PRODUCED BY THE OPERATIONS DIRECTORATE OF ENERGY NETWORKS ASSOCIATION

Engineering Recommendation G99

Issue 1 2017 Draft in Progress

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

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Amendments since publication

Issue	Date	Amendment
Issue	<Month, Year >	<Insert brief description of amendment> This issue includes the following principal technical changes. <List principal technical changes> Details of all other technical, general and editorial amendments are included in the associated Document Amendment Summary for this Issue (available on request from the Operations Directorate of ENA).

Contents

Foreword

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

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

1 Purpose

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

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

2 Scope and Structure

2.1 This EREC provides the technical requirements for the connection of **Type A**, **Type B**, **Type C** and **Type D Power Generating Modules** to the **Distribution Networks** of licensed **DNOs** in **Great Britain**. For the purposes of this EREC, a **Power Generating Module** is any source of electrical energy, irrespective of the generating technology 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 **Generators** who should refer to **EREC G59**:

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

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

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

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

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

2.3 Specific separate requirements apply to **Power Generating Facilities** connected at **LV** comprising **Fully Type Tested, Type A, Power Generating Modules** less than 16 A/phase (micro-generators) and these are covered in EREC G98. All **Power**

Generating Modules less than 16 A/phase connecting to the **DNO's Distribution Network** must be **Fully Type Tested.**

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

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

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

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

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

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

2.10 **Type B, Type C and Type D** pump-storage **Power Generating Modules** shall fulfil all the relevant requirements in both generating and pumping operation mode. Synchronous compensation operation of pump-storage **Power Generating Modules** shall not be limited in time by the technical design of **Power Generating Modules**. Pump-storage variable speed **Power Generating Modules** shall fulfil the requirements applicable to **Synchronous Power Generating Modules** as well as those set out in Section 12.3 or Section 13.4.

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

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

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

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

2.12 This document details connection process, technical and compliance requirements for **Type A**, **Type B**, **Type C** and **Type D Power Generating Modules**. The structure of the document is illustrated in Figure 2.1.

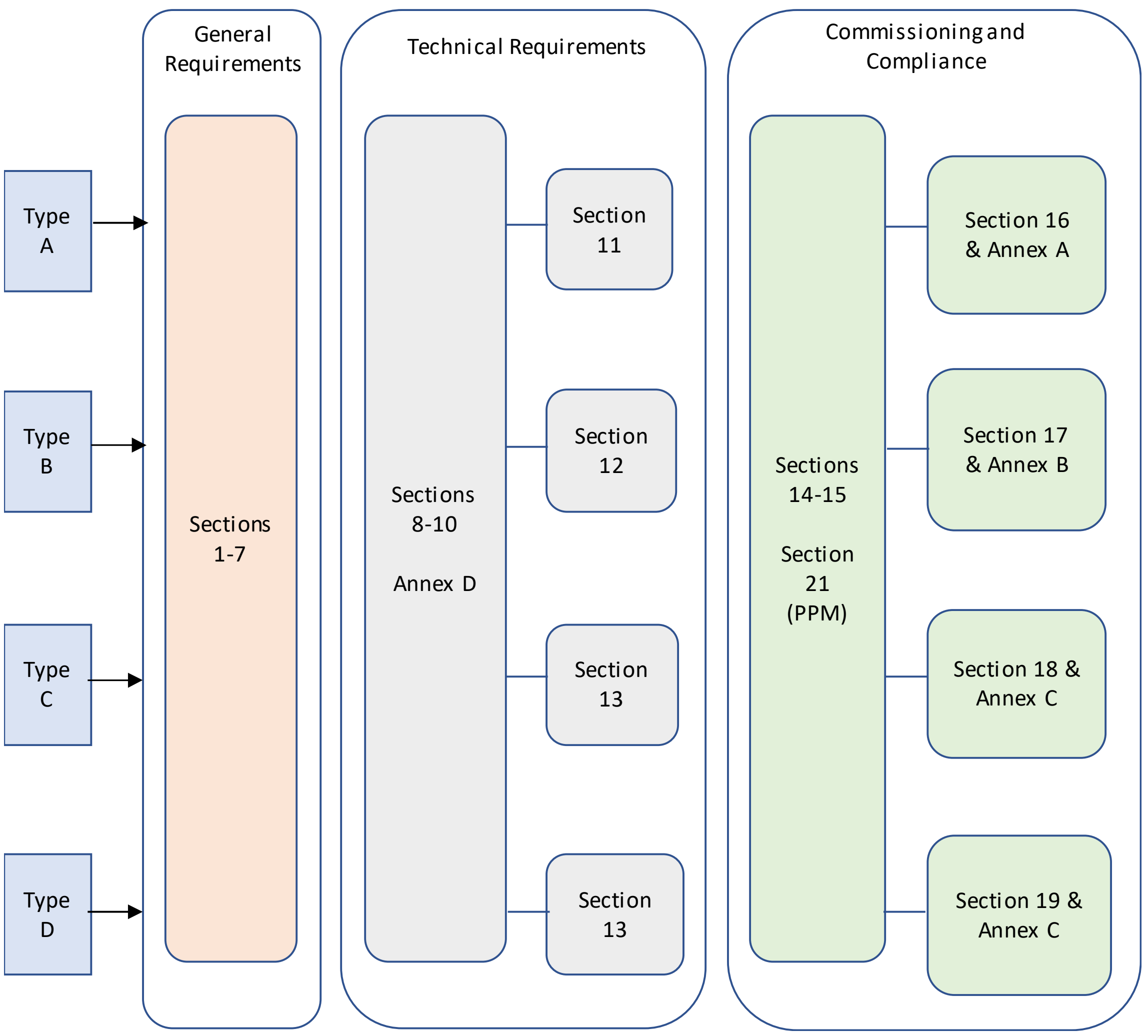


Figure 2.1 EREC G99 Document structure

3 Normative references

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

3.2 Standards publications

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

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

BS 7430:
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:
Instrument Transformers. Current Transformers.

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

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

BS EN 62116
Test procedure of islanding prevention measures for utility-interconnected photovoltaic Inverters.

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

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

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

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

3.3 Other publications

Health and Safety at Work etc. Act (HASWA):
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):
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):
The Electricity at Work regulations 1989 abbreviated to EaWR in this document.

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

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

ENA Engineering Recommendation G74
Procedure to meet the requirements of IEC 909 for the calculation of short-circuit currents in three-phase AC power systems.

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

Engineering Recommendation G98
Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16A per phase) in parallel with public Low-Voltage Distribution Networks on or after 17 May 2019

Engineering Recommendation G100
Technical Guidance for Customer Export Limiting Schemes

ENA Engineering Recommendation P2
Security of Supply.

ENA Engineering Recommendation P18
Complexity of 132 kV 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.

COMMISSION REGULATION (EU) No 2016/631
Establishing a network code on Requirements for Grid Connection of Generators

Directive 2009/72/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
Concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC

Regulation (EC) No 714/2009 of the European Parliament and of the Council
on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003

Regulation (EC) No 765/2008 of the European Parliament and of the Council
Setting out the requirements for accreditation and market surveillance relating to the marketing of products and repealing Regulation (EEC) No 339/93

4 Terms and definitions

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

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 Shutdown and to energise a part of the **Distribution Network** and be synchronised to the **Distribution Network** upon instruction from the **NETSO**, within two hours, without an external electrical power supply

Black Start Station

A **Power Generating Facility** which is registered with the **NETSO** as having a **Black Start Capability**

Combined Cycle Gas Turbine Module or CCGT Module

A collection of **Generating Units** comprising one or more Gas Turbine Units (or other gas based engine units) and one or more Steam Units where, in normal operation, the waste heat from the Gas Turbines is passed to the water/steam system of the associated Steam Unit(s) 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 **Generator**, 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 **Generator's Installation** is connected to a **Distribution Network**, as identified in the **Connection Agreement.** For the avoidance of doubt two or more connection circuits constitutes a single **Connection Point** for the purposes of EREC G99

Controller

A device for controlling the functional operation of a **Power Generating Module**

CUSC

Has the meaning set out in NGET's **Transmission Licence**

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. Whilst not mandatory, it is often common practice to express **Droop** in percentage terms

Electricity Act
The **Electricity Act** 1989 (as amended. including by the Utilities Act 2000 and the Energy Act 2004)

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

Embedded Medium Power Station
A **Power Generating Facility** in England and Wales of 50MW or greater **Registered Capacity** but less than 100MW **Registered Capacity** connected to a **DNO's Distribution Network**

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** during and after a voltage deviation caused by an electrical fault with the aim of identifying a fault by network protection systems at the initial stage of the fault, supporting system voltage retention at a later stage of the fault and system voltage restoration after fault clearance

Fault Ride Through
The capability of **Power Generating Modules** to be able to be able to remain connected to the **Distribution Network** and operate through periods of low voltage at the **Connection Point** caused by secured faults

Final Operational Notification (FON)
A notification issued by the **DNO** to a **Generator**, who complies with the relevant specifications and requirements in this EREC G99, allowing them to operate a **Power Generating Module** by using the **Distribution Network** connection

Frequency Response Deadband
An interval used intentionally to make the frequency control unresponsive

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** in which the **Active Power** output changes in response to a change in system frequency, in such a way that it assists with the recovery to target frequency

Fully Type Tested
A **Power Generating Module** which has been tested to ensure that the design meets the relevant technical and compliance requirements of this EREC G99, and for which the **Manufacturer** has declared that all similar **Power Generating Modules** supplied will be constructed to the same standards and will have the same performance. In the case where **Interface Protection** functionality is included in the

tested equipment, all similar products will be manufactured with the same protection settings as the tested product

Generating Unit
Any apparatus which produces electricity. This includes micro-generators and electricity storage devices. Note that although storage is in the scope of EREC G99, some aspects do not apply. The exclusions are noted where they apply in the text

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) and whose **Power Generating Facility** is directly or indirectly connected to a **Distribution Network**. For avoidance of doubt, also covers any competent person or agent working on behalf of the **Generator**. Often referred to as a distributed or embedded generator. Also for the avoidance of doubt any **Customer** with generation connected to that **Customer's Installation** is a **Generator**

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 the **Generating Unit** terminals or the **Connection Point** as appropriate for the **Power Generating Facility** will be expected to operate under steady state conditions

Generator's Installation
The electrical installation on the **Generator's** side of the **Connection Point** together with any equipment permanently connected or intended to be permanently connected thereto

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**

High Voltage (HV)
A voltage exceeding 1000 V AC or 1500 V DC between conductors, or 600 V AC or 900 V 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. Interface Protection** may be installed on each **Power Generating Module** or at the **Connection Point** for the **Power Generating Facility**

Interim Operational Notification
A notification from the **DNO** to a **Generator** acknowledging that the **Generator** has demonstrated compliance, except for the **Unresolved Issues** with this EREC G99 or with specific items in the **Connection Agreement i**n respect of the plant and apparatus specified in such notification.

Intermittent Power Source
The primary source of power for a **Generating Unit** that cannot be considered as controllable, eg wind, wave or solar

Inverter

A device for conversion from **Direct Current** to nominal frequency Alternating Current

Limited Frequency Sensitive Mode
A mode whereby within a range of system frequency the operation of a **Power Generating Module** is **Frequency** insensitive.

Limited Frequency Sensitive Mode – Overfrequency (LFSM-O)
A **Power Generating Module** operating mode which will result in **Active Power** output reduction in response to a change in system frequency once the system frequency exceeds a certain value

Limited Frequency Sensitive Mode – Underfrequency (LFSM-U)
A **Power Generating Module** operating mode which will result in **Active Power** output increase in response to a change in system frequency once the system frequency falls below a certain value

Limited Operational Notification (LON)
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 (50 V) but not exceeding 1000 V AC or 1500 V DC between conductors or 600 V AC or 900 V DC between conductors and earth

Manufacturer
A person or organisation that manufactures **Generating Units**

Manufacturer's Data & Performance Report
A report submitted by a **Manufacturer** to the **DNO** relating to a specific version of a **Generating Unit** demonstrating the performance characteristics of such **Generating Unit** in respect of which the **DNO** has evaluated its relevance for the purposes of compliance.

Manufacturers' Information
Information in suitable form provided by a **Manufacturer** in order to demonstrate compliance with one or more of the requirements of this EREC G99. Where Equipment Certificate(s) as defined in EU 2016/631 cover all or part of the relevant compliance points, the Equipment Certificate(s) demonstrate compliance without

need for further evidence for those aspects within the scope of the Equipment Certificate

Minimum Generation
The minimum **Active Power** output which a **Power Generating Module** can reasonably generate as registered under the Distribution Data Registration Code

Minimum Regulating Level
The minimum **Active Power**, as agreed between the **DNO** and the **Generator**, down to which the **Power Generating Module** can control **Active Power**;

Modification
Any actual or proposed replacement, renovation, modification, alteration or construction by a **Generator** to a**ny Power Generating Module**, or the manner of its operation.

National Electricity Transmission System Operator (NETSO)
National Grid Electricity Transmission (NGET) in its capacity as operator of the National **Transmission System**

Over-Excitation Limiter
Shall have the meaning ascribed to that term in IEC 34-16-1

Phase (Voltage) Unbalance
The ratio (in percent) between the rms values of the negative sequence component and the positive sequence component of the voltage

Point Of Common Coupling
The point on a **Distribution Network,** electrically nearest the **Customer's Installation,** at which other **Customers** are, or may be, connected

Power Factor
The ratio **of Active Power** to apparent power

Power Generating Facility
A facility that converts primary energy into electrical energy and which consists of one or more **Power Generating Modules** connected to a **Network** at one or more **Connection Points**

Power Generating Module (PGM)
Either a **Synchronous Power Generating Module** or a **Power Park Module**

Power Generating Module Document (PGMD)
A document provided by the **Generator** to the **DNO** for a **Type B** or **Type C Power Generating Modules** which confirms that the **Power Generating Module's** compliance with the technical criteria set out in this EREC G99 has been demonstrated and provides the necessary data and statements, including a statement of compliance.

Power Park Module (PPM)
A **Generating Unit** or ensemble of **Generating Units** (including storage devices) generating electricity, which is either asynchronously connected to the network or connected through power electronics, and that may be connected through a transformer and that also has a single **Connection Point** to a **Distribution Network**

Power System Stabiliser (PSS)
Equipment controlling the output of a **Power Generating Module** in such a way that power oscillations of the machine are damped. Input variables may be speed, frequency, or power or a combination of variables

Q/Pmax
The ratio of **Reactive Power** to the **Registered Capacity**. The relationship between **Power Factor** and **Q/Pmax** is given by the formula:-

Power Factor = Cos $[\arctan[\frac{Q}{Pmax}]]$

Rated Field Voltage
Shall have the meaning ascribed to that term in IEC 34-16-1:1991 [equivalent to British Standard BS4999 Section 116.1: 1992].

Reactive Power (Q)
The product of voltage and current and the sine of the phase angle between them which is normally measured in kilovar (kVAr) or megavar (MVAr)

Registered Capacity (P_{max})
The normal full load capacity of a **Power Generating Module**, or of a **Power Generating Facility**, as declared by the **Generator** less the MW consumed when producing the same. This will relate to the maximum level of **Active Power** deliverable to the **DNO's Distribution Network**.

For **Power Generating Modules** connected to the **DNO's Distribution Network** via an **Inverter**, the **Inverter** rating is deemed to be the **Power Generating Module's** rating

Slope
The ratio of the steady state change in voltage, as a percentage of the nominal voltage, to the steady state change in **Reactive Power** output, in per unit of **Reactive Power** capability. For the avoidance of doubt, the value indicates the percentage voltage reduction that will result in a 1 per unit increase in **Reactive Power** generated.

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 132/11 kV)

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 s after the fault clearance or system switching have taken place), but before any other automatic or manual tap-changing and switching actions have commenced

Supplier

a) A person supplying electricity under an Electricity Supply Licence; or

b) A person supplying electricity under exemption under the **Electricity Act** 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004); or

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 **Generating Units** (ie one or more units which cannot operate independently of each other) 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 **Synchronism.** Each set of **Generating Units** which cannot run independently from each other (such as those **Generating Units** on a common shaft or as part of an integrated **CCGT Module**), but can run independent of any other generating equipment, form an individual **Synchronous Power Generating Module.** Any prime mover and alternator combination that can run as an independent unit (irrespective of normal operating practice) is a **Synchronous Power Generating Module.**

This is illustrated in Figure 4.1a and b.

Synchronism
The condition under which a **Power Generating Module** or system is connected to another system so that the frequencies, voltage and phase relationships of that **Power Generating Module** or system, as the case may be, and the system to which it is connected are similar within acceptable tolerances

Total System
The integrated system of connected **Power Generating Modules, Transmission System, Distribution Networks** and associated electrical demand

Transmission Licence
The licence granted under Section 6(1)(b) of the **Electricity 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 Facilities** 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 1 MW.

Type B
A **Power Generating Module** with a **Connection Point** below 110 kV and **Registered Capacity** of 1 MW or greater but less than 10 MW

Type C
A **Power Generating Module** with a **Connection Point** below 110 kV and a **Registered Capacity** of 10 MW or greater but less than 50 MW

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 50 MW or greater

Type Tested
A product which has been tested to ensure that the design meets the relevant requirements of this EREC G99, and for which the **Manufacturer** has declared that all similar products supplied will be constructed to the same standards and will have the same performance. The **Manufacturer's** declaration will define clearly the extent of the equipment that is subject to the tests and declaration. In the case where **Interface Protection** functionality is included in the tested equipment, all similar products will be manufactured with the same protection settings as the tested product.

Examples of products which could be **Type Tested** include **Generating Units**, **Inverters** and the **Interface Protection**.

Unresolved Issues
Any relevant EREC G99 requirements identified by the **DNO** with which the **Generator** has not demonstrated compliance to the **DNO's** reasonable satisfaction at the date of issue of the **Interim Operational Notification** and/or **Limited Operational Notification** and which are detailed in such **Interim Operational Notification** and/or **Limited Operational Notification**

Under-excitation Limiter
Shall have the meaning ascribed to that term in IEC 34-16-1

Figures 4.2 to 4.6 illustrate examples of different **Power Generating Modules** comprising **Power Park Modules** and **Synchronous Power Generating Modules** to assist with the interpretation of **Power Park Module** categorisation.

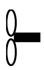
Key to following Figures:

ST: Steam Turbine

GT: Gas Turbine

HR: Heat Recovery Unit

CP: **Connection Point**

	**Synchronous Power Generating Module**
C	Clutch
	**Inverter** or asynchronous **Generating Unit**
	Storage device
	Photovoltaic source
	Wind turbine
	Doubly fed induction generator

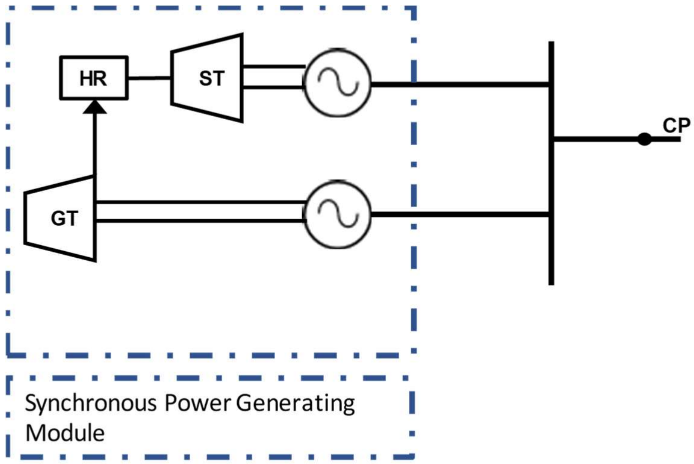


Figure 4.1a Example of a Synchronous Power Generating Module comprising a gas turbine (GT) with a steam turbine (ST) on a separate shaft (simplified diagram)

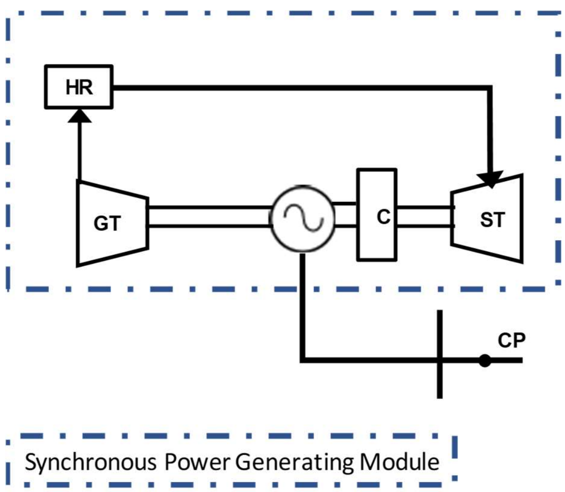
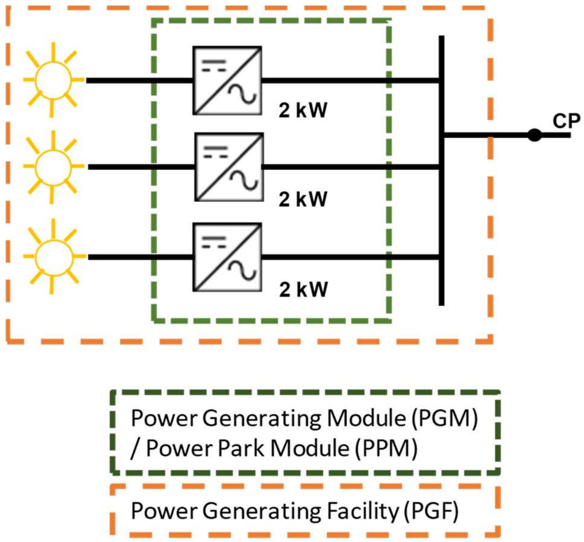
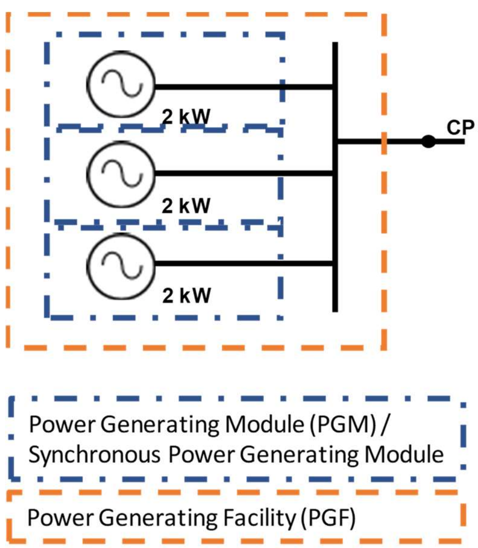


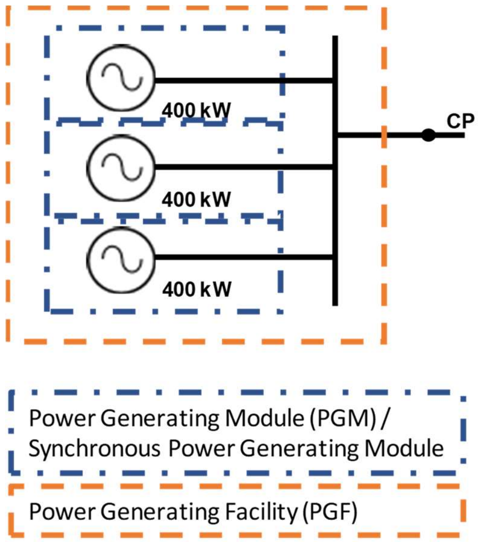
Figure 4.1b Example of a Synchronous Power Generating Module comprising a gas turbine (GT) with a steam turbine (ST) on the same shaft (simplified diagram)



a) 3 x 2 kW **Inverter** connected **Generating Units**
= 6 kW **Type A Power Park Module**
= 6 kW **Power Generating Facility**

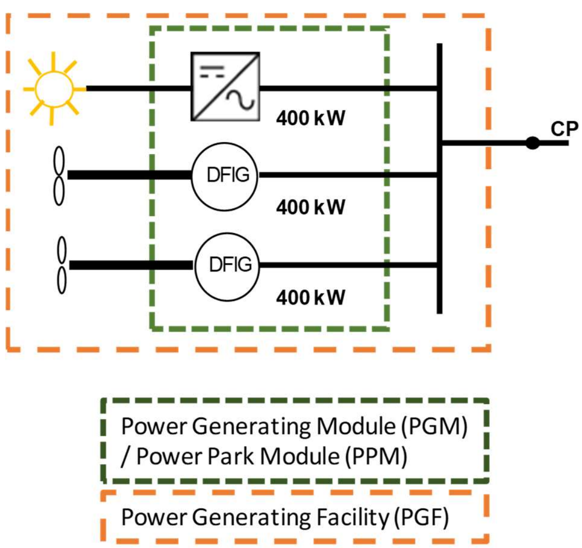


b) 3 x 2 kW **Type A Synchronous Power Generating Modules**
= 6 kW **Power Generating Facility**



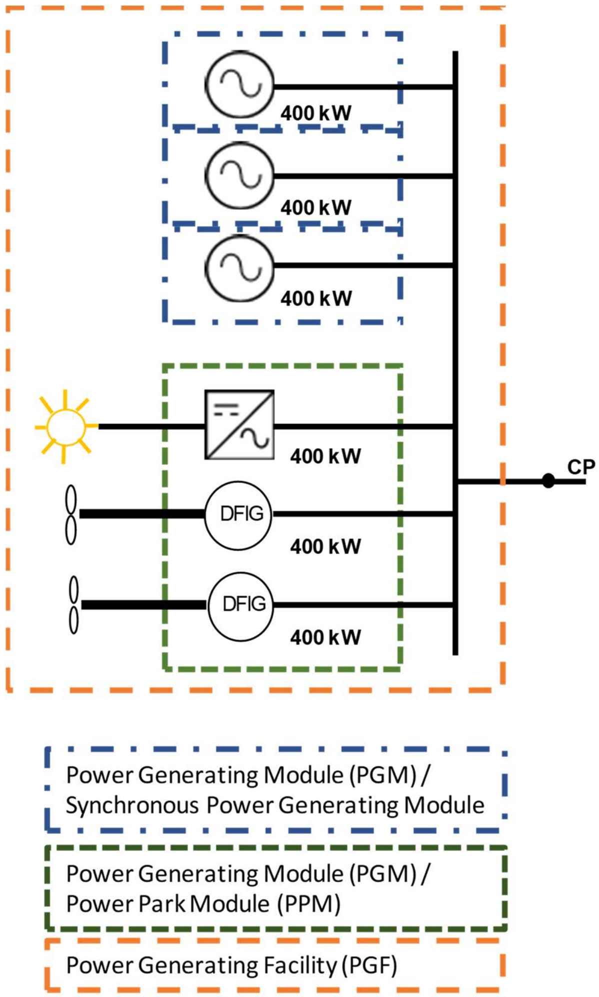
c) 3 x 400 kW **Type A Synchronous Power Generating Modules**
= 1.2 MW **Power Generating Facility**

Figure 4.2 Examples of Type A Power Generating Modules



1 x 400 kW **Inverter** connected plus 2 x 400 kW asynchronous **Generating Units**
= 1.2 MW **Type B Power Park Module**
= 1.2 MW **Power Generating Facility**

Figure 4.3 Example of Type B Power Generating Modules

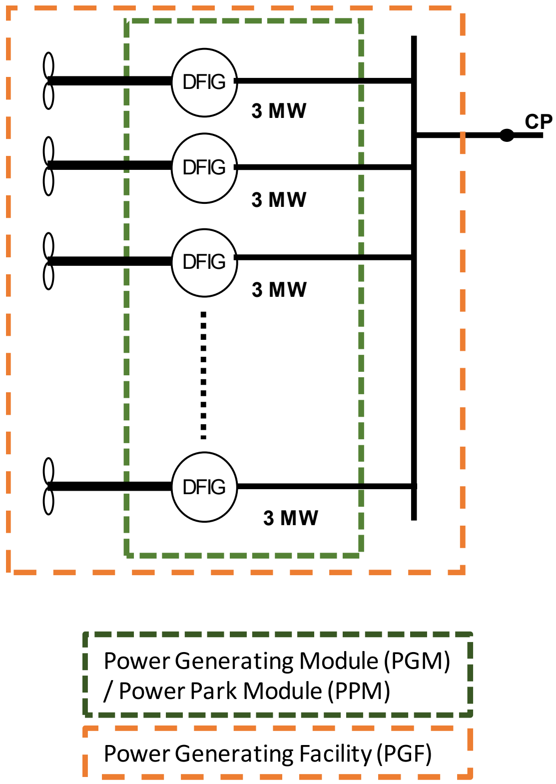


3 x 400 kW **Type A Synchronous Power Generating Modules** plus 1 x 400 kW **Inverter** connected and 2 x 400 kW asynchronous **Generating Units**

= 3 x 400 kW **Type A Synchronous Power Generating Modules** plus 1 x 1.2 MW **Type B Power Park Module**

= 2.4 MW **Power Generating Facility**

Figure 4.4 Example of combination of Type A and Type B Power Generating Modules in same Power Generating Facility



25 x 3 MW asynchronous **Generating Units**

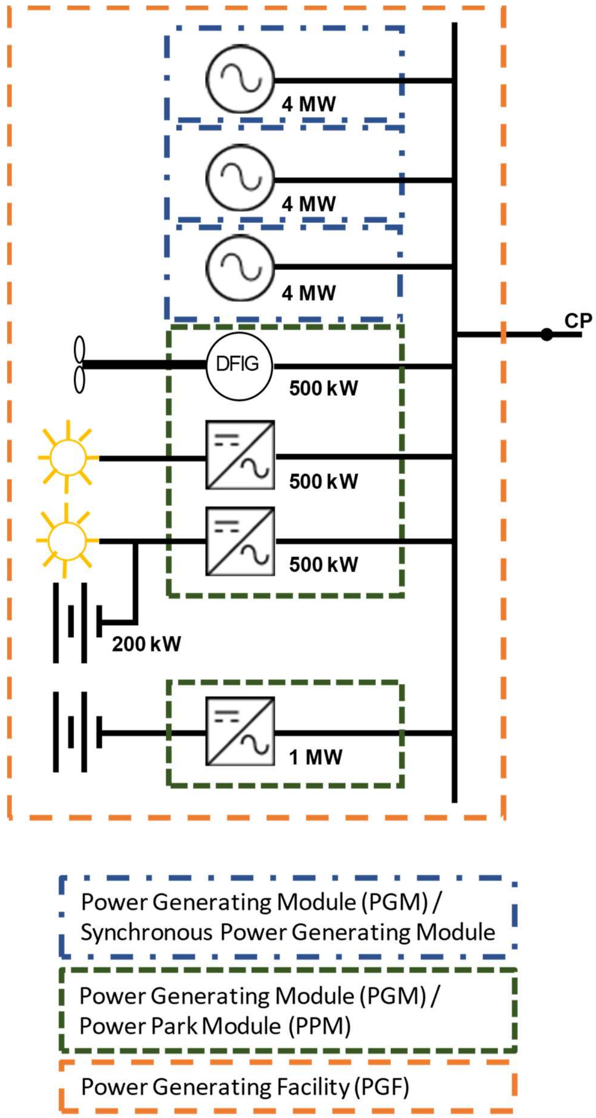
= 1 X 75 MW **Type D Power Park Module**

= 1 x 75 MW **Type D Power Generating Module**

= 75 MW **Power Generating Facility**

(**Embedded Medium Power Station** in England and Wales, large power station in Scotland)

Figure 4.5 Example of Type D Power Generating Facility comprised of a number of Power Park Modules



3 x 4 MW **Type B** Gas Engines plus 1 x 500 kW asynchronous **Generating Unit** plus 1 x 500 kW **Inverter** plus 1 x 500 kW **Inverter** with 200 kW Integral Storage plus 1 MW Storage

= 3 x 4 MW **Type B Synchronous Power Generating Modules** plus 1.5 MW **Type B Power Park Module** plus 1 MW Storage

= 14.5 MW **Power Generating Facility** (Large power station in North of Scotland)

Note the storage unit using the same **Inverter** as the PV does not contribute to the **Power Park Module Registered Capacity**, because the **Registered Capacity** is based on the **Inverter** rating. The storage unit using a dedicated **Inverter** is also a **Power Generating Module** but is excluded from some of the requirements of this EREC G99, but included in the **Power Generating Facility**.

Figure 4.6 Example of Connection of Storage with Type A and Type B Power Generating Modules in same Power Generating Facility

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**, 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 Annex D.4.

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

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

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

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

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

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

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

c) comply with the “Security of Supply” criteria defined in EREC P2;

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

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

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

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

5.9 The **DNO** shall refuse to allow the connection of a **Power Generating Module** which does not comply with the requirements and connection process set out in this EREC G99 and which is not covered by a derogation granted by the **Authority** or a **LON** as described in Section 19.5.

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 **Generators** have to comply with the appropriate parts of the **ESQCR**.

5.13 Any collection of **Power Generating Modules** under the control of one **Generator** in one installation is classed in the industry codes as a **Power Generating Facility**.

5.14 **Power Generating Facilities** that are to be connected to a **Distribution Network** and contain **Power Generating Modules** 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 **Generators** 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**, generation of electricity is a licensed activity, although the Secretary of State, may by order[1] grant exemptions. Broadly, generating stations of less than 50 MW are automatically exempt from the need to hold a licence, and those between 50 MW and 100 MW 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 **Generators** wishing to trade ancillary services for National Grid purposes will need appropriate contracts in place with the National Grid Electricity Transmission in its role as **Great Britain** System Operator.

5.19 In **GB** law, generation equipment that is powered by stored energy and connected to operate in parallel with the **DNO's Distribution Network**, ie commonly referred to as storage, is treated just as generation. Accordingly, this **EREC G99** includes storage in the definition of a **Generating Unit** and Annex A.4 details certain requirements which do not apply to storage.

6 Connection Application

6.1 General

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

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

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

6.1.3 **Power Park Modules**

6.1.3.1 Where an installation comprises a single **Generating Unit**, the application process, technical and commissioning requirements are based on the **Registered Capacity** of that **Generating Unit**. Where an installation comprises multiple **Generating Units** the application process, technical and commissioning requirements will

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

generally be based on the **Registered Capacity** of each **Power Park Module,** and also on the extent to which each **Power Park Module** is **Type Tested**. However, note that if the aggregated capacity of all the **Power Park Modules** in the **Power Generating Facility** (ie the **Registered Capacity** of the **Power Generating Facility**) reaches the threshold for Large as defined in the **Grid Code** (ie 10 MW in the north of Scotland; 30 MW in the south of Scotland, 100 MW in England and Wales), then the **Generator** will have to ensure compliance with relevant parts of the **Grid Code**. Similarly, if the **Registered Capacity** of a **Power Generating Facility** in England and Wales is 50 MW or more, the **Generator** will have to comply with 6.4.4 and 13.8.

6.1.3.2 Where a new **Generating Unit** 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 **Generating Unit** will be treated as a separate **Power Park Module** and managed for compliance with this EREC G99 as a separate **Power Generating Module**. If, however, the existing installation was completed in compliance with EREC G98 or EREC G99, then the new **Power Park Module** must be added to the aggregate capacity of the complete installation which must be used to determine which EREC is applicable irrespective of technology.

6.1.4 Synchronous Power Generating Modules

6.1.4.1 Where an installation comprises a single **Synchronous Power Generating Module**, the application process, technical and commissioning requirements are based on the **Registered Capacity** of that **Synchronous Power Generating Module**. Where an installation comprises multiple **Synchronous Power Generating Modules** the application process, technical and commissioning requirements should be based on the individual **Synchronous Power Generating Module's Registered Capacity**.

6.1.4.2 Where one or more new **Synchronous Power Generating Module(s)** is to be connected to an existing installation then each new **Power Generating Module** will be treated as a separate **Synchronous Power Generating Module**. Only the new **Power Generating Module** will be required to meet the requirements of this EREC G99 or EREC G98 if applicable. However, note that if the aggregated capacity of all the **Power Generating Modules** in the **Power Generating Facility** (ie the **Registered Capacity** of the **Power Generating Facility**) reaches the threshold for large as defined in the **Grid Code** (ie 10 MW in the north of Scotland; 30 MW in the south of Scotland, 100 MW in England and Wales), then the **Generator** will have to ensure compliance with relevant parts of the **Grid Code**. Similarly if the **Registered Capacity** of a **Power Generating Facility** in England and Wales is 50 MW or more, the **Generator** will have to comply with paragraphs 6.4.4 and 13.8.

6.1.5 Illustrative examples

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

871 **Table 6.1 Examples of connection scenarios**

Existing **Power Generating Facility**	Additional **Power Generating Modules** or **Generating Units**	Compliance requirements
Nil	**Type A Generating Unit(s)**	The unit(s) comprise a new **Power Generating Module** for compliance with EREC G98 if **Type Tested** to EREC G98 and connected at **LV**, otherwise EREC G99.
Synchronous Power Generating Modules commissioned under EREC G83 or EREC G59	**Synchronous Power Generating Modules** Figure 6.1	Original and additional **Power Generating Modules** treated separately. Only additional **Power Generating Modules** need to comply with EREC G98 or EREC G99; both need to comply with operational requirements.
Synchronous Power Generating Modules commissioned under EREC G98 or EREC G99	**Synchronous Power Generating Modules** Figure 6.2	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.
Synchronous Power Generating Modules commissioned under EREC G83 or EREC G59 and **Synchronous Power Generating Modules** commissioned under EREC G98 or EREC G99	**Synchronous Power Generating Modules** Figure 6.3	Original and additional **Power Generating Modules** treated separately. Additional **Power Generating Modules** need to comply with EREC G98 or EREC G99; all need to comply with operational requirements.
Power Park Module commissioned under EREC G83 or EREC G59	Asynchronous **Generating Units** Figure 6.4	New units form a new **Power Park Module**. Original and additional **Power Park Modules** treated separately. Only additional **Power Park Modules** need to comply with EREC G98 or EREC G99; both need to comply with operational requirements.
Power Park Module commissioned under EREC G98 or EREC G99	Asynchronous **Generating Units** Figure 6.5	Units aggregated to form a new single **Power Generating Module**. Compliance required for the new module size, with EREC G98 or EREC G99 and with operational requirements.
Power Park Module commissioned under EREC G98 or EREC G99	Storage DC coupled (ie connected to the existing **Inverters**) Figure 6.6	No compliance effect. Compliance remains based on existing **Inverters**, ie on the existing **Power Park Module**. The **Generator** must, under their **Connection Agreement** apply to the **DNO** before connecting the new storage.
Power Park Module commissioned under EREC G98 or EREC G99	Storage AC coupled – ie storage complete with its own **Inverters** Figure 6.7	The new storage units form an independent **Power Park Module** which is exempt from certain requirements as listed in Annex A4.

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

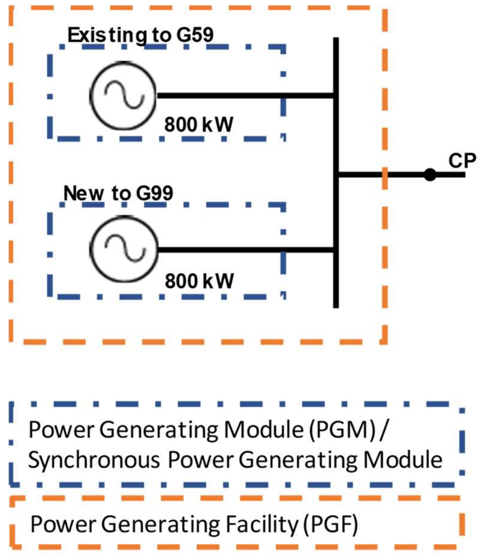


Figure 6.1. Example: 1 x 800 kW Synchronous Power Generating Module to EREC G59 plus 1 x 800 kW Type A Synchronous Power Generating Module to EREC G99 = 1.6 MW Power Generating Facility

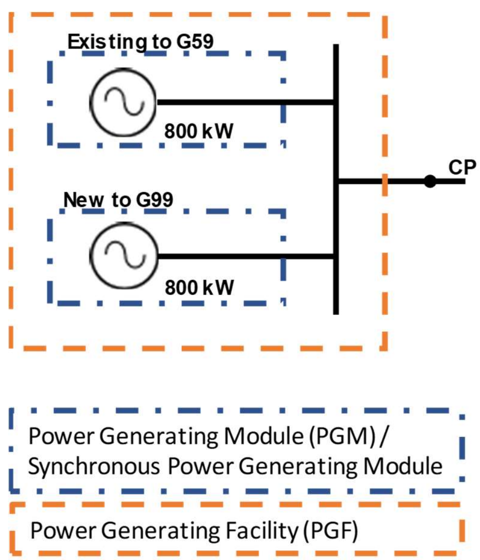
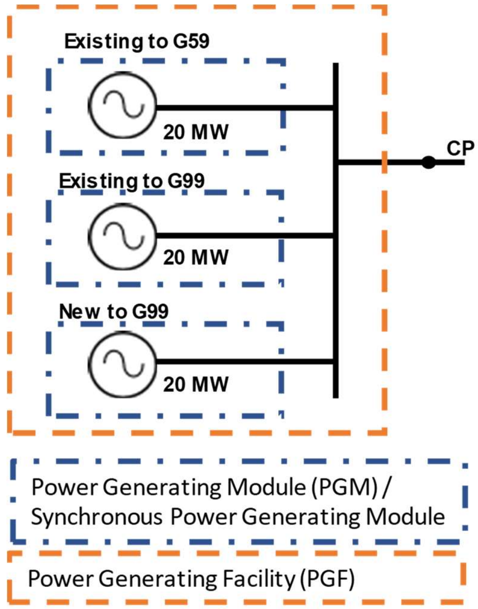


Figure 6.2. Example: 2 x 800 kW Type A Synchronous Power Generating Modules to EREC G99 = 1.6 MW Power Generating Facility



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889 **Figure 6.3. Example: Existing: 2 x 20 MW Type C Synchronous Power Generating**
890 **Modules with new unit:3 x 20 MW Type C Synchronous Power Generating Modules**
891 **= 60 MW Power Generating Facility (Embedded Medium Power Station in England &**
892 **Wales / Large Power Station in Scotland)**

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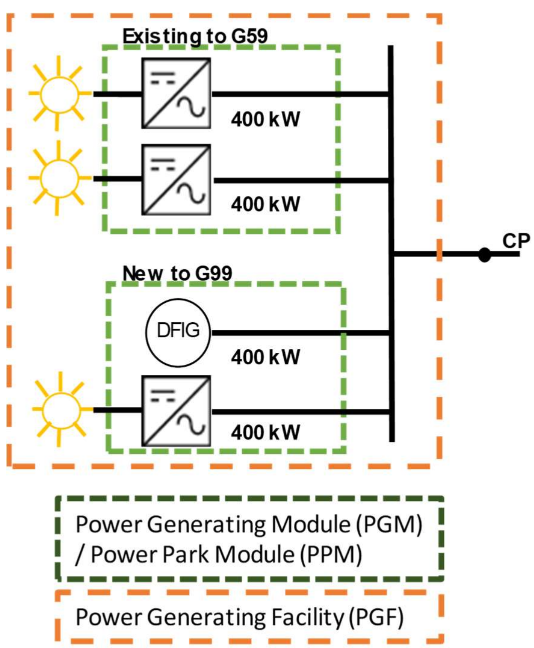

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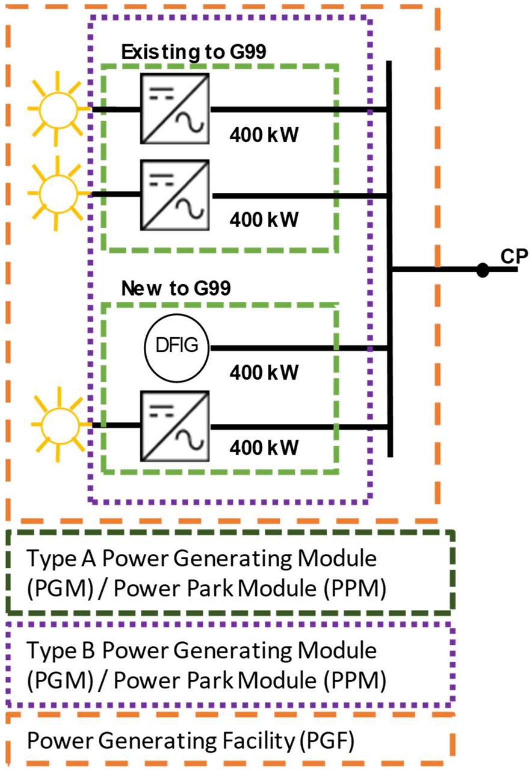
897 **Figure 6.4 Example: 1 x 800 kW Power Park Module to EREC G59 plus 1 x 800 kW**
898 **Type A Power Park Module to EREC G99**
899 **= 1.6 MW Power Generating Facility**



Note: The addition of new **Inverter** connected or asynchronous **Generating Units** to an existing **Power Park Module**, which was installed under EREC G99, takes the **Power Generating Module** from **Type A** to **Type B**, hence the existing **Generating Units** technical requirements will change in accordance with this EREC G99.

Figure 6.5. Example: 1 x 800 kW Type A Power Park Module to EREC G99 plus later expansion of 2 x 400 kW Generating Units = 1 x 1.6 MW Type B Power Park Module = 1.6 MW Power Generating Facility

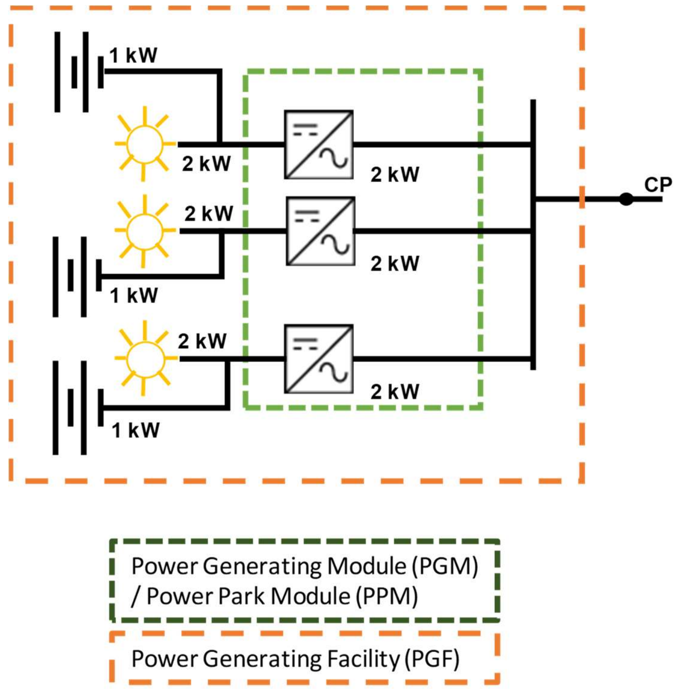


Figure 6.6. Example: Existing 6 kW Type A Power Park Module to EREC G99 plus later addition of 3 x 1 kW Storage Units (Compliance remains the same) = 6 kW Power Generating Facility

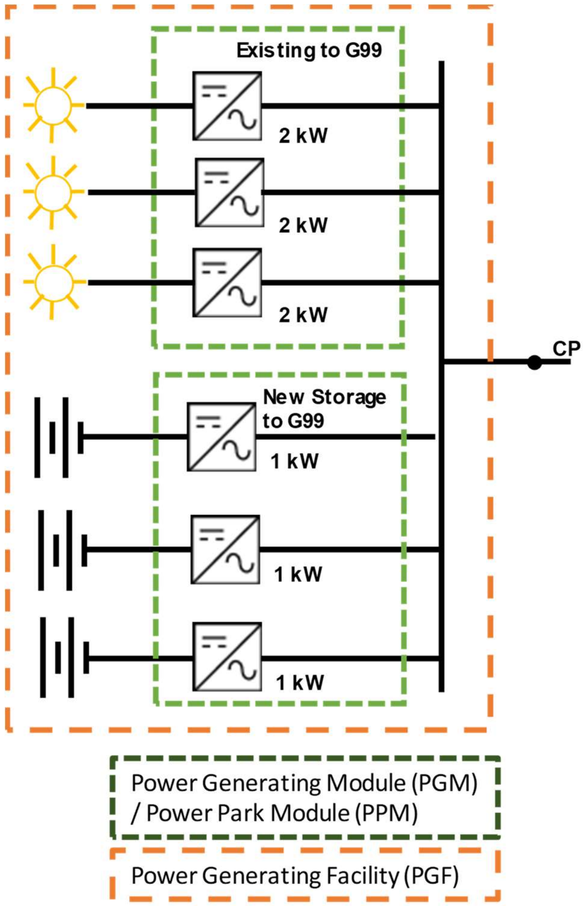


Figure 6.7. Example: Existing 6 kW Type A Power Park Module to EREC G99 plus later addition of 3 x 1 kW Storage Units with own Inverters = 6 kW Type A Power Park Module plus 3 kW Storage Type A Power Park Module (exempt from certain Type A requirements) = 9 kW Power Generating Facility

6.1.6 Interaction with the **NETSO**

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

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

6.2 Application for Connection

6.2.1 Information about the **Power Generating Module**(s) is needed by the **DNO** so that it can assess the effect that a **Power Generating Facility** may have on the **Distribution Network**. This document details the parameters to be supplied by a **Generator** 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 **Power Generating Facilities** which include **Type A Power Generating Modules**

6.2.2.1 For **Type A Power Generating Modules** the compliance, testing and commissioning requirements are detailed in Section 16 of this EREC G99.

6.2.2.2 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 **Generator**. 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 16 of this EREC G99.

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

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

6.2.3.2 For **Type B** and **Type C Power Generating Modules** the compliance, testing and commissioning requirements are detailed in Sections 17 and 18 respectively 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**.

6.2.3.3 For a **Type D Generating Unit**, once all the relevant documents have been provided to the **DNO** to their satisfaction the **DNO** will issue an **Energisation Operational Notification** to the **Generator** followed by an **Interim Operational Notification** and a **Final Operational Notification**. This process is described further in Section 19 of this EREC G99.

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

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

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

6.3.3 For **Power Generating Facilities** connected at **HV**, it is generally necessary to build an equivalent model of the **Distribution Network**. An example is shown as Figure 6.6 below.

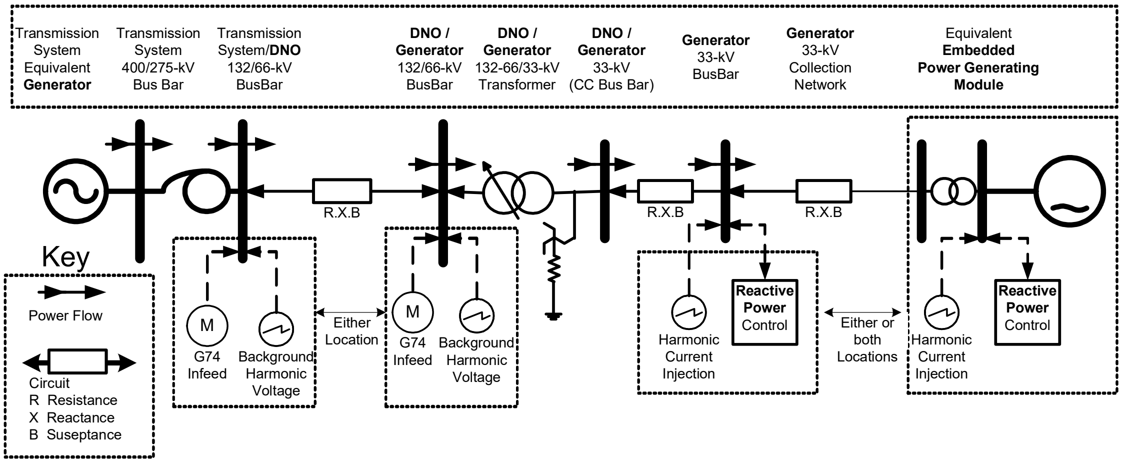


Figure 6.6 Example equivalent Total System representation

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

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

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

6.3.6 Control systems for **Synchronous Power Generating Module**s and prime movers have traditionally been provided and modelled in transparent transfer-function block diagram form. These models have been developed over many years and include lead/lag elements, gains, limiters and non-linear elements and may be tuned to obtain a satisfactory response for the particular **Power Generating Module** and grid connection. Such models will still generally satisfy the present requirements.

6.3.7 This document includes the requirement to submit validated detailed models in respect of asynchronous **Power Generating Modules** which are aggregated into a **Power Park Module Power Generating Facility**.

6.3.8 This EREC G99 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 **DNO**s will need appropriate modelling data from **Power Generating Module Manufacturers** to undertake system analysis. Note that it is the Generator's responsibility to ensure the necessary information is submitted to the **DNO**.

6.3.9.1 Simulations studies are required for **Type B**, **Type C** and **Type D Power Generating Modules** as explained in Annex B.4.

6.3.9.2 **Generator**s with **Type B Power Generating Modules** will need to submit appropriate modelling information. The traditional approach outlined in paragraph 6.3.6 will be appropriate for **Type B Power Generating Modules**.

6.3.9.3 **Generators** with **Type C** and **Type D Power Generation Module**s will need to submit appropriate simulation models. 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 **Manufacturers** to create 'black-box' models of their **Power Generating Module**s (see Section 21). These are programmed for compatibility with industry standard power analysis modelling packages. This is in order to protect the **Manufacturer's** intellectual property and so lessen the need for confidentiality agreements between parties. There are potential advantages and disadvantages to this approach, but must be generally welcomed provided that the two main disadvantages of this approach, as described below, can be resolved:

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

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

6.4 Provision of Information

6.4.1 General

6.4.1.1 **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**.

6.4.1.2 Except for **Fully Type Tested Type A Power Generating Modules, Generators** 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.**	6.4.2 and Schedule 5a of the DDRC

(b) **Power Generating Module** data for all embedded **Power Generating Modules**	6.4.3 and Schedule 5b of the DDRC
(c) **Power Generating Module** data for specified types of embedded **Power Generating Modules** 5c(i) **Synchronous Power Generating Modules** 5c(ii) Fixed speed induction **Power Generating Modules** 5c(iii) Double fed induction **Power Generating Modules** 5c(iv) Converter connected **Power Generating Modules** 5c(v) Transformers	6.4.3 and Schedules 5c of the DDRC
(d) **Power Generating Module** data for **Embedded Medium Power Stations**	6.4.4 and Schedules 5c of the DDRC

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

6.4.1.4 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 paragraph 6.4.2 will be required for **Power Generating Facilities** who are to be connected at **Low Voltage** and have less than 50 kVA in capacity, or connected at other than **Low Voltage** and have less than 300 kVA in capacity.

6.4.2 Information Required for all **Type A**, **Type B**, **Type C** and **Type D Power Generating Facilities**

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

The information required includes:

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

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

(c) Sketches of system layout:

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

(d) Interface Arrangements

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

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

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

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

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

6.4.3 Additional **Power Generating Module**, Plant and Equipment Data Required for some **Power Generating Facilities**

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

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

6.4.3.3 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**:

a) **Synchronous Power Generating Modules**

b) Fixed speed induction **Power Generating Modules**

c) Doubly fed induction **Power Generating Modules**

d) Series converter connected **Power Generating Modules**

e) 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.**

6.4.4 Extra Information for **Embedded Medium Power Stations** to be Provided to Meet **Grid Code** Requirements

6.4.4.1 The **DNO** has an obligation under ECC3.3 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 ECC3.3 of the **Grid Code**. It is incumbent on the **Embedded Medium Power Station Generator** to provide this data listed in ECC3.3 of the **Grid Code** to the **DNO**.

6.4.4.2 Where a **Generator** in respect of a **Power Generating Facility** is a party to the **CUSC** this paragraph 6.4.4 will not apply.

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

6.4.5 Information Provided by the **DNO** to **Generators**

6.4.5.1 In accordance with Condition 4 and Condition 25 of its **Distribution Licence** the **DNO** is required to provide certain information to **Generators** 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 33 kV and above is made available to **Generators** through the Long Term Development Statements provided under Condition 25 of the **Distribution Licence.** Schedule 5d of the Distribution Data Registration Code is indicative of the type of network data the **DNOs** is required to provide to **Generators** for identifying opportunities for connection of generation at voltages below 33 kV. On the production of Schedule 5d data for a **Generator**, the **DNO** will update any relevant data that would otherwise be provided from the Long Term Development Statement.

7 Connection Arrangements

7.1 Operating Modes

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

7.2 Long-Term Parallel Operation

7.2.1 This refers to the frequent or long-term operation of **Power Generating Modules** in parallel with the **Distribution Network**. Unless otherwise stated, all sections in this EREC G99 are applicable to this mode of operation.

7.3 Infrequent Short-Term Parallel Operation

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

7.3.2 In this mode of operation, parallel operation of the **Power Generating Module** and the **Distribution Network** will be infrequent and brief and under such conditions, it is considered acceptable to relax certain design requirements, such as protection requirements, that would be applicable to long-term parallel operation. The provisions of this Section 7 should also be read with Annex A.4 which details some other specific exclusions of parts of Sections 9 to 12 of this EREC G99.

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

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

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

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

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

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

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

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

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 – 200 ms. Under these conditions installing conventional **Interface Protection** with an operating time of 500 ms 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 1 s. The switch should be inhibited from making a transfer to the **DNO's Distribution Network** whilst voltage and frequency are outside expected limits.

7.4 Switched Alternative-Only Operation

7.4.1 General

7.4.1.1 Under this mode of operation it is not permissible to operate a **Power Generating Module** in parallel with the **Distribution Network**. Regulation 21 of the **ESQCR** states that it is the **Generator's** responsibility to ensure that all parts of the **Power**

Generating Module have been disconnected from the **Distribution Network** and remain disconnected while the **Power Generating Module** is operational. The provisions of this EREC do not generally apply and the earthing, protection, instrumentation etc. for this mode of operation are the responsibility of the **Generator**, however, where such **Power Generating Module** is to be installed, the **DNO** shall be given the opportunity to inspect the equipment and witness commissioning of any changeover equipment and interlocking.

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

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

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

7.4.2 Changeover Operated at **HV**

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

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

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

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

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

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

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

7.4.3 Changeover Operated at **LV**

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

a) Manual break-before-make changeover switch;

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

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

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

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

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

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

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

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

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

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

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

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

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

A **Power Generating Module** technology which operates at different times due to location eg 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 Annex A.5.

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

7.6.1 The maximum aggregate capacity of **Power Generating Modules** that can be connected to a single phase supply is 17 kW. The maximum aggregate capacity of **Power Generating Modules** that can be connected to a split single phase supply is 34 kW.

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 17 kW per phase (subject to balance of site output as per Section 7.5). A single phase 17 kW connection may result in an imbalance of up to 17 kW following a **Distribution Network** or **Power Generating Module** outage. However the connection design should result in imbalance under normal operation to be below 16 A between phases as noted above.

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

7.7 Voltage Management Units in Generator'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 **Generator**. In some cases where the **DNO's Distribution Network** voltage is low they may increase the voltage supplied to the **Generator**. 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 **Generator** 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 **Generators Installation**, it may result in the voltage at the **Generator** 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 **Generator's Installation.**

7.7.4 **Generators** 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 **Generator's Installation** or the operation of the **DNO's Distribution Network** at too high a voltage. **Generators** 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 Power Generating Modules with a Connection Point at HV

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 132 kV are generally designed for earthing at one point only and it is not normally acceptable for **HV Generators** 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.

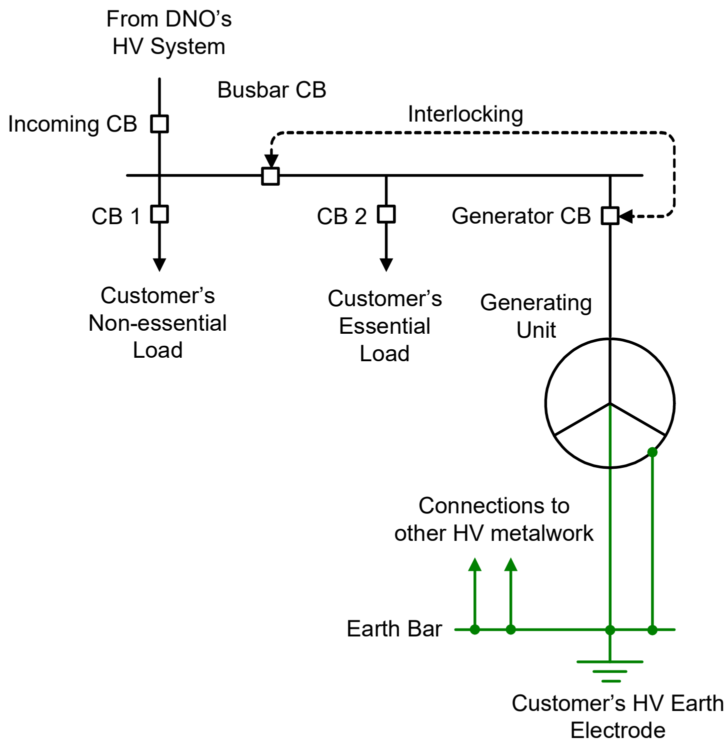
8.2.4 **HV Distribution Networks** operating at 132 kV are generally designed for multiple earthing, and in such cases the earthing requirements should be agreed in writing with the **DNO**.

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

8.2.6 **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**.

8.2.7 Typical earthing arrangements are given in Figures 8.1 to 8.4.

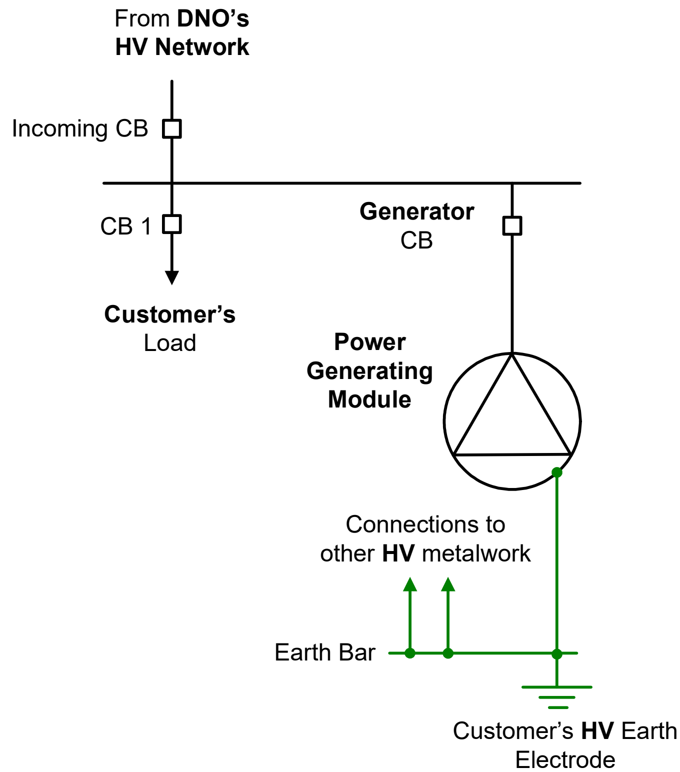
8.2.8 Earthing systems shall be designed, installed, tested and maintained in accordance with ENA TS 41-24, (Guidelines for the design, installation, testing and maintenance of main earthing systems in substations), BS7354 (Code of Practice for Design of Open Terminal Stations), BS7430 (Code of Practice 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**.



