EUROPEAN COMPLIANCE PROCESSES

(ECP)

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ECP.7. FINAL OPERATIONAL NOTIFICATION

Final Operational Notification in respect of Generators and HVDC System Owners

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ECP.7.2.5 Following completion of each of the tests specified in this ECP.7.2, **The Company** will notify the **Generator** or **HVDC System Owner** whether, in the opinion of **The Company**, the results demonstrate compliance with the relevant **Grid Code** conditions. When the **Generator** or **HVDC System Owner** submits test results to **The Company**, the **Generator** or **HVDC System Owner** may request the **The Company** to advise when the notification is expected to be provided. **The Company** should not unduly delay the notification.

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ECP.10 MANUFACTURER'S DATA & PERFORMANCE REPORT

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ECP.10.4 A **Generator** referencing a **Manufacturer's Data & Performance Report** should insert the relevant **Manufacturer's Data & Performance Report** reference in the appropriate place in the **DRC** data submission, **Power Generating Module Document** and / or in the **User Data File Structure**. **The Company** will consider the suitability of a **Manufacturer's Data & Performance Report:**

(a) in place of **DRC** data submissions a mathematical model suitable for representation of the entire **Power Park Module** as per ECP.A.3.4.4. For the avoidance of doubt only the relevant sections as specified in PC.A.2.5.5.7 apply. Site specific parameters will still need to be submitted by the **Generator**.

(b) Not Used. ~~in place of Fault simulation studies as follows;~~

~~**The Company** will not require Fault Ride Through simulation studies to be conducted as per ECP.A.3.5.1 and qualified in ECP.A.3.5.2 provided that;~~

~~(i) Adequate and relevant **Power Park Unit** data is included in respect of Fault Ride Through testing covered in ECP.A.6.7 in the relevant **Manufacturer's Data & Performance Report** , and~~

~~(ii)(i) For each type and duration of fault as detailed in ECP.A.3.5.1, the expected minimum retained voltage is greater than the corresponding minimum voltage achieved and successfully ridden through in the fault ride through tests covered by the **Manufacturer's Data & Performance Report.**~~

(c) to reduce the scope of compliance site tests as follows;

Commented [H(M1]: Additional text to address comment from MG and SPR comments at work group meeting

Commented [H(M2]: GC0141 inserts a new section for Compliance Repeat Plan

Commented [H(M3]: Removed following consideration of comments by SIB. This provision is rarely used. Virtually all sites undertake the basic FRT studies to demonstrate to owner as well as the Company that the FRT obligation is being met. FRT studies have to be done when there are multiple types of device in a wind farm and for small sites suitable MDPR for FRT testing is not mandatory and may not be available. Given the low useage of this provision and that in responding to the 9th August report calling for more robustness to the compliance process GC0141 is proposing additional FRT simulations for some sites it seems appropriate to remove this provision.

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(i) Where there is a **Manufacturer's Data & Performance Report** in respect of a **Power Park Unit** which covers Fault Ride Through, **The Company** may agree that no Fault Ride Through testing is required.

APPENDIX 3

SIMULATION STUDIES

ECP.A.3.1 SCOPE

ECP.A.3.1.1 This Appendix sets out the simulation studies required to be submitted to **The Company** to demonstrate compliance with the Connection Conditions unless otherwise agreed with **The Company**. This Appendix should be read in conjunction with ECP.6 with regard to the submission of the reports to **The Company**. Where there is any inconsistency in the technical requirements in respect of which compliance is being demonstrated by simulation in this Appendix and ECC.6.3 and the **Bilateral Agreement,** the provisions of the **Bilateral Agreement** and ECC.6.3 prevail. The studies specified in this Appendix will normally be sufficient to demonstrate compliance. However **The Company** may agree an alternative set of studies proposed by the **Generator** or **HVDC System Owner** provided **The Company** deem the alternative set of studies sufficient to demonstrate compliance with the **Grid Code** and the **Bilateral Agreement.**

ECP.A.3.1.2 The **Generator** or **HVDC System Owner** shall submit simulation studies in the form of a report to demonstrate compliance. In all cases the simulation studies must utilise models applicable to the **Synchronous Power Generating Module**, **HVDC Equipment** or **Power Park Module** with proposed or actual parameter settings. Reports should be submitted in English with all diagrams and graphs plotted clearly with legible axes and scaling provided to ensure any variations in plotted values is clear. In all cases the simulation studies must be presented over a sufficient time period to demonstrate compliance with all applicable requirements.

Commented [H(M4]: GC0141 inserts the requirement for simulation studies to be reviewed by an independent engineer

ECP.A.3.1.3 In the case of an **Offshore Power Station** where **OTSDUW Arrangements** apply simulation studies by the **Generator** should include the action of any relevant **OTSUA** where applicable to demonstrate compliance with the **Grid Code** and the **Bilateral Agreement** at the **Interface Point.**

ECP.A.3.1.4 **The Company** will permit relaxation from the requirement ECP.A.3.2 to ECP.A.3.8 where an **Equipment Certificate** for the **Power Generating Module** or **HVDC Equipment** has been provided which details the characteristics from appropriate simulations on a representative installation with the same equipment and settings and the performance of the **Power Generating Module** or **HVDC Equipment** can, in **The Company's** opinion, reasonably represent that of the installed **Power Generating Module** or **HVDC Equipment**.

ECP.A.3.1.5 For **Type B, Type C** and **Type D Power Generating Modules** the relevant **Equipment Certificate** must be supplied in the **Power Generating Module Document** or **Users Data File structure** as applicable. For **HVDC Equipment** the relevant **Equipment Certificates** must be supplied in the **Users Data File structure.**

ECP.A.3.2 Power System Stabiliser Tuning

ECP.A.3.2.1 In the case of a **Synchronous Power Generating Module** with an **Excitation System Power System Stabiliser** the **Power System Stabiliser** tuning simulation study report required by ECC.A.6.2.5.6 or required by the **Bilateral Agreement** shall contain:

(i) the **Excitation System** model including the **Power System Stabiliser** with settings as required under the **Planning Code** (PC.A.5.3.2(c))

(ii) open circuit time series simulation study of the response of the **Excitation System** to a +10% step change from 90% to 100% terminal voltage.

(iii) on load time series dynamic simulation studies of the response of the **Excitation System** with and without the **Power System Stabiliser** to 2% and 10% steps in the reference voltage and a three phase short circuit fault applied to the higher voltage side of the **Synchronous Power Generating Module** transformer for 100ms. The simulation studies should be carried out with the **Synchronous Power Generating Module** operating at full **Active Power** and maximum leading **Reactive Power** import with the fault level at the **Supergrid** HV connection point at minimum or as otherwise agreed with **The Company**. The results should show the **Synchronous Power Generating Module** field voltage, terminal voltage, **Power System Stabiliser** output, **Active Power** and **Reactive Power** output.

(iv) gain and phase Bode diagrams for the open loop frequency domain response of the **Synchronous Power Generating Module Excitation System** with and without the **Power System Stabiliser**. These should be in a suitable format to allow assessment of the phase contribution of the **Power System Stabiliser** and the gain and phase margin of the **Excitation System** with and without the **Power System Stabiliser** in service.

(v) an eigenvalue plot to demonstrate that all modes remain stable when the **Power System Stabiliser** gain is increased by at least a factor of 3 from the designed operating value.

(vi) gain Bode diagram for the closed loop on load frequency domain response of the **Synchronous Power Generating Module Excitation System** with and without the **Power System Stabiliser**. The **Synchronous Power Generating Module** operating at full load and at unity power factor. These diagrams should be in a suitable format to allow comparison of the **Active Power** damping across the frequency range specified in ECC.A.6.2.6.3 with and without the **Power System Stabiliser** in service.

In the case of **a Synchronous Power Generating Module** that may operate as **Demand** (eg. pumped storage) the on load simulations (ii) to (vi) should also carried out in both modes of operation.

Commented [H(M5]: Added to ensure design works in pumping mode as specified in ECC.A.6.2.5.8

ECP.A.3.2.2 In the case of **Onshore Non-Synchronous Power Generating Module, Onshore HVDC Equipment** and **Onshore Power Park Modules** and **OTSDUW Plant** and **Apparatus** at the **Interface Point** the **Power System Stabiliser** tuning simulation study report required by ECC.A.7.2.4.1 or ECC.A.8.2.4 or required by the **Bilateral Agreement** shall contain:

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(i) the **Voltage Control System** model including the **Power System Stabiliser** with settings as required under the **Planning Code** (PC.A.5.4) and **Bilateral Agreement**.

(ii) on load time series dynamic simulation studies of the response of the **Voltage Control System** with and without the **Power System Stabiliser** to 2% and 10% steps in the reference voltage and a three phase short circuit fault applied to the **Grid Entry Point** or the **Interface Point** in the case of **OTSDUW Plant** and **Apparatus** for 100ms. The simulation studies should be carried out operating at full **Active Power** and maximum leading **Reactive Power** import condition with the fault level at the **Supergrid** HV connection point at minimum or as otherwise agreed with **The Company**. The results should show appropriate signals to demonstrate the expected damping performance of the **Power System Stabiliser**.

(iii) any other simulation as specified in the Bilateral Agreement or agreed between the **Generator** or **HVDC System Owner** or **Offshore Transmission Licensee** and **The Company**.

ECP.A.3.3 Reactive Capability across the Voltage Range

ECP.A.3.3.1 (a) For a **Synchronous Power Generating Module**, the ~~The~~ **Generator** ~~shall supply simulation studies to demonstrate~~ the capability to meet ECC.6.3.~~4.1~~2 by submission of a report containing load flow simulation study results to demonstrate:

Commented [H(M6]: Error on simulation requirements notified by Users demonstrating ECC requirements. Missed when ECC implemented. Separate out Synchronous from Non-synchronous as ECC.6.3.2 requirements on voltage range are different from CC.6.3.4.

(i) ~~a load flow simulation study result to demonstrate~~ the maximum lagging **Reactive Power** capability ~~of the **Synchronous Power Generating Module, OTSUA** or **Power Park Module**~~ at **Maximum Capacity** when the **Grid Entry Point** or **User System Entry Point** if **Embedded** or **Interface Point** (in the case of **OTSUA**) voltage is at 105% of nominal.

(ii) ~~a load flow simulation study result to demonstrate~~ the maximum leading **Reactive Power** capability ~~of the **Synchronous Power Generating Module, OTSUA** or **Power Park Module**~~ at **Maximum Capacity** when the **Grid Entry Point** or **User System Entry Point** if **Embedded** or **Interface Point** (in the case of **OTSUA**) voltage is at 95% of nominal.

(iii) ~~a load flow simulation study result to demonstrate~~ the maximum lagging **Reactive Power** capability ~~of the **Synchronous Power Generating Module OTSUA** or **Power Park Module**~~ at the **Minimum Regulating Level** when the **Grid Entry Point** or **User System Entry Point** if **Embedded** or **Interface Point** (in the case of **OTSUA**) voltage is at 105% of nominal.

(iv) ~~a load flow simulation study result to demonstrate~~ the maximum leading **Reactive Power** capability ~~of the **Synchronous Power Generating Module, OTSUA** or **Power Park Module**~~ at the **Minimum Regulating Level** when the **Grid Entry Point** or **User System Entry Point** if **Embedded** or **Interface Point** (in the case of **OTSUA**) voltage is at 95% of nominal.

(b) For an **OSTUA** with an **Interface Point** above 33kV or **Power Park Modules** with a **Grid Entry Point** or **User System Entry Point** above 33kV, the **Generator** shall demonstrate the capability to meet ECC.6.3.2 by submission of a report containing load flow simulation study results to demonstrate operation at points A, B, E and F in

accordance with Figure ECC.A.7.2.2(b) or Figure ECC.A.8.2.2(b). The studies should be run with both the **OTSUA** and **Power Park Module** operating at **Maximum Capacity** and at the **Minimum Stable Operating Level.**

(c) For an **OSTUA** with an **Interface Point** at or below 33kV or **Power Park Modules** with a **Grid Entry Point** or **User System Entry Point** at or below 33kV, a load flow simulation study results to demonstrate operation at points A, B, E and F in accordance with Figure ECC.A.7.2.2(c) or Figure ECC.A.8.2.2(b). The studies should be run with both the **OTSUA** and **Power Park Module** operating at **Maximum Capacity** and at the **Minimum Stable Operating Level.**

Commented [H(M7]: Add in simulations for a Non-synchronous generator to align with the voltage ranges applicable in ECC

(d) For an **HVDC System**, the ~~The~~ **HVDC System Owner** shall supply simulation studies to demonstrate the capability to meet ECC.6.3.~~4.1~~2 by submission of a report containing load flow simulation study results to demonstrate operation at points A, B, E and F in accordance with Figure ECC.A.7.2.2(b). The studies should be run with both the **HVDC System** operating at the **Maximum HVDC Active Power Transmission Capacity** and **Minimum HVDC Active Power Transmission Capacity.** ~~:~~

~~(i) a load flow simulation study result to demonstrate the maximum lagging **Reactive Power** capability of the **Synchronous Power Generating Module, HVDC Equipment, OTSUA** or **Power Park Module** at **Maximum HVDC Active Power Transmission Capacity** when the **Grid Entry Point** or **User System Entry Point** if **Embedded** or **Interface Point** (in case of **OTSUA**) voltage is at 105% of nominal.~~

~~(ii) a load flow simulation study result to demonstrate the maximum leading **Reactive Power** capability of the **Synchronous Power Generating Module, HVDC Equipment, OTSUA** or **Power Park Module** at **Maximum HVDC Active Power Transmission Capacity** when the **Grid Entry Point** or **User System Entry Point** if **Embedded** or **Interface Point** (in case of **OTSUA**) voltage is at 95% of nominal.~~

~~(iii) a load flow simulation study result to demonstrate the maximum lagging **Reactive Power** capability of the **Synchronous Power Generating Module, HVDC Equipment** or **Power Park Module** at the **Minimum HVDC Active Power Transmission Capacity** when the **Grid Entry Point** or **User System Entry Point** if **Embedded** or **Interface Point** (in case of **OTSUA**) voltage is at 105% of nominal.~~

~~(iv) a load flow simulation study result to demonstrate the maximum leading **Reactive Power** capability of the **Synchronous Power Generating Module, HVDC Equipment** or **Power Park Module** at the **Minimum HVDC Active Power Transmission Capacity** when the **Grid Entry Point** or **User System Entry Point** voltage if **Embedded** or **Interface Point** (in case of **OTSUA**) is at 95% of nominal.~~

Commented [H(M8]: Correct requirements for HVDC simulations to align with ECC voltage ranges.

ECP.A.3.3.2 In the case of a **Synchronous Power Generating Module** the terminal voltage in the simulation should be the nominal voltage for the machine.

ECP.A.3.3.3 In the case of a **Power Park Module** where the load flow simulation studies show that the individual **Power Park Units** deviate from nominal voltage to meet the **Reactive Power** requirements then evidence must be provided from factory (e.g. in a **Manufacturer's Data & Performance Report**) or site testing that the **Power Park Unit** is capable of operating continuously at the operating points determined in the load flow simulation studies.

ECP.A.3.4 Voltage Control and Reactive Power Stability

ECP.A.3.4.1 This section applies to **HVDC Equipment;** and **Type C & Type D Power Park Modules** to demonstrate the voltage control capability and **Type B Power Park Modules** to demonstrate the voltage control capability if specified by **The Company.**

In the case of a power station containing **Power Park Modules** and/or **OTSUA** the **Generator** shall provide a report to demonstrate the dynamic capability and control stability of the **Power Park Module**. The report shall contain:

(i) a dynamic time series simulation study result of a sufficiently large negative step in **System** voltage to cause a change in **Reactive Power** from zero to the maximum lagging value at **Rated MW**.

(ii) a dynamic time series simulation study result of a sufficiently large positive step in **System** voltage to cause a change in **Reactive Power** from zero to the maximum leading value at **Rated MW**.

(iii) a dynamic time series simulation study result to demonstrate control stability at the lagging **Reactive Power** limit by application of a -2% voltage step while operating within 5% of the lagging **Reactive Power** limit.

(iv) a dynamic time series simulation study result to demonstrate control stability at the leading **Reactive Power** limit by application of a +2% voltage step while operating within 5% of the leading **Reactive Power** limit.

(v) a dynamic time series simulation study result of a sufficiently large negative step in **System** voltage to cause a change in **Reactive Power** from the maximum leading value to the maximum lagging value at **Rated MW**.

Commented [H(M9]: To align with ECC.A.7.2.3.1(ii)

The **Generator** should also provide the voltage control study specified in ECP.A.3.7.4.

