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TEST REPORT
Engineering Recommendation 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

Report Reference No. .....:	230501664SHA-001
Tested by (name + signature) .....:	Issac Chen
Approved by (name + signature) .....:	Sleif Sui
Date of issue.....:	2023-6-5
Contents .....:	40 pages
Testing Laboratory .....:	Intertek Testing Services Shanghai.
Address.....:	Building No.86, 1198 Qinzhou Road (North), Shanghai 200233, China.
Applicant's name .....:	VTAC UK LTD
Address.....:	V-TAC HOUSE, Kelpatrick Road, Slough, London UK
Test specification:	
Standard .....:	G98 Issue 1 Amendment 7, 3 October 2022
Test procedure.....:	PV-COC
Non-standard test method.....:	N/A
Test Report Form No......:	TTRF_G98_2023_V1.0
TRF Originator.....:	Intertek
Master TRF.....:	2023-04

Test item description.....:	Grid-connected PV inverter
Trade Mark.....:	V-TAC
Manufacturer.....:	Same as applicant
Model/Type reference.....:	VT-6607110, VT-6607015, VT-6607020, VT-6607025, VT-6607030, VT-6607033, VT-6607036
Rating.....:	See below Specifications table

Specifications table				
Model	VT-6607110	VT-6607015	VT-6607020	VT-6607025
PV input				
Vmax PV (Vdc) (absolute Max.)	500	500	500	500
Isc PV (absolute Max.) (A)	18	18	18	18
Number MPP trackers	1	1	1	1
Number input strings	1	1	1	1
Max. PV input current (A)	14	14	14	14
MPPT voltage range (Vdc)	50-500	50-500	50-500	50-500
Vdc range @ full power (Vdc)	70-500	110-500	145-500	180-500
AC Grid (output)				
Normal AC Voltage (VAC)	L/N/PE, 230Vac			
Frequency (Hz)	50			
Normal AC Current (A)	4.4	6.6	8.7	10.9
Max. cont. output current (A)	6	9	12	13
Normal Power (W)	1000	1500	2000	2500
Rated Apparent Power (VA)	1000	1500	2000	2500
Max. cont. Power (W)	1000	1500	2000	2500
Max. cont. Apparent Power (VA)	1000	1500	2000	2500
Power factor(adjustable)	1.0(-0.8~ +0.8)			
Others				
Protective class	Class I			
Ingress protection (IP)	IP65			
Temperature (℃)	-25℃ to +60℃			
Inverter Isolation	Non-isolated			
Overvoltage category	OVC III (AC Main), OVC II (PV)			
Software version	V06			

Specifications table				
Model	VT-6607030	VT-6607033	VT-6607036	
PV input				
Vmax PV (Vdc) (absolute Max.)	500	600	600	
Isc PV (absolute Max.) (A)	18	18 x 2	18 x 2	
Number MPP trackers	1	2	2	
Number input strings	1	1/1	1/1	
Max. PV input current (A)	14	14 x 2	14 x 2	
MPPT voltage range (Vdc)	50-500	70-550	70-550	
Vdc range @ full power (Vdc)	220-500	110-550	130-550	
AC Grid (output)				
Normal AC Voltage (VAC)	L/N/PE, 230Vac			
Frequency (Hz)	50			
Normal AC Current (A)	13.1	13.1	15.7	
Max. cont. output current (A)	15	15	17.5	
Normal Power (W)	3000	3000	3600	
Rated Apparent Power (VA)	3000	3000	3600	
Max. cont. Power (W)	3000	3000	3600	
Max. cont. Apparent Power (VA)	3000	3000	3600	
Power factor(adjustable)	1.0(-0.8~ +0.8)			
Others				
Protective class	Class I			
Ingress protection (IP)	IP65			
Temperature (℃)	-25℃ to +60℃			
Inverter Isolation	Non-isolated			
Overvoltage category	OVC III (AC Main), OVC II (PV)			
Software version	V06			

Possible test case verdicts:	
- test case does not apply to the test object.....	: N/A
- test object does meet the requirement	: P(Pass)
- test object does not meet the requirement	: F(Fail)
Testing.....	:
Date of receipt of test item.....	: 2023-05-23
Date (s) of performance of tests.....	: 2023-05-23 to 2023-06-05

General remarks:

The test results presented in this report relate only to the object tested, and only considered the 230Vac, 50Hz.

This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.

"(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.

Determination of the test conclusion is based on IEC Guide 115 in consideration of measurement uncertainty.

Determination of the test result includes consideration of measurement uncertainty from the test equipment and methods.

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

General product information:

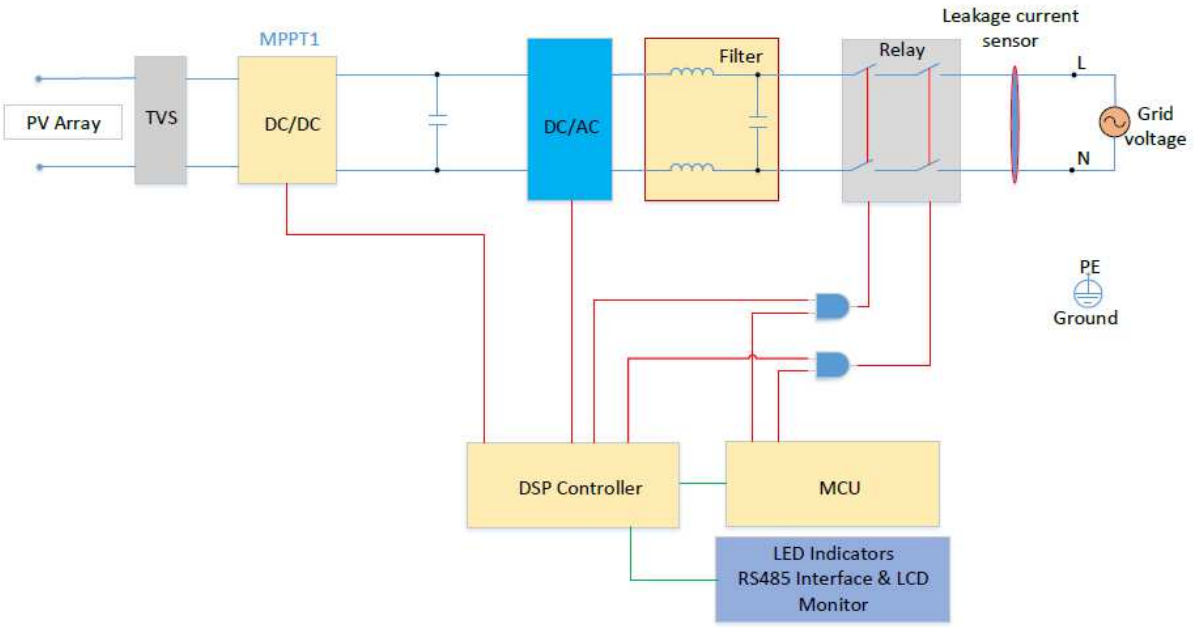
The testing unit is a grid-connected type inverter for indoor or outdoor installation.

The Inverter is single-phase type and non-isolated between input and output.

The relays are designed to redundant structure that controlled by separately.

The master controller and slave controller are used together to control relay open or close, if the single fault on one controller, the other controller can be capable to open the relay, so that still providing safety means.

The topology diagram as following:



Model differences:

All models have same circuit diagram, PWB layout and software. Only different enclosure and different power devices and ratings.

The models VT-6607110, VT-6607015, VT-6607020, VT-6607025 and VT-6607030 have same enclosure, heatsink, circuit diagram and PWB layout.

Models VT-6607033 and VT-6607036 have same enclosure, heatsink, circuit diagram and PWB layout.

Models VT-6607110, VT-6607015, VT-6607020, VT-6607025 and VT-6607030 have one MPPT tracker with one input strings.

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Models VT-6607033 and VT-6607036 have 2 MPPT trackers with 2 input strings.

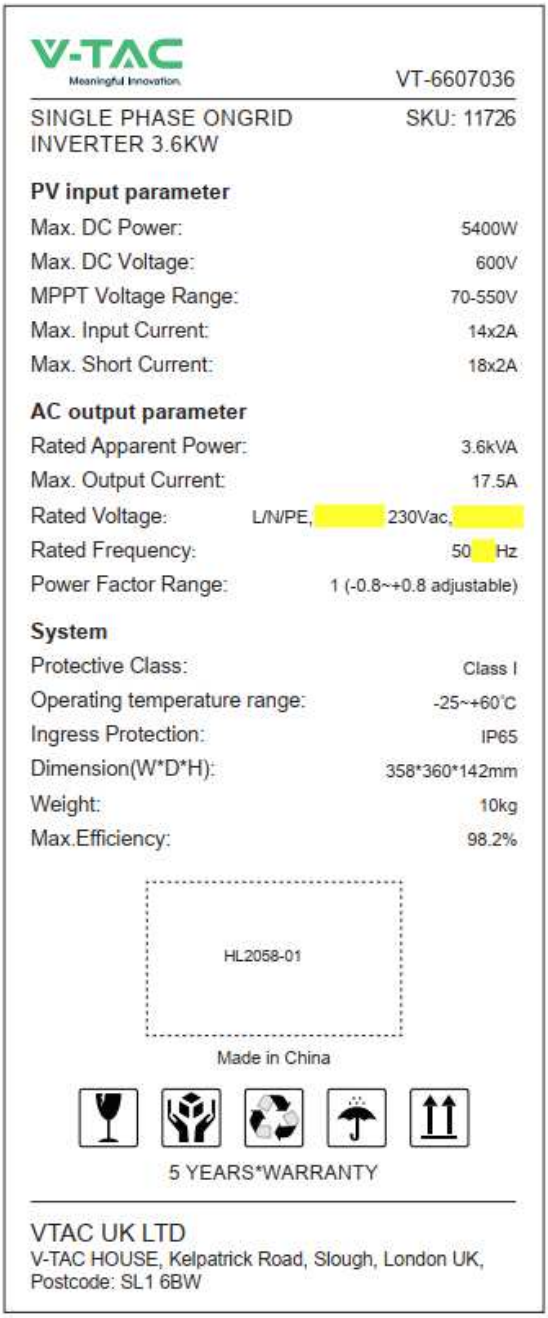
Factory information:

Afore New Energy Technology (Shanghai) Co., Ltd.

