TEST REPORT

Engineering recommendation G98/1

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 number..... :	**PVGB2310WDG0087-1**
Date of issue..... ……..:	2023-11-22
Total number of pages..... ……..:	93
Testing laboratory name..... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
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Accreditation.....:	ACCREDITED Certificate # 2951.01
Applicant's name ..... :	**Huawei Technologies Co., Ltd.**
Address.....:	Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C
Test specification	
Standard .....:	G98/1-7:2022
	A1 Requirements for Type Testing of Inverter Connected Mirco generators
Test Report Form No.....:	G98/1 VER.2
TRF Originator.....:	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF.....:	Dated 2022-11-01
Test item description.....:	**Photovoltaic (PV) and battery inverter**
Trademark .....:	HUAWEI
Model / Type.....:	SUN2000-2KTL-L1, SUN2000-3KTL-L1, SUN2000-3.68KTL-L1

Ratings ..... :	**SUN2000-2KTL-L1**	**SUN2000-3KTL-L1**	**SUN2000-3.68KTL-L1**
Max. Input PV voltage [V] ..... :	600		
MPP PV voltage range [V] ..... :	90-530		
Max. Input PV current [A] ..... :	13,5 / 13,5		
Isc PV [A] ..... :	20,0 / 20,0		
Output AC voltage [V] ..... :	L/N/PE, 230Va.c., 50Hz		
Max. Output AC current [A] ..... :	10,0	15,0	16,0
Nominal Output power [kW] ..... :	2,00	3,00	3,68
Max. Output power [kVA] ..... :	2,20	3,30	3,68
Max. Battery input voltage [V] ..... :	600		
Max. Battery current [A] ..... :	15,0		

Testing Location ..... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
Address ..... :	No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China
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Factory's name 2 ..... :	**Huizhou Huazhi New Energy Technology Co., Ltd.**
Factory address 2 ..... :	No.8 Factory, Xinhua Avenue, Chenjiang Street, Zhongkai High-tech Zone, Huizhou, Guangdong, People's Republic of China.

Document History

Date	Internal reference	Modification / Change / Status	Revision
2023-11-22	Chason Ye	Initial report was written	0

Supplementary information:

Test items particulars

Equipment mobility .....:	Permanent connection
Operating condition.....:	Continuous
Class of equipment.....:	Class I
Protection against ingress of water ..:	IP65 according to EN 60529
Mass of equipment [kg] .....:	12,6

Test case verdicts

Test case does not apply to the test object .....:	N/A
Test item does meet the requirement.....:	P(ass)
Test item does not meet the requirement.....:	F(ail)

Testing

Date of receipt of test item.....:	2023-10-24
Date(s) of performance of test.....:	2023-10-24 to 2023-11-22

General remarks:

The test result presented in this report relate only to the object(s) tested.

The report shall state compliance of the tested objects with the Type A requirements of G98.

All information within this test report limited to the type label, warning markings, trademark, block diagram, schematics, layouts, manual and datasheets are provided by the customer.

"(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

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

Conformity statements are decided in accordance with IEC GUIDE 115:2021 Procedure 2 (accuracy method), unless otherwise normatively specified or contractually agreed.

- "P_n" for the nominal active power:

  $P_n = V_n \times I_n \times \cos \varphi_n$ (single-Phase); $P_n = \sqrt{3}\ V_n \times I_n \times \cos \varphi_n$ (three-Phase)
- "P_m" for the momentary power
- "(c)" for over-excited
- "(i)" for under-excited

Active and reactive power:

The regarded system of the voltage and current vectors is the load view (Figure 2):

- If the inverter feeds to the grid the active power is measured with negative sign. For the sake of reading the document the measured active infeed power has a positive sign.

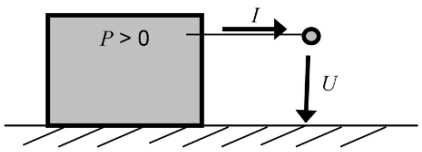


Figure 1

For the representation in quadrants, a power circle is chosen whose representation is compatible with mathematical representations of trigonometry and complex numbers (see Figure 2). Angles are counted positively counterclockwise as in mathematics. The phase angle is defined as the angle from the current pointer to the voltage pointer. The current pointer is always in the real axis; the position of the voltage pointer corresponds to the apparent power and the phase angle.

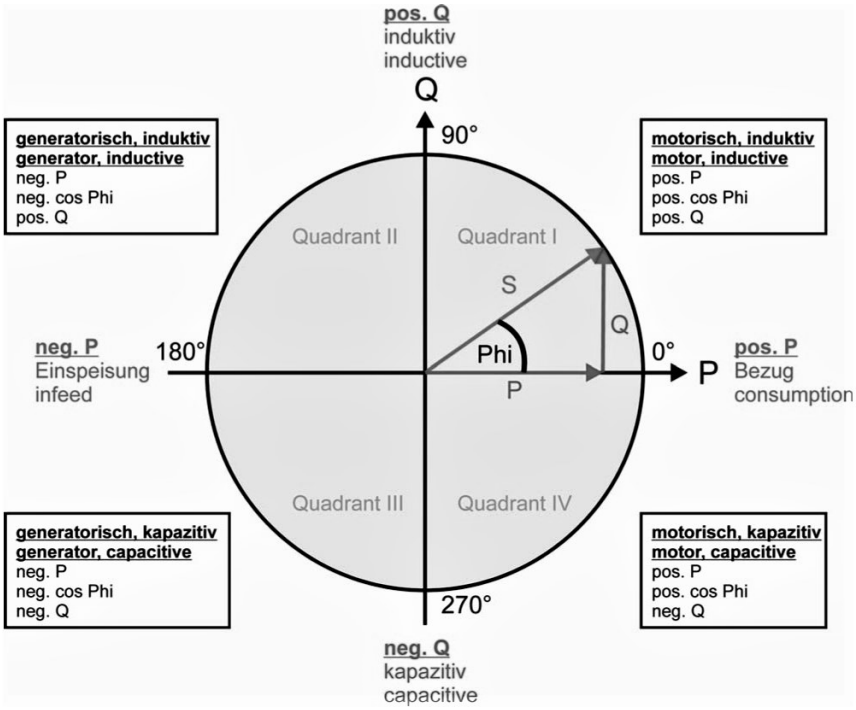


Figure 2

The different operating states can be represented in quadrants I to quadrant IV. The quadrants are named in a counter-clockwise direction.

- Quadrant I: Ohmic inductive load (coil)
- Quadrant II: One active power supplying generation plant with simultaneous reactive power consumption
- Quadrant III: A generation plant supplying active and reactive power
- Quadrant IV: Ohmic-capacitive load (capacitor)

This Test Report consists of the following documents:

1. Test Results
2. Annex No. 1 – EMC Test Report
3. Annex No. 2 – Pictures of the unit
4. Annex No. 3 – Test equipment list

Copy of marking plate

Copy of marking plate

General product information:

The unit converts DC voltage into AC voltage.
The DC input of unit can be supplied from PV array and Batteries.
The charging current to batteries from PV array and power grid, battery management unit is integrated in External Energy storage.
The unit is a single-phase type and it can be used in parallel.
The unit is providing EMC filtering at the output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundant by the high power switching bridge and two relays. This assures that the opening of the output circuit will also operate in case of one error.

Description of the electrical circuit:

The internal control is redundant built. It consists of Main MCU(U3) and slave MCU(U33).

The Main MCU(U3) can control the relays, measures voltage, and frequency, AC current with injected DC, insulation resistance and residual current, In addition it tests the array insulation resistance and the RCMU circuit before each start up.

The slave MCU (U33) is using for controlling the relays, measuring the voltage， frequency, inject a dc AC current, the residual current, and communicating with the master MCU (U3). And if the communicating with the master MCU, the slave MCU will disconnect the relays.

The unit provides two relays in series on Line and Neutral conductors. When single-fault applied to one relay, alarm an error code in display panel, another redundant relay provides basic insulation maintained between the PV array and the mains. All the relays are tested before start up. Both controllers Main MCU(U3), Slave MCU(U33) can open the relays.

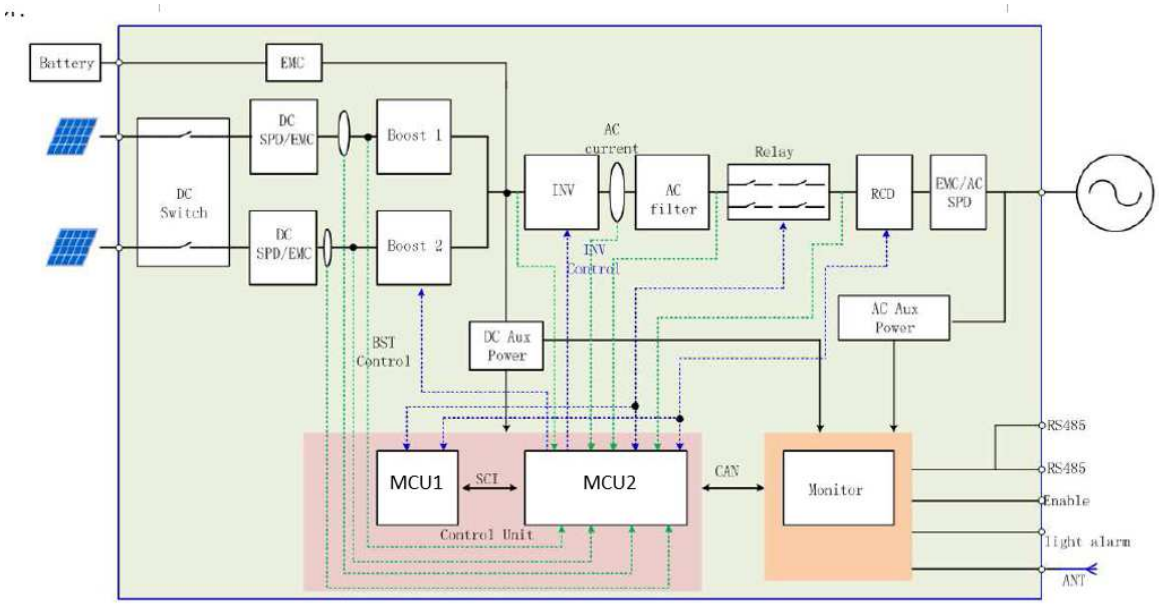


Figure 3 – Block diagram

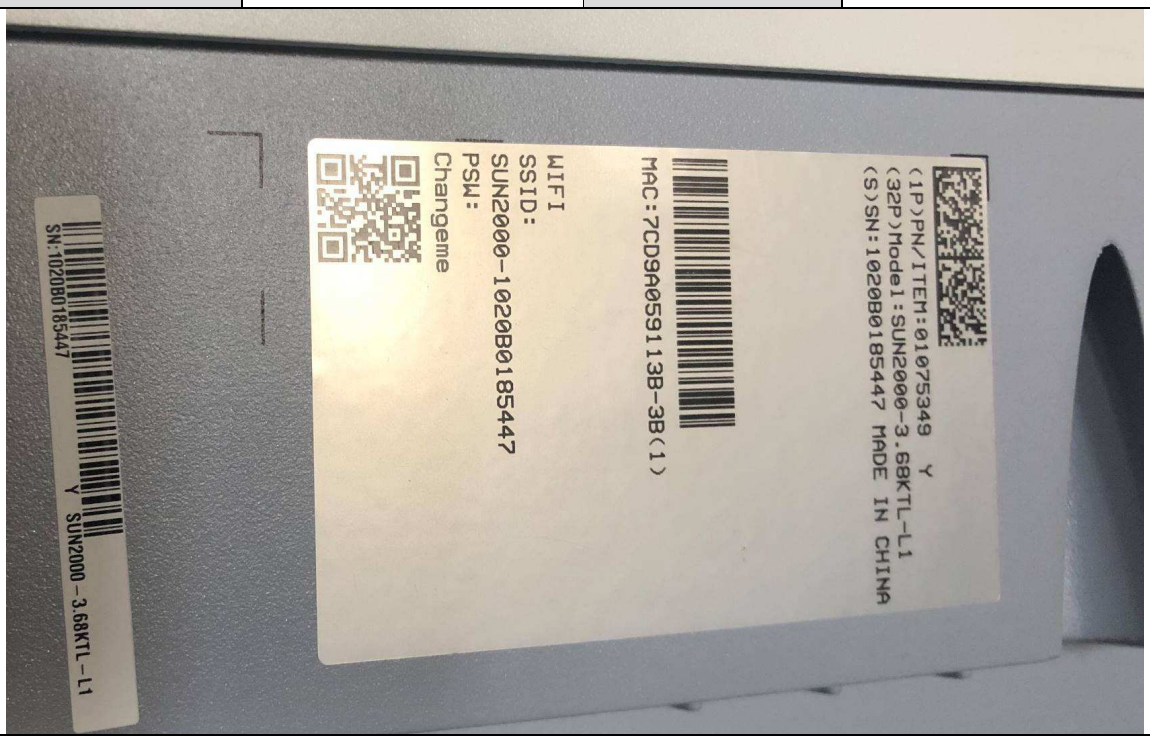
Differences of the models:

The models SUN2000-2KTL-L1, SUN2000-3KTL-L1 and SUN2000-3.68KTL-L1 are almost identical in hardware except current sampling circuit and the output power derated by software.

The product was tested on:

The product(s) with below model and serial number was tested on:

Model:	SUN2000-3.68KTL-L1	Serial number:	1020B0185447



Hardware version: V200R001

Software version: V200R001

All tests were performed on SUN2000-3.68KTL-L1. Tests of the EUT of SUN2000-3.68KTL-L1 not applicable for the models SUN2000-2KTL-L1 and SUN2000-3KTL-L1 were performed on the concerned models and a statement is given at the relevant test.

Some test results refer to test report PVUK191217N030-R1 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on September 16, 2020, details refer to the note in the relative test clauses.

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Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
Annex A1	**Requirements for Type Testing of Inverter Connected Micro-generators**		
A 1.1	**General** This Annex describes a methodology for obtaining type certification or type verification for Micro-generators which are connected to the Distribution Network via an Inverter. Typically, all interface functions are contained within an Inverter and in such cases it is only necessary to have the Inverter Fully Type Tested. In the case where a package of specific separate parts are used to assemble a Fully Type Tested Micro-generator the completed Micro-generator's Interface Protection shall not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections shall be made by plug and socket which the Manufacturer has made and tested prior to delivery to site. The Interface Protection shall satisfy the requirements of all of the following standards. Where these standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable. BS EN 61000 (Electromagnetic Standards) BS EN 60255 (Electrical Relays) BS EN 61810 (Electrical Elementary Relays) BS EN 60947 (Low Voltage Switchgear and Control gear) BS EN 61869 (Instrument Transformers: Additional requirements for current transformers) Currently there are no harmonised functional standards that apply to the Microgenerator's Interface Protection. Consequently, in cases where power electronics is used for energy conversion along with any separate Interface Protection unit they will need to be brought together and tested as a complete Microgenerator as described in this EREC G98, and recorded in a format similar to that shown in Form C (Appendix 3). Where the Interface Protection is physically integrated within the overall Micro-generator control system, the functionality of the Interface Protection unit should not be compromised by any failure of other	Considered. Test results see below.	**P**

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	elements of the control system (fail safe). This Annex applies to Micro-generators: • with or without or energy storage systems connected on the energy source or prime mover side of the Micro-generator; and • with or without load management devices.		
A 1.2	**Type Verification Functional Testing of the Interface Protection** Type testing is the responsibility of the Manufacturer. The type testing can be done by the Manufacturer of an individual component or by an external test house or by the supplier of the complete system, or any combination of them as appropriate. The type testing will verify that the operation of the Interface Protection shall result: a) in the safe disconnection of the Micro-generator from the DNO's Distribution Network in the event that the protection settings specified in Table 2 are exceeded; and b) in the Micro-generator remaining connected to the DNO's Distribution Network while Distribution Network conditions are: 1) within the envelope specified by the settings plus and minus the tolerances specified for equipment operation in Table 2; and 2) within the time delay settings specified in Table 2. Wherever possible the type testing of a Micro-generator designed for a particular type of prime mover should be proved under normal conditions of operation for that technology (unless otherwise noted).	Considered Test results see below.	**P**
A 1.2.1	**Disconnection times** The minimum trip time delay settings, for over / under voltage, over / under frequency and loss of mains tests below, are presented in Table 2. For over / under voltage, over / under frequency and loss of mains tests, reconnection shall be checked as detailed below.	Considered. Test results see below..	**P**
A 1.2.2	**Over / Under Voltage** The Interface Protection shall be tested by	Considered. Test results see below..	**P**

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Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	operating the Controller in parallel with a variable AC test supply, as an example see Figure A1.1. Correct protection and ride-through operation shall be confirmed. The set points for over and under voltage at which the Interface Protection disconnects from the supply will be established by varying the AC supply voltage. The disconnect sequence should be initiated when the network conditions mean the protection should trip in accordance with the settings in Table 2, otherwise normal operation should continue. To establish the certified trip voltage, the test voltage should be applied in steps of ± 0,5% of setting for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0,5 s. It will be necessary to carry out five tests for each trip setting. The test voltage at which this trip occurred is to be recorded as the certified trip voltage. To establish the certified trip time, the test voltage should be applied starting from ± 1,8% below the certified trip voltage in a step of at least ± 0,5% of setting for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0,5 s. Where the Interface Protection functionality is implemented in the Controller it will be necessary to carry out five tests for each trip setting. The longest trip time is to be recorded as the certified trip time. For example to test overvoltage setting stage 1 which is required to be set at nominally 262,2 V the circuit can be set up as shown below and the voltage adjusted to 254,2 V. In integrated designs where there is no separate way of establishing that the Micro-generator is disconnected, the Micro-generator should be powered up to export a measurable amount of energy so that it can be confirmed that the Micro-generator has ceased to output energy. The variable voltage supply is then increased in steps of no more than 0,5% of nominal (1,15 V) maintaining the voltage for at least 1,5 s (trip time plus 0,5 s) at each voltage level. At each voltage level confirmation that the Micro-generator has not tripped after the time delay is required to be taken. At the voltage level at which a trip occurs then this should be recorded as the provisional trip voltage. Additional tests just below and if necessary just above the provisional trip voltage will allow the actual trip voltage to be		

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Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	established on a repeatable basis. This value should be recorded. For the sake of this example the actual trip level is assumed to have been established as being 261 V. The variable voltage supply should be set to 257 V, the Micro-generator set to produce a measurable output (if necessary) and then the voltage raised to 265 V in a single step. The time from the step change to the disconnection of the Micro-generator should be recorded as the trip time. The Micro-generator then needs to operate at 4 V below the nominal overvoltage stage 1 setting which is 258,2 V for a period of at least 2 s without tripping and while producing a measurable output. This can be confirmed as a no trip in the relevant part of the Type Test Verification Report, Appendix 3 Form C. The voltage then needs to be stepped up to the next level of 269,7 V for a period of 0,98 s and then back to 258,2 V during which time the output of the relay should continue with no interruption though it may change due to the change in voltage, this can be recorded as a no trip for the second value. The step up and step down test needs to be done a second time with a max value of 277,7 V and with a time of 0,48 s. The Micro-generator is allowed to shut down during this period to protect itself as allowed by footnote 3 of Table 2 of this document, but it shall resume production again when the voltage has been restored to 258,2 V or it may continue to produce an output during this period. There is no defined time for resumption of production but it shall be shown that the Micro-generator restart timer has not operated so it begins producing again in less than 20 s. Note that this philosophy should be applied to the under voltage, over and under frequency, RoCoF and Vector shift stability tests which follow. Note: (1) The frequency required to trip is the setting ± 0,1 Hz (2) Measurement of operating time should be measured at a value of 0,3 Hz (suggestion – 2 x tolerance) above/below the setting to give “positive” operation (3) The “No trip tests” need to be carried out at the relevant values and times as shown in the		

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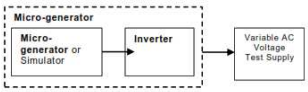
	Type Test Verification Report, Appendix 3 Form C to ensure that the protection will not trip in error. **Figure A1.1. Micro-generator Test set up – Over / Under Voltage** 		
A 1.2.3	**Over / Under Frequency** The Micro-generator shall be tested by operating in parallel with a low impedance, variable frequency test supply system, see figure A1.2. Correct protection and ride-through operation should be confirmed during operation of the Micro-generator. The set points for over and under frequency at which the Micro-generator disconnects from the supply will be established by varying the test supply frequency. To establish a trip frequency, the test frequency should be applied in a slow ramp rate of less than 0,1 Hzs-1, or if this is not possible in steps of 0,05 Hz for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0,5 s. The test frequency at which this trip occurred is to be recorded. Additional tests just above and below the trip frequency should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the Type Test Verification Report, Appendix 3 Form C. To establish the trip time, the test frequency should be applied starting from 0,3 Hz below or above the recorded trip frequency and should be changed to 0,3 Hz above or below the recorded trip frequency in a single step. The time taken from the step change to the Microgenerator tripping is to be recorded on the Type Test Verification Report, Appendix 3 Form C. It should be noted that with some loss of mains detection techniques this test may result in a faster trip due to operation of the loss of mains protection. To avoid this it is necessary to establish an accurate frequency for the trip to enable the use of a much smaller step change to initiate the trip and establish a trip time. This may require the test to be repeated several times to establish that the time delay is correct. To establish correct ride-through operation,	Considered. Test results see below.	**P**

