TEST REPORT

NRS 097-2-1

Grid interconnection of embedded generation
Part 2: Small-scale embedded generation

Report reference number ....:	**PVZA180904N057**
Date of issue ....……....:	2019-03-05
Total number of pages ....……....:	96
Testing laboratory name ....:	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
Address ....:	No. 34, Chenwulu Section, Guantai Rd., Houjie Town, Dongguan City, Guangdong 523942, China
Applicant's name...........................:	**VOLTRONIC POWER TECHNOLOGY CORP.**
Address ....:	5F, No. 151, Xinhu 1st Road, Neihu District, Taipei, Taiwan
Test specification	
Standard..:	NRS 097-2-1:2017
Zertifikate ....:	**Certificate of compliance**
Test report form number. ....:	NRS 097-2-1, version 2017
Master TRF ....:	Bureau Veritas Consumer Products Services Germany GmbH
Test item description ....:	**Hybrid photovoltaic Inverter**
Trademark.......................................:	N/A
Model / Type ....:	InfiniSolar 10k

Ratings ....:	See below.
PV Array MPP DC voltage range [V]:	400-800Vdc
PV Array Input DC voltage range [V]:	300-900Vdc
PV Array Input AC current [A] ....:	18,6A x 2 strings
Battery Input DC voltage range [V] .. [Discharge] ....:	48Vdc
Battery Input AC current [A] .... [Discharge] ....:	275A
Output DC voltage range [V] .... [Battery Charge] ....:	48Vdc
Output DC current [A]....................... [Battery Charge] ....:	200A
Output AC voltage [V] ....:	3/N/PE, 230/400Vac, 50Hz
Output AC current [A].......................:	14,5A
Output power [kW] ....:	10,0kW

Testing Location ....:	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
Address ....:	No. 34, Chenwulu Section, Guantai Rd., Houjie Town, Dongguan City, Guangdong 523942, China
Tested by (name and signature) ....:	Dora Zhang
Approved by (name and signature) ....:	James Huang
Manufacturer's name ....:	**VOLTRONIC POWER TECHNOLOGY CORP.**
Manufacturer address ....:	5F, No. 151, Xinhu 1st Road, Neihu District, Taipei, Taiwan
Factory's name..............................:	**VOLTRONIC POWER TECHNOLOGY CORP.**
Factory address	1-4F, Building 5, YuSheng Industrial Park, No.467, Section Xixiang, National Highway 107, Xixiang, Bao An District, Shenzhen, China

Document History

Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2019-03-05	Dora Zhang	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.. :	IP20 according to EN 60529
Mass of equipment [kg] .... :	45kg

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 .... :	2018-09-04
Date(s) of performance of test .... :	2018-09-04 to 2019-01-28

General remarks:

The test result presented in this report relate only to the object(s) tested.
This report shall not be reproduced, except in full, without the written approval of the applicant.

”(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.

The NRS 097-2-1 refers to the IEC 61727 and the IEC61727does not provide any limits of accuracy for the utility voltage and frequency measurement of the PV-system. Therefore the values for tolerances given in EN 50438, Table 2 are used.

Tolerances on trip values tabel 2 EN50438:

- Voltage: +/- 1% of the nominal voltage;
- Frequency: +/- 0,5% of the nominal frequency
- Clearance time: +/- 10%

This Test Report consists of the following documents:

1. Test Report
2. Annex No. 1 – Datasheet of the relay
3. Annex No. 2 – Pictures of the units
4. Annex No. 3 – Test equipment list

Copy of marking plate

Model No. : InfiniSolar 10k

Serial No. : 96161406100001

PV INPUT	Nominal operating voltage 720Vdc
	Vmax PV 900Vdc
	Isc PV 2*18.6A
	MPPT voltage range 400 ~ 800Vdc
GRID/AC OUTPUT	Nominal operating voltage 3/N/PE, 230/400 Vac
	Nominal output current 14.5A
	Nominal operating frequency 50Hz
	Maximum power 10000W
	Power factor range 0.9 lead-0.9lag
AC INPUT	Nominal operating voltage 3/N/PE, 230/400 Vac
	Maximum input current 25A
	Nominal operating frequency 50Hz
BATTERY	Battery voltage range 42~56Vdc
	Maximum battery current 275A

Ambient temperature:-10~+55°C

Enclosure:IP 20

Safety class I

VDE0126-1-1 VDE-AR-N 4105

CE

WARNING:FIRE HAZARD.

SUITABLE FOR MOUNTING ON CONCRETE OR OTHER NON-COMBUSTIBLE SURFACE ONLY

VOLTRONIC POWER TECHNOLOGY (SHENZHEN) CORP.

General product information:

The Solar converter converts DC voltage into AC voltage.

The input and output are protected by Varistors to Earth. 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.

This unit is three phase inverter, that it is combine with UPS function and operation mode. The inverter is able to generate power from solar modules to feed the grid(utility) and charge extern battery, also feed in the power to grid from the extern batteries and PV array.

The Solar converter provides with PV array and external battery of input.

The input of Solar converter can be supplied from PV array and/or external battery only.

Rate of change of frequency (RoCoF) detection was used for LOM protection.

Description of the electrical circuit: (错误!未找到引用源。):

The internal control is redundant built. It consists of Microcontroller Master DSP(U3) and Slave DSP(U4).

The Master DSP control the relays by switching signals; measures the PV voltage, PV current, Bus voltage, Battery voltage, grid voltage, frequency, AC current with injected DC and the array insulation resistance to ground. In addition it tests the current sensors and the RCMU circuit before each start up.

The Slave DSP is measures the grid voltage, AC current, grid frequency and residual current, also can switch off the relays independently, and communicate with Master DSP each other.

The current is measured by a current sensor. The AC current signal and the injected DC current signal are sent to the Master DSP. The Master DSP tests and calibrates before each start up all current sensors.

The unit provides two relays in series in all output 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 each start up. Both CPU can switch of the relays.

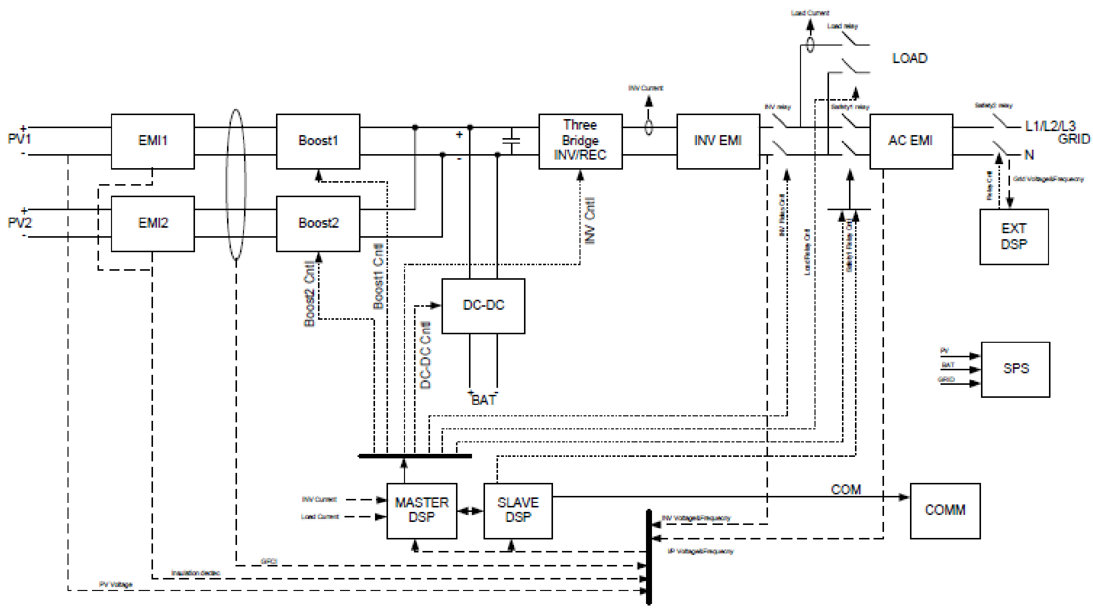

Figure 1 – Block diagram

The product was tested on:

hardware version: 00G
software version: 00G

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
4.1.1	**General**		**P**
4.1.1.1	This clause describes the technical issues and the responsibilities related to interconnecting an embedded generator to a utility network.	Noticed.	**P**
4.1.1.2	The quality of power provided by the embedded generator in the case of the on-site a.c. loads and the power delivered to the utility is governed by practices and standards on voltage, flicker, frequency, harmonics and power factor. Deviation from these standards represents out-of-bounds conditions. The embedded generator is required to sense the deviation and might need to disconnect from the utility network.	Noticed.	**P**
4.1.1.3	All power quality parameters (voltage, flicker, frequency and harmonics) shall be measured at the POC, unless otherwise specified (see annex A).	See appended table	**P**
	The power quality to be supplied to customers and influenced by SSEG shall comply with NRS 048-2. This implies that the combined voltage disturbances caused by the specific EG and other customers, added to normal background voltage disturbances, may not exceed levels stipulated by NRS 048-2. The maximum emission levels that may be contributed by SSEG are provided in this document (see 4.1.5 to 4.1.10).	Noticed.	**P**
	The customer can expect power quality at the POC in line with NRS 048-2. As such, the generator may not contribute significant disturbances to the voltage supplied at the POC. Typical contributions for small customer installations (total installation) are provided in Annex D of NRS 048-4. NOTE 1 The frequency cannot be changed by a SSEG. NOTE 2 The utility is responsible for the power quality at the POC, however, the EG is responsible to mitigate power quality exceedances should it be shown to cause excessive power quality levels.	Must be taken under consideration for the installation.	**N/A**
4.1.1.4	The embedded generator's a.c. voltage, current and frequency shall be compatible with the utility at the POC.	Noticed.	**P**
4.1.1.5	The embedded generator shall be type approved, unless otherwise agreed upon with the utility (see annex A).	Complied to type test.	**P**
4.1.1.6	The maximum size of the embedded generator is limited by the rating of the supply point on the premises. NOTE Also see NRS097-2-3.	Noticed.	**P**

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
4.1.1.7	The utility will approve the size of the embedded generator and will decide on the connection point and conditions. In some cases it may be required to create a separate supply point.	Must be taken under consideration for the installation.	**N/A**
4.1.1.8	Embedded generators larger than 13,8 kVA shall be of the balanced three-phase type unless only a single-phase network supply is available, in which case NRS 097-2-3 recommendations can be applied based on the NMD. NOTE 1 This value refers to the maximum export potential of the generation device/system. NOTE 2 In the case of long feeder spurs the maximum desired capacity of the EG might require approval by the utility and might result in the requirement for a three-phase connection for smaller units.	Balanced three phase type of SSEG.	**P**
4.1.1.9	A customer with a multiphase connection shall split the embedded generator in a balanced manner over all phases if the EG is larger than 4,6 kVA. NOTE Balancing phases in a multiphase embedded generator is deemed desirable.	Must be taken under consideration for the installation.	**N/A**
4.1.1.10	Embedded generators or generator systems larger than 100 kVA may have additional requirements, for example, they must be able to receive communication signals for ceasing generation/disconnection from the utility supply, if the utility requires such. Communication facilities shall be provided to utility at no charge for integration with SCADA or other system when required. See Annex G (G.1). NOTE The RPP Grid Code requires category A3 units to be able to interface with the utility in order to receive stop and start signals.	Must be taken under consideration for the installation.	**N/A**
4.1.1.11	In line with the current Renewable Power Plant Grid Code, embedded generators smaller than 1000 kVA connected to low-voltage form part of Category A generators, with the following subcategories:	See below.	**P**
	a) Category A1: 0 – 13,8 kVA; This sub-category includes RPPs of Category A with rated power in the range from 0 to 13,8 kVA, inclusive of 13,8 kVA.	Considered.	**P**
	b) Category A2: 13,8 kVA – 100 kVA; and This sub-category includes RPPs of Category A with rated power in the range greater than 13,8 kVA but less than 100 kVA.	Considered.	**P**

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
	c) Category A3: 100 kVA – 1 MVA. This sub-category includes RPPs of Category A with rated power in the range from 100 kVA but less than 1 MVA. NOTE 1 These sub-categories must be cross-checked with the Renewable Power Plant Grid Code (or other part of the Grid Code where applicable); where applicable, requirements will apply per sub-category and not per sizes defined here. NOTE 2 Until a separate Grid Code for non-renewable technologies have been compiled and published, relevant categories from this document will apply to non-renewable SSEG.	Considered.	**N/A**
4.1.1.12	In accordance with SANS 10142-1, all generators shall be wired permanently. NOTE 1 Some international companies are distributing so-called "plug-in" generators, where a small PV panel and inverter is connected to the supply circuit via a standard (load) plug. At present such installations are not regarded as safe and in contravention of SANS 10142-1. NOTE 2 This option will be reviewed when internationally accepted norms are finalised to ensure plugs and plug points are safe when feeding power into the grid as well as additional requirements for such generators or plugs.	Permanent and fixed connection type of unit. Must be taken under consideration for the installation.	**N/A**
4.1.1.13	Any UPS/generating device that operates in parallel with the grid may only connect to the grid when it complies fully with the requirements of this part of NRS 097. This includes UPS configurations with or without EG. NOTE The requirement is applicable irrespective of the duration of parallel operation.	No such type of SSEG.	**P**
4.1.1.14	Standby-generators are covered by SANS 10142-1.	Grid interactive type	**N/A**
4.1.1.15	All generators larger than 100 kVA will be controllable, i.e. be able to control the active output power dependent on network conditions/abnormal conditions. This includes several smaller units that totals more than 100 kVA at a single POC	Noticed.	**P**
4.1.1.16	Maximum DC Voltage may not exceed 1000V. This is the voltage on the DC side of the inverter, for example when no load is taken and maximum source energy is provided, e.g. peak solar radiation occurs on the solar panels.	V_{DC} =900V max.	**P**

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
4.1.2	**Normal voltage operating range**		**P**
4.1.2.1	In accordance with IEC 61727, utility-interconnected embedded generators do not normally regulate voltage, they inject current into the utility. Therefore the voltage operating range for embedded generators is designed as protection which responds to abnormal utility network conditions and not as a voltage regulation function.	Derived from tests.	**P**
4.1.2.2	The embedded generator shall synchronise (see 4.1.12) with the utility network before a connection is established. The embedded generator shall not control the voltage, unless agreed to by the utility (see annex A).	See appended table.	**P**
4.1.2.3	An embedded generator that operates in parallel with the utility system shall operate within the voltage trip limits defined in 4.2.2.3.2.	See appended table.	**P**
4.1.3	Reference source impedance and short-circuit levels (fault levels)	Noticed.	**P**
4.1.3.1	The impact of the generator on the network voltage and quality of supply levels is directly linked to the (complex) source impedance and short-circuit level. The minimum short-circuit level to which a generator can be connected should be based on the size of the generator as well as the design criteria.	Noticed.	**P**
4.1.3.2	For general purposes of testing and design for potential worst case conditions, a minimum network strength of the following may be assumed: Z_{source} = 1,05 + j 0,32 ohm, i.e. I_{SC} = 210 A and S_{SC} = 146 kVA (three-phase). NOTE This does not imply a guarantee that the fault level will be more than this at all times. Fault levels less than this may be sufficient for small loads in certain applications.	Noticed.	**P**
4.1.3.3	The maximum network strength will be assumed to be no more than 33 times the rated active power of the generator. The R/X ratio will be assumed between 0,33 to 3. NOTE 1 In practice, the generators will connect to the network at a wide range of short-circuit ratios. The assumption of a maximum ratio of 33 will allow safe connection of the SSEG in most practical situations. NOTE 2 The minimum fault level at which the generator may be connected is at the discretion of the manufacturer, provided that the requirements of this specification is met at the specified fault level.	Noticed.	**P**
4.1.3.4	The relevant utility will advise whether equipment may be connected at other network characteristics, i.e. for weaker parts of the network.	Must be taken under consideration for the installation.	**N/A**

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
4.1.3.5	The generator documentation and nameplate shall state the reference impedance (complex impedance) and fault level that was used for design and certification and that it is not intended to connect the generator to a network with a higher network impedance than specified for the certification. NOTE See Annex C (Network Impedance), for more information.	Must be taken under consideration for the installation.	**N/A**
4.1.4	**General QOS requirements**		**P**
4.1.4.1	Embedded generators can expect QOS levels on networks to be in line with NRS 048-2. It is expected that the embedded generator will be able to operate continuously under worst-case conditions.	Noticed.	**P**
4.1.4.2	Notwithstanding this, the embedded generator must protect itself from potential excursions beyond NRS 048-2 and ensure fail-safe conditions. Should the embedded generator be unable to operate according to requirements of this document for such excursions, it shall disconnect and cease generation onto the network.	Noticed.	**P**
4.1.5	**Flicker and voltage changes**		**P**
4.1.5.1	When connected to a network impedance equal to the reference impedance used during certification, no SSEG may generate flicker levels higher than the following: a) short-term flicker severity (Pst) = 0,35; and b) long-term flicker severity (Plt) = 0,30.	See appended table	**P**
4.1.5.2	It is anticipated that the utility will plan the connections in line with acceptable flicker limits, i.e. the ratio of the size of the generator to the network strength at the point of connection.	Noticed.	**P**
4.1.5.3	According to VDE-AR-N 4105, no generator shall be connected to a system where generation rejection (i.e. tripping of SSEG while generating at full capacity, regardless of reason) will lead to a voltage change of 3 % or more at the PCC, thereby minimising the potential to exceed rapid voltage change limits. NOTE 1 A voltage change of 3 % aligns to a ratio of the network fault level to generator size of 33 (ignoring network impedance angle and load power factor). NOTE 2 Standard connection conditions for customers typically include a maximum flicker contribution in line with annex D of NRS 048-4. Should these flicker levels be exceeded, the customer will be required to put mitigating measures in place as and when required by the utility.	Noticed.	**P**
4.1.6	**Voltage unbalance**		**P**

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
4.1.6.1	Under normal circumstances, for single and dual-phase EG, the unbalanced generation may not exceed 4,6 kVA connected between any two or different phases at an installation. Units larger than 4,6 kVA will be split evenly over the available phase connections so that this can be maintained.	Balanced three phase type of unit. See appended table	**P**
4.1.6.2	Three-phase generators may not contribute more than 0,2 % voltage unbalance when connected to a network with impedance equal to the reference impedance. NOTE Standard connection conditions for customers typically include a maximum voltage unbalance contribution in line with NRS 048-4, Annex D. Should a three-phase customer exceed these voltage unbalance levels, the customer will be required to put mitigating measures in place as and when required by the utility.	Balanced three phase type of unit. See appended table	**P**
4.1.7	**Commutation notches**		**P**
	The relative depth of commutation notches due to line-commutated inverters shall not exceed 5 % of nominal voltage at the POC for any operational state.	Noticed.	**P**
4.1.8	**DC injection**		**P**
4.1.8.1	The average d.c. current injected by the embedded generator shall not exceed 0,5 % of the rated a.c. output current over any 1-minute period, into the utility a.c. interface under any operating condition.	See appended table	**P**
4.1.8.2	According to section 4.2.2.5, the generator(s) must disconnect within 500 ms when the d.c. current exceeds this value.	See appended table	**P**
4.1.9	**Normal frequency operating range**		**P**
	An embedded generator that operates in parallel with the utility system shall operate within the frequency trip limits defined in 4.2.2.3.3.	See appended table	**P**
4.1.10	**Harmonics and waveform distortion**		**P**
4.1.10.1	Only devices that inject low levels of current and voltage harmonics will be accepted; the higher harmonic levels increase the potential for adverse effects on connected equipment.	See appended table	**P**
4.1.10.2	Acceptable levels of harmonic voltage and current depend upon distribution system characteristics, type of service, connected loads or apparatus, and established utility practice.	See appended table	**P**
4.1.10.3	The embedded generator output shall have low current-distortion levels to ensure that no adverse effects are caused to other equipment connected to the utility system.	See appended table	**P**

<table>
<tr><th colspan="4">NRS 097-2-1:2017</th></tr>
<tr><td>Clause</td><td>Requirement – Test</td><td>Result – Remark</td><td>Verdict</td></tr>
<tr><th colspan="4">SECTION 4.1: Utility compatibility</th></tr>
<tr><td>4.1.10.4</td><td>The harmonic and inter-harmonic current distortion shall comply with the relevant emission limits in accordance with IEC 61727, reproduced in table 1.</td><td>See appended table</td><td>P</td></tr>
<tr><td>4.1.10.5</td><td>The harmonic and inter-harmonic distortion applies up to 3 kHz (50th harmonic).
NOTE The harmonic limits above 2,5 kHz and all inter-harmonic limits refer to limits measured in accordance with IEC 61000-4-7.
<table>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>Harmonic order (h)</td><td>h<11</td><td>11≤h<17</td><td>17≤h<23</td><td>23≤h<35</td><td>35≤h</td></tr>
<tr><td>Percentage of rated current (Odd harmonics)</td><td>4,0</td><td>2,0</td><td>1,5</td><td>0,6</td><td>0,3</td></tr>
<tr><td>Percentage of rated current (Even harmonics)</td><td>1,0</td><td>0,5</td><td>0,38</td><td>0,15</td><td>0,08</td></tr>
<tr><td>Percentage of rated current (Inter-harmonics)</td><td>0,1</td><td>0,25</td><td>0,19</td><td>0,08</td><td>0,03</td></tr>
<tr><td colspan="6">Total Demand Distortion = 5%</td></tr>
<tr><td colspan="6">NOTE 1 Even harmonics are limited to 25 % of the odd harmonic limits
NOTE 2 Inter-harmonic are limited to 25 % of the odd harmonic limits and adjusted for the 200 Hz band measurement required by IEC 61000-4-7, except for the lower frequencies where the flicker contribution is more likely.
NOTE 3 Total Demand Distortion = Total Harmonic Distortion</td></tr>
</table></td><td>See appended table</td><td>P</td></tr>
<tr><td>4.1.11</td><td>Power factor</td><td></td><td>P</td></tr>
<tr><td>4.1.11.1</td><td>Irrespective of the number of phases to which an embedded generator is connected, it shall comply with the power factor requirements in accordance with 4.1.11.2 to 4.1.11.12 on each phase for system normal conditions when the output power exceeds 20 % of rated active power.</td><td>See below.</td><td>P</td></tr>
<tr><td>4.1.11.2</td><td>For static power converter embedded generators and synchronous embedded generators of sub-categories A1 and A2, the power factor shall remain above 0,98 as shown in Figure 1. The embedded generator shall operate anywhere in the shaded area of figure 1.
NOTE At the time of publication, this is in contradiction with the RPP Grid Code.</td><td>See appended table</td><td>P</td></tr>
<tr><td>4.1.11.3</td><td>For asynchronous embedded generators of sub-categories A1 and A2, which cannot control the power factor over any range, the power factor shall reach the shaded area of figure 1 within 60 s. The power factor shall remain above 0,98 as shown in figure 1. The embedded generator shall operate anywhere in the shaded area.
NOTE At the time of publication, this is in contradiction with the RPP Grid Code.</td><td>No such type of SSEG.</td><td>N/A</td></tr>
<tr><td>4.1.11.4</td><td>For static power converter embedded generators and synchronous embedded generators of sub-category A3, the power factor shall remain above 0,95 as shown in Figure 2. The embedded generator shall operate anywhere in the shaded area of Figure 2.</td><td>The adjustable power factor is between 0,90 under-excited and 0,90 over-excited.
See appended table</td><td>P</td></tr>
</table>

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
4.1.11.5	For asynchronous embedded generators of sub-category A3, which cannot control the power factor over any range, the power factor shall reach the shaded area of Figure 2 within 60 s. The power factor shall remain above 0,95 as shown in Figure 2. The embedded generator shall operate anywhere in the shaded area.	The adjustable power factor is between 0,90 under-excited and 0,90 over-excited. See appended table	**P**
4.1.11.6	Where the EG is capable of controlling the power factor at the POC, the EG should improve the power factor at the POC towards unity.	No such function.	**N/A**
4.1.11.7	Unless otherwise agreed with the utility, the standard power factor setting shall be unity for the full power output range.	Noticed.	**P**
4.1.11.8	The maximum tolerance on the reactive power setting is 5 % of the rated active power.	Noticed.	**P**
4.1.11.9	For embedded generators of sub-category A3, the power factor shall be settable to operate according to a characteristic curve provided by the utility, if required by the utility, within the range 0,95 leading and 0,95 lagging; An example of a standard characteristic curve is shown in figure 3.	The adjustable power factor is between 0,90 under-excited and 0,90 over-excited. See appended table	**P**
4.1.11.10	These limits apply, unless otherwise agreed upon with the utility (see annex A).	Must be taken under consideration for the installation.	**N/A**
4.1.11.11	Equipment for reactive power compensation shall either:	No such type of SSEG.	**N/A**
	a) be connected or disconnected with the embedded generator, or		**N/A**
	b) operated via automatic control equipment for disconnection when not required.		**N/A**
4.1.11.12	The requirement for and type of detuning for reactive power compensation devices will be agreed upon by the owner of the generator and utility. NOTE Detuning is highly recommended for all reactive power compensation devices to prevent (a) potential current overloading of capacitors due to existing voltage harmonics, (b) potential voltage transient amplification at the POC due to upstream switching conditions, and (c) potential resonance with the network impedance that may lead to excessive harmonic amplification.	No such type of SSEG.	**N/A**
4.1.12	**Synchronization**		**P**
4.1.12.1	All embedded generators shall synchronize with the utility network before the parallel connection is made. This applies to all embedded generators where a voltage exists at the generator terminals before connection with the utility network.	Noticed.	**P**
4.1.12.2	Automatic synchronization equipment shall be the only method of synchronization.	The method of synchronization is integrated in unit.	**P**