Build No.7, 333 Wanfang Road, Minhang District, Shanghai. China. 201112

Copy of marking plate:

The artwork below may be only a draft. The use of certification marks on a product must be authorized by the respective certification body that own these marks.



Remark:

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.
4. The information covered by on marking plate was irrelevant to this report.

Engineering recommendation G98			
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 vailable 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: • For synchronous Micro-generators: ○ Lower limit: 1/√10 (0.3162) times the tested Micro-generator nameplate rating (W) ○ Upper limit: √10 (3.162) times the tested Micro- generator nameplate rating (W) • For all other Micro-generators: ○ Lower limit: 1/√10 (0.3162) times the tested Micro-generator nameplate rating (W) ○ Upper limit: 2 times the tested Micro-generator nameplate rating (W)		P

Engineering recommendation G98			
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
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

Engineering recommendation G98			
Clause	Requirement - Test	Result - Remark	Verdict
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.		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
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 0.99 lagging to 0.99 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

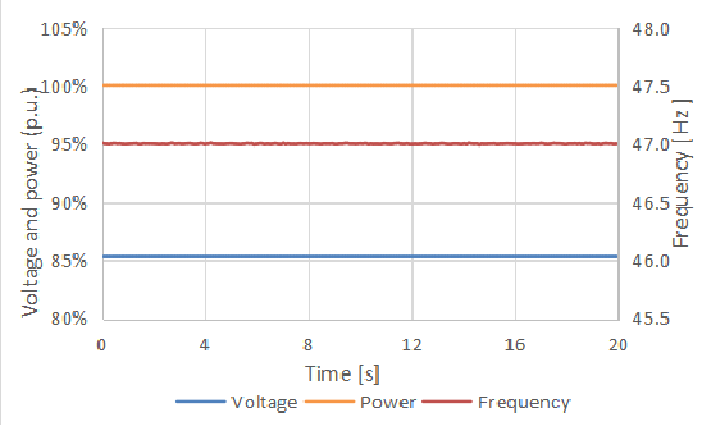
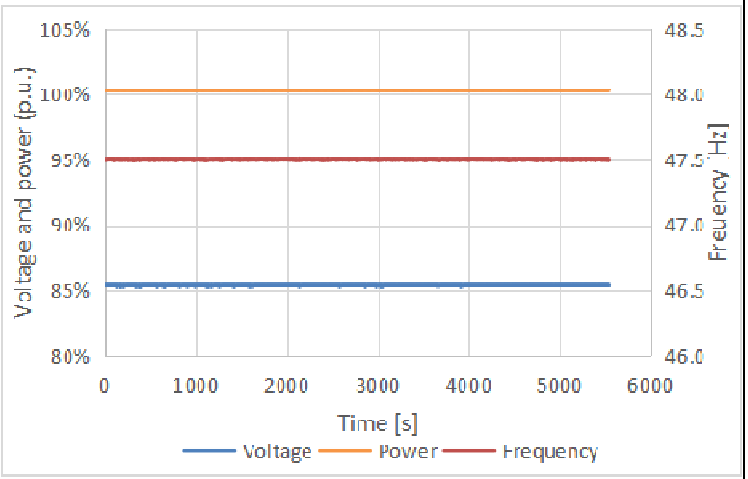
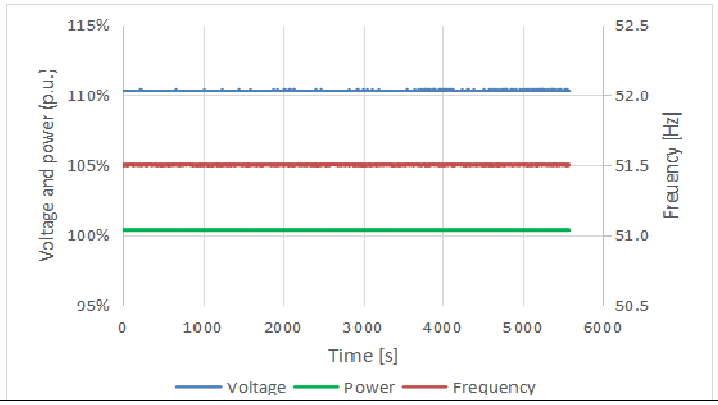
Engineering recommendation G98			
Clause	Requirement - Test	Result - Remark	Verdict
9.7.2	The Manufacturer or Installer shall provide information describing the high level cyber security approach, as well as the specific cyber security requirements complied with. The statement will make appropriate reference 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 complianed 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
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: ● 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

Engineering recommendation G98			
Clause	Requirement - Test	Result - Remark	Verdict
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
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 switch	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
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

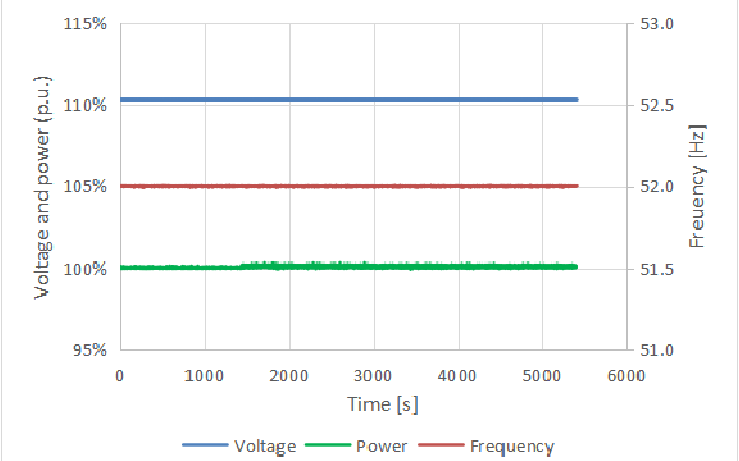
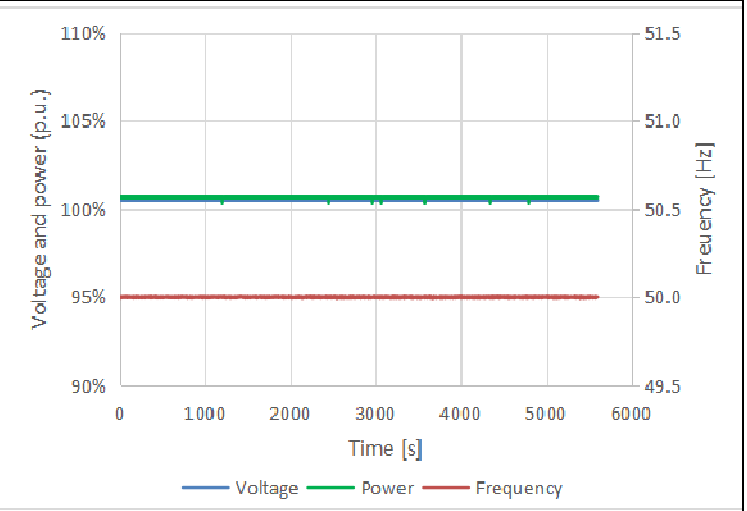
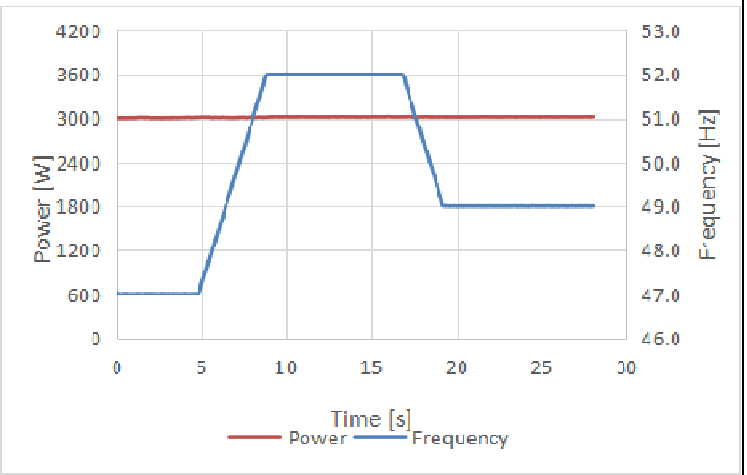
Engineering recommendation G98			
Clause	Requirement - Test	Result - Remark	Verdict
10.3.3	The Rate of Change of Frequency (RoCoF) and Vector Shift values required for these tests are marginally less than the corresponding protection settings for RoCoF in Table 2 and vector shifts of up to 50º. Both 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: ● RoCoF: 0.95 Hzs-1 from 49.0 Hz to 51.0 Hz on both rising and falling frequency; and ● Vector shift: 50ºplus from 49.5 Hz and 50ºminus 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: • EN 61000-3-2 Class A for harmonics; and • EN 61000-3-3 for voltage fluctuation and flicker with a dmax value of 4%. 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
11.2	DC injection		P
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.		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

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

Appendix 1:Testing table

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

Appendix 1:Testing table

Test 4 Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz, Power Factor = 1, Period of test 15 minutes	
Test 5 Voltage = 100% of nominal (253 V), Frequency = 50.0 Hz, Power Factor = 1, Period of test 90 minutes	
Test 6 RoCoF withstand 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.	

