TEST REPORT

IEC 61727 / IEC 62116

Photovoltaic (PV) systems
Characteristics of the utility interface

Test procedure of islanding prevention measures for utility-interconnected photovoltaic inverters

Report reference number ..... :	**PVTH200526N020-3**
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Accreditation ..... :	ilac-MRA A2LA ACCREDITED Certificate # 2951.01
Applicant's name..... :	**Shenzhen SOFARSOLAR Co., Ltd.**
Address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China.
Test specification	
Standard..... :	IEC 61727:2004, IEC 62116:2008, Deviations for Thailand according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016)
Test Report Form No. ..... :	IEC61727/IEC62116_PEA VER.2
TRF Originator ..... :	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF ..... :	Dated 2020-03-20
Test item description ..... :	**Solar Grid-tied Inverter**
Trademark..... :	SOFAR SOLAR
Model / Type ..... :	SOFAR 6KTLM-G3

Ratings .....:	**SOFAR 6KTLM-G3**
Input DC voltage [V] .....:	600 Max.
MPP DC voltage range [V] .....:	80-550
Input DC current [A] .....:	Max.2×15
Isc PV [A].....:	Max.2×22.5
Output AC voltage [V] .....:	220 / 230 Va.c., 50/60Hz
Max. Output AC current [A] .....:	29
Rated Output power [kW].....:	6
Max Output power [kVA] .....:	6

Testing Location ..... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
Address ..... :	No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China
Tested by (name and signature) ..... :	Jack Shi 
Approved by (name and signature) ..... :	James Huang 
Manufacturer's name ..... :	**Shenzhen SOFARSOLAR Co., Ltd.**
Manufacturer address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China.
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Document History			
Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2021-03-11	Jack shi	Initial report was written	0
Supplementary information:			

Test items particulars

Equipment mobility ..... :	Permanent connection
Operating condition ..... :	Continuous
Class of equipment ..... :	Class I
Protection against ingress of water .. :	IP65 according to EN 60529
Mass of equipment [kg] ..... :	Approx. 10kg

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 ..... :	2021-01-21
Date(s) of performance of test ..... :	2021-01-21 to 2021-03-08

General remarks:

The test result presented in this report relate only to the object(s) tested.
This report must not be reproduced in part or in full without the written approval of the issuing testing laboratory.

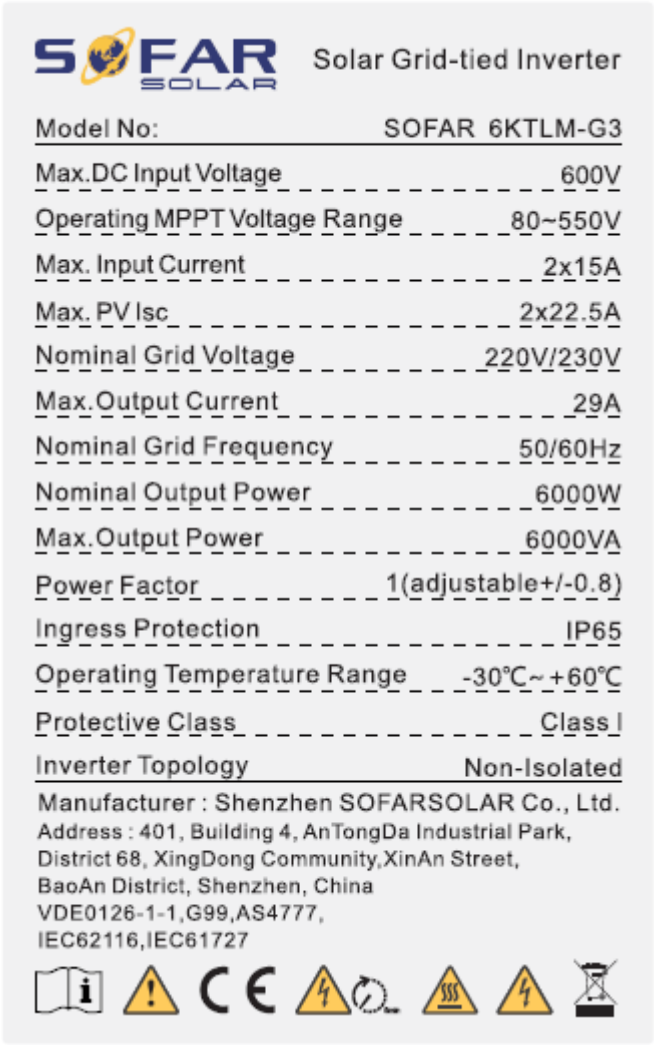
”(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