ECP.A.3.4.2 All the above studies should be completed with a network operating at the voltage applicable for zero **Reactive Power** transfer at the **Grid Entry Point** or **User System Entry Point** if **Embedded** or, in the case of **OTSUA**, **Interface Point** unless stated otherwise. The fault level at the HV connection point should be set at the minimum level as agreed with **The Company**.

ECP.A.3.5 Fault Ride Through and Fast Fault Current Injection

ECP.A.3.5.1 This section applies to **Type B, Type C and Type D Power Generating Modules** and **HVDC Equipment** to demonstrate the modules fault ride through and **Fast Fault Current** injection capability.

The **Generator** or **HVDC System Owner** shall supply time series simulation study results to demonstrate the capability of **Synchronous Power Generating Module, HVDC Equipment,** and **Power Park Modules** and **OTSUA** to meet ECC.6.3.15 and ECC.6.3.16 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 A.3.5.1 below applied at the **Grid Entry Point** or (**User System Entry Point** if **Embedded**) of the **Power Generating Module** or **HVDC Equipment** or **OTSUA**.

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(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 **Power Generating Module** or **HVDC Equipment** or **OTSUA.** 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.

Power Generating Module	Retained Voltage
Synchronous Power Generating Module	
Type B	30%
Type C or Type D with Grid **connection point** voltage <110kV	10%
Type D with connection point voltage >110kV	0%
Power Park Module	
Type B or Type C or Type D with **connection point** voltage < 110kV	10%
Type D with **connection point** voltage >110kV	0%
HVDC Equipment	~~1~~0%

Table A.3.5.1

Commented [H(M10]: Responding to MG. Correction to align with Figure ECC.6.3.15.7

For a **Power Generating Module** or **HVDC Equipment** or **OTSUA** the simulation study should be completed with the **Power Generating Module** or **HVDC Equipment** or **OTSUA** operating at full **Active Power** and 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 Power Generating Module** or **OTSUA**. 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 Power Generating Module** or **OTSUA,** the simulation study should be completed with the **Synchronous Power Generating Module** or **OTSUA** operating at full **Active Power** and 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 Power Generating Module** 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**.

(~~iii~~iv) 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 **HVDC Equipment** or **Power Park Module**. The simulation studies should include:

Commented [H(M11]: Correction to numbering

1. 30% retained voltage lasting 0.384 seconds
2. 50% retained voltage lasting 0.71 seconds

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3. 80% retained voltage lasting 2.5 seconds
4. 85% retained voltage lasting 180 seconds.

For ~~**HVDC Equipment**~~ or **Power Park Modules** the simulation study should be completed with the **HVDC Equipment** or **Power Park Module** operating at full **Active Power** and 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 ~~**HVDC Equipment** or~~ **Power Park Module** 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**.

(v) 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 **HVDC Equipment**. The simulation studies should include:

1. 30% retained voltage
2. 50% retained voltage
3. 80% retained voltage
4. 85% retained voltage

For **HVDC Equipment** the simulation study should be completed with the **HVDC Equipment** operating at full **Active Power** transfer and 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 **HVDC Equipment** 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**.

For **HVDC Equipment** ~~the simulations should include~~ the duration of each voltage dip 1 to 4 above ~~for which the **HVDC Equipment** will remain connected~~ should demonstrate the requirements of the **Bilateral Agreement**.

ECP.A.3.5.2 ~~Not Used. In the case of **Power Park Modules** comprised of **Power Park Units** in respect of which the **User's** reference to a **Manufacturer's Data & Performance Report** has been accepted by **The Company** for Fault Ride Through, ECP.A.3.5.1 will not apply provided:~~

~~(i) the **Generator** or **HVDC System Owner** demonstrates by load flow simulation study result that the faults and voltage dips at either side of the **Power Park Unit** transformer corresponding to the required faults and voltage dips in ECP.A.3.5.1 applied at the nearest point of the **National Electricity Transmission System** operating at **Supergrid** voltage are less than those included in the **Manufacturer's Data & Performance Report**,~~

~~or;~~

~~(ii) the same or greater percentage faults and voltage dips in ECP.A.3.5.1 have been applied at either side of the **Power Park Unit** transformer in the **Manufacturer's Data & Performance Report**.~~

~~ECP.A.3.5.3~~

ECP.A.3.6 **Limited Frequency Sensitive Mode** – Over Frequency (**LFSM-O**)

ECP.A.3.6.1 This section applies to **Type B, Type C and Type D Power Generating Modules, HVDC Equipment** to demonstrate the capability to modulate Active Power at high frequency as required by ECC6.3.7.3.5(ii).

Commented [H(M12]: Separate HVDC from Power Park Modules as requirements for dips longer than 140ms are different.

Commented [H(M13]: In response to SIB comments this option has been removed. It has only been used in a very small number of cases and does not fit well with GC0141 proposals to enhance the robustness of simulations studies for FRT.

Commented [H(M14]: GC0141 inserts additional FRT study requirements for complex connections

ECP.A.3.6.2 The simulation study should comprise of a **Power Generating Module** or **HVDC Equipment** connected to the total **System** with a local load shown as "X" in figure ECP.A.3.6.1. The load "X" is in addition to any auxiliary load of the **Power Station** connected directly to the **Power Generating Module** or **HVDC Equipment** and represents a small portion of the **System** to which the **Power Generating Module** or **HVDC Equipment** is attached. The value of "X" should be the minimum for which the **Power Generating Module or HVDC Equipment** can control the power island frequency to less than 52Hz consistent with ECC.6.3.7.3.5(ii). Where transient excursions above 52Hz occur the **Generator** or **HVDC Equipment Owner** should ensure that the duration above 52Hz is less than any high frequency protection system applied to the **Power Generating Module** or **HVDC Equipment.**

ECP.A.3.6.3 For **HVDC Equipment** and **Power Park Modules** consisting of units connected wholly by power electronic devices the simulation methodology may be modified by the addition of a **Synchronous Power Generating** Module (G2) connected as indicated in Figure ECP.A.3.6.2. This additional **Synchronous Power Generating Module** should have an inertia constant of 3.5MWs/MVA, be initially operating at rated power output and unity power factor. The mechanical power of the **Synchronous Power Generating Module** (G2) should remain constant throughout the simulation.

ECP.A.3.6.4 At the start of the simulation study the **Power Generating Module** or **HVDC Equipment** will be operating maximum **Active Power** output. The **Power Generating Module** or **HVDC Equipment** will then be islanded from the **Total System** but still supplying load "X" by the opening of a breaker, which is not the **Power Generating Module** or **HVDC Equipment** connection circuit breaker (the governor should therefore, not receive any signals that the breaker has opened other than the reduction in load and subsequent increase in speed). A schematic arrangement of the simulation study is illustrated by Figure ECP.A.3.6.1.

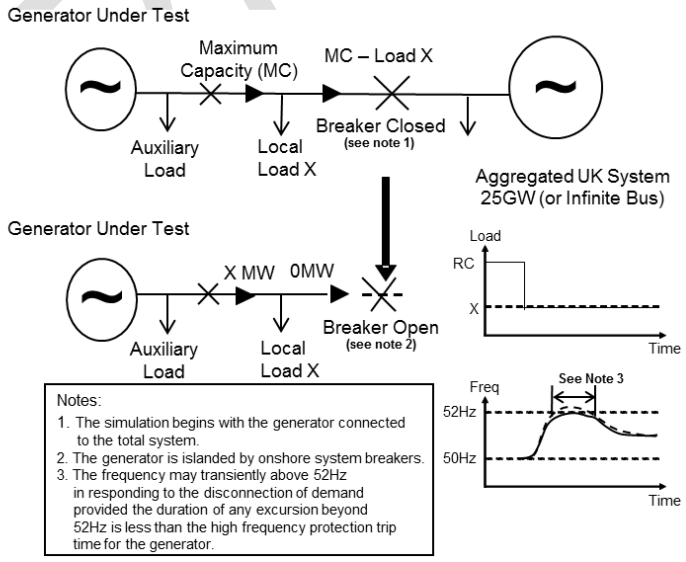

Figure ECP.A.3.6.1 – Diagram of Load Rejection Study

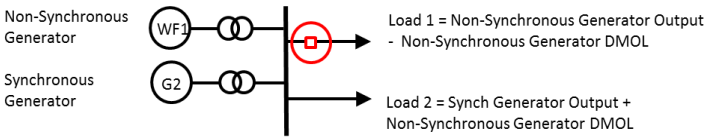

Figure ECP.A.3.6.2 – Addition of Generator G2 if applicable

ECP.A.3.6.5 Simulation study shall be performed for type B, C & D in **Limited Frequency Sensitive Mode** (LFSM) and **Frequency Sensitive Mode** (FSM) for type C & D. The simulation study results should indicate **Active Power** and **Frequency**.

ECP.A.3.6.6 To allow validation of the model used to simulate load rejection in accordance with ECC.6.3.7.3.5 as described a further simulation study is required to represent the largest positive **Frequency** injection step or fast ramp (BC1 and BC3 of Figure 2) that will be applied as a test as described in ECP.A.5.8 and ECP.A.6.6.

Limited Frequency Sensitive Mode – Under Frequency (**LFSM-U**)

ECP.A.3.6.7 This section applies to:
Synchronous Power Generating Modules, Type C & D; or,
HVDC Equipment; or,
Power Park Modules, Type C & D to demonstrate the modules capability to modulate Active Power at low frequency.

ECP.A.3.6.8 To demonstrate the LFSM-U low **Frequency** control when operating in **Limited Frequency Sensitive Mode** the **Generator** or **HVDC System Owner** shall submit a simulation study representing the response of the **Power Generating Module or HVDC Equipment** operating at 80% of **Maximum Capacity**. The simulation study event shall be equivalent to:

(i) a sufficiently large reduction in the measured **System Frequency** ramped over 10 seconds to cause an increase in Active Power output to the **Maximum Capacity** followed by
(ii) 60 seconds of steady state with the measured **System Frequency** depressed to the same level as in ECP.A.3.6.8.1 (i) as illustrated in Figure ECP.A.3.6.1 below.
(iii) then increase of the measured **System Frequency** ramped over 10 seconds to cause a reduction in Active Power output back to the original Active Power level followed by at least 60 seconds of steady output.

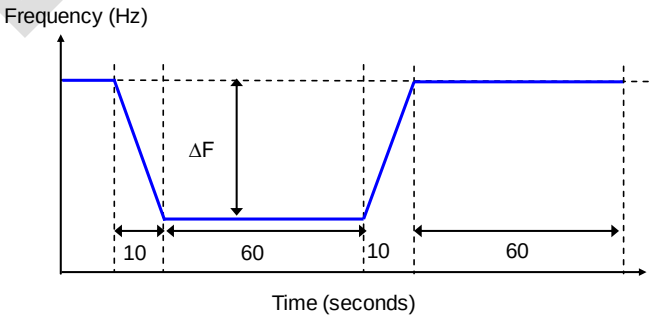

Figure ECP.A.3.6.1

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ECP.A.3.7 Voltage and **Frequency** Controller Model Verification and Validation

ECP.A.3.7.1 For **Type C** and **Type D Synchronous Power Generating Modules, HVDC Equipment or Power Park Modules** the **Generator or HVDC System Owner** shall provide simulation studies to verify that the proposed controller models supplied to **The Company** under the **Planning Code** are fit for purpose. These simulation study results shall be provided in the timescales stated in the **Planning Code**.

ECP.A.3.7.2 To demonstrate the **Frequency** control or governor/load controller/plant model the **Generator** or **HVDC System Owner** shall submit a simulation study representing the response of the **Synchronous Power Generating Module, HVDC Equipment** or **Power Park Module** operating at 80% of **Maximum Capacity**. The simulation study event shall be equivalent to:

(i) a ramped reduction in the measured **System Frequency** of 0.5Hz in 10 seconds followed by
(ii) 20 seconds of steady state with the measured **System Frequency** depressed by 0.5Hz followed by
(iii) a ramped increase in measured **System Frequency** of 0.3Hz over 30 seconds followed by
(iv) 60 seconds of steady state with the measured **System Frequency** depressed by 0.2Hz as illustrated in Figure ECP.A.3.7.2 below.

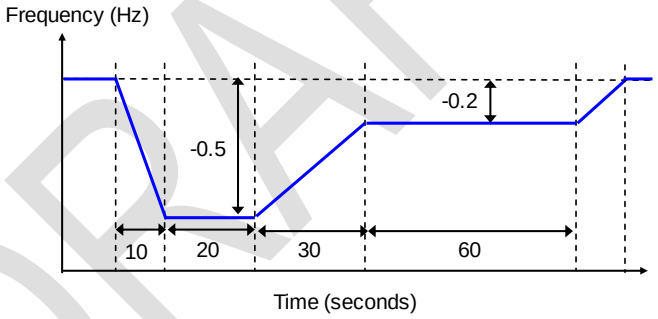

Figure ECP.A.3.7.2

The simulation study shall show **Active Power** output (MW) and the equivalent of **Frequency** injected.

ECP.A.3.7.3 To demonstrate the **Excitation System** model the **Generator** shall submit simulation studies representing the response of the **Synchronous Power Generating Module** as follows:

(i) operating open circuit at rated terminal voltage and subjected to a 10% step increase in terminal voltage reference from 90% to 100%.
(ii) operating at **Rated MW**, nominal terminal voltage and unity power factor subjected to a 2% step increase in the voltage reference. Where a **Power System Stabiliser** is included within the **Excitation System** this shall be in service.

The simulation study shall show the **Synchronous Power Generating Module** terminal voltage, field voltage, **Active Power**, **Reactive Power** and **Power System Stabiliser** output signal as appropriate.

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ECP.A.3.7.4 To demonstrate the Voltage Controller model the **Generator** or **HVDC System Owner** shall submit a simulation study representing the response of the **HVDC Equipment** or **Power Park Module** operating at **Rated MW** and unity power factor at the connection point to a 2% step increase in the voltage reference. The simulation study shall show the terminal voltage, **Active Power**, **Reactive Power** and **Power System Stabiliser** output signal as appropriate.

ECP.A.3.7.5 To validate that the excitation and voltage control models submitted under the **Planning Code** are a reasonable representation of the dynamic behaviour of the **Synchronous Power Generating Module, HVDC Equipment** or **Power Park Module** as built, the **Generator** or **HVDC System Owner** shall repeat the simulation studies outlined above but using the operating conditions of the equivalent tests. The simulation study results shall be displayed overlaid on the actual test results.

ECP.A.3.7.6 For **Type C** and **Type D Synchronous Power Generating Modules** or **HVDC Equipment** to validate that the governor/load controller/plant or **Frequency** control models submitted under the **Planning Code** is a reasonable representation of the dynamic behaviour of the **Synchronous Power Generating Module** or **HVDC Equipment Station** as built, the **Generator** or **HVDC System Owner** shall repeat the simulation studies outlined above but using the operating conditions of the equivalent tests. The simulation study results shall be displayed overlaid on the actual test results.

ECP.A.3.8 Sub-synchronous Resonance control and Power Oscillation Damping control for **HVDC System.**

ECP.A.3.8.1 To demonstrate the compliance of the sub-synchronous control capability with ECC.6.3.17.1) and the terms of the **Bilateral Agreement** the **HVDC System Owner** shall submit a simulation study report

ECP.A.3.8.2 Where power oscillation damping control function is specified on a **HVDC Equipment** the **HVDC System Owner** shall submit a simulation study report to demonstrate the compliance with ECC.6.3.17.2 and the terms of the **Bilateral Agreement.**

ECP.A.3.8.3 The simulation studies should utilise the **HVDC Equipment** control system models including the settings as required under the **Planning Code** (PC.A.5.3.2). The network conditions for the above simulation studies should be discussed with **The Company** prior to commencing any simulation studies.

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APPENDIX 4

ONSITE SIGNAL PROVISION FOR WITNESSING TESTS

ECP.A.4.1 During any tests witnessed on-site by **The Company**, the following signals shall be provided to **The Company** by the **Generator** undertaking **OTSDUW or HVDC System Owner** in accordance with ECC.6.6.3.

