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# Annex A – Type A

## 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.

|  |  |  |  |
| --- | --- | --- | --- |
| **Stage** | **Form** | **Notes / Description** | **Complete Y/N** |
| 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 A1-1: Application Form (< 50 kW)  OR  Form A1-2: Application Form (**Small Generation Installations**)  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 it wants to witness the commissioning.  For **Power Generating Module**s < 50 kW three phase or 17 kW single phase, Form A1-1 should be used.  For **Small Generation Installations**, Form A1-2 should 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 **PGM**s, it 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 Verification Report | To be provided, unless a **Manufacturer’s** reference number (the system reference) is available for **Fully Type Tested PGM**s (see Section 16.2.1). See the text at the  start of Annex A.2 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 Module**s less than 50 kW and greater than 16 A per phase.  Form A2-2 is suitable for **Power Generating Module**s greater than 50 kW or for **Synchronous Power Generating Module**s <50 kW where this approach is preferred to Form A2-1.  Form A2-3 is designed for **Power Park Module**s (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 A3-1 Installation Document for **Type A Power Generating Module**s  OR  Form A3-2 Installation Document for **Integrated Micro Generation and Storage** installations | 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.  Decommissioning | (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.

## Connection Application Forms for Type A Power Generating Facility (< 50 kW) (Form A1-1), Small Generation Installations (Form A1- 2) and Application for connection of Power Generating Module(s) with Total Aggregate Capacity < 50 kW 3-phase or 17 kW single phase where the output is shared with two or more customers (Form A1-3)

|  |  |
| --- | --- |
| **Form A1-1 : Application for connection of Power Generating Module(s) with Total Aggregate Capacity <50 kW 3-phase or 17 kW single phase**  For **Power Generating Module**s with an aggregate capacity < 50 kW 3-phase or 17 kW single-phase, this simplified application form can be used. For **Power Generating Module**s 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). A full list of the compliant device system reference numbers is available through the Type Test Register portal at ENA Type Test Register (<https://connect-direct.energynetworks.org/>) 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. Alternatively the Standard Application Form should be submitted instead of this form. | |
| To ABC electricity distribution **DNO**  99 West St, Imaginary Town, ZZ99 9AA [abced@wxyz.com](mailto: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 |  |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | |  | | | | | | |
| Post Code | | | |  | | | | | | |
| Contact person | | | |  | | | | | | |
| Telephone Number | | | |  | | | | | | |
| E-mail address | | | |  | | | | | | |
| **Installation details**: | | | | | | | | | | |
| Address | | | |  | | | | | | |
| Post Code | | | |  | | | | | | |
| MPAN(s) | | | |  | | | | | | |
| **Details of existing Generating Units – where applicable:** | | | | | | | | | | |
| **Manufacturer** | Approximate Date of Installation | Energy source and energy conversion technology (enter codes from tables 1 and 2 see Form A1-2) | | | **Manufacturer**’s Ref No. where available | **Generating Unit Registered Capacity**  (kW) | | | | |
| 3-  phase units | Single Phase Units | | | **Power Factor** |
| PH1 | PH2 | PH3 |
| Src | Tech | |
|  |  |  | | |  |  |  |  |  |  |
|  |  |  | | |  |  |  |  |  |  |
| **Details of proposed additional Generating Unit(s):** | | | | | | | | | | |
| **Manufacturer** | Approximate Date of Installation | Energy source and energy conversion technology (enter codes from tables 1 and 2 see Form A1-2) | | | **Manufacturer**’s Ref No. where available | **Generating Unit Registered Capacity**  (kW) | | | | |
| 3-  phase units | Single Phase Units | | | **Power Factor** |
| PH1 | PH2 | PH3 |
| Src | Tech | |
|  |  |  | | |  |  |  |  |  |  |
|  |  |  | | |  |  |  |  |  |  |
| **Balance of multiple single phase Generating Unit**s **– where applicable** | | | | | | | | | | |
| 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. | | | | | | | | | | |
| Signed : | | | | | | Date : | | | | |
| Use continuation sheet where required.  Record **Generating Unit 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 **Generating Units** in the **Power Generating Facility**. | | | | | | | | | | |

|  |  |
| --- | --- |
| **Form A1-2 : Application for connection of Fully Type Tested Generation under the Small Generation Installation Procedures**  For **Small Generation Installation** Procedures 2 or 3, this simplified application form can be used where all of the following eligibility conditions are met:   * The new and existing **Generating Unit**s are located in a single **Generator’s Installation**; * The **Intrinsic Design Capacity (IDC)** of each new and existing **Generating Unit** is no more than 32 A; * All of the **Generating Unit**s (including **Electricity Storage** devices) are connected via EREC G98 or EREC G99 **Fully Type Tested** inverters;[20](#_bookmark0) * The total aggregate **Registered Capacities** of all the **Generating Unit**s (including **Electricity Storage** devices) is less than 60 A per phase; and * Where required by the relevant **Small Generation Installation** procedure SGI-2 or SGI-3, an EREC G100 compliant export limitation scheme is present that limits the export from the **Generator’s Installation** to the **Distribution Network**;   **DNO**s may have their own forms; refer to the **DNO**’s websites and online application tools. The application should include the **Manufacturer**’s reference number (the system reference) from the ENA Type Test Verification Report Register. A full list of the compliant device system reference numbers is available through the Type Test Register portal at ENA Type Test Register ([[https://connect-direct.energynetworks.org/](https://www.ena-eng.org/)](https://connect-direct.energynetworks.org/)).  If all the eligibility conditions apply the **DNO** will confirm that the installation can proceed. The planned commissioning date stated on the application shall be between 10 working days and 3 months from the date the application is submitted.  On completion of the installation the **Installer** shall submit the commissioning sheets, as required in EREC G100 alongside the EREC G99 forms. | |
| To ABC electricity distribution **DNO**  99 West St, Imaginary Town, ZZ99 9AA [abced@wxyz.com](mailto:abced@wxyz.com) | |
| **Generator details:** | |
| **Generator** (name) |  |
| Address |  |
| Post Code |  |
| Contact person (if different from **Generator**) |  |
| Telephone number |  |

—————————

1. Or **Type Tested** to EREC G83 or G59 where the **Generating Unit** was connected prior to 27 April 2019.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| E-mail address | | | | |  | | | | | |
| MPAN(s) | | | | |  | | | | | |
| **Installer details:** | | | | | | | | | | |
| **Installer** | | | | |  | | | | | |
| Accreditation / Qualification | | | | |  | | | | | |
| Address | | | | |  | | | | | |
| Post Code | | | | |  | | | | | |
| Contact person | | | | |  | | | | | |
| Telephone Number | | | | |  | | | | | |
| E-mail address | | | | |  | | | | | |
| **Installation details**: | | | | | | | | | | |
| Address | | | | |  | | | | | |
| Post Code | | | | |  | | | | | |
| MPAN(s) | | | | |  | | | | | |
| **Details of existing Generating Units – where applicable:** | | | | | | | | | | |
| **Manufacturer** | Approximate Date of Installation | Energy source and energy conversion technology (enter codes from tables 1  and 2 below form) | | **Manufacturer**’s Ref No. where available | | **Generating Unit Intrinsic Design Capacity** & **Registered Capacity** (kW)\* | | | | Energy storage capacity for **Electricity Storage** devices (kWh) |
| 3 -phase units | | Single Phase Units | |
| **IDC** | **RC** | **IDC** | **RC** |
| Src | Tech |
|  |  |  | |  | |  |  |  |  |  |
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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Details of proposed additional Generating Unit(s)** | | | | | | | | | |
| **Manufacturer** | Approximate Date of Installation | Energy source and energy conversion technology (enter codes from tables 1  and 2 below) | | **Manufacturer**’s Ref No. where available | **Generating Unit Intrinsic Design Capacity** & **Registered Capacity** (kW)\* | | | | Energy storage capacity for **Electricity Storage** devices (kWh) |
| 3-phase units | | Single Phase Units | |
| **IDC** | **RC** | **IDC** | **RC** |
| Src | Tech |
|  |  |  | |  |  |  |  |  |  |
|  |  |  | |  |  |  |  |  |  |
|  |  |  | |  |  |  |  |  |  |
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|  |  |  | |  |  |  |  |  |  |
| **Details of Export Limitation Scheme** | | | | | | | | | |
| Where an export limitation scheme is required by SGI-2 or SGI-3 please state export limit setting in amps. | | | | | | |  | | |
| **Please confirm all of the statements are true by ticking each box:** | | | | | | | | | |
| The **Generating Unit**(s) is located in a single **Generator’s Installation**. | | | | | | | | |  |
| The **Intrinsic Design Capacity** of each new and existing **Generating Unit** is no more than 32 A. | | | | | | | | |  |
| All of the **Generating Unit**s (including **Electricity Storage** devices) are connected via EREC G99 or G98 **Type Tested Inverters** (or EREC G59 or G83 **Type Tested Inverter**s, where the **Power Generating Unit** was installed prior to 27 April 2019) | | | | | | | | |  |
| The total aggregate **Registered Capacity** of the **Generating Unit**s (including  **Electricity Storage** devices) is no more than 60 A per phase. | | | | | | | | |  |
| An EREC G100 compliant export limitation scheme is present that limits the export from the **Generator’s Installation** to the **Distribution Network** if required by SGI-2 or SGI-3. | | | | | | | | |  |
| **The following information should be submitted with the application:** | | | | | | | | | |
| Copy of single line diagram of export limitation scheme | | | | | | | | | |
| Explanation / description of the EREC G100 export limitation scheme operation including a description of the fail-safe functionality, ie the response of the scheme following failure of any component or device of the fail-safe system, or following any loss of communication between the components and devices of the scheme. | | | | | | | | | |

|  |  |  |
| --- | --- | --- |
| Note, fail-safe tests are not required at installations where all **Generating Unit**s are EREC G83 or EREC G98 **Type Tested**, aggregated capacity is not more than 32 A per phase and export capacity is limited to 16 A per phase. | | |
| **Additional details:** | | |
| Target date for provision of connection / commissioning of new **Generating Units** devices:\*\* |  | |
| EREC G100 compliance declaration / EREC G100 Type Test reference as applicable: |  | |
| Signed : | | Date : |
| Use continuation sheet where required.  \* Record **Generating Unit 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.  \*\*The planned commissioning date shall be at least 10 working days from the date of application but not more than 3 months in advance (connection offers are only valid for 3 months). | | |

Table 1

|  |  |
| --- | --- |
|  | Energy Source |
| A | Advanced Fuel (produced via gasification or pyrolysis of biofuel or waste) |
| B | Biofuel - Biogas from anaerobic digestion (excluding landfill & sewage) |
| C | Biofuel - Landfill gas |
| D | Biofuel - Sewage gas |
| E | Biofuel - Other |
| F | Biomass |
| G | Fossil - Brown coal/lignite |
| H | Fossil - Coal gas |
| I | Fossil - Gas |
| J | Fossil - Hard coal |
| K | Fossil - Oil |
| L | Fossil - Oil shale |
| M | Fossil - Peat |
| N | Fossil - Other |
| O | Geothermal |
| P | Hydrogen |
| Q | Nuclear |
| R | Solar |
| S | Stored Energy (all stored energy irrespective of the original energy source) |
| T | Waste |
| U | Water (flowing water or head of water) |
| V | Wind |
| W | Other |

Table 2

|  |  |
| --- | --- |
|  | Energy Conversion Technology |
| 1 | Engine (combustion / reciprocating) |
| 2 | Fuel Cell |
| 3 | Gas turbine (OCGT) |
| 4 | Geothermal power plant |
| 5 | Hydro - Reservoir (not pumped) |
| 6 | Hydro - Run of river |
| 7 | Hydro - Other |

|  |  |
| --- | --- |
|  | Energy Conversion Technology |
| 8 | Interconnector |
| 9 | Offshore wind turbines |
| 10 | Onshore wind turbines |
| 11 | Photovoltaic |
| 12 | Steam turbine (thermal power plant) |
| 13 | Steam-gas turbine (CCGT) |
| 14 | Tidal lagoons |
| 15 | Tidal stream devices |
| 16 | Wave devices |
| 17 | Storage - Chemical - Ammonia |
| 18 | Storage - Chemical - Hydrogen |
| 19 | Storage - Chemical - Synthetic Fuels |
| 20 | Storage - Chemical - Drop-in Fuels |
| 21 | Storage - Chemical - Methanol |
| 22 | Storage - Chemical - Synthetic Natural Gas |
| 23 | Storage - Electrical - Supercapacitors |
| 24 | Storage - Electrical - Superconducting Magnetic ES (SMES) |
| 25 | Storage - Mechanical - Adiabatic Compressed Air |
| 26 | Storage - Mechanical - Diabatic Compressed Air |
| 27 | Storage - Mechanical - Liquid Air Energy Storage |
| 28 | Storage - Mechanical - Pumped Hydro |
| 29 | Storage - Mechanical - Flywheels |
| 30 | Not used |
| 31 | Not used |
| 32 | Not used |
| 33 | Storage - Electrochemical Classic Batteries -Lead Acid |
| 34 | Storage - Electrochemical Classic Batteries -Lithium Polymer (Li-Polymer) |
| 35 | Storage - Electrochemical Classic Batteries -Metal Air |
| 36 | Storage - Electrochemical Classic Batteries -Nickle Cadmium (Ni-Cd) |
| 37 | Storage - Electrochemical Classic Batteries -Sodium Nickle Chloride (Na-NiCl2) |
| 38 | Storage - Electrochemical Classic Batteries -Lithium Ion (Li–ion) |
| 39 | Storage - Electrochemical Classic Batteries -Sodium Ion (Na–ion) |
| 40 | Storage - Electrochemical Classic Batteries -Lithium Sulphur (Li-S) |
| 41 | Storage - Electrochemical Classic Batteries -Sodium Sulphur (Na-S |
| 42 | Storage - Electrochemical Classic Batteries -Nickle –Metal Hydride (Ni-MH) |
| 43 | Storage - Electrochemical Flow Batteries - Vanadium Red-Oxide |
| 44 | Storage - Electrochemical Flow Batteries - Zinc – Iron (Zn –Fe) |

|  |  |
| --- | --- |
|  | Energy Conversion Technology |
| 45 | Storage - Electrochemical Flow Batteries - Zinc – Bromine (Zn –Br) |
| 46 | Storage - Other |
| 47 | Other |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Form A1-3: Application for connection of Power Generating Module(s) with Total Aggregate Capacity <50 kW 3-phase or 17 kW single phase where the output is shared with two or more Customers**  For **Power Generating Module**s with an aggregate capacity < 50 kW 3-phase or 17 kW single-phase supplying multiple **Customers** this simplified application form can be used. For **Power Generating Module**s 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). A full list of the compliant device system reference numbers is available through the Type Test Register portal at ENA Type Test Register (<https://www.ena-eng.org/>).  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. Alternatively the Standard Application Form should be submitted instead of this form.  For the purposes of this form the **Generator** is the party owning the **Power Generating Module**(s). The **Generator** may or may not have a direct connection to the **DNO**’s **Distribution** System at the installation address. | | | | | | | | | | | | |
| 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 | | | | | |  | | | | | | |
| **Installer details:** | | | | | | | | | | | | |
| **Installer** | | | | | |  | | | | | | |
| Accreditation / Qualification | | | | | |  | | | | | | |
| Address | | | | | |  | | | | | | |
| Post Code | | | | | |  | | | | | | |
| Contact person | | | | | |  | | | | | | |
| Telephone Number | | | | | |  | | | | | | |
| E-mail address | | | | | |  | | | | | | |
| **Installation details**: | | | | | | | | | | | | |
| Address | | | | | |  | | | | | | |
| Post Code | | | | | |  | | | | | | |
| MPAN of **Generator** (if applicable) | | | | | |  | | | | | | |
| **Sharing equipment details** | | | | | | | | | | | | |
| Please give a description and relevant details of the proposed sharing equipment. Please stated if export from the **Customers’ Installations** is expected, and if so, how this is to be distributed. | | | | | | | | | | | | |
| **Customer** | **MPAN** | | | | | **Address** | | | | | | |
| 1 |  | | | | |  | | | | | | |
| 2 |  | | | | |  | | | | | | |
| 3 |  | | | | |  | | | | | | |
| 4 |  | | | | |  | | | | | | |
| 5 |  | | | | |  | | | | | | |
| 6 |  | | | | |  | | | | | | |
| Please extend on a separate sheet for additional **Customers** supplied by the **Generator**. | | | | | | | | | | | | |
| **Details of existing Generating Units – where applicable:** | | | | | | | | | | | | |
| **Manufacturer** | | Approximate Date of Installation | Energy source and energy conversion technology (enter codes from tables 1 and 2 see Form A1-2) | | | | **Manufacturer**’s Ref No. where available | **Generating Unit** **Registered Capacity** (kW) | | | | |
| 3-phase units | Single Phase Units | | | **Power Factor** |
| PH1 | PH2 | PH3 |
| Src | Tech | | |
|  | |  |  |  | | |  |  |  |  |  |  |
|  | |  |  |  | | |  |  |  |  |  |  |
| **Details of proposed additional Generating Unit(s):** | | | | | | | | | | | | |
| **Manufacturer** | | Approximate Date of Installation | Energy source and energy conversion technology (enter codes from tables 1 and 2 see Form A1-2) | | | | **Manufacturer**’s Ref No. where available | **Generating Unit** **Registered Capacity** (kW) | | | | |
| 3-phase units | Single Phase Units | | | **Power Factor** |
| PH1 | PH2 | PH3 |
| Src | | Tech | |
|  | |  |  | |  | |  |  |  |  |  |  |
|  | |  |  | |  | |  |  |  |  |  |  |
| **Balance of multiple single phase Generating Unit**s **– where applicable** | | | | | | | | | | | | |
| 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. | | | | | | | | | | | | |
| Signed : | | | | | | | | Date : | | | | |
| Use continuation sheet where required.  Record **Generating Unit 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 **Generating Units** in the **Power Generating Facility**. | | | | | | | | | | | | |

## 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 Module**s 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 Unit**s. **Manufacturer**s of induction **Generating Unit**s 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 Module**s.

Type A

Synchronous

<50 kW

Asynchronous (not inverter)

<50 kW

Synchronous

>50 kW

Asynchronous (not inverter)

>50 kW

Inverter (all sizes)

Compliance Verification Report A2-1

Compliance Verification Report A2-2

Compliance Verification Report A2-3

Optional Approach for fully integrated <50 kW **Synchronous Power Generating Modules**

Conventional Compliance Approach

**Figure A.2.1 Compliance requirements for Type A Power Generating Modules**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Form A2-1: Compliance Verification Report for Synchronous and Asynchronous (non inverter) 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. 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. Tests 1 – 14 must all be completed and compliant for the **Power Generating Module** to be classified as **Fully Type Tested**.   1. 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.  Where the **Manufacturer** is seeking to obtain **Type Tested** status for an **Interface Protection**  device the appropriate section of Form A2-4 should be used.   1. 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 shall 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 A3-1 or A3-2) should include the **Manufacturer**’s reference number (the system reference), 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.  Where the **Registered Capacity** is lower than the **Intrinsic Design Capacity**, all results of tests must be based on **the Registered Capacity**, and not on the **Intrinsic Design Capacity**. | | | | |
| **PGM** technology | | |  | |
| **Manufacturer** name | | |  | |
| Address | | |  | |
| Tel. |  | | Web site |  |
| E:mail |  | | | |
| **Registered Capacity** | | kW | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 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 PGM**s tests may be carried out at the time of commissioning (Form A2-4).  Include reference(s) for **Manufacturers’ Information** including the ENA Type Test Verification Report Register system reference number where applicable. | | | | |
| **Tested option:** | **1. Fully Type Tested** | **2. Type Tested product** | **3. One-Off Manufactures’ Info.** | **4. Tested on Site at time of Commissioning** |
| 0. **Fully Type Tested**- all tests detailed below completed and evidence attached to this submission |  | **N/A** | **N/A** | **N/A** |
| 1. Operating Range | **N/A** |  |  |  |
| 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 |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 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 PGM**s tests may be carried out at the time of commissioning (Form A2-4).  Include reference(s) for **Manufacturers’ Information** including the ENA Type Test Verification Report Register system reference number where applicable. | | | | | | | |
| **Tested option:** | | **1. Fully Type Tested** | | **2. Type Tested product** | | **3. One-Off Manufactures’ Info.** | **4. Tested on Site at time of Commissioning** |
| 12. Wiring functional tests if required by para  15.2.1 (attach relevant schedule of tests) | |  | |  | |  |  |
| 13. Logic Interface (input port) | |  | |  |  |
| 14. Cyber security | |  | |  |  |
|  | | | | | | | |
| **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 **Modification**s 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 (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. | | | | | | | |

|  |  |
| --- | --- |
| **A2-1 Compliance Verification Report –Tests for Type A Synchronous Power Generating Modules up to and including 50 kW – test record** | |
| **1. Operating Range:** 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. Pass or failure of the test should be indicated in the fields below (right hand side), for example with the statement “Pass”, “No disconnection occurs”, etc. Graphical evidence is preferred. | |
| Test 1  Voltage = 85% of nominal (195.5 V), Frequency = 47 Hz**,**  **Power Factor** = 1, Period of test 20 s | Test results or chart to confirm operation |
| Test 2  Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz,  **Power Factor** = 1, Period of test 90 minutes | Test results or chart to confirm operation |
| Test 3  Voltage = 110% of nominal (253 V), Frequency = 51.5 Hz,  **Power Factor** = 1, Period of test 90 minutes | Test results or chart to confirm operation |
| Test 4  Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz,  **Power Factor** = 1, Period of test 15 minutes | Test results or chart to confirm operation |
| Test 5  Voltage = 100% of nominal (230 V),  Frequency = 50.0 Hz,  **Power Factor** = 1,  Period of test = 90 minutes | Test results or chart to confirm operation |
| Test 6 RoCoF withstand  Confirm that the **Power Generating Module** is 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. Note that this is not expected to be demonstrated on site. | Test results or chart to confirm operation |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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, and measurements for the 2nd – 13th harmonics should be provided. 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. For three phase **Power Generating Module**s, measurements for all phases should be provided.  The rating of the **Power Generating Module** (per phase) should be provided below and the Total Harmonic Distortion (THD) and Partial Weighted Harmonic Distortion (PWHD) should be provided at the bottom of this section. | | | | | | | | |
| **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) | |
| Single or three phase measurements (for single phase measurements, only complete L1 columns below) | | | |  | | |  | |
| Harmonic | At 45-55% of **Registered Capacity**[21](#_bookmark1) | | | | | | Limit in BS EN 61000-3-12 | |
| Measured value (MV) in Amps | | | Measured value (MV) in % | | |  | |
|  | L1 | L2 | L3 | L1 | L2 | L3 | 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% | .33% |
| 13 |  |  |  |  |  |  | 2% | 2% |

—————————

1. See the note in A.7.2.5.1 if 45-55% of **Registered Capacity** is below the **Minimum Stable Operating Level**. If an alternative loading level is chosen, the level should be indicated on the test form and the reason for not testing at 45-55% of **Registered Capacity** should be stated in the box at the end of this section.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD[22](#_bookmark2) |  |  |  |  |  |  | 23% | 13% |
| PWHD[23](#_bookmark3) |  |  |  |  |  |  | 23% | 22% |
| Harmonic | At 100% of **Registered Capacity** | | | | | | Limit in BS EN 61000-3-12 | |
| Measured value (MV) in Amps | | | Measured value (MV) in % | | |
|  | L1 | L2 | L3 | L1 | L2 | L3 | 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% | .33% |
| 13 |  |  |  |  |  |  | 2% | 2% |
| THD[24](#_bookmark4) |  |  |  |  |  |  | 23% | 13% |
| PWHD[25](#_bookmark5) |  |  |  |  |  |  | 23% | 22% |
| Reason for not testing at 45-55% **Registered Capacity** (if applicable): | | | | | | | | |

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1. THD = Total Harmonic Distortion
2. PWHD = Partial Weighted Harmonic Distortion
3. THD = Total Harmonic Distortion
4. 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.  The standard test impedance is 0.4 Ω for a single phase **Power Generating Module** (and for a two phase unit in a three phase system) and 0.24 Ω for a three phase **Power Generating Module** (and for a two phase unit in a split phase system). Please ensure that both test and standard impedance are completed on this form. If the test impedance (or the measured impedance) is different to the standard impedance, it must be normalised to the standard impedance as follows (where the **Power Factor** of the generation output is 0.98 or above):  d max normalised value = (Standard impedance / Measured impedance) x Measured value.  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 needs to comply with the particular requirements set out in the testing notes for the technology under test.  The test date and location must be declared. | | | | | | | | | |
| Test start date | |  | | | Test end date | |  | | |
| Test location | |  | | | | | | | |
|  | 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 | X |  | Ω | |
| Standard Impedance | | R | 0.24 \*  0.4 ^ | Ω | X | 0.15 \*  0.25 ^ | Ω | |
| Maximum Impedance | | R |  | Ω | X |  | Ω | |
| \* Applies to three phase **Power Generating Module**s and split single phase **Power Generating Module**s. Delete as appropriate.  ^ Applies to single phase **Power Generating Module** and **Power Generating Module**s using two phases on a three phase system. Delete as appropriate. | | | | | | | | |
| **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** and the measured **Power Factor** must be greater than 0.95 to pass. 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.7.2.2.3. For trip tests, frequency and time delay should be stated. For “no trip tests”, “no trip” can be stated. | | | | | | | | |
| 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  30 s | |  |
|  |  | |  |  |  | 47.2 Hz  19.5 s | |  |
| U/F stage 2 | 47 Hz | | 0.5 s |  |  | 46.8 Hz  0.45 s | |  |
| O/F | 52 Hz | | 0.5 s |  |  | 51.8 Hz  120 s | |  |
|  |  | |  |  |  | 52.2 Hz  0.45 s | |  |
|  | | | | | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **6. Protection – Voltage tests:** These tests should be carried out in accordance with Annex A.7.2.2.2. For trip tests, voltage and time delay should be stated. For “no trip tests”, “no trip” can be stated. | | | | | | | | | | | | |
| 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  5.00 s | |  | |
|  |  | |  | |  | |  | | 180 V  2.45 s | |  | |
| O/V stage 1 | 1.14 pu  (262.2 V) | | 1.0 s | |  | |  | | 258.2 V  5.0 s | |  | |
|  |  | |  | |  | |  | | 269.7 V  0.95s | |  | |
| O/V stage 2 | 1.19 pu  (273.7 V) | | 0.5 s | |  | |  | | 277.7 V  0.45s | |  | |
|  | | | | | | | | | | | | |
| **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.[26](#_bookmark6) | | | | | | | | | | | | |
| 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 Module**s 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% |

