Reyrolle
Protection
Devices

7SG26 - Tau 400/500
Auto re-close

Answers for energy

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7SG26 Tau 500
Auto Reclose and Check Synchronisation

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

Software Revision History

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Reference Material

[1] - REYDISP EVOLUTION : is a PC based relay support package which allows local or remote access to relays for uploading settings, downloading event and disturbance records, reading real-time data and allowing control of plant. The package is available from Reyrolle Protection and is compatible with all Argus and Modular II relays.

[2] - INFORMATIVE COMMUNICATIONS INTERFACE : a report detailing all aspects of the communications protocol used in the Argus and Modular II range of relays is available from Reyrolle Protection. The report reference is 434TM05B

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1 INTRODUCTION

1.1 General

This Manual details the description of the Delayed Autoreclose Tau relay range.

The Tau Auto-reclose relay range consists of Multi-shot Delayed Autoreclose with or without integral Check Synchronisation.

There are separate Tau relays for Single Pole reclosing schemes, which are described in a separate manual. The Tau 100 and Tau 200 relays consist of Two-shot Single Pole / Three Pole Autoreclose relays.

Multi-shot Delayed Autoreclose relays, both with (Tau 500) or without (Tau 400) integral Check Synchronisation. The Multi-shot Delayed Autoreclose relays are described in this manual.

Tau 100 Two Shot Single Pole or Three Pole Recloser using external Check Synchronisation relay (Argus 7). Standard version in an E8 case with 27 input, 13 output and 16 programmable LEDs.

Tau 200 Two Shot Single Pole or Three Pole Recloser using internal Check Synchronisation. Standard version in an E12 case with 27 input, 13 output and 32 programmable LEDs.

Tau 400 Multi shot Three Pole Recloser applied to rural feeders where no Synchronisation is required. Standard version in an E8 case with 11 input, 13 output and 16 programmable LEDs.

Tau 401 Multi shot Three Pole Recloser using external Check Synchronisation relay (Argus 7). Standard version in an E8 case with 11 input, 13 output and 16 programmable LEDs.

Tau 500 Multi shot Three Pole Recloser using internal Check Synchronisation. Standard version in an E8 case with 11 input, 13 output and 16 programmable LEDs.

Tau 501 Multi shot Three Pole Recloser using internal Check Synchronisation. Includes one isolator control and is suitable for application to T'd feeders, Tapped off ring circuits. Standard version in an E12 case with 19 input, 21 output and 32 programmable LEDs. Associated settings marked with a (+).

Tau 502 Multi shot Three Pole Recloser using internal Check Synchronisation. Includes two isolator control and is suitable for Single Switch mesh, Four Switch mesh, or Switch and a Half type schemes. Standard version in an E12 case with 27 input, 29 output and 32 programmable LEDs. Associated settings marked with a (*)

The relay contains scheme logic, which allows input functions and output functions to be configured to meet the requirements of a particular customer's scheme. This is achieved by a number of pre-programmed customer options and features which enable various sequences to be selected together with appropriate timer mechanisms, which allow effective control of the autoreclose process. Auxiliary functions are provided which cover all aspects of the autoreclose scheme i.e. Auto-reclosing, Manual Closing, and Check Synchronisation.

Autoreclose inputs are fully programmable: Block Reclose, Lockout, Manual Close, A/R In, A/R Out, External A/R Start, Trip And Reclose, Reset Lockout.

Outputs are fully programmable to either LEDs or output contacts.

The relay has been designed for ease of setting, clear setting ranges indicate deadtimes, close pulse and reclaim time delay settings. Front panel instruments are provided that indicate the point, which the Relay has reached during an Autoreclose sequence, this greatly improves commissioning.

Suitable for single / double busbar substations where outgoing circuits are controlled by a single circuit breaker. Compatible to 'J' unit schemes. Can be applied to Teed feeders or Mesh corners which require Auto-Isolation facilities.

The relay will automatically determine circuit breaker reclosure conditions. These conditions are dead line charge, dead bar charge, dead line and dead bar close, unconditional close, or check sync close. If one of these conditions exists and reclosure under this condition has been pre-selected by the user then reclosure will be initiated.

When the dead line or dead bar deadtime has expired and dead line or dead bar conditions are met then the circuit breaker will be reclosed.

If the relay detects the presence of line and busbar volts and check sync reclosure has been pre-selected then the relay will generate a check sync request prior to any reclosure. If the required check sync conditions are met then the circuit breaker will be reclosed.

The relay can automatically select Check or System synchronise from measurements of the relative phase angles between line and bus voltages. The relay will prevent closure of the circuit breaker if either the phase angle, slip frequency or the voltage magnitude of the incoming or running voltages fall outside prescribed limits.

If the parameters are within the limits the relay will issue an output, which can be used to close the circuit breaker. Both the check and system synchronise functions have independent settings. The relay includes split system detection, which can be used for blocking purposes. Following a system split, closure of the circuit breaker can be performed by either system sync parameters (typically $10°$), or by the Close On Zero function, which takes account of the circuit breaker close time.

A serial communications interface provides control of the relay, access to information stored, and integration of the relay into a sub-station control or data acquisition system

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1.2 Auto-reclose

Autoreclose is commonly applied to Transmission and Distribution systems. This feature is suitable for both, providing all three phases are opened on the occurrence of a fault, and all three phases are automatically reclosed.

Statistically, the majority of system faults are of a transient nature so that once the fault has been cleared by the protection, the faulted circuit can be re-energised with a likelihood of minimal disturbance to the rest of the system. An important feature of overhead line faults is that since air is the main insulant a significant majority of flash-overs cause no permanent damage to the circuits and about 88% of fault clearances can be quickly followed by the circuits return to service by operation of automatic switching and reclosing facilities.
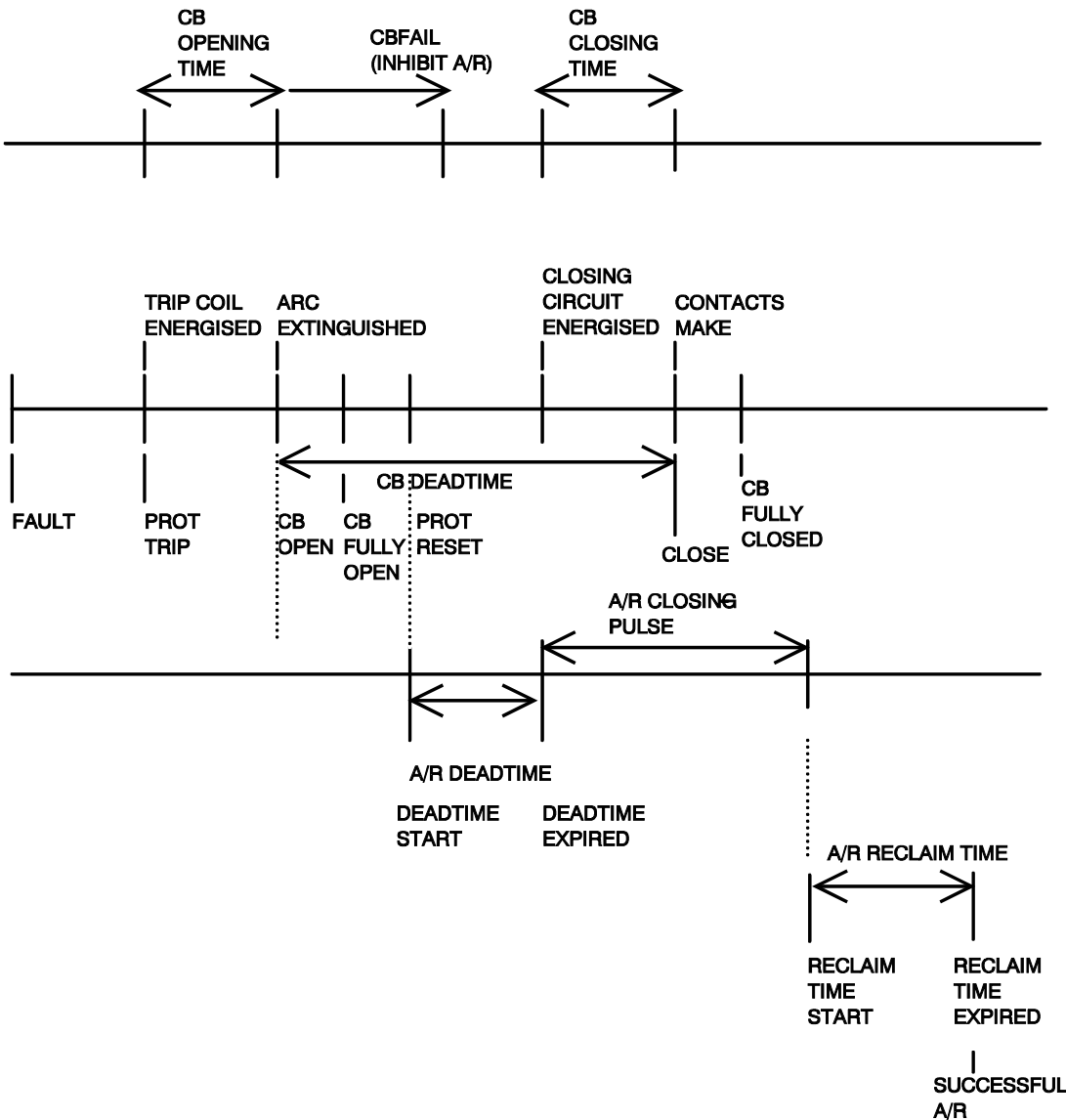
Figure 1 – Autoreclose Sequence

The relay conforms to NGTS 3.15.1, NGTS 3.24.16, TPS 12/10 and the relevant IEC255 standards.

1.3 Check Synchronisation

When two power systems are to be connected together it is essential that the systems either side of the breaker be reasonably in synchronism. Quantities such as the voltage magnitudes, the system frequencies and the relative phase angles of the two systems should be reasonably close before an attempt is made to connect. Closing the circuit breaker without due care and attention to some or all of these quantities can cause undue stresses to the system. The Check and System synchronising function measures single phase voltage quantities at each side of the CB and will only permit a CB close when the two systems fall within the relay setting parameters. Figure 2 shows the basic closing conditions for both the check and system synchronising functions.
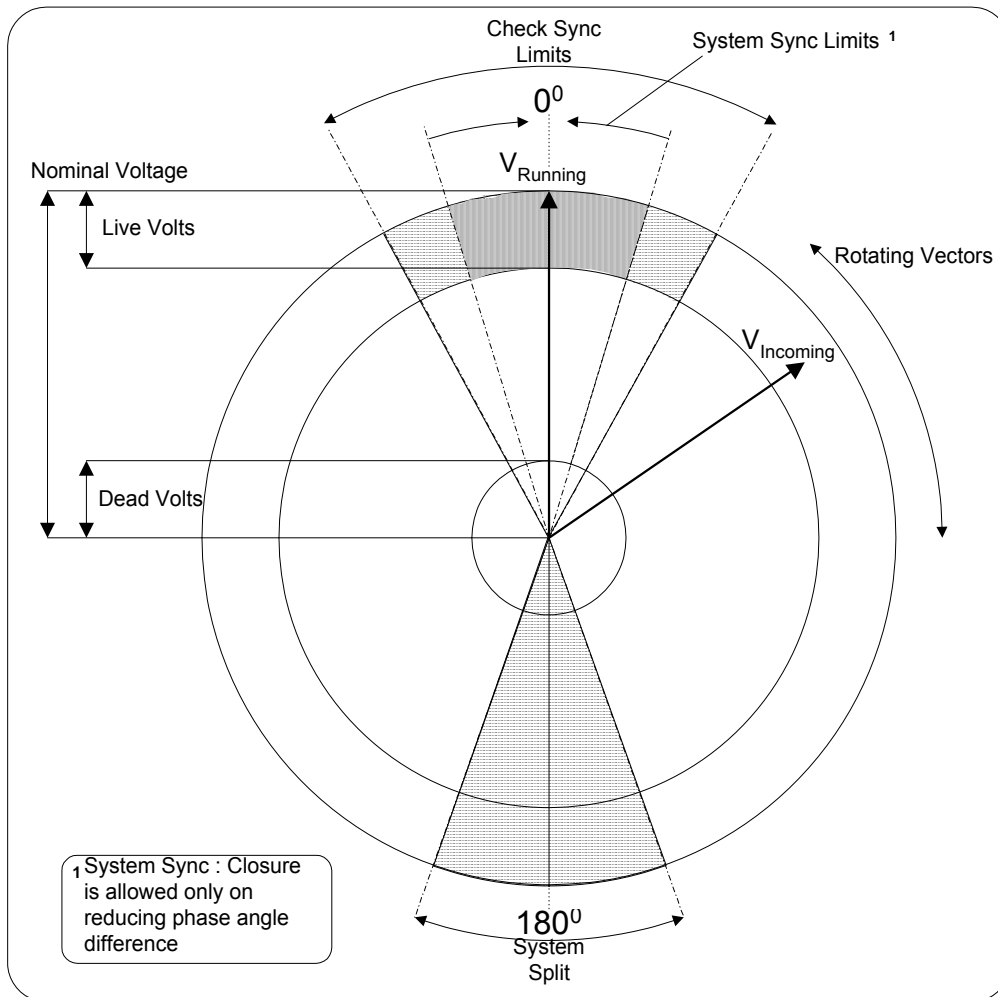
Figure 2 - Check and System Synchronising

The Check and System synchronising function is part of the comprehensive range of Modular II platform based numeric relays. These relays have extensive control functions, which are supplemented by advanced metering, data storage and fibre optic communications. Supervisory and self-monitoring features give added confidence to the user as well as reduced maintenance and down time. A menu-based interface gives user-friendly access to relay settings, meters and operational data.

The relay conforms to NGTS 3.7.7 and the relevant IEC255 standards.

2 HARDWARE DESCRIPTION

2.1 General

The Modular II series of relays are housed in E8, E12 or 19" rack size cases. They consist of standard versions with dedicated I/O: E8 11 input, 13 outputs; E12 27 input, 13 output; these have been chosen to provide the correct number of terminals for common schemes. However additional I/O can be specified, up to 19" case and 27 inputs, 29 outputs.

All Modular II relays share common hardware components and modules. The design for the mechanical arrangement of the relays has been carefully chosen to provide a high level of EMI screening using multi-layer PCB's with ground planes, RFI suppression components and earthed metal screens. The internal arrangement has been divided into noisy and quiet areas in order to improve noise immunity and reduce RFI emissions. The only direct connection from the quiet components to the external environment is via the optical serial communications interface, which is immune to radiated or conducted interference.

2.2 Analogue Inputs

The input stage of the relay measures two basic quantities, V_{Line} and V_{Bus}. The voltage transformer inputs are suitable for phase to neutral connections and the input stage overall measures in the range of 1 Vrms to 200 Vrms. It maintains accuracy within $\pm 1\%$ over the range 5 Vrms to 132 Vrms.

In order to ensure high accuracy true RMS measurements and accurate phase and slip frequency calculations, the voltage signals are sampled at a minimum of 8 samples per cycle for both 50Hz and 60Hz system frequencies. This sampling rate also provides high accuracy and waveform storage records.

2.3 Output Relays

The standard relay has 13 output relays in total, which are capable of handling circuit breaker tripping duty. All 13 relays are fully user configurable and can be programmed to operate from any or all of the control functions. They consist of 3 C/O contacts, and 10 N/O contacts.

In their normal mode of operation output relays remain energised for at least 200msec. 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.

A trip test feature is provided to exercise the output contacts.

2.4 Status Inputs

There are a total of 11 status inputs available in the standard relay. All status inputs are fully user programmable. Each of the status inputs can be programmed to perform one or more of the following functions, (see settings sheet for complete list) :

- Start Autoreclose.
- CB Auxiliary contacts.
- Close the CB.
- Autoreclose control functions.
- Bypass the sync function.
- Inhibit Check or System synchronising.
- Switch to an alternative settings group
- Trigger storage of a waveform record.
- Reset the Lockout condition.

2.5 Self Monitoring

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

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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.

3 CONTROL FUNCTIONS

3.1 Auto-reclose control

Delayed Auto-Reclose (DAR) is initiated by a valid trip relay operation while the associated circuit breaker is in service.

A circuit breaker's service status is determined by its position and (where Check Synchronisation is applied) its voltage references. The circuit breaker is defined as being in service when it is closed and its voltage references are live. The in service status has a drop-off delay of 2 sec, this delay is known as the circuit memory time. This functionality prevents autoreclosing when the line is normally de-energised, or normally open.

The transition from DAR started to initiate deadtime takes place when the circuit breaker's line voltage reference goes dead; and the CB has opened; and the trip relay has reset. If any of these do not occur within the Sequence Fail time the relay will Lockout. This is provided to prevent the DAR being primed indefinitely, or the timer can be switched OFF.

Once a DAR sequence had been initiated, up to 4 unsuccessful recloses (where a closure is followed by a re-trip) may be performed before the DAR feature is locked-out. Each reclosure is preceded by a time delay (dead time) to give transient faults time to clear.

Once a CB has reclosed and remained closed for a specified time period (the Reclaim time), the DAR feature is re-initialised and a Successful Close output issued. A single, common Reclaim time is used.

A count is kept of how many recloses have been performed.

Once lockout has occurred, an alarm is issued and all further Close commands are inhibited for a specified time period (the Minimum Lockout time). A single, common lockout time is used. Lockout can be latched until reset.

There are separate dead-time settings for each of the 4 recloses.

The relay will automatically determine circuit breaker reclosure conditions. These conditions are dead line charge, dead bar charge, dead line and dead bar, unconditional close, or check sync close. If one of these conditions exists and reclosure under this condition has been pre-selected by the user then reclosure will be initiated.

When the dead line or dead bar deadtime has expired and dead line or dead bar conditions are met then the circuit breaker will be reclosed.

If the relay detects the presence of line and busbar volts and check sync reclosure has been pre-selected then the relay shall generate a check sync request prior to any reclosure. If the required check sync conditions are met then the circuit breaker will be reclosed.

Although the Tau500 relay is intended as a DAR plus Check Sync relay it can be applied where no line VT's are fitted. The setting Live Line Check can disable the need for VT's. This allows utilities to standardise on the Tau500 relay for all applications if required.

Certain schemes require switching operations to be exactly coordinated by the deadtime of the autoreclose relay, whilst other scheme layouts can override the deadtime if In Sync conditions are met across the circuit breaker. The relay provides a setting to enable / disable this function, Check Sync During Deadtime.

3.1.1 Protection Trip
The Protection device which trips the CB should be connected to this input to prime and start the autoreclose sequence.

3.1.2 Protection Starter
Where the autoreclose relays are connected to Overcurrent protection or a protection that includes a starter then the starter can be connected to this input. This would indicate that a reclose has closed onto a fault. Multi-shot Autoreclose sequences can be co-ordinated for adjacent relays using this input, i.e. the number of shots can be kept in step.

3.1.3 External A/R Start

An External A/R Start can be received via a status input. A separate protection device would normally initiate this.

An External A/R Start will be treated the same as a Protection A/R Start by the Relay.

3.1.4 Manual Close

An External Close Command can be received via a status input or communications. This would normally be initiated manually. It causes an instantaneous closure, over-riding any DAR sequence then in operation.

An External Close will initiate Line Check. If a fault appears on the line during the Close Pulse or the Reclaim Time with Line Check set, the Protection relay will initiate a Trip and the A/R relay will Lockout. This prevents a CB being repeatedly closed onto a faulted line.

Repeated Manual Closes are avoided by checking for Positive edge triggers. Even if the Manual Close input is constantly energised the relay will only attempt one close. No Close Pulse will be issued when the Manual Close input is reset.

Manual Closing is controlled by the following settings:

Setting	Range	Default
Manual Close DBC	Enabled / Disabled	Disabled
Manual Close DLC	Enabled / Disabled	Disabled
Manual Close DLDB	Enabled / Disabled	Disabled
Manual Close CS	Enabled / Disabled	Enabled

These combinations allow full selection of the Manual Closing process.

Manual Close resets Lockout, if the conditions that set Lockout have reset i.e. there is no trip or Lockout input present.

Manual Close cannot proceed if there is a Lockout input or Block Reclose input present.

With the Autoreclose function set to Out of Service the Manual Close control is still active.

3.1.5 In/Out Switching

The DAR feature may be switched out by changing the A/R In Service setting by a number of methods. These are either a keypad change from the front panel, or via a communication, or by an A/R OUT status input. A/R OUT status input has priority over A/R IN. If both are raised the relay will be in Out Of Service. Once the relay has been switched Out Of Service the reverse action A/R IN is required before the relay will go back In Service.

3.1.6 Overall Control

The DAR feature may be disabled by a Lockout command or by an external signal applied to a status input (A/R OUT).

If the Lockout command or A/R OUT are received while a DAR operation is in progress, the feature is immediately locked-out. An External A/R IN command can be received via a status input. This will re-enable the module.

If the Lockout command is received while a Manual Close operation is in progress, the feature is immediately locked-out.

The DAR or Manual Close feature may be paused by an external Block signal applied to a status input. This causes the feature to temporarily halt before it issues the next CB close command and can be used, for example, to delay CB closure until the CB pressure has reached an acceptable level. If the Block signal has not been removed before the end of a defined time, the Reclose Block Delay, the relay is locked-out.

A Block Reclose input active within the deadtime resets the deadtime timer.

3.1.7 CB Close Command pulse

The duration of the CB Close Command pulse will be settable to allow a range of CBs to be used. The Close pulse will be terminated if any protection Starter picks-up or a trip occurs. This is to prevent Close and Trip Command pulses existing simultaneously. A Close Onto Fault Output is given if a starter or trip picks-up in the Close Pulse. This can be independently wired to Lockout.

3.1.8 CB Failed To Open and CB Failed to Close

CB Failed To Open and CB Failed to Close features are used to confirm that a CB has not responded correctly to each Trip and Close Command. If a CB fails to operate, the DAR feature can be set to lockout.

3.1.9 CB Closed by Another Device

If, during a dead time period, the Relay detects that the CB has closed (due to an external source) it increments its Reclose count and advances to the next part of the Reclose sequence (begin Reclaim time).

3.1.10 Indications

The relay has a fully programmable output to either output contacts or LEDs, see settings sheet for complete list.

The following are included:

1.   A/R In Service

2.   A/R Out of Service

3.   A/R In Progress

4.   Successful A/R

5.   Lockout

3.1.11 Trip and Reclose

This is a test function, allowing the operation of the CB to be verified.

The Trip signal should be routed directly to the Circuit Breaker. Once the CB has opened and the Trip and Reclose input is removed the DAR will wait for the first Reclose Delay and then issue a CB Close command.

A Trip and Reclose command will only be accepted if the Relay is in quiescent, or line healthy mode, i.e. no autoreclose sequences are in progress.

During the Trip and Reclose reclosure, Line Check is invoked to ensure that the CB does not repeatedly close onto a faulty line.

3.1.12 CB Close Operations

Additional DAR features are provided as an aid to maintenance.

Two counters 'Total CB Close Count' and 'Delta CB Close Count' are provided. Each counter has a User settable Alarm count. These counters can be used for Maintenance Alarms. These figures are separately re-settable by either keypad, or status input **Reset Total CB Close** or **Reset Delta CB Close**. Maximum alarm number of 999.

3.1.13 Metering

All Counters and the Status of the DAR operations are displayed in Meters under the instruments Menu.

3.1.14 Dead-time and Reclaim Timing

The Deadtime will start if a Trip has occurred and the CB is Open and the Trip and Starter have then reset and the line has gone dead. Once a trip has occurred if the CB does not open or the Trip does not reset or the starter does not reset then the DAR will Lockout. This could be due to either a CB Fail condition, which would independently notify Lockout, or the Trip or Starter relay contact failing to reset. If the line does not go dead this may signify that the remote end has failed to clear the fault, and the autoreclose will go to Lockout.

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A Trip during the deadtime will result in resetting the deadtime and then restarting the deadtime when the trip resets, provided the Sequence Fail Timer has not expired.

The Reclaim time will start once the Close Pulse has timed out and the CB has closed. Lockout is alarmed if the CB is open at the end of the reclaim time.

3.1.15 Lockout

The Lockout state can be reached for a number of reasons. Lockout will occur for the following:

  - at the end of the Reclaim time if the CB is in the open position.

  - a protection operates during the final Reclaim time.

  - if a Close Pulse is given and the CB fails to close.

  - The Reclose Lockout status input is active.

  - At the end of the Reclose Block Delay due to a persistent Block signal not cleared.

  - At the end of the Sync Close Delay due to Synchronism not being achieved.

Once the Lockout condition has been reached, it will be maintained until reset. The following will reset lockout:

  - By a Manual Close command.

  - By a Reset Lockout signal, provided there is no signal present that will cause Lockout.

  - At the end of the Minimum Lockout time if Reset Lockout is selected to be reset by a timer, provided there is no signal present which will cause Lockout.