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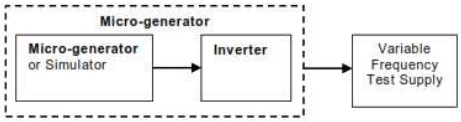
	the test frequency should be applied at each setting ± 0,2 Hz and for the relevant times shown in the Type Test Verification Report, Appendix 3 Form C. **Figure A1.2. Test set up – Over / Under Frequency** 		
A 1.2.4	**Loss of Mains Protection** The tests should be carried out in accordance with BS EN 62116 and a subset of results should be recorded as indicated in the Protection – Loss of Mains test section of the Type Test Verification Report, Appendix 3 Form C.	Considered. Test results see below.	**P**
A 1.2.5	**Reconnection** Further tests will confirm that once the AC supply voltage and frequency have returned to be within the stage 1 settings specified in Table 2 following an automatic protection trip operation there is a minimum time delay of 20 s before the Micro-generator output is restored (ie before the Micro-generator automatically reconnects to the Distribution Network).	Considered. Test results see below.	**P**
A 1.2.6	**Frequency Drift and Step Change Stability test** The tests will be carried out using the same circuit as specified in A1.2.3 above and following confirmation that the Micro-generator has passed the under and over frequency trip tests and the under and over frequency stability tests. Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the Micro-generator should not trip during the test. For the step change test the Micro-generator should be operated with a measurable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 s to complete the test. The Micro-generator should not trip during this test.	Considered. Test results see below.	**P**

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	For frequency drift tests the Micro-generator should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0,95 Hzs-1 to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10 s. The Micro-generator should not trip during this test. The results shall be recorded on the Type Test Verification Report, Appendix 3 Form C.		
A 1.2.7	**Active power feed-in at under-frequency** Tests shall be undertaken to verify the Active Power feed-in at under-frequency. The tests for providing evidence of the frequency dependent active power feed-in of the Microgenerator shall be carried out on a network simulator. Measurements shall be carried out at the following Operating points: a) 50 Hz ± 0,01Hz; b) a point between 49,5 Hz and 49,6 Hz; c) a point between 47,5 Hz and 47,6 Hz. The operating point b) and c) shall be maintained for at least 5 minutes. The test is regarded as passed if: • the Micro-generator does not disconnect from the network at the operating points a) to c) when the network frequency is changed and • the Micro-generator does not reduce output energy at point b) and • the power reduction at point c) is less than or equal to the allowed power reduction according to paragraph 9.4.2 The following data shall be documented: • variation of the network frequency with time; • the measured Active Power with time.	Considered. Test results see below.	**P**
A 1.2.8	**Micro-generators which include Electricity Storage** This paragraph provides a method for demonstrating compliance with the optional performance characteristic as discussed in the foreword. The Manufacturer shall	Considered. Test results see below.	**P**

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	demonstrate how the Micro-generator Active Power when acting as a load (ie replenishing its energy store) responds to changes in system frequency. In general four tests are proposed, one set of two at rated import capacity, and one set of two at 40% of rated import capacity. In both cases the test is to reduce frequency from 50 Hz at 2 Hzs-1. In the first case the lower frequency reached will be 49.0 Hz and the second case the lower frequency will be 48,8 Hz. In all cases the response shall meet the requirements of 9.4.3.		
A 1.2.9	**Power response to over-frequency** Tests shall be undertaken using the test set up in Figure A1.2 to verify the Active Power reduction to over-frequency using a specific standard frequency threshold of 50,4 Hz and a Droop of 10%. The test should be carried out above 80% Registered Capacity and repeated at 40-60% Registered Capacity. The Micro-generator shall be at the following frequencies (refer to Figure A1.3): • a) 50,00 Hz ± 0,01 Hz; • b) 50,40+0.05 Hz ± 0,05 Hz; • c) 50,70 Hz ± 0,10 Hz; • d) 51,15 Hz ± 0,05 Hz; • e) 50,70 Hz ± 0,10 Hz; • f) 50,40+0.05 Hz ± 0,05 Hz; • g) 50,00 Hz ± 0,01 Hz. The frequency at each step should be maintained for at least one minute and the Active Power reduction in the form of a gradient determined and assessed for compliance with paragraph 9.4.	Considered. Test results see below.	**P**

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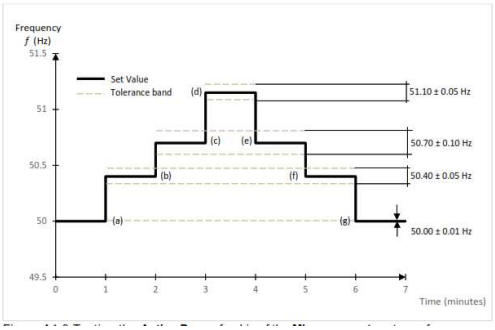
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	 Figure A1.3 Testing the Active Power feed-in of the Micro-generator at over frequency. The Droop should be determined from the measurements between 50,4 Hz and 51,15 Hz. The allowed tolerance for the frequency measurement shall be ± 0,05 Hz. The allowed tolerance for Active Power output measurement shall be ±10% of the required change in Active Power. The resulting overall tolerance range for a nominal 10% Droop is +2,8% and – 1,5%, ie a Droop less than 12,8% and greater than 8,5%.		
A 1.2.10	**Operating Range** Six tests shall be conducted with the Micro-generator operating at Registered Capacity connected to a grid simulator set as follows: • Test 1, Voltage = 85% of nominal, frequency = 47 Hz, Power factor = 1, Period of test 20 s. • Test 2, Voltage = 85% of nominal, frequency = 47,5 Hz, Power factor = 1, Period of test 90 minutes. • Test 3, Voltage = 110% of nominal, frequency = 51,5 Hz, Power factor = 1, Period of test 90 minutes. • Test 4, Voltage = 110% of nominal, frequency = 52,0 Hz, Power factor = 1, Period of test 15 minutes. • Test 5, Voltage = 100% of nominal, frequency = 50,0 Hz, Power factor = 1, Period of test 90 minutes. • Test 6, Confirm that the Micro-Generating Plant is capable of staying connected to the	Considered. Test results see below.	**P**

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	Distribution Network and operate at rates of change of frequency up to 1 Hzs-1 as measured over a period of 500 ms. The Interface Protection shall be disabled during the tests. Automatic adjustment to reduce power in the case of over frequency shall be disabled for Tests 3 and 4. Active Power shall be recorded every second. The tests will verify that the Micro-generator can operate within the required ranges for the specified period of time. In case of a PV Micro-generator the PV primary source may be replaced by a DC source. In case of a full converter Micro-generator (eg wind) the primary source and the prime mover Inverter/rectifier may be replaced by a DC source. In case of a DFIG Micro-generator the mechanical drive system may be replaced by a test bench motor.		
A 1.3	**POWER QUALITY**		**P**
A 1.3.1	**Harmonics** The tests should be carried out as specified in BS EN 61000-3-2 and can be undertaken with a fixed source of energy at two power levels firstly between 45 and 55% and at 100% of Registered Capacity. The test must be carried out with a minimum of 2 kW of rated Micro-generators. Where an individual Micro-generator is smaller than 2 kW it should be tested as a group. However, where a Micro-generator is designed to be installed singly in an installation then this can be tested alone, for example a domestic CHP unit. The maximum group size for the test is 3,68 kW. The results for all Micro-generators should be normalised to a rating of 3,68 kW. The Micro-generator or group shall meet the harmonic emissions of Table 1 in BS EN 61000-3-2 with a scaling factor applied as follows for each harmonic current: BS EN 61000-3-2 Table 1 current limit × rating of Micro-generator being tested (kW) per phase / 3,68	Considered. Test results see below.	**P**
A 1.3.2	**Power Factor** The test set up shall be such that the Inverter	Considered. Test results see below.	**P**

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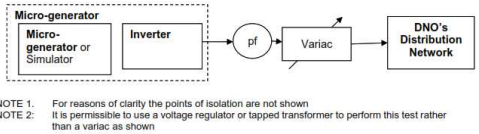
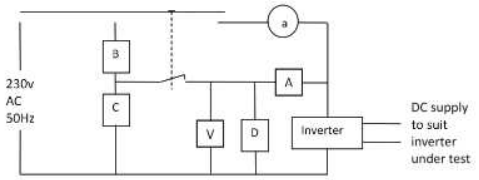
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	supplies full load to the DNO's Distribution Network via the power factor (pf) meter and the variac as shown below in Figure A1.4. The Inverter pf should be within the limits given in paragraph 9.6 for three test voltages 230 V – 6%, 230 V and 230 V +10%. The voltage shall be maintained within ±1,5% of the stated level during the test.  NOTE 1. For reasons of clarity the points of isolation are not shown NOTE 2: It is permissible to use a voltage regulator or tapped transformer to perform this test rather than a variac as shown Figure A1.4 test set up – Power Factor		
A 1.3.3	**Voltage Flicker** The test must be carried out with a minimum of 2 kW of rated Micro-generators. Where an individual Micro-generator is smaller than 2 kW it should be tested as a group. However, where a Micro-generator is designed to be installed singly in an installation then this can be tested alone, for example a domestic CHP unit. The maximum group size for the test is 3,68 kW. The Micro-generator or group shall meet the required dmax, dc, d(t), Pst, Plt requirements of BS EN 61000-3-3 with a scaling factor applied as follows for each voltage change component. dmax, dc, d(t), Pst, Plt × rating of Micro-generator being tested (kW) per phase / 3,68 The results for groups of Micro-generators should be normalised to a rating of 3,68 kW and to the standard source impedance. Single Micro-generators need to be normalised to the standard source impedance, these normalised results need to conform to the limits set out in the Type Test Verification Report, Appendix 3 Form C. For voltage change and flicker measurements the following simplified formula is to be used to convert the measured values to the normalised values where the power factor of the Micro-generator output is 0,98 or above. Where it is less than 0,98 then compliance with the full requirements of BS EN 61000-3-3 is required. Normalised value = Measured value × reference source resistance/measured source	Considered. Test results see below.	**P**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	resistance at test point. And for units which are tested as a group. Normalised value = Measured value × reference source resistance/measured source resistance at test point × 3,68/rating per phase. Single phase units reference source resistance is 0,4 Ω. Two phase units in a three phase system reference source resistance is 0,4 Ω. Two phase units in a split phase system reference source resistance is 0,24 Ω. Three phase units reference source resistance is 0,24 Ω. The stopping test should be a trip from full load output. The dates and location of the tests need to be noted in the Type Test Verification Report, Appendix 3 Form C. Note: For wind turbines, flicker testing should be carried out during the performance tests specified in IEC 61400-12-1. Flicker data should be recorded from wind speeds of 1 ms-1 below cut-in to 1,5 times 85% of the rated power. The wind speed range should be divided into contiguous bins of 1 m/s centred on multiples of 1 ms-1. The dataset shall be considered complete when each bin includes a minimum of 10 mins of sampled data. The highest value of each parameter measured across the entire range of tests shall be recorded. Note: As an alternative to type testing the Manufacturer of a Micro-generator incorporating an Inverter may give a guarantee that rates of change of output do not exceed the following ramp rate limits. Output needs to ramp up at a constant rate. This exception to site testing does not apply to devices where the output changes in steps of over 30 ms rather than as a ramp function, a site test is required for these units. • Single phase units and two phase units in a three phase system, maximum ramp up rate 333 Ws^{-1}; • Two phase units in a split phase system and three phase units, maximum ramp up rate 860 Ws^{-1}.		

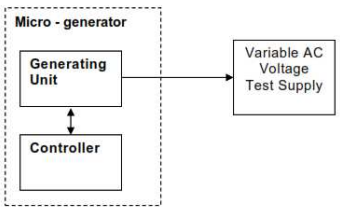
Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	It should be noted that units conforming to this declaration are likely to be less efficient at capturing energy during times when the energy source is changing. For technologies other than wind turbines, testing should ensure that the controls or automatic programs used produce the most unfavourable sequence of voltage changes. Hydro Micro-generators where the output is controlled by varying the load on the generator using the Inverter and which therefore produce variable output need to conform to the maximum voltage change requirements of BS EN 61000-3-2 and also need to be tested for Pst and Plt over a period where the range of flows varies over the design range of the turbine with a period of at least 2 hours at each step with there being 10 steps from min flow to maximum flow. Pst and Plt values to recorded and normalised as per the method laid down in the Type Test Verification Report, Appendix 3 Form C.		
A 1.3.4	**DC Injection for Inverters** Where a Micro-generator is designed to be installed singly in an installation, for example a domestic CHP unit, then this DC injection limit can be a maximum value of 20 mA for sub 2 kW Micro-generator and can be tested alone. Where Micro-generators are designed such that multiple units may be installed in an installation for example roof mounted wind turbines and PV with micro Inverters on each panel, then they should be tested as a group of at least 2 kW and with a maximum group size of 4 kW. The level of DC injection from the Inverter-connected Micro-generator into the DNO's Distribution Network shall not exceed the levels specified in Section 11 when measured during operation at three levels, 10%, 55% and 100% of Registered Capacity with a tolerance of plus or minus 5%. The DC component can be measured by one of the following two methods: • the average of the current samples (preferred); • root mean square of frequencies components below 1 Hz. The DC component level shall be measured	Considered. Test results see below.	**P**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	with an observation period large enough to ensure repeatability, and of at least 60 s. As an example, at 230 V a 2 kW single phase Inverter has a current output of 8,7 A so DC limit is 21,75 mA; a 10 kW three phase Inverter has a current output of 14,5 A per phase which is equivalent to a total of 43,5 A at 230 V so DC limit is 108,75 mA.		
A 1.3.5	**Short Circuit Current Contribution for Inverters** Inverter connected Micro-generators generally have small short circuit fault contributions, however, DNOs need to understand the contribution that they make to system fault levels in order to determine that they can continue to safely operate without exceeding design fault levels for switchgear and other circuit components. The following type tests shall be carried out and the results noted in the Type Test Verification Report, Appendix 3 Form C. **Figure A3. Test circuit** 	Considered. Test results see below.	**P**
A 1.3.6	**Self-Monitoring - Solid State Disconnection** Some Micro-generators include solid state switching devices to disconnect from the DNO's Distribution Network. In this case 10.1.9 requires the control equipment to monitor the output stage of the Micro-generator to ensure that in the event of a protection initiated trip the output voltage is either disconnected completely or reduced to a value below 50 V AC. This shall be verified either by self-certification by the Manufacturer, or additional material shall be presented to the tester sufficient to allow an assessment to be made.	A disconnection device with mechanical separation in the use of two relays in series in (each) line and neutral are provided in the unit. The internal disconnection device is comply with 4.1 function safety of the VDE 0126-1-1.	**P**

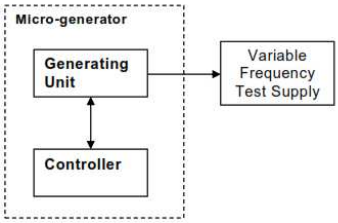
Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
Annex A2	**Requirements for Type Testing of Synchronous Micro-generators**		
A 2.1	**General** This Annex describes a methodology for obtaining type certification or type verification for the interface equipment between a directly coupled Micro-generator and the DNO's Distribution Network. Interface functions can be provided either as an integrated part of the Controller or by incorporating a protection relay but for a Fully Type Tested Micro-generator the completed Micro-generator's Interface Protection shall not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections shall be made by non-reversible plug and socket which the Manufacturer has made and tested prior to delivery to site. The Interface Protection of synchronous Micro-generators shall satisfy the requirements of all of the following standards. Where these standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable. • BS EN 61000 (Electromagnetic Standards) • BS EN 60255 (Electrical Relays) • BS EN 61810 (Electrical Elementary Relays) • BS EN 60947 (Low Voltage Switchgear and Control gear) • BS EN 61869 (Instrument Transformers: Additional requirements for current transformers) Currently there are no harmonised functional standards that apply to the Micro-generator Interface Protection, therefore in order to achieve Fully Type Tested status the Controller and any separate Interface Protection unit will require their functionality to be Fully Type Tested as described in this Annex, and recorded in format similar to that shown in the Type Test Verification Report, Appendix 3 Form C. Where the Interface Protection is physically integrated within the overall Micro-generator control system, the functionality of the Interface Protection unit should not be compromised by any failure of other	The unit is no synchronous micro-generator.	**N/A**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	elements of the control system (fail safe). This Annex applies to Micro-generators: • with or without energy storage systems connected on the alternator side of the Controller; and • with or without load management devices. Wherever possible the type testing of a Micro-generator utilising a particular type of prime mover should be proved under normal conditions of operation for that prime mover (unless otherwise noted). This Annex can also be used for asynchronous Micro-generators that are not connected to the Distribution Network via an Inverter as appropriate. This Annex also applies to any synchronous Micro-generators that are powered by stored energy (eg compressed air), but the requirement to demonstrate the LFSM-O will not be required.		
A 2.2	**Type Verification Functional Testing of the Interface Protection** Type testing is the responsibility of the Manufacturer. The type testing can be done by the Manufacturer of an individual component, by an external test house or by the supplier of the complete system, or any combination of them as appropriate. The type testing will verify that the operation of the Interface Protection shall result: a) in the safe disconnection of the Micro-generator from the DNO's Distribution Network in the event that the protection settings specified in Table 2 are exceeded; and b) in the Micro-generator remaining connected to the DNO's Distribution Network while Distribution Network conditions are: 1) within the envelope specified by the settings plus and minus the tolerances specified for equipment operation in Table 2; and 2) within the time delay settings specified in Table 2.	The unit is no synchronous micro-generator.	**N/A**
A 2.2.1	**Disconnection times** The minimum trip time delay settings, for over / under voltage, over / under frequency and loss of mains tests below, are presented	The unit is no synchronous micro-generator.	**N/A**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	in Table 2. For over / under voltage, over / under frequency and loss of mains tests, reconnection shall be checked as detailed below. In some systems it may be safer and more convenient to test the trip delay time and the disconnection time separately. This will allow the trip delay time to be measured in a test environment (in a similar way as for a protection relay). The disconnection time can be measured in the Micro-generator normal operation, allowing accurate measurement with correct inertia and prime mover characteristics. This is permitted providing the total disconnection time does not exceed the value specified in Table 2. When measuring the disconnection time where the Interface Protection is included in the Controller, 5 s disconnections should be initiated, and the average time recorded.		
A 2.2.2	**Over / Under Voltage** The Interface Protection shall be tested by operating the Controller in parallel with a variable AC test supply, as an example see Figure A2.1. Correct protection and ride-through operation shall be confirmed. The set points for over and under voltage at which the Interface Protection disconnects from the supply will be established by varying the AC supply voltage. The disconnect sequence should be initiated when the network conditions of Table 2 are met, otherwise normal operation should continue. To establish the certified trip voltage, the test voltage should be applied in steps of ± 0,5% of setting for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0,5 s. It will be necessary to carry out five tests for each trip setting. The test voltage at which this trip occurs is to be recorded as the certified trip voltage. To establish the certified trip time, the test voltage should be applied starting from ± 1,8% below the certified trip voltage in a step of at least ± 0,5% of setting for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0,5 s. Where the Interface Protection functionality is implemented in the Controller, it will be necessary to carry out five tests for each trip setting. The longest trip time is to be	The unit is no synchronous micro-generator.	**N/A**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	recorded as the certified trip time. For example, to test overvoltage setting stage 1 which is required to be set at nominally 262,2 V the circuit can be set up as shown below and the voltage adjusted to 254,2 V. In integrated designs where there is no separate way of establishing that the Micro-generator is disconnected, the Micro-generator should be powered up to export a measurable amount of energy so that it can be confirmed that the Micro-generator has ceased to output energy. The variable voltage supply is then increased in steps of no more than 0,5% of nominal voltage (1,15 V) maintaining the voltage for at least 1,5 s (trip time plus 0,5 s) at each voltage level. At each voltage level confirmation that the Micro-generator has not tripped after the time delay is required to be taken. At the voltage level at which a trip occurs then this should be recorded as the provisional trip voltage. Additional tests just below and if necessary just above the provisional trip voltage will allow the actual trip voltage to be established on a repeatable basis. This value should be recorded. For the sake of this example the actual trip level is assumed to have been established as being 261 V. The variable voltage supply should be set to 257 V, the Micro-generator set to produce a measurable output (if necessary) and then the voltage raised to 265 V in a single step. The time from the step change to the disconnection of the Micro-generator, the output of the Micro-generator falling to zero, should be recorded as the trip time. To confirm that the protection does not trip before the required time, the test voltage should be applied at each setting ± 4V and for the relevant times shown in the Type Test Verification Report, Appendix 3 Form C. Test results should be recorded on the Test Sheet shown in the Type Test Verification Report, Appendix 3 Form C. **Figure A2.1. Micro-generator Test set up – Over / Under Voltage**  		