—————————

1. See the note in A.7.2.2.4 if the suggested loading levels are below the **Minimum Stable Operating Level**. If alternative loading levels are chosen, the level should be indicated on the test form and the reason for not testing at 10%/55% of **Registered Capacity** should be stated in the box at the end of this section.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 | | | |
| Reason for not testing at suggested loading levels (if applicable): | | | | | | | | | | | |
|  | | | | | | | | | | | |
| **Loss of Mains Protection, Vector Shift Stability test:** This test should be carried out in accordance with Annex A.7.2.2.6. Confirmation is required that the **Power Generating Module** does not trip under positive / negative vector shift. | | | | | | | | | | | |
|  | | Start Frequency | | Change | | | Confirm no trip | | | | |
| Positive Vector Shift | | 49.5 Hz | | +50 degrees | | |  | | | | |
| Negative Vector Shift | | 50.5 Hz | | - 50 degrees | | |  | | | | |
| **Loss of Mains Protection, RoCoF Stability test:** This test should be carried out in accordance with Annex A.7.2.2.6. Confirmation is required that the **Power Generating Module** does not trip for the duration of the ramp up and ramp down test. | | | | | | | | | | | |
| Ramp range | | Test frequency ramp: | | | | | Test Duration | | Confirm no trip | | |
| 49.0Hz to 51.0Hz | | +0.95 Hzs-1 | | | | | 2.1 s | |  | | |
| 51.0Hz to 49.0Hz | | -0.95 Hzs-1 | | | | | 2.1 s | |  | | |
| **8. Limited Frequency Sensitive Mode – Overfrequency 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** | | |  | | |
| 49.0 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** | | |  | | |
| **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. Both the time delay setting and the measured delay should be provided in this form; both should be greater than 20 s to pass. Confirmation should be provided that the **Power Generating Module** does not reconnect at the voltage and frequency settings below; a statement of “no reconnection” can be made. | | | | | | | | |
| 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 0.78 pu  (180.0 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 |
| Provide high level description of logic interface, eg details in 11.1.3.1 such as AC or DC signal (the additional comments box below can be used) | Yes / NA |
| **14. Cyber security** | |
| Confirm that the **Power Generating Module** has been designed to comply with cyber security requirements, as detailed in 9.1.7. | Yes / NA |
| Additional comments | |
|  | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Form A2-2: Compliance Verification Report for Synchronous and Asynchronous (non inverter) Power Generating Modules > 50 kW and also for Synchronous and Asynchronous (non inverter) 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 (≤ 50 kW)   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. Tests 1 – 14 must all be completed and compliant for the **Power Generating Module** to be classified as **Fully Type Tested**.   1. 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.  Where the **Manufacturer** is seeking to obtain **Type Tested** status for an **Interface Protection**  device the appropriate section of Form A2-4 should be used.   1. 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 shall 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 A3-1 or A3-2) should include the **Manufacturer**’s reference number (the system reference), 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.  Where the **Registered Capacity** is lower than the **Intrinsic Design Capacity**, all results of tests must be based on **the Registered Capacity**, and not on the **Intrinsic Design Capacity**. | | | | | |
| **PGM** technology | |  | | | |
| **Manufacturer** name | |  | | | |
| Address | |  | | | |
| Tel |  | | Web site |  | |
| E:mail |  | | | | |
| **Registered Capacity** – use separate sheet if more than one connection option. | | | | | kW |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| There are four options for Testing: (1) **Fully Type Tested** (≤ 50 kW), (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 PGM**s tests may be carried out at the time of commissioning (Form A4). **Type Tested** status is suitable for devices > 50 kW where the power quality aspects need consideration on a site by site basis in accordance with EREC G5 and EREC P28.  Insert reference for **Manufacturers’ Information** including the ENA Type Test Verification Report Register system reference number where applicable: | | | | |
| **Tested option:** | **1. Fully Type Tested** | **2. Type Tested product** | **3. One-Off Manufacturers’ Info.** | **4. Tested on Site at time of Commissioning** |
| 0. **Fully Type Tested** - all tests detailed below completed and evidence attached to this submission |  | **N/A** | **N/A** | **N/A** |
| 1. Operating Range | **N/A** |  |  |  |
| 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 |  |  |  |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| There are four options for Testing: (1) **Fully Type Tested** (≤ 50 kW), (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 PGM**s tests may be carried out at the time of commissioning (Form A4). **Type Tested** status is suitable for devices > 50 kW where the power quality aspects need consideration on a site by site basis in accordance with EREC G5 and EREC P28.  Insert reference for **Manufacturers’ Information** including the ENA Type Test Verification Report Register system reference number where applicable: | | | | | | | | |
| **Tested option:** | | **1. Fully Type Tested** | | **2. Type Tested product** | | **3. One-Off Manufacturers’ Info.** | **4. Tested on Site at time of Commissioning** | |
| 11. Fault Level Contribution | |  | |  | |  |  | |
| 12. Wiring functional test if required by paragraph  15.2.1 (attach relevant schedule of tests) | |  | |  |  | |
| 13. Logic Interface (input port) | |  | |  |  | |
| 14. Cyber security | |  | |  |  | |
|  | | | | | | | | |
| **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 **Modification**s 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. | | | | | | | | |

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| **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 – test record** | |
| **1. Operating Range:** 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.  Pass or failure of the test should be indicated in the fields below (right hand side), for example with the statement “Pass”, “No disconnection occurs”, etc. Graphical evidence is preferred.  Note that the value of voltage stated in brackets assumes a **LV** connection. This should be adjusted for **HV** as required. | |
| Test 1  Voltage = 85% of nominal (195.5 V), Frequency = 47 Hz,  **Power Factor** = 1, Period of test 20 s | Test results or chart to confirm operation |
| Test 2  Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz,  **Power Factor** = 1, Period of test 90 minutes | Test results or chart to confirm operation |
| Test 3  Voltage = 110% of nominal (253 V), Frequency = 51.5 Hz,  **Power Factor** = 1, Period of test 90 minutes | Test results or chart to confirm operation |
| Test 4  Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz,  **Power Factor** = 1, Period of test 15 minutes | Test results or chart to confirm operation |
| Test 5  Voltage = 100% of nominal (230 V), Frequency = 50.0 Hz,  **Power Factor** = 1,  Period of test = 90 minutes | Test results or chart to confirm operation |

|  |  |
| --- | --- |
|  |  |
| Test 6 RoCoF withstand  Confirm that the **Power Generating Module** is 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. Note that this is not expected to be demonstrated on site. | Test results or chart to confirm operation |
| **2. Power Quality – Harmonics**:  The installation shall be designed in accordance with EREC G5. For **Power Generating Module**s 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 A2-1. The relevant part of Form A2- 1 can be used for this purpose. | |
| **3. Power Quality – Voltage fluctuations and Flicker**:  The installation shall be designed in accordance with EREC P28.  For **Power Generating Module**s 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. The relevant part of Form A2-1 can be used for recording the measurements. | |
| **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 – Overfrequency 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 11.2.4.  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** | |  | |
| 49.0 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** | |  | |
| **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. Both the time delay setting and the measured delay should be provided in this form; both should be greater than 20 s to pass. Confirmation should be provided that the **Power Generating Module** does not reconnect at the voltage and frequency settings below; a statement of “no reconnection” can be made. | | | | | | |
| 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 **LV**  connection,  127.6 V **HV**  connection assuming 110 V ph-ph VT) | At 0.78 pu  (180.0 V **LV**  connection,  85.8 V **HV**  connection assuming 110 V ph-ph VT) | 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. | | | | | | |

|  |  |
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| 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 |
| Provide high level description of logic interface, e.g. details in 11.1.3.1 such as AC or DC signal (the additional comments box below can be used) | Yes / NA |
| **14. Cyber security** | |
| Confirm that the **Power Generating Module** has been designed to comply with cyber security requirements, as detailed in 9.1.7. | Yes / NA |
| Additional comments. | |
|  | |

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| Form A2-3: Compliance Verification Report for Type A 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. To obtain **Fully Type Tested** status (≤ 50 kW)   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. Tests 1 – 15 must all be completed and compliant for the **Power Generating Module** to be classified as **Fully Type Tested**.   1. 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.  Where the **Manufacturer** is seeking to obtain **Type Tested** status for an **Interface Protection** device the appropriate section of Form A2-4 should be used.   1. 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 shall 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 A2-3 the term **Power Park Module** will be used but its meaning can be interpreted within Form A2-3 to mean **Power Park Module**, **Generating Unit or Inverter** as appropriate for the context.  However, note that compliance shall 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 A3-1 or A3-2) should include the **Manufacturer’s** reference number (the system reference), 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.  Where the **Registered Capacity** is lower than the **Intrinsic Design Capacity**, all results of tests must be based on **the Registered Capacity**, and not on the **Intrinsic Design Capacity**. | | | | |
| **PGM** technology | |  | | |
| **Manufacturer** name | |  | | |
| Address | |  | | |
| Tel |  | Web site | |  |
| E:mail |  | | | |
| **Registered Capacity** | | | kW | |
| Energy storage capacity for **Electricity Storage** devices | | | kWh | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| There are four options for Testing: (1) **Fully Type Tested**(≤ 50 kW), (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 PGM**s tests may be carried out at the time of commissioning (Form A4). **Type Tested** status is suitable for devices > 50 kW where the power quality aspects need consideration on a site by site basis in accordance with EREC G5 and EREC P28.  Insert Document reference(s) for **Manufacturers’ Information** | | | | |
| **Tested option:** | **1. Fully Type Tested** | **2. Type Tested product** | **3. One**-**off Manufacturers’ Info.** | **4. Tested on Site at time of Commissioning** |
| 0. **Fully Type Tested** - all tests detailed below completed and evidence attached to this submission |  | **N/A** | **N/A** | **N/A** |
| 1. Operating Range | **N/A** |  |  |  |
| 2. PQ – Harmonics |  |  |  |
| 3. PQ – Voltage Fluctuation and Flicker |  |  |  |
| 4. PQ – DC Injection (**Power Park Module**s 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 |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| There are four options for Testing: (1) **Fully Type Tested**(≤ 50 kW), (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 PGM**s tests may be carried out at the time of commissioning (Form A4). **Type Tested** status is suitable for devices > 50 kW where the power quality aspects need consideration on a site by site basis in accordance with EREC G5 and EREC P28.  Insert Document reference(s) for **Manufacturers’ Information** | | | | | | | |
| **Tested option:** | | | **1. Fully Type Tested** | | **2. Type Tested product** | **3. One**-**off Manufacturers’ Info.** | **4. Tested on Site at time of Commissioning** |
| 12. Self-monitoring Solid State Switch | | |  | |  |  |  |
| 13. Wiring functional tests if required by para 15.2.1 (attach relevant schedule of tests) | | |  |  |  |
| 14. Logic Interface (input port) | | |  |  |  |
| 15. Cyber security | | |  |  |  |
|  | | | | | | | |
| **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 **Modification**s 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. | | | | | | | |

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| **A2-3 Compliance Verification Report –Tests for Type A Inverter Connected Power Generating Modules – test record** | |
| **1. Operating Range:** 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.  Pass or failure of the test should be indicated in the fields below (right hand side), for example with the statement “Pass”, “No disconnection occurs”, etc. Graphical evidence is preferred.  Note that the value of voltage stated in brackets assumes a **LV** connection. This should be adjusted for **HV** as required. | |
| Test 1  Voltage = 85% of nominal (195.5 V), Frequency = 47 Hz,  **Power Factor** = 1, Period of test 20 s | Test results or chart to confirm operation |
| Test 2  Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz,  **Power Factor** = 1, Period of test 90 minutes | Test results or chart to confirm operation |
| Test 3  Voltage = 110% of nominal (253 V)., Frequency = 51.5 Hz,  **Power Factor** = 1, Period of test 90 minutes | Test results or chart to confirm operation |
| Test 4  Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz,  **Power Factor** = 1, Period of test 15 minutes | Test results or chart to confirm operation |

|  |  |
| --- | --- |
| Test 5  Voltage = 100% of nominal (230 V), Frequency = 50.0 Hz,  **Power Factor** = 1,  Period of test = 90 minutes | Test results or chart to confirm operation |
| Test 6 RoCoF withstand  Confirm that the **Power Generating Module** is 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. Note that this is not expected to be demonstrated on site. | Test results or chart to confirm operation |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **2. Power Quality – Harmonics**:  For **Power Generating Module**s 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, and measurements for the 2nd – 13th harmonics should be provided. 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. For three phase **Power Generating Module**s, measurements for all phases should be provided.  For **Power Generating Module**s of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation shall be designed in accordance with EREC G5.  The rating of the **Power Generating Module** (per phase) should be provided below, and the Total Harmonic Distortion (THD) and Partial Weighted Harmonic Distortion (PWHD) should be provided at the bottom of this section. | | | | | | | | |
| **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) | |
| Single or three phase measurements (for single phase measurements, only complete L1 columns below). | | | |  | | |  | |
| Harmonic | At 45-55% of **Registered Capacity** | | | | | | Limit in BS EN 61000-3-12 | |
|  | Measured Value (MV) in Amps | | | Measured Value (MV) in % | | |
|  | L1 | L2 | L3 | L1 | L2 | L3 | 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[27](#_bookmark7) |  |  |  |  |  |  | 23% | 13% |
| PWHD[28](#_bookmark8) |  |  |  |  |  |  | 23% | 22% |
| Harmonic | At 100% of **Registered Capacity** | | | | | | Limit in BS EN 61000-3-12 | |
|  | Measured value (MV) in Amps | | | Measured value (MV) in % | | |
|  | L1 | L2 | L3 | L1 | L2 | L3 | 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% |

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1. THD = Total Harmonic Distortion
2. PWHD = Partial Weighted Harmonic Distortion

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 11 |  | |  |  | |  |  |  | | 3.1% | | 3.1% | | |
| 12 |  | |  |  | |  |  |  | | 1.33% | | .33% | | |
| 13 |  | |  |  | |  |  |  | | 2% | | 2% | | |
| THD[29](#_bookmark9) |  | |  |  | |  |  |  | | 23% | | 13% | | |
| PWHD[30](#_bookmark10) |  | |  |  | |  |  |  | | 23% | | 22% | | |
| **3. Power Quality – Voltage fluctuations and Flicker**:  For **Power Generating Module**s 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 Module**s of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation shall be designed in accordance with EREC P28.  The standard test impedance is 0.4 Ω for a single phase **Power Generating Module** (and for a two phase unit in a three phase system) and 0.24 Ω for a three phase **Power Generating Module** (and for a two phase unit in a split phase system). Please ensure that both test and standard impedance are completed on this form. If the test impedance (or the measured impedance) is different to the standard impedance, it must be normalised to the standard impedance as follows (where the **Power Factor** of the generation output is 0.98 or above):  d max normalised value = (Standard impedance / Measured impedance) x Measured value.  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 needs to comply with the particular requirements set out in the testing notes for the technology under test.  The test date and location must be declared. | | | | | | | | | | | | | | |
| Test start date | | |  | | | | Test end date | | | |  | | | |
| Test location | | |  | | | | | | | | | | | |
|  | | Starting | | | | | Stopping | | | | Running | | | |
|  | | d max | d c | | d(t) | | d max | d c | d(t) | | P st | | P lt 2 hours |  |
| Measured Values at | |  |  | |  | |  |  |  | |  | |  |  |

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1. THD = Total Harmonic Distortion
2. PWHD = Partial Weighted Harmonic Distortion

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 **Power Generating Module**s and split single phase **Power Generating Module**s. Delete as appropriate.  ^ Applies to single phase **Power Generating Module** and **Power Generating Module**s using two phases on a three phase system. Delete as appropriate. | | | | | | | | | | |
| **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.  The % DC injection (“as % of rated AC current” below) is calculated as follows:  % DC injection = Recorded DC value in Amps / Base current  where the base current is the **Registered Capacity** (W) / Vphase. The % DC injection should not be greater than 0.25%. | | | | | | | | | | |
| Test power level | | | 10% | | 55% | | 100% | | | |
| Recorded DC 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** and the measured **Power Factor** must be | | | | | | | | | | |

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| greater than 0.95 to pass. 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.  Note that the value of voltage stated in brackets assumes a **LV** connection. This should be adjusted for **HV** as required. | | | | | | | | | |
| 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. For trip tests, frequency and time delay should be stated. For “no trip tests”, “no trip” can be stated. | | | | | | | | | |
| Functio n | 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  30 s | |  |
| U/F stage 2 | 47 Hz | | 0.5 s | |  |  | 47.2 Hz  19.5 s | |  |
|  |  | |  | |  |  | 46.8 Hz  0.45 s | |  |
| O/F | 52 Hz | | 0.5 s | |  |  | 51.8 Hz  120.0 s | |  |
|  |  | |  | |  |  | 52.2 Hz  0.45 s | |  |
| Note. For frequency trip tests the frequency required to trip is the setting ± 0.1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0.2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error. | | | | | | | | | |
| **7. Protection – Voltage tests:** These tests should be carried out in accordance with Annex A.7.1.2.2. For trip tests, voltage and time delay should be stated. For “no trip tests”, “no trip” can be stated.  Note that the value of voltage stated below assumes a **LV** connection This should be adjusted for **HV** taking account of the VT ratio as required. | | | | | | | | | |
| 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  5.0 s | |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | |  | | |  | |  | 180 V  2.45 s | |  | |
| O/V stage 1 | 1.14 pu  (262.2 V  ) | | 1.0 s | | |  | |  | 258.2 V  5.0 s | |  | |
| O/V stage 2 | 1.19 pu  (273.7 V  ) | | 0.5 s | | |  | |  | 269.7 V  0.95 s | |  | |
|  |  | |  | | |  | |  | 277.7 V  0.45 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[31](#_bookmark11) | |  | | |  |  |  | | |  | |  |
| **Loss of Mains Protection, Vector Shift Stability test:** This test should be carried out in accordance with Annex A.7.1.2.6. Confirmation is required that the **Power Generating Module** does not trip under positive / negative vector shift. | | | | | | | | | | | | |
|  | | Start Frequ ency | | Change | | | Confirm no trip | | | | | |
| Positive Vector Shift | | 49.5  Hz | | +50 degrees | | |  | | | | | |
| Negative Vector Shift | | 50.5  Hz | | - 50 degrees | | |  | | | | | |

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1. If the device requires additional shut down time (beyond 0.5 s but less than 1 s) then this should be stated on this form.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Loss of Mains Protection, RoCoF Stability test:** This test should be carried out in accordance with Annex  A.7.1.2.6. Confirmation is required that the **Power Generating Module** does not trip for the duration of the ramp up and ramp down test. | | | | | | | |
| Ramp range | Test frequency ramp: | | Test Duration | | | Confirm no trip | |
| 49.0 Hz to 51.0 Hz | +0.95 Hzs-1 | | 2.1 s | | |  | |
| 51.0 Hz to 49.0 Hz | -0.95 Hzs-1 | | 2.1 s | | |  | |
| **9. Limited Frequency Sensitive Mode – Overfrequency 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, which also contains the measurement tolerances. | | | | | | | |
| **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, test 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 | |  | |  | | - | |
| Step f) 50.45Hz  ±0.05Hz | |  | |  | |  | |  | |
| Step g) 50.00Hz  ±0.01Hz | |  | |  | |  | |  | |
| **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. Both the time delay setting and the measured delay should be provided in this form; both should be greater than 20 s to pass. Confirmation should be provided that the **Power Generating Module** does not reconnect at the voltage and frequency settings below; a statement of “no reconnection” can be made. | | | | | | | | | |
| 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 **LV**  connection, 127.6 V **HV** connection assuming 110 V ph-ph VT) | | At 0.78 pu  (180.0 V **LV**  connection,  85.8 V **HV**  connection assuming 110 V ph-ph VT) | | 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. Please complete each entry, even if the contribution to the fault level is zero. | | | | | | | | | |
| 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.7.1.6. | |
| 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 |
| Provide high level description of logic interface, e.g. details in 11.1.3.1 such as AC or DC signal (the additional comments box below can be used) | Yes / NA |
| **15. Cyber security** | |
| Confirm that the **Power Generating Module** has been designed to comply with cyber security requirements, as detailed in 9.1.7. | Yes / NA |
| Additional comments. | |
|  | |

## 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 A2-1, Form A2-2 or Form A2-3 as being undertaken on site (details shall be provided in the “Other onsite tests” part at the end of this form). | | | |
| **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** | **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 | |
| **L2 - N** |  | Pass/ Fail |  | 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** | **273.7 V**  230 V  system | 0.5s | *270.25* |  | *277.15* | Pass/ Fail | 277.7 | *0.5 s* | |  | *0.6 s* | Pass/ Fail | |
| **L2 - N** |  | Pass/ Fail |  | 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** | **184.0 V**  230 V  system | 2.5 s | *180.55* |  | *187.45* | Pass/ Fail | 180 | *2.5 s* | |  | *2.6 s* | Pass/ Fail | |
| **L2 - N** |  | Pass/ Fail |  | Pass/ Fail | |
| **L3 - N** |  | Pass/ Fail |  | Pass/ Fail | |
| **Over and Under Voltage Protection Tests LV** | | | | | | | | | | | | | |
| **Stability Tests** (confirm no trip of **Interface Protection**) | | | | | | | | | | | | | |

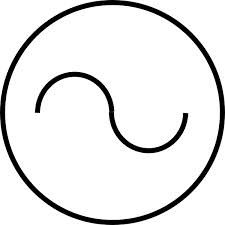
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test Description | | | Setting | | | Time Delay | Test Condition  (3-Phase Value ) | | | Test Voltage all phases  ph-n | | Test Duration | Confirm 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** | | | **2.5 s** | < UV | | | 180 V | | 2.45 s |  | | Pass/ Fail | |
| Over voltage 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.  Under voltage 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 |

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| **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** (confirm no trip of **Interface Protection**) | | | | | | | | | | | | | | | |
| Test Description | | | Setting | | | Time Delay | Test Condition (3-Phase Value ) | | | Test 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** | | | **2.5 s** | < UV | | | 86 V | | 2.45 s |  | | Pass/Fail |
| Additional Comments / Observations: | | | | | | | | | | | | | | | |
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| **Over and Under Frequency Protection**  The **Generator** shall demonstrate compliance with this EREC G99 in respect of Over and Under Frequency Protection by provision of **Manufacturers’ Information**, 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** (confirm no trip of **Interface Protection**) | | | | | | | | | | | | | | |
| Test Description | | Setting | | Time Delay | Test Condition | | | Test Frequency | | Test Duration | | Confirm No Trip | | Result |
| Inside Normal band | | **---------** | | **---------** | < OF | | | 51.8 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 | | | 47.2 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 |
| Over frequency test - Frequency shall be stepped from 51.8 Hz to the test frequency and held for the test duration and then stepped back to 51.8 Hz.  Under frequency 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: | | | | | | | | | | | | | | |
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| **Details of Loss of Mains Protection** | | | | |
| **Manufacturer** | **Manufacturer**’s type | Date of Installation | Settings | Other information |
|  |  |  |  |  |

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| **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= +**0.10 Hzs-1**  above setting | | | | | |
| **Setting = 1.0 Hzs-1** | Lower Limit | Measured Value | Upper Limit | Result | Test Condition | | Lower Limit | Measured Value | Upper Limit | Result |
| Increasing Frequency | *0.975* |  | *1.025* | Pass/Fail | 1.10 Hzs-1 | | *>0.5 s* |  | *<1.0 s* | Pass/Fail |
| Reducing Frequency | *0.975* |  | *1.025* | Pass/Fail | 1.10 Hzs-1 | | *>0.5 s* |  | *<1.0 s* | Pass/Fail |
| Ramp in range 48.5-51.5 Hz | | | | | | | | | | |
| Increasing Frequency | *0.975* |  | *1.025* | Pass/Fail | 3.00 Hzs-1 | | *>0.5 s* |  | *<1.0 s* | Pass/Fail |
| Reducing Frequency | *0.975* |  | *1.025* | Pass/Fail | 3.00 Hzs-1 | | *>0.5 s* |  | *<1.0 s* | Pass/Fail |
| **Stability Tests** (confirm no trip of **Interface Protection**) | | | | | | | | | | |
| Ramp in range 49.0-51.0 Hz | | | | | | | | | | |
|  | Test Condition | | Test frequency ramp | | | Test Duratio n | | Confirm No Trip | | Result |
| Inside Normal band | < RoCoF setting  (increasing f) | | +0.95 Hzs-1 | | | 2.1 s | |  | | Pass/Fail |
| Inside Normal band | < RoCoF setting  (reducing f) | | -0.95 Hzs-1 | | | 2.1 s | |  | | Pass/Fail |
| Ramp as shown | | | | | | | | | | |
| Inside Normal band | > RoCoF setting  (increasing f) | | +1.20 Hzs-1  (ramp between 49.80  and 50.34 Hz) | | | 0.45 s | |  | | Pass/Fail |



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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Inside Normal band | > RoCoF setting  (reducing f) | - -1.20 Hzs-1  (ramp between 50.30  and 49.76 Hz | | | 0.45 s | |  | Pass/Fail |
| Additional Comments / Observations: | | | | | | | | |
|  | | | | | | | | |
| **LoM Protection - Stability test** (confirm no trip of **Interface Protection**) | | | | | | | | |
|  | Start Frequency | | Change | | | Confirm no trip | | |
| Positive Vector Shift | 49.5 Hz | | +50 degrees | | |  | | |
| Negative Vector Shift | 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 appropriate circuit breaker.   L1 L2 L3  Interface Protection | | | | | | | | |

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| **Logic Interface Port** | |
| Confirm that an input port is provided and can be used to shut down the module |  |
| **Other onsite tests**: Provide details here of any additional tests which have been carried out (as identified as being required by Form A2-1, A2-2 or A2-3) | |
|  | |

## Installation Document for Type A Power Generating Modules (Form A3-1), Installation Notification Form for Small Generation Installation Procedures 2 and 3 (Form A3-2), Installation Notification Form for Small Generation Installation Procedure 1 (Form A3-3) and Installation Document for Type A Power Generating Modules where the output is shared between two or more Customers (Form A3-4)

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| **Form A3-1 : Installation Document for Type A Power Generating Modules**  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 Module**s being commissioned. Where the installation is phased the form should be completed on a per **Generating Unit** basis as each part of the installation is completed in accordance with EREC G99 paragraph 15.3.3. For phased installations reference to **PGM** in this form should be read as reference to **Generating Unit**s. | |
| **Form A3-1 Part 1** | |
| To ABC electricity distribution **DNO**  99 West St, Imaginary Town, ZZ99 9AA [abced@wxyz.com](mailto: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 |  |

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| 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 Module**s **-** where multiple **Power Generating Module**s will exist within one **Generator’s Installation** | | | | | | | | | | | |
| **Manufacturer** / Reference | Date of Installation | | Energy source and energy conversion technology (enter codes from tables 1 and 2 see Form A1-2) | | **Manufacturer**s Ref No. (system reference) or Reference to Form A2-1/2/3 or combination of above as applicable | **Power Generating Module Registered Capacity** in kW | | | | | |
| 3-  Phase Units | Single Phase Units | | | | **Power Factor** |
| PH 1 | | PH 2 | PH 3 |
| Src | Tech |
|  |  | |  | |  |  |  | |  |  |  |
|  |  | |  | |  |  |  | |  |  |  |
|  |  | |  | |  |  |  | |  |  |  |
| **Emerging technology classification (if applicable)** | | | | | | | | | | | |
|  | | | | | | | | | | | |
| **Commissioning Checks** | | | | | | | | | | | |
| **Description** | | | | | | | | **Confirmation** | | | |

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| **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 **PGM**s being connected in parallel with the **DNO**’s **Distribution Network** (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\* |
| **PGM** installation complies with cyber security requirements | | | Yes / No\* |
| **Form A3-1 Part 2** | | | |
| **Power Generating Module** reference or name |  | | |
| **Information to be enclosed** | | | |
| Description | | Confirmation \* | |
| Schedule of protection settings (may be included in circuit diagram) | | Yes / No\* | |
| As installed Standard Application Form data, unless already provided. | | 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 / N/A (**Type Tested**)\* | |
| The **PGM** successfully synchronises with the **DNO**’s **Distribution Network** without causing significant voltage disturbance. | | Yes / No\* | |
| The **PGM** successfully runs in parallel with the **DNO**’s **Distribution Network** without tripping and without causing significant voltage disturbances. | | Yes / No\* | |
| The **PGM** successfully disconnects without causing a significant voltage disturbance, when it is shut down. | | Yes / No\* | |
| **Interface Protection** operates and disconnects the **DNO**’s **Distribution Network** quickly (within 1 s) when a suitably rated switch, located between the **PGM** and the **DNO**’s incoming connection, is opened. | | Yes / No\* | |
| The **PGM** remains disconnected for at least 20 s after switch is reclosed. | | Yes / No\* | |

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| Loss of tripping and auxiliary supplies. Where applicable, loss of supplies to tripping and protection relays results in either **PGM** or **Generating Unit** forced trip or an alarm to a 24 hour 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 A3-1 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:   1. The commissioning checks detailed in Form A2-4 \*; 2. The commissioning checks detailed in this Form A3-1 on behalf of and that the results are an accurate record of the checks.   \*delete if not applicable ie if the **Interface Protection** and ride through capabilities are **Type Tested** | | |
| Name: | | |
| Signature: | Date: | |
| Company Name: |

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| --- | --- |
| **Form A3-2: Installation Notification Form for Small Generation Installation Procedures 2 and 3.**  Please complete and provide this document for each installation. Part 1 should be completed for the overall installation.  Part 2 should be completed for each of the **Generating Unit**s (ie for the **Electricity Storage** devices and non-**Electricity Storage Generating Unit Inverters**) being commissioned. Where the installation is phased the form should be completed on a per **Generating Unit** basis as each part of the installation is completed in accordance with EREC G99 paragraph 15.3.3. For phased installations reference to **PGM** in this form should be read as reference to **Generating Unit**s. | |
| **Form A3-2 Part 1** | |
| To ABC electricity distribution **DNO**  99 West St, Imaginary Town, ZZ99 9AA [abced@wxyz.com](mailto: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 |  |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 Generating Units where multiple Generating Units will exist within one Generator’s Installation** | | | | | | | | | | | |
| **Manufacturer** / Reference | Date of Installation | | Energy  source and energy  conversion technology (enter  codes from tables 1  and 2 see Form A1-2) | | **Manufacturer**s Ref No. (system reference) or Reference to Form A2-3 | **Generating Unit Registered Capacity**  in kW | | | | | |
| 3-  Phase Units | Single Phase Units | | | | **Power Factor** |
| PH 1 | | PH 2 | PH 3 |
| Src | Tech |
|  |  | |  | |  |  |  | |  |  |  |
|  |  | |  | |  |  |  | |  |  |  |
|  |  | |  | |  |  |  | |  |  |  |
| **Emerging technology classification (if applicable)** | | | | | | | | | | | |
|  | | | | | | | | | | | |
| **Commissioning checks** | | | | | | | | | | | |
| **Description** | | | | | | | | **Confirmation** | | | |

