This text is the current (October 2017) G99 draft for the main chapters and some Appendices. It assumes the changes to RoCoF and Loss of Mains protection being developed in GC0079 have been approved by the Authority. If GC0079 does not progress, the relevant text will need to revert to current requirements before submission for Authority approval.

Consistency of formatting has yet to be addressed.

The text has been developed by the ENA and Ricardo Energy & Environment. Please send any comments to sarah.carter@ricardo.com.

Please contact Sarah for a word version of the document to make commenting and addressing comments easier.

# Engineering Recommendation G99

Requirements for the connection of generation equipment in parallel with public distribution networks on or after 17 May 2019

**Contents**

**The colour coding of the text is as follows:**
Blue text = from the Grid Code, Distribution Code or G83
Purple text = from G59
Orange text = from Requirement for Generators (RfG)
Green text = from other EU documents e.g. EN 50438
Black text = Changes/ additional words

Red text = changes likely
Green highlights text under review by NG or ENA

Engineering Recommendation G99 Requirements for the connection of Power Generating Modules of Types A, B, C and D in parallel with the Distribution Systems of licensed Distribution Network Operators.

## Foreword

This Engineering Recommendation (EREC) is published by the Energy Networks Association (ENA) and comes into effect on 17 May 2019 for **Power Generating Modules** first installed on or after that date. It has been prepared and approved for publication under the authority of the **Great Britain Distribution Code Review Panel**. The approved abbreviated title of this engineering document is "EREC G99".

**Power Generating Modules** that fully comply with this EREC G99 can be connected in advance of 17 May 2019 as they also comply with the pre-existing EREC G59 requirements

## 1 Purpose

1.1 The purpose of this Engineering Recommendation (EREC) is to provide requirement for the connection of **Power Generating Facilities** to the **Distribution Networks** of licensed **Distribution Network Operators (DNOs)**. It is intended to address all aspects of the connection process from standards of functionality to site commissioning, such that **Customers, Manufacturers** and **Generators** are aware of the requirements that will be made by the local **DNO** before the **Power Generating Facility** will be accepted for connection to the **Distribution Network**.

1.2 The guidance given is designed to facilitate the connection of **Power Generating Module**(s) whilst maintaining the integrity of the **Distribution Network**, both in terms of safety and supply quality. It applies to all **Power Generating Module**(s) within the scope of Section 2, irrespective of the type of electrical machine and equipment used to convert any primary energy source into electrical energy.

## 2 Scope

2.1 This EREC provides the technical requirements for the connection of **Type A**, **Type B**, **Type C** and **Type D Power Generating Modules** to the **Distribution Networks** of licensed **DNOs**. For the purposes of this EREC, a **Power Generating Module** is any source of electrical energy, irrespective of the prime mover and **Power Generating Module** type. This EREC applies to all **Power Generating Modules** which are not in the scope of EREC G98 or are not compliant with EREC G98 requirements.

The requirements set out in this **EREC G99** shall not apply to the following **Customers** who should refer to **EREC G59**:

(a) **Generators** whose **Power-Generating Module(s)** was already connected to the **DNO's Distribution Network** on or before 17 May 2019 or

(b) **Generators** who had concluded a final and binding contract for the purchase of main generating plant before 17 May 2018. The **Generator** must have notified the **DNO** of the conclusion of this final and binding contract by 17 November 2018; or

(c) **Generators** who have been granted a relevant derogation by the **Authority**.

The requirements set out in this **EREC G99** shall apply to **Generators** owning any **Power-Generating Module** which has been modified on or after 17 May 2019 to such an extent that it's **Connection Agreement** must be substantially revised or replaced for example a change to a technical appendix in a **Connection Agreement**.

2.2 This EREC does not provide advice for the design, specification, protection or operation of **Power Generating Module**s themselves. These matters are for the **Generator** to determine.

2.3 Specific separate requirements apply to **Power Generating Facilities** connected at LV comprising **Fully Type Tested Type A Power Generating Modules** less than 16A/phase (micro-generators) and these are covered in EREC G98. Any **Power Generating Module**s that are <16A per phase but do not meet the requirements of EREC G98 should apply the Type A requirements in this EREC G99..

2.4 The connection of mobile generation operated by the **DNO**, EREC G98 compliant **Power Generating Modules**, Offshore **Power Generating Modules** or offshore **Transmission System**s containing generation are outside the scope of this Engineering Recommendation.

2.5 This document applies to systems where the **Power Generating Facility** can be paralleled with a **Distribution Network** or where either the **Power Generating Facility** or a **Distribution Network** with a **Power Generating Facility** connected can be used as an alternative source of energy to supply the same electrical load.

2.6 The generic requirements for all types of **Power Generating Facilities** within the scope of this document relate to the connection design requirements, connection application and notification process including confirmation of commissioning. The document does not attempt to describe in detail the overall process of connection from application, through agreement, construction and commissioning. It is recommended that the ENA publication entitled – "*Distributed Generation Connection Guide*" is consulted for more general guidance.

2.7 Any **Power Generating Module** which participates in the balancing mechanism in addition to the general requirements of this EREC will have to comply with the relevant parts of the **Grid Code**.

2.8 This EREC is written principally from the point of view of the requirements in **Great Britain**. There are some differences in the requirements in **Great Britain** and Northern Ireland, which are reflected in the separate Grid Codes for **Great Britain** and Northern Ireland, and the separate **Distribution Code** and Engineering Recommendations for Northern Ireland. These documents should be consulted where necessary, noting that the numbering of sections within these documents is not necessarily the same as in the **Distribution Code** for **Great Britain** and the **Grid Code** for **Great Britain**.

2.9 The separate synchronous network operating in the Shetland Isles has specific technical challenges which are different to those of the **Great Britain** synchronous network. This EREC is not in itself sufficient to deal with these issues

2.10 **Type B, Type C and Type D** pump-storage **Power Generating Modules** shall fulfil all the relevant requirements in both generating and pumping operation mode.

Synchronous compensation operation of pump-storage **Power Generating Modules** shall not be limited in time by the technical design of **Power Generating Modules**. Pump-storage variable speed **Power Generating Modules** shall fulfil the requirements applicable to **Synchronous Power Generating Modules** as well as those set out in Section 12.3 or Section 13.4.

2.11 Except for **Limited Frequency Sensitive Mode – Overfrequency** and the requirements in paragraph 9.4.3 relating to admissible **Active Power** reduction or where otherwise stated, requirements of this EREC G99 relating to the capability to maintain constant **Active Power** output or to modulate **Active Power** output shall not apply to **Power Generating Modules** of facilities for combined heat and power production embedded in the networks of industrial sites, where all of the following criteria are met:

(a) the primary purpose of those facilities is to produce heat for production processes of the industrial site concerned;

(b) heat and power generating is inextricably interlinked, that is to say any change of heat generation results inadvertently in a change of **Active Power** output and vice versa;

Combined heat and power generating facilities shall be assessed on the basis of their electrical **Registered Capacity**.

## 3 References

3.1 The following referenced documents, in whole or part, are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

### 3.2 Standards publications

**BS 7671: 2008 Requirements for Electrical Installations**
IEE Wiring Regulations: Seventeenth Edition.

**BS 7430: 1999**
Code of Practice for Earthing.

**BS 7354**
Code of Practice for Design of Open Terminal Stations.

**BS EN 61000 series***
Electromagnetic Compatibility (EMC).

**BS EN 61508 series***
Functional safety of electrical/ electronic/ programmable electronic safety-related systems.

**BS EN 60255 series***
Measuring relays and protection equipment.

**BS EN 61810 series***

Electromechanical Elementary Relays.

**BS EN 60947 series***
Low Voltage Switchgear and Controlgear.

**BS EN 60044-1: 1999**
Instrument Transformers. Current Transformers.

**BS EN 60034-4:2008**
Methods for determining synchronous machine quantities from tests.

**BS EN 61400-12-1:2006**
Wind turbines. Power performance measurements of electricity producing wind turbines.

**IEC 60909 series***
Short-circuit currents in three-phase a.c. systems. Calculation of currents.

**IEC TS 61000-6-5: 2001**
Electromagnetic Immunity Part 6.5 Generic Standards. Immunity for Power Station and Substation Environments.

**IEC 60364-7-712: 2002**
Electrical installations of buildings – Special installations or locations – Solar photovoltaic (PV) power supply systems.

**Where standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable.*

### 3.3 Other publications

**Health and Safety at Work etc. Act (HASWA): 1974**
The Health and Safety at Work etc. Act 1974 also referred to as HASAW or HSW, is the primary piece of legislation covering occupational health and safety in the United Kingdom. The Health and Safety Executive is responsible for enforcing the Act and a number of other Acts and Statutory Instruments relevant to the working environment.

**Electricity Safety, Quality and Continuity Regulations (ESQCR): 2002**
The Electricity Safety, Quality and Continuity Regulations 2002 (Amended 2006) - Statutory Instrument Number 2665 -HMSO ISBN 0-11-042920-6 abbreviated to ESQCR in this document.

**Electricity at Work Regulations (EaWR): 1989**
The Electricity at Work regulations 1989 abbreviated to EaWR in this document.

**ENA Engineering Recommendation G5**
Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission and distribution networks in the United Kingdom.

**ENA Engineering Recommendation G12/4**
Requirements for the application of protective multiple earthing to low voltage networks.

**ENA Engineering Recommendation G74**

Procedure to meet the requirements of IEC 909 for the calculation of short-circuit currents in three-phase AC power systems.

**ENA Engineering Recommendation G83**
Recommendations for connection of small-scale embedded Generators (up to 16 A per phase) in parallel with public low voltage distribution networks.

**Engineering Recommendation G98**
Requirements for the connection of Type Tested Micro-generators (Up to and including 16A per Phase) in Parallel with Low-Voltage Distribution Systems

**ENA Engineering Recommendation P2**
Security of Supply.

**ENA Engineering Recommendation P18**
Complexity of 132kV circuits.

**ENA Engineering Recommendation P28**
Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom.

**ENA Engineering Recommendation P29**
Planning limits for voltage unbalance in the UK for 132 kV and below.

**ENA Technical Specification 41-24**
Guidelines for the design, installation, testing and maintenance of main earthing systems in substations.

**ENA Engineering Technical Report ETR 124**
Guidelines for actively managing power flows associated with the connection of a single distributed generation plant.

**ENA Engineering Technical report ETR 126**
Guidelines for actively managing voltage levels associated with the connection of a single distributed generation plant.

**ENA Engineering Technical report ETR 130**
The application guide for assessing the capacity of networks containing distributed generation.

## 4 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

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| **Act** | The Electricity Act 1989 (as amended. including by the Utilities Act 2000 and the Energy Act 2004). |
| **Active Power (P)** | The product of voltage and the in-phase component of alternating current measured in units of watts, normally measured in kilowatts (kW) or megawatts (MW). |
| **Active Power Frequency Response** | An automatic response of **Active Power** output, from a **Power Generating Module,** to a change in system frequency from the nominal system frequency. |
| **Authority** | The Gas and Electricity Markets Authority established under Section 1 of the Utilities Act 2000 The Gas and Electricity Markets Authority |

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| | established under Section 1 of the Utilities Act 2000. |
| **Automatic Voltage Regulator** or **AVR** | The continuously acting automatic equipment controlling the terminal voltage of a synchronous **Generating Unit** by comparing the actual terminal voltage with a reference value and controlling by appropriate means the output of an **Exciter**, depending on the deviations. |
| **Black Start Capability** | An ability in respect of a **Black Start Station**, for at least one of its **Generating Units** to Start-Up from Shutdown and to energise a part of the **Distribution Network** and be synchronised to the **Distribution Network** upon instruction from the **NETSO**, within two hours, without an external electrical power supply. |
| **Black Start Station** | **A Power Generating Facility** which is registered with the **NETSO** as having a **Black Start Capability**. |
| **Combined Cycle Gas Turbine Module** or **CCGT Module** | A collection of **Generating Units** comprising one or more **Gas Turbine Units** (or other gas based engine units) and one or more **Steam Units** where, in normal operation, the waste heat from the **Gas Turbines** is passed to the water/steam system of the associated **Steam Unit** or **Steam Units** and where the component units within the **CCGT Module** are directly connected by steam or hot gas lines which enable those units to contribute to the efficiency of the combined cycle operation of the **CCGT Module**. |
| **Connection Agreement** | A contract between the **Distribution Network Operator** and the **Customer**, which includes the relevant site and specific technical requirements for the **Power Generating Module**. |
| **Connection Point** | The interface at which the **Power Generating Module** or **Customer's Installation** is connected to a **Distribution Network**, as identified in the **Connection Agreement**. |
| **CUSC** | Has the meaning set out in **NGET's Transmission Licence.** |
| **CUSC Contract** | One or more of the following agreements as envisaged in Standard Condition C1 of **NGET's Transmission Licence**:<br>(a) the **CUSC Framework Agreement**;<br>(b) a **Bilateral Agreement**;<br>(c) a **Construction Agreement**<br>or a variation to an existing **Bilateral Agreement** and/or **Construction Agreement**. |
| **Customer** | A person who is the owner or occupier of an installation or premises that are connected to the **Distribution Network**. |
| **Customer's Installation** | The electrical installation on the **Customer**'s side of the **Connection Point** together with any equipment permanently connected or intended to be permanently connected thereto. |
| **Detailed Planning Data (DPD)** | Detailed additional data which the **DNO** requires under the Distribution Planning and Connection Code in support of **Standard Planning Data** |
| **Distribution Code** | A code required to be prepared by a **DNO** pursuant to Standard Licence Condition 21 (**Distribution Code**) of a **Distribution Licence** and approved by the **Authority** as revised from time to time with the approval |

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| | of, or by the direction of, the **Authority**. |
| **Distribution Network** | An electrical network for the distribution of electrical power from and to third party[s] connected to it, a transmission or another **Distribution Network**. |
| **Distribution Network Operator (DNO)** | The person or legal entity named in Part 1 of the **Distribution Licence** and any permitted legal assigns or successors in title of the named party. A distribution licence is granted under Section 6(1)(c) of the Electricity Act 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004). |
| **Droop** | The ratio of the per unit steady state change in speed, or in **Frequency** to the per unit steady state change in power output. |
| **Electricity Safety, Quality and Continuity Regulations (ESQCR)** | The statutory instrument entitled The **Electricity Safety, Quality and Continuity Regulations** 2002 as amended from time to time and including any further statutory instruments issued under the Electricity Act 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004) in relation to the distribution of electricity. |
| **Energisation Operational Notification (EON)** | A notification issued by the **DNO** to a **Generator** prior to energisation of its internal network. |
| **Excitation System** | The equipment providing the field current of a machine, including all regulating and control elements, as well as field discharge or suppression equipment and protective devices. |
| **Exciter** | The source of the electrical power providing the field current of a synchronous machine. |
| **European Specification** | A common technical specification, a **British Standard** implementing a European standard or a European technical approval. The terms "common technical specification", "European standard" and "European technical approval" shall have the meanings respectively ascribed to them in the Utilities Contracts Regulations 1996, as amended from time to time. |
| **Fast Fault Current** | A current injected by a **Power Park Module** or HVDC system during and after a voltage deviation caused by an electrical fault with the aim of identifying a fault by network protection systems at the initial stage of the fault, supporting system voltage retention at a later stage of the fault and system voltage restoration after fault clearance. |
| **Fault Ride Through** | The capability of **Power Generating Modules** to be able to be able to remain connected to the **Distribution Network** and operate through periods of low voltage at the **Connection Point** caused by secured faults. |
| **Final Operational Notification (FON)** | A notification issued by the **DNO** to a **Generator**, who complies with the relevant specifications and requirements in this EREC G99, allowing them to operate a **Power Generating Module** by using the **Distribution Network** connection |
| **Frequency Response Deadband** | An interval used intentionally to make the frequency control unresponsive. |

**Comment [CS1]:** Definition remains to be confirmed for internal consistency and GB usage

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| | In the case of mechanical governor systems the Governor Deadband is the same as **Frequency Response Insensitivity.** |
| **Frequency Response Insensitivity** | The inherent feature of the control system specified as the minimum magnitude of change in the frequency or input signal that results in a change of output power or output signal. |
| **Frequency Sensitive Mode** | The operating mode of a **Power Generating Module** or HVDC system in which the **Active Power** output changes in response to a change in system frequency, in such a way that it assists with the recovery to target frequency. |
| **Fully Type Tested** | **A Power Generating Module** which has been tested to ensure that the design meets the relevant technical and compliance requirements of this EREC G99, and for which the **Manufacturer** has declared that all similar **Power Generating Modules** supplied will be constructed to the same standards and will have the same performance. In the case where protection functionality is included in the tested equipment, all similar products will be manufactured with the same protection settings as the tested product. |
| **Generator** | A person who generates electricity under licence or exemption under the Electricity Act 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004) or the Electricity (Northern Ireland) Order 1992 and whose **Power Generating Facility** is directly or indirectly connected to a **Distribution Network**. For avoidance of doubt, also covers any competent person or agent working on behalf of the **Generator**. Often referred to as a distributed or embedded generator. Also for the avoidance of doubt any **Customer** with generation connected to that **Customer's Installation** is a **Generator**. |
| **Generating Unit** | Any apparatus which produces electricity. This includes **Micro-generators** and electricity storage devices. |
| **Great Britain or GB** | The landmass of England & Wales and Scotland, including internal waters. |
| **Grid Code** | The code which the **NETSO** is required to prepare under its **Transmission Licence** and have approved by the **Authority** as from time to time revised with the approval of, or by the direction of, the **Authority**. |
| **Grid Entry Point** | An **Onshore Grid Entry Point** or an **Offshore Grid Entry Point**. |
| **High Voltage (HV)** | A voltage exceeding 1000V AC or 1500V DC between conductors, or 600V AC or 900V DC between conductors and earth. |
| **HV Generator Performance Chart** | A diagram showing the **Active Power** (MW) and **Reactive Power** (MVAr) capability limits within which a **Synchronous Power Generating Module** or **Power Park Module** at its **Connection Point** will be expected to operate under steady state conditions. |
| **Installer** | The person who is responsible for the installation of the **Power Generating Module**(s). |

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| **Interface Protection** | The electrical protection required to ensure that any **Power Generating Module** is disconnected for any event that could impair the integrity or degrade the safety of the **Distribution Network. Interface Protection** may be installed on each **Power Generating Module** or at the C**onnexion Point** for the **Power Generating Facility.** |
| **Intermittent Power Source** | The primary source of power for a **Generating Unit** that cannot be considered as controllable, e.g. wind, wave or solar. |
| **Inverter** | A device for conversion from **Direct Current** to nominal frequency Alternating Current. |
| **Limited Frequency Sensitive Mode** | A mode whereby the operation of a **Power Generating Module** is **Frequency** insensitive except when the system **Frequency** exceeds 50.4Hz in which case **Limited Frequency Sensitive Mode – Overfrequency** (**LFSM-O**) must be provided or **Limited Frequency Sensitive Mode - Underfrequency** (**LFSM-U**) should be provided. |
| **Limited Frequency Sensitive Mode – Overfrequency (LFSM-O)** | A **Power Generating Module** or HVDC system operating mode which will result in **Active Power** output reduction in response to a change in system frequency above a certain value. |
| **Limited Frequency Sensitive Mode – Underfrequency (LFSM-U)** | A **Power Generating Module** or HVDC system operating mode which will result in **Active Power** output increase in response to a change in system frequency below a certain value. |
| **Limited Operational Notification** | A notification issued by the **DNO** to a **Generator** who had previously attained **FON** status but is temporarily subject to either a significant modification or loss of capability resulting in non-compliance with the relevant specifications and requirements. |
| **Low Voltage (LV)** | A voltage normally exceeding extra-low voltage (50V) but not exceeding 1000V AC or 1500V DC between conductors or 600V AC or 900V DC between conductors and earth. |
| **LV Synchronous Generating Unit Performance Chart** | A diagram showing the **Active Power** (MW) and **Reactive Power** (MVAr) capability limits within which a synchronous **Generating Unit** at its stator terminals will be expected to operate under steady state conditions. |
| **Manufacturer** | A person or organisation that manufactures **Generating Units.** |
| **Manufacturers' Information** | Information in suitable form provided by a Manufacturer in order to demonstrate compliance with one or more of the requirements of this EREC G99. Where Equipment Certificate(s) as defined in EU 2016/631 cover all or part of the relevant compliance points, the Equipment Certificate(s) demonstrate compliance without need for further evidence for those aspects within the scope of the Equipment Certificate. |
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| **Minimum Generation** | The minimum output which a **Power Generating Module** can reasonably generate as registered under the Distribution Data |

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| | Registration Code, |
| **Modification** | Any actual or proposed replacement, renovation, modification, alteration or construction by a **Generator** to a **Power Generating Module**, or the manner of its operation which involves the Generator or the **DNO** in expenditure of more than £10,000. |
| **National Electricity Transmission System Operator (NETSO)** | National Grid Electricity Transmission (NGET) in its capacity as operator of the National **Transmission System**. |
| **Network** | Plant and apparatus connected together in order to transmit or distribute electricity. |
| **Onshore** | Means within **Great Britain**, and when used in conjunction with another term and not defined means that the associated term is to be read accordingly. |
| **Over-excitation Limiter** | Shall have the meaning ascribed to that term in IEC 34-16-1. |
| **Phase (Voltage) Unbalance** | The ratio (in percent) between the rms values of the negative sequence component and the positive sequence component of the voltage |
| **Point of Common Coupling** | The point on a **Distribution Network,** electrically nearest the **Customer**'s **Installation,** at which other **Customers** are, or may be, connected. |
| **Power Factor** | The ratio **of Active Power** to **Apparent Power**. |
| **Power Generating Facility** | A facility that converts primary energy into electrical energy and which consists of one or more **Power Generating Modules** connected to a **Network** at one or more **Connection Points**. |
| **Power Generating Module** | Either a **Synchronous Power Generating Module** or a **Power Park Module**. |
| **Power Park Module (PPM)** | A unit or ensemble of units generating electricity, which is either non-synchronously connected to the network or connected through power electronics, and that may be connected through a transformer and that also has a single **Connection Point** to a distribution network. |
| **Power System Stabiliser (PSS)** | Equipment controlling the output of a **Power Generating Module** in such a way that power oscillations of the machine are damped. Input variables may be speed, frequency, or power or a combination of variables. |
| **Q/Pmax** | The ratio of **Reactive Power** to the **Registered Capacity**. The relationship between **Power Factor** and **Q/Pmax** is given by the formula:- |

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| | **Power Factor** = Cos $[\arctan[\frac{Q}{Pmax}]]$ |
| **Reactive Power (Q)** | The product of voltage and current and the sine of the phase angle between them which is normally measured in kilovar (kVAr) or megavar (MVAr). |
| **Registered Capacity ($P_{max}$)** | The normal full load capacity of a **Power Generating Module**, or of a **Power Generating Facility**, as declared by the **Generator** less the MW consumed when producing the same. This will relate to the maximum level of **Active Power** deliverable to the **DNO's Distribution Network**.<br><br>For **Power Generating Modules** connected to the **DNO's Distribution Network** via an **Inverter**, the **Inverter** rating is deemed to be the **Power Generating Module's** rating. |
| **Embedded Medium Power Station** | An embedded **Power Generating Facility** in England and Wales of 50MW or greater **Registered Capacity** but less than 100MW **Registered Capacity** |
| **Standard Planning Data (SPD)** | General information required by the **DNO** under the Distribution Planning Code. |
| **Station Transformer** | A transformer supplying electrical power to the auxiliaries of a **Power Generating Facility**, which is not directly connected to the **Power Generating Module** terminals (typical voltage ratio being 132/11kV) |
| **Step Voltage Change** | Following system switching, a fault or a planned outage, the change from the initial voltage level to the resulting voltage level after all the **Power Generating Module** automatic voltage regulator (AVR) and static VAR compensator (SVC) actions, and transient decay (typically 5 seconds after the fault clearance or system switching have taken place), but before any other automatic or manual tap-changing and switching actions have commenced. |
| **Supplier** | (a) A person supplying electricity under an Electricity Supply Licence; or<br>(b) A person supplying electricity under exemption under the Electricity Act 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004);<br><br>in each case acting in its capacity as a **Supplier** of electricity to **Customers**. |
| **System Stability** | The ability of the system, for a given initial operating condition, to regain a state of operating equilibrium, after being subjected to a given system disturbance, with most system variables within acceptable limits so that practically the whole system remains intact. |
| **Synchronous Power** | means an indivisible set of **Generating Units** which can generate |

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| **Generating Module** | electrical energy such that the frequency of the generated voltage, the generator speed and the frequency of network voltage are in a constant ratio and thus in **Synchronism**. |
| **Synchronism** | The condition under which a **Power Generating Module** or system is connected to another system so that the frequencies, voltage and phase relationships of that **Power Generating Module** or system, as the case may be, and the system to which it is connected are similar within acceptable tolerances. |
| **Total System** | The integrated system of connected **Power Generating Modules, Transmission System, Distribution Networks** and associated electrical demand. |
| **Transmission Licence** | The licence granted under Section 6(1)(b) of the **Act**. |
| **Transmission System** | A system of **High Voltage** lines and plant owned by the holder of a **Transmission Licence** and operated by the **NETSO,** which interconnects **Power Generating Facilites** and substations. |
| **Type A** | A **Power Generating Module** with a **Connection Point** below 110 kV and a **Registered Capacity** of 0.8 kW or greater but less than 1MW. |
| **Type B** | A **Power Generating Module** with a **Connection Point** below 110 kV and **Registered Capacity** of 1MW or greater but less than 10MW. |
| **Type C** | A **Power Generating Module** with a **Connection Point** below 110 kV and a **Registered Capacity** of 10MW or greater but less than 50MW. |
| **Type D** | A **Power Generating Module** with a **Connection Point** at, or greater than, 110 kV; or with a **Connection Point** below 110 kV and with **Registered Capacity** of 50MW or greater. |
| **Type Tested** | A product which has been tested to ensure that the design meets the relevant requirements of this EREC G99, and for which the **Manufacturer** has declared that all similar products supplied will be constructed to the same standards and will have the same performance. The **Manufacturer's** declaration will define clearly the extent of the equipment that is subject to the tests and declaration. In the case where protection functionality is included in the tested equipment, all similar products will be manufactured with the same protection settings as the tested product.<br><br>Examples of products which could be **Type Tested** include **Generating Units**, **Inverters** and the protection system. |

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| **Unresolved Issues** | Any relevant EREC G99 requirements identified by the **DNO** with which the **Generator** has not demonstrated compliance to the **DNO's** reasonable satisfaction at the date of issue of the **Interim Operational Notification** and/or **Limited Operational Notification** and which are detailed in such **Interim Operational Notification** and/or **Limited Operational Notification**. |
| **Under Excitation Limiter** | Shall have the meaning ascribed to that term in IEC 34-16-1. |

## 5 Legal Aspects

5.1 The operation and design of the electricity system in **Great Britain** is defined principally by Directive 2009/72/EC, the Electricity Act (1989 as amended), the Electricity Safety Quality and Continuity Regulations (ESQCR) 2002, as well as general considerations under the Health and Safety at Work Act (HASWA) 1974 and the Electricity at Work Regulations (EaWR) 1989. A brief summary of the main statutory obligations on **DNO**s, **Generator**s and **Customers** is included as Appendix D.4.

5.2 Directive 2009/72/EC gives rise to a number of pieces of other EU law, the most relevant of which is Commission Regulation (EU) 2016/631, the Network Code Requirements for all Generators (RfG). This code supersedes UK law, although it is not a complete set of requirements. This EREC has been written to comply fully with the requirements of the RfG, and to include other requirements required for connection to the GB power system.

5.3 Under section 21 of the Electricity Act, **Generator**s may be required to enter into a bespoke **Connection Agreement** with the **DNO**. Such a **Connection Agreement** will specify the terms and conditions including technical, operating, safety and other requirements under which **Power Generating Module**s are entitled to remain connected to the **Distribution Network**. It is usual to include site specific commercial issues, including recovery of costs associated with the connection, GDUoS (Generator Distribution Use of System) charges and the applicable energy loss adjustment factors, in **Connection Agreement**s. It is also common practice by some **DNO**s to collect the technical issues into a subordinate “Technical and Operating Agreement” which is given contractual force by the **Connection Agreement**.

5.4 **DNO**s are required by their licences to have in force and comply with the **Distribution Code**. **Generators** will be bound by their **Connection Agreements** and licences if applicable, to comply with the **Distribution Code**.

5.5 In accordance with DPC5.4 of the **Distribution Code**, when details of the interface between a **Power Generating Facility** and the **Distribution Network** have been agreed a site responsibility schedule detailing ownership, maintenance, safety and control responsibilities will be drafted. The site responsibility schedule and operation drawing shall be displayed at the point of interconnection between the **DNO**'s and **Generator**'s systems, or as otherwise agreed.

5.6 The **DNO**s have statutory and licence obligations within which they have to offer the most economic, technically feasible option for connecting **Power Generating Facilities** to their **Distribution Network**s. The main general design obligations imposed on the **DNO**s are to:

a. maintain supplies to their **Customers** within defined statutory voltage and frequency limits;

b. ensure that the **Distribution Networks** at all voltage levels are adequately earthed;

c. comply with the "Security of Supply" criteria defined in EREC P2;

d. meet improving standards of supply in terms of customer minutes lost (CMLs) and the number of customer interruptions (CIs);

e. facilitate competition in the connection, generation and supply of electricity.

5.7 Failure to meet any of the above obligations will incur legal or regulatory penalties. The first two criteria, amongst others, define the actions needed to allow islanded operation of the **Power Generating Facility** or to ensure that the **Power Generating Facility** is rapidly disconnected from the **Distribution Network** under islanded conditions. The next two criteria influence the type of connection that may be offered without jeopardising regulated standards.

5.8 General conditions of supply to **Customer**s are also covered by Regulation 23 of the ESQCR 2002. Under Regulation 26 of the ESQCR 2002 no **DNO** is compelled to commence or continue a supply if the **Customer's Installation** may be dangerous or cause undue interference with the **Distribution Network** or the supply to other **Customer**s. The same regulation empowers the **DNO** to disconnect any part of the **Customer**'s **Installation** which does not comply with the requirements of Regulation 26. It should also be noted that each installation has to satisfy the requirements of the HASWA 1974 and the EaWR 1989.

5.9 The **DNO** shall refuse to allow the connection of a **Power Generating Module** which does not comply with the requirements set out in this EREC G99 and which is not covered by a derogation granted by the **Authority**.

5.10 Regulations 21 and 22 of the ESQCR 2002 require installations that have alternative sources of energy to satisfy Regulation 21 in relation to switched alternative supplies, and Regulation 22 in the case of sources of energy running in parallel with the **Distribution Network**.

5.11 Under Regulation 22 of the ESQCR 2002, no person may operate **Power Generating Modules** in parallel with a public **Distribution Network** without the agreement of the **DNO**.

5.12 All **Generator**s have to comply with the appropriate parts of the ESQCR.

5.13 Any collection of **Power Generating Modules** under the control of one owner or operator in one installation is classed in the Codes as a **Power Generating Facility**.

5.14 **Power Generating Facilities** that are to be connected to a **Distribution Network** and contain **Power Generating Module**s that trade in the wholesale market as Balancing Mechanism Units or have for other reasons become a party to the Balancing and Settlement Code and/or National Grid's Connection and Use of System Code, will then have to comply with the applicable **Grid Code** requirements for **Power Generating Modules**.

5.15 Information, which should assist **Generator**s wishing to connect to the **Distribution Network** at **High Voltage (HV)**, will be published by the **DNO** in accordance with condition 25 of the **Distribution Licence**. This is known as the Long Term Development Statement (LTDS). The general form and content of this statement is specified by Ofgem and covers the existing **Distribution Network** as well as authorised changes in future years on a rolling basis.

5.16 Under the terms of the Electricity Act 1989 (as amended), generation of electricity is a licensed activity, although the Secretary of State, may by order[1] grant exemptions. Broadly, generating stations of less than 50MW are automatically exempt from the need to hold a licence, and those between 50MW and 100MW may apply to the Department for Business, Energy and Industrial Strategy for an exemption if they wish.

5.17 **Generators** will need appropriate contracts in place for the purchase of any energy that is exported from the **Generator**s' **Power Generating Facilities**, and for any energy imported. For this purpose the **Generator** will need contracts with one or more **Supplier**s**,** and where the **Supplier** does not provide it, a meter operator agreement with the appropriate provider.

5.18 **Generator**s wishing to trade ancillary services for National Grid purposes will need appropriate contracts in place with the National Grid Electricity Transmission in its role as **Great Britain** System Operator.

## 6 Connection Application

### 6.1 General

6.1.1. This document describes the processes that shall be adopted for both connection of single **Power Generating Modules** and installations that comprise of a number of **Power Generating Modules.** .

6.1.2 **Type A Power Generating Module(s) ≤ 16A per phase and EREC G98 compliant**

A connection procedure to facilitate the connection and operation of **Fully Type Tested Power Generating Module**s with aggregate **Registered Capacity** of less than or equal to 16A per phase in parallel with public **Low Voltage Distribution Network** is given in EREC G98 and is not considered further in this document. These are referred to as micro-generators.

6.1.3 **Power Park Modules**

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1 see http://www.opsi.gov.uk/si/si2001/20013270.htm

6.1.3.1 Where an installation comprises multiple **Power Park Modules** the application process and commissioning requirements will generally be based on each **Power Generating Module,** and also on the extent to which each **Power Generating Module** is **Type Tested**. However note that if the aggregated capacity of all the **Power Generating Modules** in the **Power Generating Facility** (ie the **Registered Capacity**) reach the thresholds for Large as defined in the **Grid Code** (ie 10MW in the north of Scotland; 30MW in the south of Scotland, 100MW in England and Wales), then the **Generator** will have to ensure compliance with relevant parts of the **Grid Code**. Similarly if the **Registered Capacity** of a **Power Generating Facility** in England and Wales is 50MW or more, the **Generator** will have to comply with 6.4.3 and 13.9.

6.1.3.2 Where a new **Power Park Module** is connected to an existing installation the treatment of the addition will depend on the EREC under which the existing installation was connected. If the existing installation was connected under EREC G59 or EREC G83 then the new **Power Park Module** will be treated as a separate **Power Park Module** and managed for compliance with this EREC G99 as a separate PGM. If however the existing installation was completed in compliance with EREC G98 (parts 1 or 2) or EREC G99, then the new **Power Park Module** must be added to the aggregate capacity of the complete installation which must be used to determine which EREC is applicable irrespective of technology.

### 6.1.4 Synchronous Power Generating Modules

6.1.4.1 Where an installation comprises multiple synchronous **Power Generating Modules** the application process and commissioning requirements should be based on the individual synchronous **Power Generating Modules Registered Capacity**.

6.1.4.2 Where one or more new synchronous **Power Generating Module(s)** is to be connected to an existing installation then each new **Power Generating Module** will be treated as a separate synchronous **Power Generating Module**. Only the new **Power Generating Module** will be required to meet the requirements of this Engineering Recommendation.

### 6.1.5 Illustrative examples

6.1.5.1 Table 6.1 is provided to illustrate some of the connection scenarios and the EREC requirements.

| Existing **Power Generating Facility** | Additional **Power Generating Modules** | Compliance requirements |
|---|---|---|
| Nil | **Type A Power Generating Module** | EREC G98 if **Type Tested LV** connected, otherwise EREC G99 |
| Synchronous **Power Generating Modules** commissioned under EREC G83 or EREC G59 | Synchronous **Power Generating Modules** | Original and additional **Power Generating Modules** treated separately. Only additional **Power Generating Modules** need to comply with EREC G98 or EREC G99; both need to comply with operational requirements. |
| Synchronous **Power Generating Modules** | Synchronous **Power Generating Modules** | Original and additional **Power Generating Modules** treated |

| | | |
|---|---|---|
| commissioned under EREC G98 or EREC G99 | | separately. All **Power Generating Modules** need to comply with EREC G98 or EREC G99 and with operational requirements. |
| Asynchronous **Power Generating Module** commissioned under EREC G83 or EREC G59 | Asynchronous **Power Generating Modules** | Original and additional **Power Generating Modules** treated separately. Only additional **Power Generating** M**odules** need to comply with EREC G98 or EREC G99; both need to comply with operational requirements. |
| Asynchronous **Power Generating Module** commissioned under EREC G98 or EREC G99 | Asynchronous **Power Generating Units** | Units aggregated to form a new **Power Generating Module**. Compliance required for the new module size, with EREC G98 or EREC G99 and with operational requirements. |
| Synchronous **Power Generating Modules** commissioned under EREC G83 or EREC G59 and Synchronous **Power Generating Modules** commissioned under EREC G98 or EREC G99 | Synchronous **Power Generating Modules** | Original and additional **Power Generating Modules** treated separately. Only additional **Generating Power Generating Modules** need to comply with EREC G98 or EREC G99; all need to comply with operational requirements. |
| Asynchronous **Power Generating Module** commissioned under EREC G98 or EREC G99 | Asynchronous **Power Generating Units** | Additional units take the overall module size from a lower band to a higher band, (eg the original **Power Generating Module** was **Type A**; the new aggregate is **Type B**), the **Power Generating Module** must be compliant for the new higher band all need to comply with operational requirements. |
| Asynchronous **Power Generating Module** commissioned under EREC G83 or EREC G59 and Asynchronous **Power Generating Module** commissioned under EREC G98 or EREC G99 | Asynchronous **Power Generating Units** | Original **Power Generating Modules** (EREC G83 or EREC G59) treated separately to the combination of the existing EREC G98/ EREC G99 **Power Park Module** and new **Power Park Units**. Only the resultant **Power Park Module** needs to comply with EREC G98 or EREC G99; all need to comply with operational requirements. |

Table 6.1

6.1.5.2 In respect of Table 6.1 the aggregate **Registered Capacity** of all **Power Generating Modules** in the vicinity will be taken into account when the DNO considers the effect of the connection on the network.

6.1.6 **Interaction with the NETSO**

6.1.6.1 It should be noted that if the **Registered Capacity** of all **Power Generating Module** (synchronous together with asynchronous) on one or more sites in common ownership is >50MW, then the **Generator** becomes licensable.

6.1.6.2 **Generators** with an agreement with the **NETSO** may be required to comply with applicable requirements of the **Grid Code.** Where **Grid Code** requirements apply, it is the **Generator**'s responsibility to comply with the relevant parts of both the **Distribution Code** and **Grid Code**.

## 6.2 Application for Connection

6.2.1 Information about the **Power Generating Module**(s) is needed by the **DNO** so that it can assess the effect that a **Power Generating Facility** may have on the **Distribution Network**. This document details the parameters to be supplied by a **Customer** wishing to connect **Power Generating Module(s)** that do not comply with EREC G98 to a **Distribution Network**. This document also enables the **DNO** to request more detailed information if required.

### 6.2.2 Type A Power Generating Module

The **Generator** should apply to the local **DNO** for connection using the **DNO's** standard application form (available from the **DNO's** website). On receipt of the application, the **DNO** will assess whether any **Distribution Network** studies are required and whether there is a requirement to witness the commissioning tests. In some cases studies to assess the impact on the **Distribution Network** may need to be undertaken before a firm quotation can be provided to the **Customer**. On acceptance of the quote, any works at the connection site and any associated facilitating works will need to be completed before the **Power Generating Module** can be commissioned. On successful completion of the commissioning tests, the **DNO** will sanction permanent energisation of the **Power Generating Module** in accordance with Section 15 of this EREC G99.

Comment [CS2]: Consolidation with this doc to be considered

### 6.2.3 Power Generating Facilities which include Type B, Type C or Type D Power Generating Modules

The connection process is similar to that described in 6.2.2 above, although detailed system studies will almost certainly be required and consequently the **Generator** might need to provide additional information. The information should be provided using the standard application form (generally available from the **DNO's** website). The data that will generally be required is defined in the **Distribution Code**, Data Registration Code (DDRC), Schedules 5a, 5b and 5c.

Comment [MK3]: Consideration is being given to including DDRC in this document

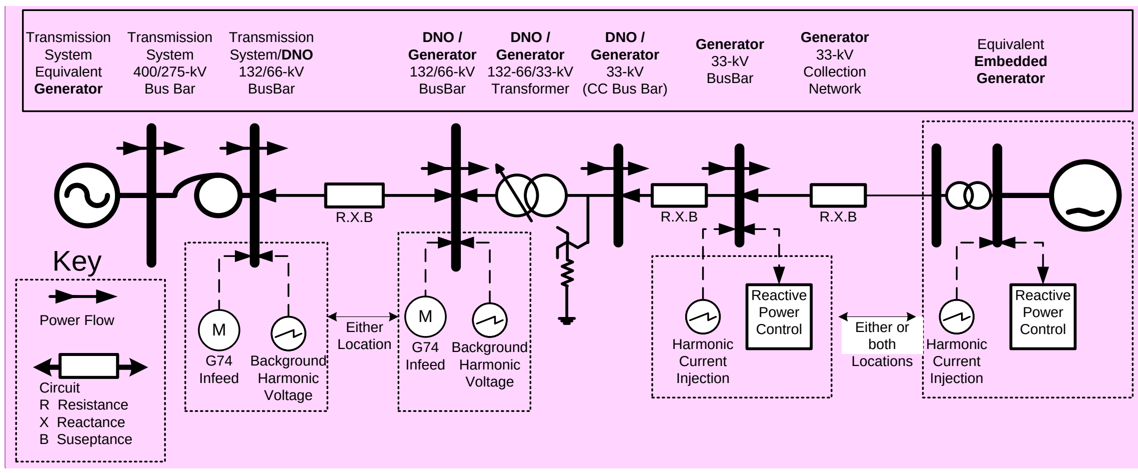
The compliance, testing and commissioning requirements are detailed in Sections 16 and 17 of this EREC G99. On successful completion of a **Type B** or **Type C Power Generating Module Document** and commissioning tests the **DNO** will issue a **Final Operational Notification** to the **Generator**. Once all the relevant documents have been provided to the DNO to their satisfaction a DNO will issue a **Type D Power Generating Module** will be issued with an **Energisation Operational Notification** followed by an **Interim Operational Notification** and a **Final Operational Notification**.

