# G98/G99 Application Guidance Forms

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# ENA EREC G98: Further Application Guidance (Form C)

This guidance note aims to provide assistance when completing **Form C: Type Test Verification Report** which is the manufacturer's declaration of compliance with the requirements of EREC G98 *"Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16 A per phase) in parallel with public Low Voltage Distribution Networks on or after 27 April 2019"*.

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Ensure all fields regarding manufacturer and device information are filled and the declaration is signed.

1) **Operating Range**
   - Ensure Tests are up-to-date and in accordance with the most recent amendment of G98.
   - Provide confirmation that device operates correctly under each test condition;
   - Provide evidence of operation (graphical or tabular).

2) **Power Quality – Harmonics**
   - Ensure rating of device (<u>per phase</u>) is provided at the top of the table.
   - Ensure tests limits are in accordance with BS EN 61000-3-22 and harmonics #2 - #40 are provided.
     <u>If device is 3-phase, ensure harmonic data for each phase is included.</u>
   - It is a requirement that, for single and 3-phase devices, all harmonic data is provided.

3) **Power Quality – Voltage Fluctuations and Flicker**
   - Ensure test & standard impedance is filled in on the form.
   - If testing single phase device, test impedance is 0.4Ω
   - If testing 3-phase device, test impedance is 0.24Ω
   - If a different test impedance is used (*measured impedance)*, it must be normalised to the standard impedance
   - E.g. for measured impedance of 0.5Ω and dmax value = 0.6 (3 phase device):
     - Dmax Normalised value: $\frac{Standard\ impedance}{Measured\ impedance} * Measured\ value$
     - Dmax Normalised value = $\frac{0.24}{0.5} * 0.6 = 0.288$
   - Ensure test date and location are declared.

4) **Power Quality – DC Injection**
   - Perform at 4 Test power levels (20%, 50%, 75% & 100%).
   - Correct calculation for "as % of rated AC current":
     - $Base\ current = \frac{Registered\ Capacity\ (W)}{230}$
     - $\%\ DC\ injection = \frac{Recorded\ DC\ value\ (A)}{Base\ current\ (A)}$
   - *Note: calculation is the same for 1 phase and 3 phase devices*

5) **Power Quality – Power Factor**
   - Perform tests to 3 voltages (216.2V/0.94pu, 230V/1pu, 253V/1.1pu) at 4 percentiles of registered capacity.
   - Ensure power factor is > 0.95pu.

6) **Protection – Frequency Tests**
   - Ensure trip/no-trip times are up-to-date and in accordance with **<u>most recent amendment</u>** of EREC G98.

**7) Protection – Voltage Tests**

- Ensure trip/no-trip times are up-to-date and in accordance with **most recent amendment** of EREC G98.

**8) Protection – Loss of Mains Test**

- **Non-PV Inverter:** Complete with test power at 10, 55 & 100% for +/- 5% of Registered Capacity (first test) - ensure trip time is within limit of 0.5s (unless additional shut down time is included, limit = 1s) – in accordance with BS EN 50438.
- **Multi-phase Micro-generators:** Same as above but for all phases – ensure trip time is within limit of 0.5s (unless additional shut down time is included, limit = 1s).
- **PV Inverter:** Complete test power and imbalance (Test 22, 12, 5, 31, 21 & 10) – ensure trip time is within limit of 0.5s – in accordance with BS EN 62116.

**Protection – Frequency Change, Vector Shift Stability Test:**

- Confirm device does not trip under positive/negative vector shift.

**Protection – Frequency change, RoCoF Stability Test:**

- Confirm device does not trip in either the ramp up/ramp down test duration.

**9) Limited Frequency Sensitive Mode – Overfrequency (LFSM-O) Test**

- Ensure that measured active power output provides a droop less than 10% (tolerance band **of 8.5% to 12.8%**).

$$1^{st}\ Droop\ \% = \frac{(\frac{Step\ D\ freq - Step\ B\ freq}{50})}{(\frac{Step\ B\ power - Step\ D\ power}{Step\ B\ power})} \times 100$$

$$2^{nd}\ Droop\ \% = \frac{(\frac{Step\ D\ freq - Step\ F\ freq}{50})}{(\frac{Step\ F\ power - Step\ D\ power}{Step\ F\ power})} \times 100$$

**10) Power Output with Falling Frequency Test**

- Device active power output should not fall below the limits outlined in EN 50438 (below).
- Confirm operating point in Test (b) and (c) is maintained for at least 5 minutes.

