



TL-395

**TEST REPORT**

Engineering Recommendation G98 Issue 1 Amendment 6 September 2021
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

Report reference No. : 220719116GZU-001

Tested by
 (printed name and signature) : Drewe Zhou
 Engineer

Approved by
 (printed name and signature) : Jason Fu
 Supervisor

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 40 pages

Testing Laboratory Name : Intertek Testing Services Shenzhen Ltd. Guangzhou Branch
Address : Room 02, & 101/E201/E301/E401/E501/E601/E701/E801 of Room 01 1-8/F.,
 No. 7-2. Caipin Road, Science City, GETDD, Guangzhou, Guangdong, China
Testing location : Same as above
Address : Same as above

Applicant's Name : Shenzhen SOFARSOLAR Co., Ltd.
Address : 11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community,
 Xin'an Sub-district, Bao'an District, Shenzhen City, China

Test specification

Standard..... : G98 Issue 1 Amendment 6, 1 September 2021
 Test procedure : Type Verification
 Non-standard test method : N/A

Test Report Form No. : G98/4
 TRF originator : Intertek
 Master TRF : dated 2019-06

Test item description : Hybrid Inverter

Trademark :



Manufacturer : Same as applicant
 Factory : Dongguan SOFAR SOLAR Co., Ltd.
 1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village,
 Fenggang Town, Dongguan City, China
 Model and/or type reference : ME 3000SP

Ratings	Battery Type: Lead-acid, Lithium-ion
	Battery Voltage Range: 42-58Vdc
	Max. Charging Current: 60A
	Max. Discharging Current: 60A
	Max. Charging & Discharging Power: 3000VA
	Nominal Grid Voltage: 230Vac
	Nominal output Voltage (stand-alone): 230Vac
	Max. output Current: 13A
	Nominal Grid frequency: 50Hz
	Power factor: 1 (adjustable +/-0.8)
	Ingress protection: IP65
	Operating Temperature Range: -25°C - 60°C
	Protective Class: Class I
	Software Version: V1.00

Test case verdicts

Test case does not apply to the test N/A
object

Test item does meet the requirement P(pass)

Test item does not meet the F(fail)
requirement

Testing

Date of receipt of test item 19 July 2022

Date(s) of performance of test 20 July 2022 – 22 August 2022

General remarks

The test results presented in this report relate only to the object tested.

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"(See Enclosure #)" refers to additional information appended to the report.

"(See appended table)" refers to a table appended to the report.

Throughout this report a point is used as the decimal separator.

When determining the test conclusion, the Measurement Uncertainty of test has been considered.

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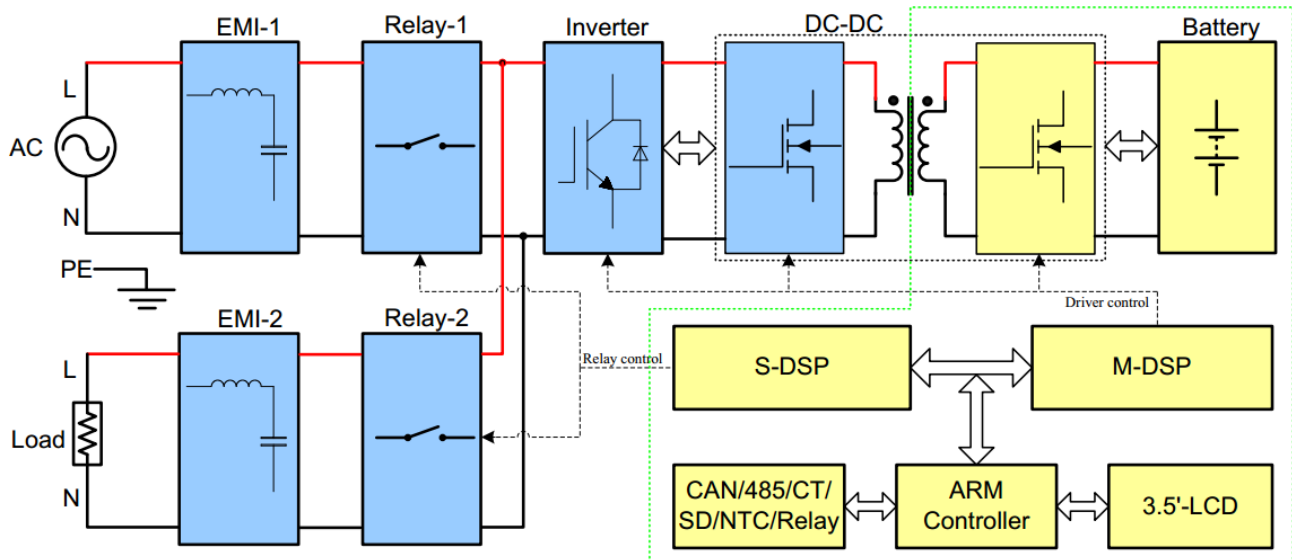
This report is based on and supersedered original report No. 190114150GZU-001 dated 18 April 2019 to update the standard from" G98 Issue 1 Amendment 3 March 2019" to" G98 Issue 1 Amendment 6, 1 September 2021".

After evaluation, relative tests have been added.

General product information:

The equipment under test is single phase energy storage inverter. They are responsible for converting the direct current generated by battery into single-phase 230V, 50 Hz. A high frequency transformer and relay are providing basic insulation between grid and battery. Hence, the mechanical disconnection device (relay) is provided between grid and battery on line and neutral conductor and off-grid in case of single fault occurs.

The topology diagram as following:



The equipments have three working mode. Charge mode, Discharge mode, Stand-alone mode :

Charge mode: The AC voltage from mains charges the battery provided in the final system.

Discharge mode: The inverter converts the energy from the battery to 230Va.c.,50 Hz voltage and connected to AC mains. In this mode the inverter works as grid connected inverter.

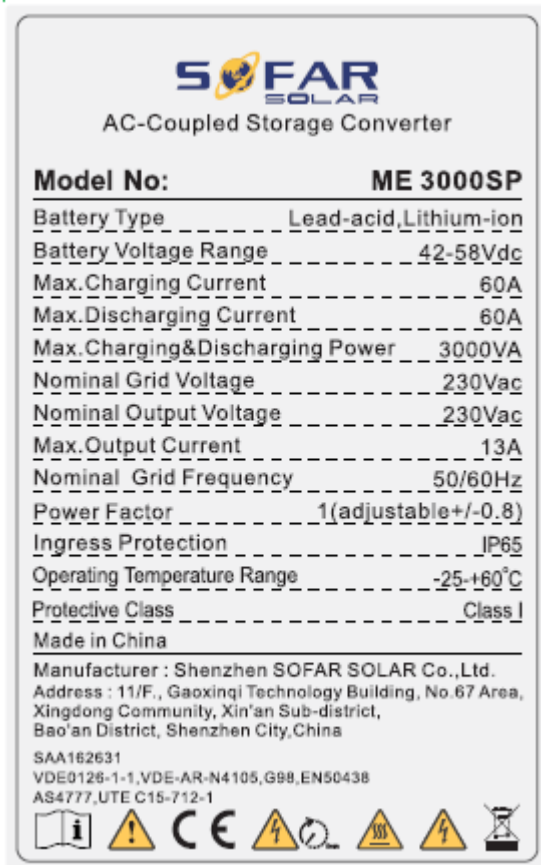
Stand-alone mode: The inverter converter the energy from the battery to 230Va.c.,50 Hz voltage and feed the general load. In this mode the inverter worked as stand-alone inverter.

The product was tested on:

The Software version: V1.00

The Hardware version: V1.00

Copy of marking plate:



Note:

1. The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.
2. Label is attached on the side surface of enclosure and visible after installation.
3. Other labels are identical to above, except the model name and ratings

Engineering recommendation G98/6			
Clause	Requirement – Test	Result – Remark	Verdict
5	Connection Procedure		N/A
5.1	Single Premises Connection Procedure		N/A
5.2	Multiple Premises Connection Procedure		N/A
5.3	General		N/A
6	Certification Requirements		P
6.1	Type Test Certification		P
6.1.1	Type Tested certification is the responsibility of the Manufacturer. The Manufacturer shall make available upon request a Type Test Verification Report confirming that the Micro-generator has been tested to satisfy the requirements of this EREC G98. The report shall detail the type and model of Micro-generator tested, the test conditions and results recorded. All of these details shall be included in a Type Test Verification Report. The required verification report and declaration are shown in Appendix 3 Form C. It is intended that Manufacturers of Micro-generators will use the requirements of this EREC G98 to develop type verification certification for each of their Micro-generator models.		P
6.1.2	Manufacturers of a Fully Type Tested Micro-generator should allocate a Manufacturer's reference number with the required details of the Micro-generator with the Energy Networks Association Type Test Verification Report Register.		P
6.2	Compliance		P
6.2.1	Compliance with the requirements detailed in this EREC G98 will ensure that the Micro-generator(s) is considered to be approved for connection to the DNO's Distribution Network.		P
6.2.2	The Micro-generator(s) shall conform to all relevant compliance and safety legislation.		P
6.3	Family approach to Type Testing		P
6.3.1	A family approach to type testing is acceptable, whereby Micro-generators that are the same model and produced by the same Manufacturer but vary in electrical output can be considered to be Fully Type Tested once one Micro-generator in the family has been shown to be compliant. The approach is permissible in the following range of Micro-generator electrical output:		P
	<ul style="list-style-type: none"> • For synchronous Micro-generators: <ul style="list-style-type: none"> o Lower limit: $1/\sqrt{10}$ (0.3162) times the tested Micro-generator nameplate rating (W) o Upper limit: $\sqrt{10}$ (3.162) times the tested Micro-generator nameplate rating (W) • For all other Micro-generators: <ul style="list-style-type: none"> o Lower limit: $1/\sqrt{10}$ (0.3162) times the tested Micro-generator nameplate rating (W) o Upper limit: 2 times the tested Micro-generator nameplate rating (W) 		P

Engineering recommendation G98/6			
Clause	Requirement – Test	Result – Remark	Verdict
6.3.2	All absolute values (e.g. operating range tests) from the tested Micro-generator shall be transferred directly in the compliance forms of an assumed compliant Micro-generator of the same family. All relative results related to design Active Power or current (e.g. power quality fluctuation and flicker) from the tested Micro-generator shall be transferred to the compliance form of a Micro-generator in the same family according to the ratio of the respective nameplate rating (W) of the tested Micro-generator and the assumed compliant Micro-generator. For the avoidance of doubt, the Manufacturer shall register each Micro-generator in the family on the Energy Networks Association Type Test register.		P
6.3.3	It is the responsibility of the Manufacturer to provide technical justification that the results are transferable. For example, the Micro-generators have the same control systems.		P
7	Operation and Safety		N/A
8	Commissioning, Notification and Decommissioning		N/A
9	General Technical Requirements		P
9.1	Frequency withstand		P
9.1.1	The Micro-generator shall be capable of remaining connected to the Distribution Network and operating within the frequency ranges and time periods specified in Table 1 unless disconnection was triggered by rate-of-change-of-frequency-type loss of mains protection.		P
9.2	Rate of Change of Frequency		P
9.2.1	With regard to the rate of change of frequency withstand capability, a Micro-generator shall be capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1.0 Hzs ⁻¹ measured over 500 ms.		P
9.3	Limited Frequency Sensitive Mode – Overfrequency		P
9.3.1	With regard to the Limited Frequency Sensitive Mode — Overfrequency (LFSM-O), the Micro-generator shall be capable of reducing its Active Power output when the frequency rises above 50.4 Hz. The Droop shall be 10%. No intentional delay should be programmed to ensure that the initial delay is as short as possible with a maximum of 2 s.	No intentional delay setting	P
9.3.2	The Micro-generator will continue to reduce power with rising frequency with a Droop of 10% until 52.0 Hz, at which point the Micro-generator should disconnect.		P
9.4	Active Power Output		P

