Reyrolle
Protection
Devices

7SG23 MSCDN – MP1

Capacitor Unbalance Protection

Answers for energy

SIEMENS

Contents

Technical Manual Chapters

MSCDN – MP1

Capacitor unbalance protection

Document Release History

This document is issue 2011/10. The list of revisions up to and including this issue is:
Pre release

2011/10	Reference to 60Hz removed
2010/02	Document reformat due to rebrand
28/04/05	R7 Changed all references to CT-X 50 to 87/50-X-1, and changed 87/50-X to 87/50-X-2. Added description of the 87/50-X-X Inhibit DO Delay and use to provide temporary blocking during switching transients.
27/02/03	R6 Default instruments added. Drawings updated
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23/01/2003	R2 Software revision now 9
23/10/2002	R1 Revision History Added. C1 and C2 Primary and Secondary Meters removed.

Software Revision History

05/05/2005	2621H80001R9a	

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1 Introduction

The MSCDN-MP1 represents an integration of the protection elements required to provide a single box Main 1 protection unit, these include Overall Differential protection and Capacitor Unbalance protection, and additional Phase Unbalance backup protection. Together with it's sister units MSCDN-MP2A and MP2B, this protection unit offers a complete solution for Main 1 and Main 2 protection of EHV capacitor banks.

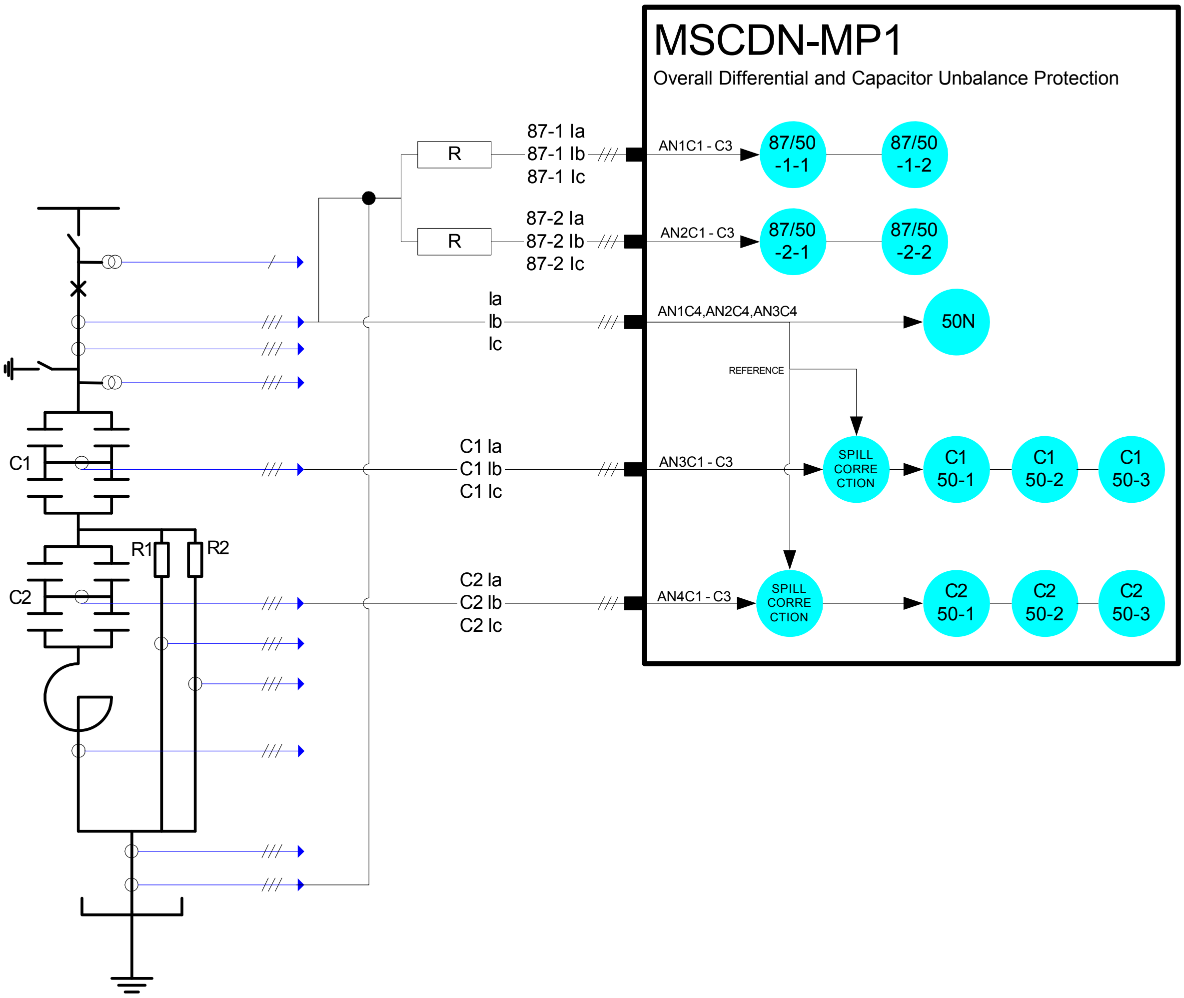

Figure 1 – MSCDN MP1 Capacitor Unbalance Protection

2 Hardware Description

2.1 General

The structure of the relay is based upon the Modular II hardware and software platform illustrated in Figure 3 where the required cards plug in from the front after opening the front fascia. Modules are interconnected by means of ribbon cable. The relay is only supplied in a standard Epsilon case size E16. The Modular II design provides commonality between products and spare parts across a range of protection and control relays including Duobias, Ohmega, Delta, Tau and Iota.

Configuration :

Analogue Inputs	Status Inputs	Output Relays	Case	Connections
16	19	21	E16	2621W11001

Each analogue module has up to four inputs; the first three are usually for measuring the CT secondary line currents from each of the three phases A, B and C.

The unit consists of the following modules:

1) Four Analogue Input modules (4 x I per module)

2) One Controller CPU module

3) One Power Supply and Basic I/O module

4) Two Output relay/Status Input Module

5) One Front Fascia

2.2 Analogue Inputs

Four analogue modules are used in the case style E16. Each module consists of up to 4 channels of current.

In order to ensure high accuracy true RMS measurements and accurate phase and slip frequency calculations, the current signals are sampled at a minimum of 8 samples per cycle for 50Hz system frequency. This sampling rate also provides high accuracy and waveform storage records

2.3 Status Inputs

The relay is fitted with 19 status inputs. The user can program the relay to use any status input for any function. A timer is associated with each input and a pickup time setting may be applied to each input. In addition each input may be logically inverted to allow easy integration of the relay within the user scheme. Each input may be mapped to any front Fascia LED and/or to any Output Relay contact. This allows the Relay to act as panel indication for alarms and scheme status without having to use additional external flagging elements. The reference for each input is “Aux I/P X Operated” (where X is the input number), in both the OUTPUT RELAY MENU and the LED MENU. The functional relationship between these features is shown in Figure 2 – Status Input Functionality

2.4 Output Relays

The relay is fitted with 21 output relays, all of which are capable of handling circuit breaker tripping duty. All relays are fully user configurable and can be programmed to operate from any or all of the control functions. There are three relays on the Power Supply/Basic I/O module which have C/O contacts and 2 with N/O contacts. An additional module is fitted with 8 N/O contacts.

In their normal mode of operation output relays remain energised for a minimum of 100msec and a maximum dependent on the energising condition duration. If required, however, outputs can be programmed to operate as latching relays. These latched outputs can be reset by either pressing the TEST/RESET button, or by sending an appropriate communications command.

The operation of the contacts can be simply checked by using the Protection Healthy setting on the Output Relay Menu to energise each relay in turn. Do not forget to reset this setting back to its correct value.

The output relays can be used to operate the trip coils of the circuit breaker directly if the circuit breaker auxiliary contacts are used to break the trip coil current and the contact rating of the relay output contacts is not exceeded for 'make and carry' currents.

With a failed breaker condition the current 'break' may be transferred to the relay output contacts and where this level is above the break rating of the contacts an auxiliary relay with heavy-duty contacts should be utilised.

2.5 Fascia LEDS

In the E16 case there are 32 user programmable LED flag indicators. By opening the front panel it is possible to insert a strip into a slip in pocket, which provides legend information about the meaning of each LED. The legend may be specified when ordering the relay or alternatively the user can create a customized legend. The user can customise which LED is used for which purpose as well as being able to program each LED as being latching or self –resetting.

2.6 Self Monitoring

The relay incorporates a number of self-monitoring features. Each of these features can initiate a controlled reset recovery sequence, which can be used to generate an alarm output. In addition, the Protection Healthy LED will give visual indication.

A watchdog timer continuously monitors the microprocessor. The voltage rails are also continuously supervised and the microprocessor is reset if any of the rails falls outside of their working ranges. Any failure is detected in sufficient time so that the micro can be shut down in a safe and controlled manner.

2.6.1 Protection Healthy/Defective

The normally closed contacts of relay 1 are used to signal protection defective, whilst the normally open contacts are used to signal protection healthy. When the DC supply is not applied to the relay or a problem is detected with the operation of the relay then this relay is de-energised and the normally closed contacts make to provide an external alarm. When the relay has DC supply and it has successfully passed its self-checking procedure then the Protection Healthy contacts are made and the Protection Defective contacts are opened.

3 Protection Functions

3.1 Overall Differential (87/50)

The Overall Differential protection uses the high impedance circulating current principle, a single line diagram of such a scheme is shown in Figure 5 – High Impedance Differential Schematic. The protection consists of two DTL over-current elements 87/50-1-1and 87/50-1-2, both elements have identical setting ranges and are normally configured to provide two stage protection. The protection is duplicated for dependability, with elements 87/50-2-1 and 87/50-2-2 available for this purpose.

Transient stability under through fault conditions is a problem with many forms of differential protection, due to variations in CT magnetising characteristics. When saturation is approached, the current transformer output waveforms become increasingly distorted, with a high percentage of 3rd and other harmonics, the algorithms employed in the Overall Differential protection ensure complete harmonic rejection, thus improving overall protection stability.

In addition the settings for high impedance differential protection are calculated assuming that one CT is completely saturated. Using this worst case condition the voltage, (determined by the value of the stabilising resistor), and current settings for the 87/50 elements can be precisely calculated, with known stability margins. Intermediate conditions where the CT is only partially saturated, increases the stability margin. This approach enables schemes to be engineered with relatively low knee-point voltages.

3.2 Capacitor Unbalance Protection (C1 50 and C2 50)

The relay contains two identical Capacitor Unbalance protection units, which are primarily designed to protect phase segregated capacitor stacks, with a central ‘H’ connection, although application to alternative stack arrangements is possible. Thus providing complete Capacitor Unbalance protection for main and auxiliary capacitor stacks.

For each unit, expected capacitive spill current for each phase is calculated, based on a proportion of the overall Capacitor Bank current. This expected spill current is then compared with the measured phase spill current and this difference is the operating quantity for the three DTL elements available per unit. Each DTL element is phase segregated, but utilises a common operate setting.

3.2.1 Principle Of Operation

Consider the single phase capacitor stack shown in Figure 6 – Capacitor Unbalance Protection – Phasor Representation of Operating principle, the overall capacitor current is designated the Reference current and therefore for a given capacitor bank configuration, the Spill current across the 'H' Section will be proportional to the Reference and at constant phase angle Ø, this is shown as *(1) - Nominal Condition*.

Should the Reference current increase, due to rise in voltage across the capacitor, then the Spill current will increase, in proportion to the Reference, but this does increase does not indicate a capacitor fault, i.e. *(2) – Normal Condition.*

Measurement of the Reference current and the Spill current at nominal conditions, i.e. rated voltage, allows determination of the Ix Reference, Cy Ix Spill and Cy Ix Angle settings, (where Cy = C1, C2 and Ix Ia, Ib, Ic). These settings allow the Ratio and Angle between Reference and Spill current under healthy conditions to be determined. The Ratio and Angle are then used to calculate the Expected Spill phasor, for any measured Reference current, which is then compared to the measured Spill current, this difference is the Operate Quantity. This is shown as diagram *(3) – Derivation of Operating Quantity*, in this case the Measured Spill current has the same magnitude as the Expected Spill current, but lags the Reference current by angle Φ, however in this case the Operate Quantity is below the pickup level of the C1 50 element.

Diagram (4) – Operate Condition shows phase lag Φ has increased due to a capacitor fault and the Operate Quantity is now above the Operate Setting and the element operates after the given DTL time delay.

A representation of the processing of a single phase calculation is shown in Figure 7 – Capacitor Unbalance Protection - RDL Processing Diagram.

3.3 Phase Unbalance Protection (50N)

The operating quantity for the 50N element, is calculated from the RMS residual of the three phase currents, which is then connected to a DTL overcurrent element.

3.4 Trip Circuit Supervision

Status inputs on the relay can be used to supervise trip circuits while the associated circuit breakers (CB) are either open or closed. Since the status inputs can be programmed to operate output contacts and LED's, alarms can be also generated from this feature.

To use the function set 'Trip Cct Pickup Delay to the required value in the Reylogic Elements Menu and then map the 'Trip Circuit Fail' settings in the Output Relay Menu and LED Menu as required.

See the Applications Guide for more details on the trip circuit supervision scheme.

4 Other Features

4.1 Metering

The metering feature provides real-time data available from the relay fascia in the 'Instruments Mode' or via the communications interface.

The following displays are available:

RMS Capacitor Bank currents (primary, secondary and relay)

RMS Overall Differential currents (secondary and relay)

RMS Capacitor Spill currents (primary, secondary and relay)

RMS Phase Unbalance currents (primary, secondary and relay)

Digital input status

Output relay status

Time and Date

4.2 Data Storage

4.2.1 General

Details of relay operation are recorded in three forms, namely Waveform records, Event records and Fault Data records. All records are time and date stamped with a resolution of one millisecond.

4.2.2 Waveform Records.

The waveform record feature stores analogue and digital information for the current inputs, status inputs and output relays and LED's.

The waveforms are stored with a sampling resolution of at least 8 samples per cycle depending upon relay model. The waveform recorder has the ability to store records for the previous four trip operations of the relay. These are labelled 1-4 with 1 being the most recent record. This however, can be altered using the 'Record Duration' setting, which offers the following selection:

- Four records of one second duration
- Two records of two seconds duration
- One record of five seconds duration

The waveform recorder will be triggered automatically when any protection element operates. It can also be triggered by any of the following means :

Via the 'Trigger Storage" status input signal.

Via the IEC870-5-103 communications interface.

The waveform recorder has a settable pre-fault triggering capability.

4.2.3 Event Records

The event recorder feature allows the time tagging of any change of state (Event) of the relay. As an event occurs the actual event condition is logged as a record along with a time and date stamp to a resolution of 1 millisecond. There is capacity for a maximum of 500 event records that can be stored in the relay and when the event buffer is full any new record will over-write the oldest. The following events are logged:

Change of state of Output Relays.

Change of state of Status Inputs.

Change of Settings and Settings Group

Change of state of any of the control functions of the relay.

4.2.4 Fault Recording

The led flag configuration, date and time of the last five faults are recorded for display via the Fascia LCD.

Note : the real-time clock, waveform records, fault records and event records are all maintained, in the event of loss of auxiliary d.c. supply voltage, by the backup storage capacitor. This capacitor has the ability to maintain the charges on the real-time clock IC and the SRAM memory device for typically 2-3 weeks time duration. This time, however, is influenced by factors such as temperature and the age of the capacitor and could be shorter.

4.3 Time Synchronisation

Time and date can be set either via the relay fascia using appropriate commands in the System Config menu or via an IRIG-B input or via the communications interface

4.3.1 IRIG-B Time Synchronisation

A BNC connector on the relay rear provides an isolated IRIG-B GPS time synchronisation port. The IRIG-B input expects an modulated 3-6 Volt signal and provides time synchronisation to the nearest millisecond.

4.3.2 IEC 60870-5-103 Time Synchronisation

Relays connected individually or in a ring or star configuration can be directly time synchronised using the IEC 60870-5-103 global time synchronisation. This can be from a dedicated substation automation system or from Reydisp Evolution Communications Support Software.

4.3.3 Real Time Clock Time Synchronisation

In the absence of IRIG-B and IEC60870 time synchronisation the relay contains a year 2000 compatible real time clock circuit which maintains real time in the absence of DC supply (See Note).

4.4 Communications

Two fibre optic communication ports, COM1 and COM 2b are provided at the rear of the relay, which give superior EMC performance. An isolated RS232 port, COM 2a is provided at the front of the relay for local access using a PC.

Communication is compatible with the IEC870-5-103 FT 1.2 transmission and application standards. For communication with the relay via a PC (personal computer) a user-friendly software package, REYDISP EVOLUTION, is available to allow transfer of the following:

Relay Settings

Waveform Records

Event Records

Fault Data Records

Instrument and meters

Control Functions

Communications operation is described in detail in Section 4 of this manual. For information about all aspects of the communications protocol used in the Modular II range of relays see [2].

4.5 Settings Groups

Depending upon the relay model then up to four alternative setting groups are provided, making it possible to edit one group while the relay protection algorithms operate using another 'active' group. An indication of which group is being viewed is given by the 'Gn' character in the top left of the display. Settings that do not indicate Gn in the top left corner of the LCD are common to all groups.

A change of group can be achieved either locally at the relay fascia or remotely via a communication interface command.

4.6 Password Feature

The programmable password feature enables the user to enter a 4 character alpha code to secure access to the relay settings. The relay is supplied with the password set to 'NOT ACTIVE', which means that the password feature is disabled. The password must be entered twice as a security measure against accident changes. Once a password has been entered then it will be required thereafter to change settings. It can, however, be de-activated by using the password to gain access and by entering the password 'NONE'. Again this must be entered twice to de-activate the security system.

As soon as the user attempts to change a setting the password is requested before any setting alterations are allowed. Once the password has been validated, the user is 'logged on' and any further changes can be made without re-entering the password. If no more changes are made within 1 hour then the user will automatically be 'logged off', re-enabling the password feature.

Note that the password validation screen also displays a numerical code. If the password is lost or forgotten, this code should be communicated to Siemens and the password can be retrieved.

If the code is 1966067850 then 4 spaces have been entered as the password. This is caused by ENTER being pressed three times on the Change Password setting screen. De-activate password using 'NOT ACTIVE' as described above if this was set un-intentionally.

5 User Interface

The user interface is designed to provide a user-friendly method of entering settings and retrieving data from the relay. The relay fascia includes a 20 character by 2 line, backlit, liquid crystal display (LCD), 32 light emitting diodes (LED) and 5 push buttons.

5.1 Liquid Crystal Display

The liquid crystal display is used to present settings, instrumentation and fault data in a textual format on a 2 lines by 20-character interface.

5.2 Back light Control

To conserve power the display backlighting is turned off if no push buttons are pressed for 5 minutes. After an hour the whole display is de-activated. A setting within the “SYSTEM CONFIG MENU” allows the timeout to be adjusted from 1 to 60 minutes and “OFF”, which means the backlight is always on.

5.3 LED Indications

The following indications are provided:

Protection Healthy – Green LED.

This LED is solidly illuminated to indicate that DC volts have been applied to the relay and that the relay is operating correctly. If the internal relay watchdog detects a protection relay unhealthy condition then this LED will continuously flash.

Programmable – Red LED.

An LED MENU is provided to map any relay output or any status input to any LED.

5.4 Keypad

Five pushbuttons are used to control the functions of the relay. They are labelled ⇧, ⇩ and ⇨, **ENTER** and **CANCEL**. Note that the ⇨ button is also labelled **TEST/RESET**.
When the relay front cover is in place only the ⇩ and ⇨ buttons are accessible. This allows only read access to all the menu displays.

5.5 Relay Identifier

The Relay Identifier setting in the SYSTEM CONFIG MENU may be used to place a circuit identifier of upto 16 alphanumeric characters onto the relay fascia e.g. BOLDON SGT1. This information is also returned as part of the System Information command from Reydisp Evolution Communications Support Software.

5.6 Settings Mode

5.6.1 Settings Adjustment

The push-buttons on the fascia are used to display the relay settings, display the operating signals, e.g. currents, on the LCD and to reset the flag indication on the LCDs.

⇩ **READ DOWN / DECREMENT**

In the Settings Display this push-button is used for scrolling down through a list of settings or signals.

In Settings Modification mode it is used for selecting the next value of (or decreasing) the displayed setting or for deselecting a bit position in a particular control setting.

⇧ **READ UP / INCREMENT**

In Settings Display or Signal Displays this push-button is used for scrolling back up through a list of settings or signals.

In Settings Modification mode it is used for selecting the previous value of (or increasing) the displayed setting or for selecting a bit position in a particular control setting.

ENTER

This push-button is used when the cover is removed to select between two modes of operation namely Settings Display or Settings Modification.

When this push-button is pressed and a relay setting is being displayed part of the display will flash to indicate that the setting being displayed can be modified by using the ⇧ **INCREMENT** or ⇩ **DECREMENT** keys on the facia.

When the required value of the setting has been established, it may be entered into the relay and acted upon by pressing the **ENTER** key again.

CANCEL

This push-button is used when the cover is removed to return the relay display to its initial status. It can be used to reject any alterations to the setting being modified provided the **ENTER** key has not been pressed to accept the changes.

⇨ **TEST / RETEST**

This push-button is used to reset the fault indication on the LEDs on the fascia It also acts as a lamp test button because when pressed all of the LEDs will momentarily light up to indicate their correct operation.

The ⇩ **READ DOWN** and ⇧ **READ UP** push-buttons may then be used to scroll through the various signals.

5.6.2 Settings And Displays

The display menu structure is shown in Figure 8. This diagram shows the three main modes of display, which are the Settings Mode, Instruments Mode and the Fault Data Mode.

When the relay is first energised the user is presented with the following message,

SETTINGS DEFAULTED PRESS ENTER

Which shows that the relay has been set with the standard factory default settings. If this message is displayed ENTER must be pressed to acknowledge this initial condition, the display will then indicate the relay software variant. e.g.

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Pressing the ⇨ **TEST / RETEST** key on this display initiates an LED test. Pressing ⇩ **READ DOWN** at this display allows access to the three display modes, which are accessed in turn by pressing the ⇨ **TEST / RETEST** key.

The Settings Mode contains 15 setting sub-menu's. These hold all of the programmable settings of the relay in separate logical groups. The sub menus are accessed by pressing the key. This enters the sub menu and presents a list of all the settings within that sub menu. Pressing ⇩ **READ DOWN** scrolls through the settings until after the last setting in the group the next sub menu is presented. Access to this group is via the same method as before. If a particular sub menu is not required to be viewed then pressing ⇩ **READ DOWN** will skip past that particular menu and present the next one in the list. Note that all screens can be viewed even if the password is not known. The password only protects against unauthorised changes to settings.

While viewing an editable screen pressing the **ENTER** key allows the user to change the displayed data. A flashing character(s) will indicate the editable field. Pressing the ⇧ **INCREMENT** or ⇩ **DECREMENT** scrolls through the available setting values or, pressing ⇨ **TEST / RETEST** moves right through the edit fields. Note that all settings can be incremented or decremented using the ⇧ **INCREMENT** or ⇩ **DECREMENT** keys and they all wraparound so that to go from a setting minimum value to the maximum value it is quicker to press the ⇩ **DECREMENT** key, rather than scroll through every setting. Also, to facilitate quicker setting changes an acceleration feature is available which if ⇧ **INCREMENT** or ⇩ **DECREMENT** are depressed and held, then the rate of scrolling through the setting values increases.

If **ESCAPE/CANCEL** is pressed during a setting change operation the original setting value is restored and the display is returned to the normal view mode.

If changes are made to the setting value then pressing **ENTER** disables the flashing character mode and displays the new setting value. This is immediately stored in non-volatile memory.

The next sections give a description of each setting in the relay. The actual setting ranges and default values can be found in the Relay Settings section of this manual.

5.7 Instruments Mode

In INSTRUMENT MODE metering points can be displayed to aid with commissioning, the following meters are available

Instrument	Description
[CAP BANK METERS]	Start of Capacitor Bank current meters
Prim'y Currents	Capacitor Bank Primary current meters
Sec'y Currents	Capacitor Bank Secondary current meters
[DIFF METERS]	Start of Overall Differential current meters
Diff1 Sec'y Currents	Differential 1 Secondary currents
Diff1 Currents	Differential 1 currents
Diff2 Sec'y Currents	Differential 2 Secondary currents
Diff2 Currents	Differential 2 currents
[UNBALANCE METERS]	Start of Capacitor Unbalance current meters
Reference Currents	Capacitor Unbalance Reference currents
C1 Ia Spill	C1 Ia Spill current
C1 Ib Spill	C1 Ib Spill current
C1 Ic Spill	C1 Ic Spill current
C1 Operate Currents	C1 Operate currents
Instrument	**Description**
C2 Ia Spill	C2 Ia Spill current
C2 Ib Spill	C2 Ib Spill current
C2 Ic Spill	C2 Ic Spill current
C2 Operate Currents	C2 Operate currents
[PH UNBAL METERS]	Start of Phase Unbalance current meters
Residual Prim'y Current	Residual Primary current
Residual Sec'y Current	Residual Secondary current
Residual Current	Residual current
[MISC METERS]	Start of miscellaneous meters
Status Inputs 1-16	Displays the state of DC status inputs 1 to 16
Status Inputs 17-19	Displays the state of DC status inputs 17 to 19
Output Relays 1-16	Displays the state of output relays 1 to 16
Output Relays 17-21	Displays the state of output relays 1 to 21
Time & Date	Time and Date

Note that meters not designated as primary or secondary values are usually displayed as multiples of nominal

i.e. x In, 1 Amp or 5 Amp.

5.7.1 Hidden Instruments

At the “INSTRUMENTS MODE” title screen, pressing ENTER and DOWN simultaneously reveals some additional metering for calibration purposes. The reference channels as well as DC offsets may be displayed along with the RMS values in raw ADC counts. The relationship between current and ADC counts is 1 x In = 600 counts.

5.8 Fault Data Mode

In “FAULT DATA MODE”, the time and date of relay operations are recorded together with a record of the LED flag states.