Figure 1 – Maximum allowable power reduction in case of under-frequency
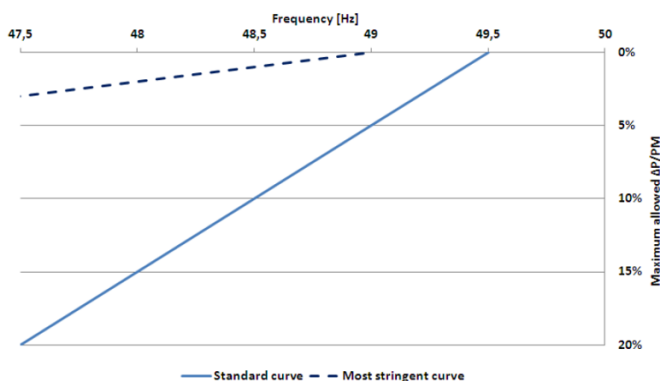


**11) Re-connection Timer**

- Provide both the time delay and measured delay settings – both should be greater than 20s.
- Provide confirmation that device does **not** reconnect at 266.2V, 180V, 47.4Hz & 52.1Hz.

**12) Fault Level Contribution**

- Ensure correct fault level contribution is provided for the correct type of device.

**13) Logic Interface**

- Confirmation of the presence of a logic interface must be provided.

**14) Self-Monitoring solid state switching:**

- Declare Yes **or** N/A – not both.

# ENA EREC G99: Further Application Guidance (Form A2-1)

This guidance note aims to provide assistance when completing **Form A2-1: Compliance Verification Report for Type A Synchronous Power Generating Modules up to and including 50kW** which is the manufacturer's declaration of compliance with the requirements of EREC G99 "*Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019*"

**Cover Page, \*may be carried out at the time of commissioning (with Form A.2-4)**

Ensure all fields regarding manufacturer and device information are filled and the declaration is signed.

1) **Operating Range**
   - **Ensure Tests are up-to-date and in accordance with the most recent amendment of G99.**
   - **Provide confirmation that device operates correctly under each test conditions;**
   - **Provide evidence of operation (graphical or tabular).**

2) **Power Quality – Harmonics**
   - **Ensure rating of device (<u>per phase</u>) is provided at the top of the table.**
   - **Ensure tests limits are in accordance with BS EN 61000-3-12 and harmonics #2 - #13 are provided.**
   - **It is a requirement that, for single and 3-phase devices, all harmonic data is provided. <u>If device is 3-phase, ensure harmonic data for each phase is included.</u>**
   - **Ensure that THD and PWHD values are provided.**

3) **Power Quality – Voltage Fluctuations and Flicker**
   - **Ensure test & standard impedance is filled in on the form.**
   - **If testing single phase device, test impedance is 0.4Ω**
   - **If testing 3-phase device, test impedance is 0.24Ω**
   - **If a different test impedance is used (*measured impedance)*, it must be normalised to the standard impedance**
   - **E.g. for measured impedance of 0.5Ω and dmax value = 0.6 (3 phase device):**
     - **Dmax Normalised value:** $\frac{Standard\ impedance}{Measured\ impedance} * Measured\ value$
     - **Dmax Normalised value =** $\frac{0.24}{0.5} * 0.6 = 0.288$
   - **Ensure test date and location are declared.**

4) **Power Quality – Power Factor\***
   - Perform tests to the 3 voltages. (216.2V/0.94pu, 230V/1pu & 253V/1.1pu)
   - Ensure power factor is > 0.95pu.

5) **Protection – Frequency Tests\***
   - Ensure trip/no-trip times are up-to-date and in accordance with **<u>most recent amendment</u>** of EREC G99.

6) **Protection – Voltage Tests\***
   - Ensure trip/no-trip times are up-to-date and in accordance with **<u>most recent amendment</u>** of EREC G99.

7) **Protection – Loss of Mains Test\***
   - Tests are carried out by connecting the PGM to the DNO network via a switch and variable load. Tests shall be carried out by varying the Test Power from 10%, 55% and 100% with the variable load at 95% & 105% of each Test Power. The switch is then opened to imitate a LoM event, trip times must be within 0.5s

- Multiphase PGM's shall be tested similarly to the above, by the removal of each individual fuse.

**Protection – Frequency Change, Vector Shift Stability Test:**
- Confirm device does not trip under positive/negative vector shift.

**Protection – Frequency change, RoCoF Stability Test:**
- Confirm device does not trip in either the ramp up/ramp down test duration.