Engineering recommendation G98/6			
Clause	Requirement – Test	Result – Remark	Verdict
9.4.1	The Micro-generator shall be capable of maintaining constant output at its Registered Capacity regardless of changes in frequency, except where the output follows the changes defined in the context of paragraphs 9.3.1 and 9.4.2.		P
9.4.2	The Micro-generator shall be capable of maintaining constant Active Power output at its Registered Capacity regardless of changes in frequency in the range 49.5 – 50.4 Hz. Below 49.5 Hz, the Active Power output should not drop by more than pro-rata with frequency, ie the maximum permitted requirement is 100% power at 49.5 Hz falling linearly to 95% power at 47.0 Hz as illustrated in Figure 3.		P
9.4.3	This paragraph describes an optional performance characteristic as discussed in the foreword. A Micro-generating Plant that incorporates an Electricity Storage device can support the Total System by being arranged to automatically respond to falling frequency in line with the characteristic of Figure 4. The required characteristics are: (a) When the frequency falls to 49.5 Hz the automatic response shall start; (b) The frequency response characteristic shall be within the shaded area of Figure 4; (c) If the Electricity Storage device is not capable of moving from an import level to an appropriate export level within 20 s of the frequency falling to 49.2 Hz, then it shall cease to import; and (d) If the Electricity Storage device has not achieved at least zero Active Power import when the frequency has reached 48.9 Hz it shall cease to import immediately.	RJ 45 interface is used for logic interface (input port), nevertheless, the logic interface can also be installed in the end system.	P
9.4.4	The Micro-generator shall be equipped with a logic interface (input port) in order to cease Active Power output within 5 s following an instruction being received from the DNO at the input port. By default the logic interface will take the form of a simple binary output that can be operated by a simple switch or contactor. When the switch is closed the Micro-generator can operate normally. When the switch is opened the Micro-generator will reduce its Active Power to zero within 5 s. The signal from the Micro-generator that is being switched can be either AC (maximum value 240 V) or DC (maximum value 110 V). The DNO may specify any additional requirements particularly regarding remote operation of this facility.		P
9.5	Power Factor		P

Engineering recommendation G98/6			
Clause	Requirement – Test	Result – Remark	Verdict
9.5.1	The power factor capability of the Micro-generator shall conform to EN 50549-1 as applicable to Micro-generating Plant. When operating at Registered Capacity the Micro-generator shall operate at a power factor within the range 0.95 lagging to 0.95 leading relative to the voltage waveform unless otherwise agreed with the DNO eg for power factor improvement.	A Fixed power factor at range 0.95 lagging to 0.95 leading	P
9.6	Automatic Connection		P
9.6.1	Micro-generators shall conform to EN 50549-1 in respect of connection and starting to generate electric power. Connection, reconnection and starting to generate electrical power is only allowed after the voltage and frequency at the Connection Point is within the limits of the Interface Protection settings for a minimum of 20 s.		P
9.7	Cyber Security		P
9.7.1	Every Micro-generator and any associated equipment must be designed and operated appropriately to ensure cyber security. The Manufacturer or Installer shall consider all cyber security risks applicable to the Micro-Generator both in terms of the communication between any home energy management system etc and also in terms of interaction with any system of the Manufacturer for product management.		P
9.7.2	The Manufacturer or Installer shall provide information describing the high level cyber security approach, as well as the specific cyber security requirements complied with. The statement will make appropriate reference to the Micro-generator's compliance with • ETSI EN 303 645; • relevant aspects of PAS 1879 "Energy smart appliances – Demand side response operation – Code of practice; • relevant aspects of "Distributed Energy Resources – Cyber Security Connection Guidance" published by BEIS and the ENA; • Any other relevant standard that has been incorporated in the design of the Micro-Generator.	The Generator has provided information describing the high level cyber security approach which complied with ETSI EN 303 645	P
10	Interface Protection		P
10.1	General		P
10.1.1	The Micro-generator shall conform to the Interface Protection settings set out below (Table 2). Means shall be provided to protect the settings from unpermitted interference (eg via a password or seal).	The settings for interface shall require a password or authored by manufactures	P

Engineering recommendation G98/6			
Clause	Requirement – Test	Result – Remark	Verdict
10.1.2	The DNO is responsible under the Distribution Code for ensuring, by design, that the voltage and frequency at the Connection Point remains within statutory limits. The Interface Protection settings have been chosen to allow for voltage rise or drop within the Customer's Installation and to allow the Micro-generator to continue to operate outside of the statutory frequency range as required by the EU Network Code on Requirements for Grid Connection of Generators.		P
10.1.3	Interface Protection shall be installed which disconnects the Micro-generator from the DNO's Distribution Network when any parameter is outside of the settings shown in Table 2.		P
10.1.4	The total disconnection time for voltage and frequency protection, including the operating time of the disconnection device, shall be the time delay setting with a tolerance of, -0s + 0.5 s.		P
10.1.5	For the avoidance of doubt, where the Distribution Network voltage or frequency exceed the trip settings in Table 2, for less than the time delay setting, the Micro-generator should not disconnect from the Distribution Network.		P
10.1.6	Fully Type Tested Micro-generators shall have protection settings set during manufacture.		P
10.1.7	The Manufacturer shall establish a secure way of displaying the Interface Protection setting information in one of the following ways: <ul style="list-style-type: none"> ● A display on a screen; ● A display on a PC which can communicate with the Micro-generator and confirm that it is the correct Micro-generator by means of a serial number permanently fixed to the Micro-generator and visible on the PC screen at the same time as the settings; or ● Display of all Interface Protection settings and nominal voltage and current outputs, alongside the serial number of the Micro-generator, permanently fixed to the Micro-generator. 		P
10.1.8	The provision of loose documents, documents attached to the Micro-generator by cable ties etc, or provision of data on adhesive paper based products which are not likely to survive due to fading, or failure of the adhesive, for at least 20 years is not acceptable.		P

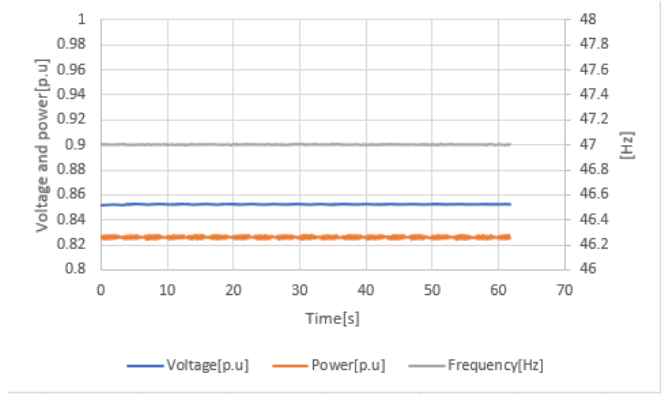
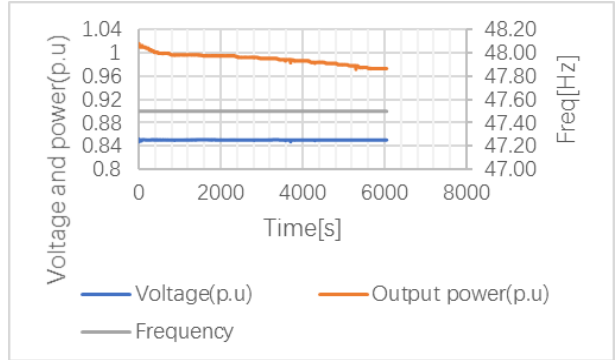
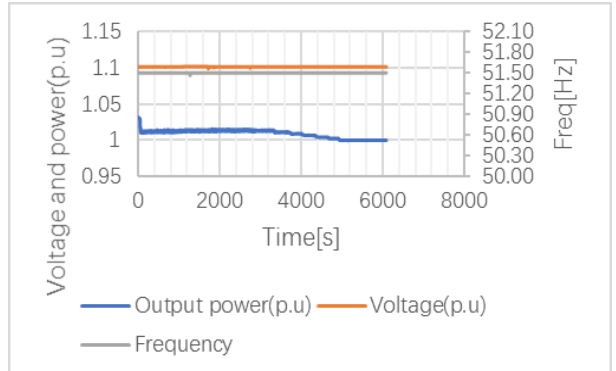
Engineering recommendation G98/6			
Clause	Requirement – Test	Result – Remark	Verdict
10.1.9	In response to a protection operation the Micro-generator shall be automatically disconnected from the DNO's Distribution Network. This disconnection must be achieved preferably by the separation of mechanical contacts or alternatively by the operation of a suitably rated solid state switching device. Where a solid state switching device is used to afford disconnection of the Micro-generator, the switching device shall incorporate fail safe monitoring to check the voltage level at its output stage. In the event that the solid state switching device fails to disconnect the Micro-generator, the voltage on the output side of the switching device shall be reduced to a value below 50 V within 0.5 s of the protection and trip delay timer operation.	Disconnected by relay	P
10.1.10	The Interface Protection shall function correctly, ie operate within the required tolerance range as given in paragraph 10.1.4, across the expected range of ambient operating temperatures and other environmental factors.		P
10.1.11	Where a common protection system is used to provide the protection function for multiple Micro-generators the complete installation cannot be considered to comprise Fully Type Tested Micro-generators if the protection and connections are made up on site and so cannot be factory tested or Fully Type Tested. In accordance with Annex A1 or Annex A2 if the units or Micro-generators are specifically designed with plugs and sockets to be interconnected on site, then provided the assembly passes the function tests required in Appendix 3 Form C, the Micro-generator(s) can retain Fully Type Tested status.		N/A
10.1.12	Once the Micro-generator has been installed and commissioned the protection settings shall only be altered following written agreement between the DNO and the Customer or their agent.		N/A
10.2	Loss of Mains Protection		P
10.2.1	Loss of mains protection shall be incorporated and tested as defined in the relevant compliance type testing annex of this EREC G98. Active methods which use impedance measuring techniques by drawing current pulses from or injecting AC currents into the DNO's Distribution Network are not considered to be suitable. For Micro-generators which generate on more than one phase, the loss of mains protection should be able to detect the loss of a single phase of the supply network. This should be tested during type testing and recorded in the Type Test Verification Report as per Appendix 3 Form C.		P

