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AUTOMATION SCHEMES

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PURPOSE AND SCOPE

This specification defines the generic technical requirements for Automation Schemes for the management of power system constraints

Automation Schemes operate primary equipment to automatically reconfigure the primary network to prevent abnormal system conditions occurring which could lead to thermal overloading, system instability, the potential to temporarily overstress switchgear, voltage transgression or loss of supply.

To accomplish this, Automation Schemes are configured to perform pre-determined switching sequences that will result in the sequenced opening and/or closing of combinations of circuit breakers and occasionally disconnectors. This functionality is used to overcome power system constraints that limit the ability to:-

- Utilise the circuit capacity available to supply local distribution networks.
- Provide transmission export capacity to local Generation following a fault.

Auto Close schemes are normally used to automatically undertake simple network re-configuration sequences but may be specified to provide more complex operations i.e. the operation of disconnectors and circuit breakers to re-configure substation busbars or circuit connectivity.

To facilitate use of this specification, Appendix D shows an informative example of a comprehensive generic Automation Scheme for an Auto Close application. This example illustrates a system designed to perform complex sequences, operating disconnectors and circuit breakers while obtaining information from a number of substation locations. Simple systems may be reduced in complexity to avoid providing unwanted and unnecessary equipment. Other scheme specific technical requirements will be defined by separate specifications which should be read in conjunction with this specification. These separate specifications are detailed in Appendix A

The purpose of this specification is to define the complete set of functionality required by an Automation Scheme for Auto Close sequences. An Automation Scheme Functional Requirements Specification (ASFRS) shall define which features are required

Specific application technical requirements shall be defined separately within a unique functional specification for each Automation Scheme. Each scheme specific functional specification should be read in conjunction with this Technical Specification. Unless specified otherwise in the scheme specific functional specification, all requirements of this Technical Specification shall apply.

This specification makes reference to or should be read in conjunction with the documents listed in the references section of this specification

PART 1 – PROCEDURAL

1 SCHEME SPECIFIC OPERATIONAL REQUIREMENTS

An Automation Scheme Functional Requirements Specification (ASFRS) shall be provided separately by National Grid to state the functional requirements of the Automation Scheme for a specific location or scheme.

The Automation Scheme shall operate plant or perform other control actions as defined by the ASFRS.

The ASFRS shall state:-

- a) The substations and plant to be monitored and controlled.
- b) The Scheme Operating Rules i.e the automation sequences to be taken in response to monitored plant states.
- c) The system performance requirements.

2 POWER SYSTEM INFORMATION

2.1 The power system information collected by the Automation Scheme shall be specified by the ASFRS and shall consist of. :-

- a) connectivity status of specified circuits
- b) connectivity status of specified substations
- c) analogue measurements
- d) conditioning signals from external systems that may influence the automation sequence

2.2 Monitoring of the Circuit Breaker Status by the Automation Scheme shall be the minimum requirement, however, the ASFRS shall specify where disconnector status is required.

2.3 The power system information collected by the Automation Scheme shall be used to determine:-

- a) the connectivity status and topology of the sections of the power system that are monitored and are defined in the scheme operating rules.
- b) The control sequence to be undertaken when the connectivity status and topology of the defined section of the power system or external conditioning signals match the operate conditions defined in the ASFRS.

3 POWER SYSTEM CONNECTIVITY STATUS

3.1 Feeder Circuit Status

Where this is required, the connection status of all ends of the feeder shall be monitored. This shall be used to determine that a feeder is out of service or in service and available for power transfer between substations.

3.2 Transformer Circuit Status

Where this is required, the connection status of the HV and LV sides shall be monitored. This shall be used to determine that a transformer is out of service, in service or available as a hot standby.

3.3 Circuits Connected to Double Busbar Substations

Circuit breaker and disconnector position indications associated with a specified circuit shall be monitored. This shall be used to determine the connectivity status of the circuit to its associated busbar.

3.4 Circuits Connected to Mesh Substations

Circuit breaker and disconnector position indications associated shall be monitored. This shall be used to determine the connectivity status of the circuit to its associated mesh corner.

3.5 Substation Connectivity Information

Where this is required the information shall be used to determine the operational state of connections between specified substation nodes. If required, indication of protection operation that can directly trip circuit breakers that interconnect substation busbars shall be provided.

