

7SG164 Ohmega 400 Series

Distance Protection Relays

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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 Siemens 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 Siemens. The report reference is 434TM05B.

1 Introduction

1.1 General

This section details the description of the Single Pole / Three Pole Auto-reclose function. The Auto-reclose function consists of a Two-shot Single Pole / Three Pole Auto-reclose device with integral Check Synchronisation.

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 auto-reclose process. Auxiliary functions are provided which cover all aspects of the auto-reclose scheme i.e. Auto-reclosing, Manual Closing, Check Synchronisation.

The auto-reclose function has been designed to only allow reclosing if system conditions dictate. A number of features are included to prevent reclosing:

CB In Service, Inhibit Close, Block Reclose; the dead times are only started if certain criteria are met i.e. the trip has reset and the CB has opened and the line has gone dead;

The close pulse will only be issued if the system synchronisation conditions are met and the CB is open and there are no trips present. The relay errs on not closing. All of this logic is internal to the relay.

Because of the complexity of auto-reclose schemes and the possibility of setting the relay incorrectly the user should be familiar with all aspects of the relay before energising any equipment.

Auto-reclose inputs are fully programmable via matrixes: Block Reclose, Reclose Lockout, Manual Close, A/R In, A/R Out, Reset Lockout etc.

Outputs are fully programmable to either LEDs or output contacts.

The relay has been designed for ease of setting, clear setting ranges indicate dead times, close pulse and reclaim time delay settings. Front panel instruments are provided that indicate the point which the Relay has reached during an Auto-reclose 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.

The Auto-reclose control function is connected to the Circuit Breaker, and integral to the Protection relays. The interconnection of this equipment allows for the auto-reclose relay to issue a number of alarms indicating system conditions and possible problems:

- the state of the CB is monitored for CB Open, CB Closed and CB Indeterminate; per phase signals are provided.
- CB Single Pole Open and CB Three Pole Open outputs which can be used as inhibits i.e. Power Swing Blocking, Zone 1 Extension Inhibit.
- CB Pole Discrepancy protection.
- VT Alarms for Line and Bus side VTs.
- CB Counter Alarms.
- CB Failed To Close.
- CB Failed To Open.
- Close Onto Fault.
- Slow CB.
- Start Auto-reclose flexibility, either Trip, Trip and CB Open, or Trip Reset.
- 3PTS logic connection provided to instruct protection to issue trips as 3P.

- CB In Service and CB Memory prevent unwanted auto-recloses if the CB is open or normally de-energised. Auto-reclose is only allowed to proceed if the CB was in a closed position.
- Flexible latched or self reset Lockout.
- Flexible connection of the CB Auxiliary switches, can be of type a, b or a&b.
- Switching A/R In/Out can be from switches, communications, keypad or telecontrol pulses.
- Close Mode Selection determining the auto-reclose sequence employed may be changed by a selector switch.

The relay will automatically determine circuit breaker reclosure conditions. These conditions are dead line close, dead bar 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 dead time 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.

1.2 Auto-reclose

Auto-reclose is commonly applied to Transmission and Distribution systems. This relay has been designed for application to Transmission systems where single pole and three pole tripping is applied.

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.

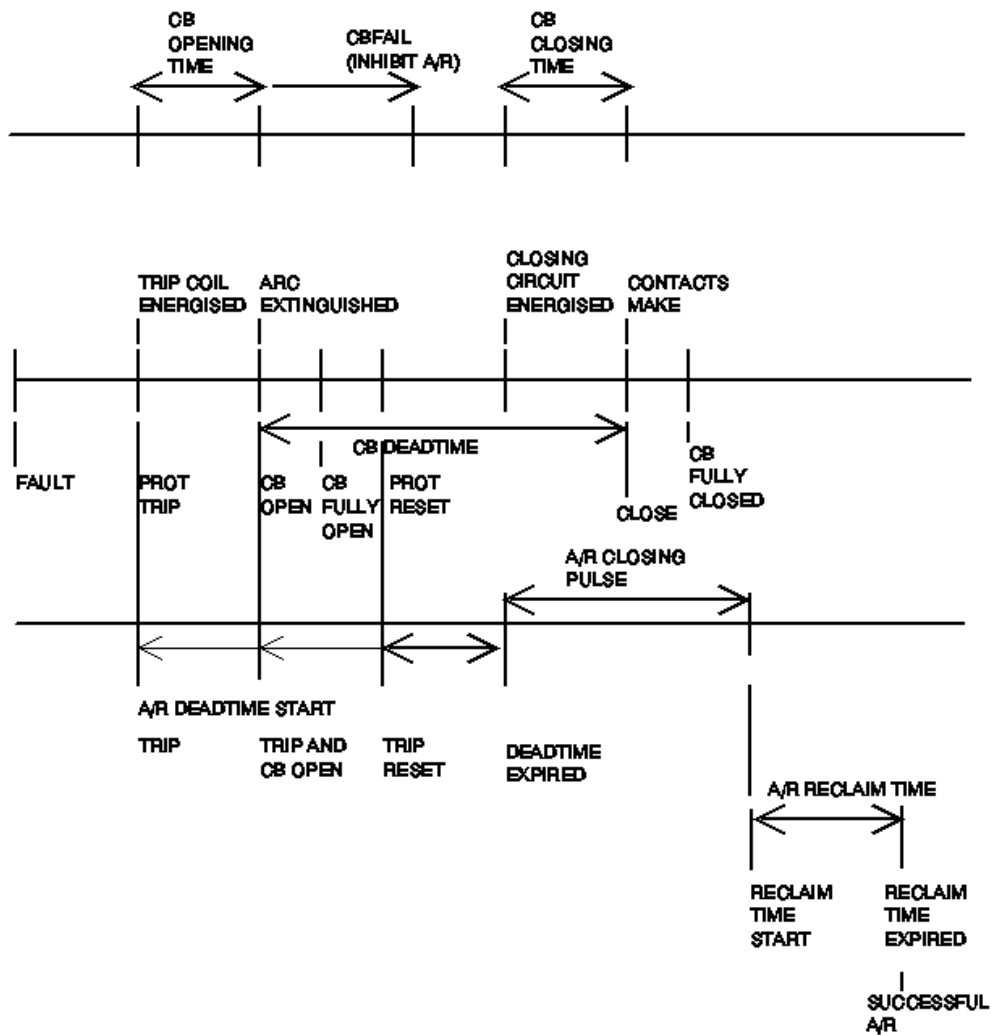


Figure 1 – Auto-reclose Sequence

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.

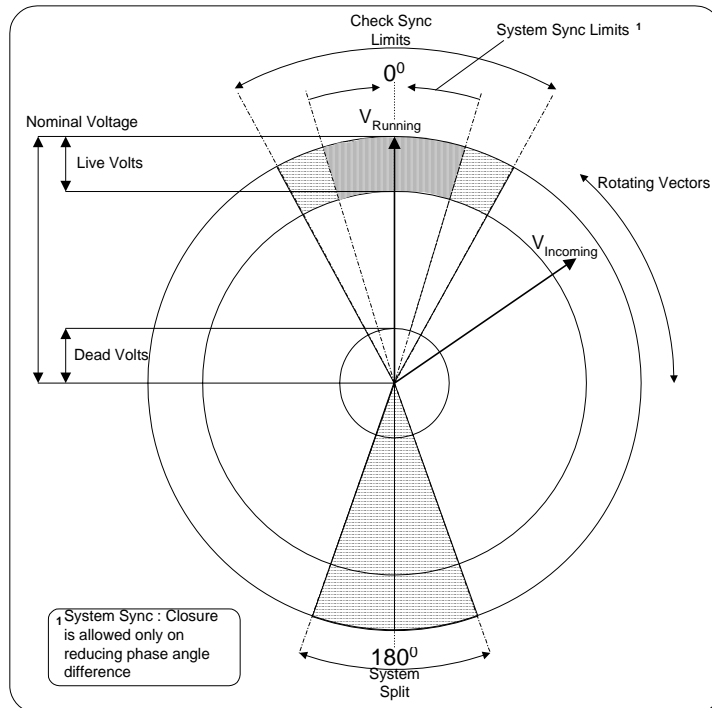


Figure 2 - Check and System Synchronising

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.

2 Hardware Description

2.1 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 quality waveform storage records.

2.2 Status Inputs

Each of the status inputs can be programmed to perform one or more of the following functions, (see settings sheet for complete list):

- Start Auto-reclose.
- CB Auxiliary contacts.
- Close the CB.
- Auto-reclose control functions.
- Bypass the sync function.
- Switch to an alternative settings group
- Trigger storage of a waveform record.
- Reset the Lockout condition.

3 Auto-Reclose Control Functions

3.1 Auto-reclose

Auto-Reclose (A/R) 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 auto-reclosing when the line is normally de-energised, or normally open.

The transition from 'A/R started' to 'initiate dead time' is programmable. It can take place when the trip signal is received; or when the trip signal is active and the CB has opened (the A/R dead time will then mimic the CB dead time); or when the trip has occurred and the CB has opened and then the trip has reset. If any of these do not occur within the Sequence Fail time the relay will Lockout. This is provided to prevent the A/R being primed indefinitely, or the Sequence Fail timer can be switched OFF.

Once an A/R sequence has been initiated, up to 2 unsuccessful recloses (where a closure is followed by a re-trip) may be performed before the A/R 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 A/R 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 per phase have been performed.

Once lockout has occurred, an alarm is issued and all further External 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 recloses.

The relay will automatically determine circuit breaker reclosure conditions. These conditions are dead line close, dead bar 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 dead time 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.

A number of settings allow a very flexible application of the relay. The relay can be applied to any combination of CB auxiliary contacts depending upon how many contacts are available, these can be type 'a', 'b' or both 'a' and 'b'.

The Close Mode Selection setting can be selected by status inputs thereby allowing remote change to the type of allowable auto-reclose sequences. Either telecontrol, or panel mounted switches, or communications, or relay front panel keypad can be used to change this setting.

3.2 Protection Trips

The Protection function which trips the CB primes and starts the auto-reclose sequence. The relay internally determines what type of fault has occurred: Phase to earth, Phase to Phase, Three Phase.

3.3 Developing Faults

The relay automatically determines developing faults and whether these can initiate an auto-reclose sequence.

A setting is provided to inhibit the three pole dead time by faults involving all three poles, if required. The relay can be programmed to allow different types of fault to initiate different types of auto-reclose

sequence. This can enhance the reliability of the reclose sequence. In systems where single pole tripping is employed the occurrence of a three phase fault can indicate severe problems and reclose can be disabled if required.

For example:

Single Pole Trips initiate 1P Auto-reclose.

Phase to Phase Faults initiate 3P Auto-reclose.

Three Pole Faults initiate either 3P Auto-reclose or Lockout.

A single pole trip which initiates a single pole dead time and then develops into a trip involving more phases or more than one CB opens will either initiate a three pole dead time if allowed or lockout.

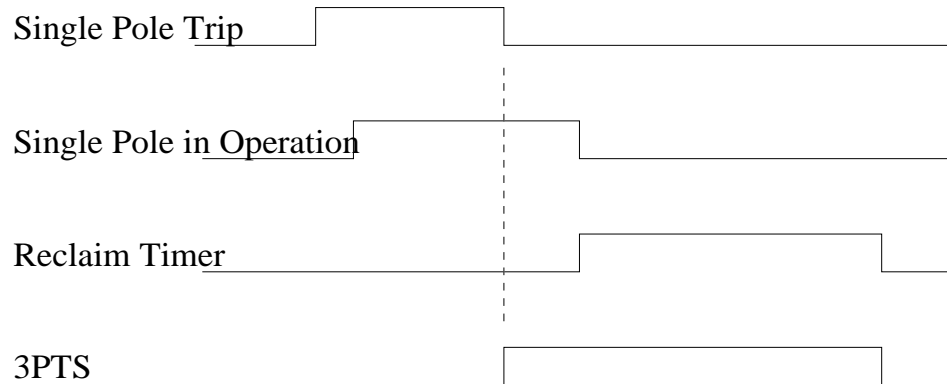
3.4 Three Pole Trip Select

The relay co-ordinates the action of the Protection with the state of the system. For conditions which dictate that a single pole reclose may be unsuccessful the auto-reclose relay instructs the protection to issue a three pole trip signal.

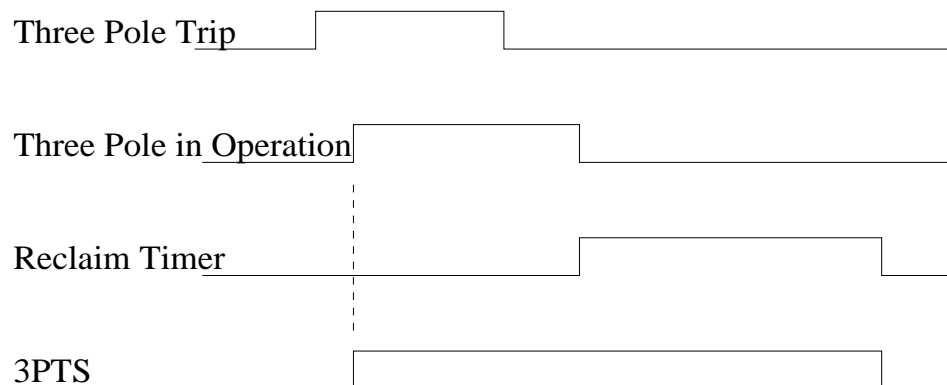
With Single pole reclosing sequences, following the first shot single pole trip and reclose subsequent tripping of the CB shall be 3 pole. An Alarm shall be issued to indicate three pole tripping is being commenced. A setting shall be provided to program an output relay to operate when the auto-reclose sequence goes to three pole either on selection or during a two shot scheme.

