PROPOSED GC0100 - 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.6.3.15 FAULT RIDE THROUGH

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ECC.6.3.15.1 General **Fault Ride Through** requirements, principles and concepts applicable to **Type B**, **Type C** and **Type D Power Generating Modules** and **OTSDUW Plant and Apparatus** subject to faults up to 140ms in duration.

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ECC.6.3.15.1.1 ECC.6.3.15.1 – 6.3.15.8 section sets out the **Fault Ride Through** requirements on **Type B**, **Type C** and **Type D Power Generating Modules**, **OTSDUW Plant and Apparatus** and **HVDC Equipment** that shall apply in the event of a fault lasting up to 140ms in duration.

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ECC.6.3.15.1.2 Each **Power Generating Module**, **Power Park Module**, **HVDC Equipment** and **OTSDUW Plant and Apparatus** is required to remain connected and stable for any balanced and unbalanced fault where the voltage at the **Grid Entry Point** or **User System Entry Point** or (**HVDC Interface Point** in the case of **Remote End DC Converter Stations** or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) remains on or above the heavy black line shown in sections ECC.6.3.15.4 – ECC.6.3.15.10 F~~igures~~ below.

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ECC.6.3.15.1.3 The voltage against time curves defined in ECC.6.3.15.2 – ECC.6.3.15.6 expresses the lower limit (expressed as the ratio of its actual value and its reference 1pu) of the actual course of the phase to phase voltage (or phase to earth voltage in the case of asymmetrical/unbalanced faults) on the **System** voltage level at the **Grid Entry Point** or **User System Entry Point** (or **HVDC Interface Point** in the case of **Remote End HVDC Converter Stations** or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) during a symmetrical or asymmetrical/unbalanced fault, as a function of time before, during and after the fault. For the purposes of this section of the Grid Code, the term voltage is considered to be the positive phase sequence root mean square voltage that would be measured at the **Grid Entry Point** or **User System Entry Point** during a **System** fault or disturbed condition.

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ECC.6.3.15.2 Voltage against time curve and parameters applicable to **Type B Synchronous Power Generating Modules**

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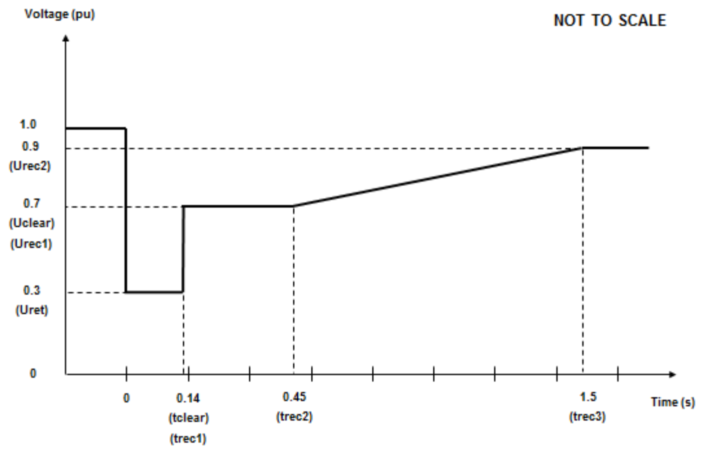

Figure 15.1~~X~~ - Voltage against time curve applicable to **Type B Synchronous Power Generating Modules**

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Voltage parameters (pu)		Time parameters (seconds)	
Uret	0.3	tclear	0.14
Uclear	0.7	trec1	0.14
Urec1	0.7	trec2	0.45

Urec2	0.9	trec3	1.5

Table 15.1~~X~~ Voltage against time parameters applicable to **Type B Synchronous Power Generating Modules**

ECC.6.3.15.3 Voltage against time curve and parameters applicable to **Type C** and **D Synchronous Power Generating Modules** connected below 110kV

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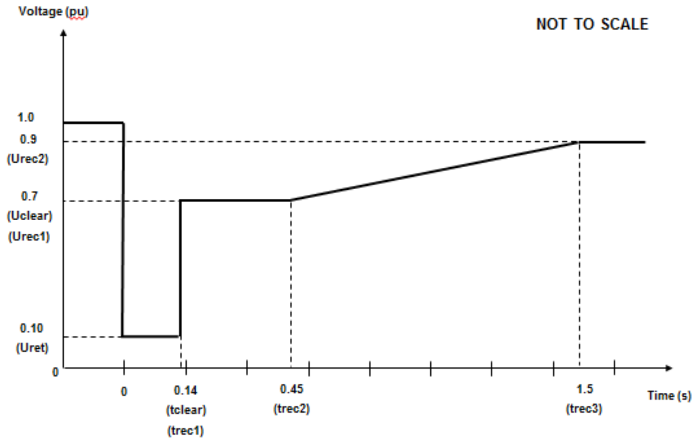

Figure 15.3~~X~~ - Voltage against time curve applicable to **Type C** and **D Synchronous Power Generating Modules** connected below 110kV

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Voltage parameters (pu)		Time parameters (seconds)	
Uret	0.1	tclear	0.14
Uclear	0.7	trec1	0.14
Urec1	0.7	trec2	0.45
Urec2	0.9	trec3	1.5

Table 15.3~~X~~ Voltage against time parameters applicable to **Type C** and **D Synchronous Power Generating Modules** connected below 110kV

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ECC.6.3.15.4 Voltage against time curve and parameters applicable to **Type D Synchronous Power Generating Modules** connected at or above 110kV

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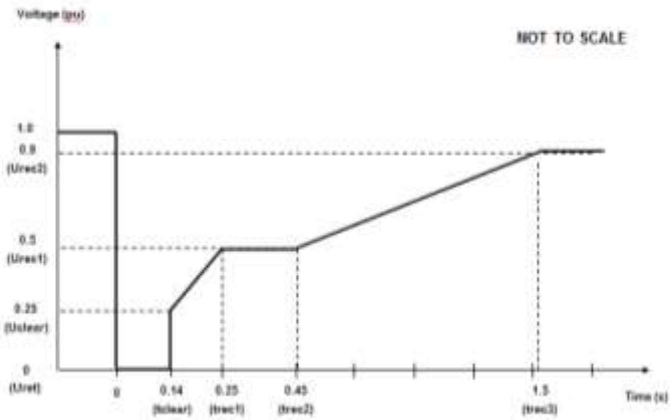

Figure 15.4~~X~~ - Voltage against time curve applicable to **Type D Synchronous Power Generating Modules** connected at or above 110kV

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Voltage parameters (pu)		Time parameters (seconds)	
Uret	0	tclear	0.14
Uclear	0.25	trec1	0.25
Urec1	0.5	trec2	0.45
Urec2	0.9	trec3	1.5

Table 15.4~~X~~ Voltage against time parameters applicable to **Type D Synchronous Power Generating Modules** connected at or above 110kV

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ECC.6.3.15.5 Voltage against time curve and parameters applicable to **Type B, C** and **D Power Park Modules** connected below 110kV

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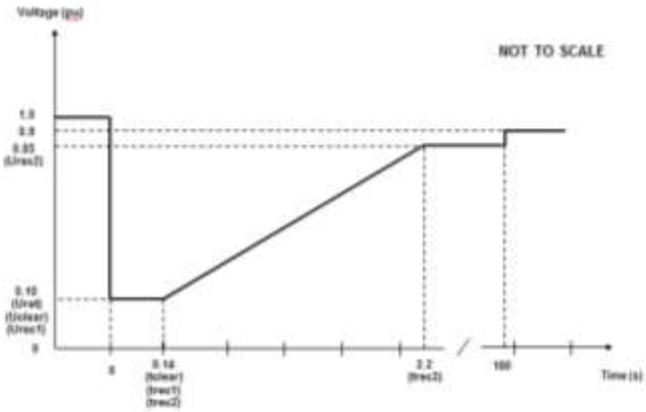

Figure 5.5~~X~~ - Voltage against time curve applicable to **Type B**, **C** and **D Power Park Modules** connected below 110kV

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Voltage parameters (pu)		Time parameters (seconds)	
Uret	0.10	tclear	0.14
Uclear	0.10	trec1	0.14
Urec1	0.10	trec2	0.14
Urec2	0.85	trec3	2.2

Table 5.5~~X~~ Voltage against time parameters applicable to **Type B**, **C** and **D Power Park Modules** connected below 110kV

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ECC.6.3.15.6 Voltage against time curve and parameters applicable to **Type D Power Park Modules** with a **Grid Entry~~Connection~~ Point** or **User System Entry Point** at or above 110kV, **DC Connected Power Park Modules** at the **HVDC Interface Point** or **OTSDUW Plant and Apparatus** at the **Interface Point**.

