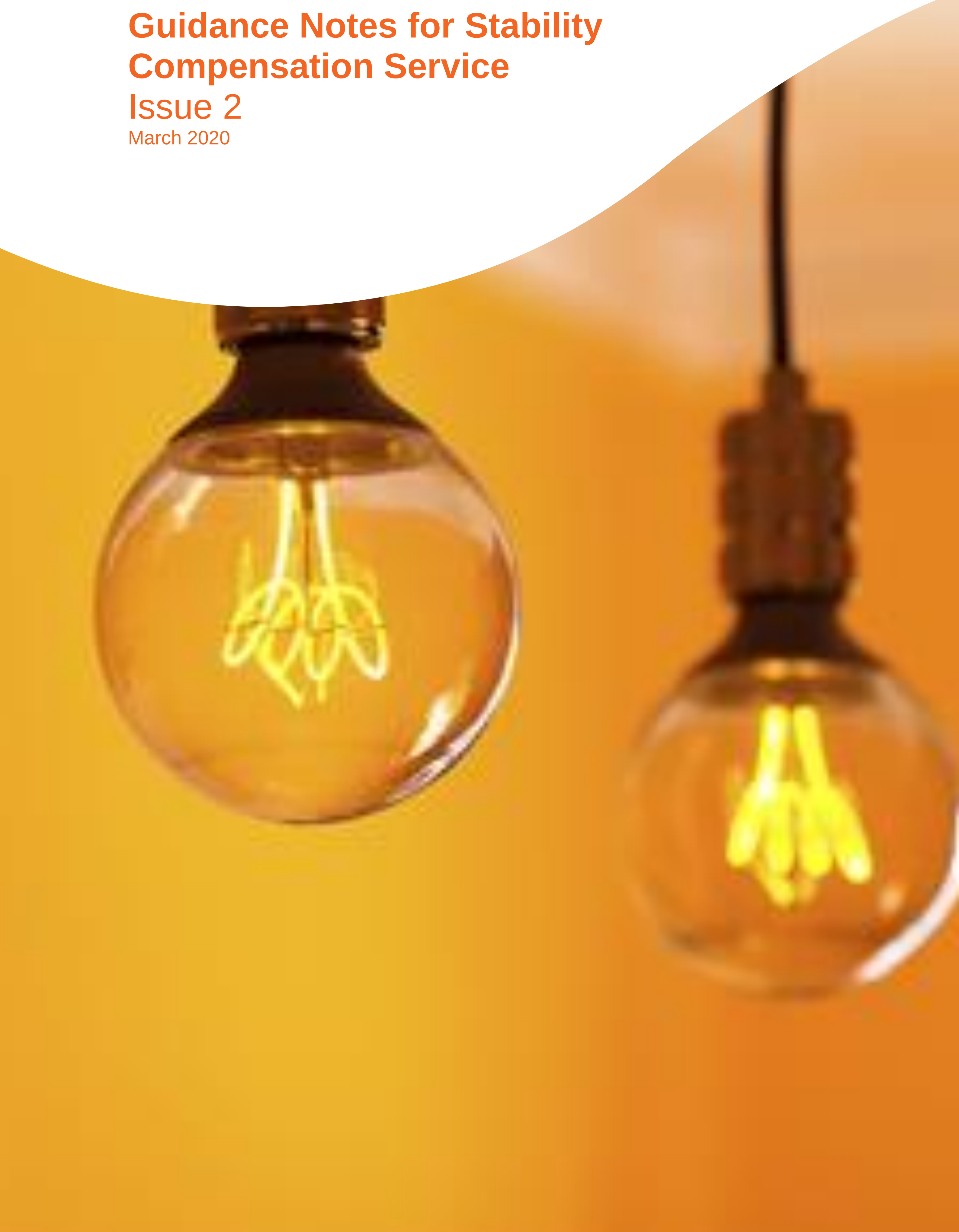
nationalgridESO

Guidance Notes for Stability Compensation Service

Issue 2

March 2020



Foreword

These Guidance Notes have been prepared by the National Grid Electricity System Operator (NGESO) to describe to accepted providers how the Compliance with the Stability Compensation Phase 2 Service may be demonstrated. Throughout this document NGESO refers to National Grid Electricity System Operator Ltd.

These Guidance Notes are prepared, solely, for the assistance of accepted providers. In the event of dispute, the Service Agreement documents will take precedence over these notes.

These Guidance Notes are based on the Grid Code, Issue 5, Revision 25, effective from the 07 September 2018. They reflect the major changes brought about by Grid Code revision to facilitate compliance with the European Requirements for provider, as approved by the regulator Ofgem on 16 May 2018.

Definitions for the terminology used this document can be found in the Grid Code.

Disclaimer: This document has been prepared for guidance only and does not contain all the information needed to comply with the specific requirements of a Bilateral Agreement with NGESO. Please note that whilst these guidance notes have been prepared with due care, NGESO does not make any representation, warranty or undertaking, express or implied, in or in relation to the completeness and or accuracy of information contained in these guidance notes, and accordingly the contents should not be relied on as such.