NOTE:

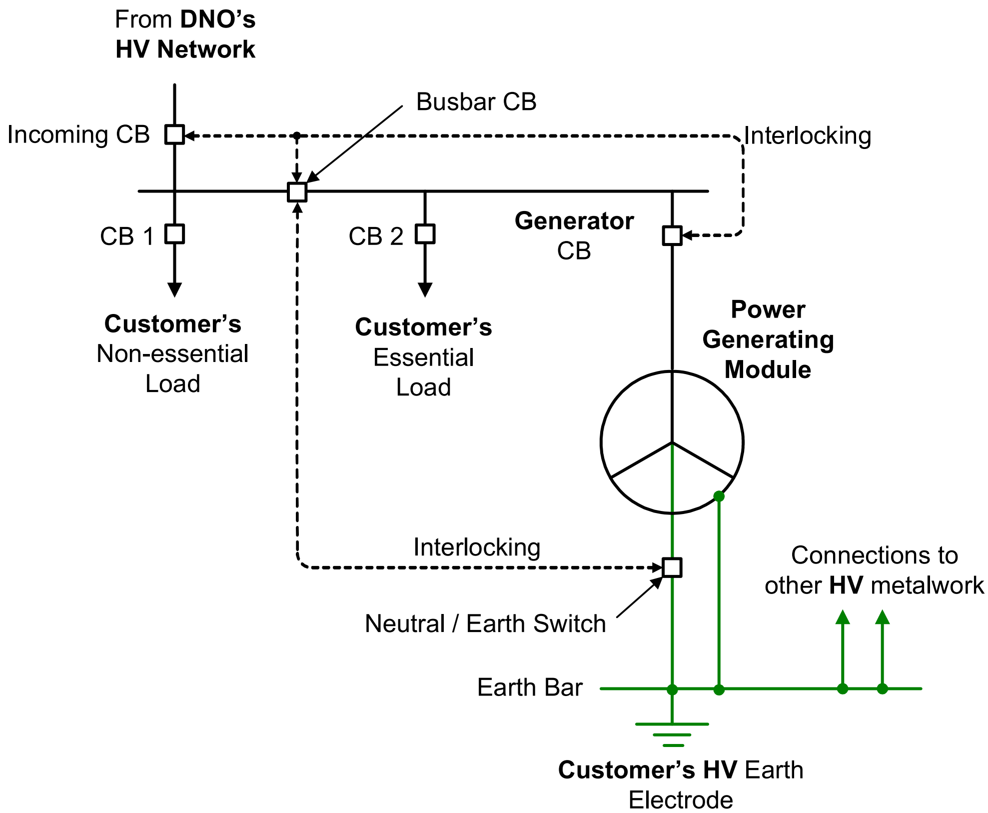
(1) Interlocking between busbar CB and **Power Generating Facility** CB is required to prevent parallel operation of the **Power Generating Module** and **DNO's Distribution Network**

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



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

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



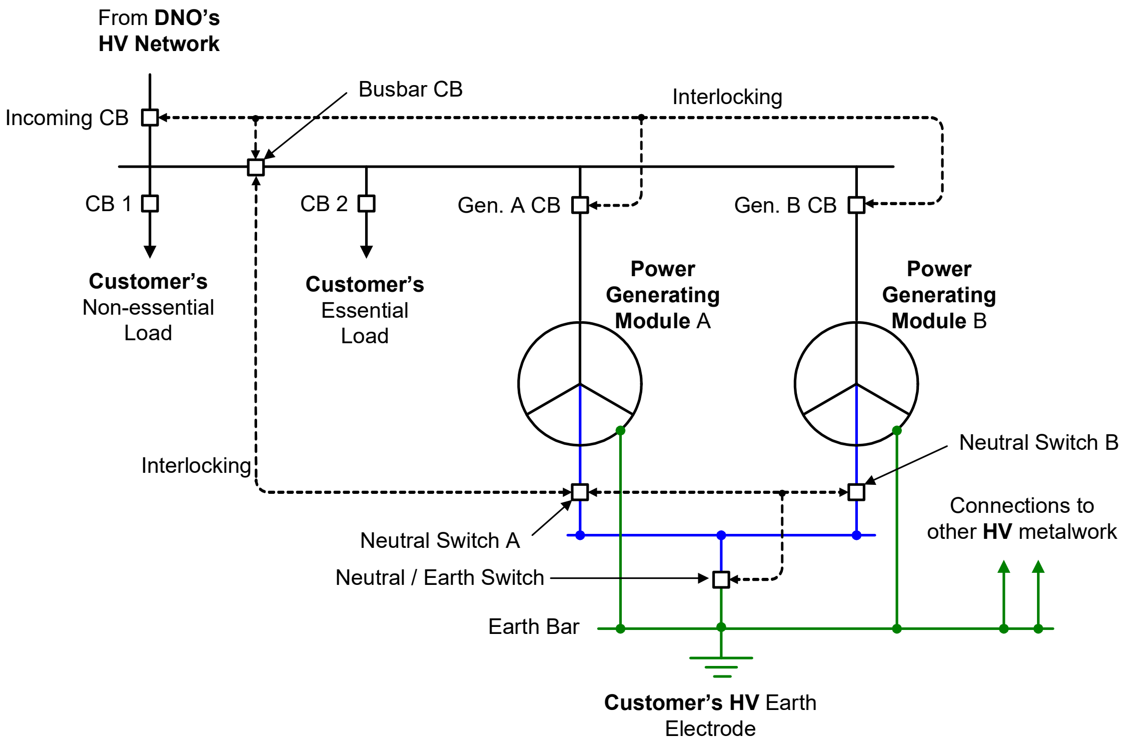
NOTE:

(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 8.3 - 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 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.

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

8.3 Power Generating Modules with a Connection Point at LV

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

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

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

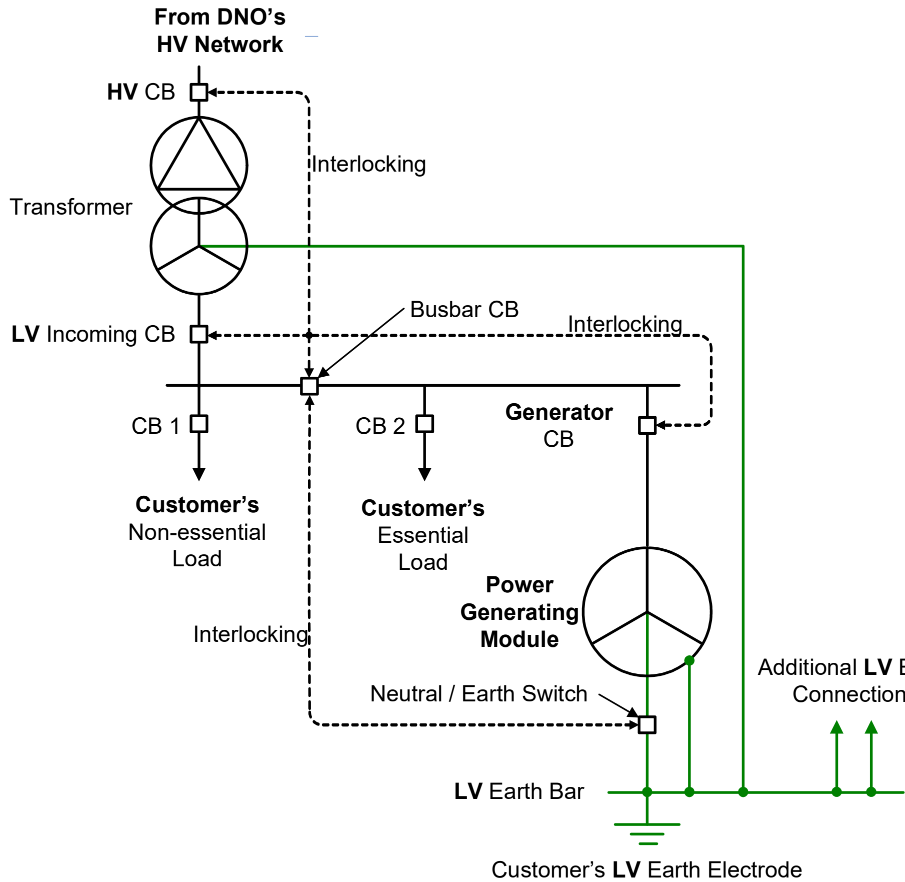
a) Where an earthing terminal is provided by the **DNO** it may be used by a **Power Generation Facility** for earthing the **Power Generating Module**, provided the **DNO** earth connection is of adequate capacity. If the **Power Generating Module** is intended to operate independently of the **DNO's**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

b) Where the **Power Generating Module** may be operated as a switched alternative only to the **DNO's Distribution Network**, the **Power Generation Facility** shall provide an independent earth electrode.

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

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

8.3.4 The following Figures 8.5 to 8.9 show typical installations.



NOTE:

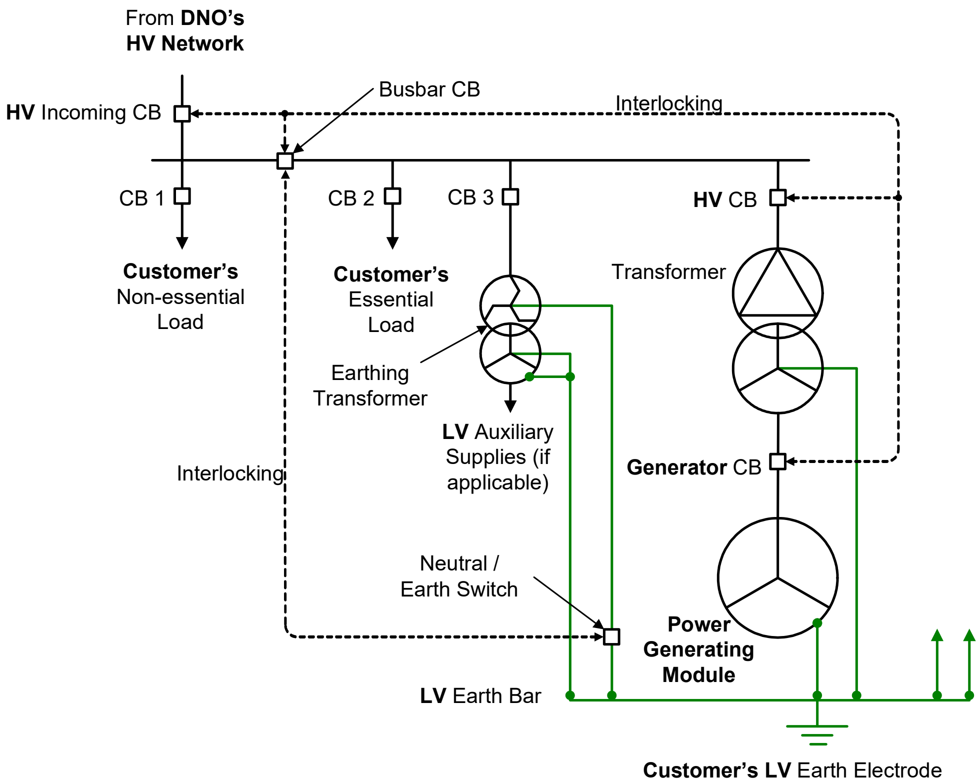
(1) **HV** earthing is not shown.

(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 8.5 - 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:

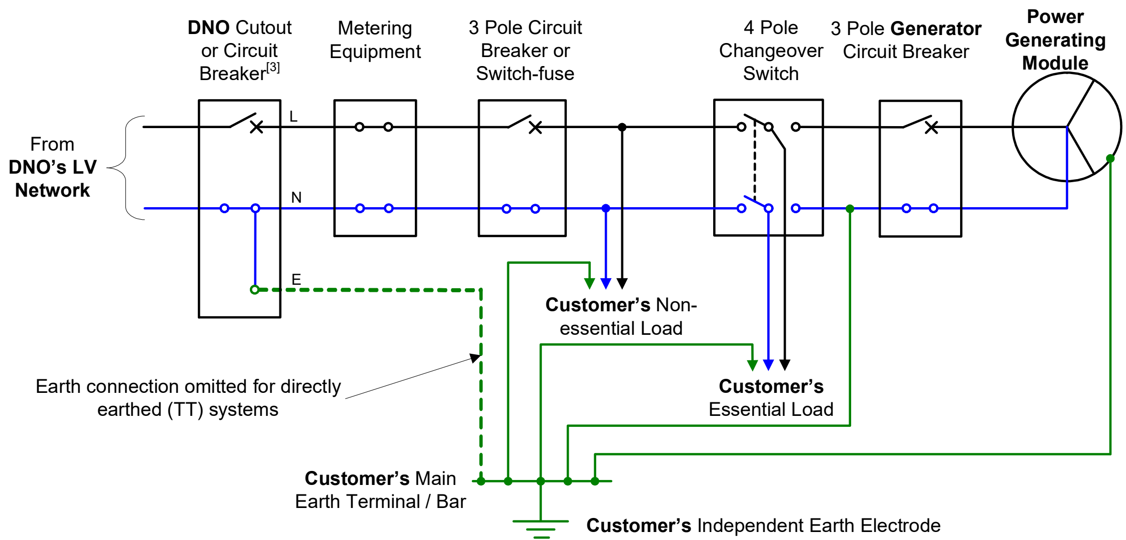
(1) **HV** earthing is not shown.

(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 Generator HV System and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation



NOTE

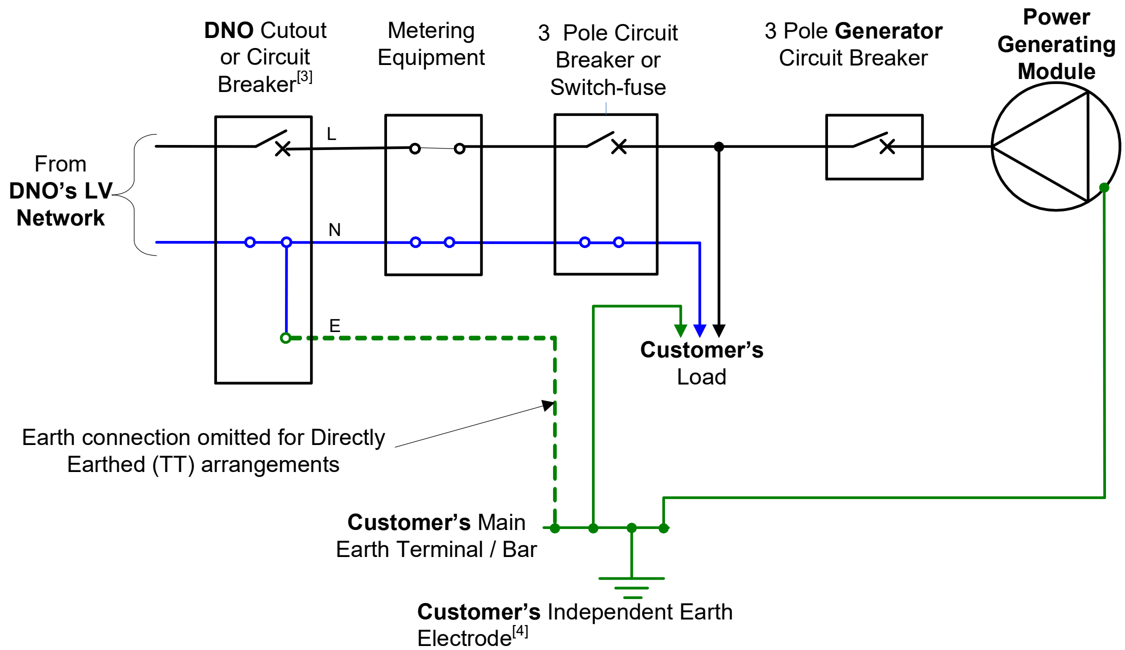
(1) Only one phase of a three phase system is shown to aid clarity.

(2) **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.

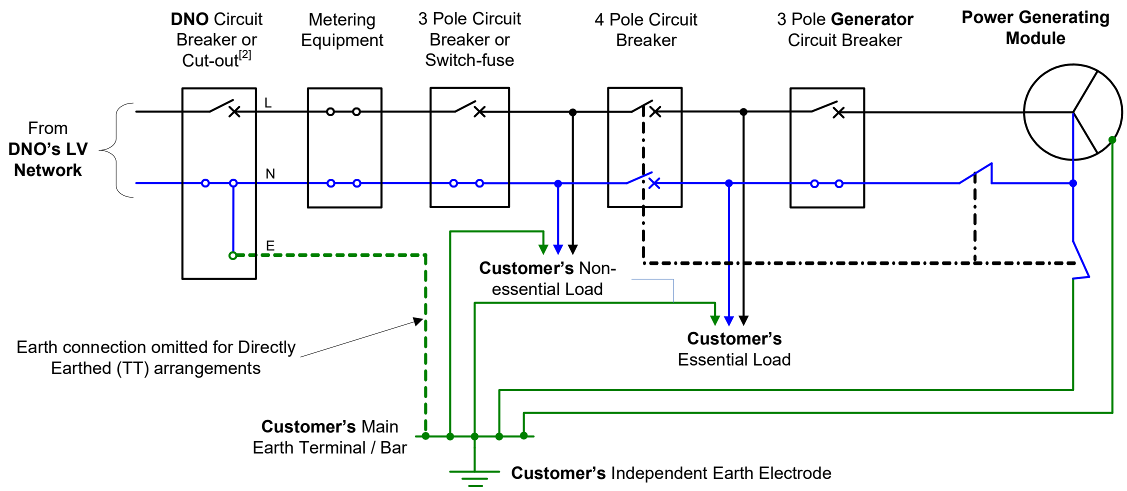
(4) The changeover switch must disconnect each phase and the neutral (ie for a three phase system a 4 pole switch is required). This prevents **Power Generating Module** neutral current from inadvertently flowing through the part of the **Generator's Installation** that is not supported by the **Power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

Figure 8.7 - Typical Earthing Arrangement for an LV Power Generating Module Embedded within a Generator LV System and Designed for Independent (ie Standby) 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 **Generator**'s independent earth electrode is only required if the installation is Directly Earthed (TT).

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



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 **Generator'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.

Figure 8.9 - Typical Earthing Arrangement for an LV Power Generating Module Embedded within a Generator LV System and Designed for both Independent Operation (ie Standby Operation) and Parallel 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 detailed in this document and DPC 4 of the **Distribution Code**. The criteria are based upon the performance requirements of the **Distribution Network** necessary to meet the above obligations.

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

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

b) according to design principles in relation to **Distribution Network**'s plant and equipment, earthing, voltage regulation and control, and protection as outlined in DPC4, subject to any **Modification** to which the **DNO** may reasonably consent.

9.1.4 **Power Generating Modules** should meet a set of technical requirements in relation to its performance with respect to frequency and voltage, control capabilities, protection coordination requirements, **Phase (Voltage) Unbalance** requirements, neutral earthing provisions, islanding and **Black Start Capability** as applicable. The technical connection requirements in this chapter are common to all **Power Generating Modules**.

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

9.2 Network Connection Design for Power Generating Modules

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

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

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

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

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

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

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

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

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

9.3 Voltage Step Change

9.3.1 The **Step Voltage Change** caused by the connection and disconnection of **Power Generating Modules** from the **Distribution Network** must be considered and be subject to limits to avoid unacceptable voltage changes being experienced by other **Customers** connected to the **Distribution Network**. The magnitude of a **Step Voltage Change** depends on the method of voltage control, types of load connected and the presence of local generation.

9.3.2 Typical limits for **Step Voltage Change** caused by the connection and disconnection of any **Customers** equipment to the **Distribution Network** should be within the limits set out in EREC P28.

9.3.3 The voltage depression arising from transformer magnetising inrush current is a short-time phenomenon not generally easily captured by the definition of **Step Voltage Change** used in this document. In addition the size of the depression is dependent on the point on wave of switching and the duration of the depression is relatively short in that the voltage recovers substantially in less than 1 s.

9.3.4 **Generator Installation**s should be designed taking account of the advice in EREC P28 in respect of transformer energisation assessment such that transformer magnetising inrush current associated with normal routine switching operations does not cause voltage fluctuations outside those in EREC P28. To achieve this it may be necessary to install switchgear so that sites containing multiple transformers can be energised in stages.

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

9.4 Power Quality

9.4.1 Introduction

9.4.1.1 The connection and operation of **Power Generating Modules** may cause a distortion of the **Distribution Network** voltage waveform resulting in voltage fluctuations, harmonics or **Phase (Voltage) Unbalance**.

9.4.2 Flicker

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

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

9.4.2.3 For **Power Generating Modules** up to 17 kW per phase or 50 kW three phase voltage step change and flicker measurements as required by BS EN 61000-3-11 shall be made and recorded in the test declaration for the **Power Generating Module.** The **DNO** will use these declared figures to calculate the required maximum supply impedance required for the connection to comply with EREC P28. This calculation may show that the voltage fluctuations will be greater than those permitted and hence reinforcement of the **Distribution Network** may be required before the **Power Generating Module** can be connected. Detailed testing requirements are described in Annex A.7.

9.4.3 Harmonic Emissions

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

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

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

9.4.4 Voltage imbalance

9.4.4.1 EREC P29 is a planning standard which sets the **Distribution Network** compatibility levels for voltage unbalance caused by uneven loading of three phase supply systems. **Power Generating Module**s should be capable of performing satisfactorily under the conditions it defines. The existing voltage unbalance on an urban **Distribution Network** rarely exceeds 0.5% but higher levels, in excess of 1%, may be experienced at times of high load and when outages occur at voltage levels above 11 kV. 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.

9.4.5 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 33 kV, or 1% for other systems with a nominal voltage no greater than 132 kV. Overall, voltage unbalance should not exceed 2% when assessed over any one minute period. EREC P29, like all planning standards, is applicable at the time of connection.

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

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

9.4.6 DC Injection

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

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

9.5 System Stability

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

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

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

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

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

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

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

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

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

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

9.5.4.1 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.

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

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

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

b) any one transformer or reactor,

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

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

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

9.5.7 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:

a) from the **Distribution Network** at the **Connection Point**. improved fault clearance times by means of faster protection;

b) improved performance of **Power Generating Module** control systems (excitation and governor/prime mover control systems; **Power System Stabilisers** to improve damping);

c) improved system voltage support (provision from either **Power Generating Module** or **Distribution Network** plant);

d) reduced plant reactance's (if possible);

e) installation of protection to identify pole-slipping;

f) increased fault level infeed

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 **Generator**s in terms of reduced risk of system instability.

9.6 Island Mode

9.6.1 A fault or planned outage, which results in the disconnection of a **Power Generating Module**, together with an associated section of **Distribution Network**, from the remainder of the **Total System**, creates the potential for island mode operation. It will be necessary for the **DNO** to decide, dependent on local network conditions, if it is desirable for the **Generators** 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 **Generator**'s site is designed to maintain supplies to that site in the event of a failure of the **DNO** supply.

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

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

b) earthing arrangements;

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

d) **System Stability**;

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

f) safety of personnel.

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

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

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

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

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

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

9.7 Fault Contributions and Switchgear Considerations

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

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

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

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

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

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

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

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

9.7.9 Disconnection of a **Power Generating Module** must be achieved by the separation of mechanical contacts unless the disconnection is at **Low Voltage** and the equipment at the point of disconnection contains appropriate self monitoring of the point of disconnection, in which case an appropriate electronic means such as a suitably rated semiconductor switching device would be acceptable. The self monitoring facility shall incorporate fail safe monitoring to check the voltage level at the output stage. In the event that the solid state switching device fails to disconnect the **Power Generating Module**, the voltage on the output side of the switching device shall be reduced to a value below 50 V within 0.5 s. 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.

10 Protection

10.1 General

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

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

10.1.3 Where a common protection system is used to provide the protection function for multiple **Power Generating Modules** the complete installation cannot be considered to comprise **Fully Type Tested Power Generating Modules** if the protection and connections are made up on site and so cannot be factory tested or **Type Tested**. If the units or **Power Generating Modules** are specifically designed to be interconnected on site via plugs and sockets, then provided the assembly passes the function tests required in Annex A.2 (Form A2-4), the **Power Generating Modules** can retain **Type Tested** status.

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

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

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

10.1.7 Note that where the **Generator** installs an Export Limiting Scheme in accordance with EREC G100 the installation will also need to comply with the requirements of that EREC.

10.2 Co-ordinating with DNO's Distribution Network's 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 **Generator**'s maintenance and testing regime, shall be agreed between the **DNO** and the **Generator** in writing during the connection consultation process.

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 0.5 s should be allowed for this. For auto-reclosers set with a dead time of 3 s, this implies a maximum **Interface Protection** response time of 2.5 s. Where auto-reclosers have a dead time of less than 3 s, there may be a need to reduce the operating time of the **Interface Protection**. For **Type Tested Power Park Modules** no changes are required to the operating times irrespective of the auto-reclose times. In all other cases where the auto-recloser dead time is less than 3 s the **Generator** will need to agree site-specific **Interface Protection** settings with the **DNO**.

10.2.2 Specific protection required for **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:

a) For all **Power Generating Modules**:

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

ii. 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.

b) For **polyphase Power Generating Modules:**

i. To inhibit connection 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;

ii. 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**;

c) For **single** phase **Power Generating Modules**

i. To inhibit connection 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;

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

10.3 Protection Requirements

10.3.1 Suitable protection arrangements and settings will depend upon the particular **Generator** installation and the requirements of the **DNO's Distribution Network**. These individual requirements must be ascertained in discussions with the **DNO**. To achieve the objectives above, the protection must include the detection of:

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

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

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

Protection settings for **Power Generating Facilities** over 100 MW **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 **Power Generating Facilities** with a **Registered Capacity** greater than 50 MW 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 Installation of automatic reconnection systems for **Type B**, **Type C** and **Type D** shall be subject to prior authorisation by the **DNO**. Unless **Generators** of **Type D** **Power Generating Modules** have prior authorisation from the **DNO** for the installation of automatic reconnection systems, they must obtain authorisation from the **DNO**, or **NETSO** as applicable, prior to synchronisation.

10.3.4 The frequency and voltage at the **DNO's** side of the supply terminals at the **Connection Point** must be within the **frequency and voltage** ranges of the **Interface Protection** as listed in paragraph 10.6.7 for at least 20 s before the **Power Generating Module** is allowed to automatically reconnect to the **DNO's Distribution Network**. There is in general no maximum admissible ramp rate for **Active Power** output on connecting or reconnecting, although it is a requirement to state the assumed maximum ramp rate for the **Power Generating Module** as part of the application for connection. If a network specific issue requires a maximum admissible ramp rate of **Active Power** output on connection it will be specified by in the **Connection Agreement**.

10.3.5 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 20 s. 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**.

10.3.6 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.

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

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

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

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

10.4 Loss of Mains (LoM)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

10.4.14 It is the responsibility of the **Generator** to incorporate what they believe to be 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

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

10.5.2.2 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.

10.5.2.3 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.

10.5.2.4 **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 200 kVA 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.

10.5.2.5 As a general rule for generation installations connected at 20 kV 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 200 kVA;
- Multiple new **Power Generating Module** connections, of any type, on a single site, with an aggregated output less than 200 kVA;
- 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 200 kVA;
- 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 200 kVA, 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 the **Power Generating Module**, **Connection Point**, network design and planning policy. This is outside the scope of this document.

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

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

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

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

10.6 Protection Settings

10.6.1 The following notes aim to explain the settings requirements as given in Section 10.6.7 below.

10.6.2 Loss of Mains

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

10.6.3 Under Voltage

In order to help maintain **Total System Stability**, the protection settings aim to facilitate transmission fault ride through capability (as required in Sections 12.3 and 13.3 below). 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 2.5 s should be applied.

10.6.4 Over Voltage

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

- Stage 1 (**LV**) should have a setting of +14% (ie the **LV** statutory upper voltage limit of +10%, with a further 4% permitted for voltage rise internal to the **Generator's Installation** and measurement errors), with a time delay of 1.0 s (to avoid nuisance tripping for short duration excursions);
- Stage 2 (**LV**) should have a setting of +19% with a time delay of 0.5 s (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 1.0 s (ie the **HV** statutory upper voltage limit of +6%, with a further 4% permitted for voltage rise internal to the **Generator's Installation** and measurement errors), with a time delay of 1.0 s to avoid nuisance tripping for short duration excursions);
- Stage 2 (**HV**) should have a setting of +13% with a time delay of 0.5 s (ie recognising the need to disconnect quickly for a material excursion).

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

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 0.5 s 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 0.5 s plus circuit breaker operating time.

10.6.6 Under Frequency

All Power Generating Facilities are required to maintain connection unless the **Total System** frequency falls below 47.5 Hz for 20 s 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 20 s;
- Stage 2 should have a setting of 47.0 Hz with a time delay of 0.5 s;

10.6.7 Protection Settings

10.6.7.1

Table 10.1 Settings for Long-Term Parallel Operation

Protection Function	**Type A, Type B and Type C Power Generating Modules**				**Type D Power Generating Modules and Power Generating Facilities with a Registered Capacity > 50 MW**	
	LV Protection(1)		**HV** Protection(1)			
	Trip Setting	Time Delay Setting	Trip Setting	Time Delay Setting	Trip Setting	Time Delay Setting
U/V	Vφ-n† -20%	2.5 s*	Vφ-φ‡ -20%	2.5 s*	Vφ-φ‡- 20%	2.5 s*
O/V st 1	Vφ-n† + 14%	1.0 s	Vφ-φ‡ + 10%	1.0 s	Vφ-φ‡ + 10%	1.0 s
O/V st 2	Vφ-n†+ 19%$	0.5 s	Vφ-φ‡ + 13%	0.5 s		
U/F st 1	47.5 Hz	20 s	47.5 Hz	20 s	47.5 Hz	20 s
U/F st 2	47.0 Hz	0.5 s	47.0 Hz	0.5 s	47.0 Hz	0.5 s
O/F	52.0 Hz	0.5 s	52.0 Hz	0.5 s	52.0 Hz	0.5 s
LoM (RoCoF)#	1 Hzs^{-1} time delay 0.5 s		1 Hzs^{-1} time delay 0.5 s		Intertripping expected	
LoM (RoCoF) **Type Tested#**	0.2 Hzs^{-1}		0.2 Hzs^{-1}			

(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. Where a private non standard **LV** network exists the settings shall be calculated from **HV** settings values as indicated by Section 10.6.14;
- If the EREC G99 protection takes its voltage reference from an **HV** source then **HV** settings shall be applied.

†A value of 230 V shall be used in all cases for **Power Generating Facilities** connected to a **DNO's LV Distribution Network** ie the U/V **LV** trip setting is 184 V, the O/V stage 1 setting is 262.2 V and the O/V stage 2 setting is 273.7 V.

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

* Might need to be reduced if auto-reclose times are <3 s. (see 10.2.1).

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

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

The required RoCoF protection requirement is expressed in Hertz per second (Hzs^{-1}). The time delay should begin when the measured RoCoF exceeds the threshold expressed in Hzs^{-1}. The time delay should be reset if measured RoCoF falls below that threshold. The relay must not trip unless the measured rate remains above the threshold expressed in Hzs^{-1} continuously for 500 ms. 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 500 ms if the system RoCoF was significantly higher than the threshold.

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

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

†A value of 230 V shall be used in all cases for **Power Generating Facilities** connected to a **DNO's LV Distribution Network** (ie the U/V **LV** trip setting is 207 V and the O/V trip setting is 262.2 V).

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

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

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

10.6.10 Once the settings 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 Modules** the voltage settings will be based on the 230 V nominal system voltage. In some cases **Power Generating Modules** may be connected to **LV** systems with non-standard operating voltages. Paragraph 10.6.14 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.

10.6.13 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.

10.6.14 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 230 V. 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 ± 5% and with delta connected **HV** windings. Where a **DNO** provides a connection at **HV** and the **Generator** 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 **Generator's LV** network. Where a **DNO** provides a connection at **HV** and the **Generator'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 **Generator** is using an 11,000 V to 230/400 V transformer and it is proposed to operate it on tap 1 representing an increase in the **HV** winding of +5% and the nominal **HV** voltage is 11,000 V.

$V_{LVsys} = V_{LVnom} \text{ x } V_{HVnom}/V_{HVtap}$

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

Where:

V_{LVsys} – **LV** system voltage

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

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

V_{HVtap} – **HV** tap position

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

OV stage 1	=	219 x 1.1	=	241 V
OV stage 2	=	219 x 1.13	=	247.5 V
UV	=	219 x 0.8	=	175 V

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

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

This approach should only be used by prior arrangement with the host **DNO**. Where all other requirements of EREC G99 would allow the **Power Generating Module** to be **Fully Type Tested**, the **Manufacturer** may produce a declaration in a similar format to Annex A.2 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 G99. 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**.

10.6.15 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.

10.6.16 Whilst the protection schemes and settings for internal electrical faults should mitigate any damage to the **Power Generating Module** they must not jeopardise the performance of a **Power Generating Module**, in line with the requirements set out in this **EREC**.

10.6.17 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**:

a) network and **Power Generating Module** protection;

b) synthetic inertia, if applicable;

c) frequency control (**Active Power** adjustment -if any);

d) power restriction (if any); and

e) power gradient constraint (if any).

10.6.18 For the avoidance of doubt where an internal fault on the **Power Generating Module** occurs during any significant event on the **Total System**, the **Power Generating Module's** internal protection should trip the module to ensure safety and minimise damage to the **Power Generating Module.**

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 Modules** 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 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 the requirements of paragraph 10.3.4 are met.

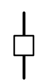
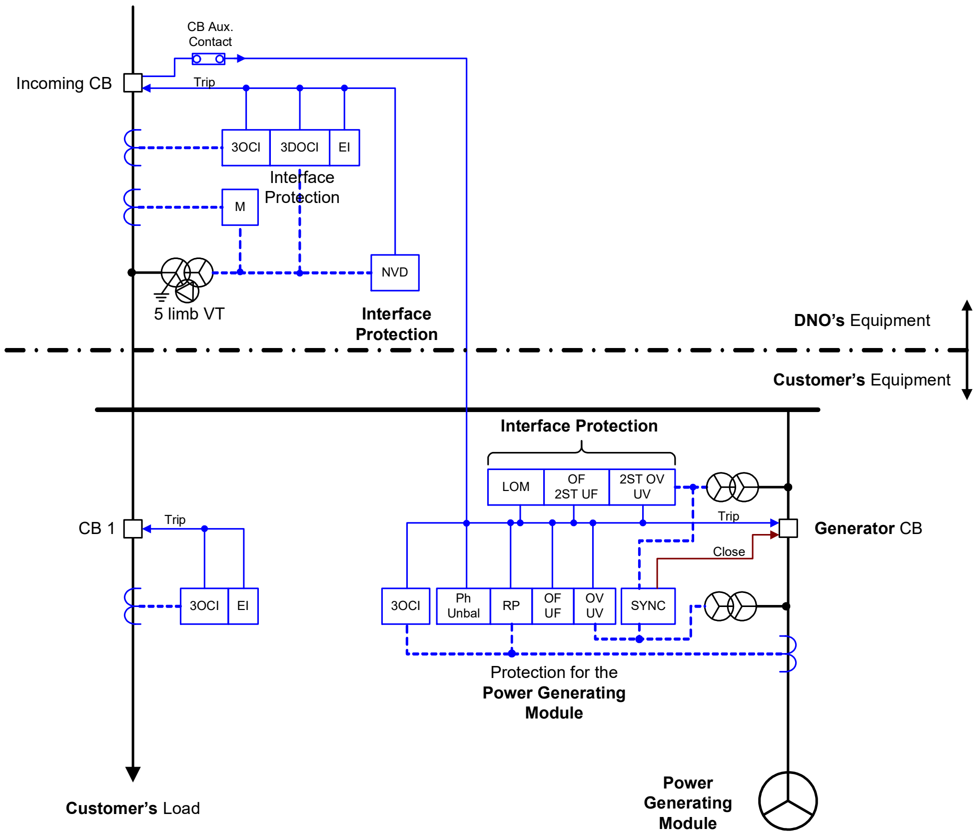
BEF	Balanced Earth Fault	OV UV	Single Stage Over Voltage & Single Stage Under Voltage
CC	Circulating Current	Ph Unbal	Phase Unbalance
3DOCI	3 Pole Directional Overcurrent (IDMT)	RP	Reverse Power
EI	Earth Fault (IDMT)	OF 2ST UF	1 Stage Over Frequency & 2 Stage Under Frequency
LOM	Loss of Mains	2ST OV UV	2 Stage Over Voltage & 1 Stage Under Voltage
M	Metering	SYNC	Synchronising
NVD	Neutral Voltage Displacement		Circuit Beaker
3OCI	3 Pole Overcurrent (IDMT)		
OF UF	Single Stage Over Frequency & Single Stage Under Frequency		

Figure 10.1 - List of Symbols in Figures 10.2 – 10.6



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2648 **Figure 10.2 - Typical Protection Arrangement for an HV Power Generating Module**
2649 **Connected to a DNO's HV Distribution Network Designed for Parallel**
2650 **Operation Only**

2651

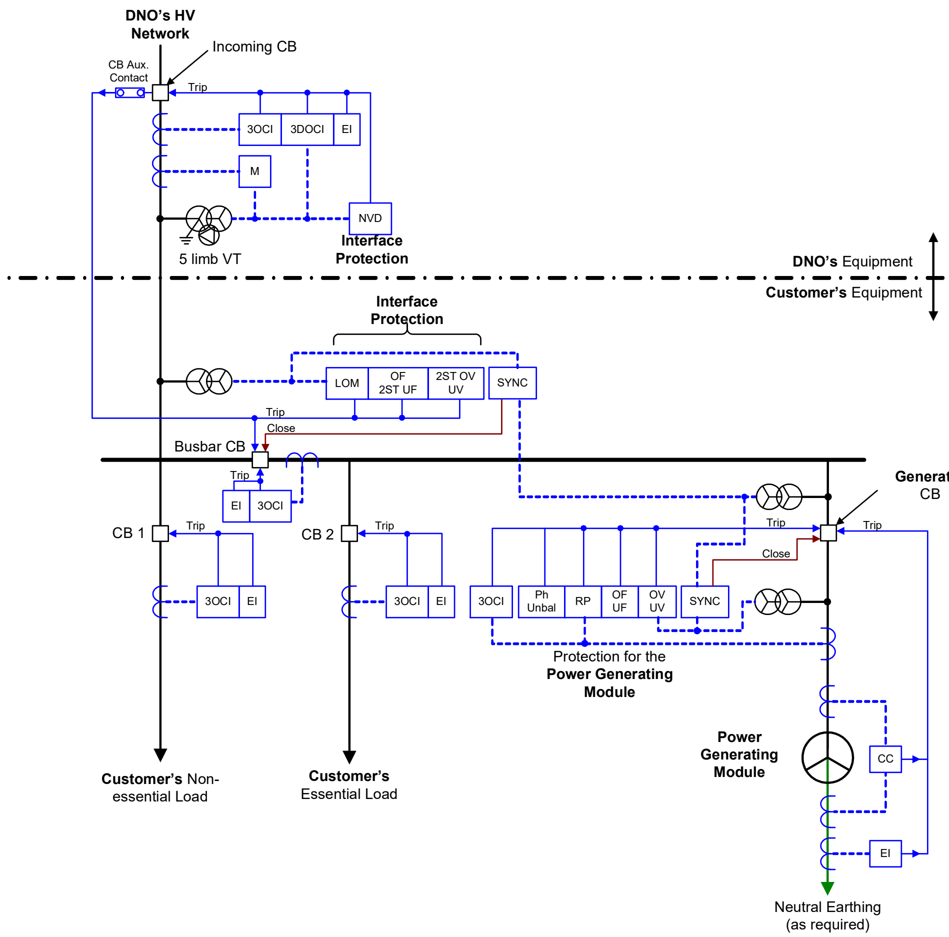
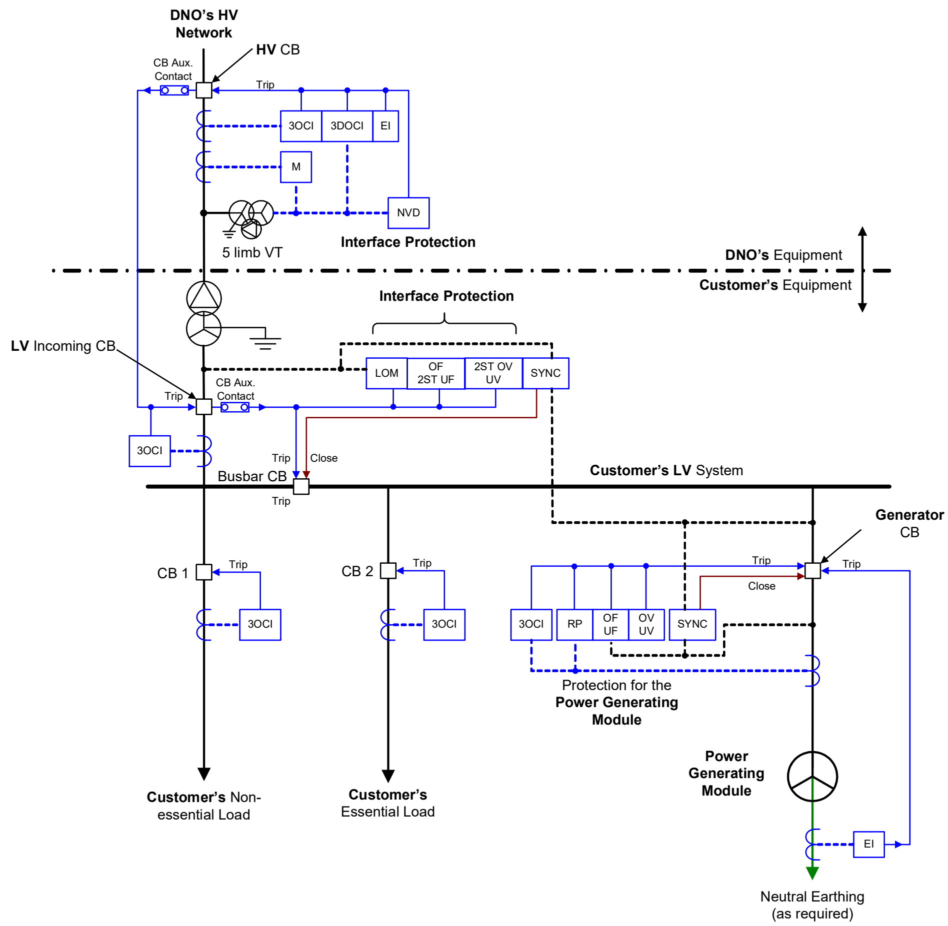


Figure 10.3 - Typical Protection Arrangement for an HV Power Generating Module Connected to a DNO's HV Distribution Network Designed for both Independent Operation (ie Standby Operation) and Parallel Operation



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2659 **Figure 10.4 - Typical Protection Arrangement for an LV Power Generating Module**
2660 **Connected to a DNO's HV Distribution Network and designed for both**
2661 **Independent Operation (ie Standby Operation) and Parallel Operation.**

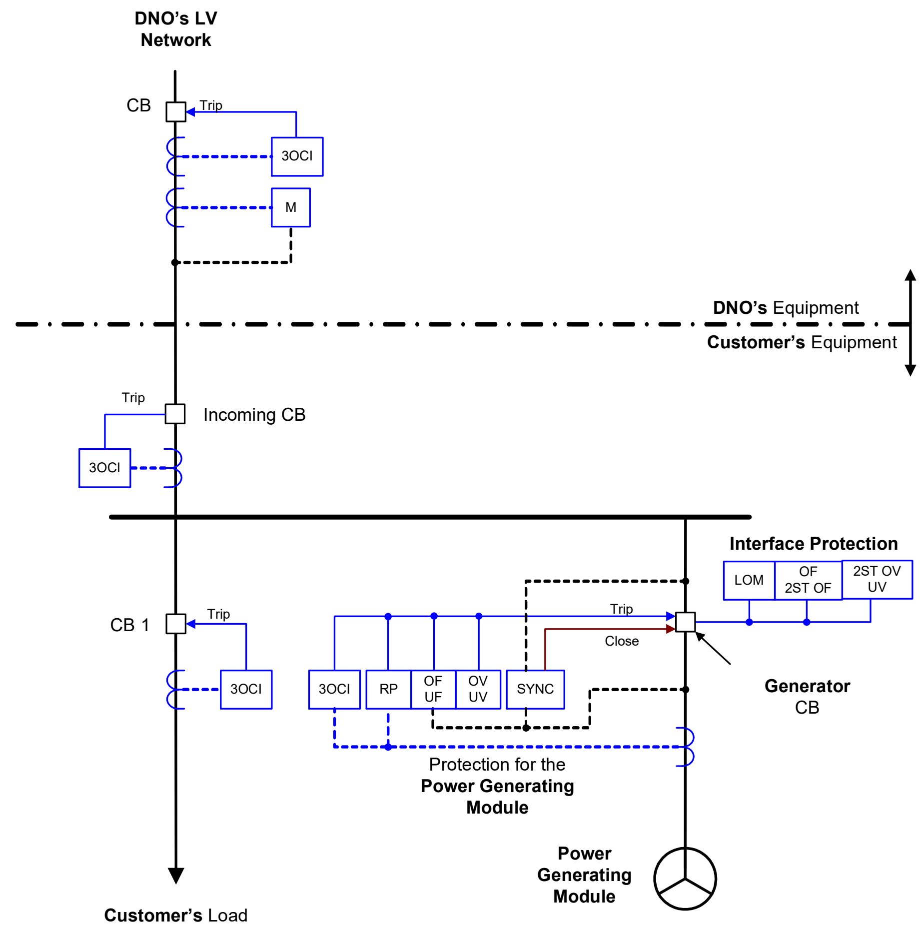
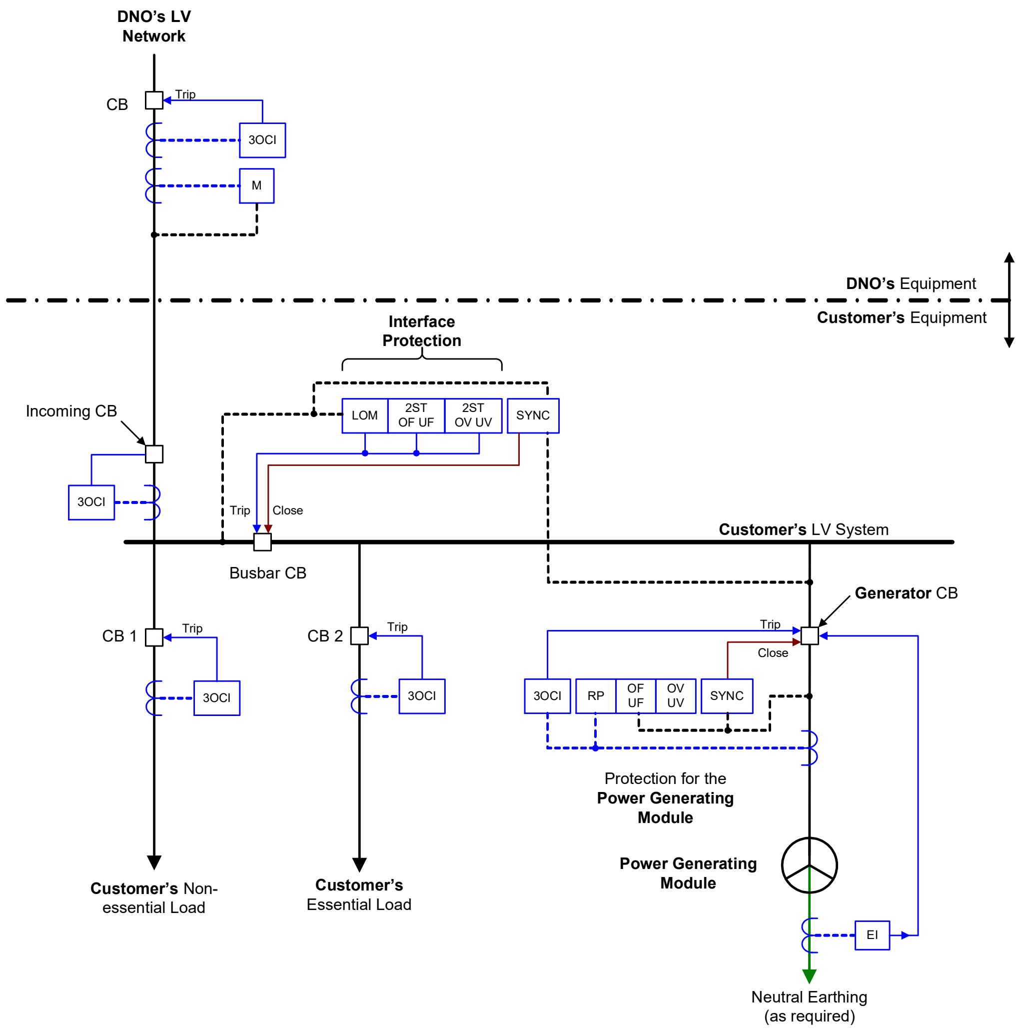


Figure 10.5 - Typical Protection Diagram for an LV Power Generating Module Connected to a DNO's LV Distribution Network Designed for Parallel Operation Only



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2668 **Figure 10.6 - Typical Protection Diagram for an LV Power Generating Module**
2669 **Connected to a DNO's LV Distribution Network Designed for both Independent**
2670 **Operation (ie Standby Operation) and Parallel Operation**

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11 Type A Power Generating Module Technical Requirements

11.1 Power Generating Module Performance and Control Requirements – General

11.1.1 The requirements of this Section 11 do not apply in full to **Power Generation Facilities** that are designed and installed for infrequent short term parallel operation only nor to storage **Power Generation Modules** within the **Power Generating Facility** – refer to Annex A.4.

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

11.1.3 **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 5 s following an instruction being received at the input port.

11.1.3.1 By default the logic interface will take the form of a simple binary output that can be operated by a simple switch or contactor. When the switch is closed the **Power Generating Module** can operate normally. When the switch is opened the **Power Generating Module** will reduce its **Active Power** to zero within 5 s. The signal from the **Power Generating Module** that is being switched can be either AC (maximum value 240 V) or DC (maximum value 110 V). If the **DNO** wishes to make use of the facility to cease **Active Power** output the **DNO** will agree with the **Generator** how the communication path is to be achieved

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

11.1.5 When operating at rated power the **Power Generating Module** shall be capable of operating at a **Power Factor** within the range 0.95 lagging to 0.95 leading relative to the voltage waveform unless otherwise agreed with the **DNO**.

11.1.6 As part of the connection application process the **Generator** shall agree with the **DNO** the set points of the control scheme for voltage control, **Power Factor** control or **Reactive Power** control as appropriate. These settings, and any changes to these settings, shall be agreed with the **DNO** and recorded in the **Connection Agreement**. The information to be provided is detailed in Schedule 5a and Schedule 5b of the Data Registration Code.

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

11.2 Frequency response

11.2.1 Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47 Hz. In exceptional circumstances, the frequency of the

DNO's Distribution Network could rise above 50.5 Hz. Therefore all **Power Generating Modules** should be capable of continuing to operate in parallel with the **Distribution Network** in accordance with the following:

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

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

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

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

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

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

11.2.3 With regard to the rate of change of frequency withstand capability, a **Power Generating Module** shall be capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1 Hzs^{-1} as measured over a period of 500 ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the **Power Generating Module's** own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.

11.2.4 Output power with falling frequency

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

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

b) (subject to the provisions of paragraph 11.2.1) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 11.1 for system frequency changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including 25^{0}C, such that if the system frequency drops to 47 Hz the **Active Power** output does not decrease by more than 5%.

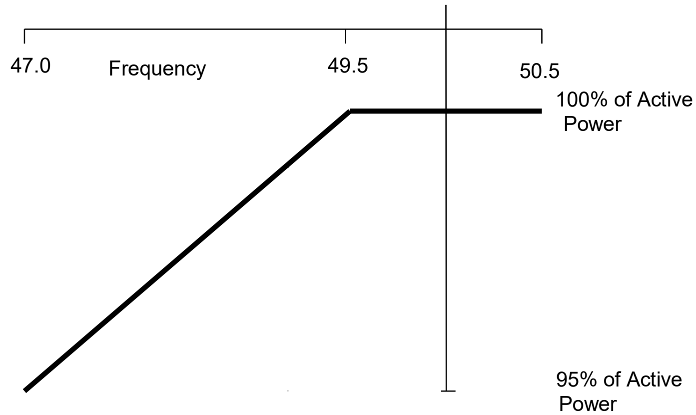


Figure 11.1 Change in Active Power with falling frequency

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

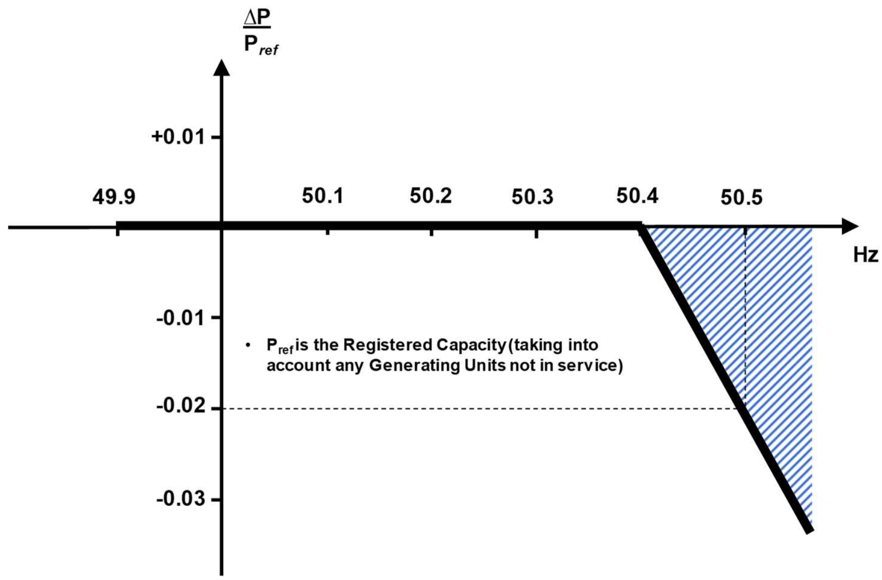
11.2.5 Limited Frequency Sensitive Mode – Over frequency

11.2.5.1 Each **Power Generating Module** shall be capable of reducing **Active Power** output in response to frequency on the **Total System** when this rises above 50.4 Hz. The **Power Generating Module** shall be capable of operating stably during **LFSM-O** operation. If a **Power Generating Module** has been contracted to operate in **Frequency Sensitive Mode** the requirements of **LFSM-O** shall apply when frequency exceeds 50.5 Hz.

a) The rate of change of **Active Power** output must be at a minimum a rate of 2% of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a **Droop** of 10%) as shown in Figure 11.2. For the avoidance of doubt, this would not preclude a **Generator** from designing their **Power Generating Module** with a **Droop** of less than 10%, but in all cases the **Droop** should be 2% or greater.

b) 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 initial delay exceeds 2 s the **Generator** shall justify the delay, providing technical evidence to the **DNO**, who will pass this evidence to the **NETSO**. 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 s of the time of the frequency increase above 50.4 Hz.

c) If the reduction in **Active Power** is such that the **Power Generation Modul**e reaches its **Minimum Generation**, it must continue to operate stably at this level.



P_{ref} is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module**.

Figure 11.2 Active Power Frequency Response capability when operating in LFSM-O

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

11.2.5.3 Steady state operation below **Minimum Generation** is not expected but if system operating conditions cause operation below **Minimum Generation** which give rise to operational difficulties then the **Generator** shall be able to return the output of the **Power Generating Module** to an output of not less than the **Minimum Generation.**

11.3 Fault Ride Through and Phase Voltage Unbalance

11.3.1 Any **Power Generating Module** or **Power Generating Facility** connected to the **DNO's Distribution Network**, where it has been agreed between the **DNO** and the **Generator** that the **Power Generating Facility** will contribute to the **DNO's Distribution Network** security, (eg for compliance with EREC P2) may be required to withstand, without tripping, the effects of a close up three phase fault and the **Phase (Voltage) Unbalance** imposed during the clearance of a close-up phase-to-phase fault ,in both cases cleared by the **DNO's** main protection. The **DNO** will advise the **Generator** in each case of the likely tripping time of the **DNO's** protection, and for phase-phase faults, the likely value of **Phase (Voltage) Unbalance** during the fault clearance time.

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

11.4 Voltage Limits and Control

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

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

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

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

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

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12 Type B Power Generating Module Technical Requirements

12.1 Power Generating Module Performance and Control Requirements - General

12.1.1 The requirements of this Section 12 do not apply in full to **Power Generation Facilities** that are designed and installed for infrequent short term parallel operation only nor to storage **Power Generation Modules** within the **Power Generating Facility** refer to Annex A.4.

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

12.1.3 **Power Generating Modules** shall be equipped with a communication interface (input port) in order to be able to reduce **Active Power** output following an instruction at the input port.

12.1.3.1 **DNOs** currently are developing active network management approaches and there is no common standard for communication interfaces.

12.1.3.2 The **DNO** will provide details of the method to be employed on a site by site basis. Protocols currently in use between **DNOs** and **Generators** include simple current loop; DNP3; IEC 61850.

12.1.3.3 The **DNO** will agree with the **Generator** for each **Power Generating Facility** the protocol to be used.

12.1.3.4 By default if nothing is specified by the **DNO** then a simple hard-wired current loop interface should be provided where a 4 mA to 20 mA DC signal corresponding to 0 pu to 1.0 pu of **Registered Capacity Active Power**.

12.1.3.5 The **Active Power** reduction will be either between 1.0 pu of **Registered Capacity Active Power** and zero, or between 1.0 pu of **Registered Capacity Active Power** and **Minimum Generation**. In the latter case the **Generator** will agree with the **DNO** how zero output can be achieved, including the option of using the logic interface as described in paragraph 11.1.3.1.

12.1.3.6 If the **DNO** wishes to make use of the facility to reduce **Active Power** output the **DNO** will agree with the **Generator** the communication interface and other necessary equipment that will be needed.

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

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

12.2 Frequency response

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

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

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

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

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

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

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

12.2.3 With regard to the rate of change of frequency withstand capability, a **Power Generating Module** shall be capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1 Hzs^{-1} as measured over a period of 500 ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the **Power Generating Module's** own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.

12.2.4 Output power with falling frequency

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

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

b) (subject to the provisions of paragraph 12.2.1) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 12.1 for system frequency changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including 25^0C, such that if the system frequency drops to 47 Hz the **Active Power** output does not decrease by more than 5%.

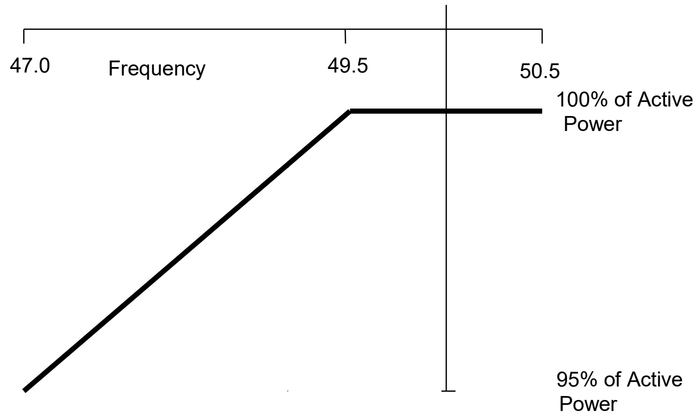


Figure 12.1 Change in Active Power with falling frequency

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

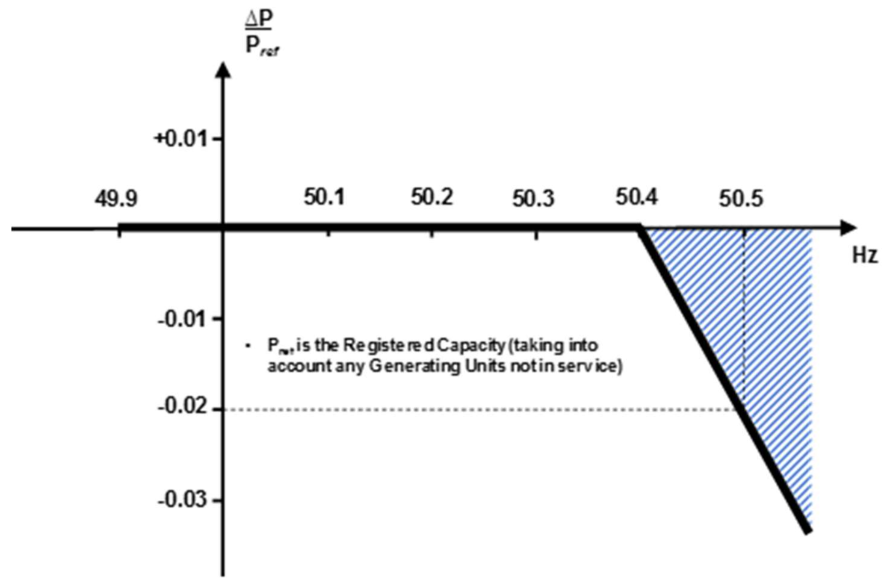
12.2.5 **Limited Frequency Sensitive Mode – Over frequency**

12.2.5.1 Each **Power Generating Module** shall be capable of reducing **Active Power** output in response to frequency on the **Total System** when this rises above 50.4 Hz. The **Power Generating Module** shall be capable of operating stably during **LFSM-O** operation. If a **Power Generating Module**, has been contracted to operate in **Frequency Sensitive Mode** the requirements of **LFSM-O** shall apply when frequency exceeds 50.5 Hz.

a) The rate of change of **Active Power** output must be at a minimum a rate of 2% of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a **Droop** of 10%) as shown in Figure 12.2. For the avoidance of doubt, this would not preclude a **Generator** from designing their **Power Generating Module** with a **Droop** of less than 10%, but in all cases the **Droop** should be 2% or greater.

b) 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 initial delay exceeds 2 s the Generator shall justify the delay, providing technical evidence to the **DNO**, who will pass this evidence to the **NETSO**. 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 s of the time of the frequency increase above 50.4 Hz.

c) If the reduction in **Active Power** is such that the **Power Generation Modul**e reaches its **Minimum Generation**, it must continue to operate stably at this level.



P_{ref} is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module**.

Figure 12.2 Active Power Frequency Response capability when operating in LFSM-O

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

12.2.5.3 Steady state operation below **Minimum Generation** is not expected but if system operating conditions cause operation below **Minimum Generation** which give rise to operational difficulties then the **Generator** shall be able to return the output of the **Power Generating Module** to an output of not less than the **Minimum Generation.**

12.3 Fault Ride Through and Phase Voltage Unbalance

12.3.1 Paragraphs 12.3.1.1 to 12.3.1.7 inclusive set out the fault ride through, principles and concepts applicable to **Synchronous Power Generating Modules** and **Power Park Modules**, subject to disturbances from faults on the **Network** up to 140 ms in duration.

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

12.3.1.2 The voltage against time curves defined in Table 12.1 and Table 12.2 express the lower limit (expressed as the ratio of its actual value and its reference 1pu) of the actual course of the phase to phase voltages (or phase to earth voltage in the case of asymmetrical/unbalanced faults) on the network voltage level at the **Connection Point** during a symmetrical or asymmetrical/unbalanced fault, as a function of time before, during and after the fault.