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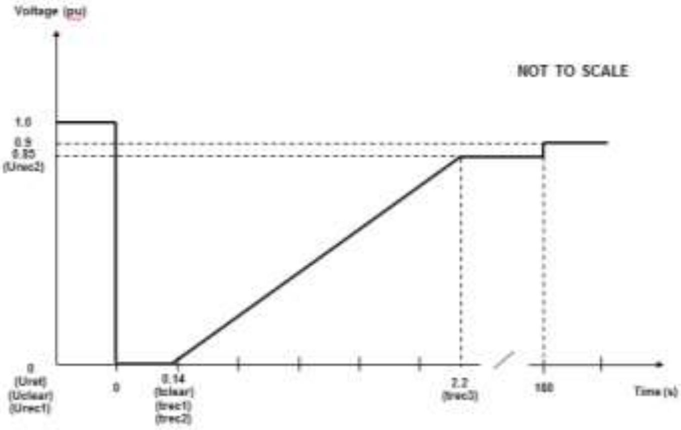

Figure 15.6~~X~~ - Voltage against time curve applicable to ~~a~~ **Type D Power Park Modules** with a **Grid Entry Point** or **User System Entry** ~~**Connection**~~ **Point** at or above 110kV, **DC Connected Power Park Modules** at the **HVDC Interface Point** or **OTSDUW Plant and Apparatus** at the **Interface Point**.

Voltage parameters (pu)		Time parameters (seconds)	
Uret	0	tclear	0.14
Uclear	0	trec1	0.14
Urec1	0	trec2	0.14
Urec2	0.85	trec3	2.2

Table 15.6~~X~~ Voltage against time parameters applicable to a **Type D Power Park Modules** with a **Grid Entry Point** or **User System Entry** ~~**Connection**~~ **Point** at or above 110kV, **DC Connected Power Park Modules** at the **HVDC Interface Point** or **OTSDUW Plant and Apparatus** at the **Interface Point**.

ECC.6.3.15.7 Voltage against time curve and parameters applicable to **HVDC Systems** and **Remote End HVDC Converter Stations**

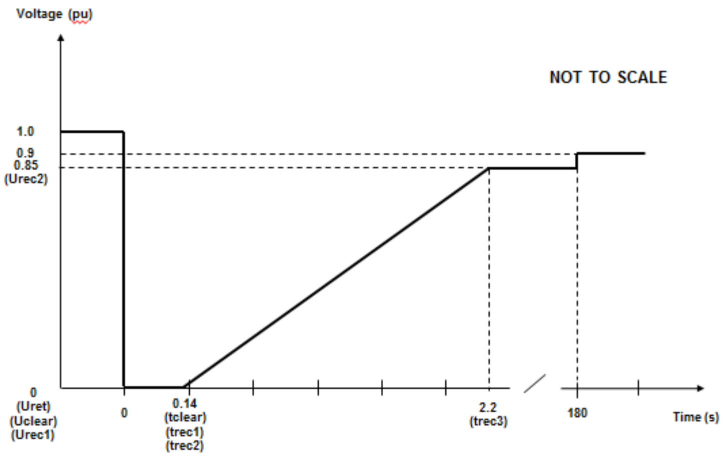

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Figure 15.7~~X~~ - Voltage against time curves applicable to **HVDC Systems** and **Remote End HVDC Converter Stations**~~.~~

Voltage parameters (pu)		Time parameters (seconds)	
Uret	0	tclear	0.14
Uclear	0	trec1	0.14
Urec1	0	trec2	0.14
Urec2	0.85	trec3	2.2

Table 15.7~~X~~ Voltage against time parameters applicable to **HVDC Systems** and **Remote End HVDC Converter Stations**

ECC.6.3.15.8. In addition to the requirements in ECC.6.3.15.1 – ECC.6.3.15.7:

(i) Each **Type B**, **Type C** and **Type D Power Generating Module** at the **Grid Entry Point** or **User System Entry Point**, **HVDC Equipment** (or **OTSDUW Plant and Apparatus** at the **Interface Point**) shall be capable of satisfying the above requirements when operating at **Rated MW** output and maximum leading **Power Factor**.

(ii) **NGET** will specify upon request by the **User** the pre-fault and post fault short circuit capacity (in MVA) at the **Grid Entry Point** or **User System Entry Point** (or **HVDC Interface Point** in the case of a remote end **HVDC Converter Stations** or **Interface Point** in the case of **OTSDUW Plant and Apparatus**).

(iii) The pre-fault voltage shall be taken to be 1.0pu and the post fault voltage shall not be less than 0.9pu.

(iv) To allow a **User** to model the **Fault Ride Through** performance of its **Type B**, **Type C** and **Type D Power Generating Modules** or **HVDC Equipment**, **NGET** will provide additional network data as may reasonably be required by the **User** to undertake such study work in accordance with PC.A.8. Alternatively, **NGET** may provide generic values derived from typical cases.

(v) **NGET** will publish fault level data under maximum and minimum demand conditions in the **Electricity Ten Year Statement**.

(v) Each **Generator** (in respect of **Type B**, **Type C**, **Type D Power Generating Modules** and **DC Connected Power Park Modules**) and **HVDC** ~~**Converter Station**~~**System Owners** (in respect of **HVDC Systems**) shall satisfy the requirements in ECC.6.3.15.8(i) – (iv) unless the protection schemes and settings for internal electrical faults trips ~~-~~the **Type B**, **Type C** and **Type D Power Generating Module, HVDC Equipment** (or **OTSDUW Plant and Apparatus**) from the **System**~~network~~. The protection schemes and settings should not jeopardise **Fault Ride Through** performance as specified in ECC.6.3.15.8(i) – (iv). The undervoltage protection at the **Grid Entry Point** or **User System Entry Point** (or **HVDC Interface Point** in the case of a **Remote End HVDC Converter Stations** or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) shall be set by the **Generator** (or **HVDC** ~~**Converter Station**~~**System Owner** or **OTSDUA** in the case of **OTSDUW Plant and Apparatus**) according to the widest possible range unless **NGET** and the **User** have agreed to narrower settings. All protection settings associated with undervoltage protection shall be agreed between the **Generator** and/or **HVDC System Owner** with **NGET** and **Relevant Transmission Licensee's** and r~~R~~elevant **Network Operator** (as applicable).

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Comment [A1]: TBC that this can be done - Note as of 19/10/2017 - Under the ten year statement we only publically provide the maximum fault level values not minumum. This requires further National Grid discussion

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(vi) Each **Type B**, **Type C** and **Type D Power Generating Module**, **HVDC** **System**~~**Equipment**~~ and **OTSDUW Plant and Apparatus** at the **Interface Point** shall be designed such that upon clearance of the fault on the **Onshore Transmission System** and within 0.5 seconds of restoration of the voltage at the **Grid Entry Point** or **User System Entry Point** or **HVDC Interface Point** in the case of a **Remote End HVDC Converter Stations** or **Interface Point** in the case of **OTSDUW Plant and Apparatus** to 90% of nominal voltage or greater, **Active Power** output (or **Active Power** transfer capability in the case of **OTSDW Plant and Apparatus** or **Remote End HVDC Converter Stations**) shall be restored to at least 90% of the level immediately before the fault. Once **Active Power** output (or **Active Power** transfer capability in the case of **OTSDUW Plant and Apparatus** or **Remote End HVDC Converter Stations**) has been restored to the required level, **Active Power** oscillations shall be acceptable provided that:

- The total **Active Energy** delivered during the period of the oscillations is at least that which would have been delivered if the **Active Power** was constant
- The oscillations are adequately damped.

For AC Connected **Onshore** and **Offshore Power Park Modules** ~~**Plant and Apparatus** installed on or after 1 December 2017,~~ comprising switched reactive compensation equipment (such as mechanically switched capacitors and reactors), such switched reactive compensation equipment shall be controlled such that it is not switched in or out of service during the fault but may act to assist in post fault voltage recovery.

ECC.6.3.15.9 General **Fault Ride Through** requirements for faults in excess of 140ms in duration.

ECC.6.3.15.9.1 General **Fault Ride Through** requirements applicable to **HVDC Equipment** and **OTSDUW DC Converters** subject to faults and voltage dips in excess of 140ms.

ECC.6.3.15.9.1.1 The requirements applicable to **HVDC Equipment** including **OTSDUW DC Converters** subject to faults and voltage disturbances at the **Grid Entry Point** or **User System Entry Point** or **Interface Point** or **HVDC Interface Point**, including **Active Power** transfer capability shall be specified in the **Bilateral Agreement**.

