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 ..... :	**PVUK200917N006-1**
Date of issue ..... ……..:	2021-01-29
Total number of pages ..... ……..:	77
Testing laboratory name ..... :	**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
Accreditation ..... :	ilac-MRA A2LA ACCREDITED Certificate # 2951.01
Applicant's name ..... :	**Shenzhen SOFARSOLAR Co., Ltd.**
Address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Test specification	
Standard ..... :	G98/1-4:2019
Test Report Form No. ..... :	G98/1 VER.2
TRF Originator ..... :	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF ..... :	Dated 2020-03-07
Test item description ..... :	**Hybrid Inverter**
Trademark ..... :	SOFAR SOLAR
Model / Type ..... :	HYD 3680-EP, HYD 3000-EP

Ratings .....:	**HYD 3000-EP**	**HYD 3680-EP**
Full load MPP DC voltage range [V]. :	160-520V	180-520V
Input DC voltage range[V] ..... :	90-600V	
Input DC current [A]..... :	Max. 13A/13A	
Output AC voltage [V]..... :	L/N/PE, 230Vac, 50Hz	
Output AC current [A]..... :	15,0	16,0
Output power [W] ..... :	3000	3680
Max. output power [VA] ..... :	3300	3680
Output DC voltage range [V] ..... : [Battery charge]……:	42-58V	
Input/Output DC current [A]..... : [Battery charge/discharge] ……:	Max. 75A	Max. 80A
Charge and discharge power[W]..... :	Max. 3750	Max. 4000
Output AC voltage [V]..... :	L/N/PE, 230Vac, 50Hz	
Max. Input/Output AC current [A] ..... : [Battery charge/discharge mode] …:	13,6	16,0
Max. Input/Output AC power [VA] .... : [Battery charge/discharge mode] …:	3000	3680

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
Tested by (name and signature) ..... :	Lukes Lin 
Approved by (name and signature) ..... :	James Huang 
Manufacturer's name ..... :	**Shenzhen SOFARSOLAR Co., Ltd.**
Manufacturer address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Factory's name 1 ..... :	**Dongguan SOFAR SOLAR Co.,Ltd**
Factory address 1	1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City

Document History

Date	Internal reference	Modification / Change / Status	Revision
2021-01-29	Lukes Lin	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]..... :	Approx. 21,5 kg

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..... :	2020-09-17
Date(s) of performance of test..... :	2020-09-17 to 2021-01-08

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 requirements of G98/1. This report must not be reproduced in part or in full without the written approval of the issuing testing laboratory.

”(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.

This Test Report consists of the following documents:

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

Copy of marking plate

SOFAR SOLAR

Hybrid Inverter

Model No:	HYD 3000-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	75A
Max.Discharging Current	75A
Max.Charging&Discharging Power	3750W
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	15.0A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	3000W
Backup Rated Current	13.6A
Backup Rated Apparent Power	3000VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

Manufacturer : Shenzhen SOFARSOLAR Co., Ltd.
Address : 401, Building 4, AnTongDa Industrial Park,
District 68, XingDong Community,XinAn Street,
BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105
G98,AS4777,UTE C15-712-1

SOFAR SOLAR

Hybrid Inverter

Model No:	HYD 3680-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	80A
Max.Discharging Current	80A
Max.Charging&Discharging Power	4000W
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	16.0A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	3680W
Backup Rated Current	16.0A
Backup Rated Apparent Power	3680VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

Manufacturer : Shenzhen SOFARSOLAR Co., Ltd.
Address : 401, Building 4, AnTongDa Industrial Park,
District 68, XingDong Community,XinAn Street,
BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105
G98,AS4777,UTE C15-712-1

General product information:

The Hybrid Inverter converts DC voltage into AC voltage.
The DC input of Solar converter 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 Solar converter is a single-phase type and only one machine use connected to pre each phase.
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.

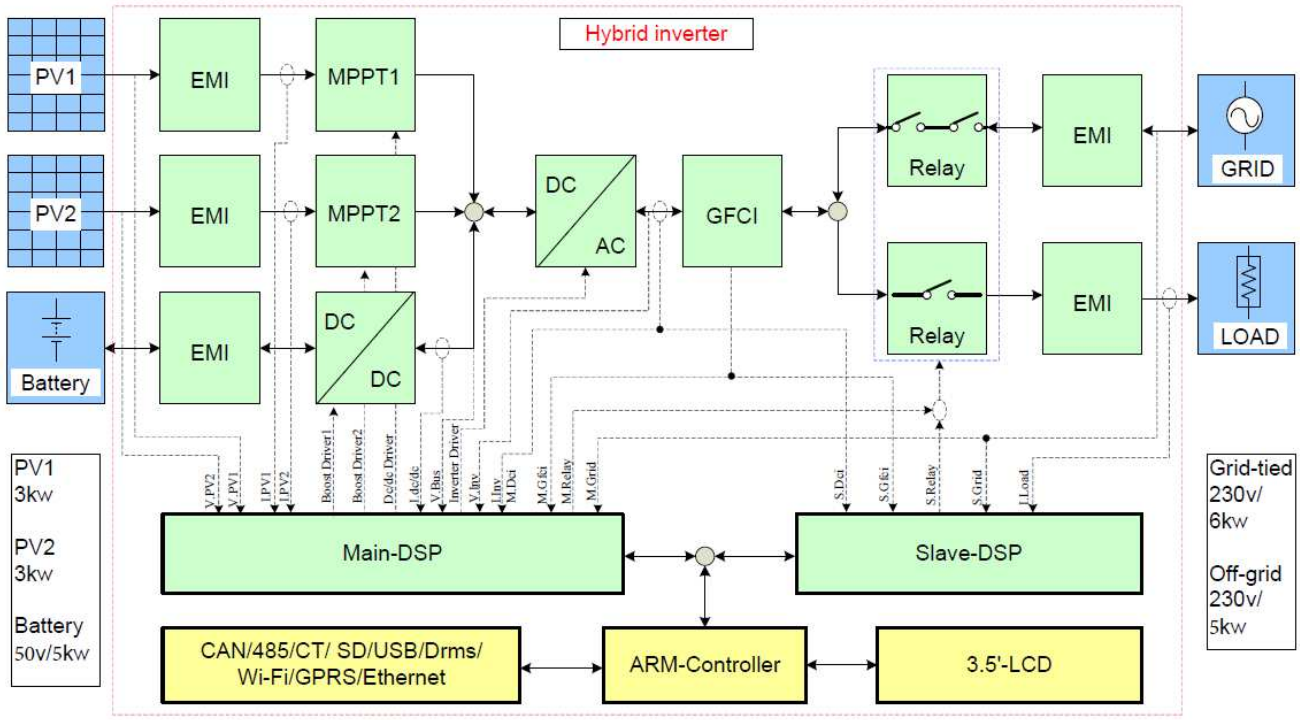


Figure 1 – Block diagram

The internal control is redundant built. It consists of Main MCU(U4) and slave MCU(U43).

The Main MCU(U4) 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 (U43) is using for controlling the relays, measuring the voltage， frequency, inject a dc AC current, the residual current, and communicating with the master MCU (U4). 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(U4), Slave MCU(U43) can open the relays.

Model difference:

The models HYD 3680-EP and HYD 3000-EP are almost identical in hardware except current sampling circuit and the output power derated by software.

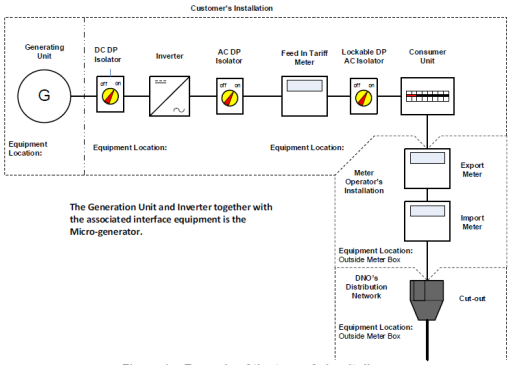
The product was tested on:
Hardware: V001
Software: V02000

All tests were performed on HYD 3680-EP are valid for the HYD 3000-EP since it's use the identical hardware and software construction except output power derated by software.

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
5	**Connection Procedure**		
5.1	**Single Premises Connection Procedure**		
5.1.1	In most instances the installation of Micro-generating Plant, the aggregate Registered Capacity of which is no greater than 16 A per phase, connected in parallel with the public Low Voltage Distribution Network, will have negligible impact on the operation of the public Low Voltage Distribution Network; as such there will be no need for the DNO to carry out detailed network studies to assess the impact of the connection. As required by the ESQCR Certificate of Exemption (2008) the Installer shall provide the DNO with all necessary information on the installation no later than 28 days after the Micro-generating Plant has been commissioned; the format and content shall be as shown in Appendix 3 Form B Installation Document.	Rely in the responsibility of the installer.	**N/A**
5.1.2	This procedure will not apply where an Installer plans (within the next 28 days) or has already installed (in the previous 28 days) other Micro-generating Plants in a Close Geographic Region; in this case the procedure in 5.2 shall be followed. Failure to comply with this requirement may lead to the disconnection of the Micro-generating Plant under ESQCR (26) or failure of the Micro-generating Plant to operate as intended.	Rely in the responsibility of the installer.	**N/A**
5.2	**Multiple Premises Connection Procedure**		**N/A**
5.2.1	In the case of projects where the proposal is to install single or multiple Micro-generators in a number of Customer Installations in a Close Geographic Region, the Installer shall discuss the installation project with the local DNO at the earliest opportunity. The DNO will need to assess the impact that these connections may have on the Distribution Network and specify conditions for connection. The initial application will need to be in a format similar to that shown in Appendix 3 Form A. Connection of the Micro-generator is only allowed after the application for connection has been approved by the DNO and any DNO works facilitating the connection have been completed. Confirmation of the commissioning of each Micro-generator will	The required wiring for the SSEG is stated in the manual. The installation relies in the responsibility of the installer.	**N/A**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	need to be made no later than 28 days after commissioning; the format and content shall be as shown in Appendix 3 Form B Installation Document.		
5.3	**General**		**N/A**
5.3.1	It is the responsibility of the Installer to ensure that the relevant information as specified in this section and in section 6 is forwarded to the local DNO as appropriate. The pro formas in Appendix 3 are designed to: a) simplify the connection procedure for both DNO and Micro-generator Installer; b) provide the DNO with all the information required to assess the potential impact of the Micro-generator connection on the operation of the Distribution Network; c) inform the DNO that the Micro-generator installation complies with the requirements of this EREC G98; and d) allow the DNO to accurately record the location of all Micro-generators connected to the Distribution Network.	The installation relies in the responsibility of the installer.	**N/A**
6	**Certification Requirements**		
6.1	**Type Test Certification**		**P**
6.1.1	Type Tested certification is the responsibility of the Manufacturer. The Manufacturer shall make available upon request a Type Test Verification Report confirming that the Micro-generator has been tested to satisfy the requirements of this EREC G98. The report shall detail the type and model of Micro-generator tested, the test conditions and results recorded. All of these details shall be included in a Type Test Verification Report. The required verification report and declaration are shown in Appendix 3 Form C. It is intended that Manufacturers of Micro-generators will use the requirements of this EREC G98 to develop type verification certification for each of their Micro-generator models.	Considered	**P**
6.1.2	Manufacturers of a Fully Type Tested Micro-generator should allocate a Manufacturer's reference number with the required details of the Micro-generator with the Energy Networks Association Type Test Verification Report Register.	Considered	**P**

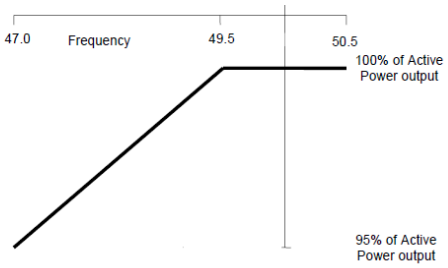
Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
6.2	**Compliance**		**P**
6.2.1	Compliance with the requirements detailed in this EREC G98 will ensure that the Micro-generator(s) is considered to be approved for connection to the DNO's Distribution Network.	Considered	**P**
6.2.2	The Micro-generator(s) shall conform to all relevant European Directives and should be labelled with a CE marking.	Considered	**P**
7	**Operation and Safety**		
7.1	**Operational Requirements**		**P**
7.1.1	Compliance with this EREC G98 in respect of the design, installation, operation and maintenance of a Micro-generating Plant, will ensure that the Customer is discharging their legal obligations under ESQCR 22(1)(a) and the EU Network Code on Requirements for Grid Connection of Generators.	The inverter is tested according the relevant requirements. The operational requirements in all cases rely in the responsibility of the user.	**P**
7.2	**Isolation**		**P**
7.2.1	The Micro-generator(s) shall be connected via an accessible isolation switch that is capable of isolating all phases and neutral. The isolation switch shall be capable of being secured in the 'off' (isolated) position.		**P**
7.3	**Labelling**		**P**
7.3.1	Labelling shall be placed in accordance with EN 50438. It should be noted that the warning label does not imply a right on the Customer, Installer or maintainer to operate (remove / replace) the DNO's cut-out fuse and a note to this effect should be included on the warning label.	The required labelling is stated in the manual of the SSEG. The installation relies in the responsibility of the installer.	**P**
7.3.2	In addition to the warning label, this EREC G98 requires the following, up to date, information to be displayed at the Connection Point with the DNO's Distribution Network. a) A circuit diagram relevant to the installation showing the circuit wiring, including all protective devices, between the Micro-generator and the DNO's fused cut-out. This diagram should also show by whom all apparatus is owned and maintained; and b) A summary of the Interface Protection settings incorporated within the Micro-	The required labelling is stated in the manual of the SSEG. The installation relies in the responsibility of the installer.	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	generator.		
7.3.3	Figure 1 shows an outline example of the type of circuit diagram that will need to be displayed. Figure 1 is non-prescriptive and is for illustrative purposes only.  Figure 1 – Example of the type of circuit diagram	The required labelling is stated in the manual of the SSEG. The installation relies in the responsibility of the installer.	**P**
7.3.4	The Installer shall advise the Customer that it is the Customer's responsibility to ensure that this safety information is kept up to date. The installation operating instructions shall contain the Manufacturer's contact details eg name, telephone number and web address.	See user manual	**P**
7.4	**Maintenance & Routine Testing**		**P**
7.4.1	Periodic testing of the Micro-generator is recommended at intervals prescribed by the Manufacturer. This information shall be included in the installation and user instructions. The method of testing and/or servicing should be included in the servicing instructions.	See user manual	**P**
7.5	**Phase Unbalance**		**P**
7.5.1	There is no requirement to balance phases on installations below or equal to 16 A per phase.	Less than 16A per phase	**N/A**
7.5.2	For multiple installations of Micro-generators (eg new housing developments), balancing the Micro-generators evenly against the load on the three phases will need to be considered by the DNO. The DNO will advise the Installer of any phase balancing requirements.	See user manual	**P**
7.6	**Voltage Management Units**		**P**
7.6.1	If a Voltage Management Unit is installed in a Customer's Installation between the Connection Point and the Micro-generator, it may result in the voltage at the Micro-generator side of the Voltage Management	Considered.	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	Unit remaining within the limits of the protection settings defined in Table 2 while the voltage at the Connection Point side of the unit might be outside the limits of the protection settings. This would negate the effect of the protection settings. Therefore, this connection arrangement is not acceptable and all Micro-generators connected to the DNO's LV Distribution Network under this EREC G98 shall be made on the Connection Point side of any Voltage Management Unit installed in a Customers' Installation.		
8	**Commissioning, Notification and Decommissioning**		
8.1	**General**		**N/A**
8.1.1	The installation shall be carried out by Installers who are competent and have sufficient skills and training (complete with recognised and approved qualifications relating to the fuels used and general electrical installations) to apply safe methods of work to install a Micro-generator in compliance with this EREC G98. Notwithstanding the requirements of this EREC G98, the installation will be carried out to no lower a standard than that required in the Manufacturer's installation instructions.	Rely in the responsibility of the installer.	**N/A**
8.2	**Commissioning**		**N/A**
8.2.1	No parameter relating to the electrical connection and subject to type verification certification shall be modified unless previously agreed in writing between the DNO and the Customer or their agent. Customer access to such parameters shall be prevented.	Rely in the responsibility of the installer.	**N/A**
8.2.2	As part of the on-site commissioning tests the Installer shall carry out a functional check of the loss of mains protection, for example by removing the supply to the Micro-generator during operation and checking that the Interface Protection operates to disconnect the Micro-generator from the DNO's Distribution Network. For three phase installations this test can be achieved by opening a three phase circuit breaker or isolator and confirming that the Micro-generator has shut down. Testing for the loss of a single phase is covered in the	Rely in the responsibility of the installer.	**N/A**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	type testing of Inverters, see section 10.2.		
8.3	**Notification of Commissioning**		**N/A**
8.3.1	In accordance with ESQCR and the HSE Certificate of Exemption (2008) (see Appendix 4) the Installer shall ensure that the DNO is advised of the intention to use the Micro-generator in parallel with the Distribution Network no later than 28 days (inclusive of the day of commissioning) after commissioning the Micro-generator. Notification that the Micro-generator has been commissioned is achieved by completing an Installation Document as per Appendix 3 Form B (Installation Document), which also includes the relevant details on the Micro-generator installation required by the DNO.	Rely in the responsibility of the installer.	**N/A**
8.3.2	The Installer shall supply separate Installation Documents for each premises in which Micro-generators are installed under EREC G98. Documentation may be submitted via an agent acting on behalf of the Installer and may be submitted electronically.	Rely in the responsibility of the installer.	**N/A**
8.4	**Notification of Changes**		**N/A**
8.4.1	If a Micro-generator requires modification the Manufacturer must re-submit the Type Test Verification Report prior to the modification being made and the Micro-generator being recommissioned.	Rely in the responsibility of the installer.	**N/A**
8.4.2	The DNO shall be notified of any operational incidents or failures of a Micro-generator that affect its compliance with this EREC G98, without undue delay, after the occurrence of those incidents.	Rely in the responsibility of the installer.	**N/A**
8.4.3	The DNO shall have the right to request that the Customer arrange to have compliance tests undertaken after any failure, modification or replacement of any equipment that may have an impact on the Micro-generator's compliance with this EREC G98.	Rely in the responsibility of the installer.	**N/A**
8.5	**Notification of Decommissioning**		**N/A**
8.5.1	The Customer shall notify the DNO about the permanent decommissioning of a Micro-generator by providing the information as detailed under Appendix 3 Form D. Documentation may be submitted by an agent acting on behalf of the Customer and may be submitted	Rely in the responsibility of the installer.	**N/A**