12.3.1.3

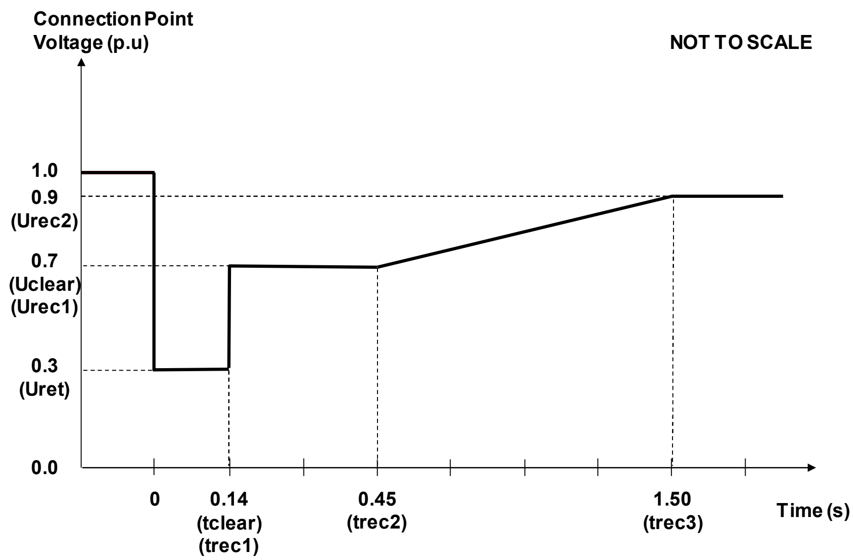


Figure 12.3 - Voltage against time curve applicable to Type B Synchronous Power Generating Modules

12.3.1.4

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

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

12.3.1.5

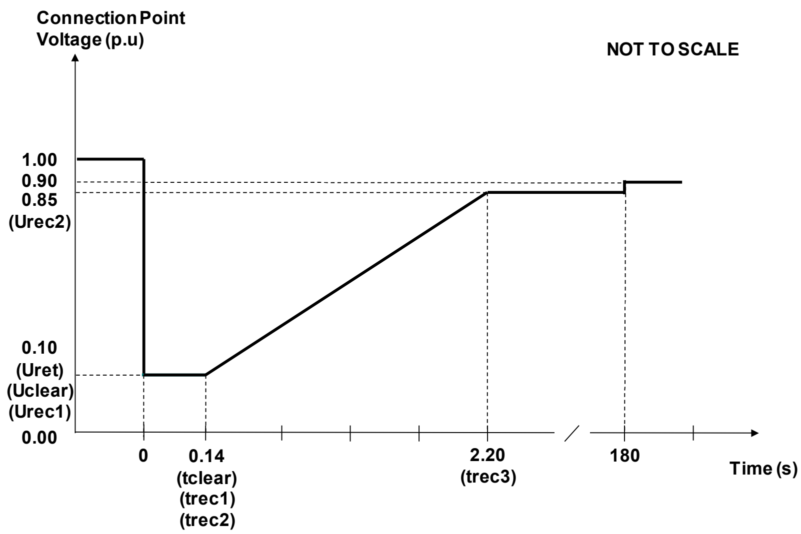


Figure 12.4 - Voltage against time curve applicable to Type B Power Park Modules

12.3.1.6

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

Voltage parameters (pu)		**Time parameters (s)**	
U_{ret}	0.1	t_{clear}	0.14
U_{clear}	0.10	t_{rec1}	0.14
U_{rec1}	0.10	t_{rec2}	0.14
U_{rec2}	0.85	t_{rec3}	2.2

12.3.1.7 In addition to the requirements in 12.3.1.2 to 12.3.1.6:

a) Each **Power Generating Module** shall be capable of satisfying the above requirements at the **Connection Point** when operating at **Registered Capacity** output and maximum leading **Power Factor** as specified in paragraph 12.5.1.

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

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

d) The protection schemes and settings for internal electrical faults must not jeopardise **Fault Ride Through** performance as specified in Section 12.3. For the avoidance of doubt where an internal fault on the **Power Generating Module** occurs during a **Fault Ride Through** condition, the **Power Generating Module's** internal protection should trip the module to ensure safety and minimise damage.

e) Each **Power Generating Module** shall be designed such that within 0.5 s 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:

i. 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

ii. The oscillations are adequately damped.

iii. In the event of power oscillations, **Power Generating Modules** shall retain steady state stability when operating at any point on the **Generator Performance Chart**.

For **Power Park Modules**, comprising switched reactive compensation equipment (such as mechanically switched capacitors and reactors), such switched reactive compensation equipment shall be controlled such that it is not switched in or out of service during the fault but may act to assist in post fault voltage recovery.

12.3.2 In addition to paragraphs 12.3.1.1 – 12.3.1.7 any **Power Generating Module** or **Power Generating Facility** connected to the **DNO's Distribution Network**, where it has been agreed between the **DNO** and the **Generator** that the **Power Generating Facility** will contribute to the **DNO's Distribution Network** security (eg for compliance with EREC P2), may be required to withstand, without tripping, the effects of a close up three phase fault and the **Phase (Voltage) Unbalance** imposed during the clearance of a close-up phase-to-phase fault , in both cases cleared by the **DNO's** main protection. The **DNO** will advise the **Generator** in each case of the likely tripping time of the **DNO's** protection, and for phase-phase faults, the likely value of **Phase (Voltage) Unbalance** during the fault clearance time.

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

12.3.4 Other **Fault Ride Through** Requirements

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

b) **Generators** are required to confirm to the **DNO**, their repeated ability to operate through balanced and unbalanced faults and system disturbances each time the voltage at the **Connection Point** falls outside the limits specified in paragraph 12.4.1. Demonstration of this capability would be satisfied by **Generators** supplying the protection settings of their plant, informing 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

c) For the avoidance of doubt the requirements specified in this Section 12.3 do not apply to **Power Generating Modules** connected to an unhealthy circuit and islanded from the **Distribution Network** even for delayed auto reclosure times.

12.4 Voltage Limits and Control

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

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

12.4.3 Excitation Performance Requirements

12.4.3.1 Each **Synchronous Generating Unit** within a **Synchronous Power Generating Module** shall be equipped with a permanent automatic **Excitation System** that that has the capability to provide constant terminal voltage (assuming a high enough **Network** source impedance to allow the **Power Generating Module** to achieve this while remaining within its ratings) at a selectable setpoint without instability over the entire operating range of the **Synchronous Power Generating Module**.

12.4.3.2 The **DNO** will agree with the **Generator** the operation of the control system of the **Synchronous Power Generating Module** or **Power Park Module** such that it shall contribute, as agreed, to voltage control or **Reactive Power** control or **Power Factor** control at the **Connection Point**. In some cases, for example, on large industrial sites etc where the **Power Generating Module** is embedded in the **Generator's Network**, the **DNO** and **Generator** might agree a different control point, such as the **Power Generating Module**'s terminals. The performance requirements of the control system including **Slope** (where applicable) shall be agreed between the **DNO** and the **Generator**.

12.4.3.3 As part of the connection application process the **Generator** shall agree with the **DNO** the set points of the control scheme for voltage control, **Power Factor** control or **Reactive Power** control as appropriate. These settings, and any changes to these settings, shall be agreed with the **DNO** and recorded in the **Connection Agreement**. The information to be provided is detailed in Schedule 5a and Schedule 5b of the Data Registration Code.

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

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

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

12.5 Reactive Capability

12.5.1 When supplying **Registered Capacity** all **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** or the **Generating Unit** terminals as appropriate for the **Power Generating Facility** and as agreed with the **DNO.**

12.5.2 At **Active Power** output levels other than **Registered Capacity**, all **Generating Units** within a **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 **Generator Performance Chart**. **Generators** should take any site demand such as auxiliary supplies and the **Active Power** and **Reactive Power** losses of the **Power Generating Module** transformer or **Station Transformer** into account unless advised otherwise by the **DNO**.

12.6 Fast Fault Current Injection

12.6.1 **Fast Fault Current** injection is necessary to support the **Total System** during a fault on the **Transmission System**. The design of **Fast Fault Current** injection is tailored to this, and does not relate directly to faults on the **Distribution Network**, not least as those will tend to have longer clearing times than those of the **Transmission System** for which **Fast Fault Current** injection is designed. In this Section 12.6 the faults referred to are **Transmission System** faults which clear within 140 ms and which will be seen in the **Distribution Network** as a voltage depression.

12.6.2 Each **Power Park Module** shall be required to satisfy the following requirements:

a) For any balanced or unbalanced fault on the **Transmission System** which results in the voltage at the **Connection Point** falling below 0.9 pu each **Power Park Module** shall, unless otherwise agreed with the **DNO**, be required to inject a current above the shaded area shown in Figure 12.5 (a) and Figure 12.5 (b). For the purposes of this requirement, the maximum rated current is taken to be the maximum current each **Generating Unit** can supply when operating at **Registered Capacity** and 0.95 **Power Factor** at a nominal voltage of 1.0 pu. For example, in the case of a 1 MW **Power Park Module** the **Registered Capacity** would be taken as 1 MW and the rated **Reactive Power** would be taken as 0.33 MVAr (ie **Rated MW** output operating at 0.95 **Power Factor** lead or 0.95 **Power Factor** lag) giving a MVA rating of 1.05 MVA. For the avoidance of doubt, where the phase voltage at the **Connection Point** is not zero, the injected current shall be in proportion to the retained voltage at the **Connection Point** but shall still be required to remain above the shaded area in Figure 12.5(a) and Figure 12.5(b).

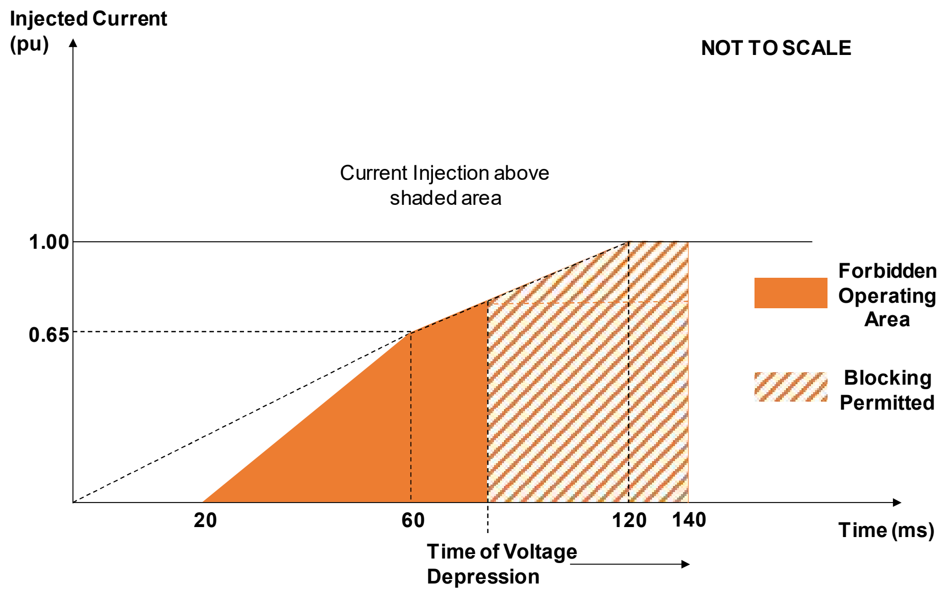


Figure 12.5 (a) Chart showing area of Reactive Current injections for voltage depressions of less than 140 ms duration

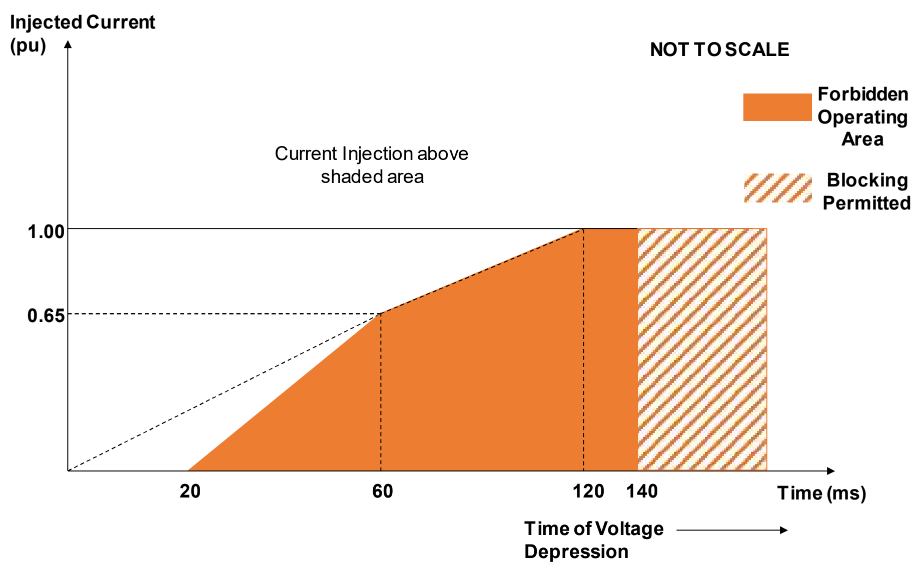


Figure 12.5 (b) Chart showing area of Reactive Current injections for voltage depressions of greater than 140ms duration

b) In addition, the injected current from each **Power Park Module** shall be in proportion and remain in phase with the change in system voltage at the **Connection Point** during the period of the voltage depression. For the avoidance of doubt, the injected current will be purely reactive for a retained voltage of zero and the reactive component of the injected current will fall in inverse proportion to the retained voltage at the **Connection Point**. The voltage generated from the injected current of the **Power Park Module** shall be in phase with the retained voltage at the **Connection Point**, whilst the total injected current remains above the shaded area in diagrams 12.5(a) and 12.5(b). Also, as can been seen on the diagrams a small delay time of no greater than 20 ms once the voltage falls to below 0.9 pu is permitted before injection of the in phase reactive current.

c) The **Inverter** is permitted to block (ie reduce the current injection) when the voltage at the **Connection Point** has returned to >0.85 pu in order to mitigate against the risk of transient overvoltage instability that would otherwise occur due to transient overvoltage excursions. Figure 12.5 (a) and Figure 12.5 (b) show the required current injection during the duration of the voltage depression. Where the **Generator** 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 Section 9.3, **Generators** are required to both advise of, and agree on, the control strategy with the **DNO**, which must also include the approach taken to de-blocking. Notwithstanding this requirement, **Generators** should be aware of their requirement to fully satisfy the **Fault Ride Through** requirements of Section 12.3.

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

e) **Generators** in respect of **Power Park Modules** are required to confirm to the **DNO,** their repeated ability to supply **Fast Fault Current** to the system each time the voltage at the **Connection Point** falls below 0.9 pu. **Generators** should inform the **DNO** of the maximum number of repeated operations that can be performed under such conditions and any limiting factors to repeated operation such as protection or thermal rating.

12.7 Operational monitoring

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

13 Type C and Type D Power Generating Module Technical Requirements

13.1 Power Generating Module Performance and Control Requirements

13.1.1 The requirements of this Section 13 do not apply in full to **Power Generation Facilities** that are designed and installed for infrequent short term parallel operation only nor to storage **Power Generation Modules** within the **Power Generating Facility** – refer to Annex A.4.

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

13.1.3 **Power Generating Modules** shall be capable of adjusting the **Active Power** setpoint in accordance with instructions issued by the **DNO**.

13.1.3.1 **DNOs** currently are developing active network management approaches and there is no common standard for communication interfaces.

13.1.3.2 The **DNO** will provide details of the method to be employed on a site by site basis. Protocols currently in use between **DNOs** and **Generators** include simple current loop; DNP3; IEC 61850.

13.1.3.3 The **DNO** will agree with the **Generator** for each **Power Generating Facility** the interface to be used.

13.1.3.4 By default if nothing it specified by the **DNO** then a simple hard-wired current loop interface should be provided where a 4 mA to 20 mA DC signal corresponding to 0 pu to 1.0 pu of **Registered Capacity Active Power**.

13.1.3.5 The **Active Power** reduction will be either between 1.0 pu of **Registered Capacity Active Power** and zero, or between 1.0 pu of **Registered Capacity Active Power** and **Minimum Generation**. In the latter case the **Generator** will agree with the **DNO** how zero output can be achieved.

13.1.3.6 If the **DNO** wishes to make use of the facility to reduce **Active Power** output the **DNO** will agree with the **Generator** the communication interface and other necessary equipment that will be needed.

13.1.4 Any changes to the **Active Power** or voltage/**Reactive Power** control setpoints must result in the **Power Generating Module** achieving the new **Active Power** or voltage/**Reactive Power** output, as appropriate, within 2 minutes.

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

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

13.2 Frequency response

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

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

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

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

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

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

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

13.2.3 With regard to the rate of change of frequency withstand capability, a **Power Generating Module** shall be capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1 Hzs^{-1} as measured over a period of 500 ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the **Power Generating Module's** own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.

13.2.4 Output power with falling frequency

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

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

b) (subject to the provisions of paragraph 13.2.1) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 13.1 for system frequency changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including 25^0C, such that if the system frequency drops to 47 Hz the **Active Power** output does not decrease by more than 5%.

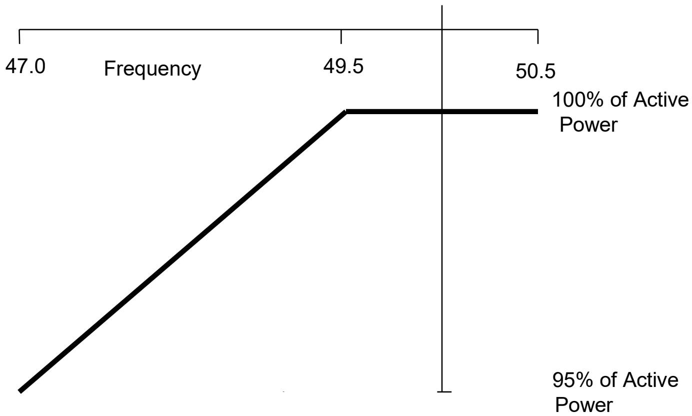


Figure 13.1 Change in Active Power with falling frequency

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

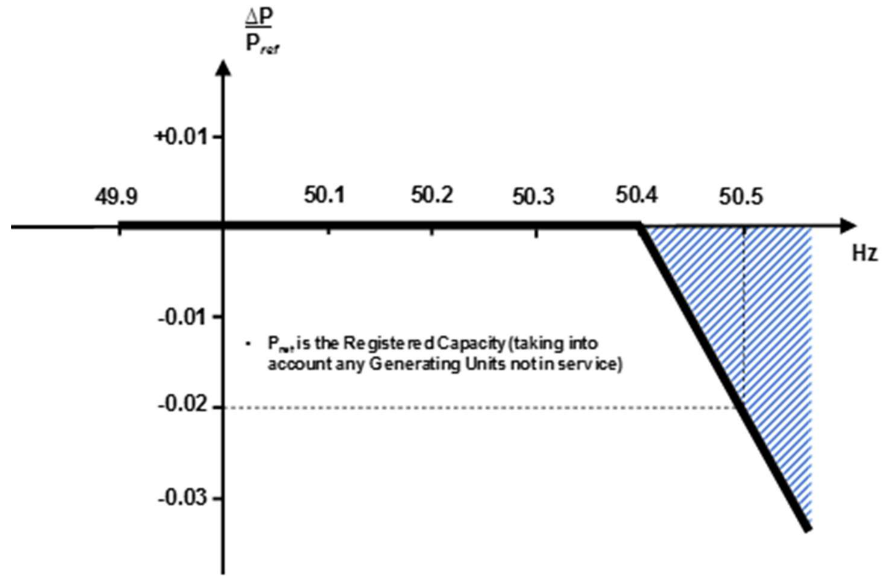
13.2.5 **Limited Frequency Sensitive Mode – Over frequency**

13.2.5.1 Each **Power Generating Module** shall be capable of reducing **Active Power** output in response to frequency on the **Total System** when this rises above 50.4 Hz. The **Power Generating Module** shall be capable of operating stably during **LFSM-O** operation. If a **Power Generating Module**, has been contracted to operate in **Frequency Sensitive Mode** the requirements of **LFSM-O** shall apply when frequency exceeds 50.5 Hz.

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

b) 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 (c) below.

c) 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 s 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 s the Generator shall justify the delay, providing technical evidence to the **DNO**, who will pass this evidence to the **NETSO**.



P_{ref} is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module**.

Figure 13.2 Active Power Frequency Response capability when operating in LFSM-O

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

13.2.5.3 Steady state operation below **Minimum Generation** is not expected but if system operating conditions cause operation below **Minimum Generation** which give rise to operational difficulties then the **Generator** shall be able to return the output of the **Power Generating Module** to an output of not less than the **Minimum Generation.**

13.2.6 Limited Frequency Sensitive Mode – Under frequency (LFSM-U)

13.2.6.1 Each **Power Generating Module** shall be capable of increasing **Active Power** output in response to system frequency when this falls below 49.5 Hz. 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**.

a) 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 49.5 Hz (ie a **Droop** of 10%) as shown in Figure 13.3 below. This requirement only applies if the **Power Generating Module** has headroom and the ability to increase **Active Power** output. In the case of a **Power Park Module** the requirements of Figure 13.3 shall be reduced pro-rata to the amount of **Generating Units** in service and available to generate. For the avoidance of doubt, this would not preclude a **Generator** from designing their **Power Generating Module** with a lower **Droop** setting, for example between 3 – 5%.

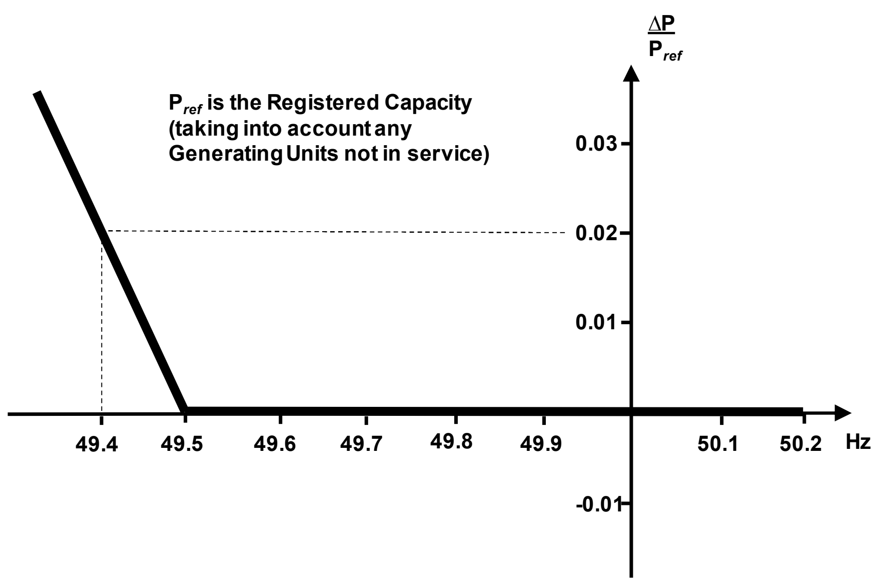
b) As much as possible of the proportional increase in **Active Power** output must result from the frequency control device (or speed governor) action and must be achieved for frequencies below 49.5 Hz. The **Power Generating**

Module shall be capable of initiating a power frequency response with minimal delay. If the delay exceeds 2 s the **Generator** shall justify the delay, providing technical evidence to the **DNO**.

c) The actual delivery of **Active Power frequency Response** in **LFSM-U** mode shall take into account

- The ambient conditions when the response is to be triggered.
- The operating conditions of the **Power Generating Module**. In particular limitations on operation near **Registered Capacity** at low frequencies.
- The availability of primary energy sources.

In **LFSM-U Mode** the **Power Generating Module** shall be capable of providing a power increase up to its **Registered Capacity** (based on the number of **Generating Units** in service at that point in time).



P_{ref} is the reference **Active Power** to which ΔP is related and ΔP is the change in **Active Power** output from the **Power Generating Module**. The **Power Generating Module** has to provide a positive **Active Power** output change with a **Droop** of 10% or less based on P_{ref}.

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

13.2.7 Frequency Sensitive Mode – (FSM)

13.2.7.1 Each **Power Generating Module** must be fitted with a fast acting proportional frequency control device (or turbine speed governor) and unit load controller or equivalent control device to provide frequency response under normal operational conditions. In the case of a **Power Park Module** the frequency or speed control device(s) may be on the **Power Park Module** or on each individual **Generating Unit** or be a combination of both. The frequency control device(s) (or speed governor(s)) must be designed and operated to the appropriate:

i. **European Specification**: or

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

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

The **European Specification** or other standard utilised in accordance with (i) above will be notified to the **DNO** by the **Generator**:

a) as part of the application for a **Connection Agreement**;

b) as soon as possible prior to any **Modification** or alteration to the frequency control device (or governor);

13.2.7.2 The frequency control device (or speed governor) in co-ordination with other control devices must control each **Power Generating Module Active Power** output with stability over the entire operating range of the **Power Generating Module**; and

13.2.7.3 **Power Generating Modules** shall also meet the following minimum requirements:

a) **Power Generating Modules** shall be capable of providing **Active Power Frequency Response** in accordance with the performance characteristic shown in Figure 13.4 and parameters in Table 13.1.

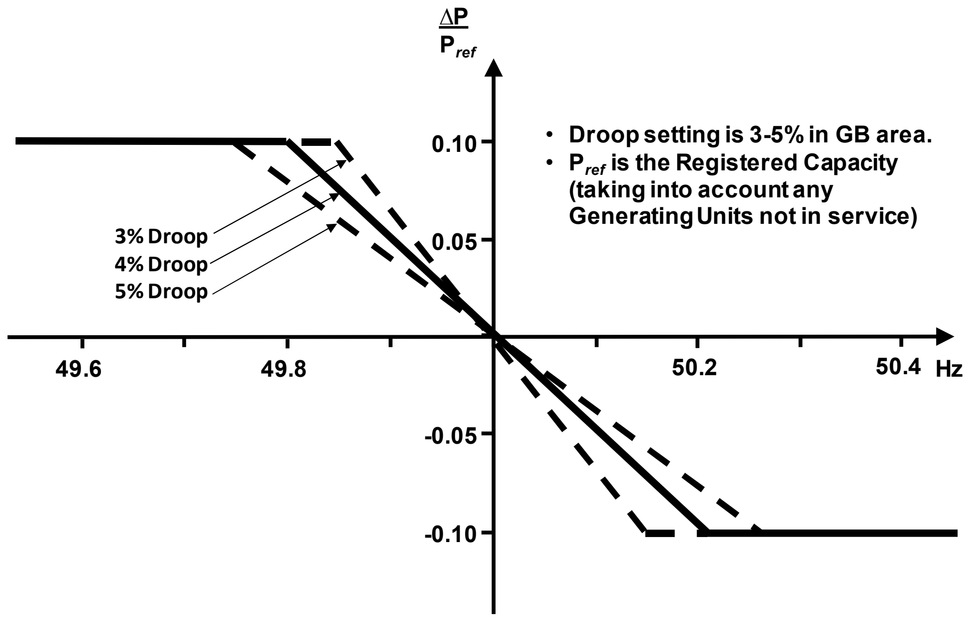


Figure 13.4 – Frequency Sensitive Mode capability of Power Generating Modules and Power Park Modules

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

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

b) In satisfying the performance requirements specified in paragraph 13.2.7.1 **Generators** in respect of each **Power Generating Module** should be aware:-

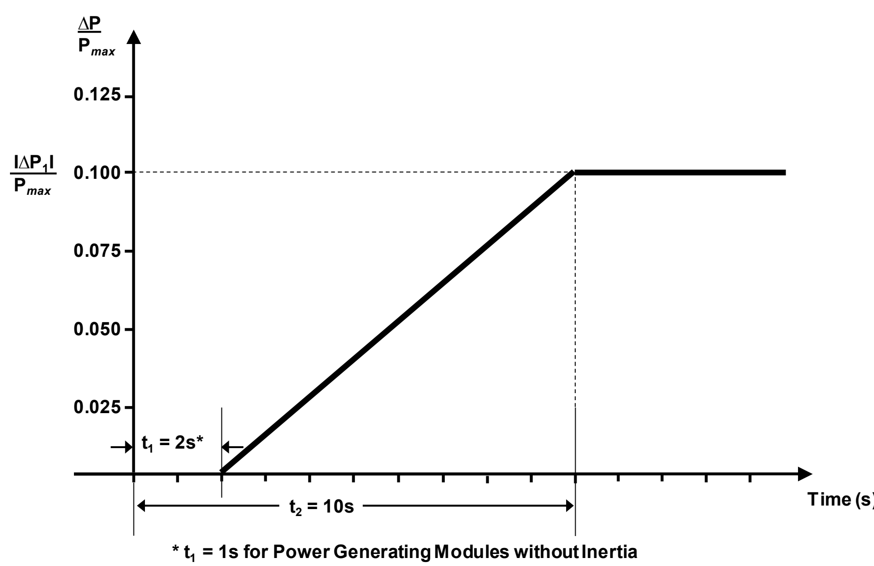
i. in the case of overfrequency, the **Active Power Frequency Response** is limited by the **Minimum Generation**,

ii. in the case of underfrequency, the **Active Power Frequency Response** is limited by the **Registered Capacity,**

iii. the actual delivery of **Active Power Frequency Response** depends on the operating and ambient conditions of the **Power Generating Module** when this response is triggered, in particular limitations on operation near **Registered Capacity** at low frequencies as specified in 13.2.6 and available primary energy sources.

iv. 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 reset at any time and as required by the **DNO**. 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.

c) In the event of a frequency step change, each **Power Generating Module** shall be capable of activating full and stable **Active Power Frequency Response** (without undue power oscillations), in accordance with the performance characteristic shown in Figure 13.5 and parameters in Table 13.2.



P_{max} is the **Registered Capacity** to which Δ*P* relates. ΔP is the change in **Active Power** output from the **Power Generating Module**. The **Power Generating Module** has to provide **Active Power** output ΔP up to the point ΔP_1 in accordance with the times t_1 and t_2 with the values of ΔP_1, $t_1$and t_2 being specified in Table 13.2. t_1 is the initial delay. t_2 is the time for full activation.

Figure 13.5 Active Power Frequency Response capability

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

Parameter	Setting
Active power as a percentage of **Registered Capacity** **(**frequency response range**)** $(\frac{\lvert \Delta P_1 \rvert}{P_{max}})$	10%
Maximum admissible initial delay t_1 for **Power Generating Modules** with inertia unless justified as specified in 13.2.7.3(d)	2 s
Maximum admissible initial delay t_1 for **Power Generating Modules** which do not contribute to system inertia unless justified as specified in 13.2.7.3(d)	1 s
Activation time t_2	10 s

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

d) The initial activation of **Active Power** primary frequency response shall not be unduly delayed. For **Power Generating Modules** with inertia the delay in initial **Active Power Frequency Response** shall not be greater than 2 s. For **Power Generating Modules** without inertia the delay in initial **Active Power Frequency Response** shall not be greater than 1 s. 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**.

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

13.2.7.4 In addition to the requirements of Section 13.2.7 each **Power Generating Module** shall be capable of meeting the minimum frequency response requirement profile subject to and in accordance with the provisions of Annex C.10.

13.3 Fault Ride Through

13.3.1 Paragraphs 13.3.1.1 to 13.3.1.10 inclusive set out the **Fault Ride Through**, principles and concepts applicable to **Synchronous Power Generating Modules** and **Power Park Modules**, subject to disturbances from faults on the **Network** up to 140 ms in duration.

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

13.3.1.2 The voltage against time curves defined in Table 13.3 to Table 13.6 expresses the lower limit (expressed as the ratio of its actual value and its reference 1 pu) of the actual course of the phase to phase voltages (or phase to earth voltage in the case of asymmetrical/unbalanced faults) on the network voltage level at **Connection Point** during a symmetrical or asymmetrical/unbalanced fault, as a function of time before, during and after the fault.

13.3.1.3

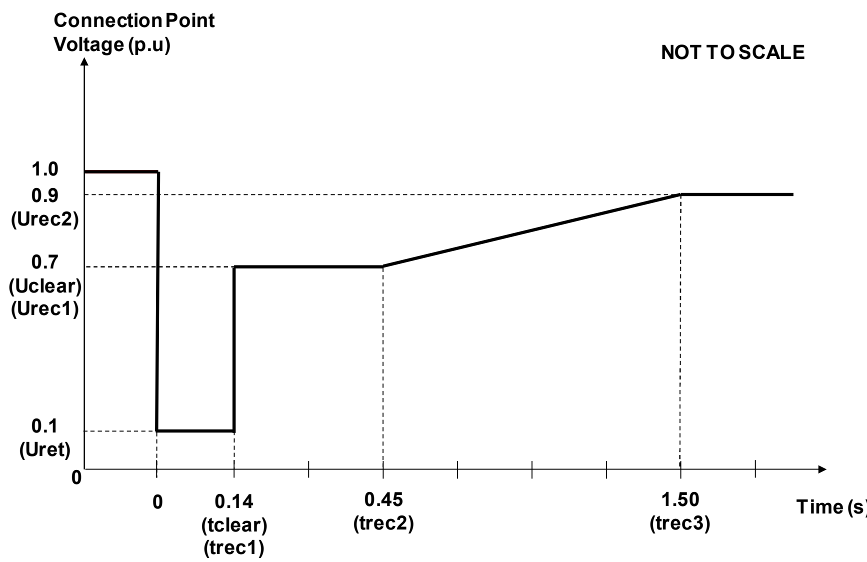


Figure 13.6 Voltage against time curve applicable to Type C and Type D Synchronous Power Generating Modules connected below 110 kV

13.3.1.4

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

Voltage parameters (pu)		Time parameters (s)	
U_{ret}	0.1	t_{clear}	0.14
U_{clear}	0.7	t_{rec1}	0.14
U_{rec1}	0.7	t_{rec2}	0.45
U_{rec2}	0.9	t_{rec3}	1.5

13.3.1.5

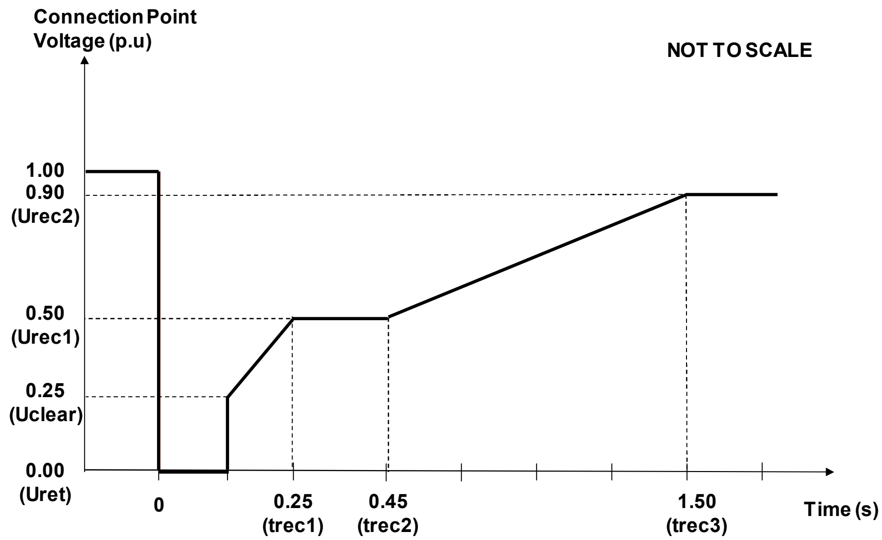


Figure 13.7 - Voltage against time curve applicable to Type D Synchronous Power Generating Modules connected at or above 110 kV

13.3.1.6

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

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

13.3.1.7

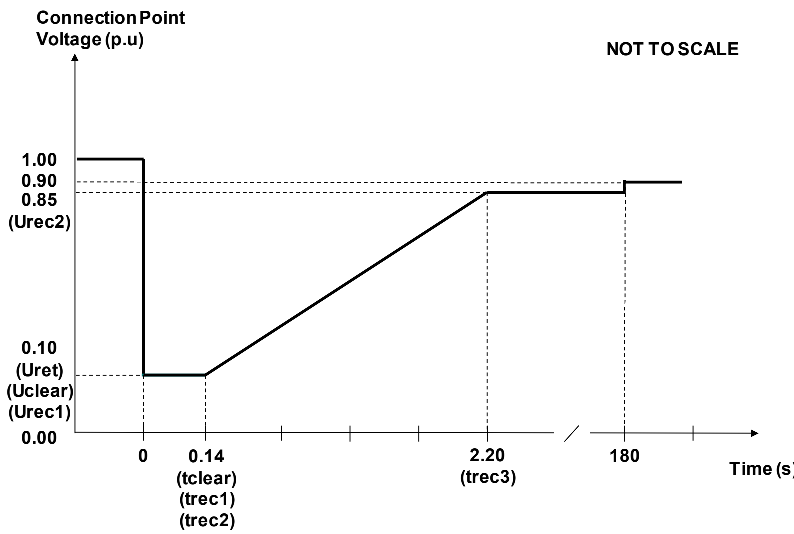


Figure 13.8 - Voltage against time curve applicable to Type C and Type D Power Park Modules connected below 110 kV

13.3.1.8

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

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

13.3.1.9

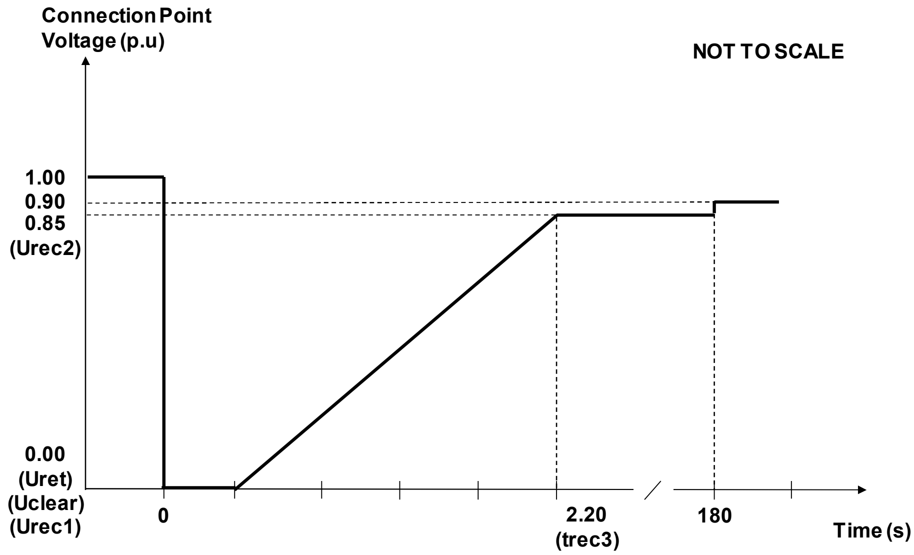


Figure 13.9 - Voltage against time curve applicable to Type D Power Park Modules connected at or above 110 kV

13.3.1.10

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

Voltage parameters (pu)		Time parameters (s)	
U_{ret}	0	t_{clear}	0.14
U_{clear}	0	t_{rec1}	0.14
U_{rec1}	0	t_{rec2}	0.14
U_{rec2}	0.85	t_{rec3}	2.2

13.3.1.11 In addition to the requirements in 13.3.1.3 to 13.3.1.10:

a) Each **Power Generating Module** shall be capable of satisfying the above requirements at the **Connection Point** when operating at **Registered Capacity** output and maximum leading **Power Factor** as specified in paragraph 13.5.1.

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

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

d) The protection schemes and settings for internal electrical faults must not jeopardise **Fault Ride Through** performance as specified in paragraphs 13.3. For the avoidance of doubt where an internal fault on the **Power Generating Module** occurs during a **Fault Ride Through** condition, the **Power Generating Module's** internal protection should trip the module to ensure safety and minimise damage

e) Each **Power Generating Module** shall be designed such within 0.5 s 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.

- In the event of power oscillations, **Power Generating Modules** shall retain steady state stability when operating at any point on the **Generator Performance Chart**.

For **Power Park Modules**, comprising switched reactive compensation equipment (such as mechanically switched capacitors and reactors), such switched reactive compensation equipment shall be controlled such that it is not switched in or out of service during the fault but may act to assist in post fault voltage recovery.

13.3.2 In addition to paragraphs 13.3.1.1 – 13.3.1.11 any **Power Generating Module** or **Power Generating Facility** connected to the **DNO's Distribution Network**, where it has been agreed between the **DNO** and the **Generator** that the **Power Generating Facility** will contribute to the **DNO's Distribution Network** security (eg for compliance with EREC P2), may be required to withstand, without tripping, the effects of a close up three phase fault and the **Phase (Voltage) Unbalance** imposed during the clearance of a close-up phase-to-phase fault, in both cases cleared by the **DNO's** main protection. The **DNO** will advise the **Generator** in each case of the likely tripping time of the **DNO's** protection, and for phase-phase faults, the likely value of **Phase (Voltage) Unbalance** during the fault clearance time.

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

13.3.4 Other **Fault Ride Through** Requirements

a) In the case of a **Power Park Module**, the requirements in paragraph 13.3 do not apply when the **Power Park Module** is operating at less than 5% of its **Registered Capacity** or during very high primary energy source conditions when more than 50% of the **Generating Units** in a **Power Park Module** have been shut down or disconnected under an emergency shutdown sequence to protect **Generator's** plant and apparatus.

b) **Generators** are required to confirm to the **DNO**, their repeated ability to operate through balanced and unbalanced faults and system disturbances each time the voltage at the **Connection Point** falls outside the limits specified in paragraph 13.4.1. Demonstration of this capability would be satisfied by **Generators** supplying the protection settings of their plant, informing 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

c) For the avoidance of doubt the requirements specified in this Section 13.3 do not apply to **Power Generating Modules** connected to an unhealthy circuit and islanded from the **Distribution Network** even for delayed auto reclosure times.

13.4 Voltage Limits and Control

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

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

13.4.3 **Synchronous Power Generating Modules** Excitation Performance Requirements

13.4.3.1 Each **Synchronous Generating Unit** within a **Synchronous Power Generating Module** shall be equipped with a permanent automatic **Excitation System** that that has the capability to provide constant terminal voltage (assuming a high enough **Network** source impedance to allow the **Power Generating Module** to achieve this while remaining within its ratings) at a selectable setpoint without instability over the entire operating range of the **Synchronous Power Generating Module**.

13.4.3.2 The requirements for **Synchronous Generating Unit** excitation control facilities are specified in Annex C.4. The **DNO** will agree any site specific requirements with the **Generator**.

13.4.3.3 Unless otherwise required for testing in accordance with Annex C.8.2, the automatic excitation control system of a **Synchronous Power Generating Module** shall always be operated such that it controls the **Synchronous Generating Unit** terminal voltage to a value that is

- equal to its rated value: or

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

13.4.3.4 In some cases, particularly on large industrial sites etc where the **Power Generating Module** is embedded in the **Generator's Network**, the **DNO** and **Generator** might agree a different control point, such as the **Connection Point**.

13.4.4 Voltage Control Performance Requirements for **Power Park Modules**

13.4.4.1 Each **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 below 20% of **Active Power** output and the non-shaded area above 20% of **Active Power** output in Figure 13.13.

13.4.4.2 The performance requirements for a continuously acting Automatic Voltage Control system that shall be complied with by the **Generator** in respect of **Power Park Modules** are defined in Annex C.5. The **DNO** will agree any site specific requirements with the **Generator.**

13.4.5 As part of the connection application process the **Generator** shall agree with the **DNO** the set points of the control scheme for voltage control, **Power Factor** control or **Reactive Power** control as appropriate. These settings, and any changes to these settings, shall be agreed with the **DNO** and recorded in the **Connection Agreement**. The information to be provided is detailed in Schedule 5a and Schedule 5b of the Data Registration Code.

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

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

13.4.8 **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 Power** and **Reactive Power** flows. ETR 136 provides guidance on connecting generation to such networks using techniques such as removing the generation circuit from the AVC scheme using cancellation CTs.

13.5 Reactive Capability

13.5.1 All **Synchronous Power Generating Modules** shall be capable of satisfying the **Reactive Power** capability requirements at the **Connection Point** as defined in Figure 13.10 when operating at **Registered Capacity**.

13.5.2 At **Active Power** output levels other than **Registered Capacity** all **Generating Units** within a **Synchronous Power Generating Module** must be capable of continuous operation at any point between the **Reactive Power** capability limit identified on the **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 **Generator Performance Chart** of the **Synchronous Power Generating Module**, taking the auxiliary supplies and the **Active Power** and **Reactive Power** losses of the **Power Generating Module** transformer or **Station Transformer** into account.

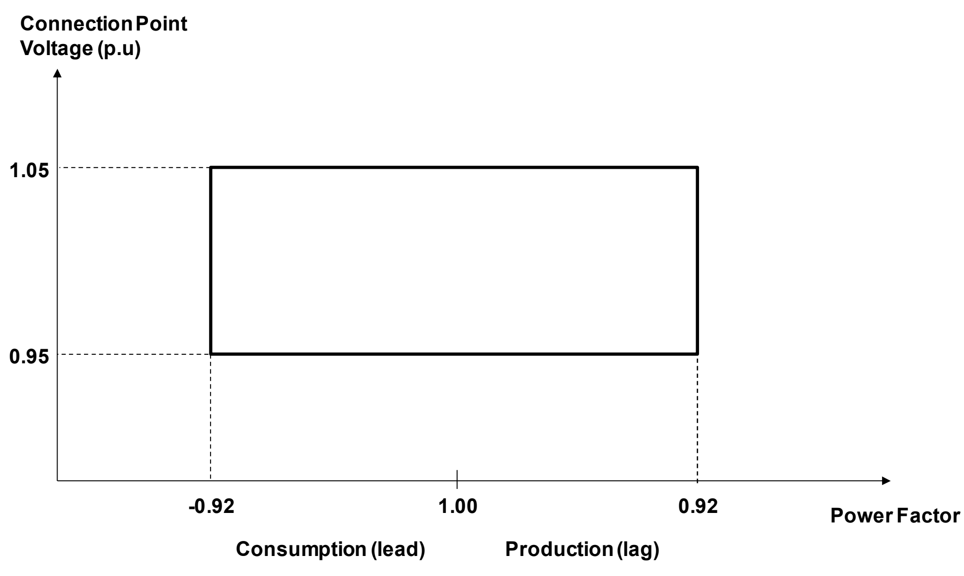


Figure 13.10 Reactive Power capability requirements (Synchronous Power Generating Modules)

13.5.3 All **Power Park Modules** with a **Connection Point** voltage above 33 kV, shall be capable of satisfying the **Reactive Power** capability requirements at the **Connection Point** as defined in Figure 13.11 when operating at **Registered Capacity**.

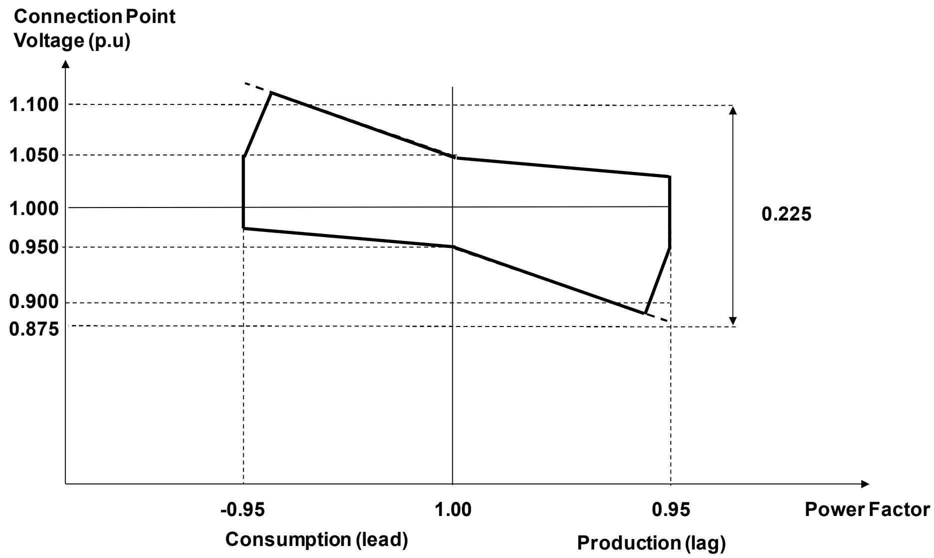


Figure 13.11 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage above 33 kV)

13.5.4 All **Power Park Modules** with a **Connection Point** voltage at or below 33 kV shall be capable of satisfying the **Reactive Power** capability requirements at the **Connection Point** as defined in Figure 13.12 when operating at **Registered Capacity**.

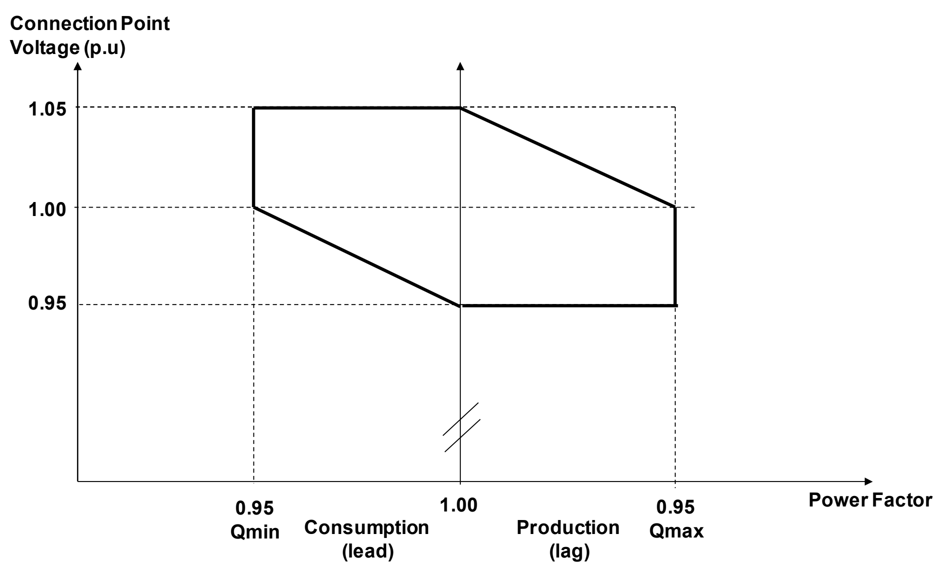


Figure 13.12 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage below 33 kV)

13.5.5 All **Power Park Modules**, shall be capable of satisfying the **Reactive Power** capability requirements at the **Connection Point** as defined in Figure 13.13 when operating below **Registered Capacity**. With all plant in service, the **Reactive Power** limits will reduce linearly below 50% **Active Power** output as shown in Figure 13.13 unless the requirement to maintain the **Reactive Power** limits defined at **Registered Capacity** under absorbing **Reactive Power** conditions down to 20% **Active Power** output has been specified by the **DNO**. These **Reactive Power** limits will be reduced pro rata to the amount of plant in service.

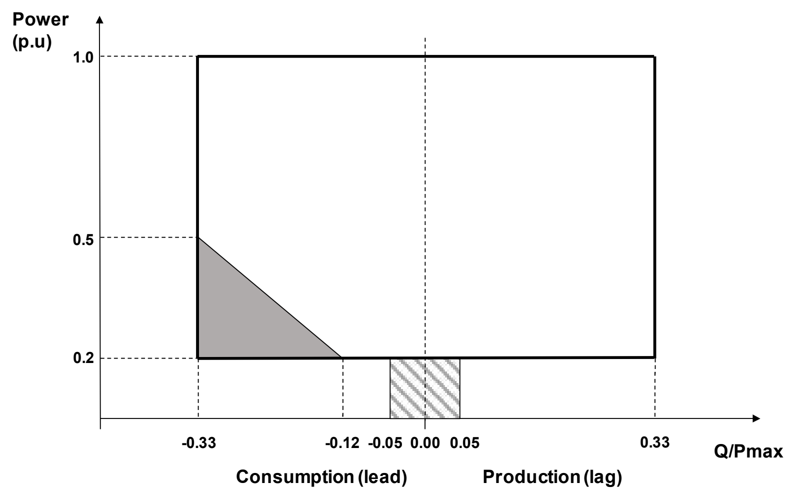


Figure 13.13 Reactive Power capability requirements (Power Park Modules operating below Registered Capacity)

13.6 Fast Fault Current Injection

13.6.1 **Fast Fault Current** injection is necessary to support the **Total System** during a fault on the **Transmission System**. The design of **Fast Fault Current** injection is tailored to this, and does not relate directly to faults on the **Distribution Network**, not least as these will tend to have longer clearing times than those of the **Transmission System** for which **Fast Fault Current** injection is designed. In this Section 13.6 the faults referred to are **Transmission System** faults which clear within 140 ms and which will seen in the **Distribution Network** as a voltage depression.

13.6.2 Each **Power Park Module** shall be required to satisfy the following requirements.

a) For any balanced or unbalanced fault on the **Transmission System** which results in the voltage at the **Connection Point** falling below 0.9 pu each **Power Park Module** shall be required to inject a current above the shaded area shown in Figure 13.14(a) and Figure 13.14(b). For the purposes of this requirement, the maximum rated current is taken to be the maximum current each **Generating Unit** can supply when operating at **Registered Capacity** and 0.95 **Power Factor** at a nominal voltage of 1.0 pu. For example, in the case of a 10 MW **Power Park Module** the **Registered Capacity** would be taken as 10 MW and the rated **Reactive Power** would be taken as

3.28 MVAr (ie **Rated MW** output operating at 0.95 **Power Factor** lead or 0.95 **Power Factor** lag) giving an MVA rating of 10.53 MVA. For the avoidance of doubt, where the phase voltage at the **Connection Point** is not zero, the injected current shall be in proportion to the retained voltage at the **Connection Point** but shall still be required to remain above the shaded area in Figure 13.14(a) and Figure 13.14(b).

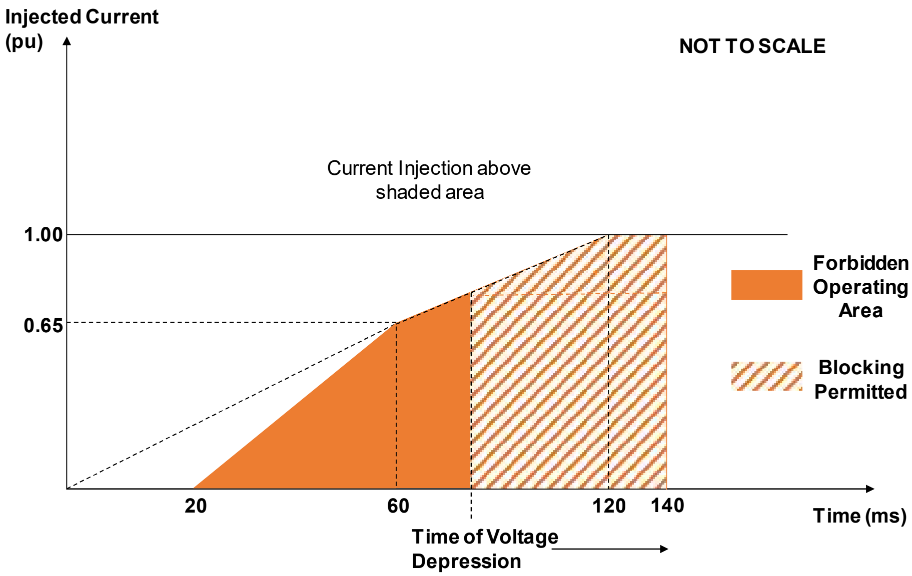


Figure 13.14 (a) Chart showing area of Reactive Current injections for voltage depressions of less than 140ms duration

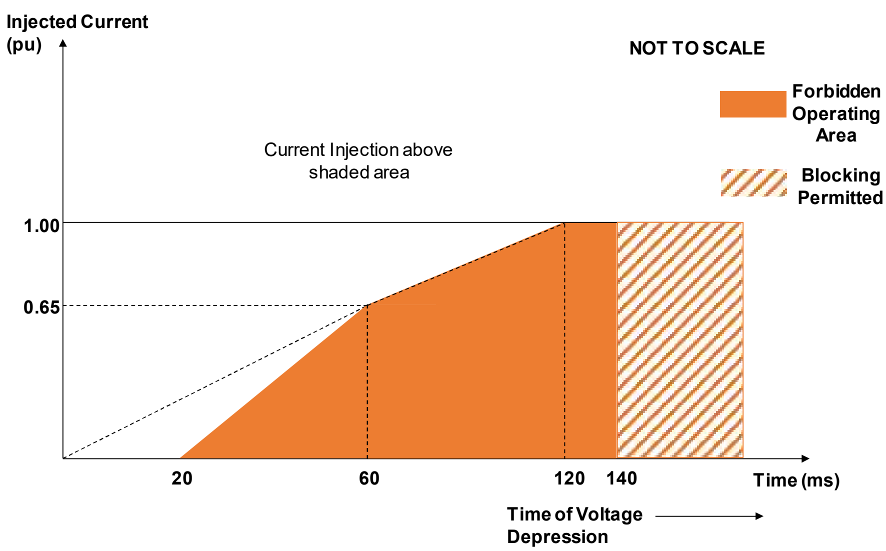


Figure 13.14 (b) Chart showing area of Reactive Current injections for voltage depressions of greater than 140ms duration

b) In addition, the injected current from each **Power Park Module** shall be in proportion and remain in phase with the change in system voltage at the **Connection Point** during the period of the voltage depression. For the avoidance of doubt, the injected current will be purely reactive for a retained voltage of zero and the reactive component of the injected current will fall in inverse proportion to the retained voltage at the **Connection Point**. The voltage generated from the injected current of the **Power Park Module** shall be in phase with the retained voltage at the **Connection Point**, whilst the total injected current remains above the shaded area in diagrams 13.14(a) and 13.14(b). Also, as can been seen on the diagrams a small delay time of no greater than 20 ms once the voltage falls to 0.9 pu is permitted before injection of the in phase reactive current.

c) The **Inverter** is permitted to block (ie reduce the current injection) when the voltage at the **Connection Point** has returned to >0.85 pu in order to mitigate against the risk of transient overvoltage instability that would otherwise occur due to transient overvoltage excursions. Figure 13.14 (a) and Figure 13.14 (b) show the required current injection during the duration of the voltage depression. Where the **Generator** 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 13.6.1(d) **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. Notwithstanding this requirement, **Generators** should be aware of their requirement to fully satisfy the **Fault Ride Through** requirements of paragraph 13.3.

d) Each **Power Park Module** shall be designed to reduce the risk of transient over voltage levels arising following voltage restoration. **Generators** shall be permitted to block where the anticipated transient overvoltage would not otherwise exceed the maximum permitted values specified in paragraph 13.4.1. Any additional requirements relating to transient overvoltage performance will be specified by the **DNO**.

e) **Generators** in respect of **Power Park Modules** are required to confirm to the **DNO,** their repeated ability to supply **Fast Fault Current** to the system each time the voltage at the **Connection Point** falls below 0.9 pu. **Generators** should inform **the DNO** of the maximum number of repeated operations that can be performed under such conditions and any limiting factors to repeated operation such as protection or thermal rating.

13.7 Black Start Capability

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

13.8 Technical Requirements for Embedded Medium Power Stations

13.8.1 Where a **Generator** in respect of an **Embedded Medium Power Station** is a party to the **CUSC** this Section 13.8 will not apply.

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

13.8.3 Where data is required by the **NETSO** from **Embedded Medium Power Stations**, nothing in the **Grid Code** or this EREC G99 precludes the **Generator** from providing the information directly to the **NETSO** in accordance with **Grid Code** requirements. However, a copy of the information should always be provided in parallel to the **DNO**.

13.8.4 **Grid Code** Connection Conditions Compliance

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

13.8.4.2 Should the **Generator** make any material change to such designs or parameters as will have any effect on the statement of compliance referred to in paragraph 13.8.4.1, the **Generator** must notify the change to the **DNO**, as soon as reasonably practicable, who will in turn notify the **NETSO.**

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

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

13.9 Operational monitoring

13.9.1 With regard to information exchange:

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

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

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

13.9.3 Additionally each **Power Generating Facility** 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 Annex C.6.

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**:

- 1 Hz for reactive range tests
- 10 Hz for frequency control tests
- 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 **Generator** and the **DNO** and recorded in the **Connection Agreement.**

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

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

13.9.4 The **Generator** will provide all relevant signals in a format to be agreed between the **Generator** and the **DNO** for onsite monitoring. All signals shall be suitably terminated in a single accessible location at the **Generators** site.

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

a) 0 MW to **Registered Capacity** 0-8 V DC

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

c) 48 – 52Hz as -8 to 8 V DC

d) Nominal terminal or **Connection Point** voltage -10% to +10% as -8 to 8 V DC

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

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

13.9.7.1 **Power Generating Modules** shall be fitted with facilities to record and monitor the operation of **Active Power Frequency Response** in real time.

13.9.7.2 Provisions for the submission **Frequency Sensitive Mode** data to the **DNO** including the data to be monitored, communications and protocols shall be specified, if required, by the **DNO** in the **Connection Agreement**.

13.10 Steady State Load Inaccuracies

13.10.1 The standard deviation of load error at steady state load over a 30 minute period must not exceed 2.5% of a **Power Generating Modules Registered Capacity**. Where a **Power Generating Module** is instructed to operate in **Frequency** sensitive operation, allowance will be made in determining whether there has been an error according to the governor **Droop** characteristic registered under the **DDRC**.

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

14 Installation, Operation and Control Interface

14.1 General

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

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

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

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

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

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

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

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

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

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

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

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

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

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

14.2 Isolation and Safety Labelling

14.2.1 Every **Generator's Installation** which includes **Power Generating Modules** operating in parallel with the **Distribution Network** must include a means of isolation capable of disconnecting the whole of the **Power Generating Module**[3] infeed to the **Distribution Network.** This equipment will normally be owned by the **Generator**, but may by agreement be owned by the **DNO**.

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

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

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

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[3] Where the Power Generating Module is designed to support part of the **Generator**'s system independently from the **DNO** system, the switch that is used to separate the independent part of the **Generator**'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.

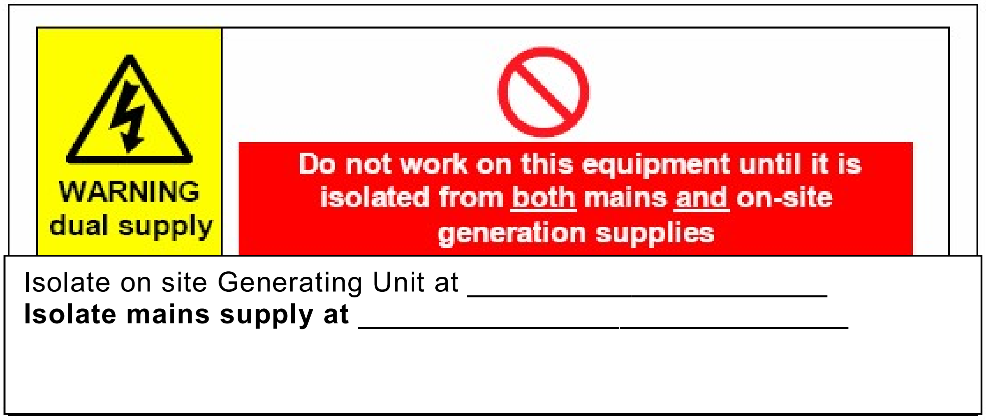

Figure 14.1 Warning label

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

14.3 Site Responsibility Schedule

14.3.1 In order to comply with the Distribution Planning and Connection Code DPC 5.4.3 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**. Where the **Power Generating Facility** has a **Registered Capacity** of 50 kW (or 17 kW per phase) or less and is connected at **LV** then only compliance with paragraph 14.3.3 is required.

