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# National Grid

National Grid  
Technical  
Specification

**Automatic Tap Change  
Control**

NGTS 3.24.61  
Issue 1  
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| CONTENTS                                                                                                 | Page |
|----------------------------------------------------------------------------------------------------------|------|
| Foreword .....                                                                                           | 1    |
| 1 Scope .....                                                                                            | 1    |
| 2 References .....                                                                                       | 1    |
| 3 Abbreviations and Definitions .....                                                                    | 1    |
| 4 Functional Requirements .....                                                                          | 2    |
| 5 Interface .....                                                                                        | 7    |
| 6 Performance Requirements .....                                                                         | 9    |
| 7 Implementation .....                                                                                   | 10   |
| Appendix A: I/O Requirements .....                                                                       | 11   |
| Appendix B: Contract Specific Information<br>(Site Details) .....                                        | 13   |
| Appendix C: ATCC Control facilities<br>required at different control points .....                        | 15   |
| Appendix D: Minimum Requirements for<br>the ATCC System for Different<br>Substation Configurations ..... | 16   |
| Appendix E: Figures .....                                                                                | 18   |

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## AUTOMATIC TAP CHANGE CONTROL

### FOREWORD

*This Specification is a functional specification within the Substation Information, Control and Protection suite of technical specifications. It shall be called up and applied by appropriate station level specifications.*

### 1 SCOPE

This Specification describes the functional and performance requirements for Automatic Tap Change Control (ATCC) for National Grid transformers (supergrid transformers) operating between 400 kV or 275 kV circuits and lower voltage busbars.

The requirements for ATCC in this document are designated for a substation with up to six busbars and seven transformers. For substations with different configurations, these specified functions may not be fully required. The minimum requirements for the ATCC systems for different substation configurations are listed in Appendix D.

### 2 REFERENCES

This Specification makes reference to, or should be read in conjunction with the following documents:

- NGTS 3.24.4    Hardware Platform
- BS EN 60688    Electrical Measuring Transducers for Converting A.C. Electrical Quantities to Analogue or Digital Signals.
- BS 7194        Direct-Current and Low Frequency Electrical Measuring Instruments with A Digital Display.
- EN60051-1    Direct Acting Indicating Analogue Electrical Instruments and Their Accessories, Part 1.

### 3 ABBREVIATIONS AND DEFINITIONS

- ATCC:**            Automatic Tap Change Control. ATCC systems control the voltage at LV busbar(s) of supergrid transformers by changing transformer tap positions.
- Busbar:**         A length of conductor in a substation to which circuits (comprising transformers) are connected.
- Busbar group:** A busbar or a group of connected busbars to which one or more transformers are connected together on the lower voltage side.
- IED:**            Intelligent Electronic Device.
- INHIBIT:**       To temporarily suspend a defined function when the specified conditions are detected. The suspended function shall automatically recover when the specified conditions clear.
- MCB:**           Miniature Circuit Breaker, used to trip the motor for driving transformer tap change mechanism.
- Plant:**          In this document, plant refers to heavy current equipment at a substation, such as power transformers, voltage and current transformers as well as circuit breakers and disconnectors, etc.
- RCP:**            Remote Control Point. This is normally at the National Grid Control Centre but may be at a manned control point.

|       |                                                                                                                                                                                                                                                                                                                                                           |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SCP:  | Substation Control Point. A facility on site, providing full centralised control and monitoring facilities for the whole site. It is to be used for maintenance roles and for operation of the site in the event of loss of remote facilities. For ATCC, this control facility may be either integrated with the substation control system or standalone. |
| SCS:  | Substation Control System, see NGTS 2.24.                                                                                                                                                                                                                                                                                                                 |
| SGT:  | Supergrid Transformer. Transformers used in National Grid transmission system.                                                                                                                                                                                                                                                                            |
| TCIP: | Tap Change In Progress. A signal produced by transformer tap change mechanism to indicate that the tap is changing position.                                                                                                                                                                                                                              |

## 4 FUNCTIONAL REQUIREMENTS

### General

**4.1** The ATCC system shall detect busbar voltages on the LV side of supergrid transformers which are outside set voltage limits (deadbands) and shall initiate the operation of transformer tap changers to restore the LV voltage to within limits.

**4.2** The ATCC system shall be capable of controlling up to six busbars and seven transformers, maximum four transformers in parallel within a busbar group.

*Informative: Examples for substations with different configurations are illustrated by Figure 5 – 9 in Appendix E. The site details for specific contracts will be given by National Grid in Appendix B. A diagram of the substation layout will also be provided by National Grid.*

**4.3** The ATCC system shall automatically detect the topology of the LV substation and recognise the busbar grouping for transformer tap change control.

### Control Points

**4.4** There shall be a Remote Control Point (RCP) and a Substation Control Point (SCP) for the ATCC system.

**4.5** When selected to RCP, control from the SCP shall be inhibited and when selected to the SCP, Remote Control shall be inhibited.

