APPLICATION GUIDE

AG015 – J-UNIT DELAYED AUTO-RECLOSE (DAR)

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SUMMARY

This document looks to provide sections of logic and settings for the Alstom MiCOM P14x product to facilitate its use as a "J-Unit" DAR relay.

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1. INTRODUCTION

Within the control & protection community there are a myriad of different (and often customer unique) auto-reclose schemes that are specified. Each scheme has been tailored over a number of years by either one, or a group of, network operators based upon their system needs and responses. One such scheme that is used extensively within the UK network is simply referred to as "J-Unit" auto-reclose and has previously been offered by Alstom Grid products such as VAR114, MVRT59 and KAVR159. Its simple reference belies the different applications it finds usage in covering old CEGB standards TPS12/10, TPS12/12, TPS 12/25 and TPS12/72 as well as other ancillary units such as the "F-unit" and "H-unit". These are now generically covered by National Grid Technical Specification (NGTS) 3.24.16. Primarily, it is a simple repetitive, single-shot auto-reclose scheme with the ability to select both starting and closure criteria according to the availability of voltage (check synchronising) information.

This document looks to provide sections of logic and settings for the Alstom MiCOM P14x products to facilitate it use as a "J-Unit" DAR relay. It should be noted that the logic presented in this document interfaces with the integral auto-reclose and check synchronising facilities of the relays to allow correct scheme operation. However, it is not intended to be a document to explain the generic auto-reclose functionality of the relay, or even the "J-Unit" auto-reclose itself.

The logic presented can be used in its entirety with the control inputs being used to enable or disable individual sections of logic according to the needs of the particular application. The Programmable Scheme Logic (PSL) diagrams displayed have all been based upon a P143 with firmware version 41 but could be similarly applied to all versions of P14x with integral auto-reclose facilities with firmware version 15 or later with some minor modifications.

2. REFERENCES

REF.	DOC. NUMBER	DOC. NAME / TITLE
A	NGTS 3.24.16 Issue 1	Delayed Automatic Reclosing (DAR) [National Grid]
B	KAVR159/EN M/F11	KAVR159 Multi-shot Auto-Reclose & Check Synchronism Relay Service Manual [Alstom Grid]
C	P14x/EN OP/B74	Operation section of P14x Feeder Management Relay Technical Manual [Alstom Grid]
D	P14x/EN ST/B74	Settings section of P14x Feeder Management Relay Technical Manual [Alstom Grid]

3. "J-UNIT" DELAYED AUTO-RECLOSE

3.1. DAR IN SERVICE SELECTION

The Alstom MiCOM P14x range has extensive facilities for switching the auto-reclose function in and out of service both locally, and remotely. In addition, "Live-Line" working modes are also available. However, the traditional "J-unit" DAR only requires simplistic In/Out switching and so only a part of the facilities are used (see **Error! Reference source not found.**).

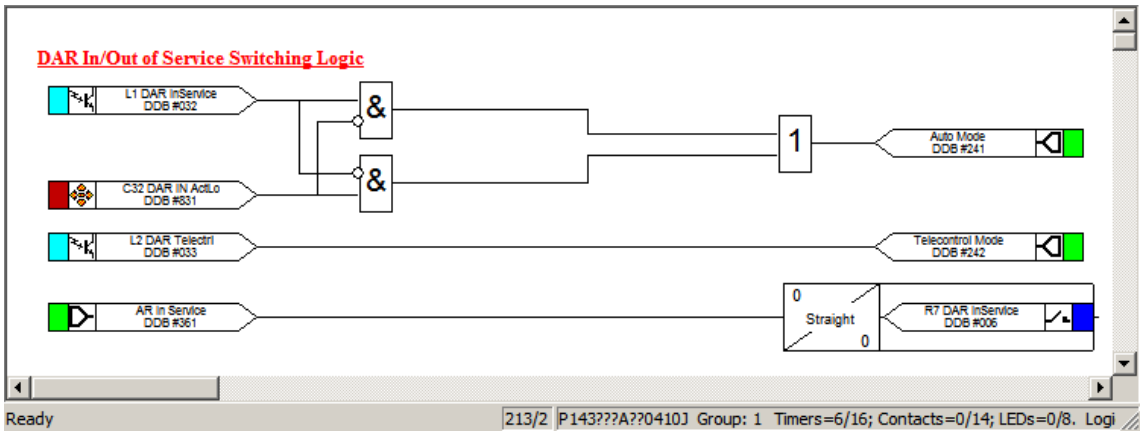

Figure 1: DAR In/Out of Service Logic

In or out of service selection is facilitated by the operation of input "L1 DAR InService" and depending upon the setting of Control Input 32 "C32 DAR IN ActLo", will either be active high or active low (see *Figure 2*).

CONTROL INPUT 32 STATUS	INPUT L1 STATUS	AUTORECLOSE MODE
Disabled	**De-energised (OFF)**	**Out of Service**
Disabled	**Energised (ON)**	**In Service**
Enabled	**De-energised (OFF)**	**In Service**
Enabled	**Energised (ON)**	**Out of Service**

Figure 2: Selection of DAR Service Mode

An output relay "R7 DAR InService" is used to indicate the current mode of the auto-reclose, noting that the chosen output is a changeover type so can be open or closed to indicate either status. Generally connections across terminals H17 and H18 which make to indicate auto-reclose in service, or terminals H16 and H18 which make to indicate auto-reclose out of service, would be "normal".

In addition to the input described above, input "L2 DAR Telectrl" has been made available in the logic. In conjunction with the "AR Mode Select" setting in the Autoreclose menu column, this input can be used to define whether input L1 is permanently energised to change auto-reclose state (as per most local control switches) or whether pulsed inputs are used (as per remote commands via SCADA). Further details of the mode selection can be found in section 2.1.2.1 of P14x/EN OP/B74 [ref C].

3.2. CIRCUIT BREAKER POSITION STATUS

The Alstom MiCOM P14x range has extensive facilities for monitoring the status of the CB that are controlled by suitable connection within the PSL and settings in the CB Control menu column. However, traditionally the status of the CB has been monitored utilising a single input configurable for either normally open (52a) or normally closed (52b) operation. In an effort to repeat this functionality, CB positional information is gathered using a single digital input "L3 CB Position", conditioned by Control Input 11 "C11 CBStat ActLo" (see *Figure 3* and *Figure 4*).

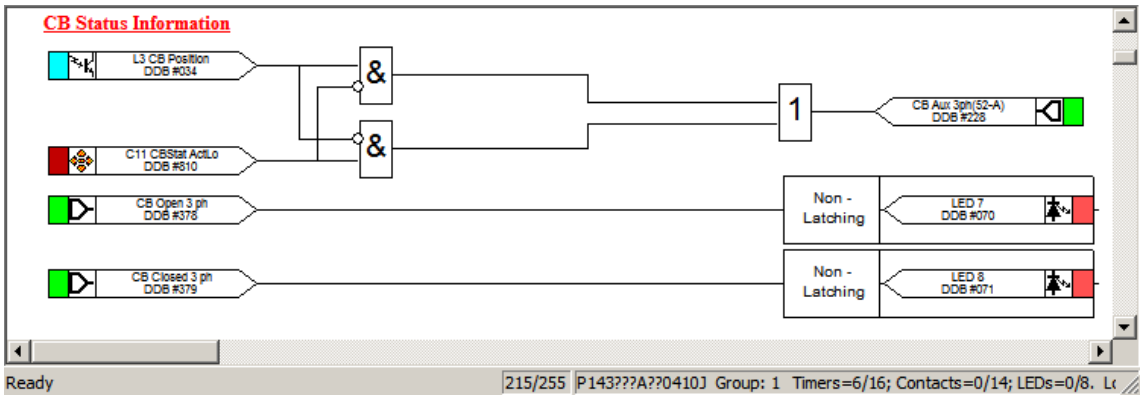

Figure 3: CB Position Logic

CONTROL INPUT 11 STATUS	INPUT L3 STATUS	CB POSITION IN DEVICE
Disabled	**De-energised (OFF)**	**Open**
Disabled	**Energised (ON)**	**Closed**
Enabled	**De-energised (OFF)**	**Closed**
Enabled	**Energised (ON)**	**Open**

Figure 4: CB Position mode

The state of the CB as considered by the relay, is indicated on programmable LEDs 7 and 8, with 7 being illuminated if the CB is open and 8 being illuminated if the CB is closed.

In order for the logic of *Figure 3* to work correctly, the "CB Status Input" setting in the CB Control menu column must be set to "52A".

It should be noted that if sufficient digital inputs are available, the use of two auxiliary contacts (52a and 52b) can offer some benefits (DBI status and additional security). However, this would require some minor modification of the PSL and adjustment to the "CB Status Input" setting. If this dual input method is preferred, Control Input 11 would not be required.

3.3. CIRCUIT BREAKER CHARGE STATUS

In addition to the positional state of the CB, its energy levels are also typically monitored to ensure that it is ready for an auto-reclose cycle, typically allowing for a full "Trip-Close-Trip" cycle. This information is gathered using a single digital input "L4 CB Charge", conditioned by Control Input 12 "C12 CBChrg ActLo" (see *Figure 5* and *Figure 6*.)

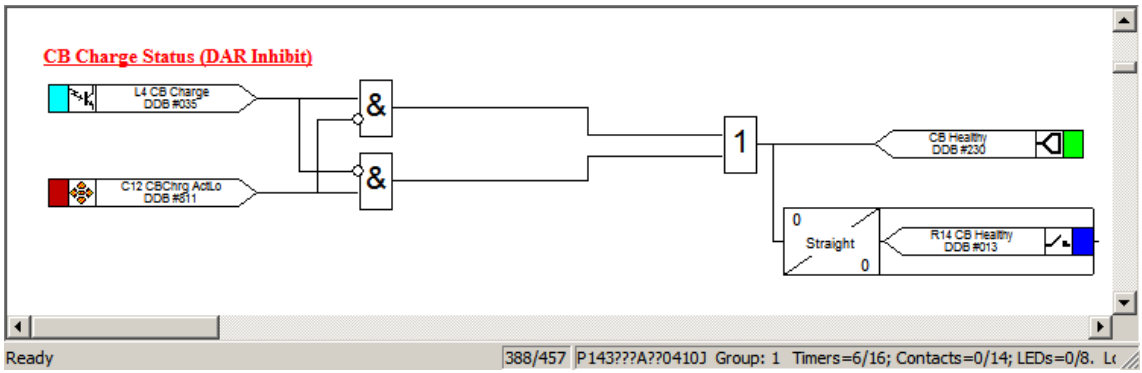

Figure 5: CB Charge Status Logic

CONTROL INPUT 12 STATUS	INPUT L4 STATUS	CB CHARGE STATUS
Disabled	**De-energised (OFF)**	**CB Not Ready (Unhealthy)**
Disabled	**Energised (ON)**	**CB Ready (Healthy)**
Enabled	**De-energised (OFF)**	**CB Ready (Healthy)**
Enabled	**Energised (ON)**	**CB Not Ready (Unhealthy)**

Figure 6: CB Charge status mode

An output relay "R14 CB Healthy" is used to indicate the current charge status of the CB, noting that the chosen output is a changeover type so can be open or closed to indicate either status. Generally connections across terminals G17 and G18 which make to indicate healthy status, or terminals G16 and G18 which make to indicate unhealthy status, would be "normal". If the CB charge is seen as unhealthy for a long period of time, it is possible to set the relay to stop the auto-reclose cycle and proceed to a lockout state. This logic is shown in sub-clause 3.5.