5.9 Default Instruments Screens

The menu presentation of the various instruments allows the user to view a single screen at a time. However, for in service use, it is desirable that a small number of high interest, user selectable screens are presented automatically by default without user intervention. The instrument screens of interest to the user e.g. those required to be presented to a visiting engineer for record purposes can be selected by the user by pressing ENTER when viewing the required screen. On pressing ENTER a **‘D’** symbol will appear at the top right of that screen. The ‘**D’** indicates that a screen is a ‘default screen’. To de-select a default screen, simply press ENTER while on that particular screen and the **‘D’** symbol will be cleared.

Time & Date	**D**
01/01/1980 01:31:39	

If no keys have been pressed for a pre-determined time the relay will jump to the default instrument display regardless of where the menu has been left by the user. It will then scroll through each of the selected default instruments and remain on each for approximately 5 seconds. The Default Screens Timer that sets the time to elapse before the relay goes into the default instruments mode is found in the SYSTEM CONFIG MENU.

6 Diagrams

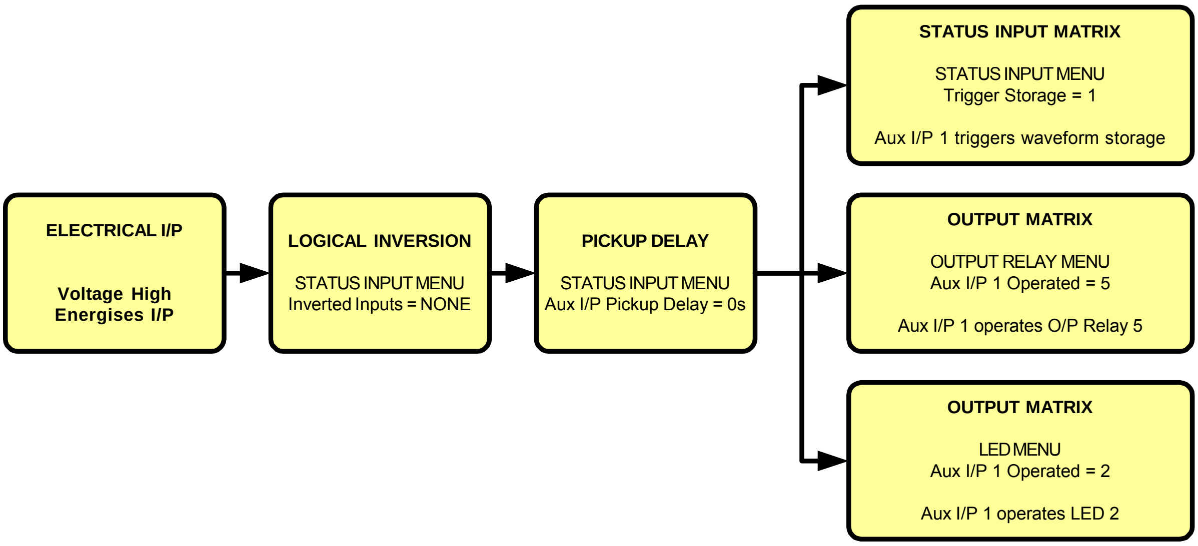

Figure 2 – Status Input Functionality

Figure 3 – MSCDN-MP1 in E16 case with front panel open

Figure 4 – MSCDN-MP1 Rear View

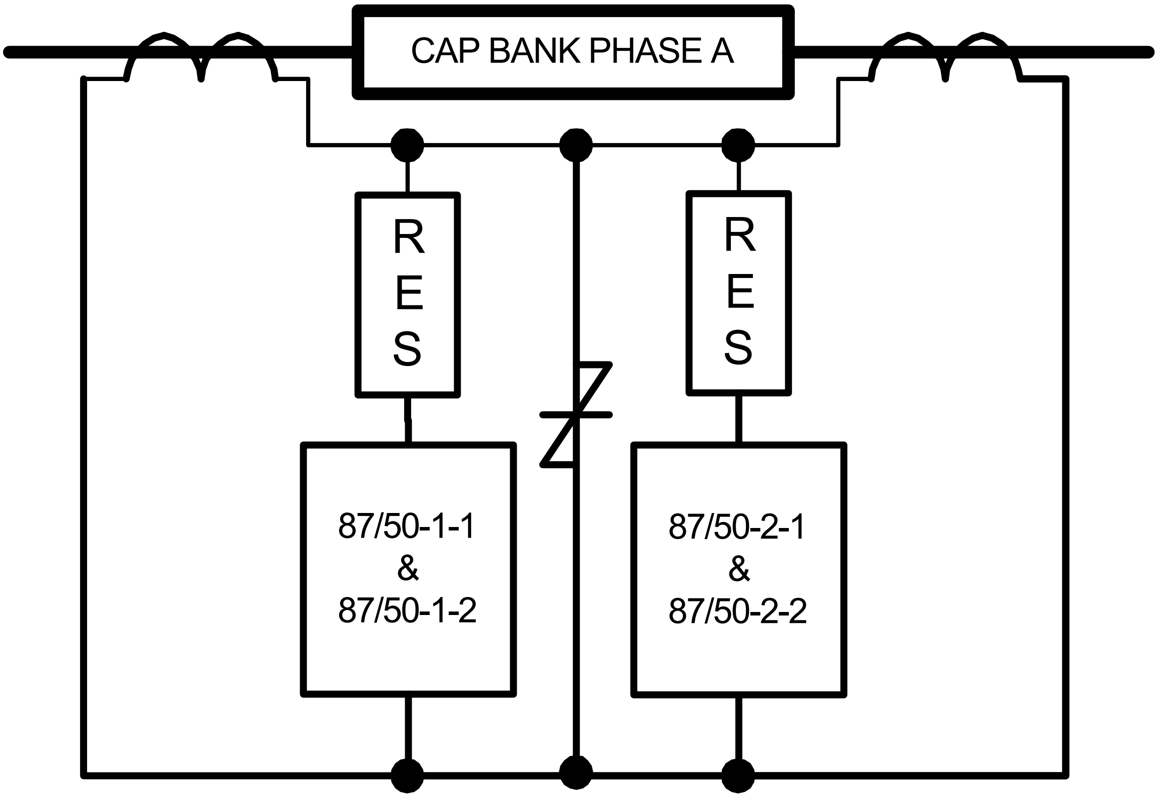

Figure 5 – High Impedance Differential Schematic

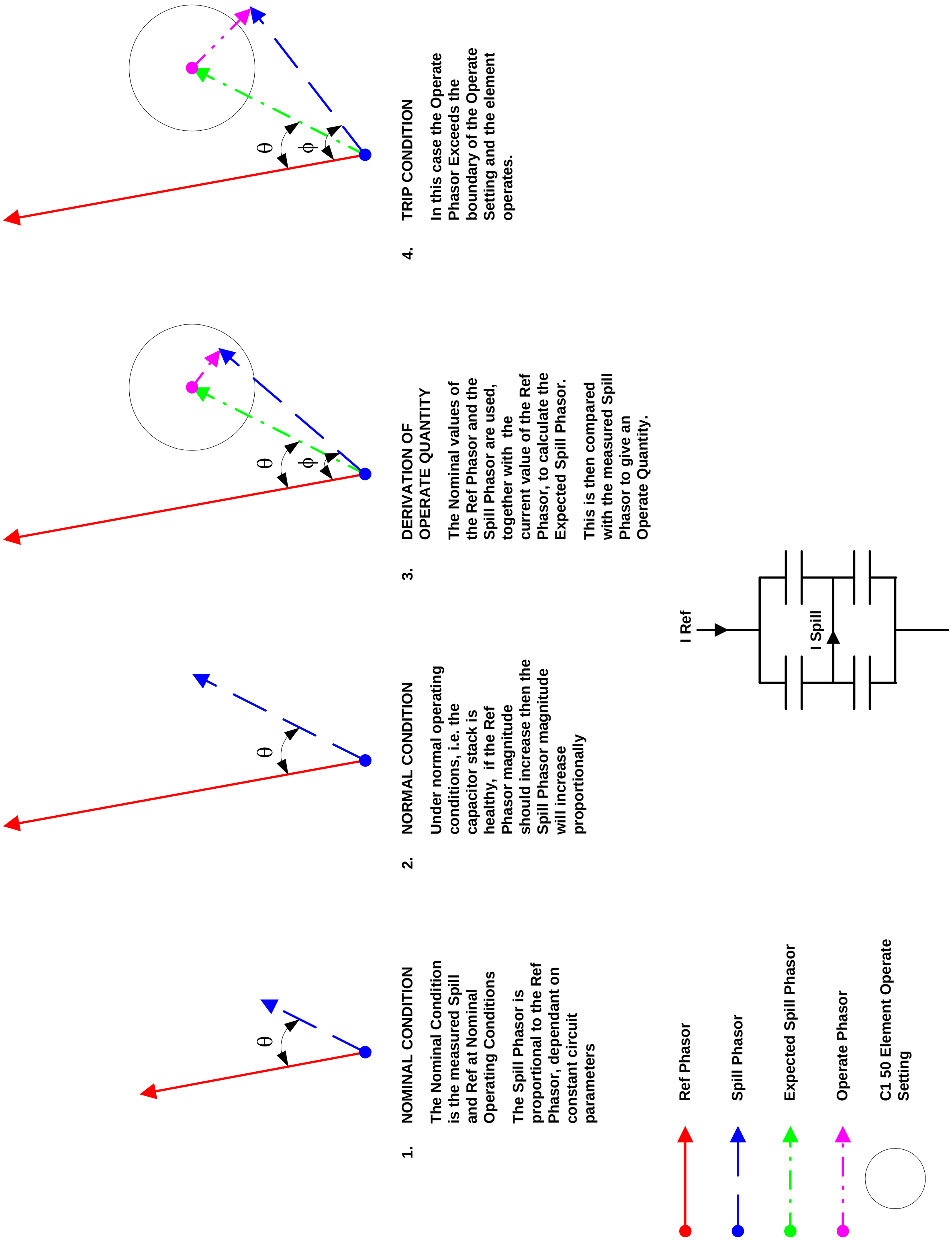

Figure 6 – Capacitor Unbalance Protection – Phasor Representation of Operating principle

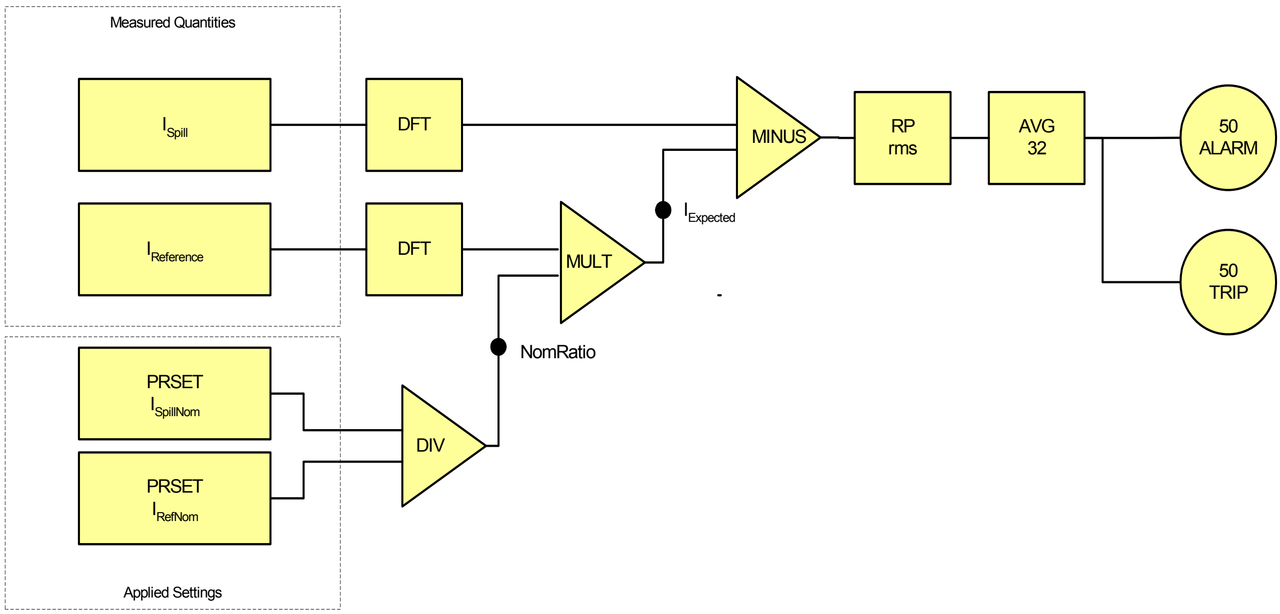

Figure 7 – Capacitor Unbalance Protection - RDL Processing Diagram

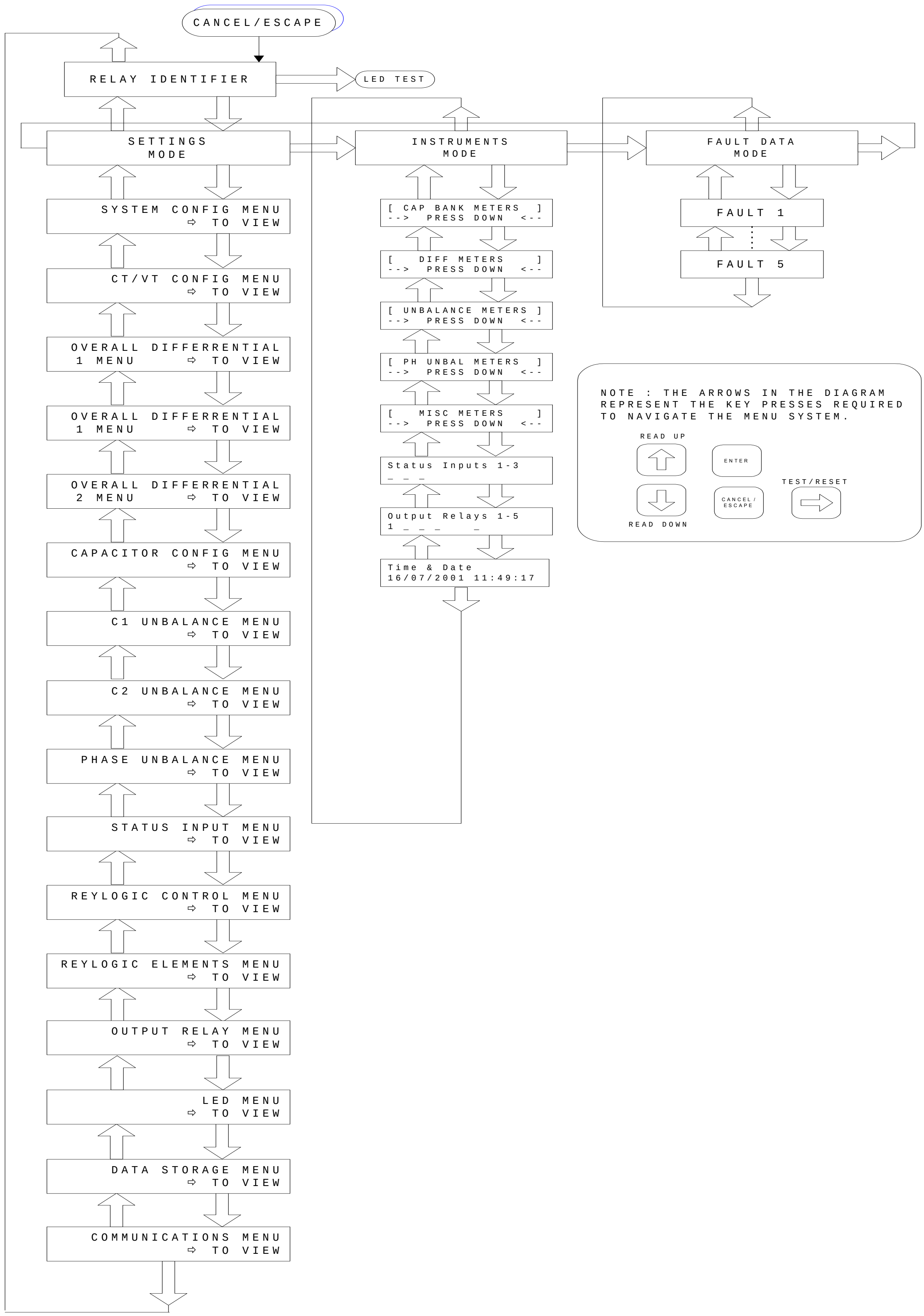

Figure 8 – MSCDN-MP1 Menu Structure

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Capacitor unbalance protection

Document Release History

This document is issue 2011/10. The list of revisions up to and including this issue is:
Pre release

2011/10	References to 60Hz removed
2010/02	Document reformat due to rebrand
28/04/2005	R9 CT-X and 87/50 elements unified to 87/50-X-X Auxiliary Timer Accuracy added. 87/50-x-x 2X operating time corrected.
12/10/2004	R9 AC Voltage Input ratings added VT Supervision function added Status input minimum operate current corrected Corrected operating time variation over frequency
28/02/2003	R8 IDMTL picks up at 105% of setting. Three DTL elements are now available for Capacitor Unbalance
18/02/2003	R7 IDMTL O/C & E/F minimum operate time corrected
14/02/2003	R6 Operate time claims added for O/C and O/V elements
13/02/2003	R5 Removed incorrect references to drop-off timers on the status inputs.
10/02/2003	R4 All MP1 DO changed to ≥ 80% Cx Unbalance Accuracy changed to ± 5% of setting or ± 0.01 I_n
21/01/2003	R3 Corrected element names Added 59DT element
27/11/2002	R2 Resistor thermal overload characteristics added Resistor open circuit characteristics added
24/10/2002	R1 Revision History Added.

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Contents

1 Introduction

The following document defines the technical and performance specification of the MSCDN Series relays. MSCDN relays are based upon the Siemens Modular II series of protection units.

Section 3 describes performance that is common to all Modular II protections.

Section 4 describes the performance of protection elements that may be fitted to MSCDN series relays. Therefore for any one MSCDN series model, only the performance for those elements described in the Description of Operation, as available in that model will be applicable.

Performance Data to:
IEC60255-6, IEC60255-6A and IEC60255-13.

Note:
Where performance is described as "X or Y", then performance is "whichever is greater", unless specified.

2 Accuracy Reference Conditions

General	IEC60255 Parts 6, 6A & 13
Auxiliary Supply	Nominal
Frequency	50 Hz
Ambient Temperature	20°C

3 Modular Ii Specification

3.1 Environmental Withstand

Temperature - IEC 60068-2-1/2

Operating range	-10°C to +55°C
Storage range	-25°C to +70°C

Humidity - IEC 60068-2-3

Operational test	56 days at 40°C and 95% RH

Transient Overvoltage –IEC 60255-5

Between all terminals and earth or between any two independent circuits without damage or flashover	5kV 1.2/50μs 0.5J

Insulation - IEC 60255-5

Between all terminals and earth	2.0kV rms for 1 min
Between independent circuits	2.0kV rms for 1 min
Across normally open contacts	1.0kV rms for 1 min

High Frequency Disturbance - IEC 60255-22-1 Class III

	Variation
2.5kV Common (Longitudinal) Mode	≤ 5%
1.0kV Series (Transverse) Mode	≤ 5%

Electrostatic Discharge - IEC 60255-22-2 Class IV

	Variation
8kV contact discharge	≤ 5%

Conducted & Radiated Emissions -
EN 55022 Class A (IEC 60255-25)

Conducted 0.15MHz – 30MHz Radiated 30MHz – 1GHz

Conducted Immunity -
(IEC 61000-4-6; IEC 60255-22-6)

	Variation
0.15MHz – 80MHz 10V rms 80% modulation	≤ 5%

Radiated Immunity - IEC60255-22-3 Class III

	Variation
80MHz to 1000MHz, 10V/m 80% modulated	≤ 5%

Fast Transient – IEC 60255-22-4 Class IV

	Variation
4kV 5/50ns 2.5kHz repetitive	≤ 5%

Surge Impulse -
IEC 61000-4-5 Class IV; (IEC 60255-22-5)

	Variation
4KV Line-Earth (O/C Test voltage ±10%) 2KV Line-Line	≤ 10

Vibration (Sinusoidal) –IEC 60255-21-1 Class 1

		Variation
Vibration response	0.5gn	≤ 5%
Vibration endurance	1.0gn	≤ 5%

Shock and Bump–IEC 60255-21-2 Class 1

		Variation
Shock response	5 gn 11ms	≤ 5%
Shock withstand	15 gn 11ms	≤ 5%
Bump test	10 gn 16ms	≤ 5%

Seismic – IEC 60255-21-3 Class 1

		Variation
Seismic Response	1gn	≤ 5%

Mechanical Classification

Durability	In excess of 10^6 operations

Auxiliary Energizing Quantity
DC Power Supply

Nominal	Operating Range
30V	24V to 37.5V dc
50/110V	37.5V to 137.5V dc
220/250V	175V to 286V dc

Auxiliary DC Supply – IEC 60255-11

Allowable superimposed ac component	≤ 12% of DC voltage
Allowable breaks/dips in supply (collapse to zero from nominal voltage)	≤ 20ms

D.C. Burden

Quiescent (Typical)	15 Watts
Max	27 Watts

3.2 A.C Current Inputs

1 Amp and 5 Amp current inputs are both available on the rear terminal blocks for most functions except Capacitor Unbalance.

3.2.1 Thermal Withstand

Continuous and Limited Period Overload
AC Current Inputs

3.0 x In	Continuous
3.5 x In	for 10 minutes
4.0 x In	for 5 minutes
5.0 x In	for 3 minutes
6.0 x In	for 2 minutes
250A	for 1 second

625A peak	for 1 cycle

3.2.2 A.C. Burden

A.C. Burden

1A tap	≤0.1 VA
5A tap	≤0.3 VA

NB. Burdens are measured at nominal rating.

3.3 A.C Voltage Inputs

Thermal Withstand
Continuous Overload

AC Voltage	320Vrms (452Vpk)

3.3.1 A.C. Burden

A.C. Burden

110Vrms	≤0.05 VA
63.5Vrms	≤0.01 VA

3.4 Rated Frequency

Frequency: 50Hz

Frequency

Range	47Hz to 52Hz
Setting variation	≤ 5%
Operating time variation	≤ 5% or 5ms

3.5 Accuracy Influencing Factors

Temperature

Ambient range	-10°C to +55°C
Variation over range	≤ 5%

3.6 Output Contacts

Output contacts functionality is fully programmable. The basic I/O module has 5 output contacts three of which are change over. Additional modules can be added with consequential increase in case size, to provide more contacts. These are added in-groups of eight up to a maximum of 29

3.6.1 Output Contact Performance

Contact rating to IEC 60255-0-2.

Carry continuously 5A ac or dc

Make and Carry
(limit L/R ≤ 40ms and V ≤ 300 volts)

for 0.5 sec	20A ac or dc
for 0.2 sec	30A ac or dc

Break
(limit ≤ 5A or ≤ 300 volts)

Ac resistive	1250VA
Ac inductive	250VA @ PF ≤ 0.4
Dc resistive	75W
Dc inductive	30W @ L/R ≤ 40 ms 50W @ L/R ≤ 10 ms

Minimum number of operations	1000 at maximum load
Minimum recommended load	0.5W, limits 10mA or 5V

3.7 Status inputs

Status Inputs functionality is fully programmable. The basic I/O module has 3 status inputs, additional modules can be added to provide more inputs, these inputs are added in-groups of eight up to a maximum of 27.

A pickup timer is associated with each input and each input may be individually inverted where necessary. The pickup timer may be used to provide rejection at power system frequency.

Nominal Voltage	Operating Range
30 / 34	18V to 37.5V
48 / 54	37.5V to 60V
110 / 125	87.5V to 137.5V
220 / 250	175 to 280V

NB: the status input operating voltage does not have to be the same as the power supply voltage.

3.7.1 Status Input Performance

Minimum DC current for operation	48V 10mA 110V 2.25mA 220V 2.16mA
Reset/Operate Voltage Ratio	≥ 90%
Typical response time	< 5ms
Typical response time when programmed to energise an output relay contact	< 15ms
Minimum pulse duration	40ms

To meet the requirements of ESI 48-4 then 48V status inputs should be ordered together with external dropper resistors as follows:-

Status Input External Dropper Resistances

Nominal Voltage	Resistor Value (Wattage)
110 / 125V	2k7 ± 5% ; (2.5W)
220 / 250V	8k2 ± 5% ; (6.0W)

3.7.2 Status Input PU Timer

Each status input has an associated timer that can be programmed to give time-delayed pick-up. The pick-up timers can be set to 20ms to provide immunity to an AC input signal. Status inputs will then not respond to the following:

- 250V RMS 50Hz applied for two seconds through a 0.1μF capacitor.
- 500V RMS 50Hz applied between each terminal and earth.
- Discharge of a 10μF capacitor charged to maximum DC auxiliary supply voltage.

Accuracy

Timing	< ±1% or ±10ms

3.8 Auxiliary Timer Accuracy

Auxiliary Timers are those timers created in Reylogic, whose delay settings appear in the REYLOGIC ELEMENTS MENU

Accuracy

Setting	
0 ms	Instantaneous
> 0 ms	< +1% or +10ms

3.9 Indication

There are two types of LED indication, General and Protection Healthy.

Case Size	Number of LEDs
E8	16 General + Protection Healthy
E12	32 General + Protection Healthy
E16	32 General + Protection Healthy

All General LED indication is fully configurable by the user. All General indications are stored in non-volatile memory without the use of an internal backup battery.

3.10 Settings And Configuration

Settings changes may be done via the front panel user-friendly fascia keypad and LCD or via standard Reydisp Evolution windows software either locally or remotely. Settings changes are stored in EEPROM memory. Configuration changes may be achieved locally via the front serial port with a Windows based toolbox support package. Configuration changes and software upgrades are stored in Flash EPROM memory.

3.11 Recording

Up to 5 fault records may be stored within the relay, Fault records are accessible via the front panel showing the date and time of trips. New faults automatically overwrite the oldest fault record when they occur.

Waveform records are automatically stored whenever a trip is generated. Waveform recording can also be triggered by the status inputs. New waveform records automatically overwrite the oldest waveform record when they are triggered. The exact number and duration of waveform records, for any particular relay model, is available from the Relay Settings section of this Manual in the Data Storage Menu listing.

Up to 500 time tagged event records are stored within the relay. New events automatically overwrite the oldest event record when the 500 are used up.