Definitions:

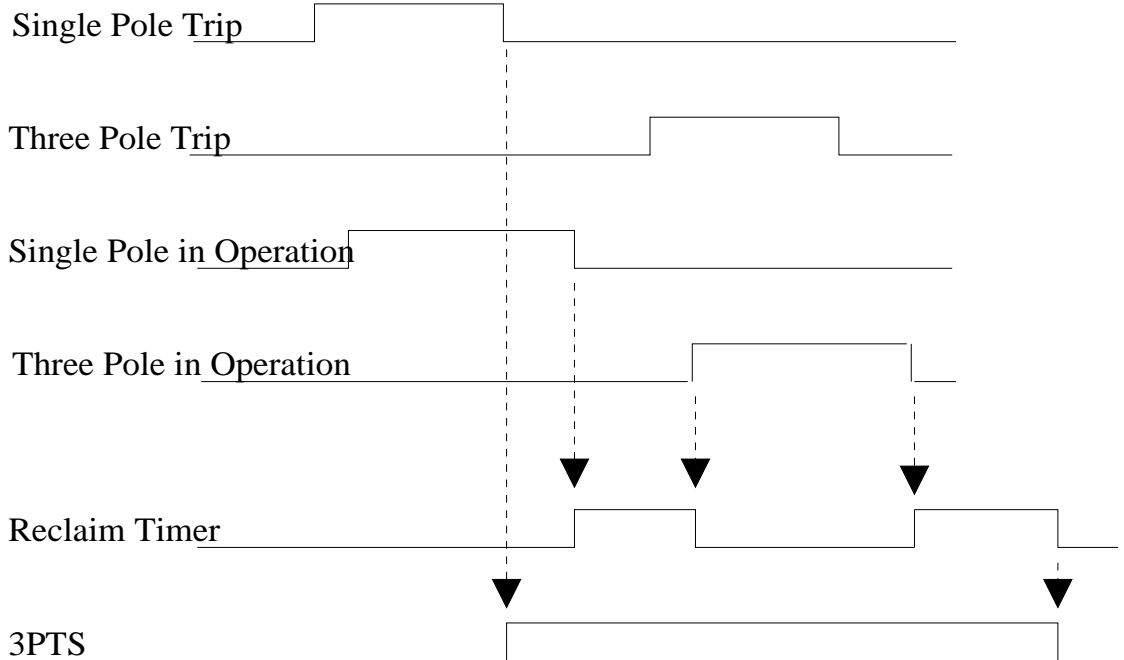
- Following a Single Pole auto-reclose sequence: All tripping after a single pole sequence will be 3 Pole. i.e. Prepare the main protection to go into 3 Pole mode.



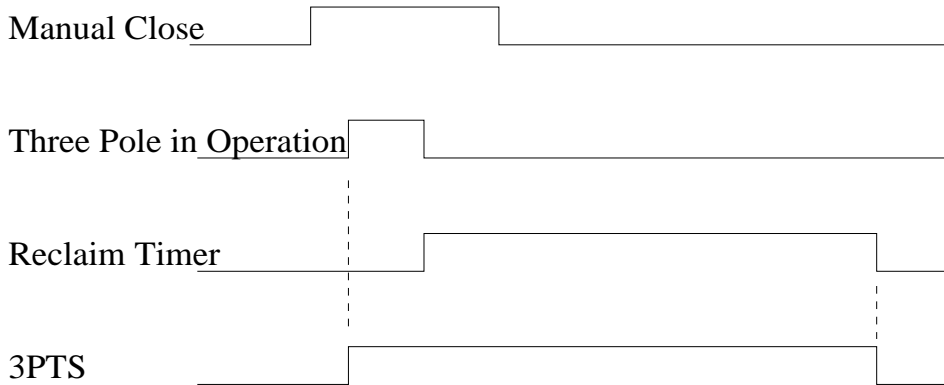
- Three pole auto-reclose.



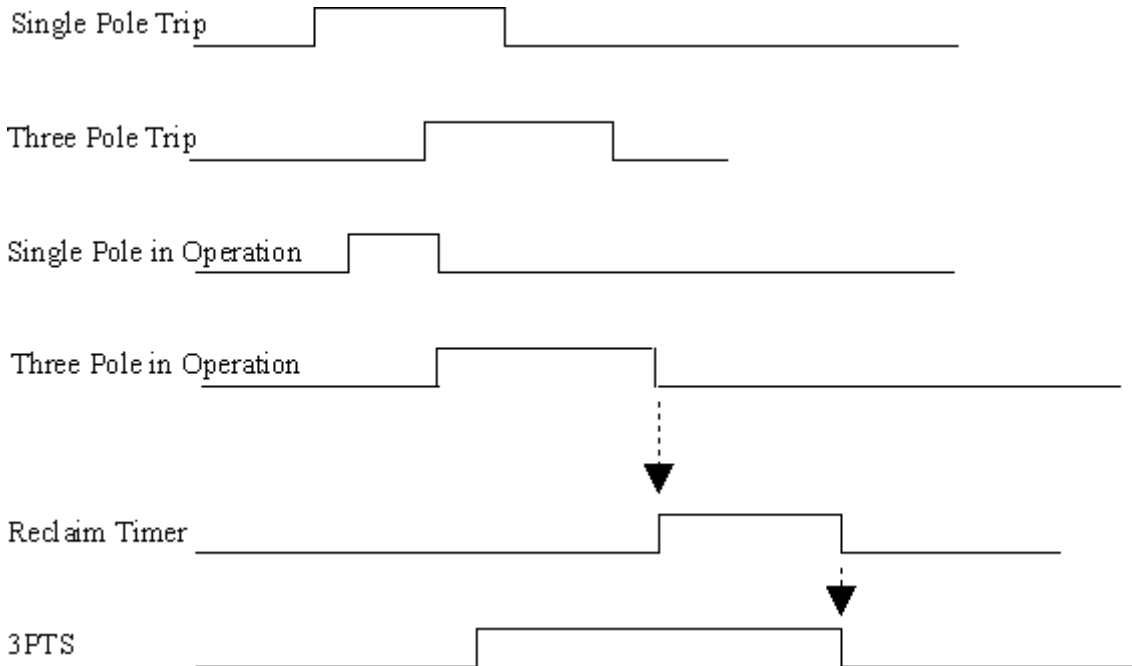
- For a sustained fault sequence (CMS set to 1P3P/3P): Subsequent tripping of the CB shall be 3 pole. An alarm will be issued to indicate 3 pole closing. We remain with 3PTS if fault in reclaim time. The Protection relay has tripped single phase and then reset, the recloser will complete the single phase reclosing sequence, a second trip within the reclaim time must be three pole, to force this second trip to be three pole the 3PTS output is given after the single pole trip has cleared.



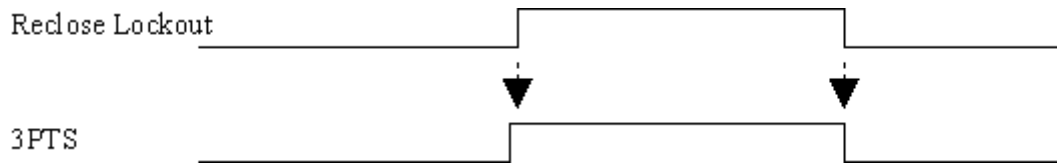
- Following the Manual Close Command: 3 pole trip select (3PTS) is initiated following a manual close command. Any subsequent faults shall initiate a 3PT.



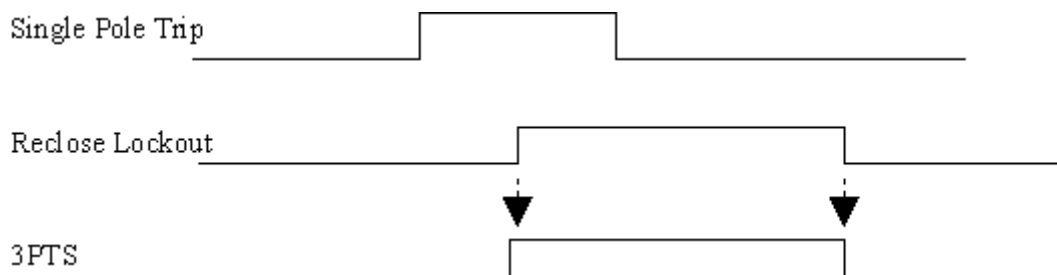
- Evolving Fault: Should the relay change to a 3 pole trip sequence during a single pole reclosure sequence, the 1PARC sequence will reset and a three pole closing alarm will be issued.



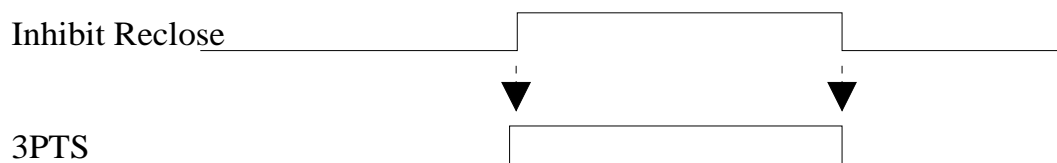
- During a Reclose Lockout signal: If a Reclose Lockout signal becomes active during a 1P auto-reclose sequence the relay will select 3PT. Reclose Lockout will initiate 3PTS.



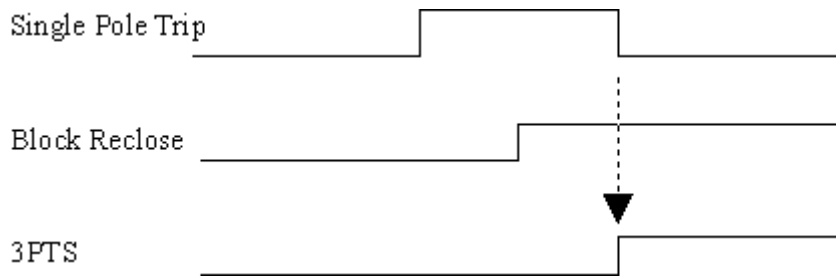
- If Reclose Lockout during Single Pole Trip: Go to Lockout, Trip 3P straight away.



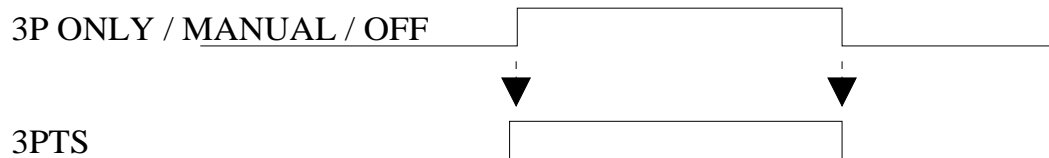
- During Block Reclose or Inhibit Close:



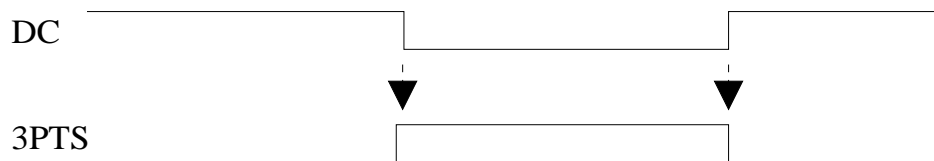
- If Block Reclose during a 1P auto-reclose sequence: Should a Block Reclose signal become present during a 1PARC sequence, 3PTS shall initiate upon resetting of the current 1PARC initiate signal. i.e. give the 1P shot a chance, the Block may be transient.



- As a result of selected CMS:



- For loss of DC: Should the DC supply be lost 3PT shall be selected.



This requires that a normally energised N/C contact is used as the output for 3PTS. A separate flag 3PTS Flag is provided for use as the LED indication.

3.5 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 A/R sequence then in operation. Manual Close resets Lockout.

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 of the Manual Close input. Even if the Manual Close input is constantly energised the relay will only attempt one close.

There is a separate input Inhibit Close which prevents the close pulse being issued from a Manual Close. If the Inhibit Close signal has not been removed before the end of a defined time, the Permissive Close Delay, the A/R feature is locked-out. The input Block Reclose does not prevent Manual Closing. Block Reclose only prevents auto-reclosing. Both Inhibit Close and Block Reclose utilise the Permissive Close Delay timer.

3.6 In/Out Switching

The A/R 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. A/R In Status Input is positive edge triggered.

3.7 Overall Control

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

If the Lockout command or A/R OUT are received while an A/R 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.

The A/R feature may be paused by an external Block Reclose or Inhibit Close 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 Reclose signal has not been removed before the end of a defined time, the Permissive Close Delay, the A/R feature is locked-out. A Block Reclose active within the dead time resets the dead time timer.

3.8 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 trips occur. This is to prevent Close and Trip Command pulses existing simultaneously. A Close Onto Fault Output is given if a trip picks-up in the Close Pulse. This can be independently wired to Lockout.

3.9 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 A/R feature can be set to lockout.

CB Failed To Open utilises the CB Closed status input and trip signal. If the CB remains closed after a trip signal has been received for longer than the CB Fail To Open time delay setting then an alarm is issued. This alarm could be used to lockout the auto-reclose sequence; or could indicate a slow CB opening.

CB Failed To Close results in lockout if the CB is still open at the end of the Close Pulse time delay setting.

3.10 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).

3.11 Indications

The relay has a fully programmable output to either output contacts or LEDs.

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
6. 3PTS and 3PTS Flag

see Output Relay Menu and LED Menu for complete list.

3.12 CB Close Counters

Additional A/R 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 re-settable and have a maximum alarm number of 999.