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

This Test Report consists of the following documents:

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

Copy of marking plate:



General product information:

The Grid tied photovoltaic inverter 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 a two relays. This assures that the opening of the output circuit will also operate in case of one error.

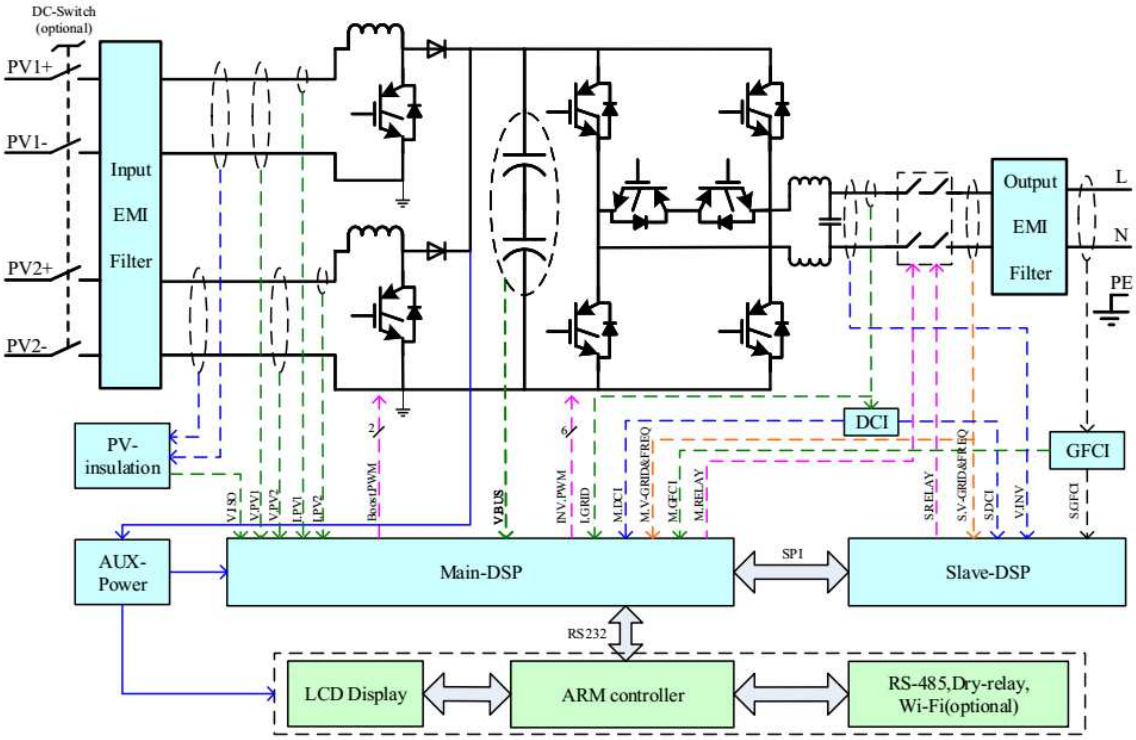


Figure 1-Block diagram

The internal control is redundant built. It consists of Microcontroller Main DSP (U9) and RCU DSP(U14).

The Main DSP(U9) control the relays by switching signals; measures the PV voltage, PV current, Bus 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 RCU DSP (U14) is measures the grid voltage, AC current, grid frequency and residual current, also can switch off the relays independently, and communicate with Main DSP (U9) each other.