<table>
<tr><th colspan="4">Engineering recommendation G98/1-4</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result – Remark</th><th>Verdict</th></tr>
<tr><td></td><td>electronically.</td><td></td><td></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>9</td><td colspan="3">General Technical Requirements</td></tr>
<tr><td>9.1</td><td colspan="2">Frequency withstand</td><td>P</td></tr>
<tr><td>9.1.1</td><td>The Micro-generator shall be capable of remaining connected to the Distribution Network and operating within the frequency ranges and time periods specified in Table 1 unless disconnection was triggered by rate-of-change-of-frequency-type loss of mains protection.
Table 1 – Minimum time periods for which a Micro-generator has to be capable of operating within different frequency ranges without disconnecting from the Distribution Network
<table><tr><td>47.0 Hz – 47.5 Hz</td><td>20 seconds</td></tr><tr><td>47.5 Hz – 48.5 Hz</td><td>90 minutes</td></tr><tr><td>48.5 Hz -49.0 Hz</td><td>90 minutes</td></tr><tr><td>49.0 Hz – 51.0 Hz</td><td>Unlimited</td></tr><tr><td>51.0 Hz – 51.5 Hz</td><td>90 minutes</td></tr><tr><td>51.5 Hz – 52.0 Hz</td><td>15 minutes</td></tr></table></td><td>Considered</td><td>P</td></tr>
<tr><td>9.2</td><td colspan="2">Rate of Change of Frequency</td><td>P</td></tr>
<tr><td>9.2.1</td><td>With regard to the rate of change of frequency withstand capability, a Micro-generator shall be capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1.0 Hzs-1 measured over 500 ms.</td><td>Considered</td><td>P</td></tr>
<tr><td>9.3</td><td colspan="2">Limited Frequency Sensitive Mode – Overfrequency</td><td>P</td></tr>
<tr><td>9.3.1</td><td>With regard to the Limited Frequency Sensitive Mode — Overfrequency (LFSM-O), the Micro-generator shall be capable of activating the provision of Active Power Frequency Response according to EN 50438. The GB specific standard frequency threshold shall be 50.4 Hz; the Droop setting 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.</td><td>Considered</td><td>P</td></tr>
<tr><td>9.3.2</td><td>The Micro-generator will continue to reduce power with rising frequency with a Droop of 10% until 52.0 Hz, at which point the Micro-generator should disconnect.</td><td>Considered</td><td>P</td></tr>
</table>

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
9.4	**Active Power Output**		**P**
9.4.1	The Micro-generator shall be capable of maintaining constant output at its Registered Capacity regardless of changes in frequency, except where the output follows the changes defined in the context of paragraphs 9.3.1 and 9.4.2.	Considered	**P**
9.4.2	The Micro-generator shall be capable of maintaining constant output at its Registered Capacity regardless of changes in frequency in the range 49.5 – 50.4 Hz. Below 49.5 Hz, the power output should not drop by more than pro-rata with frequency, ie the maximum permitted requirement is 100% power at 49.5 Hz falling linearly to 95% power at 47.0 Hz as illustrated in Figure 2.  **Figure 2 – Change in output power with falling frequency**	Considered	**P**
9.4.3	The Micro-generator shall be equipped with a logic interface (input port) in order to cease Active Power output within 5 s following an instruction being received from the DNO at the input port. By default the logic interface will take the form of a simple binary output that can be operated by a simple switch or contactor. When the switch is closed the Micro-generator can operate normally. When the switch is opened the Micro-generator will reduce its Active Power to zero within 5 s. The signal from the Micro-generator that is being switched can be either AC (maximum value 240 V) or DC (maximum value 110 V). The DNO may specify any additional requirements particularly regarding remote operation of this facility.	Considered	**P**
9.5	**Power Factor**		**P**
9.5.1	The power factor capability of the Micro-generator shall conform to EN 50438. When operating at Registered Capacity the Micro-generator shall operate at a power factor within the range 0.95 lagging to 0.95	Considered	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	leading relative to the voltage waveform unless otherwise agreed with the DNO eg for power factor improvement.		
9.6	**Automatic Connection**		**P**
9.6.1	Micro-generators shall conform to EN 50438 in respect of connection and starting to generate electric power. This includes automatic reconnection where the minimum observation time shall be as stated in Annex A12 of EN 50438.	Considered	**P**
10	**Interface Protection**		
10.1	**General**		**P**
10.1.1	The Micro-generator shall conform to the Interface Protection settings set out below (Table 2). Means shall be provided to protect the settings from unpermitted interference (eg via a password or seal).	Considered	**P**
10.1.2	The DNO is responsible under the Distribution Code for ensuring, by design, that the voltage and frequency at the Connection Point remains within statutory limits. The Interface Protection settings have been chosen to allow for voltage rise or drop within the Customer's Installation and to allow the Micro-generator to continue to operate outside of the statutory frequency range as required by the EU Network Code on Requirements for Grid Connection of Generators.	Considered	**P**
10.1.3	Interface Protection shall be installed which disconnects the Micro-generator from the DNO's Distribution Network when any parameter is outside of the settings shown in Table 2. Table 2 – Interface Protection settings Protection Function / Trip Setting / Time Delay Setting U/V / Vφ-n† - 20% = 184 V / 2.5 s O/V stage 1 / Vφ-n† +14% = 262.2 V / 1.0 s O/V stage 2 / Vφ-n†+ 19% = 273.7 V[4] / 0.5 s U/F stage 1 / 47.5 Hz / 20 s U/F stage 2 / 47 Hz / 0.5 s O/F / 52 Hz / 0.5 s LoM (RoCoF) / 1.0 Hzs^{-1} / † A value of 230 V phase to neutral	Test results see appended table.	**P**
10.1.4	The total disconnection time for voltage and frequency protection, including the operating time of the disconnection device, shall be the time delay setting with a	Test results see appended table.	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	tolerance of, -0s + 0.5 s.		
10.1.5	For the avoidance of doubt, where the Distribution Network voltage or frequency exceed the trip settings in Table 2, for less than the time delay setting, the Micro-generator should not disconnect from the Distribution Network.	Test results see appended table.	**P**
10.1.6	Fully Type Tested Micro-generators shall have protection settings set during manufacture.	Considered	**P**
10.1.7	The Manufacturer shall establish a secure way of displaying the Interface Protection setting information in one of the following ways: • A display on a screen; • A display on a PC which can communicate with the Micro-generator and confirm that it is the correct Micro-generator by means of a serial number permanently fixed to the Micro-generator and visible on the PC screen at the same time as the settings; or • Display of all Interface Protection settings and nominal voltage and current outputs, alongside the serial number of the Micro-generator, permanently fixed to the Micro-generator.	Considered	**P**
10.1.8	The provision of loose documents, documents attached to the Micro-generator by cable ties etc, or provision of data on adhesive paper based products which are not likely to survive due to fading, or failure of the adhesive, for at least 20 years is not acceptable.	Considered	**P**
10.1.9	In response to a protection operation the Micro-generator shall be automatically disconnected from the DNO's Distribution Network. This disconnection must be achieved preferably by the separation of mechanical contacts or alternatively by the operation of a suitably rated solid state switching device. Where a solid state switching device is used to afford disconnection of the Micro-generator, the switching device shall incorporate fail safe monitoring to check the voltage level at its output stage. In the event that the solid state switching device fails to disconnect the Micro-generator, the voltage on the output side of the switching device shall be reduced to a value below 50 V within 0.5 s	Considered	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	of the protection and trip delay timer operation.		
10.1.10	Where a common protection system is used to provide the protection function for multiple Micro-generators the complete installation cannot be considered to comprise Fully Type Tested Micro-generators if the protection and connections are made up on site and so cannot be factory tested or Fully Type Tested. In accordance with Annex A1 or Annex A2 if the units or Micro-generators are specifically designed with plugs and sockets to be interconnected on site, then provided the assembly passes the function tests required in Appendix 3 Form C, the Micro-generator(s) can retain Fully Type Tested status.	Test results see appended table.	**P**
10.1.11	Once the Micro-generator has been installed and commissioned the protection settings shall only be altered following written agreement between the DNO and the Customer or their agent.	Considered	**P**
10.2	**Loss of Mains Protection**		**P**
10.2.1	Loss of mains protection shall be incorporated and tested as defined in the compliance type testing annex of EN 50438. Active methods which use impedance measuring techniques by drawing current pulses from or injecting AC currents into the DNO's Distribution Network are not considered to be suitable. For Micro-generators which generate on more than one phase, the loss of mains protection should be able to detect the loss of a single phase of the supply network. This should be tested during type testing and recorded in the Type Test Verification Report as per Appendix 3 Form C.	Test results see appended table.	**P**
10.3	**Frequency Drift and Step Change Stability Test**		**P**
10.3.1	Under normal operation of the Distribution Network, the frequency changes over time due to continuous unbalance of load and generation or can experience a step change due to the loss of a Distribution Network component which does not cause a loss of supply.	Considered	**P**
10.3.2	In order to ensure that such phenomena do not cause unnecessary tripping of Micro-generators, stability type tests shall be carried out.	Considered	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
10.3.3	The Rate of Change of Frequency (RoCoF) and Vector Shift values required for these tests are marginally less than the corresponding protection settings for RoCoF in Table 2 and vector shifts of up to 50º. Both stability tests shall be carried out in all cases.	Test results see appended table.	**P**
10.3.4	The stability tests are to be carried out as per the table in Appendix 3 Form C of this document and the Micro-generator should remain connected during each and every test. The tests shall check that the Micro-generator remains stable and connected during the following scenarios: • RoCoF: 0.95 Hzs^{-1} from 49.0 Hz to 51.0 Hz on both rising and falling frequency; and • Vector shift: 50º plus from 49.5 Hz and 50º minus from 50.5 Hz.	Test results see appended table.	**P**
11	**Quality of Supply**		
11.1	The power quality requirements set out in EN 50438 should be met along with the requirements described in this section of EREC G98.	Considered	**P**
11.2	Micro-generators are likely to be installed in large numbers on LV Distribution Networks. They are likely to operate for long periods with no diversity between them, and adjacent Micro-generators are likely to be of the same technology. Therefore, in order to accommodate a high number of Micro-generators on a Distribution Network, procedures are specified in Annex A1 and Annex A2, which need to be applied when testing for harmonic current emissions and flicker.	Considered	**P**
11.3	The requirements of EN 50438 shall be met for DC injection.	Considered	**P**
12	**Short Circuit Current Contribution**		
12.1	**Directly Coupled Micro-generators**		**P**
12.1.1	The short-circuit parameters of synchronous Micro-generators shall be determined by means of a short-circuit test in accordance with EN 50438.	Considered	
12.2	**Inverter Connected Micro-generators**		**P**
12.2.1	In addition to EN 50438 Manufacturers of Inverters shall take account of the	Considered	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	following: • DNOs need to understand the contribution that Inverters make to system fault levels in order to determine that they can continue to safely operate their Distribution Networks without exceeding design fault levels for switchgear and other circuit components; and • As the output from an Inverter reduces to zero when a short circuit is applied to its terminals, a short circuit test does not represent the worst case scenario; in most cases the voltage will not collapse to zero for a Distribution Network fault.		
12.2.2	To address this issue a test, which ensures that at least 10% of nominal voltage remains and which allows the Micro-generator to feed into a load with an X to R ratio of 2.5, is specified as detailed in Annex A1.	Considered	**P**
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. The compliance testing annex of EN 50438 should be complied with except where alternative requirements are detailed in this Annex.	Considered	**P**
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;	Considered Test results see appended table.	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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).		
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.	Test results see appended table.	**P**
A 1.2.2	**Over / Under Voltage** In addition to the EN 50438 over / under voltage tests the tests in this paragraph shall be undertaken. The Interface Protection shall be tested by 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.	Test results see appended table.	**P**
A 1.2.3	**Over / Under Frequency** In addition to the EN 50438 over / under frequency tests the tests in this paragraph shall be undertaken into account. The Micro-generator shall be tested by operating in parallel with a low impedance,	Test results see appended table.	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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.		
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.	Test results see appended table.	**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).	Test results see appended table.	**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.	Test results see appended table.	**P**
A 1.2.7	**Active power feed-in at under-frequency** EN 50438 shall be complied with in respect of active power feed-in at under-frequency.	Test results see appended table.	**P**
A 1.2.8	**Power response to over-frequency** EN 50438 shall be complied with in respect of power response to over-frequency using a specific standard frequency threshold of 50.4 Hz and a Droop setting of 10%.	Test results see appended table.	**P**
A 1.3	**POWER QUALITY**	Test results see appended table.	**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	Test results see appended table.	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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		
A 1.3.2	**Power Factor** The test should be undertaken as laid out in EN 50438 with the following three test voltages 230 V –6%, 230V and 230 V +10%.	Test results see appended table.	**P**
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 results see appended table.	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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.		
A 1.3.4	**DC Injection for Inverters** DC injection compliance testing in EN 50438 shall be applicable to all Inverter connected Micro-generators regardless of connection configuration.	Test results see appended table.	**P**
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.	Test results see appended table.	**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 line and neutral are provided in the SSEG.	**P**
A 1.3.7	**Electromagnetic Compatibility (EMC)** All equipment shall conform to the generic EMC standards: BS EN61000-6-3: Electromagnetic Compatibility, Generic Emission Standard; and BS EN61000-6-1: Electromagnetic Compatibility, Generic	Considered.	**P**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	Immunity Standard.		
Annex A2	**Requirements for Type Testing of Synchronous Micro-generators**		
A 2.1	**General** The compliance testing annex of EN 50438 should be complied with except where alternative requirements are detailed in this Annex.	The SSEG is a photovoltaic inverter.	**N/A**
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 SSEG is a photovoltaic inverter.	**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 in Table 2. For over / under voltage, over / under frequency and loss of mains tests, reconnection shall be checked as detailed below.	The SSEG is a photovoltaic inverter.	**N/A**
A 2.2.2	**Over / Under Voltage** In addition to the EN 50438 over / under	The SSEG is a photovoltaic inverter.	**N/A**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	voltage tests the tests in this paragraph shall be undertaken. 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.		
A 2.2.3	**Over / Under Frequency** In addition to the EN 50438 over / under frequency tests the tests in this paragraph shall be undertaken into account. 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.	The SSEG is a photovoltaic inverter.	**N/A**
A 2.2.4	**Loss of Mains Protection** The test described in EN 50438 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.	The SSEG is a photovoltaic inverter.	**N/A**
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).	The SSEG is a photovoltaic inverter.	**N/A**
A 2.2.6	**Frequency Drift and Step Change Stability test**	The SSEG is a photovoltaic inverter.	**N/A**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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.		
A 2.2.7	**Active power feed-in at under-frequency** EN 50438 shall be complied with in respect of active power feed-in at under-frequency.	The SSEG is a photovoltaic inverter.	**N/A**
A 2.2.8	**Power response to over-frequency** EN 50438 shall be complied with in respect of power response to over-frequency using a specific standard frequency threshold of 50.4 Hz and a Droop setting of 10%.	The SSEG is a photovoltaic inverter.	**N/A**
A 2.3	**POWER QUALITY**	The SSEG is a photovoltaic inverter.	**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. 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 SSEG is a photovoltaic inverter.	**N/A**
A 2.3.2	**Power Factor** The test should be undertaken as laid out in EN 50438 with the following three test voltages 230 V –6%, 230V and 230 V +10%.	The SSEG is a photovoltaic inverter.	**N/A**
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 SSEG is a photovoltaic inverter.	**N/A**

Engineering recommendation G98/1-4			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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.		
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. The tests in EN 50438 shall apply. 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 SSEG is a photovoltaic inverter.	**N/A**
A 2.3.5	**Electromagnetic Compatibility (EMC)** All equipment shall conform to the generic EMC standards: BS EN61000-6-3: Electromagnetic Compatibility, Generic Emission Standard; and BS EN61000-6-1: Electromagnetic Compatibility, Generic Immunity Standard.	The SSEG is a photovoltaic inverter.	**N/A**

G98-1/1 Test Results:

A1 Common Directly Coupled Connected SSEG Requirements

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

	ambient temperature [°C] :	24,9
	model/type of power supply :	AC: 61512 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 RL4	Short before start-up	230V <1A	520V <1A	10Min.	--	230V <1A	520V <1A	Indicate Relay fault,error code “ID41: RecoverRelayFail”. Do not connect to AC mainsn. No damage,no hazards.
Relay RL1	Short before start-up	230V <1A	520V <1A	10Min.	--	230V <1A	520V <1A	Indicate Relay fault,error code “ID41: RecoverRelayFail”. Do not connect to AC mainsn. No damage,no hazards.
Relay RL2	Short before start-up	230V <1A	520V <1A	10Min.	--	230V <1A	520V <1A	Indicate Relay fault,error code “ID41: RecoverRelayFail”. Do not connect to AC mainsn. No damage,no hazards.
Relay RL5	Short before start-up	230V <1A	520V <1A	10Min.	--	230V <1A	520V <1A	Indicate Relay fault,error code “ID41: RecoverRelayFail”. Do not connect to AC mainsn. No damage,no hazards.
Rectifier bridge BR1	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated immediately, disconnected with grid. No damage, no hazards.
Q23 pin G-S	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. error code “ID41: RecoverRelayFail”. No damage,no hazards.
Q17 pin G-S	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. error code “ID41: RecoverRelayFail”. No damage,no hazards.
Q18 pin G-S	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. error code “ID41: RecoverRelayFail”. No damage,no hazards.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
Q16 pin G-S	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. error code “ID41: RecoverRelayFail”. No damage,no hazards.
RCM/LP1 pin GND-Vout	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. error code “ID05:GFCI fault”. No damage,no hazards.
Monitoring voltage defect R203	Open	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code “GridUVP”. No damage. No hazards.
Monitoring voltage defect R219	Open	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code “GridUVP”. No damage. No hazards.
U1 pin 485-1TX 485-1RX	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. 4851 Communication failure. No damage. No hazards.
U1 pin 485-2TX 485-2RX	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. 4852 Communication failure. No damage. No hazards.
U1 pin ARMToDSP ARMFromDSP-TX	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. SCI Communication failure. No damage. No hazards.
U1 pin M_CAN_RX M_CAN_TX	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. CAN Communication failure. No damage. No hazards.
U1,+3.3V.S	Open	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. SCI Communication failure. No damage. No hazards.
PV voltage monitoring R283	Open	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. No damage. No hazards
PV voltage monitoring R277	Open	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. No damage. No hazards
L to N(Grid)	Reversed	230V 15,5A	520V 11,8 A	10Min.	--	230V 15,5A	520V 11,8A	EUT operationed normally. No damage, no hazards.
C324	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. L2 ,L7,breakdown, no hazards.
EC2	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. EC2 damage, no hazards.
EC3	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. EC3 damage, no hazards.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
Q61 pin D-S	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid. No damage. No hazards
Q16 pin D-S	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code "ID81" (SwBatOCP). No damage, no hazards.
Q17 pin D-S	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code "ID81" (SwBatOCP). No damage, no hazards.
Q18 pin D-S	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code "ID81" (SwBatOCP). No damage, no hazards.
Q19 pin D-S	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code "ID81" (SwBatOCP). No damage, no hazards.
D13	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID69.PVOVP. No damage, no hazards.
R28	Open	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID69.PVOVP. No damage, no hazards.
R68	Open	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID71 LLCBusOVP". No damage, no hazards.
R32	Open	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID71 LLCBusOVP". No damage, no hazards.
R71	Open	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID71 LLCBusOVP". No damage, no hazards.
Q27	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID71 LLCBusOVP". No damage, no hazards.
Q9 pin G-C-E	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	The EUT shut down immediately. Q9,Q13 damaged, no hazards

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
Q8 pin G-C-E	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	The EUT shut down immediately. Q8,Q14 damaged, no hazards
Q7 pin G-C	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	The EUT shut down immediately. Q7 damaged, no hazards
Q12 pin G-C	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	The EUT shut down immediately. Q12 damaged, no hazards
Q1 pin G-S-D	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	The EUT shut down immediately. Q1,Q2,Q3 damaged, no hazards
Q2 pin G-S-D	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	The EUT shut down immediately. Q1,Q2,Q3,Q6 damaged, no hazards
R531	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID42,IsoFault". No damage, no hazards.
R602	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID42,IsoFault". No damage, no hazards.
R611	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID42,IsoFault". No damage, no hazards.
R620	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID42,IsoFault". No damage, no hazards.
EC25	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID42,IsoFault". No damage, no hazards.
EC27	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC16	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
EC17	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC29	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC31	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC18	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC19	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC24	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC26	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC20	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC21	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC28	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC30	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
EC22	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC23	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " ID17HwADFaultIGrid". No damage, no hazards.
EC32	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c. relays operated, disconnected with grid, error code " SCI Communication failure". No damage, no hazards.
U4 pin M_LINRX M_LINTX	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c.relays operated, disconnected with grid. M_LINRX Communication failure No damaged. No hazards
INSYN,TX1, INSYN,RX1	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c.relays operated, disconnected with grid. Error code"ID47(ParallelFault) No damaged. No hazards.
INSYN,TX1, INSYN,RX1	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c.relays operated, disconnected with grid. Error code"ID47(ParallelFault) No damaged. No hazards.
C384	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c.relays operated, disconnected with grid. error code "ID81(SwBatOCP) . No damaged. No hazards.
EC6	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	The EUT shut down immediately. No damaged, no hazards.
EC9	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	The EUT shut down immediately. No damaged, no hazards.
EC11	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	The EUT shut down immediately. No damaged, no hazards.
U58	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	The EUT shut down immediately. No damaged, no hazards.
C463	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c.relays operated, disconnected with grid. error code"GFCI fault" No damaged. No hazards
C105	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c.relays operated, disconnected with grid. error code"CT current fault" No damaged. No hazards.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
C130	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c.relays operated, disconnected with grid. error code" OverTempDerating" No damaged. No hazards.
C107	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c.relays operated, disconnected with grid. error code"HwLLCBusOCP" No damaged. No hazards.
C120	Short	230V 15,5A	520V 11,8 A	10Min.	--	230V <1A	520V <1A	Output a.c.relays operated, disconnected with grid. error code"HwLLCBusOCP" No damaged. No hazards.
The errors in the control circuit simulate that the safety is even ensured during single fault. The tests had been performed on the HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software. The test results refer to the test report "PVTR200917N016" issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2021.01.20.								

Operating Range: This test should be carried out as specified in EN 50438 D.3.1.					**P**
Setting values	Over-voltage [V]:	253,0			
	Under-voltage [V]:	195,5			
	Over-frequency [Hz]:	52,00			
	Under-frequency [Hz]:	47,50			
- Test 1: U = 195,5 V; f = 47,5 Hz; P = 1,00 Sn; cosφ = 1; at least 90 mins - Test 2: U = 253,0 V; f = 51,5 Hz; P = 1,00 Sn; cosφ = 1; at least 90 mins - Test 3: U = 253,0 V; f = 52,0 Hz; P = 1,00 Sn; cosφ = 1; at least 15 mins					
Test sequence	Voltage [V]	Frequency [Hz]	Output power [W]	Cos φ [1]	
1	195,40	47,5	3662	0,996	
2	253,40	51,5	3637	0,996	
3	253,35	52,0	3624	0,994	

Note:

During the tests the interface protection was disabled.

Operation at reduced power is allowed during test 1, 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 2, automatic adjustment to reduce power in the case of over-frequency was disabled.

The tests had been performed on the HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

A1.2.2 Over / Under Voltage
The test procedure in Annex A.1.2.2 (Inverter connected) or Annex A2 A.2.2.2 (Synchronous). **P**

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	183,7V	2,530s	188V / 5,0s	No trip
					180V / 2,45s	No trip
O/V stage 1	262,2V	1,0s	261,8V	1,017s	258,2V / 5,0s	No trip
O/V stage 2	273,7V	0,5s	273,8V	0,525s	269,7V / 0,95s	No trip
					277,7V / 0,45s	No trip

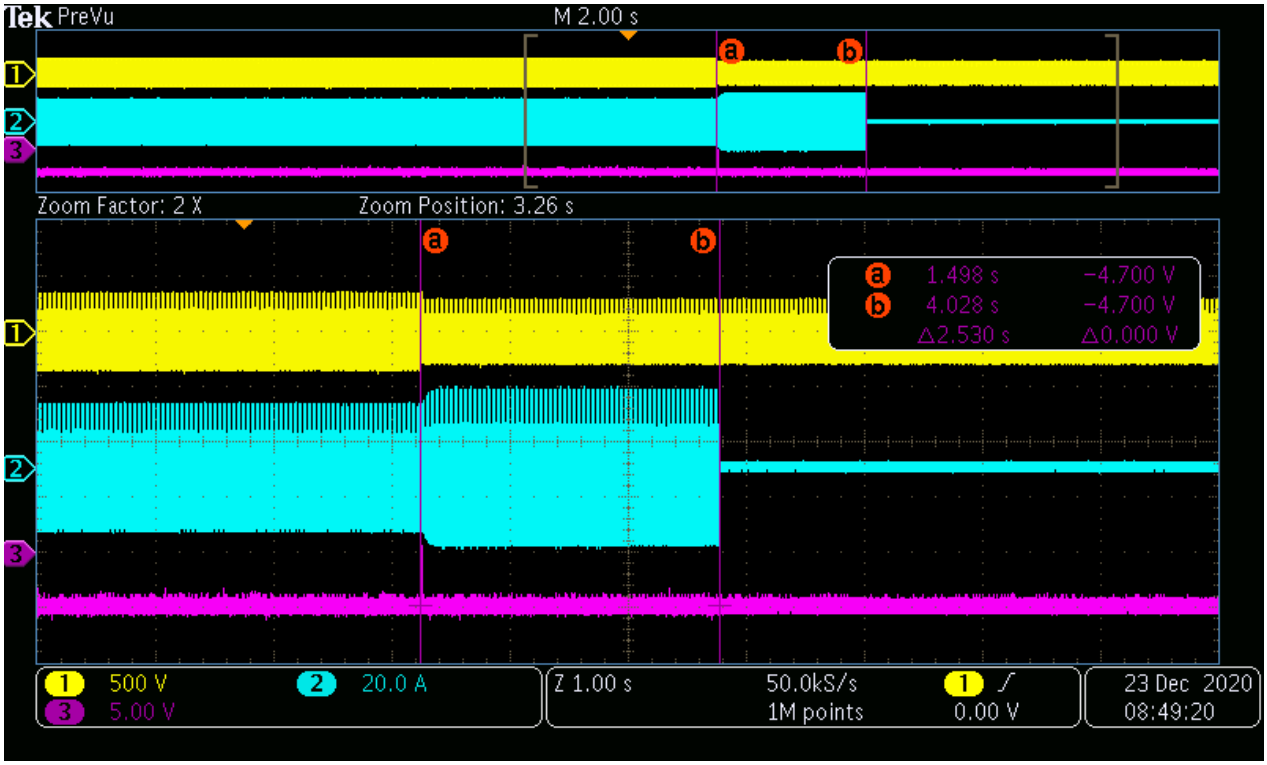
Note:

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.

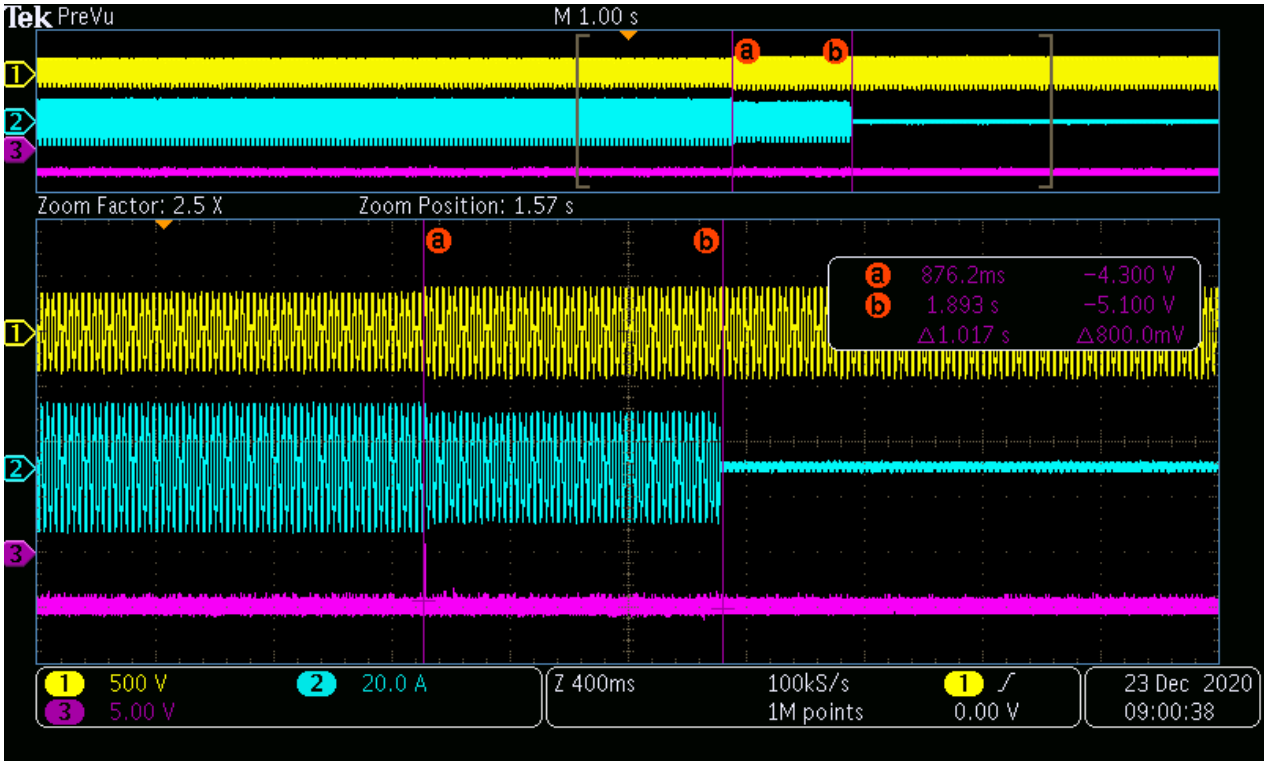
The Voltage required to trip is the setting ±3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±4 V and for the relevant times as shown in the table above to ensure that the protection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

The tests had been performed on the HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

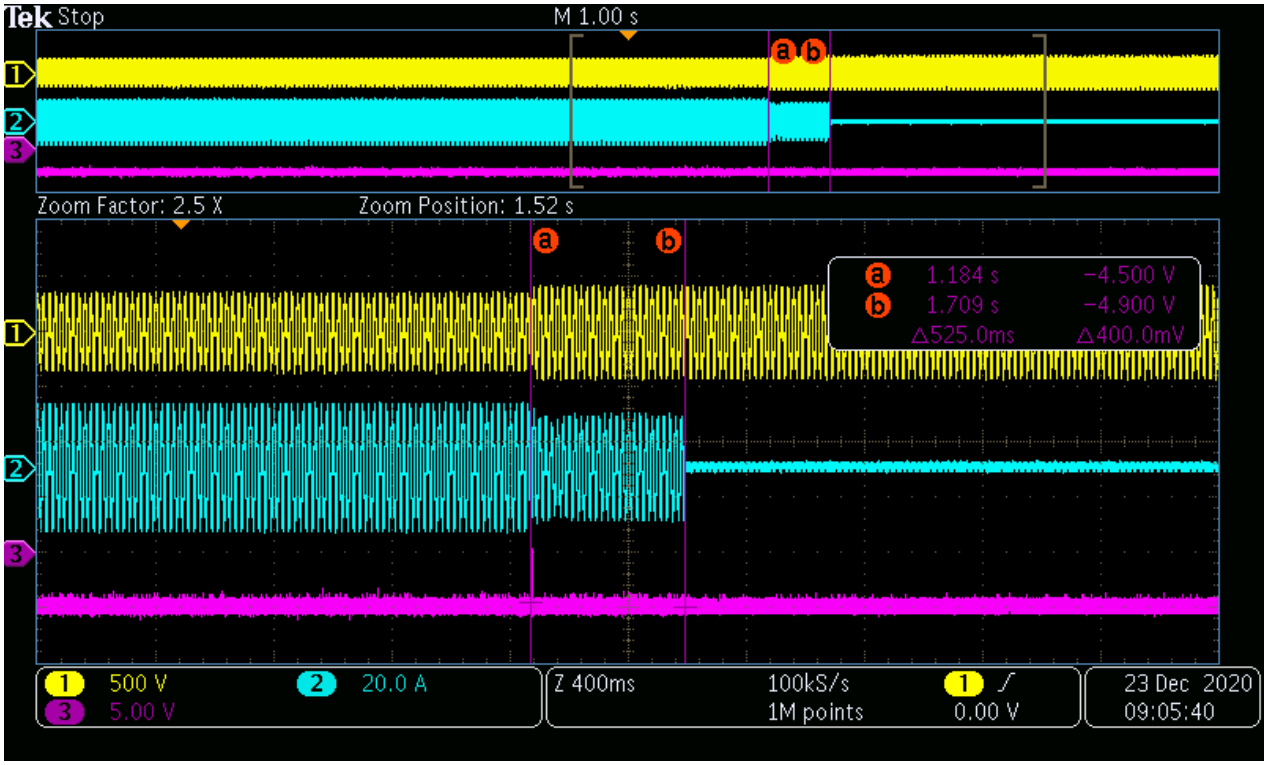
U/V


Tek PreVu
M 2.00 s
Zoom Factor: 2 X
Zoom Position: 3.26 s
a 1.498 s -4.700 V
b 4.028 s -4.700 V
Δ2.530 s Δ0.000 V
1 500 V
3 5.00 V
2 20.0 A
Z 1.00 s
50.0kS/s
1M points
1 0.00 V
23 Dec 2020
08:49:20