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| **Generator’s Installation** satisfies the requirements of BS7671 (IET Wiring Regulations). | | | Yes / No\* |
| Suitable lockable points of isolation have been provided between the  **PGM(s**) 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 the **PGM(s**) being connected in parallel with the **DNO**’s **Distribution Network** (without synchronising) is in place and operates correctly. | | | Yes / No\* |
| Balance of Multiple Single Phase **PGM(s**). 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\* |
| The **PGM** complies with cyber security requirements | | | Yes / No\* |
| Export limitation scheme meets the requirements of EREC G100 and has been commissioned in accordance with EREC G100. | | | Yes / No\* |
| **Information to be enclosed** | | |  |
| Description | | | Confirmation \* |
| As installed Standard Application Form data, unless already provided. | | | Yes / No\* |
| Final copy of circuit diagram | | | Yes / No\* |
| EREC G100 Export limitation scheme installation and commissioning test form. | | | Yes / No\* |
| **Form A3-2 Part 2** | | | |
| **Power Generating Module** reference or name |  | | |
| **Information to be enclosed** | | | |
| Description | | Confirmation \* | |
| 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\* | |
| The **PGM** successfully synchronises with the **DNO**’s **Distribution Network** without causing significant voltage disturbance. | | Yes / No\* | |
| The **PGM** successfully runs in parallel with the **DNO**’s **Distribution Network** without tripping and without causing significant voltage disturbances. | | Yes / No\* | |

|  |  |
| --- | --- |
| The **PGM** successfully disconnects without causing a significant voltage disturbance, when it is shut down. | Yes / No\* |
| **Interface Protection** operates and disconnects the **DNO**’s **Distribution Network** quickly (within 1 s) when a suitably rated switch, located between the **PGM** and the **DNO**’s incoming connection, is opened. | Yes / No\* |
| The **PGM** remains disconnected for at least 20 s after switch is reclosed. | Yes / No\* |
| Loss of tripping and auxiliary supplies. Where applicable, loss of supplies to tripping and protection relays results in the forced trip of the **PGM** (or relevant **Generating Unit**) or an alarm to a 24 hour 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 **PGM** 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 **Power Generating Module** within the scope of this EREC G99, and the installation:   1. Compliance with the requirements of EREC G99 and EREC G100 is achieved. 2. The **Power Generating Module** is **Fully Type Tested**. 3. The commissioning checks detailed in this Form A3-2 Part 2 have been successfully completed. | |
| Name: | |
| Signature: | Date: |
| Company Name: |
| Position: | |

|  |  |
| --- | --- |
| **Form A3-3 – Installation Notification Form for Small Generation Installation Procedure 1**  This form is to be used for the notification to the **DNO** of **Generating Unit**s installed and commissioned under **Small Generation Installation** Procedure 1 and where the eligibility conditions are met:   * The new and existing **Generating Unit**s are located in a single **Generator’s Installation**; * The **Intrinsic Design Capacity** of each new and existing **Generating Unit** is no more than 32 A per phase; * The **Registered Capacity** of each new or existing **Generating Unit** is no more than 16A per phase; * All of the **Generating Unit**s (including **Electricity Storage** devices) are connected via EREC G98 or EREC G99 **Fully Type Tested** Inverters;[32](#_bookmark12); and * The total aggregate **Registered Capacities** of all the **Generating Unit**s (including **Electricity Storage** devices) is less than 16 A per phase;   **DNO**s may have their own forms; refer to the **DNO**’s websites and online application tools. The application should include the **Manufacturer’s** reference number (the system reference) from the ENA Type Test Verification Report Register.  On completion of the installation the **Installer** shall submit this form A3-3, alongside an application for the removal of the limitation on the appropriate EREC G99 forms (if permission is being sought for the removal of the limitation at the same time as submitting this notification).  Please complete and provide this document for each premises, once the installation is complete. | |
| To ABC electricity distribution **DNO**  99 West St, Imaginary Town, ZZ99 9AA [abced@wxyz.com](mailto:abced@wxyz.com) | |
| **Customer details:** | |
| **Customer** (name) |  |
| Address |  |
| Post Code |  |
| Contact person (if different from  **Customer**) |  |
| Telephone number |  |
| E-mail address |  |

—————————

1. Or **Type Tested** to EREC G83 or G59 where the **Generating Unit** was connected prior to 27 April 2019.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Customer** signature | | | |  | | | | | | |
| **Installer details:** | | | | | | | | | | |
| **Installer** | | | |  | | | | | | |
| Accreditation / Qualification | | | |  | | | | | | |
| Address | | | |  | | | | | | |
| Post Code | | | |  | | | | | | |
| Contact person | | | |  | | | | | | |
| Telephone Number | | | |  | | | | | | |
| E-mail address | | | |  | | | | | | |
| **Installer** signature | | | |  | | | | | | |
| **Installation details** | | | | | | | | | | |
| Address | | | |  | | | | | | |
| Post Code | | | |  | | | | | | |
| MPAN(s) | | | |  | | | | | | |
| Location within **Customer’s Installation** | | | |  | | | | | | |
| Location of Lockable Isolation Switch | | | |  | | | | | | |
| **Details of Generating Units.** Use a separate line for new and existing installations and for different technology types. Use PH 1 column for single phase supply. | | | | | | | | | | |
| **Manufacturer** | Date of Installation | Energy source and energy conversion technology (enter codes from tables 1 and 2 below) | | | **Manufacturer**‘s Ref No (this number should be registered on the ENA **Type Test Verification Report** Register as the system reference) | **Generating Unit** capacities in kW | | | | Energy storage capacity for **Electricity Storage** devices (kWh) |
| 3-  Phase Units | Single Phase Units | | |
| Src | Tech | | PH1 | PH2 | PH3 |
|  |  |  | | |  | **Intrinsic Design Capacity** (kW)\* | | | | |
|  |  |  |  |  |
| **Registered Capacity** (kW)\* | | | | |
|  |  |  |  |  |
|  |  |  | | |  | **Intrinsic Design Capacity** (kW) | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | |  |  |  | |  | |  | |  | |
| **Registered Capacity** (kW) | | | | | | | | |
|  |  | |  | |  | |  | |
|  |  |  | |  | **Intrinsic Design Capacity** (kW) | | | | | | | | |
|  | |  | |  | |  | |  |
| **Registered Capacity** (kW) | | | | | | | | |
|  | |  | |  | |  | |  |
|  |  |  | |  | **Intrinsic Design Capacity** (kW) | | | | | | | | |
|  | |  | |  | |  | |  |
| **Registered Capacity** (kW) | | | | | | | | |
|  | |  | |  | |  | |  |
| **Declaration – to be completed by Installer for Generating Units tested to EREC G98 or EREC G99.** | | | | | | | | | | | | | |
| I declare that the relevant **Generating Unit**s and the installation which together form a **Power Generating Module** at the above address, conform to the requirements of EREC G99. | | | | | | | | | | | | | |
| Signature: | | | Date: | | | | | | | | | | |

\* **Intrinsic Design Capacity** is the basic design capacity of the **Generating Unit** (and will be the value of **Registered Capacity** in the ENA’s Type Test Register). For SGI-1, where the **Registered Capacity** is limited and is less than the **Intrinsic Design Capacity**, both values should be recorded here.

Table 1

|  |  |
| --- | --- |
|  | Energy Source |
| A | Advanced Fuel (produced via gasification or pyrolysis of biofuel or waste) |
| B | Biofuel - Biogas from anaerobic digestion (excluding landfill & sewage) |
| C | Biofuel - Landfill gas |
| D | Biofuel - Sewage gas |
| E | Biofuel - Other |
| F | Biomass |
| G | Fossil - Brown coal/lignite |
| H | Fossil - Coal gas |
| I | Fossil - Gas |
| J | Fossil - Hard coal |
| K | Fossil - Oil |

|  |  |
| --- | --- |
|  | Energy Source |
| L | Fossil - Oil shale |
| M | Fossil - Peat |
| N | Fossil - Other |
| O | Geothermal |
| P | Hydrogen |
| Q | Nuclear |
| R | Solar |
| S | Stored Energy (all stored energy irrespective of the original energy source) |
| T | Waste |
| U | Water (flowing water or head of water) |
| V | Wind |
| W | Other |

Table 2

|  |  |
| --- | --- |
|  | Energy Conversion Technology |
| 1 | Engine (combustion / reciprocating) |
| 2 | Fuel Cell |
| 3 | Gas turbine (OCGT) |
| 4 | Geothermal power plant |
| 5 | Hydro - Reservoir (not pumped) |
| 6 | Hydro - Run of river |
| 7 | Hydro - Other |
| 8 | Interconnector |
| 9 | Offshore wind turbines |
| 10 | Onshore wind turbines |
| 11 | Photovoltaic |
| 12 | Steam turbine (thermal power plant) |
| 13 | Steam-gas turbine (CCGT) |
| 14 | Tidal lagoons |
| 15 | Tidal stream devices |
| 16 | Wave devices |
| 17 | Storage - Chemical - Ammonia |
| 18 | Storage - Chemical - Hydrogen |
| 19 | Storage - Chemical - Synthetic Fuels |
| 20 | Storage - Chemical - Drop-in Fuels |
| 21 | Storage - Chemical - Methanol |

|  |  |
| --- | --- |
|  | Energy Conversion Technology |
| 22 | Storage - Chemical - Synthetic Natural Gas |
| 23 | Storage - Electrical - Supercapacitors |
| 24 | Storage - Electrical - Superconducting Magnetic ES (SMES) |
| 25 | Storage - Mechanical - Adiabatic Compressed Air |
| 26 | Storage - Mechanical - Diabatic Compressed Air |
| 27 | Storage - Mechanical - Liquid Air Energy Storage |
| 28 | Storage - Mechanical - Pumped Hydro |
| 29 | Storage - Mechanical - Flywheels |
| 30 | Not used |
| 31 | Not used |
| 32 | Not used |
| 33 | Storage - Electrochemical Classic Batteries -Lead Acid |
| 34 | Storage - Electrochemical Classic Batteries -Lithium Polymer (Li-Polymer) |
| 35 | Storage - Electrochemical Classic Batteries -Metal Air |
| 36 | Storage - Electrochemical Classic Batteries -Nickle Cadmium (Ni-Cd) |
| 37 | Storage - Electrochemical Classic Batteries -Sodium Nickle Chloride (Na-NiCl2) |
| 38 | Storage - Electrochemical Classic Batteries -Lithium Ion (Li–ion) |
| 39 | Storage - Electrochemical Classic Batteries -Sodium Ion (Na–ion) |
| 40 | Storage - Electrochemical Classic Batteries -Lithium Sulphur (Li-S) |
| 41 | Storage - Electrochemical Classic Batteries -Sodium Sulphur (Na-S |
| 42 | Storage - Electrochemical Classic Batteries -Nickle –Metal Hydride (Ni-MH) |
| 43 | Storage - Electrochemical Flow Batteries - Vanadium Red-Oxide |
| 44 | Storage - Electrochemical Flow Batteries - Zinc – Iron (Zn –Fe) |
| 45 | Storage - Electrochemical Flow Batteries - Zinc – Bromine (Zn –Br) |
| 46 | Storage - Other |
| 47 | Other |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Form A3-4: Installation Document for Type A Power Generating Modules where the output is shared between two or more Customers**  The **Generator** (ie the owner of the **Power Generating Module(s)**) must complete and provide this document for every **Power Generating Facility** were the output of one or more **Power Generating Module**s is shared between separate **Customer**s.  Part 1 shall be completed for the **Power Generating Facility**.  Part 2 shall be completed for each of the **Power Generating Module**s being commissioned. Where the installation is phased the form should be completed on a per **Generating Unit** basisas each part of the installation is completed in accordance with EREC G99 paragraph 15.3.3. For phased installations reference to **PGM** in this form should be read as reference to **Generating Unit**s.  Part 3 shall be completed, giving the address and MPAN of each **Customer** who has a connection to the **Generator’s Installation.** | | | | | | | | | | | | | | | |
| **Form A3-4 Part 1** | | | | | | | | | | | | | | | |
| To ABC electricity distribution **DNO**  99 West St, Imaginary Town, ZZ99 9AA [abced@wxyz.com](mailto:abced@wxyz.com) | | | | | | | | | | | | | | | |
| **Generator Details:** | | | | | | | | | | | | | | | |
| **Generator** (name) | | |  | | | | | | | | | | | | |
| Address | | |  | | | | | | | | | | | | |
| Post Code | | |  | | | | | | | | | | | | |
| Contact person (if different from **Generator**) | | |  | | | | | | | | | | | | |
| Telephone number | | |  | | | | | | | | | | | | |
| E-mail address | | |  | | | | | | | | | | | | |
| MPAN(s) (if applicable) | | |  | | | | | | | | | | | | |
| **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 Switches | | |  | | | | | | | | | | | | |
| **Summary details of Power Generating Module**s **-** where multiple **Power Generating Module**s will exist within one **Generator’s Installation** | | | | | | | | | | | | | | | |
| **Manufacturer** / Reference | Date of Installation | | | Energy source and conversion technology (enter codes from tables 1 & 2 below) | | **Manufacturer**sRef No. (system reference) or Reference to Form A2-1/2/3 or combination of above as applicable | | **Power Generating Module Registered Capacity** in kW | | | | | | | |
| 3-Phase Units | | Single Phase Units | | | | | **Power Factor** |
| Src | Tech | PH1 | | | PH2 | PH3 |
|  |  | | |  |  |  | |  | |  | | |  |  |  |
|  |  | | |  |  |  | |  | |  | | |  |  |  |
|  |  | | |  |  |  | |  | |  | | |  |  |  |
|  |  | | |  |  |  | |  | |  | | |  |  |  |
| **Emerging technology classification (if applicable)** | | | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | |
| **Commissioning Checks (in addition to the standard checks for the PGM(s))** | | | | | | | | | | | | | | | |
| **Description** | | | | | | | | | | | | **Confirmation** | | | |
| Confirm that a specific bilateral agreement between the Generator and the DNO is in place | | | | | | | | | | | | Yes/No\* | | | |
| **Generator’s Installation** satisfies the requirements of BS7671 (IET Wiring Regulations). | | | | | | | | | | | | Yes / No\* | | | |
| Suitable lockable points of isolation have been provided between the **PGM**s, the rest of the **Generator’s Installation** and all **Customers’ Installations**. | | | | | | | | | | | | Yes / No\* | | | |
| Labels have been installed at all points of isolation in accordance with EREC G99. | | | | | | | | | | | | Yes / No\* | | | |
| Labels have been installed in all **Customers Installations** warning of the external source of electrical energy connected, and that single line diagrams are posted in the **Generator’s Installation** and at the service position of each **Customer**. | | | | | | | | | | | | Yes / No\* | | | |
| Interlocking that prevents **PGM**s being connected in parallel with the **DNO**’s **Distribution Network** (without synchronising) is in place and operates correctly. | | | | | | | | | | | | Yes / No\* | | | |
| Confirmation that **Active Power** cannot flow from each and every **Customer’s Installation** towards the **PGM** (except where permitted by 5.3 and 5.4) | | | | | | | | | | | | Yes / No\* | | | |
| The equipment/installation has been designed such that all protection in each **Customers’** **Installation** and the **Generator’s Installation** operates correctly by design for faults anywhere on the **Generator’s** and **Customers’ Installations**. | | | | | | | | | | | | Yes / No\* | | | |
| Synchronizing facilities/checks exist that check for correct phasing each and every time a **Customer’s Installation** is connected to and/or energized from the **Generator’s Installation.** | | | | | | | | | | | | Yes / No\* | | | |
| Balance of multiple single phase **PGM**s. Confirm that design of the **Generator’s** **Installation** has been carried out to limit output power imbalance to below [32] A per phase, as required by EREC G99. | | | | | | | | | | | | Yes / No\* | | | |
| **Active Power** export balance from all **Customers** has been agreed with **DNO**? | | | | | | | | | | | | Yes / No\* | | | |
| Confirmation that if **Electricity Storage** is included in the **Power Generating Module** that a mismatch between the **Electricity Storage i**mport and the aggregate **Active Power** flows from the **Generator’s Installation** and **Customers’ Installations** triggers the appropriate response and an alarm. | | | | | | | | | | | | Yes / No\* | | | |
| Confirmation that any loss of communication path triggers the correct response and alarm from the sharing system. | | | | | | | | | | | | Yes / No\* | | | |
| **PGM** installation complies with cyber security requirements | | | | | | | | | | | | Yes / No\* | | | |
| Confirmation that the alarm operates as intended and alerts the **Generator** to the alarm condition. | | | | | | | | | | | | Yes / No\* | | | |
| **Form A3-4 Part 2** | | | | | | | | | | | | | | | |
| **Power Generating Module** reference or name | | | | | | |  | | | | | | | | |
| **Information to be enclosed** | | | | | | | | | | | | | | | |
| Description | | | | | | | | | | | Confirmation \* | | | | |
| Schedule of protection settings (may be included in circuit diagram) | | | | | | | | | | | Yes / No\* | | | | |
| As installed Standard Application Form data, unless already provided. | | | | | | | | | | | 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 / N/A (**Type Tested**)\* | | | | |
| The **PGM** successfully synchronises with the **DNO**’s **Distribution Network** without causing significant voltage disturbance. | | | | | | | | | | | Yes / No\* | | | | |
| The **PGM** successfully runs in parallel with the **DNO**’s **Distribution Network** without tripping and without causing significant voltage disturbances. | | | | | | | | | | | Yes / No\* | | | | |
| The **PGM** successfully disconnects without causing a significant voltage disturbance, when it is shut down. | | | | | | | | | | | Yes / No\* | | | | |
| **Interface Protection** operates and disconnects the **DNO**’s **Distribution Network** quickly (within 1 s) when a suitably rated switch, located between the **PGM** and the **DNO**’s incoming connection, is opened. | | | | | | | | | | | Yes / No\* | | | | |
| The **PGM** remains disconnected for at least 20 s 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** or **Generating Unit** forced trip or an alarm to a 24 hour 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: | | | | | | | | | | | | | | | |
| **Form A3-4 Part 3** | | | | | | | | | | | | | | | |
| **Customer** | | **MPAN** | | **Address** | | | | | | | | | | | |
| 1 | |  | |  | | | | | | | | | | | |
| 2 | |  | |  | | | | | | | | | | | |
| 3 | |  | |  | | | | | | | | | | | |
| 4 | |  | |  | | | | | | | | | | | |
| 5 | |  | |  | | | | | | | | | | | |
| 6 | |  | |  | | | | | | | | | | | |
| Please extend on a separate sheet for additional **Customers** supplied by the **Generator.** | | | | | | | | | | | | | | | |
| 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 A3-1 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:  1. The commissioning checks detailed in Form A2-4 \*;  2. The commissioning checks detailed in this Form A3-1 on behalf of and that the results are an accurate record of the checks.  \*delete if not applicable ie if the **Interface Protection** and ride through capabilities are **Type Tested** | | | | | | | | | | | | | | | |
| Name: | | | | | | | | | | | | | | | |
| Signature: | | | | | | | | | Date: | | | | | | |
| Company Name: | | | | | | | | |

## Emerging Technologies and other Exceptions

### Emerging Technologies

Ofgem published details of **Power Generating Module**s which are classified as emerging technologies in **Great Britain** in its 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 Stirling SE Flussiggas |

For **Power Generating Module**s 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.

* 11.2.1 (frequency withstand capability);
* 11.2.2 (rate of change of frequency);
* 11.2.3 (constant **Active Power** output);
* 11.2.4 (**Limited Frequency Sensitive Mode – Overfrequency**);
* 10.6.7 (**Interface Protection** settings).

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 Module**s 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.

### Electricity Storage

* + - 1. For **Electricity Storage** devices commissioned before 01 September 2022 the following sections and their corresponding compliance requirements in Annex A, Annex B and Annex C of EREC G99 do not apply:

**Type A** - less than 1 MW:

11.2.3 (constant **Active Power** output); and

11.2.4 **(Limited Frequency Sensitive Mode – Over frequency**).

**Type B** - 1 MW or greater but less than 10 MW:

12.2.3 (constant **Active Power** output);

12.2.4 (**Limited Frequency Sensitive Mode – Over frequency**); and

12.3.1 – 12.3.1.7 inclusive, 12.3.4 and 12.6 (**Fault Ride Through**, **Fast Fault Current** injection).

**Type C** and **Type D** - 10 MW or greater and / or with a **Connection Point** at greater than 110 kV:

* + 1. (constant **Active Power** output);
    2. (**Limited** **Frequency Sensitive Mode – Over frequency**);
    3. (**Limited Frequency Sensitive Mode – Under frequency**);
    4. (**Frequency Sensitive Mode**); and

13.3 – 13.3.1.11 inclusive, 13.3.4 and 13.6 (**Fault Ride Through**, **Fast Fault Current** injection).

* + - 1. Where **Electricity Storage** devices are **DC** coupled with generation, the **Electricity Storage** exceptions do not apply to the **Inverter**.
      2. For **Electricity Storage** devices commissioned before 01 September 2022 the Type categorisation in the example in Figure 4.6 has a different interpretation: The non integral **Electricity Storage** device is not part of the Type classification and hence this is a 3 x 4 MW **Type B Synchronous Power Generating Module**s plus a 1.5 MW **Type B Power Park Module** plus 1 MW **Electricity Storage** device. This is illustrated in Figure A.4.1.



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 **Electricity Storage** plus 1 MW **Electricity Storage** device

= 3 x 4 MW **Type B Synchronous Power Generating Module**s plus 1.5 MW

**Type B Power Park Module** plus 1 MW **Electricity Storage**

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

Note the **Electricity Storage** device 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 **Electricity Storage** device 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 A.4.1 Example of Connection of Electricity Storage with Type A and Type B Power Generating Modules in the same Power Generating Facility**

* + - 1. For **Electricity Storage** devices commissioned before 01 September 2022 the connection scenario examples detailed below have a different interpretation or applicability to that detailed in Section 6:
         1. Scenario 7 and Figure 6.7: The **Electricity Storage** devices are not included in the **Power Park Module** in this example, hence this example is a 60 kW **Power Park Module** and a 90 kW **Power Generating Facility**. This is illustrated in Figure A.4.2.



**Figure A.4.2. Example: Existing 60 kW Type A Power Park Module to EREC G99 plus later addition of 3 x 10 kW Electricity Storage devices with own Inverters**

**= 60 kW Type A Power Park Module plus 30 kW Electricity Storage (exempt from certain Type A requirements)**

**= 90 kW Power Generating Facility**

* + - * 1. Scenario 8 and Figure 6.8: The later addition of 3 x 10kW **Electricity Storage** devices do not form a **Type A Power Park Module** and hence this example is 60 kW **Electricity Storage** + 30 kW **Electricity Storage** = 90 kW **Power Generating Facility**. This is illustrated in Figure A.4.3.



**Figure A.4.3. Example: Existing 3 x 20 kW Electricity Storage devices to EREC G59 plus later addition of 3 x 10 kW Electricity Storage devices with own Inverters**

**= 60 kW Electricity Storage + 30 kW Electricity Storage (exempt from certain Type A requirements)**

**= 90 kW Power Generating Facility**

* + - * 1. Scenario 9 and Figure 6.9: The existing **Electricity Storage** devices and the later addition of 3 x 10kW **Electricity Storage** devices do not form a **Type A Power Park Module** and hence this example is 60 kW **Electricity Storage** + 30 kW **Electricity Storage** = 90 kW **Power Generating Facility**. This is illustrated in Figure A.4.4.



**Figure A.4.4. Example: Existing 3 x 20 kW Electricity Storage devices to EREC G99 plus later addition of 3 x 10 kW Electricity Storage devices with own Inverters**

**= 60 kW Electricity Storage (exempt from certain Type A requirements) + 30 kW Electricity Storage (exempt from certain Type A requirements)**

**= 90 kW Power Generating Facility**

* + - * 1. Scenario 10 and Figure 6.10; This example is not applicable, however it should be noted that before a **Vehicle to Grid Electric Vehicle** is connected to the fixed installation the **Customer** must ensure there is an appropriate **Connection Agreement** with the **DNO** and that the **Power Generating Module** is compliant with this EREC G99 ie compliant with all the requirements in this document except the exclusions stated in this Annex A.4.2.
        2. Scenario 11 and Figure 6.11: This example is not applicable it should be noted that before a **Vehicle to Grid Electric Vehicle** is connected to the fixed installation the **Customer** must ensure there is an appropriate **Connection Agreement** with the **DNO** and that the **Power Generating Module** is compliant with this EREC G99 ie

compliant with all the requirements in this document except the exclusions stated in this Annex A.4.2.

* + - * 1. Scenario 12 and Figure 6.12: This example is not applicable however it should be noted that before a **Vehicle to Grid Electric Vehicle** is connected to the fixed installation the **Customer** must ensure there is an appropriate **Connection Agreement** with the **DNO** and that the **Power Generating Module** is compliant with this EREC G99 ie compliant with all the requirements in this document except the exclusions stated in this Annex A.4.2.

### Infrequent Short-Term Parallel Operation

For **Power Generating Module**s 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:

**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

## Example calculations to determine if unequal generation across different phases is acceptable or not

A **Generator Installation** might have 21 kW of PV and a 6 kW CHP plant. Due to the areas of roof available the PV plant comprises 2 by 4.5 kW **Inverter**s and two by 3 kW **Inverter**s, all of these devices being single phase.

1. The following connection would be deemed acceptable:
   * Ph 1 4.5 kW PV
   * Ph 2 3 kW PV plus 6 kW CHP
   * Ph 3 3kW + 4.5 kW PV

This would lead to:

* 4.5 kW imbalance with CHP at zero output
* 4.5 kW imbalance with CHP and PV at maximum output
* 6 kW imbalance with CHP at maximum output and PV at zero output. All of which are below the 32 A imbalance limit.

1. The following alternative connection for the same plant would be deemed unacceptable:
   * Ph1 4.5 kW PV plus 6 kW CHP
   * Ph 2 3 kW PV
   * Ph3 4.5 kW PV plus 3 kW PV

This is not acceptable as at full output Phases 1 would have 7.5 kW more output than Ph2 and this exceeds the 32 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 **PGM**s 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)

1. 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
2. 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 32A.

## Significant Modernization – application of EREC G99 to generation equipment commissioned before EREC G99 was published

These scenarios present examples in respect of connection to new sites or modifications to existing sites, as well as considering whether a modification to an existing **Power Generating Module** would be considered to be substantial and therefore compliance with this EREC G99 would be required. Note that this table is applicable to **Type A**, **B**, **C** and **D** **Power Generating Module**s.