Engineering recommendation G98/6			
Clause	Requirement – Test	Result – Remark	Verdict
10.3	Frequency Drift and Step Change Stability Test		P
10.3.1	Under normal operation of the Distribution Network, the frequency changes over time due to continuous unbalance of load and generation or can experience a step change due to the loss of a Distribution Network component which does not cause a loss of supply.		P
10.3.2	In order to ensure that such phenomena do not cause unnecessary tripping of Micro-generators, stability type tests shall be carried out.		P
10.3.3	The Rate of Change of Frequency (RoCoF) and Vector Shift values required for these tests are marginally less than the corresponding protection settings for RoCoF in Table 2 and vector shifts of up to 50°. Both stability tests shall be carried out in all cases.		P
10.3.4	The stability tests are to be carried out as per the table in Appendix 3 Form C of this document and the Micro-generator should remain connected during each and every test. The tests shall check that the Micro-generator remains stable and connected during the following scenarios: <ul style="list-style-type: none"> ● RoCoF: 0.95 Hzs-1 from 49.0 Hz to 51.0 Hz on both rising and falling frequency; and ● Vector shift: 50° plus from 49.5 Hz and 50° minus from 50.5 Hz. 		P
11	Quality of Supply		P
11.1	Harmonics and voltage fluctuation		P
11.1.1	The connection and operation of a Micro-generator in parallel with a DNO's Distribution Network shall not impair the quality of supply provided by the DNO to any Customers. In this respect the Micro-generator shall comply with: <ul style="list-style-type: none"> • EN 61000-3-2 Class A for harmonics; and • EN 61000-3-3 for voltage fluctuation and flicker with a dmax value of 4%. <p>Micro-generators are likely to be installed in large numbers on LV Distribution Networks. They are likely to operate for long periods with no diversity between them, and adjacent Micro-generators are likely to be of the same technology. Therefore, in order to accommodate a high number of Micro-generators on a Distribution Network, procedures are specified in Annex A1 and Annex A2, which need to be applied when testing for harmonics, voltage fluctuations, flicker and DC injection.</p>		P
11.2	DC injection		P

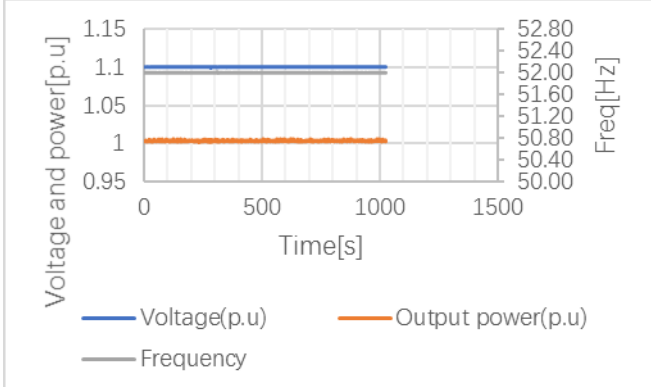
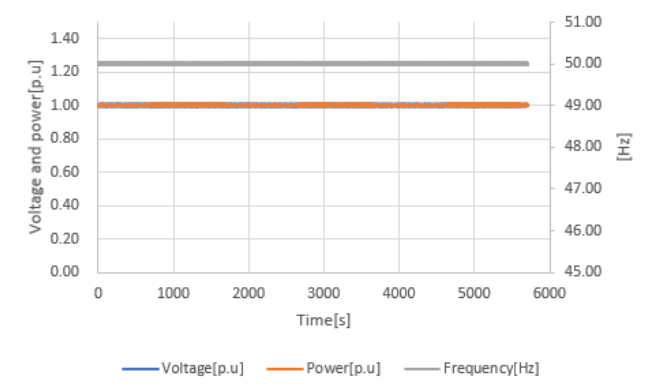
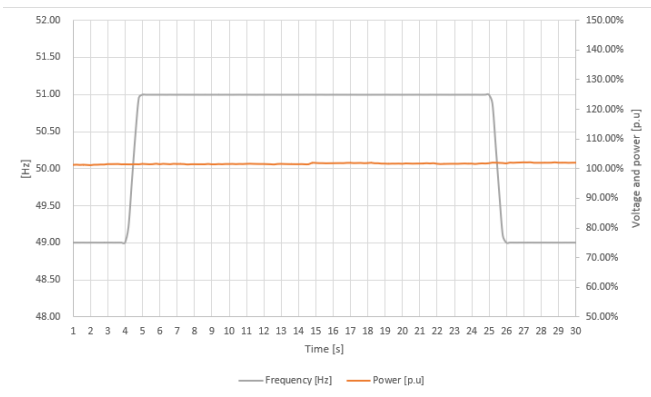
Engineering recommendation G98/6			
Clause	Requirement – Test	Result – Remark	Verdict
11.2.1	The upper limit for DC injection is 0.25% of AC current rating per phase.		P
11.3	Electromagnetic Compatibility (EMC)		P
11.3.1	All equipment shall conform to the generic EMC standards: BS EN61000-6-3: Electromagnetic Compatibility, Generic Emission Standard; and BS EN61000-6-1: Electromagnetic Compatibility, Generic Immunity Standard.	Refer to: 161008077GZU-001: 29 Nov., 2016	P
11.4	Short Circuit Current Contribution.		P
11.4.1	Directly Coupled Micro-generators		N/A
11.4.2	Inverter Connected Micro-generators		P
Appendix 1	Emerging Technologies and other Exceptions		N/A
Appendix 2	Connection Procedure Flow Chart		N/A
Appendix 3	Micro-generator Documentation		N/A
Appendix 4	Relaxation of Commissioning Notification Timescales for Micro-generator: HSE Certificate of Exemption (August 2008)		N/A
A1	Annex A1 Requirements for Type Testing of Inverter Connected Micro-generators		P
A1.2	Type Verification Functional Testing of the Interface Protection		P
A1.2.1	Disconnection times		P
A1.2.2	Over / Under Voltage		P
A1.2.3	Over / Under Frequency		P
A1.2.4	Loss of Mains Protection		P
A1.2.5	Reconnection		P
A1.2.6	Frequency Drift and Step Change Stability test		P
A1.2.7	Active power feed-in at under-frequency		P
A1.2.8	Micro-generators which include Electricity Storage		N/A
A1.2.9	Power response to over-frequency		P
A1.2.10	Operating Range		P
A1.3	POWER QUALITY		P
A1.3.1	Harmonics		P
A1.3.2	Power Factor		P
A1.3.3	Voltage Flicker		P
A1.3.4	DC Injection for Inverters		P
A1.3.5	Short Circuit Current Contribution for Inverters		P
A1.3.6	Self-Monitoring - Solid State Disconnection		N/A

Engineering recommendation G98/6			
Clause	Requirement – Test	Result – Remark	Verdict
A.2	Annex A2 Requirements for Type Testing of Synchronous Micro-generators		N/A

Appendix 1: Testing table

<p>Operating Range: This test should be carried out as specified in A.1.2.10.</p> <p>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.</p>	
<p>Test 1</p> <p>Voltage = 85% of nominal (195.5 V)</p> <p>Frequency = 47.0 Hz</p> <p>Power factor = 1</p> <p>Period of test 20 seconds</p>	
<p>Test 2</p> <p>Voltage = 85% of nominal (195.5 V)</p> <p>Frequency = 47.5 Hz</p> <p>Power factor = 1</p> <p>Period of test 90 minutes</p>	
<p>Test 3</p> <p>Voltage = 110% of nominal (253 V).</p> <p>Frequency = 51.5 Hz</p> <p>Power factor = 1</p> <p>Period of test 90 minutes</p>	

Appendix 1: Testing table

<p>Test 4</p> <p>Voltage = 110% of nominal (253 V).</p> <p>Frequency = 52.0 Hz</p> <p>Power factor = 1</p> <p>Period of test 15 minutes</p>	 <p>Graph showing Voltage (p.u.), Output power (p.u.), and Frequency (Hz) over Time (s). The x-axis represents Time in seconds (0 to 1500). The left y-axis represents Voltage and power in per unit (0.95 to 1.15). The right y-axis represents Frequency in Hz (50.00 to 52.80). Voltage (blue line) is constant at 1.1 p.u. Output power (orange line) is constant at 1.0 p.u. Frequency (grey line) is constant at 52.0 Hz.</p>
<p>Test 5</p> <p>Voltage = 100% of nominal (230 V).</p> <p>Frequency = 50.0 Hz</p> <p>Power factor = 1</p> <p>Period of test 90 minutes</p>	 <p>Graph showing Voltage (p.u.), Power (p.u.), and Frequency (Hz) over Time (s). The x-axis represents Time in seconds (0 to 6000). The left y-axis represents Voltage and power in per unit (0.00 to 1.40). The right y-axis represents Frequency in Hz (45.00 to 51.00). Voltage (blue line) is constant at 1.0 p.u. Power (orange line) is constant at 1.0 p.u. Frequency (grey line) is constant at 50.0 Hz.</p>
<p>Test 6 RoCoF withstand</p> <p>Confirm that the Micro-Generating Plant 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.</p>	 <p>Graph showing Frequency (Hz) and Power (p.u.) over Time (s). The x-axis represents Time in seconds (1 to 30). The left y-axis represents Frequency in Hz (48.00 to 52.00). The right y-axis represents Voltage and power in per unit (50.00% to 150.00%). Frequency (grey line) ramps up from 49.00 Hz to 51.00 Hz between 4s and 5s, remains constant at 51.00 Hz until 25s, and then ramps back down to 49.00 Hz between 26s and 27s. Power (orange line) remains constant at 1.0 p.u. throughout the test.</p>

Appendix 1: Testing table

Power Quality – Harmonics: These tests should be carried out as specified in BS EN 61000-3-2. The chosen test should be undertaken with a fixed source of energy at two power levels a) between 45 and 55% and b) at 100% of Registered Capacity. The test requirements are specified in Annex A1 A.1.3.1 (Inverter connected) or Annex A2 A.2.3.1 (Synchronous).

Micro-generator tested to BS EN 61000-3-2				
Micro-generator rating per phase (rpp)		3.0	kW	
Harmonic	At 45-55% of Registered Capacity			
	Measured Value MV in Amps	%	Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
	L1	L1		
2	0.0143	0.0011	1.080	
3	0.0835	0.0064	2.300	
4	0.0112	0.0009	0.430	
5	0.0323	0.0025	1.140	
6	0.0143	0.0011	0.300	
7	0.0108	0.0008	0.770	
8	0.0176	0.0014	0.230	
9	0.0206	0.0016	0.400	
10	0.0130	0.0010	0.184	
11	0.0215	0.0017	0.330	
12	0.0125	0.0010	0.153	
13	0.0235	0.0018	0.210	
14	0.0100	0.0008	0.131	
15	0.0252	0.0019	0.150	
16	0.0087	0.0007	0.115	
17	0.0248	0.0019	0.132	
18	0.0088	0.0007	0.102	
19	0.0234	0.0018	0.118	
20	0.0091	0.0007	0.092	
21	0.0201	0.0015	0.107	0.160
22	0.0076	0.0006	0.084	
23	0.0175	0.0013	0.098	0.147
24	0.0101	0.0008	0.077	
25	0.0166	0.0013	0.090	0.135
26	0.0105	0.0008	0.071	
27	0.0151	0.0012	0.083	0.124
28	0.0051	0.0004	0.066	
29	0.0131	0.0010	0.078	0.117
30	0.0012	0.0001	0.061	
31	0.0113	0.0009	0.073	0.109
32	0.0015	0.0001	0.058	
33	0.0102	0.0008	0.068	0.102
34	0.0025	0.0002	0.054	
35	0.0095	0.0007	0.064	0.096
36	0.0036	0.0003	0.051	
37	0.0080	0.0006	0.061	0.091
38	0.0023	0.0002	0.048	
39	0.0087	0.0007	0.058	0.087
40	0.0022	0.0002	0.046	

Test Model: ME 3000SP

Note the higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below.

