be set to enable to make them operational.

8.4.1 I/O Control

The I/O module converts voltages applied to each input into a status.

Refer to 4.7.1 I/O Modules for polarity information.

After activation of a control generated by applying voltage to an I/O module input, the input is ignored until its signal is removed and re-applied. Similarly, if a separate event affects a control operated by an input, the input continues to be ignored until its signal is removed and re-applied. This is to eliminate spurious activation of the control.

Input voltages depend on the model of I/O module used. Refer to section 2.2.7 for input ratings such as voltage, input resistance, recognition times, transmission times and reset times.

Notes: When an I/O module is set in test mode activation of any digital input leads to activation of all its digital outputs.

When an I/O module is set in Disable mode, its input control voltages are ignored.

8.4.2 I/O Indication

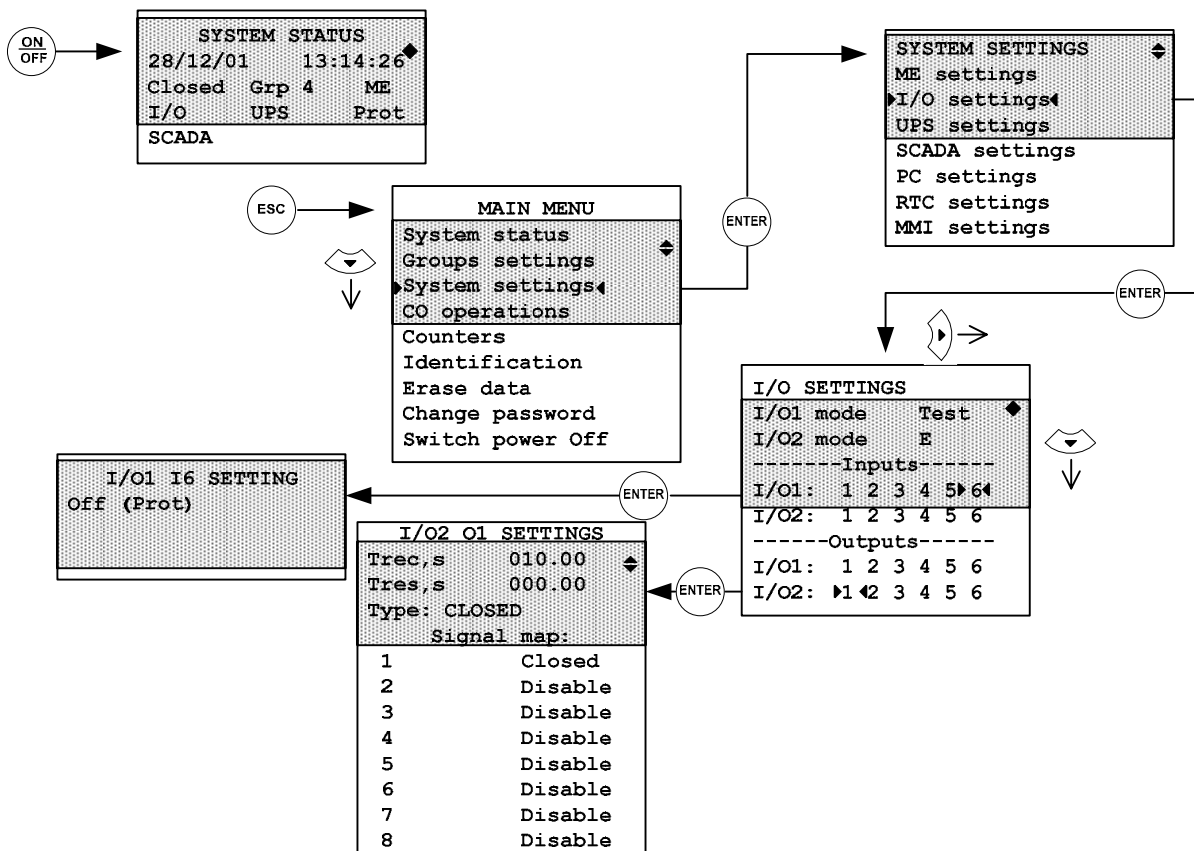
The I/O module converts indication signals mapped for a particular output to an output.

Up to 8 indication signals can be mapped for each output. Activation of any the mapped signals sets the output status On.

In Test mode activation of any digital input leads to activation of all IOM digital outputs.

Refer to section 2.2.7 for output relay ratings.

8.4.3 I/O settings



General settings

Title	Designation	Range	Resolution	Factory Default
I/O1 operation mode ¹	I/O1 mode	Enable/Disable/Test	–	D
I/O2 operation mode ¹	I/O2 mode	Enable/Disable/Test	–	D

Note: 1. Selection of modes (Enable/Disable/Test) is only applicable if the relevant module is connected and communication is established between the module and MPM.

Digital input signal map²

Input	Range	Factory Default
1	Any control signal + Disable	Trip
2	Any control signal + Disable	Close
3	Any control signal + Disable	On (AR)
4	Any control signal + Disable	Off (AR)
5	Any control signal + Disable	On (SEF)
6	Any control signal ³ + Disable	Off (SEF)

Notes: 2. Refer to section 8 for available I/O controls.

3. On (Power) control signal can only be mapped to the 6th input of I/O 1.

Digital output settings⁴

Title	Designation	Range	Resolution	Factory Default
Recognition time	Trec	0 – 180s	0.01s	000.00
Reset time	Tres	0 – 180s	0.01s	000.00

Note: 4. Applicable for each digital output.

Digital output map⁵

Output	Range	Factory Default
1	Any indication signal + disable	Open
2	Any indication signal + disable	Closed
3	Any indication signal + disable	Status
4	Any indication signal + disable	Status
5	Any indication signal + disable	General
6	Any indication signal + disable	General

Note: 5. Refer to section 8 for available I/O indication.

9 Installation

Installation of both the OSM Auto Circuit Recloser and RC cubicle is straightforward. It is recommended the preparation for installation be done in a clean workshop environment and the prepared equipment is transported to site.

9.1 De-crating

The OSM Auto Circuit Recloser and RC cubicle are packed in a single crate containing;

- Routine test summary
- OSM15-079, OSM15-200 or OSM27-203 recloser
- RC cubicle with this manual in the document pocket on the inside of the door
- Control cable
- Pole mounting bracket and fasteners
- Mechanical Trip Ring

Access to the crate is by panels fastened with screws and the contents can be removed without dismantling the nailed sections.



CAUTION: Inappropriate lifting of either the OSM recloser or RC cubicle can result in personal injury or equipment damage.

9.1.1 Mechanical Trip Ring

The Mechanical Trip Ring is located inside the crate and should be fitted prior to conducting the tests described in the following sections. Make sure the OSM is in the closed position before installation. Some models may be shipped with the trip ring pre-installed.

1. Screw the retaining nut up to the end of the thread on the trip ring.
2. Screw the trip ring into the mechanical trip mechanism underneath the tank. Do not tighten – leave it a little loose.
3. Hold the trip ring with one hand so it won't move. Use the other hand to tighten the retaining nut against the trip mechanism using a ½" spanner.



CAUTION: The trip ring is held in place by the retaining nut. Do not allow the mechanism to twist when installing the ring as it can be damaged.

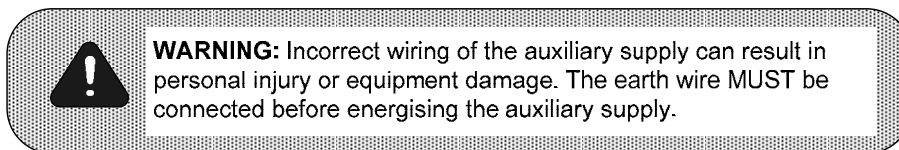
9.2 RC Cubicle Preparation

Once removed from the crate the Recloser Control (RC) cubicle should have an auxiliary supply fitted prior to carrying out any testing. This will ensure that the controller will be restored from shutdown mode should the battery have become discharged during transit or subsequent storage.

9.2.1 Auxiliary Supply Connections

The RC cubicle can be fitted with two separate AC supplies where required and is connected into a circuit breaker. The cubicle is configured for the correct auxiliary supply voltage (110Vac, 127Vac or 220Vac) at the factory as requested by the customer prior to delivery.

Refer to section 4.6 for configuration and connection details.



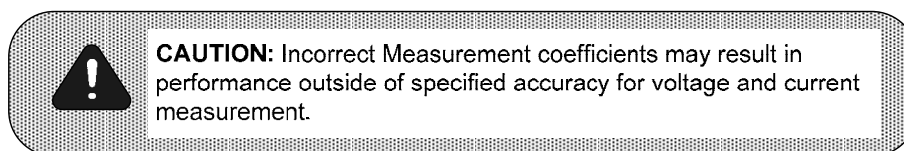
Note: The capacitive filtering on the auxiliary supply input will cause Earth Leakage Circuit Breakers to trip. This filtering is provided to protect the electronics from high voltage spikes. During workshop testing it may be necessary to connect the auxiliary supply through an isolating transformer to prevent nuisance tripping on the power circuit. The earth wire **MUST** be connected even when in a workshop environment as the leakage from the capacitors can cause damage to equipment.

9.2.2 RC and OSM Compatibility

The RC control can be connected to any recloser with OSM15 or OSM27 in the model number. However, the OSM and RC pair shipped in the same cubicle should be retained wherever possible.

For measurement within specification, each OSM requires a set of calibration coefficients for current and voltage to be programmed into the RC Cubicle memory. For details of the information required, refer to the Operation section of this manual, section 5.2. During manufacturer routine testing, the calibration coefficients relating to the OSM have been pre-programmed into the memory of the RC accompanying it.

Retaining pairing is not critical, but where this is not done, the correct OSM measurement coefficients must be programmed into the RC; these are recorded on the routine test summary document provided with the OSM. If programming for another OSM is required, section 5.2 shows where the Measurement Settings are located. Alternately TELUS software can be used to download a configuration file that has been prepared in advance.



If the correct Measurement settings have been misplaced, they can be supplied by your nearest NOJA Power office or distributor. For provision of the correct settings the OSM serial number, as recorded on the rating plate, is required.

9.2.3 Initial Checks

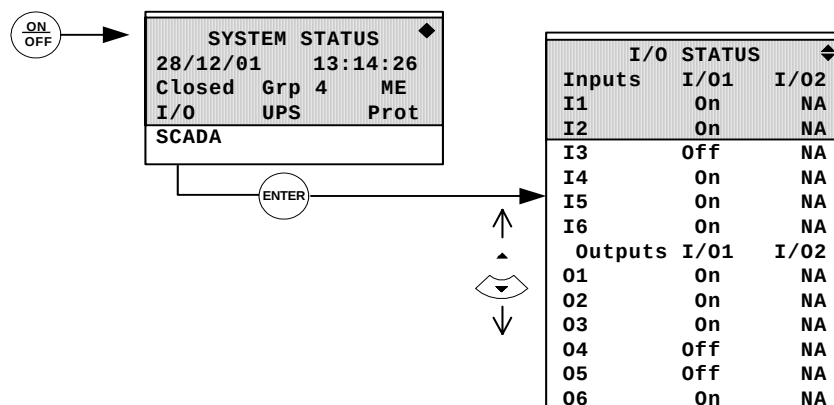
The RC control is shipped with default Protection settings, refer to section 1 for details. Prior to commissioning, the correct settings for the intended application must be programmed.

Before commencing tests make sure the AC supply is connected. Next open the escutcheon panel and re-connect the battery by plugging connector X1 into socket XP14 on the PSM module.

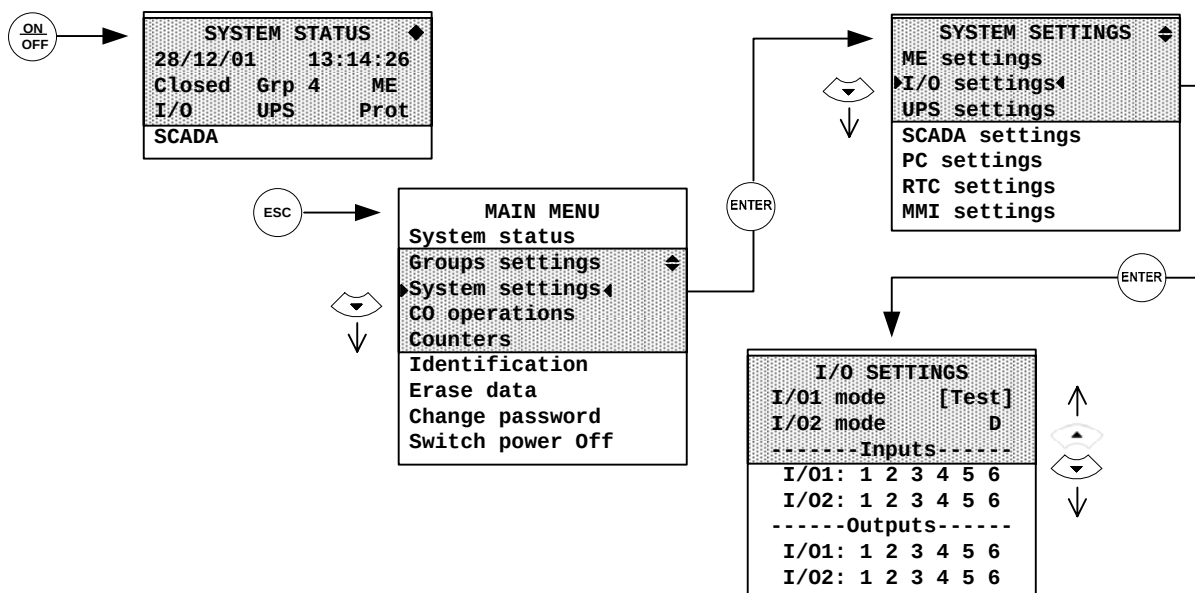
1. Press the MMI On button to see the SYSTEM STATUS display.
 - Pressing the arrow keys will move brackets to allow selection of any field.
 - Square brackets [] indicate the value in the field can be changed.
 - Arrow Brackets ▶ ◀ indicate more information is accessible.

Confirm that 12Vdc appears across terminals 1 and 2 of the RS-485 connector (refer section 4.7.2). Set Ext. Load voltage back to OFF, press the ESC key to return to SYSTEM STATUS.

5. If I/O modules are fitted, note the part number on the module case. Modules with part number IOM-12/60 will accept input voltage from 12Vdc to 60Vdc. Modules with part number IOM-100/250 will accept input voltage from 100Vac to 250Vac.
6. From the SYSTEM STATUS screen, select and view 'System Settings' then select and view 'I/O settings' group to confirm the I/O Modules are indicating correctly. Note that if an IOM is not fitted, or is disabled, NA appears next to the input / output status.



7. Select 'Test' mode for an I/O module. In this mode, application of the correct operating voltage to any input will cause ALL outputs to change state. Applying voltage to each input and confirming that all outputs change state each time tests operation of the I/O module.



On completion set the module under test back to 'Enable' mode. Press the ESC key to return to SYSTEM SETTINGS

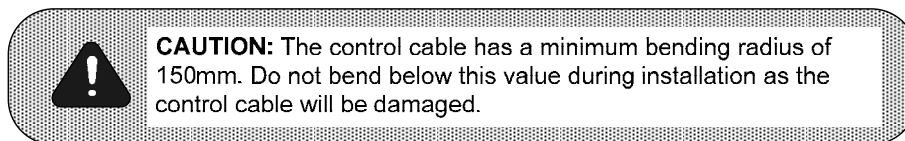
The above checks confirm the Recloser Control is functioning correctly and can be connected to an OSM recloser for further testing.

9.2.4 Control Cable

The control cable is shipped together with the RC cubicle and was tested together with the RC during factory testing. Remove the plastic covering the ends of the cable and inspect the connectors to ensure they have not been damaged in transit. Also inspect the length of the cable to ensure it has not been crushed or otherwise damaged.

The cable has a male and female connector, the female connector fits into the RC cubicle, the male connector fits into the base of the recloser.

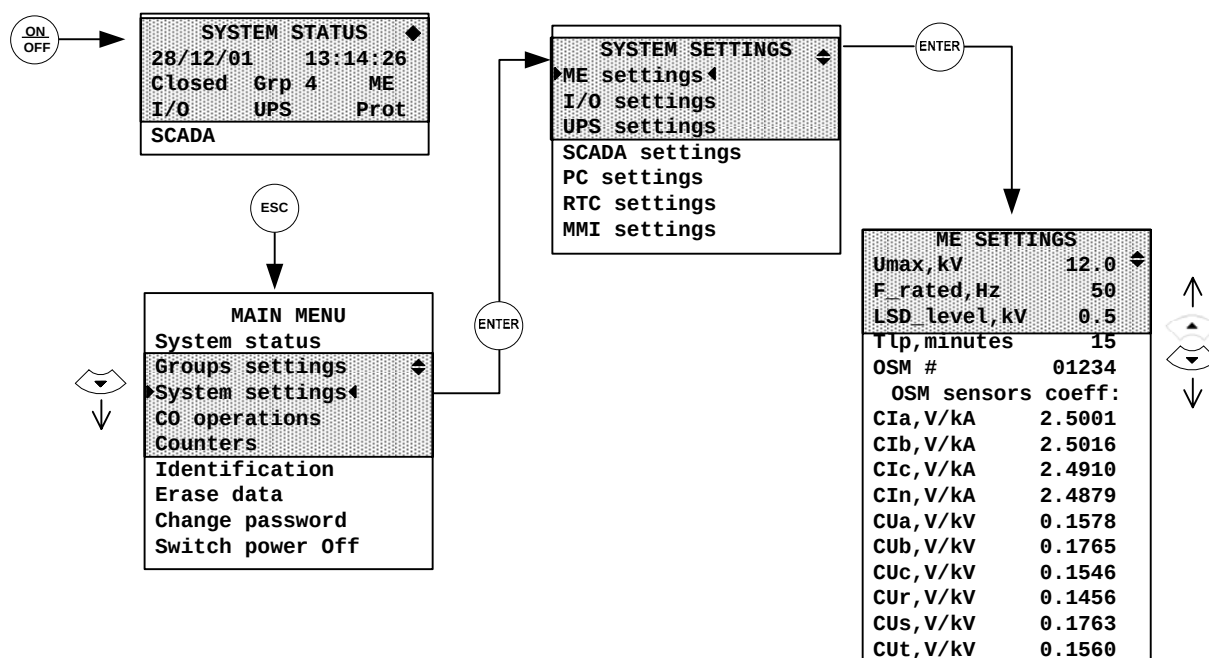
Remove the security cover from the RC cubicle, it can be left off during workshop testing. Connect the control cable to the RC plug and secure it using the integral clamping arrangement.