3.13 Metering

All Counters and the Status of the A/R sequence are displayed in Meters under the Instruments Menu.

3.14 Dead-time and Reclaim Timing

The Dead time will start if a Trip has occurred and the CB is Open and the Trip has 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 then the A/R will Lockout. This could be due to either a CB Fail condition, which would independently notify Lockout, or the Trip 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 auto-reclose will go to Lockout.

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. If the CB remains closed for the Reclaim time, the relay will reset and be ready for further operation.

3.15 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 Permissive Close Delay due to a persistent Block Reclose or Inhibit Close.
- At the end of the Sync Close Delay due to Synchronism not being achieved.
- At the end of the Sequence Fail time.
- At the end of the Overall Sequence time.

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

- By a Manual Close command.
- By a Reset Lockout signal, provided there is no signal present which 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 Auto-reclose 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 A/R sequences are prevented by using a combination of Trip and CB In Service to start the sequence.

3.16 Intertrip Initiated Auto-reclose

Auto-reclose can be initiated by an Intertrip Receive signal. A Persistent Intertrip timer is provided. If the Persistent Intertrip timer times-out before the Intertrip Receive signal has reset then the relay will go to Lockout. Only a one shot auto-reclose sequence is allowed by intertripping, any other intertrips cause the relay to go to Lockout. Intertrip dead time initiate must correspond to Trip Reset.

3.17 Sequential Isolation

Some utilities apply an arrangement when a CB is opened to automatically open the isolator. This is called Sequential Isolation. This needs to be inhibited if the CB is to be automatically reclosed. Facilities to inhibit sequential isolation are provided to enable the A/R system to stop sequential isolation if an associated A/R 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.

3.18 CB Single Pole In Op / CB Three Pole In Op

Two outputs are provided which indicate whether all CB's are open (Three Pole In Op) or a single pole CB is open (Single Pole In Op). These outputs can be used for inhibit purposes i.e. Power Swing Blocking, Zone 1 Extension Inhibit.

3.19 VT Alarms

The relay detects if a VT Fail has occurred. This could be a Line VT Fail or a Bus VT Fail. If the CB is closed and the Line is Live and the Bus is Dead for greater than 2 seconds a Bus VT Alarm is issued. If the CB is closed and the Line is Dead and the Bus is Live for greater than 2 seconds a Line VT Alarm is issued. The relay cannot distinguish between the system VT and the measuring VT within the relay, the VT Fail could be either.

3.20 Close Onto Fault

This output provides flexibility to be able to distinguish faults occurring during the close pulse. Any Trip occurring within the close pulse is designated as a Close Onto Fault. This can be used to stop the auto-

reclose sequence if required, wired to Lockout. There can now be a difference between trips in the close pulse and trips in the reclaim time. A trip in the reclaim time can be designated as a separate fault. This can be enhanced further by extending the close pulse time setting to longer than usual, say 5 seconds, effectively creating two reclaim times.

3.21 CB Pole Discrepancy

Systems using single pole tripping or CB's with separate phase operation govern the time which a single CB may be open by CB Pole Discrepancy Protection. If the single pole is open greater than the Pole Discrepancy time, typically 1.6 seconds, the auto-reclose process is normally Locked out. This is also applied to three pole tripping schemes.

3.22 Close Mode Selection (CMS)

Close Mode Selection (CMS) refers to the auto-reclose sequence selected. The setting can be changed by the front panel keypad; or status inputs wired to panel switches or telecontrol; or communications.

The table below illustrates the available auto-reclose schemes i.e. 1st Action = 1P refers to first reclose attempt is allowed to be a Single Pole Reclose; 1st Action = 1P/3P refers to first reclose attempt can be either Single Pole OR Three Pole; 2nd Action = 3P refers to second reclose attempt can only be Three Pole Reclose; 2nd Action = LO refers that no reclose will be allowed and that for any further reclose initiations (protection trips), the relay will go to Lockout.

| 1 st Action | 2 nd Action | 3 rd Action | CMS Setting from keypad/ comm's. |
|------------------------|------------------------|------------------------|----------------------------------|
| F-LO | | | Off |
| 1PF-1PR | F-LO | | 1P |
| F-3PR | F-LO | | 3P |
| 1PF-1PR 3PF-3PR | F-LO | | 1P/3P |
| 1PF-1PR 3PF-3PR | 3PR 2*3PF-LO | F-LO | 1P3P/3P |
| F-3PR | F-3PR | F-LO | 3P3P |
| 1PF-1PR 3PF-LO | 1PF-1PR 3PF-LO | F-LO | 1P1P |
| 1PF-1PR 3PF-3PR | 1PF-1PR 3PF-3PR | F-LO | 1P1P/3P3P |

The Close Mode Selection defines the allowable number and type of reclose shots allowed during the sequence.

| | | |
|------|-----|---------------------|
| KEY: | 1PF | Single Pole Fault |
| | 1PT | Single Pole Trip |
| | 1PR | Single Pole Reclose |
| | LO | Lockout |
| | 3PF | Three Pole Fault |
| | 3PR | Three Pole Reclose |
| | F | Any Fault |

SINGLE SHOT SEQUENCE

The following tables attempt to define the auto-reclose sequence for that selected Close Mode setting. For example

1st Action

1PF - 1PR

A Single Pole Fault which results in a Single Pole Protection trip will initiate a Single Pole Reclose.

1st Action

3PF - LO

If the first protection trip is multi-phase then no reclose attempt will be allowed and the reclose relay will proceed directly to Lockout.

2nd Action**F - LO**

Any fault occurring in the Reclaim time will result in the reclose relay proceeding directly to Lockout.

CMS set to 1P, Single Phase Operating Sequence - 1 POLE

| 1 st Action | 2 nd Action |
|------------------------|------------------------|
| 1PF - 1PR 3PF - LO | F - LO |

Single Pole Operation

The CMS setting provides for a one shot Single Pole auto-reclose sequence.

The Auto-reclose sequence will be started by a single pole reclose initiation provided only a single pole of the CB pole has opened, there is no Reclose Lockout signal present and the selection of the Close Mode Selection (CMS) function permits single pole reclosing.

If the single pole trip evolves into a multiple phase trip the single pole reclosing sequence is disabled.

The single pole initialisation signal will be maintained until it is reset by the closing of the open pole of the CB.

If no Lockout condition exists after the single phase reclosing sequence has elapsed the open pole is closed directly by issuing a Close Pulse to the breaker close coils.

The Reclaim time timer will be started by the Close command to the CB.

All subsequent tripping within the Reclaim time following an auto-reclose can be set to be three pole.

CMS set to 3P, Three Phase Operating Sequence - 3 POLE

| 1 st Action | 2 nd Action |
|------------------------------|------------------------|
| 1PF - 3PT - 3PR 3PF - 3PR | F - LO F - LO |

The CMS setting provides for a one shot Three Pole auto-reclose sequence.

The 3 phase Dead time timer will be started by a three pole reclose initiation provided all poles of the CB have opened, there is no Reclose Lockout signal present, the selection of the CMS function permits 3 pole reclosing.

If 3 pole closing only is selected, the recloser will issue a three pole trip select.

The initiation command will be maintained until it is reset by the closing of the open breaker.

For a 3 pole reclose, if the line and/or busbar are 'dead', and if no lockout condition exists, it will be possible to issue a close pulse directly to the CB. However should both the line and busbar be 'live', a 3 pole reclose of the open breaker is only possible following a successful Check Synchronism, whereupon a closing pulse will be issued to the CB.

Following a decision to close, a timer will ensure that the Close Pulse is maintained long enough to allow for the spring rewind time if a single pole trip and reclose preceded the 3 pole trip.

The Reclaim time timer will be started by the close command to the CB.

All subsequent tripping within the Reclaim time following an auto-reclose can be set to be three pole.

CMS set to 1P/3P, Single or Three Pole Operation - 1P/3P

| 1 st Action | 2 nd Action |
|------------------------|------------------------|
| 1PF - 1PR 3PF - 3PR | F - LO F - LO |

Single or Three Pole Operation

The CMS setting provides for a single shot Single or Three Pole auto-reclose sequence.

If the single pole trip evolves into a multiple phase trip the single pole reclosing sequence will be disabled and the sequence will proceed with a three phase reclose after the appropriate three phase dead time provided all three poles of the CB have opened.

If a single pole trip causes all poles of the CB to open then a three pole reclose will be allowed after the appropriate three pole dead time.

TWO SHOT SEQUENCES

CMS set to 1P3P/3P, Two Shot Reclosing Sequence - IP3P/3P

| 1 st Action | 2 nd Action | 3 rd Action |
|------------------------|------------------------------|------------------------|
| 1PF - 1PR | 1PF - 3PT - 3PR 3PF - 3PR | F - LO |
| 3PF - 3PR | F - LO | |

Single Pole then Three Pole Operation OR Three Pole

The CMS setting provides for a two shot auto-reclose sequence if the first shot has been a Single Pole reclose. This option is commonly applied to Transmission systems and succeeds because the opening of all three poles of the CB after a failed single pole reclose can remove the mechanism of induced voltage across the phases which caused the reclose to fail.

If the CB re-trips for a recurring fault within the Reclaim time following a single pole auto-reclose, a 3 pole auto-reclose can be initiated if a second reclose attempt is permitted. A second reclose is permitted if the CMS function is selected to 1P3P and the Block Second Shot input has not been initiated.

When the Block Second Shot input is initiated, a second reclose attempt is not permitted.

When a second reclose is permitted, the Reclaim time is reset by the renewed reclose initiation signal and commences again with the close command to the CB.

For a 3 pole reclose, if the line and/or busbar are 'dead', and if no lockout condition exists, it will be possible to issue a close pulse directly to the CB. However should both the line and busbar be 'live', a 3 pole reclose of the open breaker will only be possible following a successful synchronism check, whereupon a close pulse is issued to the CB.

Following a decision to reclose, a timer ensures that the close pulse is maintained long enough to allow for the spring rewind time if a single pole trip and reclose preceded the 3 pole trip.

The 3 phase Dead time timer is started by a 3 pole reclose initiation for a recurring fault within the Reclaim time following a single pole trip and auto-reclose.

If the breaker re-trips within the Reclaim time following a 3 pole second reclose, the Lockout condition will be established immediately to ensure no further 3 pole recloses are attempted.

All subsequent tripping within the Reclaim time following an auto-reclose can be set to be three pole.

CMS set to 3P3P, Two Shot Reclosing Sequence - 3P3P

| 1 st Action | 2 nd Action | 3 rd Action |
|------------------------|------------------------|------------------------|
| 1PF - 3PT - 3PR | 1PF - 3PT - 3PR | F - LO |
| 3PF - 3PR | 3PF - 3PR | F - LO |

3P3P

The CMS setting provides for a two shot Three Pole auto-reclose sequence.

CMS set to 1P1P/3P3P, Two Shot Reclosing Sequence - 1P1P/3P3P

| 1 st Action | 2 nd Action | 3 rd Action |
|------------------------|------------------------|------------------------|
| 1PF - 3PT - 3PR | 1PF - 3PT - 3PR | F - LO |
| 3PF - 3PR | 3PF - 3PR | F - LO |

1P1P/3P3P

The CMS setting provides for a two shot, Single or Three Pole auto-reclose sequence.

CMS set to 1P1P, Two Shot Reclosing Sequence - 1P1P

| 1 st Action | 2 nd Action | 3 rd Action |
|------------------------|------------------------|------------------------|
| 1PF - 1PR | 1PF - 3PT - 3PR | F - LO |
| 3PF - LO | F - LO | |

1P1P

The CMS setting provides for a two shot Single Pole auto-reclose sequence.

CMS Change Selection

The method of changing the Close Mode Selection by a connection of status inputs wired to a switch or telecontrol is outlined below:

| CMS Change One | CMS Change Two | CMS Change Three | CMS Scheme Selected |
|----------------|----------------|------------------|---------------------|
| 0 | 0 | 0 | No Change |
| 0 | 0 | 1 | 1P |
| 0 | 1 | 0 | 3P |
| 0 | 1 | 1 | 1P/3P |
| 1 | 0 | 0 | 1P3P/3P |
| 1 | 0 | 1 | 3P3P |
| 1 | 1 | 0 | 1P1P |
| 1 | 1 | 1 | 1P1P/3P3P |

A change to the CMS scheme is implemented if the switch position remains at the new setting for greater than 2 seconds. To allow for connection to tele-control pulses, no change is implemented when all inputs are not energised. The switch should either stay at its selection or return to its 'no change' position after the change has completed.

Note: It is not possible to select Close Mode Selection to OFF by the CMS Change Status Inputs. A/R Out Status Input can be used for this purpose.

3.23 Voltage monitoring elements

3.23.1 Undervoltage detectors

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

3.23.2 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.

3.23.3 Voltage detectors

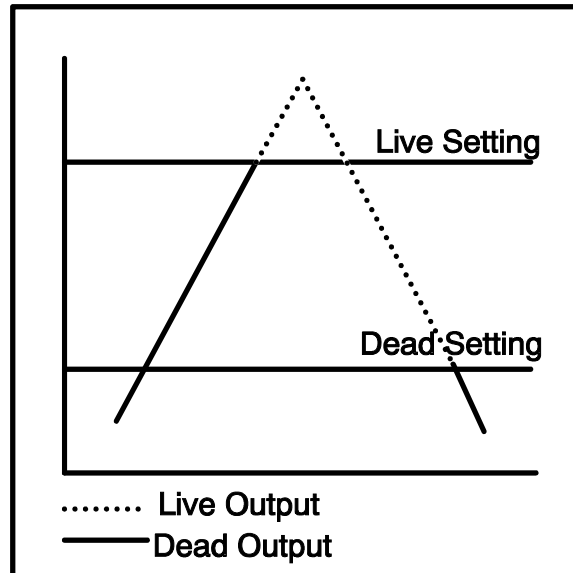
Voltage detectors determine the status of the line or bus. If the voltages on either the line or bus are below a set threshold level they can be considered to be 'dead'. If the voltages are within a setting band around the nominal voltage they are classed as 'live'. Independent voltage detectors are 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 hysteresis 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 and this is 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 so that this operation is clear to the user.