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)			1	kW		
Harmonic	At 45-55% of Registered Capacity		At 100% of Registered Capacity			
	Measured Value MV in Amps	Normalised Value (NV)	Measured Value MV in Amps	Normalised Value (NV)	Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
	L1		L1			
2	0.026	0.095	0.035	0.130	1.080	
3	0.087	0.321	0.067	0.245	2.300	
4	0.015	0.057	0.015	0.054	0.430	
5	0.016	0.057	0.014	0.052	1.140	
6	0.006	0.022	0.003	0.013	0.300	
7	0.016	0.058	0.008	0.029	0.770	
8	0.006	0.020	0.005	0.019	0.230	
9	0.014	0.050	0.009	0.032	0.400	
10	0.005	0.018	0.003	0.012	0.184	
11	0.007	0.026	0.007	0.024	0.330	
12	0.006	0.022	0.008	0.030	0.153	
13	0.016	0.058	0.006	0.022	0.210	
14	0.006	0.021	0.005	0.019	0.131	
15	0.016	0.060	0.012	0.043	0.150	
16	0.004	0.015	0.003	0.012	0.115	
17	0.008	0.029	0.004	0.014	0.132	
18	0.003	0.013	0.005	0.020	0.102	
19	0.012	0.045	0.011	0.041	0.118	
20	0.004	0.014	0.006	0.022	0.092	
21	0.011	0.040	0.012	0.045	0.107	0.160
22	0.002	0.007	0.003	0.013	0.084	
23	0.007	0.025	0.005	0.017	0.098	0.147
24	0.003	0.012	0.004	0.016	0.077	
25	0.010	0.037	0.015	0.054	0.090	0.135
26	0.004	0.016	0.006	0.022	0.071	
27	0.005	0.020	0.005	0.019	0.083	0.124
28	0.002	0.008	0.004	0.016	0.066	
29	0.006	0.020	0.004	0.014	0.078	0.117
30	0.002	0.006	0.002	0.007	0.061	
31	0.007	0.026	0.010	0.037	0.073	0.109
32	0.002	0.007	0.003	0.012	0.058	
33	0.004	0.016	0.003	0.012	0.068	0.102
34	0.002	0.006	0.002	0.007	0.054	
35	0.006	0.021	0.004	0.016	0.064	0.096
36	0.005	0.017	0.005	0.017	0.051	
37	0.005	0.020	0.008	0.029	0.061	0.091
38	0.002	0.006	0.002	0.006	0.048	
39	0.004	0.015	0.004	0.014	0.058	0.087
40	0.002	0.007	0.002	0.007	0.046	
Test Model: VT-6607110						
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	kW		
Harmonic	At 45-55% of Registered Capacity		At 100% of Registered Capacity			
	Measured Value MV in Amps		Measured Value MV in Amps		Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
	L1		L1			
2	0.037	0.045	0.058	0.071	1.080	
3	0.051	0.062	0.077	0.094	2.300	
4	0.018	0.022	0.024	0.030	0.430	
5	0.016	0.019	0.075	0.092	1.140	
6	0.003	0.003	0.003	0.004	0.300	
7	0.022	0.027	0.027	0.034	0.770	
8	0.006	0.007	0.006	0.007	0.230	
9	0.007	0.009	0.014	0.017	0.400	
10	0.003	0.004	0.004	0.005	0.184	
11	0.012	0.014	0.016	0.020	0.330	
12	0.009	0.011	0.008	0.010	0.153	
13	0.010	0.012	0.013	0.015	0.210	
14	0.007	0.009	0.006	0.008	0.131	
15	0.013	0.016	0.011	0.013	0.150	
16	0.003	0.004	0.006	0.007	0.115	
17	0.009	0.011	0.017	0.020	0.132	
18	0.008	0.010	0.009	0.011	0.102	
19	0.012	0.014	0.008	0.010	0.118	
20	0.008	0.009	0.009	0.010	0.092	
21	0.013	0.016	0.012	0.014	0.107	0.160
22	0.005	0.006	0.007	0.008	0.084	
23	0.010	0.013	0.014	0.017	0.098	0.147
24	0.005	0.007	0.009	0.011	0.077	
25	0.016	0.020	0.014	0.017	0.090	0.135
26	0.008	0.010	0.008	0.010	0.071	
27	0.005	0.006	0.014	0.017	0.083	0.124
28	0.005	0.006	0.005	0.006	0.066	
29	0.006	0.007	0.011	0.014	0.078	0.117
30	0.003	0.003	0.009	0.011	0.061	
31	0.012	0.015	0.015	0.019	0.073	0.109
32	0.004	0.005	0.006	0.008	0.058	
33	0.002	0.003	0.004	0.005	0.068	0.102
34	0.002	0.003	0.004	0.005	0.054	
35	0.005	0.006	0.008	0.010	0.064	0.096
36	0.005	0.006	0.006	0.007	0.051	
37	0.009	0.011	0.014	0.017	0.061	0.091
38	0.002	0.003	0.004	0.005	0.048	
39	0.003	0.004	0.008	0.010	0.058	0.087
40	0.002	0.002	0.004	0.005	0.046	
Test Model: VT-6607030						
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 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	2023-05-24			Test end date			2023-05-24	
Test location	Intertek Testing Services Shanghai.							
	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	0.56	0.27	0	1.43	0.27	0	0.22	0.19
Normalised to standard impedance	0.56	0.27	0	1.43	0.27	0	0.22	0.19
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

Power quality – DC injection: This test should be carried out in accordance with A 1.3.4 as applicable. 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) / 230 V. The % **DC** injection should not be greater than 0.25%.				
Model: VT-6607110				
Test power level	20%	50%	75%	100%
Recorded DC injection value in Amps	0.007	0.008	0.008	0.008
as % of rated AC current	0.16%	0.18%	0.18%	0.18%
Limit	0.25%	0.25%	0.25%	0.25%

Power quality – DC injection: This test should be carried out in accordance with A 1.3.4 as applicable. 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) / 230 V. The % **DC** injection should not be greater than 0.25%.				
Model: VT-6607030				
Test power level	20%	50%	75%	100%
Recorded DC injection value in Amps	0.014	0.015	0.014	0.016
as % of rated AC current	0.11%	0.12%	0.11%	0.12%
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 ±1.5% of the stated level during the test.			
Model: VT-6607110			
Voltage	216.2 V	230 V	253 V
Measured value	0.9996	0.9996	0.9997
Power Factor Limit	>0.95	>0.95	>0.95
Model: VT-6607030			
Voltage	216.2 V	230 V	253 V
Measured value	0.9994	0.9996	0.9996
Power Factor Limit	>0.95	>0.95	>0.95

Appendix 1:Testing table

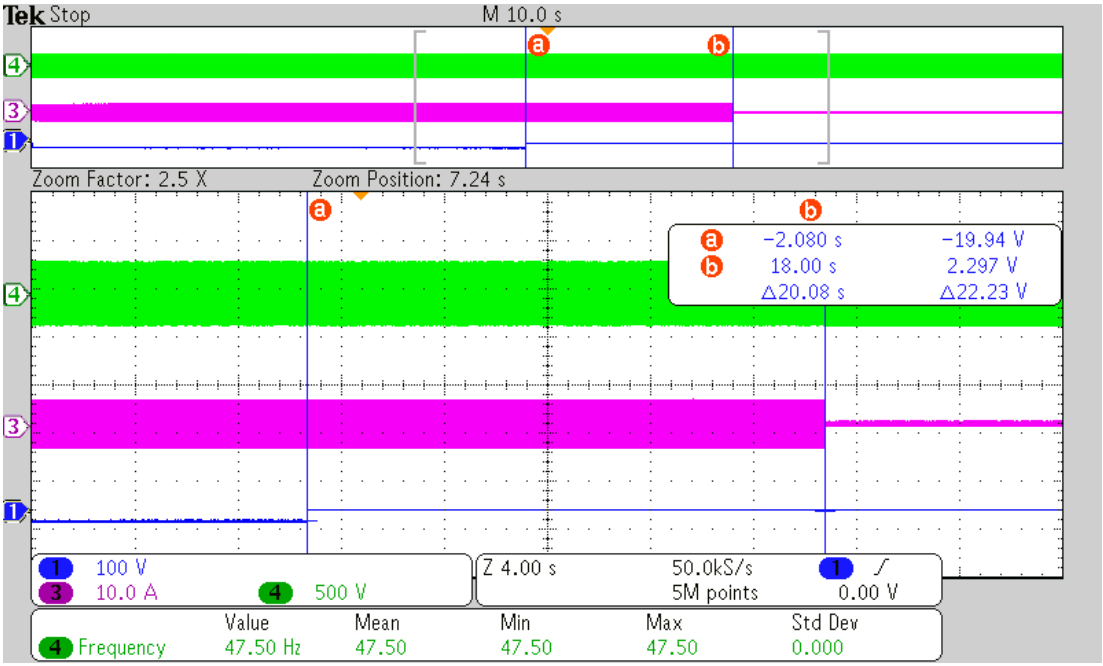
Protection – Frequency tests:

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.