  - if Lockout was entered by an A/R Out signal during an Autoreclose sequence then an A/R In signal must be received before Lockout can reset.

  - by the CB Closed, provided there is no signal present which will cause Lockout.

The Lockout condition has a delayed drop-off of 2s.

The Lockout condition will initiate the Lockout indication and alarm contact.

Lockout does not issue a trip signal.

Lockout indicates an abnormal system occurrence, an event that needs to be investigated. When a CB is normally open the A/R relay does not go to Lockout, but using a combination of Trip and CB In Service to start the sequence prevents A/R sequences.

3.1.16 Inter-trip Initiated Autoreclose

Autoreclose can be initiated by an Inter-trip Receive signal. A Persistent Inter-trip timer is provided. If the Persistent Inter-trip timer times-out before the Inter-trip Receive signal has reset then the relay will go to Lockout. Only a one-shot autoreclose sequence is allowed by inter-tripping, any other inter-trips cause the relay to go to Lockout.

3.1.17 Auto Isolation (+)(*)

Facilities are provided to apply auto-isolation to mesh corner or T'd feeders. An auto-isolation scheme is provided. If a trip occurs within the close pulse then auto-isolation is started if selected, the isolator should send Auto-Isolation Complete when the system is isolated, the relay will then continue with its next sequence. If Auto-Isolation Complete is not received before the end of the Auto-Isolation timer then Auto-Isolation Fail is issued, and the relay will go to Lockout.

The Tau 501 provides the input/output to control one isolator. This relay is intended to be applied to T'd feeders or Ring connected feeders where permanently faulted plant can be isolated and the busbar reclosed.

The Tau 502 provides the input/output to control two isolators. This provides applications to Single Switch Mesh, Four Switch Mesh, and Switch and a Half schemes. One relay per circuit breaker is required. Features are provided to adapt the isolation dependent upon whether the feeder is cable or overhead line. This is achieved by allowing isolation prior or after reclose. Functions are provided for Transformer isolation. The Ferro-resonance Suppression F3 scheme is included.

3.1.18 Sequential Isolation

Facilities to inhibit sequential isolation are provided to enable the DAR system to stop sequential isolation if an associated DAR sequence has started. The Inhibit Sequential Isolation output is set when an A/R sequence is started and is reset at the start of the close pulse or at lockout.

3.1.19 Voltage Failure Lockout

Facilities to Lockout Autoreclose and Manual Closing if a VT Failure occurs are provided. There is a setting provided which enables and disables this feature. VT Failure is set for either:

CB Closed and Live Line and Dead Bar >> 2 sec.

Or

CB Closed and Live Bar and Dead Line >> 2 sec.

This function has been provided as a setting due to the uncertainty of isolator positions within the scheme.

3.2 Voltage monitoring elements

3.2.1 Under-voltage detectors

The under-voltage detectors, if enabled, can block a close output command if either the line voltage or the bus voltage is below the under-voltage setting value. Both line and bus have their own independent settings.

3.2.2 Differential voltage detectors

The differential voltage detector, if enabled, can block a close output command if the difference between the line and bus voltages is greater than the differential voltage setting value.

3.2.3 Voltage detectors

Voltage detectors determine the status of the line or bus. If the voltages on either the line or bus are below a set threshold level they can be considered to be 'dead'. If the voltages are within a setting band around the nominal voltage they are classed as 'live'. Independent voltage detectors are provided for both line and bus.

If a voltage is in the dead band range then it will be classed as dead until it has reached the live band area. Similarly, if a voltage is live, it continues to be live until it has reached the dead band area. This effectively allows for variable amounts of hysterisis to be set. Figure 3 illustrates the voltage detector operation.

Note: the area between the dead and live zones is not indeterminate. When any voltage is applied to the relay it will ramp up the software RMS algorithm and always pass through the dead zone first.

Although a wide range is provided for live and dead voltage detector levels, these must not overlap. The relay software acts to prevent this from happening to stop unusual alarm outputs and conflicts with internal logic elements. If the user attempts to increment the dead voltage level to the live voltage level, the relay will not accept the setting. Similarly, if the live level is decremented to the dead level, the setting will not be allowed. The two voltages are displayed simultaneously on the LCD display so that this operation is clear to the user.
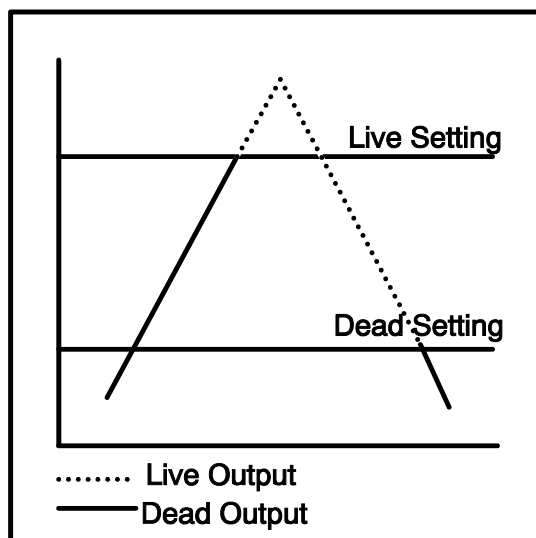
Figure 3 - Voltage Detector Operation

3.2.4 Sync Override Logic

For certain switching operations, a means of bypassing the Check Synchronisation function is provided. This is provided with a separate Sync Override and a separate Manual Sync Override.

3.3 Check Synchronising Mode

For the relay to issue a Check Sync Close the following conditions have to be met :

CS PHASE ANGLE – the phase difference between the line and bus voltages has to be less than the phase angle setting value. Whilst within the limits the phase angle can be increasing or decreasing and the element will still issue a valid close signal.

CS SLIP FREQUENCY, [If ENABLED] – the frequency difference between line and bus has to be less than the slip frequency setting value.

CS SLIP TIMER, [If ENABLED] – the phase angle and voltage blocking features have to be within their parameters for the length of the slip timer setting. If either the phase angle or the voltage elements fall outside of their limits the slip timer is reset. If they subsequently come back in then the slip timer has to time out before an output is given. (This ensures that a close output will not be given if there is a transient disturbance on the system due to e.g. some remote switching operations).

LINE U/V DETECTOR, [If ENABLED] – the line voltage has to be above the line under-voltage setting value and also above 5V for an output to be given.

BUS U/V DETECTOR, [If ENABLED] – the bus voltage has to be above the bus under-voltage setting value and also above 5V for an output to be given.

DIFFERENTIAL VOLTAGE DETECTOR, [If ENABLED] – the difference between the line and bus voltages has to be less than the ∆V detector setting value for an output to be given.

The relay is always started in Check Synchronising mode of operation. To proceed to System Synchronisation a system split must occur.
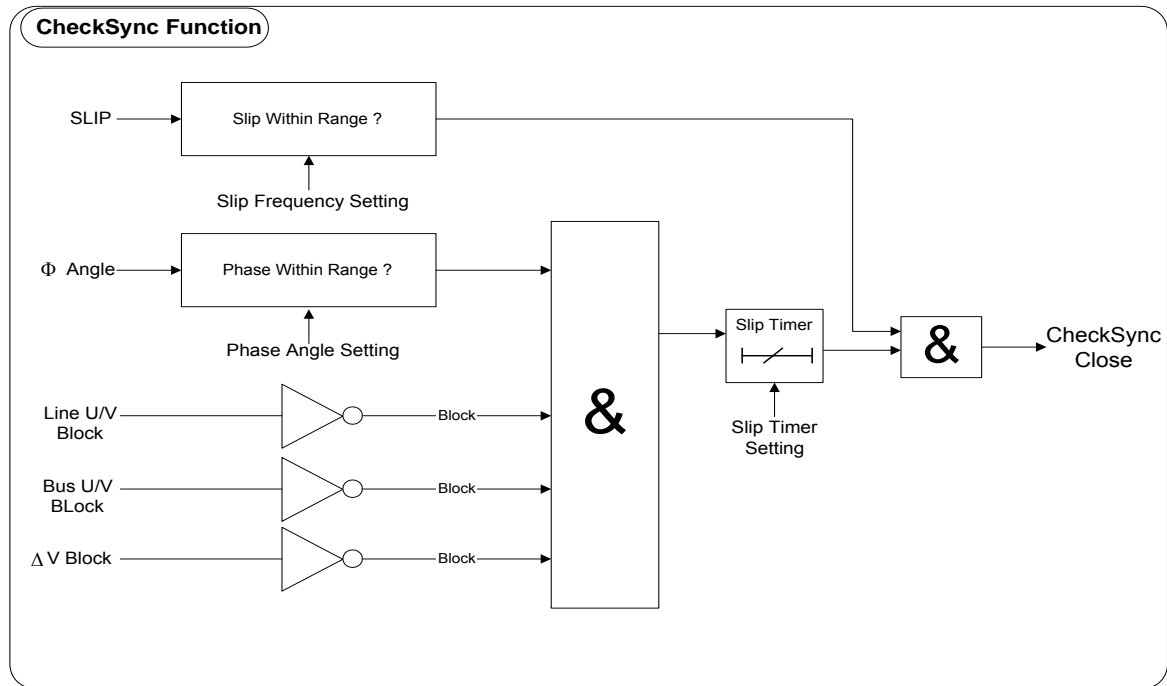
Figure 4 - Check Sync Function

3.3.1 Manual Sync Override Feature

If manual closes are required to be carried out via an operator, these will be performed with Check Synchronisation unless the Manual Sync Override input is energised.

3.4 System Split Detector

A system split occurs where there is a loosely tied or non-parallel circuits on a power system. Under these conditions the frequencies of the voltages either side of the breaker are asynchronous and therefore high phase angle differences can occur as the frequencies slip past each other. The system split detector operates when the phase angle difference exceeds a pre-set value. The setting range for a system split is from 90°-175° step 1°.

Note : the system split setting is effectively an absolute value and therefore a split will occur at the value regardless of the direction of the frequency slip e.g. if an angle of 170° is selected, then starting from 0°, a split will occur at +170° or -170° (effectively +190°).

If a system split occurs during a Check Sync operation the following events occur:

- The Check Sync function is inhibited.

- The System Sync function is started if the setting has been set to A/R Split Action SYSTEM SYNC. If the A/R Split Action has been set to LOCKOUT, then, a system split LED indication is given. The relay will stay in this lockout mode until one of the following methods of resetting it is performed:

  1) The relay is reset from Lockout.

  2) A status input command is received.

  3) An appropriate IEC870 communications command is received.

- An event is recorded.

- The split flag can be mapped to an output relay for alarm indication.

- The system split LED will stay on for a minimum time, or can be latched using non self reset LEDs.

3.5 System Synchronising Mode

For the relay to issue a System Sync Close the following conditions have to be met :

SS PHASE ANGLE – the phase difference between the line and bus voltages has to be less than the phase angle setting value and the phase angle has to be decreasing before the element will issue a valid close signal.

SS SLIP FREQUENCY, [If ENABLED] – the frequency difference between line and bus has to be less than the slip frequency setting value.

SS SLIP TIMER, [If ENABLED] – the phase angle and voltage blocking features have to be within their parameters for the length of the slip timer setting. If either the phase angle or the voltage elements fall outside of their limits the slip timer is reset. If they subsequently come back in then the slip timer has to time out before an output is given. (This ensures that a close output will not be given if there is a transient disturbance on the system due to e.g. some remote switching operations).

LINE U/V DETECTOR, [If ENABLED] – the line voltage has to be above the line under-voltage setting value and also above 5V for an output to be given.

BUS U/V DETECTOR, [If ENABLED] – the bus voltage has to be above the line under-voltage setting value and also above 5V for an output to be given.

DIFFERENTIAL VOLTAGE DETECTOR, [If ENABLED] – the difference between the line and bus voltages has to be less than the V detector setting value for an output to be given.

The System Synchronising operation of the relay can be started in two different ways. It is set by the 'A/R Split Action' setting which has three parameters: LOCKOUT, SYSTEM SYNC, CLOSE ON ZERO; or 'MC Split Action' setting which also has three parameters: CLOSE ON ZERO, CHECK SYNC, SYSTEM SYNC.

If the 'A/R Split Action' setting is set to:

LOCKOUT: after a split has occurred the relay will go into lockout mode

SYSTEM SYNC: the relay will only start system synchronising after a split condition has occurred. It will issue a System Sync Close automatically if the relevant parameters are met. There is also a **Start System Sync** input which when energised will switch the Check Synchronisation to System Sync.

CLOSE ON ZERO: the relay will only start system synchronising after a split condition has occurred. The relay will issue a close command determined by the CB close time and synchronisation parameters.

If the 'MC Split Action' setting is set to:

CLOSE ON ZERO: the relay will only start system synchronising after a split condition has occurred. The relay will issue a close command determined by the CB close time and synchronisation parameters.

CHECK SYNC: the relay will only start system synchronising after a split condition has occurred. It will issue a Check Sync Close automatically if the relevant parameters are met.

SYSTEM SYNC: the relay will only start system synchronising after a split condition has occurred. It will issue a System Sync Close automatically if the relevant parameters are met. There is also a **Start System Sync** input which when energised will switch the Check Synchronisation to System Sync.
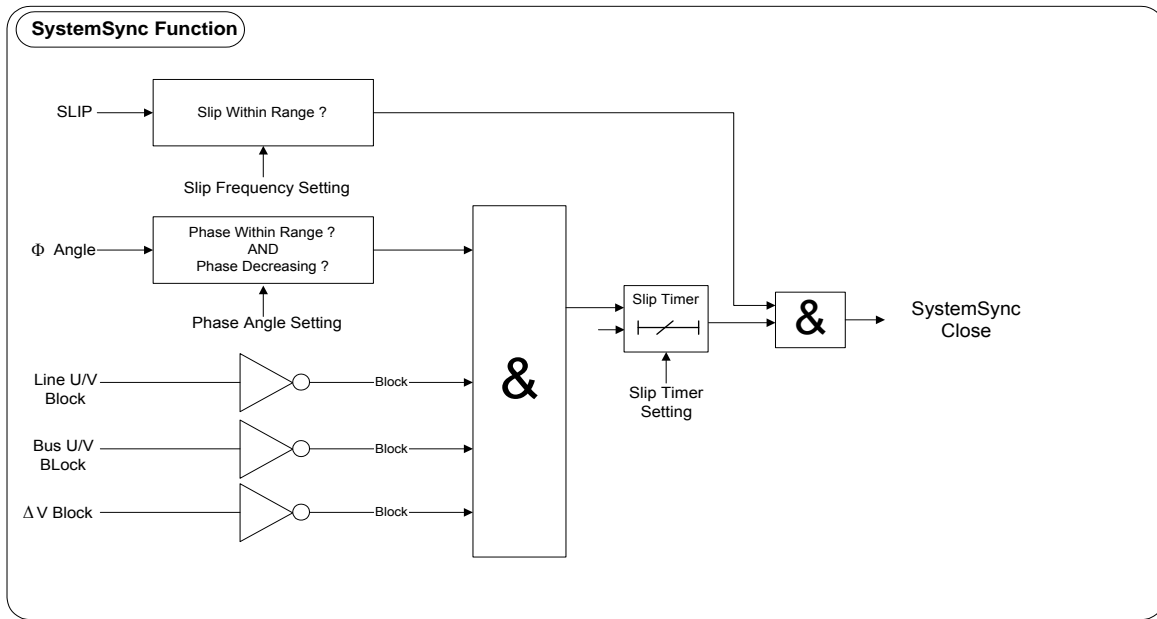
Figure 5 - System Sync Function

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:

- Phase difference between Line and Bus
- Frequency of both Line and Bus
- Frequency slip between Line and Bus
- RMS volts for both Line and Bus
- Voltage Differential between line and Bus
- Total Number of CB Closes
- Delta Number of CB Closes
- A/R Sequence Shot Number
- A/R State
- Digital input status
- Output relay status
- Date - displayed in DD/MM/YY format
- Time - displayed in HH:MM:SS format

Note: while the instrument displays are updated as often as the software routines can service them, some have their response time deliberately slowed down to enable them to be read.

Figure 6 shows the display menu structure from where the available instruments can be accessed.

4.2 Data Storage

Data records are available in two forms, namely Waveform records and Event records. All records are time and date stamped with a real time clock which maintains the time even when the relay is de-energised [see Note]. Time and date can be set either via the relay fascia using appropriate commands in the System Config menu or

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via the communications interface. In the latter case, relays connected in a network can be synchronised by a global time sync command.

Alternatively, synchronising pulses can be received via a special input.

4.2.1 Waveform Records.

The waveform record feature stores analogue and digital information for the voltage inputs, status inputs and output relays. A single phase waveform record for both the line and bus voltages can be stored and this shows the voltages at either side of the breaker at the moment of closing of the switch. The waveform record is 1 second wide with a sampling resolution of 8 samples per cycle. The recorder feature has the ability to store records for the previous ten close operations of the relay. These are labelled 1-10 with 1 being the most recent record.

The waveform recorder can be triggered in the following ways;

- Via the waveform trigger status input signal.

- By the Close Pulse.

4.2.2 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 5msec. There is capacity for a maximum of 500 event records to 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 setting (though not the actual setting change). Also indication of which group of settings is active.

- Change of state of Output Relays.

- Change of state of Status Inputs.

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

- Change of state of any of the voltage elements.

For a full list of all the events available see Table 1.

4.3 Communications

A fibre optic communication port is provided which gives superior EMC performance. Communication is compatible with the IEC60870-5-103 FT 1.2 transmission and application standards. For communication with the relay via a PC (personal computer) a user-friendly software package, REYDISP EVOLUTION [1], is available to allow transfer of the following:

- Relay Settings

- Waveform Records

- Event Records

- Close Data Records

- Instrument and meters

- Control Functions

Communications operation is described in detail in Section 4 of this manual.

4.4 Multiple Setting Group.

The relay provides four alternative setting groups, 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. The relay can then be switched instantaneously from one group of settings to another to cater for reconfiguration of the power system. Changeover will occur within 25 msec.

A change of group can be achieved either locally at the relay fascia, remotely via a communication interface command or by energisation of a status input. In the case of the latter method, the 'Sett Grp Select' setting in the SYSTEM CONFIG MENU is used to configure one of the status inputs to select a settings group. The selected group is then made active if the status input is energised and remains active for as long as the input remains energised.

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4.5 Password Feature

The programmable password feature enables the user to enter a 4 character alphanumeric code to secure access to the relay settings. The relay is supplied with the password set to 'NONE', which means that the password feature is not activated. 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 resetting it back to 'NONE'.

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 can be communicated to Reyrolle Protection by authorised personnel, and the password can be retrieved.

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), 16 (E8), or 32 (E12) light emitting diodes (LED) and 5 push buttons. Figure 7 shows the fascia.

5.1 Liquid Crystal Display

The liquid crystal display is used to present settings, instrumentation and close data in a textual format.

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 except if the display is left in the 'Instruments Mode' where it remain visible permanently. This is so that instruments such as voltages can be displayed continuously.

5.2 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 steer any output to an LED. Useful during commissioning to check the autoreclose logic.

5.3 Keypad

Five pushbuttons are used to control the functions of the relay. They are labelled ⇧ ⇩ ⇨ 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.

6 SETTINGS AND DISPLAYS

The display menu structure is shown in Figure 6. This diagram shows the three main modes of display, which are the Settings Mode, Instruments Mode and the Fault Data Mode.

On relay start up the user is presented with a default relay identifier,

Settings Defaulted

Which shows that the relay has been set with the standard factory default settings.

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

The Settings Mode contains 11 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 the ⇩ key 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

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before. If a particular sub menu is not required to be viewed then pressing the ⇩ key 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 ⇧ or ⇩ scrolls through the available setting values or, pressing the ⇨ key moves right through the edit fields. Note that all settings can be incremented or decremented using the ⇧ or ⇩ keys and they all wraparound so that to go from e.g. a setting minimum value to the maximum value it is quicker to press the ⇩ key, rather than scroll through every setting. Also, to facilitate quicker setting changes an acceleration feature is available which if ⇧ or ⇩ are depressed and held, then the rate of scrolling through the setting values increases.

If 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.

Note: the relay exhibits a method of locking settings that are not relevant to a particular customer's scheme, which is known as setting dependencies. Some settings are dependant on others and if a function is not enabled then associated settings can not be used e.g. example if System Sync is not required then all System Sync settings are locked.

There are many examples of setting dependencies and care must be taken to ensure a function is enabled before looking for other associated settings that may be hidden. The following list of settings shows all possible settings that can be displayed.

6.1 System Config Menu

Active Group - this setting selects the settings group that the relay will act upon.

View/Edit Group – this setting selects the settings group to be displayed on the LCD.

Calendar – Set Date – this setting sets the current date in DD/MM/YY format.

Clock – Set Time – this setting sets the time in HH:MM:SS format. Note that only the hours and minutes can be set. The seconds default to zero on pressing the ENTER key.

Switched Group – this setting sets the group number that will be selected when the Switch Group Status Input is active.

Change Password – this setting allows a 4 character alphanumeric code to be entered as the password. Note that the display shows a password dependant encrypted code on the second line of the LCD.

Set Identifier – this setting allows a 16-character alphanumeric code or unique identification reference to be entered for the relay.

6.2 DAR Menu

A/R In Service – this setting switches the Autoreclose in or out.

Gn Dead Bar Charge – this setting determines the autoreclosing action.

Gn Dead Line Charge – this setting determines the autoreclosing action.

Gn Dead Line & Dead Bar Close – this setting determines the autoreclosing action.

Gn Check Sync Close – this setting determines the autoreclosing action.

Gn Unconditional Close – this setting determines the autoreclosing action.

Gn Manual Close DBC – this setting determines the Manual Closing action. Closing will occur if there is a Dead Bar and Live Line.

Gn Manual Close DLC – this setting determines the Manual Closing action. Closing will occur if there is a Dead Line and Live Bar.

Gn Manual Close DLDB – this setting determines the Manual Closing action. Closing will occur if there is a Dead Bar and Dead Line.

Gn Manual Close CS – this setting determines the Manual Closing action. Closing will occur if the system is within the Synchronisation limits.

Gn Number of Shots – this setting sets the number of autoreclose closes in a sequence.

Gn First Deadtime – this setting sets the first shot three pole deadtime time delay.

Gn Second Deadtime – this setting sets the second shot three pole deadtime time delay

Gn Third Deadtime – this setting sets the third shot three pole deadtime time delay.

Gn Fourth Deadtime – this setting sets the fourth shot three pole deadtime time delay.

Gn Live Line Check – this setting determines whether a line VT is fitted.

Gn Check Sync During Deadtime – this setting allows the deadtime to be over-ridden if an In Synch signal is present.

Gn VT Fail Lockout – this setting determines whether Lockout is set if a VT Fail occurs.

Gn CB Close Pulse – this setting sets the close pulse duration.

Gn Reclaim Time – this setting sets the reclaim time.

Gn Dead Line Charge Delay – this setting adds an additional delay to the deadtime when the Dead Line Charge conditions are met.

Gn Dead Bar Charge Delay – this setting adds an additional delay to the deadtime when the Dead Bar Charge conditions are met.

Gn Reclose Blocked Delay – this setting sets the allowable time a Block may be active before the Autoreclose sequence is locked out.

Gn Sync Close Delay – this setting sets the allowable time the Autoreclose sequence will wait for an In Sync signal before the sequence is locked out.

Gn Sequence Fail Timer – this setting sets the time to lockout if all the DAR start signals are not received. These are Trip Reset, CB Open and Dead Line.

Gn CB Fail To Open Delay – this setting sets the CB Fail to Open time delay.

Gn Persistent Intertrip – this setting sets the time to lockout if the Intertrip Receive input does not reset.

Gn AutoIsolation Action (+)(*) – this setting sets whether AutoIsolation can occur.

Gn AutoIsolation Timer (+)(*) – this setting sets the time delay which the AutoIsolation will wait for the AutoIsolation Complete signal before going to Lockout.

Gn Minimum LO Timer – this setting sets the minimum Lockout timer.

Gn Reset LO By Timer – this setting determines whether Lockout can be reset by the time delay setting, or by some other means i.e. a Reset LO status input.

Gn Total CB Close Counter – this setting sets the count at which an alarm will be given if that number of closes occur.

Gn Delta CB Close Counter – this setting sets the count at which an alarm will be given if that number of closes occur.

Gn Reset Total CB Count – this setting resets the count and alarm.

Gn Reset Delta CB Count – this setting resets the count and alarm.

6.3   CB Pole Discrepancy Menu

Gn Pole Discrepancy Time – this setting sets the time delay before Pole Discrepancy is issued.

6.4   Sync Menu

Gn Check Sync Vnom – this setting sets the nominal voltage used at the measuring Voltage Transformer.

Gn Live Bus/Dead Bus – this setting sets the voltage levels for Live and Dead Bus.

Gn Live Line/Dead Line – this setting sets the voltage levels for Live and Dead Line.