## 6.3 System Analysis for Connection Design Type A, Type B, Type C and Type D

6.3.1 **DNO**s use a variety of modelling tools to undertake system analysis. Their exact needs for data and models will vary dependent on the voltage level, size, and location of the connection. Generally the **DNO** will seek the key information from the **Generator** via the application forms referred to in 6.2 above. Occasionally the **DNO** may also need additional data for modelling purposes and will seek this information in accordance with the requirements of this document and the **Distribution Code**.

6.3.2 In the course of planning and designing a power system, it is often necessary to model a small section of the wider system in detail. This could be an embedded system at 132kV or less, which is connected to the **Transmission System** (400/275kV) via one or more step-down transformers.

6.3.3 For **Power Generating Facilities** connected at **HV**, it is generally necessary to build an equivalent model of the **Distribution Network**. An example is shown as Fig 6.1 below.




Comment [CS4]: Diagram to be refreshed for final draft

Fig 6.1 Example equivalent **Total System** representation

This model will typically include equivalent source representing existing **Power Generating Modules** fault level arising from asynchronous plant (EREC G74), interconnection impedances, loads, and possibly the **Generator**'s proposal for reactive compensation plant. The parameters of these elements will depend upon the selection of the boundary nodes between the equivalent and detailed networks in the model.

6.3.4 It may be beneficial to model some of the 'active' elements in full detail. Supergrid, grid primary and other transformers can be considered active for the purpose of determining voltage control limits. Knowledge of the voltage control set points, transformer tap changer deadbands, and control methods is often essential. Also a knowledge of which items of **Power Generating Modules** are mainly responsible for the range of fault contributions offered at the **Connection Point** by the **DNO** is a useful addition. Fault contribution may also arise from other rotating plant – shown here as an equivalent asynchronous motor (EREC G74).

6.3.5 This equivalent **Total System** model will not accurately represent the fast dynamic (sub second) behaviour of the active elements within the **Distribution Network** and **Transmission System**.

6.3.6 Control systems for synchronous **Power Generating Module**s and prime movers have traditionally been provided and modelled in transparent transfer-function block diagram form. These models have been developed over many years and include lead/lag elements, gains, limiters and non-linear elements and may be tuned to obtain a satisfactory response for the particular **Power Generating Module** and grid connection. The requirement to submit models in this form for directly connected synchronous **Power Generating Module**s is written into this document and the **Grid Code**.

6.3.7 For other generation technologies, this document includes the requirement to submit validated detailed models in respect of non-synchronous **Power Generating Modules** which are aggregated into a '**Power Park Module' Generating Facilities**.

6.3.8 This document has a similar requirement of the **Generator** where the **DNO** deems it necessary to ensure **System Stability** and security. The DDRC accepts models of all types of **Power Generating Module**s.

6.3.9 Validated detailed models are required in respect of **Type B**, **Type C and Type D Power Generating Facilities.** This requires the **Power Generating Module Manufacturer** to submit a **Power Generating Module** (Synchronous or Power Park) model in a format suitable for the **DNO** usually in a documented block diagram format.

6.3.10 The model will normally be requested in a compiled form suitable for use with the particular variety of power system analysis software used by the **DNO** or the **NETSO**. Recently there is a move by **Manufacturer**s to create 'black-box' models of their **Power Generating Module**s. These are programmed for compatibility with industry standard power analysis modelling packages. This is in order to protect the **Manufacturer'**s intellectual property and so lessen the need for confidentiality agreements between parties. There are potential advantages and disadvantages to this approach, but must be generally welcomed provided that the two main disadvantages of this approach, as described below, can be resolved:

a. The model must not be software 'version' specific ie will work in all future versions, or has an assurance of future upgrades for a particular software package;

b. The **Manufacturer** must provide assurance that the black box model correctly represents the performance of the **Power Generating Module** for load flow, fault level and transient analysis for the typical range of faults experienced by **DNO**s.

### 6.4 Provision of Information

**Power Generating Facilities** can have a significant effect on the **DNO's Distribution Network** and as a result its **Customers**. To enable the **DNO** to assess the impact embedded **Power Generating Modules** will have on the **DNO's**

**Distribution Network,** the **Generator** will be required to supply information to the **DNO.**

Except for **Fully Type Tested Type A Power Generating Modules, Generator's** shall provide the following minimum information to the **DNO** during the connection application process or otherwise as requested by the **DNO**:-

Relevant Sections:

| | |
|---|---|
| (a) **Power Generating Facility** and site data for all embedded **Power Generating Facilities.** | 6.4.1 and Schedule 5a of the DDRC |
| (b) **Power Generating Module** data for all embedded **Power Generating Modules** | 6.4.2 and Schedule 5b of the DDRC |
| (c) **Power Generating Module** data for specified types of embedded **Power Generating Modules**<br>5c(i) Synchronous **Power Generating Modules**<br>5c(ii) Fixed speed induction **Power Generating Modules**<br>5c(iii) Double fed induction **Power Generating Modules**<br>5c(iv) Converter connected **Power Generating Modules**<br>5c(v) Transformers | 6.4.2 and Schedules 5c of the DDRC |
| (d) **Power Generating Module** data for **Type D Generating Facilities** | 6.4.3 and Schedules 5c of the<br>DDRC |

When applying for connection to the **DNO's Distribution Network Generators** shall also refer to DPC5.

The **DNO** will use the information provided to model the **DNO's Distribution Network** and to decide what method of connection will need to be employed and the voltage level to which the connection should be made. If the **DNO** reasonably concludes that the nature of the proposed connection or changes to an existing connection requires more detailed consideration then further information may be requested. It is unlikely that more information than that specified in 6.4.1 will be required for **Power Generating Facilities** who are to be connected at **Low Voltage** and have less than 50kVA in capacity, or connected at other than **Low Voltage** and have less than 300kVA in capacity.

### 6.4.1 Information Required from all Type A, Type B, Type C and Type Power Generating Facilities

It will be necessary for each **Generator** to provide to the **DNO** information on physical and electrical characteristics of the **Power Generating Facility** and site as a whole as set out in Schedule 5a of the Distribution Data Registration Code before entering into an agreement to connect any **Power Generating Module** onto the **DNO's Distribution Network:-**

The information required includes:

(a) Details of the proposed **Connection Point** (geographical and electrical) and connection voltage.

(b) The number and types of **Power Generating Modules** and the total capacity of the **Power Generating Facility** and auxiliary supplies under various operating conditions.

(c) Sketches of system layout:

Operation Diagrams showing the electrical circuitry of the existing and proposed main features within the **Customer's** system and showing as appropriate busbar arrangements, phasing arrangements, earthing arrangements, switching facilities and operating voltages.

(d) Interface Arrangements

(i) The means of synchronisation between the **DNO** and **Customer**;

(ii) Details of arrangements for connecting with earth that part of the **Customer** system directly connected to the **DNO's Distribution Network**.

(iii) The means of connection and disconnection which are to be employed.

(iv) Precautions to be taken to ensure the continuance of safe conditions should any earthed neutral point of the **Power Generating Facility's** system operated at **HV** become disconnected from earth.

More or less detailed information than that contained above might need to be provided, subject to the type and size of **Power Generating Module** or the point at which connection is to be made to the **DNO's Distribution Network**. This information will need to be provided by the **Generator** at the reasonable request of the **DNO**.

**6.4.2 Additional Power Generating Module, Plant and Equipment Data Required from some Power Generating Facilities.**

The **Standard Planning Data** and **Detailed Planning Data** specified in Schedule 5b and Schedule 5c of the Distribution Data Registration Code may be requested by the **DNO** from the **Customer** before entering into an agreement to connect any **Power Generating Module** onto the **DNO's Distribution Network.**

The information specified in Schedule 5b of the Distribution Data Registration Code includes generic data for all **Power Generating Modules.**

The information specified in Schedule 5c of the Distribution Data Registration Code includes the more detailed electrical parameters of individual **Power Generating Modules** and associated plant such as transformers, **Power Factor** correction equipment. The information required is classified as **Standard Planning Data** and **Detailed Planning Data** for each of the following categories of **Power Generating Modules**:

(i) Synchronous **Power Generating Modules**

(ii) Fixed speed induction **Power Generating Modules**

(iii) Doubly fed induction **Power Generating Modules**

(iv) Series converter connected **Power Generating Modules**.

(v) Transformers

Under certain circumstances either more or less detailed information than that specified above might need to be provided and will be made available by the **Generator** at the request of the **DNO.**

### 6.4.3 Extra Information From Embedded Medium Power Stations to be Provided to Meet Grid Code Requirements

(a) The **DNO** has an obligation under EPC3.3 of the **Grid Code** to submit certain planning data relating to **Embedded Medium Power Stations** to **the NETSO**. The relevant data requirements of the **Grid Code** are also listed in EPC3.3 of the **Grid Code**. It is incumbent on the **Embedded Medium Power Station Generator** to provide this data listed in EPC3.3 of the **Grid Code** to the **DNO**.

Where a **Generator** in respect of a **Power Generating Facility** is a party to the **CUSC** this paragraph will not apply.

(b) In addition to supplying the **DNO** with details of **Power Generating Modules** there is a requirement for the Generator to provide information to the **NETSO** where it has been specifically requested by the **NETSO** in the circumstances provided for under the **Grid Code**.

### 6.4.4 Information Provided by the DNO to Customers

In accordance with Condition 4 and Condition 25 of its **Distribution Licence** the **DNO** is required to provide certain information to **Customers** so that they have the opportunity to identify and evaluate opportunities to connect to the **DNO's Distribution Network** as set out in DPC4.5. Comprehensive information on the **DNO's Distribution Network** operating at 33kV and above is made available to **Customers** through the Long Term Development Statements provided under Condition 25 of the **Distribution Licence.** Schedule 5d of the Distribution Data Registration Code is indicative of the type of network data the **DNOs** is required to provide to **Customers** for identifying opportunities for connection of generation at voltages below 33kV. On the production of Schedule 5d data for a **Customer**, the **DNO** will update any relevant data that would otherwise be provided from the Long Term Development Statement.

# 7 CONNECTION ARRANGEMENTS

## 7.1 Operating Modes

7.1.1 **Power Generating Modules** may be designed for one of three operating modes. These are termed long-term parallel operation, infrequent short-term parallel operation and switched alternative-only operation.

## 7.2 Long-Term Parallel Operation

7.2.1 This refers to the frequent or long-term operation of **Power Generating Modules** in parallel with the **Distribution Network**. Unless otherwise stated, all sections in this Engineering Recommendation are applicable to this mode of operation.

### 7.3 Infrequent Short-Term Parallel Operation

7.3.1 This mode of operation typically enables **Power Generating Modules** to operate as a standby to the **DNO**s supply. A short-term parallel is required to maintain continuity of supply during changeover and to facilitate testing of the **Power Generating Module**.

7.3.2 In this mode of operation, parallel operation of the **Power Generating Module** and the **Distribution Network** will be infrequent and brief and under such conditions, it is considered acceptable to relax certain design requirements, such as protection requirements, that would be applicable to long-term parallel operation.

7.3.3 As the design requirements for **Power Generating Module** operating in this mode are relaxed compared with those for long-term parallel operation, it is necessary for the **DNO** to specify a maximum frequency and duration of short-term parallel operation, to manage the risk associated with the relaxed design requirement.

The **Power Generating Module** may be permitted to operate in parallel with the **Distribution Network** for no more than 5 minutes in any month, and no more frequently than once per week. If the duration of parallel connection exceeds this period, or this frequency, then the **Power Generating Module** must be considered as if it is, or can be, operated in Long-Term Parallel Operation mode. An alternative frequency and duration may be agreed between the **DNO** and the **Generator** taking account of particular site circumstances and **Power Generating Module** design. An electrical time interlock should be installed to ensure that the period of parallel operation does not exceed the agreed period. The timer should be a separate device from the changeover control system such that failure of the auto changeover system will not prevent the parallel being broken.

7.3.4 The following design variations from those in the remainder of the document are appropriate for infrequent short-term parallel operation:

a. Protection Requirements – Infrequent short-term parallel operation requires only under/over voltage and under/over frequency protection. This protection only needs to be in operation for the time the **Power Generating Module** is operating in parallel. A specific Loss of Mains (LoM) protection relay is not required, although many multifunction relays now have this function built in as standard. Similarly, additional requirements such as neutral voltage displacement, intertripping and reverse power are not required. This is based on the assumptions that as frequency and duration of paralleling during the year are such that the chance of a genuine LoM event coinciding with the parallel operation is unlikely. However, if a coincidence does occur, consideration must be given to the possibility of the **Power Generating Module** supporting an island of **Distribution Network** as under voltage or under frequency protection is only likely to disconnect the **Power Generating Module** if the load is greater than the **Power Generating Module** capacity. Consequently it is appropriate to apply different protection settings for short term parallel connection. As this **Power Generating Module** will not be expected to provide grid support or contribute to system security, more sensitive settings based on statutory limits would compensate for lack of LoM protection. Ultimately, if an island was established the situation would only persist for the duration of the parallel operation timer setting before generation was tripped.

b. Connection with Earth – It is recommended that the **Power Generating Module**'s star points or neutrals are permanently connected to earth. In that way, the risks associated with switching are minimized and the undesirable effects of circulating currents and harmonics will be tolerable for the timescales associated with short-term paralleling.

c. Fault Level – There is the need to consider the effect of the **Power Generating Module's** contribution to fault level. The risks associated with any overstressing during the short term paralleling will need to be individually assessed and the process for controlling this risk agreed with the **DNO**.

d. Voltage rise / **Step Voltage Change** - Connections should be designed such that the operation of a **Power Generating Module** does not produce voltage rise in excess of statutory limits. In general this should not be an issue with most Short-Term Parallel Operation as at the time of synchronising with the mains most sites will normally be generating only sufficient output to match the site load. Therefore the power transfer on synchronising should be small, with the **Power Generating Module** ramping down to transfer site load to the mains. If the **Power Generating Module** tripped at this point it could introduce a larger **Step Voltage Change** than would normally be acceptable for loss of **Power Generating Module** operating under a long-term parallel arrangement but in this event it could be regarded as an infrequent event and a step change of up to 10% as explained in Section 9.3 would be acceptable.

e. Out-of-phase capabilities - All newly installed switchgear should be specified for the duty it is to undertake. Where existing switchgear which might not have this capability is affected by short-term paralleling it is expected that it will not be warranted to replace it with gear specifically tested for out-of-phase duties, although the owner of each circuit breaker should specifically assess this. Clearly the synchronizing circuit breaker (owned by the **Generator**) must have this certified capability. For the avoidance of doubt it is a requirement of the Electricity at Work Regulations that “no electrical equipment shall be put into use where its strength and capability may be exceeded in such a way as may give rise to danger.” Section 9.7 below provides more information on the assessment of such situations.

f. Some clauses of this EREC G99 shall not apply to **Power Generating Modules** operating in in this mode of operation. The exclusions for **Power Generating Modules** which operate under an infrequent short-term parallel operation mode are given in Appendix A.5.

7.3.5 Some **Manufacturers** have developed fast acting automatic transfer switches. These are devices that only make a parallel connection for a very short period of time, typically 100 - 200ms. Under these conditions installing a conventional G59 protection with an operating time of 500ms is not appropriate when the parallel will normally be broken before the protection has a chance to operate. There is however the risk that the device will fail to operate correctly and therefore a timer should be installed to operate a conventional circuit breaker if the parallel remains on for more than 1s. The switch should be inhibited from making a transfer to the **DNO Network** whilst voltage and frequency are outside expected limits.

## 7.4 Switched Alternative-Only Operation

### 7.4.1 General

7.4.1.1 Under this mode of operation it is not permissible to operate a **Power Generating Module** in parallel with the **Distribution Network**. Regulation 21 of the **ESQCR** states that it is the **Generator's** responsibility to ensure that all parts of the **Power Generating Module** have been disconnected from the **Distribution Network** and remain disconnected while the **Power Generating Module** is operational. The provisions of this EREC do not generally apply and the earthing, protection, instrumentation etc. for this mode of operation are the responsibility of the **Generator**, however where such **Power Generating Module** is to be installed, the **DNO** shall be given the opportunity to inspect the equipment and witness commissioning of any changeover equipment and interlocking.

7.4.1.2 The changeover devices must be of a ‘fail-safe’ design so that one circuit controller cannot be closed if the other circuit controller in the changeover sequence is closed, even if the auxiliary supply to any electro-mechanical devices has failed. Changeover methods involving transfer of removable fuses or those having no integral means of preventing parallel connection with the **Distribution Network** are not acceptable. The equipment must not be installed in a manner which interferes with the **DNO**s cut-out, fusegear or circuit breaker installation, at the supply terminals or with any metering equipment.

7.4.1.3 The direct operation of circuit-breakers or contactors must not result in the defeat of the interlocking system. For example, if a circuit-breaker can be closed mechanically, regardless of the state of any electrical interlocking, then it must have mechanical interlocking in addition to electrical interlocking. Where an automatic mains fail type of **Power Generating Module** is installed, a conspicuous warning notice should be displayed and securely fixed at the **Connection Point**.

7.4.1.4 The **Power Generating Facility** shall use an earth electrode independent from the **Distribution Network**.

7.4.1.5

### 7.4.2 Changeover Operated at HV

7.4.2.1 Where the changeover operates at **HV**, the following provisions may be considered by the **Generator** to meet the requirements of Regulation 21 of the **ESQCR**:

a. An electrical interlock between the closing and tripping circuits of the changeover circuit breakers;

b. A mechanical interlock between the operating mechanisms of the changeover circuit breakers;

c. An electro-mechanical interlock in the mechanisms and in the control circuit of the changeover circuit breakers;

d. Two separate contactors which are both mechanically and electrically interlocked.

Electrically operated interlocking should meet the requirements of BS EN 61508.

7.4.2.2 Although any one method may be considered to meet the minimum requirement, it is recommended that two methods of interlocking are used wherever possible. The **Generator** must be satisfied that any arrangement will be sufficient to fulfil their obligations under **ESQCR**.

### 7.4.3 Changeover Operated at LV

7.4.3.1 Where the changeover operates at **LV**, the following provisions may be considered by the **Generator** to meet the requirements of Regulation 21 of the **ESQCR**:

a. Manual break-before-make changeover switch;

b. separate switches or fuse switches mechanically interlocked so that it is impossible for one to be moved when the other is in the closed position;

c. An automatic break-before-make changeover contactor;

d. Two separate contactors which are both mechanically and electrically interlocked;

e. A system of locks with a single transferable key.

Electrically operated interlocking should meet the requirements of BS EN 61508.

7.4.3.2 The **Generator** must be satisfied that any arrangement will be sufficient to fulfil their obligations under **ESQCR**.

7.4.3.3 The switchgear that is used to separate the two systems shall break all four poles (3 phases and neutral). This prevents any phase or neutral current, produced by the **Power Generating Facility**, from flowing into the **DNOs Distribution Network** when it operates as a switched alternative only supply.

## 7.5 Phase Balance of Type A Power Generating Module output at LV

**7.5.1.** Connection of single phase **Power Generating Modules** may require **Distribution Network** reinforcement and extension before commissioning for technical reasons (such as voltage issues and unacceptable phase imbalance) depending on the point of connection and **Distribution Network** design.

7.5.2. A solution to these voltage issues and phase imbalance issues may be to utilise 3-phase **Power Generating Modules** or to use multiple single phase **Power Generating Modules** connected across three phases. For this arrangement the same export power will result in lower voltage rises due to decreased line currents and a 3 phase connected Power Generating Module will result in voltage rises of a sixth of those created by a single phase connected Power Generating Module. If the individual Power Generating Modules have different ratings, current and voltage imbalance may occur. To maintain current and voltage imbalance within limits the **Generator** shall consider the phase that each **Power Generating Module** is connected to in an installation. In addition the **DNO** may define to an **Generator** the phases to which the **Power Generating Modules** in any given installation should be connected.

7.5.3. **Generator** should design an installation on a maximum unbalance output of 16A between the highest and lowest phase. Where there are a mixture of different technologies, or technologies which may be operational at different times (e.g.. wind and solar) **Power Generating Module**s shall be connected to give a total imbalance of less than 16A based on assumed worst case conditions, those being:

a. One **Power Generating Module** at maximum output with the other(s) at zero output –all combinations to be considered.

b. Both / all **Power Generating Modules** being at maximum output

A **Power Generating Module** technology which operates at different times due to location e.g. east and west facing roofs for PV, must allow for the PV on one roof to be at full output and the PV on the other roof to be at zero output.

7.5.4 In order to illustrate this requirement examples of acceptable and unacceptable connections have been given in Appendix A.6.

## 7.6 Type A Power Generating Module capacity for single and split LV phase supplies

7.6.1 The maximum aggregate capacity of **Power Generating Modules** that can be connected to a single phase supply is 17kW. The maximum aggregate capacity of

**Power Generating Modules** that can be connected to a split single phase supply is 34kW.

7.6.2 There is no requirement to provide intertripping between single phase inverters where these are installed on multi-phase supplies up to a limit of 17kW per phase (subject to balance of site output as per section 7.5). A single phase 17kW connection may result in an imbalance of up to 17kW following a **Distribution Network** or **Power Generating Module** outage. However the connection design should result in imbalance under normal operation to be below 16A between phases as noted above.

7.6.3 **Power Generating Facilities** with a capacity above 17kW per phase are expected to comprise three phase units. The requirement to disconnect all phases following a fault in the **Customer's Installation** or a **Distribution Network** outage applies to three phase the **Power Generating Modules** only and will be tested as part of the compliance testing of the **Power Generating Module**. In some parts of the country where provision of three phase networks is costly then the **DNO** may be able to provide a solution using single or spilt phase networks for **Power Generating Facilities** above the normal limits as set out above.

**7.7 Voltage Management Units in Customer's premises**

7.7.1 Voltage Management Units are becoming more popular and use various methods, in most cases, to reduce the voltage supplied from the **DNO's Distribution Network** before it is used by the **Customer**. In some cases where the **DNO's Distribution Network** voltage is low they may increase the voltage supplied to the **Customer**. Some technologies are only designed to reduce voltage and cannot increase the voltage.

7.7.2 The use of such equipment has the advantage to the **Customer** of running appliances at a lower voltage and in some cases this can reduce the energy consumption of the appliance. Some appliances when running at a lower voltage will result in higher current consumption as the device needs to take the same amount of energy from the system to carry out its task.

7.7.3 If a Voltage Management Unit is installed between the **Connection Point** and the **Power Generating Module** in a **Customers Installation**, it may result in the voltage at the **Customer** side of the Voltage Management Unit remaining within the limits of the protection settings defined in Table 10.1 while the voltage at the **Connection Point** side of the unit might be outside the limits of the protection settings. This would negate the effect of the protection settings. Therefore, this connection arrangement is not acceptable and all **Power Generating Modules** connected to the **DNO's LV Distribution Network** under this Engineering Recommendation must be made on the **Connection Point** side of any Voltage Management Unit installed in a **Customer's Installation.**

7.7.4 **Customers** should note that the overvoltage setting defined in Table 10.1 is 4% above the maximum voltage allowed for the voltage from the **DNO's Distribution**

**Network** under the **ESQCR** and that provided they have designed their installation correctly there should be very little nuisance tripping of the **Power Generating Module**. Frequent nuisance tripping of a **Power Generating Module** may be due to a fault in the **Customer's Installation** or the operation of the **DNO's Distribution Network** at too high a voltage. **Customers** should satisfy themselves that their installation has been designed correctly and all **Power Generating Modules** are operating correctly before contacting the **DNO** if nuisance tripping continues. Under no circumstances should they resort to the use of Voltage Management Units installed between the **Connection Point** and the **Power Generating Module**.

# 8 EARTHING

## 8.1 General

8.1.1 The earthing arrangements of the **Power Generating Module** shall satisfy the requirements of DPC4 of the Distribution Code.

## 8.2 HV Power Generating Modules

8.2.1 **HV Distribution Networks** may use direct, resistor, reactor or arc suppression coil methods of earthing the **Distribution Network** neutral. The magnitude and duration of fault current and voltage displacement during earth faults depend on which of these methods is used. The method of earthing therefore has an impact on the design and rating of earth electrode systems and the rating of plant and equipment.

8.2.2 To ensure compatibility with the earthing on the **Distribution Network** the earthing arrangements of the **Power Generating Module** must be designed in consultation and formally agreed with the **DNO**. The actual earthing arrangements will also be dependent on the number of **Power Generating Modules** in use and the **Generators** system configuration and method of operation. The system earth connection shall have adequate electrical and mechanical capability for the duty.

8.2.3 **HV Distribution Networks** operating at voltages below 132kV are generally designed for earthing at one point only and it is not normally acceptable for **HV Customers** or **HV Generators** to connect additional **HV** earths when operating in parallel. One common exception to this rule is where the **Power Generating Module** uses an **HV** voltage transformer (VT) for protection, voltage control or instrumentation purposes and this VT requires an **HV** earth connection to function correctly.

**HV Distribution Networks** operating at 132kV are generally designed for multiple earthing, and in such cases the earthing requirements should be agreed in writing with the **DNO**.

8.2.4 In some cases the **DNO** may allow the **Generator** to earth the **Generator's HV** system when operating in parallel with the **Distribution Network**. The details of any such arrangements shall be agreed in writing between the relevant parties.

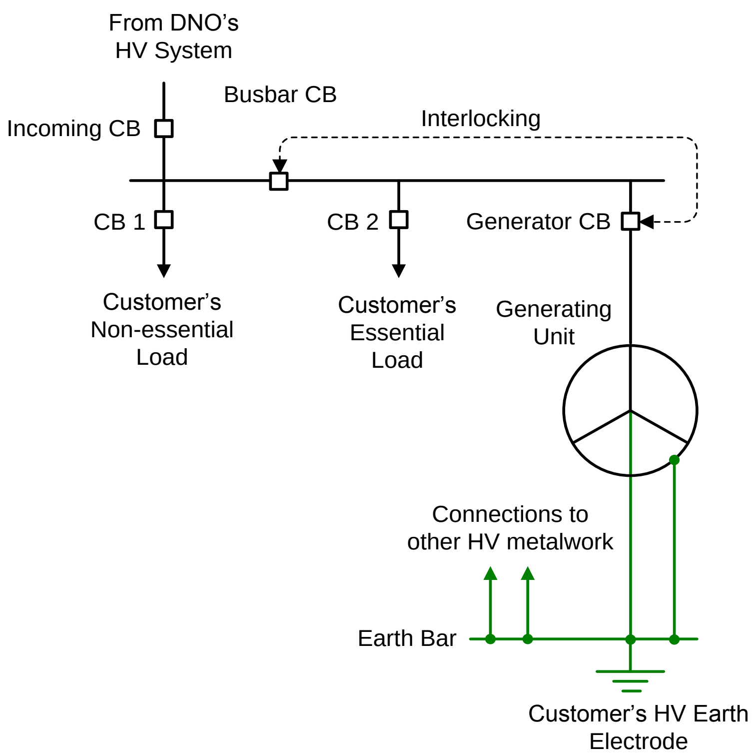
8.2.5 **Generator**s must take adequate precautions to ensure their **Power Generating Module** is connected to earth via their own earth electrodes when operating in isolation from the **Distribution Network**.

8.2.6 Typical earthing arrangements are given in figures 8.1 to 8.4.

8.2.7 Earthing systems shall be designed, installed, tested and maintained in accordance with ENA TS 41-24, (Guidelines for the design, installation, testing and maintenance of main earthing systems in substations), BS7354 (Code of Practice for Design of Open Terminal Stations) ~~and~~ BS7430 (Code of Practice for Earthing) and Engineering Recommendation S.34 (A guide for assessing the rise of earth potential at substation sites). Precautions shall be taken to ensure hazardous step and touch potential do not arise when earth faults occur on **HV** systems. Where necessary, **HV** earth electrodes and **LV** earth electrodes shall be adequately segregated to prevent hazardous earth potentials being transferred into the **LV Distribution Network**.

**Figure 8.1** - Typical Earthing Arrangement for an **HV Power Generating Module** Designed for Independent Operation (ie Standby Operation) Only

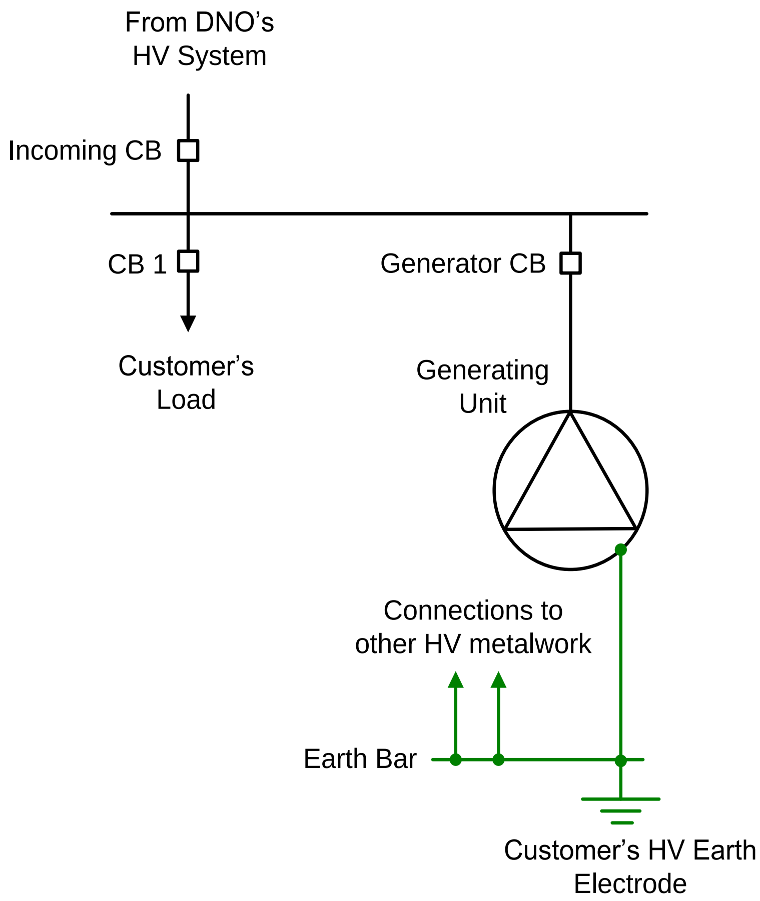
Comment [CS5]: Diagrams to be refreshed for final drafting




NOTE:

(1) Interlocking between busbar CB and **Power Generating Facility** CB is required to prevent parallel operation of the **Power Generating Module** and **DNO's Distribution Network**

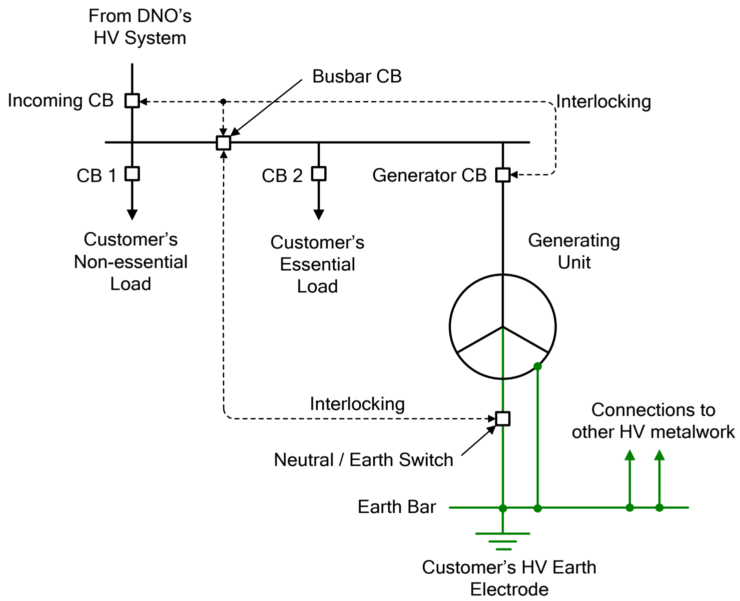
**Figure 8.2** - Typical Earthing Arrangement for a **HV Power Generating Module** Designed for Parallel Operation Only




NOTE:

(1) **Power Generating Module** winding is not connected to earth irrespective of whether it is star or delta connected

**Figure 8.3** - Typical Earthing Arrangement for an **HV Power Generating Module** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation



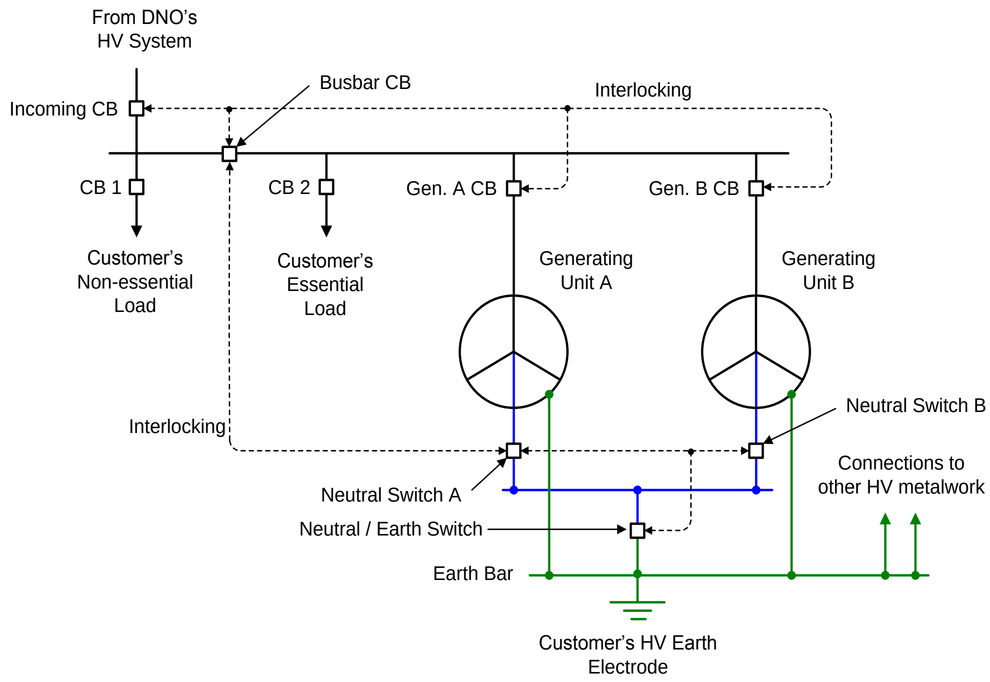

NOTE:

(1) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Power Generating Module** operates independently from the **DNO's Distribution Network**

(2) When the **Power Generating Module** operates independently from the **DNO's Distribution Network** (ie busbar CB is open) the neutral / earth switch is closed.

(3) When the **Power Generating Module** operates in parallel with the **DNO's Distribution Network** (ie busbar CB is closed) the neutral / earth switch is open.

**Figure 8.4** - Typical Earthing Arrangement for two **HV Power Generating Modules** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation




NOTE:

(1) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Power Generating Modules** operate independently from the **DNO's Distribution Network**.

(2) If one **Power Generating Module** is operating independently from the **DNO's Distribution Network** (ie busbar CB is open) then its neutral switch is closed and the neutral / earth switch is closed.

(3) If both **Power Generating Modules** are operating independently from the **DNO's Distribution Network** (ie busbar CB is open) then one neutral switch is closed and the neutral / earth switch is closed.

(4) If one or both of the **Power Generating Modules** are operating in parallel with the **DNO's Distribution Network** (ie busbar CB is closed) then both neutral switches and the neutral /earth switch are open.

## 8.3 LV Power Generating Modules

8.3.1 **LV Distribution Networks** are always solidly earthed, and the majority are multiple earthed. Design practice for protective multiple earthing is detailed in the **Electricity Supply Industry (ESI)** engineering publications including Engineering Recommendation G12/4, , and in the references contained in those publications.

8.3.2 The winding configuration and method of earthing connection shall be agreed with the **DNO.**

In addition, where the **Power Generation Facility's Connection Point** is at **Low Voltage** the following shall apply

(a) Where an earthing terminal is provided by the **DNO** it may be used by a **Power Generation Facility** for earthing the **Power Generating Module**, provided the **DNO** earth connection is of adequate capacity. If the **Power Generating Module** is intended to operate independently of the **DNO's** supply, the **Power Generating Module** must include an earthing system which does not rely upon the **DNO's** earthing terminal. Where use of the **DNO's** earthing terminal is retained, it must be connected to the **Power Generating Modules** earthing system by means of a conductor at least equivalent in size to that required to connect the **DNO's** earthing terminal to the installation.

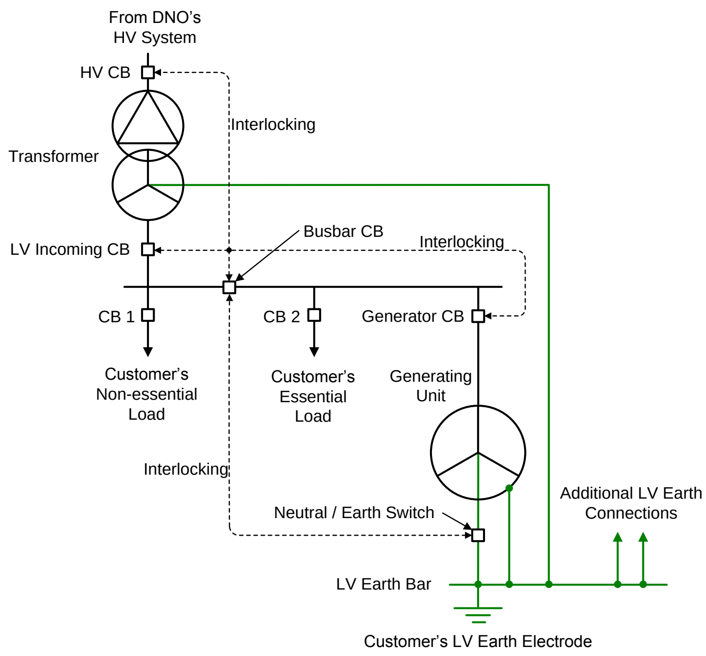
(b) Where the **Error! Reference source not found.Power Generating Module** ay be operated as a switched alternative only to the **DNO's Network**, the **Power Generation Facility** shall provide an independent earth electrode.

(c) Where it is intended to operate in parallel with the **DNO's Low Voltage Network** with the star point connected to the neutral and/or earthing system, precautions will need to be taken to limit the effects of circulating harmonic currents. It is permissible to insert an impedance in the supply neutral of the **Power Generating Module** for this purpose, for those periods when it is paralleled with the **DNO's Network**. However, if the **Power Generating Module** is operating in isolation from the **DNO's Distribution Network** it will be necessary to have the **Power Generating Module** directly earthed.

(d) Where the **Power Generating Module**s designed to operate independently from the **DNO's Distribution Network** the switchgear that is used to separate the two systems shall break all four poles (3 phases and neutral). This prevents any phase or neutral current, produced by the **Power Generating Module**, from flowing into the **DNO's Distribution Network** when it operates as a switched alternative only supply.

8.3.3 The following diagrams 8.5 to 8.9 show typical installations.

**Figure 8.5 -** Typical Earthing Arrangement for an **LV Power Generating Module** Connected to the **DNO's Distribution Network** at **HV** and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation.




NOTE:

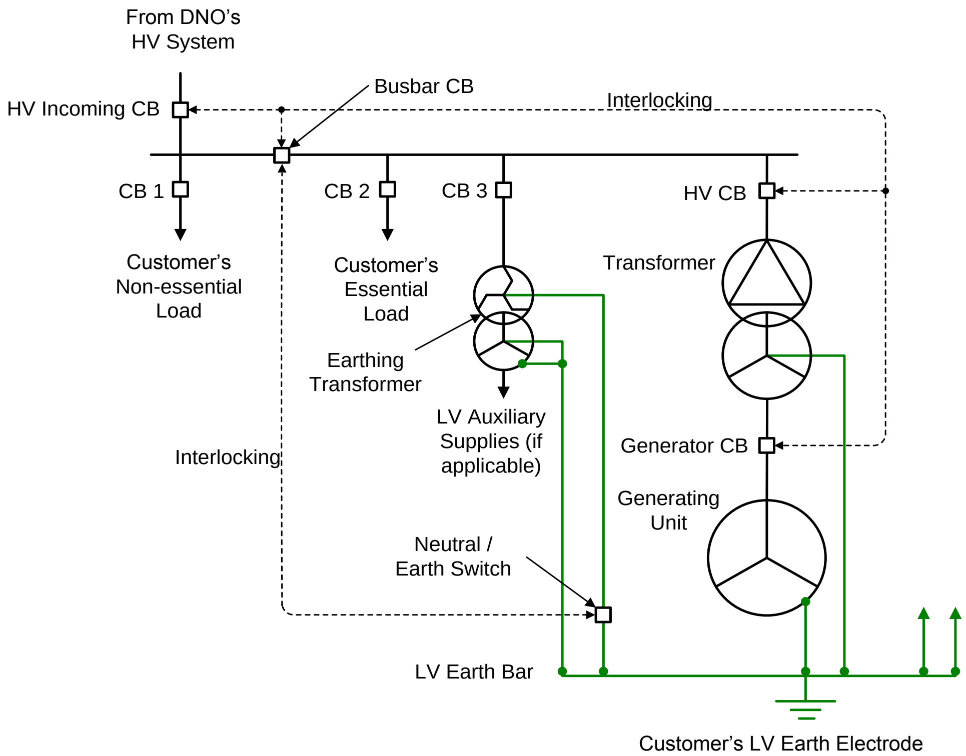
(1) **HV** earthing is not shown.