Appendix 1: Testing table

Power Quality – Harmonics: These tests should be carried out as specified in BS EN 61000-3-2. The chosen test should be undertaken with a fixed source of energy at two power levels a) between 45 and 55% and b) at 100% of Registered Capacity. The test requirements are specified in Annex A1 A.1.3.1 (Inverter connected) or Annex A2 A.2.3.1 (Synchronous).

Micro-generator tested to BS EN 61000-3-2

Micro-generator rating per phase (rpp)		3.0	kW		
Harmonic	At 100% of Registered Capacity				
	Measured Value MV in Amps	%		Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
	L1	L1			
2	0.0219	0.0017		1.080	
3	0.1033	0.0079		2.300	
4	0.0093	0.0007		0.430	
5	0.0356	0.0027		1.140	
6	0.0137	0.0011		0.300	
7	0.0279	0.0021		0.770	
8	0.0134	0.0010		0.230	
9	0.0350	0.0027		0.400	
10	0.0125	0.0010		0.184	
11	0.0416	0.0032		0.330	
12	0.0099	0.0008		0.153	
13	0.0429	0.0033		0.210	
14	0.0099	0.0008		0.131	
15	0.0425	0.0033		0.150	
16	0.0066	0.0005		0.115	
17	0.0397	0.0031		0.132	
18	0.0088	0.0007		0.102	
19	0.0363	0.0028		0.118	
20	0.0087	0.0007		0.092	
21	0.0324	0.0025		0.107	0.160
22	0.0072	0.0006		0.084	
23	0.0294	0.0023		0.098	0.147
24	0.0088	0.0007		0.077	
25	0.0254	0.0020		0.090	0.135
26	0.0081	0.0006		0.071	
27	0.0223	0.0017		0.083	0.124
28	0.0110	0.0008		0.066	
29	0.0203	0.0016		0.078	0.117
30	0.0044	0.0003		0.061	
31	0.0185	0.0014		0.073	0.109
32	0.0028	0.0002		0.058	
33	0.0156	0.0012		0.068	0.102
34	0.0043	0.0003		0.054	
35	0.0134	0.0010		0.064	0.096
36	0.0040	0.0003		0.051	
37	0.0110	0.0008		0.061	0.091
38	0.0041	0.0003		0.048	
39	0.0108	0.0008		0.058	0.087
40	0.0036	0.0003		0.046	

Test Model: ME 3000SP

Note the higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below.

Appendix 1: Testing table

Power Quality – Voltage fluctuations and Flicker: These tests should be undertaken in accordance with EREC G98 Annex A1 A.1.3.3 (Inverter connected) or Annex A2 A.2.3.3 (Synchronous).

The standard test impedance is 0.4 Ω for a single phase Micro-generating Plant (and for a two phase unit in a three phase system) and 0.24 Ω for a three phase Micro-generating Plant (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):

$d \text{ max normalised value} = (\text{Standard impedance} / \text{Measured impedance}) \times \text{Measured value}.$

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	27 Apr 2022			Test end date	27 Apr 2022				
Test location	Intertek Testing Services Shenzhen Ltd. Guangzhou Branch								
	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	L1	0.176	0.039	0.00	0.176	0.039	0.00	0.041	0.029
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	0.4	Ω	X	0.25			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 and split single phase Micro-generators. Delete as appropriate.

^ Applies to single phase Micro-generators and Micro-generators using two phases on a three phase system. Delete as appropriate.

Appendix 1: Testing table

<p>Power quality – DC injection: This test should be carried out in accordance with A 1.3.4 as applicable.</p> <p>The % DC injection (“as % of rated AC current” below) is calculated as follows:</p> <p>% DC injection = Recorded DC value in Amps / base current</p> <p>where the base current is the Registered Capacity (W) / 230 V. The % DC injection should not be greater than 0.25%.</p>												
Model: ME 3000SP												
Test power level	20%			50%			75%			100%		
Phase	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Recorded value in Amps	0.023	--	--	0.026	--	--	0.023	--	--	0.019	--	--
as % of rated AC current	0.17%	--	--	0.20%	--	--	0.18%	--	--	0.14%	--	--
Limit	0.25%			0.25%			0.25%			0.25%		

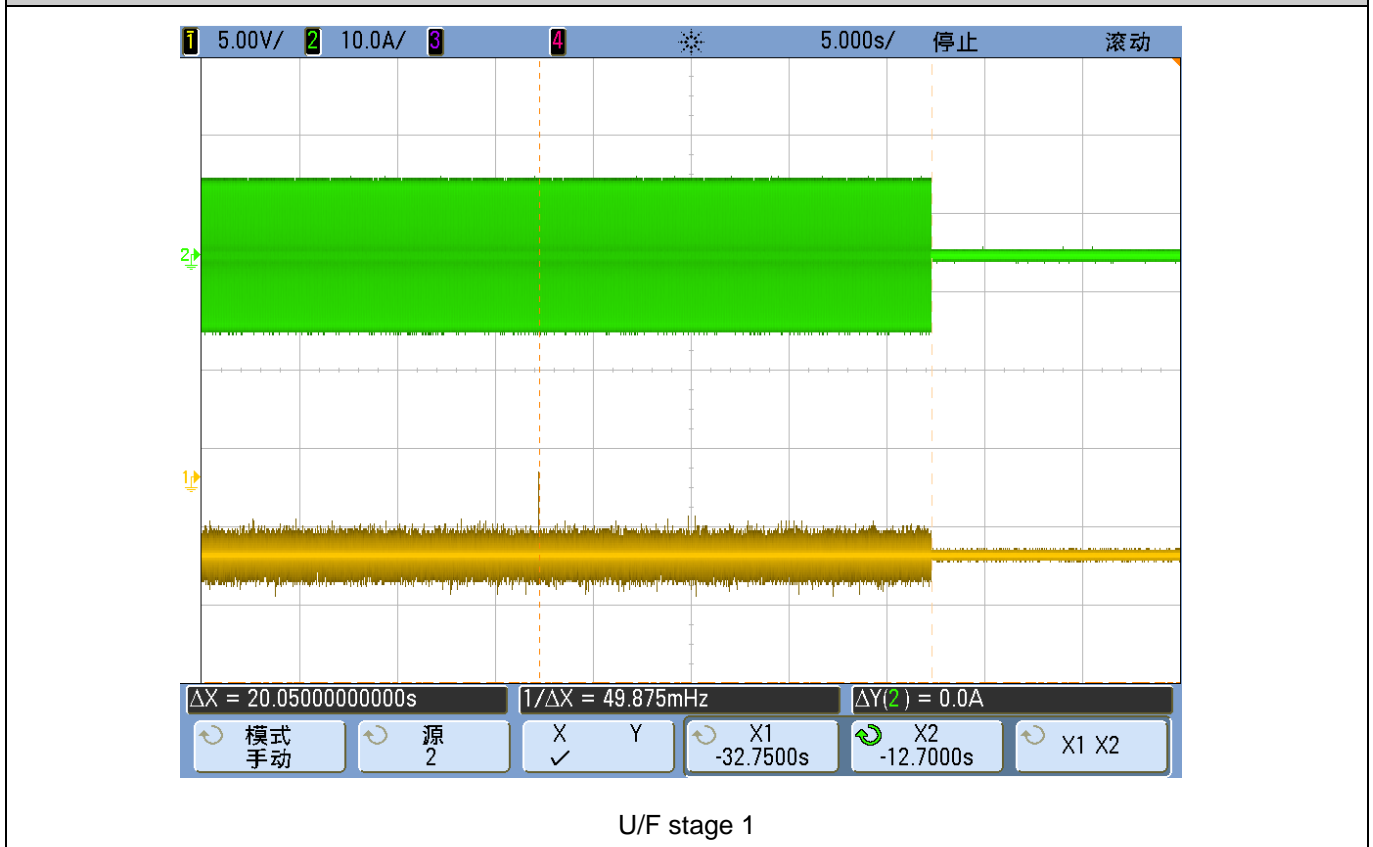
Appendix 1: Testing table

Power Quality – Power factor: This test shall be carried out in accordance with A.1.3.2 and A.2.3.2 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 $\pm 1.5\%$ of the stated level during the test.			
	216.2 V	230 V	253 V
20% of Registered Capacity	0.9820	0.9781	0.9714
50% of Registered Capacity	0.9966	0.9958	0.9943
75% of Registered Capacity	0.9981	0.9977	0.9971
100% of Registered Capacity	0.9986	0.9984	0.9981
Limit	>0.95	>0.95	>0.95

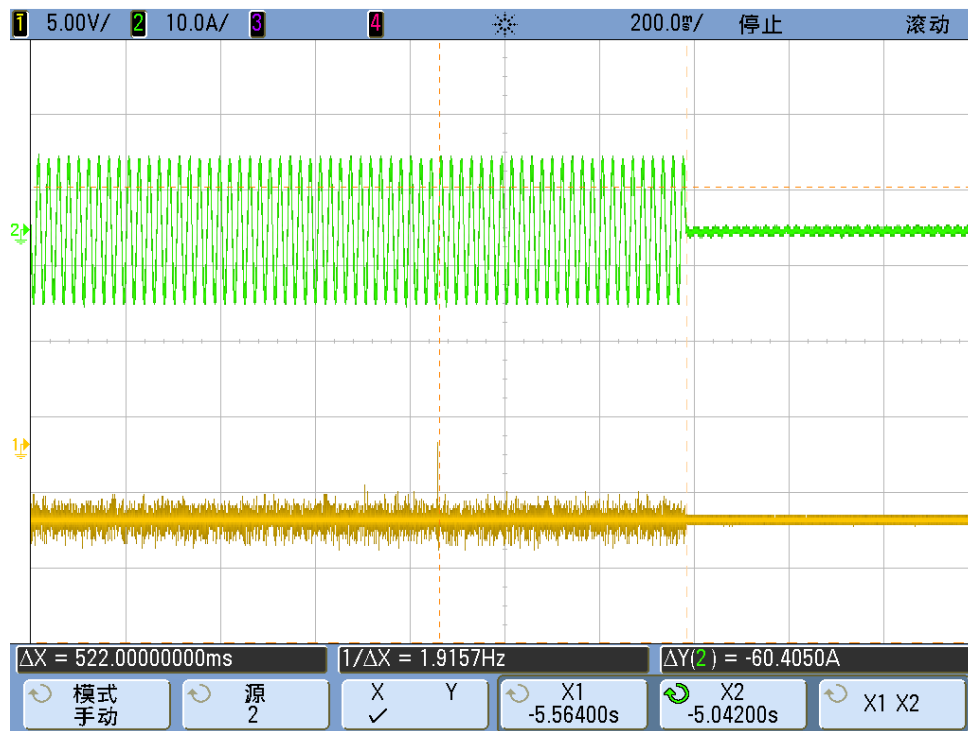
Appendix 1: Testing table

Protection – Frequency tests: These tests should be carried out in accordance with Annex A1 A.1.2.3 (Inverter connected) or Annex A2 A.2.2.3 (Synchronous). 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	47.48Hz	20.05s	47.7 Hz 30.0 s	No trip
U/F stage 2	47 Hz	0.5 s	46.96Hz	0.522s	47.2 Hz 19.5 s	20.1s trip
					46.8 Hz 0.45 s	0.524s trip
O/F stage 1	52 Hz	0.5 s	52.01Hz	0.510s	51.8 Hz 120.0s	No trip
					52.2 Hz 0.45 s	0.532s trip