3.6 Mesh Substations

Circuit breaker and disconnector position indications associated to a specified mesh corner shall be monitored. These shall be used to determine the connectivity status / topology of the substation busbars.

3.7 Double Busbar Substations

Circuit breaker and disconnector position indications associated to specified bus couplers and bus sections shall be monitored. These shall be used to determine the connectivity status / topology of the substation busbars.

3.8 Analogue Indications

Where analogue indicators are used to determine the service status of a circuit, then:-

- a) Voltage, current and/or power measurements shall be used to determine circuit status.
- b) Validation of the analogue measurements shall be performed by the automation scheme.

4 INTERFACE WITH DELAYED AUTO RECLOSE (DAR), BUSBAR AND BACKUP PROTECTION

Informative : In certain circumstances, it is necessary to delay, cancel or reverse an automation sequence for an ongoing or successful DAR sequence. In other circumstances it may be necessary to delay or cancel a DAR sequence while the Automation Sequence is in progress.

4.1 When an interface with Delayed Auto Reclose equipment is required, the Delayed Auto Reclose and Automation Scheme equipments shall be configurable to provide the following functionality:-

Provide a physical interface with the DAR scheme to enable conditioning signals to be exchanged between the Automation Scheme and the DAR scheme. The following should be included:-

- a) DAR IN Progress – Input.
- b) DAR Complete – Input.
- c) DAR Lockout – Input.
- d) Lockout DAR – Output.

Delay the specified automation sequence while an associated DAR sequence is in progress.

Cancel the automation sequence if an associated DAR sequence is successfully completed.

Complete the specified automation sequence on the controlled circuit breaker and then undertake a complete or defined reversal of the specified automation sequence if the associated DAR sequence is successfully completed.

Carry out the specified automation sequence and lockout DAR.

Informative : In certain circumstances, it may be necessary to cancel an automation sequence or prevent an automation sequence from commencing due to circuit load restrictions or inadequate fault level. An interface with Busbar or Backup protection may be necessary to fulfil these requirements.

4.2 An interface with Busbar or Backup Protection shall be provided if it is necessary to cancel or prevent the initiation of an automation sequence due to:-

- a) A busbar fault.
- b) An un-cleared fault on an outgoing circuit e.g Feeder or Transformer.

4.3 An Automation Scheme Inhibit or Sequence Cancel condition shall be raised to indicate all interaction of this type between the Automation Scheme and a DAR System or Busbar Protection. While the Automation Scheme Inhibit or Sequence Cancel condition is active it shall be reported as per the requirements of Section 18 and the table in Appendix B of this specification. The Automation Scheme Inhibit condition shall remain active until the condition has been cleared whereas the Sequence Cancel condition shall be a fleeting indication.

5 ANALOGUE MEASUREMENTS

Informative: Measurement system components include VT's, CT's, transducers and Automation Scheme measurement devices.

5.1 Where an analogue measurement event can initiate an Automation Scheme control action then analogue measurements shall be validated using any of the following possible methods:-

- a) Comparison of measurement from multiple points on each circuit.
- b) Comparison of consecutive measurements from the same point.
- c) Monitoring of measurement system health.
- d) Comparison with a reference measurement.

5.2 Where analogue measurements are validated by consecutive measurement samples, the number of samples and the time interval between samples shall be user configurable.

5.3 An analogue measurement failure condition shall exist if:-

- a) an analogue measurement has an error or discrepancy greater than a user defined level.
- b) Comparison of measurements from multiple points are not within a user configurable range or as expected by the system.
- c) The measurement system health monitor reports a failure of an analogue sub-system.
- d) Significant errors between consecutive measurements are reported.

5.4 While an analogue failure condition is active it shall be reported as per the requirements of Section 18 and the table in Appendix B of this specification and shall remain active until the faulty condition has been cleared and:-

- a) The respective analogue measurements shall be excluded as an input to Automation Scheme operating rules.
- b) Any additional action specified in the ASFRS shall be undertake e.g lock out the Automation Scheme.

6 OPERATION OF CONTROLLED PLANT USING POWER SYSTEM SYNCROCHECK FACILITIES

6.1 Where the Automation Scheme is required to close circuit breakers the system shall be provided with either of the following functionality:-

- a) An interface to a system capable of closing the respective circuit breaker under synchronising conditions (e.g a synchronizing syscheck relay.), and;
- b) Functionality to accept and react to an external System Split Indication, or;
- c) Synchronising functionality that is an integral part of the Automation Scheme equipment, and;
- d) Functionality to detect and react to a System Split condition.