(2) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Power Generating Module** operates independently from the **DNO's Distribution Network**.

(3) When the **Power Generating Module** operates independently from the **DNO's Distribution Network** (ie busbar CB is open) the neutral earth switch is closed.

(4) When the **Power Generating Module** operates in parallel with the **DNO's Distribution Network** (ie busbar CB is closed) the neutral / earth switch is open.

**Figure 8.6 -** Typical Earthing Arrangement for an **LV Power Generating Module** Embedded within a **Customer HV** System and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation




NOTE:

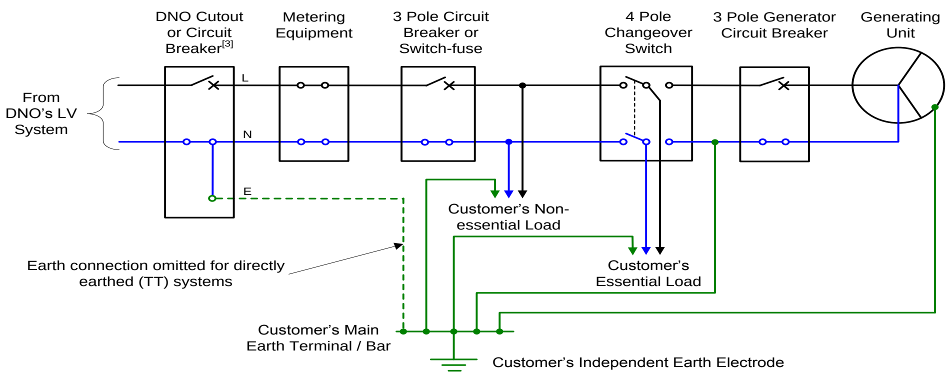
(1) **HV** earthing is not shown.

(2) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Power Generating Module** operates independently from the **DNO's Distribution Network**.

(3) When the **Power Generating Module** operates independently from the **DNO's Distribution Network** (ie busbar CB is open) the neutral / earth switch is closed.

(4) When the **Power Generating Module** operates in parallel with the **DNO's Distribution Network** (ie busbar CB is closed) the neutral / earth switch is open.

**Figure 8.7** - Typical Earthing Arrangement for an **LV Power Generating Module** Embedded within a **Customer LV** System and Designed for Independent (ie Standby) Operation Only




NOTE

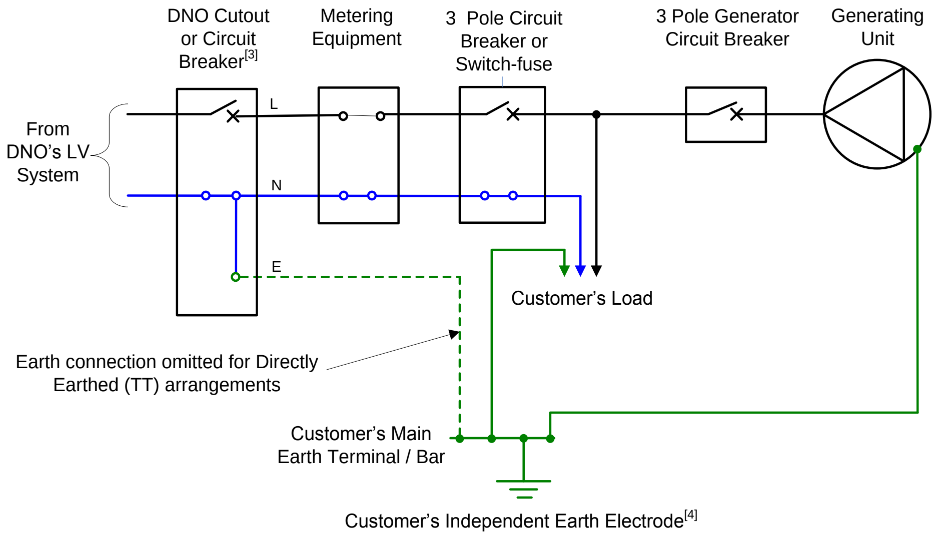
(1) Only one phase of a three phase system is shown to aid clarity.

(2) **Power Generating Module** is not designed to operate in parallel with the **DNO's Distribution Network**.

(3) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

(4) The changeover switch must disconnect each phase and the neutral (ie for a three phase system a 4 pole switch is required). This prevents **Power Generating Module** neutral current from inadvertently flowing through the part of the **Customer's Installation** that is not supported by the **Power Generating Module.**

**Figure 8.8 -** Typical Earthing Arrangement for an **LV Power Generating Module** Embedded within a **Customer LV** System and Designed for Parallel Operation Only




NOTE:

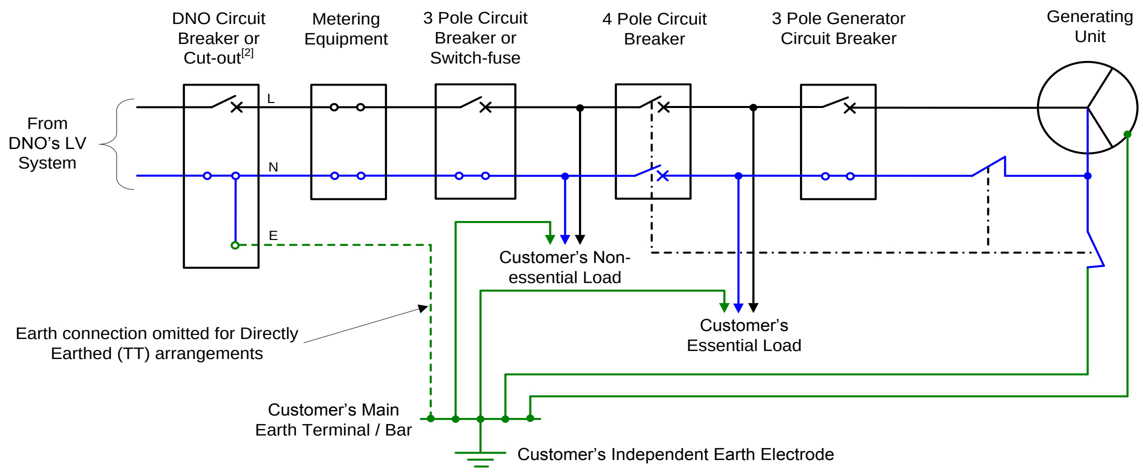
(1) Only one phase of the three phase system is shown to aid clarity.

(2) **Power Generating Module** is not designed to operate in standby mode.

(3) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

(4) The **Customer**'s independent earth electrode is only required if the installation is Directly Earthed (TT).

**Figure 8.9** - Typical Earthing Arrangement for an **LV Power Generating Module** Embedded within a **Customer LV** System and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation**.**




NOTE:

(1) Only one phase of a three phase system is shown to aid clarity.

(2) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

(3) When the **Power Generating Module** operates independently from the DNO's system, the switch that is used to isolate between these two systems must disconnect each phase and neutral (ie for a three phase system a 4 pole switch is required). This prevents **Power Generating Module** neutral current from inadvertently flowing through the part of the **Customer's Installation** that is not supported by the **Power Generating Module.** This switch should also close the **Power Generating Module** neutral and earth switches during independent operation.

# 9 NETWORK CONNECTION DESIGN AND OPERATION, Type A, Type B, Type C and Type D Common requirements

## 9.1 General Criteria

**9.1.1** As outlined in Section 5, **DNO**s have to meet certain statutory and **Distribution Licence** obligations when designing and operating their **Distribution Networks**. These obligations will influence the options for connecting **Power Generating Modules**.

**9.1.2** The technical and **design** criteria to be applied in the design of the **Distribution Network** and **Power Generating Module** connection are detailed in this document. The criteria are based upon the performance requirements of the **Distribution Network** necessary to meet the above obligations.

**9.1.3** The **Distribution Network**, and any **Power Generating Module** connection to that network, shall be designed:

a. to comply with the obligations (to include security, frequency and voltage; voltage disturbances and harmonic distortion; auto reclosing and single phase protection operation).

b. according to design principles in relation to **Distribution Network**'s plant and equipment, earthing, voltage regulation and control, and protection as outlined in this section, subject to any modification to which the **DNO** may reasonably consent.

**9.1.4** **Power Generating Modules** should meet a set of technical requirements in relation to its performance with respect to frequency and voltage, control capabilities, protection coordination requirements, phase voltage unbalance requirements, neutral earthing provisions, islanding and **Black Start Capability** as applicable. Requirements common to all **Power Generating Module** types are listed in this section.

Requirements for **Type A Power Generating Modules** are detailed in Section 11. Requirements for **Type B Power Generating Modules** are detailed in Section 12. Requirements for **Type C and Type D Power Generating Modules** are detailed in Section 13.

## 9.2 Network Connection Design for Power Generating Modules

9.2.1 The connection of new **Customer**s, including **Generators**, to the **Distribution Network** should not generally increase the risk of interruption to existing **Customers**. For example, alterations to existing **Distribution Network** designs that cause hitherto normally closed circuits to have to run on open standby such that other **Customers** might become disconnected for the duration of the auto-switching times are deprecated.

9.2.2 Connection of **Power Generating Modules** to **Distribution Networks** will be subject to rules for managing the complexity of circuits. For example, EREC P18 sets out the normal limits of complexity of 132kV circuits by stipulating certain restrictions to be applied when they are designed e.g. the operation of protective gear for making dead any 132kV circuit shall not require the opening of more than seven circuit breakers and these circuit breakers shall not be located at more than four different sites. Each **DNO** will have similar policies for managing complexity of lower voltage circuits.

9.2.3 The security requirements for the connection of **Power Generating Modules** are subject to economic consideration by the **DNO** and the **Generator.** A firm connection for a **Power Generating Module** should allow the full export at the **Registered Capacity** across the required power factor operating range to be exported via the **Distribution Network** at all times of year and after one outage on any one circuit of the **Distribution Network**. ETR 124 provides additional advice on the management of constraints and security.

9.2.4 The decision as to whether or not a firm connection is required should be by agreement between the **DNO** and the **Generator**. The **DNO** should be able to provide an indication of the likely duration and magnitude of any constraints so that the **Generator** can make an informed decision. The **Generator** should consider the financial implications of a non-firm connection against the cost of a firm connection, associated **Distribution Network** reinforcement and the risk of any constraints due to **Distribution Network** restrictions.

9.2.5 Where the **DNO** expects the **Power Generating Module** to contribute to system security, the provisions of EREC P2 and the guidance of ETR 130 will apply. In addition, the **Power Generating Module** should either remain synchronised and in parallel with the **Distribution Network** under the outage condition being considered or be capable of being resynchronised within the time period specified in EREC P2. There may be commercial issues to consider in addition to the connection cost and this may influence the technical method which is used to achieve a desired security of supply.

9.2.6 When designing a scheme to connect **a Power Generating Module**, consideration must be given to the contribution which that **Power Generating Module** will make to short circuit current flows on the **Distribution Network**. The assessment of the fault level contribution from **a Power Generating Module** and the impact on the suitability of connected switchgear are discussed in Section 9.7.

9.2.7 It is clearly important to avoid unwanted tripping of the **Power Generating Module** particularly where the **Power Generating Module** is providing **Distribution Network** or **Total System** security. The quality of supply and stability of **Power Generating Module** performance are dealt with in Sections 9.4 and 9.5 respectively.

9.2.8 **Power Generating Modules** may be connected via existing circuits to which load and/or existing **Power Generating Modules** are also connected. The duty on such circuits, including load cycle, real and reactive power flows, and voltage implications on the **Distribution Network** will need to be carefully reviewed by the **DNO**, taking account of maximum and minimum load and generation export conditions during system intact conditions and for maintenance outages of both the **Distribution Network** and **Power Generating Modules**. In the event of network limitations, ETR 124 provides guidance to **DNO**s on overcoming such limitations using active management solutions.

9.2.9 A **DNO** assessing a proposed connection of a **Power Generating Module** must also consider its effects on the **Distribution Network** voltage profile and voltage control employed on the **Distribution Network**. Voltage limits and control issues are discussed in Sections 11, 12 and 13 for each **Power Generating Module** type.

## 9.3 Voltage Step Change

9.3.1 The Step Voltage Change caused by the connection and disconnection of Power Generating Modules from the Distribution Network must be considered and be subject to limits to avoid unacceptable voltage changes being experienced by other Customers connected to the Distribution Network. The magnitude of a Step Voltage

Change depends on the method of voltage control, types of load connected and the presence of local generation.

9.3.2 Typical limits for **Step Voltage Change** caused by the connection and disconnection of any **Customers** equipment to the **Distribution Network** should be ± 3% for infrequent planned switching events or outages in accordance with EREC P28. For unplanned outages such faults it will generally be acceptable to design to a **Step Voltage Change** of ±10%.

9.3.3 The voltage depression arising from transformer magnetising inrush current is a short-time phenomenon not generally easily captured by the definition of **Step Voltage Change** used in this document. In addition the size of the depression is dependent on the point on wave of switching and the duration of the depression is relatively short in that the voltage recovers substantially in less than one second.

9.3.4 **Customer Installation**s should be designed such that transformer magnetising inrush current associated with normal routine switching operations does not cause voltage fluctuations outside those in EREC P28 (i.e. a maximum of ±3%). To achieve this it may be necessary to install switchgear so that sites containing multiple transformers can be energised in stages.

9.3.5 Situations will arise from time to time when complete sites including a significant presence of transformers are energised as a result of post fault switching, post fault maintenance switching, carrying out commissioning tests on **Distribution Network** or on the **Customer**’s **Installation**. In these situations it will generally be acceptable to design to an expected depression of around 10% recognising that a worst case energisation might be a larger depression, on the basis that such events are considered to be rare and it is difficult to predict the exact depression because of the point on wave switching uncertainty. Should these switching events become more frequent than once per year then the design should revert to aiming to limit depressions to less than 3%.

9.3.6 These threshold limits should be complied with at the **Point of Common Coupling** as required by EREC P28.

## 9.4 Power Quality

### 9.4.1 Introduction

9.4.1.1 The connection and operation of **Power Generating Modules** may cause a distortion of the **Distribution Network** voltage waveform resulting in voltage fluctuations, harmonics or phase voltage unbalance.

### 9.4.2 Flicker

9.4.2.1 Where the input motive power of the **Power Generating Module** may vary rapidly, causing corresponding changes in the output power, flicker may result. The operation of a **Power Generating Module** including synchronisation, run-up and desynchronisation shall not result in flicker that breaches the limits for flicker in EREC P28.

9.4.2.2 The fault level of the **Distribution Network** needs to be considered to ensure that the emissions produced by the **Power Generating Module** do not cause a problem on the **Distribution Network**.

9.4.2.3 For **Power Generating Modules** up to 17kW per phase or 50kW three phase voltage step change and flicker measurements as required by BS EN 61000-3-11 shall be made and recorded in the test declaration for the **Power Generating Module.** The **DNO** will use these declared figures to calculate the required maximum supply impedance required for the connection to comply with EREC P28. This calculation may show that the voltage fluctuations will be greater than those permitted and hence reinforcement of the **Distribution Network** may be required before the **Power Generating Module** can be connected.

9.4.2.4 For wind turbines, flicker testing should be carried out during the performance tests specified in BS EN 61400-12. Flicker data should be recorded from wind speeds of $1ms^{-1}$ below cut-in to 1.5 times 85% of the rated power. The wind speed range should be divided into contiguous bins of $1ms^{-1}$ centred on multiples of $1ms^{-1}$. The dataset shall be considered complete when each bin includes a minimum of 10 minutes of sampled data.

9.4.2.5 The highest recorded values across the whole range of measurements should be used as inputs to the calculations described in BS EN 61000-3-11 to remove background flicker values. Then the required maximum supply impedance values can be calculated as described in 13.1. Note that occasional very high values may be due to faults on the associated HV network and may be discounted, though care should be taken to avoid discounting values which appear regularly.

9.4.2.6 For technologies other than wind, the controls or automatic programs used shall produce the most unfavourable sequence of voltage changes for the purposes of the test.

9.4.3 **Harmonic Emissions**

9.4.3.1 Harmonic voltages and currents produced within the **Generator**'s system may cause excessive harmonic voltage distortion in the **Distribution Network**. The **Generator**'s installation must be designed and operated to comply with the planning criteria for harmonic voltage distortion as specified in EREC G5. EREC G5, like all planning standards referenced in this recommendation, is applicable at the time of connection of additional equipment to a **Customer**'s **Installation**.

9.4.3.2 For **Power Generating Modules** of up to 17kW per phase or 50kW three phase harmonic measurements as required by BS EN 61000-3-12 shall be made and recorded in the test declaration for the **Power Generating Module**. The **DNO** will use these declared figures to calculate the required maximum supply impedance required for the connection to comply with BS EN 61000-3-12 and will use this data in their design of the connection for the **Power Generating Module**. This standard requires a minimum ratio between source fault level and the size of the **Power Generating Module**, and connections in some cases may require the installation of a transformer between 2 and 4 times the rating of the **Power Generating Module** in order to accept the connection to a **DNO's Distribution Network.**

9.4.3.3 Alternatively, if the harmonic emissions are low and they are shown to meet the requirements of BS EN 61000-3-2 then there will be no need to carry out the fault level to **Power Generating Module** size ratio check. **Power Generating Module**s meeting the requirements of BS EN 61000-3-2 will need no further assessment with regards to harmonics.

9.4.3.4 Where the **Power Generating Module** is connected via a long cable circuit the likelihood of a resonant condition is greatly increased, especially at 132kV. This arises from the reaction of the transformer inductance with the cable capacitance. Resonance is likely in the low multiples of the fundamental frequency (8th-11th harmonic). The resonant frequency is also a function of the **Total System** fault level. If there is the possibility that this can change significantly eg by the connection of another **Power Generating Module** then a full harmonic study should be carried out.

### 9.4.4 Voltage imbalance

9.4.4.1 EREC P29 is a planning standard which sets the **Distribution Network** compatibility levels for voltage unbalance caused by uneven loading of three phase supply systems. **Power Generating Module**s should be capable of performing satisfactorily under the conditions it defines. The existing voltage unbalance on an urban **Distribution Network** rarely exceeds 0.5% but higher levels, in excess of 1%, may be experienced at times of high load and when outages occur at voltage levels above 11kV. 1% may exist continuously due to unbalance of the system impedance (common on remote rural networks). In addition account can be taken of the neutralising effect of rotating plant, particularly at 11kV and below.

9.4.4.2 The level of voltage unbalance at the **Point of Common Coupling** should be no greater than 1.3% for systems with a nominal voltage below 33kV, or 1% for other systems with a nominal voltage no greater than 132kV. Overall, voltage unbalance should not exceed 2% when assessed over any one minute period. EREC P29, like all planning standards, is applicable at the time of connection.

9.4.4.3 For **Power Generating Facilities** of 50kW or less section 7.5 of this document specifies maximum unbalance of **Power Generating Modules**. Where these requirements are met then no further action is required by the **Generator**.

9.4.4.4 **Power Factor** correction equipment is sometimes used with **Power Park Module**s to decrease reactive power flows on the **Distribution Network**. Where the **Power Factor** correction equipment is of a fixed output, stable operating conditions in the event of loss of the **DNO** supply are extremely unlikely to be maintained, and therefore no special protective actions are required in addition to the standard protection specified in this document.

### 9.4.5 DC Injection

9.4.5.1 The effects of, and therefore limits for, DC currents injected into the **Distribution Network** is an area currently under investigation. Until these investigations are concluded the limit for DC injection is less than 0.25% of the AC rating per **Power Generating Module**.

9.4.5.2 The main source of these emissions are from transformer-less **Inverters**. Where necessary DC emission requirements can be satisfied by installing a transformer on the AC side of an **Inverter**.

## 9.5 System Stability

9.5.1 Instability in **Distribution Networks** may result in unacceptable quality of supply and tripping of **Customer**'s plant. In severe cases, instability may cascade across the **Distribution Network**, resulting in widespread tripping and loss of demand and generation. There is also a risk of damage to plant.

9.5.2 In general, **System Stability** is an important consideration in the design of **Power Generating Module** connections to the **Distribution Network** at 33kV and above. Stability considerations may also be appropriate for some **Power Generating Module** connections at lower voltages. The risks of instability generally increase as **Power Generating Module** capacity increases relative to the fault level infeed from the **Distribution Network** at the **Connection Point**.

9.5.3 **System Stability** may be classified into several forms, according firstly to the main system variable in which instability can be observed, and secondly to the size of the system disturbance. In **Distribution Networks**, the forms of stability of interest are rotor angle stability and voltage stability.

9.5.3.1 Rotor angle stability refers to the ability of synchronous machines in an interconnected system to remain in **Synchronism** after the system is subjected to a disturbance.

9.5.3.2 Voltage stability refers to the ability of a system to maintain acceptable voltages throughout the system after being subjected to a disturbance.

9.5.3.3 Both rotor angle stability and voltage stability can be further classified according to the size of the disturbance.

9.5.3.4 Small-disturbance stability refers to the ability of a system to maintain stability after being subjected to small disturbances such as small changes in load, operating points of **Power Generating Module**s, transformer tap-changing or other normal switching events.

9.5.3.5 Large-disturbance stability refers to the ability of a system to maintain stability after being subjected to large disturbances such as short-circuit faults or sudden loss of circuits or **Power Generating Module**s.

9.5.5 Traditionally, large-disturbance rotor angle stability (also referred to as transient stability) has been the form of stability predominantly of interest in **Distribution Network**s with synchronous machines. However, it should be noted that the other forms of stability may also be important and may require consideration in some cases.

9.5.6 It is recommended that **a Power Generating Module** and its connection to the **Distribution Network** be designed to maintain stability of the **Distribution Network** for a defined range of initial operating conditions and a defined set of system disturbances.

9.5.6.1 The range of initial operating conditions should be based on those which are reasonably likely to occur over a year of operation. Variables to consider include system loads, system voltages, system outages and configurations, and **Power Generating Module** operating conditions.

19.5.6.2 The system disturbances for which stability should be maintained should be selected on the basis that they have a reasonably high probability of occurrence. It is recommended that these include short-circuit faults on single **Distribution Network** circuits (such as transformers, overhead lines and cables) and busbars, that are quickly cleared by main protection.

9.5.7 With the system in its normal operating state, it is desirable that all **Power Generation Modules** remain connected and stable for any of the following credible fault outages,

(a) any one single circuit overhead line, transformer feeder or cable circuit, independent of length,

(b) any one transformer or reactor,

(c) any single section of busbar at or nearest the point of connection where busbar protection with a total clearance time of less than 200ms is installed,

(d) if demand is to be secured under a second circuit outage as required by EREC P2, fault outages (a) or (b), overlapping with any pre-existing first circuit outage, usually for maintenance purposes. In this case the combination of circuit outages considered should be that causing the most onerous conditions for **System Stability**, taking account of the slowest combination of main protection, circuit breaker operating times and strength of the connections to the system remaining after the faulty circuit or circuits have been disconnected

9.5.8 It should be noted that it is impractical and uneconomical to design for stability in all circumstances. This may include double circuit fault outages and faults that are cleared by slow protection. **Power Generating Module**s that become unstable following system disturbances should be disconnected as soon as possible to reduce the risk of plant damage and disturbance to the system.

9.5.9 Various measures may be used, where reasonably practicable, to prevent or mitigate system instability. These may include **Distribution Network** and **Power Generating Module** solutions, such as:

- improved fault clearance times by means of faster protection;
- improved performance of **Power Generating Module** control systems (excitation and governor/prime mover control systems; **Power System Stabilisers** to improve damping);

- improved system voltage support (provision from either **Power Generating Module** or **Distribution Network** plant);
- reduced plant reactance's (if possible);
- installation of protection to identify pole-slipping;
- increased fault level infeed from the **Distribution Network** at the **Connection Point**.

In determining mitigation measures which are reasonably practicable, due consideration should be given to the cost of implementing the measures and the benefits to the **Distribution Network** and **Customer**s in terms of reduced risk of system instability.

## 9.6 Island Mode

9.6.1 A fault or planned outage, which results in the disconnection of a **Power Generating Module**, together with an associated section of **Distribution Network**, from the remainder of the **Total System**, creates the potential for island mode operation. It will be necessary for the **DNO** to decide, dependent on local network conditions, if it is desirable for the **Customers** to continue to generate onto the islanded **DNO's Distribution Network**. The key potential advantage of operating in Island Mode is to maintain continuity of supply to the portion of the **Distribution Network** containing the **Power Generating Module**. The principles discussed in this section generally also apply where **Power Generating Modules** on a **Customer**'s site is designed to maintain supplies to that site in the event of a failure of the **DNO** supply.

9.6.2 When considering whether **Power Generating Modules** can be permitted to operate in island mode, detailed studies need to be undertaken to ensure that the islanded system will remain stable and comply with all statutory obligations and relevant planning standards when separated from the remainder of the **Total System**. Before operation in island mode can be allowed, a contractual agreement between the **DNO** and **Generator** must be in place and the legal liabilities associated with such operation must be carefully considered by the **DNO** and the **Generator**. Consideration should be given to the following areas:

a. load flows, voltage regulation, frequency regulation, voltage unbalance, voltage flicker and harmonic voltage distortion;

b. earthing arrangements;

c. short circuit currents and the adequacy of protection arrangements;

d. **System Stability**;

e. resynchronisation to the **Total System**;

f. safety of personnel.

9.6.3 Suitable equipment will need to be installed to detect that an island situation has occurred and an intertripping scheme is preferred to provide absolute discrimination at the time of the event. Confirmation that a section of **Distribution Network** is operating in island mode, and has been disconnected from the **Total System**, will need to be transmitted to the **Power Generating Module(s)** protection and control schemes.

9.6.4 The **ESQCR** requires that supplies to **Customers** are maintained within statutory limits at all times ie when they are supplied normally and when operating in island mode. Detailed system studies including the capability of the **Power Generating Module** and its control / protections systems will be required to determine the capability of the **Power Generating Module** to meet these requirements immediately as the island is created and for the duration of the island mode operation.

9.6.5 The ESQCR also require that **Distribution Networks** are earthed at all times. **Generator**s, who are not permitted to operate their installations and plant with an earthed star-point when in parallel with the **Distribution Network**, must provide an earthing transformer or switched star-point earth for the purpose of maintaining an earth on the system when islanding occurs. The design of the earthing system that will exist during island mode operation should be carefully considered to ensure statutory obligations are met and that safety of the **Distribution Network** to all users is maintained. Further details are provided in Section 8.

9.6.6 Detailed consideration must be given to ensure that protection arrangements are adequate to satisfactorily clear the full range of potential faults within the islanded system taking into account the reduced fault currents and potential longer clearance times that are likely to be associated with an islanded system.

9.6.7 Switchgear shall be rated to withstand the voltages which may exist across open contacts under islanded conditions. The **DNO** may require interlocking and isolation of its circuit breaker(s) to prevent out of phase voltages occurring across the open contacts of its switchgear. Intertripping or interlocking should be agreed between the **DNO** and the **Generator** where appropriate.

9.6.8 It will generally not be permissible to interrupt supplies to **DNO Customers** for the purposes of resynchronisation. The design of the islanded system must ensure that synchronising facilities are provided at the point of isolation between the islanded network and the **DNO** supply. Specific arrangements for this should be agreed and recorded in the **Connection Agreement** with the **DNO**. If no facilities exist for the subsequent resynchronisation with the rest of the **DNO's Distribution Network** then the **Customer** will, under **DNO instruction**, ensure that the **Power Generating Module** is disconnected for re-synchronisation.

## 9.7 Fault Contributions and Switchgear Considerations

9.7.1 Under the **ESQCR** 2002 and the EaWR 1989 the **Generator** and the **DNO** have legal duties to ensure that their respective systems are capable of withstanding the short circuit currents associated with their own equipment and any infeed from any other connected system.

9.7.2 The **Generator** may accept that protection installed on the **Distribution Network** can help discharge some of his legal obligations relating to fault clearance and, if requested, the **DNO** should consider allowing such faults on the **Generator's** system to be detected by **DNO** protection systems and cleared by the **DNO'**s circuit breaker. The **DNO** will not allow the **Generator** to close the **DNO'**s circuit breaker nor to synchronise using the **DNO'**s circuit breaker. In all such cases the exact nature of the protection afforded by the **DNO'**s equipment should be agreed and documented. The **DNO** may make a charge for the provision of this service.

9.7.3 The design and safe operation of the **Generator**'s and the **DNO'**s installation's depend upon accurate assessment of the contribution to the short circuit current made by all the **Power Generating Modules** operating in parallel with the **Distribution Network** at the instant of fault and the **Generator** should discuss this with the **DNO** at the earliest possible stage.

9.7.4 Short circuit current calculations should take account of the contributions from all synchronous and asynchronous infeeds including induction motors and the contribution from inverter connected **Power Generating Module**s. The prospective short circuit 'make' and 'break' duties on switchgear should be calculated to ensure that plant is not potentially over-stressed. The maximum short circuit duty might not occur under maximum generation conditions; it may occur during planned or automatic operations carried out either on the **Distribution Network** or **Transmission System**. Studies must therefore consider all credible **Distribution Network** running arrangements which are likely to increase **Distribution Network** short circuit levels. The level of load used in the assessment should reflect committed projects as well as the existing loads declared in the **DNO'**s Long Term Development Statement (LTDS). Guidance on short circuit calculations is given in EREC G74.

9.7.5 The connection of **a Power Generating Module** can raise the **Distribution Network** reactance/resistance (X/R) ratio. In some cases, this will place a more onerous duty on switchgear by prolonging the duration of the DC component of fault current from fault inception. This can increase the proportion of the DC component of the fault current and delay the occurrence of current zeros with respect to voltage zeros during the interruption of fault current. The performance of connected switchgear must be assessed to ensure safe operation of the **Distribution Network**. The performance of protection may also be impaired by partial or complete saturation of current transformers resulting from an increase in **Distribution Network** X/R ratio.

9.7.6 Newly installed protection systems and circuit breakers for **Power Generating Module** connections should be designed, specified and operated to account for the possibility of out-of-phase operation. It is expected that the **DNO'**s metering/interface circuit breaker will be specified for this duty, but in the case of existing circuit breakers on the **Distribution Network**, the **DNO** will need to establish the possibility or otherwise of the **DNO**s protection (or the **Generator**'s protection if arranged to trip the **DNO'**s circuit breaker) initiating a circuit breaker trip during a period when one of more **Power Generating Module**s might have lost **Synchronism** with the **Total System**. Where necessary, switchgear replacement, improved security arrangements and other control measures should be considered to mitigate this risk.

9.7.7 When connection of a **Power Generating Module** is likely to increase short circuit currents above **Distribution Network** design ratings, consideration should be given to the installation of reactors, sectionalising networks, connecting the **Power Generating Module** to part of the **Distribution Network** operating at a higher voltage, changing the **Power Generating Module** specification or other means of limiting short circuit current infeed. If fault limiting measures are not cost effective or feasible or have a significant effect on other users, **Distribution Network** plant with the potential to be subjected to short circuit currents in excess of its rating should be replaced or reference made to the relevant **Manufacturer** to determine whether or not the existing plant rating(s) can be enhanced. In situations where **Distribution Network** design ratings would be exceeded in infrequent but credible **Distribution Network** configurations, then constraining the **Power Generating Module** off during periods of such **Distribution Network** configurations may provide a suitable solution. When assessing short circuit currents against **Distribution Network** design ratings, suitable safety margins should be allowed to cater for tolerances that exist in the **Distribution Network** data and **Power Generating Module** parameters used in system modelling programs. On request from a **Generator** the **DNO** will provide the rationale for determining the value of a specific margin being used in **Distribution Network** studies.

9.7.8 For busbars with three or more direct connections to the rest of the **Total System**, consideration may be given to reducing fault levels by having one of the connections 'open' and on automatic standby. This arrangement will only be acceptable provided that the loss of one of the remaining circuits will not cause the group to come out of **Synchronism**, cause unacceptable voltage excursions or overloading of **Distribution Network** or **Transmission System** plant and equipment. The use of the proposed **Power Generating Module** to prevent overloading of **Distribution Network** plant and equipment should be considered with reference to EREC P2.

9.7.9 Disconnection of a **Power Generating Module** must be achieved by the separation of mechanical contacts unless the disconnection is at **Low Voltage** and the equipment at the point of disconnection contains appropriate self monitoring of the point of disconnection, in which case an appropriate electronic means such as a suitably rated semiconductor switching device would be acceptable. The self monitoring facility shall incorporate fail safe monitoring to check the voltage level at the output stage. In the event that the solid state switching device fails to disconnect the **Power Generating Module**, the voltage on the output side of the switching device shall be reduced to a value below 50V within 0.5s. For the avoidance of doubt this disconnection is a means of providing LoM disconnection and not as a point of isolation to provide a safe system of work.

**Comment [MK6]:** The technical requirements of this text are under review

# 10 PROTECTION

## 10.1 General

10.1.1 The main function of the protection systems and settings described in this document is to prevent the **Power Generating Module** supporting an islanded section of the **Distribution Network** when it would or could pose a hazard to the **Distribution Network** or **Customers** connected to it. The settings recognize the need to avoid nuisance tripping and therefore require a two stage approach where practicable, ie to have a long time delay for smaller excursions that may be experienced during normal **Distribution Network** operation, to avoid nuisance tripping, but with a faster trip, where possible, for greater excursions.

10.1.2 In accordance with established practice it is for the **Generator** to install, own and maintain this protection. The **Generator** can therefore determine the approach, ie per **Power Generating Module** or per installation, and where in the installation the protection is sited.

10.1.3 Where a common protection system is used to provide the protection function for multiple **Power Generating Modules** the complete installation cannot be considered to comprise **Fully Type Tested Power Generating Modules** if the protection and connections are made up on site and so cannot be factory tested or **Type Tested**. In accordance with Appendix A.8 if the units or **Power Generating Modules** are specifically designed with plugs and sockets to be interconnected on site, then provided the assembly passes the function tests required in Appendix A.4, the **Power Generating Modules** can retain **type tested** status.

10.1.4 **Type Tested Interface Protection** shall have protection settings set during manufacture**.**

10.1.5 Once the **Power Generating Modules** has been installed and commissioned the protection settings shall only be altered following written agreement between the **DNO** and the **Generator**.

10.1.5 In exceptional circumstances additional protection may be required by the **DNO** to protect the **Distribution Network** and its **Customers** from the **Power Generating Module**.

## 10.2 Co-ordinating with Existing Protection

Comment [MK7]: This section might need further review to confirm compliant with latest G59

10.2.1 It will be necessary for the protection associated with **Power Generating Modules** to co-ordinate with the protection associated with the **DNO's Distribution Network** as follows:-

(a) For **Power Generating Modules directly** connected to the **DNO's Distribution Network** the **Power Generating Module** must meet the target clearance times for fault current interchange with the **DNO's Distribution Network** in order to reduce to a minimum the impact on the **DNO's Distribution Network** of faults on circuits owned by **the Generator**. The **DNO** will ensure that the **DNO** protection settings meet its own target clearance times.

The target clearance times are measured from fault current inception to arc extinction and will be specified by the **DNO** to meet the requirements of the relevant part of the **Distribution Network**.

(b) The settings of any protection controlling a circuit breaker or the operating values of any automatic switching device at any point of connection with the **DNO's Distribution Network**, as well as the **Customer's** maintenance and testing regime, shall be agreed between the **DNO** and the **Customer** in writing during the connection consultation process.

(c) It will be necessary for the **Power Generating Module** protection to co-ordinate with any auto-reclose policy specified by the **DNO**. In particular the **Power Generating Module** protection should detect a loss of mains situation and disconnect the **Power Generating Module** in a time shorter than any auto reclose dead time. This should include an allowance for circuit breaker operation and generally a minimum of 0.5s should be allowed for this. For pole mounted auto-reclosers often set with a dead time of 1s, this implies a loss of mains response time of 0.5s. Similar response time is expected from under and over voltage relays.

10.2.2 Specific protection Required for Embedded **Power Generating Modules**

In addition to any protection installed by the **Generator** to meet his own requirements and statutory obligations on him, the **Generator** must install protection to achieve the following objectives:

i. For all **Power Generating Modules**:

a. To disconnect the **Power Generating Module** from the system when a system abnormality occurs that results in an unacceptable deviation of the **Frequency** or voltage at the **Connection Point,** recognizing the requirements to ride through faults as detailed in 12.3 and 13.4;

b. To ensure the automatic disconnection of the **Power Generating Module**, or where there is constant supervision of an installation, the operation of an alarm with an audio and visual indication, in the event of any failure of supplies to the protective equipment that would inhibit its correct operation.

ii. For polyphase **Power Generating Modules:**

a. To inhibit connexion of **Power Generating Modules** to the system unless all phases of the **DNO's Distribution Network** are present and within the agreed ranges of protection settings;

b. To disconnect the **Power Generating Module** from the system in the event of the loss of one or more phases of the **DNO's Distribution Network**;

iii. For single phase **Power Generating Modules**

a. To inhibit connexion of **Power Generating Modules** to the system unless that phase of the **DNO's Distribution Network** is present and within the agreed ranges of protection settings;

b. To disconnect the **Power Generating Module** from the system in the event of the loss of that phase of the **DNO's Distribution Network** ;

## 10.3 Protection Requirements

10.3.1 Suitable protection arrangements and settings will depend upon the particular **Generator** installation and the requirements of the **DNO's Distribution Network**.

These individual requirements must be ascertained in discussions with the **DNO**. To achieve the objectives above, the protection must include the detection of:

- UnderVoltage (1 stage);
- OverVoltage (2 stage);
- UnderFrequency (2 stage);
- OverFrequency (1 stage);
- Loss of Mains (LoM).

The LoM protection will depend for its operation on the detection of some suitable parameter, for example, rate of change of frequency (RoCoF), or unbalanced voltages. More details on LoM protection are given in Section 10.4.

There are different protection settings dependent upon the system voltage at which the **Power Generating Module** is connected (LV or HV).

Protection settings for Type D **Generating Modules** over 100MW Registered Capacity must be consistent with **Grid Code** requirements. Loss of Mains protection will only be permitted at these sites if sanctioned by the **NETSO**– see section 10.4.2 below.

It is in the interest of **Generators, DNOs** and **NETSO** that **Power Generating Modules** remains synchronised to the **Distribution Network** during system disturbances, and conversely to disconnect reliably for true LoM situations. Frequency and voltage excursions less than the protection settings should not cause protection operation. As some forms of LoM protection might not readily achieve the required level of performance (eg under balanced load conditions), the preferred method for **Type D Power Generating Modules** is by means of intertripping. This does not preclude consideration of other methods that may be more appropriate for a particular connection.

10.3.2 The protective equipment, provided by the **Generator**, to meet the requirements of this section must be installed in a suitable location that affords visual inspection of the protection settings and trip indicators and is secure from interference by unauthorised personnel.

10.3.3 The frequency and voltage at the **DNO's** side of the supply terminals at the **Connection Point** must be within the **frequency and voltage** ranges of the interface protection as listed in 10.6.7 for at least 20s before the **Type A, Type B** or **Type C Power Generating Module** is allowed to automatically connect to the **DNO's Distribution Network**. There is in general no maximum admissible gradient of increase in **Active Power** output on connecting. If a network specific issue requires a maximum admissible gradient of increase in **Active Power** output on connection it will be specified by in the Connection Agreement.

10.3.4 Installation of automatic reconnection systems for **Type B**, **Type C** and **Type D** shall be subject to prior authorisation by the **DNO**. If automatic resetting of the protective equipment is used, there must be a time delay to ensure that healthy supply conditions exist for a minimum continuous period of 20s. Reset times may need to be co-ordinated where more than one **Power Generating Module** is connected to the same feeder. The automatic reset must be inhibited for faults on the **Generator's** installation.

10.3.5 Protection equipment is required to function correctly within the environment in which it is placed and shall satisfy the following standards:

- BS EN 61000 (Electromagnetic Standards)
- BS EN 60255 (Electrical Relays);
- BS EN 61810 (Electrical Elementary Relays);
- BS EN 60947 (Low Voltage Switchgear and Control gear);
- BS EN 60044 (Instrument Transformers).

Where these standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable.

10.3.6 Protection equipment and protection functions may be installed within, or form part of the **Power Generating Module** control equipment as long as:

a. the control equipment satisfies all the requirements of Section 10 including the relevant standards specified in 10.3.5.

b. the **Power Generating Module** shuts down in a controlled and safe manner should there be an equipment failure that affects both the protection and control functionality, for example a power supply failure or microprocessor failure.

c. the equipment is designed and installed so that protection calibration and functional tests can be carried out easily and safely using secondary injection techniques (ie using separate low voltage test equipment).

## 10.4 Loss of Mains (LoM)

10.4.1 To achieve the objectives of Section 10.1.1, in addition to protection installed by the **Generator** for his own purposes, the **Generator** must install protection to achieve (amongst other things) disconnection of the **Power Generating Module** from the **Distribution Network** in the event of loss of one or more phases of the **DNO**s supply. This LoM protection is required to ensure that the **Power Generating Module** is disconnected, to ensure that the requirements for **Distribution Network** earthing, and out-of-**Synchronism** closure are complied with and that **Customers** are not supplied with voltage and frequencies outside statutory limits.