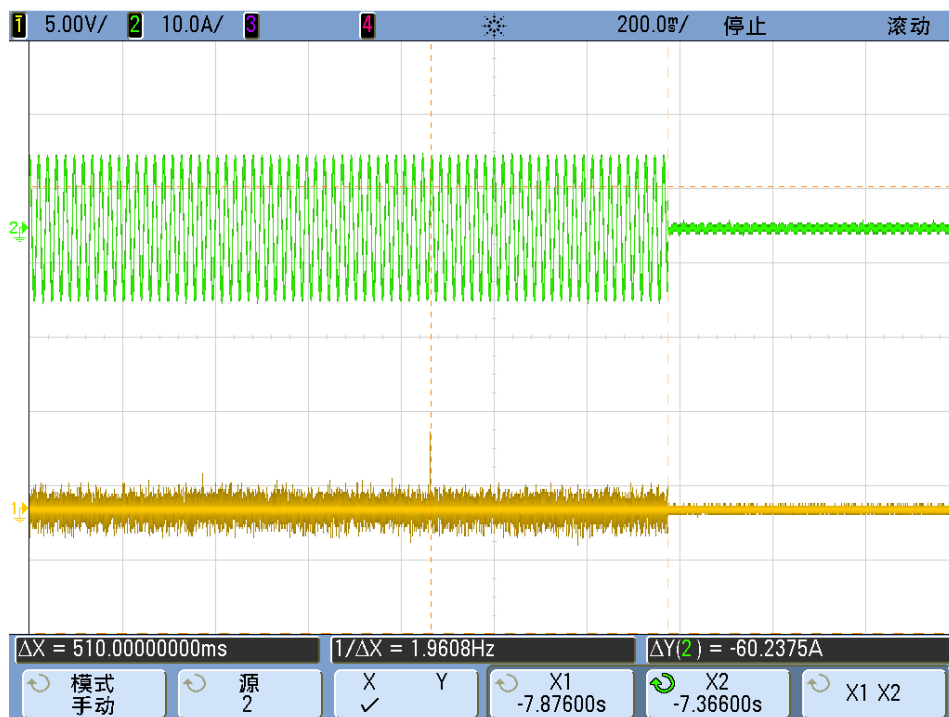
Note. For frequency trip tests the frequency required to trip is the setting ± 0.1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0.2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.



Appendix 1: Testing table



U/F stage 2



O/F stage 1

CH2: Current of EUT; CH1: trip signal

Appendix 1: Testing table

Protection – Voltage tests: These tests should be carried out in accordance with Annex A1 A.1.2.2 (Inverter connected) or Annex A2 A.2.2.2 (Synchronous). 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	184 V	2.5 s	183.37V	2.53s	188 V 5.0 s	No trip
					180 V 2.45 s	2.537s trip
O/V stage 1	262.2 V	1.0 s	261.9V	1.01s	258.2 V 5.0 s	No trip
O/V stage 2	273.7 V	0.5 s	273.3V	0.515s	269.7 V 0.95 s	1.05s trip
					277.7 V 0.45 s	0.517s trip

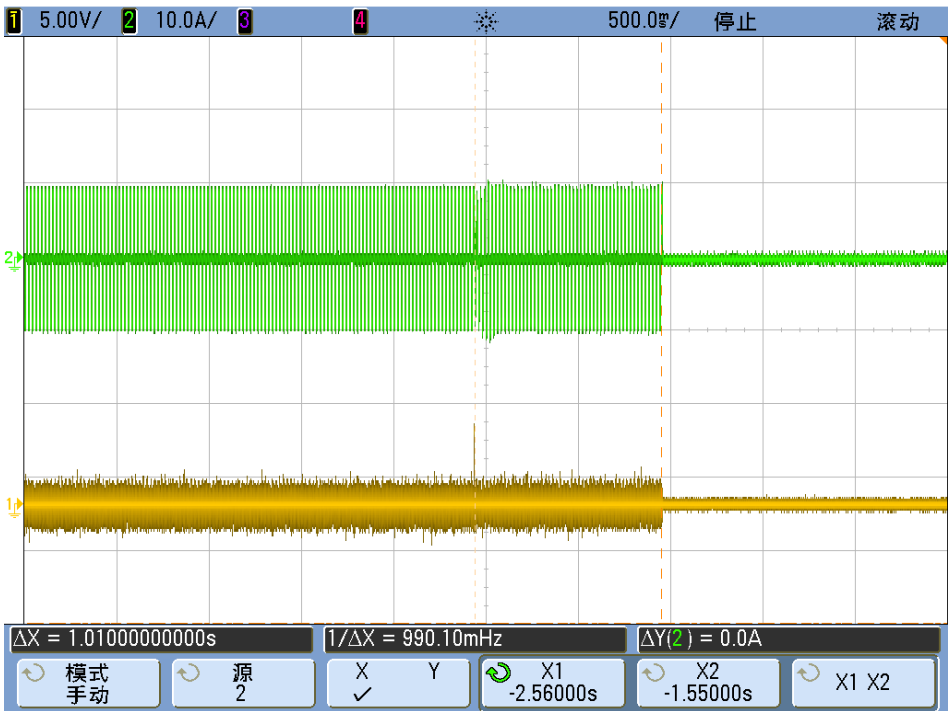
Note for Voltage tests the Voltage required to trip is the setting ± 3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ± 4 V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.



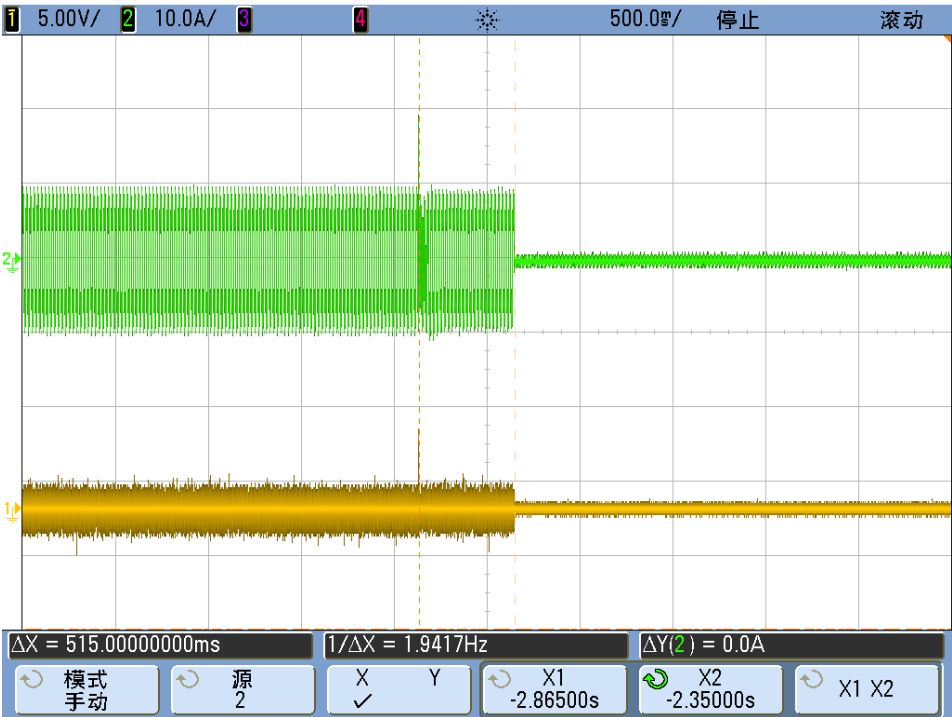
U/V

CH1: Voltage of EUT; CH4: Current of EUT; CH2: trip signal

Appendix 1: Testing table



O/V stage 1



O/V stage 2

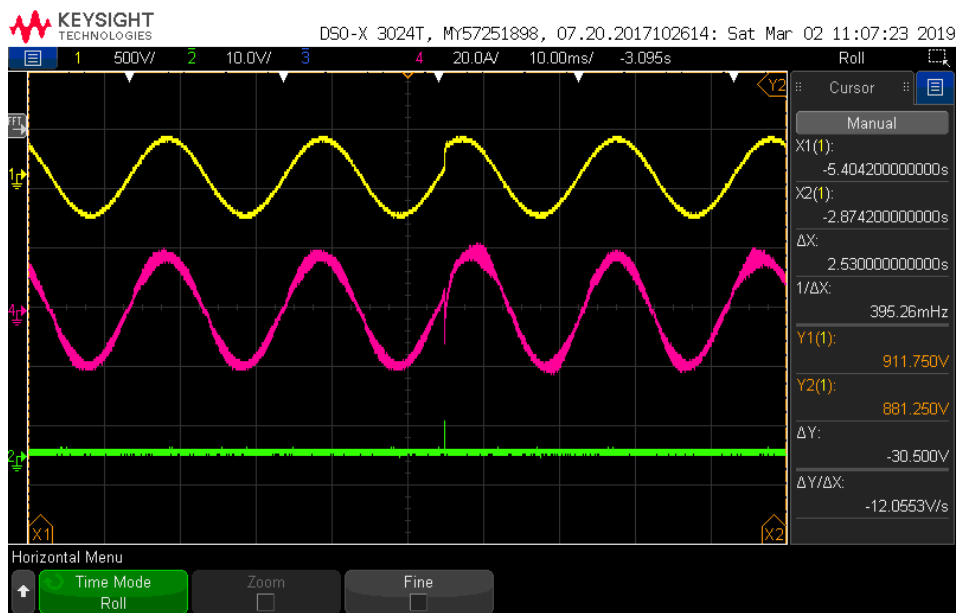
Appendix 1: Testing table

Protection – Loss of Mains test: For PV Inverters shall be tested in accordance with BS EN 62116. Other Micro-generators should be tested in accordance with A.2.2.4 at 10%, 55% and 100% of rated power.						
To be carried out at three output power levels with a tolerance of plus or minus 5% in Test Power levels.						
Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of Registered Capacity	95% of Registered Capacity	95% of Registered Capacity	105% of Registered Capacity	105% of Registered Capacity	105% of Registered Capacity
Trip time. Limit is 0.5 s	201.5ms	209.0ms	298.0ms	263.0ms	288.0ms	287.0ms
For Multi phase Micro-generators confirm that the device shuts down correctly after the removal of a single fuse as well as operation of all phases.						
Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of Registered Capacity	95% of Registered Capacity	95% of Registered Capacity	105% of Registered Capacity	105% of Registered Capacity	105% of Registered Capacity
Trip time. Ph1 fuse removed	--	--	--	--	--	--
Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of Registered Capacity	95% of Registered Capacity	95% of Registered Capacity	105% of Registered Capacity	105% of Registered Capacity	105% of Registered Capacity
Trip time. Ph2 fuse removed	--	--	--	--	--	--
Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of Registered Capacity	95% of Registered Capacity	95% of Registered Capacity	105% of Registered Capacity	105% of Registered Capacity	105% of Registered Capacity
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		
Additional comments:						