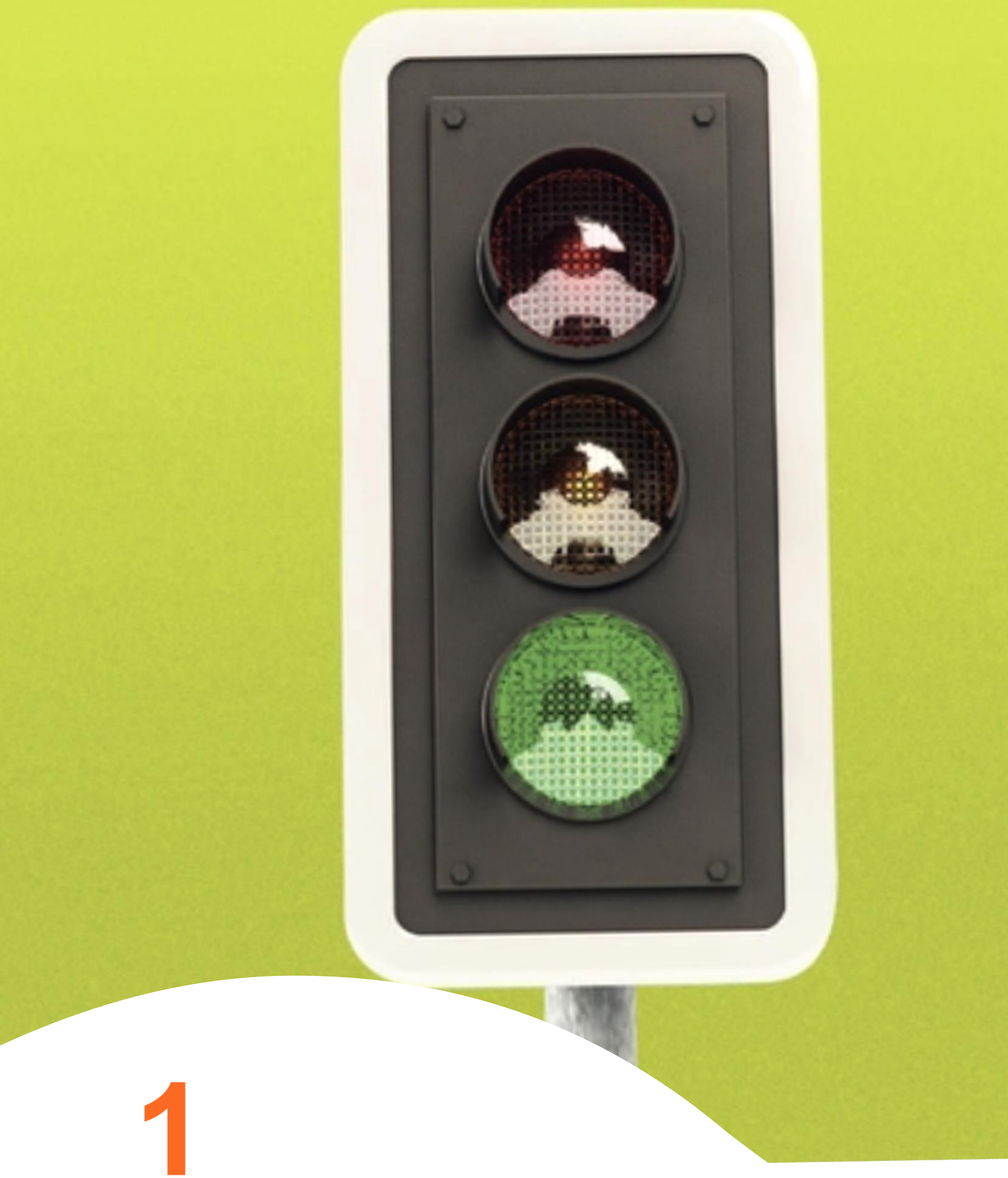
Contents

Abbreviations

This section includes a list of the abbreviations that appear in this document.

Abbreviation	**Description**
AVC	Automatic Voltage Control (on transformers)
AVR	Automatic Voltage Regulator
BA / BCA	Bilateral Agreement / Bilateral Connection Agreement
BC	Balancing Code
BM / BMU	Balancing Mechanism / Balancing Mechanism Unit
CC / CC.A	Connection Conditions / Connection Conditions Appendix
CCGT	Combined Cycle Gas Turbine
CP	Compliance Processes
CUSC	Connection and Use of System Code
DCS	Distributed Control System
DNO	Distribution Network Operator
DMOL	Design Minimum Operating Level
DPD	Detailed Planning Data
DRC	Data Registration Code
EDL/EDT	Electronic Data Logging / Electronic Data Transfer
ELEXON	Balancing and Settlement Code Company
FON	Final Operational Notification
FRT	Fault Ride Through
FSM	Frequency Sensitive Mode
GB	Great Britain
GCRP	Grid Code Review Panel
GT	Gas Turbine
ION	Interim Operational Notification
LSFM	Limited Frequency Sensitive Mode
LON	Limited Operational Notification
MC	Maximum Capacity
MEL	Maximum Export Limit
MG	Minimum Generation
MLP	Machine Load Point

MRL	Minimum Regulating Level
MSOL	Minimum Stable Operating Level
NGESO	National Grid Electricity System Operator
NGET	National Grid Electricity Transmission
OC	Operating Code
OCGT	Open Cycle Gas Turbine
OEL	Over Excitation Limiter
OFGEM	Office of Gas and Electricity Markets
PC	Planning Code
PSS	Power System Stabiliser
POD	Power Oscillation Damping
PSSE	Power System Simulation for Engineering software
RISSP	Record of Inter System Safety Precautions
SCL	Short Circuit Level
SEL	Stable Export limit
SO	System Operator (NGESO)
SPT	Scottish Power Transmission
SHET	Scottish Hydro Electric Transmission
ST	Steam Turbine
STC	System Operator Transmission Owner Code
TO	Transmission Owner
TOGA	Transmission Outages, Generation Availability
UDFS	User Data File Structure
UEL	Under Excitation Limiter



1

Guidance Notes

Introduction

This document gives additional description of the technical studies and proving tests set out within the Service Agreement for Stability Compensation. The contents are based on the Grid Code European Compliance Processes with respect to conventional synchronous machine technologies.