Model: VT-6607030

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	47.50Hz	20.08s	47.7 Hz 30 s	No trip
U/F stage 2	47 Hz	0.5 s	47.00Hz	0.522s	47.2 Hz 19.5 s	No trip
					46.8 Hz 0.45 s	No trip
O/F stage 1	52 Hz	0.5 s	52.00Hz	0.531s	51.8 Hz 120.0 s	No trip
					52.2 Hz 0.45 s	No trip

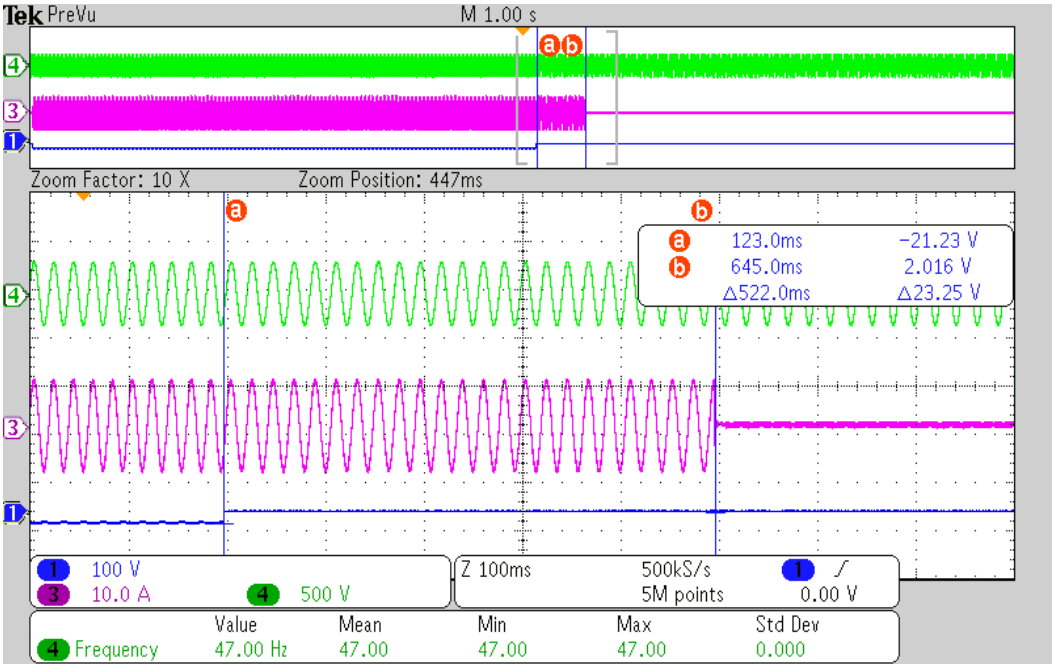
Note: For frequency trip tests the frequency required to trip is the setting ± 0.1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0.2 Hz and for the relevant times as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



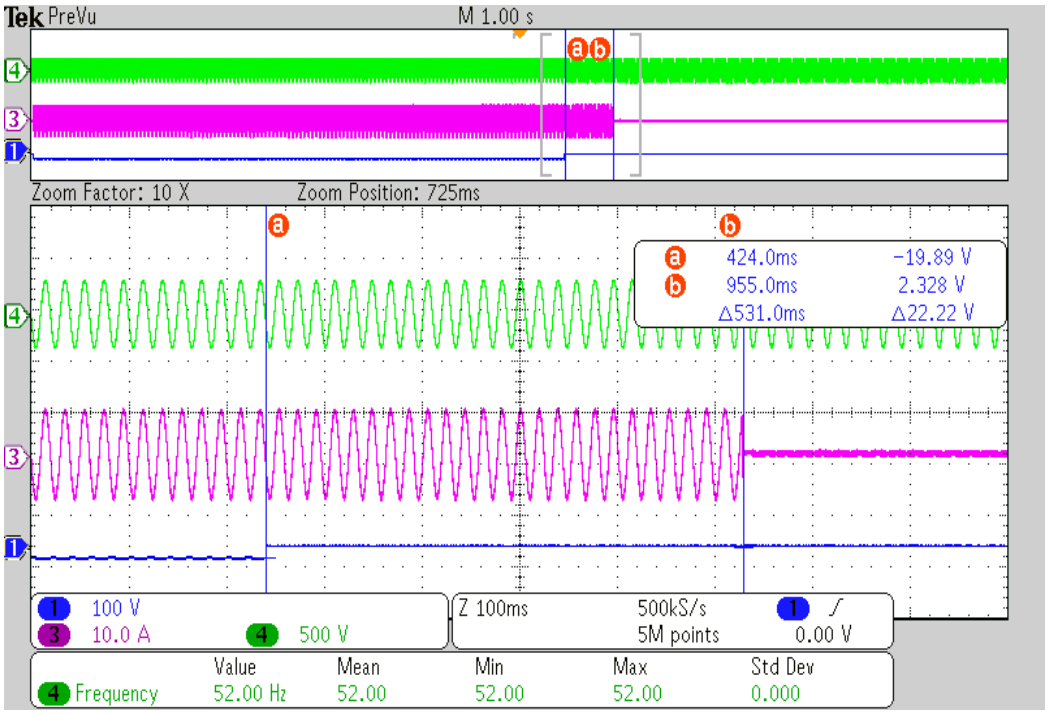
U/F stage 1

CH1: trip signal; CH3: Current of EUT; CH4: Voltage of EUT

Appendix 1:Testing table



U/F stage 2



O/F stage 1

Appendix 1:Testing table

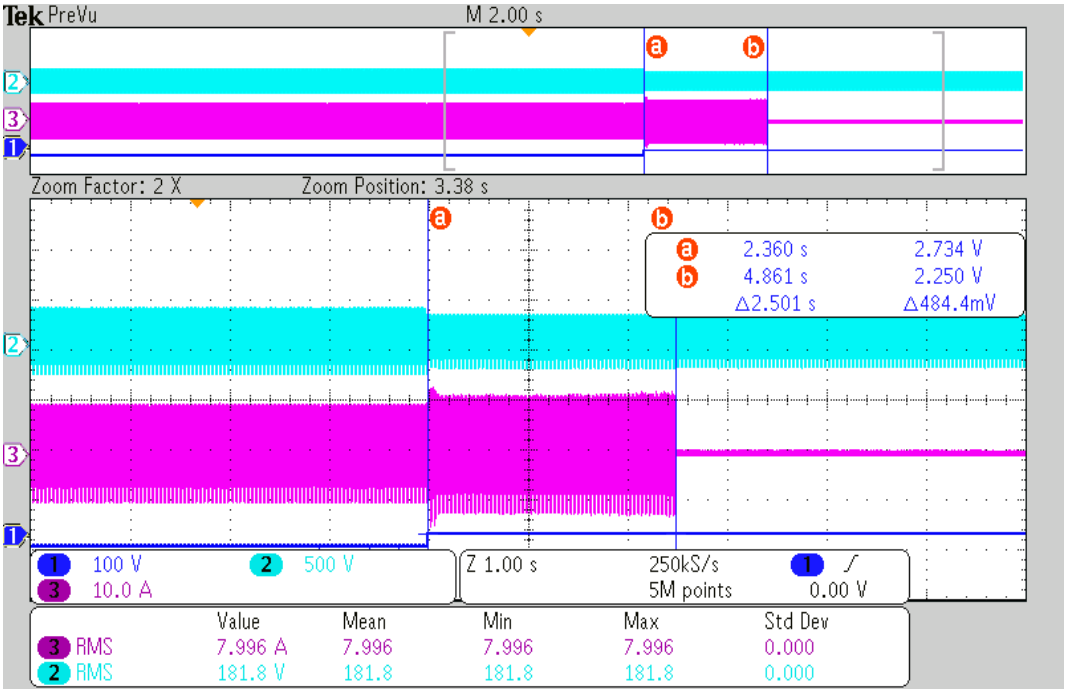
Protection – Voltage tests:

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.

Model:VT-6607030

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	181.8V	2.501s	188 V 5.0 s	No trip
					180 V 2.45 s	No trip
O/V stage 1	262.2 V	1.0 s	265.4V	1.001s	258.2 V 5.0 s	No trip
O/V stage 2	273.7 V	0.5 s	276.6V	0.550s	269.7 V 0.95s	No trip
					277.7 V 0.45 s	No trip

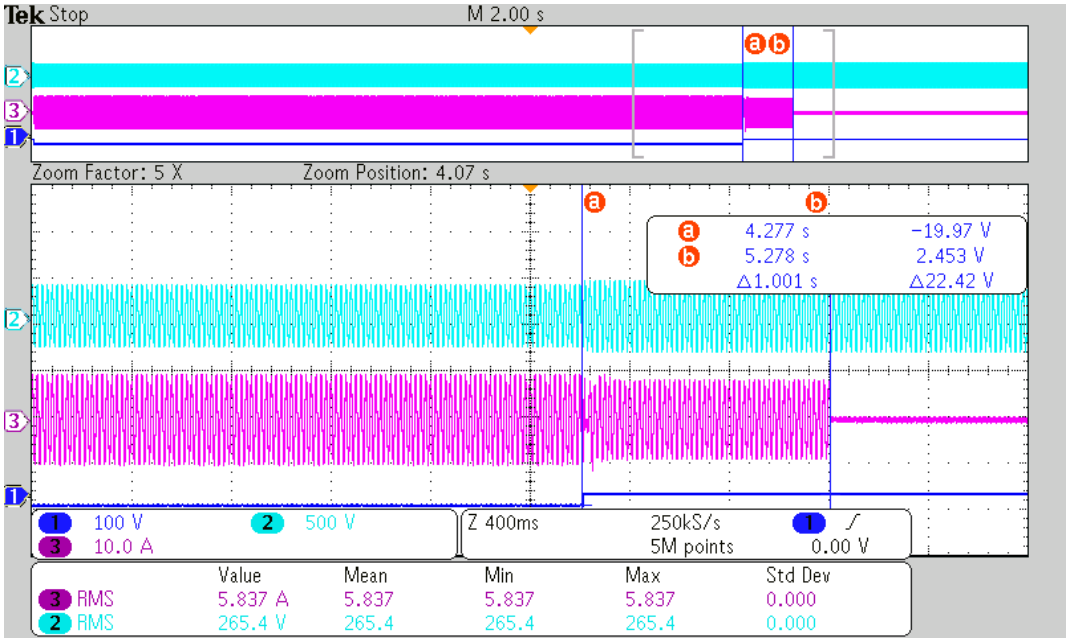
Note: For Voltage tests the Voltage required to trip is the setting ±3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±4 V and for the relevant times as shown in the table above to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