8) **Limited Frequency Sensitive Mode – Overfrequency (LFSM-O) Test***
   - Ensure that measured active power output provides a droop less than 10% (tolerance band **of 8.5% to 12.8%**).

$$1^{st}\ Droop\ \% = \frac{(\frac{Step\ D\ freq - Step\ B\ freq}{50})}{(\frac{Step\ B\ power - Step\ D\ power}{Step\ B\ power})} \times 100$$

$$2^{nd}\ Droop\ \% = \frac{(\frac{Step\ D\ freq - Step\ F\ freq}{50})}{(\frac{Step\ F\ power - Step\ D\ power}{Step\ F\ power})} \times 100$$

9) **Power Output with failing frequency test***

Tests prove that the PGM does not reduce output power as the frequency falls

10) **Re-connection Timer***
    - Provide both the time delay and measured delay settings – both should be greater than 20s.
    - Provide confirmation that device does **not** reconnect at 266.2V, 180V, 47.4Hz & 52.1Hz.

11) **Fault Level Contribution**
    - Ensure correct fault level contribution is provided for the correct type of device.

12) **Logic Interface**
    - Confirmation of the presence of a logic interface must be provided.

13) **Self-Monitoring solid state switching:**
    - Declare Yes **or** N/A – not both.

# ENA EREC G99: Further Application Guidance (Form A2-2)

This guidance note aims to provide assistance when completing **Form 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 which is the manufacturer's declaration of compliance with the requirements of EREC G99 "*Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019*".

**Cover Page, \*may be carried out at the time of commissioning (with Form A.2-4 or appropriate)**

Ensure all fields regarding manufacturer and device information are filled and the declaration is signed.

1) **Operating Range**
   - Ensure Tests are up-to-date and in accordance with the most recent amendment of G99.
   - Provide confirmation that device operates correctly under each test conditions;
   - Provide evidence of operation (graphical or tabular).

2) **Power Quality – Harmonics\***
   - For PGM's above 50kW, they will need to be designed in accordance with EREC G5 – Form A2-1 can be used in the meantime**. *This is a discussion of which we are having with the ENA as to how they can provide evidence of compliance with G5 before connecting to the network.***

3) **Power Quality – Voltage Fluctuations and Flicker**
   - For PGM's above 50kW, they will need to be designed in accordance with EREC P28 – Form A2-1 can be used in the meantime**. *This is a discussion of which we are having with the ENA as to how they can provide evidence of compliance with P28 before connecting to the network.***

4) **Power Quality – Power Factor\***
   - Ensure PGM Power Factor remains >0.95 as network voltage changes from 0.94, 1 and 1.1puV

5) **Protection – Frequency Tests\***
   - Ensure trip/no-trip times are up-to-date and in accordance with **most recent amendment** of EREC G99 – *Form A2-4 to be used for site commissioning test requirements.*

6) **Protection – Voltage Tests\***
   - Ensure trip/no-trip times are up-to-date and in accordance with **most recent amendment** of EREC G99 - *Form A2-4 to be used for site commissioning test requirements.*

7) **Protection – Loss of Mains Test\***
   - Vector Shift and RoCoF stability - *Form A2-4 to be used for site commissioning test requirements.*

- Multiphase PGM's shall be tested similarly to the above, by the removal of each individual fuse.

**Protection – Frequency Change, Vector Shift Stability Test:**
- Confirm device does not trip under positive/negative vector shift.

**Protection – Frequency change, RoCoF Stability Test:**
- Confirm device does not trip in either the ramp up/ramp down test duration.

8) **Limited Frequency Sensitive Mode – Overfrequency (LFSM-O) Test\***
   - Ensure that measured active power output provides - *in accordance with Annex A.7.2.4*, a droop less than 10% (tolerance band **of 8.5% to 12.8%**).

$$1^{st}\ Droop\ \% = \frac{(\frac{Step\ D\ freq - Step\ B\ freq}{50})}{(\frac{Step\ B\ power - Step\ D\ power}{Step\ B\ power})} \times 100$$

$$2^{nd}\ Droop\ \% = \frac{(\frac{Step\ D\ freq - Step\ F\ freq}{50})}{(\frac{Step\ F\ power - Step\ D\ power}{Step\ F\ power})} \times 100$$

9) **Power Output with failing frequency test\***

Tests prove that the PGM does not reduce output power as the frequency falls – *in accordance with Annex A.7.2.3*

10) **Re-connection Timer\***
    - Provide both the time delay and measured delay settings – both should be greater than 20s.
    - Provide confirmation that device does **not** reconnect at 266.2V, 180V, 47.4Hz & 52.1Hz.