Figure 3 - Voltage Detector Operation



3.23.4 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.

3.24 Check Synchronising Mode

For the relay to issue a CheckSync 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 undervoltage setting value for an output to be given.

BUS U/V DETECTOR, [If ENABLED] – the bus voltage has to be above the bus undervoltage setting value 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 ΔV 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.

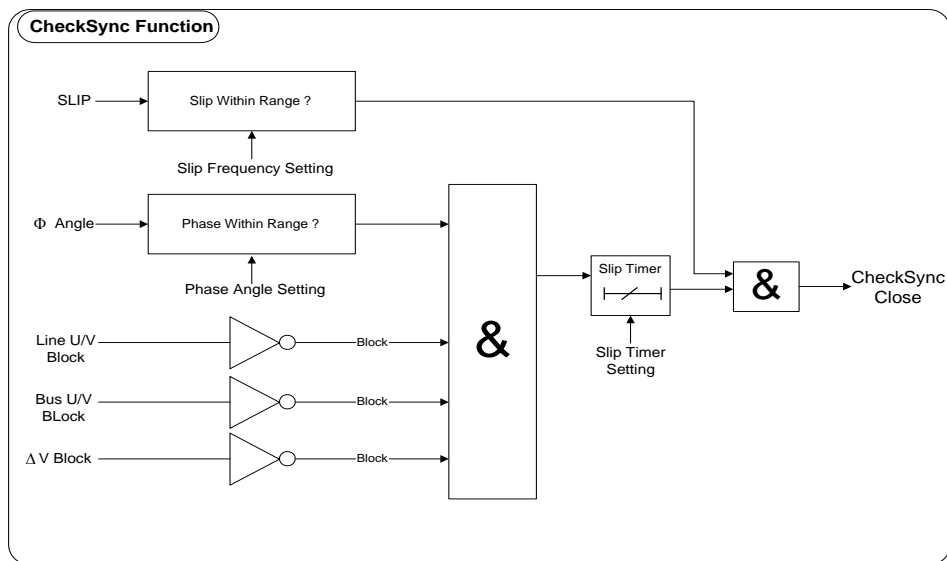


Figure 4 - Check Sync Function

3.25 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.

3.26 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 CheckSync operation the following events occur :

- The CheckSync function is inhibited.
- The SystemSync 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 comms. Command is received.
 - 4)
- 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.

3.27 System Synchronising Mode

For the relay to issue a SystemSync 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 undervoltage setting value for an output to be given.

BUS U/V DETECTOR, [If ENABLED] – the bus voltage has to be above the line undervoltage setting value 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 ΔV 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.

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.

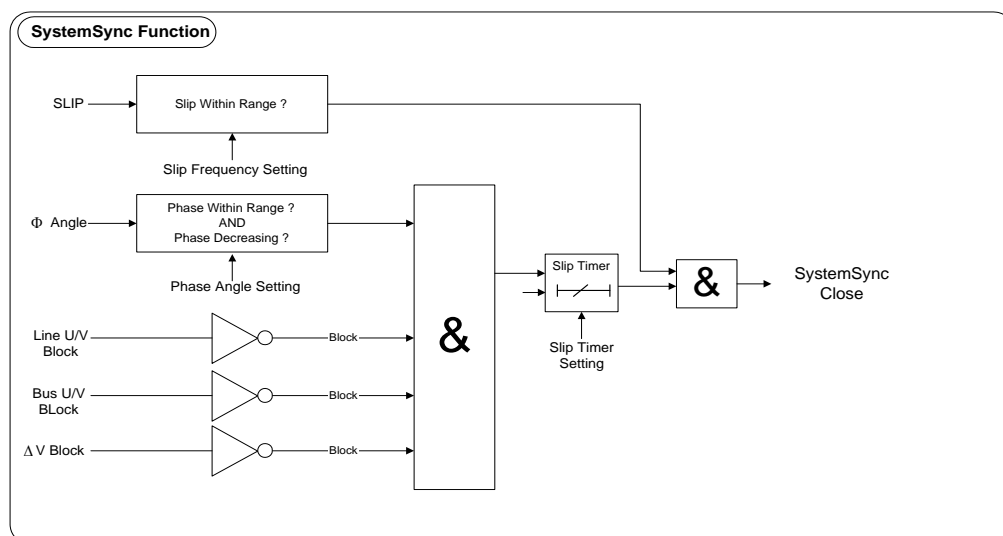


Figure 5 - System Sync Function

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.

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 per phase
- Delta Number of CB Closes per phase
- 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. Time and date can be set either via the relay fascia using appropriate commands in the System Config menu or 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 is 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

The following additional information is available via the communications:

- Close Data Records
- Instrument and meters
- Control Functions

5 Menu Settings

5.1 A/R Menu

A/R In Service – this setting switches the Auto-reclose in or out.

Close Mode Selection – this setting selects the appropriate auto-reclose sequence.

Gn Dead Bar Close – this setting determines the closing action.

Gn Dead Line Close – this setting determines the closing action.

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

Gn First 1P Dead time – this setting sets the first shot Single pole dead time time delay.

Gn Second 1P Dead time – this setting sets the second shot Single pole dead time time delay

Gn First 3P Dead time – this setting sets the first shot Three pole dead time time delay.

Gn Second 3P Dead time – this setting sets the second shot Three pole dead time time delay.

Gn Start Dead time – this setting selects how to initiate the dead time.

Gn 3P Dead time Initiate – this setting sets whether the dead time can be initiated from three phase faults.

Gn CB Aux Switches – this setting sets the type of connection to the CB Auxiliary contacts.

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

Gn Reclaim Time – this setting sets the reclaim time.

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

Gn Permissive Close Delay – this setting sets the allowable time a Block Reclose or Inhibit Close may be active before the Auto-reclose sequence is locked out.

Gn Overall Sequence Timer – this setting sets the time to lockout to complete the auto-reclose sequence.

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

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

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

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 CB Indeterminate – this setting sets the time which indicates that CB Open and CB Closed are in an Indeterminate position.

Gn CB Memory Timer – this setting sets the drop-off time which indicates that the CB was In Service.

Gn Set Type – Where dual auto-reclose relays are applied this setting sets which is the master and which the slave.

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.

5.2 CB Pole Discrepancy Menu

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

5.3 Sync Menu

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 which will occur if a Manual Close is given after a system split.

Gn A/R Split Action – this setting sets the action which will occur if a system split occurs during an auto-reclose 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.

5.4 Status Input Menu

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

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

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

Inhibit Close - this setting sets the status input(s) which, when energised, inhibits the Close pulse for either Manual or auto-reclose sequences.

Block Reclose - this setting sets the status input(s) which, when energised, Blocks Reclose during the auto-reclose sequence. An associated time delay is provided Permissive Close Delay which if not expired allows the Block Reclose input to be used as a temporary block.

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

Block Second Shot - this setting sets the status input(s) which, when energised, stops the second auto-reclose sequence.

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

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

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

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

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

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

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

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

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

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

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

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 auto-reclosing, 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.

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.

CMS Change One - this setting sets the status input(s) which, when energised, indicate which Auto-reclose Sequence is selected. If not required no connection should be made.

CMS Change Two - this setting sets the status input(s) which, when energised, indicate which Auto-reclose Sequence is selected. If not required no connection should be made.

CMS Change Three - this setting sets the status input(s) which, when energised, indicate which Auto-reclose Sequence is selected. If not required no connection should be made.

Master Slave - this setting sets the status input(s) which, when energised, provide a means of selecting which auto-reclose relay has priority over another.

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.

5.5 Reylogic Control Menu

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

5.6 Reylogic Elements Menu

Gn ManualCloseTimer PU – this setting sets the pick up time delay associated with that input.

Gn ManualCloseTimer DO – this setting sets the drop off time delay associated with that input.

Gn InhibitCloseTimer PU – this setting sets the pick up time delay associated with that input.

Gn InhibitCloseTimer DO – this setting sets the drop off time delay associated with that input.

Gn AROutTimer PU – this setting sets the pick up time delay associated with that input.

Gn AROutTimer DO – this setting sets the drop off time delay associated with that input.

Gn ARInTimer PU – this setting sets the pick up time delay associated with that input.

Gn ARInTimer DO – this setting sets the drop off time delay associated with that input.

Gn TripATimer PU – this setting sets the pick up time delay associated with that input.

Gn TripATimer DO – this setting sets the drop off time delay associated with that input.

Gn TripBTimer PU – this setting sets the pick up time delay associated with that input.

Gn TripBTimer DO – this setting sets the drop off time delay associated with that input.

Gn TripCTimer PU – this setting sets the pick up time delay associated with that input.

Gn TripCTimer DO – this setting sets the drop off time delay associated with that input.

Gn Trip3Timer PU – this setting sets the pick up time delay associated with that input.

Gn Trip3Timer DO – this setting sets the drop off time delay associated with that input.

Gn RecloseLockoutTimer PU – this setting sets the pick up time delay associated with that input.

Gn RecloseLockoutTimer DO – this setting sets the drop off time delay associated with that input.

Gn ResetLockoutTimer PU – this setting sets the pick up time delay associated with that input.

Gn ResetlockoutTimer DO – this setting sets the drop off time delay associated with that input.

Gn IntertripReceiveTimer PU – this setting sets the pick up time delay associated with that input.

Gn IntertripReceiveTimer DO – this setting sets the drop off time delay associated with that input.

Gn BlockSecondShotTimer PU – this setting sets the pick up time delay associated with that input.

Gn BlockSecondShotTimer DO – this setting sets the drop off time delay associated with that input.

Gn BlockRecloseTimer PU – this setting sets the pick up time delay associated with that input.

Gn BlockRecloseTimer DO – this setting sets the drop off time delay associated with that input.

5.7 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.

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

3PTS – this setting sets the output relay(s) which is operated when the auto-reclose sequence indicates 3PTS is active. Use 3PTS for the output contact and 3PTS Flag as the LED indication.

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.

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

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

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

Three Pole In Op – this setting sets the output relay(s) which is operated when all three poles of the CB are open.

Single Pole In Op – this setting sets the output relay(s) which is operated when a single pole CB is open.

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

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

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

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

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

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

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

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

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

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

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

CB In Service Alarm – this setting sets the output relay(s) which is operated when the CB is in service.

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.

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

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

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

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

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

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

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

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

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.

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

3PTS Flag – this setting sets the output relay(s) which is operated when a 3PTS is not set. It is a negated 3PTS signal intended to be used as the LED indication for the 3PTS signal. 3PTS is a normally energised N/C contact like Protection Healthy i.e. it gives a 3PTS signal if the auto-reclose relay loses its power supply.

PCD Timeout – this setting sets the output relay(s) which is operated when the end of the Permissive Close Delay is reached.

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 auto-reclose sequence but the CB was not in service.

CMS Change Allowed – this setting sets the output relay(s) which is operated to indicate that a change to the Close Mode Selection setting is allowed.

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.

1Pole Close Flag – this setting sets the output relay(s) which is operated when the relay has closed due to a Single Pole reclose.

Inhibit Seq Isolation – this setting sets the output relay(s) which is operated to stop sequential isolation – Normally Set.

A Trip – this setting sets the output relay(s) which is operated to indicate an A Phase trip has been received.

B Trip – this setting sets the output relay(s) which is operated to indicate an B Phase trip has been received.

B Trip – this setting sets the output relay(s) which is operated to indicate an C Phase trip has been received.

Three Trip – this setting sets the output relay(s) which is operated to indicate an Three Phase trip has been received.

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.

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

Inhibit Seq Isolation OP – this setting sets the output relay(s) which is operated to stop sequential isolation. A normally energised N/C contact is usually used – Normally Reset.

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

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

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.

5.8 LED Menu

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

6 Event List

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 |
| AR in progress | 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 |
| 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 |
| Autolsolation Complete I/P | 244 | 6 | 1 |
| Inhibit Seq Isolation | 245 | 6 | 1 |
| Persistent Intertrip | 246 | 6 | 1 |
| Autolsolation Fail | 247 | 6 | 1 |
| Autolsolation Completed | 248 | 6 | 1 |
| Autolsolation Initiate | 249 | 6 | 1 |
| | | | |
| | | | |

Table 1 - Event Codes**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.