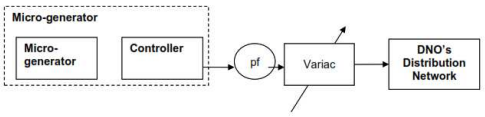
Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
A 2.2.3	**Over / Under Frequency** The Interface Protection shall be tested by operating the Controller in parallel with a low impedance, variable frequency test supply system, as an example see Figure A2.2. Correct protection and ride-through operation should be confirmed during the test. The set points for over and under frequency at which the Interface Protection disconnects from the supply will be established by varying the test supply frequency. To establish a trip frequency, the test frequency should be applied in a slow ramp rate of less than 0,1 Hzs-1, or if this is not possible in steps of 0,05 Hz for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0,5 s. The test frequency at which this trip occurred is to be recorded. Additional tests just above and below the trip frequency should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the Type Test Verification Report Appendix 3 Form C. To establish the trip time, the test frequency should be applied starting from 0,3 Hz below or above the recorded trip frequency and should be changed to 0,3 Hz above or below the recorded trip frequency in a single step. The time taken from the step change to the Microgenerator tripping is to be recorded on the Type Test Verification Report Appendix 3 Form C. It should be noted that with some loss of mains detection techniques this test may result in a faster Trip due to operation of the loss of mains protection and if possible the loss of mains protection should be turned off in order to carry out this test. Otherwise a much smaller step change should be used to initiate the trip and establish a trip time, which may require the test to be repeated several times to establish that the time delay is correct. To confirm that the protection does not trip before the required time the test frequency should be applied at each setting ±0,2 Hz and for the relevant times shown in the table in the Type Test Verification Report, Appendix 3 Form C.	The unit is no synchronous micro-generator.	**N/A**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	Figure A2.2. Test set up – Over / Under Frequency  		
A 2.2.4	**Loss of Mains Protection** The test described in this Annex should be completed at 10%, 55%, and 100% of the Registered Capacity. In both cases a subset of results should be recorded as indicated in the Protection – Loss of Mains test section of the Type Test Verification Report, Appendix 3 Form C. Note that if the suggested loading points are below the Micro-generator's minimum stable operating level the test should be completed at 100%, and at least one loading level below 100%, of the Registered Capacity. It is recommended that a power level is chosen that is 5% of the difference between the Registered Capacity and the minimum stable operating level above the minimum stable operating level: Power level = Minimum stable operating level + (Registered Capacity – minimum stable operating level) x 5% The resonant test circuit specified in this test has been designed to model the interaction of the directly coupled Micro-generator under test with the local load including multiple directly coupled connected Micro-generators in parallel. The directly coupled Micro-generators output shall be connected to a network combining a resonant circuit with a Q factor of >0,5 and a variable load. The value of the load is to match the directly coupled Micro-generator output. To facilitate the test for LoM there shall be a switch placed between the test load/directly coupled Micro-generator combination and the DNO's Distribution Network, as shown in Figure A2.3. Figure A2.3 test set up – Loss of Mains The directly coupled Micro-generator is to be tested at three levels of the directly coupled Micro-generator's output power: 10%, 55% and 100%. For each test the load match is to	The unit is no synchronous micro-generator.	**N/A**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	be within ± 5%. Each test is to be repeated five times. Load match conditions are defined as being when the current from the directly coupled Microgenerator meets the requirements of the test load ie there is no export or import of supply frequency current to or from the DNO's Distribution Network. The tests will record the directly coupled Micro-generator's output voltage and frequency from at least 2 cycles before the switch is opened until the protection system operates and disconnects itself from the DNO's Distribution Network, or for five seconds whichever is the lower duration. The time from the switch opening until the protection disconnection occurs is to be measured and must comply with the requirements in Table 2.		
A 2.2.5	**Reconnection** Further tests will confirm that once the AC supply voltage and frequency have returned to be within the stage 1 settings specified in Table 2 following an automatic protection trip operation there is a minimum time delay of 20 s before the Micro-generator output is restored (ie before the Micro-generator automatically reconnects to the Distribution Network). Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the Micro-generator should not trip during the test. For the step change test the Micro-generator should be operated with a measurable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 s to complete the test. The Micro-generator should not trip during this test. For frequency drift tests the Micro-generator should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0.95 Hzs-1 to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10 s. The Micro-generator should not trip during this test.	The unit is no synchronous micro-generator.	**N/A**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
A 2.2.6	**Frequency Drift and Step Change Stability test** The tests will be carried out using the same circuit as specified in A.2.2.3 above and following confirmation that the Micro-generator has passed the under and over frequency trip tests and the under and over frequency stability tests. Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the Micro-generator should not trip during the test. For the step change test the Micro-generator should be operated with a measurable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 s to complete the test. The Micro-generator should not trip during this test. For frequency drift tests the Micro-generator should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0,95 Hzs-1 to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10 s. The Micro-generator should not trip during this test.	The unit is no synchronous micro-generator.	**N/A**
A 2.2.7	**Active power feed-in at under-frequency** The tests detailed in A.1.2.7 shall be undertaken to verify the Active Power feed-in at underfrequency	The unit is no synchronous micro-generator.	**N/A**
A 2.2.8	**Micro-generators which include Electricity Storage** This paragraph provides a method for demonstrating compliance with the optional performance characteristic as discussed in the foreword. The Manufacturer shall demonstrate how the Micro-generator Active Power when acting as a load (ie replenishing its energy store) responds to changes in system frequency. In general four tests are proposed, one set of two at rated import capacity, and one set of two at 40% of rated import capacity. In both cases the test is to reduce frequency from 50 Hz at 2 Hzs-1. In the first case the lower frequency reached will be 49,0 Hz and the second case the lower frequency will be		**N/A**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	48,8 Hz. In all cases the response shall meet the requirements of 9.4.3.		
A 2.2.7	**Power response to over-frequency** The tests detailed in A.1.2.9 shall be undertaken to verify the power reduction to overfrequency using a specific standard frequency threshold of 50,4 Hz and a Droop of 10%.	The unit is no synchronous micro-generator.	**N/A**
A 2.3	**POWER QUALITY**	The unit is no synchronous micro-generator.	**N/A**
A 2.3.1	**Harmonics** The tests should be carried out as specified in BS EN 61000-3-2 and can be undertaken with a fixed source of energy at two power levels firstly between 45 and 55% and at 100% of Registered Capacity. Note that if the suggested power levels are below the Microgenerator's minimum stable operating level the test should be carried out at 100%, and at Least one stable loading level below 100%, of Registered Capacity. It is recommended that a power level is chosen that is 5% of the difference between the Registered Capacity and the minimum stable operating level above the minimum stable operating level: Power level = Minimum stable operating level + (Registered Capacity – minimum stable operating level) x 5% The test must be carried out with a minimum of 2 kW of rated Micro-generators. Where an individual Micro-generator is smaller than 2 kW it should be tested as a group. However, where a Micro-generator is designed to be installed singly in an installation then this can be tested alone, for example a domestic CHP unit. The maximum group size for the test is 3,68 kW.	The unit is no synchronous micro-generator.	**N/A**
A 2.3.2	**Power Factor** The test set up shall be such that the directly coupled Micro-generator supplies full load to the DNO's Distribution Network via the power factor (pf) meter and the variac as shown below in Figure A2.4. The directly coupled Micro-generator power factor should be within the limits given in paragraph 9.6 for the three test voltages 230 V –6%, 230 V and 230 V +10%.	The unit is no synchronous micro-generator.	**N/A**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	The voltage shall be maintained within ±1,5% of the stated level during the test.  NOTE 1. For reasons of clarity the points of isolation are not shown NOTE 2: It is permissible to use a voltage regulator or tapped transformer to perform this test rather than a variac as shown Figure A2.4 test set up – Power Factor		
A 2.3.3	**Voltage Flicker** The test must be carried out with a minimum of 2 kW of rated Micro-generators. Where an individual Micro-generator is smaller than 2 kW it should be tested as a group. However, where a Micro-generator is designed to be installed singly in an installation then this can be tested alone, for example a domestic CHP unit. The maximum group size for the test is 3,68 kW. The Micro-generator or group shall meet the required dmax, dc, d(t), Pst, Plt requirements of BS EN 61000-3-3 with a scaling factor applied as follows for each voltage change component. dmax, dc, d(t), Pst, Plt × rating of Micro-generator being tested (kW) per phase / 3,68 For voltage change and flicker measurements the following simplified formula is to be used to convert the measured values to the normalised values where the power factor of the Micro-generator output is 0,98 or above. Where it is less than 0,98 then compliance with the full requirements of BS EN 61000-3-3 is required. Normalised value = Measured value × reference source resistance/measured source resistance at test point. And for units which are tested as a group. Normalised value = Measured value × reference source resistance/measured source resistance at test point × 3,68/rating per phase. Single phase units reference source resistance is 0,4 Ω. Two phase units in a three phase system reference source resistance is 0,4 Ω. Two phase units in a split phase system reference source resistance is 0,24 Ω.	The unit is no synchronous micro-generator.	**N/A**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	Three phase units reference source resistance is 0,24 Ω. The stopping test should be a trip from full load output. The dates and location of the tests need to be noted in the Type Test Verification Report, Appendix 3 Form C. Hydro Micro-generators with manually fixed output or where the output is fixed by controlling the water flow through the turbine to a steady rate, need to conform to the maximum voltage change requirements of BS EN 61000-3-2 but do not need to be tested for Pst or Plt.		
A 2.3.4	**Short Circuit Current Contribution for Directly Coupled technology** DNOs need to understand the contribution a Micro-generator makes to system fault levels in order to determine that they can continue to safely operate without exceeding design fault levels for switchgear and other circuit components. For rotating machines and linear piston machines the test should produce a 0 – 2 s plot of the short circuit current as seen at the Micro-generator terminals. The short circuit current contribution shall be measured upon application of a short circuit on the Micro-generator terminals (all phases / phase to neutral) with the Micro-generator(s) operating at rated output steady state conditions. Current measurements shall be taken from application of fault until the time the fault has been disconnected, following operation of the Micro-generator protection. A current decay plot shall be produced for each phase from inception of the fault until the Micro-generator has been disconnected – trip time. The plot shall show the highest value of peak short circuit current, eg for a Micro-generator supplying a purely inductive load the highest value of peak short circuit current will result when the fault is applied at a voltage zero. Where practicable the tests will need to determine values for all of the relevant parameters listed in Table A.1. Table A.1 Micro-generator Short Circuit Parameters	The unit is no synchronous micro-generator.	**N/A**

Engineering recommendation G98/1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	<table><tr><th>Parameter</th><th>Symbol</th><th>Method of Determination</th></tr><tr><td>Peak short-circuit current</td><td>i_p</td><td>Direct measurement</td></tr><tr><td>Initial value of aperiodic component</td><td>A</td><td>Direct measurement</td></tr><tr><td>Initial symmetrical short-circuit current</td><td>Ik"</td><td>Interpolation of plot</td></tr><tr><td>Decaying (aperiodic) component of short-circuit current</td><td>i_{dc}</td><td>Interpolation of plot & calculation</td></tr><tr><td>Reactance / Resistance ratio of source</td><td>$^X/_R$</td><td>Calculation</td></tr></table>		

G98-1
Test Results:

A1 Requirements for Type Testing of Inverter connected Mirco-generators

A1.2/A2.2 Type Verification Functional Testing of the Interface Protection (Functional safety - fault condition tests according DIN V VDE V 0126-1-1)	**P**

Test result: SUN2000-3.68KTL-L1

ambient temperature [°C]:	24,9	
model/type of power supply:	AC: 6560 DC: 62150h-1000s	
manufacturer of power supply:	Chroma	
rated markings of power supply:	AC: 0-300V, 6kVA DC: 0-1000V,15A	

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
Relay defect Q501_PIN1-PIN2	Short before Start up	220V <0,1A	530V <0,1 A	10min	--	220V <0,1A	530V <0,1A	PCE can't start up. Error message: "Device fault". No damage, no hazard, no reconnetion.
Relay defect Q502_ PIN1-PIN2	Short before Start up	220V <0,1A	530V <0,1 A	10min	--	220V <0,1A	530V <0,1A	PCE can't start up. Error message: "Device fault". No damage, no hazard, no reconnetion.
Grid voltage monitoring R1048	Open	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	PCE can't start up. Error message: "Grid undervolt". No damage, no hazard, no reconnetion.
Grid voltage monitoring R104	Open	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	PCE can't start up. Error message: "Grid undervolt". No damage, no hazard, no reconnetion.
Grid voltage monitoring R1048	Open	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: "Grid undervolt". No damage, no hazard, no reconnetion.
Grid voltage monitoring R1048	Short	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: "Grid undervolt". No damage, no hazard, no reconnetion.
RCMU detect R101	Open	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: "RCD fault". No damage, no hazard, no reconnetion.
RCMU detect C1303 PIN1-PIN2	Open	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: "RCD fault". No damage, no hazard, no reconnetion.
Grid current sensor defect U74.5->U74.4	Open	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: "Device fault". No damage, no hazard, no reconnetion.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
Grid current sensor defect U74.5->U74.11	Open	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: “Device fault”. No damage, no hazard, no reconnetion.
BUS voltage defect D61.3->D61.2	Short	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: “Device fault”. No damage, no hazard, no reconnetion.
BUS voltage defect D61.3->D61.1	Short	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: “Device fault”. No damage, no hazard, no reconnetion.
PV voltage defect D49.3->D49.2	Short	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: “PV Arry Voltage High”. No damage, no hazard, no reconnetion.
PV voltage defect D49.3->D49.1	Short	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: “PV Arry Voltage High”. No damage, no hazard, no reconnetion.
ISO detect R1116	Short before Start up	220V <0,1A	530V <0,1 A	10min	--	220V <0,1A	530V <0,1A	PCE can’t start up. Error message: “ISO Fault”. No damage, no hazard, no reconnetion.
ISO detect Q5 PIN2-PIN3	Short before Start up	220V <0,1A	530V <0,1 A	10min	--	220V <0,1A	530V <0,1A	PCE can’t start up. Error message: “ISO Fault”. No damage, no hazard, no reconnetion.
ISO detect K1101 Pin1-Pin8	Short before Start up	220V <0,1A	530V <0,1 A	10min	--	220V <0,1A	530V <0,1A	PCE can’t start up. Error message: “ISO Fault”. No damage, no hazard, no reconnetion.
MCU communication defect R943 PIN1-PIN2	Short	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: “Device fault”. No damage, no hazard, no reconnetion.
MCU communication defect R261 PIN1-PIN2	Short	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: “Device fault”, No damage, no hazard, no reconnetion.
AFCI defect T2 PIN9-PIN10	Short before Start up	220V <0,1A	530V <0,1 A	10min	--	220V <0,1A	530V <0,1A	PCE can’t start up. Error message: “AFCI Self-Check Fault”, No damage, no hazard, no reconnetion.
AFCI defect T2 PIN7-PIN8	Short before Start up	220V <0,1A	530V <0,1 A	10min	--	220V <0,1A	530V <0,1A	PCE can’t start up. Error message: “AFCI Self-Check Fault”. No damage, no hazard, no reconnetion.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
AFCI defect D1403 PIN1-PIN2	Short before Start up	220V <0,1A	530V <0,1 A	10min	--	220V <0,1A	530V <0,1A	PCE can't start up. Error message: "AFCI Self-Check Fault". No damage, no hazard, no reconnetion.
AFCI defect D36 PIN1-PIN2	Short before Start up	220V <0,1A	530V <0,1 A	10min	--	220V <0,1A	530V <0,1A	PCE can't start up. Error message: "AFCI Self-Check Fault". No damage, no hazard, no reconnetion.
AFCI defect R1702	Open before Start up	220V <0,1A	530V <0,1 A	10min	--	220V <0,1A	530V <0,1A	PCE can't start up. Error message: "AFCI Self-Check Fault". No damage, no hazard, no reconnetion.
Loss of control R105	Open	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: "Output Current DCI Fault". No damage, no hazard, no reconnetion.
Loss of control R717	Open	220V 22,7A	530V 9,6A	10min	--	220V <0,1A	530V <0,1A	Unit shutdown immediately. Error message: "Output Current DCI Fault". No damage, no hazard, no reconnetion.

Note:

The errors in the control circuit simulate that the safety is even ensured during single fault.

The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.

The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

Addendum – Shutdown device	
Each active phase can be switched.	Yes. In each line and neutral a Relay with min. 2,00 mm gab used.
If no galvanic separation between AC and DC (PV): Two relays in series on each active phase are necessary to fulfil the basic insulation or simple separation based on the PV working voltage.	Two relays in series used in each active phase (L and N).

Operating Range: This test should be carried out as specified in A.1.2.10	**P**

Test result: SUN2000-3.68KTL-L1

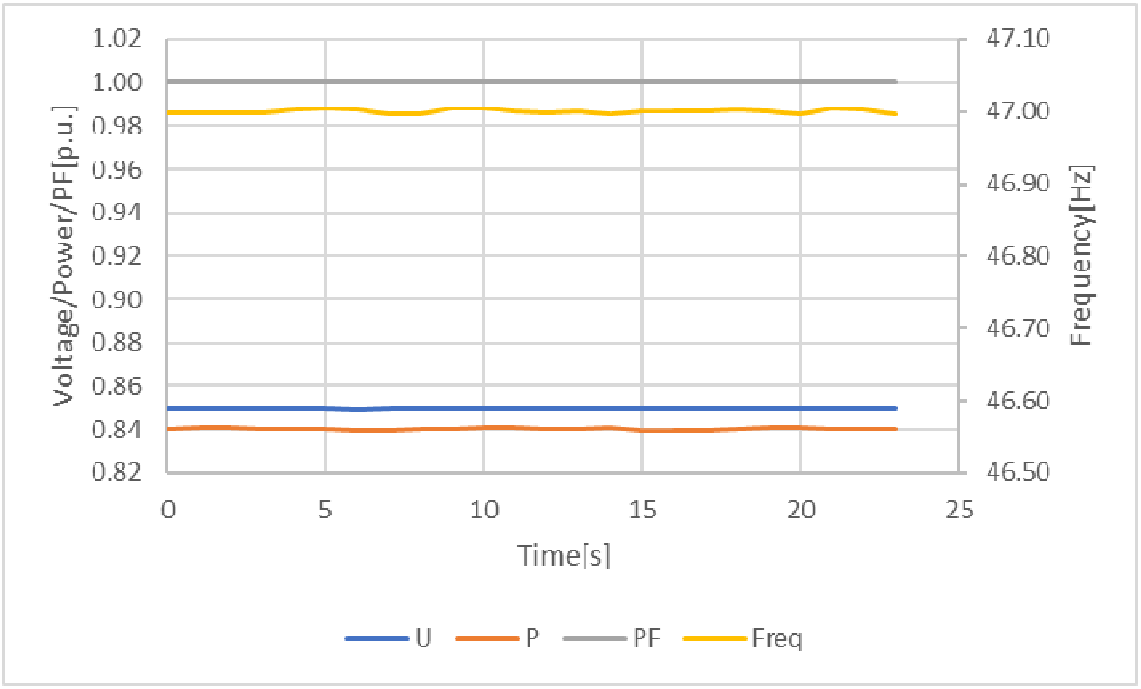
Setting values	Over-voltage [V]:	253,0
	Under-voltage [V]:	195,5
	Over-frequency [Hz]:	52,0
	Under-frequency [Hz]:	47,0

- Test 1: U = 195,5 V; f = 47,0 Hz; P = 1,00 Sn; cosφ = 1; at least 20 seconds
- Test 2: U = 195,5 V; f = 47,5 Hz; P = 1,00 Sn; cosφ = 1; at least 90 mins
- Test 3: U = 253,0 V; f = 51,5 Hz; P = 1,00 Sn; cosφ = 1; at least 90 mins
- Test 4: U = 253,0 V; f = 52,0 Hz; P = 1,00 Sn; cosφ = 1; at least 15 mins
- Test 5: U = 230,0 V; f = 50,0 Hz; P = 1,00 Sn; cosφ = 1; at least 90 mins
- Test 6: 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.