10.4.2 LoM protection is required for all **Type A, Type B and Type C Power Generating Modules**. For **Type D Power Generating Modules** the **DNO** will advise if LoM protection is required. The requirements of 10.6.2 apply to LoM protection for all **Power Generating Modules.**

10.4.3 A problem can arise for **Generator**s who operate a **Power Generating Module** in parallel with the **Distribution Network** prior to a failure of the network supply because if their **Power Generating Module** continues to operate in some manner, even for a relatively short period of time, there is a risk that when the network supply is restored the **Power Generating Module** will be out of **Synchronism** with the **Total System** and suffer damage. LoM protection can be employed to disconnect the **Power Generating Module** immediately after the supply is lost, thereby avoiding damage to the **Power Generating Module**.

10.4.4 Where the amount of **Distribution Network** load that the **Power Generating Module** will attempt to pick up following a fault on the **Distribution Network** is significantly more than its capability the **Power Generating Module** will rapidly disconnect, or stall. However depending on the exact conditions at the time of the **Distribution Network** failure, there may or may not be a sufficient change of load on the **Power Generating Module** to be able to reliably detect the failure. The **Distribution Network** failure may result in one of the following load conditions being experienced by the **Power Generating Module**:

a. The load may slightly increase or reduce, but remain within the capability of the **Power Generating Module**. There may even be no change of load;

b. The load may increase above the capability of the prime mover, in which case the **Power Generating Module** will slow down, even though the alternator may maintain voltage and current within its capacity. This condition of speed/frequency reduction can be easily detected; or

c. The load may increase to several times the capability of the **Power Generating Module** , in which case the following easily detectable conditions will occur:

- Overload and accompanying speed/frequency reduction
- Over current and under voltage on the alternator

10.4.5 Conditions (b) and (c) are easily detected by the under and over voltage and frequency protection required in this document. However Condition (a) presents most difficulty, particularly if the load change is extremely small and therefore there is a possibility that part of the **Distribution Network** supply being supplied by the **Power Generating Module** will be out of **Synchronism** with the **Total System**. LoM protection is designed to detect these conditions.

10.4.6 LoM signals can also be provided by means of intertripping signals from circuit breakers that have operated in response to the **Distribution Network** fault.

10.4.7 The LoM protection can utilise one or a combination of the passive protection principles such as reverse power flow, reverse reactive power and rate of change of frequency (RoCoF). Alternatively, active methods such as reactive export error detection or frequency shifting may be employed. These may be arranged to trip the interface circuit breaker at the **DNO Generator** interface, thus, leaving the **Power Generating Module** available to satisfy the load requirements of the site or the **Power Generating Module** circuit breaker can be tripped, leaving the breaker at the interface closed and ready to resume supply when the **Distribution Network** supply is restored. The most appropriate arrangement is subject to agreement between the **DNO** and **Generator**.

10.4.8 Protection based on measurement of reverse flow of **Active Power** or **Reactive Power** can be used when circumstances permit and must be set to suit the **Power Generating Module** rating, the site load conditions and requirements for **Reactive Power**.

10.4.9 Where the **Power Generating Module** capacity is such that the site will always import power from the **Distribution Network**, a reverse power relay may be used to detect failure of the supply. It will usually be appropriate to monitor all three phases for reverse power.

10.4.10 However, where the **Power Generating Module**s normal mode of operation is to export power, it is not possible to use a reverse power relay and consequently failure of the supply cannot be detected by measurement of reverse power flow. The protection should then be specifically designed to detect loss of the mains connection using techniques to detect the rate of change of frequency and/or **Power Factor**. All these techniques are susceptible to **Distribution Network** conditions and the changes that occur without islanding taking place. These relays must be set to prevent islanding but with the best possible immunity to unwanted nuisance operation.

10.4.11 RoCoF relays use a measurement of the period of the mains voltage cycle. The RoCoF technique measures the rate of change in frequency caused by any difference between prime mover power and electrical output power of the **Power Generating Module** over a number of cycles. RoCoF relays should normally ignore the slow changes but respond to relatively rapid changes of frequency which occur when the **Power Generating Module** becomes disconnected from the **Total System**. The voltage vector shift technique is not an acceptable loss of mains

10.4.12 Should spurious tripping present a nuisance to the **Generator**, the cause must be jointly sought with the **DNO**. Raising settings on any relay to avoid spurious operation may reduce a relay's capability to detect islanding and it is important to evaluate fully such changes. Appendix D.2 provides some guidance for assessments, which assume that during a short period of islanding the trapped load is unchanged. In some circumstances it may be necessary to employ a different technique, or a combination of techniques to satisfy the conflicting requirements of safety and avoidance of nuisance tripping. In those cases where the **DNO** requires LoM protection this must be provided by a means not susceptible to spurious or nuisance tripping, eg intertripping.

10.4.13 For a radial or simple **Distribution Network** controlled by circuit breakers that would clearly disconnect the entire circuit and associated **Power Generating Module**, for a LoM event an intertripping scheme can be easy to design and install. For meshed or ring **Distribution Network**s, it can be difficult to define which circuit breakers may need to be incorporated in an intertripping scheme to detect a LoM event and the inherent risks associated with a complex system should be considered alongside those associated with a using simple, but potentially less discriminatory LoM relay.

10.4.14 It is the responsibility of the **Generator** to incorporate the most appropriate technique or combination of techniques to detect a LoM event in his protection systems. This will be based on knowledge of the **Power Generating Module,** site and network load conditions. The **DNO** will assist in the decision making process by providing information on the **Distribution Network** and its loads. The settings applied must be biased to ensure detection of islanding under all practical operating conditions.

## 10.5 Additional DNO Protection

10.5.1 Following the **DNO** connection study, the risk presented to the **Distribution Network** by the connection of a **Power Generating Module** may require additional protection to be installed and may include the detection of:

- Neutral Voltage Displacement (NVD);
- Over Current;
- Earth Fault;
- Reverse Power.

This protection will normally be installed on equipment owned by the **DNO** unless otherwise agreed between the **DNO** and **Generator**. This additional protection may be installed and arranged to operate the **DNO** interface circuit breaker or any other circuit breakers, subject to the agreement of the **DNO** and the **Generator**.

The requirement for additional protection will be determined by each **DNO** according to size of **Power Generating Module**, point of connection, network design and planning policy. This is outside the scope of this document.

When intertripping is considered to be a practical alternative, for detecting a LoM event, to using discriminating protection relays, the intertripping equipment would be installed by the **DNO**.

10.5.2 **Neutral Voltage Displacement (NVD) Protection**

Section 9.6 states that the **DNO** will undertake detailed consideration to ensure that protection arrangements are adequate to satisfactorily clear the full range of potential faults within an islanded system.

Section 10.4 describes LoM protection which the **Generator** must install to achieve (amongst other things) disconnection of the **Power Generating Module** from the **Distribution Network** in the event of loss of one or more phases of the **DNO**s supply.

Where a **Power Generating Module** inadvertently operates in island mode, and where there is an earth fault existing on the **DNO'**s **HV Distribution Network** NVD protection fitted on the **DNO**s **HV** switchgear will detect the earth fault, and disconnect the **HV** system from the island.

**DNO**s need to consider specific investigation of the need for NVD protection when, downstream of the same prospective island boundary, there are one or more **Power Generating Module**s (with an output greater than 200kVA per unit) having the enabled capacity to dynamically alter **Active Power** and **Reactive Power** output in order to maintain voltage profiles, and where such aggregate embedded generation output exceeds 50% of prospective island minimum demand.

10.5.3 As a general rule for generation installations connected at 20kV or lower voltages **DNO**s will not require NVD protection for the following circumstances:

- Single new **Power Generating Module** connection, of any type with an output less than 200kVA;
- Multiple new **Power Generating Module** connections, of any type, on a single site, with an aggregated output less than 200kVA;
- Single or multiple new **Power Generating Module** connections, of any type, where the voltage control is disabled or not fitted, on a single site, and where the aggregate output is greater than 200kVA ;
- Single or multiple new **Power Generating Module** connections, of any type, and where the voltage control is enabled, on a single site, where the aggregate output is greater than 200kVA, but where the aggregate output is less than 50% of the prospective island minimum demand.

It should be noted that above is a "general rule"; each **DNO** will have differing network designs and so the decision will be made by the **DNO** according to size of **Power Generating Module**, **Connection Point**, network design and planning policy. This is outside the scope of this document.

10.5.4 If the assessed minimum load on a prospective island is less than twice the maximum combined output of new **Power Generating Module** consideration should be given to use of NVD protection as a part of the **Interface Protection**. The consideration should include an assessment of:

a. The specification of capability of the LoM protection, including the provision of multiple independent detection techniques;

b. The influence of activation of pre-existing NVD protection already present elsewhere on the same prospective island;

c. The opportunity arising from asset change/addition associated with the proposed new Power Generating Module connection eg the margin of additional cost associated with NVD protection.

## 10.6 Protection Settings

10.6.1 The following notes aim to explain the settings requirements as given in Section 10.6.7.1 below.

10.6.2 **Loss of Mains**

A LoM protection of the RoCoF type will generally be appropriate for **Type A, Type B and Type C Power Generating Modules**, but this type of LoM protection must not be installed for **Power Generating Facilities** at or above 50 MW. In those cases where the **DNO** requires LoM protection this must be provided by a means not susceptible to spurious or nuisance tripping, eg intertripping.

10.6.3 **Under Voltage**

In order to help maintain **Total System Stability**, the protection settings should be such as to facilitate transmission fault ride through capability. The overall aim is to ensure that **Power Generating Module** is not disconnected from the **Distribution Network** unless there is material disturbance on the **Distribution Network**, as disconnecting generation unnecessarily will tend to make an under voltage situation worse. To maximize the transmission fault ride through capability a single undervoltage setting of 20% with a time delay of 2.5s should be applied.

10.6.4 **Over Voltage**

Over voltages are potentially more dangerous than under voltages and hence the acceptable excursions from the norm are smaller and time delays shorter, a 2-Stage over voltage protection[2] is to be applied as follows:

- Stage 1 (**LV**) should have a setting of +14% (ie the **LV** statutory upper voltage limit of +10%, with a further 4% permitted for voltage rise internal to the **Customer**'s installation and measurement errors ),with a time delay of 1.0s (to avoid nuisance tripping for short duration excursions);
- Stage 2 (**LV**) should have a setting of +19% with a time delay of 0.5s (ie recognising the need to disconnect quickly for a material excursion);
- Stage 1 (**HV**) should have a setting of +10% with a time delay of 1.0s (ie the **HV** statutory upper voltage limit of +6%, with a further 4% permitted for voltage rise internal to the **Customer's Installation** and measurement errors), with a time delay of 1.0s to avoid nuisance tripping for short duration excursions);

2 Over Voltage Protection is not intended to maintain statutory voltages but to detect islanding

- Stage 2 (**HV**) should have a setting of +10% with a time delay of 0.5s (ie recognising the need to disconnect quickly for a material excursion).

To achieve high utilisation and **Distribution Network** efficiency, it is common for the **HV Distribution Network** to be normally operated near to the upper statutory voltage limits. The presence of **Power Generating Module** within such **Distribution Network** may increase the risk of the statutory limit being exceeded, eg when the **Distribution Network** is operating abnormally. In such cases the **DNO** may specify additional over voltage protection at the **Power Generating Module Connection Point**. This protection will typically have an operating time delay long enough to permit the correction of transient over voltages by automatic tap-changers.

10.6.5 **Over Frequency**

**Power Generating Modules** are required to stay connected to the **Total System** for frequencies up to 52 Hz for up to 15 minutes so as to provide the necessary regulation to control the **Total System** frequency to a satisfactory level. In order to prevent the unnecessary disconnection of a large volume of smaller **Power Generating Module** for all **LV** and **HV** connected **Power Generating Module** a single stage protection is to be applied that has a time delay of 0.5s and a setting of 52 Hz. If the frequency rises to or above 52 Hz as the result of an undetected islanding condition, the **Power Generating Module** will be disconnected with a delay of 0.5s plus circuit breaker operating time.

10.6.6 **Under Frequency**

**All Power Generating Facilities** are required to maintain connection unless the **Total System** frequency falls below 47.5 Hz for 20s or below 47 Hz.

For all **LV** and **HV** connected **Power Generating Module** , the following 2-stage under frequency protection should be applied:

- Stage 1 should have a setting of 47.5 Hz with a time delay of 20s;
- Stage 2 should have a setting of 47.0 Hz with a time delay of 0.5s;

10.6.7 .

10.6.7.1 Table 10.1 Settings for Long-Term Parallel Operation

| Prot Function | Type A, Type B and Type C Power Generating Modules | | | | Type D Power Generating Modules | |
|---|---|---|---|---|---|---|
| | **LV** Protection(1) | | **HV** Protection(1) | | | |
| | Setting | Time | Setting | Time | Setting | Time |
| U/V | Vφ-n† -20% = 184.0V | 2.5s* | Vφ-φ‡ -13% | 2.5s* | Vφ-φ‡- 20% | 2.5s* |
| O/V st 1 | Vφ-n† + 14% =262.2V | 1.0s | Vφ-φ‡ + 10% | 1.0s | Vφ-φ‡ + 10% | 1.0s |
| O/V st 2 | Vφ-n†+ 19% =273.7V$ | 0.5s | Vφ-φ‡ + 13% | 0.5s | | |
| U/F st 1 | 47.5Hz | 20s | 47.5Hz | 20s | 47.5Hz | 20s |
| U/F st 2 | 47.0Hz | 0.5s | 47.0Hz | 0.5s | 47.0Hz | 0.5s |
| O/F | 52.0 Hz | 0.5s | 52.0Hz | 0.5s | 52.0Hz | 0.5s |
| LoM (RoCoF)# | 1 $Hzs^{-1}$ time delay 0.5s | | 1 $Hzs^{-1}$ time delay 0.5s | | Intertripping expected | |

(1) **HV** and **LV** Protection settings are to be applied according to the voltage at which the voltage related protection reference is measuring, eg:

- If the EREC G99 protection takes its voltage reference from an **LV** source then **LV** settings shall be applied. Except where a private non standard LV network exists, in this case the settings shall be calculated from **HV** settings values as indicated by section 10.5.16;
- If the EREC G99 protection takes its voltage reference from an **HV** source then **HV** settings shall be applied.

†A value of 230V shall be used in all cases for **Power Generating Facilities** connected to a **DNO's LV Distribution Network**

‡A value to suit the nominal voltage of the **HV Connection Point**.

* Might need to be reduced if auto-reclose times are <3s. (see 10.5.13).

# Intertripping may be considered as an alternative to the use of a LoM relay

$ For voltages greater than 230V +19% which are present for periods of<0.5s the **Power Generating Module** is permitted to reduce/cease exporting in order to protect the **Power Generating Module**.

The required RoCoF protection requirement is expressed in Hertz per second ($Hzs^{-1}$). The time delay should begin when the measured RoCoF exceeds the threshold expressed in $Hzs^{-1}$. The time delay should be reset if measured RoCoF falls below that threshold. The relay must not trip unless the measured rate remains above the threshold expressed in $Hzs^{-1}$ continuously for 500ms. Setting the number of cycles on the relay used to calculate the RoCoF is not an acceptable implementation of the time delay since the relay would trip in less than 500ms if the system RoCoF was significantly higher than the threshold.

The LoM function shall be verified by confirming that the LoM tests specified in Appendix A.8 have been completed successfully

(2) Note that the times in the table are the time delays to be set on the appropriate relays. Total protection operating time from condition detection to circuit breaker opening will be of the order of 100ms longer than the time delay

settings in the above table with most circuit breakers, slower operation is acceptable in some cases.

The **Manufacturer** must ensure that the **Interface Protection** in a **Type Tested Power Generating Module** is capable of measuring voltage to an accuracy of ±1.5% of the nominal value and of measuring frequency to ± 0.2% of the nominal value across its operating range of voltage, frequency and temperature.

10.6.7.2 Table 10.2 – Settings for Infrequent Short-Term Parallel Operation

| Prot Function | **Type A, Type B and Type C Power Generating Facility** | | | |
|---|---|---|---|---|
| | **LV** Protection | | **HV** Protection | |
| | Setting | Time | Setting | Time |
| U/V | Vφ-n† -10% = 207V | 0.5s | Vφ-φ‡ -6% | 0.5s |
| O/V | Vφ-n† + 14% = 262.2V | 0.5s | Vφ-φ‡ + 6% | 0.5s |
| U/F | 49.5Hz | 0.5s | 49.5Hz | 0.5s |
| O/F | 50.5Hz | 0.5s | 50.5Hz | 0.5s |

†A value of 230V shall be used in all cases for **Power Generating Facilities** connected to a **DNO's LV Distribution Network**

‡A value to suit the voltage of the **HV Connection Point.**

10.6.8 Over and Under voltage protection must operate independently for all three phases in all cases.

10.6.9 The settings in Table 10.1 should generally be applied to all **Power Generating Module**. In exceptional circumstances **Generator**s have the option to agree alternative settings with the **DNO** if there are valid justifications in that the **Power Generating Module** may become unstable or suffer damage with the settings specified in Table 10.1. The agreed settings should be recorded in the **Connection Agreement**.

10.6.10 Once the settings and Operating Values of relays have been agreed between the **Generator** and the **DNO** they must not be altered without the written agreement of the **DNO**. Any revised settings should be recorded again in the amended **Connection Agreement**.

10.6.11 The under/over voltage and frequency protection may be duplicated to protect the **Power Generating Module** when operating in island mode although different settings may be required.

10.6.12 For **LV** connected **Power Generating Module** the voltage settings will be based on the 230V nominal system voltage. In some cases **Power Generating Module** may be connected to **LV** systems with non-standard operating voltages. Section 10.6.16 details how suitable settings can be calculated based upon the **HV** connected settings in Table 10.1. Note that **Power Generating Modules** with non-standard **LV** protection settings need to be agreed by the **DNO** on a case by case basis.

10.6.15 Where an installation contains **Power Factor** correction equipment which has a variable susceptance controlled to meet the **Reactive Power** demands, the probability of sustained generation is increased. For **LV** installations, additional protective equipment provided by the **Generator**, is required as in the case of self-excited asynchronous machines.

10.6.16 Non-Standard private LV networks calculation of appropriate protection settings

The standard over and under voltage settings for **LV** connected **Power Generating Modules** have been developed based on a nominal **LV** voltage of 230V. Typical **DNO** practice is to purchase transformers with a transformer winding ratio of 11000:433, with off load tap changers allowing the nominal winding ratio to be changed over a range of plus or minus 5% and with delta connected **HV** windings. Where a **DNO** provides a connection at **HV** and the **Customer** uses transformers of the same nominal winding ratio and with the same tap selection as the **DNO** then the standard **LV** settings in table 10.1 can be used for **Power Generating Modules** connected to the **Customer's LV** network. Where a **DNO** provides a connection at **HV** and the **Customer's** transformers have different nominal winding ratios, and he chooses to take the protection reference measurements from the **LV** side of the transformer, then the **LV** settings stated in table 10.1 should not be used without the prior agreement of the **DNO**. Where the **DNO** does not consider the standard **LV** settings to be suitable, the following method shall be used to calculate the required **LV** settings based on the **HV** settings for Type A and Type B **Power Generating Facilities** stated in table 10.1.

Identify the value of the transformers nominal winding ratio and if using other than the nominal tap, increase or decrease this value to establish a **LV** system nominal value based on the transformer winding ratio and tap position and the **DNO**s declared **HV** system nominal voltage.

For example a **Customer** is using an 11,000V to 230/400V transformer and it is proposed to operate it on tap 1 representing an increase in the high voltage winding of +5% and the nominal HV voltage is 11,000V.

$V_{LVsys} = V_{LVnom} \times V_{HVnom}/V_{HVtap}$

$V_{LVsys}$ = 230 x 11000/11550 = 219V

Where:

$V_{LVsys}$ – LV system voltage

$V_{LVnom}$ - LV system nominal voltage (230V)

$V_{HVnom}$ - HV system nominal voltage (11,000V)

$V_{HVtap}$ – HV tap position

The revised **LV** voltage settings required therefore would be:

| | | | | |
|---|---|---|---|---|
| OV stage 1 | = | 219x1.1 | = | 241V |
| OV stage 2 | = | 219x1.13 | = | 247.5V |
| UV | = | 219x0.8 | = | 175V |

The time delays required for each stage are as stated in table 10.1.

Where **Power Generating Modules** are designed with balanced 3 phase outputs and no neutral is required then phase to phase voltages can be used instead of phase to neutral voltages.

This approach should only be used by prior arrangement with the host **DNO**. Where all other requirements of EREC G99 would allow the **Power Generating Module** to be **Fully Type Tested**, the **Manufacturer** may produce a declaration in a similar format to Appendix A.4 for presentation to the **DNO** by the **Generator**, stating that all **Power Generating Modules** produced for a particular **Power Generating Facility** comply with the revised over and under voltage settings. All other required data should be provided as for **Type Tested Power Generating Module**s as required by EREC G98. This declaration should make reference to a particular **Power Generating Facility** and its declared **LV** system voltage. These documents should not be registered on the ENA web site as they will not be of use to other **Generator**s who will have to consult with the **Manufacturer** and **DNO** to agree settings for each particular **Power Generating Facility**.

10.6.17 The **Generator** shall provide a means of displaying the protection settings so that they can be inspected if required by the **DNO** to confirm that the correct settings have been applied. The **Manufacturer** needs to establish a secure way of displaying the settings in one of the following ways:

a. A display on a screen which can be read;

b. A display on an electronic device which can communicate with the **Power Generating Module** and confirm that it is the correct device by means of a Identification number / name permanently fixed to the device and visible on the electronic device screen at the same time as the settings;

c. Display of all settings including nominal voltage and current outputs, alongside the identification number / name of the device, permanently fixed to the **Power Generating Module**.

The provision of loose documents, documents attached by cable ties etc., a statement that the device conforms with a standard, or provision of data on adhesive paper based products which are not likely to survive due to fading, or failure of the adhesive, for at least 20 years is not acceptable.

The protection arrangements (including changes to protection arrangements) for individual schemes will be agreed between the **Generator** and the **DNO** in accordance with this document.

10.6.18 The protection schemes and settings for internal electrical faults must not jeopardise the performance of a **power generating module**, in line with the requirements set out in this **EREC**.

10.6.19 The **Generator** shall organise its protection and control devices in accordance with the following priority ranking (from highest to lowest) for **Type B**, **Type C** and **Type D Power Generating Modules**:

(i) network and **Power Generating Module** protection;

(ii) synthetic inertia, if applicable;

(i) **frequency control** (**Active Power** adjustment);

(iv) power restriction; and

(i) power gradient constraint.

## 10.7 Typical Protection Application Diagrams

10.7.1 This Section provides some typical protection application diagrams in relation to parallel operation of **Power Generating Module** within **DNO Distribution Networks**. The diagrams only relate to **DNO** requirements in respect of the connection to the **Distribution Network** and do not necessarily cover the safety of the **Generator**'s installation. The diagrams are intended to illustrate typical installations.

Figure 10.1 - List of Symbols used in Figures 10.2 to 10.6.

Figure 10.2 - Typical Protection Arrangement for an **HV Power Generating Module** Connected to a **DNO's HV Distribution Network** Designed for Parallel Operation Only

Figure 10.3 - Typical Protection Arrangement for an **HV Power Generating Module** Connected to a **DNO's HV Distribution Network** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation

Figure 10.4 - Typical Protection Arrangement for an **LV Power Generating Module** Connected to a **DNO's HV Distribution Network** and designed for both Independent Operation (ie Standby Operation) and Parallel Operation

Figure 10.5 - Typical Protection Diagram for an **LV Power Generating Module** Connected to a **DNO's LV Distribution Network** Designed for Parallel Operation Only

Figure 10.6 - Typical Protection Diagram for an **LV Power Generating Module** Connected to a **DNO's LV Distribution Network** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation

**Diagram Notes:**

a. Neutral Voltage Displacement Protection

With arc suppression coil systems, the NVD relay should be arranged to provide an alarm only.

b. Reverse Power Protection

Reverse power protection may be either a standard three phase reverse power relay set to operate at above the agreed level of export into the **Distribution Network**, or a more sensitive relay if no export is permitted.

c. Directional Protection

In some cases overcurrent protection may afford adequate back-up protection to the **Distribution Network** during system faults. However, where increased sensitivity is required, three phase directional overcurrent IDMT relays, or alternative voltage based protection may be used.

d Load Limitation Relay

Three phase definite time overcurrent relays, in addition to providing overload protection, could be arranged to detect phase unbalance. This condition may be due to pulled joints or broken jumpers on the incoming **DNO** underground or overhead **HV** supply.

NB Items (c) and (d) are alternatives and may be provided as additional protection.

e. Phase Unbalance Protection

Three phase thermal relays for detecting phase unbalance on the incoming **DNO HV** supply, eg pulled joints, broken jumpers or uncleared unbalanced faults.

f. Supply Healthy Protection

Some form of monitoring or protection is required to ensure that the **DNO**s supply is healthy before synchronizing is attempted. This could be simply under and over voltage monitoring of all phases on the **DNO** side of the synchronising circuit breaker. Alternatively automatic under and over voltage monitoring, applied across all three phases, together with synchronising equipment designed such that closing of the synchronising circuit breaker cannot occur unless all three phases of the supply have frequency and voltages within statutory limits and have a voltage phase balance within the limits in EREC P29.

**Figure 10.1** - List of Symbols in Figures 10.2 – 10.6

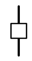
| | |
|---|---|
| BEF | Balanced Earth Fault |
| CC | Circulating Current |
| 3DOCI | 3 Pole Directional Overcurrent (IDMT) |
| EI | Earth Fault (IDMT) |
| LOM | Loss of Mains |
| M | Metering |
| NVD | Neutral Voltage Displacement |
| 3OCI | 3 Pole Overcurrent (IDMT) |
| OF UF | Single Stage Over Frequency & Single Stage Under Frequency |
| OV UV | Single Stage Over Voltage & Single Stage Under Voltage |
| Ph Unbal | Phase Unbalance |
| RP | Reverse Power |
| 2ST OF UF | 2 Stage Over Frequency & 2 Stage Under Frequency |
| 2ST OV UV | 2 Stage Over Voltage & 2 Stage Under Voltage |
| SYNC | Synchronising |
|  | Circuit Beaker |

**Figure 10.2** - Typical Protection Arrangement for an **HV Power Generating Module** Connected to a **DNO's HV Distribution Network** Designed for Parallel Operation Only

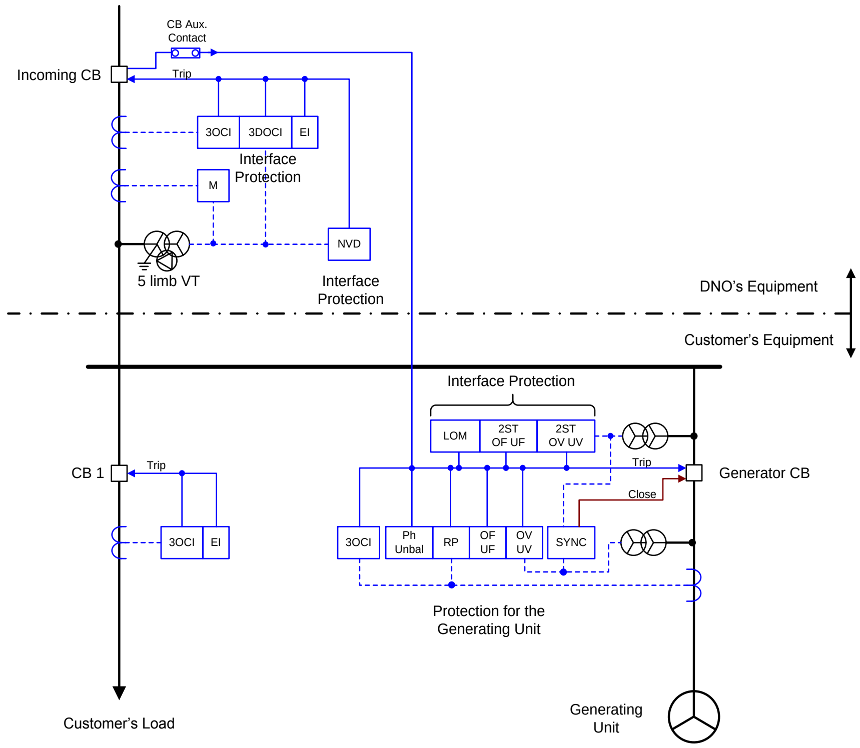


**Figure 10.3** - Typical Protection Arrangement for an **HV Power Generating Module** Connected to a **DNO's HV Distribution Network** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation

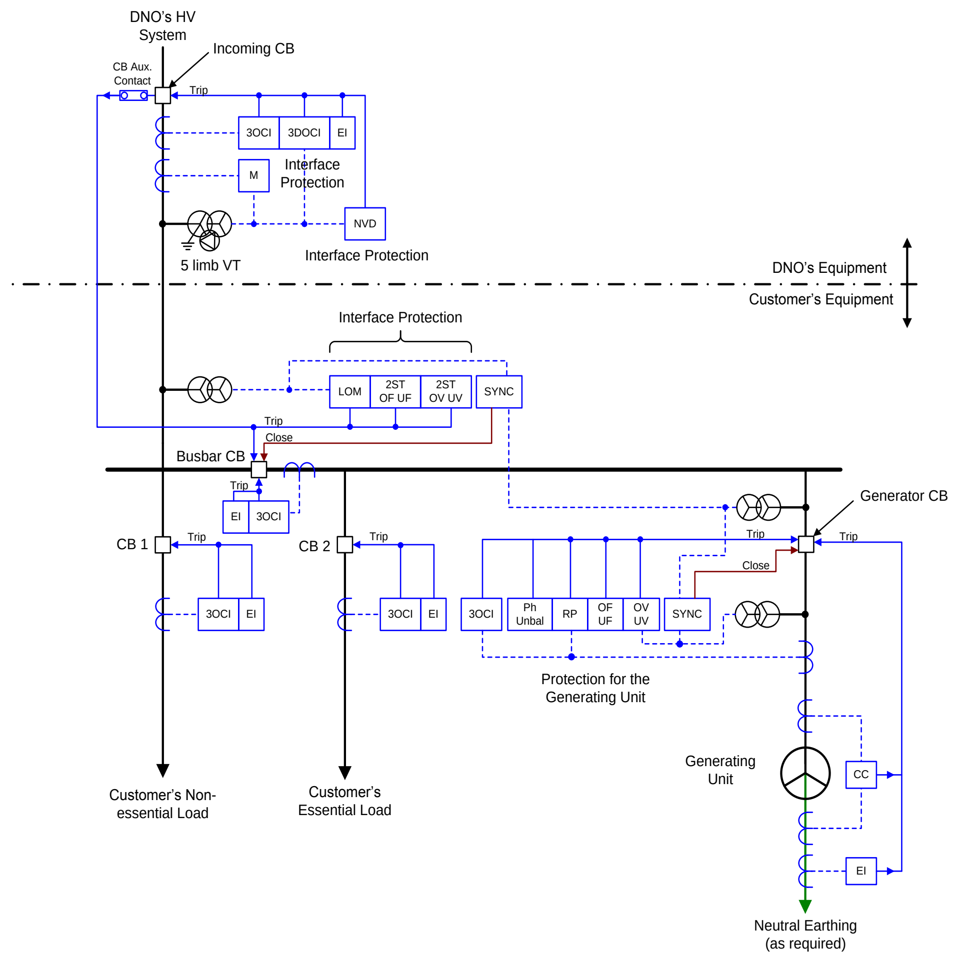


**Figure 10.4** - Typical Protection Arrangement for an **LV Power Generating Module** Connected to a **DNO's HV Distribution Network** and designed for both Independent Operation (ie Standby Operation) and Parallel Operation..

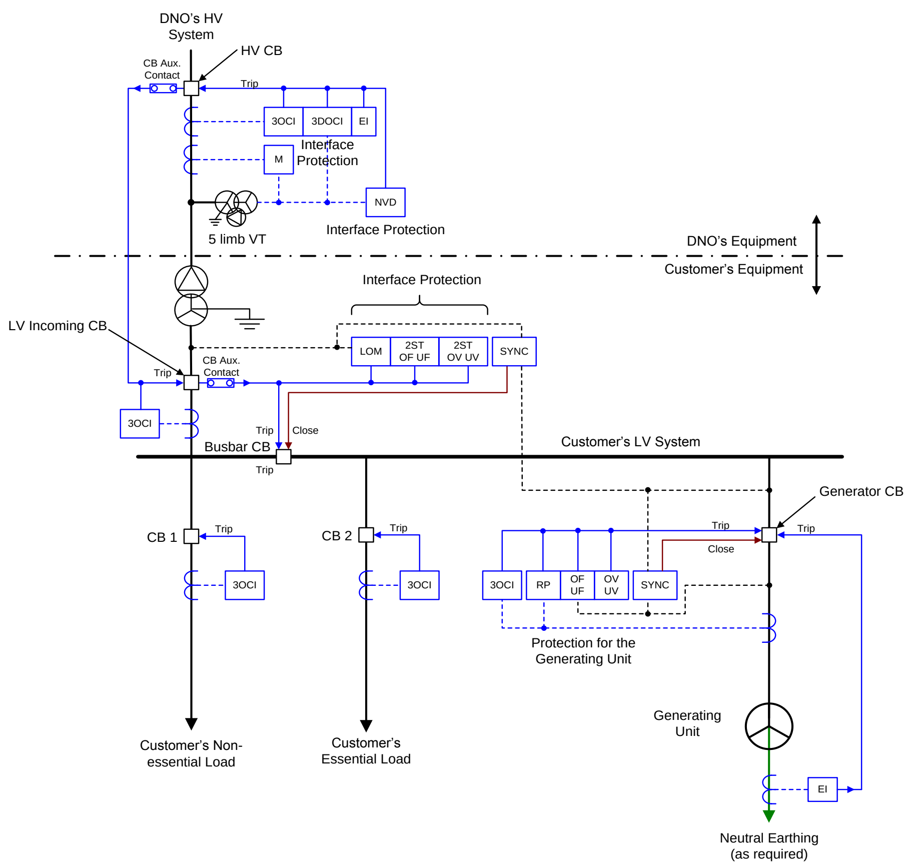


**Figure 10.5** - Typical Protection Diagram for an **LV Power Generating Module** Connected to a **DNO's LV Distribution Network** Designed for Parallel Operation O

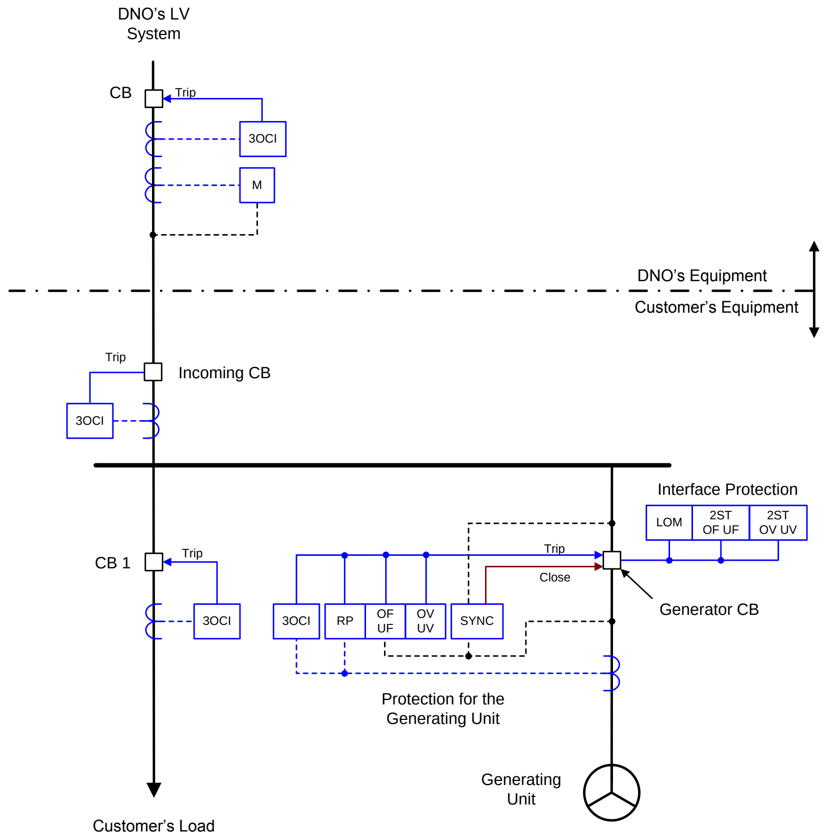
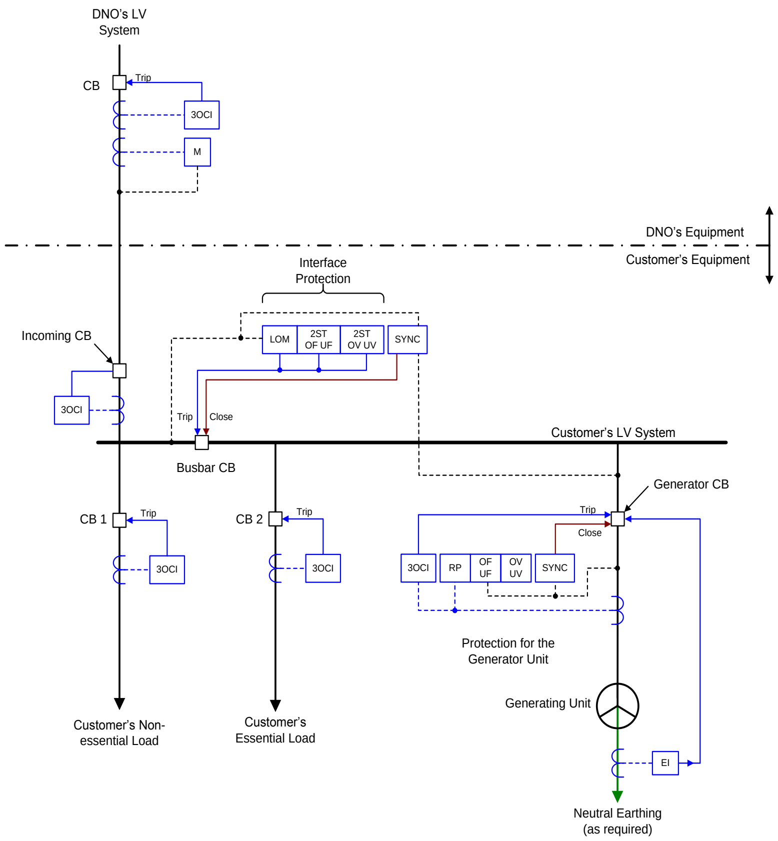


**Figure 10.6** - Typical Protection Diagram for an **LV Power Generating Module** Connected to a **DNO's LV Distribution Network** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation



## 11 Type A Power Generating Module Technical Requirements

### 11.1 Power Generating Module Performance and Control Requirements – General

11.1.1 The requirements of this section do not apply in full to **Power Generation Facilities** that include storage and/or are designed and installed for infrequent short term parallel operation only – refer to Appendix A5

11.1.2 For **Power Generating Modules,** which do not constitute or contain **BM Units** that are active (ie submitting bid-offer data) in the **Balancing Mechanism**, the electrical parameters required to be achieved at the **Connection Point** are defined according to the connection method and will be specified by the **DNO** with the offer for connection.

11.1.3 The **Active Power** output of a **Power Generating Module** should not be affected by voltage changes within the statutory limits declared by the **DNO** in accordance with the **ESQCR**.

11.1.4 **Type A Power Generating Modules** connected to the **DNO's Distribution Network** 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. The **DNO** may specify any additional requirements particularly regarding remote operation of this facility.

11.1.5 Each item of a **Power Generating Module** and its associated control equipment must be designed for stable operation in parallel with the **Distribution Network**.

11.1.6 The **Generator** will notify, and keep notified, the **DNO** of the set points of the control scheme for voltage control or **Power Factor** control, or Reactive Power control as appropriate and which have previously been agreed between the **Generator** and **DNO**. The information to be provided is detailed in Schedule 5a and Schedule 5b of the Data Registration Code.

11.1.7 Load flow and **System Stability** studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The **Connection Agreement** should include details of the relevant outage conditions. It may be necessary under these fault conditions, where the combination of **Power Generating Module** output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the **Power Generating Module**.

### 11.2 Frequency response

11.2.1 Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47Hz. In exceptional circumstances, the frequency of the **DNO's Distribution Network** could rise above 50.5 Hz. Therefore all **Power Generating**

**Modules** should be capable of continuing to operate in parallel with the **Distribution Network** in accordance with the following:

a. 47 Hz – 47.5 Hz Operation for a period of at least 20 seconds is required each time the frequency is within this range.

b. 47.5 Hz – 49.0 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.

c. 49.0Hz – 51.0 Hz Continuous operation of the **Power Generating Module** is required.

d. 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.

e. 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range.

11.2.2 As stated in 11.2.1, the system frequency could rise to 52Hz or fall to 47Hz. Each **Power Generating Module** must continue to operate within this frequency range for at least the periods of time given in 11.2.1.