6.2 The provision and configuration of External or Internal Synchronisation functionality shall comply with the requirements specified in the respective reference documents listed at the front of this specification:-

- a) Policy for Synchronising.
- b) Technical Specification for Synchronising.
- c) Technical Guidance Note for Synchronising.
- d) ASFRS.

7 SYSTEM INTERFACES

7.1 Plant State Open/Closed Indications

Informative: Where Feeder and Substation Connectivity status information is required, this shall be determined by monitoring Plant State (Switchgear) open/closed indications.

7.1.1 Plant State Indications shall be provided using double point complementary status indications. These shall provide positive confirmation of the following plant states – Open, Closed, DBI (00 state) DBI (11 state).

7.1.2 While Plant State Indications indicate DBI then the automation scheme shall:-

- a) Assume the switchgear to be in the last known state while the DBI condition persists.
- b) Allow the switchgear DBI condition to be manually overridden by the operator.
- c) Initiate a Plant State Indication Faulty condition.

7.1.3 A Plant State Indication Faulty condition is initiated by the Automation Scheme if a switchgear position does not indicate either open or closed for a user configurable period of time. If a Plant State Indication Faulty condition is detected it shall be reported as per the requirements of Section 18 and the table in Appendix B of this specification and shall remain active until the faulty condition has been cleared.

Informative: At a mesh station, a circuit (feeder or transformer) can remain in service while an associated mesh corner circuit breaker is out of service for maintenance. In this instance, the circuit breaker may present plant status conditions that could result in incorrect Automation Scheme operation. The Plant State Indication Override facilities shall allow circuit breaker plant status to be temporarily overridden.

- 7.1.4 A Plant State Indication Override facility shall be available to allow circuit breaker position indications to be forced to a user selectable state during circuit breaker maintenance or to override a DBI condition. While a plant state indication has been overridden, the condition shall be reported as per the requirements of Section 18 and the table in Appendix B of this specification and shall remain active until the override condition has been cleared.

8 INTERFACE BETWEEN AUTOMATION SYSTEM AND CONTROLLED OR MONITORED PLANT

Informative: The Interface between the Automation System and Controlled or Monitored Plant defines the facilities required at the point of interface between the Automation Scheme and the plant being controlled or monitored.

- 8.1 The Automation Scheme shall interface with the controlled and monitored plant defined in the ASFRS.
- 8.2 The interface point between Controlled or Monitored Plant and the Automation Scheme shall be the plant cable terminations.
- 8.3 The Interface between the Automation Scheme and Controlled or Monitored Plant shall include all items or equipment or wiring up to the plant cable terminations and shall include
- a) The plant control outputs from the Automation Scheme.
 - b) The Indication inputs to the Automation Scheme from the Controlled or Monitored Plant.
 - c) Any follower relays used to increase the output or input capability of the Automation Scheme.
- 8.4 The ability to test and monitor the Automation Scheme inputs and outputs shall be provided by a combination of Isolation Facilities and Plant Override facilities.
- 8.5 Output Isolation Facilities shall be provided for each of the Automation Scheme control outputs. This will provide facilities to allow physical isolation of the plant control circuit between the System Control outputs and the controlled plant.
- 8.6 The point of Output Isolation for the Automation Scheme Plant Control outputs shall have facilities that prevent accidental restoration of the associated control circuit to the controlled plant.
- 8.7 While a specific control output on the Automation Scheme is isolated the condition shall be reported as per the requirements of Section 18 and the table in Appendix B of this specification and shall remain active until the isolation condition has been cleared.-
- 8.8 The Operation of any controlled plant by the Automation Scheme shall only be permitted if the plant is indicating it is available for control or if a Controlled Plant Override condition is active.

9 SYSTEM CONTROL AND PLANT OPERATION INTEGRITY CHECKS

Informative:- Automation systems usually consist of multiple components e.g. a sequence controller with input and output facilities, circuit breakers, disconnectors, etc. If the Automation System fails to carry out its specified operation due to a failure of any component to perform the correct operation, it is necessary to identify which component has failed and why. To facilitate Automation System performance monitoring and fault diagnosis, it is necessary to include certain feedback signals as part of the system design. Other sections within this specification deal with the reliability of the automation scheme equipment. This section specifies the requirements to enable the integrity of the controlled plant operation to be validated.

