PROPOSED GC0101 - LEGAL DRAFTING

This section contains the proposed legal text to give effect to the proposals. The proposed new text is colour coded according to the following key.

Key

1) Blue Text – From Grid Code
2) Black Text – Changes / Additional words
3) Orange/ Brown text – From RfG
4) Purple – From HVDC Code
5) Green – From DCC
4) Highlighted Green text – Questions for Stakeholders / Consultation
5) Highlighted yellow text – Nomenclature / Table / Figure numbers – to be finalised when more detail has been added
6) Extracts from GC0100 and GC0101 Consultations (Note Existing Grid Code text has been deleted)

GLOSSARY AND DEFINITIONS

A complete review of the Glossary and Definitions will be required when the full suite of European Codes has been implemented. The current assumption is to use GB definitions where appropriate with use of European definitions where required. The current European definitions used in the text are summarised below but it should be stressed that this is very much work in progress and further revisions will be required in the future. It should be noted that consistency checks will be required between the terms used in the Grid Code and those used in the Distribution Code.

Term	Definition
European Regulation (EU) 2016/631	**Commission Regulation (EU) 2016/631** of 14 April 2016 establishing a network code on requirements of generators
European Regulation (EU) 2016/1388	**Commission Regulation (EU) 2016/1388** of 17 August 2016 establishing a network code on Demand Connection
Commission Regulation (EU) 2016/1447	**Commission Regulation (EU) 2016/1447** of 26 August 2016 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules

ECC.6 TECHNICAL, DESIGN AND OPERATIONAL CRITERIA

ECC.6.1 National Electricity Transmission System Performance Characteristics

ECC.6.1.1 **NGET** shall ensure that, subject as provided in the **Grid Code**, the **National Electricity Transmission System** complies with the following technical, design and operational criteria in relation to the part of the **National Electricity Transmission System** at the **Connection Site** with a **User** and in the case of **OTSDUW Plant and Apparatus**, a **Transmission Interface Point** (unless otherwise specified in ECC.6) although in relation to operational criteria **NGET** may be unable (and will not be required) to comply with this obligation to the extent that there are insufficient **Power Stations** or **User Systems** are not available or **Users** do not comply with **NGET's** instructions or otherwise do not comply with the **Grid Code** and each **User** shall ensure that its **Plant** and **Apparatus** complies with the criteria set out in ECC.6.1.5.

ECC.6.1.2 Grid Frequency Variations

ECC.6.1.2.1 Grid Frequency Variations for all **User's** excluding **HVDC Equipment**

ECC.6.1.2.1.1 The **Frequency** of the **National Electricity Transmission System** shall be nominally 50Hz and shall be controlled within the limits of 49.5 - 50.5Hz unless exceptional circumstances prevail.

ECC.6.1.2.1.2 The **System Frequency** could rise to 52Hz or fall to 47Hz in exceptional circumstances. Design of **User's Plant** and **Apparatus** and **OTSDUW Plant and Apparatus** must enable operation of that **Plant** and **Apparatus** within that range in accordance with the following:

Frequency Range	Requirement
51.5Hz - 52Hz	Operation for a period of at least 15 minutes is required each time the Frequency is above 51.5Hz.
51Hz - 51.5Hz	Operation for a period of at least 90 minutes is required each time the Frequency is above 51Hz.
49.0Hz - 51Hz	Continuous operation is required
47.5Hz - 49.0Hz	Operation for a period of at least 90 minutes is required each time the Frequency is below 49.0Hz.
47Hz - 47.5Hz	Operation for a period of at least 20 seconds is required each time the Frequency is below 47.5Hz.

ECC.6.1.2.1.3 For the avoidance of doubt, disconnection, by frequency or speed based relays is not permitted within the frequency range 47.5Hz to 51.5Hz. **Generators** should however be aware of combined voltage and frequency operating ranges as defined in ECC.6.3.12 and ECC.6.3.134X.

ECC.6.1.2.1.4 **NGET** in co-ordination with the **Relevant Transmission Licensee** and/or **Network Operator** and a **User** may agree on wider variations in frequency or longer minimum operating times to those set out in ECC.6.1.2.1.2 or specific requirements for combined frequency and voltage deviations. Any such requirements in relation to **Power Generating Modules** shall be in accordance with ECC.6.3.12. The **User** shall not unreasonably withhold consent to apply wider frequency ranges or longer minimum times for operation taking account of their economic and technical feasibility.

ECC.6.1.2.2 Grid Frequency variations for **HVDC Systems** and **Remote End HVDC Converter Stations**

ECC.6.1.2.2.1 **HVDC Systems** and **Remote End HVDC Converter Stations** shall be capable of staying connected to the **System** and remaining operable within the frequency ranges and time periods specified in Table X1 below. This requirement shall continue to apply during the conditions defined in ECC.6.3.15 ~~*(Fault Ride Through) – This requirement backs off reference to Art 32(2).*~~

Frequency Range (Hz)	Time Period for Operation (s)
47.0 – 47.5Hz	60 seconds
47.5 – 49.0Hz	90~~100~~ minutes and 30 seconds
49.0 – 51.0Hz	Unlimited
51.0 – 51.5Hz	90~~100~~ minutes and 30 seconds
51.5Hz – 52 Hz	20 minutes

Table X1 – Minimum time periods **HVDC Systems** and **Remote End HVDC Converter Stations** shall be able to operate for different frequencies deviating from a nominal value without disconnecting from the **National Electricity Transmission System**

ECC.6.1.2.2.2 **NGET** in coordination with the **Relevant Transmission Licensee** and a **HVDC System Owner** may agree wider frequency ranges or longer minimum operating times if required to preserve or restore system security. If wider frequency ranges or longer minimum times for operation are economically and technically feasible, the HV**DC System Owner** shall not unreasonably withhold consent.

ECC.6.1.2.2.3 Not withstanding the requirements of ECC.6.1.2.2.1, an **HVDC System** or **Remote End HVDC Converter Station** shall be capable of automatic disconnection at frequencies specified by **NGET** and/or **Relevant Network Operator**. ~~*(Note – Art 11(4) not reflected in drafting as this is picked up by ECC.6.3.3 – Output Power with falling frequency).*~~

ECC.6.1.2.2.4 In the case of **Remote End HVDC Converter Stations** where the **Remote End DC Converter Station** is operating at either nominal frequency other than 50Hz or a variable frequency, the requirements defined in ECC6.1.2.2.1 to ECC.6.1.2.2.3 shall apply to the **Remote End HVDC Converter Station** other than in respect of the frequency ranges and time periods.

ECC.6.1.2.3 Grid Frequency Variations for **DC Connected Power Park Modules**

ECC.6.1.2.3.1 **DC Connected Power Park Modules** shall be capable of staying connected to the **Remote End DC Converter** network and operating within the frequency ranges and time periods specified in Table X2 below. Where a nominal frequency other than 50Hz, or a **Frequency** variable by design is used as agreed with **NGET** and the **Relevant Transmission Licensee** the applicable frequency ranges and time periods shall be specified in the **Bilateral Agreement** which shall (where applicable) reflect the requirements in Table X2.

Frequency Range (Hz)	Time Period for Operation (s)
47.0 – 47.5Hz	20~~60~~ seconds
47.5 – 49.0Hz	90~~100~~ minutes~~ and 30 seconds~~
49.0 – 51.0Hz	Unlimited

51.0 – 51.5Hz	909100 minutes and 30 seconds
51.5Hz – 52 Hz	1520 minutes

Table X1 X2 – Minimum time periods a DC Connected Power Park Module Converter at a DC Converter Station shall be able to operate for different frequencies deviating from a nominal value without disconnecting from the **System** National Electricity Transmission System

ECC.6.1.2.3.2 **NGET** in coordination with the **Relevant Transmission Licensee** and a **Generator** may agree wider frequency ranges or longer minimum operating times if required to preserve or restore system security and to ensure the optimum capability of the **DC Connected Power Park Module**. If wider frequency ranges or longer minimum times for operation are economically and technically feasible, the **Generator** shall not unreasonably withhold consent.

ECC.6.1.2.2.3 Not withstanding the requirements of ECC.6.1.2.3.1, a **DC Connected Power Park Module** shall be capable of automatic disconnection at frequencies specified by **NGET**. Such requirements (including the conditions and settings) for automatic disconnection shall be agreed between **NGET** and the **Generator** . *(Note – Art 11(4) not reflected in drafting as this is picked up by ECC.6.3.3 – Output Power with falling frequency).*

ECC.6.1.4 Grid Voltage Variations

ECC.6.1.4.1 Grid Voltage Variations for all **User's** excluding **DC Connected Power Park Modules** and **Remote End DC Converters**

Subject as provided below, the voltage on the 400kV part of the **National Electricity Transmission System** at each **Connection Site** with a **User** (and in the case of **OTSDUW Plant and Apparatus**, a **Transmission Interface Point**, excluding **DC Connected Power Park Modules** and **Remote End DC Converters**) will normally remain within ±5% of the nominal value unless abnormal conditions prevail. The minimum voltage is -10% and the maximum voltage is +10% unless abnormal conditions prevail, but voltages between +5% and +10% will not last longer than 15 minutes unless abnormal conditions prevail. Voltages on the 275kV and 132kV parts of the **National Electricity Transmission System** at each **Connection Point** (and in the case of **OTSDUW Plant and Apparatus**, a **Transmission Interface Point**) will normally remain within the limits ±10% of the nominal value unless abnormal conditions prevail. At nominal **System** voltages below 110132kV the voltage of the **National Electricity Transmission System** at each **Connection Site** with a **User** (and in the case of **OTSDUW Plant and Apparatus**, a **Transmission Interface Point**), excluding **Connection Sites** for **DC Connected Power Park Modules** and **Remote End DC Converters**) will normally remain within the limits ±6% of the nominal value unless abnormal conditions prevail. Under fault conditions, the voltage may collapse transiently to zero at the point of fault until the fault is cleared. The normal operating ranges of the **National Electricity Transmission System** are summarised below:

National Electricity Transmission System Nominal Voltage	Normal Operating Range	Time period for Operation
400kV	400kV -10% to +5% 400kV +5% to +10%	Unlimited 15 minutes
275kV	275kV ±10%	Unlimited

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Comment [A1]: Agreement via NGET and the Relevant Transmission Licensee would be via the STC Proresses hence reference to Relevent Network Operator has been removed

Comment [A2]: Note - text extracted from GC0101 - Frequency

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132kV	132kV ±10%	Unlimited
110kV	110kV ±10%	Unlimited
Below 110kV	Below 110kV ±6%	Unlimited

NGET and a **User** may agree greater ~~or lesser wider~~ variations or longer minimum time periods of operation in voltage to those set out above in relation to a particular **Connection Site**, and insofar as a greater ~~or lesser~~ variation is agreed, the relevant figure set out above shall, in relation to that **User** at the particular **Connection Site**, be replaced by the figure agreed.

ECC.6.1.4.2 Grid Voltage Variations for all **DC Connected Power Park Modules**

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ECC.6.1.4.2.1 All **DC Connected Power Park Modules** shall be capable of staying connected to the **Remote End HVDC Converter Station** at the **HVDC Interface Point** and operating within the voltage ranges and time periods specified in Tables X3~~1~~ and X4~~2~~ below. The applicable voltage range and time periods specified are selected based on the reference 1pu voltage.

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Voltage Range (pu)	Time Period for Operation (s)
0.85pu – 0.9pu	60 minutes
0.9pu – 1.1pu	Unlimited
1.1pu – 1.15pu	15 minutes

Table X3~~1~~ – Minimum time periods for which **DC Connected Power Park Modules** shall be capable of operating for different voltages deviating from reference 1pu without disconnecting from the network where the nominal voltage base is 110kV or above and less than 300kV.

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Voltage Range (pu)	Time Period for Operation (s)
0.85pu – 0.9pu	60 minutes
0.9pu – 1.05pu	Unlimited
1.05pu – 1.15pu	15 minutes

Table X4~~2~~ – Minimum time periods for which **DC Connected Power Park Modules** shall be capable of operating for different voltages deviating from reference 1pu without disconnecting from the network where the nominal voltage base is from 300kV up to and including 400kV.

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ECC.6.1.4.2.2 **NGET** and a **Generator** may agree greater voltage ranges or longer minimum operating times~~-~~. – If ~~wider~~ greater voltage ranges or longer minimum times for operation are economically and technically feasible, the **Generator** shall not unreasonably withhold any agreement .

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ECC.6.1.4.2.3 For **DC Connected Power Park Modules** which have an **HVDC Interface Point** to the **Remote End HVDC Converter Station**, **NGET** in coordination with the **Relevant Transmission Licensee** may specify voltage limits at the **HVDC Interface Point** at which the **DC Connected Power Park Module** is capable of automatic disconnection.

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ECC.6.1.4.2.4 For **HVDC Interface Points** which fall outside the scope of ECC.6.1.4.2.2, ECC.6.1.4.2.2 and ECC.6.1.4.2.3 **NGET** in coordination with the **Relevant Transmission Licensee** shall specify any applicable requirements at the **Grid Entry Point** or **User System Entry Point**.

ECC.6.1.4.2.5 Where the nominal frequency of the AC collector **System** which is connected to an **HVDC Interface Point** is at a value other than 50Hz, the voltage ranges and time periods specified by **NGET** in coordination with the **Relevant Transmission Licensee** shall be proportional to the values specified in Tables X3~~1~~ and X4~~2~~ of ECC.6.1.4.2.1

ECC.6.1.4.3 <u>Grid Voltage Variations for all **Remote End HVDC Converters**</u>

ECC.6.1.4.2.1 All **Remote End HVDC Converter Stations** shall be capable of staying connected to the **HVDC Interface Point** and operating within the voltage ranges and time periods specified in Tables X5~~3~~ and X6~~4~~ below. The applicable voltage range and time periods specified are selected based on the reference 1pu voltage.

Voltage Range (pu)	Time Period for Operation (s)
0.85pu – 0.9pu	60 minutes
0.9pu – 1.1pu	Unlimited
1.1pu – 1.15pu	15 minutes

Table X5~~1~~ – Minimum time periods for which a **Remote End HVDC Converter** shall be capable of operating for different voltages deviating from reference 1pu without disconnecting from the network where the nominal voltage base is 110kV or above and less than 300kV.

Voltage Range (pu)	Time Period for Operation (s)
0.85pu – 0.9pu	60 minutes
0.9pu – 1.05pu	Unlimited
1.05pu – 1.15pu	15 minutes

Table X6~~2~~ – Minimum time periods for which **a Remote End HVDC Converter** shall be capable of operating for different voltages deviating from reference 1pu without disconnecting from the network where the nominal voltage base is from 300kV up to and including 400kV.

ECC.6.1.4.2.2 **NGET** and a **Generator** may agree greater voltage ranges or longer minimum operating times which shall be in accordance with the requirements of ECC.6.1.4.2.

ECC.6.1.4.2.4 For **HVDC Interface Points** which fall outside the scope of ECC.6.1.4.2.1 **NGET** in coordination with the **Relevant Transmission Licensee** shall specify any applicable requirements at the **Grid Entry Point** or **User System Entry Point**.

ECC.6.1.4.2.5 Where the nominal frequency of the AC collector **System** which is connected to an **HVDC Interface Point** is at a value other than 50Hz, the voltage ranges and time periods specified by **NGET** in coordination with the **Relevant Transmission Licensee** shall be proportional to the values specified in Tables X5~~3~~ and X6~~4~~ of ECC.6.1.4.2.1

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ECC.6.3 GENERAL POWER GENERATING MODULE, OTSDUW AND HVDC EQUIPMENT ~~GENERATING UNIT (AND OTSDUW)~~ REQUIREMENTS

ECC.6.3.1 This section sets out the technical and design criteria and performance requirements for **Power Generating Modules** and **HVDC Equipment** ~~**DC Converters** and **Power Park Modules**~~ (whether directly connected to the **National Electricity Transmission System** or **Embedded**) and (where provided in this section) **OTSDUW Plant and Apparatus** which each **Generator** or **HVDC SystemOwner** must ensure are complied with in relation to its **Power Generating Modules**, **HVDC Equipment** ~~**Generating** and **Power Park Modules**~~ and **OTSDUW Plant and Apparatus** ~~but does not apply to **Small Power Stations** or individually to **Power Park Units**~~. References to **Power Generating Modules** ~~**Units**~~, **HVDC Equipment** ~~and **Power Park Modules**~~ in this ECC.6.3 should be read accordingly.

Plant Performance Requirements

ECC.6.3.2 REACTIVE CAPABILITY

ECC.6.3.2.1 Reactive Capability for **Type B Synchronous Power Generating Modules**

ECC.6.3.2.1.1 When operating at **Maximum Capacity** all **Type B Synchronous Power Generating Modules** must be capable of continuous operation at any points between the limits of 0.95 **Power Factor** lagging and 0.95 **Power Factor** leading at the **Grid Entry Point** or **User System Entry Point** unless otherwise agreed with **NGET** or relevant **Network Operator**. At **Active Power** output levels other than **Maximum Capacity**, all **Generating Units** within a **Type B Synchronous Power Generating Module** must be capable of continuous operation at any point between the **Reactive Power** capability limits identified on the **HV Generator Performance Chart** unless otherwise agreed with **NGET** or relevant **Network Operator**.

ECC.6.3.2.2 Reactive Capability for **Type B Power Park Modules**

ECC.6.3.2.2.1 When operating at **Maximum Capacity** all **Type B Power Park Modules** must be capable of continuous operation at any points between the limits of 0.95 **Power Factor** lagging and 0.95 **Power Factor** leading at the **Grid Entry Point** or **User System Entry Point** unless otherwise agreed with **NGET** or relevant **Network Operator**. At **Active Power** output levels other than **Maximum Capacity**, each **Power Park Module** must be capable of continuous operation at any point between the **Reactive Power** capability limits identified on the **HV Generator Performance Chart** unless otherwise agreed with **NGET** or **Network Operator**.

ECC.6.3.2.3 Reactive Capability for **Type C** and **D Synchronous Power Generating Modules**

ECC.6.3.2.3.1 In addition to meeting the requirements of ECC.6.3.2.3.2 – ECC.6.3.2.3.5, **Generators** which connect a **Type C** or **Type D Synchronous Power Generating Module**(s) to a **Non Embedded Customers System** or pPrivate nNetwork, may be required to meet additional reactive compensation requirements at the point of connection between the **System** and the **Non Embedded Customer** or private network where this is required for **System** reasons. ~~at the **Grid Supply Point** or **Grid Supply Point** of that **Non Embedded Customer** or point of connection with the **Network Operator** where this is required for **System** reasons.~~

ECC.6.3.2.3.2~~3~~ All **Type C** and **Type D Synchronous Power Generating Modules** shall be capable of satisfying the **Reactive Power** capability requirements at the **Grid Entry Point** or **User System Entry Point** as defined in Figure X1 when operating at **Maximum Capacity**.

ECC.6.3.2.3.3~~4~~ At **Active Power** output levels other than **Maximum Capacity** all **Generating Units** within a **Synchronous Power Generating Module** must be capable of continuous operation at any point between the **Reactive Power** capability limit identified on the **HV Generator Performance Chart** at least down to the **Minimum Stable Operating Level**. At reduced **Active Power** output, **Reactive Power** supplied at the **Grid Entry Point** (or **User System Entry Point** if **Embedded)** shall correspond to the **HV Generator Performance Chart** of the **Synchronous Power Generating Module**, taking the auxiliary supplies and the **Active Power** and **Reactive Power** losses of the **Generating Unit** transformer or **Station Transformer** into account.

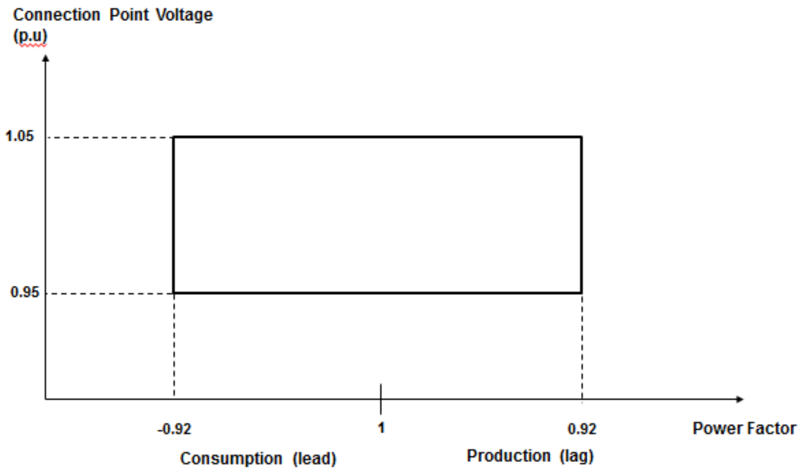

Figure X1

ECC.6.3.2.3.4~~5~~ In addition, to the requirements of ECC.6.3.2.3.1 – ECC.6.3.2.3.4 the short circuit ratio of all **Onshore Synchronous Generating Units** with an **Apparent Power** rating of less than 1600MVA shall not be less than 0.5. The short circuit ratio of **Onshore Synchronous Generating Units** with a rated **Apparent Power** of 1600MVA or above shall be not less than 0.4.