9.2.5 OSM Operation

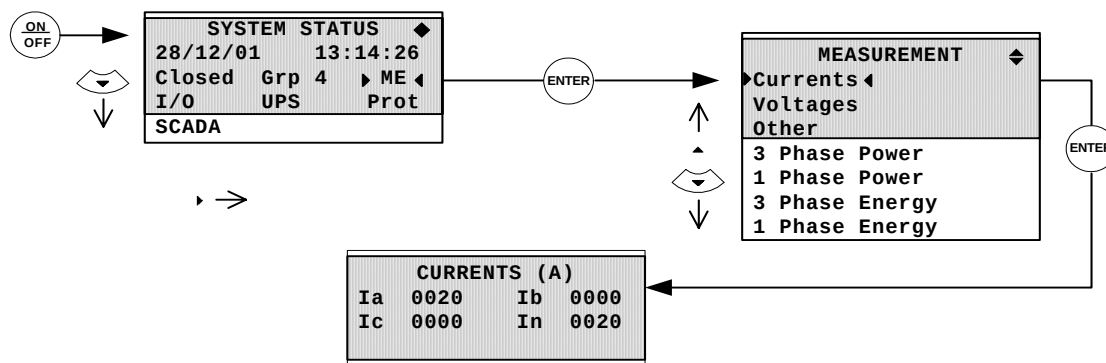
Once the OSM recloser has been removed from the crate it should be placed on a worktable or level surface.

1. Connect the control cable to the plug in the base of the recloser and ensure the plug is firmly locked into place using the integral clamping arrangement.
2. Press the ON button on the RC cubicle operator panel, confirm the position LED is lit and agrees with the indicator at the base of the recloser. If the OSM is closed, press the green trip button and confirm the recloser opens, that the OPEN LED is lit and that the indicator shows the correct status.
3. Press the red close button and confirm that the recloser closes and the CLOSED LED is lit.
4. Trip the OSM using the mechanical trip ring and ensure the mechanism is fully withdrawn.
5. View 'System Status' on the MMI, select 'Warning' and confirm that an 'OSM Coil Isolated' message indicates that the recloser is unable to be closed. Confirm that pressing the CLOSE push button does not cause the recloser to close, press the ESC key to return to 'SYSTEM STATUS' and again to return to 'MAIN MENU'. Refer to section 10.3.2.1 for information on Warning Events.
6. Push the mechanical trip ring back into the operating position and confirm that pressing the close pushbutton causes the recloser to close.
7. Navigate to 'ME Settings' as illustrated in the diagram below and confirm the 'OSM #' field matches the number engraved on the rating plate of the recloser. Also confirm the OSM Measurement coefficients match those on the testing document supplied with the OSM recloser.



Press the 'ESC' button to return to SYSTEM SETTINGS.

8. Ensure the OSM is in the closed position.
9. Select 'ME' (measurements) from the SYSTEM STATUS page, then 'Current' from the MEASUREMENTS page. Inject 20A primary current, one phase at a time and confirm that indications of phase and earth current are correct in each case.



10. If HV testing is required, refer to section 9.3.2
11. Turn the Operator Panel OFF using the ON/OFF pushbutton and disconnect the Auxiliary supply.
12. Disconnect the control cable and replace the plastic covering over each end to protect the connectors from dust and grit during transport to site.

The above confirms the OSM and RC are functioning correctly.

9.2.6 Programming Settings

Settings for the RC cubicle must be programmed by a competent technician with knowledge of the equipment as described in this manual and the intended protection application.



CAUTION: Settings for this device require an understanding of the equipment and the conditions of service. Incorrect settings will result in equipment maloperation.

Settings can be manually entered using the MMI (refer section 4.4.2) or transferred using the PC based TELUS software. This can be done on site or in the workshop as preferred.

9.3 OSM Recloser Preparation

9.3.1 OSM HV Terminal Connections

No preparation is required for the OSM HV terminals other than to ensure they are clean prior to installation.

9.3.2 HV Testing

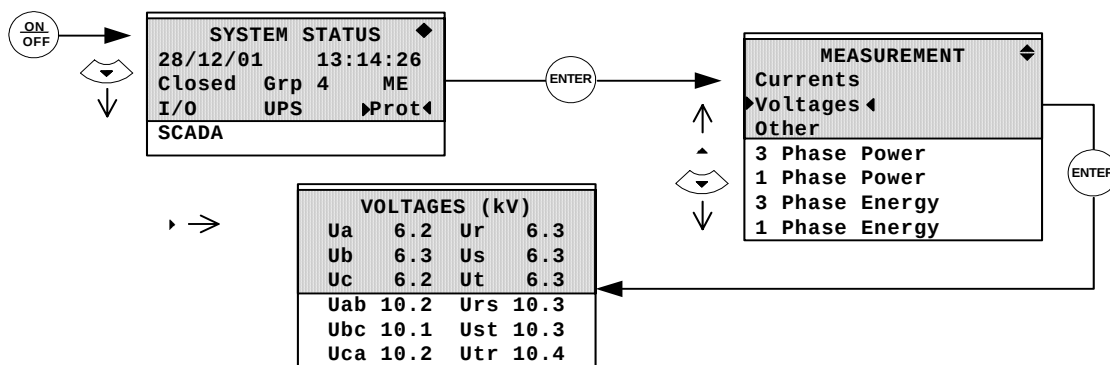
All NOJA Power outdoor switching devices pass ANSI C37-60 requirements for power frequency and partial discharge testing prior to dispatch from the manufacturer. Where Power frequency testing is required prior to installation, testing to 80% ANSI C37-60 Power Frequency withstand voltage is recommended to confirm insulation integrity without unduly stressing insulating components.

Equipment Rating	Recommended 1minute Test Voltage	
15kV	42kV AC	50 kV DC
27kV	50kV AC	60 kV DC

HV should be applied to the OSM HV terminals.

The OSM recloser should be connected to the RC Cubicle by the control cable. The recloser should be tested in the closed position.

1. Apply an earth (min 1.5mm²) from the OSM earth point to the RC earth point and then to the HV test set earth point.
2. Where a single phase HV test set is being used, tie the three phases together, on one side only, using fusing wire or test each phase individually as preferred.
3. Select 'System Status', 'ME' and then 'Voltage' from the RC cubicle operating panel. Energise the recloser terminals to system phase to ground voltage, confirm voltage indications for each terminal.



4. Disconnect the control cable from the OSM recloser.
5. Energise the OSM HV circuit to 42kV (OSM15-079 and OSM15-200) or 50kV (OSM27-203) for 1 minute as appropriate.



CAUTION: Inappropriate energisation or excessive voltage may result in equipment damage.



WARNING: Inappropriate grounding of the recloser, cubicle or test equipment will apply hazardous voltage that may result in personnel injury or death or equipment damage. Only personnel trained in HV testing should carry out the tests described in this section.

9.3.3 Mounting Bracket

The OSM15-200 and OSM27-203 mounting bracket is mounted on the tank at the factory prior to delivery.

The OSM15-079 mounting brackets must be removed from the crate and fitted to the tank using the four supplied stainless steel M12 bolts with ring and flat washers.

Two M20 bolts (not supplied) are required for fitting the recloser and mounting bracket to the pole.

9.4 Site Installation

The recommendations in the section that follow are designed to maximise the effectiveness of the OSM recloser and RC cubicle.



CAUTION: Failure to comply with installation recommendations may result in equipment damage.



WARNING: Follow all locally approved safety procedures when installing or operating this equipment. Failure to comply may result in death or severe personal injury.

9.4.1 Transport to Site

For transport to site the recloser should be strapped to a pallet. The OSM15-079 should have the manual trip ring removed to prevent damage.

The RC cubicle and control cable should be separately secured to a pallet for transportation.

9.4.2 HV Surge Arrestors

It is recommended that HV surge arrestors are fitted to the OSM prior to installation on a pole.

All six surge arrestors can be mounted on the OSM15-200 and OSM27-203 tank using the mounting points supplied.

The OSM15-079 is supplied with two brackets. These must be mounted onto the tank before lifting onto the pole.

The surge arrestor mounts have a 13mm diameter hole for fitting of a surge arrestor or stand off. The OSM15-079 requires the arrestor earths to be separately connected to the M12 earthing stud on the tank.

The recommended connection to the HV conductor is by means of a parallel groove clamp with cable length as short as possible.

9.4.3 Installation: OSM15-200 and OSM27-203

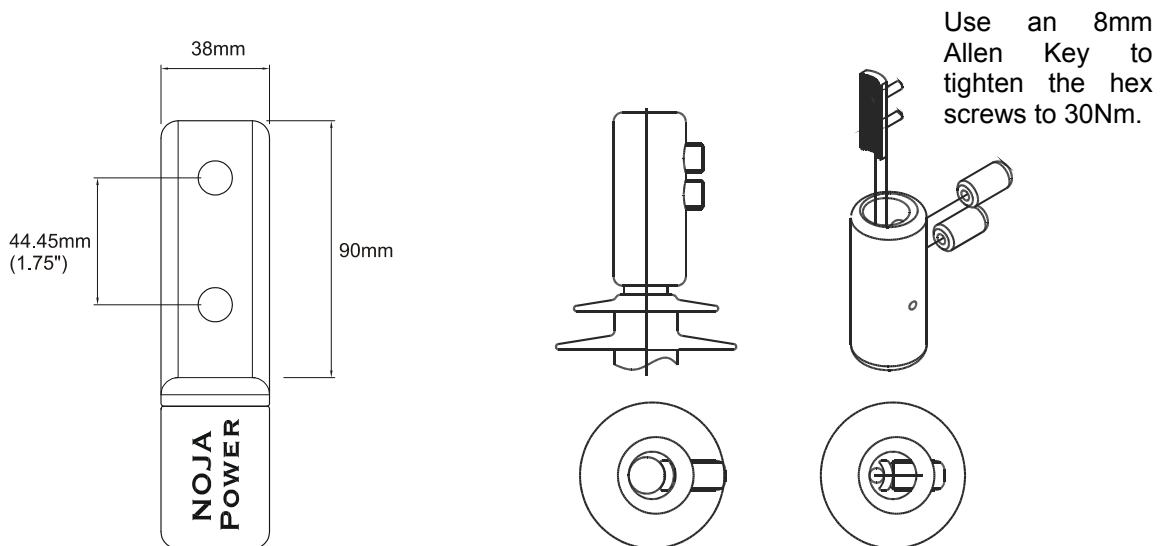
Make sure the pole mounting bracket is fitted to the OSM before lifting it onto the pole. The mounting bracket has four lifting points for lifting the OSM with a sling.

The pole mounting bracket is secured to the pole by two M20 bolts at 280mm centres and the bracket has the top hole keyed to facilitate fitting over a bolt head or nut. Once the top is secured, the bottom bolt can be tightened to fix the recloser in place.

The pole mounting bracket can also be used to mount the recloser on concrete poles using banded strapping. In this case two steel bands are threaded through the slots provided on the bracket and around the pole.

Connect the HV cables into the HV connectors on each bushing. Tighten the hexagonal socket screws with an 8mm Allen Key to 30Nm.

A tin-plated brass palm connector can be fitted to the bushing instead if required. This has two holes 44.45mm (1.75") apart so a lug can be bolted onto the bushings.



9.4.4 Installation: OSM15-079

The OSM recloser is fitted with four lifting brackets to facilitate installation; these must be removed prior to energisation.



CAUTION: The lifting brackets must be removed prior to energisation. Failure to do so can result in degradation of OSM impulse withstand characteristics.

The pole mounting bracket is secured to the pole by two M20 bolts at 280mm centres and the bracket has the top hole keyed to facilitate fitting over a bolt head or nut. Once the top is secured, the bottom bolt can be tightened to fix the recloser in place.

The pole mounting bracket can also be used to mount the recloser on concrete poles using banded strapping. In this case two steel bands are threaded through the slots provided on the bracket and around the pole.

An appropriate parallel groove clamp is recommended for HV connection.

The OSM has tinned copper termination stems with a 22mm diameter.



CAUTION: Parallel groove clamp orientation must be chosen to maximise phase clearances. Failure to do so may result in fault currents when energised.

9.4.5 RC Installation

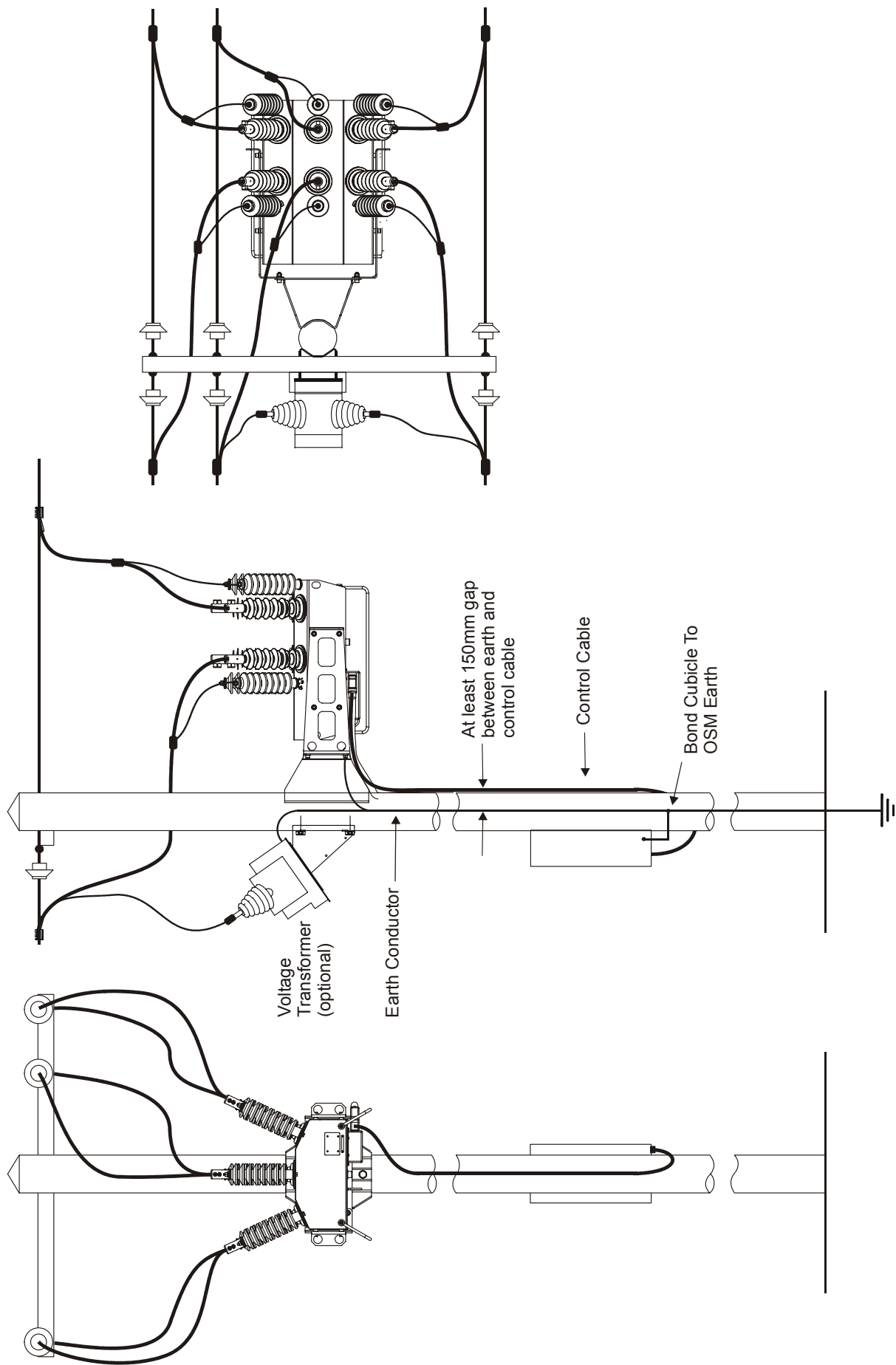
The RC cubicle has lifting lugs in the top section of the pole mounting bracket. The RC cubicle is secured to the pole by bolts or coach screws with diameter up to 22mm, the top hole is keyed to allow fitting over a bolt or nut. Once the top is secured the bottom bolt can be fitted.

Refer to section 4.2 for RC cubicle dimensions.