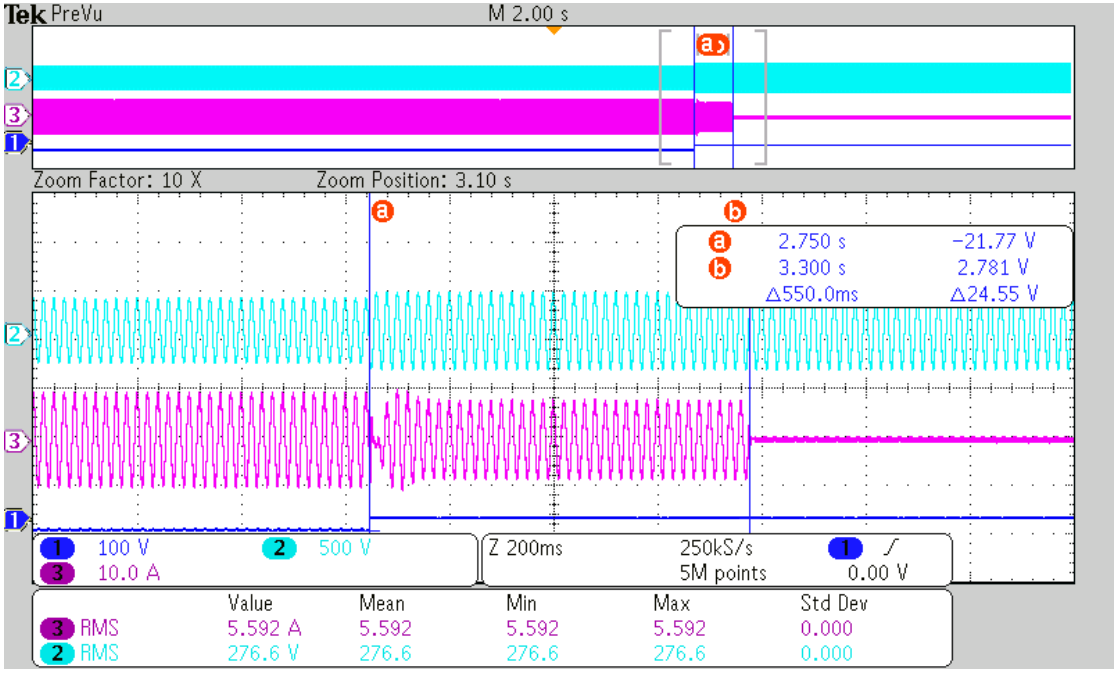
U/V

CH1: trip signal; CH2: Voltage of EUT; CH3: Current of EUT

Appendix 1:Testing table



O/V stage 1



O/V stage 2

Appendix 1:Testing table

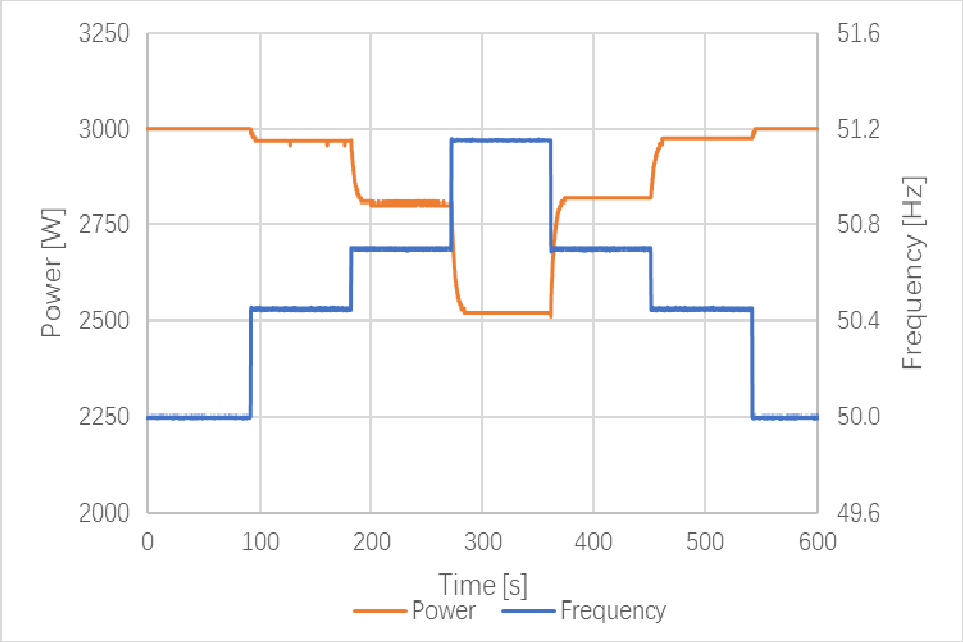
Protection - Loss of Mains test: For PV Inverters shall be tested in accordance with BS EN 62116. Other Micro-generators should be tested in accordance with A.2.2.4 at 10%, 55% and 100% of rated power.						
For Inverters tested to BS EN 62116 the following sub set of tests should be recorded in the 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	0.091s	0.081s	0.079s	0.082s	0.082s	0.072s

Protection – Frequency change, Vector Shift Stability test:			**P**
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.			
Model: VT-6607030			
	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
Protection – Frequency change, RoCoF Stability test:			**P**
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.			
Model: VT-6607030			
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

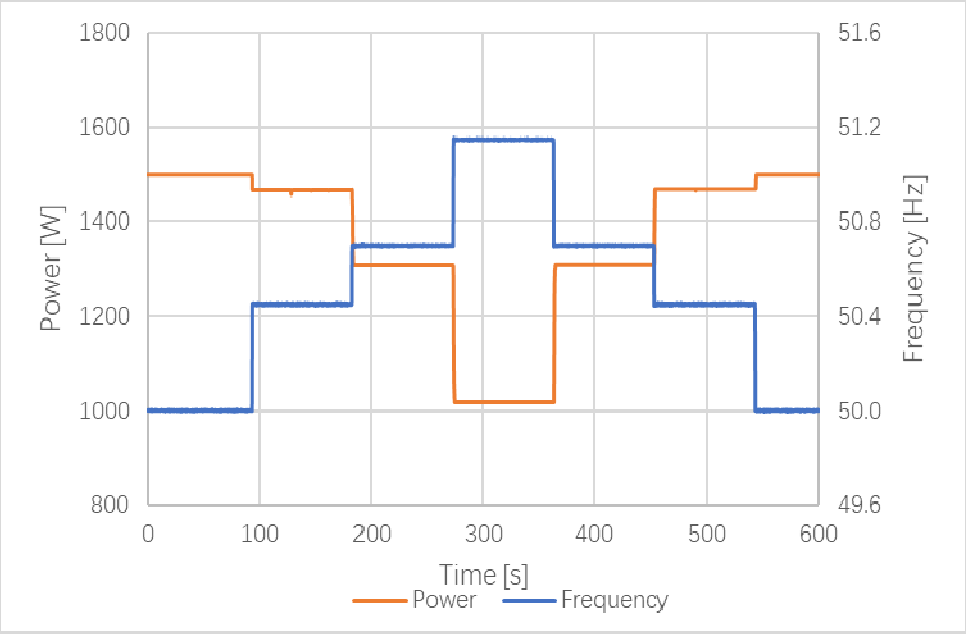
Appendix 1:Testing table

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) 50.00Hz ±0.01Hz	3000.00W	50.00Hz	Photovoltaic array simulator	--
Step b) 50.45Hz ±0.05Hz	2968.54W	50.45Hz		9.50
Step c) 50.70Hz ±0.10Hz	2810.45W	50.70Hz		9.49
Step d) 51.15Hz ±0.05Hz	2531.23W	51.15Hz		9.60
Step e) 50.70Hz ±0.10Hz	2810.33W	50.70Hz		9.48
Step f) 50.45Hz ±0.05Hz	2969.15W	50.45Hz		9.69
Step g) 50.00Hz ±0.01Hz	2999.66W	50.00Hz		--
Test sequence at Registered Capacity 40% - 60%	Measured Active Power Output	Frequency	Primary Power Source	Active Power Gradient Droop(%)
Step a) 50.00Hz ±0.01Hz	1500.00W	50.00Hz	Photovoltaic array simulator	--
Step b) 50.45Hz ±0.05Hz	1467.97W	50.45Hz		9.50
Step c) 50.70Hz ±0.10Hz	1309.80W	50.70Hz		9.49
Step d) 51.15Hz ±0.05Hz	1020.84W	51.15Hz		9.60
Step e) 50.70Hz ±0.10Hz	1308.33W	50.70Hz		9.48
Step f) 50.45Hz ±0.05Hz	1469.30W	50.45Hz		9.69
Step g) 50.00Hz ±0.01Hz	1499.80W	50.00Hz		--