Gn Bus Undervolts – this setting sets the Bus undervoltage detector.

Gn Line Undervolts – this setting sets the Line undervoltage detector.

Gn Voltage Differential – this setting sets the differential voltage allowed between Bus and Line.

Gn Split Angle – this setting sets the angle at which a system split will occur.

Gn MC Split Action – this setting sets the action that will occur if a Manual Close is given after a system split.

Gn A/R Split Action – this setting sets the action that will occur if a system split occurs during an autoreclose sequence.

Gn Check Sync Angle – this setting sets the phase angle limits for the Check Sync element.

Gn Check Sync Slip – this setting sets the Check Sync Slip frequency.

Gn Check Sync Timer – this setting sets the Check Sync time delay.

Gn System Sync Angle – this setting sets the phase angle limits for the System Sync element.

Gn SS and COZ Slip Frequency – this setting sets the slip frequency for the System Sync and Close On Zero functions

Gn System Sync Timer – this setting sets the System Sync time delay.

Gn CB Close Time – this setting sets the CB Close time required for the Close On Zero function.

6.5 Status Input Menu

Manual Close - this setting sets the status input(s) which, when energised, starts the Manual Close operation of the relay.

Block Reclose - this setting sets the status input(s) which, when energised, Blocks Reclose during the autoreclose sequence.

A/R Out - this setting sets the status input(s) which, when energised, switches the Autoreclose Out. This input has priority over A/R In.

A/R In - this setting sets the status input(s) which, when energised, switches the Autoreclose In, unless the A/R Out is raised.

Trip - this setting sets the status input(s) which, when energised, starts the autoreclose cycle. It is required in conjunction with the state of the Circuit Breaker and Line.

Starter - this setting sets the status input(s) which, when energised, monitors the Starter output from the Protection relay. It is used to keep Autoreclose relays connected in series on a Distribution Feeder in sequence by counting the number of trip and closes on a line. If there is no starter available then this input is not connected.

Reclose Lockout - this setting sets the status input(s) which, when energised, causes the relay to go to Lockout.

Trip And Reclose - this setting sets the status input(s) which, when energised, cause a trip and reclose to occur. It is intended as a test input and cannot be used whilst an autoreclose sequence is in progress.

External A/R Start - this setting sets the status input(s) which, when energised, starts the operation of the relay. Provided as an alternative to the Trip input.

Reset Lockout - this setting sets the status input(s) which, when energised, will reset a latched lockout condition if there is no signal still present to cause the relay to be still in Lockout.

Sync Override - this setting sets the status input(s) which, when energised, will allow a Close Pulse to be issued irrelevant of the condition of the Check Sync function.

Manual Sync Override - this setting sets the status input(s) which, when energised, will allow a Close Pulse to be issued when it has been initiated by Manual Closing, irrelevant of the condition of the Check Sync function.

Start System Sync - this setting sets the status input(s) which, when energised, puts the Check Synchronisation function into the System Sync mode.

Intertrip Receive - this setting sets the status input(s) which, when energised, starts the autoreclose cycle. The Intertrip Receive is required to reset within the Persistent Intertrip time. Only a one shot Intertrip initiated autoreclose sequence is allowed.

AutoIsol Complete (+)(*) - this setting sets the status input(s) which, when energised, indicate that AutoIsolation has completed and the sequence may continue.

CB Phase A Closed - this setting sets the status input(s) which, when energised, indicates the condition of the CB Auxiliary contacts.

CB Phase B Closed - this setting sets the status input(s) which, when energised, indicates the condition of the CB Auxiliary contacts.

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CB Phase C Closed - this setting sets the status input(s) which, when energised, indicates the condition of the CB Auxiliary contacts.

CB Phase A Open - this setting sets the status input(s) which, when energised, indicates the condition of the CB Auxiliary contacts.

CB Phase B Open - this setting sets the status input(s) which, when energised, indicates the condition of the CB Auxiliary contacts.

CB Phase C Open - this setting sets the status input(s) which, when energised, indicates the condition of the CB Auxiliary contacts.

Input 1..16 - this setting sets the status input(s) which, when energised, provide a time delayed output.

Switch Groups - this setting sets the status input(s) which, when energised, switches the active Group to the number programmed in Switched Group in the SYSTEM CONFIG MENU.

Trigger Storage - this setting sets the status input(s) which, when energised, triggers the data storage.

Reset Total CB Close - this setting sets the status input(s) which, when energised, will cause the counter Total CB Close to reset.

Reset Delta CB Close - this setting sets the status input(s) which, when energised, will cause the counter Delta CB Close to reset.

Inverted Inputs - this setting sets the status input(s) which, when energised, will cause the selected inputs to invert. This is of special importance where series connected N/C contacts are used to drive status input logic.

6.6   Reylogic Control Menu

General Logic – this setting allows any Reylogic to be enabled/disabled.

6.7   Reylogic Elements Menu

Gn Input 1..8 Timer PU – this setting sets the pick up time delay associated with that input.

Gn Input 1..8 Timer DO – this setting sets the drop off time delay associated with that input.

6.8   Output Relay Menu

Close Pulse – this setting sets the output relay(s) which is operated when a Close Pulse is given.

Lockout – this setting sets the output relay(s) which is operated when Lockout is given.

A/R Out Of Service – this setting sets the output relay(s) which is operated when A/R Out of Service is given.

A/R In Service – this setting sets the output relay(s) which is operated when A/R In Service is given.

A/R In Progress – this setting sets the output relay(s) which is operated when A/R In Progress is given.

Manual Close – this setting sets the output relay(s) which is operated when a Manual Close is given.

Line Check – this setting sets the output relay(s) which is operated when a Line Check is commenced.

Live Line – this setting sets the output relay(s) which is operated when a Live Line is detected.

Live Bus – this setting sets the output relay(s) which is operated when a Live Bus is detected.

In Sync – this setting sets the output relay(s) which is operated when an In Sync is given.

CB Open – this setting sets the output relay(s) which is operated when a CB Open is detected.

CB Closed – this setting sets the output relay(s) which is operated when a CB Closed is detected.

CB Failed To Close – this setting sets the output relay(s) which is operated when the CB Fails To Close within the close pulse time.

System Split – this setting sets the output relay(s) which is operated when a System Split occurs.

Manual Close Fail – this setting sets the output relay(s) which is operated when the CB Fails To Close during a Manual Close sequence.

Successful Close – this setting sets the output relay(s) which is operated when the autoreclose sequence has successfully completed.

CB Failed To Open – this setting sets the output relay(s) which is operated when the CB has failed to open within the allocated time.

Block Reclose Alarm – this setting sets the output relay(s) which is operated when a Block Reclose input is active.

Check Sync Start – this setting sets the output relay(s) which is operated when the required Check Sync relay is requested to start.

Sync In Progress Flag – this setting sets the output relay(s) which is operated when the relay is waiting for In Sync.

Dead Line Close Flag – this setting sets the output relay(s) which is operated when the relay has closed due to Dead Line closing.

Dead Bus Close Flag – this setting sets the output relay(s) which is operated when the relay has closed due to Dead Bus closing.

Close Onto Fault – this setting sets the output relay(s) which is operated when a trip has occurred during the close pulse.

Delta CB Count Alarm – this setting sets the output relay(s) which is operated when the count exceeds it's setting.

Total CB Count Alarm – this setting sets the output relay(s) which is operated when the count exceeds it's setting.

VT Failure – this setting sets the output relay(s) which is operated when either the line or bus VT has failed.

Bus VT Failure – this setting sets the output relay(s) which is operated when the Bus VT has failed.

Line VT Failure – this setting sets the output relay(s) which is operated when the Line VT has failed.

CB Pole Discrepancy – this setting sets the output relay(s) which is operated when a CB Pole Discrepancy condition exists.

CB Not In Service Alarm – this setting sets the output relay(s) which is operated when the CB is not in service.

CB Memory – this setting sets the output relay(s) which is operated when the CB is closed and the Line is live with a 2 sec delayed drop-off.

A/R Not Allowed – this setting sets the output relay(s) which is operated to indicate an alarm condition that a trip has tried to initiate an autoreclose sequence but the CB was not in service.

Inhibit Seq Isolation – this setting sets the output relay(s) which is operated to stop sequential isolation. (N/O contact).

Persistent Intertrip – this setting sets the output relay(s) which is operated when a Persistent Intertrip is given.

AutoIsolation Fail (+)(*) – this setting sets the output relay(s) which is operated when an AutoIsolation Fail is given.

AutoIsolation Completed (+)(*) – this setting sets the output relay(s) which is operated when an AutoIsolation Completed is given.

AutoIsolation Initiate (+)(*) – this setting sets the output relay(s) which is operated when an AutoIsolation is required to be initiated.

Input1..16Operated – this setting sets the output relay(s) which are operated when the associated input(s) are operated.

ExtGroupSwitched – this setting sets the output relay(s) which is operated when the Group has changed.

New Data Stored – this setting sets the output relay(s) which is operated when new data has been stored.

Inhibit Seq Isol OP - this setting sets the output relay(s) which is operated to stop sequential isolation. (N/C contact).

Hand Reset Outputs – this setting sets the output relay(s) which are required to be latched until reset.

Protection Healthy – this setting sets the output relay(s) which is operated when Protection Healthy is given. This acts as a normally energised C/O contact.

6.9   LED Menu

The LED menu is a duplication of the output relay menu, allowing all outputs to be steered to an LED.

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6.10 Data Storage Menu

Waveform Pre-Trigger – this setting sets the percentage of pre-trigger that is required.

6.11 Communications Menu

Station Address – this setting sets the required address of a particular relay within a network.

IEC870 on port – this setting can direct to communications to either of the relay comms ports.

COM1 Comms Baud Rate – this setting sets the required communications Baud rate.

COM1 Parity – this setting sets the required communications parity bit.

COM1 Line Idle – this setting sets the required communications line idle sense.

COM1 Data Echo – this setting enables data echo, which is necessary for use with relays connected in a ring.

COM2 Comms Baud Rate – this setting sets the required communications Baud rate.

COM2 Parity – this setting sets the required communications parity bit.

COM2 Line Idle – this setting sets the required communications line idle sense.

COM2 Data Echo – this setting enables data echo, which is necessary for use with relays connected in a ring.

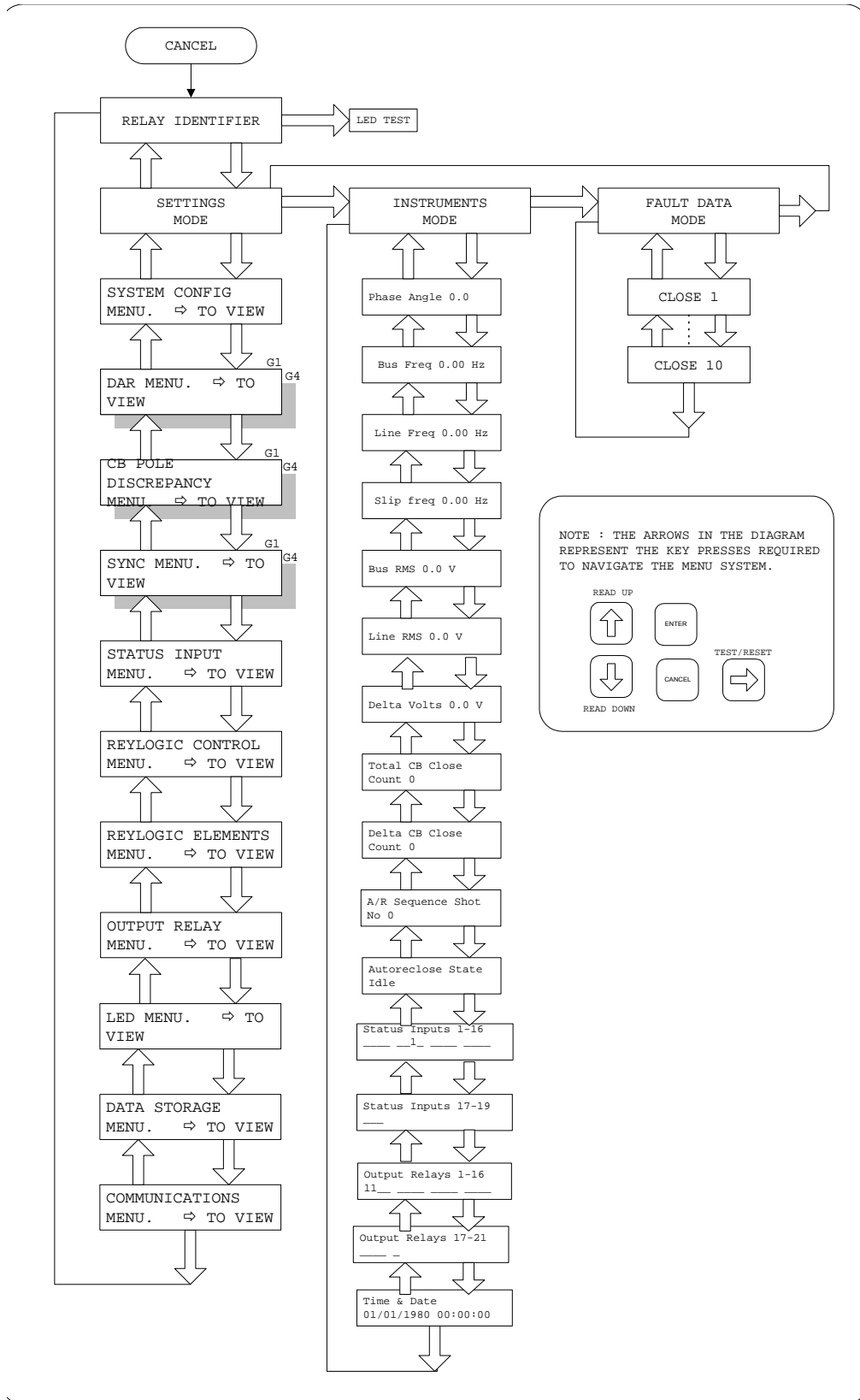*COM2 Direction – this setting switches COM 2 to either front or rear ports.*

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Figure 6 - Display Menu Structure

Figure 7 - Tau E8 Relay Fascia
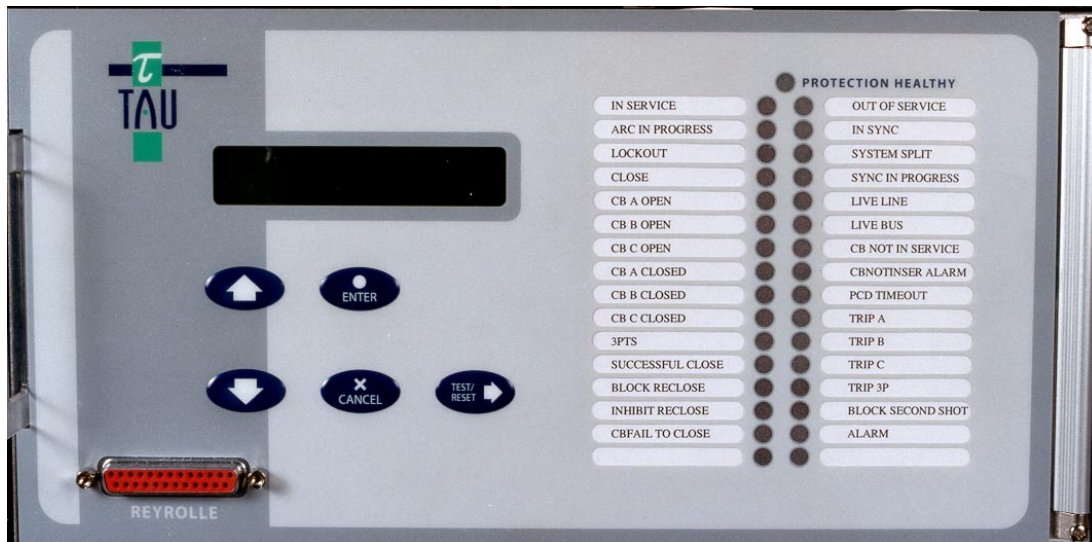
Figure 8 – Tau E12 Relay Fascia

Event Table

Event Description	Event Code	GI	Frame Type
Data lost	0	6	1
Reset FCB	2	6	5
Reset CU	3	6	5
Start/Restart	4	6	5
Power On	5	6	5
Auto-reclose active	16	6	1
Teleprotection Active	17	6	1
Protection Active	18		
LEDs reset	19	6	1
Monitor Direction Reset	20		
Trip Test	21		
Settings Changed	22	4	1
Setting G1 selected	23	4	1
Setting G2 selected	24	4	1
Setting G3 selected	25	4	1
Setting G4 selected	26	4	1
Input 1	27	4	1
Input 2	28	4	1
Input 3	29	4	1
Input 4	30	4	1
CB on by AR	128	6	1
CB "on" by long time AR	129	6	1
Reclose blocked	130	6	1
Lockout	131	6	1
CBFailToClose	132	6	1
CBFailToOpen	133	6	1
CloseOntoFault	134	6	1
VTFailAlarm	135	6	1
CBCloseCounterAlarm	136	6	1
SyncInProgress	137	6	1
SyncOverride	138	6	1
DeadLineClose	139	6	1
DeadBusClose	140	6	1
SystemSplit	141	6	1
CheckSyncStart	142	6	1
Input 5	165	4	1
Input 6	166	4	1
Input 7	167	4	1
Input 8	168	4	1
Input 9	169	4	1
Input 10	170	4	1
Input 11	171	4	1

Input 12	172	4	1
Input 13	173	4	1
Input 14	174	4	1
Input 15	175	4	1
Input 16	176	4	1
Input 17	177	4	1
Input 18	178	4	1
Input 19	179	4	1
Input 20	180	4	1
Input 21	181	4	1
Input 22	182	4	1
Input 23	183	4	1
Input 24	184	4	1
Input 25	185	4	1
Input 26	186	4	1
Input 27	187	4	1
Input 28	188	4	1
Input 29	189	4	1
Input 30	190	4	1
Input 31	191	4	1
Input 32	192	4	1
Output 1	193	4	1
Output 2	194	4	1
Output 3	195	4	1
Output 4	196	4	1
Output 5	197	4	1
Output 6	198	4	1
Output 7	199	4	1
Output 8	200	4	1
Output 9	201	4	1
Output 10	202	4	1
Output 11	203	4	1
Output 12	204	4	1
Output 13	205	4	1
Output 14	206	4	1
Output 15	207	4	1
Output 16	208	4	1
Output 17	209	4	1
Output 18	210	4	1
Output 19	211	4	1
Output 20	212	4	1
Output 21	213	4	1
Output 22	214	4	1
Output 23	215	4	1
Output 24	216	4	1
Output 25	217	4	1
Output 26	218	4	1
Output 27	219	4	1
Output 28	220	4	1

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Output 29	221	4	1	
Output 30	222	4	1	
Output 31	223	4	1	
Output 32	224	4	1	
Successful Close	225	6	1	
External AR Start	226	6	1	
Manual Close	227	6	1	
Reset lockout	228	6	1	
AR Out	229	6	1	
AR In	230	6	1	
In Sync	231	4	1	
Live Bus	232	4	1	
Live Line	233	4	1	
Trip	234	6	1	
Starter	235	6	1	
Reclose Lockout	236	6	1	
Trip And Reclose Input	237	6	1	
CB PoleDiscrepancy	238	6	1	
Reclaim	239	6	1	
Ext Group Change	240	6	1	
Ext Group Back	241	6	1	
Manual Sync Override	242	6	1	
Intertrip Receive	243	6	1	
AutoIsolation Complete I/P	244	6	1	
Inhibit Seq Isolation	245	6	1	
Persistent Intertrip	246	6	1	
AutoIsolation Fail	247	6	1	
AutoIsolation Completed	248	6	1	
AutoIsolation Initiate	249	6	1	
CB 'on' by MC	250	6	1	
A/R In Progress	251	6	1	
Total CB Count Reset	252	6	1	
Delta CB Count Reset	253	6	1	

KEY :

Event Code – is the allocated number given to a particular event.

GI – If the relay is interrogated for its events using the general interrogation (GI) command then only those indicated with the 4 will respond.

Frame Type – a '1' indicates that the event is time tagged. A '5' indicates an event which is generated only on power-on or reset of the relay.

Table 1 - Tau Event Codes

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Auto Reclose and Check Synchronisation

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1. GENERAL

The relay complies with the relevant clauses in the following specifications:-

- IEC 255

2. CHARACTERISTIC ENERGIZING QUANTITY

AC Voltage Vn	63.5/110 Vrms
Frequency	50 / 60Hz

3. AUXILIARY ENERGIZING QUANTITY

3.1 DC Power Supply

	Nominal	Operating Range
V_{AUX}	48V, 110V	37.5 to 137.5V dc
V_{AUX}	220V	88V to 280V dc

3.2 DC Status Inputs

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

Min. 3 status inputs. Additional modules of 8 self configuring programmable status inputs, opto-isolated may be installed.
Options Available   24V, 30V, 48V, 110 or 220V DC
NB. The 30/34V and 48/54V inputs meet the requirements of ESI 48-4 ESI 1. However, the 110/125V or 220/250V inputs will operate with a DC current of less than 10mA. If 110/125V or 220/250V inputs compliant with ESI48-4 ESI 1 are required, a relay with 48/54V status inputs can be supplied with external dropper resistors as follows:-

Status Input External Resistances

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

Status Input Performance

Minimum DC current for operation	10mA
Reset/Operate Voltage Ratio	$\geq 90\%$
Typical response time	<20ms
Typical response time when programmed to energise an output relay contact	<25ms
Minimum pulse duration	40ms

Each status input has associated timers which can be programmed to give time delayed pick-up and time delayed drop-off. The pick-up timers have default settings of 15ms, thus providing immunity to an AC input signal. Status inputs will not respond to the following:
- 250V RMS 50/60Hz applied for two seconds through a $0.1\mu F$ capacitor.
- 500V RMS 50/60Hz applied between each terminal and earth.
- Discharge of a $10\mu F$ capacitor charged to maximum DC auxiliary supply voltage.

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4.   SETTING RANGES

DAR Settings

A/R In Service	In/Out
Dead Bar Charge	Enabled/Disabled
Dead Line Charge	Enabled/Disabled
Dead Line & Dead Bar Close	Enabled/Disabled
Check Sync Close	Enabled/Disabled
Unconditional Close	Enabled/Disabled
Manual Close DBC	Enabled/Disabled
Manual Close DLC	Enabled/Disabled
Manual Close DLDB	Enabled/Disabled
Manual Close CS	Enabled/Disabled
Number of Shots	1..4
First Deadtime	0.1 – 900sec in 0.1sec steps
Second Deadtime	0.1 – 900sec in 0.1sec steps
Third Deadtime	0.1 – 900sec in 0.1sec steps
Fourth Deadtime	0.1 – 900sec in 0.1sec steps
Live Line Check	Enabled/Disabled
CS during dead	Enabled/Disabled
VT Fail Lockout	Enabled/Disabled
Close Pulse	0.1 – 20sec in 0.1sec steps
Reclaim Time	OFF - 1 – 600sec in 1sec steps
Dead Line Charge Delay	0 – 60 sec in 1sec steps
Dead Bar Charge Delay	0 – 60 sec in 1sec steps
Reclose Blocked Delay	1 – 600sec in 1sec steps
Sync Close Delay	OFF – 900sec in 1sec steps
Sequence Fail Delay	OFF - 1 – 200sec in 1sec steps
Persistent Intertrip	1 – 180sec in 1sec steps
CB Fail To Open Delay	0.1 – 2000msec in 10msec steps
AutoIsolation Action	Enabled/Disabled
AutoIsolation Timer	OFF - 1 – 200sec in 1sec steps
Minimum LO Time	0 – 60sec in 1sec steps
Reset LO By Timer	Enabled/Disabled
Total Close Count Alarm	1..999
Delta Close Count Alarm	1..999

Check Synchronising Settings

Nominal Volts	63.5/110V
Dead Bus	5 – 150%
Live Bus	10 – 155%
Dead Line	5 – 150%
Live Line	10 – 155%
Bus Undervolts	OFF – 150%
Line Undervolts	OFF – 150%
Voltage Differential	OFF – 100%
Split Angle	OFF – 175°
Manual Close Split Action	COZ/SS/CS
Autoreclose Split Action	Lockout/COZ/SS
Check Sync Angle	5 - 90°
Check Sync Slip	OFF – 2000mHz
Check Sync Timer	OFF – 100s
System Sync Angle	5 - 90°
SS and COZ Slip Frequency	OFF – 2000mHz

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System Sync Timer	OFF – 100s
CB Close Time	5 – 200ms

5.   ACCURACY REFERENCE CONDITIONS

General	IEC255
Auxiliary Supply	Nominal
Rating	63.5 Vrms
Frequency	50 or 60Hz
Ambient Temperature	20°C

6.   ACCURACY

CS and SS Phase Angle measurement	
Operate	Setting -3° + 0°
Reset	operate value -0° + 3°
CS and SS Slip Frequency	
Operate	Setting -15mHz + 0mHz
Reset	operate value -0mHz + 15mHz
Split Detector measurement	
Operate	setting ±1.5°
Reset	detector is latched
Line and Bus Voltage Detector Elements	
Live Operate	setting ±1%
Live Reset	dead operate setting ±1%
Dead Operate	setting ±1%
Dead Reset	live operate setting ±1%
Line and Bus U/V Detector Elements	
Operate	Setting ±1%
Reset	< 104% of operate value
ΔV Detector Element	
Operate	Setting ±2% or 0.5V whichever is greater
Reset	Typically > 90% (and always within 2V) of operate value
All Timers	
Timing Accuracy	±1% or 10ms

7.   ACCURACY GENERAL

Measuring Accuracy

Voltage	± 1% (for range 7V-132Vrms)
Frequency	Typically ± 10mHz
Phase	Typically ± 1°

8.   ACCURACY INFLUENCING FACTORS

Temperature

Ambient Range	-10°C to +55°C
Variation over range	$\leq$ 5%

Frequency

Range	47Hz to 51Hz 57Hz to 61Hz

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Setting variation	≤ 1%
Phase Angle Measurement	≤ 1%
Operating time variation	≤ 1%

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

9. THERMAL WITHSTAND

Continuous Overload

AC Voltage	250Vrms

10. BURDENS

AC Burden

	AC Burden
63.5Vrms Input	≤ 0.05VA

DC Burden

	DC Burden
Quiescent (Typical)	<9 Watts
Max	<12 Watts

11. OUTPUT CONTACTS

Contact rating to IEC60255-0-2.