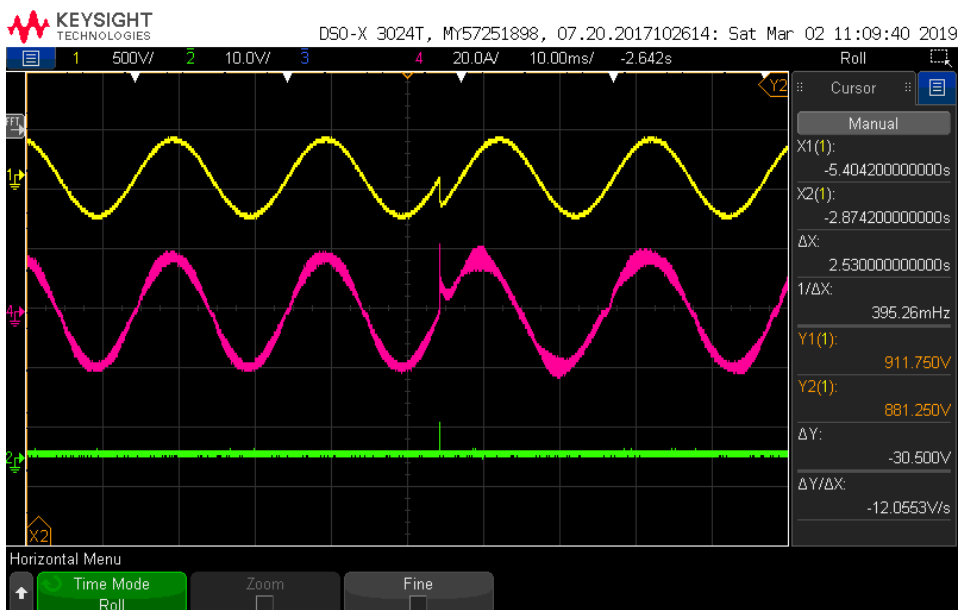
For Inverters tested to BS EN 62116 the following sub set of tests should be recorded in the following table.						
Test Power and imbalance	33% -5% Q Test 22	66% -5% Q Test 12	100% -5% P Test 5	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
Trip time. Limit is 0.5 s	--	--	--	--	--	--

Appendix 1: Testing table

Protection – Frequency change, Vector Shift Stability test: This test should be carried out in accordance with EREC G98 Annex A1 A.1.2.6 (Inverter connected) or Annex A2 A.2.2.6 (Synchronous). Confirmation is required that the Micro-generating Plant does not trip under positive / negative vector shift.			
	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.0 Hz	+50 degrees	No trip
Negative Vector Shift	50.0 Hz	- 50 degrees	No trip



Positive Vector Shift

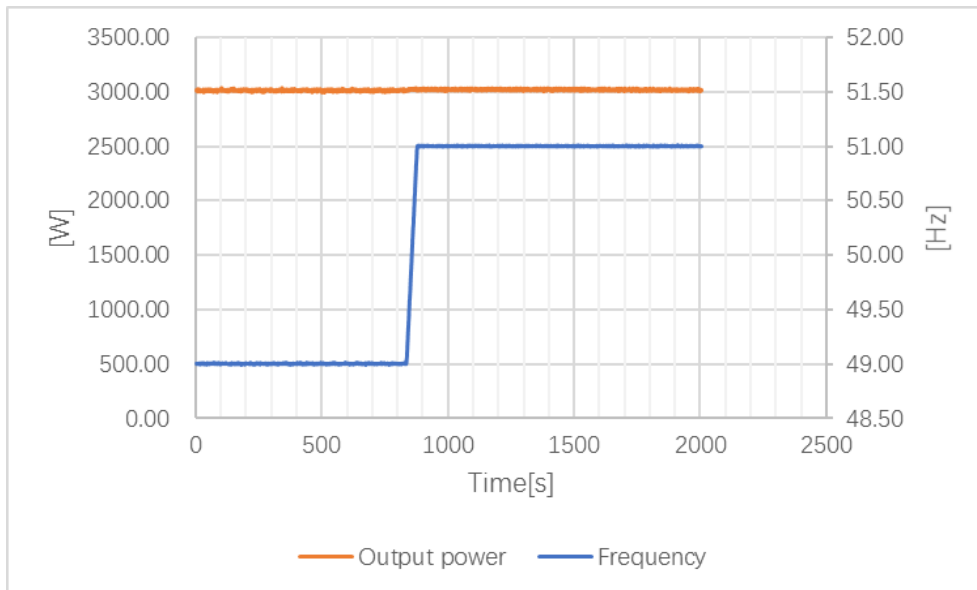


Negative Vector Shift

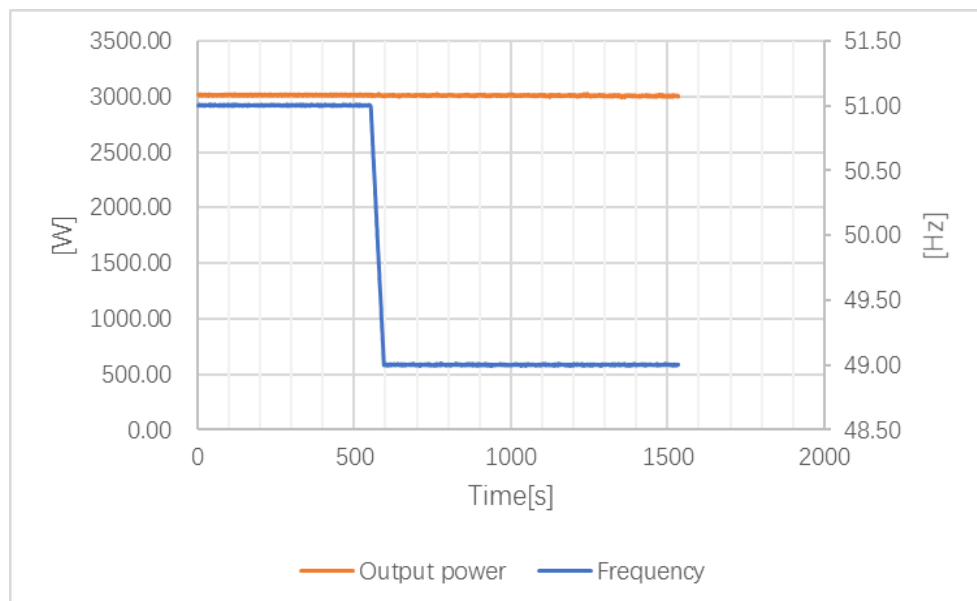
Appendix 1: Testing table

Protection – Frequency change, RoCoF Stability test: The requirement is specified in section 11.3, test procedure in Annex A.1.2.6 (Inverter connected) or Annex A2 A.2.2.6 (Synchronous). Confirmation is required that the Micro-generating Plant 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	No trip
51.0 Hz to 49.0 Hz	-0.95 Hzs ⁻¹	2.1 s	No trip