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

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

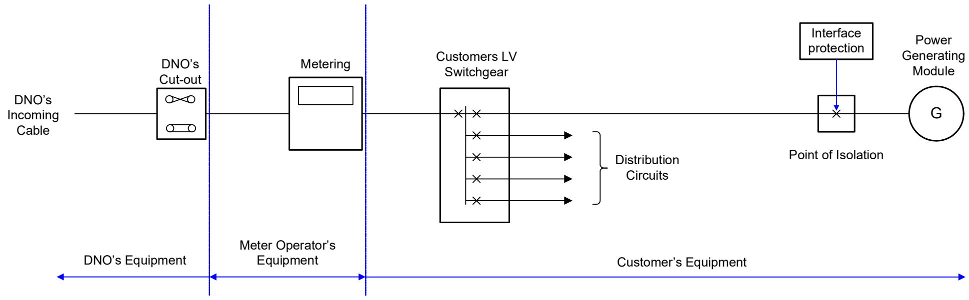

Fig 14.2 – Example of an Operational Diagram

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

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

14.4 Operational and Safety Aspects

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

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

b) Where in the case that it is necessary for the **Generator's** staff to operate the **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.

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

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

14.5 Synchronizing and Operational Control

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

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

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

14.5.4 The facility to use the **DNO**s interface circuit breaker for synchronizing can only be used with the specific agreement of the **DNO. Generating Modules** shall be equipped with the necessary synchronisation facilities.

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

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

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

15 Common Compliance and Commissioning Requirements for all Power Generating Modules

15.1 Demonstration of Compliance

15.1.1 Where the **Generator** and the **DNO** agree that it is not practical to demonstrate the technical compliance requirements of this EREC G99 at the **Connection Point**, the **DNO** will accept demonstration of the requirements at the **Generating Unit** terminals.

15.1.2 The **DNO** will allow the **Power Generating Facility Owner** to carry out alternative tests, provided that those tests are efficient and suffice to demonstrate that a **Power Generating Module** complies with the requirements of this EREC G99.

15.2 Wiring for Type Tested Power Generating Modules

15.2.1 Where **Type Tested** components are wired together on site, ie not using specifically designed plugs and sockets for the purpose, it will be necessary to prove that all wiring has been correctly terminated by proving the functions which rely on the wiring. The **Generator** will submit to the **DNO** for agreement a schedule of the wiring connections to be made, the functions that they enable, and the tests to prove them. Satisfactory completion of the agreed tests will enable the **Power Generating Modules** to attain or retain **Type Tested** status. An example of this requirement is given in Form A2-4, Annex A.2.

15.3 Commissioning Tests / Checks required at all Power Generating Facilities

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

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

- Protection
- Earthing and bonding
- Selection and installation of equipment

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

c) Check that safety labels have been installed in accordance with paragraph 14.2;

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

e) Where possible undertake a visual check that the correct protection settings have been applied in accordance with Table 10.1 or check the Compliance Verification Report, Annex A2;

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

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

b) Carry out an appropriate functional test to confirm that the **Interface Protection** operates when all phases are disconnected between the **Power Generating Module** and the **DNO's Distribution Network**. For installations where the **Power Generating Module** is not designed to automatically switch to support the installation's demand in island mode, this test can be carried out by opening a suitably rated switch between the **Power Generating Module** and the **Connection Point** and checking that the supplies are disconnected between the **Power Generating Module** and the **DNO**'s **Distribution Network** quickly (eg within 1 s);

c) Where the **Power Generating Module** is designed to support the demand of the installation automatically in island mode on failure of the incoming supply, the **Generator** will undertake a suitable test as agreed with the **DNO** (such as removing one or all of the voltage sensing supplies to the **Interface Protection** relay) to prove that under these conditions that the supplies are disconnected between the **Power Generating Module** and the **DNO**'s **Distribution Network** quickly (eg within 1 s);

d) Check that once the phases are restored following the functional test described in (b) at least 20 s elapses before the **Power Generating Modules** re-connect to the **DNO's Distribution Network**.

15.3.3 The tests and checks shall be carried out once the installation is complete, or, in the case of a phased installation (ie where **Power Generating Modules** are installed in different phases), when that part of the installation has been completed. The results of these tests and checks shall be recorded on the commissioning forms included in the Annexes (Form A3, Form B3, or Form C3 as applicable to **Type A**, **Type B** and **Type C** or **Type D Power Generating Modules** respectively). 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 and checks are witnessed) or within 28 days of the commissioning date (where the tests and checks are not witnessed).

15.4 Additional Commissioning requirements for Non Type Tested Interface Protection

15.4.1 Where **Type Testing** or **Manufacturers' Information** is not being used to demonstrate **Interface Protection** compliance, protection commissioning tests are required and the following describes how these should be carried out for the standard range of protection required. Where additional protection is fitted then this should also be tested, additional test requirements are to be agreed between the **DNO** and **Generator**.

The results of these tests shall be recorded in the schedule provided in the Annexes (Form A2-4, Form B2-2, Form C2-2 as applicable to **Type A**, **Type B** and **Type C** or **Type D Power Generating Modules** respectively). using the relevant sections for **HV** and **LV** protection along with any additional test results required.

a) Calibration and stability tests shall be carried out on the over voltage and under voltage protection for each phase, as described below:

- The operating voltage shall be checked by applying nominal voltage to the protection (so that it resets) and then slowly increasing this voltage (for over voltage protection) or reducing it (for under voltage protection) until the protection picks up. The voltage at which the protection picks up shall be recorded. Where the test equipment increases / decreases the voltage in distinct steps, these shall be no greater than 0.5% of the voltage setting. Each pickup value shall be within 1.5% of the required setting value.

- Timing tests shall be carried out by stepping the voltage from the nominal voltage to a value 4 V above the setting voltage (for overvoltage protection) and 4 V below the setting (for under voltage protection) and recording the operating time of the protection. The operating time of the protection relay shall be no shorter than the setting and no greater than the setting + 100 ms.

- Stability tests (no-trip tests) shall also be carried out at the voltages and for the durations defined in Form A2-4, Form B2-2, Form C2-2 as applicable to **Type A**, **Type B** and **Type C** or **Type D Power Generating Modules** respectively. The protection must not trip during these tests.

b) Calibration and stability tests shall be carried out on the over frequency and under frequency protection as described below:

- The operating frequency shall be checked by applying nominal frequency to the protection (so that it resets) and then slowly increasing this frequency (for over frequency protection) or reducing it (for under frequency protection) until the protection picks up. The frequency at which the protection picks up shall be recorded. Where the test equipment increases / decreases the frequency in distinct steps, these shall be no greater than 0.1% of the frequency setting. Each pick up value shall be within 0.2% (ie 0.1 Hz) of the setting value.

- Timing tests shall be carried out by stepping the frequency from 50 Hz to a value 0.2 Hz above the setting frequency (for over frequency protection) and 0.2 Hz below the setting (for under frequency protection) and recording the operating time of the protection. The operating time of the protection relay shall be no shorter than the setting and no greater than the setting + 100 ms or the setting + 1% of the setting, whichever gives the longer time.

- Stability tests (no-trip tests) shall also be carried out at the frequencies and for the durations defined in the commissioning test record, Form A2-4, Form B2-2, Form C2-2 as applicable to **Type A**, **Type B** and **Type C** or **Type D Power Generating Modules** respectively. The protection must not trip during these tests.

c) Calibration tests for rate of change of frequency protection, where used, shall be carried out as follows:

- Rate of change of frequency shall be checked by first applying a voltage with the frequency of 51.0 Hz to the protection and then ramping this frequency down at 0.1 Hzs^{-1} less than the RoCoF protection setting until a frequency reaches 49.0 Hz. This test is repeated at increasing values of rate of change of frequency (in increments of 0.025 Hzs^{-1} or less) until the protection operates. The test shall be repeated for rising frequency but this time each test shall be start at 49.0 Hz and end at 51.0 Hz. The operating values should be within 0.025 Hzs^{-1} of the required setting. Timing tests shall be carried out by applying a falling and a rising frequency at rate of 0.05 Hzs^{-1} above the setting value. The protection relay operating times shall be no longer than 1.0 s.

d) RoCoF and vector shift stability tests shall be performed on all **Interface Protection** relays irrespective of the type of loss of mains protection employed for a particular **Power Generating Module** or **Power Generating Facility**.

16 Type A Compliance Testing, Commissioning and Operational Notification

16.1 Type Test Certification

16.1.1 The **Power Generating Module** can comprise **Fully Type Tested** equipment or be made up of some **Type Tested** equipment and require additional site testing prior to operation. The use of **Fully Type Tested** equipment simplifies the connection process, the protection arrangements and reduces the commissioning test requirements.

16.1.2 **Type Tested** certification is the responsibility of the **Manufacturer**. The **Manufacturer** shall submit the Type Test Verification Report confirming that the product has been **Type Tested** to satisfy the requirements of this EREC G99 to the Energy Networks Association (ENA) Type Test Verification Report Register. The report shall detail the type and model of product tested, the test conditions and results recorded. The report can include reference to **Manufacturers' Information**. Examples of the combination of the use of type testing and the provision of **Manufacturers' Information** are given in Section 22.1. Further information about **Manufacturers' Information** in respect of **Power Park Modules** is given in Section 21. A **Manufacturer** of a **Type Tested** product should allocate a **Manufacturer's** reference number, which should be registered on the ENA Type Test Verification Report Register as the Product ID.

16.1.3 The required Type Test Verification Report and declarations including that for a **Fully Type Tested Power Generating Module** are shown in Annex A.2:

- Form A2-1 - Compliance Verification Report for **Synchronous Power Generating Modules** up to and including 50kW,

- Form A2-2 Compliance Verification Report for **Synchronous Power Generating Modules** greater than> 50 kW and also for **Synchronous Power Generating Modules** ≤ 50 kW where the approach of this form is preferred to that in Form A2-1or

- Form A2-3 - Compliance Verification Report for **Inverter** Connected **Power Generating Modules**.

The choice of compliance route available is shown in Figure 16-1 below.

It is intended that the **Manufacturers** will use the requirements of this EREC G99 to develop type verification certification (ie the Compliance Verification Report as shown in Annex A.2) for each of their **Power Generating Module** models.

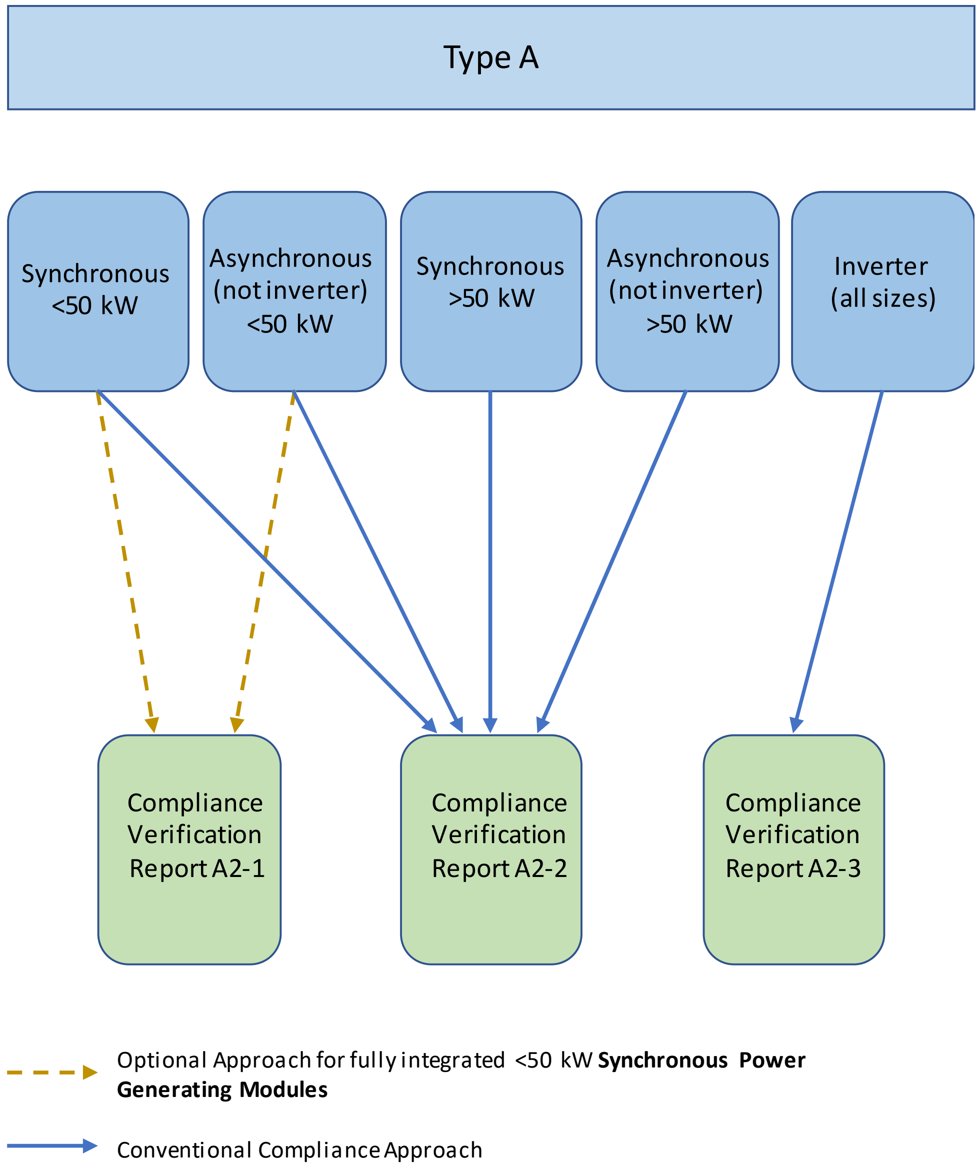

Figure 16-1 Illustration of the choice of compliance route

16.1.4 Guidance for **Manufacturers** on type testing for **Power Generating Modules** is included in Annex A.7 of this document.

16.1.5 Compliance with the requirements detailed in this EREC G99 will ensure that the **Power Generating Module** is considered to be approved for connection to the **DNO's Distribution Network**.

16.1.6 The **Power Generating Module** shall comply with all relevant European Directives and should be labelled with a corresponding CE marking.

16.2 Connection Process

16.2.1 The **Installer** shall discuss the installation project with the local **DNO** at the earliest opportunity. The connection application will need to be in format as shown in Annex A.1 (Form A1) or for **Power Generating Modules** greater than 50 kW by using the

Standard Application Form (generally available from the **DNO**s website). Where a **Power Generating Module** is **Fully Type Tested** and registered with the Energy Networks Association Type Test Verification Report Register, the application should include the **Manufacturer's** reference number (the Product ID), and the compliance test results do not need to be submitted as part of the application.

16.2.2 Where a **Power Generating Module** is not **Fully Type Tested**, the **Generator** or **Installer** shall provide the **DNO** with a Compliance Verification Report as per Annex A.2 (Forms A2-1, A2-2 or A2-3 as applicable) confirming that the **Power Generating Module** has or will be tested to satisfy the requirements of this EREC G99. On receipt of the application, the **DNO** will assess:

- whether any **Distribution Network** studies are required;
- whether there is a need for work on the **Distribution Network** before the **Tested Power Generating Module** can be connected to the **Distribution Network**; and
- whether there is a requirement to witness the commissioning tests and checks.

16.2.3 Connection of the **Power Generating Module** is only allowed after the application for connection has been approved by the **DNO** and any **DNO** works facilitating the connection have been completed.

16.2.4 Where **Power Generating Modules** require connection to the **DNO's Distribution Network** in advance of the commissioning date, for the purposes of testing, the **Power Generating Facility** must comply with the requirements of the **Connection Agreement**. The **Generator** shall provide the **DNO** with a commissioning programme, which will be approved by the **DNO** if reasonable in the circumstances, to allow commissioning tests to be co-ordinated.

16.2.5 Where commissioning tests are not witnessed, confirmation of the commissioning of each **Power Generating Module** will need to be made no later than 28 days after commissioning; the format and content shall be as shown in Annex A.3 (Form A3) Installation Document. The **Installe**r or **Generato**r, as appropriate, shall complete the declaration at the bottom of the Installation Document (Form A3) noting that this declaration also covers the Site Compliance and Commissioning Test Form (Form A2-4). Where the tests are witnessed a copy shall be provided to the **DNO** at the time of commissioning.

16.2.6 It is the responsibility of the **Generator** (which may be delegated to the **Installer**) to ensure that the relevant information is forwarded to the local **DNO.** The pro forma in Annex A are designed to:

a) simplify the connection procedure for both **DNO** and **Installer**;

b) provide the **DNO** with all the information required to assess the potential impact of the **Power Generating Module** connection on the operation of the **Distribution Network**;

c) inform the **DNO** that the **Generator's Installation** complies with the requirements of this EREC G99;

d) allow the **DNO** to accurately record the location of all **Power Generating Modules** connected to the **Distribution Network**.

16.3 Witnessing and Commissioning

16.3.1 The **DNO** will not normally witness the commissioning checks and tests for **Fully Type Tested Power Generating Modules** connected to the **DNO's Distribution Network** at **LV**. In such cases, where the **DNO** does decide to witness they will advise this as part of the connection offer. Reasons for witnessing such installations may include:

a) A new **Installer** with no track record in the **DNO** area.

b) A check on the quality of an installation either on a random basis or as a result of problems that have come to light at previous installations.

16.3.2 Where commissioning tests and checks are to be witnessed the **Installer** shall discuss and agree the scope of these tests with the **DNO** at an early stage of the project. The tests shall take account of the requirements in Section 15.3. The **Installer** shall submit the scope, date and time of the commissioning tests at least 15 days before the proposed commissioning date.

16.3.3 Where the **DNO** chooses to witness the **PGM** commissioning tests and checks, the **DNO** shall charge the **Generator** for attendance of staff for witness testing in accordance with its charging regime.

16.3.4 No parameter relating to the electrical connection and subject to type test verification certification shall be modified unless previously agreed in writing between the **DNO** and the **Generator** or their agent. **Generator** access to such parameters in **Type Tested** equipment shall be prevented by seals or passwords as appropriate.

16.3.5 The checks and tests as detailed in Section 15.2, 15.3 and 15.4 must be undertaken to the extent applicable.

16.3.6 Where **Type Testing** or **Manufacturers' Information** is not being used to demonstrate the compliance of the **Interface Protection** the tests detailed in Section 15.4 must be undertaken.

16.4 Operational Notification

16.4.1 Notification that the **Power Generating Module** has been connected / commissioned is achieved by completing an Installation Document as per Annex A.3, which also includes the relevant details on the **Generator's Installation** required by the **DNO**.

16.4.2 The **Installer**, or an agent acting on behalf of the **Installer**, shall supply separate Installation Documents (Annex A.3, Form A3) for each **Power Generating Facility** installed under EREC G99 to the **DNO**. Documentation shall be supplied either at the time of commissioning (where tests are witnessed) or within 28 days of the commissioning date (where the tests are not witnessed) and may be submitted electronically.

17 Type B Compliance Testing, Commissioning and Operational Notification

17.1 General

17.1.1 Where **Power Generating Modules** require connection to the **DNO's Distribution Network** in advance of the commissioning date, for the purposes of testing, the **Power Generating Facility** must comply with the requirements of the **Connection Agreement**. The **Generator** shall provide the **DNO** with a commissioning programme, which will be approved by the **DNO** if reasonable in the circumstances, to allow commissioning tests to be co-ordinated. The tests shall take account of the requirements in Section 15.3 and Section 15.4 where applicable.

17.1.2 The **Generator** shall use **Type Tested** equipment and/or **Manufacturers' Information** and/or site tests, as well as demonstrating commissioning tests performed on his **Power Generating Module** in order to discharge the requirements of this document. Examples of the combination of the use of type testing and the provision of **Manufacturers' Information** are given in Section 22.1. Further information about **Manufacturers' Information** for **Inverter** connected **Power Park Modules** is given in Section 21. Note that the **DNO** shall charge the **Generator** for attendance of staff for witness testing in accordance with its charging regime. The **Generator** shall make arrangements for the **DNO** to witness the commissioning tests unless otherwise agreed with the **DNO**.

17.1.3 It is the responsibility of the **Generator** to undertake commissioning tests / checks and to ensure the **Power Generating Facility** and **Power Generating Module**s meet all the relevant requirements.

17.1.4 In addition to the commissioning tests and checks required under EREC G99, in exceptional circumstances further tests may be required by the **DNO** from the **Manufacturer**, **Supplier, Generator** or **Installer** of the **Power Generating Module**s as may be required to satisfy legislation and other standards.

17.2 Connection Process

17.2.1 The **Generator** shall discuss the project with the local **DNO** at the earliest opportunity. The **Generator** will need to provide information using the Standard Application Form (generally available from the **DNO**s website) to allow detailed system studies to be undertaken.

17.2.2 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to synchronise its **Power Generating Module** for the first time the **Generator** will submit to the **DNO** a **Power Generating Module Document** containing at least but not limited to the items referred to in paragraph 17.2.3.

17.2.3 Items for submission in the **Power Generating Module Document:**

a) updated **DDRC** data (both **Standard Planning Data** and **Detailed Planning Data**), with any estimated values assumed for planning purposes confirmed or, where practical, replaced by validated actual values and by updated estimates for the future and by updated forecasts for **Forecast Data** items such as **Demand.** In practice this data can be supplied by updating the information provided in the Standard Application Form.

b) details of any special **Power Generating Module(s)** protection as applicable.

c) simulation study carried out in accordance with the provisions of Annex B.4 and the results demonstrating compliance with EREC G99: Frequency Capability and **Frequency Sensitive Mode** requirements of paragraph 12.2, **Fault Ride Through** requirements of Section 12.3, reactive capability requirements of Section 12.5 and **Power Park Module Fast Fault Current** injection requirements of paragraph 12.6 unless agreed otherwise by the **DNO**.

d) a detailed schedule of the tests and the procedures for the tests required to be carried out by the **Generator** to achieve a **Final Operational Notification**. Such schedule to be consistent with the requirements of Section 12 and Annex B.5 (in the case of a **Synchronous Power Generating Module**) or Annex B.6 (in the case of a **Power Park Module**).

e) copies of **Manufactures Information** where these are relied upon as part of the evidence of compliance and

f) a Compliance Declaration completed by the **Generator.**

17.2.4 A **Power Generating Module Document (PGMD)** shall be submitted for each applicable **Power Generating Module**. An example of a **Power Generating Module Document** is given in Annex B.2, Form B2-1.

17.2.5 The **Generator** will give at least 28 days' notice for the date of tests which are required to achieve a **Final Operational Notification** and that are to be witnessed by the **DNO** The **DNO** shall assess the schedule of tests submitted by the **Generato**r and agree the test start date. The **DNO** can agree to a shorter period of notice than 28 days. Approval of the test start date, and agreement to a shorter period of notice than 28 days, shall be made in a timely manner and not be unreasonably withheld by the **DNO.**

17.3 Witnessing and Commissioning

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

17.3.2 The tests as detailed in the **Power Generating Module Document** shall be carried out by the **Generator** (and which may be delegated to the **Installer**).

17.3.3 The checks and tests as detailed in Section 15.2 and 15.3 must be undertaken to the extent applicable.

17.3.4 Where **Type Testing** or **Manufacturers' Information** is not being used to demonstrate the compliance of the **Interface Protection** the tests detailed in Section 15.4 must be undertaken.

17.3.5 The tests and checks shall be carried out once the installation is complete, or, in the case of a phased installation (ie 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,, Form B3 and the additional compliance and commissioning tests, Form B2-2 if applicable The **Installer** or **Generator**, as appropriate, shall complete the declaration at the bottom of Form B3, sign and date it and provide a copy to the **DNO** at the time of commissioning.

17.3.6 If compliance tests or simulations cannot be carried out as agreed between the **DNO** and the **Power Generating Facility Owner** due to reasons attributable to the **DNO**, then the **DNO** shall not unreasonably withhold the **Final Operational Notification** to be issued under Section 17.4.

17.4 Operational Notification for Type B Power Generating Modules

17.4.1 Prior to the issue of a **Final Operational Notification** the **Generator** must submit to the **DNO** to the **DNO**'s satisfaction:

a) updated DDRC data (both **Standard Planning Data** and **Detailed Planning Data**), with validated actual values and updated estimates for the future including forecast data items such as demand. In practice, this data can be supplied by updating the information provided in the Standard Application Form.

b) evidence to the **DNO's** satisfaction that demonstrates that the **Controller** models and/or parameters (as required under DDRC schedule 5c) supplied to the **DNO** provide a reasonable representation of the behaviour of the **Generator's** plant and apparatus.

c) copies of **Manufacturers' Information** where these are relied upon as part of the evidence of compliance.

d) results from the tests carried out by the **Generator** to demonstrate compliance with relevant EREC G99 requirements including the tests witnessed by the **DNO**; and

e) the Compliance Declaration signed by the **Generator**.

17.4.2 The items in paragraph 17.4.1 should be submitted by the **Generator** using the **Power Generating Module Document,** Form B2-1 and DDRC (via the Standard Application Form).

17.4.3 If the requirements of this Section 17.4 have been successfully met, the **DNO** will notify the **Generator** that compliance with the relevant EREC G99 provisions has been demonstrated for the **Power Generating Module(s)** as applicable through the issue of a **Final Operational Notification** as part of the **Connection Agreement.**

18 Type C Compliance Testing, Commissioning and Operational Notification

18.1 General

18.1.1 Where **Power Generating Modules** require connection to the **DNO's Distribution Network** in advance of the commissioning date, for the purposes of testing, the **Power Generating Facility** must comply with the requirements of the **Connection Agreement**. The **Generator** shall provide the **DNO** with a commissioning programme, which will be approved by the **DNO** if reasonable in the circumstances, to allow commissioning tests to be co-ordinated. The tests shall take account of the requirements in Section 15.3 and Section 15.4 where applicable.

18.1.2 The **Generator** shall use **Type Tested** equipment and/or **Manufacturers' Information** and/or site tests as well demonstrating all the commissioning tests performed on his **Power Generating Module** in order to discharge the requirements of this document. Further information about **Manufacturers' Information** is given in Section 21. Examples of the combination of the use of type testing and the provision of **Manufacturers' Information** are given in Section 22.1. Note that the **DNO** shall charge the **Generator** for attendance of staff for witness testing in accordance with its charging regime. The **Generator** shall make arrangements for the **DNO** to witness the commissioning tests unless otherwise agreed with the **DNO**.

18.1.3 It is the responsibility of the **Generator** to undertake commissioning tests / checks and to ensure the **Power Generating Facility** and **Power Generating Modules** meet all the relevant requirements.

18.1.4 In addition to the commissioning tests and checks required under EREC G99, further tests may be required by the **Manufacturer**, **Supplier, Generator** or **Installer** of the **Power Generating Modules** as may be required to satisfy legislation and other standards.

18.2 Connection Process

18.2.1 The **Generator** shall discuss the project with the local **DNO** at the earliest opportunity. The **Generator** will need to provide information using the Standard Application Form (generally available from the **DNO**s website) to allow detailed system studies to be undertaken.

18.2.2 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to synchronise its **Power Generating Module** for the first time the **Generator** will submit to the **DNO** a **Power Generating Module Document** containing at least but not limited to the items referred to in paragraph 18.2.3.

18.2.3 Items for submission in the **Power Generating Module Document:**

a) updated **DDRC** data (both **Standard Planning Data** and **Detailed Planning Data**), with any estimated values assumed for planning purposes confirmed or, where practical, replaced by validated actual values and by updated estimates for the future and by updated forecasts for **Forecast Data** items such as **Demand.** In practice, this data can be supplied by updating the information provided in the Standard Application Form.

b) details of any special **Power Generating Module(s)** protection. This may include pole slipping protection and islanding protection schemes as applicable;

c) the simulation models;

d) simulation study carried out in accordance with the provisions of Annex C.7 and the results demonstrating compliance with the frequency capability and **Frequency Sensitive Mode** requirements of paragraph 13.2, **Fault Ride Through** requirements of Section 13.3, reactive capability requirements of Section 13.5 and **Fast Fault Current** injection requirements of paragraph 13.6 unless agreed otherwise by the **DNO**;

e) a detailed schedule of the tests and the procedures for the tests required to be carried out by the **Generator** to achieve a **Final Operational Notification**. Such schedule to be consistent with Section 13, Annex C.8 (in the case of a **Synchronous Power Generating Module**) or Annex C.9 (in the case of a **Power Park Module**);

f) copies of **Manufactures Information** where these are relied upon as part of the evidence of compliance and

g) a Compliance Declaration completed by the **Generator.**

18.2.4 A **Power Generating Module Document (PGMD)** shall be submitted for each applicable **Power Generating Module**. An example of a **Power Generating Module Document** is given in Annex C.2, Form C2-1.

18.2.5 The **Generator** will give at least 28 days' notice for the date of tests which are required to achieve a **Final Operational Notification** and that are to be witnessed by the **DNO.** The **DNO** shall assess the schedule of tests submitted by the **Generato**r and agree the test start date. The **DNO** can agree to a shorter period of notice than 28 days. Approval of the test start date, and agreement to a shorter period of notice than 28 days, shall be made in a timely manner and not be unreasonably withheld by the **DNO.**

18.3 Witnessing and Commissioning

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

18.3.2 The checks and tests as detailed in Section 15.2 and 15.3 must be undertaken to the extent applicable.

18.3.3 Where **Type Testing** or **Manufacturers' Information** is not being used to demonstrate **Interface Protection** the tests detailed in Section 15.4 must be undertaken.

18.3.4 The tests as detailed in the **Power Generating Module Document** shall be carried out by the **Installer** or **Generator.**

18.3.5 The tests and checks shall be carried out once the installation is complete, or, in the case of a phased installation (ie 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 **Power Generating Module Document** and the installation and commissioning document included in Annex C.3 and Annex C2-1. The **Installer** or **Generator**, as appropriate, shall complete the declaration at the bottom of Form C3, sign and date it and provide a copy to the **DNO** at the time of commissioning.

18.3.6 If compliance tests or simulations cannot be carried out as agreed between the **DNO** and the **Power Generating Facility Owner** due to reasons attributable to the **DNO**, then the **DNO** shall not unreasonably withhold the **Final Operational Notification** to be issued under Section 18.4.

18.4 Operational Notification for Type C Power Generating Modules

18.4.1 Prior to the issue of a **Final Operational Notification** the **Generator** must submit to the **DNO** to the **DNO**'s satisfaction:

a) updated DDRC data (both **Standard Planning Data** and **Detailed Planning Data**), with validated actual values and updated estimates for the future including forecast data items such as demand. In practice, this data can be supplied by updating the information provided in the Standard Application Form.

b) evidence to the **DNO's** satisfaction that demonstrates that the **Controller** models and/or parameters (as required under DDRC schedule 5c) supplied to the **DNO** provide a reasonable representation of the behaviour of the **Generator's** plant and apparatus;

c) copies of **Manufacturers' Information** where these are relied upon as part of the evidence of compliance;

d) results from the tests carried out by the **Generator** to demonstrate compliance with relevant EREC G99 requirements including the tests witnessed by the **DNO**; and

e) the Compliance Declaration signed by the **Generator**.

18.4.2 The items in paragraph 18.4.1 should be submitted by the **Generator** using the **Power Generating Module Document,** Form C2-1 and the DDRC (via the Standard Application Form).

18.4.3 If the requirements of this Section 18.4 have been successfully met, the **DNO** will notify the **Generator** that compliance with the relevant EREC G99 provisions has been demonstrated for the **Power Generating Module(s)** as applicable through the issue of a **Final Operational Notification** as part of the **Connection Agreement.**

19 Type D Compliance Testing, Commissioning and Operational Notification

19.1 General

19.1.1 A **Type D Power Generating Module** will be required to obtain an **Energisation Operational Notification** followed by an **Interim Operational Notification** and a **Final Operational Notification** as set out in this Section.

19.1.2 The **Generator** will use **Type Tested** equipment and or use **Manufacturers' Information** as well as demonstrating all the commissioning tests performed on his **Power Generating Module** in order to discharge the requirements of this document. Examples of the combination of the use of type testing and the provision of **Manufacturers' Information** are given in Section 22.1. Further information about **Manufacturers' Information** is given in Section 21. It is expected that the **DNO** will witness these tests for **Power Generating Modules.** Note that the **DNO** shall charge the **Generator** for attendance of staff for witness testing in accordance with its charging regime. The **Generator** shall make arrangements for the **DNO** to witness the commissioning tests unless otherwise agreed with the **DNO**.

19.1.3 It is the responsibility of the **Generator** to undertake these commissioning tests / checks and to ensure the **Power Generating Facility** and **Power Generating Module**s meet all the relevant requirements.

19.1.4 In addition to the commissioning tests and checks required under EREC G99, further tests may be required by the **Manufacturer**, **Supplier, Generator** or **Installer** of the **Power Generating Module**s as may be required to satisfy legislation and other standards.

19.2 Connection Process

19.2.1 The **Generator** shall discuss the project with the local **DNO** at the earliest opportunity. The **Generator** will need to provide information using the Standard Application Form (generally available from the **DNO**s website) to allow detailed system studies to be undertaken.

19.2.2 In order to energise a Generator's internal network it is necessary to obtain an **Energisation Operational Notification.** The following provisions apply in relation to the issue of an **Energisation Operational Notification** in respect of **Embedded Medium Power Stations and Type D Power Generating Modules or Power Park Modules** connecting to the **Distribution Network.** If the **Power Generating Facility** is large as defined in the **Grid Code** (ie 10 MW in the north of Scotland; 30 MW in the south of Scotland, 100 MW in England and Wales) it should follow the procedures in the **Grid Code**.

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

a) updated DDRC Schedule 5 Planning data (both **Standard Planning Data** and **Detailed Planning Data**), with any estimated values assumed for planning purposes confirmed or, where practical, replaced by validated actual values and by updated estimates for the future and by updated forecasts for forecast data as required by the DDRC;

b) details of the protection arrangements at the **Connection Point** and settings;

c) The site responsibility schedule completed to the **DNO's** satisfaction;

d) any additional provisions in the connection offer and or the **Connection Agreement**

19.2.4 The items referred to in this Section shall be submitted using the appropriate DDRC schedules or Standard Application Form where applicable.

19.2.5 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to energise its plant and apparatus for the first time the **Generator** will confirm in writing the plant and apparatus that is ready to be connected to the **DNOs Distribution Network** specifying the items of plant and apparatus in a form acceptable to the **DNO**.

19.2.6 If the conditions of Section 19.2 have been completed to the **DNO**'s reasonable satisfaction then the **DNO** shall issue an **Energisation Operational Notification**.

19.3 Interim Operational Notification

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

19.3.2 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to synchronise its plant and apparatus for the first time the **Generator** will submit to the **DNO** the items referred to in paragraph 19.3.3.

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

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

a) an update of any of the items required to achieve an **Energisation Operational Notification** and any updated DDRC data (both **Standard Planning Data** and **Detailed Planning Data**), with any estimated values assumed for planning purposes confirmed or, where practical, replaced by validated actual values and by updated estimates for the future and by updated forecasts for forecast data items such as demand;

b) details of any special **Power Generating Module**(s) or protection. This may include Pole Slipping protection and islanding protection schemes as applicable;

c) a simulation study report in accordance with the provisions of Annex C.7 containing the results demonstrating compliance with EREC G99 **Frequency Sensitive Mode** requirements of paragraph 13.2.5 (**LFSM-O**) and paragraph 13.2.6 (**LFSM-U**), **Fault Ride Through** requirements of Section 13.3 and **Fast Fault Current** injection requirements of Section 13.6 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**;

d) 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 Section 13, Site testing and commission requirements, Annex C.7, together with Annex C.8 (in the case of **Synchronous Power Generating Modules**) or Annex C.8 (in the case of **Power Park Modules**); 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. If applicable this should include a declaration that black start compliance has been obtained from the **NETSO.**

19.3.4 The items in paragraph 19.3.3 are intended to be submitted by the **Generator** using the **Power Generating Module Document**, Annex C.2, Form C2-1 and as required by the DDRC.

19.3.5 No **Type D Power Generating Module** shall be synchronised to the **Total System** until the date specified by the **DNO** in the **Interim Operational Notification** issued in respect of the **Power Generating Module(s)**;

19.3.6 The **DNO** shall assess the schedule of tests submitted by the **Generator** with the Notification of **Generator**'s Intention to Synchronise and shall determine whether such schedule has been completed to the **DNO's** satisfaction.

19.3.7 When the requirements of paragraph 19.3.2 to paragraph 19.3.6 have been met, the **DNO** will notify the **Generator** that the **Synchronous Power Generating Module**, **CCGT Module** or **Power Park Module** as applicable may (subject to the **Generator** having fulfilled the requirements of paragraph 19.3.3 where that applies) be synchronised to the **Total System** through the issue of an **Interim Operational Notification**.

19.3.7.1 The **Interim Operational Notification** will be time limited, the expiration date being specified at the time of issue. The **Interim Operational Notification** may be renewed by the **DNO** for up to a maximum of 24 months from the date of the first issue of the **Interim Operational Notification**. The **DNO** may only issue an extension to an **Interim Operational Notification** beyond 24 months provided the **Generator** has applied for a derogation for any remaining **Unresolved Issues** to the **Authority** as detailed in Section 19.6**.**

19.3.8 The **Generator** must operate the **Power Generating Facility** in accordance with the terms, arising from the **Unresolved Issues** of the **Interim Operational Notification**. Where practicable, the **DNO** will discuss such terms with the **Generator** prior to including them in the **Interim Operational Notification**.

19.3.9 The **Interim Operational Notification** will include the following limitations:

a) In the case of a **Power Park Module** the **Interim Operational Notification** will limit the proportion of the **Power Park Module** which can be simultaneously synchronised to the **Total System** such that neither of the following figures is exceeded:

(i) 20% of the **Registered Capacity** of the **Power Park Module** (or the output of a single **Generating Unit** where this exceeds 20% of the **Power Park Module's Registered Capacity**); nor

(ii) 50 MW

until the **Generator** has completed the voltage control tests (detailed in Annex C.9.2) 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).

a) 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 any **Power System Stabiliser** to the **DNO's** satisfaction.

19.3.10 Operation in accordance with the **Interim Operational Notification** whilst it is in force will meet the requirements for compliance by the **Generator** of all the relevant provisions of this EREC G99.

19.3.11 Other than **Unresolved Issues** that are subject to tests required prior to issue of a **Final Operation Notification**, the **Generator** must resolve any **Unresolved Issues** prior to the commencement of the tests, unless the **DNO** agrees to a later resolution. The **Generator** must liaise with the **DNO** in respect of such resolution. The tests that may be witnessed by the **DNO** are specified in paragraph 19.4.2.

19.3.12 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to commence tests required to be witnessed by the **DNO** prior to issue of a **Final Operation Notification**, the **Generato**r will notify the **DNO** that the **Power Generating Module(s)** is ready to commence such tests.

19.4 Final Operational Notification

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

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

19.4.2.1 Prior to the issue of a **Final Operational Notification** the **Generator** must have completed the tests specified in paragraph 19.4.2.2 to the **DNO's** satisfaction to demonstrate compliance with the relevant EREC G99 provisions.

19.4.2.2 In the case of any **Power Generating Module** these tests will comprise one or more of the following as agreed with the **DNO**:

a) Reactive capability tests to demonstrate that the **Power Generating Module** can meet the requirements of paragraph 13.5. **Synchronous Power Generating Modules** shall demonstrate **Reactive Power** capability following the procedure in Annex C.7. **Power Park Modules** shall demonstrate **Reactive Power** capability following the procedure in Annex C.8. These tests may be witnessed by the **DNO** on site if there is no metering to the **DNO**s Control Centre.

b) Voltage control system tests to demonstrate that the **Power Generating Module** can meet the requirements of paragraph 13.4.3 and paragraph 13.4.4 as applicable. **Synchronous Power Generating Modules** shall demonstrate **Excitation System** capability following the procedure in Annex C.7. **Power Park Modules** shall demonstrate **Excitation System** capability following the procedure in Annex C.8, and any site specific requirements. These tests may also be used to validate the **Excitation System** model or voltage control system model as applicable (DDRC schedule 5c). These tests may be witnessed by the **DNO**.

c) Governor or frequency control system tests to demonstrate that the **Power Generating Module** can meet the requirements of paragraph 13.1.3 and Section 13.2. **Synchronous Power Generating Modules** shall demonstrate the governor and load controller response performance capability following the procedure in Annex C.7. **Power Park Generating Modules** shall demonstrate the governor and load controller response performance capability following the procedure in Annex C.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**.

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

19.4.2.4 Following completion of each of the tests specified in this Section 19.4, the **DNO** will notify the **Generator** whether, in the opinion of the **DNO**, the results demonstrate compliance with EREC G99.

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

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

19.4.3.1 Prior to the issue of a **Final Operational Notification** the **Generator** must submit to the **DNO** to the **DNO**'s satisfaction:

a) updated Planning Code data (both **Standard Planning Data** and **Detailed Planning Data**), with validated actual values and updated estimates for the future including Forecast Data items such as Demand;

b) any items required in order to obtain the **Energisation Operational Notification** and the **Interim Operational Notification**, updated by the **Generator** as necessary;

c) evidence to the **DNO's** satisfaction that demonstrates that the **Controller** models and/or parameters (as required under DDRC schedule 5c) supplied to the **DNO** provide a reasonable representation of the behaviour of the **Generator's** plant and apparatus;

d) copies of **Manufacturers' Information** where these are relied upon as part of the evidence of compliance;

e) results from the tests required in accordance with paragraph 19.4.2 carried out by the **Generator** to demonstrate compliance with relevant EREC G99 requirements including the tests witnessed by the **DNO**;

f) the final Compliance Declaration signed by the **Generator** and a statement of any requirements that the **Generator** has identified that have not been met together with a copy of the derogation in respect of the same from the **Authority**.

19.4.3.2 The items in paragraph 19.4.3 should be submitted by the **Generator** as required by the DDRC and the **Power Generating Module Document**, Annex C.2, Form C2-1.

19.4.4 If the requirements of paragraph 19.4.2 and paragraph 19.4.3 have been successfully met, the **DNO** will notify the **Generator** that compliance with the relevant EREC G99 provisions has been demonstrated for the **Power Generating Module(s)** as applicable through the issue of a **Final Operational Notification** as part of the **Connection Agreement.**

19.4.5 If compliance tests or simulations cannot be carried out as agreed between the **DNO** and the **Power Generating Facility Owner** due to reasons attributable to the **DNO**, then the **DNO** shall not unreasonably withhold the **Final Operational Notification** to be issued under this Section 19.4 or other appropriate notification.

19.4.6 If a **Final Operational Notification** cannot be issued because the requirements of paragraph 19.4.2 and paragraph 19.4.3 have not been successfully met prior to the expiry of an **Interim Operational Notification** then the **Generator** and/or the **DNO** shall apply to the **Authority** for a **Derogation**. The provisions of paragraph 19.6 shall then apply.

19.5 Limited Operational Notification

19.5.1 Following the issue of a **Final Operational Notification** for a **Type D Power Generating Module** if:

(i) the **Generator** becomes aware, that its plant and/or apparatus' capability to meet any provisions of EREC G99, or where applicable the **Connection Agreement** is not fully available then the **Generator** shall follow the process in paragraph 19.5.2 to paragraph 19.5.10; or,

(ii) The **DNO** becomes aware through monitoring as described in paragraph 13.9, that a **Generator** and/or apparatus' capability to meet any provisions of EREC G99, or where applicable the **Connection Agreement,** then the **DNO** shall inform the **Generator**. Where the **DNO** and the **Generator** cannot agree from the monitoring as described in paragraph 13.9 whether the plant and/or apparatus is fully available and/or is compliant with the requirements of EREC G99 and where applicable the **Connection Agreement**, the **DNO** shall first issue an instruction requiring the **Generator** to carry out a test, before applying the process defined in Section 19.5 if applicable. Where the testing indicates that the plant and/or apparatus is not compliant with the requirements of EREC G99 and/or the **Connection Agreement**, or if the parties so agree, the process in paragraph 19.5.2 to paragraph 19.5.10 shall be followed.

19.5.2 Immediately upon a **Generator** becoming aware that its **Power Generating Module** may be unable to comply with certain provisions of EREC G99 or (where applicable) the **Connection Agreement**, the **Generator** shall notify the **DNO** in writing. Additional details of any operating restrictions or changes in applicable data arising from the potential non-compliance and an indication of the date from when the restrictions will be removed and full compliance demonstrated shall be provided as soon as reasonably practical.

19.5.3 Where the restriction notified in paragraph 19.5.2 is not resolved in 28 days then the **Generator** with input from and discussions with the **DNO**, shall undertake an investigation to attempt to determine the causes of and solution to the non-compliance. Such investigation shall continue for no longer than 56 days. During such investigation, the **Generato**r shall provide to the **DNO** the relevant data which has changed due to the restriction in respect of paragraph 19.4.3 as notified to the **Generator** by the **DNO** as being required to be provided.

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

19.5.4.1 Following the issue of a **Final Operational Notification**, the **DNO** will issue to the **Generator** a **Limited Operational Notification** if:

a) by the end of the 56 day period referred to at 19.5.3 the investigation has not resolved the non-compliance to the **DNO**'s satisfaction; or

b) The **DNO** is notified by a **Generator** of a **Modification** to its plant and apparatus; or

c) The **DNO** receives a submission of data, or a statement from a **Generator** indicating a change in plant or apparatus or settings (including but not limited to governor and excitation control systems) that may in the **DNOs** reasonable opinion, acting in accordance with Good Industry Practice be expected to result in a material change of performance.

19.5.4.2 The **Limited Operational Notification** will be time limited to expire no later than 12 months from the start of the non-compliance or restriction or from reconnection following a change. The **DNO** may agree a longer duration in the case of a **Limited Operational Notification** following a **Modification** or whilst the **Authority** is considering the application for a derogation in accordance with paragraph 19.6.1.

19.5.4.3 The **Limited Operational Notification** will notify the **Generator** of any restrictions on the operation of the **Synchronous Power Generating Module(s)**, **CCGT Module(s)** or **Power Park Module(s)** and will specify the **Unresolved Issues**. The **Generator** must operate in accordance with any notified restrictions and must resolve the **Unresolved Issues**.

19.5.4.4 The **Generator** will be deemed compliant with all the relevant provisions of EREC G99 provided operation is in accordance with the **Limited Operational Notification**, whilst it is in force, and that the provisions of and referred to in Section 19.5 are complied with.

19.5.4.5 The **Unresolved Issues** included in a **Limited Operational Notification** will show the extent that the provisions of paragraph 19.4.2 (testing) and paragraph 19.4.3 (final data submission) shall apply. In respect of selecting the extent of any tests which may in the **DNO's** view reasonably be needed to demonstrate the restored capability and in agreeing the time period in which the tests will be scheduled, the **DNO** shall, where reasonably practicable, take account of the **Generator**'s input to contain its costs associated with the testing.

19.5.4.6 In the case of a **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 Annex C.7 and the results demonstrating compliance with EREC G99 requirements relevant to the **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 Annex C.8 or Annex C.9 as appropriate; and

e) an interim Compliance Declaration completed by the **Generator** (including any **Unresolved Issues**) against the relevant EREC G99 requirements including details of any requirements that the **Generator** has identified that will not or may not be met or demonstrated; and

f) any other items specified in the **Limited Operational Notification**.

19.5.4.7 The items referred to in paragraph 19.5.4.6 shall be submitted by the **Generator** as required by the DDRC and the **Power Generating Module Document**, Annex C.2, Form C2-1.

19.5.4.8 In the case of **Synchronous Power Generating Module(s)** only, the **Unresolved Issues** of the **Limited Operational Notification** may require that the **Generator** must complete the following tests to the **DNO's** satisfaction to demonstrate compliance with the relevant provisions of EREC G99 prior to the **Synchronous Power Generating Module** being synchronised to the **Total System**:

a) those tests required to establish the open and short circuit saturation characteristics of the **Synchronous Power Generating Module** (as detailed in Annex C.8.3) 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 Annex C.8.2) to demonstrate compliance with Annex C.4.2.4.1 and Annex C5.2.3.1 as applicable.

19.5.5 In the case of a **Modification**, 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 plant and apparatus for the first time following the **Modification**, the **Generator** shall submit to the **DNO** the items referred to in paragraph 19.5.4.6.

19.5.6 Other than **Unresolved Issues** that are subject to tests to be witnessed by the **DNO**, the Generator must resolve any **Unresolved Issues** prior to the commencement of the tests, unless the **DNO** agrees to a later resolution. The **Generator** must liaise with the **DNO** in respect of such resolution. The tests that may be witnessed by the **DNO** are specified in paragraph 19.4.2.2.

19.5.7 Not less than 28 days, or such shorter period as may be acceptable in the **DNO's** reasonable opinion, prior to the **Generator** wishing to commence tests listed as **Unresolved Issues** to be witnessed by the **DNO**, the **Generator** or will notify the **DNO** that the **Synchronous Power Generating Module(s)**, **CCGT Module(s)** or **Power Park Module(s)** as applicable is ready to commence such tests.

19.5.8 The items referred to in paragraph 19.4.3 and listed as **Unresolved Issues** shall be submitted by the **Generator** after successful completion of the tests.

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

19.5.10 If a **Final Operational Notification** has not been issued by the **DNO** within the 12 month period referred to in paragraph 19.5.4.2 (or where agreed following a

Modification by the expiry time of the **Limited Operational Notification**) then the **Generator** and the **DNO** shall apply to the **Authority** for a derogation.

19.6 Processes Relating to Derogations

19.6.1 Whilst the A**uthority** is considering the application for a derogation, the **Interim Operational Notification** or **Limited Operational Notification** will be extended to remain in force until the **Authority** has notified the **DNO** and the **Generator** of its decision.

19.6.2 If the **Authority**:

a) grants a derogation in respect of the plant and/or apparatus, then the **DNO** shall issue **Final Operational Notification** once all other **Unresolved Issues** are resolved; or

b) decides a derogation is not required in respect of the plant and/or apparatus then the **DNO** will reconsider the relevant **Unresolved Issues** and shall issue a **Final Operational Notification** once all other **Unresolved Issues** are resolved; or

c) decides not to grant any derogation in respect of the plant and/or apparatus, then there will be no Operational Notification in place and in accordance with Article 3.1 of the RfG the **DNO** will initiate a process to disconnect the **Power Generating Facility** from the **DNO's Distribution Network**.

19.6.3 Where an **Interim Operational Notification** or **Limited Operational Notification** is so conditional upon a derogation and such derogation includes any conditions (including any time limit to such derogation) the **Generator** will progress the resolution of any **Unresolved Issues** and / or progress and / or comply with any conditions upon such derogation and the provisions of paragraph 19.4 shall apply and shall be followed.

20 Ongoing Obligations

20.1 Periodic Testing for Power Generating Modules

20.1.1 The **DNO** shall have the right to request that the **Generator** carry out compliance tests and simulations according to a repeat plan or general scheme or after any failure, **Modification** or replacement of any equipment that may have an impact on the **Power Generating Module's** compliance with the requirements of this EREC G99.

20.1.2 The **DNO** will assess the results of the tests and inform the **Generator** of the outcome.

20.1.3 It may be necessary to undertake ad-hoc testing to determine[4], for example:

a) the voltage dip on synchronising;

b) the harmonic voltage distortion;

c) the voltage levels as a result of the connection of the **Power Generating Facilities** and to confirm that they remain within the statutory limits.

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

20.2 Operational Incidents affecting Compliance of any Power Generating Module

20.2.1 The **DNO** shall be notified of any operational incidents or failures of **Power Generating Modules** that affect its compliance with this EREC G99, without undue delay, after the occurrence of those incidents.

20.2.2 The **DNO** shall have the right to request that the **Generator** arrange to have compliance tests undertaken after any failure or replacement of any equipment that may have an impact on the **Power Generating Module's** compliance with this EREC G99.

20.3 Changes to the Power Generating Facility or Power Generating Module

20.3.1 The **DNO** shall have the right to request that the **Generator** arrange to have compliance tests undertaken after any **Modification** or replacement of any equipment that may have an impact on the **Power Generating Module's** compliance with this EREC G99.The **DNO** shall have the right to request that the **Generator** arrange to have compliance

20.3.2 If during the lifetime of the **Power Generating Modules** it is necessary to replace a component of a **Power Generating Module**, its protection system or **Interface Protection**, the **Generator** shall notify the **DNO** before the **Modification** is initiated. The **DNO** and the **Generator** will agree whether the nature of the **Modification** is

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[4] Such periodic testing may be required due to system changes, **DNO** protection changes, fault investigations etc.

such that the **Generator** is only required to reconfirm the compliance with the requirements in this EREC G99 in relation to the affected component, or whether the **Modification** is sufficiently material (eg with a higher **Registered Capacity**) such that the **Generator** should submit a new Standard Application Form for the new equipment and a Decommissioning Form for the old equipment. Where a **Generating Unit** or **Power Generating Module** is replaced, the replacement must comply with this EREC G99 (rather than the EREC G59 if it originally complied with EREC G59).

20.3.3 Where one or more **Power Generating Modules** are to be added or replaced at an existing **Generator's Installation** which was installed prior to the introduction of this EREC G99, it is not necessary to modify the other existing **Power Generating Modules** to comply with this document. For the avoidance of doubt, this also applies where the changes increase the capacity of the **Generator's Installation** above the 16 A per phase threshold.

20.3.4 For example the addition of a new 3 kW single phase **Power Generating Module** to an existing **Generator's Installation** comprising an existing 3 kW single phase **Power Generating Module** complying with EREC G83 increases the capacity of the **Generator's Installation** from 3 kW (13.04 A per phase) to 6 kW (26.08 A per phase). In this case the new **Power Generating Module** will have to comply with EREC G99 but the existing **Power Generating Module** will not need to be modified. For more information on the treatment of additions, see Section 6 and paragraph 6.1.5.

20.4 Notification of Decommissioning

20.4.1 The **Generator** shall notify the **DNO** about the permanent decommissioning of a **Power Generating Module** by providing the information as detailed under Annex D.1. Documentation may be submitted by an agent or third party such as an aggregator, acting on behalf of the **Generator** and may be submitted electronically. Where the presence of **Power Generating Modules** is indicated in a bespoke **Connection Agreement**, it will be necessary to amend the **Connection Agreement** appropriately.

21 Manufacturers’ Information applicable to Power Park Modules

21.1 General

21.1.1 Data and performance characteristics in respect of EREC G99 requirements may be registered with the **DNO** by **Generating Unit Manufacturers** in respect of specific models of **Generating Units** by submitting information in the form of **Manufacturers’ Information** to the **DNO**.

21.1.2 **Manufacturers’ Information** covers such information as type testing details, parameters or data, simulation models and reports on studies run using those models. For the purpose of this Section 21 **Manufacturers’ Information** will generally relate to simulation models.

21.1.3 A **Generator** planning to construct a new **Power Generating Facility** containing the appropriate version of **Generating Units** in respect of which **Manufacturers’ Information** has been submitted to the **DNO** may reference the **Manufacturers’ Information** in its submissions to the **DNO**. Any **Generator** considering referring to **Manufacturers’ Information** for any aspect of its plant and apparatus may contact the **DNO** to discuss the suitability of the relevant **Manufacturers’ Information** to its project to determine if, and to what extent, the data included in the **Manufacturers’ Information** contributes towards demonstrating compliance with those aspects of this EREC G99 applicable to the **Generator**. The **DNO** will inform the **Generator** if the reference to the **Manufacturers’ Information** is not appropriate or not sufficient for its project.

21.1.4 The process to be followed by **Generating Unit Manufacturers** submitting **Manufacturers’ Information** must be agreed by the **DNO**. Paragraph 21.2 below indicates the specific requirement areas in respect of which **Manufacturers’ Information** may be submitted.

21.1.5 The **DNO** may 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 **Generating 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 **Generating Unit**(s) covered by a report is or will be compliant with EREC G99.

21.2 **Manufacturers’ Information** in respect of **Generating Units** may cover one (or part of one) or more of the following provisions:

a) **Fault Ride Through** capability

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

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

A Generator referencing **Manufacturers’ Information** should insert the relevant **Manufacturers’ Information** reference in the appropriate place in the submission forms detailed in the Appendices. The **DNO** will consider the suitability of **Manufacturers' Information** in place of DDRC data submissions a mathematical model suitable for representation of the entire **Power Park Module** as per Annex B.4.3.5 or Annex C.7.4.5 as applicable. Site specific parameters will still need to be submitted by the **Generator**.

21.4 It is the responsibility of the **Generator** to ensure that the correct reference for the **Manufacturers' Information** is used and the **Generator** by using that reference accepts responsibility for the accuracy of the information. The **Generator** shall ensure that the **Manufacturer** has kept the **DNO** informed of any relevant variations in plant specification since the submission of the relevant **Manufacturers' Information** which could affect the validity of the information.

21.5 The **DNO** may contact the **Generating 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**.

22 Type Testing and Annex information

22.1 Fully Type Tested and Partially Type Tested equipment

The following matrix demonstrates where **Manufacturers' Information** and compliance and installation checks on site can be combined to demonstrate **compliance** for each **Power Generating Module**.

	Manufacturers' Information	**Site Tests**
Fully Type Tested (assumed **Type A** only)	Registered as **Fully Type Tested** information on ENA website via the Compliance Verification Report (Form A2-1, A2-2 or A2-3 as appropriate)	Only installation checks required – as on the Installation Document (Form A3)
Partially **Type Tested** (**Type A**)	(i) Registered as product or component Type Test information on ENA Website using applicable parts of Compliance Verification Report (Form A2-1, A2-2 or A2-3); and/or (ii) Supplied by the **Generator** using applicable parts of Compliance Verification Report (Form A2-1, A2-2 or A2-3)	Demonstration of technical requirements not covered by **Manufacturers' Information**. (Form A3) Standard installation checks (Form A3). Additional Site Compliance and Commissioning Checks (Form A2-4) may also be required
Partially **Type Tested** (B, C, D)	(i) Registered as product or component Type Test information on ENA Website; and/or (ii) Supplied by the **Generator**	Demonstration of technical requirements not covered by **Manufacturers' Information**. (Form B2-1 or Form C2-1) Standard installation checks (Form B3 or Form C3). Additional Site Compliance and Commissioning Checks (Form B2-2 or Form C2-2) may also be required
One off installation (B, C, D)	To be provided by the **Generator** for those aspects that cannot be demonstrated on site (including simulations etc)	Demonstration of technical requirements not covered by **Manufacturers' Information**. (Form B2-1 or Form C2-1)

		Standard installation checks also required (Form B3 or Form C3). Additional Site Compliance and Commissioning Checks (Form B2-2 or Form C2-2) may also be required

22.2 Annex Contents and Form Guidance

Annex	Application	Form Title
A.0	Cover Sheet for **Type A Power Generating Facility** Forms	
A.1	Connection Application for **Type A Fully Type Tested** (<50 kW) Note for all other **Power Generating Modules** the **DNO's** Standard Application Form shall be used.	Form A1: Application for connection of **Power Generating Module(s)** with Total Aggregate Capacity <50 kW 3-phase or 17 kW single phase
A.2	Compliance report for **Type A Type Tested**	Form A2-1: Compliance Verification Report for **Synchronous Power Generating Modules** up to and including 50 kW Form A2-2: Compliance Verification Report for **Synchronous Power Generating Modules** > 50 kW and also for **Synchronous Power Generating Modules** ≤ 50 kW where the approach of this form is preferred to that in Form A2-1 Form A2-3 Compliance Verification Report for **Inverter** Connected **Power Generating Modules**
A.2	Additional Compliance and Commissioning test requirements for **Type A Power Generating Modules**	Form A2-4: Site Compliance and Commissioning test requirements for **Type A Power Generating Modules**
A.3	Installation and Commissioning a **Power Generating Facility** comprising one or more **Type A Generating**	Form A3: Installation Document

	Modules	
A.4	Emerging Technologies and other Exceptions	
A.5	Example calculations to determine if unequal generation across different phases is acceptable or not	
A.6	Non-Standard private **LV** networks calculation of appropriate protection settings	
A.7	Requirements for Type Testing **Type A Power Generating Modules**	
B.1	Application	Refer to Standard Application Form
B.2-1	Compliance documentation for **Type B, Type C** and **Type D PGFs**	Form B2-1: **Power Generating Module Document** for **Type B Power Generating Modules**
B.2-2	Additional Compliance and Commissioning test requirements for **Power Generating Modules**	Form B2-2 Site Compliance and Commissioning test requirements for **Type B Power Generating Modules**
B.3	Installation and Commissioning Confirmation Form	Form B2: Installation and Commissioning Confirmation Form for **Type B Power Generating Modules**
B.4	Simulation Studies for **Type B Power Generating Modules**	
B.5	Compliance Testing of **Type B Synchronous Power Generating Modules**	
B.6	Compliance testing of **Type B Power Park Modules**	
C.1	Application	Refer to Standard Application Form
C.2-1	**Power Generating Module Document for Type C and Type D**	Form C2-1: **Power Generating Module Document** for **Type C and Type D Power Generating Modules**
C.2-2	Additional Compliance and Commissioning test requirements for **Power Generating Modules**	Form C2-2 Site Compliance and Commissioning test requirements for and **Type D Power Generating Modules**
C.3	Installation and Commissioning Confirmation Form	Form C3: Installation and Commissioning Confirmation Form for **Type C** and **Type D Power Generating Modules**
C.4	Performance Requirements For Continuously Acting Automatic Excitation Control Systems For **Type C** and **Type D Synchronous Power Generating Modules**	
C.5	Performance Requirements For Continuously Acting	

	Automatic Excitation Control Systems For **Type C** and **Type D Power Park Modules**	
C.6	Functional Specification for Fault Recording and Power Quality Monitoring Equipment Studies for **Type C** and **Type D Power Generating Modules**	
C.7	Simulation Studies for **Type C** and **Type D Power Generating Modules**	
C.8	Compliance Testing of **Type C** and **Type D Synchronous Power Generating Modules**	
C.9	Compliance Testing of **Type C** and **Type D Power Park Modules**	
C.10	Minimum Frequency Response Capabilities for **Type C** and **Type D Power Generating Modules**	
D.1	Decommissioning of any **Power Generating Module**	Form D1**: Decommissioning Confirmation**
D.2	Additional Information Relating to **System Stability** Studies	
D.3	Loss of Mains Protection Analysis	
D.4	Main Statutory and other Obligations	

Annex A

A.0 Type A Power Generating Module Forms Cover Sheet

A number of forms are required to be completed and submitted to the **DNO** for the connection of **Type A Power Generating Modules** and any subsequent **Modifications** to equipment, and/or permanent decommissioning. These are summarised in the table below. The stages in the table below are described in more detail in the Distributed Generation Connection Guides, which are available free of charge on the Energy Networks Association website[5].