3.12 Communications

IEC 60870-5-103 communications is standard on Reyrolle Modular II numerical product range. IEC 60870-5-103 has the advantage of built in time synchronisation of all devices, reduced communications overhead, high data security and compatibility with all of the major substation automation and control systems.

COM1 is a dedicated rear fibre optic serial port. COM2 can be auto-switched between rear fibre optic serial port and a front isolated RS232 serial port. IEC 60870-5-103 may be directed to use either COM1 or COM2.

All fibre optic ports can be star connected to a Sigma passive hub or simply daisy-chained in a loop-in loop-out configuration with other Reyrolle relays e.g. Argus, Delta, Ohmega, Tau. Up to 254 relays maybe connected to a Sigma network server to provide relay access over an Ethernet local area network (LAN).

3.13 Irig-B Time Synchronisation

The relay incorporates an IRIG-B time synchronisation port as standard for connection to a GPS time receiver. The input accepts an a.c. modulated input signal that should be in the range 3Vp-p or 6Vp-p.

4 Protection Elements

4.1 Common Performance

Disengaging Time

Disengaging Time	30ms

Note: Output contacts have a minimum dwell time of 100ms, after which the disengaging time is as above.

4.2 87/50-x-x Overall Differential

Phase segregated High impedance Overall Differential scheme using external stabilizing resistors. Function is insensitive to third harmonic currents. Each element with individual Inhibit DO Delay timer (Auxiliary Timer) and following time delay.

Accuracy

Pickup	100% of setting ± 5% or ± 0.01 I_n
Reset	≥ 80% of I_s
Repeatability	± 2%
Transient Overreach	≤5%
Operate Time	± 1% or ± 10ms

Operating Time

Current Applied	Typical
2 x setting	≤ 1.5 cycle
4 x setting	≤ 1 cycle

4.3 C1/2 50-x Capacitor Unbalance

Phase segregated Capacitor Unbalance element, whose operate quantity is calculated from the ratio of capacitor load current and the measured spill current, followed by three identical instantaneous Overcurrent elements with following time delay

Accuracy

Pickup	100% of setting ± 5% or ± 0.02 I_n
Reset	≥ 80% of I_s
Repeatability	± 2%
Operate Time	± 1% or ± 10ms

Operating Time

Current Applied	Typical
2 x setting	1.5 cycles
4 x setting	1 cycle

4.4 50N Cap Bank Phase Unbalance

Derived phase unbalance quantity, from the sum of phase currents, applied to an instantaneous overcurrent element with following time delay.

Accuracy

Pickup	100% of setting ± 5% or ± 0.01 I_n
Reset	≥ 80% of I_s
Repeatability	± 2%
Operate Time	± 1% or ± 10ms

Operating Time

Current Applied	Typical
2 x setting	1.5 cycles
4 x setting	1 cycle

4.5 R1/2 49 Resistor Thermal Overload

Thermal overload element applied to each phase of each resistor independently.

Accuracy

Pickup	100% of setting ± 5% or ± 0.02 I_n
Reset	≥ 95% of I_s
Repeatability	± 2%
Operate Time	± 5% or ± 0.1s
Frequency Range	1^{st}, 2^{nd} …15^{th} Harmonic

Operating Time

Characteristic	**Ranges**
THERMAL IEC 60255-8	Operate times are calculated from: $t = \tau \times \ln\left\{\frac{I^2 - I_P^2}{I^2 - (k \times I_B)^2}\right\}$ τ = thermal time constant I = measured current I_P = prior current I_B = basic current k = constant
□ Factor	1 to 10000 Δ 0.5 seconds

4.6 50 Resistor Open Circuit

An instantaneous/delayed overcurrent element measures the difference in currents on each resistor on a phase-by-phase basis.

Accuracy

Pickup	100% of setting ± 5% or ± 0.02 I_n
Reset	≥ 95% of I_s
Repeatability	± 2%
Operate Time	± 1% or ± 10ms

Operating Time

Current Applied	Typical
2 x setting	2 cycles
4 x setting	1.5 cycle

4.7 49 Reactor Thermal Overload

Thermal overload element applied to each phase of the reactor independently.

Accuracy

Pickup	100% of setting ± 5% or ± 0.02 I_n
Reset	≥ 95% of I_s
Repeatability	± 2%
Operate Time	± 5%
Frequency Range	1st, 2nd …15th Harmonic

Operating Time

Characteristic	**Ranges**
THERMAL IEC 60255-8	Operate times are calculated from: $t = \tau \times \ln \left\{ \frac{I^2 - I_P^2}{I^2 - (k \times I_B)^2} \right\}$ τ = thermal time constant I = measured current I_P = prior current I_B = basic current k = constant
□ Factor	1 to 1000 Δ 0.5 minutes

4.8 50 Backup Overcurrent

Three phase definite time overcurrent element.

Accuracy

Pickup	100% of setting ± 5% or ± 0.02 I_n
Reset	≥ 95% of I_s
Repeatability	± 2%
Operate Time	± 1% or ± 10ms
Frequency Range	1st, 2nd …15th Harmonic

Operating Time

Current Applied	Typical
2 x setting	2 cycles
4 x setting	1.5 cycle

4.9 50N Backup Earth Fault

Definite time derived earth fault element.

Accuracy

Pickup	100% of setting ± 5% or ± 0.02 I_n
Reset	≥ 95% of I_s
Repeatability	± 2%
Operate Time	± 1% or ± 10ms
Frequency Range	1st, 2nd …15th Harmonic

Operating Time

Current Applied	Typical
2 x setting	2 cycles
4 x setting	1.5 cycle

4.10 51 Backup Overcurrent,

Three phase inverse time overcurrent element.

Accuracy

Pickup	105% of setting ± 5% or ± 0.02 I_n
Reset	≥ 95% of I_s
Repeatability	± 2%
Operate Time	± 5% or ± 40ms
Frequency Range	1st, 2nd …15th Harmonic

Operating Time

Characteristic	**Ranges**
IEC IDMTL CURVES	Operate times are calculated from: $t = Tm \times \left[\frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \right]$ I = fault current Is = current setting Tm = time multiplier NI: K = 0.14, α = 0.02 VI: K = 13.5, α = 1.0 EI: K = 80.0, α = 2.0 LTI: K = 120.0, α = 1.0
Time Multiplier	0.025 to 1.600 Δ 0.025 sec
Reset	0.0 to 60.0 Δ 1.0 sec
ANSI IDMTL CURVES	Operate times are calculated from: $t = M \times \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B \right]$ I = fault current Is = current setting M = time multiplier MI: A = 0.0515, B = 0.114, P = 0.02 VI: A = 19.61, B = 0.491, P = 2.0 EI: A = 28.2, B = 0.1217, P = 2.0
ANSI RESET CURVES	Operate times are calculated from: $t = M \times \left[\frac{R}{\left[\frac{I}{Is}\right]^{2} - 1} \right]$ I = fault current Is = current setting M = time multiplier MI: R = 4.85 VI: R = 21.6 EI: R = 29.1

4.11 51N Derived Earth Fault

Inverse time derived earth fault element.

Accuracy

Pickup	105% of setting ± 5% or ± 0.02 I_n
Reset	≥ 95% of I_s
Repeatability	± 2%
Operate Time	± 5% or ± 40ms
Frequency Range	1st, 2nd …15th Harmonic

Operating Time

Characteristic	Ranges
IEC IDMTL CURVES	Operate times are calculated from: $t = Tm \times \left[\frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \right]$ I = fault current Is = current setting Tm = time multiplier NI: K = 0.14, α= 0.02 VI: K = 13.5, α = 1.0 EI: K = 80.0, α = 2.0 LTI: K = 120.0, α = 1.0
Time Multiplier	0.025 to 1.600 Δ 0.025 sec
Reset	0.0 to 60.0 Δ 1.0 sec
ANSI IDMTL CURVES	Operate times are calculated from: $t = M \times \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B \right]$ I = fault current Is = current setting M = time multiplier MI: A = 0.0515, B = 0.114, P = 0.02 VI: A = 19.61, B = 0.491, P = 2.0 EI: A = 28.2, B = 0.1217, P = 2.0
ANSI RESET CURVES	Operate times are calculated from: $t = M \times \left[\frac{R}{\left[\frac{I}{Is}\right]^{2} - 1} \right]$ I = fault current Is = current setting M = time multiplier MI: R = 4.85 VI: R = 21.6 EI: R = 29.1

4.12 27 Undervoltage

Single phase definite time undervoltage element. An under voltage guard element may be used to block this elements operation.

Accuracy

Pickup	100% of setting ± 0.1% or ± 0.1 V
Reset	≤ 100.5% of V_s (Adjustable)
Repeatability	± 0.1%
Operate Time	± 1% or ± 20ms
Frequency Range	1^{st}, 2^{nd} …15^{th} Harmonic

Operating Time

Operate Time	< 3 cycles

4.13 59DT Definite Time Overvoltage

Three phase definite time overvoltage element

Accuracy

Pickup	100% of setting ± 0.1% or ± 0.1 V
Reset	≥ 99.5% of V_s
Repeatability	± 0.1%
Frequency Range	1^{st}, 2^{nd} …15^{th} Harmonic

Operating Time

Operate Time	< 4 cycles

4.14 59IT Inverse Time Overvoltage

Three phase inverse time overvoltage element specified using seven user defined points on a curve.

Accuracy

Pickup	± 0.1% of setting or ± 0.1 V
Reset	≥ 99.5% of V_s
Repeatability	± 0.1%
Operate Time	± 5% or ± 0.1s
Frequency Range	1st, 2nd …15th Harmonic

Operating Time

Characteristic	**Ranges**
CURVE	7 Point user defined inverse curve X_0,Y_0 : X_6,Y_6 X_i:=1.00xVn … 2.00xVn Y_i:=0.1 … 20000s

4.15 VT Supervision

The VT supervision element operates when the 27 VTS and the 50 VTS element operate to indicate that the capacitor bank is energised but rated voltage has not been applied to the relay on a phase by phase basis.

4.15.1 27 VTS Undervoltage

Three phase definite time undervoltage element

Accuracy

Pickup	100% of setting ± 0.1% or ± 0.1 V
Reset	≥ 99.5% of V_s
Repeatability	± 0.1%

Operating Time

Operate Time	< 4 cycles

4.15.2 50 VTS Current Check

Three phase definite time overcurrent check element

Accuracy

Pickup	100% of setting ± 5% or ± 0.02 I_n
Reset	≥ 95% of I_s
Repeatability	± 2%
Operate Time	± 1% or ± 10ms

Operating Time

Current Applied	Typical
2 x setting	2 cycles
4 x setting	1.5 cycle

MSCDN – MP1

Capacitor unbalance protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand
05/05/2005	R7a Caught the R9 on the labels.
12/04/2005	R7 CT-X-50 removed Now use non-descript names 87/50-X-1 and 87/50-X-2. Added the 87/50-X-X Inhibit DO Delay Settings. LED labels changed.
12/02/2003	R6 Deleted ANSI diagram from frontsheet
27/01/2003	R5 Added missing 50N inhibit inputs
21/01/2003	R4 C1 50-3, C2 50-3 capacitor unbalance elements added
09/01/2003	R3 Allowed for up to 19 SI and 21OR in various tables Inhibits added to tables and diagrams
24/10/2002	R2 Reference and Spill Current setting now have a maximum of 2.5 xIn to match the maximum continuous rating of the input.
23/10/2002	R1 Revision history added Spill Setting and Angle modified. Cx Spill Input and Ratio settings Deleted and corresponding meters.

Software Revision History

05/05/2005	2621H80001R9a	

Contents

1 MSCDN-MP1 Relay Setting List

1.1 System Config Menu

Description	Range	Default	Setting
Active Group *Selects which settings group is currently activated*	1,2…4	1	
View/Edit Group *Selects which settings group is currently being displayed*	1,2…4	1	
Default Screens Timer *Selects the time delay after which, if no key presses have been detected, the relay will begin to poll through any screens which have been selected as default instruments screens*	OFF, 1,2,5,10,15,30,60 min	60 min	
Backlight timer *Controls when the LCD backlight turns off*	OFF, 1,2,5,10,15,30,60 min	5 Min	
Date	Date	1/1/1980	
Time	Time	00:00:00	
Clock Sync. From Status *Real time clock may be synchronised using a status input (See Clock Sync. in Status Input Menu)*	Disabled, Seconds,Minutes	Minutes	
Operating Mode *To allow access to change configuration files using Reylogic Toolbox the relay must be placed Out Of Service.*	Local, Remote, Local Or Remote, Out Of Service	Local Or Remote	
Change Password *Allows a 4 character alpha code to be entered as the password. Note that the display shows a password dependant encrypted code on the second line of the display*	AAAA…ZZZZ	“NONE” displayed as “NOT ACTIVE”	
Relay Identifier *An alphanumeric string shown on the LCD normally used to identify the circuit the relay is attached to or the relays purpose*	Up to 16 characters	MSCDN-MP1	

1.2 CT/VT Config Menu

Description	Range	Default	Setting
Cap Bank Input *Selects whether 1 or 5 Amp terminals are being used for Cap Bank Input*	1,5 A	1 A	
Cap Bank CT Ratio *Cap Bank CT ratio to scale primary current instruments*	5:0.2…5000:7	2000:1	
Overall Diff 1 Input *Selects whether 1 or 5 Amp terminals are being used for Overall Diff 1 Input*	1,5 A	1 A	
Overall Diff 2 Input *Selects whether 1 or 5 Amp terminals are being used for Overall Diff 2 Input*	1,5 A	1 A	

1.3 Overall Differential 1 Menu

Description	Range	Default	Setting
87/50-1-1 Element *Selects whether the 87/50-1/1 element is enabled.*	Disabled, Enabled	Disabled	
87/50-1-1 Setting *Pickup level*	0.020,0.025…0.960 xIn	0.10 xIn	
87/50-1-1 Delay *Pickup delay*	0,0.01…864000 s	10.00 s	
87/50-1-2 Element *Selects whether the 87/50-1-2 Element is enabled.*	Disabled, Enabled	Disabled	
87/50-1-2 Setting *Pickup level*	0.020,0.025…0.960 xIn	0.50 xIn	
87/50-1-2 Delay *Pickup delay*	0,0.01…864000 s	0.00 s	

1.4 Overall Differential 2 Menu

Description	Range	Default	Setting
87/50-2-1 Element *Selects whether the 87/50-2-1 element is enabled.*	Disabled, Enabled	Disabled	
87/50-2-1 Setting *Pickup level*	0.020,0.025…0.960 xIn	0.10 xIn	
87/50-2-1 Delay *Pickup delay*	0,0.01…864000 s	10.00 s	
87/50-2-2 Element *Selects whether the 87/50-2-2 Element is enabled.*	Disabled, Enabled	Disabled	
87/50-2-2 Setting *Pickup level*	0.020,0.025…0.960 xIn	0.50 xIn	
87/50-2-2 Delay *Pickup delay*	0,0.01…864000 s	0.00 s	

1.5 Capacitor Config Menu

Description	Range	Default	Setting
Ia Reference *The nominal value of the Capacitor Bank Ia reference current*	0.10, 0.11…2.50	1.00 xIn	
Ib Reference *The nominal value of the Capacitor Bank Ib reference current*	0.10, 0.11…2.50	1.00 xIn	
Ic Reference *The nominal value of the Capacitor Bank Ic reference current*	0.10, 0.11…2.50	1.00 xIn	

1.6 C1 Unbalance Menu

Description	Range	Default	Setting
C1 Ia Spill *The value of C1 Ia Spill current at Ia Reference current*	0.00, 0.01…2.50	0.00 xIn	
C1 Ia Spill Angle *The angle of C1 Ia Spill current with respect to Ia reference current*	-180,-179…180°	0 °	
C1 Ib Spill *The value of C1 Ib Spill current at Ib Reference current*	0.00, 0.01…2.50	0.00 xIn	
C1 Ib Spill Angle *The angle of C1 Ib Spill current with respect to Ib reference current*	-180,-179…180°	0 °	
C1 Ic Spill *The value of C1 Ia Spill current at Ia Reference current*	0.00, 0.01…2.50	0.00 xIn	
C1 Ic Spill Angle *The angle of C1 Ic Spill current with respect to Ic reference current*	-180,-179…180°	0 °	
C1 50-1 Element *Selects whether the C1 50-1 Element is enabled.*	Disabled, Enabled	Disabled	
C1 50-1 Setting *Pickup level*	0.020,0.025…25.00 xIn	0.10 xIn	
C1 50-1 Delay *Pickup delay*	0,0.01…864000 s	5.00 s	
C1 50-2 Element *Selects whether the C1 50-2 Element is enabled.*	Disabled, Enabled	Disabled	
C1 50-2 Setting *Pickup level*	0.020,0.025…25.00 xIn	0.50 xIn	
C1 50-2 Delay *Pickup delay*	0,0.01…864000 s	1.00 s	
C1 50-3 Element *Selects whether the C1 50-3 Element is enabled.*	Disabled, Enabled	Disabled	
C1 50-3 Setting *Pickup level*	0.020,0.025…25.00 xIn	1.0 xIn	
C1 50-3 Delay *Pickup delay*	0,0.01…864000 s	0.10 s	

1.7 C2 Unbalance Menu

Description	Range	Default	Setting
C2 Ia Spill *The value of C2 Ia Spill current at Ia Reference current*	0.00, 0.01…2.50	0.00 xIn	
C2 Ia Spill Angle *The angle of C2 Ia Spill current with respect to Ia reference current*	-180,-179…180°	0 °	

Description	Range	Default	Setting
C2 Ib Spill *The value of C2 Ib Spill current at Ib Reference current*	0.00, 0.01…2.50	0.00 xIn	
C2 Ib Spill Angle *The angle of C2 Ib Spill current with respect to Ib reference current*	-180,-179…180°	0 °	
C2 Ic Spill *The value of C2 Ia Spill current at Ia Reference current*	0.00, 0.01…2.50	0.00 xIn	
C2 Ic Spill Angle *The angle of C2 Ic Spill current with respect to Ic reference current*	-180,-179…180°	0 °	
C2 50-1 Element *Selects whether the C2 50-1 Element is enabled.*	Disabled, Enabled	Disabled	
C2 50-1 Setting *Pickup level*	0.020,0.025…25.00 xIn	0.10 xIn	
C2 50-1 Delay *Pickup delay*	0,0.01…864000 s	5.00 s	
C2 50-2 Element *Selects whether the C2 50-2 Element is enabled.*	Disabled, Enabled	Disabled	
C2 50-2 Setting *Pickup level*	0.020,0.025…25.00 xIn	0.50 xIn	
C2 50-2 Delay *Pickup delay*	0,0.01…864000 s	1.00 s	
C2 50-3 Element *Selects whether the C2 50-3 Element is enabled.*	Disabled, Enabled	Disabled	
C2 50-3 Setting *Pickup level*	0.020,0.025…25.00 xIn	1.00 xIn	
C2 50-3 Delay *Pickup delay*	0,0.01…864000 s	0.10 s	

1.8 Phase Unbalance Menu

Description	Range	Default	Setting
50N Element *Selects whether the 50N Element is enabled.*	Disabled, Enabled	Disabled	
50N Setting *Pickup level*	0.020,0.025…25.00 xIn	0.20 xIn	
50N Delay *Pickup delay*	0,0.01…864000 s	1.00 s	

1.9 Status Input Menu

Description	Range	Default	Setting
Aux I/P 1 Pickup Delay *Delay on pickup of DC Status input 1*	0.000,0.005…864000 s	0 s	
Aux I/P 2 Pickup Delay	0.000,0.005…864000 s	0 s	
Aux I/P 3 Pickup Delay	0.000,0.005…864000 s	0 s	
Aux I/P 4 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 5 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 6 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 7 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 8 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 9 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 10 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 11 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 12 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 13 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 14 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 15 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 16 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 17 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 18 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 19 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
87/50-1-1 Inhibit *Selects which inputs inhibit the 87/50-1-1 element*	NONE, 1…19[2]	NONE	
87/50-1-2 Inhibit *Selects which inputs inhibit the 87/50-1-2 element*	NONE, 1…19[2]	NONE	

Description	Range	Default	Setting
87/50-2-1 Inhibit *Selects which inputs inhibit the 87/50-2-1 element*	NONE, 1…19[2]	NONE	
87/50-2-2 Inhibit *Selects which inputs inhibit the 87/50-2-2 element*	NONE, 1…19[2]	NONE	
C1 50-1 Inhibit *Selects which inputs inhibit the C1 50-1 element*	NONE, 1…19[2]	NONE	
C1 50-2 Inhibit *Selects which inputs inhibit the C1 50-2 element*	NONE, 1…19[2]	NONE	
C1 50-3 Inhibit *Selects which inputs inhibit the C1 50-3 element*	NONE, 1…19[2]	NONE	
C2 50-1 Inhibit *Selects which inputs inhibit the C2 50-1 element*	NONE, 1…19[2]	NONE	
C2 50-2 Inhibit *Selects which inputs inhibit the C2 50-2 element*	NONE, 1…19[2]	NONE	
C2 50-3 Inhibit *Selects which inputs inhibit the C2 50-3 element*	NONE, 1…19[2]	NONE	
50N Inhibit *Selects which inputs inhibit the 50N element*	NONE, 1…19[2]	NONE	
Trip Circuit Fail *Selects which inputs are monitoring trip circuits, inputs should normally also be selected as Inverted Inputs (see below)*	NONE, 1…19[2]	NONE	
Trigger Storage *Selects which inputs can trigger a waveform record*	NONE, 1…19[2]	NONE	
Clock Sync. *Selects which input is used to synchronise the real time clock*	NONE, 1…19[2]	NONE	
Inverted Inputs *Selects which inputs pickup when voltage is removed, often used when monitoring trip circuits.*	NONE, 1…19[2]	NONE	

1) Only when fitted.

2) 19 status inputs represents maximum configuration.

1.10 Reylogic Control Menu

Description	Range	Default	Setting
General Logic *Selects whether the logic diagram is enabled, if disabled then no outputs will be driven.*	Enable, Disable	Enable	

1.11 Reylogic Element Menu

Description	Range	Default	Setting
Trip Cct Pickup Delay	0,1…60000 ms	400 ms	
87/50-1-1 Inhibit DO Delay	0,1…60000 ms	0 ms	
87/50-1-2 Inhibit DO Delay	0,1…60000 ms	0 ms	
87/50-2-1 Inhibit DO Delay	0,1…60000 ms	0 ms	
87/50-2-2 Inhibit DO Delay	0,1…60000 ms	0 ms	

1.12 Output Relay Menu

Description	Range	Default	Setting
87/50-1-1 *Overall Diferential 1-1 DTL operated*	NONE, 1…21[1]	4,5	
87/50-1-2 *Overall Differential 1-2 DTL operated*	NONE, 1…21[1]	4,5	
87/50-2-1 *Overall Differential 2-1 DTL operated*	NONE, 1…21[1]	4,5	
87/50-2-2 *Overall Differential 2-2 DTL operated*	NONE, 1…21[1]	4,5	
C1 50-1 *C1 Capacitor Unbalance DTL 1 operated*	NONE, 1…21[1]	3	
C1 50-2 *C1 Capacitor Unbalance DTL 2 operated*	NONE, 1…21[1]	4,5	
C1 50-3 *C1 Capacitor Unbalance DTL 3 operated*	NONE, 1…21[1]	4,5	
C2 50-1 *C2 Capacitor Unbalance DTL 1 operated*	NONE, 1…21[1]	3	
C2 50-2 *C2 Capacitor Unbalance DTL 2 operated*	NONE, 1…21[1]	4,5	

C2 50-3 *C2 Capacitor Unbalance DTL 3 operated*	NONE, 1…21[1]	4,5	
50N *Phase Unbalance DTL operated*	NONE, 1…21[1]	6	
Phase A *A phase A element operated*	NONE, 1…21[1]	NONE	
Phase B *A phase B element operated*	NONE, 1…21[1]	NONE	
Phase C *A phase C element operated*	NONE, 1…21[1]	NONE	
General Starter *A starter element is picked up*	NONE, 1…21[1]	NONE	
General Trip *An element has operated. Useful when testing individual functions!*	NONE, 1…21[1]	NONE	
Trip Circuit Fail *A trip circuit has failed, look at status input Leds to find out which one*	NONE, 1…21[1]	NONE	
New Data Stored *The waveform recorder has stored new information Note: this is a pulsed output*	NONE, 1…21[1]	NONE	
Aux I/P 1 Operated *DC Status 1 has operated*	NONE, 1…21[1]	NONE	
Aux I/P 2 Operated	NONE, 1…21[1]	NONE	
Aux I/P 3 Operated	NONE, 1…21[1]	NONE	
Aux I/P 4 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 5 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 6 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 7 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 8 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 9 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 10 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 11 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 12 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 13 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 14 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 15 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 16 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 17 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 18 Operated[2]	NONE, 1…21[1]	NONE	
Aux I/P 19 Operated[2]	NONE, 1…21[1]	NONE	
Hand Reset Outputs *Relays selected, as Hand Reset will remain latched until manually reset from front panel or via communications link or by removing DC Supply. By default relays are Self Resetting and will reset when the driving signal is removed.*	NONE, 1…21[1]	NONE	
Protection Healthy *Relays selected are energised whilst relay self-monitoring does NOT detect any hardware or software errors and DC Supply is healthy. A changeover contact or normally closed contact may be used to generate Protection Defective from this output*	NONE, 1…21[1]	1	

1) 21 output relays represents maximum configuration.

2) Only when fitted.