ECP.A.4.2 **Synchronous Power Generating Modules**

ECP.A.4.2(a) All Tests	• MW - **Active Power** at **Synchronous Generating Unit** terminals
ECP.A.4.2(b) Reactive & **Excitation System**	• MVAr - **Reactive Power** at terminals • Vt - **Synchronous Generating Unit** terminal voltage • Efd- **Synchronous Generating Unit** field voltage and/or main exciter field voltage • Ifd – **Synchronous Generating Unit** Field current (where possible) • **Power System Stabiliser** output, where applicable. • Noise – Injected noise signal (where applicable and possible)
ECP.A.4.2(c) Governor System & **Frequency Response**	• Fsys - **System Frequency** • Finj - Injected Speed Setpoint • Logic - Stop / Start Logic Signal
	For Gas Turbines: • GT Fuel Demand • GT Fuel Valve Position • GT Inlet Guide Vane Position • GT Exhaust Gas Temperature
	For Steam Turbines at >= 1Hz: • Pressure before Turbine Governor Valves • Turbine Governor Valve Positions • Governor Oil Pressure* • Boiler Pressure Set Point * • Superheater Outlet Pressure * • Pressure after Turbine Governor Valves* • Boiler Firing Demand* *Where applicable (typically not in **CCGT module**)
	For Hydro Plant: • Speed Governor Demand Signal • Actuator Output Signal • Guide Vane / Needle Valve Position
ECP.A.4.2(d) Compliance with ECC.6.3.3	• Fsys - **System Frequency** • Finj - Injected Speed Setpoint • Appropriate control system parameters as agreed with **The Company** (See ECP.A.5.9)
ECP.A.4.2(e) Real Time on site or Down-loadable	• MW - **Synchronous Power Generating Module Active Power** at the **Grid Entry Point** or **(User System Entry Point** if **Embedded)**. • MVAr - **Synchronous Power Generating Module Reactive Power** at the **Grid Entry Point** or **(User System Entry Point** if **Embedded)**.

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	• Line-line Voltage (kV) at the **Grid Entry Point** or (**User System Entry Point** if **Embedded**).

ECP.A.4.3 **Power Park Modules, OTSDUA** and **HVDC Equipment**

	Each **Power Park Module** and **HVDC Equipment** at **Grid Entry Point** or **User System Entry Point**
ECP.A.4.3.1(a) Real Time on site.	• Total **Active Power** (MW) • Total **Reactive Power** (MVAr) • Line-line Voltage (kV) • **System Frequency** (Hz)
ECP.A.4.3.1(b) Real Time on site or Down-loadable	• Injected frequency signal (Hz) or test logic signal (Boolean) when appropriate • Injected voltage signal (per unit voltage) or test logic signal (Boolean) when appropriate • In the case of an **Onshore Power Park Module** the **Onshore Power Park Module** site voltage (MV) (kV) • **Power System Stabiliser** output, where appropriate • In the case of a **Power Park Module** or **HVDC Equipment** where the **Reactive Power** is provided by from more than one **Reactive Power** source, the individual **Reactive Power** contributions from each source, as agreed with **The Company.** • In the case of **HVDC Equipment** appropriate control system parameters as agreed with **The Company** (See ECP.A.7) • In the case of an **Offshore Power Park Module** the Total **Active Power** (MW) and the Total **Reactive Power** (MVAr) at the offshore **Grid Entry Point**
ECP.A.4.3.1(c) Real Time on site or Down-loadable	• Available power for **Power Park Module** (MW) • Power source speed for **Power Park Module** (e.g. wind speed) (m/s) when appropriate • Power source direction for **Power Park Module** (degrees) when appropriate See ECP.A.4.3.2

ECP.A.4.3.2 **The Company** accept that the signals specified in ECP.A.4.3.1(c) may have lower effective sample rates than those required in ECC.6.6.3 although any signals supplied for connection to **The Company's** recording equipment which do not meet at least the sample rates detailed in ECC.6.6.3 should have the actual sample rates indicated to **The Company** before testing commences.

ECP.A.4.3.3 For all **The Company** witnessed testing either;

(i) the **Generator** or **HVDC System Owner** shall provide to **The Company** all signals outlined in ECP.A.4.3.1 direct from the **Power Park Module** control system without any attenuation, delay or filtering which would result in the inability to fully demonstrate the objectives of the test, or identify any potential safety or plant instability issues, and with a signal update rate corresponding to ECC.6.6.3.2; or

(ii) in the case of **Onshore Power Park Modules** the **Generator HVDC System Owner** shall provide signals ECP.A.4.3.1(a) direct from one or more transducer(s) connected to current and voltage transformers for monitoring in real time on site; or,

(iii) In the case of **Offshore Power Park Modules** and **OTSDUA** signals ECP.A.4.3.1(a) will be provided at the **Interface Point** by the **Offshore Transmission Licensee** pursuant to the STC or by the **Generator** when **OTSDUW Arrangements** apply.

ECP.A.4.3.4 Options ECP.A.4.3.3 (ii) and (iii) will only be available on condition that;

(a) all signals outlined in ECP.A.4.3.1 are recorded and made available to **The Company** by the **Generator** or **HVDC System Owner** from the **Power Park Module** or **OTSDUA** or **HVDC Equipment** control systems as a download once the testing has been completed; and

(b) the full test results are provided by the **Generator HVDC System Owner** within 2 working days of the test date to **The Company** unless **The Company** agrees otherwise; and

(c) all data is provided with a sample rate in accordance with ECC.6.6.3.3 unless **The Company** agrees otherwise; and

(d) in **The Company's** reasonable opinion the solution does not unreasonably add a significant delay between tests or impede the volume of testing which can take place on the day.

ECP.A.4.3.5 In the case of where transducers connected to current and voltage transformers are installed (ECP.A.4.3.3(ii) and (iii)), the transducers shall meet the following specification

(a) The transducer(s) shall be permanently installed to easily allow safe testing at any point in the future, and to avoid a requirement for recalibration of the current transformers and voltage transformers.

(b) The transducer(s) should be directly connected to the metering quality current transformers and voltage transformers or similar.

(c) The transducers shall either have a response time no greater than 50ms to reach 90% of output, or no greater than 300ms to reach 99.5%.

ECP.A.4.3.6 Testing not witnessed by **The Company** on-site

ECP.A.4.3.6.1.1 Where **The Company** has decided not to witness testing on-site, the results shall be submitted to **The Company** in spreadsheet format with the signal data in columns arranged as follows. Signal data denoted by "#" is not essential but if not provided the column should remain in place but without values entered. Where two signal names are given in a column these are alternatives related to the type of plant under test.)

ECP.A.4.6.3.1.2 Where **The Company** has requested addition signals to be recorded prior to the testing these signals shall be placed in columns to the right of the spreadsheet.

ECP.A.4.3.6.2.1 Onshore Synchronous Generator Excitation System and Reactive Capability

Commented [H(M15]: Responding to SPR comments. The tables are intended to give a standard layout to test result data being submitted for each plant type so a wind farm will provide the same data layout for all tests. However, as some data is not essential for particular types of test (eg frequency injection signal for reactive capability testing) the column must be present in layout but may be empty.

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	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 #	Freq 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	PSS Output #	Noise Injection #					
# Columns may be left blank but the column must still be included in the files								

ECP.A.4.3.6.2.2 Onshore Synchronous Generator Frequency Response and ECC.6.3.3

	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	Freq Injection	Logic / Test Start	Fuel Demand
2								Guide Vane Setpoint
	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14	Col 15	Col 16
1	Inlet Guide Vane	Exhaust Gas Temp	ST Valve Pos	Fuel Valve Pos	HP Steam Valve Pos	IP Steam Valve Pos	LP Steam Valve Pos	
2	Guide Vane Position	Head						
# Columns may be left blank but must still be included in the files								

ECP.A.4.3.6.3.1 Onshore Power Park Modules Voltage Control & Reactive Capability

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
1	Time	Active Power	Reactive Power	Connection Point Voltage #	Speed /Frequency #	Freq Injection #	Logic / Test Start #	Statcom or Windfarm Output #
	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14	Col 15	Col 16
1	Power Available	Wind Speed	Wind Direction	Voltage Setpoint				
2	State of Charge							
# Columns may be left blank but the column must still be included in the files								

ECP.A.4.3.6.3.2 Offshore Power Park Modules Voltage Control & Reactive Capability

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
1	Time	Onshore Interface	Onshore Interface	Onshore Interface	Speed /Frequency	Freq Injection	Logic /	Statcom or

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		Point Active Power	Point Reactive Power	Point Voltage	#	#	Test Start #	Windfarm Output
	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14	Col 15	Col 16
1	Power Available	Wind Speed m/s	Wind Direction	Voltage Setpoint				
2	State of Charge							
# Columns may be left blank but the column must still be included in the files								

ECP.A.4.3.6.3.3 Power Park Modules Frequency Control

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
1	Time	GEP Active Power	GEP Reactive Power #	GEP Connection Voltage #	Speed /Frequency	Freq Injection	Logic / Test Start	Statcom or Windfarm Output #
	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14	Col 15	Col 16
1	Power Available	Wind Speed m/s	Wind Direction					
2	State of Charge							
# Columns may be left blank but must still be included in the files								

ECP.A.4.3.7.1 Where test results are completed without the presence of **The Company** 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 below:

Time and Date of test

Name of **Power Station** and **Power Generating Module** if applicable.

Name of Test engineer(s) and company name.

Name of **Users** representative(s) 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, UEL & OEL settings

ECP.A.4.3.7.2 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 **The Company** in advance of the test.

ECP.A.4.3.7.2 .1 Voltage Control Tests

Start time of each test step.

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Active Power.

Reactive Power.

Connection voltage.

Voltage Control Setpoint, if applicable or changed.

Voltage Control Slope, if applicable or changed.

Terminal Voltage if applicable.

Generator tap position or Grid Transformer tap position, as applicable.

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

For Offshore Connections

Offshore Grid Entry Point Voltage.

ECP.A.4.3.7.2.2 Reactive Power Capability Tests

Start time of test.

Active Power.

Reactive Power.

Connection Voltage.

Terminal Voltage if applicable.

Generator tap position or Grid Transformer tap position as applicable.

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

For Offshore Connections

Offshore Grid Entry Point Voltage.

ECP.A.4.3.7.2.3 Frequency Response Capability Tests

Start time of test.

Active Power.

System Frequency.

For **CCGT Modules**, **Active Power** for the individual units (GT &ST).

For Boiler plant, HP steam pressure.

Droop setting of controller if applicable

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

For Offshore Connections

Offshore Grid Entry Point Active Power for each **Power Park Module**.

ECP.A.4.3.7.3 Material changes during the test period should be recorded e.g. Units tripping / starting, changes to tapchange positions.

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APPENDIX 5

COMPLIANCE TESTING OF SYNCHRONOUS POWER GENERATING MODULES

ECP.A.5.1 SCOPE

ECP.A.5.1.1 This Appendix sets out the tests contained therein to demonstrate compliance with the relevant clauses of the European Connection Conditions of the **Grid Code**. This Appendix shall be read in conjunction with the ECP with regard to the submission of the reports to **The Company**.

ECP.A.5.1.2 The tests specified in this Appendix will normally be sufficient to demonstrate compliance however **The Company** may:

(i) agree an alternative set of tests provided **The Company** deem the alternative set of tests sufficient to demonstrate compliance with the **Grid Code** and **Bilateral Agreement**; and/or

(ii) require additional or alternative tests if information supplied to **The Company** during the compliance process suggests that the tests in this Appendix will not fully demonstrate compliance with the relevant section of the **Grid Code** or **Bilateral Agreement.**

(iii) Agree a reduced set of tests for subsequent **Synchronous Power Generating Module** following successful completion of the first **Synchronous Power Generating Module** tests in the case of a **Power Station** comprised of two or more **Synchronous Power Generating Module** which **The Company** reasonably considers to be identical.

If:

(a) the tests performed pursuant to ECP.A.5.1.2(iii) in respect of subsequent **Synchronous Power Generating Modules** do not replicate the full tests for the first **Synchronous Power Generating Module** , or

(b) any of the tests performed pursuant to ECP.A.5.1.2(iii) do not fully demonstrate compliance with the relevant aspects of the **Grid Code**, **Ancillary Services Agreement** and / or **Bilateral Agreement**,

then notwithstanding the provisions above, the full testing requirements set out in this Appendix will be applied.

ECP.A.5.1.3 The **Generator** is responsible for carrying out the tests set out in and in accordance with this Appendix and the **Generator** retains the responsibility for the safety of personnel and plant during the test. **The Company** will witness all of the tests outlined or agreed in relation to this Appendix unless **The Company** decides and notifies the **Generator** otherwise. Reactive Capability tests may be witnessed by **The Company** remotely from the **The Company** control centre. For all on site **The Company** witnessed tests the **Generator** should ensure suitable representatives from the **Generator** and manufacturer (if appropriate) are available on site for the entire testing period. In all cases the **Generator** shall provide suitable monitoring equipment to record all relevant test signals as outlined below in ECP.A.6.1.5.

ECP.A.5.1.6 The **Generator** shall submit a schedule of tests to **The Company** in accordance with CP.4.3.1.

ECP.A.5.1.7 Prior to the testing of a **Synchronous Power Generating Module** the

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Generator shall complete the **Integral Equipment Test** procedure in accordance with OC.7.5.

ECP.A.5.1.8 Full **Synchronous Power Generating Module** testing as required by CP.7.2 is to be completed as defined in ECP.A.5.2 through to ECP.A.5.9.

ECP.A.5.1.9 **The Company** will permit relaxation from the requirement ECP.A.5.2 to ECP.A.5.9 where an **Equipment Certificate** for the **Synchronous Power Generating Module** has been provided which details the characteristics from tests on a representative machine with the same equipment and settings and the performance of the **Synchronous Power Generating Module** can, in **The Company's** opinion, reasonably represent that of the installed **Synchronous Power Generating Module** at that site. For **Type B**, **Type C** and **Type D Power Generating Modules** the relevant **Equipment Certificate** must be supplied in the **Power Generating Module Document** or **Users Data File structure** as applicable.

ECP.A.5.2 Excitation System Open Circuit Step Response Tests

ECP.A.5.2.1 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 Power Generating Module** terminal voltage, with the **Synchronous Power Generating Module** on open circuit and at rated speed.

ECP.A.5.2.1 The test shall be carried out prior to synchronisation in accordance with CP.6.4. This is not witnessed by **The Company** unless specifically requested by **The Company**. Where **The Company** is not witnessing the tests, the Generator shall supply the recordings of the following signals to **The Company** in an electronic spreadsheet format:

Vt - **Synchronous Generating Unit** terminal voltage
Efd - **Synchronous Generating Unit** field voltage or main exciter field voltage
Ifd- **Synchronous Generating Unit** field current (where possible)
Step injection signal

ECP.A.5.2.3 Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

ECP.A.5.3 Open & Short Circuit Saturation Characteristics

ECP.A.5.3.1 The test shall normally be carried out prior to synchronisation in accordance with ECP.6.2.4 or ECP.6.3.4 **Equipment Certificates** or Manufacturer's Test Certificates may be used where appropriate may be used if agreed by **The Company**.

ECP.A.5.3.2 This is not witnessed by **The Company**. Graphical and tabular representations of the results in an electronic spreadsheet format showing per unit open circuit terminal voltage and short circuit current versus per unit field current shall be submitted to **The Company**.

ECP.A.5.3.3 Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

ECP.A.5.4 **Excitation System** On-Load Tests

ECP.A.5.4.1 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.

ECP.A.5.4.2 Where a **Power System Stabiliser** is present:

(i) The **PSS** must only be commissioned in accordance with BC2.11.2. When a **PSS** is switched on for the first time as part of on-load commissioning or if parameters have been adjusted the **Generator** should consider reducing the **PSS** output gain by at least 50% and should consider reducing the limits on **PSS** output by at least a factor of 5 to prevent unexpected PSS action affecting the stability of the **Synchronous Generating Unit** or the **National Electricity Transmission System.**

(ii) 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, repeating with and without the **PSS** in service.

(iii) The frequency domain tuning of the **PSS** shall also be demonstrated by injecting a 0.2Hz-3Hz band limited random noise signal into the **Automatic Voltage Regulator** Setpoint with the **Synchronous Generating Unit** operating at points specified by **The Company** (up to rated MVA output).

(iv) The **PSS** gain margin shall be tested by increasing the **PSS** gain gradually to threefold and observing the **Synchronous Generating Unit** steady state **Active Power** output.

(v) The interaction of the **PSS** with changes in **Active Power** shall be tested by application of a +0.5Hz frequency injection to the governor while the **Synchronous Generating Unit** is selected to **Frequency Sensitive Mode**.

(vi) If the **Synchronous Power Generating Module** is of the **Pumped Storage** type then the step tests shall be carried out, with and without the **PSS**, in the pumping mode in addition to the generating mode.

(vii) Where the **Bilateral Agreement** requires that the **PSS** is in service at a specified loading level additional testing witnessed by **The Company** will be required during the commissioning process before the **Synchronous Power Generating Module** may exceed this output level.

(viii) Where the **Excitation System** includes a **PSS**, the **Generator** shall provide a suitable noise source to facilitate noise injection testing.

ECP.A.5.4.3 The following typical procedure is provided to assist **Generators** in drawing up their own site specific procedures for the **The Company** witnessed **PSS** Tests.

Test	Injection	Notes
	Synchronous Generating Unit running at Maximum Capacity, unity pf, PSS Switched Off	
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 +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	
3	• Inject band limited (0.2-3Hz) random noise signal into voltage Setpoint and measure frequency spectrum of Real Power.	

