This text is the current (October 2017) G99 draft for the main chapters and some Appendices. It also 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](mailto:sarah.carter@ricardo.com).

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

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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 B, C and D, and also non type-tested Type A generating plant, in parallel with the distribution systems of licensed distribution network operators on or after 17 May 2019.

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”.

# 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.

1.3 This EREC is intended to provide guidance to **Generator**s and **DNO**s. The mandatory requirements governing the connection of Distributed **Power Generating Module**s are generally set out in this document and in the European Connection Conditions (ECC) of the **Grid Code**. In the event of any conflict with this EREC, the provisions of the **Distribution Code** and **Grid Code** will prevail.

# Scope

2.1 This EREC provides the technical requirements for the connection of **Type A, Type B, Type C and Type D Power Generating Module**s to the **Distribution Networks** of licensed **DNO**s. 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**:

1. **Generators** whose **Power-Generating Module(s)** was already connected to the **DNO’s Distribution Network** on or before 17 May 2019 or
2. **Generators** who had concluded a final and binding contract for the purchase of main generating glantbefore 17 May 2018. The **Generator** must notify the **DNO** of the conclusion of this final and binding contract by 17November 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.

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 **Type Tested Type A Power Generating Module**s and these are covered in EREC G98. However, **Type A** **Power Generating Module**s that have not been **Type Tested** in accordance with EREC G98 or that are connected at HV should comply with the requirements set out in this document. Section 6 of this document provides more guidance on how to apply this document to **Power Generating Module**s that are <16A per phase but do not meet the requirements of EREC G98.

2.4 The connection of mobile generation owned 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.

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** 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 9.11.

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** generating and vice versa;

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

# References

* 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.
  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.***

* 1. **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 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 Part 1**

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

**Engineering Recommendation G98 Part 2**

Connection procedure and technical requirements for (1) multiple Type Tested Micro-generating Plants in a Close Geographic Region and (2) Type A Type Tested Power Generating Modules (PGM) greater than 16 A per phase and connected at Low Voltage within the Customer’s Installation. **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.

# Terms and Definitions

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

Note: Except where otherwise stated, the terms defined in this section shall have the same meaning as in the European Network Code Requirements for Generators, the **Grid Code** and the **Distribution Code**.

|  |  |
| --- | --- |
| **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 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 Shutdownand to energise a part of the **Distribution Network** and be synchronisedto the **Distribution Network** upon instruction from the NE**TSO**, within two hours, without an external electrical power supply. |
| **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**:  (a) the **CUSC Framework Agreement**;  (b) a **Bilateral Agreement**;  (c) a **Construction Agreement**  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 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, 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.  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. |
| **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 orembedded generator. Also for the avoidance of doubt any **Customer** with generation connected to that Customer’s Installation is a **Generator**. |
| **Generating Unit** | Any apparatuswhich 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. |
| **Installer** | The person who is responsible for the installation of the **Power Generating Module**(s). |
| **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.** The interface protection is typically not all installed at the interface between the **DNO** and **Customer’s** **Installation**. |
| **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. |
| **Manufacturer** | A person or organisation thatmanufactures **Generating Units** which can be **Type Tested** to meet the requirements of this Engineering Recommendation if it is of a suitable size |
| **Manufacturers Information** | Information in suitable form provided by a Manufacturer in order to demonstrate compliance with one or more of the requirements of this G99. Such information can include Equipment Certificate(s) as defined in EU 2016/631. |
| **Material Effect** | An effect causing the **DNO** to effect any works or to alter the manner of operation of the **Distribution Network** at the **Connection Point** or a **Generator** to effect any works or to alter the manner of operation at the **Connection Point** which in either case involves that party in expenditure of more than £10,000. |
| **Minimum Generation** | **The minimum output which a Power Generating Module can reasonably generate as registered under the Distribution Data 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 has or may have a **Material Effect** on the **DNO** or a **Customer**, as the case may be, at a particular **Connection Point**. |
| **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. |
| **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. |
| **LV Synchronous Generating Unit Performance Chart** | A diagram showing the **Active Power** (MW) and **Reactive Power** (MVAr) capability limits within which asynchronous **Generating Unit** at its stator terminals will be expected to operate under steady state conditions. |
| **Point of Common Coupling** | The point on a **Distribution Network,** electrically nearest the **Customer**’sInstallation**,** at which other **Customer**s 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.g |
| **Protection** | The provisions for detecting abnormal conditions on a systemand initiating fault clearance or actuating signals or indications. |
| **Q/Pmax** | The ratio of **Reactive Power** to the **Registered Capacity**. The relationship between **Power Factor** and **Q/Pmax** is given by the formula:-  **Power Factor** = Cos ]] |
| **Rated MW** | The “rating-plate” MW output of a **Synchronous Power Generating Module**, **Power Park Module** or **DC Converter**, being:  (a) that output up to which the **Synchronous Power Generating Module** was designed to operate (Calculated as specified in **British Standard BS** EN 60034 – 1); or  (b) the nominal rating for the MW output of a **Power Park Module** being the maximum continuous electric output power which the **Power Park Module** was designed to achieve under normal operating conditions; or  (c) the nominal rating for the MW import capacity and export capacity (if at a **DC Converter Station**) of a **DC Converter**. |
| **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 (Pmax)** | 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 System.  For Power Generating Modules connected to the DNO’s Distribution System via an inverter, the inverter rating is deemed to be the Power Generating Module’s rating. The maximum continuous Active Power which a Power Generating Module can produce, less any demand associated solely with facilitating the operation of that Power Generating Module and not fed into the Network. |
| **Embedded Medium Power Station** | An embedded **Power Generating Facility** 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** | 1. A person supplying electricity under an Electricity Supply Licence; or 2. A person supplying electricity under exemption under the Electricity Act 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004);   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 Generating Module** | means an indivisible set of installations which can generate 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 s**ynchronism**. |
| **Synchronism** | The condition under which a **Generating Unit** or system is connected to another system so that the frequencies, voltage and phase relationships of that **Generating Unit** 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 **Generating Unit** design which has been tested to ensure that the design meets the requirements of this EREC G99, and for which the **Manufacturer** has declared that all similar products supplied will be constructed to the same standards, 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. |
| **Unresolved Issues** | Any relevant EREC G99requirements 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 IEC34-16-1 |

# 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 A.x.

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**sto 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’**ssystems, 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:

1. maintain supplies to their **Customers** within defined statutory voltage and frequency limits;
2. ensure that the **Distribution Networks** at all voltage levels are adequately earthed;
3. comply with the “Security of Supply” criteria defined in EREC P2;
4. meet improving standards of supply in terms of customer minutes lost (CMLs) and the number of customer interruptions (CIs);
5. 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]](#footnote-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**swishing 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.** The process for the connection of single or multiple **Type A** **Type Tested** **Power Generating Modules** in parallel with public Low Voltage Distribution Networkswith an aggregate installed capacity of less than or equal to 16A per phase in a single premises is described in ERECG98 part 1. **Type A Type Tested** Power Generating Modules to be connected in parallel with a public Low Voltage Distribution Network in multiple premises or with a capacity greater than 17 kW single phase, is described in EREC G98 part 2. The connection of other **Power Generating Module**s (ie **Power Generating Module**s outside the scope of EREC G98) is covered by this Engineering Recommendation.

6.1.2 Where an installation comprises multiple **Power Park Modules** the application process and commissioning requirements should be based on the **Power Generating Facility** capacity (ie the aggregate capacity of all the **Power Park Module**s to be installed in any one installation), and whether the individual **Power Park Modules** are **Type Tested**.

6.1.3 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** capacity, and whether the individual synchronous **Power Generating Modules** are **Type Tested**. Where one or more new synchronous **Power Generating Module(s)** is to be connected to an existing installation then each new PGM 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.

6.1.4 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.

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

|  |  |  |
| --- | --- | --- |
| Existing **Power Generating Facility** | Additional **Power Generating Modules** | Comments |
| Nil | **Type A** **Power Generating Module** | EREC G98 if **Type Tested LV** connected, otherwise EREC G99 |
| Synchronous **Power Generating Units** commissioned under EREC G83 or EREC G59 | Synchronous **Power Generating Modules** | Original and additional units 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** commissioned under EREC G98 or EREC G99 | Synchronous **Power Generating Modules** | Original and additional **Power Generating Modules** treated separately. All **Power Generating Modules** need to comply with EREC G98 or EREC G99 and with operational requirements. |
| Asynchronous **Power Generating Units** commissioned under EREC G83 or EREC G59 | Asynchronous **Power Generating Units** | Original and additional units treated separately. Only additional **Power Generating Unit**s 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 Units** 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; both need to comply with operational requirements. |
| Asynchronous **Power Generating Units** commissioned under EREC G83 or EREC G59 and Asynchronous **Power Generating Modules** commissioned under EREC G98 or EREC G99 | Asynchronous **Power Generating Units** | Original units (EREC G83 or EREC G59) treated separately to the combined existing **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

6.1.6 It should be noted that if the aggregate 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.

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

A connection procedure to facilitate the connection and operation of **Type Tested** **Power Generating Module**s with aggregate installed 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.

**6.1.8 Type A Power Generating Module(s) ≤ 16A per phase and not EREC G98 compliant**

Where the **Power Generating Module** does not meet the requirements of EREC G98 because the **Power Generating Module** has not successfully been through the type testing process the connection process shall follow that for **Type A** **Power Generating Module**s as described in this document.

6.1.9 **Type A** **Power Generating Module(s)** **> 16A per phase and EREC G98 compliant.**

A connection procedure to facilitate the connection and operation of Type A **Type Tested** **Power Generating Module**s with aggregate installed capacity greater than 16 A per phase in parallel with public **Low Voltage** **Distribution Network** is given in EREC G98 part 2 and is not considered further in this document.

6.1.10 **Power Generating Module(s) not EREC G98** **compliant**

The connection process for these **Power Generating Module**s is described in this document.

**Generators** with a **Bilateral Agreement** with **NGET** are required to comply with applicable requirements of the **Grid Code**.**.** Where **Grid Code** requirements apply, it is the **Generator**’sresponsibility 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 and not EREC G98 compliant 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 12 of this EREC G99.

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 6.2.3 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.

The compliance, testing and commissioning requirements are detailed in Section 12 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**. 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**.

## 6.3 System Analysis for Connection Design

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 plant 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.



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 For synchronous machines, control systems for **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 Module**s 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 obtained in respect of **Type B**, **Type C and Type D 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:

1. 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;
2. 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**

Embedded **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.**

**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**  5c(i) Synchronous generators  5c(ii) Fixed speed induction generators  5c(iii) Double fed induction generators  5c(iv) Converter connected generators  5c(v) Transformers | 6.4.2 and Schedules 5c of the DDRC |
| (d) **Power Generating Module** data for **Type C Generating Faciliti**es | 6.4.3 and Schedules 5c of the  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 Embedded 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 Codebefore 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 systemlayout:

**Operation Diagrams** showing the electrical circuitry of the existing and proposed main features within the **Customer’s** systemand 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** systemdirectly 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** systemoperated 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 generation 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 Embedded Power Generating Facilities.**

The **Standard Planning Data** and **Detailed Planning Data** specified in Schedule 5b and Schedule 5c of the Distribution Data Registration Codemay 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 Codeincludes 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 generators

(ii) Fixed speed induction generators

(iii) Doubly fed induction generators

(iv) Series converter connected generators.

(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.

1. In addition to supplying the **DNO** with details of **Power Generating Modules** there is a requirement 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 **Customer s** 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 Codeis indicative of the type of network data the **DNOs** is required to provide to **Customer s** 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 Module** 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 Module** 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

1. This mode of operation typically enables **Power Generating Module** 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**.
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.
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:

1. 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.
2. 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.
3. 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**.
4. 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 9.9 would be acceptable.
5. 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.” Paragraph 9.5.6 below provides more information on the assessment of such situations.

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 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 .

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

7.4.1.5 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 DNO’s Distribution Network when it operates as a switched alternative only supply

### 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**:

1. An electrical interlock between the closing and tripping circuits of the changeover circuit breakers;
2. A mechanical interlock between the operating mechanisms of the changeover circuit breakers;
3. An electro-mechanical interlock in the mechanisms and in the control circuit of the changeover circuit breakers;
4. 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**:

1. Manual break-before-make changeover switch;
2. 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;
3. An automatic break-before-make changeover contactor;
4. Two separate contactors which are both mechanically and electrically interlocked;
5. 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**.

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

7.5.1. Connection of single phase **Type A** **Type Tested Power Generating Modules** under EREC G98 part 2 requires application to the **DNO** and may not be possible in many cases for technical reasons depending on point of connection and network design.

7.5.2. A solution to voltage and phase imbalance issues may be to utilise 3-phase **Power Generating Module**s (the same export power will result in lower voltage rises due to decreased line currents and a 3 phase connection will result in voltage rises of a sixth of those created by a single phase connection), or to use multiple single phase **Power Generating Module**s connected across three phases. If these individual **Power Generating Modules** are of differing 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. An **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:

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

## 7.6 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. Howeverover 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 inverters only and will be tested as part of the type 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 Module**s 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 Generator**s 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** systemwhen 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



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 Module**s 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, “Requirements for the application of protective multiple earthing to low voltage networks”, 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

1. 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.
2. Where the **Power Generating Module** may be operated as a switched alternative only to the **DNO’s Network**, the **Power Generation Facility** shall provide an independent earth electrode.
3. 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.
4. 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 systemsshall 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**

# 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 detailedin 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:

1. to comply with the obligations (to include security, frequency and voltage; voltage disturbances and harmonic distortion; auto reclosing and single phase protection operation).
2. 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**. These requirements are listed in this section.

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 **Power Generating Module** should allow the full MVA capacity 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 9.5.

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 9.12 and 9.13 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 Section 9.8.

9.3 **Power Generating Module Performance and Control Requirements**

9.3.1 The requirements of this section do not apply to **Power Generation Facilities** that are designed and installed for infrequent short term parallel operation only.

9.3.2 The design of and any changes to the schemes and settings of the different control devices of a **Type B, Type C or Type D** **Power Generating Module** that are known to be necessary for **Transmission System Stability** and for taking emergency action shall be coordinated and agreed between **NETSO**, the **DNO** and the **Generator**.

9.3.3For **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 **Generating Unit** terminals are defined according to the connection method and will be specified by the **DNO** with the offer for connection. The **Registered Capacity** 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** unless otherwise agreed with the **DNO**.

9.3.4 **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 (including remote operation).

9.3.5 **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 (including remote operation).

9.3.6 **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.** In the event the load controller or related control system is out of service, manual local measures may be permitted. In such cases the **DNO** shall notify **The Authority** of the time required to reach any new **Active Power** setpoint together with the tolerance for the **Active Power**.

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

9.3.8 The **Generator** will notify, and keep notified, the **DNO** of the set points of the control scheme for voltage control or **Power Factor** 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.

9.3.9 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** .

9.4 **Frequency response**

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

1. 47 Hz – 47.5 Hz Operation for a period of at least 20 seconds is required each time the frequency is within this range.
2. 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.
3. 49.0Hz – 51.0 Hz The **Power Generating Module** must remain connected in this range
4. 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.
5. 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range.

9.4.2 As stated in 9.4.1, 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 9.4.1. .

9.4.3 **Output power with falling frequency**

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

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

(b) (subject to the provisions of paragraph 9.4.1) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 9.1 for system frequency changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including 25⁰C, such that if the system frequency drops to 47 Hz the **Active Power** output does not decrease by more than 5%. In the case of a **CCGT Module**, the above requirement shall be retained down to 48.8 Hz. For system frequency below 48.8 Hz, the existing requirement shall be retained for a minimum period of 5 minutes while system frequency remains below that setting, and special measure(s) that may be required to meet this requirement shall be kept in service during this period. After that 5 minutes period, if system frequency remains below that setting, the special measure(s) must be discontinued if there is a materially increased risk of the **Gas Turbine** tripping. The need for special measure(s) is linked to the inherent **Gas Turbine Active Power** output reduction caused by reduced shaft speed due to falling system frequency. Where the need for special measures is identified in order to maintain output in line with the level identified in Figure 9.1 these measures should be still continued at ambient temperatures above 25⁰C maintaining as much of the **Active Power** achievable within the capability of the plant.

Figure 9.1



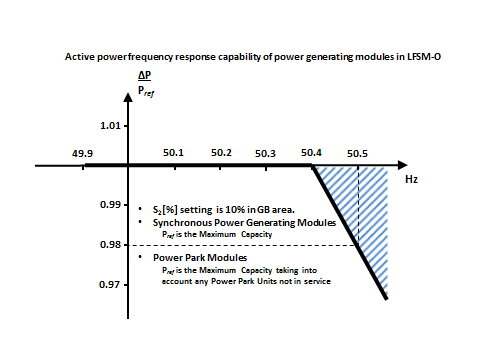
9.4.3.2 For the avoidance of doubt in the case of a **Power Generating Module** using an **Intermittent Power Source** where the power input will not be constant over time, the requirement is that the **Active Power** output shall be independent of system frequencyunder (a) above and should not drop withsystem frequencyby greater than the amount specified in (b) above.

9.4.4 **Limited Frequency Sensitive Mode – Over frequency**

9.4.4.1 Each Power Generating Module shall be capable of reducing Active Power output in response to system frequency when this rises above 50.4Hz. Such provision is known as Limited High Frequency Response. 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.

1. 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 9.2 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%.
2. 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.
3. 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**.
4. 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 50.4Hz.

Figure 9.2



Pref is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module**. Fn is the nominal frequency (50Hz) in the network and Δf is the frequency deviation in the network, At overfrequencies where Δf is below Δf1 the **Power Generating Module** has to provide a negative **Active Power** output change according to **Droop** S2

9.4.4.2 Each **Power Generating Module** which is providing **Limited High Frequency Response (LFSM-O)** must continue to provide it until the frequency has returned to or below 50.4Hz or until otherwise instructed by the **DNO**.

9.4.5 **Limited Frequency Sensitive Mode – Under frequency**

9.4.5.1 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**.

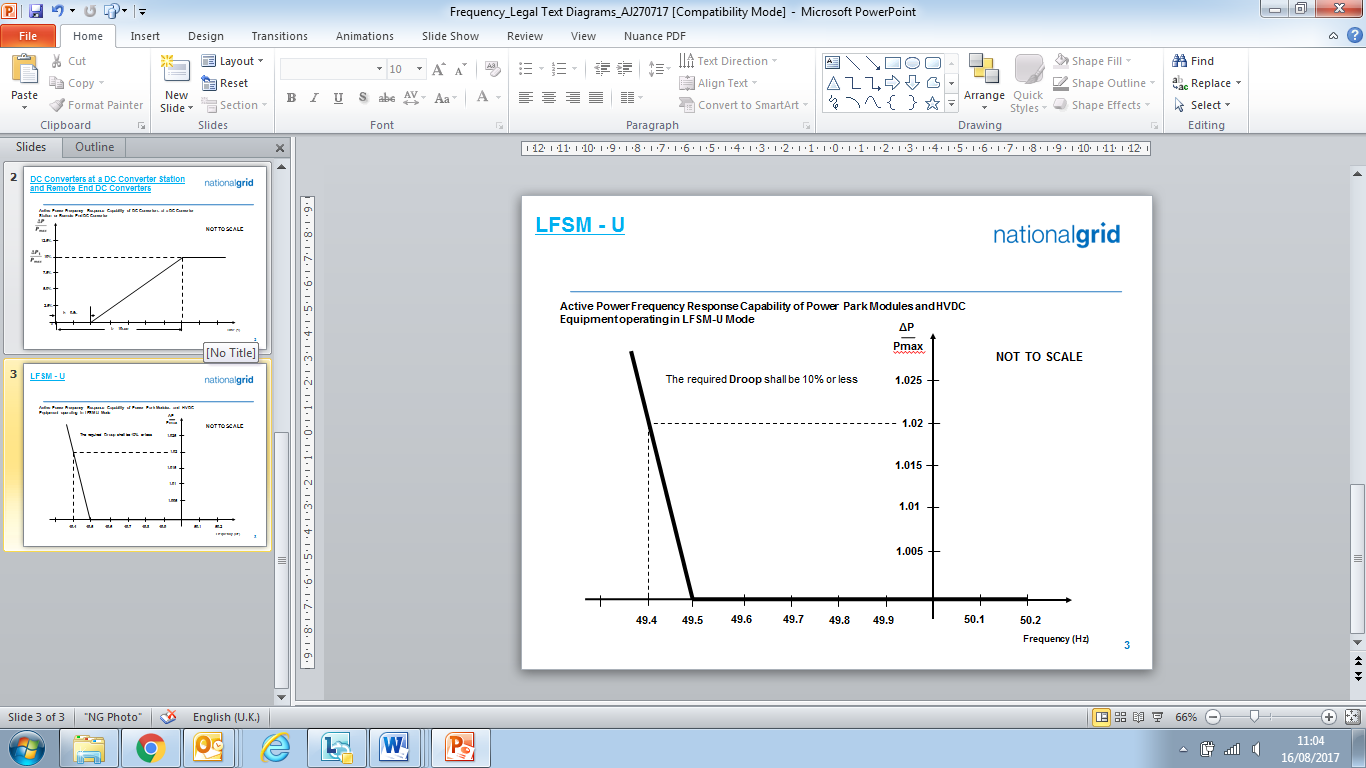
i) The rate of change of **Active Power** output must be at a minimum a rate of 2 percent of output per 0.1 Hz deviation of system frequency below 49.5Hz (ie a **droop** of 10%) as shown in Figure 9.3 below. This requirement only applies if the **Power Generating Module** has headroom and the ability to increase **Active Power** output. In the case of a **Power Park Module** the requirements of Figure 9.3 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%.

1. 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**.
2. 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 **Capacity** at low frequencies.
* The availability of primary energy sources.

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

Figure 9.3 - Limited Frequency Sensitive Mode – Underfrequency capability of Power Generating Modules



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

9.4.6.1 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 accordance with the **Grid Code** **Balancing Code 3** (**BC3**). 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:

1. **European Specification**: or
2. 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 9.4.6.1 (ii) will be notified to **the DNO** by the **Generator**:

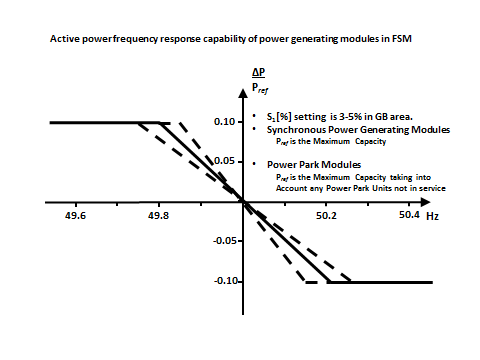
(i)assoon as possible prior to any modification or alteration to the frequency control device (or governor); and

9.4.6.2 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

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

1. **Power Generating Modules** shall be capable of providing **Active Power** frequency response in accordance with the performance characteristic shown in Figure 9.4 and parameters in Table 9.1.

Figure 9.4 – **Frequency Sensitive Mode** capability of **Power Generating Modules** and **DC Connected Power Park Modules**



**Active PowerActive Power**Table 9.1 – Parameters for Active PowerFrequency response in **Frequency Sensitivity Mode** including the mathematical expressions in Figure 9.4.

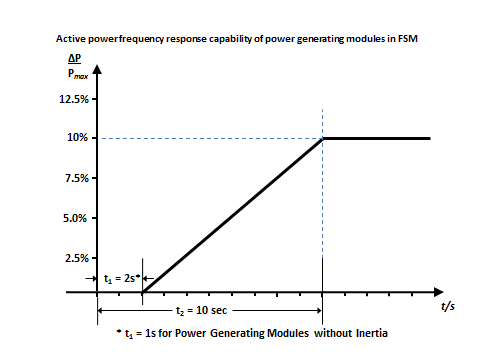
|  |  |
| --- | --- |
| Parameter | Setting |
| Nominal system frequency | 50Hz |
| Active power as a percentage of **Registered Capacity ()** | 10% |
| **Frequency Response Insensitivity** in mHz (ǀ) | ±15mHz |
| **Frequency Response Insensitivity** as a percentage of nominal frequency () | ±0.03% |
| **Frequency Response Deadband** in mHz | 0 (mHz) |
| Droop (%) | 3 – 5% |

1. In satisfying the performance requirements specified in paragraph 9.5c **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 lowfrequencies as specified in 9.4.1 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.

1. 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 9.5 and parameters in Table 9.2.

Figure 9.5 **Active Power** frequency response capability



Pmax is the **Registered Capacity** to which Δ*Ρ* relates. ΔΡ is the change in **Active Power** output from the **Power Generating Module**. The **Power Generating Module** has to provide **Active Power** output ΔΡ up to the point ΔΡ1 in accordance with the times t1 and t2 with the values of ΔΡ1, t1and t2 being specified in Table 9.2. t1 is the initial delay. t2 is the time for full activation.

Table 9.2 – 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**) ()** | 10% |
| Maximum admissible initial delay t1 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 t2 | 10 seconds |

Table 9.2 also includes the mathematical expressions used in Figure 9.5.

1. 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.

(vi) 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.

9.5 **Fault Contributions and Switchgear Considerations**

9.5.1 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.

9.5.2 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.

9.5.3 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.

9.5.4 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.

9.5.5 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.

9.5.6 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.

9.5.7 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 material detrimental 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.

9.5.8For 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.

9.5.9Disconnection 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.

9.6 **Negative phase sequence loadings**

9.6.1 Each Type C and Type D **Synchronous** **Power** **Generating Module** 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 DNO system.

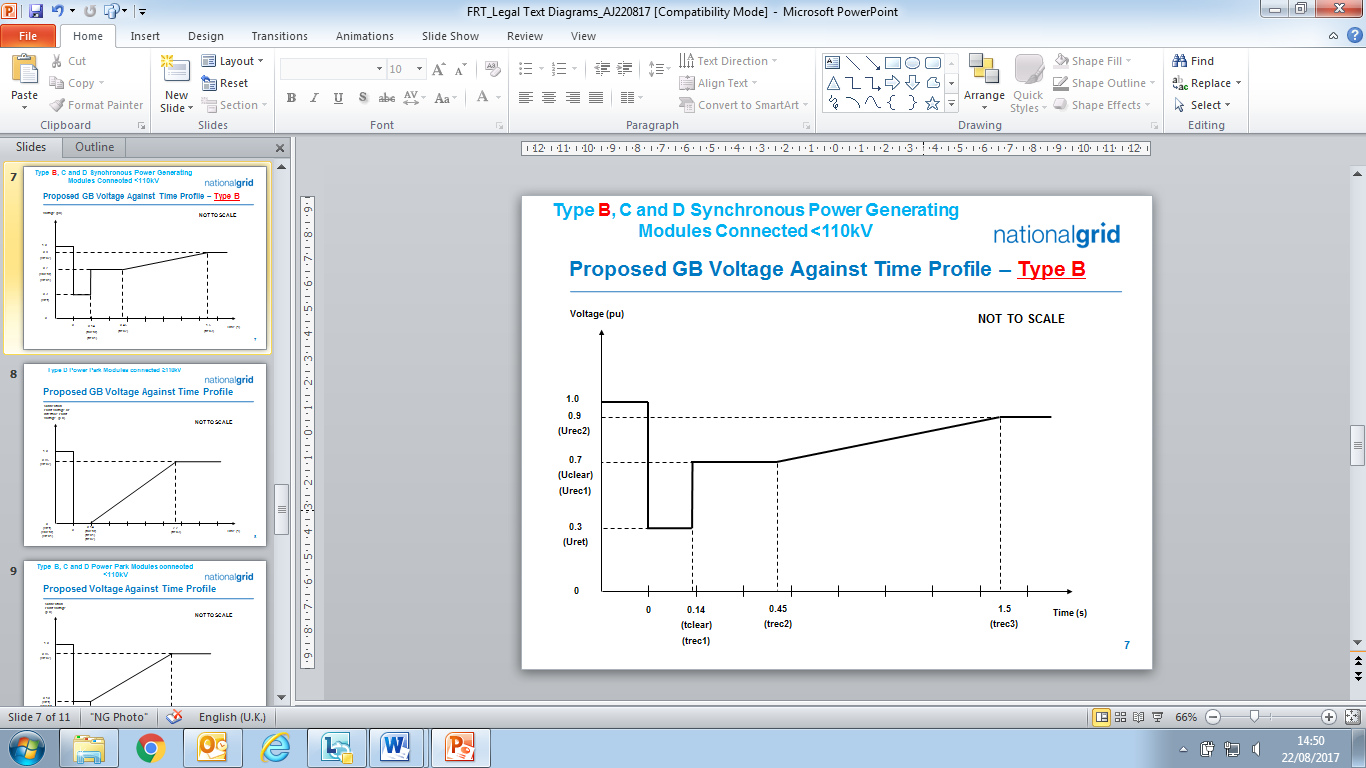
9.7 **Fault Ride Through**

9.7.1 Paragraphs 9.7.1.1 to 9.7.13 inclusive set out the fault ride through, principles and concepts applicable to **Type B, 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.