1.13 LED Menu

Description	**Range**	**Default**	**Setting**
87/50-1-1 *Overall Diferential 1-1 DTL operated*	NONE, 1…32	17	
87/50-1-2 *Overall Differential 1-2 DTL operated*	NONE, 1…32	18	
87/50-2-1 *Overall Differential 2-1 DTL operated*	NONE, 1…32	19	
87/50-2-2 *Overall Differential 2-2 DTL operated*	NONE, 1…32	20	
C1 50-1 *C1 Capacitor Unbalance DTL 1 operated*	NONE, 1…32	5,21	
C1 50-2 *C1 Capacitor Unbalance DTL 2 operated*	NONE, 1…32	5,22	

Description	Range	Default	Setting
C1 50-3 *C1 Capacitor Unbalance DTL 3 operated*	NONE, 1…32	5,23	
C2 50-1 *C2 Capacitor Unbalance DTL 1 operated*	NONE, 1…32	6,21	
C2 50-2 *C2 Capacitor Unbalance DTL 2 operated*	NONE, 1…32	6,22	
C2 50-3 *C2 Capacitor Unbalance DTL 3 operated*	NONE, 1…32	6,23	
50N *Phase Unbalance DTL operated*	NONE, 1…32	24	
Phase A *A phase A element operated*	NONE, 1…32	2	
Phase B *A phase B element operated*	NONE, 1…32	3	
Phase C *A phase C element operated*	NONE, 1…32	4	
General Starter *A starter element is picked up. Useful when testing individual functions!*	NONE, 1…32	1	
General Trip *An element has operated. Useful when testing individual functions!*	NONE, 1…32	1	
Trip Circuit Fail *A trip circuit has failed, look at status inputs Leds to find out which one*	NONE, 1…32	7	
New Data Stored *The waveform recorder has stored new information*	NONE, 1…32	NONE	
Aux I/P 1 Operated *DC Status 1 has operated*	NONE, 1…32	9	
Aux I/P 2 Operated	NONE, 1…32	10	
Aux I/P 3 Operated	NONE, 1…32	11	
Aux I/P 4 Operated[1]	NONE, 1…32	12	
Aux I/P 5 Operated[1]	NONE, 1…32	13	
Aux I/P 6 Operated[1]	NONE, 1…32	14	
Aux I/P 7 Operated[1]	NONE, 1…32	15	
Aux I/P 8 Operated[1]	NONE, 1…32	16	
Aux I/P 9 Operated[1]	NONE, 1…32	25	
Aux I/P 10 Operated[1]	NONE, 1…32	26	
Aux I/P 11 Operated[1]	NONE, 1…32	27	
Aux I/P 12 Operated[1]	NONE, 1…32	NONE	
Aux I/P 13 Operated[1]	NONE, 1…32	NONE	
Aux I/P 14 Operated[1]	NONE, 1…32	NONE	
Aux I/P 15 Operated[1]	NONE, 1…32	NONE	
Aux I/P 16 Operated[1]	NONE, 1…32	NONE	
Aux I/P 17 Operated[1]	NONE, 1…32	NONE	
Aux I/P 18 Operated[1]	NONE, 1…32	NONE	
Aux I/P 19 Operated[1]	NONE, 1…32	NONE	
Self Reset LEDs *LEDs selected, as Self Reset will automatically reset when the driving signal is removed. By default all LEDs are Hand Reset and must be manually reset either locally via the front fascia or remotely via communications.*	NONE, 1…32	1	

1) Only when fitted.

1.14 Data Storage Menu

Description	Range	Default	Setting
Pre-Trigger Storage	10…90 %	20 %	
Data Record Duration	4 Recs x 1 Seconds, 2 Recs x 2 Seconds, 1 Recs x 4 Seconds	4 Recs x 1 Second	

1.15 Communications Menu

Description	Range	Default	Setting
Station Address	0…254	0	

Description	Range	Default	Setting
IEC 60870-5-103 Station Address			
IEC870 On Port *Selects which port to use for IEC 60870-5-103 communications*	None, Com1, Com2, Auto	Com1	
Line Switch Time *When IEC870 On Port is selected to Auto the communications ports are scanned for valid IEC 60870-5-103 communications frames. Once valid frames are detected the com port will remain selected. Subsequently if there are no valid frames received for the Line Switch Time period then the driver will assume the communications circuit has failed and will resume scanning the com ports.* *Only visible when set to Auto.*	1,2,…60 s	30 s	
Com1 Baud Rate *Sets the communications baud rate for com port 1 (Rear upper Fibre optic port)*	75, 110, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	19200	
Com1 Parity *Selects whether parity information is used*	Even, Odd, None	Even	
Com1 Line Idle *Selects the communications line idle sense*	Light Off, Light On	Light Off	
Com1 Data Echo *Enables echoing of data from RX port to TX port when operating relays in a Fibre Optic ring configuration*	Off, On	Off	
Com2 Baud Rate *Sets the communications baud rate for com port 2 (Rear lower Fibre optic port AND Front Fascia RS232 port)*	75, 110, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	19200	
Com2 Parity *Selects whether parity information is used*	Even, Odd, None	None	
Com2 Line Idle *Selects the communications line idle sense*	Light Off, Light On	Light Off	
Com2 Data Echo *Enables echoing of data from RX port to TX port when operating relays in a Fibre Optic ring configuration*	Off, On	Off	
Com2 Direction *Selects how Com2 is shared between the front fascia port and the rear fibre optic port. This allows interlocking to prevent remote access whilst an engineer is attached locally on site if IEC870 is on Com2 and Auto-detect is enabled*	AUTO-DETECT, FRONT PORT, REAR PORT	AUTO-DETECT	

2 Instruments

INSTRUMENT	DESCRIPTION
[CAP BANK METERS] --> press down <--	Start of Capacitor Bank current meters
Prim'y Currents 0.00 0.00 0.00 kA	Capacitor Bank Primary current meters
Sec'y Currents 0.00 0.00 0.00 A	Capacitor Bank Secondary current meters
[DIFF METERS] --> press down <--	Start of Overall Differential current meters
Diff1 Sec'y Currents 0.00 0.00 0.00 A	Differential 1 Secondary currents
Diff1 Currents 0.00 0.00 0.00 xIn	Differential 1 currents
Diff2 Sec'y Currents 0.00 0.00 0.00 A	Differential 2 Secondary currents
Diff2 Currents 0.00 0.00 0.00 xIn	Differential 2 currents
[UNBALANCE METERS] --> press down <--	Start of Capacitor Unbalance current meters
Reference Currents 0.00 0.00 0.00 xIn	Capacitor Unbalance Reference currents
C1 Ia Spill 0.000 xIn @ 0 deg	C1 Ia Spill current
C1 Ib Spill 0.000 xIn @ 0 deg	C1 Ib Spill current
C1 Ic Spill 0.000 xIn @ 0 deg	C1 Ic Spill current
C1 Operate Currents 0.00 0.00 0.00 xIn	C1 Operate currents
C2 Ia Spill 0.000 xIn @ 0 deg	C2 Ia Spill current
C2 Ib Spill 0.000 xIn @ 0 deg	C2 Ib Spill current
C2 Ic Spill 0.000 xIn @ 0 deg	C2 Ic Spill current
C2 Operate Currents 0.00 0.00 0.00 xIn	C2 Operate currents
[PH UNBAL METERS] --> press down <--	Start of Phase Unbalance current meters
Residual Prim'y Current 0.00 kA	Residual Primary current
Residual Sec'y Current 0.00 A	Residual Secondary current
Residual Current 0.00 xIn	Residual current
[MISC METERS] --> press down <--	Start of miscellaneous meters
Status Inputs 1-16 ---- ---- ---- ----	Displays the state of DC status inputs 1 to 16[1]
Status Inputs 17-19 ---	Displays the state of DC status inputs 17 to 19[1]
Output Relays 1-16 ---- ---- ---- ----	Displays the state of output relays 1 to 16[2]
Output Relays 17-21 ---- -	Displays the state of output relays 17 to 21[2]
Time & Date 13/08/2002 10:16:11	Time and Date

1) Display is different when fewer status inputs are fitted

2) Display is different when fewer output relays are fitted

3 IEC 60870-5-103 Communications Information

3.1 IEC 60870-5-103 Semantics in Monitor Direction

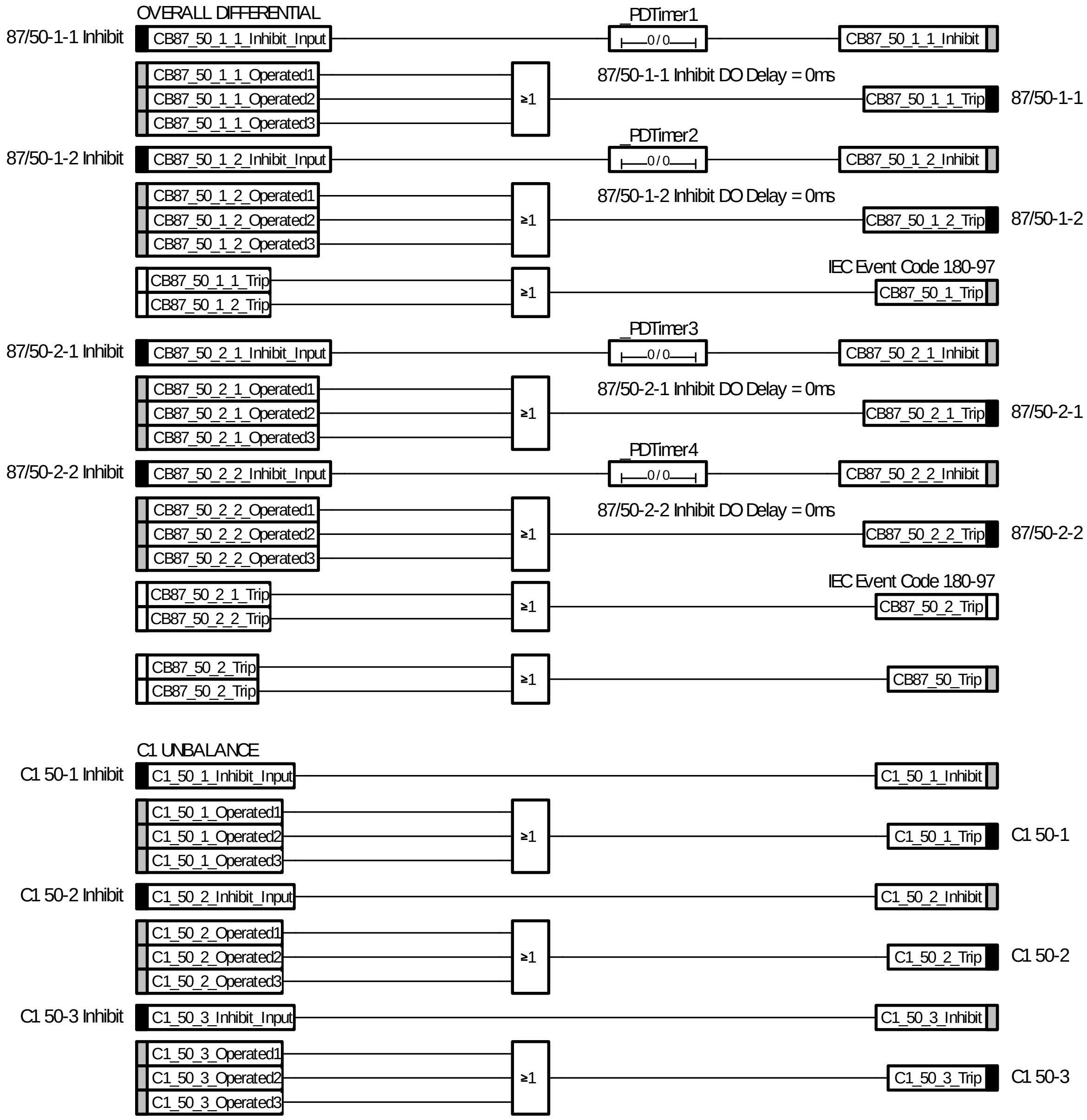
FUN	INF	Description	GI	TYP	COT
60	1	IEC870 Active Com1	x	1	1,9
60	2	IEC870 Active Com2	x	1	1,9
60	3	Front Port OverRide	x	1	1,9
60	4	Remote Mode	x	1	1,9
60	5	Service Mode	x	1	1,9
60	6	Local Mode	x	1	1,9
60	7	Local & Remote	x	1	1,9
60	8	Real Time Clock Set	-	1	1
60	9	Real Time Clock Drift Corrected	-	1	1
60	10	Real Time Clock Not Synchronised	-	1	1
60	11	Real Time Clock Synchronised	-	1	1
60	128	Cold Start	-	1	1
60	129	Warm Start	-	1	1
60	130	Re-Start	-	1	1
60	135	Trigger Storage	-	1	1
70	1	Status Input 1	x	1	1,9
70	2	Status Input 2	x	1	1,9
70	3	Status Input 3	x	1	1,9
70	4	Status Input 4	x	1	1,9
70	5	Status Input 5	x	1	1,9
70	6	Status Input 6	x	1	1,9
70	7	Status Input 7	x	1	1,9
70	8	Status Input 8	x	1	1,9
70	9	Status Input 9	x	1	1,9
70	10	Status Input 10	x	1	1,9
70	11	Status Input 11	x	1	1,9
70	12	Status Input 12	x	1	1,9
70	13	Status Input 13	x	1	1,9
70	14	Status Input 14	x	1	1,9
70	15	Status Input 15	x	1	1,9
70	16	Status Input 16	x	1	1,9
70	17	Status Input 17	x	1	1,9
70	18	Status Input 18	x	1	1,9
70	19	Status Input 19	x	1	1,9
80	1	Plant Control Relay 1	x	1	1,9
80	2	Plant Control Relay 2	x	1	1,9
80	3	Plant Control Relay 3	x	1	1,9
80	4	Plant Control Relay 4	x	1	1,9
80	5	Plant Control Relay 5	x	1	1,9
80	6	Plant Control Relay 6	x	1	1,9
80	7	Plant Control Relay 7	x	1	1,9
80	8	Plant Control Relay 8	x	1	1,9
80	9	Plant Control Relay 9	x	1	1,9
80	10	Plant Control Relay 10	x	1	1,9

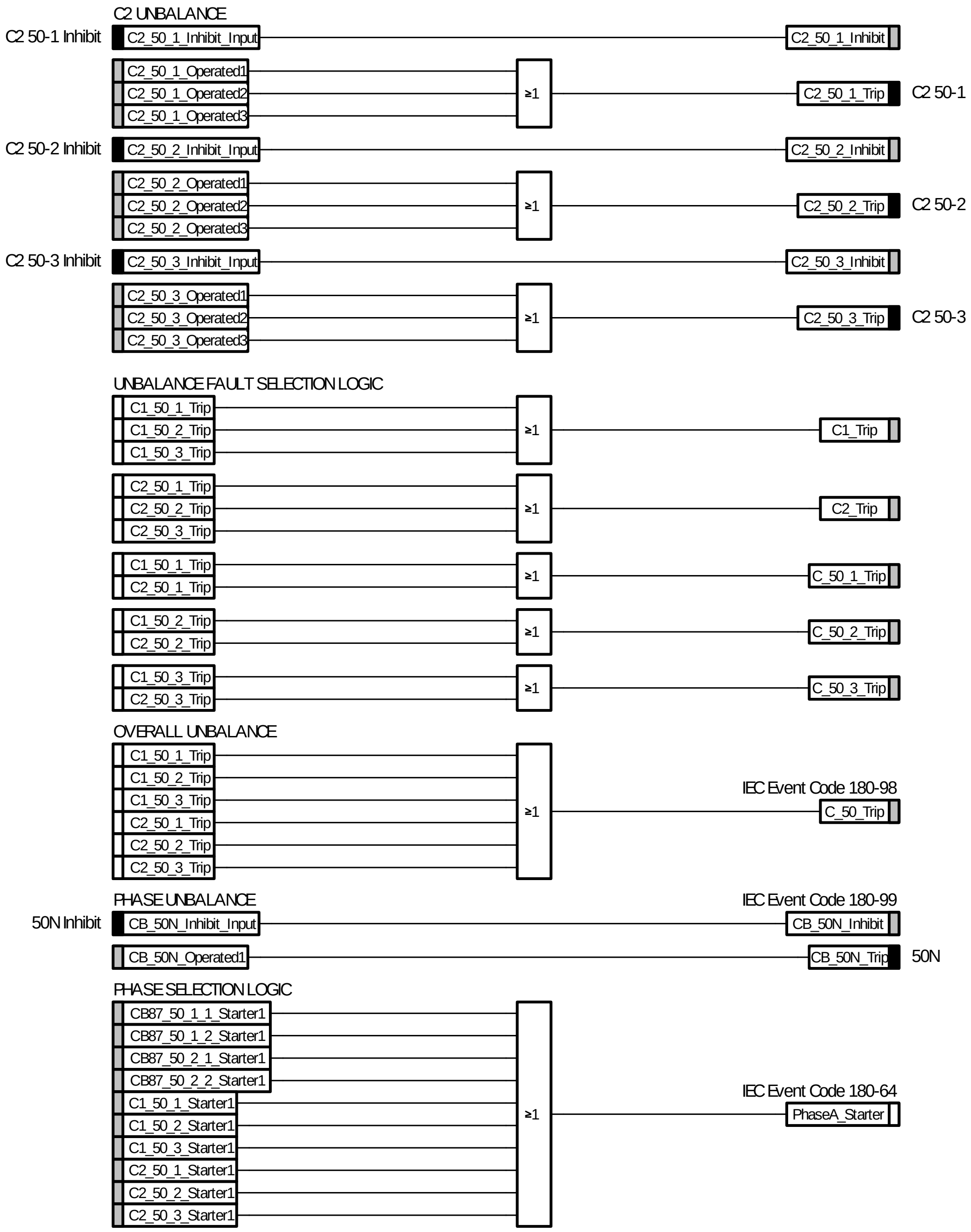
FUN	INF	Description	GI	TYP	COT
80	11	Plant Control Relay 11	x	1	1,9
80	12	Plant Control Relay 12	x	1	1,9
80	13	Plant Control Relay 13	x	1	1,9
80	14	Plant Control Relay 14	x	1	1,9
80	15	Plant Control Relay 15	x	1	1,9
80	16	Plant Control Relay 16	x	1	1,9
80	17	Plant Control Relay 17	x	1	1,9
80	18	Plant Control Relay 18	x	1	1,9
80	19	Plant Control Relay 19	x	1	1,9
80	20	Plant Control Relay 20	x	1	1,9
80	21	Plant Control Relay 21	x	1	1,9
180	0	GI End	-	8	10
180	0	Time Synchronisation	-	6	8
180	2	Reset FCB	-	2	3
180	3	Reset CU	-	2	4
180	4	Start/Restart	-	2	5
180	22	Settings changed	-	1	1
180	23	Setting G1 selected	x	1	1,9
180	24	Setting G2 selected	x	1	1,9
180	25	Setting G3 selected	x	1	1,9
180	26	Setting G4 selected	x	1	1,9
180	36	Trip Circuit Fail	x	1	1,9
180	64	Start/Pick-up L1	x	2	1,9
180	65	Start/Pick-up L2	x	2	1,9
180	66	Start/Pick-up L3	x	2	1,9
180	67	Start/Pick-up N	x	2	1,9
180	68	General Trip	-	2	1
180	69	Trip L1	-	2	1
180	70	Trip L2	-	2	1
180	71	Trip L3	-	2	1
180	84	General Start/Pick-up	x	2	1,9
180	97	Overall Differential	-	2	1
180	98	Capacitor Unbalance	-	2	1
180	99	Phase Unbalance	-	2	1

3.2 IEC 60870-5-103 Semantics in control direction

FUN	INF	Description	COM	TYP	COT
180	0	GI Initiation		7	9
180	0	Time Synchronisation		6	8
180	19	LED reset	ON	20	20

4 Reylogic Diagrams

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C2 50-1 Inhibit
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C2_50_1_Inhibit
C2_50_1_Operated1
C2_50_1_Operated2
C2_50_1_Operated3
≥1
C2_50_1_Trip
C2 50-1
C2 50-2 Inhibit
C2_50_2_Inhibit_Input
C2_50_2_Inhibit
C2_50_2_Operated1
C2_50_2_Operated2
C2_50_2_Operated3
≥1
C2_50_2_Trip
C2 50-2
C2 50-3 Inhibit
C2_50_3_Inhibit_Input
C2_50_3_Inhibit
C2_50_3_Operated1
C2_50_3_Operated2
C2_50_3_Operated3
≥1
C2_50_3_Trip
C2 50-3
UNBALANCE FAULT SELECTION LOGIC
C1_50_1_Trip
C1_50_2_Trip
C1_50_3_Trip
≥1
C1_Trip
C2_50_1_Trip
C2_50_2_Trip
C2_50_3_Trip
≥1
C2_Trip
C1_50_1_Trip
C2_50_1_Trip
≥1
C_50_1_Trip
C1_50_2_Trip
C2_50_2_Trip
≥1
C_50_2_Trip
C1_50_3_Trip
C2_50_3_Trip
≥1
C_50_3_Trip
OVERALL UNBALANCE
C1_50_1_Trip
C1_50_2_Trip
C1_50_3_Trip
C2_50_1_Trip
C2_50_2_Trip
C2_50_3_Trip
≥1
IEC Event Code 180-98
C_50_Trip
PHASE UNBALANCE
IEC Event Code 180-99
50N Inhibit
CB_50N_Inhibit_Input
CB_50N_Inhibit
CB_50N_Operated1
CB_50N_Trip
50N
PHASE SELECTION LOGIC
CB87_50_1_1_Starter1
CB87_50_1_2_Starter1
CB87_50_2_1_Starter1
CB87_50_2_2_Starter1
C1_50_1_Starter1
C1_50_2_Starter1
C1_50_3_Starter1
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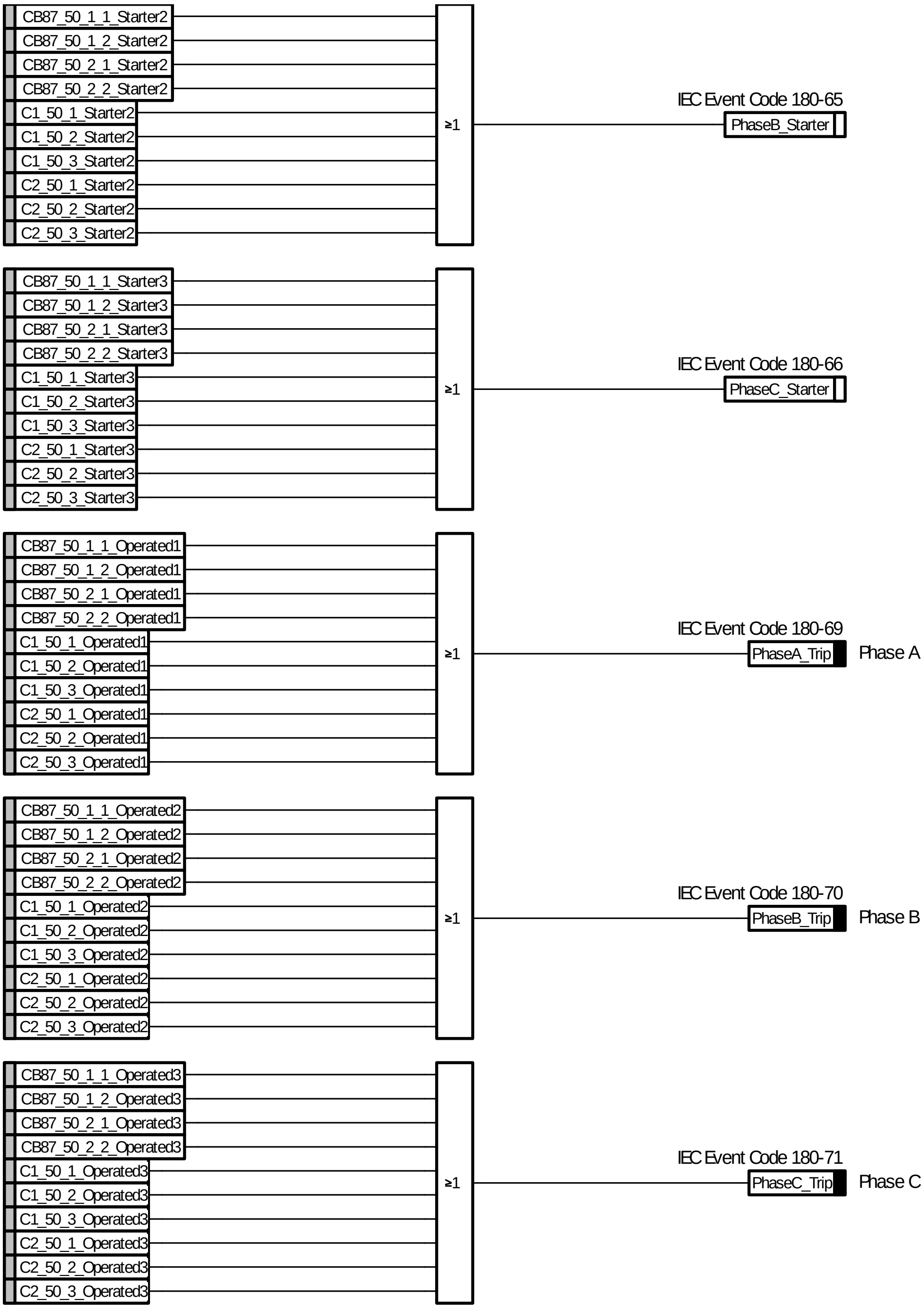
C2_50_2_Starter1
C2_50_3_Starter1
≥1
IEC Event Code 180-64
PhaseA_Starter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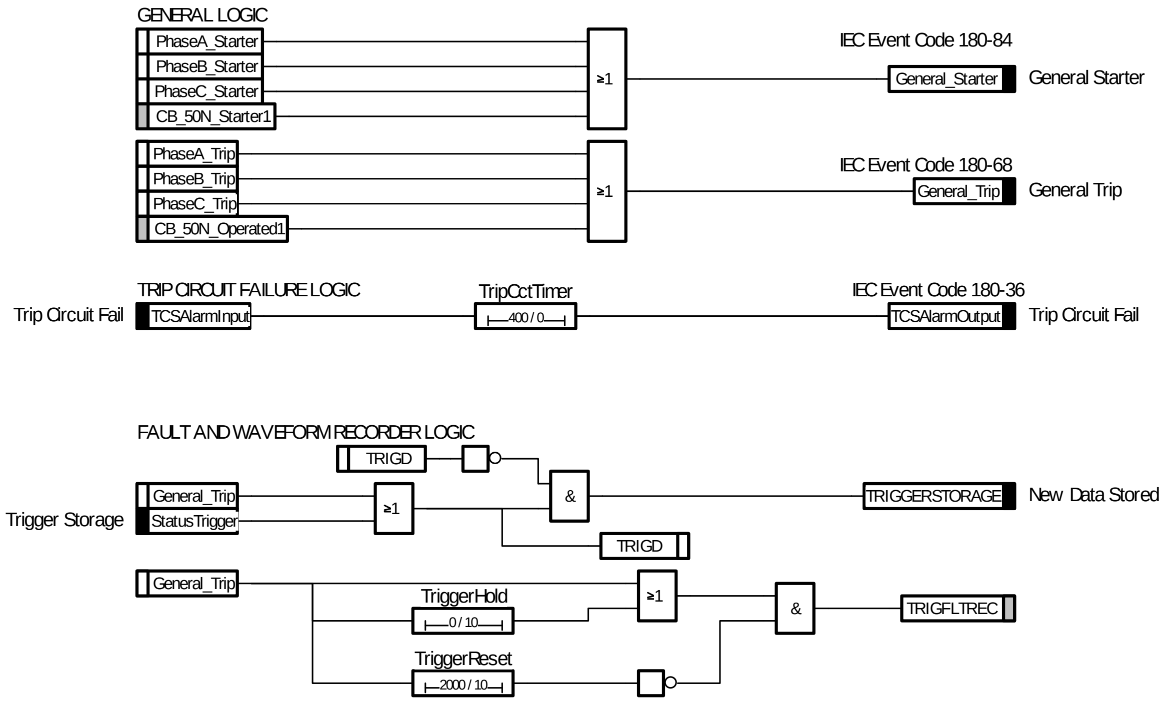
C1_50_2_Starter2
C1_50_3_Starter2
C2_50_1_Starter2
C2_50_2_Starter2
C2_50_3_Starter2
≥1
IEC Event Code 180-65
PhaseB_Starter
CB87_50_1_1_Starter3
CB87_50_1_2_Starter3
CB87_50_2_1_Starter3
CB87_50_2_2_Starter3
C1_50_1_Starter3
C1_50_2_Starter3
C1_50_3_Starter3
C2_50_1_Starter3
C2_50_2_Starter3
C2_50_3_Starter3
≥1
IEC Event Code 180-66
PhaseC_Starter
CB87_50_1_1_Operated1
CB87_50_1_2_Operated1
CB87_50_2_1_Operated1
CB87_50_2_2_Operated1
C1_50_1_Operated1
C1_50_2_Operated1
C1_50_3_Operated1
C2_50_1_Operated1
C2_50_2_Operated1
C2_50_3_Operated1
≥1
IEC Event Code 180-69
PhaseA_Trip
Phase A
CB87_50_1_1_Operated2
CB87_50_1_2_Operated2
CB87_50_2_1_Operated2
CB87_50_2_2_Operated2
C1_50_1_Operated2
C1_50_2_Operated2
C1_50_3_Operated2
C2_50_1_Operated2
C2_50_2_Operated2
C2_50_3_Operated2
≥1
IEC Event Code 180-70
PhaseB_Trip
Phase B
CB87_50_1_1_Operated3
CB87_50_1_2_Operated3
CB87_50_2_1_Operated3
CB87_50_2_2_Operated3
C1_50_1_Operated3
C1_50_2_Operated3
C1_50_3_Operated3
C2_50_1_Operated3
C2_50_2_Operated3
C2_50_3_Operated3
≥1
IEC Event Code 180-71
PhaseC_Trip
Phase C