Min 3 relays with c/o contacts. Additional modules of 8 self configuring programmable normally open output relays may be installed.
Any relay contact can be programmed for any function.

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

12. INDICATION

Green LED   Protection Healthy.

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32 Red LED Array   Summary Info.
LCD   Alphanumeric display for settings, instrumentation and fault data.

13.   ENVIRONMENTAL WITHSTAND

Temperature - IEC 68-2-1/2

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

Humidity - IEC 68-2-3

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

Transient Overvoltage –IEC60255-5

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 -
IEC60255-22-1 Class III

	Variation
2.5kV Common (Longitudinal) Mode	≤ 3%
1.0kV Series (Transverse) Mode	≤ 3%

Electrostatic Discharge -
IEC60255-22-2 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 – IEC60255-22-4 Class IV

	Variation
4kV 5/50ns 2.5kHz repetitive	≤ 3%

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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) – IEC60255-21-1 Class 1

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

Shock and Bump – IEC60255-21-2 Class 1

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

Seismic – IEC60255-21-3 Class 1

		Variation
Seismic Response	1gn	≤ 5%

Mechanical Classification

Durability	In excess of 10^6 operations

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## 1.	SYSTEM CONFIG MENU

SETTING	RANGE	DEFAULT
Active Settings Group	G1-G4	G1
Settings Group Edit/View	G1-G4	G1
Calendar - Set Date	DD/MM/YY	01/01/99
Clock - Set Time	HH:MM:SS	00:00:00
Sett Grp Select	G1-G4	1
Change Password	4 alphanumeric characters	NONE
Set Identifier	Up to 16 alphanumeric characters	TAU

## 2.	DAR MENU

SETTING	RANGE	DEFAULT
A/R In Service	IN/OUT	OUT
Dead Bar Charge	Enabled/Disabled	Disabled
Dead Line Charge	Enabled/Disabled	Disabled
Dead Line & Dead Bar Close	Enabled/Disabled	Disabled
Check Sync Close	Enabled/Disabled	Enabled
Unconditional Close	Enabled/Disabled	Disabled
Manual Close DBC	Enabled/Disabled	Disabled
Manual Close DLC	Enabled/Disabled	Disabled
Manual Close DLDB	Enabled/Disabled	Disabled
Manual Close CS	Enabled/Disabled	Enabled
Number Of Shots	1-4	1
First Deadtime	0.1-900s step 0.1s	5.0s
Second Deadtime	0.1-900s step 0.1s	5.0s
Third Deadtime	0.1-900s step 0.1s	5.0s
Fourth Deadtime	0.1-900s step 0.1s	5.0s
Live Line Check	Enabled/Disabled	Enabled
CS During Dead	Enabled/Disabled	Enabled
VT Fail Lockout	Enabled/Disabled	Disabled
CB Close Pulse	0.2-20s step 0.1s	2.0s
Reclaim Time	OFF - 1-600s step 1s	5s
Dead Line Charge Delay	0 – 60s step 1s	0s
Dead Bar Charge Delay	0 – 60s step 1s	0s
Reclose Blocked Delay	0-600s step 1s	60s
Sync Close Delay	OFF-900s step 1s	30s
Sequence Fail Timer	OFF-1-200s step 1s	OFF
Persistent Intertrip	1-180s step 1s	60s
CB Fail To Open Delay	50-2000ms step 10ms	100ms
AutoIsolation Action(+)(*)	Enabled/Disabled	Disabled
AutoIsolation Timer(+)(*)	OFF-1-200s step 1s	OFF
Minimum LO Timer	0-60s step 1s	2s
Reset LO By Timer	Enabled/Disabled	Disabled
Total CB Close Counter	1-999 step1	100
Delta CB Close Counter	1-999 step1	20
Reset Total CB Count	YES/NO	NO

SETTING	RANGE	DEFAULT
Reset Delta CB Count	YES/NO	NO

3. POLE DISCREPANCY MENU

SETTING	RANGE	DEFAULT
Pole Discrepancy Time	OFF-0.1-20.0s step 0.1s	1.6s

4. SYNC MENU

SETTING	RANGE	DEFAULT
Nominal Volts	63.5/110V	63.5V
Gn Bus Dead : Live	5-150% step1% 10-155% step 1%	20% 90%
Gn Line Dead : Live	5-150% step1% 10-155% step 1%	20% 90%
Gn Bus U/V Detector	OFF, 5-150% step 1%	90%
Gn Line U/V Detector	OFF, 5-150% step 1%	90%
Gn Voltage Differential	OFF-1-100% step 1%	10%
Gn Split Angle	OFF-95°-175° step1°	175°
Gn MC Split Action	Close On Zero/Check Sync/System Sync	Close On Zero
Gn A/R Split Action	Lockout/System Sync/Close On Zero	Lockout
Gn Check Sync Angle	5° - 90° step 1°	20°
Gn Check Sync Slip	OFF, 0.020 - 2.000Hz step 0.005Hz	0.050Hz
Gn Check Sync Timer	OFF, 0.1 - 100sec step 0.1sec	OFF
Gn System Sync Angle	5° - 90° step 1°	10°
Gn SS and COZ Slip Frequency	OFF, 0.010 - 2.000Hz step 0.005Hz	0.125Hz
Gn System Sync Timer	OFF, 0 – 100sec step 0.1sec	OFF
Gn CB Close Time	5-200ms step 5ms	60ms

5. STATUS CONFIG MENU

SETTING	RANGE	DEFAULT
Manual Close	S1..S11	1
Block Reclose	S1..S11	5
A/R Out	S1..S11	4
A/R In	S1..S11	3
Trip	S1..S11	11
Starter	S1..S11	None
Reclose Lockout	S1..S11	2
Trip And Reclose	S1..S11	None
External A/R Start	S1..S11	None
Reset Lockout	S1..S11	10
Sync Override	S1..S11	None
Manual Sync Override	S1..S11	None
Start System Sync	S1..S11	None
Intertrip Receive	S1..S11	None
AutoIsolation Complete(+)(*)	S1..S11	None

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SETTING	RANGE	DEFAULT
CB Phase A Closed	S1..S11	9
CB Phase B Closed	S1..S11	9
CB Phase C Closed	S1..S11	9
CB Phase A Open	S1..S11	8
CB Phase B Open	S1..S11	8
CB Phase C Open	S1..S11	8
Input1	S1..S11	None
Input2	S1..S11	None
Input3	S1..S11	None
Input4	S1..S11	None
Input5	S1..S11	None
Input6	S1..S11	None
Input7	S1..S11	None
Input8	S1..S11	None
Input9	S1..S11	None
Input10	S1..S11	None
Input11	S1..S11	None
Input12	S1..S11	None
Input13	S1..S11	None
Input14	S1..S11	None
Input15	S1..S11	None
Input16	S1..S11	None
Switch Groups	S1..S11	None
Trigger Storage	S1..S11	None
Reset Total CB Close	S1..S11	None
Reset Delta CB Close	S1..S11	None
Inverted Inputs	S1..S11	None

6. REYLOGIC CONTROL MENU

SETTING	RANGE	DEFAULT
General Logic	Enable/Disable	Enable

7. REYLOGIC ELEMENTS MENU

SETTING	RANGE	DEFAULT
Input1Timer PU	0-60000ms step 1ms	0
Input1Timer DO	0-60000ms step 1ms	0
Input2Timer PU	0-60000ms step 1ms	0
Input2Timer DO	0-60000ms step 1ms	0
Input3Timer PU	0-60000ms step 1ms	0
Input3Timer DO	0-60000ms step 1ms	0
Input4Timer PU	0-60000ms step 1ms	0
Input4Timer DO	0-60000ms step 1ms	0
Input5Timer PU	0-60000ms step 1ms	0
Input5Timer DO	0-60000ms step 1ms	0
Input6Timer PU	0-60000ms step 1ms	0

SETTING	RANGE	DEFAULT
Input6Timer DO	0-60000ms step 1ms	0
Input7Timer PU	0-60000ms step 1ms	0
Input7Timer DO	0-60000ms step 1ms	0
Input8Timer PU	0-60000ms step 1ms	0
Input8Timer DO	0-60000ms step 1ms	0

8.   OUTPUT RELAY MENU

SETTING	RANGE	DEFAULT
Close Pulse	RL1..RL13	4
Lockout	RL1..RL13	5
A/R Out Of Service	RL1..RL13	None
A/R In Service	RL1..RL13	2
A/R In Progress	RL1..RL13	6
Manual Close	RL1..RL13	None
Line Check	RL1..RL13	None
Live Line	RL1..RL13	None
Live Bus	RL1..RL13	None
In Sync	RL1..RL13	None
CB Open	RL1..RL13	None
CB Closed	RL1..RL13	None
CB Failed To Close	RL1..RL13	8
System Split	RL1..RL13	None
Manual Close Fail	RL1..RL13	None
Successful Close	RL1..RL13	7
CB Failed To Open	RL1..RL13	None
Block Reclose Alarm	RL1..RL13	None
Check Sync Start	RL1..RL13	12
Sync In Prog Flag	RL1..RL13	None
Dead Line Close Flag	RL1..RL13	None
Dead Bus Close Flag	RL1..RL13	None
Close Onto Fault	RL1..RL13	None
Delta CB Count Alarm	RL1..RL13	9
Total CB Count Alarm	RL1..RL13	9
VT Failure	RL1..RL13	10
Bus VT Failure	RL1..RL13	None
Line VT Failure	RL1..RL13	None
CB Pole Discrepancy	RL1..RL13	13
CB Not In Ser Alarm	RL1..RL13	None
CB Memory	RL1..RL13	None
A/R Not Allowed	RL1..RL13	None
Inhibit SeqIsolation	RL1..RL13	None
Persistent Intertrip	RL1..RL13	None
AutoIsol Fail (+)(*)	RL1..RL13	None
AutoIsol Completed (+)(*)	RL1..RL13	None
AutoIsol Initiate (+)(*)	RL1..RL13	None
Input1Operated	RL1..RL13	None

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SETTING	RANGE	DEFAULT
Input2Operated	RL1..RL13	None
Input3Operated	RL1..RL13	None
Input4Operated	RL1..RL13	None
Input5Operated	RL1..RL13	None
Input6Operated	RL1..RL13	None
Input7Operated	RL1..RL13	None
Input8Operated	RL1..RL13	None
Input9Operated	RL1..RL13	None
Input10Operated	RL1..RL13	None
Input11Operated	RL1..RL13	None
Input12Operated	RL1..RL13	None
Input13Operated	RL1..RL13	None
Input14Operated	RL1..RL13	None
Input15Operated	RL1..RL13	None
Input16Operated	RL1..RL13	None
ExtGroupSwitched	RL1..RL13	None
New Data Stored	RL1..RL13	None
Inhibit Seq Isol OP	RL1..RL13	None
Hand Reset Outputs	RL1..RL13	None
Protection Healthy	RL1..RL13	1

9.   LED MENU

SETTING	RANGE	DEFAULT
Close Pulse	L1..L16	4
Lockout	L1..L16	3
A/R Out Of Service	L1..L16	1
A/R In Service	L1..L16	None
A/R In Progress	L1..L16	2
Manual Close	L1..L16	2
Line Check	L1..L16	None
Live Line	L1..L16	None
Live Bus	L1..L16	None
In Sync	L1..L16	None
CB Open	L1..L16	5
CB Closed	L1..L16	6
CB Failed To Close	L1..L16	8
System Split	L1..L16	12
Manual Close Fail	L1..L16	8
Successful Close	L1..L16	13
CB Failed To Open	L1..L16	7
Block Reclose Alarm	L1..L16	14
Check Sync Start	L1..L16	None
Sync In Prog Flag	L1..L16	None
Dead Line Close Flag	L1..L16	None
Dead Bus Close Flag	L1..L16	None
Close Onto Fault	L1..L16	None

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SETTING	RANGE	DEFAULT
Delta CB Count Alarm	L1..L16	16
Total CB Count Alarm	L1..L16	16
VT Failure	L1..L16	None
Bus VT Failure	L1..L16	None
Line VT Failure	L1..L16	None
CB Pole Discrepancy	L1..L16	12
CB Not In Ser Alarm	L1..L16	9
CB Memory	L1..L16	10
A/R Not Allowed	L1..L16	15
Inhibit SeqIsolation	L1..L16	None
Persistent Intertrip	L1..L16	11
AutoIsol Fail (+)(*)	L1..L16	None
AutoIsol Completed (+)(*)	L1..L16	None
AutoIsol Initiate (+)(*)	L1..L16	None
Input1Operated	L1..L16	None
Input2Operated	L1..L16	None
Input3Operated	L1..L16	None
Input4Operated	L1..L16	None
Input5Operated	L1..L16	None
Input6Operated	L1..L16	None
Input7Operated	L1..L16	None
Input8Operated	L1..L16	None
Input9Operated	L1..L16	None
Input10Operated	L1..L16	None
Input11Operated	L1..L16	None
Input12Operated	L1..L16	None
Input13Operated	L1..L16	None
Input14Operated	L1..L16	None
Input15Operated	L1..L16	None
Input16Operated	L1..L16	None
ExtGroupSwitched	L1..L16	None
New Data Stored	L1..L16	None
Inhibit Seq Isol OP	L1..L16	None
Self Reset LEDs	L1..L16	1-16
Protection Healthy	L1..L16	Green

10. 1DATA STORAGE MENU

SETTING	RANGE	DEFAULT
Waveform Pre-trigger	OFF, 10%-100% step 10%	50%

11. COMMS INTERFACE MENU

SETTING	RANGE	DEFAULT
Relay Address	0 - 254	0
IEC870 on port	COM1/COM2	COM1

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SETTING	RANGE	DEFAULT
COM1 Baud Rate	75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200	19200
COM1 Parity	NONE, EVEN	EVEN
COM1 Line Idle	LIGHT ON, LIGHT OFF	LIGHT OFF
COM1 Data Echo	OFF / ON	OFF
COM2 Baud Rate	75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200	19200
COM2 Parity	NONE, EVEN	NONE
COM2 Line Idle	LIGHT ON, LIGHT OFF	LIGHT OFF
COM2 Data Echo	OFF / ON	OFF
COM2 Direction	AUTO-DETECT/FRONT PORT/REAR PORT	AUTO-DETECT

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1. INTRODUCTION

This document describes how to connect the IEC870-5-103 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 (e.g. Reydisp Evolution).

2. CONNECTION SPECIFICATION AND RELAY SETTINGS

This section defines the connection medium as defined by IEC 870-5-103. Appendix A shows some typical communication connections.

2.1. Recommended cable

Selection of fibre optic cable is critical. Fibres should be terminated with 9mm SMA connectors.

The recommended type is 200μm Plastic Coated Silica (PCS). This will allow a maximum transmission distance of 100m between Argus relays. It will also be the maximum distance between the ring network and the fibre to RS232 converter.

Alternatively, 1mm polymer cable may be used to reduce cost. This will provide transmission distances of upto 43m between relays. Note that the distance from the transmit output of the RS232 / fibre optic converter to the receive input of the first Argus relay should be not more than 6m. The distance from the transmit output of the last Argus to the receive input of the converter may be upto 43m.

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

2.2. 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 Argus 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.

Reydisp Evolution is a PC based software package providing capability for both local and remote communication. 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.

2.3. Transmission Method

The transmission method is Half Duplex serial asynchronous transmission. In IEC 870-5-103 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).

2.4. 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 defined in IEC 870-5-103, the additional rates are provided for local or modem communications.

2.5. 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 870-5-103 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 Protection.

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.

2.6. Parity Setting

IEC 870-5-103 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.

2.7. 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.

3. MODEMS

The communications interface has been designed to allow data transfer via modems. However, IEC 870-5-103 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 IEC870 control systems.

3.1 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 Connections
Tx	**Rx**
Rx	**Tx**

3.2 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.

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.

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3.3 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, 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 configuration (figure 5), 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).
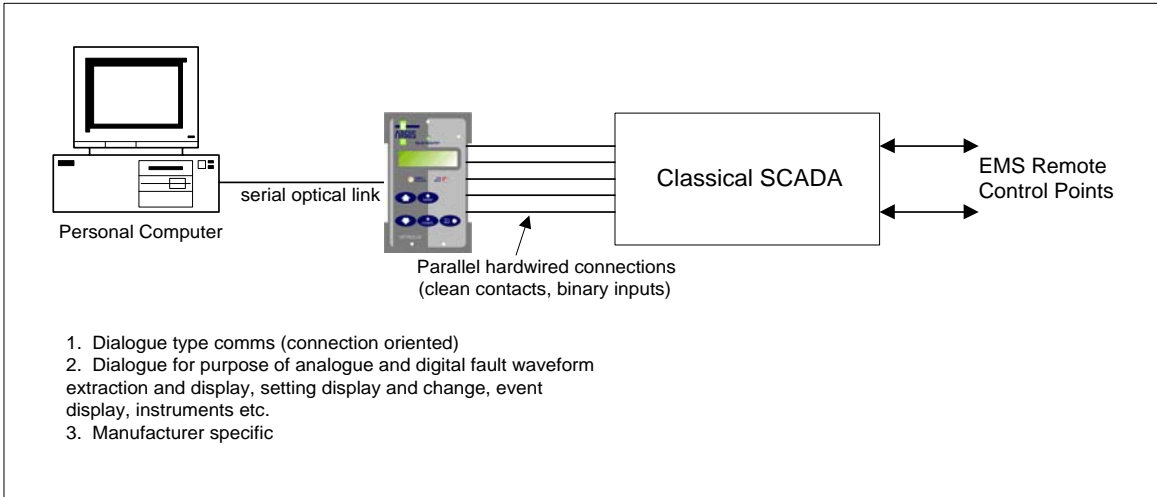
Figure 1 - Basic Communications Configuration
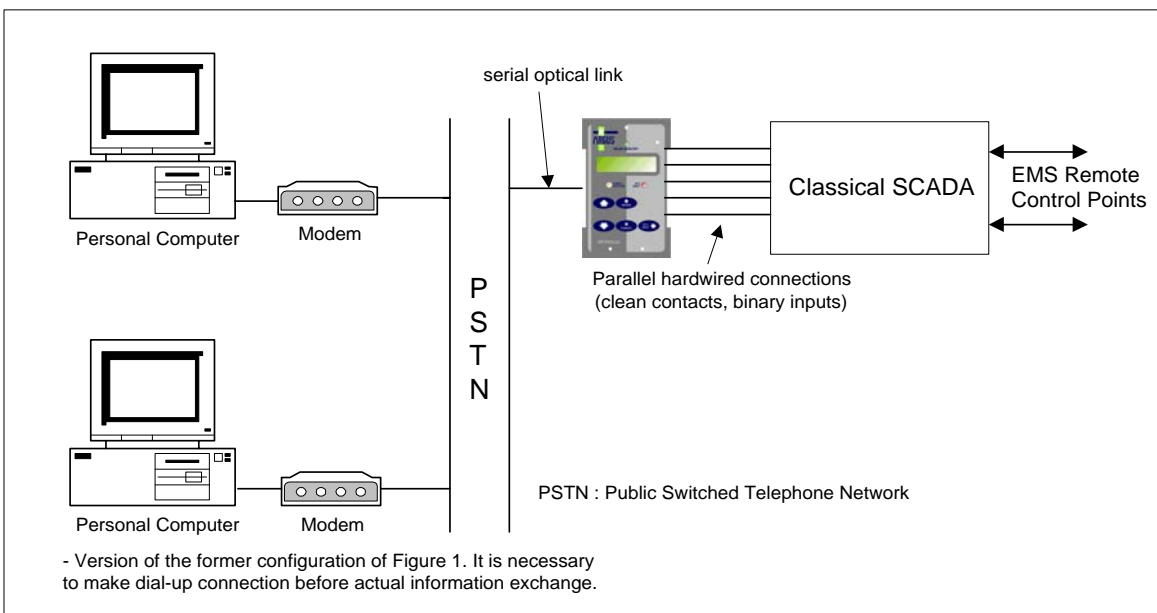
Figure 2 - Basic Communications Configuration (Remote)

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- A more sophisticated version of the former configuration of Figure 2. Several relays within the substation can be accessed via one modem but only one can be communicated with at a time.
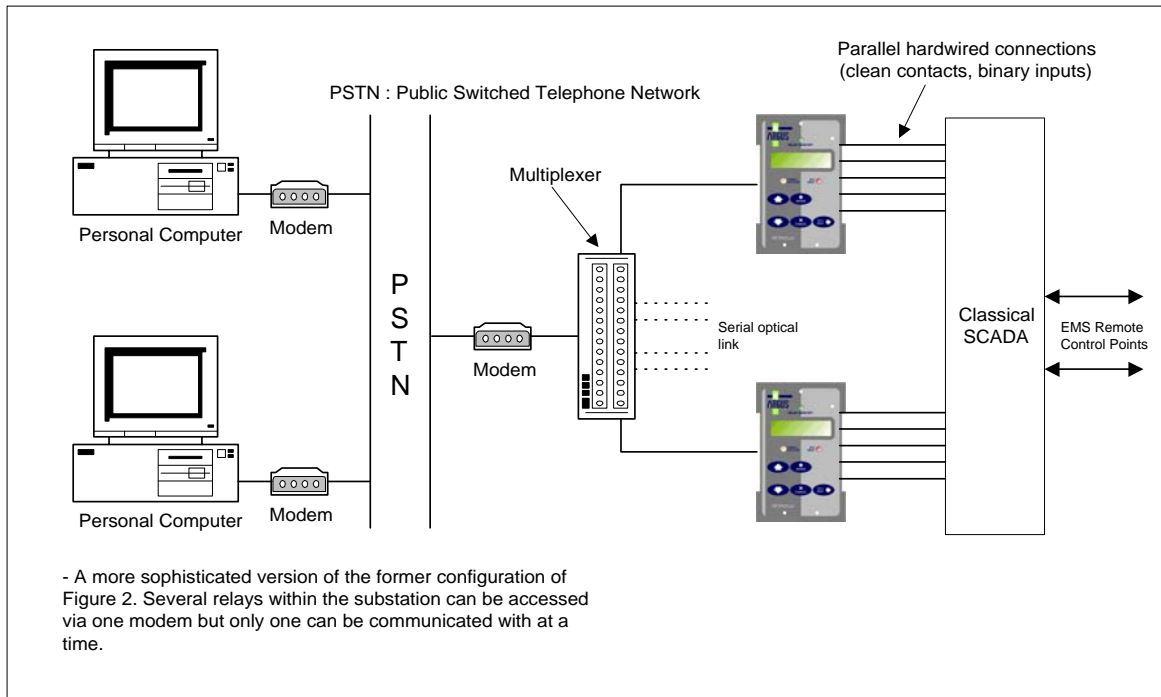
Figure 3 - Star Type Comms. Configuration (Multiplexer)