O/V stage 1


Tek PreVu
M 1.00 s
Zoom Factor: 2.5 X
Zoom Position: 1.57 s
a 876.2ms -4.300 V
b 1.893 s -5.100 V
Δ1.017 s Δ800.0mV
1 500 V
3 5.00 V
2 20.0 A
Z 400ms
100kS/s
1M points
1 0.00 V
23 Dec 2020
09:00:38

O/V stage 2


Tek Stop
M 1.00 s
Zoom Factor: 2.5 X
Zoom Position: 1.52 s
a 1.184 s -4.500 V
b 1.709 s -4.900 V
Δ525.0ms Δ400.0mV
1 500 V
3 5.00 V
2 20.0 A
Z 400ms
100kS/s
1M points
1 0.00 V
23 Dec 2020
09:05:40

A1.2.3 Over / Under Frequency
The test procedure in Annex A.1.2.3 (Inverter connected) or Annex A2 A.2.2.3 (Synchronous). **P**

Function	Setting		Trip test		No trip test	
	Frequency	Time delay	Frequency	Time delay	Frequency / time	Confirm no trip
U/F stage 1	47,50Hz	20s	47,50Hz	20,200s	47,7Hz / 30s	No trip
U/F stage 2	47,00Hz	0,5s	47,00Hz	0,535s	47,2Hz / 19,5s	No trip
					46,8 Hz / 0,45s	No trip
O/F	52,00Hz	0,5s	52,00Hz	0,529s	51,8Hz / 120,0s	No trip
					52,2 Hz / 0,45s	No trip

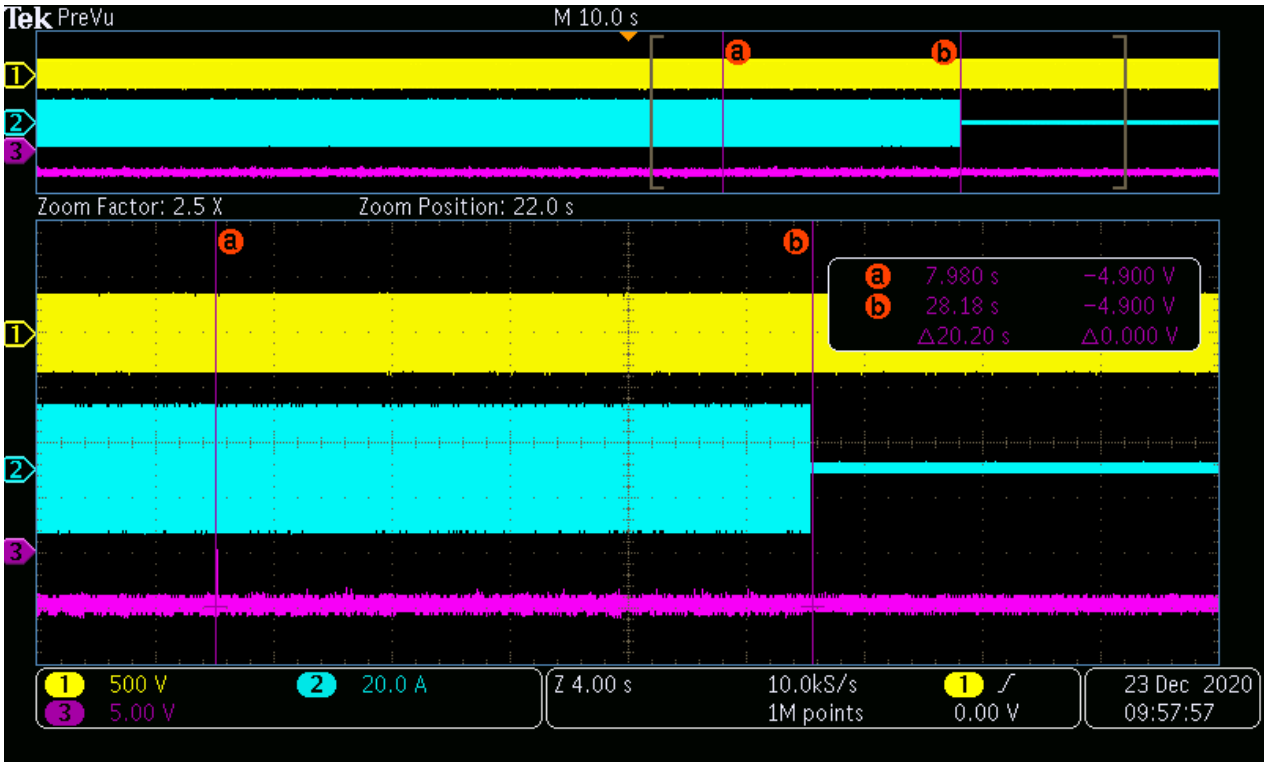
Note:

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.

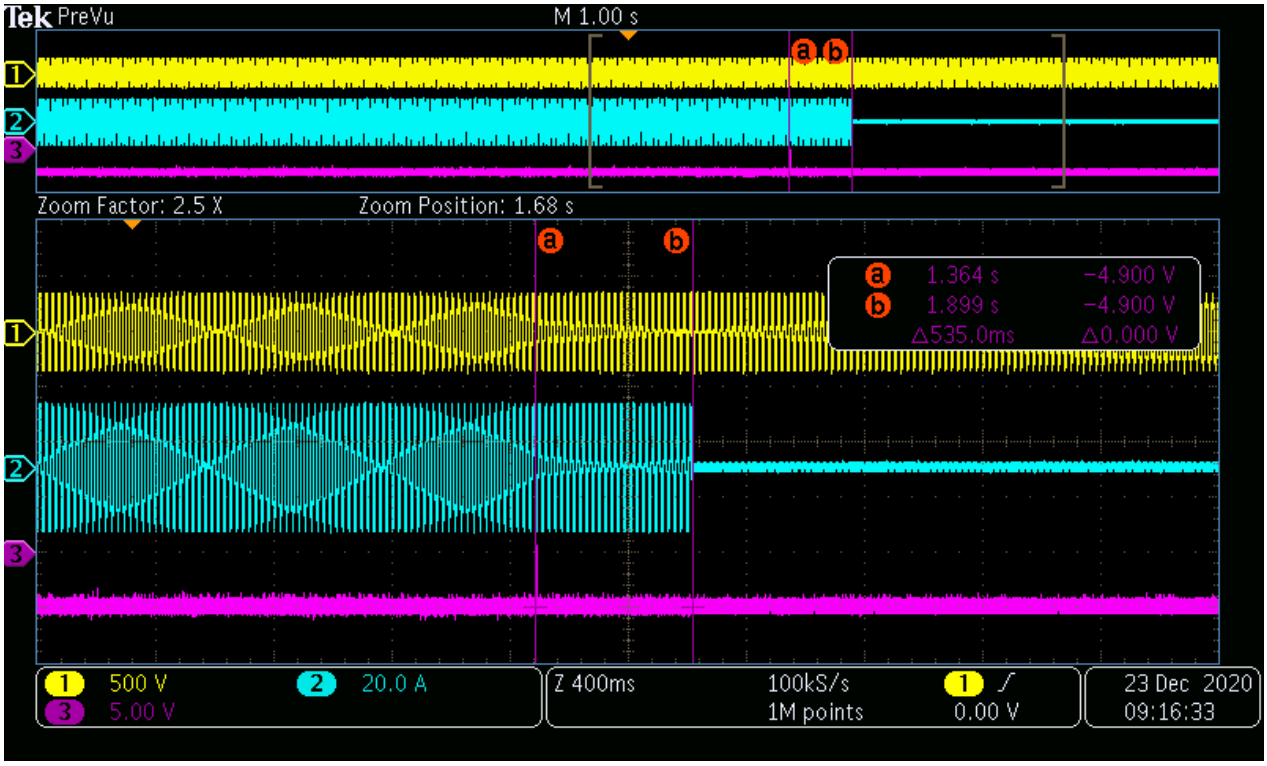
For frequency trip tests the frequency required to trip is the setting ± 0.1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0.2 Hz and for the relevant times as shown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

The tests had been performed on the HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

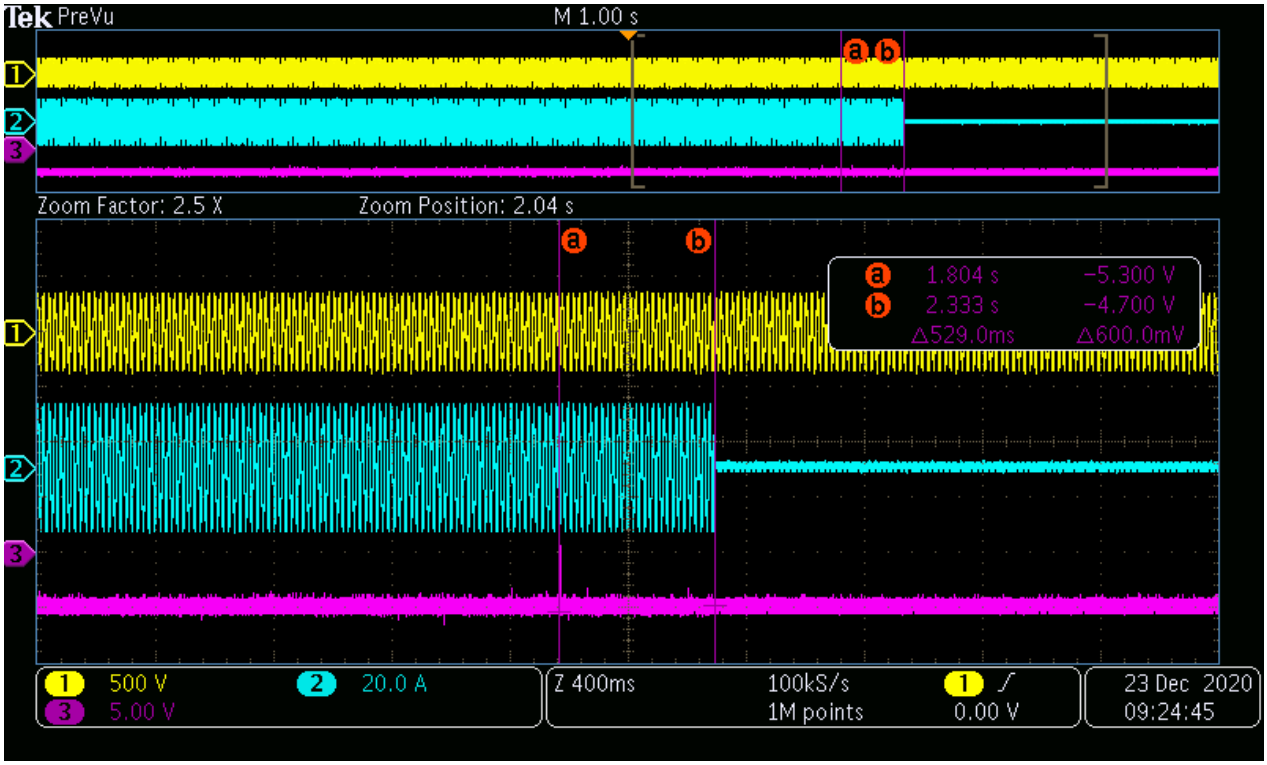
U/F stage 1



U/F stage 2



O/F


Tek PreVu
M 1.00 s
Zoom Factor: 2.5 X
Zoom Position: 2.04 s
a 1.804 s -5.300 V
b 2.333 s -4.700 V
Δ529.0ms Δ600.0mV
1 500 V
3 5.00 V
2 20.0 A
Z 400ms
100kS/s
1M points
1 0.00 V
23 Dec 2020
09:24:45

A1.2.4 Loss of mains protection according BS EN 62116 **P**

The requirement is specified in section 10.2, test procedure in Annex A.2.2.4
Load imbalance (real, reactive load) for test condition A (EUT output = 100%)

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

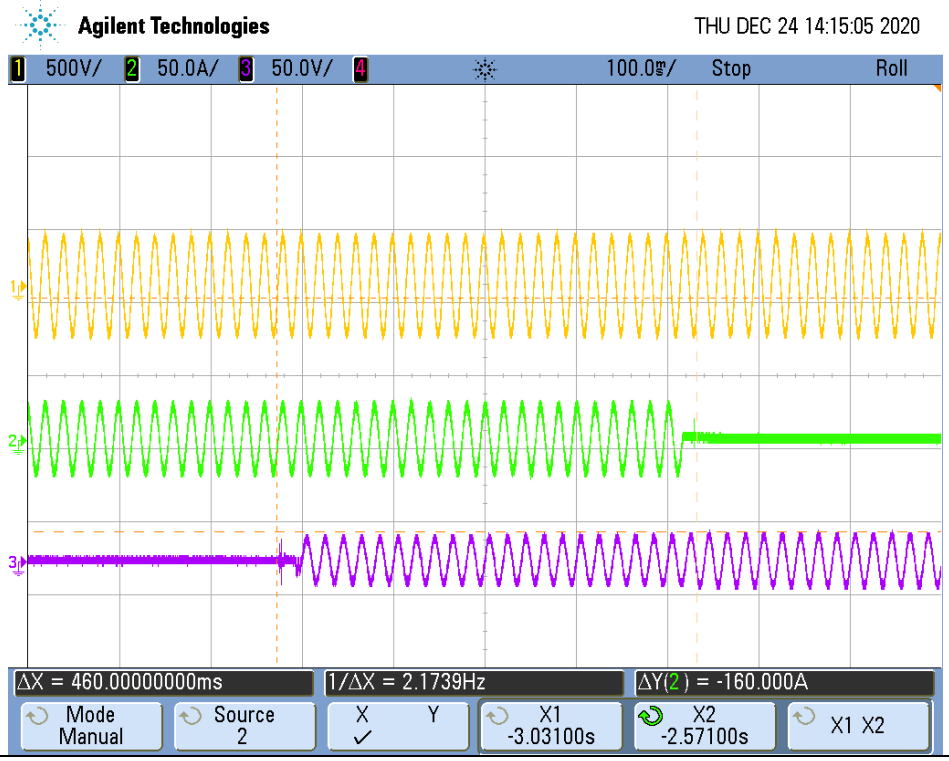
No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) 1]	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks5)
1	100	100	0	0	0,117	3680	441	1,000	460	BL
2	100	100	-5	-5	0,892	3680	441	1,026	425	IB
3	100	100	-5	0	0,913	3680	441	1,052	441	IB
4	100	100	-5	+5	0,892	3680	441	1,078	408	IB
5	100	100	0	-5	0,141	3680	441	0,974	388	IB
6	100	100	0	+5	0,141	3680	441	1,024	436	IB
7	100	100	+5	-5	0,941	3680	441	0,928	391	IB
8	100	100	+5	0	0,922	3680	441	0,952	427	IB
9	100	100	+5	+5	0,941	3680	441	0,976	400	IB

Parameter at 0%	L= 45,74 mH	R= 14,37 Ω	C= 221,49 µF

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 0.5s. 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) BL: Balance condition, IB: Imbalance condition.
Condition A:
EUT output power PEUT = Maximum 5)
EUT input voltage 6) = >90% of rated input voltage range
5) Maximum EUT output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.
6) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % of range =X + 0,9 × (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 HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

Disconnection at P_{AC} -0% and Q_{AC} 0% reactive load and 100% nominal power



A1.3.4 Loss of mains protection according BS EN 62116 The requirement is specified in section 10.2, test procedure in Annex A.2.2.4 Load imbalance (real, reactive load) for test condition A (EUT output = 50 % – 66 %)	**P**

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]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks5)
1	66	66	0	-5	0,109	2430	285	0,975	400	IB
2	66	66	0	-4	0,104	2430	285	0,980	424	IB
3	66	66	0	-3	0,101	2430	285	0,985	404	IB
4	66	66	0	-2	0,098	2430	285	0,990	440	IB
5	66	66	0	-1	0,097	2430	285	0,995	402	IB
6	66	66	0	0	0,096	2430	285	1,000	450	BL
7	66	66	0	+1	0,097	2430	285	1,005	439	IB
8	66	66	0	+2	0,098	2430	285	1,010	413	IB
9	66	66	0	+3	0,101	2430	285	1,015	418	IB
10	66	66	0	+4	0,104	2430	285	1,020	398	IB
11	66	66	0	+5	0,109	2430	285	1,025	385	IB