GENERAL LOGIC
PhaseA_Starter
PhaseB_Starter
PhaseC_Starter
CB_50N_Starter1
≥1
IEC Event Code 180-84
General_Starter
General Starter
PhaseA_Trip
PhaseB_Trip
PhaseC_Trip
CB_50N_Operated1
≥1
IEC Event Code 180-68
General_Trip
General Trip
TRIP CIRCUIT FAILURE LOGIC
Trip Circuit Fail
TCSAlarmInput
TripCctTimer
400 / 0
IEC Event Code 180-36
TCSAlarmOutput
Trip Circuit Fail
FAULT AND WAVEFORM RECORDER LOGIC
TRIGD
General_Trip
StatusTrigger
Trigger Storage
≥1
&
TRIGGERSTORAGE
New Data Stored
TRIGD
General_Trip
TriggerHold
0 / 10
≥1
&
TRIGFLTREC
TriggerReset
2000 / 10

5 Label Inserts

	MSCDN-MP1	MSCDN-MP1	
	R9a	R9a	
	Left	Right	
	27/04/2010 14:49:00	27/04/2010 14:49:00	
1	GENERAL STARTER	(87/50-1-1) OVERALL DIFF	17
2	PHASE A	(87/50-1-2) OVERALL DIFF	18
3	PHASE B	(87/50-2-1) OVERALL DIFF	19
4	PHASE C	(87/50-2-2) OVERALL DIFF	20
5	CAPACITOR C1	(50-1) CAP UNBALANCE	21
6	CAPACITOR C2	(50-2) CAP UNBALANCE	22
7	TRIP CIRCUIT FAIL	(50-3) CAP UNBALANCE	23
8		(50N) PHASE UNBAL.	24
9	*AUX 1 I/P OPERATED*	*AUX 9 I/P OPERATED*	25
10	*AUX 2 I/P OPERATED*	*AUX 10 I/P OPERATED*	26
11	*AUX 3 I/P OPERATED*	*AUX 11 I/P OPERATED*	27
12	*AUX 4 I/P OPERATED*		28
13	*AUX 5 I/P OPERATED*		29
14	*AUX 6 I/P OPERATED*		30
15	*AUX 7 I/P OPERATED*		31
16	*AUX 8 I/P OPERATED*		32

MSCDN – MP1

Capacitor unbalance protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand
12/02/2003	R1 Revision history added

Software Revision History

05/05/2005	2621H80001R9a	

Contents

Figures

Glossary

Baud Rate	See *bits per second*.
Bit	The smallest measure of computer data.
Bits Per Second (BPS)	Measurement of data transmission speed.
Data Bits	A number of *bits* containing the data. Sent after the *start bit*.
Half-Duplex Asynchronous Communications	Communications in two directions, but only one at a time.
Hayes 'AT'	Modem command set developed by Hayes Microcomputer products, Inc.
IEC 60870-5-103	The International Electrotechnical Commission's Standard for communications with Protection Relays.
Master Station	See *primary station*.
Modem	MOdulator / DEModulator device for connecting computer equipment to a telephone line.
Parity	Method of error checking by counting the value of the bits in a sequence, and adding a parity bit to make the outcome, for example, even.
Parity Bit	*Bit* used for implementing parity checking. Sent after the *data bits*.
Primary Station	The device controlling the communication.
PSTN	Public Switched Telephone Network
RS232C	Serial Communications Standard. Electronic Industries Association Recommended Standard Number 232, Revision C.
Secondary Station	The device being communicated with.
Slave Station	See *secondary station*.
Start Bit	*Bit* (logical 0) sent to signify the start of a byte during data transmission.
Stop Bit	*Bit* (logical 1) sent to signify the end of a byte during data transmission.

1. Introduction

All Reyrolle relays utilise the International Communications Standard for Protection Relays, IEC 60870-5-103. This document describes how to connect the IEC60870-5-103 compliant communications interface to a control system or interrogating computer.

To access the interface the user will need appropriate software within the control system or on the interrogating computer such as Reydisp Evolution.

The Reyrolle Argus 1 to Argus 8 range of protection relays have a single rear communications interface. The Reyrolle Modular II relay range which includes Ohmega, Delta, Duobias, Iota, Tau and MicroTaPP have two rear communications interfaces COM1 & COM2. COM2 is multiplexed with an RS232 port mounted upon the Fascia :-

1. COM1: this port is used for IEC60870-5-103 communications to a substation SCADA or integrated control system by default.
2. COM2: this port can also be used for IEC60870-5-103 communications to a substation SCADA or integrated control system. Note however that only one port can be mapped to the IEC60870-5-103 protocol at any one time. (The COMMS INTERFACE submenu includes a setting “IEC60870 on port”, which maps the protocol to either COM1 or COM2). COM2 can also be accessed through an isolated RS232 (female 25-pin D-type) connector on the relay fascia. This provides facilities for access to the relay from a laptop or PC when commissioning or interrogating relays. A “COM2 Direction” setting is available which, when set to “AUTO-DETECT” automatically allows the front port to take control away from the rear port when a computer is plugged into the D-type connector.

2. Reydisp Evolution

Reydisp Evolution is a PC based software package providing capability for both local and remote communication to all Reyrolle Protection Relays . It provides features such as download of disturbance and event records, upload of relay settings, real-time monitoring of measurands and remote control of plant. Reydisp Evolution can be configured to connect to the relays using RS232, Fibre Optic, Modem or using Ethernet. When Ethernet is used the IEC 60870-5-103 protocol is transported using the TCP/IP protocol suite across a Local or Wide Area Network (LAN/WAN).

3. Connection Specification And Relay Settings

This section defines the connection medium as defined by IEC60870-5-103. Appendix A shows some typical communication connections.

3.1. Recommended cable

Two types of fibre-optic connectors are available with Reyrolle relays:

1. Fibres terminated with 9mm SMA connectors. With this type of connector the recommended cable is 62.5 / 125μm glass fibre. This will allow a maximum transmission distance of 1.7km between Reyrolle relays. It will also be the maximum distance between the ring network and the fibre to RS232 converter.

   Alternatively, 1.0mm polymer cable may be used to reduce cost. This will provide transmission distances of up to 5m between relays. Note that the distance from the transmit output of the RS232 / fibre optic converter to the receive input of the first Reyrolle relay should not be more than 6m.
2. Fibres terminated with BFOC/2.5 (ST®) bayonet-style connectors. With this type of connector the recommended cable is also 62.5 / 125μm glass fibre. This offers superior performance over the SMA connectors in terms of better coupling to the fibre and therefore has lower losses.

No other types of cable are suitable for use with Reyrolle relays.

3.2. Connection Method

Reyrolle relays can be connected in either a Star or Ring fibre-optic communications network. If star connected then a passive fibre optic hub must be used. A lower cost option is the ring configuration where the Reyrolle relays are ‘daisy chained.’ That is, the transmit output of the first relay is connected to the receive input of the second relay, and so on until the ring is complete.

Communication to the ring may be achieved either locally in the substation or remotely via the Public Switched Telephone Network (PSTN). If remote communication is desired, then additional modem equipment must be installed.

3.3. Transmission Method

The transmission method is Half Duplex serial asynchronous transmission. In IEC 60870-5-103 the line idle state is defined as Light ON. This can alternatively be selected as Light OFF in the Communications Interface menu of the relay if required for use with alternate hardware (See Section 2.5).

3.4. Transmission Rate

Rates of 19200, 9600, 4800, 2400, 1200, 600, 300, 150, 110 and 75 bits per second (BPS) are provided. Only 19200 and 9600 BPS are standard in IEC 60870-5-103, the additional rates are provided for local or modem communications.

3.5. Line Idle Setting

The line idle setting can be set to be either ON or OFF and the setting must be compatible with the device connected to the relay. The IEC 60870-5-103 standard defines a line idle state of Light On. If the device the relay is connected to, does not have a compatible fibre-optic port then a suitable electrical to optical converter is required to connect it to a standard RS232C electrical interface. A suitable converter is the Sigma 4 type, which is available from Reyrolle.

Alternative converters are the Reyrolle Dual RS232 Port (Sigma 3) or Reyrolle Passive Fibre-Optic Hub (Sigma 1).

1. The Sigma 3 Dual RS232 port provides a fibre-optic interface to a relay and two RS232 ports. The RS232 system port is typically connected to a control system while the second port is a local port. When the local port is in use the system port is automatically disabled. The Sigma 3 has an internal link to switch between line idle Light ON or Light OFF. The default configuration is Light OFF.
2. The Sigma 1 Passive Fibre-Optic Hub provides fibre-optic interfaces for up to 29 relays. It has a fibre-optic port to the control system and multiple relay connections. Each of the 30 fibre-optic ports can be configured for either Light ON or Light OFF operation. Default for all is OFF.

3.6. Parity Setting

IEC60870-5-103 defines the method of transmission as using EVEN Parity. However, in some instances an alternative may be required. This option allows the parity to be set to NONE.

3.7. Address Setting

The address of the relay must be set to a value between 1 and 254 inclusive before any communication can take place. Setting the address to zero disables communications to the relay, although if it is in an optical ring it will still obey the Data Echo setting. All relays in an optical ring must have a unique address. Address 255 is reserved as a global broadcast address.

4. Modems

The communications interface has been designed to allow data transfer via modems. However, IEC60870-5-103 defines the data transfer protocol as an 11 bit format of 1 start, 1 stop, 8 data and 1 parity bit which is a mode most commercial modems do not support. High performance modems, for example, Sonix (now 3Com), Volante and MultiTech Systems MT series will support this mode but are expensive. For this reason a parity setting (see section 2.6) to allow use of easily available and relatively inexpensive commercial modems has been provided. The downside to using no parity is that the data security will be reduced slightly and the system will not be compatible with true IEC60870 control systems.

4.1 Connecting a modem to the relay(s)

The RS232C standard defines devices as being either Data Terminal Equipment (DTE) e.g. computers, or Data Communications Equipment (DCE) e.g. modems. To connect the modem to a relay requires a fibre-optic to electrical connector and a Null Terminal connector which switches various control lines. The fibre-optic converter is then connected to the relay in the following manner :

Fibre-Optic Converter	Relay Connection
Tx	**Rx**
Rx	**Tx**

4.2 Setting the Remote Modem

Most modems support the basic Hayes 'AT' command format, though different manufacturers can use different commands for the same functions. In addition, some modems use DIP switches to set parameters while others are entirely software configured. Before applying the following settings it is necessary to return the modem to its factory default settings to ensure that it is in a known state.

The remote modem must be configured as Auto Answer, which will allow it to initiate communications with the relays. Auto answer usually requires 2 parameters to be set. One switches auto answer on and the other, the number of rings after which it will answer. The Data Terminal Ready (DTR) settings should be forced on which tells the modem that the device connected to it is ready to receive data. The parameters of the modem's RS232C port need to be set to match those set on the relay i.e. baud rate and parity to be the same as the settings on the relay, and number of data bits to be 8 and stop bits 1.

Note: although it may be possible to communicate with the modem at e.g. 19200bps, it may not be possible to transmit at this rate over the telephone system, which may be limited to 14400. A baud rate setting needs to be chosen which is compatible with the telephone system. As 14400 is not available in the relay, the next lowest rate, 9600, would have to be used.

Since the modem needs to be transparent, simply passing on the data sent from the controller to the device and vice versa, the error correction and buffering must be turned off. In addition if possible force the Data Carrier Detect (DCD) setting to ON as this control line will be used by the fibre-optic converter.

Finally these settings should be stored in the modem's memory for power on defaults.

4.3 Connecting to the remote modem

Once the remote modem is configured correctly it should be possible to dial into it using the standard configuration from a local PC. As the settings on the remote modem are fixed, the local modem should negotiate with it on connecting and choose suitable matching settings. If it does not, however, set the local modem to mimic the settings of the remote modem described above.

APPENDIX A - COMMUNICATION CONNECTIONS

Figures 1 to 6 illustrate a number of methods of connecting relays in communications networks.

Note that in the case of the optical ring configurations (Figure 4, Figure 6 and Figure 7), the Data Echo feature must be switched ON in the communications settings menu of the relay. In all other cases this setting should be set to OFF. In the data echo mode, everything that is received on the fibre optic receiver port is automatically (in hardware) re-transmitted from the transmitter port. This is made possible because of the communications standard IEC 60870-5-103 which operates half-duplex.

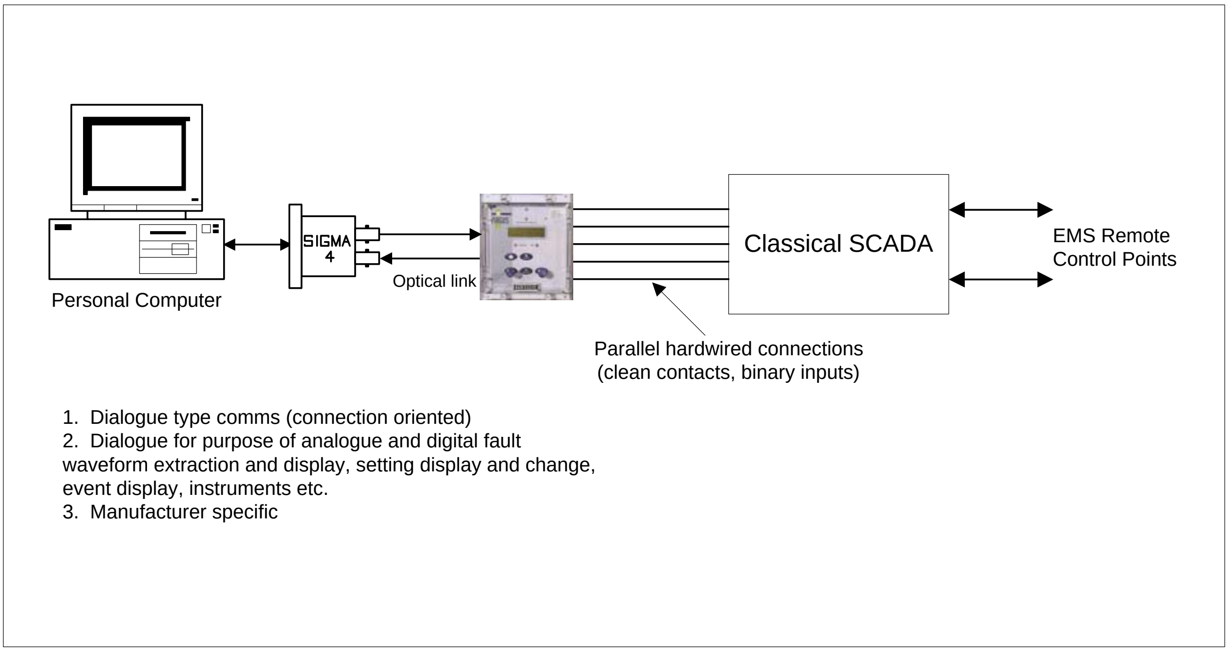
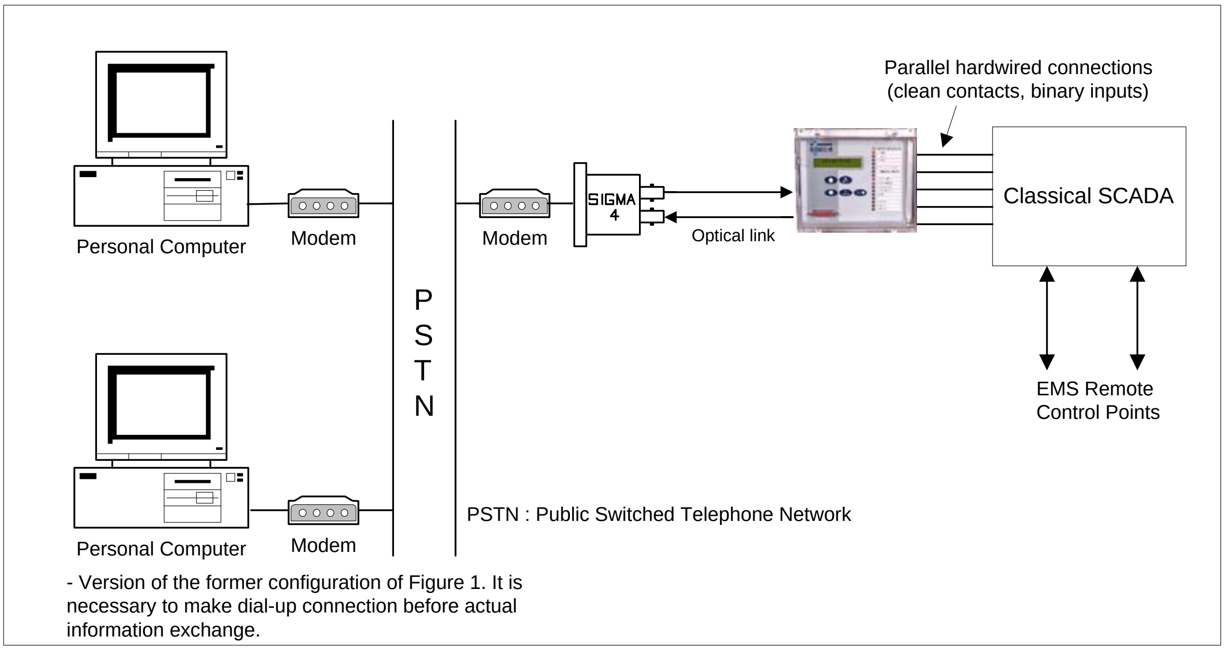


Figure 1 - Basic Communications Configuration



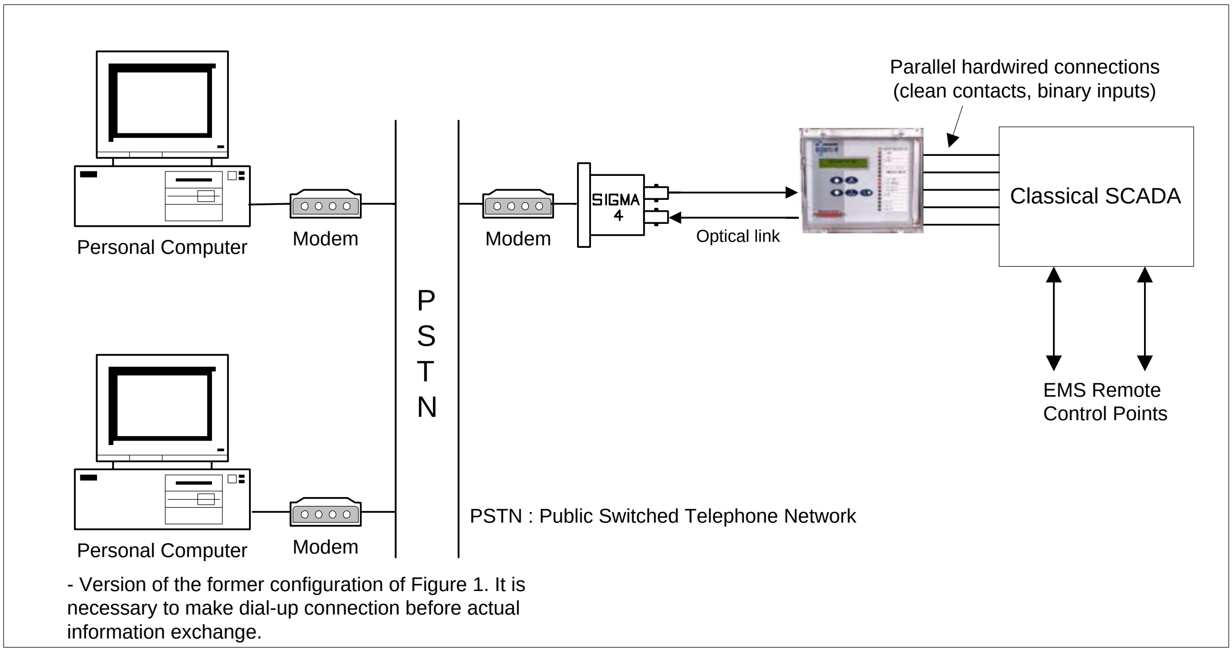


Figure 2 - Basic Communications Configuration (Remote)

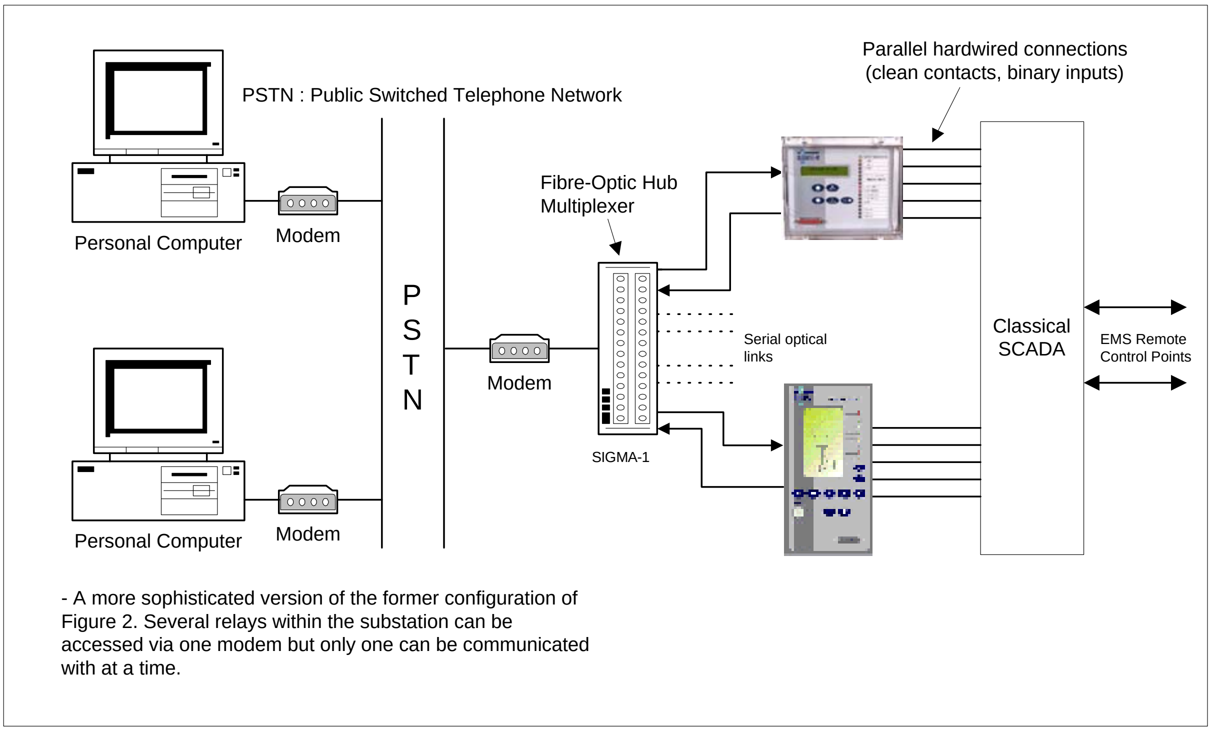


Figure 3 - Star Type Configuration (Using SIGMA-1 Multiplexer)