*Informative: The detailed requirements about the control points for different implementation schemes are specified in Clause 7.1 – 7.3. These control points are illustrated by Figure 1 in Appendix E. The facilities required at all the control points are detailed in Appendix C.*

### Busbar Control Principles

**4.6** It shall be possible to select each busbar, or busbar group, to either Auto Control “In” or Auto Control “Out”. When a transformer is switched to a busbar with Auto Control “In”, the manual control function of the ATCC system for that transformer shall be inhibited.

*Informative: Auto Control “In” refers to ATCC being selected for automatic voltage control for a busbar or busbar group. Auto Control “Out” refers to ATCC not being selected for automatic voltage control for a busbar or busbar group.*

**4.7** When two or more busbars/busbar groups are coupled by switching action to produce a single busbar group, the composite busbar group shall be Auto Control “In” **if and only if** all the component busbar/busbar groups were under Auto Control “In” prior to the switching.

**4.8** When two or more busbars/busbar groups are coupled by switching action to produce a single busbar group, the composite busbar group, shall adopt the single voltage target determined by the priority busbar. The priority order is Main Busbar 1, Main Busbar 2, Main Busbar 3, Reserve Busbar 1, Reserve Busbar 2, Reserve Busbar 3. (ie Main Busbar takes priority over Reserve Busbar, lower numbered busbar sections take priority over higher numbered busbar sections).

- 4.9 After two or more busbars/busbar groups are coupled into a single busbar group, the Auto control “In/Out” and “Target Voltage” for the composite busbar group shall be selectable from any of the busbars within the group.
- 4.10 When a busbar group comprising two or more busbars is split into two or more busbar groups, all busbar groups shall retain the Auto Control status and the voltage target of the original composite busbar group.
- 4.11 When the DBI status is detected for a switchgear (see Clause 5.9), the affected busbars/busbar groups with auto control “In” shall be automatically switched to “Auto Out”. Unaffected busbars/busbar group shall remain the Auto Control status unchanged. An alarm “Plant DBI” shall be generated.
- 4.12 A selective facility shall be available to override the DBI status for a switchgear. This facility shall be achieved via monitoring/diagnostic facilities (see 5.24) or the LCP/SCP as appropriate. When the DBI override is set for a switchgear, ATCC system shall treat the status of the switchgear as open regardless of its actual state, and an indication “DBI override” shall be illuminated at the LCP and SCP.
- 4.13 If a plant fault occurs while Auto Control is “In”, then the busbar group(s), with which that faulted plant is associated shall revert to Auto Control “Out”. Any busbar groups not affected by the fault shall remain unaffected and the ATCC shall continue to function (See Clause 5.21).
- 4.14 Any ATCC internal failure that results in failure of the ATCC system to function shall result in the ATCC reverting all busbar groups to Auto Control “Out” (See Clause 5.22).
- 4.15 All events or faults associated with or affecting the ATCC function shall be logged.

#### Voltage Control

- 4.16 When Auto Control “In” is selected for a busbar/busbar group, the ATCC system shall attempt to maintain the voltage of the busbar/busbar group within pre-set deadbands around a target voltage.
- 4.17 It shall be possible to select a target voltage, for each busbar group, from a selection of minimum four (preferably five) pre-set target voltages. The target voltages shall be settable in the range  $\pm 10\%$  of nominal busbar voltage.
- 4.18 Target voltage for a busbar shall be capable of being changed no matter whether Auto Control is “In” or “Out” for that busbar. The ATCC system shall accept the new voltage target and indicate that target at all control points.
- 4.19 When Auto Control is “Out” for a busbar, the target change shall happen immediately. When Auto control is “In” for a busbar, the new target shall be indicated immediately but the target value shall be ramped to the new value at a pre-set rate.
- 4.20 The target voltage ramping rate shall be settable in range 0.1 kV/min to 30 kV/min at increment of 0.1 kV/min.
- 4.21 While the target value is ramping, should the busbar be switched to Auto Control “Out” or be coupled to a higher priority busbar, then it immediately assumes its selected target or the target of the higher priority busbar.
- 4.22 When the ATCC starts up, the ATCC shall be on Auto Control “Out” and adopt a target voltage pre-set in database.

*Informative: Starting up refers to the situation where an ATCC system is powered up.*

- 4.23 Dual deadbands shall be used to ensure that the post tapping voltage is sufficiently close to the selected target voltage. Deadband 1 is used to initiate tapping and deadband 2 is used to end tapping.

*Informative: The choice of the deadbands requires careful consideration by the user in order to avoid hunting. For a busbar with single transformer, it may not always be possible to control the system voltage into deadband 2. In this case, tapping will be ended when the system voltage crosses target voltage, see Clause 4.29. This dual deadbands requirement is illustrated by Figure 2 in Appendix E.*

**4.24** It shall be possible to set the voltage deadband 1 in the range  $\pm 0.5\%$  to  $\pm 10\%$  of the nominal system voltage in 0.5% increments, and to set the voltage deadband 2 in the range  $\pm 0.1\%$  to  $\pm 5\%$  in 0.1% increment.

**4.25** The ATCC shall not drive the system voltage by more than a pre-set rate. This rate, "maximum voltage change rate" shall be settable between 0.1 kV/min and 30 kV/min in 0.1 kV/min increment.