Providers may, if they wish, suggest alternative tests or studies, which they believe will demonstrate compliance in accordance with the requirements placed on themselves and NGESO.

Model

The provider is required to provide NGESO and the relevant Transmission Owner (NGET, SPT or SHET) with a model of their compensation unit as detailed in PC.A.5.3.2 of the Grid Code. The model data is to be provided as Laplace transfer functions in a block diagram format. Control systems with a number of discrete states or logic elements may be provided in flow chart format if a block diagram format does not provide a suitable representation.

The model structure and complexity must be suitable for NGESO to integrate into their power system analysis software (currently DigSilent). In cases where the model's functionality cannot be correctly or satisfactorily represented within NGESO's power system analysis software, the provider may be required to liaise with NGESO to determine appropriate simplifications or changes in representation to produce an appropriate model. The model should not require integration time steps less than 10ms. Should a DigSilent Powerfactory model be supplied then it shall not contain DLL code or require calls to external routines or setup scripts.

All model parameters must be identified along with units and site-specific values. A brief description of the model should ideally be provided as ultimately this will save time and money for both parties.

The model representation provided should ideally be implemented on a power system analysis software package of the provider's choosing, as it is otherwise highly unlikely to produce valid results when compared with the test results from the real equipment. In the event the model does not produce the correct output, the data submission will be considered incorrect and not contractually compliant. NGESO will confirm the model accuracy. Validation of the model is completed by the provider following the compliance tests.

The model also needs to be suitable for integration into the power system analysis software used by the relevant Transmission Owner (NGET, SPT or SHET). Support may be required from the provider to implement and, if necessary, modify the model representation for use on the Transmission Owner's power system analysis software (ordinarily this will not be the case if the model has already been satisfactorily implemented by NGESO).

Simulation Studies

Simulation studies are required from the provider to provide evidence that the plant and apparatus comply with the Fault Ride Through provisions of the Service Agreement prior to connection. Section of the Grid Code ECP.A.3 describes the simulations studies which need to be carried out before any compensator unit will commence service,

In general, simulation studies are required to be based on the models supplied to NGESO under the Service Agreement or in accordance with Grid Code Planning Code Appendix section 5.3 (PC.A.5.3).

Simulations should be submitted in the form of a report (ECP.A.3.1.2) to demonstrate compliance in sufficient time to allow NGESO to review the content and validity of the report and models utilised prior to the planned synchronisation date (typically 3 -6 months).

Proving Tests

The Service Agreement requires providers to complete Initial Proving tests to the satisfaction of NGESO prior to commencement of the service. These tests are generally in accordance with the Grid Code tests laid out in ECP.A.5.

For each test to be carried out the description and purpose of the test, results required, the relevant Grid Code clause(s) and criteria of assessment are given in the contract or Grid Code ECC. The provider is responsible for drafting test procedures for the compensation plant as part of the compliance process prior to the commercial operation. The appendices of these Guidance Notes provide outline test schedules which may assist the provider with this activity.

NGESO may require further compliance tests or evidence to confirm site-specific technical requirements (in line with the Service Agreement) or to address compliance issues that are of particular concern. Additional compliance tests, if required, will be identified following NGESO's review of submission.

The tests are carried out by the provider, or by their agent, and not by NGESO. Tests should be completed following the test procedures drafted by the provider.

The provider should also provide suitable digital monitoring equipment to record all relevant test signals needed to verify the synchronous compensator performance.

Proving Test Signals

NGESO requires that a number of signals are provided from the Proving Tests to NGESO to allow assessment of the performance. The list of these signals is set out in Grid Code ECP.A.4.

Where these signals are provided to NGESO following proving tests there is a need to provide them in a consistent electronic format with a time stamp in a numerical format which can be interpreted in Excel. To facilitate efficient analysis the test results should include signals requested by NGESO set out in the columns order as indicated in the tables in Appendix E.

- Signals for non-witness tests should be provided in excel format and in the order and format presented in Appendix E unless otherwise agreed, in advance, with NGESO.
- Where any additional test signals to those indicated in the tables are presented these should only be added with the agreement of NGESO and be entered within the files as additional columns to the right of the required signals.
- Where a signal cannot be provided, and this has been agreed with NGESO in advance of the tests, a blank column should be retained within the data.
- Where additional signals are included or the signals are presented but not in the arrangement detailed above the data may be rejected and the customer will be asked to resubmit the data in the agreed format.

Compliance Test Logsheet

Where proving test results are completed without any NGESO presence but are relied upon as evidence of the compliance they should be accompanied by a logsheet. This sheet should be legible, in English and detail the items as indicated in AppendixE.