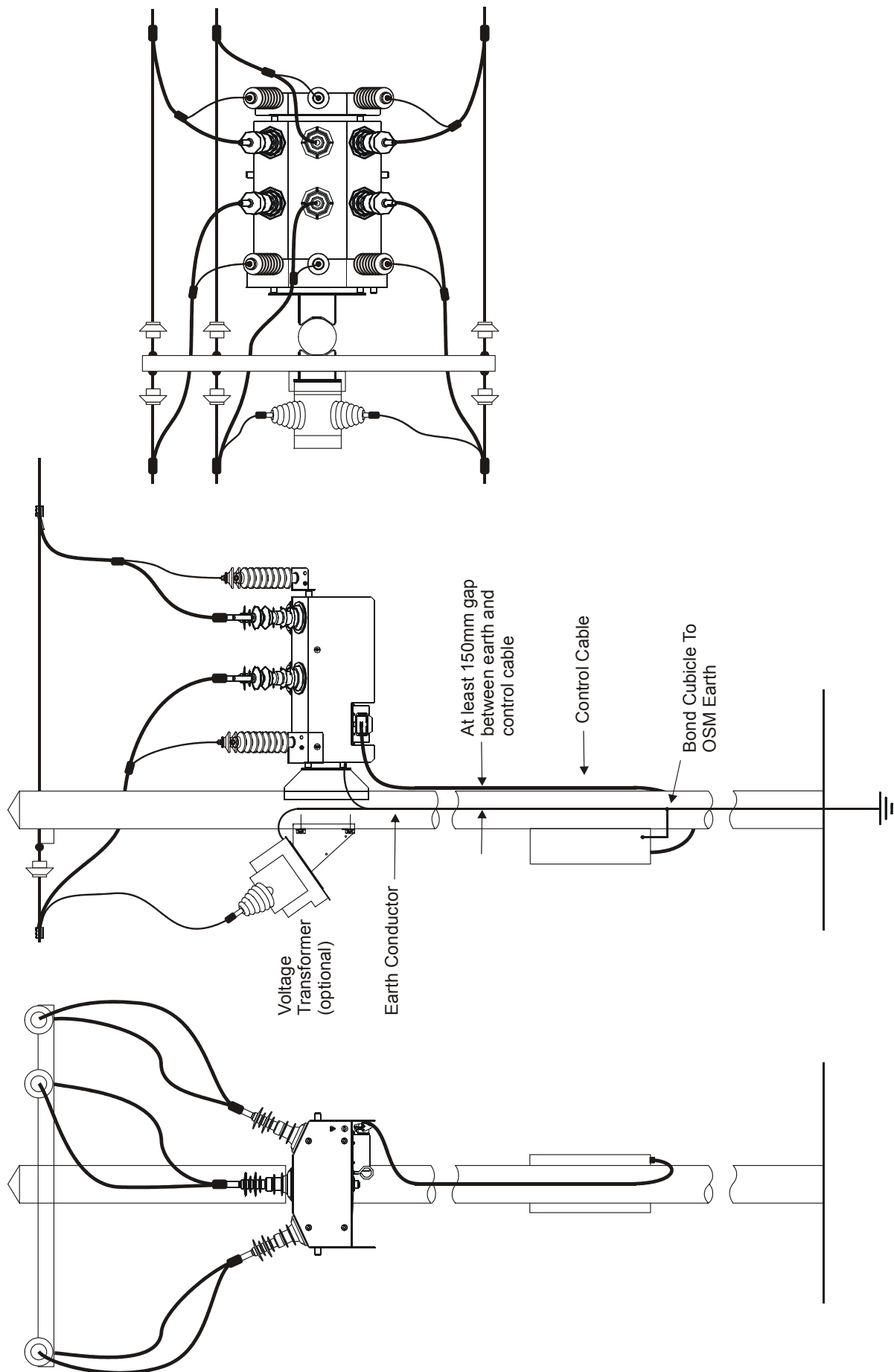
9.4.6 Earthing

The OSM recloser is earthed by means of a (provided) M12 hex head bolt into a captive thread on the back wall of the tank, recommended torque is 40Nm and 35mm² copper conductor is the minimum requirement for earth conductor, crimp lugs are recommended for connection to the OSM earth point.

The RC cubicle is earthed by means of an M12 stud on the base of the cubicle. Crimp connection at the RC end is recommended, connect to the OSM earth by means of a short length of earth conductor and parallel groove clamp or similar.



Typical Pole Mounting Arrangement for OSM15-200 and OSM27-203



Typical Pole Mounting Arrangement for OSM15-079

9.4.7 Auxiliary Supply

The Recloser Control allows connection of one or two AC supplies and can be configured for 110Vac or 220Vac supply voltages as required, refer section 4.4 for connection details.

The Recloser Control is set up for a single or dual AC supplies at the factory as requested by the customer at time of purchase. Check the testing documentation to ensure the correct voltage configuration has been supplied.

9.4.7.1 LV Arrestors

It is recommended the user install an LV surge protector at the point of supply of the auxiliary voltage, either at the VT terminals or tee off from utility mains.

9.4.8 Communications Interface

Remote communications with the Recloser Control can be achieved by using the I/O Modules or by connecting to the RS-485 and RS-232 interfaces. In either case, all communications wiring must be by means of screened cable with the screens earthed to the RC cubicle earth at one end only. Where cabling exits the RC cubicle, it should be fitted with an appropriate RFI ferrite filter, located as close as possible to the (inside) floor of the cubicle.

Opto or galvanic isolation must be used on the RS485 and RS232 ports if conductive twisted pair cables are to be used as the communications medium.

Refer to section 4.7 for details of connections for the communications interface.

10 Maintenance

The OSM Auto Circuit Recloser and RC cubicle are designed for a maintenance free pole life. This section provides recommendations for monitoring equipment condition.



CAUTION: Failure to comply with recommendations may result in equipment damage.



WARNING: Follow all locally approved safety procedures when installing or operating this equipment. Failure to comply may result in death or severe personal injury.

10.1 OSM Recloser Contact Wear

Contact wear is calculated for every Open / Close operation except for operations initiated from the mechanical trip ring. Mechanical wear due to a single Open / Close operation is negligible since the mechanism is rated for 30,000 operations, but is calculated for every operation. Fault wear is calculated from the energy throughput during fault interruption, refer section 2.1.4 for the rated number of operations under fault conditions.

The maximum contact wear on any one phase is indicated by the MPM as percentage consumed. On reaching 100% the Vacuum Interrupter contacts should be considered to be at the end of their service life. The values for number of operations and contact wear should be monitored by the user through periodic captures of RC memory to a computer using TELUS software or a SCADA master application.

Where an RC cubicle is connected to a new OSM recloser, the lifetime counter values for that OSM must be programmed. This can be done by loading the TELUS file associated with the OSM into the MPM or by manually keying in the counter values from the MMI.

Once the mechanism or vacuum interrupter contact wear on any pole has reached 100% contact your nearest NOJA Power office or distributor for a refurbishment assessment.

10.2 RC Cubicle

The RC cubicle is maintenance free with the exception of the sealed lead acid battery which requires periodic replacement.

10.2.1 Battery Replacement

Approved batteries:

Model	Recommended service interval	Temp rating
Genesis G12V26Ah10EPX	4 years	-40 °C to +60 °C
Century-Yuasa PS12240	4 years	-15 °C to +50 °C

Temperatures outside of ambient 25 °C may negatively affect battery longevity. For further information contact the manufacturer. NOJA Power does not warrant battery life.

To ensure information is not accidentally lost during battery replacement, all historical data stored within the MMI should be captured using TELUS software prior to proceeding.

There are two means of carrying out battery replacement, which method is used depends on whether an AC supply is available.

10.2.1.1 AC Supply Not Available

With no AC supply available the UPS must be switched into Off mode which causes a Power Supply Module relay to disable the battery connection. Off mode also disables the RC protection and communications capabilities.

1. Turn MMI On using the On/Off pushbutton, press ESC to view the Main Menu.
2. Select 'Switch Power Off' from the 'Main Menu' to set the UPS into Standby mode.



CAUTION: Setting the UPS into standby mode saves the last 96 load profile events. Prior load profile data will be erased and should be captured using TELUS if required.

3. Wait until the MMI screen goes blank, this can take up to 60 seconds.
4. Replace battery (refer section 10.2.1.3). Turn the MMI ON, set the date and time.

10.2.1.2 AC Supply Available

Where AC supply is available, the UPS can be left active and the battery can be replaced without switching it into Standby mode. Disconnection at the negative terminal breaks the battery circuit without risk of battery generated arcing.

In this case battery replacement involves no loss of load profile data and no interruption to the RC protection capabilities.

10.2.1.3 Replacement Procedure

Battery replacement is carried out as follows:

1. Open the escutcheon and disconnect the negative terminal of the battery, secure the wiring harness to avoid accidental shorting.
2. Disconnect the positive terminal of the battery.
3. Remove the wingnuts securing the battery.
4. Remove the battery, install a replacement and tighten the wingnuts.
5. Connect the positive terminal followed by the negative terminal.



CAUTION: Connecting the battery terminals in reverse polarity will cause the battery fuse to operate. The battery fuse should be replaced by a V5x20 Ferrule Fuse, type GDAS501 f 6.3AH 250V.

6. Close the escutcheon, turn MMI ON, select 'System Status' and then 'UPS' to confirm battery voltage and charging current are correctly indicated.

Note: Damage due to accidental reverse polarity connection is prevented by an in-line fuse located near the battery terminals. An incorrect fuse can result in Power Supply Module damage in the event of subsequent reverse polarity connection.

10.2.2 Door Seal

The integrity of the cubicle door seal should be monitored, it is recommended to be included as a periodic check with the same cycle as battery replacement.

Ingress of dust at any time indicates the cubicle IP rating has been compromised and that the cubicle door seal or cable entry glands require attention.

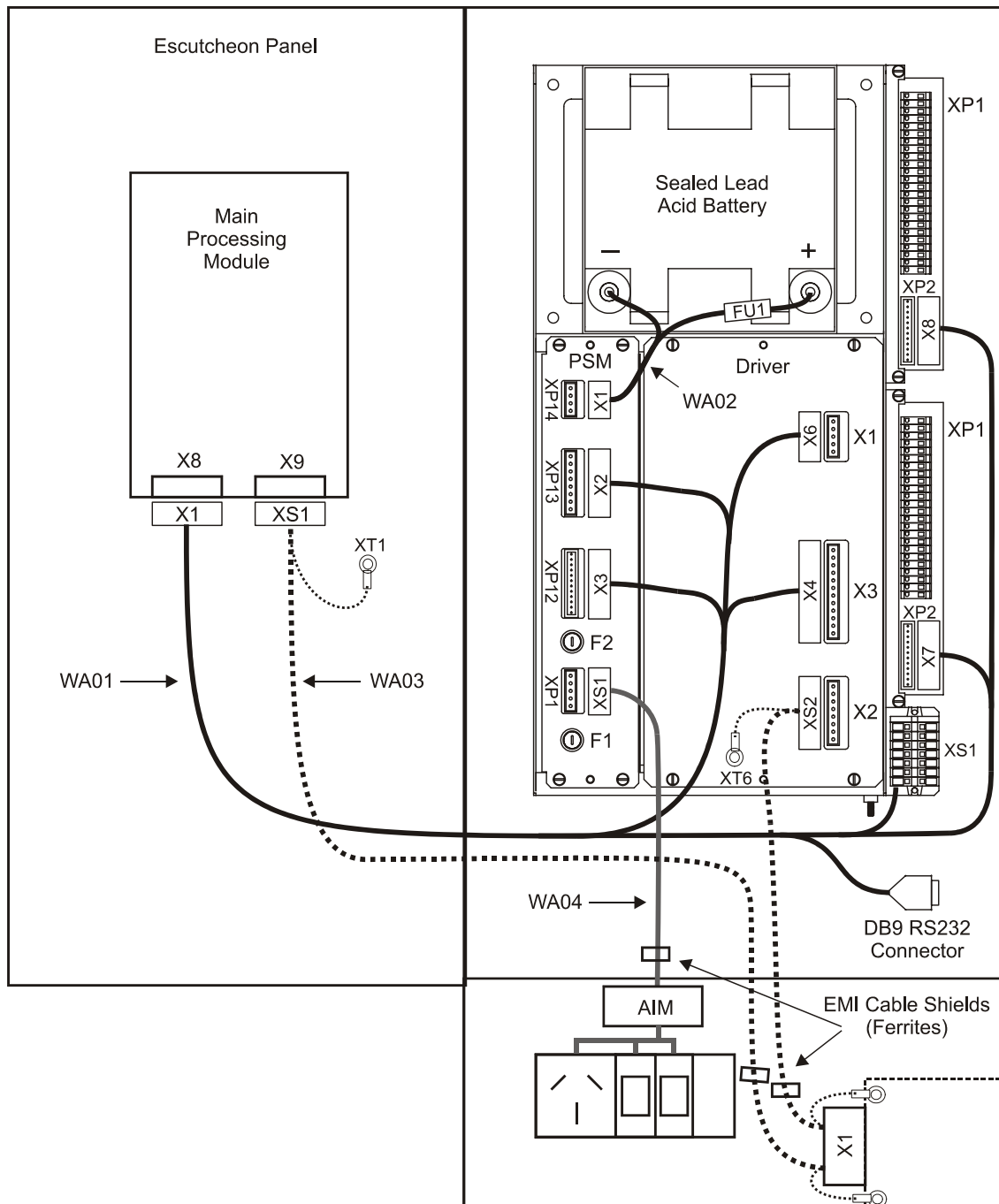
10.3 Troubleshooting

This section provides information to allow fault determination to a module level by a qualified, competent technician.

If problems are detected during normal service life the RC Malfunction events should be studied for a probable cause. Fault events for the OSM Recloser, Power Supply Module, Main Processing Module, I/O Module, UPS Module and driver module are indicated by specific events, refer section 10.3.2.

10.3.1 RC Cubicle

The diagram below identifies RC Cubicle Modules, Wiring Assemblies and connection points referenced in this chapter.

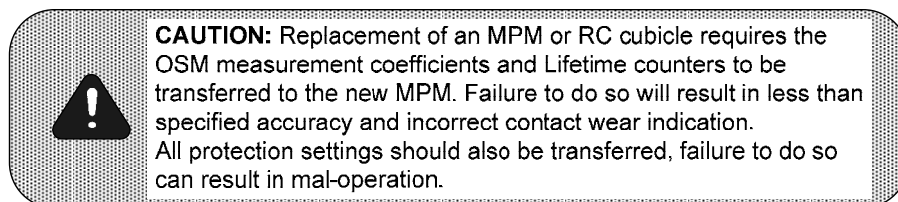


The first thing to determine is what information is available from the Main Processing Module.

1. Press the ON/OFF pushbutton on the MMI to view the 'SYSTEM STATUS' screen.
2. Select 'Warnings' from 'SYSTEM STATUS' and note all warning events with a recent time tag. Press 'ESC' to return to 'SYSTEM STATUS'
3. Select 'Malfunctions' from 'SYSTEM STATUS' and note all diagnostic events. Press 'ESC' to return to 'SYSTEM STATUS'
4. Select 'UPS' from 'SYSTEM STATUS' and note status of battery, AC supplies and ext load (if applicable).

Alternately, the same information can be accessed from the MPM using the PC based TELUS software. Once the information has been extracted refer to section 10.3.2.1 for an explanation of Warning events and section 10.3.2.2 for an explanation of Malfunction events.

Where tests point to an RC cubicle fault, it can be replaced and returned to a workshop environment for further diagnostic testing. Carrying out the Tests described in this chapter and in section 9.2 should allow faults to be traced to a module level.



10.3.1.1 MPM diagnostic check

If the MPM is not responding to MMI or TELUS software, proceed as follows:

1. Disconnect X3 from the PSM, disconnect X4 and X6 from the driver, disconnect X7 and X8 (if applicable) from the I/O Modules.
2. If the MPM now operates normally, proceed to step 8.
3. Measure voltage on PSM connector XP13, pins 5 to 7, measure voltage at battery terminals. Both should be in the range 10 to 16Vdc.
4. If battery voltage is below 10Vdc then it should be replaced, refer section 10.2.1.
5. If battery voltage is OK but XP13 output voltage is not, then the Power Supply Module fuses (F1 and F2) should be checked. If they are OK, the PSM should be replaced.
6. If both battery voltage and XP13 voltage are OK then the Main Processing Module should be replaced.
7. If this does not fix the problem then replace WA01
8. If the MPM works, reconnect X4 and X6 to the driver, if the LCD on the MPM goes blank then the Driver is defective and should be replaced.
9. If reconnecting the driver causes no problems, reconnect each I/O Module sequentially. If either causes the LCD to turn off then it should be replaced.

10.3.2 Diagnostic Events

The Main Processor Module provides diagnostic information in the form of Warning or Malfunction messages that can be viewed on the MMI, captured using TELUS software or transmitted over SCADA.

Each event provides information to assist in troubleshooting; the sections that follow contain detailed recommendations to use as a guide to assist in diagnosis.



WARNING: Where diagnosis indicates replacement of PSM, WA01 or WA04, the auxiliary supply must be isolated at the MCB. Failure to do so may result in death, personal injury or equipment damage.



CAUTION: Where diagnosis indicates replacement of the RC Cubicle or WA03, the auxiliary supply must be isolated and the control cable must be disconnected at the base of the RC cubicle (X1). Failure to do so can result in equipment damage.