11.2.3 With regard to the rate of change of frequency withstand capability, a **PGM** shall be capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1 Hzs-1 as measured over a period of 500ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection

11.2.4 **Output power with falling frequency**

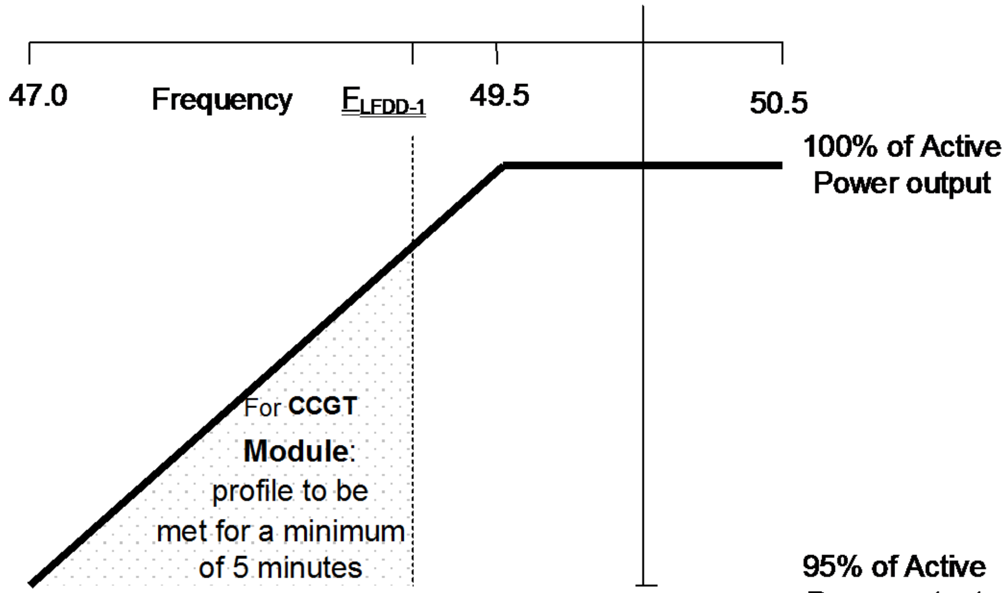
11.2.4.1 Each **Power Generating Module**, must be capable of:

(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 paragraph 11.2.1) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 11.1 for system frequency changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including 25$^{0}$C, such that if the system frequency drops to 47 Hz the **Active Power** output does not decrease by more than 5%. Where the need for special measures is identified in order to maintain output in line with the level identified in Figure 11.1 these measures should be still continued at ambient temperatures above 25$^{0}$C maintaining as much of the **Active Power** achievable within the capability of the plant.

Figure 11.1

**Comment [CS8]:** Diagram to be refreshed for final draft and CCGT text removed




Note: **Frequency** $F_{LFDD-1}$ is the relay trip setting of the first stage of the Automatic Low **Frequency Demand Disconnection** Scheme

11.2.4.2 For the avoidance of doubt in the case of a **Power Generating Module** using an **Intermittent Power Source** where the 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.

### 11.2.5 Limited Frequency Sensitive Mode – Over frequency

11.2.5.1 Each Power Generating Module shall be capable of reducing Active Power output in response to system frequency when this rises above 50.4Hz.. The Power Generating Module shall be capable of operating stably during LFSM-O operation. However for a Power Generating Module, operating in Frequency Sensitive Mode the requirements of LFSM-O shall apply when frequency exceeds 50.5Hz.

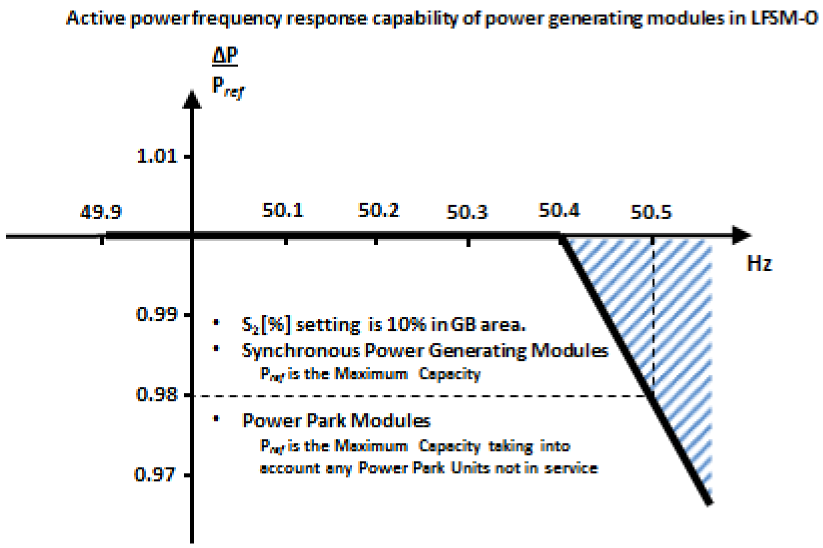
(i) The rate of change of **Active Power** output must be at a minimum a rate of 2 percent of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a Droop of 10%) as shown in Figure 11.2. For the avoidance of doubt, this would not preclude a **Generator** from designing their **Power Generating Module** with a lower **Droop** setting, for example between 3 – 5%.

(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** 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 shall justify the delay, providing technical evidence to the **DNO**, who will pass this evidence to the **NETSO**.

(iv) The residue of the proportional reduction in **Active Power** output which results from automatic action of the **Power Generating Module** 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 50.4 Hz.

Figure 11.2




$P_{ref}$ is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module**. $F_n$ is the nominal frequency (50Hz) in the network and Δf is the frequency deviation in the network, At overfrequencies where Δf is below $\Delta f_1$ the **Power Generating Module** has to provide a negative **Active Power** output change according to **Droop** $S_2$

11.2.5.2 Each **Power Generating Module** which is providing **Limited Frequency Sensitive Mode Over frequency (LFSM-O)** must continue to provide it until the frequency has returned to or below 50.4Hz.

## 11.3 Fault Ride Through and Phase Voltage Unbalance

11.3.1 Any **Power Generating Module** or **Power Generating Facility** connected to the **DNO's Distribution Network**, where it has been agreed between the **DNO** and the **Generator** that the **Power Generating Facility** will contribute to the **DNO's**

**Distribution Network** security, may be required to withstand, without tripping, the effects of a close up three phase fault and the **Phase (Voltage) Unbalance** imposed during the clearance of a close-up phase-to-phase fault , in both cases cleared by the **DNO's** main protection. The **DNO** will advise the **Generator** in each case of the likely tripping time of the **DNO's** protection, and for phase-phase faults, the likely value of **Phase (Voltage) Unbalance** during the fault clearance time.

11.3.2 In the case of phase to phase faults on the **DNO**'s system that are cleared by system back-up protection which will be within the plant short time rating on the **DNO's Distribution Network** the **DNO**, on request during the connection process, will advise the **Generator** of the expected Phase Voltage Unbalance.

## 11.4 Voltage Limits and Control

11.4.1 Where **a Power Generating Module** is remote from a **Network** voltage control point it may be required to withstand voltages outside the normal statutory limits. In these circumstances, the **DNO** should agree with the **Generator** the declared voltage and voltage range at the **Connection Point**. Immunity of the **Power Generating Module** to voltage changes of ± 10% of the declared voltage is recommended, subject to design appraisal of individual installations.

11.4.2 The connection of a **Power Generating Module** to the **Distribution Network** shall be designed in such a way that operation of the **Power Generating Module** does not adversely affect the voltage profile of and voltage control employed on the **Distribution Network**. ETR 126 provides **DNO**s with guidance on active management solutions to overcome voltage control limitations. Information on the voltage regulation and control arrangements will be made available by the **DNO** if requested by the **Customer.**

11.4.3 The final responsibility for control of **Distribution Network** voltage does however remain with the **DNO**.

11.4.4 Automatic Voltage Control (AVC) schemes employed by the **DNO** assume that power flows from parts of the **Distribution Network** operating at a higher voltage to parts of the **Distribution Network** operating at lower voltages. Export from **Power Generating Modules** in excess of the local loads may result in power flows in the reverse direction. In this case AVC referenced to the low voltage side will not operate correctly without an import of reactive power and relay settings appropriate to this operating condition. When load current compounding is used with the AVC and the penetration level of **Power Generating Modules** becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.

11.4.5 **Power Generating Modules** can cause problems if connected to networks employing AVC schemes which use negative reactance compounding and line drop compensation due to changes in active and reactive power flows. ETR 126 provides guidance on connecting generation to such networks using techniques such as removing the generation circuit from the AVC scheme using cancellation CTs.

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# 12 Type B Power Generating Module Technical Requirements

## 12.1 Power Generating Module Performance and Control Requirements - General

12.1.2 The requirements of this section do not apply in full to **Power Generation Facilities** that include storage and/or that are designed and installed for infrequent short term parallel operation only – refer to Appendix A5.

12.1.2 For **Power Generating Modules,** which do not constitute or contain **BM Units** that are active (ie submitting bid-offer data) in the **Balancing Mechanism**, the electrical parameters required to be achieved at the **Connection Point** are defined according to the connection method and will be specified by the **DNO** with the offer for connection.

12.1.3 The **Active Power** output of a **Power Generating Module** should not be affected by voltage changes within the statutory limits declared by the **DNO** in accordance with the **ESQCR**.

12.1.4 **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. The DNO may specify any additional requirements particularly in relation to remote operation of this facility.

12.1.5 Each item of a **Power Generating Module** and its associated control equipment must be designed for stable operation in parallel with the **Distribution Network**.

12.1.6 The **Generator** will notify, and keep notified, the **DNO** of the set points of the control scheme for voltage control or **Power Factor** control, or Reactive Power control as appropriate and which have previously been agreed between the **Generator** and **DNO**. The information to be provided is detailed in Schedule 5a and Schedule 5b of the Data Registration Code.

12.1.7 Load flow and **System Stability** studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The **Connection Agreement** should include details of the relevant outage conditions. It may be necessary under these fault conditions, where the combination of **Power Generating Module** output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the **Power Generating Module**.

## 12.2 Frequency response

12.2.1 Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47Hz. In exceptional circumstances, the frequency of the **DNO's Distribution Network** could rise above 50.5 Hz. Therefore all **Power Generating Modules** should be capable of continuing to operate in parallel with the **Distribution Network** in accordance with the following:

f. 47 Hz – 47.5 Hz Operation for a period of at least 20 seconds is required each time the frequency is within this range.

g. 47.5 Hz – 49.0 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.

h. 49.0Hz – 51.0 Hz Continuous operation of the **Power Generating Module** is required.

i. 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.

j. 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range.

12.2.2 As stated in 12.2.1, the system frequency could rise to 52Hz or fall to 47Hz. Each **Power Generating Module** must continue to operate within this frequency range for at least the periods of time given in 12.2.1.

12.2.3 With regard to the rate of change of frequency withstand capability, a **Power Generating Module** shall be capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1 Hzs-1 as measured over a period of 500ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection.

12.2.4 **Output power with falling frequency**

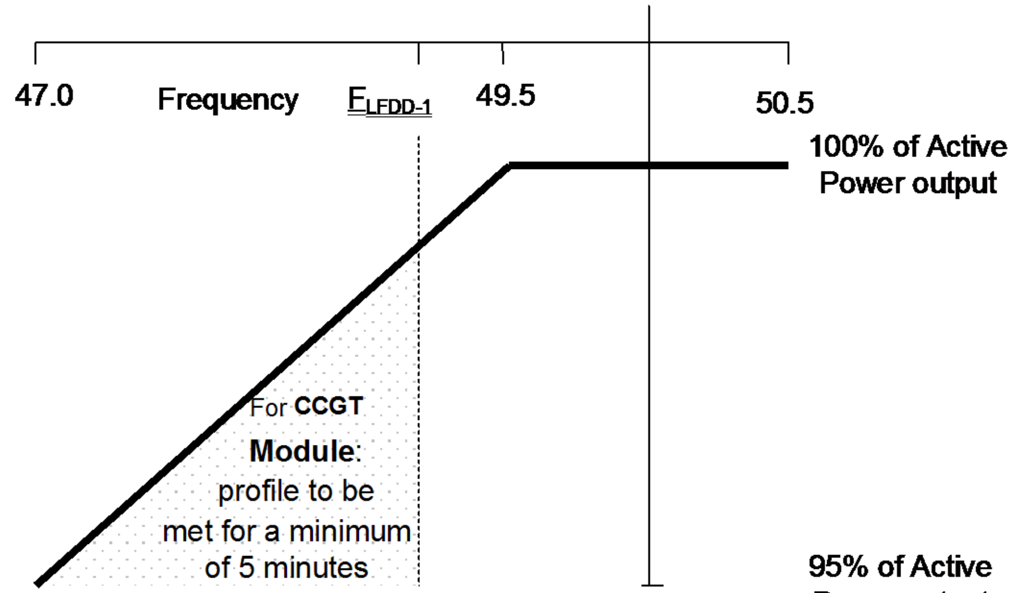
12.2.4.1 Each **Power Generating Module**, must be capable of:

(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 paragraph 12.2.1) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 12.1 for system frequency changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including $25^{0}$C, such that if the system frequency drops to 47 Hz the **Active Power** output does not decrease by more than 5%. Where the need for special measures is identified in order to maintain output in line with the level identified in Figure 12.1 these measures should be still continued at ambient temperatures above $25^{0}$C maintaining as much of the **Active Power** achievable within the capability of the plant.

Figure 12.1

**Comment [CS9]:** Diagram to be refreshed for final draft and CCGT text removed




12.2.4.2 For the avoidance of doubt in the case of a **Power Generating Module** using an **Intermittent Power Source** where the 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.

### 12.2.5 Limited Frequency Sensitive Mode – Over frequency

12.2.5.1 Each **Power Generating Module** shall be capable of reducing **Active Power** output in response to system frequency when this rises above 50.4Hz. The **Power Generating Module** shall be capable of operating stably during **LFSM-O** operation. However for a **Power Generating Module**, operating in Frequency Sensitive Mode the requirements of **LFSM-O** shall apply when frequency exceeds 50.5Hz.

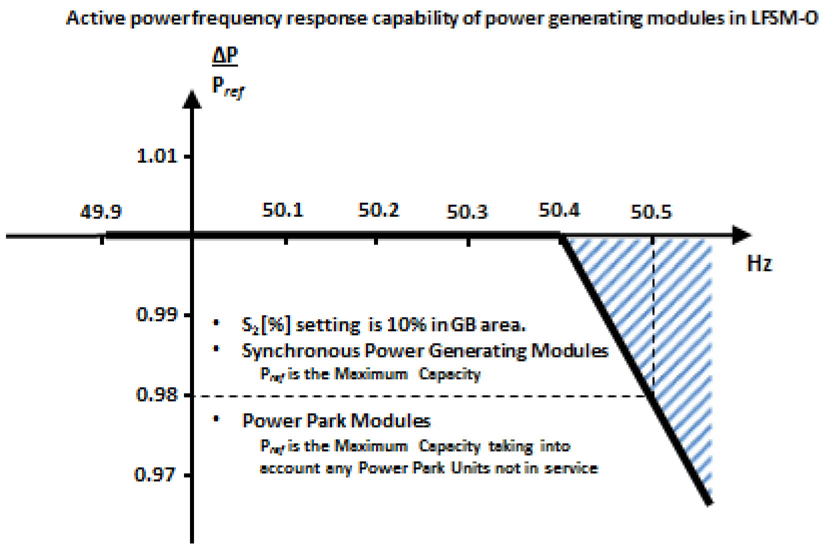
(i) The rate of change of **Active Power** output must be at a minimum a rate of 2 percent of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a Droop of 10%) as shown in Figure 12.2 below. For the avoidance of doubt, this would not preclude a **Generator** from designing their **Power Generating Module** with a lower **Droop** setting, for example between 3 – 5%.

(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** 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 shall justify the delay, providing technical evidence to the **DNO**, who will pass this evidence to the **NETSO**.

(iv) The residue of the proportional reduction in **Active Power** output which results from automatic action of the **Power Generating Module** 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 50.4 Hz.

Figure 12.2




$P_{ref}$ is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module**. $F_n$ is the nominal frequency (50Hz) in the network and Δf is the frequency deviation in the network, At overfrequencies where Δf is below $\Delta f_1$ the **Power Generating Module** has to provide a negative **Active Power** output change according to **Droop** $S_2$

12.2.5.2 Each **Power Generating Module** which is providing **Limited Frequency Sensitive Mode Over frequency (LFSM-O)** must continue to provide it until the frequency has returned to or below 50.4Hz.

## 12.3 Fault Ride Through

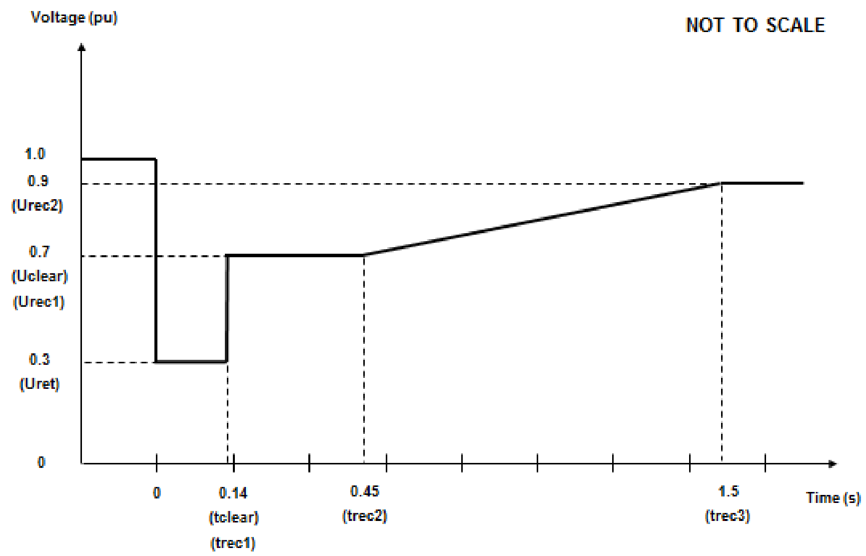
12.3.1 Paragraphs 12.3.1.1 to 12.3.1.7 inclusive set out the fault ride through, principles and concepts applicable to **Type B Synchronous Power Generating Modules** and

**Power Park Modules**, subject to disturbances from faults on the **Network** up to 140ms in duration.

12.3.1.1 Each **Synchronous Power Generating Module** and **Power Park Module** is required to remain connected and stable for any balanced and unbalanced fault where the voltage at the **Connection Point** remains on or above the heavy black line shown in Figures 12.3 and 12.4 below.

12.3.1.2 The voltage against time curves defined in Table 12.1 and Table 12.2 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 voltages (or phase to earth voltage in the case of asymmetrical/unbalanced faults) on the network voltage level at **Connection Point** during a symmetrical or asymmetrical/unbalanced fault, as a function of time before, during and after the fault.

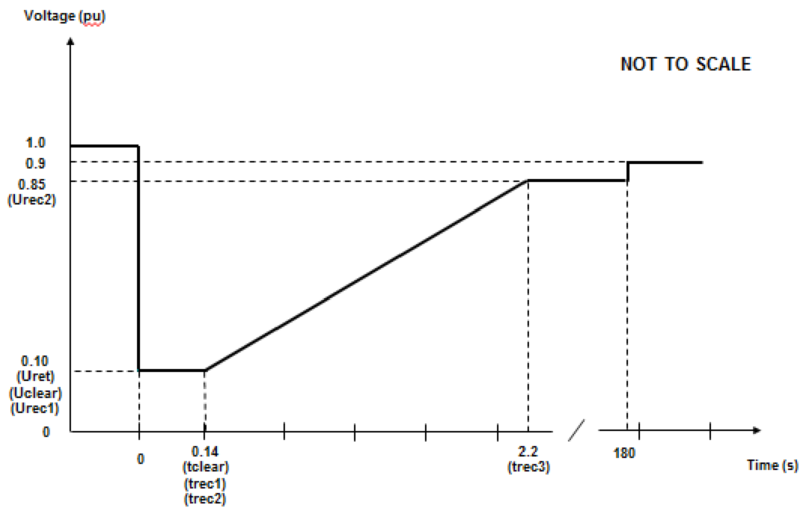
12.3.1.3 Figure 12.3 - Voltage against time curve applicable to Type B **Synchronous Power Generating Modules**




12.3.1.4 Table 12.1 Voltage against time parameters applicable to Type B **Synchronous Power Generating Modules**

| Voltage parameters (pu) | | Time parameters (seconds) | |
|---|---|---|---|
| $U_{ret}$ | 0.3 | $t_{clear}$ | 0.14 |
| $U_{clear}$ | 0.7 | $t_{rec1}$ | 0.14 |
| $U_{rec1}$ | 0.7 | $t_{rec2}$ | 0.45 |
| $U_{rec2}$ | 0.9 | $t_{rec3}$ | 1.5 |

12.3.1.5 Figure 12.4 - Voltage against time curve applicable to **Type B Power Park Modules**




12.3.1.6 Table 12.2 Voltage against time parameters applicable to **Type B Power Park Modules**

| Voltage parameters (pu) | | Time parameters (seconds) | |
|---|---|---|---|
| $U_{ret}$ | 0.1 | $t_{clear}$ | 0.14 |
| $U_{clear}$ | 0.10 | $t_{rec1}$ | 0.14 |
| $U_{rec1}$ | 0.10 | $t_{rec2}$ | 0.14 |
| $U_{rec2}$ | 0.85 | $t_{rec3}$ | 2.2 |

12.3.1.7 In addition to the requirements in 12.3.1.2 to 12.3.1.6:

(i) Each **Type B Power Generating Module** shall be capable of satisfying the above requirements at the **Connection Point** when operating at **Registered Capacity** output and maximum leading **Power Factor**.

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

(iii) **The DNO** will publish fault level data under maximum and minimum demand conditions in the Long Term Development Statements. To allow a **Customer** to model the fault ride through performance of its **Power Generating Modules**, **the DNO** will provide generic fault level values derived from typical cases. Where necessary, on reasonable request the DNO will specify the pre-fault and post fault short circuit capacity (in MVA) at the **Connection Point** and will provide additional network data as may reasonably be required for the **Customer** to undertake such study work.

(iv) Each **Generator** shall satisfy the fault ride through requirements in paragraphs 12.3 unless the protection schemes and settings for internal electrical faults trips the **Power Generating Module** from the network. The protection schemes and settings should not jeopardise fault ride through performance as specified in paragraphs 12.3.

(v) Each **Type B Power Generating Module** shall be designed such within 0.5 seconds of restoration of the voltage at the **Connection Point** to 90% of nominal voltage or greater, **Active Power** output shall be restored to at least 90% of the level immediately before the fault. Once **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.

For **Type B Power Park Modules**, 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.

12.3.2 In addition to paragraphs 12.3.1.1 – 12.3.1.7 any **Power Generating Module** or **Power Generating Facility** connected to the **DNO's Distribution Network**, where it has been agreed between the **DNO** and the **Generator** that the **Power Generating Facility** will contribute to the **DNO's Distribution Network** security, may be required to withstand, without tripping, the effects of a close up three phase fault and the **Phase (Voltage) Unbalance** imposed during the clearance of a close-up phase-to-phase fault , in both cases cleared by the **DNO's** main protection. The **DNO** will advise the **Generator** in each case of the likely tripping time of the **DNO's** protection, and for phase-phase faults, the likely value of **Phase (Voltage) Unbalance** during the fault clearance time.

12.3.3 In the case of phase to phase faults on the **DNO**'s system that are cleared by system back-up protection which will be within the plant short time rating on the **DNO's Distribution Network** the **DNO**, on request during the connection process, will advise the **Generator** of the expected Phase Voltage Unbalance.

12.3.4 Paragraphs 12.3.4.1 to 12.3.4.3 inclusive set out the fault ride through requirements, principles and concepts applicable to **Type B Power Generating Modules** subject to faults in excess of 140ms in duration.

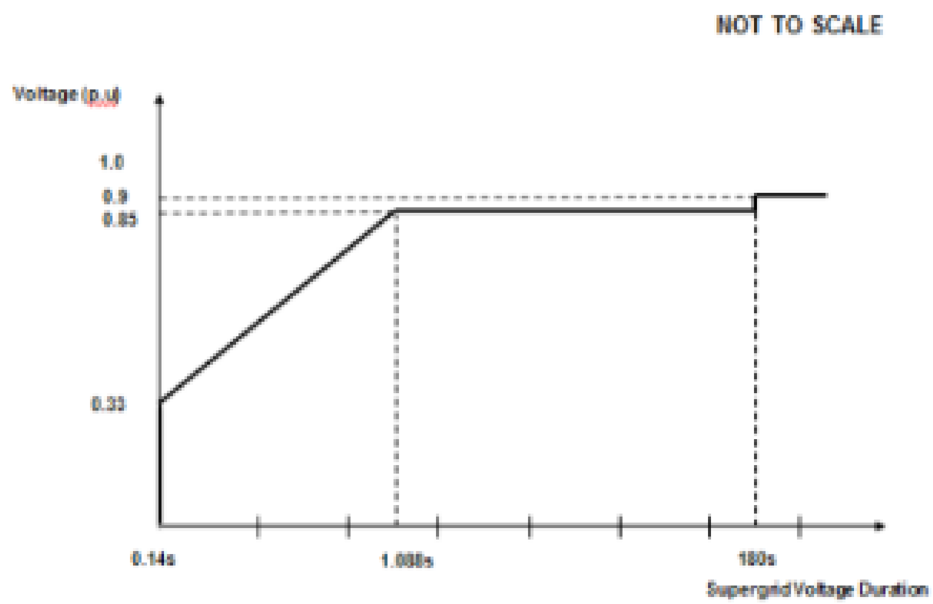
12.3.4.1 The Fault Ride Through requirements on **Type B Synchronous Power Generating Modules** and **Power Park Modules** for voltage dips on the **Network** greater than 140ms in duration are defined in this section.

12.3.4.2 Each **Synchronous Generating Module** shall:

(i) remain transiently stable and connected to the system without tripping for balanced voltage dips and associated durations on the **Network** anywhere on or above the heavy black line shown in Figure 12.5. and

Comment [CS10]: Diagram to be redrawn and further consistency checks made

Figure 12.5




(ii) provide **Active Power** output at the **Connection Point**, during voltage dips on the **Network** as described in Figure 12.5, at least in proportion to the retained balanced voltage at the **Connection Point** and shall generate maximum reactive current (where the voltage at the **Connection Point** is outside the limits specified in paragraph 12.4.1) without exceeding the transient rating limits of the **Synchronous Power Generating Module** and,

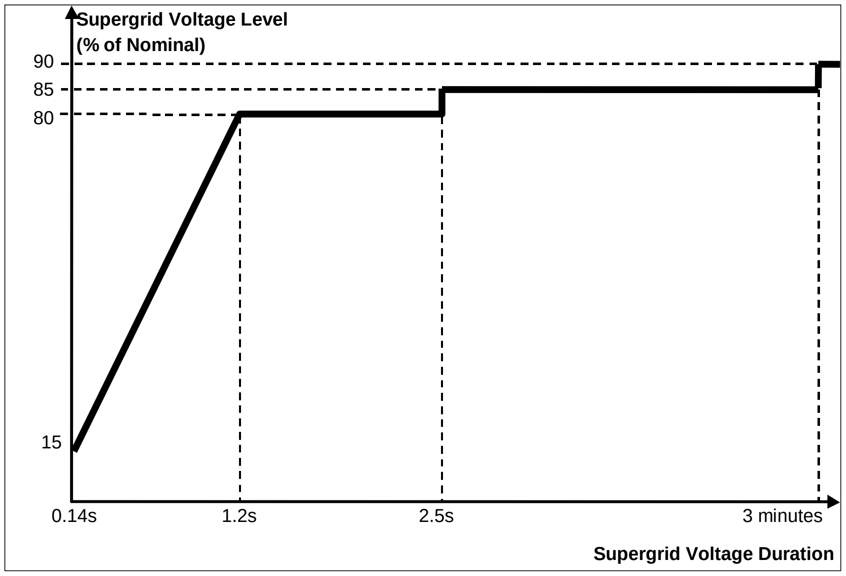
(iii) restore **Active Power** output following voltage dips on the **Network** as described in Figure 12.5, within 1 second of restoration of the voltage to 1.0pu of the nominal voltage at the **Connection Point** to at least 90% of the level available immediately before the occurrence of the dip. Once 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.

12.3.4.3 Each **Power Park Module** and / or any constituent **Generating Unit** shall:

(i) remain transiently stable and connected to the system without tripping for balanced voltage dips and associated durations on the **Network** anywhere on or above the heavy black line shown in Figure 12.6; and,

Figure 12.6




(ii) provide **Active Power** output at the **Connection Point** during voltage dips on the **Network** as described in Figure 12.6, at least in proportion to the retained balanced voltage at the at the **Connection Point** except in the case of a **Power Park Module** where there has been a reduction in the **Intermittent Power Source** in the time range in Figure 12.6 that restricts the **Active Power** output below this level.

(iii) restore **Active Power** output, following voltage dips on the **Network** as described in Figure 12.6, within 1 second of restoration of the voltage at the **Connection Point** to the minimum levels specified in paragraph 12.4.1 to at least 90% of the level available immediately before the occurrence of the dip except in the case of a **Power Park Module** where there has been a reduction in the **Intermittent Power Source** in the time range in Figure 12.6 that restricts the **Active Power** output below this level. 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.

### 12.3.5 Other Fault Ride Through Requirements

(i) In the case of a **Power Park Module**, the requirements in paragraph 12.3.4 do not apply when the **Power Park Module** is operating at less than 5% of its **Registered Capacity** or during very high primary energy source conditions when more than 50% of the **Generating Units** in a **Power Park Module** have been shut down or disconnected under an emergency shutdown sequence to protect **Customer's** plant and apparatus.

(ii) For the avoidance of doubt the requirements specified in this paragraph 12.4.5 do not apply to **Power Generating Modules** connected to an unhealthy circuit and islanded from the **Distribution Network** even for delayed auto reclosure times.

## 12.4 Voltage Limits and Control

12.4.1 Where **a Power Generating Module** is remote from a **Network** voltage control point it may be required to withstand voltages outside the normal statutory limits. In these circumstances, the **DNO** should agree with the **Generator** the declared voltage and voltage range at the **Connection Point**. Immunity of the **Power Generating Module** to voltage changes of ± 10% of the declared voltage is recommended, subject to design appraisal of individual installations.

12.4.2 The connection of a **Power Generating Module** to the **Distribution Network** shall be designed in such a way that operation of the **Power Generating Module** does not adversely affect the voltage profile of and voltage control employed on the **Distribution Network**. ETR 126 provides **DNO**s with guidance on active management solutions to overcome voltage control limitations. Information on the voltage regulation and control arrangements will be made available by the **DNO** if requested by the **Customer.**

12.4.3 **Excitation Performance Requirements**

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

12.4.3.2 The **DNO** will specify the control system of the **Type B Synchronous Power Generating Module** or **Power Park Module** such that it shall contribute to voltage control or **Reactive Power** control or **Power Factor** control at the **Connection Point** (or other defined busbar that is agreed with the **DNO**). The performance requirements of the control system including **Droop** (where applicable) shall be agreed between the **DNO** and the **Generator**.

12.4.4 The final responsibility for control of **Distribution Network** voltage does however remain with the **DNO**.

12.4.5 Automatic Voltage Control (AVC) schemes employed by the **DNO** assume that power flows from parts of the **Distribution Network** operating at a higher voltage to parts of the **Distribution Network** operating at lower voltages. Export from **Power Generating Modules** in excess of the local loads may result in power flows in the reverse direction. In this case AVC referenced to the low voltage side will not operate correctly without an import of reactive power and relay settings appropriate to this operating condition. When load current compounding is used with the AVC and the penetration level of **Power Generating Modules** becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.

12.4.6 **Power Generating Modules** can cause problems if connected to networks employing AVC schemes which use negative reactance compounding and line drop compensation due to changes in active and reactive power flows. ETR 126 provides guidance on connecting generation to such networks using techniques such as removing the generation circuit from the AVC scheme using cancellation CTs.

## 12.5 Reactive Capability for all Type B Power Generating Modules

12.5.1 When supplying **Registered Capacity** all **Type B 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 **Connection Point** unless otherwise agreed with the **DNO.**

12.5.2 At **Active Power** output levels other than **Registered Capacity**, all **Generating Units** within a **Type B Synchronous Power Generating Modules** or **Power Park Modules** 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 the **DNO**.

## 12.6 Fast Fault Current Injection

12.6.1 Each **Type B Power Park Module** shall be required to satisfy the following requirements:

(i) For any balanced or unbalanced fault which results in the voltage on one or more phases falling to zero at the **Connection Point** each **Power Park Module** shall be required to inject a reactive current above the shaded red area shown in Figure 12.7 (a) and Figure 12.7 (b).

Figure 12.7 (a)

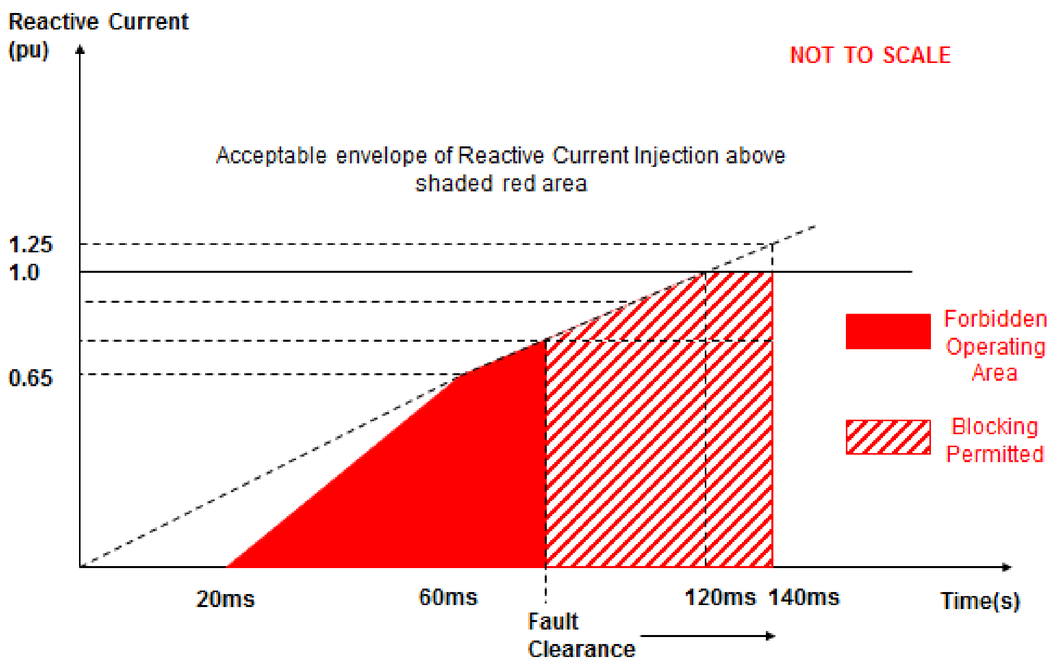
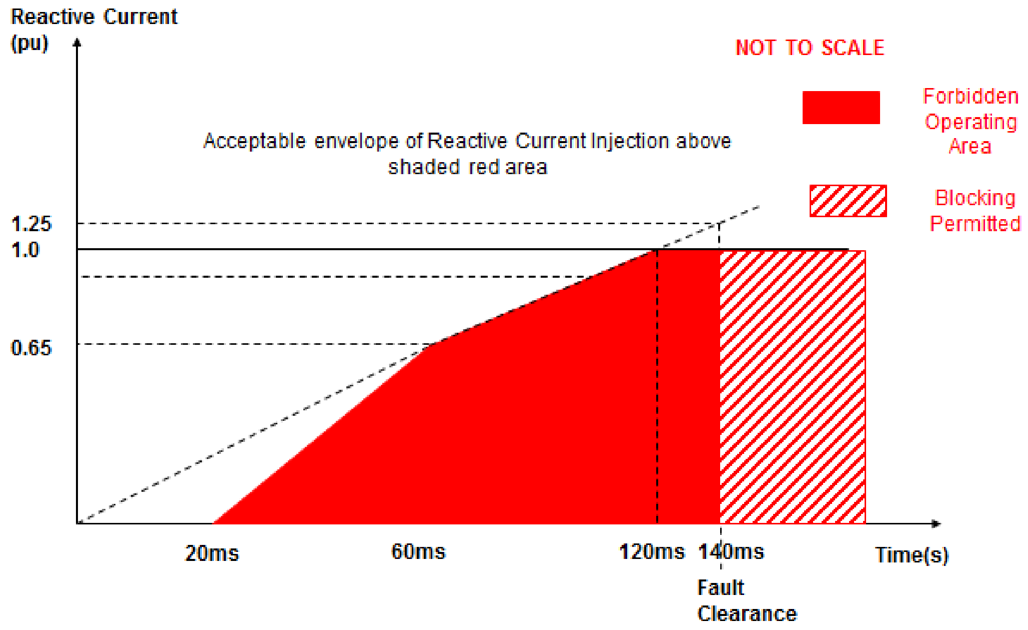



Figure 12.7 (b)




(ii) The **Inverter** 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 12.7 (a) and Figure 12.7 (b) show the impact of variations in fault clearance time which shall be no greater than 140ms. Where the **Customer** is able to demonstrate to the **DNO** that blocking is required in order to prevent the risk of transient over voltage excursions as specified in paragraph 9.3.3 **Generators** are required to both advise and agree with the **DNO** of the control strategy **,** which must also include the approach taken to de-blocking. Not withstanding this requirement, **Generators** should be aware of their requirement to fully satisfy the requirements of paragraph 12.3 (fault ride through).

(iii) In addition, the reactive current injected from each **Power Park Module** shall be injected in proportion and remain in phase to the change in system voltage at the **Connection 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**.

(iv) Each **Type B Power Park Module** shall be designed to reduce the risk of transient over voltage levels arising following clearance of the fault. **Generators** shall be permitted to block where the anticipated transient overvoltage would not otherwise exceed the maximum permitted values specified in paragraph 12.4.1. Any additional requirements relating to transient overvoltage performance will be specified by the **DNO**.

(v) In addition to the requirements of paragraph 12.6 **Generators** in respect of **Type B Power Park Modules** are required to confirm to the **DNO,** their repeated ability to supply **Fast Fault Current** to the system each time the voltage at the **Connection Point** falls outside the limits specified in paragraph 12.4.1. **Generators** should inform **the DNO** 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.

## 12.7 Operational monitoring

12.7.1 With regard to information exchange:

(i) **Power Generating Facilities** shall be capable of exchanging information with the **DNO** in real time or periodically with time stamping;

(ii) the **DNO**, in coordination with the **NETSO**, shall specify the content of information exchanges including a precise list of data to be provided by the **Power Generating Facility**.

12.7.2 At each **Power Generating Facility including Type B Power Generating Modules** the **DNO** will install their own Telecontrol/SCADA outstation which will generally meet all the **DNO's** necessary and legal operational data requirements. The **DNO** will inform the **Generator** if additional specific data are required.

## 13 Type C and D Power Generating Module Technical Requirements

### 13.1 Power Generating Module Performance and Control Requirements

13.1.1 The requirements of this section do not apply in full to **Power Generation Facilities** that include storage and/or that are designed and installed for infrequent short term parallel operation only – refer to Appendix A5

13.1.2 For **Power Generating Modules,** which do not constitute or contain **BM Units** that are active (ie submitting bid-offer data) in the **Balancing Mechanism**, the electrical parameters required to be achieved at the **Connection Point** are defined according to the connection method and will be specified by the **DNO** with the offer for connection.

13.1.3 The **Active Power** output of a **Power Generating Module** should not be affected by voltage changes within the statutory limits declared by the **DNO** in accordance with the **ESQCR**.

13.1.4 **Type C** and **Type D Power Generating Modules** shall be capable of adjusting the **Active Power** setpoint in accordance with instructions issued by the **DNO.**

13.1.5 Each item of a **Power Generating Module** and its associated control equipment must be designed for stable operation in parallel with the **Distribution Network**.

13.1.6 The **Generator** will notify, and keep notified, the **DNO** of the set points of the control scheme for voltage control or **Power Factor** control, or Reactive Power control as appropriate and which have previously been agreed between the **Generator** and **DNO**. The information to be provided is detailed in Schedule 5a and Schedule 5b of the Data Registration Code.

13.1.7 Load flow and **System Stability** studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The **Connection Agreement** should include details of the relevant outage conditions. It may be necessary under these fault conditions, where the combination of **Power Generating Module** output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the **Power Generating Module** .

### 13.2 Frequency response

13.2.1 Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47Hz. In exceptional circumstances, the frequency of the **DNO's Distribution Network** could rise above 50.5 Hz. Therefore all **Power Generating Modules** should be capable of continuing to operate in parallel with the **Distribution Network** in accordance with the following:

k. 47 Hz – 47.5 Hz Operation for a period of at least 20 seconds is required each time the frequency is within this range.

l. 47.5 Hz – 49.0 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.

m. 49.0Hz – 51.0 Hz Continuous operation of the **Power Generating Module** is required.

n. 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.

o. 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range.

13.2.2 As stated in 13.1.1, the system frequency could rise to 52Hz or fall to 47Hz. Each **Power Generating Module** must continue to operate within this frequency range for at least the periods of time given in 13.2.1.

13.2.3 With regard to the rate of change of frequency withstand capability, a **Power Generating Module** shall be capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1 $Hzs^{-1}$ as measured over a period of 500ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection.