ECC.6.3.2.6 Reactive Capability for **Type C** and **D Power Park Modules, HVDC Equipment** and **OTSDUW Plant and Apparatus** at the **Interface Point**

ECC.6.3.2.6.1 In addition to meeting the requirements of ECC.6.3.2.3.2 – ECC.6.3.2.3.5, **Generators** or **HVDC System Owners** which connect a Onshore **Type C** or **Type D Power Park Module** or **HVDC Equipment** to a **Non Embedded Customers System** or p~~P~~rivate n~~N~~etwork, may be required to meet additional reactive compensation requirements may be required to meet additional reactive compensation requirements at the point of connection between the **System** and the **Non Embedded Customer** or private network ~~at the **Grid Supply Point** of that **Non Embedded Customer** or point of connection with the **Network Operator**~~ where this is required for **System** reasons.

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Comment [A3]: Test Updates - SC/AJ to disucss. Further discussion required on HVDC but believed to capture HVDC Code -Art 21(1)

ECC.6.3.2.6.2 All **Onshore** **Type C** and **Type D Power Park Modules** or **HVDC Converters** at an **HVDC Converter Station** with a **Grid Entry Point** or **User System Entry Point** voltage above 33kV, or **Remote End HVDC Converters** with an **HVDC Interface Point** voltage above 33kV, or **OTSDUW Plant and Apparatus** with an **Interface Point** voltage above 33kV shall be capable of satisfying the **Reactive Power** capability requirements at the **Grid Entry Point** or **User System Entry Point** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus**, or **HVDC Interface Point** in the case of a **Remote End HVDC Converter Station**) as defined in Figure X2 when operating at **Maximum Capacity** (or **Interface Point Capacity** in the case of **OTSUW Plant and Apparatus**). In the case **of Remote End HVDC Converters** and **DC Connected Power Park Modules**, **NGET** in co-ordination with the **Relevant Transmission Licensee** may agree to alternative reactive capability requirements to those specified in Figure X2, where it is demonstrated that it is uneconomic and inefficient to do so, for example in the case of new technologies or advanced control strategies. For the avoidance of doubt, the requirements for **Offshore Power Park Modules** and **DC Connected Power Park Modules** are defined in ECC.6.3.2.7 and ECC.6.3.2.8.

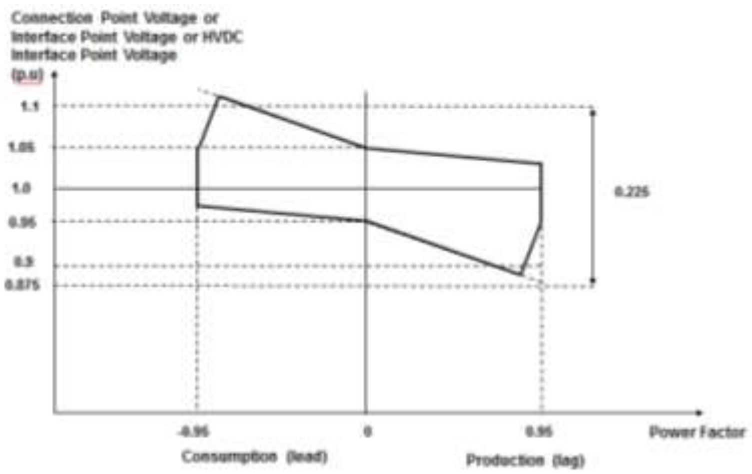

Figure X2

ECC.6.3.2.6.3 All **Onshore** **Type C** or **Type D Power Park Modules** or **HVDC Converters** at a **HVDC Converter Station** with a **Grid Entry Point** or **User System Entry Point** voltage at or below 33kV or **Remote End HVDC Converter Station** with an **HVDC Interface Point Voltage** at or below 33kV shall be capable of satisfying the **Reactive Power** capability requirements at the **Grid Entry Point** or **User System Entry Point** as defined in Figure X3 when operating at **Maximum Capacity**. ~~).~~ In the case **of Remote End HVDC Converters** ~~and **DC Connected Power Park Modules**,~~ **NGET** in co-ordination with the **Relevant Transmission Licensee** may agree to alternative reactive capability requirements to those specified in Figure X3, where it is demonstrated that it is uneconomic and inefficient to do so, for example in the case of new technologies or advanced control strategies. For the avoidance of doubt, the requirements for **Offshore Power Park Modules** and **DC Connected Power Park Modules** are defined in ECC.6.3.2.7 and ECC.6.3.2.8.

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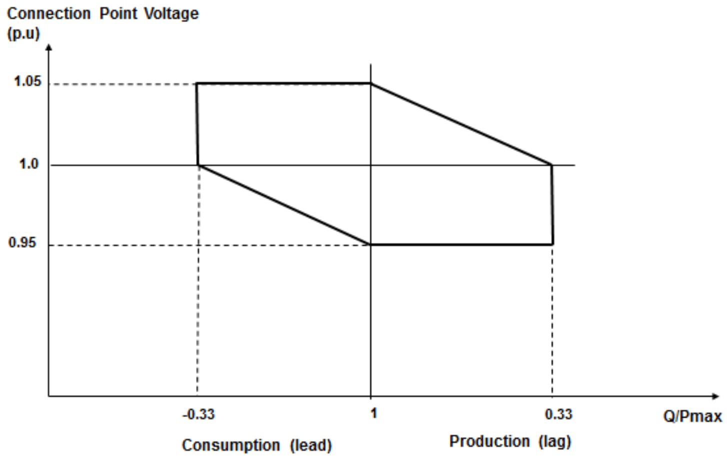

Figure X3

ECC.6.3.2.6.4 All **Type C** and **Type D Power Park Modules**, **HVDC Converters** at a **HVDC Converter Station** including **Remote End HVDC Converters** or **OTSDUW Plant and Apparatus**, shall be capable of satisfying the **Reactive Power** capability requirements at the **Grid Entry Point** or **User System Entry Point** (or **Interface Point Capacity** in the case of **OTSUW Plant and Apparatus** or **HVDC Interface Point** in the case of **Remote End HVDC Converter Stations**) as defined in Figure X4 when operating below **Maximum Capacity**. With all **Plant** in service, the **Reactive Power** limits will reduce linearly below 50% **Active Power** output as shown in Figure X4 unless the requirement to maintain the **Reactive Power** limits defined at **Maximum Capacity** (or **Interface Point Capacity** in the case of **OTSDUW Plant and Apparatus**) under absorbing **Reactive Power** conditions down to 20% **Active Power** output has been specified by **NGET**. These **Reactive Power** limits will be reduced pro rata to the amount of **Plant** in service. – In the case **of Remote End HVDC Converters** ~~and **DC Connected Power Park Modules**,~~ **NGET** in co-ordination with the **Relevant Transmission Licensee** may agree to alternative reactive capability requirements to those specified in Figure X2, where it is demonstrated that it is uneconomic and inefficient to do so, for example in the case of new technologies or advanced control strategies. For the avoidance of doubt, the requirements for **Offshore Power Park Modules** and **DC Connected Power Park Modules** are defined in ECC.6.3.2.7 and ECC.6.3.2.8.

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Comment [A5]: Based on meeting on the 10/11th August the reference to Bilateral Agreement has been removed. This is however a direct lift from the current Grid Code and represents no change from the current GB drafting requirements.

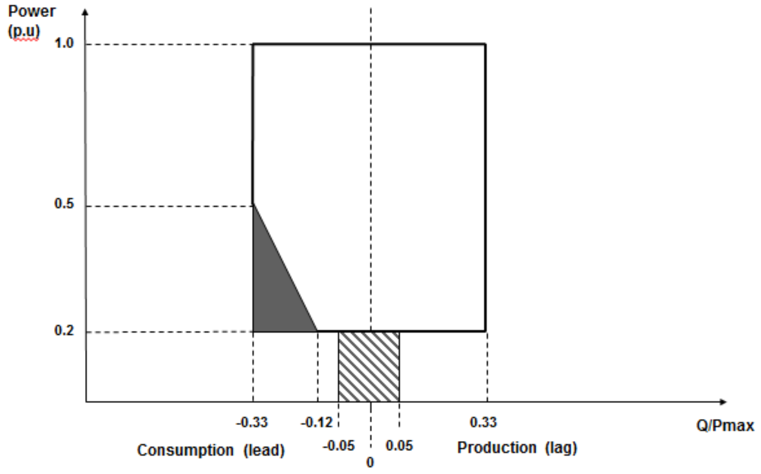

Figure X4

ECC.6.3.2.7 Reactive Capability for **Offshore Synchronous Power Generating Modules, Configuration 1 AC connected Offshore Power Park Modules** and **Configuration 1~~2~~ DC Connected Power Park Modules.**

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ECC.6.3.2.7.1 The short circuit ratio of any **Offshore Synchronous Generating Units** within a **Synchronous Power Generating Module** shall not be less than 0.5. All **Offshore Synchronous Generating Units, Configuration 1 AC connected Offshore Power Park Modules** or **Configuration 1~~2~~ DC Connected Power Park Modules** must be capable of maintaining zero transfer of **Reactive Power** at the **Offshore Grid Entry Point** . The steady state tolerance on **Reactive Power** transfer to and from an **Offshore Transmission System** expressed in **MVAr** shall be no greater than 5% of the **Maximum Capacity**.

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ECC.6.3.2.7.2 For the avoidance of doubt if a **Generator** (including those in respect of **DC Connected Power Park Modules**) wishes to provide a **Reactive Power** capability in excess of the minimum requirements defined in ECC.6.3.2.7.1 then such capability (including steady state tolerance) shall be agreed ~~it could consider the use of a commercial agreement~~ between the **Generator**, **Offshore Transmission Licensee** and **NGET** and/or the relevant **Network Operator.**

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ECC.6.3.2.8 Reactive Capability for **Configuration 2 AC connected Offshore Power Park Modules** and **Configuration 2 DC Connected Power Park Modules**.

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ECC.6.3.2.8.1 All **Configuration 2 AC connected Offshore Power Park Modules** and **Configuration 2 DC Connected Power Park Modules** shall be capable of satisfying the minimum **Reactive Power** capability requirements at the **Offshore Grid Entry Point** as defined in Figure X5 when operating at **Maximum Capacity. NGET** in co-ordination with the **Relevant Transmission Licensee** may agree to alternative reactive capability requirements to those specified in Figure X5, where it is demonstrated that it is uneconomic and inefficient to do so, for example in the case of new technologies or advanced control strategies.

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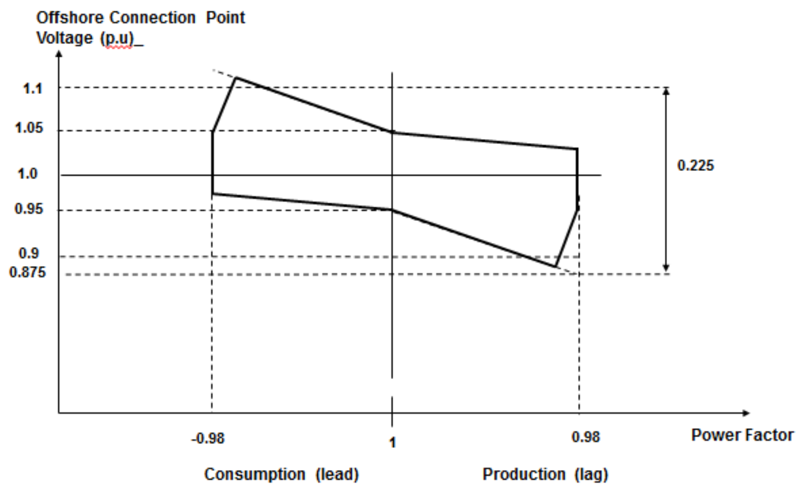

Figure X5

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ECC.6.3.2.8.2 All **AC Connected Configuration 2 Offshore Power Park Modules** and **Configuration 2 DC Connected Power Park Modules** ~~(where the **HVDC Converter System** or **Transmission DC Converter** is connected to one or more **Onshore** substations)~~ shall be capable of satisfying the **Reactive Power** capability requirements at the **Offshore Grid Entry Point** as defined in Figure X6 when operating below **Maximum Capacity**. With all **Plant** in service, the **Reactive Power** limits will reduce linearly below 50% **Active Power** output as shown in Figure X6 unless the requirement to maintain the **Reactive Power** limits defined at **Maximum Capacity** (or **Interface Point Capacity** in the case of **OTSDUW Plant and Apparatus**) under absorbing **Reactive Power** conditions down to 20% **Active Power** output has been specified with **NGET**. These **Reactive Power** limits will be reduced pro rata to the amount of **Plant** in service. **NGET** in co-ordination with the **Relevant Transmission Licensee** may agree to alternative reactive capability requirements to those specified in Figure X5, where it is demonstrated that it is uneconomic and inefficient to do so, for example in the case of new technologies or advanced control strategies.

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Comment [A6]: This has been deleted as it will be picked up aspart of the definitions.

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Comment [A7]: This requires further assessment and discussion - we also need to discuss if the need to mandate unity power factor control as a minimum is required

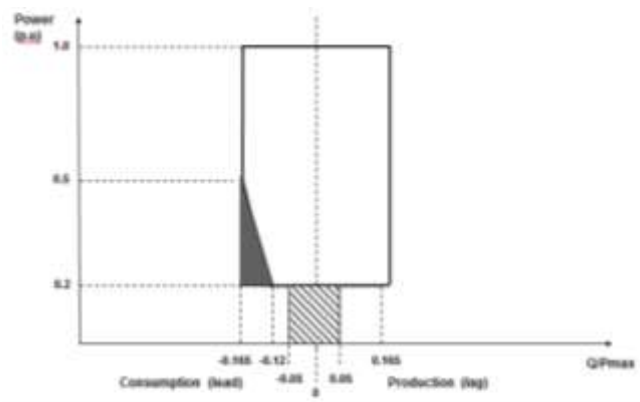

Figure X6

ECC.6.3.2.8.3 For the avoidance of doubt if a **Generator** (including **Generators** in respect of **DC Connected Power Park Modules** referred to in ECC.6.3.2.8.2) wishes to provide a **Reactive Power** capability in excess of the minimum requirements defined in ECC.6.3.2.8.1 then such capability (including any steady state tolerance) shall be agreed ~~it could consider the use of a commercial agreement~~ between the **Generator**, **Offshore Transmission Licensee** and **NGET** and/or the relevant **Network Operator**

ECC.6.3.3 OUTPUT POWER WITH FALLING FREQUENCY

ECC.6.3.3.1 Output power with falling frequency for **Power Generating Modules** and **HVDC Equipment**

CC.6.3.3.1.1 Each **Power Generating Module** and **HVDC Equipment** must be capable of:

(a) continuously maintaining constant **Active Power** output for **System Frequency** changes within the range 50.5 to 49.5 Hz; and

(b) (subject to the provisions of ECC.6.1.2) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure X2 for **System Frequency** changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including 25°C, such that if the **System Frequency** drops to 47 Hz the **Active Power** output does not decrease by more than 5%. In the case of a **CCGT Module**, the above requirement shall be retained down to the **Low Frequency Relay** trip setting of 48.8 Hz, which reflects the first stage of the Automatic Low **Frequency Demand Disconnection** scheme notified to **Network Operators** under ~~E~~OC6.6.2. For **System Frequency** below that setting, the existing requirement shall be retained for a minimum period of 5 minutes while **System Frequency** remains below that setting, and special measure(s) that may be required to meet this requirement shall be kept in service during this period. After that 5 minutes period, if **System Frequency** remains below that setting, the special measure(s) must be discontinued if there is a materially increased risk of the **Gas Turbine** tripping. The need for special measure(s) is linked to the inherent **Gas Turbine Active Power** output reduction caused by reduced shaft speed due to falling **System Frequency**. Where the need for special measures is identified in order to maintain output in line with the level identified in Figure X2 these measures should be still continued at ambient temperatures above 25°C maintaining as much of the **Active Power** achievable within the capability of the plant.

~~Figure X2~~

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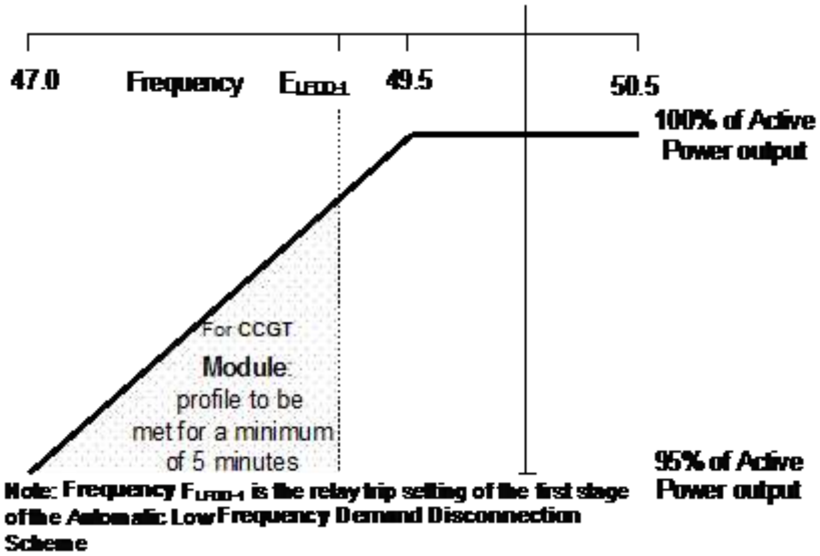

Figure X2

(c) For the avoidance of doubt, in the case of a **Power Generating Module** including a **DC Connected Power Park Module** ~~**Generating Unit** or **Power Park Module** (or **OTSDUW DC Converters** at the **Interface Point**)~~ using an **Intermittent Power Source** where the mechanical power input will not be constant over time, the requirement is that the **Active Power** output shall be independent of **System Frequency** under (a) above and should not drop with **System Frequency** by greater than the amount specified in (b) above.

(d) An **HVDC System**~~and a **Remote End HVDC Converter**~~ must be capable of maintaining its **Active Power** input (i.e. when operating in a mode analogous to **Demand**) from the **National Electricity Transmission System** (or **User System** in the case of an **Embedded HVDC System**) at a level not greater than the figure determined by the linear relationship shown in Figure 3 for **System Frequency** changes within the range 49.5 to 47 Hz, such that if the **System Frequency** drops to 47.8 Hz the **Active Power** input decreases by more than 60%.

(d) In the case of an **Offshore Generating Unit** or **Offshore Power Park Module** or **DC Connected Power Park Module** or **Remote End HVDC Converter** or **Transmission DC Converter** ~~*(legal check does this includes OTSDUW DC Converter?)* **Offshore DC Converter** and **OTSDUW DC Converter**~~, the **Generator** shall comply with the requirements of ECC.6.3.3. **Generators** should be aware that Section K of the **STC** places requirements on **Offshore Transmission Licensees** which utilise a **Transmission DC Converter** as part of their **Offshore Transmission System** to make appropriate provisions to enable **Generators** to fulfil their obligations.

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(f) ~~In the case of a~~ **Transmission DC Converters** and **Remote End HVDC Converters** ~~**OTSDUW**~~ the ~~**OTSDUW Plant and Apparatus**~~ shall provide a continuous signal indicating the real time frequency measured at the **Interface Point** to the **Offshore Grid Entry Point** or **HVDC Interface Point** for the purpose of **Offshore Generators** or **DC Connected Power Park Modules** to respond to changes in **System Frequency** on the Main Interconnected **Transmission System**. A **DC Connected Power Park Module** or **Offshore Power Generating Module** shall be capable of receiving and processing this signal within 100ms.

ECC.6.3.4 ACTIVE POWER OUTPUT UNDER SYSTEM VOLTAGE VARIATIONS

ECC.6.3.4.1 At the **Grid Entry Point** or **User System Entry Point** , the **Active Power** output under steady state conditions of any **Power Generating Module** or **HVDC Equipment** directly connected to the **National Electricity Transmission System** or in the case of **OTSDUW**, the **Active Power** transfer at the **Interface Point**, under steady state conditions of any **OTSDUW Plant and Apparatus** should not be affected by voltage changes in the normal operating range specified in paragraph ECC.6.1.4 by more than the change in **Active Power** losses at reduced or increased voltage.

ECC.6.3.5 BLACK START

ECC.6.3.5.1 **Black Start** is not a mandatory requirement, however **Users** may wish to notify **NGET** of their ability to provide a **Black Start** facility and the cost of the service. **NGET** will then consider whether it wishes to contract with the **User** for the provision of a **Black Start** service which would be specified via a **Black Start Contract**. Where a **User** does not offer to provide a cost for the provision of a **Black Start Capability**, **NGET** may make such a request if it considers **System** security to be at risk due to a lack of **Black Start** capability.

ECC.6.3.5.2 It is an essential requirement that the **National Electricity Transmission System** must incorporate a **Black Start Capability**. This will be achieved by agreeing a **Black Start Capability** at a number of strategically located **Power Stations** and **HVDC Systems**. For each **Power Station** or **HVDC System** **NGET** will state in the **Bilateral Agreement** whether or not a **Black Start Capability** is required.

ECC.6.3.5.3 Where a **User** has entered into a **Black Start Contract** to provide a **Black Start Capability** in respect of a **Type C** and **Type D Power Generating Module** including **DC Connected Power Park Modules** the following requirements shall apply.

(i) The **Power-Generating Module** or **DC Connected Power Park Module** shall be capable of starting from shutdown without any external electrical energy supply within a time frame specified by **NGET** in the **Black Start Contract**.

(ii) Each **Power Generating Module** or **DC Connected Power Park Module** shall be able to synchronise within the frequency limits defined in ECC.6.1.2 ~~laid down in point (a) of Article 13(1)~~ and, where applicable, voltage limits specified ~~by the relevant system operator or in Article 16(2)~~ in ECC.6.1.4;

(iii) The **Power Generating Module** or **DC Connected Power Park Module** shall be capable of connecting on to an unenergised **System**.