10.3.2.1 Warning Events

Warning events are provided with a time stamp to allow a sequence of events to be determined, connector and other designations used in the table below are with reference to the diagram in section 10.3.1

Event	Description	Possible Cause	Recommended action
AC supply	UPS is set into AC supply mode, battery volts sustained below 10Vdc	1. Failed battery fuse 2. Disconnected battery 3. Flat Battery 4. Damaged battery 5. WA02 fault	1. Check battery fuse, FU1 2. Check battery connections 3. Provided battery voltage is in the range 2V to 10V and charging current is indicating positive, no action is necessary and the battery will charge with time. 4. If the battery voltage is less than 2V it should be replaced 5. If battery voltage is between 10.5 and 16V conduct a continuity check on WA02 (refer section 10.4.4) and replace if necessary.
Battery supply	UPS is set into Battery supply mode due to loss of AC supply.	1. Auxiliary supply interruption 2. Low Auxiliary supply 3. Incorrectly configured PSM 4. Failed PSM fuse 5. Damaged WA04 assembly 6. Damaged AIM	1. Check AC supply, ensure PSM XS1 is securely connected 2. Measure supply 3. Confirm PSM correctly configured for aux supply voltage 4. Check PSM fuses F1 and F2 5. Conduct a continuity check on WA04 (refer section 10.4.5) and replace if necessary. 6. Bypass AIM temporarily (refer section 10.4.5). Replace AIM if faulty.
Driver not ready	Driver is not ready to execute next control signal	1. Charging time has not expired 2. OSM Coil SC or OSM Coil Isolated 3. Driver module fault 4. PSM module fault	1. Wait for 1 minute to see whether warning disappears 2. Address the cause of the OSM coil problem 3. Replace Driver module 4. Replace PSM module
Memory error	Corrupted memory cell found	Memory cells have become corrupted due to excessive EMI	Download system and protection settings using TELUS software
Off state	UPS controller is set into Off state	Operator action	Not applicable

Event	Description	Possible Cause	Recommended action
OSM Coil Isolated	OSM coil open circuit detected	1. Mechanical trip mechanism is fully extended 2. XS2 plug is disconnected from Driver module 3. Wiring assembly WA03 fault 4. Control cable disconnected 5. Control Cable open circuit 6. OSM operating coil open circuit	1. Ensure mechanical trip ring is pushed fully home 2. Check XS2 connection 3. Disconnect control cable, if warning event disappears, conduct a continuity check on WA03 (refer section 10.4.2) and replace if necessary. 4. Ensure both ends of control cable are securely connected and latched. 5. Refer to section 10.4.1 to carry out a control cable continuity test 6. Replace OSM
Shutdown	UPS controller is set into Shutdown state	AC failure and Battery volts <10.2Vdc	Restore AC, replace battery if required.
Standby	UPS controller is set into Standby state	Activation of any control (MMI, PC, I/O or SCADA) while in Shutdown state.	Not applicable

10.3.2.2 Malfunction Events

The following table of events describes the malfunction events available from the RC control and what they indicate. It also suggest steps to follow to assist in determining why the event was generated, connector and other designations used in the table below are with reference to the diagram in section 10.3.1.

Event	Description	Possible Cause	Recommended action
Bus Comms Error	Data error between modules	1. IOM fault 2. Wiring assembly WA01 fault 3. PSM Fault 4. MPM Fault	1. Disconnect IOMX7 (X8), if disconnection causes the event to clear, replace the faulty IOM 2. Disconnect PSM X3, if the event does not clear, conduct a continuity check on WA01 (refer section 10.4.3) and replace if necessary. 3. If the event does clear on disconnection of PSM X3, replace PSM 4. Replace MPM
Driver comms error	No response from driver	1. X1 or X3 is disconnected from Driver module 2. Wiring assembly WA01 fault 3. Driver fault 4. PSM Fault 5. MPM fault	1. Check driver module connections X1 and X3 2. If damage is evident on visual inspection, conduct a continuity check on WA01 (refer section 10.4.3) and replace if necessary. 3. Replace Driver module 4. Replace PSM 5. Replace MPM
Driver SC	Driver short circuit found	1. Short circuit in wiring assembly WA01 2. Internal short circuit in driver module 3. PSM Fault	1. Conduct a continuity check on WA01 (refer section 10.4.3) and replace if necessary. 2. Replace driver module 3. Replace PSM

Event	Description	Possible Cause	Recommended action
Excessive T_c	Contact Closing time (including driver registration time) exceeds 100ms Excessive T_c is reset when the OSM is opened.	1. Driver not ready 2. Short circuit in wiring assembly WA01 3. Open circuit in WA03 wiring assembly	1. Refer Warning event, section 10.3.2.1 2. If the OSM has opened (Exc T_o) or closed (Exc T_c) then check continuity across Control Cable X1 connector pins 5 and 7 to determine whether the auxiliary switch within the OSM is operating. If OK, then conduct a continuity check on WA01 (refer section 10.4.3) and replace if necessary.
Excessive T_o	Contact Opening time (including driver registration time) exceeds 60ms Excessive T_o signal is deactivated when the OSM is closed.	4. Short (Exc T_c) or Open (Exc T_o) circuit in control cable 5. OSM auxiliary switch fault 6. OSM mechanism fault	3. Conduct a continuity check on WA03 (refer section 10.4.2) and replace if necessary. 4. Test control cable by substitution or continuity test, refer section 10.4.1 for a control cable schematic 5 or 6. If the above indicates a problem within the OSM, it should be replaced
Ext Load SC	Short circuit detected on the external power supply terminals of the RS-485 connector.	1. PSM fault 2. Communications device fault 3. Communications wiring fault	1. Disconnect wiring at the RS-485 interface, connection XS1. If the ext load is still unable to be turned on, replace the PSM. 2. If the ext load is able to be turned on check wiring by continuity test. 3. If wiring OK replace comms equipment.
I/O 1 Comms error I/O 2 Comms error	No communications with identified I/O module.	1. IOM1 (IOM2) is not installed 2. WA01 X7 (X8) is disconnected 3. PSM X3 plug is disconnected 4. WA01 fault 5. IOM (IOM2) fault	1. Install IOM if required 2. Check WA01 connection 3. Check PSM X3 plug connection 4. If damage is evident on visual inspection, replace WA01 5. Replace IOM
I/O 1 Fault I/O 2 Fault	Internal Fault detected in identified I/O module.	I/O Module	Replace identified I/O Module
MPM fault	Fault detected within Main Processing Module	MPM	Replace Main Processing Module
OSM coil SC	OSM coil short circuit found	1. WA03 short circuit 2. Control cable short circuit 3. OSM operating coil short circuit	1. Disconnect control cable from RC X1, if event is not cleared then WA03 should be replaced. 2. Disconnect control cable from OSM, if event is not cleared then the control cable is faulty. 3. If the above indicates an OSM fault, replace OSM
PSM comms error	No response from PSM	1. PSM X3 plug is disconnected 2. WA01 fault 3. PSM fault	1. Check PSM X3 plug connection 2. Conduct a continuity check on WA01 (refer section 10.4.3) and replace if necessary. 3. Replace PSM
T_{Bt} sensor fault	Battery temperature sensor fault detected	1. WA02 X1 is disconnected 2. Faulty battery temperature sensor	1. Check plug X1 is connected 2. Replace battery temperature sensor
T_{mpm} comms error	No response from MPM temperature sensor	MPM	Replace Main Processing Module
RTC comms error	No response from real time clock	MPM	Replace Main Processing Module

10.3.2.3 Communications

Refer to section 9.2.3 for a procedure to check the health of the I/O Modules.

RS-485 and RS-232 communications can be checked by monitoring signals at their terminals. If signals are not within the expected range, check the wiring from MPM to the port, refer schematic on section 10.4.3. If no wiring fault can be found then replace the Main Processing Module.

10.3.3 OSM Recloser

Where an OSM fault is suspected it should be confirmed by substituting a second RC cubicle and control cable. If the fault reoccurs the OSM should be taken to a workshop for further diagnostic testing.



CAUTION: Replacement of an OSM Recloser requires the measurement coefficients for the new OSM to be transferred to the RC cubicle. Failure to do so will result in less than specified measurement accuracy.

Carrying out testing as described in section 9.2.5 and 9.3.2 should allow the fault to be located.

10.3.3.1 OSM Output Signals

Output signals from Rogowski sensors and Capacitive Voltage sensors are not easily confirmed in the field. The most effective way to test that these sensors are operating correctly is through substitution.

Where a current or voltage indication appears to be in error, use a different RC cubicle to see whether it reports the same problem. If the new RC is correctly programmed with the OSM measurement coefficients and displays the same errors as the old one then the OSM should be replaced.

10.3.3.2 OSM Actuator Coil Resistance Testing

The actuator coil resistance can be measured on pins 1 and 3 of the control cable if a malfunction is suspected. The resistance measured should be 15 ohms +/-2ohms.

10.3.3.3 OSM Current Sensor Resistance Testing

The current sensors can be measured from the control cable pins as follows:

- I(n) – Pins 17 and 21 – 195 ohms +/-10 ohms
- I(a) – Pins 10 and 14 – 66 ohms +/-3 ohms
- I(b) – Pins 11 and 15 – 66 ohms +/-3 ohms
- I(c) – Pins 12 and 16 – 66 ohms +/-3 ohms

10.3.3.4 Microswitch Status Testing

The OSM recloser reports its position status to the RC Cubicle using microswitches. Their status is the opposite to the main contacts and are checked on the control cable pins 5 and 7:

- When OSM is Open – microswitch is closed
- When OSM is closed – microswitch is open

10.3.3.5 Contact Resistance Testing

Contact resistance across a closed VI should on each phase should be:

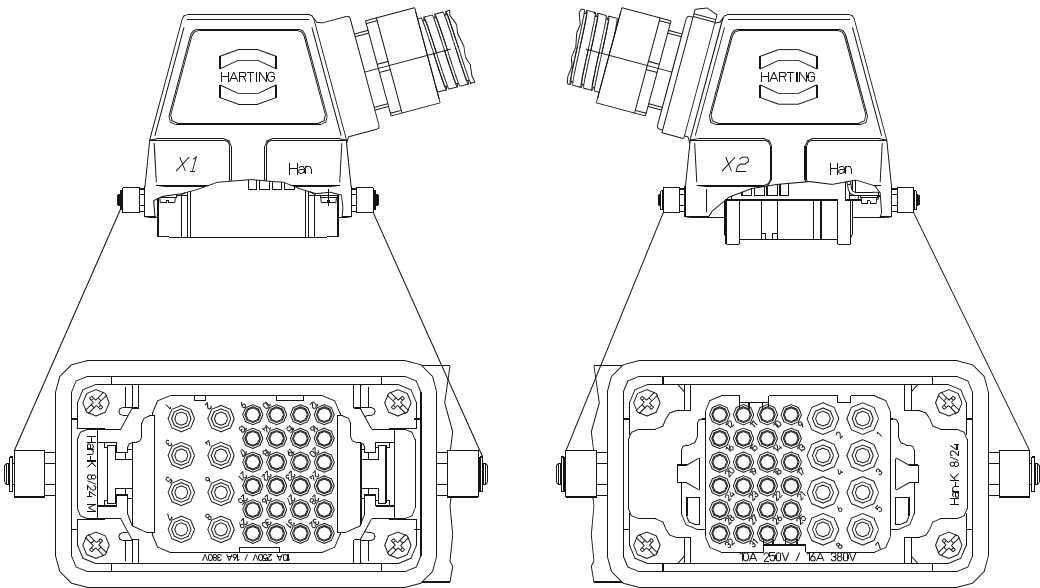
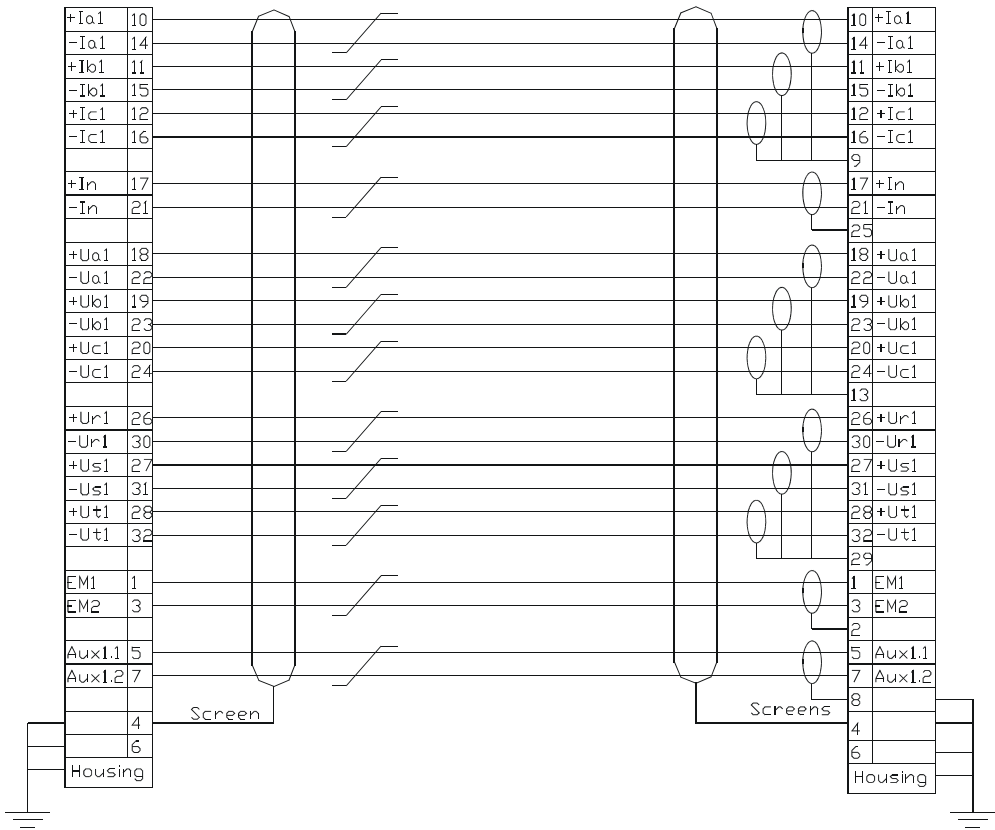
- OSM15 - 85 micro ohms or less
- OSM27 – 95 micro ohms or less

10.4 Schematics

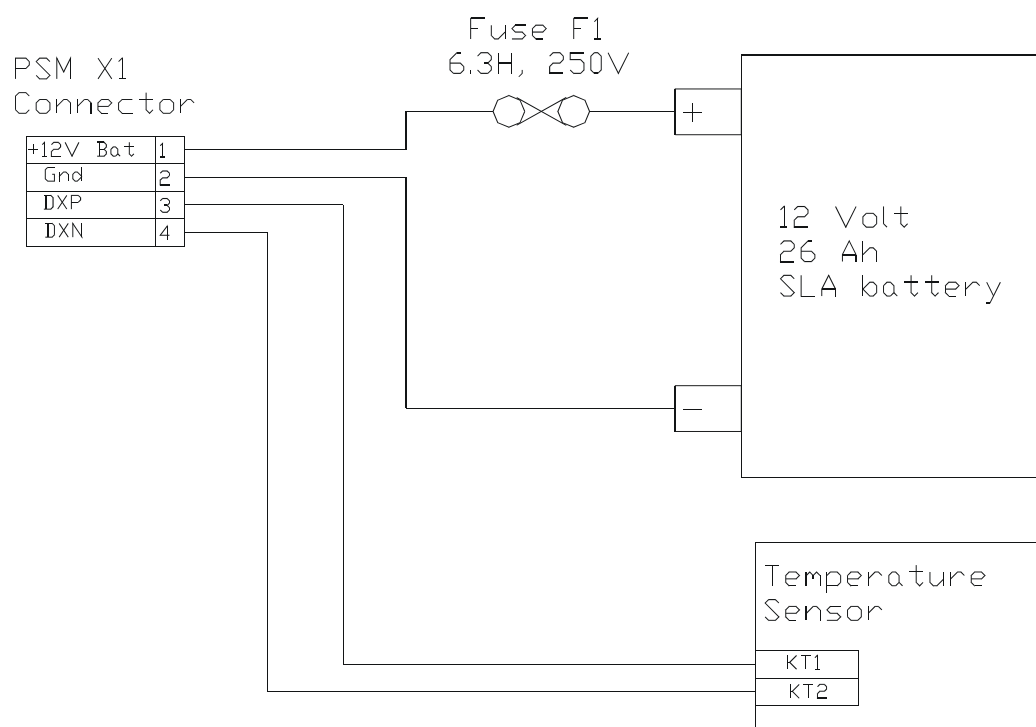
10.4.1 Control Cable

X1 Male Connector
Connection to OSM Recloser

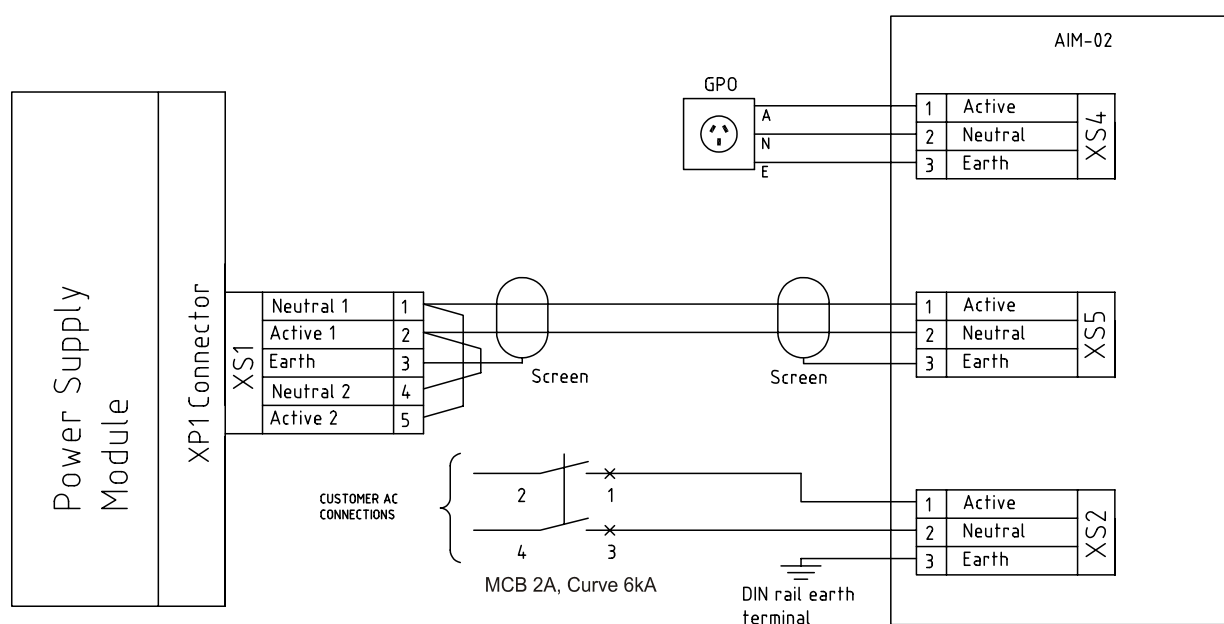
X2 Female Connector
Connection to RC Cubicle