### 13.2.3 Output power with falling frequency

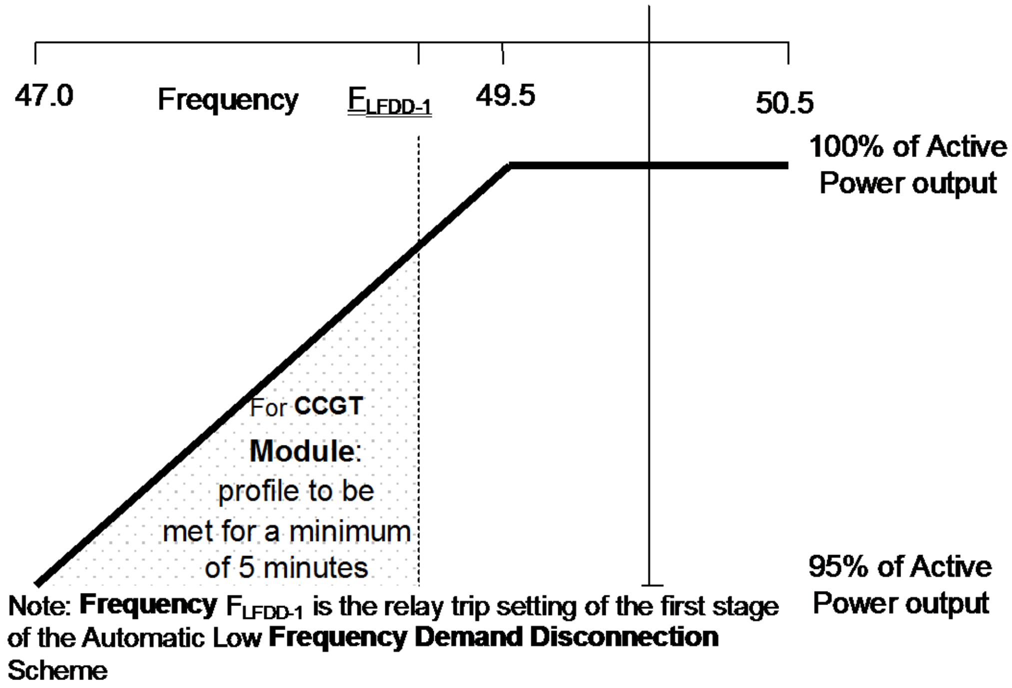
13.2.3.1 Each **Power Generating Module**, must be capable of:

(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 paragraph 13.2.1) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 13.1 for system frequency changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including 25$^{0}$C, such that if the system frequency drops to 47 Hz the **Active Power** output does not decrease by more than 5%. Where the need for special measures is identified in order to maintain output in line with the level identified in Figure 13.1 these measures should be still continued at ambient temperatures above 25$^{0}$C maintaining as much of the **Active Power** achievable within the capability of the plant.

Figure 13.1

**Comment [CS11]:** Diagram to be refreshed for final draft and CCGT text removed t




13.2.3.2 For the avoidance of doubt in the case of a **Power Generating Module** using an **Intermittent Power Source** where the 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.

### 13.2.4 Limited Frequency Sensitive Mode – Over frequency

13.2.4.1 Each Power Generating Module shall be capable of reducing Active Power output in response to system frequency when this rises above 50.4Hz.. The Power Generating Module shall be capable of operating stably during LFSM-O operation. However for a Power Generating Module, operating in Frequency Sensitive Mode the requirements of LFSM-O shall apply when frequency exceeds 50.5Hz.

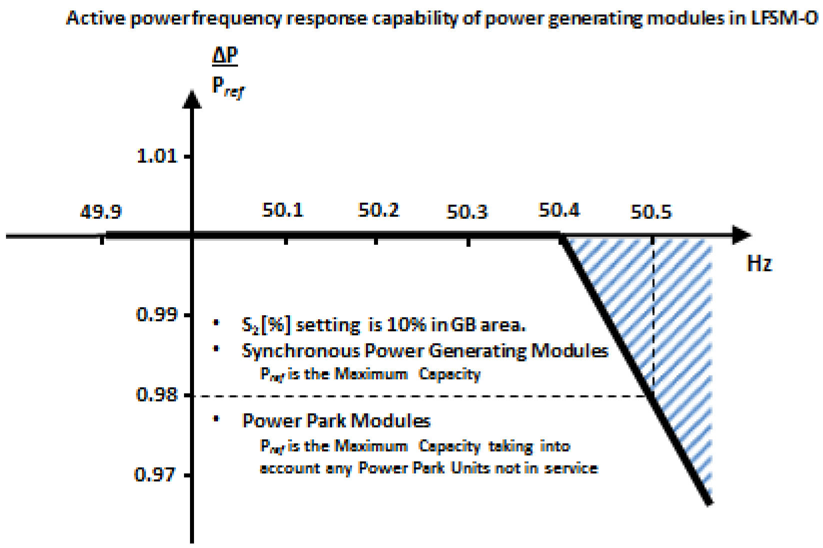
(i) The rate of change of **Active Power** output must be at a minimum a rate of 2 percent of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a Droop of 10%) as shown in Figure 13.2. For the avoidance of doubt, this would not preclude a **Generator** from designing their **Power Generating Module** with a lower **Droop** setting, for example between 3 – 5%.

(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** 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 shall justify the delay, providing technical evidence to the **DNO**, who will pass this evidence to the **NETSO**.

(iv) The residue of the proportional reduction in **Active Power** output which results from automatic action of the **Power Generating Module** 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 50.4 Hz.

Figure 13.2




$P_{ref}$ is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module**. $F_n$ is the nominal frequency (50Hz) in the network and Δf is the frequency deviation in the network, At overfrequencies where Δf is below $\Delta f_1$ the **Power Generating Module** has to provide a negative **Active Power** output change according to **Droop** $S_2$

13.2.4.2 Each **Power Generating Module** which is providing **Limited Frequency Sensitive Mode Over frequency (LFSM-O)** must continue to provide it until the frequency has returned to or below 50.4Hz.

### 13.2.5 Limited Frequency Sensitive Mode – Under frequency

13.2.5.1 Each **Type C** and **Type D** **Power Generating Module** shall be capable of increasing **Active Power** output in response to system frequency when this falls below 49.5Hz. it is not anticipated **Power Generating Modules** 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** shall be capable of stable operation during **LFSM-U Mode**.

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 13.3 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** the requirements of Figure 13.3 shall be reduced pro-rata to the amount of **Generating Units** in service and available to generate. For the avoidance of doubt, this would not preclude a **Generator** 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** shall be capable of initiating a power frequency response with minimal delay. If the delay exceeds 2 seconds the **Generator** shall justify the delay, providing technical evidence to the **DNO**.

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

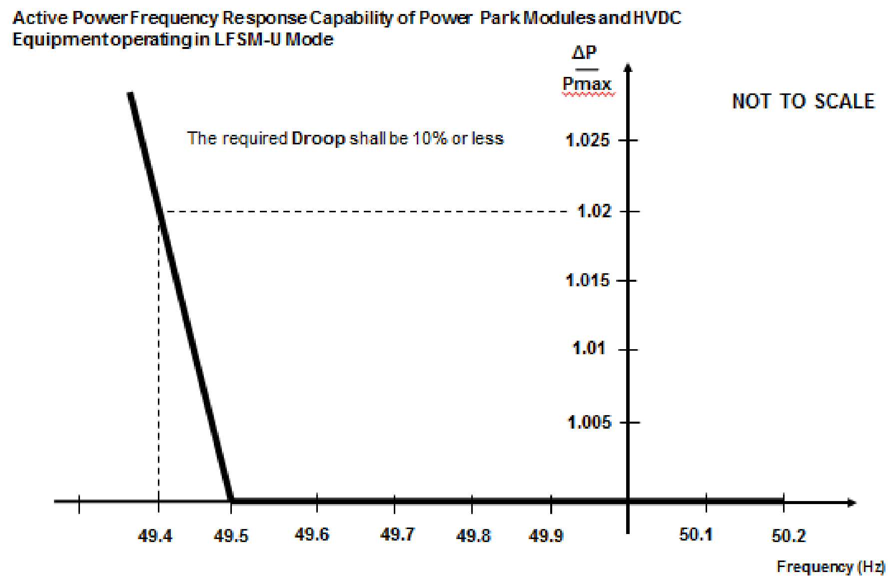
- The ambient conditions when the response is to be triggered

- The operating conditions of the **Power Generating Module**. In particular limitations on operation near **Registered Capacity** at low frequencies.

- The availability of primary energy sources.

(iv) In **LFSM-U Mode** the **Power Generating Module** shall be capable of providing a power increase up to its **Registered Capacity**.

Figure 13.3 - Limited Frequency Sensitive Mode – Underfrequency capability of Power Generating Modules




13.2.6 **Frequency Sensitive Mode – (FSM)**

13.2.6.1 Each **Type C** and **Type D Power Generating Module** 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 the case of a **Power Park Module** the frequency or speed control device(s) may be on the **Power Park Module** or on each individual **Generating Unit** 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.

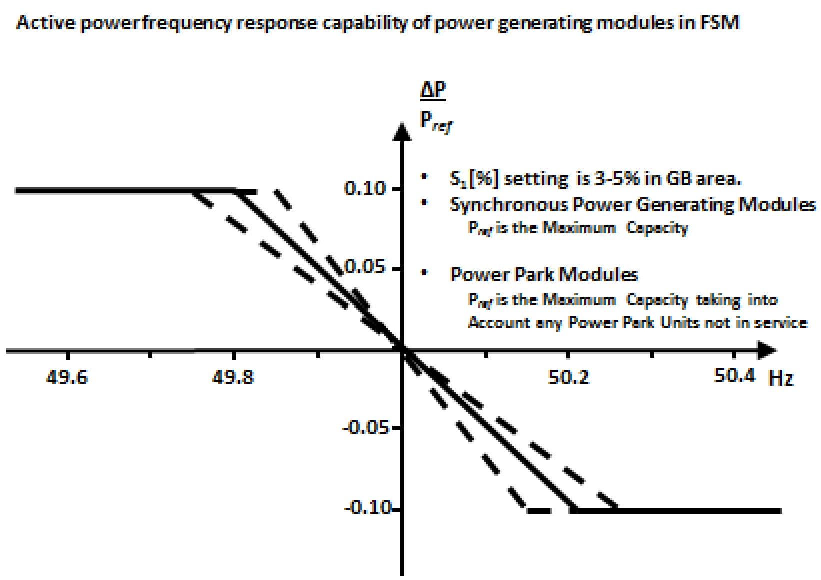
The **European Specification** or other standard utilised in accordance with sub paragraph 13.2.6.1 (ii) will be notified to the **DNO** by the **Generator**:as soon as possible prior to any modification or alteration to the frequency control device (or governor);

13.2.6.2 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 Active Power** output with stability over the entire operating range of the **Power Generating Module**; and

13.2.6.3 **Type C** and **Type D Power Generating Modules** shall also meet the following minimum requirements:

(i) **Power Generating Modules** shall be capable of providing **Active Power** frequency response in accordance with the performance characteristic shown in Figure 13.4 and parameters in Table 13.1.

Figure 13.4 – **Frequency Sensitive Mode** capability of **Power Generating Modules** and **DC Connected Power Park Modules**




**Active Power** Table 13.1 – Parameters for Active Power Frequency response in **Frequency Sensitivity Mode** including the mathematical expressions in Figure 13.4.

| Parameter | Setting |
|---|---|
| Nominal system frequency | 50Hz |
| Active power as a percentage of **Registered 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 ($\frac{\|\Delta f_i\|}{f_n}$) | ±0.03% |
| **Frequency Response Deadband** in mHz | 0 (mHz) |
| Droop $s_1$ (%) | 3 – 5% |

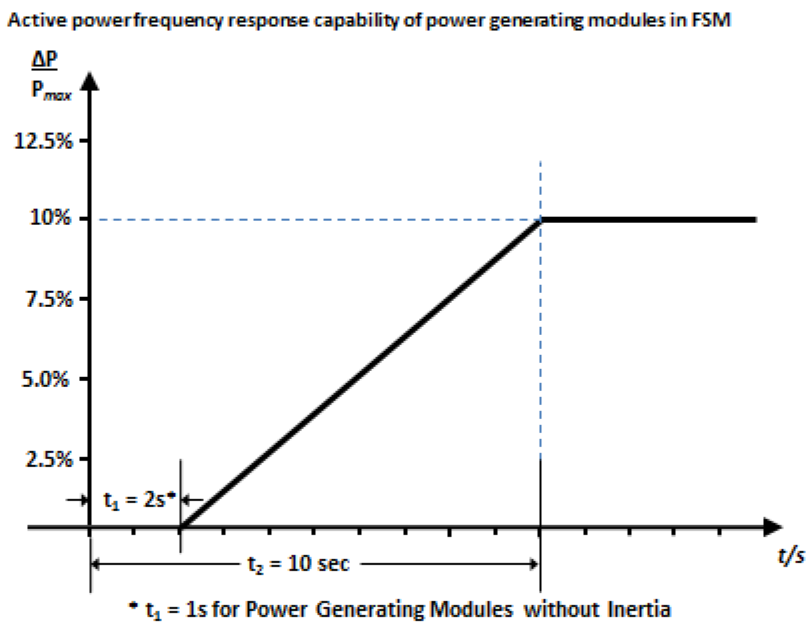
(ii) In satisfying the performance requirements specified in paragraph 13.2.6.1 **Generators** in respect of each **Type C** and **Type D Power Generating Module** should be aware:-

- in the case of overfrequency, the **Active Power** frequency response is limited by the **Minimum Generation**,

- in the case of underfrequency, the **Active Power** frequency response is limited by the **Registered Capacity,**
- the actual delivery of **Active Power** frequency response depends on the operating and ambient conditions of the **Power Generating Module** when this response is triggered, in particular limitations on operation near **Registered Capacity** at low frequencies as specified in 13.2.5 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** the speed **Droop** should be equivalent of a fixed setting between 3% and 5% applied to each **Generating Unit** in service.

(iii) In the event of a frequency step change, each **Type C** and **Type D** **Power Generating 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 13.5 and parameters in Table 13.2.

Figure 13.5 **Active Power** frequency response capability




$P_{max}$ is the **Registered Capacity** to which Δ*P* relates. ΔP is the change in **Active Power** output from the **Power Generating Module**. The **Power Generating Module** has to provide **Active Power** output ΔP up to the point $\Delta P_1$ in accordance with the times $t_1$ and $t_2$ with the values of $\Delta P_1$, $t_1$and $t_2$ being specified in Table 13.2. $t_1$ is the initial delay. $t_2$ is the time for full activation.

Table 13.2 – Parameters for full activation of **Active Power** frequency response resulting from a frequency step change.

| Parameter | Setting |
|---|---|
| Active power as a percentage of **Registered Capacity (**frequency response range**)** $\left(\frac{\lvert\Delta P_1\rvert}{P_{max}}\right)$ | 10% |
| Maximum admissible initial delay $t_1$ for **Power Generating Modules** with inertia unless justified as specified in 9.4.6.3 (iv) | 2 seconds |
| Maximum admissible initial delay t1 for **Power Generating Modules** which do not contribute to system inertia unless justified as specified in 9.4.6.3 (iv) | 1 second |
| Activation time $t_2$ | 10 seconds |

Table 13.2 also includes the mathematical expressions used in Figure 13.5.

(iv) The initial activation of **Active Power** primary frequency response shall not be unduly delayed. For **Type C** and **Type D Power Generating 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** 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 the **DNO** demonstrating why a longer time is needed for the initial activation of **Active Power** frequency response.

(v) with regard to disconnection due to underfrequency, **Generators** responsible for **Type C** and **Type D Power Generating Modules** capable of acting as a load, including but not limited to Pumped Storage **Power Generating Modules**, shall be capable of disconnecting their load in case of underfrequency which will be agreed with the **DNO**. For the avoidance of doubt this requirement does not apply to station auxiliary supplies.

## 13.3 Not Used

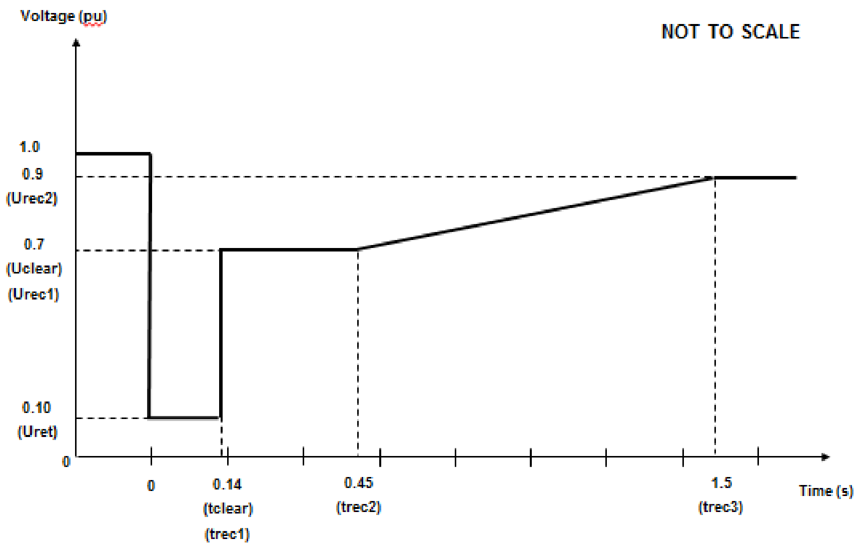
## 13.4 Fault Ride Through

13.4.1 Paragraphs 13.4.1.1 to 13.4.1.10 inclusive set out the fault ride through, principles and concepts applicable to **Type C and Type D Synchronous Power Generating Modules** and **Power Park Modules**, subject to disturbances from faults on the **Network** up to 140ms in duration.

13.4.1.1 Each **Synchronous Power Generating Module** and **Power Park Module** is required to remain connected and stable for any balanced and unbalanced fault where the voltage at the **Connection Point** remains on or above the heavy black line shown in Figures 13.6 to 13.9 below.

13.4.1.2 The voltage against time curves defined in Table 13.3 to Table 13.6 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 voltages (or phase to earth voltage in the case of asymmetrical/unbalanced faults) on the network voltage level at **Connection Point** during a symmetrical or asymmetrical/unbalanced fault, as a function of time before, during and after the fault.

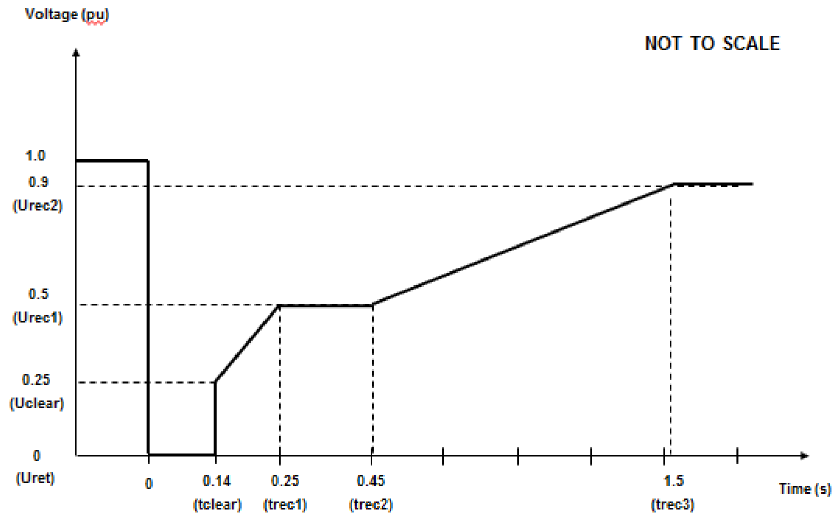
13.4.1.3 Figure 13.6 Voltage against time curve applicable to **Type C** and **Type D** **Synchronous Power Generating Modules** connected below 110kV




13.4.1.4 Table 13.3 Voltage against time parameters applicable to **Type C** and **D** **Synchronous Power Generating Modules** connected below 110kV

| **Voltage parameters (pu)** | | **Time parameters (seconds)** | |
|---|---|---|---|
| $U_{ret}$ | 0.1 | $t_{clear}$ | 0.14 |
| $U_{clear}$ | 0.7 | $t_{rec1}$ | 0.14 |
| $U_{rec1}$ | 0.7 | $t_{rec2}$ | 0.45 |
| $U_{rec2}$ | 0.9 | $t_{rec3}$ | 1.5 |

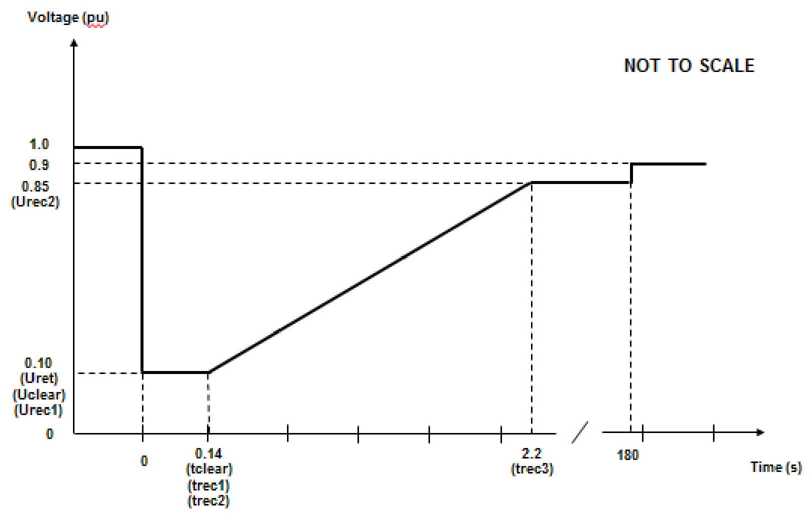
13.4.1.5 Figure 13.7 - Voltage against time curve applicable to **Type D** **Synchronous Power Generating Modules** connected at or above 110kV




13.4.1.6 Table 13.4 Voltage against time parameters applicable to **Type D Synchronous Power Generating Modules** connected at or above 110kV

| Voltage parameters (pu) | | Time parameters (seconds) | |
|---|---|---|---|
| $U_{ret}$ | 0 | $t_{clear}$ | 0.14 |
| $U_{clear}$ | 0.25 | $t_{rec1}$ | 0.25 |
| $U_{rec1}$ | 0.5 | $t_{rec2}$ | 0.45 |
| $U_{rec2}$ | 0.9 | $t_{rec3}$ | 1.5 |

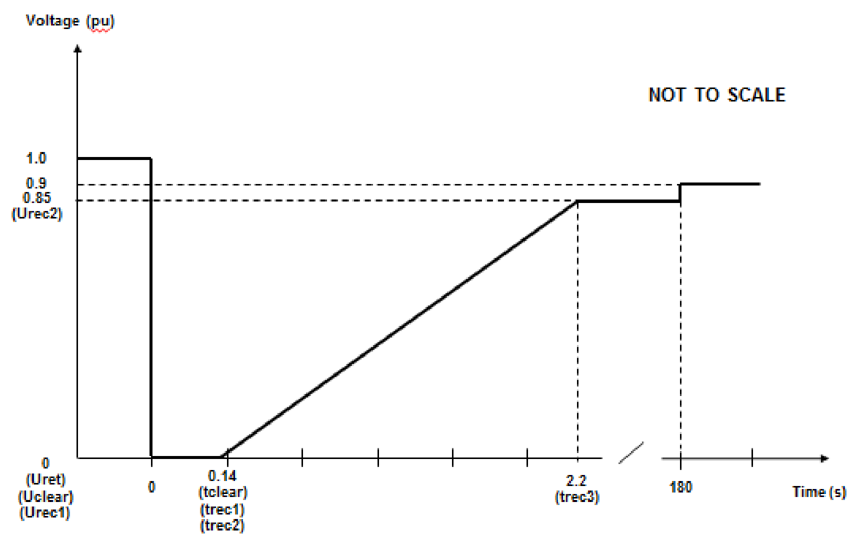
13.4.1.7 Figure 13.8 - Voltage against time curve applicable to **Type C** and **Type D Power Park Modules** connected below 110kV



13.4.1.8 Table 13.5 Voltage against time parameters applicable to **Type C** and **Type D Power Park Modules** connected below 110kV

| Voltage parameters (pu) | | Time parameters (seconds) | |
|---|---|---|---|
| $U_{ret}$ | 0.1 | $t_{clear}$ | 0.14 |
| $U_{clear}$ | 0.10 | $t_{rec1}$ | 0.14 |
| $U_{rec1}$ | 0.10 | $t_{rec2}$ | 0.14 |
| $U_{rec2}$ | 0.85 | $t_{rec3}$ | 2.2 |

13.4.1.9 Figure 13.9 - Voltage against time curve applicable to **Type D Power Park Modules** connected at or above 110kV




13.4.1.10 Table 13.6 Voltage against time parameters applicable to **Type D Power Park Modules** connected at or above 110kV

| Voltage parameters (pu) | | Time parameters (seconds) | |
|---|---|---|---|
| $U_{ret}$ | 0 | $t_{clear}$ | 0.14 |
| $U_{clear}$ | 0 | $t_{rec1}$ | 0.14 |
| $U_{rec1}$ | 0 | $t_{rec2}$ | 0.14 |
| $U_{rec2}$ | 0.85 | $t_{rec3}$ | 2.2 |

13.4.1.11 In addition to the requirements in 13.4.1.3 to 13.4.1.10:

(i) Each **Type C and Type D Power Generating Module** shall be capable of satisfying the above requirements at the **Connection Point** when operating at **Registered Capacity** output and maximum leading **Power Factor**.

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

(iii) **The DNO** will publish fault level data under maximum and minimum demand conditions in the Long Term Development Statements. To allow a **Customer** to model the fault ride through performance of its **Type C** or **Type D Power Generating Modules**, **the DNO** will provide generic fault level values derived from typical cases. Where necessary, on reasonable request the **DNO** will specify the pre-fault and post fault short circuit capacity (in MVA) at the **Connection Point** and will provide additional network data as may reasonably be required for the **Customer** to undertake such study work.

(iv) Each **Generator** shall satisfy the fault ride through requirements in paragraphs 13.4 unless the protection schemes and settings for internal electrical faults trips the **Power Generating Module** from the network. The protection schemes and settings should not jeopardise fault ride through performance as specified in paragraphs 13.4.

(v) Each **Type C** or **Type D Power Generating Module** shall be designed such within 0.5 seconds of restoration of the voltage at the **Connection Point** to 90% of nominal voltage or greater, **Active Power** output shall be restored to at least 90% of the level immediately before the fault. Once **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.

For **Type C** or **Type D Power Park Modules**, 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.

13.4.2 In addition to paragraphs 13.4.1.1 – 13.4.1.11 any **Power Generating Module** or **Power Generating Facility** connected to the **DNO's Distribution Network**, where it has been agreed between the **DNO** and the **Generator** that the **Power Generating Facility** will contribute to the **DNO's Distribution Network** security, may be required to withstand, without tripping, the effects of a close up three phase fault and the **Phase (Voltage) Unbalance** imposed during the clearance of a close-up phase-to-phase fault , in both cases cleared by the **DNO's** main protection. The **DNO** will advise the **Generator** in each case of the likely tripping time of the **DNO's** protection, and for phase-phase faults, the likely value of **Phase (Voltage) Unbalance** during the fault clearance time.

13.4.3 In the case of phase to phase faults on the **DNO**'s system that are cleared by system back-up protection which will be within the plant short time rating on the **DNO's Distribution Network** the **DNO**, on request during the connection process, will advise the **Generator** of the expected Phase Voltage Unbalance.

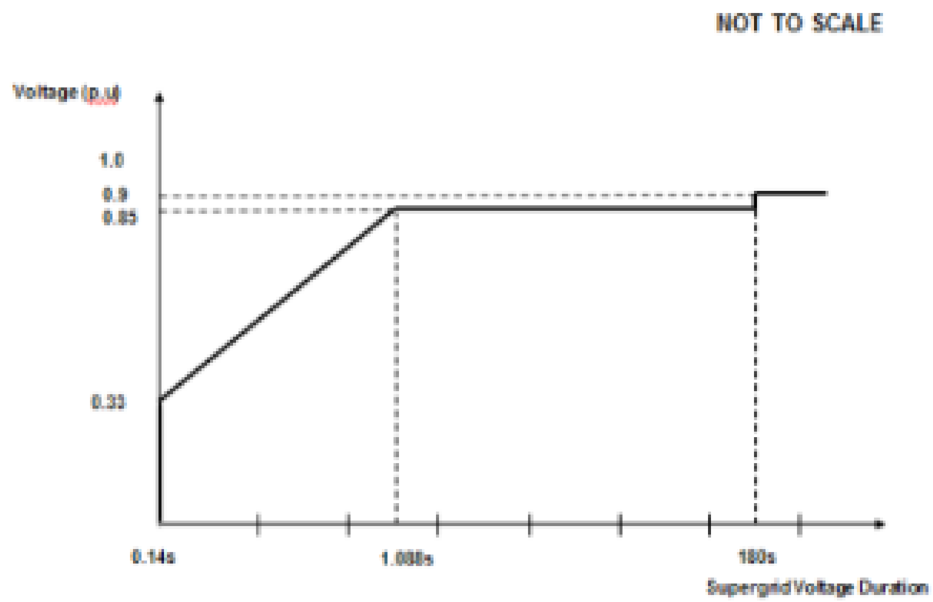
13.4.4 Paragraphs 13.4.4.1 to 13.4.4.3 inclusive set out the fault ride through requirements, principles and concepts applicable to **Type C** and **Type D Power Generating Modules** subject to faults in excess of 140ms in duration.

13.4.4.1 The Fault Ride Through requirements on **Type C** and **Type D Synchronous Power Generating Modules** and **Power Park Modules** for voltage dips on the **Network** greater than 140ms in duration are defined in this section.

13.4.4.2 Each **Synchronous Generating Module** shall:

(i) remain transiently stable and connected to the system without tripping for balanced voltage dips and associated durations on the **Network** anywhere on or above the heavy black line shown in Figure 13.10; and,

Figure 13.10




(iii) provide **Active Power** output at the **Connection Point**, during voltage dips on the **Network** as described in Figure 13.10, at least in proportion to the retained balanced voltage at the **Connection Point** and shall generate maximum reactive current (where the voltage at the **Connection Point** is outside the limits specified in paragraph 12.4.1) without exceeding the transient rating limits of the **Synchronous Power Generating Module** and,

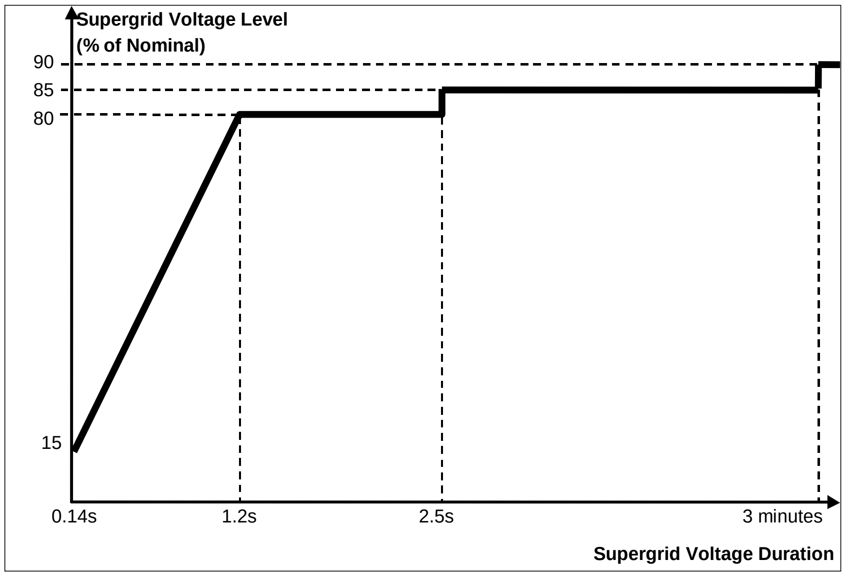
(iii) restore **Active Power** output following voltage dips on the **Network** as described in Figure 13.10, within 1 second of restoration of the voltage to 1.0pu of the nominal voltage at the **Connection Point** to at least 90% of the level available immediately before the occurrence of the dip. 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.

13.4.4.3 Each **Power Park Module** and / or any constituent **Generating Unit** shall:

(i) remain transiently stable and connected to the system without tripping for balanced voltage dips and associated durations on the **Network** anywhere on or above the heavy black line shown in Figure 13.11.; and,

Figure 13.11




(ii) provide **Active Power** output at the **Connection Point** during voltage dips on the **Network** as described in Figure 13.11, at least in proportion to the retained balanced voltage at the at the **Connection Point** except in the case of a **Power Park Module** where there has been a reduction in the **Intermittent Power Source** in the time range in Figure 13.11 that restricts the **Active Power** output below this level.

(iii) restore **Active Power** output, following voltage dips on the **Network** as described in Figure 13.11, within 1 second of restoration of the voltage at the **Connection Point** to the minimum levels specified in paragraph 12.4.1 to at least 90% of the level available immediately before the occurrence of the dip except in the case of a **Power Park Module** where there has been a reduction in the **Intermittent Power Source** in the time range in Figure 13.11 that restricts the **Active Power** output below this level. 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.

### 13.4.5 Other Fault Ride Through Requirements

(i) In the case of a **Power Park Module**, the requirements in paragraph 13.4 do not apply when the **Power Park Module** is operating at less than 5% of its **Registered Capacity** or during very high primary energy source conditions when more than 50% of the **Generating Units** in a **Power Park Module** have been shut down or disconnected under an emergency shutdown sequence to protect **Customer's** plant and apparatus.

(ii) Each **Power Park Module** and any constituent **Generating 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) For the avoidance of doubt the requirements specified in this paragraph 13.4 do not apply to **Power Generating Modules** connected to an unhealthy circuit and islanded from the **Distribution Network** even for delayed auto reclosure times.

## 13.5 Voltage Limits and Control

13.5.1 Where **a Power Generating Module** is remote from a **Network** voltage control point it may be required to withstand voltages outside the normal statutory limits. In these circumstances, the **DNO** should agree with the **Generator** the declared voltage and voltage range at the **Connection Point**. Immunity of the **Power Generating Module** to voltage changes of ± 10% of the declared voltage is recommended, subject to design appraisal of individual installations.

13.5.2 The connection of a **Power Generating Module** to the **Distribution Network** shall be designed in such a way that operation of the **Power Generating Module** does not adversely affect the voltage profile of and voltage control employed on the **Distribution Network**. ETR 126 provides **DNO**s with guidance on active management solutions to overcome voltage control limitations. Information on the voltage regulation and control arrangements will be made available by the **DNO** if requested by the **Customer.**

### 13.5.3 Excitation Performance Requirements

13.5.3.1 Each **Synchronous Generating Unit** within a **Type C or Type D Synchronous Power Generating Module** shall be equipped with a permanent automatic excitation system that has the capability to provide constant terminal voltage at a selectable setpoint without instability over the entire operating range of the **Synchronous Power Generating Module**.

13.5.4 Voltage Control Performance Requirements for **Type C** and **Type D Power Park Modules**

13.5.4.1 Each **Type C** and **Type D Power Park Module** shall be fitted with a continuously acting automatic control system to provide control of the voltage at the **Connection Point** without instability over the entire operating range of the **Power Park Module**. Any plant or apparatus used to provide such voltage control within a **Power Park Module** may be located at the **Generating Unit** terminals, an appropriate intermediate busbar or the **Connection Point**. When operating below 20% **Registered 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 Figure 9.15.

13.5.4.2 The requirements for excitation control facilities are specified in Appendix C.2. Any site specific requirements shall be specified by the **DNO**

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

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

13.5.4.4 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 the **DNO**.

13.5.4.5 The performance requirements for a continuously acting automatic voltage control system that shall be complied with by the **Generator** in respect of **Power Park Modules** are defined in Appendix C.2.

13.5.4.5 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 the **DNO**.

13.5.5 The final responsibility for control of **Distribution Network** voltage does however remain with the **DNO**.

13.5.6 Automatic Voltage Control (AVC) schemes employed by the **DNO** assume that power flows from parts of the **Distribution Network** operating at a higher voltage to parts of the **Distribution Network** operating at lower voltages. Export from **Power Generating Modules** in excess of the local loads may result in power flows in the reverse direction. In this case AVC referenced to the low voltage side will not operate correctly without an import of reactive power and relay settings appropriate to this operating condition. When load current compounding is used with the AVC and the penetration level of **Power Generating Modules** becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.

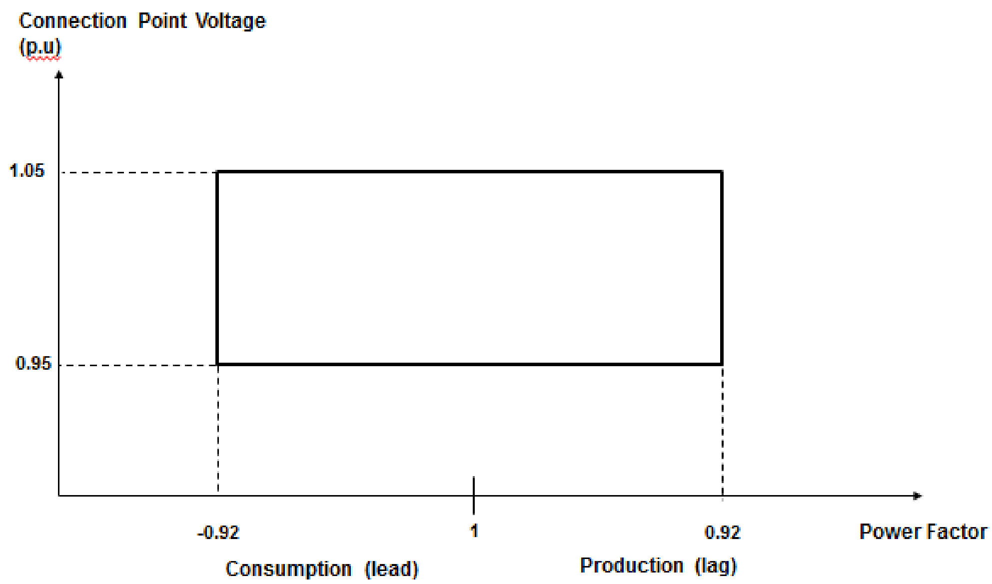
13.5.7 **Power Generating Modules** can cause problems if connected to networks employing AVC schemes which use negative reactance compounding and line drop compensation due to changes in active and reactive power flows. ETR 136 provides guidance on connecting generation to such networks using techniques such as removing the generation circuit from the AVC scheme using cancellation CTs.

## 13.6 Reactive Capability for Type C and D Power Generating Modules

13.6.1 All **Type C** and **Type D Synchronous Power Generating Modules** shall be capable of satisfying the **Reactive Power** capability requirements at the **Connection Point** as defined in Figure 13.12 when operating at **Registered Capacity**.

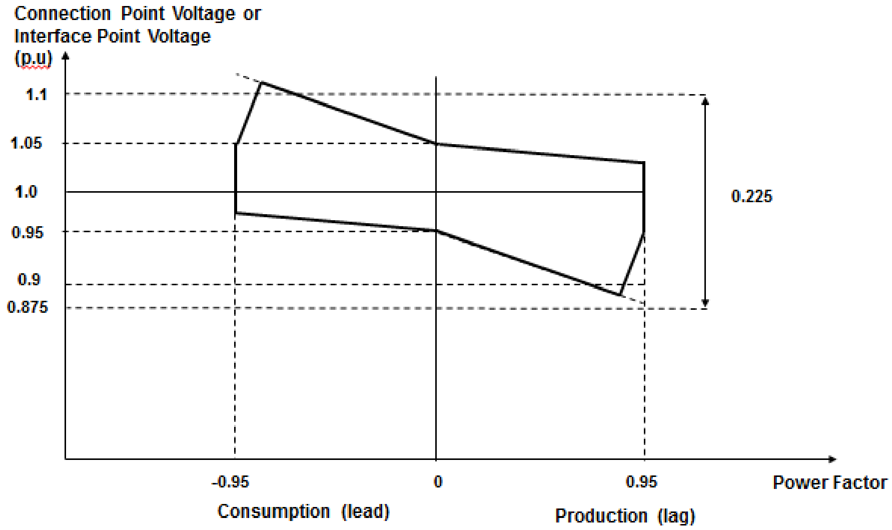
13.6.2 At **Active Power** output levels other than **Registered Capacity** all **Type C** and **Type D Generating Units** within a **Synchronous Power Generating Module** must be capable of continuous operation at any point between the Reactive Power capability limit identified on the **HV Generator Performance Chart** at least down to the **Minimum Generation**. At reduced **Active Power** output, **Reactive Power** supplied at the **Connection Point** 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 **Power Generating Module** transformer or **Station Transformer** into account.

Figure 13.12



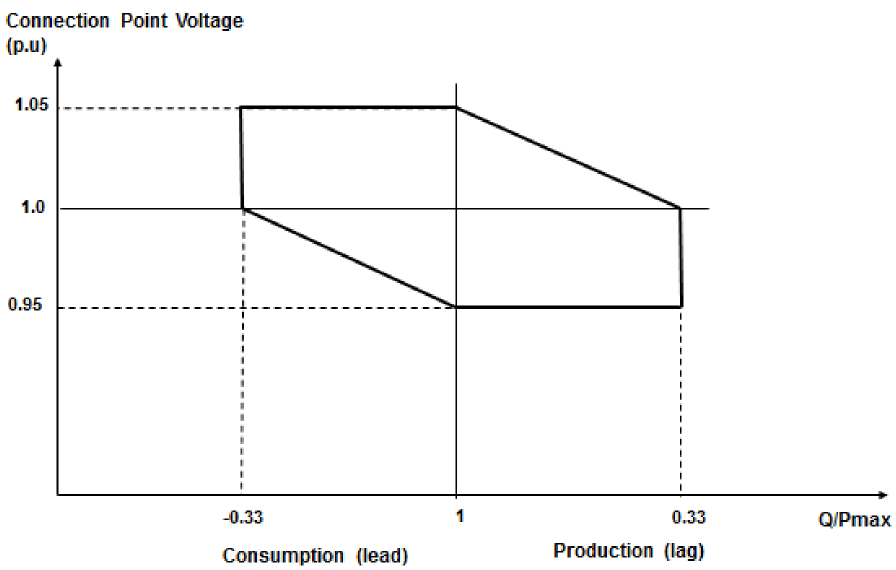

13.6.3 All **Type C** and **Type D Power Park Modules** with a **Connection Point** voltage above 33kV, shall be capable of satisfying the **Reactive Power** capability requirements at the **Connection Point** as defined in Figure 13.13 when operating at **Registered Capacity**.