ECC.6.3.15.9.2 **Fault Ride Through** requirements for **Type C** and **Type D Synchronous Power Generating Modules** and **Type C** and **Type D Power Park Modules** and **OTSDUW Plant and Apparatus** subject to faults and voltage disturbances on the **Onshore Transmission System** in excess of 140ms

ECC.6.3.15.9.2.1 The **Fault Ride Through** requirements for **Type C** and **Type D Synchronous Power Generating Modules** subject to faults and voltage disturbances on the **Onshore Transmission System** in excess of 140ms are defined in ECC.6.3.15.9.2.1(a) and the **Fault Ride Through Requirements** for **Power Park Modules** and **OTSDUW Plant and Apparatus** subject to faults and voltage disturbances on the **Onshore Transmission System** greater than 140ms in duration are defined in ECC.6.3.15.9.2.1(b).

(a) Requirements applicable to **Synchronous Power Generating Modules** subject to **Supergrid Voltage** dips on the **Onshore Transmission System** greater than 140ms in duration.

In addition to the requirements of ECC.6.3.15.1 – ECC.6.3.15.8 each **Synchronous Power Generating Module** shall:

(i) remain transiently stable and connected to the **System** without tripping of any **Synchronous Power Generating Module** for balanced **Supergrid Voltage** dips and associated durations on the **Onshore Transmission System** (which could be at the **Interface Point**) anywhere on or above the heavy black line shown in Figure

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15.9(a). Appendix E4 and Figures EA.4.3.2 (a), (b) and (c) provide an explanation and illustrations of Figure 15.9(a); and,

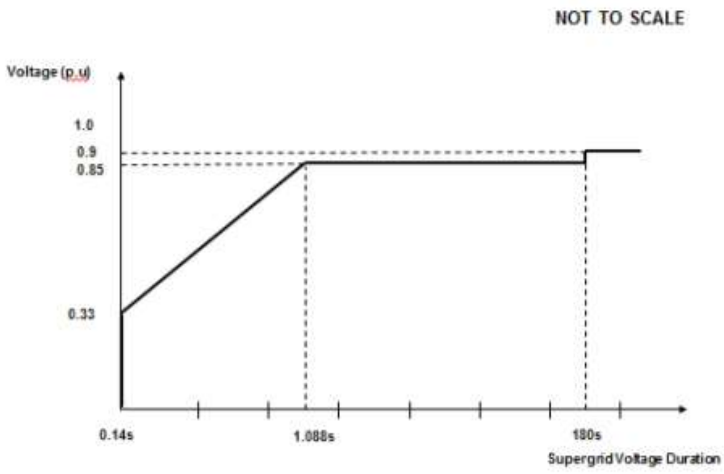

Figure 15.9(a)

(ii) provide **Active Power** output at the **Grid Entry Point**, during **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure 15.9(a), at least in proportion to the retained balanced voltage at the **Onshore Grid Entry Point** (for **Onshore Synchronous** **Power** **Generating** **Modules)** or **Interface Point** (for **Offshore Synchronous** **Power** **Generating** **Modules**) (or the retained balanced voltage at the **User System Entry Point** if **Embedded**) and shall generate maximum reactive current (where the voltage at the **Grid Entry Point** is outside the limits specified in ECC.6.1.4) without exceeding the transient rating limits of the **Synchronous** **Power** **Generating** **Module** and,

(iii) restore **Active Power** output following **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure 15.9(a), within 1 second of restoration of the voltage to 1.0pu of the nominal voltage at the:

Onshore Grid Entry Point for directly connected **Onshore Synchronous** **Power Generating Modules** or,

Interface Point for **Offshore Synchronous** **Power** **Generating** **Modules** or,

User System Entry Point for **Embedded Onshore Synchronous** **Power** **Generating** **Modules** or

User System Entry Point for **Embedded Medium Power Stations** not subject to a **Bilateral Agreement** which comprise **Synchronous Generating Units** and with an **Onshore User System Entry Point** (irrespective of whether they are located **Onshore** or **Offshore**)

to at least 90% of the level available immediately before the occurrence of the dip. Once the **Active Power** output has been restored to the required level, **Active Power** oscillations shall be acceptable provided that:

- the total **Active Energy** delivered during the period of the oscillations is at least that which would have been delivered if the **Active Power** was constant
- the oscillations are adequately damped.

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For the avoidance of doubt a balanced **Onshore Transmission System Supergrid Voltage** meets the requirements of ECC.6.1.5 (b) and ECC.6.1.6.

(b) Requirements applicable to **Type C** and **Type D Power Park Modules** and **OTSDUW Plant and Apparatus** subject to **Supergrid Voltage** dips on the **Onshore Transmission System** greater than 140ms in duration.

In addition to the requirements of ECC.6.3.15.5, ECC.6.3.15.6 and ECC.6.3.15.8 (as applicable)~~1 (a)~~ each **OTSDUW Plant and Apparatus** or each **Power Park Module** and / or any constituent **Power Park Unit**, shall:

(i) remain transiently stable and connected to the **System** without tripping of any **OTSDUW Plant and Apparatus**, or **Power Park Module** and / or any constituent **Power Park Unit**, for balanced **Supergrid Voltage** dips and associated durations on the **Onshore Transmission System** (which could be at the **Interface Point**) anywhere on or above the heavy black line shown in Figure 15.9~~5~~(b). Appendix E4~~A~~ and Figures EA.4.3.4 (a), (b) and (c) provide an explanation and illustrations of Figure 15.9(b); and,

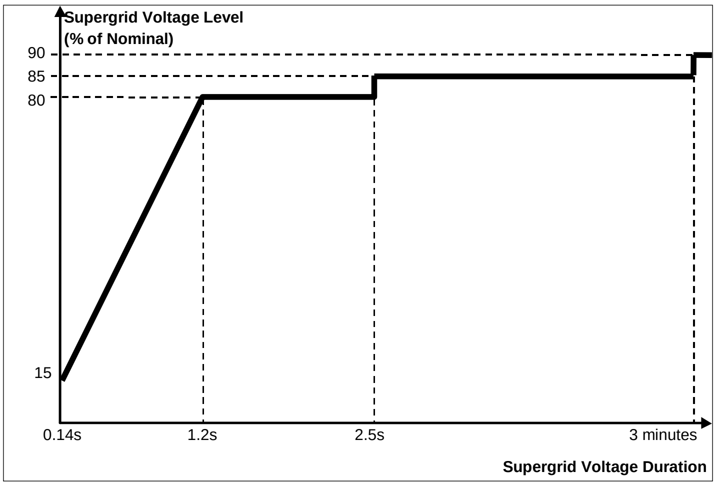

Figure 15.9(b)

(ii) provide **Active Power** output at the **Grid Entry Point** or in the case of an **OTSDUW**, **Active Power** transfer capability at the **Transmission Interface Point**, during **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure 15.9(b), at least in proportion to the retained balanced voltage at the **Onshore Grid Entry Point** (for **Onshore Power Park Modules**) or **Interface Point** (for **OTSDUW Plant and Apparatus** and **Offshore Power Park Modules**) (or the retained balanced voltage at the **User System Entry Point** if **Embedded**) except in the case of a **Non-Synchronous Generating Unit** or **OTSDUW Plant and Apparatus** or **Power Park Module** where there has been a reduction in the **Intermittent Power Source** or in the case of **OTSDUW Active Power** transfer capability in the time range in Figure 15.9(b) that restricts the **Active Power** output or in the case of an **OTSDUW Active Power** transfer capability below this level.

(iii) restore **Active Power** output (or, in the case of **OTSDUW, Active Power** transfer capability), following **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure 15.9(b), within 1 second of restoration of the voltage at the:

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Onshore Grid Entry Point for directly connected **Onshore Power Park Modules** or,

Interface Point for **OTSDUW Plant and Apparatus** and **Offshore Power Park Modules** or,

User System Entry Point for **Embedded Onshore Power Park Modules** or ,

User System Entry Point for **Embedded Medium Power Stations** which comprise **Power Park Modules** not subject to a **Bilateral Agreement** and with an **Onshore User System Entry Point** (irrespective of whether they are located **Onshore** or **Offshore**)

to the minimum levels specified in ECC.6.1.4 to at least 90% of the level available immediately before the occurrence of the dip except in the case of a **Non-Synchronous Generating Unit**, **OTSDUW Plant and Apparatus** or **Power Park Module** where there has been a reduction in the **Intermittent Power Source** in the time range in Figure 15.9(b) that restricts the **Active Power** output or, in the case of **OTSDUW**, **Active Power** transfer capability below this level. Once the **Active Power** output or, in the case of **OTSDUW**, **Active Power** transfer capability has been restored to the required level, **Active Power** oscillations shall be acceptable provided that:

- the total **Active Energy** delivered during the period of the oscillations is at least that which would have been delivered if the **Active Power** was constant
- the oscillations are adequately damped.

