SYNCHRONISING

This document is for Relevant Electrical Standards document only.

PURPOSE AND SCOPE

This document describes the technical requirements for User's equipment directly connected to the England and Wales Transmission system and located within NGET's busbar protection zone operating at nominal voltages of 400 kV, 275 kV, 132 kV and 66 kV unless otherwise agreed with the user as defined in the Bilateral agreement. The principles of this document applies to equipment connected at other voltages".

This specification details the functional, performance and interface requirements for synchronising associated with the qualification of circuit breaker closure on the Transmission System in England and Wales. It is also applicable to those associated circuit breakers not owned by NGET but where such qualification is necessary in order to ensure the safety of personnel, plant and equipment

It defines the operations to be undertaken by the synchronising equipment in undertaking either the automatic or manual closure of a circuit breaker or switch with synchronising. This Specification is applicable to the interfacing to all synchronising facilities for control actions undertaken from either the Remote or Substation control points.

PART 1 – PROCEDURAL

1 GENERAL REQUIREMENTS

1.1 The system shall be arranged such that synchronising under manual control can only take place on one circuit at a time on each voltage level at any one substation.

Synchronising Scheme and Voltage Selection Facilities

1.2 The voltage supplies for synchronising on systems operating at 400 kV, 275 kV and 132 kV shall be derived from a single phase-to-earth primary voltage by means of single phase VT's.

1.3 The synchronising scheme shall be able to cater for substation extensions

1.4 Two basic schemes of synchronising cover the substation layouts used by NGET:

(i) Busbar Stations - The standard scheme shall be based on the use of either busbar VT's or individual circuit VT's with a suitable voltage selection scheme for selection of the appropriate supplies for synchronising purposes.

Informative: Where busbar VT's are not provided a simple priority scheme is preferred so that circuit VT supplies are not connected in parallel and the busbar running voltage is derived from only one VT from the circuit having the highest priority.

(ii) Mesh Type Stations - The standard scheme shall be based on a ring system with a suitable voltage selection scheme for selection of the appropriate supplies for synchronising purposes.

1.5 The synchronising equipment shall be capable of selecting the appropriate running voltage for synchronising by checking the position of disconnectors and circuit breakers.

Voltage Parameters and Burdens

1.6 a.c. measuring systems shall be capable of being earthed and use interposing voltage transformers (IVT) supplied from the secondary side of voltage transformers connected to the primary plant.

Interposing Voltage Transformers

1.7 The rating shall be designed to suit the requirements of the scheme.

1.8 The synchronising facilities shall incorporate suitable means to interface the voltage outputs from main VT's, providing adequate isolation.

Synchronising Function

1.9 Functionality is required to operate circuit breakers for check synchronising, system synchronising and dead line/dead bar conditions and shall automatically select the appropriate method of closure dependant on settings and from measurement of the incoming and running voltages.

1.10 The equipment shall automatically select check or system synchronise, from measurement of the relative frequency between the incoming and running voltages.

1.11 The normal or default mode shall be as a check synchroniser. On initiation, the equipment shall operate in the check synchronise mode.

1.12 Upon receipt of a close command and subsequent initiation of the synchronising function, an indication output shall be provided to indicate that synchronising is in progress. The output shall remain active until either the Circuit Breaker has closed or the synchronising sequence has timed out.

1.13 A facility shall be provided to inhibit the operation of the synchronising function for the failure of either incoming or running VT supplies. Typically, this may be achieved by the use of the following ;-

(a) Appropriate auxiliary switch contacts from each VT MCB

(b) A suitable algorithm within the equipment

(c) A combination of (a) and (b) above

1.14 Circuit breaker closure shall be prevented and operation inhibited for either an under-voltage or differential voltage condition outside the settings chosen within the range stated in Table 2.

1.15 Receipt of the close command shall initiate the Synchronising timer. This timer defines the maximum duration for attempting to close the circuit breaker and the sequence shall abort and reset if the circuit breaker has failed to close at the end of this period.

1.16 Upon receipt of the close command and subsequent circuit breaker close indication the synchronising sequence shall be reset and cleared down.

1.17 Circuit Breaker closure outputs shall be initiated without any appreciable delay and any delay shall be constant and quantified.