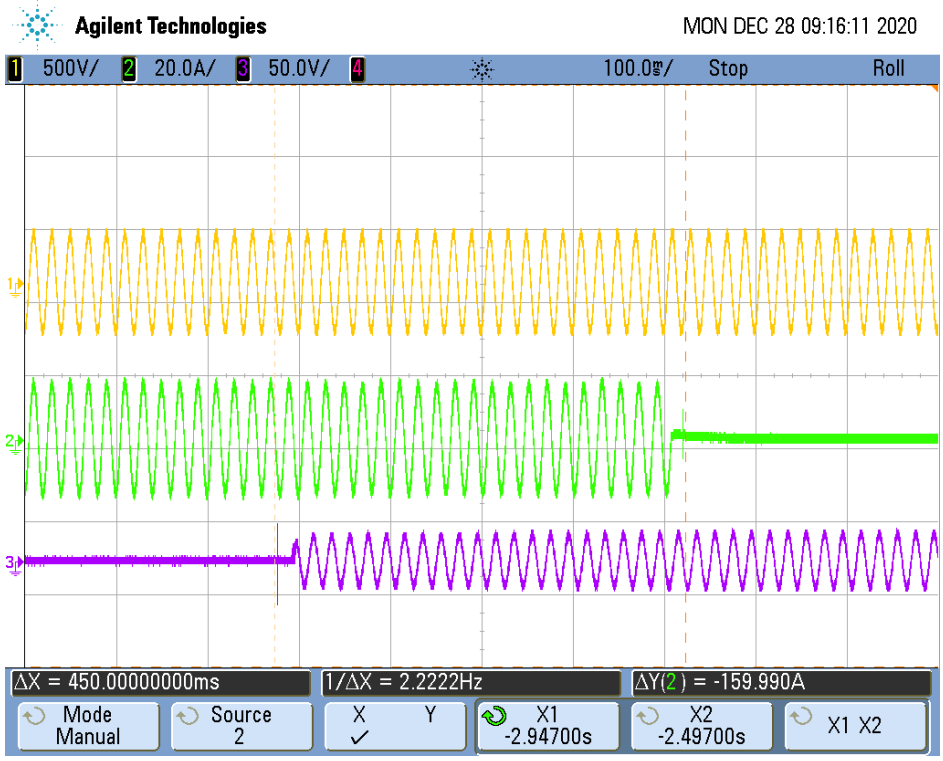
Parameter at 0% per phase	L= 69,29 mH	R= 21,77 Ω	C= 146,22 µF

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] 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 %
[5] Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % 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 HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 66% nominal power



A1.3.4 Loss of mains protection according BS EN 62116 The requirement is specified in section 10.2, test procedure in Annex A.2.2.4 Load imbalance (real, reactive load) for test condition A (EUT output = 25 % – 33 %)	**P**

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

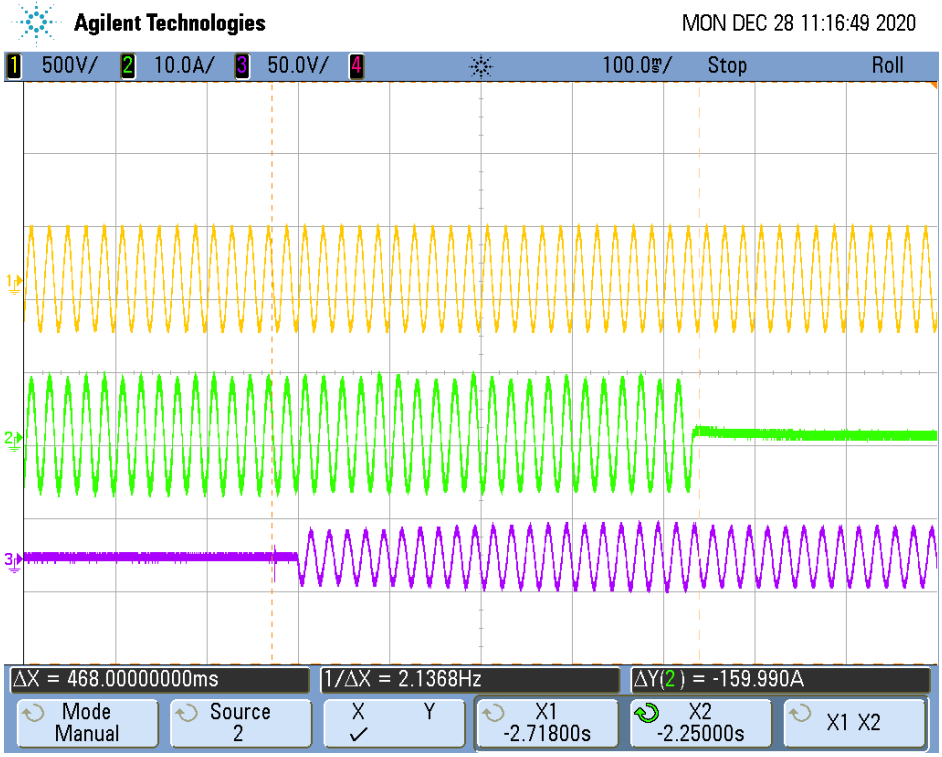
No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) 1]	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks 5)
1	33	33	0	-5	0,127	1216	129	0,974	418	IB
2	33	33	0	-4	0,125	1216	129	0,979	430	IB
3	33	33	0	-3	0,123	1216	129	0,984	427	IB
4	33	33	0	-2	0,122	1216	129	0,990	431	IB
5	33	33	0	-1	0,121	1216	129	0,995	435	IB
6	33	33	0	0	0,121	1216	129	1,000	468	BL
7	33	33	0	1	0,121	1216	129	1,005	427	IB
8	33	33	0	2	0,122	1216	129	1,010	429	IB
9	33	33	0	3	0,124	1216	129	1,014	395	IB
10	33	33	0	4	0,125	1216	129	1,019	430	IB
11	33	33	0	5	0,128	1216	129	1,024	406	IB

Parameter at 0% per phase	L= 138,48 mH	R= 43,50 Ω	C= 73,17 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] 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
[5] Or minimum allowable EUT output level if greater than 33 %.
[6] Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % 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 HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

Disconnection at P_{AC} 0% and Q_{AC} 0 reactive load and 33% nominal power



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

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(180V)	
Time delay setting	Measured delay
20s	62s
Over Voltage(266,2V)	
Time delay setting	Measured delay
20s	62s
Under Frequency(47,4Hz)	
Time delay setting	Measured delay
20s	64s
Over Frequency(52,1Hz)	
Time delay setting	Measured delay
20s	64s

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

Note:.
The tests had been performed on the HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

A1.2.6 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**

	Start Frequency	Change	End Frequency	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	+0,95Hz/sec	51,0Hz	No trip
Negative Frequency drift	51,0Hz	-0,95Hz/sec	49,0Hz	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.

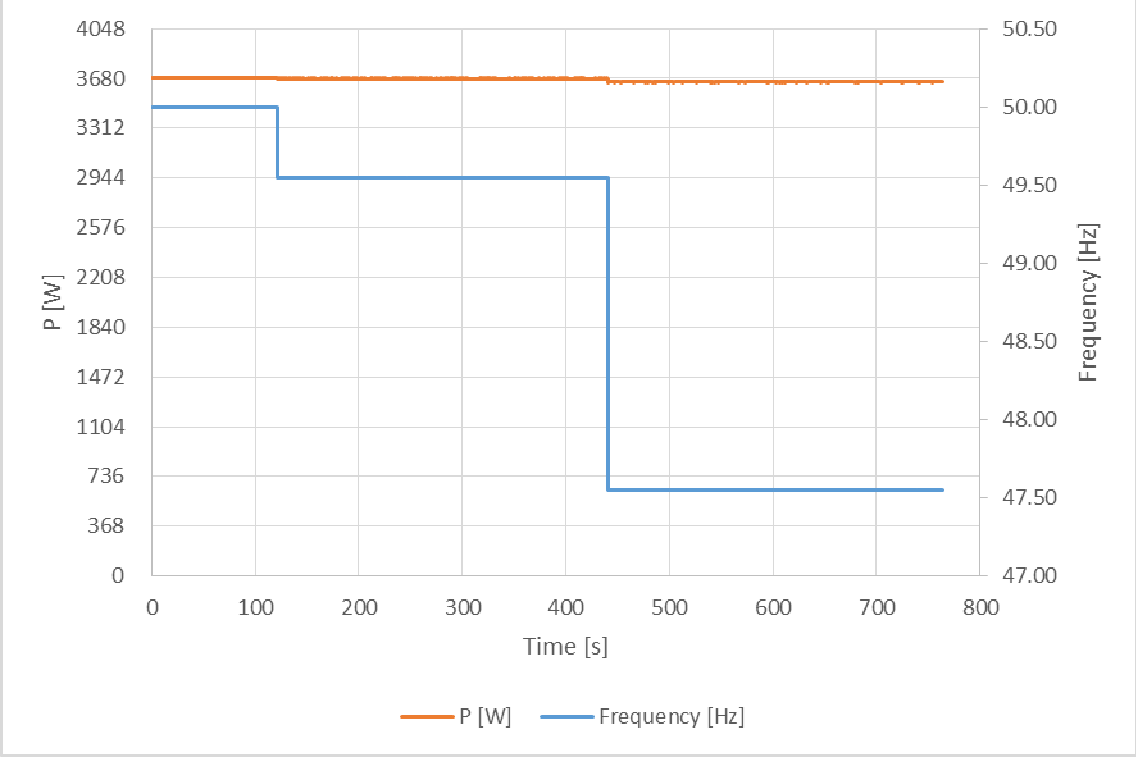
For the step change test the SSEG should be operated with a measureable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for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

For frequency drift tests the SSEG should be operated with a measureable 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 SSEG should not trip during this test.

The tests had been performed on the HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

A 1.2.7 Active power feed-in at under-frequency This test should be carried out in accordance with EN 50438 Annex D.3.2 active power feed-in at under-frequency.	**P**

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



Test:

	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	49,55	47,55
Active power [kW]:	3,680	3,679	3,652
$\Delta P/P_M$ [%] per 1 Hz:			0,76%

Test:

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

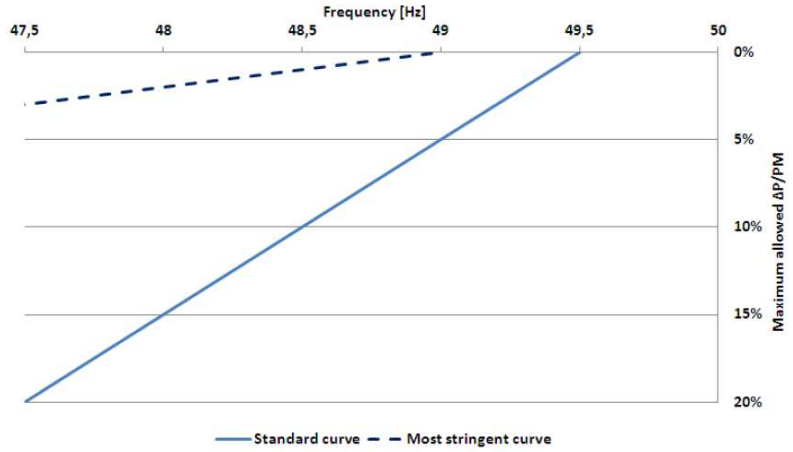
The test must be carried out at 100% P_n.

With a programmable AC source, the PGU is operated at 100% P_n and 50 ± 0,01 Hz, thereafter the frequency is reduced by 1 Hz/min. to - 0,4 to – 0,5 Hz and in addition to - 2,4 to - 2,5 Hz. A 5-min mean value is recorded both before and after the frequency change.

Assessment criterion:

The test is passed when the micro-generator

- does not disconnect from the network on a network frequency change at the operating points a) to c),
- continues to feed in 100% P_n in b) and
- the power reduction in point c) is less or equal to the power reduction of 10 % P_M per 1 Hz drop.



Maximum allowable power reduction in case of under-frequency

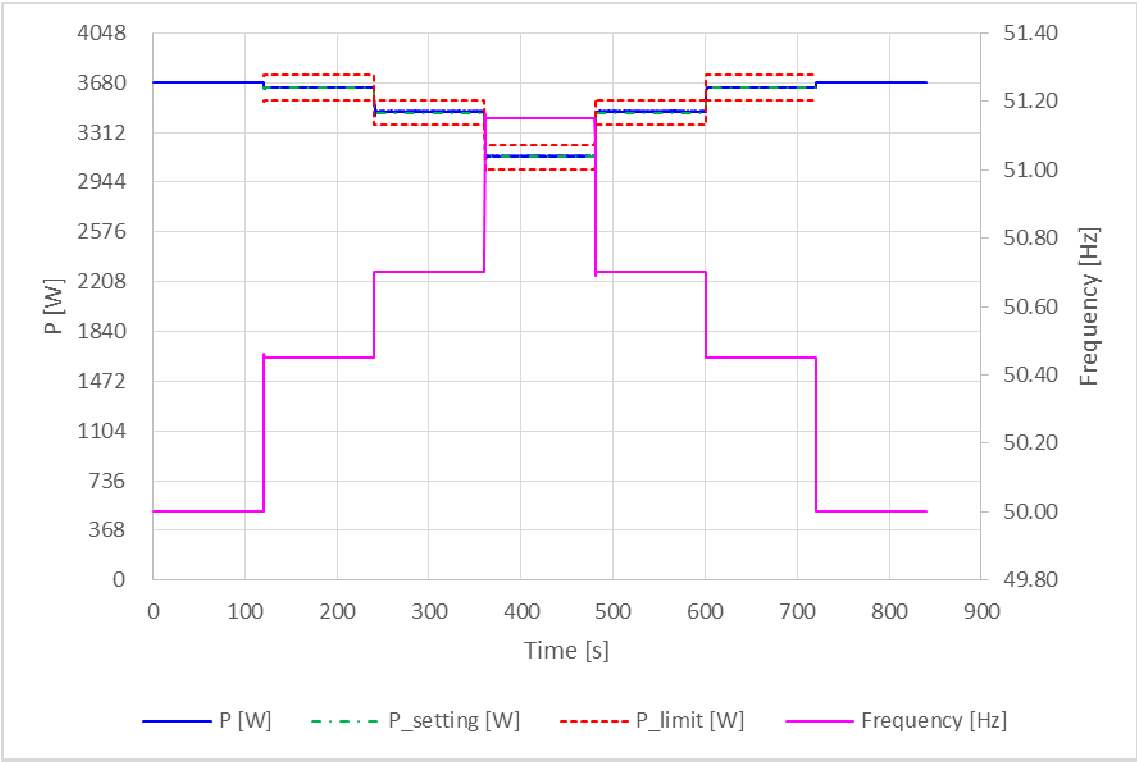
Note:

The tests had been performed on the HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

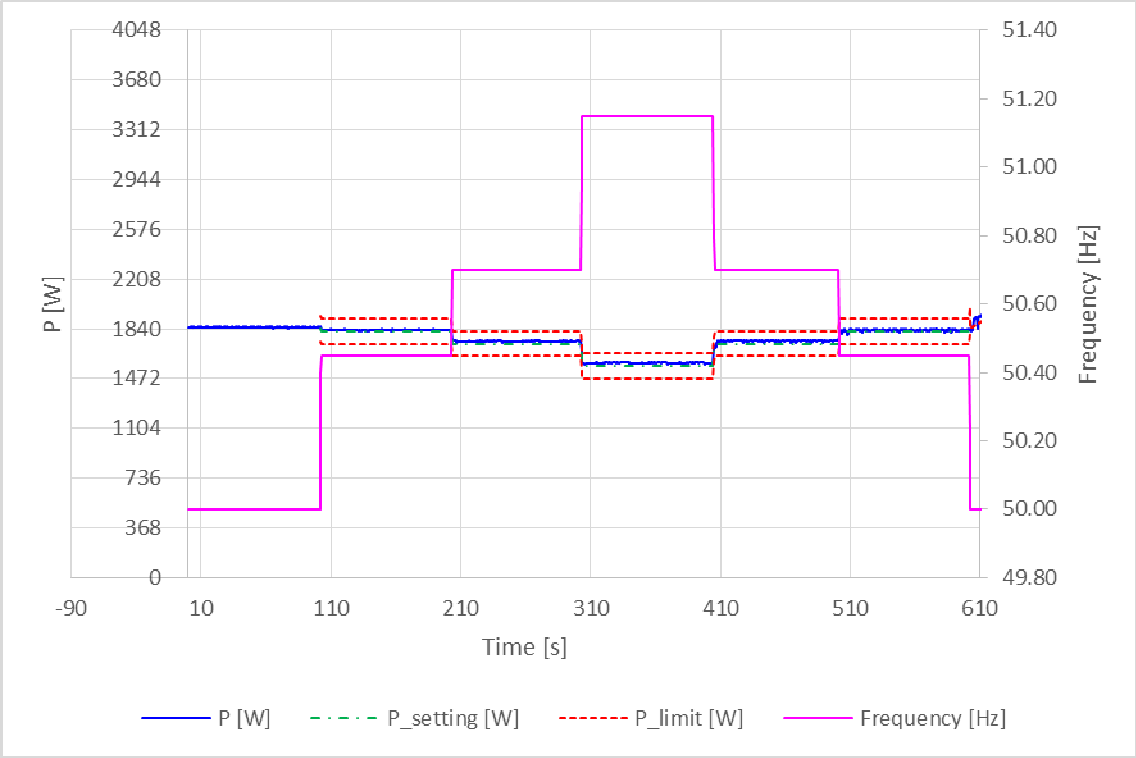
A 1.2.8 Power response to over-frequency This test should be carried out in accordance with EN 50438 Annex D.3.3 Power response to over- frequency. The test should be carried out using the specific threshold frequency of 50.4 Hz and Droop of 10%.	**P**