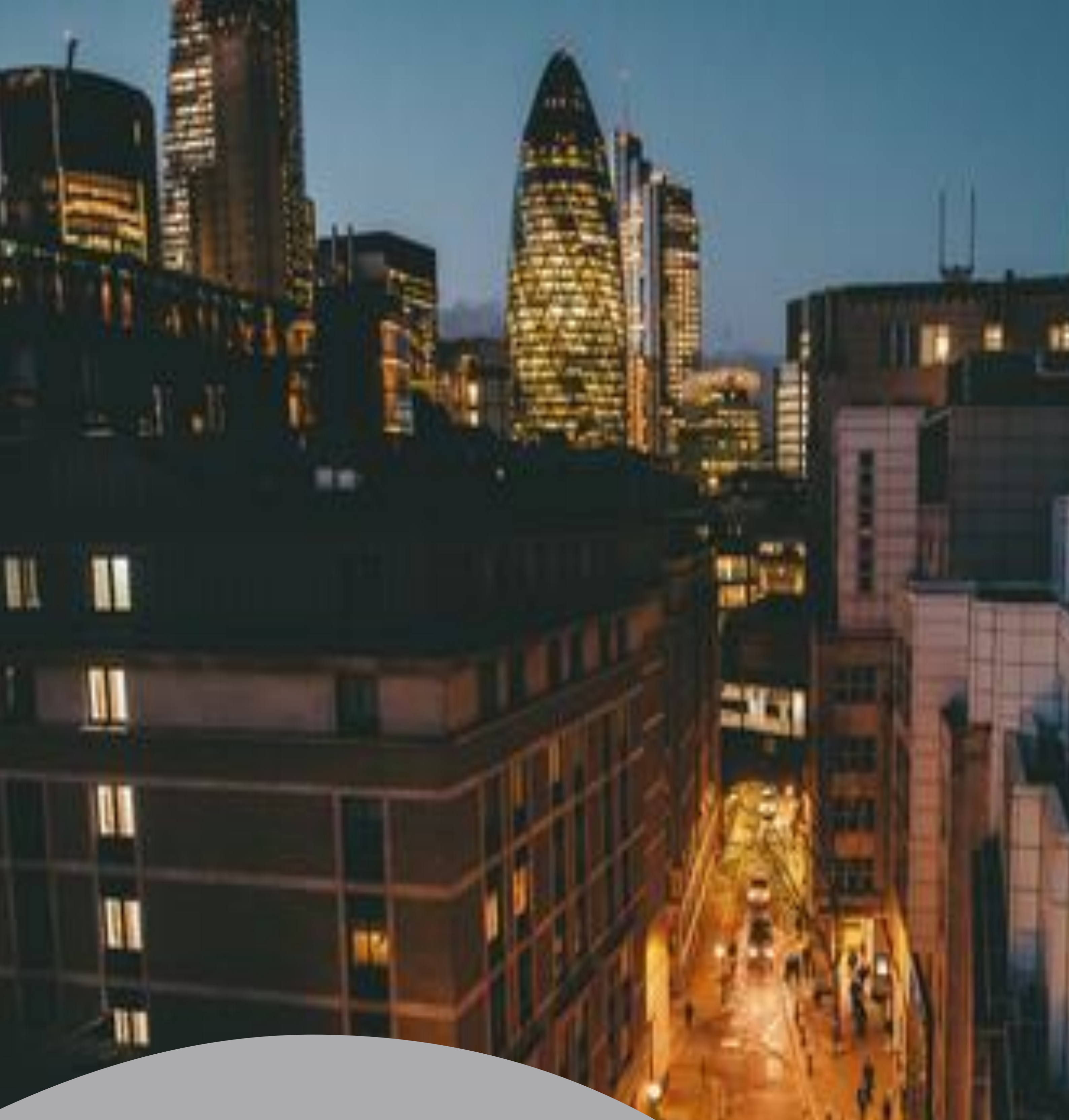
Test Notification to Control Room

The provider is responsible for notifying the 'NGESO Control Centre' of any tests to be carried out on their plant, which could have a material effect on the National Electricity Transmission System. The procedures for planning and co-ordinating all plant testing with the 'NGESO Control Centre is detailed in OC7.5 of the Grid Code (i.e. Procedure in Relation to Integral Equipment Tests). For further details relating to this procedure, refer to "Integral Equipment Tests - Guidance Notes" which can be found on National Grid's Internet site in Grid Code, Associated Documents.

The provider should be aware that this interface with NGESO transmission planning will normally be available in week-day working hours only. As best practice, the provider should advise the 'NGESO Control Centre' and the relevant Transmission Owner, or Distribution Network Operator (if embedded) of the times and nature of the proposed tests at the earliest stage possible. If there is insufficient notice or information provided by the provider, then the proposed testing may not be allowed to proceed.

Islanding Protection

If islanding protection is required, an inter-tripping scheme is recommended by G59/G99. If 'Rate of Change of Frequency' (ROCOF) trip relays are to be considered, there could be compliance implications which need to be discussed with NGESO at the earliest opportunity. NGESO does not require or desire providers to fit ROCOF protection but needs to be consulted on the settings of any such protections in service. Vector Shift protection is no longer accepted.



A

Appendices

Appendix A Reactive Capability

Summary of Requirements

The reactive capability requirements for a compensator unit are set out in the Service Agreement. The delivery of this reactive power is required at the Grid Entry Point or User System Entry point if embedded. The compliance tests are required at the metering points of a synchronous compensator unit.

The Service Agreement requires that a synchronous compensator unit is capable to deliver the reactive range specified in the service agreement across a variation in system voltage. The voltage variation on a 400kV system should remain within +/-5% of the nominal voltage in normal system conditions. For transmission system with voltages of 275kV, 132kV and 110kV the variation must stay between +/-10%. This capability is typically achieved for a synchronous provider by the application of an on load tapchanger in the synchronous unit step-up transformer. The tapchanger being capable of on-load changes in tap position and having sufficient taps to satisfy the combined requirements of ECC.6.3.2 and ECC.6.3.4.

Reactive Capability Testing

In order to demonstrate that a synchronous compensator unit can satisfy the reactive capability requirements it is necessary to perform reactive capability tests.

The following procedure is provided to assist providers in drawing up their own site specific procedures.