Although primarily designed to gather information on the charge status of the CB, this input could also be used to temporarily inhibit the DAR sequence, without causing lockout (unless it satisfies the persistent timeout criterion in sub-clause 3.5.).

If the Dead Time on the P14x relay has been completed, the state of the CB Healthy input (DDB#230) is checked in the internal logic of the relay and if it remains de-energised for greater than the "CB Healthy Time", auto-reclose lockout will occur. (See section 2.1.1.1.1 of P14x/EN OP/B74 [ref C]).

3.4. EXTERNAL TRIP INITIATION

Although the Alstom MiCOM P14x range of relays have extensive protection functional capability, it is likely that the main protection for which auto-reclose will be required will be satisfied by another device. It is therefore important that all possible external protection trips are routed to the P14x relay to initiate the auto-reclose and provide local indication as appropriate. Traditionally the tripping devices have been grouped as "Main Protection" and "Intertrip" and so these have been facilitated using two digital inputs: "L5 Ext Prot Trip" and "L6 Intertrip Rx" (see *Figure 7*).

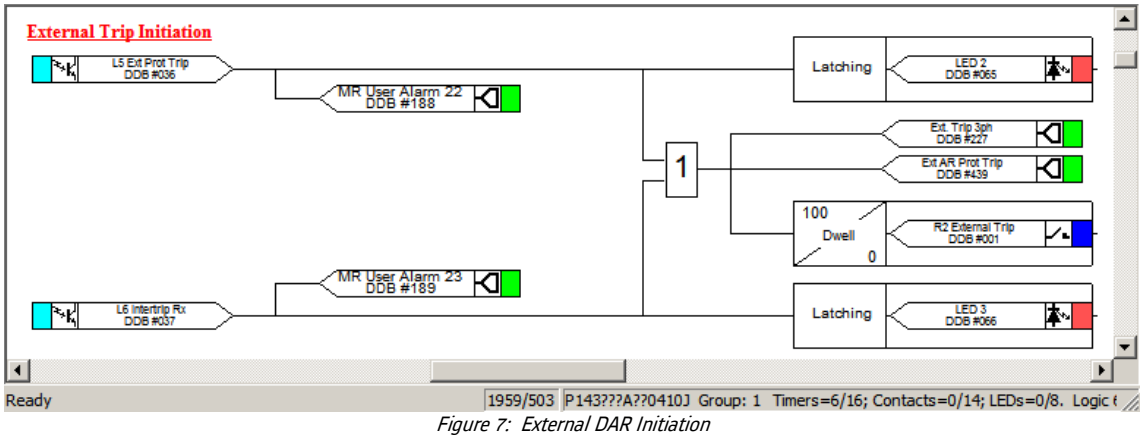

Figure 7: External DAR Initiation

An output relay "R2 External Trip" is used to indicate that an external trip initiation has occurred whilst LEDs 2 and 3 indicate that a main protection and intertrip have been received, respectively. User alarms may also be raised (alternative text for these alarms may be created using the Menu Text Editor facilities in MiCOM S1 Studio).

This logic drives two signals into the relay for initiating the auto-reclose as well as other functions such as CB condition monitoring statistics and CB breaker fail (if enabled).

3.5. BLOCK AUTO RECLOSE (BAR)

Traditionally on "J-unit" DAR schemes, there has been an input typically labelled "BB/VT" (or similar) which caused the reclaim timer to be triggered, cancelled any active auto-reclose sequence and leave the CB in an open position. In modern auto-reclose schemes, this functionality has been superseded by the "Block Auto-reclose" functionality that essentially does the same task but without artificially triggering the reclaim timer. Both methods prevent subsequent initiations of the auto-reclose relay i.e DAR Lockout had been invoked, until such time as the CB had been manually closed and remained healthy for a settable period of time.

To block auto-reclose and cause DAR "lockout" a single digital input "L7 Block DAR", conditioned by Control Input 13 "C13 BAR ActiveLo" is used (see *Figure 8* and *Figure 9*).

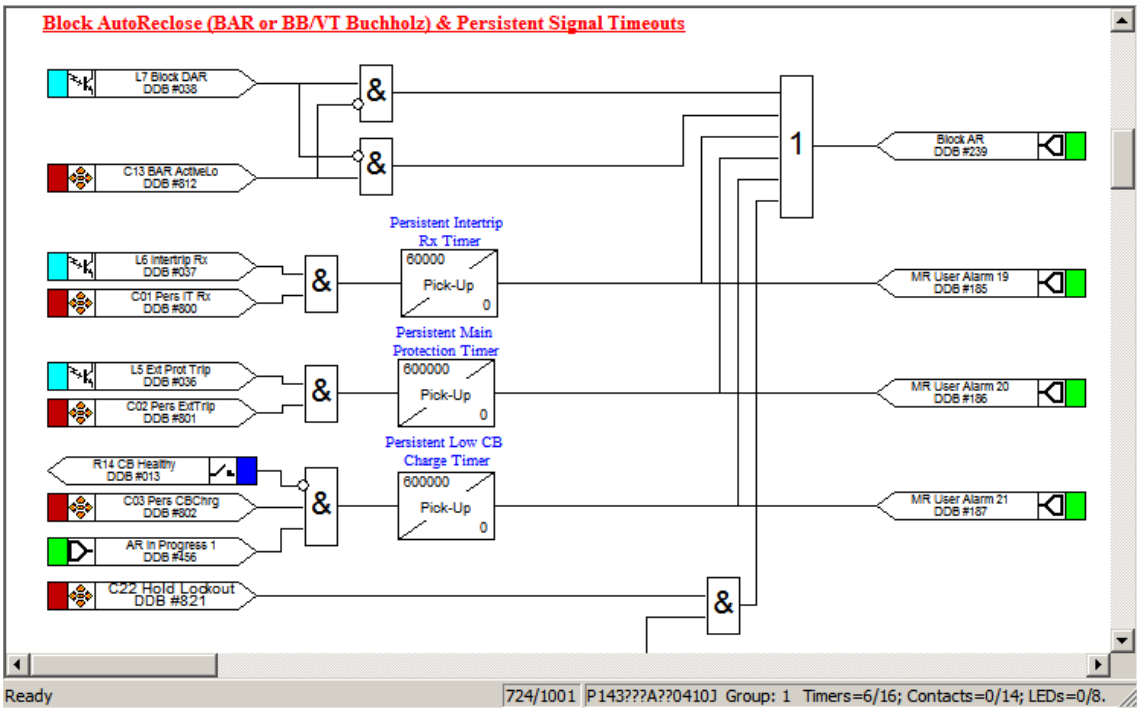

Figure 8: Block AutoReclose (BAR) Logic

CONTROL INPUT 13 STATUS	INPUT L7 STATUS	AUTORECLOSE STATUS
Disabled	**De-energised (OFF)**	**Auto-reclose available**
Disabled	**Energised (ON)**	**Auto-reclose locked out**
Enabled	**De-energised (OFF)**	**Auto-reclose locked out**
Enabled	**Energised (ON)**	**Auto-reclose available**

Figure 9: Block AutoReclose input mode

In addition to the specific ability to force the relay into a "lockout" condition, in the event of persistent initiation or unhealthy CB charge conditions, lockout may be desired. This ability is presented to the user using three additional control inputs and PSL timers. On expiration of the appropriate time delay, lockout will occur and user alarms may be raised (alternative text for these alarms may be created using the Menu Text Editor facilities in MiCOM S1 Studio).

CONTROL INPUT NO.	LABEL	SETTING	FUNCTION
1	**C01 Pers IT Rx**	**Enabled**	**If input "L6 Intertrip Rx" is energised for greater than the "Persistent Intertrip Rx Timer" (in PSL) then DAR is forced to lockout.**
		Disabled	**Input "L6 Intertrip Rx" can remain energised without directly forcing lockout.**
2	**C02 Pers ExtTrip**	**Enabled**	**If input "L5 Ext Prot Trip" is energised for greater than the "Persistent Main Protection Timer" (in PSL) then DAR is forced to lockout.**
		Disabled	**Input "L5 Ext Prot Trip" can remain energised without directly forcing lockout.**
3	**C03 Pers CBChrg**	**Enabled**	**If output "R14 CB Healthy" is de-energised for greater than the "Persistent Low CB Charge Timer" (in PSL) then DAR is forced to lockout, as long as an auto-reclose cycle has started.**
		Disabled	**Output "R14 CB Healthy" can remain de-energised without directly forcing lockout.**

Figure 10: Persistent timer lockout functions

Control input 22 "C22 Hold Lockout" gives the user the facility to force the relay into a lockout state if a system split condition is detected during the closure process. This is only possible if the "Split Hold Latch" is active in the PSL. See sub-clause 3.12 for details of how this latch is used.

Various other scenarios during the auto-reclose cycle will cause lockout to occur eg protection operation during reclaim time, CB failure to trip or close, etc. These are documented in section 2.1.2.8 of P14x/EN OP/B74 [ref C].

An output relay "R6 DAR Lockout" and programmable LED 5 are used to indicate that a lockout condition has arisen. Both of these indications will remain operated until the lockout condition has been reset.

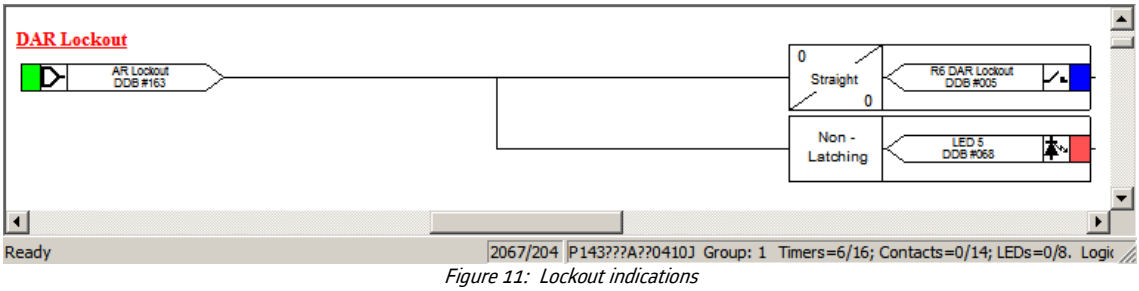

Figure 11: Lockout indications

3.5.1. Reset from Lockout

As well as being able to force the lockout condition to arise, it is also important to be able to reset the lockout condition thereby permitting auto-reclosure for future protection events. Typically (including on "J-Unit" logic), this reset from lockout would either be from a direct manual reset of the relay, or after a suitable time delay following manual closure. These features are part of the integral auto-reclose logic of the Alstom MiCOM P14x range and therefore only settings need to be applied, as shown in *Figure 12* and *Figure 13*.