Figure 13.13



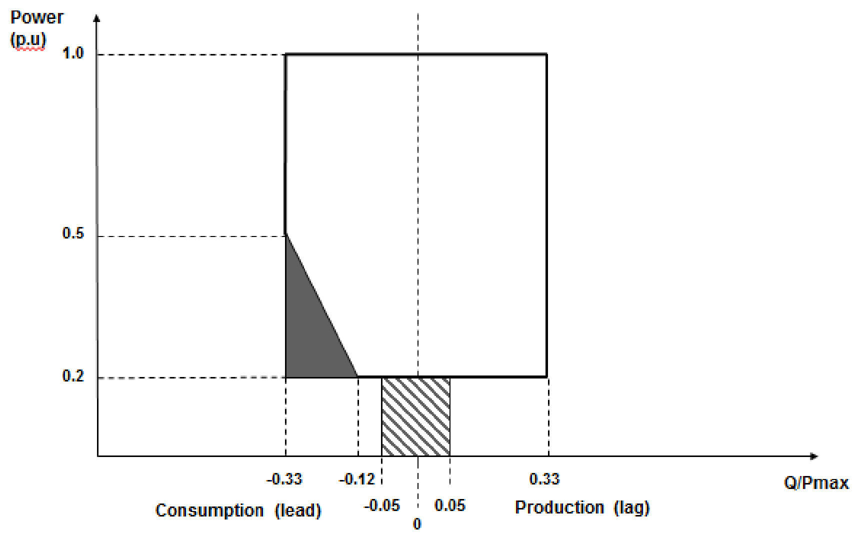

13.6.4 All **Type C or Type D Power Park Modules** with a **Connection Point** voltage at or below 33kV shall be capable of satisfying the **Reactive Power** capability requirements at the **Connection Point** as defined in Figure 13.14 when operating at **Registered Capacity**.

Figure 13.14



13.6.5 All **Type C** and **Type D Power Park Modules**, shall be capable of satisfying the **Reactive Power** capability requirements at the **Connection Point** as defined in Figure 13.15 when operating below **Registered Capacity**. With all plant in service, the **Reactive Power** limits will reduce linearly below 50% **Active Power** output as shown in Figure 13.15 unless the requirement to maintain the **Reactive Power** limits defined at **Registered Capacity** under absorbing **Reactive Power** conditions down to 20% **Active Power** output has been specified by the **DNO**. These **Reactive Power** limits will be reduced pro rata to the amount of plant in service.

Figure 13.15




## 13.7 Fast Fault Current Injection

13.7.1 Each **Type C** and **Type D Power Park Module** shall be required to satisfy the following requirements.

(i) For any balanced or unbalanced fault which results in the voltage on one or more phases falling to zero at the **Connection Point** each **Type C** and **Type D Power Park Module** shall be required to inject a reactive current above the shaded red area shown in Figure 13.16 (a) and Figure 13.16 (b).

Figure 13.16 (a)

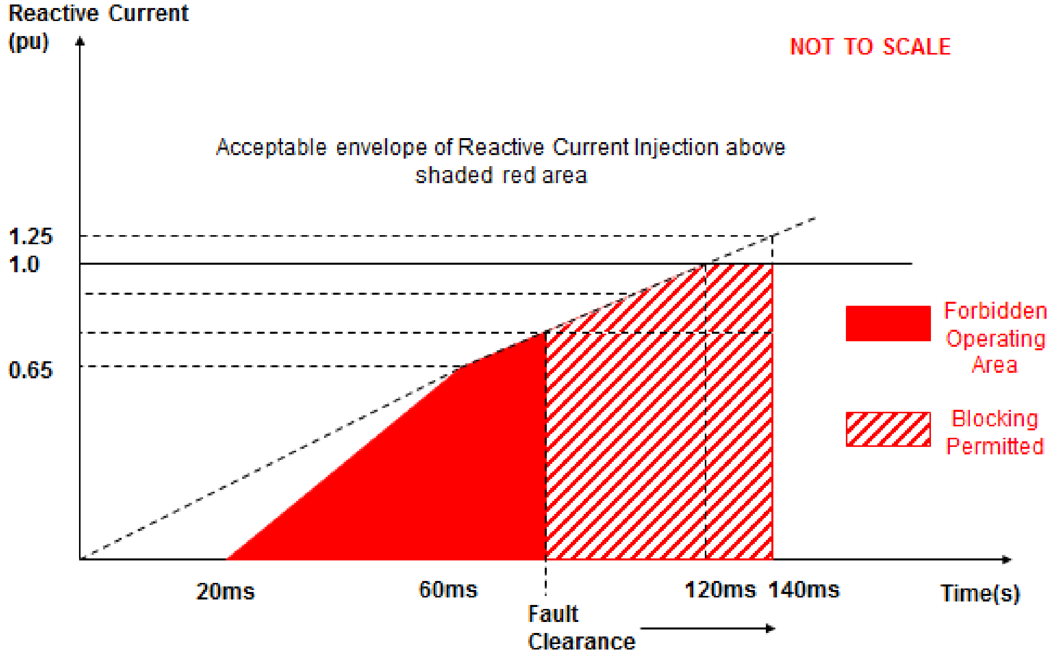
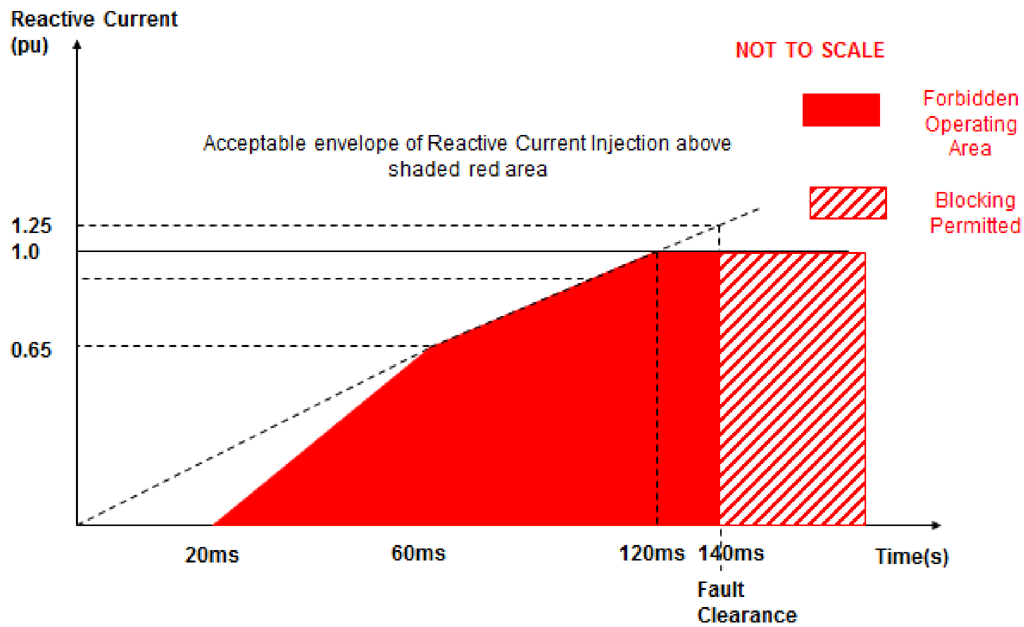



Figure 13.16 (b)



(ii) The **Inverter** of each **Type C** and **Type D Power Park Module** 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 13.16 (a) and Figure 13.16 (b) show the impact of variations in fault clearance time which shall be no greater than 140ms. Where the **Customer** is able to demonstrate to the **DNO** that blocking is required in order to prevent the risk of transient over voltage excursions as specified in paragraph 9.9.2 **Generators** are required to both advise and agree with the **DNO** of the control strategy **,** which must also include the approach taken to de-blocking. Not withstanding this requirement, **Generators** should be aware of their requirement to fully satisfy the requirements of paragraph 13.4 (fault ride through).

(iii) In addition, the reactive current injected from each **Power Park Module** shall be injected in proportion and remain in phase to the change in system voltage at the **Connection 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**.

(iv) Each **Type C** and **Type D Power Park Module** shall be designed to reduce the risk of transient over voltage levels arising following clearance of the fault. **Generators** shall be permitted to block where the anticipated transient overvoltage would not otherwise exceed the maximum permitted values specified in paragraph 9.9.2. Any additional requirements relating to transient overvoltage performance will be specified by the **DNO**.

(v) In addition to the requirements of paragraph 13.7 **Generators** in respect of **Type C** and **Type D Power Park Modules** are required to confirm to the **DNO,** their repeated ability to supply **Fast Fault Current** to the system each time the voltage at the **Connection Point** falls outside the limits specified in paragraph 12.4.1. **Generators** should inform **the DNO** 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;.

## 13.8 Black Start Capability

13.8.1 The National Electricity Transmission System will be equipped with **Black Start Stations**. It will be necessary for each **Customer** to notify the **DNO** if its **Power Generating Module** has a restart capability without connection to an external power supply, unless the **Customer** shall have previously notified the **NETSO** accordingly under the **Grid Code**. Such generation may be registered by the **NETSO** as a **Black Start Station**.

## 13.9 Technical Requirements for Embedded Medium Power Stations

13.9.1 Where a Generator in respect of a **Embedded Medium Power Station** is a party to the **CUSC** this paragraph will not apply.

13.9.2 In addition to the requirements in Section 9 of this EREC G99, the **DNO** has an obligation under ECC 3.3 of the **Grid Code** to ensure that all relevant **Grid Code** Connection Condition requirements are met by **Embedded Medium Power Stations**. These requirements are summarised in ECC 3.4 of the **Grid Code**. It is incumbent on the **Generator** of the **Embedded Medium Power Station** to comply with the relevant **Grid Code** requirements listed in ECC3.4 of the **Grid Code** as part of compliance with this EREC G99.

13.9.3 Where data is required by the **NETSO** from **Embedded Medium Power Stations**, nothing in the **Grid Code** or **Distribution Code** precludes the **Generator** from providing the information directly to the **NETSO** in accordance with **Grid Code** requirements. However, a copy of the information should always be provided in parallel to the **DNO**.

13.9.4 **Grid Code Connection Conditions Compliance**

13.9.4.1 The technical designs and parameters of the **Embedded Medium Power Station** shall comply with the relevant Connection Conditions of the **Grid Code**. A statement to this effect, stating compliance with ECP4.3 of the **Grid Code** is required to be presented to the **DNO** for onward transmission to the **NETSO**, before commissioning of the **Embedded Medium Power Station**. Note that the statement might need to be resubmitted post commissioning when assumed values etc have been confirmed.

13.9.4.2 Should the **Generator** make any material change to such designs or parameters as will have any effect on the statement of compliance referred to in paragraph 13.9.4.1, the **Generator** must notify the change to the **DNO**, as soon as reasonably practicable, who will in turn notify the **NETSO.**

13.9.4.3 Tests to ensure **Grid Code** compliance may be specified by the **NETSO** in accordance with the **Grid Code.** It is the **Generator's** responsibility to carry out these tests

13.9.4.4 Where the **NETSO** can reasonably demonstrate that for **Total System** stability issues the **Embedded Medium Power Station** should be fitted with a **Power System Stabiliser**, the **NETSO** will notify the **DNO** who will then require it to be fitted.

## 13.11 Operational monitoring

13.11.1 With regard to information exchange:

(i) **Power Generating Facilities** shall be capable of exchanging information with the **DNO** in real time or periodically with time stamping;

(ii) the **DNO**, in coordination with the **NETSO**, shall specify the content of information exchanges including a precise list of data to be provided by the **Power Generating Facility**.

13.11.2 At each **Power Generating Facility including Type C** or **Type D Power Generating Modules** the **DNO** will install their own Telecontrol/SCADA outstation which will generally meet all the **DNO's** necessary and legal operational data requirements. The **DNO** will inform the **Generator** if additional specific data are required.

13.11.3 Additionally each **Power Generating Facility comprising Type C** and **Type D Power Generating Module** shall;

(a) be fitted with fault recording and dynamic system monitoring facilities which shall be capable of recording **System** data including voltage, **Active Power**, **Reactive Power** and frequency in accordance with Appendix C.3.

(b) The signals which shall be provided by the **Generator** to the **DNO** for onsite monitoring shall be of the following resolution, unless otherwise agreed by the **DNO**:

(i) 1 Hz for reactive range tests

(ii) 10 Hz for frequency control tests

(iii) 100 Hz for voltage control tests

(c) The settings of the fault recording equipment and dynamic system monitoring equipment (which is required to detect poorly damped power oscillations) including triggering criteria shall be agreed between the **Customer** and the **DNO** and recorded in the **Connection Agreement.**

(d) The **DNO** may also specify that **Generators** must install power quality monitoring equipment. Any such requirement including the parameters to be monitored would be specified by the **DNO** in the **Connection Agreement**.

(e) Provisions for the submission fault recording, dynamic system monitoring and power quality data to the **DNO** including the communications and protocols shall be specified by the **DNO** in the **Connection Agreement**.

13.11.4 The **Customer** will provide all relevant signals for onsite monitoring in the form of dc voltages within the range -10V to +10V. In exceptional circumstances, some signals may be accepted as d.c. voltages within the range -60V to +60V with prior agreement between the **Customer** and the **DNO**. All signals shall be suitably terminated in a single accessible location at the **Generator**s site.

13.11.5 All signals shall be suitably scaled across the range. The following scaling would (unless the **DNO** notifes the **Generator** otherwise) be acceptable to the **DNO**:

(a) 0MW to **Registered Capacity** 0-8V dc

(b) Maximum leading **Reactive Power** to maximum lagging **Reactive Power** -8 to 8V dc

(c) 48 – 52Hz as -8 to 8V dc

(d) Nominal terminal or connection point voltage -10% to +10% as -8 to 8V dc

13.11.6 The **Customer** shall provide to the DNO a 230V power supply adjacent to the signal terminal location.

13.11.7 **Frequency sensitive mode (FSM) monitoring in real time**

13.11.7.1 **Type C** and **Type D Power Generating Modules** shall be fitted with facilities to record and monitor the operation of **Active Power** frequency response in real time. The monitored data provided at the **Connection Point** shall be capable of being transmitted to the **DNOs** control centre, on request, as specified in the **Connection Agreement**. The monitored data shall include signals of status signal FSM (on/off), scheduled **Active Power** output, actual value of the **Active Power** output, actual parameter settings for **Active Power** frequency response, **Droop** and deadband.

13.11.7.2 The **DNO** shall specify any additional signals to be provided by the **Generator** by monitoring and recording devices in order to verify the performance of the **Active Power** frequency response provision of **Power Generating Modules** which have been instructed by the **DNO** to operate in **Frequency Sensitive Mode**.

13.11.7.3 Provisions for the submission **Frequency Sensitive Mode** data to the **DNO** including the communications and protocols shall be specified by the **DNO** in the **Connection Agreement**.

13.12 **Steady State Load Inaccuracies**

13.12.1 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 Registered Capacity**. Where a **Type C** or **Type D Power Generating Module** 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 **DDRC**.

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.

# 14 INSTALLATION, OPERATION AND CONTROL INTERFACE

## 14.1 General

14.1.1 Installations should be carried out by competent persons, who have sufficient skills and training to apply safe methods of work to install the **Power Generating Module** in compliance with this EREC. Ideally they should have recognised and approved qualifications relating to the fuel / energy sources and general electrical installations[3].

14.1.2 Notwithstanding the requirements of this EREC, the installation should be carried out to the standards required in the **Manufacturer**'s installation instructions.

14.1.3 The **Generator** and **DNO** must give due regard to these requirements and ensure that all personnel are competent in that they have adequate knowledge and sufficient judgement to take the correct action when dealing with an emergency. Failure to take correct action may jeopardise the **Generator**'s equipment or the **Distribution Network** and give rise to danger.

14.1.5 The **DNO** and the **Generator** must agree in writing the salient technical requirements of the interface between their two systems. These requirements will generally be contained in the Site Responsibility Schedule and/or the **Connection Agreement.** In particular it is expected that the agreement will include:

a. the means of synchronisation between the **Generator**'s system and the **Distribution Network**, where appropriate;

b. the responsibility for plant, equipment and protection systems maintenance, and recording failures;

c. the means of connection and disconnection between the **DNO**s and **Generator**'s systems;

d. key technical data eg import and export capacities, operating **Power Factor** range, **Interface Protection** settings;

e. the competency of all persons carrying out operations on their systems;

f. details of arrangements that will ensure an adequate and reliable means of communication between the **DNO** and **Generator**;

g. the obligation to inform each other of any condition, occurrence or incident which could affect the safety of the other's personnel, or the maintenance of equipment and to keep records of the communication of such information;

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3 The Installers can choose to be approved under the 'Microgeneration Certification Scheme (MCS) supported by Department of Business, Energy & Industrial Strategy. This certification scheme for microgeneration products and Installers provides an ongoing, independent, third party assessment of Installers of microgeneration systems and technologies to ensure that the requirements of the appropriate standards are met and maintained. The scope of MCS scheme includes the supply, design, installation, set to work and commissioning of a range of microgeneration technologies. For more details, see http://www.greenbooklive.com/page.jsp?id=4

h. the names of designated persons with authority to act and communicate on their behalf and their appropriate contact details.

i. the obligation of a Generator to notify the DNO of any operational incidents or failures of a **Power Generating Module** that affect its compliance with this EREC G99, without undue delay, after the occurrence of those incidents

14.1.6 **Generator**s should be aware that many **DNO**s apply auto-reclose systems to **High Voltage** overhead line circuits. This may affect the operations of directly connected **HV Power Generating Module**s and also **Power Generating Module**s connected to **LV Distribution Networks** supplied indirectly by **HV** overhead lines.

## 14.2 Isolation and Safety Labelling

14.2.1 Every **Customer's Installation** which includes **Power Generating Modules** operating in parallel with the **Distribution Network** must include a means of isolation capable of disconnecting the whole of the **Power Generating Module**[4] infeed to the **Distribution Network.** This equipment will normally be owned by the **Generator**, but may by agreement be owned by the **DNO**.

14.2.2 The **Generator** must grant the **DNO** rights of access to the means of isolation without undue delay and the **DNO** must have the right to isolate the **Power Generation Modules** infeed at any time should such disconnection become necessary for safety reasons and in order to comply with statutory obligations. The isolating device should normally be installed at the **Connection Point**, but may be positioned elsewhere with the **DNO's** agreement.

14.2.3 To ensure that **DNO** staff and that of the **Customer** and their contractors are aware of the presence of **a Power Generating Module**, appropriate warning labels should be used.

14.2.4 Where the installation is connected to the **DNO LV Distribution Network** the **Generator** should generally provide labelling at the **Connection Point** (Fused Cut-Out), meter position, consumer unit and at all points of isolation within the **Customer**'s premises to indicate the presence of **a Power Generating Module.** The labelling should be sufficiently robust and if necessary fixed in place to ensure that it remains legible and secure for the lifetime of the installation. The Health and Safety (Safety Signs & Signals) Regulations 1996 stipulates that labels should display the prescribed triangular shape, and size, using black on yellow colouring. A typical label, for both size and content, is shown below in figure 14.1.

**Figure 14.1 Warning label**

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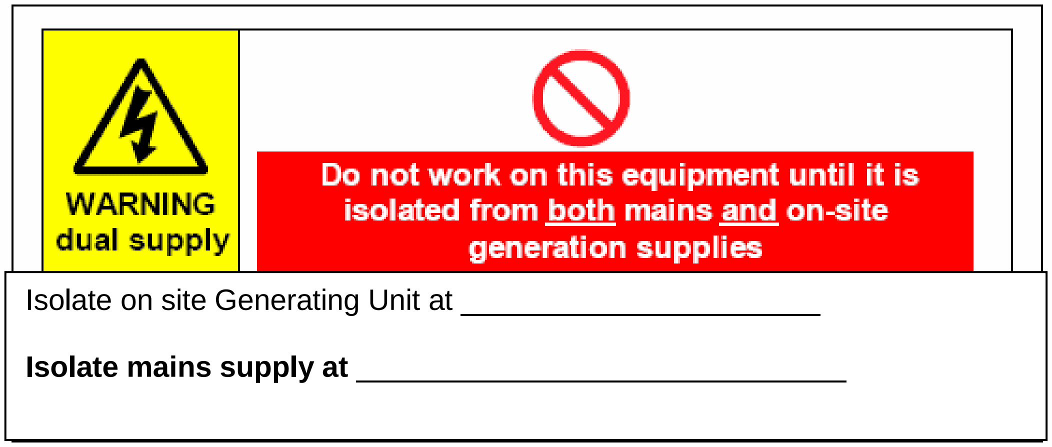
[4] Where the Power Generating Module is designed to support part of the customer's system independently from the DNO system, the switch that is used to separate the independent part of the customer's system from the DNO system must disconnect each phase and neutral. This prevents neutral current from inadvertently flowing through the part of the system that is not supported by the Power Generating Module . See also Figure 8.7 and 8.9




14.2.5 Where the installation is connected to the **DNO's HV Distribution Network** the **Generator** should give consideration to the labelling requirements. In some installations eg a complex CHP installation, extensive labelling may be required, but in others eg a wind farm connection, it is likely to be clear that **Power Generating Module**s are installed on site and labelling may not be required. Any labels should comply with The Health and Safety (Safety Signs & Signals) Regulations 1996 which stipulates that labels should display the prescribed triangular shape, and size, using black on yellow colouring.

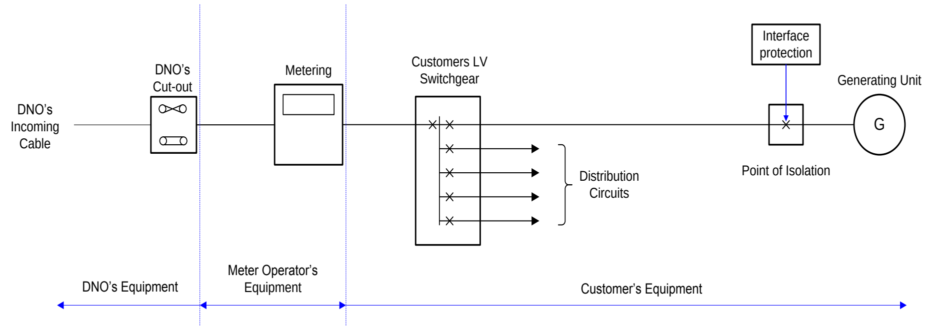
## 14.3 Site Responsibility Schedule

14.3.1 In order to comply with the Distribution Planning and Connection Code DPC5.4.3 of the **Distribution Code** a Site Responsibility Schedule (SRS) should be prepared by the **DNO** in conjunction with the **Generator.** The SRS should clearly indicate the ownership, operational and maintenance responsibility of each item of equipment at the interface between the **Distribution Network** and the **Power Generating Module**, and should include an operational diagram so that all persons working at the interface have sufficient information so that they can undertake their duties safely and to minimise the risk of inadvertently interrupting supplies. The SRS should also record the agreed method of communication between the **DNO** and the **Generator**.

14.3.2 The operational diagram should be readily available to those persons requiring access to the information contained on it. For example, this could be achieved by displaying a paper copy at the **Connection Point**, or alternatively provided as part of a computer based information system to which all site staff has access. The most appropriate form for this information to be made available should be agreed as part of the connection application process.

14.3.3 In the case of a **LV** connected **Power Generating Module,** a simple diagram located at the **Connection Point** may be sufficient. The scope of the diagram should cover the **Distribution Network**, **Customer**'s **installation** and the **Power Generating Module** as shown below in Fig 14.2, however the location of any metering devices, consumer unit and **Interface Protection** (together with their settings) within the **Customer**'s **installation** should also be shown.

**Fig 14.2 – Example of an Operational Diagram**




14.3.4 In the case of an **HV** connected **Power Generating Module** the diagram is likely to be more complex and contain more detailed information.

14.3.5 In addition to preparing the diagram as part of the connection process, there are obligations on the **DNO** and the **Generator** to ensure that the Site Responsibility Schedule including the operational diagram are updated to reflect any changes on site. To facilitate this, the **Generator** must contact the **DNO** when any relevant changes are being considered.

## 14.4 Operational and Safety Aspects

14.4.1 Where the **Connection Point** provided by the **DNO** for parallel operation is at **HV**, in addition to the provisions of DOC 8, the **Generator** must ensure:

a. that a person with authority, or his staff, is available at all times to receive communications from the **DNO** Control Engineer so that emergencies, requiring urgent action by the **Generator**, can be dealt with adequately. Where required by the **DNO**, it will also be a duty of the **Generator's** staff to advise the **DNO** Control Engineer of any abnormalities that occur on the **Power Generating Module** which have caused, or might cause, disturbance to the **Distribution Network**, for example earth faults;

b. Where in the case that it is necessary for the **Generator's** staff to operate the **DNOs** equipment, they must first have been appropriately trained and designated as a **DNO** 'Authorised Person' for this purpose. The names of the **Generators** authorised persons should be included on the Site Responsibility Schedule. All operation of **DNO** equipment must be carried out to the specific instructions of the **DNO** Control Engineer in accordance with the **DNOs** safety rules.

14.4.2 For certain **Power Generating Module** connections to an **HV Connection Point**, the **Generator** and the **DNO** may have mutually agreed to schedule the **Active Power** and / or **Reactive Power** outputs to the **Distribution Network** to ensure stability of the local **Distribution Network**. The **DNO** may require agreement on specific written procedures to control the bringing on and taking off of such **Power Generating Module**. The action within these procedures will normally be controlled by the **DNOs** Control Engineer.

14.4.3 Where the **Connection Point** provided by the **DNO** for parallel operation is at **LV**, the **DNO**, depending upon local circumstances, may require a similar communications procedure as outlined in sub-paragraph 14.4.1(a) above.

## 14.5 Synchronizing and Operational Control

14.5.1 Before connecting two energised electrical systems, for example a **Distribution Network** and **Power Generating Module**, it is necessary to synchronise them by minimising their voltage, frequency and phase differences.

14.5.2 Operational switching, for example synchronising, needs to take account of **Step Voltage Changes** as detailed in Section 9.3.

14.5.3 Automatic synchronising equipment will be the norm which, by control of the **Power Generating Module**'s field system (**Automatic Voltage Regulator**) and governor, brings the incoming unit within the acceptable operating conditions of voltage and speed (frequency), and closes the synchronising circuit breaker. Manual synchronising can only be done with the specific agreement of the **DNO.**

14.5.4 The facility to use the **DNO**s interface circuit breaker for synchronizing can only be used with the specific agreement of the **DNO**.

14.5.6 The synchronising voltage supply may, with **DNO** agreement, be provided from a **DNO** owned voltage transformer. Where so provided, the voltage supplies should be separately fused at the voltage transformer.

14.5.7 Where the **Generator**'s **system** comprises ring connections with normal open points, it may not be economic to provide synchronising at all such locations. In such cases mechanical key interlocking may be applied to prevent closure unless one side of the ring is electrically dead. A circuit breaker or breakers will still, however, require synchronising facilities to achieve paralleling between the **Generator**'s system and the **DNO** supply.

14.5.8 The conditions to be met in order to allow automatic reconnection when the **DNO** supply is restored are defined in Section 10. Where a **Generator** requires his **Power Generating Module** to continue to supply a temporarily disconnected section of the **Distribution Network** in island mode**,** the special arrangements necessary will need to be discussed with the **DNO**.

## 15 Common Commissioning Requirements for all Power Generating Modules

### 15.1 Commissioning Tests / Checks required at all Power Generating Facilities

15.1.1 The following checks shall be carried out by the Installer at all **Power Generating Facilities** and on all **Power Generating Modules** irrespective of whether they have been fully or partially **Type Tested**:

a. Inspect the **Power Generating Facility** to check compliance with BS7671. Checks should consider:

(i) Protection

(ii) Earthing and bonding

(iii) Selection and installation of equipment

b. Check that suitable lockable points of isolation have been provided between the **Power Generating Modules** and the rest of the installation.

c. Check that safety labels have been installed in accordance with clause 14.2 of EREC G99;

d. Check interlocking operates as required. Interlocking should prevent **Power Generating Modules** being connected to the **DNO Network** without being synchronised;

e. Where possible undertake a visual check that the correct protection settings have been applied (in accordance with EREC G99 Table 10.1) or check the Compliance Verification Report;

15.1.2 The following checks shall be carried out by the Installer at all **Power Generating Facilities** and on all **Power Generating Modules** irrespective of whether they have been fully or partially **Type Tested**:

a. Complete functional tests to ensure each **Power Generating Module** synchronises with, and disconnects from, the **DNOs Network** successfully and that it operates without tripping under normal conditions;

Carry out a functional test to confirm that the **Interface Protection** operates when all phases are disconnected between the **Power Generating Module** and the **DNOs Network**. This test is carried out by opening a suitably rated switch between the **Power Generating Module** and the **Connection Point** and checking that the supplies are disconnected between the **Power Generating Module** and the **DNO's Distribution Network** quickly (eg within 1s);

b. Check that once the phases are restored following the functional test described in (b) at least 20s elapses before the **Power Generating Modules** re-connect to the **DNO's Distribution Network**.

15.1.3 The tests and checks shall be carried out once the installation is complete, or, in the case of a phased installation (i.e. where **Power Generating Modules** are installed in different phases), when that part of the installation has been completed. The results of these tests shall be recorded on the commissioning form included in Appendix A.3. The **Installer** or **Generator**, as appropriate, shall complete the declaration at the bottom of the form, sign and date it and provide a copy to the **DNO** at the time of commissioning (where tests are witnessed) or within 28 days of the commissioning date (where the tests are not witnessed).

### 15.2 Additional Commissioning requirements for Non Type Tested Interface Protection

15.2.1 Where **Type Testing** or **Manufacturers' information** is not being used to demonstrate **Interface Protection** compliance, protection commissioning tests are required and the following describes how these should be carried out for the standard range of protection required. Where additional protection is fitted then this should also be tested, additional test requirements are to be agreed between the **DNO** and **Generator**.

The results of these tests shall be recorded in the schedule provided in Appendix A.4 using the relevant sections for **HV** and **LV** protection along with any additional test results required.

a) Calibration and stability tests shall be carried out on the over voltage and under voltage protection for each phase, as described below:

   (i) The operating voltage shall be checked by applying nominal voltage to the protection (so that it resets) and then slowly increasing this voltage (for over voltage protection) or reducing it (for under voltage protection) until the protection picks up. The voltage at which the protection picks up shall be recorded. Where the test equipment increases / decreases the voltage in distinct steps, these shall be no greater than 0.5% of the voltage setting. Each pickup value shall be within 1.5% of the required setting value.

   (ii) Timing tests shall be carried out by stepping the voltage from the nominal voltage to a value 4V above the setting voltage (for overvoltage protection) and 4V below the setting (for under voltage protection) and recording the operating time of the protection. The operating time of the protection shall be no shorter than the setting and no greater than the setting + 100ms.

   (iii) Stability tests (no-trip tests) shall also be carried out at the voltages and for the durations defined in Appendix A.4. The protection must not trip during these tests.

b) Calibration and stability tests shall be carried out on the over frequency and under frequency protection as described below:

   (i) The operating frequency shall be checked by applying nominal frequency to the protection (so that it resets) and then slowly increasing this frequency (for over frequency protection) or reducing it (for under frequency protection) until the protection picks up. The frequency at which the protection picks up shall be recorded. Where the test equipment increases / decreases the frequency in distinct steps, these shall be no greater than 0.1% of the frequency setting. Each pick up value shall be within 0.2% (ie 0.1Hz) of the setting value.

   (ii) Timing tests shall be carried out by stepping the frequency from 50Hz to a value 0.2Hz above the setting frequency (for over frequency protection) and 0.2Hz below the setting (for under frequency protection) and recording the operating time of the protection. The operating time of the protection shall be no shorter than the setting and no greater than the setting + 100ms or the setting + 1% of the setting, whichever gives the longer time.

(iii) Stability tests (no-trip tests) shall also be carried out at the frequencies and for the durations defined in the commissioning test record, Appendix B.2. The protection must not trip during these tests.

c) Calibration tests for rate of change of frequency protection, where used, shall be carried out as follows:

(i) Rate of change of frequency shall be checked by first applying a voltage with a frequency of 50.5Hz to the protection and then ramping this frequency down at 0.1Hz$s^{-1}$ until a frequency reaches 49.5Hz. This test is repeated at increasing values of rate of change of frequency (in increments of 0.025Hz$s^{-1}$ or less) until the protection operates. The test shall be repeated for rising frequency but this time each test shall be start at 49.5Hz and end at 50.5Hz. The operating values should be within 0.025Hz per second of the required setting.

(ii) Timing tests shall be carried out by applying a falling and a rising frequency at rate of 0.05Hz$s^{-1}$ above the setting value. The protection operating times shall be no longer than 1.0.

d) RoCoF and vector shift stability checks shall be performed on all loss of mains protection in accordance with Appendix A.4 irrespective of the type of loss of mains protection employed for a particular **Power Generating Module** or **Power Generating Facility**.

# 16 Type A COMPLIANCE TESTING, COMMISSIONING AND OPERATIONAL NOTIFICATION

## 16.1 Type Test Certification

16.1.1 The **Power Generating Module** can comprise **Fully Type Tested** equipment or be made up of some **Type Tested** equipment and require additional site testing prior to operation. The use of **Fully Type Tested** equipment simplifies the connection process, the protection arrangements and reduces the commissioning test requirements.

16.1.2 **Type Tested** certification is the responsibility of the **Manufacturer**. The **Manufacturer** shall make available upon request a Type Test Verification Report confirming that the product has been **Type Tested** to satisfy the requirements of this EREC G99. The report shall detail the type and model of product tested, the test conditions and results recorded. These details shall be included in a **Type Test Verification Report**. This report can include reference to **Manufacturers' information**. Further information about **Manufacturers' information** is given in Section 21.

16.1.3 The required Type Test Verification Report and declarations including that for a **Fully Type Tested Power Generating Module** are shown in Appendix A.4 (Form C). It is intended that the **Manufacturers** will use the requirements of this EREC G99 to develop type verification certification (i.e. the Type Test Verification Report as shown in Appendix A.4 (Form C) for each of their **Type A Power Generating Module** models.

16.1.4 Guidance for **Manufacturers** on type testing is included in Appendix A.8 of this document.

16.1.5 Compliance with the requirements detailed in this EREC G99 which are applicable to **Type A Power Generating Modules** will ensure that the **Type A Power Generating Module** is considered to be approved for connection to the **DNO's Distribution Network**.

16.1.6 The **Power Generating Module** shall comply with all relevant European Directives and should be labelled with a corresponding CE marking.

## 16.2 Connection Process

16.2.1 The **Installer** shall discuss the installation project with the local **DNO** at the earliest opportunity. The connection application will need to be in format as shown in Appendix A.2 (Form A). Where a **Power Generating Module** is **Fully Type Tested** and registered with the Energy Networks Association Type Test Verification Report Register, the application should include the Type Test Reference Number, and the Type Test results do not need to be submitted as part of the application.

16.2.2 Where a Type Test reference number is not available, the **Customer** or **Installer** shall provide the **DNO** with a Test Verification Report as per Appendix A.4 (Form C) confirming that the **Power Generating Module** has been tested to satisfy the requirements of this EREC G99. On receipt of the application, the **DNO** will assess:

- whether any **Distribution Network** studies are required;
- whether there is a need for work on the **Distribution Network** before the **Tested Power Generating Module** can be connected to the **Distribution Network**; and
- whether there is a requirement to witness the commissioning tests.

16.2.3 Connection of the **Tested Power Generating Module** is only allowed after the application for connection has been approved by the **DNO** and any **DNO** works facilitating the connection have been completed.

16.2.4 Where **Power Generating Modules** require connection to the **DNO's Distribution Network** in advance of the commissioning date, for the purposes of testing, the **Power Generating Facility** must comply with the requirements of the **Connection Agreement**. The **Generator** shall provide the **DNO** with a commissioning programme, which will be approved by the **DNO** if reasonable in the circumstances, to allow commissioning tests to be co-ordinated.

16.2.5 Where commissioning tests are not witnessed, confirmation of the commissioning of each **Power Generating Module** will need to be made no later than 28 days after commissioning; the format and content shall be as shown in Appendix A.3 (Form B) Installation Document. Where tests are witnessed, the **Installer** or **Generator**, as appropriate, shall complete the declaration at the bottom of the both the Installation Document and Site Summary Form, sign and date them and provide a copy to the **DNO** at the time of commissioning.

16.2.6 It is the responsibility of the **Installer** or the **Generator** to ensure that the relevant information is forwarded to the local **DNO.** The pro forma in Appendices A.2, A.3 and A.4 are designed to:

(a) simplify the connection procedure for both **DNO** and **Installer**;

(b) provide the **DNO** with all the information required to assess the potential impact of the **Power Generating Module** connection on the operation of the **Distribution Network**;

(c) inform the **DNO** that the **Customer's** **Installation** complies with the requirements of this EREC G98 Part 2;

(d) allow the **DNO** to accurately record the location of all **Power Generating Modules** connected to the **Distribution Network**.

### 16.3 Witnessing and Commissioning

16.3.1 The **DNO** will not normally witness the commissioning checks and tests for **Fully Type Tested PGM**. In such cases, where the **DNO** does decide to witness they will advise this as part of the connection offer. Reasons for witnessing such installations may include:

(a) A new **Installer** with no track record in the **DNO** area.

(b) A check on the quality of an installation either on a random basis or as a result of problems that have come to light at previous installations.

16.3.2 Where commissioning tests and checks are to be witnessed the **Installer** shall discuss and agree the scope of these tests with the **DNO** at an early stage of the project. The **Installer** shall submit the scope, date and time of the commissioning tests at least 16 days before the proposed commissioning date.

16.3.3 Where the **DNO** chooses to witness the **PGM** commissioning tests and checks, the **DNO** shall charge the **Customer** for attendance of staff at its own common methodology charging statement rates.

16.3.4 No parameter relating to the electrical connection and subject to type test verification certification shall be modified unless previously agreed in writing between the **DNO** and the **Customer** or their agent. **Customer** access to such parameters shall be prevented.

16.3.5 As part of the on-site commissioning tests the **Installer** shall carry out a functional check of the loss of mains protection, for example by removing the supply to the **Power Generating Module** during operation and checking that the **Interface Protection** operates to disconnect the **Power Generating Module** from the **DNO's Distribution Network**. For three phase installations this test can be achieved by opening a three phase Circuit Breaker or isolator and confirming that the **Power Generating Module** has shut down. Testing for the loss of a single phase is covered in the type testing of **Inverters** see Appendix A.4.

**Comment [MK12]:** This text still under review

16.3.6 The checks and tests as detailed in Section 15.1 must be undertaken.

16.3.7 Where **Type Testing** or **Manufacturers' information** is not being used to demonstrate **Interface Protection** the tests detailed in Section 15.2 must be undertaken.

16.4 **Operational Notification**

16.4.1 Notification that the **Power Generating Module** has been connected / commissioned is achieved by completing an Installation Document as per Appendix A.3 (Form B), which also includes the relevant details on the **Customer's Installation** required by the **DNO**.

16.4.2 The **Installer**, or an agent acting on behalf of the **Installer**, shall supply separate Installation Documents (Appendix A.3, Form B) for each Power Generating Module installed under EREC **G99** within the **Customer's Installation** to the **DNO**. Documentation shall be supplied either at the time of commissioning (where tests are witnessed) or within 28 days of the commissioning date (where the tests are not witnessed) and may be submitted electronically.

16.5 **Notification of Changes**

16.5.1 The **DNO** shall be notified of any operational incidents or failures of **Power Generating Modules** that affect its compliance with this EREC G99, without undue delay, after the occurrence of those incidents.

16.5.2 The **DNO** shall have the right to request that the **Customer** arrange to have compliance tests undertaken after any failure, modification or replacement of any equipment that may have an impact on the **Power Generating Module's** compliance with this EREC G99.

16.5.3 Where one or more **Power Generating Modules** are to be added or replaced at an existing **Customer's Installation** which was installed prior to the introduction of this EREC G99, it is not necessary to modify the other existing **Power Generating Modules** to comply with this document. For the avoidance of doubt, this also applies where the changes increase the capacity of the **Customer's Installation** above the 16A per phase threshold.

16.5.4 For example the addition of a new 3kW single phase **Power Generating Module** to an existing **Customer's Installation** comprising an existing 3kW single phase **Power Generating Module** complying with EREC G83 increases the capacity of the **Customer's Installation** from 3kW (13.04A per phase) to 6kW (26.08A per phase). In this case the new **Power Generating Module** will have to comply with EREC G99 but the existing **Power Generating Module** will not need to be modified. For more information on the treatment of additions, see section 6 and 6.1.5.

16.5.5 If a **Power Generating Module** is changed at a **Customer's Installation** the replacement must comply with the current version of this EREC G99.

## 17 **Type B COMPLIANCE TESTING, COMMISSIONING AND OPERATIONAL NOTIFICATION**

### 17.1 General

17.1.1 Where **Power Generating Modules** require connection to the **DNO's Distribution Network** in advance of the commissioning date, for the purposes of testing, the **Power Generating Facility** must comply with the requirements of the **Connection Agreement**. The **Generator** shall provide the **DNO** with a commissioning programme, which will be approved by the **DNO** if reasonable in the circumstances, to allow commissioning tests to be co-ordinated.

17.1.2 The **Generator** will use **Type Tested** equipment and or use **Manufacturers' information** as well demonstrating all the commissioning tests performed on his **Power Generating Module** in order to discharge the requirements of this document. Further information about **Manufacturers' information** is given in Section 21. It is expected that the **DNO** will witness these tests for **Power Generating Modules.** Note that the **DNO** shall charge the **Generator** for attendance of staff for witness testing in accordance with its charging regime. The **Generator** shall make arrangements for the **DNO** to witness the commissioning tests unless otherwise agreed with the **DNO**.