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	• Remove noise injection.	
	• Switch On Power System Stabiliser	
4	• 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	
5	• 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	
6	• Increase PSS gain at 30second intervals. i.e. x1 – x1.5 – x2 – x2.5 – x3 • Return PSS gain to initial setting	
7	• Inject band limited (0.2-3Hz) random noise signal into voltage Setpoint and measure frequency spectrum of Real Power. • Remove noise injection.	
8	• Select the governor to FSM • Inject +0.5 Hz step into governor. • Hold until generator MW output is stabilised • Remove step	

ECP.A.5.5 **Under-excitation Limiter** Performance Test

ECP.A.5.5.1 Initially the performance of the **Under-excitation Limiter** should be checked by moving the limit line close to the operating point of the **Synchronous Generating Unit** when operating close to unity power factor. The operating point of the **Synchronous Generating Unit** is then stepped into the limit by applying a 2% decrease in **Automatic Voltage Regulator** Setpoint voltage.

ECP.A.5.5.2 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 Generating Unit** is operating just off the limit line, at the designed setting as indicated on the **Performance Chart** [P-Q Capability Diagram] submitted to **The Company** under OC2.

ECP.A.5.5.3 Where possible the **Under-excitation Limiter** should also be tested by operating the tap- changer when the **Synchronous Generating Unit** is operating just off the limit line, as set up.

ECP.A.5.5.4 The **Under-excitation Limiter** will normally be tested at low active power output and at maximum **Active Power** output.

ECP.A.5.5.5 The following typical procedure is provided to assist **Generators** in drawing up their own site specific procedures for the **The Company** witnessed **Under-excitation Limiter** Tests.

Test	Injection	Notes
	Synchronous Generating Unit running at **Maximum Capacity** and unity power factor. Under-excitation limit temporarily moved close to the operating point of the **Synchronous Generating Unit**.	
1	• **PSS** on. • 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 Generating Unit** running at **Maximum Capacity** and at leading **Reactive Power** close to Under-excitation limit.	
2	• PSS on. • 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	

ECP.A.5.6 Over-excitation Limiter Performance Test

ECP.A.5.6.1 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 Generating Unit** shall be generating **Maximum Capacity** and 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 **The Company** and the **Generator**. 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 Power Generating Module**. The step shall be removed immediately on completion of the test.

ECP.A.5.6.2 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.

ECP.A.5.6.3 The following typical procedure is provided to assist **Generators** in drawing up their own site specific procedures for the **The Company** witnessed **Under-excitation Limiter** Tests.

Test	Injection	Notes
	Synchronous Generating Unit running at **Maximum Capacity** and maximum lagging **Reactive Power**.	
	Over-excitation Limit temporarily set close to this operating point. **PSS** on.	
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.	
	Over-excitation Limit restored to its normal operating value. **PSS** on.	

ECP.A.5.7 Reactive Capability

ECP.A.5.7.1 The **Reactive Power** capability on each **Synchronous Power Generating Module** will normally be demonstrated by :

(a) operation of the **Synchronous Power Generating Module** at maximum lagging **Reactive Power** and Maximum Capacity for 1 hour

(b) operation of the **Synchronous Power Generating Module** at maximum leading **Reactive Power** and Maximum Capacity for 1 hour.

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(c) operation of the **Synchronous Power Generating Module** at maximum lagging **Reactive Power** and **Minimum Stable Operating Level** for 1 hour

(d) operation of the **Synchronous Power Generating Module** at maximum leading **Reactive Power** and **Minimum Stable Operating Level** for 1 hour.

(e) operation of the **Synchronous Power Generating Module** at maximum lagging **Reactive Power** and a power output between **Maximum Capacity** and **Minimum Stable Operating Level**.

(f) operation of the **Synchronous Power Generating Module** at maximum leading **Reactive Power** and a power output between **Maximum Capacity** and **Minimum Stable Operating Level**.

ECP.A.5.7.2 In the case of an **Embedded Synchronous Power Generating Module** where distribution network considerations restrict the **Synchronous Power Generating Module Reactive Power** Output **The Company** will only require demonstration within the acceptable limits of the **Network Operator's System**.

ECP.A.5.7.3 The test procedure, time and date will be agreed with **The Company** and will be to the instruction of **The Company** control centre and shall be monitored and recorded at both **The Company** control centre and by the **Generator**.

ECP.A.5.7.4 Where the **Generator** is recording the voltage, **Active Power** and **Reactive Power** at the HV connection point the voltage for these tests **Active Power** and **Reactive Power** at the **Synchronous Power Generating Module** terminals may also be included. The results shall be supplied in an electronic spreadsheet format. Where applicable the **Synchronous Power Generating Module** transformer tapchanger position should be noted throughout the test period.

ECP.A.5.8 Governor and Load Controller Response Performance

ECP.A.5.8.1 The governor and load controller response performance will be tested by injecting simulated frequency deviations into the governor and load controller systems. Such simulated frequency deviation signals must be injected simultaneously at both speed governor and load controller setpoints. For **CCGT modules**, simultaneous injection into all gas turbines, steam turbine governors and module controllers is required.

ECP.A.5.8.2 Prior to witnessing the governor tests set out in ECP.A.5.8.6, **The Company** requires the **Generator** to conduct the preliminary tests detailed in ECP.A.5.8.4 and send the results to **The Company** for assessment unless agreed otherwise by **The Company**. The results should be supplied in an electronic spreadsheet format. These tests shall be completed at least two weeks prior to the witnessed governor response tests.

ECP.A.5.8.3 Where a **CCGT module** or **Synchronous Power Generating Module** is capable of operating on alternative fuels, tests will be required to demonstrate performance when operating on each fuel. **The Company** may agree a reduction from the tests listed in ECP.A.5.8.6 for demonstrating performance on the alternative fuel. This includes the case where a main fuel is supplemented by bio-fuel.

Preliminary Governor Frequency Response Testing

ECP.A.5.8.4 Prior to conducting the full set of tests as per ECP.A.5.8.6, **Generators** are required to conduct a preliminary set of tests below to confirm the frequency injection method is correct and the plant control performance is within

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expectation. The test numbers refer to Figure 1 below. With the plant running at 80% of full load, the following frequency injections shall be applied.

Test No (Figure1)	Frequency Injection	Notes
8	• Inject -0.5Hz frequency fall over 10 sec • Hold for a further 20 sec • At 30 sec from the start of the test, Inject a +0.3Hz frequency rise over 30 sec. • Hold until conditions stabilise • Remove the injected signal as a ramp over 10 seconds	
13	• Inject - 0.5Hz frequency fall over 10 sec • Hold until conditions stabilise • Remove the injected signal as a ramp over 10 seconds	
14	• Inject +0.5Hz frequency rise over 10 sec • Hold until conditions stabilise • Remove the injected signal as a ramp over 10 seconds	
H	• Inject - 0.5Hz frequency fall as a stepchange • Hold until conditions stabilise • Remove the injected signal as a stepchange	
I	• Inject +0.5Hz frequency rise as a stepchange • Hold until conditions stabilise • Remove the injected signal as a stepchange	

ECP.A.5.8.5 The recorded results (e.g. Finj, MW and control signals) should be sampled at a minimum rate of 1 Hz to allow **The Company** to assess the plant performance from the initial transients (seconds) to the final steady state conditions (5-15 minutes depending on the plant design). This is not witnessed by **The Company**. The **Generator** shall supply the recordings including data to **The Company** in an electronic spreadsheet format. Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

Full Frequency Response Testing Schedule Witnessed by **The Company**

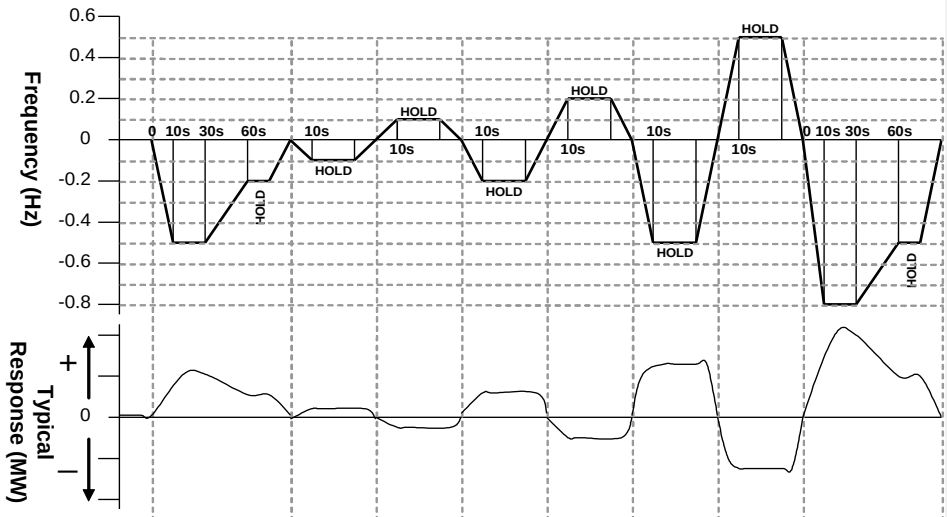
ECP.A.5.8.6 The tests are to be conducted at a number of different Module Load Points (MLP). The load points are conducted as shown below unless agreed otherwise by **The Company**.

Module Load Point 6 (**Maximum Export Limit**)	100% MEL
Module Load Point 5	95% MEL
Module Load Point 4 (**Mid-point of Operating Range**)	80% MEL
Module Load Point 3	70% MEL
Module Load Point 2 (Lower of MRL+10% or Minim**um Stable Operating Level**	MRL+10% or MSOL
Module Load Point 1 (**Minimum regulating level**)	MRL

ECP.A.5.8.7 The tests are divided into the following three types;

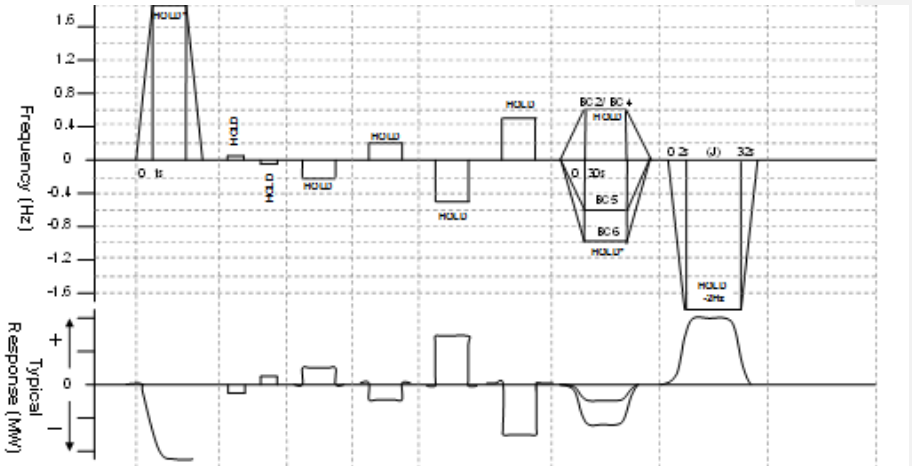
(i) Frequency response compliance and volume tests as per ECP.A.5.8. Figure 1. These tests consist of frequency profile and ramp tests and adjustments to the target frequency setpoint as per ECP.5.8 Figure 3.
(ii) System islanding and step response tests as shown by ECP.A.5.8. Figure 2.
(iii) Frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** and **LFSM-U** capability as shown by ECP.A.5.8 Figure 2.

ECP.A.5.8.8 There should be sufficient time allowed between tests for control systems to reach steady state. Where the diagram states 'HOLD' the current injection should be maintained until the **Active Power** (MW) output of the **Synchronous Power Generating Module** or **CCGT Module** has stabilised or 90s, whichever is the longer. The frequency response capability test (see Figure 1) injection signal shall be returned to zero at the same rate at which it was applied. **The Company** may require repeat tests should the tests give unexpected results. When witnessed by **the Company** each test should be carried out as a separate injection, when not witnessed by **the Company** there must be sufficient time allowed between tests for the **Plant** to have reached a stable steady state operating condition or 90s, whichever is the longer.



Load Point	LF Event Profile 1	LF Ramp -0.1Hz	HF Ramp +0.1Hz	LF Ramp -0.2Hz	HF Ramp +0.2Hz	LF Ramp -0.5Hz	HF Ramp +0.5Hz	LF Event Profile 2
MLP6			1	2	3		4	
MLP5	5			6			7	
MLP4	8	9	10	11	12	13	14	
MLP3	15						16	17
MLP2	18			19	20	21		22
MLP1	23			24	25			26

Figure 1: Frequency Response Capability FSM Ramp Response Tests



Load Point	+2.0*	±0.02	-0.2	+0.2	-0.5	+0.5	+/-0.6 -1.0	-2.0	±0**
MLP6	BC1					O	BC2		L
MLP6 LF SM	BC3						BC4		
MLP5					A				
MLP4		D/E	F	G	H	I		J	M
MLP4 LF SM							BC5/6		N
MLP3									
MLP2					P	Q			
MLP1					K				

Figure 2: Frequency Response Capability LFSM-O, LFSM-U and FSM Step Response Tests

* This will generally be +2.0Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum ~~Stable Operating~~Regulating Level** in which case an appropriate injection should be calculated in accordance with the following:
For example 0.9Hz is needed to take an initial output 65% to a final output of 20%. If the initial output was not 65% and the **Minimum ~~Stable Operating~~Regulating Level** is not 20% then the injected step should be adjusted accordingly as shown in the example given below

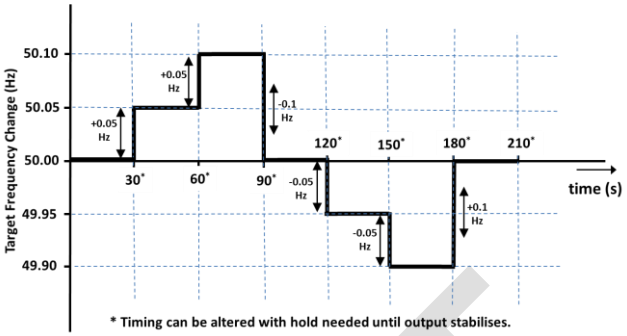
Commented [H(M16]: Correction to terminology advised by SPR

Initial Output	65%	
Minimum ~~Stable Operating~~Regulating Level		20%
Frequency Controller Droop	4%	
Frequency to be injected = (0.65-0.20)x0.04x50 =	0.9Hz	

** Tests L and M in Figure 2 shall be conducted if in this range of tests the system frequency feedback signal is replaced by the injection signal rather than the injection signal being added to the system frequency signal. The tests will consist of monitoring the **Synchronous Power Generating Module and CCGT Module** in **Frequency Sensitive Mode** during normal system frequency variations without applying any injection. Test N in figure 2 shall be conducted in all cases. All three tests should be conducted for a period of at least 10 minutes.

ECP.A.5.8.9 The target frequency adjustment facility should be demonstrated from the

normal control point within the range of 49.9Hz to 50.1Hz by step changes to the target frequency setpoint as indicated in ECP.A.5.8 Figure 3



ECP.A.5.8 Figure 3 – Target Frequency setting changes

ECP.A.5.9 Compliance with ECC.6.3.3 Functionality Test

ECP.A.5.9.1 Where the plant design includes active control function or functions to deliver ECC.6.3.3 compliance, the **Generator** will propose and agree a test procedure with **The Company**, which will demonstrate how the **Synchronous Power Generating Module Active Power** output responds to changes in **System Frequency** and ambient conditions (e.g. by **Frequency** and temperature injection methods).

ECP.A.5.9.2 The **Generator** shall inform **The Company** if any load limiter control is additionally employed.

ECP.A.5.9.3 With Setpoint to the signals specified in ECP.A.4, **The Company** will agree with the **Generator** which additional control system parameters shall be monitored to demonstrate the functionality of ECC.6.3.3 compliance systems. Where **The Company** recording equipment is not used results shall be supplied to **The Company** in an electronic spreadsheet format

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APPENDIX 6

COMPLIANCE TESTING OF POWER PARK MODULES

ECP.A.6.1 SCOPE

ECP.A.6.1.1 This Appendix outlines the general testing requirements for **Power Park Modules** and **OTSDUA** to demonstrate compliance with the relevant aspects of the **Grid Code**, **Ancillary Services Agreement** and **Bilateral Agreement**. The tests specified in this Appendix will normally be sufficient to demonstrate compliance however **The Company** may:

i) agree an alternative set of tests provided **The Company** deem the alternative set of tests sufficient to demonstrate compliance with the **Grid Code**, **Ancillary Services Agreement** and **Bilateral Agreement**; and/or

ii) require additional or alternative tests if information supplied to **The Company** during the compliance process suggests that the tests in this Appendix will not fully demonstrate compliance with the relevant section of the **Grid Code**, **Ancillary Services Agreement** or **Bilateral Agreement**; and/or

iii) require additional tests if a **Power System Stabiliser** is fitted; and/or

iv) agree a reduced set of tests if a relevant **Manufacturer's Data & Performance Report** has been submitted to and deemed to be appropriate by **The Company**; and/or

v) agree a reduced set of tests for subsequent **Power Park Modules** or **OTSDUA** following successful completion of the first **Power Park Module** or **OTSDUA** tests in the case of a **Power Station** comprised of two or more **Power Park Modules** or **OTSDUA** which **The Company** reasonably considers to be identical.