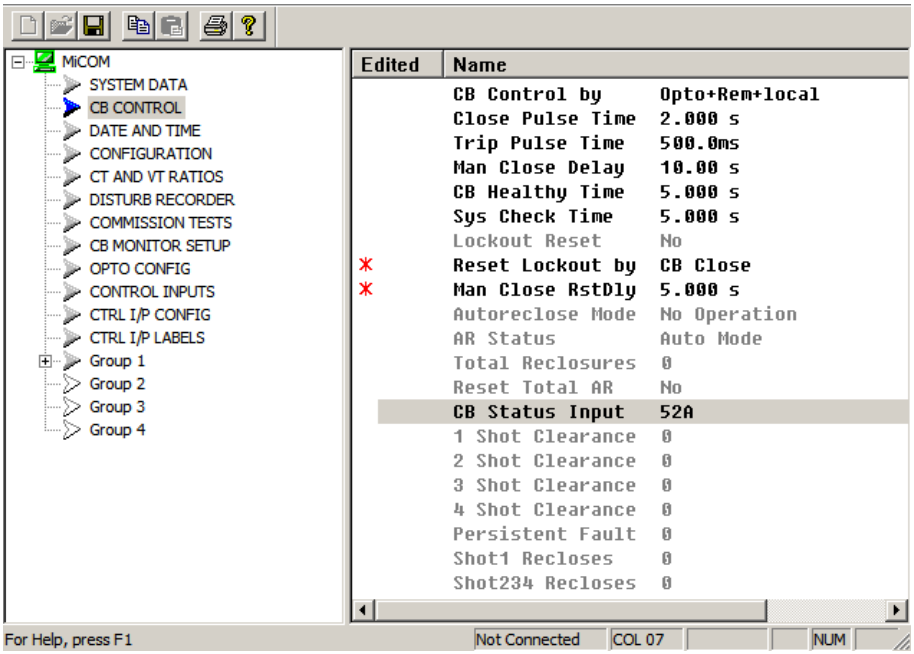

Figure 12: Key CB Control settings for resetting lockout

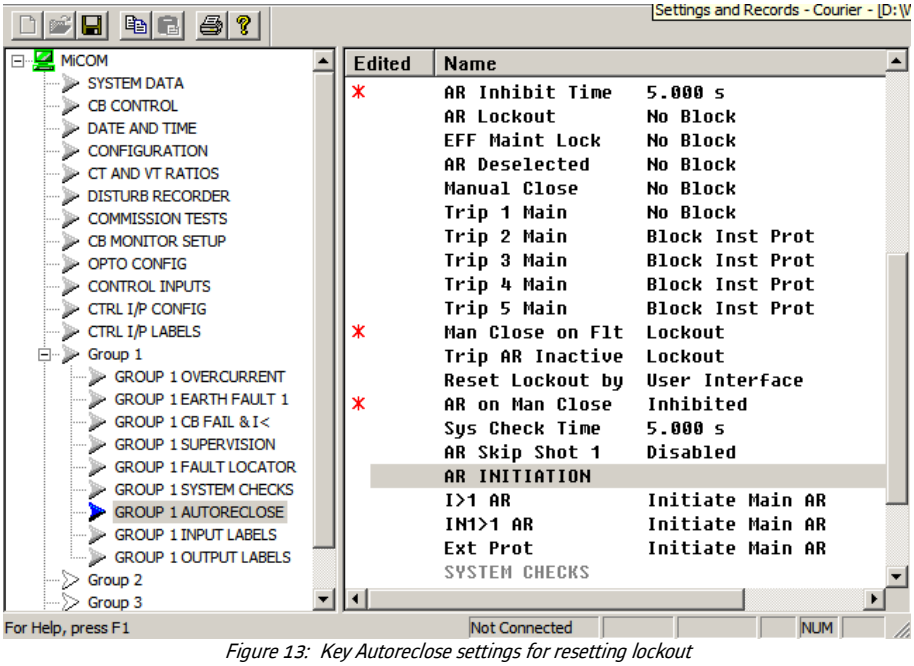

Figure 13: Key Autoreclose settings for resetting lockout

With the key settings highlighted as '*', on successful manual CB closure, a time delay given by "Man ClsRst Delay" is invoked to reset the lockout state if the CB remains closed for this time period. Furthermore, for a period given by the "AR Inhibit Time" auto-reclose will be blocked and will cause immediate lockout as "Man Close on Flt" is set. Manual reset of lockout may also be forced from the user interface, or via the PSL.

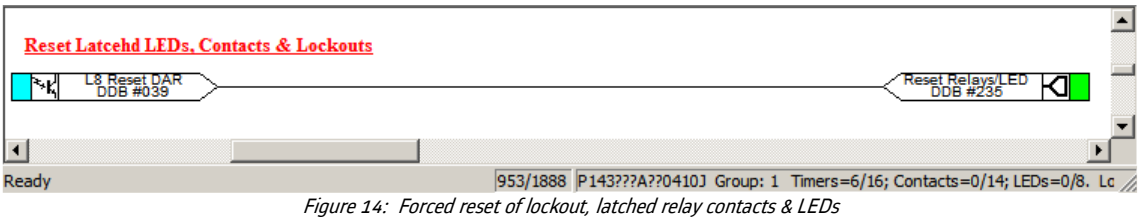

Figure 14: Forced reset of lockout, latched relay contacts & LEDs

3.6. CB CONDITION MONITORING (MAINTENANCE) & GENERAL ALARMS

The Alstom MiCOM P14x has considerable logic for monitoring the circuit breaker and assessing its ability to clear faults, or whether maintenance is advised. Features include monitoring of the sum of the broken currents, number of trip operations, time taken for the CB to operate and excessive fault frequency. All of these features have both alarm and lockout setting thresholds, except the excessive fault frequency which immediately forces a lockout condition.

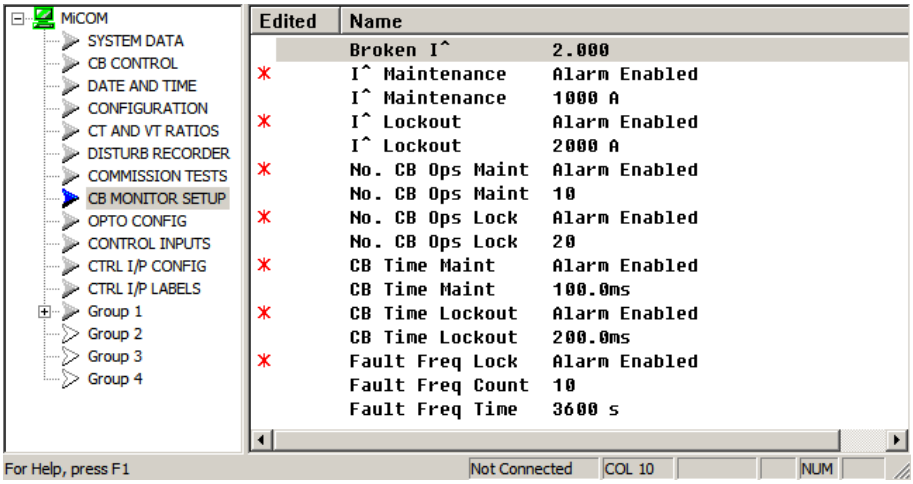

Figure 15: CB Condition monitoring settings

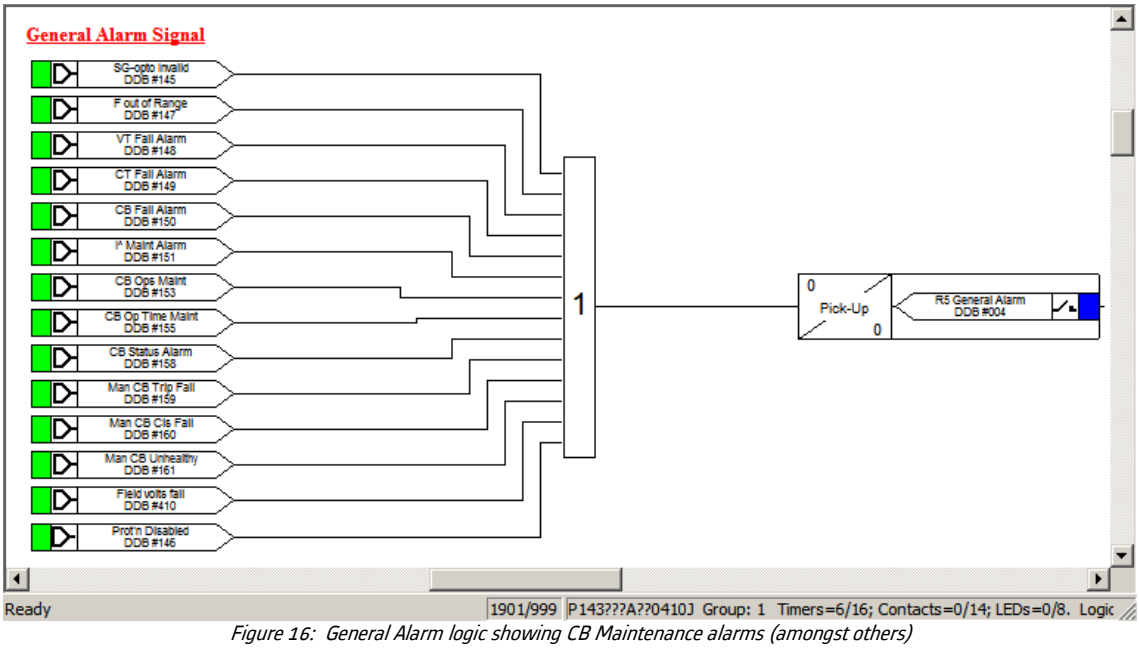

Figure 16: General Alarm logic showing CB Maintenance alarms (amongst others)

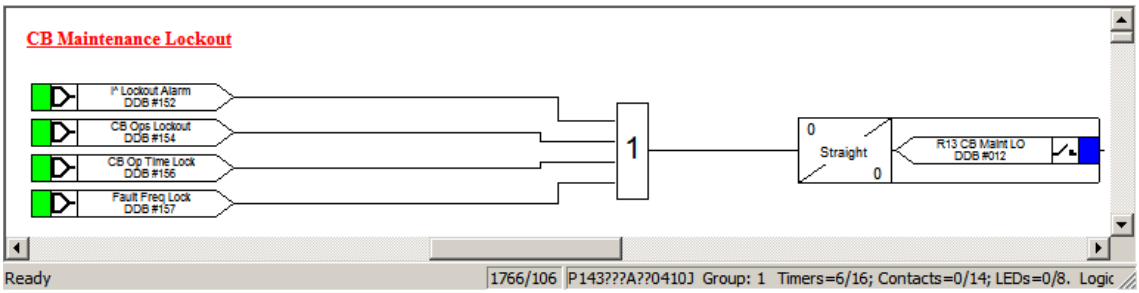

Figure 17: CB Maintenance Lockout logic

Within the PSL, an output relay "R13 CB Maint LO" is used to indicate that a lockout condition has arisen but the alarm levels are indicated as part of the "R5 General Alarm" output. When the lockout level is attained, auto-reclose will be blocked as part of the fixed internal logic of the P14x relay autoreclose.

Further details of the CB condition monitoring operation and settings may be found in section 2.9 of P14x/EN OP/B74 [ref C] and section 1.3.9 of P14x/EN ST/B74 [ref D].

3.7. PRE-TRIPPING INTERLOCKS (VTF)

One of the features of the "J-unit" logic is the extent of checks that are performed before the auto-reclose cycle is actually initiated. Most schemes simply require that auto-reclose is in service and that the CB is closed prior to protection operation. However, the "J-unit" logic can also be set to monitor the status of the line and bus voltages, depending upon VT availability. In the Alstom MiCOM P14x range, this capability is permitted by controlling the "CB In Service" DDB signal in the PSL (as shown in *Figure 18*). Control inputs "C04 Bus VT Avail" and "C05 LineVT Avail" define which voltage interlocks are actually required (see *Figure 19*).