Stage	Form	Notes / Description	Complete
1. Find an **Installer**	N/A	No form required – see ENA Distributed Generation Connection Guides for more information. Outside of the scope of this document.	
2. Discuss with the **DNO**	N/A	As above.	
3. Submit application	Form A1: Application Form (< 50 kW) OR Standard Application Form (> 50 kW)	Submit an application, so that the **DNO** can assess whether there is a requirement for network studies and network reinforcement, and whether they want to witness the commissioning. **Power Generating Modules** < 50 kW three phase or 17 kW single phase, Form A can be used. For larger schemes, the Standard Application Form should be used, which is generally available on **DNO** websites.	
4. Application acceptance	N/A	If the **DNO** determines that network reinforcement is required to facilitate connecting your **PGMs**, they will make you a Connection Offer. Once you have accepted the **DNO's** Connection Offer, construction can begin. See ENA Distributed Generation Connection Guides for more information.	
5. Compliance	Form A2: Compliance	To be provided, unless a **Manufacturer's** reference number (the Product ID) is available for **Fully**	

[5] http://www.energynetworks.org/electricity/engineering/distributed-generation/dg-connection-guides.html

	Verification Report	**Type Tested PGMs** (see Section 16.2.1). See the text at the start of Annex A2 regarding the options for the Compliance Verification Report Form. One Compliance Verification Report is required for each type / model of **Power Generating Module**. Form A2-1 is suitable for **Synchronous Power Generating Modules** less than 50 kW and greater than 16 A per phase. Form A2-2 is suitable for **Power Generating Modules** greater than 50 kW or for **Synchronous Power Generating Modules** <50 kW where this approach is preferred to Form A2-1. Form A2-3 is designed for **Power Park Modules** (excepting induction generators who are advised to use A2-1 or A2-2 as appropriate).	
6. Construction and commissioning	Form A2-4 Site Compliance and Commissioning test requirements	Where the **DNO** does not witness commissioning, the form should be submitted within 28 days. Where the **DNO** does witness, the forms can be signed and submitted on the day.	
7. Inform the **DNO**	Form A3 Installation Document	Submit one form per **Power Generating Facility**, signed by the owner and **Installer**, with declarations signed by the **Generator** or **Generator's** Technical Representative, (and the **DNO** Witness Representative where the **DNO** has elected to witness).	
8. Ongoing responsibilities	**Modification**	If a **Modification** is made to the **PGM** that affects its technical capabilities and compliance with this document, the **Generator** should inform the **DNO** who may require compliance tests.	
9. Decommisioning	(D0) Notification of decommissioning	Notify the **DNO** about the permanent decommissioning of a **PGM**.	

The forms have been designed with the same format of **Generator** and **Installer** information at the top of each form. If you are completing forms electronically, this will allow you to copy and paste your information from one form to another, as you move through the stages of the connection process, unless you need to update your contact details.

A.1 Type A Power Generating Facility Connection Application Form

Form A1 : Application for connection of Power Generating Module(s) with Total Aggregate Capacity <50 kW 3-phase or 17 kW single phase

For **Power Generating Modules** < 50 kW 3-phase or 17 kW single-phase, this simplified application form can be used. For **Power Generating Modules** with an aggregate capacity > 50 kW 3-phase, the connection application should be made using the Standard Application Form (generally available from the **DNO** website).

If the **Power Generating Module** is **Fully Type Tested** and registered in the ENA Type Test Verification Report Register, this application form should include the **Manufacturer's** reference number (the Product ID).

If part of the **Power Generating Module** is **Type Tested** and registered with the ENA Type Test Verification Report Register, this application form should include the **Manufacturer's** reference number (the Product ID) and Form A2-1 or A2-2 or A2-3 (as appropriate) should be submitted to the **DNO** with this form.

If the **Power Generating Module** is neither **Fully Type Tested** or **Type Tested** then and Form A2-1 or A2-2 or A2-3 should be submitted to the **DNO** with this form.

To ABC electricity distribution **DNO**

99 West St, Imaginary Town, ZZ99 9AA abced@wxyz.com

Generator Details:	
Generator (name)	
Address	
Post Code	
Contact person (if different from **Generator**)	
Telephone number	
E-mail address	
MPAN(s)	
Installer Details:	
Installer	
Accreditation / Qualification	
Address	

<table>
<tr><td>Post Code</td><td></td></tr>
<tr><td>Contact person</td><td></td></tr>
<tr><td>Telephone Number</td><td></td></tr>
<tr><td>E-mail address</td><td></td></tr>
<tr><td colspan="2">Installation details:</td></tr>
<tr><td>Address</td><td></td></tr>
<tr><td>Post Code</td><td></td></tr>
<tr><td>MPAN(s)</td><td></td></tr>
</table>

<table>
<tr><td colspan="9">Details of Existing PGMs – where applicable:</td></tr>
<tr><td rowspan="3">Manufacturer</td><td rowspan="3">Approximate Date of Installation</td><td rowspan="3">Technology Type</td><td rowspan="3">Manufacturer's Ref No. where available</td><td colspan="5">PGM installed capacity (kW)</td></tr>
<tr><td rowspan="2">3-phase units</td><td colspan="3">Single Phase Units</td><td rowspan="2">Power Factor</td></tr>
<tr><td>PH1</td><td>PH2</td><td>PH3</td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">Details of Proposed Additional Generating Unit(s):</td></tr>
<tr><td rowspan="3">Manufacturer</td><td rowspan="3">Approximate Date of Installation</td><td rowspan="3">Technology Type</td><td rowspan="3">Manufacturer's Ref No. where available</td><td colspan="5">PGM installed capacity (kW)</td></tr>
<tr><td rowspan="2">3-phase units</td><td colspan="3">Single Phase Units</td><td rowspan="2">Power Factor</td></tr>
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</table>

<table>
<tr><td colspan="2">Balance of Multiple Single Phase Generating Units – where applicable</td></tr>
<tr><td colspan="2">I confirm that design of the Generator's Installation has been carried out to limit output power imbalance to below 16A/phase, as required by EREC G99.</td></tr>
<tr><td>Signed :</td><td>Date :</td></tr>
<tr><td colspan="2">Use continuation sheet where required.

Record Power Generating Module Registered Capacity kW at 230 AC, to one decimal place, under PH1 for single phase supplies and under the relevant phase for two and three phase supplies.
Detail on a separate sheet if there are any proposals to limit export to a lower figure than the aggregate Registered Capacity of all the Power Generating Modules in the Power Generating Facility.</td></tr>
</table>

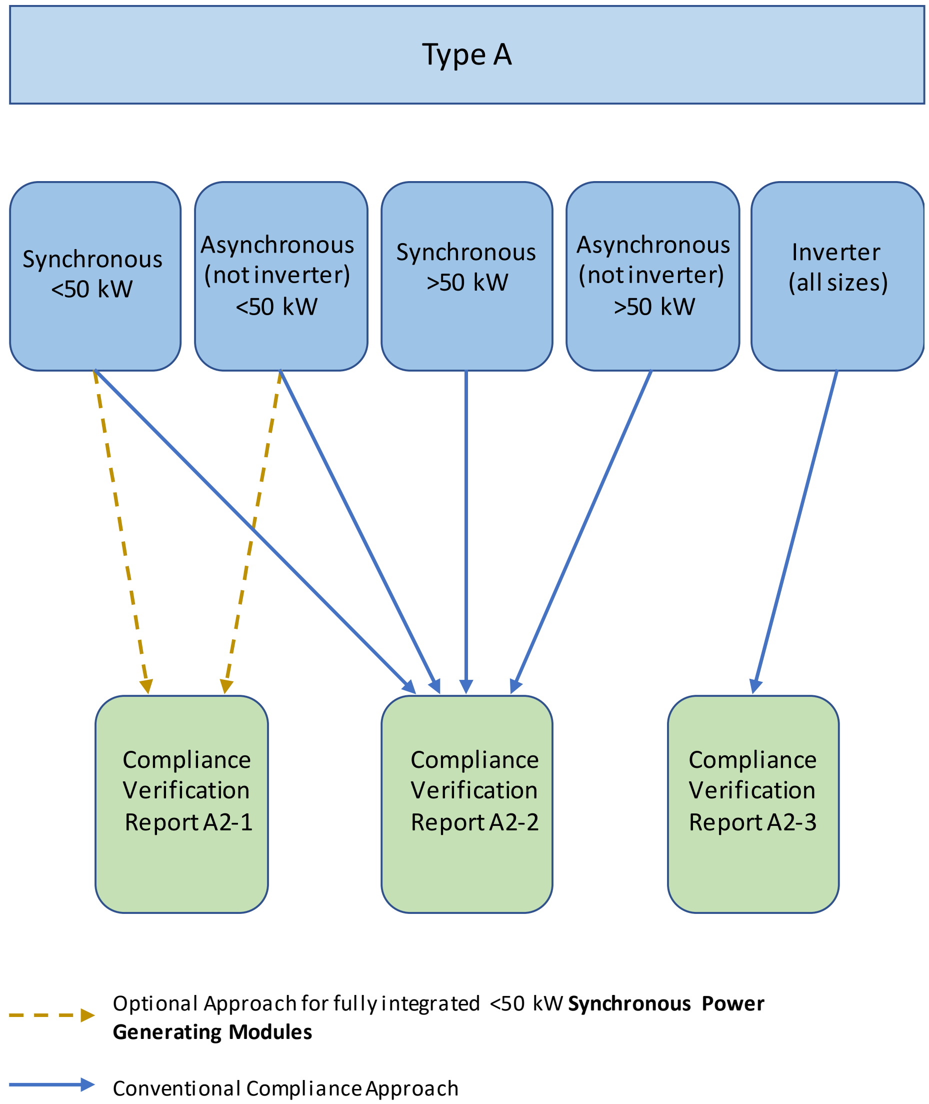
A.2 Type A Compliance Verification Report

Where a **Synchronous Power Generating Module** (assumed to be <50 kW although this is not a mandatory upper limit) is fully integrated as a package and where the **Manufacturer** wishes to take this approach, the whole package can be tested in a factory environment, for example, on a grid simulator. Form A2-1 in this Annex caters for this approach in describing a methodology for verification or obtaining type certification or for a < 50 kW **Synchronous Power Generating Module**.

Alternatively, rather than follow Form A2-1 and the requirements of Annex A.7.2.1, Form A2-2 and the tests it requires can be used for compliance of any size of **Power Generating Module**, including those 50 kW or smaller. It is envisaged that most **Synchronous Power Generating Modules** will use a conventional approach to compliance verification, for which Form A2-2 is appropriate.

Form A2-3 caters for all **Type A** asynchronous and inverter technologies of any size, with the exception of conventional induction **Generating Units. Manufacturers** of induction **Generating Units** may find it more appropriate to use forms A2-2 or A2-1 in preference to A2-3.

Figure A.2.1 illustrates the various compliance forms that are applicable to **Type A Power Generating Modules**.



5008

5009 **Figure A.2.1 Compliance requirements for Type A Power Generating Modules**

5010

Form A2-1: Compliance Verification Report for Synchronous Power Generating Modules up to and including 50 kW

This form should be used by the **Manufacturer** to demonstrate and declare compliance with the requirements of EREC G99. The form can be used in a variety of ways as detailed below:

1. <u>To obtain **Fully Type Tested** status</u>

   The **Manufacturer** can use this form to obtain **Fully Type Tested** status for a **Power Generating Module** by registering this completed form with the Energy Networks Association (ENA) Type Test Verification Report Register.

2. <u>To obtain **Type Tested** status for a product</u>

   This form can be used by the **Manufacturer** to obtain **Type Tested** status for a product which is used in a **Power Generating Module** by registering this form with the relevant parts completed with the Energy Networks Association (ENA) Type Test Verification Report Register.

3. <u>One-off Installation</u>

   This form can be used by the **Manufacturer** or **Installer** to confirm that the **Power Generating Module** has been tested to satisfy all or part of the requirements of this EREC G99. This form must be submitted to the **DNO** as part of the application.

A combination of (2) and (3) can be used as required, together with Form A2-4 where compliance of the **Interface Protection** is to be demonstrated on site.

Note:

If the **Power Generating Module** is **Fully Type Tested** and registered with the Energy Networks Association (ENA) Type Test Verification Report Register, the Installation Document (Form A3) should include the **Manufacturer's** reference number (the Product ID), and this form does not need to be submitted.

Where the **Power Generating Module** is not registered with the ENA Type Test Verification Report Register or is not **Fully Type Tested** this form (all or in parts as applicable) needs to be completed and provided to the **DNO**, to confirm that the **Power Generating Module** has been tested to satisfy all or part of the requirements of this EREC G99.

PGM technology			
Manufacturer name			
Address			
Tel.		Web site	
E:mail			
Registered Capacity	kW		

5011

There are four options for Testing: (1) **Fully Type Tested**, (2) **Type Tested** product, (3) one-off installation, (4) tested on site at time of commissioning. The check box below indicates which tests in this Form have been completed for each of the options. With the exception of **Fully Type Tested PGMs** tests marked with * may be carried out at the time of commissioning (Form A2-4).

Tested option:	**1. Fully Type Tested**	**2. Partially Type Tested**	**3. One-Off Man. Info.**	**4. Tested on Site at time of Commission-ing**
0. **Fully Type Tested**- all tests detailed below completed and evidence attached to this submission		**N/A**	**N/A**	**N/A**
1. Operating Range				
2. PQ – Harmonics				
3. PQ – Voltage Fluctuation and Flicker				
4. **Power Factor** (PF)*				
5. Frequency protection trip and ride through tests*				
6. Voltage protection trip and ride through tests*				
7. Protection – Loss of Mains Test*, Vector Shift and RoCoF Stability Test*				
8. **LFSM-O** Test*				
9. Power Output with Falling Frequency Test*				
10. Protection – Reconnection Timer*				
11. Fault Level Contribution				
12. Wiring functional tests if required by para 15.2.1 (attach relevant schedule of tests)*	**N/A**			
13. Logic Interface (input port)*				

* may be carried out at the time of commissioning (Form A.2-4).

Document reference(s) for **Manufacturers' Information** including the ENA Type Test Verification Report Register Product ID number where applicable:

<table>
<tr><td colspan="4">Manufacturer compliance declaration - I certify that all products supplied by the company with the above Type Tested Manufacturer’s reference number will be manufactured and tested to ensure that they perform as stated in this document, prior to shipment to site and that no site Modifications are required to ensure that the product meets all the requirements of EREC G99.</td></tr>
<tr><td>Signed</td><td></td><td>On behalf of</td><td></td></tr>
<tr><td colspan="4">Note that testing can be done by the Manufacturer of an individual component (ie product) 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.</td></tr>
</table>

A2-1 Compliance Verification Report –Tests for Type A Synchronous Power Generating Modules up to and including 50 kW

1. Operating Range: Two tests should be carried with the **Power Generating Module** operating at **Registered Capacity** and connected to a suitable test supply, grid simulation set or load bank. 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 **Power Generating Module** shall be recorded every second. The tests will verify that the **Power Generating Module** can operate within the required ranges for the specified period of time.

The **Interface Protection** shall be disabled during the tests.

Test 1 Voltage = 85% of nominal (195.5 V), Frequency = 47 Hz**,** **Power Factor** = 1, Period of test 20 s	
Test 2 Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz, **Power Factor** = 1, Period of test 90 minutes	
Test 3 Voltage = 110% of nominal (253 V), Frequency = 51.5 Hz, **Power Factor** = 1, Period of test 90 minutes	
Test 4 Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz, **Power Factor** = 1, Period of test 15 minutes	

2. Power Quality – Harmonics: The test requirements are specified in A.7.2.5. These tests should be carried out as specified in BS EN 61000-3-12. The results need to comply with the limits of Table 2 of BS EN 61000-3-12 for single phase equipment and Table 3 of BS EN 610000-3-12 for three phase equipment. **Power Generating Modules** with emissions close to the limits laid down in BS EN 61000-3-12 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 **Distribution Network.**						
Power Generating Module tested to BS EN 61000-3-12						
Power Generating Module rating per phase (rpp)				kVA	Harmonic % = Measured Value (A) x 23/rating per phase (kVA)	
Harmonic	At 45-55% of **Registered Capacity**		100% of **Registered Capacity**		Limit in BS EN 61000-3-12	
	Measured Value (A)	%	Measured Value (A)	%	1 phase	3 phase
2					8%	8%
3					21.6%	Not stated
4					4%	4%
5					10.7%	10.7%
6					2.67%	2.67%
7					7.2%	7.2%
8					2%	2%
9					3.8%	Not stated
10					1.6%	1.6%
11					3.1%	3.1%
12					1.33%	1.33%
13					2%	2%
THD[6]					23%	13%
PWHD[7]					23%	22%

5017

[6] THD = Total Harmonic Distortion

[7] PWHD = Partial Weighted Harmonic Distortion

3. Power Quality – Voltage fluctuations and Flicker: These tests should be undertaken in accordance with Annex A.7.2.5.3. Results should be normalised to a standard source impedance, or if this results in figures above the limits set in BS EN 61000-3-11 to a suitable maximum impedance.

	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 **Power Generating Modules.**

^ Applies to single phase **Power Generating Module** and **Power Generating Modules** 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 x 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 X 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			

4. Power Factor: The tests should be carried out on a single **Power Generating Module**. Tests are to be carried out at three voltage levels and at **Registered Capacity**. Voltage to be maintained within ±1.5% of the stated level during the test. These tests should be undertaken in accordance with Annex A.7.2.5.2.

Voltage	0.94 pu (216.2 V)	1.0 pu (230 V)	1.1 pu (253 V)
Measured value			
Power Factor Limit	>0.95	>0.95	>0.95

5. Protection – Frequency tests: These tests should be carried out in accordance with Annex A.7. A.7.2.2.3**.**

Function	Setting		Trip test		"No trip tests"	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5 Hz	20 s			47.7 Hz 25 s	
U/F stage 2	47 Hz	0.5 s			47.2 Hz 19.98 s	
					46.8 Hz 0.48 s	
O/F	52 Hz	0.5 s			51.8 Hz 89.98 s	
					52.2 Hz 0.48 s	

6. Protection – Voltage tests: These tests should be carried out in accordance with Annex A.7.2.2.2.

Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V	0.8 pu (184 V)	2.5 s			188 V 3.50 s	

					180 V 2.48 s	
O/V stage 1	1.14 pu (262.2 V)	1.0 s			258.2 V 2.0 s	
O/V stage 2	1.19 pu (273.7 V)	0.5 s			269.7 V 0.98s	
					277.7 V 0.48s	

Note for Voltage tests the Voltage required to trip is the setting ±3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±4 V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

7. Protection – Loss of Mains test: The tests are to be carried out at three output power levels ±5%. These tests should be carried out in accordance with Annex A.7.2.2.4.

To be carried out at three output power levels with a tolerance of ± 5% in Test Power levels.

Test Power (% of **Registered Capacity)**	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of Test Power	95% of Test Power	95% of Test Power	105% of Test Power	105% of Test Power	105% of Test Power
Trip time. Limit is 0.5 s						

For Multi phase **Power Generating Modules** confirm that the device shuts down correctly after the removal of a single fuse as well as operation of all phases.

Test Power (% of **Registered Capacity)**	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of Test Power	95% of Test Power	95% of Test Power	105% of Test Power	105% of Test Power	105% of Test Power
Trip time. Ph1 fuse removed						
Test Power (% of **Registered Capacity)**	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of Test Power	95% of Test Power	95% of Test Power	105% of Test Power	105% of Test Power	105% of Test Power
Trip time. Ph2 fuse removed						
Test Power (% of **Registered Capacity)**	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of Test Power	95% of Test Power	95% of Test Power	105% of Test Power	105% of Test Power	105% of Test Power

Trip time. Ph3 fuse removed						

Note for technologies which have a substantial shut down time this can be added to the 0.5 s in establishing that the trip occurred in less than 0.5 s. Maximum shut down time could therefore be up to 1.0 s for these technologies.	
Indicate additional shut down time included in above results.	ms

Loss of Mains Protection, Vector Shift Stability test. This test should be carried out in accordance with Annex A.7.2.2.6.

	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.5 Hz	+9 degrees	
Negative Vector Shift	50.5 Hz	- 9 degrees	

Loss of Mains Protection, RoCoF Stability test: This test should be carried out in accordance with Annex A.7.2.2.6.

Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0Hz to 51.0Hz	+0.19 Hzs^{-1}	2.1 s	
51.0Hz to 49.0Hz	-0.19 Hzs^{-1}	2.1 s	

8. 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%.

This test should be carried out in accordance with Annex A.7.2.4 .

Active Power response to rising frequency/time plots are attached	**Y/N**

9. Power output with falling frequency test

Tests should prove that the **Power Generating Module** does not reduce output power as the frequency falls. These tests should be carried out in accordance with Annex A.7.2.3.

Test sequence	Measured **Active Power** Output	Acceptable **Active Power**	Primary power source (if applicable)
49.5 Hz for 5 minutes		100% **Registered Capacity**	
49.5 Hz for 5 minutes		99% **Registered Capacity**	
48.0 Hz for 5 minutes		97% **Registered Capacity**	
47.6 Hz for 5 minutes		96.2% **Registered Capacity**	
47.1 Hz for 20 s		95% **Registered Capacity**	

<table>
<tr><td colspan="6">11. Protection – Re-connection timer.</td></tr>
<tr><td colspan="6">Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 10.1.</td></tr>
<tr><td>Time delay setting</td><td>Measured delay</td><td colspan="4">Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of Table 10.1.</td></tr>
<tr><td></td><td></td><td>At 1.16 pu (266.2 V)</td><td>At 0.85 pu (196.1 V)</td><td>At 47.4 Hz</td><td>At 52.1 Hz</td></tr>
<tr><td colspan="2">Confirmation that the Power Generating Module does not re-connect.</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">12. Fault level contribution: Manufacturers’ Information in respect of the fault level contribution shall be provided.</td></tr>
<tr><td colspan="6">13. Wiring functional tests: If required by para 15.2.1,</td></tr>
<tr><td colspan="5">Confirm that the relevant test schedule is attached (tests to be undertaken at time of commissioning)</td><td>Yes / NA</td></tr>
<tr><td colspan="6">14. Logic interface (input port)</td></tr>
<tr><td colspan="5">Confirm that an input port is provided and can be used to shut down the module.</td><td>Yes / NA</td></tr>
<tr><td colspan="6">Additional comments</td></tr>
<tr><td colspan="6"></td></tr>
</table>

5018

Form A2-2: Compliance Verification Report for Synchronous Power Generating Modules > 50 kW and also for Synchronous Power Generating Modules ≤ 50 kW where the approach of this form is preferred to that in Form A2-1

This form should be used by the **Manufacturer** to demonstrate and declare compliance with the requirements of EREC G99. The form can be used in a variety of ways as detailed below:

1. To obtain **Fully Type Tested** status

   The **Manufacturer** can use this form to obtain **Fully Type Tested** status for a **Power Generating Module** by registering this completed form with the Energy Networks Association (ENA) Type Test Verification Report Register.

2. To obtain **Type Tested** status for a product

   This form can be used by the **Manufacturer** to obtain **Type Tested** status for a product which is used in a **Power Generating Module** by registering this form with the relevant parts completed with the Energy Networks Association (ENA) Type Test Verification Report Register.

3. One-off Installation

   This form can be used by the **Manufacturer** or **Installer** to confirm that the **Power Generating Module** has been tested to satisfy all or part of the requirements of this EREC G99. This form must be submitted to the **DNO** as part of the application.

A combination of (2) and (3) can be used as required, together with Form A2-4 where compliance of the **Interface Protection** is to be demonstrated on site.

Note:

If the **Power Generating Module** is **Fully Type Tested** and registered with the Energy Networks Association (ENA) Type Test Verification Report Register, the Installation Document (Form A3) should include the **Manufacturer's** reference number (the Product ID), and this form does not need to be submitted.

Where the **Power Generating Module** is not registered with the ENA Type Test Verification Report Register or is not **Fully Type Tested** this form (all or in parts as applicable) needs to be completed and provided to the **DNO**, to confirm that the **Power Generating Module** has been tested to satisfy all or part of the requirements of this EREC G99.

PGM technology			
Manufacturer name			
Address			
Tel		Web sit	

		e	
E:mail			

Registered Capacity, use separate sheet if more than one connection option.	kW

There are four options for Testing: (1) **Fully Type Tested**, (2) Partially **Type Tested**, (3) one-off installation, (4) tested on site at time of commissioning. The check box below indicates which tests in this Form have been completed for each of the options. With the exception of **Fully Type Tested PGMs** tests marked with * may be carried out at the time of commissioning (Form A4).

Tested option:	**1. Fully Type Tested**	**2. Partially Type Tested**	**3. One-Off Man. Info.**	**4. Tested on Site at time of Commission-ing**
0. **Fully Type Tested** - all tests detailed below completed and evidence attached to this submission		**N/A**	**N/A**	**N/A**
1. Operating Range				
2. PQ – Harmonics				
3. PQ – Voltage Fluctuation and Flicker				
4. **Power Factor** (PF)				
5 Frequency protection trip and ride through tests*				
6 Voltage protection trip and ride through tests*				
7. Protection – Loss of Mains Test, Vector Shift and RoCoF Stability Test*				
8.**LFSM-O** Test*				
9. Power Output with Falling Frequency Test*				
10. Protection – Reconnection Timer*				
11. Fault Level Contribution				
13. Logic Interface (input port)				

* may be carried out at the time of commissioning (Form A2-4).

Document reference for **Manufacturers' Information** including the ENA Type Test Verification Report Register Product ID number where applicable:

Manufacturer compliance declaration. - I certify that all products supplied by the company with the above **Type Tested Manufacturer's** reference number will be manufactured and tested to ensure

that they perform as stated in this document, prior to shipment to site and that no site **Modifications** are required to ensure that the product meets all the requirements of EREC G99.			
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.			

A2-2 Compliance Verification Report –Tests for Type A Synchronous Power Generating Modules > 50 kW and also for Synchronous Power Generating Modules ≤ 50 kW where the approach of this form is preferred to that in Form A2-1

1. Operating Range: Two tests should be carried with the **Power Generating Module** operating at **Registered Capacity** and connected to a suitable load bank, test supply, or 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 **Power Generating Module** shall be recorded every second. The tests will verify that the **Power Generating Module** can operate within the required ranges for the specified period of time.

The **Interface Protection** shall be disabled during the tests.

Test 1 Voltage = 85% of nominal ((195.5 V), Frequency = 47 Hz, **Power Factor** = 1, Period of test 20 s	
Test 2 Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz, **Power Factor** = 1, Period of test 90 minutes	
Test 3 Voltage = 110% of nominal (253 V), Frequency = 51.5 Hz, **Power Factor** = 1, Period of test 90 minutes	
Test 4 Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz, **Power Factor** = 1, Period of test 15 minutes	

2. Power Quality – Harmonics:

The installation must be designed in accordance with EREC G5. For **Power Generating Modules** of up to 17 kW per phase or 50 kW three phase harmonic measurements as required by BS EN 61000-3-12 shall be made and recorded in a test declaration as in Form A3-1. The relevant part of Form A3-1 can be used for this purpose.

3. Power Quality – Voltage fluctuations and Flicker:

The installation must be designed in accordance with EREC P28.

For **Power Generating Modules** of up to 17kW per phase or 50kW three phase the voltage fluctuations and flicker emissions from the **Generating Unit** shall be measured in accordance with BS EN 61000-3-11

4. Power Factor: **Manufacturers' Information** shall be provided or factory test results or on site testing in respect of the operation of the control system at 0.94 pu V, 1.0 pu V and 1.1 pu V shall be undertaken. The test can be undertaken by stepping the network voltage such as via an appropriate transformer/tap changer, or alternatively by injecting a test voltage signal into the **Controller**.

This test shall be undertaken with the **Controller** in constant **Power Factor** mode and a set point of 1.0.

The tests are successful if the **Power Factor** is > 0.95 (leading and lagging).

5. Protection operation and stability– Frequency tests: See Form A2-4.

6. Protection operation and stability – Voltage tests: See Form A2-4 for **LV** or **HV** as applicable.

7. Protection – Loss of Mains test and Vector Shift and RoCoF Stability test: See Form A2-4.

8. Limited Frequency Sensitive Mode – Over frequency test: The tests below should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10% in accordance with paragraph 11.2.5.

The tests should be carried out in accordance with Annex A.7.2.4

Active Power response to rising frequency/time plots are attached	**Y/N**

9. Power output with falling frequency test

Tests should prove that the **Power Generating Module** does not reduce output power as the frequency falls. These tests should be carried out in accordance with Annex A.7.2.3.

Test sequence	Measured **Active Power** Output	Acceptable **Active Power**	Primary power source (if applicable)
49.5 Hz for 5 minutes		100% **Registered Capacity**	
49.5 Hz for 5 minutes		99% **Registered Capacity**	
48.0 Hz for 5 minutes		97% **Registered Capacity**	
47.6 Hz for 5 minutes		96.2% **Registered Capacity**	
47.1 Hz for 20 s		95% **Registered Capacity**	

5021

10. Protection – Re-connection timer.					
Test should prove that the reconnection sequence starts after a minimum delay of 20 s 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 1.16 pu (266.2 V)	At 0.85 pu (196.1 V)	At 47.4 Hz	At 52.1 Hz
Confirmation that the **Power Generating Module** does not re-connect.					
11. Fault level contribution: **Manufacturers' Information** in respect of the fault level contribution shall be provided.					
12. Wiring functional tests: If required by para 15.2.1,					
Confirm that the relevant test schedule is attached (tests to be undertaken at time of commissioning)					Yes / NA
13. Logic interface (input port)					
Confirm that an input port is provided and can be used to shut down the module.					Yes / NA
Additional comments					

5022

Form A2-3: Compliance Verification Report for Inverter Connected Power Generating Modules

This form should be used by the **Manufacturer** to demonstrate and declare compliance with the requirements of EREC G99. The form can be used in a variety of ways as detailed below:

1. <u>To obtain **Fully Type Tested** status</u>

   The **Manufacturer** can use this form to obtain **Fully Type Tested** status for a **Power Generating Module** by registering this completed form with the Energy Networks Association (ENA) Type Test Verification Report Register.

2. <u>To obtain **Type Tested** status for a product</u>

   This form can be used by the **Manufacturer** to obtain **Type Tested** status for a product which is used in a **Power Generating Module** by registering this form with the relevant parts completed with the Energy Networks Association (ENA) Type Test Verification Report Register.

3. <u>One-off Installation</u>

   This form can be used by the **Manufacturer** or **Installer** to confirm that the **Power Generating Module** has been tested to satisfy all or part of the requirements of this EREC G99. This form must be submitted to the **DNO** as part of the application.

A combination of (2) and (3) can be used as required, together with Form A2-4 where compliance of the **Interface Protection** is to be demonstrated on site.

Note:

Within this Form A3-3 the term **Power Park Module** will be used but its meaning can be interpreted within Form A3-3 to mean **Power Park Module**, **Generating Unit or Inverter** as appropriate for the context. However, note that compliance must be demonstrated at the **Power Park Module** level.

If the **Power Generating Module** is **Fully Type Tested** and registered with the Energy Networks Association (ENA) Type Test Verification Report Register, the Installation Document (Form A3) should include the **Manufacturer's** reference number (the Product ID), and this form does not need to be submitted.

Where the **Power Generating Module** is not registered with the ENA Type Test Verification Report Register or is not **Fully Type Tested** this form (all or in parts as applicable) needs to be completed and provided to the **DNO**, to confirm that the **Power Generating Module** has been tested to satisfy all or part of the requirements of this EREC G99.

PGM technology			
Manufacturer name			
Address			
Tel		Web site	
E:mail			
Registered Capacity			kW
There are four options for Testing: (1) **Fully Type Tested**, (2) Partially **Type Tested**, (3) one-off installation,			

(4) tested on site at time of commissioning. The check box below indicates which tests in this Form have been completed for each of the options. With the exception of **Fully Type Tested PGMs** tests marked with * may be carried out at the time of commissioning (Form A4).

Tested option:	**1. Fully Type Tested**	**2. Partially Type Tested**	**3. One-off Man. Info.**	**4. Tested on Site at time of Commission-ing**
0. **Fully Type Tested** - all tests detailed below completed and evidence attached to this submission		**N/A**	**N/A**	**N/A**
1. Operating Range				
2. PQ – Harmonics				
3. PQ – Voltage Fluctuation and Flicker				
4. PQ – DC Injection (**Power Park Modules** only)				
5. **Power Factor** (PF)*				
6. Frequency protection trip and ride through tests*				
7. Voltage protection trip and ride through tests*				
8. Protection – Loss of Mains Test*, Vector Shift and RoCoF Stability Test*				
9. **LFSM-O** Test*				
10. Protection – Reconnection Timer*				
11. Fault Level Contribution				
12. Self-monitoring Solid State Switch				
13. Wiring functional tests if required by para 15.2.1 (attach relevant schedule of tests)*	**N/A**			
14. Logic Interface (input port)*				

* may be carried out at the time of commissioning (Form A.2-4).

Document reference(s) for **Manufacturers' Information:**

Manufacturer compliance declaration. - I certify that all products supplied by the company with the above **Type Tested Manufacturer's** reference number will be manufactured and tested to ensure that they perform as stated in this document, prior to shipment to site and that no site **Modifications** are required to ensure that the product meets all the requirements of EREC G99.

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.

A2-3 Compliance Verification Report –Tests for Type A Inverter Connected Power Generating Modules

1. Operating Range: Two tests should be carried with the **Power Generating Module** operating at **Registered Capacity** and connected to a suitable test supply or 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 **Power Generating Module** shall be recorded every second. The tests will verify that the **Power Generating Module** can operate within the required ranges for the specified period of time.

The **Interface Protection** shall be disabled during the tests.

In case of a PV **Power Park Module** the PV primary source may be replaced by a DC source.

In case of a full converter **Power Park Module** (eg wind) the primary source and the prime mover I**nverter**/rectifier may be replaced by a DC source.

Test 1 Voltage = 85% of nominal (195.5 V), Frequency = 47 Hz, **Power Factor** = 1, Period of test 20 s	
Test 2 Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz, **Power Factor** = 1, Period of test 90 minutes	
Test 3 Voltage = 110% of nominal (253 V)., Frequency = 51.5 Hz, **Power Factor** = 1, Period of test 90 minutes	
Test 4 Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz, **Power Factor** = 1, Period of test 15 minutes	

5024

2. Power Quality – Harmonics: For **Power Generating Modules** of **Registered Capacity** of less than 75 A per phase (ie 50 kW) the test requirements are specified in Annex A.7.1.5**.** These tests should be carried out as specified in BS EN 61000-3-12 The results need to comply with the limits of Table 2 of BS EN 61000-3-12 for single phase equipment and Table 3 of BS EN 610000-3-12 for three phase equipment. **Power Generating Modules** with emissions close to the limits laid down in BS EN 61000-3-12 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 **Distribution Network.** For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation must be designed in accordance with EREC G5.						
Power Generating Module tested to BS EN 61000-3-12						
Power Generating Module rating per phase (rpp)				kVA	Harmonic % = Measured Value (A) x 23/rating per phase (kVA)	
Harmonic	At 45-55% of **Registered Capacity**		100% of **Registered Capacity**		Limit in BS EN 61000-3-12	
	Measured Value MV in Amps	%	Measured Value MV in Amps	%	1 phase	3 phase
2					8%	8%
3					21.6%	Not stated
4					4%	4%
5					10.7%	10.7%
6					2.67%	2.67%
7					7.2%	7.2%
8					2%	2%
9					3.8%	Not stated
10					1.6%	1.6%
11					3.1%	3.1%
12					1.33%	1.33%
13					2%	2%
THD[8]					23%	13%
PWHD[9]					23%	22%

[8] THD = Total Harmonic Distortion

[9] PWHD = Partial Weighted Harmonic Distortion

3. Power Quality – Voltage fluctuations and Flicker:

For **Power Generating Modules** of **Registered Capacity** of less than 75 A per phase (ie 50 kW) these tests should be undertaken in accordance with Annex A.7.1.4.3. Results should be normalised to a standard source impedance, or if this results in figures above the limits set in BS EN 61000-3-11 to a suitable Maximum Impedance.

For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation must be designed in accordance with EREC P28.

	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 **Power Generating Modules.**

^ Applies to single phase **Power Generating Module** and **Power Generating Modules** 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 x 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			

4. 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 230 V a 50 kW three phase **Inverter** has a current output of 217 A so DC limit is 543 mA. These tests should be undertaken in accordance with Annex A.7.1.4.4.

Test power level	10%	55%	100%
Recorded value in Amps			
as % of rated AC current			
Limit	0.25%	0.25%	0.25%

5. Power Factor: The tests should be carried out on a single **Power Generating Module**. Tests are to be carried out at three voltage levels and at **Registered Capacity**. Voltage to be maintained within ±1.5% of the stated level during the test. These tests should be undertaken in accordance with Annex A.7.1.4.2.

Voltage	0.94 pu (216.2 V)	1 pu (230 V)	1.1 pu (253 V)
Measured value			
Power Factor Limit	>0.95	>0.95	>0.95

6. Protection – Frequency tests: These tests should be carried out in accordance with the Annex A.7.1.2.3.

Function	Setting		Trip test		"No trip tests"	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5 Hz	20 s			47.7 Hz 25 s	
U/F stage 2	47 Hz	0.5 s			47.2 Hz 19.98 s	
					46.8 Hz	

					0.48 s	
O/F	52 Hz	0.5 s			51.8 Hz 89.98 s	
					52.2 Hz 0.48 s	
7. Protection – Voltage tests: These tests should be carried out in accordance with Annex A.7.1.2.2.						
Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V	0.8 pu (184 V)	2.5 s			188 V 3.50 s	
					180 V 2.48 s	
O/V stage 1	1.14 pu (262.2 V)	1.0 s			258.2 V 2.0 s	
O/V stage 2	1.19 pu (273.7 V)	0.5 s			269.7 V 0.98s	
					277.7 V 0.48 s	
Note for Voltage tests the Voltage required to trip is the setting ±3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±4 V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

8.Protection – Loss of Mains test: These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4						
The following sub set of tests should be recorded in the following table.						
Test Power and imbalance	33% -5% Q Test 22	66% -5% Q Test 12	100% -5% P Test 5	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
Trip time. Limit is 0.5s						

Loss of Mains Protection, Vector Shift Stability test. This test should be carried out in accordance with Annex A.7.1.2.6.			
	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.5 Hz	+9 degrees	
Negative Vector	50.5 Hz	- 9 degrees	

Shift			

Loss of Mains Protection, RoCoF Stability test: This test should be carried out in accordance with Annex A.7.1.2.6.

Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0 Hz to 51.0 Hz	+0.19 Hzs^{-1}	2.1 s	
51.0 Hz to 49.0 Hz	-0.19 Hzs^{-1}	2.1 s	

9. 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%.

This test should be carried out in accordance with Annex A.7.1.3.

Active Power response to rising frequency/time plots are attached if frequency injection tests are undertaken in accordance with Annex A.7.2.4	**Y/N**

Alternatively, simulation results should be noted below

Test sequence at **Registered Capacity** >80%	Measured **Active Power** Output	Frequency	Primary Power Source	**Active Power** Gradient
Step a) 50.00Hz ±0.01Hz				-
Step b) 50.45Hz ±0.05Hz				-
Step c) 50.70Hz ±0.10Hz				-
Step d) 51.15Hz ±0.05Hz				-
Step e) 50.70Hz ±0.10Hz				-
Step f) 50.45Hz ±0.05Hz				-
Step g) 50.00Hz ±0.01Hz				
Test sequence at **Registered Capacity** 40% - 60%	Measured **Active Power** Output	Frequency	Primary Power Source	**Active Power** Gradient
Step a) 50.00Hz ±0.01Hz				-
Step b) 50.45Hz ±0.05Hz				-

Step c) 50.70Hz ±0.10Hz				-
Step d) 51.15Hz ±0.05Hz				-
Step e) 50.70Hz ±0.10Hz				-

10. Protection – Re-connection timer.					
Test should prove that the reconnection sequence starts after a minimum delay of 20 s 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 1.16 pu (266.2 V)	At 0.85 pu (196.1 V)	At 47.4 Hz	At 52.1 Hz
Confirmation that the **Power Generating Module** does not re-connect.					

11. Fault level contribution: These tests shall be carried out in accordance with EREC G99 Annex A.7.1.5.		
For **Inverter** output		
Time after fault	Volts	Amps
20ms		
100ms		
250ms		
500ms		
Time to trip		In seconds

12. Self-Monitoring solid state switching: No specified test requirements. Refer to Annex A.7.1.7.	
It has been verified that in the event of the solid state switching device failing to disconnect the **Power Park Module**, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 s.	Yes/ NA
13. Wiring functional tests: If required by para 15.2.1	
Confirm that the relevant test schedule is attached (tests to be undertaken at time of commissioning)	Yes / NA
14. Logic interface (input port)	
Confirm that an input port is provided and can be used to shut down the module.	Yes / NA

Additional comments

5026 Site Compliance and Commissioning test requirements

Form A2-4: Site Compliance and Commissioning test requirements for Type A Power Generating Modules

This form should be completed if site compliance tests are being undertaken for some or all of the **Interface Protection** where it is not **Type Tested** and for other compliance tests that have been identified in Form 2-1, Form 2-2 or Form 2-3 as being undertaken on site.

Generator Details:	
Generator (name)	
Installation details:	
Address	
Post Code	
Date of commissioning	

Requirement	Compliance by provision of **Manufacturers Information** or type test reports. Reference number should be detailed and **Manufacturers Information** attached.	Compliance by commissioning tests Tick if true and complete relevant sections of form below
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		

Wiring functional tests: If required by para 15.2.1		

Over and Under Voltage Protection Tests 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,** type test reports or by undertaking the following tests on site.

Calibration and Accuracy Tests

Phase	Setting	Time Delay	**Pickup Voltage**				**Relay Operating Time - step from 230 V to test value**				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - N						Pass/ Fail					Pass/ Fail
L2 - N	**262.2 V** 230 V system	**1.0 s**	*258.75*		*265.65*	Pass/ Fail	266.2	*1.0 s*		*1.1 s*	Pass/ Fail
L3 - N						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 - N						Pass/ Fail					Pass/ Fail
L2 - N	**273.7 V** 230 V system	0.5s	*270.25*		*277.15*	Pass/ Fail	277.7	*0.5 s*		*0.6 s*	Pass/ Fail
L3 - N						Pass/ Fail					Pass/ Fail
Under Voltage			Lower Limit	Measured Value	Upper Limit		Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - N						Pass/ Fail					Pass/ Fail
L2 - N	**184.0 V** 230 V system	2.5 s	*180.55*		*187.45*	Pass/ Fail	180	*2.5 s*		*2.6 s*	Pass/ Fail
L3 - N						Pass/ Fail					Pass/ Fail

Over and Under Voltage Protection Tests LV

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	258.2 V	5.00 s		Pass/

							Fail
Stage 1 Over Voltage	**262.2 V**	**1.0 s**	> OV Stage 1	269.7 V	0.95 s		Pass/ Fail
Stage 2 Over Voltage	**273.7 V**	**0.5 s**	> OV Stage 2	277.7 V	0.45 s		Pass/ Fail
Inside Normal band	---------	---------	> UV	188 V	5.00 s		Pass/ Fail
Under Voltage	**184.0 V**	**0.5 s**	< UV	180 V	2.45 s		Pass/ Fail

Overvoltage test - Voltage shall be stepped from 258 V to the test voltage and held for the test duration and then stepped back to 258 V.

Undervoltage test – Voltage shall be stepped from 188 V to the test voltage and held for the test duration and then stepped back to 188 V

Additional Comments / Observations:

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,** type test reports or by undertaking the following tests on site.

Tests referenced to 110 V ph-ph VT output

Calibration and Accuracy Tests

Phase	Setting	Time Delay	**Pickup Voltage**				**Relay Operating Time** measured value ± 2 V				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2	**121 V** 110 V VT secondary	**1.0 s**	*119.35*		*122.65*	Pass/ Fail	Measured value plus 2 V	*1.0 s*		*1.1 s*	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	**124.3 V** 110 V VT secondary	0.5 s	*122.65*		*125.95*	Pass/ Fail	Measured value plus 2 V	*0.5 s*		*0.6 s*	Pass/ Fail
L2 - L3						Pass/ Fail					Pass/ Fail
L3 - L1						Pass/ Fail					Pass/ Fail
Under Voltage			Lower Limit	Measured Value	Upper Limit		Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2	**88.0 V** 110 V VT secondary	2.5s	*86.35*		*89.65*	Pass/ Fail	Measured value minus 2 V	*2.5 s*		*2.6 s*	Pass/ Fail
L2 - L3						Pass/ Fail					Pass / Fail
L3 - L1						Pass/ Fail					Pass/ Fail

Over and Under Voltage Protection Tests HV

referenced to 110 V 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	119 V	5.00 s		Pass/ Fail
Stage 1 Over Voltage	**121 V**	**1.0 s**	> OV Stage 1	122.3 V	0.95 s		Pass/ Fail
Stage 2 Over Voltage	**124.3 V**	**0.5 s**	> OV Stage 2	126.3 V	0.45 s		Pass/ Fail
Inside Normal band	---------	---------	> UV	90 V	5.00 s		Pass/ Fail
Under Voltage	**88 V**		< UV	86 V	2.45 s		Pass/ Fail

Additional Comments / Observations:

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**, type test reports 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
52 Hz	0.5 s	*51.90*		*52.10*	Pass/ Fail	51.7-52.3 Hz	*0.50 s*		*0.60 s*	Pass/ Fail
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5 Hz	20	*47.40*		*47.60*	Pass /Fail	47.8-47.2 Hz	*20.0 s*		*20.2 s*	Pass/ Fail
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47 Hz	0.5 s	*46.90*		*47.1*	Pass/ Fail	47.3-46.7 Hz	*0.50 s*		*0.60 s*	Pass /Fail

Stability Tests							
Test Description	Setting	Time Delay	Test Condition	Test Frequency	Test Duration	Confirm No Trip	Result
Inside Normal band	---------	---------	< OF	51.3 Hz	120 s		Pass/ Fail
Over Frequency	52 Hz	0.5 s	> OF	52.2 Hz	0.45 s		Pass/ Fail
Inside Normal band	---------	---------	> UF Stage 1	47.7 Hz	30 s		Pass/ Fail
Stage 1 Under Frequency	47.5 Hz	20 s	< UF Stage 1	47.3 Hz	19.5 s		Pass/ Fail
Stage 2 Under Frequency	47 Hz	0.5 s	< UF Stage 2	46.8 Hz	0.45 s		Pass/ Fail

Overfrequency test - Frequency shall be stepped from 51.3 Hz to the test frequency and held for the test duration and then stepped back to 51.3 Hz.

Underfrequency test - Frequency shall be stepped from 47.7 Hz to the test frequency and held for the test duration and then stepped back to 47.7 Hz

Additional Comments / Observations:

Details of Loss of Mains Protection				
Manufacturer	**Manufacturer's** type	Date of Installation	Settings	Other information

5027

Loss-of-Mains (LOM) Protection Tests									
The **Generator** shall demonstrate compliance with this EREC G99 in respect of LOM Protection by either providing the **DNO** with appropriate **Manufacturers' Information,** type test reports or by undertaking the following tests on site									
Calibration and Accuracy Tests									
Ramp in range 49.0-51.0 Hz	**Pickup (**+ / -0.025 Hzs^{-1})				**Relay Operating Time** oCoF= $\pm$**0.05 / 0.10 Hzs^{-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}	*>0.5 s*		*<1.0 s*	Pass/Fail
Reducing Frequency	*0.475* *0.975*		*0.525* *1.025*	Pass/Fail	0.55 Hzs^{-1} 1.1 Hzs^{-1}	*>0.5 s*		*<1.0 s*	Pass/Fail

Stability Tests					
Ramp in range 49.0-51.0 Hz	Test Condition	Test frequency ramp	Test Duration	Confirm No Trip	Result
Inside Normal band	< RoCoF (increasing f)	0.45 Hzs^{-1} 0.95 Hzs^{-1}	4.4 s		Pass/Fail
Inside Normal band	< RoCoF (reducing f)		2.1 s		Pass/Fail
Additional Comments / Observations:					

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

Wiring functional tests:	
If required by para 15.2.1, confirm that wiring functional tests have been carried out in accordance with the instructions below	Yes/ NA

Where components of a **Power Generating Module** are separately **Type Tested** and assembled into a **Power Generating Module**, if the connections are made via loose wiring, rather than specifically designed error-proof connectors, then it will be necessary to prove the functionality of the components that rely on the connections that have been made by the loose wiring.

As an example, consider a **Type Tested** alternator complete with its control systems etc. It needs to be connected to a **Type Tested Interface Protection** unit. In this case there are only three voltage connections to make, and one tripping circuit. The on-site checks need to confirm that the **Interface Protection** sees the correct three phase voltages and that the tripping circuit is operative. It is not necessary to inject the **Interface Protection** etc to prove this. Simple functional checks are all that are required.

Test schedule:

- With **Generating Unit** running and energised, confirm L1, L2, L3 voltages on **Generating Unit** and on **Interface Protection**.
- Disconnect one phase of the control wiring at the **Generating Unit**. Confirm received voltages at the **Interface Protection** have one phase missing.
- Repeat for other phases.
- Confirm a trip on the **Interface Protection** trips the **Generating Unit**.

Insert here any additional tests which have been carried out (as identified as being required by Form A3-1, A3-2 or A3-3)

A.3 Installation Document for Type A Power Generating Modules

Form A3: Installation Document

Please complete and provide this document for every **Power Generating Facility.**

Part 1 should be completed for the **Power Generating Facility**.

Part 2 should be completed for each of the **Power Generating Modules** being commissioned. Where the installation is phased the form should be completed as each part of the installation is completed in accordance with EREC G99 paragraph 15.3.3

Form A3 Part 1

To ABC electricity distribution **DNO**
99 West St, Imaginary Town, ZZ99 9AA abced@wxyz.com

Generator Details:	
Generator (name)	
Address	
Post Code	
Contact person (if different from **Generator**)	
Telephone number	
E-mail address	
MPAN(s)	
Generator signature	
Installer Details:	
Installer	
Accreditation / Qualification	
Address	

Post Code	
Contact person	
Telephone Number	
E-mail address	
Installer signature	
Installation details	
Address	
Post code	
Location within **Generator's Installation**	
Location of Lockable Isolation Switch	

Summary details of Power Generating Modules - where multiple **Power Generating Modules** will exist within one premises.

Manufacturer / Reference	Date of Installation	Technology Type	**Manufacturers** Ref No. (Product ID) or Reference to Form A-2-1/2/3 or combination of above as applicable	**Power Generating Module Registered Capacity in kW**				
				3-Phase Units	Single Phase Units			**Power Factor**
					PH1	PH2	PH3	

Emerging technology classification (if applicable)

Commissioning Checks

Description	**Confirmation**
Generator's 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 **Generator's 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*
Balance of Multiple Single Phase **PGMs**. Confirm that design of the **Generator's Installation** has been carried out to limit output power imbalance to below 16 A per phase, as required by EREC G99.	Yes / No*

5031

Form A3 Part 2	
Information to be enclosed	
Description	Confirmation *
Schedule of protection settings (may be included in circuit diagram)	Yes / No*
Final copy of circuit diagram	Yes / No*
Commissioning Checks	
The **Interface Protection** settings have been checked and comply with EREC G99.	Yes / No*
PGM successfully synchronises with the **DNO's Distribution Network** without causing significant voltage disturbance.	Yes / No*
PGM successfully runs in parallel with the **DNO's Distribution Network** without tripping and without causing significant voltage disturbances.	Yes / No*
PGM successfully disconnects without causing a significant voltage disturbance, when they are shut down.	Yes / No*
Interface Protection operates and disconnects the **DNO's Distribution Network** quickly (within 1s) when a suitably rated switch, located between the **PGM** and the **DNO's** incoming connection, is opened.	Yes / No*
PGM remains 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*
*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 **Generator's** Appointed Technical Representative	
I declare that for the **Type A Power Generating Module** within the scope of this EREC G99, and the installation: 1. Compliance with the requirements of EREC G99 is achieved. 2. The commissioning checks detailed in Form A2-4 have been successfully completed*. 3. The commissioning checks detailed in this Form A3 have been successfully completed. *delete if not applicable ie if the **Interface Protection** and ride through capabilities are **Type Tested**.	
Name:	
Signature:	Date:
Company Name:	
Position:	
Declaration – to be completed by **DNO** Witnessing Representative if applicable. Delete if not witnessed by the **DNO**.	
I confirm that I have witnessed the commissioning checks in this document on behalf of ______________________________ and that the results are an accurate record of the checks	
Name:	
Signature:	Date:
Company Name:	

A.4 Emerging Technologies and other Exceptions

A.4.1 Emerging Technologies

Ofgem published details of **Power Generating Modules** which are classified as emerging technologies in **Great Britain** in their document "Requirement for generators – 'emerging technology' decision document", 17 May 2017. The list is reproduced in the table A.4.1 below for reference.

Table A.4.1 Power Generating Modules classified as emerging technologies in GB

Manufacturer	Micro-generator
Baxi	'Baxi Ecogen' generators (the specific products are the Baxi Ecogen 24/1.0, Baxi Ecogen 24/1.0 LPG and Baxi Ecogen System).
KD Navien	KD Navien stirling engine m-CHP (Hybrigen SE) (the specific products that use this **Power Generating Module** are the 'NCM-1130HH – 1 KWel' and the 'NCM-2030HH – 2 kWel').
OkoFEN	Pellematic Smart_e
SenerTec	Dachs Stirling SE Erdgas and Dachs Stilring SE Flussiggas

For **Power Generating Modules** classified as an emerging technology at the time of their connection to a **DNO's Distribution Network**, the following sections of EREC G99 do not apply.

- The frequency withstand capability in 11.2.1;
- The rate of change of frequency requirements in 11.2.3;
- The constant **Active Power** output requirement in 11.2.4;
- The **Limited Frequency Sensitive Mode – Overfrequency** requirements in 11.2.5;
- The **Interface Protection** settings in 10.6.7.

Performance requirements for these emerging technologies and other exemptions will be within the voltage protection setting limits in Table 10.1 in Section 10.6.7 of this EREC G99, but they do not have to extend to the full ranges of the frequency protection requirements. For example if a technology can only operate in a frequency range from 49.5Hz to 50.5 Hz and outside of this it will disconnect from the **Distribution Network**, this technology would still be deemed to meet this EREC G99. Appropriate protection settings should be agreed with the **DNO**.

Emerging technology classification may be revoked as detailed in the Ofgem document "Requirement for generators – 'emerging technology' decision document", 17 May 2017.

Power Generating Modules classified as emerging technologies and connected to the **Distribution Network** prior to the date of revocation of that classification as an emerging technology shall be considered to be existing generators, and this Annex continues to apply.

A.4.2 Storage

For electricity storage devices the following sections of EREC G99 do not apply:

<u>**Type A** -less than 1 MW</u>:

- The constant **Active Power** output requirement in 11.2.4;
- The **Limited Frequency Sensitive Mode – Overfrequency** requirements in 11.2.5;

<u>**Type B** - 1 MW or greater but less than 10 MW</u>:

- The constant **Active Power** output requirement in 12.2.4;
- The **Limited Frequency Sensitive Mode – Overfrequency** requirements in 12.2.5;
- The **Fault Ride Through** requirements of 12.3 and 12.6

<u>**Type C** and **Type D** - 10 MW or greater and / or with a **Connection Point** at greater than 110 kV</u>:

- The constant **Active Power** output requirement in 13.2.3;
- The **Limited Frequency Sensitive Mode – Overfrequency** requirements in 13.2.5;
- The **Limited Frequency Sensitive Mode – Underfrequency** requirements in 13.2.6;
- **Frequency Sensitive Mode** in 13.2.7
- The **Fault Ride Through** requirements of 13.4 and 13.7

A.4.3 Infrequent Short-Term Parallel Operation

For **Power Generating Modules** that operate in parallel with the **Distribution Network** under an infrequent short-term parallel operation mode the following sections of EREC G99 do not apply:

<u>All</u>

- Section 9.1 to 9.5, 9.7
- Section 10

Type A - Less than 1 MW:

- All of Section 11

Type B - 1 MW or greater but less than 10 MW:

- All of Section 12

Type C and **Type D** -10 MW or greater and / or with a **Connection Point** at greater than 110 kV:

- All of Section 13

A.5 Example calculations to determine if unequal generation across different phases is acceptable or not

A **Generator Installation** might have 12 kW of PV and a 3 kW CHP plant. Due to the areas of roof available the PV plant comprises 2 by 4.5 kW **Inverters** and a 3 kW **Inverter**.

A. The following connection would be deemed acceptable:

- Ph 1 4.5 kW PV
- Ph 2 3 kW PV plus 3 kW CHP
- Ph 3 4.5 kW PV

This would lead to:

- 1.5 kW imbalance with CHP at zero output
- 1.5 kW imbalance with CHP and PV at maximum output
- 3 kW imbalance with CHP at maximum output and PV at zero output.

All of which are below the 16 A imbalance limit.

B. The following alternative connection for the same plant would be deemed unacceptable:

- Ph1 4.5 kW PV plus 3 kW CHP
- Ph 2 3 kW PV
- Ph3 4.5 kW PV

This is not acceptable as at full output Ph1 would have 4.5 kW more output than Ph2 and this exceeds the 16 A limit described above even though on an individual technology basis the limit of 16 A is not exceeded.

If a **Generator Installation** has a single technology installed which has **PGMs** with different output patterns for example PV mounted on roofs facing different directions then they should be regarded separately

(For these cases the assumption is that in the morning the east roof would produce full output and the west roof zero output with the opposite in the afternoon. Whilst this might not be strictly true the simplification makes the calculations much simpler)

A. The following connection would be deemed acceptable.

- Ph 1 6 kW east roof 6 kW west roof

- Ph 2 6 kW east roof 6 kW west roof
- Ph 3 5 kW east roof 5 kW west roof

B. The following alternative connection for the same plant would be deemed unacceptable.

- Ph1 12 kW east roof
- Ph2 5 kW east roof 5 kW west roof
- Ph 3 12 kW west roof

This is not acceptable as Ph 1 would produce more than Ph 3 in the morning and in the afternoon Ph 3 would produce more than Ph 1 in each case by a margin greater than 16 A.

A.6 Non-Standard private LV networks calculation of appropriate protection settings

The standard over and under voltage settings for **LV** connected **PGMs** have been developed based on a nominal **LV** voltage of 230 V. Typical **DNO** practice is to purchase transformers with a transformer winding ratio of 11 000:433, with off load tap changers allowing the nominal winding ratio to be changed over a range of ± 5% and with delta connected **HV** windings. Where a **DNO** provides a connection at **HV** and the **Generator** 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 **PGMs** connected to the **Generators LV** network. Where a **DNO** provides a connection at **HV** and the **Generators** 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 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 **Generator** is using a 11 000 V to 230/400 V transformer and it is proposed to operate it on tap 1 representing an increase in the **HV** winding of +5% and the nominal **HV** voltage is 11 000 V.

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

V_{LVsys} = 230 x 11 000/11 550 = 219 V

Where:

V_{LVsys} – **LV** system voltage

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

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

V_{HVtap} – **HV** tap position

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

OV stage 1	=	219x1.1	=	241 V
OV stage 2	=	219x1.13	=	247.5 V
UV stage 1	=	219x0.87	=	190.5 V
UV stage 2	=	219x0.8	=	175 V

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

Where **PGMs** 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 does not lend itself to **Fully Type Tested PGM**s and should only be used by prior arrangement with the host **DNO**. Where all other requirements of EREC G99 would allow the **Generating Unit** to be **Fully Type Tested**, the **Manufacturer** may produce a declaration in a similar format to Annex A.2, Form (A2-4) for presentation to the **DNO** by the **Installer**, stating that all **Generating Units** produced for a particular **Power Station** comply with the revised over and under voltage settings. All other required data should be provided as for **Fully Type Tested Generating Unit**s. This declaration should make reference to a particular **PGM** 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 **Installers** who will have to consult with the **Manufacturer** and **DNO** to agree settings for each particular **Power Station**.

A.7 Requirements for Type Testing Power Generating Modules

This Annex describes methodologies for undertaking compliance verification for **Type A Power Generating Modules**. The Annex describes approaches which were originally intended for small **Power Park Modules**. **Manufacturers** are free to adapt techniques described in Annex B where this is more economic or efficient, provided the **Type A** performance requirements are fully demonstrated. The Forms provided in Annex 3 should be used as a basis for demonstration of compliance.

Annex A.7.1 **Power Park Module** Requirements.

Annex A.7.2 **Synchronous Power Generating Module** Requirements.

Annex A.7.3 Additional Technology Requirements.

- A.7.3.1. Domestic CHP
- A.7.3.2. Photo-voltaic
- A.7.3.3. Fuel Cells
- A.7.3.4. Hydro
- A.7.3.5. Wind
- A.7.3.6. Energy Storage Devices

Annex A.7.1 relates to any **Generating Unit** that uses an **Inverter** (or Converter) as its means of connecting to the **Distribution Network**.

Annex A.7.2 relates to any **Synchronous Power Generating Module** that during normal running operation is connected directly to the **Distribution Network** and has a **Rated Capacity** < 50 kW, although **Manufacturers** may choose to use these requirements for larger **Type A Synchronous Power Generating Modules**.

For type testing any **Generating Unit** select either Annex A.7.1 or Annex A.7.2 as is most appropriate to the **Generating Unit** under test. Annex A.7.2 should also be used for asynchronous **Generating Units** that are not connected to the **Distribution Network** via an **Inverter** (ie induction **generating units)**.

The **Generating Unit** may also require additional technology type tests as identified in Annex A.7.3.

Examples

A Wind Turbine system using an **Inverter** (or **Inverters**) for connection is required to use Annex A.7.1 – "Common **Power Park Module** Requirements" and Annex A.7.3.5 – "Wind" Additional Technology Requirements.

A Hydro system using an induction generator connected directly to the **Distribution Network** is suggested to use Annex A.7.2 – "**Synchronous**" and Annex A.7.3.4– "Hydro" Additional Technology Requirements.

A.7.1 Power Park Module Requirements

A7.1.1 Certification & Type Testing Generating Unit Requirements

A.7.1 can apply to **Power Park Module**s or to individual **Inverters** and/or **Generating Unit**s if the functionality is included in each unit of a **Power Park Module**. Within this Section A.7.1 the term **Power Park Module** will be used but its meaning can be interpreted within A.7.1 to mean **Power Park Module**, **Generating Unit or Inverter** as appropriate.

A.7.1 describes a methodology for obtaining type certification or type verification for a **Power Park Module** containing an **Inverter**. Typically, all interface functions are contained within the **Inverter** and in such cases it is only necessary to have the **Inverter Type Tested.** Alternatively, a package of specific separate parts of equivalent function may also be **Type Tested**.

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

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)

Currently there are no harmonised functional standards that apply to the **Power Park Module**'s **Interface Protection**. Consequently, in cases where power electronics is used for energy conversion along with any separate **Interface Protection** unit they will need to be brought together and tested as a complete **Power Park Module** as described in this EREC G99, and recorded in format similar to that shown in Annex A.2 (Form A2-3).