7 Setting Ranges

DAR Settings

| | |
|-------------------------|---|
| A/R In Service | In/Out |
| Close Mode Selection | OFF,1P,3P,1P/3P,1P3P/3P,1P1P,3P3P,1P1P/3P3P |
| Dead Bar Close | Enabled/Disabled |
| Dead Line Close | Enabled/Disabled |
| Check Sync Close | Enabled/Disabled |
| First 1P Dead time | 0.05 – 100sec in 0.05sec steps |
| Second 1P Dead time | 0.05 – 100sec in 0.05sec steps |
| First 3P Dead time | 0.1 – 900sec in 0.1sec steps |
| Second 3P Dead time | 0.1 – 900sec in 0.1sec steps |
| Start Dead time | Trip Make, Trip & CB Open, Trip Reset |
| 3P Dead time Initiate | 1P/2P,1P/2P/3P |
| CB Aux Switches | Type a, Type b, Type a&b |
| Close Pulse | 0.1 – 20sec in 0.1sec steps |
| Reclaim Time | OFF - 1 – 600sec in 1sec steps |
| Sync Close Delay | 1 – 60sec in 1sec steps |
| Permissive Close Delay | OFF - 1 – 600sec in 1sec steps |
| Overall Sequence Timer | OFF – 1 – 3000sec in 1 sec 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 |
| Minimum LO Time | 0 – 60sec in 1sec steps |
| Reset LO By Timer | Enabled/Disabled |
| CB Indeterminate | 50 – 200ms in 10ms steps |
| CB Memory Timer | 0 – 5sec in 1 sec steps |
| Set Type | Master / Slave |
| Total Close Count Alarm | 1..999 |
| Delta Close Count Alarm | 1.999 |

Check Synchronising Settings

| | |
|---------------------------|----------------|
| 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 |
| Auto-reclose 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 |
| System Sync Timer | OFF – 100s |
| CB Close Time | 5 – 200ms |

8 Accuracy

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

| | |
|--|--|
| CS and SS Phase Angle measurement | |
| Operate | Setting $-3^{\circ} + 0^{\circ}$ |
| Reset | operate value $-0^{\circ} + 3^{\circ}$ |
| CS and SS Slip Frequency | |
| Operate | Setting $-15\text{mHz} + 0\text{mHz}$ |
| Reset | operate value $-0\text{mHz} + 15\text{mHz}$ |
| Split Detector measurement | |
| Operate | setting $\pm 1.5^{\circ}$ |
| Reset | detector is latched |
| Line and Bus Voltage Detector Elements | |
| Live Operate | setting $\pm 1\%$ |
| Live Reset | dead operate setting $\pm 1\%$ |
| Dead Operate | setting $\pm 1\%$ |
| Dead Reset | live operate setting $\pm 1\%$ |
| Line and Bus U/V Detector Elements | |
| Operate | Setting $\pm 1\%$ |
| Reset | < 104% of operate value |
| ΔV Detector Element | |

| | |
|-----------------|--|
| Operate | Setting $\pm 2\%$ or 0.5V whichever is greater |
| Reset | Typically $> 90\%$ (and always within 2V) of operate value |
| All Timers | |
| Timing Accuracy | $\pm 1\%$ or 10ms |

Measuring Accuracy

| | |
|-----------|----------------------------------|
| Voltage | $\pm 1\%$ (for range 7V-132Vrms) |
| Frequency | Typically $\pm 10\text{mHz}$ |
| Phase | Typically $\pm 1^\circ$ |

Frequency

| | |
|--------------------------|------------------------------|
| Range | 47Hz to 51Hz 57Hz to 61Hz |
| Setting variation | $\leq 1\%$ |
| Phase Angle Measurement | $\leq 1\%$ |
| Operating time variation | $\leq 1\%$ |

Continuous Overload

| | |
|------------|---------|
| AC Voltage | 250Vrms |
|------------|---------|

9 Auto-Reclose Menu Settings

9.1 DAR Menu

| SETTING | RANGE | DEFAULT |
|------------------------|--|----------------|
| A/R In Service | IN/OUT | OUT |
| Close Mode Selection | OFF, 1P, 3P, 1P/3P, 1P3P/3P, 1P1P, 3P3P, 1P1P/3P3P | 3P |
| Dead Bar Close | Enabled/Disabled | Disabled |
| Dead Line Close | Enabled/Disabled | Disabled |
| Check Sync Close | Enabled/Disabled | Enabled |
| First 1P Dead time | 0.05-100s step 0.05s | 1.0s |
| Second 1P Dead time | 0.05-100s step 0.05s | 1.0s |
| First 3P Dead time | 0.1-900s step 0.1s | 5.0s |
| Second 3P Dead time | 0.1-900s step 0.1s | 5.0s |
| Start Dead time | Trip & CB Open, Trip Make, Trip reset | Trip & CB Open |
| 3P Dead time Initiate | 1P/2P/3P, 1P/2P | 1P/2P/3P |
| CB Aux Switches | Type a, Type b, Type a&b | Type a |
| CB Close Pulse | 0.2-20s step 0.1s | 2.0s |
| Reclaim Time | OFF - 1-600s step 1s | 5s |
| Sync Close Delay | 0-60s step 1s | 30s |
| Permissive Close Delay | OFF - 0-600s step 1s | 60s |
| Overall Sequence Timer | OFF – 1 – 3000s step 1s | OFF |
| 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 |
| Minimum LO Timer | 0-60s step 1s | 2s |
| Reset LO By Timer | Enabled/Disabled | Disabled |
| CB Indeterminate | 50 – 200ms step 10ms | 80ms |
| CB Memory Timer | 0 – 5s step 1s | 2s |
| Set Type | Master / Slave | Master |
| Total CB Close Counter | 1-999 step1 | 100 |
| Delta CB Close Counter | 1-999 step1 | 20 |
| Reset Total CB Count | YES/NO | NO |
| Reset Delta CB Count | YES/NO | NO |

9.2 Pole Discrepancy Menu

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

9.3 Sync Menu

| SETTING | RANGE | DEFAULT |
|-------------------------|---|------------------|
| 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 |

| SETTING | RANGE | DEFAULT |
|------------------------------|-----------------------------------|---------|
| 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 |

9.4 Status Config Menu

| SETTING | RANGE | DEFAULT |
|----------------------|---------|---------|
| Manual Close | S1..S13 | None |
| A/R Out | S1..S13 | None |
| A/R In | S1..S13 | None |
| Inhibit Close | S1..S13 | None |
| Block Reclose | S1..S13 | None |
| Reclose Lockout | S1..S13 | None |
| Block Second Shot | S1..S13 | None |
| A Trip | S1..S13 | None |
| B Trip | S1..S13 | None |
| C Trip | S1..S13 | None |
| 3 Trip | S1..S13 | None |
| Intertrip Receive | S1..S13 | None |
| CB A Aux One | S1..S13 | None |
| CB B Aux One | S1..S13 | None |
| CB C Aux One | S1..S13 | None |
| CB A Aux Two | S1..S13 | None |
| CB B Aux Two | S1..S13 | None |
| CB C Aux Two | S1..S13 | None |
| Sync Override | S1..S13 | None |
| Manual Sync Override | S1..S13 | None |
| Reset lockout | S1..S13 | None |
| CMS Change One | S1..S13 | None |
| CMS Change Two | S1..S13 | None |
| CMS Change Three | S1..S13 | None |
| Master Slave | S1..S13 | None |
| Switch Groups | S1..S13 | None |
| Trigger Storage | S1..S13 | None |

9.5 Reylogic Control Menu

| SETTING | RANGE | DEFAULT |
|---------------|----------------|---------|
| General Logic | Enable/Disable | Enable |

9.6 Reylogic Elements Menu

| SETTING | RANGE | DEFAULT |
|----------------------|--------------------|---------|
| ManualCloseTimer PU | 0-60000ms step 1ms | 15 |
| ManualCloseTimer DO | 0-60000ms step 1ms | 0 |
| InhibitCloseTimer PU | 0-60000ms step 1ms | 15 |
| InhibitCloseTimer DO | 0-60000ms step 1ms | 0 |

| SETTING | RANGE | DEFAULT |
|--------------------|--------------------|---------|
| AROutTimer PU | 0-60000ms step 1ms | 15 |
| AROutTimer DO | 0-60000ms step 1ms | 0 |
| ARInTimer PU | 0-60000ms step 1ms | 15 |
| ARInTimer DO | 0-60000ms step 1ms | 0 |
| TripATimer PU | 0-60000ms step 1ms | 15 |
| TripATimer DO | 0-60000ms step 1ms | 0 |
| TripBTimer PU | 0-60000ms step 1ms | 15 |
| TripBTimer DO | 0-60000ms step 1ms | 0 |
| TripCTimer PU | 0-60000ms step 1ms | 15 |
| TripCTimer DO | 0-60000ms step 1ms | 0 |
| Trip3Timer PU | 0-60000ms step 1ms | 15 |
| Trip3Timer DO | 0-60000ms step 1ms | 0 |
| RecloseLoTimer PU | 0-60000ms step 1ms | 15 |
| RecloseLoTimer DO | 0-60000ms step 1ms | 0 |
| ResetLOTimer PU | 0-60000ms step 1ms | 15 |
| ResetLOTimer DO | 0-60000ms step 1ms | 0 |
| ITReceiveTimer PU | 0-60000ms step 1ms | 15 |
| ITReceiveTimer DO | 0-60000ms step 1ms | 0 |
| Block2ShotTimer PU | 0-60000ms step 1ms | 15 |
| Block2ShotTimer DO | 0-60000ms step 1ms | 0 |
| BlockARTimer PU | 0-60000ms step 1ms | 15 |
| BlockARTimer DO | 0-60000ms step 1ms | 0 |

9.7 Output Relay Menu

| SETTING | RANGE | DEFAULT |
|----------------------|-----------|---------|
| Close Pulse | RL1..RL13 | None |
| Lockout | RL1..RL13 | None |
| A/R Out Of Service | RL1..RL13 | None |
| A/R In Service | RL1..RL13 | None |
| A/R In Progress | RL1..RL13 | None |
| Successful Close | RL1..RL13 | None |
| 3PTS | RL1..RL13 | None |
| CB Failed To Close | RL1..RL13 | None |
| Manual Close Fail | RL1..RL13 | None |
| Close Onto Fault | RL1..RL13 | None |
| Check Sync Start | RL1..RL13 | None |
| Three Pole In Op | RL1..RL13 | None |
| Single Pole In Op | RL1..RL13 | None |
| CB A Open | RL1..RL13 | None |
| CB B Open | RL1..RL13 | None |
| CB C Open | RL1..RL13 | None |
| CB A Closed | RL1..RL13 | None |
| CB B Closed | RL1..RL13 | None |
| CB C Closed | RL1..RL13 | None |
| CB A Indeterminate | RL1..RL13 | None |
| CB B Indeterminate | RL1..RL13 | None |
| CB C Indeterminate | RL1..RL13 | None |
| Total CB Count Alarm | RL1..RL13 | None |
| Delta CB Count Alarm | RL1..RL13 | None |
| CB In Service | RL1..RL13 | None |
| CB Not In Ser Alarm | RL1..RL13 | None |
| CB Memory | RL1..RL13 | None |
| Persistent Intertrip | RL1..RL13 | None |
| Manual Close | RL1..RL13 | None |
| Line VT Failure | RL1..RL13 | None |

| SETTING | RANGE | DEFAULT |
|-------------------------|-----------|---------|
| Bus VT Failure | RL1..RL13 | None |
| VT Failure | RL1..RL13 | None |
| Reclose Lockout | RL1..RL13 | None |
| Block Reclose Alarm | RL1..RL13 | None |
| Inhibit Close | RL1..RL13 | None |
| Live Line | RL1..RL13 | None |
| Live Bus | RL1..RL13 | None |
| In Sync | RL1..RL13 | None |
| System Split | RL1..RL13 | None |
| 3PTS Flag | RL1..RL13 | None |
| PCD Timeout | RL1..RL13 | None |
| A/R Not Allowed | RL1..RL13 | None |
| CMS Change Allowed | RL1..RL13 | None |
| Sync In Prog Flag | RL1..RL13 | None |
| Dead Line Close Flag | RL1..RL13 | None |
| Dead Bus Close Flag | RL1..RL13 | None |
| 1P Close Flag | RL1..RL13 | None |
| Inhibit SeqIsolation | RL1..RL13 | None |
| A Trip | RL1..RL13 | None |
| B Trip | RL1..RL13 | None |
| C Trip | RL1..RL13 | None |
| Three Trip | RL1..RL13 | None |
| CB Failed to Open | RL1..RL13 | None |
| CB Pole Discrepancy | RL1..RL13 | None |
| Inhibit SeqIsolation OP | RL1..RL13 | None |
| New Data Stored | RL1..RL13 | None |
| ExtGroupSwitched | RL1..RL13 | None |
| Hand Reset Outputs | RL1..RL13 | None |
| Protection Healthy | RL1..RL13 | 1 |

9.8 LED Menu

| SETTING | RANGE | DEFAULT |
|----------------------|------------|---------|
| Close Pulse | L1..L16/32 | |
| Lockout | L1..L16/32 | |
| A/R Out Of Service | L1..L16/32 | |
| A/R In Service | L1..L16/32 | |
| A/R In Progress | L1..L16/32 | |
| Successful Close | L1..L16/32 | |
| 3PTS | L1..L16/32 | |
| CB Failed To Close | L1..L16/32 | |
| Manual Close Fail | L1..L16/32 | |
| Close Onto Fault | L1..L16/32 | |
| Check Sync Start | L1..L16/32 | |
| Three Pole In Op | L1..L16/32 | |
| Single Pole In Op | L1..L16/32 | |
| CB A Open | L1..L16/32 | |
| CB B Open | L1..L16/32 | |
| CB C Open | L1..L16/32 | |
| CB A Closed | L1..L16/32 | |
| CB B Closed | L1..L16/32 | |
| CB C Closed | L1..L16/32 | |
| CB A Indeterminate | L1..L16/32 | |
| CB B Indeterminate | L1..L16/32 | |
| CB C Indeterminate | L1..L16/32 | |
| Total CB Count Alarm | L1..L16/32 | |

| SETTING | RANGE | DEFAULT |
|-------------------------|------------|---------|
| Delta CB Count Alarm | L1..L16/32 | |
| CB In Service | L1..L16/32 | |
| CB Not In Ser Alarm | L1..L16/32 | |
| CB Memory | L1..L16/32 | |
| Persistent Intertrip | L1..L16/32 | |
| Manual Close | L1..L16/32 | |
| Line VT Failure | L1..L16/32 | |
| Bus VT Failure | L1..L16/32 | |
| VT Failure | L1..L16/32 | |
| Reclose Lockout | L1..L16/32 | |
| Block Reclose Alarm | L1..L16/32 | |
| Inhibit Close | L1..L16/32 | |
| Live Line | L1..L16/32 | |
| Live Bus | L1..L16/32 | |
| In Sync | L1..L16/32 | |
| System Split | L1..L16/32 | |
| 3PTS Flag | L1..L16/32 | |
| PCD Timeout | L1..L16/32 | |
| A/R Not Allowed | L1..L16/32 | |
| CMS Change Allowed | L1..L16/32 | |
| Sync In Prog Flag | L1..L16/32 | |
| Dead Line Close Flag | L1..L16/32 | |
| Dead Bus Close Flag | L1..L16/32 | |
| 1P Close Flag | L1..L16/32 | |
| Inhibit SeqIsolation | L1..L16/32 | |
| A Trip | L1..L16/32 | |
| B Trip | L1..L16/32 | |
| C Trip | L1..L16/32 | |
| Three Trip | L1..L16/32 | |
| CB Failed to Open | L1..L16/32 | |
| CB Pole Discrepancy | L1..L16/32 | |
| Inhibit SeqIsolation OP | L1..L16/32 | |
| New Data Stored | L1..L16/32 | |
| ExtGroupSwitched | L1..L16/32 | |
| Hand Reset Outputs | L1..L16/32 | |
| Protection Healthy | L1..L16/32 | |

10 Applications

10.1 Introduction

The relays provide a full closing system: Auto-reclose, 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 which 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 auto-reclose scheme.