49.0 Hz to 51.0 Hz

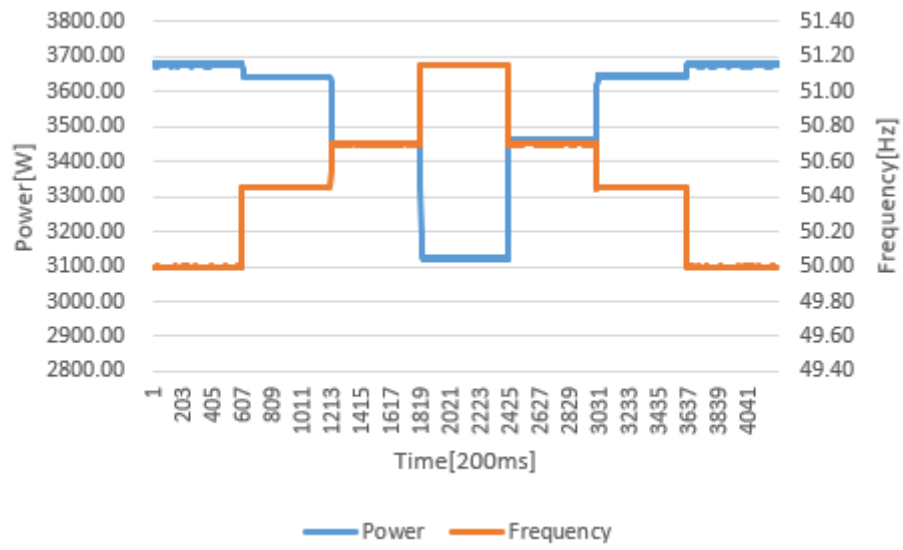


51.0 Hz to 49.0 Hz

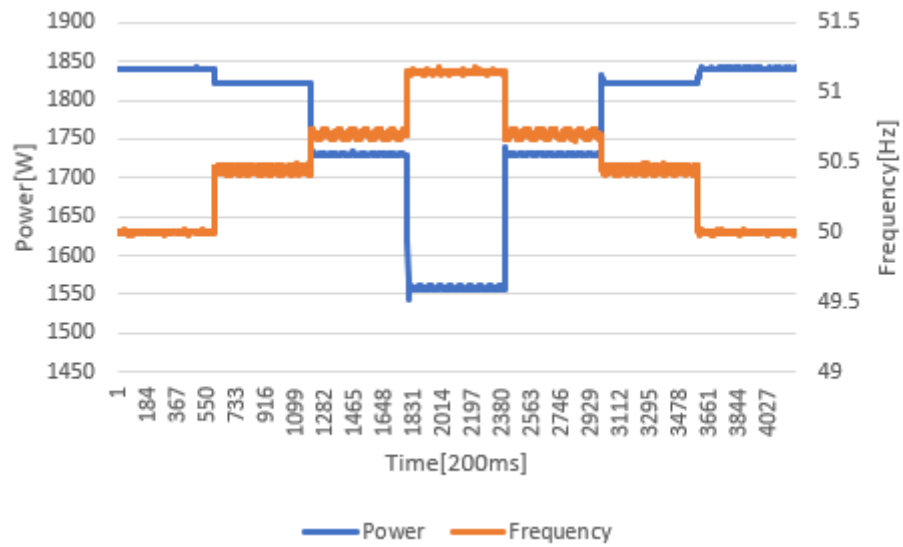
Appendix 1: Testing table

Limited Frequency Sensitive Mode – Overfrequency test: This test should be carried out in accordance with A.1.2.8. The test should be carried out using the specific threshold frequency of 50.4 Hz and Droop of 10%. The measurement tolerances are contained in A.1.2.8.				
Test sequence at Registered Capacity >80%	Measured Active Power Output	Frequency	Primary Power Source	Active Power Gradient Droop(%)
Step a) 50.00 Hz ± 0.01 Hz	3002.91W	50.00Hz	3139.53W	N/A
Step b) 50.45 Hz ± 0.05 Hz	2973.52W	50.45Hz		10.14
Step c) 50.70 Hz ± 0.10 Hz	2823.62W	50.70Hz		10.03
Step d) 51.15 Hz ± 0.05 Hz	2553.79W	51.15Hz		10.02
Step e) 50.70 Hz ± 0.10 Hz	2822.44W	50.70Hz		9.96
Step f) 50.45 Hz ± 0.05 Hz	2972.98W	50.45Hz		9.96
Step g) 50.00 Hz ± 0.01 Hz	3003.31W	50.00Hz		N/A
Test sequence at Registered Capacity 40% - 60%	Measured Active Power Output	Frequency	Primary Power Source	Active Power Gradient Droop(%)
Step a) 50.00 Hz ± 0.01 Hz	1502.20W	50.00Hz	1581.75W	N/A
Step b) 50.45 Hz ± 0.05 Hz	1472.26W	50.45Hz		9.84
Step c) 50.70 Hz ± 0.10 Hz	1319.08W	50.70Hz		9.80
Step d) 51.15 Hz ± 0.05 Hz	1058.18W	51.15Hz		10.12
Step e) 50.70 Hz ± 0.10 Hz	1319.67W	50.70Hz		9.83
Step f) 50.45 Hz ± 0.05 Hz	1472.31W	50.45Hz		9.86
Step g) 50.00 Hz ± 0.01 Hz	1503.30W	50.00Hz		N/A

Appendix 1: Testing table



Test at Registered Capacity of 100%

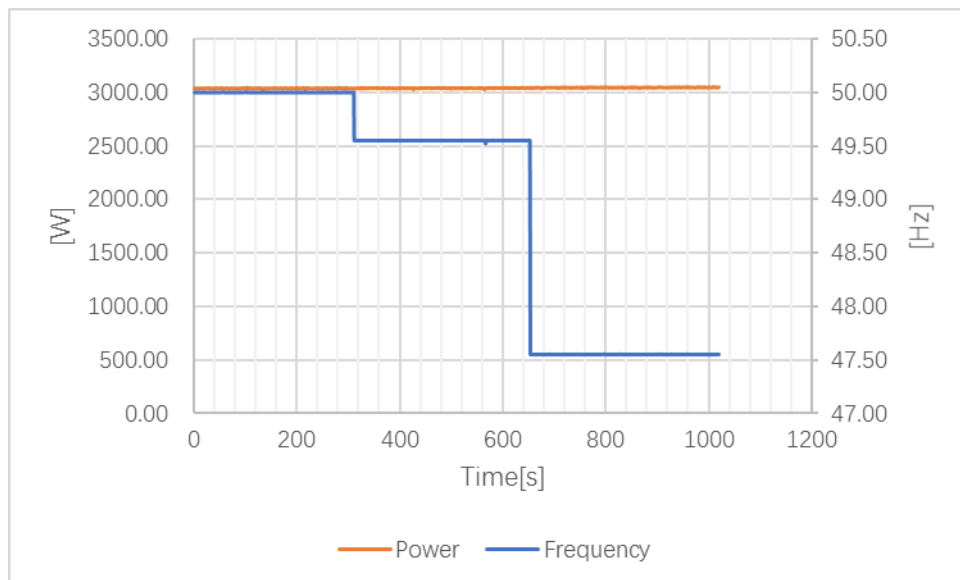


Test at Registered Capacity of 50%

Appendix 1: Testing table

Power output with falling frequency test: This test should be carried out in accordance with A.1.2.7.			
Test sequence	Measured Active Power Output	Frequency	Primary power source
Test a) 50 Hz \pm 0.01 Hz	3036.26W	50.00Hz	3281.28W
Test b) Point between 49.5 Hz and 49.6 Hz	3038.11W	49.55Hz	3286.85W
Test c) Point between 47.5 Hz and 47.6 Hz	3042.95W	47.55Hz	3294.60W

NOTE: The operating point in Test (b) and (c) shall be maintained for at least 5 minutes



Appendix 1: Testing table

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 2. 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 Micro-generating Plant 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 2.			
60s	70.2s	At 266.2 V	At 180.0V	At 47.4 Hz	At 52.1 Hz
Confirmation that the Micro-generator does not re-connect.		Not reconnection	Not reconnection	Not reconnection	Not reconnection

Fault level contribution: These tests shall be carried out in accordance with EREC G98 Annex A1 A.1.3.5 (Inverter connected) and Annex A2 A.2.3.4 (Synchronous). Please complete each entry, even if the fault contribution is zero.					
For machines with electro-magnetic output			For Inverter output		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p	--	20 ms	110V	11.95A
Initial Value of aperiodic current	A	--	100 ms	112V	11.95A
Initial symmetrical short-circuit current*	I_k	--	250 ms	-78.3V	0A
Decaying (aperiodic) component of short circuit current*	i_{DC}	--	500 ms	-67.0V	0A
Reactance/Resistance Ratio of source*	X/R	2.5	Time to trip	0.218	In seconds
For rotating machines and linear piston machines the test should produce a 0 s – 2 s plot of the short circuit current as seen at the Micro-generator terminals.					
* Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot					

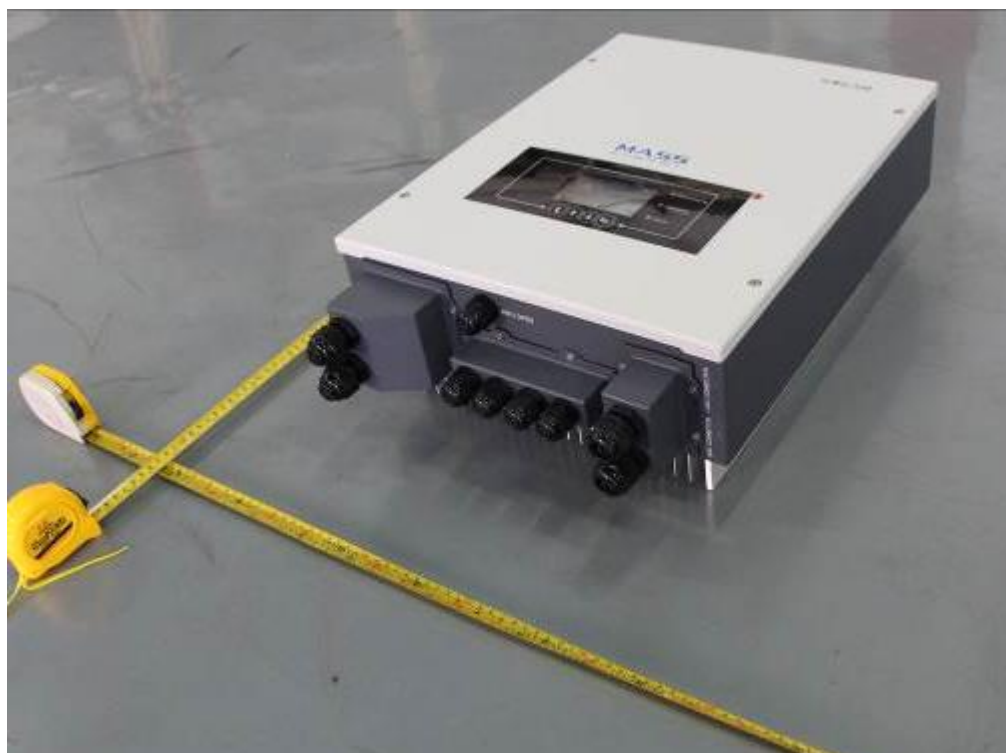
Appendix 1: Testing table

Logic Interface (input port)	
Confirm that an input port is provided and can be used to reduce the Active Power output to zero	Yes
Provide high level description of logic interface, e.g. details in 9.4.3 such as AC or DC signal (the additional comments box below can be used)	Yes
Self-Monitoring solid state switching: No specified test requirements. Refer to EREC G98 Annex A1 A.1.3.6 (Inverter connected).	N/A
It has been verified that in the event of the solid state switching device failing to disconnect the Micro-generator, the voltage on the output side of the switching device is reduced to a value below 50 V within 0.5 s.	N/A
Cyber security	
Confirm that the Manufacturer or Installer of the Micro-generator has provided a statement describing how the Micro-generator has been designed to comply with cyber security requirements, as detailed in 9.7.	Yes The Manufacturer of the Micro-generator has provided a statement describing how the Micro-generator has been designed to comply with cyber security requirements in 9.7.
Additional comments	
the DNO logic interface will take the form of a simple binary output that can be operated by the relay. When the relay is opened the Power Generating Module can operate normally. When the relay is closed the Power Generating Module will reduce its Active Power to zero within 5 s. The signal from the Power Generating Module that is being switched is DC (maximum value 110 V)	