A ✓ indicates that the example triggers full compliance of the Power Generating Module with the latest version of EREC G99, whereas a × indicates that full compliance with the latest EREC G99 is not required.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Scenario** | **DNO position** | **EREC G99?** | **Rationale** |
| 1 | Existing EREC G59 PPM installation (eg solar PV or wind)– the **Generator** replaces a failed **Generating Unit** (ie Inverter or turbine) at a **PPM** comprising multiple **Generating Units.** | Like-for-like replacements do not immediately lead to EREC G99 compliance for the whole module.  The new **Inverter** or Turbine does need to be compliant with the latest EREC G99. | × | This is a maintenance issue – the overall characteristics of the **PPM** are essentially unchanged – at least until 80% of the capacity of the PGM is replaced. |
| 2 | Existing EREC G59 PPM installation (eg solar PV or wind)– the **Generator** operates a planned replacement programme of **Generating Units** (ie Inverter or turbine) of the same capacity at a **PPM** comprising multiple **Generating Units.** | Like-for-like replacements do not immediately lead to EREC G99 compliance for the whole module, until 80% of the capacity of the PGM has been replaced.  The new **Inverter** does need to be compliant with the latest EREC G99. | × | This is a maintenance issue – the overall characteristics of the **PPM** are essentially unchanged – at least until 80% of the capacity of the PGM is replaced. |
| 3 | Existing EREC G59 PPM installation (eg solar PV or wind)– the **Generator** completes 80% (by capacity) of planned replacement programme of **Generating Units** (ie Inverter or turbine) of the same capacity at a **PPM** comprising multiple **Generating Units.** | On completion, the PPM must comply fully with the latest version of EREC G99 by the date agreed with the DNO. |  | The Generator has made a capital investment in the site and as the whole of the PPM has been replaced, it must now comply with the latest version of EREC G59. |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Scenario** | **DNO position** | **EREC G99?** | **Rationale** |
| 4 | Existing EREC G59 **PPM** site, the **Generator** adds an additional **PPM** after 27/4/19. | The new **PPM** to be compliant with EREC G99. |  | This is a new capital investment but cannot sensibly be integrated with the existing module (see figure 6.4 in EREC G99). |
| 5 | EREC G59 installation – the **Generator** fully replaces a **Type A** or **Type B PGM** with a **PGM** that has previously been installed elsewhere under EREC G59. No increase of the **PGM** **Registered Capacity** at the destination site. | Provided the relocated unit is **Type A** or **Type B** and comes from an EREC G59 compliant site, the destination site is also EREC G59 compliant, and there is no increase in **Registered Capacity** at the destination site, then compliance with EREC G59 only is required. | × | This is a modest investment compared to the costs of a new **PGM**. There is no net change to the electrical characteristics at the destination site. |
| 6 | EREC G59 installation – the **Generator** installs an additional **PGM** that has previously been installed under EREC G59 but interlocked as a switched alternative to the existing **PGM**(s). | A variant of scenario 6 if the additional unit was connected under EREC G59, has been relocated to use as a standby/spare (ie switched alternative) on the site, and is interlocked so it cannot run in parallel with the existing **PGM**(s) such that the effective **Registered Capacity** (and/or export capacity) of the site is unchanged compliance with EREC G59 only is required, | × | There is no effective change to the electrical characteristics of the site and no need to comply with EREC G99. |
| 7 | EREC G59 installation – the **Generator** fully replaces a **PGM** with a new **PGM** (ie scenarios 5 and 6 do not apply) | EREC G99 paragraph 20.6: The new **PGM** must be compliant with EREC G99.  Other EREC G59 units that are not being replaced do not need to be upgraded. |  | There is significant capital investment in replacing a **PGM** with a new **PGM**. |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Scenario** | **DNO position** | **EREC G99?** | **Rationale** |
| 8 | Existing EREC G59 installation – the **Generator** changes from infrequent short term parallel operation or switched alternative, to long term parallel operation. | Does not need to be upgraded to comply with EREC G99. Does need to comply with the full EREC G59 requirements. | × | The **PGM** is already connected and is not being modified (although protection upgrades might be needed). |
| 9 | Existing EREC G59 or G99 installation – the **Generator** moves the **Interface Protection** within the existing site. | The **Generator** does not need to upgrade the equipment to comply with the latest EREC G99.  However, if the relay and generation equipment is capable of accepting up-to-date EREC G99 protection settings, the **DNO** shall ask the **Generator** to upgrade the settings to the latest version of EREC G99.  The **DNO** would witness the moved **Interface Protection** if there have been any wiring or relay changes, and according to the witness thresholds in each license area. | × | This is just a maintenance issue – there is no change to generation characteristics etc. |
| 10 | Existing EREC G59 or G99 installation – the **Generator** replaces the **Interface Protection** but makes no change to **PGM**. | As 8 above.  The new Interface Protection should be G99 compliant. | × | As 8 above. |
| 11 | Existing EREC G59 or G99 installation – the **Generator** changes the fuel source (eg gas to bio-fuel, landfill gas to natural gas), with no change to main electrical equipment eg alternator or **Inverter**. | If no significant change to the electrical characteristics there is no need to upgrade to be compliant with the latest EREC G99, | × | The assumption is that the investment associated with the main plant to make this change is modest and that there is no significant effect on the relevant characteristics of the machine. |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Scenario** | **DNO position** | **EREC G99?** | **Rationale** |
| 12 | Existing EREC G59 or G99 installation – the **Generator** changes the prime mover (eg landfill gas site replaces landfill gas engine with a natural gas engine). | Assuming a new engine this is likely to be a significant Modification and the installation should comply with the latest version of EREC G99. Note – a replacement like for like engine would not require compliance with the latest version. |  | Significant capital investment in the main plant. The change to the prime mover is likely to have a significant effect on key electrical characteristics –eg stability and fault current contribution. |
| 13 | Existing EREC G59 or G99 installation – the **Generator** replaces / upgrades the control system (eg AVR, excitation system). | Replacement of components of a **PGM** with modern equivalent components would normally be considered to be maintenance work and therefore the **PGM** does not need to be upgraded to comply with the latest EREC G99, unless this, results in changes to the fundamental performance characteristics of generation.  However any reduction in the specific reactive capability specified in the **Connection Agreement** greater than 20%could trigger the need for full compliance with the latest EREC G99. Similarly the control system might influence other technical issues eg system stability which may trigger the need for compliance with EREC G99. | × | In the main these sorts of changes are not likely to have significant effect on the electrical characteristics of importance to network operators. |
| 14 | Existing **Synchronous PGM** EREC G59 or G99 installation – the **Generator** replaces the alternator with a new non-identical unit. | Complete replacement of the alternator – the **PGM** needs to be compliant with the latest EREC G99. |  | This is in effect a new **PGM**. |
| 15 | Existing **Synchronous PGM** EREC G59 or G99 installation –the **Generator** replaces the alternator with one of the same vintage and identical **Manufacturer**s type (eg a reclaimed or spare unit). | Provided the replacement alternator is identical, the **PGM** does not need to be upgraded to be compliant with the latest EREC G99. | × | This is a maintenance issue – there is no change to generation characteristics etc.  This covers the case of strategic spares – there is no change to electrical characteristics. |
| 16 | EREC G59 or G99 installation – the **Generator** replaces the transformer between the **PGM** terminals and the **Connection Point** with similar unit. | A like for like replacement has no effect on electrical characteristics. The **PGM** does not need to comply with the latest EREC G99. | × | This is a maintenance issue – there is no change to generation characteristics etc. |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Scenario** | **DNO position** | **EREC G99?** | **Rationale** |
| 17 | EREC G59 or G99 installation – the **Generator** replaces the transformer between the **PGM** terminals and the  **Connection Point** with one of significantly different impedance. | The replacement transformer will have an effect on fault level contribution and reactive  capability. Any reduction in the reactive capability specified in the **Connection**  **Agreement** >20%could trigger the need for full compliance with EREC G99 – but otherwise the **PGM** can remain as EREC G59. | × | This is a maintenance issue – there is no change to generation characteristics etc. |
| 18 | An existing EREC G99 installation where the **Intrinsic Design Capacity** has been restricted so that the **Registered Capacity** is below the **Intrinsic Design Capacity** for the purposes of meeting a restriction on maximum export capacity, and where maximum export capacity restriction is removed such that the **Registered Capacity** increases by 25%. | It will be necessary to demonstrate compliance with the EREC G99 requirements applicable when the **PGM** was commissioned based on the new **Registered Capacity**. Note that crossing a Type threshold will require to comply with the requirements applicable at that time to the higher Type. | × | There has been no new investment by the **Generator**; the relaxation of the maximum export capacity is occasioned by issues on the **DNO**’s network, ie outside of the **Generator**’s control. However compliance is still required with the version of EREC G99 in force when the **PGM** was commissioned. |
| 19 | An existing EREC G99 installation where the **PGM** is modified such that its **Registered Capacity** is increased by 10%, and which takes it over a type threshold (eg a 9.99MW **Type B** being increased to 10.9MW). | The **PGM** shall remain compliant with its original requirements. Not need to upgrade. | × | As the increase in **Registered Capacity** is less than the 20% threshold for being considered as significant **Modification** there is no need to comply with the requirements of the type above the existing type. |
| 20 | New **Connection Agreement** for a site where the Generating Units are compliant with either EREC G59 or EREC G99. | The **Generating Units** are not being replaced and do not need to be upgraded | × | The site is in the same ownership and the **Generating Unit**s are unchanged – there is no reason to consider retrospective applicability of EREC G99. |

## Requirements for Type Testing Power Generating Modules

This Annex describes methodologies for undertaking compliance verification for **Type A Power Generating Module**s. The Annex describes approaches which were originally intended for small **Power Park Module**s. **Manufacturer**s 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 A.2 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. **Electricity 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 **Manufacturer**s may choose to use these requirements for larger **Type A Synchronous Power Generating Module**s.

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 Unit**s that are not connected to the **Distribution Network** via an **Inverter** (ie induction **Generating Unit**s**)**.

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 **Inverter**s) 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.

### Power Park Module Requirements

#### **Certification & Type Testing Generating Unit Requirements**

A.7.1 can apply to **Power Park Module**s or to individual **Inverter**s 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 61869 (Instrument Transformers: Additional requirements for current 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 Form A2-3 (Annex A.2).

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** shall not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections shall 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 Module**s. 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 Module**s either with or without load management or **Electricity Storage** devices connected on the prime mover side of the **Power Park Module**.

#### **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:

1. 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
2. in the **Power Park Module** remaining connected to the **DNO**’s **Distribution Network** while **Distribution 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.

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).

##### 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.

##### Over / Under Voltage

The **Power Park Module** shall be tested by operating in parallel with a variable AC test supply, see Figure A.7.1. 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 the trip voltage, the test voltage should be applied in steps of ± 0.5% or less, of the voltage 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 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 over voltage 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 over voltage 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 shall 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 shall be shown that restart timer has not operated so it will 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:

The frequency required to trip is the setting ± 0.1 Hz

Measurement of operating time should be measured at a value of 0.3 Hz (suggestion – 2 x tolerance) above/below the setting to give “positive” operation

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.

**Power Park Module**

**Inverter**

Prime mover or Simulator

Variable AC Voltage Test Supply

**Figure A.7.1. Power Park Module test set up – over / under voltage**

##### 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.

**Power Park Module**

**Prime Mover** or Simulator

**Inverter**

Variable Frequency Test Supply

**Figure A.7.2 Power Park Module test set up – over / under frequency**

##### 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 Module**s 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.

##### 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 **Distribution Network**).

##### 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 0.95 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.

The results shall be recorded on the test sheet of Annex A.2-3.

#### **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.7.2.5.

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 as illustrated in figure A.7.3 and the **Active Power** reduction in the form of a gradient determined and assessed for compliance with paragraph 11.2.4.

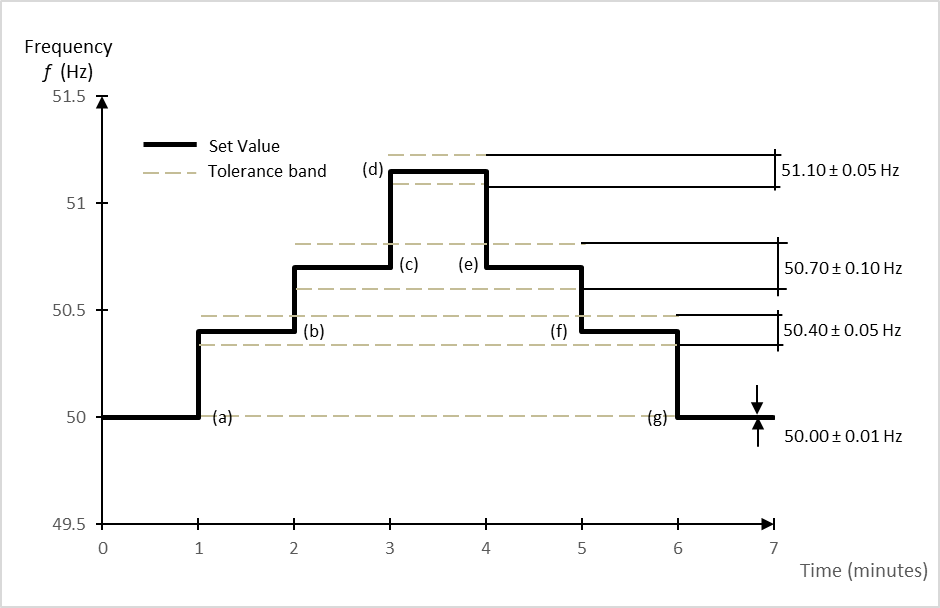


Figure A.7.3 Testing the **Active Power** feed-in of the **Power Generating Module**

at over frequency

The **Droop** should be determined from the measurements between 50.4 Hz and

51.15 Hz. The allowed tolerance for the frequency measurement shall be ±

0.05 Hz. The allowed tolerance for **Active Power** output measurement shall be

±10% of the required change in **Active Power**. The resulting overall tolerance range for a nominal 10% **Droop** is +2.8% and – 1.5%, ie a **Droop** less than 12.8% and greater than 8.5%.

#### **Power Quality**

##### 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**.

##### 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.7.4. 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[33](#_bookmark13) and 1.1 pu V.

—————————

1. For a **LV** connected **Power Generating Module** 1 pu V = 230 V

pf

Variac

**DNO’s**

**Distribution Network**

**Power Park Module**

**Prime Mover**

or Simulator

**Inverter**

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.7.4 Power Park Module test set up – Power Factor**

##### 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 in Form A2-3 (Annex A.2).

##### **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 9.4.6 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.

#### **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.

The following type tests shall be carried out and the results noted in Annex A.2-3.

B

C

D

**Inverter**

V

A

230 V

AC

50 Hz

DC supply to suit **Power Park Module** under test

**Figure A.7.5 Power Park Module short circuit test circuit**

**Test procedure**

In Figure A.7.5 ‘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).

#### **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.

#### **Power Park Modules which include Electricity Storage**

This paragraph provides a method for demonstrating compliance with the optional performance characteristic as discussed in the foreword. The tests shall be carried out to demonstrate how the **Power Park Module Active Power** when acting as a load (ie replenishing its energy store) responds to changes in system frequency.

In general, four tests are proposed, one set of two at **Rated Import Capacity**, and one set of two at 40% of **Rated Import Capacity**.

In both cases the test is to reduce frequency from 50 Hz at 2 Hzs-1. In the first case the lower frequency reached will be 49.0 Hz and the second case the lower frequency will be 48.8 Hz. The lower frequency should be held in each case for at least 60 s.

When returning the frequency to nominal, the ramp rate shall be of the order of 0.1 Hzs‑1.

In all cases the response shall meet the requirements of 11.2.3.3.

### Synchronous Power Generating Module Requirements (up to and including 50 kW)

* + - 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 A2-1. Other compliance requirements are detailed in Form A2-2 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 61869 (Instrument Transformers: Additional requirements for current 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 **Power Generating Module** 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 **Fully Type Tested Power Generating Module** the completed **Power Generating Module**’s **Interface Protection** shall not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections shall 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 Unit**s that are not connected to the **Distribution Network** via an **Inverter** as appropriate.

## 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:

1. 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
2. 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 **Power Generating Module** in which case it should be tested as part of the **Power Generating Module**. 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 **Power Generating Module**.

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**.

* + - * 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 **Power Generating Module**, 5 s disconnections should be initiated, and the average time recorded.

* + - * 1. Over / Under Voltage

The **Interface Protection** shall be tested by operating the **Power Generating Module** in parallel with a variable AC test supply, as an example see Figure A.7.6. 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 frequency of 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% or less of the voltage 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 starting at least 4 V below or above the setting. 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.2-1.

To establish the certified trip time, the test voltage should be applied starting from 4 V below or above the certified trip voltage and should be changed to 4 V above or below the certified trip voltage 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.

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.2-1.

For example, to test over voltage 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.



**Power Generating Module**

Variable AC Voltage Test Supply

**Controller**

**Generating Unit**

**Figure A.7.6 Power Generating Module test set up – over / under voltage**

* + - * 1. Over / Under Frequency

The **Interface Protection** shall be tested by operating the **Power Generating Module** in parallel with a low impedance, variable frequency test supply system, as an example, see Figure A.7.7. 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.

**Power Generating Module**

Variable Frequency Test Supply

**Controller**

**Generating Unit**

**Figure A.7.7 Power Generating Module test set up – over / under frequency**

* + - * 1. 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.7.8.



**DNO**’s

**Distribution Network**



**Power Generating Module**

Variable Resistance Load

Resonant Circuit Q >

0.5 at 50 Hz

**Controller**

**Generating Unit**

**Figure A.7.8 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. Note that if the suggested output level is below the **Power Generating Module**’s **Minimum Stable Operating Level** the test should be completed at 100%, and at least one output level below 100% of the **Registered Capacity**. It is recommended that an output level is chosen that is 5% of the difference between the **Registered Capacity** and the **Minimum Stable Operating Level** above the **Minimum Stable Operating Level**:

Output level = **Minimum Stable Operating Level** + (**Registered Capacity** –

**Minimum Stable Operating Level) x 5%**

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 shall comply with the requirements in Table 10.1.

Multi phase **Power Generating Module**s 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.

* + - * 1. 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 of 20 s before reconnection will be allowed.

* + - * 1. 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 0.95 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.

The results shall be recorded on the test sheet of Annex A.2-1.

## Power Output with Falling Frequency

* + - * 1. All **Synchronous Power Generating Module**s

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 A.7.7. 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 shall 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 shall 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 shall 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 shall not be below 95.0% of **Registered Capacity** and the **Synchronous Power Generating Module** shall not trip in less than the 20s of the test.

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

## Synchronous Power Generating Modules which include Electricity Storage

This paragraph provides a method for demonstrating compliance with the optional performance characteristic as discussed in the foreword. The tests shall be carried out to demonstrate how the **Synchronous Power Generating Module Active Power** when acting as a load (ie replenishing its energy store) responds to changes in system frequency.

In general four tests are proposed, one set of two at **Rated Import Capacity**, and one set of two at 40% of **Rated Import Capacity.**

In both cases the test is to reduce frequency from 50 Hz at 2 Hzs-1. In the first case the lower frequency reached will be 49.0 Hz and the second case the lower frequency will be 48.8 Hz.

In all cases the response shall meet the requirements of 11.2.3.3.

## Limited Frequency Sensitive Mode – Over (LFSM-O)

The tests described in this Annex A.7.2.4 are also suitable for **Type A Power Generating Module**s > 50 kW.

* + - * 1. This paragraph is applicable to all **Synchronous Power Generating Module**s other than slow acting micro hydro **Synchronous Power Generating Module**s which should refer to paragraph A.7.2.5.2.

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 Figures

A.7.9 and Figures A.7.10 are to be conducted at **Registered Capacity** (although a lower power output may be agreed with the **DNO** if site conditions preclude attaining **Registered Capacity**, such as an absence of adequate wind).

There should be sufficient time allowed between tests for control systems to reach steady state. 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 frequency input and the expected **Active Power** response are illustrated for different periods from 0 s to 130 s in Figure A.7.9 for a step change in frequency and in Figures A.7.10 for a ramp change in frequency. This should be in accordance with Section 11.2.4 (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. Note for diagram purposes only a short interval is shown between the frequency increase and decrease for each test. In practice the return step or ramp can start any time after the output has stabilized after the first step or ramp.

The response should commence within 2 s and shall be to the left of the red line (ie between the green line and the red line) and be as close to the green line as possible when following the frequency step or ramp. Note that the red line represents the 0.5% s-1 specified in 11.2.4.1.

52

51.5

**2 Hzs-1 Step 0-60 s**

**&**

**70 s - 130 s**

51

*Δf\**

50.5

50

-2 6 14 22 30 38 46 54 62 70 78 86 94 102 110 118 126

**Time/s**

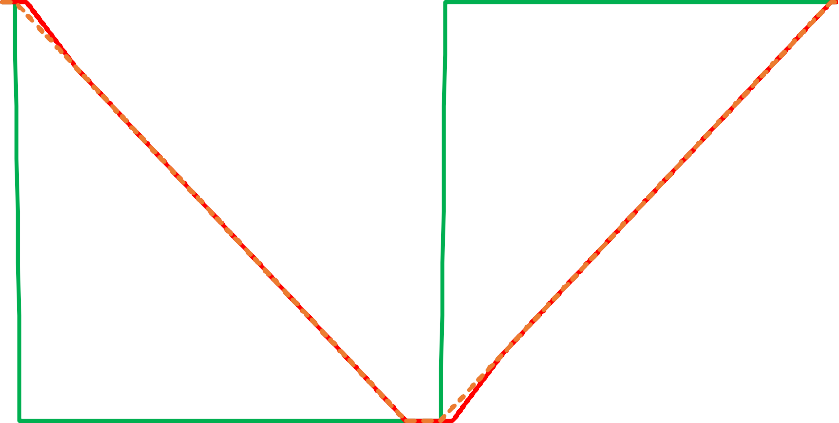
Frequency Injection

frequency

**Figure A.7.9(i): LFSM-O step response test – frequency injection**

Output

**Figure A.7.9(ii): LFSM-O step response test – target response and limits**



100%

95%

**2 Hzs-1 Step 0-130 s**

90%

85%

80%

75%

70%

65%

**Time/s**

Target Response

Limit +2s

Limit

101%

100%

99%

**2 Hzs-1 Step**

98%

97%

96%

95%

94%

93%

92%

-2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0

**Time/s**

Target Response

Limit +2s

Limit

Output

-2

2

6

10

14

18

22

26

30

34

38

42

46

50

54

58

62

66

70

74

78

82

86

90

94

98

102

106

110

114

118

122

126

130

134

**Figure A.7.9(iii): LFSM-O step response test – expansion of the allowed 2 s response delay (frequency increase)**

Output

**Figure A.7.9(iv): LFSM-O step response test – expansion of the allowed 2 s response delay (frequency decrease)**

74%

73%

**2 Hzs-1 Step**

72%

71%

70%

69%

68%

67%

69.0 70.0 71.0 72.0 73.0 74.0 75.0 76.0 77.0 78.0 79.0 80.0 81.0 82.0 83.0 84.0 85.0 86.0

**Time/s**

Target Response

Limit +2s

Limit

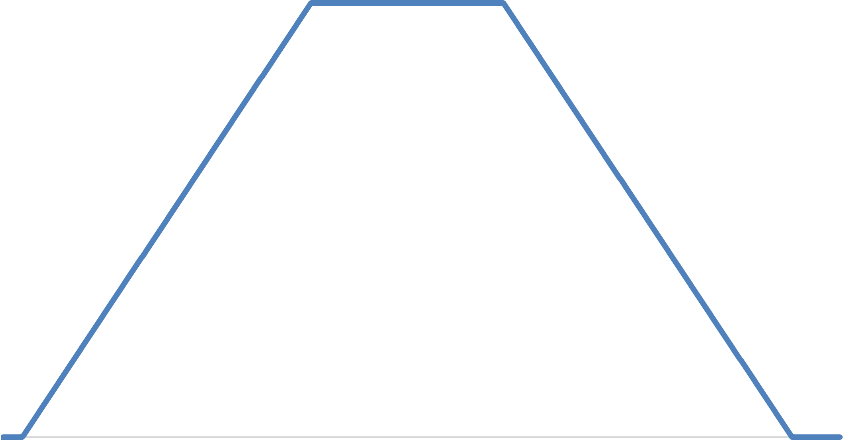
\* This frequency step *Δf* will generally be +2.0 Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum Regulating Level** in which case an appropriate injection should be calculated in accordance with the following:

For example 1.5 Hz is needed to take an initial output of 100% to a final output of 70%. If the initial output is not 100% and the **Minimum Regulating Level** is not 70% then the injected step should be adjusted accordingly as shown in the example given below:

|  |  |
| --- | --- |
| Initial output | 100% |
| **Minimum Regulating Level** | 70% |
| Frequency controller  **Droop** | 10% |
| Frequency to be injected | = (1.00 – 0.70) x 0.1 x 50 = 1.5Hz |

frequency

**Figure A.7.10(i): LFSM-O ramp response test – frequency injection**



50.7

50.6

50.5

**0.02Hzs-1 Ramp**

50.4

50.3

50.2

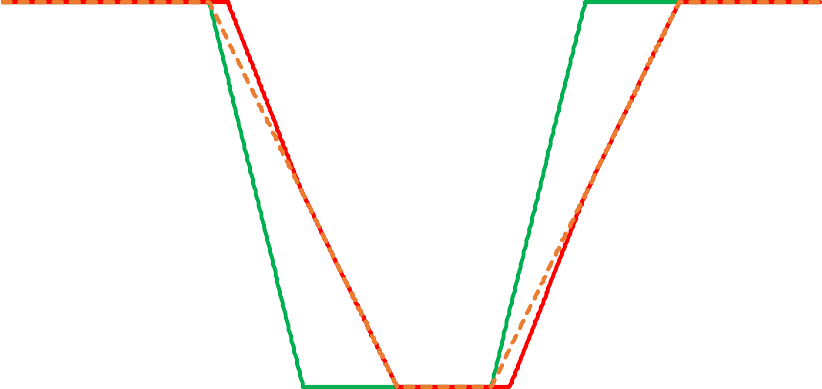
50.1

50

-2 2 6 10 14 18 22 26 30 34 38 42 46 50 54 58 62 66 70 74 78 82

**Time/s**

Frequency Injection



100.5%

100.0%

99.5%

**0.02Hzs-1 Ramp**

99.0%

98.5%

98.0%

97.5%

97.0%

96.5%

96.0%

95.5%

-2 2 6 10 14 18 22 26 30 34 38 42 46 50 54 58 62 66 70 74 78 82

**Time/s**

Target Response

Limit +2s

Limit

Output

**Figure A.7.10(ii): LFSM-O – target response and limits**

Output

**Figure A.7.10(iii): LFSM-O ramp response test – expansion (frequency increase)**

100.5%

100.0%

99.5%

**0.02 Hzs-1 Ramp**

99.0%

98.5%

98.0%

97.5%

97.0%

96.5%

96.0%

95.5%

20

24

28

**Time/s**

Target Response

Limit +2s

Limit

100.5%

100.0%

99.5%

**0.02 Hzs-1 Ramp**

99.0%

98.5%

98.0%

97.5%

97.0%

96.5%

96.0%

95.5%

50

54

58

**Time/s**

Target Response

Limit +2s

Limit

Output

**Figure A.7.10(iv): LFSM-O ramp response test – expansion (frequency decrease)**

* + - * 1. This paragraph is applicable to slow acting micro hydro **Synchronous Power Generating Module**s.

Recognising the significant engineering challenge of physically reducing the electrical energy exported from a slow acting micro hydro **Power Generating Module**, given the mechanical and hydraulic lags involved, the **Generator** may engineer an appropriate **LFSM-O** response by automatically switching in load banks to absorb the electrical energy, using frequency sensitive relays or control gear.

Output

Frequency

A single frequency response step test (ie no ramp test) is required in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate the **LFSM-O** capability in response to a frequency injection of 2.0 Hzs-1 for 1 s as shown by the Figures A.7.11 below. The test is to be conducted at **Registered Capacity** (although a lower power output may be agreed with the **DNO** if site conditions preclude attaining **Registered Capacity**, such as an absence of adequate water flow rate). Similarly if the frequency step takes the operating point below the **Minimum Stable Operating Level** an alternative appropriate injection should be calculated that demonstrates **LFSM-O** across the range that is available without breaching the **Minimum Stable Operating Level**.

There should be sufficient time allowed between the step up in frequency for control systems to reach steady state before the following step down in frequency. 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 frequency input and the expected **Active Power** response are illustrated below. This should be in accordance with Section 11.2.4. Undamped oscillations should not occur after the step frequency change.

For both the step up and step down parts of the test the response should commence within 2 s and shall always be to the left of the red line and be as close as possible to the green line representing 10% **Droop** (unless some other **Droop** is desired by the **Generator**). It is permissible to be to the left of the 2% **Droop** line when the first load bank is switched in (or the final one switched out, ie the first one to be switched out) but the output must be to the right of the 2% **Droop** line by the time the frequency has reached 52.0 Hz (or returned to 50.0 Hz).



**Figure A.7.11(i): LFSM-O step response test (frequency increase) for slow acting micro hydro**

Output

Frequency



0s

**Figure A.7.11(ii): LFSM-O step response test (frequency decrease) for slow acting micro hydro**

## Power Quality

* + - * 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 **Registered Capacity**. Note that if the suggested output level is below the **Power Generating Module**’s **Minimum Stable Operating Level** the test should be carried out at 100%, and at least one stable output level below 100%, of **Registered Capacity**. It is recommended that an output level is chosen that is 5% of the difference between the **Registered Capacity** and the **Minimum Stable Operating Level** above the **Minimum Stable Operating Level**:

Power level = **Minimum Stable Operating Level** + (**Registered Capacity** –

**Minimum Stable Operating Level)** x 5%

* + - * 1. **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.7.12. 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%.



**Power Generating Module**

Variac

**DNO**’s

**Distribution Network**

**Controller**

**Generating Unit**

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.7.12 Power Generating Module test set up – Power Facto**r

* + - * 1. **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.

### Additional Power Generating Module Technology Requirements

* + - 1. **Domestic CHP**

For Domestic CHP **Power Park Module**s 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 Module**s the type verification testing and **Interface Protection** requirements will be as per the requirements defined in Annex A.7.2.

## Photovoltaic

As all current Photovoltaic **Power Park Module**s 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.

## Fuel Cells

As all current Fuel Cell **Power Generating Module**s 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.