The current is measured by a current sensor. The AC current signal and the injected DC current signal are sent to the Main DSP(U9). The Main DSP(U9) 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..

The product was tested on:

Hardware version: V002

Software version: V000001

Interface protection settings with deviations according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016) **(Thailand PEA)**		
Parameter	**Max. clearance time***	**Trip setting**
Over voltage (level 2)	0,16s	220V +20% (264V)
Over voltage (level 1)	1,0s	220V +10% (242V)
Under voltage (level 1)	2,0s	220V -10% (198V)
Under voltage (level 2)	0,3s	220V -50% (110V)
Over frequency	0,1s	50Hz +4% (52,0Hz)
Under frequency	0,1s	50Hz -6% (47,0Hz)
Reconnection time	20s - 5min	
Permanent DC-injection	0,5% of rated inverter output current	
Loss of main IEC 62116:2008	Inverter shall detect and disconnect within 1s	
* Trip time refers to the time between the abnormal condition occurring and the inverter ceasing to energize the utility line. The PV system control circuits shall actually remain connected to the utility to allow sensing of utility electrical conditions for use by the “reconnect” feature.		

IEC61727:2004			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4: Utility compatibility			
4	**General** The quality of power provided by the PV system for the on-site AC loads and for 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 and may require the PV system to sense the deviation and properly disconnect from the utility system. All power quality parameters (voltage, flicker, frequency, harmonics, and power factor) must be measured at the utility interface/ point of common coupling unless otherwise specified.	Noticed	**P**
4.1	**Voltage, current and frequency** The PV system AC voltage, current and frequency shall be compatible with the utility system.	Derived from tests	**P**
4.2	**Normal voltage operating range** Utility-interconnected PV systems do not normally regulate voltage; they inject current into the utility. Therefore, the voltage operating range for PV inverters is selected as a protection function that responds to abnormal utility conditions, not as a voltage regulation function.	Derived from tests	**P**
4.3	**Flicker** The operation of the PV system should not cause voltage flicker in excess of limits stated in the relevant sections of IEC 61000-3-3 for systems less than 16 A or IEC 61000-3-5 for systems with current of 16 A and above.	See table 4.3	**P**
4.4	**DC injection** The PV system shall not inject DC current greater than 1 % of the rated inverter output current, into the utility AC interface under any operating condition.	The following deviations were used: Provincial Electricity Authority (PEA:2016) See table 4.4	**P**
4.5	**Normal frequency operating range** The PV system shall operate in synchronism with the utility system, and within the frequency trip limits defined in 5.2.2.	The following deviations were used: Provincial Electricity Authority (PEA:2016) See table 5.2.2	**P**

IEC61727:2004			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4: Utility compatibility			
4.6	**Harmonics and waveform distortion** Low levels of current and voltage harmonics are desirable; the higher harmonic levels increase the potential for adverse effects on connected equipment. Acceptable levels of harmonic voltage and current depend upon distribution system characteristics, type of service, connected loads/apparatus, and established utility practice. The PV system output should have low current-distortion levels to ensure that no adverse effects are caused to other equipment connected to the utility system. Total harmonic current distortion shall be less than 5 % at rated inverter output. Each individual harmonic shall be limited to the percentages listed in Table 1. Even harmonics in these ranges shall be less than 25 % of the lower odd harmonic limits listed. (see Clause 4.6 Table 1 – Current distortion limits)	The following deviations were used: Provincial Electricity Authority (PEA:2016) See tables 4.6 (1) and 4.6 (2)	**P**
4.7	**Power factor** 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.	See table 3.4	**P**