For the avoidance of doubt a balanced **Onshore Transmission System Supergrid Voltage** meets the requirements of ECC.6.1.5 (b) and ECC.6.1.6.

ECC.6.3.15.10 Other **Fault Ride Through** Requirements

(i) In the case of a **Power Park Module** ~~including a **DC Connected Power Park Module**~~ , the requirements in ECC.6.3.15.9 do not apply when the **Power Park Module** ~~(including a **DC Connected Power Park Module**)~~ is operating at less than 5% of its **Rated MW** or during very high primary energy source conditions ~~wind speed~~ conditions when more than 50% of the ~~wind turbine generator~~ **Power Park Units** in a **Power Park Module** have been shut down or disconnected under an emergency shutdown sequence to protect **User's Plant** and **Apparatus**.

(ii) In addition to meeting the conditions specified in ECC.6.1.5(b) and ECC.6.1.6, each **Non-Synchronous Generating Unit**, **OTSDUW Plant and Apparatus** or **Power Park Module** and any constituent **Power Park Unit** thereof 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 **Onshore Transmission System** operating at **Supergrid Voltage**.

(iii) **Generators** in respect of **Type B**, **Type C** and **Type D Power Park Modules** and **HVDC System Owners** are required to confirm to **NGET**, their repeated ability to operate through balanced and unbalanced faults and **System** disturbances each time the voltage at the **Grid Entry Point** or **User System Entry Point** falls outside the limits specified in ECC.6.1.4. Demonstration of this capability would be satisfied by **Generators** and **HVDC Equipment Owners** supplying the protection settings of their plant, informing **NGET** of the maximum number of repeated operations that can be performed under such conditions and any limiting factors to repeated operation such as protection or thermal rating; and

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Comment [A4]: This is complementary to the fast fault current injeciton requirement. We need to make sure developers and maufacturers are comfortable with this requirement

(iv) For the avoidance of doubt the requirements specified in ECC.6.3.15 do not apply to **Power Generating Modules** connected to an unhealthy circuit and islanded from the **Transmission System** even for delayed auto reclosure times.

~~(i)~~ ....

ECC.6.3.16 **FAST FAULT CURRENT** INJECTION

ECC.6.3.16.1 General **Fast Fault Current** injection, principles and concepts applicable to **Type B, Type C** and **Type D Power Park Modules** and **HVDC Equipment**

ECC.6.3.16.1.1 Each **Type B**, **Type C** and **Type D Power Park Module** or **HVDC Equipment** shall be required to satisfy the following requirements.

ECC.6.3.16.1.2 For any balanced or unbalanced fault which results in the positive phase sequence rms voltage on one or more phases falling to zero at the **Grid Entry Point** or **User System Entry Point,** each **Type B**, **Type C** and **Type D Power Park Module** or **HVDC Equipment** shall, unless otherwise agreed with **NGET**, be required to inject a reactive current above the shaded red area shown in Figure 16.1~~2~~(a) and Figure 16.1~~2~~(b). For the purposes of this requirement, the maximum rated current is taken to be the maximum current each **Power Park Unit** or **HVDC Converter** can supply when operating at rated **Active Power** and zero **Reactive Power** (in other words unity **Power Factor**).

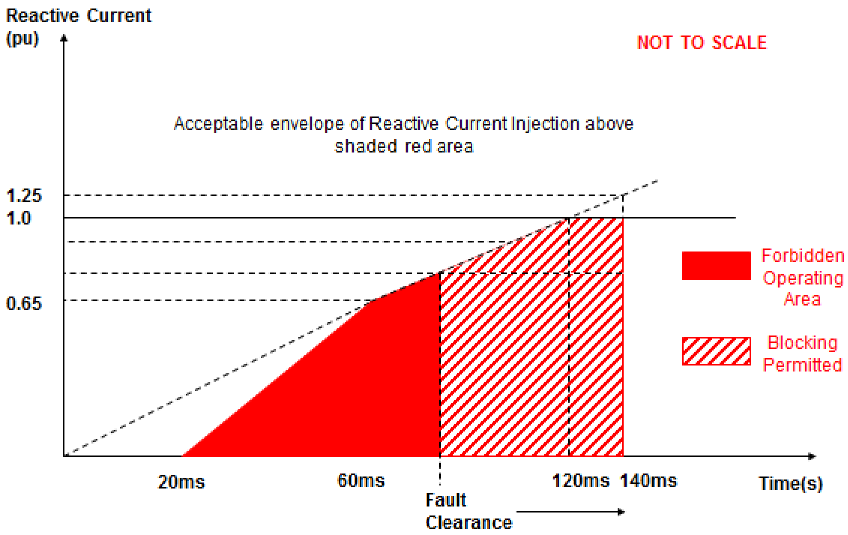

Figure 16.1(a)

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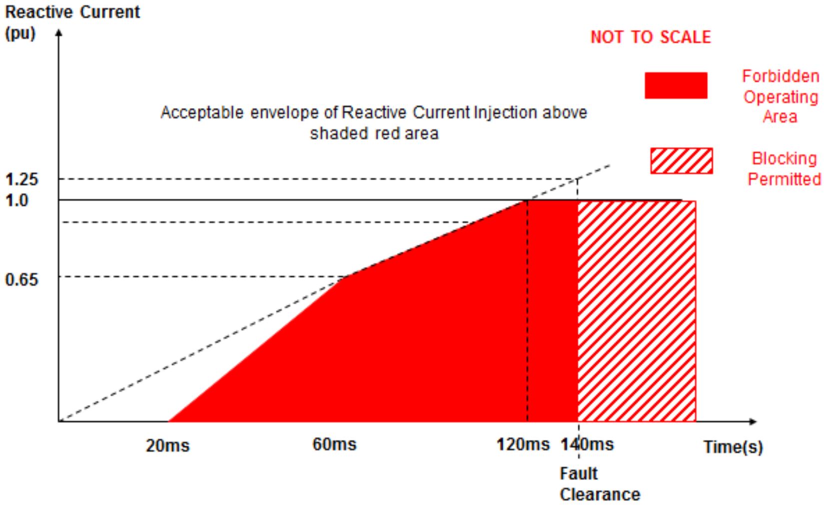

~~(i)~~ Figure 16.1(b)

~~(ii)~~ ECC.6.3.16.1.3 The converter(s) of each **Type B**, **Type C** and **Type D Power Park Module** or **HVDC Equipment** is permitted to block upon fault clearance in order to mitigate against the risk of instability that would otherwise occur ~~-~~due to transient overvoltage excursions. Figure 16.1(a) and Figure 16.1(b) shows the impact of variations in fault clearance time which shall be no greater than 140ms. Where the **User** is able to demonstrate to **NGET** that blocking is required in order to prevent the risk of transient over voltage excursions as specified in ECC.6.3.16.~~4~~3.1(iv)) **Generators** and **HVDC System Owners** are required to both advise and agree with **NGET** of the control strategy, which must also include the approach taken to de-blocking. Not withstanding this requirement, **Generators** and **HVDC System Owners** should be aware of their requirement to fully satisfy the fault ride through requirements specified in ECC.6.3.15.

ECC.6.3.16.1.4 In addition, the reactive current injected from each **Power Park Module** or **HVDC Equipment** shall be injected in proportion and remain in phase to the change in **System** voltage at the **Connection Point** or **User System Entry Point** during the period of the fault. For the avoidance of doubt, a small delay time of no greater than 20ms from the point of fault inception is permitted before injection of the in phase reactive current. For voltage depressions of 0.65p.u or below, reactive current injection shall take priority over active current injection up to a maximum of 1.0p.u. of the rating of the **Power Park Module** or **HVDC Converter Equipment**.

ECC.6.3.16.1.5 Each **Type B**, **Type C** and **Type D Power Park Module** or **HVDC Equipment** shall be designed to reduce the risk of transient over voltage levels arising following clearance of the fault. **Generators** or **HVDC System Owners** shall be permitted to block where the anticipated transient overvoltage would not otherwise exceed the maximum permitted values specified in ECC.6.1.7. Any additional requirements relating to transient overvoltage performance will be specified by **NGET**.