If:

(a) the tests performed pursuant to ECP.A.6.1.1(iv) do not replicate the results contained in the **Manufacturer's Data & Performance Report** or

(b) the tests performed pursuant to ECP.A.6.1.1(v) in respect of subsequent **Power Park Modules** or **OTSDUA** do not replicate the full tests for the first **Power Park Module** or **OTSDUA**, or

(c) any of the tests performed pursuant to ECP.A.6.1.1(iv) or ECP.A.6.1.1(v) do not fully demonstrate compliance with the relevant aspects of the **Grid Code**, **Ancillary Services Agreement** and / or **Bilateral Agreement**,

then notwithstanding the provisions above, the full testing requirements set out in this Appendix will be applied.

ECP.A.6.1.2 The **Generator** is responsible for carrying out the tests set out in and in accordance with this Appendix and the **Generator** retains the responsibility for the safety of personnel and plant during the test. **The Company** will witness all of the tests outlined or agreed in relation to this Appendix unless **The Company** decides and notifies the **Generator** otherwise. Reactive Capability tests may be witnessed by **The Company** remotely from **The Company** control centre. For all on site **The Company** witnessed tests the **Generator**

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must ensure suitable representatives from the **Generator** and / or **Power Park Module** manufacturer (if appropriate) and/or **OTSDUA** manufacturer (if appropriate) are available on site for the entire testing period. In all cases and in addition to any recording of signals conducted by **The Company** the **Generator** shall record all relevant test signals as outlined in ECP.A.4.

ECP.A.6.1.3 In addition to the dynamic signals supplied in ECP.A.4 the **Generator** shall inform **The Company** of the following information prior to the commencement of the tests and any changes to the following, if any values change during the tests:

(i) All relevant transformer tap numbers; and

(ii) Number of **Power Park Units** in operation

ECP.A.6.1.4 The **Generator** shall submit a detailed schedule of tests to **The Company** in accordance with CP.6.3.1, and this Appendix.

ECP.A.6.1.5 Prior to the testing of a **Power Park Module** or **OTSDUA** the **Generator** shall complete the **Integral Equipment Tests** procedure in accordance with OC.7.5

ECP.A.6.1.6 Partial **Power Park Module** or **OTSDUA** testing as defined in ECP.A.6.2 and ECP.A.6.3 is to be completed at the appropriate stage in accordance with ECP.6, ECP6.4A, ECP6.4B.

ECP.A.6.1.7 Full **Power Park Module** or **OTSDUA** testing as required by CP.7.2 is to be completed as defined in ECP.A.6.4 through to ECP.A.6.7

ECP.A.6.1.8 Where **OTSDUW Arrangements** apply and prior to the **OTSUA Transfer Time** any relevant **OTSDUW Plant and Apparatus** shall be considered within the scope of testing described in this Appendix. Performance shall be assessed against the relevant Grid Code requirements for **OTSDUW Plant and Apparatus** at the **Interface Point** and other **Generator Plant and Apparatus** at the **Offshore Grid Entry Point**. This Appendix should be read accordingly.

ECP.A.6.1.9 **The Company** will permit relaxation from the requirement ECP.A.6.2 to ECP.A.6.8 where an **Equipment Certificate** for the **Power Park Module** has been provided which details the characteristics from tests on a representative installation with the same equipment and settings and the performance of the **Power Park Module** can, in **The Company's** opinion, reasonably represent that of the installed **Power Park Module** at that site. For **Type B**, **Type C** and **Type D Power Park Modules** the relevant **Equipment Certificate** must be supplied in the **Power Generating Module Document** or **Users Data File structure** as applicable.

ECP.A.6.2 Pre 20% (or <50MW) **Synchronised Power Park Module** Basic Voltage Control Tests

ECP.A.6.2.1 Before 20% of the **Power Park Module** (or 50MW if less) has commissioned, either voltage control test ECP.A.6.5.6(i) or (ii) must be completed in accordance with ECP.6, ECP.6A or ECP.6B. In the case of an **Offshore Power Park Module** the test must be completed by the **Generator** undertaking **OTSDUW** or the **Offshore Transmission Licencee** under STCP19-5.

ECP.A.6.2.2 In the case of an **Offshore Power Park Module** which provides all or a portion of the **Reactive Power** capability as described in ECC.6.3.2.5.2 or ECP.6.3.2.6.3 and / or voltage control requirements as described in ECC.6.3.8.5 to enable an **Offshore Transmission Licensee** to meet the requirements of **STC** Section K**,** the **Generator** is required to cooperate with the **Offshore Transmission Licensee** to conduct the 20% voltage control test.

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The results in relation to the **Offshore Power Park Module** will be assessed against the requirements in the **Bilateral Agreement**.

ECP.A.6.3 **Power Park Modules** with **Maximum Capacity** ≥100MW Pre 70% **Power Park Module** Tests

ECP.A.6.3.1 Before 70% but with at least 50% of the **Power Park Module** commissioned the following **Limited Frequency Sensitive** tests as detailed in ECP.A.6.6.2 must be completed.
(a) BC3
(b) BC4

ECP.A.6.4 Reactive Capability Test

ECP.A.6.4.1 This section details the procedure for demonstrating the reactive capability of an **Onshore Power Park Module** or an **Offshore Power Park Module** or **OTSDUA** which provides all or a portion of the **Reactive Power** capability as described in ECC.6.3.2.5.2 or ECP.6.3.2.6.3 as applicable (for the avoidance of doubt, an **Offshore Power Park Module** which does not provide part of the **Offshore Transmission Licensee Reactive Power** capability as described in ECC.6.3.2.5.1 and ECP.6.3.2.6.1 should complete the **Reactive Power** transfer / voltage control tests as per section ECP.A.6.8). These tests should be scheduled at a time where there are at least 95% of the **Power Park Units** within the **Power Park Module** in service. There should be sufficient MW resource forecasted in order to generate at least 85% of **Maximum Capacity** of the **Power Park Module**.

ECP.A.6.4.2 The tests shall be performed by modifying the voltage set-point of the voltage control scheme of the **Power Park Module** or **OTSDUA** by the amount necessary to demonstrate the required reactive range. This is to be conducted for the operating points and durations specified in ECP.A.6.4.5.

ECP.A.6.4.3 An **Embedded Generator** or **Embedded Generator** undertaking **OTSDUW** should liaise with the relevant **Network Operator** to ensure the following tests will not have an adverse impact upon the **Network Operator's System** as per OC.7.5. In situations where the tests have an adverse impact upon the **Network Operator's System The Company** will only require demonstration within the acceptable limits of the **Network Operator**. For the avoidance of doubt, these tests do not negate the requirement to produce a complete **Power Park Module** or **OTSDUA** performance chart as specified in OC2.4.2.1

ECP.A.6.4.4 In the case where the **Reactive Power** metering point is not at the same location as the **Reactive Power** capability requirement, then an equivalent **Reactive Power** capability for the metering point shall be agreed between the **Generator** and **The Company**.

ECP.A.6.4.5 The following tests shall be completed:

(i) Operation in excess of 60% **Maximum Capacity** and maximum continuous lagging **Reactive Power** for 30 minutes. For the avoidance of doubt this test must start with power output in excess of 85% of **Maximum Capacity** of the **Power Park Module** as ECP.A.6.4.1 and must not fall below 60% of **Maximum Capacity** of the **Power Park Module** during the 30 minutes.

Commented [H(M17]: Responding to SPR comments the wording of the clarification on requirement has been altered to explain test must start with more than 85% output

(ii) Operation in excess of 60% **Maximum Capacity** and maximum continuous leading **Reactive Power** for 30 minutes. For the avoidance of doubt this test must start with power output in excess of 85% of **Maximum Capacity** of the **Power Park Module** as ECP.A.6.4.1 and

must not fall below 60% of **Maximum Capacity** of the **Power Park Module** during the 30 minutes.

(iii) Operation at 50% **Maximum Capacity** and maximum continuous leading **Reactive Power** for 30 minutes.

~~(iii)~~(iv) Operation at 50% **Maximum Capacity** and maximum continuous lagging **Reactive Power** for 30 minutes.

~~(iv)~~(v) Operation at 20% **Maximum Capacity** and maximum continuous leading **Reactive Power** for 60 minutes.

~~(v)~~(vi) Operation at 20% **Maximum Capacity** and maximum continuous lagging **Reactive Power** for 60 minutes.

~~(vi)~~(vii) Operation at less than 20% **Maximum Capacity** and unity **Power Factor** for 5 minutes. This test only applies to systems which do not offer voltage control below 20% of **Maximum Capacity**.

~~(vii)~~(viii) Operation at the lower of the **Minimum ~~Stable Operating~~Regulating Level** or 0% **Maximum Capacity** and maximum continuous leading **Reactive Power** for 5 minutes. This test only applies to systems which offer voltage control below 20% and hence establishes actual capability rather than required capability.

~~(viii)~~(ix) Operation at the lower of the **Minimum ~~Stable Operating~~Regulating Level** or 0% **Maximum Capacity** and maximum continuous lagging **Reactive Power** for 5 minutes. This test only applies to systems which offer voltage control below 20% and hence establishes actual capability rather than required capability.

ECP.A.6.4.6 Within this ECP lagging **Reactive Power** is the export of **Reactive Power** from the **Power Park Module** to the **Total System** and leading **Reactive Power** is the import of **Reactive Power** from the **Total System** to the **Power Park Module** or **OTSDUA.**

ECP.A.6.5 Voltage Control Tests

ECP.A.6.5.1 This section details the procedure for conducting voltage control tests on **Onshore Power Park Modules** or **OTSDUA** or an **Offshore Power Park Module** which provides all or a portion of the voltage control capability as described in ECC.6.3.8.5 (for the avoidance of doubt, **Offshore Power Park Modules** which do not provide part of the **Offshore Transmission Licensee** voltage control capability as described in CC6.3.8.5 should complete the **Reactive Power** transfer / voltage control tests as per section ECP.A.6.8). These tests should be scheduled at a time when there are at least 95% of the **Power Park Units** within the **Power Park Module** in service. There should be sufficient MW resource forecasted in order to generate at least 65% of **Maximum Capacity** of the **Onshore Power Park Module**. An **Embedded Generator** or **Embedded Generators** undertaking **OTSDUW** should also liaise with the relevant **Network Operator** to ensure all requirements covered in this section will not have a detrimental effect on the **Network Operator's System**.

ECP.A.6.5.2 The voltage control system shall be perturbed with a series of step injections to the **Power Park Module** voltage Setpoint, and where possible, multiple up-stream transformer taps. In the case of an **Offshore Power Park Module** providing part of the **Offshore Transmission Licensee** voltage control capability this may require a series of step injections to the voltage Setpoint of the **Offshore Transmission Licensee** control system.

Commented [H(M18]: Responding to SPR comments the wording of the clarification on requirement has been altered to explain test must start with more than 85% output

Commented [H(M19]: Correction to align with EU Regulations

Commented [H(M20]: Terminology queried by SIB and correction suggested by SPR

Commented [H(M21]: Terminology queried by SIB and correction suggested by SPR

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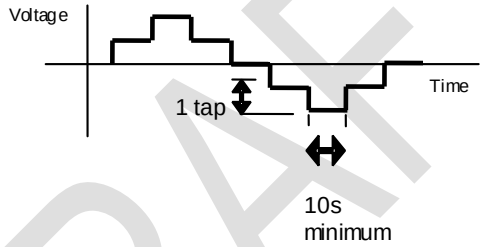
ECP.A.6.5.3 For steps initiated using network tap changers the **Generator** will need to coordinate with **The Company** or the relevant **Network Operator** as appropriate. The time between transformer taps shall be at least 10 seconds as per ECP.A.6.5 Figure 1.

ECP.A.6.5.4 For step injection into the **Power Park Module** or **OTSDUA** voltage Setpoint, steps of ±1%, ±2% and ±~~2~~4% (or larger if required by **The Company**) shall be applied to the voltage control system Setpoint summing junction. The injection shall be maintained for a (minimum) of 10 seconds as per ECP.A.6.5 Figure 2.

ECP.A.6.5.5 Where the voltage control system comprises of discretely switched plant and apparatus (eg.) Mechanically Switched Shunt Reactors or Capacitors) additional tests will be required to demonstrate that ~~its~~ overall performance of the voltage control system when switching these devices as part of the response is in accordance with **Grid Code** and **Bilateral Agreement** requirements.

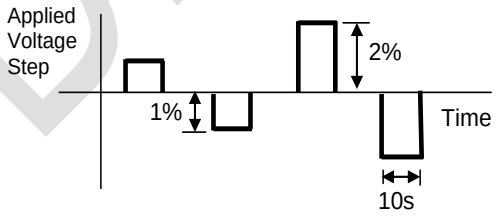
ECP.A.6.5.6 Tests to be completed:

(i)



ECP.A.6.5 Figure 1 – Transformer tap sequence for voltage control tests

(ii)



Commented [H(M22]: 4% step test added as the 2% step test was found not to give a large enough change in reactive power output to adequately demonstrate speed of performance. Actual system voltage responds to the reactive power change reducing the effective size of the voltage setpoint change.

Commented [H(M23]: Change in response to SPR comment and to align with figure

Commented [H(M24]: Example added to highlight that the tests need to demonstrate that all elements of the reactive power solution are demonstrated during the test sequence

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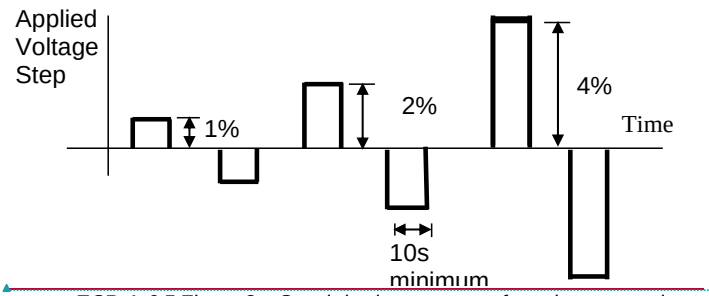

ECP.A.6.5 Figure 2 – Step injection sequence for voltage control tests

ECP.A.6.5.7 In the case of **OTSDUA** where the **Bilateral Agreement** specifies additional damping facilities additional testing to demonstrate these damping facilities may be required.

ECP.A.6.5.8 In the case of **Power Park Modules** that do not provide voltage control down to zero **Active Power** a test to demonstrate the smooth transition from voltage control mode to unity **Power Factor** shall be carried out. The **Power Park Module** voltage setpoint should be altered to produce lagging **Reactive Power** or absorbing leading **Reactive Power** at a low **Active Power** level where voltage control is provided. The **Power Park Module Active Power** should then be reduced to zero **Active Power** as a ramp over a short period (60 seconds is suggested).

ECP.A.6.6 Frequency Response Tests

ECP.A.6.6.1 This section describes the procedure for performing frequency response testing on a **Power Park Module**. These tests should be scheduled at a time where there are at least 95% of the **Power Park Units** within the **Power Park Module** in service. There should be sufficient MW resource forecasted in order to generate at least 65% of **Maximum Capacity** of the **Power Park Module**.

ECP.A.6.6.2 The frequency controller shall be in **Frequency Sensitive Mode** or **Limited Frequency Sensitive Mode** as appropriate for each test. Simulated frequency deviation signals shall be injected into the frequency controller setpoint/feedback summing junction. If the injected frequency signal replaces rather than sums with the real system frequency signal then the additional tests outlined in ECP.A.6.6.6 shall be performed with the **Power Park Module** or **Power Park Unit** in normal **Frequency Sensitive Mode** monitoring actual system frequency, over a period of at least 10 minutes. The aim of this additional test is to verify that the control system correctly measures the real system frequency for normal variations over a period of time.

ECP.A.6.6.3 In addition to the frequency response requirements it is necessary to demonstrate the **Power Park Module** ability to deliver a requested steady state power output which is not impacted by power source variation as per ECC.6.3.9. This test shall be conducted in **Limited Frequency Sensitive Mode** at a part-loaded output for a period of 10 minutes as per ECP.A.6.6.6.

