7SG26 Tau

Auto Re-close

Document Release History

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

2010/02	Document reformat due to rebrand

Software Revision History

Contents

1. INTRODUCTION

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

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

If the parameters are within the limits the relay will issue an output 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 autoreclose scheme.

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

2. GENERAL INFORMATION

2.1 General

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

On initial switch on of AC volts to the relay, the Check Sync function will wait for 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.

2.2 Autoreclose

The Autoreclose function provides the flexibility to be applied to a number of different Autoreclose schemes. This is achieved by a number of settings 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

Deadtime:

There are four deadtime settings:

First Single Pole Deadtime, Second Single Pole Deadtime, First Three Pole Deadtime, Second Three Pole Deadtime.

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

The deadtime can be started in three ways:

1. When the Protection Trip is received. Set Start Deadtime setting to Trip Make.
2. When the Protection Trip is received AND the CB has opened AND the line has gone dead. Set Start Deadtime 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 Deadtime 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 autoreclosing if the fault involves all three phases but to proceed if the fault involves one or two phases.

To allow three pole autoreclosing for faults involving all phases set the 3P Deadtime Initiate setting to 1P\2P\3P.

To prevent three pole autoreclosing for faults involving all three phases set the 3P Deadtime Initiate setting to 1P\2P.

Sequence Fail timer:

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

Permissive Close Delay:

The Permissive Close Delay works in conjunction with the Block Reclose and Inhibit Close inputs. Block Reclose stops the autoreclose sequence, Inhibit Close stops the autoreclose 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 Deadtime 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 deadtime 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 deadtime was set longer than the slip frequency rotation time the close may be required just at the point where the vector has left the setting range, in which case a full rotation would be required to get back into the limits. 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 deadtime is started when the Intertrip resets provided the CB has opened, there are no other trips or starter active, the line has gone dead, and the Persistent Intertrip timer has not timed out. 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 autoreclose 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 autoreclose 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 autoreclose, 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 autoreclose 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 autoreclose applications where conventional CB Fail protection was not fitted. The CB Fail To Open output would be independently wired to Lockout and stop the autoreclose sequence. Alternatively a time delay setting could be set which indicates CB Slow, and give an alarm if the CB is still closed after this setting, 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 autoreclose 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 autoreclose 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 deadtimes would be applied, example: 5sec and Dead Line Charge at local end (small generation); and 10sec and Check Sync and Dead Line Charge at remote end (large generation). Choosing to Dead Line Charge from the small source would ensure that closing onto a fault causes the least shock to the system. The Transmission line is reclosed even if the remote or local CB cannot close. Closure is only permitted if the line has gone dead which indicates that both local and remote CBs have opened.

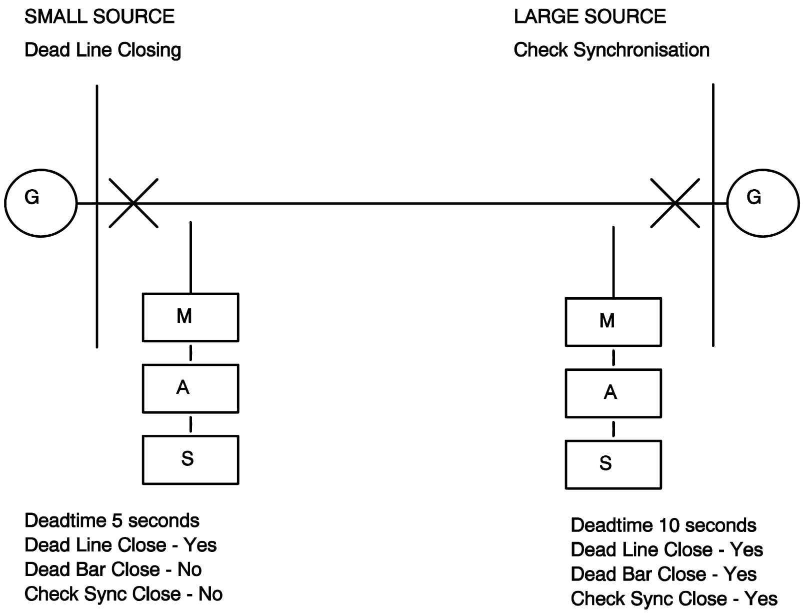

Figure 1 Typical Feeder Diagram

Application to T'd Feeder or Mesh Corner:

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

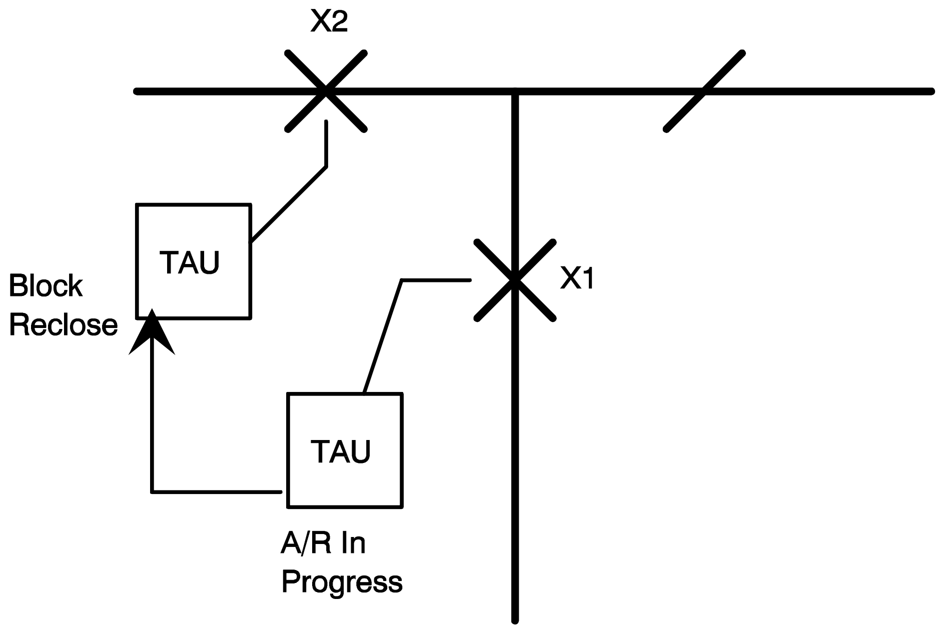

Figure 2 Mesh or T'd Feeder Connection Diagram

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 autoreclose 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' - CLOSES WHEN CB CLOSES.

Auxiliary type contacts 'b' - CLOSES WHEN CB OPENS.

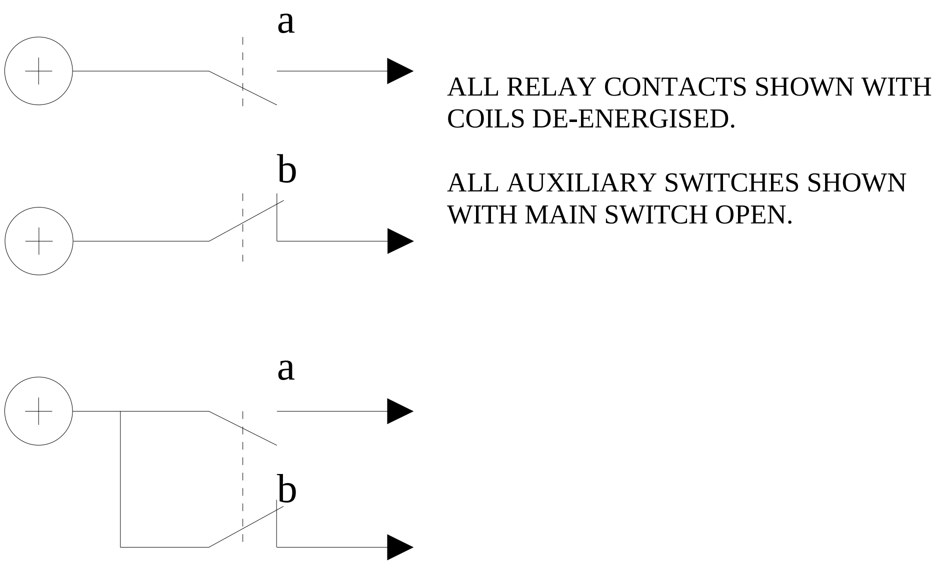

Fig 3. Primary Plant Auxiliary Switches

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:

CBOpen = NOT Aux One AND Aux Two

CBClosed = Aux One AND NOT Aux Two

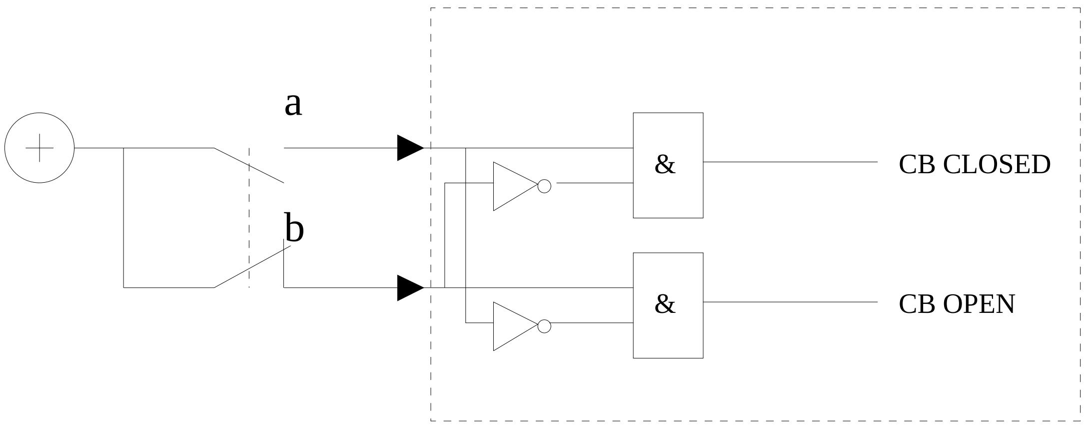

Fig 4. Processing of CB Closed and CB Open when using a + b Primary Plant Auxiliary Switches

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.

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

Table 2. Using 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

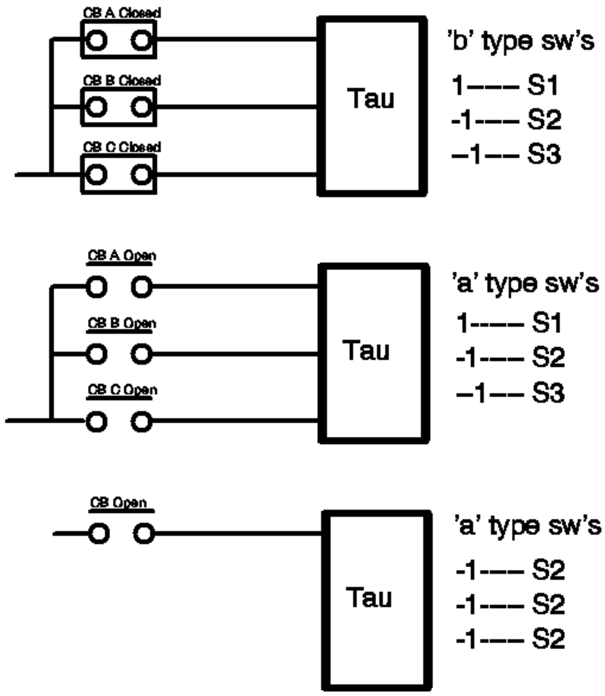

Figure 5 Possible CB Auxiliary Contact Connections

Output Alarms:

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

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

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

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

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

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

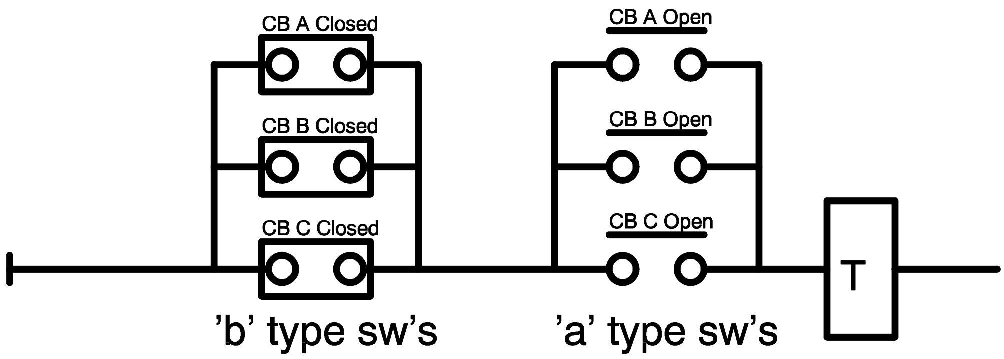

Figure 6 Standard Connection of Pole Discrepancy Protection

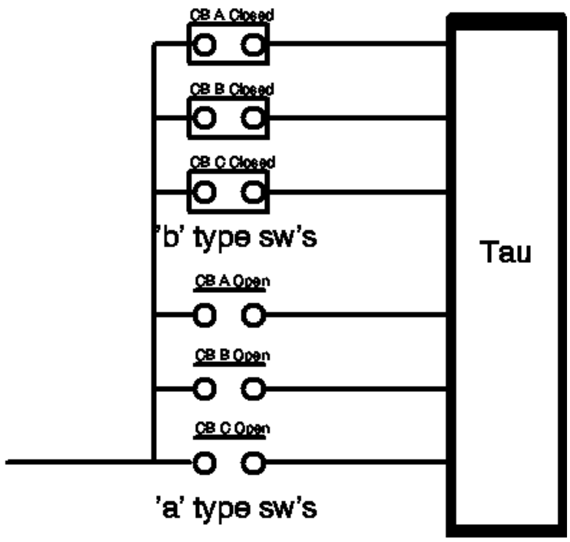

Figure 7 Tau Connection of Pole Discrepancy

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

VT Alarm: An alarm indicates that there is a VT Failure. The Bus VT Fail alarm is generated when the relay detects a live line and CB Closed and dead bus for greater than 2 seconds. The Line VT alarm is generated when the relay detects a live bar and CB Closed and dead line for greater than 2 seconds. The relay cannot distinguish between a VT Fail on the system and the VT Fail in the relay, the VT Fail indication may mean either.

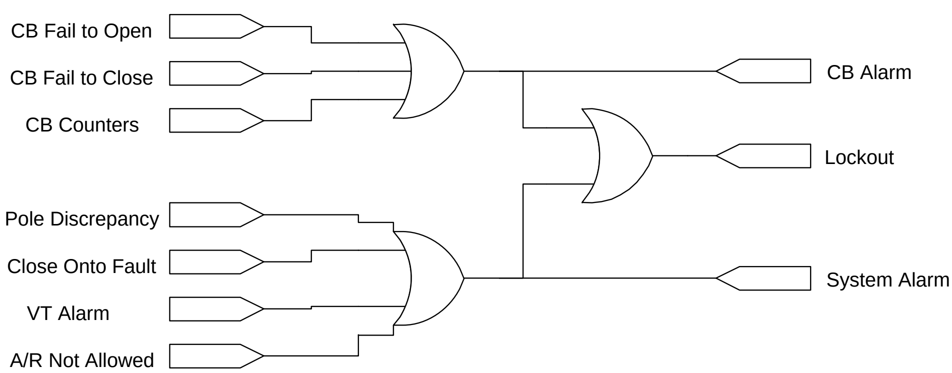

Figure 8 Possible A/R Alarms

2.3 Synchronising Modes

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

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

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

   Set System Split Detector to OFF.

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

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

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

   Set A/R Split Action to LOCKOUT

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

3. Set A/R Split Action to LOCKOUT

   Set MC Split Action to System Sync

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

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

2.4 Manual Closing

Manual Closing can occur at any point. The decision to close the CB lies with the operator. Manual Closing overrides a Locked out autoreclose sequence. The close decision is dependent upon the 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.

2.5 Typical Voltage Settings

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

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

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

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

e.g. for a phase to neutral connection nominally at 63.5 Vrms but which can run as low as 59 Vrms, the undervoltage setting should be set no higher than 59 V – 1 V (error margin) = 58V x 96% = 55.68V (the actual setting would have to be 55.5V). This is equivalent to approximately 87% of rated voltage. If the setting is set higher than this then the element may never reset and will continuously block.