(iv) The **Power-Generating Module** or **DC Connected Power Park Module** shall be capable of automatically regulating dips in voltage caused by connection of demand;

(v) The **Power Generating Module** or **DC Connected Power Park Module** shall:

be capable of **Block Load Capability**,

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Comment [A8]: Need to check with the Black Start team the specification of times between each incramental step and where this information is provided.

be capable of operating in **LFSM-O** and **LFSM-U**, as specified in ECC.6.3.7.1 and ECC.6.3.7.2~~point (c) of paragraph 2 and Article 13(2), XXXX.(subnote – include ECC refs to LFSM-O and LFSM-U).~~

control **Frequency** in case of overfrequency and underfrequency within the whole **Active Power** output range between the **Minimum Regulating Level** and **Maximum Capacity** as well as at hHouseload oOperation levels~~,~~

be capable of parallel operation of a few **Power Generating Modules** including **DC Connected Power Park Modules** within an isolated part of the **Total System** that is still supplying **Customers** , and control voltage automatically during the system restoration phase;

ECC.6.3.5.4 Each **HVDC System** or **Remote End HVDC Converter Station** and has a **Black Start Capability** shall be capable of energising the busbar of an AC substation to which another **DC Converter Station** is connected. The timeframe after shutdown of the **HVDC System** prior to energisation of the AC substation shall be pursuant to the terms of the **Black Start Contract**. The **HVDC System** shall be able to synchronise within the **Frequency** limits defined in ECC.6.1.2.1.2 and voltage limits defined in ECC.6.1.4.1 unless otherwise specified in the **Black Start Contract**. Wider **Frequency** and voltage ranges can be specified in the **Black Start Contract** in order to restore **System** security. *(Art 37(3) – Not reflected as these elements should be covered by the Black Start Contract)*

ECC.6.3.5.4 With regard to the capability to take part in operation of an isolated part of the **Total System** that is still supplying **Customers**:

(i) **Power Generating Modules** including **DC Connected Power Park Modules** shall be capable of taking part in island operation if specified in the **Black Start Contract** required by **NGET** and:

the **Frequency** limits for island operation shall be those specified in ECC.6.1.2 ~~established in accordance with point (a) of Article 13(1),~~

the voltage limits for island operation shall be those defined in ECC.6.1.4 *(Need to ensure consistency with Art 15(3)* ~~established in accordance with Article 15(3) or Article 16(2), where applicable~~;

~~(ii)~~ **Power Generating Modules** including **DC Connected Power Park Modules** shall be able to operate in **Frequency Sensitive Mode** during island operation, as specified in ECC.6.3.7.3X~~point (d) of paragraph 2~~. In the event of a power surplus, **Power Generating Modules** including **DC Connected Power Park Modules** shall be capable of reducing the **Active Power** output from a previous operating point to any new operating point within the **Generator Performance Chart** ~~P-Q Capability Diagram~~. ~~In that regard, the~~ **Power Generating Modules** including **DC Connected Power Park Modules** shall be capable of reducing **Active Power** output as much as inherently technically feasible, but to at least 55 % of ~~its~~ **Maximum Capacity**~~;~~

The method for detecting a change from interconnected system operation to island operation shall be agreed between the **Generator** ~~power generating facility owner~~ **NGET** and the **Relevant Transmission Licensee**. ~~the relevant system operator in coordination with the relevant TSO~~. The agreed method of detection must not rely solely on **NGET, Relevant Transmission Licensee's** or **Network Operators** ~~system operator's~~ switchgear position signals;

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Comment [A9]: Unbold in susequent sections of code or consider this in wider context -. Defined as a new term copied from RfG - discuss with Legal

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(iv) **Power Generating Modules** including **DC Connected Power Park Modules** shall be able to operate in **LFSM-O** and **LFSM-U** during island operation, as specified in ECC.6.3.7.1X point (c) of paragraph 2 and ECC.6.3.7.2X.X.Article 13(2);

ECC.6.3.5.5 With regard to quick re-synchronisation capability:

(iii) In case of disconnection of the **Power Generating Module** including **DC Connected Power Park Modules** from the **System**, the **Power Generating Module** shall be capable of quick re-synchronisation in line with the **Protection** strategy agreed between **NGET** and/or **Network Operator** in co-ordination with the **Relevant Transmission Licensee**.the relevant system operator in coordination with the relevant TSO and the **Generator** power generating facility;

(iv) A **Power Generating Module** including a **DC Connected Power Park Module** with a minimum re-synchronisation time greater than 15 minutes after its disconnection from any external power supply must be capable of **Houseload Operation** from any operating point on in its **P-Q Capability Diagram** **Generator Performance Chart**. In this case, the identification of **Houseload Operation** must not be based solely on the **System's**the switchgear position signals;

(v) **Power Generating Modules** including **DC Connected Power Park Modules** shall be capable of **Houseload Operation**, irrespective of any auxiliary connection to the **System** external network. The minimum operation time shall be specified by **NGET** the relevant system operator in coordination with the relevant TSO, taking into consideration the specific characteristics of prime mover technology.

CONTROL ARRANGEMENTS

ECC.6.3.6.1 **ACTIVE POWER CONTROL**

ECC.6.3.6.1.2 **Active Power** control in respect of **Power Park Modules** including **DC Connected Power Park Modules**

ECC.6.3.6.1.2.1 **Type A Power Generating Modules** shall be equipped with a logic interface (input port) in order to cease **Active Power** output within five seconds following an instruction being received at the input port. . **NGET** may specify any additional requirements (including remote operation)

ECC.6.3.6.1.2.2 **Type B Power Generating Modules** shall be equipped with an interface (input port) in order to be able to reduce **Active Power** output following an instruction at the input port. **NGET** may specify any additional requirements (including remote operation).

ECC.6.3.6.1.2.3 **Type C** and **Type D Power Generating Modules** and **DC Connected Power Park Modules** shall be capable of adjusting the **Active Power** setpoint in accordance with instructions issued by **NGET**. -. In the event the load controller or related control system is out of service, manual local measures may be permitted. In such cases **NGET** shall notify **The Authority** of the time required to reach any new **Active Power** setpoint together with the tolerance for the **Active Power**.

ECC.6.3.6.1.3 **Active Power** control in respect of **HVDC Systems** and **Remote End HVDC Converter Stations**

ECC.6.3.6.1.3.1 NGET shall specify the maximum delay within which the **HVDC Systems** and **Remote End HVDC Converter Station** shall be capable of adjusting the transmitted **Active Power** upon receipt of an instruction from **NGET** which shall be in accordance with the requirements of BC2.6.1request from NGET.

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Comment [A10]: Note:- Active Power Control as referenced in GC0101 as ECC.6.3.X has been added into the control arrangments section of the drafting. This is a slight departure from GC0101 but purley for formatting and numbering / nomenclature purposes.

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Comment [A11]: An addtional specification is likely to be required here for both Type A and Type B for example what form does the signal take and is it digital or analogue.

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Comment [A12]: Not sure this is required - I am not sure we would permit this and even then notifying Ofgem of the parameters for each new load point would be a challenging task in itself. Suggest it is deleted but needs to be reflected in the mapping table.

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ECC.6.3.6.1.3.2 The requirements for fast **Active Power** reversal (if required) shall be specified by **NGET**. Where **Active Power** reversal is specified, each **HVDC System** and **Remote End HVDC Converter Station** shall be capable of operating from maximum import to maximum export in a time no greater than 2 seconds except where a HVDC **Converter Station Owner** has justified to **NGET** that a longer reversal time is required.

ECC.6.3.6.1.3.3 Where an **HVDC System** connects various **Control Areas** or **Synchronous Areas**, each **HVDC System** – or **Remote End HVDC Converter Station** shall be capable of responding to instructions issued by **NGET** under the **Balancing Code** to modify the transmitted **Active Power** for the purposes of cross-border balancing. *(Note Article 13(2) and 13(3) get picked up as part of the OC's and BC's)*

ECC.6.3.6.1.3.4 An **HVDC System** shall be capable of adjusting the ramping rate of **Active Power** variations within its technical capabilities in accordance with instructions issued ~~sent~~ by **NGET** ~~relevant TSOs~~. In case of modification of **Active Power** according to ECC.6.3.15 and ECC.6.3.6.1.3.2 ~~points (b) and (c) of paragraph 1~~, there shall be no adjustment of ramping rate.

ECC.6.3.6.1.3.5 If specified by **NGET** ~~a relevant TSO~~, in coordination with the **Relevant Tansmission Licensees** ~~adjacent TSOs~~, the control functions of an **HVDC System** shall be capable of taking automatic remedial actions including, but not limited to, stopping the ramping and blocking FSM, LFSM-O, LFSM-U and **Frequency** control. The triggering and blocking criteria shall be specified by **NGET** ~~relevant TSO and subject to notification to the regulatory authority. The modalities of that notification shall be determined in accordance with the applicable national regulatory framework.~~

ECC.6.3.6.2 MODULATION OF ACTIVE ~~AND REACTIVE~~ POWER

ECC.6.3.6.2.1 Each **Power Generating Module** (including **DC Connected Power Park Modules**) and **Onshore HVDC Converters** at an **Onshore HVDC Converter Station** ~~**Equipment**~~ must be capable of contributing to **Frequency** control by continuous modulation of **Active Power** supplied to the **National Electricity Transmission System**. For the avoidance of doubt each **Onshore HVDC Converter** at an **Onshore HVDC Converter Station** ~~**System**~~ and/or **OTSDUW DC Converter** shall provide each **User** in respect of its **Offshore Power Stations** connected to and/or using an **Offshore Transmission System** a continuous signal indicating the real time **Frequency** measured at the **Transmission Interface Point**. A **DC Connected Power Park Module** or **Offshore Power Generating Module** shall be capable of receiving and processing this signal within 100ms.

ECC.6.3.6.3 MODULATION OF ~~ACTIVE AND~~ REACTIVE POWER

ECC.6.3.6.3.1 Notwithstanding the requirements of ECC.6.3.2, e~~E~~ach **Power Generating Module or HVDC Equipment** (and **OTSDUW Plant and Apparatus** at a **Transmission Interface Point** and **Remote End HVDC Converter** at an **HVDC Interface Point**) (as applicable) must be capable of contributing to voltage control by continuous changes to the **Reactive Power** supplied to the **National Electricity Transmission System** or the **User System** in which it is **Embedded**.

ECC.6.3.7 FREQUENCY RESPONSE

ECC.6.3.7.1 **Limited Frequency Sensitive Mode – Overfrequency (LFSM-O)**

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Comment [A13]: Need to refer to the Bilateral Agreement in this case

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Comment [A14]: Additional text included over an above that from GC0101.

Comment [A15]: This requires further discussion with the Workgroup and can it be removed.

Comment [A16]: This section has been updated from GC0101 to inlclude Active Power Control from RfG.

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Comment [A17]: This wording has been changed - the inference is that if CC.6.3.2 does not require a reactive capability range then this requirement is not applicable. The current Grid Code is more precise so consideration could be given to splitting this out into two discrete sections.

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ECC.6.3.7.1.1 Each **Power Generating Module** (including **DC Connected Power Park Modules**) and **HVDC** **Systems**~~**Equipment**~~ shall be capable of reducing **Active Power** output in response to ~~**System**~~ **Frequency** on the **Total System** when this rises above 50.4Hz. For the avoidance of doubt, the provision of this reduction in **Active Power** output is not an **Ancillary Service**. Such provision is known as **Limited High Frequency Response**. The **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC** **Systems** ~~**Equipment**~~ shall be capable of operating stably during **LFSM-O** operation. However for a **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC** **Systems**~~**Equipment**~~ operating in **Frequency Sensitive Mode** the requirements of LFSM-O shall apply when the frequency exceeds 50.5Hz.

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ECC.6.3.7.1.2 (i) The rate of change of **Active Power** output must be at a minimum a rate of 2 percent of output per 0.1 Hz deviation of **System Frequency** above 50.4Hz (ie a **Droop** of 10%) as shown in Figure X1 below. For the avoidance of doubt, this would not preclude a **Generator** or **HVDC System Owner** from designing their **Power Generating Module** with a lower **Droop** setting, for example between 3 – 5%.

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(ii) The reduction in **Active Power** output must be continuously and linearly proportional, as far as is practicable, to the excess of **Frequency** above 50.4 Hz and must be provided increasingly with time over the period specified in (iii) below.

(iii) As much as possible of the proportional reduction in **Active Power** output must result from the frequency control device (or speed governor) action and must be achieved within 10 seconds of the time of the **Frequency** increase above 50.4 Hz. The **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC** **Systems**~~**Equipment**~~ shall be capable of initiating a power **Frequency** response with an initial delay that is as short as possible. If the delay exceeds 2 seconds the **Generator** or **HVDC** ~~**Converter Station**~~**System** **Owner** shall justify the delay, providing technical evidence to **NGET**.

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(vi) The residue of the proportional reduction in **Active Power** output which results from automatic action of the **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC** **System**~~**Equipment**~~ output control devices other than the frequency control devices (or speed governors) must be achieved within 3 minutes for the time of the **Frequency** increase above 50.4Hz.

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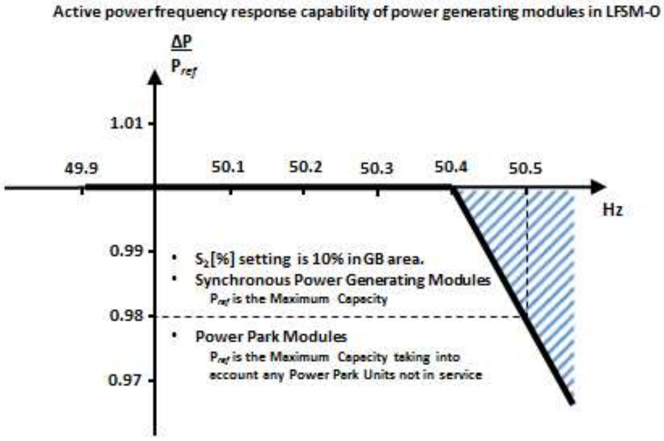

Comment [A18]: Update or duplicate diagram to include DC Converters, DC Connected Power Park Modules and Remote End DC Converters

Figure X1 – P_{ref} is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems**~~**Equipment**~~. Fn is the nominal frequency (50Hz) in the network and Δf is the **Frequency** deviation in the network. At overfrequencies where Δf is below Δf_1 the **Power Generating Module** (including **DC Connected Power Park Modules** or **HVDC Systems**~~**Equipment**~~ has to provide a negative **Active Power** output change according to droop S_2 which shall be no greater than 10%.

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Comment [A19]: . Note Synchronous Plant is treated differently from Asynchronous Plant. We would not want this characterisitc as we would expect all plant to behave in the same way irrespective of its type - ie deload by 2% of output irrespective of its loading level. The diagram wiull be updated to include this.

ECC.6.3.7.1.3 Each **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems**~~**Equipment**~~ which is providing **Limited High Frequency Response (LFSM-O)** must continue to provide it until the **Frequency** has returned to or below 50.4Hz or until otherwise instructed by **NGET**. **Generators** in respect of **Gensets** and **HVDC Converter Station Owners** in respect of an **HVDC System** should also be aware of the requirements in BC.3.7.2.

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~~ECC.6.3.7.1.4~~

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Comment [A20]: This section was removed following the legal review back in August.

ECC.6.3.7.1.5 Steady state operation below the **Minimum Stable Operating Level** ~~**Generation**~~ in the case of **Power Generating Modules** including **DC Connected Power Park Modules** or minimum **Active Power** transfer capability in the case of **HVDC Systems** is not expected but if **System** operating conditions cause operation below the **Minimum Stable Operating Level** ~~**Generation**~~ or minimum **Active Power** transfer capability which give rise to operational difficulties for the **Power Generating Module** including a **DC Connected Power Park Module** or **HVDC Systems** then the **Generator** or **DC Converter Station Owner** shall be able to return the output of the **Power Generating Module** including a **DC Connected Power Park Module** to an output of not less than the **Minimum Stable Operating Level** ~~**Generation**~~ or **HVDC System** to an output of not less than the minimum transfer capability.

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ECC.6.3.7.1.6 All reasonable efforts should in the event be made by the **Generator** or **DC Converter Station Owner** to avoid such tripping provided that the **System Frequency** is below 52Hz in accordance with the requirements of ECC.6.1.3. If the **System Frequency** is at or above 52Hz, the requirement to make all reasonable efforts to avoid tripping does not apply and the **Generator** or **HVDC System**~~**Converter Station**~~ **Owner** is required to take action to protect its **Power Generating Modules** including **DC Connected Power Park Modules** or HV**DC Converter Stations** ~~as specified in ECC.6.3.13.~~

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ECC.6.3.7.2 **Limited Frequency Sensitive Mode – Underfrequency (LFSM-U)**

ECC.6.3.7.2.1 Each **Type C** and **Type D Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC** ~~SystemsEquipment~~ operating in **Limited Frequency Sensitive Mode** shall be capable of increasing **Active Power** output in response to **System Frequency** when this falls below 49.5Hz. For the avoidance of doubt, the provision of this increase in **Active Power** output is not a mandatory **Ancillary Service** and it is not anticipated **Power Generating Modules** (including **DC Connected Power Park Modules**) or **HVDC** ~~SystemsEquipment~~ are operated in an inefficient mode to facilitate delivery of **LFSM-U** response, but any inherent capability should be made available without undue delay. The **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC** ~~SystemsEquipment~~ shall be capable of stable operation during **LFSM-U Mode**.

ECC.6.3.7.2.2 (i) The rate of change of **Active Power** output must be at a minimum a rate of 2 percent of output per 0.1 Hz deviation of **System Frequency** below 49.5Hz (ie a **Droop** of 10%) as shown in Figure X2 below. This requirement only applies if the **Power Generating Module** has headroom and the ability to increase **Active Power** output. In the case of a **Power Park Module** or **DC Connected Power Park Module** the requirements of Figure X2 shall be reduced pro-rata to the amount of **Power Park Units** in service and available to generate. For the avoidance of doubt, this would not preclude a **Generator** or **HVDC System Owner** from designing their **Power Generating Module** with a lower **Droop** setting, for example between 3 – 5%.

(ii) As much as possible of the proportional increase in **Active Power** output must result from the **Frequency** control device (or speed governor) action and must be achieved for **Frequencies** below 49.5 Hz. The **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC** ~~SystemsEquipment~~ shall be capable of initiating a power **Frequency** response with minimal delay. If the delay exceeds 2 seconds the **Generator** or **DC Converter Station Owner** shall justify the delay, providing technical evidence to **NGET**).

(iii) The actual delivery of **Active Power Frequency Response** in **LFSM-U** mode shall take into account

The ambient conditions when the response is to be triggered

The operating conditions of the **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC** ~~SystemsEquipment~~ in particular limitations on operation near **Maximum Capacity** or maximum transfer capacity at low frequencies and the respective impact of ambient conditions as detailed in ECC.6.3.3.

The availability of primary energy sources.

(iv) In **LFSM_U Mode** the **Power Generating Module** (including **DC Connected Power Park Modules**) and **HVDC Systems**, ~~**DC Converter at a DC Converter Station, DC Connected Power Park Module or Remote End DC Converter**~~ shall be capable of providing a power increase up to its **Registered** ~~**Maximum**~~ **Capacity**.

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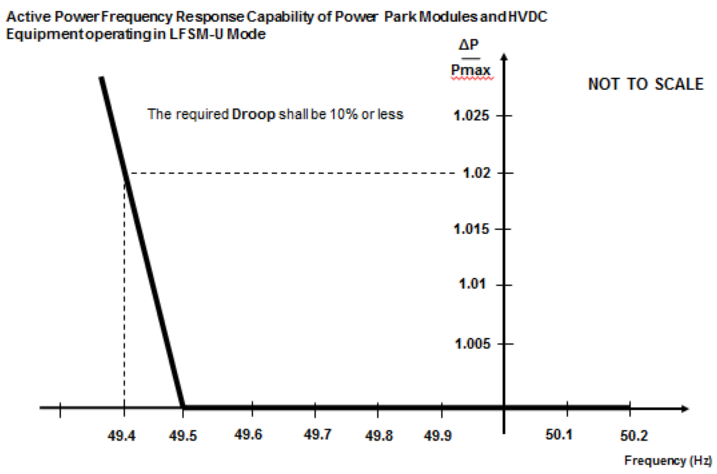

Figure X2 –Limited Frequency Sensitive Mode – Underfrequency capability of Power Generating Modules (including DC Connected Power Park Modules) and HVDC SystemsEquipment.

ECC.6.3.7.3 **Frequency Sensitive Mode – (FSM)**

ECC.6.3.7.3.1 In addition to the requirements of ECC.6.3.7.1 and ECC.6.3.7.2 each **Type C** and **Type D Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC SystemsEquipment** must be fitted with a fast acting proportional **Frequency** control device (or turbine speed governor) and unit load controller or equivalent control device to provide **Frequency** response under normal operational conditions in accordance with **Balancing Code 3** (**BC3**). In the case of a **Power Park Module** including a **DC Connected Power Park Module**, the **Frequency** or speed control device(s) may be on the **Power Park Module** (including a **DC Connected Power Park Module**) or on each individual **Power Park Unit** (including a **Power Park Unit** within a **DC Connected Power Park Module**) or be a combination of both. The **Frequency** control device(s) (or speed governor(s)) must be designed and operated to the appropriate:

(i) **European Specification**: or

(ii) in the absence of a relevant **European Specification**, such other standard which is in common use within the European Community (which may include a manufacturer specification);

as at the time when the installation of which it forms part was designed or (in the case of modification or alteration to the **Frequency** control device (or turbine speed governor)) when the modification or alteration was designed.