For target voltage mode:

Test No	Step	Description	Notes
1		• Plant in Voltage Control Mode • Target Voltage (*) selected to generate a maximum continuous lagging Reactive Power for 60 minutes.	
2		• Plant in Voltage Control Mode • Target Voltage (*) selected to generate a maximum continuous leading Reactive Power for 60 minutes.	
3		• Return Target Voltage to a value to achieve zero reactive power transfer	

For target voltage mode connected via a tapping transformer:

Tests should be done at 1 p.u. terminal voltage Setpoint and tapping the transformer as the first method to achieve the reactive output. The terminal voltage Setpoint can then be tweaked if needed to demonstrate the final part of the reactive range if necessary.

Test No	Step	Description	Notes
		•	
1	1 2	• Confirm AVR in control in constant terminal voltage mode. • Confirm AVR Voltage Setpoint set to 1 per unit	

	3	• Connection transformer tapped to generate maximum continuous leading Reactive Power and hold for 60 minutes.	
2	4 5	• Confirm AVR in control • AVR Voltage Setpoint set to 1 per unit	
	6	• Connection transformer tapped to generate maximum continuous lagging Reactive Power and hold for 60 minutes.	
	7	• Connection transformer tapped to generate zero Reactive Power and hold for 60 minutes.	

For Constant Q mode, where applicable:

Test No	Step	Description	Notes
1		• Plant in Constant Q mode • Target Q (*) selected to generate a maximum continuous lagging Reactive Power for 60 minutes.	
2		• Plant in Constant Q Mode • Target Q (*) selected to generate a maximum continuous leading Reactive Power for 60 minutes.	
3		• Return Target Q to a value to achieve zero reactive power transfer	

Appendix B Target Voltage Mode Testing

Summary of Requirements

The synchronous compensators must meet the requirements with regards to excitation control. The performance requirements for Automatic Voltage Regulator (AVR) are set out in ECC.A.6.1 of the Grid Code and ECC.6.3.8. The details of the tests can be found below and based on Grid Code ECPA.5.4.3 and for plant operating in target voltage mode.

Open Circuit Tests

Open circuit tests are not required for units that do not have a prime mover.

Prior to first synchronising a compensator unit (or an existing generation unit one with a new excitation system) onto the system, the provider should perform open circuit testing. The details of the test are given below (based on in ECP.A.5.2). The results should be presented to NGESO in the form of graphs with legible axes and scaling plus the data in a form which can readily be imported into Excel. NGESO will indicate acceptance of the open circuit tests in writing whereupon the provider provided there are no other active restrictions may synchronise the relevant compensator unit.

The open circuit step response of the Excitation System will be tested by applying a voltage step change from 90% to 100% of the nominal Synchronous Compensator terminal voltage, with the Synchronous Compensator on open circuit and at rated speed.

The test shall be carried out prior to synchronisation. The provider shall supply the recordings of the following signals to NGESO in an electronic spreadsheet format at 100Hz update rate:

Vt - Synchronous Unit terminal voltage

Efd - Synchronous Unit field voltage or main exciter field voltage

Ifd- Synchronous Unit field current (where possible)

Step injection signal

Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

Synchronised AVR Step Testing

With the compensator synchronised to the Total System operating at zero reactive power transfer the time domain performance of the Excitation System shall be tested by application of voltage step changes corresponding to +/-1% and +/-2% of the nominal terminal voltage.

The following typical procedure is provided to assist providers in drawing up their own site specific procedures.

Test	Injection	Notes
	Synchronous Compensator Unit running zero reactive power, POD Switched Off (if switchable) AVR starting voltage Setpoint for each test set to 1p.u.	
1	• Record steady state for 10 seconds • Inject +1% step to AVR Voltage Setpoint and hold for at least 10 seconds until stabilised • Remove step returning AVR Voltage Setpoint to nominal and hold for at least 10 seconds	
2	• Record steady state for 10 seconds • Inject -1% step to AVR Voltage Setpoint and hold for at least 10 seconds until stabilised • Remove step returning AVR Voltage Setpoint to nominal and hold for at least 10 seconds	
3	• Record steady state for 10 seconds • Inject +2% step to AVR Voltage Setpoint and hold for at least 10 seconds until stabilised • Remove step returning AVR Voltage Setpoint to nominal and hold for at least 10 seconds	
4	• Record steady state for 10 seconds • Inject -2% step to AVR Voltage Setpoint and hold for at least 10 seconds until stabilised • Remove step returning AVR Voltage Setpoint to nominal and hold for at least 10 seconds	

Repeat the above steps 1-4 with POD switched On (if switchable).

The provider shall supply the recordings of the following signals to NGESO in an electronic spreadsheet format at 100Hz update rate:

Vt - Synchronous Unit terminal voltage

Mvar - Synchronous Unit Reactive Power

Efd - Synchronous Unit field voltage or main exciter field voltage

Ifd- Synchronous Unit field current (where possible)

Step injection signal

Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

Under Excitation (UEL) Testing

This test is carried out to establish the setting of the limiter and to verify its correct operation including adequate damping. If the excitation control system includes a switchable POD then the tests should be carried out with POD switched on.

When the provider is operating near the UEL limit the stability margin is less than when it is operating at unity power factor. For safety, a preliminary set of tests are specified below with the UEL limit moved towards unity power factor line. If the preliminary tests are successful, then the UEL limit is moved to its design position and the tests are repeated.

Initially the performance of the Under-excitation Limiter should be checked by moving the limit line close to the operating point of the Synchronous Compensator Unit when operating close to unity power factor. The operating point of the Synchronous Compensator Unit is then stepped into the limit by applying a 2% decrease in Automatic Voltage Regulator Setpoint voltage.