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
4.1.12.3	For a synchronous generator, the limits for the synchronizing parameters for each phase are: a) frequency difference: 0,3 Hz, b) voltage difference: 5 % of nominal voltage per phase, and c) phase angle difference: 20 ° (degrees).	Static power converters	**N/A**
4.1.12.4	Mains excited generators do not need to synchronise when the generator is started as a motor before generation starts.	Static power converters	**N/A**
4.1.12.5	Mains excited generators may require soft-starting when the start-up voltage change is anticipated to be more than 3 %.	Static power converters	**N/A**
4.1.12.6	The start-up current for static power converters shall not exceed the full-power rated current of the generator.	Noticed.	**P**
4.1.12.7	Also refer to 4.2.4 for re-synchronising conditions.	Noticed.	**P**
4.1.12.8	The embedded generator shall synchronize with the utility network only when the voltage and frequency has been stable within the ranges provided in 4.2.2.3 for at least 60 seconds. NOTE Some utilities may require this to be longer than 60 seconds.	See appended table	**P**
4.1.13	**Electromagnetic compatibility (EMC)**		**P**
4.1.13.1	Until acceptable EMC limits are available in the form of a published IEC standard (IEC 62578 or similar), the conditions of 4.1.13.2 to 4.1.13.3 shall apply. NOTE Acceptable EMC limits for conducted emissions of inverters in the range up to 150 kHz are currently being debated at IEC. A proposed edition of IEC 62578, which provided significantly relaxed limits for inverters specifically, has been rejected by the wider IEC community.	See appended table and EMC Test Report No. NTC1408090E-2, issued by Dongguan Nore Testing Center Co., Ltd.	**P**
4.1.13.2	Electromagnetic compatibility (EMC) refers to the ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. EMC comprises two components, namely a radiated and conducted component. Significant attention is given to radiated EMC due to the potential impact over larger distances. However, with advances in smart grids and business management systems, the potential impacts from conducted EMI must be considered. The conditions in 4.1.13.3 and 4.1.13.4 apply to unintentional signals.	See appended table and EMC Test Report No. NTC1408090E-2, issued by Dongguan Nore Testing Center Co., Ltd.	**P**

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
4.1.13.3	All unintentional conducted emissions from generating equipment shall comply with limits for unintentional emissions in SANS 50065-1 in the frequency band 3 kHz to 150 kHz and with SANS 211 (CISPR11) above 150 kHz, using limits for Class B group 1 equipment. NOTE The start frequency given in SANS 211 is 150 kHz; however, to avoid the existing gap, limits applying at 150 kHz will be extrapolated down to 148,5 kHz.	See appended table and EMC Test Report No. NTC1408090E-2, issued by Dongguan Nore Testing Center Co., Ltd.	**P**
4.1.13.4	The conducted emission requirement applies to all ports or connections to the utility supply, whether the connection is intended for monitoring, communication, power transfer or any other reason for connecting to the utility supply.	Inverters are tested according to IEC/EN 61000-6-2 Immunity standard for industrial environment and IEC/EN 61000-6-3 Emission standard for residential, commercial and light-industrial environments.	**P**
4.1.13.5	In the event of susceptibility to electromagnetic interference, the unit shall be fail-safe, i.e. any deviation from intended performance must comply with all relevant specifications, both in terms of safety (i.e. disconnection) and impact on the network.	Inverters are tested according to IEC/EN 61000-6-2 Immunity standard for industrial environment and IEC/EN 61000-6-3 Emission standard for residential, commercial and light-industrial environments.	**P**
4.1.13.6	Notwithstanding this, should any interference be experienced to existing or new ripple control, building management system equipment and/or other PLC-based communication, the owner of the embedded generator should take the necessary remedial action to prevent further interference as will be agreed with the utility or the other affected party.	Inverters are tested according to IEC/EN 61000-6-2 Immunity standard for industrial environment and IEC/EN 61000-6-3 Emission standard for residential, commercial and light-industrial environments.	**P**
4.1.13.7	All radiated emissions from generating equipment shall comply with SANS 211 (CISPR11), using limits for Class B group 1 equipment.	Inverters are tested according to IEC/EN 61000-6-3 Emission standard for residential, commercial and light-industrial environments. Measurement procedure and limits are identical to the radiated emissions according to EN 55032 : 2012 (CISPR 32).	**P**
4.1.14	**Mains signalling (e.g. PLC and ripple control)**	No such device	**N/A**
4.1.14.1	Mains signalling refers to intentional signals induced into the utility supply network, where the intention is to facilitate data transfer from one component to another.		**N/A**
4.1.14.2	All intentional emissions (communication signals) from generating equipment shall comply with limits for intentional emissions in SANS 50065-1, limited to an acceptable band as prescribed by SANS 50065-1.		**N/A**

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
4.1.14.3	Notwithstanding this, should any interference be experienced to existing or new ripple control, building management system equipment and/or other PLC-based communication, the owner of the embedded generator shall take the necessary remedial action to prevent further interference as will be agreed with the utility or the other affected party.		**N/A**

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety protection and control			
4.2.1	**General** The safe operation of the embedded generator in conjunction with the utility network shall be ensured at all times. Safe operation includes people and equipment safety	Noticed.	**P**
4.2.2	**Safety disconnect from utility network**		**P**
4.2.2.1	**General**	Derived from tests.	**P**
4.2.2.1.1	All SSEG shall comply with the safety requirements in accordance with SANS/IEC 62109-1 and IEC 62109-2. NOTE In principle, IEC 62109 documents only apply to PV inverters. However, other SSEG shall prove compliance to these safety requirements to the satisfaction of the utility.	The inverters meet the requirements of IEC 62109-1 and IEC 62109-2. Details see reports No. LD140506N039-R2.	**P**
	The embedded generator shall automatically and safely disconnect from the grid in the event of an abnormal condition. Abnormal conditions include:	See below.	**P**
	a) network voltage or frequency out-of-bounds conditions,	See appended table	**P**
	b) loss-of-grid conditions,	See appended table	**P**
	c) d.c. current injection threshold exceeded (per phase),.	See appended table	**P**
	d) and residual d.c. current (phase and neutral currents summated).	See IEC 62109-1 and IEC 62109-2 reports No. LD140506N039-R2.	**P**
4.2.2.2	**Disconnection device (previously disconnection switching unit)**		**P**
4.2.2.2.1	The embedded generator shall be equipped with a disconnection device, which separates the embedded generator from the grid due to abnormal conditions. The disconnection unit may be integrated into one of the components of the embedded generator (for example the PV utility interconnected inverter) or may be an independent device installed between the embedded generator and the utility interface.	The transformer less inverter provides two relays in series for each line.	**P**
4.2.2.2.2	The disconnection switching unit shall be able to operate under all operating conditions of the utility network. NOTE It is the responsibility of the embedded generator owner to enquire about the operating conditions of the utility network, e.g. fault levels for the foreseeable future.	The disconnection switching unit was tested according the single fault safety of the IEC 62109-2. See appended table.	**P**
4.2.2.2.3	A failure within the disconnection device shall lead to disconnection of the generator from the utility supply and indication of the failure condition.	The disconnection switching unit was tested according the single fault safety of the IEC 62109-2. See appended table.	**P**

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Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety protection and control			
4.2.2.2.4	A single failure within the disconnection switching unit shall not lead to failure to disconnect. Failures with one common cause shall be taken into account and addressed through adequate redundancy.	The disconnection switching unit was tested according the single fault safety of the IEC 62109-2. See appended table.	**P**
4.2.2.2.5	The disconnection device shall disconnect the generator from the network by means of two series connected robust automated load disconnect switches.	The disconnection switching unit was tested according the single fault safety of the IEC 62109-2. See appended table.	**P**
4.2.2.2.6	Both switches shall be electromechanical switches.	Complied.	**P**
4.2.2.2.7	Each electromechanical switch shall disconnect the embedded generator on the neutral and the live wire(s). NOTE The switching unit need not disconnect its sensing circuits.		**P**
4.2.2.2.8	All rotating generating units, e.g. synchronous or asynchronous generating units shall have adequate redundancy in accordance with 4.2.2.2.5.	Not such type of SSEG.	**N/A**
4.2.2.2.9	A static power converter without simple separation shall make use of two series connected electromechanical disconnection switches.	The output is switched off redundant by two relays in series for each line.	**P**
4.2.2.2.10	The current breaking capacity of each disconnecting switch shall be appropriately sized for the application. In cases where the disconnecting device is an electromechanical switching device such as a contactor, this requires suitable coordination with the upstream short circuit protection device (circuit breaker).	See Annex No. 1 – Datasheet of the relay.	**P**
4.2.2.2.11	Any programmable parameters of the disconnection switching unit shall be protected from interference by third-parties, i.e. password protected or access physically sealed.	Protected by password.	**P**
4.2.2.2.12	In order to allow customers to supply their own load in isolated operation (islanded) where this is feasible and required, the disconnection device may be incorporated upstream of part of or all of a customers' loads, provided that none of the network disconnection requirements in this document are violated.	Rely in the responsibility of the installer.	**N/A**

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Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety protection and control			
4.2.2.2.13	All EG installations larger than 30 kVA shall have a central disconnection device. NOTE 1 This requirement may be amended by the utility, i.e. the utility may require a central disconnection switch unit for any size and type of generator. NOTE 2 This requirement may be amended by the utility. The central disconnection switch unit will typically be waived only when a lockable disconnection switch, accessible to the utility, is installed. NOTE 3 This is an interim requirement based on requirements of VDE AR 4105 and will be revisited as more information becomes available.	Rely in the responsibility of the installer.	**N/A**
4.2.2.2.14	The network and system grid protection voltage and frequency relay for the central disconnection device will be type-tested and certified on its own (stand-alone tested). All clauses of 4.2.2, except 4.2.2.4 (anti-islanding) apply.	Rely in the responsibility of the installer.	**N/A**
4.2.2.3.1	**General**		**P**
	The accuracy for voltage trip values shall be within 0 % to +1 % of the nominal voltage from the upper boundary trip setting, and within -1% to 0% of the nominal voltage from the lower boundary trip setting.	Noticed.	**P**
	The accuracy for frequency trip values shall be within 0 to +0,1 % of the fundamental frequency from the upper boundary trip setting, and within -0,1 % to 0 % of the fundamental frequency from the lower boundary the trip setting.	Noticed.	**P**
4.2.2.3.2	**Overvoltage and undervoltage**		**P**
	The embedded generator in sub-category A1 and A2 shall cease to energize the utility distribution system should the network voltage deviate outside the conditions specified in table 2. The following conditions shall be met, with voltages in r.m.s. and measured at the POC. NOTE 1 All discussions regarding system voltage refer to the nominal voltage. NOTE 2 At the time of publication, these settings are in contradiction to the RPP Grid Code. These may only be applied with exemption to the relevant clause or after the RPP Grid Code has been suitably amended. NOTE 3 Measurements at the generator terminals will generally be sufficient for the overvoltage settings. If the expected voltage drop across the cable connecting the EG to the POC is too high, undervoltage settings might have to be adjusted.	See appended table.	**P**
	The purpose of the allowed time delay is to ride through short-term disturbances to avoid excessive nuisance tripping. The generator does not have to cease to energize if the voltage returns to the normal utility continuous operating condition within the specified trip time. NOTE Induction/synchronous generators need to be mindful of synchronisation issues and may have to apply faster trip times.	Noticed.	**P**

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Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety protection and control			
	A customer with a multiphase connection shall monitor all phases for out-of-bounds voltage conditions. The EG shall be disconnected if an out-of-bounds voltage condition is detected on any of the phases.	Noticed.	**P**
	In line with NRS 048-2, it is recommended that A1 and A2 SSEG be able to ride through at least Y and X1 type dips, i.e. not disconnect for these events. The purpose is to avoid excessive nuisance tripping.	The SSEG have LVRT function. See appended table.	**P**
	Category A3 SSEG shall be able to ride through low and/or high voltage events in accordance with the RPP Grid Code.		**N/A**
	The generator shall maintain the pre-dip current during any dip event for which it remains connected.	Noticed.	**P**
	The ride-through and trip times are shown graphically in figure 4.	Noticed.	**P**
4.2.2.3.3	**Over-frequency and under-frequency**		**P**
	This requirement is in line with the RPP Grid Code (version 2.8) and applies to all EG in category A.		**P**
	The embedded generation system shall cease to energize the utility network when the utility frequency deviates outside the specified conditions. Both over- and under-frequency conditions indicate system abnormal conditions and all generators are expected to assist in stabilising the system during such periods.	Noticed.	**P**
	When the utility frequency is less than 47 Hz, the embedded generator shall disconnect from the utility network within 0,2 s.	See appended table.	**P**

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Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety protection and control			
	While the utility frequency is in the range of 47 Hz and 50,5 Hz, the system shall operate normally. In order to prevent hysteresis switching (on-off toggling) during over-frequency conditions, the output power shall be reduced as follows: When the utility frequency exceeds 50,5 Hz, the active power available at the time shall be stored as the maximum power value PM; this value PM shall not be exceeded until the frequency has stabilized below 50,5 Hz for at least 4 seconds. The EG system shall control the output power as a function of PM at a gradient of 50 % per Hertz as illustrated in figure 5. The power generation shall follow the curve shown in figure 5 up and down while the system frequency is in the range 50,5 Hz to 52 Hz. When the utility frequency is more than 52 Hz for longer than 4 seconds, the embedded generator shall cease to energise the utility line within 0,5 s.	See appended table.	**P**
4.2.2.3.3.1	**Relaxation for non-controllable generators**	No such type of SSEG.	**N/A**
	Non-controllable generators may disconnect randomly within the frequency range 50.5 Hz to 52 Hz. The disconnect frequency for non-controllable generators will each be set at a random value by the manufacturer, with the option of changing this to a utility provided setting. The random disconnect frequency shall be selected so that all generators from any specific manufacturer will disconnect uniformly over the range with 0,1 Hz increments.		**N/A**
	When the utility frequency is more than the non-controllable generator over-frequency setpoint for longer than 4 seconds, the non-controllable generator shall cease to energise the utility line within 0,5 s. NOTE At the time of publication, this is in contradiction with the RPP Grid Code.		**N/A**
4.2.2.4	**Prevention of islanding**		**P**

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Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety protection and control			
4.2.2.4.1	A utility distribution network can become de-energized for several reasons: for example, a substation breaker that opens due to a fault condition or the distribution network might be switched off for maintenance purposes. Should the load and (embedded) generation within an isolated network be closely matched, then the voltage and frequency limits may not be triggered. If the embedded generator control system only made use of passive voltage and frequency out-of-bounds detection, this would result in an unintentional island that could continue beyond the allowed time limits.	See appended table.	**P**
4.2.2.4.2	In order to detect an islanding condition, the embedded generator shall make use of at least one active islanding detection method. An active islanding detection method intentionally varies an output parameter and monitors the response or it attempts to cause an abnormal condition at the utility interface to trigger an out-of-bounds condition. If the utility supply is available, the attempt to vary an output parameter or cause an abnormal condition will fail and no response will be detected. However, if the utility supply network is de-energized, there will be a response to the change which can be detected. This signals an island condition to the embedded generator upon detection of which the embedded generator shall cease to energize the utility network within a specific time period.	See appended table.	**P**
4.2.2.4.3	Active island detection shall be used in all cases where the EG interfaces with the utility network.	Noticed.	**P**
4.2.2.4.4	An islanding condition shall cause the embedded generator to cease to energize the utility network within 2 s, irrespective of connected loads or other embedded generators. The embedded generator employing active islanding detection shall comply with the requirements of IEC 62116 (ed.1). NOTE Prevention of islanding measures is only considered on the embedded generator side, i.e. no utility installed anti-islanding measures are considered.	See appended table.	**P**
4.2.2.4.5	All rotating generators shall use a minimum of two islanding detection methods (e.g. rate of-change-of-frequency and voltage vector shift detection due to the dead bands (slow detection) of islands in both methods). NOTE It is possible for a condition to exist, where a mains-excited generator becomes self-excited due to capacitance of the network (either cable capacitance or power factor correction). Under such conditions, the mains-excited generator will not disconnect from an island, hence effective islanding detection is required for all rotating generators.	Not such type of SSEG.	**N/A**

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Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety protection and control			
4.2.2.4.6	Passive methods of islanding detection shall not be the sole method to detect an island condition. When used, passive methods of islanding detection shall be done by three-phase voltage detection and shall be verified by an AC voltage source.	Both methods of active and passive island detection are used.	**P**
4.2.2.4.7	The embedded generator shall physically disconnect from the utility network in accordance with the requirements in 4.2.2.2.	See 4.2.2.2.	**P**
4.2.2.5	**DC current injection**		**P**
	The embedded generator shall not inject d.c. current greater than 0,5 % of the rated a.c. output current into the utility interface under any operating condition, measured over a 1-minute interval. The EG shall cease to energize the utility network within 500 ms if this threshold is exceeded.	See appended table.	**P**
4.2.3	No requirements for emergency personnel safety (e.g. fire brigade) existed at the time of publication. It is expected that such issues will be dealt with in other documents, e.g. OHS Act, SANS 10142-1.	Rely in the responsibility of the installer.	**N/A**
4.2.4	**Response to utility recovery**		**P**
4.2.4.1	The embedded generator shall ensure synchronisation before re-energizing at all times in accordance with 4.1.12.	Complied.	**P**
4.2.4.2	After a voltage or frequency out-of-range condition that has caused the embedded generator to cease energizing the utility network, the generator shall not re-energize the utility network until the utility service voltage and frequency have remained within the specified ranges for a continuous and uninterrupted period of 60 s. The reconnection shall commence as follows:	See appended table.	**P**
4.2.4.2.1	Non-controllable generators may connect randomly within the 1 minute to 10 minute period after voltage and frequency recovery (period includes the 60 s to confirm recovery). The delay for non-controllable generators will each be set at a random value by the manufacturer, with the option of changing this to a utility provided setting. The random value shall be selected so that no more than 2 % of generators from any specific manufacturer will reconnect within 10s of each other.	Not such type of SSEG.	**N/A**

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Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety protection and control			
4.2.4.2.2	Controllable generators may reconnect immediately after the 60 s delay confirming recovery of the system voltage and frequency at a maximum rate of 10 % of rated power per minute, i.e. full power output will only be reached after 10 minutes. This ramp rate may be modified at the request of the utility or in consultation with the utility.	See appended table.	**P**
4.2.5	**Isolation**		**N/A**
4.2.5.1	In line with SANS 10142-1 (as amended), each energy source should have its own, appropriately rated, isolation device.		**N/A**
4.2.5.2	It is expected that isolation requirements will be dealt with in more detail in future in e.g. SANS 10142-1/3. Such requirements shall supersede 4.2.5.		**N/A**
4.2.5.3	The embedded generator shall provide a means of isolating from the utility interface in order to allow for safe maintenance of the EG. The disconnection device shall be a double pole for a single-phase EG, a three-pole for a three-phase delta-connected EG, and a four-pole for a three-phase star-connected EG. The grid supply side shall be wired as the source.	Disconnecting device is not integral part of the unit. The installation instructions specify a disconnection device for the final installation. The correct assembling is part of the installer.	**N/A**
4.2.5.4	The breaking capacity of the isolation circuit-breaker closest to the point of utility connection shall be rated appropriately for the installation point in accordance with SANS 60947-2. This disconnection device does not need to be accessible to the utility.	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**
4.2.5.5	For dedicated supplies, a means shall be provided of isolating from the point of supply in order to allow for safe maintenance of the utility network. The disconnection device shall be a double pole for a single-phase EG, a three-pole for a three-phase delta-connected EG, and a four-pole for a three-phase star-connected EG. This disconnection device shall be lockable and accessible to the utility. NOTE 1 A device inside a lockable box is deemed a lockable device. NOTE 2 This disconnection device may become the new point of control as defined by SANS10142-1.		**N/A**
4.2.5.6	The requirement for the utility accessible disconnection device may only be waived by the utility where the risk to the network is deemed acceptable to the utility. Such permission shall be provided in writing. NOTE Full verification form to be signed off and accepted by the utility.		**N/A**
4.2.6	**Earthing**		**P**

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Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety protection and control			
4.2.6.1	The electrical installation shall be earthed in accordance with SANS 10142-1 (as applicable). The earthing requirements for different embedded generation configurations in conjunction with the customer network are described in annex B for the most common earthing systems. NOTE SANS 10142-1 applies to EG feeding a UPS and no connection to the utility supply (see table B5).	Rely in the responsibility of the installer.	**N/A**
4.2.6.2	Installations with utility-interconnected inverters without simple separation shall make use of earth leakage protection which are able to respond to d.c. fault currents including smooth d.c. fault currents (i.e. without zero crossings) according to IEC 62109-2 unless the inverter can exclude the occurrence of d.c. earth fault currents on any phase, neutral or earth connection through its circuit design1). This function may be internal or external to the inverter. NOTE IEC 62109-2, Edition 2011, section 4.8.3.5 gives selection criteria for RCD sensitivities.	The inverter was tested according IEC 62109-2 for the residual current device (RCD) or monitoring (RCM). Therefore The unit can be provided with an external RMCU type A, based on the construction and internal protection (the unit provides a galvanic basic insulation between PV and DC-Link): - insulation measurement detection fault current of 1mA - single faults could not cause residual direct current between 6mA and 300mA	**P**
4.2.6.3	Where an electrical installation includes a PV power supply system without at least simple separation between the AC side and the DC side, an integrated RCD function shall be present to provide fault protection by automatic disconnection of supply shall be type B according to IEC/TR 60755, amendment 2. Where the PV inverter by construction is not able to feed DC fault currents into the electrical installation, an RCD of type B according to IEC/TR 60755 amendment 2 is not required. NOTE 1 Consideration must also be given to ensure that any d.c. currents do not impair the effectiveness of any other RCD'S installed throughout the a.c. system. NOTE 2 The earth leakage unit may also fulfil the requirement of the all-pole disconnection device as stated in 4.2.6. NOTE 3 The function of this RCD is not to provide protection against circulating d.c. currents in the inverter and a.c. supply, i.e. does not override 4.1.8.	The RCD protection is provided integral to the unit. The inverter was tested according to IEC 62109-2.	**P**
4.2.7	**Short-circuit protection**		**N/A**
4.2.7.1	The embedded generator shall have suitably rated short-circuit protection at the connection to the AC mains in accordance with SANS 10142-1 and 3.	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**
4.2.7.2	The short-circuit characteristics for the SSEG shall be supplied to the utility.		**N/A**

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Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety protection and control			
4.2.8	**Maximum short-circuit contribution**		**P**
	Embedded generators have the potential to increase the fault level of the network to which it is connected. In order to limit the fault level changes in low voltage networks and allow coordination of fault levels with the utility, no generator will exceed the following fault level contribution: NOTE At the time of installation, the short-circuit capacity of all existing equipment should be confirmed and upgraded where necessary. Suitable fault current limiting devices may be required to ensure a safe installation. The potential impact on neighbouring installations should also be considered to ensure that those installations remain safe.	See below.	**P**
	a) for synchronous generators: 8 times the rated current;		**N/A**
	b) for asynchronous generators: 6 times the rated current; and		**N/A**
	c) for generators with inverters: 1 times the rated current.	The SSEG is specified 25 A r.m.s..	**P**
4.2.9	**Labelling**		**N/A**
4.2.9.1	A label on the distribution board of the premises where the embedded generator is connected shown in figure 6, shall state: “WARNING: ON-SITE EMBEDDED GENERATION . DO NOT WORK ON THIS EQUIPMENT UNTIL IT IS ISOLATED FROM BOTH MAINS AND ON-SITE GENERATION SUPPLIES.” or similar warning. Disconnection points for all supplies shall be indicated.	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**
4.2.9.2	The label shall be permanent with lettering of height at least 8 mm.		**N/A**
4.2.9.3	The label shall comply to requirements of SABS 1186-1.		**N/A**
4.2.9.4	The absence of emergency shutdown capabilities will be indicated on signage in accordance with 4.2.2.		**N/A**
4.2.10	**Robustness requirements**		**P**
	According to 4.2.2.1 all SSEG shall comply with safety requirements in accordance to SANS/IEC 62109-1 and IEC 62109-2. NOTE This section will be expanded in future revisions.	See 4.2.2.1.	**P**

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Clause	Requirement – Test	Result – Remark	Verdict
Metering			
4.3	**Metering**	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**

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Clause	Requirement – Test	Result – Remark	Verdict
Annex			
Annex A	**Notes to purchase**	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**
Annex B	**Earthing system**	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**
Annex C	**Network impedance**	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**
Annex D	**(Annex A of VDE-AR-N 4105) Explanations** (normative)	Noticed.	**P**
Annex E	**(Annex B of VDE-AR-N 4105) Connection examples** (normative)	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**
Annex F	**(Annex C of VDE-AR-N 4105) Example of meter panel configurations** (normative)	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**
Annex G	**Generation management network security management** (normative)	Noticed.	**P**