The **European Specification** or other standard utilised in accordance with sub paragraph ECC.6.3.7.3.1 (a) (ii) will be notified to **NGET** by the **Generator** or **HVDC Converter StationSystem Owner**:

(i) as part of the application for a **Bilateral Agreement**; or

(ii) as part of the application for a varied **Bilateral Agreement**; or

(iii) in the case of an Embedded Development, within 28 days of entry into the Embedded Development Agreement (or such later time as agreed with **NGET**) or

Comment [A22]: This diagram will need to be updated in respect of DC Converters
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Comment [A23]: Diagram updated to reflect GB interpretation. Droop set at 10% on maximum capacity which is the same for Power Park Modules and Synchronous Power Generating Modules - note this is capability on full output not based on loading level Will need to be raised as part of Stakeholder consultation
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(iv~~ii~~) as soon as possible prior to any modification or alteration to the **Frequency** control device (or governor); and

ECC.6.3.7.3.2 The **Frequency** control device (or speed governor) in co-ordination with other control devices must control each **Type C** and **Type D Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems~~Equipment~~ Active Power Output** or **Active Power** transfer capability with stability over the entire operating range of the **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems~~Equipment~~** ; and

ECC.6.3.7.3.3 **Type C** and **Type D Power Generating Modules** and **DC Connected Power Park Modules** shall also meet the following minimum requirements:

(i) capable of providing **Active Power Frequency** response in accordance with the performance characteristic shown in Figure X3 and parameters in Table X1.

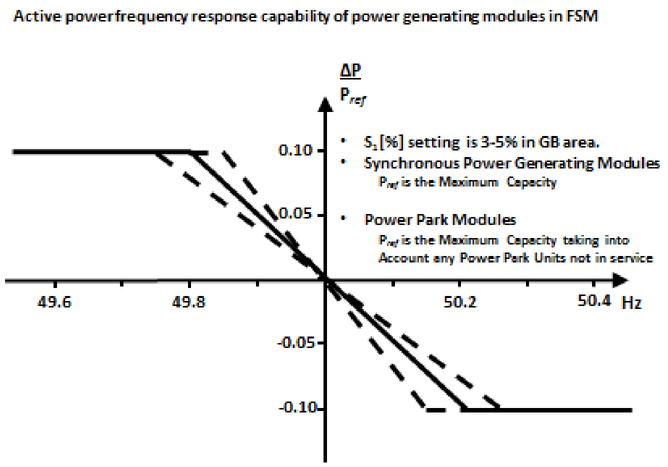

Figure X3 – **Frequency Sensitive Mode** capability of **Power Generating Modules** and **DC Connected Power Park Modules**

Parameter	Setting
Nominal **System Frequency**	50Hz
Active Power as a percentage of **Maximum Capacity** ($\frac{\|\Delta P_1\|}{P_{max}}$)	10%
Frequency Response Insensitivity in mHz ($\|\Delta f_i\|$)	±15mHz
Frequency Response Insensitivity as a percentage of nominal frequency ($\frac{\|\Delta f_i\|}{fn}$)	±0.03%
Frequency Response Deadband in mHz	0 (mHz)
Droop (%)	3 – 5%

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Comment [A24]: Diagram to be changed to remove the difference between Synchronous and Power Park Modules. - Capability is based on Maximum Capacity - further discussion required with Generator Compliance

Table X1 – Parameters for **Active Power Frequency** response in **Frequency Sensitve Mode** including the mathematical expressions in Figure X3.

(ii) In satisfying the performance requirements specified in ECC.6.3.7.3(i) **Generators** in respect of each **Type C** and **Type D Power Generating Modules and DC Connected Power Park Module** should be aware:-

in the case of overfrequency, the **Active Power Frequency** response is limited by the **Minimum Regulating Level**,

in the case of underfrequency, the **Active Power Frequency** response is limited by the **Maximum Capacity,**

the actual delivery of **Active Power** frequency response depends on the operating and ambient conditions of the **Power Generating Module** (including **DC Connected Power Park Modules**) when this response is triggered, in particular limitations on operation near **Maximum Capacity** at low **Frequencies** as specified in ECC.6.3.3 and available primary energy sources.

The frequency control device (or speed governor) must also be capable of being set so that it operates with an overall speed **Droop** of between 3 – 5%. The **Frequency Response Deadband** and **Droop** must be able to be reselected repeatedly. For the avoidance of doubt, in the case of a **Power Park Module** (including **DC Connected Power Park Modules**) the speed **Droop** should be equivalent of a fixed setting between 3% and 5% applied to each **Power Park Unit** in service.

(iii) In the event of a **Frequency** step change, each **Type C** and **Type D Power Generating Module** and **DC Connected Power Park Module** shall be capable of activating full and stable **Active Power Frequency** response (without undue power oscillations), in accordance with the performance characteristic shown in Figure X4 and parameters in Table X2.

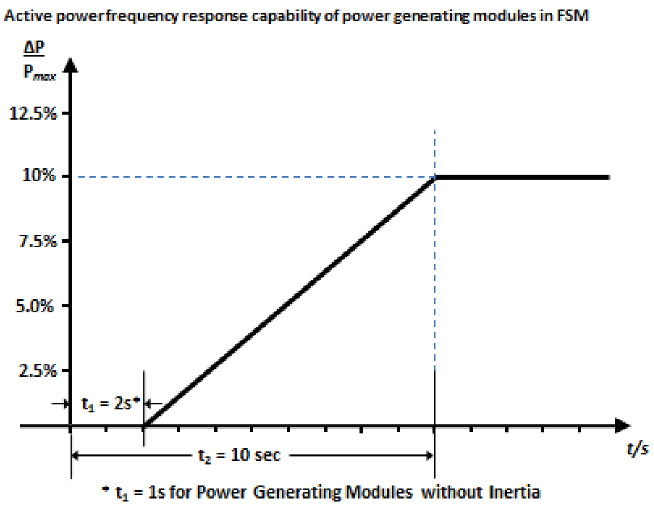

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Figure X4 **Active Power Frequency Response** capability. P_{max} is the **Maximum Capacity** to which ΔP relates. ΔP is the change in **Active Power** output from the **Power Generating Module** including **DC Connected Power Park Modules**. The **Power Generating Module** including **DC Connected Power Park Modules** has to provide **Active Power** output ΔP up to the point ΔP_1 in accordance with the times t_1 and t_2 with the values of ΔP_1, $t_1$and t_2 being specified in Table X2. t_1 is the initial delay. t_2 is the time for full activation.

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Comment [A25]: This could be simplified with just the parameters inserted and references to t1 and t2 removed.

Parameter	Setting
Active Power as a percentage of **Maximum Capacity (frequency response range)** ($\frac{\|\Delta P_1\|}{P_{max}}$)	10%
Maximum admissible initial delay t_1 for **Power Generating Modules** (including **DC Connected Power Park Modules**) with inertia unless justified as specified in ECC.6.3.7.3.3 (iv)	2 seconds
Maximum admissible initial delay t1 for **Power Generating Modules** (including **DC Connected Power Park Modules**) which do not contribute to **System** inertia unless justified as specified in ECC.6.3.7.3.3 (iv)	1 second
Activation time t2	10 seconds

Table X2 – Parameters for full activation of **Active Power Frequency** response resulting from a **Frequency** step change. Table X2 also includes the mathematical expressions used in Figure X4.

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(iv) The initial activation of **Active Power Primary Frequency** response ~~required~~ shall not be unduly delayed. For **Type C** and **Type D Power Generating Modules** (including **DC Connected Power Park Modules**) with inertia the delay in initial **Active Power Frequency** response shall not be greater than 2 seconds. For **Type C** and **Type D Power Generating Modules** (including **DC Connected Power Park Modules**) without inertia, the delay in initial **Active Power Frequency** response shall not be greater than 1 second. If the **Generator** cannot meet this requirement they shall provide technical evidence to **NGET** demonstrating why a longer time is needed for the initial activation of **Active Power Frequency** response.

(v) in the case of **Type C** and **Type D Power Generating Modules** (including **DC Connected Power Park Modules**) other than the **Steam Unit** within a **CCGT Module** the combined effect of the **Frequency Response Insensitivity** and **Frequency Response Deadband** of the **Frequency** control device (or speed governor) should be no greater than 0.03Hz (for the avoidance of doubt, ±0.015Hz). In the case of the **Steam Unit** within a **CCGT Module**, the **Frequency Response Deadband** should be set to an appropriate value consistent with the requirements of ECC.6.3.7(c)(i) and the requirements of BC3.7.2 for the provision of **LFSM-O** taking account of any **Frequency Response Insensitivity** of the Frequency control device (or speed governor);

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ECC.6.3.7.3.4 **HVDC Systems** ~~and Remote End HVDC Converter Stations~~ shall also meet the following minimum requirements:

(i) **HVDC Systems** ~~and Remote End HVDC Converter Stations~~ shall be capable of responding to **Frequency** deviations in each connected AC **System** by adjusting their **Active Power** import or export as shown in Figure X4 with the corresponding parameters in Table X2.

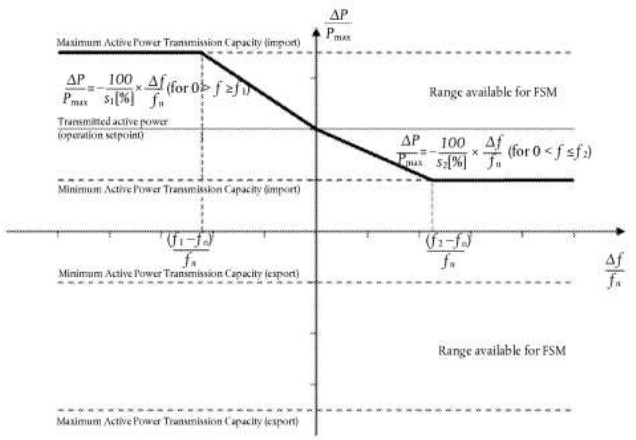

Figure X4 – **Active Power** frequency response capability of a **HVDC System** ~~or Remote End HVDC Converter Station~~ operating in **Frequency Sensitive Mode** (FSM) ~~illustrating the case of zero deadband and insensitivity with a positive active power setpoint (import mode)~~. ΔP is the change in active power output from the **HVDC System**. fn is the target frequency in the AC network where the FSM service is provided and Δf is the frequency deviation in the AC network where the FSM service is provided.

Parameter	Setting
Frequency Response Deadband	0
Droop S1 (upward regulation)	3 – 5%
Droop S2 (downward regulation)	3 – 5 %
Frequency Response Insensitivity	±15mHz

Table X2 – Parameters for **Active Power Frequency** response in **FSM** including the mathematical expressions in Figure X3.

(ii) Each **HVDC System** ~~and Remote End HVDC Converter Station~~ shall be capable of adjusting the **Droop** for both upward and downward regulation ~~the frequency response deadband~~ and the **Active Power** range over which **Frequency Sensitive Mode** of operation is available as defined in **ECC.6.3.7.3.4**.

(iii) In addition to the requirements in ECC.6.3.7.4(i) and ECC.6.3.7.4(ii) each **HVDC System** ~~and Remote End HVDC Converter Station~~ shall be capable of:-

delivering the response as soon as technically feasible

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delivering the response on or above the solid line in Figure X2 in accordance with the parameters shown in Table X3

initiating the delivery of **Primary Response** in no less than 0.5 seconds unless otherwise agreed with **NGET**. Where the initial delay time (t_1 – as shown in Figure X2) is longer than 0.5 seconds the **HVDC Converter Station Owner** shall reasonably justify it to **NGET**.

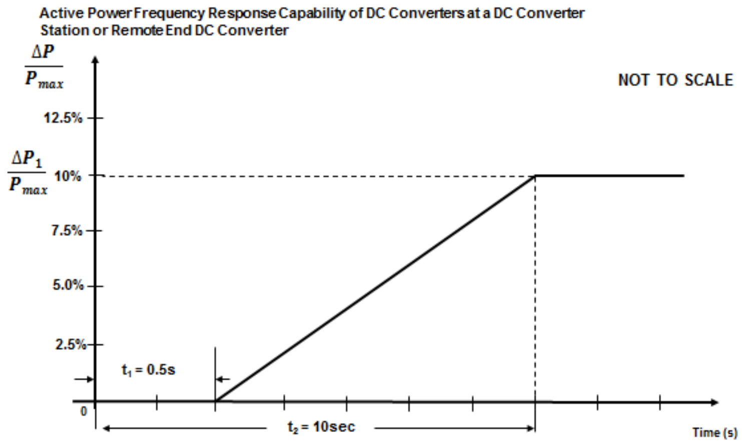

Figure X2 **Active Power Frequency Response** capability of a **HVDC System** ~~and Remote End HVDC Converter Station~~. ΔP is the change in **Active Power** triggered by the step change in frequency

Parameter	Setting
Active Power as a percentage of **Maximum Capacity (frequency response range)** ($\frac{\lvert\Delta P_1\rvert}{P_{max}}$)	10%
Maximum admissible delay t_1	0.5 seconds
Maximum admissible time for full activation t_2, unless longer activation times are agreed with **NGET**	10 seconds

Table X3 – Parameters for full activation of **Active Power Frequency** response resulting from a **Frequency** step change.

(iv) For **HVDC Systems** connecting various **Synchronous Areas**, each **HVDC System** ~~and Remote End HVDC Converter Station~~ shall be capable of adjusting the full **Active Power Frequency Response** when operating in **Frequency Sensitive Mode** at any time and for a continuous time period. In addition, the **Active Power** controller of each **HVDC System** ~~or Remote End DC Converter Station~~ shall not have any adverse impact on the delivery of frequency response.

ECC.6.3.7.3.5 For **HVDC Systems** ~~and Remote End HVDC Converter Stations~~ and **Type C** and

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Type D Power Generating Modules (including **DC Connected Power Park Modules**), other than the **Steam Unit** within a **CCGT Module** the combined effect of the **Frequency Response Insensitivity** and **Frequency Response Deadband** of the **Frequency** control device (or speed governor) should be no greater than 0.03Hz (for the avoidance of doubt, ±0.015Hz). In the case of the **Steam Unit** within a **CCGT Module**, the **Frequency Response Deadband** should be set to an appropriate value consistent with the requirements of ECC.6.3.7(c)(i) and the requirements of BC3.7.2 for the provision of **LFSM-O** taking account of any **Frequency Response Insensitivity** of the Frequency control device (or speed governor);

(vi) With regard to disconnection due to underfrequency, **Generators** responsible for **Type C** and **Type D Power Generating Modules** (including **DC Connected Power Park Modules**) capable of acting as a load, including but not limited to **Pumped Storage** and tidal **Power Generating Modules**, **HVDC Systems** and **Remote End HVDC Converter Stations** ~~hydro pump-storage power-generating facilities~~, shall be capable of disconnecting their load in case of underfrequency which will be agreed with **NGET**. For the avoidance of doubt this requirement does not apply to station auxiliary supplies; **Generators** in respect of **Type C** and **Type D Pumped Storage Power Generating Modules** should also be aware of the requirements in OC.6.6.6.

(vii) Where a **Type C** or **Type D Power Generating Module**, **DC Connected Power Park Module** or~~,~~ **HVDC System** ~~or Remote End HVDC Converter Station~~ becomes isolated from the rest of the **Total System** but is still supplying **Customers**, the **Frequency** control device (or speed governor) must also be able to control **System Frequency** below 52Hz unless this causes the **Type C** or **Type D Power Generating Module** or **DC Connected Power Park Module** to operate below its **Minimum Regulating Level** when it is possible that it may, as detailed in BC 3.7.3, trip after a time. For the avoidance of doubt **Power Generating Modules** (including **DC Connected Power Park Modules**) and **HVDC Systems** ~~**Equipment**~~ are only required to operate within the **System Frequency** range 47 - 52 Hz as defined in ECC.6.1.2~~3~~ and for converter based technologies, the remaining island contains sufficient fault level for effective commutation;

(viii) Each **Type C** and **Type D Power Generating Module** and **HVDC Systems**~~**Equipment**~~ shall have the facility to modify the **Target Frequency** setting either continuously or in a maximum of 0.05Hz steps over at least the range 50 ±0.1Hz should be provided in the unit load controller or equivalent device.

ECC.6.3.7.3.6~~4~~ In addition to the requirements of ECC.6.3.7.3 each **Type C** and **Type D Power Generating Module** and **HVDC System**~~**Equipment**~~ shall be capable of meeting the minimum **Frequency** response requirement profile subject to and in accordance with the provisions of Appendix A3.

ECC.6.3.7.3.7~~5~~ For the avoidance of doubt, the requirements of Appendix A3 do not apply to **Type A** and **Type B Power Generating Modules**.

ECC.6.3.8 EXCITATION AND VOLTAGE CONTROL PERFORMANCE REQUIREMENTS

ECC.6.3.8.1 Excitation Performance Requirements for **Type B Synchronous Power Generating Modules**

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Comment [A28]: For DC Converters they are bi-directional so reference to HVDC Systems has been removed. Discussion point? Nedd to make sure these terms work equally well for DC Converters.

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ECC.6.3.8.1.1 Each **Synchronous Generating Unit** within a **Type B Synchronous Power Generating Module** shall be equipped with a permanent automatic excitation control system that shall have the capability to can provide constant terminal voltage at a selectable setpoint without instability over the entire operating range of the **Type B Synchronous Power Generating Module**.

ECC.6.3.8.1.2 In addition to the requirements of ECC.6.3.8.1.1, **NGET** or the relevant **Network Operator** will specify if the control system of the **Type B Synchronous Power Generating Module** shall contribute to voltage control or **Reactive Power** control or **Power Factor** control at the **Grid Entry Point** or **User System Entry Point** (or other defined busbar). The performance requirements of the control system including slopedroop (where applicable) shall be agreed between **NGET** and/or the relevant **Network Operator** and the **Generator**.

ECC.6.3.8.2 Voltage Control Requirements for **Type B Power Park Modules**

ECC.6.3.8.2.1 **NGET** or the relevant **Network Operator** will specify if the control system of the **Type B Power Park Module** shall contribute to voltage control or **Reactive Power** control or **Power Factor** control at the **Grid Entry Point** or **User System Entry Point** (or other defined busbar). The performance requirements of the control system including slope droop (where applicable) shall be agreed between **NGET** and/or the relevant **Network Operator** and the **Generator**.

ECC.6.3.8.3 Excitation Performance Requirements for **Type C** and **Type D Onshore Synchronous Power Generating Modules**

ECC.6.3.8.3.1 Each **Synchronous Generating Unit** within a **Type C** and **Type D Onshore Synchronous Power Generating Modules** shall be equipped with a permanent automatic excitation control system that can provide constant terminal voltage control at a selectable setpoint without instability over the entire operating range of the **Synchronous Power Generating Module**.

ECC.6.3.8.3.2 The requirements for excitation control facilities are specified in ECC.A.6. Any site specific requirements shall be specified by **NGET** or the relevant **Network Operator**.

ECC.6.3.8.3.3 Unless otherwise required for testing in accordance with OC5.A.2, the automatic excitation control system of an **Onshore Synchronous Power Generating Module** shall always be operated such that it controls the **Onshore Synchronous Generating Unit** terminal voltage to a value that is

- equal to its rated value: or
- only where provisions have been made in the **Bilateral Agreement**, greater than its rated value.

ECC.6.3.8.3.4 In particular, other control facilities including constant **Reactive Power** output control modes and constant **Power Factor** control modes (but excluding VAR limiters) are not required. However if present in the excitation or voltage control system they will be disabled unless otherwise agreed with **NGET** or the relevant **Network Operator**. Operation of such control facilities will be in accordance with the provisions contained in **BC2**.

ECC.6.3.8.3.5 The excitation performance requirements for **Offshore Synchronous Power Generating Modules** with an **Offshore Grid Entry Point** shall be specified by **NGET**.

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ECC.6.3.8.4 Voltage Control Performance Requirements for **Type C** and **Type D Onshore Power Park Modules**, Onshore HVDC Converters ~~Equipment~~ and **OTSUW Plant and Apparatus** at the **Interface Point**

ECC.6.3.8.4.1 Each **Type C** and **Type D** Onshore **Power Park Module**, Onshore **HVDC** Converter~~Equipment~~ and **OTSDUW Plant and Apparatus** shall be fitted with a continuously acting automatic control system to provide control of the voltage at the **Grid Entry Point** or **User System Entry Point** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus** ~~or HVDC Interface Point in the case of a Remote End HVDC Converter Station~~) without instability over the entire operating range of the **Onshore Power Park Module**, or Onshore **HVDC** Converter~~Equipment~~ or **OTSDUW Plant and Apparatus**. Any **Plant** or **Apparatus** used in the provisions of such voltage control within an Onshore **Power Park Module** ~~(including a DC Connected Power Park Module)~~ may be located at the **Power Park Unit** terminals, an appropriate intermediate busbar or the **Grid Entry Point** or **User System Entry Point**. In the case of an Onshore **HVDC Converter** at a **HVDC Converter Station** ~~or a Remote End HVDC Converter Station~~ any **Plant or Apparatus** used in the provisions of such voltage control may be located at any point within the **User's Plant and Apparatus** including the **Grid Entry Point** or **User System Entry Point** ~~(or HVDC Interface Point in the case of Remote End HVDC Converter Stations)~~. **OTSDUW Plant and Apparatus** used in the provision of such voltage control may be located at the **Offshore Grid Entry Point** an appropriate intermediate busbar or at the **Interface Point**. When operating below 20% **Maximum Capacity** the automatic control system may continue to provide voltage control using any available reactive capability. If voltage control is not being provided the automatic control system shall be designed to ensure a smooth transition between the shaded area bound by CD and the non-shaded area bound by AB in Figures X4 of ECC.6.3.2.6.4.