The auto-reclose function requires the correct application, setting and commissioning to verify operation. Because of the complexity of auto-reclose schemes and the possibility of setting the relay incorrectly the user should be familiar with all aspects of the relay before energising any equipment.

10.2 General Information

The relay can directly replace older Auto-reclose relays. The relay contains the equivalent UK specification Auto-reclose 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 2 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.

10.3 Auto-reclose

The Auto-reclose function provides the flexibility to be applied to a number of different Auto-reclose schemes. This is achieved by a number of settings which 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, additional control auxiliary relays are not required because the relay has separately grounded inputs. The reclosure options are circuit breaker specific.

| Reclosure Options | Option Range |
|-------------------|------------------|
| Dead Bar Close | Enabled/Disabled |
| Dead Line Close | Enabled/Disabled |
| Check Sync Close | Enabled/Disabled |

Dead time:

There are four dead time settings:

First Single Pole Dead time, Second Single Pole Dead time, First Three Pole Dead time, Second Three Pole Dead time.

The Dead time is the time taken from the circuit breaker tripping and the trip reset to a reclose signal being issued.

The dead time can be started in three ways:

1. When the Protection Trip is received. Set Start Dead time setting to Trip Make.

2. When the Protection Trip is received AND the CB has opened AND the line has gone dead. Set Start Dead time setting to Trip & CB Open.
3. When the Protection Trip is received AND the CB has opened AND the line has gone dead AND the Protection Trip resets. Set Start Dead time setting to Trip Reset.

The different methods are provided to take account of different utilities preferences. Some utilities use a trip reset interlock to facilitate isolation. This may hold the trip active until any post-fault isolation has completed. Should use Trip Reset setting.

A method is provided to prevent three pole auto-reclosing if the fault involves all three phases but to proceed if the fault involves one or two phases.

To allow three pole auto-reclosing for faults involving all phases set the 3P Dead time Initiate setting to 1P\2P\3P.

To prevent three pole auto-reclosing for faults involving all three phases set the 3P Dead time Initiate setting to 1P\2P.

Sequence Fail timer:

To prevent the auto-reclose 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 auto-reclose sequence will lockout. If the timer is not required then it can be set to OFF.

Permissive Close Delay:

The Permissive Close Delay works in conjunction with the Block Reclose and Inhibit Close inputs. Block Reclose stops the auto-reclose sequence, Inhibit Close stops the auto-reclose sequence and the Manual Close sequence. If the Permissive Close Delay expires the relay will lockout. CB conditions such as Low Pressure should be connected to the Inhibit Close input. At the end of the Dead time if there is a Block Reclose or Inhibit Close present the relay will wait for as long as the Permissive Close Delay. If the Block Reclose or Inhibit Close input resets before the end of the Permissive Close 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 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 dead time is set to 5sec it would be necessary to set the Sync Close Delay to approximately 20 seconds. It is recommended to set the Sync Close Delay to the minimum slip frequency rotation time.

For worst case, where the dead time 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. Allow enough time or it may lockout while trying to come into synch.

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 problems with these channels if the intertrip is present for longer than the Persistent Intertrip time the reclosure will not be initiated and the relay will lockout.

The dead time 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. Only a one shot intertrip initiated scheme is allowed, any intertrips occurring in the close pulse or reclaim cause lockout, even if set to more than one shot.

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

If multi-shot reclosing is required by intertripping then the Intertrip Receive should be connected to the External A/R Start (3 Trip) input rather than the Intertrip Receive input. The Persistent Intertrip setting in the relay would not be used

Overall Sequence Time:

The Overall Sequence time is provided to govern the maximum time which the complete auto-reclose sequence can take. It would generally be set greater than all the constituent times. If the Overall Sequence Timer expires the relay will go to Lockout. This timer is provided as a back-up to prevent the auto-reclose being primed indefinitely and giving a close pulse when not expected. However the correct setting of the Sequence Fail timer and Permissive Close Delay mean the Overall Sequence timer is not required. It has been left in the relay to satisfy existing customers who require it.

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 20 seconds.

Reclaim Time:

The reclaim time would be set to a value which represents a correct reconnection. If the CB remains closed for the Reclaim time following an auto-reclose, the relay will reset and be ready for further operations. At the end of the reclaim time a fleeting contact 'Successful A/R' will be issued, for 2 seconds. A trip within the reclaim time would initiate another reclose if the next shot is allowed, otherwise the auto-reclose sequence will be locked out.

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 Yes 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.

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 auto-reclose applications where conventional CB Fail protection was not fitted. The CB Fail To Open output would be independently wired to Lockout and stop the auto-reclose 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, typically 100ms.

CB Indeterminate:

The connection of the CB auxiliary contacts can include one contact indicating Open and another contact indicating Closed. If the CB Auxiliary contacts were to indicate either both open or both closed for greater than the CB Indeterminate time, (typically set to 80ms) then a CB Indeterminate Alarm is issued. Separate phase outputs are provided. These could all be mapped to the same output contact to provide a common alarm.

CB Memory Time:

A setting is provided which indicates when the CB has been In Service. This is defined as being when the CB is Closed and the Line is Live and has a delayed drop-off, the CB Memory time. It is expected that this would be set to 2 seconds.

Set Type:

Where two auto-reclose relays are applied for one CB the relay which is designated Master can be set to override the Slave. This requires that the Master's output A/R In Progress is wired to the Master Slave input of the Slave. When the Master Slave input of the Slave is active it will cancel any auto-reclose sequence, reset and wait in its ready state until the A/R In Progress of the Master is released.

Application to Transmission Feeder:

Where applied to a feeder with A/R at each end, different dead times 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.

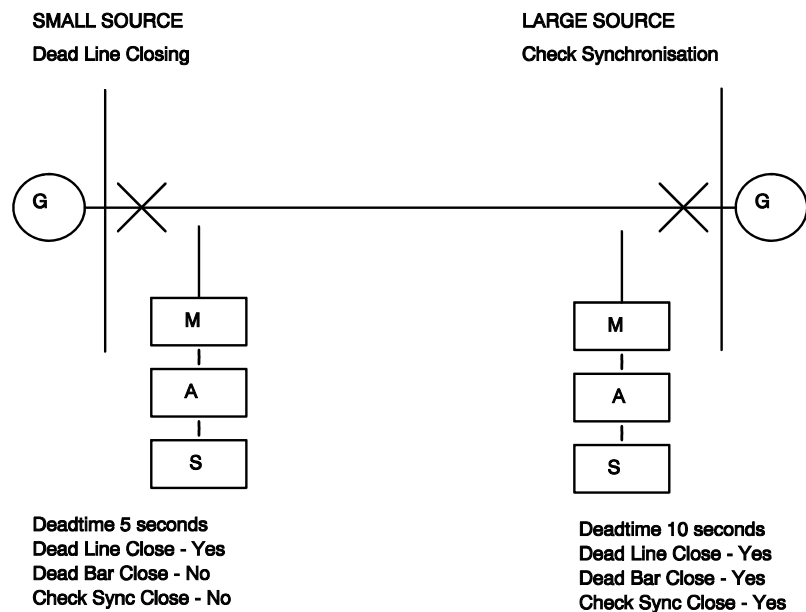


Figure 1 Typical Feeder Diagram

Application to T'd Feeder or Mesh Corner:

Two auto-reclose relays would need to be specified for a double CB situation such as Teed feeders or Mesh Corner. One auto-reclose relay per CB. Each relay could be set to the same dead time 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 dead time of X2.

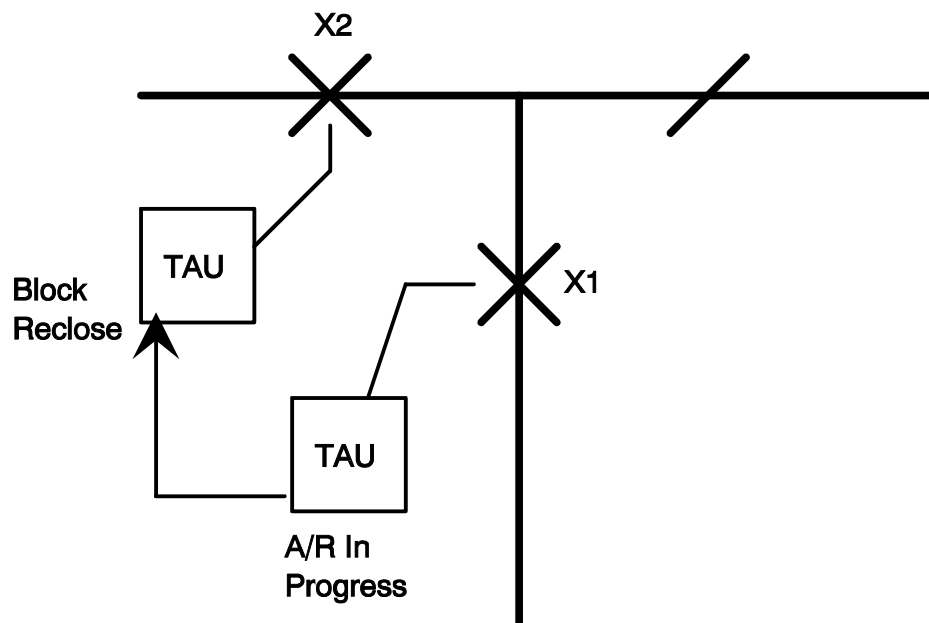


Figure 2 Mesh or T'd Feeder Connection Diagram

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.

The CB Status module takes account of separate phase CB's (A, B and C). Due to differing applications of auto-reclose schemes and availability or non-availability of CB auxiliary contacts this module has been designed to return the state of each CB from a number of possible arrangements of contacts. To allow this flexibility there are a number of settings provided. The relay can determine CB open or closed from a combination of 'a' or 'b' or 'a' and 'b' contacts.

This means that the status input is processed to return the definitive CB condition.

Auxiliary type contacts 'a' - CLOSING WHEN CB CLOSING.

Auxiliary type contacts 'b' - CLOSING WHEN CB OPENING.

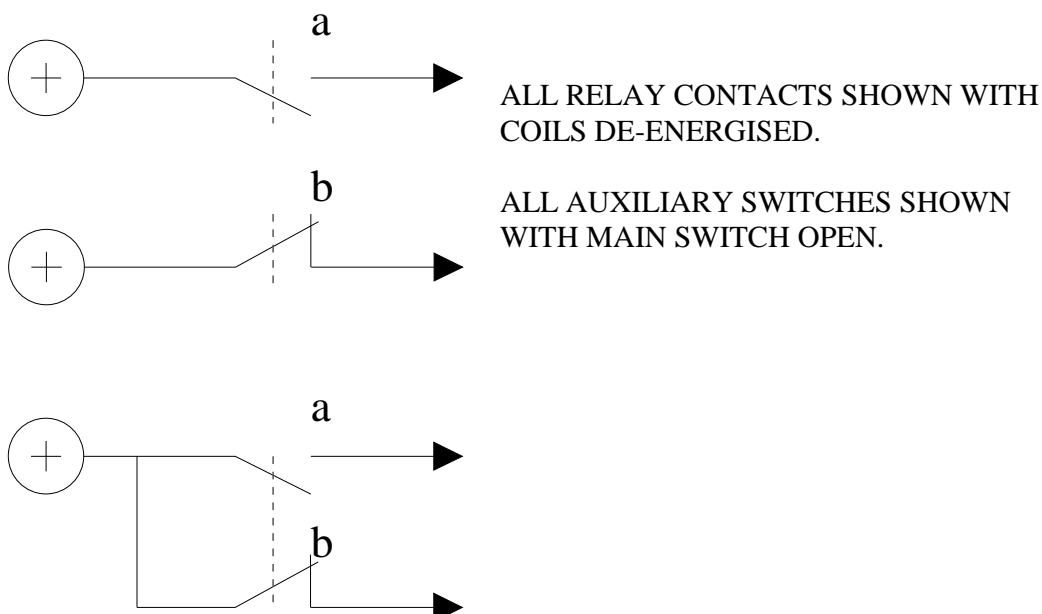


Fig 3. Primary Plant Auxiliary Switches

The relay provides a CB Auxiliary Switch setting which allows either 'a' type contacts only, or 'b' type contacts only, or both 'a' and 'b' contacts.