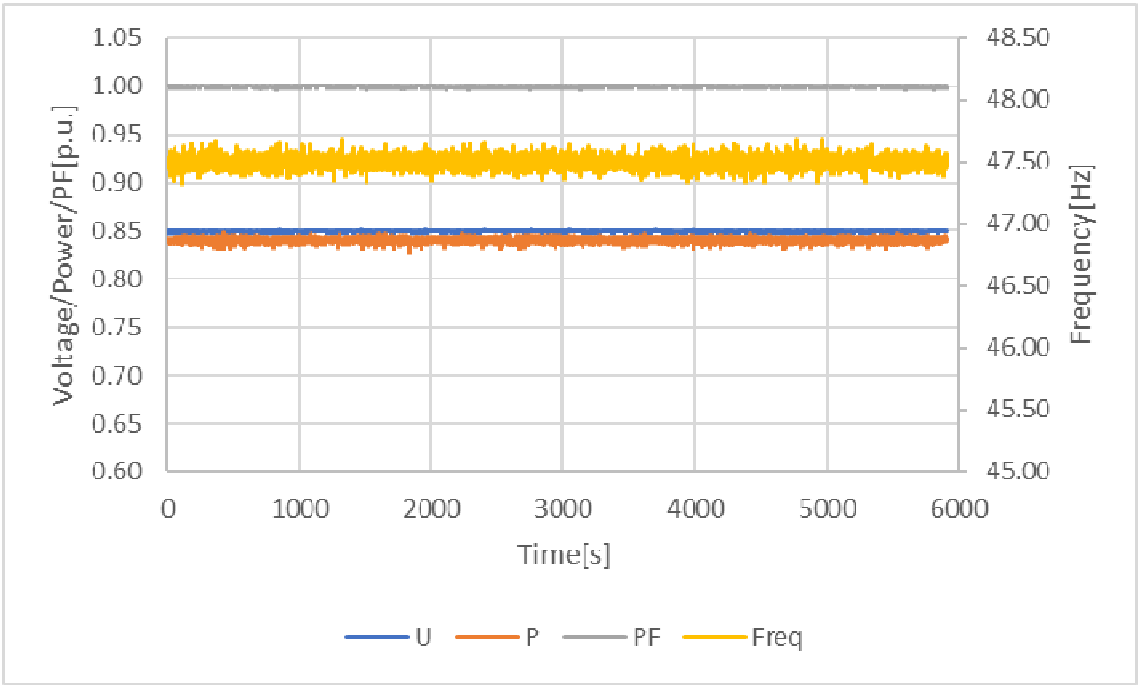
Test sequence	Voltage [V]	Frequency [Hz]	Output power [W]	Cos φ [1]
1	195,4	47,0	3093	1,000
2	195,4	47,5	3094	1,000
3	253,2	51,5	3673	1,000
4	253,2	52,0	3682	1,000
5	230,2	50,0	3677	1,000
6	230,0	50,0 Hz to 50,5 Hz	3673	1,000

Graph

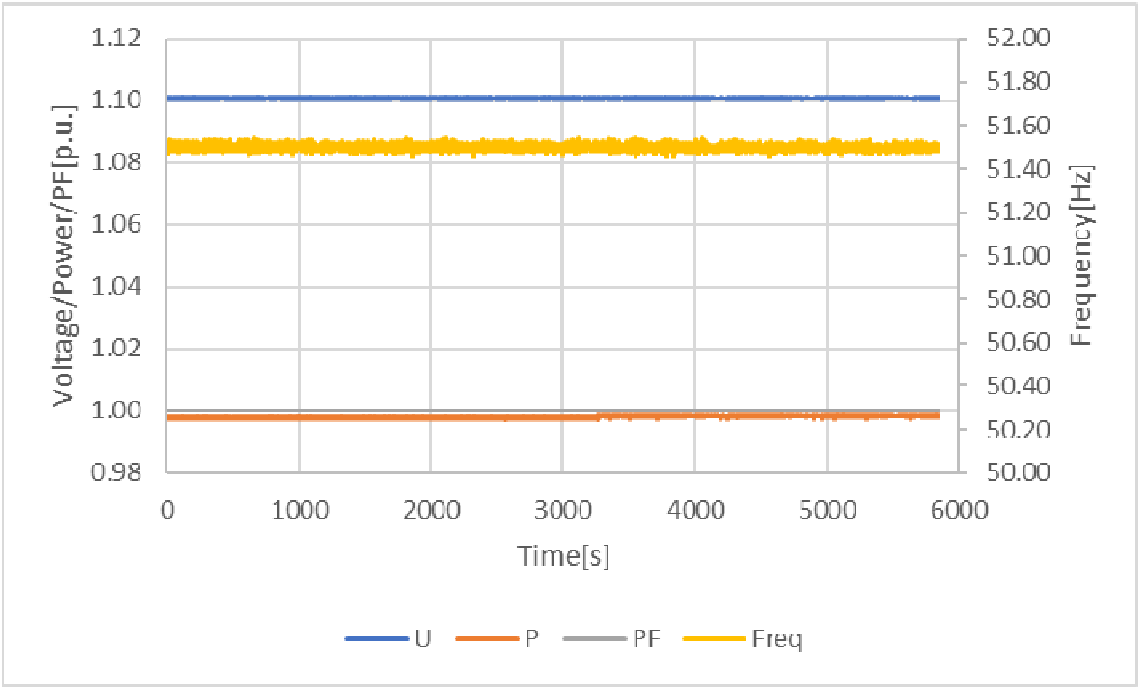
Test 1



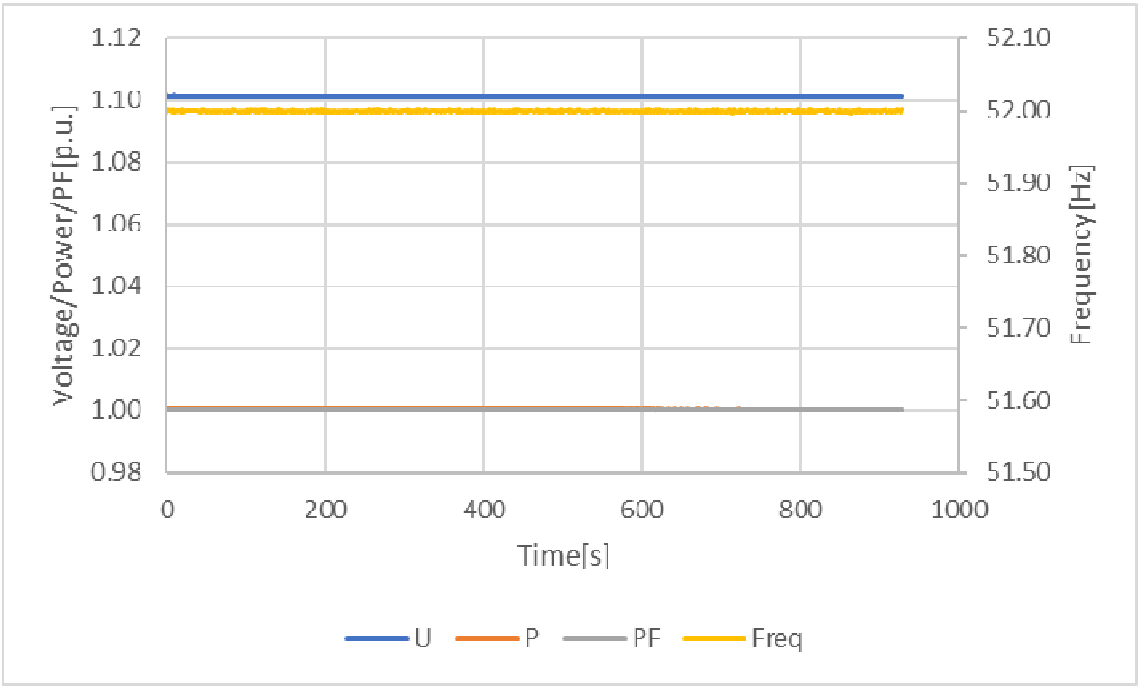
Test 2


1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
Voltage/Power/PF[p.u.]
48.50
48.00
47.50
47.00
46.50
46.00
45.50
45.00
Frequency[Hz]
0
1000
2000
3000
4000
5000
6000
Time[s]
U
P
PF
Freq

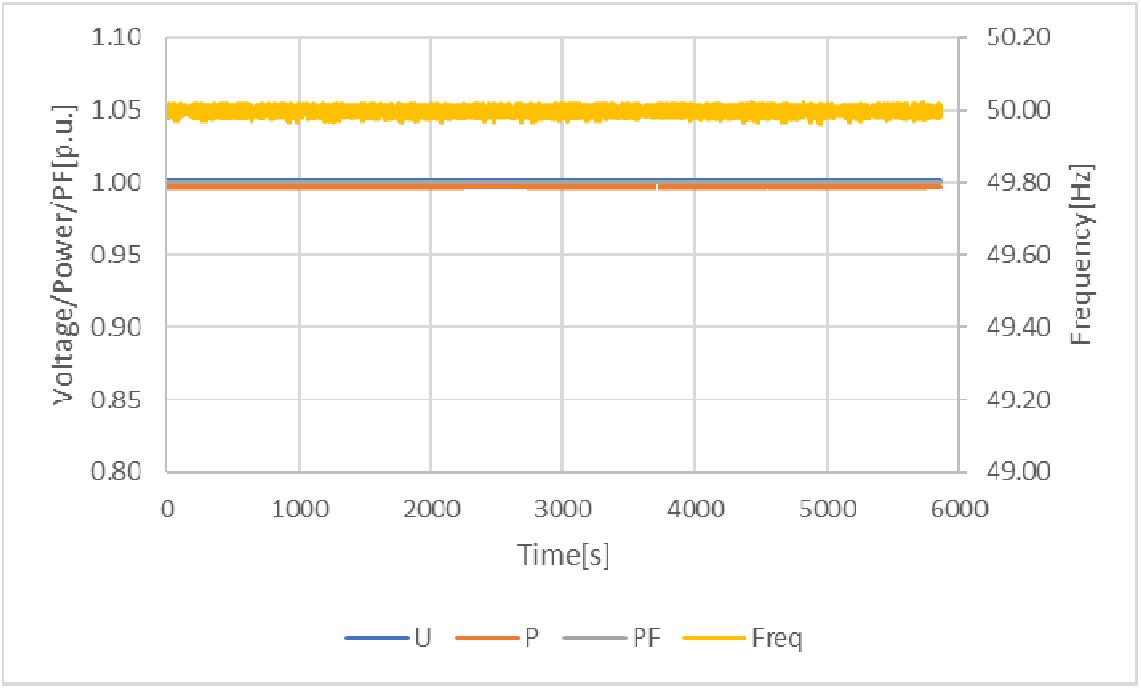
Test 3


1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.98
Voltage/Power/PF[p.u.]
52.00
51.80
51.60
51.40
51.20
51.00
50.80
50.60
50.40
50.20
50.00
Frequency[Hz]
0
1000
2000
3000
4000
5000
6000
Time[s]
U
P
PF
Freq

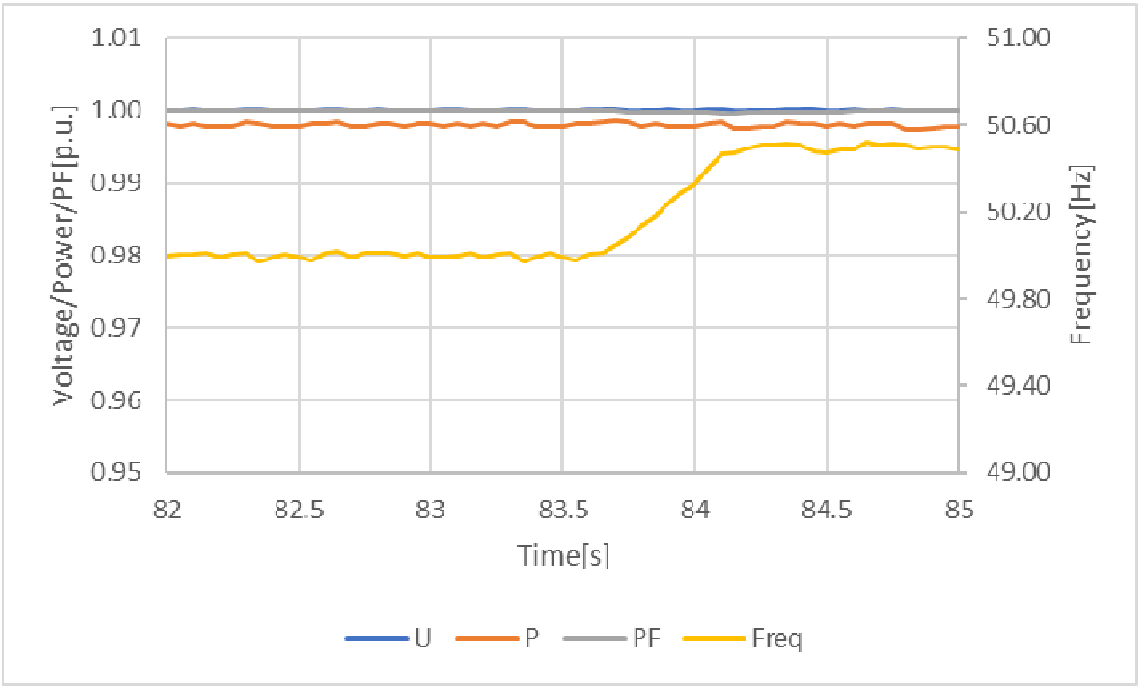
Test 4


1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.98
Voltage/Power/PF[p.u.]
52.10
52.00
51.90
51.80
51.70
51.60
51.50
Frequency[Hz]
0
200
400
600
800
1000
Time[s]
U
P
PF
Freq

Test 5


1.10
1.05
1.00
0.95
0.90
0.85
0.80
Voltage/Power/PF[p.u.]
50.20
50.00
49.80
49.60
49.40
49.20
49.00
Frequency[Hz]
0
1000
2000
3000
4000
5000
6000
Time[s]
U
P
PF
Freq

Test 6



Note:

During the tests the interface protection was disabled.

Operation at reduced power is allowed during test 1 and 2, equal to the maximum power that can be supplied on reaching the maximum output current limit (P ≥ 0,85 Sn).

During the sequence of test 3 and test 4 automatic adjustment to reduce power in the case of over-frequency was disabled.

The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.

A 1.2.2/A 2.2.2 Over / Under Voltage The test procedure in Annex A.1.2.2 (Inverter connected) or Annex A2 A.2.2.2 (Synchronous).	**P**

Test result: SUN2000-3.68KTL-L1

Single Phase

Function	Setting		Trip test		No trip test	
	Voltage	Time delay	Voltage	Time delay	Voltage / time	Confirm no trip
U/V	184,0V	2,5s	183,6V	2,540s	188V / 5,0s	No trip
					180V / 2,45s	No trip
O/V stage 1	262,2V	1,0s	261,5V	1,080s	258,2V / 5,0s	No trip
O/V stage 2	273,7V	0,5s	273,0V	0,540s	269,7V / 0,95s	No trip
					277,7V / 0,45s	No trip

Note:

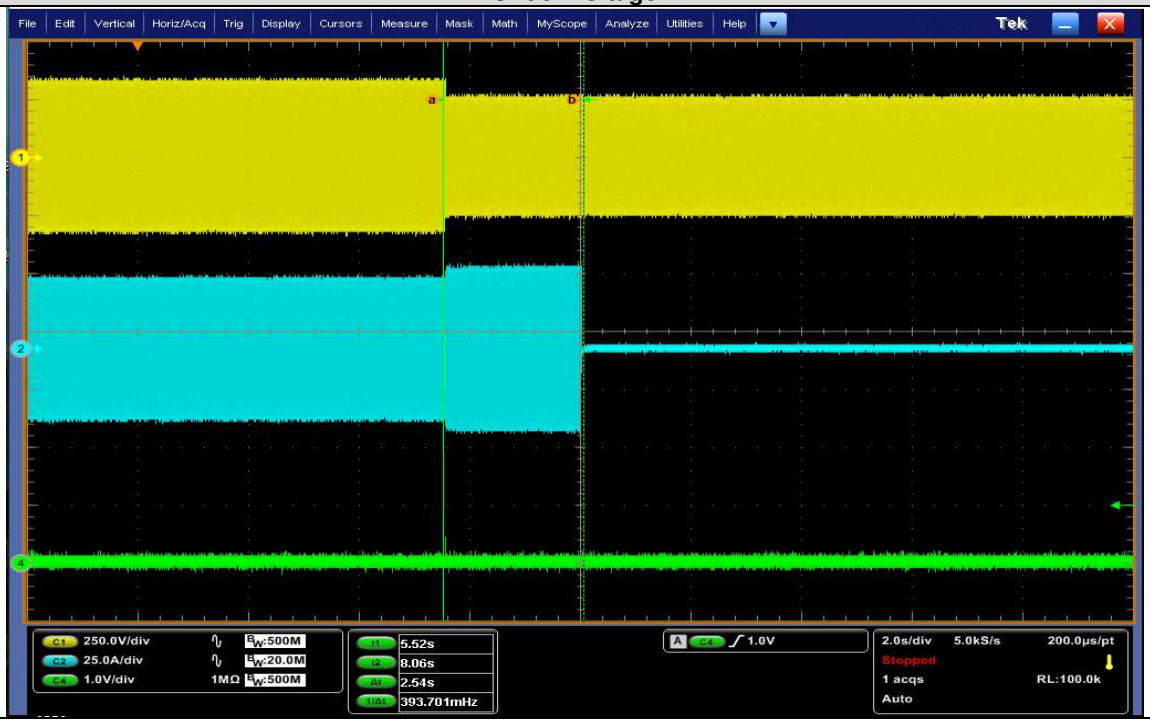
The total disconnection time for voltage and frequency protection, including the operating time of the disconnection device, shall be the time delay setting with a tolerance of, -0s + 0,5 s.

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.

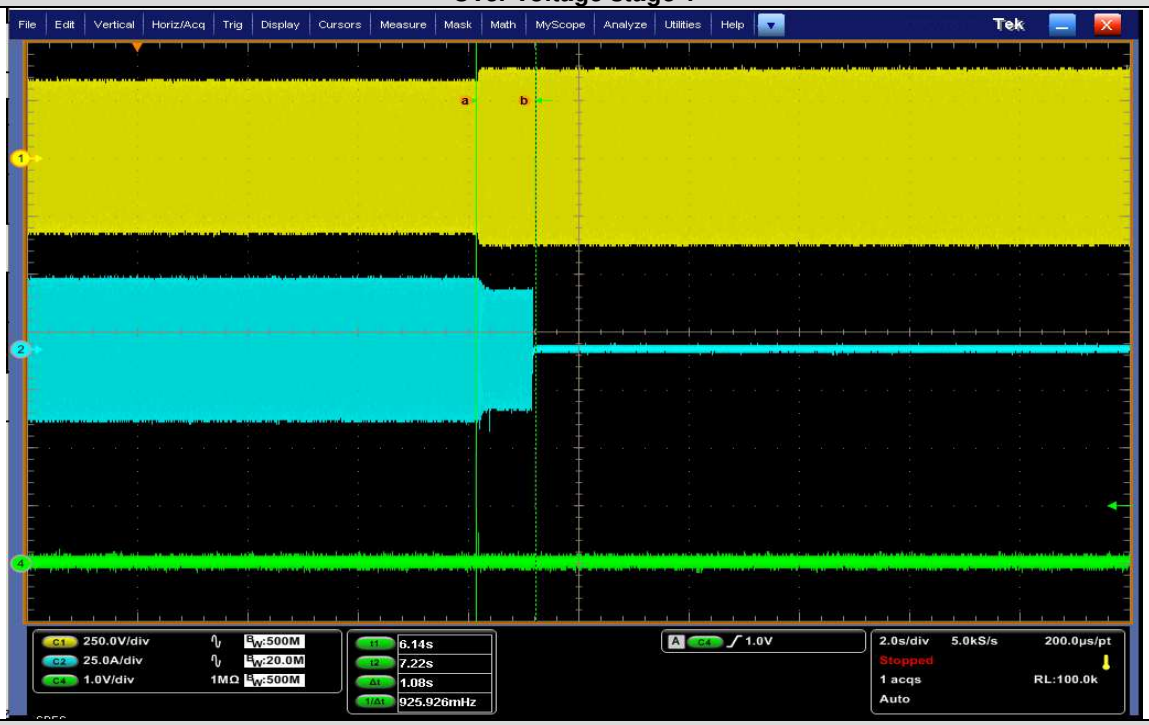
The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.