ECC.6.3.8.4.2 The performance requirements for a continuously acting automatic voltage control system that shall be complied with by the **User** in respect of **Onshore Power Park Modules**, Onshore **HVDC Converters** at an Onshore **HVDC Converter Station**, **OTSDUW Plant and Apparatus** at the **Interface Point** ~~and Remote End HVDC Converter Stations at an HVDC Interface Point~~ are defined in ECC.A.7.

ECC.6.3.8.4.3 In particular, other control facilities, including constant **Reactive Power** output control modes and constant **Power Factor** control modes (but excluding VAR limiters) are not required. However if present in the voltage control system they will be disabled unless otherwise agreed with **NGET** or the relevant **Network Operator**. Operation of such control facilities will be in accordance with the provisions contained in BC2. Where **Reactive Power** output control modes and constant **Power Factor** control modes have been fitted within the voltage control system they shall be required to satisfy the requirements of ECC.A.7.3.1.

ECC.6.3.8.5 Excitation Control Performance requirements applicable to AC Connected **Offshore Synchronous Power Generating Modules** and voltage control performance requirements applicable to AC connected **Offshore Power Park Modules**, ~~and~~ **DC Connected Power Park Modules** and Remote End HVDC Converters

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ECC.6.3.8.5.1 A continuously acting automatic control system is required to provide control of **Reactive Power** (as specified in ECC.6.3.2.7) at the **Offshore Grid Entry Point** (or **HVDC Interface Point** in the case of **Configuration 1 DC Connected Power Park Modules** and **Remote End HVDC Converters**) without instability over the entire operating range of the AC connected **Offshore Synchronous Power Generating Module** or **Configuration 1 AC connected Offshore Power Park Module** or **Configuration 1 DC Connected Power Park Modules** or **Remote End HVDC Converter**. The performance requirements for this automatic control system will be specified by **NGET** which would be consistent with the requirements of ECC.6.3.2.6 and ECC.6.3.2.7..

ECC.6.3.8.5.2 A continuously acting automatic control system is required to provide control of **Reactive Power** (as specified in ECC.6.3.2.8) at the **Offshore Grid Entry Point** (or **HVDC Interface Point** in the case of **Configuration 2 DC Connected Power Park Modules**) without instability over the entire operating range of the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Modules.** otherwise the requirements of ECC.6.3.2.7 shall apply. The performance requirements for this automatic control system are specified in ECC.A.8

ECC.6.3.8.5.3 In addition to ECC.6.3.8.5.1 and ECC.6.3.8.5.2 the requirements for excitation or voltage control facilities, including **Power System Stabilisers**, where these are necessary for system reasons, will be specified by **NGET**. Reference is made to on-load commissioning witnessed by **NGET** in BC2.11.2.

ECC.6.3.9 STEADY STATE LOAD INACCURACIES

ECC.6.3.9.1 The standard deviation of **Load** error at steady state **Load** over a 30 minute period must not exceed 2.5 per cent of a **Type C** or **Type D Power Generating Modules** (including a **DC Connected Power Park Module**) ~~Genset~~ **Maximum Capacity**. Where a **Type C** or **Type D Power Generating Module** (including a **DC Connected Power Park Module**) ~~Genset~~ is instructed to **Frequency** sensitive operation, allowance will be made in determining whether there has been an error according to the governor droop characteristic registered under the **PC**.

For the avoidance of doubt in the case of a **Power Park Module** allowance will be made for the full variation of mechanical power output.

ECC.6.3.10 NEGATIVE PHASE SEQUENCE LOADINGS

ECC.6.3.10.1 In addition to meeting the conditions specified in ECC.6.1.5(b), each **Synchronous Power Generating Module**~~Unit~~ will be required to withstand, without tripping, the negative phase sequence loading incurred by clearance of a close-up phase-to-phase fault, by **System Back-Up Protection** on the **National Electricity Transmission System** or **User System** located **Onshore** in which it is **Embedded**.

ECC.6.3.11 NEUTRAL EARTHING

ECC.6.3.11.1 At nominal **System** voltages of 110~~132~~kV and above the higher voltage windings of a transformer of a **Power Generating Module** or **HVDC Equipment** ~~**Generating Unit**~~ or transformer resulting from **OTSDUW** must be star connected with the star point suitable for connection to earth. The earthing and lower voltage winding arrangement shall be such as to ensure that the **Earth Fault Factor** requirement of paragraph ECC.6.2.1.1 (b) will be met on the **National Electricity Transmission System** at nominal **System** voltages of 110~~132~~kV and above.

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ECC.6.3.12 FREQUENCY AND VOLTAGE DEVIATIONS

ECC.6.3.12.1 As stated in ECC.6.1.2~~3~~, the **System Frequency** could rise to 52Hz or fall to 47Hz. Each **Power Generating Module** (including **DC Connected Power Park Modules**) ~~**Generating Unit**, **DC Converter**, **OTSDUW Plant and Apparatus**, **Power Park Module** or any constituent element~~ must continue to operate within this **Frequency** range for at least the periods of time given in ECC.6.1.2~~3~~ unless **NGET** has specified any requirements for combined **Frequency** and voltage deviations which are required to ensure the best use of technical capabilities of **Power Generating Modules** (including **DC Connected Power Park Modules**) if required to preserve or restore system security. ~~**Frequency** level relays and/or rate-of-change of **Frequency** relays which will trip such **Power Generating Module Generating Unit**, **DC Converter**, **OTSDUW Plant and Apparatus**, **Power Park Module** and any constituent element within this **Frequency** range, under the **Bilateral Agreement**.~~ Notwithstanding this requirement, **Generators** should also be aware of the requirements of ECC.6.3.1~~3~~4~~X~~.

ECC.6.3.13 ~~GENERATOR~~ FREQUENCY, RATE OF CHANGE OF FREQUENCY AND VOLATGE PROTECTION SETTING ARRANGEMENTS

ECC.6.3.13.1 **Generators** (including in respect of **OTSDUW Plant and Apparatus**) and **HVDC** SystemOwners will be responsible for protecting all their **Power Generating Modules** ~~**Generating Units**~~ (and **OTSDUW Plant and Apparatus**) or **HVDc Equipment**~~or **Power Park Modules**~~ against damage should **Frequency** excursions outside the range 52Hz to 47Hz ever occur. Should such excursions occur, it is up to the **Generator** or HV**DC System** to decide whether to disconnect his **Apparatus** for reasons of safety of **Apparatus**, **Plant** and/or personnel.

ECC.6.3.13.2 Each **Power Generating Module** when connected and synchronised to the **System,** shall be capable of withstanding without tripping a rate of change of **Frequency** up to and including 1 Hz per second as measured over a rolling 500 milliseconds period. Voltage dips may cause localised rate of change of **Frequency** values in excess of 1 Hz per second for short periods, and in these cases, the requirements under ECC.6.3.15 (fault ride through) supersedes this clause. For the avoidance of doubt, this requirement relates to the capabilities of **Power Generating Modules** only and does not impose the need for rate of change of **Frequency** protection nor does it impose a specific setting for anti-islanding or loss-of-mains protection relays.

ECC.6.3.13.3 Each **HVDC System** and **Remote End HVDC Converter Station** when connected and synchronised to the **System,** shall be capable of withstanding without tripping a rate of change of **Frequency** up to and including ±2.5Hz per second as measured over the previous 1 second period. Voltage dips may cause localised rate of change of **Frequency** values in excess of ±2.5 Hz per second for short periods, and in these cases, the requirements under ECC.6.3.15 (fault ride through) supersedes this clause. For the avoidance of doubt, this requirement relates to the capabilities of **HVDC Systems** and **Remote End HVDC Converter Stations** only and does not impose the need for rate of change of **Frequency** protection nor does it impose a specific setting for anti-islanding or loss-of-mains protection relays.

ECC.6.3.13.4 Each **DC Connected Power Park Module** when connected to the **System,** shall be capable of withstanding without tripping a rate of change of **Frequency** up to and including ±2.0Hz per second as measured over the previous 1 second period. **Voltage** dips may cause localised rate of change of **Frequency** values in excess of ±2.0 Hz per second for short periods, and in these cases, the requirements under ECC.6.3.15 (fault ride through)

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supersedes this clause. For the avoidance of doubt, this requirement relates to the capabilities of **DC Connected Power Park Modules** only and does not impose the need for rate of change of **Frequency** protection nor does it impose a specific setting for anti-islanding or loss-of-mains protection relays.

ECC.6.3.13.5 SIMULTANEOUS OVER VOLTAGE AND UNDERFREQUENCY OR SIMULTANEOUS UNDERVOLTAGE AND OVERFREQUENCY

ECC.6.3.13.5 As stated in ECC.6.1.23, the **System Frequency** could rise to 52Hz or fall to 47Hz and the **System** voltage at the **Grid Entry Point** or **User System Entry Point** could rise or fall within the values outlined in ECC.6.1.4. **Each Type C** and **Type D Power Generating Module** (including **DC Connected Power Park Modules**) **Generating Unit**, **DC Converter**, or **OTSDUW Plant and Apparatus**, Power Park Module or any constituent element must continue to operate within this **Frequency** range for at least the periods of time given in ECC.6.1.23 and voltage range as defined in ECC.6.1.4 unless **NGET** has agreed to any simultaneous overvoltage and underfrequency relays and/or simultaneous undervoltage and over frequency relays or **Frequency** level relays and/or rate of change of **Frequency** relays which will trip such **Power Generating Module** (including **DC Connected Power Park Modules**), **Generating Unit, DC Converterower Park Module** and any constituent element within this **Frequency** or voltage range.

ECC.6.3.15X RATE OF CHANGE OF FREQUENCY WITHSTAND CAPABILITY

ECC.6.3.15X.1 Each **Power Generating Module** when connected and synchronised to the **System,** shall be capable of withstanding without tripping a rate of change of **Frequency** up to and including 1 Hz per second as measured over a rolling 500 milliseconds period. Voltage dips may cause localised rate of change of **Frequency** values in excess of 1 Hz per second for short periods, and in these cases, the requirements under ECC.6.3.15 (fault ride through) supersedes this clause. For the avoidance of doubt, this requirement relates to the capabilities of **Power Generating Modules** only and does not impose the need for rate of change of **Frequency** protection nor does it impose a specific setting for anti-islanding or loss-of-mains protection relays.

ECC.6.3.15X.2 Each **HVDC System** and **Remote End HVDC Converter Station** when connected and synchronised to the **System,** shall be capable of withstanding without tripping a rate of change of **Frequency** up to and including ±2.5Hz per second as measured over the previous 1 second period. Voltage dips may cause localised rate of change of **Frequency** values in excess of ±2.5 Hz per second for short periods, and in these cases, the requirements under ECC.6.3.15 (fault ride through) supersedes this clause. For the avoidance of doubt, this requirement relates to the capabilities of **HVDC Systems** and **Remote End HVDC Converter Stations** only and does not impose the need for rate of change of **Frequency** protection nor does it impose a specific setting for anti-islanding or loss-of-mains protection relays.

ECC.6.3.15X.3 Each **DC Connected Power Park Module** when connected to the **System,** shall be capable of withstanding without tripping a rate of change of **Frequency** up to and including ±2.0Hz per second as measured over the previous 1 second period. **Voltage** dips may cause localised rate of change of **Frequency** values in excess of ±2.0 Hz per second for short periods, and in these cases, the requirements under ECC.6.3.15 (fault ride through) supersedes this clause. For the avoidance of doubt, this requirement relates to the capabilities of **DC Connected Power Park Modules** only and does not impose the need for rate of change of **Frequency** protection nor does it impose a specific setting for anti-islanding or loss-of-mains protection relays.

ECC.6.3.14 FAST START CAPABILITY

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ECC.6.3.146X.1 It may be agreed in the **Bilateral Agreement** that a **Genset** shall have a **Fast-Start Capability**. Such **Gensets** may be used for **Operating Reserve** and their **Start-Up** may be initiated by **Frequency**-level relays with settings in the range 49Hz to 50Hz as specified pursuant to **OC2**.

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APPENDIX E3 - MINIMUM FREQUENCY RESPONSE CAPABILITY REQUIREMENT PROFILE AND OPERATING RANGE FOR POWER GENERATING MODULES AND HVDC EQUIPMENT

The current text has been taken from Issue 5 Revision 16 of the Grid Code and will require checking to ensure consistency with latest version of the GB Grid Code.

ECC.A.3.1 Scope

The frequency response capability is defined in terms of **Primary Response**, **Secondary Response** and **High Frequency Response**. In addition to the requirements defined in ECC.6.3.7 this appendix defines the minimum frequency response requirements for:-

(a) each **Type C** and **Type D Power Generating Module**

(b) each **DC Connected Power Park Module**

(c) each **HVDC** ~~**Converter at a HVDC Converter Station**~~**System**

~~(d) each **HVDC Converter** at a **HVDC Converter Station** including **Remote End HVDC Converters**~~

~~Frequency response capability is defined in terms of the response to a step change in frequency and the ability to respond with an Active Power change satisfying the minimum requirements set out in ECC.6.3.7.3.3.~~

~~(i) Frequency response service is defined in terms of Primary, Secondary and High frequency response profiles. The definitions of these services are illustrated diagrammatically in Figures EC.A.3.2 and EC.A.3.3.~~

For the avoidance of doubt, this appendix does not apply to **Type A** and **Type B Power Generating Modules**.

OTSDUW Plant and Apparatus should facilitate the delivery of frequency response services provided by **Offshore Generating Units** and **Offshore Power Park Units**.

The functional definition provides appropriate performance criteria relating to the provision of **Frequency** control by means of **Frequency** sensitive generation in addition to the other requirements identified in ECC.6.3.7.

In this Appendix 3 to the ECC, for a **Power Generating Module** including a **CCGT Module** or a **Power Park Module** or **DC Connected Power Park Module**, the phrase **Minimum Regulating Level** applies to the entire **CCGT Module** or **Power Park Module** or **DC Connected Power Park Module** operating with all **Generating Units Synchronised** to the **System**.

The minimum **Frequency** response requirement profile is shown diagrammatically in Figure ECC.A.3.1. The capability profile specifies the minimum required level of **Frequency Response** Capability throughout the normal plant operating range.

ECC.A.3.2 Plant Operating Range

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The upper limit of the operating range is the **Maximum Capacity** of the **Power Generating Module** or **Generating Unit** or **CCGT Module** or **HVDC Equipment**.

The **Minimum Regulating Level** level may be less than, but must not be more than, 65% of the **Maximum Capacity**. Each **Power Generating Module** and/or **Generating Unit** and/or **CCGT Module** and/or **Power Park Module** **or HVDC Equipment**must be capable of operating satisfactorily down to the **Minimum Regulating Level** as dictated by **System** operating conditions, although it will not be instructed to below its **Minimum Stable Operating Level**level. If a **Power Generating Module** or **Generating Unit** or **CCGT Module** or **Power Park Module**, or **HVDC Equipment** is operating below **Minimum Stable Operating Level** because of high **System Frequency**, it should recover adequately to its **Minimum Stable Operating Level** as the **System Frequency** returns to **Target Frequency** so that it can provide **Primary** and **Secondary Response** from its **Minimum Stable Operating Level** if the **System Frequency** continues to fall. For the avoidance of doubt, under normal operating conditions steady state operation below the **Minimum Stable Operating Level** is not expected. The **Minimum Regulating Level** must not be more than 55% of **Maximum Capacity**.

In the event of a **Power Generating Module** or **Generating Unit** or **CCGT Module** or **Power Park Module** or **HVDC Equipment** load rejecting down to no less than its **Minimum Regulating Level** it should not trip as a result of automatic action as detailed in BC3.7. If the load rejection is to a level less than the **Minimum Regulating Level** then it is accepted that the condition might be so severe as to cause it to be disconnected from the **System**.

ECC.A.3.3 Minimum Frequency Response Requirement Profile

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Figure ECC.A.3.1 shows the minimum **Frequency** response capability requirement profile diagrammatically for a 0.5 Hz change in **Frequency**. The percentage response capabilities and loading levels are defined on the basis of the **Maximum Capacity** of the **Power Generating Module** or **CCGT Module** or **Power Park Module** or **HVDC Equipment**. Each **Power Generating Module** or and/or **CCGT Module** or **Power Park Module** (including a **DC Connected Power Park Module**) and/or **HVDC Equipment**must be capable of operating in a manner to provide **Frequency** response at least to the solid boundaries shown in the figure. If the **Frequency** response capability falls within the solid boundaries, the **Power Generating Module** or **CCGT Module** or **Power Park Module** or **HVDC Equipment** is providing response below the minimum requirement which is not acceptable. Nothing in this appendix is intended to prevent a **Power Generating Module** or **CCGT Module** or **Power Park Module** or **HVDC Equipment** from being designed to deliver a **Frequency** response in excess of the identified minimum requirement.

The **Frequency** response delivered for **Frequency** deviations of less than 0.5 Hz should be no less than a figure which is directly proportional to the minimum **Frequency** response requirement for a **Frequency** deviation of 0.5 Hz. For example, if the **Frequency** deviation is 0.2 Hz, the corresponding minimum **Frequency** response requirement is 40% of the level shown in Figure ECC.A.3.1. The **Frequency** response delivered for **Frequency** deviations of more than 0.5 Hz should be no less than the response delivered for a **Frequency** deviation of 0.5 Hz.

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Each **Power Generating Module** and/or **CCGT Module** and/or **Power Park Module** or **HVDC Equipment** must be capable of providing some response, in keeping with its specific operational characteristics, when operating between 95% to 100% of **Maximum Capacity** as illustrated by the dotted lines in Figure ECC.A.3.1.

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At the **Minimum Stable Operating** level, each **Power Generating Module** and/or **CCGT Module** and/or **Power Park Module** and/or HV**DC Equipment** is required to provide high and low frequency response depending on the **System Frequency** conditions. Where the **Frequency** is high, the **Active Power** output is therefore expected to fall below the **Minimum Stable Operating** level.

The **Minimum Regulating Level** is the output at which a **Power Generating Module** and/or **CCGT Module** and/or **Power Park Module** and/or HV**DC Equipment** has no **High Frequency Response** capability. It may be less than, but must not be more than, 55% of the **Maximum Capacity**. This implies that a **Power Generating Module** or **CCGT Module** or **Power Park Module**) or **HVDC Equipment** is not obliged to reduce its output to below this level unless the **Frequency** is at or above 50.5 Hz (cf BC3.7).

ECC.A.3.4 Testing of Frequency Response Capability

The frequency response capabilities shown diagrammatically in Figure ECC.A.3.1 are measured by taking the responses as obtained from some of the dynamic step response tests specified by **NGET** and carried out by **Generators** and HV**DC System** owners for compliance purposes. The injected signal is a step of 0.5Hz *(an additional diagram may be required here)* from zero to 0.5 Hz **Frequency** change ~~over a ten second period~~, and is sustained at 0.5 Hz **Frequency** change thereafter, the latter as illustrated diagrammatically in figures ~~ECC.A.3.2 and ECC.A.3.3~~ ECC.A.3.4 and ECC.A.3.5.

In addition to provide and/or to validate the content of **Ancillary Services Agreements** a progressive injection of a **Frequency** change to the plant control system (i.e. governor and load controller) is used. The injected signal is a ramp of 0.5Hz from zero to 0.5 Hz **Frequency** change over a ten second period, and is sustained at 0.5 Hz **Frequency** change thereafter, the latter as illustrated diagrammatically in figures ECC.A.3.2 and ECC.A.3.3 For the avoidance of doubt, these tests will be conducted with ramp signals for the purposes of determining **Primary, Secondary and High Frequency Responses**.

The **Primary Response** capability (P) of a **Power Generating Module** or a **CCGT Module** or **Power Park Module** or **HVDC Equipment** is the minimum increase in **Active Power** output between 10 and 30 seconds after the start of the ramp injection as illustrated diagrammatically in Figure ECC.A.3.2. This increase in **Active Power** output should be released increasingly with time over the period 0 to 10 seconds from the time of the start of the **Frequency** fall as illustrated by the response from Figure ECC.A.3.2.

The **Secondary Response** capability (S) of a **Power Generating Module** or a **CCGT Module** or **Power Park Module** or **HVDC Equipment** is the minimum increase in **Active Power** output between 30 seconds and 30 minutes after the start of the ramp injection as illustrated diagrammatically in Figure ECC.A.3.2.

The **High Frequency Response** capability (H) of a **Power Generating Module** or a **CCGT Module** or **Power Park Module** or **HVDC Equipment** is the decrease in **Active Power** output provided 10 seconds after the start of the ramp injection and sustained thereafter as illustrated diagrammatically in Figure ECC.A.3.3. This reduction in **Active Power** output should be released increasingly with time over the period 0 to 10 seconds from the time of the start of the **Frequency** rise as illustrated by the response in Figure ECC.A.3.2.

ECC.A.3.5 Repeatability Of Response

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When a **Power Generating Module** or **CCGT Module** or **Power Park Module** or **HVDC Equipment** has responded to a significant **Frequency** disturbance, its response capability must be fully restored as soon as technically possible. Full response capability should be restored no later than 20 minutes after the initial change of **System Frequency** arising from the **Frequency** disturbance.