1.18 If the d.c. supplies or incoming and running voltages are removed the synchronising close output shall be prohibited except when DLLB, LLDB and DLDB modes have been pre-selected and the conditions have been detected.

Energising Check

1.19 The energising check facility shall be selectable and shall be configurable for all combinations of the following:

(a) Dead line live bus (DLLB)

(b) Dead bus live line (DBLL)

(c) Dead bus dead line (DBDL)

1.20 The voltage levels, which define both live and dead conditions, shall be configurable separately and within the ranges shown in table 2.

Check Synchronising

1.21 Pre-set selectable values of phase angle shall be provided in the range shown in table 2.

1.22 Whilst in check synchronising mode the functionality shall prevent closure in the event of slip being in excess of a pre selected value in the range defined in Table 2. This shall be irrespective of the phase angle setting.

1.23 If during the period when the function is verifying the system phase angle the voltage vectors move out of the phase angle setting and system synchronising conditions are not detected, circuit breaker closure shall be prevented.

System Synchronising

1.24 The System Synchronising mode of operation shall commence automatically upon detection of a close command and detection of slip within pre-set selectable values.

1.25 The initiation of the system synchronising function shall result in the following actions:

(a) Check Synchronising closure shall be inhibited whilst asynchronous conditions are detected.

(b) The System Synchronising mode of the device is primed to permit closure of the circuit breaker to proceed within the limits specified for the System Synchronising function.

(c) An output is initiated to provide external indications that the mode of closure has changed. This output shall remain active until either; the Circuit Breaker has closed, asynchronous conditions are no longer detected or the synchronising sequence has timed out.

1.26 When the system synchronising mode is activated the close command shall be initiated with the minimum delay, provided the following requirements are met:

(a) The phase angle between the incoming and running voltages is decreasing and measures less than a pre-set selectable value in the range defined in table 2.

(b) The slip frequency is within the range defined in table 2.

(c) The under-voltage or differential check facilities have not operated.

1.27 The circuit breaker operating time and measured slip should be taken into account when operating in System Synchronising mode to ensure that circuit breaker closure occurs within the phase angle window of closure.

1.28 If during a system synchronising sequence the system conditions change such that the criteria for check synchronising closure are met the equipment shall be capable of reverting to check synchronising mode of operation and attempt closure of the Circuit Breaker under these conditions. This feature shall be selectable by configuration settings.

2 FUNCTIONAL INTERFACES

Informative: The functional interfaces for the Synchronising function are depicted in Figure 1.

2.1 The Synchronising function shall provide the functional interfaces as detailed in Figure 1. The User bay(s) synchronising facility shall meet the same design and functional requirement as NGET's site synchronising scheme that it interfaces with Figure 2.