IEC61727:2004			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 5: Personnel safety and equipment protection			
5	**General** This Clause provides information and considerations for the safe and proper operation of the utility-connected PV systems.	Noticed	**P**
5.1	**Loss of utility voltage** To prevent islanding, a utility connected PV system shall cease to energize the utility system from a de-energized distribution line irrespective of connected loads or other generators within specified time limits. A utility distribution line can become de-energized for several reasons. For example, a substation breaker opening due to fault conditions or the distribution line switched out during maintenance. If inverters (single or multiple) have DC SELV input and have accumulated power below 1 kW then no mechanical disconnect (relay) is required.	The following deviations were used: Provincial Electricity Authority (PEA:2016)	**P**
5.2	**Over/under voltage and frequency** Abnormal conditions can arise on the utility system that requires a response from the connected photovoltaic system. This response is to ensure the safety of utility maintenance personnel and the general public, as well as to avoid damage to connected equipment, including the photovoltaic system. The abnormal utility conditions of concern are voltage and frequency excursions above or below the values stated in this Clause, and the complete disconnection of the utility, presenting the potential for a distributed resource island.	The following deviations were used: Provincial Electricity Authority (PEA:2016) See table 5.2.1 and 5.2.2	**P**
5.2.1	**Over/under voltage** When the interface voltage deviates outside the conditions specified in Table 2, the photovoltaic system shall cease to energize the utility distribution system. This applies to any phase of a multiphase system. All discussions regarding system voltage refer to the local nominal voltage. The system shall sense abnormal voltage and respond. The following conditions should be met, with voltages in RMS and measured at the point of utility connection. (see clause 5.2.1 Table 2 – Response to abnormal voltages) The purpose of the allowed time delay is to ride through short-term disturbances to avoid excessive nuisance tripping. The unit does not have to cease to energize if the voltage returns to the normal utility continuous operation condition within the specified trip time.	The following deviations were used: Provincial Electricity Authority (PEA:2016) See table 5.2.1	**P**

IEC61727:2004			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 5: Personnel safety and equipment protection			
5.2.2	**Over/under frequency** When the utility frequency deviates outside the specified conditions the photovoltaic system shall cease to energize the utility line. The unit does not have to cease to energize if the frequency returns to the normal utility continuous operation condition within the specified trip time. When the utility frequency is outside the range of ±1 Hz, the system shall cease to energize the utility line within 0,2 s. The purpose of the allowed range and time delay is to allow continued operation for short-term disturbances and to avoid excessive nuisance tripping in weak-utility system conditions.	The following deviations were used: Provincial Electricity Authority (PEA:2016) See table 5.2.2	**P**
5.3	**Islanding protection** The PV system must cease to energize the utility line within 2 s of loss of utility.	The following deviations were used: Provincial Electricity Authority (PEA:2016) See table 6.1	**P**
5.4	**Response to utility recovery** Following an out-of-range utility condition that has caused the photovoltaic system to cease energizing, the photovoltaic system shall not energize the utility line for 20 s to 5 min after the utility service voltage and frequency have recovered to within the specified ranges**.**	See table 5.2.1 and 5.2.2	**P**
5.5	**Earthing** The utility interface equipment shall be earthed/grounded in accordance with IEC 60364-7-712.	Stated in the manual.	**P**
5.6	**Short circuit protection** The photovoltaic system shall have short-circuit protection in accordance with IEC 60364-7-712.	Stated in the manual.	**P**
5.7	**Isolation and switching** A method of isolation and switching shall be provided in accordance with IEC 60364-7-712.	Stated in the manual.	**P**

Test overview:

IEC 61727:2004		
Clause	**Type Test**	**Result**
4	Type test:	
4.3	Voltage Fluctuations and Flicker (see Annex 1 EMC Report)	**P**
4.4	Monitoring of DC-Injection	**P**
4.5	Normal frequency operating range (see 5.2.2 below)	**P**
4.6	Harmonics and waveform distortion	**P**
4.7	Power factor	**P**
5.2.1	Voltage monitoring	**P**
5.2.2	Frequency monitoring	**P**

IEC 62116:2008		
Clause	**Type Test**	**Result**
6.1	Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%)	**P**
6.1	Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %)	**P**
6.1	Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %)	**P**

Deviations for Thailand according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016)		
Clause	**Type Test**	**Result**
3.4	Reactive power control	
3.4.1, 8.1.2	A fixed displacement factor cosφ	**P**
3.4.2, 8.1.2	A variable reactive power depending on the voltage Q(U)	**N/A**
3.5, 12.1	Active power control	**P**
3.6, 12.2	Low voltage fault ride through capability	**N/A**