Test overview:		
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Clause	**Test**	**Result**
1	Response to protection operation - fault condition tests	**P**
4.	**Type test:**	
4.1.5	Voltage fluctuations and Flicker	**P**
4.1.6	Voltage unbalance	**P**
4.1.8	DC injection	**P**
4.1.10	Harmonics and waveform distortion	**P**
4.1.11.3	Power factor (no controllable reactive power)	**P**
4.1.11.4	Power factor (Fixed cos φ)	**P**
4.1.11.9	Test for a displacement factor/active power characteristic curve cos φ (P) (For embedded generators of sub-category A3)	**P**
4.1.12	Synchronization	**P**
4.2.2	Safety disconnect from utility network Response to protection operation - fault condition tests (according VDE AR-N 4105:2011 and VDE0124-100:2013)	**P**
4.2.2.3.2	Over voltage and under voltage	**P**
4.2.2.3.2	Low voltage fault Ride through capability	**P**
4.2.2.3.3	Over-frequency and under-frequency	**P**
4.2.2.3.3	Active power feed-in for over-frequency	**P**
4.2.2.4	Preventing of islanding	**P**

Test Results

1. Response to protection operation - fault condition tests			P
	ambient temperature (°C) :	25°C	—
	model/type of power supply :	AC: 61215 DC: 62150H-1000S * 2 set	—
	manufacturer of power supply :	Chroma	—
	rated markings of power supply :	AC: 300Vac, 18kVA DC: 1000Vdc, 30A, 30kVA	—

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
71-000293-00G Output current sensor defect CT3(Pin8)	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,05A	Error message:"05 ERROR" (Inverter current exceed the upper limit); Inverter was disconnect from grid immediately.
71-000293-00G Output current sensor defect CT2(Pin9)	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,05A	Error message:"05 ERROR" (Inverter current exceed the upper limit); Inverter was disconnect from grid immediately.
71-000293-00G Relay defect RY7(Pin3&Pin4)	Short before start up	230V 0,01 A	800V 0,02 A	10min	--	230V 0,01A	800V 0,02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY5(Pin3&Pin4)	Short before start up	230V 0,01 A	800V 0,02 A	10min	--	230V 0,01A	800V 0,02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY2(Pin3&Pin4)	Short before start up	230V 0,01 A	800V 0,02 A	10min	--	230V 0,01A	800V 0,02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY1(Pin3&Pin4)	Short before start up	230V 0,01 A	800V 0,02 A	10min	--	230V 0,01A	800V 0,02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
71-000293-00G Relay defect RY9(Pin3&Pin4)	Short before start up	230V 0,01 A	800V 0,02 A	10min	--	230V 0,01A	800V 0,02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY8(Pin3&Pin4)	Short before start up	230V 0,01 A	800V 0,02 A	10min	--	230V 0,01A	800V 0,02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY6(Pin3&Pin4)	Short before start up	230V 0,01 A	800V 0,02 A	10min	--	230V 0,01A	800V 0,02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY4(Pin3&Pin4)	Short before start up	230V 0,01 A	800V 0,02 A	10min	--	230V 0,01A	800V 0,02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Grid voltage monitoring R93	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R89	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R13	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R17	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R8	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R4	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
71-000293-00G Grid voltage monitoring R92	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R88	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R18	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R16	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R7	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R3	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000297-00G Isolation monitoring defect R56	Open before start up	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message:"13 ERROR" (insulation resistance); Inverter does not start up.
71-000297-00G Isolation monitoring R68	Open before start up	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message:"13 ERROR" (insulation resistance); Inverter does not start up.
71-000297-00G Isolation monitoring defect R82	Open before start up	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message:"13 ERROR" (insulation resistance); Inverter does not start up.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
71-000297-00G Isolation monitoring defect R89	Open before start up	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message:"13 ERROR" (insulation resistance); Inverter does not start up.
71-000297-00G Isolation monitoring defect R158	Open before start up	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message:"13 ERROR" (insulation resistance); Inverter does not start up.
71-000368-00G Grid voltage monitoring defect R1	Open	230V 14,3 A	800V 2x6,2 5A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R 5	Open	230V 14,3 A	800V 2x6,2 5A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R9	Open	230V 14,3 A	800V 2x6,2 5A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R13	Open	230V 14,3 A	800V 2x6,2 5A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R17	Open	230V 14,3 A	800V 2x6,2 5A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R21	Open	230V 14,3 A	800V 2x6,2 5A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
71-000368-00G RELAY Board R25	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R29	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R33	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R37	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R41	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R45	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R2	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R6	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
71-000368-00G Grid voltage monitoring defect R10	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R14	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R18	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R22	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R26	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R30	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R34	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R38	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
71-000368-00G Grid voltage monitoring defect R42	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R46	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G DSP lost of control C73	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Inverter was shut down immediately.
71-500375-00G DSP lost of control XL1	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Shutdown immediately, No breakdown
71-500375-00G DSP lost of control C12	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Shutdown immediately, No breakdown
71-500375-00G DSP lost of control C72	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Shutdown immediately, No breakdown
71-500375-00G DSP lost of control XL3	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Shutdown immediately, No breakdown
71-500375-00G DSPs communication defect R528	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message: "17 ERROR" (Comminication loss between master CPU and slave CPU)', PV inverter was disconnected from grid immediately.
71-500375-00G DSPs communication defect R527	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message: "17 ERROR" (Comminication loss between master CPU and slave CPU)', PV inverter was disconnected from grid immediately.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
71-500375-00G Inverter voltage monitoring defect U10(Pin5&Pin6)	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:”36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Inverter voltage monitoring defect R75	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:”36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Inverter voltage monitoring defect U10(Pin9&Pin10)	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:”36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Inverter voltage monitoring defect R84	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:”36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Grid frequency monitoring defect R93	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message: “04 warning” (Line frequency LOW)’, PV inverter was disconnected from grid immediately.
71-500375-00G Grid frequency monitoring defect U4(Pin8&Pin9)	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message: “04 warning” (Line frequency LOW)’, PV inverter was disconnected from grid immediately.

component No.	fault	test condition AC	test condition DC	test time	fuse No.	fault condition AC	fault condition DC	result
71-500375-00G Grid voltage monitoring defect U11(Pin2&Pin3)	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Grid voltage monitoring defect R101	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Grid voltage monitoring defect U11(Pin5&Pin6)	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Grid voltage monitoring defect R106	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message:"36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Gird frequency monitoring defect U81(Pin5&Pin6)	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message: "04 warning" (Line frequency LOW)', PV inverter was disconnected from grid immediately.
71-500375-00G Gird frequency monitoring defect R119	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message: "04 warning" (Line frequency LOW)', PV inverter was disconnected from grid immediately.
71-500375-00G Gird frequency monitoring defect U81(Pin2&Pin3)	Short	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message: "04 warning" (Line frequency LOW)', PV inverter was disconnected from grid immediately.

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
71-500375-00G Gird frequency monitoring defect R126	Open	230V 14,3 A	800V 2x6,25A	2min	--	230V 0,01A	800V 0,02A	Error message: “04 warning” (Line frequency LOW)’, PV inverter was disconnected from grid immediately.
71-500375-00G Isolation detection defect U14(Pin9&Pin10)	Short before start-up	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message:”13 ERROR” (Solar insulation resistance too low)’, PV inverter was disconnected from grid immediately.
71-500375-00G Isolation detection defect R182	Open before start-up	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message:”13 ERROR” (Solar insulation resistance too low)’, PV inverter was disconnected from grid immediately.
71-500375-00G Isolation detection defect U14(Pin12&Pin13)	Short before start-up	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message:”13 ERROR” (Solar insulation resistance too low)’, PV inverter was disconnected from grid immediately.
71-500375-00G Isolation detection defect R187	Open before start-up	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message:”13 ERROR” (Solar insulation resistance too low)’, PV inverter was disconnected from grid immediately.
71-500375-00G Residual current monitoring defect R25	Open	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message: “16 ERROR” (GFCI Over), No hazard, PV inverter was disconnected from grid immediately.
71-500375-00G Residual current monitoring defect C52	Short	230V 0,01 A	800V 0,02 A	2min	--	230V 0,01A	800V 0,02A	Error message: “16 ERROR” (GFCI Over), No hazard, PV inverter was disconnected from grid immediately.

Note:
The errors in the control circuit simulate that the safety is even under one error ensured.

4.1.5 Voltage fluctuation and flicker				P
Test conditions:	Maximum permissible voltage fluctuation (expressed as a percentage of nominal voltage at 100 % power) and flicker as per EN 61000-3-3			
	Starting	**Stopping**	**Running**	
Limit	3,3%	3,3%	P_{st}=1,0	P_{lt}=0,65
Test value	*	*	*	*
inverter >16A				
Limit	dc% = 3,3		P_{st}=1,0	P_{lt}=0,65
Test value	See below			

L1 Phase

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	14.7182			2	0.3008	1.0800	72.1
3	0.1676	2.3000	92.7	4	0.0635	0.4300	85.2
5	0.2054	1.1400	82.0	6	0.0334	0.3000	88.9
7	0.0643	0.7700	91.7	8	0.0223	0.2300	90.3
9	0.0369	0.4000	90.8	10	0.0193	0.1840	89.5
11	0.0283	0.3300	91.4	12	0.0213	0.1533	86.1
13	0.0259	0.2100	87.7	14	0.0216	0.1314	83.6
15	0.0343	0.1500	77.1	16	0.0236	0.1150	79.5
17	0.0374	0.1324	71.8	18	0.0282	0.1022	72.4
19	0.0365	0.1184	69.2	20	0.0306	0.0920	66.7
21	0.0444	0.1071	58.5	22	0.0331	0.0836	60.4
23	0.0467	0.0978	52.2	24	0.0398	0.0767	48.0
25	0.0496	0.0900	44.9	26	0.0395	0.0708	44.1
27	0.0560	0.0833	32.7	28	0.0431	0.0657	34.5
29	0.0559	0.0776	27.9	30	0.0434	0.0613	29.3
31	0.0553	0.0726	23.8	32	0.0412	0.0575	28.3
33	0.0481	0.0682	29.5	34	0.0363	0.0541	33.0
35	0.0434	0.0643	32.5	36	0.0300	0.0511	41.4
37	0.0405	0.0608	33.4	38	0.0290	0.0484	40.1
39	0.0306	0.0577	47.0	40	0.0252	0.0460	45.1

L2 Phase

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	14.4302			2	0.2461	1.0800	77.2
3	0.2600	2.3000	88.7	4	0.0623	0.4300	85.5
5	0.1714	1.1400	85.0	6	0.0307	0.3000	89.8
7	0.0953	0.7700	87.6	8	0.0208	0.2300	90.9
9	0.0395	0.4000	90.1	10	0.0180	0.1840	90.2
11	0.0438	0.3300	86.7	12	0.0202	0.1533	86.8
13	0.0392	0.2100	81.3	14	0.0215	0.1314	83.7
15	0.0230	0.1500	84.7	16	0.0197	0.1150	82.9
17	0.0519	0.1324	60.8	18	0.0226	0.1022	77.9
19	0.0284	0.1184	76.0	20	0.0291	0.0920	68.4
21	0.0459	0.1071	57.2	22	0.0289	0.0836	65.4
23	0.0481	0.0978	50.8	24	0.0313	0.0767	59.1
25	0.0495	0.0900	45.0	26	0.0386	0.0708	45.5
27	0.0561	0.0833	32.7	28	0.0384	0.0657	41.6
29	0.0540	0.0776	30.4	30	0.0303	0.0613	50.5
31	0.0639	0.0726	11.9	32	0.0378	0.0575	34.3
33	0.0417	0.0682	38.8	34	0.0306	0.0541	43.4
35	0.0482	0.0643	25.1	36	0.0257	0.0511	49.8
37	0.0387	0.0608	36.4	38	0.0242	0.0484	50.0
39	0.0344	0.0577	40.4	40	0.0206	0.0460	55.2

L3 Phase

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	14.4048			2	0.2937	1.0800	72.8
3	0.1767	2.3000	92.3	4	0.0644	0.4300	85.0
5	0.2002	1.1400	82.4	6	0.0346	0.3000	88.5
7	0.0626	0.7700	91.9	8	0.0227	0.2300	90.1
9	0.0391	0.4000	90.2	10	0.0197	0.1840	89.3
11	0.0271	0.3300	91.8	12	0.0234	0.1533	84.8
13	0.0266	0.2100	87.3	14	0.0232	0.1314	82.4
15	0.0332	0.1500	77.8	16	0.0226	0.1150	80.3
17	0.0358	0.1324	72.9	18	0.0293	0.1022	71.4
19	0.0353	0.1184	70.2	20	0.0324	0.0920	64.8
21	0.0428	0.1071	60.1	22	0.0314	0.0836	62.4
23	0.0472	0.0978	51.8	24	0.0400	0.0767	47.9
25	0.0476	0.0900	47.1	26	0.0446	0.0708	[illegible]
27	0.0529	0.0833	36.5	28	0.0409	0.0657	37.7
29	0.0557	0.0776	28.2	30	0.0408	0.0613	33.4
31	0.0564	0.0726	22.3	32	0.0413	0.0575	28.2
33	0.0441	0.0682	35.3	34	0.0358	0.0541	33.9
35	0.0415	0.0643	35.4	36	0.0304	0.0511	40.5
37	0.0414	0.0608	31.9	38	0.0285	0.0484	41.1
39	0.0306	0.0577	46.9	40	0.0254	0.0460	44.8

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

Mains Impedance according EN61000-3-11: **R_{max} = 0,24 Ω; jX_{max}= 0,15 Ω @50Hz (|Z_{max}| = 0,472 Ω)**
for single phase inverter use also **R_n = 0,16 Ω; jX_n= 0,1 Ω**

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 EN 61000-3-11 for more than 16A.

4.1.5.3 Rapid voltage changes	P

The purpose of the test is to determine k_i and k_{imax}.

The following three cases must be tested to VDE-AR-N 4105, Annex F.3 (where applicable).

- Switch-on for any capacity
- Unfavourable case when switching the generator step
- Switch-on for nominal capacity
  Note: For PV-plants the inverter is the generator

Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)

Test conditions:
Frequency: 50 Hz ± 0,5%
THD of the voltage supply: ≤ 3 %
Voltage rise of the PGU at 100 P_{Emax} %: ≤ 3 %

Switch-on for any capacity (10% P_{Emax})

	Measurement 1			Measurement 2			Measurement 3		
phase	L1	L2	L3	L1	L2	L3	L1	L2	L3
Single period effective values of the current [A]	4,529	3,966	3,820	4,926	4,119	4,484	4,119	3,610	4,078
Single period effective values of the voltage [V]	229,4	229,5	229,5	230,6	230,5	230,4	230,6	230,5	230,2
k_i value	0,313	0,274	0,264	0,340	0,284	0,309	0,284	0,249	0,281
k_{imax} value	0,340								

Unfavourable case when switching the generator step

	Measurement 1			Measurement 2			Measurement 3		
phase	L1	L2	L3	L1	L2	L3	L1	L2	L3
Single period effective values of the current [A]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_i value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value	N/A								

Switch-on for nominal capacity

	Measurement 1			Measurement 2			Measurement 3		
phase	L1	L2	L3	L1	L2	L3	L1	L2	L3
Single period effective values of the current [A]	3,977	3,894	4,348	4,754	4,109	4,411	4,132	3,964	4,192
Single period effective values of the voltage [V]	229,7	229,8	229,6	230,6	230,5	230,5	230,5	230,5	230,6
k_i value	0,274	0,269	0,300	0,328	0,284	0,304	0,285	0,274	0,289
k_{imax} value	0,328								

Highest k_{imax} value for all switching operations

0,340

Note:
The test results base on the test report "PVDE140506N039" issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2014-09-10.

Flicker
These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.4.3 are met.

The purpose of the test is to determine long-term flicker strength P_{lt}.

For power generation systems with rated currents of up to 75 A, reactions are deemed to be limited sufficiently, if the power generation units comply with the limit values given in DIN EN 61000-3-3 (VDE 0838-3) or DIN EN 61000-3-11 (VDE 0838-11), respectively.

Test conditions:
Voltage: 86% U_n to 109% U_n
Frequency: 50 Hz ± 0,5%
THD of the voltage supply: ≤ 3 %
Voltage rise of the PGU at 100 P_{Emax} %: ≤ 3 %

Flicker to DIN EN 61000-3-3 (VDE 0838-3) or DIN EN 61000-3-11 (VDE 0838-11) for generator units ≤ 75 A

Flicker to:	Result:		
	P_{lt}	P_{st}	*dc%*
DIN EN 61000-3-3	0,10	0,10	0,24

Assessment criterion:

Long-term flicker strength P_{lt} to or DIN EN 61000-3-11 must be ≤ 0,3.

Determination of the flicker coefficient:

$$c_{\psi k} = P_{st} \times (S_k / P_n)$$

where S_k is the short-circuit power of the network standby element (during the determination of the appropriate Pst values)

The following applies according to DIN EN 61000-3-11 (> 16 A and ≤ 75 A) for the network standby element: S_k =
The value for the network standby element must be determined separately with measurements for rated currents > 75 A.

Flicker to DIN EN 61400-21 (VDE 0127-21) (or FGW TR3)	
Grid impedance angle ψ_k	32°
Flicker coefficient $c(\psi_k)$	5,653
Short-term flicker P_{st}	0,10

Assessment criterion:

Long-term flicker strength**:** $P_{lt} \leq 0,3$

If the result of these flicker levels be exceeded, the customer will be required to put mitigating measures in place as and when required by the utility.

The test results base on the test report "PVDE140506N039" issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2014-09-10.

4.1.6 Calculation of asymmetry							**P**
Setting values	cos φ = 1:			1,00			
	cos φ over-excited:			0,90			
	cos φ under-excited:			0,90			
Test:							
1-min mean value	L1	L2	L3	L1 – L2	L2 – L3	L3 – L1	
a) cos φ = 1 at 100 % P_n ± 5 % P_n							
S_{E60} [kVA]:	3,379	3,318	3,305	0,062	0,013	-0,074	
	3,384	3,322	3,310	0,061	0,012	-0,074	
	3,384	3,323	3,310	0,061	0,013	-0,074	
	3,384	3,323	3,310	0,061	0,013	-0,074	
	3,384	3,323	3,310	0,061	0,013	-0,074	
cos $φ_{E60}$:	0,999						
max. asymmetry [kVA]:	-0,074						
U_{60} [V]:	230,97	230,71	230,65	0,258	0,063	-0,320	
	230,93	230,72	230,67	0,218	0,044	-0,262	
	230,95	230,72	230,64	0,228	0,078	-0,307	
	230,94	230,72	230,64	0,222	0,081	-0,303	
	230,95	230,72	230,64	0,234	0,083	-0,316	
max. asymmetry [V]:	0,316						
max. asymmetry [%]:	0,14						
b) cos φ = 1 at 50 % P_n ± 5 % P_{Emax}							
S_{E60} [kVA]:	1,690	1,647	1,652	0,043	-0,005	-0,038	
	1,691	1,648	1,653	0,043	-0,005	-0,038	
	1,691	1,648	1,653	0,043	-0,005	-0,038	
	1,691	1,649	1,654	0,042	-0,005	-0,037	
	1,691	1,648	1,654	0,042	-0,005	-0,037	
cos $φ_{E60}$:	0,998						
max. asymmetry [kVA]:	0,043						
U_{60} [V]:	230,88	230,44	230,40	0,440	0,047	-0,488	
	230,81	230,44	230,41	0,362	0,037	-0,399	
	230,75	230,44	230,41	0,308	0,033	-0,342	
	230,67	230,44	230,41	0,230	0,035	-0,265	
	230,70	230,44	230,42	0,257	0,021	-0,278	
max. asymmetry [V]:	0,278						
max. asymmetry [%]:	0,12						

Power Limit [kVA]:	4,6 kVA
Voltage Limit [%]:	0,2 %

Test:

The maximum absolute difference between the apparent powers of the three phases is determined for each of the five measurements (1-min means) in the respective operating point. The maximum of these five values is again determined.

Assessment criterion:

The test is passed if the maximum value from the above measurements does not exceed 4,6 kVA for apparent power imbalance and 0,2% for voltage unbalance.

Note:

The maximum inductive and capacitive values are specified by the manufacturer.

4.1.6	**Additional tests for communicatively coupled inverter modules Failure of single inverter modules**					**N/A**
Test:						
1-min mean value	L1	L2	L3	L1 – L2	L2 – L3	L3 – L1
a) Failure of an inverter module						
S_{E60} [kVA]:	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
cos φ_{E60}:	--					
max. asymmetry [kVA]:	--					
U_{60} [V]:	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
max. asymmetry [V]:	--					
max. asymmetry [%]:	--					
b) Failure of two inverter modules						
S_{E60} [kVA]:	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
cos φ_{E60}:	--					
max. asymmetry [kVA]:	--					
U_{60} [V]:	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
	--	--	--	--	--	--
max. asymmetry [V]:	--					
max. asymmetry [%]:	--					

Power Limit [kVA]:	4,6 kVA
Voltage Limit [%]:	0,2 %

Test:
The maximum absolute difference between the apparent powers of the three phases is determined for each of the five measurements (1-min means) in the respective operating point. The maximum of these five values is again determined.

Assessment criterion:
The test is passed if the maximum value from the above measurements does not exceed 4,6 kVA for apparent power imbalance and 0.2% for voltage unbalance.

Note:

4.1.6 Power drop of single inverter modules							**N/A**
Test:							
1-min mean value	L1	L2	L3	L1 – L2	L2 – L3	L3 – L1	
a) Power reduction of one phase by at least 4,6 kVA + 10%							
S_{E60} [kVA]:	--	--	--	--	--	--	
	--	--	--	--	--	--	
	--	--	--	--	--	--	
	--	--	--	--	--	--	
	--	--	--	--	--	--	
cos φ_{E60}:	--						
max. asymmetry [kVA]:	--						
U_{60} [V]:	--	--	--	--	--	--	
	--	--	--	--	--	--	
	--	--	--	--	--	--	
	--	--	--	--	--	--	
	--	--	--	--	--	--	
max. asymmetry [V]:	--						
max. asymmetry [%]:	--						
Power Limit [kVA]:	4,6 kVA						
Voltage Limit [%]:	0,2 %						

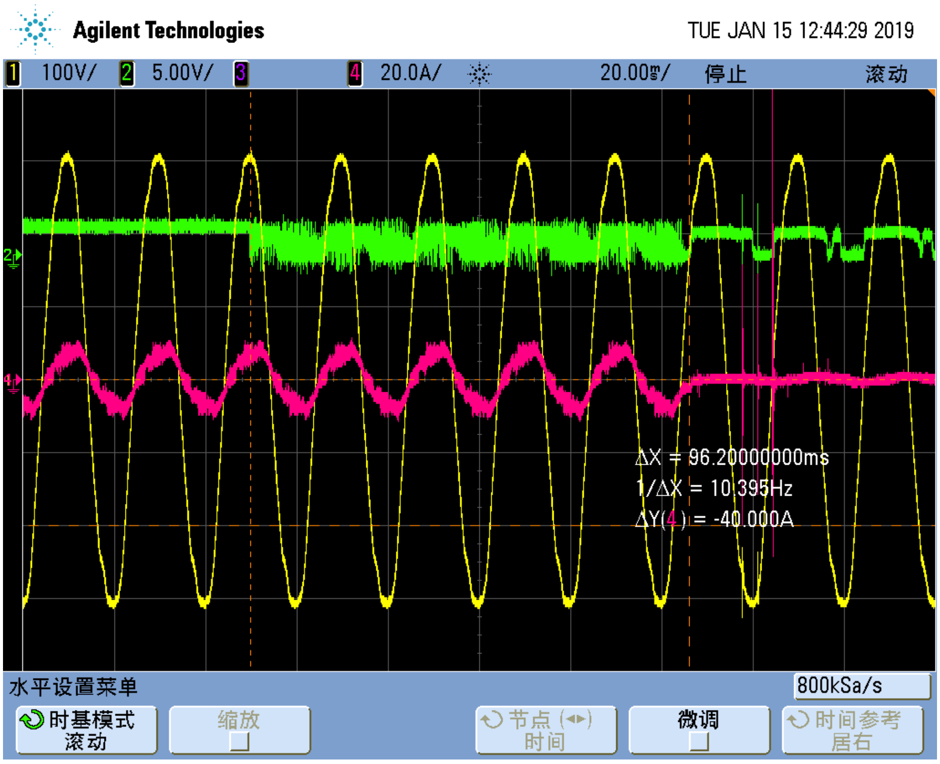
Test:
The maximum absolute difference between the apparent powers of the three phases is determined for each of the five measurements (1-min means) in the respective operating point. The maximum of these five values is again determined.

Assessment criterion:
The test is passed if the maximum value from the above measurements does not exceed 4,6 kVA for apparent power imbalance and 0.2% for voltage unbalance.