Test:							
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_M [W]:	N/A	3643	3459	3128	3459	3643	N/A
P_{E60} [W]:	3680	3642	3468	3137	3468	3643	3680
$\Delta P_{E60}/P_M$ [%]:	N/A	-0,027	0,244	0,244	0,244	0,000	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_M [W]:	N/A	1822	1730	1564	1730	1822	N/A
P_{E60} [W]:	1852	1832	1749	1589	1753	1831	1852
$\Delta P_{E60}/P_M$ [%]:	N/A	0,271	0,515	0,678	0,624	0,244	N/A
Limit $\Delta P/P_{1min}$:	2,5 % of P_M						

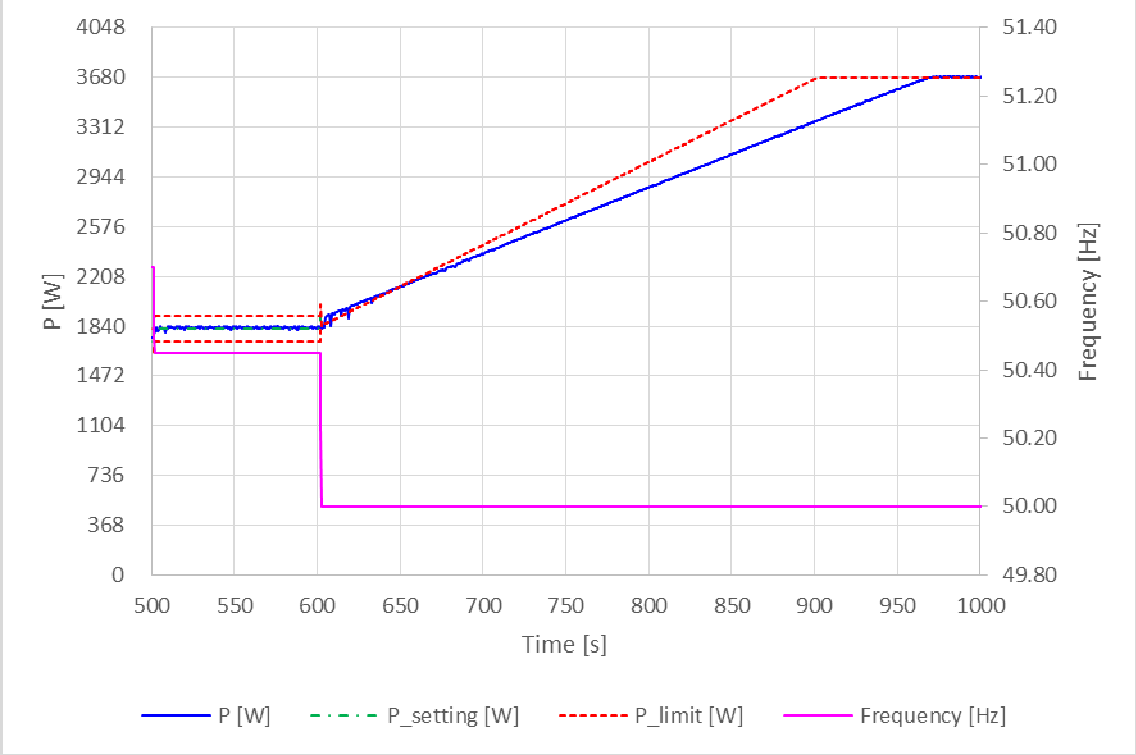
Graph of Measurement 1.: Active power output > 80% P_n



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



Graph of power gradient:



Test:

The test is conducted for two powers. First, the test must start at a power > 80% P_n ("Measurement 1"), and in a second test, for a power between 40% to 60% P_n ("Measurement 2"). In the second test, after freezing of the P_M, the available active power output must be increased to a value > 80% P_n, and after the network frequency of 50,2 Hz is fallen below, the rise of the active power gradient must be recorded.

Point g) must be held until the micro-generator is again feeding in with the active power output available.

Assessment criterion:

For f = 50,2 Hz, the value of the P_M active power currently being generated is "frozen".

a) For adjustable micro-generators when:

1) the active power reduces between measuring points b) and f) given above with the set gradient P_M per Hz for a increasing frequency (or rises for a frequency decreasing again).

2) the maximum active power gradient occurring in point is less than the configured maximum active power per minute

3) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from P_n by more than ± 10%.

4) the settling time is equal or below 2 s with an intentional delay set to zero

b) For partly adjustable micro-generators

1) when they behave as in a) within their adjustment range, and

2) when, outside the adjustable range, the power fed in on leaving the adjustment range remains constant until shutdown. Shutdown must be no later than at 51,5 Hz.

Note:

The tests had been performed on the HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

A1.3.1 Harmonic Current Emissions **P**

The test requirements are specified in Annex A1 A.1.3.1 (Inverter connected) or Annex A2 A.2.3.1 (Synchronous).

HYD 3000-EP

SSEG rating per phase (rpp)			3,0kW		NV=MV*3,68/rpp	
	At 45-55% of rated ouput 1,506 kW		100% of rated output 3,006 kW			
Harmonic	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit inBS EN61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
1nd	6,561	--	13,056	--	--	--
2nd	0,003	0,046	0,002	0,015	0,880	
3rd	0,162	2,469	0,168	1,287	1,875	
4th	0,002	0,030	0,002	0,015	0,351	
5th	0,076	1,158	0,074	0,567	0,929	
6th	0,001	0,015	0,001	0,008	0,245	
7th	0,042	0,640	0,039	0,299	0,628	
8th	0,001	0,015	0,001	0,008	0,188	
9th	0,022	0,335	0,021	0,161	0,326	
10th	0,001	0,015	0,001	0,008	0,150	
11th	0,014	0,213	0,010	0,077	0,269	
12th	0,001	0,015	0,001	0,008	0,125	
13th	0,011	0,168	0,008	0,061	0,171	
14th	0,001	0,015	0,001	0,008	0,107	
15th	0,009	0,137	0,008	0,061	0,122	
16th	0,001	0,015	0,001	0,008	0,094	
17th	0,008	0,122	0,011	0,084	0,108	
18th	0,001	0,015	0,001	0,008	0,083	
19th	0,007	0,107	0,012	0,092	0,096	
20th	0,001	0,015	0,001	0,008	0,075	
21th	0,008	0,122	0,013	0,100	0,087	0,160
22th	0,001	0,015	0,001	0,008	0,068	
23th	0,008	0,122	0,014	0,107	0,080	0,147
24th	0,001	0,015	0,001	0,008	0,063	
25th	0,008	0,122	0,014	0,107	0,073	0,135
26th	0,001	0,015	0,001	0,008	0,058	
27th	0,009	0,137	0,014	0,107	0,068	0,124
28th	0,001	0,015	0,001	0,008	0,054	
29th	0,008	0,122	0,014	0,107	0,064	0,117
30th	0,001	0,015	0,001	0,008	0,050	
31th	0,008	0,122	0,014	0,107	0,060	0,109
32th	0,001	0,015	0,001	0,008	0,047	
33th	0,008	0,122	0,014	0,107	0,055	0,102
34th	0,001	0,015	0,001	0,008	0,044	
35th	0,007	0,107	0,013	0,100	0,052	0,096
36th	0,001	0,015	0,001	0,008	0,042	
37th	0,007	0,107	0,013	0,100	0,050	0,091
38th	0,001	0,015	0,001	0,008	0,039	
39th	0,007	0,107	0,013	0,100	0,047	0,087
40th	0,001	0,015	0,001	0,008	0,038	
THD_[%]	--	2,869	--	1,494	23	
PWHD_[%]	--	2,240	--	1,897	23	

A1.3.1 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**

HYD 3680-EP

SSEG rating per phase (rpp)			3,68 kW		NV=MV*3,68/rpp	
	At 45-55% of rated ouput 1,852 kW		100% of rated output 3,679 kW			
Harmonic	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit inBS EN61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
1nd	8,059	--	15,970	--	--	
2nd	0,002	0,025	0,002	0,013	1,080	
3rd	0,163	2,023	0,174	1,090	2,300	
4th	0,001	0,012	0,002	0,013	0,430	
5th	0,076	0,943	0,071	0,445	1,140	
6th	0,001	0,012	0,001	0,006	0,300	
7th	0,040	0,496	0,036	0,225	0,770	
8th	0,001	0,012	0,001	0,006	0,230	
9th	0,023	0,285	0,019	0,119	0,400	
10th	0,001	0,012	0,001	0,006	0,184	
11th	0,013	0,161	0,010	0,063	0,330	
12th	0,001	0,012	0,001	0,006	0,153	
13th	0,007	0,087	0,011	0,069	0,210	
14th	0,001	0,012	0,001	0,006	0,131	
15th	0,006	0,074	0,013	0,081	0,150	
16th	0,001	0,012	0,001	0,006	0,115	
17th	0,007	0,087	0,016	0,100	0,132	
18th	0,001	0,012	0,001	0,006	0,102	
19th	0,007	0,087	0,016	0,100	0,118	
20th	0,001	0,012	0,001	0,006	0,092	
21th	0,008	0,099	0,017	0,106	0,107	0,160
22th	0,001	0,012	0,001	0,006	0,084	
23th	0,008	0,099	0,018	0,113	0,098	0,147
24th	0,001	0,012	0,001	0,006	0,077	
25th	0,008	0,099	0,017	0,106	0,090	0,135
26th	0,001	0,012	0,001	0,006	0,071	
27th	0,009	0,112	0,017	0,106	0,083	0,124
28th	0,001	0,012	0,001	0,006	0,066	
29th	0,009	0,112	0,017	0,106	0,078	0,117
30th	0,001	0,012	0,001	0,006	0,061	
31th	0,009	0,112	0,016	0,100	0,073	0,109
32th	0,001	0,012	0,001	0,006	0,058	
33th	0,009	0,112	0,016	0,100	0,068	0,102
34th	0,001	0,012	0,001	0,006	0,054	
35th	0,008	0,099	0,015	0,094	0,064	0,096
36th	0,001	0,012	0,001	0,006	0,051	
37th	0,007	0,087	0,015	0,094	0,061	0,091
38th	0,001	0,012	0,001	0,006	0,048	
39th	0,008	0,099	0,015	0,094	0,058	0,087
40th	0,001	0,012	0,001	0,006	0,046	
THD_[%]	--	2,339	--	1,261	23	
PWHD_[%]	--	1,897	--	1,883	23	

A1.3.1 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**

SUN2000-3.68KTL-L1

SSEG rating per phase (rpp)			3,68kW		NV=MV*3,68/rpp	
	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 inBS EN61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
1nd	7,903	--	16,141	--	--	
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	
41th	0,008	0,101	0,018	0,112		
42th	0,005	0,063	0,013	0,081		
43th	0,008	0,101	0,014	0,087		

A1.3.1 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**
44th	0,005	0,063	0,013	0,081		
45th	0,007	0,089	0,016	0,099		
46th	0,005	0,063	0,012	0,074		
47th	0,006	0,076	0,014	0,087		
48th	0,005	0,063	0,011	0,068		
49th	0,007	0,089	0,012	0,074		
50th	0,005	0,063	0,010	0,062		
THD_[%]	--	1,305	--	0,972	23	
PWHD_[%]	--	3,799	--	3,644	23	

Note:
The higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below.
The tests had been performed on the SUN2000-2KTL-L1, SUN2000-3KTL-L1 and SUN2000-3.68KTL-L1 are valid for the SUN2000-4KTL-L1,since it is same as in hardware and just power derated by software.

A1.3.2 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**
HYD 3000-EP				
Output power	216,2 V	230,0 V	253,0 V	
20%	0,981c	0,976c	0,964c	Measured at three voltage levels and at full output. Voltage to be maintained within ±1.5% of the stated level during the test.
50%	0,997c	0,997c	0,995c	
75%	0,999c	0,999c	0,998c	
100%	0,999c	0,999c	0,999c	
Limit	>0,95	>0,95	>0,95	
HYD 3680-EP				
Output power	216,2 V	230 V	253 20 V	
20%	0,988c	0,984c	0,977c	Measured at three voltage levels and at full output. Voltage to be maintained within ±1.5% of the stated level during the test.
50%	0,998c	0,998c	0,997c	
75%	0,999c	0,999c	0,999c	
100%	0,999c	0,999c	0,999c	
Limit	>0,95	>0,95	>0,95	

Note:
The power factor capability of the SSEG shall conform to EN 50438. When operating at Registered Capacity the SSEGshall 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%.

A 1.3.3 Voltage Flicker The requirement is specified in section 5.4.2, test procedure in Annex A or B 1.4.3	**P**

HYD 3000-EP

	Phase	Starting			Stopping			Running	
		d_{max}	d_c	$d_{(t)}$	d_{max}	d_c	$d_{(t)}$	P_{st}	P_{lt} 2 hours
Measured values at test impedance	L1	0,227	0,064	--	0,224	0,052	--	0,153	0,151
Normalised to standard impedance	L1	0,227	0,064	--	0,224	0,052	--	0,153	0,151
Normalised to required maximum impedance	L1	0,227	0,064	--	0,224	0,052	--	0,153	0,151
Limits set under BS EN 61000-3-3		4%	3,3%	3,3% 500ms	4%	3,3%	3,3% 500ms	1,0	0,65

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

HYD 3680-EP

	Phase	Starting			Stopping			Running	
		d_{max}	d_c	$d_{(t)}$	d_{max}	d_c	$d_{(t)}$	P_{st}	P_{lt} 2 hours
Measured values at test impedance	L1	0,233	0,087	--	0,218	0,029	--	0,145	0,138
Normalised to standard impedance	L1	0,233	0,087	--	0,218	0,029	--	0,145	0,138
Normalised to required maximum impedance	L1	0,233	0,087	--	0,218	0,029	--	0,145	0,138
Limits set under BS EN 61000-3-3		4%	3,3%	3,3% 500ms	4%	3,3%	3,3% 500ms	1,0	0,65

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

Note:
*The stationary deviance of dc% is more relevant than the dynamic deviance of d_{max} at starting and stopping.

Mains Impedance according EN61000-3-3: **R_{max} = 0,24Ω; jX_{max}= 0,15Ω @50Hz (|Z_{max}| = 0,283 / 0,472 Ω)**
For single phase inverter Zmax + Rn and jxn **R_n = 0,16Ω; jX_n= 0,1Ω**

Calculation of the maximum permissible grid impedance at the point of common coupling based on d_c:
$Z_{max} = Z_{ref} * 3,3\% / d_c(P_n)$

The tests should be based on the limits of the EN61000-3-3 for less than 16A.

A.1.3.4 DC injection The test procedure in Annex A1 A.1.3.4 (Inverter connected) or Annex A2 A.2.3.4 (Synchronous).	**P**

HYD 3680-EP				
Test level power	20%	50%	75%	100%
Recorded value in Amps[A]	0,017	0,024	0,024	0,019
As % of rated AC current	0,106	0,150	0,150	0,119
Limit	0,25%	0,25%	0,25%	0,25%

HYD 3000-EP				
Test level power	20%	50%	75%	100%
Recorded value in Amps	0,018	0,018	0,018	0,019
As % of rated AC current	0,113	0,113	0,113	0,119
Limit	0,25%	0,25%	0,25%	0,25%