The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

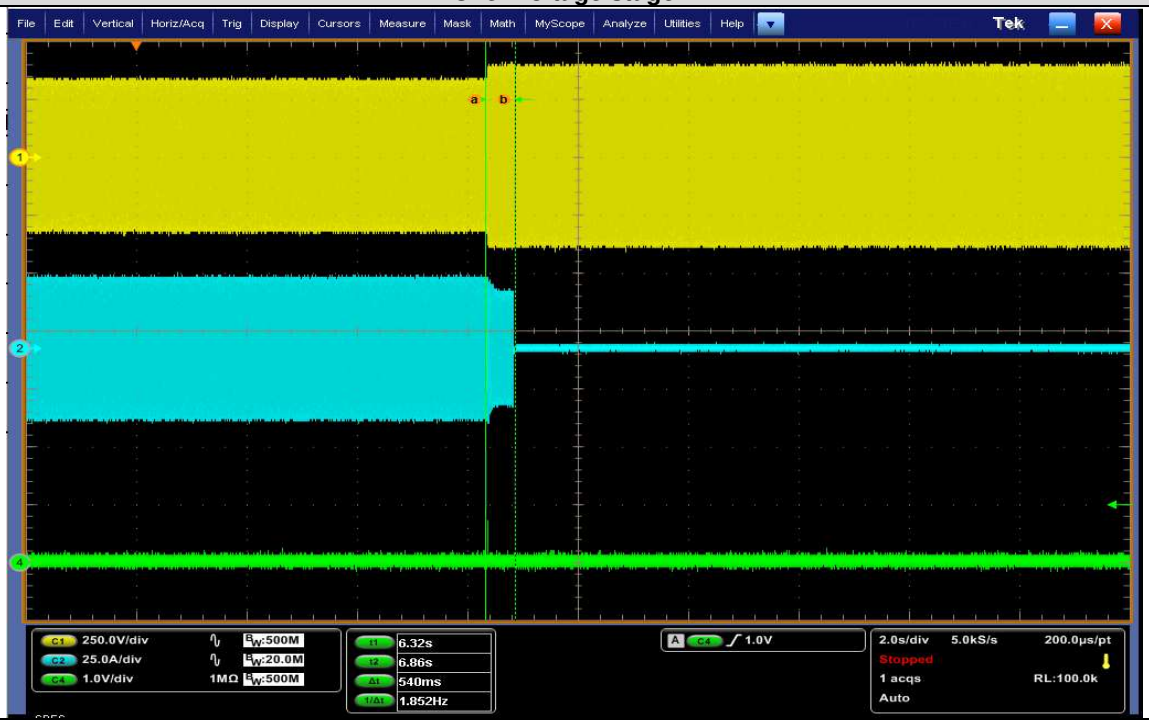
Under voltage



Over voltage stage 1



Over voltage stage 2



A 1.2.3/A 2.2.3 Over / Under Frequency The test procedure in Annex A.1.2.3 (Inverter connected) or Annex A2 A.2.2.3 (Synchronous).						**P**
Test result: SUN2000-3.68KTL-L1						
Function	Setting		Trip test		No trip test	
	Frequency	Time delay	Frequency	Time delay	Frequency / time	Confirm no trip
U/F stage 1	47,5Hz	20s	47,5Hz	20,000s	47,7Hz / 30s	No trip
U/F stage 2	47Hz	0,5s	47,0Hz	0,540s	47,2Hz / 19,5s	No trip
					46,8 Hz / 0,45s	No trip
O/F	52Hz	0,5s	52,0Hz	0,520s	51,8Hz / 120,0s	No trip
					52,2 Hz / 0,45s	No trip

Note:

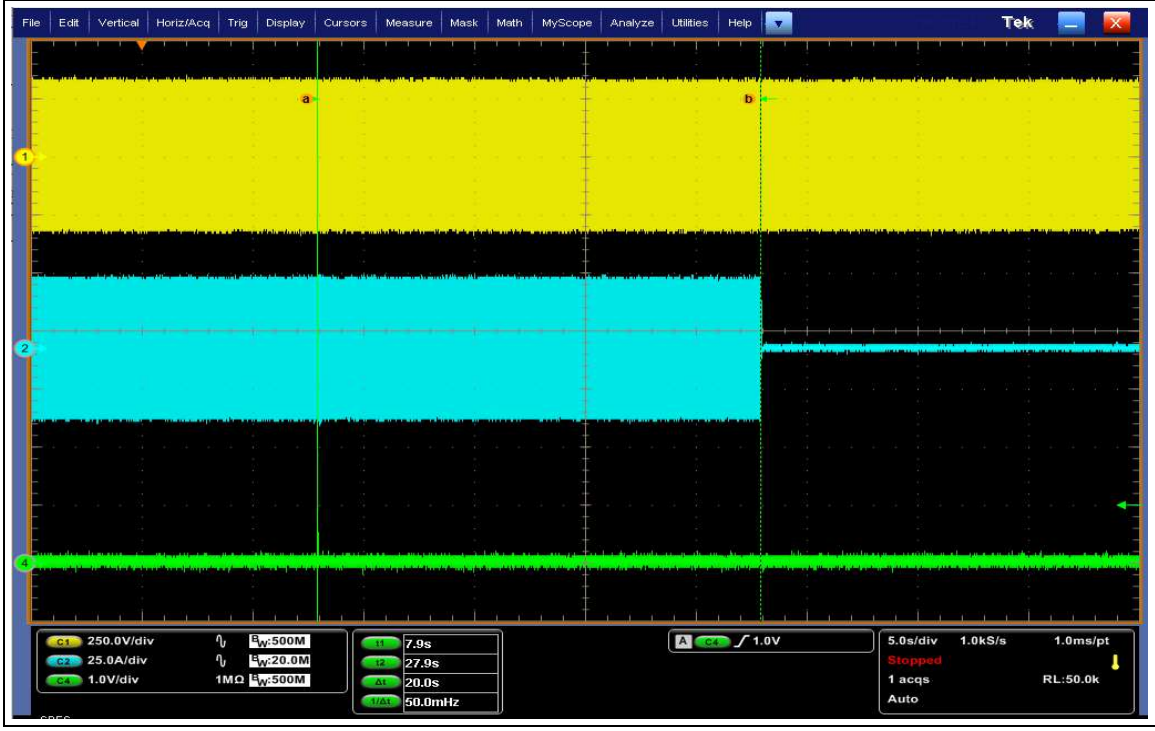
The total disconnection time for voltage and frequency protection, including the operating time of the disconnection device, shall be the time delay setting with a tolerance of, -0s + 0,5 s.

For frequency trip tests the frequency required to trip is the setting ± 0,5 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.

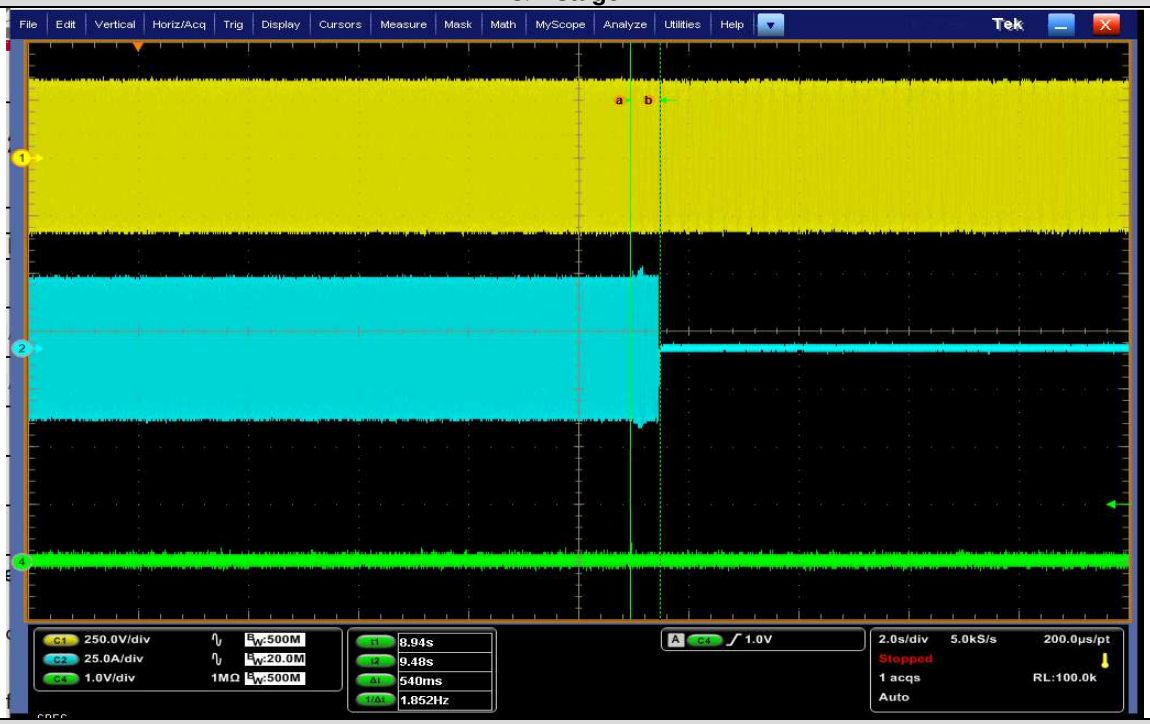
The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.

The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

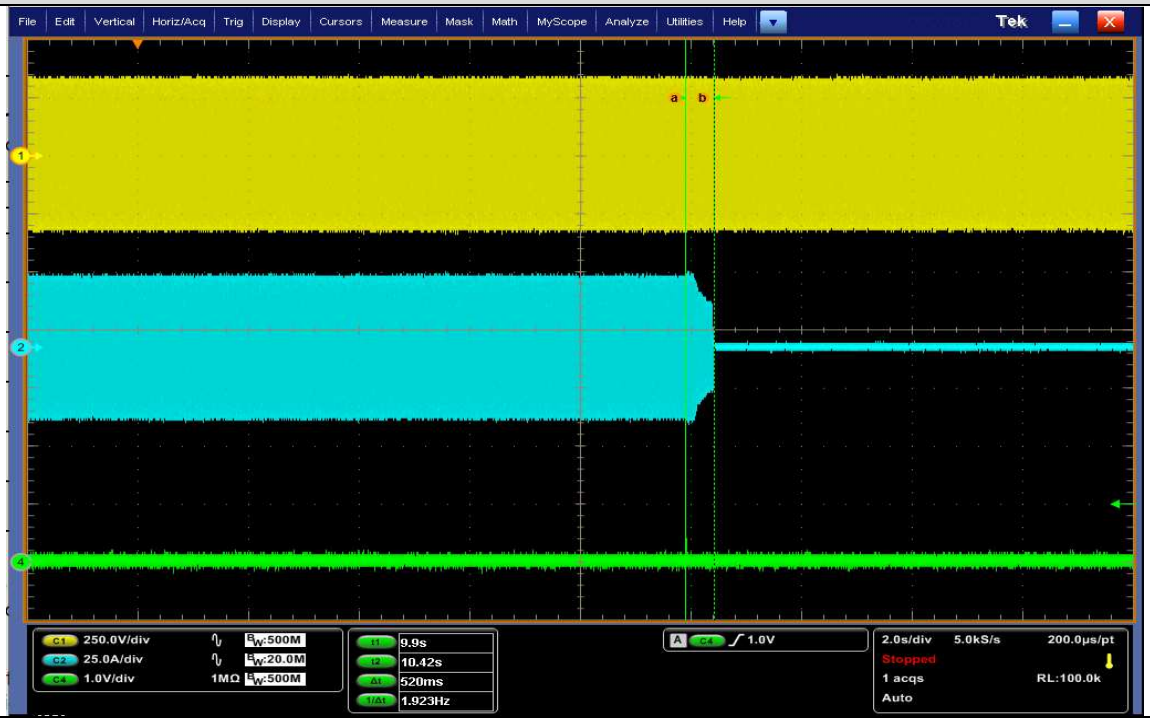
U/F stage 1



U/F stage 2


File Edit Vertical Horiz/Acq Trig Display Cursors Measure Mask Math MyScope Analyze Utilities Help
Tek
C1 250.0V/div
C2 25.0A/div
C4 1.0V/div
1MΩ
BW:500M
BW:20.0M
BW:500M
t1 8.94s
t2 9.48s
Δt 540ms
1/Δt 1.852Hz
A C4 1.0V
2.0s/div 5.0kS/s 200.0µs/pt
Stopped
1 acqs
RL:100.0k
Auto

O/F


File Edit Vertical Horiz/Acq Trig Display Cursors Measure Mask Math MyScope Analyze Utilities Help
Tek
C1 250.0V/div
C2 25.0A/div
C4 1.0V/div
1MΩ
BW:500M
BW:20.0M
BW:500M
t1 9.9s
t2 10.42s
Δt 520ms
1/Δt 1.923Hz
A C4 1.0V
2.0s/div 5.0kS/s 200.0µs/pt
Stopped
1 acqs
RL:100.0k
Auto

A 1.2.4 Loss of mains protection according BS EN 62116 The requirement is specified in section 10.2, test procedure in Annex A.1.2.4 Load imbalance (real, reactive load) for test condition A (EUT output = 100%)	**P**

Test result: SUN2000-3.68KTL-L1

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	0,5s

No	P_{EUT} 1) (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{AC} 2) (% of nominal)	Q_{AC} 3) (% of nominal)	I_{AC} 4) [A]	Run on Time (ms)	P_{EUT} (W)	Qf	V_{DC}	Remarks5)
1	100	100	0	0	0,140	308	3680	1,000	480	Test A at BL
32	100	100	-10	-10	--	250	3680	1,054	480	Test A at IB
33	100	100	-10	-5	--	267	3680	1,083	480	Test A at IB
34	100	100	-10	0	--	295	3680	1,111	480	Test A at IB
35	100	100	-10	+5	--	287	3680	1,139	480	Test A at IB
36	100	100	-10	+10	--	278	3680	1,165	480	Test A at IB
37	100	100	-5	-10	--	258	3680	0,999	480	Test A at IB
4	100	100	-5	-5	--	278	3680	1,026	480	Test A at IB
5	100	100	-5	0	--	316	3680	1,053	480	Test A at IB
6	100	100	-5	+5	--	294	3680	1,079	480	Test A at IB
38	100	100	-5	+10	--	278	3680	1,104	480	Test A at IB
39	100	100	0	-10	--	287	3680	0,949	480	Test A at IB
7	100	100	0	-5	--	266	3680	0,975	480	Test A at IB
8	100	100	0	+5	--	270	3680	1,025	480	Test A at IB
40	100	100	0	+10	--	303	3680	1,049	480	Test A at IB
41	100	100	+5	-10	--	273	3680	0,904	480	Test A at IB
9	100	100	+5	-5	--	281	3680	0,928	480	Test A at IB
10	100	100	+5	0	--	297	3680	0,952	480	Test A at IB
11	100	100	+5	+5	--	282	3680	0,976	480	Test A at IB
42	100	100	+5	+10	--	283	3680	0,999	480	Test A at IB
43	100	100	+10	-10	--	276	3680	0,862	480	Test A at IB
44	100	100	+10	-5	--	277	3680	0,886	480	Test A at IB
45	100	100	+10	0	--	345	3680	0,909	480	Test A at IB
46	100	100	+10	+5	--	297	3680	0,932	480	Test A at IB
47	100	100	+10	+10	--	278	3680	0,953	480	Test A at IB

Parameter at 0%	L= 45,76 mH	R= 14,38 Ω	C= 221,43 µF

Indicate additional shut down time included in above results. (Disconnection device operation time)	20ms

Note:

Note for technologies which have a substantial shut down time this can be added to the 0,5 seconds in establishing that the trip occurred in less than 0,5 s. Maximum shut down time could therefore be up to 1,0 seconds for these technologies.

RLC is adjusted to min. +/-1% of the inverter rated output power

[1] P_{EUT}: EUT output power

[2] P_{AC}: Real 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] Fundamental of I_{AC} when RLC is adjusted.

[5] BL: Balance condition, IB: Imbalance condition.

Condition A:

EUT output power PEUT = Maximum [5]

EUT input voltage [6] = >75% of rated input voltage range

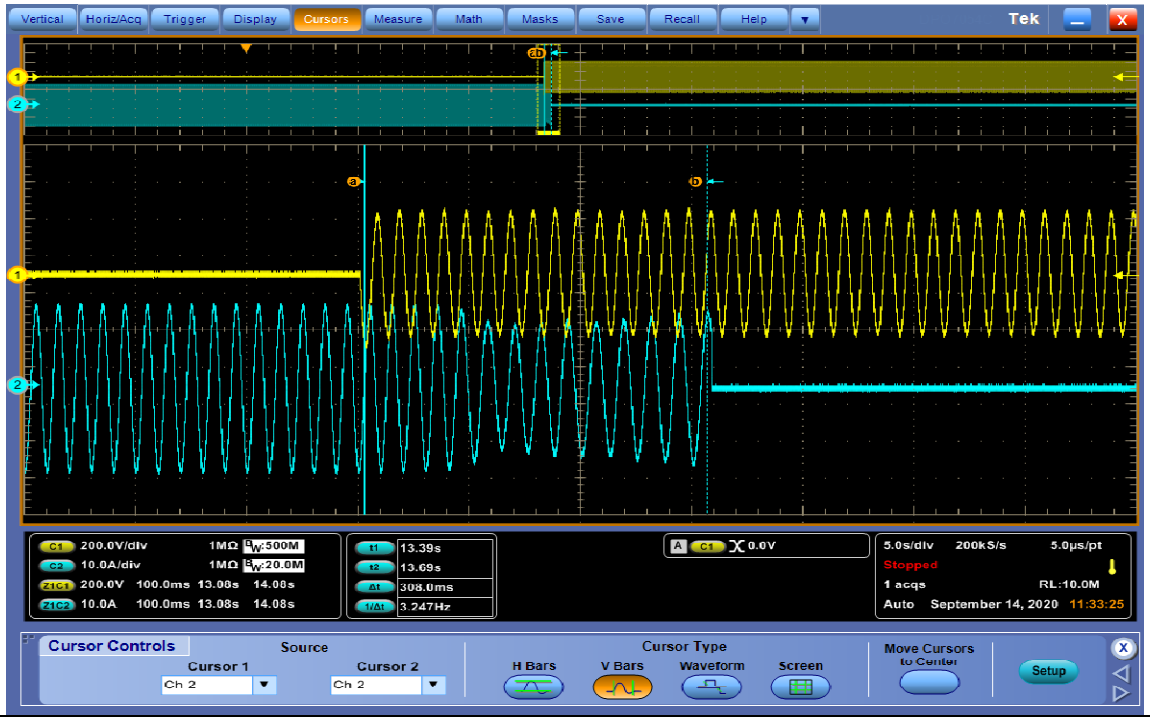
[6] Maximum EUT output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.

[7] Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 75% of range =X + 0,75 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.

The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 100% nominal power
Disconnection at No. 1



A 1.2.4 Loss of mains protection according BS EN 62116 **P**

The requirement is specified in section 10.2, test procedure in Annex A.1.2.4
Load imbalance (real, reactive load) for test condition A (EUT output = 50 % – 66 %)

Test result: SUN2000-3.68KTL-L1

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	0,5s

No	P_{EUT} 1) (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{AC} 2) (% of nominal)	Q_{AC} 3) (% of nominal)	I_{AC} 4) [A]	Run on Time (ms)	P_{EUT} (W)	Qf	V_{DC}	Remarks5)
12	66	66	0	-5	--	275	2429	0,974	300	Test B at IB
13	66	66	0	-4	--	282	2429	0,979	300	Test B at IB
14	66	66	0	-3	--	280	2429	0,984	300	Test B at IB
15	66	66	0	-2	--	292	2429	0,990	300	Test B at IB
16	66	66	0	-1	--	308	2429	0,995	300	Test B at IB
2	66	66	0	0	0,139	336	2429	1,000	300	Test B at BL
17	66	66	0	1	--	316	2429	1,005	300	Test B at IB
18	66	66	0	2	--	314	2429	1,009	300	Test B at IB
19	66	66	0	3	--	288	2429	1,014	300	Test B at IB
20	66	66	0	4	--	302	2429	1,019	300	Test B at IB
21	66	66	0	5	--	287	2429	1,024	300	Test B at IB

Parameter at 0%	L= 69,32 mH	R= 21,78 Ω	C= 146,16 µF

Indicate additional shut down time included in above results. (Disconnection device operation time)	20ms

Note:
RLC is adjusted to min. +/-1% of the inverter rated output power
1) P_{EUT}: EUT output power
2) P_{AC}: Real 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) Fundamental of I_{AC} when RLC is adjusted.
5) BL: Balance condition, IB: Imbalance condition.
Condition B:
EUT output power PEUT = 50 % – 66 % of maximum
EUT input voltage 5) = 50 % of rated input voltage range, ±10 %

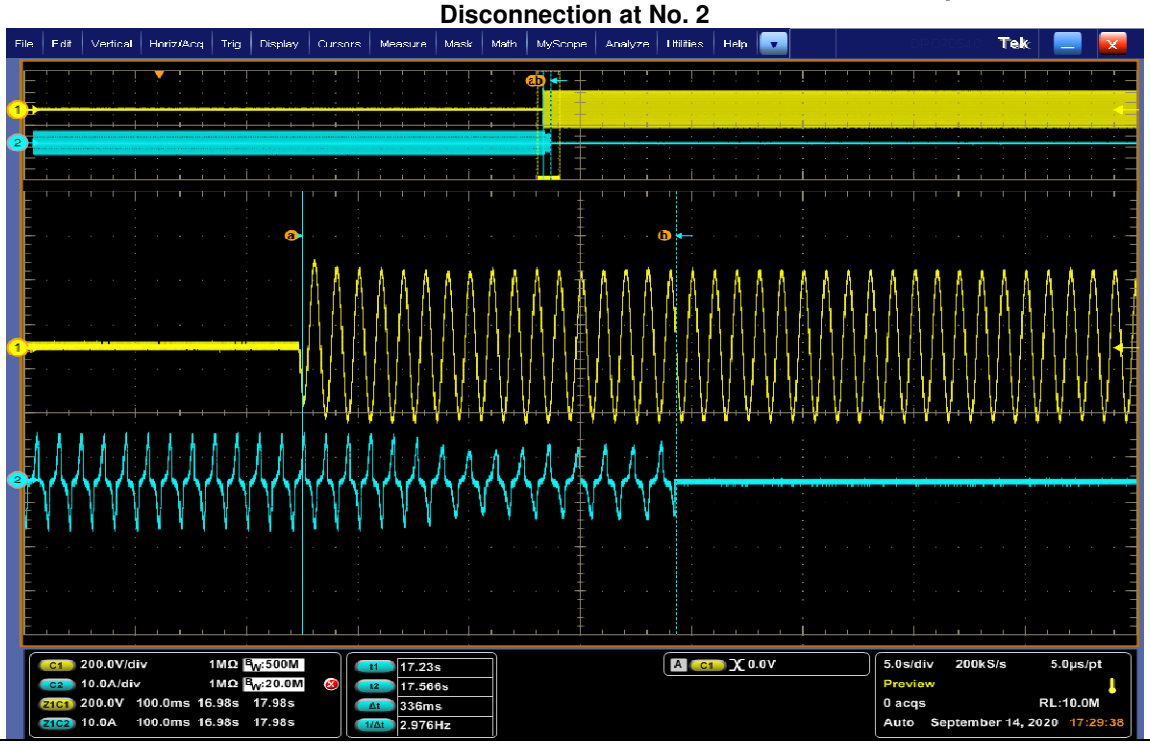
6) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 50 % of range =X + 0,5 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.