Appendix 1:Testing table



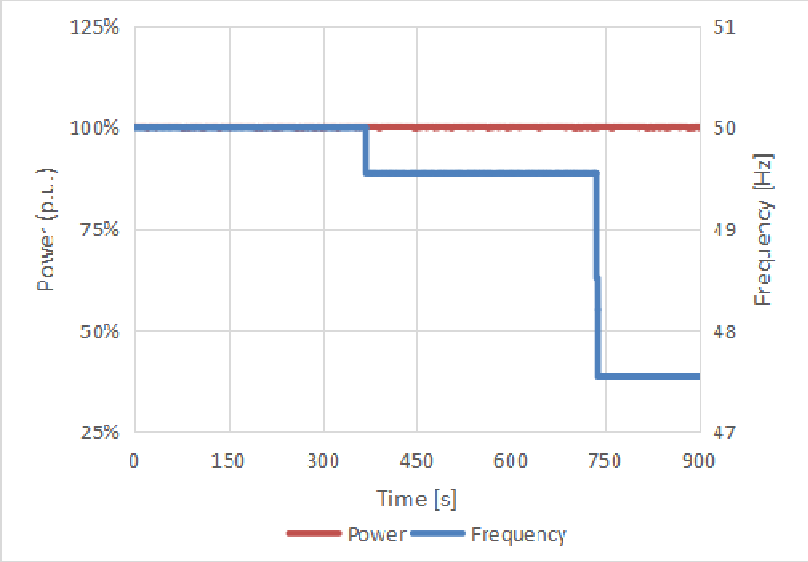
Test at Registered Capacity of 100%



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 ±0.01 Hz	3005.95W	50.00Hz	Photovoltaic array simulator
Test b) Point between 49.5 Hz and 49.6 Hz	3006.08W	49.55Hz	Photovoltaic array simulator
Test c) Point between 47.5 Hz and 47.6 Hz	3006.10W	47.55Hz	Photovoltaic array simulator
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.			
30 s	32 s	At 266.2 V	At 180V	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	187.7V	9.806A
Initial Value of aperiodic current	A	--	100ms	0.899 V	8.758A
Initial symmetrical short-circuit current*	I_k	--	250 ms	0	0
Decaying (aperiodic) component of short circuit current*	i_{DC}	--	500 ms	0	0
Reactance/Resistance Ratio of source*	X/R	2.5	Time to trip	116.53 ms	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	
To short or open pin1 and pin5 of logic interface port (RS485 port) to control the inverter to normal or shutdown active power of output. A logic interface is provided that can be operated by an external switch or contactor. Users can install by themselves. Users install the switch connected to pin1 and pin5 of RS485 port and just need control the switch signal causing the switch to open or short. When the switch is closed, the inverter will operate normally. When the switch is opened, the inverter will cease to export active power within 5 seconds. The signal from the inverter that is being switched is DC (maximum value 3.3V).	

Appendix 1:Testing table

Protection – Loss of Mains test:

For PV **Inverter**s shall be tested in accordance with BS EN 62116.

Model: VT-6607030

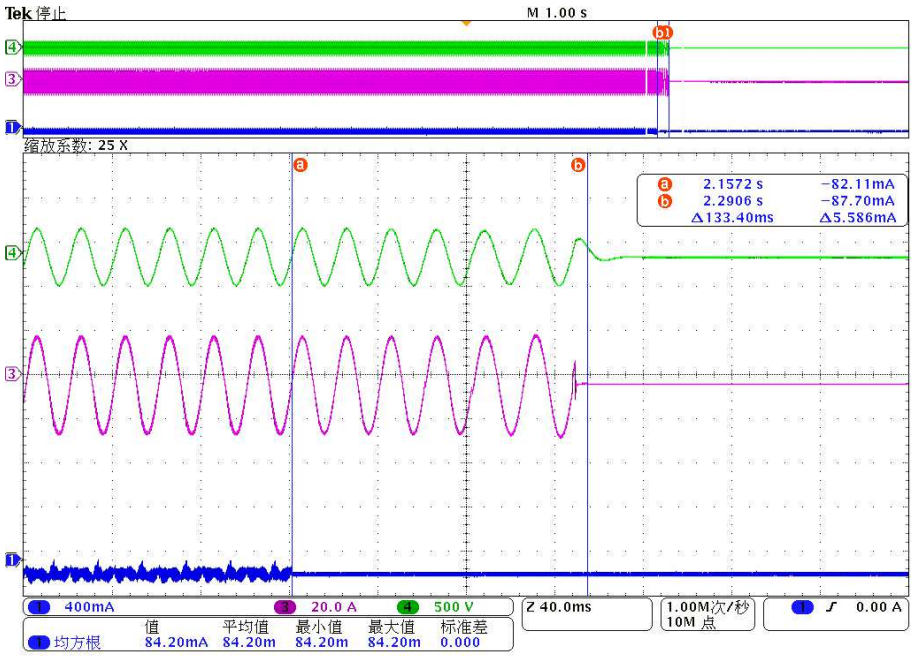
No.	P_{EUT} a) (% of EUT rating)	Reactive load (% of Q_L)	P_{AC} b) (% of nominal)	Q_{AC} c) (% of nominal)	Run-on time (ms)	P_{EUT} (W)	Actual Q_f	V_{DC} d)	Remarks e)
1	100	100	0	0	133.4	3000	1.00	435	Test A at BL
2	66	66	0	0	133.6	1980	1.00	320	Test B at BL
3	33	33	0	0	130.8	990	0.98	182	Test C at BL
4	100	100	-5	-5	108.0	3000	0.99	435	Test A at IB
5	100	100	-5	0	74.8	3000	0.99	435	Test A at IB
6	100	100	-5	+5	70.4	3000	1.02	435	Test A at IB
7	100	100	0	-5	79.4	3000	1.00	435	Test A at IB
8	100	100	0	+5	72.0	3000	1.00	435	Test A at IB
9	100	100	+5	-5	95.2	3000	0.96	435	Test A at IB
10	100	100	+5	0	72.8	3000	0.98	435	Test A at IB
11	100	100	+5	+5	101.2	3000	0.99	435	Test A at IB
12	66	66	0	-5	81.2	1980	0.93	320	Test B at IB
13	66	66	0	-4	91.6	1980	0.98	320	Test B at IB
14	66	66	0	-3	94.0	1980	0.99	320	Test B at IB
15	66	66	0	-2	105.6	1980	0.98	320	Test B at IB
16	66	66	0	-1	112.4	1980	0.96	320	Test B at IB
17	66	66	0	+1	111.2	1980	0.98	320	Test B at IB
18	66	66	0	+2	105.6	1980	1.01	320	Test B at IB
19	66	66	0	+3	108.4	1980	0.95	320	Test B at IB
20	66	66	0	+4	93.2	1980	1.02	320	Test B at IB
21	66	66	0	+5	81.6	1980	0.98	320	Test B at IB
22	33	33	0	-5	90.8	990	0.96	182	Test B at IB
23	33	33	0	-4	92.0	990	0.93	182	Test C at IB
24	33	33	0	-3	109.6	990	0.97	182	Test C at IB
25	33	33	0	-2	114.0	990	0.96	182	Test C at IB
26	33	33	0	-1	122.4	990	0.95	182	Test C at IB
27	33	33	0	+1	123.2	990	0.97	182	Test C at IB
28	33	33	0	+2	110.8	990	1.01	182	Test C at IB
29	33	33	0	+3	101.2	990	0.97	182	Test C at IB
30	33	33	0	+4	95.6	990	0.99	182	Test C at IB
31	33	33	0	+5	81.6	990	0.96	182	Test C at IB

Note:

1) PEUT: EUT output power.
2) Pac: Active power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
3) Q_{ac}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
4) BL: Balance condition, IB: Imbalance condition.

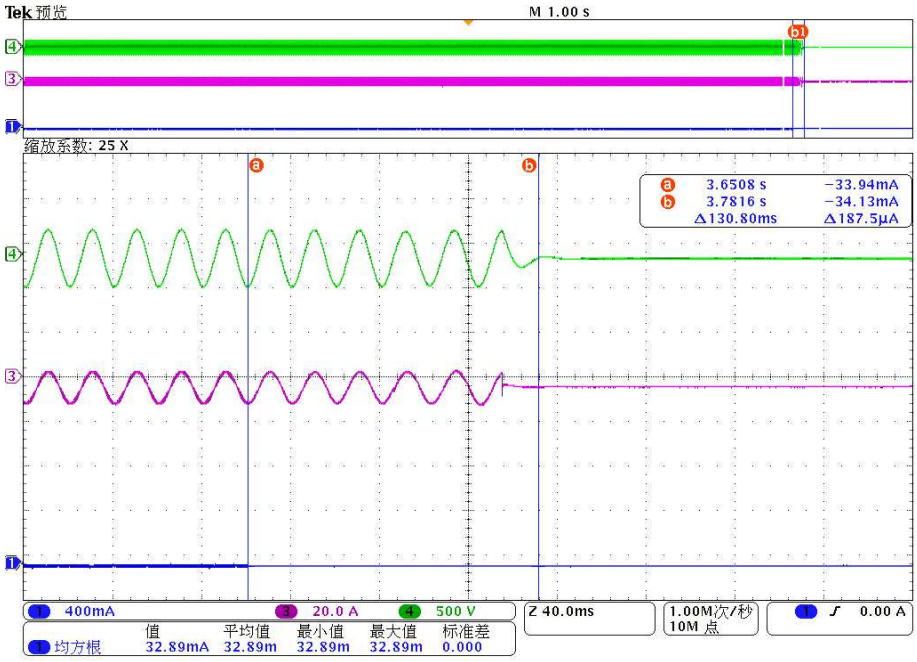
Appendix 1:Testing table

Graph of disconnection at P_{AC} 0 and Q_{AC} 0 reactive load and 100% nominal power