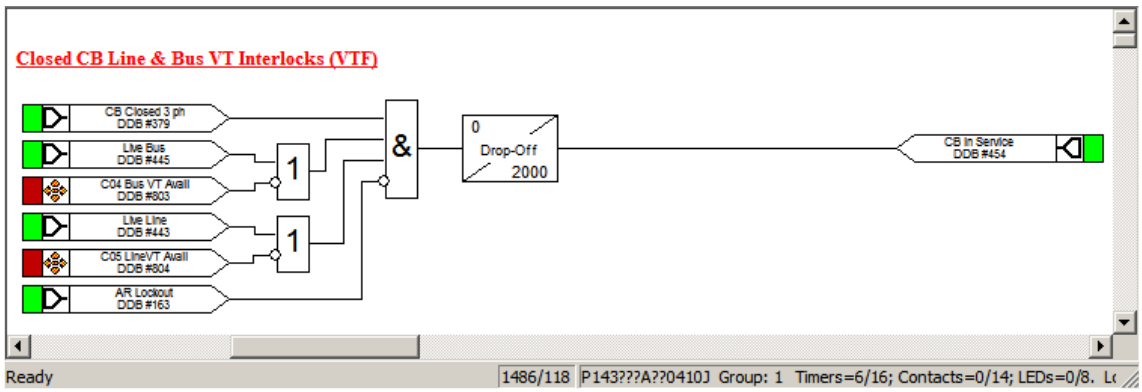

Figure 18: Pre-tripping Interlocks (VTF)

CONTROL INPUT 4 STATUS	CONTROL INPUT 5 STATUS	CB IN SERVICE STATUS
Out	**Out**	**No reference to bus or line voltages available. CB closed position used only.**
Out	**In**	**No reference to bus voltage but line must be live prior to fault and CB closed.**
In	**Out**	**No reference to line voltage but bus must be live prior to fault and CB closed.**
In	**In**	**Line and bus voltages must be live prior to fault and CB closed.**

Figure 19: Pre-tripping interlock (VTF) conditioning

Provided the appropriate conditions in accordance with Control Inputs 4 and 5 are met, the CB is seen as closed and there is no auto-reclose lockout condition, auto-reclose will be permitted to start when a protection trip occurs. If any of the conditions are not satisfied, the auto-reclose sequence will not be initiated and no automatic CB closure will follow. On successful initiation of the auto-reclose cycle, the "CB In Service" is no longer monitored i.e it is only a pre-tripping interlock.

3.8. TRIPPING INTERLOCKS OR PRIMING THE DEAD TIME

Most auto-reclose schemes simply monitor that tripping has occurred, that the CB subsequently opens and then the Dead Time is permitted to run. As part of the "J-unit" DAR scheme, as well as looking for these standard conditions, it may also be necessary to check the voltage status of the line and bus to ensure that they have become dead. The requirements will depend upon the actual application but in the Alstom MiCOM P14x they can be managed by controlling DDB #458 "DT OK To Start" (see *Figure 20*). Control inputs

"C09 Dead Line IL" and "C10 Dead Bus IL" define which voltage interlocks are actually required (see *Figure 21*).

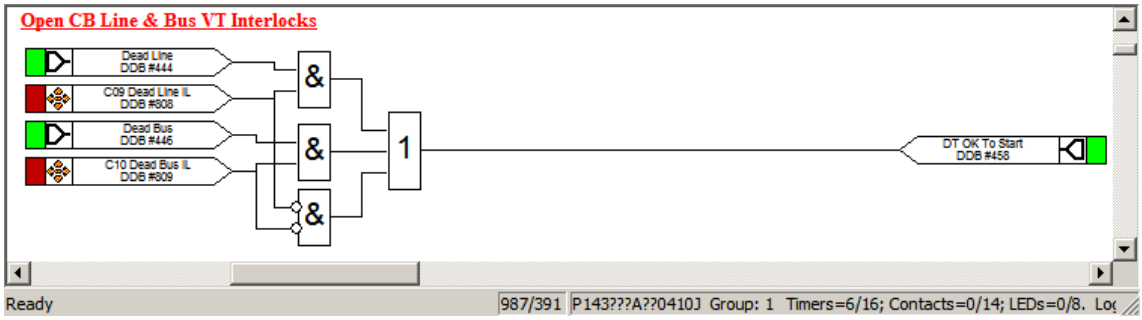

Figure 20: Tripping Interlocks

CONTROL INPUT 9 STATUS	CONTROL INPUT 10 STATUS	CB IN SERVICE STATUS
Disabled	**Disabled**	**No reference to voltage status is made.**
Disabled	**Enabled**	**Bus voltage must go dead to allow dead time to run. No check of line voltage is made.**
Enabled	**Disabled**	**Line voltage must go dead to allow dead time to run. No check of bus voltage is made.**
Enabled	**Enabled**	**Line OR bus voltage must go dead to allow dead time to run.**

Figure 21: Tripping Interlock conditioning

Once the "DT OK To Start" DDB signal has been energised, the dead timer is "primed" ready for operation but only if other checks (CB open and protection reset) are satisfied. Once primed, it has no effect on scheme operation until the next auto-reclose cycle.

If it is not required to prime the dead time as described in this sub-clause, DDB#458 "DT OK To Start" can be totally omitted from the PSL as it defaults high if not mapped.

The internal fixed logic of the P14x always requires the CB to be seen as open to permit the dead time to run. If the protection must also reset, then it will be necessary to configure the "Start Dead t On" setting in the Autoreclose menu column to "Protection Reset". This is normally required for "J-unit" operation.

Although the dead time logic has been primed via this section of PSL, the dead time will actually not start running until DDB#457 "DeadTime Enabled" is also operated. See sub-clause 3.9.

3.9. RUNNING THE DAR SEQUENCE AND DEAD TIME

With the protection operated, CB being healthy, Auto-reclose in Service and no lockout conditions, the auto-reclose cycle is initiated. At this point, an output "R12 Seq Isol Inh" is energised that would normally be used to block any isolators from being operated during the cycle. This output will only reset when the closing pulse is given or lockout occurs.

Sub-clause 3.8 has described how the dead time is primed ready for operation noting that before the dead time can actually run, it is necessary to energise DDB#457 "DeadTime Enabled" in the PSL. This allows various interlocks to be checked in alignment with the normal procedure of the traditional "J-unit" relay.

Essentially once the auto-reclose cycle is initiated, the following checks are required to allow the dead time to start running:

- Protection reset, AND
- CB open, AND
- Sufficient charge in the CB for full DAR cycle, AND
- Tripping interlocks satisfied, AND
- Suitable Dead/Live, Line/Bus voltage conditions satisfied

Alternatively, if an in-synchronism condition is detected across the open CB, the dead time can be bypassed and immediate closure command given, provided all other interlocks are satisfied.

Most of these conditions are checked within the internal fixed logic of the P14x relays but the voltage check conditions are addressed in the logic of *Figure 22*. (The Tripping interlocks of sub-clause 3.8 force DDB#460 "Reclose Checks" to be energised as indication of the dead time being "primed"). Control inputs "C06 DLC Permit", "C07 DBC Permit" and "C08 DLDB Permit" define which voltage interlocks are actually required (see *Figure 23*).

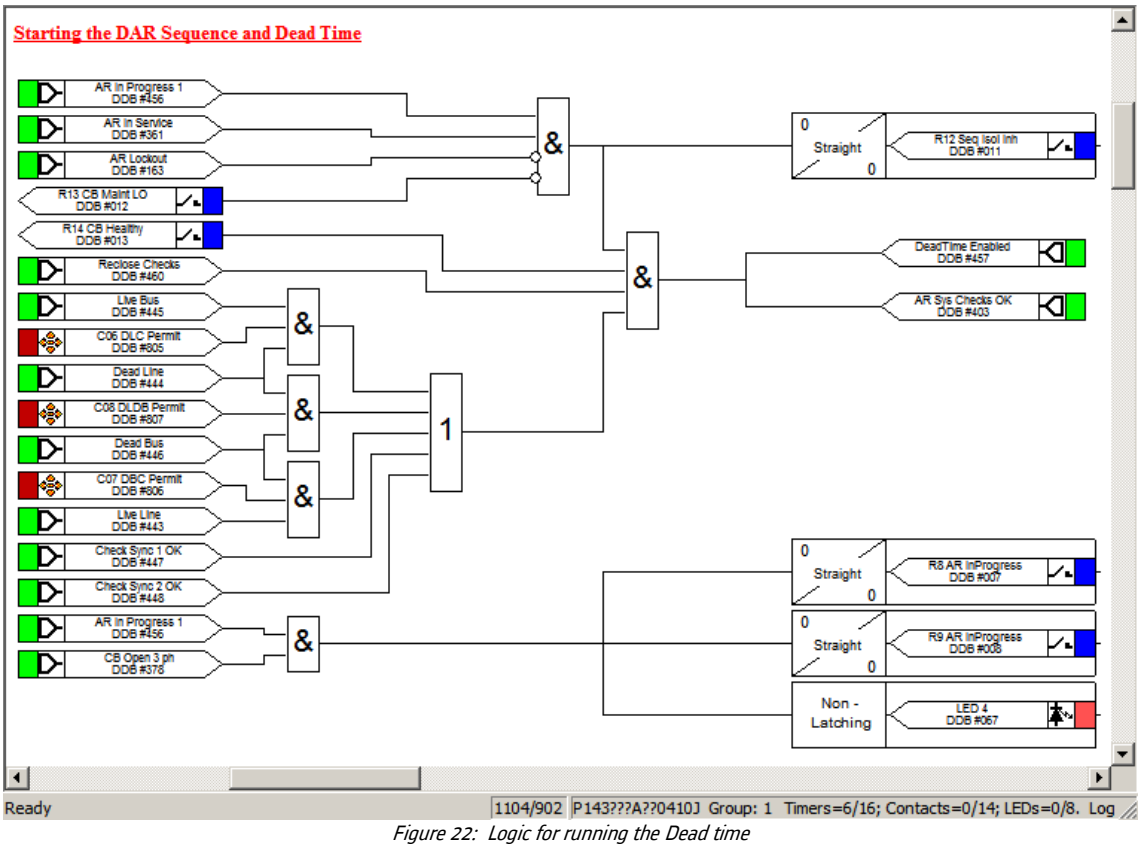

Figure 22: Logic for running the Dead time

CONTROL INPUT NO.	LABEL	SETTING	FUNCTION
6	C06 DLC Permit	Enabled	Live Bus AND Dead Line conditions will allow the dead time run. (Dead Line Charging is permitted).
		Disabled	Live Bus AND Dead Line conditions will not allow the dead time run. (Dead Line Charging is not permitted).
7	C07 DBC Permit	Enabled	Live Line AND Dead Bus conditions will allow the dead time run. (Dead Bus Charging is permitted).
		Disabled	Live Line AND Dead Bus conditions will not allow the dead time run. (Dead Bus Charging is not permitted).
8	C08 DLDB Permit	Enabled	Dead Line AND Dead Bus conditions will allow the dead time run.
		Disabled	Dead Line AND Dead Bus conditions will not allow the dead time run.

Figure 23: Voltage interlock settings to allow Dead time operation

With the checks satisfied, DDB#457 "DeadTime Enabled" is energised which allows the dead time to start running. If the system voltage checks or CB Healthy reset whilst the dead time is running, it will simply reset the timer back to 0s, wait for the conditions to be satisfied again and re-start the timer. This is a result of the fact that DDB#458 "DT OK To Start" has initially been activated to get this far in the sequence (see sub-clause 3.8). Only lockout conditions will cause the DAR sequence to be reset at this point.