The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau

Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 66% nominal power
Disconnection at No. 2



A 1.2.4 Loss of mains protection according BS EN 62116 **P**

The requirement is specified in section 10.2, test procedure in Annex A.1.2.4
Load imbalance (real, reactive load) for test condition A (EUT output = 25 % – 33 %)

Test result: SUN2000-3.68KTL-L1

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	0,5s

No	P_{EUT} 1) (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{AC} 2) (% of nominal)	Q_{AC} 3) (% of nominal)	I_{AC} 4) [A]	Run on Time (ms)	P_{EUT} (W)	Qf	V_{DC}	Remarks5)
22	33	33	0	-5	--	284	1214	0,975	130	Test C at IB
23	33	33	0	-4	--	309	1214	0,980	130	Test C at IB
24	33	33	0	-3	--	288	1214	0,985	130	Test C at IB
25	33	33	0	-2	--	294	1214	0,990	130	Test C at IB
26	33	33	0	-1	--	367	1214	0,995	130	Test C at IB
3	33	33	0	0	0,138	348	1214	1,000	130	Test C at BL
27	33	33	0	1	--	342	1214	1,005	130	Test C at IB
28	33	33	0	2	--	335	1214	1,010	130	Test C at IB
29	33	33	0	3	--	288	1214	1,015	130	Test C at IB
30	33	33	0	4	--	300	1214	1,020	130	Test C at IB
31	33	33	0	5	--	297	1214	1,025	130	Test C at IB

Parameter at 0%	L= 138,70 mH	R= 43,57 Ω	C= 73,05 µF

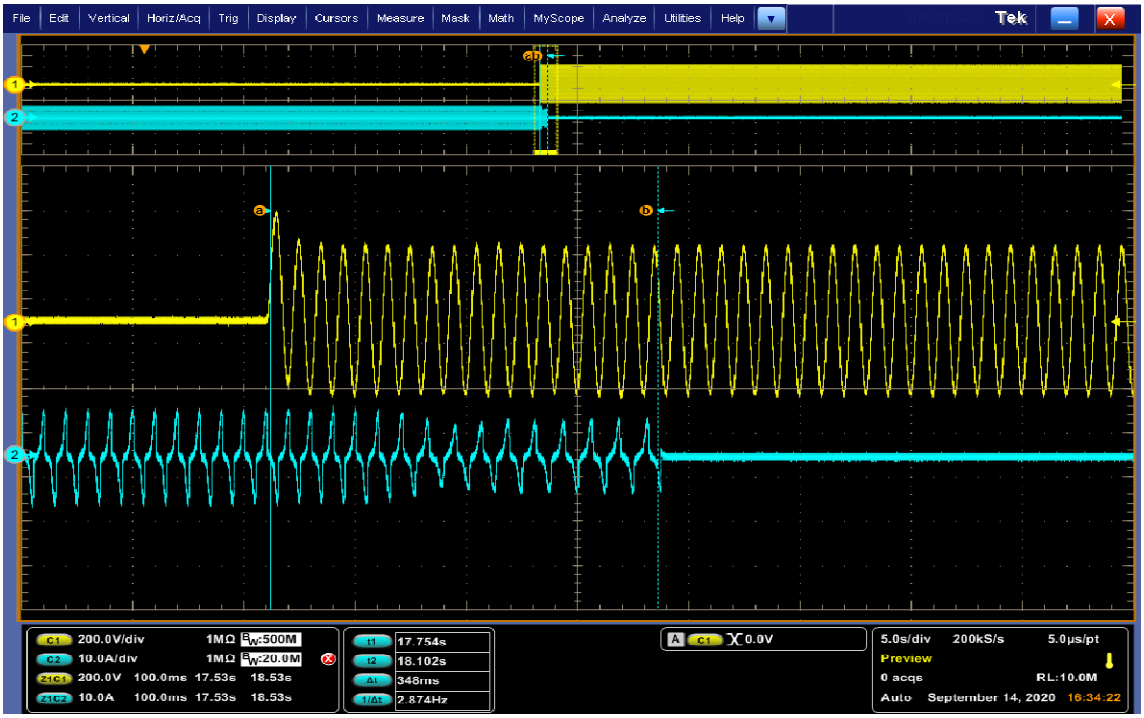
Indicate additional shut down time included in above results. (Disconnection device operation time)	20ms

Note:
RLC is adjusted to min. +/-1% of the inverter rated output power
1) P_{EUT}: EUT output power
2) P_{AC}: Real 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) Fundamental of I_{AC} when RLC is adjusted.
5) BL: Balance condition, IB: Imbalance condition.
Condition C:
EUT output power PEUT = 25 % – 33 % 5) of maximum
EUT input voltage 6) = <10 % of rated input voltage range
6) Or minimum allowable EUT output level if greater than 33 %.
7) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 10% of range =X + 0,1 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.

The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 33% nominal power
Disconnection at No. 3



A 1.2.5/A 2.2.5 Reconnection The test procedure in Annex A 1.2.5 (Inverter connected) or Annex A2 A 2.2.5 (Synchronous).	**P**

Test result: SUN2000-3.68KTL-L1

Test should prove that the reconnection sequence starts after a minimum delay of 20 seconds for restoration of voltage and frequency to within the stage 1 settings of table 1.

Under Voltage(188,0V)	
Time delay setting	Measured delay
60s	76,1s
Over Voltage(258,2V)	
Time delay setting	Measured delay
60s	76,6s
Under Frequency(47,6Hz)	
Time delay setting	Measured delay
60s	76,4s
Over Frequency(51,9Hz)	
Time delay setting	Measured delay
60s	76,3s

	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 1.			
	At 266,2V	At 180,0V	At 47,4Hz	At 52,1Hz
Confirmation that the unit does not re-connect.	No reconnection	No reconnection	No reconnection	No reconnection

Note:
The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.

A 1.2.6/A 2.2.6 Frequency Drift and Step change 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).	**P**

Test result: SUN2000-3.68KTL-L1

	Start Frequency	Change	Test time	Confirm no trip
Positive Vector Shift	49,0Hz	+50 degrees		No trip
Negative Vector Shift	50,0Hz	-50 degrees		No trip
Positive Frequency drift	49,0Hz - 51,0Hz	+0,95Hz/sec	2,1s	No trip
Negative Frequency drift	51,0Hz - 49,0Hz	-0,95Hz/sec	2,1s	No trip

Note:

Manufacturers considering new designs should allow for the RoCoF where stability is required to be increased to, up to 2Hz per second, as proposed in the new European network codes, which are expected to come into force over the period 2014/2015. Under these conditions RoCoF will cease to be an effective loss of mains protection and is unlikely to be permitted in future revisions of this document.

For the step change test the unit should be operated with a measurable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 seconds to complete the test. The unit should not trip during this test.

For frequency drift tests the unit should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0,95Hz per second to the end frequency. On reaching the end frequency it should be maintained for a period of at least10 seconds. The unit should not trip during this test.

The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.

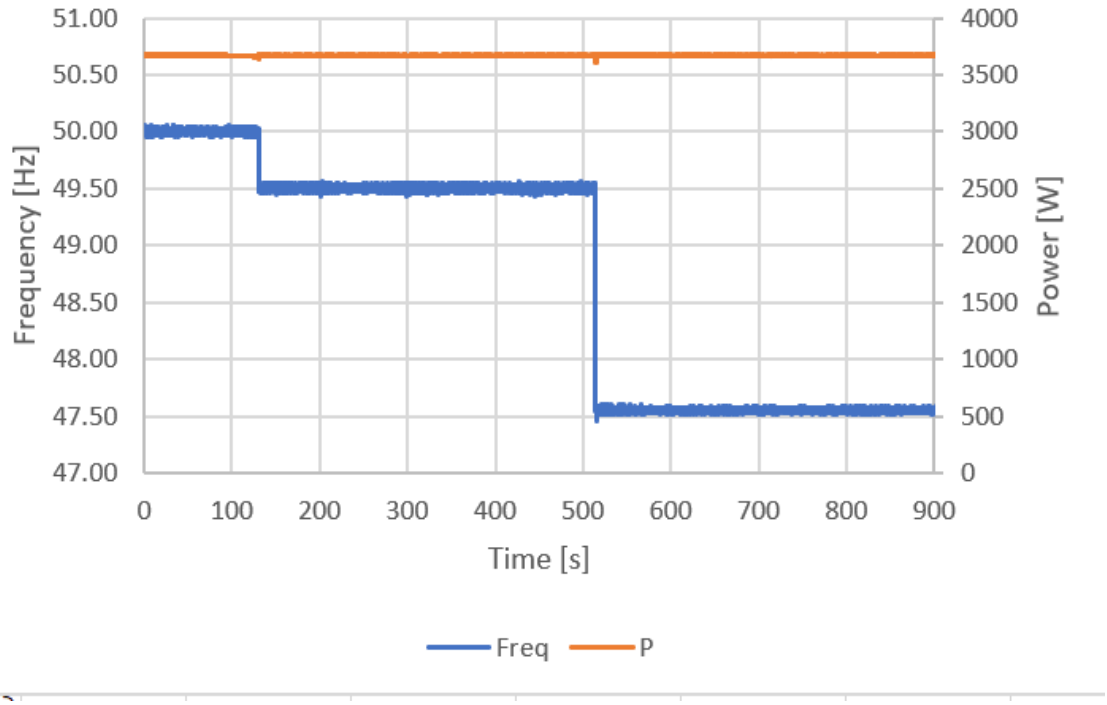
The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

A 1.2.7/A 2.2.7 Active power feed-in at under-frequency This test should be carried out in accordance with A.1.2.7. (Inverter connected) or Annex A2 A.2.2.7 (Synchronous).	**P**

Test result: SUN2000-3.68KTL-L1

	Switch to:		
5-min mean value (each)	a) 50 ± 0,01 [Hz]	b) - 0,4 to – 0,5 [Hz]	c) - 2,4 to - 2,5 [Hz]
Frequency [Hz]:	50,00	49,50	47,55
Active power [W]:	3673	3672	3672
$\Delta P/P_{max}$ [%]:			0,22

Graph of frequency a) to b) to c):



Test:

Operating points b) and c) must be kept for at least 5 minutes.

For a CHP the test point a) at 50,00Hz is taken as Registered capacity (Pmax) due to limited discrete operating points of the CHP's thermal process.

Electronic inverter no power reduction take place.

Assessment criterion:

The test is regarded as passed if:
• the Micro-generator does not disconnect from the network at the operating points a) to c) when the network frequency is changed and
• the Micro-generator does not reduce output energy at point b) and
• the power reduction at point c) is less than or equal to the allowed power reduction according to paragraph 9.4.2

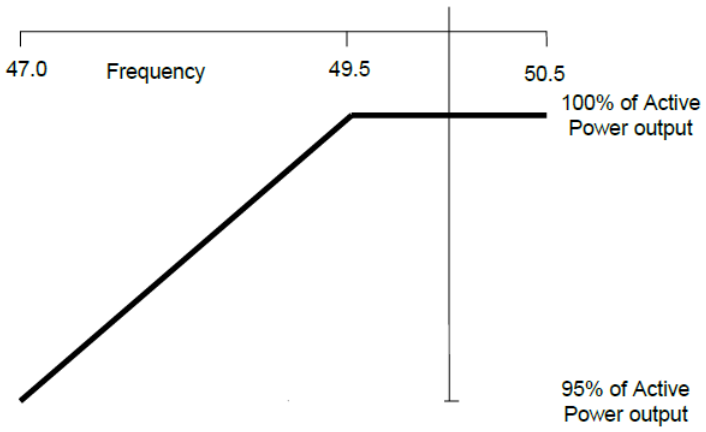


Figure 3 – Change in Active Power output with falling frequency

Note:

The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.

A.1.2.8	**Micro-generators which include Electricity Storage** This test should be carried out in accordance with 9.4.3.	**P**

Test result: SUN2000-3.68KTL-L1

	Test 1: 100% rated import power, 50,00 Hz to 49,00 Hz with 2 Hzs^{-1}	
	Start: 50 ± 0,01 Hz	End: 49,00 Hz
Frequency [Hz]:	50,00	49,00
Active power [W]:	-3048	-74
Reactive Power [Var]:	8	20
	Test 2: 100% rated import power 50,00 Hz to 48,80 Hz with 2 Hzs^{-1}	
	Start: 50 ± 0,01 Hz	End: 48,80 Hz
Frequency [Hz]:	50,00	48,8
Active power [W]:	-3050	914
Reactive Power [Var]:	8	19
	Test 3: 40% rated import power 50,00 Hz to 49,00 Hz with 2 Hzs^{-1}	
	Start: 50 ± 0,01 Hz	End: 49,00 Hz
Frequency [Hz]:	50,00	49,90
Active power [W]:	-1222	1727
Reactive Power [Var]:	15	20
	Test 4: 40% rated import power 50,00 Hz to 48,80 Hz with 2 Hzs^{-1}	
	Start: 50 ± 0,01 Hz	End: 48,80 Hz
Frequency [Hz]:	50,00	48,80
Active power [W]:	-1222	2708
Reactive Power [Var]:	15	13

Test:

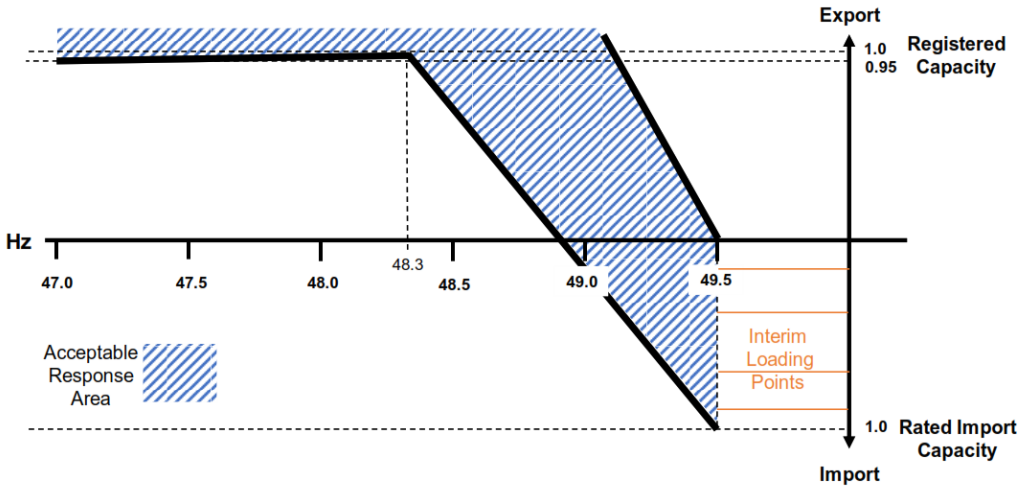
(a) When the frequency falls to 49,5 Hz the automatic response shall start;

(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.

A.1.2.8	**Micro-generators which include Electricity Storage** This test should be carried out in accordance with 9.4.3.	P



In general four tests are proposed, one set of two at rated import capacity, and one set of two at 40% of rated import capacity**.** In both cases the test is to reduce frequency from 50 Hz at 2 Hzs^{-1}. In the first case the lower frequency reached will be 49,0 Hz and the second case the lower frequency will be 48,8 Hz.

Note:

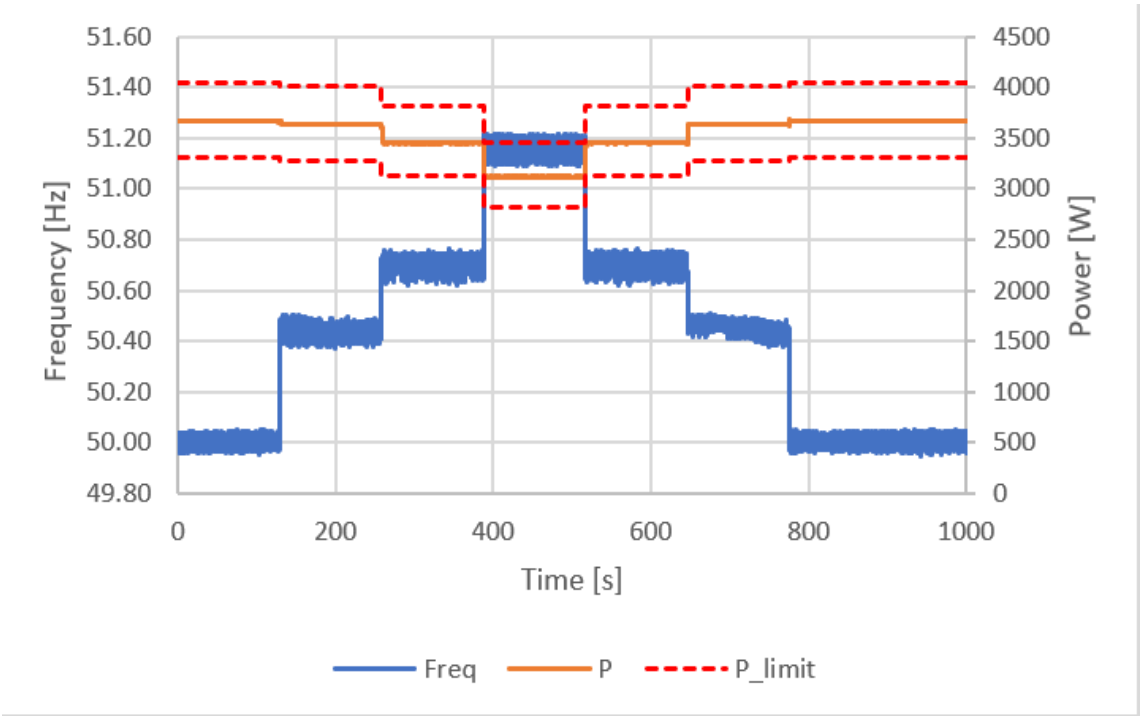
The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software..

A 1.2.9/A 2.2.9 Power response to over-frequency This test should be carried out in accordance with EN 50438 Annex D.3.3 Power response to over- frequency. The test should be carried out using the specific threshold frequency of 50,4 Hz and Droop of 10%.	**P**

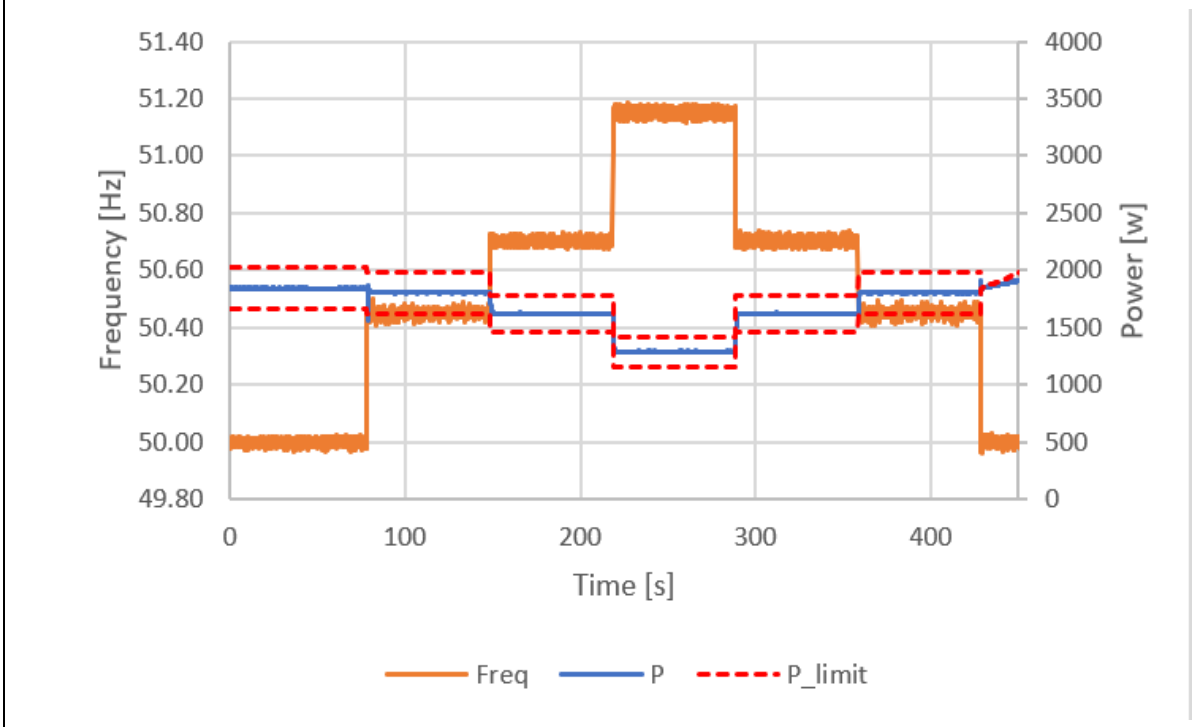
Test result: SUN2000-3.68KTL-L1

1-min mean value [Hz]:	a) 50,00	b) 50,45	c) 50,70	d) 51,15	e) 50,70	f) 50,45	g) 50,00
1. Measurement a) to g): Active power output > 80% P_n							
Frequency [Hz]:	50,00	50,45	50,70	51,15	50,70	50,45	50,00
$P_{expected}$ [W]:	N/A	3643	3467	3135	3467	3643	N/A
$P_{measured}$ [W]:	3670	3633	3448	3118	3448	3632	3670
$\Delta P_{E60}/P_M$ [%]:	N/A	-0,26	-0,50	-0,45	-0,50	-0,29	N/A
2. Measurement a) to g): Active power output 40% and 60% after freezing > 80% P_n							
Frequency [Hz]:	50,00	50,45	50,70	51,15	50,70	50,45	50,00
$P_{expected}$ [W]:	N/A	1803	1619	1288	1619	1803	N/A
$P_{measured}$ [W]:	1840	1805	1620	1288	1620	1804	3680
$\Delta P_{E60}/P_M$ [%]:	N/A	0,05	0,03	0,00	0,03	0,03	N/A
Active Power Gradient	N/A	N/A	N/A	N/A	N/A	N/A	5,04%/Pn
Limit $\Delta P/P_{1min}$:	±10 % of P_M						