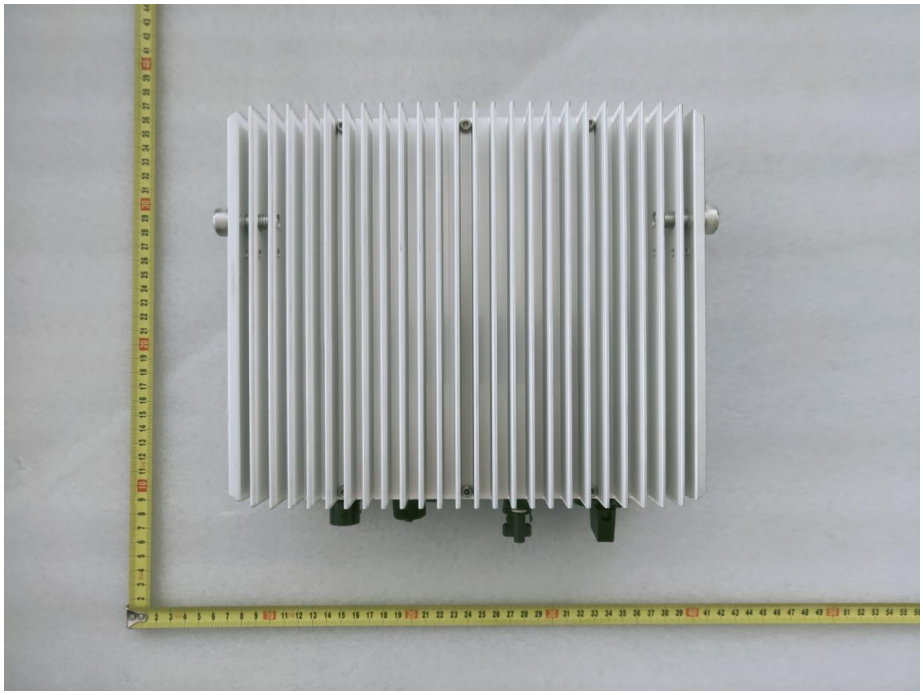
Appendix 1:Testing table

Graph of disconnection at PAC 0 and QAC 0 reactive load and 33% nominal power

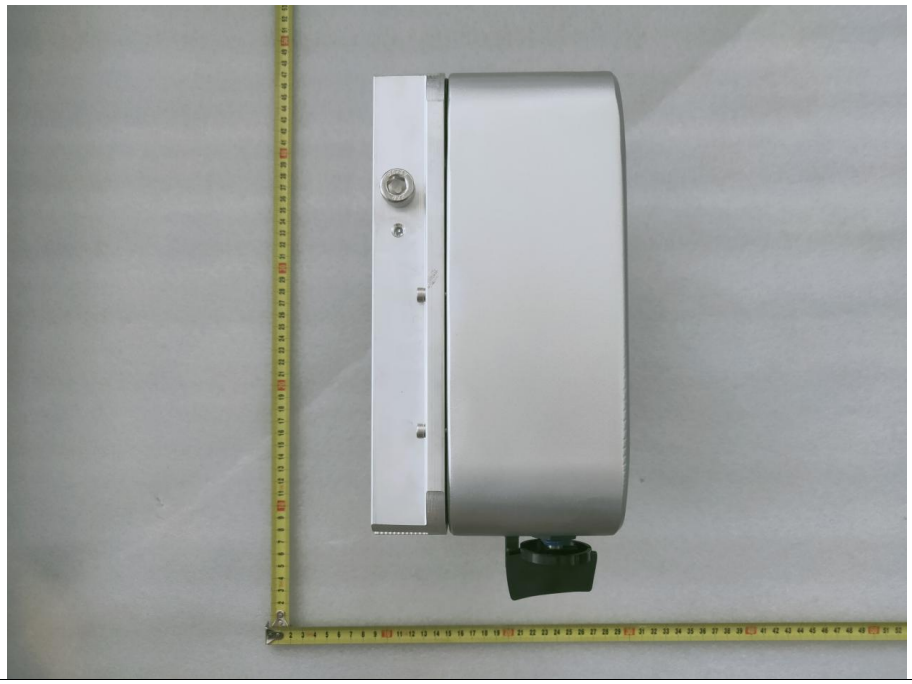
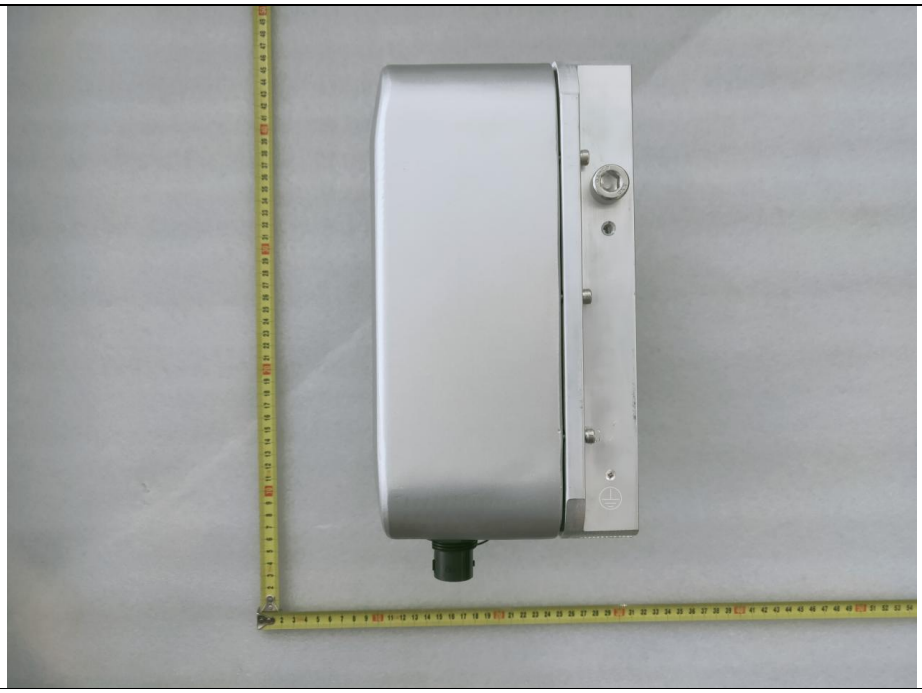


Appendix 1:Testing table

Front View (VT-6607030)

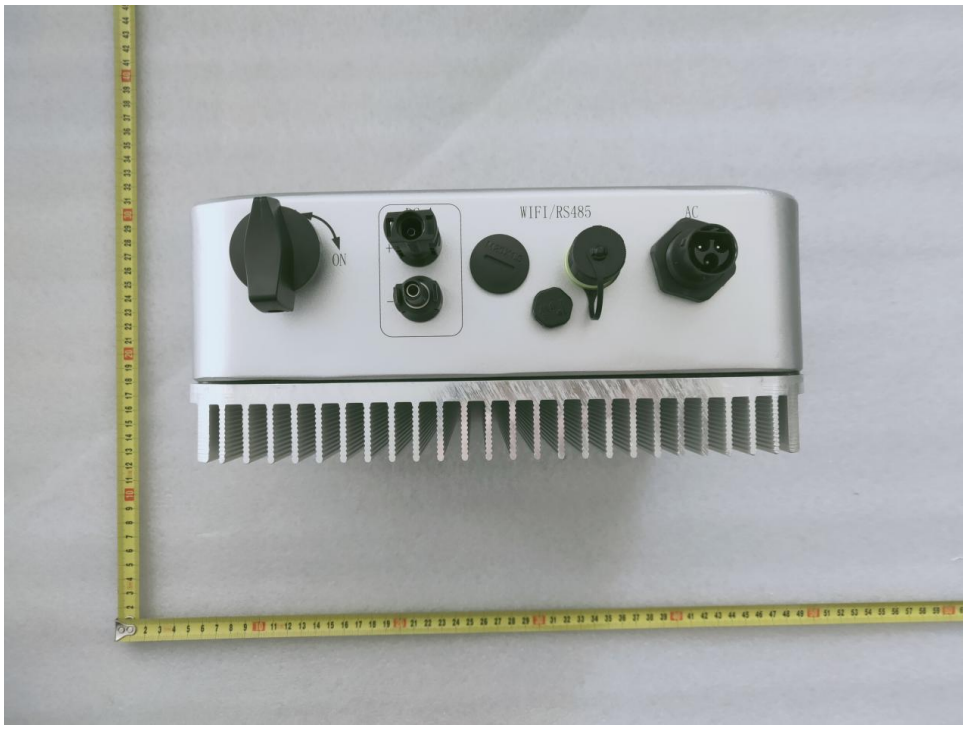
Rear View (VT-6607030)


Appendix 1:Testing table

Left side View (VT-6607030)

Right Side View (VT-6607030)


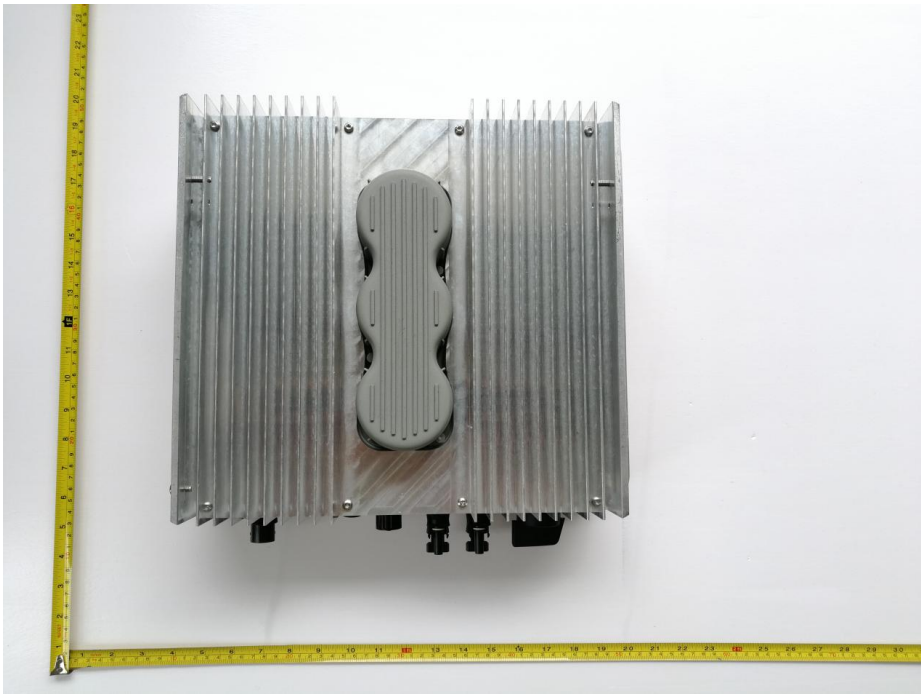
Appendix 1:Testing table

Top Side View (VT-6607030)