Preliminary Frequency Response Testing

ECP.A.6.6.4 Prior to conducting the full set of tests as per ECP.A.6.6.6, **Generators** are required to conduct the preliminary set of tests below to confirm the frequency injection method is correct and the plant control performance is within

Field Code Changed

Commented [H(M25]: Added to demonstrate the smooth transition between operating modes detailed in ECC.6.3.8.4.1.

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expectation. The test numbers refer to Figure 1 below. The test should be conducted when sufficient MW resource is forecasted in order to generate at least 65% of **Maximum Capacity** of the **Power Park Module**. The following frequency injections shall be applied when operating at module load point 4.

Test No (Figure1)	Frequency Injection	Notes
8	• Inject -0.5Hz frequency fall over 10 sec • Hold for a further 20 sec • At 30 sec from the start of the test, Inject a +0.3Hz frequency rise over 30 sec. • Hold until conditions stabilise • Remove the injected signal as a ramp over 10 seconds	
13	• Inject - 0.5Hz frequency fall over 10 sec • Hold until conditions stabilise • Remove the injected signal as a ramp over 10 seconds	
14	• Inject +0.5Hz frequency rise over 10 sec • Hold until conditions stabilise • Remove the injected signal as a ramp over 10 seconds	
H	• Inject - 0.5Hz frequency fall as a stepchange • Hold until conditions stabilise • Remove the injected signal as a stepchange	
I	• Inject +0.5Hz frequency rise as a stepchange • Hold until conditions stabilise • Remove the injected signal as a stepchange	

ECP.A.6.6.5 The recorded results (e.g. Finj, MW and control signals) should be sampled at a minimum rate of 1 Hz to allow **The Company** to assess the plant performance from the initial transients (seconds) to the final steady state conditions (5-15 minutes depending on the plant design). This is not witnessed by **The Company**. The **Generator** shall supply the recordings including data to **The Company** in an electronic spreadsheet format. Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

Full Frequency Response Testing Schedule Witnessed by **The Company.**

ECP.A.6.6.6 The tests are to be conducted at a number of different Module Load Points (MLP). In the case of a **Power Park Module** the module load points are conducted as shown below unless agreed otherwise by **The Company**.

Module Load Point 6 (**Maximum Export Limit**)	100% MEL
Module Load Point 5	90% MEL
Module Load Point 4 ~~(Mid point of Operating Range)~~	80% MEL
Module Load Point 3	MRL+~~20%~~ 0.6 x (MEL – MRL)
Module Load Point 2 Lower of MRL + 0.3 x (MEL – MRL)~~+10%~~ or MSOL **Minimum Stable Operating Level**	MRL+0.3 x (MEL – MRL)~~10%~~
Module Load Point 1 (**Minimum regulating level**)	MRL

Commented [H(M26]: Not the mid point but set at the minimum deload to demonstrate 10% response.

ECP.A.6.6.7 The tests are divided into the following two types;

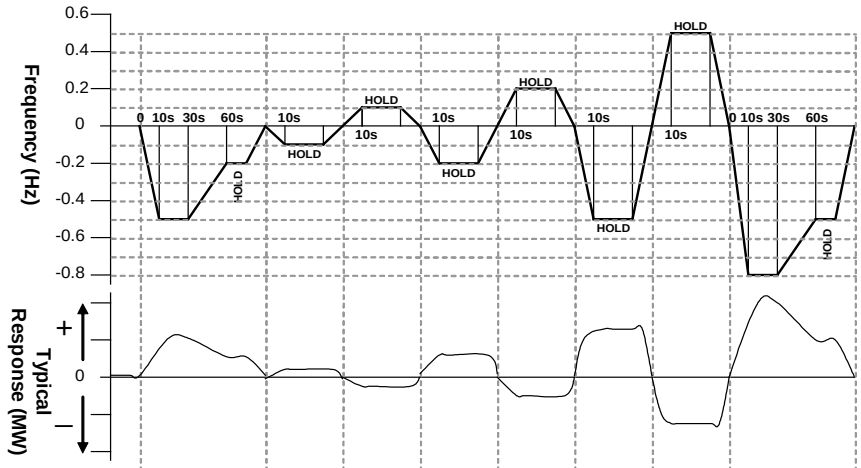
(i) Frequency response compliance and volume tests as per ECP.A.6.6. Figure 1. These tests consist of frequency profile and ramp tests and adjustments to target frequency setpoint as per ECP.A.6.6 Figure 3.

(ii) System islanding and step response tests as shown by ECP.A.6.6. Figure 2.

(iii) Frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** and **LFSM-U** capability as shown by ECP.A.6.6 Figure 2.

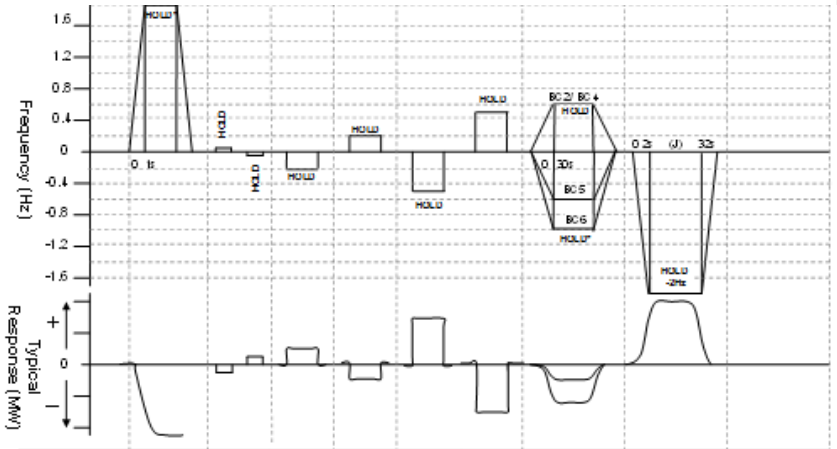
ECP.A.6.6.8 There should be sufficient time allowed between tests for control systems to reach steady state (depending on available power resource). Where the diagram states 'HOLD' the current injection should be maintained until the **Active Power** (MW) output of the **Power Park Module** has stabilised for 90s whichever is the longer. All frequency response tests should be removed over the same timescale for which they were applied. **The Company** may require repeat tests should the response volume be affected by the available power, or if tests give unexpected results. When witnessed by **The Company** each test should be carried out as a separate injection, when not witnessed by **The Company** there must be sufficient time allowed between tests for the **Active Power** (MW) output of the **Power Park Module** to have stabilised or 90s whichever is the longer.

Commented [H(M27]: Added to ensure the hold period is long enough to demonstrate "Secondary Response" time frame.



Load Point	LF Event Profile 1	LF Ramp -0.1Hz	HF Ramp +0.1Hz	LF Ramp -0.2Hz	HF Ramp +0.2Hz	LF Ramp -0.5Hz	HF Ramp +0.5Hz	LF Event Profile 2
MLP6			1	2	3		4	
MLP5	5			6			7	
MLP4	8	9	10	11	12	13	14	
MLP3	15						16	17
MLP2	18			19	20	21		22
MLP1	23			24	25			26

ECP.A.6.6. Figure 1 – Frequency Response Capability FSM Ramp Response tests



Load Point	+2.0*	±0.02	-0.2	+0.2	-0.5	+0.5	+/-0.6 -1.0	-2.0	±0**
MLP6	BC1					O	BC2		L
MLP6 LFSM	BC3						BC4		
MLP5					A				
MLP4		D/E	F	G	H	I		J	M
MLP4 LFSM							BC5/6		N
MLP3									
MLP2					P	Q			
MLP1					K				

ECP.A.6.6. Figure 2 – Frequency Response Capability LFSM-O, LFSM-U, FSM Step Response tests

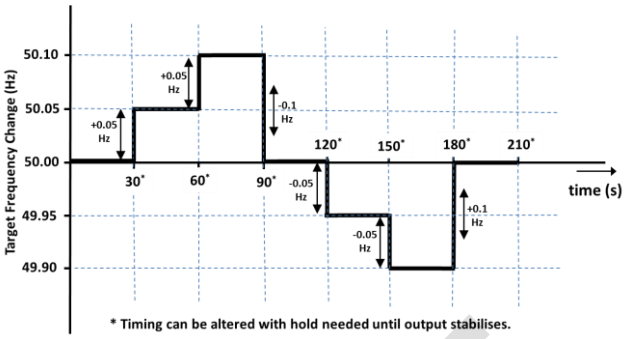
* This will generally be +2.0Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum ~~Stable Operating~~Regulating Level** in which case an appropriate injection should be calculated in accordance with the following:
For example 0.9Hz is needed to take an initial output 65% to a final output of 20%. If the initial output was not 65% and the **Minimum ~~Stable Operating~~Regulating Level** is not 20% then the injected step should be adjusted accordingly as shown in the example given below

Commented [H(M28]: Correction advised by SPR

Initial Output	65%	
Minimum ~~Stable Operating~~Regulating Level		20%
Frequency Controller Droop	4%	
Frequency to be injected = (0.65-0.20)x0.04x50 =	0.9Hz	

** Tests L and M in Figure 2 shall be conducted if in this range of tests the system frequency feedback signal is replaced by the injection signal rather than the injection signal being added to the system frequency signal. The tests will consist of monitoring the **Power Park Module** in **Frequency Sensitive Mode** during normal system frequency variations without applying any injection. Test N in Figure 2 shall be conducted in all cases. All three tests should be conducted for a period of at least 10 minutes.

ECP.A.6.6.9 The target frequency adjustment facility should be demonstrated from the normal control point within the range of 49.9Hz to 50.1Hz by step changes to the target frequency setpoint as indicated in ECP.A.6.6 Figure 3.



ECP.A.6.6. Figure 3 – Target Frequency setting changes

ECP.A.6.7 Fault Ride Through Testing

ECP.A.6.7.1 This section describes the procedure for conducting fault ride through tests on a single **Power Park Unit** as required by ECP.7.2.2(d).

ECP.A.6.7.2 The test circuit will utilise the full **Power Park Unit** ~~with no exclusions~~ (e.g. in the case of a wind turbine it would include the full wind turbine nacelle structure, all inverters and converters along with step up transformer to medium voltage, all control systems including pitch control emulation) and shall be conducted with sufficient power input resource available to produce at least 95% of the **Maximum Capacity** of the **Power Park Unit**. The test will comprise of a number of controlled short circuits applied to a test network to which the **Power Park Unit** is connected, typically comprising of the **Power Park Unit** transformer and a test impedance or other decoupling equipment to shield the connected network from voltage dips at the **Power Park Unit** terminals.

Commented [H(M29]: Change of requirement to allow option of factory testing for Fault ride through to facilitate development of larger wind turbines

ECP.A.6.7.3 In each case the tests should demonstrate the minimum voltage at the **Power Park Unit** terminals or **High Voltage** side of the **Power Park Unit** transformer which the **Power Park Unit** can withstand for the length of time specified in ECP.A.6.7.5. Any test results provided to **The Company** should contain sufficient data pre and post fault in order to determine steady state values of all signals, and the power recovery timescales.

ECP.A.6.7.4 In addition to the signals outlined in ECP.A.4.2. the following signals from either the **Power Park Unit** terminals or **High Voltage** side of the **Power Park Unit** transformer should be provided for this test only:

(i) Phase voltages
(ii) Positive phase sequence and negative phase sequence voltages
(iii) Phase currents
(iv) Positive phase sequence and negative phase sequence currents
(v) Estimate of **Power Park Unit** negative phase sequence impedance
(vi) MW – **Active Power** at the power generating module.
(vii) MVAr – **Reactive Power** at the power generating module.
(viii) Mechanical Rotor Speed
(ix) Real / reactive, current / power Setpoint as appropriate
(x) Fault ride through protection operation (e.g. a crowbar in the case of a doubly fed induction generator)
(xi) Any other signals relevant to the control action of the fault ride through control deemed applicable for model validation.

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At a suitable frequency rate for fault ride through tests as agreed with **The Company**.

ECP.A.6.7.5 The tests should be conducted for the times and fault types indicated in ECC.6.3.15 as applicable.

ECP.A.6.8 Reactive Power Transfer / Voltage Control Tests for **Offshore Power Park Modules**

ECP.A.6.8.1 In the case of an **Offshore Power Park Module** which provides all or a portion of the **Reactive Power** capability as described in ECP.6.3.2.5.2 or ECP.6.3.6.3 and / or voltage control requirements as described in ECC.6.3.8.5 to enable an **Offshore Transmission Licensee** to meet the requirements of **STC** Section K**,** the testing, will comprise of the entire control system responding to changes at the onshore **Interface Point**. Therefore the tests in this section ECP.A.6.8 will not apply. The **Generator** shall cooperate with the relevant **Offshore Transmission Licensee** to facilitate these tests as required by **The Company**. The testing may be combined with testing of the corresponding **Offshore Transmission Licensee** requirements under the **STC.** The results in relation to the **Offshore Power Park Module** will be assessed against the requirements in the **Bilateral Agreement**.

ECP.A.6.8.2 In the case of an **Offshore Power Park Module** which does not provide part of the **Offshore Transmission Licensee Reactive Power** capability the following procedure for conducting **Reactive Power** transfer control tests on **Offshore Power Park Modules** and / or voltage control system as per CC6.3.2(e)(i) and CC6.3.2(e)(ii) apply. These tests should be carried out prior to 20% of the **Power Park Units** within the **Offshore Power Park Module** being synchronised, and again when at least 95% of the **Power Park Units** within the **Offshore Power Park Module** in service. There should be sufficient power resource forecast to generate at least 85% of the **Maximum Capacity** of the **Offshore Power Park Module**.

ECP.A.6.8.3 The **Reactive Power** control system shall be perturbed by a series of system voltage changes and changes to the **Active Power** output of the **Offshore Power Park Module**.

ECP.A.6.8.4 System voltage changes should be created by a series of multiple upstream transformer taps. The **Generator** should coordinate with **The Company** or the relevant **Network Operator** in order to conduct the required tests. The time between transformer taps should be at least 10 seconds as per ECP.A.6.8 Figure 1.

ECP.A.6.8.5 The active power output of the **Offshore Power Park Module** should be varied by applying a sufficiently large step to the frequency controller Setpoint/feedback summing junction to cause a 10% change in output of the **Maximum Capacity** of the **Offshore Power Park Module** in a time not exceeding 10 seconds. This test does not need to be conducted provided that the frequency response tests as outlined in ECP.A.6.6 are completed.

ECP.A.6.8.6 The following diagrams illustrate the tests to be completed:

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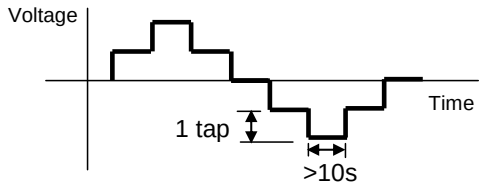
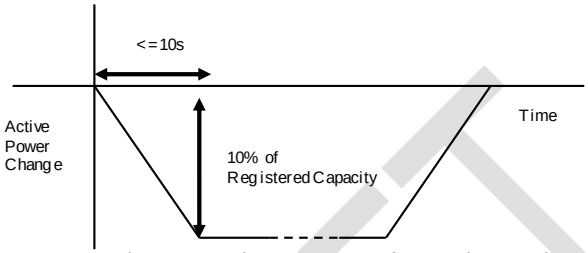


ECP.A.6.8 Figure 1 – Transformer tap sequence for reactive transfer tests



ECP.A.6.8 Figure 2 – Active Power ramp for reactive transfer tests

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APPENDIX 7

COMPLIANCE TESTING FOR HVDC EQUIPMENT

ECP.A.7.1 SCOPE

ECP.A.7.1.1 This Appendix outlines the general testing requirements for **HVDC System Owner**s to demonstrate compliance with the relevant aspects of the **Grid Code**, **Ancillary Services Agreement** and **Bilateral Agreement**. The tests specified in this Appendix will normally be sufficient to demonstrate compliance however **The Company** may:

i) agree an alternative set of tests provided **The Company** deem the alternative set of tests sufficient to demonstrate compliance with the **Grid Code**, **Ancillary Services Agreement** and **Bilateral Agreement**; and/or

ii) require additional or alternative tests if information supplied to **The Company** during the compliance process suggests that the tests in this Appendix will not fully demonstrate compliance with the relevant section of the **Grid Code**, **Ancillary Services Agreement** or **Bilateral Agreement**; and/or

iii) require additional tests if control functions to improve damping of power system oscillations and/or subsynchronous resonance torsional oscillations required by the **Bilateral Agreement** or included in the control scheme and active; and/or

iv) agree a reduced set of tests for subsequent **HVDC Equipment** following successful completion of the first **HVDC Equipment** tests in the case of an installation comprising of two or more **HVDC Systems** or **DC Connected Power Park Modules** which **The Company** reasonably considers to be identical.