9.7.1.1 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 9.6 and 9.4 below.

9.7.1.2 The voltage against time curves defined in paragraphs 9.7.1.3 – 9.7.1.12 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 networkvoltage level at **Connection Point** during a symmetrical or asymmetrical/unbalanced fault, as a function of time before, during and after the fault.

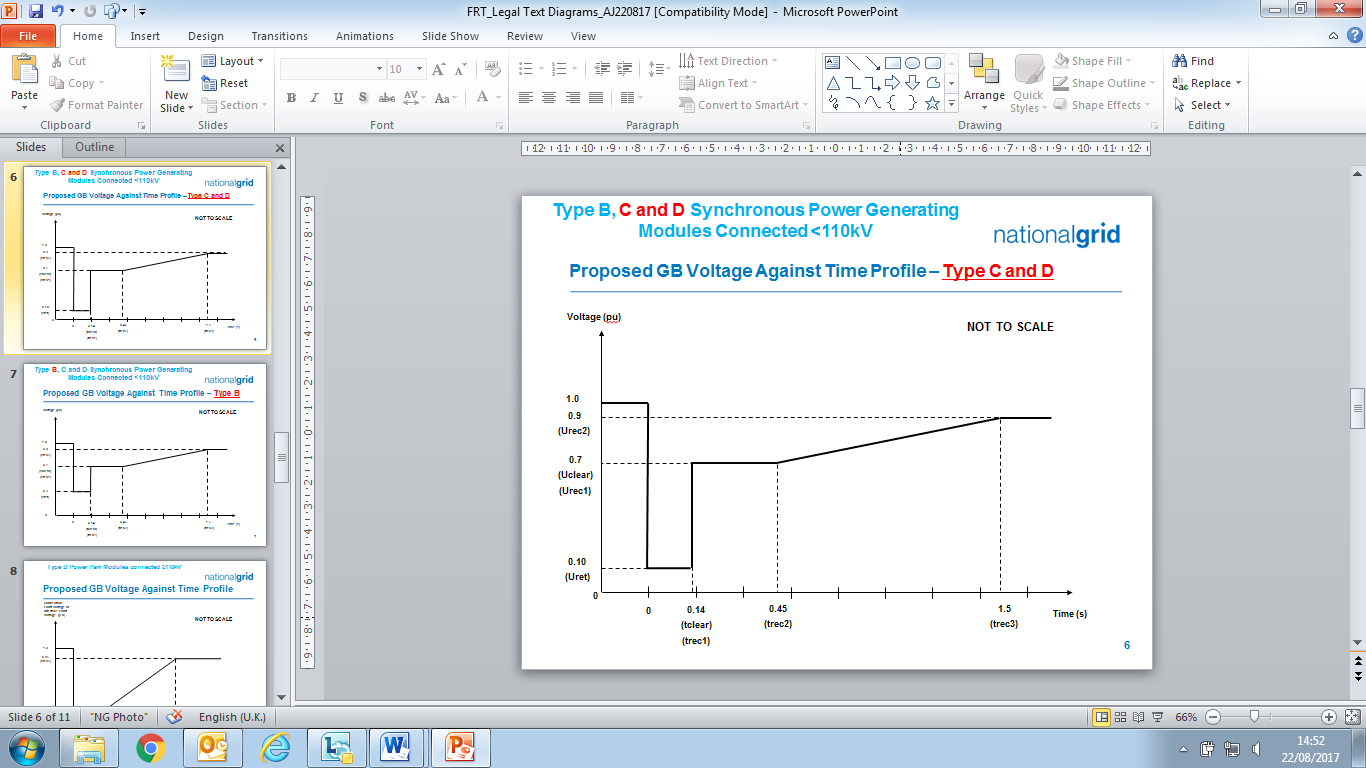
9.7.1.3 Figure 9.6 - Voltage against time curve applicable to Type B **Synchronous Power Generating Modules**



9.7.1.4 Table 9.3 Voltage against time parameters applicable to Type B **Synchronous Power Generating Modules**

|  |  |  |  |
| --- | --- | --- | --- |
| **Voltage parameters (pu)** | | **Time parameters (seconds)** | |
| Uret | 0.3 | tclear | 0.14 |
| Uclear | 0.7 | trec1 | 0.14 |
| Urec1 | 0.7 | trec2 | 0.45 |
| Urec2 | 0.9 | trec3 | 1.5 |

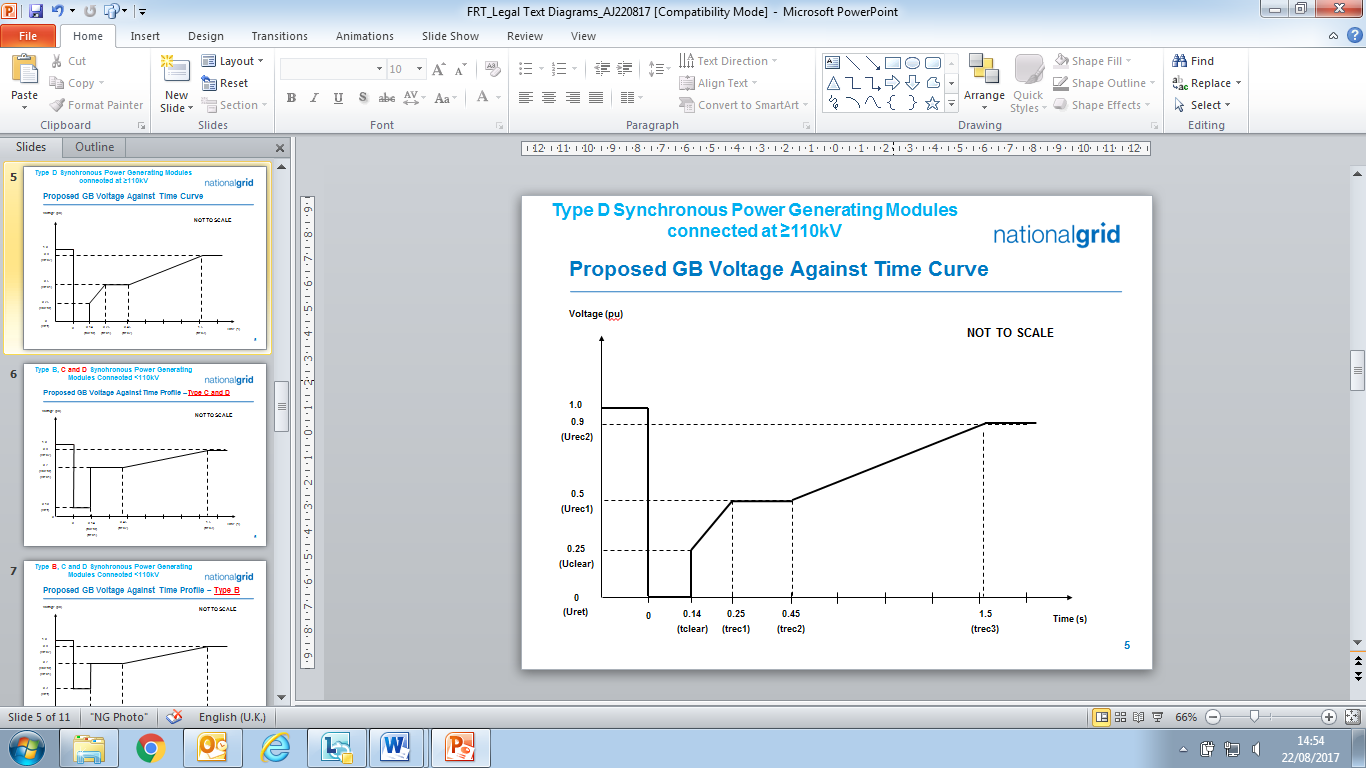
9.7.1.5 Figure 9.7 Voltage against time curve applicable to **Type C** and **D Synchronous Power Generating Modules** connected below 110kV



9.7.1.6 Table 9.4 Voltage against time parameters applicable to **Type C** and **D Synchronous Power Generating Modules** connected below 110kV

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

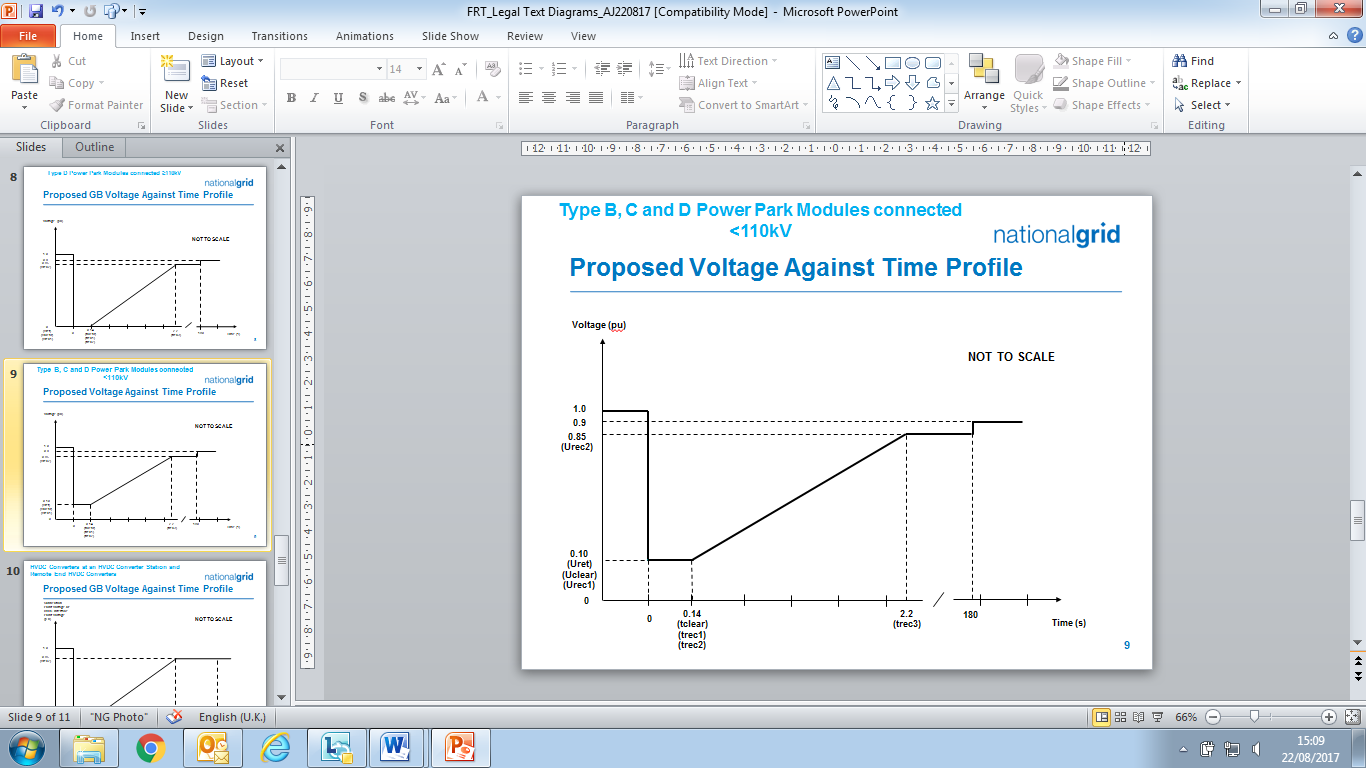
9.7.1.7 Figure 9.8 - Voltage against time curve applicable to **Type D Synchronous Power Generating Modules** connected at or above 110kV



9.7.1.8 Table 9.5 Voltage against time parameters applicable to **Type D Synchronous Power Generating Modules** connected at or above 110kV

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

9.7.1.9Figure 9.9 - Voltage against time curve applicable to **Type B, C** and **D** **Power Park Modules** connected below 110kV

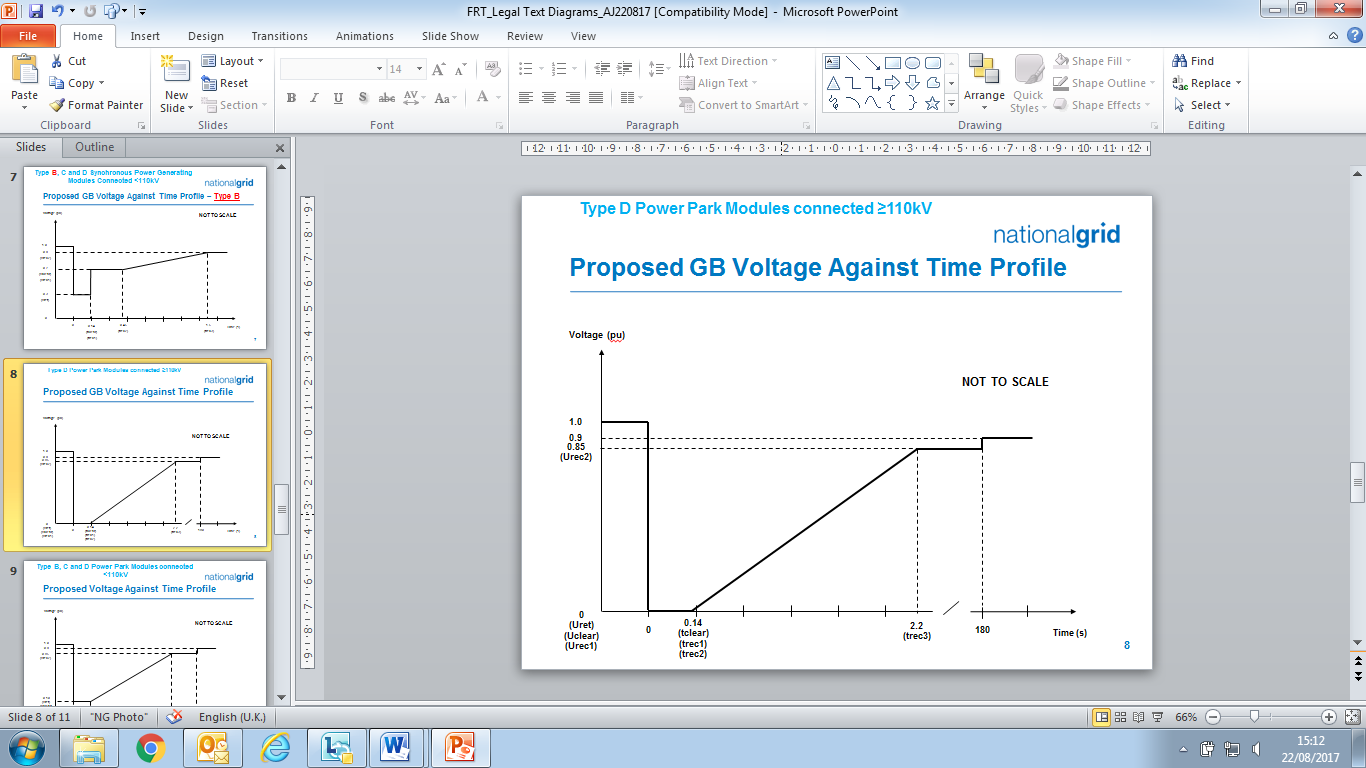


9.7.1.10

|  |  |  |  |
| --- | --- | --- | --- |
| **Voltage parameters (pu)** | | **Time parameters (seconds)** | |
| Uret | 0.1 | tclear | 0.14 |
| Uclear | 0.10 | trec1 | 0.14 |
| Urec1 | 0.10 | trec2 | 0.14 |
| Urec2 | 0.85 | trec3 | 2.2 |

Table 9.6 Voltage against time parameters applicable to **Type B, C** and **D Power Park Modules** connected below 110kV

9.7.1.11 Figure 9.10 - Voltage against time curve applicable to **Type D Power Park Modules** connected at or above 110kV



9.7.1.12 Table 9.7 Voltage against time parameters applicable to **Type D Power Park Modules** connected at or above 110kV

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

9.7.1.13 In addition to the requirements in 9.7.1.3 to 9.7.12:

1. Each **Type B, Type C and Type D Power Generating Module** shall be capable of satisfying the above requirements at the **Connection Point** when operating at **Rated MW** output and maximum leading **Power Factor**.
2. The pre-fault voltage shall be taken to be 1.0pu and the post fault voltage shall not be less than 0.9pu.
3. **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 B, C** or **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.
4. Each **Generator** shall satisfy the requirements in paragraphs 9.7.1.13 (i) to (iii) unless the protection schemes and settings for internal electrical faults trips the **Type B, C** or **D** **Power Generating Module** from the network. The protection schemes and settings should not jeopardise fault ride through performance as specified in paragraphs 9.7.1.13 (i) to (iii). The undervoltage protection at the **Connection Point** shall be set by the **Generator** according to the widest possible range unless **the DNO** has agreed to narrower settings. All protection settings associated with undervoltage protection shall be agreed between the **DNO** and the **Generator**.
5. Each **Type B, 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 B, 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.

9.7.2 In addition to paragraphs 9.7.1.1 – 9.7.1.13 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.

9.7.3 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 Agreement** process, will advise the **Generator** of the expected Phase Voltage Unbalance.

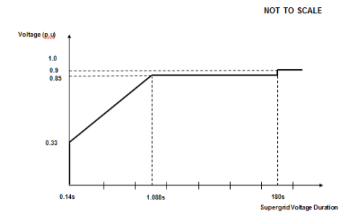
9.7.4 **General Fault Ride Through requirements, principles and concepts applicable to Type B, Type C and Type D Power Generating Modules subject to faults in excess of 140ms in duration.**

9.7.4.1 The Fault Ride Through requirements on **Type B, Type C** and **Type D Synchronous Power Generating Modules** and **Power Park Modules** forvoltagedips on the **Network** greater than 140ms in duration are defined in this section.

9.7.4.2 Each **Synchronous** **Generating Module** shall:

(i) remain transiently stable and connected to the system without tripping of any **Synchronous** **Power** **Generating Module** forbalanced voltage dips and associated durations on the **Network** anywhere on or above the heavy black line shown in Figure 9.11. Appendix X and Figures X5 (a), (b) and (c) provide an explanation and illustrations of Figure 9.11; and,

Figure 9.11



1. provide **Active Power** output at the **Connection Point**, during voltage dips on the **Network** as described in Figure 9.11, 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 9.8.1) 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 9.11, within 1 second of restoration ofthevoltage 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.

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

(i) remain transiently stable and connected to the system without tripping of any **Power Park Module** and / or any constituent **Generating Unit**, for balanced voltage dips and associated durations on the **Network** anywhere on or above the heavy black line shown in Figure 9.12. Appendix X and Figures X7 (a), (b) and (c) provide an explanation and illustrations of Figure 9.12; and,

Figure 9.12



(ii) provide **Active Power** output at the **Connection Point** during voltage dips on the **Network** as described in Figure 9.12, at least in proportion to the retained balanced voltage at theat 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 9.12 that restricts the **Active Power** output below this level.

(iii) restore **Active Power** output, following voltage dips on the **Network** as described in Figure 9.12, within 1 second of restoration ofthevoltage at the **Connection Point** to the minimum levels specified in paragraph 9.8.1 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 9.12 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.

9.7.5 **Other Fault Ride Through Requirements**

1. In the case of a **Power Park Module**, the requirements in paragraph 9.7 do not apply when the **Power Park Module** is operating at less than 5% of its **Rated MW** 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.
2. 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**.
3. For the avoidance of doubt the requirements specified in this paragraph 9.7 do not apply to **Power Generating Modules** connected to an unhealthy circuit and islanded from the **Transmission System** even for delayed auto reclosure times.

**9.8** **Voltage Limits and Control**

9.8.1 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.

9.8.2 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.**

9.8.3 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.**

9.8.4 At **Active Power** output levels other than **Registered Capacity**, allalternators 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**.

9.8.5 **Excitation Performance Requirements**

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

9.8.6 The **DNO** will specify if the control system of the **Type B** **Synchronous Power Generating Module** or **Power Park Module** 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**.

9.8.7

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

9.8.8.1 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 9.16 of paragraph 9.10.2.4.

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

9.8.10Automatic 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.

9.8.11 **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.

## 9.9. Voltage Step Change

9.9.1 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.

9.9.2 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%.

9.9.3 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.

9.9.4 **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.

9.9.5 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%.

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

9.10 **Reactive Capability**

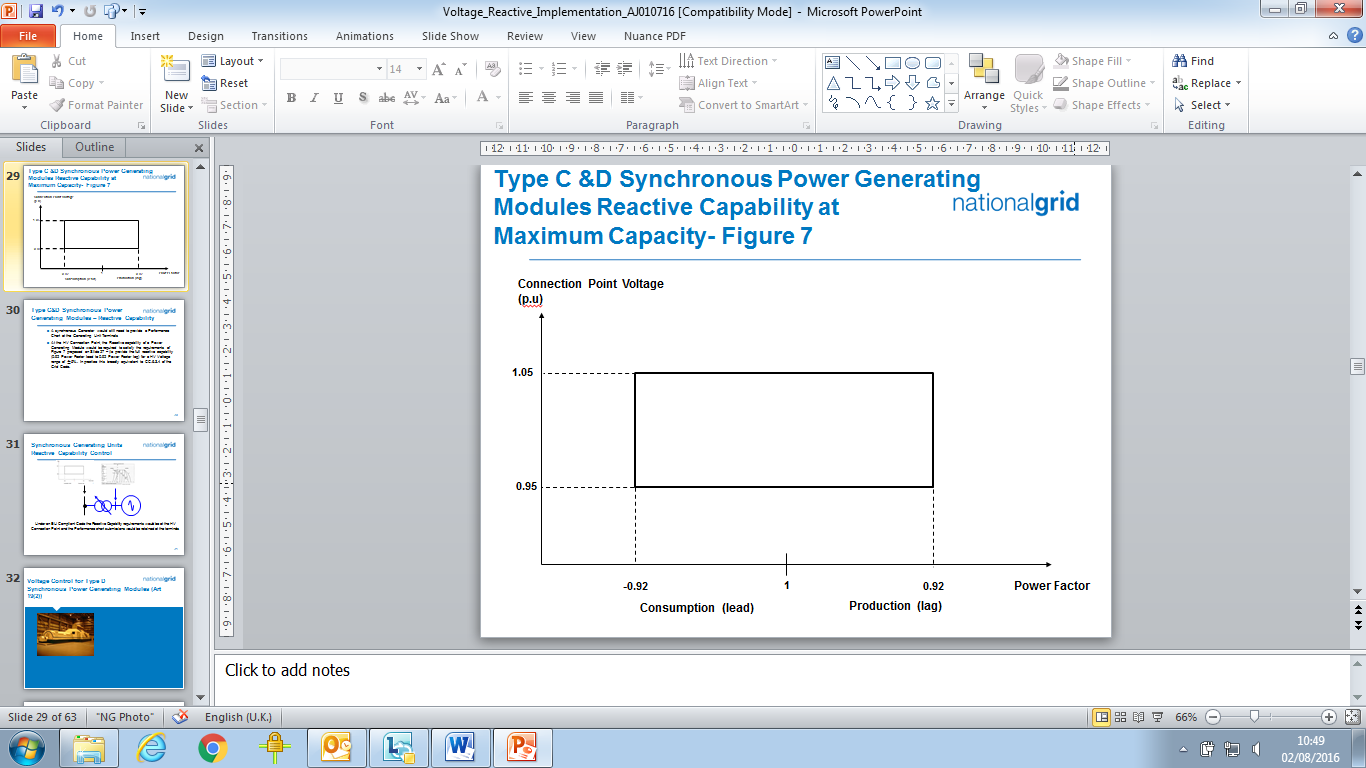
9.10.1 **Reactive Capability for Type C and D Synchronous Power Generating Modules**

9.10.1.1 In addition to meeting the requirements of Sections 9.10.1.2 and 9.10.1.3, **Generators** which connect a **Type C** or **Type D** **Synchronous** **Power Generating Module**(s) to private **Network**, may be required to meet reactive compensation requirements at the **Connection** where this is required for system reasons.

9.10.1.2 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 9.13 when operating at **Registered Capacity**.

9.10.1.3 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 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 9.13

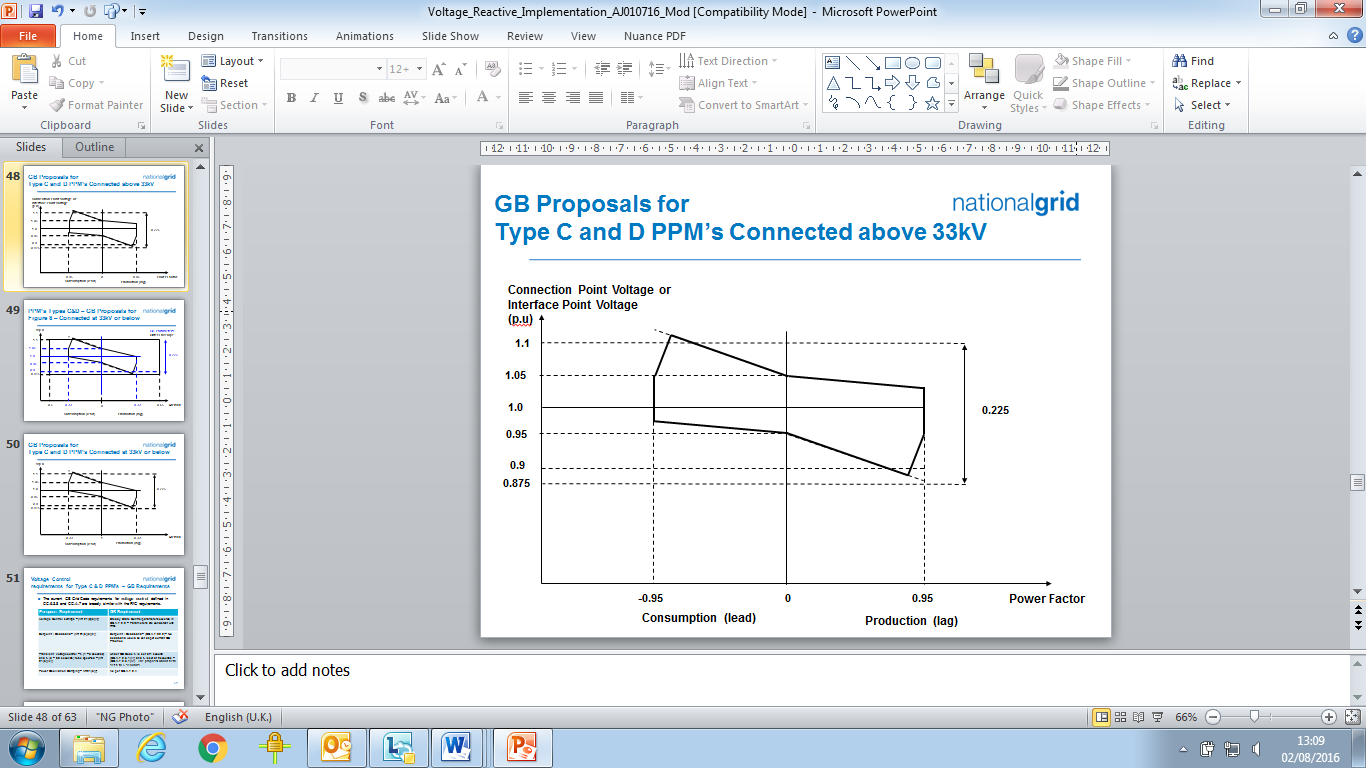


9.10.2 **Reactive Capability for Type C and D Power Park Modules**

9.10.2.1 In addition to meeting the requirements of Sections 9.10.2.2 to 9.10.2.4, **Generators** which connect a **Type C** or **Type D** **Power Park Module** to a private **Network**, may be required to meet reactive compensation requirements at the **Connection Point** where this is required for system reasons.