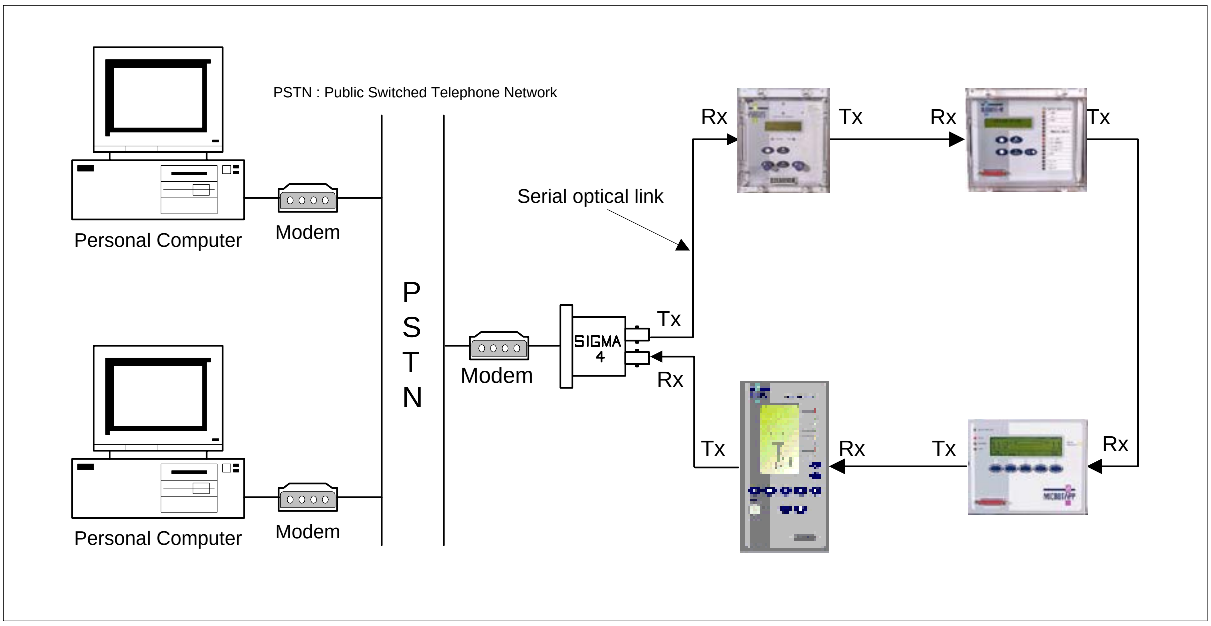


Figure 4 - Optical Ring Configuration (Using SIGMA-4 Fibre/RS232 Convertor)

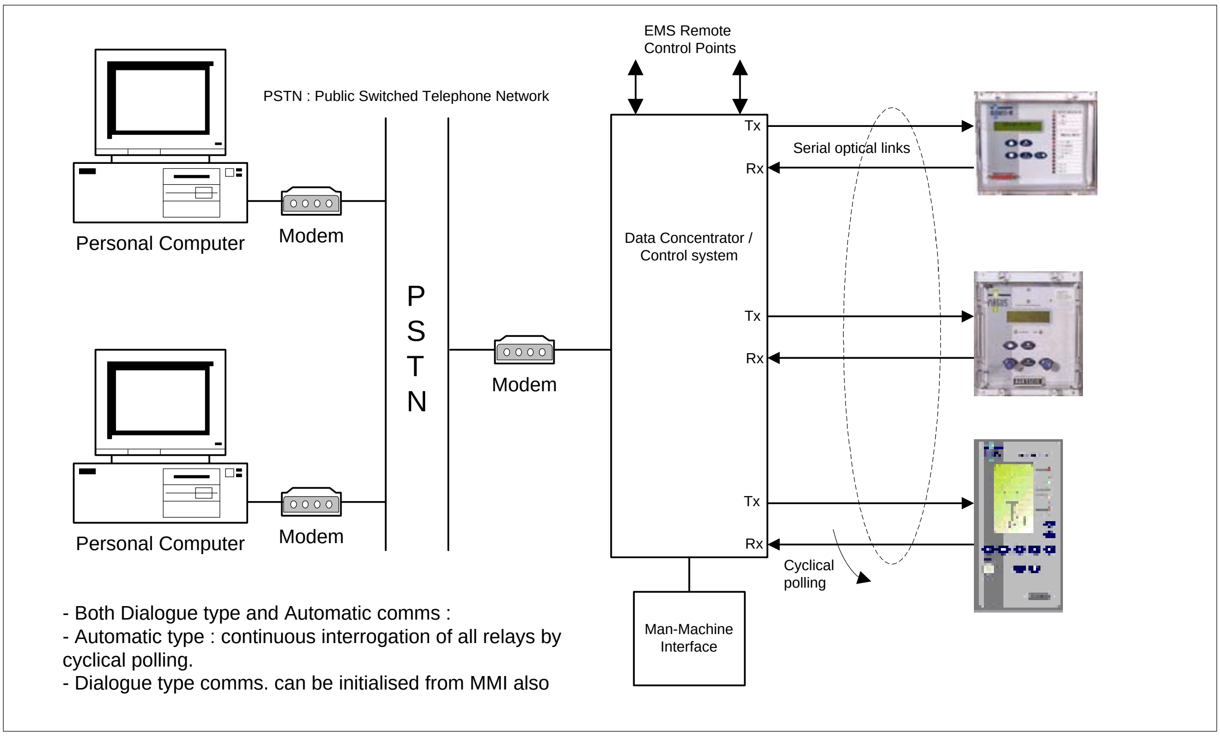


Figure 5 – Direct Control System/Data Concentrator Configuration

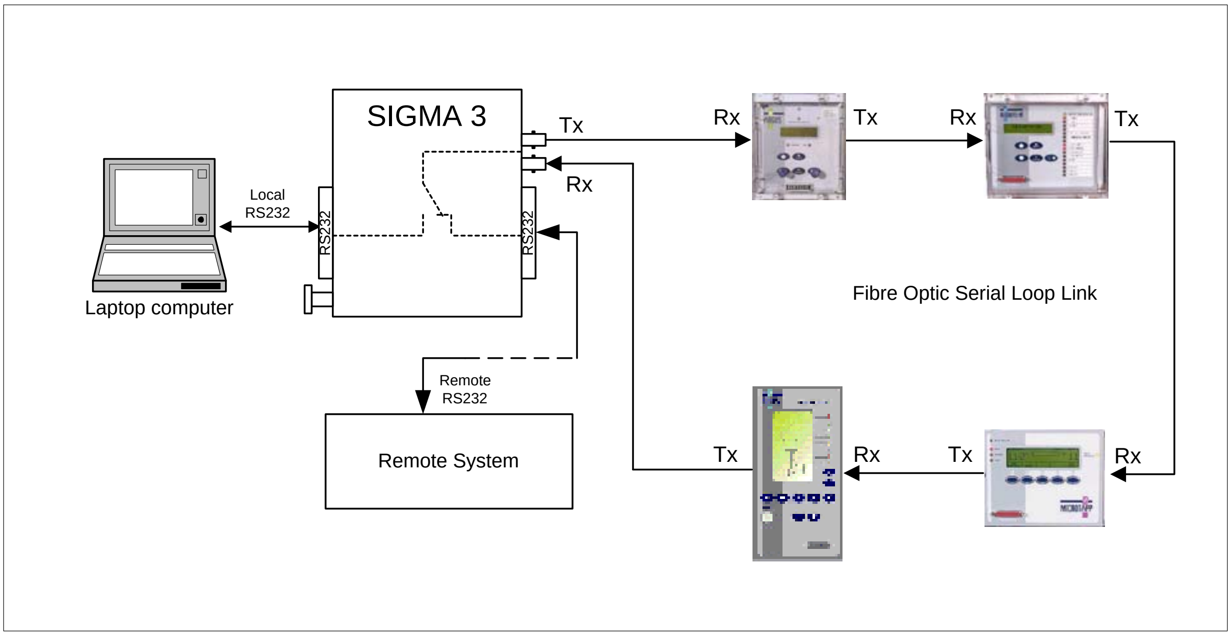


Figure 6 – Automatic switchover remote to local control using the SIGMA-3

When a portable PC is plugged into the front port of a SIGMA-3 then the remote system is automatically disconnected to ensure local control only. Alternatively on Modular II relays the portable PC may be plugged directly into the front fascia RS232 connection.

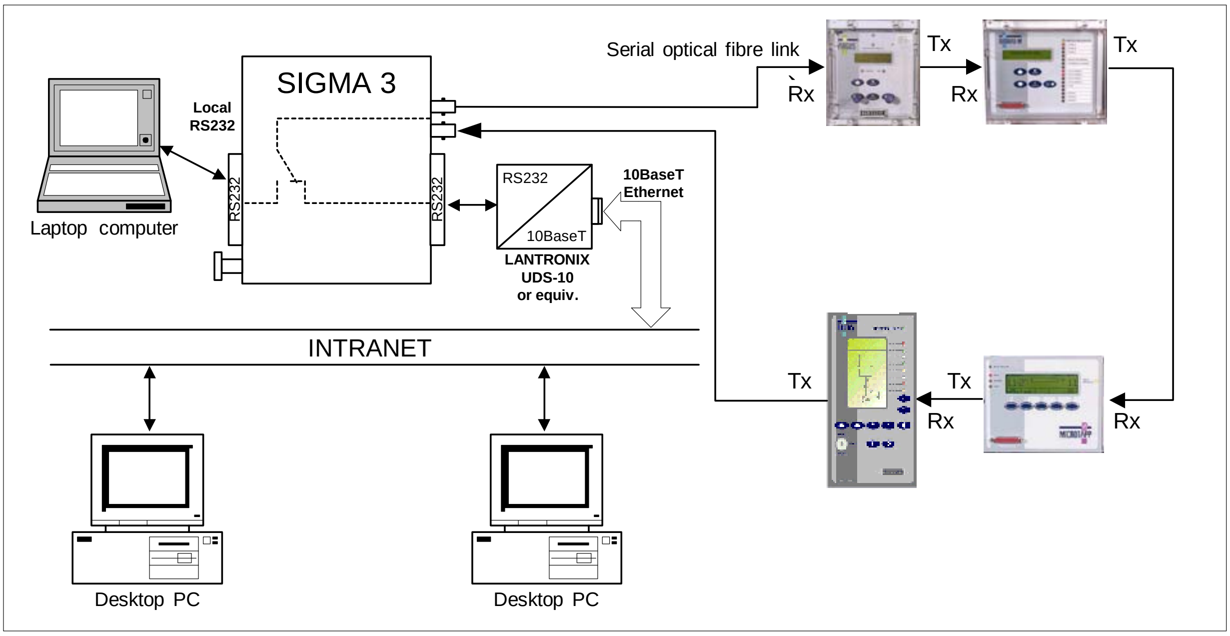


Figure 7 – LAN Network connectivity using a SIGMA-3 + Lantronix UDS-10 or equivalent

A SIGMA-3 unit may be used to as shown in Figure 7 to connect Argus and Modular II protection relays to a local area network via an Ethernet to RS232 convertor such as the Lantronix UDS-10 or similar device. SIGMA-3 units may be used on a per bay or per substation basis. They provide a single point of contact to the protection relays for monitoring and diagnostic purposes.

MSCDN – MP1

Capacitor unbalance protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand
27/08/2008	R6 Figures renumbered. Figure 4 redrawn with 50N connections added.
20/10/2005	R5 Page footer, “MSCDM” corrected to “MSCDN” Software number added.
24/05/2005	R4 Removed 2nd paragraph Sec. 2.0 - references to CT-X,. Added Fig.3 Application of 87/50 Inhibit DO Delay
28/04/2005	R3 References to CT-X and 87/50-X removed. Use of 87/50 Inhibit DO Delay described.
28/02/2003	R2 50-3 Added
07/02/2003	R1 Revision History Added

Software Revision History

05/05/2005	2621H80001R9a	

Contents

Figures

1 Introduction

The MSCDN-MP1 represents an integration of the protection elements required to provide a single box Main 1 protection unit for capacitor banks, these include Overall Differential protection, Capacitor Unbalance protection, and additional Phase Unbalance backup protection. Together with it's sister units MSCDN-MP2A and MP2B, this protection unit offers a complete solution for Main 1 and Main 2 protection of EHV capacitor banks.

The relay is based on Reyrolle's Modular II protection family, which offers the following features as standard :-

- User programmable Output Relays, Status Inputs and LED indication
- Waveform Recording
- Fault Recording
- Remote interrogation of the state of the relay logic and of the stored fault data.

These notes give guidance on the application of the relay and the protection elements integrated in it, reference may be made to the Commissioning Chapter, which provides detailed set-up instructions.

2 Overall Differential Protection

Transient stability under through fault conditions is a problem with many forms of differential protection due to variations in CT magnetising characteristics. As saturation is approached, the CT output current waveforms become increasingly distorted with a high percentage of 3rd and other higher odd harmonics. These problems can be overcome by either using biased differential protection, or more elegantly by the use of high impedance schemes. In the latter case the relay settings are calculated assuming one CT is completely saturated. Using this worst-case condition the voltage and current settings for the 87/50 Overall Differential protection can be precisely calculated with known stability margins. Intermediate condition's, where a CT is only partially saturated, increases the stability margin. This approach enables schemes to be engineered using CT's with relatively low knee point voltages.

2.1 High Impedance Differential Protection

The stability of a current balance scheme using a high impedance relay circuit depends upon the circuit voltage setting being greater than the maximum voltage which can appear across the relay under a given through fault condition. A setting resistor or resistors, and non-linear resistor per phase, complete the scheme and are mounted externally to the relay. The voltage level required for stability and the value of relay current calculated to provide the required primary fault setting determines the resistor value. Non linear resistors protect the CT's and relay from the excessively high voltages which may occur e.g. for high values of in-zone fault current, see Figure 1 – Basic Dual Element High Impedance Differential .

2.1.1 Determination of Stability

The stability of a current balance scheme using a high impedance relay circuit is based on the fact that for a given through fault condition, the maximum voltage that can occur across the relay circuit is determined by means of a simple calculation. If the setting voltage of the relay is made equal to or greater than this voltage, then the protection will be stable. In calculating the required setting voltage of the relay it is assumed that one current transformer is fully saturated and that the remaining CT's maintain their ratio. In this condition, the excitation impedance of the saturated CT is negligible and the resistance of the secondary winding, together with leads connecting the CT to the relay terminals, constitute the only burden in parallel with the relay as shown in figure 2. Thus the voltage across the relay is given by:

$$V = I \times (X1 + Y1) \quad \text{for CT1 saturated}$$
$$V = I \times (X2 + Y2) \quad \text{for CT2 saturated}$$

Where :-

X1 and X2 = the secondary winding resistances of the CT's.

Y1 and Y2 = the value of the pilot loop resistance between the relative CT and the relay circuit terminals.

I = the CT secondary current corresponding to the maximum steady state through fault current of the protected equipment.

V = the maximum voltage that can occur across the relay circuit under through fault conditions.

For stability, the voltage setting, Vs, of the relay must be made equal to or exceed, the highest value of V calculated above. Experience and extensive laboratory tests have proved that if this method of estimating the relay setting voltage is adopted, the stability of the protection will be very much greater than the value of I used in the calculation. This is because a CT is normally not continuously saturated and consequently any voltage generated by this CT will reduce the voltage appearing across the relay circuit. The relay is a low burden, current operated relay and the stability voltage setting is achieved by employing a series resistor of appropriate ohmic value (e.g. depending on the current setting chosen) and power dissipation rating.

2.1.2 Current Transformer Requirements

For high impedance schemes it is necessary to establish characteristics of the CT in accordance with Class ‘X’ to BS 3938 and that where the CT’s are specifically designed for this protection their overall size may be smaller than that required for an alternative current balance protection. The basic requirements are:

- All CT’s should, if possible have identical turns ratios.
- The knee point voltage of each CT, should be at least 2 x Vs.
- The knee point voltage is expressed as the voltage applied to the secondary circuit with the primary open circuit which when increased by 10% causes the magnetising current to increase by 50%.

2.1.3 Overvoltage Protection

The maximum primary fault current in the protected zone will cause high voltage spikes across the relay at instants of zero flux since a practical CT core enters saturation on each half-cycle for voltages of this magnitude. Thus it is necessary to suppress the voltage with a non-linear resistor in a shunt connection, which will pass the excess current as the voltage rises. The type of non-linear resistor required is chosen by its thermal rating.

2.1.4 Fault Setting

The fault setting of a current balance protection using a high impedance relay circuit can be calculated in the following manner.

Primary fault setting = N (I + I1 + I2 + I3 +Ish)

where :-

I = the relay operating current. I1, I2, I3 = the excitation currents of the CTs at the relay setting voltage.
N = the CT ratio.
Ish = other shunt circuits where provided e.g. non-linear resistor etc.

The fault setting of the protective scheme depends upon the protected equipment and the type of system earthing.

2.2 Setting Example

A Setting Example is included in Application Guide – High Impedance Circulating Current Protection Calculations (Report No. 990/TR/7/1)

2.3 Application of 87/50 Inhibit DO Delay

The 87/50 Elements are high speed elements and in certain scheme configurations e.g. the application of in-zone surge arrestors, may operate due to switching transients. When it is not possible to reach a suitable compromise of security and dependability by application of the elements’ setting and stabilising delay, then a particular element may be inhibited via external signal. A signal is applied to a status input (Aux I/P), via either one of the CB auxiliary contacts or a control signal. Using the STATUS INPUT MENU, this signal may be inverted to realise the optimum scheme security, based on the use of NO or NC energising contacts. The signal is then logically connected to the 87/50 Inhibit and a combination of Aux I/P Pickup Delay and 87/50 Inhibit DO Delay used to optimise the required blocking period. See Figure 2 – Application of 87/50 Inhibit DO Delay.

3 Capacitor Unbalance Protection

Although the relay capacitor unbalance element may be applied to other arrangements, such as Star-connected, Split star-connected and Delta-connected capacitor banks, it has primarily been designed for use on capacitor banks incorporating a single phase bridge arrangement, as shown in Figure 3 - Simplified Single Phase Bridge Capacitor Bank

3.1 Principal Of Operation

Consider Figure 3 - Simplified Single Phase Bridge Capacitor Bank, which shows the protection current measuring points I_{Ref} and I_{Spill}.

I_{Ref} being the chosen reference current, in this case the capacitor current, but which may be any current, which varies in proportion to I_{Spill}.

I_{Spill} is the current measured across the H-section of the capacitor bank.

Consider the equation below, for an un-faulted capacitor bank, any given I_{Ref} will produce a proportional Spill Current I_{Spill}, such that the ratio of I_{Spill} to I_{Ref} is a constant i.e.

$$\overrightarrow{Ratio} = \frac{\overrightarrow{I_{Spill}}}{\overrightarrow{I_{Ref}}}$$ **Eq. 1**

At Nominal Operating Conditions i.e. Rated Voltage, the Nominal Values for I_{Ref} and I_{Spill} can be calculated. Using these values, I_{RefNom} and $I_{SpillNom}$, which are entered as settings, then the NomRatio may be calculated from Eq. 1.

$$\overrightarrow{NomRatio} = \frac{\overrightarrow{I_{SpillNom}}}{\overrightarrow{I_{RefNom}}}$$ **Eq. 2**

By re-arranging Eq. 1, and substituting for NomRatio and the latest value of I_{Ref}, the Expected Spill Current, $I_{Expected}$ can be calculated for any instant, as follows :-

$$\overrightarrow{I_{Expected}} = \overrightarrow{NomRatio} \times \overrightarrow{I_{Ref}}$$ **Eq. 3**

Using $I_{Expected}$ and I_{Spill} (the measured spill current), $I_{Operate}$ is the difference between the two i.e.

$$\overrightarrow{I_{Operate}} = \overrightarrow{I_{Spill}} - \overrightarrow{I_{Expected}}$$ **Eq. 4**

The RMS value of $I_{Operate}$ is calculated and compared with the Operate Setting.

3.2 Discussion of Principal of Operation and Measurement Accuracy

The choice of current transformer (CT) ratios is important to ensure optimum performance of the protection. CT ratio's for measurement of I_{Ref} and I_{Spill} should be chosen, so that at Nominal Operating Conditions i.e. Rated Voltage :-

I_{Ref} Secondary $\geq$ I_{Spill} Secondary

If through poor choice of CT ratio's and/or high standing spill current, I_{Spill} Secondary > I_{Ref} Secondary and therefore the settings entered for I_{RefNom} and $I_{SpillNom}$ produce an NomRatio which is > 1, then the accuracy of the protection element will be impaired, since measurement errors inherent in I_{Ref} are multiplied by NomRatio, see Eq. 3.

For this reason, it is strongly recommended that CT ratio's are chosen to ensure that the ratio of $I_{SpillNom}$ to I_{RefNom} is less than or equal to 1 i.e.

$$\frac{\overrightarrow{I_{Spill}}}{\overrightarrow{I_{Ref}}} \leq 1$$

If this is not the case then the accuracy and the minimum setting, which may be applied, will be degraded as follows :-

Minimum Applied Setting :-

Minimum Applied Setting ≥ $\left(5\times\frac{\overrightarrow{I_{Spill}}}{\overrightarrow{I_{Ref}}}\right)\times$ Minimum Relay Setting

or Minimum Relay Setting, whichever is greater.

Eq. 5

Accuracy :-

Accuracy ≤ $\left(5\times\frac{\overrightarrow{I_{Spill}}}{\overrightarrow{I_{Ref}}}\right)\%$ or 5% whichever is greater.

Eq. 6

Note :-

The above calculations for Minimum Applied Setting and Accuracy include a 5x safety margin.

Consider this example :-

The values entered for I_{RefNom} and $I_{SpillNom}$ are such that $I_{SpillNom}$ is 4 x I_{RefNom}, and produce a NomRatio vector, which is the equivalent of 4x.

Therefore the Minimum Setting which may be applied is (see Eq. 5) :-

(5 x 4) x 0.02 x In = **0.40 x In**

And the Accuracy will be degraded to (see Eq. 6) :-

(5 x 4)% = **20%**

3.3 Application of the Capacitor Unbalance Element

During the construction of the capacitor bank, it is common practice to measure the capacitance of each element of the making up the capacitor bank and then calculate the expected standing spill, for each phase.

The capacitor bank will be energised and the standing spill for each phase measured and checked against the calculated value.

After de-energisation, the capacitance of each element will then be measured again, to confirm that there are no failures following initial energisation.

The standing spill correction settings, are calculated and checked during testing, as described above. The Reference currents would normally be set to the default value of 1.00 xIn and the Spill current magnitude setting would be the calculated spill for each phase capacitor configuration.

In the case of capacitor bank shown in Figure 5 – Capacitor Unbalance - Single Phase Bridge Connection Schematic, the spill current of capacitor C1 and capacitor C2 will be normally be in-phase or in anti-phase to the reference current, therefore the angle setting for the spill current any particular phase would be 0˚ or 180˚. The relay includes, the setting range –180˚ to 180˚ in 1˚ steps, to cater for situations where the Spill Angle may not be exactly 0˚ or 180˚, or the capacitor configuration is such that the nominal angles are not 0˚ and 180˚.

The Cx 50-1 element setting would be calculated based on the number of fuse failures required to generate an alarm condition. For example, a single fuse failure, the setting would be 20-80% of the spill current due to the failure and for a failure of two fuses the setting may be 75% of the calculated current, so that the alarm will not operate for a failure of one fuse, but is sure to operate for failure of two fuses.

The Cx 50-2 element would normally be used as the trip element and the setting calculation would be based on the number of fuse failures, which would be deemed a fault condition, the general formula would be :-

$$Setting = \frac{\left((N-1)+{}^{P}\!/\!_{100}\right)*Spill}{N}$$

where :

N = Number of fuse failures.

P = Percentage of single fuse failure for stability.

Spill = Calculated spill current for failure of N fuses.

4 Phase Unbalance Protection

The Phase Unbalance element calculates the RMS phase residual current, which is then applied to an overcurrent detector, with a following DTL. This element will primarily be applied as a backup protection, which will detect open circuit faults on one or two capacitor bank phases.

Consider Figure 6 – Phase Unbalance – Backup Open Circuit Protection, which shows the protective zone for open circuits, an open circuit, within this zone, in any single or two phases,will cause an increase in residual current. The setting must be chosen to provide adequate operation at the minimum generated residual current for single or two phase open-circuits, as a guide 20% of rated capacitor bank current is a common setting.

5 Current Transformer Requirements

The current transformer requirements are dominated by the requirements for the Overall Differential protection – please refer to the current transformer requirements for that particular protection element, when determining the CT requirements.