Diagram of Permanent DC-injection
HYD 3680-EP

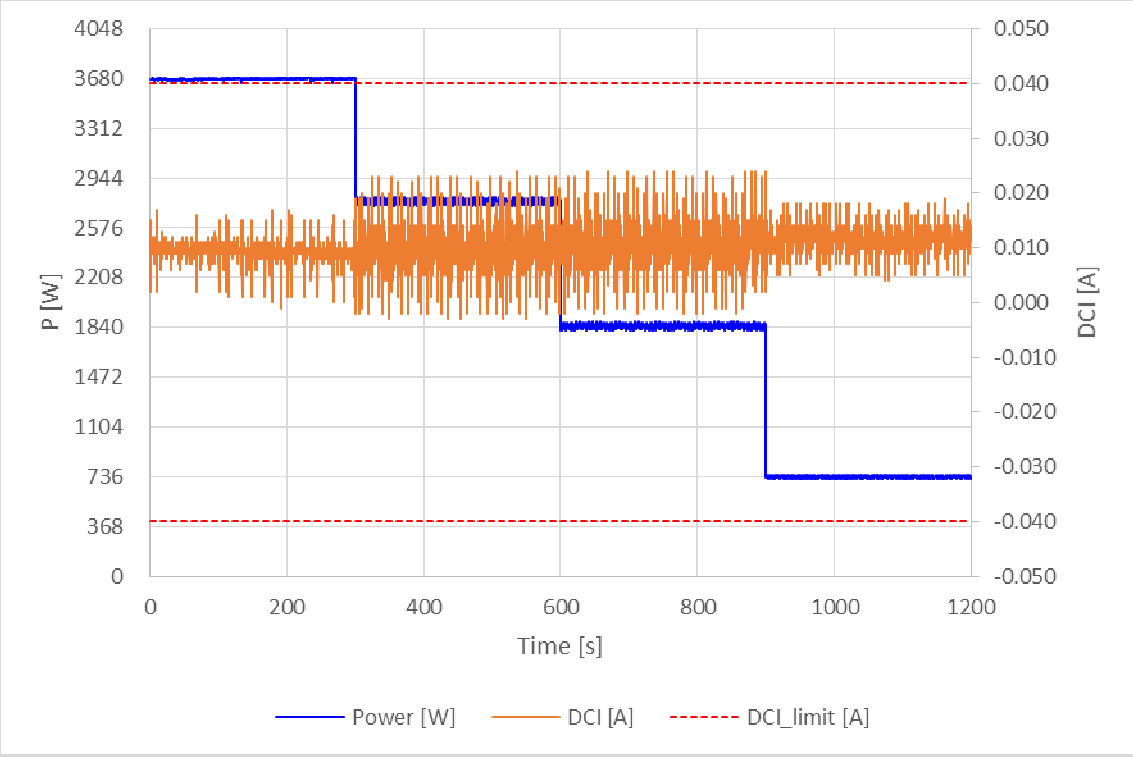
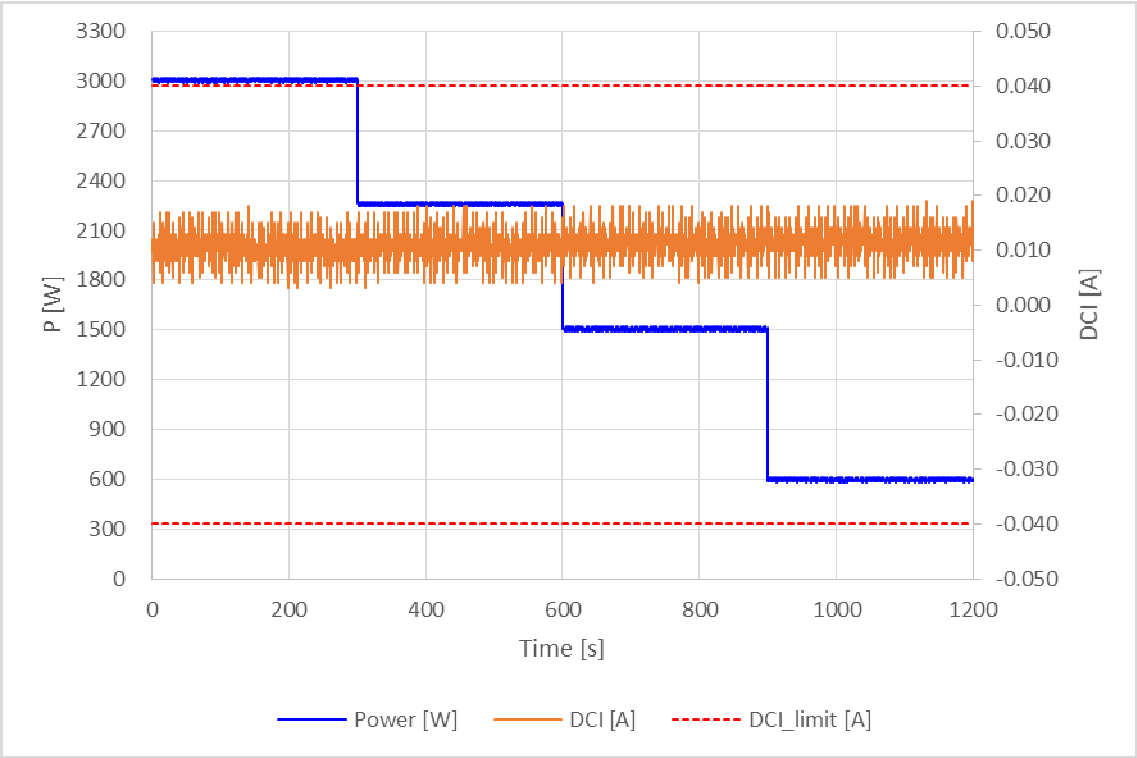


Diagram of Permanent DC-injection
HYD 3680-EP

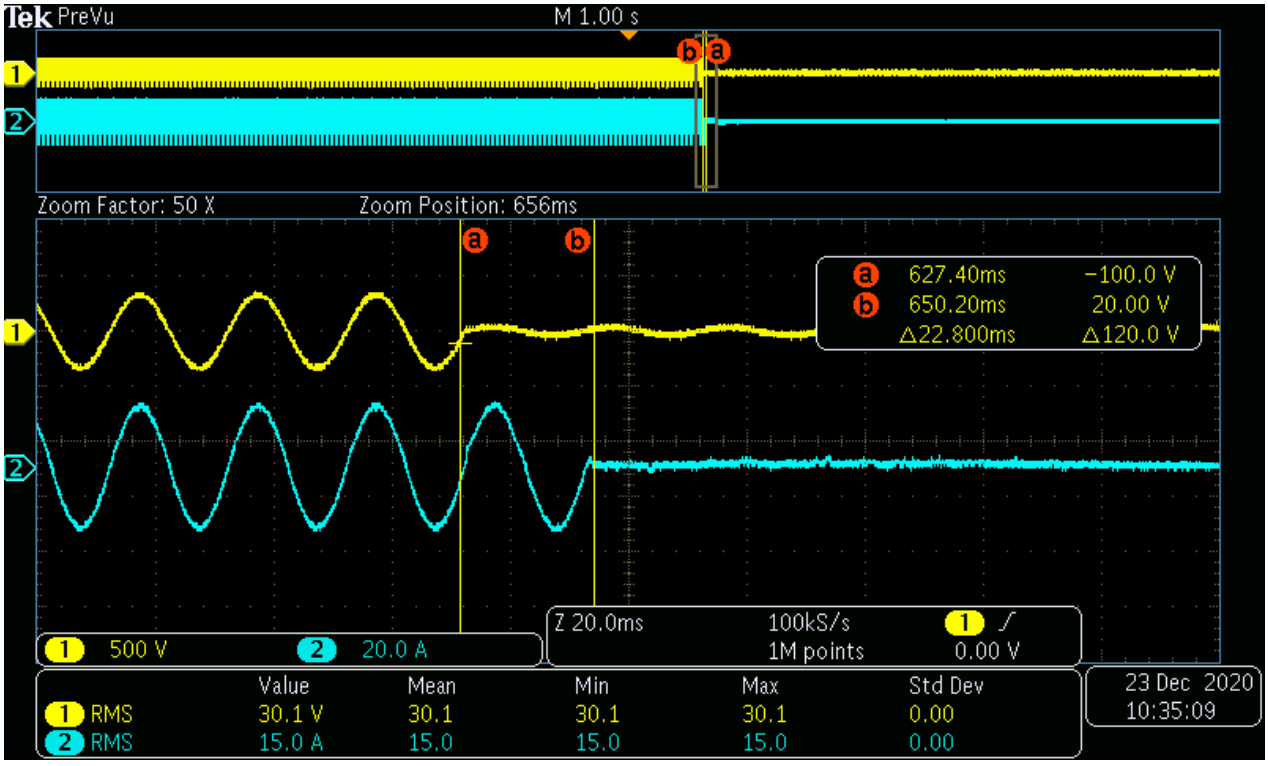


Test:
The level of DC injection from the Inverter-connected PV generator in to the DNO's Distribution System shall not exceed the levels specified in 5.5 when measured during operation at three levels, 20%, 50%, 75% and 100% of rating with a tolerance of plus or minus 5%.

A 1.3.5 Short Circuit Current Contribution for Inverters The test procedure in Annex A1 A.1.3.5 (Inverter connected) or Annex A2 A.2.3.5 (Synchronous).	**P**

For a directly coupled SSEG			For a Inverter SSEG		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p	N/A	20ms	31,7 V	15,9A
Initial Value of aperiodic current	A	N/A	100ms	29,3 V	7,24A
Initial symmetrical short-circuit current*	I_k	N/A	250ms	28,8 V	4,62A
Decaying (aperiodic) component of short circuit current*	i_{DC}	N/A	500ms	N/A	N/A
Reactance/Resistance Ratio of source*	X/R	N/A	Time to trip	0,023s	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 1 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 including the time taken for the Inverter to trip.

The tests had been performed on the HYD 3680-EP are valid for the HYD 3000-EP since it is same as in hardware and just power derated by software.

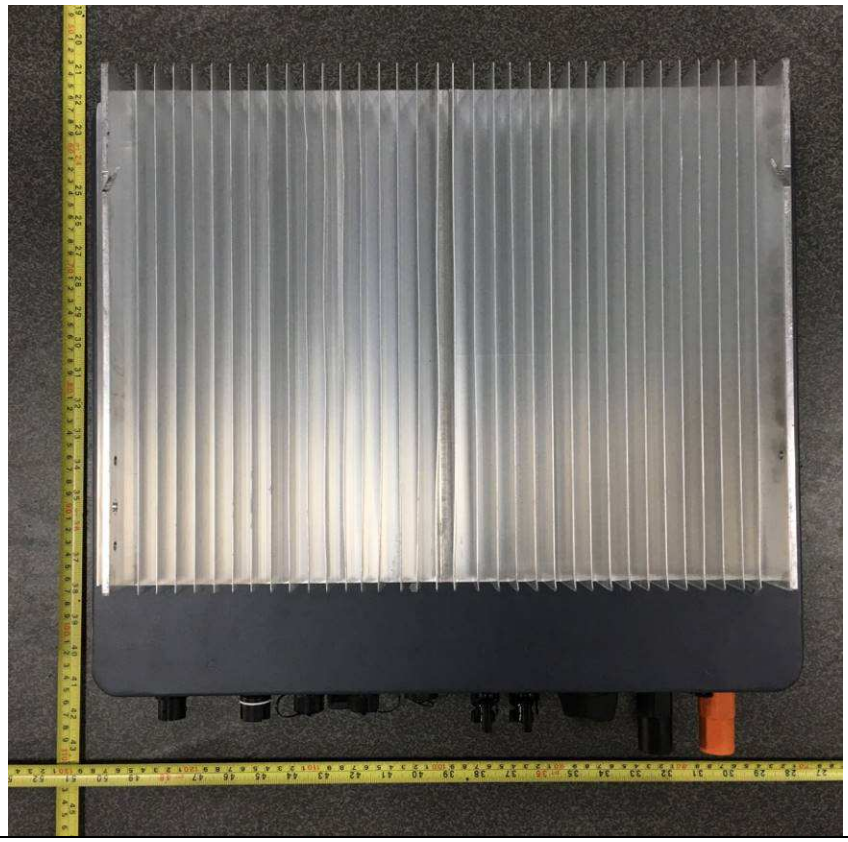
A1.3.6 Self Monitoring – Solid state Disconnection The test procedure in Annex A1 A.1.3.6 (Inverter connected) or Annex A2 A.2.3.6 (Synchronous).	**N/A**
It has been verified that in the event of the solid state switching device failing to disconnect the SSEG, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 seconds.	N/A

A 1.3.7 Electromagnetic Compatibillity (EMC)	**P**
All equipment shall comply with the generic EMC standards: BS EN61000-6-3: 2007 Electromagnetic Compatibility, Generic Emission Standard; and BS EN61000-6-1: 2007 Electromagnetic Compatibility, Generic Immunity Standard.	
Note:	

Logic Interface (Input port)	**P**
Confirm that an input port is provided and can be used to shut down the module.	Yes

Annex No. 1

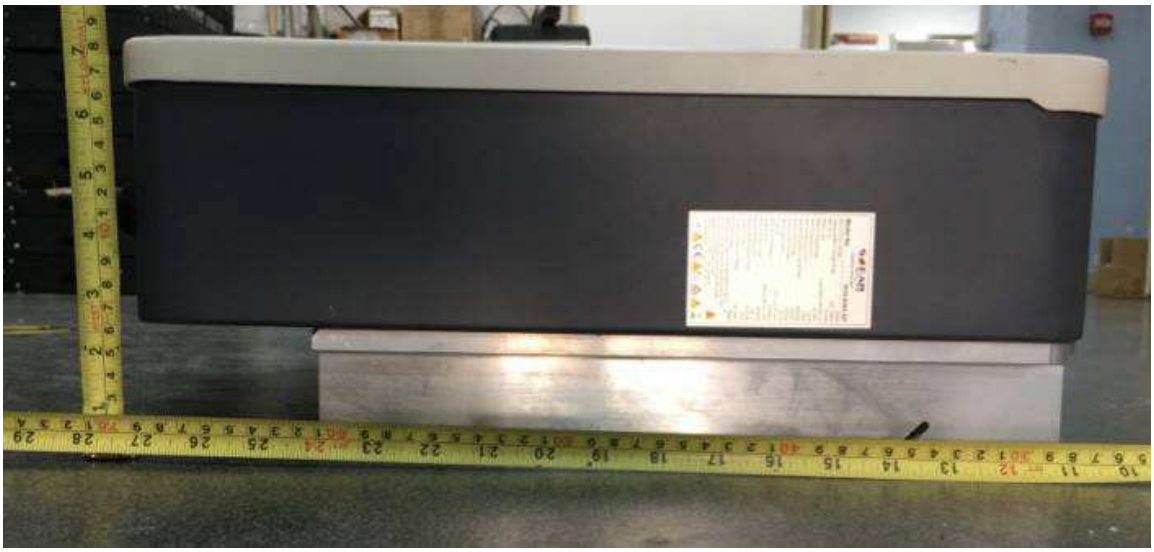
Pictures of the unit

EUT Photo
General view – 1 of Front 
General view – 1 of Rear 

EUT Photo

General view – 1 of Bottom

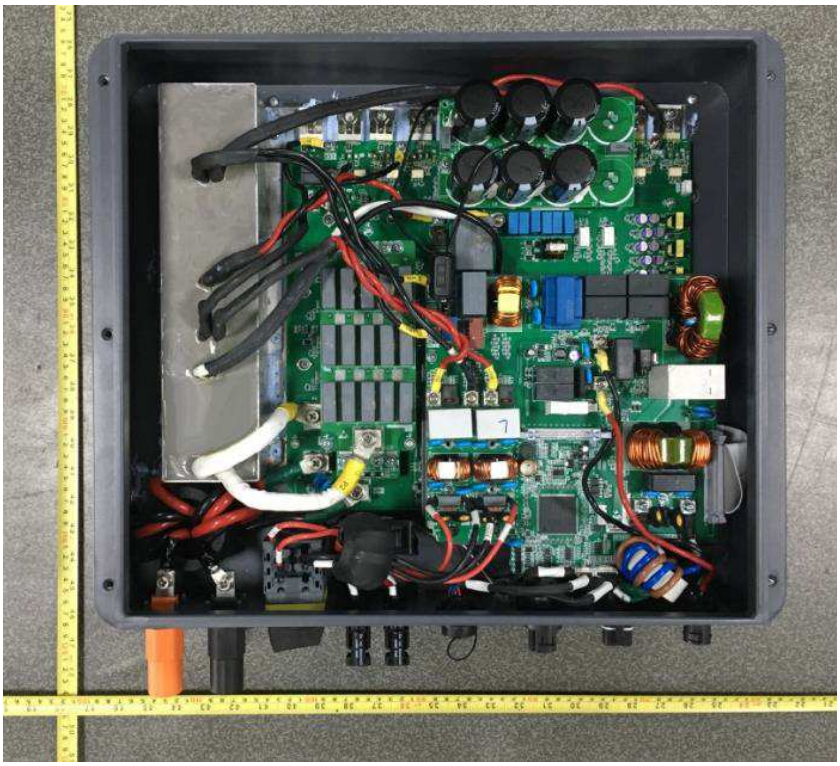
General view – 1 of Side



EUT Photo

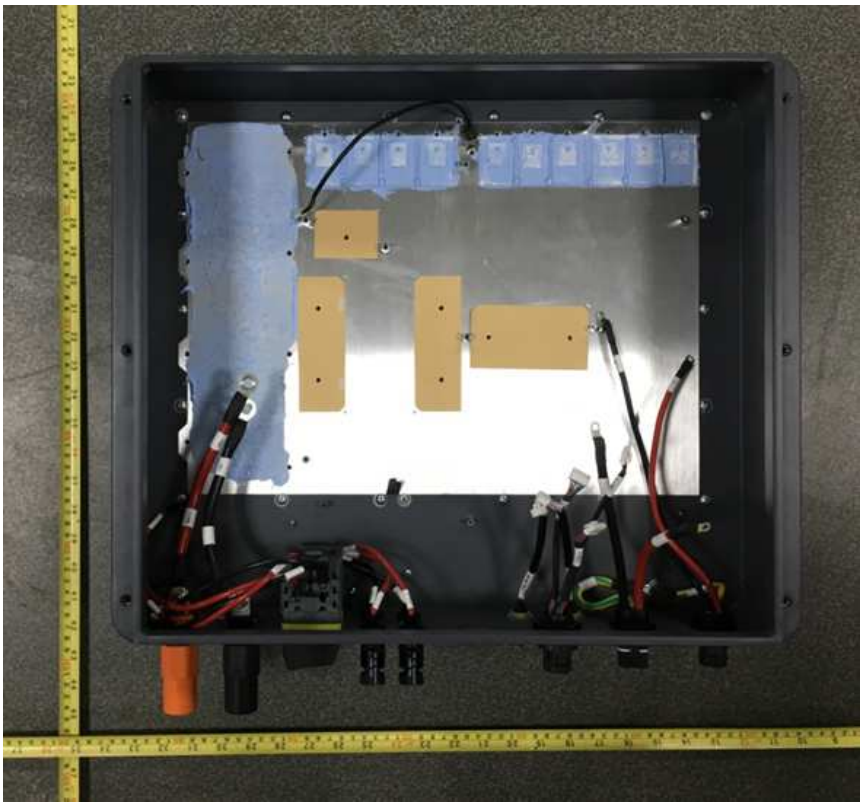
Internal view – 1
(HYD 4600-EP, HYD 5000-EP, HYD 5500-EP,HYD 6000-EP)