- Both Dialogue type and Automatic comms :
- Automatic type : continuous interrogation of all relays by cyclical polling.
- Dialogue type comms. can be initialised from MMI also
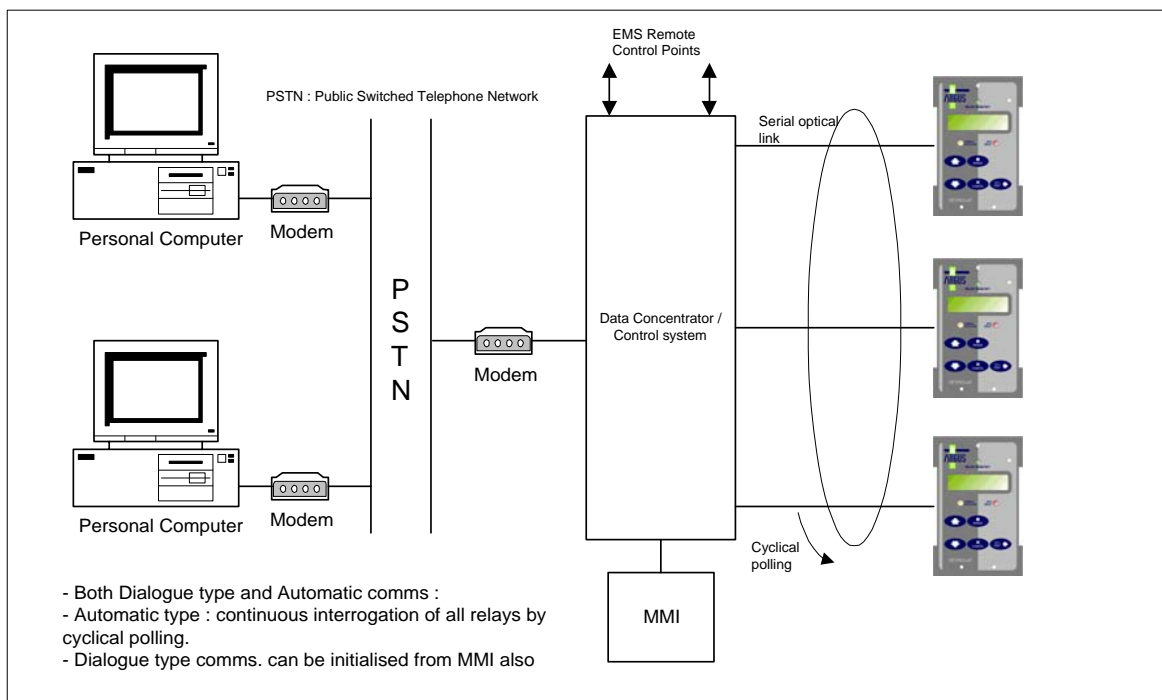
Figure 4 - Data Concentrator Configuration

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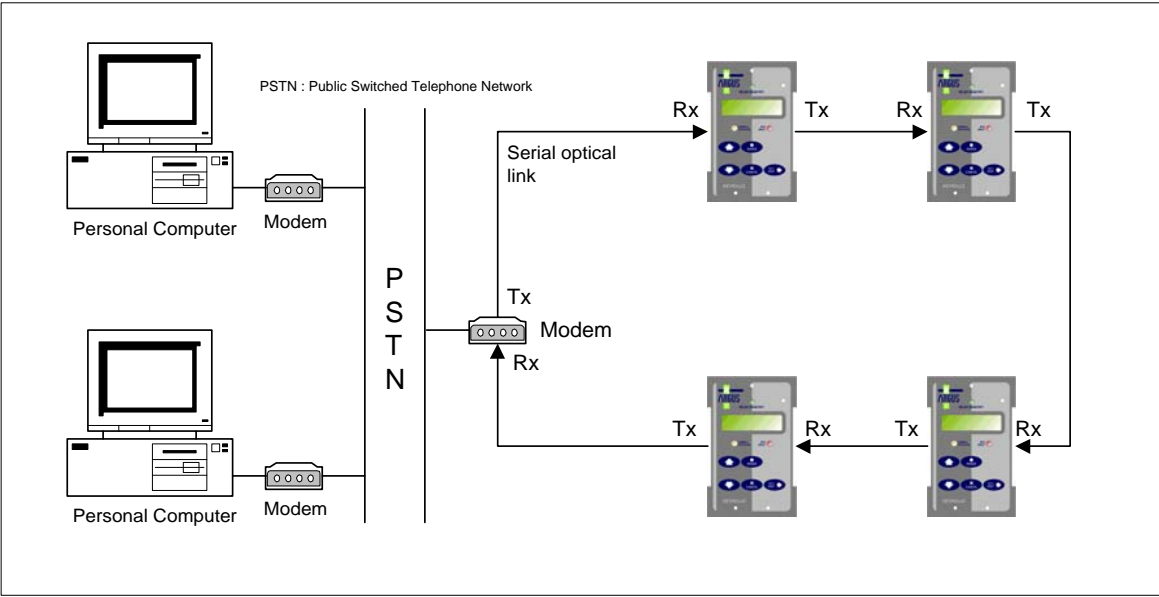
Figure 5 - Optical Ring Configuration
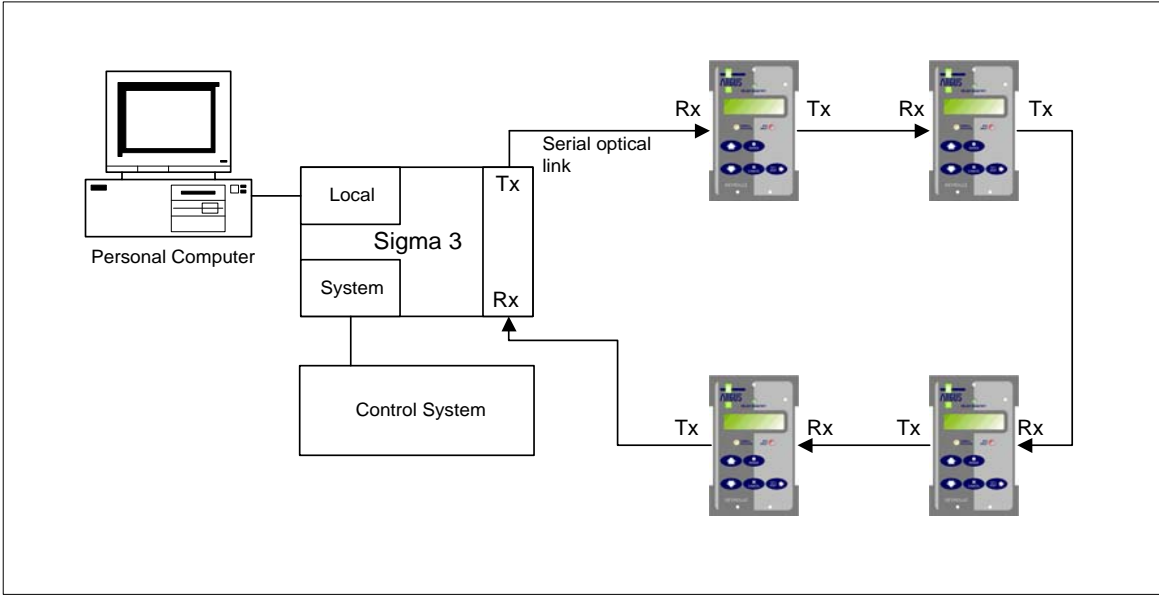
Figure 6 - Configuration using the Sigma 3 – Dual Port RS232 Device

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7SG26 Tau 500
Auto Reclose and Check Synchronisation

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

Software Revision History

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Figures

1. INTRODUCTION

The relays provide a full closing system: Autoreclose, Manual Closing and Check Synchronisation. The input/output is fully programmable to matrixes from the status inputs to the output contacts or/and LEDs.

The combined check and system synchronising function can automatically select check or system synchronise from measurements of the relative phase angles between the line and bus voltages. The relay will prevent closure of the circuit breaker if the phase angle, slip frequency or the voltage magnitude of the incoming and running voltages fall outside prescribed limits.

If the parameters are within the limits the relay will issue an output that can be used to close the circuit breaker directly. Both the check and system synchronise functions have independent settings and blocking features. The relay also includes split system detection, which can be used for blocking purposes within the autoreclose scheme.

2. GENERAL INFORMATION

2.1 General

The relay can directly replace older Autoreclose relays. The relay contains the equivalent UK specification Autoreclose logic ('J' unit, or 'C' unit), Indication ('F' unit) and In/Out Switching ('H' unit) all within the relay.

On initial switch on of AC volts to the relay, the Check Sync function will wait for 0.5 seconds before any output can be given. This is to allow time for the frequency and phase measuring elements to settle and establish healthy outputs and also allow for any transient conditions on voltage switch on.

It also allows busbar connection of multiple incoming volts to use a common check sync relay.

2.2 Autoreclose

The Autoreclose function provides the flexibility to be applied to a number of different Autoreclose schemes. This is achieved by a number of settings that provide choices as to connections and time delays. The relay can be easily connected as a basic scheme with minimal input and output or more of the functions can be set to provide extra alarms and control.

Settings:

In/Out Switching can be connected directly to the relay's status inputs; remote control auxiliary relays are not required because the relay has separately grounded inputs.

The Number of Autoreclose shots can be programmed from 1 to 4 depending upon the system.

The reclosure options are circuit breaker specific.

Reclosure Options	Option Range
Dead Bar Charge	Enabled/Disabled
Dead Line Charge	Enabled/Disabled
Dead Line & Dead Bar Close	Enabled/Disabled
Check Sync Close	Enabled/Disabled
Unconditional Close	Enabled/Disabled

Deadtime:

There are four deadtime settings. This is the time taken from the circuit breaker tripping and the trip reset to a reclose signal being issued. Some systems use a trip reset interlock to facilitate isolation. This may hold the trip active until any post-fault isolation has completed.

Live Line Check

This setting allows the Tau 500 range of relays to be applied to schemes which do not have line VT's.

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CS During Dead

This setting allows the deadtime to be over-ridden if an In Sync signal is received. Alternatively some schemes require that the deadtime must elapse before the close pulse is issued.

Sequence Fail timer:

To prevent the autoreclose sequence being primed indefinitely a Sequence Fail time delay should be set greater than any trip reset time delays. If the Sequence Fail timer expires because either the trip fails to reset, or the CB does not open, or the line does not go dead then the autoreclose sequence will lockout. If the timer is not required then it can be set to OFF.

Block Reclose Delay:

The Block Reclose Delay works in conjunction with the Block Reclose input. If the Block Reclose Delay expires the relay will lockout. CB conditions such as Low Pressure should be connected to this input. At the end of the Deadtime if there is a Block Reclose present the relay will wait for as long as the Block Reclose Delay. If the Block Reclose input resets before the end of the Block Reclose Delay then reclosure will be permitted.

Sync Close Delay:

This timer limits how long the relay will wait for the In Sync signal. If Check Sync Close is allowed but the Sync Check function is returning Not In Sync the relay will wait. If the Sync Close Delay expires the relay will lockout. This setting needs to be set to accommodate the closing operation programmed.

For a one shot reclosure scheme with Dead Line Charge at the remote end and Check Sync Close at this end it is likely that a Sync Close Delay of 5sec would suffice. This is dependent upon whether the system will island. If it is not possible for the system to split and Check Sync is being used (i.e. there will be a constant phase angle, say 6°), then the setting of the Sync Close Delay should be set to 5sec.

For a reclosure scheme which may split and the reclosure is programmed for Check or System Sync at tighter angles or Close On Zero after system split, it may take a considerable time for the two systems to come into synchronism. This will be dependent upon the slip frequency. The Sync Close Delay needs to be set longer than the possible delay the two systems take to get back in Sync, otherwise the relay will lockout before a reclosure can be attempted. For a slip frequency of 50mHz it takes 20 seconds for a complete rotation. If the deadtime is set to 5sec it would be necessary to set the Sync Close Delay to approximately 20seconds. It is recommended to set the Sync Close Delay to the minimum slip frequency rotation time. For worst case, where the deadtime was set longer than the slip frequency rotation time the close may be required just at the point where the vector has left the setting range, in which case a full rotation would be required to get back into the limits.

The setting can be selected to OFF which will cause the relay to wait indefinitely.

Persistent Intertrip:

The reclosure can be started by an intertrip receive. Intertrips are generally connected to some form of inter-tripping communication channel. To prevent autoreclose from the remote circuit breaker, if the intertrip is present for longer than the Persistent Intertrip time the reclosure will not be initiated and the relay will lockout. The deadtime is started when the Intertrip resets provided the CB has opened, there are no other trips or starter active, the line has gone dead, and the Persistent Intertrip timer has not timed out.

The Persistent Intertrip time is only associated with the Intertrip Receive status input.

CB Close Pulse:

The CB Close Pulse should be set to a value to ensure that the CB is closed, typically 2sec. To take account of slow spring rewind times the close pulse setting range has deliberately been extended up to 20seconds.

Reclaim Time:

The reclaim time would be set to a value that represents a correct reconnection. If the CB remains closed for the Reclaim time following an autoreclose, the relay will reset and be ready for further operations. This is usually set to correspond to the spring rewind time of the circuit breaker. At the end of the reclaim time a

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fleeting contact 'Successful A/R' will be issued. A trip or starter pick-up within the reclaim time would initiate another reclose if the next shot is allowed, otherwise the autoreclose sequence will be locked out.

Dead Line Charge Delay / Dead Bar Charge Delay:

These settings allow a flexible restoration sequence to be programmed. Used in conjunction with the deadtime settings very flexible autoreclose sequences can be programmed.

Certain applications require system restoration of some items of plant to be time sequenced. This could be T'd feeders with connected transformers. The Transformer LV CB may be time delayed to allow the transformer to be live for a time setting before reclosure, typically the Dead Line Charge Delay would be set to 20sec.

Minimum Lockout Timer:

Once the relay enters the lockout state this may be latched until reset or reset automatically provided there is no mechanism to keep the relay in lockout. However a minimum lockout time can be set. Recommended setting 2 seconds.

Reset LO By Timer:

If Reset LO By Timer is set to Enabled the relay will automatically reset from lockout provided there is no mechanism to cause lockout. This will be set depending upon how lockout is dealt with by individual utilities. Some utilities investigate every lockout occurrence (in which case this setting should be set to Disabled) whilst others accept lockout as normal operation.

Application to Transmission Feeder:

Where applied to a feeder with DAR at each end, different deadtimes would be applied, example: 5sec and Dead Line Charge at local end (small generation); and 10sec and Check Sync and Dead Line Charge at remote end (large generation). Choosing to Dead Line Charge from the small source would ensure that closing onto a fault causes the least shock to the system. The Transmission line is reclosed even if the remote or local CB cannot close. Closure is only permitted if the line has gone dead which indicates that both local and remote CBs have opened.
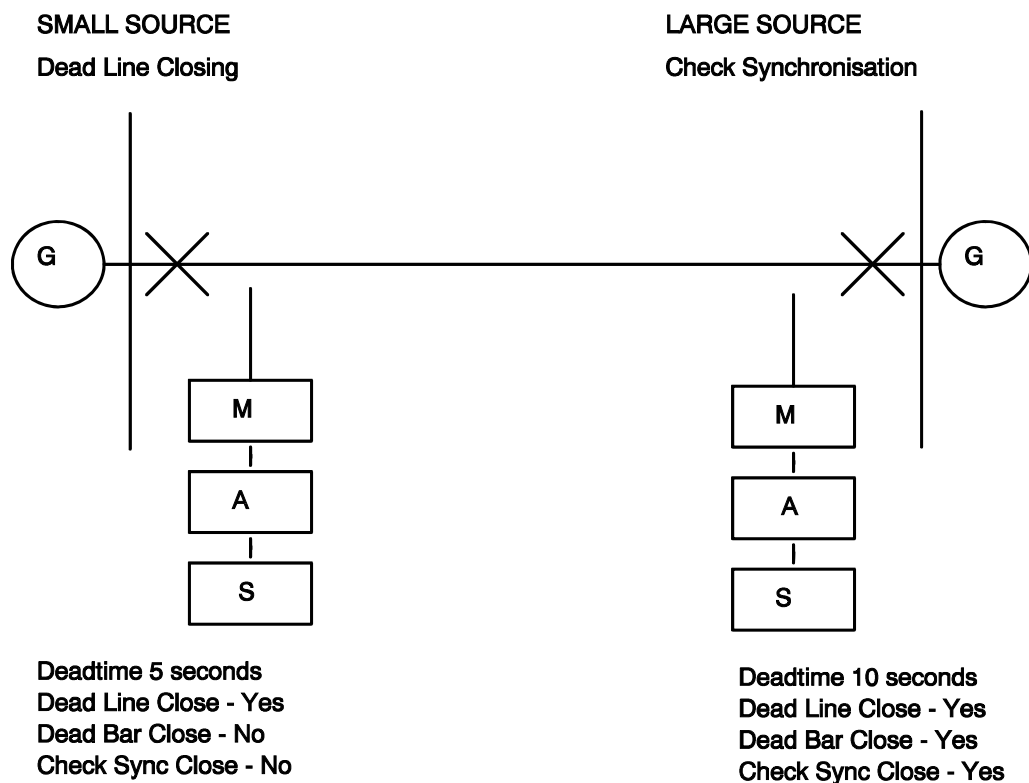

Figure 1 Typical Feeder Diagram

Application to T'd Feeder or Mesh Corner:

Two autoreclose relays would need to be specified for a double CB situation such as Teed feeders or Mesh Corner. One autoreclose relay per CB. Each relay could be set to the same deadtime i.e. 5 seconds, and priority of closing would be X1 then X2. X1's A/R In Progress output would be connected to X2's Block Reclose input which would reset the deadtime of X2.
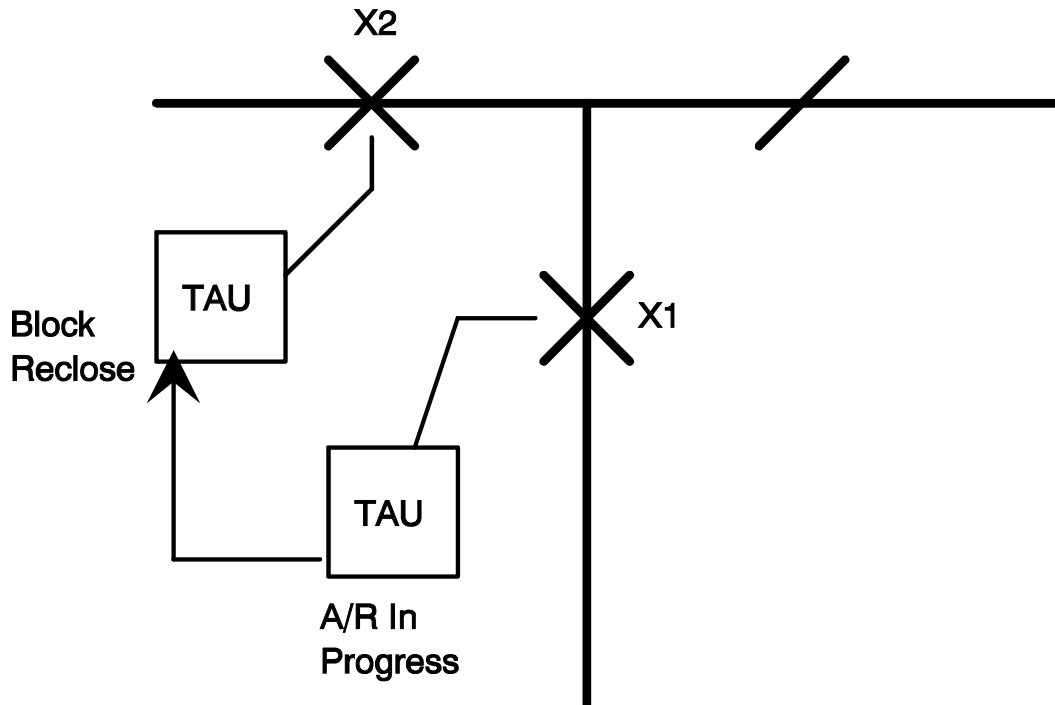

Figure 2 Mesh or T'd Feeder Connection Diagram

Autoisolation (+)(*):

Any Protection Trips or Starters within the close pulse will truncate the close pulse. A trip within the close pulse can start the Autoisolation sequence if selected. Autoisolation will complete before the next reclose operation takes place. If a reclose is required after an autoisolation sequence then the Number of shots should be set to a minimum of 2.

The relay can distinguish between a trip in the close pulse (autoisolate allowed) and a trip in the reclaim. Although it may be required to perform the sequence:

Trip – Reclose – Trip in Close Pulse – Auto Isolate – Reclose

With the Number of shots set to 2 the sequence could perform two recloses without autoisolation:

Trip – Reclose – Trip in Reclaim – Reclose

But to avoid the second reclose without first autoisolating, a different sequence may be required:

Trip – Reclose – Trip in Close Pulse (Reclaim) – Auto Isolate – Reclose

To accommodate this sequence it is possible to set the reclaim timer to OFF, and extend the close pulse setting to act as a reclaim time, say close pulse set to 10sec.

The Autoisolation timer should be set greater than the time it takes the Isolator to close and the AutoIsolation Complete signal is returned to the relay. This may be of the order of 10 seconds.
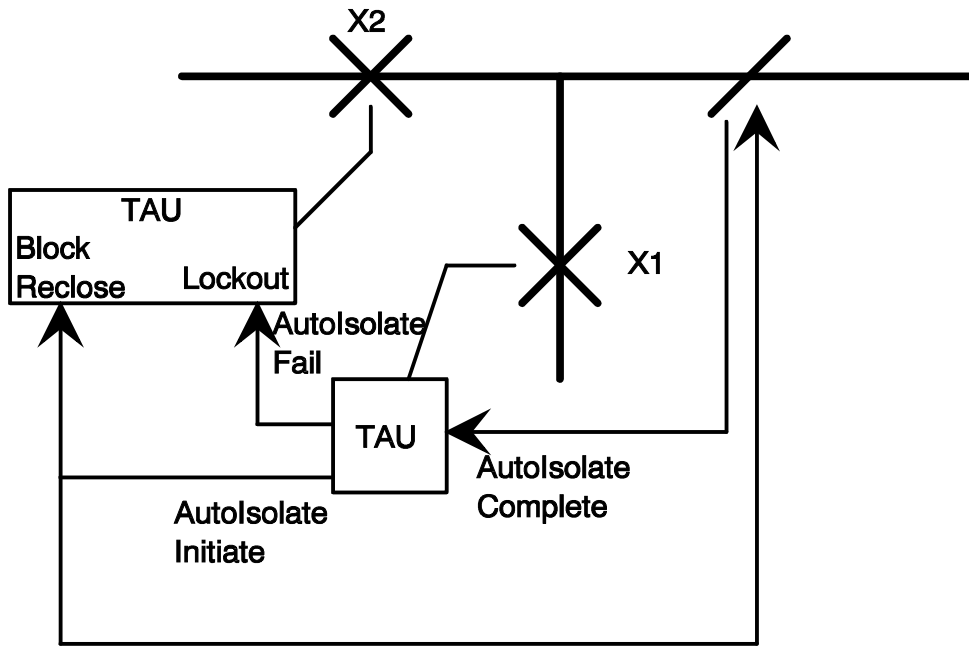
AutoIsolate Action - Required
AutoIsolate Timer - 10sec

Figure 3 AutoIsolation Connection Diagram

CB Status:

The status of the CB can be determined by a combination of connections. Either a full connection of CB Phase A Open, CB Phase B Open, CB Phase C Open and CB Phase A Closed, CB Phase B Closed, CB Phase C Closed. Or a simpler connection of only CB And Isolator Open, and CB And Isolator Closed, in this case the matrix has to account for phase A,B,C connected to the same input.
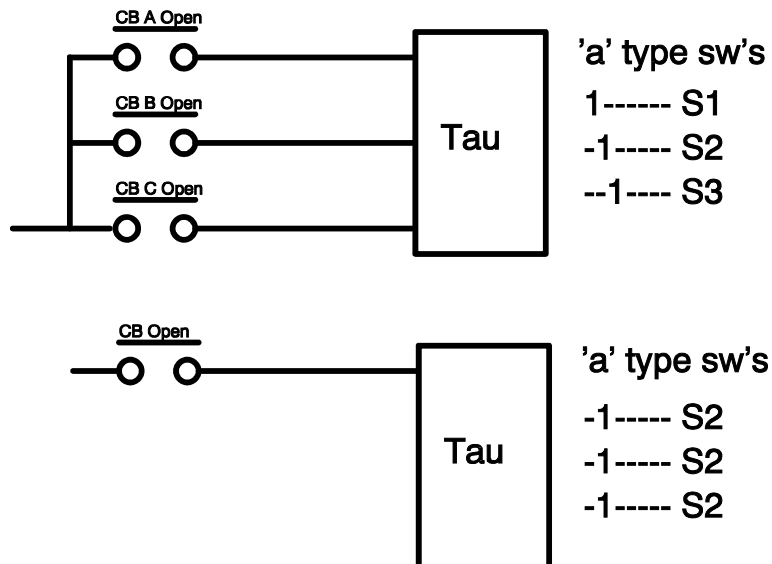

Figure 4 CB Status Connection Diagram

Output Alarms:

Various outputs are given during the autoreclose sequence, these can be used for alarm purposes or to Lockout the sequence; or could be further divided into System Alarm/CB Alarm indication, or not used. If they are not used the output setting would be left blank.