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

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

2.6 Synchronising Override Logic

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

Check Sync Close Enabled/Disabled

Dead Line Close Enabled/Disabled

Dead Bar Close Enabled/Disabled

Sync Override

Manual Sync Override

2.7 Slip and Phase Angle Relationship

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

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

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.

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

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.

2.8 Check Synchronising Settings

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

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

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

Table 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.

2.9 System Synchronising Settings

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

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

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

Table 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.

2.10 Example Setting Calculations For Slip Timer

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

Proof :

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

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

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

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

Using the equation given in section 2.7 for check synchronising,

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

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

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

Substituting for this in the above equation gives,

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

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

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

2.11 Diagrams

At the back of this section figure 9/10 shows a typical connection diagram for the relay. Figure 11 shows a programming matrix (with Default setting information), which is a convenient way of recording the input / output logic for the relay. Figure 12 shows a blank programming matrix.

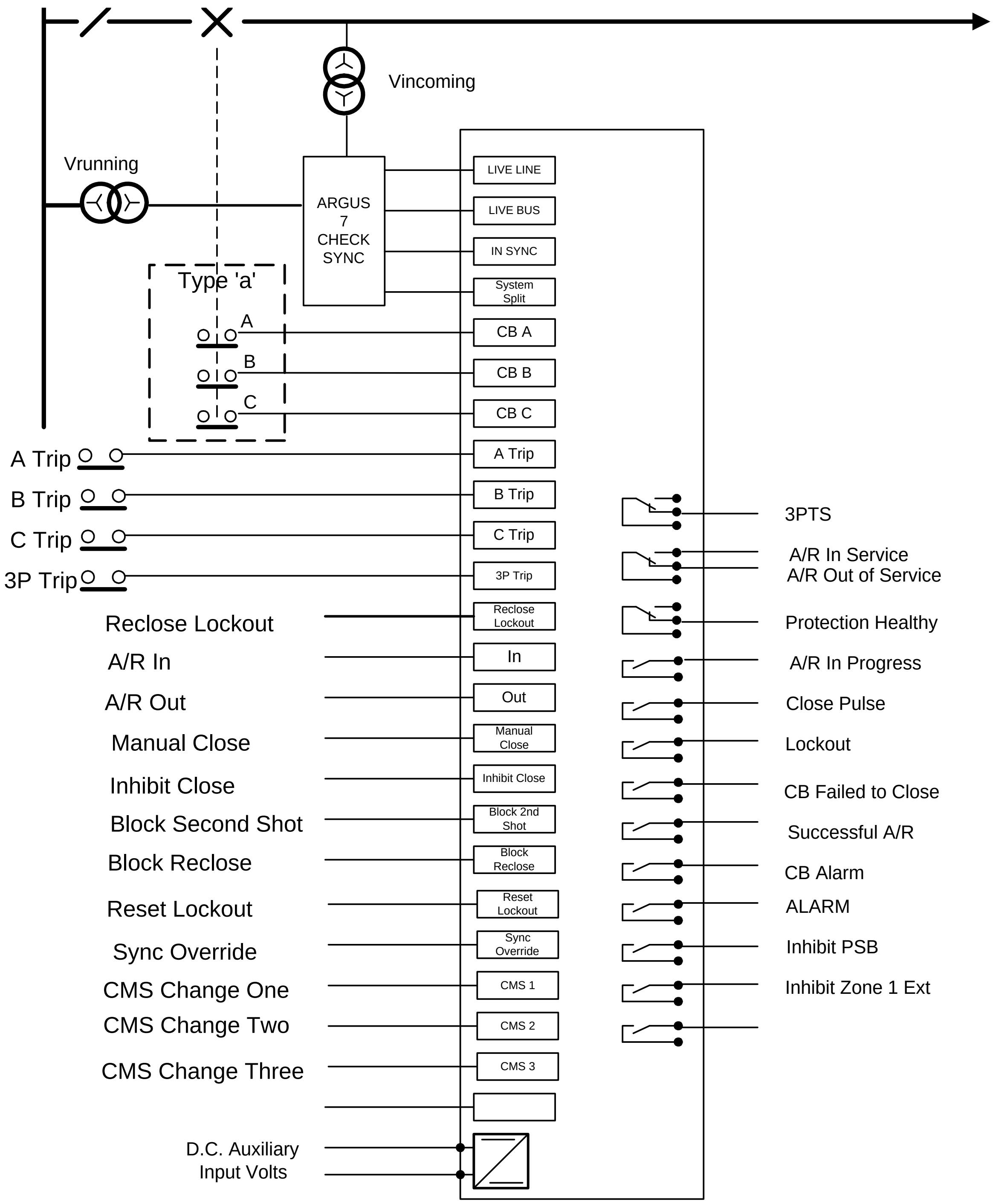

Figure 9 Tau 100 Connection diagram

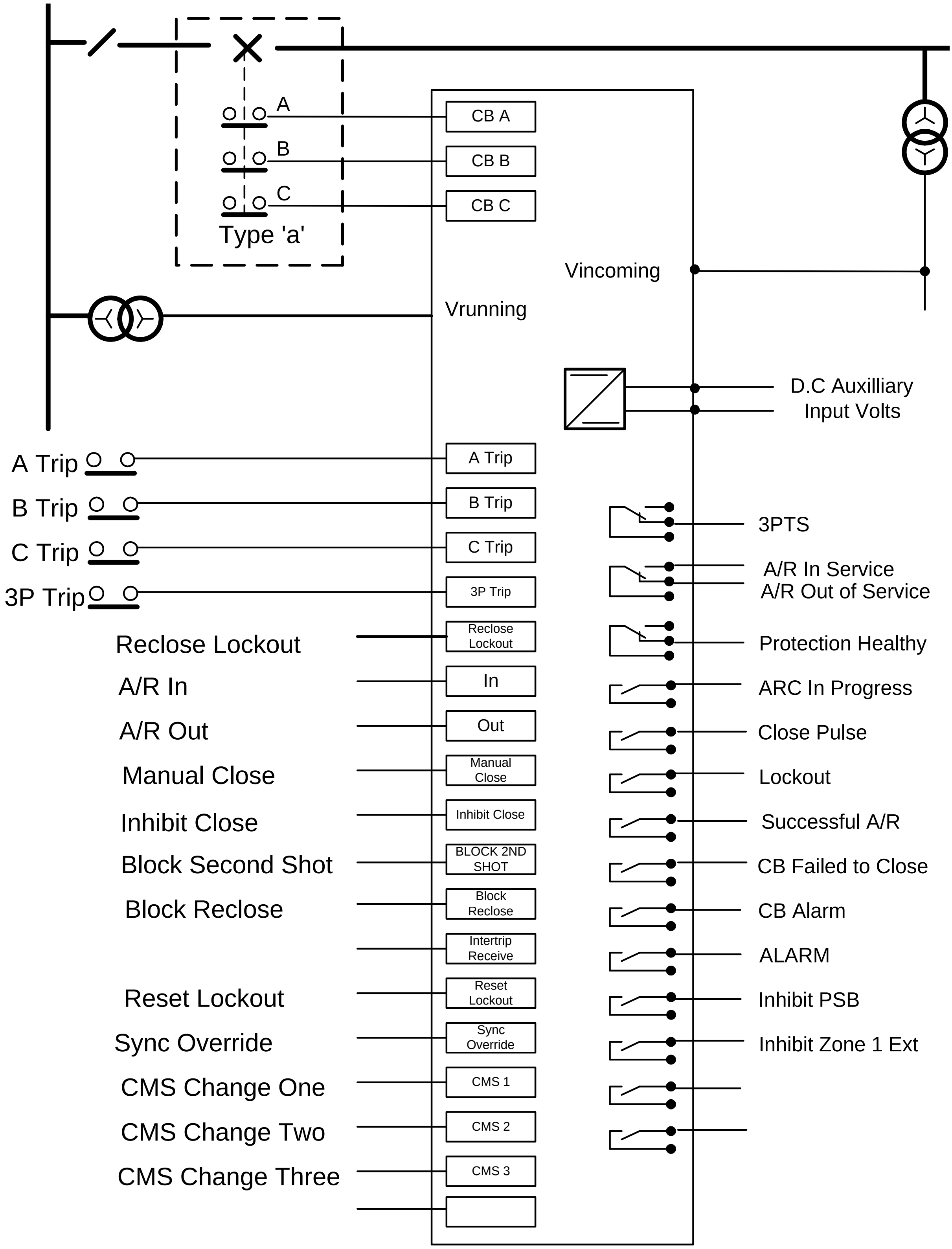

Figure 10 Tau 200 Connection diagram

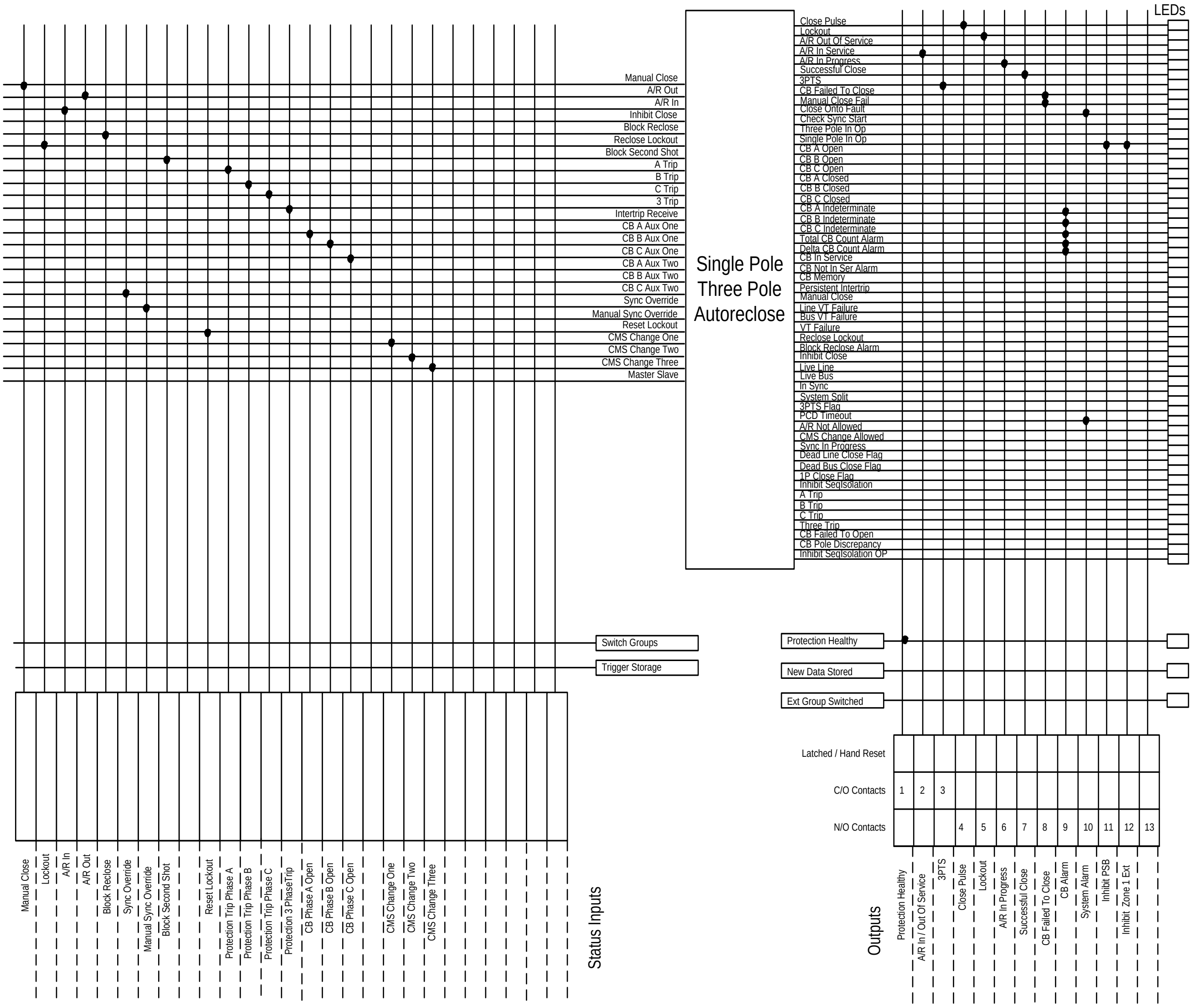

Figure 11 Programming Matrix – Default Settings

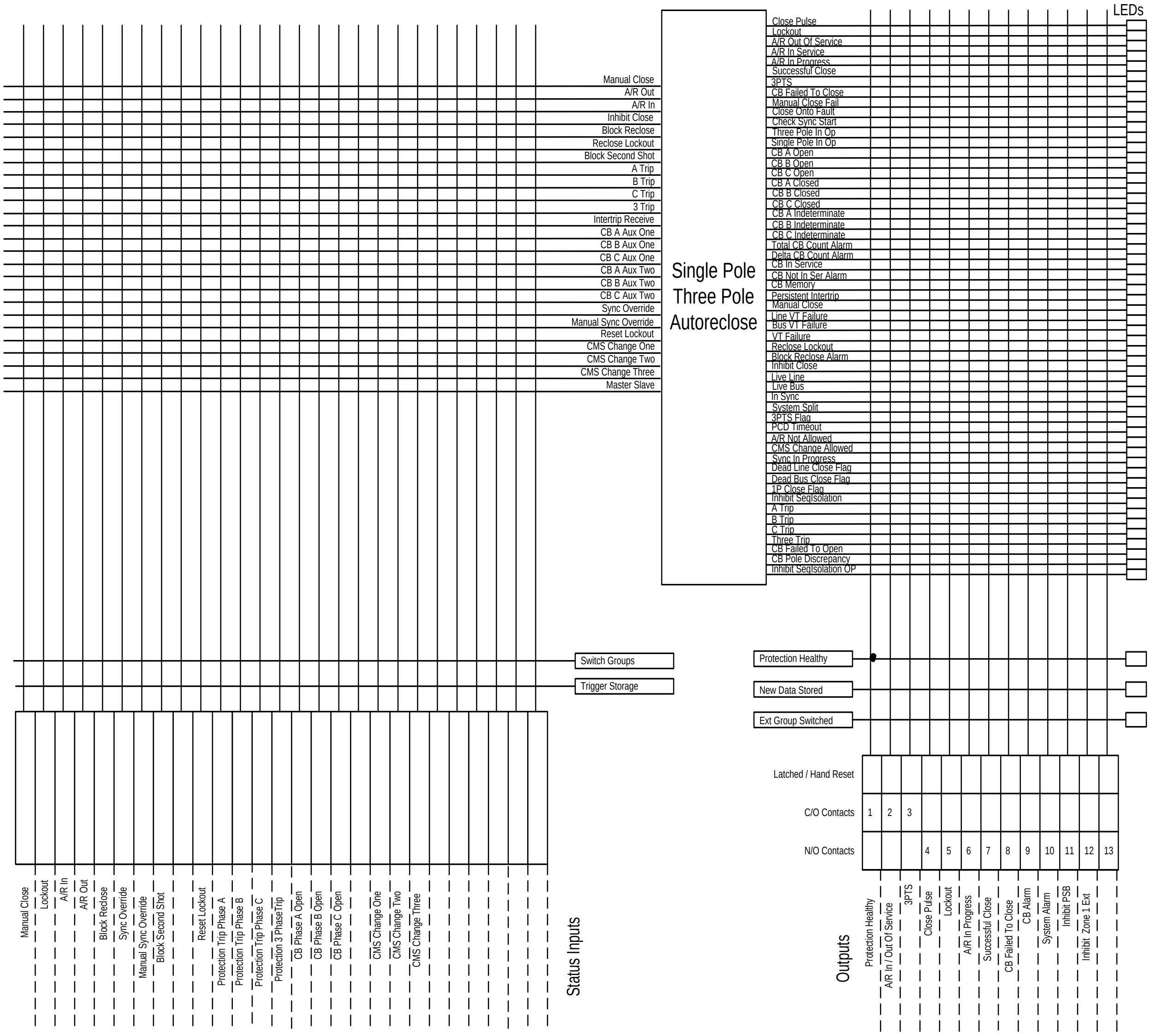

Figure 12 Blank Programming Matrix