10.4.4 Battery Wiring Assembly (WA02)



10.4.5 Auxiliary Supply Wiring Assembly (WA04)



10.4.8 TELUS Communications Cable

PC End
DB9 Female

MMI End
DB9 Female

Rx	2		Tx	3
Tx	3		Rx	2
Gnd	5		Gnd	5
RTS	7			
CTS	8			
DCD	1			
DTR	4			
DSR	6			

10.5 Spare Parts List

Description	Part Number
Battery, Sealed Lead Acid Genesis 12V26AhEPX / Century PS12240	BAT-01 / BAT-02
Driver Module	DRV12-01
Control Cable, 7 metres long	CC07-01
Input / Output Module 12 – 60V input 100 – 250V input	IOM12/60-01 IOM100/250-01
Main Processor Module	MPM-03E
OSM15-079 Pole Mounting Bracket	OMB-01
OSM15-200 Pole Mounting Bracket	OMB-04
OSM27-203 Pole Mounting Bracket	OMB-03
OSM15-079 Front Surge Arrestor Bracket	SAB15-01
OSM15-079 Rear Surge Arrestor Bracket	SAB15-02
Power Supply Module	PSM12-01
Substation Mounting Frame	SMF-01
Phase to Phase Voltage Transformer (auxiliary supply) 11kV primary, 220V secondary 22kV primary, 220V secondary	VT11/220-01 VT22/220-02
Voltage Transformer Mounting Bracket 11Kv	VTMB-01
Voltage Transformer Mounting Bracket 22Kv	VTMB-03
Wiring Assembly (RC Cubicle) RC Main RC Battery RC Control RC Auxiliary Supply	WA01-01 WA02-01 WA03-01 WA04-01
AC Input Module (AIM)	AIM-02

11 Appendices

11.1 Appendix A – Protection Element Structure

Element designation	Description
PROT	Protection element
Group1	Protection Group 1
Group2	Protection Group 2
Group3	Protection Group 3
Group4	Protection Group 4
OCEF	Phase and earth overcurrent element
OC	Phase overcurrent element
OC1+	Low set time delayed phase overcurrent element attributed with forward power flow
OC2+	Low set phase overcurrent element attributed with forward power flow
OC3+	High set instantaneous phase overcurrent element attributed with forward power flow
OC1-	Low set time delayed phase overcurrent element attributed with reverse power flow
OC2-	Low set phase overcurrent element attributed with reverse power flow
OC3-	High set instantaneous phase overcurrent element attributed with reverse power flow
DE OC	Phase overcurrent directional element
EF	Earth overcurrent element
EF1+	Low set time delayed earth overcurrent element attributed with forward power flow
EF2+	Low set earth overcurrent element attributed with forward power flow
EF3+	High set instantaneous earth overcurrent element attributed with forward power flow
EF1-	Low set time delayed earth overcurrent element attributed with reverse power flow
EF2-	Low set earth overcurrent element attributed with reverse power flow
EF3-	High set instantaneous earth element attributed with reverse power flow
DE EF	Earth overcurrent directional element
CLP	Cold load pickup element
IR	Inrush restraint element
AR OCEF	Phase and earth overcurrent reclosing element
TTA	Temporary time adder
SEF	Sensitive earth fault element
SEF+	Sensitive earth fault element attributed with forward power flow
SEF-	Sensitive earth fault element attributed with reverse power flow
AR SEF	Sensitive earth fault reclosing element
DE SEF	Sensitive earth fault directional element
LL	Live line overcurrent element
OCLL	Live line phase overcurrent element
EFL	Live line earth overcurrent element
UV	Undervoltage element
UV1	Phase undervoltage balanced element
UV2	Line to line undervoltage element
UV3	Loss of supply element
AR UV	Undervoltage reclosing element
UF	Underfrequency load shed element
ABR	Automatic backfeed restoration element
LSD	Loss of supply detector
Uabc<	Loss of voltage detector related to ABC HV terminals
Urst<	Loss of voltage detector related to RST HV terminals
Iabc<	Loss of current detector
VRC	Voltage reclosing control element
Uabc>	Voltage restoration detector related to ABC HV terminals
Urst>	Voltage restoration detector related to RST HV terminals
PSC	Protection status control element

Note: Each individual protection Group 1 to 3 has the same functional structure as Group 4.

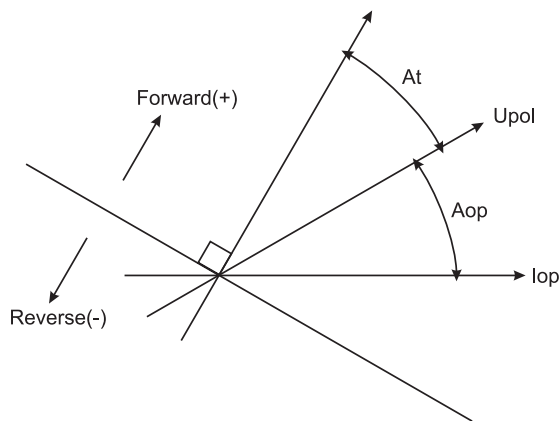
11.2 Appendix B – Directional Protection

11.2.1 Overcurrent directional elements (DE OC, DE EF and DE SEF)

NOJA's directional protection uses symmetrical components to provide polarising voltage and operating current for calculation of the operating angle associated with directional protection. Which symmetrical components are used depends on the element in question, DE OC, DE EF or DE SEF.

The phase overcurrent directional element (DE OC) uses positive sequence voltage as the polarising voltage and positive sequence current as the operating current.

The Earth Fault (DE EF) and Sensitive Earth Fault (DE SEF) elements use zero sequence voltage as the polarising voltage and zero sequence current as the operating current.



In general, a directional element operates as illustrated in the diagram.

where: U_{pol} polarising voltage
 I_{op} operating current
 A_{op} phase angle between U_{pol} and current I_{op}
 A_t preset torque angle

Depending upon the derived operating angle, the relevant directional element selects states as follows:

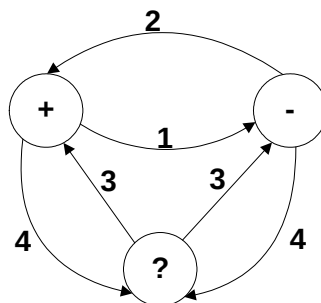
- + A_{op} is within $A_t \pm 90^\circ$,
- A_{op} is outside $A_t \pm 90^\circ$.
- ? U_{pol} or I_{op} is too low to provide polarisation ($U_{pol} \leq 0.5kV$, $I_1 \leq 10A$, $I_0 \leq 3A$).

Note: I_1 is the current level for DE OC while I_0 is for DE EF and DE SEF.

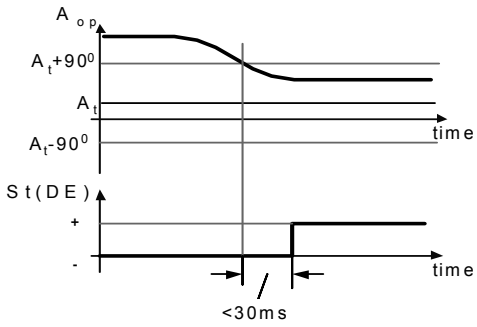
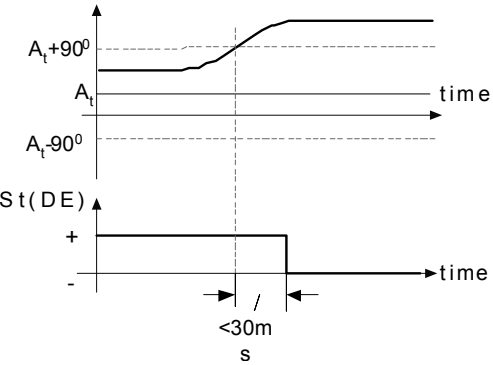
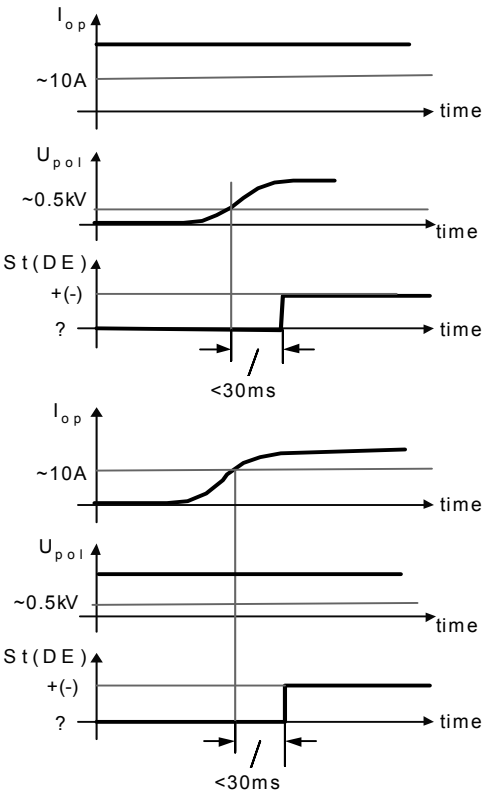
where states are defined as:

- + forward fault direction; the directional element activates a blocking output for reverse protection elements enabled for directional control.
- reverse fault direction; the directional element activates a blocking output for forward direction protection elements enabled for directional control
- ? undetermined fault direction; the directional element activates a blocking output for all protection elements enabled for directional control.

Operation of the Directional Element is illustrated in the state diagram below. Transitions 1 - 4 are illustrated on the following pages.



The following operation diagrams describe transition conditions 1 – 4.

Transition	Operation diagram	Description
1		Power flow direction changes from reverse to forward
2		Power flow direction changes from forward to reverse
3	or 	Polarization

4	or Notes 1. during the 3 cycles DE uses remembered voltage or current for polarization 2. if a pickup related to any element enabled for directional control is detected within 3 cycles of voltage dropping below 0.5kV, depolarization cannot proceed until the pickup is reset. This avoids depolarization of DE during close short circuit faults.	Depolarization
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11.3 Appendix C – Time Current Characteristic (TCC) Curves

11.3.1 ANSI TCC

ANSI TCC's are described by the following general equation:

$$T_t = \left(\frac{A}{\left(\frac{I}{I_p} \right)^p - 1} + B \right) * TM$$

where:

A, B, p	constants
TM	time multiplier
I_p	pickup current
T_t	tripping time
I	fault current

The ANSI TCC programmable within the RC Cubicle are defined by the parameters in the following Table, as applied to the above equation.

For currents below 6kA the ANSI TCC programmable within the RC cubicle are defined by the parameters in the following Table, as applied to the above equation.

For currents above 6kA, the time to trip is a constant time defined by the above equation with $I=6kA$ and the appropriate parameters from the table below.

TCC type	Designation	A	B	D	p
Extremely Inverse	EI	6.407	0.025	3	2.0
Very Inverse	VI	2.855	0.0712	1.346	2.0
Inverse	I	0.0086	0.0185	0.46	0.02
Short Time Inverse	STI	0.00172	0.0037	0.092	0.02
Short Time Extremely Inverse	STEI	1.281	0.005	0.6	2.0
Long Time Extremely Inverse	LTEI	64.07	0.250	30	2.0
Long Time Very Inverse	LTVI	28.55	0.712	13.46	2.0
Long Time Inverse	LTI	0.086	0.185	4.6	0.02

ANSI TCC's are provided with a disk emulating reset timer described by the following general equation:

$$T_{res}(I) = \frac{D}{1 - 0.998 * \left(\frac{I}{I_{min}} \right)}$$

where:

$T_{res}(I)$	reset time at given current I .
D	constant
I_{min}	minimum operating current;
I_{min}	$MIN * I_p * \max(OCLM \& OIRM)$,
and:	MIN minimum current multiplier
	$OCLM$ operational cold load multiplier
	$OIRM$ operational inrush restraint multiplier

11.3.2 IEC TCC

IEC TCC's are described by the following general equation:

$$T_t = \frac{A * TM}{\left(\frac{I}{I_p} \right)^p - 1}$$

where:

TM	time multiplier
A, p	constants
I_p	pickup current
T_t	tripping time
I	fault current

The IEC TCC programmable within the RC Cubicle are defined by the parameters in the following Table, as applied to the above equation.

For currents below 6kA the IEC TCC programmable within the RC cubicle are defined by the parameters in the following Table, as applied to the above equation.

For currents above 6kA, the time to trip is a constant time defined by the above equation with $I=6\text{kA}$ and the appropriate parameters from the table below.

TCC type	Designation	A	p
Extremely Inverse	EI	80	2.0
Very Inverse	VI	13.5	1.0
Inverse	I	0.14	0.02
Long Time Inverse	LTI	120	1.0

IEC TCC's have a user configured, definite time reset timer. Consequently the IEC TCC reset characteristic is independent of current.

11.3.3 User Defined Curves

11.3.3.1 Universal Inverse TCC (UD1)

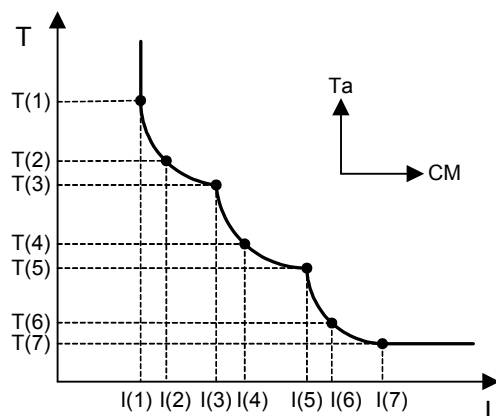
This TCC can be applied to the master OCEF elements (OC1+, OC1-, EF1+, EF1-) and consists of up to three sections, each described by the following equation:

$$T_t = \frac{T_m}{\left(\frac{I}{I_p}\right)^n - 1} + T_a \quad \text{where:}$$

T_m	time multiplier
T_t	time to trip at current I
I_p	pickup current
n	power function coefficient
T_a	additional time

Note that T_m , I_p , n apply to each section whereas T_a applies to the entire TCC.

A maximum of seven pairs of time-current coordinates describe UD1 as illustrated in the diagram below. The current coordinate of the first characteristic point (I_1) determines the minimum operating current ($I_{\min}$) and time coordinate of the last characteristic (T_7) point determines the minimum operating time.



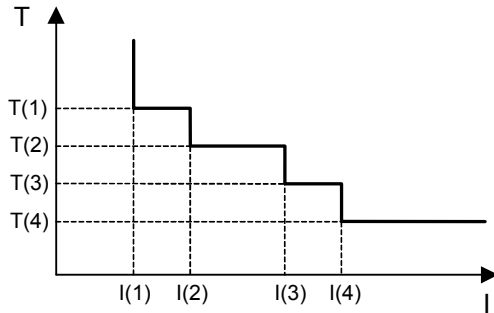
UD1 has a user configured, definite time reset timer. Consequently the reset characteristic is independent of current.

UD1 can be modified with the aid of curve modifiers in the form of a current multiplier (CM) and additional time (T_a). The effect of these modifiers is to move the entire curve, as indicated by the arrows in the diagram.

Note that setting (eg) $T_1 < T_3$ or $I_1 > I_3$ will automatically reduce the number of sections, and correspondingly, the number of characteristic points; similar for the other sections.

11.3.3.2 Universal Definite TCC (UD2)

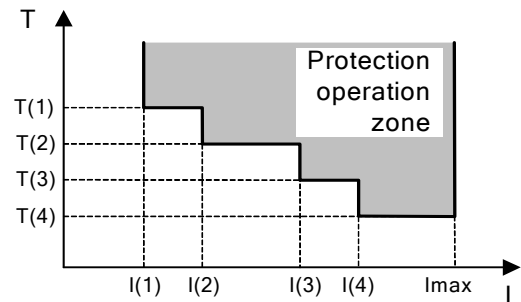
This TCC is applied to OCEF low set elements (OC2+, OC2-, EF2+, EF2-) and consists of a maximum of four definite time sections described by a maximum of four pairs of time-current coordinates as illustrated below left.



UD2 is equipped with a user configured, definite time reset timer. Consequently the reset characteristic is independent of current.

Maximum current modification is the only applicable curve modifier for this TCC and its effect on operation is illustrated in the diagram on the right.

Note: if I_{max} is less than or equal to $I(i)$, the i -th and subsequent sections are disabled.