Close Onto Fault Inhibit: A trip or starter has picked-up within the close pulse. A trip within the close pulse is recognised and a Close Onto Fault output issued. This can be used to prevent autoreclosing, i.e. independently wired to Lockout.

CB Counter: CB Maintenance is required, the number of CB Close counts since last maintenance has exceeded its alarm setting.

A/R Not Allowed: A trip has occurred but the CB is not in service. This indicates an alarm condition – autoreclose is not allowed for a normally open or de-energised line.

CB Fail To Open: A combination of a Protection Trip and the CB auxiliary contacts indicating CB Closed after a settable time delay results in the alarm CB Fail To Open. This would be useful in Distribution autoreclose applications where conventional CB Fail protection was not fitted because of cost. The CB Fail To Open output would be independently wired to Lockout and stop the autoreclose sequence. Alternatively a time delay setting could be set which indicates CB Slow, and give an alarm if the CB is still closed after this setting.

Pole Discrepancy: A mismatch of CB positions across the three phases might indicate CB problems. Generally if one or two of the phases is indicating closed whilst the others are open, and vice versa, for longer than a time delay setting then an alarm will be issued. This alarm can be used to Lockout the autoreclose sequence. This is applied as a separate protection to single pole reclose schemes, and is sometimes quoted as requiring a separate supply to the main protection. Three Pole tripping schemes also use Pole Discrepancy, especially where separate phase circuit breaker mechanisms are employed. The function is easily integrated into the Autoreclose relay and provides the same functionality. A requirement for Pole Discrepancy would be to connect all phases of CB Open and CB Closed to the relay. Additional I/O would probably need to be ordered to take account of this, 19 inputs instead of 11.
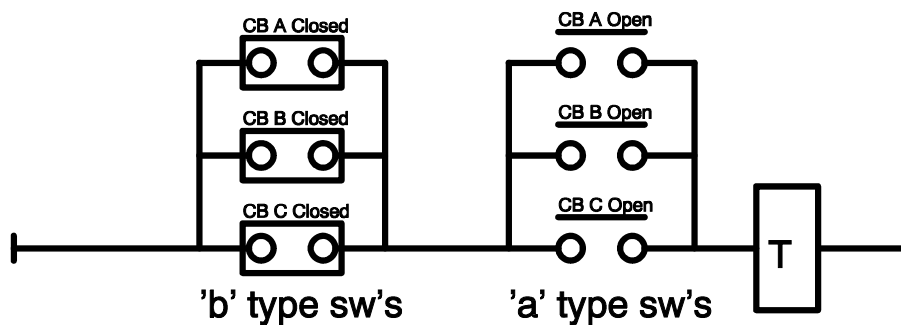

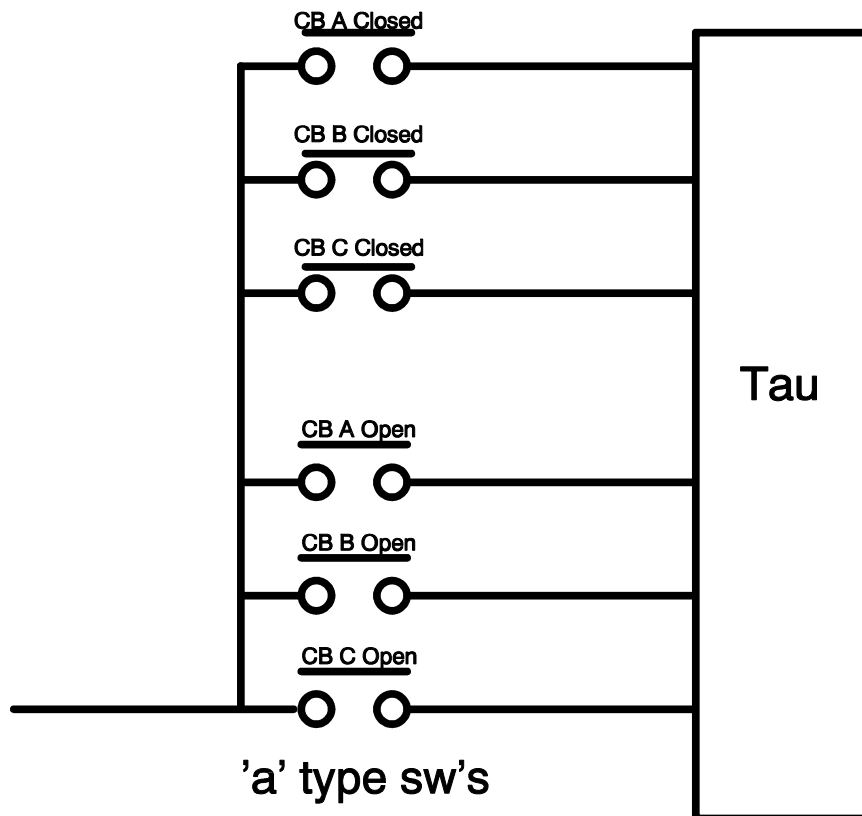**Figure 5 Standard Connection of Pole Discrepancy Protection**

Figure 6 Tau Connection of Pole Discrepancy

CB Fail To Close: At the end of the close pulse if the CB is open then the CB Fail To Close output is issued. Lockout will be established.

VT Alarm: An alarm indicates that there is a VT Failure. The Bus VT Fail alarm is generated when the relay detects a live line and CB Closed and dead bus for greater than 2 seconds. The Line VT alarm is generated when the relay detects a live bar and CB Closed and dead line for greater than 2 seconds. The relay cannot distinguish between VT Fail on the system and the VT Fail in the relay; the VT Fail indication may mean either. If this feature is required to prevent reclose it needs to be programmed to Lockout the autoreclose sequence.
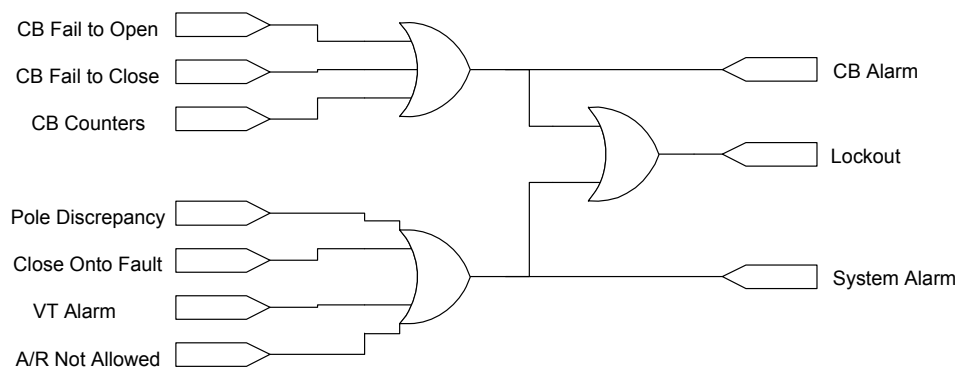
Figure 7 Possible A/R Alarms

2.3   Synchronising Modes

The relay operates in Check Sync (CS) mode until a system split occurs. After a system split the relay can be programmed to perform a number of actions. These can be Lockout, or set to close via Check Sync, System Sync (SS) or Close On Zero (COZ). The close can be automatic or via Manual Closing.

The check sync (CS) and system sync (SS) functions each have independent settings. If the requirement is for the relay to be set up as a check synchronising relay, then there are a number of ways of implementing this using the settings.

1.   Set CS Phase, CS Slip Frequency and CS Timer to required settings.

Set System Split Detector to OFF.

Set A/R Split Action to Lockout. Or A/R Split Action to System Sync and set the System Sync setting to be identical to the Check Sync settings.

Setting the split detector to off will ensure that the relay never goes into system synchronising mode even if a split in the power system occurs. The relay will continue to attempt a check sync close if the power system conditions fall within the relay setting parameters.

2.   Set System Split Detector to a suitable angle e.g. 170°

Set A/R Split Action to LOCKOUT

This will ensure that if the power system splits the relay will not go into system synchronising mode but revert to lockout mode.

3.   Set A/R Split Action to LOCKOUT

Set MC Split Action to System Sync

Lockout will be exited by a Manual Close at tighter angles.

Note : the relay settings groups could be used to switch between the different modes of the relay. The relay could be set up to be a check synchroniser in settings group 1 and a check and system synchronising relay in settings group 2. The group selection and thus the actual relay mode of operation could then be changed remotely using a status input signal or a communications command from a control system.

2.4   Manual Closing

Manual Closing can occur at any point. The decision to close the CB lies with the operator. Manual Closing overrides a Locked out autoreclose sequence. The close decision is dependent upon the Manual Close settings: Dead Line Close, Dead Bus Close or Check Synchronisation. The relay automatically closes dependent upon these conditions. A Synch Close Delay is provided which governs the available time the relay will wait for an In Synch signal to appear. If the In Synch signal does not appear before the end of the Synch Close Delay timer the relay will Lockout. The Manual Close input has to be present to allow a Close CB output. If this input resets before the Close CB output is given then no output will be issued.

The relay without Check Synchronisation closes without checking the state of the system.

A separate Manual Sync Override is provided.

2.5   Typical Voltage Settings

The relay can be connected to either single phase or 3 phase V.T's. It is usual, particularly in transmission networks, to use the output of the B (centre) phase V.T's for the reference line and bus voltages and thus the nominal voltage is 63.5 Vrms.

Note : the input measuring range actually measures upto 200 Vrms.

The relay undervoltage blocking elements, if enabled, can be used to block the close operation if either the incoming (line) or running (bus) volts fall below a certain percentage of rated voltage. Typically, the undervoltage elements are set somewhere between 80% and 90% of rating.

Note : when using the undervoltage elements care should be taken to ensure that the reset of the element occurs at below the expected minimum operating voltage of the system. The undervoltage elements reset at <104% of the operate level. If the system is expected to run at less than the rated voltage the undervoltage element reset level must be set to operate at a value below this plus some margin for error.

e.g.

- for a phase to neutral connection nominally at 63.5 Vrms but which can run as low as 59 Vrms,

the undervoltage setting should be set no higher than 59 V – 1 V (error margin) = 58V x 96% = 55.68V (the actual setting would have to be 55.5V). This is equivalent to approximately 87% of rated voltage. If the setting is set higher than this then the element may never reset and will continuously block.

A differential voltage detector is incorporated and this, if enabled, blocks the synchronising function if the difference between the measured voltages is greater than the setting. This is used to prevent closing of the circuit breaker with a large voltage differential between the incoming (line) and running (bus) voltages, which could overstress the electrical systems. Typically, the differential voltage elements are set below 10% of rated voltage.

The relay Dead and Live voltage monitors are used along with corresponding internal logic to bypass the synchronising operation of the relay. Typically, anywhere above 80% to 90% of rating can be classed as a live line or live bus. The dead voltage monitors should be set to somewhere above the expected level of induced voltages on the line or bus. It should be noted that a dead line or bus can have a considerable potential induced onto it from a parallel line or capacitance across open breaker contacts. This potential can be as high as 30% of rated voltage.

2.6 Synchronising Override Logic

The synchronising override logic is provided to close immediately and not wait for the relay's synchronisation. Settings provide options for Dead Line and Live Bus closing, Live Line and Dead Bus closing. All of the possible combinations are shown below.

Check Sync Close Yes/No

Dead Line Close Yes/No

Dead Bar Close Yes/No

Sync Override

Manual Sync Override

2.7 Slip and Phase Angle Relationship

Slip frequency is defined as the difference between two frequencies. As two different frequencies 'slip' past each other large phase angle differences can ensue. Another way to calculate slip is to measure the phase difference between two waveforms and check that the phase angle change in a defined time period is less than a predetermined value. If F1 and F2 represent the frequencies of two systems then it can be shown that for check synchronising operation,

$$\Delta F = F1 - F2 = \frac{1}{Td} \times \frac{\theta}{180°}$$

where Td = time delay setting and θ = phase angle setting.

For system synchronising operation the following formula is used because in this mode the relay will only issue a close signal if the phase angle is decreasing in value. It will not issue a close if the phase angle is increasing in value.

$$\Delta F = F1 - F2 = \frac{1}{Td} \times \frac{\theta}{360°}$$

where Td = time delay setting and θ = phase angle setting.

The relay has both a frequency measuring element and phase detector and so can be set up to measure slip either directly or by the phase detector plus timer method. Use of either method is perfectly valid, as is use of both at the same time.

Note : if using both the slip frequency detector and the phase angle plus slip timer for a particular scheme then care has to be taken in setting selection. It is possible to set the relay up with an incorrect slip timer setting which will prevent the relay from issuing a valid close signal. For example if there is a high rate of slip on a system and the time delay setting has been set too long the incoming vector could pass through the valid close window too quickly and not allow the time delay to time out and give a valid output.

2.8 Check Synchronising Settings

The check synchronising operation of the relay is used mainly in switching operations which link two parts of a system which are weakly tied via other paths elsewhere in the system. In this synchronous system there should be no frequency difference across the breaker but large differences in phase angle and voltage magnitude may exist due to the line characteristics such as its length and type of loading.

For check synchronising the relay should be set to the maximum phase angle and maximum voltage differences which still permit the circuit breaker to close without causing large disturbances to the system. For most systems the phase angle should be set between 20° and 30°. There should not be any slip frequency but a setting of 50mHz is typically applied as a check against loss of synchronism. Table 1 shows some possible check synchronising settings when using the phase detector plus time delay method.

Phase Angle Setting (θ)	Ideal Time Delay	Actual Timer Setting (Td)	Actual Slip Frequency (mHz)
10	1.11	1.1	50.505
15	1.67	1.7	49.020
20	2.22	2.2	50.505
25	2.78	2.8	49.603
30	3.33	3.3	50.505
35	3.89	3.9	49.858
40	4.44	4.4	50.505
45	5.00	5.0	50.000

Table 1 - Typical Check Synchronising Settings

Alternatively, if the slip frequency detector is used and the slip timer turned OFF, a setting of 50mHz could be applied to the slip frequency detector directly to achieve the same ends.

Note : in check synchronising mode the valid phase window for closing is actually twice the phase angle setting value because the valid close can be given when the phase angle is either decreasing or increasing.

2.9 System Synchronising Settings

The system synchronising operation of the relay can automatically start if the two systems become asynchronous i.e. there are no ties between the two systems and one system is effectively 'islanded'. If this situation occurs the frequencies will slip past each other and may cause the phase angle to come into the system split limits. The system split detector can be set anywhere from 90° to 175° and is typically set to 170°. This will start system synchronising automatically.

When there are high rates of slip between the two systems greater care is needed when closing the breaker and for this reason the system synchronising mode has independent settings from the check synchronising mode. The allowable phase angle close window is usually set much narrower than for check synchronising operation. Also the close decision from the relay is only given in the case of the phase angle decreasing. It will not issue a close if the phase angle is increasing in value. Typically the slip frequency will be set to a limit of 250mHz or less and the phase angle to 10° or 15°. Table 2 shows some possible system synchronising settings for limits of 100mHz and 250mHz respectively.

Phase Angle Setting (θ)	Ideal Time Delay	Actual Timer Setting (Td)	Actual Slip Frequency (mHz)
10	0.56	0.5	111.111
15	0.83	0.8	104.167
10	0.11	0.1	277.778
15	0.33	0.3	277.778

Table 2 - Typical System Synchronising Settings

Alternatively, if the slip frequency detector is used and the slip timer turned OFF, settings of 100mHz and 250mHz could be applied to the slip frequency detector directly to achieve the same ends.

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2.10 Example Setting Calculations For Slip Timer

For check synchronising the relay can issue a valid close signal at any time while the incoming vector is within the phase angle setting range. If it gives the close signal at the boundary of the setting then the breaker will close with the phase angle outside of the setting limits. This is due to delays with the software timing loop issuing the close command, the output relay picking up and the actual breaker closing time delays. To reduce the risk of a late closure it is common practice to set the time delay setting (Td) to typically 10x the circuit breaker closing time. This will ensure that the breaker will close no later than 1.2x the actual phase angle setting of the relay.

Proof :

The change in phase angle between two waveforms is directly related to the frequency difference, or slip, between them. The change in phase angle $\Delta\theta$ for a system with 1Hz slip is 360^0 in 1 second. Thus,

Change in phase angle $\Delta\theta$ = (Slip x 360^0) / sec.

The amount the phasor can travel during the breaker close time can therefore be given by,

$\Delta\theta$ = Slip x 360^0 x tc   - where tc is the breaker close time.

Using the equation given in section 2.7 for check synchronising,

$$\text{Slip} = \frac{1}{\text{Td}} \times \frac{\theta}{180°}$$ and substituting this into $\Delta\theta$ = Slip x 360^0 x tc gives the following,

$$\Delta\theta = \frac{1}{\text{Td}} \times \frac{\theta}{180°} \times 360° \times \text{tc} \;;$$

It was stated that the slip timer setting Td should be set to 10x the breaker closing time tc.

Substituting for this in the above equation gives,

$\Delta\theta$ = (2 x θ) / 10   or $\Delta\theta$ 0.2 x θ

Thus for a time delay (Td) of 10x breaker closing time (tc) the actual change in phase angle will be 20% of the phase angle setting. The maximum closing angle will be 120% of phase angle setting.

In practice the relay operating times need to be taken into consideration. A typical example now follows :

- Maximum allowed phase angle for closure = 30^0.

- Circuit breaker closure time = 150ms.

- Maximum relay delays – S/W loop + Output relay delays = 5ms + 7ms = 12ms.

Therefore slip timer time delay should be set to 10x (150ms + 12ms) = 1.62sec.

The phase angle setting should be set to 80% of the maximum allowable closing angle which is 24^0.

If the relay was to issue a close right on the boundary of 24^0 then the breaker will definitely not close outside of 30^0.

With an angle of 24^0 and Td of 1.62sec, using the equation from section 2.7, the slip is therefore

24 / (1.62 x 180) = 82mHz. If the relay were to close on the boundary the phase angle traversed in the 162ms total delay time is given by,

$\Delta\theta$ = Slip x 360^0 x (tc + trelay) = 0.082 x 360 x 0.162 = 4.78^0.

2.11 Diagrams

At the back of this section figure 8 shows a typical connection diagram for the relay. Figure 9 shows a programming matrix (with Default setting information), which is a convenient way of recording the input / output logic for the relay. Figure 10 shows a blank programming matrix.
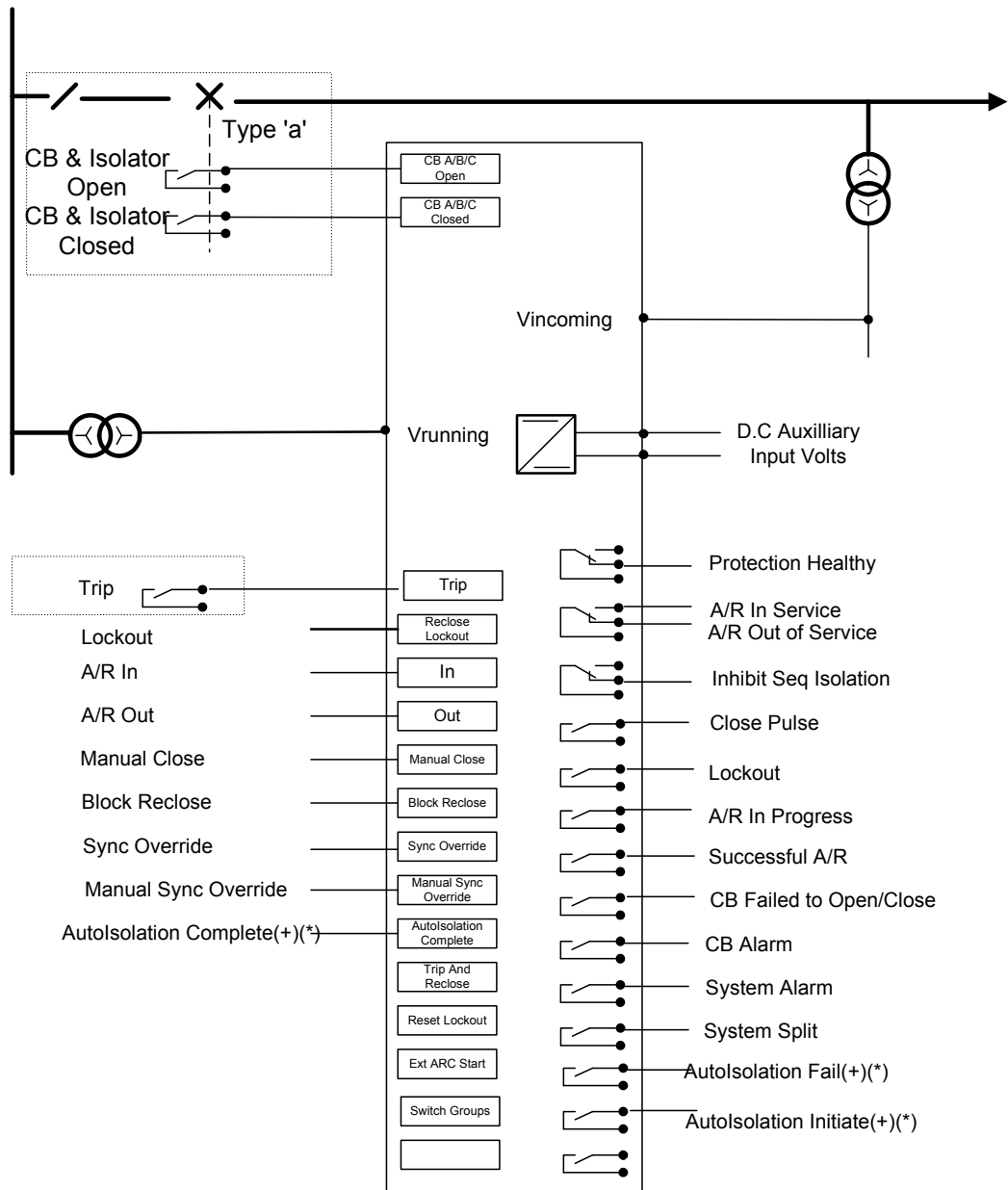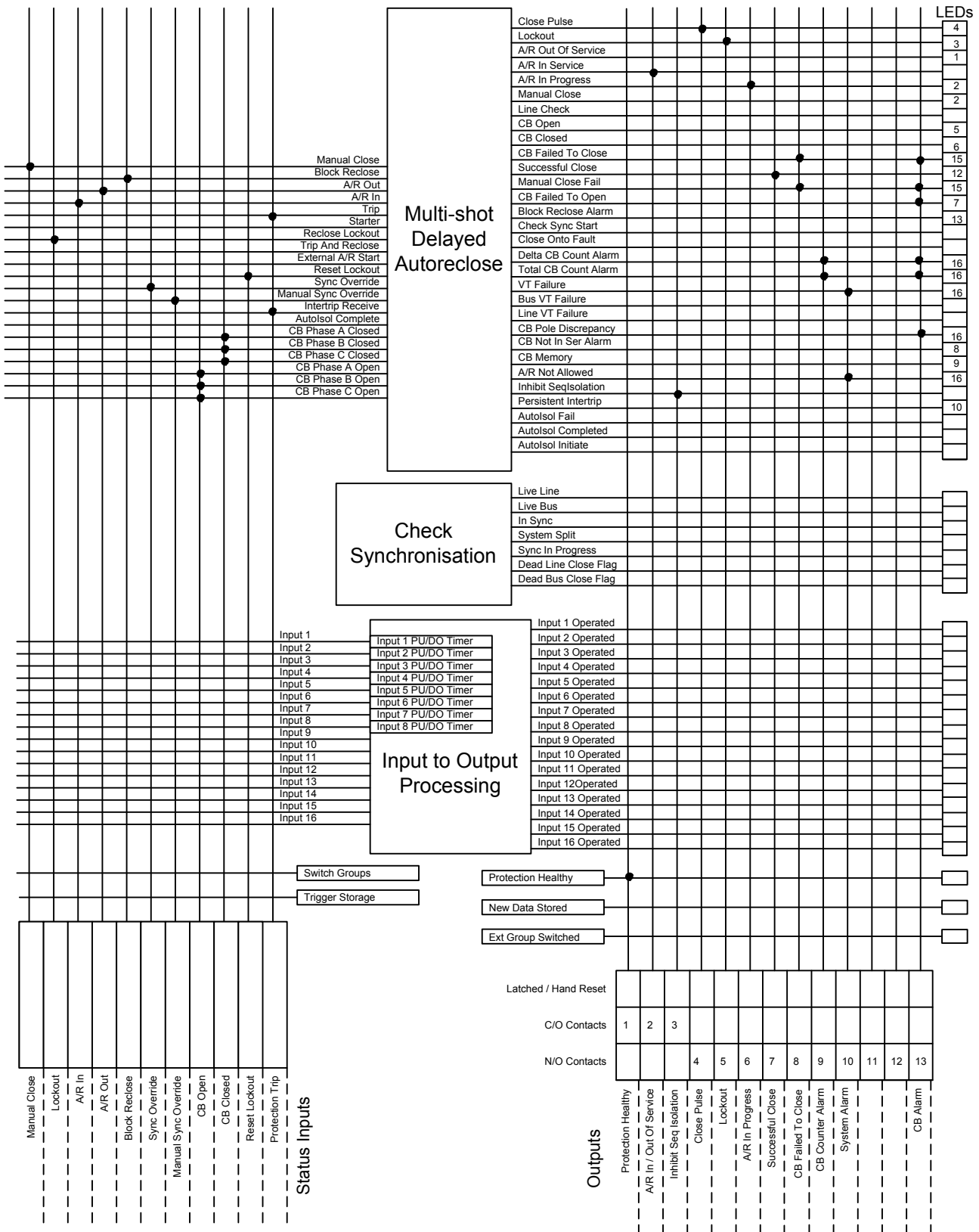
Figure 8 Tau Connection diagram