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ECC.6.3.16.1.6 In addition to the requirements of ECC.6.3.15, **Generators** in respect of **Type B**, **Type C** and **Type D Power Park Modules** and **HVDC System Owners** are required to confirm to **NGET,** their repeated ability to supply **Fast Fault Current** to the **System** each time the voltage at the **Grid Entry Point** or **User System Entry Point** falls outside the limits specified in ECC.6.1.4. **Generators** and **HVDC Equipment Owners** should inform **NGET** of the maximum number of repeated operations that can be performed under such conditions and any limiting factors to repeated operation such as protection or thermal rating; and

ECC.6.3.16.1.7 In the case of a **Power Park Module** or **DC Connected Power Park Module**, where it is not practical to demonstrate the requirements of ECC.6.3.16.1.1 to ECC.6.3.16.1.6 at the **Grid Entry Point** or **User System Entry Point**, **NGET** will accept demonstration of the above requirements at the **Power Park Unit** terminals.

ECC.6.3.16.1.8 An illustration and examples of the performance requirements expected are illustrated in Appendix 4EC.

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ECC.4 - APPENDIX 4 - FAULT RIDE THROUGH REQUIREMENTS

FAULT RIDE THROUGH REQUIREMENTS FOR TYPE B, TYPE C AND TYPE D POWER GENERATING MODULES (INCLUDING OFFSHORE POWER PARK MODULES WHICH ARE EITHER AC CONNECTED POWER PARK MODULES OR DC CONNECTED POWER PARK MODULES), HVDC SYSTEMS AND OTSDUW PLANT AND APPARATUS

ECC.A.4A.1 Scope

The **Fault Ride Through** requirements are defined in ECC.6.3.15. This Appendix provides illustrations by way of examples only of ECC.6.3.15.1 to ~~-~~ ECC.6.3.15.10 and further background and illustrations and is not intended to show all possible permutations.

ECC.A.4A.2 Short Circuit Faults At Supergrid Voltage On The Onshore Transmission System Up To 140ms In Duration

For short circuit faults at **Supergrid Voltage** on the **Onshore Transmission System** (which could be at an **Interface Point**) up to 140ms in duration, the **Fault Ride Through** requirement is defined in ECC.6.3.15. In summary any **Power Generating Module** (including a **DC Connected Power Park Module**) or **HVDC System** is required to remain connected and stable whilst connected to a healthy circuit. Figure ECC.A.4.A.2 illustrates this principle.

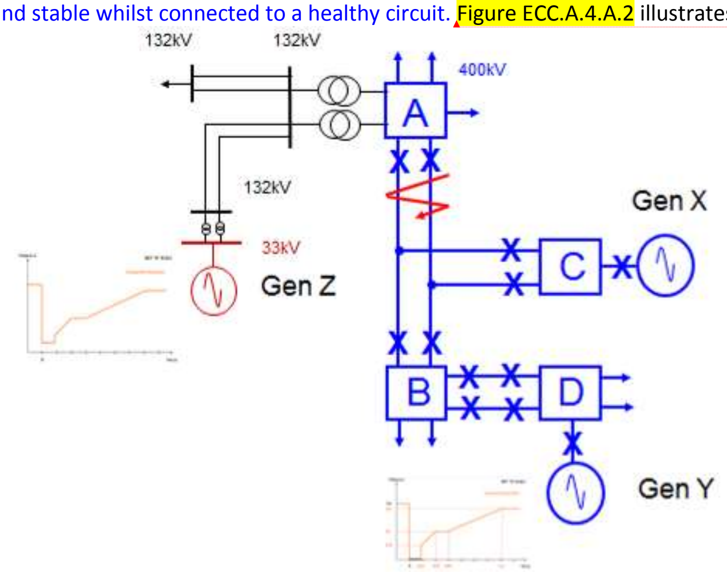

Figure EA4.1

In Figure EA4.1 a solid three phase short circuit fault is applied adjacent to substation A resulting in zero voltage at the point of fault. All circuit breakers on the faulty circuit (Lines ABC) will open within 140ms resulting in Generator X tripping. The effect of this fault, due to the low impedance of the network, will be the observation of a low voltage at each substation node across the **Total System** until the fault has been cleared. ~~Under this example, Generator X in Figure ECC.A.4.A.2, will trip as it is disconnected and isolated from the **Transmission System** by the opening of circuit breakers on circuit ABC.~~ In this example, Generator Y and Generator Z (an Embedded Generator) would need to remain connected and stable as both are still connected to the **Total System** and remain connected to healthy circuits .

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The criteria for assessment is based on a voltage against time curve at each **Grid Entry Point** or **User System Entry Point**. The voltage against time curve at the **Grid Entry Point** or **User System Entry Point** varies for each different type and size of **Power Generating Module** as detailed in ECC.6.3.15.2. – ECC.6.3.15.7.

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The voltage against time curve represents the voltage profile at a **Grid Entry Point or User System Entry Point** that would be obtained by plotting the voltage at that **Grid Entry Point** or **User System Entry Point** before during and after the fault. This is not to be confused with a voltage duration curve (as defined under ECC.6.3.15.9) which represents a voltage level and associated time duration.

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The post fault voltage at a **Grid Entry Point** or **User System Entry Point** is largely influenced by the topology of the network rather than the behaviour of the **Power Generating Module** itself. The **Generator** therefore needs to ensure each **Power Generating Module** remains connected and stable for a close up solid three phase short circuit fault for 140ms at the **Grid Entry Point** or **User System Entry Point**.

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Two examples are shown in Figure EA.4.2(a) and Figure EA4.2(b). In Figure EA.4.2(a) the post fault profile is above the heavy black line. In this case the **Power Generating Module** must remain connected and stable. In Figure EA4.2(b) the post fault voltage dips below the heavy black line in which case the **Power Generating Module** is permitted to trip.

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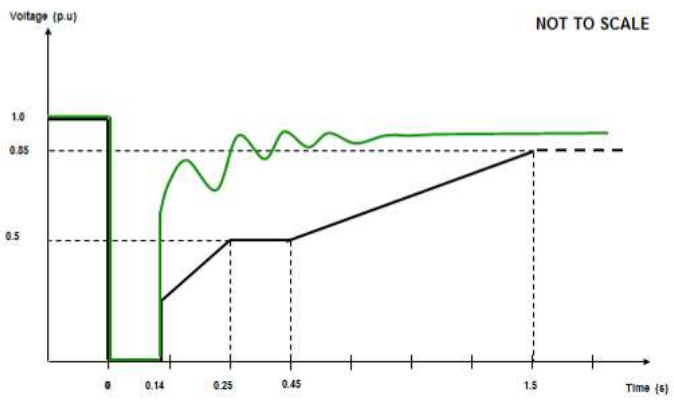

Figure EA.4.2(a)

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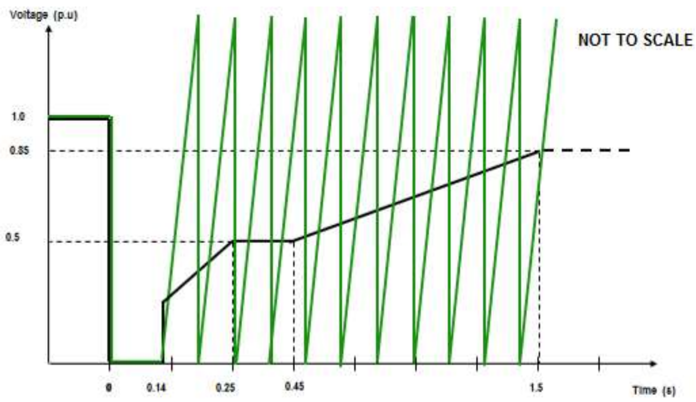

Figure EA.4.2(b)

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The process for demonstrating **Fault Ride Through** compliance against the requirements of ECC.6.3.15 is detailed in ECP.A.3.5.

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ECC.A.4A.3 Supergrid Voltage Dips On The Onshore Transmission System Greater Than 140ms In Duration

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ECC.A.4A3.1 Requirements applicable to **Synchronous Power Generating Modules** subject to **Supergrid Voltage** dips on the **Onshore Transmission System** greater than 140ms in duration.

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For balanced **Supergrid Voltage** dips on the **Onshore Transmission System** having durations greater than 140ms and up to 3 minutes, the **Fault Ride Through** requirement is defined in ECC.6.3.15.9.2.1(a) and Figure 15.9(a) which is reproduced in this Appendix as Figure EA.4.3.1 and termed the voltage–duration profile.