If:

(a) the tests performed pursuant to ECP.A.7.1.1(iv) in respect of subsequent **HVDC Systems** or **DC Connected Power Park Modules** do not replicate the full tests for the first **HVDC Equipment**, or

(b) any of the tests performed pursuant to ECP.A.7.1.1(iv) do not fully demonstrate compliance with the relevant aspects of the **Grid Code**, **Ancillary Services Agreement** and / or **Bilateral**

ECP.A.7.1.2 The **HVDC System Owner** is responsible for carrying out the tests set out in and in accordance with this Appendix and the **HVDC System Owner** retains the responsibility for the safety of personnel and plant during the test. The **HVDC System Owner** is responsible for ensuring that suitable arrangements are in place with the **Externally Interconnected System Operator** to facilitate testing. **The Company** will witness all of the tests outlined or agreed in relation to this Appendix unless **The Company** decides and notifies the **HVDC System Owner** otherwise. Reactive Capability tests if required, may be witnessed by **The Company** remotely from **The Company** control centre. For all on site **The Company** witnessed tests the **HVDC System Owner** must ensure suitable representatives from the **HVDC System Owner** and / or **HVDC Equipment** manufacturer (if appropriate) are available on site for the entire testing period. In all cases and in addition to any recording of signals conducted by **The Company** the **HVDC System Owner** shall record all relevant test signals as outlined in ECP.A.4.

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ECP.A.7.1.3 In addition to the dynamic signals supplied in ECP.A.4 the **HVDC System Owner** shall inform **The Company** of the following information prior to the commencement of the tests and any changes to the following, if any values change during the tests:

(i) All relevant transformer tap numbers.

ECP.A.7.1.4 The **HVDC System Owner** shall submit a detailed schedule of tests to **The Company** in accordance with CP.6.3.1, and this Appendix.

ECP.A.7.1.5 Prior to the testing of **HVDC Equipment** the **HVDC System Owner** shall complete the **Integral Equipment Tests** procedure in accordance with OC.7.5

ECP.A.7.1.6 Full **HVDC Equipment** testing as required by ECP.7.2 is to be completed as defined in ECP.A.7.2 through to ECP.A.7.5

ECP.A.7.1.7 **The Company** will permit relaxation from the requirement ECP.A.7.2 to ECP.A.7.5 where an **Equipment Certificate** for **HVDC Equipment** has been provided which details the characteristics from tests on a representative installation with the same equipment and settings and the performance of the **HVDC Equipment** can, in **The Company's** opinion, reasonably represent that of the installed **HVDC Equipment** at that site. The relevant **Equipment Certificate** must be supplied in the **Users Data File structure**.

ECP.A.7.1.8 (**The**) **Company** may agree a reduction from the requirement ECP.A.7.2 to ECP.A.7.5 for on site testing where suitable factory acceptance testing on a representative installation with the same equipment and settings of the **HVDC Equipment** that can, in **The Company's** opinion, reasonably represent the performance of the installed **HVDC Equipment** at that site. This is also conditional on **The Company** and the **DC Converter Station** owner agreeing sufficient on site testing of the fully commissioned **DC Converter Station** to demonstrate that the factory acceptance tests are valid. (If in the reasonable opinion of **The Company**, the on site testing does not demonstrate the factory acceptance tests are valid then the full set of on-site tests should be carried out.)

Commented [H(M30]: ECP.A.7.1.8 added to regularise the use of Factory Acceptance Tests which is regular part of HVDC system demonstration.

Commented [H(M31]: Responding to MG comments that there will never be exact match between FAC and site tests the drafting of this sentence has been altered.

ECP.A.7.2 Reactive Capability Test

ECP.A.7.2.1 This section details the procedure for demonstrating the reactive capability of **HVDC Equipment.** These tests should be scheduled at a time where there are sufficient MW resource forecasted in order to import and export full **Maximum Capacity** of the **HVDC Equipment**.

ECP.A.7.2.2 The tests shall be performed by modifying the voltage set-point of the voltage control scheme of the **HVDC Equipment** by the amount necessary to demonstrate the required reactive range. This is to be conducted for the operating points and durations specified in ECP.A.7.2.5.

ECP.A.7.2.3 **Embedded HVDC System Owners** should liaise with the relevant **Network Operator** to ensure the following tests will not have an adverse impact upon the **Network Operator's System** as per OC.7.5. In situations where the tests have an adverse impact upon the **Network Operator's System The Company** will only require demonstration within the acceptable limits of the **Network Operator**. For the avoidance of doubt, these tests do not negate the requirement to produce a complete **HVDC Equipment** performance chart as specified in OC2.4.2.1

ECP.A.7.2.4 In the case where the **Reactive Power** metering point is not at the same location as the **Reactive Power** capability requirement, then an equivalent **Reactive Power** capability for the metering point shall be agreed between the **HVDC**

System Owner and **The Company**.

ECP.A.7.2.5 The following tests shall be completed for both importing and exporting of Active Power for a **DC Converter**:

(i) Operation at **Maximum Capacity** and maximum continuous lagging **Reactive Power** for 60 minutes.

(ii) Operation at **Maximum Capacity** and maximum continuous leading **Reactive Power** for 60 minutes.

(iii) Operation at 50% **Maximum Capacity** and maximum continuous leading **Reactive Power** for 60 minutes.

(iv) Operation at 50% **Maximum Capacity** and maximum continuous lagging **Reactive Power** for 60 minutes.

(v) Operation at **Minimum Capacity** and maximum continuous leading Reactive Power for 60 minutes.

(vi) Operation at **Minimum Capacity** and maximum continuous lagging **Reactive Power** for 60 minutes.

ECP.A.7.2.6 For the avoidance of doubt, lagging **Reactive Power** is the export of **Reactive Power** from the **HVDC Equipment** to the **Total System** and leading **Reactive Power** is the import of **Reactive Power** from the **Total System** to the **HVDC Equipment.**

ECP.A.7.3 Not Used

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ECP.A.7.4 Voltage Control Tests

ECP.A.7.4.1 This section details the procedure for conducting voltage control tests on **HVDC Equipment.** These tests should be scheduled at a time where there are sufficient MW resource in order to import and export **Maximum Capacity** of the **HVDC Equipment** . An **Embedded HVDC System Owner** should also liaise with the relevant **Network Operator** to ensure all requirements covered in this section will not have a detrimental effect on the **Network Operator's System**.

ECP.A.7.4.2 The voltage control system shall be perturbed with a series of step injections to the **HVDC Equipment** voltage Setpoint, and where possible, multiple up-stream transformer taps.

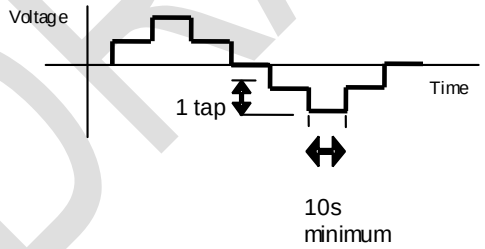
ECP.A.7.4.3 For steps initiated using network tap changers the **HVDC System Owner** will need to coordinate with **The Company** or the relevant **Network Operator** as appropriate. The time between transformer taps shall be at least 10 seconds as per ECP.A.7.4 Figure 1.

ECP.A.7.4.4 For step injection into the **HVDC Equipment** voltage Setpoint, steps of ±1%, ±2% and ±~~2~~4% shall be applied to the voltage control system Setpoint summing junction. The injection shall be maintained for 10 seconds as per ECP.A.7.4 Figure 2.

ECP.A.7.4.5 Where the voltage control system comprises of discretely switched plant and apparatus additional tests will be required to demonstrate that its performance is in accordance with **Grid Code** and **Bilateral Agreement** requirements.

ECP.A.7.4.6 Tests to be completed:

(i)



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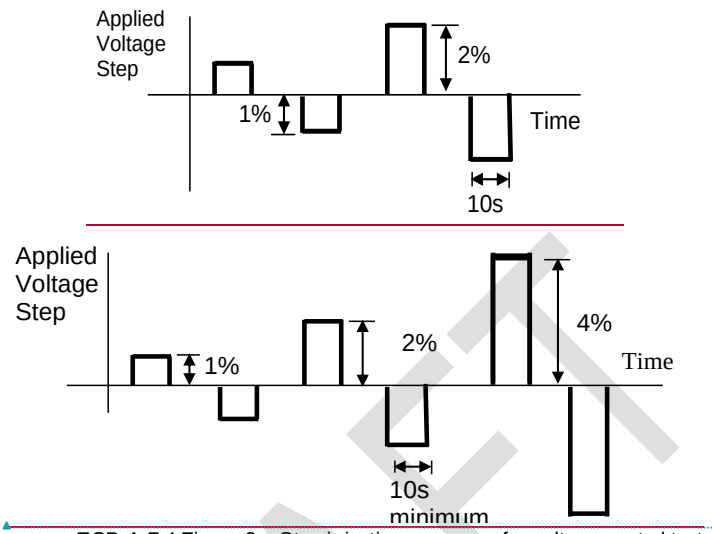
ECP.A.7.4 Figure 1 – Transformer tap sequence for voltage control tests

(ii)



Field Code Changed

ECP.A.7.4 Figure 2 – Step injection sequence for voltage control tests

ECP.A.7.5 Frequency Response Tests

ECP.A.7.5.1 This section describes the procedure for performing frequency response testing on **HVDC Equipment**. These tests should be scheduled at a time where there are sufficient MW resource in order to import and export full **Maximum Capacity** of the **HVDC Equipment**. The **HVDC System Owner** is responsible for ensuring that suitable arrangements are in place with the **Externally Interconnected System Operator** to facilitate the active power changes required by these tests

ECP.A.7.5.2 The frequency controller shall be in **Frequency Sensitive Mode** or **Limited Frequency Sensitive Mode** as appropriate for each test. Simulated frequency deviation signals shall be injected into the frequency controller Setpoint/feedback summing junction. If the injected frequency signal replaces rather than sums with the real system frequency signal then the additional tests outlined in ECP.A.7.5.6 shall be performed with the **HVDC Equipment** in normal **Frequency Sensitive Mode** monitoring actual system frequency, over a period of at least 10 minutes. The aim of this additional test is to verify that the control system correctly measures the real system frequency for normal variations over a period of time.

ECP.A.7.5.3 In addition to the frequency response requirements it is necessary to demonstrate the **HVDC Equipment** ability to deliver a requested steady state power output which is not impacted by power source variation as per ECC.6.3.9. This test shall be conducted in **Limited Frequency Sensitive Mode** at a part-loaded output for a period of 10 minutes as per ECP.A.7.5.6.

Preliminary Frequency Response Testing

ECP.A.7.5.4 Prior to conducting the full set of tests as per ECP.A.7.5.6, **HVDC System Owners** are required to conduct a preliminary set of tests below to confirm the

frequency injection method is correct and the plant control performance is within expectation. The test numbers refer to Figure 1 below. These tests should be scheduled at a time where there are sufficient MW resource in order to export full **Maximum Capacity** from the **HVDC Equipment**. The following frequency injections shall be applied when operating at module load point 4.

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Test No (Figure1)	Frequency Injection	Notes
8	• Inject -0.5Hz frequency fall over 10 sec • Hold for a further 20 sec • At 30 sec from the start of the test, Inject a +0.3Hz frequency rise over 30 sec. • Hold until conditions stabilise • Remove the injected signal as a ramp over 10 seconds	
13	• Inject - 0.5Hz frequency fall over 10 sec • Hold until conditions stabilise • Remove the injected signal as a ramp over 10 seconds	
14	• Inject +0.5Hz frequency rise over 10 sec • Hold until conditions stabilise • Remove the injected signal as a ramp over 10 seconds	
H	• Inject - 0.5Hz frequency fall as a stepchange • Hold until conditions stabilise • Remove the injected signal as a stepchange	
I	• Inject +0.5Hz frequency rise as a stepchange • Hold until conditions stabilise • Remove the injected signal as a stepchange	

ECP.A.7.5.5 The recorded results (e.g. Finj, MW and control signals) should be sampled at a minimum rate of 1 Hz to allow **The Company** to assess the plant performance from the initial transients (seconds) to the final steady state conditions (5-15 minutes depending on the plant design). This is not witnessed by **The Company**. The **HVDC System Owner** shall supply the recordings including data to **The Company** in an electronic spreadsheet format. Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

Full Frequency Response Testing Schedule Witnessed by **The Company**

ECP.A.7.5.6 The tests are to be conducted for importing and exporting power conditions at a number of different Module Load Points (MLP). In the case of **HVDC Equipment** the load points are conducted as shown below unless agreed otherwise by **The Company**. **Maximum** and **Minimum HVDC Active Power Transmission Capacity** should be applied for both importing and exporting conditions.

Commented [H(M32]: Responding to MG comment. This applies importing and exporting. Terminology based on ECC.6.3.8.4.

Module Load Point 6 (**Maximum HVDC Active Power Transmission Capacity** ~~**Export Limit**~~)	100% ~~MEL~~MaxHAPTC
Module Load Point 5	90% MaxHAPTC~~MEL~~
Module Load Point 4 ~~(Mid point of Operating Range)~~	80% MaxHAPTC~~MEL~~
Module Load Point 3	~~MRL~~MinHAPTC+0.6 x (80% MaxHAPTC–MinHAPTC) ~~20%~~
Module Load Point 2	~~MRL~~MinHAPTC+0.3 x (80% MaxHAPTC–MinHAPTC)~~10%~~
Module Load Point 1 (**Minimum HVDC Active Power Transmission Capacity** ~~**regulating level**~~)	~~MRL~~MinHAPTC

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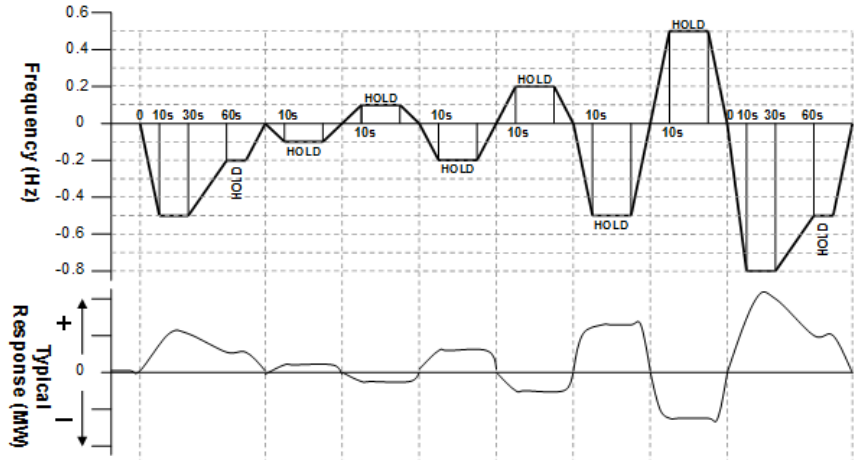
ECP.A.7.5.7 The tests are divided into the following two types;

(i) Frequency response compliance and volume tests as per ECP.A.7.5. Figure 1. These tests consist of frequency profile and ramp tests and adjustments to target frequency setpoint as per ECP.A.7.5 Figure 3
(ii) System islanding and step response tests as shown by ECP.A.7.5 Figure 2

ECP.A.7.5. Fig 1 and 2 are shown for the Importing of Active Power, simulated frequency polarity should be reversed when exporting Active Power.

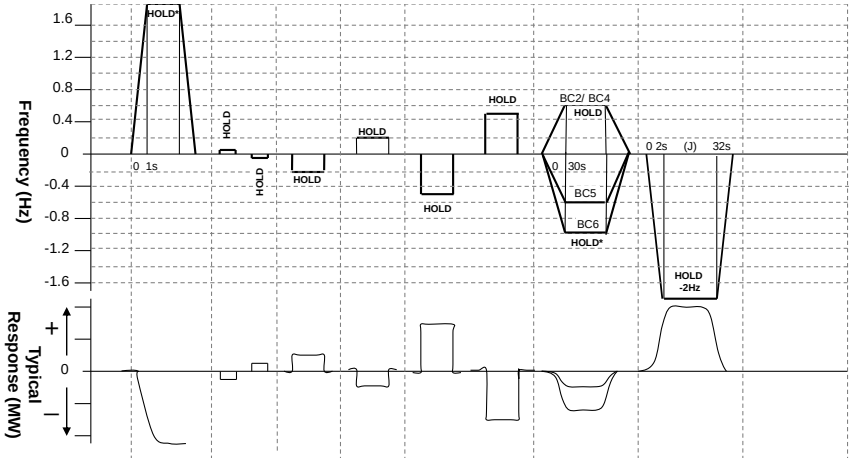
ECP.A.7.5.8 There should be sufficient time allowed between tests for control systems to reach steady state (depending on available power resource). Where the diagram states 'HOLD' the current injection should be maintained until the **Active Power** (MW) output of the **HVDC Equipment** has stabilised (or 90s) whichever is the longer. All frequency response tests should be removed over the same timescale for which they were applied. **The Company** may require repeat tests should the response volume be affected by the available power, or if tests give unexpected results. When witnessed by **The Company** each test should be carried out as a separate injection, when not witnessed by **The Company** there must be sufficient time allowed between tests for the **Active Power** (MW) output of the **HVDC Equipment** to have stabilised or 90s whichever is the longer.