The final performance of the Under-excitation Limiter shall be demonstrated by testing its response to a step change corresponding to a 2% decrease in Automatic Voltage Regulator Setpoint voltage when the Synchronous Compensator Unit is operating just off the limit line, at the designed setting as indicated on the Performance Chart submitted to NGESO under the Service Agreement.

Where possible the Under-excitation Limiter should also be tested by operating the tap- changer when the Synchronous Compensator Unit is operating just off the limit line, as set up.

The following typical procedure is provided to assist providers in drawing up their own site specific procedures.

Test	Injection	Notes
	• Synchronous Compensator Unit running zero reactive power. Under-excitation limit temporarily moved close to the operating point of the Synchronous Compensator Unit.	
1	• Inject -2% voltage step into AVR voltage Setpoint and hold at least for 10 seconds until stabilised • Remove step returning AVR Voltage Setpoint to nominal and hold for at least 10 seconds	
	• Under-excitation limit moved to normal position. Synchronous Compensator Unit running at leading Reactive Power close to Under-excitation limit.	
2	• Inject -2% voltage step into AVR voltage Setpoint and hold at least for 10 seconds until stabilised • Remove step returning AVR Voltage Setpoint to nominal and hold for at least 10 seconds	

If the unit is connected via a transformer tap changer, an additional test demonstrating the UEL control action by tapping the generating unit transformer to move the output of the unit into the limiter.

Test	Injection	Notes
	• Under-excitation limit at normal position. Synchronous Compensator Unit running at leading Reactive Power close to Under-excitation limit.	
3	• Tap the connection transformer until the operating point is beyond the limit line and the UEL is active and hold at least for 10 seconds until stabilised	

	• Tap the connection transformer to return the operating point into normal operating area and hold at least for 10 seconds until stabilised	

These tests are based on Grid code ECP.A.5.5.5 to assist providers in drawing up their own site specific procedures.

The provider shall supply the recordings of the following signals to NGESO in an electronic spreadsheet format at 100Hz update rate:

Vt - Synchronous Unit terminal voltage

Mvar - Synchronous Unit Reactive Power

Efd - Synchronous Unit field voltage or main exciter field voltage

Ifd- Synchronous Unit field current (where possible)

Step injection signal

Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

Over Excitation Limiter (OEL) Testing

The action of an OEL differs from that of an UEL. NGESO are particularly interested in ensuring the OEL is set as high as possible, whilst ensuring the machine design limits are not breached and that the machine protection will not operate before or whilst the OEL is active. If the excitation control system includes a switchable POD then the tests should be carried out with POD switched on.

The OEL action is typically initiated by injecting a +2% to +10% positive voltage step into the AVR voltage reference. The OEL would normally be set at the maximum value within the design limit for the generating unit. Excitation at OEL setting is well above excitation at rated MVA. For this reason, the test is not typically carried out at the OEL setting. For the test, the OEL setting is typically reduced to a level equivalent to 0MW and maximum lagging MVAr. A positive step is then applied to the AVR Voltage reference or the generating unit step-up transformer is tapped to take the MVAr output higher. If the OEL is working correctly, the OEL should operate after sufficient time delay to bring back the excitation within limits.

The steady state accuracy of the limit level and any overshoot are of particular interest, as the provider and NGESO may need to determine the limit level once the setting is restored and ensure that any protection does not operate. If the OEL has multiple levels to account for heating effects, an explanation of this functionality will be necessary and if appropriate, a description of how this can be tested.

The performance of the Over-excitation Limiter, where it exists, shall be demonstrated by testing its response to a step increase in the Automatic Voltage Regulator Setpoint voltage that results in operation of the Over-excitation Limiter. Prior to application of the step the Synchronous Compensator Unit shall be operating within its continuous Reactive Power capability. The size of the step will be determined by the minimum value necessary to operate the Over-excitation Limiter and will be agreed by NGESO and the provider. The resulting operation beyond the Over-excitation Limit shall be controlled by the Over-excitation Limiter without the operation of any protection that could trip the Synchronous Compensator. The step shall be removed immediately on completion of the test.

If the Over-excitation Limiter has multiple levels to account for heating effects, an explanation of this functionality will be necessary and if appropriate, a description of how this can be tested.

The following typical procedure is provided to assist providers in drawing up their own site specific procedures.

Test	Injection	Notes
	Synchronous Compensator Unit running at maximum lagging Reactive Power.	
	Over-excitation Limit temporarily set close to this operating point.	
1	• Inject positive voltage step into AVR voltage Setpoint and hold • Wait till Over-excitation Limiter operates after sufficient time delay to bring back the excitation back to the limit. • Remove step returning AVR Voltage Setpoint to nominal.	
2	• Wait no more than 30s and then repeat (stage below) to test that transient field forcing is not being limited.	
3	• Inject positive voltage step into AVR voltage Setpoint and hold • Wait till Over-excitation Limiter operates after sufficient time delay to bring back the excitation back to the limit. • Remove step returning AVR Voltage Setpoint to nominal.	
	Over-excitation Limit restored to its normal operating value.	

This test is based on Grid Code ECP.A.5.6.3 to assist providers in drawing up their own site specific procedures although NGESO will be happy to consider an alternative test procedure suggested by the provider.

The provider shall supply the recordings of the following signals to NGESO in an electronic spreadsheet format at 100Hz update rate:

Vt - Synchronous Unit terminal voltage

Mvar - Synchronous Unit Reactive Power

Efd - Synchronous Unit field voltage or main exciter field voltage

Ifd- Synchronous Unit field current (where possible)

Step injection signal

Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

Appendix C Constant Mvar Mode Testing

Summary of Requirements

For plant in constant Mvar mode, consideration should be given to devise a test to show behaviour during a voltage disturbance (2% step change). This may be achieved by tapping connection transformer or a nearby network transformer.