Where the **Interface Protection** is physically integrated within the overall **Power Park Module** control system, the functionality of the **Interface Protection** unit should not be compromised by any failure of other elements of the control system (fail safe). For a **Full Type Tested Power Park Module** the completed **Power Park Module's Interface Protection** must not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections must be made by non-reversible plug and socket which the **Manufacturer** has made and tested prior to delivery to site.

Where **Type Tested** components are wired together on site, ie not using specifically designed plugs and sockets for the purpose, it will be necessary to prove that all wiring has been correctly terminated by proving the functions which rely on the wiring at the time of commissioning as detailed in paragraph 15.2 and Form A2-4, Annex A.2.

This Annex is primarily designed for the testing of three phase **Power Park Modules**. However, where practicable, a single phase, or split phase test may be carried out if it can be shown that it will produce the equivalent results.

This Annex applies to **Power Park Modules** either with or without load management or without energy storage systems connected on the energy source or prime mover side of the **Power Park Module**.

A7.1.2 Type Verification Functional Testing of the Interface Protection

Type Testing is the responsibility of the **Manufacturer**. This test will verify that the operation of the **Power Park Module Interface Protection** shall result:

a) in the safe disconnection of the **Power Park Module** from the **DNO's**

Distribution Network in the event that system parameters exceed the protection settings specified in Table 10.1; and

b) in the **Power Park Module** remaining connected to the **DNO's Distribution Network** while:

(1) network conditions are within the envelope specified by the settings plus and minus the tolerances specified for equipment operation in Table 10.1; and

(2) within the trip delay settings specified in Table 10.1.

Wherever possible the type testing of a **Power Park Module** designed for a particular type of prime mover should be proved under normal conditions of operation for that technology (unless otherwise noted).

A7.1.2.1 Disconnection times

The minimum trip time delay settings, for over / under voltage, over / under frequency and loss of mains tests below, are presented in Table 10.1.

For over / under voltage, over / under frequency and loss of mains tests, reconnection shall be checked as detailed below.

A7.1.2.2 Over / Under Voltage

The **Power Park Module** shall be tested by operating in parallel with a variable AC test supply, see Figure A7.1. Correct protection and ride-through operation shall be confirmed during operation of the **Power Park Module.** The set points for over and under voltage at which the **Power Park Module** disconnects from the supply will be established by varying the AC supply voltage.

To establish a trip voltage, the test voltage should be applied in steps of ± 0.5% or less, of the nominal voltage for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0.5 s starting at least 4 V below or above the setting. The test voltage at which this trip occurred is to be recorded. Additional tests just above and below the trip voltage should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the type verification test report Annex A.2-3.

To establish the trip time, the test voltage should be applied starting from 4 V below or above the recorded trip voltage and should be changed to 4 V above or below the recorded trip voltage in a single step. The time taken from the step change to the **Inverter** tripping is to be recorded on the type verification test report Annex A.2-3.

To establish correct ride-through operation, the test voltage should be applied at each setting ± 4 V and for the relevant times shown in the Table in Annex A.2-3.

For example to test overvoltage setting stage 1 which is required to be set at nominally 262.2 V the circuit should be set up as shown below and the voltage adjusted to 254.2 V. The **Power Park Module** should then be powered up to export a measurable amount of energy so that it can be confirmed that the **Power Park Module** has ceased to output energy. The variable voltage supply is then increased in steps of no more than 0.5% of nominal (1.15 V) maintaining the voltage for at least 1.5 s (trip time plus 0.5 s) at each voltage level. At each voltage level confirmation that the **Power Park Module** has not tripped after the time delay is required to be taken. At the voltage level at which a trip occurs then this should be recorded as the provisional trip voltage. Additional tests just below and if necessary just above the provisional trip voltage will allow the actual trip voltage to be established on a repeatable basis. This value should be recorded. For the sake of this example the actual trip level is assumed to have been established as being 261 V. The variable voltage supply should be set to 257 V the **Power Park Module** set to produce a measurable output and then the voltage raised to 265 V in a single step. The time from the step change to the output of **Power Park Module** falling to zero should be recorded as the trip time.

The **Power Park Module** then needs to operate at 4 V below the nominal overvoltage stage 1 setting which is 258.2 V for a period of at least 2 s without tripping and while producing a measurable output. This can be confirmed as a no trip in the relevant part of Annex A.2-3. The voltage then needs to be stepped up to the next level of 269.7 V for a period of 0.98 s and then back to 258.2 V during which time the output of the relay should continue with no interruption though it may change due to the change in voltage, this can be recorded as a no trip for the second value. The step up and step down test needs to be done a second time with a max value of 277.7 V and with a time of 0.48 s. The **Power Park Module** is allowed to shut down during this period to protect its self as allowed by note 1 of Table 10.1, but it must resume production again when the voltage has been restored to 258.2 V or it may continue to produce an output during this period. There is no defined time for resumption of production but it must be shown that restart timer has not operated so it must begin producing again in less than 20 s.

Note that this philosophy should be applied to the under voltage, over and under frequency, RoCoF and Vector shift stability tests which follow.

Note:
(1) The frequency required to trip is the setting ± 0.1 Hz
(2) Measurement of operating time should be measured at a value of 0.2 Hz (suggestion – 2 x tolerance) above/below the setting to give “positive” operation
(3) The “No trip tests” need to be carried out at the relevant values and times as shown in the table in Annex A.2-3 to ensure that the protection will not trip in error.

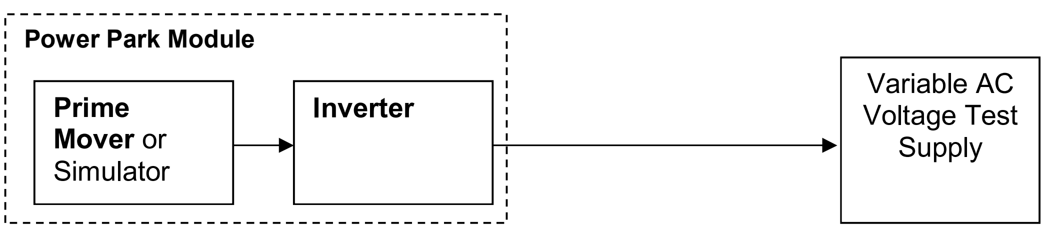


Figure A.7.1. Power Park Module test set up – over / under voltage

A.7.1.2.3 Over / Under Frequency

The **Power Park Module** shall be tested by operating in parallel with a low impedance, variable frequency test supply system, see Figure A.7.2. Correct protection and ride-through operation should be confirmed during operation of the **Power Park Module** . The set points for over and under frequency at which the **Power Park Module** system disconnects from the supply will be established by varying the test supply frequency.

To establish a trip frequency, the test frequency should be applied in a slow ramp rate of less than 0.1 Hzs^{-1}, or if this is not possible in steps of 0.05 Hz for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0.5 s. The test frequency at which this trip occurred is to be recorded. Additional tests just above and below the trip frequency should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the type verification test report Annex A.2-3.

To establish the trip time, the test frequency should be applied starting from 0.3 Hz below or above the recorded trip frequency and should be changed to 0.3 Hz above or below the recorded trip frequency in a single step. The time taken from the step change to the **Power Park Module** tripping is to be recorded on the type verification test report Annex A.2-3. It should be noted that with some loss of mains detection techniques this test may result in a faster trip due to operation of the loss of mains protection. There are two ways around this. Firstly the loss of mains protection may be able to be turned off in order to carry out this test. Secondly by establishing an accurate frequency for the trip a much smaller step change could be used to initiate the trip and establish a trip time. This may require the test to be repeated several times to establish that the time delay is correct.

To establish correct ride-through operation, the test frequency should be applied at each setting ± 0.2 Hz and for the relevant times shown in the table in Annex A.2-3.

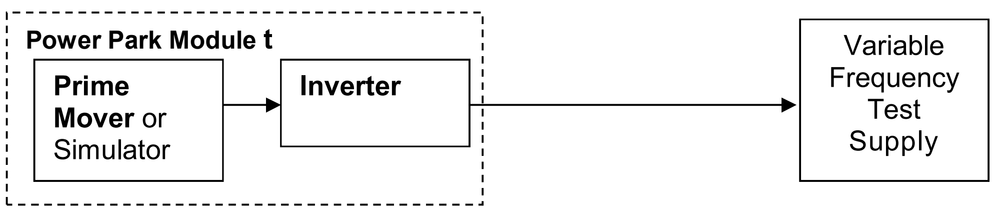


Figure A.7.2 Power Park Module test set up – over / under frequency

A.7.1.2.4 Loss of Mains Protection

The tests should be carried out in accordance with BS EN 62116 and a subset of results should be recorded as indicated in the Protection – loss of mains test section of Annex A.2-3 Type Test Verification Report.

Multi phase **Power Park Modules** should be operated at part load while connected to a network running at about 50 Hz and one phase only shall be disconnected with no disturbance to the other phases. The **Power Park Module** should trip within 1 s. The test needs to be repeated with each phase disconnected in turn while the other two phases remain in operation and the results recorded in the Type Test declaration.

A.7.1.2.5 Re-connection

Further tests will be carried out with the three test circuits above to check the **Power Park Module** time out feature prior to automatic network reconnection. This test will confirm that once the AC supply voltage and frequency have returned to be within the stage 1 settings specified in Table 1 following an automatic protection trip operation there is a minimum time delay of 20 s before the **Power Park Module** output is restored (ie before the **Power Park Module** automatically reconnects to the network).

A.7.1.2.6 Frequency Drift and Step Change Stability test.

The tests will be carried out using the same circuit as specified in A.7.1.2.3 above and following confirmation that the **Power Park Module** has passed the under and over frequency trip tests and the under and over frequency stability tests.

Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the **Power Park Module** should not trip during the test.

For the step change test the **Power Park Module** should be operated with a measurable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 s to complete the test. The **Power Park Module** should not trip during this test.

For frequency drift tests the **Power Park Module** should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0.19 Hzs^{-1} to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10 s. The **Power Park Module** should not trip during this test.

A.7.1.3 Limited Frequency Sensitive Mode – Over (LFSM-O)

There are two possible approaches to demonstrating **LFSM-O**. The first to use the test set up of Figure A.7.2. The second approach can be used where it is possible to inject a frequency control signal into the **Power Generating Module**. The **Manufacturer** or **Generator** can choose which is the more appropriate test for the **Power Generating Module**.

The test below uses the test set up of Figure A.7.2 to demonstrate **LFSM-O** using a variable frequency supply. The alternative approach is covered in A.7.2.4.

The test should be carried out above 80% **Registered Capacity** and repeated at 40-60% **Registered Capacity** using the specific threshold frequency of 50.4 Hz and **Droop** of 10%.

The **Power Park Module** should be tested at the following frequencies:

Step a) 50.00 Hz ±0.01 Hz
Step b) 50.45 Hz ±0.05 Hz
Step c) 50.70 Hz ±0.10 Hz
Step d) 51.15 Hz ±0.05 Hz
Step e) 50.70 Hz ±0.10 Hz
Step f) 50.45 Hz ±0.05 Hz
Step g) 50.00 Hz ±0.01 Hz

The frequency at each step should be maintained for at least one minute and the **Active Power** reduction in the form of a gradient determined and assessed for compliance with paragraph 11.2.4.

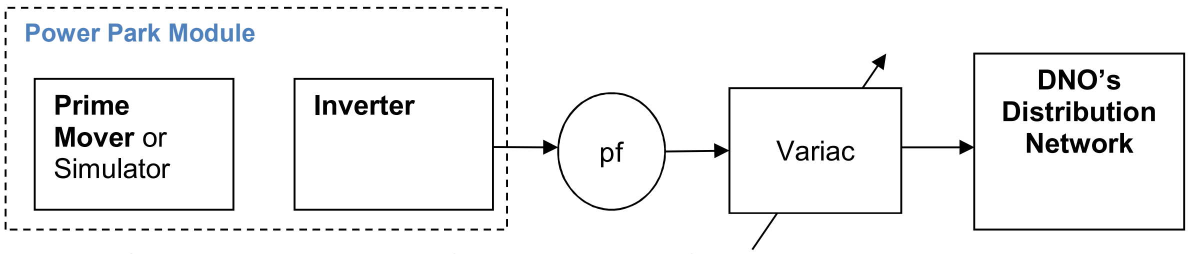
A.7.1.4 Power Quality

A.7.1.4.1 Harmonics

The tests should be carried out as specified in BS EN 61000-3-12 and can be undertaken with a fixed source of energy at two power levels firstly between 45 and 55% and at 100% of **Registered Capacity**.

A.7.1.4.2 Power Factor

The test set up shall be such that the **Power Park Module** supplies full load to the **DNO's Distribution Network** via the **Power Factor** (pf) meter and the variac as shown below in Figure A.7.3. The **Power Park Module Power Factor** should be within the limits given in paragraph 11.1.5, for three test voltages 0.94 pu, 1 pu V[10] and 1.1 pu V.



NOTE 1 For reasons of clarity the points of isolation are not shown.
NOTE 2: It is permissible to use a voltage regulator or tapped transformer to perform this test rather than a variac as shown.

Figure A.7.3 Power Park Module test set up – Power Factor

A.7.1.4.3 Voltage Flicker

The voltage fluctuations and flicker emissions from the **Power Park Module** shall be measured in accordance with BS EN 61000-3-11 and the technology specific Annex A.7.3. The required maximum supply impedance should be calculated and recorded in the relevant part of Compliance Verification Report Appendix A.3 (Form A3-1).

A.7.1.4.4 DC Injection

The level of **DC** injection from the **Power Park Module** -connected prime mover in to the **DNO's Distribution Network** shall not exceed the levels specified in 9.4.5 when measured during operation at three levels, 10%, 55% and 100% of rating with a tolerance of ±5%.

The DC injection requirements can be satisfied by the installation of an isolation transformer on the AC side of an **Inverter**-connected **Power Park Module**. A declaration that an isolating transformer is fitted can be made in lieu of the tests noted above.

A.7.1.5 Short Circuit Current Contribution

Power Park Module connected **Power Generating Module's** generally have small short circuit fault contributions however **DNO**'s need to understand the contribution that they make to system fault levels in order to determine that they can continue to safely operate without exceeding design fault levels for switchgear and other circuit components.

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[10] For a LV connected **Power Generating Module** 1 pu V = 230 V

The following type tests shall be carried out and the results noted in Annex A.2-3.

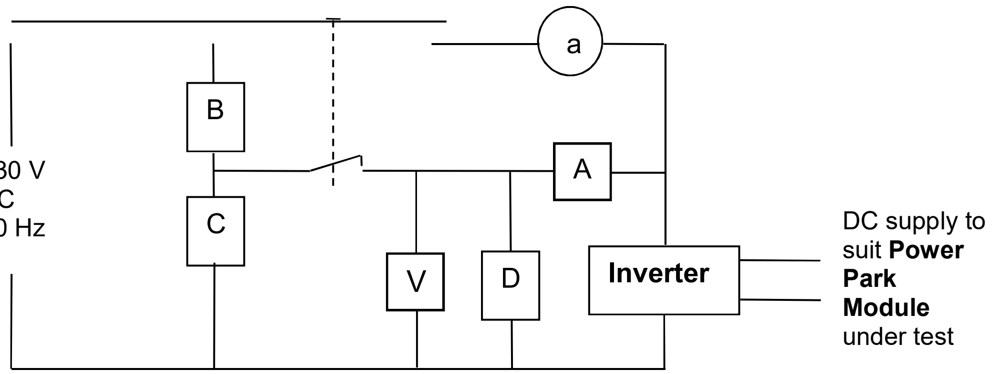

Figure A.7.4 Power Park Module short circuit test circuit

Test procedure

In Figure A.7.4 ‘A’ and ‘V’ are ammeters and voltmeters used to record the test data required. Component ‘D’ is a resistive load plus resonant circuit as required for the loss of mains test as specified in BS EN 62116 set up to absorb 100% **Registered Capacity** of the **Power Park Module**. Component ‘a’ is an ammeter used to confirm that all the output from the **Inverter** is being absorbed by component D. Components ‘B’ and ‘C’ are set up to provide a voltage of between 10% and 40% of nominal when component ‘C’ carries the **Registered Capacity** of the **Power Park Module** in Amps.

Component ‘C’ should be short term rated to carry the load which would appear through it should it be energised at 253 V for at least 1 s. Component ‘B’ is to have an impedance of between 10 and 20 Ω per phase. If components ‘B’ and ‘C’ are short time rated then an additional switch in series with ‘B’ and ‘C’ can be inserted and arranged to be closed shortly before the main change over switch shown on the drawing and opened at the end of the test period. Components ‘B’ and ‘C’ are to have an X to R ratio of 2.5 to 1.

The test is carried out by setting up the **Power Park Module** and load ‘D’ to produce and then absorb the **Registered Capacity** of the **Inverter**. When zero export is shown by ammeter ‘a’ then the changeover switch shown is operated connecting the **Inverter** to the reduced voltage connection created by components ‘B’ and ‘C’ and disconnecting it from the normal connection. The make contact is an early make and the break contact a late break so that the **Power Park Module** is not disconnected from a mains connection for any significant time.

The values of voltage and current should be recorded for a period of up to 1 s when the changeover switch should be returned to the normal position. The voltage and current at relevant times shall be recorded in the type test report (Annex A.2-3) including the time taken for the **Power Park Module** to trip. (It is expected that the **Power Park Module** will trip on either loss of mains or under voltage in less than 1 s).

A7.1.6 Self-Monitoring - Solid State Disconnection

Some **Power Park Modules** include solid state switching devices to disconnect from the **DNO's Distribution Network**. In this case paragraph 9.7.9 requires the control equipment to monitor the output stage of the **Power Park Module** to ensure that in the event of a protection initiated trip the output voltage is either disconnected completely or reduced to a value below 50 V AC. This shall be verified either by self-certification by the **Manufacturer**, or additional material shall be presented to the tester sufficient to allow an assessment to be made.

A.7.2 Synchronous Power Generating Module Requirements (up to and including 50 kW)

A7.2.1 Certification & Type Testing Generating Unit Requirements

This Annex describes a methodology for obtaining type certification or type verification for a **Synchronous Power Generating Module** in conjunction with Form A3-1. Other compliance requirements are detailed in Form A3-2 which may be used as an alternative to this Annex.

The **Interface Protection** of the **Synchronous Power Generating Module** shall satisfy the requirements of all of the following standards. Where these standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable.

- 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)

Currently there are no harmonised functional standards that apply to the **Power Generating Module Interface Protection**, therefore in order to achieve **Type Tested** status the **Controller** and any separate **Interface Protection** unit will require their functionality to be **Type Tested** as described in this Annex, and recorded in format similar to that shown in Annex A.2-1.

Where the **Interface Protection** is physically integrated within the overall **Power Generating Module** control system, the functionality of the **Interface Protection** unit should not be compromised by any failure of other elements of the control system (fail safe). For a **Full Type Tested Power Generating Module** the completed **Power Generating Module's Interface Protection** must not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections must be made by non-reversible plug and socket which the **Manufacturer** has made and tested prior to delivery to site.

Where **Type Tested** components are wired together on site, ie not using specifically designed plugs and sockets for the purpose, it will be necessary to prove that all wiring has been correctly terminated by proving the functions which rely on the wiring at the time of commissioning as detailed in paragraph 15.2 and Form A2-4, Annex A.2.

Wherever possible the type testing of a **Power Generating Module** utilising a particular type of prime mover should be proved under normal conditions of operation for that prime mover (unless otherwise noted).

This Annex can also be used for asynchronous **Generating Units** that are not connected to the **Distribution Network** via an **Inverter** as appropriate.

This Annex also applies to any **Synchronous Power Generating Modules** that are powered by stored energy (eg compressed air), but the requirement to demonstrate the **LFSM-O** will not be required.

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A.7.2.2 Type Verification Testing of the Interface Protection Functions

Type verification testing is the responsibility of the **Manufacturer**. This test will verify that the operation of the **Power Generating Module Interface Protection** shall result:

a) in the safe disconnection of the **Power Generating Module** from the **DNO's Distribution Network** in the event that the protection settings specified in Table 10.1 are exceeded; and

b) in the **Power Generating Module** remaining connected to the **DNO's Distribution Network** while network conditions are:

   (1) within the envelope specified by the settings plus and minus the tolerances specified for equipment operation in Table 10.1; and

   (2) within the trip delay settings specified in Table 10.1.

The **Interface Protection** may be incorporated into the **Controller** in which case it should be tested as part of the **Controller**. Alternatively, the constituent devices that form the **Interface Protection** may be discrete in which case the tests may be carried out on the discrete protection devices independently from the **Controller**.

In either case it will be necessary to verify that a protection operation will disconnect the **Power Generating Module** from the **DNO's Distribution Network**.

A7.2.2.1 Disconnection times

The minimum trip time delay settings, for over / under voltage, over / under frequency and loss of mains tests below, are presented in Table 10.1.

For over / under voltage, over / under frequency and loss of mains tests, reconnection shall be checked as detailed below.

In some systems it may be safer and more convenient to test the trip delay time and the disconnection time separately. This will allow the trip delay time to be measured in a test environment (in a similar way as for a protection relay). The disconnection time can be measured in the **Power Generating Module's** normal operation, allowing accurate measurement with correct inertia and prime mover characteristics. This is permitted providing the total disconnection time does not exceed the value specified in Section 10.6.7.1. When measuring the disconnection time where the **Interface Protection** is included in the **Controller**, 5 s disconnections should be initiated, and the average time recorded.

A.7.2.2.2 Over / Under Voltage

The **Interface Protection** shall be tested by operating the **Controller** in parallel with a variable AC test supply, as an example see Figure A.7.5. Correct protection and ride-through operation shall be confirmed. The set points for over and under voltage at which the **Interface Protection** disconnects from the supply, will be established by varying the AC supply voltage. The disconnect sequence should be initiated when the network conditions mean the protection should trip in accordance with the settings in Table 10.1, otherwise normal operation should continue.

To establish the certified trip voltage, the test voltage should be applied in steps of ± 0.5% of setting for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0.5 s. It will be necessary to carry out five tests for each trip setting. The test voltage at which this trip occurred is to be recorded as the certified trip voltage.

To establish the certified trip time, the test voltage should be applied starting from ± 1.8% below the certified trip voltage in a step of at least ± 0.5% of setting for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0.5 s. Where the **Interface Protection** functionality is implemented in the **Controller** it will be necessary to carry out five tests for each trip setting. The longest trip time is to be recorded as the certified trip time.

For example, to test overvoltage setting stage 1 which is required to be set at nominally 262.2 V the circuit can be set up as shown below and the voltage adjusted to 254.2 V. In integrated designs where there is no separate way of establishing that the **Power Generating Module** is disconnected, the **Power Generating Module** should be powered up to export a measurable amount of energy so that it can be confirmed that the **Power Generating Module** has ceased to output energy. The variable voltage supply is then increased in steps of no more than 0.5% of nominal voltage (1.15 V) maintaining the voltage for at least 1.5 s (trip time plus 0.5 s) at each voltage level. At each voltage level confirmation that the **Power Generating Module** has not tripped after the time delay is required to be taken. At the voltage level at which a trip occurs then this should be recorded as the provisional trip voltage. Additional tests just below and if necessary just above the provisional trip voltage will allow the actual trip voltage to be established on a repeatable basis. This value should be recorded. For the sake of this example the actual trip level is assumed to have been established as being 261 V. The variable voltage supply should be set to 257 V the **Power Generating Module** set to produce a measurable output (if necessary) and then the voltage raised to 265 V in a single step. The time from the step change to the disconnection of the **Power Generating Module**, the output of the **Power Generating Module** falling to zero should be recorded as the trip time.

To confirm that the protection does not trip before the required time, the test voltage should be applied at each setting ± 4V and for the relevant times shown in the table in Annex A.2-1.

Test results should be recorded on the Test Sheet shown in Annex A.2-1.

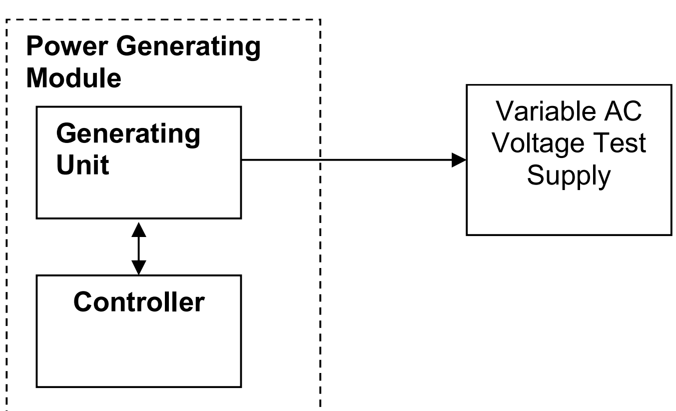


Figure A.7.5.- Power Generating Module test set up – over / under voltage

A.7.2.2.3 Over / Under Frequency

The **Interface Protection** shall be tested by operating the **Controller** in parallel with a low impedance, variable frequency test supply system, as an example, see Figure A.7.6. Correct protection and ride-through operation should be confirmed during the test. The set points for over and under frequency at which the **Interface Protection** disconnects from the supply will be established by varying the test supply frequency.

To establish a trip frequency, the test frequency should be applied in a slow ramp rate of less than 0.1 Hzs^{-1}, or if this is not possible in steps of 0.05 Hz for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0.5 s. The test frequency at which this trip occurred is to be recorded. Additional tests just above and below the trip frequency should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the type verification test report Annex A.2-1.

To establish the trip time, the test frequency should be applied starting from 0.3 Hz below or above the recorded trip frequency and should be changed to 0.3 Hz above or below the recorded trip frequency in a single step. The time taken from the step change to the **Power Generating Module** tripping is to be recorded on the type verification test report Annex A.2-1. It should be noted that with some loss of mains detection techniques this test may result in a faster trip due to operation of the loss of mains protection and if possible the loss of mains protection should be turned off in order to carry out this test. Otherwise a much smaller step change should be used to initiate the trip and establish a trip time which may require the test to be repeated several times to establish that the time delay is correct.

To confirm that the protection does not trip before the required time the test frequency should be applied at each setting ± 0.2 Hz and for the relevant times shown in the table in Annex A.2-1.

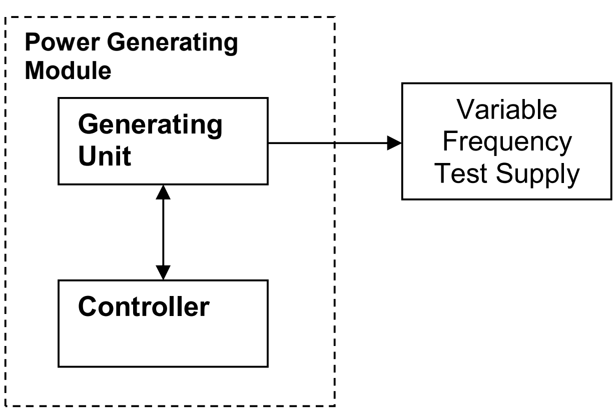


Figure A.7.6. Power Generating Module test set up – over / under frequency

A.7.2.2.4 Loss of Mains Protection

The resonant test circuit specified as an option for this test has been designed to model the interaction of the **Power Generating Module** under test with the local load including multiple **Power Generating Module's** in parallel.

The **Power Generating Module** output shall be connected to a network combining a resonant circuit with a Q factor of >0.5 and a variable load. The value of the load is to match the **Power Generating Module** output. To facilitate the test for LoM there shall be a switch placed between the test load/ **Power Generating Module** combination and the **DNO's Distribution Network**, as shown in Figure A.7.7.

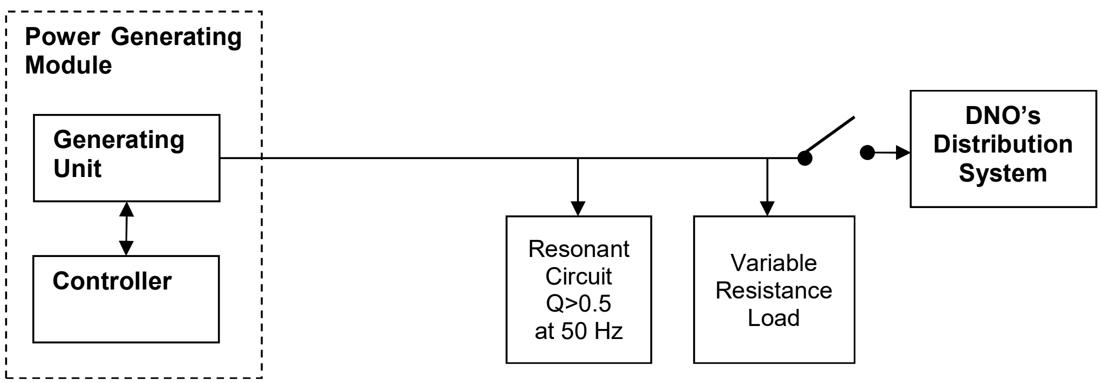


Figure A.7.7 Power Generating Module test set up - loss of mains

The **Power Generating Module** is to be tested at three levels of the **Power Generating Module's Registered Capacity**: 10%, 55% and 100% and the results recorded on the test sheet of Annex A.2-1.
For each test the load match is to be within ± 5%. Each test is to be repeated five times.

Load match conditions are defined as being when the current from the **Power Generating Module** meets the requirements of the test load ie there is no export or import of supply frequency current to or from the **DNO's Distribution Network**.

The tests will record the **Power Generating Module**'s output voltage and frequency from at least 2 cycles before the switch is opened until the protection system operates and disconnects itself from the **DNO's Distribution Network**, or for 5 s whichever is the lower duration.

The time from the switch opening until the protection disconnection occurs is to be measured and must comply with the requirements in Table 10.1.

Multi phase **Power Generating Modules** should be operated at part load while connected to a network running at about 50 Hz and one phase only shall be disconnected with no disturbance to the other phases. The **Power Generating Module** should trip within 1 s. The test needs to be repeated with each phase disconnected in turn while the other two phases remain in operation and the results recorded in the **Type Test** declaration.

A.7.2.2.5 Re-connection

Further tests will be carried out with the three test circuits above to check the **Power Generating Module** time- out feature prior to automatic network reconnection. This test will confirm that once the AC supply voltage and frequency have returned to within the stage 1 settings specified in Table 10.1 following an automatic protection trip operation there is a minimum time delay as specified in Table 10.1 before reconnection will be allowed.

A.7.2.2.6 Frequency drift and vector shift stability test.

The tests will be carried out using the same circuit as specified in A.7.2.2.3 above and following confirmation that the **Power Generating Module** has passed the under and over frequency trip and no trip tests.

Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the **Power Generating Module** should not trip during the test.

For the step change test the **Power Generating Module** should be operated with a measurable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 s to complete the test. The **Power Generating Module** should not trip during this test.

For frequency drift tests the **Power Generating Module** should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0.19 Hzs^{-1} to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10 s. The **Power Generating Module** should not trip during this test.

A.7.2.3 Power Output with Falling Frequency

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.

The tests can be undertaken by the **Synchronous Power Generating Module** powering a suitable load bank, or alternatively using the test set up of Figure A8.6. In both cases a suitable test could be to start the test at nominal frequency with the **Synchronous Power Generating Module** operating at 100% of its **Registered Capacity**.

The frequency should then be set to 49.5 Hz for 5 minutes. The output should remain at 100% of **Registered Capacity**.

The frequency should then be set to 49.0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 99% of **Registered Capacity**.

The frequency should then be set to 48.0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 97% of **Registered Capacity**.

The frequency should then be set to 47.6 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 96.2% of **Registered Capacity**.

The frequency should then be set to 47.1 Hz and held at this frequency for 20 s. The **Active Power** output must not be below 95.0% of **Registered Capacity** and the **Synchronous Power Generating Module** must not trip in less than the 20s of the test.

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

A.7.2.4 Limited Frequency Sensitive Mode – Over (LFSM-O)

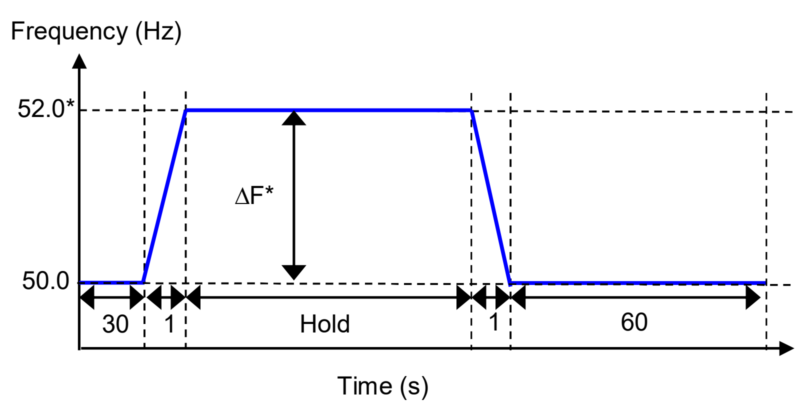
Note that this test is also an alternative to the test in A.7.1.3.

The two frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** capability to a frequency injection as shown by Figure A.7.8 and Figure A.7.9 are to be conducted at **Registered Capacity**.

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

The expected **Active Power** response which is illustrated in Figure A.7.9 and Figure A.7.10 should be in accordance with Section 11.2.5 (a threshold frequency of 50.4 Hz and a **Droop** of 10%) and undamped oscillations should not occur after the step or ramp frequency change.

The response should commence within 2 s (or such time as the **DNO** might agree with the **Generator**); ie the response should normally be contained within the blue lines, and as close to the left as possible, when following the frequency ramp. The response should be complete in a reasonable time and the **DNO** can agree with the **Generator** a longer completion time than suggested by the blue lines taking into account the technical capabilities of the **Power Generating Module** and its prime mover.



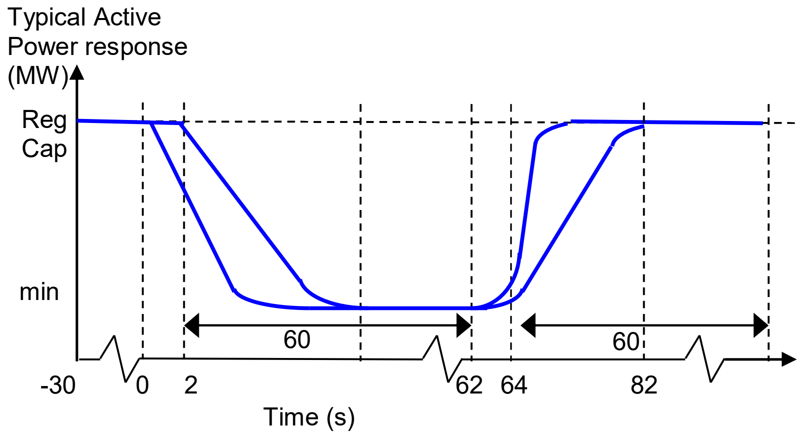
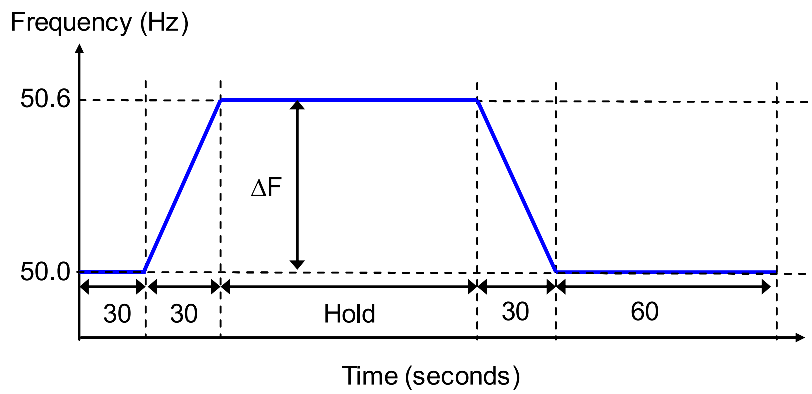


Figure A.7.8: LFSM-O step response test

* This will generally be +2.0 Hz 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 1.5 Hz is needed to take an initial output 100% to a final output of 70%. If the initial output is not 100% and the **Minimum Generation** is not 70% then the injected step should be adjusted accordingly as shown in the example given below:

Initial output	100%
Minimum Generation	70%
Frequency controller **Droop**	10%
Frequency to be injected	= (1.00 – 0.70) x 0.1 x 50 = 1.5Hz



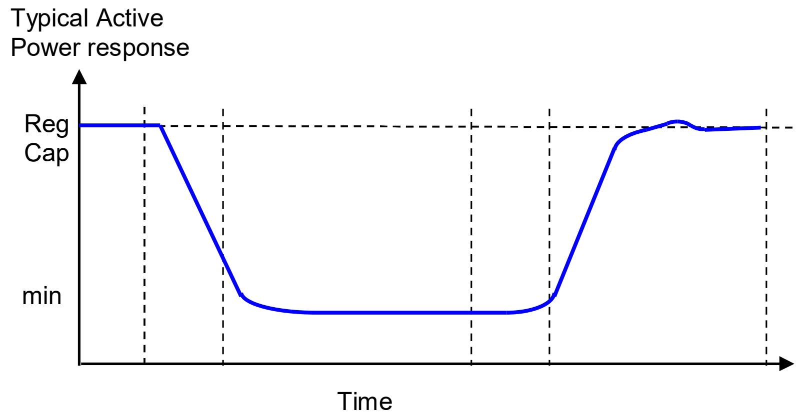


Figure A.7.9: LFSM-O ramp response test

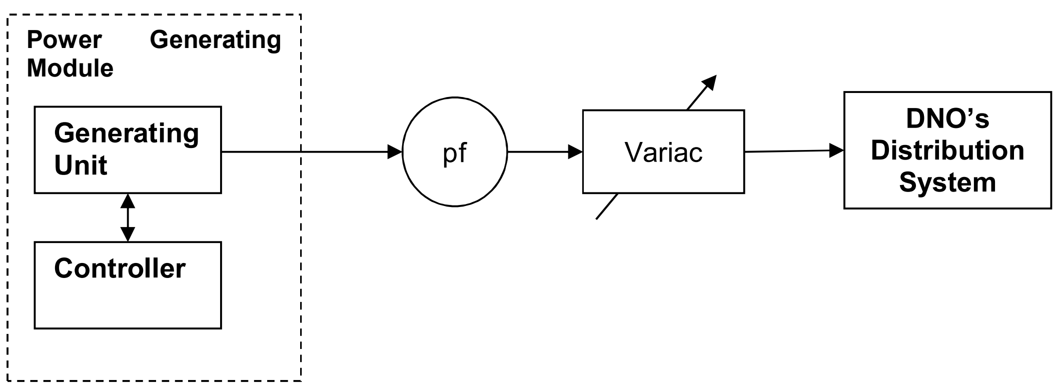
A.7.2.5 Power Quality

A.7.2.5.1 Harmonics

The tests should be carried out as specified in BS EN 61000-3-12 and can be undertaken with a fixed source of energy at two power levels firstly between 45 and 55% and at 100% of maximum export capacity.

A.7.2.5.2 Power Factor

The test set up shall be such that the **Power Generating Module** supplies full load to the **DNO's Distribution Network** via the **Power Factor** (pf) meter and the variac as shown below in Figure A.7.10. The **Power Generating Module** pf should be within the limits given in paragraph 11.1.5, for three test voltages 230 V –6%, 230 V and 230 V +10%.



NOTE 1. For reasons of clarity the points of isolation are not shown
NOTE 2: It is permissible to use a voltage regulator or tapped transformer to perform this test rather than a variac as shown

Figure A.7.10 Power Generating Module test set up – Power Factor

A.7.2.5.3 Voltage Flicker

The voltage fluctuations and flicker emissions from the **Generating Unit** shall be measured in accordance with BS EN 61000-3-11 and technology specific annex. The required maximum supply impedance should be calculated and recorded in the **Type Test** declaration Annex A.2-1.

A.7.3 Additional Power Generating Module Technology Requirements

A.7.3.1 Domestic CHP

For Domestic CHP **Power Park Modules** the type verification testing and **Interface Protection** requirements will be as per the requirements defined in Annex A.7.1.

For Domestic CHP **Synchronous Power Generating Modules** the type verification testing and **Interface Protection** requirements will be as per the requirements defined in Annex A.7.2.

A.7.3.2 Photovoltaic

As all current Photovoltaic **Power Park Modules** will connect to the **DNO's Distribution Network** via an **Inverter**, the type verification testing and **Interface Protection** requirements will be as per the requirements defined in Annex A.7.1.

A.7.3.3 Fuel Cells

As all current Fuel Cell **Power Generating Modules** will connect to the **DNO's Distribution Network** via an **Inverter**, the type verification testing and **Interface Protection** requirements will be as per the requirements defined in Annex A.7.1.

A.7.3.4 Hydro

Hydro can be connected to the **DNO's Distribution Network** directly using induction or **Synchronous Power Generating Modules** or it can be connected by an **Inverter**.

The common requirements for the generator technologies will apply to micro hydro in addition the following needs to be taken into consideration.

Power Generating Modules with manually fixed output or where the output is fixed by controlling the water flow through the turbine to a steady rate, need to comply with the maximum voltage change requirements of BS EN 61000-3-2 but do not need to be tested for P_{st} or P_{lt}.

Power Park Modules where the output is controlled by varying the load on the generator using the **Inverter** and which therefore produces variable output need to comply with the maximum voltage change requirements of BS EN 61000-3-2 and also need to be tested for P_{st} and P_{lt} over a period where the range of flows varies over the design range of the turbine with a period of at least 2 hours at each step with there being 10 steps from min flow to maximum flow. P_{st} and P_{lt} values to recorded and normalised as per the method laid down in Annex A.3.

A7.3.5 Wind

Wind turbines can be connected to the **DNO's Distribution Network** directly, typically using asynchronous induction generators, or using **Inverters**.

For those connected via **Inverters**, the type verification testing and **Interface Protection** requirements shall be as specified in Annex A.7.1.

For those connected directly to the **DNO's Distribution Network**, the type verification testing and **Interface Protection** requirements shall be as specified in Annex A.7.2.

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 1 ms^{-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 1 ms^{-1}. The dataset shall be considered complete when each bin includes a minimum of 10 minutes of sampled data.

The highest recorded values across the whole range of measurements should be used as inputs to the calculations described in BS EN 61000-3-11 to remove background flicker values. Then the required maximum supply impedance values can be calculated as described in Annex A.2-3. 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.

A.7.3.6 Electricity Storage Device

Electricity storage devices can be connected to the **DNO's Distribution Network** directly or using **Inverters**.

For those connected via **Inverters**, the type verification testing and **Interface Protection** requirements shall be as specified in Annex A.7.1

For those connected directly to the **DNO's Distribution Network**, the type verification testing and **Interface Protection** requirements shall be as specified in Annex A.7.2.

The tests associated with any requirements which have been identified in Annex A4 as not being applicable to electricity storage devices can be considered to be excluded tests in this Annex A7.

Annex B

B.1 Application

The application for connection of a **Power Generating Module** should be made to the **DNO** using the Standard Application Form on the **DNO** or ENA website.

B.2 Power Generating Module Document Type B

<table>
<tr><td colspan="2">Form B2-1 Power Generating Module Document for Type B Power Generating Modules

Compliance Statement

This document shall be completed by the Generator</td></tr>
<tr><td><u>Power Generating Module (PGM)</u>

PGM Name:

Compliance Contact (name/tel/email):</td><td><u>Distribution Network Operator (DNO)</u>:

DNO Name: ABC electricity distribution

Compliance Contact (name/tel/email):</td></tr>
<tr><td colspan="2">Key to Submission Stage

A – Application: Submission of the Standard Application Form

IS – Initial Submission: The programme of initial compliance document submission to be agreed between the Generator and the DNO as soon as possible after acceptance of a Connection Offer. Initial Submission of this Power Generating Module Document to be completed at least 28 days before the Generator wishes to synchronise its Power Generating Module for the first time.

FONS – Final Operational Notification Submission: The Generator shall submit post energisation verification test documents to obtain Final Operational Notification from the DNO.</td></tr>
<tr><td>Key to evidence requested

S - Indicates that DNO would expect to see the results of a simulation study

P - Generating Unit or Power Generating Module design data

MI - Manufacturers' Information, generic data or test results as appropriate

D - Copies of correspondence or other documents confirming that a requirement has been met

T - Indicates that the DNO would expect to see results of, and/or witness, tests or monitoring which demonstrates compliance

TV - Indicates Type Test reports (if Generator pursues this compliance option)</td><td>Key to Compliance

Y = Yes (Compliant),

O = Outstanding (outstanding submission)

UR= Unresolved issue

N = No (Non-Compliant)</td></tr>
</table>

Note that second part of this form is split into two Sections, the first Section is applicable to **Synchronous Power Generating Modules**, the second Section is applicable to **Power Park Modules**				
Issue	Date of Issue	Compliance Declaration Signatory Name	Compliance Declaration Signature	Issue Notes
Issue #	DD/MM/YY		I declare that the details provided in this issue of this **Power Generating Module Document** comply with the requirements of G99	Insert brief description of amendment
1				
Final Issue Prior to **FON**				
Details of Power Generating Module				
Connection Voltage				
Registered Capacity				
Manufacturer / Reference				
Technology Type				

Compliance Requirements for Synchronous Power Generating Modules				Response	
G99 Reference	**Compliance Requirement of the Power Generating Module**	**Submission Stage**	**Evidence Requested (and / or)**	**Compliance** **Y, O, UR, N**	**User's Statement** *(Provide document references with any additional comments)*
17.2.1, 17.2.3, 17.4.1	Confirmation that a completed Standard Application Form has been submitted to the **DNO**	A, IS, FONS	P, MI, D		
9.4.3	**Power Quality – Voltage fluctuations and Flicker**: The installation must be designed in accordance with EREC P28.	IS	MI, D, TV		
9.4.2	**Power Quality – Harmonics**: The installation must be designed in accordance with EREC G5	IS	MI, D, TV		
12.5	**Reactive Power capability** Confirm compliance with Section 12.5 by carrying out simulation study in accordance with B.4.2 and by submission of a report	IS	S, MI, TV		
12.4	**Voltage Control and Reactive Power Stability** Confirm compliance with Section 12.4 by carrying out simulation study in	IS	S, MI, TV		

	accordance with B.4.3 and by submission of a report				
12.2	Confirm that the plant and apparatus is able of continue to operate during frequency ranges specified in 12.2	IS	MI, TV		
12.2.5	**Limited Frequency Sensitive Mode – Over frequency** Confirm the compliance with 12.2.5 by carrying out simulation study in accordance with B.4.5 and by submission of a report.	IS	S, TV		
12.1.3	Confirm the **Active Power** set point can be adjusted in accordance with instructions issued by the **DNO**	IS	MI, TV		
12.3	**Fault Ride Through** Confirm the compliance with 12.3 by carrying out simulation study in accordance with B.4.4 and by submission of a report.	IS	MI, TV, S		
Section 10 and Form B2-2	**Interface Protection:** • Over and under voltage protection • Over and Under Frequency protection • Loss of mains protection	IS, FONS	MI, TV, T		

	Other protection: • Details of any special protection, eg Pole Slipping or islanding As an alternative to demonstrating protection compliance with Section 10 using **Manufacturers' Information** or type test reports, site tests can be undertaken at the time of commissioning the **Power Generating Module**.				
12.4	**Excitation System Open Circuit Step Response Tests** Confirm the performance requirements of a continuously acting voltage control system by testing in accordance with B6.2	FONS	T, MI, TV		
12.4	**Open & Short Circuit Saturation Characteristics** Confirm the performance requirements of a continuously acting voltage control system by testing in accordance with B.5.3	FONS	T, MI, TV		
12.4.3	**Excitation System On-Load Tests** Confirm the operation of the **Excitation System** on load is compliant with paragraph 12.4.3 by testing in accordance with B.5.4	FONS	T, MI, TV		

12.5	**Reactive Capability Test** Confirm the **Reactive Power** capability of the **Synchronous Power Generating Module** to meet the requirements of Section 12.5 by testing in accordance with B.5.5.	FONS	T, MI, TV		
12.2	**Frequency Response Tests** Confirm the **Synchronous Power Generating Module** meets the requirements of 12.2 by testing in accordance with B.5.6.	FONS	T, MI, TV		
12.2.4	**Output Power with falling frequency** Confirm the **Synchronous Power Generating Module** meets the requirements of 12.2.4 by testing in accordance with B.5.7.	FONS	T, MI, TV		
10.3.4	**Automatic reconnection** Confirm by testing that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency.	FONS	T, MI, TV		
B3	Installation and Commissioning Form B3 completed with signed acceptance from the **DNO** representative.	FONS	T		

Compliance Requirements for Power Park Module				**Response**	
G99 Reference	**Compliance Requirement of the Power Generating Module**	**Submission Stage**	**Evidence Requested (and / or)**	**Compliance** **Y, O, UR, N,**	**User's Statement** *(Provide document references with any additional comments)*
17.2.1, 17.2.3, 17.4.1	Confirmation that a completed Standard Application Form has been submitted to the **DNO**	A, IS, FONS	P, MI, D		
9.4.3	**Power Quality – Voltage fluctuations and Flicker**: The installation must be designed in accordance with EREC P28.	IS	MI, D, TV		
9.4.2	**Power Quality – Harmonics**: The installation must be designed in accordance with EREC G5	IS	MI, D, TV		
12.5	**Reactive Power capability** Confirm compliance with Section 12.5 by carrying out simulation study in accordance with B.4.2 and by submission of a report	IS	S, MI, TV		
12.4	**Voltage Control and Reactive Power Stability** Confirm compliance with Section 12.4 by	IS	S, MI, TV		

	carrying out simulation study in accordance with B.4.3 and by submission of a report				
13.2.1	**Limited Frequency Sensitive Mode – Over frequency** Confirm the compliance with 13.2.1 by carrying out simulation study in accordance with C.7.6 and by submission of a report.	IS	S, MI, TV		
12.2	Confirm that the plant and apparatus is able of continue to operate during frequency ranges specified in 12.2	IS	MI, TV		
12.2.5	**Limited Frequency Sensitive Mode – Under frequency** Confirm the compliance with 12.2.5 by carrying out simulation study in accordance with B.4.5 and by submission of a report.	IS	S, MI, TV		
12.1.3	Confirm the **Active Power** set point can be adjusted in accordance with instructions issued by the **DNO**	IS	MI, TV		
12.3 and 12.6	**Fault Ride Through and Fast Fault Current Injection** Confirm the compliance with 12.3 and 12.6 by carrying out simulation study in	IS	MI, TV, S		

	accordance with B.4.4 and by submission of a report.				
Section 10 and Form B2-2	**Interface Protection:** • Over and under voltage protection • Over and Under Frequency protection • Loss of mains protection Other protection: • Details of any special protection, eg Pole Slipping or islanding As an alternative to demonstrating protection compliance with Section 10 using **Manufacturers' Information** or type test reports, site tests can be undertaken at the time of commissioning the **Power Generating Module**.	IS, FONS	MI, TV, T		
12.4	**Voltage Control Test** Confirm the performance requirements of a continuously acting voltage control system by testing in accordance with B.6.4	FONS	T, MI, TV		
12.5	**Reactive Capability Test** Confirm the **Reactive Power** capability of the **Power Park Module** meet the requirements of Section 12.5 by testing in accordance with B.6.3	FONS	T, MI, TV		

12.2	**Frequency Response Test** Confirm the **Power Park Module** meets the requirements of 12.2 by testing in accordance with B.6.5.	FONS	T, MI, TV		
10.3.4	**Automatic reconnection** Confirm by testing that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency.	FONS	T, MI, TV		
B.3	Installation and Commissioning Form B3 completed with signed acceptance from the **DNO** representative.	FONS	T		

Site Compliance and Commissioning test requirements for Type B Power Generating Modules

Form B2-2: Site Compliance and Commissioning test requirements for Type B Power Generating Modules

This form should be completed if site compliance tests are being undertaken for some or all of the **Interface Protection** where it is not **Type Tested** and for other compliance tests that are being undertaken on site.

Generator Details:	
Generator (name)	
Installation details:	
Address	
Post Code	
Date of commissioning	

Requirement	Compliance by provision of **Manufacturers' Information** or type test reports. Reference number should be detailed and **Manufacturers' Information** attached.	Compliance by commissioning tests Tick if true and complete relevant sections of form below
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		
Wiring functional tests: If required by para 15.2.1		

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,** type test reports or by undertaking the following tests on site.

Tests referenced to 110 V ph-ph VT output

Calibration and Accuracy Tests

Phase	Setting	Time Delay	**Pickup Voltage**				**Relay Operating Time** measured value ± 2 V				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2	**121 V** 110 V VT secondary	**1.0 s**	*119.35*		*122.65*	Pass/ Fail	Measured value plus 2 V	*1.0 s*		*1.1 s*	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	**124.3 V** 110 V VT secondary	0.5 s	*122.65*		*125.95*	Pass/ Fail	Measured value plus 2 V	*0.5 s*		*0.6 s*	Pass/ Fail
L2 - L3						Pass/ Fail					Pass/ Fail
L3 - L1						Pass/ Fail					Pass/ Fail
Under Voltage			Lower Limit	Measured Value	Upper Limit		Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2	**88.0 V** 110 V VT secondary	2.5s	*86.35*		*89.65*	Pass/ Fail	Measured value minus 2 V	*2.5 s*		*2.6 s*	Pass/ Fail
L2 - L3						Pass/ Fail					Pass / Fail
L3 - L1						Pass/ Fail					Pass/ Fail

Over and Under Voltage Protection Tests HV

referenced to 110 V 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	119 V	5.00 s		Pass/

							Fail
Stage 1 Over Voltage	**121 V**	**1.0 s**	> OV Stage 1	122.3 V	0.95 s		Pass/ Fail
Stage 2 Over Voltage	**124.3 V**	**0.5 s**	> OV Stage 2	126.3 V	0.45 s		Pass/ Fail
Inside Normal band	---------	---------	> UV	90 V	5.00 s		Pass/ Fail
Under Voltage	**88 V**		< UV	86 V	2.45 s		Pass/ Fail
Additional Comments / Observations:							

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**, type test reports 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
52 Hz	0.5 s	*51.90*		*52.10*	Pass/ Fail	51.7-52.3 Hz	*0.50 s*		*0.60 s*	Pass/ Fail
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5 Hz	20	*47.40*		*47.60*	Pass /Fail	47.8-47.2 Hz	*20.0 s*		*20.2 s*	Pass/ Fail
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47 Hz	0.5 s	*46.90*		*47.1*	Pass/ Fail	47.3-46.7 Hz	*0.50 s*		*0.60 s*	Pass /Fail

Stability Tests							
Test Description	Setting	Time Delay	Test Condition	Test Frequency	Test Duration	Confirm No Trip	Result
Inside Normal band	---------	---------	< OF	51.3 Hz	120 s		Pass/

							Fail
Over Frequency	52 Hz	0.5 s	> OF	52.2 Hz	0.45 s		Pass/ Fail
Inside Normal band	---------	---------	> UF Stage 1	47.7 Hz	30 s		Pass/ Fail
Stage 1 Under Frequency	47.5 Hz	20 s	< UF Stage 1	47.3 Hz	19.5 s		Pass/ Fail
Stage 2 Under Frequency	47 Hz	0.5 s	< UF Stage 2	46.8 Hz	0.45 s		Pass/ Fail
Overfrequency test - Frequency shall be stepped from 51.3 Hz to the test frequency and held for the test duration and then stepped back to 51.3 Hz. Underfrequency test - Frequency shall be stepped from 47.7 Hz to the test frequency and held for the test duration and then stepped back to 47.7 Hz							
Additional Comments / Observations:							

Details of Loss of Mains Protection				
Manufacturer	**Manufacturer's** type	Date of Installation	Settings	Other information

6069

Loss-of-Mains (LOM) Protection Tests The **Generator** shall demonstrate compliance with this EREC G99 in respect of LOM Protection by either providing the **DNO** with appropriate **Manufacturers' Information,** type test reports or by undertaking the following tests on site									
Calibration and Accuracy Tests									
Ramp in range 49.0-51.0 Hz	**Pickup** (+ / -0.025 Hzs^{-1})				**Relay Operating Time** RoCoF= $\pm$**0.05 / 0.10 Hzs^{-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}	*>0.5 s*		*<1.0 s*	Pass/Fail
Reducing Frequency	*0.475* *0.975*		*0.525* *1.025*	Pass/Fail	0.55 Hzs^{-1} 1.1 Hzs^{-1}	*>0.5 s*		*<1.0 s*	Pass/Fail
Stability Tests									

Ramp in range 49.0-51.0 Hz	Test Condition	Test frequency ramp	Test Duration	Confirm No Trip	Result
Inside Normal band	< RoCoF (increasing f)	$0.45\ Hzs^{-1}$	4.4 s		Pass/Fail
Inside Normal band	< RoCoF (reducing f)	$0.95\ Hzs^{-1}$	2.1 s		Pass/Fail
Additional Comments / Observations:					

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

Wiring functional tests:	
If required by para 15.2.1, confirm that wiring functional tests have been carried out in accordance with the instructions below	Yes/ NA

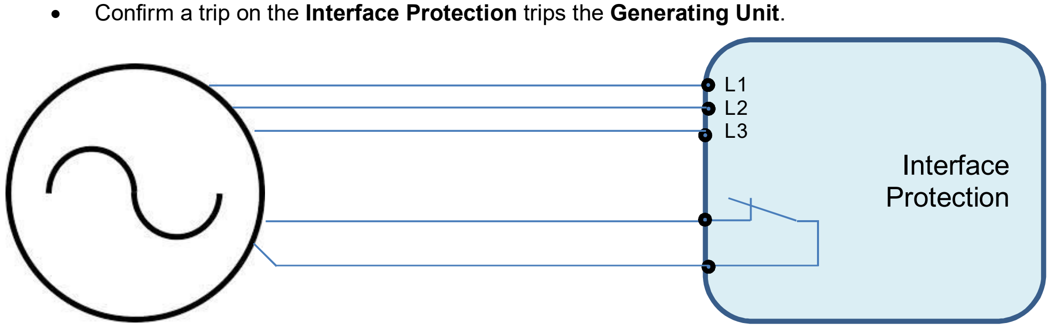
Where components of a **Power Generating Module** are separately **Type Tested** and assembled into a **Power Generating Module**, if the connections are made via loose wiring, rather than specifically designed error-proof connectors, then it will be necessary to prove the functionality of the components that rely on the connections that have been made by the loose wiring.

As an example, consider a **Type Tested** alternator complete with its control systems etc. It needs to be connected to a **Type Tested Interface Protection** unit. In this case there are only three voltage connections to make, and one tripping circuit. The on-site checks need to confirm that the **Interface Protection** sees the correct three phase voltages and that the tripping circuit is operative. It is not necessary to inject the **Interface Protection** etc to prove this. Simple functional checks are all that are required.

Test schedule:

With **Generating Unit** running and energised, confirm L1, L2, L3 voltages on **Generating Unit** and on **Interface Protection**.

- Disconnect one phase of the control wiring at the **Generating Unit**. Confirm received voltages at the **Interface Protection** have one phase missing.
- Repeat for other phases.
- Confirm a trip on the **Interface Protection** trips the **Generating Unit**.



Insert here any additional tests which have been carried out (as identified as being required by FormB3)

B.3 Installation and Commissioning Confirmation Form

Form B3- Installation and Commissioning Confirmation Form for Type B PGMs Please complete and provide this document for every **Power Generating Facility.** Part 1 should be completed for the **Power Generating Facility**. Part 2 should be completed for each of the **Power Generating Modules** being commissioned. Where the installation is phased the form should be completed as each part of the installation is completed in accordance with EREC G99 paragraph 15.3.3	
Form B3 Part 1	
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 **Generator's Installation**	
Location of Lockable Isolation Switch	
Details of Power Generating Module(s) –	

Manufacturer / Reference	Date of Installation	Technology Type	**Manufacturers** Reference Number (Product id on ENA database) and or Equipment Certificate references as applicable	**Power Generating Module**	
				Registered Capacity in kW	**Power Factor**

Commissioning Checks	
Description	**Confirmation**
Generator's Installation satisfies the requirements of BS7671 (IET Wiring Regulations).	Yes / No*
Suitable lockable points of isolation have been provided between the **PGM** and the rest of the **Generator's Installation**.	Yes / No*
Labels have been installed at all points of isolation in accordance with EREC G99.	Yes / No*
Interlocking that prevents **PGM** being connected in parallel with the **DNO** system (without synchronising) is in place and operates correctly.	Yes / No*
Balance of Multiple Single Phase PGMs. Confirm that design of the **Generator's Installation** has been carried out to limit output power imbalance to below 16 A per phase, as required by EREC G99.	Yes / No*

Form B3 Part 2	
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	
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*
*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 for the **Type B Power Generating Module** within the scope of this EREC G99, and the installation: 1. The **Power Generating Module Document** Form B2-1 is complete 2. The commissioning checks detailed in Form B2-2 have been successfully completed*. 3. The commissioning checks detailed in this Form B3 have been successfully completed. *delete if not applicable ie if the **Interface Protection** and ride through capabilities are **Type Tested**.	
Name:	
Signature:	Date:
Company	
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:	
Company	
Signature:	Date:

B.4 Simulation Studies for Type B Power Generating Modules

B.4.1 Scope

B.4.1.1 This Annex 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 Annex should be read in conjunction with Section 21.4 with regard to the submission of the reports to the **DNO**. The studies specified in this Annex 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**.

B.4.1.2 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. In all cases the simulation studies must be presented over a sufficient time period to demonstrate compliance with all applicable requirements.

B.4.1.3 **The DNO** may permit relaxation from the requirement in paragraph B.4.2 to paragraph B.4.5 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**.

B.4.2 Reactive Capability across the Voltage Range

B.4.2.1 If specified by the **DNO** the **Generator** shall supply simulation studies to demonstrate the capability to meet Section 12.5 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.

B.4.2.2 In the case of a **Synchronous Power Generating Module** the terminal voltage in the simulation should be the nominal voltage for the machine.

B.4.2.3 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 (eg **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.

B.4.3 Voltage Control and Reactive Power Stability

B.4.3.1 This section applies to **Power Park Modules** to demonstrate the voltage control capability if specified by the **DNO.**

B.4.3.2 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 Modules**. 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 **Registered Capacity**.

(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 **Registered Capacity**.

(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.

B.4.3.3 All the above studies should be completed with a network operating at the voltage applicable for zero **Reactive Power** transfer at the **Connection Point** unless stated otherwise. The fault level at the **Connection Point** should be set at the minimum level as agreed with the **DNO**.

B.4.3.4 The **DNO** may permit relaxation from the requirements of B.4.3.2(i) and (ii) for voltage control if the **Power Park Modules** are comprised of **Generating 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.

B.4.3.5 In addition the **DNO** may permit a further relaxation from the requirements of B.4.3.2(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**.

B.4.4 Fault Ride Through and Fast Fault Current Injection

B.4.4.1 This section applies to **Power Generating Modules** to demonstrate the modules **Fault Ride Through** and **Fast Fault Current** injection capability.