11) **Fault Level Contribution**
    - Ensure correct fault level contribution is provided for the correct type of device.

12) **Wiring functional tests**
    - Confirmation of the presence of a logic interface must be provided.

13) **Self-Monitoring solid state switching:**
    - Declare Yes **or** N/A – not both.

# ENA EREC G99: Further Application Guidance (Form A2-3)

This guidance note aims to provide assistance when completing **Form A2-3: Compliance Verification Report for Type A Inverter Connected Power Generating Modules** which is the manufacturer's declaration of compliance with the requirements of EREC G99 "*Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019*"

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Ensure all fields regarding manufacturer and device information are filled and the declaration is signed.

1) **Operating Range**
   - **Ensure Tests are up-to-date and in accordance with the most recent amendment of G99.**
   - **Provide confirmation that device operates correctly under each test conditions;**
   - **Provide evidence of operation (graphical or tabular).**
2) **Power Quality – Harmonics**
   - **Ensure rating of device (<u>per phase</u>) is provided at the top of the table.**
   - **Ensure tests limits are in accordance with BS EN 61000-3-12 and harmonics #2 - #13 are provided.**
   - **It is a requirement that, for single and 3-phase devices, all harmonic data is provided.
   <u>If device is 3-phase, ensure harmonic data for each phase is included.</u>**
   - **Ensure that THD and PWHD values are provided.**
3) **Power Quality – Voltage Fluctuations and Flicker**
   - **Ensure test & standard impedance is filled in on the form.**
   - **If testing single phase device, test impedance is 0.4Ω**
   - **If testing 3-phase device, test impedance is 0.24Ω**
   - **If a different test impedance is used (*measured impedance*), it must be normalised to the standard impedance**
   - **E.g. for measured impedance of 0.5Ω and dmax value = 0.6 (3 phase device):**
     - **Dmax Normalised value:** $\frac{Standard\ impedance}{Measured\ impedance} * Measured\ value$
     - **Dmax Normalised value** $= \frac{0.24}{0.5} * 0.6 = 0.288$
   - **Ensure test date and location are declared.**
4) **Power Quality – DC Injection**
   - **Perform at 3 Test power levels (10%, 55% & 100%).**
   - **Correct calculation for "as % of rated AC current":**
     - $Base\ current = \frac{Registered\ Capacity\ (W)}{230}$
     - $\%\ DC\ injection = \frac{Recorded\ DC\ value\ (A)}{Base\ current\ (A)}$
   - ***Note: calculation is the same for 1 phase and 3 phase devices***
5) **Power Quality – Power Factor**
   - Perform tests to the 3 voltages. (216.2V/0.94pu, 230V/1pu & 253V/1.1pu)
   - Ensure power factor is > 0.95pu.
6) **Protection – Frequency Tests**
   - Ensure trip/no-trip times are up-to-date and in accordance with **<u>most recent amendment</u>** of EREC G99.

7) **Protection – Voltage Tests**

- Ensure trip/no-trip times are up-to-date and in accordance with **<u>most recent amendment</u>** of EREC G99.

**8) Protection – Loss of Mains Test**
- **Non-PV Inverter:** Complete with test power at 10, 55 & 100% for +/- 5% of Registered Capacity (first test) - ensure trip time is within limit of 0.5s (unless additional shut down time is included, limit = 1s) – in accordance with BS EN 50438.
- **Multi-phase Micro-generators:** Same as above but for all phases – ensure trip time is within limit of 0.5s (unless additional shut down time is included, limit = 1s).
- **PV Inverter:** Complete test power and imbalance (Test 22, 12, 5, 31, 21 & 10) – ensure trip time is within limit of 0.5s in accordance with BS EN 62116.

  **Protection – Frequency Change, Vector Shift Stability Test:**
- Confirm device does not trip under positive/negative vector shift.

  **Protection – Frequency change, RoCoF Stability Test:**
- Confirm device does not trip in either the ramp up/ramp down test duration.

**9) Limited Frequency Sensitive Mode – Overfrequency (LFSM-O) Test**
- Ensure that measured active power output provides a droop less than 10% (tolerance band **of 8.5% to 12.8%**).

$$1^{st} \ Droop \ \% = \frac{(\dfrac{Step \ D \ freq - Step \ B \ freq}{50})}{(\dfrac{Step \ B \ power - Step \ D \ power}{Step \ B \ power})} \times 100$$

$$2^{nd} \ Droop \ \% = \frac{(\dfrac{Step \ D \ freq - Step \ F \ freq}{50})}{(\dfrac{Step \ F \ power - Step \ D \ power}{Step \ F \ power})} \times 100$$

**10) Re-connection Timer**
- Provide both the time delay and measured delay settings – both should be greater than 20s.
- Provide confirmation that device does **not** reconnect at 266.2V, 180V, 47.4Hz & 52.1Hz.