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Figure 9 Programming Matrix – Default Settings
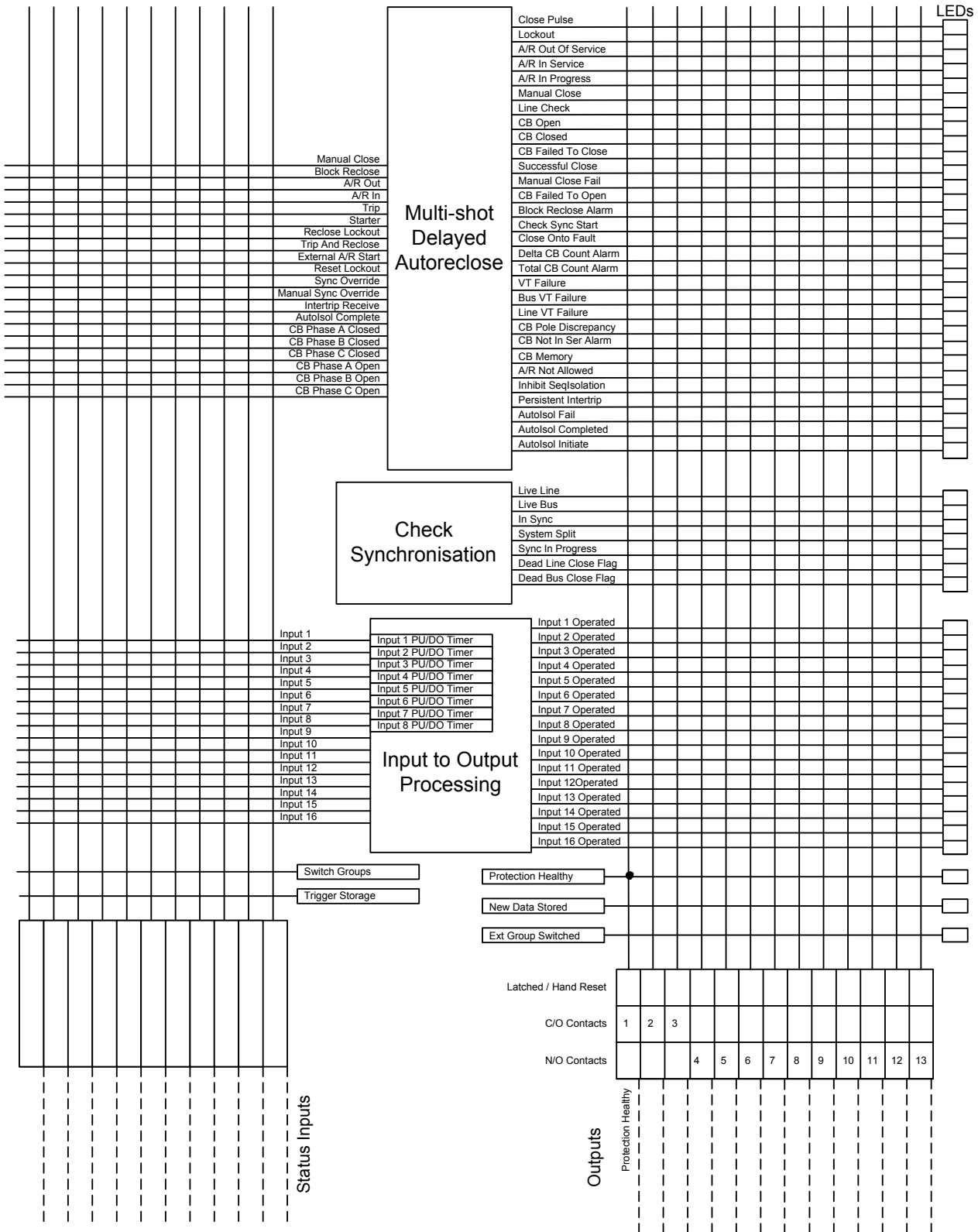
Figure 10 Blank Programming Matrix

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Auto Reclose and Check Synchronisation

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1. UNPACKING, STORAGE AND HANDLING

On receipt, remove the relay from the container in which it was received and inspect it for obvious damage. Check that the relay is the correct model number and the rating information is correct. It is recommended that the relay is 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 and Reyrolle Protection and the nearest Reyrolle agent should be informed.

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, which are susceptible to damage due to static discharge and for this reason it is essential that the correct handling procedure is followed. The relays' electronic circuits are protected from damage by static discharge when it is housed in its case. When it has been withdrawn from the case, static handling procedures should be observed.

- Before removing the relay from its case the operator must first ensure that they are at the same potential as the relay by touching the case.

- The relay must not be handled by any of the relay terminals on the rear of the chassis.

- Relays must be packed for transport in an anti-static container.

- Ensure that anyone else handling the relays is at the same potential as the relay.

As there are no user serviceable parts in the relay, then there should be no requirement to remove any modules from the chassis. If any modules have been removed or tampered with, then the guarantee will be invalidated. Reyrolle Protection reserves the right to charge for any subsequent repairs.

2. RECOMMENDED MOUNTING POSITION

The relay uses a liquid crystal display (LCD) which displays setting and metering information. It has a viewing angle of ± 70º and an internal back light. The recommended viewing position is at eye level.

The relay should be mounted onto the circuit breaker or panel at a level which allows the user easiest access to the relay functions.

3. RELAY DIMENSIONS

The relay is supplied in a range of cases the Epsilon case size E8 (standard size), E12 or 19" rack. Mechanical diagrams of the case dimensions and panel cut-out requirements are provided in section 9 of 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

Kit – 2995G10046 comprising :

- Screw M4 X10TT   2106F14010 – 4 off

- Lock Washers   2104F70040 – 4 off

- Nut M4   2103F11040 – 4 off

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4.3　　　Communications

9mm SMA fibre optic connections – 2 per relay.

(Refer to section 4 of this manual – Communications Interface).

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. For local interrogation a portable PC with a fibre to RS232 modem (Sigma 4) is required. The PC must be capable of running Microsoft Windows Ver 3.1 or greater, and it must have a standard RS232 port in order to drive the modem. For remote communications more specialised equipment is required. Refer to section 4 of this manual – Communications Interface.

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Auto Reclose and Check Synchronisation

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1 REQUIRED TEST EQUIPMENT

The following equipment will be required to perform commissioning tests on the relay.

- 500V Insulation resistance test set.

- Two variable A.C. voltage sources with a means of varying the phase relationship between them e.g. phase shifting transformer. Ideally, a portable relay test set e.g. Doble, Omicron etc.

- Time interval meter.

- 2 A.C. Voltmeters.

- Phase angle meter.

- D.C. supply with nominal voltage within the working range of the relay's D.C. auxiliary supply rating.

- D.C. supply with nominal voltage within the working range of the relay's D.C. status input rating.

- Continuity tester e.g. multi-meter.

Additional equipment for testing the communications channel:

- Portable PC with an electrical-to-optical RS232 converter and fibre optic connectors.

- A copy of Reydisp Evolution software installed on the PC to exercise the communications channel.

2 INSPECTION

Check that the relay has not been damaged in any way since being installed into the panel Check that the serial numbers of the relay, the case and the relay cover are all identical. Check also that the relay is the correct model and that the rating is correct.

Ensure that all connections are tight and in accordance with the relay wiring diagram or the scheme diagram. Check that all the modules are fully connected and inserted. Ensure that the relay case is solidly bonded to a local earth point by checking the earthing connection to the case.

3 APPLYING SETTINGS

Before applying settings to the relay the engineers should take time out to familiarise themselves with the relay's menu system. Section 1 and section 3 of this manual are helpful in this respect. The relay settings for the particular application should be applied before any secondary testing occurs. If they are not available then the relay has default settings that can be used for pre-commissioning tests. See section 3 of this manual for a list of the relay default settings.

Settings can be entered into the relay using the keypad on the front of the relay or they can be sent to the relay, from a file, using a portable PC and Reydisp Evolution software package.

Tau relays feature four alternative setting groups. In applications where more than one setting group is to be used then it may be necessary to test the relay in more than one configuration.

Note: when using setting groups it is important to remember that the relay need not necessarily be operating according to the settings that are currently being displayed. There is an "active setting group" on which the relay operates and an "edit/view setting group" which allows the settings in one group to be viewed and altered while protection continues to operate on a different unaffected group. The "active setting group" and the "edit setting group" are selected in the "System Configuration Menu".

4 PRECAUTIONS

Before testing commences the relay should be isolated from the voltage transformers in line with the local site procedures. The closing and alarm circuits should also be isolated where practical. Ensure that the correct d.c. Auxiliary voltage is applied to the circuit. See the relevant scheme diagrams for the relay connections.

5 TESTS

5.1 Insulation

Connect together all of the V.T. terminals and measure the insulation resistance between these terminals and all of the other relay terminals connected together and to earth.

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Connect together the terminals of the DC auxiliary supply circuit and measure the insulation resistance between these terminals and all of the other relay terminals connected together and to earth.

Connect together the terminals of the DC status input circuits and measure the insulation resistance between these terminals and all of the other relay terminals connected together and to earth.

Connect together the terminals of the output relay circuits and measure the insulation resistance between these terminals and all of the other relay terminals connected together and to earth.

Satisfactory values for the various readings above depend upon the amount of wiring concerned. Where considerable multi-core wiring is involved a reading of 2.5 to 3.0 M can be considered satisfactory. For short lengths of wiring higher values can be expected. A value of 1.0 M should not be considered satisfactory and should be investigated.

Remove temporary connections.

5.2 Commissioning Tests

Select the required relay configuration and settings for the application.

4.2.1 Status input tests

This test checks that the status input circuits are functioning correctly. The status input circuits should be energised in turn and observed to be operating using the Instruments mode 'Status Inputs 1-11' display. A '1' indicates that the status circuit is energised, a '0' indicates that it is not.

Connect the correct D.C. voltage to the following terminals to energise the status inputs :

Status Input	+ DC Volts	- DC Volts
Status 1	A21	A23
Status 2	A25	A27
Status 3	A26	A28
Status 4	B1	B3
Status 5	B5	B7
Status 6	B9	B11
Status 7	B13	B15
Status 8	B17	B21
Status 9	B19	B21
Status 10	B23	B27
Status 11	B25	B27

4.2.2 Output relay tests

This test checks that the output relays are functioning correctly. The output relays should be energised in turn and the contacts should be checked for correct operation using a continuity tester. The output relays can be energised in a number of ways. The following is the recommended method:

Assign each output relay in turn to 'Relay Healthy' in the output relay menu. On pressing the ENTER key the output relay selected will be energised. Check with a continuity tester that the actual contacts have operated. De-select the output relay and check that the contact returns.

Output Relay	Type	Terminal No.
Relay 1	N/O	A4 – A5
Relay 1	N/C	A5 – A6
Relay 2	N/O	A8 – A9
Relay 2	N/C	A7 – A8
Relay 3	N/O	A10 –A12
Relay 3	N/C	A11 – A12
Relay 4	N/O	A17 –A19
Relay 5	N/O	A18 – A20
Relay 6	N/O	B2 – B4
Relay 7	N/O	B6 – B8

Relay 8	N/O	B10 – B12
Relay 9	N/O	B14 – B16
Relay 10	N/O	B18 – B22
Relay 11	N/O	B20 – B22
Relay 12	N/O	B24 – B28
Relay 13	N/O	B26 – B28

Note: when finished testing the output relays make sure that the 'Relay healthy' is re-assigned to the correct output relay given in the settings file.

4.2.3 Measurement Tests

Apply A.C.volts to both of the voltage input circuits of the relay using the A.C. variable voltage sources or portable relay test set. The relay should display the correct value of voltage   5% which is the tolerance of the measurement display meters. The instruments mode 'Vline' and 'Vbus' meters display the secondary voltage levels.

The applied A.C. volts can be in the range of 5 – 200Vrms. Nominal volts of 63.5V.

4.2.4 Scheme Tests

It is not necessary to perform tests on all internal elements of the relay. If the settings have been checked, the external wiring checked, the status inputs and output relays verified and the relay measures satisfactorily then the relay can be deemed to be working to its design requirements. It will operate correctly, to the performance claims, and its operation under all service conditions is guaranteed.

However, if added confidence is required, then the following elements can be checked. Note that the relay should be commissioned with the actual settings calculated for the particular scheme.

Autoreclose schemes vary between different utilities. Some of the functions such as Block Reclose are used differently. Therefore it is important that tests are carried out with relevance to the engineered scheme.

The purpose of these tests is to confirm the correct operation of the status and control inputs. Some of the tests will require the application of voltage.

In order to ensure that all operations proceed correctly, the following should be observed:

-                        A working circuit breaker, complete with auxiliary supplies, should be connected to the relay, if possible; if not, then an electronic circuit simulating the circuit breaker operation may be used instead. See Appendix 2. If this is not available a switch may suffice, care will be required with settings. Or alternatively the test equipment may provide a CB control circuit.

-                        Throughout the tests, a close pulse length should be selected which is suitable for the circuit breaker or simulation circuit, given that the CB closing operation must be complete, before the close pulse is removed by the relay.

To facilitate ease of commissioning an instrument shows what state the autoreclose sequence has reached. The states are as follows:

StartUpLockout: Temporarily displayed after power on.

AROutOfService: When the relay is switched Out Of Service either at start up or from the idle state.

InServiceLockout: When switching IN from Out Of Service there is a temporary switch in lockout.

Idle: quiescent state, waiting for an autoreclose sequence to begin.

Lockout: Lockout state. No Autoreclosing allowed.

The Autoreclose sequence is performed with the following states:

SequenceInProgress: DAR Start. A trip has occurred and the CB was in service whilst in idle. Will wait for DAR Primed conditions: CB Open AND Trip reset AND Dead Line.

Deadtime: The three pole delayed deadtime.

Close Inhibit: At the end of the deadtime if waiting for synchronisation or Block Reclose to reset then will be in this state.

Autoisolate: Isolator is being opened.(+)(*)

Close Pulse: The Close Pulse is being issued.

Reclaim: checking for correct reclose.

The Manual Closing sequence is performed with the following states:

ManualClose: Wait for correct close conditions, i.e. synchronisation.

ManualClosePulse: The Close Pulse is being issued.

ManualReclaim: checking for correct close.

After receiving the relay the default position is Out Of Service, therefore at power up the meter will display StartUpLockout to AROutOfService.

With the state displaying AROutOfService an A/R IN signal is required to switch in the relay. The meter will then display InServiceLockout to Idle. There should be a 4 second delay while the relay is temporarily in Lockout.

Idle is the quiescent state when waiting for an autoreclose sequence to begin. This should be the initial displayed state when performing the majority of the tests.

1. Phase Angle Tests

The CS Phase Angle detector and the SS Phase Angle detector can be tested in the following way:

Apply nominal volts to both the line and bus input terminals of the relay. On initial turn on, the relay will start in check synchronising mode. If the voltage vectors are displaced by an amount greater than the CS Phase Angle setting but not as much as the System Split Detector angle then the relay will stay in check synchronising mode. Using the instruments display, locate the Phase Angle instrument as shown below:

> **Phase Angle 0.0°**

Check the Check Sync Angle setting in the SYNC MENU. Assign an unused LED to indicate In Sync i.e. L = 16. At switch on, the relay has a 2sec. delay before In Sync is issued, but if voltages are continuously applied and only the phase angle changed the In Sync LED can then be used to check pick-up and drop-off of the Check Sync function. Apply voltage, after 2 sec the LED will come on, Slowly increase the phase angle past the setting so that the LED goes out. Slowly bring in the phase angle and check the pick up. Then slowly increase the phase angle and check the drop off. The pick up and drop off values should fall within the performance claims given in Section 2 - Performance Specification subsection 6. Repeat for opposite angles.

Note: the phase angle should be adjusted slowly so that the LCD has time to update. The instrument has a delay on updating.

This test should be repeated for the system synchronising settings. This is best carried out by increasing the phase angle until a split occurs and then bringing the angles in. The split will cause the relay to go into system synchronising mode.

The results can be put into Table 1 at the back of this section.

2. Slip Frequency Tests

The CS Slip Frequency detector and SS Slip Frequency detector elements are more difficult to test and require variable frequency sources. A portable relay test set is ideal for this.

Depending on the relay scheme settings it may be difficult to test the CS and SS slip frequency elements independently without adjusting the settings.

To test the CS Slip Frequency element turn the Split Angle to OFF. This will ensure that a split does not happen and the relay is in check sync mode. Increase the frequency slip to a value outside of the slip frequency limits and then slowly reduce it until the element picks up. This will be indicated on the same LED as above. Gradually increase the slip until the element drops off as indicate. Record the results in Table 2.

To test the SS Slip Frequency element turn the Split Angle back to the value required for the scheme. System Sync only occurs after a system split. Turn CS Slip Frequency element to OFF. Increase the phase angle until a split occurs and then repeat the above tests. Record the results in Table 2.

To test the Close On Zero function an Omicron test set or similar should be used. This function closes when the two voltages are in phase. Using Check Sync or System Sync the relay will always close after it passes the set limits. With Close On Zero the relay uses the CB Closing time and works out from the slip frequency the point at which the two voltages are at actual zero phase angle. COZ is part of the reclosing scheme and can only proceed when an autoreclose sequence or a Manual Close is issued after a system split. The easiest way to test this function is to use a Manual Close input. The setting MC Split Action should be set to Close On Zero. The test equipment can be used to stop recording from a Close Pulse output relay. Make sure that all Closing links are removed prior to the test. The following sequence can be used to test the COZ function: Increase the phase angle until a split occurs, the CB should be open, issue Manual Close, decrease the phase

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angle until a close pulse is issued. Make sure that the time it takes to decrease the phase angle is not greater than the Sync Close delay otherwise the relay will go to Lockout before the test is complete. Record the results in Table 2.

All the results should fall within the performance claims given in Section 2 - Performance Specification.

Note: remember to return all settings back to the original scheme settings if they have had to be changed.

3. Timer Tests

The Check Sync Timer and System Sync Timer can be tested by setting the angle between the two voltages to a value outside of the phase angle settings. Reduce the phase angle to zero and the output should not close until after the timer has timed out.

In practice however, the timers are difficult to test without specialist test equipment and test software. There are three recommended methods:

1. Apply in phase nominal volts to the relay. The relay will issue a close only after the timer has timed out. Note, however, that the relay has a start-up timer of 2sec. which is the minimum time before an output is given. This start-up timer effectively runs in parallel with the timer. If for example a Check Sync Time of 2.0sec has been selected then the time for close will be 2.0sec. If however, 0.5sec has been selected then the time for close will be 2.0sec.

2. Apply in phase volts to the relay at a level below the under-voltage blocking element level. The relay will time through the start-up timer. If the volts are then increased to nominal then the relay will close after the set slip time. If 0.5sec has been selected then the relay will close after 0.5sec.

All results should fall within the performance claims given in Section 2 - Performance Specification.

3. Using Reydisp Evolution software the event records will give accurate times for all of the timing events within the relay. The following events were extracted from a relay which had the Check Sync Timer set to 1.0 sec. When the phase angle moved inside the close window the actual close output was given after a time of 1.005 seconds.

> 09:08:43.020 , 21/02/00 Rey Raised   In Sync
>
> 09:08:44.025 , 21/02/00 IEC Raised   CB 'on' by AR

4. Voltage Detectors

Check the pick up and drop off levels for the voltage detector elements. Individually ramp up and down the line and bus volts and examine a Live Line / Live Bus LED indication to see where the elements actually operate. Record the results in Table 4.

5. Undervoltage Elements

Check the pick up and drop off levels for both the line undervoltage and bus undervoltage blocking elements. The In Sync indication is derived from In Phase AND No Slip AND No Differential AND Not Undervolts. Apply voltage from the same source to the Line and Bus inputs, decrease the voltage until the In Sync LED goes out, then increase the voltage until the LED comes back on. It is better to set the Check Sync timer to zero for this test. Separate results for the Line and Bus can be recorded by varying the Undervolts settings. Record the results in Table 4.

6. Differential Voltage Elements

Check the pick up and drop off levels for the differential voltage blocking element. Apply different voltages to the Line and Bus. Keep the voltages in phase and no slip and above the undervoltage levels. The In Sync LED will go out when the Voltage Differential setting goes above the setting. Record the results in Table 4.

All results should fall within the performance claims given in Section 2 - Performance Specification.

7. A/R In/Out Switching

The relay can be switched out at any point. The commissioning to confirm the action of the In/Out switching mechanism requires a full understanding of how this function works. A/R Out has priority over A/R In. This function can be used as an Autoreclose Inhibit.

Energise A/R Out and check for A/R Out of Service indication. Check in the instruments mode that Autoreclose State displays AROutOfService.

Energise A/R In and not A/R Out, the relay should then go back to indicate A/R In Service. Whilst performing the test check in the instruments mode that the Autoreclose State progresses from displaying AROutOfService to InServiceLockout to Idle.

With both A/R In and A/R Out energised the relay should indicate A/R Out of Service.

There is a temporary 4 second Lockout whilst the relay is switched back into service.

During an autoreclose sequence if A/R Out is asserted the relay will go to Lockout. Whilst in Lockout an A/R In is required before Lockout can be exited.

8. **CB Open**

The CB Status should be checked before any other input as correct operation of the autoreclose sequence relies upon the state of the circuit breaker being received correctly from the auxiliary contact circuit. Various connections can be used, as described in the Applications Guide.

Ensure that with the circuit breaker in the open position, the CB Open status input is enabled. Check that with the CB in the open position, the CB Open LED is lit. Operate the CB manually, and ensure that it is in the closed position. Check that the CB Closed LED is lit.

There should be no indication if the CB is Open and Closed, or not Open and not Closed.

9. **CB In Service**

To prevent unwanted autorecloses a CB In Service feature is provided which only allows autoreclosing to start provided the CB was in the closed position prior to a trip input being received. For the relay with Check Synchronisation the CB in Service feature includes CB Closed and Live Line. This is classified as the CB Memory and has a 2 second delayed drop off.

To facilitate commissioning the logic outputs from this function are mapped to the LED menu: CB Not In Service Alarm (which is at the end of the 2 sec delayed drop-off) and CB Memory.

Figure 1 CB In Service
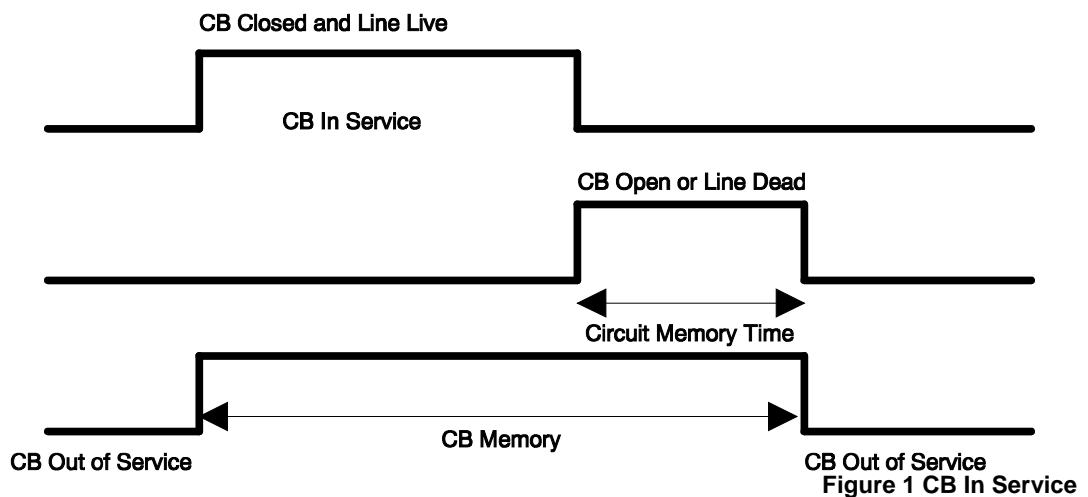
Map the CB Memory and CB Not In Service Alarm to LEDs. Manually close the CB and energise the line voltage, CB Memory should be lit. De-energise either the line or open the CB (manually open the CB), the CB Memory should reset after a 2 second delay and the CB Not In Service Alarm should be lit.