Appendix 1: photos



Overview



Overview

Appendix 1: photos

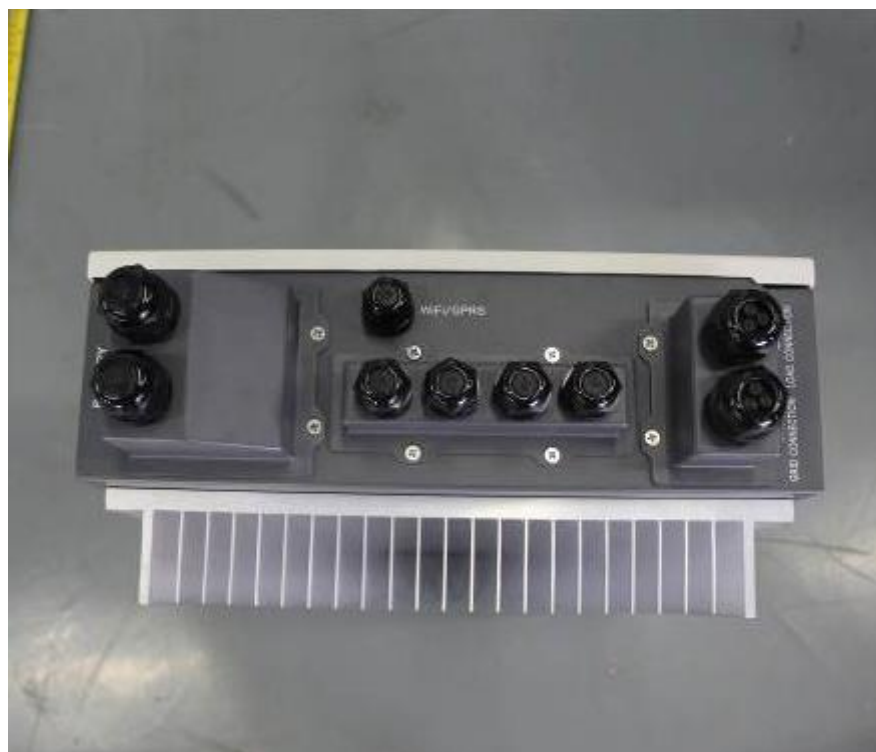


Top view



Heatsink view

Appendix 1: photos



Terminal view



Terminal view

Appendix 1: photos

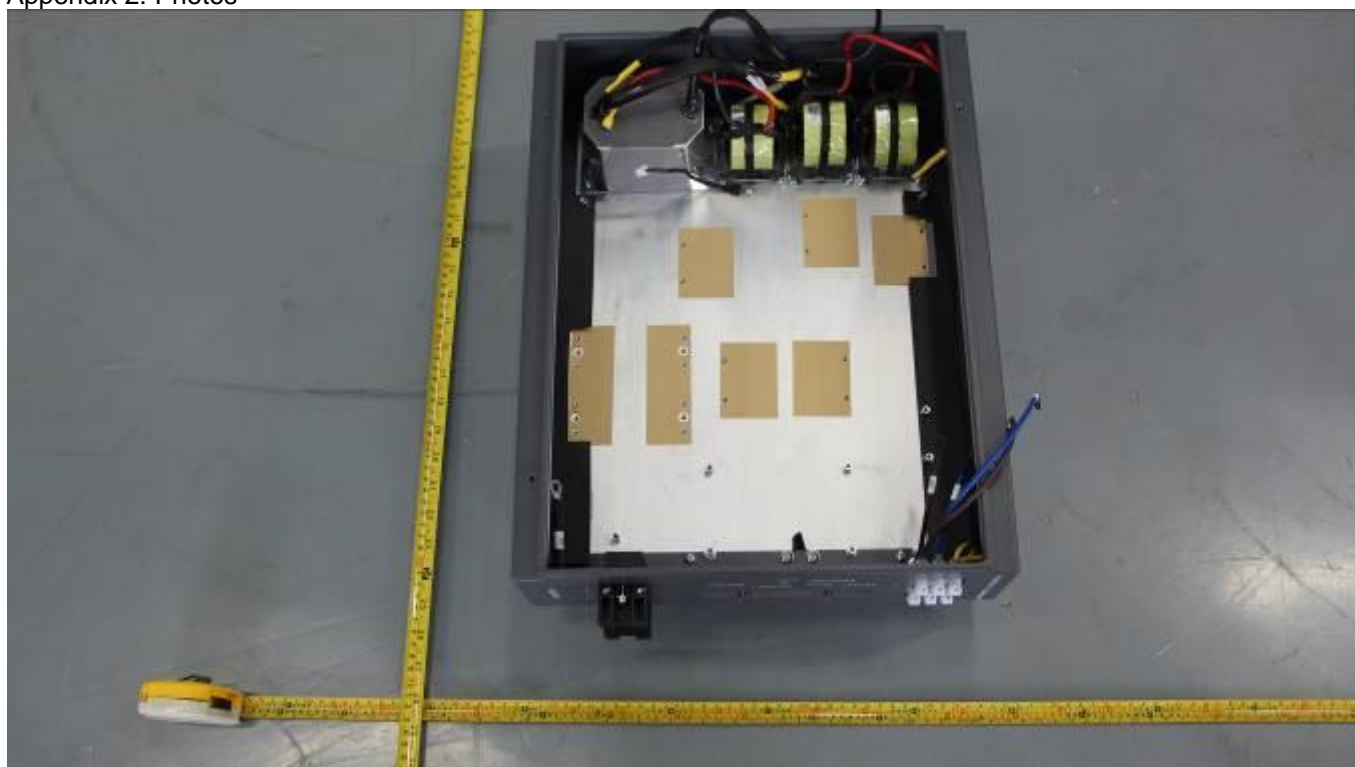


Inside view



Inside view

Appendix 2: Photos

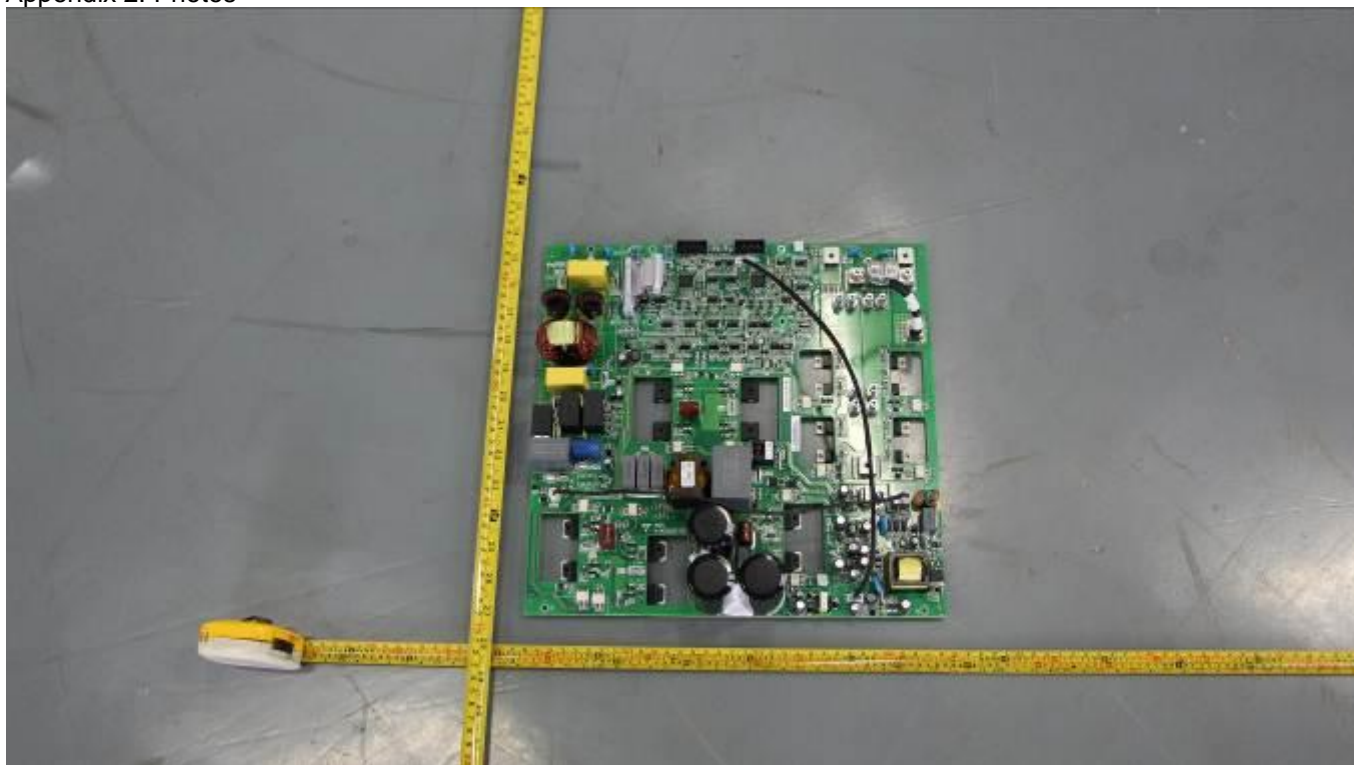


Inside view

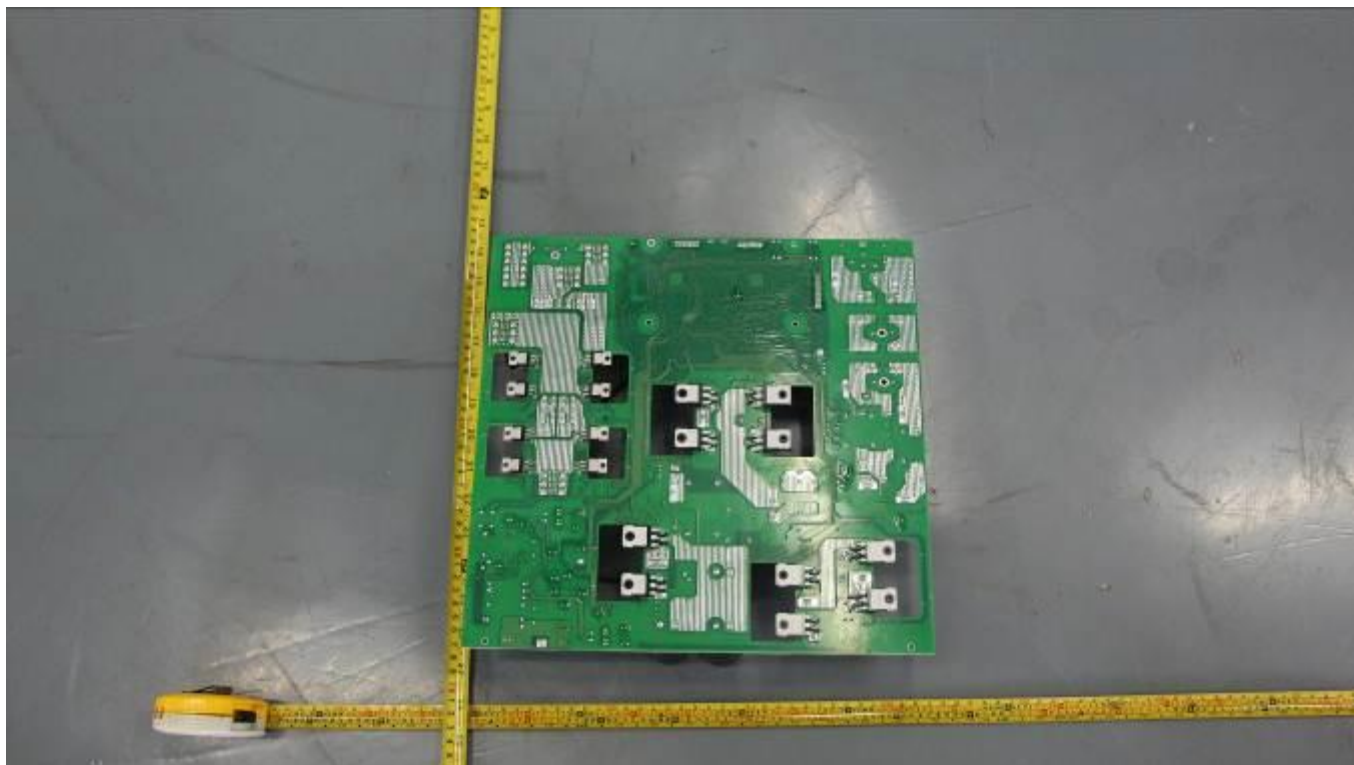


Communication board view

Appendix 2: Photos



Main board view



Soldered view

(End of Report)