## Hydro

Hydro can be connected to the **DNO**’s **Distribution Network** directly using induction or **Synchronous Power Generating Module**s 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 Module**s 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 Pst or Plt.

**Power Park Module**s 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 Pst and Plt 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. Pst and Plt values to recorded and normalised as per the method laid down in Annex A.3.

## Wind

Wind turbines can be connected to the **DNO**’s **Distribution Network** directly, typically using asynchronous induction generators, or using **Inverter**s.

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.

## Electricity Storage Device

**Electricity Storage** devices can be connected to the **DNO**’s **Distribution Network**

directly or using **Inverter**s.

For those connected via **Inverter**s, 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.

## Requirements for Testing of Power Generation Module Sharing Systems

### This annex describes the general requirements for the tests necessary to be undertaken on a Power Generating Module sharing arrangement and/or its component parts, whether performed by the Manufacturer or by the Installer on site. These tests relate only to the Power Generating Module sharing arrangements; the Power Generating Module shall be subject to the relevant commissioning and other tests as described elsewhere in this EREC G99.

### Tests shall be undertaken to demonstrate that when the sharing device is energised by the Power Generating Module any fault on the sharing device or on the Customers’ Installations fed from it, are correctly identified and disconnected, whether by fuses or circuit breakers, or combination thereof.

### Tests shall be undertaken to detect any reverse Active Power flow (other than that permitted in sections 7.8.5.3 and 7.8.5.4) on any of the connections from the sharing device to the Customers’ Installations. The test shall be passed if the flow is interrupted and the appropriate alarm initiated.

### Tests shall be undertaken to demonstrate that should a Customer’s Installation become de-energized from the DNO’s Distribution Network the Power Generating Module is disconnected from that Customer’s Installation.

### When the sharing device is energised by the Power Generating Module, and some or all of the Customers’ Installations are not being supplied with Active Power, it shall be proved that the sharing device detects whether there is an out-of-phase condition present (ie phase shift of more than [90º]) between Power Generating Module and a Customer’s Installation and that it is not possible to then attempt to share Active Power to that Customer and that the appropriate alarm is initiated.

### Tests shall be undertaken to prove the failsafe nature of any communications employed by the sharing arrangement, and that the appropriate disconnection of that Customer’s Installation or overall shutdown of the Power Generating Module, as appropriate, and that triggering of an alarm occurs.

# Annex B – Type B

## Application

The application for connection of a **Type B Power Generating Module** should be made to the **DNO** using the Standard Application Form on the **DNO** or ENA website.

## Power Generating Module Document Type B

|  |  |
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| **Form B2-1 Power Generating Module Document for Type B Power Generating Modules Compliance Statement**  This document shall be completed by the **Generator**.  Note: For phased installations reference to **PGM** in this form should be read as reference to **Generating Unit**s and the project phase noted. | |
| **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): |

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| **Key to Submission Stage**  **A – Application:** Submission of the Standard Application Form.  **E – Energisation:** Documentation required prior to Energisation.  **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. The **Power Generating Module Document** shall be completed as agreed in accordance with paragraph 17.2.2 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 within 28 days of synchronising in accordance with paragraph 17.4.2 to obtain **Final Operational Notification** from the **DNO**. | |
| **Key to evidence requested** | **Key to Compliance** |
| S - Indicates that **DNO** would expect to see the results of a simulation study | Y = Yes (Compliant), |
| P - **Generating Unit** or **Power Generating Module** design data | O = Outstanding (outstanding submission) |
| MI - **Manufacturers’ Information**, generic data or test results as appropriate | UR= Unresolved issue |
| D - Copies of correspondence or other documents confirming that a requirement has been met | N = No (Non-Compliant) |
|  | E = Exempt |
| 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) |  |
| Note that where multiple types of evidence are indicated in the “compliance” column in the **Power Generating Module Document**, this indicates that the evidence could be provided in a number of different formats, as determined by the **Generator** and/or **Manufacturer**. |  |

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| Note that the second part of this form is split into two Parts: Part 1 is applicable to **Synchronous Power Generating Module**s and Part 2 is applicable to  **Power Park Module**s. | | | | | | | | | | | |
| Issue | Date of Issue | Compliance Declaration Signatory Name | Compliance Declaration Signature | | Issue Notes (completed by the  **Generator**) | | | **DNO** review date and comment | | | |
| Issue # | DD/M M/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 | | | **DNO** comments on evidence provided and any outstanding issues | | | |
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| Final Issue Prior to **FON** |  |  |  | |  | | |  | | | |
| **Details of Power Generating Module** | | | | | | | | | | | |
| Connection Voltage | |  | | **Registered Capacity** | |  | **Manufacturer** / Reference | | |  | |
| Energy source and energy conversion technology (enter codes from tables 1 and 2 see Form A1-2) | | | | | | | Source: | |  | Technology |  |



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| **Form B2-1 Part 1 - 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, E** | **Generator’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 |  |  |
| 14.3 | Site Responsibility Schedule | E | D |  |  |
| 9.4.2 | **Power Quality – Voltage fluctuations and Flicker**:  The installation shall be designed in accordance with EREC P28 | IS, FONS | MI, D, T, S |  |  |
| 9.4.3 | **Power Quality – Harmonics**:  The installation shall be designed in accordance with EREC G5 | IS, FONS | MI, D, T, S |  |  |
| 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 |  |  |

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| 12.2 | Confirm that the plant and apparatus is able to continue to operate in the frequency ranges specified in 12.2.1 and to withstand the rate of change of frequency specified 12.2.2 | IS | MI, TV |  |  |
| 12.2.4 | **Limited Frequency Sensitive Mode – Overfrequency**  Confirm the compliance with 12.2.4 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 |  |  |
| 9.1.7 | Confirm that the **Power Generating Module** has been designed to comply with cyber security requirements, as detailed in 9.1.7 | IS | MI, D |  |  |
| 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. Testing of **Fault Ride Through** is not required | IS | MI, TV, S |  |  |

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| Section10 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 |  |  |
| 12.2.4 | **Frequency Response Tests** Confirm the **Synchronous Power Generating Module** meets the requirements of 12.2.4 by testing in accordance with B.5.2 | FONS | T, MI, TV |  |  |
| 12.2.3 | **Output Power with falling frequency** Confirm the **Synchronous Power Generating Module** meets the requirements of 12.2.3 by testing in accordance with B.5.3 | FONS | T, MI, TV |  |  |

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| 10.3.3 | **Automatic reconnection**  Confirm by testing that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency in accordance with paragraph  10.3.3 and 10.3.4 | FONS | T, MI, TV |  |  |
| B3 | Installation and Commissioning Form B3 completed with signed acceptance from the **DNO** representative | FONS | D |  |  |

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| **Form B2-1 Part 2 - 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, E** | **Generator’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 |  |  |
| 14.3 | Site Responsibility Schedule | E | D |  |  |

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| 9.4.2 | **Power Quality – Voltage fluctuations and Flicker**:  The installation shall be designed in accordance with EREC P28. | IS, FONS | MI, D, T, S |  |  |
| 9.4.3 | **Power Quality – Harmonics**:  The installation shall be designed in accordance with EREC G5 | IS, FONS | MI, D, T, S |  |  |
| 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 |  |  |
| 12.2.4 | **Limited Frequency Sensitive Mode – Overfrequency**  Confirm the compliance with 12.2.4 by carrying out simulation study in accordance with B.4.5 and by submission of a report | IS | S, MI, TV |  |  |
| 12.2 | Confirm that the plant and apparatus is able to continue to operate in the frequency ranges specified in 12.2.1 and to withstand the rate of change of frequency specified in 12.2.2 | IS | MI, TV |  |  |

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| 12.1.3 | Confirm the **Active Power** set point can be adjusted in accordance with instructions issued by the **DNO** | IS | MI, TV |  |  |
| 9.1.7 | Confirm that the **Power Generating Module** has been designed to comply with cyber security requirements, as detailed in 9.1.7. | IS | MI, D |  |  |
| 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 accordance with B.4.4 and by submission of a report. Testing of **Fault Ride Through** is not required. | 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   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 | IS, FONS | MI, TV, T |  |  |

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|  | type test reports, site tests can be undertaken at the time of commissioning the **Power Generating Module** |  |  |  |  |
| 12.2.4 | **Frequency Response Test**  Confirm the **Power Park Module** meets the requirements of 12.2.4 by testing in accordance with B.6.2 | FONS | T, MI, TV |  |  |
| 10.3.3 | **Automatic reconnection**  Confirm by testing that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency in accordance with paragraph  10.3.3 and 10.3.4 | FONS | T, MI, TV |  |  |
| B3 | Installation and Commissioning Form B3 completed with signed acceptance from the **DNO** representative | FONS | D |  |  |

**Site Compliance and Commissioning test requirements for Type B Power Generating Modules**

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| **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**. | | |
| **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 |  |  |

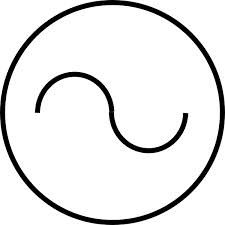
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| **Over and Under Voltage Protection HV**  Where the **Connection Point** is at **HV** the **Generator** shall demonstrate compliance with this EREC G99 in respect of Over and Under Voltage Protection by provision of **Manufacturers’ Information,** 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** | | | Low er Limi t | 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** | | | Low er Limi t | 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** | | | Low er Limi t | Measured Value | Upper Limit |  | Test Value | Lower Limit | Measured Value | Upper Limit | Result |
| **L1 - L2** | **88.0 V**  110 V VT  secondary | 2.5s | *86.3*  *5* |  | *89.65* | Pass/ Fail | Measured value minus 2 V |  |  | *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** | | | | | | | | | | | |

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| **Stability Tests** (confirm no trip of **Interface Protection**) | | | | | | | | | | | | | | | | |
| 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** | | **2.5 s** | | < 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 | |

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| **Stability Tests** (confirm no trip of **Interface Protection**) | | | | | | | | | | | |
| Test Description | | Setting | Time Delay | | Test Condition | | Test Frequency | Test Duration | | Confirm No Trip | Result |
| Inside Normal band | | **---------** | **---------** | | < OF | | 51.8 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 | | 47.2 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 |
| Over frequency test - Frequency shall be stepped from 51.8 Hz to the test frequency and held for the test duration and then stepped back to 51.8 Hz.  Under frequency 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 | | |
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| **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= +**0.10 Hzs-1** above setting | | | | |
| **Setting =**  **1.0 Hzs-1** | Lower Limit | Measured Value | Upper Limit | Result | Test Condition | Lower Limit | Measured Value | Upper Limit | Result |

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| Increasing Frequency | *0.975* |  | *1.025* | Pass/Fail | | 1.10 Hzs-1 | | *>0.5 s* | |  | | *<1.0 s* | Pass/Fail | |
| Reducing Frequency | *0.975* |  | *1.025* | Pass/Fail | | 1.10 Hzs-1 | | *>0.5 s* | |  | | *<1.0 s* | Pass/Fail | |
| Ramp in range 48.5-51.5 Hz | | | | | | | | | | | | | | |
| Increasing Frequency | *0.975* |  | *1.025* | Pass/Fail | | 3.00 Hzs-1 | | *>0.5 s* | |  | | *<1.0 s* | Pass/Fail | |
| Reducing Frequency | *0.975* |  | *1.025* | P  as s/ Fa il | | 3.00 Hzs-1 | | *>0.5 s* | |  | | *<1.0 s* | Pass/Fail | |
| **Stability Tests** (confirm no trip of **Interface Protection**) | | | | | | | | | | | | | | |
| Ramp in range 49.0-51.0 Hz | | | | | | | | | | | | | | |
|  | Test Condition | | Test frequency ramp | | | | Test Duration | | | Confirm No Trip | | | Result | |
| Inside Normal  band | < RoCoF setting  (increasing f) | | +0.95 Hzs-1 | | | | 2.1 s | | |  | | | Pass/Fail | |
| Inside Normal  band | < RoCoF setting (reducing f) | | -0.95 Hzs-1 | | | | 2.1 s | | |  | | | Pass/Fail | |
| Ramp as shown | | | | | | | | | | | | | | |
| Inside Normal  band | > RoCoF setting  (increasing f) | | +1.20 Hzs-1 (ramp between 49.80 and 50.34 Hz) | | | | 0.45 s | | |  | | | Pass/Fail | |
| Inside Normal band | > RoCoF setting  (reducing f) | | - -1.20 Hzs-1 (ramp between range 50.30 and 49.76 Hz | | | | 0.45 s | | |  | | | Pass/Fail | |
| Additional Comments / Observations: | | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | |
| **LoM Protection - Stability test** (confirm no trip of **Interface Protection**) | | | | | | | | | | | | | |  |
|  | | | Start Frequency | | Change | | | |  | | Confirm no trip | | |
| Positive Vector Shift | | | 49.5 Hz | | +50 degrees | | | |  | |  | | |
| Negative Vector Shift | | | 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 that a trip on the **Interface Protection** trips the appropriate circuit breaker.

L1 L2 L3

Interface Protection

Any other comments or notes:

## 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 Module**s being commissioned. Where the installation is phased the form should be completed on a **Generating Unit** basis as each part of the installation is completed in accordance with EREC G99 paragraph 15.3.3. For phased installations reference to **PGM** in this form should be read as reference to **Generating Unit**s. | |
| **Form B3 Part 1** | |
| To ABC electricity distribution **DNO**  99 West St, Imaginary Town, ZZ99 9AA [abced@wxyz.com](mailto: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 | Energy source and energy conversion technology (enter codes from tables 1 and 2 see Form A1-2) | | **Manufacturer**s Reference Number (system reference on ENA database) and or Equipment Certificate references as applicable | | | **Power Generating Module** | | |
| Src | Tech | **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**s 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 the **PGM**s being connected in parallel with the **DNO**’s **Distribution Network** (without synchronising) is in place and operates correctly. | | | | | | Yes / No\* | | | |
| **PGM** installation complies with cyber security requirements. | | | | | | Yes / No\* | | | |
| **Form B3 Part 2** | | | | | | | | | |
| **Power Generating Module** reference or name | | | | |  | | | | |
| **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 / N/A (**Type Tested**)\* | |
| The **PGM** successfully synchronises with the **DNO**’s **Distribution Network** without causing significant voltage disturbance. | | | | | | | | Yes / No\* | |

|  |  |  |
| --- | --- | --- |
| The **PGM** successfully runs in parallel with the **DNO**’s **Distribution Network**  without tripping and without causing significant voltage disturbances. | | Yes / No\* |
| The **PGM** successfully disconnects without causing a significant voltage disturbance, when it is shut down. | | Yes / No\* |
| **Interface Protection** operates and disconnects the **PGM** quickly (within 1s) when a suitably rated switch, located between the **PGM** and the **DNO**’s incoming connection, is opened. | | Yes / No\* |
| The **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** or **Generating Unit** forced trip or an alarm to a 24 hour manned control centre. | | Yes / No\* |
| \*Circle as appropriate. If “No” is selected the **Power Generating Facility** is deemed to have failed the commissioning tests and the **Power Generating Module** shall not be put in service. | | |
| Additional Comments / Observations: | | |
| **Declaration – to be completed by Generator or Generators Appointed Technical Representative** | | |
| I declare that for the **Type B Power Generating Module** within the scope of this EREC G99, and the installation:   1. The commissioning checks detailed in Form B2-2 have been successfully completed\*. 2. 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:   1. The commissioning checks detailed in Form B2-2 \*; 2. The commissioning checks detailed in this Form B3 and that the results are an accurate record of the checks.   \*delete if not applicable ie if the **Interface Protection** and ride through capabilities are **Type Tested** | | |
| Name: | | |
| Company Name | | |
| Signature: | Date: | |

## Simulation Studies for Type B Power Generating Modules

### Scope

* + - 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**.
      2. The **Generator** shall submit simulation studies in the form of a report to demonstrate compliance. In all cases the simulation studies shall 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 shall be presented over a sufficient time period to demonstrate compliance with all applicable requirements.
      3. Where the **Power Generating Module** will be connected to a substantial **Customer’s Installation** that will have an effect on the simulation modelling the **Generator** should include relevant equivalents to adequately represent the effect of the **Customer’s Installation** and its equipment. Note that most rotating plant will tend to make issues such as **Fault Ride Through** less onerous so modelling without including other equipment in the **Customer’s Installation** will generally be more conservative for compliance purposes. The **DNO** will agree with the **Generator** the extent to which substantial and complex **Customer’s Installation**s will need to be modelled.

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**.

### Reactive Capability across the Voltage Range

* + - 1. The **Generator** shall demonstrate the capability to meet Section 12.5 by submission of a report containing load flow simulation study results showing:[34](#_bookmark14)
         1. the maximum lagging **Reactive Power** capability when the **Connection Point**

voltage is at nominal (1 pu).

* + - * 1. the maximum leading **Reactive Power** capability when the **Connection Point**

voltage is at nominal (1 pu).

* + - 1. In the case of a **Power Park Module** where the load flow simulation studies show that the individual **Generating Unit**s deviate from nominal voltage to meet the

—————————

1. This report may include reference to the **Generator Performance Chart**.

**Reactive Power** requirements then evidence shall 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.

### Not used

### Fault Ride Through and Fast Fault Current Injection

* + - 1. This section applies to **Power Generating Module**s to demonstrate the modules

**Fault Ride Through** and **Fast Fault Current** injection capability.

* + - 1. The **Generator** shall supply time series simulation study results to demonstrate the capability of **Synchronous Power Generating Module**s and **Power Park Module**s to meet paragraphs 12.3 and paragraph 12.6 as applicable by submission of a report containing:
         1. a time series simulation study of a 140 ms 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**.
         2. a time series simulation study of 140 ms 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:

a phase to phase fault

a two phase to earth fault

a single phase to earth fault.

**Table B.4.1**

|  |  |
| --- | --- |
| **Power Generating Module** | Retained Voltage |
| **Synchronous Power Generating Module** | 30% |
| **Power Park Module** | 10% |

* + - 1. 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**. A minimum short circuit power of 50 MVA is a generic minimum fault level that should be assumed. For the few cases where the fault level is lower than this the **DNO** will advise the **Generator** the regarding the fault level assumptions to be used.
      2. The simulation study will show acceptable performance providing compliance with the requirements of paragraph 12.3.1.7 (e) are demonstrated.
      3. In the case of **Power Generating Module**s comprised of **Generating Unit**s 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:
         1. 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;
         2. 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**.

### Limited Frequency Sensitive Mode – Overfrequency (LFSM-O)

* + - 1. This section applies to **Power Generating Module**s to demonstrate the capability to modulate **Active Power** at high frequency as required by Section 12.2.4.
      2. Simulation studies shall be undertaken to demonstrate the governor or controller model response to increasing frequency.

The simulation study event shall be equivalent to:

* + - * 1. a sufficiently large increase in the measured system frequency ramped over 10 s to cause a decrease in **Active Power** output in accordance with the **Droop** setting followed by
        2. 60 s of steady state with the measured system frequency increased to the same level as in B.4.5.2 (i) as illustrated in Figure B.4.1 below
        3. then decrease of the measured system frequency ramped over 10 s to cause an increase in **Active Power** output back to the maximum **Active Power** level followed by at least 60 s of steady output.

Frequency (Hz)



∆F

10

60

10

60

Time (seconds)

**Figure B.4.1 – LFSM-O frequency step response simulation**

Figure B.4.2 – Not used

* + - 1. Simulation studies shall be performed for **Limited Frequency Sensitive Mode** (**LFSM**). The simulation study results should indicate **Active Power** and frequency. The **Active Power** reduction should occur between 50.4 Hz and 52 Hz in accordance with the **Droop** setting.

## Compliance Testing of Synchronous Power Generating Modules

### Scope

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

If:

the tests performed pursuant to B.5.1.2(iii) in respect of subsequent **Synchronous Power Generating Module**s do not replicate the full tests for the first **Synchronous Power Generating Module**, or

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.

* + - 1. 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. 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.
      2. Full **Synchronous Power Generating Module** testing is to be completed as defined in B.5.2 and B.5.3.
      3. The **DNO** may permit relaxation from the requirement B.5.2 and B.5.3 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.

frequency

### Governor and Load Controller Response Performance

* + - 1. The governor and load controller response performance will be tested by injecting simulated frequency deviations into the governor and load controller systems.
      2. The two frequency response tests in **Limited Frequency Sensitive Mode (LFSM)**

to demonstrate **LFSM-O** capability to a frequency injection as shown by Figures

B.5.1 and Figures B.5.2 are to be conducted at **Registered Capacity** (although a lower power output may be agreed with the **DNO** if site conditions preclude attaining **Registered Capacity**, such as an absence of adequate wind).

* + - 1. There should be sufficient time allowed between tests for control systems to reach steady state. 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.
      2. The frequency input and the expected **Active Power** response which are illustrated for different time periods from 0 s to 130 s in Figures B.5.1 for a step change in frequency and B.5.2 for a ramp change in frequency. These should be in accordance with Section 12.2.4 and undamped oscillations should not occur after the step or ramp frequency change. Note for diagram purposes only a short interval is shown between the frequency increase and decrease for each test. In practice the return step or ramp can start any time after the output has stabilised after the first step or ramp.
      3. The response should commence within 2 s and the response shall be to the left of the red line (ie between the green and red lines), and as close to the green line as possible when following the frequency step or ramp. Note that the red line represents the 0.5 s-1 specified in paragraph 12.2.4.

52

51.5

**2 Hzs-1 Step 0-60 s**

**&**

**70 s - 130 s**

51

*Δf\**

50.5

50

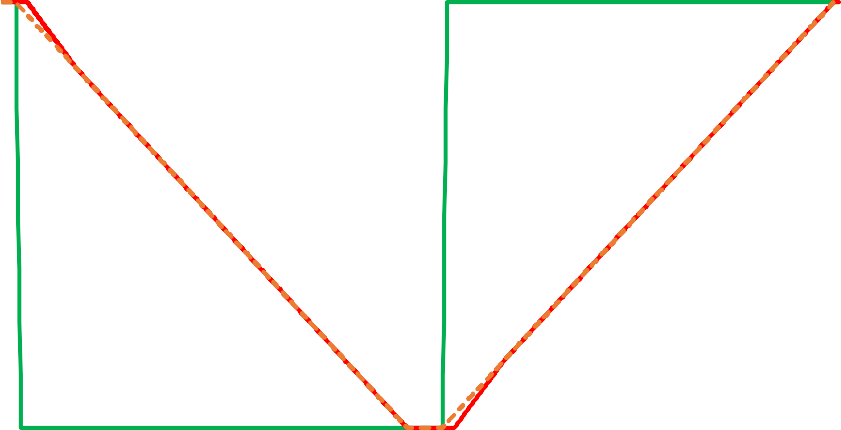
-2 6 14 22 30 38 46 54 62 70 78 86 94 102 110 118 126

**Time/s**

Frequency Injection

**Figure B.5.1(i): LFSM-O step response test – frequency injection**

Output



100%

95%

**2 Hzs-1 Step 0-130 s**

90%

85%

80%

75%

70%

65%

**Time/s**

Target Response

Limit +2s

Limit

**Figure B.5.1(ii): LFSM-O step response test – target response and limits**

101%

100%

99%

**2 Hzs-1 Step**

98%

97%

96%

95%

94%

93%

92%

-2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0

**Time/s**

Target Response

Limit +2s

Limit

Output

-2

2

6

10

14

18

22

26

30

34

38

42

46

50

54

58

62

66

70

74

78

82

86

90

94

98

102

106

110

114

118

122

126

130

134

**Figure B.5.1(iii): LFSM-O step response test – expansion of the allowed 2s delay (frequency increase)**

Output

**Figure B.5.1(vi): LFSM-O step response test – expansion of the allowed 2s delay (frequency decrease)**

74%

73%

72%

**2 Hzs-1 Step**

71%

70%

69%

68%

67%

69.0 70.0 71.0 72.0 73.0 74.0 75.0 76.0 77.0 78.0 79.0 80.0 81.0 82.0 83.0 84.0 85.0 86.0

**Time/s**

Target Response

Limit +2s

Limit

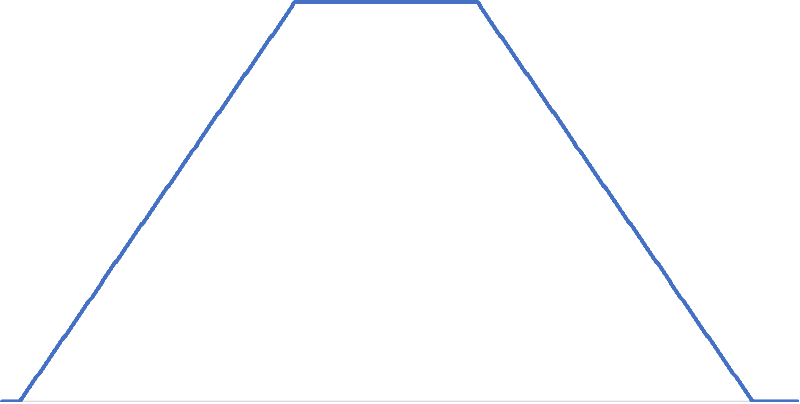
\* The frequency step *Δf* will generally be +2.0 Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum Regulating Level** in which case an appropriate injection should be calculated in accordance with the following:

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 Regulating Level** is not 70% then the injected step should be adjusted accordingly as shown in the example given below:

|  |  |
| --- | --- |
| Initial output | 100% |
| **Minimum Regulating Level** | 70% |
| Frequency controller  **Droop** | 10% |
| Frequency to be injected | = (1.00 – 0.70) x 0.1 x 50 = 1.5Hz |

frequency

**Figure B.5.2(i): LFSM-O ramp response test – frequency injection**



50.7

50.6

50.5

**0.02 Hzs-1 Ramp**

50.4

50.3

50.2

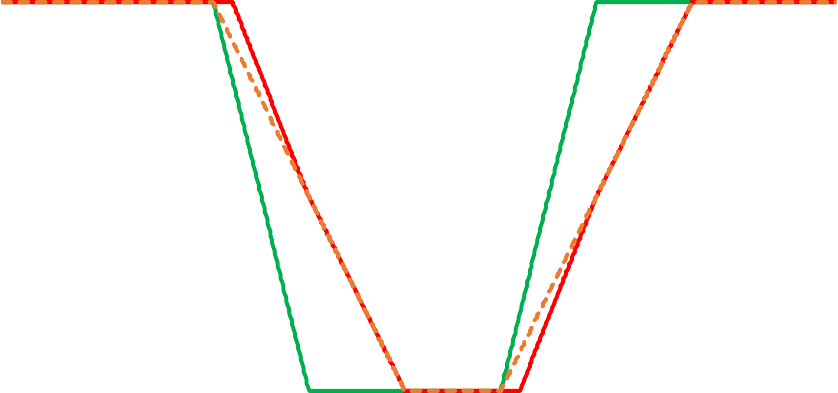
50.1

50

-2 2 6 10 14 18 22 26 30 34 38 42 46 50 54 58 62 66 70 74 78 82

**Time/s**

Frequency Injection



100.5%

100.0%

99.5%

**0.02 Hzs-1 Ramp**

99.0%

98.5%

98.0%

97.5%

97.0%

96.5%

96.0%

95.5%

-2 2 6 10 14 18 22 26 30 34 38 42 46 50 54 58 62 66 70 74 78 82

**Time/s**

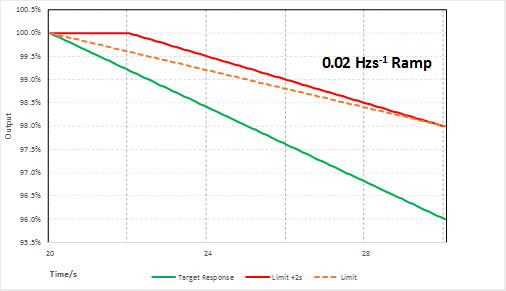
Target Response

Limit +2s

Limit

Output

**Figure B.5.2(ii): LFSM-O ramp response test – target response and limits**



**Figure B.5.2(iii): LFSM-O ramp response test – expansion (frequency increase)**

100.5%

100.0%

99.5%

**0.02 Hzs-1 Ramp**

99.0%

98.5%

98.0%

97.5%

97.0%

96.5%

96.0%

95.5%

50

54

58

**Time/s**

Target Response

Limit +2s

Limit

Output

**Figure B.5.2(iv): LFSM-O ramp response test – expansion (frequency decrease)**

### Compliance with Output Power with falling frequency Functionality Test

* + - 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.
      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 A7.7. 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**.
      3. The frequency should then be set to 49.5 Hz for 5 minutes. The output should remain at 100% of **Registered Capacity**.
      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 shall not be below 99% of **Registered Capacity**.
      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 shall not be below 97% of **Registered Capacity**.
      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 shall not be below 96.2% of **Registered Capacity**.
      7. The frequency should then be set to 47.1 Hz and held at this frequency for 20 s. The **Active Power** output shall not be below 95.0% of **Registered Capacity** and the **Synchronous Power Generating Module** shall not trip in less than the 20 s of the test.
      8. The **Generator** shall inform the **DNO** if any load limiter control is additionally employed.