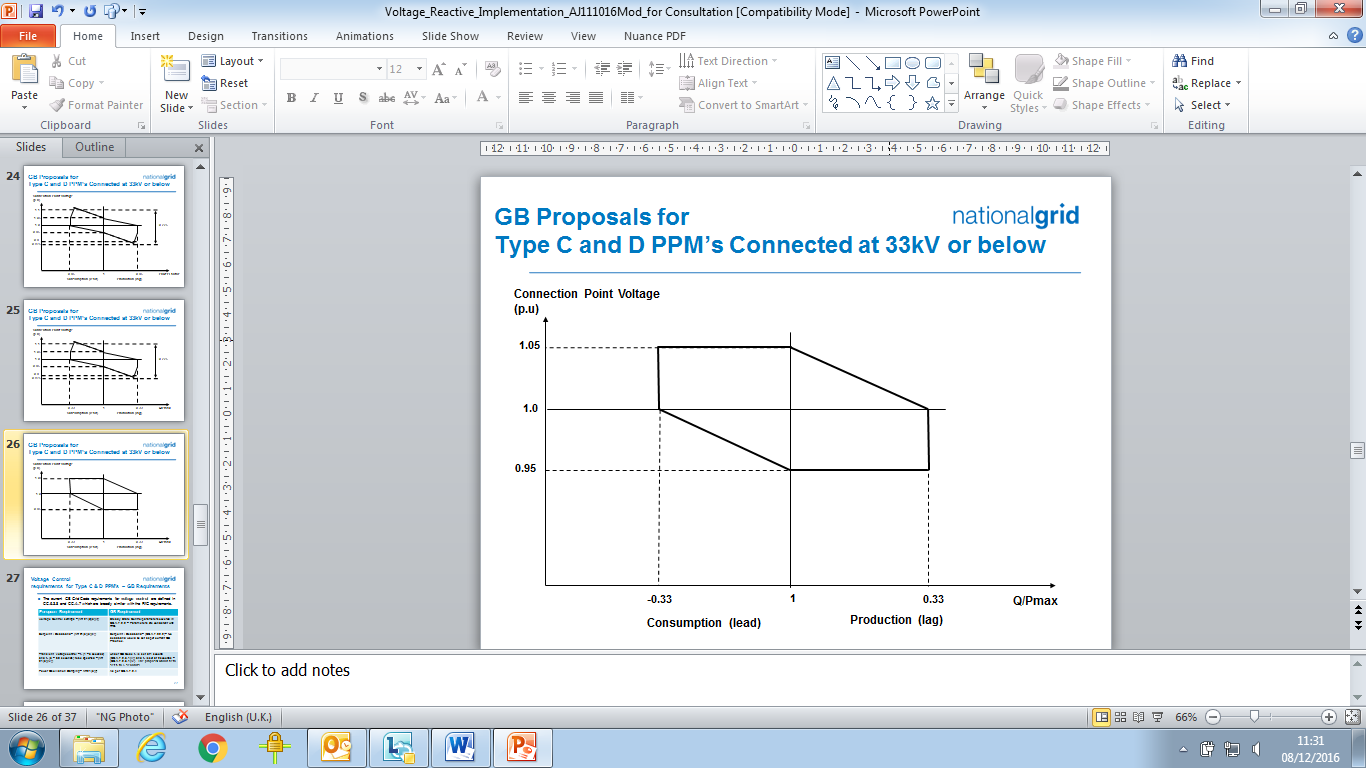
9.10.2.2 All **Type C** and **Type D Power Park Modules** with a **Connection Point** voltage above 33kV, shall be capable of satisfying the **Reactive Power** capability requirements at the **Connection Point** as defined in Figure 9.14 when operating at **Registered Capacity**.

Figure 9.14



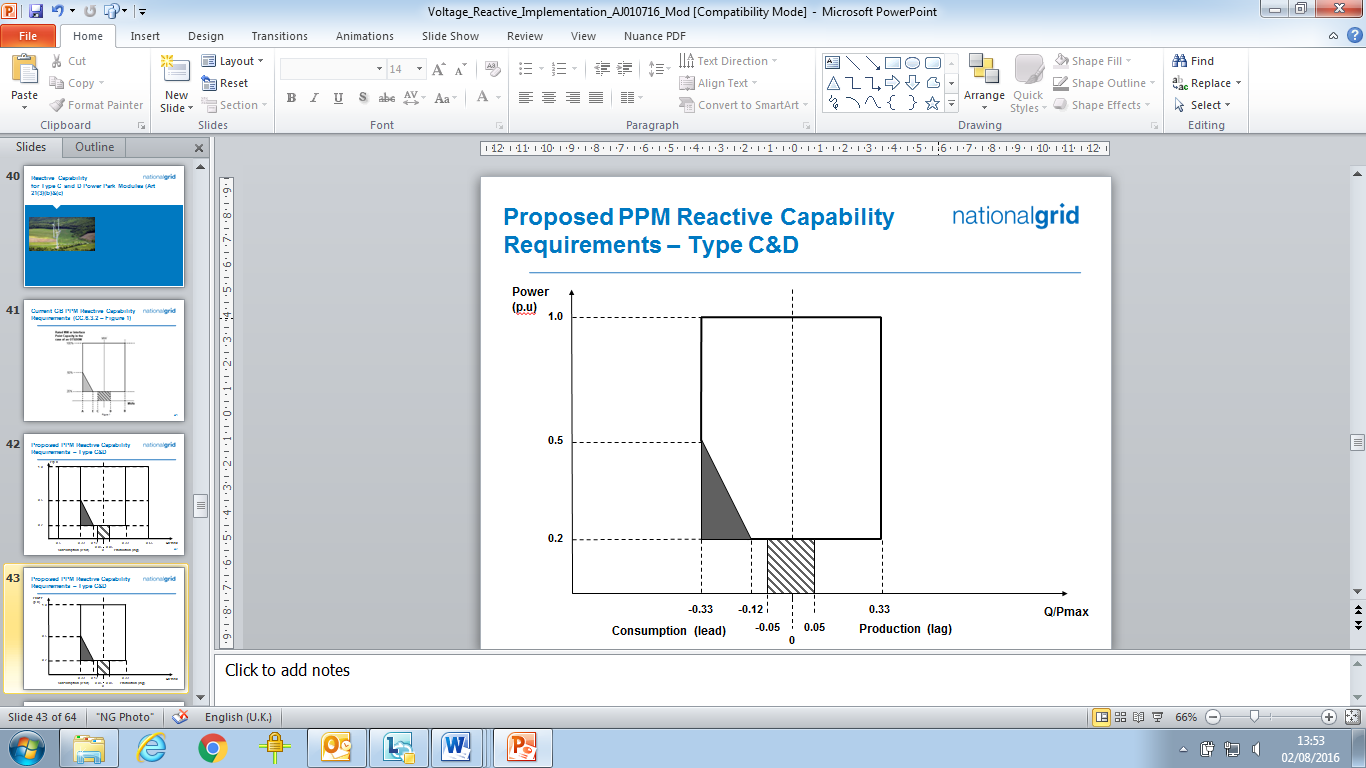
9.10.2.3 All **Type C or Type D Power Park Modules** with a **Connection Point** voltage at or below 33kV shall be capable of satisfying the **Reactive Power** capability requirements at the **Connection Point** as defined in Figure 9.15 when operating at **Registered Capacity**.

Figure 9.15



9.10.2.4 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 9.16 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 9.16 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 9.16



9.11 **Fast Fault Current Injection**

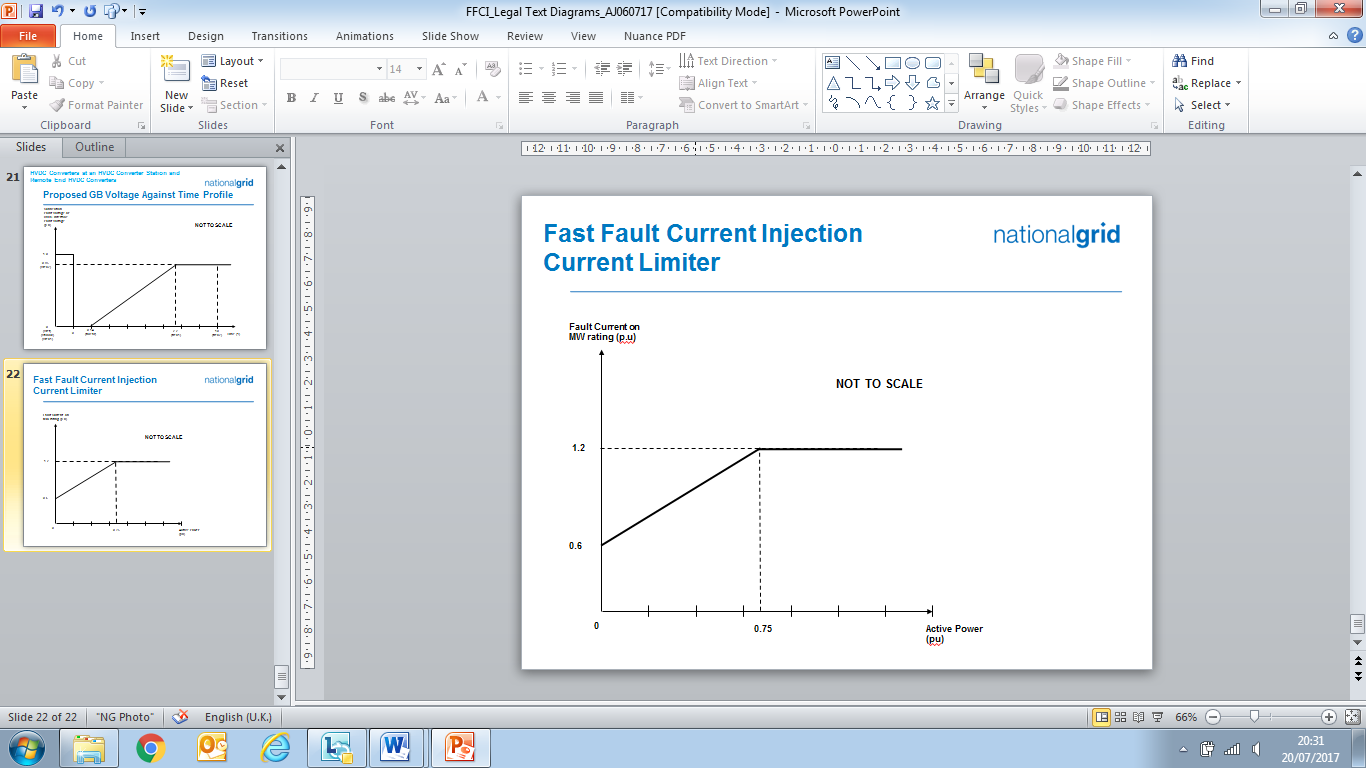
9.11.1 This section sets out the **Fast Fault Current** injection requirements for **Type B**, **Type C** and **Type D Power Park Modules**. **Generators** who own **Type B**, **Type C** and **Type D Power Park Modules** **NOTE;- AS PART OF THE STAKEHOLDER DISCUSSIONS THREE OPTIONS FOR FAST FAULT CURRENT INJECTION HAVE BEEN DISCUSSED. IT IS ANTICPATED THAT ONLY ONE OF THESE OPTIONS WILL ONLY EVENTUALLY BE INCOPORATED INTO THE FINAL GRID CODE AS APPROVED BY THE AUTHORITY. Please see NG drafting for more details**9.11.2

9.11.3 **Fast Fault Current injection – Option 1**

9.11.3.1 Each **Type B**, **Type C** and **Type D Power Park Module** shall be required to satisfy the following requirements which apply to both balanced and unbalanced faults:-

1. Each **Type B**, **Type C** and **Type D Power Park Module** shall across the frequency range defined in paragraph 9.4.1 behave as a voltage source behind a reactance over the 5Hz to 1kHz frequency band before, during and after the fault. A reactance of 10% of machine rating would be considered appropriate for this application unless the **DNO** has agreed to an alternative value; and
2. The phase voltages of the voltage source (as described in paragraph 9.11.3.1 (i)) may be changed in order to limit the amount of current delivered in any phase to no less than 1.5pu;
3. The phase angle and frequency of the voltage source (as described in paragraph 9.11.3.1 (i)) shall remain unchanged during the period of the fault. For the avoidance of doubt the phase angle of the current delivered into the system from each **Power Park Module** will be a function of the system load during the fault.
4. Upon clearance of the fault or disturbance, the phase voltages of the voltage source (as described in paragraph 9.11.3.1 (i)) shall maintain current up to a maximum of 1.5pu current until restoration of the voltage to the minimum levels specified in paragraph 9.8.1. For the avoidance of doubt, the post fault current and **Active Power** recovery will be determined by the system impedance following fault clearance.
5. For **Type B**, **Type C** and **Type D** **Power Park Modules** the measurement of the voltage deviation at each **Connection Point** shall be in accordance with the requirements defined under paragraph 9.12.4.2 and
6. The reactive current delivered from each **Type B**, **Type C** and **Type D** **Power Park Module** shall respond instantaneously and in proportion to the change in system voltage at the **Connection Point**.These requirements applyover the fullvoltage against time periods specified in paragraph 9.7.
7. **Generators** in respect of **Type B**, **Type C** and **Type D Power Park Modules** are required to inform the **DNO** prior to connection regarding the maximum number of repeated operations that can be performed each time the voltage at the **Connection Point** falls outside the limits specified in paragraphs 9.8.1 and 9.9.2and any limiting factors to repeated operation such as protection or thermal rating;
8. In the event that the **Power Park Module** fails to limit the current as detailed in paragraph 9.11.3.1 (i), it is permissible to restrict the maximum current to less than 1.5pu as agreed with the **DNO**. The **Customer** shall provide details of the current limiting condition including any necessary control block diagrams as required in **Schedule 5c of the Data Registration Code.** For the avoidance of doubt, each **Power Park Module** will also need to comply with the full fault ride through requirements detailed in paragraph 9.7 including the requirements for **Active Power** recovery.
9. **Generators** should have the capability to limit the fault infeed based on their current continuous MW output. There should be three parameter settings associated with this feature which shall be notified to the **DNO**. These shall be the maximum current infeed in pu on MVA rating adjustable between 1.05pu and 1.5pu with a default value of 1.5pu, minimum current infeed adjustable between 0.5pu with a default value of 1.5pu and the pu **Active Power** below which the fault current ramps down from the high level to the low level specified by the other parameters. This will be adjustable between 0 to 1pu **Active Power** and it will default to zero pu shown in Figure 9.17.

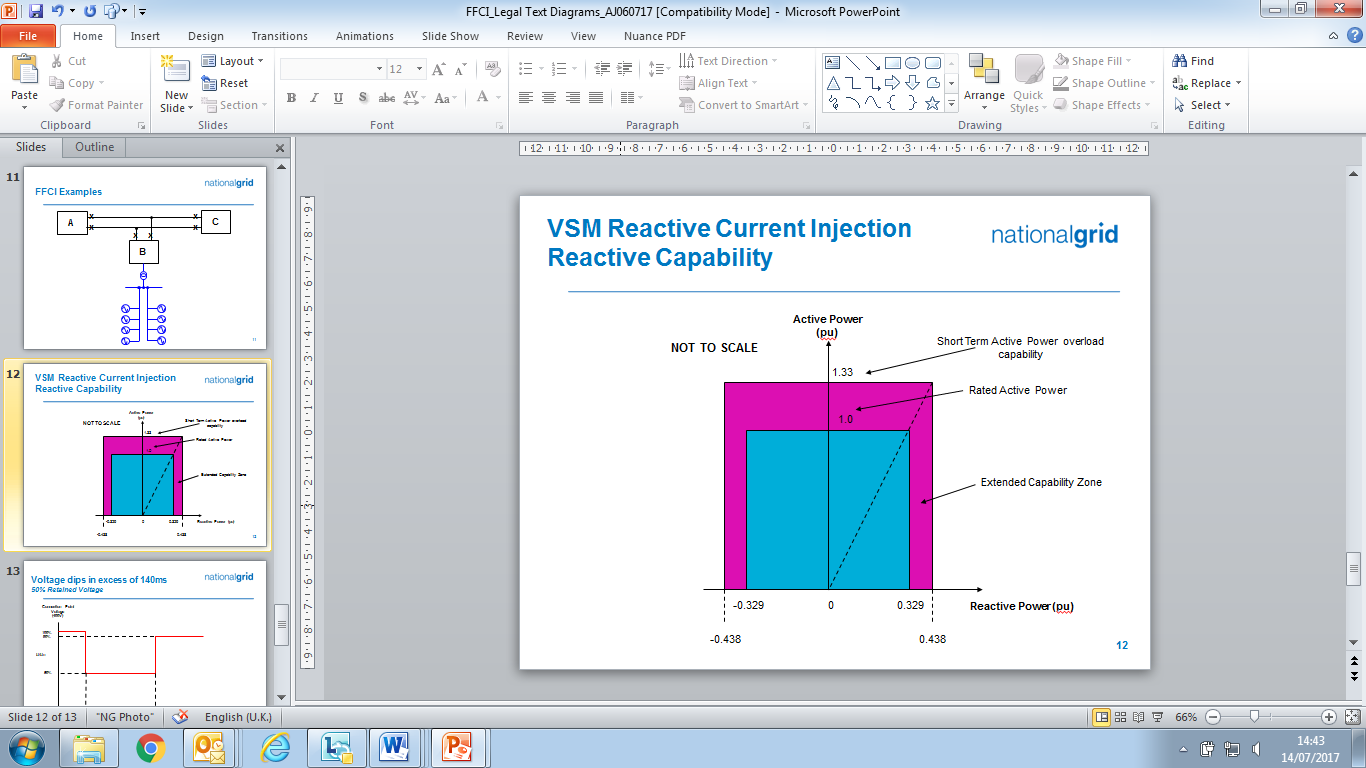
Figure 9.17



9.11.3.2 In addition to the requirements of paragraph 9.11.3.1 each **Type B**, **Type C** and **Type D Power Park Module** shall also be required to satisfy the following requirements:-

1. Following the clearance of the disturbance, reactive current delivery from each **Power Park Module** shall not increase voltages to levels beyond those specified within paragraph 9.8.1 and paragraph 9.9.2 and shall ensure that the **Power Park Module** is designed such that there is no risk of transient over voltages arising from clearance of the fault; and
2. In addition to the requirements of paragraphs 9.8 and 9.10 each **Type B**, **Type C** and **Type D Power Park Module** is required to meet the reactive capability requirements shown in Figure 9.18.

Figure 9.18



1. The short term **Active Power** overload capability defined in Figure 9.18 shall be limited to the lesser of a maximum value of 1.33pu of the **Rated Active Power** of each **Power Park Module** or 0.33pu increase in **Active Power** from the current operating point. It shall be required to be sustained for a period of 20 seconds.
2. For the voltage source defined in paragraph 9.11.3.1 rapid changes to the phase voltage, frequency and phase angle in the greater than 5Hz band are not permitted whilst the operating point remains within the extended capability zone specified in Figure 9.18.
3. The voltage source specified in paragraph 9.11.3.1 will maintain a balanced three phase sinusoidal voltage up to 1kHz provided the quality of supply limits remain within the limits of paragraphs 9.8.4, 9.12.3 and 9.12.4 provided that each **Power Park Module** is operating within its normal operating range specified in paragraphs 9.8 and 9.10. If the levels stated are exceeded, they may be reduced by adjusting the wave shape or phase voltages. The speed at which this occurs shall be limited such that they are bandwidth limited to less than 5Hz.
4. When operating within the extended range and operating at 1.05pu or above of rated current, the requirements of paragraphs 9.8.4, 9.12.3 and 9.12.4 may be relaxed such that each **Power Park Module** injects balanced three phase current and that the sinusoidal voltage source specified in paragraph 9.11.3.1 operates over a reduced bandwith of between 5Hz to 75Hz. Normal operation shall be resumed once the current falls below 1.05pu.

*Following paras and Appendix to be included in distribution document once Option selected (Appendix will replicate Grid Code text as suitable for distribution):*

1. The overall control system (including damping performance) of each **Type B**, **Type C** and **Type D** **Power Park Module** shall be designed in accordance with the requirements of ECC.6.3.X.X(*Control System Design as taken from Grid Code Appendix 6*)

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

**9.11. Fast Fault Current injection - Option 2**

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

1. 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 B**, **Type C** and **Type D Power Park Module** shall be required to inject a reactive current above the shaded red area shown in Figure 9.19(a) and Figure 9.19 (b).

Figure 9.19 (a)

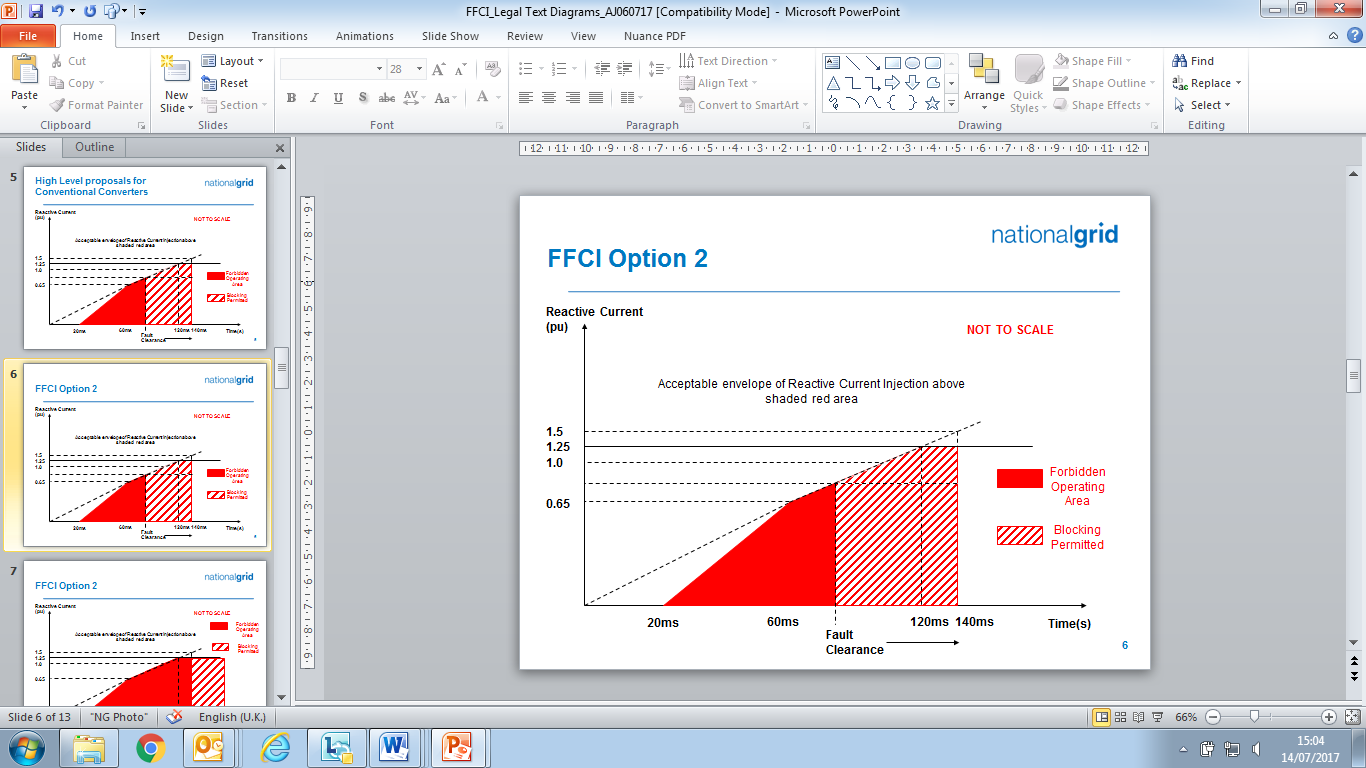
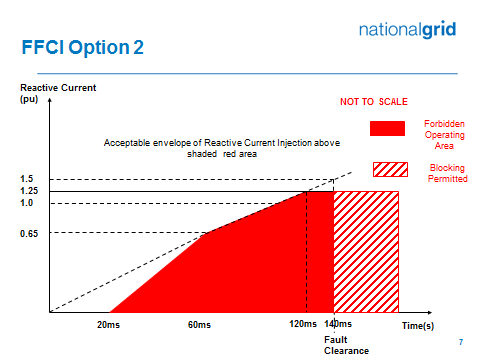


Figure 9.19 (b)



1. The converter of each **Type B**, **Type C** and **Type D Power Park Module** ispermitted to block upon fault clearance in order to mitigate against the risk of instability that would otherwise occur due to transient overvoltage excursions. Figure 9.19 (a) and Figure 9.19 (b) shows 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 9.7 (fault ride through).
2. 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 1.25pu of the rating of the **Power Park Module.**
3. Each **Type B**, **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**.
4. In addition to the requirements of paragraph 9.7 (*Fault Ride Through*) **Generators** in respect of **Type B**, **Type C** and **Type D Power Park Modules** are required to inform the **DNO,** their repeated ability to supply **Fast Fault Current** to the systemeach time the voltage at the **Connection Point** falls outside the limits specified in paragraph 9.8.1. **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;

An illustration and examples of the performance requirements expected are illustrated in Appendix 4EC. *(to be included once Option selected)*

**9.11.5 Fast Fault Current injection - Option 3**

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

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 B**, **Type C** and **Type D Power Park Module** shall be required to inject a reactive current above the shaded red area shown in Figure 9.20 (a) and Figure 9.20 (b).