Test Results

4.3 Voltage fluctuation and flicker **3.2, 8.3 Voltage Fluctuation Regulation (PEA 2016)**				**P**
Test conditions:	Maximum permissible voltage fluctuation (expressed as a percentage of nominal voltage at 100 % power) and flicker as per EN 61000-3-11			
	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			

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	0.112	Pass	0.219	Pass	0.0	Pass	0.206	Pass		
2	0.104	Pass	0.222	Pass	0.0	Pass	0.207	Pass		
3	0.111	Pass	0.228	Pass	0.0	Pass	0.206	Pass		
4	0.107	Pass	0.204	Pass	0.0	Pass	0.205	Pass		
5	0.109	Pass	0.228	Pass	0.0	Pass	0.207	Pass		
6	0.105	Pass	0.201	Pass	0.0	Pass	0.207	Pass		
7	0.109	Pass	0.244	Pass	0.0	Pass	0.208	Pass		
8	0.110	Pass	0.202	Pass	0.0	Pass	0.206	Pass		
9	0.112	Pass	0.197	Pass	0.0	Pass	0.205	Pass		
10	0.099	Pass	0.199	Pass	0.0	Pass	0.206	Pass		
11	0.108	Pass	0.216	Pass	0.0	Pass	0.206	Pass		
12	0.115	Pass	0.200	Pass	0.0	Pass	0.207	Pass		
Result		Pass		Pass		Pass		Pass	0.206	Pass

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

Mains Impedance according EN61000-3-3: **R_{max} = 0,24Ω; jX_{max}= 0,15Ω @50Hz ($|Z_{max}|$ = 0,283 Ω)**
for single phase inverter use also **R_n = 0,16Ω; jX_n= 0,1Ω**

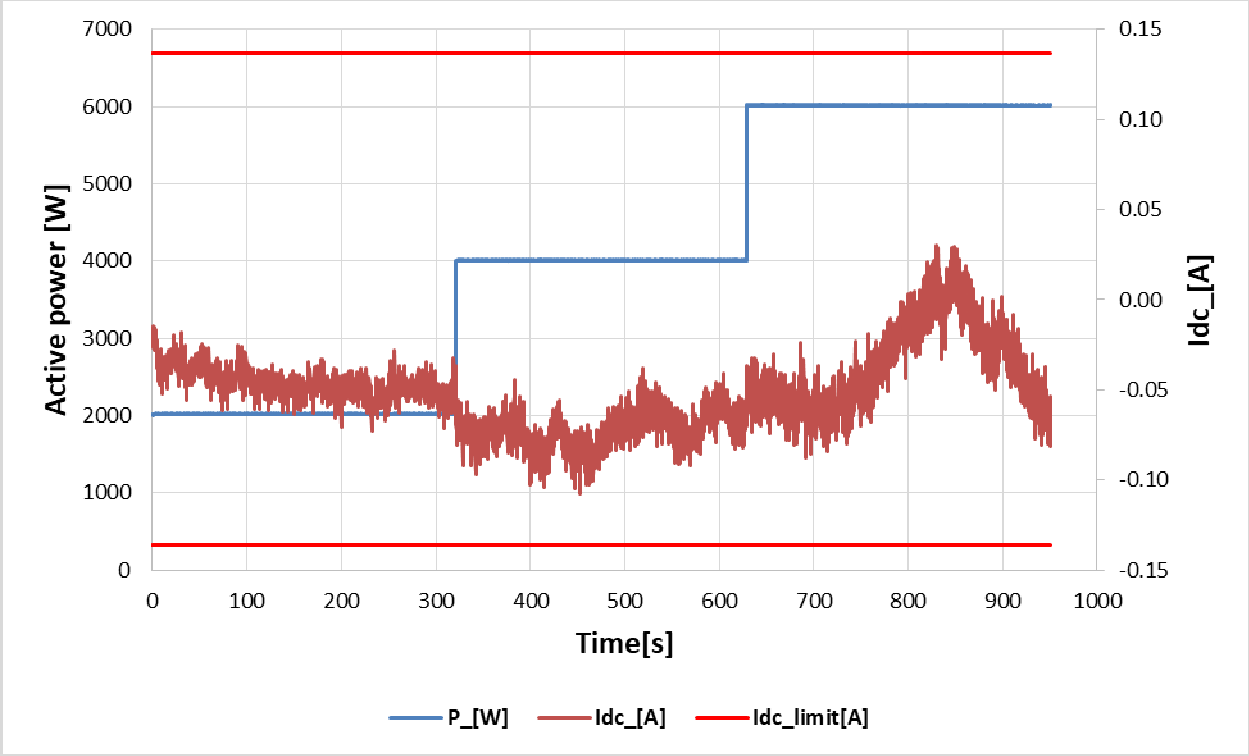
Calculation of the maximum permissible grid impedance at the point of common coupling based on d_c:
$Z_{max} = Z_{ref} * 3,3\% / d_c(P_n)$