17.1.3 It is the responsibility of the **Generator** to undertake these commissioning tests / checks and to ensure the **Power Generating Facility** and **Power Generating Module**s meet all the relevant requirements.

17.1.4 In addition to the commissioning tests and checks required under EREC G99, in exceptional circumstances further tests may be required by the **Manufacturer**, **Supplier, Generator** or **Installer** of the **Power Generating Module**s as may be required to satisfy legislation and other standards.

### 17.2 Connection Process

17.2.1 The **Generator** shall discuss the project with the local **DNO** at the earliest opportunity. The connection application will need to be in format as shown in Appendix A.2 (Form A), although detailed system studies will almost certainly be required and consequently the **Generator** might need to provide additional information. This information should be provided using the standard application form (generally available from the **DNO**s website). The data that might be required will all be defined within DPC7 and DPC8 and the Distribution Data Registration Code (DDRC) of the **Distribution Code**.

17.2.2 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to synchronise its **Power Generating Module** for the first time the **Generator** owner will submit to the **DNO** a **Power Generating Module Document** containing at least but not limited to the items referred to in paragraph 16.2.3.

17.2.3 Items for submission in the **Power Generating Module Document:**

(i) updated **DPRC** data (both **Standard Planning Data** and **Detailed Planning Data**), with any estimated values assumed for planning purposes confirmed or, where practical, replaced by validated actual values and by updated estimates for the future and by updated forecasts for **Forecast Data** items such as **Demand;**

(iii) details of any special **Power Generating Module(s)** protection as applicable. This may include Pole Slipping protection and islanding protection schemes as applicable;

(iv) simulation study provisions of Appendix B.6 and the results demonstrating compliance with EREC G99: Frequency Capability and **Frequency Sensitive Mode** requirements of paragraph 12.2, fault ride through requirements of section 12.3, reactive capability requirements of section 12.5 and fast fault current injection requirements of paragraph 12.6 unless agreed otherwise by the **DNO**;

(v) a detailed schedule of the tests and the procedures for the tests required to be carried out by the **Generator** to achieve a **Final Operational Notification**. Such schedule to be consistent with the requirements of Section 12 and Appendix B.5 (in the case of a Synchronous Power **Generating Module**) or Appendix B.6 (in the case of a **Power Park Module**);

(vi) copies of **Manufactures Information** where these are relied upon as part of the evidence of compliance and

(vii) a Compliance Declaration completed by the **Generator.**

17.2.4 A **Power Generating Module Document** (PGMD) shall be submitted for each applicable Power Generating Module. An example of a **Power Generating Module Document** is given in Appendix B.2.

17.2.5 The **DNO** shall assess the schedule of tests submitted by the **Generato**r and not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to commence tests required to achieve a **Final Operational Notification** be witnessed by the **DNO**, the **Generator** will notify the **DNO** that the **Power Generating Module(s)** is ready to commence such tests. Such approval by the **DNO** shall be provided in a timely manner and shall not be unreasonably withheld.

## 17.3 Witnessing and Commissioning

17.3.1 No **Power Generating Module** shall be synchronised to the **Total System** until the **Generator** has received written confirmation from the **DNO** that the **Power Generating Module** has demonstrated compliance with the following requirements to the **DNO's** satisfaction:

(a) those tests required to establish the open and short circuit saturation characteristics of the **Synchronous Power Generating Module** (as detailed in Appendix B.5.3) to enable assessment of the short circuit ratio. Such tests may be carried out at a location other than the **Power Generating Facility** site and supplied in the form of **Manufacturers' information**; and

(b) open circuit step response tests (as detailed in Appendix B.5.2).

17.3.2 The **Generator** is responsible for carrying out the tests and retains the responsibility for safety and personnel during the test.

17.3.3 As part of the on-site commissioning tests the **Generator** shall carry out a functional check of the loss of mains protection, for example by removing the supply to the **Power Generating Module** during operation and checking that the **Interface Protection** operates to disconnect the **Power Generating Module** from the **DNO's Distribution Network**. For three phase installations this test can be achieved by opening a three phase Circuit Breaker or isolator and confirming that the **Power Generating Module** has shut down. Testing for the loss of a single phase is covered in the type testing of **Inverter**s see Appendix A.8.

17.3.4 The checks and tests as detailed in Section 15.1 must be undertaken.

17.3.5 Where **Type Testing** or **Manufacturers' information** is not being used to demonstrate **Interface Protection** the tests detailed in Section 15.2 must be undertaken.

17.3.6 The tests as detailed in the **Power Generating Module Document** shall be carried out by the **Installer** or **Generator:**

17.3.7 The tests and checks shall be carried out once the installation is complete, or, in the case of a phased installation (i.e. where **Power Generating Modules** are installed in different phases), when that part of the installation has been completed. The results of these tests shall be recorded on the installation and commissioning document included in Appendix A.3. The **Installer** or **Generator**, as appropriate, shall complete the declaration at the bottom of the form, sign and date it and provide a copy to the **DNO** at the time of commissioning.

17.3.8 Where the **DNO** chooses to witness the **PGM** commissioning tests and checks, the **DNO** shall charge the **Customer** for attendance of staff at its own common methodology charging statement rates

## 17.4 Operational Notification for Type B Power Generating Modules

17.4.1 Prior to the issue of a **Final Operational Notification** the **Generator** must submit to the **DNO** to the **DNO**'s satisfaction:

(a) updated DDRC data (both Standard Planning Data and Detailed Planning Data), with validated actual values and updated estimates for the future including Forecast Data items such as Demand;

(b) evidence to the **DNO's** satisfaction that demonstrates that the controller models and/or parameters (as required under DDRC schedule 5c) supplied to the **DNO** provide a reasonable representation of the behaviour of the **Generator's** plant and apparatus;

(c) copies of **Manufacturers' information** where these are relied upon as part of the evidence of compliance;

(d) results from the tests carried out by the **Generator** to demonstrate compliance with relevant EREC G99 requirements including the tests witnessed by the **DNO**; and

(f) the Compliance Declaration signed by the **Generator**.

17.4.2 The items in paragraph 17.4.1 should be submitted by the **Generator** using the Power **Generating Module Document** and DDRC.

17.4.3 If the requirements of this Section 17.4 have been successfully met, the **DNO** will notify the **Generator** that compliance with the relevant EREC G99 provisions has been demonstrated for the **Power Generating Module(s)** as applicable through the issue of a **Final Operational Notification.**

# 18 Type C COMPLIANCE TESTING, COMMISSIONING AND OPERATIONAL NOTIFICATION

## 18.1 General

18.1.1 Where **Power Generating Modules** require connection to the **DNO's Distribution Network** in advance of the commissioning date, for the purposes of testing, the **Power Generating Facility** must comply with the requirements of the **Connection Agreement**. The **Generator** shall provide the **DNO** with a commissioning programme, which will be approved by the **DNO** if reasonable in the circumstances, to allow commissioning tests to be co-ordinated.

18.1.2 The **Generator** will use **Type Tested** equipment and or use **Manufacturers' information** as well demonstrating all the commissioning tests performed on his **Power Generating Module** in order to discharge the requirements of this document. Further information about **Manufacturers' information** is given in Section 21. It is expected that the **DNO** will witness these tests for **Power Generating Modules.** Note that the **DNO** shall charge the **Generator** for attendance of staff for witness testing in accordance with its charging regime. The **Generator** shall make arrangements for the **DNO** to witness the commissioning tests unless otherwise agreed with the **DNO**.

18.1.3 It is the responsibility of the **Generator** to undertake these commissioning tests / checks and to ensure the **Power Generating Facility** and **Power Generating Module**s meet all the relevant requirements.

18.1.4 In addition to the commissioning tests and checks required under EREC G99, further tests may be required by the **Manufacturer**, **Supplier, Generator** or **Installer** of the **Power Generating Module**s as may be required to satisfy legislation and other standards.

## 18.2 Connection Process

18.2.1 The **Generator** shall discuss the project with the local **DNO** at the earliest opportunity. The connection application will need to be in format as shown in Appendix A.2 (Form A), although detailed system studies will almost certainly be required and consequently the **Generator** might need to provide additional information. This information should be provided using the standard application form (generally available from the **DNO**s website). The data that might be required will all be defined within DPC7 and DPC8 and the Distribution Data Registration Code (DDRC) of the **Distribution Code**.

18.2.2 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to synchronise its **Power Generating Module** for the first time the **Generator** owner will submit to the **DNO** a **Power Generating Module Document** containing at least but not limited to the items referred to in paragraph 16.2.3.

18.2.3 Items for submission in the **Power Generating Module Document:**

(i) updated **DPRC** data (both **Standard Planning Data** and **Detailed Planning Data**), with any estimated values assumed for planning purposes confirmed or, where practical, replaced by validated actual values and by updated estimates for the future and by updated forecasts for **Forecast Data** items such as **Demand;**

(ii) for Type C **Power Generating Modules** the simulation models;

(iii) details of any special **Power Generating Module(s)** protection as applicable. This may include Pole Slipping protection and islanding protection schemes as applicable;

(viii) simulation study provisions of Appendix B.4 and the results demonstrating compliance with EREC G99: Frequency Capability and **Frequency Sensitive Mode** requirements of paragraph 13.2, fault ride through requirements of section 13.4, reactive capability requirements of section 13.6 and fast fault current injection requirements of paragraph 13.7 unless agreed otherwise by the **DNO**;

(ix) a detailed schedule of the tests and the procedures for the tests required to be carried out by the **Generator** to achieve a **Final Operational Notification**. Such schedule to be consistent with Section 13, Appendix B.5 (in the case of a Synchronous Power **Generating Module**) or Appendix B.6 (in the case of a **Power Park Module**);

(x) copies of **Manufactures Information** where these are relied upon as part of the evidence of compliance and

(xi) a Compliance Declaration completed by the **Generator.**

18.2.4 A **Power Generating Module Document** (PGMD) shall be submitted for each applicable Power Generating Module. An example of a **Power Generating Module Document** is given in Appendix B.2.

18.2.5 The **DNO** shall assess the schedule of tests submitted by the **Generato**r and not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to commence tests required to achieve a **Final Operational Notification** be witnessed by the **DNO**, the **Generator** will notify the **DNO** that the **Power Generating Module(s)** is ready to commence such tests. Such approval by the **DNO** shall be provided in a timely manner and shall not be unreasonably withheld.

## 18.3 Witnessing and Commissioning

18.3.1 No **Power Generating Module** shall be synchronised to the **Total System** until the **Generator** has received written confirmation from the **DNO** that the **Power Generating Module** has demonstrated compliance with the following requirements to the **DNO's** satisfaction:

(a) those tests required to establish the open and short circuit saturation characteristics of the **Synchronous Power Generating Module** (as detailed in Appendix B.5.3) to enable assessment of the short circuit ratio. Such tests may be carried out at a location other than the **Power Generating Facility** site and supplied in the form of **Manufacturers' information**; and

(b) open circuit step response tests (as detailed in Appendix B.5.2).

18.3.2 The **Generator** is responsible for carrying out the tests and retains the responsibility for safety and personnel during the test.

18.3.3 As part of the on-site commissioning tests the **Generator** shall carry out a functional check of the loss of mains protection, for example by removing the supply to the **Power Generating Module** during operation and checking that the **Interface Protection** operates to disconnect the **Power Generating Module** from the **DNO's Distribution Network**. For three phase installations this test can be achieved by opening a three phase Circuit Breaker or isolator and confirming that the **Power Generating Module** has shut down. Testing for the loss of a single phase is covered in the type testing of **Inverter**s see Appendix A.4.

18.3.4 The checks and tests as detailed in Section 15.1 must be undertaken.

18.3.5 Where **Type Testing** or **Manufacturers' information** is not being used to demonstrate **Interface Protection** the tests detailed in Section 15.2 must be undertaken.

18.3.6 The tests as detailed in the **Power Generating Module Document** shall be carried out by the **Installer** or **Generator:**

18.3.7 The tests and checks shall be carried out once the installation is complete, or, in the case of a phased installation (i.e. where **Power Generating Modules** are installed in different phases), when that part of the installation has been completed. The results of these tests shall be recorded on the installation and commissioning document included in Appendix A.3. The **Installer** or **Generator**, as appropriate, shall complete the declaration at the bottom of the form, sign and date it and provide a copy to the **DNO** at the time of commissioning.

### 18.4 Operational Notification for Type C Power Generating Modules

18.4.1 Prior to the issue of a **Final Operational Notification** the **Generator** must submit to the **DNO** to the **DNO**'s satisfaction:

(a) updated DDRC data (both Standard Planning Data and Detailed Planning Data), with validated actual values and updated estimates for the future including Forecast Data items such as Demand;

(b) evidence to the **DNO's** satisfaction that demonstrates that the controller models and/or parameters (as required under DDRC schedule 5c) supplied to the **DNO** provide a reasonable representation of the behaviour of the **Generator's** plant and apparatus;

(c) copies of **Manufacturers' information** where these are relied upon as part of the evidence of compliance;

(d) results from the tests carried out by the **Generator** to demonstrate compliance with relevant EREC G99 requirements including the tests witnessed by the **DNO**; and

(f) the Compliance Declaration signed by the **Generator**.

18.4.2 The items in paragraph 18.4.1 should be submitted by the **Generator** using the Power **Generating Module Document** and DDRC.

18.4.3 If the requirements of this Section 18.4 have been successfully met, the **DNO** will notify the **Generator** that compliance with the relevant EREC G99 provisions has been demonstrated for the **Power Generating Module(s)** as applicable through the issue of a **Final Operational Notification.**

## 19 Type D COMPLIANCE TESTING, COMMISSIONING AND OPERATIONAL NOTIFICATION

### 19.1 General

19.1.1 A **Type D Power Generating Module** will be required to obtain an **Energisation Operational Notification** followed by an **Interim Operational Notification** and a **Final Operational Notification**.

19.1.2 The **Generator** will use **Type Tested** equipment and or use **Manufacturers' information** as well as demonstrating all the commissioning tests performed on his **Power Generating Module** in order to discharge the requirements of this document. Further information about **Manufacturers' information** is given in Section 21. It is expected that the **DNO** will witness these tests for **Power Generating Modules.** Note that the **DNO** shall charge the **Generator** for attendance of staff for witness testing in accordance with its charging regime. The **Generator** shall make arrangements for the **DNO** to witness the commissioning tests unless otherwise agreed with the **DNO**.

19.1.3 It is the responsibility of the **Generator** to undertake these commissioning tests / checks and to ensure the **Power Generating Facility** and **Power Generating Module**s meet all the relevant requirements.

19.1.4 In addition to the commissioning tests and checks required under EREC G99, further tests may be required by the **Manufacturer**, **Supplier, Generator** or **Installer** of the **Power Generating Module**s as may be required to satisfy legislation and other standards.

## 19.2 Connection Process

19.2.1 The **Generator** shall discuss the project with the local **DNO** at the earliest opportunity. The connection application will need to be in format as shown in Appendix A.2 (Form A), although detailed system studies will almost certainly be required and consequently the **Generator** might need to provide additional information. This information should be provided using the standard application form (generally available from the **DNO**s website). The data that might be required will all be defined within DPC7 and DPC8 and the Distribution Data Registration Code (DDRC) of the **Distribution Code**.

19.2.2 In order to energisation a Generator's internal network it is necessary to obtain an **Energisation Operational Notification.** The following provisions apply in relation to the issue of an **Energisation Operational Notification** in respect of **Embedded Medium Power Stations and Type D Power Generating Modules or Power Park Modules** connecting to the **Distribution Network.** If the **Generator** is licenced it should follow the procedures in the **Grid Code**.

19.2.3 The items for submission prior to the issue of an **Energisation Operational Notification** are detailed below:

(a) updated DDRC Schedule 7 Planning data (both **Standard Planning Data** and **Detailed Planning Data**), with any estimated values assumed for planning purposes confirmed or, where practical, replaced by validated actual values and by updated estimates for the future and by updated forecasts for forecast data as required by the DDRC;

(b) details of the **Interface Protection** arrangements and settings referred to in Section 9;

(c) the proposed name of the **Power Generating Facility.**

(d) any additional provisions in the **Connection Agreement**

19.2.4 The items referred to in this Section shall be submitted using the appropriate DDRC schedules where applicable.

19.2.5 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to energise its plant and apparatus for the first time the **Generator** will submit to the **DNO** a Certificate of Readiness to Energise High Voltage Equipment which specifies the items of plant and apparatus ready to be energised in a form acceptable to the **DNO**.

19.2.6 If the conditions of Section 12.8 have been completed to the **DNO**'s reasonable satisfaction then the **DNO** shall issue an **Energisation Operational Notification**.

## 19.3 Type D Interim Operational Notification

19.3.1 The following provisions apply in relation to the issue of an **Interim Operational Notification** in respect of **Type D Power Generating Modules**.

19.3.2 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the wishing to synchronise its plant and apparatus for the first time the **Generator** will:submit to the **DNO** the items referred to in paragraph 19.3.3.

19.3.3 Items for submission prior to issue of the Interim Operational Notification.

19.3.3.1 Prior to the issue of an **Interim Operational Notification** the **Generator** must submit to the **DNO** to the **DNO**'s satisfaction:

(a) updated DDRC data (both Standard Planning Data and Detailed Planning Data), with any estimated values assumed for planning purposes confirmed or, where practical, replaced by validated actual values and by updated estimates for the future and by updated forecasts for Forecast Data items such as Demand;

(b) details of any special **Power Generating Module**(s) or protection as applicable. This may include Pole Slipping protection and islanding protection schemes;

(c) An update of any of the items required to achieve an **Energisation Operational Notification**;

(d) simulation study provisions of Appendix B.4 and the results demonstrating compliance with EREC G99 **Frequency Sensitive Mode** requirements of paragraph 9.4.4 (LFSM-O) and paragraph 9.4.5 (LFSM-U), fault ride through requirements of section 9.7 as applicable to the **Power Generating Module(s)** unless agreed otherwise by the **DNO.** If a **Power System Stabiliser** is fitted the appropriate studies should be undertaken in accordance with the **Grid Code**;

(e) a detailed schedule of the tests and the procedures for the tests required to be carried out by the Generator to demonstrate compliance in order to gain a **Final Operational Notification**. Such schedule to be consistent with paragraph 12.2, Appendix B.1, Appendix B.3, Appendix B.4 together with Appendix B.5 (in the case of Synchronous Power Generating Modules) or Appendix B.6 (in the case of Power Park Modules); and

(f) an interim Compliance Declaration completed by the **Customer** (including any Unresolved Issues) against the relevant EREC G99 requirements including details of any requirements that the **Generator** has identified that will not or may not be met or demonstrated. If applicable this should include a declaration that Black start compliance has been obtained from the **NETSO.**

19.3.4 No **Type D Power Generating Module** shall be synchronised to the **Total System** until the date specified by the **DNO** in the **Interim Operational Notification** issued in respect of the **Power Generating Module(s)**;

19.3.5 The **DNO** shall assess the schedule of tests submitted by the **Generator** with the Notification of **Customer**'s Intention to Synchronise and shall determine whether such schedule has been completed to the **DNO's** satisfaction.

19.3.6 When the requirements of paragraph 19.3.2 to paragraph 19.3.5 have been met, the **DNO** will notify the **Generator** that the **Synchronous Power Generating Module**, **CCGT Module** or **Power Park Module** as applicable may (subject to the **Generator** having fulfilled the requirements of paragraph 19.3.3 where that applies) be synchronised to the **Total System** through the issue of an **Interim Operational Notification**.

19.3.6.1 The **Interim Operational Notification** will be time limited, the expiration date being specified at the time of issue. The **Interim Operational Notification** may be renewed by the **DNO** for up to a maximum of 24 months from the date of the first issue of the **Interim Operational Notification**. The **DNO** may only issue an extension to an **Interim Operational Notification** beyond 24 months provided the **Generator** has applied for a Derogation for any remaining Unresolved Issues to the **Authority** as detailed in Section 19.6**.**

19.3.7 The **Generator** must operate the **Power Generating Facility** in accordance with the terms, arising from the Unresolved Issues, of the **Interim Operational Notification**. Where practicable, the **DNO** will discuss such terms with the **Generator** prior to including them in the **Interim Operational Notification**.

19.3.8 The **Interim Operational Notification** will include the following limitations:

(a) In the case of a **Power Park Module** the **Interim Operational Notification** will limit the proportion of the **Power Park Module** which can be simultaneously synchronised to the **Total System** such that neither of the following figures is exceeded:

(i) 20% of the **Registered Capacity** of the **Power Park Module** (or the output of a single **Generating Unit** where this exceeds 20% of the **Power Generating Facilities Registered Capacity**); nor

(ii) 50MW

until the **Generator** has completed the voltage control tests (detailed in Appendix B.6.2) to the DNO's reasonable satisfaction. Following successful completion of this test each additional **Generating Unit** should be included in the voltage control scheme as soon as is technically possible (unless the **DNO** agrees otherwise).

(b) In the case of a **Synchronous Power Generating Module** employing a static Excitation System or a **Power Park Module** employing a **Power System Stabiliser** the **Interim Operational Notification** may if applicable limit the maximum **Active Power** output and **Reactive Power** output of the **Synchronous Power Generating Module** or **CCGT module** prior to the successful commissioning of the **Power System Stabiliser** to the **DNO's** satisfaction.

19.3.9 Operation in accordance with the **Interim Operational Notification** whilst it is in force will meet the requirements for compliance by the **Generator** and the **DNO** of all the relevant provisions of the European Connection Conditions.

19.3.10 Other than Unresolved Issues that are subject to tests required prior to issue of a **Final Operation Notification**, the **Generator** must resolve any Unresolved Issues prior to the commencement of the tests, unless the **DNO** agrees to a later resolution. The Generator must liaise with the **DNO** in respect of such resolution. The tests that may be witnessed by the **DNO** are specified in paragraph 19.4.2.

19.3.11 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to commence tests required to be witnessed by the **DNO** prior to issue of a **Final Operation Notification**, the **Generato**r will notify the **DNO** that the **Power Generating Module(s)** is ready to commence such tests.

## 19.4 Final Operational Notification

19.4.1 The following provisions apply in relation to the issue of **a Final Operational Notification** in respect of **Type D Power Generating Modules**.

19.4.2 Tests to be carried out prior to issue of the **Final Operational Notification**.

19.4.2.1 Prior to the issue of a **Final Operational Notification** the **Generator** must have completed the tests specified in paragraph 19.4.2.2 to the **DNO's** satisfaction to demonstrate compliance with the relevant EREC G99 provisions.

19.4.2.2 In the case of any **Power Generating Module** these tests will comprise one or more of the following:

(a) Reactive capability tests to demonstrate that the **Power Generating Module** can meet the requirements of paragraph 13.6 and in the case of **Power Park Module** the requirements of Appendix B.6 and, in the case of **Synchronous Power Generating Module** and **CCGT Module**, the requirements of Appendix B.5. These may be witnessed by the **DNO** on site if there is no metering to the **DNO**s Control Centre.

(b) Voltage control system tests to demonstrate that the **Power Generating Module** can meet the requirements of paragraph 13.5.3 and paragraph 13.5.4, in the case of **Power Park Module** the requirements of Appendix B.6 and, in the case of **Synchronous Power Generating Module** and **CCGT Module**, the requirements of

Appendix B.5, and any terms specified in the **Connection Agreement** as applicable. These tests may also be used to validate the Excitation System model or voltage control system model as applicable (DDRC schedule 5c). These tests may be witnessed by the **DNO**.

(c) Governor or frequency control system tests to demonstrate that the **Power Generating Module** can meet the requirements of paragraph 13.1.4, paragraph 13.2 and Appendix B.5 and Appendix B.6. These tests may also be used to validate the Governor model or frequency control system model as applicable (DDRC schedule 5c). These tests may be witnessed by the **DNO**.

19.4.2.3 The **DNOs** preferred range of tests to demonstrate compliance with this EREC G99 are specified in Appendix B.5 (in the case of **Synchronous Power Generating Modules**) or Appendix B.6 (in the case of **Power Park Modules**) and are to be carried out by the **Generator** with the results of each test provided to the **DNO**. The **Generator** may carry out an alternative range of tests if this is agreed with the **DNO**. The **DNO** may agree a reduced set of tests where relevant **Manufacturers' information** has been provided.

19.4.2.4 Following completion of each of the tests specified in this paragraph 19.4, the **DNO** will notify the **Generator** whether, in the opinion of the **DNO**, the results demonstrate compliance with EREC G99.

19.4.2.5 The **Generator** is responsible for carrying out the tests and retains the responsibility for safety and personnel during the test.

19.4.3 Items for submission prior to issue of the **Final Operational Notification**

19.4.3.1 Prior to the issue of a **Final Operational Notification** the **Generator** must submit to the **DNO** to the **DNO**'s satisfaction:

(a) updated Planning Code data (both Standard Planning Data and Detailed Planning Data), with validated actual values and updated estimates for the future including Forecast Data items such as Demand;

(b) any items required in order to obtain the **Energisation Operational Notification** and the **Interim Operational Notification**, updated by the **Generator** as necessary;

(c) evidence to the **DNO's** satisfaction that demonstrates that the controller models and/or parameters (as required under DDRC schedule 5c) supplied to the **DNO** provide a reasonable representation of the behaviour of the **Generator's** plant and apparatus;

(d) copies of **Manufacturers' information** where these are relied upon as part of the evidence of compliance;

(e) results from the tests required in accordance with paragraph 19.3 carried out by the **Generator** to demonstrate compliance with relevant EREC G99 requirements including the tests witnessed by the **DNO**;

(f) the final Compliance Declaration signed by the **Generator** and a statement of any requirements that the Generator has identified that have not been met together with a copy of the derogation in respect of the same from the **Authority**.

19.4.3.2 The items in paragraph 19.4.3 should be submitted by the **Generator** using the DDRC and a **Power Generating Module Document**.

19.4.4 If the requirements of paragraph 19.4.2 and paragraph 19.4.3 have been successfully met, the **DNO** will notify the **Generator** that compliance with the relevant EREC G99 provisions has been demonstrated for the **Power Generating Module(s)** as applicable through the issue of a **Final Operational Notification.**

19.4.5 If a **Final Operational Notification** cannot be issued because the requirements of paragraph 19.4.2 and paragraph 19.4.3 have not been successfully met prior to the expiry of an **Interim Operational Notification** then the **Generator** and/or the **DNO** shall apply to the **Authority** for a derogation. The provisions of paragraph 19.6 shall then apply.

## 19.5 Limited Operational Notification

19.5.1 Following the issue of a **Final Operational Notification** for a **Type D Power Generating Module** if:

(i) the Generator becomes aware, that its plant and/or apparatus' capability to meet any provisions of EREC G99, or where applicable the **Connection Agreement** is not fully available then the **Generator** shall follow the process in paragraph 19.5.2 to paragraph 19.5.10; or,

(ii) The **DNO** becomes aware through monitoring as described in paragraph 13.11, that a **Generator** and/or apparatus' capability to meet any provisions of EREC G99, or where applicable the **Connection Agreement** is not fully available then the **DNO** shall inform the **Generator**. Where the **DNO** and the **Generator** cannot agree from the monitoring as described in paragraph 13.11 whether the plant and/or apparatus is fully available and/or is compliant with the requirements of EREC G99 and where applicable the **Connection Agreement**, the **DNO** shall first issue an instruction requiring the **Generator** to carry out a test, before applying the process defined in Section 19.5 if applicable. Where the testing indicates that the plant and/or apparatus is not fully available and/or is not compliant with the requirements of EREC G99 and/or the **Connection Agreement**, or if the parties so agree, the process in paragraph 19.5.2 to paragraph 19.5.10 shall be followed.

19.5.2 Immediately upon a **Generator** becoming aware that its **Power Generating Module** may be unable to comply with certain provisions of EREC G99 or (where applicable) the **Connection Agreement**, the **Generator** shall notify the **DNO** in writing. Additional details of any operating restrictions or changes in applicable data arising from the potential non-compliance and an indication of the date from when the restrictions will be removed and full compliance demonstrated shall be provided as soon as reasonably practical.

19.5.3 Where the restriction notified in paragraph 19.5.2 is not resolved in 28 days then the **Generator** with input from and discussion of conclusions with the **DNO**, shall undertake an investigation to attempt to determine the causes of and solution to the non-compliance. Such investigation shall continue for no longer than 56 days. During such investigation, the **Generato**r shall provide to the **DNO** the relevant data which has changed due to the restriction in respect of paragraph 19.4.3 as notified to the **Generator** by the **DNO** as being required to be provided.

19.5.4 Issue and Effect of **Limited Operational Notification**

19.5.4.1 Following the issue of a **Final Operational Notification**, the **DNO** will issue to the **Generator** a **Limited Operational Notification** if:

(b) The **DNO** is notified by a **Generator** of a **Modification** to its plant and apparatus; or

(c) The **DNO** receives a submission of data, or a statement from a **Generator** indicating a change in plant or apparatus or settings (including but not limited to governor and excitation control systems) that may in the **DNOs** reasonable opinion, acting in accordance with Good Industry Practice be expected to result in a material change of performance.

19.5.4.2 The **Limited Operational Notification** will be time limited to expire no later than 12 months from the start of the non-compliance or restriction or from reconnection following a change. The **DNO** may agree a longer duration in the case of a **Limited Operational Notification** following a **Modification** or whilst the **Authority** is considering the application for a derogation in accordance with paragraph 19.6.1.

19.5.4.3 The **Limited Operational Notification** will notify the **Generator** or of any restrictions on the operation of the **Synchronous Power Generating Module(s), CCGT Module(s) or Power Park Module(s)** and will specify the Unresolved Issues. The **Generator** must operate in accordance with any notified restrictions and must resolve the Unresolved Issues.

19.5.4.4 The **Generator** and the **DNO** will be deemed compliant with all the relevant provisions of EREC G99 provided operation is in accordance with the **Limited Operational Notification**, whilst it is in force, and that the provisions of and referred to in Section 19.5 are complied with.

19.5.4.5 The Unresolved Issues included in a **Limited Operational Notification** will show the extent that the provisions of 19.4.2 (testing) and 19.4.3 (final data submission) shall apply. In respect of selecting the extent of any tests which may in the **DNO's** view reasonably be needed to demonstrate the restored capability and in agreeing the time period in which the tests will be scheduled, the **DNO** shall, where reasonably practicable, take account of the **Generator**'s input to contain its costs associated with the testing.

19.5.4.6 In the case of a change or Modification the **Limited Operational Notification** may specify that the affected plant and/or apparatus or associated **Generating Unit(s)** must not be synchronised until all of the following items, that in the **DNO's** reasonable opinion are relevant, have been submitted to the **DNO** to the **DNO's** satisfaction:

(a) updated Planning Code data (both Standard Planning Data and Detailed Planning Data);

(b) details of any relevant special **Power Generating Facility**, **Synchronous Power Generating Module(s)** or **Power Park Module(s)** protection as applicable. This may include Pole Slipping protection and islanding protection schemes; and

(c) simulation study provisions of Appendix B.4 and the results demonstrating compliance with EREC G99 requirements relevant to the change or Modification as agreed by the **DNO**; and

(d) a detailed schedule of the tests and the procedures for the tests required to be carried out by the **Generator** to demonstrate compliance with EREC G99 requirements as agreed by the **DNO**. The schedule of tests shall be consistent with Appendix B.5 or Appendix B.6 as appropriate; and

(e) an interim Compliance Declaration completed by the **Generator** (including any Unresolved Issues) against the relevant EREC G99 requirements including details of any requirements that the **Generator** has identified that will not or may not be met or demonstrated; and

(f) any other items specified in the **Limited Operational Notification**.

19.5.4.7 The items referred to in paragraph 19.5.4.6 shall be submitted by the **Generator** using the DDRC.

19.5.4.8 In the case of **Synchronous Power Generating Module(s)** only, the Unresolved Issues of the **Limited Operational Notification** may require that the **Generator** must complete the following tests to the **DNO's** satisfaction to demonstrate compliance with the relevant provisions of EREC G99 prior to the **Synchronous Power Generating Module** being synchronised to the **Total System**:

(a) those tests required to establish the open and short circuit saturation characteristics of the **Synchronous Power Generating Module** (as detailed in Appendix B.5.3) to enable assessment of the short circuit ratio. Such tests may be carried out at a location other than the **Power Generating Facility** site; and

(b) open circuit step response tests (as detailed in Appendix B.5.2) to demonstrate compliance with Appendix C.1.2.4.1 and Appendix C2.2.3.1 as applicable.

19.5.5 In the case of a change or Modification, not less than 28 days, or such shorter period as may be acceptable in NGET's reasonable opinion, prior to the **Generator** wishing to synchronise its plant and apparatus for the first time following the change or Modification, the **Generator** will:

(i) submit a Notification of **Customer**'s Intention to Synchronise; and

(ii) submit to the **DNO** the items referred to in paragraph 19.5.4.6.

19.5.6 Other than Unresolved Issues that are subject to tests to be witnessed by the **DNO**, the Generator must resolve any Unresolved Issues prior to the commencement of the tests, unless the **DNO** agrees to a later resolution. The **Generator** must liaise with the **DNO** in respect of such resolution. The tests that may be witnessed by the **DNO** are specified in paragraph 19.4.2.2.

19.5.7 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to commence tests listed as Unresolved Issues to be witnessed by the **DNO**, the **Generator** or will notify the **DNO** that the **Synchronous Power Generating Module(s)**, **CCGT Module(s)** or **Power Park Module(s)** as applicable is ready to commence such tests.

19.5.8 The items referred to in paragraph 19.4.3 and listed as Unresolved Issues shall be submitted by the **Generator** after successful completion of the tests.

19.5.9 Where the Unresolved Issues have been resolved a **Final Operational Notification** will be issued to the **Generator**.

19.5.10 If a **Final Operational Notification** has not been issued by the DNO within the 12 month period referred to in paragraph 19.5.4.2 (or where agreed following a Modification by the expiry time of the **Limited Operational Notification**) then the **Generator** and the **DNO** shall apply to the **Authority** for a derogation.

### 19.6 Processes Relating to Derogations

19.6.1 Whilst the A**uthority** is considering the application for a derogation, the **Interim Operational Notification** or **Limited Operational Notification** will be extended to remain in force until the **Authority** has notified the **DNO** and the **Generator** of its decision. The **DNO** may propose any necessary changes to the **Connection Agreement** with the Generator.

19.6.2 If the **Authority**:

(a) grants a derogation in respect of the plant and/or apparatus, then the **DNO** shall issue **Final Operational Notification** once all other Unresolved Issues are resolved; or

(b) decides a derogation is not required in respect of the plant and/or apparatus then the **DNO** will reconsider the relevant Unresolved Issues and may issue a **Final Operational Notification** once all other Unresolved Issues are resolved; or

(c) decides not to grant any derogation in respect of the plant and/or apparatus, then there will be no Operational Notification in place and the **DNO** and the **Generator** shall consider its rights pursuant to the **CUSC**.

19.6.3 Where an **Interim Operational Notification** or **Limited Operational Notification** is so conditional upon a derogation and such derogation includes any conditions (including any time limit to such derogation) the **Generator** will progress the resolution of any Unresolved Issues and / or progress and / or comply with any conditions upon such derogation and the provisions of paragraph 19.4 shall apply and shall be followed.

## 20 Ongoing Obligations

### 20.1 Periodic Testing for Type A, Type B and Type C Power Generating Modules

20.1.1 The **DNO** shall have the right to request that the **Generator** carry out compliance tests and simulations as set out in this section in accordance with DOC 5 and according to a repeat plan or general scheme or after any failure, modification or replacement of any equipment that may have an impact on the **Power Generating Module's** compliance with the requirements of this EREC G99.

20.1.2 The **Generator** shall be informed of the outcome of those compliance tests and simulations.

20.1.3 It may be necessary to undertake ad-hoc testing to determine[5], for example:

a. the voltage dip on synchronising;
b. the harmonic voltage distortion;
c. the voltage levels as a result of the connection of the **Power Generating Facilities** and to confirm that they remain within the statutory limits.

20.1.4 The **Interface Protection** shall be tested by the **Generator** at intervals to be agreed with the **DNO.**

### 20.2 Changes in the Installation of a Type A, Type B, Type C or Type D Power Generating Module

20.2.1 If during the lifetime of the **Power Generating Modules** it is necessary to replace a major component of a **Power Generating Module** or its protection system, that may affect its compliance with the requirements in this EREC G99, the DNO should be notified before the modification is initiated.

20.2.2 In the event that **Power Generating Module** is to be decommissioned and will no longer operate as a source of electrical energy in parallel with the **Distribution Network**, the **Generator** or third parties (including aggregators) shall notify the **DNO** by providing the information as detailed in Appendix D.1. Where the presence of **Power Generating Modules** is indicated in a bespoke **Connection Agreement**, it will be necessary to amend the **Connection Agreement** appropriately.

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[5] Such periodic testing may be required due to system changes, **DNO** protection changes, fault investigations etc.

20.2.3 If a **Power Generating Module** is changed at a **Power Generating Facility** the replacement must comply with the current version of EREC G99 or EREC G98, as applicable.

### 20.3 Notification of Decommissioning

20.3.1 The **Generator** shall notify the **DNO** about the permanent decommissioning of a **Power Generating Module** by providing the information as detailed under Appendix D.1. Documentation may be submitted by an agent acting on behalf of the **Generator** and may be submitted electronically.

20.3.2 Where the presence of a **Power Generating Module** or any **Generating Unit** is indicated in a bespoke **Connection Agreement**, it will be necessary to amend the **Connection Agreement** appropriately.

## 21 MANUFACTURER'S DATA & PERFORMANCE REPORT

### 21.1 General

21.1.1 Data and performance characteristics in respect of EREC G99 requirements may be registered with the **DNO** by **Power Park Unit** manufacturers in respect of specific models of **Power Park Units** by submitting information in the form of **Manufacturers' Information** to the **DNO**.

21.1.2 A **Generator** planning to construct a new **Power Generating Facility** containing the appropriate version of **Power Park Units** in respect of which **Manufacturers' Information** has been submitted to the **DNO** may reference the **Manufacturers' Information** in its submissions to the **DNO**. Any **Generator** considering referring to **Manufacturers' Information** for any aspect of its plant and apparatus may contact the **DNO** to discuss the suitability of the relevant **Manufacturers' Information** to its project to determine if, and to what extent, the data included in the **Manufacturers' Information** contributes towards demonstrating compliance with those aspects of this EREC G99 applicable to the **Generator**. The **DNO** will inform the **Generator** if the reference to the **Manufacturers' Information** is not appropriate or not sufficient for its project.

21.1.3 The process to be followed by **Power Park Unit** manufacturers submitting **Manufacturers' Information** must be agreed by the **DNO**. Paragraph 21.2 below indicates the specific requirement areas in respect of which **Manufacturers' Information** may be submitted.

21.1.4 The **DNO** will maintain and publish a register of that **Manufacturers' Information** which the **DNO** has received and accepted as being an accurate representation of the performance of the relevant plant and / or apparatus. Such register will identify the manufacturer, the model(s) of **Power Park Unit**(s) to which the report applies and the provisions of EREC G99 in respect of which the report contributes towards the demonstration of compliance. The inclusion of any report in the register does not in any way confirm that any **Power Park Modules** which utilise any **Power Park Unit**(s) covered by a report is or will be compliant with EREC G99.

21.2 **Manufacturers' Information** in respect of **Power Park Units** may cover one (or part of one) or more of the following provisions:

(a) **Fault Ride Through** capability

(b) Power Park Module mathematical model DDRC 5c.

21.3 Reference to **a Manufacturer's Data & Performance Report** in a **Generator**'s submissions does not by itself constitute compliance with EREC G99.

21.4 A Generator referencing **Manufacturers' Information** should insert the relevant **Manufacturers' Information** reference in the appropriate place in the submission forms detailed in the Appendices. The **DNO** will consider the suitability of **Manufacturers' Information:**

(a) in place of DDRC data submissions a mathematical model suitable for representation of the entire **Power Park Module** as per Appendix B.4.4.5. Site specific parameters will still need to be submitted by the Generator.

(b) in place of Fault simulation studies as follows;

The **DNO** will not require **Fault Ride Through** simulation studies to be conducted as per Appendix B.4.5.2 and qualified in Appendix B.4.5.3 provided that;

(i) Adequate and relevant **Power Park Uni**t data is included in respect of **Fault Ride Through** testing covered in Appendix B.6.7 in the relevant **Manufacturers' Information**, and

(ii) For each type and duration of fault as detailed in Appendix B.4.5.2, the expected minimum retained voltage is greater than the corresponding minimum voltage achieved and successfully ridden through in the F**ault Ride Through** tests covered by the **Manufacturers' Information**.

(c) to reduce the scope of compliance site tests where there is **Manufacturers' Information** in respect of a **Power Park Unit** which covers **Fault Ride Through**, the **DNO** may agree that no **Fault Ride Through** testing is required.

21.5 It is the responsibility of the **Generator** to ensure that the correct reference for the **Manufacturers' Information** is used and the **Generator** by using that reference accepts responsibility for the accuracy of the information. The **Generator** shall ensure that the manufacturer has kept the **DNO** informed of any relevant variations in plant specification since the submission of the relevant **Manufacturers' Information** which could affect the validity of the information.

21.6 The **DNO** may contact the Power Park Unit **Manufacturer** directly to verify the relevance of the use of such **Manufacturers' Information**. If the **DNO** believes the use some or all of such **Manufacturers' Information** is incorrect or the referenced data is inappropriate then the reference to the **Manufacturers' Information** may be declared invalid by the **DNO**. Where, and to the extent possible, the data included in the **Manufacturers' Information** is appropriate, the compliance assessment process will be continued using the data included in the **Manufacturers' Information**.