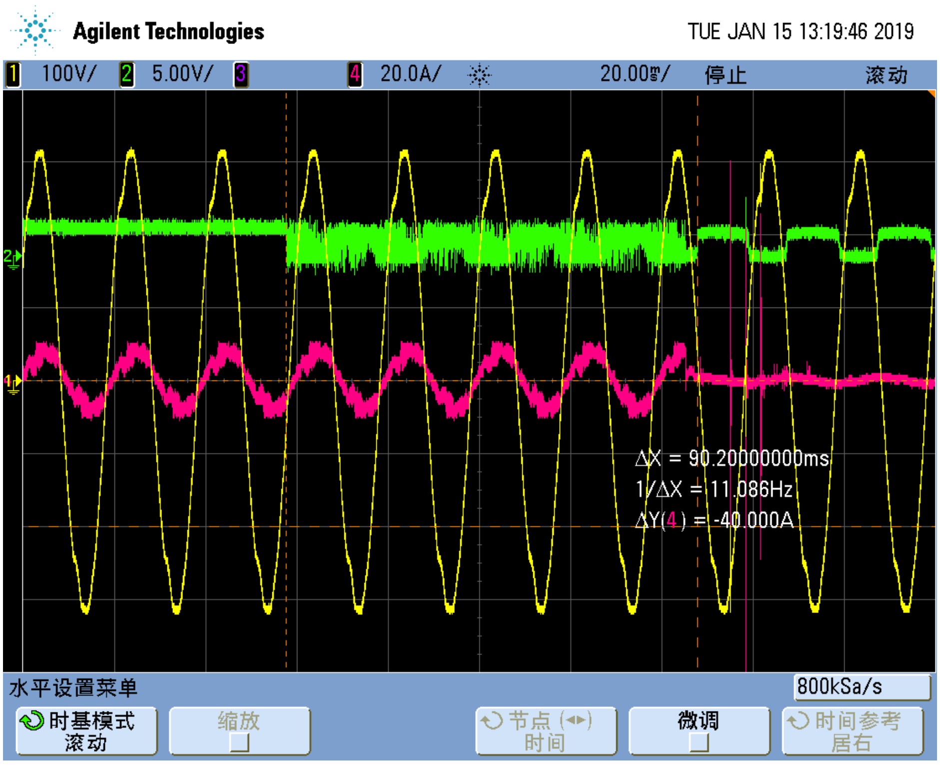
Note:

4.1.8 DC-Injection					**P**
Test conditions:	U_N = 230Vac Uinput = 600Vdc Rated Power: 10,0kW				
Test result:					
DC Injection (A)	**Limits**		**Trip Time L1 (ms)**	**Trip Time L2 (ms)**	**Trip Time L3 (ms)**
+0,075A	I_{DC}:>0,5%I_{rated} than disconnection within 0,5 sec		88	90	90
-0,075A	I_{DC}:>0,5%I_{rated} than disconnection within 0,5 sec		96	95	86
Note: A dc-current of greater than 0,5% of Iac nom cause a disconnection time of max. 0,5s					

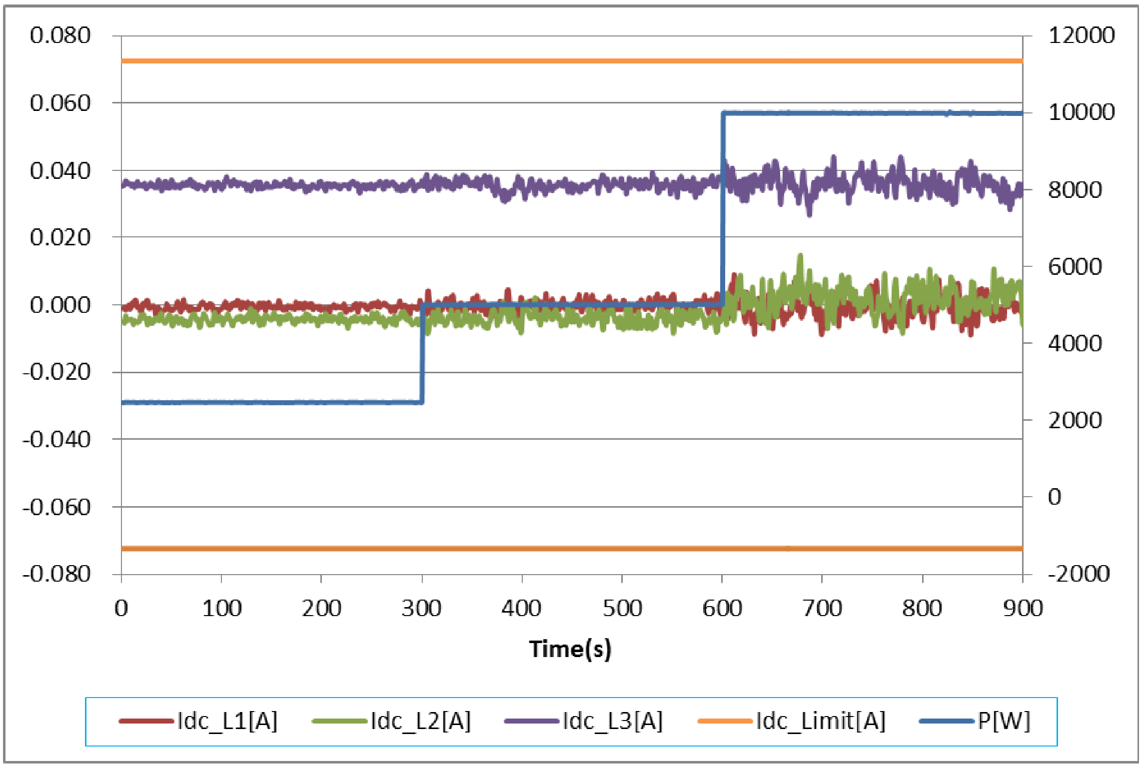
Negative DC-Injection:



Positive DC-Injection:



4.1.8 DC-Injection (Monitoring)			P
Test result:			
IEC61727 Limit:	0,5% of Inom (72mA)		
Output power:	25%	50%	100%
Max test value phase 1:	3,0	4,5	4,5
Average test value phase 1:	0,6	0,3	0,3
Max test value phase 2:	7,0	8,4	8,4
Average test value phase 2:	4,3	4,0	4,0
Max test value phase 3:	38,1	39,3	39,3
Average test value phase 3:	35,6	35,7	35,7



Note:

4.1.10 Harmonics and waveform distortion	P
The currents of the interharmonics to 2 kHz must be measured in accordance with IEC 61000-4-7, Annex A. The measurements of higher-frequency harmonic currents between 2 kHz and 9 kHz must be conducted in line with IEC 61000-4-7, Annex B.	
Test:	

Harmonics:											
P/Pn [%]	0/5	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
THD	3,04	3,07	4,27	3,77	2,62	2,51	2,70	2,98	3,20	3,42	3,64
1	3,64	11,12	20,31	29,89	41,29	50,57	60,80	71,10	81,15	91,20	101,30
2	0,26	0,28	0,30	0,31	0,35	0,39	0,43	0,47	0,52	0,56	0,60
3	0,81	1,14	1,17	1,21	1,21	1,20	1,20	1,23	1,27	1,33	1,40
4	0,09	0,08	0,09	0,11	0,11	0,12	0,12	0,14	0,14	0,16	0,17
5	0,35	0,52	0,90	1,12	1,20	1,15	1,11	1,09	1,08	1,07	1,09
6	0,05	0,06	0,06	0,08	0,08	0,08	0,08	0,09	0,09	0,10	0,11
7	0,28	0,11	0,49	0,49	0,77	0,84	0,86	0,86	0,86	0,86	0,86
8	0,05	0,06	0,06	0,10	0,09	0,10	0,09	0,10	0,09	0,10	0,11
9	0,42	0,46	0,49	0,44	0,69	0,81	0,87	0,90	0,91	0,92	0,93
10	0,06	0,06	0,06	0,11	0,10	0,11	0,11	0,11	0,10	0,10	0,11
11	0,42	0,89	0,61	0,56	0,49	0,68	0,77	0,83	0,87	0,90	0,93
12	0,07	0,08	0,07	0,13	0,11	0,10	0,10	0,10	0,10	0,11	0,12
13	0,97	0,97	1,14	0,82	0,37	0,56	0,69	0,81	0,89	0,95	1,01
14	0,09	0,08	0,09	0,15	0,12	0,12	0,11	0,13	0,13	0,13	0,15
15	0,90	0,83	1,80	1,02	0,29	0,51	0,77	0,97	1,09	1,18	1,25
16	0,09	0,08	0,09	0,17	0,12	0,14	0,14	0,16	0,16	0,15	0,16
17	1,11	0,95	1,81	1,22	0,36	0,41	0,69	0,90	1,03	1,12	1,20
18	0,08	0,08	0,09	0,20	0,14	0,13	0,13	0,15	0,15	0,15	0,17
19	1,11	0,96	1,71	1,46	0,48	0,29	0,49	0,68	0,82	0,94	1,05
20	0,08	0,08	0,09	0,16	0,13	0,11	0,10	0,12	0,13	0,14	0,17
21	1,09	0,86	1,35	1,42	0,51	0,28	0,34	0,52	0,68	0,85	1,00
22	0,05	0,07	0,07	0,11	0,11	0,09	0,09	0,11	0,13	0,13	0,15
23	0,82	0,80	0,97	1,07	0,45	0,23	0,21	0,30	0,41	0,52	0,64
24	0,05	0,05	0,06	0,07	0,09	0,07	0,06	0,08	0,09	0,10	0,12
25	0,70	0,67	0,69	0,83	0,42	0,21	0,18	0,21	0,27	0,34	0,42
26	0,04	0,04	0,05	0,05	0,08	0,06	0,05	0,06	0,06	0,07	0,08
27	0,63	0,63	0,56	0,65	0,41	0,20	0,17	0,18	0,20	0,23	0,27
28	0,03	0,04	0,04	0,05	0,07	0,05	0,04	0,05	0,06	0,06	0,07
29	0,48	0,50	0,45	0,50	0,37	0,15	0,13	0,12	0,11	0,13	0,15
30	0,03	0,03	0,04	0,05	0,06	0,05	0,04	0,04	0,05	0,06	0,06
31	0,42	0,41	0,37	0,42	0,37	0,17	0,13	0,13	0,12	0,12	0,13
32	0,03	0,03	0,04	0,05	0,06	0,05	0,03	0,04	0,04	0,05	0,06
33	0,39	0,39	0,31	0,36	0,36	0,18	0,14	0,14	0,14	0,13	0,13
34	0,02	0,02	0,03	0,05	0,06	0,05	0,03	0,03	0,04	0,04	0,05
35	0,31	0,31	0,30	0,28	0,32	0,18	0,12	0,13	0,14	0,12	0,11
36	0,03	0,02	0,03	0,05	0,05	0,04	0,03	0,03	0,03	0,04	0,05
37	0,26	0,27	0,24	0,20	0,27	0,16	0,09	0,10	0,11	0,09	0,07
38	0,02	0,03	0,03	0,06	0,04	0,04	0,03	0,03	0,03	0,04	0,04
39	0,27	0,30	0,21	0,16	0,27	0,18	0,09	0,11	0,12	0,10	0,06
40	0,02	0,02	0,02	0,06	0,05	0,05	0,03	0,03	0,03	0,04	0,04
41	0,21	0,22	0,15	0,14	0,23	0,17	0,10	0,12	0,13	0,11	0,08
42	0,02	0,02	0,02	0,05	0,04	0,04	0,03	0,03	0,03	0,04	0,04

Harmonics:											
P/Pn [%]	0/5	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
43	0,17	0,20	0,12	0,11	0,23	0,17	0,09	0,11	0,12	0,11	0,08
44	0,03	0,02	0,03	0,05	0,04	0,04	0,03	0,04	0,03	0,04	0,05
45	0,18	0,23	0,09	0,08	0,23	0,16	0,10	0,10	0,11	0,09	0,07
46	0,03	0,03	0,02	0,05	0,04	0,04	0,03	0,04	0,04	0,04	0,04
47	0,11	0,14	0,05	0,07	0,18	0,14	0,09	0,09	0,10	0,10	0,09
48	0,02	0,03	0,03	0,05	0,05	0,05	0,04	0,04	0,04	0,04	0,04
49	0,10	0,13	0,07	0,08	0,16	0,13	0,10	0,10	0,12	0,13	0,13
50	0,03	0,03	0,03	0,05	0,05	0,04	0,04	0,05	0,04	0,03	0,05
51	0,09	0,13	0,10	0,10	0,19	0,15	0,13	0,11	0,13	0,15	0,14
52	0,03	0,03	0,03	0,05	0,06	0,05	0,04	0,04	0,05	0,04	0,05
53	0,06	0,08	0,08	0,08	0,11	0,11	0,11	0,09	0,11	0,13	0,12
54	0,03	0,03	0,03	0,05	0,06	0,03	0,05	0,05	0,05	0,04	0,06
55	0,05	0,06	0,10	0,10	0,09	0,10	0,11	0,08	0,10	0,12	0,11
56	0,04	0,04	0,04	0,06	0,05	0,04	0,05	0,05	0,04	0,05	0,06
57	0,05	0,07	0,15	0,12	0,08	0,13	0,15	0,12	0,14	0,16	0,13
58	0,03	0,04	0,03	0,05	0,06	0,04	0,05	0,06	0,06	0,07	0,05
59	0,08	0,07	0,14	0,13	0,04	0,08	0,10	0,08	0,09	0,10	0,09
60	0,04	0,03	0,04	0,05	0,06	0,04	0,05	0,05	0,05	0,06	0,04

Interharmonics at continuous operation:											
P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
f [Hz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
75	0,29	0,32	0,38	0,48	0,60	0,71	0,81	0,92	1,06	1,19	1,28
125	0,22	0,21	0,23	0,25	0,31	0,35	0,40	0,45	0,50	0,56	0,59
175	0,18	0,16	0,15	0,17	0,20	0,22	0,24	0,27	0,30	0,33	0,36
225	0,20	0,18	0,17	0,16	0,19	0,21	0,23	0,25	0,27	0,30	0,32
275	0,14	0,18	0,17	0,19	0,19	0,19	0,18	0,20	0,21	0,22	0,25
325	0,14	0,18	0,20	0,18	0,17	0,17	0,18	0,19	0,21	0,23	0,24
375	0,11	0,15	0,14	0,20	0,19	0,17	0,14	0,14	0,13	0,14	0,15
425	0,16	0,18	0,20	0,21	0,19	0,17	0,15	0,16	0,16	0,18	0,19
475	0,10	0,14	0,09	0,17	0,24	0,24	0,21	0,19	0,18	0,18	0,18
525	0,19	0,25	0,19	0,26	0,32	0,31	0,26	0,21	0,20	0,19	0,20
575	0,14	0,16	0,11	0,17	0,30	0,30	0,26	0,21	0,20	0,19	0,19
625	0,23	0,19	0,24	0,23	0,39	0,41	0,35	0,29	0,25	0,24	0,22
675	0,16	0,12	0,19	0,19	0,38	0,39	0,34	0,27	0,24	0,22	0,21
725	0,19	0,16	0,33	0,26	0,42	0,46	0,41	0,33	0,27	0,24	0,22
775	0,13	0,13	0,25	0,20	0,35	0,38	0,34	0,27	0,24	0,23	0,22
825	0,27	0,23	0,34	0,31	0,41	0,45	0,43	0,34	0,27	0,23	0,21
875	0,17	0,13	0,30	0,20	0,27	0,31	0,30	0,28	0,29	0,30	0,32
925	0,19	0,22	0,23	0,34	0,44	0,49	0,47	0,41	0,35	0,32	0,29
975	0,16	0,12	0,28	0,28	0,27	0,27	0,27	0,25	0,26	0,29	0,31
1025	0,15	0,17	0,15	0,22	0,37	0,42	0,44	0,41	0,39	0,38	0,37
1075	0,13	0,13	0,20	0,24	0,28	0,26	0,26	0,23	0,22	0,22	0,24
1125	0,13	0,12	0,13	0,15	0,27	0,29	0,31	0,30	0,30	0,30	0,29
1175	0,11	0,13	0,17	0,20	0,21	0,19	0,17	0,16	0,15	0,15	0,16
1225	0,12	0,09	0,11	0,12	0,20	0,20	0,18	0,17	0,16	0,17	0,18
1275	0,15	0,13	0,16	0,18	0,16	0,11	0,10	0,11	0,11	0,12	0,14
1325	0,07	0,07	0,08	0,07	0,13	0,17	0,16	0,15	0,15	0,15	0,15
1375	0,12	0,12	0,12	0,13	0,15	0,13	0,10	0,12	0,13	0,14	0,14
1425	0,05	0,05	0,06	0,07	0,08	0,11	0,11	0,10	0,11	0,14	0,16
1475	0,08	0,09	0,10	0,10	0,11	0,11	0,09	0,08	0,10	0,12	0,12
1525	0,06	0,05	0,07	0,07	0,06	0,09	0,09	0,07	0,08	0,09	0,10
1575	0,09	0,09	0,10	0,09	0,11	0,10	0,08	0,07	0,09	0,10	0,11

Interharmonics at continuous operation:

P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
f [Hz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
1625	0,07	0,06	0,08	0,07	0,07	0,08	0,07	0,06	0,07	0,09	0,10
1675	0,10	0,09	0,11	0,09	0,11	0,11	0,09	0,09	0,11	0,13	0,12
1725	0,06	0,05	0,07	0,06	0,06	0,06	0,06	0,05	0,06	0,07	0,08
1775	0,09	0,08	0,12	0,08	0,09	0,10	0,10	0,09	0,11	0,13	0,15
1825	0,06	0,05	0,07	0,07	0,06	0,05	0,04	0,05	0,07	0,08	0,09
1875	0,07	0,08	0,10	0,08	0,05	0,06	0,07	0,06	0,06	0,08	0,09
1925	0,06	0,06	0,07	0,09	0,04	0,05	0,04	0,05	0,06	0,07	0,08
1975	0,07	0,08	0,09	0,09	0,04	0,05	0,07	0,06	0,06	0,07	0,08
2025	0,07	0,06	0,07	0,10	0,04	0,04	0,05	0,05	0,06	0,07	0,08
2075	0,08	0,09	0,10	0,10	0,04	0,05	0,08	0,08	0,08	0,09	0,10
2125	0,07	0,06	0,07	0,09	0,04	0,04	0,04	0,05	0,05	0,06	0,06
2175	0,08	0,08	0,10	0,10	0,05	0,04	0,08	0,09	0,08	0,08	0,10
2225	0,07	0,07	0,07	0,09	0,04	0,05	0,05	0,06	0,06	0,07	0,08
2275	0,07	0,07	0,08	0,08	0,05	0,04	0,05	0,06	0,05	0,05	0,07
2325	0,07	0,06	0,06	0,10	0,05	0,04	0,05	0,05	0,05	0,06	0,07
2375	0,06	0,06	0,07	0,08	0,06	0,05	0,04	0,05	0,04	0,05	0,06
2425	0,07	0,07	0,07	0,10	0,06	0,04	0,04	0,05	0,05	0,05	0,06
2475	0,07	0,08	0,09	0,10	0,06	0,04	0,04	0,06	0,06	0,06	0,08
2525	0,07	0,07	0,08	0,10	0,06	0,04	0,03	0,04	0,04	0,04	0,05
2575	0,08	0,07	0,09	0,09	0,07	0,05	0,04	0,05	0,06	0,07	0,08
2625	0,07	0,07	0,08	0,10	0,06	0,04	0,04	0,05	0,06	0,06	0,08
2675	0,06	0,06	0,07	0,07	0,06	0,06	0,06	0,03	0,04	0,06	0,06
2725	0,07	0,07	0,07	0,09	0,05	0,04	0,04	0,03	0,05	0,06	0,06
2775	0,05	0,05	0,06	0,05	0,06	0,07	0,07	0,04	0,03	0,05	0,05
2825	0,07	0,07	0,08	0,09	0,05	0,05	0,05	0,03	0,03	0,05	0,05
2875	0,05	0,05	0,07	0,06	0,06	0,07	0,06	0,03	0,03	0,05	0,05
2925	0,06	0,06	0,07	0,08	0,04	0,05	0,05	0,04	0,04	0,04	0,05
2975	0,05	0,05	0,06	0,05	0,06	0,06	0,06	0,04	0,04	0,05	0,04

Higher Frequencies components:

P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
f [kHz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
2,1	0,30	0,33	0,25	0,26	0,34	0,26	0,20	0,22	0,22	0,22	0,22
2,3	0,25	0,30	0,17	0,21	0,31	0,23	0,16	0,18	0,19	0,18	0,18
2,5	0,20	0,24	0,20	0,22	0,27	0,22	0,18	0,19	0,22	0,23	0,23
2,7	0,16	0,16	0,20	0,21	0,19	0,18	0,19	0,16	0,18	0,22	0,20
2,9	0,15	0,15	0,24	0,24	0,15	0,19	0,20	0,17	0,19	0,22	0,18
3,1	0,16	0,14	0,23	0,23	0,11	0,17	0,18	0,16	0,18	0,17	0,17
3,3	0,16	0,15	0,19	0,19	0,11	0,14	0,15	0,15	0,15	0,13	0,18
3,5	0,16	0,16	0,16	0,18	0,10	0,11	0,12	0,13	0,13	0,13	0,16
3,7	0,16	0,15	0,14	0,14	0,10	0,10	0,11	0,12	0,11	0,13	0,12
3,9	0,13	0,13	0,11	0,11	0,09	0,08	0,09	0,10	0,11	0,10	0,08
4,1	0,10	0,11	0,08	0,08	0,06	0,07	0,07	0,08	0,08	0,07	0,07
4,3	0,08	0,09	0,07	0,07	0,05	0,06	0,07	0,06	0,07	0,05	0,08
4,5	0,08	0,08	0,06	0,06	0,05	0,05	0,06	0,05	0,06	0,06	0,09
4,7	0,06	0,06	0,06	0,06	0,05	0,05	0,05	0,05	0,05	0,07	0,07
4,9	0,05	0,05	0,06	0,06	0,04	0,04	0,05	0,04	0,05	0,06	0,05
5,1	0,05	0,05	0,06	0,06	0,04	0,04	0,04	0,04	0,05	0,05	0,05
5,3	0,04	0,04	0,05	0,05	0,04	0,03	0,04	0,03	0,04	0,04	0,05
5,5	0,05	0,05	0,05	0,05	0,04	0,04	0,04	0,03	0,04	0,04	0,04
5,7	0,04	0,04	0,05	0,04	0,04	0,03	0,03	0,03	0,03	0,04	0,03
5,9	0,04	0,04	0,04	0,04	0,03	0,03	0,03	0,02	0,02	0,03	0,03
6,1	0,04	0,04	0,03	0,04	0,03	0,02	0,03	0,02	0,03	0,02	0,03

Higher Frequencies components:											
P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
f [kHz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
6,3	0,04	0,04	0,04	0,03	0,03	0,02	0,03	0,02	0,03	0,02	0,03
6,5	0,03	0,03	0,03	0,03	0,03	0,02	0,02	0,02	0,02	0,03	0,03
6,7	0,03	0,03	0,03	0,03	0,03	0,02	0,02	0,02	0,02	0,03	0,02
6,9	0,03	0,03	0,03	0,03	0,02	0,02	0,02	0,02	0,02	0,03	0,02
7,1	0,03	0,03	0,03	0,03	0,02	0,02	0,02	0,02	0,02	0,02	0,02
7,3	0,04	0,04	0,03	0,04	0,03	0,03	0,03	0,03	0,03	0,04	0,04
7,5	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,05
7,7	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,05
7,9	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,1	0,03	0,03	0,04	0,03	0,03	0,03	0,04	0,04	0,04	0,05	0,05
8,3	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,05	0,05
8,5	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
8,7	0,02	0,02	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,02
8,9	0,02	0,02	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01

Assessment criterion:

The harmonic and inter-harmonic current distortion shall comply with the relevant emission limits in accordance with IEC 61727, reproduced in table 1.

Note:

The normalization current is: 14,5 A per phase.

The stated harmonics are maximum value of all 3 phases.

4.1.7 Power factor					P
Test result:					
Test conditions:					
Output power / **Test voltage (Vac)**	**~10%**	**~25%**	**~50%**	**~75%**	**~100%**
230V	0,9931c	0,9982c	0,9996c	0,9998c	0,9999c

Note:
*The PV system shall have a lagging power factor greater than 0,9 when the output is greater than 50% of the rated inverter output power.

The letter "i" is short for "inductive" and indicates inductive power factor. In case of capacitive power factor the letter "c" is used instead.

4.1.11.3 Power factor (Fixed cos φ)				P
Test:				
Test condition: over-excited (c) (cos φ = 0,95)				
Rating power [%]	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage [V]
10% ±5%	0,864	0,347	0,9279	231,27
20% ±5%	1,895	0,663	0,9439	231,26
50% ±5%	4,910	1,653	0,9477	231,38
75% ±5%	7,538	2,533	0,9479	230,94
100% ±5%	9,473	3,200	0,9474	230,90
Test condition: under-excited (i) (cos φ = 0,95)				
Rating power [%]	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage [V]
10% ±5%	1,181	0,444	0,9087	230,54
20% ±5%	2,165	-0,690	0,9476	230,63
50% ±5%	5,284	-1,559	0,9555	230,77
75% ±5%	7,886	-2,310	0,9561	230,66
100% ±5%	9,895	-2,910	0,9558	230,25
Test condition: power factor (cos φ = 1)				
Rating power [%]	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage [V]
10% ±5%	0,871	0,105	0,9928	231,23
20% ±5%	1,908	0,115	0,9982	231,28
50% ±5%	4,937	0,152	0,9995	231,47
75% ±5%	7,525	0,206	0,9996	231,61
100% ±5%	9,504	0,252	0,9996	231,38

Assessment criterion:

The power factor resulting in each of the measurement points greater than between 20 % of the nominal power is equal to or lower than 0,98 for SSEG categories A1/A2 and 0,95 for SSEG categories A3 both in over excited and under excited operation.