### Synchronous Power Generating Modules incorporating Electricity Storage

* + - 1. This paragraph provides a method for demonstrating compliance with the optional performance characteristic as discussed in the foreword. The tests shall be carried out to demonstrate how the **Synchronous Power Generating Module Active Power** when acting as a load (ie replenishing its energy store) responds to changes in system frequency.
      2. In general four tests are proposed, one set of two at **Rated Import Capacity**, and one set of two at 40% of **Rated Import Capacity.**

In both cases the test is to reduce frequency from 50 Hz at 2 Hzs-1. In the first case the lower frequency reached will be 49.0 Hz and the second case the lower frequency will be 48.8 Hz. The lower frequency should be held in each case for at least 60 s.

When returning the frequency to nominal, the ramp rate shall be of the order of 0.1 Hzs‑1.

* + - 1. In all cases the response shall meet the requirements of 12.2.3.3.

## Compliance Testing of Power Park Modules

### Scope

* + - 1. This Annex outlines the general testing requirements for **Power Park** to demonstrate compliance with the relevant clauses of the EREC G99.
      2. The tests specified in this Annex will normally be sufficient to demonstrate compliance however the **DNO** may:
         1. agree an alternative set of tests provided the **DNO** deems the alternative set of tests sufficient to demonstrate compliance with this EREC G99 and the **Connection Agreement**; and/or
         2. require additional or alternative tests if information supplied to the **DNO** during the compliance process suggests that the tests in this Annex will not fully demonstrate compliance with the relevant section of this EREC G99 and the **Connection Agreement**; and/or
         3. 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
         4. agree a reduced set of tests for subsequent **Power Park Module**s 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 Module**s which the **DNO** reasonably considers to be identical.

If:

the tests performed pursuant to B.6.1.2(iii) do not replicate the results contained in the **Manufacturer’s Data & Performance Report** or

the tests performed pursuant to B.6.1.2(iv) in respect of subsequent **Power Park Module**s do not replicate the full tests for the first **Power Park Module**, or

any of the tests performed pursuant to B.6.1.2(iii) or B.6.1.2(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.

* + - 1. 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. For all on site **DNO** witnessed tests the **Generator** shall 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.
      2. 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:
* All relevant transformer tap numbers; and
* Number of **Generating Unit**s in operation.
  + - 1. 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.
      2. The **DNO** may permit relaxation from the requirement B.6.2 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.

### Frequency Response Tests

* + - 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 Unit**s 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**.
      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.
      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 Figures

B.6.1 and B.6.2 are to be conducted at **Registered Capacity** (although a lower power output may be agreed with the **DNO** if site conditions preclude attaining **Registered Capacity**, such as an absence of adequate wind).

* + - 1. There should be sufficient time allowed between tests for control systems to reach steady state (depending on available power resource). 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.
      2. The frequency input and the expected **Active Power** response which are illustrated for different time periods from 0 s to 130 s in Figures B.6.1 for a step change in frequency and B.6.2 for a ramp change in frequency. These should be in accordance with Section 12.2.4 and undamped oscillations should not occur after the step or ramp frequency change. Note for diagram purposes only a short interval is shown between the frequency increase and decrease for each test. In practice the return step or ramp can start any time after the output has stabilised after the first step or ramp.
      3. The response should commence within 2 s and the response shall be to the left of the red line (ie between the green and red lines), and as close to the green line as possible when following the frequency step or ramp. Note that the red line represents the 0.5% s-1 specified in paragraph 12.2.4.

frequency

**Figure B.6.1(i): LFSM-O step response test – frequency injection**

52

51.5

**2 Hzs-1 Step 0-60 s**

**&**

**70 s - 130 s**

51

*Δf\**

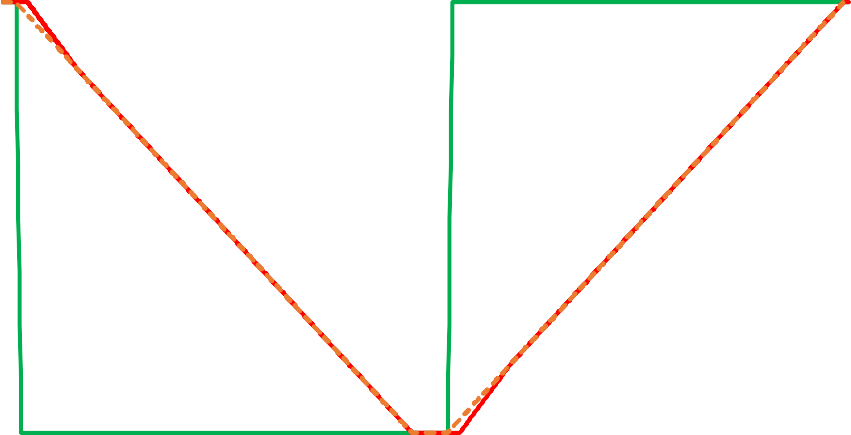
50.5

50

-2 6 14 22 30 38 46 54 62 70 78 86 94 102 110 118 126

**Time/s**

Frequency Injection



100%

95%

**2 Hzs-1 Step 0-130 s**

90%

85%

80%

75%

70%

65%

**Time/s**

Target Response

Limit +2s

Limit

Output

**Figure B.6.1(ii): LFSM-O step response test – target response and limits**

-2

2

6

10

14

18

22

26

30

34

38

42

46

50

54

58

62

66

70

74

78

82

86

90

94

98

102

106

110

114

118

122

126

130

134

Output

**Figure B.6.1(iii): LFSM-O step response test – expansion of the allowed 2s response delay (frequency increase)**

101%

100%

99%

**2 Hzs-1 Step**

98%

97%

96%

95%

94%

93%

92%

-2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0

**Time/s**

Target Response

Limit +2s

Limit

74%

73%

72%

**2 Hzs-1 Step**

71%

70%

69%

68%

67%

69.0 70.0 71.0 72.0 73.0 74.0 75.0 76.0 77.0 78.0 79.0 80.0 81.0 82.0 83.0 84.0 85.0 86.0

**Time/s**

Target Response

Limit +2s

Limit

Output

**Figure B.6.1(iv): LFSM-O step response test – expansion of the allowed 2s response delay (frequency decrease)**

\* The frequency step *Δf* 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 Regulating Level** in which case an appropriate injection should

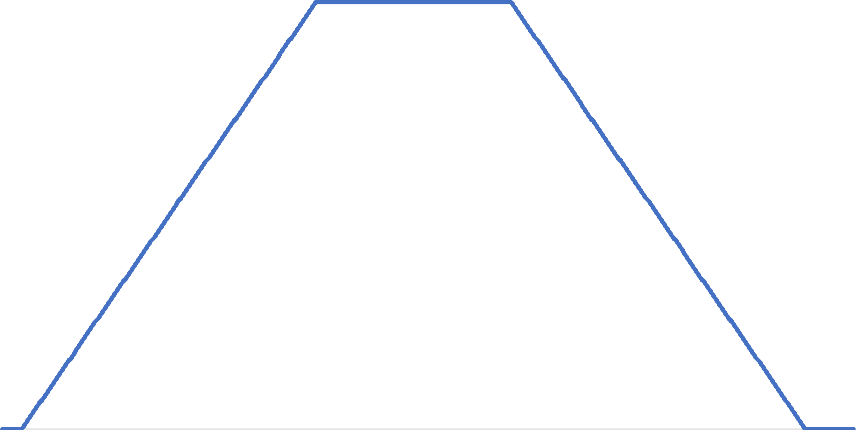
For example, 1.5 Hz is needed to take an initial output 100% to a final output of 70%. If the initial output is not 100% and the **Minimum Regulating Level** is not

70% then the injected step should be adjusted accordingly as shown in the example given below:

frequency

|  |  |
| --- | --- |
| Initial output | 100% |
| **Minimum Regulating Level** | 70% |
| Frequency controller  **Droop** | 10% |
| Frequency to be injected | = (1.00 – 0.70) x 0.1 x 50 = 1.5Hz |

**Figure B.6.2(i): LFSM-O BC2 ramp response test – frequency injection**



50.7

50.6

50.5

**0.02 Hzs-1 Ramp**

50.4

50.3

*Δf\**

50.2

50.1

50

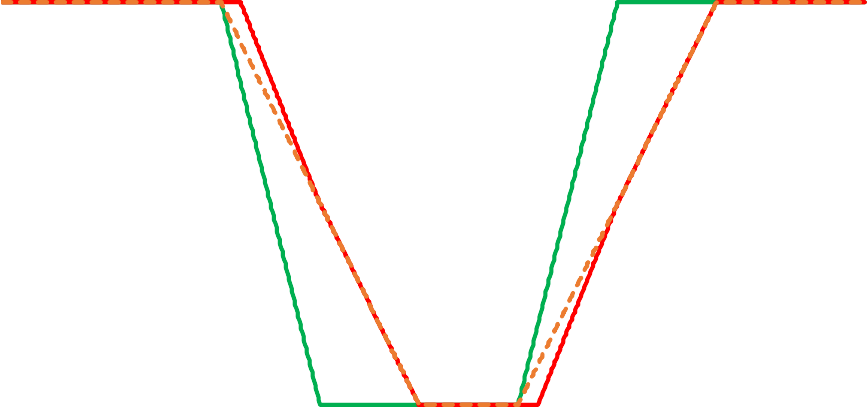
-2 2 6 10 14 18 22 26 30 34 38 42 46 50 54 58 62 66 70 74 78 82

**Time/s**

Frequency Injection

Output

**Figure B.6.2(ii): LFSM-O BC2 ramp response test – target response and limits**



100.5%

100.0%

99.5%

**0.02 Hzs-1 Ramp**

99.0%

98.5%

98.0%

97.5%

97.0%

96.5%

96.0%

95.5%

-2 2 6 10 14 18 22 26 30 34 38 42 46 50 54 58 62 66 70 74 78 82

**Time/s**

Target Response

Limit +2s

Limit

100.5%

100.0%

99.5%

**0.02 Hzs-1 Ramp**

99.0%

98.5%

98.0%

97.5%

97.0%

96.5%

96.0%

95.5%

20

24

28

**Time/s**

Target Response

Limit +2s

Limit

Output

**Figure B.6.2(iii): LFSM-O BC2 ramp response test – expansion (frequency increase)**

Output

**Figure B.6.2(iv): LFSM-O BC2 ramp response test – expansion (frequency decrease)**

100.5%

100.0%

99.5%

**0.02 Hzs-1 Ramp**

99.0%

98.5%

98.0%

97.5%

97.0%

96.5%

96.0%

95.5%

50

54

58

**Time/s**

Target Response

Limit +2s

Limit

### Power Park Modules incorporating Electricity Storage

* + - 1. This paragraph provides a method for demonstrating compliance with the optional performance characteristic as discussed in the foreword. The tests shall be carried out to demonstrate how the **Power Park Module Active Power** when acting as a load (ie replenishing its energy store) responds to changes in system frequency.
      2. In general four tests are proposed, one set of two at **Rated Import Capacity**, and one set of two at 40% of **Rated Import Capacity**.

In both cases the test is to reduce frequency from 50 Hz at 2 Hzs-1. In the first case the lower frequency reached will be 49.0 Hz and the second case the lower frequency will be 48.8 Hz. . The lower frequency should be held in each case for at least 60 s.

When returning the frequency to nominal, the ramp rate shall be of the order of 0.1 Hzs‑1.

* + - 1. In all cases the response shall meet the requirements of 12.2.3.3.

# Annex C – Type C and Type D

## Application

The application for connection of a **Type C or Type D Power Generating Module** should be made to the **DNO** using the Standard Application Form on the **DNO** or ENA website.

## 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**.  Note: For phased installations reference to **PGM** in this form should be read as reference to **Generating Unit**s and the project phase noted. | |
| **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. The **Power Generating Module Document** shall be completed as agreed in accordance with paragraph 18.2.2 at least 28 days before the **Generator** synchronising the **Power Generating Module** for the first time.  **E – Energisation:** Documentation required prior to Energisation.  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. The **Power Generating Module Document** shall be completed as agreed in accordance with paragraph 19.3.2 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 within 28 days of synchronising in accordance with paragraph 18.4.2 or 19.5.4 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, tests or monitoring which demonstrates compliance  TV - Indicates Type Test reports (if **Generator** pursues this compliance option) | **Key to Compliance**  Y = Yes (Compliant),  O = Outstanding (outstanding submission) UR= Unresolved issue  N = No (Non-Compliant) E = Exempt |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Note that where multiple types of evidence are indicated in the “compliance” column in the **Power Generating Module Document**, this indicates that the evidence could be provided in a number of different formats, as determined by the **Generator** and/or **Manufacturer**. | | | |  | | |
| Note that the second part of this form is split into two Parts: Part 1 is applicable to **Synchronous Power Generating Module**s and Part 2 is applicable to **Power Park Module**s. | | | | | | |
| Issue | Date of Issue | Compliance Declaration Signatory Name | Compliance Declaration Signature | | Issue Notes (completed by the  **Generator**) | **DNO** review date and comment |
| 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 | **DNO** comments on evidence provided and any outstanding issues |
|  |  |  |  | |  |  |
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|  |  |  |  | |  |  |
| Final Issue Prior to **FON** |  |  |  | |  |  |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Details of Power Generating Module** | | | | | | | |
| Connection Voltage |  | **Registered Capacity** |  | **Manufacturer** / Reference | |  | |
| Energy source and energy conversion technology (enter codes from tables 1 and 2 see Form A1-2) | | | | Source: |  | Technology |  |



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Form C2-1 Part 1 - 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, E** | **Generator’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 |  |  |
| 14.3 | Site Responsibility Schedule | E | D |  |  |
| 9.4.2 | **Power Quality – Voltage fluctuations and Flicker**: | IS, ION | MI, D, TV, S |  |  |

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|  | The installation shall be designed in accordance with EREC P28 |  |  |  |  |
| 9.4.3 | **Power Quality – Harmonics**:  The installation shall be designed in accordance with EREC G5 | IS, ION | MI, D, TV, S |  |  |
| 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 |  |  |
| 13.2 | Confirm that the plant and apparatus is capable of continue to operate in the frequency ranges specified in 13.2.1 and to withstand the rate of change of frequency specified in 13.2.2 | IS | MI, TV |  |  |
| 13.2.4 | **Limited Frequency Sensitive Mode – Over frequency and Frequency Sensitive Mode**  Confirm compliance with 13.2.4 by carrying out simulation study in accordance with C.7.6 and by submission of a report. | IS, ION | S, MI, TV |  |  |
| 13.2.5 | **Limited Frequency Sensitive Mode – Under frequency**  Confirm compliance with 13.2.5 by | IS. ION | S, MI, TV |  |  |

|  |  |  |  |  |  |
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|  | carrying out simulation study in accordance with C.7.7 and by submission of a report. |  |  |  |  |
| C.10 | Confirm compliance with minimum frequency response requirements in Annex C.10 by testing in accordance with C.10.4. | IS, ION | MI, TV, T |  |  |
| 13.1.3 | Confirm the **Active Power** set point can be adjusted in accordance with instructions issued by the **DNO** | IS, ION | MI, TV |  |  |
| 9.1.7 | Confirm that the **Power Generating Module** has been designed to comply with cyber security requirements, as detailed in 9.1.7 | IS, ION | MI, D |  |  |
| 13.3 | **Fault Ride Through**  Confirm 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 |  |  |

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| 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.4 | **Excitation System Open Circuit Step Response Tests**  Confirm the performance requirements of a continuously acting voltage control | FONS | T, MI, TV |  |  |

|  |  |  |  |  |  |
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|  | system compliant with C.4 by testing in accordance with C.8.2 |  |  |  |  |
| 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 |  |  |

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| 13.2.3 | **Output Power with falling frequency** Confirm the **Synchronous Power Generating Module** meets the requirements of 13.2.3 by testing in accordance with C.8.7 | FONS | T, MI, TV |  |  |
| 10.3.3 | **Automatic reconnection**  Confirm by testing that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency in accordance with paragraph  10.3.3 and 10.3.4 | FONS | T, MI, TV |  |  |
| 13.7.2 | Where rapid re-synchronisation is required, confirm capability to supply houseload operation, as per 13.7.2 | FONS | T, MI, TV |  |  |
| C.6 | Confirm that the dynamic system monitoring, fault recording and power quality monitoring equipment is provided, installed and functioning in accordance with Annex C.6 | IS, ION, FONS | MI, TV, T |  |  |
| C.3 | Installation and Commissioning Form C3 completed with signed acceptance from the **DNO** representative | ION, FONS | D |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Form C2-1 Part 2 - 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,** | **Generator’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 |  |  |
| 14.3 | Site Responsibility Schedule | E | D |  |  |
| 9.4.2 | **Power Quality – Voltage fluctuations and Flicker**:  The installation shall be designed in accordance with EREC P28 | IS, ION | MI, D, TV, S |  |  |
| 9.4.3 | **Power Quality – Harmonics**:  The installation shall be designed in accordance with EREC G5 | IS, ION | MI, D, TV, S |  |  |
| 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 |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 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 |  |  |
| 13.2 | Confirm that the plant and apparatus is capable of continuing to operate in the frequency ranges specified in 13.2.1 and to withstand the rate of change of frequency specified in 13.2.2 | IS | MI, TV |  |  |
| 13.2.4 | **Limited Frequency Sensitive Mode – Over frequency and Frequency Sensitive Mode**  Confirm the compliance with 13.2.4 by carrying out simulation study in accordance with C.7.6 and by submission of a report | IS, ION | S, MI, TV |  |  |
| 13.2.5 | **Limited Frequency Sensitive Mode – Under frequency**  Confirm the compliance with 13.2.5 by carrying out simulation study in accordance with C.7.7 and by submission of a report | IS, ION | S, MI, TV |  |  |
| C.10 | Confirm compliance with minimum frequency response requirements in | IS, ION, FONS | MI, TV, T |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Annex C.10 by testing in accordance with C.10.4. |  |  |  |  |
| 13.1.3 | Confirm the **Active Power** set point can be adjusted in accordance with instructions issued by the **DNO** | IS, ION | MI, TV |  |  |
| 9.1.7 | Confirm that the **Power Generating Module** has been designed to comply with cyber security requirements, as detailed in 9.1.7 | IS, ION | MI, D |  |  |
| 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 |  |  |
| 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.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.9.2 | ION, 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 | FONS | T, MI, TV |  |  |

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|  | the **Power Park Module** meet the requirements of Section 13.5 by testing in accordance with C.9.3 |  |  |  |  |
| 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 |  |  |
| 10.3.3 | **Automatic reconnection**  Confirm by testing that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency in accordance with paragraph  10.3.3 and 10.3.4 | FONS | T, MI, TV |  |  |
| 13.7.2 | Where rapid re-synchronisation is required, confirm capability to supply houseload operation, as per 13.7.2 | FONS | T, MI, TV |  |  |
| C.6 | Confirm that the dynamic system monitoring, fault recording and power quality monitoring equipment is provided, installed and functioning in accordance with Annex C.6 | IS, ION, FONS | MI, TV, T |  |  |
| C.3 | Installation and Commissioning Form C3 completed with signed acceptance from the **DNO** representative | ION, FONS | D |  |  |

## 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**. | | |
| **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 |  |  |

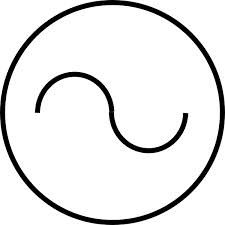
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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Over and Under Voltage Protection HV**  Where the **Connection Point** is at **HV** the **Generator** shall demonstrate compliance with this EREC G99 in respect of Over and Under Voltage Protection by provision of **Manufacturers Information,** 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** (confirm no trip of **Interface Protection**) | | | | | | | | | | | | | | | |
| 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** | | | **2.5 s** | | < 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** (confirm no trip of **Interface Protection**) | | | | | | | | | | | | | | | | | | | | |
| Test Description | | Setting | | Time Delay | | Test Condition | | | | Test Frequency | | | Test Duration | | | Confirm No Trip | | | Result | |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Inside Normal band | | **---------** | **---------** | | < OF | | 51.8 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 | | 47.2 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 |
| Over frequency test - Frequency shall be stepped from 51.8 Hz to the test frequency and held for the test duration and then stepped back to 51.8 Hz.  Under frequency 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 | | |
|  |  | | |  | |  | | |  | | |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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=  +**0.10 Hzs-1** above setting | | | | |
| **Setting = 1.0 Hzs-1** | Lower Limit | Measured Value | Upper Limit | Result | Test Condition | Lower Limit | Measured Value | Upper Limit | Result |
| Increasing Frequency | *0.975* |  | *1.025* | Pass/Fail | 1.10 Hzs-1 | *>0.5 s* |  | *<1.0 s* | Pass/Fail |
| Reducing Frequency | *0.975* |  | *1.025* | Pass/Fail | 1  1.10 Hzs-1 | *>0.5 s* |  | *<1.0 s* | Pass/Fail |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ramp in range 48.5-51.5 Hz | | | | | | | | | | | | | | |
| Increasing Frequency | *0.975* | |  | *1.025* | | Pass/Fail | | 3.00 Hzs-1 | | *>0.5 s* |  | | *<1.0 s* | Pass/Fail |
| Reducing Frequency | *0.975* | |  | *1.025* | | Pass/Fail | | 3.00 Hzs-1 | | *>0.5 s* |  | | *<1.0 s* | Pass/Fail |
| **Stability Tests** (confirm no trip of **Interface Protection**) | | | | | | | | | | | | | | |
| Ramp in range 49.0-51.0 Hz | | | | | | | | | | | | | | |
|  | Test Condition | | | Test frequency ramp | | | | | Test Duration | | Confirm No Trip | | | Result |
| Inside Normal band | > RoCoF setting  (increasing f) | | | +0.95 Hzs-1 | | | | | 2.1 s | |  | | | Pass/Fail |
| Inside Normal band | < RoCoF setting  (reducing f) | | | -0.95 Hzs-1 | | | | | 2.1 s | |  | | | Pass/Fail |
| Ramp as shown | | | | | | | | | | | | | | |
| Inside Normal band | > RoCoF setting  (increasing f) | | | +1.20 Hzs-1 (ramp  between 49.80 and  50.34 Hz) | | | | | 0.45 s | |  | | | Pass/Fail |
| Inside Normal band | > RoCoF setting  (reducing f) | | | - -1.20 Hzs-1(ramp  between 50.30 and  49.76 Hz | | | | | 0.45 s | |  | | | Pass/Fail |
| Additional Comments / Observations: | | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | |
| **LoM Protection - Stability test** (confirm no trip of **Interface Protection**) | | | | | | | | | | | | | | |
|  | | Start Frequency | | | Change | | | | |  | | Confirm no trip | | |
| Positive Vector Shift | | 49.5 Hz | | | +50 degrees | | | | |  | |  | | |
| Negative Vector Shift | | 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 appropriate circuit breaker.

L1 L2 L3

Interface Protection

Any other comments or notes:

## Installation and Commissioning Confirmation Form

|  |  |
| --- | --- |
| **Form C3 Installation and Commissioning Confirmation Form for Type C and Type D PGM**s  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 Module**s being commissioned. Where the installation is phased the form should be completed on a **Generating Unit** basis as each part of the installation is completed in accordance with EREC G99 paragraph 15.3.3. For phased installations reference to **PGM** in this form should be read as reference to **Generating Unit**s. | |
| **Form C3 Part 1** | |
| To ABC electricity distribution **DNO**  99 West St, Imaginary Town, ZZ99 9AA [abced@wxyz.com](mailto: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 | | Energy source and energy conversion technology (enter codes from tables 1 and 2 see Form A1-2) | | **Manufacturers** Reference Number (system reference on ENA database) and or Equipment Certificate references as applicable | **Power Generating Module** | | |
| Src | Tech | **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**s 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 the **PGM** being connected in parallel with the **DNO**’s **Distribution Network** (without synchronising) is in place and operates correctly. | | | | | | | Yes / No\* | |
| **PGM** installation complies with cyber security requirements | | | | | | | Yes / No\* | |

|  |  |  |
| --- | --- | --- |
| **Form C3 Part 2** | | |
| **Power Generating Module** reference or name |  | |
| **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 / N/A (**Type Tested**)\* |
| The Dynamic System Monitoring & Fault Recording equipment has been commissioned and the agreed setting applied. | | Yes / No |
| The Power Quality Monitoring equipment (where required) has been commissioned and the agreed setting applied. | | Yes / No / NA |
| The **PGM** successfully synchronises with the **DNO**’s **Distribution Network**  without causing significant voltage disturbance. | | Yes / No\* |
| The **PGM** successfully runs in parallel with the **DNO**’s **Distribution Network**  without tripping and without causing significant voltage disturbances. | | Yes / No\* |
| The **PGM** successfully disconnects without causing a significant voltage disturbance, when it is shut down. | | Yes / No\* |
| **Interface Protection** operates and disconnects the **PGM** quickly (within 1s) when a suitably rated switch, located between the **PGM** and the **DNO**’s incoming connection, is opened. | | Yes / No\* |
| The **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** or **Generating Unit** forced trip or an alarm to a 24 hour manned control centre. | | Yes / No\* |
| \*Circle as appropriate. If “No” is selected the **Power Generating Facility** is deemed to have failed the commissioning tests and the **Power Generating Module** shall not be put in service. | | |
| Additional Comments / Observations: | | |

|  |  |
| --- | --- |
| **Declaration – to be completed by Generator or Generators Appointed Technical Representative** | |
| I declare that for the **Type C or Type D**# **Power Generating Module** within the scope of this EREC G99, and the installation:   1. The commissioning checks detailed in Form C2-2 have been successfully completed\*. 2. 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:   1. The commissioning checks detailed in Form C2-2 \*; 2. The commissioning checks detailed in this Form C3 and that the results are an accurate record of the checks.   \*delete if not applicable ie if the **Interface Protection** and ride through capabilities are **Type Tested** | |
| Name: | |
| Company Name: | |
| Signature: | Date: |

## Performance Requirements For Continuously Acting Automatic Excitation Control Systems For Type C and Type D Synchronous Power Generating Modules

### Scope

* + - 1. This Annex sets out the performance requirements of continuously acting automatic excitation control systems for **Type C** and **Type D Synchronous Power Generating Module**s that shall 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.
      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**.
      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**.

### Requirements

* + - 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.

## Steady State Voltage Control

* + - * 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.

## Transient Voltage Control

* + - * 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.
        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. Typical rise times are given in Table C.4.1.

|  |  |
| --- | --- |
| Type of **Exciter** | Typical rise time |
| Static  **Excitation System** fed from machine terminals DC supply via power electronics | 50 ms |
| Rotating Brushless  **Excitation System** fed from separate DC machine fixed to rotor of main generator | 300 ms |

**Table C.4.1 Typical rise times for types of Exciter**

* + - * 1. 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.

Normal ceiling voltages are given in Table C.4.2

|  |  |
| --- | --- |
| Type of **Exciter** | Normal ceiling voltage |
| Static  **Excitation System** fed from machine terminals DC supply via power electronics | 2 pu |
| Rotating Brushless  **Excitation System** fed from separate DC machine fixed to rotor of main generator | 2 pu |
| * If short circuit level is low the ceiling voltage may need to be 3 pu – this can be determined by stability study to ensure 2pu excitation system is stable. * Significant improvements in stability occur between from 2 pu to 3 pu, The improvement is limited between 3 pu and 4 pu. * Increase insulation is required for higher pu excitation systems which has a cost implication | |

**Table C.4.2 Normal ceiling voltages**

* + - * 1. If a static type **Exciter** is employed:

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.4.2.4.2. The specified value will be 80% of the value specified in C.4.2.4.2. The **DNO** may specify a value outside the above limits where the **DNO** identifies a system need.

the **Exciter** shall 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.

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.

## Overall Excitation System Control Characteristics

* + - * 1. The overall **Excitation System** shall include elements that limit the bandwidth of the output signal. The bandwidth limiting shall 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.
        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.

## Under-excitation Limiters

* + - * 1. The security of the power system shall also be safeguarded by means of MVAr **Under-excitation Limiter**s 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.
        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.
        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.
      1. Over-Excitation and Stator Current Limiters
         1. The settings of the **Over-excitation Limiter** and stator current limiter, shall ensure that the **Synchronous Generating Unit**’s 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**’s 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**.
         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**.

* + - * 1. 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.