Figure 9.20 (a)

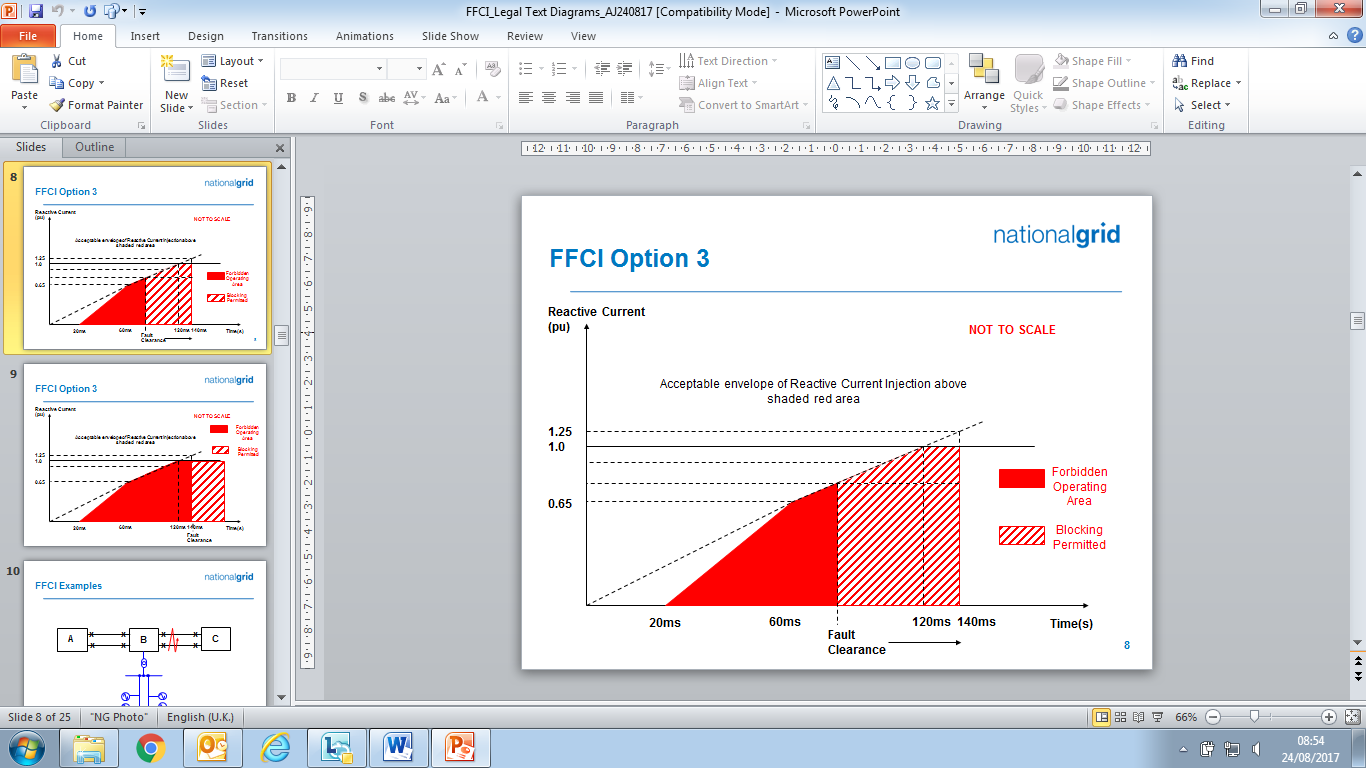
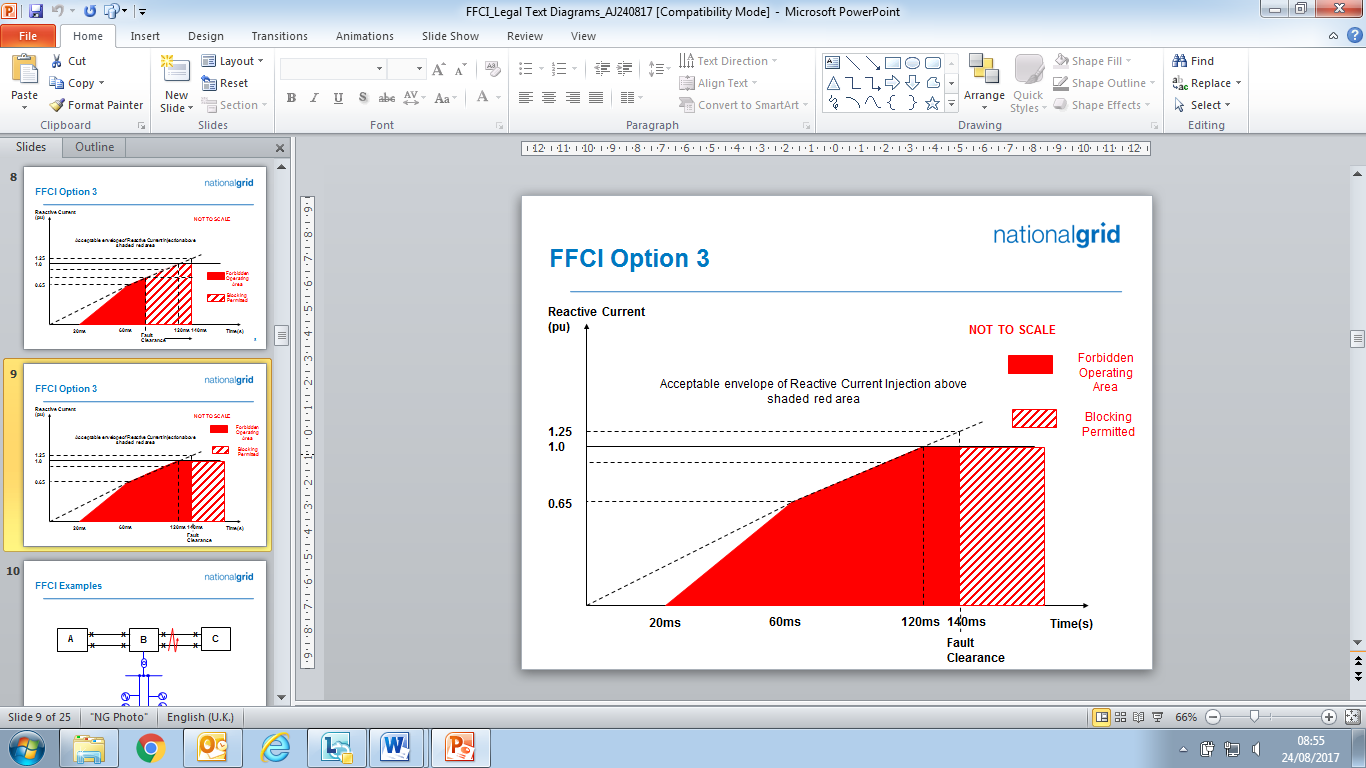


Figure 9.20 (b)



The converter of each **Type B**, **Type C** and **Type D Power Park Module** ispermitted to block upon fault clearance in order to mitigate against the risk of instability that would otherwise occur due to transient overvoltage excursions. Figure 9.20 (a) and Figure 9.20 (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 9.7 (fault ride through).

1. 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**.
2. Each **Type B**, **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**.
3. In addition to the requirements of paragraph 9.7 (*Fault Ride Through*) **Generators** in respect of **Type B**, **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 systemeach time the voltage at the **Connection Point** falls outside the limits specified in paragraph 9.8.1. **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; and

An illustration and examples of the performance requirements expected are illustrated in Appendix 4EC. *(To be completed once Option selected)*

## 9.12 Power Quality

9.12.1 **Introduction**

9.12.1.1 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.

9.12.2 **Flicker**

9.12.2.1 Where the input motive powerof 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.

9.12.2.2 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**.

9.12.2.3 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.

9.12.2.4 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.

9.12.2.5 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 back ground 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.

9.12.2.6 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.

9.12.3 **Harmonic Emissions**

9.12.3.1 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**.

9.12.3.2 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.**

9.12.3.3 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.

9.12.3.4 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.

9.12.4 **Voltage imbalance**

9.12.4.1 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 11 kV and below.

9.12.4.2 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.

9.12.4.3 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**.

9.12.4.4 **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.

9.12.5 **DC Injection**

9.12.5.1 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**.

9.12.5.2 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**.

## 9.13 System Stability

9.13.1 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.

9.13.2 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**.

9.13.3 **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.

9.13.3.1 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.

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

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

9.13.3.4 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.

9.13.3.5 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.

9.13.5 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.

9.13.6 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.

9.13.6.1 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.

19.13.6.2 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.

9.13.7 With the systemin 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 ER P2/6, 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

9.13.8 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.

9.13.9 Any **Power Generating Module**that causes the systemto become unstable under fault conditions must be rapidly disconnected to reduce the risk of plantdamage and disturbance to the system.

9.13.10 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);
* 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.

## 9.14 Island Mode

9.14.1 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.

9.14.2 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:

1. load flows, voltage regulation, frequency regulation, voltage unbalance, voltage flicker and harmonic voltage distortion;
2. earthing arrangements;
3. short circuit currents and the adequacy of protection arrangements;
4. **System Stability**;
5. resynchronisation to the **Total System**;
6. safety of personnel.

9.14.3 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.

9.14.4 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.

9.14.5 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.

9.14.6 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.

9.14.7 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.

9.14.8 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.

9.15 **Black Start Capability**

9.15.1 The National Electricity Transmission System will be equipped with Black Start Stations (in accordance with the Distribution Operating Code DOC 9). 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.

9.16 **Technical Requirements for Embedded Medium Power Stations**

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

9.16.2 In addition to the requirements in Section 9 of this EREC G99, the **DNO** has an obligation under CC 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 CC 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 CC3.4 of the **Grid Code** as part of compliance with this EREC G99.

9.16.3 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**.

9.16.4 **Grid Code Connection Conditions Compliance**

9.16.4.1 The technical designs and parameters of the **Embedded Medium Power Station** will comply with the relevant Connection Conditions of the **Grid Code**. A statement to this effect, stating compliance with OC5.8 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.

9.16.4.2 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 9.16.4.1, the **Generator** must notify the change to the **DNO**, as soon as reasonably practicable, who will in turn notify the **NETSO.**

9.16.4.3 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

9.16.4.4 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.

9.17 **Operational monitoring**

9.17.1 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.]

9.17.2 At each **Power Generating Facility including Type B**, **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.

9.17.3 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 X.

(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**.

9.17.4 The **Customer** will provide all relevant signals for onsite monitoring in the form of d.c. 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 **B DNO**. All signals shallbe suitably terminated in a single accessible location at the **Generator**s site.

9.17.5 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

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

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

9.17.7.1 **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 secure and 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.

9.17.7.2 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**.

9.17.7.3 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**.

9.18 **Steady State Load Inaccuracies**

9.18.1 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 **PC**.

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

# 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.

Where a common protection system is used to provide the protection function for multiple **Power Generating Module**s the complete installation cannot be considered to comprise **Type Tested** **Power Generating Module**s as the protection and connections are made up on site and so cannot be factory tested or **Type Tested**.

10.1.3 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**

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:

1. For all **Power Generating Modules**:
   1. 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**;
   2. 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.
2. For polyphase **Power Generating Module** **Error! Reference source not found.**
   1. 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;
   2. 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**;
3. For single phase **Power Generating Modules**
4. 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;
5. 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), phase angle change or unbalanced voltages. More details on LoM protection are given in Section 10.3.

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 **Connection Point** on the **DNO’s** side of the supply terminals must be within the **frequency and voltage** ranges of the interface protection as listed in 10.6.7 for at least 20s before the **Power Generating Module** is allowed to automatically connect to the **DNO’s Distribution Network**. If there is a maximum admissible gradient of increase in **Active Power** output on connecting this will be specified by in the Connection Agreement.10.3.4 Installation of automatic reconnection systems 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:

1. the control equipment satisfies all the requirements of Section 10 including the relevant standards specified in 10.2.4.
2. 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.
3. 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 is mandatory for all **Type A** and **Type B Power Generating Modules**. For **Type C** and **Type D Power Generating Modules** the **DNO** will advise if LoM 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 Many **Customers** are connected to parts of **Distribution Networks** which will be automatically re-energised within a relatively short period following a fault; with dead times typically between 1s and 180s. The use of such schemes is likely to increase in the future as **DNO**s seek to improve supply availability by installing automatic switching equipment on their **Distribution Network**s.

10.4.5 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**:

1. 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;
2. 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
3. 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

10.4.6 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. In some particularly critical circumstances it may be necessary to improve the dependability of LoM detection by using at least two LoM techniques operating with different principles or by employing a LoM relay using active methods.

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

10.4.8 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**.

10.4.9 Protection based on measurement of reverse flow of **Active Po**weror **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**.

10.4.10 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.

10.4.11 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.

10.4.12 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

10.4.13 It is recognized that the steady evolution of the GB **Transmission System**, particularly with the displacement of traditional steam powered turbo alternators by renewable generation, the concomitant reduction in system inertia is leading to greater volatility of system frequency. This volatility and its implications for loss of mains protection systems is being kept under review by National Grid and the DNOs. Nevertheless the settings required in this current G99 document are believed to be appropriate for the long term.

10.4.14

10.4.16 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 A.x 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 caseswhere the **DNO** requires LoM protection this must be provided by a means not susceptible to spurious or nuisance tripping, eg intertripping.

10.4.17 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.

10.4.18 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 9.14.6 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**, point of connection, 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:

1. The specification of capability of the LoM protection, including the provision of multiple independent detection techniques;
2. The influence of activation of pre-existing NVD protection already present elsewhere on the same prospective island;
3. 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 and Type B 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]](#footnote-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);
* Stage 2 (**HV**) should have a setting of +13% 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**

Section 9.4 requires **all Power Generating Facilities** 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 and Type B Power Generating Modules** | | | | **Type C and Type D PGMs** | |
| **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 (Hz/s). The time delay should begin when the measured RoCoF RoCoF exceeds the threshold expressed in Hz/s. 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 Hz/s 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 13.8 have been completed successfully

1. 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 and Type B 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.

10.6.9The settings in 10.6.7.1 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 10.6.7.1. 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.

VLVsys =VLVnom xVHVnom/VHVtap

VLVsys = 230 x 11000/11550 = 219V

Where:

VLVsys – LV system voltage

VLVnom - LV system nominal voltage (230V)

VHVnom - HV system nominal voltage (11,000V)

VHVtap – 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 **Type Tested**, the **Manufacturer** may produce a declaration in a similar format toAppendix.A..1 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** with a **Registered Capacity** of more than 1 MW:

(i) network and **power generating module** protection;

(ii) **synthetic inertia**, if applicable;

1. **frequency control** (**Active Power** adjustment);

(iv) power restriction; and

1. 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



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 - 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 INSTALLATION, OPERATION AND CONTROL INTERFACE

**11.1 General**

11.1.1 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]](#footnote-3).

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

11.1.3 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.

11.1.5 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:

1. the means of synchronisation between the **Generator**’s system and the **Distribution Network**, where appropriate;
2. the responsibility for plant, equipment and protection systems maintenance, and recording failures;
3. the means of connection and disconnection between the **DNO**s and **Generator**’s systems;
4. key technical data eg import and export capacities, operating **Power Factor** range, **Interface Protection** settings;
5. the competency of all persons carrying out operations on their systems;
6. details of arrangements that will ensure an adequate and reliable means of communication between the **DNO** and **Generator**;
7. 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;
8. the names of designated persons with authority to act and communicate on their behalf and their appropriate contact details.
9. 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 Engineering Recommendation, without undue delay, after the occurrence of those incidents

11.1.6 **Generator**sshould be aware that many **DNO**sapply 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.

## 11.2 Isolation and Safety Labelling

11.2.1 Every installation or system 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]](#footnote-4) infeed to the **Distribution Network.** This equipment will normally be owned by the **Generator**, but may by agreement be owned by the **DNO**.

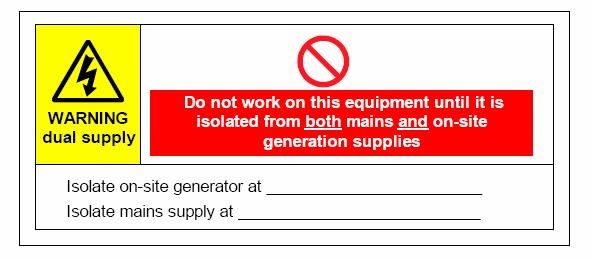
11.2.2 The disconnection of a **Power Generation Module** must be achieved by the physical separation of mechanical contacts unless the disconnection is at **Low Voltage** and the equipment for achieving the disconnection contain appropriate self-monitoring of the point of disconnection, in which case an appropriate electronic means such as a suitably rated semiconductor switching device would be acceptable.

11.2.3 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.

11.2.4 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.

11.2.5Where 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 11.1.

**Figure 11.1 Warning label**



Isolate on site Generating Unit at \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Isolate mains supply at** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

11.2.6 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.

## 11.3 Site Responsibility Schedule

11.3.1 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**.

11.3.2 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.

11.3.3 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 11.2, however the location of any metering devices, consumer unit and circuit protective devices (together with their settings) within the **Customer**’s **installation** should also be shown.

**Fig 11.2 – Example of an Operational Diagram**



11.3.4In the case of an **HV** connected **Power Generating Module** the diagram is likely to be more complex and contain more detailed information.

11.3.5 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.

## 11.4 Operational and Safety Aspects

11.4.1 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:

1. 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;
2. Where in the case that it is necessary for the **Generator’s** staff to operate the **DNO**s 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 **DNO**s safety rules.

11.4.2 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 **DNO**s Control Engineer.

11.4.3 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 11.4.1(a) above.

## 11.5 Synchronizing and Operational Control

11.5.1 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.

11.5.2 Operational switching, for example synchronising, needs to take account of **Step Voltage Changes** as detailed in Section 9.9.

11.5.3 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.**.

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

11.5.6 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.

11.5.7 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**’ssystem and the **DNO** supply.

11.5.8 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**.

# 12 TESTING, COMMISSIONING AND OPERATIONAL NOTIFICATION

## General

12.1.1 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.

12.1.2 The **Generator** will demonstrate all the commissioning tests performed on his **Power** **Generating** **Module** in order to discharge the requirements of this document. In general the **DNO** will witness these tests for **Power Generating Modules** connected to the **DNO’s Distribution Network** at **HV**. For **Power Generating Modules** connected to the **DNO’s Distribution Network** at **LV** it is not expected that the **DNO** will witness the commissioning tests in the majority of cases.

12.1.3 This section provides further details on the compliance, testing, commissioning and witnessing requirements.

12.1.4 General procedural issues, including the requirements for witnessing the commissioning tests and checks are described in Section 12.2.

12.1.5 Data required to be submitted by the **Generator** to the **DNO** is provided in the Distribution Data Registration Code (DDRC).

12.1.6 A **Power Generating Module** document shall be provided by the **Generator** to the **DNO**. The format of this document is given in Appendix A.2.

12.1.7 The requirements for the general commissioning tests and checks are given in section 12.3.

12.1.8 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.

12.1.9 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.

12.1.10 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.**

12.1.11 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**. Further details are given in paragraphs 12.6 and 12.7.

## Test Procedures and Witnessing Requirements

12.2.1 The **DNO** may decide to witness the **Power Generating Facility** and **Power Generating Module** commissioning tests and checks. The **DNO** will witness **HV** connections and may witness **LV** connections. Note that the **DNO** shall charge the **Generator** for attendance of staff for witness testing at its own commercial rates. The **Generator** shall make arrangements for the **DNO** to witness the commissioning tests unless otherwise agreed with the **DNO**.

12.2.2 The **Generator** shall notify the **DNO** of the planned test schedules and procedures to be followed for verifying the compliance of a **power generating module** with the requirements of this EREC G99, in due time and prior to their launch The **Generator** shall submit the scope, date and time of the commissioning tests at least 15 days before the proposed commissioning date. The **DNO** shall approve the planned test schedules and procedures in advance. Such approval by the **DNO** shall be provided in a timely manner and shall not be unreasonably withheld.

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

12.3.1 The following tests and checks shall be carried out by the **Installer** at all **Power Generating Facilities** and on all **Power Generating Module**s:

1. Inspect the **Power Generating Facility** to check compliance with BS7671. Checks should consider:
   1. Protection
   2. Earthing and bonding
   3. Selection and installation of equipment
2. Check that suitable lockable points of isolation have been provided between the **Power Generating Module**s and the rest of the installation.
3. Check that safety labels have been installed in accordance with paragraph 11.2;
4. Check interlocking operates as required. Interlocking should prevent **Power Generating Module**s being connected to the **DNO** system without being synchronised;
5. Check that the correct protection settings have been applied (in accordance with paragraph 10.6.7.1;
6. Complete functional tests to ensure each **Power Generating Module** synchronises with, and disconnects from, the **DNO’**s **Distribution Network** successfully and that it operates without tripping under normal conditions;
7. Carry out a functional test to confirm that the **Interface Protection** operates and trips each **Power Generating Module** when all phases are disconnected between the **Power Generating Module** and the **Distribution 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 **Power Generating Module** disconnect quickly (e.g. within 1s);
8. Check that once the phases are restored following the functional test described in (g) at least 20s elapses before the **Power Generating Module**s re-connect.
   * 1. In addition to the 3 phase disconnection test specified in 12.3.2 (g) the **Installer** shall carry out an additional functional check of the LoM protection by removing one phase of the supply to the **Power Generating Module** and confirming that the protection operates to disconnect the **Power Generating Module** from the **Distribution Network**. This test is applicable to all **Power Generating Module**s where **LV** protection settings are applied (i.e. not applicable if protection voltage reference is at **HV**), and should be repeated for all phases
   1. Disconnection of a voltage sensing feed from a voltage monitoring relay does not accurately replicate the conditions arising from the loss of an incoming phase and is not an acceptable test method.
   2. **Manufacturers, Generators** and **Installers** should be encouraged to incorporate disconnection points into the design of all **LV** **Power Generating Module**s or installations in order to facilitate this test.
   3. Where this test is considered to be impractical due to network arrangement or safety concerns, it may be replaced by an injection test to prove the operation of current unbalance protection, provided that such protection is installed and is set at an appropriately sensitive level. (For example, according to BS EN 60034-1, this should be <8%, 20s for a salient pole **Power Generating Module**).

It should be noted that experience of current imbalance protection in this application can be problematic once in service, and has led to nuisance tripping due to load and network voltage imbalance.

12.3.2 The results of these tests shall be recorded in the schedule provided in Appendix A.3.

12.3.3 Where **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.

1. Calibration and stability tests shall be carried out on the over voltage and under voltage protection for each phase, as described below:
2. The operating voltage shall 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.
3. 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.
4. 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.
5. Calibration and stability tests shall be carried out on the over frequency and under frequency protection as described below:
6. 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% (i.e. 0.1Hz) of the setting value.
7. 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.
8. Stability tests (no-trip tests) shall also be carried out at the frequencies and for the durations defined in the commissioning test record, Appendix A.3. The protection must not trip during these tests.
9. Calibration tests for rate of change of frequency protection, where used, shall be carried out as follows:
10. Rate of change of frequency shall be checked by first applying a voltage with a frequency of 51.0Hz to the protection and then ramping this frequency down at 0.1Hzs-1 less than the RoCoF protection setting until a frequency reaches 49.0Hz. This test is repeated at increasing values of rate of change of frequency (in increments of 0.025Hzs-1 or less) until the protection operates. The test shall be repeated for rising frequency but this time each tests shall be start at 49.0Hz and end at 51.0Hz. The operating values should be within 0.025Hz s-1  of the required setting.
11. Timing tests shall be carried out by applying a falling and a rising frequency at rate of 0.05Hzs-1 above the setting value. The protection operating times shall be no longer than 1.0s.
12. RoCoF stability checks shall be performed on all interface protection relays 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**.

12.3.4 It may be necessary to undertake ad-hoc testing to determine[[5]](#footnote-5), for example:

1. the voltage dip on synchronising;
2. the harmonic voltage distortion;
3. the voltage levels as a result of the connection of the **Power Generating Facilities** and to confirm that they remain within the statutory limits.

12.3.5 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 (where tests are witnessed) or within 28 days of the commissioning date (where the tests are not witnessed).

# Operational Notification Process for Type A Power Generating Modules

12.4.1 **Type Tested Type A** P**ower Generating Modules** should refer to EREC G98 parts 1 and 2. The following provisions apply in relation to the notification process in **in respect of non Type Tested Type A Power Generating Modules.**

12.4.2 Not less than 7 days, or such shorter period as may be acceptable in **the DNO’s** reasonable opinion, prior to the **Generator** wishing to synchroniseits **Power Generating Module** for the first timethe **Generator** will:

* + 1. submit to the **DNO** a Notification of the **Customer**’s Intention to Connect; and
    2. submit to the **DNO** an **Installation Document** as detailed in Appendix A.1 containingat least but not limited to the items referred to in paragraph 12.4.3.

12.4.3 Items for submission prior to connection**.**

1. The location at which the connection is made**;**
2. The date of the connection;
3. The **Registered Capacity** of the installation in kW;
4. The type of primary energy source;
5. The classification of the **Power Generating Module** as an emerging technology;
6. A list of references to **Manufacturers Information**
7. Details of compliance with this EREC G99 where **Manufactures Information** is not provided.
8. The contact details of the **Generator** and the **Installer** and their signatures.

12.4.4 Separate installation documents, in the format given in Appendix A1 shall be provided for each **Type A** **Power Generating Module** within the **Power Generating Facility**

12.4.5 When the requirements of paragraphs 12.4.2 to 12.4.4 have been met, the **DNO** will notify the **Generator** that the **Power Generating Module** may be synchronised to the **Total System**.

## Operational Notification for Type B and Type C Power Generating Modules

12.5.1 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 timethe **Generator** owner will:

* + 1. submit to **the DNO** a Notification of **Customer**’s Intention to Synchronise; and
    2. submit to the **DNO** a **Power Generating Module Document** containingat least but not limited to the items referred to in paragraph 12.5.2.
    3. Items for submission in the **Power Generating Module Document:**

(i) updated **Planning Code** 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 M**odules 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;

1. simulation study provisions of Appendix A.6 and the results demonstrating compliance with EREC G99 **Frequency Sensitive Mode** requirements of paragraph 9.4.4 and paragraph 9.4.5, fault ride through requirements of section 9.7 as applicable to the **Power Generating Module(s)** unless agreed otherwise by the **DNO**;
2. 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 Paragraph 12.2, Paragraph 12.3, Appendix A.7 (in the case of a Synchronous Power **Generating Module**) or Appendix A.8 (in the case ofa **Power Park Module**);
3. copies of **Manufactures Information** where these are relied upon as part of the evidence of compliance and
4. a Compliance Declaration completed by the **Generator.**

12.5.3 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 A.2.

12.5.4 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 A.7.3) 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.A.7.2)..

12.5.5 The **DNO** shall assess the schedule of tests submitted by the **Generato**r with the Notification of **Customer**’s Intention to Synchroniseunder 12.5.2 and shall determine whether such schedule has been completed to the **DNO’s** satisfaction.

12.5.6 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.

12.5.7 The **Generator** is responsible for carrying out the tests and retains the responsibility for safety and personnel during the test.

12.5.8 Following completion of the tests specified in this paragraph 12.5, the **DNO** will notify the **Generator** whether, in the opinion of the **DNO**, the results demonstrate compliance with EREC G99.

12.5.9 Items for submission prior to issue of the **Final Operational Notification**

12.5.9.1 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) 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 required in accordance with paragraph 12.5 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**.

12.5.9.2 The items in paragraph 12.7.5 should be submitted by the **Generator** using the Power Generating Module Document and DDRC.

12.5.10 If the requirements of this Section 12.5 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.**

## 12.6 Periodic Testing for Type A, Type B and Type C Power Generating Modules

12.6.1 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.

12.6.2 The **Generator** shall be informed of the outcome of those compliance tests and simulations.

12.6.3 The **Interface Protection** shall be tested by the **Generator** at intervals to be agreed with the **DNO.**

## 12.7 Changes in the Installation of a Type A, Type B,Type C or Type D Power Generating Module

12.7.1 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.

12.7.2 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 A.9. Where the presence of **Power Generating Modules** is indicated in a bespoke **Connection Agreement**, it will be necessary to amend the **Connection Agreement** appropriately.

12.7.3 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.

# 12.8 Type D Energisation Operational Notification

12.8.1 The following provisions apply in relation to the issue of an **Energisation Operational Notification** in respect of **Embedded Medium Power Station 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**.

12.8.2 The items for submission prior to the issue of an Energisation Operational Notification are detailed below:

(a) updated DDRC Schedule 7 Planningdata (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 **Protection** arrangements and settings referred to in Section 9;

(c) the proposed name of the **Power Generating Facility.**

12.8.3 In the case of a **Power Generating Facility Owner** the items referred to in this Section shall be submitted using the appropriate DDRC schedules.

12.8.5 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**.

12.8.6 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**.

# 12.9 Type D Interim Operational Notification

12.9.1 The following provisions apply in relation to the issue of an **Interim Operational Notification** in respect of **Type D Power Generating Modules**.

12.9.2 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:

* + 1. submit to the **DNO** a Notification of **Customer**’s Intention to Synchronise; and
    2. submit to the **DNO** the items referred to in paragraph 12.9.3.

12.9.3 Items for submission prior to issue of the Interim Operational Notification.

12.9.3.1 Prior to the issue of an **Interim Operational Notification** the **Generator** must submit to the **DNO** to the **DNO**’s satisfaction:

(a) updated Planning Code 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;

1. An update of any of the items required to achieve an **Energisation Operational Notification**;

(d) simulation study provisions of Appendix A.6 and the results demonstrating compliance with EREC G99 **Frequency Sensitive Mode** requirements of paragraph 9.4.4 and paragraph 9.4.5, 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 A.4, Appendix A.5, Appendix A.6 together with Appendix A.7 (in the case of Synchronous Power Generating Modules) or Appendix A.8 (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.

12.9.4 No **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)**;

12.9.5 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.

12.9.6 When the requirements of paragraph 12.9.2 to paragraph 12.9.5 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 12.9.3 where that applies) be synchronised to the **Total System** through the issue of an **Interim Operational Notification**.