Using 'a' type contacts only: input is Auxiliary One Status Input

Open when CB open therefore input is low when CB is open.

Closed when CB closed therefore input is high when CB closed.

Using 'b' type contacts only: input is Auxiliary One Status Input

Open when CB closed therefore input is low when CB is closed.

Closed when CB open therefore input is high when CB open.

Using both 'a' and 'b' type contacts:

'a' contacts: input is Auxiliary One Status Input

Open when CB open therefore input is low when CB is open.

Closed when CB closed therefore input is high when CB closed.

'b' contacts: input is Auxiliary Two Status Input

Open when CB closed therefore input is low when CB is closed.

Closed when CB open therefore input is high when CB open.

When both 'a' and 'b' type contacts are used there are now 4 possible positions:

| Auxiliary One Status Input | Auxiliary Two Status Input | CB Position |
|----------------------------|----------------------------|------------------------|
| FALSE | FALSE | Don't Believe It (DBI) |
| FALSE | TRUE | CB OPEN |
| TRUE | FALSE | CB CLOSED |
| TRUE | TRUE | INDETERMINATE |

Table 1. CB Position using a + b Primary Plant Auxiliary Switches

When 'a' and 'b' contacts are used CB Open and CB Closed are determined from the following logic:

$CB_{Open} = \text{NOT Aux One AND Aux Two}$

$CB_{Closed} = \text{Aux One AND NOT Aux Two}$

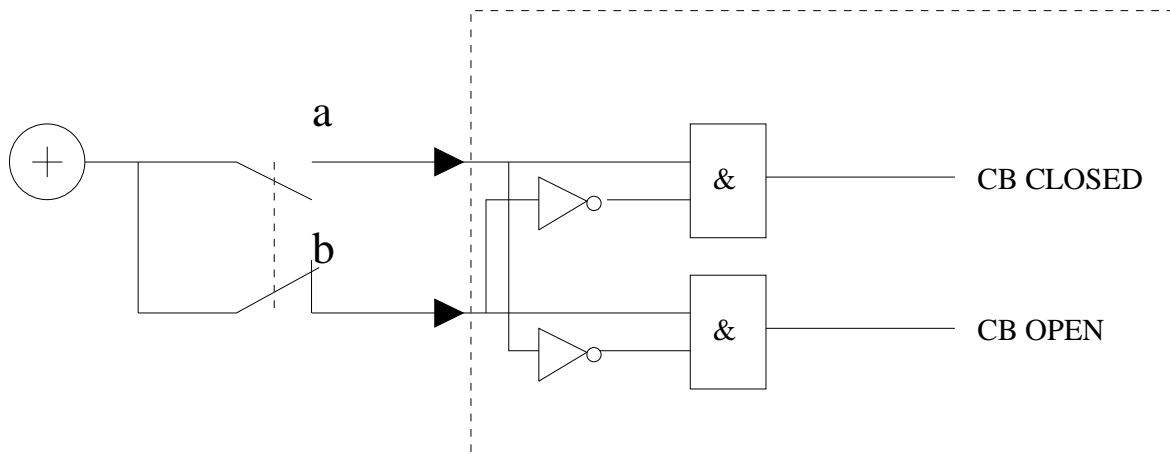


Fig 4. Processing of CB Closed and CB Open when using a + b Primary Plant Auxiliary Switches

It is intended that for application to Transmission systems separate phase CB Auxiliary contacts will be wired to the status inputs. This is essential for systems using Single Pole Reclose. However for systems which only apply Three Pole Reclose it is possible to gang the switches externally and wire to one status input only. To achieve this the following Trip Matrix settings need to be applied.

Table Using

| Status Input | S1 | S2 | S3 | .. | Sn |
|--------------|----|----|----|----|----|
| CB A Aux One | 1 | 0 | 0 | 0 | 0 |
| CB B Aux One | 0 | 1 | 0 | 0 | 0 |
| CB C Aux One | 0 | 0 | 1 | 0 | 0 |

2.

separate phase CB Auxiliary contacts with Single Pole reclose, 3 inputs to the relay

| Status Input | S1 | S2 | S3 | .. | Sn |
|--------------|----|----|----|----|----|
| CB A Aux One | 1 | 0 | 0 | 0 | 0 |
| CB B Aux One | 1 | 0 | 0 | 0 | 0 |
| CB C Aux One | 1 | 0 | 0 | 0 | 0 |

Table 3. Using externally ganged separate phase CB Auxiliary contacts with Three Pole reclose, 1 input to the relay

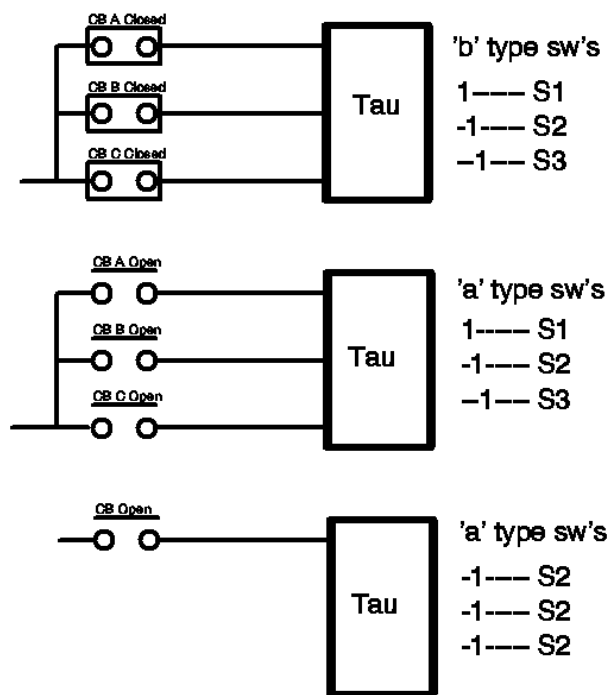


Figure 5 Possible CB Auxiliary Contact Connections

Output Alarms:

Various outputs are given during the auto-reclose 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 auto-reclosing, 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 – auto-reclose 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 auto-reclose applications where conventional CB Fail protection was not fitted. The CB Fail To Open output would be independently wired to Lockout and stop the auto-reclose 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 auto-reclose 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. The function is easily integrated into the Auto-reclose relay and provides the same functionality. A requirement for Pole Discrepancy would be to connect all phases of CB Open or/and CB Closed to the relay.

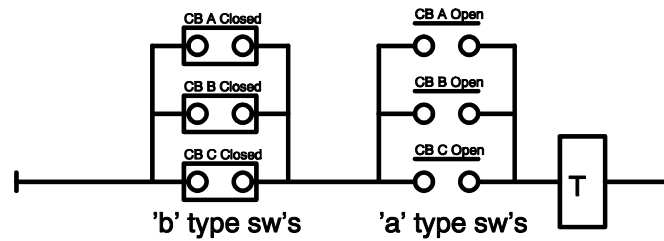


Figure 6 Standard Connection of Pole Discrepancy Protection

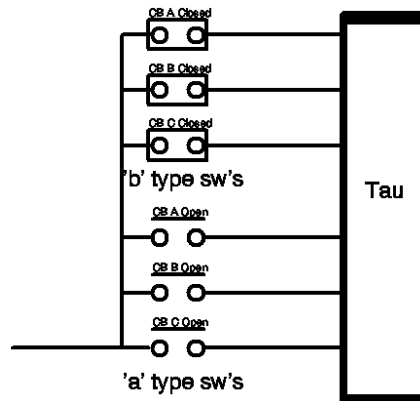


Figure 7 Connection of Pole Discrepancy

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 a VT Fail on the system and the VT Fail in the relay, the VT Fail indication may mean either.

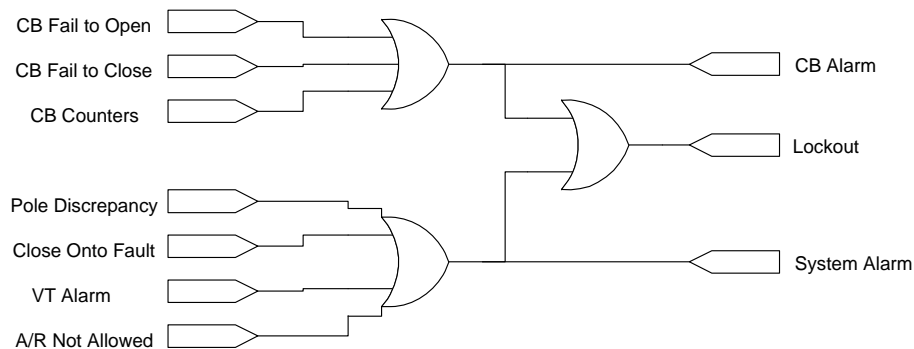


Figure 8 Possible A/R Alarms

10.4 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.

10.5 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 auto-reclose sequence. The close decision is dependent upon the active CB condition: Dead Line, Dead Bus or Check Synchronisation.

The relay automatically closes dependent upon these conditions. The relay will not wait indefinitely for the system to come into sync. 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.

A separate Manual Sync Override is provided.

10.6 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 $59\text{ V} - 1\text{ V}$ (error margin) = $58\text{ V} \times 96\% = 55.68\text{ V}$ (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.

10.7 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 Enabled/Disabled
 Dead Line Close Enabled/Disabled
 Dead Bar Close Enabled/Disabled
 Sync Override
 Manual Sync Override

10.8 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,

$$\Delta F = F1 - F2 = \frac{1}{T_d} \times \frac{\theta}{180^\circ}$$

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.

$$\Delta F = F1 - F2 = \frac{1}{T_d} \times \frac{\theta}{360^\circ}$$

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.

10.9 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 4 - 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.

10.10 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 5 - 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.

10.11 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° in 1 second. Thus,

Change in phase angle $\Delta\theta = (\text{Slip} \times 360^\circ) / \text{sec}$.

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

$\Delta\theta = \text{Slip} \times 360^\circ \times t_c$ - where t_c is the breaker close time.

Using the equation given in section 2.7 for check synchronising,

$\text{Slip} = \frac{1}{T_d} \times \frac{\theta}{180^\circ}$ and substituting this into $\Delta\theta = \text{Slip} \times 360^\circ \times t_c$ gives the following,

$$\Delta\theta = \frac{1}{T_d} \times \frac{\theta}{180^\circ} \times 360^\circ \times t_c ;$$

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

Substituting for this in the above equation gives,

$$\Delta\theta = (2 \times \theta) / 10 \quad \text{or} \quad \Delta\theta = 0.2 \times \theta$$

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°.
- 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°.

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

With an angle of 24° and Td of 1.62sec, using the equation from section 2.7, the slip is therefore $24 / (1.62 \times 180) = 82\text{mHz}$. If the relay were to close on the boundary the phase angle traversed in the 162ms total delay time is given by,

$$\Delta\theta = \text{Slip} \times 360^\circ \times (t_c + t_{\text{relay}}) = 0.082 \times 360 \times 0.162 = 4.78^\circ.$$

11 Commissioning

11.1 Required Test Equipment

The following additional equipment will be required to commission the auto-reclose and check synch functions on the relay.

- 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.

11.2 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.

11.3 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 which can be used for pre-commissioning tests.

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.

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 which 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".

11.4 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.

12 Tests

12.1 Commissioning Tests

Select the required relay configuration and settings for the application.

12.1.1 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 $\pm 5\%$ which is the tolerance of the measurement display meters. The instruments mode 'Line RMS' and 'Bus RMS' meters display the secondary voltage levels.

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

12.1.2 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.

Auto-reclose 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 a meter is included in the instruments which shows what state the auto-reclose 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 auto-reclose sequence to begin.

Lockout: Lockout state. No Auto-reclosing allowed.

The Auto-reclose sequence is performed with the following states:

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

SecDead timeInitiate: A trip within the first close pulse or first reclaim and a second reclose is allowed. Will wait for AR Primed conditions: CB Open AND Trip reset AND Dead Line.

SingleFirstDead time, ThreeFirstDead time, SingleSecDead time, ThreeSecondDead time: The auto-reclose dead time.

FirstCloseInhibit, SecondCloseInhibit: At the end of the dead time if waiting for synchronisation or Block Reclose to reset then will be in this state.

FirstClosePulse, SecondClosePulse: The Close Pulse is being issued.

FirstReclaim, SecondReclaim: 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 auto-reclose sequence to begin. This should be the initial displayed state when performing the majority of the tests.

12.1.3 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.

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.

12.1.4 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 indicated. 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.

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

12.1.5 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 undervoltage 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

12.1.6 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.

12.1.7 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.

12.1.8 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 the Performance Specification.

12.1.9 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 Auto-reclose Inhibit.

Energise A/R Out and check for A/R Out of Service indication. Check in the instruments mode that Auto-reclose 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 Auto-reclose 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 auto-reclose 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.

12.1.10 CB Status

The CB Status should be checked before any other input as correct operation of the auto-reclose 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.

There are separate signals provided for each phase:

CB A Open, CB B Open, CB C Open.

CB A Closed, CB B Closed, CB C Closed.

CB A indeterminate, CB B Indeterminate, CB C Indeterminate.

Ensure that with the circuit breaker in the open position, the CB Open (appropriate CB Aux input) status input is enabled. Check that with the CB in the open position, the CB Open LED is lit.

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

The indication if the CB is Open and Closed, or not Open and not Closed is a separate CB Indeterminate LED and output for this.