11.4 Appendix D – RC-01ES ANSI Support

ANSI / IEEE standard C37.2, 1996 provides definition and application of function numbers for devices used in electrical substations, generating plants and in installations of power utilisation and conversion apparatus.

The table below links RC-01ES protection functions to the relevant ANSI device number.

ANSI Device Function Number	Definition	Comment
27	Undervoltage Relay A device that operates when its input voltage is less than a predetermined value.	RC-01ES can be set to operate on three variants of under voltage: UV1 - Phase under voltage operates in response to positive sequence voltage UV2 – Line to Line under voltage operates in response to a voltage drop across any two phases. UV3 – Loss of Supply under voltage operates in response to a loss of voltage on all six terminals and loss of current on all three phases.
50	Instantaneous Overcurrent Relay A device that operates with no intentional time delay when the current exceeds a preset value.	
50N	Instantaneous Overcurrent Relay (Neutral current)	Instantaneous Overcurrent applied to the neutral or residual current in a three phase system is differentiated as 50N. Residual current is sensed via Rogowski sensors on each phase connected in series.
51	AC Time Overcurrent Relay A device that functions when the ac input current exceeds a predetermined value, and in which the input current and operating time are inversely related through a substantial portion of the performance range.	
51N	AC Time Overcurrent Relay (Neutral Current)	AC time overcurrent applied to the neutral or residual current in a three phase system is differentiated as 51N. Residual current is sensed via Rogowski sensors on each phase connected in series. EF and SEF protection are provided, each with independent trip characteristics and reclose sequence settings.
67	AC Directional Overcurrent Relay A device that functions at a desired value of ac overcurrent flowing in a predetermined direction.	Positive sequence voltage is used as the reference (polarising voltage) for determining direction.

ANSI Device Function Number	Definition	Comment
67N	AC Directional Overcurrent Relay (Neutral Current)	AC directional overcurrent applied to the neutral or residual current in a three phase system is sometimes differentiated as 67N. Residual current is sensed via Rogowski sensors on each phase connected in series. Zero sequence voltage is used as the reference (polarising voltage) for determining direction. EF and SEF directional protection is provided.
79	Reclosing Relay A device that controls the automatic reclosing and locking out of an ac circuit interrupter.	
81	Frequency Relay A device that responds to the frequency of an electrical quantity, operating when the frequency or rate of change of frequency exceeds or is less than a predetermined value.	Partially Supported The RC-01ES can be set to provide under frequency protection.
86	Lockout Relay A device that trips and maintains the associated equipment or devices inoperative until it is reset by an operator, either locally or remotely.	

11.5 Appendix E – Indication Signals

Indication Signals are generated by the Indication Signals Conditioner Element (ISC). The Indication Signals Conditioner derives signals applicable for indication from data generated by other elements.

It also provides diagnostic functions by monitoring operation of the Main Processing Module, internal communications and opening/closing times of the OSM. If any discrepancy in operation is detected, an indication signal is generated.

A complete list of indication signals available for use by SCADA and I/O is presented in the table below

Signal	Description
TYPE: GENERAL	
Lockout	All AR OCEF, AR SEF, AR SEF, ABR elements are set in the O1 state
Remote off	Control mode is set Local
AR initiated	Any of AR OCEF, AR SEF, AR UV or ABR elements set in one of O2, O3 or O4 states
Prot initiated	Logical OR of AR initiated and Pickup signals
TYPE: PICKUP	
Pickup	Pickup output of any of OC1+, OC2+, OC3+, OC1-, OC2-, OC3-, EF1+, EF2+, EF3+, EF1-, EF2-, EF3-, SEF+, SEF-, EFLL, OCLL, UF, UV1, UV2, UV3 elements activated
P(OC1+)	Pickup output of OC1+ activated
P(OC2+)	Pickup output of OC2+ activated
P(OC3+)	Pickup output of OC3+ activated
P(OC1-)	Pickup output of OC1- activated
P(OC2-)	Pickup output of OC2- activated
P(OC3-)	Pickup output of OC3- activated
P(EF1+)	Pickup output of EF1+ activated
P(EF2+)	Pickup output of EF2+ activated
P(EF3+)	Pickup output of EF3+ activated
P(EF1-)	Pickup output of EF1- activated
P(EF2-)	Pickup output of EF2- activated
P(EF3-)	Pickup output of EF3- activated
P(SEF+)	Pickup output of SEF+ activated
P(SEF-)	Pickup output of SEF- activated
P(OCLL)	Pickup output of OCLL activated
P(EFLL)	Pickup output of EFLL activated
P(UV1)	Pickup output of UV1 activated
P(UV2)	Pickup output of UV2 activated
P(UV3)	Pickup output of UV3 activated
P(UF)	Pickup output of UF activated
P(Uabc>)	Pickup output of Uabc> activated
P(Urst>)	Pickup output of Urst> activated
P(Uabc<)	Pickup output of Uabc< activated
P(Urst<)	Pickup output of Urst< activated
TYPE: OPEN	
Open	PS=0 irrespective to source
Open (Prot)	Open due to OC1+, OC2+, OC3+, OC1-, OC2-, OC3-, EF1+, EF2+, EF3+, EF1-, EF2-, EF3-, SEF+, SEF-, EFLL, OCLL, UF, UV1, UV2 or UV3 tripping
Open (OC1+)	Open due to OC1+ tripping
Open (OC2+)	Open due to OC2+ tripping
Open (OC3+)	Open due to OC3+ tripping
Open (OC1-)	Open due to OC1- tripping

Signal	Description
Open (OC2-)	Open due to OC2- tripping
Open (OC3-)	Open due to OC3- tripping
Open (EF1+)	Open due to EF1+ tripping
Open (EF2+)	Open due to EF2+ tripping
Open (EF3+)	Open due to EF3+ tripping
Open (EF1-)	Open due to EF1- tripping
Open (EF2-)	Open due to EF2- tripping
Open (EF3-)	Open due to EF3- tripping
Open (SEF+)	Open due to SEF+ tripping
Open (SEF-)	Open due to SEF- tripping
Open (OCLL)	Open due to OCLL tripping
Open (EFLL)	Open due to EFLL tripping
Open (UV1)	Open due to UV1 tripping
Open (UV2)	Open due to UV2 tripping
Open (UV3)	Open due to UV3 tripping
Open (UF)	Open due to UF tripping
Open (Remote)	Open due to SCADA or I/O control signal
Open (SCADA)	Open due to SCADA control signal
Open (I/O)	Open due to I/O control signal
Open (Local)	Open due to MMI, PC control signal or manual tripping
Open (MMI)	Open due to MMI control signal
Open (PC)	Open due to PC control signal
Open (Manual)	Open due to manual tripping (no origin discovered)
TYPE: ALARM	
Alarm	Alarm output of any of OC1+, OC2+, OC3+, OC1- , OC2- , OC3- , EF1+, EF2+, EF3+, EF1-, EF2- , EF3- , SEF+, SEF-, EFLL, OCLL, UF, UV1, UV2, UV3 elements activated
A(OC1+)	Alarm output of OC1+ activated
A(OC2+)	Alarm output of OC2+ activated
A(OC3+)	Alarm output of OC3+ activated
A(OC1-)	Alarm output of OC1- activated
A(OC2-)	Alarm output of OC2- activated
A(OC3-)	Alarm output of OC3- activated
A(EF1+)	Alarm output of EF1+ activated
A(EF2+)	Alarm output of EF2+ activated
A(EF3+)	Alarm output of EF3+ activated
A(EF1-)	Alarm output of EF1- activated
A(EF2-)	Alarm output of EF2- activated
A(EF3-)	Alarm output of EF3- activated
A(SEF+)	Alarm output of SEF+ activated
A(SEF-)	Alarm output of SEF- activated
A(UV1)	Alarm output of UV1 activated
A(UV2)	Alarm output of UV2 activated
A(UF)	Alarm output of UV3 activated
A (F<)	Alarm output of UF activated
TYPE: CLOSED	
Closed	PS=1 irrespective to origin
Closed (AR)	Closed due to AR OCEF, AR SEF, AR UV, ABR control signal
Closed (AR OCEF)	Closed due to AR OCEF reclosing

Signal	Description
Closed (AR SEF)	Closed due to AR SEF reclosing
Closed (AR UV)	Closed due to AR UV reclosing
Closed (ABR)	Closed due to ABR closing
Closed (Remote)	Closed due to SCADA or I/O control signal
Closed (SCADA)	Closed due to SCADA control signal
Closed (I/O)	Closed due to I/O control signal
Closed (Local)	Closed due to MMI, PC control signal or undefined closed
Closed (MMI)	Closed due to MMI control signal
Closed (PC)	Close due to PC control signal
Closed (undef)	Source of close undefined, recognized after On (Power) or servicing
TYPE: STATUS	
Prot On	Protection is switched on
Group1 On	Active Group 1
Group2 On	Active Group 2
Group3 On	Active Group 3
Group4 On	Active Group 4
EF On	Earth overcurrent element is switched on
SEF On	Sensitive Earth fault element is switched on
UV On	Undervoltage element is switched on
UF On	Underfrequency element is switched on
CLP On	Cold load pickup element is switched on
LL On	Live line element is switched on
AR=On	OC/EF, UV, SEF reclosing and ABR are switched on
AR SEF Off	SEF reclosing is switched off
ABR On	Automatic backfeed restoration is switched on
Connection established	"CONNECT" string received from DCE or the DCD signal has changed state from low to high.
Connection completed	Hangup due to inactive timeout or received "NO CARRIER" string from DCE or the DCD signal has changed from high to low.
Dial-up initiated	Started dialling to master due to unsolicited response.
Dial-up failed	Failed to dial-in to master one time, using all 5 phone numbers.
TYPE: MALFUNCTION	
Malfunction	Any malfunction signal activated
Ext load SC	External load short circuit detected
Driver SC	Driver short circuit detected
T _{Bt} sensor fault	Battery Temperature sensor fault detected
OSM coil SC	OSM coil short circuit detected
Excessive T _o	Opening time (including driver registration time) exceeds 60ms: within 60ms after activation of T(E) control signal PS has been deactivated. "Excessive To) signal is deactivated when PS is deactivated or when C(E) control signal is activated.
Excessive T _c	Closing time (including driver recognition time) exceeds 100ms: within 100ms after activation of C(E) control signal PS has not been activated. "Excessive Tc" signal is deactivated when PS is activated or when T(E) control signal is activated.
MPM fault	Internal fault of main processing module detected
Driver comms error	No response from driver
UPS comms error	No response from UPS
RTC comms error	No response from real time clock
T _{mpm} comms error	No response from MPM temperature sensor
I/O1 comms error	No response from I/O1

Signal	Description
I/O2 comms error	No response from I/O2
I/O1 fault	I/O1 internal fault detected
I/O2 fault	I/O2 internal fault detected
DCE Error	DSR signal is low, CTS signal is low or receive "ERROR" string when commands are sent to DCE.
TYPE: WARNING	
Warning	Any warning signal activated
Standby	UPS controller set into Standby state
Off	UPS controller is set into Off state
Shutdown	UPS controller is set into Shutdown state
Battery supply	UPS is in Battery supply mode
AC supply	UPS is in AC supply mode
Driver not ready	Driver is not ready to execute next control signal
Memory error	Corrupted memory cell found
OSM coil isolated	OSM coil open circuit detected

11.6 Appendix F – Events

Event title		Relevant signal/parameter		Source of event	Critical parameter
		Title	Old value → New value		
Pickup	Start	P(E)	0→1	OC1+, OC2+, OC3+ OC1-, OC2-, OC3- EF1+, EF2+, EF3+ EF1-, EF2-, EF3- SEF+, SEF-, OCLL, EFLL, UF, UV1, UV2, UV3, Uabc<, Urst<, Uabc>, Urst>, LSD	lop and A,B or C phase for: OC1+, OC2+, OC3+, OC1-, OC2-, OC3-, OCLL I op for EF1+, EF2+, EF3+, EF1-, EF2-, EF3-, EFLL, SEF+, SEF- Up AB, BC or CA phase for UV2 Up for UV1, Uabc>, Urst> Fp for UF
	End	P(E)	1→0	OC1+, OC2+, OC3+ OC1-, OC2-, OC3- EF1+, EF2+, EF3+ EF1-, EF2-, EF3- SEF+, SEF-, OCLL, EFLL, UF, UV1, UV2, UV3, Uabc<, Urst<, Uabc>, Urst>, LSD	Maximum current registered during pickup duration and A. B or C phase for OC1+, OC2+, OC3+, OC1-, OC2-, OC3-, OCLL Maximum current registered during pickup duration for EF1+, EF2+, EF3+, EF1-, EF2-, EF3-, EFLL, SEF+, SEF- Maximum voltage registered during pickup duration for Uabc>, Urst> Minimum voltage registered during pickup duration for UV1 Minimum voltage registered during pickup duration and AB, BC or CA phase for UV2 Minimum frequency registered during pickup duration for UF
Timer freezing	Start	Input current	below I _{max} → above I _{max}	OC2+, OC2-	I _{max} and A, B or C phase for OC2+, OC2- I _{max} for EF2+, EF2-
	End	Input current	above I _{max} → below I _{max}	OC2+, OC2-, EF2+, EF2-	A, B or C phase for OC2+, OC2-
Alarm	N/A	A(E)	0→1	OC1+, OC2+, OC3+ OC1-, OC2-, OC3- EF1+, EF2+, EF3+ EF1-, EF2-, EF3- SEF+, SEF-, UF, UV1, UV2, UV3	lop and A,B or C phase for OC1+, OC2+, OC3+, OC1-, OC2-, OC3- lop for EF1+, EF2+, EF3+, EF1-, EF2-, EF3-, SEF+, SEF- Up for UV1 Up for AB, BC or CA phase for UV2 Fp for UF
Reset	N/A	N(E)	above 0→0	OC1+, OC2+, OC3+ OC1-, OC2-, OC3- EF1+, EF2+, EF3+ EF1-, EF2-, EF3- SEF+, SEF-, OCLL, EFLL, AR OCEF, AR SEF	A, B or C phase for OC1+, OC2+, OC3+, OC1-, OC2-, OC3-

Event title		Relevant signal/parameter		Source of event	Critical parameter
		Title	Old value → New value		
Trip	N/A	T(E)	0→1	OC1+, OC2+, OC3+, OC1-, OC2-, OC3-, EF1+, EF2+, EF3+, EF1-, EF2-, EF3-, SEF+, SEF-, OCLL, ELL, UF, UV1, UV2, UV3, MMI, PC, I/O, SCADA	R (trip to reclose) or L (Trip to lockout) and A,B or C phase for OC1+, OC2+, OC3+, OC1-, OC2-, OC3- R (trip to reclose) or L (Trip to lockout) selection for EF1+, EF2+, EF3+, EF1-, EF2-, EF3-, SEF+, SEF-, UV1, UV3 R (trip to reclose) or L (Trip to lockout) and AB, BC or CA phase for UV2
Close	N/A	C(E)	0→1	AR OCEF, AR SEF AR UV, ABR, MMI PC, I/O, SCADA	N/A
Time addition	N/A	Toat	0→Tat	RTA	Tta
Trec	start	N(CLP)	0→above 0	CLP	CLM
Trec	end	N(CLP)	below 1→1	CLP	N/A
Tocl	start	N(CLP)	Incrementing or stable → decrementing	CLP	OCLM
Tocl	end	N(CLP)	above 0→0	CLP	N/A
Toir	start	N(IR)	1→below 1	IR	OIRM
Toir	end	N(IR)	above 0→0	IR	N/A
AR initiation	N/A	St(E)	Any closed→O2/O3/O4	AR OCEF, AR SEF AR UV, ABR	Tr
ZSC	N/A	St(AR OCEF)	C1→C2, C2→C3, C3→C4	AR OCEF	N/A
Dir. control change	N/A	St(E)	Old→New	DE OC, DE EF, DE SEF	N/A
Closed	N/A	PS	0→1	Driver	N/A
Open	N/A	PS	1→0	Driver	N/A
Grp settings changed	N/A	Set(Grp1), Set(Grp2), Set(Grp3), Set(Grp4)	Old→New	MMI, PC, SCADA	N/A
System settings changed	N/A	Set(ME)	Old→New	MMI, PC, SCADA	N/A
Prot status change	N/A	Protection status	Old→New	MMI, PC, SCADA	List of protection elements being switched On
Remote control	Start	Control mode	Local → Remote	MMI	N/A
	End	Control mode	Remote → Local	MMI	N/A
RTC settings change	N/A	Set(RTC)	Old→New	MMI, PC, SCADA	N/A

Event title		Relevant signal/parameter		Source of event	Critical parameter
		Title	Old value → New value		
Ext. load Off	Start	S(Ext)	On→Off	MMI, PC, SCADA,UPS	N/A
	End	S(Ext)	Off→On	MMI, PC, SCADA,UPS	N/A
Off (Power)	N/A	Off(Power)	0→1	MMI, PC, I/O, SCADA	N/A
Battery Off	Start	Mode (Change)	Normal supply → AC supply	UPS	N/A
	End	Mode (Change)	AC supply → Normal supply	UPS	N/A
AC Off	Start	Mode (Change)	Normal supply → Battery supply	UPS	S(AC1),S(AC2)
	End	Mode (Change)	Battery supply → Normal supply	UPS	N/A
Shutdown	N/A	St(UPSC)	DS2→Shutdown	UPS	N/A
Data saving	Start	St(UPSC)	On→DS1 / DS2	UPS	N/A
	End	St(UPSC)	DS1→Off / DS2	UPS	N/A
Power Restart	N/A	St(UPSC)	Off→On Shutdown → On	UPS	N/A
Excessive To	Start	Excessive To	0→1	ISC	To
	End	Excessive To	1→0	ISC	N/A
Excessive Tc	Start	Excessive Tc	0→1	ISC	Tc
	End	Excessive Tc	1→0	ISC	N/A
Driver not ready	Start	Driver not ready	0 →1	Driver	N/A
	End	Driver not ready	1→0		
OSM coil SC	Start	OSM coil SC	0→1	Driver	N/A
	End	OSM coil SC	1→0	Driver	N/A
OSM coil isolated	Start	OSM Coil Isolated	0→1	Driver	N/A
	End	OSM Coil Isolated	1→0	Driver	N/A
Driver SC	Start	Driver SC	0→1	UPS	N/A
	End	Driver SC	1→0	UPS	N/A