B.4.4.2 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 paragraphs 12.3 and paragraph 12.6 as applicable 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 B.4.1 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 B.4.1 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.

Table B.4.1

Power Generating Module	Retained Voltage
Synchronous Power Generating Module	30%
Power Park Module	10%

B.4.4.3 The simulation study should be completed with the **Power Generating Module** operating at full **Active Power** and maximum leading **Reactive Power** and the fault level at the **Connection Point** at minimum as notified by the **DNO**.

B.4.4.4 The simulation study will show acceptable performance providing compliance with the requirements of paragraph 12.3.1.7 (e) are demonstrated.

B.4.4.5 In the case of **Power Generating 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**, B.4.4.2 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 B.4.4.2 applied at the **Connection Point** are less than those included in the **Manufacturers' Information**, or;

(ii) the same or greater percentage faults and voltage dips in B.4.4.2 have been applied at either side of the **Generating Unit** transformer in the **Manufacturers' Information**.

B.4.5 Limited Frequency Sensitive Mode – Over Frequency (LFSM-O)

B.4.5.1 This section applies to **Power Generating Modules** to demonstrate the capability to modulate **Active Power** at high frequency as required by Section 12.2.5.

B.4.5.2 The simulation study should comprise of a **Power Generating Module** connected to the **Total System** with a local load shown as "X" in Figure B.4.1. 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 52 Hz. Where transient excursions above 52 Hz occur the **Generator** should ensure that the duration above 52 Hz is less than any high frequency protection system applied to the **Power Generating Module**.

B.4.5.3 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 B.4.2. This additional **Synchronous Power Generating Module** should have an inertia constant of 3.5 MWs/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.

B.4.5.4 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** or connection circuit breaker (the governor should therefore, not receive any signals that the breaker has opened other than the reduction in load and subsequent increase in speed). A schematic arrangement of the simulation study is illustrated by Figure B.4.1.

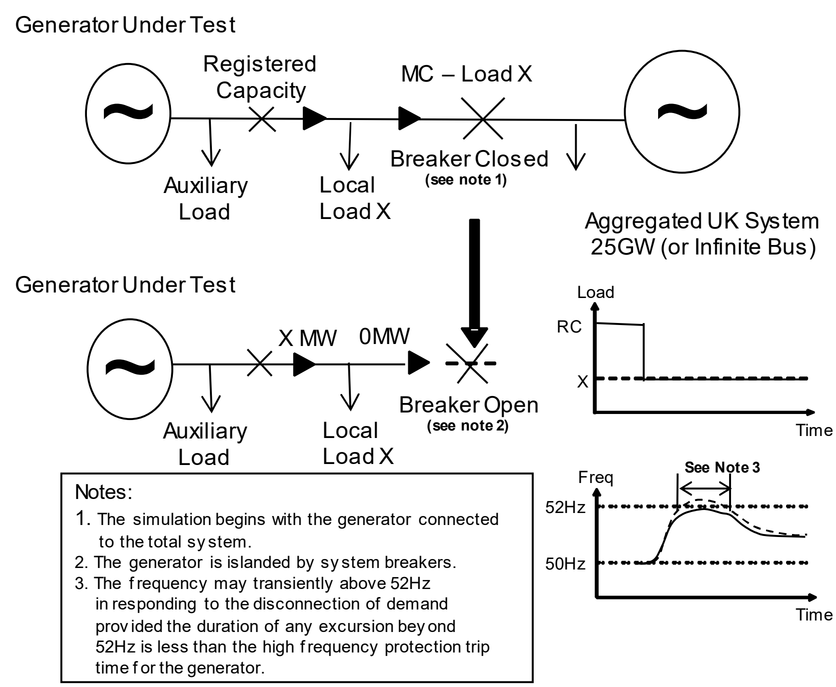


Figure B.4.1 – Diagram of Load Rejection Study

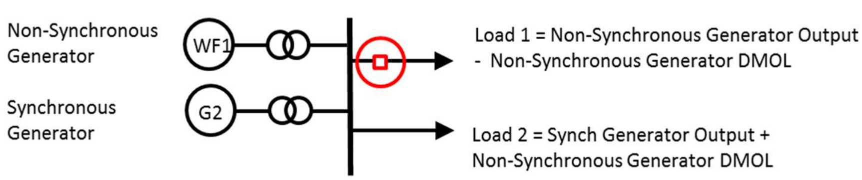


Figure B.4.2 – Addition of Generator G2 if applicable

B.4.5.5 Simulation studies shall be performed for **Limited Frequency Sensitive Mode** (**LFSM**). The simulation study results should indicate **Active Power** and frequency.

B.4.5.6 To allow validation of the model used to simulate load rejection in accordance with paragraph 12.2.5 as described a further simulation study is required to represent the largest positive frequency injection step or fast ramp (BC3 of Figure B.5.1) that will be applied as a test as described in B.5.6.

B.5 Compliance Testing of Synchronous Power Generating Modules

B.5.1 Scope

B.5.1.1 This Annex sets out the tests contained therein to demonstrate compliance with the relevant clauses of the EREC G99.

B.5.1.2 The tests specified in this Annex will normally be sufficient to demonstrate compliance however the **DNO** may:

(i) 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

(ii) require additional or alternative tests if information supplied to the **DNO** during the compliance process suggests that the tests in this Annex will not fully demonstrate compliance with the relevant section of the EREC G99 or the **Connection Agreement.**

(iii) Agree a reduced set of tests for subsequent **Synchronous Power Generating Module** following successful completion of the first **Synchronous Power Generating Module** tests in the case of a **Power 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 B.5.1.2(iii) in respect of subsequent **Synchronous Power Generating Modules** do not replicate the full tests for the first **Synchronous Power Generating Module**, or

(b) any of the tests performed pursuant to B.5.1.2(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 Annex will be applied.

B.5.1.3 The **Generator** is responsible for carrying out the tests set out in and in accordance with this Annex 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 Annex 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.

B.5.1.8 Full **Synchronous** Power Generating M**odule** testing is to be completed as defined in B.5.2 through to B.5.7.

B.5.1.9 The **DNO** may permit relaxation from the requirement B.5.2 to B.5.7 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.

B.5.2 Excitation System Open Circuit Step Response Tests

B.5.2.1 The open circuit step response of the **Excitation System** will be tested by applying a voltage step change from 90% to 100% of the nominal **Synchronous Power Generating Module** terminal voltage, with the **Synchronous Power Generating Module** on open circuit and at rated speed.

B.5.2.2 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:

V_t - Synchronous **Generating Unit** terminal voltage

E_{fd} - Synchronous **Generating Unit** field voltage or main **Exciter** field voltage

I_{fd}- Synchronous **Generating Unit** field current (where possible)

Step injection signal

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

B.5.3 Open & Short Circuit Saturation Characteristics

B.5.3.1 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**.

B.5.3.2 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**.

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

B.5.4 Excitation System On-Load Tests

B.5.4.1 The time domain performance of the **Excitation System** shall be tested by application of voltage step changes corresponding to 1% and 2% of the nominal terminal voltage.

B.5.4.2 Under-excitation Limiter Performance Test

B.5.4.2.1 Initially 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.

B.5.4.2.2 The final performance of the **Under-excitation Limiter** shall be demonstrated by testing its response to a step change corresponding to a 2% decrease in **Automatic Voltage Regulator** Setpoint Voltage when the **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.

B.5.4.2.3 Where 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.

B.5.4.2.4 The **Under-excitation Limiter** will normally be tested at low **Active Power** output (**Minimum Generation**) and at maximum **Active Power** output (**Registered Capacity**).

B.5.4.2.5 The 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	• Inject -2% voltage step into **AVR** voltage Setpoint and hold at least for 10 s until stabilised • Remove step returning **AVR** Voltage Setpoint to nominal and hold for at least 10 s	
	Under-excitation limit moved to normal position. **Generating Unit** running at **Registered Capacity** and at leading **Reactive Power** close to Under-excitation limit.	
2	• Inject -2% voltage step into **AVR** Voltage Setpoint and hold at least for 10 s until stabilised • Remove step returning **AVR** Voltage Setpoint to nominal and hold for at least 10 s	

B.5.4.3 Over-excitation Limiter Performance Test

B.5.4.3.1 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.

B.5.4.3.2 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.

B.5.4.3.3 The 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.	
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.	

B.5.5 Reactive Capability

B.5.5.1 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**.

B.5.5.2 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.

B.5.5.3 The test procedure, time and date will be agreed with the **DNO** and will be to the instruction of the **DNO** control centre and shall be monitored and recorded at both the **DNO** control centre and by the **Generator**.

B.5.5.4 Where the **Generator** is recording the voltage, **Active Power** and **Reactive Power** at the **Connection Point** the voltage, **Active Power** and **Reactive Power** at the **Synchronous Power Generating Module** terminals may also be included. The results shall be supplied in an electronic spreadsheet format. Where applicable the **Synchronous Power Generating Module** transformer tap changer position should be noted throughout the test period

B.5.6 Governor and Load Controller Response Performance

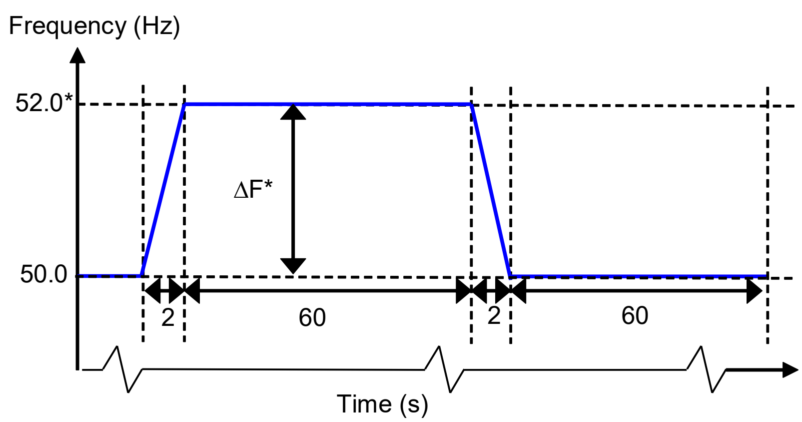
B.5.6.1 The governor and load controller response performance will be tested by injecting simulated frequency deviations into the governor and load controller systems.

B.5.6.2 The two frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** capability to a frequency injection as shown by Figure B.5.1 and Figure B.5.2 are to be conducted at **Registered Capacity**.

B.5.6.3 There should be sufficient time allowed between tests for control systems to reach steady state. Where the diagram states 'HOLD' the injection signal 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.

B.5.6.4 The expected **Active Power** response which is illustrated in Figure B.5.1 and B.5.2 should be in accordance with Section 12.2.5 and undamped oscillations should not occur after the step or ramp frequency change.

B.5.6.5 The response should commence within 2 s (or such time as the **DNO** might agree with the **Generator**); ie the response should normally be contained within the blue lines, and as close to the left as possible, when following the frequency ramp. The response should be complete in a reasonable time and the **DNO** can agree with the **Generator** a longer completion time than suggested by the blue lines taking into account the technical capabilities of the **Power Generating Module** and its prime mover.



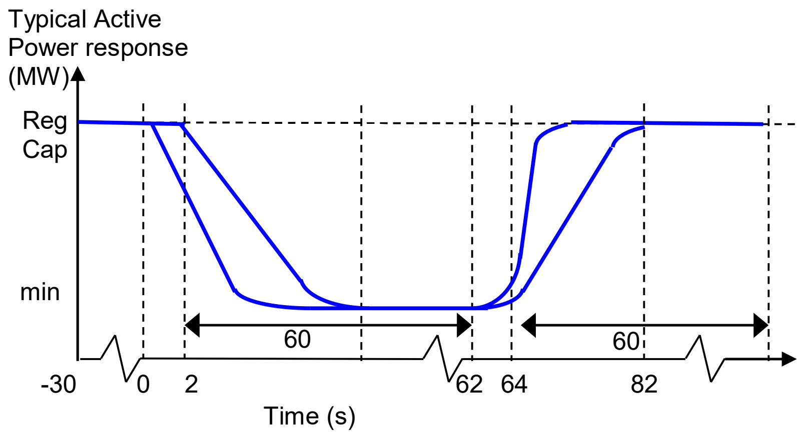
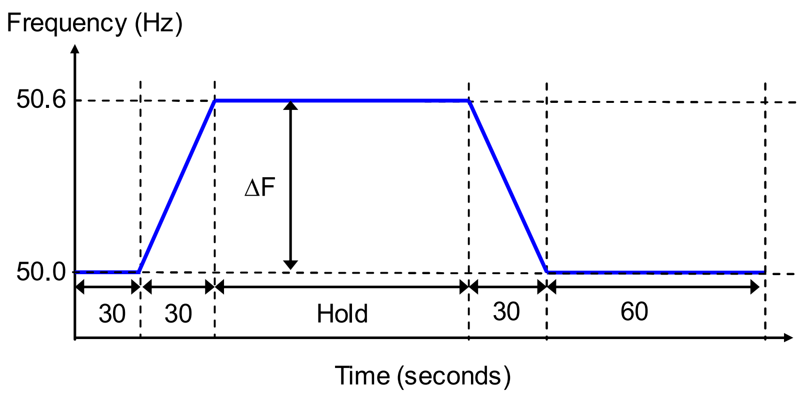


Figure B.5.1: LFSM-O step response test

* This will generally be +2.0 Hz 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 1.5 Hz is needed to take an initial output 100% to a final output of 70%. If the initial output is not 100% and the **Minimum Generation** is not 70% then the injected step should be adjusted accordingly as shown in the example given below:

Initial output	100%
Minimum Generation	70%
Frequency controller **Droop**	10%
Frequency to be injected	= (1.00 – 0.70) x 0.1 x 50 = 1.5Hz



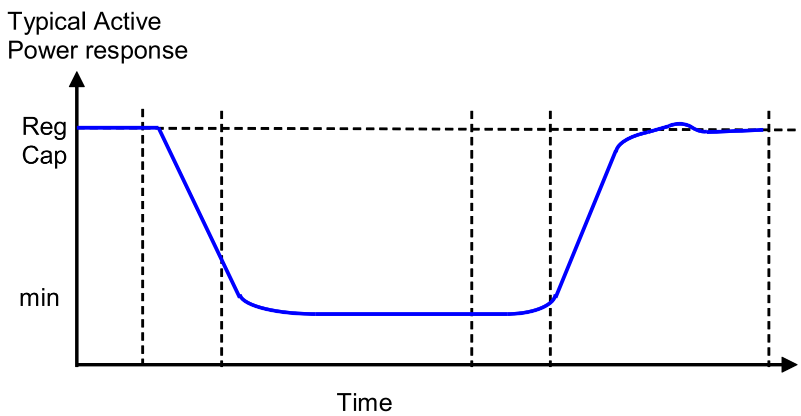


Figure B.5.2: LFSM-O ramp response test

B.5.7 Compliance with Output Power with falling frequency Functionality Test

B.5.7.1 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.

B.5.7.2 The tests can be undertaken by the **Synchronous Power Generating Module** powering a suitable load bank, or alternatively using the test set up of Figure A8.6. In both cases a suitable test could be to start the test at nominal frequency with the **Synchronous Power Generating Module** operating at 100% of its **Registered Capacity**.

B.5.7.3 The frequency should then be set to 49.5 Hz for 5 minutes. The output should remain at 100% of **Registered Capacity**.

B.5.7.4 The frequency should then be set to 49.0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 99% of **Registered Capacity**.

B.5.7.5 The frequency should then be set to 48.0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 97% of **Registered Capacity**.

B.5.7.6 The frequency should then be set to 47.6 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 96.2% of **Registered Capacity**.

B.5.7.7 The frequency should then be set to 47.1 Hz and held at this frequency for 20 s. The **Active Power** output must not be below 95.0% of **Registered Capacity** and the **Synchronous Power Generating Module** must not trip in less than the 20s of the test.

B.5.7.8 The Generator shall inform the **DNO** if any load limiter control is additionally employed.

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B.6 Compliance Testing of Power Park Modules

B.6.1 Scope

B.6.1.1 This Annex outlines the general testing requirements for **Power Park** to demonstrate compliance with the relevant clauses of the EREC G99.

B.6.1.2 The tests specified in this Annex will normally be sufficient to demonstrate compliance however the **DNO** may:

i) 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

ii) require additional or alternative tests if information supplied to the **DNO** during the compliance process suggests that the tests in this Annex will not fully demonstrate compliance with the relevant section of this EREC G99 and the **Connection Agreement**; and/or

iii) 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

iv) 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 Generating Facility** comprised of two or more **Power Park Modules** which the **DNO** reasonably considers to be identical.

If:

(a) the tests performed pursuant to B.6.1.2(iii) do not replicate the results contained in the **Manufacturers' Information** and Performance Report or

(b) the tests performed pursuant to B.6.1.2(iv) in respect of subsequent **Power Park Modules** do not replicate the full tests for the first **Power Park Module**, or

(c) any of the tests performed pursuant to B.6.1.1(iii) or B.6.1.1(iv) do not fully demonstrate compliance with the relevant aspects of this EREC G99 and the **Connection Agreement**,

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

B.6.1.2 The **Generator** is responsible for carrying out the tests set out in and in accordance with this Annex 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 Annex 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.

B.6.1.3 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:

(i) All relevant transformer tap numbers; and

(ii) Number of **Generating Units** in operation

B.6.1.4 The Generator shall submit a detailed schedule of tests to the **DNO** in accordance with the compliance testing requirements of EREC G99 and this Annex.

B.6.1.5 Partial **Power Park Module** testing as defined in B.6.2 and B.6.3 is to be completed at the appropriate stage.

B.6.1.6 The **DNO** may permit relaxation from the requirement B.6.2 to B.6.8 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.

B.6.2 Pre 20% Synchronised **Power Park Module** Basic Voltage Control Tests

B.6.2.1 Before 20% of the **Power Park Module** has commissioned, either voltage control test B.6.5.6(i) or (ii) must be completed.

B.6.3 Reactive Capability Test

B.6.3.1 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**.

B.6.3.2 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 B.6.4.5.

B.6.3.2 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**.

B.6.3.3 The following tests shall be completed:

(i) Operation in excess of 60% **Registered capacity** and maximum continuous lagging **Reactive Power** for 30 minutes.

(ii) Operation in excess of 60% **Registered capacity** and maximum continuous leading **Reactive Power** for 30 minutes.

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

(iv) Operation at 20% **Registered capacity** and maximum continuous leading **Reactive Power** for 60 minutes.

(v) Operation at 20% **Registered capacity** and maximum continuous lagging **Reactive Power** for 60 minutes.

(vi) 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**.

(vii) Operation at the lower of the **Minimum Generation** or 0% **Registered Ccapacity** and maximum continuous leading **Reactive Power** for 5 minutes. This test only applies to systems which offer voltage control below 20% and hence establishes actual capability rather than required capability.

(viii) 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.

B.6.3.4 Within this Annex lagging **Reactive Power** is the export of **Reactive Power** from the **Power Park Module** to the **DNO's** Distribution **Network** and leading **Reactive Power** is the import of **Reactive Power** from the **DNO's Distribution Network** to the **Power Park Module.**

B.6.4 Voltage Control Tests

B.6.4.1 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 the relevant technical requirements section of this EREC G99. 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**.

B.6.4.2 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.

B.6.4.3 The time between transformer taps shall be at least 10 s as per Figure B.6.1.

B.6.4.4 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 s as per Figure 7.2.

B.6.4.5 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.

B.6.4.6 Tests to be completed:

(i)

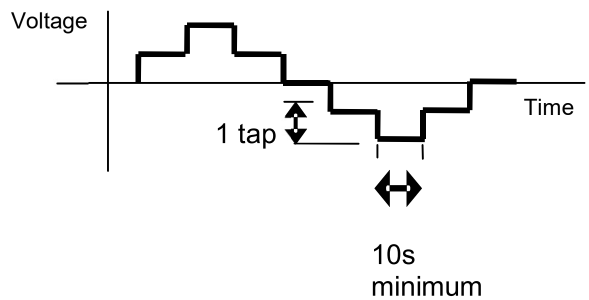

Figure B.6.1 – Transformer tap sequence for voltage control tests

(ii)

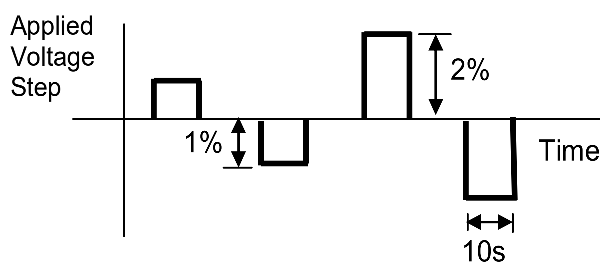

Figure B.6.2 – Step injection sequence for voltage control tests

B.6.5 Frequency Response Tests

B.6.5.1 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**.

B.6.5.2 The frequency controller shall be in **Limited Frequency Sensitive Mode** for each test. Simulated frequency deviation signals shall be injected into the frequency controller setpoint/feedback summing junction.

B.6.5.3 The two frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** capability to a change in frequency as shown by Figure B.6.3 and B.6.4 are to be conducted at **Registered Capacity**.

B.6.5.4 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 injection signal should be maintained until the **Active Power** (MW) output of the **Power Park Module** has stabilised. the **DNO** may require repeat tests should the response volume be affected by the available power, or if tests give unexpected results.

B.6.5.5 The expected **Active Power** response which is illustrated in Figure B.6.1 and B.6.2 should be in accordance with Section 12.2.5 and undamped oscillations should not occur after the step or ramp frequency change.

B.6.6.5 The response should commence within 2 s (or such time as the **DNO** might agree with the Generator) and complete in a reasonable time (typically no longer than 30 s); ie the response should be contained within the blue lines, and as close to the left as possible, when following the frequency ramp.

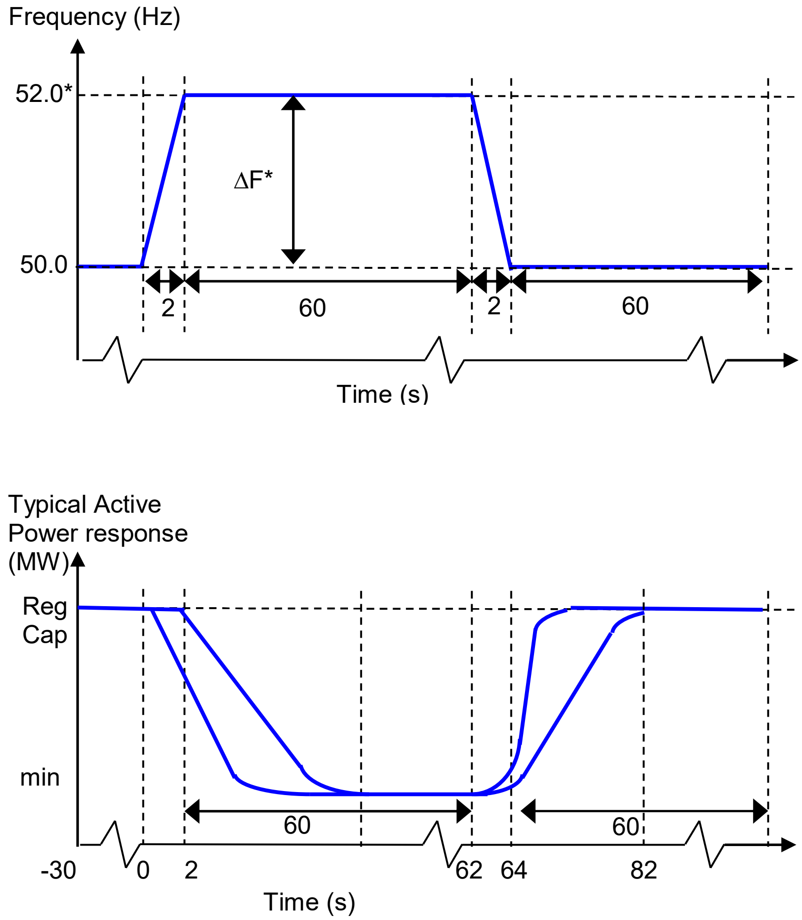

Figure B.6.3: LFSM-O BC3 step response test

* This will generally be +2.0 Hz 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

For example 1.5 Hz is needed to take an initial output 100% to a final output of 70%. If the initial output is not 100% and the **Minimum Generation** is not 70% then the injected step should be adjusted accordingly as shown in the example given below:

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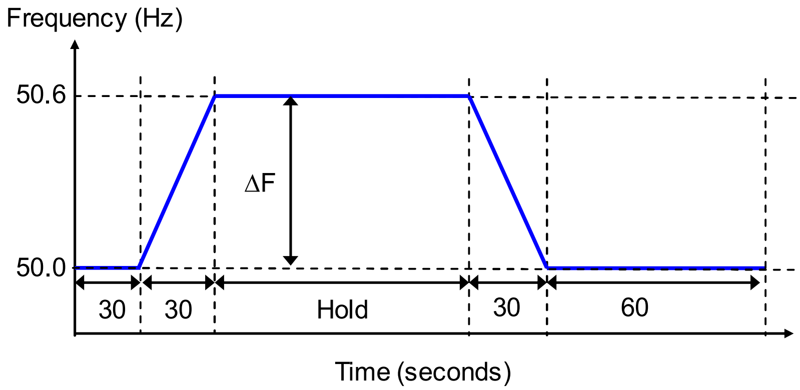
Initial output	100%
Minimum Generation	70%
Frequency controller **Droop**	10%
Frequency to be injected	= (1.00 – 0.70) x 0.1 x 50 = 1.5Hz



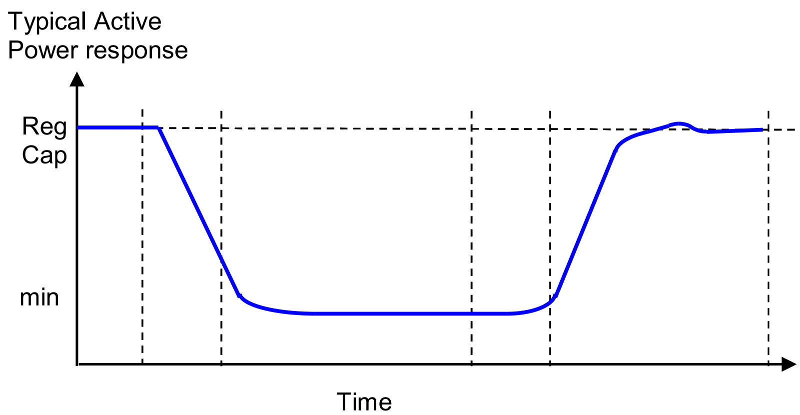


Figure B.6.4: LFSM-O BC2 ramp response test

Annex C

C.1 Application

The application for connection of a **Power Generating Module** should be made to the **DNO** using the Standard Application Form on the **DNO** or ENA website

C.2 Power Generating Module Document Type C and Type D

Form C2-1 Power Generating Module Document for Type C and Type D Power Generating Modules **Compliance Statement** This document shall be completed by the **Generator**	
Power Generating Module (PGM) **PGM Name:** **Compliance Contact** (name/tel/email)**:**	**Distribution Network Operator (DNO)**: **DNO Name**: ABC electricity distribution **Compliance Contact** (name/tel/email):
Key to Submission Stage **A – Application:** Submission of the Standard Application Form For **Type C: IS – Initial Submission:** The programme of initial compliance document submission to be agreed between the **Generator** and the **DNO** as soon as possible after acceptance of a Connection Offer. Initial Submission of this **Power Generating Module Document** to be completed at least 28 days before the **Generator** synchronising the **Power Generating Module** for the first time. For **Type D: ION** – **Interim Operational Notification:** The programme of initial compliance document submission to be agreed between the **Generator** and the **DNO** as soon as possible after acceptance of a Connection Offer. Initial Submission of this **Power Generating Module Document** to be completed at least 28 days before the **Generator** synchronising the **Power Generating Module** for the first time. **FONS – Final Operational Notification Submission:** The **Generator** shall submit post energisation verification test documents to obtain **Final Operational Notification** from the **DNO**.	
Key to evidence requested S - Indicates that **DNO** would expect to see the results of a Simulation study P - **Generating Unit** design data MI - **Manufacturer** Information, generic data or test results as appropriate D - Copies of correspondence or other documents confirming that a requirement has been met T - Indicates that **DNO** would expect to see results of, and/or witness,	**Key to Compliance** Y = Yes (Compliant), O = Outstanding (outstanding submission) UR= Unresolved issue N = No (Non-Compliant)

tests or monitoring which demonstrates compliance TV - Indicates Type Test reports (if **Generator** pursues this compliance option)				
Note that second part of this form is split into two Sections, the first Section is applicable to **Synchronous Power Generating Modules**, the second Section is applicable to **Power Park Modules**				
Issue	Date of Issue	Compliance Declaration Signatory Name	Compliance Declaration Signature	Issue Notes
Issue #	DD/MM/YY		I declare that the details provided in this issue of this **Power Generating Module Document** comply with the requirements of G99	Insert brief description of amendment
Final Issue Prior to **FON**				
Details of Power Generating Module				
Connection Voltage				
Registered Capacity				
Manufacturer / Reference				
Technology Type				

Compliance Requirements for Synchronous Power Generating Modules				Response	
G99 Reference	**Compliance Requirement of the Power Generating Module**	**Submission Stage**	**Evidence Requested (and / or)**	**Compliance** **Y, O, UR, N,**	**User's Statement** *(Provide document references with any additional comments)*
18.2.1, 18.2.3, 18.4.1	Confirmation that a completed Standard Application Form has been submitted to the **DNO**	A, IS, ION, FONS	P, MI, D		
13.5	**Reactive Power capability** Confirm compliance with Section 13.5 by carrying out simulation study in accordance with C.7.3 and by submission of a report	IS, ION	S, MI, TV		
13.4	**Voltage Control and Reactive Power Stability** Confirm compliance with Section 13.4 by carrying out simulation study in accordance with C.7.4 and by submission of a report	IS, ION	S, MI, TV		
13.2.5	**Limited Frequency Sensitive Mode – Over frequency and Frequency Sensitive Mode** Confirm the compliance with 13.2.5 by carrying out simulation study in	IS, ION	S, MI, TV		

	accordance with C.7.6 and by submission of a report.				
13.2.6	**Limited Frequency Sensitive Mode – Under frequency** Confirm the compliance with 13.2.6 by carrying out simulation study in accordance with C.7.7 and by submission of a report.	IS. ION	S, MI, TV		
13.1.3	Confirm the **Active Power** set point can be adjusted in accordance with instructions issued by the **DNO**	IS, ION	MI, TV		
13.3	**Fault Ride Through** Confirm the compliance with 13.3 by carrying out simulation study in accordance with C.7.5 and by submission of a report.	IS, ION	S, MI, TV		
18.2.3 (e)	Confirm a detailed schedule of tests and test procedures have been provided.	IS, ION	D		
Section 10 and Form C2-2	**Interface Protection:** • Over and under voltage protection • Over and Under Frequency protection • Loss of mains protection Other protection:	IS, ION, FONS	MI, TV, T		

	• Details of any special protection, eg Pole Slipping or islanding As an alternative to demonstrating protection compliance with Section 10 using **Manufacturers' Information** or type test reports, site tests can be undertaken at the time of commissioning the **Power Generating Module**.				
C.7.8	**Model validation** Demonstration of the frequency control or governor/load controller/plant model, **Excitation System** and voltage controller by carrying out simulation studies in accordance with C.7.8	FONS	S, MI, TV		
C.4	**Excitation System Open Circuit Step Response Tests** Confirm the performance requirements of a continuously acting voltage control system compliant with C.5 by testing in accordance with C.8.2	FONS	T, MI, TV		
C.4	**Open & Short Circuit Saturation Characteristics** Confirm the performance requirements of a continuously acting voltage control system compliant with C.4 by testing in accordance with C.8.3	FONS	T, MI, TV		

13.4.3	**Excitation System On-Load Tests** Confirm the operation of the **Excitation System** on load is compliant with paragraph 13.4.3 and Annex C.4 by testing in accordance with C.8.4	FONS	T, MI, TV		
13.5	**Reactive Capability Test** Confirm the **Reactive Power** capability of the **Synchronous Power Generating Module** to meet the requirements of Section 13.5 by testing in accordance with C.8.5.	FONS	T, MI, TV		
13.2	**Frequency Response Tests** Confirm the **Synchronous Power Generating Module** meets the requirements of 13.2 by testing in accordance with C.8.6.	FONS	T, MI, TV		
13.2.4	**Output Power with falling frequency** Confirm the **Synchronous Power Generating Module** meets the requirements of 13.2.4 by testing in accordance with C.8.7.	FONS	T, MI, TV		
10.3.4	**Automatic reconnection** Confirm by testing that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency.	FONS	T, MI, TV		

C.3	Installation and Commissioning Form C3 completed with signed acceptance from the **DNO** representative.	FONS	T		

Compliance Requirements for Power Park Module				**Response**	
G99 Reference	**Compliance Requirement of the Power Generating Module**	**Submission Stage**	**Evidence Requested (and / or)**	**Compliance** **Y, O, UR, N,**	**User's Statement** *(Provide document references with any additional comments)*
18.2.1, 18.2.3, 18.4.1	Confirmation that a completed Standard Application Form has been submitted to the **DNO**	A, IS, FONS	P, MI, D		
13.5	**Reactive Power capability** Confirm compliance with Section 13.5 by carrying out simulation study in accordance with C.7.3 and by submission of a report	IS, ION	S, MI, TV		
13.4	**Voltage Control and Reactive Power Stability** Confirm compliance with Section 13.4 by carrying out simulation study in accordance with C.7.4 and by submission of a report	IS, ION	S, MI, TV		
13.3	**Fault Ride Through capability** Confirm compliance with Section13.3 by carrying out time series simulation study in accordance with C.7.5 and by	IS, ION	MI, TV, S		

	submission of a report.				
13.2.5	**Limited Frequency Sensitive Mode – Over frequency and Frequency Sensitive Mode** Confirm the compliance with 13.2.5 by carrying out simulation study in accordance with C.7.6 and by submission of a report.	IS, ION	S, MI, TV		
13.2.6	**Limited Frequency Sensitive Mode – Under frequency** Confirm the compliance with 13.2.6 by carrying out simulation study in accordance with C.7.7 and by submission of a report.	IS, ION	S, MI, TV		
13.1.3	Confirm the **Active Power** set point can be adjusted in accordance with instructions issued by the **DNO**	IS, ION	MI, TV		
13.3 and 13.6	**Fault Ride Through and Fast Fault Current Injection** Confirm the compliance with 13.3 and 13.6 by carrying out simulation study in accordance with C.7.5 and by submission of a report.	IS, ION	S, MI, TV		
12.2.1	Confirm that the plant and apparatus is able of continue to operate during	IS, ION	MI, TV		

	frequency ranges specified in 12.2.1				
18.2.3 (e)	Confirm a detailed schedule of tests and test procedures have been provided.	IS, ION	D		
Section 10 and Form C2-2	**Interface Protection:** • Over and under voltage protection • Over and Under Frequency protection • Loss of mains protection Other protection: • Details of any special protection, eg Pole Slipping or islanding As an alternative to demonstrating protection compliance with Section 10 using **Manufacturers' Information** or type test reports, site tests can be undertaken at the time of commissioning the **Power Generating Module.**	IS, ION, FONS	MI, TV, T		
C.7.8	**Model validation** Demonstration of the frequency control or governor/load controller/plant model, **Excitation System** and voltage controller by carrying out simulation studies in accordance with C.7.8	FONS	S, MI, TV		

C.5	**Voltage Control Test (pre 20%)** Confirm the performance requirements of a continuously acting voltage control system compliant with C.5 by testing in accordance with C.9.4	FONS	T, MI, TV		
C.5	**Voltage Control Test** Confirm the performance requirements of a continuously acting voltage control system compliant with C.5 by testing in accordance with C.9.4	FONS	T, MI, TV		
13.5	**Reactive Capability Test** Confirm the **Reactive Power** capability of the **Power Park Module** meet the requirements of Section 13.5 by testing in accordance with C.9.3.	FONS	T, MI, TV		
C.9.5	**Frequency Response Test** Confirm the **Generator** meets the requirements of 13.2 by testing in accordance with C.9.5.	FONS	T, MI, TV		
10.3.4	**Automatic reconnection** Confirm by testing that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency.	FONS	T, MI, TV		

C.3	Installation and Commissioning Form C3 completed with signed acceptance from the **DNO** representative.	FONS	T		

Additional Compliance and Commissioning test requirements for Power Generating Modules

Form C2-2: Site Compliance and Commissioning test requirements for Type C and Type D Power Generating Modules

This form should be completed if site compliance tests are being undertaken for some or all of the **Interface Protection** where it is not **Type Tested** and for other compliance tests that are being undertaken on site.

Generator Details:	
Generator (name)	
Installation details:	
Address	
Post Code	
Date of commissioning	

Requirement	Compliance by provision of **Manufacturers' Information** or type test reports. Reference number should be detailed and **Manufacturers' Information** attached.	Compliance by commissioning tests Tick if true and complete relevant sections of form below
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		
Wiring functional tests: If required by para 15.2.1		

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,** type test reports or by undertaking the following tests on site.

Tests referenced to 110 V ph-ph VT output

Calibration and Accuracy Tests

Phase	Setting	Time Delay	**Pickup Voltage**				**Relay Operating Time** measured value ± 2 V				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2						Pass/ Fail					Pass /Fail
L2 - L3	**121 V** 110 V VT secondary	**1.0 s**	*119.35*		*122.65*	Pass/ Fail	Measured value plus 2 V	*1.0 s*		*1.1 s*	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						Pass/ Fail					Pass/Fail
L2 - L3	**124.3 V** 110 V VT secondary	0.5 s	*122.65*		*125.95*	Pass/ Fail	Measured value plus 2 V	*0.5 s*		*0.6 s*	Pass/Fail
L3 - L1						Pass/ Fail					Pass/Fail
Under Voltage			Lower Limit	Measured Value	Upper Limit		Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2						Pass/ Fail					Pass/ Fail
L2 - L3	**88.0 V** 110 V VT secondary	2.5s	*86.35*		*89.65*	Pass/ Fail	Measured value minus 2 V	*2.5 s*		*2.6 s*	Pass / Fail
L3 - L1						Pass/ Fail					Pass/ Fail

Over and Under Voltage Protection Tests HV

referenced to 110 V ph-ph VT output

Stability Tests

Test Description	Setting	Time Delay	est Condition (3-Phase Value)	est Voltage All phase s ph-ph	Test Duration	Confirm No Trip	Result
Inside Normal band	---------	---------	< OV Stage 1	119 V	5.00 s		Pass/Fail

Stage 1 Over Voltage	**121 V**	**1.0 s**	> OV Stage 1	122.3 V	0.95 s		Pass/Fail
Stage 2 Over Voltage	**124.3 V**	**0.5 s**	> OV Stage 2	126.3 V	0.45 s		Pass/Fail
Inside Normal band	---------	---------	> UV	90 V	5.00 s		Pass/Fail
Under Voltage	**88 V**		< UV	86 V	2.45 s		Pass/Fail
Additional Comments / Observations:							

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**, type test reports 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
52 Hz	0.5 s	*51.90*		*52.10*	Pass/ Fail	51.7-52.3 Hz	*0.50 s*		*0.60 s*	Pass/ Fail
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5 Hz	20	*47.40*		*47.60*	Pass /Fail	47.8-47.2 Hz	*20.0 s*		*20.2 s*	Pass/ Fail
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47 Hz	0.5 s	*46.90*		*47.1*	Pass/ Fail	47.3-46.7 Hz	*0.50 s*		*0.60 s*	Pass /Fail

Stability Tests							
Test Description	Setting	Time Delay	Test Condition	Test Frequency	Test Duration	Confirm No Trip	Result
Inside Normal band	---------	---------	< OF	51.3 Hz	120 s		Pass/ Fail

Over Frequency	52 Hz	0.5 s	> OF	52.2 Hz	0.45 s		Pass/ Fail
Inside Normal band	---------	---------	> UF Stage 1	47.7 Hz	30 s		Pass/ Fail
Stage 1 Under Frequency	47.5 Hz	20 s	< UF Stage 1	47.3 Hz	19.5 s		Pass/ Fail
Stage 2 Under Frequency	47 Hz	0.5 s	< UF Stage 2	46.8 Hz	0.45 s		Pass/ Fail
Overfrequency test - Frequency shall be stepped from 51.3 Hz to the test frequency and held for the test duration and then stepped back to 51.3 Hz. Underfrequency test - Frequency shall be stepped from 47.7 Hz to the test frequency and held for the test duration and then stepped back to 47.7 Hz							
Additional Comments / Observations:							

Details of Loss of Mains Protection				
Manufacturer	**Manufacturer's** type	Date of Installation	Settings	Other information

6608

Loss-of-Mains (LOM) Protection Tests The **Generator** shall demonstrate compliance with this EREC G99 in respect of LOM Protection by either providing the **DNO** with appropriate **Manufacturers' Information,** type test reports or by undertaking the following tests on site									
Calibration and Accuracy Tests									
Ramp in range 49.0-51.0 Hz	**Pickup (**+ / -0.025 Hzs^{-1})				**Relay Operating Time** RoCoF= **±0.05 / 0.10 Hzs^{-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}	*>0.5 s*		*<1.0 s*	Pass/Fail
Reducing Frequency	*0.475* *0.975*		*0.525* *1.025*	Pass/Fail	0.55 Hzs^{-1} 1.1 Hzs^{-1}	*>0.5 s*		*<1.0 s*	Pass/Fail
Stability Tests									
Ramp in range 49.0-	Test Condition		Test frequency ramp			Test	Confirm No Trip		Result

51.0 Hz			Duration		
Inside Normal band	< RoCoF (increasing f)	0.45 Hzs^{-1}	4.4 s		Pass/Fail
Inside Normal band	< RoCoF (reducing f)	0.95 Hzs^{-1}	2.1 s		Pass/Fail
Additional Comments / Observations:					

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

Wiring functional tests:	
If required by para 15.2.1, confirm that wiring functional tests have been carried out in accordance with the instructions below	Yes/ NA

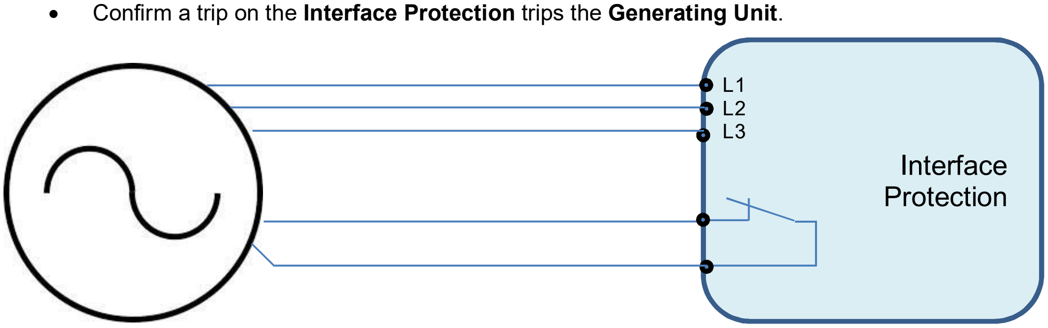
Where components of a **Power Generating Module** are separately **Type Tested** and assembled into a **Power Generating Module**, if the connections are made via loose wiring, rather than specifically designed error-proof connectors, then it will be necessary to prove the functionality of the components that rely on the connections that have been made by the loose wiring.

As an example, consider a **Type Tested** alternator complete with its control systems etc. It needs to be connected to a **Type Tested Interface Protection** unit. In this case there are only three voltage connections to make, and one tripping circuit. The on-site checks need to confirm that the **Interface Protection** sees the correct three phase voltages and that the tripping circuit is operative. It is not necessary to inject the **Interface Protection** etc to prove this. Simple functional checks are all that are required.

Test schedule:

With **Generating Unit** running and energised, confirm L1, L2, L3 voltages on **Generating Unit** and on **Interface Protection**.

- Disconnect one phase of the control wiring at the **Generating Unit**. Confirm received voltages at the **Interface Protection** have one phase missing.
- Repeat for other phases.
- Confirm a trip on the **Interface Protection** trips the **Generating Unit**.



Insert here any additional tests which have been carried out (as identified as being required by Form C2-1)

C.3 Installation and Commissioning Confirmation Form

Form C3 Installation and Commissioning Confirmation Form for Type C and Type D PGMs Please complete and provide this document for every **Power Generating Facility.** Part 1 should be completed for the **Power Generating Facility**. Part 2 should be completed for each of the **Power Generating Modules** being commissioned. Where the installation is phased the form should be completed as each part of the installation is completed in accordance with EREC G99 paragraph 15.3.3	
Form C3 Part 1	
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 **Generator's Installation**	
Location of Lockable Isolation Switch	

Details of Power Generating Module(s) –					
Manufacturer / Reference	Date of Installation	Technology Type	**Manufacturers** Reference Number (Product id on ENA database) and or Equipment Certificate references as applicable	**Power Generating Module**	
				Registered Capacity in kW	**Power Factor**

Commissioning Checks	
Description	**Confirmation**
Generator's Installation satisfies the requirements of BS7671 (IET Wiring Regulations).	Yes / No*
Suitable lockable points of isolation have been provided between the **PGM** and the rest of the **Generator's Installation**.	Yes / No*
Labels have been installed at all points of isolation in accordance with EREC G99.	Yes / No*
Interlocking that prevents **PGM** being connected in parallel with the **DNO** system (without synchronising) is in place and operates correctly.	Yes / No*
Balance of Multiple Single Phase PGMs. Confirm that design of the **Generator's Installation** has been carried out to limit output power imbalance to below 16 A per phase, as required by EREC G99.	Yes / No*

Form C3 Part 2	
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	
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*
*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 for the **Type C or Type D#** **Power Generating Module** within the scope of this EREC G99, and the installation: 1. The **Power Generating Module Document** Form C2-1 is complete 2. The commissioning checks detailed in Form C2-2 have been successfully completed*. 3. The commissioning checks detailed in this Form C3 have been successfully completed. # delete **Type C** or **Type D** as applicable *delete if not applicable ie if the **Interface Protection** and ride through capabilities are **Type Tested**.	
Name:	
Signature:	Date:
Company:	
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:	
Company:	

Signature:	Date:

C.4 Performance Requirements For Continuously Acting Automatic Excitation Control Systems For Type C and Type D Synchronous Power Generating Modules

C.4.1 Scope

C.4.1.1 This Annex sets out the performance requirements of continuously acting automatic excitation control systems for **Type C** and **Type D Synchronous Power Generating Modules** that must be complied with by the **Generator**. This Annex does not limit any site specific requirements where in the **DNO's** reasonable opinion these facilities are necessary for system reasons.

C.4.1.2 Where the requirements may vary the likely range of variation is given in this Annex. It may be necessary to specify values outside this range where the **DNO** identifies a system need, and notwithstanding anything to the contrary the **DNO** may specify values outside of the ranges provided in this Annex C.4. The most common variations are in the on-load excitation ceiling voltage requirements and the response time required of the **Exciter**. Actual values will be included in the **Connection Agreement**.

C.4.1.3 Should a **Generator** anticipate making a change to the excitation control system it shall notify the **DNO** as the **Generator** anticipates making the change. The change may require a revision to the **Connection Agreement**.

C.4.2 Requirements

C.4.2.1 The **Excitation System** of a **Synchronous Power Generating Module** shall include an excitation source (**Exciter**) and a continuously acting **Automatic Voltage Regulator** (**AVR**) and shall meet the following functional specification.

C.4.2.3 Steady State Voltage Control

C.4.2.3.1 An accurate steady state control of the **Synchronous Power Generating Module** pre-set **Synchronous Generating Unit** terminal voltage is required. As a measure of the accuracy of the steady-state voltage control, the **Automatic Voltage Regulator** shall have static zero frequency gain, sufficient to limit the change in terminal voltage to a drop not exceeding 0.5% of rated terminal voltage, when the output of a **Synchronous Generating Unit** within a **Synchronous Power Generating Module** is gradually changed from zero to **Registered Capacity** at rated voltage and frequency.

C.4.2.4 Transient Voltage Control

C.4.2.4.1 For a step change from 90% to 100% of the nominal **Synchronous Generating Unit** terminal voltage, with the **Synchronous Generating Unit** on open circuit, the **Excitation System** response shall have a damped oscillatory characteristic. For this characteristic, the time for the **Synchronous Generating Unit** terminal voltage to first reach 100% shall be less than 0.6 s. Also, the time to settle within 5% of the voltage change shall be less than 3 s.

C.4.2.4.2 To ensure that adequate synchronising power is maintained, when the **Power Generating Module** is subjected to a large voltage disturbance, the **Exciter** whose output is varied by the **Automatic Voltage Regulator** shall be capable of providing its achievable upper and lower limit ceiling voltages to the **Synchronous Generating Unit** field in a time not exceeding that specified in the

Connection Agreement. This will normally be not less than 50 ms and not greater than 300 ms. The achievable upper and lower limit ceiling voltages may be dependent on the voltage disturbance.

C.4.2.4.3 The **Exciter** shall be capable of attaining an **Excitation System On Load Positive Ceiling Voltage** of not less than a value specified in the **Connection Agreement** that will be:

not less than 2 per unit (pu)

normally not greater than 3 pu

exceptionally up to 4 pu

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

C.4.2.4.4 If a static type **Exciter** is employed:

(i) the field voltage should be capable of attaining a negative ceiling level specified in the **Connection Agreement** after the removal of the step disturbance of C.4.2.4.3. The specified value will be 80% of the value specified in C.4.2.4.3. The **DNO** may specify a value outside the above limits where the **DNO** identifies a system need.

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

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

C.4.2.6 Overall **Excitation System** Control Characteristics

C.4.2.6.1 The overall **Excitation System** shall include elements that limit the bandwidth of the output signal. The bandwidth limiting must be consistent with the speed of response requirements and ensure that the highest frequency of response cannot excite torsional oscillations on other plant connected to the network. A bandwidth of 0-5 Hz will be judged to be acceptable for this application.

C.4.2.6.2 The response of the **Automatic Voltage Regulator** shall be demonstrated by injecting step signal disturbances into the **Automatic Voltage Regulator** reference. The **Automatic Voltage Regulator** shall include a facility to allow step injections into the **Automatic Voltage Regulator** voltage reference, with the **Type D Power Generating Module** operating at points specified by the **DNO** (up to rated MVA output). The damping shall be judged to be adequate if the corresponding **Active Power** response to the disturbances decays within two cycles of oscillation.

C.4.2.7 **Under-excitation Limiters**

C.4.2.7.1 The security of the power system shall also be safeguarded by means of MVAr **Under-excitation Limiters** fitted to the **Synchronous Power Generating Module Excitation System**. The **Under-excitation Limiter** shall prevent the **Automatic Voltage Regulator** reducing the **Synchronous Generating Unit** excitation to a level which would endanger synchronous stability. The **Under-excitation Limiter** shall operate when the **Excitation System** is providing automatic control. The **Under-excitation Limiter** shall respond to changes in the **Active Power** (MW) the **Reactive Power** (MVAr) and to the square of the **Synchronous Generating Unit** voltage in such a direction that an increase in voltage will permit an increase in leading MVAr. The characteristic of the **Under-excitation Limiter** shall be substantially linear from no-load to the maximum **Active Power** output of the **Power Generating Module** at any setting and shall be readily adjustable.

C.4.2.7.2 The performance of the **Under-excitation Limiter** shall be independent of the rate of change of the **Synchronous Power Generating Module** load and shall be demonstrated by testing as detailed in C.8.4.3. The resulting maximum overshoot in response to a step injection which operates the **Under-excitation Limiter** shall not exceed 4% of the **Synchronous Generating Unit** rated MVA. The operating point of the **Synchronous Generating Unit** shall be returned to a steady state value at the limit line and the final settling time shall not be greater than 5 s. When the step change in **Automatic Voltage Regulator** reference voltage is reversed, the field voltage should begin to respond without any delay and should not be held down by the **Under-excitation Limiter**. Operation into or out of the preset limit levels shall ensure that any resultant oscillations are damped so that the disturbance is within 0.5% of the **Synchronous Generating Unit** MVA rating within a period of 5 s.

C.4.2.7.3 The **Generator** shall also make provision to prevent the reduction of the **Synchronous Generating Unit** excitation to a level which would endanger synchronous stability when the **Excitation System** is under manual control.

C.4.2.8 Over-Excitation and Stator Current Limiters

C.4.2.8.1 The settings of the **Over-excitation Limiter** and stator current limiter, shall ensure that the **Synchronous Generating Unit** excitation is not limited to less than the maximum value that can be achieved whilst ensuring the **Synchronous Generating Unit** is operating within its design limits. If the **Synchronous Generating Unit** excitation is reduced following a period of operation at a high level, the rate of reduction shall not exceed that required to remain within any time dependent operating characteristics of the **Synchronous Power Generating Module**.

C.4.2.8.2 The performance of the **Over-excitation Limiter** shall be demonstrated by testing as described in C.8.4.4. Any operation beyond the over-excitation limit shall be controlled by the **Over-excitation Limiter** or stator current limiter without the operation of any **Protection** that could trip the **Synchronous Power Generating Module**.

C.4.2.8.3 The **Generator** shall also make provision to prevent any over-excitation restriction of the **Synchronous Generating Unit** when the **Excitation System** is under manual control, other than that necessary to ensure the **Power Generating Module** is operating within its design limits.

C.5 Performance Requirements for Continuously Acting Automatic Voltage Control Systems for Type C and Type D Power Park Modules

C.5.1 Scope

C.5.1.1 This Annex sets out the performance requirements of continuously acting Automatic Voltage Control systems for **Type C** and **Type D Power Park Modules** that must be complied with by the **User**. This Annex does not limit any site specific requirements where in the **DNO's** reasonable opinion these facilities are necessary for system reasons.

C.5.1.2 Should a **Generator** anticipate making a change to the excitation control system it shall notify the **DNO** as the **Generator** anticipates making the change. The change may require a revision to the **Connection Agreement**.

C.5.2 Requirements

C.5.2.1 The **DNO** requires that the continuously acting Automatic Voltage Control system for the **Power Park Module** shall meet the following functional performance specification.

C.5.3 Steady State Voltage Control

C.5.3.1 The **Power Park Module** shall provide continuous steady state control of the voltage at the **Connection Point** with a Setpoint Voltage and **Slope** characteristic as illustrated in Figure C.5.1.

NOT TO SCALE

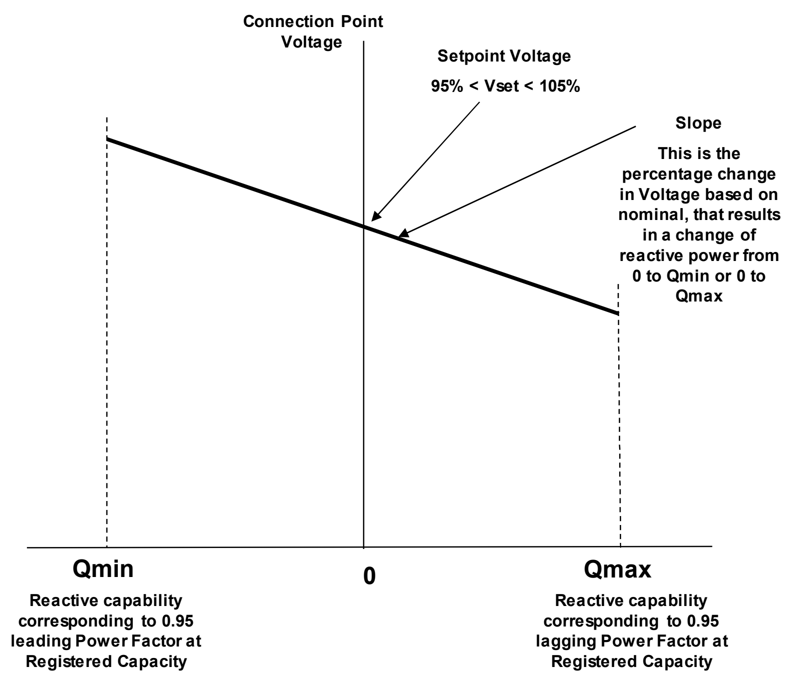


Figure C.5.1 Setpoint Voltage and Slope Characteristic

C.5.3.2 The continuously acting automatic control system shall be capable of operating to a Setpoint Voltage between 95% and 105% with a resolution of 0.25% of the nominal voltage. For the avoidance of doubt values of 95%, 95.25%, 95.5% may be specified, but not intermediate values. The initial Setpoint Voltage will be 100%. The tolerance within which this Setpoint Voltage shall be achieved is 0.25% and a Setpoint Voltage of 100%, the achieved value shall be between 99.75% and 100.25%. The **DNO** may request the **Generator** to implement an alternative Setpoint Voltage within the range of 95% to 105%.

C.5.3.3 The **Slope** characteristic of the continuously acting automatic control system shall be adjustable over the range 2% to 7% (with a resolution of 0.5%). For the avoidance of doubt values of 2%, 2.5%, 3% may be specified, but not intermediate values. The initial **Slope** setting will be 4%. The tolerance within which this **Slope** shall be achieved is 0.5% and a **Slope** setting of 4%, the achieved value shall be between 3.5% and 4.5%. The **DNO** may request the **Generator** to implement an alternative **Slope** setting within the range of 2% to 7%.

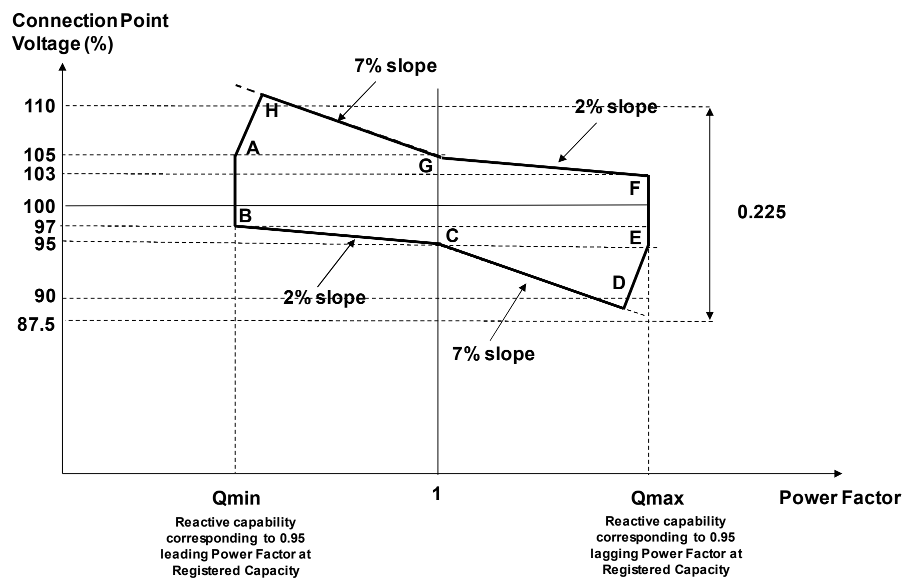


Figure C.5.2 Required envelope of operation for Power Park Modules

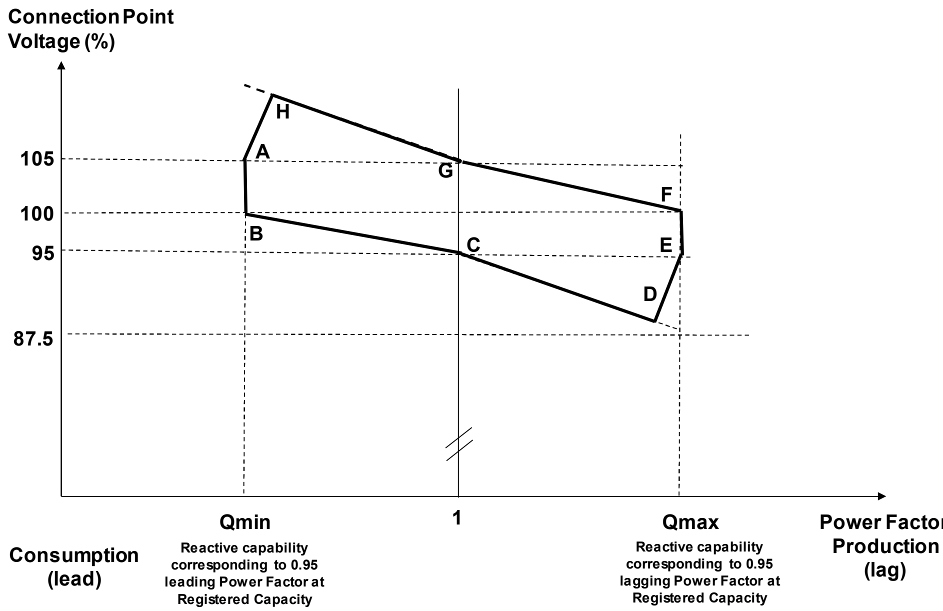


Figure C.5.3 Required envelope of operation for Power Park Modules connected at 33 kV and below

C.5.3.4 Figure C.5.2 shows the required envelope of operation for **Power Park Modules**. Figure C.5.3 shows the required envelope of operation for **Power Park Modules** connected at 33 kV and below. The enclosed area within points ABCDEFGH is the required capability range within which the **Slope** and Setpoint Voltage can be changed.

C.5.3.5 Should the operating point of the **Power Park Module** deviate so that it is no longer a point on the operating characteristic (Figure C.5.1) defined by the target Setpoint Voltage and **Slope**, the continuously acting Automatic Voltage Control system shall act progressively to return the value to a point on the required characteristic within 5 s.

C.5.3.6 Should the **Reactive Power** output of the **Power Park Module** reach its maximum lagging limit at a **Connection Point** voltage above 95%, the **Power Park Module** maintain maximum lagging **Reactive Power** output for voltage reductions down to 95%. This requirement is indicated by the line EF in Figures C.5.2 and C.5.3 as applicable. Should the **Reactive Power** output of the **Power Park Module** reach its maximum leading limit at a **Connection Point** below 105%, the **Power Park Module** shall maintain maximum leading **Reactive Power** output for voltage increases up to 105%. This requirement is indicated by the line AB in Figures C.5.2 and C.5.3 as applicable.

C.5.3.7 For **Connection Point** voltages below 95%, the lagging **Reactive Power** capability of the **Power Park Module** should be that which results from the supply of maximum lagging reactive current whilst ensuring the current remains within design operating limits. An example of the capability is shown by the line DE in Figures C.5.2and C.5.3. For **Connection Point** voltages above 105%, the leading **Reactive Power** capability of the **Power Park Module** should be that which results from the supply of maximum leading reactive current whilst ensuring the current remains within design operating limits. An example of the capability is shown by the line AH in Figures C.5.2and C.5.3 as applicable. Should the **Reactive Power** output of the **Power Park Module** reach its maximum lagging limit at a **Connection Point** voltage below 95%, the **Power Park Module** shall maintain maximum lagging reactive current output for further voltage decreases. Should the **Reactive Power** output of the **Power Park Module** reach its maximum leading limit at a **Connection Point** voltage above 105%, the **Power Park Module** shall maintain maximum leading reactive current output for further voltage increases.