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This profile is not a voltage-time response curve that would be obtained by plotting the transient voltage response at a point on the **Onshore Transmission System** (or **User System** if located **Onshore**) to a disturbance. Rather, each point on the profile (ie the heavy black line) represents a voltage level and an associated time duration which connected **Synchronous Power Generating Modules** must withstand or ride through.

Figures EA.4.3.2 ~~ECC.A.4A3.2~~ (a), (b) and (c) illustrate the meaning of the voltage-duration profile for voltage dips having durations greater than 140ms.

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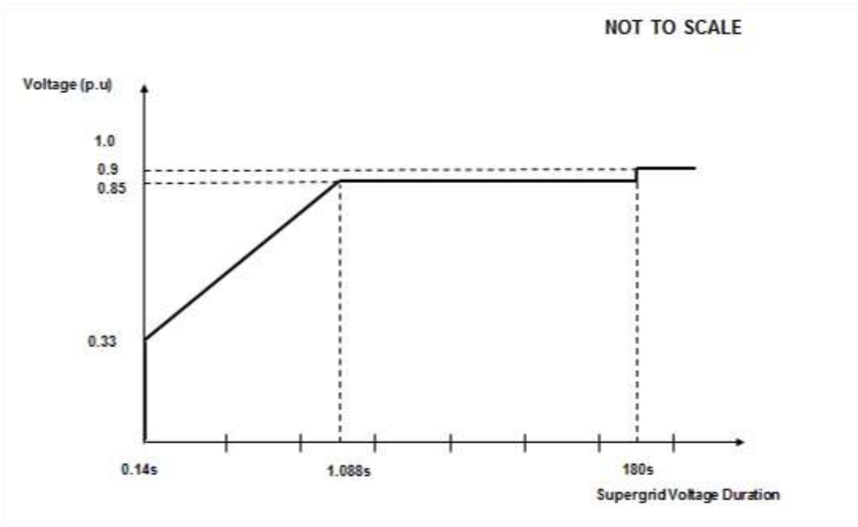

Figure EA.4.3.1

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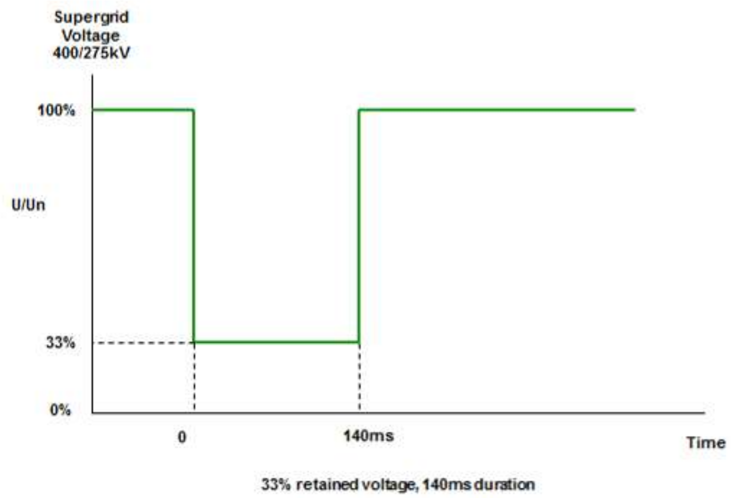

Figure EA.4.3.2 (a)

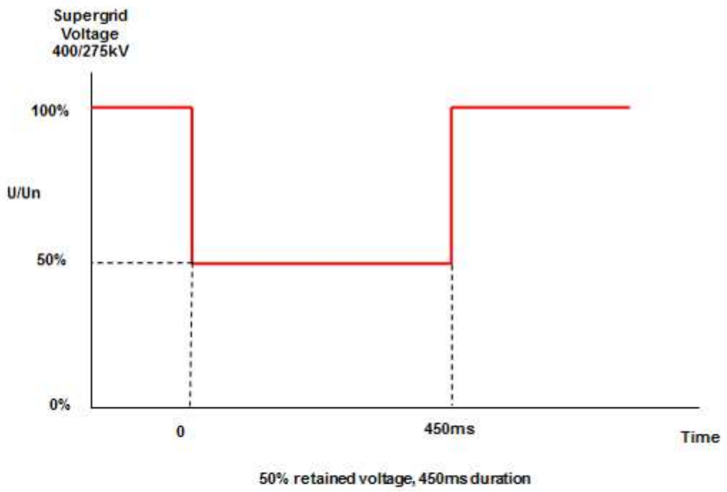

Figure EA.4.3.2 (b)

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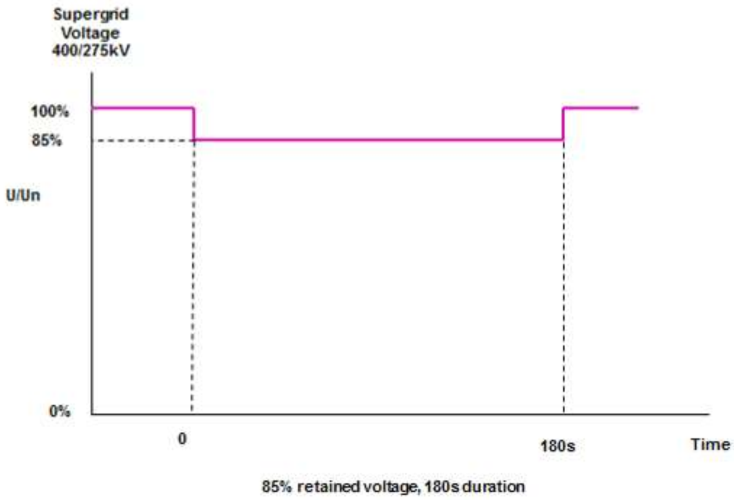

Figure EA.4.3.2 (c)

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ECC.A.4A3.2 Requirements applicable to **Power Park Modules** or **OTSDUW Plant and Apparatus** subject to **Supergrid Voltage** dips on the **Onshore Transmission System** greater than 140ms in duration

For balanced **Supergrid Voltage** dips on the **Onshore Transmission System** (which could be at an **Interface Point**) having durations greater than 140ms and up to 3 minutes the **Fault Ride Through** requirement is defined in ECC.6.3.15.9.2.1(b) and Figure 15.9(b) which is reproduced in this Appendix as Figure EA.4.3.3 and termed the voltage–duration profile.

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This profile is not a voltage-time response curve that would be obtained by plotting the transient voltage response at a point on the **Onshore Transmission System** (or **User System** if located **Onshore**) to a disturbance. Rather, each point on the profile (ie the heavy black line) represents a voltage level and an associated time duration which connected **Power Park Modules** or **OTSDUW Plant and Apparatus** must withstand or ride through.

Figures EA.4.3.4 (a), (b) and (c) illustrate the meaning of the voltage-duration profile for voltage dips having durations greater than 140ms.

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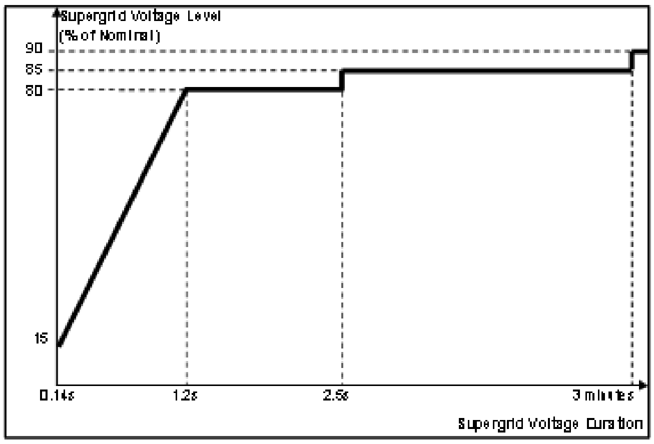

Figure EA.4.3.3

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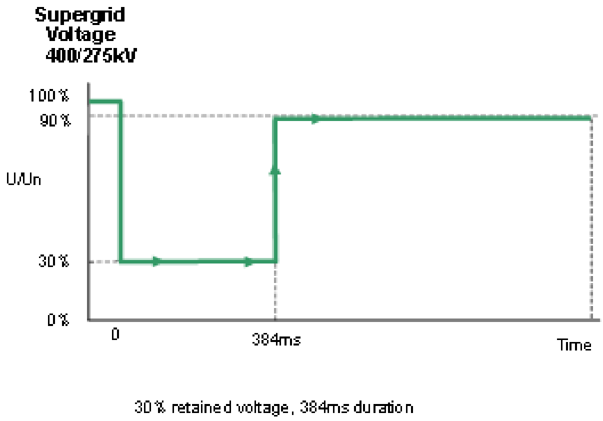