Event title		Relevant signal/parameter		Source of event	Critical parameter
		Title	Old value → New value		
Ext. load SC	Start	Ext. load SC	0→1	UPS	N/A
	End	Ext. load SC	1→0	UPS	N/A
Connection established	Start	Connection established	DCD=0 → DCD = 1 or receive "CONNECT" string or receive valid frame	Comms	Unsol, remote
Connection completed	End	Connection completed	DCD=1 → DCD = 0 or receive "NO CARRIER" string or hang up modem	Comms	Inactive, DCD
Dial-up initiated	Start	Dial-up initiated	Unsol=0 → Unsol = 1	Comms	Unsol
Dial-up failed	End	Dial-up failed	Dialled all 5 phone numbers without connecting to a master	Comms	N/A
Tbt – sensor fault	Start	Tbt – sensor fault	0→1	UPS	N/A
	End	Tb – sensor fault	1→0	UPS	N/A
MPM fault	Start	MPM fault	0→1	ISC	N/A
	End	MPM fault	1→0	ISC	N/A
I/O1 fault	Start	I/O1 fault	0→1	I/O	N/A
	End	I/O1 fault	1→0	I/O	N/A
I/O2 fault	Start	I/O2 fault	0→1	I/O	N/A
	End	I/O2 fault	1→0	I/O	N/A
Memory error	Start	Memory error	0→1	ISC	N/A
	End	Memory error	1→0	ISC	N/A
Bus comms error	Start	Bus comms error	0→1	ISC	N/A
	End	Bus comms error	1→0	ISC	N/A
PSM comms error	Start	PSM comms error	0→1	ISC	N/A
	End	PSM comms error	1→0	ISC	N/A
Driver comms error	Start	Driver comms error	0→1	ISC	N/A
	End	Driver comms error	1→0	ISC	N/A

Event title		Relevant signal/parameter		Source of event	Critical parameter
		Title	Old value → New value		
I/O1 comms error	Start	I/O1 comms error	0→1	ISC	N/A
	End	I/O1 comms error	1→0	ISC	N/A
I/O2 comms error	Start	I/O2 comms error	0→1	ISC	N/A
	End	I/O2 comms error	1→0	ISC	N/A
Tpm comms error	Start	Tpm comms error	0→1	ISC	N/A
	End	Tpm comms error	1→0	ISC	N/A
RTC comms error	Start	RTC comms error	0→1	ISC	N/A
	End	RTC comms error	1→0	ISC	N/A
DCE Error	Start	DCE Error	DSR = 0 or CTS = 0 or "ERROR" string received on DCE commands	Comms	N/A
	End	DCE Error	DSR=0 → DSR=1 or CTS=0 → CTS=1 or receive "OK" string on DCE commands	Comms	N/A

11.7 Appendix G – Change Messages

Parameter	Old value	New value
GRP 1 (2; 3; 4) OC1+ (OC1-; EF1+; EF1-; OC2+; OC2-; EF2+; EF2-): TCC type	Old TCC type	New TCC type
GRP 1 (2; 3; 4) OC1+ (OC1-; EF1+; EF1-; OC2+; OC2-; EF2+; EF2-; OC3+; OC3-; EF3+; EF3-; SEF+; SEF-; OCLL; EFLL): Ip,A (Tt,s; TM; MIN; Tmin,s; Tmax,s; Ta,s; Tres,s; MAX; CM)	Old value	New value
GRP 1 (2; 3; 4) OC2+ (OC2-; EF2+; EF2-): MAX mode	Old mode	New mode
GRP 1 (2; 3; 4) DE OC (DE EF; DE SEF): At°	Old value	New value
GRP 1 (2; 3; 4) DE OC (DE EF; DE SEF): OC1+ (OC1-; EF1+; EF1-; OC2+; OC2-; EF2+; EF2-; OC3+; OC3-; EF3+; EF3-; SEF+; SEF-)	Old mode	New mode
GRP 1 (2; 3; 4) AR OCEF MAP (AR SEF MAP)	N/A	Changed
GRP 1 (2; 3; 4) AR OCEF (AR SEF): Tr1,s (Tr2,s; Tr3,s; Tres,s)	Old value	New value
GRP 1 (2; 3; 4) AR OCEF: ZSC mode	Old mode	New mode
GRP 1 (2; 3; 4) CLP: CLM (Tcl,min; Trec,min)	Old value	New value
GRP 1 (2; 3; 4) IR: IRM (Tir,s)	Old value	New value
GRP 1 (2; 3; 4) RTA: RTA mode	Old mode	New mode
GRP 1 (2; 3; 4) RTA: Tat,s	Old value	New value
GRP 1 (2; 3; 4) VRC: VRC mode	Old mode	New mode
GRP 1 (2; 3; 4) VRC: UM	Old value	New value
GRP 1 (2; 3; 4) ABR: ABR mode	Old mode	New mode
GRP 1 (2; 3; 4) ABR: UM	Old value	New value
GRP 1 (2; 3; 4) UV: UV1 UM (UV2 UM; UV1 Tt,s; UV2 Tt,s; UV3 Tt,s)	Old value	New value
GRP 1 (2; 3; 4) AR UV: UV1 mode (UV2, UV3)	Old mode	New mode
GRP 1 (2; 3; 4) AR UV: Tr,s	Old value	New value
GRP 1 (2; 3; 4) UF: UF mode	Old mode	New mode
GRP 1 (2; 3; 4) UF: Fp,HZ (Tt,s)	Old value	New value
PC SETTINGS: Baud rate	Old value	New value
SCADA SETTINGS: Comm Device (Protocol type)	Old type	New type
SCADA SETTINGS: SCADA time	Old value	New value
MODBUS SETTINGS: Slave addr	Old value	New value
DNP3 SETTINGS: Slave addr (Master addr, Unsolicited)	Old value	New value
PORT SETTINGS: Port type (Baud rate, Duplex type, Parity)	Old value	New value
ME SETTINGS: U _{rated} ,kV (F _{rated} ,Hz; Cla,V/kA; Clb,V/kA; Cic,V/kA; Cln,V/kA; CUa,V/kV; Cub,V/kV; CUc,V/kV; CUr,V/kV; Cus,V/kV; CUt,V/kV; OSM#)	Old value	New value
MMI SETTINGS: Prot On/Off (EF On/Off, SEF On/Off, AR On/Off, LL On/Off, Grp 1 – 4 On/Off)	Old mode	New mode
RTC SETTINGS: Date fmt (Time fmt)	Old format	New format
UPS SETTINGS: Shutdown level (C _{rated} , A*h; External load time, min)	Old value	New value
UPS SETTINGS: Tres _{ext} , hrs	Old value	New value
I/O SETTINGS: I/O1 mode (I/O2 mode)	Old mode	New mode
I/O1 (I/O2) O1 (O2; O3; O4; O5; O6) SETTINGS: Trec, s (Tres, s)	Old value	New value
I/O1 (I/O2) O1 (O2; O3; O4; O5; O6) SETTINGS: Indication signal	Old signal	New signal
I/O1 (I/O2) I1 (I2; I3; I4; I5; I6) SETTINGS: Control signal	Old signal	New signal
GRP1 (2; 3; 4) settings	N/A	Changed
System settings	N/A	Changed
Lifetime counters readings	N/A	Changed
Date/time	N/A	Changed
PROTECTION STATUS: Prot (Active group, LL, AR, OC, EF, SEF, UV, UF, ABR, CLP, AR SEF, AR OCEF)	Old status	New status
UPS STATUS: Ext. load status	Old status	New status
Control mode	Old mode	New mode
Energy meter readings	N/A	Erased
Fault counters readings	N/A	Erased
CO Operations	N/A	Erased
Event log	N/A	Erased
Load profile	N/A	Erased
Change messages	N/A	Erased
Password	N/A	Erased
Password	N/A	Changed

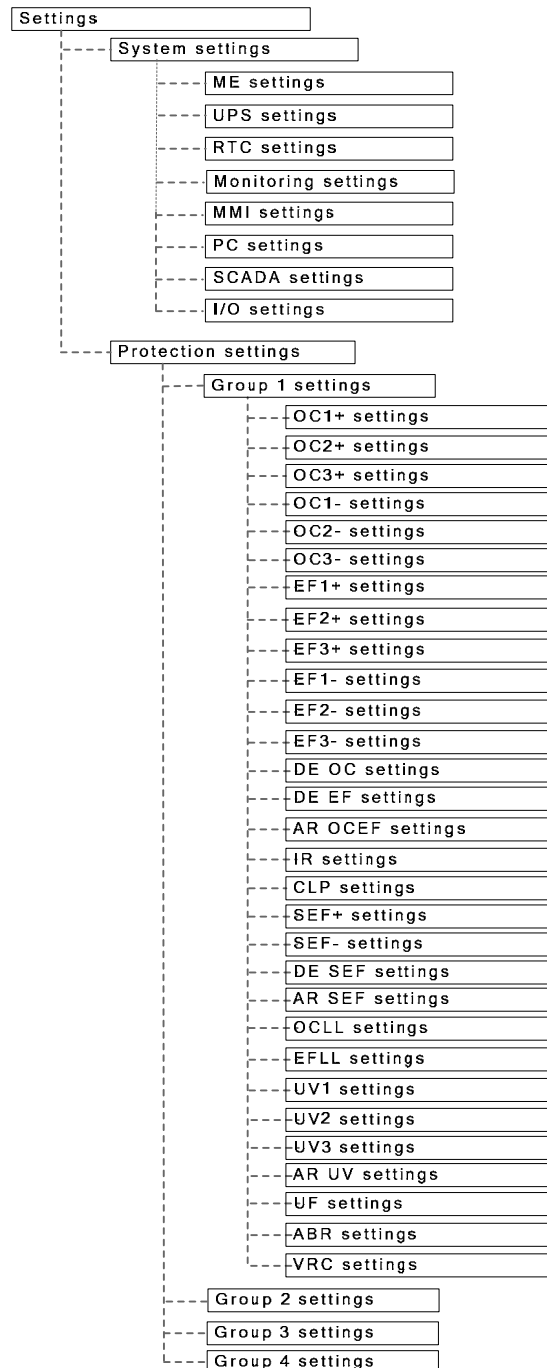
Notes: 1 for groups of parameters (AR maps, Group settings, System settings, Lifetime counters readings, Date/Time) old and new values are not shown in the record. Statement “NA” is used in place of Old value and statement “Changed” in place of a New one. Similarly, for erased data (Energy meter readings, Fault counters readings, CO Operations, Event log, Load profile and Change messages) Old and New values are not shown in the record. Statement “NA” is used in place of Old value and statement “Erased” instead of New one.

2 refer to the description of control and indication element for applicability of MMI, PC, SCADA and I/O for different control functions.

3 in the Table above capital letters represent a particular parameter example. Applicable alternative parameters are presented in parentheses.

11.8 Appendix H – Control and Indication of Settings

Control and Indication of Element settings are provided by the MMI and PC Control and Indication elements only. The structure of Control and Indication settings is illustrated below.



Notes:

Groups 1 to 4 have the same settings as shown for group 1

Within the Group 1 – 4 settings, the Group Names can only be assigned or edited using TELUS software

Within the OC and EF settings, User Defined 1 (UD1) characteristic points can only be assigned or edited using TELUS software

11.9 Appendix I – MMI Menu Layout

This appendix illustrates layout of the MMI menus and how to navigate within the menus to access information.

Each menu generally contains the following information:

- menu title;
- navigation symbols (“◀”, “▶”, “↕”, “↻”) indicating applicability of vertical or four directional scrolling respectively. Absence of these symbols means that scrolling is not applicable for a particular screen);
- permanent information which always exists and has the same appearance;
- transient information which appears only if relevant conditions are met;
- parameter values which always exist in the designated space but are generally different.

Permanent information, transient information and parameter values may be used for indication only or for transition to another menu. Parameter values may be subject to editing.

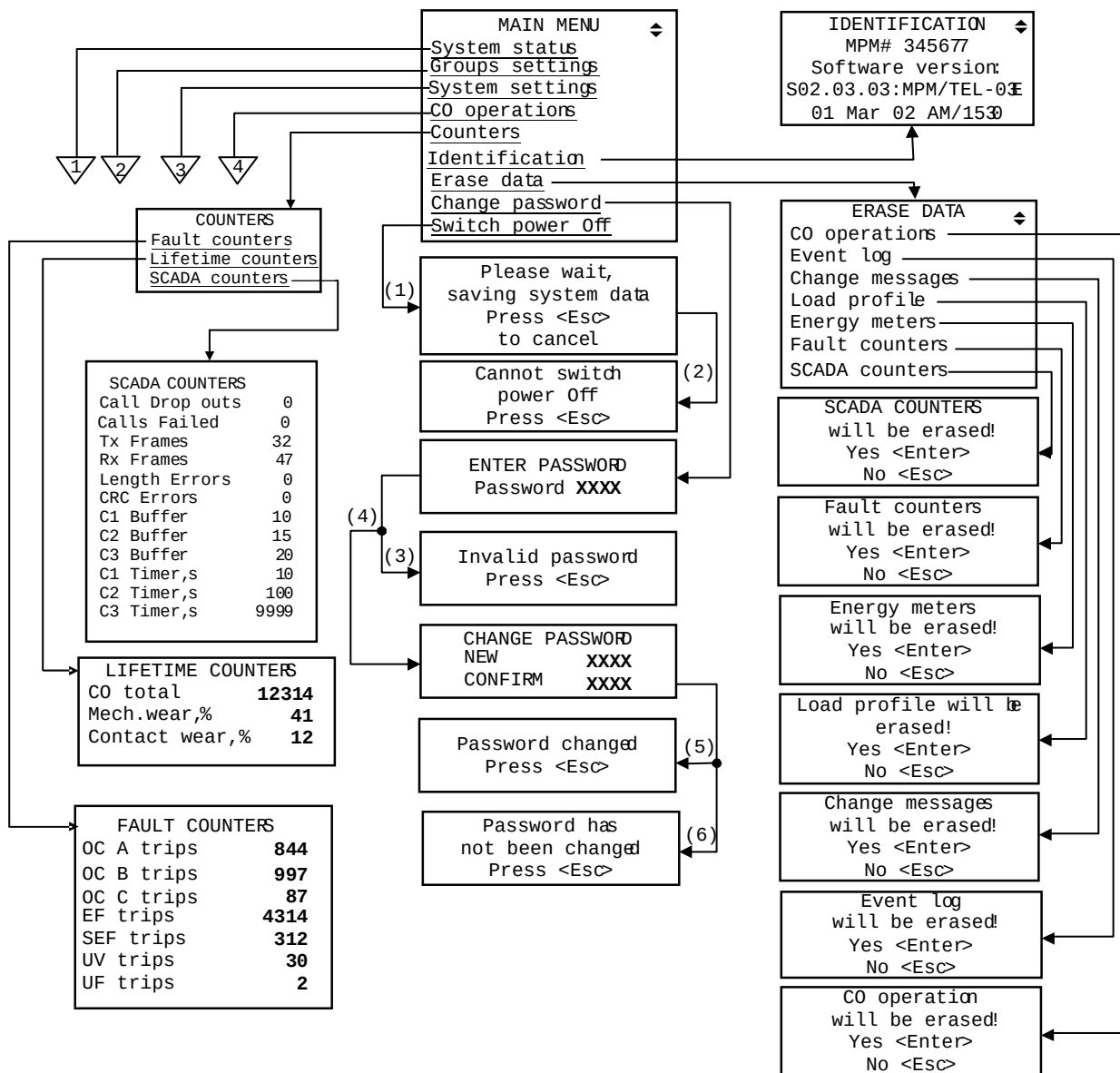
Permanent information is printed in normal type.

Transient information is printed in *italic* type.

Parameter values are printed in **bold** type.