## Performance Requirements for Continuously Acting Automatic Voltage Control Systems for Type C and Type D Power Park Modules

## Scope

* + - 1. This Annex sets out the performance requirements of continuously acting Automatic Voltage Control systems for **Type C** and **Type D Power Park Module**s that shall 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.
      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**.

## Requirements

* + - 1. The **DNO** requires that the continuously acting Automatic Voltage Control system for the **Power Park Module** shall meet the following functional performance specification.

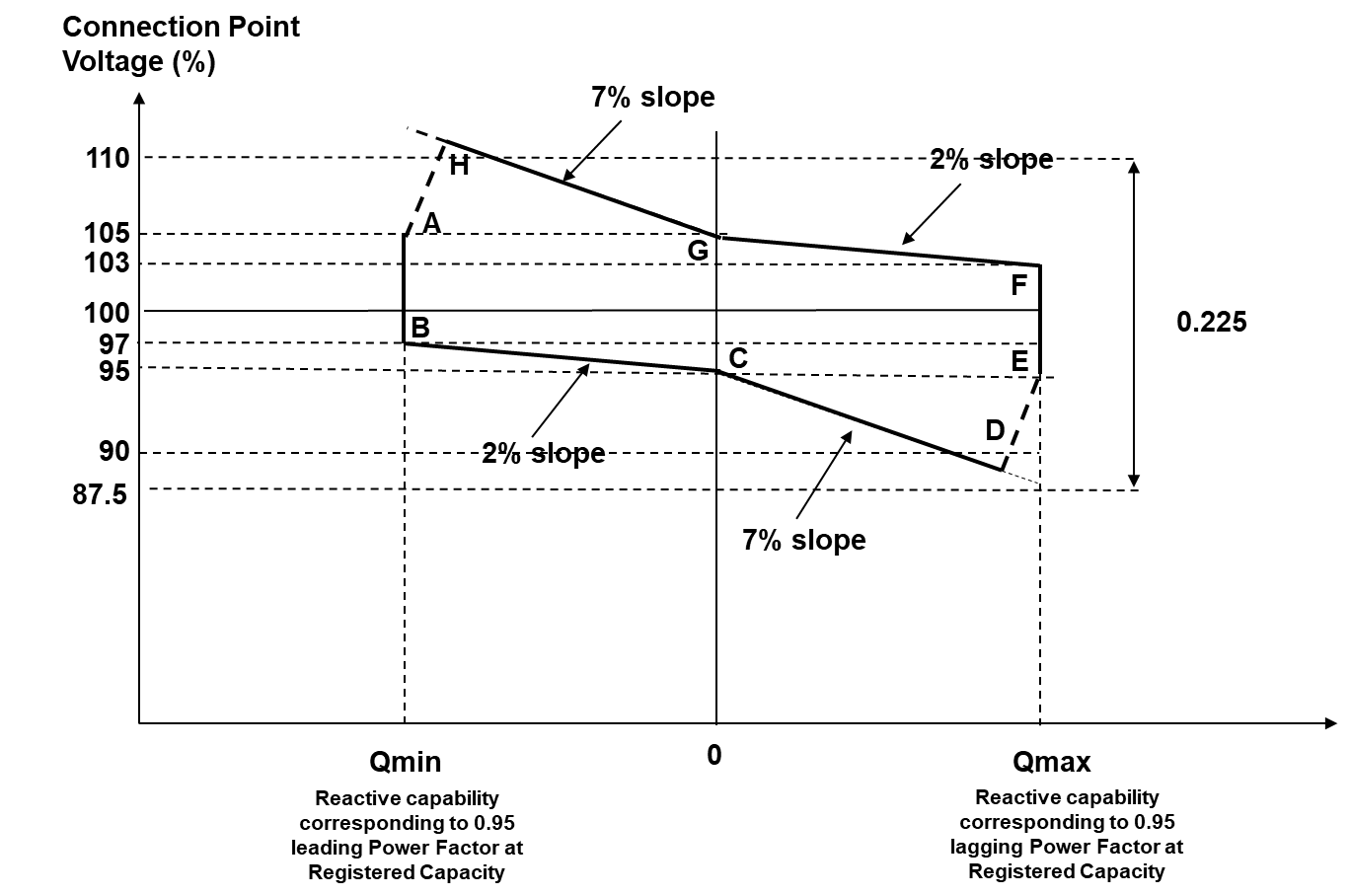
## Steady State Voltage Control

* + - 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.

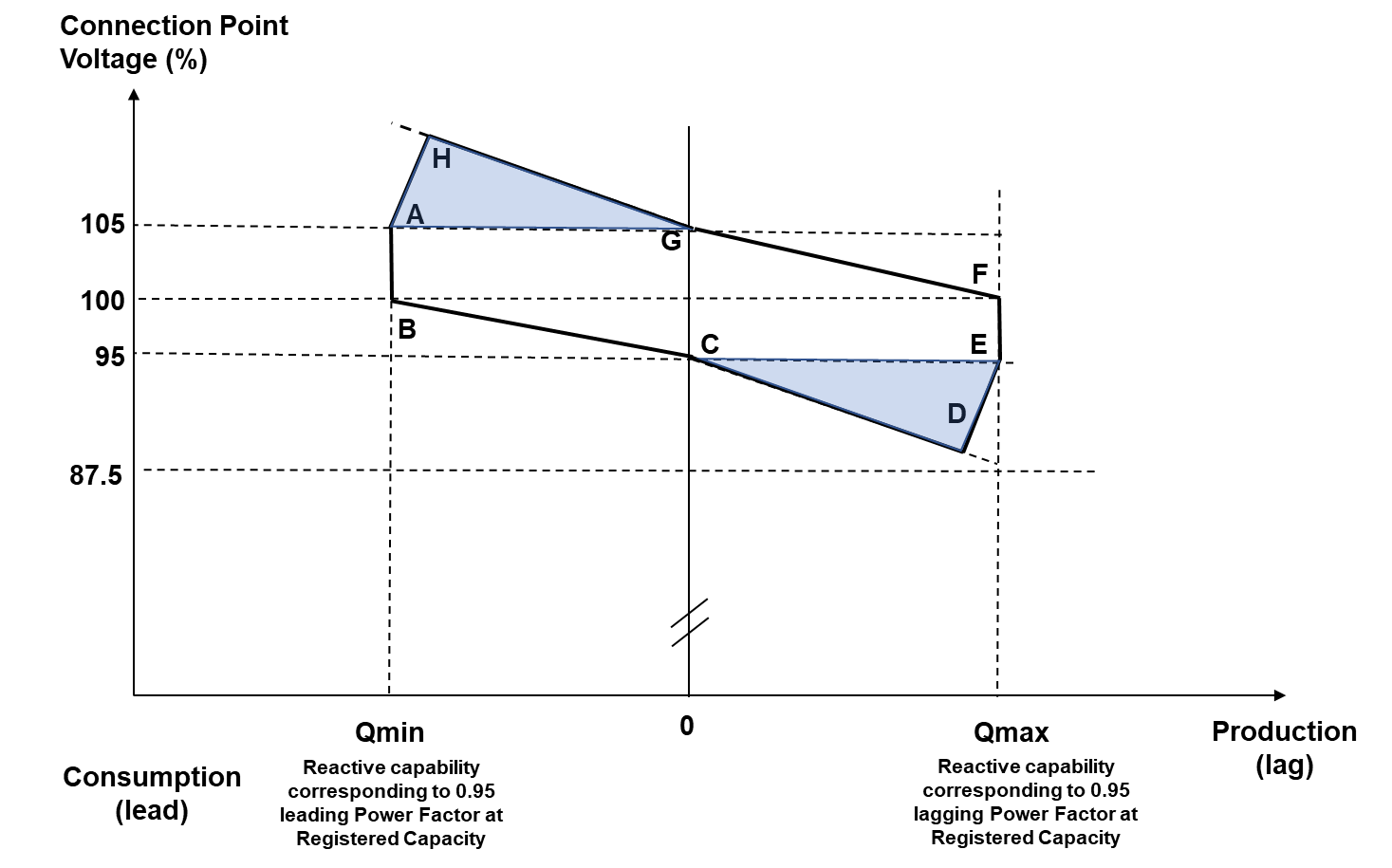


**Figure C.5.1 Setpoint Voltage and Slope Characteristic**

* + - 1. 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%.
      2. 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 connected above 33 kV**

****

**Figure C.5.3 Required envelope of operation for Power Park Modules connected at 33 kV and below** (note capability is not required in the blue shaded area)

* + - 1. Figure C.5.2 shows the required envelope of operation for **Power Park Module**s connected above 33 kV. The enclosed area within points ABCDEFGH is the required capability range within which the **Slope** and setpoint voltage can be changed. Figure C.5.3 shows the required envelope of operation for **Power Park Module**s connected at 33 kV and below. The enclosed area within points ABCEFG is the required capability range within which the **Slope** and setpoint voltage can be changed.
      2. 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.
      3. 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** shall 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.

* + - 1. 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.5.2 and

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.5.2 and 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.

## Transient Voltage Control

* + - 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:
         1. 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.
         2. 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.

* + - * 1. the magnitude of the **Reactive Power** output response produced within 1 s shall vary linearly in proportion to the magnitude of the step change.
        2. 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**.
        3. following the transient response, the conditions of C.5.3 apply.

MVAr

Required response at 1 s

0.2 1 s

**Figure C.5.4 Reactive Power Output Response**

* + - 1. **Power Park Modules** shall be capable of

1. 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
2. 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.

## Overall Voltage Control System Characteristics

* + - 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.
      2. The overall voltage control system shall include elements that limit the bandwidth of the output signal. The bandwidth limiting shall 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.
      3. The response of the **Power Park Module** voltage control system shall be demonstrated by testing in accordance with Annex C.9.

## Reactive Power Control

* + - 1. For **Power Generating Modules** that are required to comply with applicable parts of the **Grid Code**, **Grid Code** ECC.6.3.8.3.4 states that **Reactive Power** control mode of operation is not required in respect of **Power Park Module**s unless otherwise specified by the **DNO** (in coordination with the **NETSO**). However, where there is a requirement for **Reactive Power** control mode of operation, the following requirements shall apply.
      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**.
      3. Any additional requirements for **Reactive Power** control mode of operation shall be specified by the **DNO** in coordination with the **NETSO**.

## Power Factor Control

* + - 1. For **Power Generating Modules** that are required to comply with applicable parts of the **Grid Code**, **Grid Code** ECC.6.3.8.4.3 states that **Power Factor** control mode of operation is not required in respect of **Power Park Module**s unless otherwise specified by the **DNO** (in coordination with the **NETSO**). However, where there is a requirement for **Power Factor** control mode of operation, the following requirements shall apply.
      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**.

## Functional Specification for Dynamic System Monitoring, Fault Recording and Power Quality Monitoring Equipment for Type C and Type D Power Generating Modules

## Purpose and Scope

This Annex describes the functional requirements for dynamic system monitoring, fault recording and power quality monitoring that **Generator**s 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 , although other options are not discounted, installed at the **Connection Point**.

All **Power Generating Facilities** containing any **Type C** or **Type D Power Generating Module**s are within the scope of this Annex. The exact requirements, particularly if there is a need for power quality monitoring, will be agreed bilaterally and recorded in the **Connection Agreement**.

## Functional Requirements

## Inputs and Outputs

The recording device shall have analogue inputs:

1. Three phase voltage
2. Open delta/neutral-earth voltage
3. Three phase current
4. Neutral current.

The recording device 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 **Generator’s Installation** as agreed with the **DNO**.

The recording device shall have digital outputs:

1. recording device healthy
2. recording device triggered.

## Measured and Derived Quantities

At each agreed relevant point on the **Generator’s Installation** dynamic system monitoring, fault recording and power quality monitoring shall be provided.

## Dynamic System Monitoring

Measured and derived quantities for dynamic system monitoring shall comprise:

3 phase voltage quantities, including positive and negative phase sequence values.

3 phase current quantities, including positive and negative phase sequence values.

**Active Power** and **Reactive Power** flows

Frequency.

## Fault Recording

Measured and derived quantities for fault recording shall comprise:

3 phase voltage quantities, including positive, negative and zero sequence values

3 phase current quantities, including positive, negative and zero sequence values

1. Protection, control and plant status.

## Power Quality Monitoring

Measured and derived quantities for power quality recording shall comprise:

Frequency

Voltage magnitude

Short-term flicker

Long-term flicker

Voltage dips, swells and interruptions

Voltage unbalance

Voltage THD and harmonics

Voltage inter-harmonics

Rapid voltage change

Voltage change

Current magnitude

Current THD and harmonics

Current inter-harmonics

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 those as specified in EREC G5, BS EN 50160 and BS EN 61000-4-7.

## 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 measured input | Resolution  ±% of nominal | Comment |
| RMS voltage | 0 – 1.5 Vn | 0.1 | 0.01 | Crest factor ≤1.5 |
| Voltage phase sequence components | 0.8 Vn – 1.5 Vn | 0.1 | 0.01 | Crest factor ≤1.5 |
| Current phase sequence components | 0.1 – 5.0 In | 0.5 | 0.01 | Crest factor ≤3.0 |
| **Active Power** | 0.1 – 5 Pn | 0.5 | 0.01 | For all **Power Factor**s between 0.5 and  1.0 |
| **Reactive Power** | 0.1 – 5 RPn | 1.0 | 0.01 | For all **Power Factor**s between 0.00  and 0.984 |
| Frequency | 42.5 Hz –57.5 Hz | 0.005 | 0.001 | 20%<Vn<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.

## Instrument Transformers

Note that the specification of instrument transformers is based on optimising the dynamic system monitor accuracy over the fault recording and power quality accuracy.

Analogue inputs to the recording device shall be derived from instruments with a frequency response appropriate to the application (eg error <5% up to 5 kHz if power quality monitoring is required).

The three phase voltage analogue inputs shall be derived from a voltage transformer arrangement comprising three single phase voltage transformers connected in primary star with the centre point earthed or, where a three single phase voltage transformer arrangement is not possible, a three phase 5 limb voltage transformer. The voltage transformers shall comply with the requirements as specified in Table C.6.2 and C.6.3:

**Table C.6.2 Minimum Accuracy Class Requirements for Voltage Transformers**

|  |  |  |
| --- | --- | --- |
|  | **Minimum Accuracy Class for Dynamic System Monitoring, Fault Recording and Power Quality Monitoring Equipment** | |
| **Applicable Elexon Code of Practice** | Star connected windings | Open delta windings |
| 1 (metering of circuits with a rated capacity exceeding 100 MVA) | 0.2/3P dual class | 3P |
| 2 (metering of circuits with a rated capacity between 10 MVA and 100 MVA) | 0.5/3P dual class | 3P |

**Table C.6.3 Minimum Voltage Factor Requirement for Voltage Transformers**

|  |  |  |
| --- | --- | --- |
|  | Rated Voltage | |
| ≤72 kV | 145 kV |
| Voltage Factor | 1.9 | 1.5 |

The three phase current analogue inputs shall be derived from a current transformer arrangement comprising three single phase current transformers. The current transformers shall comply with the requirements appropriate to the appropriate Elexon Code of Practice but amended as shown in Table C.6.4: The difference is that the C.6.4 requirements are Class 0.2 compared to the more stringent Class 0.2S required by the Elexon Code of Practice.

**Table C.6.4 Minimum Accuracy Class Requirements for Current Transformers**

|  |  |
| --- | --- |
| **Applicable Elexon Code of Practice** | **Minimum Accuracy Class for Dynamic System Monitoring, Fault Recording and Power Quality Monitoring Equipment** |
| 1 (metering of circuits with a rated capacity exceeding 100 MVA) | 0.2/5P10 dual class |
| 2 (metering of circuits with a rated capacity between 10 MVA and 100 MVA) | 0.2/5P10 dual class |

## Overall Accuracy

Generally the overall accuracy from the measuring chain of monitoring equipment and instrument transformers as specified above will be sufficient. However, where the **DNO** can demonstrate a need for a higher overall accuracy to be required from the overall measuring chain the **DNO** will specify the required overall accuracy in the **Connection Agreement**.

## Time Keeping

Inputs and all the derived data from inputs shall be time tagged to a resolution of 1 μs. The recording device internal clock shall be synchronised with Universal Time (UTC) via GPS satellite or other functionally similar method. It is permissible to compensate for specific communication delays between the monitoring equipment and a time server (or similar device) in local area network implementations etc. It should also be possible to set a local time offset.

## Triggering

## Dynamic System Event Triggering

The dynamic system monitor shall have configurable dynamic system event triggers as follows:

Frequency (half-cycle)

Voltage (half cycle RMS and waveform)

Current (half-cycle RMS and waveform)

Positive sequence voltage (half cycle RMS)

Negative sequence voltage (half cycle RMS)

**Active Power** (half-cycle RMS)

**Reactive Power** (half-cycle RMS)

**Active Power** oscillation

**Power Factor** (half-cycle)

Digital inputs.

Dynamic system event half-cycle triggering shall be as detailed in Table C.6.5 below as a minimum requirement.

**Table C.6.5 Dynamic system event half-cycle triggering**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **Over (+)/ Under (-) Deviation (%)** | **Step (%)** | **Phase step (o)** | **Rate of Change** |
| Frequency | * (+/-) | * (+/-)\* |  | * (+/-) |
| Voltage | * (+/-) | * (+/-) | * (+/-) | * (+/-) |
| Current | * (+/-) | * (+/-)\* |  |  |
| Positive sequence voltage | * (+/-) |  |  | * (+/-) |
| Negative sequence voltage | * (+) |  |  |  |
| **Active Power** | * (+/-) |  |  | * (+/-) |
| **Reactive Power** | * (+) | * (+/-) |  |  |
| **Power Factor** | * (+/-) |  |  |  |
| Digital inputs | rising edge/falling edge | | | |

\*note that frequency and current step changes are not mandatory requirements

Dynamic system event waveform triggering shall be as detailed in Table C.6.6 below as a minimum requirement.

**Table C.6.6 Dynamic system event waveform triggering**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **Over (+)/**  **Under (-) Deviation (%)** | **Step (%)** | **Phase step (o)** | **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.

**Active Power** oscillation recording shall be triggered by any oscillation of 2% or more in **Active Power** at a frequency up to 5 Hz measured over 1.2 s.

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’.

**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.

**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. Alternatively capturing each 20 ms cycle in a fixed repeating period (eg 1 minute) would satisfy this requirement.

**Fault Event Triggering**

The fault recorder shall have configurable fault event triggers as follows:

Voltage (half cycle RMS and waveform)

Current (half-cycle RMS and waveform)

Digital inputs.

Fault recorder half-cycle triggering shall be as be as detailed in Table C.6.7 below as a minimum requirement.

**Table C.6.7 Fault recorder half-cycle triggering**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **Over (+)/ Under (-) Deviation (%)** | **Step (%)** | **Phase step (o)** | **Rate of Change** |
| Voltage | * (+/-) | * (+/-) | * (+/-) | * (+/-) |
| Current | * (+/-) | * (+/-) |  |  |
| Negative sequence voltage | * (+) |  |  |  |
| Zero sequence voltage | * (+) |  |  |  |
| Negative sequence current | * (+) |  |  |  |
| Zero sequence current | * (+) |  |  |  |
| Digital inputs | rising edge/falling edge | | | |

Fault recorder waveform triggering shall be as detailed in Table C.6.8 below as a minimum requirement.

**Table C.6.8 Fault recorder waveform triggering**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Over (+)/**  **Under (-) Deviation (%)** | **Step (%)** | **Phase step (o)** |
| Voltage waveform | * (+/-) | * (+/-) |  |
| Current waveform | * (+/-) | * (+/-) |  |
| Negative sequence voltage | * (+) |  |  |
| Zero sequence voltage | * (+) |  |  |
| Negative sequence current | * (+) |  |  |
| Zero sequence current | * (+) |  |  |
| Digital inputs | rising edge/falling edge | | |

**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.

**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. Alternatively capturing each 20 ms cycle in a fixed repeating period (eg 1 minute) would satisfy this requirement.

## Power Quality Event Triggering

The power quality monitor shall have configurable power quality event triggers as follows:

Frequency (10 s)

Voltage magnitude (10 minute)

Short-term flicker (10 minute)

Long-term flicker (2 hour)

Voltage dip

Voltage swell

Voltage interruption

Voltage unbalance (10 minute)

Voltage THD and harmonics (10 minute)

Voltage inter-harmonics (10 minute)

Rapid voltage change

Voltage change.

Power quality event triggering shall be as detailed in Table C.6.9 below as a minimum.

**Table C.6.9 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 | * (+/-) |

Triggering on voltage notching (as described in EREC G5) is not required for compliance with this Annex C.6 of EREC G99.

## Analysis and Reporting

## Dynamic System Records

Analysis software shall be provided to enable selection and plotting of each of the following dynamic system parameters against time:

Frequency (half-cycle min, max and mean)

Voltage (half cycle RMS min, max and mean)

Current (half-cycle RMS min, max and mean)

Positive sequence voltage (half cycle RMS)

Negative sequence voltage (half cycle RMS min, max and mean)

**Active Power** (half-cycle RMS min, max and mean)

**Reactive Power** (half-cycle RMS min, max and mean)

**Power Factor** (half-cycle).

The facility to graphically zoom in and out shall be provided. Provision shall be made for display of:

1. Dynamic system triggered event summary information in tabular form
2. Dynamic system triggered event detail graphically
3. Dynamic system triggered event occurrence versus time.

## Fault Records

Provision shall be made for display of:

Fault recorder triggered event summary information in tabular form

Fault recorder triggered event detail graphically

Fault recorder triggered event occurrence versus time.

## Power Quality Records

Analysis software shall be provided to enable selection and plotting of each of the following power quality parameters against time:

Frequency (10 s min, max and mean)

Voltage magnitude (10 minute min, max and mean)

Short-term flicker (10 minute)

Long-term flicker (2 hour)

Voltage unbalance (10 minute)

Voltage THD and harmonics (10 minute)

Voltage inter-harmonics (10 minute).

The facility to graphically zoom in and out shall be provided. Provision shall be made for display of:

1. Power quality triggered event summary information in tabular form
2. Voltage dips, swells and interruptions in residual voltage versus time graphical form and in the tabular form specified in BS EN 50160
3. Power quality triggered events graphically
4. Fault recorder triggered event occurrence versus time.

## 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.

Where data is shared via connected or common data systems, the **Generator** shall ensure that these arrangements comply with their own and the **DNO’**s cyber security requirements. Compliance may require physically separate data communication systems and/or additional firewalls.

## Environmental

The recording device 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.

## Additional Requirements

The following requirements specified in IEC 62586-1 shall apply:

1. Start-up requirements
2. Marking and operating instructions
3. Functional, environmental and safety type tests
4. EMC tests
5. Climatic tests
6. Mechanical tests
7. Functional and uncertainty tests
8. Routine tests
9. Declarations
10. Re-calibration and re-verification.

## Relevant Standards

The following standards are likely to be relevant. The **Generator** will quote all the standards the recording device 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 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

## Calibration and Testing

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

Correct operation of the recording device will normally be demonstrated to the

**DNO** when the facility is commissioned.

## Simulation Studies for Type C and Type D Power Generating Modules

## Scope

* + - 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 this EREC G99 and the **Connection Agreement**.
      2. The **Generator** shall submit simulation studies in the form of a report to demonstrate compliance. In all cases the simulation studies shall 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 shall be presented over a sufficient time period to demonstrate compliance with all applicable requirements.
      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**.
      4. For **Type C** and **Type D Power Generating Module**s the relevant **Manufacturers’ Information** shall be supplied in the **Power Generating Module Document** or DDRC as applicable.

## Power System Stabiliser Tuning

* + - 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.
      2. In the case of **Power Park Module**s 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.

## Reactive Capability across the Voltage Range

* + - 1. For **Synchronous Power Generating Modules** the **Generator** shall demonstrate the capability to meet Section 13.5 by submission of a report containing load flow simulation study results showing:[35](#_bookmark15)

—————————

1. This report may include reference to the **Generator Performance Chart**.
   1. the maximum lagging **Reactive Power** capability when the **Connection Point**

voltage is at 105% of nominal.

* 1. the maximum leading **Reactive Power** capability when the **Connection Point**

voltage is at 95% of nominal.

* 1. the maximum lagging **Reactive Power** capability at the **Minimum Stable Operating Level** when the **Connection Point** voltage is at 105% of nominal.

(vi) the maximum leading **Reactive Power** capability at **the Minimum Stable Operating Level** when the **Connection Point** voltage is at 95% of nominal.

The terminal voltage in the simulation should be the nominal voltage for the machine.

* + - 1. For **Power Park Modules** with a **Connection Point** voltage above 33 kV the **Generator** shall demonstrate the capability to meet paragraph 13.5.4 by submission of a report containing load flow simulation studies to demonstrate operation at points A, B, E and F in accordance with Figure C.5.2. The studies shall be undertaken with the **Power Park Module** operating at **Registered Capacity** and **Minimum Stable Operating Level**.
      2. For **Power Park Modules** with a **Connection Point** voltage at or below 33 kV the **Generator** shall demonstrate the capability to meet paragraph 13.5.5 by submission of a report containing load flow simulation studies to demonstrate operation at points A, B, E and F in accordance with Figure C.5.3. The studies shall be undertaken with the **Power Park Module** operating at **Registered Capacity** and **Minimum Stable Operating Level**.
      3. In the case of a **Power Park Module** where the load flow simulation studies show that the individual **Generating Unit**s deviate from nominal voltage to meet the **Reactive Power** requirements then evidence shall 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.

## Voltage Control and Reactive Power Stability

* + - 1. This section applies to **Power Park Module**s to demonstrate the voltage control capability.
      2. In the case of a **Power Generating Facility** containing **Power Park Module**s the **Generator** shall provide a report to demonstrate the dynamic capability and control stability of the **Power Park Module**s. The report shall contain:
         1. 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**.
         2. 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**.
         3. 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.
         4. 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.
      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**.
      4. The **DNO** may permit relaxation from the requirements of C.7.4.2(i) and (ii) for voltage control if the **Power Park Module**s are comprised of **Generating Unit**s 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.
      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**.

## Fault Ride Through and Fast Fault Current Injection

* + - 1. This section applies to **Power Generating Module**s to demonstrate the modules

**Fault Ride Through** capability.

* + - 1. The **Generator** shall supply time series simulation study results to demonstrate the capability of **Synchronous Power Generating Module**s and **Power Park Module**s to meet paragraph 13.3 and paragraph 13.6 by submission of a report containing:
         1. 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**.
         2. a time series simulation study of 140 ms 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:

a phase to phase fault

a two phase to earth fault

a single phase to earth fault.

**Table C.7.1**

|  |  |
| --- | --- |
| **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% |

* + - 1. 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**. A minimum short circuit power of 50 MVA is a generic minimum fault level that should be assumed. For the few cases where the fault level is lower than this the **DNO** will advise the **Generator** regarding the fault level assumptions to be used.
      2. The simulation study will show acceptable performance providing compliance with the requirements of paragraph 13.3.1.11 (e) are demonstrated.
      3. In the case of **Power Generating Module**s comprised of **Generating Units** in respect of which the **Generator’s** reference to **Manufacturers’ Information** has been accepted by the **DNO** (or by the **NETSO** as **Grid Code** compliant and confirmed by the **NETSO** to the **DNO**) for **Fault Ride Through**, C.7.5.2 will not apply provided:
         1. 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;
         2. 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**.

## Limited Frequency Sensitive Mode – Overfrequency (LFSM-O)

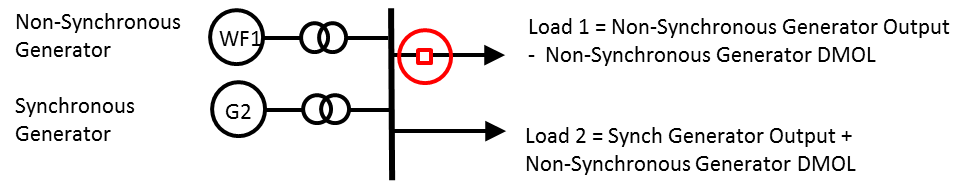
* + - 1. Paragraphs C.7.6.2 to C.7.6.6 apply to **Power Generating Modules** which have the capability to run in island mode where required under section 9.6.4, to demonstrate the capability to modulate **Active Power** at high frequency as required by paragraph 9.6.4.3 and Section 13.2.4. Where the **Generator** will not operate the **Power Generating Module** in island mode for the purposes of section 9.6.4, simulation studies as required by Section B.4.5 may be undertaken to demonstrate the capability to modulate **Active Power** at high frequency as required by Section 13.2.4.
      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 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**.