Appendix D Power Oscillation Damping

Summary of Requirements

The industry codes (Grid Code, CUSC etc.) in general, assume a generating unit is fully operational from the moment of connection. This is not practical as many systems will need on-load commissioning in order to ensure their correct operation. Some systems such as the power oscillation damping (POD) have been identified as having significant potentially negative impacts on the security of the National Grid transmission system if incorrectly commissioned.

Through this test, NGESO is looking to;

- establish and understand the power oscillation damping capability of a synchronous compensator under the stability compensation service
- is looking for the ability from the provider to contribute to damping the sub-synchronous system oscillations

NGESO doesn't have a minimum standard for the providers to achieve an amount of damping over a period.

POD functionality should be tuneable to a range of sub-synchronous frequencies (narrow or wide range).

POD functionality can be achieved via AVR alone or via additional control systems.

POD tests

NGESO expects these tests to be performed in a simulation environment. The provider must provide time series simulation results with legible axes and scaling, and an accompanying report to demonstrate that their solution can:

1. detect system voltage oscillations in the sub-synchronous frequency range 0.3-2Hz
2. upon detecting oscillations inject reactive current adequately antiphase to achieve reduction in voltage oscillations at the grid entry point.
3. change the amount of reactive current injection proportional to the amplitude of the oscillations
4. the influence of these subsidiary control functions be no more than 10% of the primary function
5. achieve 1-4 whilst keeping the solution stable and not compromise other aspects of the technical specification

The ESO expect the provider to contribute to damping over the frequency range 0.3-2 Hz. If more than one tuning is required to cover the full range simulations must be presented for all these tunings. The report must include any limitations on damping caused by different tunings. Damping across the full frequency range with a single tuning is desired but is not a requirement.

The following procedure is provided to assist providers in drawing up their own site specific procedures.

Test	Injection
	Synchronous Compensator Unit running at 0 Mvar
	System represented as thevenin equivalent as per the minimum SCL in the stability contract (example shown in Figure 1).
1	Inject 0.3 Hz oscillations in system voltage waveform without POD functionality. The amplitude of the oscillation should be sufficiently large to demonstrate damping capability. Record voltage waveform and reactive current from the unit.
2	Turn ON POD functionality. Inject the same oscillation as step 1. Record voltage waveform and reactive current from the unit
3	Observe the difference with and without POD and comment on its performance.
4	Repeat steps 1-3 for increasing oscillations frequencies with steps of 0.1 Hz up to 2Hz.
5	If more than one POD tuning is required to achieve damping across the full frequency range, repeat steps 1-4 for each tuning. Technical report results must cover the range 0.3- 2 Hz.

If POD functionality is not switchable then the steps above may be modified to show how the unit contributes to the damping of system voltage oscillations.

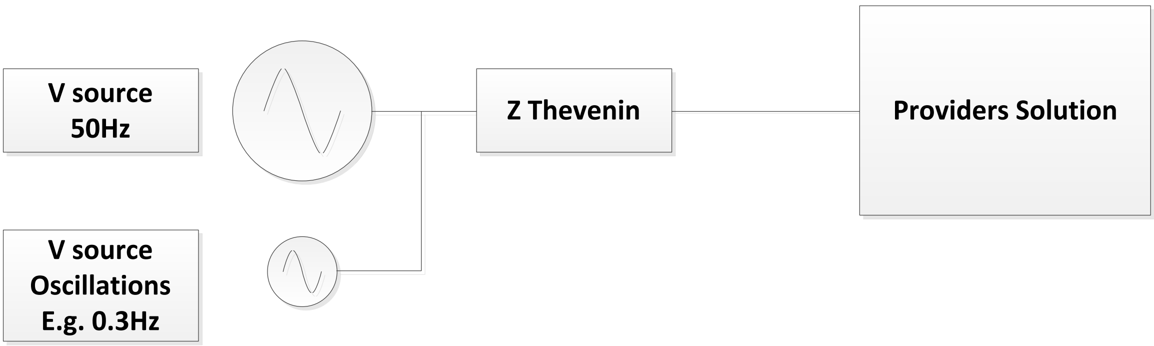


Figure 1- Examples system representation (alternate setups can achieve the same functionality)

If the unit has constant Mvar mode, the provider must show how POD performance is impacted by operating in Mvar mode.

Appendix E Test Signal Schedule and Logsheet

Compliance Test Signal Schedules

Table 1 – Synchronous AVR/POD, UEL/OEL Limiters								
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
1	Time	Active Power	Reactive Power	Terminal Voltage	Speed /Frequency #	Reference Injection #	Logic / Test Start #	Field Voltage
	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14	Col 15	Col 16
1	Field Current	POD Output #	Noise Injection #					
# Columns may be left blank but the column must still be included in the files								

Compliance Test Logsheet

Where test results are completed without any NGESO presence but are relied upon as evidence of the compliance they should be accompanied by a logsheet. This sheet should be legible, in English and detail the items as indicated in Appendix D:

- Time and Date of test
- Name of Power Station and module if applicable.
- Name of Test engineer(s) and company name.
- Name of Customer(s) representative and company name.
- Type of testing being undertake eg Voltage Control.
- Ambient Conditions eg. Temperature, pressure, wind speed, wind direction.
- Controller settings, eg Voltage slope, Frequency droop, Voltage setpoint.

For each test the following items should be recorded as relevant to the type of test being undertaken. Where there is uncertainty on the information to be recorded this should be discussed with NGESO in advance of the test.