*Informative: The voltage change rate refers to the average value of system voltage changes driven by the tapping control actions. It is preferred to have a dedicated control/monitoring module rather than using tap delay settings (see below) to implement 4.25 requirement. The use of tap delay settings may cause the system voltage to change too slowly for a group of parallel transformers.*

#### **Tap Change**

**4.26** When tapping is needed to correct voltage or to minimise circulating currents, the initial tap control output shall be delayed by a pre-set time. This time delay, the "initial tap time delay", shall be settable between 15 and 120 seconds in 5 second increments.

**4.27** If more than one tap control action is required for a busbar group then it shall be possible to delay each subsequent tap by a pre-set inter tap delay time. This inter tap delay time shall be settable between 5 and 120 seconds in 5 second increments.

**4.28** Where the voltage is drifting in and out of deadband 1, tapping action shall be determined by difference between the accumulated times that the voltage is outside and inside the deadband. The ATCC system shall count up to the initial tap delay time for each second that the voltage is outside the deadband. If before the initial tap delay time is reached the voltage returns within the deadband, then the ATCC system shall count down by one second, for each second that the voltage is within the deadband.

**4.29** If the system voltage changes from one side of the target voltage to the other at a time when the initial tap time delay is running, this time delay shall reset to zero immediately.

**4.30** Only one tap operation shall be initiated at one time within a busbar group. When two or more transformers in a group are required to tap consecutively, the tap change operation of a transformer shall complete before tapping commences on the next transformer.

**4.31** When Auto Control is selected to be "In", and a transformer tap-changer reaches its end stop while tapping is required to go further, then the ATCC for the busbar or busbar group shall be inhibited until the condition clears, and the alarm: "Target Not Achievable" shall be generated.

**4.32** If the tap changer motor miniature circuit breaker (MCB) of a transformer trips, then the busbar/busbar group containing that transformer shall revert to Auto Control "Out", see Clause 5.8.

#### **Transformer Parallel Operation**

**4.33** The ATCC system shall allow for the operation of up to four parallel transformers within a busbar group and for the simultaneous operation of more than one group.

**4.34** Where the paralleled transformers are operated under ATCC, the tap position of the transformers in a group shall be controlled to maintain the system voltage within the deadbands and to minimise circulating current. This shall include the situations where the HV busbars of the paralleled transformers are connected or split. However, the control algorithm of the ATCC systems shall not need the information about the connectivity of the HV busbars to achieve this requirement.

*Informative: Maximum 1 tap difference between paralleled transformers with connected HV busbars is to be used to calculate the limits for the minimisation of the circulating currents. These limits shall be applied to all conditions of transformer parallel operation, including the HV busbars connected and split.*

**4.35** The ratings of transformers should be taken into account for the control of the parallel operation. Within a busbar group, generally higher rated transformers shall proportionally take higher MVars load.

**4.36** The control algorithm shall ensure that tapping actions are evenly distributed among the parallel transformers in a busbar group.

## Manual Tapping

- 4.37** When a busbar group is Auto Control “Out”, it shall be possible to manually issue tap change commands (raise/lower) from ATCC control points to the transformers in the busbar group.

## Homing

*Informative: Homing is a facility used for transformers with their busbar disconnectors closed and LV circuit breakers open. It taps transformers such that their open circuit terminal voltages follow the voltage of the busbar group that they are connected to within  $\pm 3\%$  when the busbar group is Auto Control “In”.*

- 4.38** It shall be possible to pre-set “Homing” function “On/Off” for a substation. A delay of 30 seconds shall be applied to the initial and successive tapping for the Homing.

## Line Drop Compensation

- 4.39** In order to maintain the voltage of busbars, remote from the sittings of the transformers being controlled, the ATCC shall be able to compensate the voltage drops on the connection circuits between transformers and busbars by selecting resistive and reactive compounding. It shall be possible to set the resistive and reactive compounding either positive or negative.

*Informative: This remote busbar configuration is illustrated by Figure 3 in Appendix E. Two methods for the line drop compensation are described in 4.40 – 4.41 and 4.42 – 4.43 respectively.*

- 4.40** The line drop compensation can be achieved by adjusting the target voltage such that:

$$V_{\text{Target}} = V_{\text{target0}} + \alpha$$

$$\alpha = \beta_P \times P + \beta_Q \times Q$$

Where,

$V_{\text{Target}}$  is the actual target voltage,

$V_{\text{Target0}}$  is the pre-set target voltage,

$\alpha$  is the adjusting factor for the target voltage,

P and Q are the MW and MVar flows (3 phase) respectively on the connection circuit for the remote busbar,

$\beta_P$  and  $\beta_Q$  are the settings for the resistive and reactive compounding respectively.

- 4.41** The  $\beta_P$  and  $\beta_Q$  are preset quantities per LV busbar or per transformer. The resistive setting shall be settable in the range  $\pm(0.01$  to  $0.1)$  kV/MW at increments of 0.01. The reactive setting settable in the range  $\pm(0.01$  to  $0.1)$  kV/MVar at increments of 0.01.