6 Diagrams

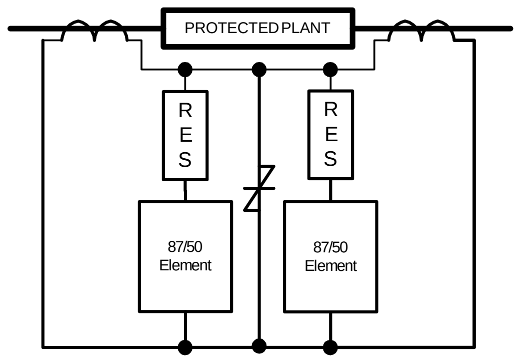


Figure 1 – Basic Dual Element High Impedance Differential Protection

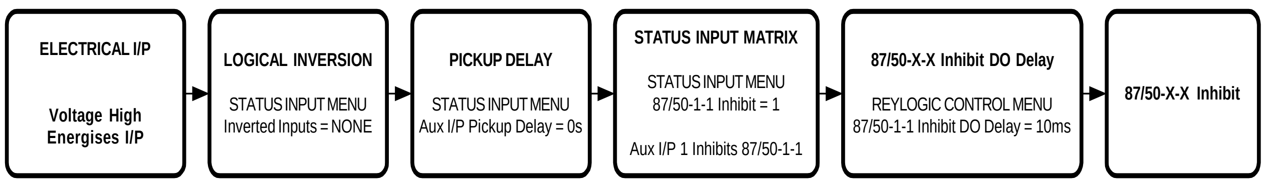


Figure 2 – Application of 87/50 Inhibit DO Delay

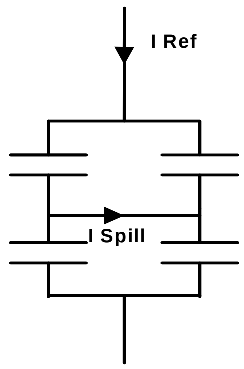


Figure 3 - Simplified Single Phase Bridge Capacitor Bank

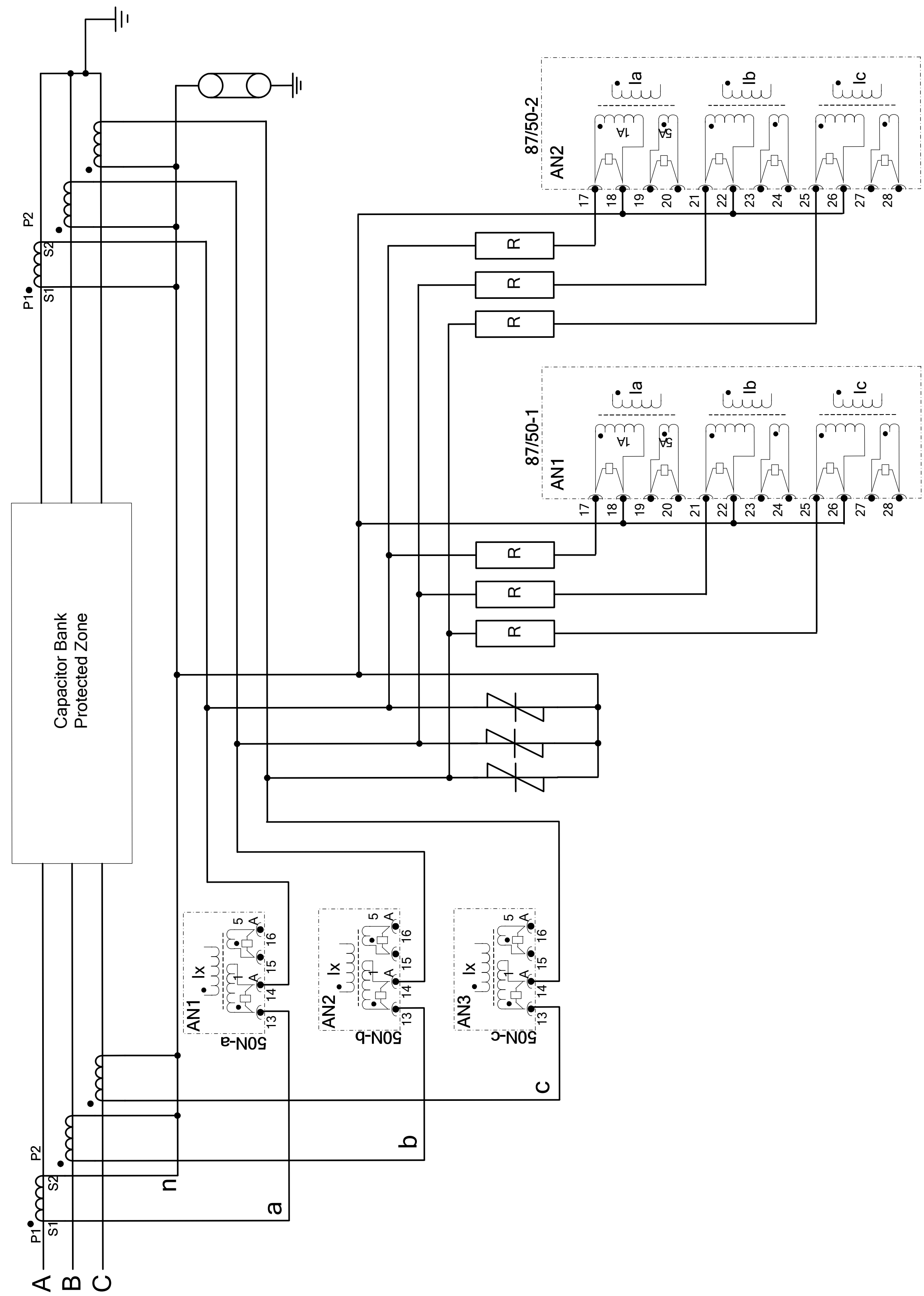


Figure 4 – Typical Dual High Impedance scheme with additional 50N protection

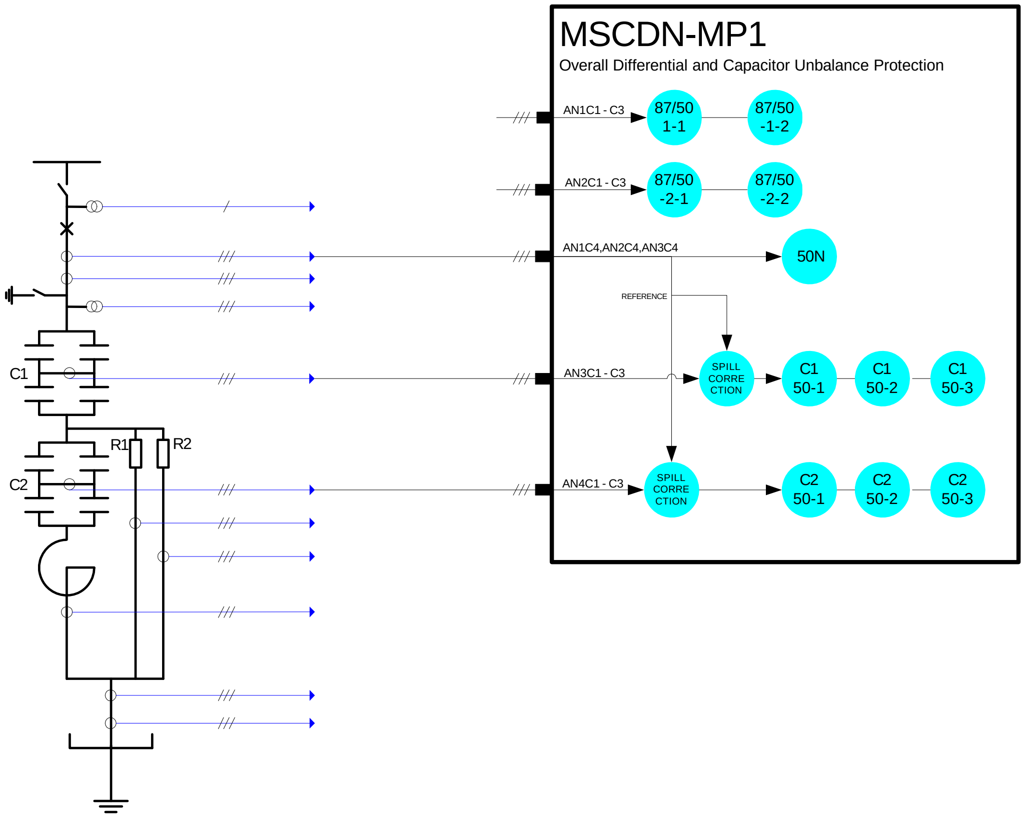


Figure 5 – Capacitor Unbalance - Single Phase Bridge Connection Schematic

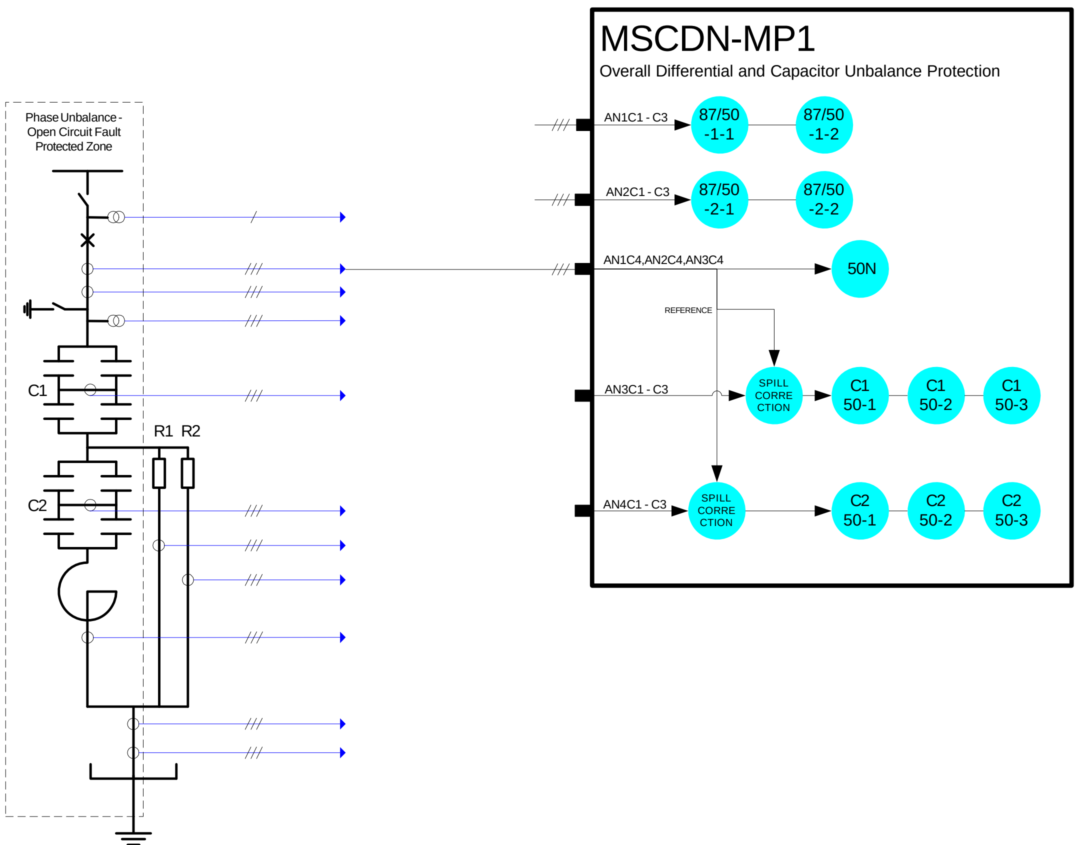


Figure 6 – Phase Unbalance – Backup Open Circuit Protection

MSCDN – MP1

Capacitor unbalance protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand
18/10/2004	R4 Software revision Ref. changed to R9a
18/10/2004	R3 ST fibre optics added
10/02/2003	R2 Adopted for MP1,MP2A and MP2B
23/10/2002	R1 Revision History Added..

Software Revision History

05/05/2005	2621H80001R9a	

Contents

1 Unpacking, Storage and Handling

On receipt, remove the relay from the container in which it was received and inspect it for obvious damage. It is recommended that the relay modules are not removed from the case. To prevent the possible ingress of dirt, the sealed polythene bag should not be opened until the relay is to be used.

If damage has been sustained a claim should immediately be made against the carrier, also inform Reyrolle Protection and the nearest Reyrolle agent, using the Defect Report Form in the Maintenance section of this manual.

When not required for immediate use, the relay should be returned to its original carton and stored in a clean, dry place.

The relay contains static sensitive devices, these devices are susceptible to damage due to static discharge and for this reason it is essential that the correct handling procedure is followed.

The relay's electronic circuits are protected from damage by static discharge when the relay is housed in its case. When individual modules are withdrawn from the case, static handling procedures should be observed.

- Before removing the module from its case the operator must first ensure that he is at the same potential as the relay by touching the case.
- The module must not be handled by any of the module terminals on the rear of the chassis.
- Modules must be packed for transport in an anti-static container.
- Ensure that anyone else handling the modules is at the same potential.

As there are no user serviceable parts in any module, there should be no requirement to remove any component parts.

If any component parts have been removed or tampered with, then the guarantee will be invalidated. Reyrolle Protection reserve the right to charge for any subsequent repairs.

2 Recommended Mounting Position

The relay uses a liquid display (LCD) which is used in programming and or operation. The LCD has a viewing angle of ± 45º and is back lit. However, the best viewing position is at eye level, and this is particularly important when using the built-in instrumentation features.

The relay should be mounted to allow the operator the best access to the relay functions.

3 Relay Dimensions

The relay is supplied in an Epsilon case 16. Diagrams are provided elsewhere in this manual.

4 Fixings

4.1 Crimps

Amp Pidg or Plasti Grip Funnel entry ring tongue

Size	AMP Ref	Reyrolle Ref
0.25-1.6mm^2	342103	2109E11602
1.0-2.6mm^2	151758	2109E11264

4.2 Panel Fixing Screws

2-Kits – 2995G10046 each comprising:

- Screw M4 X10
2106F14010 – 4 off

- Lock Washes
2104F70040 – 4 off

- Nut M4
2103F11040 – 4 off

4.3 Communications

Two pairs of fibre optic ST™ (BFOC/2.5) bayonet connectors (COM1 and COM2 rear), each made up of a transmitter and receiver), optimised for glass-fibre, are fitted to the rear of the case. (Refer to section 4 – Communications Interface).

25 Pin RS232 D Type connector on front of relay (COM2 front) accessible with front cover removed. Note this shares COM2 with COM2 Rear.

5 Ancillary Equipment

The relay can be interrogated locally or remotely by making connection to the fibre optic terminals on the rear of the relay or the RS232 port on the relay fascia. For local interrogation a portable PC is required. The PC must be capable of running Microsoft Windows Ver 3.1 or greater, and it must have a standard RS232 port. A standard data cable is required to connect from the PC to the 25 pin female D type connector on the front of the relay. For remote communications more specialised equipment is required. See the section on Communications for further information, and also see Report No. 690/0/01 on Relay Communications.

6 Precautions

When running fibre optic cable, the bending radius must not be more than 50mm.

If the fibre optic cables are anchored using cable ties, these ties must be hand tightened – under no circumstances should cable tie tension tools or cable tie pliers be used.

MSCDN – MP1

Capacitor unbalance protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand
28/04/2005	R2 References to CT-X and 87/50-X removed and replaced with 87/50-X-1 and 87/50-X-2 respectively.
12/02/2003	R1 Revision History Added. First Issue.

Software Revision History

05/05/2005	2621H80001R9a	

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1. Introduction

These commissioning recommendations apply to the testing, putting into service and subsequent maintenance of MSCDN-MP1 (**Modular II)** series integrated capacitor bank protection.

A software program called Reydisp Evolution is available for download from the www.siemens.com/energy website. This allows access to settings, waveform records and event records via relay communications with an IBM PC compatible computer.

Before starting the test procedures, the protection settings, the D.C. inputs, output relay configuration details must be available. This requires the following information: Capacitor Bank current rating, nominal Spill currents and the C.T. ratios. The Overall Differential protections setting must also have been determined using the calculated performance for stability and sensitivity.

It is recommended that use is made of all the tables provided so that a comprehensive record of the protection settings, as commissioned, is available for reference.

2. Safety

The commissioning and maintenance of this equipment should only be carried out by skilled personnel trained in protective relay maintenance and capable of observing all the safety precautions and Regulations appropriate to this type of equipment and also the associated primary plant.

Ensure that all test equipment and leads have been correctly maintained and are in good condition. It is recommended that all power supplies to test equipment be connected via a Residual Current Device (RCD) which should be located as close to the supply source as possible.

The choice of test instrument and test leads must be appropriate to the application. Fused instrument leads should be used when measurements of power sources are involved, since the selection of an inappropriate range on a multi-range instrument could lead to a dangerous flashover. Fused test leads should not be used where the measurement of a current transformer (C.T.) secondary current is involved, the failure or blowing of an instrument fuse or the operation of an instrument cut-out could cause the secondary winding of the C.T. to become an open circuit.

Open circuit secondary windings on energised current transformers are a hazard that can produce high voltages dangerous to personnel and damaging to equipment, test procedures must be devised so as to eliminate this risk.

3. Sequence of Tests

If other equipment is to be tested at the same time as the relay, then such testing must be co-ordinated to avoid danger to personnel and equipment.

When cabling and wiring is complete, a comprehensive check of all terminations for tightness and compliance with the approved diagrams must be carried out. This can then be followed by the insulation resistance tests, which if satisfactory allows the wiring to be energised by either the appropriate supply or test supplies. When injection tests are completed satisfactorily, all remaining systems can be functionally tested before the primary circuit is energised. Some circuits may require further tests, e.g synchronising before being put on load.

4. Test Equipment Required

Various test sets designed for protection testing can be used to test the relay providing these provide the required current source with sinusoidal waveform within practical limits.

Test currents of the following range are required:

Testing of the C1/C2 Unbalance elements requires a minimum of 2 sources to be applied simultaneously, however 3 sources may be connected in such a way as to make testing of this element easier.

Overall Differential	Both up to I_N
C1/C2 Unbalance Reference	up to 2.5 xI_N
C1/C2 Unbalance Spill	up to 2.5 xI_N
Phase Unbalance	up to 2.5 xI_N

Where I_N is the relay nominal current rating being used.

The basic test equipment for primary and secondary injection test is as follows:

a) A digital test set capable of at least 2 x three phase current injection. The set must be capable of injecting at least 4 x the rated current on any of the relay inputs. For relay models with voltage inputs the amplifiers need to be reconfigured for voltage output.

b) 1 - 500V insulation resistance test set.

c) 1 – Digital Multimeter

d) Laptop PC to drive the test set and the Reydisp Evolution relay software.

e) 500volt Variac to measure CT magnetizing characteristics and inject the Restricted Earth Fault elements.

f) Primary test leads and injection set.

Suitable primary injection connectors and secondary injection test plugs and leads and a suitable a.c supply may be required and must be suitable for the site concerned.

When making secondary injection tests ensure that the test circuit is earthed at one point only.

5. Insulation Resistance Test

Before commencing to inspect the wiring take the following precautions:

Isolate the auxiliary supplies
Remove the trip and inter-trip links

Check that the relay wiring is complete and that all terminal connections are tight and remove the C.T. earth link for the insulation resistance tests.

Measure the insulation resistance between each section of the wiring and the other sections connected together and to earth.

The sections comprise:

a) C.T. secondary wiring connected to module AN1
b) C.T. secondary wiring connected to module AN2
c) C.T. secondary wiring connected to module AN3
d) C.T. secondary wiring connected to module AN4
e) D.C. wiring connected to PSU and I/O modules, excluding power supply wiring to the PSU Module.

Before testing the D.C. wiring to earth, apply test connections between suitable points to short circuit each status input and series resistor to avoid possible damage to the opto-coupler should the wiring be earthed.

f) Test the power supply wiring to module PSU separately. Note that the D.C. +ve and D.C. -ve are each connected to earth by surge capacitors.

Record the results in Table 1 - Insulation Resistance Values.

Wiring Section	**Resistance MegaOhms**
AN1 C.T.'s to earth and other circuits	
AN2 C.T.'s to earth and other circuits	
AN3 C.T.'s to earth and other circuits	
AN4 C.T.'s to earth and other circuits	
D.C. Wiring to Earth and other circuits	
Power Supply wiring to earth	

Table 1 - Insulation Resistance Values

Insulation resistance values that are considered satisfactory must depend upon the amount of wiring involved. Generally, where a considerable amount of multi-core wiring is included, a reading of 2M ohms to 3M ohms is reasonable, For short lengths of wiring on a panel, higher readings should be expected. A reading of 1M ohm should not normally be considered satisfactory.

6. Check of C.T. and Secondary Wiring Resistance

This test is to be applied to each of the Overall Differential protections.

Isolate the auxiliary supplies
Remove the trip and inter-trip links

Refer to the calculated performance data for the Overall Differential. This will give the maximum permissible lead resistance values.

Measure the resistance of the wiring between the relay equipment and the C.T.'s. The readings obtained should be recorded. These should be approximately equal to or less than the values used in the calculated settings for the Overall Differential elements.

Wiring Section	Resistance Ohms
AN1C1 (Overall Differential 1 Phase A)	
AN1C2 (Overall Differential 1 Phase B)	
AN1C3 (Overall Differential 1 Phase C)	
AN2C1 (Overall Differential 2 Phase A)	
AN2C2 (Overall Differential 2 Phase B)	
AN2C3 (Overall Differential 2 Phase C)	
AN1C4 (Ia Reference)	
AN2C4 (Ib Reference)	
AN3C4 (Ic Reference)	
AN3C1 (C1 Spill Phase A)	
AN3C2 (C1 Spill Phase B)	
AN3C3 (C1 Spill Phase C)	
AN4C1 (C2 Spill Phase A)	
AN4C2 (C2 Spill Phase B)	
AN4C3 (C2 Spill Phase C)	

Table 2 – Lead Resistance Values

7. Power Supply

Remove the relay front cover to give access to all the fascia push buttons. Relays are provided with a power supply suitable for one of the standard auxiliary supply ratings of 30V, 48V, 110V, 220V D.C. Ensure that the actual supply is the same as the relay rating as marked on the fascia. Ensure the polarity of the supply is correct before energising the relay. Note, the minimum recommended fuse rating of the supply is 6 A slow-blow or 12 A HRC fuse. Note that the relay D.C. status inputs are current rated.

With the relay energised the green LED will provide a steady illumination, all the red LEDs should be out. Operate the TEST/RESET button and check that all the red LEDs are illuminated while the push is depressed.

8. Programming the Relay

The relay can either be set using the fascia buttons or from a laptop PC running Reydisp Evolution. Due to the number of possible settings, it is recommended that the laptop method be used for speed and ease of commissioning.

8.1 Setting by Laptop

The relay is supplied with an RS232 port on the front of the fascia. This should be connected to a laptop using a 25 to 9 way RS232 cable. Reydisp Evolution should be installed – this will run on any MS Windows © operating system.

To access the relay communications port the Communications Settings in the relays must match the settings Communications settings selected in the Reydisp Evolution software.

To change the communications settings on the relay use the following procedure. On the relay fascia, keep tapping the ⇩ key until the COMMUNICATIONS MENU is displayed on the relay LCD. Press the TEST/RESET ⇨ once to bring up the STATION ADDRESS on the LCD. Press the ENTER button to alter the address to any desired number between 1 and 254. Set each relay to a unique number in the substation. The relays address and the relay address must be set identically. The relay address can be changed by tapping the ⇩ or ⇧ buttons. Press ENTER to register the selected number.

Continue to scroll down and set IEC 870 ON PORT to COM2 (front RS232 and bottom rear fibre ports are COMM 3 relay ports) and set AUTO DETECT to ON. The Auto Detect feature will automatically switch the active port to the front RS232 from the bottom rear fibre port when connection is made.

Ensure that the Communications baud rate and parity check settings on the Reydisp Evolution software running on laptop and Relay are the same. It is advisable to select the maximum baud rate on the relay and Reydisp Evolution, as this speeds up response times.

The communications setting can be changed in Reydisp Evolution by selecting:
OPTIONS -> COMMUNICATIONS. This window displays the active part of the laptop. Select " OK" when changes are complete. Set the address on Reydisp Evolution to be the same as the relay station address.

Check the communications link by retrieving the relay settings (Relay->Settings->Get Settings)

Reydisp Evolutions allows off line generation of relay setting by saving the relay Settings File and then downloading it. This saves time and possibly sore fingers if the relay type is a more advance model with many protection functions.

To download a Settings File On the laptop, select Relay->Settings->Send All Settings. Confirm the action and the program will inform whether the settings have been successfully entered into the relay. It is worth doing a few spot checks on the setting to be confidant the correct setting are installed.

8.2 Setting via Relay Fascia

The relay can be set from the fascia by utilising the ⇧, ⇩ ,⇨ and ENTER buttons. Settings can be selected with the arrow buttons. Pressing ENTER when the setting to change is found will make the setting flash. This allows the ⇧ and ⇩ buttons to be used to alter the setting. Once the desired setting is selected the ENTER pushbutton MUST be pressed for the relay to active the selected setting. The setting will now stop flashing indicating this value will be utilised by the relay software.

The menu structure is shown in the "Description of Operation " section of this manual.

9. Secondary Injection Tests

Isolate the auxiliary D.C. supplies for alarm and tripping from the relay and remove the trip and intertrip links.

We recommend the use of an Omicron Test Set Type CMA156. The Omicron set should be connected in accordance with the manufacturer's instructions.

By default all protection elements are disabled, however if this is not the case, then disable all protection and alarm elements.

9.1 Accuracy of Measurement

Inject all of the current inputs with nominal current in turn, and record the following currents measured by the relay in Table 3 – Accuracy of Measurement.

Tap ⇩ to select: -
e.g. Diff1 Currents
0.00 0.00 0.00 x I_n

Use ⇩ and ⇧ to select the current measured by each of the inputs injected: -
e.g. Diff2 Currents
0.00 0.00 0.00 x I_n

If the relay measurement is within tolerance proceed to 9.2 below. If any of the measurements are outside the stated tolerance (±5%) the relay must be sent back to the Quality Assurance Department for investigation.

Meter	A	B	C
Diff1 Currents	A xIn	B xIn	C xIn
Diff2 Currents	A xIn	B xIn	C xIn
Reference Currents	A xIn	B xIn	C xIn
C1 Ia Spill	xIn	Angle	
C1 Ib Spill	xIn	Angle	
C1 Ic Spill	xIn	Angle	
C2 Ia Spill	xIn	Angle	
C2 Ib Spill	xIn	Angle	
C2 Ic Spill	xIn	Angle	
Residual Current	xIn		

Table 3 – Accuracy of Measurement

9.2 Checking the Overall Differential 1 Elements

When testing the Overall Differential 1 Element the Differential 1 Currents can be displayed on the LCD by changing to INSTRUMENTS mode and scrolling down to [Diff1 Currents]. Generally 87/50-1-1 is used for tripping with no time delay applied and 87/501-2 is used for CT supervision (broken CT connection) and is therefore set very low but with a 10 second time delay.

Connect a single phase current source to Phase A, see Table below :-

		Connection	
Phase	**Unit**	**Start**	**Finish**
A	AN1C1	17	18
B	AN1C2	21	22
C	AN1C3	25	26

Modify the following settings :-

Setting Description	Setting Value
87/50-1-1 Element	Enabled
87/50-1-1 Delay	0.1

Modify the operate setting and determine the PU and DO at each setting :-

Setting Description	Setting Value	PU	DO
87/50-1-1 Setting	0.05		
87/50-1-1 Setting	0.10		
87/50-1-1 Setting	0.50		
87/50-1-1 Setting	0.90		

Table 4 – 87/50-1-1 Element PU/DO

Record the results and verify the accuracy complies with performance stated in the Performance Specification.

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Repeat Tests for connections to Phase B and C.

Modify the following settings :-

Setting Description	Setting Value
87/50-1-1 Element	Disabled
87/50-1-2 Element	Enabled
87/50-1-2 Delay	0.1

Modify the operate setting and determine the PU and DO at each setting :-

Setting Description	Setting Value	PU	DO
87/50-1-2 Setting	0.05		
87/50-1-2 Setting	0.10		
87/50-1-2 Setting	0.50		
87/50-1-2 Setting	0.90		

Table 5 – 87/50-1-2 Element PU/DO

Record the results and verify the accuracy complies with performance stated in the Performance Specification.