The maximum tolerance on the reactive power setting is ±0,01 of power factor.

Note:

a) 1 min-average-values were calculated using measurements at the basic frequency in a period of 200 ms.

b) For each of the 10 active power levels, at least 3 under excited and 3 over excited reactive power levels were recorded.

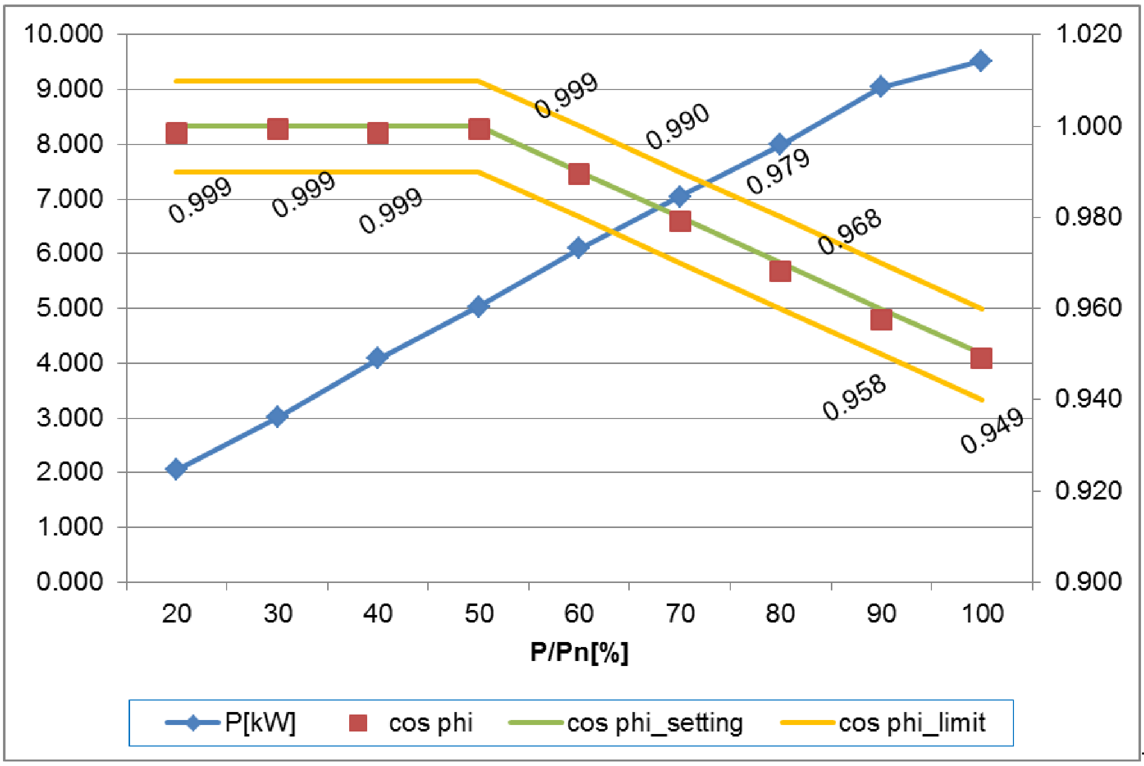
c) 1 min-average-values were calculated using voltage measurements at the basic frequency in a period of 200 ms.

4.1.11.9	Test for a displacement factor/active power characteristic curve cos φ (P) (For embedded generators of sub-category A3)	P

Test:

Rating power [%]	Active power P [kW]	Reactive power Q [kVar]	cos φ measured	cos φ expected	Δ cos φ
20%	2,046	0,112	0,999	1,00	-0,001
30%	3,011	0,120	0,999	1,00	-0,001
40%	4,081	0,129	0,999	1,00	-0,001
50%	5,036	0,139	0,999	1,00	-0,001
60%	6,097	0,890	0,990	0,99	0,000
70%	7,046	1,465	0,979	0,98	-0,001
80%	7,998	2,068	0,968	0,97	-0,002
90%	9,047	2,722	0,958	0,96	-0,002
100%	9,520	3,156	0,949	0,95	-0,001

Graph:



Note:

4.1.12 4.2.4	**Synchronization** **Response to utility recovery**	**P**

Test:		
	Voltage conditons	
a) Out of voltage range	<=95%V	>=105%
Connection:	No reconnected.	No reconnected.
Limit	No connection allowed	
a) In voltage range	95% U_n < U <105% U_n	
Reconnection time [s]	173	77
Limit:	At least 60s	
	Frequency conditons	
b) Out of frequency range	<=49,7Hz	>=50,3Hz
Connection:	No reconnected.	No reconnected.
Limit	No connection allowed	
b) In frequency range	49,7Hz < f<50,3Hz	
Reconnection time [s]	75	71
Limit:	At least 60s	
	Phase angle condition	
c) Out of Phase angle range	<=100°	>=140°
Connection:	No reconnected.	No reconnected.
Limit	No connection allowed	
c) In phase angle range	100° < φ <140°	
Reconnection time [s]	110	151
Limit:	At least 60s	
Gradient:	The maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute Max gradient: 10%Pn/min. The connection after trip of the interface protection is delayed by a randomized value between 1 min and 10 min. For recorded gradient see diagram underneath.	

Note:
The limits for the synchronizing parameters for each phase are

a) frequency difference: 0,3 Hz,

b) voltage difference: 5 % = 11,5 V per phase, and

c) phase angle difference: 20°.

Test:

Test condition a) : voltage within the limits of 95% to 105%Vn

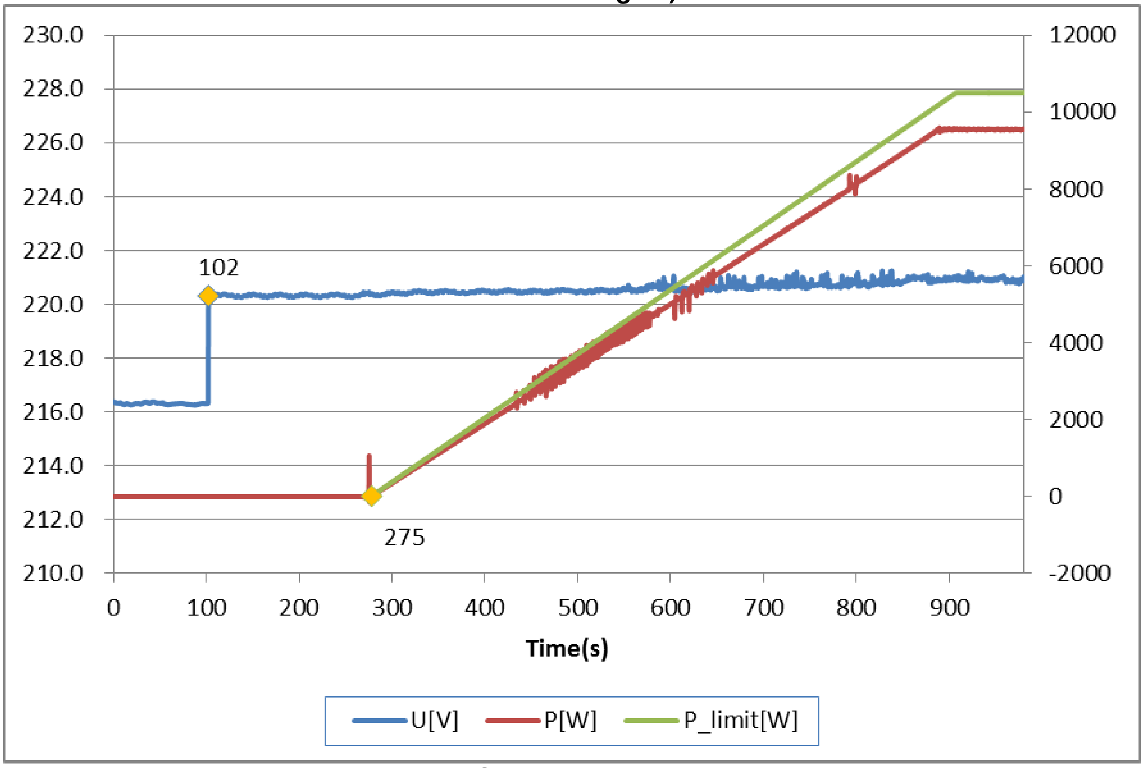
Test condition b) : frequency within the limits of 47Hz to 50,5Hz

Test condition c) : phase angle within the limits of 100° to 140° (Three phase type of genneration only)

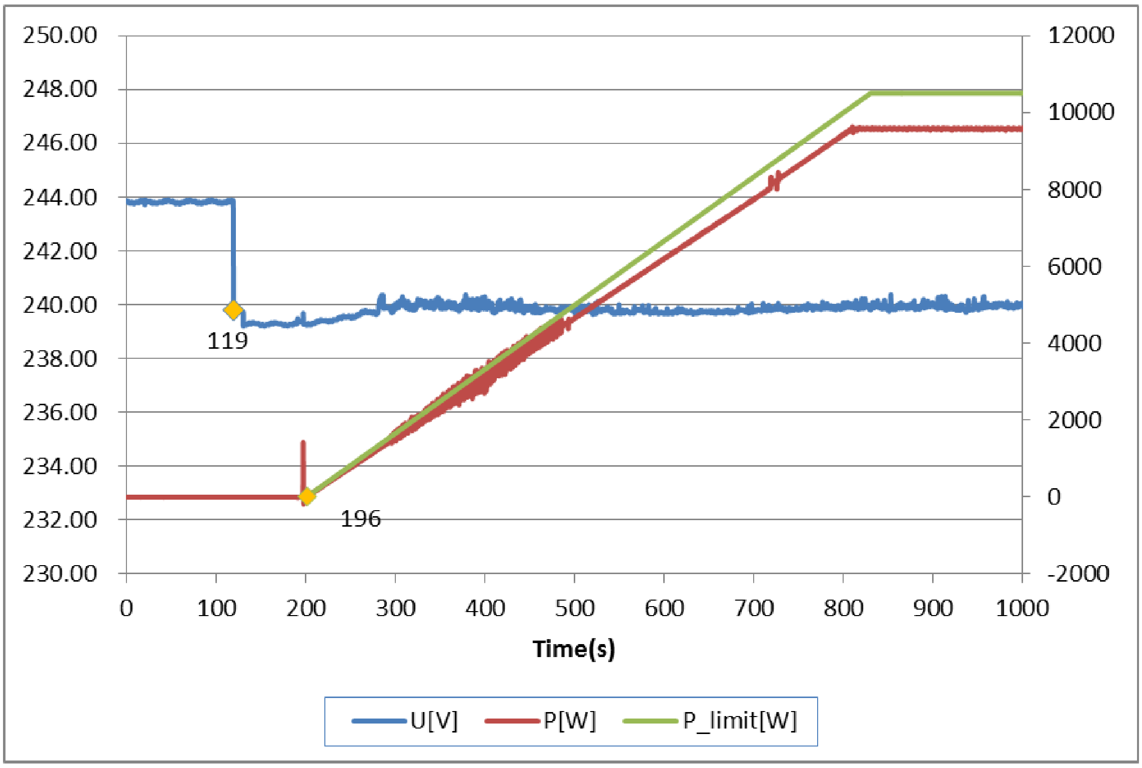
In order to avoid continuous starting and disengaging operations of the interface protection relay, the disengaging value of frequency and voltage functions shall be above 0,2%Fn and 2%Un deviating from the operate value.

4.2.4.2.2 Graph of reconnection with gradient:

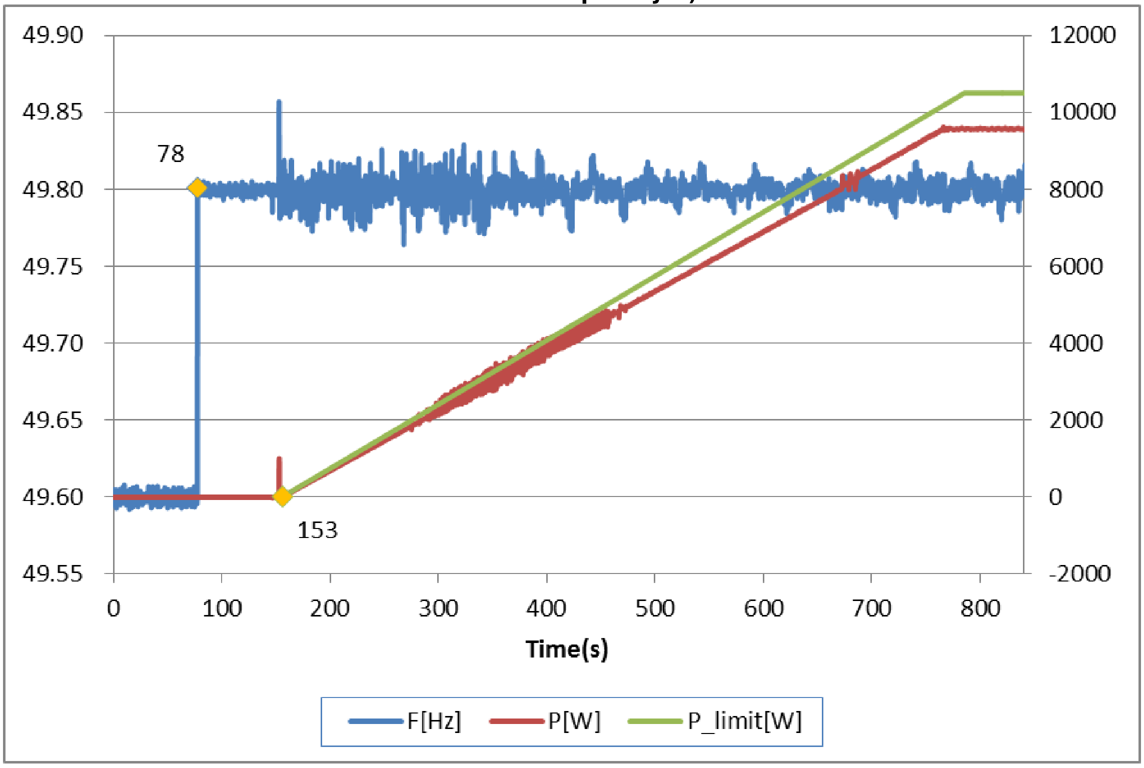
Under Voltage a)



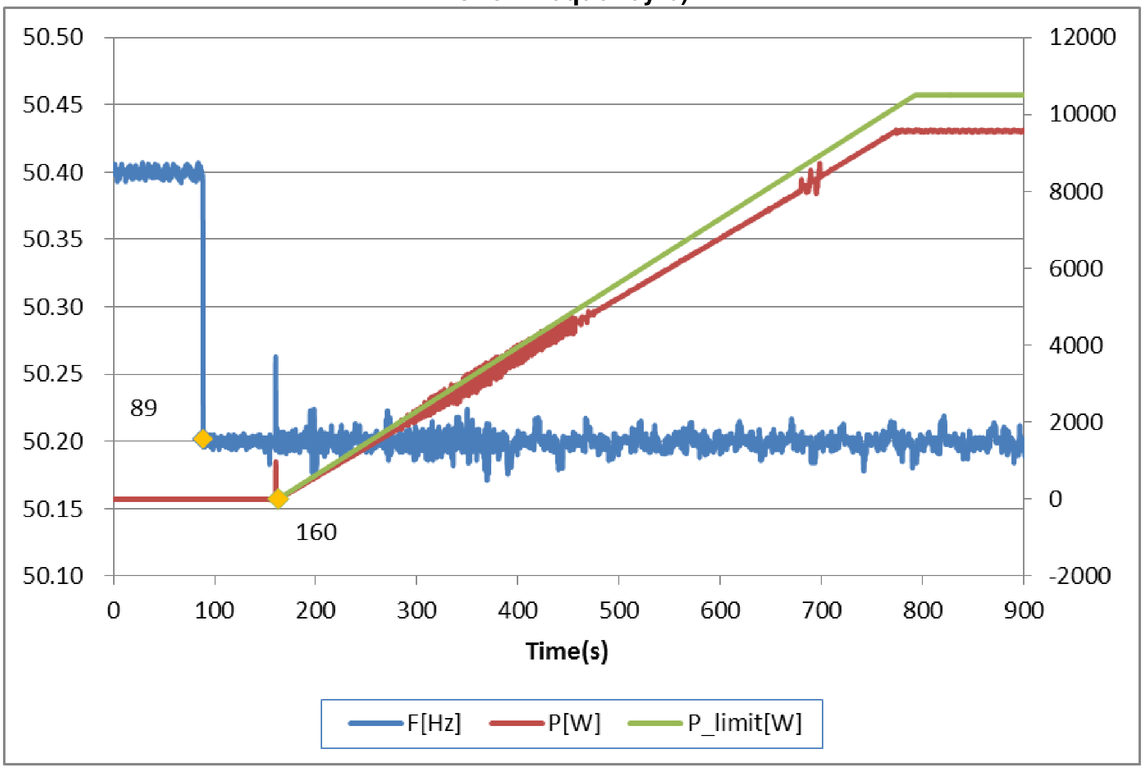
Over Voltage a)



Under Frequency b)



Over Frequency b)



Controllable generators may reconnect immediately after the 60 s delay confirming recovery of the system voltage and frequency at a maximum rate of 10 % of rated power per minute, i.e. full power output will only be reached after 10 minutes.

4.2.2.3.2	Overvoltage and undervoltage								P
First Level									
	Under Voltage				**Over Voltage**				
Parameter		Voltage [V]				Voltage [V]			
Set value		**195,5**				**253**			
Measured trip value [V]	Phase	L1	L2	L3	Phase	L1	L2	L3	
		195,5	195,7	195,7		253,4	253,5	253,6	
		195,5	195,7	195,7		253,4	253,5	253,6	
		195,5	195,7	195,7		253,4	253,5	253,6	
Parameter		Time [s]				Time [s]			
Limit		**≤ 10,0**				**≤ 40,0**			
Disconnetion time [s]	200V to 190V	8,000	8,040	8,060	248V to 258V	0,072	0,061	0,062	
		8,000	8,020	8,030		0,076	0,075	0,067	
		8,030	8,050	8,000		0,070	0,062	0,065	
Second Level									
	Under Voltage				**Over Voltage**				
Parameter		Voltage [V]				Voltage [V]			
Set value		**115**				**264,5**			
Measured trip value [V]	Phase	L1	L2	L3	Phase	L1	L2	L3	
		114,5	114,6	115,0		265,0	264,9	265,0	
		114,5	114,6	115,0		265,0	264,9	265,0	
		114,5	114,6	115,0		265,0	264,9	265,0	
Parameter		Time [s]				Time [s]			
Limit		**≤ 0,2**				**≤ 2,0**			
Disconnetion time [s]	200V to 113V	0,011	0,014	0,013	248V to 270V	0,052	0,051	0,058	
		0,012	0,014	0,013		0,060	0,056	0,074	
		0,012	0,016	0,018		0,046	0,046	0,064	

Third Level							
	--			Over Voltage			
Parameter		--		Voltage [V]			
Set value				276			
Measured trip value [V]	--		Phase	L1	L2	L3	
				276,3	275,4	275,2	
				276,3	275,4	275,2	
				276,3	275,3	275,2	
Parameter				Time [s]			
Limit				≤ 0,16			
Disconnetion time [s]	--		248V to 280V	0,074	0,075	0,065	
				0,070	0,072	0,075	
				0,074	0,077	0,062	

Note:

The NRS 097-2-1 provide limits of accuracy for the utility voltage and frequency measurement of the power system. The values for tolerances given in Table 2 are used.

The accuracy for voltage trip values shall be within 0 % to +1 % of the nominal voltage from the upper boundary trip setting, and within -1% to 0% of the nominal voltage from the lower boundary trip setting.

If multi-voltage control settings are not possible, the more stringent trip time should be implemented, e.g. 2 s between 110% and 120% of voltage.