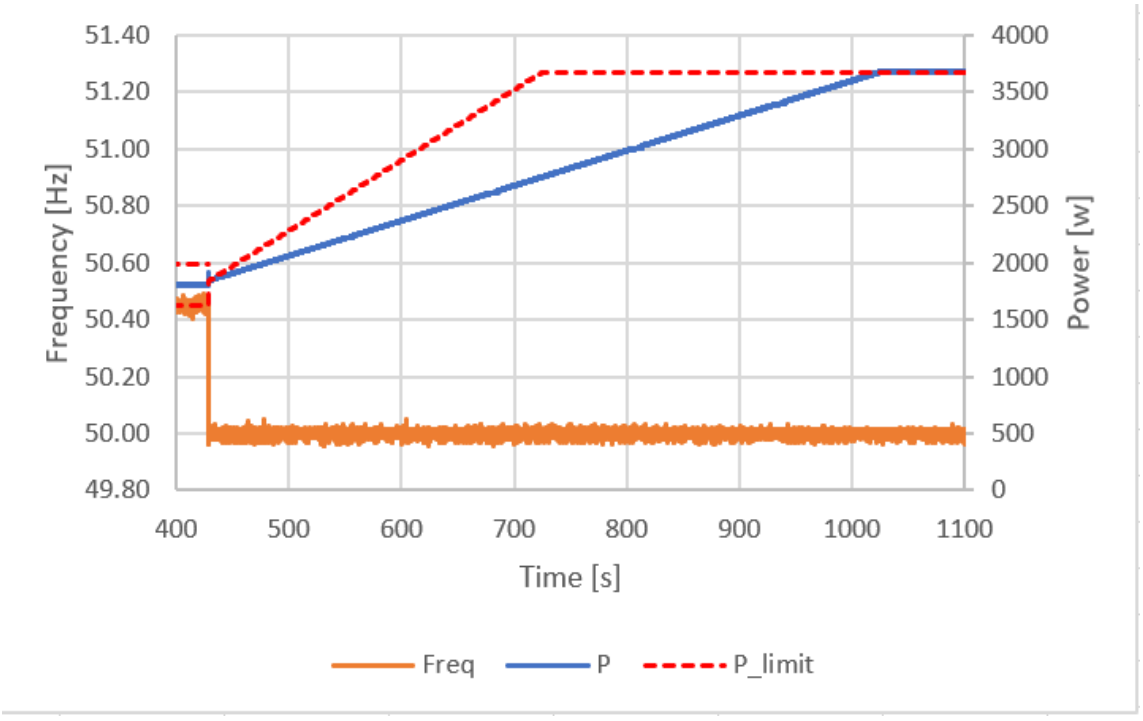
Graph of Measurement 1.: Active power output > 80% P_n



Graph of Measurement 2.:Active power output 40% and 60% after freezing > 80% P_n



Graph of power gradient:



Test:

With regard to the Limited Frequency Sensitive Mode — Overfrequency (LFSMO), 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.

The Micro-generator shall continue to reduce its Active Power output with rising frequency with a Droop of 10% until 52,0 Hz, at which point the Micro-generator should disconnect.

If the reduction in Active Power output is such that the Micro-generator reaches its minimum stable operating level, it shall continue to operate stably at this level.

Assessment criterion:

The Droop should be determined from the measurements between 50,4 Hz and 51,15 Hz. The allowed tolerance for the frequency measurement shall be ± 0,05 Hz. The allowed tolerance for Active Power output measurement shall be ±10% of the required change in Active Power. The resulting overall tolerance range for a nominal 10% Droop is +2,8% and – 1,5%, ie a Droop less than 12,8% and greater than 8,5%.

Note:

The test was performed without default delay setting 0s. A delay can be set from 0s – 60s (in 0,001s steps).

The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1 and SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software..

A 1.3.1/A 2.3.1 Harmonic Current Emissions The test requirements are specified in Annex A1 A.1.3.1 (Inverter connected) or Annex A2 A.2.3.1 (Synchronous).	**P**

Test result: SUN2000-2KTL-L1

Generating Unit rating per phase (rpp)			2 kW			
Harmonic order	At 45-55% of rated ouput 1 kW		100% of rated output 2 kW		Harmonic %	
	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit in BS EN61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2nd	0,007	0,150	0,011	0,131	1,080	--
3rd	0,031	0,665	0,029	0,344	2,300	--
4th	0,007	0,150	0,009	0,107	0,430	--
5th	0,035	0,751	0,013	0,154	1,140	--
6th	0,012	0,258	0,015	0,178	0,300	--
7th	0,028	0,601	0,019	0,226	0,770	--
8th	0,009	0,193	0,012	0,143	0,230	--
9th	0,013	0,279	0,017	0,202	0,400	--
10th	0,009	0,193	0,009	0,107	0,184	--
11th	0,021	0,451	0,012	0,143	0,330	--
12th	0,007	0,150	0,011	0,131	0,153	--
13th	0,031	0,665	0,017	0,202	0,210	--
14th	0,009	0,193	0,010	0,119	0,131	--
15th	0,030	0,644	0,018	0,214	0,150	--
16th	0,008	0,172	0,007	0,083	0,115	--
17th	0,020	0,429	0,019	0,226	0,132	--
18th	0,009	0,193	0,008	0,095	0,102	--
19th	0,015	0,322	0,020	0,238	0,118	--
20th	0,008	0,172	0,007	0,083	0,092	--
21th	0,013	0,279	0,016	0,190	0,107	0,160
22th	0,007	0,150	0,011	0,131	0,084	--
23th	0,014	0,300	0,016	0,190	0,098	0,147
24th	0,007	0,150	0,009	0,107	0,077	--
25th	0,013	0,279	0,014	0,166	0,090	0,135
26th	0,008	0,172	0,010	0,119	0,071	--
27th	0,010	0,215	0,012	0,143	0,083	0,124
28th	0,008	0,172	0,009	0,107	0,066	--
29th	0,008	0,172	0,009	0,107	0,078	0,117

30th	0,007	0,150	0,008	0,095	0,061	--
31th	0,008	0,172	0,010	0,119	0,073	0,109
32th	0,007	0,150	0,007	0,083	0,058	--
33th	0,009	0,193	0,012	0,143	0,068	0,102
34th	0,007	0,150	0,006	0,071	0,054	--
35th	0,010	0,215	0,013	0,154	0,064	0,096
36th	0,008	0,172	0,007	0,083	0,051	--
37th	0,012	0,258	0,014	0,166	0,061	0,091
38th	0,008	0,172	0,008	0,095	0,048	--
39th	0,014	0,300	0,013	0,154	0,058	0,087
40th	0,009	0,193	0,009	0,107	0,046	--

Note:
The normal current is 8,70A.
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.
The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

A 1.3.1/A 2.3.1 Harmonic Current Emissions The test requirements are specified in Annex A1 A.1.3.1 (Inverter connected) or Annex A2 A.2.3.1 (Synchronous).	**P**

Test result: SUN2000-3KTL-L1

Generating Unit rating per phase (rpp)			3 kW			
Harmonic order	At 45-55% of rated ouput 1,5 kW		100% of rated output 3 kW		Harmonic %	
	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit in BS EN61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2nd	0,013	0,191	0,010	0,075	1,080	--
3rd	0,064	0,942	0,046	0,346	2,300	--
4th	0,004	0,059	0,012	0,090	0,430	--
5th	0,047	0,692	0,016	0,120	1,140	--
6th	0,006	0,088	0,011	0,083	0,300	--
7th	0,038	0,559	0,013	0,098	0,770	--
8th	0,003	0,044	0,009	0,068	0,230	--
9th	0,031	0,456	0,020	0,150	0,400	--
10th	0,006	0,088	0,007	0,053	0,184	--
11th	0,029	0,427	0,015	0,113	0,330	--
12th	0,003	0,044	0,008	0,060	0,153	--
13th	0,024	0,353	0,018	0,135	0,210	--
14th	0,003	0,044	0,008	0,060	0,131	--
15th	0,020	0,294	0,017	0,128	0,150	--
16th	0,003	0,044	0,008	0,060	0,115	--
17th	0,021	0,309	0,017	0,128	0,132	--
18th	0,003	0,044	0,008	0,060	0,102	--
19th	0,020	0,294	0,018	0,135	0,118	--
20th	0,003	0,044	0,007	0,053	0,092	--
21th	0,016	0,235	0,019	0,143	0,107	--
22th	0,004	0,059	0,007	0,053	0,084	0,160
23th	0,019	0,280	0,020	0,150	0,098	--
24th	0,003	0,044	0,007	0,053	0,077	0,147
25th	0,022	0,324	0,019	0,143	0,090	--
26th	0,004	0,059	0,007	0,053	0,071	0,135
27th	0,020	0,294	0,021	0,158	0,083	--
28th	0,004	0,059	0,007	0,053	0,066	0,124
29th	0,019	0,280	0,016	0,120	0,078	--
30th	0,003	0,044	0,007	0,053	0,061	0,117

31th	0,017	0,250	0,015	0,113	0,073	--
32th	0,003	0,044	0,007	0,053	0,058	0,109
33th	0,014	0,206	0,017	0,128	0,068	--
34th	0,003	0,044	0,008	0,060	0,054	0,102
35th	0,011	0,162	0,015	0,113	0,064	--
36th	0,003	0,044	0,007	0,053	0,051	0,096
37th	0,009	0,132	0,015	0,113	0,061	--
38th	0,003	0,044	0,007	0,053	0,048	0,091
39th	0,006	0,088	0,013	0,098	0,058	--
40th	0,003	0,044	0,007	0,053	0,046	0,087

Note:
The normal current is 13,0A.
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.
The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

A 1.3.1/A 2.3.1 Harmonic Current Emissions The test requirements are specified in Annex A1 A.1.3.1 (Inverter connected) or Annex A2 A.2.3.1 (Synchronous).	**P**

Test result: SUN2000-3.68KTL-L1

Generating Unit rating per phase (rpp)			3,68 kW			
Harmonic order	At 45-55% of rated ouput 1,84 kW		100% of rated output 3,68 kW		Harmonic %	
	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit in BS EN61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2nd	0,014	0,177	0,033	0,204	1,080	--
3rd	0,051	0,645	0,064	0,397	2,300	--
4th	0,006	0,076	0,049	0,304	0,430	--
5th	0,037	0,468	0,031	0,192	1,140	--
6th	0,008	0,101	0,023	0,142	0,300	--
7th	0,032	0,405	0,028	0,173	0,770	--
8th	0,006	0,076	0,029	0,180	0,230	--
9th	0,025	0,316	0,017	0,105	0,400	--
10th	0,006	0,076	0,029	0,180	0,184	--
11th	0,024	0,304	0,021	0,130	0,330	--
12th	0,005	0,063	0,025	0,155	0,153	--
13th	0,024	0,304	0,016	0,099	0,210	--
14th	0,005	0,063	0,020	0,124	0,131	--
15th	0,021	0,266	0,015	0,093	0,150	--
16th	0,005	0,063	0,020	0,124	0,115	--
17th	0,020	0,253	0,014	0,087	0,132	--
18th	0,005	0,063	0,015	0,093	0,102	--
19th	0,020	0,253	0,018	0,112	0,118	--
20th	0,005	0,063	0,015	0,093	0,092	--
21th	0,014	0,177	0,022	0,136	0,107	0,160
22th	0,005	0,063	0,015	0,093	0,084	--
23th	0,014	0,177	0,024	0,149	0,098	0,147
24th	0,005	0,063	0,012	0,074	0,077	--
25th	0,015	0,190	0,024	0,149	0,090	0,135
26th	0,005	0,063	0,009	0,056	0,071	--
27th	0,014	0,177	0,028	0,173	0,083	0,124
28th	0,005	0,063	0,008	0,050	0,066	--
29th	0,012	0,152	0,028	0,173	0,078	0,117
30th	0,005	0,063	0,009	0,056	0,061	--

31th	0,011	0,139	0,027	0,167	0,073	0,109
32th	0,005	0,063	0,010	0,062	0,058	--
33th	0,011	0,139	0,026	0,161	0,068	0,102
34th	0,005	0,063	0,011	0,068	0,054	--
35th	0,010	0,127	0,026	0,161	0,064	0,096
36th	0,005	0,063	0,012	0,074	0,051	--
37th	0,010	0,127	0,025	0,155	0,061	0,091
38th	0,005	0,063	0,013	0,081	0,048	--
39th	0,009	0,114	0,021	0,130	0,058	0,087
40th	0,006	0,076	0,013	0,081	0,046	

Note:
The normal current is 16,0A.
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.
The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

A 1.3.2/A 2.3.2 Power factor The requirement is specified in section 9.5, test procedure in Annex A1 A.1.3.2 (Inverter connected) or Annex A2 A.2.3.2 (Synchronous).				**P**
Test result: SUN2000-2KTL-L1				
Output power	216,2 V	230,0 V	253,2 V	
20%	0,9998i	0,9999i	0,9999i	Measured at three voltage levels and at full output. Voltage to be maintained within ±1,5% of the stated level during the test.
50%	0,9999i	0,9999i	0,9999i	
75%	0,9999i	0,9999i	0,9999i	
100%	0,9999i	0,9999i	0,9999i	
Limit	>0,95	>0,95	>0,95	
Test result: SUN2000-3.68KTL-L1				
Output power	216,2 V	230,0 V	253,2 V	
20%	0,9999i	0,9999i	0,9999i	Measured at three voltage levels and at full output. Voltage to be maintained within ±1,5% of the stated level during the test.
50%	0,9999i	0,9999i	0,9999i	
75%	0,9999i	0,9999i	0,9999i	
100%	0,9999i	0,9999i	0,9999i	
Limit	>0,95	>0,95	>0,95	

Note:
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.

The test set up shall be such that the Inverter supplies full load to the DNO's Distribution System via the power factor (pf) meter and the variac as shown below in figure A5. The Inverter pf should be within the limits given in 5.6, for three test voltages 230 V –6%, 230V and 230 V +10%. The voltage shall be maintained within ±1,5% of the stated level during the test.
The tests had been performed on the SUN2000-3.68KTL-L1 and SUN2000-2KTL-L1 are valid for the SUN2000-3KTL-L1,since it is same as in hardware and just power derated by software.
The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

A 1.3.3/A 2.3.3 Voltage Flicker	P

Test result: SUN2000-3.68KTL-L1

Test conditions:	Maximum permissible voltage fluctuation (expressed as a percentage of nominal voltage at 100 % power) and flicker as per EN 61000-3-3							
	Starting			Stopping			Running	
Limit	d_{max}	d_c	$d_{(t)}$	d_{max}	d_c	$d_{(t)}$	P_{st}	P_{lt} 2 hours
Measured Values at test impedance	1,98	1,87	--	2,01	1,85	--	0,028	0,023
Normalised to standard impedance	1,98	1,87	--	2,01	1,85	--	0,028	0,023
Normalised to required maximum impedance	1,98	1,87	--	2,01	1,85	--	0,028	0,023
Limits set under BS EN 61000-3-11	4%	3,3%	3,3% 500ms	4%	3,3%	3,3% 500ms	1,0	0,65

Test impedance	R	0,4	Ω	Xl	0,25	Ω
	Z	0,472	Ω			
Standard impedance	R	0,4	Ω	Xl	0,25	Ω
	Z	0,472	Ω			
Maximum impedance	R	0,4	Ω	Xl	0,25	Ω
	Zmax	0,472	Ω			

Note:

For voltage change and flicker measurements the following formula is to be used to convert the measured values to the normalised values where the power factor of the generation output is 0,98 or above.

Normalised value = Measured value*reference source resistance/measured source resistance at test point.

Single phase unit reference source resistance is 0,4Ω

Two phase units in a three phase system reference source resistance 0,4Ω

Two phase units in a split phase system reference source resistance is 0,24Ω

Three phase units reference source resistance is 0,24Ω

Where the power factor of the output is under 0,98 then the Xl to R ratio of the test impedance should be close to that of the Standard impedance.

The stopping test should be a trip from full load operation.

The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1, SUN2000-3KTL-L1 since it is same as in hardware and just power derated by software.
The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

A.1.3.4 DC injection				P
Test result:SUN2000-2KTL-L1				
Test level power	20%	50%	75%	100%
Recorded value in Amps[mA]	2	2	3	4
As % of rated AC current	0,02	0,02	0,03	0,05
Limit	0,25%	0,25%	0,25%	0,25%
Note: The tests should be carried out on a single Generating Unit. Tests are to be carried out at four defined power levels ±5%. At 230 V a 2kW single phase Inverter has a current output of 8,70 A so DC limit is 21,7 mA. These tests should be undertaken in accordance with Annex A.1.3.4. The % DC injection ("as % of rated AC current" below) is calculated as follows: % DC injection = Recorded DC value in Amps / Base current where the base current is the Registered Capacity (W) / V phase. The % DC injection should not be greater than 0,25%.				
Test result:SUN2000-3.68KTL-L1				
Test level power	20%	50%	75%	100%
Recorded value in Amps[mA]	22	21	19	27
As % of rated AC current	0,14	0,13	0,12	0,17
Limit	0,25%	0,25%	0,25%	0,25%
Note: The tests should be carried out on a single Generating Unit. Tests are to be carried out at four defined power levels ±5%. At 230 V a 3,68 kW single phase Inverter has a current output of 16,0 A so DC limit is 40,0 mA. These tests should be undertaken in accordance with Annex A.1.3.4. The % DC injection ("as % of rated AC current" below) is calculated as follows: % DC injection = Recorded DC value in Amps / Base current where the base current is the Registered Capacity (W) / V phase. The % DC injection should not be greater than 0,25%.				