On completion of the dead time, provided suitable system voltage checks are still active, the sequence will progress to the closure phase.

As mentioned previously in this sub-clause, if suitable in-synchronism checks are active at any point after the dead time has been primed, the dead time is actually bypassed to allow immediate reclosure. This is permitted by setting "CS AR Immediate" to "Enabled" within the Autoreclose column.

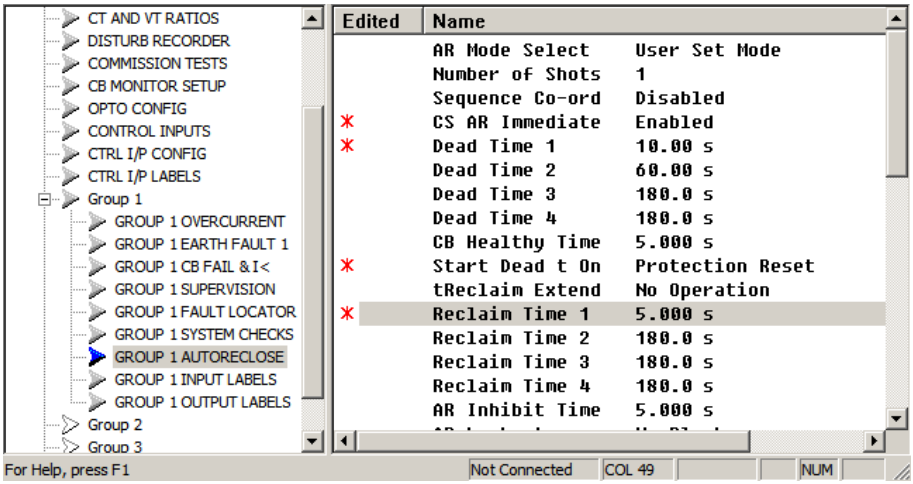

Figure 24: Key settings for correct DAR operation

The actual phase & frequency settings used for the in-synchronism check(s) will be dependent upon the Automatic Synchronising Selection logic (see sub-clause 3.12) as well as the settings in the System Checks menu column.

Conventionally on auto-reclose schemes, the autoreclose in progress signal is given from the moment protection operation occurs, right through to completion of the reclaim time, or to lockout. However, in the case of the "J-Unit" logic the auto-reclose in progress is terminated when the CB closure command is given i.e when the reclaim time starts running. To facilitate this arrangement on the Alstom MICOM P14x range of relays, two different auto-reclose in progress signals are available: "AR In Progress" and "AR In Progress 1". The only difference between these signals is that the user has the ability to turn off the second signal "AR In Progress 1" by activating another DDB signal called "DAR Complete". This DDB#453 "DAR Complete" would be energised from the CB close command to satisfy the requirements of "J-unit" functionality. (See *Figure 28*)

Two output relays ("R8 AR inProgress" and "R9 AR inProgress") and LED 4 are all operated when the auto-reclose progress is initiated and the CB is seen as being open.

3.10. DAR COMPLETE

As the "AR In Progress 1" signal resets, a 2s pulsed output is given on output contact "R10 DAR Complete" to indicate that the DAR sequence is coming to an end, regardless of whether the CB has been successfully closed or not. Another 2s pulsed output is given on "R11 DAR Success" to indicate that the DAR sequence has finished successfully i.e CB closure has been performed and remained closed.

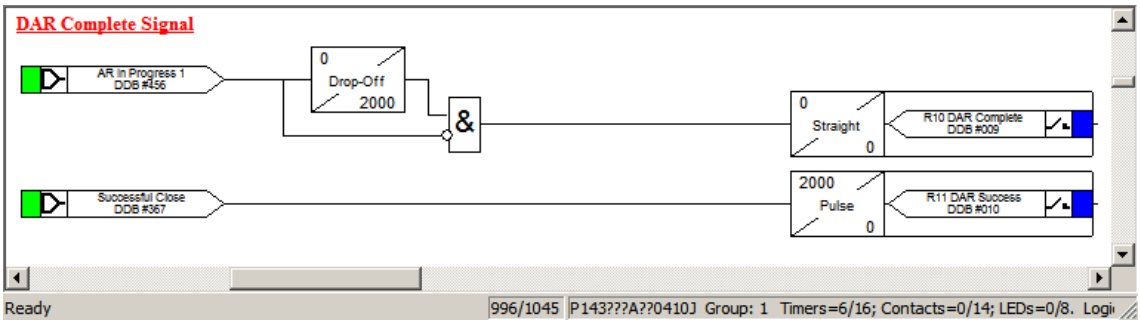

Figure 25: DAR Complete logic

3.11. CB CONTROL

3.11.1. Trip & Open Commands

All the internal protection functions of the P14x relay are grouped together to form part of the protection trip command, as per the default PSL. This grouping also causes output contact "R1 Internal Trip" and LED 1 to operate.

In addition to these signals, the external trip commands direct from digital input "L5 Ext Prot Trip" and "L6 Intertrip Rx" are also added to create the main trip command for opening the breaker, as well as triggering the fault recorder and illuminating the fixed Trip LED. (See *Figure 26*).

For many applications it would be a requirement to reset the main trip LED if DAR had been successful and the CB had remained closed for a period of time. This may be achieved by setting "Sys Fn Links" in the System Data column of the menu structure. See section 2.2 of P14x/EN OP/B74 [ref C] for further details.

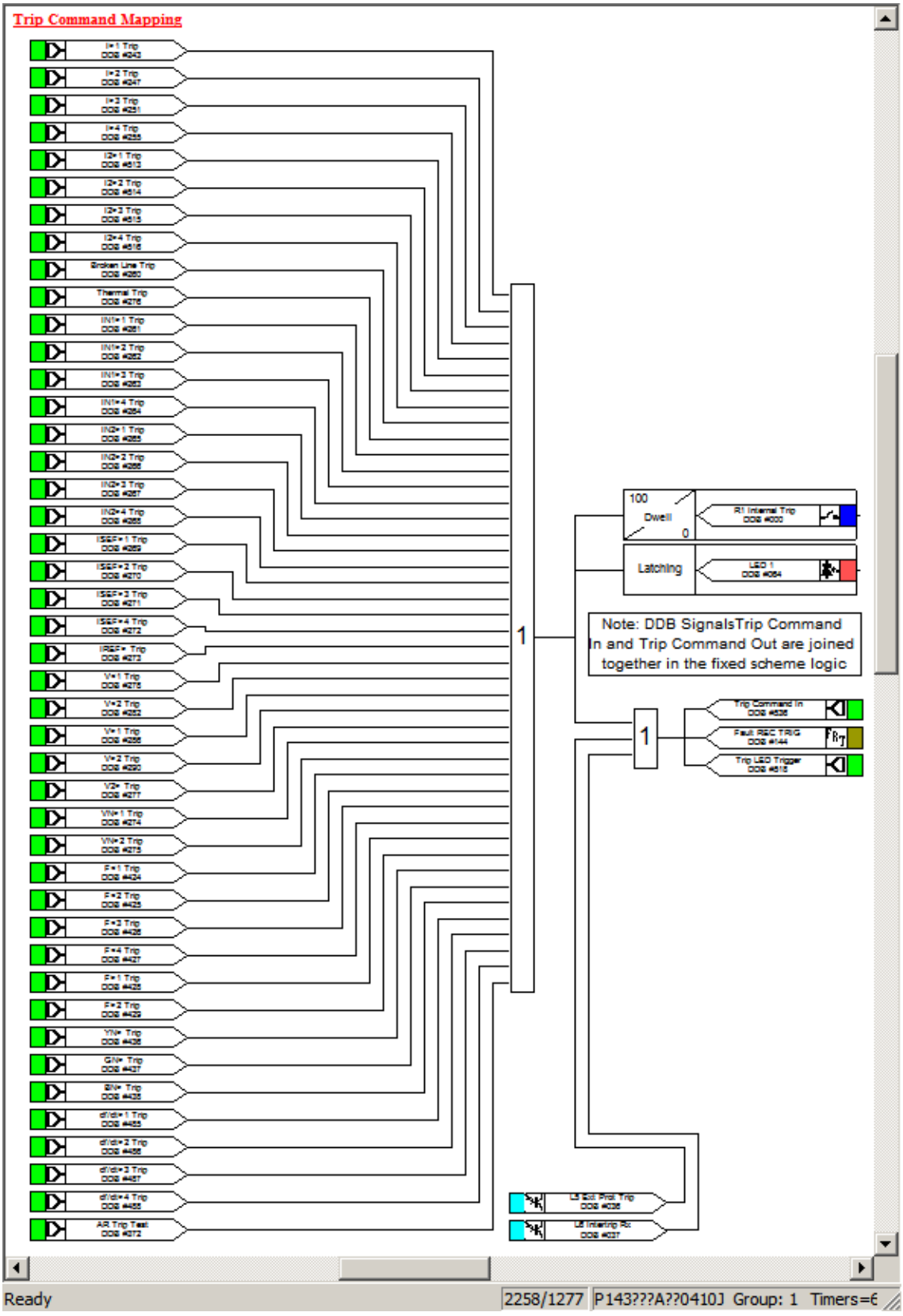

Figure 26: Trip Command logic

In addition to the trip command created in *Figure 26*, the direct control trip output is also used to actually form the main trip command to the CB, as seen in *Figure 27*. As the logic is shown in this document, this would allow manual opening of the CB via the relay user interface, via remote communications or via input "L10 Manual Open".

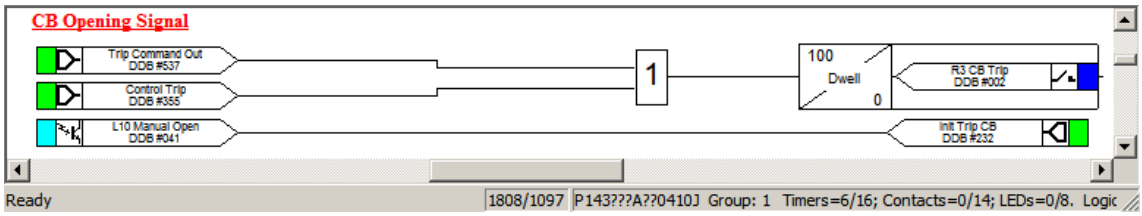

Figure 27: CB Trip / Open logic

3.11.2. Close Commands

When the dead time has completed with all the necessary system check conditions satisfied and the CB being healthy, the internal fixed logic of the relay will cause the CB close signal to be generated. The duration of the close pulse is defined by the "Close Pulse Time" setting in the CB Control menu column.
In addition to the auto-reclose close pulse, any manual close command will also cause operation of the same "R4 CB Close" output contact. However, it should also be noted that the control close will be governed by the "Man Close Delay" time setting in the CB Control menu. This setting allows for a time delay between the request for manual closure and the actual close signal being given to enhance operator safety.