Under Voltage First Level:L1 phase

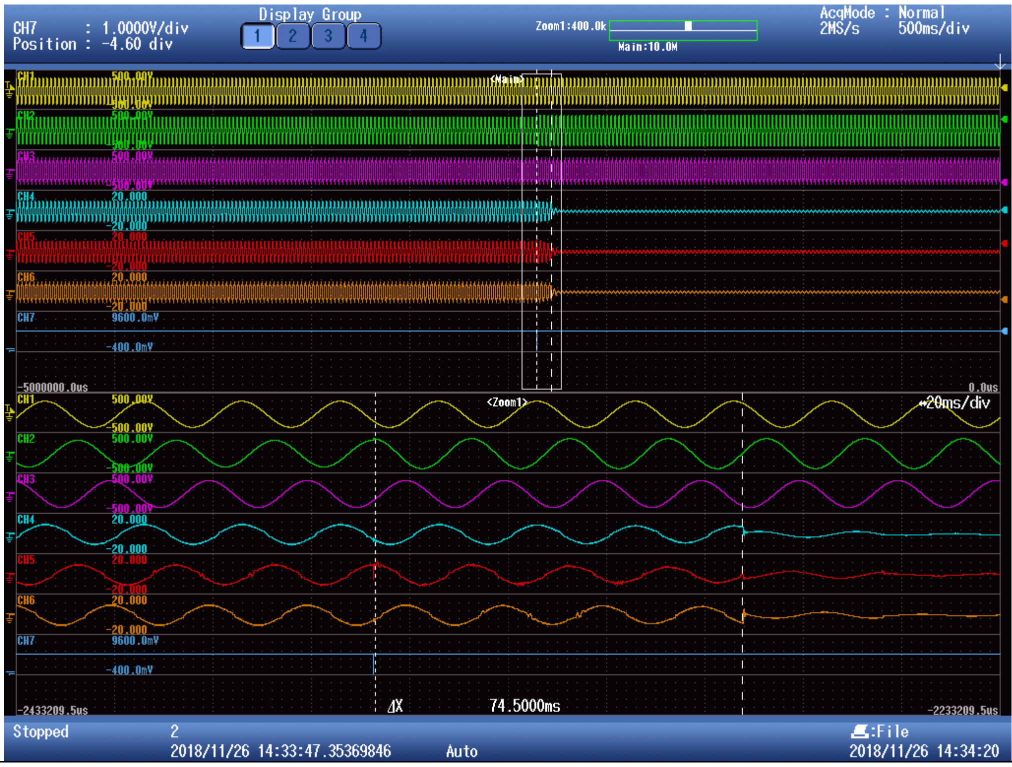
Over voltage First Level L1 phase

Under Voltage Second Level L1 phase

Over voltage Second Level L1 phase

Under Voltage First Level:L2 phase

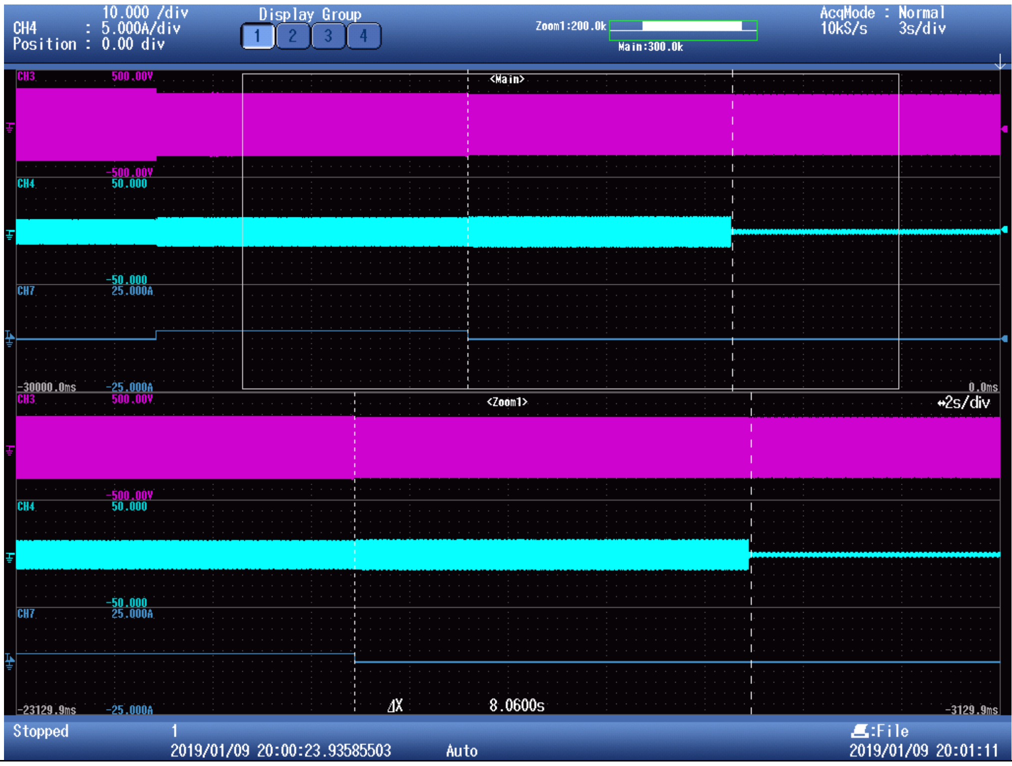
Over voltage First Level L2 phase



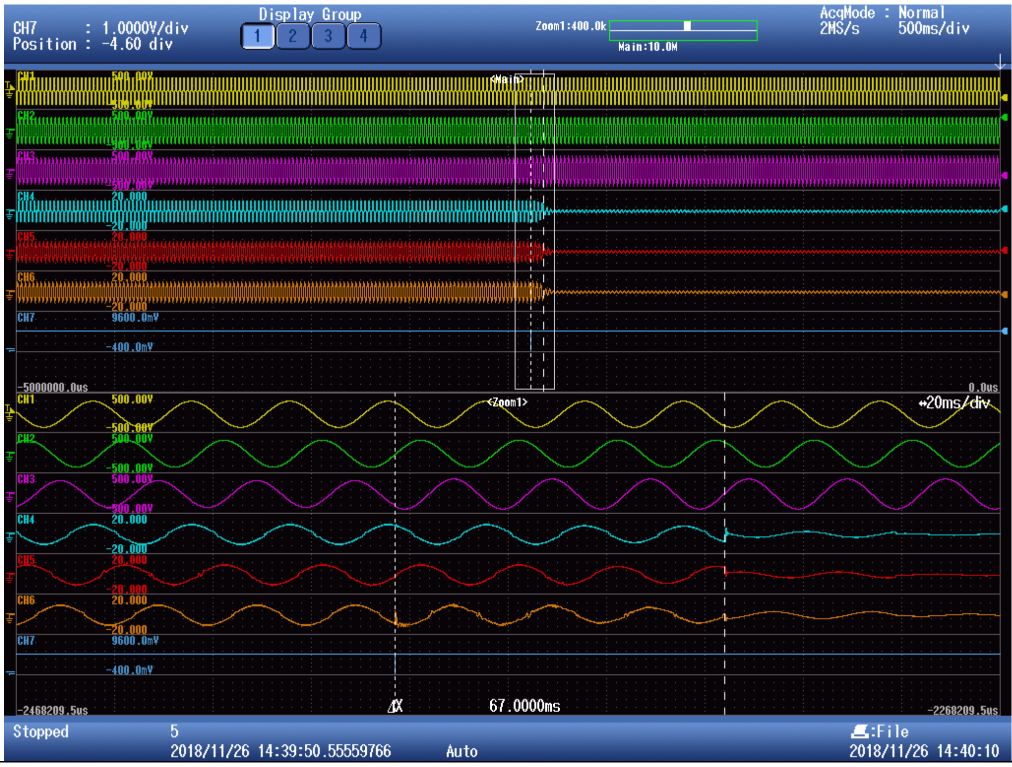
Under Voltage Second Level L2 phase

Over voltage Second Level L2 phase

Under Voltage First Level:L3 phase

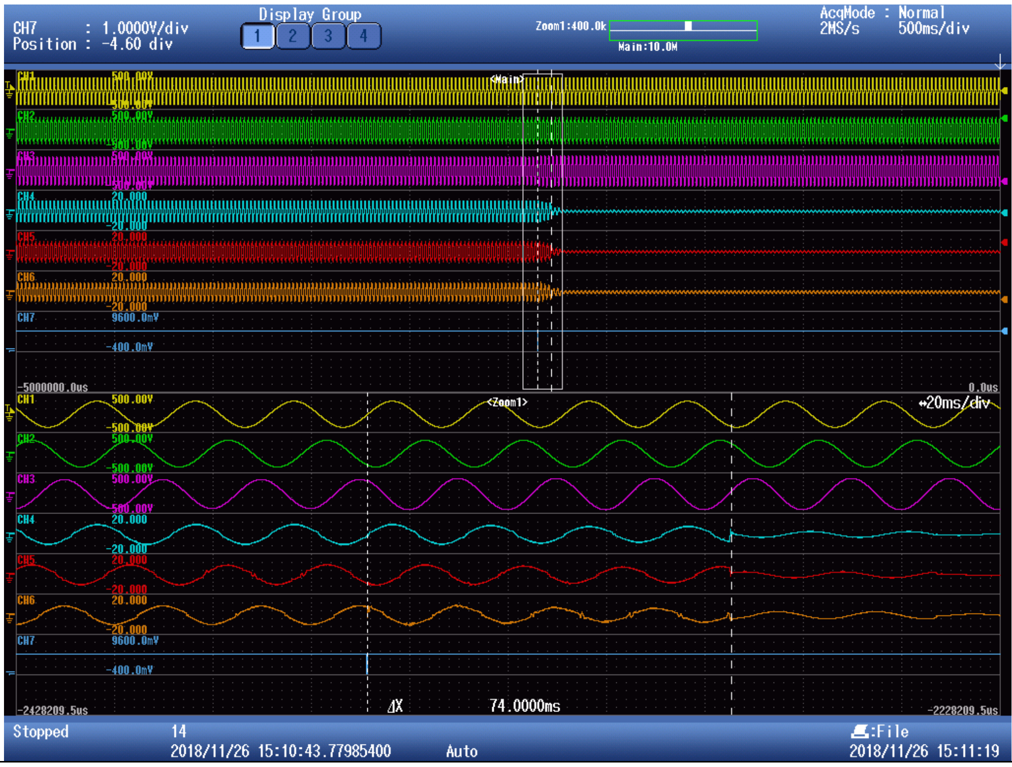


Over voltage First Level L3 phase



Under Voltage Second Level L3 phase

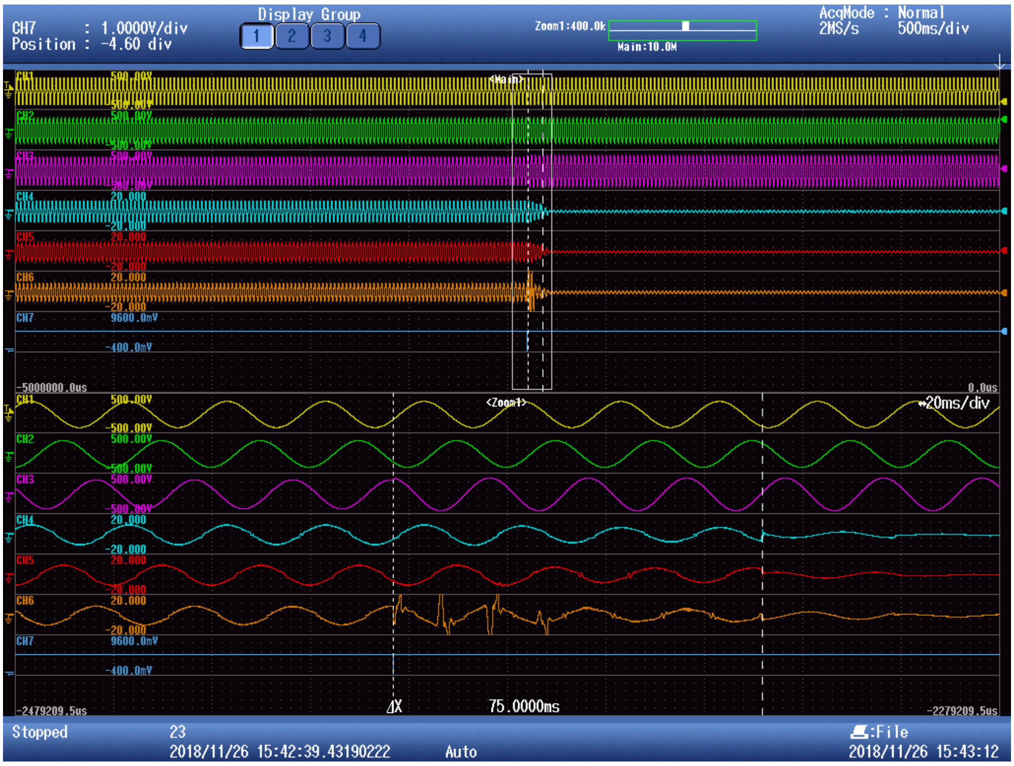
Over voltage Second Level L3 phase



Over voltage Third Level L1 phase

Over voltage Third Level L2 phase

Over voltage Third Level L3 phase



4.2.2.3.2	Low voltage fault Ride through capability (Category A1 and A2)	P

General:

The purpose of these tests is to ensure that the converter, which in category A1 and A2, is insensitive to voltage dips according to the time-amplitude profile shown in the diagram.

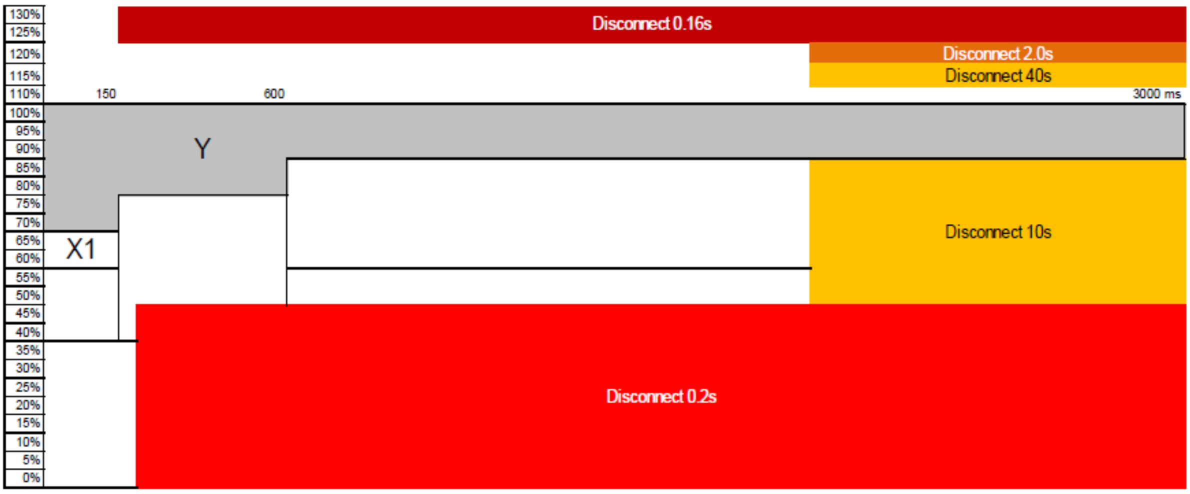


Figure 4 — Graphical representation of voltage-ride-through and voltage disconnect requirements for A1 and A2 EG

List of tests	Residual amplitude of phase-to-phase voltage V/V_{nom}		Duration [ms]	Form (*)
file: 1 - three-phase symmetrical fault	0,60	± 0,05 ($V1/V_{nom}$)	150 + 20	
file: 2 - three-phase symmetrical fault	0,70	± 0,05 ($V2/V_{nom}$)	150 + 20	
file: 3 - three-phase symmetrical fault	0,80-0,85	($V3/V_{nom}$)	600 + 20	
file: 4 - two-phase asymmetrical fault	0,60	± 0,05 ($V4/V_{nom}$)	150 + 20	
file: 5 - two -phase asymmetrical fault	0,70	± 0,05 ($V5/V_{nom}$)	150 + 20	
file: 6 - two -phase asymmetrical fault	0,80-0,85	($V6/V_{nom}$)	600 + 20	
file: 7 - single-phase symmetrical fault	0,60	± 0,05 ($V7/V_{nom}$)	150 + 20	
file: 8 - single-phase symmetrical fault	0,70	± 0,05 ($V8/V_{nom}$)	150 + 20	
file: 9 - single-phase symmetrical fault	0,80-0,85	($V9/V_{nom}$)	600 + 20	

* Regardless of the method used to simulate transients (simulator or impedance network), the rise and fall time of the voltage must be less than 10 ms

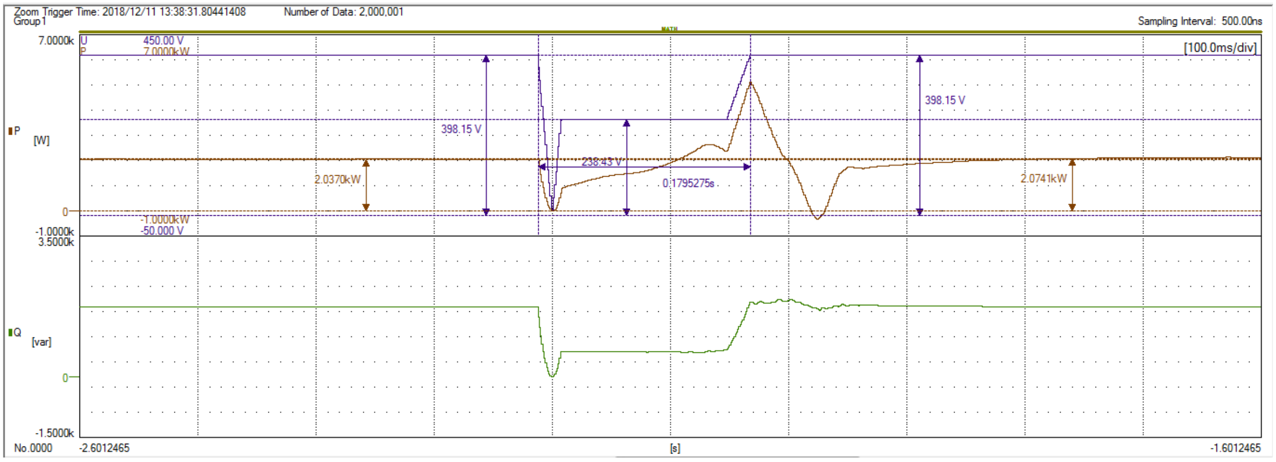
Assessment criterion:

The SSEG shall be able to withstand voltage drops without disconnecting, as shown in Figures 4 for Area X1 and Y. SSEGs of category A1 and A2 should not inject any reactive current into the network.

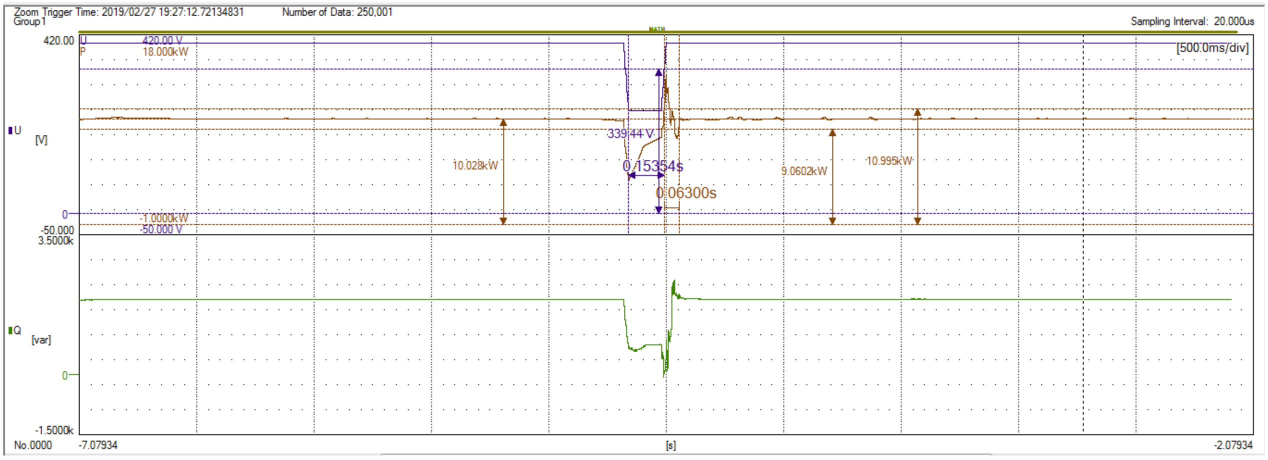
Upon clearance of fault each *RPP* shall restore active power production to at least 90% of the level available immediately prior to the fault within 1 second.

Graph of LVRT test one				
Test:				
List of tests	**Residual amplitude of phase-to-phase voltage V/V_{nom}**	**Duration limit of Voltage dips [ms]**	**Duration measured [ms]**	**Result**
1 – three-phase symmetrical fault (P = 0,1 - 0,3)	0,60± 0,05	150 + 20	159	P
1 – three-phase symmetrical fault (P > 0,9)	0,60± 0,05	150 + 20	153	P
2 – three-phase symmetrical fault (P = 0,1 - 0,3)	0,70± 0,05	150 + 20	161	P
2 – three-phase symmetrical fault (P > 0,9)	0,70± 0,05	150 + 20	157	P
3 – three-phase symmetrical fault (P = 0,1 - 0,3)	0,80-0,85	600 + 20	609	P
3 – three-phase symmetrical fault (P > 0,9)	0,80-0,85	600 + 20	609	P
4 – two-phase asymmetrical fault (P = 0,1 - 0,3)	0,60± 0,05	150 + 20	159	P
4 – two-phase asymmetrical fault (P > 0,9)	0,60± 0,05	150 + 20	159	P
5 – two-phase asymmetrical fault (P = 0,1 - 0,3)	0,70± 0,05	150 + 20	160	P
5 – two-phase asymmetrical fault (P > 0,9)	0,70± 0,05	150 + 20	151	P
6 – two-phase asymmetrical fault (P = 0,1 - 0,3)	0,80-0,85	600 + 20	609	P
6 – two-phase asymmetrical fault (P > 0,9)	0,80-0,85	600 + 20	609	P
7 –single-phase symmetrical fault (P = 0,1 - 0,3)	0,60± 0,05	150 + 20	157	P
7 –single-phase symmetrical fault (P > 0,9)	0,60± 0,05	150 + 20	165	P
8 –single-phase symmetrical fault (P = 0,1 - 0,3)	0,70± 0,05	150 + 20	154	P
8 –single-phase symmetrical fault (P > 0,9)	0,70± 0,05	150 + 20	163	P
9 –single-phase symmetrical fault (P = 0,1 - 0,3)	0,80-0,85	600 + 20	609	P
9 –single-phase symmetrical fault (P > 0,9)	0,80-0,85	600 + 20	609	P
Test conditions: Voltage simulator fall and rise time: < 10ms				
Note:/				

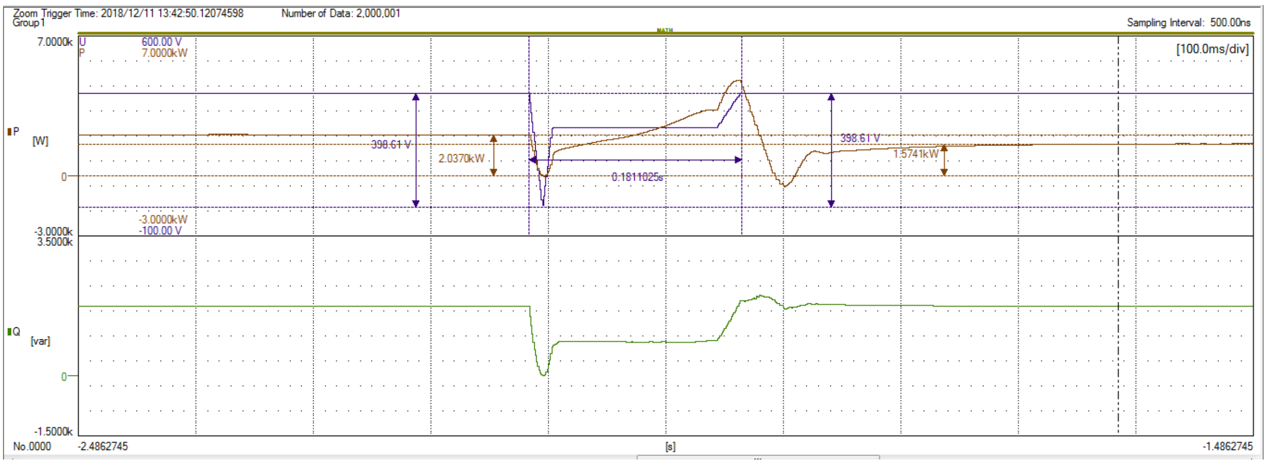
Test 1 – three-phase symmetrical fault (V/V_{nom} = 0,60)
P = 0,1 - 0,3



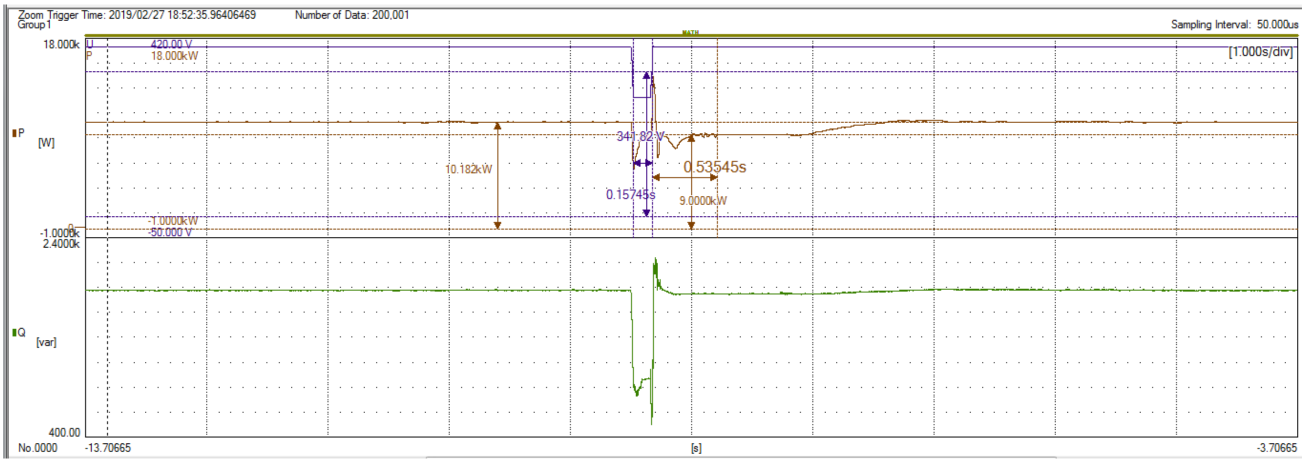
Test 1 – three-phase symmetrical fault (V/V_{nom} = 0,60)
P > 0,9



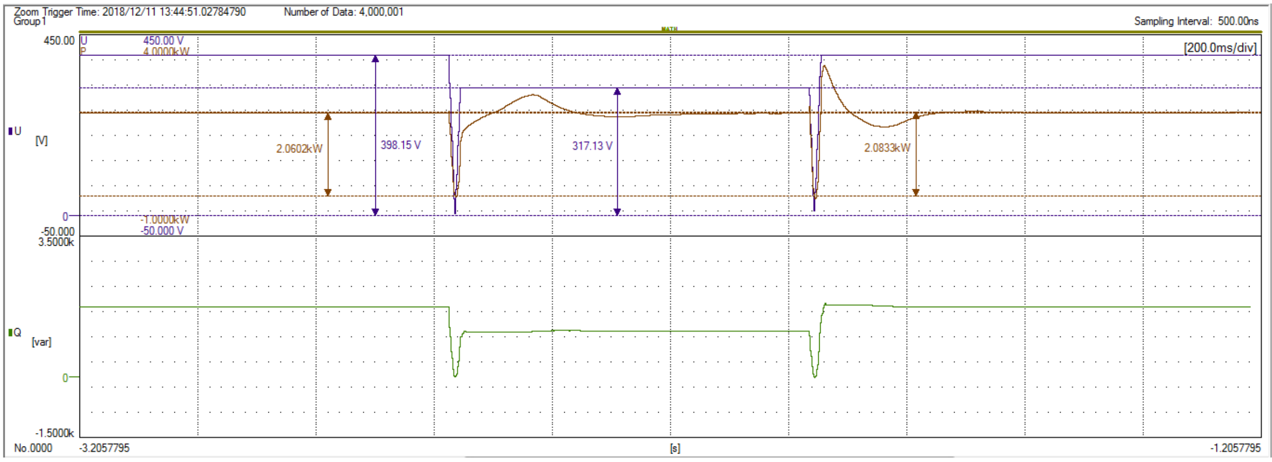
Test 2 – three-phase symmetrical fault (V/V_{nom} = 0,70)
P = 0,1 - 0,3



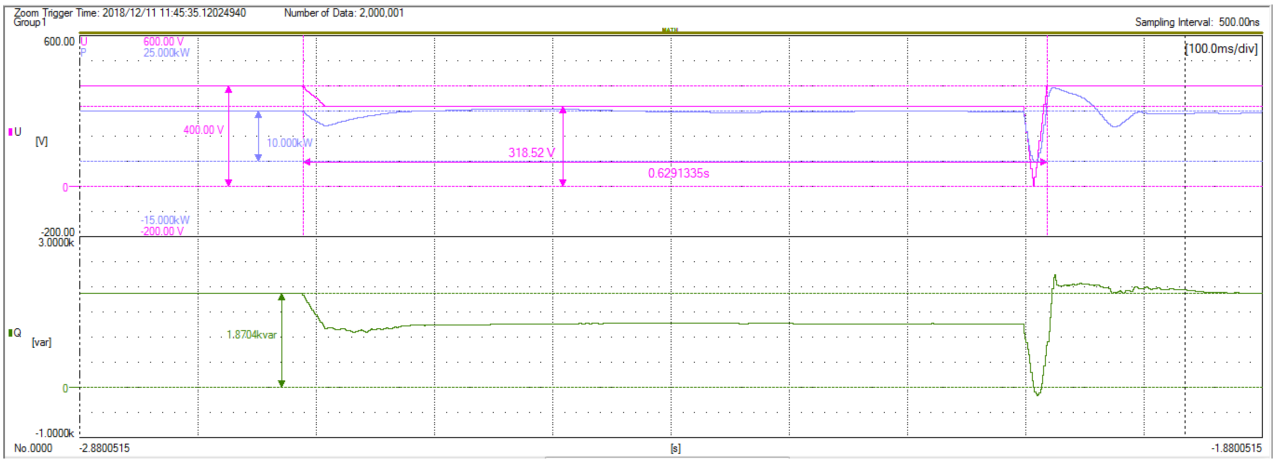
Test 2 – three-phase symmetrical fault (V/V_{nom} = 0,70)
P > 0,9