12.9.6.1 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 12.12**.**

12.9.2 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**.

12.9.3 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:

1. 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
2. 50MW

until the **Generator** has completed the voltage control tests (detailed in A.8.2) 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.

12.9.4 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.

12.9.5 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 12.10.2.

12.9.6 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.

12.9.7 The items referred to in paragraph 12.10.3 shall be submitted by the **Generator** after successful completion of the tests required under paragraph 12.10.2.

# 12.10 Final Operational Notification

12.10.1 The following provisions apply in relation to the issue of **a Final Operational Notification** in respect of **Type D Power Generating Modules**.

12.10.2 Tests to be carried out prior to issue of the **Final Operational Notification**.

12.10.2.1 Prior to the issue of a **Final Operational Notification** the **Generator** must have completed the tests specified in paragraph 12.10.2.2 to the **DNO’s** satisfaction to demonstrate compliance with the relevant EREC G99 provisions.

12.10.2.2 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 9.10 and in the case of **Power Park Module** the requirements of Appendix A.8 and, in the case of **Synchronous Power Generating Module** and **CCGT Module**, the requirements of Appendix A.7. 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 9.3.6 and paragraph 9.8.7, in the case of **Power Park Module** the requirements of Appendix A.8 and, in the case of **Synchronous Power Generating Module** and **CCGT Module**, the requirements of Appendix A.7, 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 9.3.6, paragraph 9.4 and Appendix A.7 and Appendix A.8. 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**.

12.10.2.3 The **DNOs** preferred range of tests to demonstrate compliance with this EREC G99 are specified in Appendix A.7 (in the case of **Synchronous Power Generating Modules**) or Appendix A.8 (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***.***

12.10.2.4Following completion of each of the tests specified in this paragraph 12.10, the **DNO** will notify the **Generator** whether, in the opinion of the **DNO**, the results demonstrate compliance with EREC G99.

12.10.2.5 The **Generator** is responsible for carrying out the tests and retains the responsibility for safety and personnel during the test.

12.10.3 Items for submission prior to issue of the **Final Operational Notification**

12.10.3.1 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 12.10 carried out by the **Generator** to demonstrate compliance with relevant EREC G99 requirements including the tests witnessed by the **DNO**;

(f) and

(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**.

12.10.3.2 The items in paragraph 12.10.3 should be submitted by the **Generator** using the DDRC and a **Power Generating Module Document**.

12.10.4 If the requirements of paragraph 12.10.2 and paragraph 12.10.3 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.**

12.10.5 If a **Final Operational Notification** cannot be issued because the requirements of paragraph 12.10.2 and paragraph 12.10.3 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 12.12 shall then apply.

# 12.11 Limited Operational Notification

12.11.1 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 12.11.2 to paragraph 12.11.10; or,

(ii) The **DNO** becomes aware through monitoring as described in paragraph 9.17, 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 9.17 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 12.11 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 12.11.2 to paragraph 12.11.10 shall be followed.

12.11.2 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.

12.11.3 Where the restriction notified in paragraph 12.11.2 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 12.10.3.1 as notified to the **Generator** by the **DNO** as being required to be provided.

12.11.4 Issue and Effect of **Limited Operational Notification**

12.11.4.1 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.

12.11.4.2 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 12.12.1.

12.11.4.3 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.

12.11.4.4 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 12.11 are complied with.

12.11.4.5 The Unresolved Issues included in a **Limited Operational Notification** will show the extent that the provisions of 12.10.2 (testing) and 12.10.3 (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.

12.11.4.6In 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 A.6 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 A.7 or Appendix A.8 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**.

12.11.4.7 The items referred to in paragraph 12.11.4.6 shall be submitted by the **Generator** using the DDRC.

12.11.4.8 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 A.7.3) 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 A.7.2) to demonstrate compliance with Appendix A.13 and Appendix A.14 as applicable.

12.11.5 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 12.11.4.6.

12.11.6 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 12.10.2.2.

12.8.7 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.

12.11.8 The items referred to in paragraph 12.10.3 and listed as Unresolved Issues shall be submitted by the **Generator** after successful completion of the tests.

12.11.9 Where the Unresolved Issues have been resolved a **Final Operational Notification** will be issued to the **Generator**.

12.11.10 If a **Final Operational Notification** has not been issued by the DNO within the 12 month period referred to in paragraph 12.11.4.2 (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.

# 12.12 Processes Relating to Derogations

12.12.1 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.

12.12.2 If the **Authority**:

1. 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
2. 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
3. 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**.

12.12.3 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 12.6.7 to paragraph 12.7.3 shall apply and shall be followed.

## [12.13] MANUFACTURER’S DATA & PERFORMANCE REPORT

12.13.1 General

12.13.1.1 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**.

12.13.1.2 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.

12.13.1.3 The process to be followed by **Power Park Unit** manufacturers submitting **Manufacturers’ Information** must be agreed by the **DNO**. 12.13.2 below indicates the specific requirement areas in respect of which **Manufacturers’ Information** may be submitted.

12.13.1.4 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.

12.13.2 **Manufacturers’ Information** in respect of **Power Park Units** may cover one (or part of one) or more of the following provisions of the Grid Code:

(a) **Fault Ride Through** capability – Section 9.7

(b) Power Park Module mathematical model DDRC 5(c).

12.13.3 Reference to **a Manufacturer’s Data & Performance Report** in a **Generator**’s submissions does not by itself constitute compliance with EREC G99.

12.13.4 A Generator referencing **Manufacturers’ Information** should insert the relevant **Manufacturers’ Information** reference in the appropriate place in the DDRC data submission. 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 A.6.4.5. 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 A.6.5.2 and qualified in A.6.5.3 provided that;

(i) Adequate and relevant **Power Park Uni**t data is included in respect of **Fault Ride Through** testing covered in Appendix A.8.7 in the relevant **Manufacturers’ Information**, and

(ii) For each type and duration of fault as detailed in A.6.5.2, 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.

12.13.5 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.

12.13.6 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**.

# APPENDICES

|  |  |  |
| --- | --- | --- |
| **Appendix** | **Application** | **Form Title** |
| A.1 | Installation and Commissioning a **Power Generating Facility** comprising one or more non-**Type Tested Type A Generating Modules** | Installation and Commissioning Confirmation Form for **Type A PGMs** |
| A.2 | Type A Compliance documentation | **Type A** Compliance Verification Report |
| A.3 | Compliance documentation for **Type B** and **Type C PGMs** | **Power Generating Module** **Document** for **Type B** and **Type C PGMs** |
| A.4 | Installation and Commissioning of **Type B** and **Type C PGMs** | Installation and Commissioning Confirmation Form for **Type B** and **Type C PGMs** |
| A.5 | Protection commissioning tests | Compliance and Commissioning test requirements for **PGMs** in addition to those required in Appendix A.2 |
| A.6 | Simulation Studies to demonstrate compliance | Simulation Studies |
| A.7 |  | Compliance Testing of **Synchronous Power Generating Modules** |
| A.8 |  | Compliance Testing of **Power Park Modules** |
| A.9 | Decommissioning of any **Power Generating Module** | **Power Generating Facility** Decommissioning Confirmation |
|  | Other Appendices to be added that are relevant to Section 9 |  |
| A.16 | Additional Information Relating to System Stability Studies |  |
| A.17 | Loss of Mains Protection Analysis |  |
| A.18 | Main Statutory and other Obligations |  |
|  |  |  |
|  |  |  |

## A.1 Type A Power Generating Facility Installation and Commissioning Confirmation

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Installation and Commissioning Confirmation Form for Type A PGMs**  Note if all PGMs are Type Tested Type A then the Installation documents in G98 part 1 or part 2 should be used as applicable | | | | | | | | |
| To ABC electricity distribution DNO  99 West St, Imaginary Town, ZZ99 9AA abced@wxyz.com | | | | | | | | |
| **Installer or Generator Details:** | | | | | | | | |
| Installer |  | | | | | | | |
| Accreditation/Qualification |  | | | | | | | |
| Address |  | | | | | | | |
| Post Code |  | | | | | | | |
| Contact person |  | | | | | | | |
| Telephone Number |  | | | | | | | |
| E-mail address |  | | | | | | | |
| **Installation Details** | | | | | | | | |
| Site Contact Details |  | | | | | | | |
| Address |  | | | | | | | |
| Post Code |  | | | | | | | |
| Site Telephone Number |  | | | | | | | |
| MPAN(s) |  | | | | | | | |
| Location within Customer’s Installation |  | | | | | | | |
| Location of Lockable Isolation Switch |  | | | | | | | |
| **Details of PGM(s) –** | | | | | | | | |
| Manufacturer / Reference | Date of Installation | Technology Type | **Manufactures Information** reference as applicable | **PGM Registered Capacity in kW** | | | | |
| 3-Phase Units | Single Phase Units | | | Power Factor |
| PH1 | PH2 | PH3 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

|  |  |  |
| --- | --- | --- |
| **Information to be enclosed** | | |
| Description | | Confirmation |
| Final copy of circuit diagram | | Yes / No\* |
| Schedule of protection settings (may be included in circuit diagram) | | Yes / No\* |
| Is the **Power Generating Module** classified as an Emerging Technology? | | Yes / No\* |
| Details of tests undertaken in accordance with Appendix A.2 where **Manufactures Information** is not sufficient to demonstrate compliance with this EREC G99 | | Yes / No\* |
| **Commissioning Checks** | | |
| Installation satisfies the requirements of BS7671 (IET Wiring Regulations). | | Yes / No\* |
| Suitable lockable points of isolation have been provided between the **PGMs** and the rest of the installation. | | Yes / No\* |
| Labels have been installed at all points of isolation in accordance with EREC G99. | | Yes / No\* |
| Interlocking that prevents **PGMs** being connected in parallel with the **DNO** system (without synchronising) is in place and operates correctly. | | Yes / No\* |
| The **Interface Protection** settings have been checked and comply with EREC G99 | | Yes / No\* |
| **PGMs** successfully synchronise with the **DNO** system without causing significant voltage disturbance. | | Yes / No\* |
| **PGMs** successfully run in parallel with the DNO system without tripping and without causing significant voltage disturbances. | | Yes / No\* |
| **PGMs** successfully disconnect without causing a significant voltage disturbance, when they are shut down. | | Yes / No\* |
| **Interface Protection** operates and disconnects the **PGMs** quickly (within 1s) when a suitably rated switch, located between the **PGMs** and the **DNO’**s incoming connection, is opened. | | Yes / No\* |
| **PGMs** remain disconnected for at least 20s after switch is reclosed. | | Yes / No\* |
| **Loss of tripping and auxiliary supplies** Where applicable, loss of supplies to tripping and protection relays results in either **PGM** lockout or an alarm to a 24hr manned control centre. | | Yes / No\* |
| **Balance of Multiple Single Phase PGMs** Confirm that design of the complete installation has been carried out to limit output power imbalance to below 16A/phase, as required by section 7.5 of EREC G99 | | Yes / No\* |
| \* Circle as appropriate. If “No” is selected the **Power Generating Facility** is deemed to have failed the commissioning tests and the **Power Generating Modules** shall not be put in service. | | |
| Additional Comments / Observations: | | |
| **Declaration – to be completed by Generator or Generators Appointed Technical Representative.** | | |
| I declare that the **Type A** **PGMs** and the installation comply with the requirements of EREC G99 (or ERG59 or ERG83 in the case of pre-existing PGMs at the installation) and the commissioning checks detailed in A.1 and A.5 have been successfully completed | | |
| Name: | | |
| Signature: | Date: | |
| Position. | | |
| **Declaration – to be completed by DNO Witnessing Representative** | | |
| I confirm that I have witnessed the tests in this document on behalf of  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and that the results are an accurate record of the tests | | |
| Name: | | |
| Signature: | Date: | |

## A.2 Type A Compliance Declaration

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **Type A Compliance Verification Report**  **Manufacturer** declaration of compliance with the requirements of G99 for **Type A Power Generating Modules** where **Manufacturers Information** is not provided | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Unique **Power Generating Module** Identifier | | | | | | | | | | | | | | | |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **PGM** technology | | | | | | | | | | | | | | | |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Manufacturer** name | | | | | | | | | | | | | | | |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Address | | | | | | | | | | | | | | | |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tel | |  | | | | | | | | | | | | | | | | | | | | | | | Fax | | | | | | | | |  | | | | | | | | | | | |
| E:mail | |  | | | | | | | | | | | | | | | | | | | | | | | Web site | | | | | | | | |  | | | | | | | | | | | |
| Maximum rated capacity, use separate sheet if more than one connection option. | | | | | | | | Connection Option | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | | | | | | | kW single phase, single, split or three phase system | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | | | | | | | kW three phase | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | | | | | | | kW two phases in three phase system | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | | | | | | | kW two phases split phase system | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Manufacturer’s** declaration of **Compliance**. - I certify the **Power Generating Module** with the above unique reference number has been manufactured and tested to ensure that it performs as stated in this document, prior to shipment to site. I enclose **Manufactures Information** as appropriate. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Signed | |  | | | | | | | | | | | | | | On behalf of | | | | | | | | | | | | | | | | | |  | | | | | | | | | | | |
| Note that testing can be done by the **Manufacturer** of an individual component or by an external test house.  Where parts of the testing are carried out by persons or organisations other than the **Manufacturer** then that person or organisation shall keep copies of all test records and results supplied to them to verify that the testing has been carried out by people with sufficient technical competency to carry out the tests. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Operating Range:** Two tests should be carried with the **PGM** operating at nominal power and connected to a grid simulation set. The power supplied by the primary source shall be kept stable within ± 5 % of the Apparent Power value set for the entire duration of each test sequence.  Frequency, voltage and active power measurements at the output terminals of the **PGM** shall be recorded every second.  The **Interface Protection** shall be disabled during the tests. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Test 1  Voltage = 85% of nominal (195.5 V)  Frequency = 47.5 Hz  Power factor = 1  Period of test 90 minutes  Operation at reduced power is allowed where Real Power ≥ 0.85 Apparent Power | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Test 2  Voltage = 110% of nominal (253 V).  Frequency = 51.5 Hz  Power factor = 1  Period of test 90 minutes  Automatic adjustment to reduce power in the case of over-frequency shall be disabled | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Power Quality – Harmonics**: These tests should be carried out as specified in BS EN 61000-3-2. The chosen test should be undertaken with a fixed source of energy at two power levels a) between 45 and 55% and b) at 100% of maximum export capacity.  The test should be carried out on a single **PGM.** The results need to comply with the limits of table 1 of BS EN 61000-3-2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **PGM** tested to BS EN 61000-3-2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **PGM** rating per phase (rpp) | | | | | | | | | | | | | | | | |  | | | | | | | | kW | | | | | | | | |  | | | | | | | | | | | |
| Harmonic | At 45-55% of rated output | | | | | | | | | | | | | | | | 100% of rated output | | | | | | | | | | | | | | | | |
|  | Measured Value MV in Amps | | | | | | | | | |  | | | | | | Measured Value MV in Amps | | | | | | | | | | |  | | | | | | Limit in BS EN 61000-3-2 in Amps | | | | | | | Higher limit for odd harmonics 21 and above | | | | |
| 2 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 1.080 | | | | | | |  | | | | |
| 3 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 2.300 | | | | | | |  | | | | |
| 4 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.430 | | | | | | |  | | | | |
| 5 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 1.140 | | | | | | |  | | | | |
| 6 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.300 | | | | | | |  | | | | |
| 7 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.770 | | | | | | |  | | | | |
| 8 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.230 | | | | | | |  | | | | |
| 9 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.400 | | | | | | |  | | | | |
| 10 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.184 | | | | | | |  | | | | |
| 11 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.330 | | | | | | |  | | | | |
| 12 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.153 | | | | | | |  | | | | |
| 13 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.210 | | | | | | |  | | | | |
| 14 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.131 | | | | | | |  | | | | |
| 15 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.150 | | | | | | |  | | | | |
| 16 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.115 | | | | | | |  | | | | |
| 17 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.132 | | | | | | |  | | | | |
| 18 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.102 | | | | | | |  | | | | |
| 19 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.118 | | | | | | |  | | | | |
| 20 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.092 | | | | | | |  | | | | |
| 21 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.107 | | | | | | | 0.160 | | | | |
| 22 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.084 | | | | | | |  | | | | |
| 23 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.098 | | | | | | | 0.147 | | | | |
| 24 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.077 | | | | | | |  | | | | |
| 25 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.090 | | | | | | | 0.135 | | | | |
| 26 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.071 | | | | | | |  | | | | |
| 27 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.083 | | | | | | | 0.124 | | | | |
| 28 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.066 | | | | | | |  | | | | |
| 29 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.078 | | | | | | | 0.117 | | | | |
| 30 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.061 | | | | | | |  | | | | |
| 31 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.073 | | | | | | | 0.109 | | | | |
| 32 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.058 | | | | | | |  | | | | |
| 33 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.068 | | | | | | | 0.102 | | | | |
| 34 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.054 | | | | | | |  | | | | |
| 35 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.064 | | | | | | | 0.096 | | | | |
| 36 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.051 | | | | | | |  | | | | |
| 37 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.061 | | | | | | | 0.091 | | | | |
| 38 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.048 | | | | | | |  | | | | |
| 39 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.058 | | | | | | | 0.087 | | | | |
| 40 |  | | | | | | | | | |  | | | | | |  | | | | | | | | | | |  | | | | | | 0.046 | | | | | | |  | | | | |
| Note the higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| **Power Quality – Voltage fluctuations and Flicker**: These tests should be undertaken in accordance with EREC G98 Part 2 Annex A1 A 1.4.3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | | | Starting | | | | | | | | | | | | | | | | Stopping | | | | | | | | | | | | | | | | | | Running | | | | | | | |
|  | | | | d max | | | d c | | | | | | | d(t) | | | | | | d max | | | | | | d c | | | d(t) | | | | | | | | | P st | | | | | | P lt 2 hours | |
| Measured Values at test impedance | | | |  | | |  | | | | | | |  | | | | | |  | | | | | |  | | |  | | | | | | | | |  | | | | | |  | |
| Normalised to standard impedance | | | |  | | |  | | | | | | |  | | | | | |  | | | | | |  | | |  | | | | | | | | |  | | | | | |  | |
| Normalised to required maximum impedance | | | |  | | |  | | | | | | |  | | | | | |  | | | | | |  | | |  | | | | | | | | |  | | | | | |  | |
| Limits set under BS EN 61000-3-11 | | | | 4% | | | 3.3% | | | | | | | 3.3% | | | | | | 4% | | | | | | 3.3% | | | 3.3% | | | | | | | | | 1.0 | | | | | | 0.65 | |
|  | | | |  | | | | |  | | | | | | | |  | | | | | | | |  | | | | |  | | | | | | | | |  | | | | | | |
| Test Impedance | | | | R | | | | |  | | | | | | | | Ω | | | | | | | | Xl | | | | |  | | | | | | | | | Ω | | | | | | |
| Standard Impedance | | | | R | | | | | 0.24 \*  0.4 ^ | | | | | | | | Ω | | | | | | | | Xl | | | | | 0.15 \*  0.25 ^ | | | | | | | | | Ω | | | | | | |
| Maximum Impedance | | | | R | | | | |  | | | | | | | | Ω | | | | | | | | Xl | | | | |  | | | | | | | | | Ω | | | | | | |
| Applies to three phase and split single phase **PGMs.**  ^ Applies to single phase **PGM** and **PGMs** using two phases on a three phase system  For voltage change and flicker measurements the following formula is to be used to convert the measured values to the normalised values where the power factor of the generation output is 0.98 or above.  Normalised value = Measured value\*reference source resistance/measured source resistance at test point  Single phase units reference source resistance is 0.4 Ω  Two phase units in a three phase system reference source resistance is 0.4 Ω  Two phase units in a split phase system reference source resistance is 0.24 Ω  Three phase units reference source resistance is 0.24 Ω  Where the power factor of the output is under 0.98 then the Xl to R ratio of the test impedance should be close to that of the Standard Impedance.  The stopping test should be a trip from full load operation.  The duration of these tests need to comply with the particular requirements set out in the testing notes for the technology under test. Dates and location of the test need to be noted below | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Test start date | | | | | | | |  | | | | | | | | | | | | | Test end date | | | | | | | | | | | | | | |  | | | | | | | | | |
| Test location | | | | | | | |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Power quality – DC injection:** The tests should be carried out on a single **Generating Unit**. Tests are to be carried out at three defined power levels ±5%. At 230V a 2kW single phase inverter has a current output of 8.7A so DC limit is 21.75mA, a 10kW three phase inverter has a current output of 43.5A at 230V so DC limit is 108.75mA. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Test power level | | | | | 20% | | | | | | | 50% | | | | | | | | | | 75% | | | | | | | | | | | | | 100% | | | | | | | | | | |
| Recorded value in Amps | | | | |  | | | | | | |  | | | | | | | | | |  | | | | | | | | | | | | |  | | | | | | | | | | |
| as % of rated AC current | | | | |  | | | | | | |  | | | | | | | | | |  | | | | | | | | | | | | |  | | | | | | | | | | |
| Limit | | | | | 0.25% | | | | | | | 0.25% | | | | | | | | | | 0.25% | | | | | | | | | | | | | 0.25% | | | | | | | | | | |
| **Power Quality – Power factor**: The tests should be carried out on a single **Generating Unit**. Tests are to be carried out at three voltage levels and at full output. Voltage to be maintained within + or – 1.5% of the stated level during the test. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | | | | | | 216.2V | | | | | | | | | | | | | | | 230V | | | | | | | | | | | | | | | 253V | | | | | | | | |
| Measured value | | | | | | |  | | | | | | | | | | | | | | |  | | | | | | | | | | | | | | |  | | | | | | | | |
| Limit | | | | | | | >0.95 | | | | | | | | | | | | | | | >0.95 | | | | | | | | | | | | | | | >0.95 | | | | | | | | |
| **Fault level contribution**: These tests shall be carried out in accordance with EREC G98 Part 2 Annex A1 A 1.4.6 and A 1.4.7. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| For machines with electro-magnetic output | | | | | | | | | | | | | | | | | | | | | | | | For **Inverter** output | | | | | | | | | | | | | | | | | | | | | |
| Parameter | | | | | | | | | | | Symbol | | | | | | | | Value | | | | | Time after fault | | | | | | | | Volts | | | | | | | | | | | Amps | | |
| Peak Short Circuit current | | | | | | | | | | | *ip* | | | | | | | |  | | | | | 20ms | | | | | | | |  | | | | | | | | | | |  | | |
| Initial Value of aperiodic current | | | | | | | | | | | *A* | | | | | | | |  | | | | | 100ms | | | | | | | |  | | | | | | | | | | |  | | |
| Initial symmetrical short-circuit current\* | | | | | | | | | | | *Ik* | | | | | | | |  | | | | | 250ms | | | | | | | |  | | | | | | | | | | |  | | |
| Decaying (aperiodic) component of short circuit current\* | | | | | | | | | | | *iDC* | | | | | | | |  | | | | | 500ms | | | | | | | |  | | | | | | | | | | |  | | |
| Reactance/Resistance Ratio of source\* | | | | | | | | | | | *X/R* | | | | | | | |  | | | | | Time to trip | | | | | | | |  | | | | | | | | | | | In seconds | | |
| For rotating machines and linear piston machines the test should produce a 0s – 2s plot of the short circuit current as seen at the **PGM** terminals.  \* Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Self-Monitoring solid state switching:** No specified test requirements. Refer to EREC G98 Part 2 Annex A1 A 1.4.8. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Yes/or NA |
| It has been verified that in the event of the solid state switching device failing to disconnect the **PGM**, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 seconds. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |  |
| Additional comments | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| **Limited Frequency Sensitive Mode – Over frequency test:** The test should be carried out using the specific threshold frequency of 50.4 Hz and droop of 10%.  Simulated: Evidence of the frequency dependent active power feed-in of the **PGM** shall be provided.  Alternatively the tests can be carried out by one of the following methods:   * adjusting the input signals on the control unit of the **PGM**; * adjusting the limit values (set values) in the control unit of the **PGM** if the manufacturer declares the full functionality of the **PGM** control and feed-in at all required operating frequencies (47.5 Hz to 51.5 Hz). | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Measured Active Output Power | | | | | | Frequency | | | | | | | | | | | | Primary Power Source | | | | | | | | | | | | | | | Active Power Gradient | | | | | | | | | | | | |
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| Measured Active Output Power | | | | | | Frequency | | | | | | | | | | | | Primary Power Source | | | | | | | | | | | | | | | Active Power Gradient | | | | | | | | | | | | |
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| **Power output with falling frequency test** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tests should prove that the **PGM** does not disconnect when the frequency is changed and that the PGM does not reduce output power during test (a) or (b). The PGM output power reduction must be less or equal to that allowed in para 10.4.2 during test (c). | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Test sequence | | | | | | | | | | | | | Measured Active Output Power | | | | | | | | | | | | | | Frequency | | | | | | | | | | | | | Primary power source | | | | | |
| Test a) 50Hz ± 0.01Hz | | | | | | | | | | | | |  | | | | | | | | | | | | | |  | | | | | | | | | | | | |  | | | | | |
| Test b) Point between 49.5 Hz and 49.6 Hz | | | | | | | | | | | | |  | | | | | | | | | | | | | |  | | | | | | | | | | | | |  | | | | | |
| Test c) Point between 47.5 Hz and 47.6 Hz | | | | | | | | | | | | |  | | | | | | | | | | | | | |  | | | | | | | | | | | | |  | | | | | |
| NOTE: The operating point in Test (b) and (c) shall be maintained for at least 5 minutes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Re-connection timer**. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Test should prove that the reconnection sequence starts after a minimum delay of 20 seconds for restoration of voltage and frequency to within the stage 1 settings of table 10.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Time delay setting | | | Measured delay | | | | | | |  | | | | | Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 10.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | |  | | | | | | |  | | | | | At 266.2V | | | | | | | | At 196.1V | | | | | | | | At 47.4Hz | | | | | | | | | | | At 51.6Hz | | | |
| Confirmation that the SSEG does not re-connect. | | | | | | | | | | | | | | |  | | | | | | | |  | | | | | | | |  | | | | | | | | | | |  | | | |