10. **Trip and Autoreclose**

Ensure that the CB is closed, and voltage is applied to both the line and bus VT's. Operate the trip status input whilst CB Memory is lit, A/R In Progress should light.
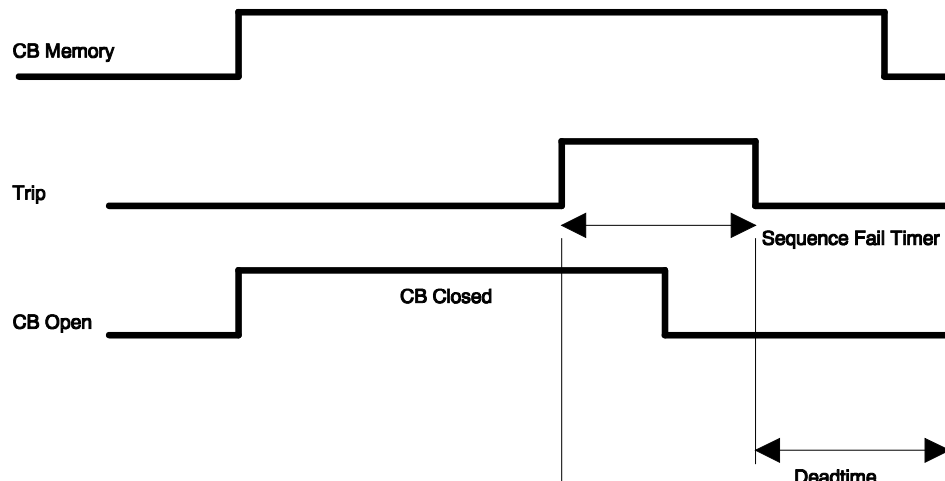
Figure 2 Trip And Autoreclose

If a trip input occurs and CB Memory is not lit then an A/R Not Allowed indication is raised. This may be connected to cause the relay to go to Lockout, check scheme details to determine whether this needs testing.

The deadtime is started when the CB opens and the trip resets. There is a timer Sequence Fail Timer provided which can be set to go to Lockout if either the CB does not open or the trip fails to reset within the set time. This is provided to prevent the autoreclose sequence being primed indefinitely; or the Sequence Fail timer can be set to OFF.

Assuming the trip operation to be successful, a close pulse should be issued after the first deadtime setting – close the CB during the close pulse, followed by a reclaim period, before the relay returns to an idle condition, and indicates Successful Close.

If the CB is not closed during the close pulse the relay will indicate Lockout and CB Failed To Close.

11. Measurement of Autoreclose Time Delays

Software testing proves all of the time delays. The autoreclose time delays may be measured to give added confidence. The measurements may be recorded using Reydisp.

Measure the Sequence Fail Timer (if applied) – Set the Sequence Fail timer to greater than the trip reset time, say 60 seconds. With CB Memory lit, energise a trip signal (start the timer), stop the timer when lockout is issued.

Measure the Deadtime time delay – To measure the deadtime the correct sequence of events must occur: With CB Memory lit, energise a trip signal, then open the CB, de-energise the line, remove the trip signal (start the timer). Stop the timer when the Close Pulse is issued. The Close Pulse will be issued if the line is de-energised and the setting Dead Line Charge is selected to Enabled.

Measure the Close Pulse – measure the duration of the close pulse, which should correspond to the setting.

Measure the Reclaim time - Start at the end of the close pulse, stop when Successful Close is issued, provided the CB has closed.

Measure the Sync Close Delay (if applied) – apply Dead Line Charge = Disabled, Dead Bar Charge = Disabled, Check Sync Close = Enabled. Start the deadtime but do not reapply voltage, the system will wait for as long as the deadtime + Sync Close Delay before going to Lockout.

Measure the Persistent Intertrip Timer (if applied) – Energise the Intertrip Receive status input (start timer). Keep energised until Lockout is issued (stop timer).

Measure the AutoIsolation Timer (if applied) – Set AutoIsolation Action = Enabled, During the close pulse apply a trip signal (start timer). Check that AutoIsolate Initiate is issued (alternative start timer), Stop timer at AutoIsolate Fail when Lockout is issued.

The time delays for the CB Memory, Start Up Lockout Timer, In Service Lockout Timer, Minimum Lockout Timer and Lockout Delayed Drop Off Timer are set within the relay and are not adjustable, they are therefore not required to be tested.
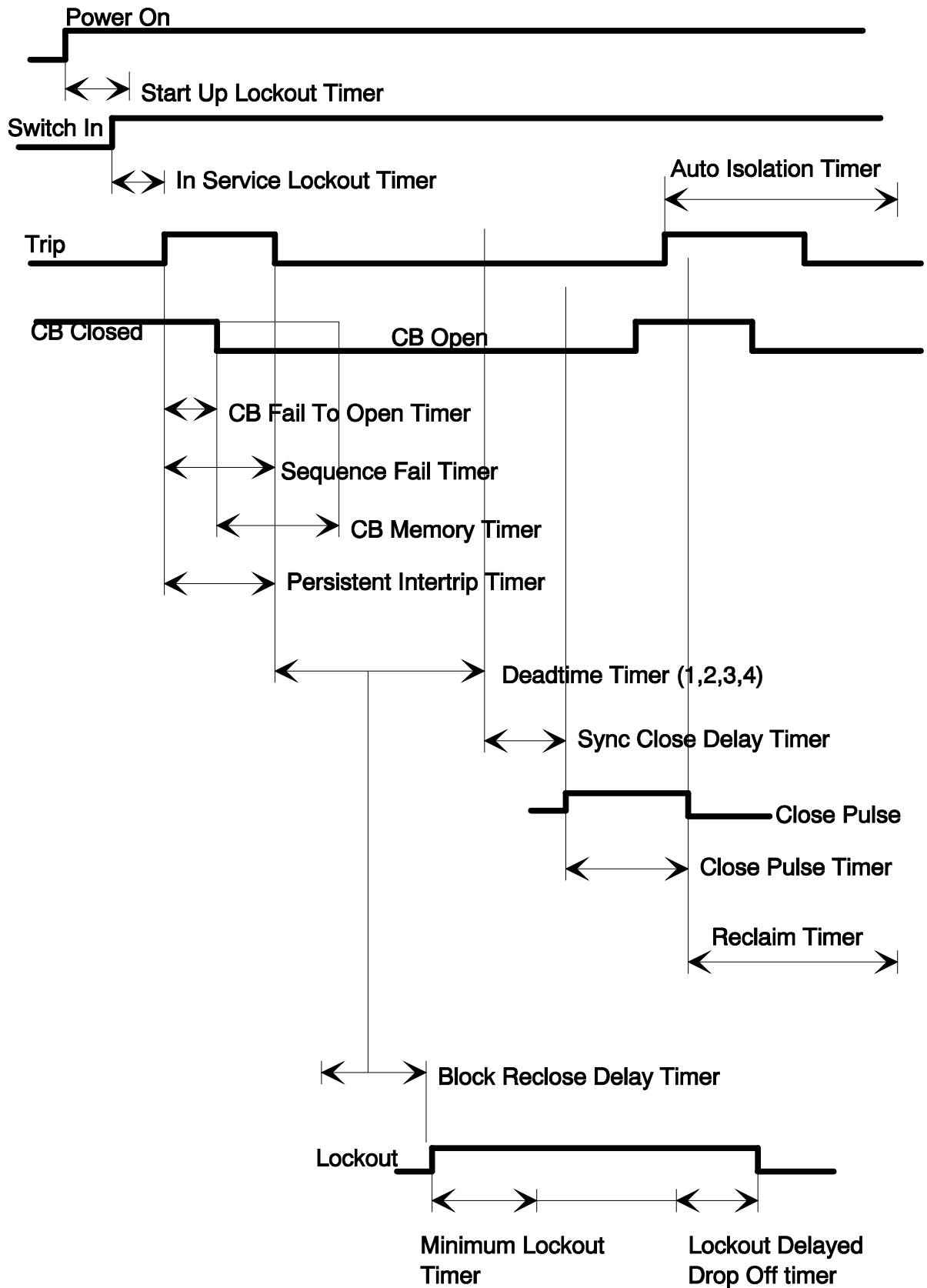
Power On

Start Up Lockout Timer

Switch In

In Service Lockout Timer

Auto Isolation Timer

Trip

CB Closed

CB Open

CB Fail To Open Timer

Sequence Fail Timer

CB Memory Timer

Persistent Intertrip Timer

Deadtime Timer (1,2,3,4)

Sync Close Delay Timer

Close Pulse

Close Pulse Timer

Reclaim Timer

Block Reclose Delay Timer

Lockout

Minimum Lockout Timer

Lockout Delayed Drop Off timer

Figure 3 Autoreclose Timers

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12.   Reclose Lockout

The autoreclose sequence can be locked out at any point in the sequence provided that the A/R is In Service. Ensure that the relay is In Service, energise the Reclose Lockout status input, confirm that the relay indicates Lockout.

13.   Manual Close

Manual Closing can occur at any point. This mimics a hard-wired close command to the circuit breaker.

Manually close the circuit breaker. Operate the Manual Close input and ensure that no close pulse is issued.

Manually trip the circuit breaker. Operate the Manual Close input, and ensure that a close pulse of the programmed time is issued.

14.   System Closing Conditions

The test for Dead Line Charging, Dead Bar Charging or Check Sync Closing is different dependent upon whether it is a Manual Close or Autoreclose.

There are five settings associated with the circuit breaker's closing conditions:

Dead Line Charge

Dead Bar Charge

Dead Line & Dead Bar Close

Check Sync Close

Unconditional Close

The priority given to these system closing settings is Dead Line then Dead Bar then Check Sync.

These settings are only relevant to autoreclosing. When a Manual Close is issued the relay does not check these settings, the relay just checks the state of the system.

To test for the Manual Close conditions:

Manually open the circuit breaker. Apply voltage to indicate Live Bar and issue a Manual Close. The relay should issue a close pulse and a Dead Line Close Flag.

Manually open the circuit breaker. Apply voltage to indicate Live Line and issue a Manual Close. The relay should issue a close pulse and a Dead Bus Close Flag.

Manually open the circuit breaker. Apply voltage to indicate Live Line and Live Bar and issue a Manual Close. The relay should issue a close pulse and a Sync In Progress Flag.

To test for the autoreclosing conditions:

Dead Line Charging - Ensure that the circuit breaker is closed. Select Dead Line Charge = Enabled in the DAR MENU. For an autoreclosing sequence to start, the CB must be closed and the line live. Issue a trip input and then open the circuit breaker, switch off the line voltage. Keep the line voltage off, and the bar voltage on to simulate a dead line charge. After the first deadtime the close pulse should be issued together with a Dead Line Close Flag.

Dead Bar Charging - Ensure that the circuit breaker is closed. Select Dead Bar Charge = Enabled and Dead Line Charge = Disabled in the DAR MENU. For an autoreclosing sequence to start, the CB must be closed and the line live. Issue a trip input and then open the circuit breaker, switch off the line and bar voltage. Keep the bar voltage off, switch on the line voltage (simulates remote end closing first) to simulate a dead bar charge. After the first deadtime the close pulse should be issued together with a Dead Bus Close Flag.

There are two instances where closing can be performed by Sync Check. These are either at the end of the deadtime when the system will wait for as long as the Sync Close Delay; Or during the deadtime when the system comes into synchronisation and Check Sync Close is allowed. For the latter the deadtime will be bypassed and the close pulse issued directly. To test for both of these:

Check Sync Closing at end of deadtime - Ensure that the circuit breaker is closed. Select Dead Bar Charge = Disabled and Dead Line Charge = Disabled and Check Sync Close = Enabled in the DAR MENU. For an autoreclosing sequence to start, the CB must be closed and the line live. Issue a trip input and then open the circuit breaker, switch off the line voltage. Keep the bar voltage live. At the end of the deadtime switch on the line voltage and bring the line and bar volts into synchronism. The close pulse should be issued together with a Sync In Progress Flag.

Check Sync Closing during the deadtime - Ensure that the circuit breaker is closed. Select Dead Bar Charge = Disabled, and Dead Line Charge = Disabled, and Check Sync Close = Enabled, and CS During Dead = Enabled in the DAR MENU. For an autorelcosing sequence to start, the CB must be closed and the line live. Issue a trip input and then open the circuit breaker, switch off the line voltage. Keep the bar voltage live.

During the deadtime switch on the line voltage and bring the line and bar volts into synchronism. A suitably long deadtime should be set. The close pulse should be issued together with a Sync In Progress Flag.

15.   Multi-shot Autoreclose sequence

The relay can be programmed to perform four autoreclose shots (five trips to lockout).

The setting Number Of Shots in the DAR MENU controls the number of closes, from 1 to 4.

16.   Starter

The relay can accept a Starter input from the protection relay. This will only be used if the protection has a starter otherwise it will remain unconnected. Experience with Overcurrent relays has shown that adjacent autoreclose relays can lose count of which shot is being performed by which relay. Sometimes during a sequence a different relay may pickup and clear the fault or close. By using a starter into the autoreclose sequence the counts of adjacent relays can be kept co-ordinated. This is the same functionality as the Reyrolle GAD/Argus 4 relays. The tests for this function should consist of determining that a status input can be correctly identified as a Starter.

6. PUTTING INTO SERVICE

After tests have been performed satisfactorily the relay should be put back into service as follows :

- Remove all test connections

- Where possible, the relay settings should be downloaded to a computer and a printout of the settings obtained. This should then be compared against the required settings. It is important that the correct settings group is active, if more than one group has been programmed.

- Replace all fuses and links.

APPENDIX 1 – Test Tables

Table 1 – Phase Angle Tests

Phase Element	Phase Setting (Degrees)	Positive angle		Negative angle	
		Pick Up (Degrees)	Drop Off (Degrees)	Pick Up (Degrees)	Drop Off (Degrees)
CS Phase Angle					
SS Phase Angle					

Table 2 – Slip Frequency Tests

Slip Element	Slip Setting (Hz)	Positive Slip		Negative Slip	
		Pick Up (Hz)	Drop Off (Hz)	Pick Up (Hz)	Drop Off (Hz)
CS Slip Freq.					
SS Slip Freq.					

Table 3 – Sync Timer Tests

Timer Type	Timer Setting (sec)	Actual Time (sec)
CS Timer		
SS Timer		

Table 4 – DAR Timer Tests

Timer Type	Timer Setting (sec)	Actual Time (sec)
First Deadtime		
Second Deadtime		
Third Deadtime		
Fourth Deadtime		
Close Pulse		
Reclaim		
Reclose Blocked Delay		
Sync Close Delay		
Sequence Fail Timer		
CB Fail To Open		
Persistent Intertrip		

Table 5 – Voltage Element Tests

Voltage Detector	Live Level			Dead Level		
	Setting (V)	Pick Up (V)	Drop Off (V)	Setting (V)	Pick Up (V)	Drop Off (V)
Line						
Bus						

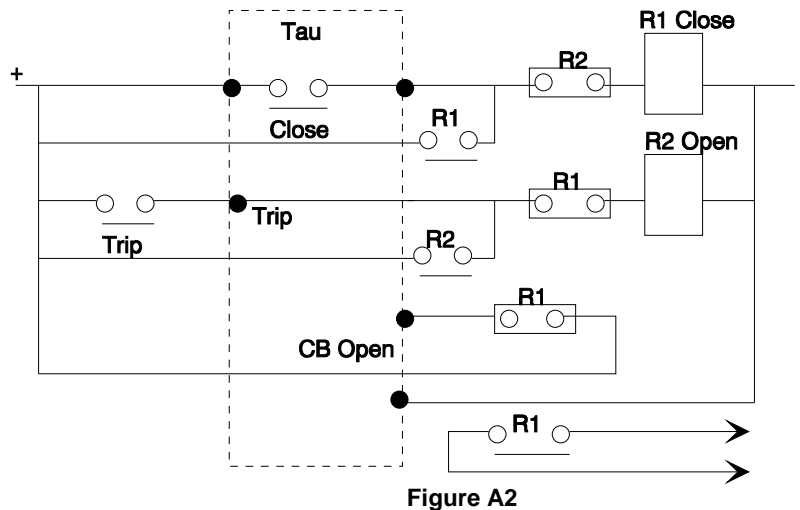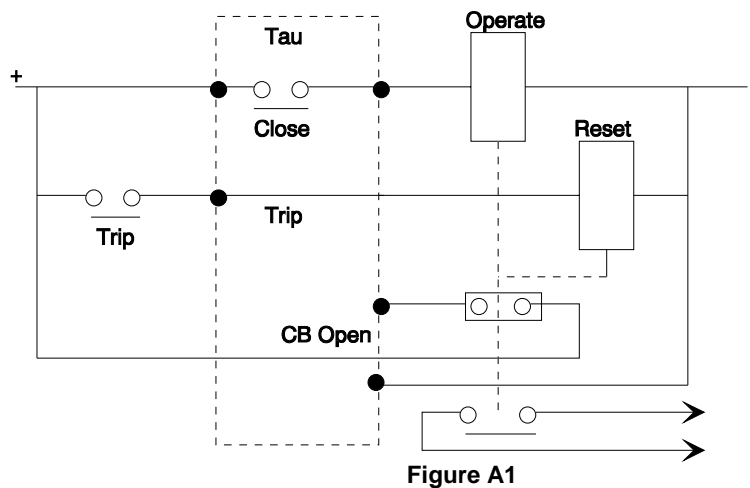| Voltage Element	Setting (V)	Pick Up (V)	Drop Off (V)
Line Undervoltage			
Bus Undervoltage			
Differential Element			

APPENDIX 2 - Circuit Breaker Simulation Circuit

This appendix describes the circuit used at Reyrolle to simulate circuit breaker operation during the development of the relay software, enabling the Tau to be tested in isolation from a full working circuit breaker.

The circuit consisted of a two coil, magnetic latching bistable relay, which operated form trip and close signals. The latching relay was used to drive a 5 volt, 8mm relay, with double pole, changeover contacts. These contacts were then used as follows:

a)   One pair of normally closed contacts was used to drive the CB OPEN status input of the TAU to provide circuit breaker position information for the trip and close operation tests.

b)   One pair of normally open contacts was used to simulate the circuit breaker main contacts.

The circuit used is shown in figure A1 below. Any suitable latching relay could be used. Alternatively, two 8mm relays connected as in figure A2 could be used in place of the magnetic latching relay.

Figure A1

Figure A2

7SG26 Tau 500

Auto Reclose and Check Synchronisation

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

Software Revision History

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Contents

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1 Maintenance Instructions

The Tau range of relays are maintenance free, 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)

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

Type of failure:

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

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

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7SG26 Tau 500

Auto Reclose and Check Synchronisation

Document Release History

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

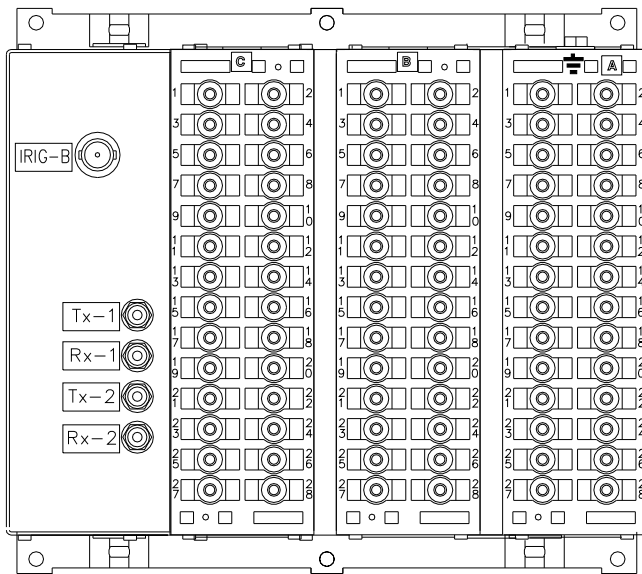Pre release

2010/02	Document reformat due to rebrand

Software Revision History

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Attached is a mechanical drawing for the Epsilon E8 case size with panel cut-out and drilling dimensions.
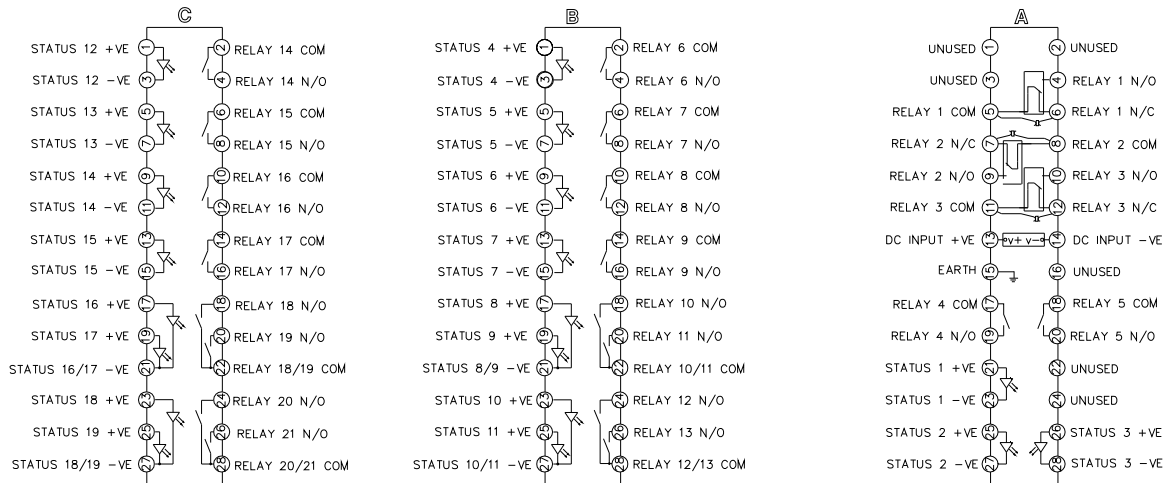
BOX VIEWED FROM REAR

NOTES

1 TERMINALS RECOMMENDED ARE PRE INSULATED & MUST
   BE CRIMPED USING APPROVED TOOLING.
   AMP PIDG OR PLASTI GRIP FUNNEL ENTRY (RING TONGUE)
   FOR M4 FIXING STUD.

SUPPLIER	AMP	CABLE SIZE
AMP	342103	0.25-1.6 SQ MM
AMP	342143	1.0-2.6 SQ MM.

OR ANY OTHER MANUFACTURERS EQUIVALENT TERMINAL.

2 FOR OUTLINE & DRILLING DRG SEE 2995X10008 (A4).
   FOR 19" RACK MOUNTING USE FRAME 2994B10046.

C

STATUS 12 +VE	RELAY 14 COM
STATUS 12 -VE	RELAY 14 N/O
STATUS 13 +VE	RELAY 15 COM
STATUS 13 -VE	RELAY 15 N/O
STATUS 14 +VE	RELAY 16 COM
STATUS 14 -VE	RELAY 16 N/O
STATUS 15 +VE	RELAY 17 COM
STATUS 15 -VE	RELAY 17 N/O
STATUS 16 +VE	RELAY 18 N/O
STATUS 17 +VE	RELAY 19 N/O
STATUS 16/17 -VE	RELAY 18/19 COM
STATUS 18 +VE	RELAY 20 N/O
STATUS 19 +VE	RELAY 21 N/O
STATUS 18/19 -VE	RELAY 20/21 COM

B

STATUS 4 +VE	RELAY 6 COM
STATUS 4 -VE	RELAY 6 N/O
STATUS 5 +VE	RELAY 7 COM
STATUS 5 -VE	RELAY 7 N/O
STATUS 6 +VE	RELAY 8 COM
STATUS 6 -VE	RELAY 8 N/O
STATUS 7 +VE	RELAY 9 COM
STATUS 7 -VE	RELAY 9 N/O
STATUS 8 +VE	RELAY 10 N/O
STATUS 9 +VE	RELAY 11 N/O
STATUS 8/9 -VE	RELAY 10/11 COM
STATUS 10 +VE	RELAY 12 N/O
STATUS 11 +VE	RELAY 13 N/O
STATUS 10/11 -VE	RELAY 12/13 COM

A

UNUSED	UNUSED
UNUSED	RELAY 1 N/O
RELAY 1 COM	RELAY 1 N/C
RELAY 2 N/C	RELAY 2 COM
RELAY 2 N/O	RELAY 3 N/O
RELAY 3 COM	RELAY 3 N/C
DC INPUT +VE	DC INPUT -VE
EARTH	UNUSED
RELAY 4 COM	RELAY 5 COM
RELAY 4 N/O	RELAY 5 N/O
STATUS 1 +VE	UNUSED
STATUS 1 -VE	UNUSED
STATUS 2 +VE	STATUS 3 +VE
STATUS 2 -VE	STATUS 3 -VE

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