12.1.11 CB In Service

With the CB Status correctly commissioned the CB In Service is not required to be checked. However the test is explained below:

To prevent unwanted auto-recloses a CB In Service feature is provided which only allows auto-reclosing 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.

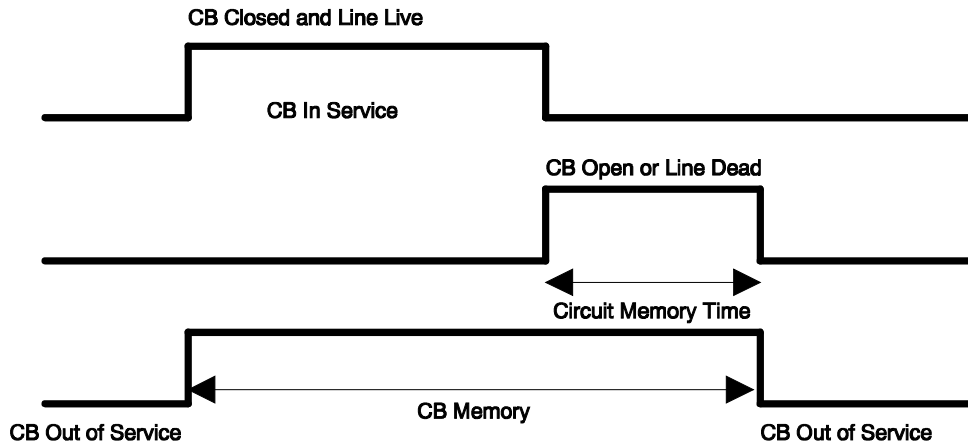


Figure 1 CB In Service

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.

12.1.12 Trip and Auto-reclose

Ensure that the CB is closed, and voltage is applied to both the line and bus VTs. Operate the trip status input whilst CB Memory is lit, A/R In Progress should light.

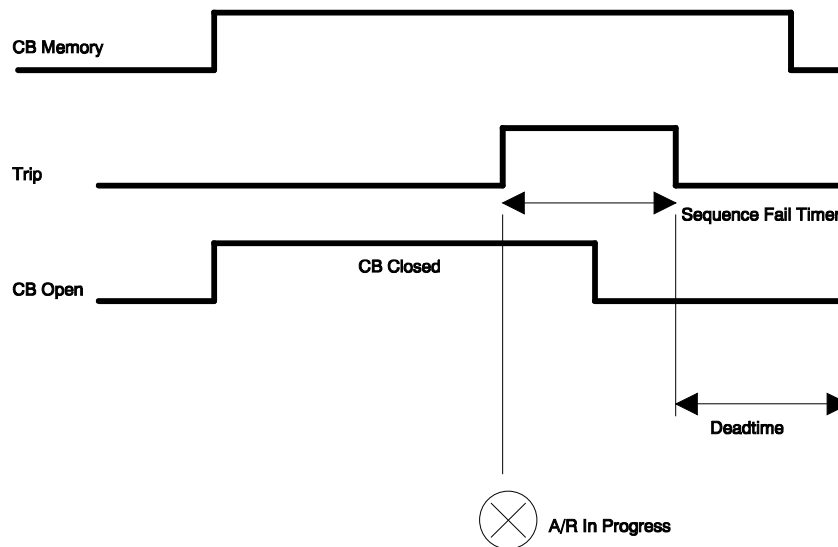


Figure 2 Trip And Auto-reclose

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 dead time 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 auto-reclose sequence being primed indefinitely; or the Sequence Fail timer can be set to OFF.

Assuming the trip operation to be successful, the close pulse will be issued after the first dead time 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.

12.1.13 Measurement of Auto-reclose Time Delays

All of the time delays are proven by software testing. The auto-reclose 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 Dead time time delay – To measure the dead time the correct sequence of events must occur: Set Start Dead time to Trip Reset. 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 Close 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 Close = Disabled, Dead Bar Close = Disabled, Check Sync Close = Enabled. Start the dead time but do not reapply voltage, the system will wait for as long as the dead time + 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).

The time delays for the 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.

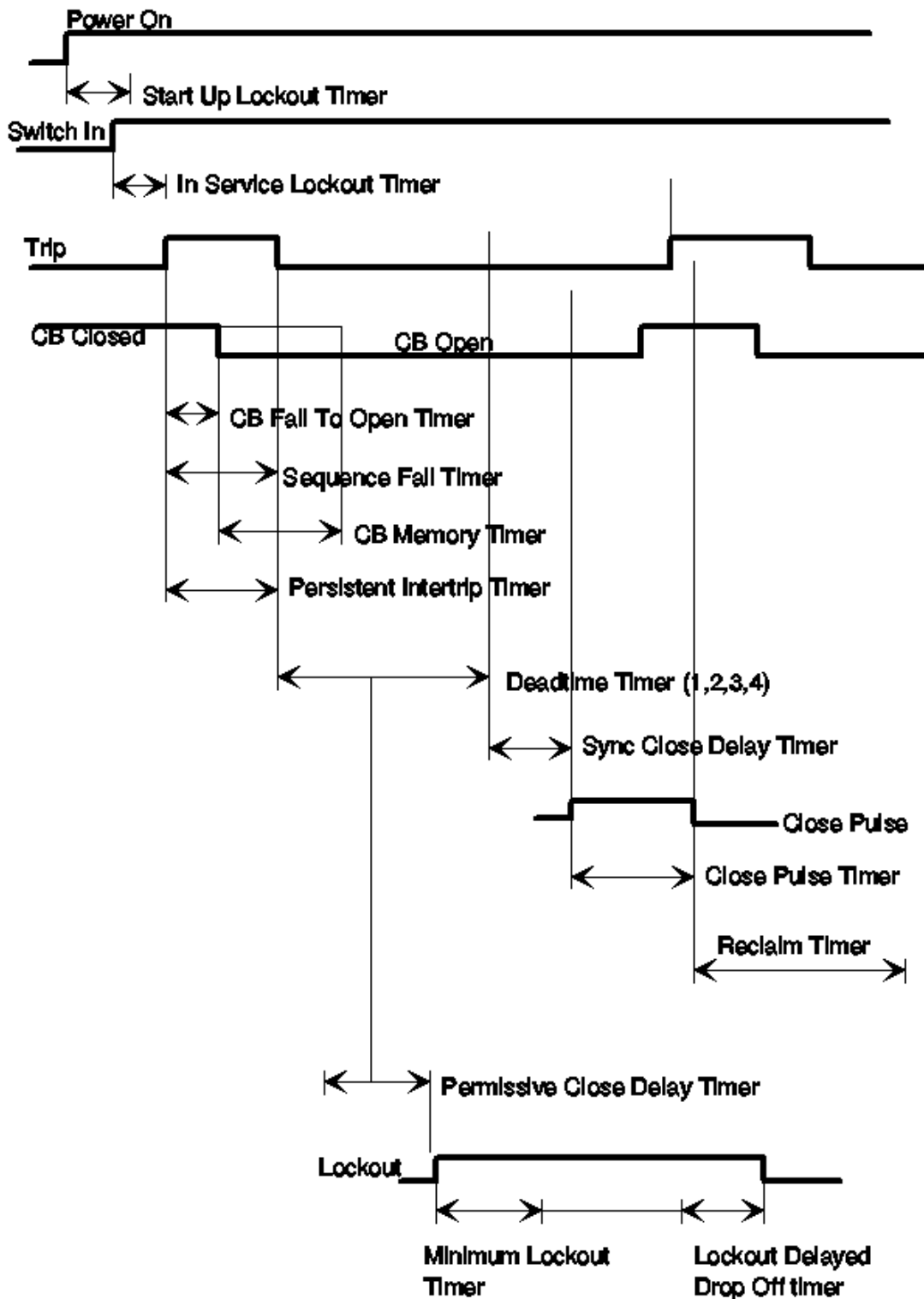


Figure 3 Auto-reclose Timers

12.1.14 Reclose Lockout

The auto-reclose 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.

12.1.15 Manual Close

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

12.1.16 System Closing Conditions

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

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

Dead Line Close Enabled/Disabled.

Dead Bar Close Enabled/Disabled.

Check Sync Close Enabled/Disabled.

The order at which these are checked is Dead Line then Dead Bar then Check Sync. However Check Sync has priority.

These settings are only relevant to Three Pole auto-reclosing. Single Pole Auto-reclosing does not check these settings. Also, 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 breakers. 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 breakers. 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 breakers. 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 three pole auto-reclosing conditions:

Dead Line Closing - Ensure that the circuit breaker is closed. Select Dead Line Close = Enabled in the A/R MENU. For an auto-reclosing sequence to start, the CB must be closed and the line live. Issue a 3P trip input and then open all the circuit breakers, switch off the line voltage. Keep the line voltage off to simulate a dead line close. After the first dead time the close pulse should be issued together with a Dead Line Close Flag.

Dead Bar Closing - Ensure that the circuit breaker is closed. Select Dead Bar Close = Enabled and Dead Line Close = Disabled in the A/R MENU. For an auto-reclosing sequence to start, the CB must be closed and the line live. Issue a 3P trip input and then open all the circuit breakers, switch off the line voltage. Keep the line voltage and bar voltage off to simulate a dead bar close. After the first dead time 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 dead time when the system will wait for as long as the Sync Close Delay; Or during the dead time when the system comes into synchronisation and Check Sync Close is allowed. For the latter the dead time will be bypassed and the close pulse issued directly. To test for both of these:

Check Sync Closing at end of dead time - Ensure that the circuit breaker is closed. Select Dead Bar Close = Disabled and Dead Line Close = Disabled and Check Sync Close = Enabled in the A/R MENU.

For an auto-reclosing sequence to start, the CB must be closed and the line live. Issue a 3P trip input and then open all the circuit breakers, switch off the line voltage. Keep the bar voltage live. At the end of the dead time 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 dead time - Ensure that the circuit breaker is closed. Select Dead Bar Close = Disabled and Dead Line Close = Disabled and Check Sync Close = Enabled in the A/R MENU. For an auto-reclosing sequence to start, the CB must be closed and the line live. Issue a 3P trip input and then open all the circuit breakers, switch off the line voltage. Keep the bar voltage live. During the dead time switch on the line voltage and bring the line and bar volts into synchronism. A suitably long dead time should be set. The close pulse should be issued together with a Sync In Progress Flag.

To test for single pole auto-reclosing:

Ensure that the circuit breaker is closed. Select Close Mode Selection = 1P/3P in the A/R MENU. For an auto-reclosing sequence to start, the CB must be closed and the line live. Issue an A Phase trip input and then open the A Phase circuit breaker. Keep the line voltage on to simulate a single pole open. After the first 1P dead time the close pulse should be issued together with a 1Pole Close Flag. Repeat for other phases.

12.1.17 Multi-shot Auto-reclose sequence

The relay can be programmed to perform a number of auto-reclose shots. The setting Close Mode Selection controls the number of closes.

13 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.

14 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 – Timer Tests

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

Table 4 – 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 | | | |

15 APPENDIX 2 - Circuit Breaker Simulation Circuit

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

The circuit consisted of a two coil, magnetic latching bi-stable relay, which operated from 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:

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

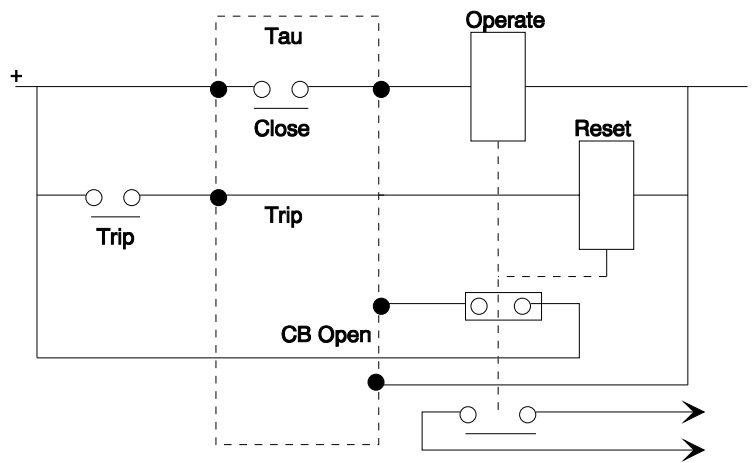


Figure A1

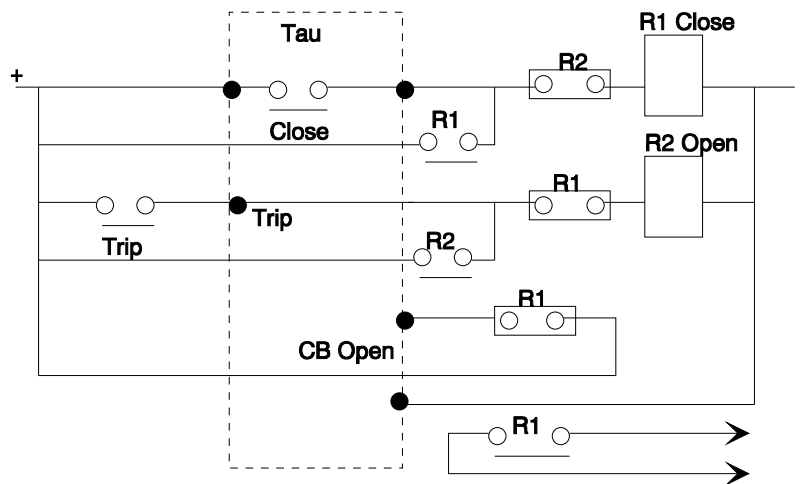


Figure A2