Internal view – 2
(HYD 3000-EP, HYD 3680-EP, HYD 4000-EP)

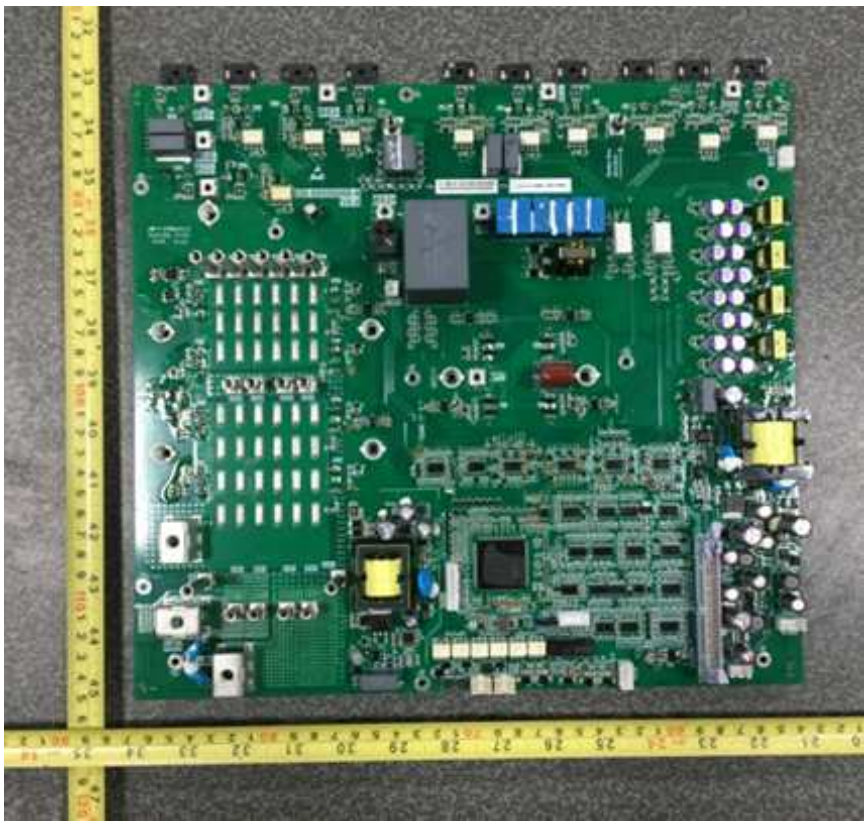


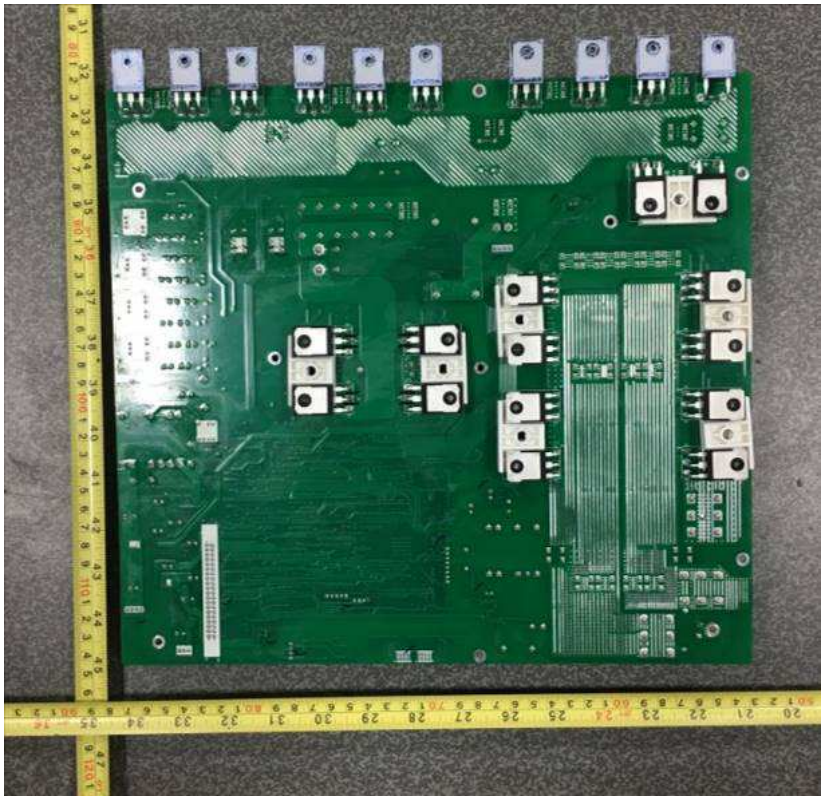
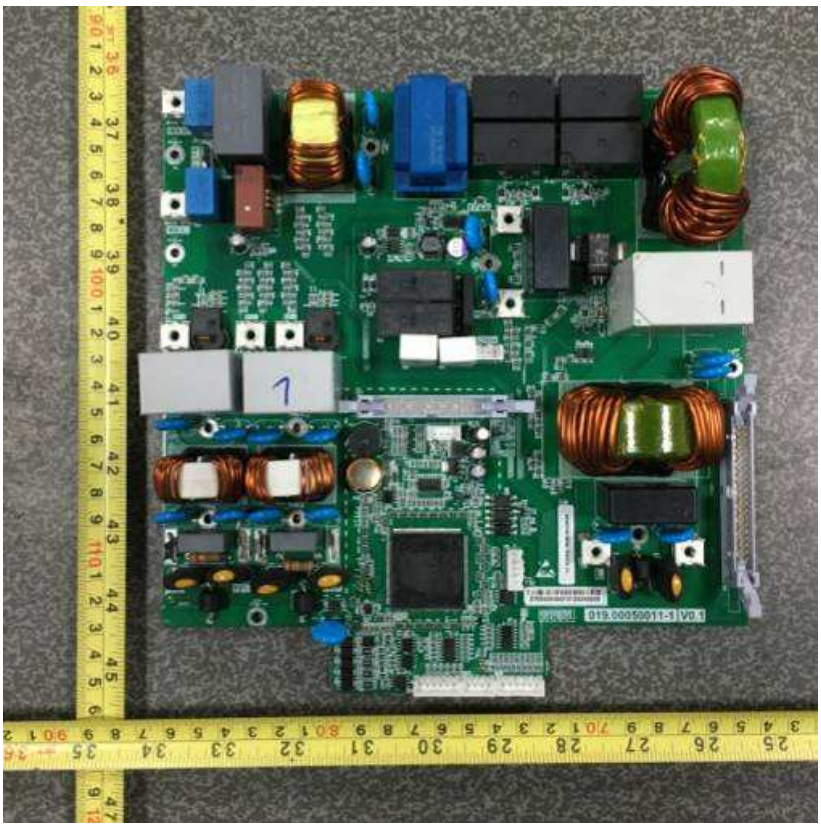
EUT Photo

Internal view - 3



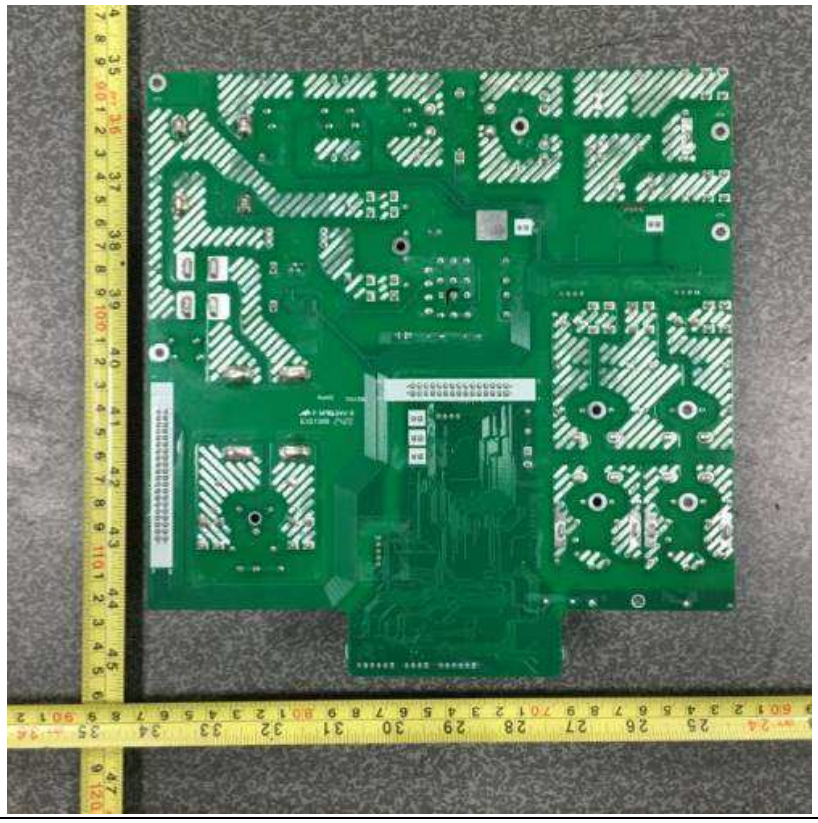
General view – 1 of Power board



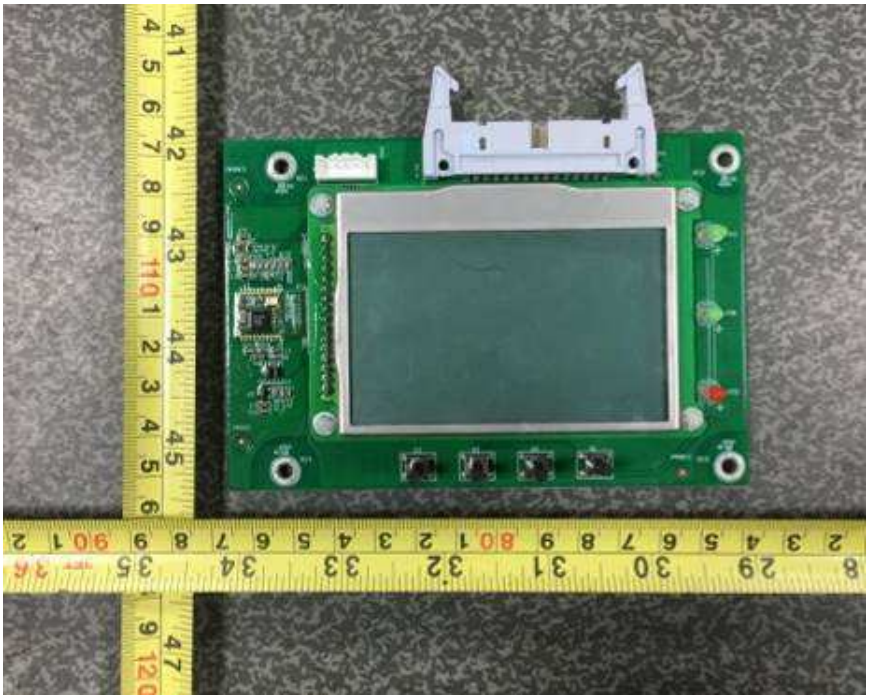
EUT Photo
General view – 2 of Power board 
General view – 1 of Output board 

EUT Photo

General view – 2 of Output board

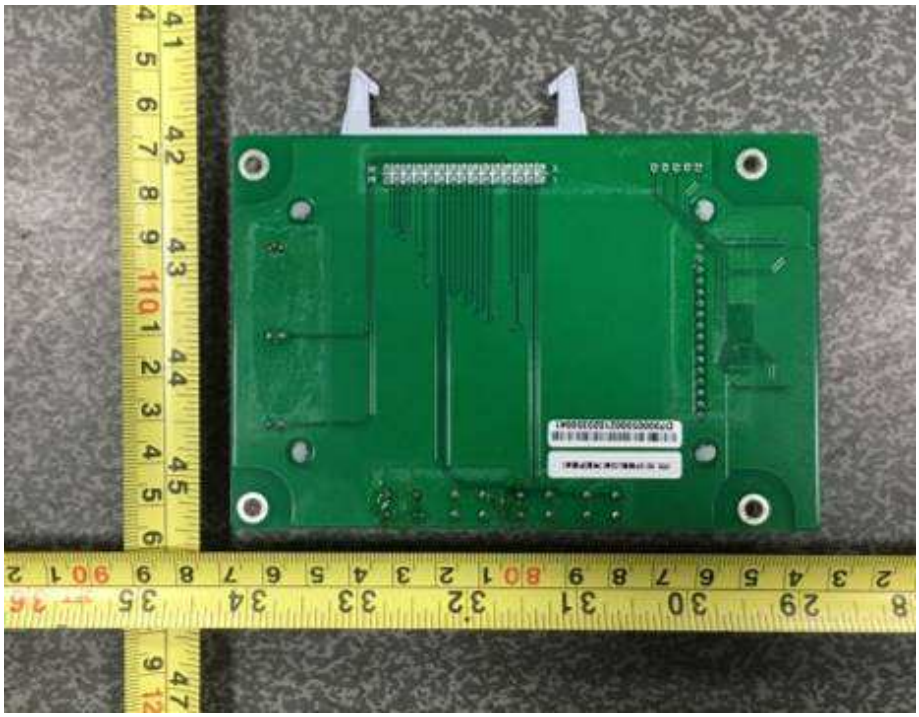


General view – 1 of LCD panel



EUT Photo

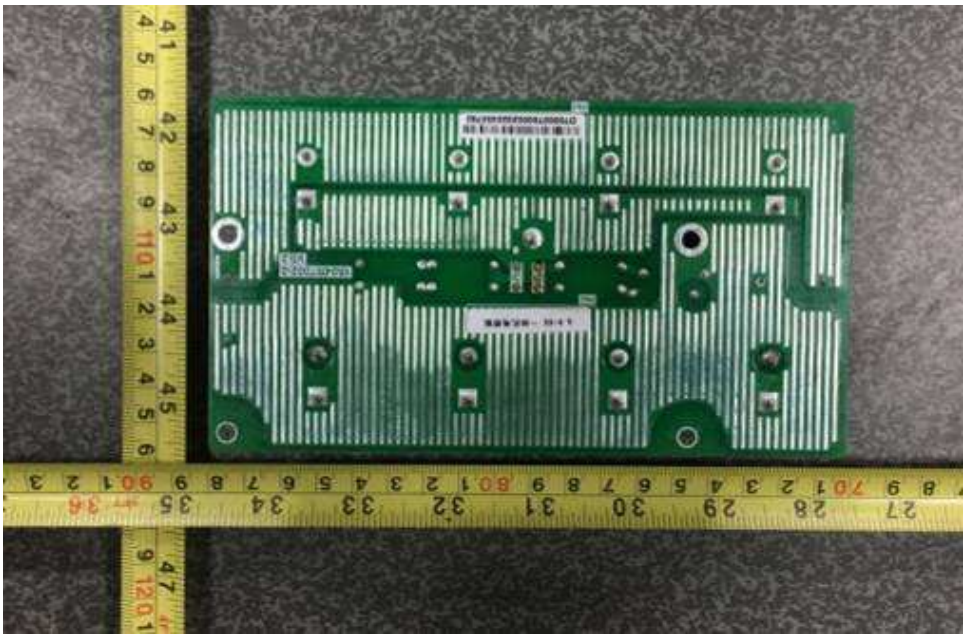
General view – 2 of LCD panel



General view - 1 of BUS board

EUT Photo

General view - 2 of BUS board



General view of Grouding point

Annex No. 2

Test Equipment list

Testing Location: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch

No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China

Date(s) of performance test: 2020-09-17 to 2021-01-08

Equipment	Internal No.	Manufacturer	Type	Serial No.	Next Calibration date
Power Analyser	A4080002DG	YOKOGAWA	WT3000	91M210852	Jun. 16, 2021
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyser
	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040015DG	Chroma	62150H-1000S	62150EF00488	
	A7040016DG	Chroma	62150H-1000S	62150EF00490	
	A7040017DG	Chroma	620028	620028EF00120	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 23, 2021
Oscilloscope probe	A4089008DG	Tektronix	TPP1000	C008230	Aug. 10, 2021
	A4089010DG	Tektronix	TPP1000	C008228	Aug. 10, 2021
	A4089011DG	Tektronix	TPP1000	C008229	Aug. 10, 2021
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Sep. 02, 2021
	A1060008DG	YOKOGAWA	CT200	1130700017	Sep. 02, 2021
	A1060012DG	YOKOGAWA	CT200	1130700018	Sep. 02, 2021
Power Analyser	//	ZLG	PA5000H	C820290908200 2110001	Mar. 02, 2021
Oscilloscope	//	Agilent	DS05014A	MY50070288	Jan. 13, 2021
Oscilloscope current probe	//	CYBERTEK	CP1000A	C181000922	Jan. 13, 2021
	//	CYBERTEK	CP1000A	C181000925	Jan. 13, 2021
	//	CYBERTEK	CP1000A	C181000929	Jan. 13, 2021
	//	CYBERTEK	CP1000A	C181000931	Jan. 13, 2021
Oscilloscope probe	//	SANHUA	SI-9110	152627	Jan. 13, 2021
	//	SIALENT	DS5034X	SDS5XEAC3R0 011	Jan. 13, 2021
	//	AGILENT	N2863B	YF0139	Jan. 13, 2021