* + - 1. For **Power Park Module**s 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.
      2. 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**

* + - 1. Simulation studies shall be performed for **Type C** and **Type D Power Generating Module**s in **Limited Frequency Sensitive Mode** (**LFSM**) and for **Type C** and **Type D Power Generating Module**s in **Frequency Sensitive Mode** (**FSM**). The simulation study results should indicate **Active Power** and frequency.
      2. To allow validation of the model used to simulate load rejection in accordance with paragraph 13.2.4, a further simulation study is required that shows simulation results for the largest positive frequency injection step or fast ramp (BC1 and BC3 of Figure C.8.1 and or Figure C.9.3) that will be applied during compliance tests as described in C.8.6 and C.9.5.

## Limited Frequency Sensitive Mode – Underfrequency (LFSM-U)

* + - 1. This section applies to **Synchronous Power Generating Module**s and **Power Park Module**s to demonstrate the module’s capability to modulate **Active Power** at low frequency.
      2. To demonstrate the **LFSM-U** low frequency control when operating in **Limited Frequency Sensitive Mode** the **Generator** shall submit a simulation study representing the response of the **Power Generating Module** operating at 80% of **Registered Capacity**. The simulation study event shall be equivalent to:
         1. a sufficiently large reduction in the measured system frequency ramped over 10 s to cause an increase in **Active Power** output to the **Registered Capacity** followed by
         2. 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.
         3. 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 LFSM-U step response simulation**

## Voltage and Frequency Controller Model Verification and Validation

* + - 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.
      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:
         1. a ramped reduction in the measured system frequency of 0.5Hz in 10 s followed by
         2. 20 s of steady state with the measured system frequency depressed by 0.5Hz followed by
         3. a ramped increase in measured system frequency of 0.3Hz over 30 s followed by
         4. 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 Controller simulation**

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

* + - 1. To demonstrate the **Excitation System** model the **Generator** shall submit simulation studies representing the response of the **Synchronous Power Generating Module** as follows:
         1. operating open circuit at rated terminal voltage and subjected to a 10% step increase in terminal voltage reference from 90% to 100%.
         2. 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.

* + - 1. 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.
      2. 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.
      3. For **Synchronous Power Generating Module**s 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.

## Compliance Testing of Type C and Type D Synchronous Power Generating Modules

## Scope

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

If:

the tests performed pursuant to C.8.1.2(iii) in respect of subsequent **Synchronous Power Generating Module**s do not replicate the full tests for the first **Synchronous Power Generating Module**, or

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.

* + - 1. 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.
      2. Full **Synchronous** Power Generating M**odule** testing is to be completed as defined in C.8.2 through to C.8.7.
      3. 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** shall be supplied in the **Power Generating Module Document** or the **DDRC** as applicable.

## Excitation System Open Circuit Step Response Tests

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

Vt - Synchronous **Generating Unit** terminal voltage

Efd - Synchronous **Generating Unit** field voltage or main **Exciter** field voltage Ifd- Synchronous **Generating Unit** field current (where possible)

Step injection signal

* + - 1. Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

## Open & Short Circuit Saturation Characteristics

* + - 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**.
      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**.
      3. Results shall be legible, identifiable by labelling, and shall have appropriate scaling.

## Excitation System On-Load Tests

* + - 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.
      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.

## Under-excitation Limiter Performance Test

* + - * 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.
        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.

* + - * 1. 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.
        2. The **Under-excitation Limiter** will normally be tested at low **Active Power** output (**Minimum Stable Operating Level**) and at maximum **Active Power** output (**Registered Capacity**).
        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 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 |  |

## Over-excitation Limiter Performance Test

* + - 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.

* + - 1. 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.
      2. The following typical procedure is provided to assist **Generator**s 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 until **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). |  |

## Reactive Capability

* + - 1. The **Reactive Power** capability on each **Synchronous Power Generating Module**

will normally be demonstrated by:

* + - * 1. operation of the **Synchronous Power Generating Module** at maximum lagging **Reactive Power** and **Registered Capacity** for 1 hour.
        2. operation of the **Synchronous Power Generating Module** at maximum leading **Reactive Power** and **Registered Capacity** for 1 hour.
        3. operation of the **Synchronous Power Generating Module** at maximum lagging **Reactive Power** and **Minimum Stable Operating Level** for 1 hour.
        4. operation of the **Synchronous Power Generating Module** at maximum leading **Reactive Power** and **Minimum Stable Operating Level** for 1 hour.
        5. operation of the **Synchronous Power Generating Module** at maximum lagging **Reactive Power** and a power output between **Registered Capacity** and **Minimum Stable Operating Level**.
        6. operation of the **Synchronous Power Generating Module** at maximum leading **Reactive Power** and a power output between **Registered Capacity** and **Minimum Stable Operating Level**.
      1. 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.
      2. 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**.
      3. 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.

## Governor and Load Controller Response Performance

* + - 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 shall be injected simultaneously at both speed governor and load controller setpoints. For **CCGT Module**s, simultaneous injection into all gas turbines, steam turbine governors and module controllers is required.
      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.

## 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 Stable Operating Level**) | MG |
| Module Load Point 1  (**Minimum Regulating Level**) | **MRL** |

* + - 1. The tests are divided into the following two types;
         1. 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.
         2. System islanding and step response tests if required by the **DNO**.
      2. 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.

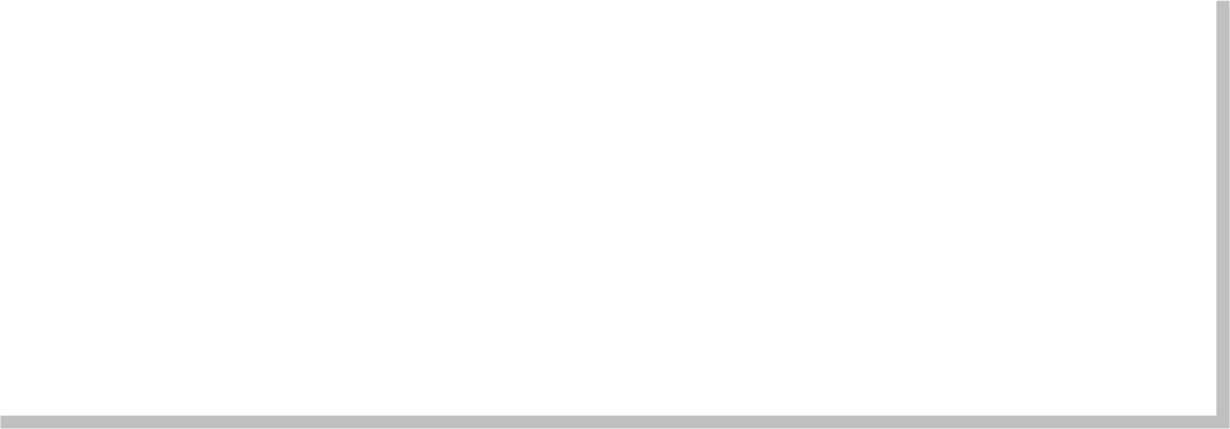
**Typical Response (MW)**

**Frequency (Hz)**

**HOLD**

**HOLD**

**Figure C.8.1: Frequency Response Capability LFSM-O, LFSM-U, FSM Step Tests**



1.6

**HOLD\***

1.2

0.8

**HOLD**

0.4

BC2/ BC4

**HOLD**

**HOLD**

0

0 2s (J) 32s

0 1s

0 30s

-0.4

**HOLD**

BC5

-0.8

**HOLD**

-1.2

BC6

**HOLD\***

-1.6

**HOLD**

**-2Hz**

+

BC6

BC5

0

\_

BC4

BC2

**Load Point MLP6**

**MLP6 LFSM**

**MLP5 MLP4**

**MLP4 LFSM MLP3 MLP2**

**MLP1**

**+2.0\***

BC1 BC3

**+0.02 -0.2 +0.2 -0.5 +0.5**

O

**+/-0.6 -1.0**

BC2 BC4

**-2.0**

**±0\*\***

L

D/E

F

G

A

H

I

J

BC5/6

M

N

P

K

Q

\* 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 Regulating Level** 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 Regulating Level** is not 20% then the injected step should be adjusted accordingly as shown in the example given below

|  |  |
| --- | --- |
| Initial Output | 65% |
| **Minimum Regulating Level** | 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.

* + - 1. 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 while operating at MLP4 (Figure C.8.1).

## Compliance with Output Power with falling frequency Functionality Test

* + - 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.
      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 A.7.6. 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**.
      3. The frequency should then be set to 49.5 Hz for 5 minutes. The output should remain at 100% of **Registered Capacity**.
      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 shall not be below 99% of **Registered Capacity**.
      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 shall not be below 97% of **Registered Capacity**.
      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 shall not be below 96.2% of **Registered Capacity**.
      7. The frequency should then be set to 47.1 Hz and held at this frequency for 20 s. The **Active Power** output shall not be below 95.0% of **Registered Capacity** and the **Synchronous Power Generating Module** shall not trip in less than the 20s of the test.
      8. The **Generator** shall inform the **DNO** if any load limiter control is additionally employed.

## Synchronous Power Generating Modules incorporating Electricity Storage

* + - 1. This paragraph provides a method for demonstrating compliance with the optional performance characteristic as discussed in the foreword. The tests shall be carried out to demonstrate how the **Synchronous Power Generating Module Active Power** when acting as a load (ie replenishing its energy store) responds to changes in system frequency.
      2. In general four tests are proposed, one set of two at **Rated Import Capacity**, and one set of two at 40% of **Rated Import Capacity.**

In both cases the test is to reduce frequency from 50 Hz at 2 Hzs-1. In the first case the lower frequency reached will be 49.0 Hz and the second case the lower frequency will be 48.8 Hz. The lower frequency should be held in each case for at least 60 s.

When returning the frequency to nominal, the ramp rate shall be of the order of 0.1 Hzs‑1.

* + - 1. In all cases the response shall meet the requirements of 13.2.3.3.

## Compliance Testing of Type C and Type D Power Park Modules

## Scope

* + - 1. This Annex outlines the general testing requirements for **Power Park** to demonstrate compliance with the relevant clauses of the EREC G99.
      2. The tests specified in this Annex will normally be sufficient to demonstrate compliance however the **DNO** may:
         1. agree an alternative set of tests provided the **DNO** deems the alternative set of tests sufficient to demonstrate compliance with this EREC G99 and the **Connection Agreement**; and/or
         2. require additional or alternative tests if information supplied to the **DNO** during the compliance process suggests that the tests in this Annex will not fully demonstrate compliance with the relevant section of this EREC G99 and the **Connection Agreement**; and/or
         3. require additional tests if a **Power System Stabiliser** is fitted; and/or
         4. agree a reduced set of tests if a relevant **Manufacturer's Data & Performance Report** has been submitted to and deemed to be appropriate by the **DNO;** and/or
         5. agree a reduced set of tests for subsequent **Power Park Module**s 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 Module**s which the **DNO** reasonably considers to be identical.

If:

the tests performed pursuant to C.9.1.1(iv) do not replicate the results contained in the **Manufacturer’s Data & Performance Report**, or

the tests performed pursuant to C.9.1.1(v) in respect of subsequent **Power Park Module**s do not replicate the full tests for the first **Power Park Module**, or

any of the tests performed pursuant to C.9.1.1(iv) or C.9.1.1(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.

* + - 1. 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** shall 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.
      2. 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:
         * All relevant transformer tap numbers; and
         * Number of **Generating Unit**s in operation
      3. 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.
      4. **Power Park Module** testing as defined in C.9.2 and C.9.3 is to be completed at the appropriate stage.
      5. 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** shall be supplied in the **Power Generating Module Document** or **DDRC** as applicable.

## Pre 20% Synchronised Power Park Module Basic Voltage Control Tests

* + - 1. Before 20% of the **Power Park Module** has commissioned, either voltage control test C.9.4.6(i) or (ii) shall be completed.

## Reactive Capability Test

* + - 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 Unit**s 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**.
      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.9.3.4.
      3. 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**.
      4. The following tests shall be completed:
         1. Operation in excess of 60% **Registered Capacity** and maximum continuous lagging **Reactive Power** for 30 minutes.
         2. Operation in excess of 60% **Registered Capacity** and maximum continuous leading **Reactive Power** for 30 minutes.
         3. Operation at 50% **Registered Capacity** and maximum continuous leading

**Reactive Power** for 30 minutes.Operation at 50% **Registered Capacity** and maximum continuous lagging

**Reactive Power** for 30 minutes.

* + - * 1. Operation at 20% **Registered Capacity** and maximum continuous leading

**Reactive Power** for 60 minutes.

* + - * 1. Operation at 20% **Registered Capacity** and maximum continuous lagging

**Reactive Power** for 60 minutes.

* + - * 1. 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**.
        2. Operation at the lower of the **Minimum Stable Operating Level** 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.
        3. Operation at the lower of the **Minimum Stable Operating Level** 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.
      1. 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**.

## Voltage Control Tests

* + - 1. This section details the procedure for conducting voltage control tests on **Power Park Module**s 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 Unit**s 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**.
      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.
      3. The time between transformer taps shall be at least 10 s as per Figure C.9.1.
      4. For a 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.

* + - 1. 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.
      2. Tests to be completed:

(i)

Time

Voltage

10s

minimum

1 tap

**Figure C.9.1 – Transformer tap sequence for voltage control tests**

(ii)



**Figure C.9.2 – Step injection sequence for voltage control tests**

## Frequency Response Tests

* + - 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 Unit**s within the **Power Park Module** in service. There should be sufficient MW resource forecast in order to generate at least 65% of **Registered Capacity** of the **Power Park Module**.
      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.9.5.4 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.
      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 13.2.3.1. 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.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  Lower of **Minimum Regulating Level** + 10% or **Minimum Stable Operating Level** | **MRL**+10% or  **MSOL** |
| Module Load Point 1 (**Minimum Regulating Level**) | **MRL** |

* + - 1. The tests are divided into the following two types;
         1. Frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** and **LFSM-U** capability as shown by Figure C.9.3.
         2. System islanding and step response tests as shown by Figure C.9.3.
      2. 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.

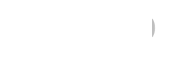
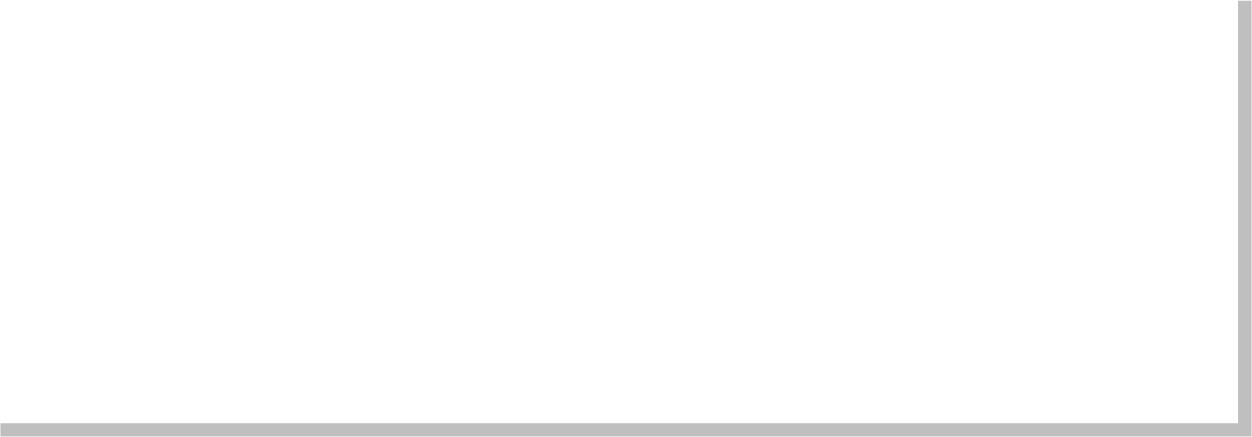
**Typical Response (MW)**

**Frequency (Hz)**

**HOLD**

**HOLD**

**Figure C.9.3 – Frequency Response Capability LFSM-O, LFSM-U, FSM Step Tests**



1.6

**HOLD\***

1.2

0.8

**HOLD**

0.4

BC2/ BC4

**HOLD**

**HOLD**

0

0 2s (J) 32s

0 1s

0 30s

-0.4

**HOLD**

BC5

-0.8

**HOLD**

-1.2

BC6

**HOLD\***

-1.6

**HOLD**

**-2Hz**

+

BC6

BC5

0

\_

BC4

BC2

**Load Point MLP6**

**MLP6 LFSM**

**MLP5 MLP4**

**MLP4 LFSM MLP3 MLP2**

**MLP1**

**+2.0\***

BC1 BC3

**+0.02 -0.2 +0.2 -0.5 +0.5**

O

**+/-0.6 -1.0**

BC2 BC4

**-2.0**

**±0\*\***

L

D/E

F

G

A

H

I

J

BC5/6

M

N

P

K

Q

\* 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 the **Minimum Regulating Level** 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 Regulating Level** is not 20% then the injected step should be adjusted accordingly as shown in the example given below:

|  |  |
| --- | --- |
| Initial Output | 65% |
| **Minimum Regulating Level** | 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*.*

* + - 1. 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 while operating at MLP4 (Figure C.9.3).

## Power Park Modules incorporating Electricity Storage

* + - 1. This paragraph provides a method for demonstrating compliance with the optional performance characteristic as discussed in the foreword. The tests shall be carried out to demonstrate how the **Power Park Module Active Power** when acting as a load (ie replenishing its energy store) responds to changes in system frequency.
      2. In general four tests are proposed, one set of two at **Rated Import Capacity**, and one set of two at 40% of **Rated Import Capacity**.

In both cases the test is to reduce frequency from 50 Hz at 2 Hzs-1. In the first case the lower frequency reached will be 49.0 Hz and the second case the lower frequency will be 48.8 Hz. The lower frequency should be held in each case for at least 60 s.

When returning the frequency to nominal, the ramp rate shall be of the order of 0.1 Hzs‑1.

* + - 1. In all cases the response shall meet the requirements of 13.2.5.2.

## Minimum Frequency Response Capability Requirement Profile and Operating Range for Type C and Type D Power Generating Modules

## Scope

* + - 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**.
      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.
      3. It is a requirement that **Type C** and **Type D Power Generating Module**s 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.

## Plant Operating Range

* + - 1. This section uses the following terms:
         1. primary response to mean the automatic increase in **Active Power** output of a **Power Generating Modul**e 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).
         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).
         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).
      2. The upper limit of the operating range is the **Registered Capacity** of the **Power Generating Module** or **Generating Unit**.
      3. The **Minimum Regulating Level** may be less than, but shall not be more than, 55% of the **Registered Capacity**. Each **Synchronous Power Generating Module** and/or **Generating Unit** and/or **Power Park Module** shall be capable of operating satisfactorily down to the **Minimum Regulating Level** as dictated by system operating conditions.
      4. If a **Synchronous Power Generating Module** or **Generating Unit** or **Power Park Module**, is operating below **Minimum Stable Operating Level** because of high system frequency, it should recover adequately to its **Minimum Stable Operating Level** as the system frequency returns to target frequency so that it can provide primary and secondary response from its **Minimum Stable Operating Level** if the system frequency continues to fall. Steady state operation below the **Minimum Stable Operating Level** is not expected under normal operating conditions. The **Minimum Regulating Level** shall not be more than 55% of **Registered Capacity**.
      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** shall 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** shall 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 Stable Operating Level**, 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 Stable Operating Level**.

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 shall 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.

## Repeatability of Response

* + - 1. When a **Power Generating Module** has responded to a significant frequency disturbance, its response capability shall 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.

## 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 of the **Grid Code**.

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**



**Figure C.10.3 Interpretation of High (H) Frequency Response Service Values**



**Figure C.10.4 Interpretation of Low Frequency Response Capability Values**



**Figure C.10.5 Interpretation of High Frequency Response Capability Values**

# Annex D

## 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: |

## Additional Information Relating to System Stability Studies

### 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 shall be able to adjust to the changing conditions and operate satisfactorily. The system shall 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 Unit**s’ rotors from the system, or an uncontrolled increase in the speed of asynchronous **Generating Unit**s’ 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 the 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 Module**s and the rest of the system, or between groups of **Synchronous Power Generating Module**s, 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 Stabiliser**s **(PSS**s**)** may offer a solution.

Undamped oscillations which result in sustained voltage and power swings, and even loss of **Synchronism** between **Synchronous Power Generating Module**s, 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 three phase short circuit fault or circuit outage, can result in large excursions of **Synchronous Power Generating Module**s 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 Module**s, cause maloperation of **Distribution Network** protection and produce unacceptable voltage depressions in supply systems.

In the case of some types of **Power Park Module**s, 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 Module**s and series converter connected **Power Generating Module**s, 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 Module**s the capability to ride through certain **Transmission System** faults is critical to **Distribution Network** and **Total System** stability.

Where larger **Synchronous Power Generating Module**s 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 Module**s 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.

### 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.

### 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 Module**s 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 shall be compliant with ER P28.

## 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**.

### 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** 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.

1. **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)

Note that vector shift protection is no longer allowed to be used in Great Britain.

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 D.2.2 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.

### 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 106  *J*  *N* 2

where K = kinetic energy in kJ

equation 1

J = moment of inertia in kgm2 N = machine in speed in rpm

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

1

*K*

*H*  equation 2

*G*

Where K1 = Kinetic energy at rated speed and frequency (Fr) G = kVA capacity of the **Generating Unit**

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

 *F* 2

*K*   

*F*

 *H*  *G*

equation 3

 *r* 

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

*P*  *dK*

*c dt*

equation 4

Rewriting:

*P*

 *dK*  *dF*

equation 5

*c dF dt*

Differentiating equation 3 gives:

*dK*  2*FHG*

equation 6

*dF* 2

*F*

*r*

Substituting in equation 5:

*P*  2*FHG*  *dF*

*c* 2 *dt*

*F*

*r*

Re-arranging:

2

*dF*  *P F*

equation 7

*c r*

*dt* 2*HGF*

## Main Statutory and Other Obligations

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

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 ofequipment when unsafe situations have developed, as well as preserving supplies to other

**Customer**s.

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reference** | **Obligation** | **DNO** | **Generator** | **Customer** |
| **ESQCR** Reg 3 | Ensure equipment is sufficient for purpose and electrically protected to prevent danger, so far as is reasonably practicable. | X | X | - |
| **ESQCR** Reg 4 | Disclose information and co-operate with each other to ensure compliance with the ESQC Regulations 2002 | X | X | - |
| **ESQCR** Reg 6 | Apply protective devices to their network, so far as is reasonably practicable, to prevent overcurrents from exceeding equipment ratings. | X | X | - |
| **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 Network**s cannot operate in parallel with those networks and that such equipment which is part of an **LV** consumer’s installation complies with BS 7671. |  | X | X |
| **ESQCR** Reg 22 | Not install or operate sources of energy in parallel with **Distribution Network**s 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 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reference** | **Obligation** | **DNO** | **Generator** | **Customer** |
| **ESQCR** Reg 24 | **DNO** equipment which is on a consumer’s premises but not under the consumer’s control is protected by a suitable fused cut- out or circuit breaker which is situated as close as reasonably practicable to the supply terminals, which is enclosed in a locked or sealed container. | X |  |  |
| **ESQCR** Reg 25 | Not give consent to making or altering of connections where there are reasonable grounds to believe that the consumer’s installation does not comply with **ESQCR** / BS 7671 or, so far as is reasonably practicable, is not protected to prevent danger or interruption of supply. | X |  |  |
| **ESQCR** Reg 27 | Declare the number of phases, frequency and voltage of the supply and, save in exceptional circumstances, keep this within permitted variations. | X |  |  |
| **ESQCR** Reg 28 | Provide a written statement of the type and rating of protective devices. | X |  |  |
| **EaWR** Reg 4 | Construct systems including suitable protective devices that can handle the likely load and fault conditions. | X | X | X |
| **EaWR** Reg 5 | Not put into service electrical equipment where it strength and capability may be exceeded in such a way as to pose a danger. | X | X | X |
| **EaWR** Reg 11 | Provide an efficient and suitably located means to protect against excess current that would otherwise result in danger. | X | X | X |
| MHSWR Reg 3 | Carry out an assessment of risks to which employees are exposed to at work and risks to other persons not employed arising from the activities undertaken. | X | X | X |
| BS 7671 | Provide protective devices to break overload/fault current in **LV** consumer installations before danger arises. |  |  | X |
| BS 7671 | Take suitable precautions where a reduction in voltage, or loss and subsequent restoration of voltage, could cause danger. |  |  | X |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reference** | **Obligation** | **DNO** | **Generator** | **Customer** |
| **Distribution Code** DPC4.4.4 | Incorporate protective devices in **Distribution Network**s in accordance with the requirements of the **ESQCR**.  Agree protection systems, operating times, discrimination and sensitivity at the ownership boundary.  Normally provide back-up protection in case of circuit breaker failure on **HV** systems. | X  X  X | X  X  X | X  X  X |
| **Distribution Code** DPC6.3 | **Customer**’s equipment shall be compatible with **DNO** standards and practices.  Design protection systems that take into account auto-reclosing or sequential switching features on the **DNO** network.  Be aware that **DNO** protection arrangements may cause disconnection of one or two phases only of a three phase supply. |  | X  X  X | X  X  X |
| **Distribution Code** DPC8.10 | Assess the transient over voltage effects at the network ownership boundary, where necessary. | X | X |  |

## Summary of Reactive Power and voltage control requirements for Type A, Type B, Type C and Type D Power Generating Modules

This table summarises the **Reactive Power** and voltage control requirements that are given in Section 11, Section 12 and Section 13 for **Type A**, **Type B**, and **Type C** and **Type D Power Generating Module**s respectively.

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | **Reactive range requirement** | **Voltage range for reactive range** | **Voltage control requirements** |
| **Type A** | Capable of operating within the range ±0.95 **Power Factor** (paragraph 11.1.5) at **Registered Capacity**– Control scheme (and specific **Power Factor** for operation) by individual agreement (paragraph 11.1.6). | Nominal voltage only | Typically will be **Power Factor** control with **Generator** choosing the **Power Factor** – but to be agreed bilaterally in all cases (paragraph 11.1.6) |
| **Type B** | Must be capable of continuous operation anywhere within the range ±0.95 **Power Factor** (paragraph 12.5.1) **at Registered Capacity**.  Must be capable of operating in accordance with **Generator Performance Chart** (paragraph 12.5.2). | Nominal voltage only | Typically will be **Power Factor** control with **Generator** choosing the **Power Factor** – but to be agreed bilaterally in all cases (paragraph 12.4.3.3).  Control point is at the **Connection Point**, except for **PGMs** located remote from the **Connection Point** where a different control point can be agreed with the **DNO** (paragraph 12.4.3.2). |
| **Type C** and **Type D** - Synchronous | Must be capable of operating anywhere within ±0.92 **Power Factor** (paragraph 13.5.1) at **Registered Capacity**.  Must be capable of operating in accordance with **Generator Performance Chart** (paragraph 13.5.2). | ±0.05 pu of nominal voltage (paragraph 13.5.1).  Maintain reactive performance as far as possible above 1.05 pu and below 0,95 pu within **Generator Performance Chart** (paragraph 13.5.3). | Agreed bilaterally as part of the connection process (paragraph 13.4.5)  Control point is at the **Connection Point**, except for **PGMs** embedded within **Generator’s Installation** where a different control point can be agreed with the **DNO** (paragraph 13.5.1). |
| **Type C** and **Type D** – **PPM** ≤ 33 kV | Lozenge as per paragraph 13.5.5 at **Registered Capacity**.  Q/Pmax requirements (paragraph 13.5.6) below **Registered Capacity** unless otherwise specified by the **DNO**. | Lozenge as per paragraph 13.5.5 | Agreed bilaterally as part of the connection process (paragraph 13.4.5). Control at the **Connection Point** (paragraph 13.4.4.1)  Automatic Voltage Control system requirements as Annex C.5.2, C.5.3 and C.5.4.  **Reactive Power** Control (agreed if required) requirements as Annex C.5.6. |

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  | **Power Factor** Control (agreed if required) requirements as Annex C.5.7. |
| **Type C** and **Type D** – **PPM** >  33 kV | Bow tie as per paragraph 13.5.4 at **Registered Capacity**.  Q/Pmax requirements (paragraph 13.5.6) below **Registered Capacity** unless otherwise specified by the **DNO**. | Bow tie as per 13.5.4 | Agreed bilaterally as part of the connection process (paragraph 13.4.5). Control at the **Connection Point** (paragraph 13.4.4.1).  Automatic Voltage Control system requirements as Annex C.5.2, C.5.3 and C.5.4.  **Reactive Power** Control (agreed if required) requirements as Annex C.5.6.  **Power Factor** Control (agreed if required) requirements as Annex C.5.7. |