- 9.1** The integrity and correct operation of the Automation Scheme control outputs and controlled plant shall be monitored. This shall be achieved using feedback signals from these devices. These feedback signals shall report:-
- a) The operation of the correct system control output.
 - b) confirmation that the operate circuit for the controlled plant has received a control command from the automation system.
 - c) That the plant has responded correctly to the control command from the automation system.
- 9.2** A Control Output Fail condition shall be raised for a failure of any Automation Scheme control output to correctly respond to the system logic. The operation of the Automation Scheme control outputs shall be validated against the system logic and a Control Output Fail condition shall be raised for any discrepancy. The Automation Scheme shall be able to detect and report the following conditions:-
- a) The failure of a system control output to operate when required by the system logic.
 - b) The failure of a system control output to reset when required by the system logic.
 - c) The spurious operation of a system control output.
- 9.3** When a Control Output Fail condition is active it shall be reported as per the requirements of Section 18 and the table in Appendix B of this specification.
- 9.4** A Plant Control Fail condition shall be raised for a failure of the trip or close circuits in the controlled plant to correctly respond to a control output from the Automation Scheme. When a Plant Control Fail condition is initiated, it shall be reported as per the requirements of Section 18 and the table in Appendix B of this specification.
- 9.5** A Plant Operation Fail condition shall be raised to indicate the failure of any item of controlled plant to correctly respond to a received plant control from the Automation Scheme. The controlled plant status shall be monitored and validated against the Automation Scheme control outputs. The controlled plant shall be required to operate successfully within a configurable maximum operate time from the point of activation of the control output. If the controlled plant does not operate within the maximum operate time, a Plant Operation Failed condition shall be raised when the sequence has terminated. When a Plant Operation Fail condition is initiated, it shall be reported as per the requirements of Section 18 and the table in Appendix B of this specification.

9.6 A Control Action Complete condition shall be raised to indicate that all items of controlled plant have correctly responded to a control output from the Automation Scheme by indicating a change of state. In order for the Control Action Complete condition to be raised, the Automation Scheme shall compare all the intended controlled plant operations with the actual changes of state returned from controlled plant. A Control Action Complete condition shall be raised only in response to the successful completion of the sequence i.e. the confirmation of the change of state of all controlled plant. When a Control Action Complete condition is initiated, it shall be reported as per the requirements of Section 18 and the table in Appendix B of this specification

9.7 In the event of a Plant Operation Fail or a Control Output Fail Condition, the ASFRS shall define what alternative action, if any, should be performed by the Automation Scheme.

Informative: Alternative actions include: provision of circuit breaker fail scheme; backup Automation Scheme control action etc.

10 SYSTEM COMMUNICATIONS

Informative: Communication links from remote substations may be required to interconnect Automation Scheme nodes and convey the system connectivity, status and event information that form part of the Automation Scheme Operating Rules or system health monitoring.

Informative:- The term "Communications link(s)" shall refer to and include all communications equipment and media used to convey the automation system information between nodes of the automation system.

10.1 Where Communication links are required to connect nodes of the Automation Scheme, these shall be specified and provided to achieve the required functional, performance, dependability and security.

10.2 All communications links between Automation Scheme nodes shall be monitored by the system. Any abnormality of the communications shall be reported by the Automation Scheme. Abnormalities shall include:-

- a) Increase in the bit errors over the communication link.
- b) Lost packets.
- c) Complete loss of communications on any communications link e.g no response from remote node.

10.3 A Comms Link Faulty condition shall be raised for any abnormal communications link condition. While a Comms Link Faulty condition is active, it shall be reported as per the requirements of Section 18 and the table in Appendix B of this specification and shall remain active until the faulty condition has been cleared.

10.4 Minimisation of spurious abnormal Comms Link Faulty conditions shall be achieved by providing a configurable delay and/or threshold setting. These should be provided to prevent the Automation Scheme from raising an alarm until one or both of these limits have been exceeded.