Figure EA.4.3.4(a)

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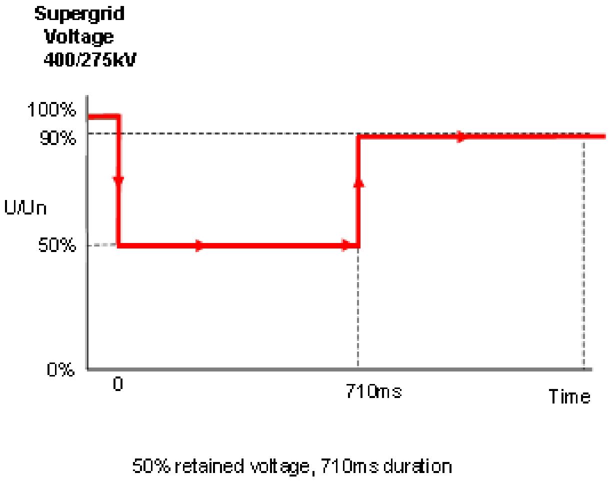

Figure EA.4.3.4 (b)

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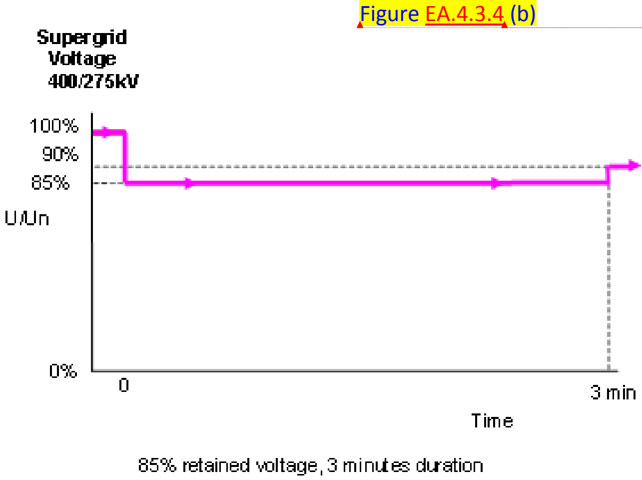

Figure EA.4.3.4 (c)

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APPENDIX 4EC – FAST FAULT CURRENT INJECTION REQUIREMENTS

FAST FAULT CURRENT INJECTION REQUIREMENTS FOR POWER PARK MODULES, HVDC ~~CONVERTERS AT A DC CONVERTER STATION~~ SYSTEMS, DC CONNECTED POWER PARK MODULES AND REMOTE END HVDC CONVERTERS

ECC.A.4EC1 Fast Fault Current Injection requirements ~~(ECC.6.3.16.4) – Option 3~~

ECC.4EC1.1 Fast Fault Current Injection behaviour during a solid three phase close up short circuit fault lasting up to 140ms

ECC.4EC1.1.1 For a voltage depression at a **Grid Entry Point or User System Point**, the Fast Fault Current Injection requirements are detailed in ECC.6.3.16. Figure ECC4.1 shows an example of a 500MW **Power Park Module** subject to a close up solid three phase short circuit fault connected directly connected to the **Transmission System** operating at 400kV.

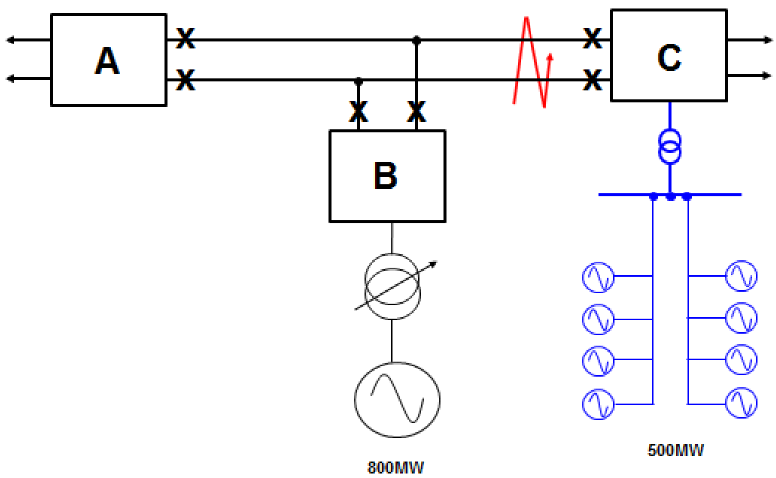

Figure ECC4.1

ECC.4EC1.1.2 Assuming negligible impedance between the fault and substation C, the voltage at Substation C will be close to zero until circuit breakers at Substation C open, typically within 80 – 100ms, subsequentially followed by the opening of circuit breakers at substations A and B, typically 140ms after fault inception. The operation of circuit breakers at Substations A, B and C will also result in the tripping of the 800MW Generator which is permitted under the SQSS. The **Power Park Module** is required to satisfy the requirements of ECC.6.3.16, and an example of the deviation in system voltage at the Grid Entry Point and expected reactive current injected by the **Power Park Module** before and~~,~~ during ~~and after~~ the fault is shown in Figure ECC4.2(a) and (b). For the purposes of this example it is assumed that the voltage at the **Grid Entry Point** is assumed to be the positive phase sequence voltage and the current is the positive phase sequence rms current at the **Grid Entry Point**.

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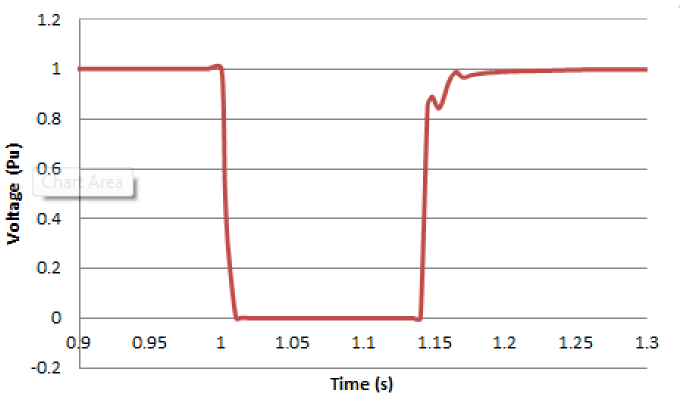

Figure ECC4.2(a) –Voltage deviation at Substation C

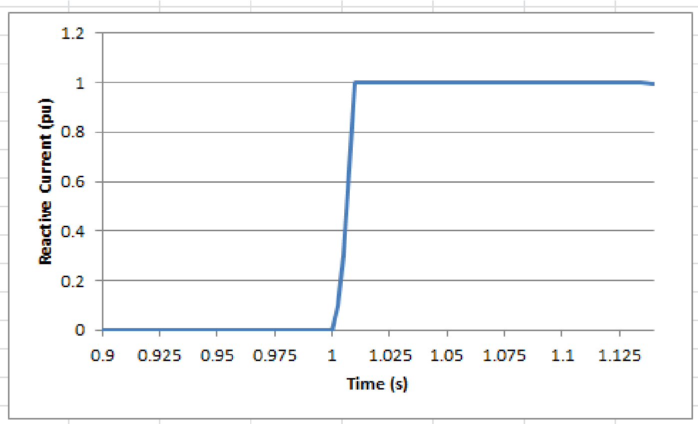

Figure ECC4.2 – Reactive Current Injected from the Power Park Module connected to Substation C

It is important to note that b~~B~~locking is permitted upon fault clearance in order to limit the impact of t~~T~~ransient o~~O~~vervoltages. This effect is shown in Figure ECC4.3(a) and Figure ECC4.3(b)

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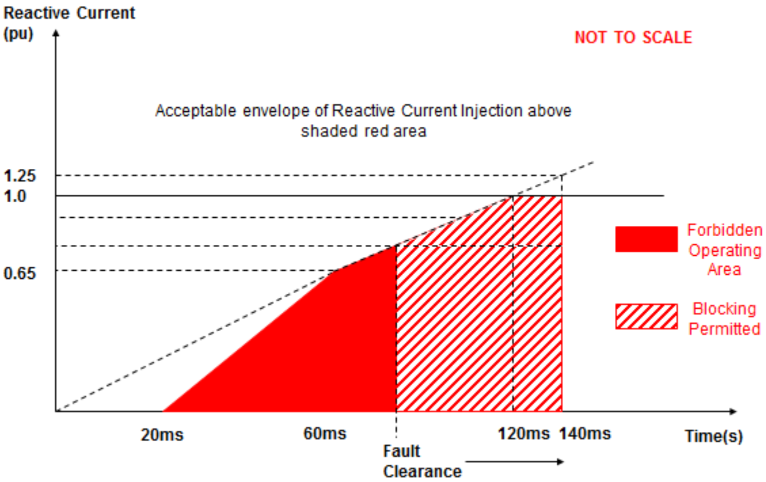