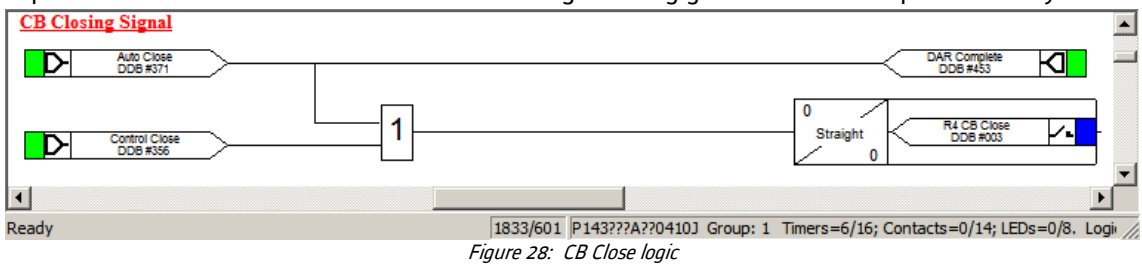

Figure 28: CB Close logic

In all cases, the CB close command will only be permitted if the CB is open and no protection trip signal is active. A protection trip command always takes priority over the close command.

As well as the close pulse being given, completion of the dead time will also instigate the start of the reclaim time. Given that "J-unit" auto-reclose is a single-shot scheme, with the reclaim timer running, any protection operation will cause immediate lockout of the scheme. New auto-reclose cycles will only be permitted once the reclaim timer has completed operation and reset the scheme.

3.12. AUTOMATIC SYNCHRONISING SELECTION

Sub-clause 3.9 (*Figure 22*) utilised both check synchronising elements to be able to satisfy the system check requirements of the DAR scheme. Each of these elements (Check Sync 1 and Check Sync 2) has totally independent settings and can be used independently if required. However, some utilities require that the 2 elements are used in conjunction with a "System Split" detector to change the in-synchronism criteria that are used to permit closure. The logic of *Figure 29* permits either "independent" mode, "parallel" mode or "switched" mode to be active by appropriate selection of Control Inputs 16 to 21.

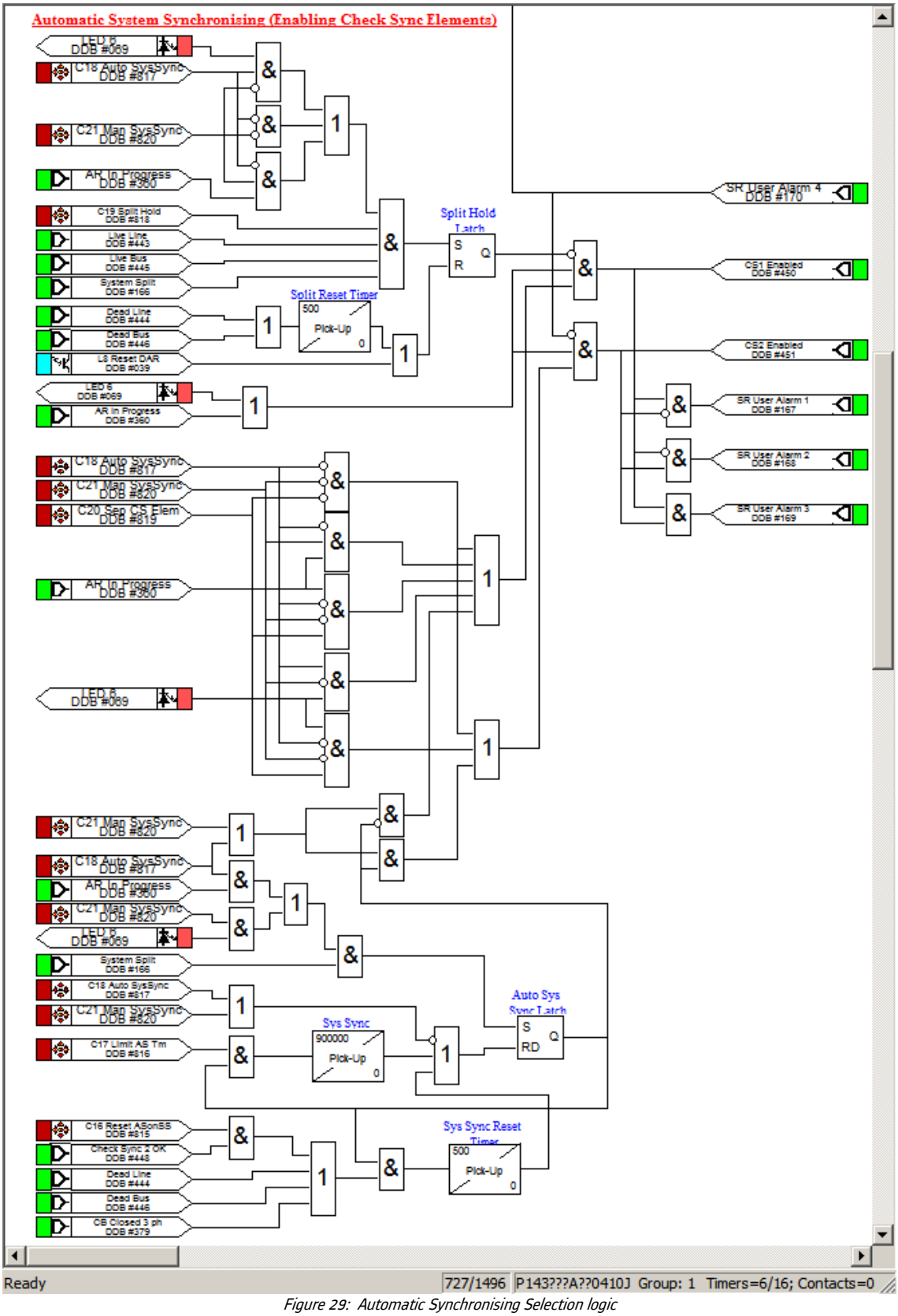

Figure 29: Automatic Synchronising Selection logic

In configuring the operating mode, Control Input 18 "C18 Auto SysSync" and Control Input 21 "C21 Man SysSync" play pivotal roles and allow for automatic synchronising selection to be independently associated with DAR or manual close events. If these control inputs are both set to "Disabled", both Check Sync 1 and

Check Sync 2 will be enabled during either an auto-reclose or manual close scenario, unless Control Input 20 "C20 Sep CS Elem" is set to "Enabled". In this case, Check Sync 1 would be used for auto-reclose and Check Sync 2 for manual closure. However, if Control Input 19 "C19 Split Hold" is set to "Enabled" and a system split condition is detected, then both Check Sync 1 and Check Sync 2 will not be permitted to operate. (There is also an option to cause auto-reclose lockout in this scenario – see sub-clause 3.5). If this occurs, the Check Sync 1 and Check Sync 2 elements will only be re-enabled once a dead line or dead bus condition has been detected for a period greater than the "Split Reset Timer", or if digital input "L8 Reset DAR" is energised. Until the split hold feature is reset, user alarm 4 is used to indicate that a split condition is present (alternative text for this alarm may be created using the Menu Text Editor facilities in MiCOM S1 Studio)..

Control Inputs 19 and 20 have no effect on scheme operation if both Control Input 18 and Control Input 21 are set to "Enabled".

The "Split Reset Timer" is a timer residing within the Programmable Scheme Logic of the P14x relay. As such its time delay cannot be set from the relay user interface and can only be changed by modifying the PSL and downloading it to the relay.

With Control Input 18 "C18 Auto SysSync" or Control Input 21 "C21 Man SysSync" set to "Enabled" either Check Sync 1 or Check Sync 2 will be enabled, but never both. Typically, Check Sync 1 may be set to allow a relatively large phase angle difference but with minimal slip frequency whereas Check Sync 2 may be set to allow for a larger slip frequency but with much smaller phase angle. Obviously, these settings will need to be adjusted according to system parameters and also aligned with suitable System Split settings.

With Control Input 18 set to "Enabled" the voltages either side of the open breaker are monitored during an auto-reclose cycle. If a "System Split" condition is not detected, Check Sync 1 will be enabled as the check synchronising element. However, if a "System Split" condition is detected, the "Auto Sys Sync" latch is set and Check Sync 2 will be enabled. The "Auto Sys Sync" latch is only reset by one (or more) of the following conditions:

- CB Closure detected for a period greater than the "Sys Sync Reset Timer"
- Dead line or Dead bus voltage detected for a period greater than the "Sys Sync Reset Timer"
- If the in-synch conditions of Check Sync 2 are satisfied and Control Input 16 "C16 Reset ASonSS" is enabled for a period greater than the "Sys Sync Reset Timer"
- If the "Auto Sys Sync" latch and Control Input 17 "C17 Limit AS Tm" is enabled for a period greater than the "Sys Sync Window"
- If Control Input 18 "C18 Auto SysSync" and Control Input 21 "C21 Man SysSync" is set to "Disabled"

User alarms 1, 2 and 3 may be configured to offer indication of which check synchronising system is active at any time (alternative text for these alarms may be created using the Menu Text Editor facilities in MiCOM S1 Studio).

If Control Input 21 is set to "Disabled" whilst control input 18 is "Enabled", manual close events will be forced to use Check Sync 1 conditions, which may be inhibited by the split detection if control input 19 is "Enabled".

The "Sys Sync Reset Timer" and "Sys Sync Window" are timers residing within the Programmable Scheme Logic of the P14x relay. As such their time delays cannot be set from the relay user interface and can only be changed by modifying the PSL and downloading it to the relay.

With Control Input 21 set to "Enabled" the voltages either side of the open breaker are monitored during a manual closure event in the same way as Control Input 18 controls the sequence during an auto-reclose cycle. Similarly, if Control Input 18 is set to "Disabled" whilst control input 21 is "Enabled", auto-reclose events will be forced to use Check Sync 1 conditions, which may be inhibited by the split detection if control input 19 is "Enabled".

A summary of the check sync element control and the effect of control inputs 18 to 21 is shown in *Figure 30*.

Control Input			Method of Closure	Check Sync Status		Effect of Control Input 19 being Enabled	
18	20	21		Check Sync 1	Check Sync 2	Check Sync 1	Check Sync 2
Disabled	Disabled	Disabled	DAR	Enabled	Enabled	Inhibit on Split	Inhibit on Split
			Manual	Enabled	Enabled	Inhibit on Split	Inhibit on Split
Disabled	Enabled	Disabled	DAR	Enabled	Disabled	Inhibit on Split	Inhibit on Split
			Manual	Disabled	Enabled	Inhibit on Split	Inhibit on Split
Disabled	Setting Irrelevant	Enabled	DAR	Enabled	Disabled	Inhibit on Split	Inhibit on Split
			Manual	Automatic selection determined by system split		No Effect	No Effect
Enabled	Setting Irrelevant	Disabled	DAR	Automatic selection determined by system split		No Effect	No Effect
			Manual	Enabled	Disabled	Inhibit on Split	Inhibit on Split
Enabled	Setting Irrelevant	Enabled	DAR	Automatic selection determined by system split		No Effect	No Effect
			Manual	Automatic selection determined by system split		No Effect	No Effect

Figure 30: Check Sync element control

3.13. MANUAL SYNCHRONISING SELECTION

In addition to the provision of auto-reclose with full voltage & synchronism check facilities, the logic proposed also allows for manual closure of the CB utilising the same range of voltage & synchronism checks. The logic of *Figure 31* controls the selection of "suitable" closing conditions based upon the status of Control Inputs 26 to 31. It is worth noting that operation of the two check synchronising elements is still controlled by the logic of sub-clause 3.12 and so the manual closure checks will also be governed by that section of logic.