Figure ECC.A.3.1 - Minimum **Frequency** Response requirement profile for a 0.5 Hz frequency change from **Target Frequency**

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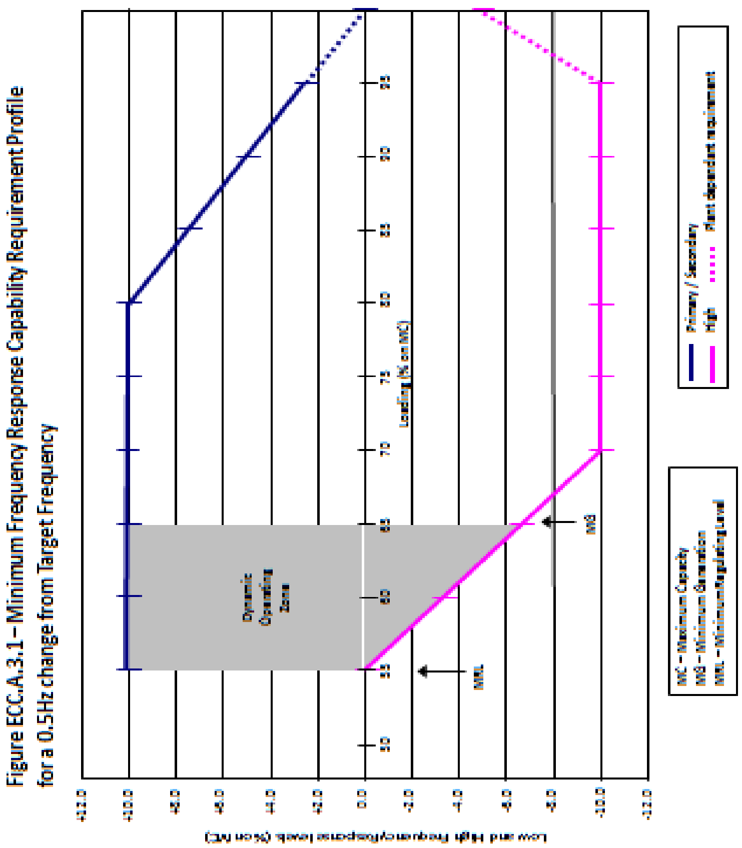

Figure ECC.A.3.2 - Interpretation of **Primary** and **Secondary Response** values

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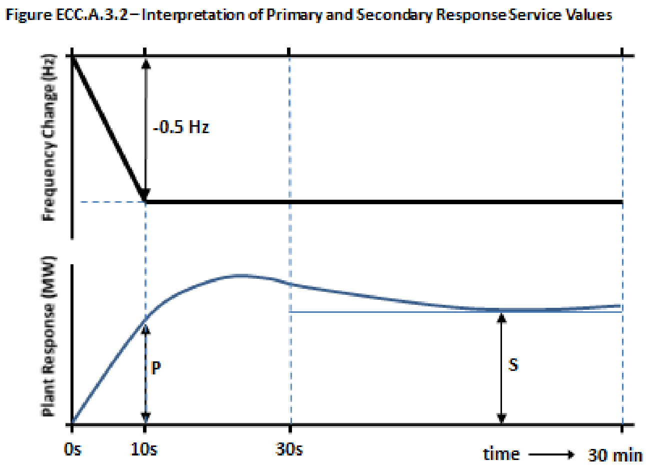

Figure ECC.A.3.3 - Interpretation of **High Frequency Response** Values

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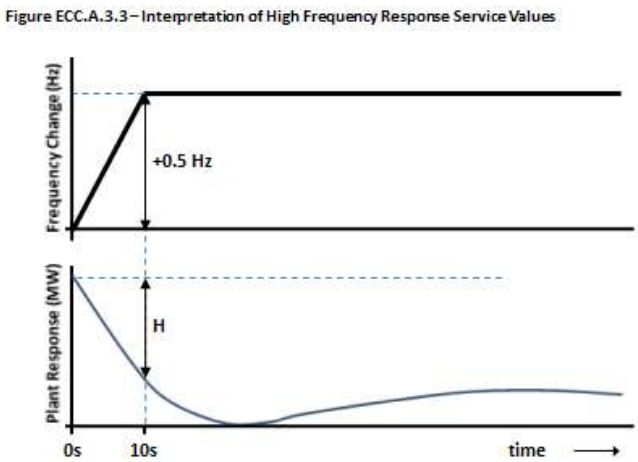


New Figure ECC.A.3.5 – Interpretation of Low Frequency Response Capability Values

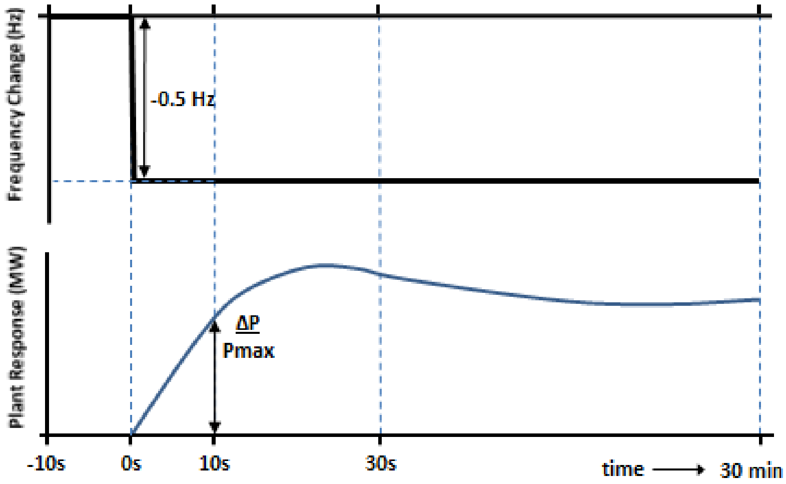
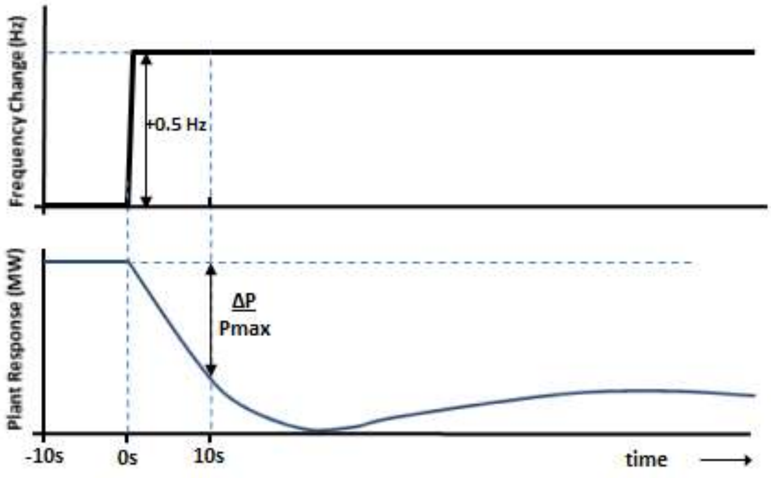


Figure ECC.A.3.5 – Interpretation of High Frequency Response Capability Values



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APPENDIX E6 - PERFORMANCE REQUIREMENTS FOR CONTINUOUSLY ACTING AUTOMATIC EXCITATION CONTROL SYSTEMS FOR ONSHORE SYNCHRONOUS POWER GENERATING MODULES,

ECC.A.6.1 Scope

ECC.A.6.1.1 This Appendix sets out the performance requirements of continuously acting automatic excitation control systems for **Type C** and **Type D Onshore Synchronous Power Generating Modules** that must be complied with by the **User**. This Appendix does not limit any site specific requirements where in **NGET's** reasonable opinion these facilities are necessary for system reasons.

ECC.A.6.1.2 Where the requirements may vary the likely range of variation is given in this Appendix. It may be necessary to specify values outside this range where **NGET** identifies a system need, and notwithstanding anything to the contrary **NGET** may specify values outside of the ranges provided in this Appendix 6. The most common variations are in the on-load excitation ceiling voltage requirements and the response time required of the **Exciter**. Actual values will be included in the **Bilateral Agreement**.

ECC.A.6.1.3 Should a **Generator** anticipate making a change to the excitation control system it shall notify **NGET** under the **Planning Code** (PC.A.1.2(b) and (c)) as soon as the **Generator** anticipates making the change. The change may require a revision to the **Bilateral Agreement**.

ECC.A.6.2 Requirements

ECC.A.6.2.1 The **Excitation System** of a **Type C** or **Type D Onshore Synchronous Power Generating Module** shall include an excitation source (**Exciter**), ~~a **Power System Stabiliser**~~ and a continuously acting **Automatic Voltage Regulator** (**AVR**) and shall meet the following functional specification. **Type D Synchronous Power Generating Modules** are also required to be fitted with a **Power System Stabiliser** in accordance with the requirements of ECC.A.6.2.5.

~~CC.A.6.2.2 In respect of **Onshore Synchronous Generating Units** with a **Completion Date** on or after 1 January 2009, and **Onshore Synchronous Generating Units** with a **Completion Date** before 1 January 2009 subject to a **Modification** to the excitation control facilities where the **Bilateral Agreement** does not specify otherwise, the continuously acting automatic excitation control system shall include a **Power System Stabiliser (PSS)** as a means of supplementary control. The functional specification of the **Power System Stabiliser** is included in CC.A.6.2.5.~~

ECC.A.6.2.3 Steady State Voltage Control

ECC.A.6.2.3.1 An accurate steady state control of the **Onshore Synchronous Power Generating Module** pre-set **Synchronous Generating Unit** terminal voltage is required. As a measure of the accuracy of the steady-state voltage control, the **Automatic Voltage Regulator** shall have static zero frequency gain, sufficient to limit the change in terminal voltage to a drop not exceeding 0.5% of rated terminal voltage, when the output of a **Synchronous Generating Unit** within an **Onshore Synchronous Power Generating Module** is gradually changed from zero to rated MVA output at rated voltage, **Active Power** and **Frequency**.

ECC.A.6.2.4 Transient Voltage Control

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ECC.A.6.2.4.1 For a step change from 90% to 100% of the nominal **Onshore Synchronous Generating Unit** terminal voltage, with the **Onshore Synchronous Generating Unit** on open circuit, the **Excitation System** response shall have a damped oscillatory characteristic. For this characteristic, the time for the **Onshore Synchronous Generating Unit** terminal voltage to first reach 100% shall be less than 0.6 seconds. Also, the time to settle within 5% of the voltage change shall be less than 3 seconds.

ECC.A.6.2.4.2 To ensure that adequate synchronising power is maintained, when the **Onshore Power Generating Module** is subjected to a large voltage disturbance, the **Exciter** whose output is varied by the **Automatic Voltage Regulator** shall be capable of providing its achievable upper and lower limit ceiling voltages to the **Onshore Synchronous Generating Unit** field in a time not exceeding that specified in the **Bilateral Agreement**. This will normally be not less than 50 ms and not greater than 300 ms. The achievable upper and lower limit ceiling voltages may be dependent on the voltage disturbance.

ECC.A.6.2.4.3 The **Exciter** shall be capable of attaining an **Excitation System On Load Positive Ceiling Voltage** of not less than a value specified in the **Bilateral Agreement** that will be:

not less than 2 per unit (pu)

normally not greater than 3 pu

exceptionally up to 4 pu

of **Rated Field Voltage** when responding to a sudden drop in voltage of 10 percent or more at the **Onshore Synchronous Generating Unit** terminals. **NGET** may specify a value outside the above limits where **NGET** identifies a system need.

ECC.A.6.2.4.4 If a static type **Exciter** is employed:

(i) the field voltage should be capable of attaining a negative ceiling level specified in the **Bilateral Agreement** after the removal of the step disturbance of ECC.A.6.2.4.3. The specified value will be 80% of the value specified in ECC.A.6.2.4.3. **NGET** may specify a value outside the above limits where **NGET** identifies a system need.

(ii) the **Exciter** must be capable of maintaining free firing when the **Onshore Synchronous Generating Unit** terminal voltage is depressed to a level which may be between 20% to 30% of rated terminal voltage

(iii) the **Exciter** shall be capable of attaining a positive ceiling voltage not less than 80% of the **Excitation System On Load Positive Ceiling Voltage** upon recovery of the **Onshore Synchronous Generating Unit** terminal voltage to 80% of rated terminal voltage following fault clearance. **NGET** may specify a value outside the above limits where **NGET** identifies a system need.

(iv) the requirement to provide a separate power source for the **Exciter** will be specified if **NGET** identifies a **Transmission System** need.

ECC.A.6.2.5 Power Oscillations Damping Control

ECC.A.6.2.5.1 To allow **Type D Onshore Power Generating Modules** to maintain second and subsequent swing stability and also to ensure an adequate level of low frequency electrical damping power, the **Automatic Voltage Regulator** of each **Onshore Synchronous Generating Unit** within each **Type D Onshore Synchronous Power Generating Module** shall include a **Power System Stabiliser** as a means of supplementary control.

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ECC.A.6.2.5.2 Whatever supplementary control signal is employed, it shall be of the type which operates into the **Automatic Voltage Regulator** to cause the field voltage to act in a manner which results in the damping power being improved while maintaining adequate synchronising power.

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ECC.A.6.2.5.3 The arrangements for the supplementary control signal shall ensure that the **Power System Stabiliser** output signal relates only to changes in the supplementary control signal and not the steady state level of the signal. For example, if generator electrical power output is chosen as a supplementary control signal then the **Power System Stabiliser** output should relate only to changes in the **Synchronous Generating Unit** electrical power output and not the steady state level of power output. Additionally the **Power System Stabiliser** should not react to mechanical power changes in isolation for example during rapid changes in steady state load or when providing frequency response.

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ECC.A.6.2.5.4 The output signal from the **Power System Stabiliser** shall be limited to not more than ±10% of the **Onshore Synchronous Generating Unit** terminal voltage signal at the **Automatic Voltage Regulator** input. The gain of the **Power System Stabiliser** shall be such that an increase in the gain by a factor of 3 shall not cause instability.

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ECC.A.6.2.5.5 The **Power System Stabiliser** shall include elements that limit the bandwidth of the output signal. The bandwidth limiting must ensure that the highest frequency of response cannot excite torsional oscillations on other plant connected to the network. A bandwidth of 0-5Hz would be judged to be acceptable for this application.

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ECC.A.6.2.5.6 The **Generator** in respect of its **Type D Synchronous Power Generating Modules** will agree **Power System Stabiliser** settings with **NGET** prior to the on-load commissioning detailed in BC2.11.2(d). To allow assessment of the performance before on-load commissioning the **Generator** will provide to **NGET** a report covering the areas specified in ECP.A.3.2.1.

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ECC.A.6.2.5.7 The **Power System Stabiliser** must be active within the **Excitation System** at all times when **Synchronised** including when the **Under Excitation Limiter** or **Over Excitation Limiter** are active. When operating at low load when **Synchronising** or **De-Synchronising** an **Onshore Synchronous Generating Unit,** within a **Type D Synchronous Power Generating Modul**e, the **Power System Stabiliser** may be out of service.

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ECC.A.6.2.5.8 Where a **Power System Stabiliser** is fitted to a **Pumped Storage Unit** within a **Type D Synchronous Power Generating Module** it must function when the **Pumped Storage Unit** is in both generating and pumping modes.

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ECC.A.6.2.6 Overall **Excitation System** Control Characteristics

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ECC.A.6.2.6.1 The overall **Excitation System** shall include elements that limit the bandwidth of the output signal. The bandwidth limiting must be consistent with the speed of response requirements and ensure that the highest frequency of response cannot excite torsional oscillations on other plant connected to the network. A bandwidth of 0-5 Hz will be judged to be acceptable for this application.

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ECC.A.6.2.6.2 The response of the **Automatic Voltage Regulator** combined with the **Power System Stabiliser** shall be demonstrated by injecting similar step signal disturbances into the **Automatic Voltage Regulator** reference as detailed in ECPXXXX~~OC5A.2.2~~ and ECPXXX ~~OC5.A.2.4~~. The **Automatic Voltage Regulator** shall include a facility to allow step injections into the **Automatic Voltage Regulator** voltage reference, with the **Onshore Type D Power Generating Module** operating at points specified by **NGET** (up to rated MVA output). The damping shall be judged to be adequate if the corresponding **Active Power** response to the disturbances decays within two cycles of oscillation.

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ECC.A.6.2.6.3 A facility to inject a band limited random noise signal into the **Automatic Voltage Regulator** voltage reference shall be provided for demonstrating the frequency domain response of the **Power System Stabiliser**. The tuning of the **Power System Stabiliser** shall be judged to be adequate if the corresponding **Active Power** response shows improved damping with the **Power System Stabiliser** in combination with the **Automatic Voltage Regulator** compared with the **Automatic Voltage Regulator** alone over the frequency range 0.3Hz – 2Hz.

ECC.A.6.2.7 Under-Excitation Limiters

ECC.A.6.2.7.1 The security of the power system shall also be safeguarded by means of MVAr **Under Excitation Limiters** fitted to the **Synchronous Power Generating Module Excitation System**. The **Under Excitation Limiter** shall prevent the **Automatic Voltage Regulator** reducing the **Synchronous Generating Unit** excitation to a level which would endanger synchronous stability. The **Under Excitation Limiter** shall operate when the excitation system is providing automatic control. The **Under Excitation Limiter** shall respond to changes in the **Active Power** (MW) the **Reactive Power** (MVAr) and to the square of the **Synchronous Generating Unit**r voltage in such a direction that an increase in voltage will permit an increase in leading MVAr. The characteristic of the **Under Excitation Limiter** shall be substantially linear from no-load to the maximum **Active Power** output of the **Onshore Power Generating Module** at any setting and shall be readily adjustable.

ECC.A.6.2.7.2 The performance of the **Under Excitation Limiter** shall be independent of the rate of change of the **Onshore Synchronous Power Generating Module** load and shall be demonstrated by testing as detailed in ECPXXX~~OC5.A.2.5~~. The resulting maximum overshoot in response to a step injection which operates the **Under Excitation Limiter** shall not exceed 4% of the **Onshore Synchronous Generating Unit** rated MVA. The operating point of the **Onshore Synchronous Generating Unit** shall be returned to a steady state value at the limit line and the final settling time shall not be greater than 5 seconds. When the step change in **Automatic Voltage Regulator** reference voltage is reversed, the field voltage should begin to respond without any delay and should not be held down by the **Under Excitation Limiter**. Operation into or out of the preset limit levels shall ensure that any resultant oscillations are damped so that the disturbance is within 0.5% of the **Onshore Synchronous Generating Unit** MVA rating within a period of 5 seconds.

ECC.A.6.2.7.3 The **Generator** shall also make provision to prevent the reduction of the **Onshore Synchronous Generating Unit** excitation to a level which would endanger synchronous stability when the **Excitation System** is under manual control.

ECC.A.6.2.8 Over-Excitation and Stator Current Limiters

ECC.A.6.2.8.1 The settings of the **Over-Excitation Limiter** and stator current limiter, ~~where it exists,~~ shall ensure that the **Onshore Synchronous Generating Unit** excitation is not limited to less than the maximum value that can be achieved whilst ensuring the **Onshore Synchronous Generating Unit** is operating within its design limits. If the **Onshore Synchronous Generating Unit** excitation is reduced following a period of operation at a high level, the rate of reduction shall not exceed that required to remain within any time dependent operating characteristics of the **Onshore Synchronous Power Generating Module**.

ECC.A.6.2.8.2 The performance of the **Over-Excitation Limiter**~~, where it exists,~~ shall be demonstrated by testing as described in ECPXXXOC5.A.2.6. Any operation beyond the **Over-Excitation Limit** shall be controlled by the **Over-Excitation Limiter** or stator current limiter without the operation of any **Protection** that could trip the **Onshore Synchronous Power Generating Module**.

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ECC.A.6.2.8.3 The **Generator** shall also make provision to prevent any over-excitation restriction of the **Onshore Synchronous Generating Unit** when the **Excitation System** is under manual control, other than that necessary to ensure the **Onshore Power Generating Module** is operating within its design limits.

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APPENDIX E7 - PERFORMANCE REQUIREMENTS FOR CONTINUOUSLY ACTING AUTOMATIC VOLTAGE CONTROL SYSTEMS FOR AC CONNECTED ONSHORE NON-SYNCHRONOUS GENERATING UNITS, ONSHORE DC CONVERTERS, POWER PARK MODULES AND OTSDUW PLANT AND APPARATUS AT THE INTERFACE POINT, HVDC SYSTEMS AND REMOTE END HVDC CONVERTER STATIONS

ECC.A.7.1 Scope

ECC.A.7.1.1 This Appendix sets out the performance requirements of continuously acting automatic voltage control systems for **Onshore** **Non-Synchronous Generating Units**, **Power Park Modules**, **Onshore** HVDC **ConvertersSystems**, **Remote End HVDC Converter Stations** and **OTSDUW Plant and Apparatus** at the **Interface Point** that must be complied with by the **User**. This Appendix does not limit any site specific requirements where in **NGET's** reasonable opinion these facilities are necessary for system reasons. The control performance requirements applicable to **Configuration 2 AC Connected Offshore Power Park Modules** and, **DC Connected Power Park Modules** and **Remote End HVDC Converters** are defined in Appendix E8.

ECC.A.7.1.2 Proposals by **Generators** or **HVDC System Owners** to make a change to the voltage control systems are required to be notified to **NGET** under the **Planning Code** (PC.A.1.2(b) and (c)) as soon as the **Generator** or **HVDC System Owner** anticipates making the change. The change may require a revision to the **Bilateral Agreement**.