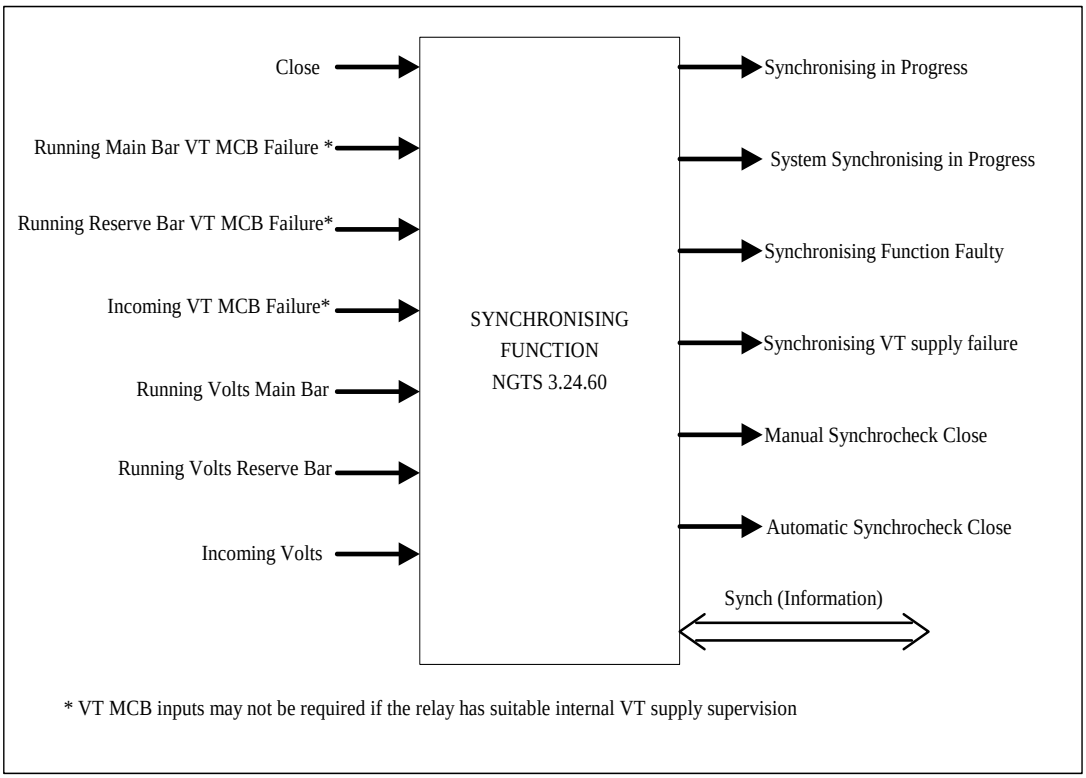

Figure 1: Synchronising Functional Interfaces

Table 1: Details each interface's ID, function and type.

Table 1: Synchronising Functional Interfaces		
Interface	Interface Function	Type of Interface
2.2	.Retracted in line with requirements	÷
2.3 Manual Synchrocheck Close	A Manual Synchrocheck close control output shall be initiated when all criteria are met for a manual synchronising close.	Double Pole Control Output
2.4 Automatic Synchrocheck Close	An Automatic Synchrocheck close control output shall be initiated as part of an automatic close sequence such as Delayed	Double Pole Control Output

Table 1: Synchronising Functional Interfaces			
Interface		Interface Function	Type of Interface
		Automatic Reclosure when all criteria are met.	
2.5	Synchronising in Progress Indication	This indication shall be active for transmission to the control point when the synchronising function has been activated and shall remain on until the conditions in section 4.12 are met.	Single Point Digital Output
2.6	System Synchronising Indication	This indication shall be active for transmission to the control point when the synchronising function has been activated and has detected asynchronous system synchronising conditions and shall remain on until any of the conditions in section 4.25(c) are met.	Single Point Digital Output
2.7	Synchronising VT Failure	This indication shall be active for transmission to the control point when a failure of a synchronising VT supply is detected.	Single Point Digital Output
2.8	Synchronising Function Faulty	This alarm shall be active for any detectable fault within the synchronising function.	Single Point Digital Output
2.9	Synchronising Information Port	Retracted in line with requirements	Information Port

3 SETTING RANGES

3.1 The Synchronising facility function settings as detailed in Table 2 shall be provided as a set of settings that the user can change.

Table 2: Synchronising Setting Ranges			
Setting		Minimum Setting Range	Maximum Setting Resolution
3.2	VT Ratio Error Correction	1:1 - 5000:1	10
3.3	Under-voltage Check Facility	80% – 90% of Rated Voltage	2.5%
3.4	Voltage Difference	10% – 50% of Rated Voltage	5%
3.5	Check Synchronising Phase Angle	20º - 90º	5º

Table 2: Synchronising Setting Ranges			
Setting		Minimum Setting Range	Maximum Setting Resolution
3.6	Check Synchronising Slip Speed	0.01 – 0.1Hz	0.01Hz
3.7	System Synchronising Phase Angle	10º - 20º (or less)	5º
3.8	System Synchronising Slip Speed	0.02Hz - 0.3Hz	0.01Hz
3.9	Energising Check dead volts	10% – 50% of Rated Voltage	5%
3.10	Energising Check live volts	60% – 100% of Rated Voltage	5%
3.11	Synchronising Sequence Timer	0 – 15 minutes	1 minute

4 PERFORMANCE REQUIREMENTS

Voltage Transformers and Burdens

4.1 The burden of the synchronising system on the primary voltage transformers shall not normally exceed 5 VA.

4.2 Selection of the IVT voltage tap shall ensure that with nominal system voltage, the voltage at the synchronising equipment from any switchgear circuit is 63.5 V ±1%.