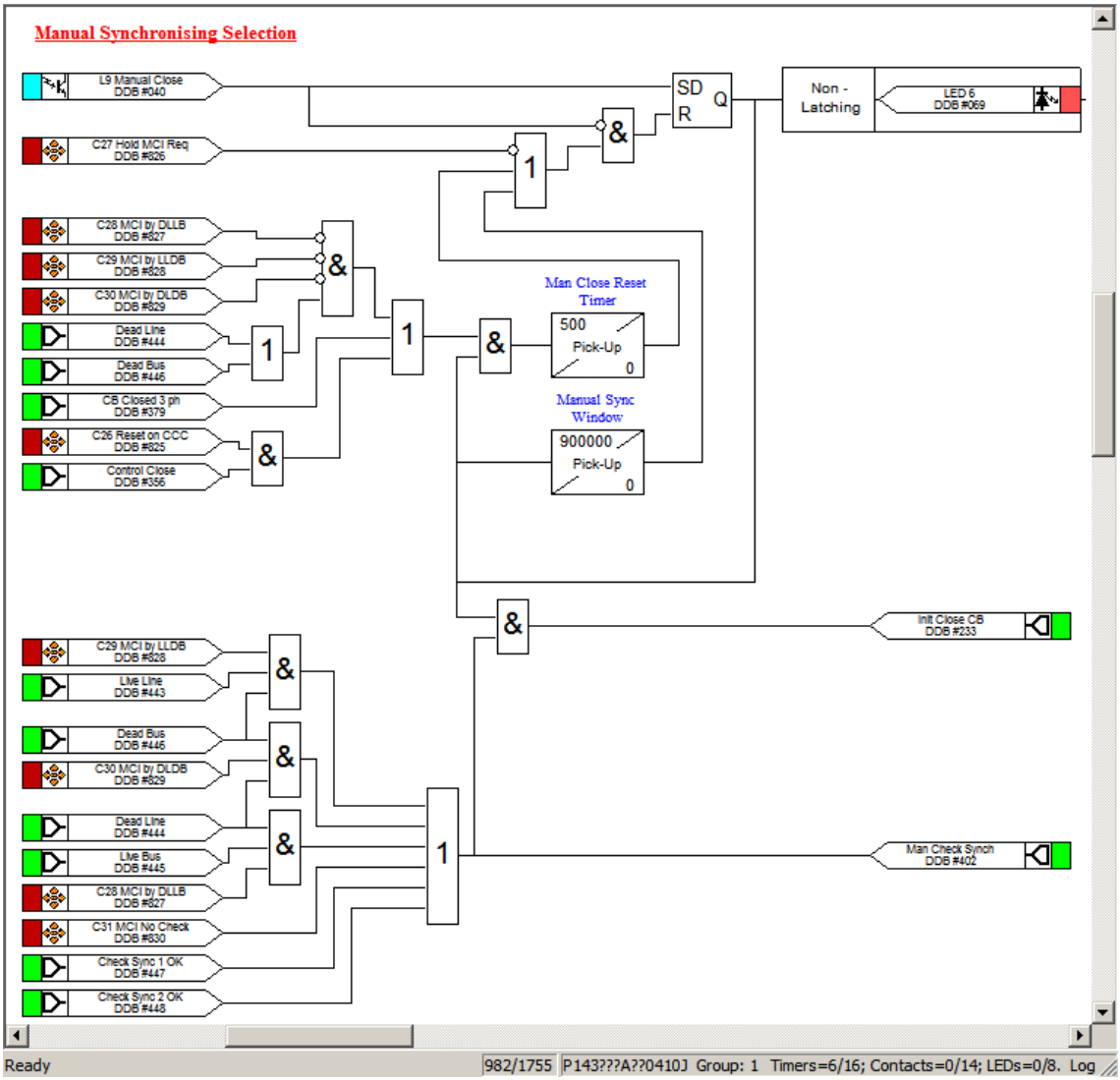

Figure 31: Manual Synchronising Selection logic

Initiation of a manual close of the CB occurs when digital input "L9 Manual Close" is energised. If Control Input 27 "C27 Hold MCI Req" is set to "Disabled" this input must remain energised until the CB is closed. However, if this control input is set to "Enabled", the initiating signal will automatically be maintained until input L9 is de-energised and one (or more) of the following conditions occur:

- Dead line or Dead bus voltage detected with control inputs 28, 29 and 30 all set to "Disabled" for a period greater than the "Man Close Reset Timer"
- CB Closure detected for a period greater than the "Man Close Reset Timer"
- If Control Input 26 "C26 Reset on CCC" is set to "Enabled" and the control close pulse is operated for a period greater than the "Man Close Reset Timer"
- If the manual close request is on for a period greater than the "Manual Sync Window"

The "Man Close Reset Timer" and "Manual Sync Window" are timers residing within the Programmable Scheme Logic of the P14x relay. As such their time delays cannot be set from the relay user interface and can only be changed by modifying the PSL and downloading it to the relay.

If Control Input 28 "C28 MCI on DLLB" is set to "Enabled", manual closure is permitted based upon Dead Line / Live Bus conditions.

If Control Input 29 "C29 MCl on LLDB" is set to "Enabled", manual closure is permitted based upon Live Line / Dead Bus conditions.

If Control Input 30 "C30 MCl on DLDB" is set to "Enabled", manual closure is permitted based upon Dead Line / Dead Bus conditions.

If Control Input 31 "C31 MCl No Check" is set to "Enabled", manual closure is permitted regardless of the line and bus voltage conditions.

In addition to the permissions given by control inputs 28 to 31, if Check Sync 1 or Check Sync 2 conditions are satisfied, manual closure is permitted. Again, it is re-iterated that these two check synchronism elements are always controlled by the logic proposed in sub-clause 3.12 as well as the settings in the System Checks menu column.

With the appropriate system checks performed and provided the request for manual closure is still active, a signal to initiate manual closure is passed to the fixed scheme logic of the P14x relay using DDB#233 "Init Close CB".

Programmable LED6 will illuminate for as long as the request for manual closure is active.

4. INTERFACE SUMMARY

Sub-clauses 4.2, 4.3, 4.4, 4.5 and 4.6 highlight the interface mappings that could be used on the Alstom MiCOM P14x range to facilitate "J-unit" type auto-reclose. The actual configuration for any real-life application may vary from this but could be used as a starting point for any scheme creation.

4.1. TYPICAL APPLICATION DIAGRAM

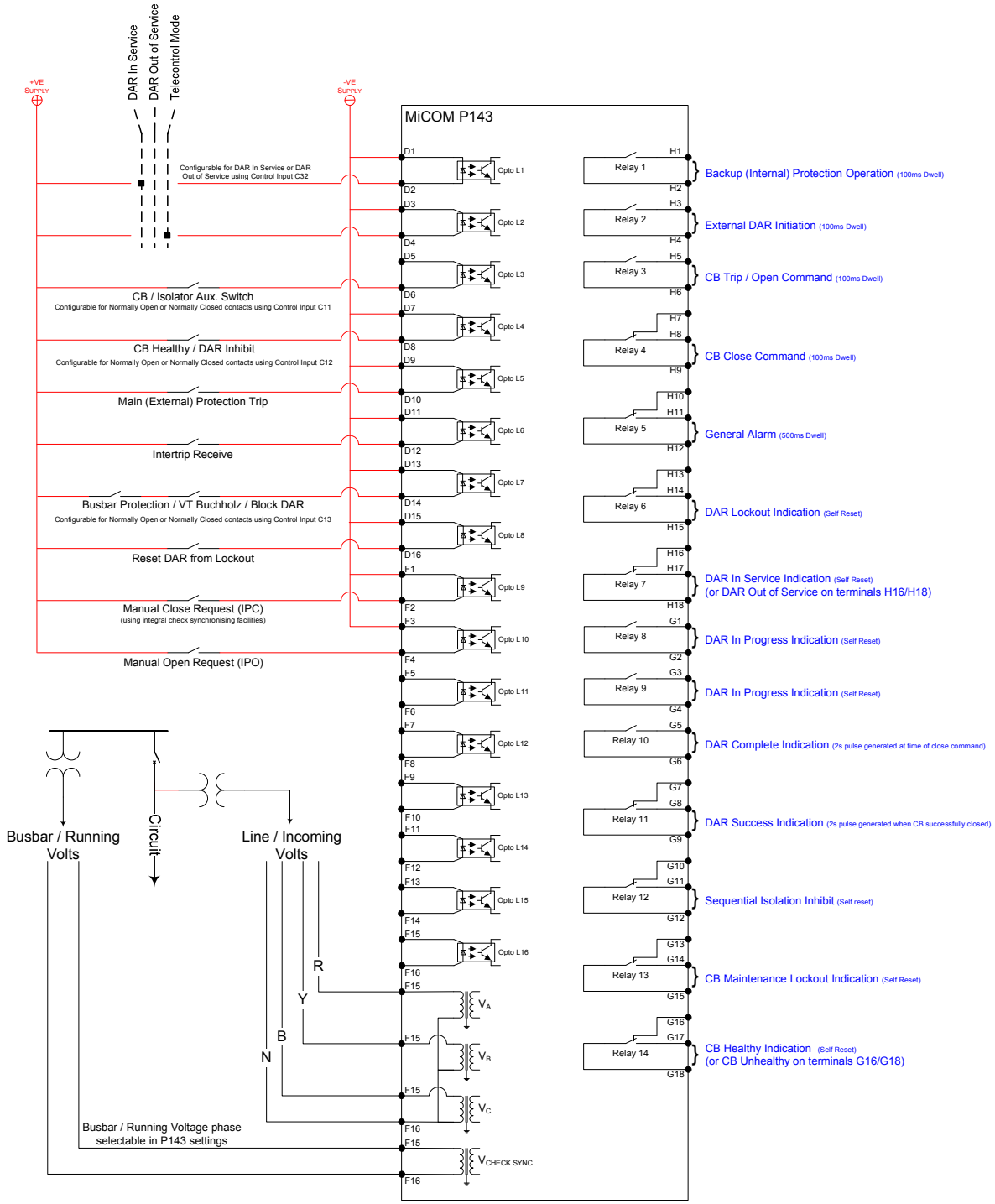

Figure 32: Typical application diagram based upon P143

4.2. DIGITAL INPUTS

Digital Inputs			
NO	TEXT	FUNCTION	CONDITIONING CONTROL INPUT
1	L1 DAR InService	Switches DAR into service locally	C32 DAR IN ActLo
2	L2 DAR Telectrl	If activated, DAR In Service is driven by remote commands	-
3	L3 CB Position	Single point CB position	C11 CBStat ActLo
4	L4 CB Charge	Single point indication of CB energy (spring charge/gas pressure) or DAR Inhibit	C12 CBChrg ActLo
5	L5 Ext Prot Trip	Trip signal from external protection(s) to initiate DAR	-
6	L6 Intertrip Rx	Intertrip receive signal used to initiate DAR	-
7	L7 Block DAR	Causes lockout of DAR and prevents further DAR attempts until lockout is reset. Typically from busbar or VT buchholz protection	C13 BAR ActiveLo
8	L8 Reset DAR	Input signal used to reset the DAR relay from lockout but also resets latched flags & contacts	-
9	L9 Manual Close	Input signal used to initiate a manual close with appropriate system checks	-
10	L10 Manual Open	Input signal used to initiate a manual open	-