10.5 Communications links shall comply with the requirements stated in the current version of the Technical Specification for Communications for Teleprotection where:-

- a) Communication Links are used to convey events between automation system nodes at multiple substations, and;

- b) The conveyed events will directly result in the operation of plant by the Automation Scheme
- 10.6** Duplicate Communication Links shall be provided unless otherwise specified in the ASFRS.
- 10.7** Where communications links between substations are duplicated, the following conditions apply:-
 - a) Communication channels shall be provided over physically diverse and segregated routes that shall not cross.
 - b) there shall be no single failure mode, which affects both links.
 - c) In the event of a failure of the main power source to the communications equipment, the design shall ensure that at least one communications channel remains operational. In this instance, the “power source” shall include the fuses and cables used to connect the main power source to the equipment.
- 10.8** Where data is conveyed using duplicate communications links between Automation Scheme nodes, the system shall be capable of managing duplication of information or arbitration and switching between duplicate links.
- 10.9** Protection signalling equipment with multiple event channels may be used to convey time critical events between substations. When this is utilised, it shall be permissible to utilise all channels and convey a separate event on each channel provided:-
 - a) Two independent protection signaling devices (communication links) are provided.
 - b) There shall be no single failure mode, which affects both links.
- 10.10** Single Pole switching of event channel inputs and outputs may be used where protection signalling equipment with multiple event channels is fitted. Single Pole switching shall only be used if the inputs and outputs are:-
 - a) Connected directly to the Automation Scheme inputs and outputs.
 - b) Not connected directly to any substation plant.

11 AUTOMATION SCHEME OPERATING RULES

Informative: Automation Scheme Operating Rules determine the response of the Automation Scheme to system conditions and events defined in the ASFRS.

11.1 Operating Rules - Introduction

- 11.1.1** A set of Operating Rules shall be maintained and used by the Automation Scheme as part of a continuous monitor on the primary and secondary system.
- 11.1.2** There will always be a minimum of one Operating Rule
- 11.1.3** The number of Operating Rules available will depend on the complexity of the scheme i.e.
 - a) The complexity of the primary and secondary system that is monitored, and;
 - b) The different permutations for the configuration and operation of the primary and secondary systems monitored by the Automation Scheme.
- 11.1.4** The state of each Operating Rule shall define how it shall be used by the Automation Scheme.

11.1.5 Each Operating Rule shall have two states:-

- a) Active for Operating Rules that shall produce a response that can operate primary plant only when the correct system conditions are detected and the system is armed.
- b) Offline for Operating Rules that shall not produce a response that can operate primary plant even if the correct system conditions are detected and the system is armed.

11.1.6 Immediately after Resetting or Powering Up the Automation Scheme:-

- a) All Operating Rule(s) shall default to the Offline state.
- b) All Operating Rule(s) shall default to the de-selected state.
- c) The Automation Scheme shall default to the Disarmed state.

11.2 Operating Rules – Process For Validation And Activation Or De-Activation

Informative:- Before an Offline Operating Rule is activated, a validation process shall be undertaken to verify that activation of the Offline Operating Rule will not cause an undesired operation of plant.

11.2.1 Activation or De-Activation of Operating Rules shall only be possible when:-

- a) The Automation Scheme has been disarmed.
- b) The operating rule has been selected for activation or de-activation.
- c) Validation of an Offline Operating Rule has been undertaken.
- d) The validation checks have been completed on the selected Offline Operating rule.

11.2.2 A multi stage process shall be implemented during the deactivation or validation and activation of Operating Rules. The Validation/Activation or De-activation Process shall be as follows:-

Informative:- In small Automation Schemes it may be possible to combine some of the following stages to simplify the Validation and Activation process. The supplier shall agree any simplification of the processes with National Grid before implementation.

11.2.3 Stage 1 – Disarm the system. The user shall select and activate the System Disarmed mode in order to prevent unwanted plant operation during the selection of Active and Offline Operating Rules

Informative:- In small systems where only 1 rule can be activated at any time or only a small number of fixed and individually selectable rules are available, it may be possible to combine stages 2, 3 and 4.

11.2.4 Stage 2 – Select an Active Operating Rule or an Offline Operating Rule The user shall not be able to Select an Active or Offline Operating Rule until the System Disarmed mode is active.

11.2.5 Stage 3 – Validate an Offline Active Operating Rule. The user shall not be able to Validate an Offline Operating Rule until

- a) The System Disarmed mode is active, and;
- b) An Offline Operating Rule is selected.