4.3 The IVT shall withstand 2 kV a.c. r.m.s. between windings and between windings and frame and earth screen for 1 minute.

Accuracy

4.4 The synchronising function shall maintain the accuracy given below over the frequency range given in TS 1_RES

4.5 The accuracy of the under-voltage and differential voltage check facilities shall be not greater than ±5% of the set value under all specified environmental and power supply variations.

4.6 Phase angle accuracy at 50 Hz shall be ±1º at each setting. The alteration of phase angle settings on site shall not require any re-calibration.

4.7 The total variation from actual setting shall not exceed 2º under the worst combination of voltage, frequency and auxiliary supply deviation.

4.8 If abnormal power supply conditions are encountered then, either accuracy shall be maintained by the synchronising function, or circuit breaker closure shall be inhibited.

4.9 Circuit- breaker closure should not be initiated with a phase angle greater than the nominal setting angle plus tolerance stated above.

4.10 The interposing voltage transformers shall meet the accuracy requirements of Class B of BS 3941.

4.11 Timers shall have an accuracy of ±2% or better.

4.12 The slip measurement accuracy shall be 0.01 Hz or better.

5 FORMS AND RECORDS

None

PART 2 - DEFINITIONS AND DOCUMENT HISTORY

6 DEFINITIONS

Informative When voltages are present on both sides of an open circuit breaker it is necessary to ensure that these voltages are reasonably in synchronism before closure of the circuit breaker. Two possible conditions apply:

a) More usually, the voltage vectors are static in relation to each other with a fixed phase angle between them and;

b) Rare occasions when the voltage vectors are at different frequencies because the system has become split.

In addition to the two synchronising conditions above, one or both of the voltages may be unavailable in which case the circuit breaker must be closed to energise a dead line, dead busbar or to close a circuit breaker in a dead system.

CHECK SYNCHRONISING – Check Synchronising is the term which has historically been used by National Grid to check that the voltage vectors across an open circuit breaker are within preset limits of magnitude, phase angle and practically zero slip. This condition is the most common when closing circuit breakers with voltages on either side.

DAR - Delayed Automatic Reclose as applied by National Grid to feeder circuits usually comprising or mainly comprising overhead line whereby, following the operation of a main protection and subsequent trip of a circuit, the circuit is automatically switched back into service after a minimum period of 10 seconds. The first circuit breaker to close energises the feeder by performing a Dead Line Charge (DLC). The second circuit breaker to close requires that the voltages across its open contacts are reasonably in synchronism. DAR is also applied to certain transformer LV circuit breakers when the transformer is banked on its HV side with a feeder that has DAR.

INCOMING VOLTAGE – The incoming voltage is the voltage on the opposite side of an open circuit breaker from the running voltage. At busbar-type substations the incoming voltage is on the feeder or transformer side of the circuit breaker. In those cases where the distinction between incoming and running voltages is not clear, for example bus section circuit breakers, the voltages may be identified as ‘A’ and ‘B’ voltages where the ‘A’ voltage is normally associated with the main busbar or the lowest numbered busbar or mesh corner.

PHASE ANGLE – Phase angle is the angular difference in degrees between the incoming voltage vector and the running voltage vector across the open contacts of a circuit breaker.

POWER SYSTEM SYNCHRONISING – Power system synchronising, or simply System Synchronising, is the term which has historically been used by National Grid to cover the situation in paragraph b) above. This is when a circuit breaker is being closed to re-parallel a part of the transmission system that has become separated from the main part of the transmission system i.e. islanded. It is necessary to check that the voltage vectors across this open circuit breaker are within acceptable limits of magnitude, phase angle and slip when the two parts of the transmission system are running asynchronously.

RUNNING VOLTAGE - The running voltage is the voltage on the substation side of an open circuit breaker across which synchronism is to be checked.

SLIP – Slip is the frequency difference between the two voltage vectors across the contacts of an open circuit breaker and is measured in Hertz (Hz).

7 AMENDMENTS RECORD

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
1	October 2014	New document	Richard Poole	GCRP

7.1 Procedure Review Date

4 years from publication date.

PART 3 - GUIDANCE NOTES AND APPENDICES

8 REFERENCES

TS 1_(RES) Ratings and General Requirements for Plant, Equipment, Apparatus and Services for the National Grid System and Connection Points to it.