## A.3. Type B and Type C Power Generating Module Document

|  |  |
| --- | --- |
| **Power Generating Module Document for Type B and Type C PGMs**  This document shall be completed by the **Generator** | |
| To ABC electricity distribution DNO  99 West St, Imaginary Town, ZZ99 9AA abced@wxyz.com | |
| **Site Details** | |
| Site Contact Details |  |
| Address |  |
| Post Code |  |
| Site Telephone Number |  |
| **Details of Power Generating Module** | |
| Manufacturer / Reference |  |
| Technology Type |  |
| **Registered Capacity** |  |
|  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | | Initial submission (at least 28 days before synchronisation) | In order to obtain **Final Operational Notification** from the **DNO** |
| #1 | Information specified in DDRC Schedules 5a, 5b,5c and 6 has been provided to the DNO | | Required | Update required |
| #2 | Simulation studies in accordance with Appendix A.6 have been provided | | Required |  |
| #3 | A detailed schedule of tests and test procedures are consistent with Paragraph 12.2, Paragraph 12.3 and Appendix A.7 (in the case of a **Synchronous Power** **Generating Module**) or Appendix A.8 (in the case ofa **Power Park Module**) have been provided. | | Required |  |
| #2 | For **Type C PGMs** the Active Power Set Point can be adjusted in accordance with instructions issued by the DNO. | | Yes / No\* |  |
| #3 | **PGM Steady State Compliance** | | |  |
| 3.1 | **Manufacturers Information** or compliance test reports are referenced or attached to this submission. This shall include: | |  |  |
| a | Excitation System Open Circuit Step Response tests (Appendix A.7.2) | | Required for **Synchronous Power Generating Modules** |  |
| b | Open and Short Circuit Saturation Characteristics tests (Appendix A.7.3) | | Required for **Synchronous Power Generating Modules** |  |
| c | Under-excitation Limiter Performance test (Appendix A.7.4) | |  | Required for **Synchronous Power Generating Modules** |
| d | Over-excitation Limiter Performance test (Appendix A.7.4) | |  | Required for **Synchronous Power Generating Modules** |
|  | Power Park Module Voltage Control tests (Appendix A.8.2) | |  | Required for **Power Park Modules.** |
| e | Reactive capability  This shall include compliance with the reactive capability requirements in Section 9.10. For Synchronous Power Generating Modules this will be demonstrated in accordance with Appendix A7.5 For Power Park Modules this will be demonstrated in accordance with Appendix A8.3. | |  | Required |
| #4 | **PGM Dynamic Performance Compliance** | | |  |
| 4.1 | **Manufacturers Information** or compliance test reports are referenced or attached to this submission. This should include: | | Yes / No\* |  |
| a | Governor and Load Controller Response Performance tests (frequency response) | |  | Required |
| b | Demonstration of Active Power Output with falling frequency | |  | Required |
| #5 | If applicable **PGM Black Start Compliance** | | |  |
| 5.1 | Black start compliance has been obtained from the **NETSO.** | | Yes / No\*/ Not applicable |  |
| #6 | **PGM Interface Protection Compliance**  As an alternative to demonstrating protection compliance with Section 10 using **Manufacturers Information,** site tests can be undertaken at the time of commissioning the **Power Generating Module**. | | |  |
| 6.1 | Over and under voltage protection LV **Manufacturers Information** is referenced or attached to this submission | | Yes / No\* | Required in accordance with Appendix A.4 where **Manufacturers Information** not previously provided |
| 6.2 | Over and under voltage protection HV **Manufacturers Information** is referenced or attached to this submission | | Yes / No\* | Required in accordance with Appendix A.4 where **Manufacturers Information** not previously provided |
| 6.3 | Over and Under Frequency protection **Manufacturers Information** is referenced or attached to this submission | | Yes / No\* | Required in accordance with Appendix A.4 where **Manufacturers Information** not previously provided |
| 6.4 | Loss of mains protection **Manufacturers Information** is referenced or attached to this submission | | Yes / No\* | Required in accordance with Appendix A.4 where **Manufacturers Information** not previously provided |
| #7 | Installation and Commissioning Form Appendix A.4 completed with signed acceptance from the **DNO** representative | | - | Required |
|  | \* Circle as appropriate. | |  |  |
|  | Date upon which the **Power Generating Module** will be ready to be **Synchronised** to the **Total System** | |  |  |
|  | **Compliance Declaration – to be completed by Generator or Authorised Certifier.**  This declaration to be completed after the onsite testing and commissioning has been undertaken | | |  |
|  | I declare that the **PGM** complies with the requirements of EREC G99. | | |  |
|  | Name: | | |  |
|  | Signature: | Date: | |  |
|  | Position. | | |  |

A.4 **Type B**, **Type C** and **Type D** Installation and Commissioning Confirmation Form

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Installation and Commissioning Confirmation Form for Type B,Type C and Type D PGMs** | | | | | | | | |
| To ABC electricity distribution DNO  99 West St, Imaginary Town, ZZ99 9AA abced@wxyz.com | | | | | | | | |
| **Installer or Generator Details:** | | | | | | | | |
| Installer |  | | | | | | | |
| Accreditation/Qualification |  | | | | | | | |
| Address |  | | | | | | | |
| Post Code |  | | | | | | | |
| Contact person |  | | | | | | | |
| Telephone Number |  | | | | | | | |
| E-mail address |  | | | | | | | |
| **Installation Details** | | | | | | | | |
| Site Contact Details |  | | | | | | | |
| Address |  | | | | | | | |
| Post Code |  | | | | | | | |
| Site Telephone Number |  | | | | | | | |
| MPAN(s) |  | | | | | | | |
| Location within Customer’s Installation |  | | | | | | | |
| Location of Lockable Isolation Switch |  | | | | | | | |
| **Details of Power Generating Module(s) –** | | | | | | | | |
| Manufacturer / Reference | Date of Installation | Technology Type | Equipment certicate reference as applicable | **Power Generating Module Registered Capacity in kW** | | | | |
| 3-Phase Units | Single Phase Units | | | Power Factor |
| PH1 | PH2 | PH3 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

|  |  |  |
| --- | --- | --- |
| **Information to be enclosed** | | |
| Description | | Confirmation |
| Final copy of circuit diagram | | Yes / No\* |
| Schedule of protection settings ( may be included in circuit diagram ) | | Yes / No\* |
| **Commissioning Checks** | | |
| Installation satisfies the requirements of BS7671 (IET Wiring Regulations). | | Yes / No\* |
| Suitable lockable points of isolation have been provided between the **PGMs** and the rest of the installation. | | Yes / No\* |
| Labels have been installed at all points of isolation in accordance with EREC G99. | | Yes / No\* |
| Interlocking that prevents **PGMs** being connected in parallel with the **DNO** system (without synchronising) is in place and operates correctly. | | Yes / No\* |
| The **Interface Protection** settings have been checked and comply with EREC G99 (refer to 13.4) | | Yes / No\* |
| **PGMs** successfully synchronise with the **DNO** system without causing significant voltage disturbance. | | Yes / No\* |
| **PGMs** successfully run in parallel with the DNO system without tripping and without causing significant voltage disturbances. | | Yes / No\* |
| **PGMs** successfully disconnect without causing a significant voltage disturbance, when they are shut down. | | Yes / No\* |
| **Interface Protection** operates and disconnects the **PGMs** quickly (within 1s) when a suitably rated switch, located between the **PGMs** and the **DNO**s incoming connection, is opened. | | Yes / No\* |
| **PGMs** remain disconnected for at least 20s after switch is reclosed. | | Yes / No\* |
| **PGMs** disconnects when one phase of the supply is removed (**PGMs** with **LV** protection settings only) | |  |
| **Loss of tripping and auxiliary supplies** Where applicable, loss of supplies to tripping and protection relays results in either **Power Generating Module** lockout or an alarm to a 24hr manned control centre. | | Yes / No\* |
| \* Circle as appropriate. If “No” is selected the **Power Generating Facility** is deemed to have failed the commissioning tests and the **Power Generating Module** shall not be put in service. | | |
| Additional Comments / Observations: | | |
| **Declaration – to be completed by Generator or Generators Appointed Technical Representative.** | | |
| I declare that the **PGM** and the installation comply with the requirements of EREC G99 and the commissioning checks detailed in A.4 and A.5 have been successfully completed | | |
| Name: | | |
| Signature: | Date: | |
| Position. | | |
| **Declaration – to be completed by DNO Witnessing Representative** | | |
| I confirm that I have witnessed the tests in this document on behalf of  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and that the results are an accurate record of the tests | | |
| Name: | | |
| Signature: | Date: | |

## A.5 Generating Plant Installation and Commissioning Tests

**Compliance and Commissioning test requirements for PGMs in addition to those required in Appendix A.2**

Summary

|  |  |  |
| --- | --- | --- |
| Requirement (refer to paragraph12.3.4) | Compliance by provision of **Manufacturers Information**.  Reference number should be detailed and **Manufacturers Information** attached. | Compliance by commissioning tests |
| Over and under voltage protection LV –calibration test |  |  |
| Over and under voltage protection LV –stability test |  |  |
| Over and under voltage protection HV –calibration test |  |  |
| Over and under voltage protection HV –stability test |  |  |
| Over and Under Frequency protection – calibration test |  |  |
| Over and Under Frequency protection -stability test |  |  |
| Loss of mains protection – calibration test |  |  |
| Loss of mains protection – stability test |  |  |

|  |  |  |  |  |  |  |  |  |
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| **Over and Under Voltage Protection LV**  Where the **Connection Point** is at **LV** the Generator shall demonstrate compliance with this EREC G99 in respect of Over and Under Voltage Protection by provision of **Manufacturers Information** or by undertaking the following tests on site. | | | | | | | | |
| **Stability Tests** | | | | | | | | |
| Test Description | Setting | Time Delay | Test Condition  ( 3-Phase Value ) | Test Voltage all phases ph-n | Test Duration | Confirm No Trip | Result | |
| Inside Normal band | **---------** | **---------** | < OV Stage 1 | 258.2V | 5.00s |  | Pass/Fail | |
| **Stage 1 Over Voltage** | **262.2V** | **1.0s** | > OV Stage 1 | 269.7V | 0.95s |  | Pass/Fail | |
| **Stage 2 Over Voltage** | **273.7V** | **0.5s** | > OV Stage 2 | 277.7V | 0.45s |  | Pass/Fail | |
| Inside Normal band | **---------** | **---------** | > UV Stage 1 | 204.1V | 5.00s |  | Pass/Fail | |
| **Stage 1 Under Voltage** | **200.1V** | **2.5s** | < UV Stage 1 | 188V | 2.45s |  | Pass/Fail | |
| **Stage 2 Under Voltage** | **184.0V** | **0.5s** | < UV Stage 2 | 180V | 0.45s |  | Pass/Fail | |
| Overvoltage test - Voltage shall be stepped from 258V to the test voltage and held for the test duration and then stepped back to 258V.  Undervoltage test – Voltage shall be stepped from 204.1V to the test voltage and held for the test duration and then stepped back to 204.1V | | | | | | | |
| **Additional Comments / Observations:**: | | | | | | | |
|  | | | | | | | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Over and Under Voltage Protection HV**  Where the **Connection Point** is at **HV** the Generator shall demonstrate compliance with this EREC G99 in respect of Over and Under Voltage Protection by provision of **Manufacturers Information** or by undertaking the following tests on site.  Tests referenced to 110V ph-ph VT output | | | | | | | | | | | | | | | | | | | |
| **Calibration and Accuracy Tests** | | | | | | | | | | | | | | | | | | | |
| Phase | Setting | Time Delay | | **Pickup Voltage** | | | | | | | **Relay Operating Time** measured value plus or minus 2V | | | | | | | | |
| **Stage 1 Over Voltage** | | | | Lower Limit | Measured Value | | | Upper Limit | Result | | Test Value | Lower Limit | | Measured Value | | Upper Limit | | Result | |
| **L1 - L2** | **121V**  110V VT secondary | **1.0s** | | *119.35* |  | | | *122.65* | Pass/Fail | | Measured value plus 2V | *1.0s* | |  | | *1.1s* | | Pass/Fail | |
| **L2 - L3** |  | | | Pass/Fail | |  | | Pass/Fail | |
| **L3 - L1** |  | | | Pass/Fail | |  | | Pass/Fail | |
| **Stage 2 Over Voltage** | | | | Lower Limit | Measured Value | | | Upper Limit | Result | | Test Value | Lower Limit | | Measured Value | | Upper Limit | | Result | |
| **L1 - L2** | **124.3V**  110V VT secondary | 0.5s | | *122.65* |  | | | *125.95* | Pass/Fail | | Measured value plus 2V | *0.5s* | |  | | *0.6s* | | Pass/Fail | |
| **L2 - L3** |  | | | Pass/Fail | |  | | Pass/Fail | |
| **L3 - L1** |  | | | Pass/Fail | |  | | Pass/Fail | |
| **Stage 1 Under Voltage** | | | | Lower Limit | Measured Value | | | Upper Limit |  | | Test Value | Lower Limit | | Measured Value | | Upper Limit | | Result | |
| **L1 - L2** | **95.70V**  110V VT secondary | 2.5s | | *94.05* |  | | | *97.35* | Pass/Fail | | Measured value minus 2V | *2.5s* | |  | | *2.6s* | | Pass/Fail | |
| **L2 - L3** |  | | | Pass/Fail | |  | | Pass/Fail | |
| **L3 - L1** |  | | | Pass/Fail | |  | | Pass/Fail | |
| **Stage 2 Under Voltage** | | | | Lower Limit | Measured Value | | | Upper Limit |  | | Test Value | Lower Limit | | Measured Value | | Upper Limit | | Result | |
| **L1 - L2** | **88.00V**  110V VT secondary | 0.5s | | *86.35* |  | | | *89.65* | Pass/Fail | | Measured value minus 2V | *0.5s* | |  | | *0.6s* | | Pass/Fail | |
| **L2 - L3** |  | | | Pass/Fail | |  | | Pass/Fail | |
| **L3 - L1** |  | | | Pass/Fail | |  | | Pass/Fail | |
| **Over and Under Voltage Protection Tests HV**  **referenced to 110V ph-ph VT output** | | | | | | | | | | | | | | | | | | | |
| **Stability Tests** | | | | | | | | | | | | | | | | | | | |
| Test Description | | | Setting | | | Time Delay | Test Condition  ( 3-Phase Value ) | | | Test Voltage  All phases ph-ph | | | Test Duration | | Confirm No Trip | | Result | | |
| Inside Normal band | | | **---------** | | | **---------** | < OV Stage 1 | | | 119V | | | 5.00s | |  | | Pass/Fail | | |
| **Stage 1 Over Voltage** | | | **121V** | | | **1.0s** | > OV Stage 1 | | | 122.3V | | | 0.95s | |  | | Pass/Fail | | |
| **Stage 2 Over Voltage** | | | **124.3V** | | | **0.5s** | > OV Stage 2 | | | 126.3V | | | 0.45s | |  | | Pass/Fail | | |
| Inside Normal band | | | **---------** | | | **---------** | > UV Stage 1 | | | 97.7V | | | 5.00s | |  | | Pass/Fail | | |
| **Stage 1 Under Voltage** | | | **95.7V** | | | **2.5s** | < UV Stage 1 | | | 90V | | | 2.45s | |  | | Pass/Fail | | |
| **Stage 2 Under Voltage** | | | **88V** | | | **0.5s** | < UV Stage 2 | | | 86V | | | 0.45s | |  | | Pass/Fail | | |
| Additional Comments / Observations: | | | | | | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | | |

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| **Over and Under Frequency Protection**  The Generator shall demonstrate compliance with this EREC G99 in respect of Over and Under Frequency Protection by provision of **Manufacturers Information** or by undertaking the following tests on site | | | | | | | | | | | | | | |
| **Calibration and Accuracy Tests** | | | | | | | | | | | | | | |
| Setting | Time Delay | **Pickup Frequency** | | | | | **Relay Operating Time** | | | | | | | |
| **Over Frequency** | | Lower Limit | Measured Value | | Upper Limit | Result | Freq step | | Lower Limit | | Measured Value | | Upper Limit | Result |
| 52Hz | 0.5s | *51.90* |  | | *52.10* | Pass/Fail | 51.7-52.3Hz | | *0.50s* | |  | | *0.60s* | Pass/Fail |
| **Stage 1 Under Frequency** | | Lower Limit | Measured Value | | Upper Limit | Result | Freq step | | Lower Limit | | Measured Value | | Upper Limit | Result |
| 47.5Hz | 20s | *47.40* |  | | *47.60* | Pass/Fail | 47.8-47.2Hz | | *20.0s* | |  | | *20.2s* | Pass/Fail |
| **Stage 2 Under Frequency** | | Lower Limit | Measured Value | | Upper Limit | Result | Freq step | | Lower Limit | | Measured Value | | Upper Limit | Result |
| 47Hz | 0.5s | *46.90* |  | | *47.1* | Pass/Fail | 47.3-46.7Hz | | *0.50s* | |  | | *0.60s* | Pass/Fail |
| **Stability Tests** | | | | | | | | | | | | | | |
| Test Description | | Setting | | Time Delay | Test Condition | | | Test Frequency | | Test Duration | | Confirm No Trip | | Result |
| Inside Normal band | | **---------** | | **---------** | < OF Stage 1 | | | 51.3Hz | | 120s | |  | | Pass/Fail |
| **Over Frequency** | | 52Hz | | 0.5s | > OF Stage 2 | | | 52.2Hz | | 0.45s | |  | | Pass/Fail |
| Inside Normal band | | **---------** | | **---------** | > UF Stage 1 | | | 47.7Hz | | 30s | |  | | Pass/Fail |
| **Stage 1 Under Frequency** | | 47.5Hz | | 20s | < UF Stage 1 | | | 47.3Hz | | 19.5s | |  | | Pass/Fail |
| **Stage 2 Under Frequency** | | 47Hz | | 0.5s | < UF Stage 2 | | | 46.8Hz | | 0.45s | |  | | Pass/Fail |
| Overfrequency test - Frequency shall be stepped from 51.3Hz to the test frequency and held for the test duration and then stepped back to 51.3Hz.  Underfrequency test - Frequency shall be stepped from 47.1Hz to the test frequency and held for the test duration and then stepped back to 47.1Hz | | | | | | | | | | | | | | |
| Additional Comments / Observations: | | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Details of Loss of Mains Protection** | | | | |
| Manufacturer | Manufacturer’s type | Date of Installation | Settings | Other information |
|  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Loss-of-Mains (LOM) Protection Tests – RoCoF for Type A and Type B Power Generating Facilities**  The **Generator** shall demonstrate compliance with this EREC G99 in respect of LOM Protection by either providing the **DNO** with appropriate **Manufacturers Information** or by undertaking the following tests on site | | | | | | | | | | | | |
| **Calibration and Accuracy Tests** | | | | | | | | | | | | |
| Ramp in range 49.0-51.0Hz | **Pickup (**+ / -0.025Hzs-1) | | | | **Relay Operating Time**  RoCoF= +**0.05 / 0.10Hzs-1** above setting | | | | | | | |
| **Setting = 0.5 / 1.0 Hzs-1** | Lower Limit | Measured Value | Upper Limit | Result | Test Condition | | Lower Limit | | Measured Value | Upper Limit | | Result |
| Increasing Frequency | *0.475*  *0.975* |  | *0.525*  *1.025* | Pass/Fail | 0.55 Hzs-1  1.10 Hzs-1 | | *>0.5s* | |  | *<1.0s* | | Pass/Fail |
| Reducing Frequency | *0.475*  *0.975* |  | *0.525*  *1.025* | Pass/Fail | 0.55 Hzs-1  1.1 Hzs-1 | | *>0.5s* | |  | *<1.0s* | | Pass/Fail |
| **Stability Tests** | | | | | | | | | | | | |
| Ramp in range 49.0-51.0Hz | Test Condition | | Test frequency ramp | | | Test Duration | | Confirm No Trip | | | Result | |
| Inside Normal band | < RoCoF  ( increasing f ) | | 0.45Hzs-1  0.95 Hzs-1 | | | 4.4s | |  | | | Pass/Fail | |
| Inside Normal band | < RoCoF  ( reducing f ) | | 2.1s | |  | | | Pass/Fail | |
| Additional Comments / Observations: | | | | | | | | | | | | |
|  | | | | | | | | | | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **LoM Protection - Stability test** | | | |
| Start Frequency | Change | End Frequency | Confirm no trip |
| 49.5Hz | +50 degrees |  |  |
| 50.5Hz | - 50 degrees |  |  |

|  |
| --- |
| Insert here any additional tests which have been carried out |

# A.6 Simulation Studies for Type B, Type C and Type D Power Generating Modules

A6.1.1 This Appendix sets out the simulation studies required to be submitted to the **DNO** to demonstrate compliance with EREC G99 unless otherwise agreed with the **DNO**. This Appendix should be read in conjunction with Section 12.9 with regard to the submission of the reports to the **DNO**. Where there is any inconsistency in the technical requirements in respect of which compliance is being demonstrated by simulation in this Appendix and paragraph 12.9.3 and the **Connection Agreement**, the provisions of the **Connection Agreement** and paragraph 12.9.3 prevail. The studies specified in this Appendix will normally be sufficient to demonstrate compliance. However, the **DNO** may agree an alternative set of studies proposed by the **Generator** provided the **DNO** deems the alternative set of studies sufficient to demonstrate compliance with the EREC G99 and the **Connection Agreement**.

A.6.1.2 The **Generator** shall submit simulation studies in the form of a report to demonstrate compliance. In all cases the simulation studies must utilise models applicable to the **Synchronous Power Generating Module** or **Power Park Module** with proposed or actual parameter settings. Reports should be submitted in English with all diagrams and graphs plotted clearly with legible axes and scaling provided to ensure any variations in plotted values is clear.

A.6.1.3 **The DNO** may permit relaxation from the requirement in paragraph A.6.2 to paragraph A.6.8 where **Manufacturers Information** for the **Power Generating Module** has been provided which details the characteristics from appropriate simulations on a representative installation with the same equipment and settings and the performance of the **Power Generating Module** can, in **the DNO**s opinion, reasonably represent that of the installed **Power Generating Module**.

A.6.1.4 For **Type B,** **Type C** and **Type D** **Power Generating Modules** the relevant **Manufacturers Information** must be supplied in the **Power Generating Module** **Document** or DDRC as applicable.

A.6.2 Power System Stabiliser Tuning

A.6.2.1 In the case of a **Synchronous Power Generating Module** with a **Power System Stabiliser** the **Power System Stabiliser** tuning simulation study report required by the **Grid Code** ECC.A.6.2.5.6 shall be submitted in accordance with **Grid Code** EPC.A.3.2.1.

A.6.2.2 In the case of **Power Park Modules** with a **Power System Stabiliser** at the **Connection Point** the **Power System Stabiliser** tuning simulation study report required by the **Grid Code** ECC.A.7.2.4.1 shall contain be submitted in accordance with **Grid Code** ECP.A.3.2.2.

A.6.3 Reactive Capability across the Voltage Range

A.6.3.1 The **Generator** shall supply simulation studies to demonstrate the capability to meet Section 9.10 by submission of a report containing:

(i) a load flow simulation study result to demonstrate the maximum lagging **Reactive Power** capability of the **Synchronous Power Generating Module** or **Power Park Module** at **Registered Capacity** when the **Connection Point** voltage is at 105% of nominal.

(ii) a load flow simulation study result to demonstrate the maximum leading **Reactive Power** capability of the **Synchronous Power Generating Modul**e or **Power Park Module** at **Registered Capacity** when the **Connection Point** voltage is at 95% of nominal.

(iii) a load flow simulation study result to demonstrate the maximum lagging **Reactive Power** capability of the **Synchronous Power Generating Module** or **Power Park Module** at the **Minimum Generation** when the **Connection Point** voltage is at 105% of nominal.

(iv) a load flow simulation study result to demonstrate the maximum leading **Reactive Power** capability of the **Synchronous Power Generating Module** or Power Park Module at **the Minimum Generation** when the **Connection Point** voltage is at 95% of nominal.

A.6.3.2 In the case of a **Synchronous Power Generating Module** the terminal voltage in the simulation should be the nominal voltage for the machine.

A.6.3.3 In the case of a **Power Park Module** where the load flow simulation studies show that the individual **Generating Units** deviate from nominal voltage to meet the **Reactive Power** requirements then evidence must be provided from factory (e.g. **Manufactures Information**) or site testing that the **Generating Unit** is capable of operating continuously at the operating points determined in the load flow simulation studies.

A.6.4 Voltage Control and Reactive Power Stability

A.6.4.1 This section applies to **Type C** and **Type D** **Power Park Modules** to demonstrate the voltage control capability and **Type B Power Park Modules** to demonstrate the voltage control capability if specified by the **DNO.**

A.6.4.2 In the case of a **Power Generating Facility** containing **Power Park Modules** the **Generator** shall provide a report to demonstrate the dynamic capability and control stability of the **Power Park Module**. The report shall contain:

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

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

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

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

A.6.4.3 All the above studies should be completed with a nominal network voltage for zero **Reactive Power** transfer at the **Connection Point** unless stated otherwise and the fault level at the **Connection Point** at minimum as agreed with the **DNO**.

A.6.4.4 The **DNO** may permit relaxation from the requirements of A.3.4.2(i) and (ii) for voltage control if the **Power Park Modules** are comprised of **Power Park Units** in respect of which the **Generator** has in its submissions to the **DNO** referenced an appropriate **Manufacturers’ Information** which is acceptable to the **DNO** for voltage control.

A.6.4.5 In addition the **DNO** may permit a further relaxation from the requirements of CP.A.3.4.2(iii) and (iv) if the **Generator** has in its submissions to the **DNO** referenced appropriate **Manufacturers’ Information** for a **Power Park Module** mathematical model for voltage control acceptable to the **DNO**.

A.6.5 Fault Ride Through and Fast Fault Current Injection

A.6.5.1 This section applies to **Type B, Type C and Type D Power Generating Modules** to demonstrate the modules fault ride through and **Fast Fault Current** injection capability.

A.6.5.2 The **Generator** shall supply time series simulation study results to demonstrate the capability of **Synchronous Power Generating Module**s and **Power Park Modules** to meet Section 9.7 by submission of a report containing:

(i) a time series simulation study of a 140ms three phase short circuit fault with a retained voltage as detailed in table A.6.5.1 applied at the **Connection Point** of the **Power Generating Module**.

(ii) a time series simulation study of 140ms unbalanced short circuit faults with a retained voltage as detailed in table A.6.5.1 on the faulted phase(s) applied at the **Connection Point** of the **Power Generating Module**. The unbalanced faults to be simulated are:

1. a phase to phase fault

2. a two phase to earth fault

3. a single phase to earth fault.

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

Table A.6.5.1

For a Synchronous Power Generating Module the simulation study should be completed with the Synchronous Power Generating Module operating at full Active Power and maximum leading **Reactive Power** and the fault level at the **Connection Point** at minimum or as otherwise agreed with the **DNO**.

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

1. 50% retained voltage lasting 0.45 seconds

2. 70% retained voltage lasting 0.81 seconds

3. 80% retained voltage lasting 1.00 seconds

4. 85% retained voltage lasting 180 seconds.

For a **Type C** or **Type D Synchronous Power Generating Module**, the simulation study should be completed with the **Synchronous Power Generating Module** operating at full **Active Power** and zero Reactive **Power** output. The minimum **DNOs** system impedance to the Supergrid HV connection point shall be used which may be calculated from the maximum fault level at the **Connection Point** or taken from standard values for this purpose provided by the DNO.

(iv) time series simulation studies of balanced Supergrid voltage dips applied on the nearest point of the **National Electricity Transmission System** operating at Supergrid voltage to the **Power Park Module**. The simulation studies should include:

1. 30% retained voltage lasting 0.384 seconds

2. 50% retained voltage lasting 0.71 seconds

3. 80% retained voltage lasting 2.5 seconds

4. 85% retained voltage lasting 180 seconds.

For Power Park Modules the simulation study should be completed with the Power Park Module operating at full **Active Power** and zero **Reactive Power** output. The minimum **DNO**s system impedance to the Supergrid HV connection point shall be used which may be calculated from the maximum fault level at the **Connection** Point.

A.6.5.3 In the case of **Power Park Modules** comprised of **Generating Units** in respect of which the **Generator’s** reference to **Manufacturers Information** has been accepted by the **DNO** for **Fault Ride Through**, A.6.5.2 will not apply provided:

(i) the **Generator** demonstrates by load flow simulation study result that the faults and voltage dips at either side of the **Generating Unit** transformer corresponding to the required faults and voltage dips in A.6.5.2 applied at the nearest point of the **National Electricity Transmission System** operating at Supergrid voltage are less than those included in the **Manufacturers Information**,

or;

(ii) the same or greater percentage faults and voltage dips in A.6.5.2 have been applied at either side of the **Generating Unit** transformer in the **Manufacturers Information**.

A.6.6 **Limited Frequency Sensitive Mode – Over Frequency (LFSM-O)**

A.6.6.1 This section applies to **Type B, Type C** and **Type D Power Generating Modules** to demonstrate the capability to modulate **Active Power** at high frequency.

A.6.6.2 The simulation study should comprise of a **Power Generating Module** connected to the **Total System** with a local load shown as “X” in figure A.6.1. The load “X” is in addition to any auxiliary load of the **Power Generating Facility** connected directly to the **Power Generating Module** and represents a small portion of the system to which the **Power Generating Module** is attached. The value of “X” should be the minimum for which the **Power Generating Module** can control the power island frequency to less than 52Hz. Where transient excursions above 52Hz occur the **Generator** should ensure that the duration above 52Hz is less than any high frequency protection system applied to the **Power Generating Module**.

A.6.6.3 For **Power Park Modules** consisting of units connected wholly by power electronic devices an additional **Synchronous Power Generating** **Module** (G2) may be connected as indicated in Figure A.6.2. This additional **Synchronous** **Power Generating Module** should have an inertia constant of 3.5MWs/MVA, be initially operating at rated power output and unity power factor. The mechanical power of the **Synchronous** **Power Generating Module** (G2) should remain constant throughout the simulation.