4.3. DIGITAL OUTPUT CONTACTS

Digital Output Contacts			
NO	MODE	TEXT	FUNCTION
1	Dwell (100ms)	R1 Internal Trip	Indication of any internally configured protection function trip
2	Dwell (100ms)	R2 External Trip	Indication of any external protection function trip that drives DAR
3	Dwell (100ms)	R3 CB Trip	CB open command signal
4	Dwell (100ms)	R4 CB Close	CB close command signal
5	Dwell (500ms)	R5 General Alarm	General alarm output
6	SR	R6 DAR Lockout	Indication of any lockout condition that will prevent DAR
7	SR	R7 DAR InService	Indication of DAR in service (or DAR Out of Service if normally closed contact used)
8	SR	R8 AR InProgress	Indication that DAR sequence is in progress (from protection trip to CB close command)
9	SR	R9 AR InProgress	Indication that DAR sequence is in progress (from protection trip to CB close command)
10	Pulse (2s)	R10 DAR Complete	Indication that DAR sequence has completed (but not necessarily successful closure)
11	Pulse (2s)	R11 DAR Success	Indication that DAR sequence has completed successfully to healthy closure
12	SR	R12 Seq Isol Inh	Output to prevent sequential isolator opening during DAR sequence
13	SR	R13 CB Maint LO	Indication of any CB maintenance lockout condition
14	SR	R14 CB Healthy	Indication of healthy state of CB (or unhealthy state of CB if normally closed contact used)

4.4. PROGRAMMABLE LEDS

LED INDICATIONS		
LED	MODE	FUNCTION
1	MR	Internal Protection Trip
2	MR	Main (External) Protection Trip
3	MR	Intertrip Receive
4	SR	DAR In Progress
5	SR	DAR Lockout
6	SR	Manual Close Initiated
7	SR	CB Open
8	SR	CB Close

4.5. CONTROL INPUTS

CONTROL INPUTS				
NO	MODE	TEXT	SETTING	FUNCTION
1	Latched	C01 Pers IT Rx	Enabled	Allows persistent intertrip receive signal to block DAR
			Disabled	Persistent intertrip receive signal doesn't block DAR
2	Latched	C02 Pers ExtTrip	Enabled	Allows persistent main (external) protection trip signal to block DAR
			Disabled	Main (external) protection trip signal doesn't block DAR
3	Latched	C03 Pers CBChrg	Enabled	Allows persistent low CB energy signal to block DAR
			Disabled	Low CB energy signal doesn't block DAR
4	Latched	C04 Bus VT Avail	In	Bus VT is available and therefore Bus voltage must be Live before CB opening
			Out	No Bus VT is available and therefore Bus voltage isn't considered before CB opening
5	Latched	C05 LineVT Avail	In	Line VT is available and therefore Line voltage must be Live before CB opening
			Out	No Line VT is available and therefore Line voltage isn't considered before CB opening
6	Latched	C06 DLC Permit	Enabled	Dead Line Charging (Dead Line & Live Bus voltages) is permitted to start the Dead Time running
			Disabled	Dead Line Charging (Dead Line & Live Bus voltages) is not permitted to start the Dead Time
7	Latched	C07 DBC Permit	Enabled	Dead Bus Charging (Live Line & Dead Bus voltages) is permitted to start the Dead Time running
			Disabled	Dead Bus Charging (Live Line & Dead Bus voltages) is not permitted to start the Dead Time
8	Latched	C08 DLDB Permit	Enabled	Dead Line & Dead Bus voltage condition is permitted to start the Dead Time running
			Disabled	Dead Line & Dead Bus voltage condition is not permitted to start the Dead Time running
9	Latched	C09 Dead Line IL	Enabled	Only the Line voltage must be seen to go "Dead" to allow the Dead Time to start running
			Disabled	Line voltage isn't required to go "Dead" to allow the Dead Time to start running (control input 10 must also be disabled).

CONTROL INPUTS				
NO	MODE	TEXT	SETTING	FUNCTION
10	Latched	C10 Dead Bus IL	Enabled	Only the Bus voltage must be seen to go "Dead" to allow the Dead Time to start running
			Disabled	Bus voltage isn't required to go "Dead" to allow the Dead Time to start running (control input 9 must also be disabled).
11	Latched	C11 CBStat ActLo	Enabled	The CB status input is de-energised when the CB is closed i.e a 52b type input is connected to input L3. (CB Status Input setting must be 52a in the CB Control column of the menu).
			Disabled	The CB status input is energised when the CB is closed i.e a 52a type input is connected to input L3. (CB Status Input setting must be 52a in the CB Control column of the menu).
12	Latched	C12 CBChrg ActLo	Enabled	The CB energy (DAR Inhibit) input is de-energised when the CB is considered healthy (or inhibit not required)
			Disabled	The CB energy (DAR Inhibit) input is energised when the CB is considered healthy (or inhibit not required)
13	Latched	C13 BAR ActiveLo	Enabled	The Block Auto-reclose (BB/VT Buchholz protection) input is de-energised when DAR lockout is required.
			Disabled	The Block Auto-reclose (BB/VT Buchholz protection) input is energised when DAR lockout is required.
16	Latched	C16 Reset ASonSS	Enabled	Permits resetting of the Auto Synchronising mode when a Check Sync 2 output is given (resetting is time delayed by "Sys Sync Reset Timer in PSL)
			Disabled	Resetting of the Auto Synchronising mode is not permitted as a result of a positive Check Sync 2 output.
17	Latched	C17 Limit AS Tm	Enabled	Limits the amount of time that the scheme can be in Auto Synchronising mode. Time period fixed by "Sys Sync Window" timer in PSL.
			Disabled	No limit is placed on how long the DAR scheme can remain in Auto Synchronising mode.
18	Latched	C18 Auto SysSync	Enabled	Either Check Sync 1 or Check Sync 2 elements will be enabled during DAR depending upon whether a System Split condition is detected.
			Disabled	Check Sync 1 and Check Sync 2 elements operate in independently during DAR in accordance with control input C20.
19	Latched	C19 Split Hold	Enabled	This will prevent both check sync elements from giving an output to permit closure if a system split condition is detected. (Only relevant if C18 or C21 is set to disabled)
			Disabled	System split doesn't prevent the check sync elements from giving an output to permit closure.

CONTROL INPUTS				
NO	MODE	TEXT	SETTING	FUNCTION
20	Latched	C20 Sep CS Elem	Enabled	This ensures that only Check Sync 1 is used for auto-reclose and only Check Sync 2 for manual closure. (Only relevant if C18 and C21 is set to Disabled).
			Disabled	Check synchronising element usage is controlled by "Automatic System Synchronising" logic and control inputs C16 to C19 and C21.
21	Latched	C21 Man SysSync	Enabled	Either Check Sync 1 or Check Sync 2 elements will be enabled during manual closure depending upon whether a System Split condition is detected.
			Disabled	Check Sync 1 and Check Sync 2 elements operate in independently during manual closure in accordance with control input C20.
22	Latched	C22 Hold Lockout	Enabled	If C19 is Enabled and a split condition is detected such that both Check Sync 1 and Check Sync 2 are inhibited, DAR is immediately forced to lockout.
			Disabled	If C19 is Enabled and a split condition is detected such that both Check Sync 1 and Check Sync 2 are inhibited, DAR lockout is not forced.
26	Latched	C26 Reset on CCC	Enabled	Initiation of the manual close command can be reset by the control close pulse after the "Man Close Reset Timer" delay provided input "L9 Manual Close" has also been de-energised.
			Disabled	Resetting of the manual close command is not performed with reference to the control close pulse. (Other reset conditions must be satisfied).
27	Latched	C27 Hold Mcl Req	Enabled	Manual close command is latched until the CB closes regardless of the state of the initiating input. (Used if the input is a short pulse to initiate the manual close process).
			Disabled	Manual closure is only permitted for as long as the input is energised.
28	Latched	C28 MCl by DLLB	Enabled	Permit manual closure by Dead Line / Live Bus (Dead Line Charge) conditions
			Disabled	Manual closure by Dead Line / Live Bus (Dead Line Charge) not permitted
29	Latched	C29 MCl by LLDB	Enabled	Permit manual closure by Live Line / Dead Bus (Dead Bus Charge) conditions
			Disabled	Manual closure by Live Line / Dead Bus (Dead Bus Charge) not permitted
30	Latched	C30 MCl by DLDB	Enabled	Permit manual closure by Dead Line / Dead Bus conditions
			Disabled	Manual closure by Live Line / Dead Bus not permitted
31	Latched	C31 Mcl No Check	Enabled	Permit manual closure without requirement for check synchronising or system voltage checks
			Disabled	Manual closure only permitted by check synchronising and system checks (according to control inputs 28, 29 & 30)

CONTROL INPUTS				
NO	MODE	TEXT	SETTING	FUNCTION
32	Latched	C32 DAR IN ActLo	Enabled	The DAR In Service input is de-energised when DAR In Service is required.
			Disabled	The DAR In Service input is energised when DAR In Service is required.

4.6. USER ALARMS

USER (Text) ALARMS			
ALARM	MODE	TEXT	FUNCTION
1	SR	A1 CS1 Active	Check sync 1 element enabled
2	SR	A2 CS2 Active	Check sync 2 element enabled
3	SR	A3 CS1+2 Active	Check sync element 1 and 2 enabled
4	SR	A4 Split Hold	Check sync element 1and 2 blocked due to split detection.
19	MR	A19 Pers IT Rx	Persistent Intertrip Receive Signal
20	MR	A20 Pers ExtTrip	Persistent Main (External) Protection Signal
21	MR	A21 Pers CBChrg	Persistent CB Low Charge Signal (or DAR Inhibit signal)
22	MR	A22 DAR ExtTrip	DAR initiated by external main protection trip
23	MR	A23 DAR IT Rx	DAR initiated by intertrip receive

5. CONCLUSION

It is hoped that this document has demonstrated the ability of the MiCOM P14x to emulate the delayed auto-reclose (DAR) requirements previously covered by CEGB standards TPS12/10, TPS12/12, TPS 12/25 and TPS12/72 which are now generically covered by National Grid Technical Specification (NGTS) 3.24.16. The necessary logic arrangements necessary for correct scheme operation have been demonstrated and the full programmable scheme logic (PSL) file based upon firmware version 41 is available from the Sales Support team at Alstom Grid in Stafford.

REVIEW HISTORY

Issue	Name	Position
F	M. Stockton	Business Development Manager

VERSION CONTROL

Issue	Author(s)	Reason for change	Date
A	M. Stockton	Original	18/11/09
B	M. Stockton	Modifications to check sync control selection forcing CS1 for DAR and CS2 for manual close when Ctrl IP 18=0 and Ctrl IP 20=1. Logic created to control enabling of CS1 and CS2 as opposed to original logic that blocked outputs. Figures 22, 29 and 30 replaced with new logic, and explanations in sub-clauses 3.9, 3.12 and 3.13 amended accordingly.	20/11/09
C	M. Stockton	Modifications to check sync control selection to be more flexible following comments from SPEN. Control inputs 21 & 22 added with additional user alarm 4 with consequential modified use of control inputs 18, 19 and 20. Figure 30 added and consequential renumbering of other figures. Figures 8 and 29 replaced with new logic, and explanations in sub-clauses 3.5 and 3.12 amended accordingly. Sub-clauses 4.4 and 4.5 modified to include new features. Sub-clause 3.10 modified to provide more clarity on the difference between output contacts R10 and R11.	09/12/09
D	M. Stockton	Section 4.1 and Figure 32 added and conseqential renumbering of section 4.	30/04/10
E	M. Stockton	Re-formatting to Alstom Grid. Addition of comment regarding P142 application in introduction.	10/11/10
F	M. Stockton	New Application Guide Alstom format. Document reference changed from MS-20091101-1	10/02/12