ECC.A.7.1.3 In the case of a **Remote End HVDC Converter** at a **HVDC Converter Station,** the control performance requirements shall be specified in the **Bilateral Agreement**. These requirements shall be consistent with those specified in ECC.6.3.2.6. In the case where the **Remote End HVDC Converter** is required to ensure the zero transfer of **Reactive Power** at the **HVDC Interface Point** then the requirements shall be specified in the **Bilateral Agreement** which shall be consistent with those requirements specified in ECC.A.8 shall apply. In the case where a wider reactive capability has been specified in ECC.6.3.2.6, then the requirements consistent with those specified in ECC.A.7.2 shall apply with any variations being agreed between the **User** and **NGET**. where the **HVDC System Owner** has agreed to a wider reactive capability range as defined under ECC.6.3.2.7.3 then the requirements that apply will be specified by **NGET** and which shall reflect the performance requirements detailed in ECC.A.7.2 below but with different parameters such as droop and **Setpoint Voltage**.

ECC.A.7.2 Requirements

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ECC.A.7.2.1 **NGET** requires that the continuously acting automatic voltage control system for the ~~**Onshore Non-Synchronous Generating Unit**, **Onshore DC Converter** or~~ **Onshore Power Park Module**, Onshore HVDC Converter ~~System~~ ~~or Remote End HVDC Converter Station~~ or **OTSDUW Plant and Apparatus** shall meet the following functional performance specification. If a **Network Operator** has confirmed to **NGET** that its network to which an **Embedded** ~~**Onshore Non-Synchronous Generating Unit**, **Onshore DC Converter**,~~ **Onshore Power Park Module** or Onshore HVDC Converter~~System~~ ~~or Remote End HVDC Converter Station~~ or **OTSDUW Plant and Apparatus** is connected is restricted such that the full reactive range under the steady state voltage control requirements (ECC.A.7.2.2) cannot be utilised, **NGET** may specify alternative limits to the steady state voltage control range that reflect these restrictions. Where the **Network Operator** subsequently notifies **NGET** that such restriction has been removed, **NGET** may propose a **Modification** to the **Bilateral Agreement** (in accordance with the **CUSC** contract) to remove the alternative limits such that the continuously acting automatic voltage control system meets the following functional performance specification. All other requirements of the voltage control system will remain as in this Appendix.

ECC.A.7.2.2 Steady State Voltage Control

ECC.A.7.2.2.1 The ~~**Onshore Non-Synchronous Generating Unit**, **Onshore DC Converter**,~~ **Onshore Power Park Module**, Onshore HVDC Converter ~~System~~ ~~and/or Remote End HVDC Converter Station~~ or **OTSDUW Plant and Apparatus** shall provide continuous steady state control of the voltage at the **Onshore Grid Entry Point** (or **Onshore User System Entry Point** if **Embedded**) (or the **Interface Point** in the case of **OTSDUW Plant and Apparatus** ~~or **HVDC Interface Point** in the case of a **Remote End HVDC Converter Station**~~) with a **Setpoint Voltage** and **Slope** characteristic as illustrated in Figure ECC.A.7.2.2a. ~~It should be noted that where the **Reactive Power** capability requirement of a directly connected **Onshore Non-Synchronous Generating Unit**, **Onshore DC Converter**, **Onshore Power Park Module** in Scotland, or **OTSDUW Plant and Apparatus** in Scotland as specified in CC.6.3.2 (c), is not at the **Onshore Grid Entry Point** or **Interface Point**, the values of Qmin and Qmax shown in this figure will be as modified by the 33/132kV or 33/275kV or 33/400kV transformer.~~

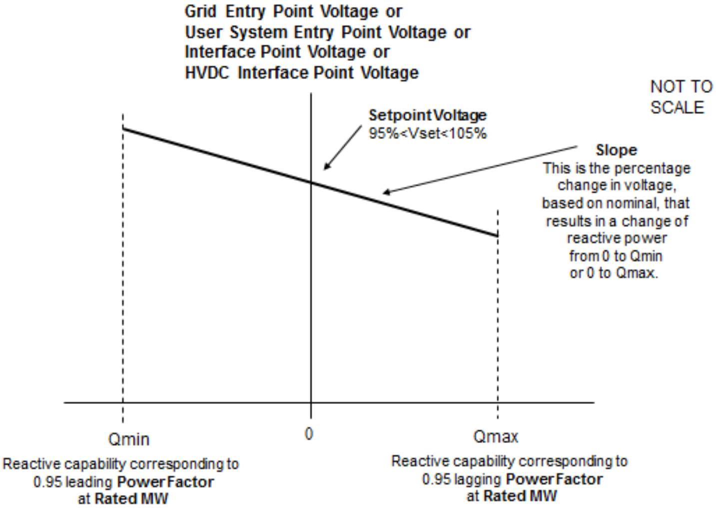

Figure ECC.A.7.2.2a

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ECC.A.7.2.2.2 The continuously acting automatic control system shall be capable of operating to a **Setpoint Voltage** between 95% and 105% with a resolution of 0.25% of the nominal voltage. For the avoidance of doubt values of 95%, 95.25%, 95.5% … may be specified, but not intermediate values. The initial **Setpoint Voltage** will be 100%. The tolerance within which this **Setpoint Voltage** shall be achieved is specified in BC2.A.2.6. For the avoidance of doubt, with a tolerance of 0.25% and a Setpoint Voltage of 100%, the achieved value shall be between 99.75% and 100.25%. **NGET** may request the **Generator** or HV**DC System Owner** to implement an alternative **Setpoint Voltage** within the range of 95% to 105%. For **Embedded Generators** and **Embedded HVDC System Owners** the **Setpoint Voltage** will be discussed between **NGET** and the relevant **Network Operator** and will be specified to ensure consistency with ECC.6.3.4.

ECC.A.7.2.2.3 The **Slope** characteristic of the continuously acting automatic control system shall be adjustable over the range 2% to 7% (with a resolution of 0.5%). For the avoidance of doubt values of 2%, 2.5%, 3% may be specified, but not intermediate values. The initial **Slope** setting will be 4%. The tolerance within which this **Slope** shall be achieved is specified in BC2.A.2.6. For the avoidance of doubt, with a tolerance of 0.5% and a **Slope** setting of 4%, the achieved value shall be between 3.5% and 4.5%. **NGET** may request the **Generator** or **HVDC System Owner** to implement an alternative slope setting within the range of 2% to 7%. For **Embedded Generators** and Onshore **Embedded HVDC Converter Station Owners** the **Slope** setting will be discussed between **NGET** and the relevant **Network Operator** and will be specified to ensure consistency with ECC.6.3.4.

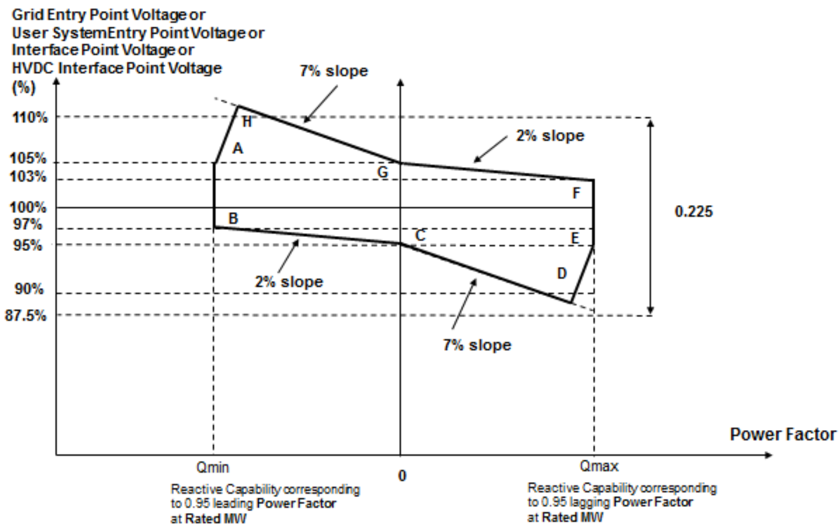

Figure ECC.A.7.2.2b

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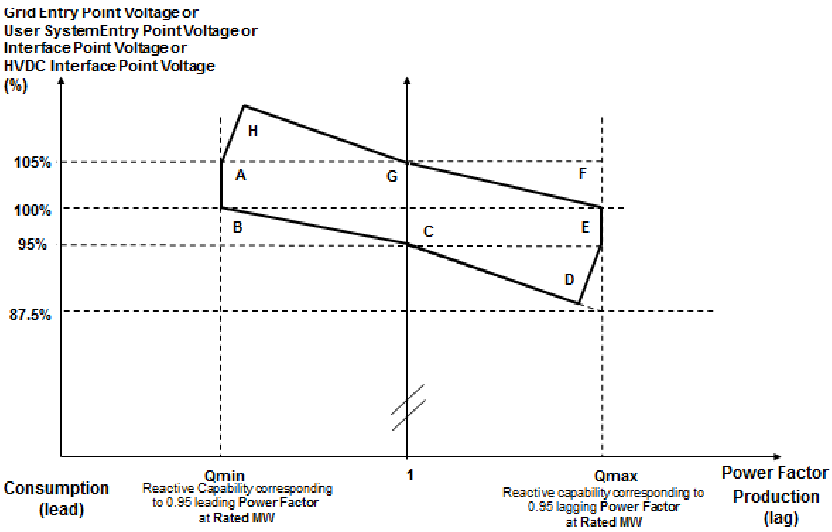

Figure ECC.A.7.2.2c

ECC.A.7.2.2.4 Figure ECC.A.7.2.2b shows the required envelope of operation for ~~**Onshore Non-Synchronous Generating Units**, **Onshore DC Converters**~~, **OTSDUW Plant** and **Apparatus**, **Onshore Power Park Modules** and~~,~~ Onshore HVDC Converters~~**Systems** and **Remote End HVDC Converter Stations**~~ except for those **Embedded** at 33kV and below or directly connected to the **National Electricity Transmission System** at 33kV and below. Figure ECC.A.7.2.2c shows the required envelope of operation for ~~**Onshore Non-Synchronous Generating Units, Onshore DC Converters** and~~ **Onshore Power Park Modules Embedded** at 33kV and below, or directly connected to the **National Electricity Transmission System** at 33kV and below. ~~Where the **Reactive Power** capability requirement of a directly connected **Onshore Non-Synchronous Generating Unit, Onshore DC Converter, OTSDUW Plant and Apparatus** or **Onshore Power Park Module** in Scotland, as specified in CC.6.3.2 (c), is not at the **Onshore Grid Entry Point** or **Interface Point** in the case of **OTSDUW Plant and Apparatus**, the values of Qmin and Qmax shown in this figure will be as modified by the 33/132kV or 33/275kV or 33/400kV transformer.~~ The enclosed area within points ABCDEFGH is the required capability range within which the **Slope** and **Setpoint Voltage** can be changed.

ECC.A.7.2.2.5 Should the operating point of the ~~**Onshore Non-Synchronous Generating Unit, Onshore DC Converter**,~~ **OTSDUW Plant and Apparatus** or **Onshore Power Park Module**, or Onshore **HVDC** Converter ~~**System** or **Remote End HVDC Converter Station**~~ deviate so that it is no longer a point on the operating characteristic (figure ECC.A.7.2.2a) defined by the target **Setpoint Voltage** and **Slope**, the continuously acting automatic voltage control system shall act progressively to return the value to a point on the required characteristic within 5 seconds.

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ECC.A.7.2.2.6 Should the **Reactive Power** output of the ~~**Onshore Non-Synchronous Generating Unit, Onshore DC Converter,**~~ **OTSDUW Plant and Apparatus** or **Onshore Power Park Module** or **Onshore HVDC Converter** ~~**System** or **Remote End HVDC Converter Station**~~ reach its maximum lagging limit at a **Onshore Grid Entry Point** voltage (or **Onshore User System Entry Point** voltage if **Embedded** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus** ~~or **HVDC Interface Point** voltage in the case of **Remote End HVDC Converter Stations**~~) above 95%, the ~~**Onshore Non-Synchronous Generating Unit, Onshore DC Converter,**~~ **OTSDUW Plant and Apparatus** or **Onshore Power Park Module** or **HVDC System** ~~or **Remote End HVDC Converter Station**~~ shall maintain maximum lagging **Reactive Power** output for voltage reductions down to 95%. This requirement is indicated by the line EF in figures ECC.A.7.2.2b and ECC.A.7.2.2c as applicable. Should the **Reactive Power** output of the ~~**Onshore Non-Synchronous Generating Unit, Onshore DC Converter,**~~ **OTSDUW Plant and Apparatus** or **Onshore Power Park Module**, or **Onshore HVDC Converter** ~~**System** or **Remote End HVDC Converter Station**~~ reach its maximum leading limit at a **Onshore Grid Entry Point** voltage (or **Onshore User System Entry Point** voltage if **Embedded** or **Interface Point** in the case of **OTSDUW Plant and Apparatus**~~, or **HVDC Interface Point** voltage in the case of **Remote End HVDC Converter Stations**~~) below 105%, the ~~**Onshore Non-Synchronous Generating Unit, Onshore DC Converter,**~~ **OTSDUW Plant and Apparatus** or **Onshore Power Park Module**, or **Onshore HVDC Converter** ~~**System** or **Remote End HVDC Converter Station**~~ shall maintain maximum leading **Reactive Power** output for voltage increases up to 105%. This requirement is indicated by the line AB in figures ECC.A.7.2.2b and ECC.A.7.2.2c as applicable.

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ECC.A.7.2.2.7 For Onshore Grid Entry Point voltages (or Onshore User System Entry Point voltages if Embedded-or Interface Point voltages) below 95%, the lagging Reactive Power capability of the ~~Onshore Non-Synchronous Generating Unit, Onshore DC Converter,~~ OTSDUW Plant and Apparatus or Onshore Power Park Module or Onshore HVDC Converters~~Systems (or Remote End HVDC Converter Stations at a HVDC Interface Point)~~ should be that which results from the supply of maximum lagging reactive current whilst ensuring the current remains within design operating limits. An example of the capability is shown by the line DE in figures ECC.A.7.2.2b and ECC.A.7.2.2c. For Onshore Grid Entry Point voltages (or User System Entry Point voltages if Embedded or Interface Point voltages~~ or HVDC Interface Point voltages~~) above 105%, the leading Reactive Power capability of the ~~Onshore Non-Synchronous Generating Unit, Onshore DC Converter,~~ OTSDUW Plant and Apparatus or Onshore Power Park Module or Onshore HVDC System Converter ~~or Remote End DC Converter~~ should be that which results from the supply of maximum leading reactive current whilst ensuring the current remains within design operating limits. An example of the capability is shown by the line AH in figures ECC.A.7.2.2b and ECC.A.7.2.2c as applicable. Should the Reactive Power output of the ~~Onshore Non-Synchronous Generating Unit, Onshore DC Converter,~~ OTSDUW Plant and Apparatus or Onshore Power Park Module or Onshore HVDC Converter~~System or Remote End HVDC Converter Station~~ reach its maximum lagging limit at an Onshore Grid Entry Connection Point voltage (or Onshore User System Entry Point voltage if Embedded or Interface Point in the case of OTSDUW Plant and Apparatus~~ or HVDC Interface Point in the case of a Remote End DC Converter~~) below 95%, the ~~Onshore Non-Synchronous Generating Unit, Onshore DC Converter or~~ Onshore Power Park Module, Onshore HVDC Converter ~~System or Remote End HVDC Converter~~ shall maintain maximum lagging reactive current output for further voltage decreases. Should the Reactive Power output of the ~~Onshore Non-Synchronous Generating Unit, Onshore DC Converter,~~ OTSDUW Plant and Apparatus or Onshore Power Park Module or Onshore HVDC Converter ~~System or Remote End HVDC Converter Station~~ reach its maximum leading limit at a Onshore Grid Entry Point voltage (or User System Entry Point voltage if Embedded or Interface Point voltage in the case of an OTSDUW Plant and Apparatus~~ or HVDC Interface Point Voltage in the case of a Remote End HVDC Converter Stations~~) above 105%, the ~~Onshore Non-Synchronous Generating Unit, Onshore DC Converter,~~ OTSDUW Plant and Apparatus or Onshore Power Park Module or Onshore HVDC~~ System~~ Converter ~~at a DC Converter Station or Remote End DC Converter~~ shall maintain maximum leading reactive current output for further voltage increases.

ECC.A.7.2.2.8 All OTSDUW Plant and Apparatus must be capable of enabling Users undertaking OTSDUW to comply with an instruction received from NGET relating to a variation of the Setpoint Voltage at the Interface Point within 2 minutes of such instruction being received.

ECC.A.7.2.2.9 For OTSDUW Plant and Apparatus connected to a Network Operator's System where the Network Operator has confirmed to NGET that its System is restricted in accordance with ECC.A.7.2.1, clause ECC.A.7.2.2.8 will not apply unless NGET can reasonably demonstrate that the magnitude of the available change in Reactive Power has a significant effect on voltage levels on the Onshore National Electricity Transmission System.

ECC.A.7.2.3 Transient Voltage Control

ECC.A.7.2.3.1 For an on-load step change in Onshore Grid Entry Point or Onshore User System Entry Point voltage, or in the case of OTSDUW Plant and Apparatus an on-load step change in Transmission Interface Point voltage, ~~or in the case of Remote End HVDC Converter Stations an on-load step change in HVDC Interface Point voltage~~, the continuously acting automatic control system shall respond according to the following minimum criteria:

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(i) the **Reactive Power** output response of the ~~**Onshore Non-Synchronous Generating Unit, Onshore DC Converter,**~~ **OTSDUW Plant and Apparatus** or **Onshore Power Park Module** or Onshore **HVDC** ~~Converter~~**System** ~~or **Remote End HVDC Converter Station**~~ shall commence within 0.2 seconds of the application of the step. It shall progress linearly although variations from a linear characteristic shall be acceptable provided that the MVAr seconds delivered at any time up to 1 second are at least those that would result from the response shown in figure ECC.A.7.2.3.1a.

(ii) the response shall be such that 90% of the change in the **Reactive Power** output of the ~~**Onshore Non-Synchronous Generating Unit, Onshore DC Converter,**~~ **OTSDUW Plant and Apparatus** or **Onshore Power Park Module**, or Onshore **HVDC** Converter ~~**System**~~ ~~or **Remote End HVDC Converter Station**~~ will be achieved within

- 2 seconds, where the step is sufficiently large to require a change in the steady state **Reactive Power** output from its maximum leading value to its maximum lagging value or vice versa and

- 1 second where the step is sufficiently large to require a change in the steady state **Reactive Power** output from zero to its maximum leading value or maximum lagging value as required by ECC.6.3.2 (or, if appropriate ECC.A.7.2.2.6 or ECC.A.7.2.2.7);

(iii) the magnitude of the **Reactive Power** output response produced within 1 second shall vary linearly in proportion to the magnitude of the step change.

(iv) within ~~2~~ 5 seconds from achieving 90% of the response as defined in ECC.A.7.2.3.1 (ii), the peak to peak magnitude of any oscillations shall be less than 5% of the change in steady state maximum **Reactive Power**.

(v) following the transient response, the conditions of ECC.A.7.2.2 apply.

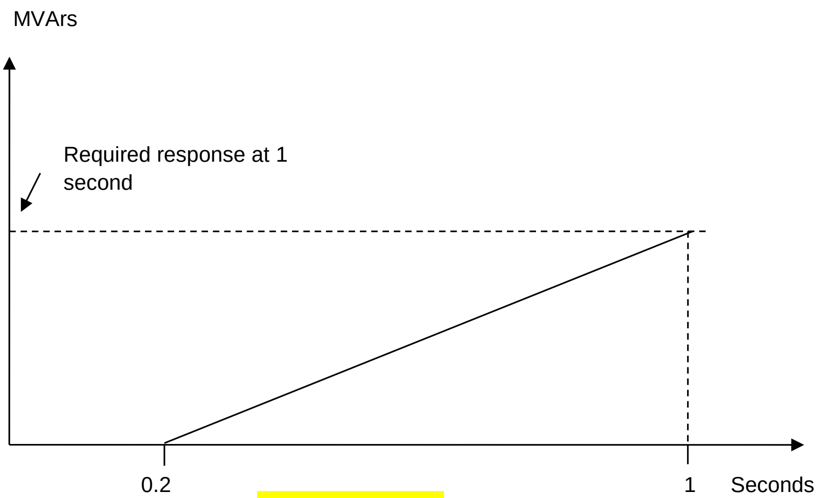

Figure ECC.A.7.2.3.1a

ECC.A.7.2.3.2 An ~~**Onshore Non-Synchronous Generating Unit, Onshore DC Converter,**~~ **OTSDUW Plant and Apparatus** or **Onshore Power Park Modules** or Onshore **HVDC** Converters ~~**Systems** or **Remote End HVDC Converter Stations**~~ shall be capable of

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(a) changing its **Reactive Power** output from its maximum lagging value to its maximum leading value, or vice versa, then reverting back to the initial level of **Reactive Power** output once every 15 seconds for at least 5 times within any 5 minute period; and

(b) changing its **Reactive Power** output from zero to its maximum leading value then reverting back to zero **Reactive Power** output at least 25 times within any 24 hour period and from zero to its maximum lagging value then reverting back to zero **Reactive Power** output at least 25 times within any 24 hour period. Any subsequent restriction on reactive capability shall be notified to **NGET** in accordance with BC2.5.3.2, and BC2.6.1.

In all cases, the response shall be in accordance to ECC.A.7.2.3.1 where the change in **Reactive Power** output is in response to an on-load step change in **Onshore Grid Entry Point** or **Onshore User System Entry Point** voltage, or in the case of **OTSDUW Plant and Apparatus** an on-load step change in **Transmission Interface Point** voltage ~~or in the case of **Remote End HVDC Converter Stations** an on-load step change in **HVDC Interface Point** voltage~~.