Diagram of Permanent DC-injection
SUN2000-2KTL-L1

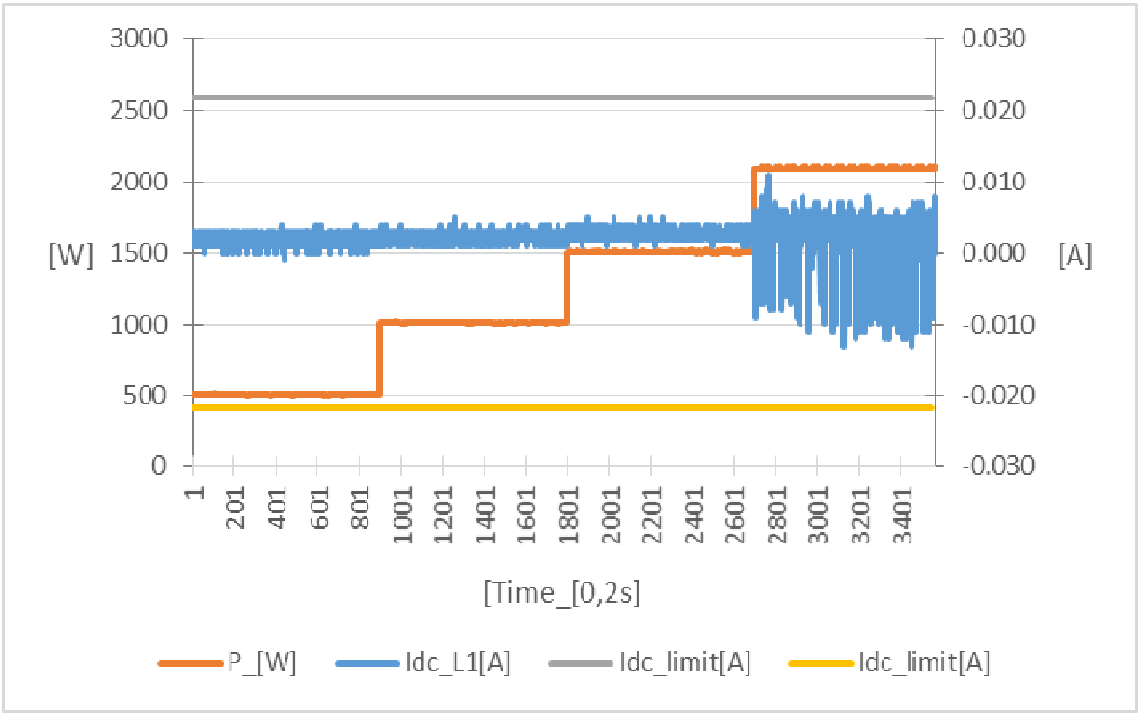
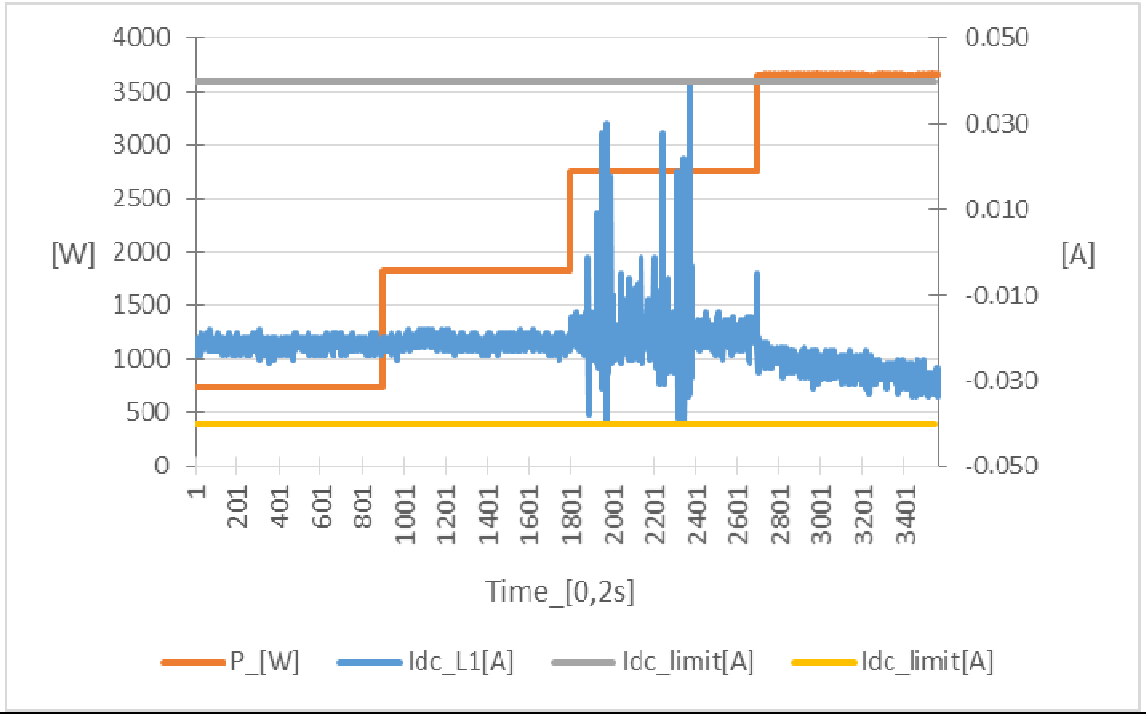


Diagram of Permanent DC-injection
SUN2000-3.68KTL-L1



Test:
The level of DC injection from the Inverter-connected PV generator in to the DNO's Distribution System shall not exceed the levels specified in 5.5 when measured during operation at three levels, 20%, 50%, 75% and 100% of rating with a tolerance of plus or minus 5%.

The tests had been performed on the SUN2000-3.68KTL-L1 and SUN2000-2KTL-L1are valid for the SUN2000-3KTL-L1 since it is same as in hardware and just power derated by software.

The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

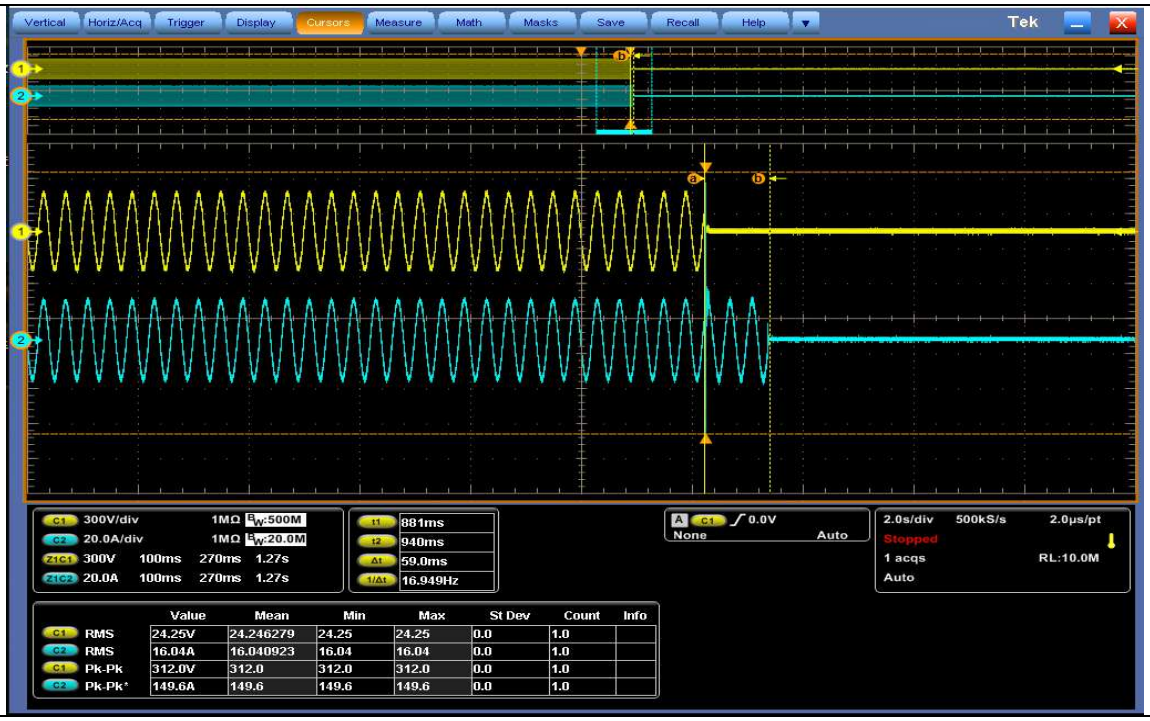
A 1.3.5/A 2.3.4 Short Circuit Current Contribution for Inverters	P

Test result: SUN2000-3.68KTL-L1

For a directly coupled unit			For a Inverter unit		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p	N/A	20ms	10,29 V	16,39A
Initial Value of aperiodic current	A	N/A	100ms	6,19V	0,41A
Initial symmetrical short-circuit current*	I_k	N/A	250ms	6,14V	0,42A
Decaying (aperiodic) component of short circuit current*	i_{DC}	N/A	500ms	6,24V	0,41A
Reactance/Resistance Ratio of source*	X/R	N/A	Time to trip	0,059	In seconds

Testing:

Testing procedure: LVRT 10 – 15 % U_{NOM} with > 500 ms shall be recorded



Note:

The values of voltage and current should be recorded for a period of up to 2 second when the changeover switch should be returned to the normal position. The voltage and current at relevant times shall be recorded in the type test report (Appendix 4) including the time taken for the Inverter to trip.

The tests had been performed on the SUN2000-3.68KTL-L1 are valid for the SUN2000-2KTL-L1, SUN2000-3KTL-L1 since it is same as in hardware and just power derated by software.

The test result were refer to original test report (with report No. PVUK191217N030-R1) issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-09-16.

A1.3.6 Self Monitoring – Solid state Disconnection	**N/A**
It has been verified that in the event of the solid state switching device failing to disconnect the UNIT, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0,5 seconds.	No
Note: Unit do not provide solid state switching relays. In case the semiconductor bridge is switched off, then the voltage on the output drops to 0. In this case the relays on the output will also open (4.1 Functional safety of the internal automatic disconnection device according to VDE 0126-1-1).	

Cyber security, required by paragraph 9.7	**P**
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

Huawei Technologies Co., Ltd.

Manufacturer's declaration

We, （Company name: Huawei Technologies Co., Ltd., address: Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C）, hearby declare that all our below listed inverters comply with the cyber security requirements of the standard G99-1 and G98-1:

- Model no.:

  For G98-1：

  SUN2000-2KTL-L1,SUN2000-3KTL-L1,SUN2000-3.68KTL-L1,SUN2000-3KTL-M1, SUN2000-4KTL-M1, SUN2000-5KTL-M1,

  SUN2000-6KTL-M1, SUN2000-8KTL-M1, SUN2000-10KTL-M1

  SUN2000-3KTL-M0, SUN2000-4KTL-M0, SUN2000-5KTL-M0,

  SUN2000-6KTL-M0, SUN2000-8KTL-M0, SUN2000-10KTL-M0

  For G99-1：SUN2000-4KTL-L1, SUN2000-4.6KTL-L1,

  SUN2000-5KTL-L1, SUN2000-6KTL-L1

- Requirements listed in the standard(s):

  - 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

Page 1 of 2

Huawei Technologies Co., Ltd.

Connection Guidance" published by BEIS and the ENA;

- Any other relevant standard that has been incorporated in the design of the **Power Generating Module**.

Declared by: Chen Dongxiang

Company name: Huawei Technologies Co., Ltd.,

Responsible person: Chen Dongxiang

Signature (and/or Stamp): Chen Dongxiang

Date: 2023.10.20

Note:

Different levels of access, all are password protected, only certain parameters can be changed on maintenance level.

Logic Interface (input port) Required by paragraph 9.4.3	**P**
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 9.4.4 such as AC or DC signal	Yes

The DNO logic interface use COM port, control the on and off of DI1 and GND by switch. When the switch is opened, the Power Generating Module can operate normally. When the switch is closed, the Power Generating Module will reduce its active power to zero within 5s. The signal from the Power Generating Module that is being switched is DC(value 12V).

Figure 5

Note:

Annex No. 1
EMC report

Report Number: 68.760.20.0257.04

EMC - TEST REPORT

Report Number	: 68.760.20.0257.04	Date of Issue: 2022-08-17
Model	: SUN2000-6KTL-L1 SUN2000-5KTL-L1 SUN2000-4.6KTL-L1 SUN2000-4KTL-L1 SUN2000-3.68KTL-L1 SUN2000-3KTL-L1 SUN2000-2KTL-L1	
Product Type	: Solar Inverter	
Applicant	: Huawei Technologies Co., Ltd.	
Address	: Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C	
Manufacturer	: Huawei Technologies Co., Ltd.	
Address	: Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C	
Test Result	: ■ Positive ☐ Negative	
Total pages including Appendices	: 55	

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Report Number: 68.760.20.0257.04

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Report Number: 68.760.20.0257.04

1 Report Version

No.	Last Report No.	Modification Description
1	N/A	First report
2	68.760.20.0257.01	Add a new model SUN2000-6KTL-L1, and a new configuration TC2, refer to section 4.2, 5.3;
3	68.760.20.0257.02	Update the standards versions

Report Number: 68.760.20.0257.04

2 General Information

2.1 Notes

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Prepared by Project Engineer	2022-08-17 Date	Vincent Zheng Name	Vincent Zheng Signature
Approved by Project Manager	2022-08-17 Date	Cookies Bu Name	 Signature

TÜV SÜD Certification and Testing (China) Co., Ltd. Shenzhen Branch
Building 12&13, Zhiheng Wisdomland Business Park, Nantou Checkpoint Road 2, Nanshan District, Shenzhen City, 518052, P. R. China Tel. +86 755 8828 6998, Fax: +86 755 8828 5299

Report Number: 68.760.20.0257.04

2.2 Applied Standard	
Applied Product Standard:	CISPR 11:2015+A1:2016(Group 1) EN 55011:2016 EN 55011:2016/A1:2017, EN 55011:2016/A11:2020 IEC 62920:2017 / EN 62920:2017+A11:2020 IEC 61000-6-1:2005/EN 61000-6-1:2007 IEC 61000-6-2:2005/EN 61000-6-2:2005 IEC 61000-6-3:2006+A1:2010/EN 61000-6-3:2007+A1:2011 IEC 61000-6-4:2006+A1:2010/EN 61000-6-4:2007+A1:2011 ETSI EN 301 489-1 V2.2.3:2019 ETSI EN 301 489-17 V3.2.4:2020 IEC 61000-3-2:2014/EN 61000-3-2:2014 IEC 61000-3-3:2013/EN 61000-3-3:2013 IEC 61000-3-11:2000/EN 61000-3-11:2000 IEC 61000-3-12:2011/EN 61000-3-12:2011
Test Methods:	IEC 61000-4-2:2008 IEC 61000-4-3:2010 IEC 61000-4-4:2012 IEC 61000-4-5:2014+A1:2017 IEC 61000-4-6:2013 IEC 61000-4-8:2009 IEC 61000-4-11:2004 IEC 61000-4-34:2005
2.3 Test Location	
Test Location 1:	Reliability Laboratory of Huawei Technologies Co., Ltd.
Address:	No.127,Jinye Road, Xi'an High-Tech Development District, Xi'an,710077,P.R.C
Test Location 2:	Reliability Laboratory of Huawei Technologies Co., Ltd.
Address:	No.2222,Xin Jinqiao Road, Pudong New Area, Shanghai, 201206, P.R.C
2.4 Details of Applicant	
Applicant:	Huawei Technologies Co., Ltd.
Address:	Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C
Product Name:	Solar Inverter
Product Model:	SUN2000-6KTL-L1 SUN2000-5KTL-L1 SUN2000-4.6KTL-L1 SUN2000-4KTL-L1 SUN2000-3.68KTL-L1 SUN2000-3KTL-L1 SUN2000-2KTL-L1
Test report Number:	SYBH(E)06562837EA

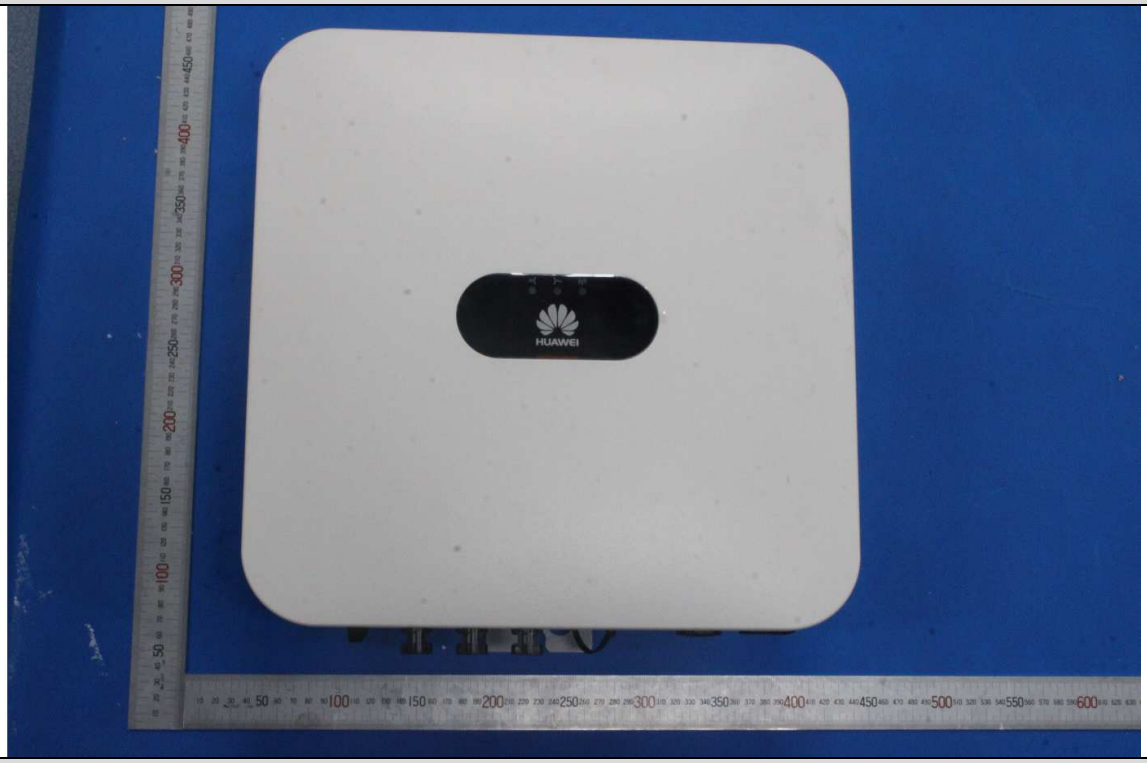
Report Number: 68.760.20.0257.04

2.5 Application Details	
Date of Receipt Test Item:	2020-06-09
Start Date of Test:	2020-06-10
End Date of Test:	2020-07-04
2.6 Test Environment Condition	
Ambient Temperature:	20–25°C
Relative Humidity:	45–55%
Atmospheric Pressure:	101kPa

Annex No. 2

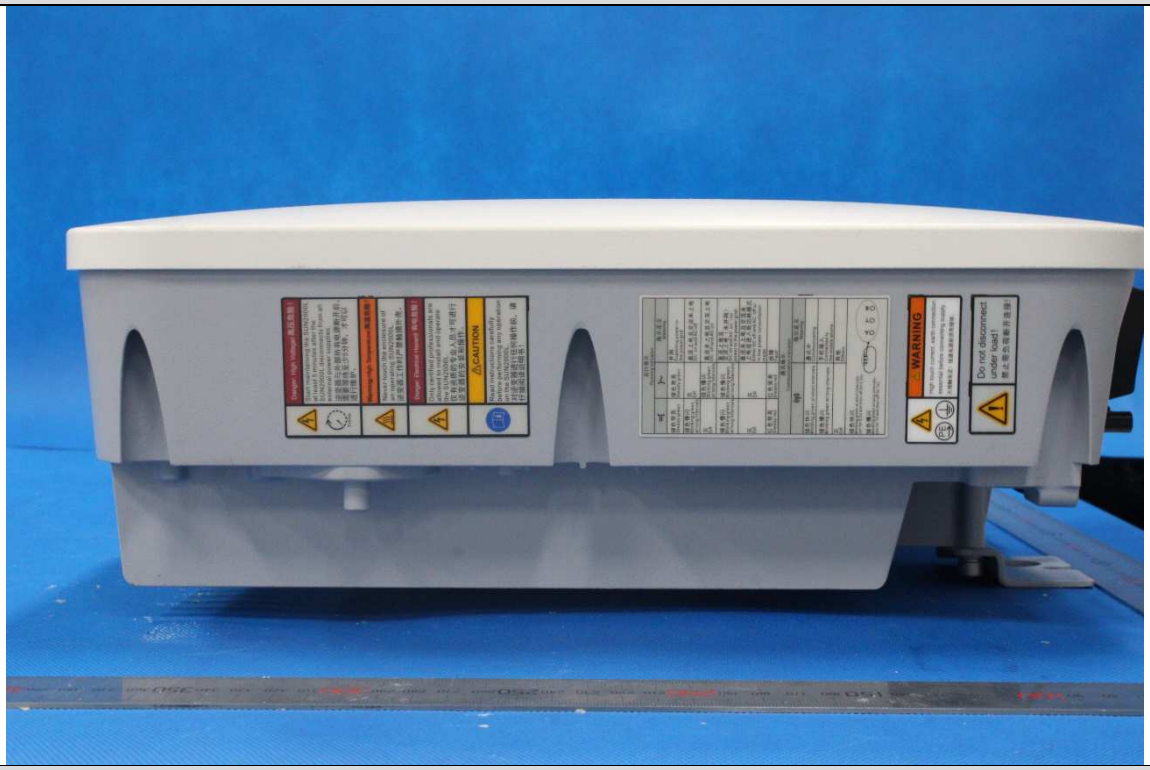
Pictures of the unit

Enclosure front view



Enclosure side view-1

Enclosure side view-2



Enclosure top view

Enclosure teminal view

Enclosure rear view

Internal view

Annex No. 3

Test Equipment list

Dates of performance test: 2023-10-24 to 2023-11-22

Equipment	Internal No.	Manufacturer	Type	Serial No.	Next Calibration
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	Jul. 21, 2024
Power Analyser	A4080004DG	DEWESoft	X	DB19104221	Jul. 21, 2024
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
DC Simulation Power Supply	A7040015DG	Chroma	62150H-1000S	62150EF00488	
	A7040016DG	Chroma	62150H-1000S	62150EF00490	
	A7040017DG	Chroma	620028	620028EF00120	
	A7040021DG	Chroma	62150H-1000S	62150EF00609	
	A7040022DG	Chroma	62150H-1000S	62150EF00595	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Jul. 16, 2024
	A1060008DG	YOKOGAWA	CT200	1130700017	Jul. 16, 2024
	A1060009DG	YOKOGAWA	CT200	1130700019	Jul. 16, 2024
	A10600010DG	YOKOGAWA	CT200	1130700016	Jul. 16, 2024
	A10600011DG	YOKOGAWA	CT200	1130700011	Jul. 16, 2024
	A10600012DG	YOKOGAWA	CT200	1130700018	Jul. 16, 2024
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Jul. 11, 2024
Oscilloscope probe	A1490008DG	YOKOGAWA	701901	//	Jul. 18, 2024
Oscilloscope probe	A1490009DG	YOKOGAWA	701901	//	Jul. 18, 2024
Oscilloscope probe	A1490010DG	YOKOGAWA	701901	//	Jul. 18, 2024
Oscilloscope probe	A1490011DG	YOKOGAWA	701901	//	Jul. 18, 2024
Temp. & Humi. Recorder	A7440034DG	HUATO	S580-TH	HT20103923	Jan. 31, 2024

--End of Test Report--