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Repeat Tests for connections to Phase B and C.

9.3 Checking the Overall Differential 2 Elements

When testing the Overall Differential 2 Element the Differential 2 Currents can be displayed on the LCD by changing to INSTRUMENTS mode and scrolling down to [Diff2 Currents].

Connect a single phase current source to Phase A, see Table below :-

		Connection	
Phase	**Unit**	**Start**	**Finish**
A	AN2C1	17	18
B	AN2C2	21	22
C	AN2C3	25	26

Modify the following settings :-

Setting Description	Setting Value
87/50-2-1 Element	Enabled
87/50-2-1 Delay	0.1

Modify the operate setting and determine the PU and DO at each setting :-

Setting Description	Setting Value	PU	DO
87/50-2-1 Setting	0.05		
87/50-2-1 Setting	0.10		
87/50-2-1 Setting	0.50		
87/50-2-1 Setting	0.90		

Table 6 – 87/50-2-1 Element PU/DO

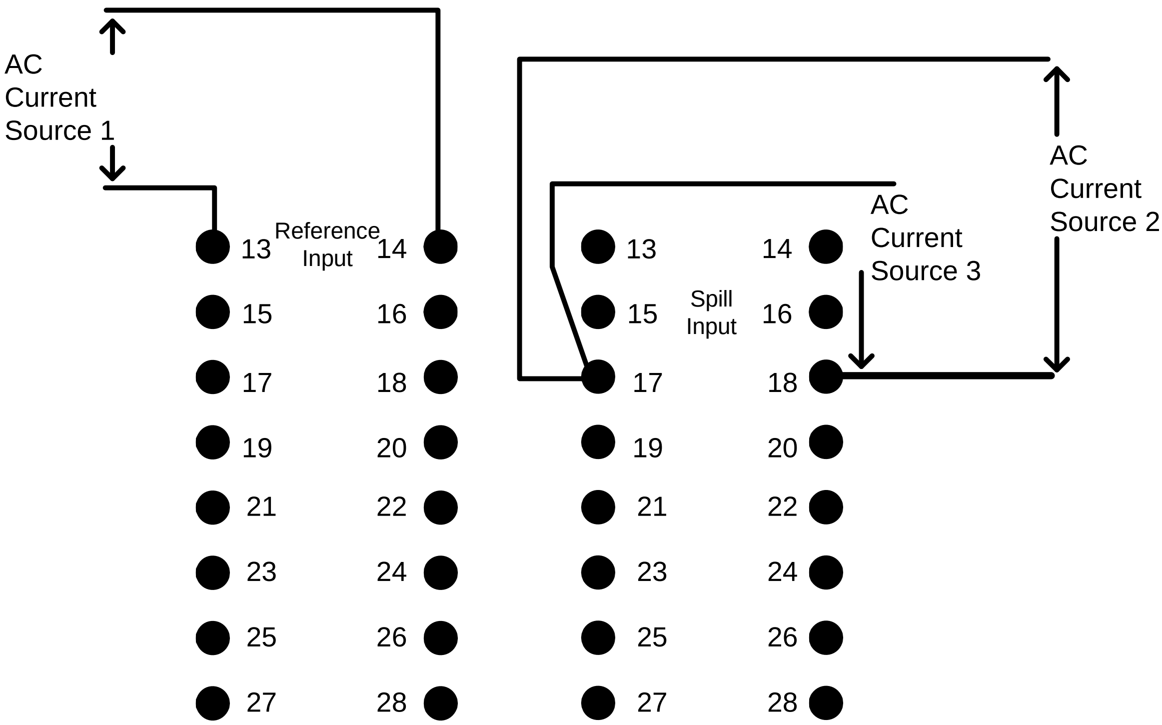
Record the results and verify the accuracy complies with performance stated in the Performance Specification.

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Repeat Tests for connections to Phase B and C.

Modify the following settings :-

Setting Description	Setting Value
87/50-2-1 Element	Disabled
87/50-2-2 Element	Enabled
87/50-2-2 Delay	0.1



Modify the operate setting and determine the PU and DO at each setting :-

Setting Description	Setting Value	PU	DO
87/50-2-2 Setting	0.05		
87/50-2-2 Setting	0.10		
87/50-2-2 Setting	0.50		
87/50-2-2 Setting	0.90		

Table 7 – 87/50-2-2 Element PU/DO

Record the results and verify the accuracy complies with performance stated in the Performance Specification.

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Repeat Tests for connections to Phase B and C.

9.4 C1 Unbalance (C1 50-2 Element)

With Reference to the connection diagram and table below :-

Figure 1 – C1 Unbalance Test Connection Diagram

	Reference			Spill		
Phase	**Unit**	**Start**	**Finish**	**Unit**	**Start**	**Finish**
A	AN1C4	13	14	AN3C1	17	18
B	AN2C4	13	14	AN3C2	21	22
C	AN3C4	13	14	AN3C3	25	26

Note:- Current Sources 1, 2 and 3 must be synchronised

Connect the current sources as described for Phase A.

Modify the following Settings :-

Menu	Setting Description	Setting Value
C1 UNBALANCE MENU	C1 50-2 Element	Enabled
C1 UNBALANCE MENU	C1 50-2 Delay	0.1

Using Table 4 – 87/50-1-1 Element PU/DO apply the necessary settings and determine the PU and DO of the element.

Settings				Current Sources						
CAPACITOR CONFIG MENU	C1 UNBALANCE MENU			Source 1		Source 2		Source 3		
Reference	Spill	Angle	C1 50-1 Setting	Magnitude	Angle	Magnitude	Angle	PU	DO	Angle
1.0	0.50	0	0.20	1.0	0	0.50	0			0
0.8	0.20	90	0.10	0.8	0	0.20	90			90
0.7	0.10	180	0.10	0.7	0	0.10	180			180
0.6	0.05	-90	0.05	0.6	0	0.05	-90			-90

Table 8 - C1 50-1Unbalance Tests

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Return all settings to their original configuration.

Repeat for Phases B and C.

Return all settings to their default values.

9.5 C2 Unbalance (C2 50-2 Element)

With Reference to the connection diagram and table below :-

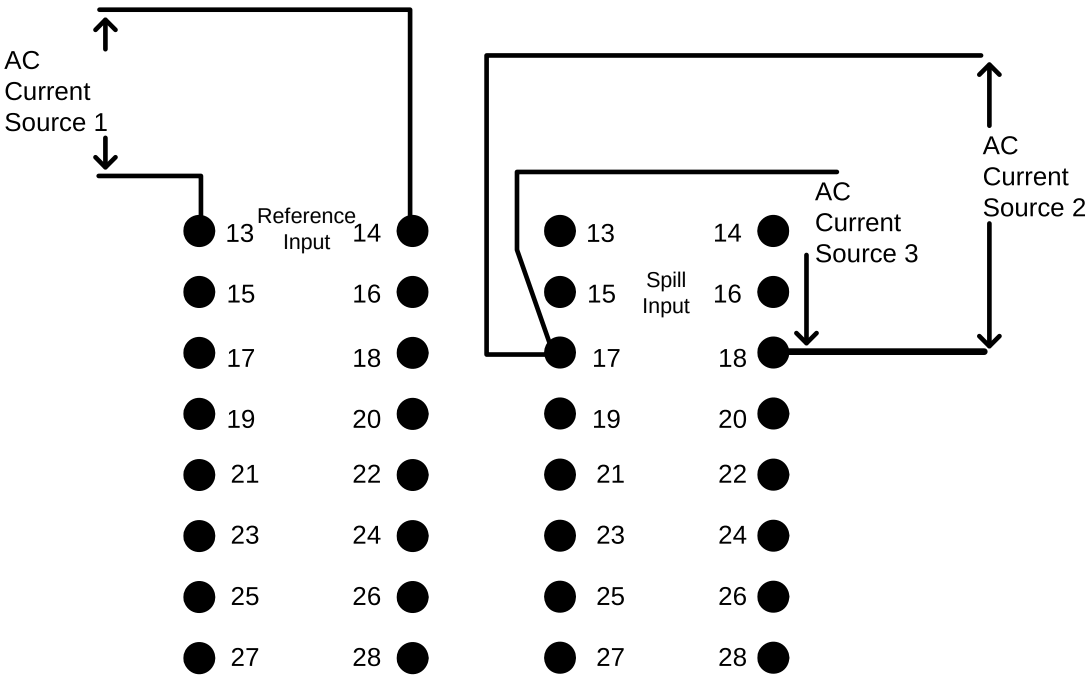


Figure 2 – C2 Unbalance Test Connection Diagram

	Reference			Spill		
Phase	**Unit**	**Start**	**Finish**	**Unit**	**Start**	**Finish**
A	AN1C4	13	14	AN3C1	17	18
B	AN2C4	13	14	AN3C2	21	22
C	AN3C4	13	14	AN3C3	25	26

Note:- Current Sources 1, 2 and 3 must be synchronised

Connect the current sources as described for Phase A.

Modify the following Settings :-

Menu	Setting Description	Setting Value
C2 UNBALANCE MENU	C2 50-2 Element	Enabled
C2 UNBALANCE MENU	C2 50-2 Delay	0.1

Using Table 9 - C2 50-1Unbalance Tests apply the necessary settings and determine the PU and DO of the element.

Settings				Current Sources						
CAPACITOR CONFIG MENU	**C2 UNBALANCE MENU**			**Source 1**		**Source 2**		**Source 3**		
Reference	**Spill**	**Angle**	**C2 50-1 Setting**	**Magnitude**	**Angle**	**Magnitude**	**Angle**	**PU**	**DO**	**Angle**
1.0	0.50	0	0.20	1.0	0	0.50	0			0
0.8	0.20	90	0.10	0.8	0	0.20	90			90
0.7	0.10	180	0.10	0.7	0	0.10	180			180
0.6	0.05	-90	0.05	0.6	0	0.05	-90			-90

Table 9 - C2 50-1Unbalance Tests

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Return all settings to their original configuration.

Repeat for Phases B and C.

Return all settings to their default values.

9.6 Phase Unbalance (50n Element)

Connect the relay as shown below :-

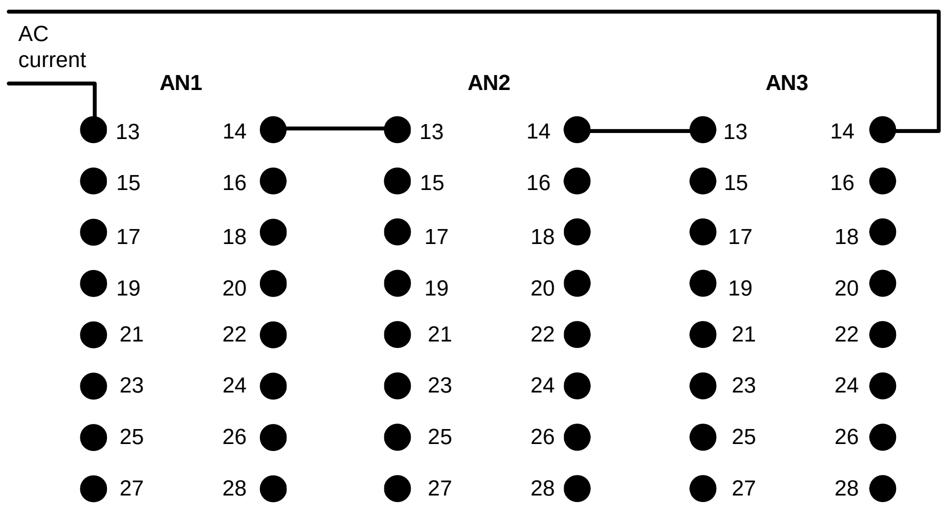


Figure 3 – Phase Unbalance Test Connection Diagram

Modify the following Settings :-

Menu	Setting Description	Setting Value
PHASE UNBALANCE MENU	50N Element	Enabled
PHASE UNBALANCE MENU	50N Delay	0.1

Modify the operate setting and determine the PU and DO at each setting :-

Setting Description	Setting Value	PU	DO
50N Setting	0.60		
50N Setting	0.90		
50N Setting	1.20		
50N Setting	1.50		

Note:- Since the applied 3 phase currents are in phase then the PU and DO levels will be approximately a third of the setting value.

Record the results and verify the accuracy is 5%.

Verify the correct operation of the Output Relay RL6 and the LED indication.

Return all settings to their default values.

10. Primary Injection Tests

Primary injection tests are required to prove the CT ratio and secondary connections to the relay. A polarity test is required for this relay, but only in respect of the phase relationship between the Phase Reference inputs and the corresponding C1 and C2 Spill inputs.

Reference Currents	A xIn	B xIn	C xIn
C1 Ia Spill	xIn	Angle	
C1 Ib Spill	xIn	Angle	
C1 Ic Spill	xIn	Angle	
C2 Ia Spill	xIn	Angle	
C2 Ib Spill	xIn	Angle	
C2 Ic Spill	xIn	Angle	

Table 10 – Primary Injection Test Results

Inject using a primary injection test set and record and verify the expected levels on the instruments on the relay, the Reference Currents and corresponding Spill current will be in phase when the Spill Angle is zero.

11. Fault Setting Tests

Fault setting tests use primary injection testing to verify the protection settings, they can conveniently be combined with the current transformer ratio and polarity tests in section 10.1.

Isolate the auxiliary d.c. supplies for trip and alarm, remove the Trip and Intertrip links. Use the test circuit shown in Fig 8. Inject primary current and record the values at which the relay operates. Relay operation is indicated by LEDs 2,3 and 4. Check the operation of all the output relays selected for this function, i.e. HV Trip, LV Trip and alarm(s) functions.

The LEDs that operate for the phase-to-phase injection will depend on the vector group compensation setting. e.g.

11.1 Overall Differential 1 & 2 Protections

Isolate the auxiliary d.c. supplies for trip and alarm and remove the Trip and Intertrip links.

Check that the setting resistor is the correct ohmic value, also that the correct Overall Differential 1 & 2 settings are selected.

Measure the primary current for operation of the 87/50-X-1 and 87/50-X-2 elements and record the value obtained.

12. Tripping and Intertripping Tests

Re-connect the auxiliary d.c. supplies for trip and alarm operations and insert the Trip and InterTrip links.

Simulate the operation of each external contact that initiates a status input and in each case check that appropriate LED illuminates and that the correct tripping, intertripping and alarm initiation occurs.

Disconnect the d.c. power supply to the relay and check for correct PROTECTION INOPERATIVE alarm. Operate all protection and alarm elements in turn by primary or secondary injection and check that the correct tripping and indication occurs.

13. Tests Using Load Currents

Isolate the auxiliary d.c. supplies for the trip and alarm functions.

Ensure that the relay is set the assigned settings for the capacitor bank installation.

Energise the Capacitor Bank.

Utilising the INSTRUMENT Displays verify the correct meter readings for each of the instruments, paying attention to the following :-

- Ensure all primary current displays are correct, thus verifying CT Ratio settings are correct.
- Ensure all secondary current displays are correct, thus verifying CT input settings are correct.
- Verify that there is minimal Diff1 Currents and Diff2 Currents displayed, thus verifying that the Overall Differential circuit is balanced.
- Verify that the Reference and Spill Currents correspond to those calculated for the capacitor bank.
- Verify that there is minimal C1 and C2 Operate Currents, thus verifying the C1 and C2 Unbalance settings.
- Verify the that there is minimal Residual Current, thus verifying the Capacitor Bank is phase balanced.

14. Putting in to Service

Ensure that: The trip supply is connected.
All the RED LEDs are off
The GREEN LED is ON steady.

Ensure that all earth links, trip links and inter-trip links are in their normal operational positions.

Operate the Cancel PUSH BUTTON

Check that the LCD displays the screen below , or the 'Relay Identifier' set in the SYSTEM CONFIG MENU.

MSCDN-MP1

Replace the cover. The above reading will remain for approximately 1 hour then the screen will go blank.

MSCDN – MP1

Capacitor unbalance protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand
03//05/2005	R2 Software Revision to R9a
21/02/2003	R1 First version

Software Revision History

05/05/2005	2621H80001R9a	

1 Maintenance Instructions

The MSCDN MP1, MP2A & MP2B relays are maintenance free relays, with no user serviceable parts. During the life of the relay it should be checked for operation during the normal maintenance period for the site on which the product is installed. It is recommended the following tests are carried out :

1. Visual inspection of the metering display (every year)
2. Operation of output contacts (every 2 years)
3. Secondary injection of each element (every 5 years)

2 Defect Report Form

Form sheet for repairs and returned goods (fields marked with * are mandatory fields)

Sender:

*** Name, first name:**	Complete phone number (incl. country code):	Complete fax number (incl. country code):
Email address:	*** Org-ID and GBK reference:**	*** AWV:**

*** Order-/ reference-no (choosing at least 1 option):**

Order-no for repair:	order-/ delivery note-no for return of commission failure:	Beginning order-no for credit note demand:

Information concerning the product and its use:

*** Order Code (MLFB):**	Firmware version: V	*** Serial number:**	
* Customer:	Product was in use approximately since:	Station/project:	Hotline Input no.:
Customer original purchase order number:	Delivery note number with position number:	Manufacturer:	

*** Type of order (choosing at least 1 option):**

- ☐ Repair
- ☐ Upgrade / Modification to …
- ☐ Return of commission failure
- ☐ Warranty repair
- ☐ For collection
- ☐ Credit Note
- ☐ Quotation (not repair V4 and current products! See prices in PMD)

Type of failure:

- ☐ Device or module does not start up
- ☐ Sporadic failure
- ☐ Permanent failure
- ☐ Repeated breakdown
- ☐ Mechanical problem
- ☐ Knock sensitive
- ☐ Temperature caused failure
- ☐ Failure after firmware update
- ☐ Overload
- ☐ Transport damage
- ☐ Failure after ca ☐ hrs in use

Error description:

- ☐ Display message:
  (use separated sheet for more info)
- ☐ Active LED messages:
- ☐ Faulty Interface(s), which?
- ☐ Wrong measured value(s), which?
- ☐ Faulty input(s)/output(s), which?

***Detailed error description** (please refer to other error reports or documentation if possible):

*** Shall a firmware update be made during repair or mechanical upgrade of protective relays? (choosing at least 1 option)**

- ☐ Yes, to most recent version
- ☐ No
- ☐ Yes, actual parameters must be reusable

repair report:

- ☐ Yes, standard report (free of charge)
- ☐ Yes, detailed report (charge: 400EUR)

Shipping address of the repaired/upgraded product:

Company, department

Name, first name

Street, number

Postcode, city, country

Date, Signature

Please contact the Siemens representative office in your country to obtain return instructions.

E D EA MF TCC 6 release from 11/2009

MSCDN – MP1

Capacitor unbalance protection

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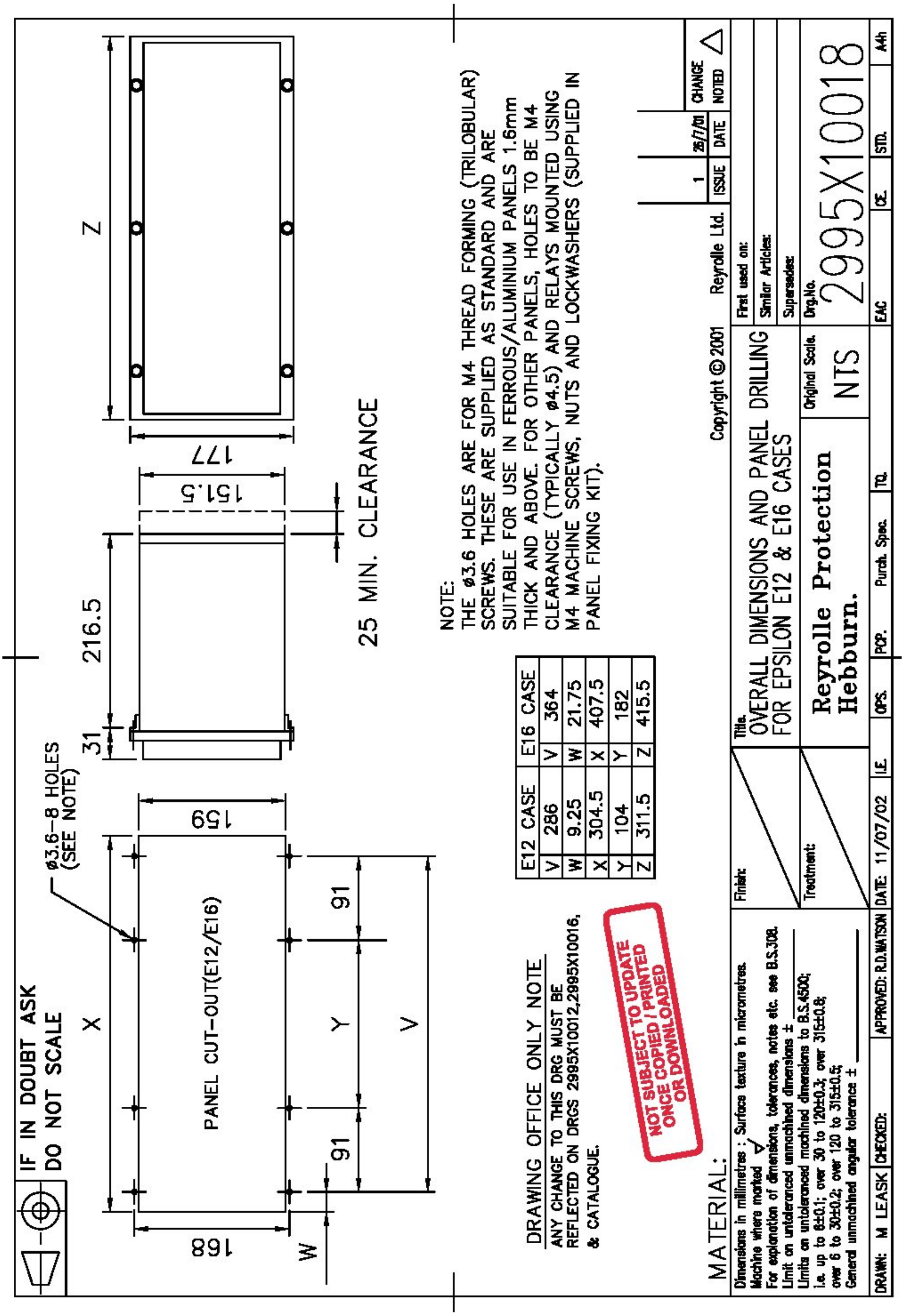

Figure 1 - Panel Fixing

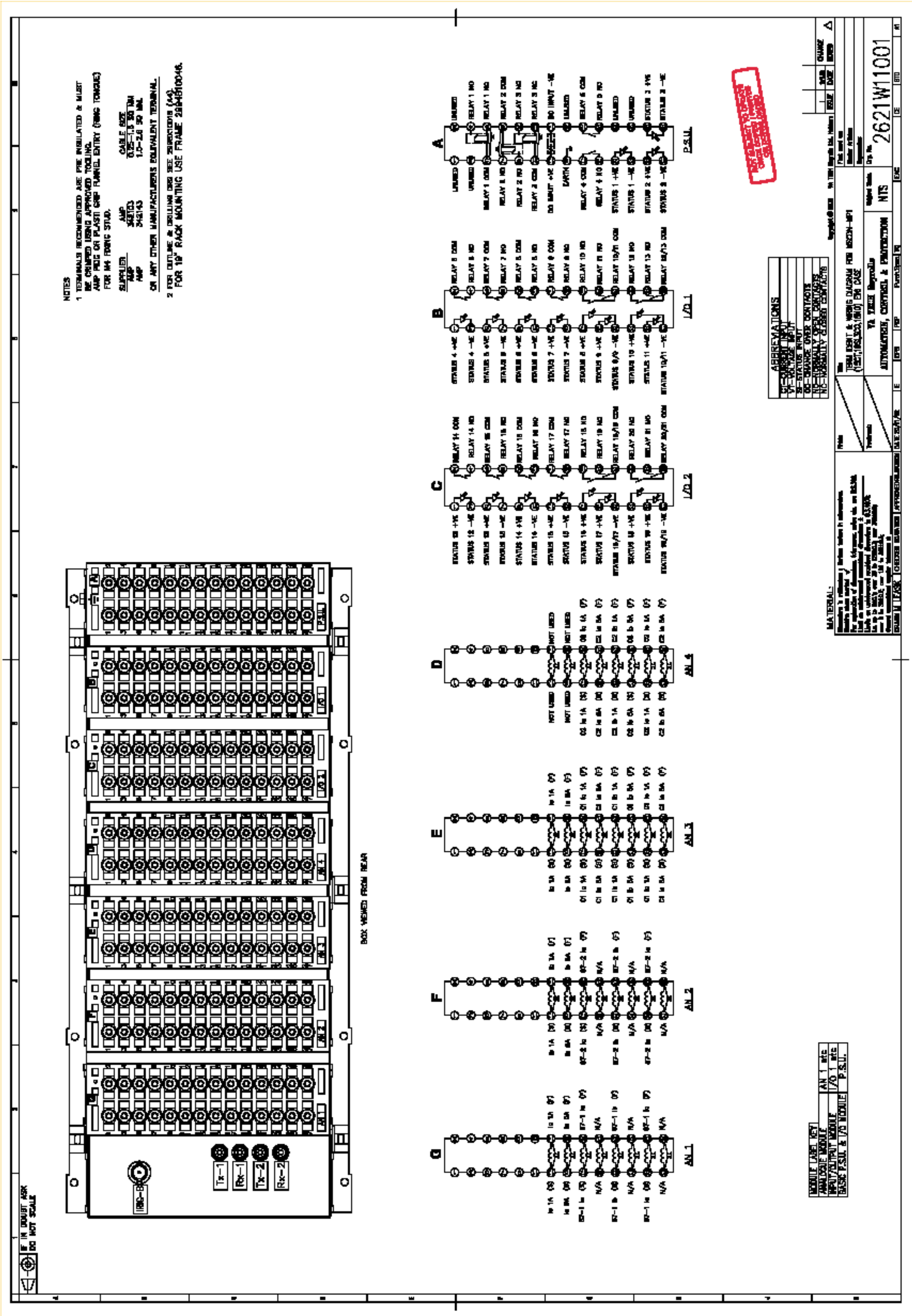

Figure 2 - Rear Terminal View

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