**11) Fault Level Contribution**
- Ensure correct fault level contribution is provided for the correct type of device.

**12) Logic Interface**
- Confirmation of the presence of a logic interface must be provided.

**13) Self-Monitoring solid state switching:**
- Declare Yes **or** N/A – not both.

# ENA EREC G99: Further Application Guidance (Form A2-4)

This guidance note aims to provide assistance when completing **Form A2-4: Compliance and Commissioning test requirements for Type A Power Generating Modules** (some or all of the interface protection where is not Type Tested) which is the manufacturer's declaration of compliance with the requirements of EREC G99 "*Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019*"

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- Ensure all fields regarding manufacturer and device information are filled.
- Declare which tests from the list provided have been performed and if compliance is met by means of manufacturers' information, type test reports or by undertaking the tests described in A2-4 on site (commissioning tests).

## Over and Under Voltage Protection Tests LV

These tests are required to assess compliance with EREC G99 where the Connection Point of the generator is at LV side (nominal voltage phase to ground is 230V).

### - Calibration and Accuracy

- Ensure Tests are up-to-date and in accordance with the most recent amendment of G99.
- Provide confirmation that device operates correctly under each test conditions;
- Ensure test results for pickup and relay operating time are in accordance with limits provided in the A2-4 for Stage 1 Over Voltage, Stage 2 Over Voltage and Under Voltage.
- Ensure that results are provided for each phase (L1, L2 and L3).

### - Stability Tests

- Ensure test results are provided for Stage 1 Over Voltage, Stage 2 Over Voltage and Under Voltage.
- Ensure that nuisance tripping will not occur if the test time duration is below the relay time delay.

## Over and Under Voltage Protection Tests HV

These tests are required to assess compliance with EREC G99 where the Connection Point of the generator is at HV side. (Tests referenced to 110V phase to phase VT output)

### - Calibration and Accuracy

- Ensure Tests are up-to-date and in accordance with the most recent amendment of G99.
- Provide confirmation that device operates correctly under each test conditions;
- Ensure test results for pickup and relay operating time are in accordance with limits provided in the A2-4 for Stage 1 Over Voltage, Stage 2 Over Voltage and Under Voltage.
- Ensure that results are provided for each phase (L1, L2 and L3).

### - Stability Tests

- Ensure test results are provided for Stage 1 Over Voltage, Stage 2 Over Voltage and Under Voltage.

- Ensure that nuisance tripping will not occur if test time duration is below the relay time delay.

## Over and Under Voltage Frequency Protection

These tests are required to assess compliance with EREC G99 in respect of Over and Under Frequency Protection

- **Calibration and Accuracy**

  - Ensure Tests are up-to-date and in accordance with the most recent amendment of G99.
  - Provide confirmation that device operates correctly under each test conditions;
  - Ensure test results for pickup frequency and relay operating time are in accordance with limits provided in the A2-4 for Over Frequency, Stage 1 Under Frequency and Stage 2 Under Frequency.

- **Stability Tests**

  - Ensure test results are provided for Over Frequency, Stage 1 Under Frequency and Stage 2 Under Frequency.
  - Ensure that nuisance tripping will not occur if test time duration is below the relay time delay.

## Loss of Mains Test (LOM) Protection Tests

- Ensure details of Loss of Mains Protection such as date of installation and protection settings have been provided.
- Demonstrate device is compliance with EREC G99 in respect of LOM Protection.

- **Calibration and Accuracy Tests**

  - Tests prove that pickup values of Δf/Δt (frequency variation by time variation in $Hzs^{-1}$) are within established limits for ramp in ranges 49 – 51Hz and 48.5 – 51.5 Hz.
  - Tests prove that relay operating time RoCoF are within limits for ramp in ranges 49 – 51Hz and 48.5 – 51.5 Hz.

- **Stability Tests**

  - Confirm device does not trip in either the ramp up/ramp down test duration.

## LoM Protection - Stability Test

- **Protection – Frequency Change, Vector Shift Stability Test:**

  - Confirm device does not trip under positive/negative vector shift.

## Wiring functional tests

- Confirmation of wiring functional tests being carried out if connections have been made by loose wiring as required by para 15.2.1.

## Logic Interface Port

- Confirm if an input port is provided to shut down the module.