Commented [H(M33]: This is to ensure that "Secondary Response" performance is demonstrated



Load Point	LF Event Profile 1	LF Ramp -0.1Hz	HF Ramp +0.1Hz	LF Ramp -0.2Hz	HF Ramp +0.2Hz	LF Ramp -0.5Hz	HF Ramp +0.5Hz	LF Event Profile 2
MLP6			1	2	3		4	
MLP5								
MLP4	8	9	10	11	12	13	14	17
MLP3								
MLP2								
MLP1	23			24	25			26

ECP.A.7.5. Figure 1 – Frequency Response Capability FSM Ramp Response tests



Load Point	+2.0*	±0.02	-0.2	+0.2	-0.5	+0.5	+/-0.6 -1.0	-2.0	±0**
MLP6	BC1				A	O	BC2		L
MLP6 LFSM	BC3						BC4		
MLP5									
MLP4		D/E	F	G	H	I		J	M
MLP4 LFSM							BC5/6		N
MLP3									
MLP2									
MLP1					K	Q			

ECP.A.7.5. Figure 2 – Frequency Response Capability LFSM-O, LFSM-U, FSM Step Response tests

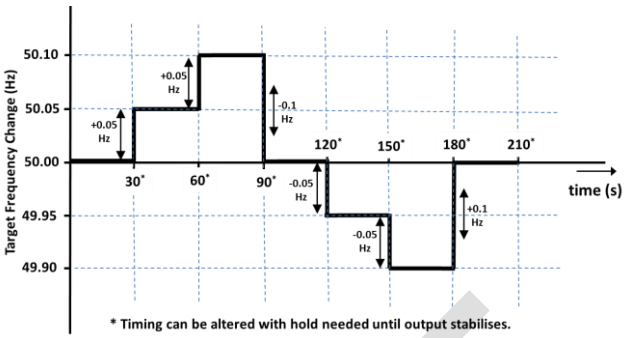
* This will generally be +2.0Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum Capacity** in which case an appropriate injection should be calculated in accordance with the following:
For example 0.9Hz is needed to take an initial output 65% to a final output of 20%. If the initial output was not 65% and the **Minimum Capacity** is not 20% then the injected step should be adjusted accordingly as shown in the example given below

Initial Output	65%
Minimum Capacity	20%
Frequency Controller Droop	4%
Frequency to be injected =	(0.65-0.20)x0.04x50 = 0.9Hz

** Tests L and M in Figure 2 shall be conducted if in this range of tests the system frequency feedback signal is replaced by the injection signal rather than the injection signal being added to the system frequency signal. The tests will consist of monitoring the **HVDC Equipment** in **Frequency Sensitive Mode** during normal system frequency variations without applying any injection. Test N in Figure 2 shall be conducted in all cases. All three tests should be conducted for a period of at least 10 minutes.

ECP.A.7.5.9 The target frequency adjustment facility should be demonstrated from the normal control point within the range of 49.9Hz to 50.1Hz by step changes to

the target frequency setpoint as indicated in ECP.A.7.5 Figure 3.



ECP.A.7.5. Figure 3 – Target Frequency setting changes

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APPENDIX 8
SIMULATION STUDIES AND COMPLIANCE TESTING FOR NETWORK OPERATORS AND NON-EMBEDDED CUSTOMERS PLANT AND APPARATUS

ECP.A.8.1 Compliance testing for disconnection and reconnection of Network Operator's Plant and Apparatus

ECP.A.8.1.1 **Network Operators** shall comply with the following applicable requirements in respect of **EU Grid Supply Points**:
(i) Demand disconnection schemes;
(ii) Synchronising; and/or
(iii) low frequency demand disconnection;

ECP.A.8.1.2 The requirements for demand disconnection, other than low frequency demand disconnection, are pursuant to the requirements of the **Bilateral Agreement.** Any requirements for testing shall be agreed with the **User** where such requirements are applicable.

ECP.A.8.1.3 The requirements for synchronising (where applicable) shall be pursuant to the requirements of the **Bilateral Agreement** and ECC.6.2.3.10. Any requirements for testing (as applicable) shall be agreed with the **User** and carried out during the commissioning process.

ECP.A.8.1.4 **Network Operators** who are **EU Code Users** must demonstrate compliance with the low frequency demand disconnection requirements of ECC.6.4.3, ECC.A.5 and OC.6.6 for their entire distribution **System**.

ECP.A.8.1.5 An equipment certificate may be submitted to **The Company** instead of part of the tests provided for in ECP.A.8.1.1.

ECP.A.8.2 Compliance testing for operational metering at EU Grid Supply Points

ECP.A.8.2.1 The requirements for operational metering (where required) shall be pursuant to the requirements of the **Bilateral Agreement** and ECC.6.5.6. Any applicable requirements for testing shall be agreed with the **User** and carried out during the commissioning process. An **Equipment Certificate** may be used for this purpose where agreed with **The Company**.

ECP.A.8.3 Compliance testing for disconnection and reconnection of Non-Embedded Customers Plant and Apparatus

ECP.A.8.3.1 **Non-Embedded Customers** shall comply with the following requirements where applicable:
(i) Demand disconnection schemes;
(ii) Synchronising; and/or
(iii) low frequency demand disconnection;

ECP.A.8.3.2 The requirements for demand disconnection, other than low frequency demand disconnection, are pursuant to the requirements of the **Bilateral Agreement.** Any requirements for testing shall be agreed with the **User**.

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ECP.A.8.3.3 The requirements for synchronising (where applicable) shall be pursuant to the requirements of the **Bilateral Agreement** and ECC.6.2.3.10. Any requirements for testing (as applicable) shall be agreed with the **User** and carried out during the commissioning process.

ECP.A.8.3.4 **Non-Embedded Customers** who are **EU Code Users** must demonstrate compliance with the low frequency demand disconnection requirements of ECC.6.4.3, ECC.A.5 and OC.6.6 of their **System**.

ECP.A.8.3.5 An equipment certificate may be submitted to **The Company** instead of part of the tests provided for in ECP.A.8.3.1.

ECP.A.8.4 Compliance testing for operational metering on Non-Embedded Customers Plant and Apparatus

ECP.A.8.4.1 The requirements for operational metering (where required)) shall be pursuant to the requirements of the **Bilateral Agreement** and ECC.6.5.6. Any applicable requirements for testing shall be agreed with the **User** and carried out during the commissioning process. An **Equipment Certificate** may be used for this purpose where agreed with **The Company**.

ECP.A.8.5 Common Provisions on Compliance Simulations

ECP.A.8.5.1 **Users** are required to provide simulation studies or equivalent information to the satisfaction of **The Company** in the following circumstances.

(i) a new connection to the **Transmission System** is required forming part of an **EU Grid Supply Point**;
(ii) a **Substantial Modification** takes place at an **EU Grid Supply Point**
(iii) **The Company** becomes aware of a potential non-compliance by the **Network Operator** or **Non-Embedded Customer** at an **EU Grid Supply Point**.

ECP.A.8.5.2 Notwithstanding the requirements of ECP.A.8.5.1, **The Company** shall be entitled to:-

(a) Allow the **Network Operator** or **Non-Embedded Customer** to carry out an alternative set of simulations (or equivalent information) provided that they demonstrate that the **Network Operators** or **Non-Embedded Customers Plant** and **Apparatus** is capable of satisfying the applicable requirements of the **Data Registration Code**.

(b) Require the **Network Operator** or **Non-Embedded Customer** to carry out additional or alternative simulations (or equivalent information) to those specified in ECP.A.8.5.1 where they would otherwise be insufficient to demonstrate compliance.

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(c) **The Company** may check that the **Network Operator** or **Non-Embedded Customer** complies with the requirements of the **Grid Code** by carrying out its own compliance simulations based on the simulation reports, models and test measurements submitted under the **Data Registration Code**.

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ECP.A.8.5.3 **The Company** will supply (under PC.A.8) upon request to the **Network Operator** or **Non-Embedded Customer**, data to enable the **Network Operator** or **Non-Embedded Customer** to carry out the required simulations or supply the equivalent information required under the **Data Registration Code**.

ECP.A.8.6 Compliance simulations for EU Grid Supply Points

ECP.A.8.6.1 **Networks Operators** who are also **EU Code Users**, are required to provide simulation studies (or make available equivalent information) at each **EU Grid Supply Point** to demonstrate compliance with the **Reactive Power** capability requirements set out in ECC.6.4.5. The study or equivalent information provided shall include a steady state simulation model under both maximum and minimum demand conditions. In addition, the model or equivalent information provided shall include the conditions when the **Reactive Power** export is at an **Active Power** flow of less than 25% of the **Maximum Import Capability** as detailed under ECC.6.4.5.2. In all cases the models or equivalent information submitted shall be agreed and approved with **The Company**.

ECP.A.8.7 Compliance simulations for Non-Embedded Customers Plant and Apparatus

ECP.A.8.7.1 **None Embedded Customers** who are also **EU Code Users** are required at each **EU Grid Supply Point** to provide simulation studies (or equivalent information) to demonstrate compliance with the **Reactive Power** capability requirements set out in ECC.6.4.5. The study or equivalent information provided shall include a steady state simulation model under both maximum and minimum demand conditions and with and without on-site generation. In all cases the models or equivalent information submitted shall be agreed and approved with **The Company**.

ECP.A.8.8 Compliance monitoring at EU Grid Supply Points

ECP.A.8.8.1 To satisfy the requirements of ECC.6.4.5, **EU Code Users** who are either **Network Operators** or **Non-Embedded Customers** shall ensure their **Plant** and **Apparatus** is equipped (where applicable) with the necessary equipment to measure the **Active Power** and **Reactive Power**, at each **EU Grid Supply Point**. The requirement for and time frame for compliance monitoring shall be agreed between **The Company** and the **EU Code User** for each **EU Grid Supply Point**.

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APPENDIX 8

SIMULATION STUDIES AND COMPLIANCE TESTING FOR NETWORK OPERATORS AND NON-EMBEDDED CUSTOMERS PLANT AND APPARATUS

ECP.A.8.1 Compliance testing for disconnection and reconnection of Network Operator's Plant and Apparatus

ECP.A.8.1.1 **Network Operators** shall comply with the following applicable requirements in respect of **EU Grid Supply Points**:

(iv) Demand disconnection schemes;
(v) Synchronising; and/or
(vi) low frequency demand disconnection;

ECP.A.8.1.2 The requirements for demand disconnection, other than low frequency demand disconnection, are pursuant to the requirements of the **Bilateral Agreement**. Any requirements for testing shall be agreed with the **User** where such requirements are applicable.

ECP.A.8.1.3 The requirements for synchronising (where applicable) shall be pursuant to the requirements of the **Bilateral Agreement** and ECC.6.2.3.10. Any requirements for testing (as applicable) shall be agreed with the **User** and carried out during the commissioning process.

ECP.A.8.1.4 **Network Operators** who are **EU Code Users** must demonstrate compliance with the low frequency demand disconnection requirements of ECC.6.4.3, ECC.A.5 and OC.6.6 for their entire distribution **System**.

ECP.A.8.1.5 An equipment certificate may be submitted to **The Company** instead of part of the tests provided for in ECP.A.8.1.1.

ECP.A.8.2 Compliance testing for operational metering at EU Grid Supply Points

ECP.A.8.2.1 The requirements for operational metering (where required) shall be pursuant to the requirements of the **Bilateral Agreement** and ECC.6.5.6. Any applicable requirements for testing shall be agreed with the **User** and carried out during the commissioning process. An **Equipment Certificate** may be used for this purpose where agreed with **The Company**.

ECP.A.8.3 Compliance testing for disconnection and reconnection of Non-Embedded Customers Plant and Apparatus

ECP.A.8.3.1 **Non-Embedded Customers** shall comply with the following requirements where applicable:

(iv) Demand disconnection schemes;
(v) Synchronising; and/or
(vi) low frequency demand disconnection;

ECP.A.8.3.2 The requirements for demand disconnection, other than low frequency demand disconnection, are pursuant to the requirements of the **Bilateral Agreement**. Any requirements for testing shall be agreed with the **User**.

ECP.A.8.3.3 The requirements for synchronising (where applicable) shall be pursuant to the requirements of the **Bilateral Agreement** and ECC.6.2.3.10. Any requirements for testing (as applicable) shall be agreed with the **User** and carried out during the commissioning process.

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ECP.A.8.3.4 **Non-Embedded Customers** who are **EU Code Users** must demonstrate compliance with the low frequency demand disconnection requirements of ECC.6.4.3, ECC.A.5 and OC.6.6 of their **System**.

ECP.A.8.3.5 An equipment certificate may be submitted to **The Company** instead of part of the tests provided for in ECP.A.8.3.1.

ECP.A.8.4 Compliance testing for operational metering on Non-Embedded Customers Plant and Apparatus

ECP.A.8.4.1 The requirements for operational metering (where required)) shall be pursuant to the requirements of the **Bilateral Agreement** and ECC.6.5.6. Any applicable requirements for testing shall be agreed with the **User** and carried out during the commissioning process. An **Equipment Certificate** may be used for this purpose where agreed with **The Company**.

ECP.A.8.5 Common Provisions on Compliance Simulations

ECP.A.8.5.1 **Users** are required to provide simulation studies or equivalent information to the satisfaction of **The Company** in the following circumstances.

(iv) a new connection to the **Transmission System** is required forming part of an **EU Grid Supply Point**;
(v) a **Substantial Modification** takes place at an **EU Grid Supply Point**
(vi) **The Company** becomes aware of a potential non-compliance by the **Network Operator** or **Non-Embedded Customer** at an **EU Grid Supply Point**.

ECP.A.8.5.2 Notwithstanding the requirements of ECP.A.8.5.1, **The Company** shall be entitled to:-

(d) Allow the **Network Operator** or **Non-Embedded Customer** to carry out an alternative set of simulations (or equivalent information) provided that they demonstrate that the **Network Operators** or **Non-Embedded Customers Plant** and **Apparatus** is capable of satisfying the applicable requirements of the **Data Registration Code**.

(e) Require the **Network Operator** or **Non-Embedded Customer** to carry out additional or alternative simulations (or equivalent information) to those specified in ECP.A.8.5.1 where they would otherwise be insufficient to demonstrate compliance.

(f) **The Company** may check that the **Network Operator** or **Non-Embedded Customer** complies with the requirements of the **Grid Code** by carrying out its own compliance simulations based on the simulation reports, models and test measurements submitted under the **Data Registration Code**.

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ECP.A.8.5.3 **The Company** will supply (under PC.A.8) upon request to the **Network Operator** or **Non-Embedded Customer**, data to enable the **Network Operator** or **Non-Embedded Customer** to carry out the required simulations or supply the equivalent information required under the **Data Registration Code**.

ECP.A.8.6 Compliance simulations for EU Grid Supply Points

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ECP.A.8.6.1 **Networks Operators** who are also **EU Code Users**, are required to provide simulation studies (or make available equivalent information) at each **EU Grid Supply Point** to demonstrate compliance with the **Reactive Power** capability requirements set out in ECC.6.4.5. The study or equivalent information provided shall include a steady state simulation model under both maximum and minimum demand conditions. In addition, the model or equivalent information provided shall include the conditions when the **Reactive Power** export is at an **Active Power** flow of less than 25% of the **Maximum Import Capability** as detailed under ECC.6.4.5.2. In all cases the models or equivalent information submitted shall be agreed and approved with **The Company**

ECP.A.8.7 Compliance simulations for Non-Embedded Customers Plant and Apparatus

ECP.A.8.7.1 **None Embedded Customers** who are also **EU Code Users** are required at each **EU Grid Supply Point** to provide simulation studies (or equivalent information) to demonstrate compliance with the **Reactive Power** capability requirements set out in ECC.6.4.5. The study or equivalent information provided shall include a steady state simulation model under both maximum and minimum demand conditions and with and without on-site generation. In all cases the models or equivalent information submitted shall be agreed and approved with **The Company**.

ECP.A.8.8 Compliance monitoring at EU Grid Supply Points

ECP.A.8.8.1 To satisfy the requirements of ECC.6.4.5, **EU Code Users** who are either **Network Operators** or **Non-Embedded Customers** shall ensure their **Plant** and **Apparatus** is equipped (where applicable) with the necessary equipment to measure the **Active Power** and **Reactive Power**, at each **EU Grid Supply Point**. The requirement for and time frame for compliance monitoring shall be agreed between **The Company** and the **EU Code User** for each **EU Grid Supply Point**.

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