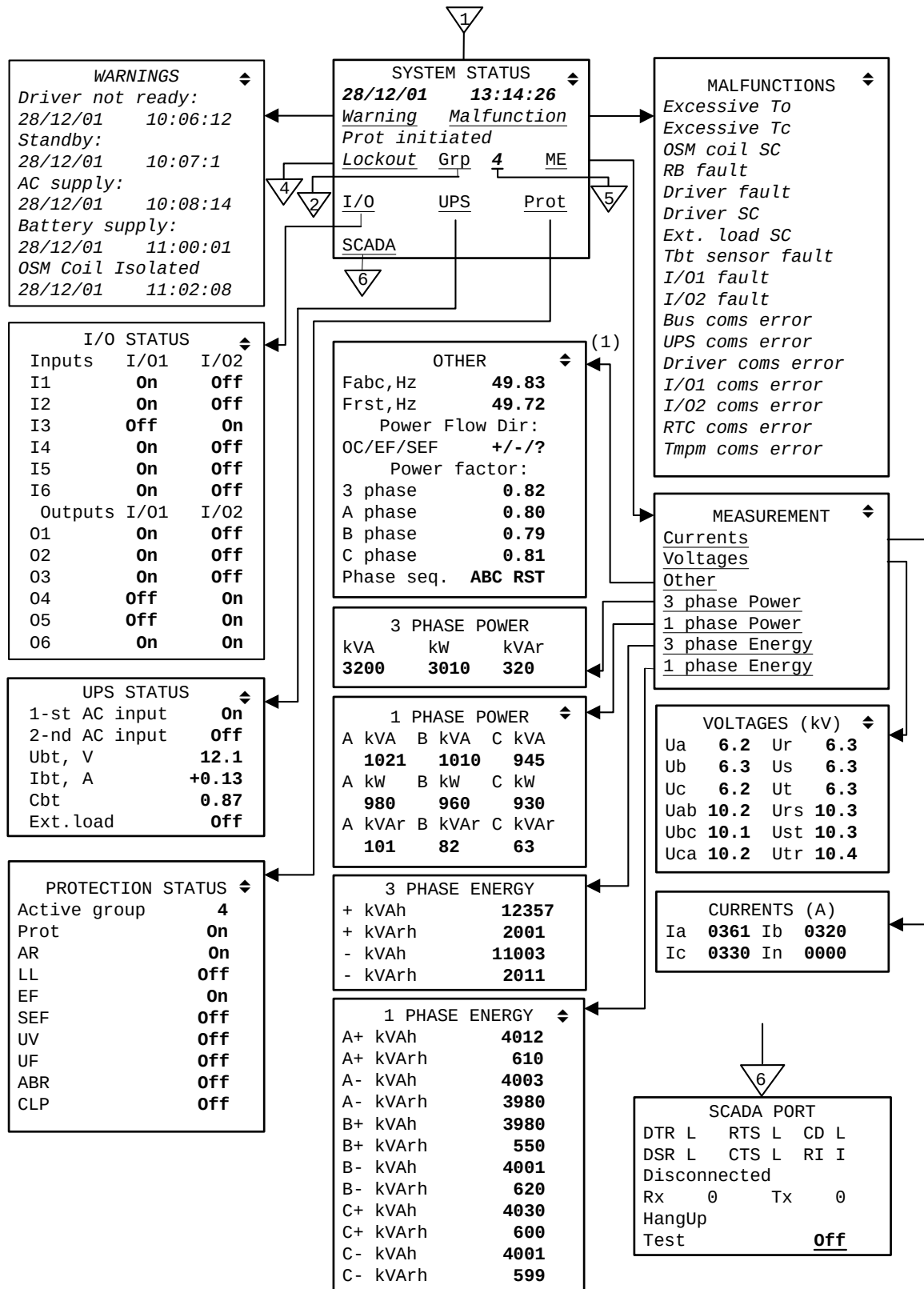
Active information (intended for transition to another menu or editing) is printed in underlined type. Where the information provides a transition to another menu, a transition arrow (→) is shown; pressing the ENTER pushbutton will transition to the next menu.

A transition to / from another page of the diagram is marked with  /  where n is the transition number

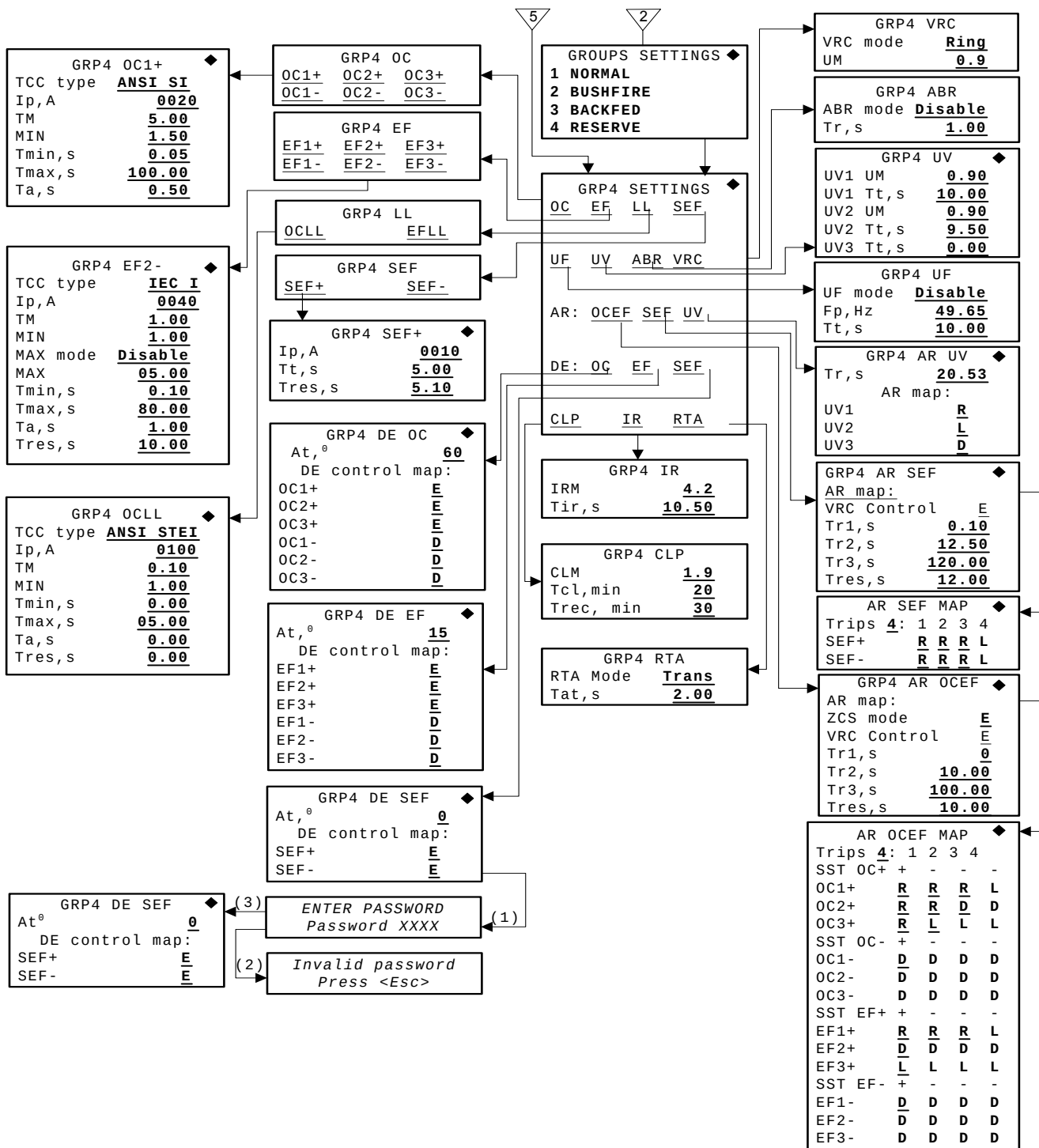


MAIN MENU, COUNTERS, IDENTIFICATION, ERASE DATA, CHANGE PASSWORD menus

- Notes:
- (1) This menu appears during the data saving process initiated by switching power Off.
 - (2) This menu appears when power cannot be switched off (eg due to UPS comms error).
 - (3) This menu appears when an incorrect password has been entered
 - (4) This menu appears when a correct password has been entered
 - (5) This menu appears when the password entered at NEW and CONFIRM are the same
 - (6) This menu appears when the password entered at NEW and CONFIRM are different.

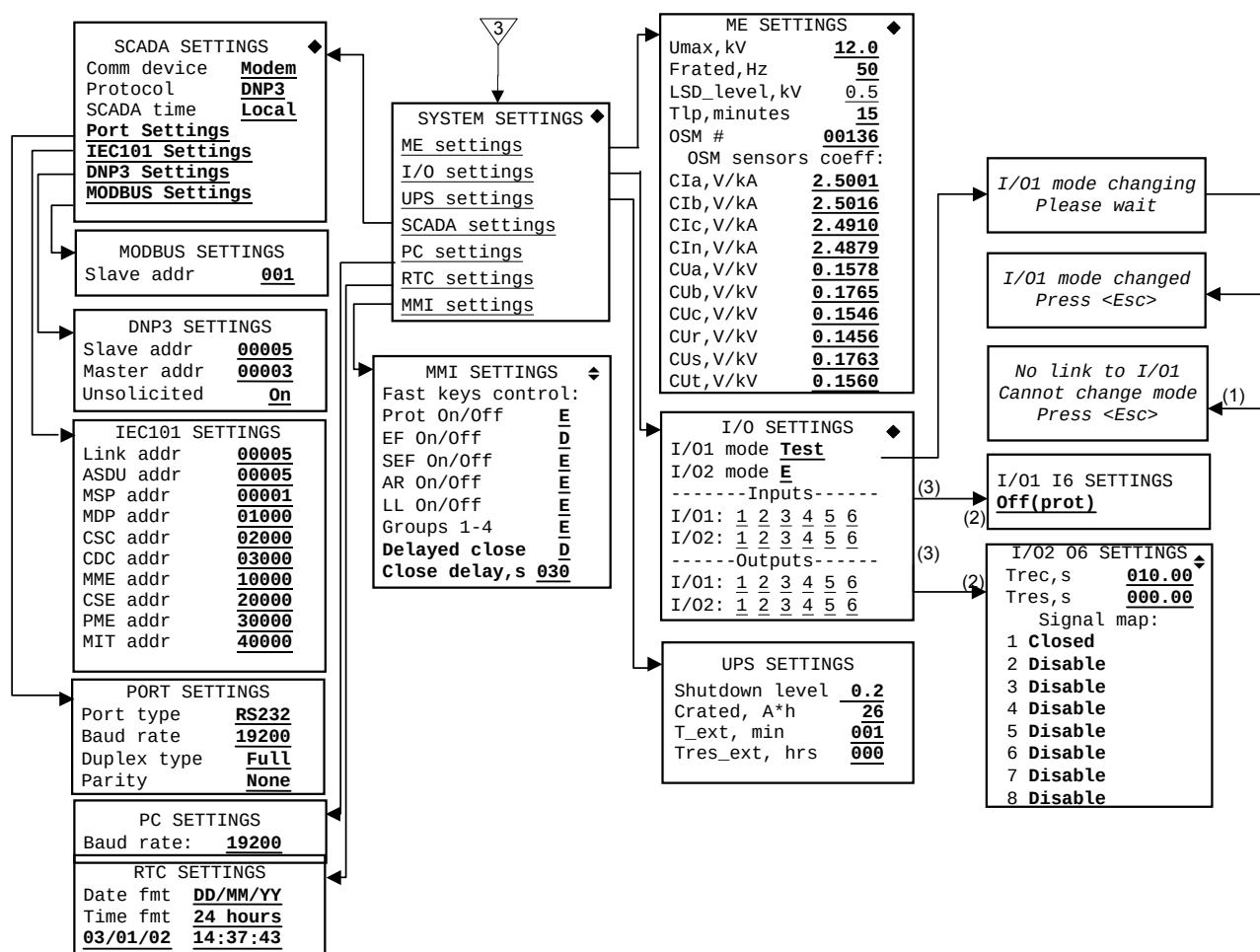
**SYSTEM STATUS menu**

Notes: (1) Power flow direction indication is based on the state readings of relevant directional elements (DE OC / DE EF / DE SEF). Refer to description of the elements for details.



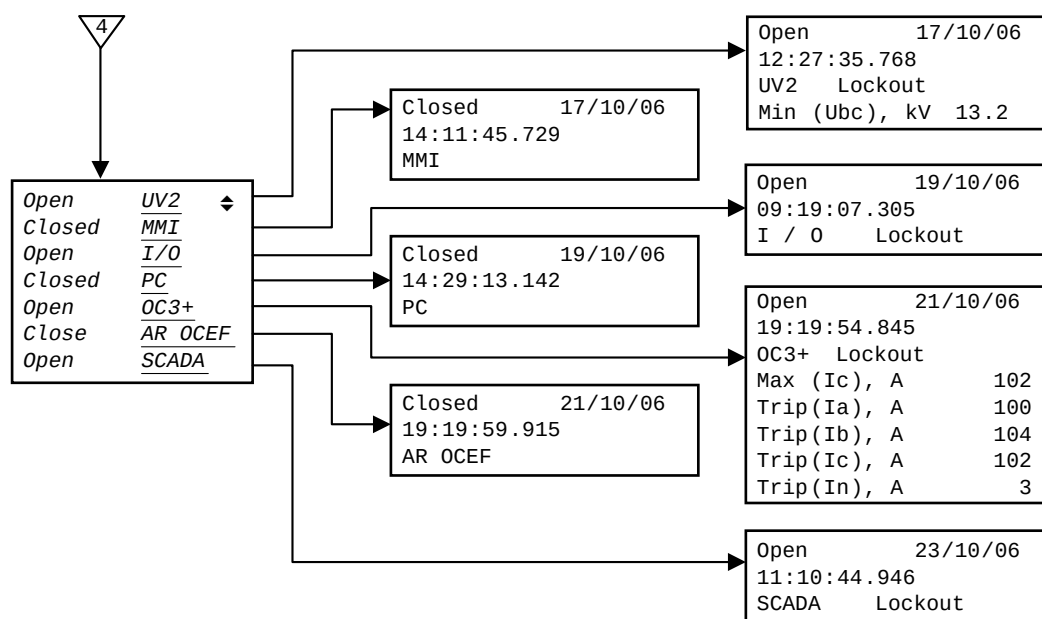
GROUP SETTINGS menu

- Notes: (1) This menu appears when user tries to edit password protected parameter
 (2) This menu appears when password has been entered
 (3) This menu appears when correct password has been entered



SYSTEM SETTINGS MENU

- Notes: (1) This menu appears when I/O comms error is discovered.
(2) These menus contain mapped control and indication signals
(3) A similar transition is possible through any digital input/output.



Close Open (CO) Operations menu

Index

A

Accuracy	
Measurement.....	5
Protection.....	6
Sensor	3
Altitude	3, 5
Auto Reclose	
Phase and Earth Overcurrent	37
Sensitive Earth Fault	41
Under Voltage.....	43
Automatic Backfeed Restoration	46
Auxiliary Supply.....	84
configuration.....	21
connector.....	21

B

Battery	8, 73
block diagram	15
Breaking Duty.....	4

C

Change Messages.....	49, 105
Close Open (CO) Operations	48
Cold Load Pickup	35
Communications	22
Contact Wear	73
Control Cable.....	64, 81
Control Mode.....	18
Counters.....	50
Creepage	13
cross section	
OSM.....	10
Cross Section	
OSM.....	10
Current Sensing	3, 13
Curve Modifiers.....	34

D

Date / Time	62
Diagnostic Events	76
Dimensions	
OSM.....	3, 11
RC Cubicle.....	5, 17
Directional Protection	88
Driver Module	15, 26

E

Earthing	11, 17, 69
EMC.....	7, 15
Event Log	49, 100

F

Fast Keys	19
-----------------	----

Fault profile	49
---------------------	----

H

Hazard Statements	2
Humidity	3
HV Arrestors.....	68
HV Terminals	13

I

Inrush Restraint.....	36
Installation	
OSM	68
RC Cubicle	69
IO Module.....	8
IO Modules.....	23
testing.....	63
wiring.....	23

L

LCD	17
LCD Control	18
Load profile	50
Local Control	18
Loss of Supply	44

M

Magnetic Actuator	9
Main Circuit Bushings	9
Main Processor Module.....	17
Maintenance.....	73
Malfunction Events.....	62, 78
Measurements	
current.....	65
voltage	67
Mechanical Trip.....	9, 13
MMI.....	17, 19, 107
Modem.....	14
Mounting Bracket	67
MPM.....	15, 17

O

Operator Interface	17
OSM 15 Terminal Stems	66
OSM Ratings	3
Overcurrent	
Directional	34
Earth	31
Live Line.....	42
Phase.....	31

P

Padlock	14
Password.....	62
Phase sequence	27

Position Indicator	13
Power Supply	7
Preparation	
OSM	66
RC Cubicle	60
Programming	66
Protection Status Control	46
PSM	15

R

Radio	14
Remote Control	18
Rogowski Sensor	13
RS232	24
RS485	15, 24, 85
RTU	14

S

Safety	1
Schematics	81
Security Cover	15
Sensitive Earth Fault	40
Settings	
Automatic Backfeed Restoration	46
Cold Load Pickup	36
Directional Overcurrent	35
Directional SEF	40
High Set element	33
Inrush Restraint	37
IO Modules	58
Live Line	42
Max current mode	33
Measurement	28
MMI	53
Phase and Earth Overcurrent	32
Protection Groups	30
Protection Status Control	46
Real Time Clock	29
Reclosing	38, 41, 44
TELUS	53
Temporary Time Addition	39
Under Frequency	44

Under Voltage	43
UPS	25
User Defined curves	33
Voltage Reclosing Control	45
Spare Parts	86
Specifications	
OSM	3
RC Cubicle	5

T

Taut String Clearance	13
TELUS Software	20
Temperature	3, 5
Temporary Time Addition	39
Testing	
High Voltage	66
RC and OSM	64
RC Cubicle	61
Time Current Characteristic (TCC) Curves	
ANSI	91
IEC	91
User Defined	92
Troubleshooting	75

U

Under Frequency	44
Under Voltage	42
Uninterruptible Power Supply	25

V

Voltage Reclosing Control	45
Voltage Sensing	3, 13

W

Warning Events	77
Weight	
OSM	3
RC Cubicle	5

Z

Zone Sequence Co-ordination	39
-----------------------------------	----

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