Voltage Control Tests

- Start time of each test step.
- Active Power.
- Reactive Power.
- Connection Voltage.
- Voltage Control Setpoint, if applicable or changed.
- Voltage Control Slope, if applicable or changed.
- Terminal Voltage if applicable.
- Provider tap position or Grid Transformer tap position, as applicable.

- Number of Power Park Units in service in each Module, if applicable.

  For Offshore Connections

- Offshore Grid Entry Voltage.

Example Voltage Control / POD Logsheet

Test No.	Time	Initial Conditions					Oscillation signal	POD in/out*	Description	Saved File
		MW	MVAr	Vt	HV	Tap				

***if switchable**

Reactive Power Capability Tests

- Start time of test.
- Active Power.
- Reactive Power.
- Connection Voltage.
- Terminal Voltage if applicable.
- Provider tap position or Grid Transformer tap position as applicable.
- Number of Power Park Units in service in each Module, if applicable.

  For Offshore Connections

- Offshore Grid Entry Voltage.

Example Reactive Capability Logsheet

Test No.	Time	Initial Conditions					Description	Saved File
		MW	MVAr	Vt	HV	Tap		

Appendix F Fault Ride Through

Summary of Grid Code Fault Ride Through (FRT) requirements

A Fault Ride Through requirement is required of the Synchronous Compensator units. Each module is expected to remain connected and stable during fault conditions. To demonstrate this capability the user is required to provide simulation studies.

The provider shall supply time series simulation study results to demonstrate the capability of Synchronous Compensator to meet the Fault Ride Through requirements by submission of a report containing:

(i) a time series simulation study of a 140ms three phase short circuit fault with a retained voltage as detailed in table below applied at the Grid Entry Point or (User System Entry Point if Embedded) of the Synchronous Compensator Unit.

(ii) a time series simulation study of 140ms unbalanced short circuit faults with a retained voltage as detailed in table 1 on the faulted phase(s) applied at the Grid Entry Point or (User System Entry Point if Embedded) of the Synchronous Compensator Unit. The unbalanced faults to be simulated are:

1. a phase to phase fault
2. a two phase to earth fault
3. a single phase to earth fault.

Synchronous Compensator Unit	Retained Voltage
connection point voltage	0%

The simulation study should be completed with the Compensator or operating at maximum leading Reactive Power and the fault level at the Supergrid HV connection point at minimum or as otherwise agreed with The Company as detailed in ECC.6.3.15.8.

(iii) time series simulation studies of balanced Supergrid voltage dips applied on the nearest point of the National Electricity Transmission System operating at Supergrid voltage to the Synchronous Compensator. The simulation studies should include:

1. 50% retained voltage lasting 0.45 seconds
2. 70% retained voltage lasting 0.81 seconds
3. 80% retained voltage lasting 1.00 seconds
4. 85% retained voltage lasting 180 seconds.

For a Synchronous Compensator, the simulation study should be completed with the Synchronous Compensator operating at zero Reactive Power output and the fault level at the Supergrid HV connection point at minimum or as otherwise agreed with The Company. Where the Synchronous Compensator is Embedded the minimum Network

Operator’s System impedance to the Supergrid HV connection point shall be used which may be calculated from the maximum fault level at the User System Entry Point.

The above required simulated voltage changes are shown in Figures ECC.6.3.15.2 – ECC.6.3.15.7 and ECC.6.3.15.9 (a) of the European Code. The requirement and providing a Fault Ride through simulation study applies to all taking part in the Stability Compensation service.

These requirements can be conveniently referred to in the context of two separate fault modes, A & B, which are respectively covered by ECC.6.3.15.1.1 and ECC.6.3.15.9.2 of the Grid Code, where A applies to faults lasting 140ms and B to faults in excess of 140ms.

The details of the simulation studies required are based on the ECP.A.3.5.1 section of Grid Code. The simulation studies requirement for 140ms unbalanced fault is set out in ECP.A.3.5.1 (ii) of the Grid Code. The simulation needs to be carried out at Maximum Leading Reactive Power. The simulation studies requirement for faults lasting longer than 140ms is set out in ECP.A.3.5.1(iii).

Appendix G Inherent Synchronous Characteristics

In the Stability compensation contract technical specification several clauses will inherently be met by a synchronous machine. For synchronous technologies, a statement of compliance will be sufficient to demonstrate compliance against these clauses.

If provider believe they are not able to meet these clauses of the technical specification they should include this in the compliance report.

The relevant clauses are:

- **Schedule E Part A 1.1.1**
- **Schedule E Part A 1.1.3**
- **Schedule E Part A 1.2.5**
- **Schedule E Part A 1.2.6**
- **Schedule E Part A 1.2.7**
- **Schedule E Part A 1.2.11**
- **Schedule E Part A 1.2.12**
- **Schedule E Part A 1.2.14**

For clause **Schedule E Part A 1.1.2**, inertia is an inherent property of the solution. We expect to see a demonstration of the tendered amount via a manufactures data sheet, set of calculations or equivalent.

Appendix H Contacting National Grid ESO

There are a number of different departments within National Grid ESO that will be involved with this service. The initial point of contact for NGESO will be your allocated Service Contract Manager.

For any correspondence relating to testing on the system following the Grid Code the IET process should be followed with notifications made to the '.Box.Tranreq' email address for England and Wales connections and '.Box.TR.Scotland' for all connections in Scotland.

Contact Address:

National Grid ESO, Faraday House, Warwick Technology Park, Gallows Hill, Warwick CV34 6DA

Faraday House, Warwick Technology Park,
Gallows Hill, Warwick, CV346DA

nationalgrideso.com