A.6.6.4 At the start of the simulation study the **Power Generating Module** will be operating maximum **Active Power** output. The **Power Generating Module** will then be islanded from the **Total System** but still supplying load “X” by the opening of a breaker, which is not the **Power Generating Module** orconnection circuit breaker (the governor should therefore, not receive any signals that the breaker has opened other than the reduction in load and subsequent increase in speed). A schematic arrangement of the simulation study is illustrated by Figure A.6.1.



Figure A.6.1 – Diagram of Load Rejection Study

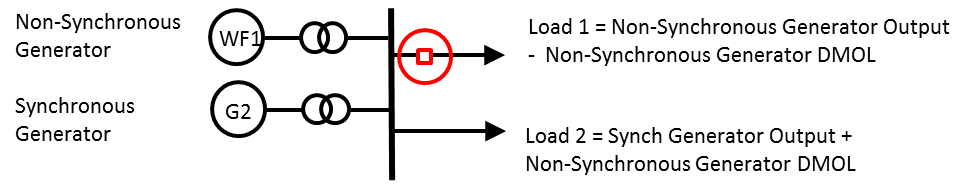


Figure A.6.2 – Addition of Generator G2 if applicable

A.6.6.5 Simulation studies shall be performed for **Type B**, **Type C** and **Type D** in **Limited Frequency Sensitive Mode** (LFSM) and **Frequency Sensitive Mode** (FSM) for **Type C** and **Type D**. The simulation study results should indicate **Active Power** and frequency.

A.6.6.7 To allow validation of the model used to simulate load rejection in accordance with Section 9.4.4 as described a further simulation study is required to represent the largest positive frequency injection step or fast ramp (BC1 and BC3 of Figure A.7.1 and Figure A.8.3) that will be applied as a test as described in A.7.8 and A.8.6.

A.6.7 **Limited Frequency Sensitive Mode – Under Frequency (LFSM-U)**

A.6.7.1 This section applies to **Type C** and **Type D Synchronous Power Generating Modules** and **Type C** and **Type D Power Park Modules** to demonstrate the modules capability to modulate **Active Power** at low frequency.

A.6.7.2 To demonstrate the **LFSM-U** low frequency control when operating in **Limited Frequency Sensitive Mode** the **Generator** shall submit a simulation study representing the response of the **Power Generating Module** operating at 80% of **Registered Capacity**. The simulation study event shall be equivalent to:

1. a sufficiently large reduction in the measured system frequency ramped over 10 seconds to cause an increase in **Active Power** output to the **Registered Capacity** followed by
2. 60 seconds of steady state with the measured system frequency depressed to the same level as in A.6.7.2 (i) as illustrated in Figure A.6.3 below.
3. then increase of the measured system frequency ramped over 10 seconds to cause a reduction in **Active Power** output back to the original **Active Power** level followed by at least 60 seconds of steady output.



Figure A.6.3

A.6.8 Voltage and Frequency Controller Model Verification and Validation

A.6.8.1 For **Type C** and **Type D** **Synchronous Power Generating Modules** and **Power Park Modules** the **Generator** shall provide simulation studies to verify that the proposed controller models supplied to the **DNO** under the DDRC are fit for purpose. These simulation study results shall be provided in the timescales stated in the DDRC.

A.6.8.2 To demonstrate the frequency control or governor/load controller/plant model the **Generator** shall submit a simulation study representing the response of the **Synchronous Power Generating Module** or **Power Park Module** operating at 80% of **Registered Capacity**. The simulation study event shall be equivalent to:

(i) a ramped reduction in the measured system frequency of 0.5Hz in 10 seconds followed by

(ii) 20 seconds of steady state with the measured system frequency depressed by 0.5Hz followed by

(iii) a ramped increase in measured system frequency of 0.3Hz over 30 seconds followed by

(iv) 60 seconds of steady state with the measured system frequency depressed by 0.2Hz as illustrated in Figure A.6.4 below.



Figure A.6.4

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

A.6.8.3 To demonstrate the Excitation System model the **Generator** shall submit simulation studies representing the response of the **Synchronous Power Generating Module** as follows:

(i) operating open circuit at rated terminal voltage and subjected to a 10% step increase in terminal voltage reference from 90% to 100%.

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

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

A.6.8.4 To demonstrate the Voltage Controller model the shall submit a simulation study representing the response of the Power Park Module operating at **Rated MW** and unity power factor at the connection point to a 2% step increase in the voltage reference. The simulation study shall show the terminal voltage, **Active Power**, **Reactive Power** and **Power System Stabiliser** output signal as appropriate.

A.6.8.5 To validate that the excitation and voltage control models submitted under the DDRC are a reasonable **representation of the dynamic behaviour of the Synchronous** **Power Generating Module** or **Power Park Module** as built, the **Generator** shall repeat the simulation studies outlined above but using the operating conditions of the equivalent tests. The simulation study results shall be displayed overlaid on the actual test results.

A.6.8.6 For **Type C** and **Type D Synchronous Power Generating Modules** to validate that the governor/load controller/plant or frequency control models submitted under the DDRC is a reasonable representation of the dynamic behaviour of the **Synchronous Power Generating Module** as built, the **Generator** shall repeat the simulation studies outlined above but using the operating conditions of the equivalent tests. The simulation study results shall be displayed overlaid on the actual test results.

# Appendix 7 Compliance Testing of Synchronous Power Generating Modules

A.7.1 **Scope**

A.7.1.1 This Appendix sets out the tests contained therein to demonstrate compliance with the relevant clauses of the EREC G99.

A.7.1.2 The tests specified in this Appendix will normally be sufficient to demonstrate compliance however the **DNO** may:

1. agree an alternative set of tests provided the **DNO** deems the alternative set of tests sufficient to demonstrate compliance with this EREC G99 and the **Connection Agreement**; and/or
2. require additional or alternative tests if information supplied to the **DNO** during the compliance process suggests that the tests in this Appendix will not fully demonstrate compliance with the relevant section of the EREC G99 or the **Connection Agreement.**
3. Agree a reduced set of tests for subsequent **Synchronous Power Generating Module** following successful completion of the first **Synchronous Power Generating Module** tests in the case of a **Power Generating Facility** comprised of two or more **Synchronous Power Generating Module**s which the **DNO** reasonably considers to be identical.

If:

(a) the tests performed pursuant to A.7.1.2(iii) in respect of subsequent **Synchronous Power Generating Modules** do not replicate the full tests for the first **Synchronous Power Generating Module**, or

(b) any of the tests performed pursuant to A.7.1.2(iii) do not fully demonstrate compliance with the relevant aspects of EREC G99, the **Connection Agreement**, or an any other contractual agreement with the DNO if applicable;

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

A.7.1.3 The **Generator** is responsible for carrying out the tests set out in and in accordance with this Appendix and the **Generator** retains the responsibility for the safety of personnel and plant during the test. The **DNO** will witness all of the tests outlined or agreed in relation to this Appendix unless the **DNO** decides and notifies the **Generator** otherwise. Reactive Capability tests may be witnessed by the **DNO** remotely from the **DNO** control centre. For all on site **DNO** witnessed tests the **Generator** should ensure suitable representatives from the **Generator** and manufacturer (if appropriate) are available on site for the entire testing period.

A.7.1.8 Full **Synchronous** Power Generating M**odule** testing is to be completed as defined in A.7.2 through to A.7.9.

A.7.1.9 The **DNO** may permit relaxation from the requirement A.7.2 to A.7.9 where **Manufacturers Information** for the **Synchronous Power Generating Module** has been provided which details the characteristics from tests on a representative machine with the same equipment and settings and the performance of the **Synchronous Power Generating Module** can, in the **DNO**s opinion, reasonably represent that of the installed **Synchronous Power Generating Module** at that site. For **Type C** and **Type D** **Power Generating Modules** the relevant **Manufacturers Information** must be supplied in the **Power Generating Module** **Document** or the **DDRC** as applicable.

## A.7.2 Excitation System Open Circuit Step Response Tests

A.7.2.1 The open circuit step response of the **Excitation System** will be tested by applying a voltage step change from 90% to 100% of the nominal **Synchronous Power Generating Module** terminal voltage, with the **Synchronous Power Generating Module** on open circuit and at rated speed.

A.7.2.2 The test shall be carried out prior to synchronisation. This is not witnessed by the **DNO** unless specifically requested by the **DNO**. Where the **DNO** is not witnessing the tests, the Generator shall supply the recordings of the following signals to the **DNO** in an electronic spreadsheet format:

Vt - Synchronous **Generating Unit** terminal voltage

Efd - Synchronous **Generating Unit** field voltage or main exciter field voltage

Ifd- Synchronous **Generating Unit** field current (where possible)

Step injection signal

A.7.2.3 Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

A.7.3 **Open & Short Circuit Saturation Characteristics**

A.7.3.1 The test shall normally be carried out prior to synchronisation. **Manufacturers Information** may be used where appropriate may be used if agreed by the **DNO**.

A.7.3.2 This is not witnessed by the **DNO**. Graphical and tabular representations of the results in an electronic spreadsheet format showing per unit open circuit terminal voltage and short circuit current versus per unit field current shall be submitted to the **DNO**.

A.7.3.3 Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

A.7.4 **Excitation System** **On-Load Tests**

A.7.4.1 The time domain performance of the **Excitation System** shall be tested by application of voltage step changes corresponding to 1% and 2% of the nominal terminal voltage.

A.7.4.2 Where a **Power System Stabiliser** is present the tests should be carried out in accordance with the Grid Code ECP.A.5.4.2.

A.7.4.3 **Under-excitation Limiter** **Performance Test**

A.7.4.3.1Initially the performance of the **Under-excitation Limiter** should be checked by moving the limit line close to the operating point of the **Generating Unit** when operating close to unity power factor. The operating point of the **Generating Unit** is then stepped into the limit by applying a 2% decrease in **Automatic Voltage Regulator** Setpoint voltage.

A.7.4.3.2The final performance of the **Under-excitation Limiter** shall be demonstrated by testing its response to a step change corresponding to a 2% decrease in **Automatic Voltage Regulator** Setpoint voltage when the **Generating Unit** is operating just off the limit line, at the designed setting as indicated on the **Performance Chart** [P-Q Capability Diagram] submitted to the **DNO** under DDRC Schedule 5.

A.7.4.3.3Where possible the **Under-excitation Limiter** should also be tested by operating the tap- changer when the **Generating Unit** is operating just off the limit line, as set up.

A.7.4.3..4The **Under-excitation Limiter** will normally be tested at low **Active Power** output (minimum generation) and at maximum **Active Power** output (**Registered Capacity**).

A.7.4.3..5The following typical procedure is provided to assist **Generators** in drawing up their own site specific procedures for the **DNO** witnessed **Under-excitation Limiter** Tests.

|  |  |  |
| --- | --- | --- |
| **Test** | **Injection** | **Notes** |
|  | **Generating Unit** running at **Registered Capacity** and unity power factor. Under-excitation limit temporarily moved close to the operating point of the **Generating Unit**. |  |
| 1 | • **PSS** on (if applicable).  • Inject -2% voltage step into AVR voltage Setpoint and hold at least for 10 seconds until stabilised  • Remove step returning AVR Voltage Setpoint to nominal and hold for at least 10 seconds |  |
|  | Under-excitation limit moved to normal position. **Generating Unit** running at **Registered Capacity** and at leading **Reactive Power** close to Under-excitation limit. |  |
| 2 | • PSS on (if applicable).  • Inject -2% voltage step into AVR voltage Setpoint and hold at least for 10 seconds until stabilised  • Remove step returning AVR Voltage Setpoint to nominal and hold for at least 10 seconds |  |

## A.7.4.4 Over-excitation Limiter Performance Test

A.7.4.1 The performance of the **Over-excitation Limiter**, where it exists, shall be demonstrated by testing its response to a step increase in the Automatic Voltage Regulator Setpoint voltage that results in operation of **the Over-excitation Limiter**. Prior to application of the step the **Generating Unit** shall be generating **Registered Capacity** and operating within its continuous **Reactive Power** capability. The size of the step will be determined by the minimum value necessary to operate the **Over-excitation Limiter** and will be agreed by the **DNO** and the **Generator**. The resulting operation beyond the **Over-excitation Limit** shall be controlled by the **Over-excitation Limiter** without the operation of any protection that could trip the **Power Generating** **Module**. The step shall be removed immediately on completion of the test.

A.7.4.4.2 If the **Over-excitation Limiter** has multiple levels to account for heating effects, an explanation of this functionality will be necessary and if appropriate, a description of how this can be tested.

A.7.4.4.3The following typical procedure is provided to assist **Generators** in drawing up their own site specific procedures for the **DNO** witnessed **Under-excitation Limiter** Tests.

|  |  |  |
| --- | --- | --- |
| **Test** | **Injection** | **Notes** |
|  | **Generating Unit** running at **Registered Capacity** and maximum lagging **Reactive Power**. |  |
|  | Over-excitation Limit temporarily set close to this operating point.  **PSS** on (if applicable). |  |
| 1 | • Inject positive voltage step into AVR voltage setpoint and hold  • Wait till **Over-excitation Limiter** operates after sufficient time delay to bring back the excitation back to the limit.  • Remove step returning AVR voltage setpoint to nominal. |  |
|  | Over-excitation Limit restored to its normal operating value.  **PSS** on (if applicable). |  |

A.7.5 **Reactive Capability**

A.7.5.1 The **Reactive Power** capability on each **Synchronous Power Generating Module** will normally be demonstrated by:

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

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

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

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

(e) operation of the **Synchronous Power Generating Module** at maximum lagging **Reactive Power** and a power output between **Registered Capacity** and **Minimum Generation**.

(f) operation of the **Synchronous Power Generating Module** at maximum leading **Reactive Power** and a power output between **Registered Capacity** and **Minimum Generation**.

A.7.5.2 Where **Distribution Network** considerations restrict the **Synchronous Power Generating Module** **Reactive Power** output then the maximum leading and lagging capability will be demonstrated without breaching the **DNO** limits.

A.7.5.3 The test procedure, time and date will be agreed with the **DNO** and will be to the instruction of the **DNO** control centreand shall be monitored and recorded at both the **DNO** control centre and by the **Generator**.

A.7.5.4 Where the **Generator** is recording the voltage and **Reactive Power** at the **Synchronous Power Generating Module** terminals the voltage, **Active Power** and **Reactive Power** at the **Connection Point** shall be included. The results shall be supplied in an electronic spreadsheet format.

A.7.6 **Governor and Load Controller Response Performance**

A.7.6.1 The governor and load controller response performance will be tested by injecting simulated frequency deviations into the governor and load controller systems. Such simulated frequency deviation signals must be injected simultaneously at both speed governor and load controller setpoints. For **CCGT modules**, simultaneous injection into all gas turbines, steam turbine governors and module controllers is required.

A.7.6.

A.7.6.2 Where a **CCGT module** or **Synchronous Power Generating Module** is capable of operating on alternative fuels, tests will be required to demonstrate performance when operating on each fuel. The **DNO** may agree a reduction from the tests listed in A.7.8.5 for demonstrating performance on the alternative fuel. This includes the case where a main fuel is supplemented by bio-fuel.

A.7.6.3 Full Frequency Response Testing Schedule Witnessed by the **DNO**

The tests are to be conducted at a number of different Module Load Points (MLP) based on fractions of the maximum export level (MEL).

The MEL is a series of MW figures and associated times, making up a profile of the maximum level at which the **Power Generating Module** may be exporting at the **Connection Point.**

The load points are conducted as shown below unless agreed otherwise by the **DNO**.

|  |  |
| --- | --- |
| Module Load Point 6  (**MEL**) | 100% MEL |
| Module Load Point 5 | 95% MEL |
| Module Load Point 4  (Mid-point of Operating Range) | 80% MEL |
| Module Load Point 3 | 70% MEL |
| Module Load Point 2  (Minimum Generation) | MG |
| Module Load Point 1  (**Minimum Generation**) | MRL |

A.7.6.4 The tests are divided into the following two types;

1. Frequency response tests in Limited Frequency Sensitive Mode (LFSM) to demonstrate **LFSM-O** and **LFSM-U** capability as shown by Figure A.7.1.
2. System islanding and step response tests if required by the DNO.

A.7.6.5 There should be sufficient time allowed between tests for control systems to reach steady state. Where the diagram states ‘HOLD’ the current injection should be maintained until the **Active Power** (MW) output of the **Synchronous Power Generating Module** or **CCGT Module** has stabilised.The **DNO** may require repeat tests should the tests give unexpected results.

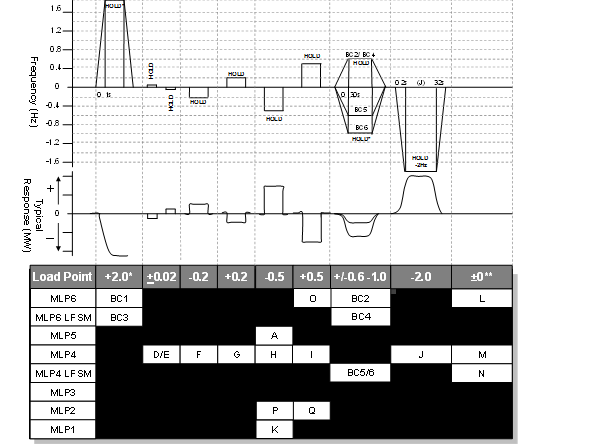


Figure A.7.1: Step response tests

\* This will generally be +2.0Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum Generation** in which case an appropriate injection should be calculated in accordance with the following:

For example 0.9Hz is needed to take an initial output 65% to a final output of 20%. If the initial output was not 65% and the **Minimum Generation** is not 20% then the injected step should be adjusted accordingly as shown in the example given below

Initial Output 65%

**Minimum Generation**  20%

Frequency Controller Droop 4%

Frequency to be injected = (0.65-0.20)x0.04x50 = 0.9Hz

\*\* Tests L and M in Figure A.7.1 shall be conducted if in this range of tests the system frequency feedback signal is replaced by the injection signal rather than the injection signal being added to the system frequency signal. The tests will consist of monitoring the **Synchronous Power Generating Module** **and CCGT Module** in **Frequency Sensitive Mode** during normal system frequency variations without applying any injection. Test N in Figure A.7.1 shall be conducted in all cases. Both tests should be conducted for a period of at least 10 minutes.

A.7.6.6 The target frequency adjustment facility should be demonstrated from the normal control point within the range of 49.9Hz to 50.1Hz by step changes to the target frequency setpoint.

A.7.7 Compliance with Section 9.4.3 Output power with falling frequency Functionality Test

A.7.7.1 Where the plant design includes active control function or functions to deliver Section 9.4.3 compliance, the **Generator** will propose and agree a test procedure with the **DNO**, which will demonstrate how the **Synchronous Power Generating Module Active Power** output responds to changes in system frequency and ambient conditions (eg by frequency and temperature injection methods).

A.7.7.2 The Generator shall inform the **DNO** if any load limiter control is additionally employed.

A.7.7.3 With Setpoint to the signals specified in Appendix A.7, the **DNO** will agree with the **Generator** which additional control system parameters shall be monitored to demonstrate the functionality of Section 9.4.3 compliance systems. The results shall be supplied to the **DNO** in an electronic spreadsheet format

# Appendix 8 Compliance Testing of Power Park Modules

A.8.1 **Scope**

A.8.1.1 This Appendix outlines the general testing requirements for **Power Park** to demonstrate compliance with the relevant clauses of the EREC G99.

A8.1.2 The tests specified in this Appendix will normally be sufficient to demonstrate compliance however the **DNO** may:

1. agree an alternative set of tests provided the **DNO** deems the alternative set of tests sufficient to demonstrate compliance with t this EREC G99 and the **Connection Agreement**; and/or
2. require additional or alternative tests if information supplied to **the DNO** during the compliance process suggests that the tests in this Appendix will not fully demonstrate compliance with the relevant section of this EREC G99 and the **Connection Agreement**; and/or
3. require additional tests if a **Power System Stabiliser** is fitted; and/or
4. agree a reduced set of tests if a relevant **Manufacturer's Data & Performance Report** has been submitted to and deemed to be appropriate by the **DNO**; and/or
5. agree a reduced set of tests for subsequent **Power Park Modules** following successful completion of the first **Power Park Module** tests in the case of a **Power Station** comprised of two or more **Power Park Modules** which **the DNO** reasonably considers to be identical.

If:

(a) the tests performed pursuant to A.8.1.1(iv) do not replicate the results contained in the **Manufacturer’s Data & Performance Report** or

(b) the tests performed pursuant to A.8.1.1(v) in respect of subsequent **Power Park Modules** or **OTSDUA** do not replicate the full tests for the first **Power Park Module** or **OTSDUA**, or

(c) any of the tests performed pursuant to A.8.1.1(iv) or A.8.1.1(v) do not fully demonstrate compliance with the relevant aspects of the this EREC G99 and the **Connection Agreement** ,

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

A.8.1.2 The **Generator** is responsible for carrying out the tests set out in and in accordance with this Appendix and the **Generator** retains the responsibility for the safety of personnel and plant during the test. The **DNO** will witness all of the tests outlined or agreed in relation to this Appendix unless the **DNO** decides and notifies the **Generator** otherwise. Reactive Capability tests may be witnessed by **the DNO** remotely from the **DNO** control centre. For all on site **DNO** witnessed tests the **Generator** must ensure suitable representatives from the **Generator** and / or **Power Park Module** manufacturer (if appropriate) are available on site for the entire testing period. In all cases and in addition to any recording of signals conducted by **the DNO** the **Generator** shall record all relevant test signals 4.

A.8.1.3 The **Generator** shall inform the **DNO** of the following information prior to the commencement of the tests and any changes to the following, if any values change during the tests:

1. All relevant transformer tap numbers; and
2. Number of **Generating Units** in operation

A.8.1.4 The Generatorshall submit a detailed schedule of tests to the **DNO** in accordance with 12.2.2 of EREC G99 and this Appendix.

A.8.1.5 Partial **Power Park Module** testing as defined in A.8.2 and A.8.3 is to be completed at the appropriate stage.

A.8.1.6 The **DNO** may permit relaxation from the requirement A.8.2 to A.8.8 where **manufacturers’ information** for the **Power Park Module** has been provided which details the characteristics from tests on a representative installation with the same equipment and settings and the performance of the **Power Park Module** can, in the **DNO**s opinion, reasonably represent that of the installed **Power Park Module** at that site. For **Type C** and **Type D** **Power Park Modules** the relevant **Manufacturers’ Information** must be supplied in the **Power Generating Module** **Document** or **DDRC** as applicable.

A.8.2 **Pre 20% Synchronised Power Park Module Basic Voltage Control Tests**

A.8.2.1Before 20% of the **Power Park Module** has commissioned, either voltage control test A.8.5.6(i) or (ii) must be completed.

A.8.3 Reactive Capability Test

A.8.3.1 This section details the procedure for demonstrating the reactive capability of a **Power Park Module** which provides all or a portion of the **Reactive Power** capability. These tests should be scheduled at a time where there are at least 95% of the **Generating Units** within the **Power Park Module** in service. There should be sufficient MW resource forecasted in order to generate at least 85% of **Registered Capacity** of the **Power Park Module**.

A.8.3.2 The tests shall be performed by modifying the voltage set-point of the voltage control scheme of the **Power Park Module** by the amount necessary to demonstrate the required reactive range. This is to be conducted for the operating points and durations specified in A.8.4.5.

A.8.3.2 In the case where the **Reactive Power** metering point is not at the same location as the **Reactive Power** capability requirement, then an equivalent **Reactive Power** capability for the metering point shall be agreed between the **Generator** and **the DNO**.

A.8.3.3 The following tests shall be completed:

1. Operation in excess of 60% **Registered capacity** and maximum continuous lagging **Reactive Power** for 30 minutes.
2. Operation in excess of 60% **Registered capacity** and maximum continuous leading **Reactive Power** for 30 minutes.
3. Operation at 50% **Registered capacity** and maximum continuous leading **Reactive Power** for 30 minutes.
4. Operation at 20% **Registered capacity** and maximum continuous leading **Reactive Power** for 60 minutes.
5. Operation at 20% **Registered capacity** and maximum continuous lagging **Reactive Power** for 60 minutes.
6. Operation at less than 20% **Registered capacity** and unity **Power Factor** for 5 minutes. This test only applies to systems which do not offer voltage control below 20% of **Registered capacity**.
7. Operation at the lower of the **Minimum Generation** or 0% **Registered capacity** and maximum continuous leading **Reactive Power** for 5 minutes. This test only applies to systems which offer voltage control below 20% and hence establishes actual capability rather than required capability.
8. Operation at the lower of the **Minimum Generation** or 0% **Registered capacity** and maximum continuous lagging **Reactive Power** for 5 minutes. This test only applies to systems which offer voltage control below 20% and hence establishes actual capability rather than required capability.

A.8.3.4 Within this Appendix lagging **Reactive Power** is the export of **Reactive Power** from the **Power Park Module** to the **DNO’s system** and leading **Reactive Power** is the import of **Reactive Power** from the **DNO’s system** to the **Power Park Module.**

A.8.4 Voltage Control Tests

A.8.4.1 This section details the procedure for conducting voltage control tests on **Power Park Modules** which provides all or a portion of the voltage control capability as described in paragraph 9.8.. These tests should be scheduled at a time when there are at least 95% of the **Generating Units** within the **Power Park Module** in service. There should be sufficient MW resource forecasted in order to generate at least 65% of **Maximum Capacity** of the **Power Park Module**.

A.8.4.2 The voltage control system shall be perturbed with a series of step injections to the **Power Park Module** voltage Setpoint, and where possible, multiple up-stream transformer taps.

A.8.4.3 The time between transformer taps shall be at least 10 seconds as per A.8.4 Figure A.8.1.

A.8.4.4 For step injection into the **Power Park Module** voltage Setpoint, steps of ±1% and ±2% (or larger if required by the **DNO**) shall be applied to the voltage control system Setpoint summing junction. The injection shall be maintained for 10 seconds as per A.8.4 Figure A.8.2.

A.8.4.5 Where the voltage control system comprises of discretely switched plant and apparatus additional tests will be required to demonstrate that its performance is in accordance with EREC G99 and the **Connection Agreement** requirements.

A.8.4.6 Tests to be completed:

(i)

Time

Voltage

10s

minimum

1 tap

A.8.4 Figure A.8.1 – Transformer tap sequence for voltage control tests

(ii)



A.8.4 Figure A.8.2 – Step injection sequence for voltage control tests

A.8.5 Frequency Response Tests

A.8.5.1 This section describes the procedure for performing frequency response testing on a **Power Park Module**. These tests should be scheduled at a time where there are at least 95% of the **Generating Units** within the **Power Park Module** in service. There should be sufficient MW resource forecasted in order to generate at least 65% of **Registered Capacity** of the **Power Park Module**.

A.8.5.2 The frequency controller shall be in **Frequency Sensitive Mode** or **Limited Frequency Sensitive Mode** as appropriate for each test. Simulated frequency deviation signals shall be injected into the frequency controller setpoint/feedback summing junction. If the injected frequency signal replaces rather than sums with the real system frequency signal then the additional tests outlined in A.8.5.6 shall be performed with the **Power Park Module** or **Generating Unit** in normal **Frequency Sensitive Mode** monitoring actual system frequency, over a period of at least 10 minutes. The aim of this additional test is to verify that the control system correctly measures the real system frequency for normal variations over a period of time.

A.8.5.3 In addition to the frequency response requirements it is necessary to demonstrate the **Power Park Module** ability to deliver a requested steady state power output which is not affected by power source variation as per paragraph 9.18. This test shall be conducted in **Limited Frequency Sensitive Mode** at a part-loaded output for a period of 10 minutes as per A.8.5.6.