ECC.A.7.2.4 Power Oscillation Damping

ECC.A.7.2.4.1 The requirement for the continuously acting voltage control system to be fitted with a **Power System Stabiliser (PSS)** shall be specified if, in **NGET's** view, this is required for system reasons. However if a **Power System Stabiliser** is included in the voltage control system its settings and performance shall be agreed with **NGET** and commissioned in accordance with BC2.11.2. To allow assessment of the performance before on-load commissioning the **Generator** will provide to **NGET** a report covering the areas specified in ECP.A.3.2.2.

ECC.A.7.2.5 Overall Voltage Control System Characteristics

ECC.A.7.2.5.1 The continuously acting automatic voltage control system is required to respond to minor variations, steps, gradual changes or major variations in **Onshore Grid Entry Point** voltage (or **Onshore User System Entry Point** voltage if **Embedded** or **Interface Point** voltage in the case of **OTSDUW Plant and Apparatus** ~~or **HVDC Interface Point** voltage in the case of **Remote End HVDC Converter Stations**~~).

ECC.A.7.2.5.2 The overall voltage control system shall include elements that limit the bandwidth of the output signal. The bandwidth limiting must be consistent with the speed of response requirements and ensure that the highest frequency of response cannot excite torsional oscillations on other plant connected to the network. A bandwidth of 0-5Hz would be judged to be acceptable for this application. All other control systems employed within the ~~**Onshore Non-Synchronous Generating Unit**, **Onshore DC Converter**~~, **OTSDUW Plant and Apparatus** or **Onshore Power Park Module** or Onshore **HVDC** Converter~~**System** or **Remote End HVDC Converter Station**~~ should also meet this requirement

ECC.A.7.2.5.3 The response of the voltage control system (including the **Power System Stabiliser** if employed) shall be demonstrated by testing in accordance with ECP XXX~~OC5A.A.3~~.

ECC.A.7.3 **Reactive Power** Control

ECC.A.7.3.1 As defined in ECC.6.3.8.3.4, **Reactive Power** control mode of operation is not required in respect of **Onshore Power Park Modules** or **OTSDUW Plant and Apparatus** or Onshore **HVDC** Converters ~~**Systems** or **Remote End HVDC Converter Stations**~~ unless otherwise specified by **NGET** in coordination with the relevant **Network Operator**. However where there is a requirement for **Reactive Power** control mode of operation, the following requirements shall apply.

ECC.A.7.3.2 The **Onshore** **Power Park Module** or **OTSDUW Plant and Apparatus** or **Onshore HVDC Converter** ~~**Systems** or **Remote End HVDC Converter Stations**~~ shall be capable of setting the **Reactive Power** setpoint anywhere in the **Reactive Power** range as specified in ECC.6.3.2.6 with setting steps no greater than 5 MVAr or 5% (whichever is smaller) of full **Reactive Power**, controlling the reactive power at the **Grid Entry Point** or **User System Entry Point** if **Embedded** ~~or **HVDC Interface Point** in the case of a **Remote End HVDC Converter Stations**~~ to an accuracy within plus or minus 5MVAr or plus or minus 5% (whichever is smaller) of the full **Reactive Power**.

ECC.A.7.3.3 Any additional requirements for **Reactive Power** control mode of operation shall be specified by **NGET** in coordination with the relevant **Network Operator**..

ECC.A.7.4 **Power Factor** Control

ECC.A.7.4.1 As defined in ECC.6.3.8.4.3, **Power Factor** control mode of operation is not required in respect of **Onshore Power Park Modules** or **OTSDUW Plant and Apparatus** or **Onshore HVDC Converters**~~**Systems**~~ ~~or **Remote End HVDC Converter Stations**~~ unless otherwise specified by **NGET** in coordination with the relevant **Network Operator.** ~~,~~ However where there is a requirement for **Power Factor** control mode of operation, the following requirements shall apply.

ECC.A.7.4.2 The **Onshore** **Power Park Module** or **OTSDUW Plant and Apparatus** or **Onshore HVDC Converter** ~~**System** or **Remote End HVDC Converter Station**~~ shall be capable of controlling the **Power Factor** at the **Grid Entry Point or User System Entry Point** (if **Embedded**)~~or **HVDC Interface Point** in the case of a **Remote End HVDC Converter Stations**)~~ within the required **Reactive Power** range as specified in ECC.6.3.2.2.1 and ECC.6.3.2.4 ~~with~~ to a specified target **Power Factor** ~~in steps no greater than 0.01~~. **NGET** shall specify the target **Power Factor** value (which shall be achieved within 0.01 of the set **Power Factor**), its tolerance and the period of time to achieve the target **Power Factor** following a sudden change of **Active Power** output. The tolerance of the target **Power Factor** shall be expressed through the tolerance of its corresponding **Reactive Power**. This **Reactive Power** tolerance shall be expressed by either an absolute value or by a percentage of the maximum **Reactive Power** of the **Onshore Power Park Module** or **OTSDUW Plant and Apparatus** or **Onshore HVDC** ~~**Remote End DC**~~ **Converter**. The details of these requirements being pursuant to the terms of the **Bilateral Agreement**.

ECC.A.7.4.3 Any additional requirements for **Power Factor** control mode of operation shall be specified by **NGET** in coordination with the relevant **Network Operator**.

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APPENDIX E8 - PERFORMANCE REQUIREMENTS FOR CONTINUOUSLY ACTING AUTOMATIC VOLTAGE CONTROL SYSTEMS FOR CONFIGURATION 2 AC CONNECTED OFFSHORE POWER PARK MODULES AND DC CONNECTED POWER PARK MODULES

ECC.A.8.1 Scope

ECC.A.8.1.1 This Appendix sets out the performance requirements of continuously acting automatic voltage control systems for **Configuration 2 AC connected Offshore Power Park Modules** that must be complied with by the **User**. This Appendix does not limit any site specific requirements that may be specified where in **NGET's** reasonable opinion these facilities are necessary for system reasons.

ECC.A.8.1.2 These requirements also apply to **DC Connected Power Park Modules**. In the case of a **Configuration 1 DC Connected Power Park Module** the technical performance requirements shall be specified by **NGET**. Where the **Generator in respect of a DC Connected Power Park Module** has agreed to a wider reactive capability range as defined under ECC.6.3.2.7.3 then the requirements that apply will be specified by **NGET** and which shall reflect the performance requirements detailed in ECC.A.8.2 below but with different parameters such as droop and **Setpoint Voltage**.

ECC.A.8.1.3~~2~~ Proposals by **Generators** to make a change to the voltage control systems are required to be notified to **NGET** under the **Planning Code** (PC.A.1.2(b) and (c)) as soon as the **Generator** anticipates making the change. The change may require a revision to the **Bilateral Agreement**.

ECC.A.8.2 Requirements

ECC.A.8.2.1 **NGET** requires that the continuously acting automatic voltage control system for the **Configuration 2 AC connected Offshore Power Park Module** and **Configuration 2 DC Connected Power Park Module** shall meet the following functional performance specification.

ECC.A.8.2.2 Steady State Voltage Control

ECC.A.8.2.2.1 The **Configuration 2 AC connected Offshore Power Park Module** and **Configuration 2 DC Connected Power Park Module** shall provide continuous steady state control of the voltage at the **Offshore Connection Point** with a **Setpoint Voltage** and **Slope** characteristic as illustrated in Figure ECC.A.8.2.2a.

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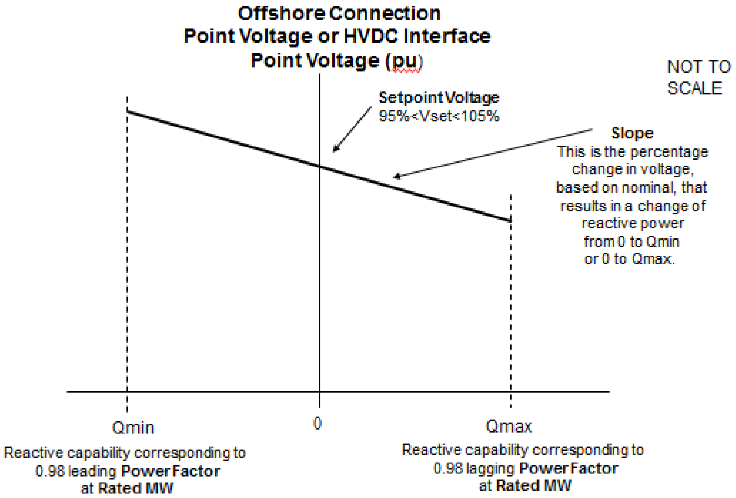

Figure ECC.A.8.2.2a

ECC.A.8.2.2.2 The continuously acting automatic control system shall be capable of operating to a **Setpoint Voltage** between 95% and 105% with a resolution of 0.25% of the nominal voltage. For the avoidance of doubt values of 95%, 95.25%, 95.5% … may be specified, but not intermediate values. The initial **Setpoint Voltage** will be 100%. The tolerance within which this **Setpoint Voltage** shall be achieved is specified in BC2.A.2.6. For the avoidance of doubt, with a tolerance of 0.25% and a Setpoint Voltage of 100%, the achieved value shall be between 99.75% and 100.25%. **NGET** may request the **Generator** to implement an alternative **Setpoint Voltage** within the range of 95% to 105%.

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ECC.A.8.2.2.3 The **Slope** characteristic of the continuously acting automatic control system shall be adjustable over the range 2% to 7% (with a resolution of 0.5%). For the avoidance of doubt values of 2%, 2.5%, 3% may be specified, but not intermediate values. The initial **Slope** setting will be 4%. The tolerance within which this **Slope** shall be achieved is specified in BC2.A.2.6. For the avoidance of doubt, with a tolerance of 0.5% and a **Slope** setting of 4%, the achieved value shall be between 3.5% and 4.5%. **NGET** may request the **Generator** to implement an alternative slope setting within the range of 2% to 7%.

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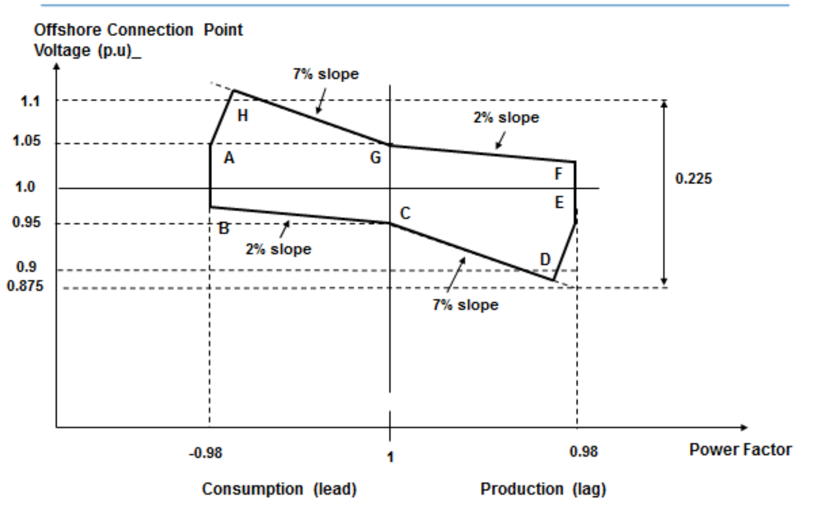

Figure ECC.A.8.2.2b

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ECC.A.8.2.2.4 Figure ECC.A.8.2.2b shows the required envelope of operation for **Configuration 2 AC connected Offshore Power Park Module** and **Configuration 2 DC Connected Power Park Module.** The enclosed area within points ABCDEFGH is the required capability range within which the **Slope** and **Setpoint Voltage** can be changed.

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ECC.A.8.2.2.5 Should the operating point of the **Configuration 2 AC connected Offshore Power Park or Configuration 2 DC Connected Power Park Module** deviate so that it is no longer a point on the operating characteristic (Figure ECC.A.8.2.2a) defined by the target **Setpoint Voltage** and **Slope**, the continuously acting automatic voltage control system shall act progressively to return the value to a point on the required characteristic within 5 seconds.

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ECC.A.8.2.2.6 Should the **Reactive Power** output of the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** reach its maximum lagging limit at an **Offshore Grid Entry Point** or **Offshore User System Entry Point** or **HVDC Interface Point** voltage above 95%, the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** shall maintain maximum lagging **Reactive Power** output for voltage reductions down to 95%. This requirement is indicated by the line EF in figure ECC.A.8.2.2b. Should the **Reactive Power** output of the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** reach its maximum leading limit at the **Offshore Grid Entry Point** or **Offshore User System Entry Point** or **HVDC Interface Point** voltage below 105%, the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** shall maintain maximum leading **Reactive Power** output for voltage increases up to 105%. This requirement is indicated by the line AB in figures ECC.A.8~~7~~.2.2b.

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ECC.A.8.2.2.7 For **Offshore Grid Entry Point** or **User System Entry Point** or **HVDC Interface Point** voltages below 95%, the lagging **Reactive Power** capability of the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** should be that which results from the supply of maximum lagging reactive current whilst ensuring the current remains within design operating limits. An example of the capability is shown by the line DE in figures ECC.A.8.2.2b. For **Offshore Grid Entry Point** or **Offshore User System Entry Point** voltages or **HVDC Interface Point** voltages above 105%, the leading **Reactive Power** capability of the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** should be that which results from the supply of maximum leading reactive current whilst ensuring the current remains within design operating limits. An example of the capability is shown by the line AH in figures ECC.A.8.2.2b. Should the **Reactive Power** output of the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** reach its maximum lagging limit at an **Offshore Grid Entry Point** or **Offshore User System Entry** voltage or **HVDC Interface Point** voltage below 95%, the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** shall maintain maximum lagging reactive current output for further voltage decreases. Should the **Reactive Power** output of the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** reach its maximum leading limit at an **Offshore Grid Entry Point** or **Offshore User System Entry** voltage or **HVDC Interface Point** voltage above 105%, the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** shall maintain maximum leading reactive current output for further voltage increases.

ECC.A.8.2.3 <u>Transient Voltage Control</u>

ECC.A.8.2.3.1 For an on-load step change in **Offshore Grid Entry Point** or **Offshore User System Entry Point** voltage or **HVDC Interface Point** voltage, the continuously acting automatic control system shall respond according to the following minimum criteria:

(i) the **Reactive Power** output response of the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** shall commence within 0.2 seconds of the application of the step. It shall progress linearly although variations from a linear characteristic shall be acceptable provided that the MVAr seconds delivered at any time up to 1 second are at least those that would result from the response shown in figure ECC.A.8.2.3.1a.

(ii) the response shall be such that 90% of the change in the **Reactive Power** output of the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** will be achieved within

– 2 seconds, where the step is sufficiently large to require a change in the steady state **Reactive Power** output from its maximum leading value to its maximum lagging value or vice versa and

– 1 second where the step is sufficiently large to require a change in the steady state **Reactive Power** output from zero to its maximum leading value or maximum lagging value as required by ECC.6.3.2 (or, if appropriate ECC.A.8.2.2.6 or ECC.A.8.2.2.7);

(iii) the magnitude of the **Reactive Power** output response produced within 1 second shall vary linearly in proportion to the magnitude of the step change.

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(iv) within 5 seconds from achieving 90% of the response as defined in ECC.A.8.2.3.1 (ii), the peak to peak magnitude of any oscillations shall be less than 5% of the change in steady state maximum **Reactive Power**.

(v) following the transient response, the conditions of ECC.A.8.2.2 apply.

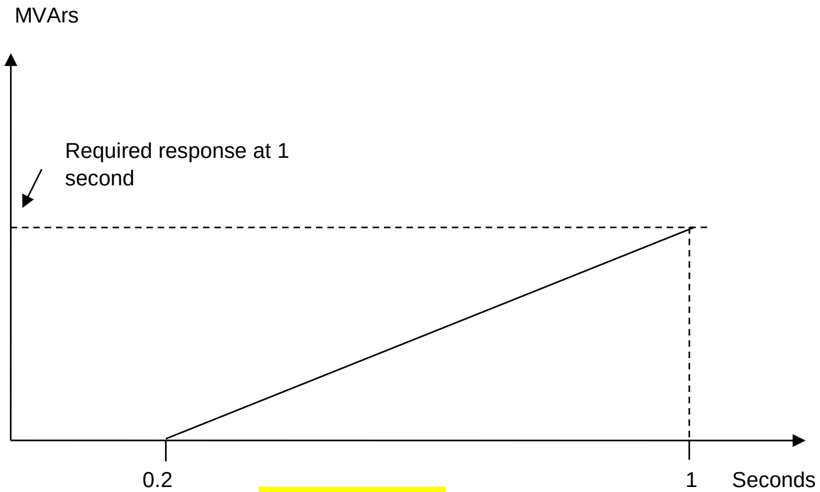

Figure ECC.A.8.2.3.1a

ECC.A.8.2.3.2 **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** shall be capable of

(a) changing their **Reactive Power** output from maximum lagging value to maximum leading value, or vice versa, then reverting back to the initial level of **Reactive Power** output once every 15 seconds for at least 5 times within any 5 minute period; and

(b) changing **Reactive Power** output from zero to maximum leading value then reverting back to zero **Reactive Power** output at least 25 times within any 24 hour period and from zero to its maximum lagging value then reverting back to zero **Reactive Power** output at least 25 times within any 24 hour period. Any subsequent restriction on reactive capability shall be notified to **NGET** in accordance with BC2.5.3.2, and BC2.6.1.

In all cases, the response shall be in accordance to ECC.A.8.2.3.1 where the change in **Reactive Power** output is in response to an on-load step change in **Offshore Grid Entry Point** or **Offshore User System Entry Point** voltage or **HVDC Interface Point** voltage.

ECC.A.8.2.4 Power Oscillation Damping

ECC.A.8.2.4.1 The requirement for the continuously acting voltage control system to be fitted with a **Power System Stabiliser (PSS)** shall be specified if, in **NGET's** view, this is required for system reasons. However if a **Power System Stabiliser** is included in the voltage control system its settings and performance shall be agreed with **NGET** and commissioned in accordance with BC2.11.2. To allow assessment of the performance before on-load commissioning the **Generator** or **HVDC System Owner** will provide to **NGET** a report covering the areas specified in ECPXXXXCP.A.3.2.2.

ECC.A.8.2.5 Overall Voltage Control System Characteristics

ECC.A.8.2.5.1 The continuously acting automatic voltage control system is required to respond to minor variations, steps, gradual changes or major variations in **Offshore Grid Entry Point** or **Offshore User System Entry Point** or **HVDC Interface Point** voltage.

ECC.A.8.2.5.2 The overall voltage control system shall include elements that limit the bandwidth of the output signal. The bandwidth limiting must be consistent with the speed of response requirements and ensure that the highest frequency of response cannot excite torsional oscillations on other plant connected to the network. A bandwidth of 0-5Hz would be judged to be acceptable for this application. All other control systems employed within the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module** should also meet this requirement

ECC.A.8.2.5.3 The response of the voltage control system (including the **Power System Stabiliser** if employed) shall be demonstrated by testing in accordance with OC5A.A.3.

ECC.A.8.3 **Reactive Power** Control

ECC.A.8.3.1 **Reactive Power** control mode of operation is not required in respect of **Configuration 2 AC connected Offshore Power Park Modules** or **Configuration 2 DC Connected Power Park Modules** unless otherwise specified by **NGET**. However where there is a requirement for **Reactive Power** control mode of operation, the following requirements shall apply.

ECC.A.8.3.2 **Configuration 2 AC connected Offshore Power Park Modules** or **Configuration 2 DC Connected Power Park Modules** shall be capable of setting the **Reactive Power** setpoint anywhere in the **Reactive Power** range as specified in ECC.6.3.2.8.2 with setting steps no greater than 5 MVAr or 5% (whichever is smaller) of full **Reactive Power**, controlling the reactive power at the **Offshore Grid Entry Point or Offshore User System Entry Point** or **HVDC Interface Point** to an accuracy within plus or minus 5MVAr or plus or minus 5% (whichever is smaller) of the full **Reactive Power**.

ECC.A.8.3.3 Any additional requirements for **Reactive Power** control mode of operation shall be specified by **NGET**.

ECC.A.8.4 **Power Factor** Control

ECC.A.8.4.1 **Power Factor** control mode of operation is not required in respect of **Configuration 2 AC connected Offshore Power Park Modules** or **Configuration 2 DC Connected Power Park Modules** unless otherwise specified by **NGET**. However where there is a requirement for **Power Factor** control mode of operation, the following requirements shall apply.

ECC.A.8.4.2 **Configuration 2 AC connected Offshore Power Park Modules** or **Configuration 2 DC Connected Power Park Modules** shall be capable of controlling the **Power Factor** at the **Offshore Grid Entry Point** or **Offshore User System Entry Point** or **HVDC Interface**

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Point within the required **Reactive Power** range as specified in ECC.6.3.2.8.2 with a target **Power Factor**. **NGET** shall specify the target **Power Factor** (which shall be achieved to within 0.01 of the set **Power Factor**), its tolerance and the period of time to achieve the target **Power Factor** following a sudden change of **Active Power** output. The tolerance of the target **Power Factor** shall be expressed through the tolerance of its corresponding **Reactive Power**. This **Reactive Power** tolerance shall be expressed by either an absolute value or by a percentage of the maximum **Reactive Power** of the **Configuration 2 AC connected Offshore Power Park Module** or **Configuration 2 DC Connected Power Park Module.** The details of these requirements being specified by **NGET**.

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ECC.A.8.4.3 Any additional requirements for **Power Factor** control mode of operation shall be specified by **NGET**.

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