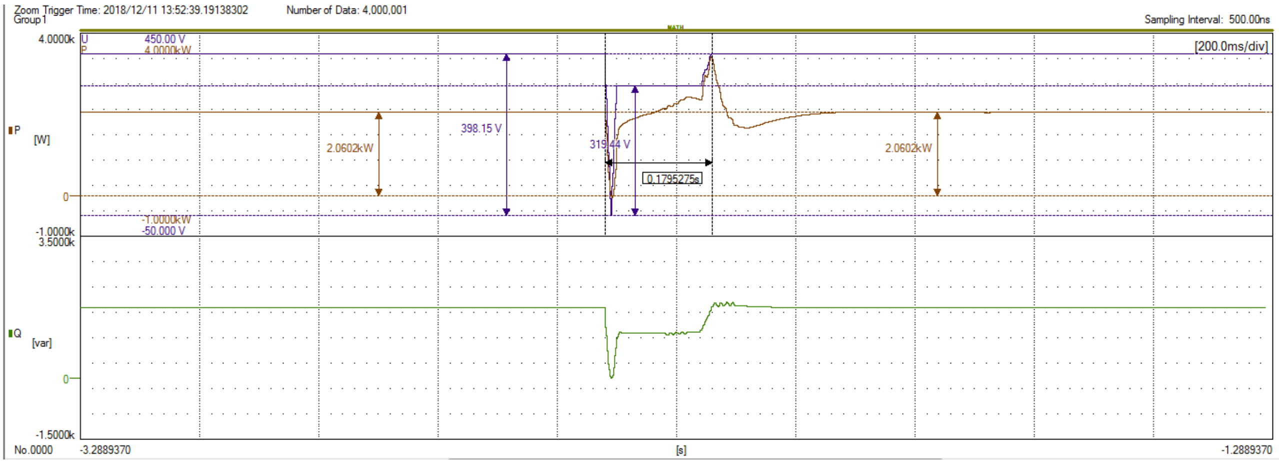
Test 3 – three-phase symmetrical fault (V/V_{nom} = 0,80)
P = 0,1 - 0,3



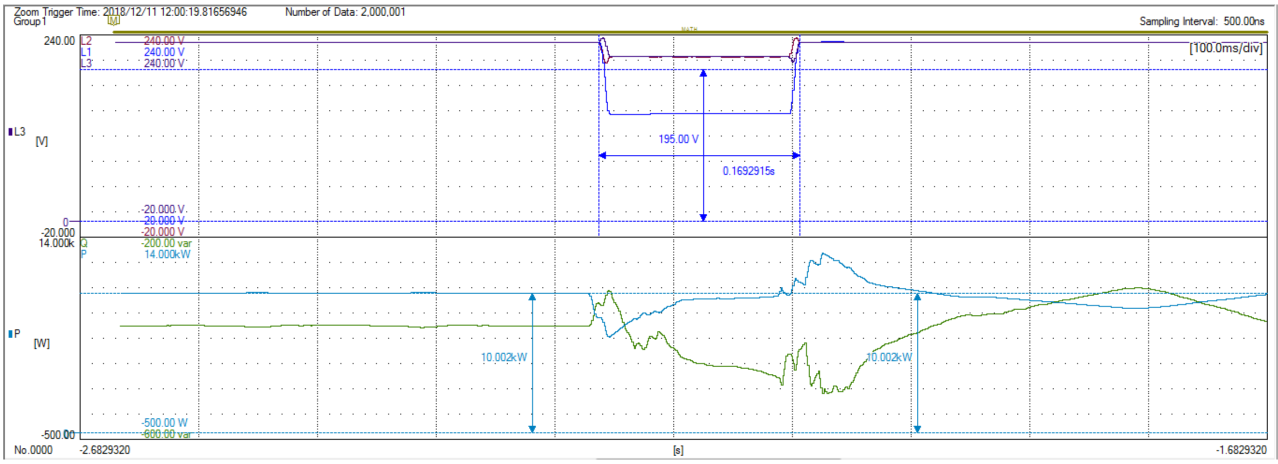
Test 3 – three-phase symmetrical fault (V/V_{nom} = 0,80)
P > 0,9



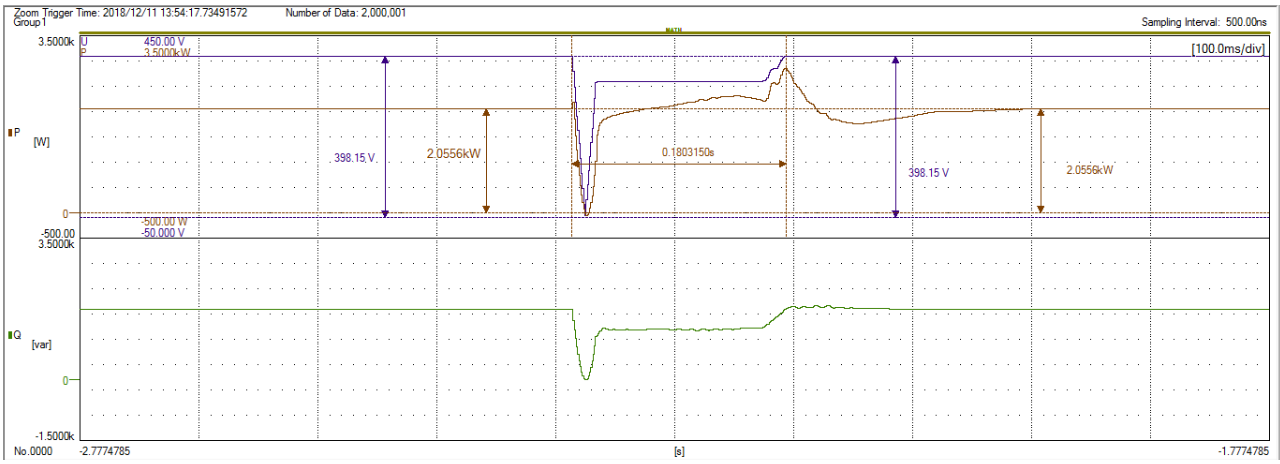
Test 4 – two-phase asymmetrical fault (V/V_{nom} = 0,60)
P = 0,1 - 0,3



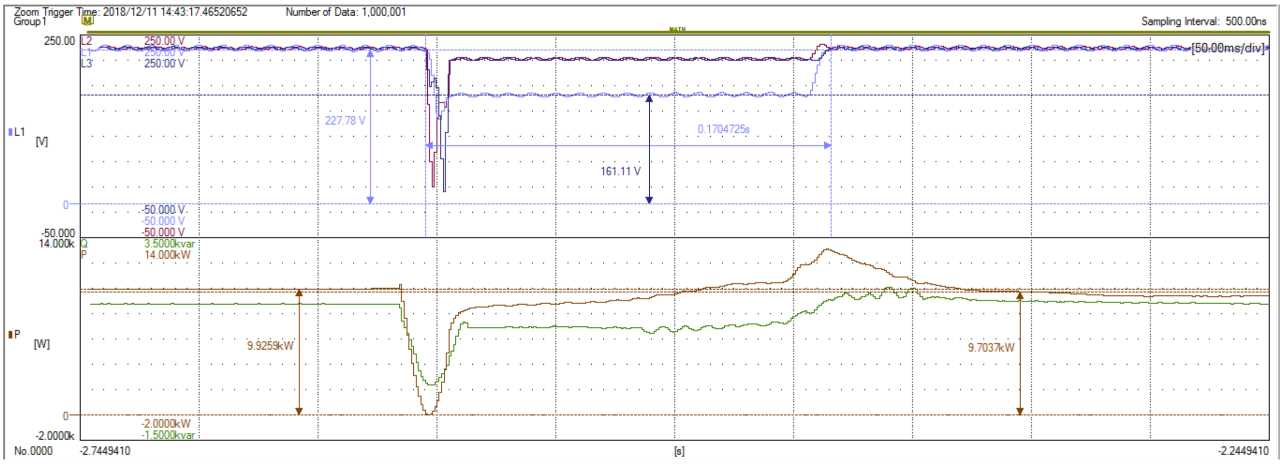
Test 4 – two-phase asymmetrical fault (V/V_{nom} = 0,60)
P > 0,9



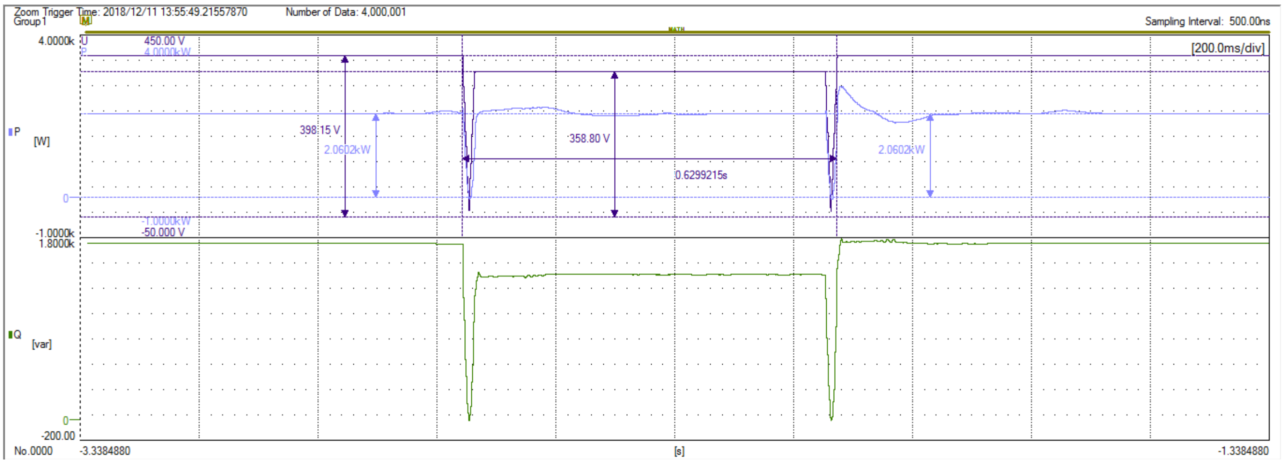
Test 5 – two-phase asymmetrical fault (V/V_{nom} = 0,70)
P = 0,1 - 0,3



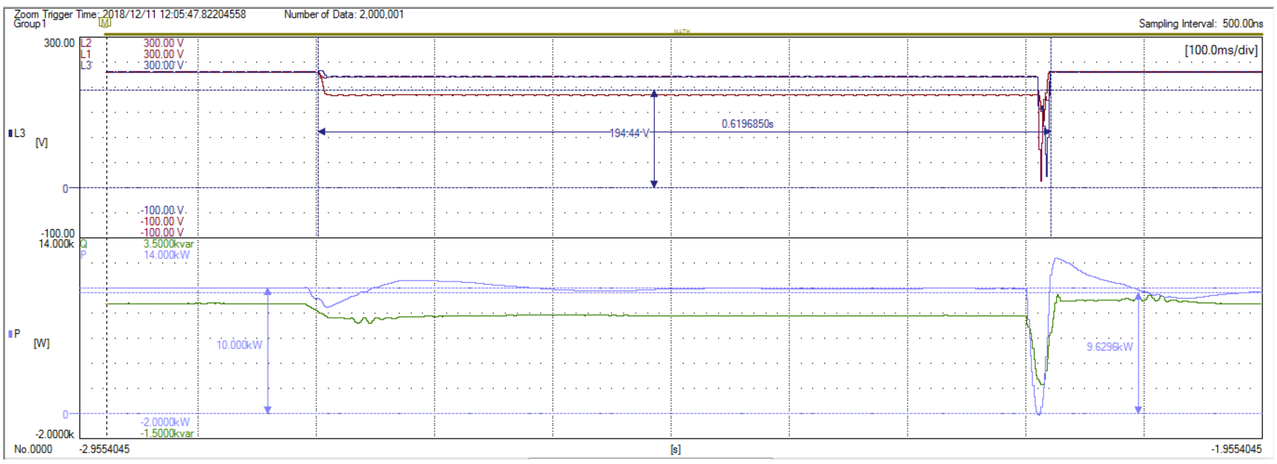
Test 5 – two-phase asymmetrical fault (V/V_{nom} = 0,70)
P > 0,9



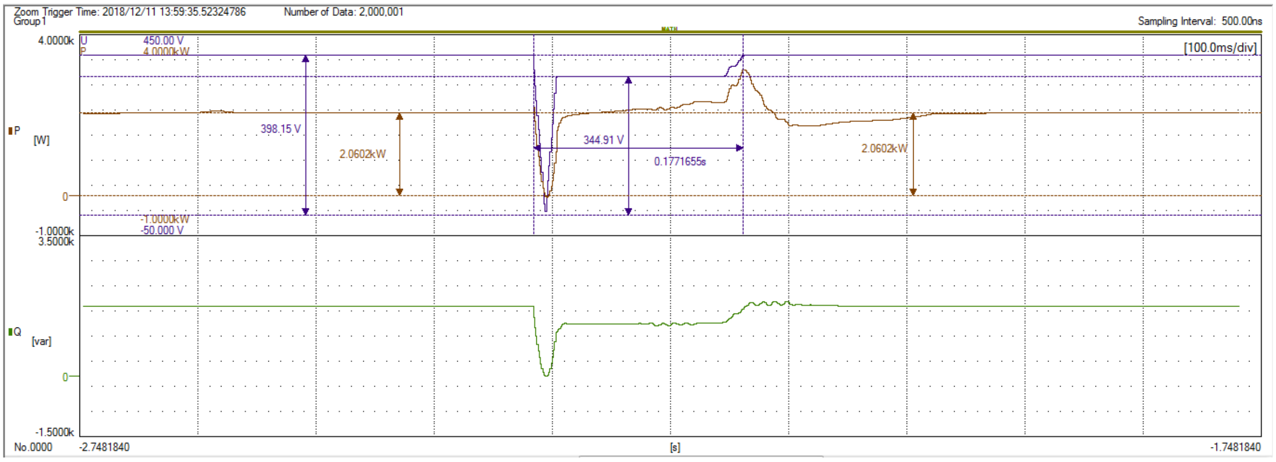
Test 6 – two-phase asymmetrical fault (V/V_{nom} = 0,80)
P = 0,1 - 0,3



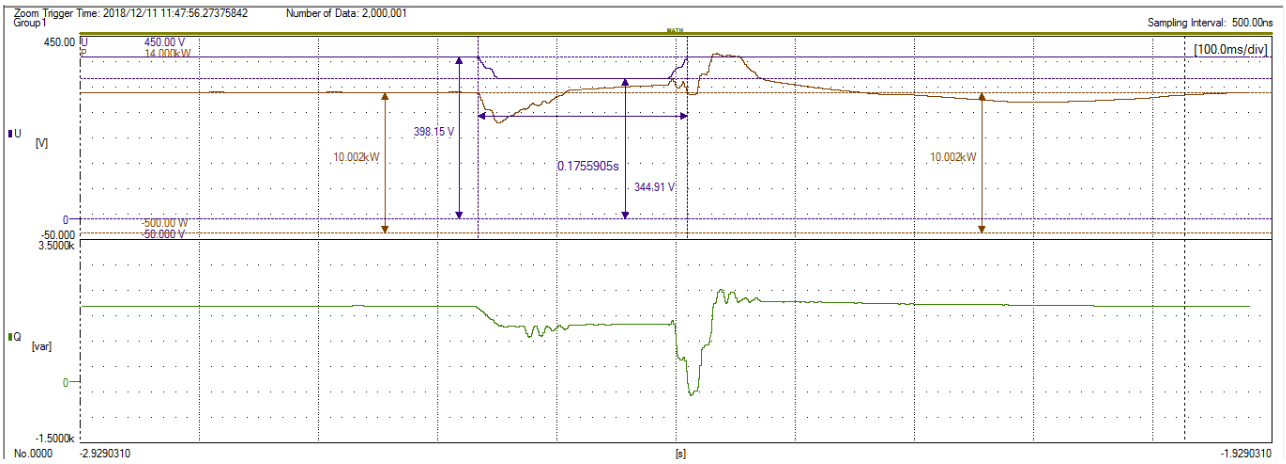
Test 6 – two-phase asymmetrical fault (V/V_{nom} = 0,80)
P > 0,9



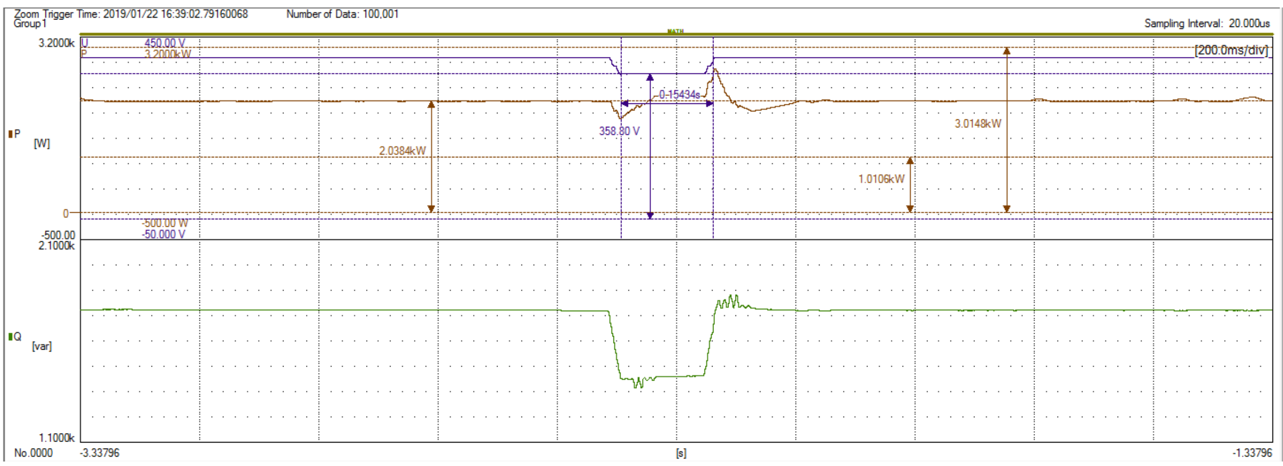
Test 7 –single-phase symmetrical fault (V/V$_{nom}$ = 0,60)
P = 0,1 - 0,3



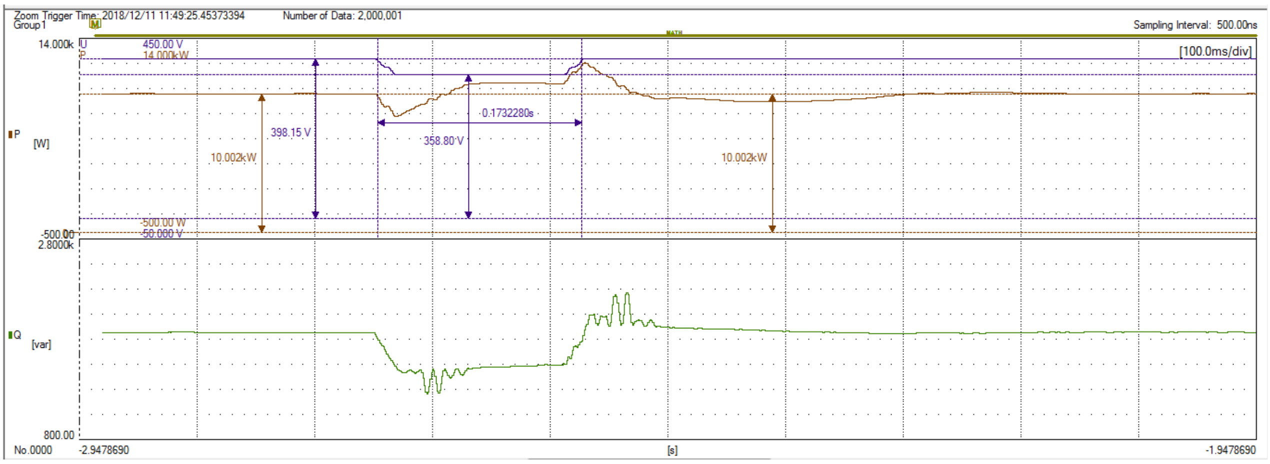
Test 7 –single-phase symmetrical fault (V/V$_{nom}$ = 0,60)
P > 0,9



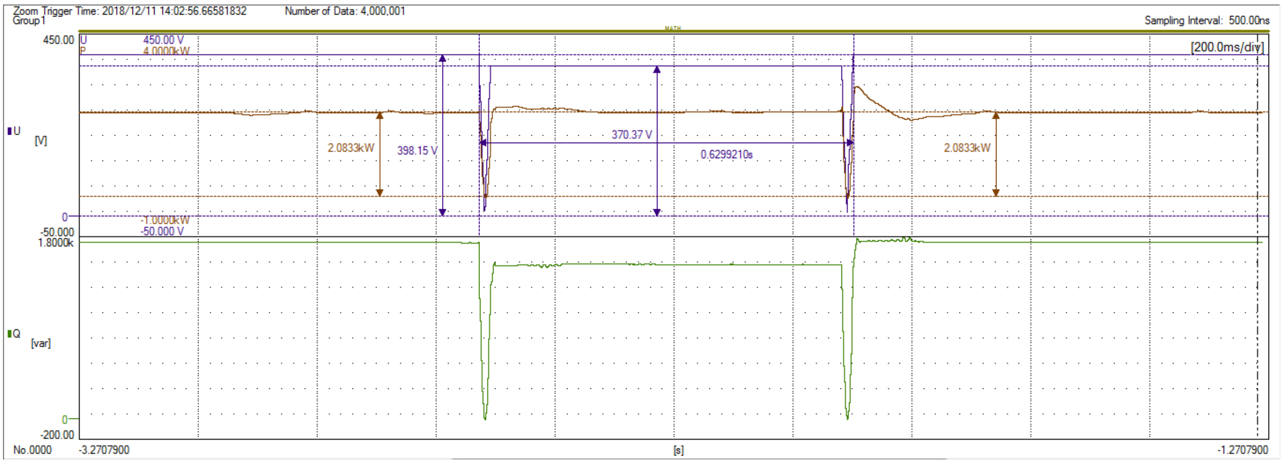
Test 8 –single-phase symmetrical fault (V/V$_{nom}$ = 0,70)
P = 0,1 - 0,3



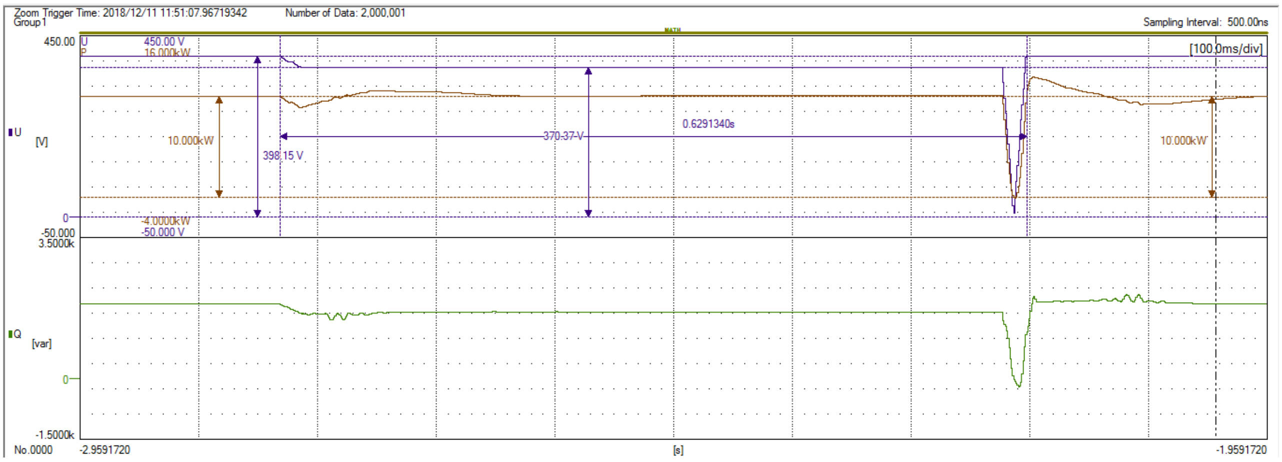
Test 8 –single-phase symmetrical fault (V/V$_{nom}$ = 0,70) P > 0,9



Test 9 –single-phase symmetrical fault (V/V$_{nom}$ = 0,80) P = 0,1 - 0,3



Test 9 –single-phase symmetrical fault (V/V$_{nom}$ = 0,80) P > 0,9



4.2.2.3.3 Overfrequency and underfrequency									P
Test:									
Test conditions:	Any output power level								
	Under frequency				**Over frequency**				
Parameter	Frequency (Hz)	Time (ms)			Frequency (Hz)	Time (ms)			
Output Voltage		~85%U_N	~U_N	~110%U_N		~85%U_N	~U_N	~110%U_N	
Limit	47,50Hz	0,2s			52,00Hz	4s < t ≤ 4,5s			
Trip value		47,50	47,51	47,50		52,00	52,01	52,01	
Disconnection time (ms)	48,00Hz to 47,00Hz	194	197	191	51,50Hz to 52,50Hz	4,058	4,060	4,065	

Note:

Method for ramp:

It was measured at a continuous change of frequency of 1Hz/s at lower, nominal and upper U_N and arbitary output power. The trip value was determined manually by reducing the frequency in 10mHz steps. When the trip value is known (e.g. 47Hz), the ac-source is programmed to run from e.g. 47,50Hz to 46,50Hz with 1Hz/s. The disconnection time is calculated by the measured time minus the 500ms from 47,5Hz to 47Hz.