A.8.5.4 Preliminary Frequency Response Testing

A.8.5.5 Full Frequency Response Testing Schedule Witnessed by the **DNO**

A.8.5.6 The tests are to be conducted at a number of different Module Load Points (MLP) based on the maximum export limit (MEL). In the case of a **Power Park Module** the module load points are conducted as shown below unless agreed otherwise by the **DNO**.

|  |  |
| --- | --- |
| Module Load Point 6  (**Maximum Export Limit**) | 100% MEL |
| Module Load Point 5 | 90% MEL |
| Module Load Point 4  (Mid point of Operating Range) | 80% MEL |
| Module Load Point 3 | MRL+20% |
| Module Load Point 2 | MRL+10% |
| Module Load Point 1  (**Minimum Generation**) | MRL |

A.8.5.7 The tests are divided into the following two types;

1. Frequency response tests in Limited Frequency Sensitive Mode (LFSM) to demonstrate LFSM-O and LFSM-U capability as shown by A.8.5.8 Figure A.8.3.
2. System islanding and step response tests as shown by A.8.6. Figure A.8.3.

A.8.5.8 There should be sufficient time allowed between tests for control systems to reach steady state (depending on available power resource). Where the diagram states ‘HOLD’ the current injection should be maintained until the **Active Power** (MW) output of the **Power Park Module** has stabilised. All frequency response tests should be removed over the same timescale for which they were applied. the **DNO** may require repeat tests should the response volume be affected by the available power, or if tests give unexpected results.

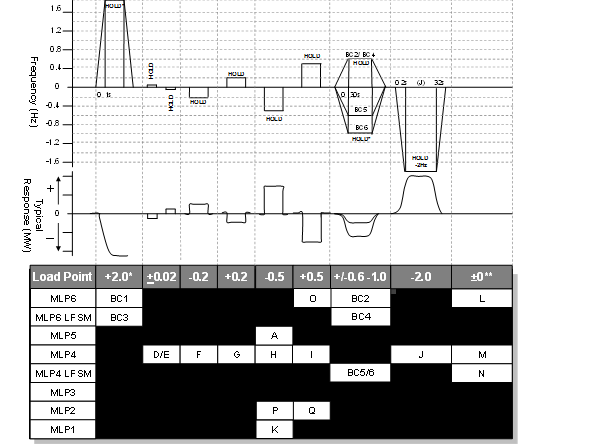


Figure A.8.2 – System islanding and step response tests

\* This will generally be +2.0Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum Generation** in which case an appropriate injection should be calculated in accordance with the following:

For example 0.9Hz is needed to take an initial output 65% to a final output of 20%. If the initial output was not 65% and the **Minimum Generation** is not 20% then the injected step should be adjusted accordingly as shown in the example given below

Initial Output 65%

**Minimum Generation** 20%

Frequency Controller Droop 4%

Frequency to be injected = (0.65-0.20) x 0.04x50 = 0.9Hz

\*\* Tests L and M in Figure A.8.3 shall be conducted if in this range of tests the system frequency feedback signal is replaced by the injection signal rather than the injection signal being added to the system frequency signal. The tests will consist of monitoring the **Power Park Module** in **Frequency Sensitive Mode** during normal system frequency variations without applying any injection. Test N in Figure A.8.3 shall be conducted in all cases. All tests should be conducted for a period of at least 10 minutes*.*

A.8.5.9 The target frequency adjustment facility should be demonstrated from the normal control point within the range of 49.9Hz to 50.1Hz by step changes to the target frequency setpoint.

A.8.6 **Fault Ride Through Testing**

A.8.6.1 This section describes the procedure for conducting fault ride through tests on a single **Generating Unit**.

A.8.6.2 The test circuit will utilise the full **Generating Unit** with no exclusions (eg in the case of a wind turbine it would include the full wind turbine structure) and shall be conducted with sufficient resource available to produce at least 95% of the **Registered Capacity** of the **Generating Unit**. The test will comprise a number of controlled short circuits applied to a test network to which the **Generating Unit** is connected, typically comprising of the **Generating Unit** transformer and a test impedance to shield the connected network from voltage dips at the **Generating Unit** terminals.

A.8.6.3 In each case the tests should demonstrate the minimum voltage at the **Generating Unit** terminals or **High Voltage** side of the **PGenerating Unit** transformer which the **Generating Unit** can withstand for the length of time specified in A.8.6.5. Any test results provided to the **DNO** should contain sufficient data pre and post fault in order to determine steady state values of all signals, and the power recovery timescales.

A.8.6.4 The following signals from either the **Generating Unit** terminals or **High Voltage** side of the **Generating Unit** transformer should be provided for this test only:

1. Phase voltages
2. Positive phase sequence and negative phase sequence voltages
3. Phase currents
4. Positive phase sequence and negative phase sequence currents
5. Estimate of **Generating Unit** negative phase sequence impedance
6. MW – **Active Power** at the power generating module.
7. MVAr – **Reactive Power** at the power generating module.
8. Mechanical Rotor Speed
9. Real / reactive, current / power Setpoint as appropriate
10. Fault ride through protection operation (e.g. a crowbar in the case of a doubly fed induction generator)
11. Any other signals relevant to the control action of the fault ride through control deemed applicable for model validation.

At a suitable frequency rate for fault ride through tests as agreed withthe **DNO**.

A.8.6.5 The tests should be conducted for the times and fault types indicated in Table A.8.1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 3 Phase | Phase to Phase | 2 Phase to Earth | 1 Phase to Earth | Grid Code Ref |
| 0.14s | 0.14s | 0.14s | 0.14s | ECC.6.3.15 |
| 0.384s |  | | | ECC.6.3.15 |
| 0.710s |
| 2.5s |
| 180.0s |

Table A.8.1 – Types of fault for fault ride through **testing**

## A.9 Power Generating Module Decommissioning Confirmation

Confirmation of the decommissioning of a **Power Generating Module** connected in parallel with the public **Distribution Network** – in accordance with Engineering Recommendation G99.

|  |  |
| --- | --- |
| **Site Details** | |
| Site Address (inc. post code) |  |
| Telephone number |  |
| MPAN(s) |  |
| **Distribution Network Operator (DNO)** |  |
| **PGM Details** | |
| **Manufacturer** and model type |  |
| Serial number of each **Generating Unit** |  |
| Rating (kVA) |  |
| Type of prime mover and fuel source |  |

|  |  |  |
| --- | --- | --- |
| **Decommissioning Agent Details** | | |
| Name |  | |
| Accreditation/Qualification: |  | |
| Address (incl post code) |  | |
| Contact person |  | |
| Telephone Number |  | |
| Fax Number |  | |
| E-mail address |  | |
| Name: | Signature: | Date: |

## 13.6 Additional Information Relating to System Stability Studies

**13.6.1 System Stability**

Stability is an important issue for secure and reliable power system operation. Consequently **System Stability** considerations deserve attention when developing **Power Generating Module** connection design and operating criteria. Power **System Stability** is defined as the ability of a power system to remain in a state of operating equilibrium under normal operating conditions and to regain an acceptable state of equilibrium after it has been subjected to a disturbance. When subjected to a disturbance, the stability of the system depends on the initial system operating condition as well as the severity of the disturbance (eg small or large). Small disturbances in the form of load changes or operational network switching occur continually; the stable system must be able to adjust to the changing conditions and operate satisfactorily. The system must also be able to survive more severe disturbances, such as a short circuit or loss of a large **Power Generating Module**. If following a disturbance the system is unstable, it will usually experience a progressive increase in angular separation of synchronous **Generating Units’** rotors from the system, or an uncontrolled increase in the speed of asynchronous **Generating Units’** rotors, or a progressive decrease in system voltages. An unstable system condition could also lead to cascading outages and ultimately to a system blackout.

The loss of **System Stability** is often related to inability of synchronous **Generating Unit**s to remain in **Synchronism** after being subjected to a disturbance, either small or large. Loss of **Synchronism** can occur between one synchronous **Power Generating Modules** and the rest of the system, or between groups of synchronous **Power Generating Modules**, with **Synchronism** being maintained within each group after separating from each other*.* Small disturbances arise frequently as a result of normal load variations and switching operations. Such disturbances cause electro-mechanical rotor oscillations, which are generally damped out by the inertia of the **Generating Unit**s, system impedance and loads connected to the **Distribution Network**. Where damping is inadequate, **Power System Stabilisers** (PSSs) may offer a solution**.**

Undamped oscillations which result in sustained voltage and power swings, and even loss of **Synchronism** between synchronous **Power Generating Modules**, can arise following a small disturbance if either

* the transfer capability of the interconnecting **Distribution Network** is insufficient; or
* the control and load characteristics either singly or in combination are such that inadequate or negative damping, or reduced synchronising torque occurs.

Large disturbances, such as a 3-phase short circuit fault or circuit outage, can result in large excursions of synchronous **Power Generating Modules** rotor angles (ie angular separation) due to insufficient synchronising torque. The associated stability problem is then concerned with the ability of the system to maintain **Synchronism** when subjected to such a disturbance. Normally the most arduous case occurs when the summer minimum demand coincides with the maximum power output of the synchronous **Power Generating Module**.

During a fault the electrical output of each synchronous **Generating Unit** may be substantially less than the mechanical input power from its prime mover and the excess energy will cause the rotor to accelerate and increase the electrical angle relative to the power system. Provided that the fault is disconnected quickly, the synchronous **Power Generating Module** controls respond rapidly and with adequate **Distribution Network** connections remaining post-fault, the acceleration will be contained and stability maintained.Pole slipping could occur and if the acceleration is not contained, this will cause large cyclic exchanges of power between the synchronous **Power Generating Module** and the **Distribution Network**. These may damage synchronous **Power Generating Modules**, cause maloperation of **Distribution Network** protection and produce unacceptable voltage depressions in supply systems.

In the case of some types of **Power Park Modules**, the voltage depression on the local **Distribution Network** will cause acceleration of the rotor (increasing slip), with subsequent increased reactive demand. For prolonged faults this may cause the **Power Park Module** to go past its breakaway torque point and result in loss of stable operation and subsequent **Power Generating Module** disconnection

In the case of doubly fed asynchronous **Power Generating Modules** and series converter connected **Power Generating Modules**, a voltage depression on the local **Distribution Network** may cause the AC-DC-AC converter to rapidly disconnect, with subsequent fast disconnection of the machine leading to a potential loss of **System** **Stability.**

In the case of **Type C** and **Type D** **Power Generating Modules** the capability to ride through certain **Transmission System** faults is critical to **Distribution Network** and **Total System** stability.

Where larger synchronous **Power Generating Modules** are installed consideration should be given by the **Generator** and the **DNO** (in conjunction with **NETSO** where necessary) for the need to provide pole-slipping protection. The ‘reach’ (ie impedance locus) of any settings applied to such a protection should be agreed between the **Generator** and the **DNO**. The settings should be optimised, with the aim of rapidly disconnecting generation in the event of pole-slipping, whilst maintaining stability of the protection against other disturbances such as load changes.

Stability investigations for new **Power Generating Modules** will initially need to use data that has been estimated from Manufacturer’s designs. On occasions, the machine size and/or equipment dynamic parameters change, and the studies may need to be repeated later during the project.

**13.6.2 Clearance times**

A **Distribution Network** can be subjected to a wide range of faults of which the location and fault type cannot be predicted. The **System Stability** should therefore be assessed for the fault type and location producing the most onerous conditions. It is recommended that three phase faults be considered.

The operating times of the equipment that have to detect and remove a fault from the system are critical to **System Stability**. Worst case situations for credible fault conditions will need to be studied, the fault locations selected for examination being dependent upon protection fault clearance times. Stability will normally be assessed on the basis of the slowest combination of the operating times of main protection signalling equipment and circuit breakers. Fault clearance times therefore need to include the operating times of protection relays, signalling, trip relays and circuit breakers.

Faster clearance times may become necessary where studies indicate that the risk to **System Stability** is unacceptable. Single phase to earth fault clearance times can be protracted but their effects on the **System Stability** are likely to be less disruptive than a three-phase fault. Each case to be studied should be considered on an individual basis in order to determine acceptable fault clearance times.

**13.6.3 Power System Stabilizers**

In general, **Power System Stabiliser**s should provide positive system damping of oscillations in the frequency range from 0 to 5Hz. The gain of the **Power System Stabiliser** shall be such that an increase in the gain by a factor of at least 2 shall not cause instability. **Type C** and **Type D** **Power Generating Modules** will need to be studied in the context of the **Total System**, in conjunction with **NETSO**.

Voltage fluctuations resulting from inadequate damping of control systems require study at the **Point of Common Coupling** (PCC) and must be compliant with ER P28.

## 13.7 Loss of Mains (LoM) Protection Analysis

The following analysis for LoM protection includes the results of practical measurements. The attached analysis of the problem demonstrates the speed with which a **Generating Unit** can move out of **Synchronism** and the consequences for the unit of a reclosure on the **Distribution Network**.

**13.7.1 Prime Mover Characteristics**

A Modern **Generating Unit** can be of four types:-

1. Synchronous **Generating Unit**: Where the stator frequency defined by the rotational speed of the applied dc magnetic field in the rotor winding. The two being magnetically locked together, with the rotor magnetic field being at a slight advance (10-20 electrical degrees) of the Stator in order to generate. When connected to a large electrical network both will track the applied frequency. The electrical inertia constant H of the generator will be in the order of 3-5 seconds (time to decrease the frequency by 50% for a 100% increase in load).
2. Asynchronous **Generating Unit**: Where the stator frequency is determined by the large electrical network it is connected to. The rotating stator field then induces a rotating magnetic field in the rotor winding. To generate, this winding will be rotating at a marginally faster speed to this induced rotating frequency (-1 to -2% slip) in order to generate. The electrical inertia constant H of the generator will be in the order of 4-5 seconds.
3. Doubly Fed Induction **Generating Unit** (DFIG): Similar to the Asynchronous generator and usually found in wind turbines. Here the rotor is directly energised by a back to back voltage source converter (VSC). This creates in the rotor a variable frequency, in magnitude and phase, which allows the generator rotor to operate over a wider speed range than the 1-2% of an Asynchronous generator. Typically +/-20% speed range is possible. The electrical inertia of the generator is less clearly defined as the rotor is effectively decoupled from the stator, but typically it is given as 4 to 5 seconds before the secondary control systems can react in a similar time period.
4. Converter Connected **Generating Unit** (CCGU): Whilst the DFIG is partly coupled to the network through the stator, here the power source is completely hidden behind the converter and the generator is fully decoupled from the network. The electrical inertia of the generator is theoretically zero unless a degree of ‘virtual inertia’ is introduced into the converter control scheme, to make the generator behave as if it were closely coupled to the network.

Acceptable LoM protection systems are based on the Rate of Change of Frequency or RoCoF (of voltage)

which can arise from an imbalance between the power applied to the prime mover (and hence generator) and the power thus sent out into the network to supply load. There is a presumption, that an unbalance in load always exists when a generatoris disconnected (Islanded) from the large electrical network. And this is then of sufficient magnitude to cause the generator to accelerate or de-accelerate (depending on its electrical inertia constant H) so changing the frequency of the generated voltage at a sufficient rate to be detected. This is assumed to be in the order of 10%.

Even if the generator remains connected, sudden changes to the impedance of the distribution network, caused by switching, or a sudden load change, can have a similar but smaller effect until a new stable operating point is achieved. This is quite common, especially on weak (low fault level) overhead networks. This is not a LoM event, but is known to cause mal-operation of LoM relays unless properly accounted for.

The initial change in frequency following the change in load is essentially a function of the inertia constant H of the combination of the **Generating Unit** and its Prime Mover. The derivation of the transient frequency response is given in section 2 below.

Note that these equations only truly apply to generator types 1 and 2 and to the initial (1-2 second) response for type 3. For type 4 generators discussions with the generator manufacturer may be required to determine if any form of LoM relay would provide effective protection.

**13.7.2 Analysis of Dynamic Behaviour of Generating Unit Following Load Change**

The kinetic energy of a rotating **Generating Unit** and its prime mover is given by the equation

 equation 1

where K = kinetic energy in kJ

J = moment of inertia in kgm2

N = machine in speed in rpm

From equation 1, theinertia constant (H) of the machine can be calculated using the expression,

 equation 2

Where K1 = Kinetic energy at rated speed and frequency (Fr)

G = kVA capacity of the **Generating Unit**

Hence at any frequency, F, the kinetic energy, K, can be expressed as

 equation 3

Now the immediate effect of any change in the power, PC, being supplied by the **Generating Unit** is to initiate a change in the kinetic energy of the machine. In fact PC is the differential of the kinetic energy with respect to time, thus

 equation 4

Rewriting

 equation 5

Differentiating equation 3 gives

 equation 6

Substituting in equation 5



Re-arranging

 equation 7

## 13.8

## 13.8 Main Statutory and other Obligations

This appendix summarises the main statutory and other obligations on **DNO**s, **Generator**s and **Customer s** in relation to the design and operation of primary and protection equipment associated with **Distribution Networks**.

The key driver on the **DNO** is to ensure that it can comply with its statutory duties, and its regulatory obligations, in protecting its network, and disconnecting the minimum amount of equipment when unsafe situations have developed, as well as preserving supplies to other customers.

A key consideration of **Generator**s and **Customer** s is similarly to ensure that they can comply with their statutory duties to protect their entire network and to disconnect relevant equipment when unsafe situations have developed.

| **Reference** | **Obligation** | **DNO** | **Generator** | **Customer** |
| --- | --- | --- | --- | --- |
| ESQCR Reg 3 | Ensure equipment is sufficient for purpose and electrically protected to prevent danger, so far as is reasonably practicable. | X | X | - |
| ESQCR Reg 4 | Disclose information and co-operate with each other to ensure compliance with the ESQC Regulations 2002 | X | X | - |
| ESQCR Reg 6 | Apply protective devices to their network, so far as is reasonably practicable, to prevent overcurrents from exceeding equipment ratings. | X | X | - |
| ESQC Reg 7 | Ensure continuity of the neutral conductor and not introduce any protective device in the neutral conductor or earthing connection of **LV** networks. | X | X | - |
| ESQCR Reg 8 | Connect the network to earth at or as near as reasonably practicable to the source of voltage; the earth connection need only be made at one point. | X | X | - |
| ESQCR Reg 11 | Take all reasonable precautions to minimise the risk of fire from substation equipment. | X | X | - |
| ESQCR Reg 21 | Ensure that switched alternative sources of energy to distribution networks cannot operate in parallel with those networks and that such equipment which is part of an **LV** consumer’s installation complies with BS 7671. |  | X | X |
| ESQCR Reg 22 | Not install or operate sources of energy in parallel with distribution networks unless there are: appropriate equipment, personnel and procedures to prevent danger, so far as is reasonably practicable; **LV** consumers’ equipment complies with BS 7671; and specific requirements are agreed with the **DNO**. |  | X | X |
| ESQCR Reg 24 | **DNO** equipment which is on a consumer’s premises but not under the consumer’s control is protected by a suitable fused cut-out or circuit breaker which is situated as close as reasonably practicable to the supply terminals, which is enclosed in a locked or sealed container. | X |  |  |
| ESQCR Reg 25 | Not give consent to making or altering of connections where there are reasonable grounds to believe that the consumer’s installation does not comply with ESQCR / BS 7671 or, so far as is reasonably practicable, is not protected to prevent danger or interruption of supply. | X |  |  |
| ESQCR Reg 27 | Declare the number of phases, frequency and voltage of the supply and, save in exceptional circumstances, keep this within permitted variations. | X |  |  |
| ESQCR Reg 28 | Provide a written statement of the type and rating of protective devices. | X |  |  |
| EAWR Reg 4 | Construct systems including suitable protective devices that can handle the likely load and fault conditions. | X | X | X |
| EAWR Reg 5 | Not put into service electrical equipment where it strength and capability may be exceeded in such a way as to pose a danger. | X | X | X |
| EAWR Reg 11 | Provide an efficient and suitably located means to protect against excess current that would otherwise result in danger. | X | X | X |
| MHSWR Reg 3 | Carry out an assessment of risks to which employees are exposed to at work and risks to other persons not employed arising from the activities undertaken. | X | X | X |
| BS 7671 | Provide protective devices to break overload/fault current in **LV** consumer installations before danger arises. |  |  | X |
| BS 7671 | Take suitable precautions where a reduction in voltage, or loss and subsequent restoration of voltage, could cause danger. |  |  | X |
| Distribution Code DPC4.4.4 | Incorporate protective devices in **Distribution Network**s in accordance with the requirements of the ESQCR.  Agree protection systems, operating times, discrimination and sensitivity at the ownership boundary.  Normally provide back-up protection in case of circuit breaker failure on **HV** systems. | X  X  X | X  X  X | X  X  X |
| Distribution Code DPC6.3 | **Customer**’s equipment must be compatible with **DNO** standards and practices.  Design protection systems that take into account auto-reclosing or sequential switching features on the **DNO** network.  Be aware that **DNO** protection arrangements may cause disconnection of one or two phases only of a three phase supply. |  | X  X  X | X  X  X |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Distribution Code DPC8.10 | Assess the transient overvoltage effects at the network ownership boundary, where necessary. | X | X |  |

# Appendix X

# Functional Specification for Fault Recording and System Monitoring Equipment

# Purpose and Scope

This document describes the functional requirements for fault recording and system monitoring equipment that **Generators** need to provide in accordance with the requirements of ER G99 and the **Distribution Code**. It is expected that the functionality will be provided via a single fault recording device (FRD), although other options are not discounted.

The requirements of this document apply to all **Power Generating Facilities** containing any **Type C** or **Type D Power Generating Modules**.

# Functional Requirements

## Operating Modes

The FRD may be configured to both record high resolution detail accompanying faults, or to run for longer periods to record quasi steady state values.

## Inputs

The FRD shall have analogue and or digital inputs to record the following quantities:

* Three Phase Voltage;
* Three Phase Active and Reactive Power;
* Frequency
* Key events such as the tripping of relevant circuit breakers, stability threshold levels exceeded etc.

The number of inputs shall be sufficient to record these quantities at relevant points on the **Customer’s** system as agreed with the **DNO**.

## Measured and Derived Quantities

At each agreed relevant point on the **Customer’s** system the following data should be made available:

1. 3 phase voltage quantities, including positive and negative phase sequence values.
2. 3 phase current quantities, including positive and negative phase sequence values.
3. Real and Reactive power flows
4. Frequency

## Accuracy and Resolution

The accuracy requirements will be met over the frequency range 45.0Hz to 55.0 Hz.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Quantity | Measurement Range | Accuracy ±% of nominal | Resolution y ±% of nominal | Comment |
| RMS voltage | 0 – 1.5Vn | 0.1 | 0.01 | Crest factor ≤1.5 |
| Voltage sequence components | 0.8 Vn – 1.5 Vn | 0.1 | 0.01 | Crest factor ≤1.5 |
| Phase sequence components | 0 – 5.0 In | 0.5 | 0.01 | Crest factor ≤3.0 |
| Active Power | 0 – 5Pn | 0.5 | 0.01 | For all power factors between 0.5 and 1.0 |
| Reactive Power | 0 – 5RPn | 0.5 | 0.01 | For all power factors between 0.87 and 1.0 |
| Frequency | 45Hz – 55Hz | 0.005 | 0.001 | 20%<Vn<150% |
| Harmonics ? | 3rd 63rd harmonic |  |  | THD computed from the harmonic magnitudes from 2 to 40. |

## Time Keeping

Inputs and all the derived data from inputs shall be time tagged to a resolution of 1μs.

The FRD’s internal clock will be synchronised with Universal Time (UTC) via GPS satellite or other functionally similar method. It should be possible to set a local time offset.

## Power Quality

Measurement of power quality will include but not limited to the following parameters and events, in accordance with BS EN 50160:

* Voltage dips, surges & short-term interruptions
* Voltage steps
* Voltage & current harmonics
* Voltage & current imbalance
* Voltage variations
* Frequency variations
* Flicker
* Rapid Voltage Changes
* Dips & swells

## Triggering

### Analogue/Digital triggering

The **DNO** will separately specify is digital triggering is required and what the triggers are to be.

Analogue trigger to be initiated by any of the following:

* Under/over/rate of change of voltage, current, frequency, power, power factor and sequence components.
* The above to have an accuracy of better than 2% and all analogue inputs shall trigger for disturbance durations shorter than 10ms.
* Multiple triggering of fault recordings shall be prevented by a hysteresis band around the trigger set point.
* The type of triggering shall be independently selectable on all analogue input channels and on all calculated quantities.

Where digital triggering to be initialised by either the opening of a normally closed contact or the closing of a normally open contact. The required trigger mode shall be independently selectable on all channels. It shall be possible to deselect any channel so that it does not trigger the substation monitor. The manufacturer shall specify the voltage tolerances for a logic ‘1’ and a logic ‘0’.

### Pre event Recoding:

For fault recording the quantities shall be recorded as specified by the **DNO** in the range 50ms to 200ms. For steady state recording the period will be in the range 60s to 300s.

### Post event Recording

For fault recording the quantities shall be recorded as specified by the **DNO** in the range 150ms to 2 000ms. For steady state recording the period will be in the range 300s to 900s.

## Storage and communication

All data will be continuously stored

Non-volatile static memory will be used to provide storage for a minimum of 28 days of data, prior to overwriting on a first in first out basis.

The source data files shall have an IEC 60255-24 COMTRADE and CSV format to allow transfer to other computer spread sheet programs or protection relay secondary test sets etc.

The **Generator** will specify what further communication options and protocols will be provided.

If the **DNO** requires the data to be transferred routinely or on demand to the **DNO**, the **DNO** will provide further specific information on protocols and connexion requirements.

## Relevant Standards

The following standards are likely to be relevant. The **Generator** will quote all the standards the FRD is compliant with.

BS EN 61000-4-2: Electromagnetic compatibility (EMC). Testing and measurement techniques. Electrostatic discharge immunity test.

EN 61000-4-3: Electromagnetic compatibility (EMC). Testing and measurement techniques. Radiated, radio-frequency, electromagnetic field immunity test.

BS EN 61000-4-4: Electromagnetic compatibility (EMC). Testing and measurement techniques. Electrical fast transient/burst immunity test.

BS EN 61000-4-6: Electromagnetic compatibility (EMC). Testing and measurement techniques. Immunity to conducted disturbances, induced by radio-frequency fields.

IEC 61000-4-30: Electromagnetic compatibility (EMC). Part 4-30: Testing and measurement techniques – Power quality measurement methods.

IEC 60255-22-1: 'Electrical Relays - Electrical disturbance tests for measuring relays and protection equipment. 1MHz burst disturbance tests'.

BS EN 50160: Voltage characteristics of electricity supplied by public electricity networks.

BS EN 55011: Industrial, scientific and medical equipment. Radio frequency disturbance characteristics. Limits and methods of measurement.

BS EN 60529: Specification for degrees of protection provided by enclosures (IP code).

BS EN ISO 9001: Quality management systems. Requirements

IEC 60870-5-101: Telecontrol equipment and systems. Transmission protocols. Companion standard for basic telecontrol tasks.

BS EN 60255-24: 'Electrical Relays. Common Format for Transient Data Exchange (COMTRADE) for Power Systems.'

BS EN 60255-27 Measuring relays and protection equipment. Product safety requirements.

ENA ER G5/4 Planning Levels for harmonic Voltage Distortion and the Connection of Non-Linear Equipment to Transmission Systems and Distribution Networks in the United Kingdom

# Calibration and Testing

It is the **Generator**’s responsibility to ensure that the FRD remains functioning and accurate. The **DNO** has the right to request the **Generator** to demonstrate the accuracy and functionality of the FRD.

Correct operation of the FRD will normally be demonstrated to the **DNO** when the **Power Generating Facility** is commissioned.

1. see <http://www.opsi.gov.uk/si/si2001/20013270.htm> [↑](#footnote-ref-1)
2. Over Voltage Protection is not intended to maintain statutory voltages but to detect islanding [↑](#footnote-ref-2)
3. The Installers can choose to be approved under the 'Microgeneration Certification Scheme (MCS) supported by Department of Energy and Climate Change. 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> [↑](#footnote-ref-3)
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 [↑](#footnote-ref-4)
5. Such periodic testing may be required due to system changes, **DNO** protection changes, fault investigations etc. [↑](#footnote-ref-5)