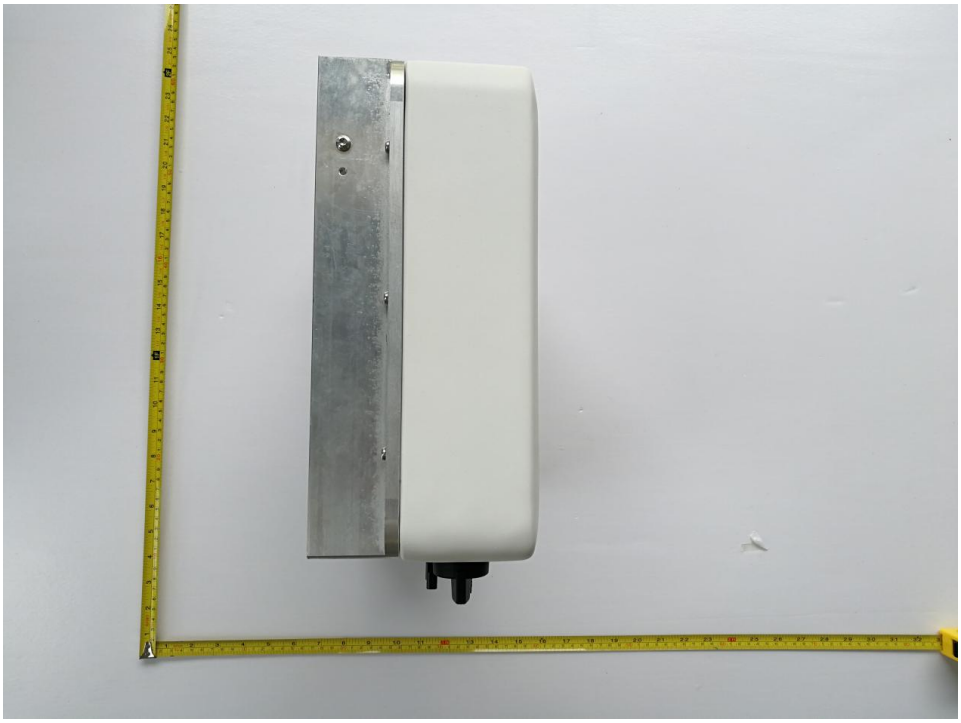
Bottom Side View (VT-6607030)


Appendix 1:Testing table

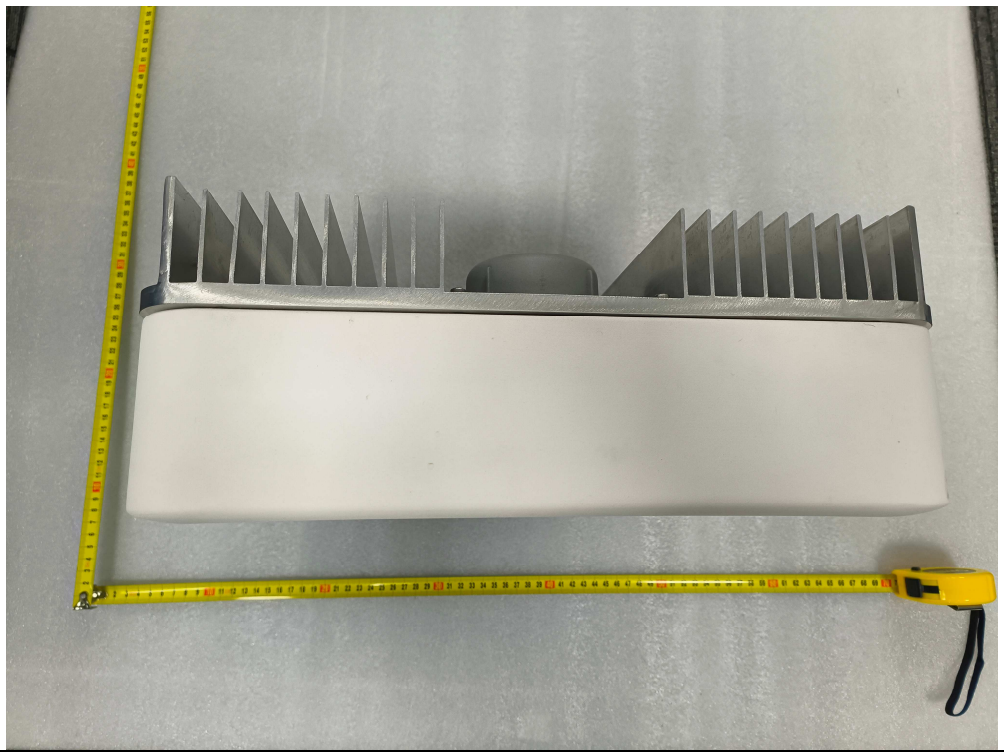
Front View (VT-6607033, VT-6607036)

Rear View (VT-6607033, VT-6607036)


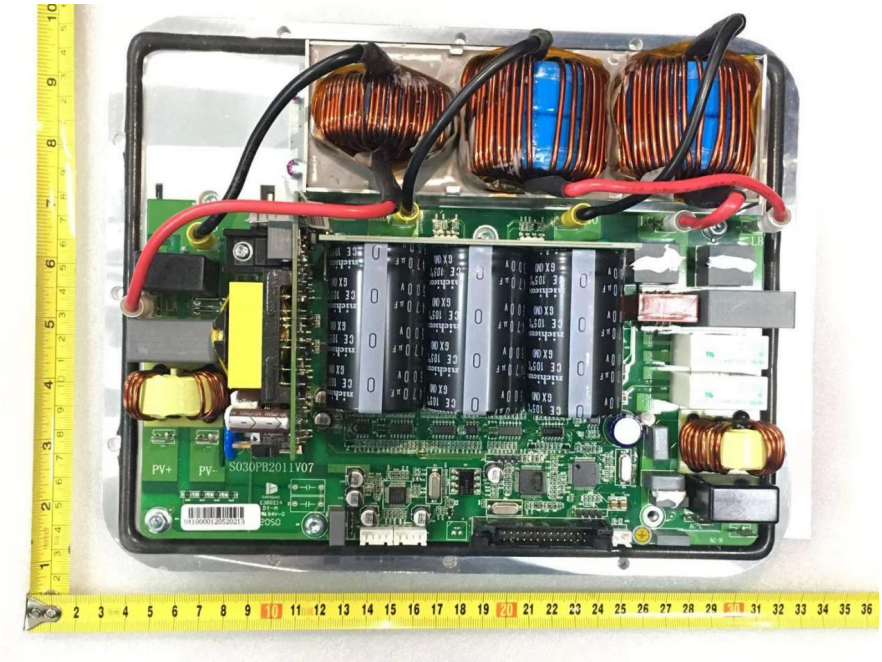
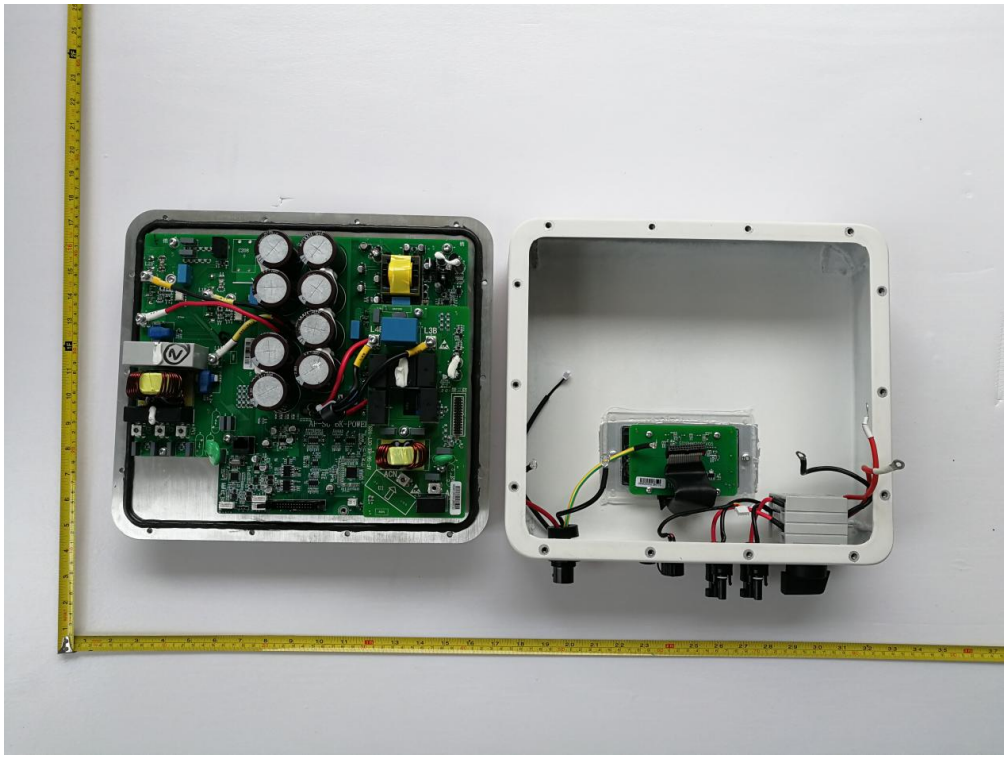
Appendix 1:Testing table

Left Side View (VT-6607033, VT-6607036)

Right Side View (VT-6607033, VT-6607036)


Appendix 1:Testing table

Top side View (VT-6607033, VT-6607036)

Bottom side View (VT-6607033, VT-6607036)


Appendix 1:Testing table

Internal View (VT-6607030)

Internal View (VT-6607033, VT-6607036)


End of Report