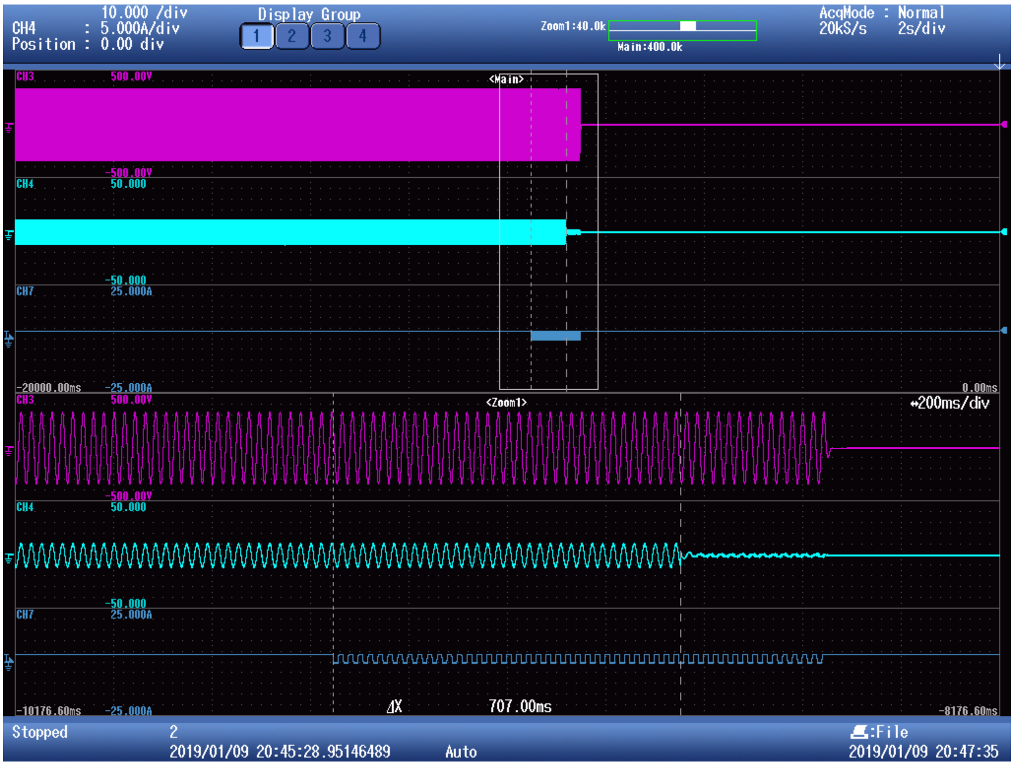
For over frequency, the ac-source is triped from 51,50Hz to 52,50Hz.

Method for trip:

The frequency which inverter stops feeding power to electrical system in each test must be in the range of the frequency trip setting +/- 0,1Hz and the time it takes to cut off the power must be within limit value.

The accuracy for frequency trip values shall be within 0 % to +1 % of the nominal frequency from the upper boundary trip setting, and within -1% to 0% of the nominal frequency from the lower boundary trip setting.

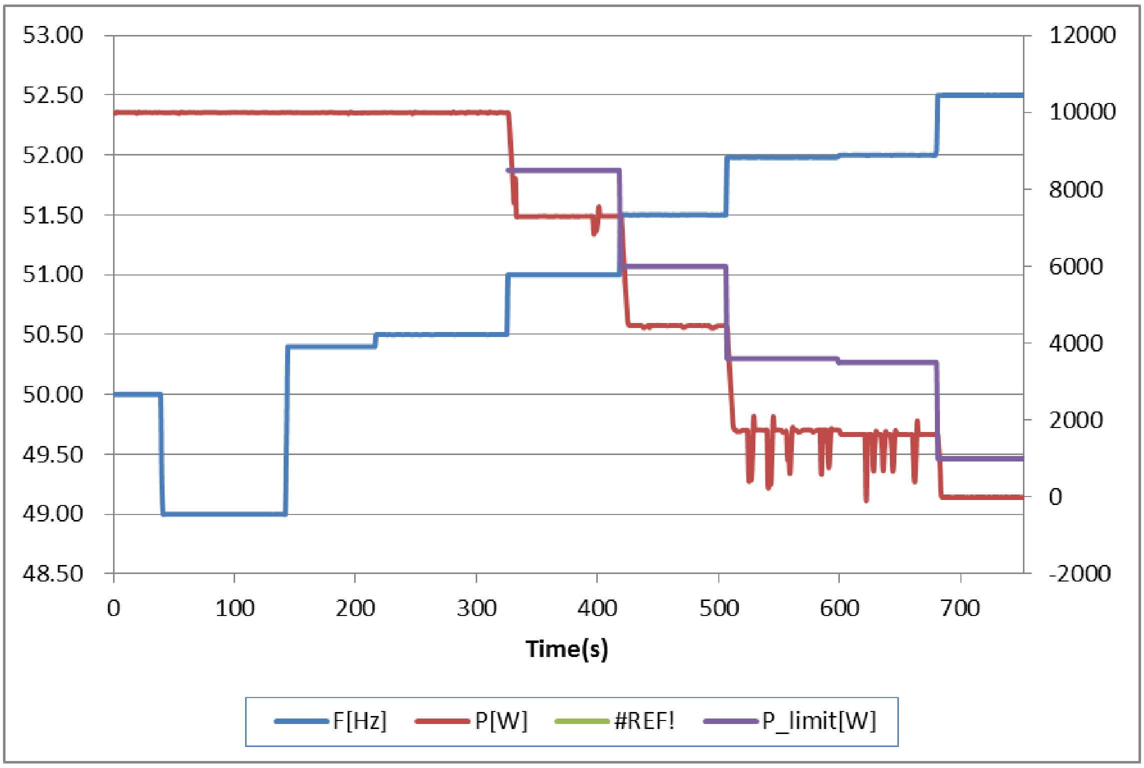
Under Frequency:



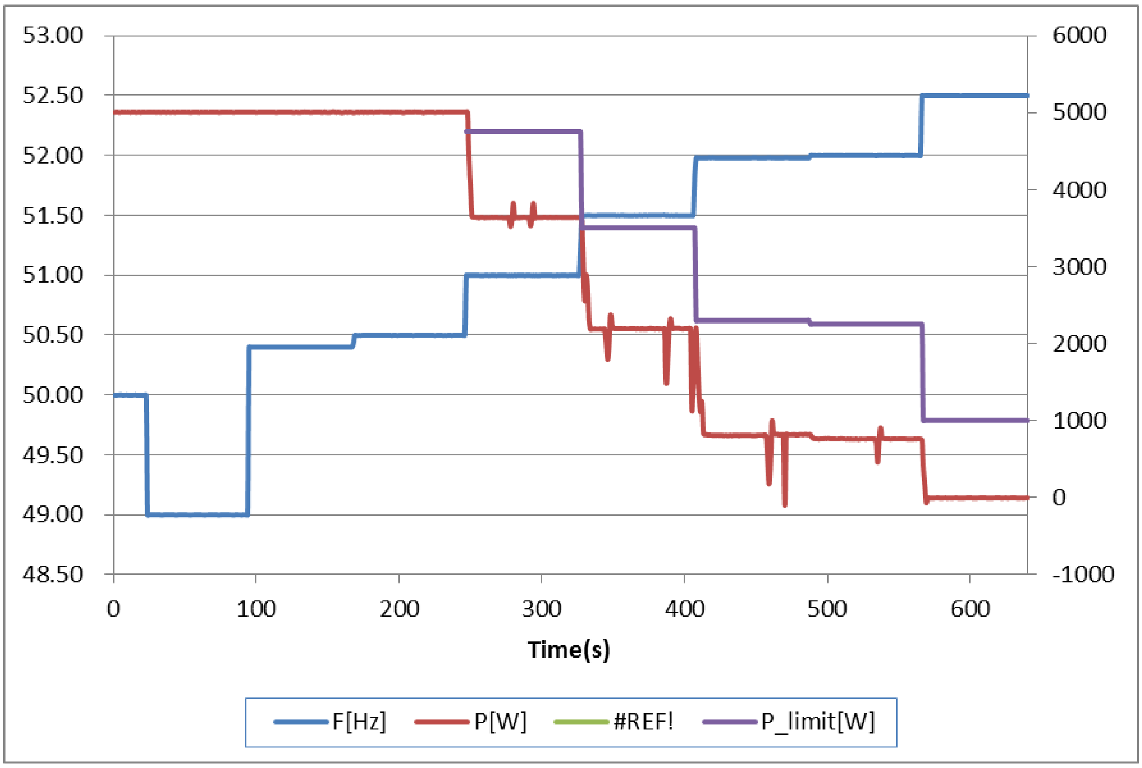
Over Frequency:

4.2.2.3.3	Active power feed-in for over-frequency							P
Test:								
1-min mean value [Hz]	a) 49,00	b) 50,40	c) 50,50	d) 51,00	e) 51,50	f) 51,98	g) 52,00	h) 52,50
1. Measurement a) to g): Active power output > 80% P_n								
Frequency [Hz]:	49,00	50,40	50,50	51,00	51,50	51,98	52,00	52,50
$P_{setpoint}$ [kW]:	10,000	10,000	10,000	7,493	4,996	2,597	2,498	0,000
P_{E60} [kW]:	9,994	9,990	9,990	7,299	4,450	1,571	1,517	-0,002
$\Delta P_{E60}/P_{Setpoint}$ [%]:	-0,065	-0,101	-0,097	-1,935	-5,462	-10,261	-9,812	-0,022
2. Measurement a) to i): Active power output 40% and 60%								
Frequency [Hz]:	49,00	50,40	50,50	51,00	51,50	51,98	52,00	52,50
$P_{setpoint}$ [kW]:	5,000	5,000	5,000	3,755	2,504	1,301	1,252	0,000
P_{E60} [kW]:	5,007	5,006	5,007	3,641	2,151	0,766	0,761	-0,002
$\Delta P_{E60}/P_{Setpoint}$ [%]:	0,065	0,061	0,069	-1,143	-3,525	-5,353	-4,905	-0,023
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 10 % of P_{Emax}							

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



Graph of Measurement 2.:Active power output 40% and 60%



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 PM, the available active power output must be increased to a value > 80% P_n, and after the network frequency of 50,5 Hz is fallen below, the rise of the active power gradient must be recorded.

Assessment criterion:

For f=50,5 Hz, the value of the PM active power currently being generated is "frozen".

For adjustable PGUs when:

1) the active power reduces between measuring points c) and g) given above with a gradient of 50% P_M per Hz for a decreasing frequency (or rises for a frequency decreasing again).
2) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from P_n by more than ± 10%.

When the utility frequency exceeds 50,5 Hz, the active power available at the time shall be stored as the maximum power value P_M; this value P_M shall not be exceeded until the frequency has stabilised below 50,5 Hz for at least 4 seconds.

Note:

4.2.2.4: Preventing of islanding (Islanding protection, Condition A)	P

Test reult:

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

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)	Run on Time (ms)	P_{EUT} (kW per phase)	Q_f	V_{DC} (V)	Remarks4)
1	100	100	0	0	212	3,160	1,074	690	Test A at BL
8	100	100	-5	-5	199	3,160	1,102	690	Test A at IB
9	100	100	-5	0	41	3,160	1,131	690	Test A at IB
10	100	100	-5	+5	210	3,160	1,159	690	Test A at IB
13	100	100	0	-5	169	3,160	1,047	690	Test A at IB
14	100	100	0	+5	208	3,160	1,101	690	Test A at IB
17	100	100	+5	-5	178	3,160	0,997	690	Test A at IB
18	100	100	+5	0	207	3,160	1,023	690	Test A at IB
19	100	100	+5	+5	162	3,160	1,048	690	Test A at IB

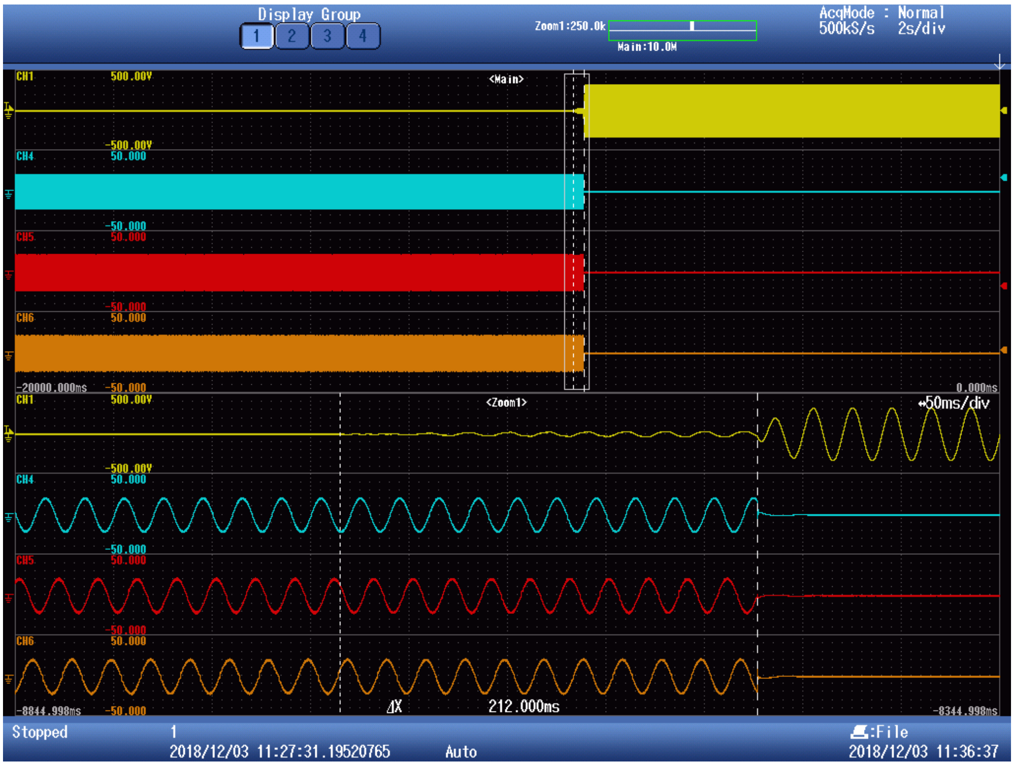
Parameter at 0% per phase	L= 49,62 mH	R= 16,74 Ω	C= 204,21 µF
I_{AC} fundamental current at balance condition	L1: 81 mA	L2: 74 mA	L3: 53 mA

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 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.

Disconnection at Pac 0% and Qac0% reactive load and 100% nominal power



4.2.2.4: Preventing of islanding (Islanding protection, Condition B)	P

Test reult:

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

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)	Run on Time (ms)	P_{EUT} (kW per phase)	Q_f	V_{DC} (V)	Remarks4)
12	66	66	0	-5	230	2,100	1,051	560	Test B at IB
13	66	66	0	-4	238	2,100	1,057	560	Test B at IB
14	66	66	0	-3	237	2,100	1,062	560	Test B at IB
15	66	66	0	-2	188	2,100	1,068	560	Test B at IB
16	66	66	0	-1	217	2,100	1,073	560	Test B at IB
2	66	66	0	0	282	2,100	1,078	560	Test B at BL
17	66	66	0	1	248	2,100	1,084	560	Test B at IB
18	66	66	0	2	236	2,100	1,089	560	Test B at IB
19	66	66	0	3	189	2,100	1,094	560	Test B at IB
20	66	66	0	4	142	2,100	1,100	560	Test B at IB
21	66	66	0	5	127	2,100	1,105	560	Test B at IB

Parameter at 0% per phase	L= 74,38 mH	R= 25,19 Ω	C= 136,22µF
I_{AC} fundamental current at balance condition	L1: 13mA	L2: 22 mA	L3: 15 mA

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 + 0,9 × (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.

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

4.2.2.4: Preventing of islanding (Islanding protection, Condition C)	P

Test result:

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

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)	Run on Time (ms)	P_{EUT} (kW)	Q_f	V_{DC} (V)	Remarks4)
22	33	33	0	-5	182	1,030	1,059	430	Test C at IB
23	33	33	0	-4	211	1,030	1,065	430	Test C at IB
24	33	33	0	-3	251	1,030	1,071	430	Test C at IB
25	33	33	0	-2	218	1,030	1,076	430	Test C at IB
26	33	33	0	-1	182	1,030	1,082	430	Test C at IB
3	33	33	0	0	304	1,030	1,087	430	Test C at BL
27	33	33	0	1	145	1,030	1,092	430	Test C at IB
28	33	33	0	2	115	1,030	1,098	430	Test C at IB
29	33	33	0	3	160	1,030	1,103	430	Test C at IB
30	33	33	0	4	159	1,030	1,109	430	Test C at IB
31	33	33	0	5	113	1,030	1,114	430	Test C at IB

Parameter at 0% per phase	L= 150,40 mH	R= 51,36 Ω	C= 67,37 µF
I_{AC} fundamental current at balance condition	L1: 29 mA	L2: 39 mA	L3: 20 mA

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 + 0,9 × (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.

Disconnection at Pac 0% and Qac 0% reactive load and 33% nominal power

Annex 1
Datasheet of the relay

HF161F-W(477) SOLAR RELAY

File No.:E134517

File No.:40031410

File No.:10002050943

Features

- 33A switching capitable
- Applicable to inverter used for photovoltaic power generation systems
- Ideal for UPS
- 1.8mm contact gap (in accordance to IEC 62109-2-2011)
- The clearance distance between contact and coil is bigger than 6.4mm, the creepage distance is bigger than 7.5mm.
- Low coil holding voltage contributes to saving energy of equipment
- UL insulation system: Class F
- Environmental friendly product (RoHS compliant)
- Outline Dimensions: (30.4 x 15.9 x 23.3) mm

CONTACT DATA

Contact arrangement	1A
Contact resistance	100mΩ max.(at 1A 6VDC)
Contact material	$AgSnO_2$
Contact rating	Resistive: 26A 250VAC Inductive: 33A 250VAC cosφ=0.8 0.1s:10s
Max. switching voltage	277VAC
Max. switching current	33A
Max. switching power	8250VA
Mechanical endurance	1 x 10^5OPS
Electrical endurance	3 x 10^4OPS (See approval reports for more details)

COIL

Coil power	Approx. 1.4W
Holding voltage	35% to 120%U_N (at 23°C) 45% to 80%U_N (at 85°C)

Notes: 1) The coil holding voltage is the voltage of coil after being applied rated voltage for 100ms.

2) By lower coil holding voltage, the purpose of saving power consumption could be achieved. The magnetic system is designed for this reduced holding power. When the holding voltage was lowered to 35% that of rated voltage, the power consumption could be decreased to approx.170mW. Continuous operation without power reduction is not permitted for ambient temperatures of > 23°C!

CHARACTERISTICS

Insulation resistance		1000MΩ (at 500VDC)
Dielectric strength	Between coil & contacts	4500VAC 1min
	Between open contacts	2500VAC 1min
Surge voltage (between coil & contacts)		10kV (1.2/50μs)
Operate time (at nomi. volt.)		20ms max.
Release time (at nomi. volt.)		10ms max.
Temperature rise (at nomi. volt.)		95K max. (Contact load current 33A, rated voltage excitation, at 60°C)
		70K max. (Contact load current 33A, 80% of rated voltage excitation, at 85°C)
Shock resistance	Functional	196m/s^2
	Destructive	980m/s^2
Vibration resistance		10Hz to 55Hz 1.5mm DA
Ambient temperature		-40°C to 60°C (Apply rated voltage to coil)
		-40°C to 85°C (Apply holding voltage to coil, which is 45% to 80% that of rated voltage)
Humidity		5% to 85% RH
Termination		PCB
Unit weight		Approx. 21g
Construction		Flux proofed

Notes: The data shown above are initial values.

COIL DATA at 23°C

Nominal Voltage VDC	Pick-up Voltage VDC max.	Drop-out Voltage VDC min.	Max. Allowable Voltage VDC	Coil Resistance Ω
9	6.3	0.9	10.8	58 x (1±10%)
12	8.4	1.2	14.4	103 x (1±10%)
18	12.6	1.8	21.6	230 x (1±10%)
24	16.8	2.4	28.8	410 x (1±10%)

Notes: The maximum voltage is the voltage value of coil over voltage, which is the instantaneous voltage relay could bear within very short function time period.

SAFETY APPROVAL RATINGS

UL/CUL	$AgSnO_2$	26A 277VAC at 75°C 22A 277VAC at 85°C
VDE	$AgSnO_2$	33A 250VAC COSØ =0.8 0.1s:10s

Notes: Only some typical ratings are listed above. If more details are required, please contact us.

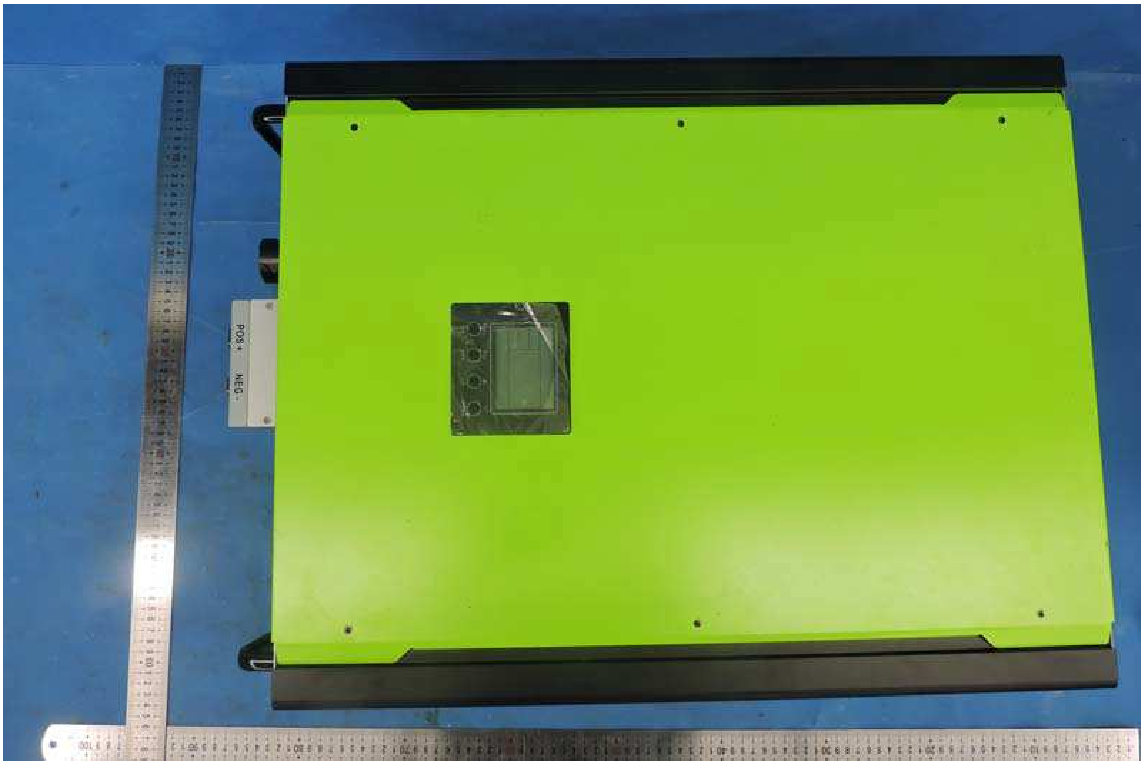
Annex 2

Pictures of the unit

The full pictures refer to PHOTO DOCUMENT

Project No.: 180904N057

Date: 20190305

Enclosure front view:

Enclosure rear view:


Enclosure bottom view:

Internal view-1:


Annex 3
Test equipment list

Test location: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Dates of performance test: 2018-09-04 to 2019-01-28

Equipment	Internal no.:	Manufacturer:	Type:	Serial no.:	Last calibration
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	Dec. 13, 2018
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
AC Source	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040016DG	Chroma	62150H-1000S	62150EF00490	
DC Simulation Power Supply	A7040021DG	Chroma	62150H-1000S	62150EF00609	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 14, 2018
Four Channel Digital Phosphor Oscilloscope	A4089003DG	Tektronix	DPO4104B	C010624	Oct. 25, 2018
Isolation voltage probe	A1490009DG	YOKOGAWA	701901	//	Nov. 01, 2018
	A1490010DG	YOKOGAWA	701901	//	Nov. 01, 2018
	A1490011DG	YOKOGAWA	701901	//	Nov. 01, 2018
Current transducer	A1060008DG	YOKOGAWA	CT200	1130700017	Nov. 17, 2018
	A1060009DG	YOKOGAWA	CT200	1130700019	Nov. 17, 2018
	A1060009DG	YOKOGAWA	CT200	1130700019	Nov. 17, 2018