Figure ECC4.3(a)

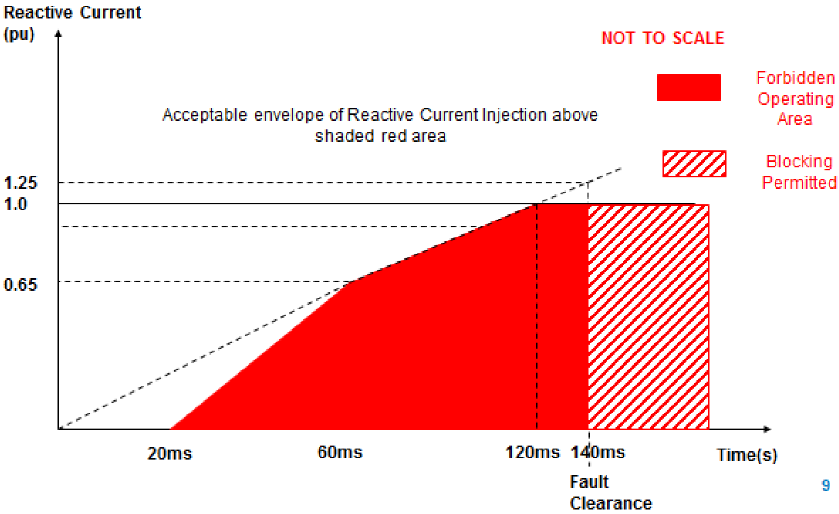

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Figure ECC4.3(b)

ECC.4EC1.1.3 So long as the reactive current injected is above the shaded area as illustrated in Figure ECC4.3(a) or ECC4.3(b), the **Power Park Module** would be considered to be compliant with the requirements of ECC.6.3.16 Taking the example outlined in ECC.4EC1.1.1 where the fault is cleared in 140ms, the following diagram in Figure ECC4.4 results.

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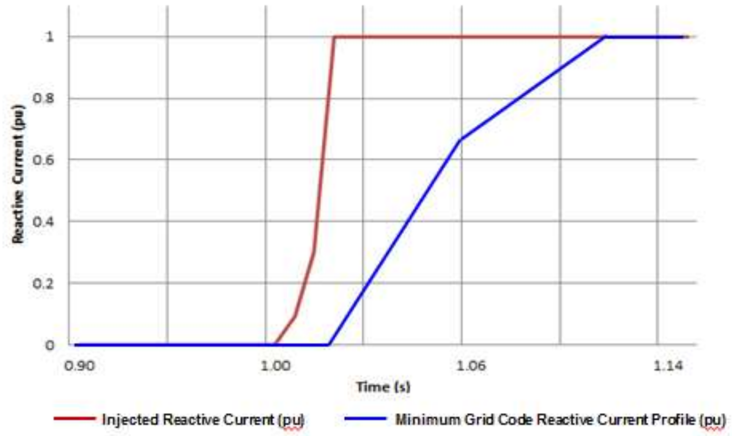

Figure ECC4.4 – Injected Reactive Current from Power Park Module compared to the minimum required Grid Code profile

ECC.4EC1.2 Fast Fault Current Injection behaviour during a voltage dip at the Connection Point lasting in excess of 140ms

ECC.4EC1.2.1 Under the fault ride through requirements specified in ECC.6.3.15.9 *(Voltage dips cleared in excess of 140ms)*, **Type B**, **Type C** and **Type D Power Park Modules** are also required to remain connected and stable for voltage dips on the **Transmission System** in excess of 140ms. Figure ECC4.4 (a) shows an example of a 500MW **Power Park Module** connected to the **Transmission System** and Figure ECC4.4 (b) shows the corresponding voltage dip seen at the **Grid Entry Point or User System Point** which has resulted from a remote fault on the **Transmission System** cleared in a backup operating time of 710ms.

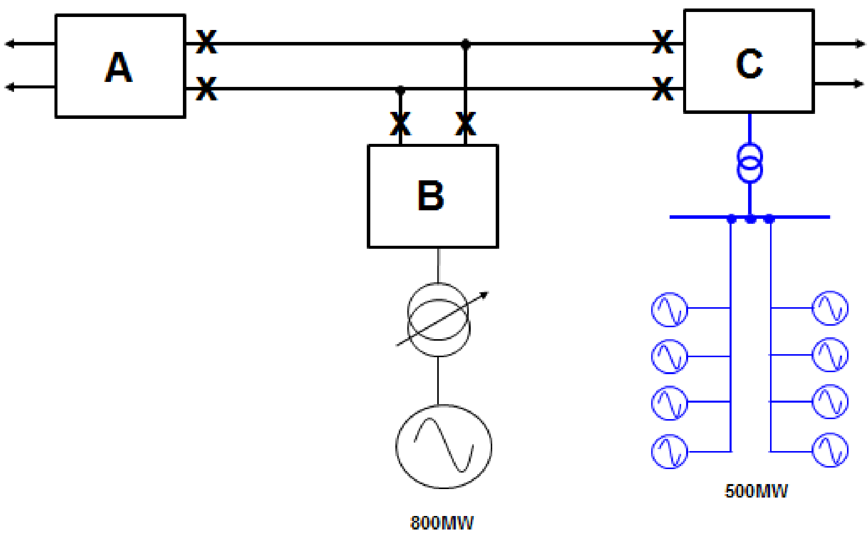

Figure ECC4.4(a)

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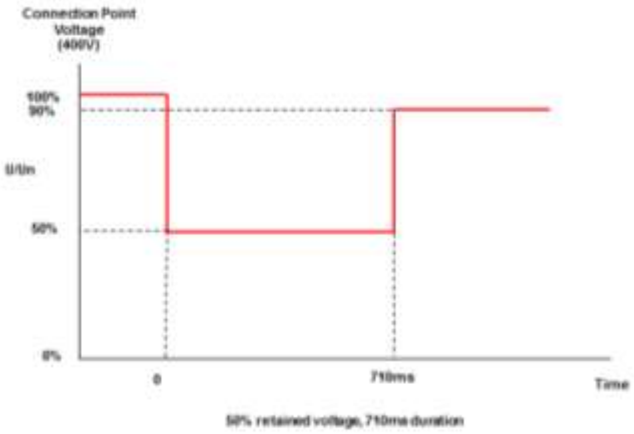

Figure ECC4.4 (b)

ECC.4EC1.2.1 In this example, the voltage dips to 0.5pu for 710ms. Under ECC.6.3.16 each **Type B**, **Type C** and **Type D Power Park Module** is required to inject reactive current into the **System** and shall respond in proportion to the change in **System** voltage at the **Grid Entry Point or User System Entry~~Connection~~ Point** up to a maximum value of 1.0pu of rated current. An example of the expected injected reactive current at the **Connection Point** is shown in Figure ECC4.5

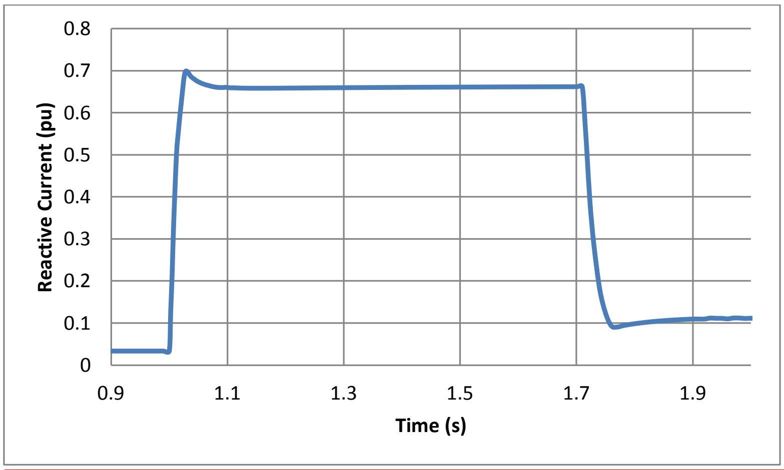

Figure ECC4.4 Reactive Current Injected for a 50% voltage dip for a period of 710ms

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