C.5.4 Transient Voltage Control

C.5.4.1 For an on-load step change in **Connection Point** voltage the continuously acting automatic control system shall respond according to the following minimum criteria:

(i) the **Reactive Power** output response of the **Power Park Module** shall commence within 0.2 s of the application of the step. It shall progress linearly although variations from a linear characteristic shall be acceptable provided that the MVAr seconds delivered at any time up to 1 s are at least those that would result from the response shown in Figure C.5.4.

(ii) the response shall be such that 90% of the change in the **Reactive Power** output of the **Power Park Module** will be achieved within

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

- 1 s where the step is sufficiently large to require a change in the steady state **Reactive Power** output from zero to its maximum leading value or maximum lagging value as specified in paragraph 13.6;

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

(iv) within 5 s from achieving 90% of the response as defined in C.5.4.1 (ii), the peak to peak magnitude of any oscillations shall be less than 5% of the change in steady state maximum **Reactive Power**.

(v) following the transient response, the conditions of C.5.3 apply.

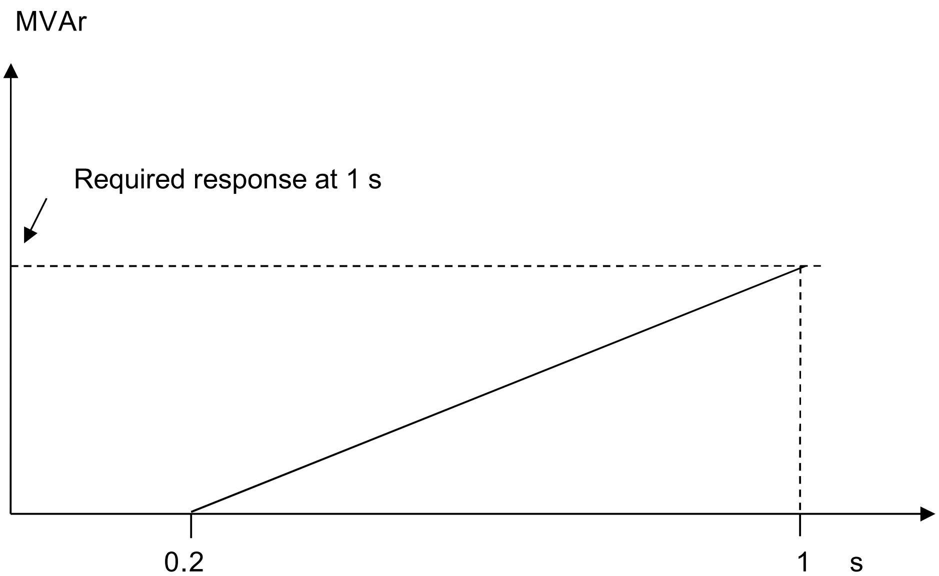


Figure C.5.4 Reactive Power Output Response

C.5.4.2 **Power Park Modules** shall be capable of

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

(b) changing its **Reactive Power** output from zero to its maximum leading value then reverting back to zero **Reactive Power** output at least 25 times within any 24 hour period and from zero to its maximum lagging value then reverting back to zero **Reactive Power** output at least 25 times within any 24 hour period.

In all cases, the response shall be in accordance to C.5.4.1 where the change in **Reactive Power** output is in response to an on-load step change in **Connection Point** voltage.

C.5.5 Overall Voltage Control System Characteristics

C.5.5.1 The continuously acting Automatic Voltage Control system is required to respond to minor variations, steps, gradual changes or major variations in **Connection Point** voltage.

C.5.5.2 The overall voltage control system shall include elements that limit the bandwidth of the output signal. The bandwidth limiting must be consistent with the speed of response requirements and ensure that the highest frequency of response cannot excite torsional oscillations on other plant connected to the network. A bandwidth of 0-5Hz would be judged to be acceptable for this application. All other control systems employed within the **Power Park Module** should also meet this requirement

C.5.5.3 The response of the **Power Park Module** voltage control system shall be demonstrated by testing in accordance with Annex C.9.

C.5.6 Reactive Power Control

C.5.6.1 As defined in **Grid Code** ECC.6.3.8.3.4, **Reactive Power** control mode of operation is not required in respect of **Power Park Modules** unless otherwise specified by the **NETSO** in coordination with the **DNO**. However where there is a requirement for **Reactive Power** control mode of operation, the following requirements shall apply.

C.5.6.2 The **Power Park** shall be capable of setting the **Reactive Power** setpoint anywhere in the **Reactive Power** range as specified in **Grid Code** ECC.6.3.2.6 with setting steps no greater than 5 MVAr or 5% (whichever is smaller) of full **Reactive Power**, controlling the **Reactive Power** at the **Connection Point** to an accuracy within ± 5 MVAr or ± 5% (whichever is smaller) of the full **Reactive Power**.

C.5.6.3 Any additional requirements for **Reactive Power** control mode of operation shall be specified by the N**ETSO** in coordination with the **DNO**.

C.5.7 Power Factor Control

C.5.7.1 As defined in **Grid Code** ECC.6.3.8.4.3, **Power Factor** control mode of operation is not required in respect of **Power Park Modules** unless otherwise specified by the **NETSO** in coordination with the **DNO.** However where there is a requirement for **Power Factor** control mode of operation, the following requirements shall apply.

C.5.7.2 The **Power Park Module** shall be capable of controlling the **Power Factor** at the **Connection Point** within the required **Reactive Power** range as specified in **Grid Code** ECC.6.3.2.2.1 and ECC.6.3.2.4 to a specified target **Power Factor**. The **DNO** shall specify the target **Power Factor** value (which shall be achieved within 0.01 of the set **Power Factor**), its tolerance and the period of time to achieve the target **Power Factor** following a sudden change of **Active Power** output. The tolerance of the target **Power Factor** shall be expressed through the tolerance of its corresponding **Reactive Power**. This **Reactive Power** tolerance shall be expressed by either an absolute value or by a percentage of the maximum **Reactive Power** of the **Power Park Module**. The details of these requirements being pursuant to the terms of the **Connection Agreement**.

C.5.7.3 Any additional requirements for **Power Factor** control mode of operation shall be specified by the N**ETSO** in coordination with the **DNO**.

C.6 Functional Specification for Dynamic System Monitoring, Fault Recording and Power Quality Monitoring Equipment for Type C and Type D Power Generating Modules

C.6.1 Purpose and Scope

This Annex describes the functional requirements for dynamic system monitoring, fault recording and power quality monitoring that **Generators** need to provide in accordance with the requirements of EREC G99 and the **Distribution Code**. It is expected that the functionality will be housed in a single recording device (RD), although other options are not discounted.

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

C.6.2 Functional Requirements

C6.2.1 Inputs and Outputs

The RD shall have analogue inputs:

a) Three phase voltage

b) Open delta/neutral-earth voltage

c) Three phase current

d) Neutral current.

The RD shall have digital inputs to record protection, control and plant status.

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

The RD shall have digital outputs:

a) RD healthy

b) RD triggered.

C6.2.2 Measured and Derived Quantities

At each agreed relevant point on the **Generator's** system dynamic system monitoring, fault recording and power quality monitoring shall be provided.

C6.2.2.1 Dynamic System Monitoring

Measured and derived quantities for dynamic system monitoring shall comprise:

a) 3 phase voltage quantities, including positive and negative phase sequence values.

b) 3 phase current quantities, including positive and negative phase sequence values.

c) **Active Power** and **Reactive Power** flows

d) Frequency.

C6.2.2.2 Fault Recording

Measured and derived quantities for fault recording shall comprise:

a) Voltage

b) Current

c) Protection, control and plant status.

C6.2.2.3 Power Quality Monitoring

Measured and derived quantities for power quality recording shall comprise:

a) Frequency

b) Voltage magnitude

c) Short-term flicker

d) Long-term flicker

e) Voltage dips, swells and interruptions

f) Voltage unbalance

g) Voltage THD and harmonics

h) Voltage inter-harmonics

i) Rapid voltage change

j) Voltage change

k) Current magnitude

l) Current THD and harmonics

m) Current inter-harmonics

n) Current unbalance.

Measurement intervals shall be in accordance with IEC 62586-1 Table 6.

Power quality monitoring shall be compliant with BS EN 61000-4-30 Class A. The harmonic and inter-harmonic orders shall correspond with the those as specified in EREC G5, BS EN 50160 and BS EN 61000-4-7.

C6.2.3 Accuracy and Resolution

The accuracy and resolution requirements for dynamic system monitoring shall be as specified in Table C.6.1 below.

Table C.6.1 Accuracy and resolution requirements for dynamic system monitoring

Quantity	Measurement Range	Accuracy ±% of nominal	Resolution ±% of nominal	Comment
RMS voltage	0 – 1.5 V_n	0.1	0.01	Crest factor ≤1.5
Voltage phase sequence components	0.8 V_n – 1.5 V_n	0.1	0.01	Crest factor ≤1.5
Current phase sequence components	0 – 5.0 I_n	0.5	0.01	Crest factor ≤3.0
Active Power	0 – 5 P_n	0.5	0.01	For all **Power Factor**s between 0.5 and 1.0
Reactive Power	0 – 5 RP_n	0.5	0.01	For all **Power Factor**s between 0.87 and 1.0
Frequency	42.5 Hz – 57.5 Hz	0.005	0.001	20%<V_n<150%

The accuracy requirements for fault recording and power quality monitoring shall be in accordance with BS EN 61000-4-30 Class A; the resolution requirements shall support the required accuracy in accordance with IEC 62586-1.

C6.2.4 Time Keeping

Inputs and all the derived data from inputs shall be time tagged to a resolution of 1μs. The RD internal clock shall be synchronised with Universal Time (UTC) via GPS satellite or other functionally similar method. It should be possible to set a local time offset.

C6.2.5Triggering

C6.2.5.1 Dynamic System Event Triggering

The dynamic system monitor shall have configurable dynamic system event triggers as follows:

a) Frequency (half-cycle)

b) Voltage (half cycle RMS and waveform)

c) Current (half-cycle RMS and waveform)

d) Positive sequence voltage (half cycle RMS)

e) Negative sequence voltage (half cycle RMS)

f) **Active Power** (half-cycle RMS)

g) **Reactive Power** (half-cycle RMS)

h) **Active Power** oscillation

i) **Power Factor** (half-cycle)

j) Digital inputs.

Dynamic system event half-cycle triggering shall be as detailed in Table C.6.2 below as a minimum requirement.

Table C.6.2 Dynamic system event half-cycle triggering

Parameter	**Over (+)/ Under (-) Deviation (%)**	**Step (%)**	**Phase step (°)**	**Rate of Change**
Frequency	● (+/-)	● (+/-)		● (+/-)
Voltage	● (+/-)	● (+/-)	● (+/-)	● (+/-)
Current	● (+/-)	● (+/-)		
Positive sequence voltage	● (+/-)			● (+/-)
Negative sequence voltage	● (+)			
Active Power	● (+/-)			● (+/-)
Reactive Power	● (+)	● (+/-)		
Power Factor	● (+/-)			
Digital inputs	rising edge/falling edge			

Dynamic system event waveform triggering shall be as be as detailed in Table C.6.3 below as a minimum requirement.

Table C.6.3 Dynamic system event half-cycle triggering

Parameter	**Over (+)/ Under (-) Deviation (%)**	**Step (%)**	**Phase step (°)**	**Period**	**Number of oscillations in time window**
Voltage waveform	● (+/-)	● (+/-)	●		

Current waveform	● (+/-)	● (+/-)	●		
Active Power oscillation	● (+)			●	●
Digital inputs	rising edge/falling edge				

The above to have an accuracy of better than 2% and all analogue inputs shall trigger for disturbance durations shorter than 10 ms.

Multiple triggering of fault recordings shall be prevented by a hysteresis band around the trigger set point.

The type and magnitude of triggering shall be independently selectable on all analogue input channels and on all calculated quantities.

Digital triggering shall 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’.

C6.2.5.1.1 Pre-event Recording

For dynamic system monitoring the pre-event time for half-cycle recording shall be **DNO** configurable in the range of 20 ms to 1000 ms; for waveform recording the pre-event time shall be **DNO** configurable in the range of 20 ms to 200 ms.

C6.2.5.1.2 Post-event Recording

For dynamic system monitoring the post-event time for half-cycle recording shall be **DNO** configurable in the range of 20 ms to 60 s; for waveform recording the post-event time shall be **DNO** configurable in the range of 20 ms to 2000 ms.

C63.2.5.2 Fault Event Triggering

The fault recorder shall have configurable dynamic system event triggers as follows:

a) Voltage (half cycle RMS and waveform)
b) Current (half-cycle RMS and waveform)
c) Digital inputs.

Fault recorder half-cycle triggering shall be as be as detailed in Table C.6.4 below as a minimum requirement.

Table C.6.4 Fault recorder half-cycle triggering

Parameter	Over (+)/ Under (-) Deviation (%)	Step (%)	Phase step (º)	Rate of Change

Voltage	● (+/-)	● (+/-)	● (+/-)	● (+/-)
Current	● (+/-)	● (+/-)		
Digital inputs	rising edge/falling edge			

Fault recorder waveform triggering shall be as detailed in Table C.6.5 below as a minimum requirement.

Table C.6.5 Fault recorder waveform triggering

Parameter	**Over (+)/ Under (-) Deviation (%)**	**Step (%)**	**Phase step (°)**
Voltage waveform	● (+/-)	● (+/-)	●
Current waveform	● (+/-)	● (+/-)	●
Digital inputs	rising edge/falling edge		

C6.2.5.2.1 Pre event Recording:

For fault recording the pre-event time for half-cycle recording shall be **DNO** configurable in the range of 20 ms to 120 s; for waveform recording the pre-event time shall be **DNO** configurable in the range of 20 ms to 200 ms.

C6.2.5.2.2 Post event Recording

For fault recording the post-event time for half-cycle recording shall be **DNO** configurable in the range of 20 ms to 120 s; for waveform recording the post-event time shall be **DNO** configurable in the range of 20 ms to 2000 ms.

C6.2.5.3 Power Quality Event Triggering

The power quality monitor shall have configurable power quality event triggers as follows:

a) Frequency (10 s)

b) Voltage magnitude (10 minute)

c) Short-term flicker (10 minute)

d) Long-term flicker (2 hour)

e) Voltage dip

f) Voltage swell

g) Voltage interruption

h) Voltage unbalance (10 minute)

i) Voltage THD and harmonics (10 minute)

j) Voltage inter-harmonics (10 minute)

k) Rapid voltage change

l) Voltage change.

Power quality event triggering shall be as detailed in Table C.6.6 below as a minimum.

Table C.6.6 Power quality event triggering

Parameter	**Over (+)/Under (-) Deviation**
Frequency	● (+/-)
Voltage magnitude	● (+/-)
Short-term flicker	● (+)
Long-term flicker	● (+)
Voltage dip	● (-)
Voltage swell	● (+)
Voltage interruption	● (-)
Voltage unbalance	● (+)
Voltage THD and harmonics	● (+)
Voltage inter-harmonics	● (+)
Rapid voltage change	● (+/-)
Voltage change	● (+/-)

C6.2.6 Analysis and Reporting

C6.2.6.1 Dynamic System Records

Analysis software shall be provided to enable selection and plotting of each of the following dynamic system parameters against time:

a) Frequency (half-cycle min, max and mean)

b) Voltage (half cycle RMS min, max and mean)

c) Current (half-cycle RMS min, max and mean)

d) Positive sequence voltage (half cycle RMS)

e) Negative sequence voltage (half cycle RMS min, max and mean)

f) **Active Power** (half-cycle RMS min, max and mean)

g) **Reactive Power** (half-cycle RMS min, max and mean)

h) **Power Factor** (half-cycle).

The facility to graphically zoom in and out shall be provided.

Provision shall be made for display of:

a) Dynamic system triggered event summary information in tabular form

b) Dynamic system triggered event detail graphically

c) Dynamic system triggered event occurrence versus time.

C6.2.6.2 Fault Records

Provision shall be made for display of:

a) Fault recorder triggered event summary information in tabular form

b) Fault recorder triggered event detail graphically

c) Fault recorder triggered event occurrence versus time.

C6.2.6.3 Power Quality Records

Analysis software shall be provided to enable selection and plotting of each of the following power quality parameters against time:

a) Frequency (10 s min, max and mean)

b) Voltage magnitude (10 minute min, max and mean)

c) Short-term flicker (10 minute)

d) Long-term flicker (2 hour)

e) Voltage unbalance (10 minute)

f) Voltage THD and harmonics (10 minute)

g) Voltage inter-harmonics (10 minute).

The facility to graphically zoom in and out shall be provided.

Provision shall be made for display of:

a) Power quality triggered event summary information in tabular form

b) Voltage dips, swells and interruptions in residual voltage versus time graphical form and in the tabular form specified in BS EN 50160

c) Power quality triggered events graphically

d) Fault recorder triggered event occurrence versus time.

C6.2.7 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's** SCADA, the **DNO** will provide further specific information on protocols and connection requirements.

C6.2.8 Environmental

The RD environmental performance shall be in accordance with IEC 62586-1 product coding PQI-A-FI2-H.

EMC emissions shall be in accordance with IEC 62586-1.

The minimum intrusion protection (IP) requirements shall be in accordance with IEC 62586-1.

C6.2.9 Additional Requirements

The following requirements specified in IEC 62586-1 shall apply:

a) Start-up requirements

b) Marking and operating instructions

c) Functional, environmental and safety type tests

d) EMC tests

e) Climatic tests

f) Mechanical tests

g) Functional and uncertainty tests

h) Routine tests

i) Declarations

j) Re-calibration and re-verification.

C.6.3 Relevant Standards

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

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

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

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

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

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

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

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

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

BS EN 61000-4-7 Testing and measurement techniques. General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto

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

IEC 62586-1 Power Quality Measurement in power systems – Part 1: Power quality instruments

C.6.4 Calibration and Testing

It is the **Generator's** responsibility to ensure that the RD remains functioning and accurate. The **DNO** has the right to request demonstration of accuracy and functionality.

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

C.7 Simulation Studies for Type C and Type D Power Generating Modules

C.7.1 Scope

C.7.1.1 This Annex 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 Annex should be read in conjunction with Section 21.4 with regard to the submission of the reports to the **DNO**. The studies specified in this Annex 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**.

C.7.1.2 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. In all cases the simulation studies must be presented over a sufficient time period to demonstrate compliance with all applicable requirements.

C.7.1.3 **The DNO** may permit relaxation from the requirement in paragraph C.7.2 to paragraph C.7.8 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**.

C.7.1.4 For **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.

C.7.2 Power System Stabiliser Tuning

C.7.2.1 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** C.1.2.5.6 shall be submitted in accordance with **Grid Code** EPC.A.3.2.1.

C.7.2.2 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** C.2.2.4.1 shall contain be submitted in accordance with **Grid Code** ECP.A.3.2.2.

C.7.3 Reactive Capability across the Voltage Range

C.7.3.1 The **Generator** shall supply simulation studies to demonstrate the capability to meet Section 13.6 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 Module 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.

C.7.3.2 In the case of a **Synchronous Power Generating Module** the terminal voltage in the simulation should be the nominal voltage for the machine.

C.7.3.3 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 (eg **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.

C.7.4 Voltage Control and Reactive Power Stability

C.7.4.1 This section applies to **Power Park Modules** to demonstrate the voltage control capability**.**

C.7.4.2 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 Modules**. 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 **Registered Capacity**.

(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 **Registered Capacity**.

(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.

C.7.4.3 All the above studies should be completed with a network operating at the voltage applicable for zero **Reactive Power** transfer at the **Connection Point** unless stated otherwise. The fault level at the **Connection Point** should be set at the minimum level as agreed with the **DNO**.

C.7.4.4 The **DNO** may permit relaxation from the requirements of C.7.4.2(i) and (ii) for voltage control if the **Power Park Modules** are comprised of **Generating 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.

C.7.4.5 In addition the **DNO** may permit a further relaxation from the requirements of C.7.4.2(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**.

C.7.5 Fault Ride Through and Fast Fault Current Injection

C.7.5.1 This section applies to **Power Generating Modules** to demonstrate the modules **Fault Ride Through** capability.

C.7.5.2 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 paragraph 13.3 and paragraph 13.6 by submission of a report containing:

(i) a time series simulation study of a 140 ms three phase short circuit fault with a retained voltage as detailed in Table C.7.1 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 C.7.1 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 C or **Type D** with **Connection Point** voltage <110 kV	10%
Type D with **Connection Point** voltage >110 kV	0%
Power Park Module	
Type C or **Type D** with **Connection Point** voltage < 110 kV	10%
Type D with **Connection Point** voltage >110 kV	0%

Table C.7.1

C.7.5.3 The simulation study should be completed with the **Power Generating Module** operating at full **Active Power** and maximum leading **Reactive Power** and the fault level at the **Connection Point** at minimum as notified by the **DNO**.

C.7.5.4 The simulation study will show acceptable performance providing compliance with the requirements of paragraph 13.3.1.11 (e) are demonstrated.

C.7.5.5 In the case of **Power Generating 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**, C.7.5.2 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 C.7.5.2 applied at the **Connection Point** are less than those included in the **Manufacturers' Information**, or;

(ii) the same or greater percentage faults and voltage dips in C.7.5.2 have been applied at either side of the **Generating Unit** transformer in the **Manufacturers' Information**.

C.7.6 Limited Frequency Sensitive Mode – Over Frequency (LFSM-O)

C.7.6.1 This section applies to **Power Generating Modules** to demonstrate the capability to modulate **Active Power** at high frequency as required by Section 13.2.5.

C.7.6.2 The simulation study should comprise of a **Power Generating Module** connected to the **Total System** with a local load shown as "X" in Figure C.7.1. 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**.

C.7.6.3 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 C.7.2. This additional **Synchronous Power Generating Module** should have an inertia constant of 3.5 MWs/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.

C.7.6.4 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** or connection circuit breaker (the governor should therefore, not receive any signals that the breaker has opened other than the reduction in load and subsequent increase in speed). A schematic arrangement of the simulation study is illustrated by Figure C.7.1.

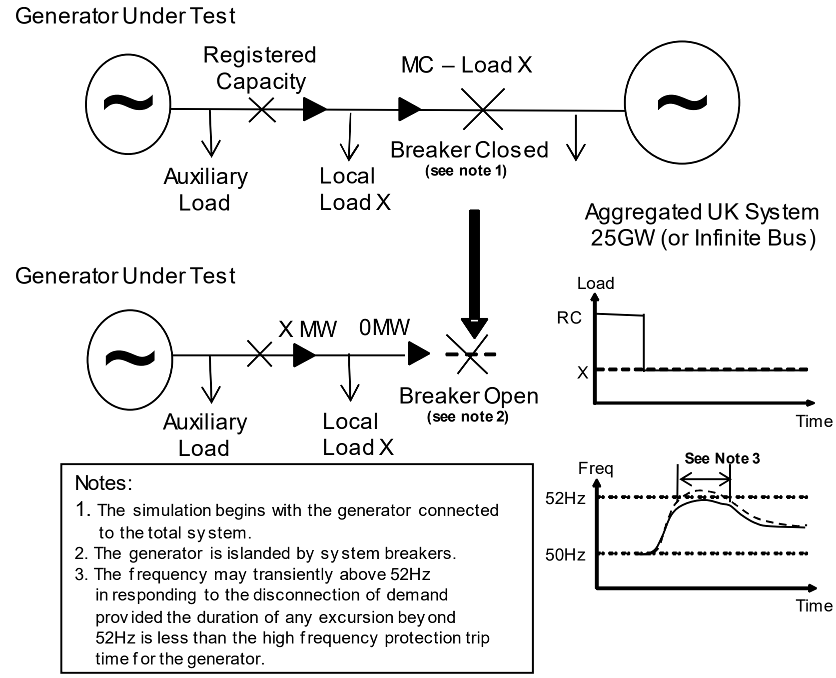


Figure C.7.1 – Diagram of Load Rejection Study

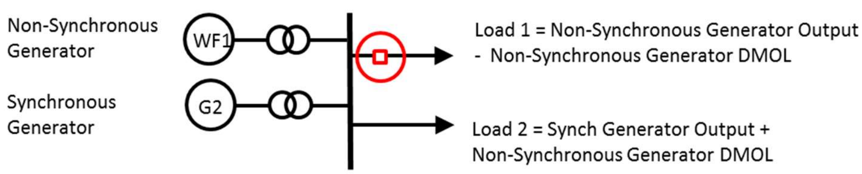


Figure C.7.2 – Addition of G2 if applicable

C.7.6.5 Simulation studies shall be performed in **Limited Frequency Sensitive Mode** (**LFSM**) and **Frequency Sensitive Mode** (**FSM**). The simulation study results should indicate **Active Power** and frequency.

C.7.6.6 To allow validation of the model used to simulate load rejection in accordance with paragraph 13.2.5 as described a further simulation study is required to represent the largest positive frequency injection step or fast ramp (BC1 and BC3 of Figure C.7.1 and Figure C.9.3) that will be applied as a test as described in C.7.8 and C.8.6.

C.7.7 Limited Frequency Sensitive Mode – Under Frequency (LFSM-U)

C.7.7.1 This section applies to **Synchronous Power Generating Modules** and **Power Park Modules** to demonstrate the module's capability to modulate **Active Power** at low frequency.

C.7.7.2 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:

(i) a sufficiently large reduction in the measured system frequency ramped over 10 s to cause an increase in **Active Power** output to the **Registered Capacity** followed by

(ii) 60 s of steady state with the measured system frequency depressed to the same level as in C.7.7.2 (i) as illustrated in Figure C.7.3 below.

(iii) then increase of the measured system frequency ramped over 10 s to cause a reduction in **Active Power** output back to the original **Active Power** level followed by at least 60 s of steady output.

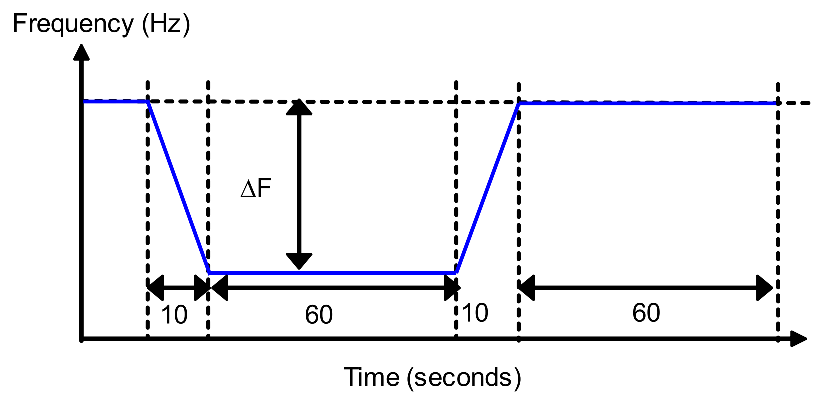


Figure C.7.3

C.7.8 Voltage and Frequency Controller Model Verification and Validation

C.7.8.1 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.

C.7.8.2 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 s followed by

(ii) 20 s 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 s followed by

(iv) 60 s of steady state with the measured system frequency depressed by 0.2Hz as illustrated in Figure C.7.4 below.

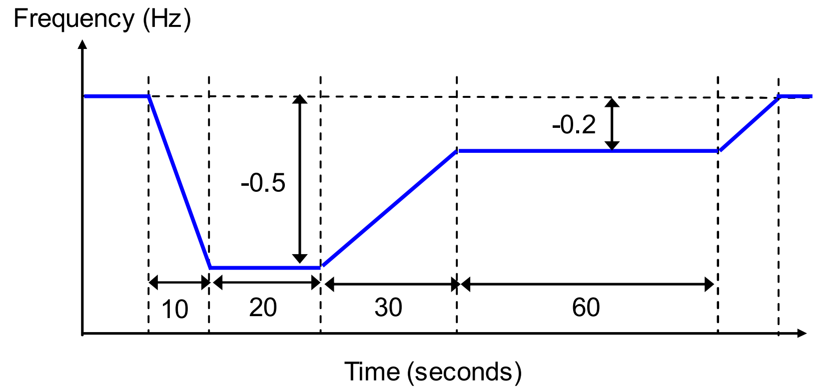


Figure C.7.4

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

C.7.8.3 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 **Registered Capacity**, 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.

C.7.8.4 To demonstrate the Voltage Controller model the shall submit a simulation study representing the response of the **Power Park Module** operating at **Registered Capacity** 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.

C.7.8.5 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.

C.7.8.6 For **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.

C.8 Compliance Testing of Type C and Type D Synchronous Power Generating Modules

C.8.1 Scope

C.8.1.1 This Annex sets out the tests contained therein to demonstrate compliance with the relevant clauses of the EREC G99.

C.8.1.2 The tests specified in this Annex will normally be sufficient to demonstrate compliance however the **DNO** may:

(i) 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

(ii) require additional or alternative tests if information supplied to the **DNO** during the compliance process suggests that the tests in this Annex will not fully demonstrate compliance with the relevant section of the EREC G99 or the **Connection Agreement.**

(iii) Agree a reduced set of tests for subsequent **Synchronous Power Generating Module** following successful completion of the first **Synchronous Power Generating Module** tests in the case of a **Power 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 C.8.1.2(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 C.8.1.2(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 Annex will be applied.

C.8.1.3 The **Generator** is responsible for carrying out the tests set out in and in accordance with this Annex 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 Annex 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.

C.8.1.8 Full **Synchronous** Power Generating M**odule** testing is to be completed as defined in C.8.2 through to C.8.7.

C.8.1.9 The **DNO** may permit relaxation from the requirement C.8.2 to C.8.7 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.

C.8.2 Excitation System Open Circuit Step Response Tests

C.8.2.1 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.

C.8.2.2 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:

V_t - Synchronous **Generating Unit** terminal voltage

E_{fd} - Synchronous **Generating Unit** field voltage or main **Exciter** field voltage

I_{fd}- Synchronous **Generating Unit** field current (where possible)

Step injection signal

C.8.2.3 Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

C.8.3 Open & Short Circuit Saturation Characteristics

C.8.3.1 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**.

C.8.3.2 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**.

C.8.3.3 Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

C.8.4 Excitation System On-Load Tests

C.8.4.1 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.

C.8.4.2 Where a **Power System Stabiliser** is present the tests should be carried out in accordance with the **Grid Code** ECP.A.5.4.2.

C.8.4.3 Under-excitation Limiter Performance Test

C.8.4.3.1 Initially 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.

C.8.4.3.2 The final performance of the **Under-excitation Limiter** shall be demonstrated by testing its response to a step change corresponding to a 2% decrease in **Automatic Voltage Regulator** Setpoint Voltage when the **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.

C.8.4.3.3 Where 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.

C.8.4.3.4 The **Under-excitation Limiter** will normally be tested at low **Active Power** output (**Minimum Generation**) and at maximum **Active Power** output (**Registered Capacity**).

C.8.4.3.5 The 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 s until stabilised • Remove step returning **AVR** Voltage Setpoint to nominal and hold for at least 10 s	
	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 s until stabilised • Remove step returning **AVR** Voltage Setpoint to nominal and hold for at least 10 s	

C.8.4.4 Over-excitation Limiter Performance Test

C.8.4.1 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.

C.8.4.2 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.

C.8.4.3 The 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).	

C.8.5 Reactive Capability

C.8.5.1 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**.

C.8.5.2 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.

C.8.5.3 The test procedure, time and date will be agreed with the **DNO** and will be to the instruction of the **DNO** control centre and shall be monitored and recorded at both the **DNO** control centre and by the **Generator**.

C.8.5.4 Where the **Generator** is recording the voltage, **Active Power** and **Reactive Power** at the **Connection Point** the voltage, **Active Power** and **Reactive Power** at the **Synchronous Power Generating Module** terminals may also be included. The results shall be supplied in an electronic spreadsheet format. Where applicable the **Synchronous Power Generating Module** transformer tap changer position should be noted throughout the test period.

C.8.6 Governor and Load Controller Response Performance

C.8.6.1 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.

C.8.6.2 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 C.8.6.3 for demonstrating performance on the alternative fuel. This includes the case where a main fuel is supplemented by bio-fuel.

C.8.6.3 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

C.8.6.4 The tests are divided into the following two types;

(i) Frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** capability and **LFSM-U** capability as shown by Figure C.8.1.

(ii) System islanding and step response tests if required by the **DNO**.

C.8.6.5 There should be sufficient time allowed between tests for control systems to reach steady state. Where the diagram states ‘HOLD’ the injection signal 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.

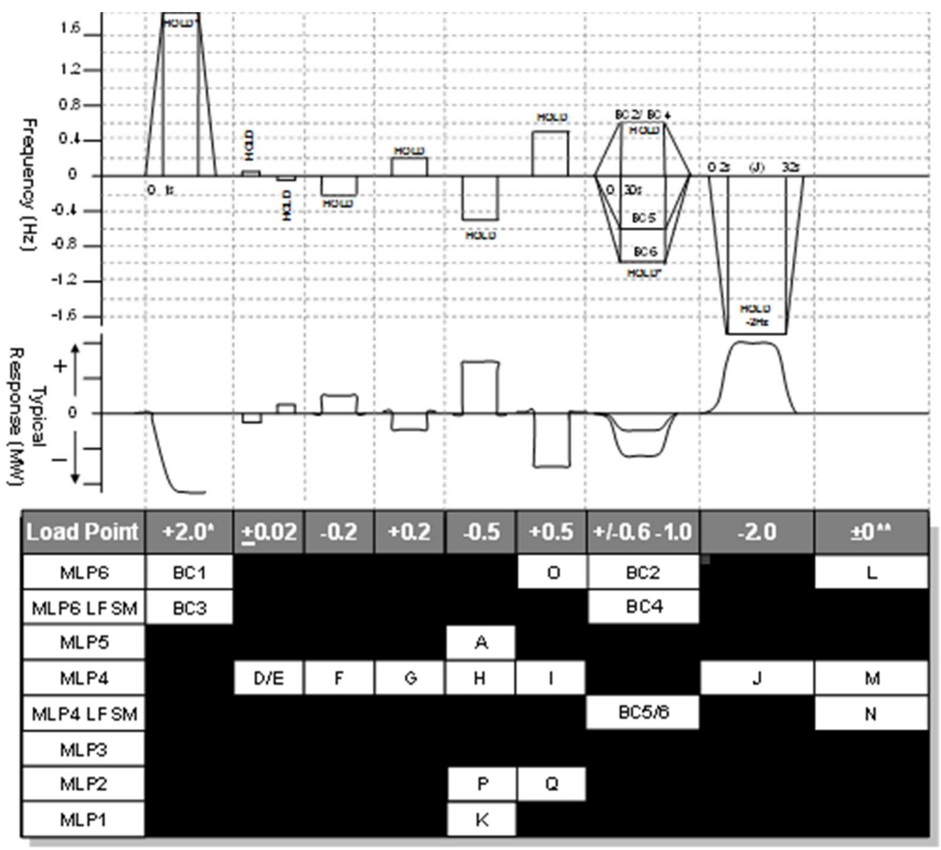


Figure C.8.1: Frequency Response Capability LFSM-O, LFSM-U, FSM Step Tests

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

* This will generally be +2.0 Hz 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 0.9 Hz 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 0.04 x 50 = 0.9 Hz

** Tests L and M in Figure C.8.1 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 C.8.1 shall be conducted in all cases. Both tests should be conducted for a period of at least 10 minutes.

C.8.6.6 The target frequency adjustment facility should be demonstrated from the normal control point within the range of 49.9 Hz to 50.1 Hz by step changes to the target frequency setpoint.

C.8.7 Compliance with Output Power with falling frequency Functionality Test

C.8.7.1 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.

C.8.7.2 The tests can be undertaken by the **Synchronous Power Generating Module** powering a suitable load bank, or alternatively using the test set up of Figure A8.6. In both cases a suitable test could be to start the test at nominal frequency with the **Synchronous Power Generating Module** operating at 100% of its **Registered Capacity**.

C.8.7.3 The frequency should then be set to 49.5 Hz for 5 minutes. The output should remain at 100% of **Registered Capacity**.

C.8.7.4 The frequency should then be set to 49.0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 99% of **Registered Capacity**.

C.8.7.5 The frequency should then be set to 48.0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 97% of **Registered Capacity**.

C.8.7.6 The frequency should then be set to 47.6 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 96.2% of **Registered Capacity**.

C.8.7.7 The frequency should then be set to 47.1 Hz and held at this frequency for 20 s. The **Active Power** output must not be below 95.0% of **Registered Capacity** and the **Synchronous Power Generating Module** must not trip in less than the 20s of the test.

C.8.7.8 The Generator shall inform the **DNO** if any load limiter control is additionally employed.

C.9 Compliance Testing of Type C and Type D Power Park Modules

C.9.1 Scope

C.9.1.1 This Annex outlines the general testing requirements for **Power Park** to demonstrate compliance with the relevant clauses of the EREC G99.

C.9.1.2 The tests specified in this Annex will normally be sufficient to demonstrate compliance however the **DNO** may:

(i) 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

(ii) require additional or alternative tests if information supplied to the **DNO** during the compliance process suggests that the tests in this Annex will not fully demonstrate compliance with the relevant section of this EREC G99 and the **Connection Agreement**; and/or

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

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

(v) 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 Generating Facility** comprised of two or more **Power Park Modules** which the **DNO** reasonably considers to be identical.

If:

(a) the tests performed pursuant to C.10.1.1(iv) do not replicate the results contained in the **Manufacturer's Data & Performance Report** or

(b) the tests performed pursuant to C.10.1.1(v) in respect of subsequent **Power Park Modules** do not replicate the full tests for the first **Power Park Module**, or

(c) any of the tests performed pursuant to C.10.1.1(iv) or C.10.1.1(v) do not fully demonstrate compliance with the relevant aspects of this EREC G99 and the **Connection Agreement**,

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

C.9.1.2 The **Generator** is responsible for carrying out the tests set out in and in accordance with this Annex 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 Annex 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.

C.9.1.3 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:

(i) All relevant transformer tap numbers; and

(ii) Number of **Generating Units** in operation

C.9.1.4 The **Generator** shall submit a detailed schedule of tests to the **DNO** in accordance with the compliance testing requirements of EREC G99 and this Annex.

C.9.1.5 Partial **Power Park Module** testing as defined in C.9.2 and C.9.3 is to be completed at the appropriate stage.

C.9.1.6 The **DNO** may permit relaxation from the requirement C.9.2 to C.9.8 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. The relevant **Manufacturers' Information** must be supplied in the **Power Generating Module Document** or **DDRC** as applicable.

C.9.2 Pre 20% Synchronised Power Park Module Basic Voltage Control Tests

C.9.2.1 Before 20% of the **Power Park Module** has commissioned, either voltage control test C.9.4.6(i) or (ii) must be completed.

C.9.3 Reactive Capability Test

C.9.3.1 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**.

C.9.3.2 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 C.10.4.5.

C.9.3.2 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**.

C.9.3.3 The following tests shall be completed:

(i) Operation in excess of 60% **Registered capacity** and maximum continuous lagging **Reactive Power** for 30 minutes.

(ii) Operation in excess of 60% **Registered capacity** and maximum continuous leading **Reactive Power** for 30 minutes.

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

(iv) Operation at 20% **Registered capacity** and maximum continuous leading **Reactive Power** for 60 minutes.

(v) Operation at 20% **Registered capacity** and maximum continuous lagging **Reactive Power** for 60 minutes.

(vi) 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**.

(vii) 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.

(viii) 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.

C.9.3.4 Within this Annex 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.**

C.9.4 Voltage Control Tests

C.9.4.1 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 the relevant technical requirements section of this EREC G99. 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**.

C.9.4.2 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.

C.9.4.3 The time between transformer taps shall be at least 10 s as per Figure C.9.1.

C.9.4.4 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 s as per Figure C.9.2.

C.9.4.5 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.

C.9.4.6

Tests to be completed:

(i)

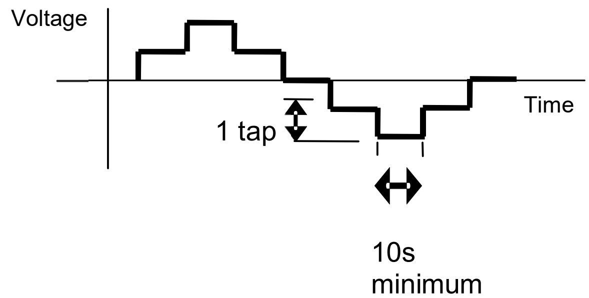


Figure C.9.1 – Transformer tap sequence for voltage control tests

(ii)

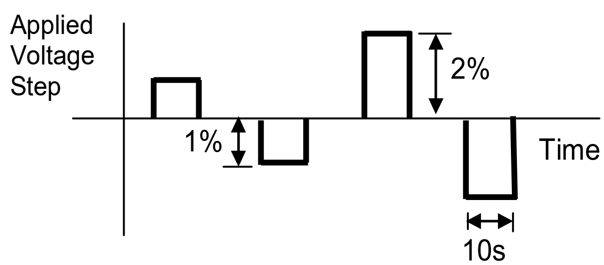


Figure C.9.2 – Step injection sequence for voltage control tests

C.9.5 Frequency Response Tests

C.9.5.1 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**.

C.9.5.2 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 C.9.5.6 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.

C.9.5.3 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 13.12. This test shall be conducted in **Limited Frequency Sensitive Mode** at a part-loaded output for a period of 10 minutes as per C.9.5.6.

C.9.5.4 The frequency response 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**.

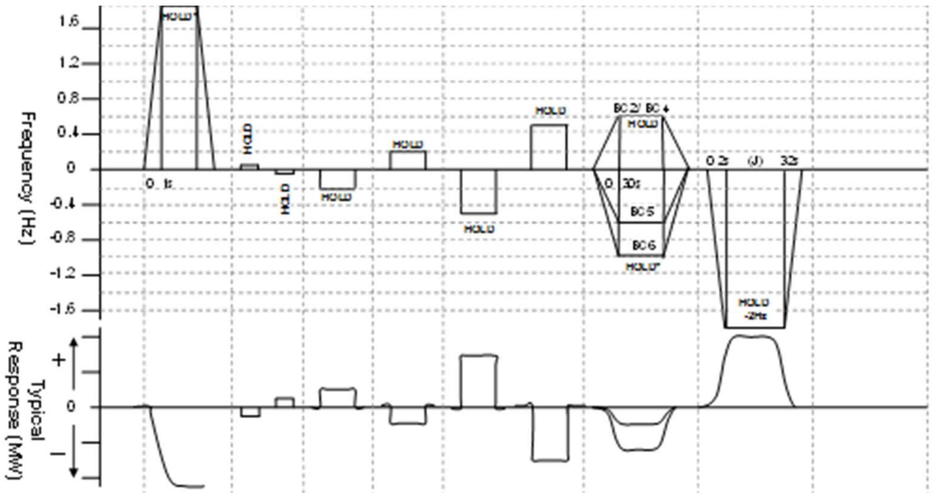
Module Load Point 6 (**Maximum Export Limit**)	100% MEL
Module Load Point 5	90% MEL
Module Load Point 4 (Mid point of Operating Range)	80% MEL
Module Load Point 3	MRL+20%
Module Load Point 2	MRL+10%
Module Load Point 1(**Minimum Generation**)	MRL

C.9.5.5 The tests are divided into the following two types;

(i) Frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** and **LFSM-U** capability as shown by Figure C.9.3.

(ii) System islanding and step response tests as shown by Figure C.9.3.

C.9.5.6 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 injection signal 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.



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

Figure C.9.2 – Frequency Response Capability LFSM-O, LFSM-U, FSM Step Tests

* This will generally be +2.0 Hz 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, 0.9 Hz 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 = 0.9 Hz

** Tests L and M in Figure C.9.3 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 C.9.3 shall be conducted in all cases. All tests should be conducted for a period of at least 10 minutes.

C.9.5.7 The target frequency adjustment facility should be demonstrated from the normal control point within the range of 49.9 Hz to 50.1 Hz by step changes to the target frequency setpoint.

C.10 Minimum Frequency Response Capability Requirement Profile and Operating Range for Type C and Type D Power Generating Modules

C.10.1 Scope

C.10.1.1 In addition to the requirements defined in Section 13.2 this Annex defines the minimum frequency response requirements for each **Type C** and **Type D Power Generating Module**.

C.10.1.2 This Annex provides appropriate performance criteria relating to the provision of frequency control by means of frequency sensitive operation in addition to the other requirements identified in Section 13.2.

C.10.1.3 It is a requirement that **Type C** and **Type D Power Generating Modules** have this capability and can demonstrate it. It will, however, only be required to be operative under an appropriate ancillary services commercial contract with the **NETSO** should the **Generator** choose to enter into such an agreement.

C.10.2 Plant Operating Range

C.10.2.1 This section uses the following terms:

C.10.2.1.1 primary response to mean the automatic increase in **Active Power** output of a **Power Generating Module** in response to falling system frequency, and which is achieved within the first 10s from the start of the fall in frequency (see Figure C.10.2).

C.10.2.1.2 secondary response to mean the automatic increase in **Active Power** output of a **Power Generating Module** in response to falling system frequency, and which is after 30s from the start of the fall in frequency and is sustainable for at least 30 minutes (see Figure C.10.2).

C.10.2.1.3 high frequency response to mean the automatic reduction in **Active Power** output of a **Power Generating Module** in response to an increase in system frequency, and which is achieved within the first 10s from the start rise in frequency and is sustainable for at least 30 minutes (see Figure C.10.3).

C.10.2.2 The upper limit of the operating range is the **Registered Capacity** of the **Power Generating Module** or **Generating Unit**.

C.10.2.3 The **Minimum Regulating Level** may be less than, but must not be more than, 55% of the **Registered Capacity**. Each **Synchronous Power Generating Module** and/or **Generating Unit** and/or **Power Park Module** must be capable of operating satisfactorily down to the **Minimum Regulating Level** as dictated by system operating conditions.

C.10.2.4 If a **Synchronous Power Generating Module** or **Generating Unit** or **Power Park Module**, is operating below **Minimum Generation** because of high system frequency, it should recover adequately to its **Minimum Generation** as the system frequency returns to target frequency so that it can provide primary and secondary response from its **Minimum Generation** if the system frequency continues to fall. For the avoidance of doubt, under normal operating conditions steady state operation below the **Minimum Generation** is not expected. The

Minimum Regulating Level must not be more than 55% of **Registered Capacity.**

C.10.2.5 In the event of a **Power Generating Module** or **Generating Unit** or **Power Park Module** load rejecting down to no less than its **Minimum Regulating Level** it should not trip as a result of automatic action. If the load rejection is to a level less than the **Minimum Regulating Level** then it is accepted that the condition might be so severe as to cause it to be disconnected from the **Distribution Network**.

C10.2.6 Figure C.10.1 shows the minimum frequency response capability requirement profile diagrammatically for a 0.5 Hz change in frequency. The percentage response capabilities and loading levels are defined on the basis of the **Registered Capacity** of the **Power Generating Module**. Each **Power Generation Module** must be capable of operating in a manner to provide frequency response at least to the solid boundaries shown in the figure. If the frequency response capability falls within the solid boundaries, the **Power Generating Module** is providing response below the minimum requirement which is not acceptable. Nothing in this Annex is intended to prevent a **Power Generating Module** from being designed to deliver a frequency response in excess of the identified minimum requirement.

C10.2.7 The frequency response delivered for frequency deviations of less than 0.5 Hz should be no less than a figure which is directly proportional to the minimum frequency response requirement for a frequency deviation of 0.5 Hz. For example, if the frequency deviation is 0.2 Hz, the corresponding minimum frequency response requirement is 40% of the level shown in Figure C.10.1. The frequency response delivered for frequency deviations of more than 0.5 Hz should be no less than the response delivered for a frequency deviation of 0.5 Hz.

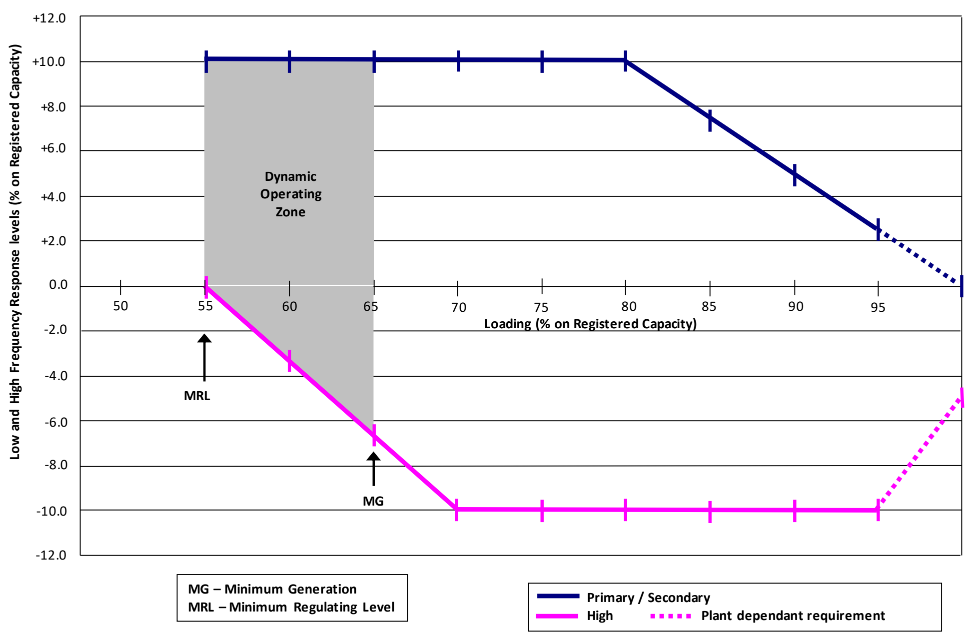


Figure C.10.1 Minimum Frequency Response Capability Requirement Profile for a 0.5 Hz change from Target Frequency

C10.2.8 Each **Power Generating Module** must be capable of providing some response, in keeping with its specific operational characteristics, when operating between 95% to 100% of **Registered Capacity** as illustrated by the dotted lines in Figure C.10.1.

C10.2.9 At **Minimum Generation**, each **Power Generating Module** is required to provide high and low frequency response depending on the system frequency conditions. Where the frequency is high, the **Active Power** output is therefore expected to fall below **Minimum Generation**.

C10.2.10 The **Minimum Regulating Level** is the output at which a **Power Generating Module** has no high frequency response capability. It may be less than, but must not be more than, 55% of the **Registered Capacity**. This implies that a **Power Generating Module** is not obliged to reduce its output to below this level unless the frequency is at or above 50.5 Hz

C.10.3 Repeatability of Response

C.10.3.1 When a **Power Generating Module** has responded to a significant frequency disturbance, its response capability must be fully restored as soon as technically possible. Full response capability should be restored no later than 20 minutes after the initial change of system frequency arising from the frequency disturbance.

C.10.4 Testing of Frequency Response Capability

C10.4.1 The frequency response capabilities shown diagrammatically in Figure C10.1 are measured by taking the responses as obtained from some of the dynamic step response tests specified by the **DNO** and carried out by **Generator**s for compliance purposes. The injected signal is a step of 0.5Hz (see C.8.6 and C.9.5) from zero to 0.5 Hz frequency change over a 10 s period, and is sustained at 0.5 Hz frequency change thereafter, the latter as illustrated diagrammatically in Figures C.10.2 through to C.10.5.

C10.4.2 In addition, at the request of the **Generator**, to provide and/or to validate the content of ancillary services agreements a progressive injection of a frequency change to the plant control system (ie. governor and load controller) is used. The injected signal is a ramp of 0.5 Hz from zero to 0.5 Hz frequency change over a 10 s period, and is sustained at 0.5 Hz frequency change thereafter, the latter as illustrated diagrammatically in Figures ECC.A.3.2 and ECC.A.3.3

C10.4.3 The primary response capability of a **Power Generating Module** is the minimum increase in **Active Power** output between 10 and 30 s after the start of the ramp injection as illustrated diagrammatically in Figure C.10.2. This increase in **Active Power** output should be released increasingly with time over the period 0 to 10 s from the time of the start of the frequency fall as illustrated by the response from Figure C.10.2.

C10.4.4 The secondary response capability of a **Power Generating Module** is the minimum increase in **Active Power** output between 30 s and 30 minutes after the start of the ramp injection as illustrated diagrammatically in Figure C.10.2.

C10.4.5 The high frequency response capability of a **Power Generating Module** is the decrease in **Active Power** output provided 10 s after the start of the ramp injection and sustained thereafter as illustrated diagrammatically in Figure C.10.3. This reduction in **Active Power** output should be released increasingly with time over the period 0 to 10 s from the time of the start of the frequency rise as illustrated by the response in Figure C.10.2.

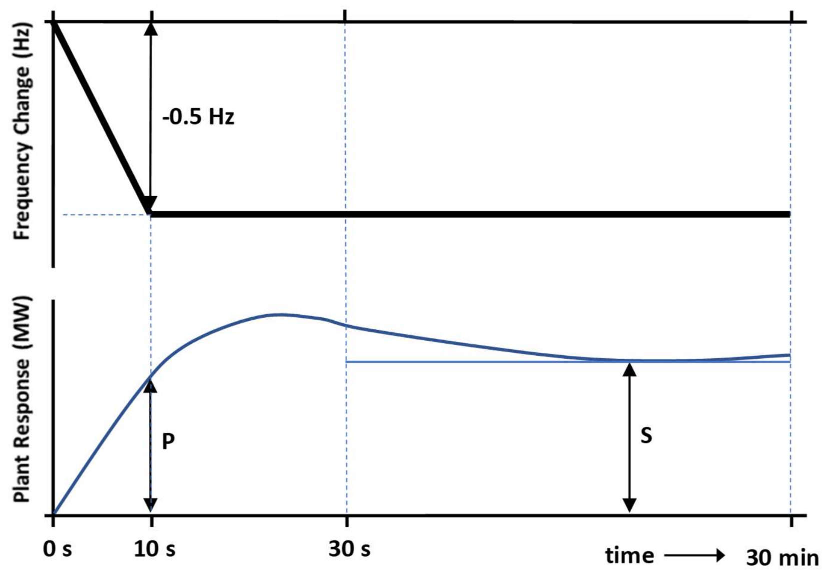
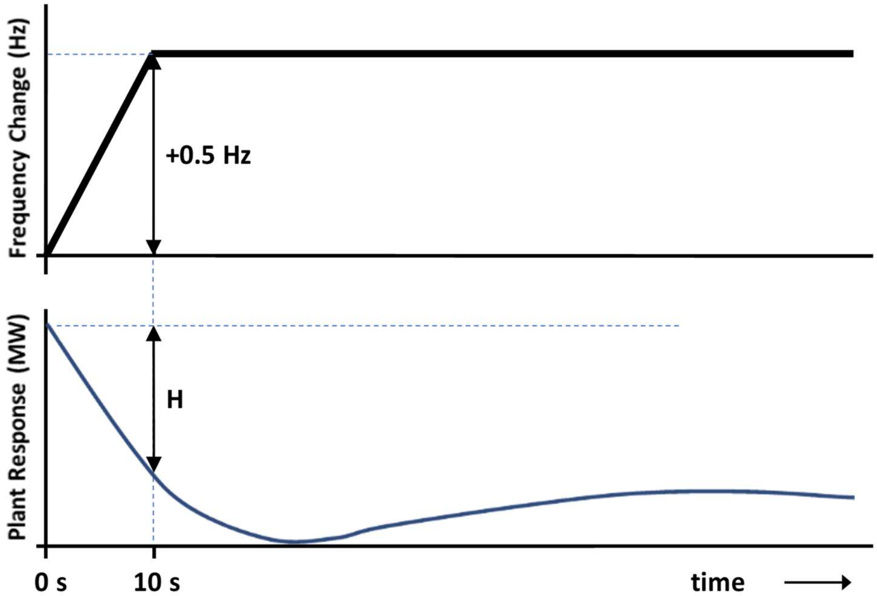


Figure C.10.2 Interpretation of Primary (P) and Secondary (S) Response Service Values



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7982 **Figure C.10.3 Interpretation of High (H) Frequency Response Service Values**

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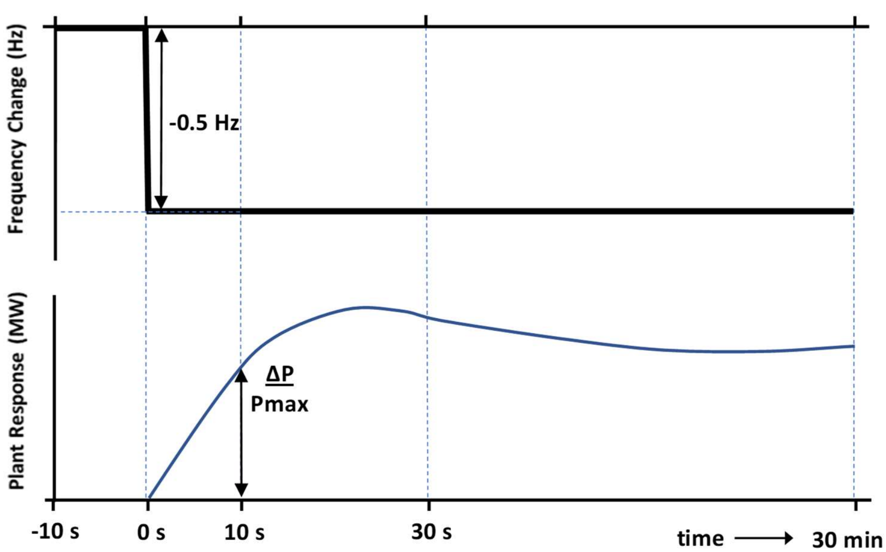

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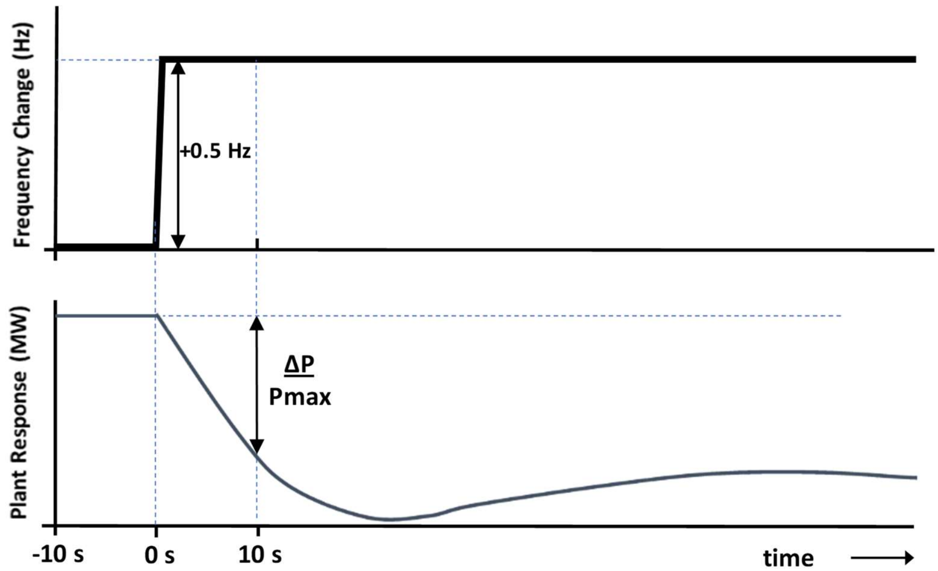
7985 **Figure C.10.4 Interpretation of Low Frequency Response Capability Values**



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7987 **Figure C.10.5 Interpretation of High Frequency Response Capability Values**

Annex D

D.1 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 EREC G99

Form D1 Decommissioning Confirmation		
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		
E-mail address		
Name:		
Signature:		Date:

D.2 Additional Information Relating to System Stability Studies

D.2.1 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.

D.2.2 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.

D.2.3 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.

D.3 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**.

D.3.1 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 **Generating Unit** will be in the order of 3 to 5 s (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 **Generating Unit** will be in the order of 4 to 5 s.

3. Doubly Fed Induction **Generating Unit** (DFIG): Similar to the asynchronous **Generating Unit** 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 rotor to operate over a wider speed range than the 1-2% of an asynchronous **Generating Unit** r. Typically +/-20% speed range is possible. The electrical inertia of the **Generating Unit** is less clearly defined as the rotor is effectively

decoupled from the stator, but typically it is given as 4 to 5 s before the secondary control systems can react in a similar time period.

4. **Inverter** Connected **Generating Unit**: Whilst the DFIG is partly coupled to the network through the stator, here the power source is completely hidden behind the converter and the **Generating Unit** is fully decoupled from the network. The electrical inertia of the **Generating Unit** is theoretically zero unless a degree of 'virtual inertia' is introduced into the converter control scheme, to make the **Generating Unit** behave as if it were closely coupled to the network.

LoM protection systems follow two interrelated principles:

- Rate of Change of Frequency or RoCoF (of voltage)
- Vector Shift or Vector Surge (of voltage)

Both situations can arise from an imbalance between the power applied to the prime mover (and hence **Generating Unit**) and the power thus sent out into the network to supply load. There is a presumption, with both types of relays, that an unbalance in load always exists when a **Generating Unit** is disconnected (Islanded) from the large electrical network. And this is then of sufficient magnitude to cause the **Generating Unit** 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 **Generating Unit** 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 **Generating Unit** types 1 and 2 and to the initial (1 to 2 s) response for type 3. For type 4 **Generating Unit** discussions with the **Manufacturer** may be required to determine if any form of LoM relay would provide effective protection.

D.3.2 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,

$$K = 5.48 \times 10^{-6} \times J \times N^2 \qquad \text{equation 1}$$

where K = kinetic energy in kJ
J = moment of inertia in kgm^2
N = machine in speed in rpm

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

$$H = \frac{K^1}{G} \qquad \text{equation 2}$$

Where K^1 = Kinetic energy at rated speed and frequency (F_r)

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

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

$$K = \left(\frac{F}{F_r}\right)^2 \times H \times G \qquad \text{equation 3}$$

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

$$P_c = \frac{dK}{dt} \qquad \text{equation 4}$$

Rewriting

$$P_c = \frac{dK}{dF} \times \frac{dF}{dt} \qquad \text{equation 5}$$

Differentiating equation 3 gives

$$\frac{dK}{dF} = \frac{2FHG}{F_r^2} \qquad \text{equation 6}$$

Substituting in equation 5

$$P_c = \frac{2FHG}{F_r^2} \times \frac{dF}{dt}$$

Re-arranging

$$\frac{dF}{dt} = \frac{P_c F_r^2}{2HGF} \qquad \text{equation 7}$$

D.4 Main Statutory and Other Obligations

This Annex summarises the main statutory and other obligations on **DNO**s, **Generators** and **Customers** 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 **Customers** 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	-
ESQCR 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

Reference	Obligation	DNO	Generator	Customer
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

Reference	Obligation	DNO	Generator	Customer
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**.	X	X	X
	Agree protection systems, operating times, discrimination and sensitivity at the ownership boundary.	X	X	X
	Normally provide back-up protection in case of circuit breaker failure on **HV** systems.	X	X	X
Distribution Code DPC6.3	**Customer**'s equipment must be compatible with **DNO** standards and practices.		X	X
	Design protection systems that take into account auto-reclosing or sequential switching features on the **DNO** network.		X	X
	Be aware that **DNO** protection arrangements may cause disconnection of one or two phases only of a three phase supply.		X	X
Distribution Code DPC8.10	Assess the transient overvoltage effects at the network ownership boundary, where necessary.	X	X	

8204