The tests should be based on the limits of the EN 61000-3-11 for more than 16A.

4.4 Monitoring of Permanent DC-Injection 3.3, 8.5 Direct Current Dispatch to the Power Network System (PEA:2016)	P

PEA Limit:	**0,5% of I_{nom} : 136mA**		
Output power:	33%	66%	100%
Max. test value (mA):	73	108	87
Mean test value(mA) :	46	69	38

Diagram of permanent DC-injection



Note:

4.6 Harmonic Current Limit Test the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016)	P

33% Output Power	
Watts (kW)	2,027
VA (kVA)	2,038
Vrms (V)	220,33
Arms (A)	9,252
PF	0,994
Frequency (Hz)	50,00
THD50 (%)	0,880

Harmonics	Current Magnitude [A]	% of Rated Current	Phase	Harmonic Current Limits [%]
1st	9,211	99,963	Single Phase	--
2nd	0,008	0,091	Single Phase	1
3rd	0,156	1,689	Single Phase	4
4th	0,006	0,064	Single Phase	1
5th	0,098	1,064	Single Phase	4
6th	0,005	0,057	Single Phase	1
7th	0,082	0,893	Single Phase	4
8th	0,004	0,045	Single Phase	1
9th	0,079	0,854	Single Phase	4
10th	0,004	0,041	Single Phase	1
11th	0,068	0,740	Single Phase	2
12th	0,004	0,048	Single Phase	0,5
13th	0,051	0,556	Single Phase	2
14th	0,004	0,041	Single Phase	0,5
15th	0,041	0,444	Single Phase	2
16th	0,004	0,042	Single Phase	0,5
17th	0,028	0,301	Single Phase	1,5
18th	0,003	0,031	Single Phase	0,375
19th	0,019	0,210	Single Phase	1,5
20th	0,003	0,031	Single Phase	0,375
21th	0,012	0,132	Single Phase	1,5
22th	0,003	0,031	Single Phase	0,375
23th	0,007	0,072	Single Phase	0,6
24th	0,002	0,026	Single Phase	0,15
25th	0,006	0,068	Single Phase	0,6
26th	0,002	0,025	Single Phase	0,15
27th	0,007	0,072	Single Phase	0,6
28th	0,002	0,024	Single Phase	0,15
29th	0,006	0,061	Single Phase	0,6
30th	0,002	0,021	Single Phase	0,15
31th	0,005	0,050	Single Phase	0,6
32th	0,002	0,017	Single Phase	0,15
33th	0,005	0,051	Single Phase	0,6
34th	0,001	0,016	Single Phase	0,15
35th	0,005	0,054	Single Phase	0,3

36th	0,002	0,018	Single Phase	0,075
37th	0,004	0,043	Single Phase	0,3
38th	0,001	0,015	Single Phase	0,075
39th	0,003	0,036	Single Phase	0,3
40th	0,002	0,016	Single Phase	0,075
41th	0,003	0,035	Single Phase	N/A
42th	0,002	0,018	Single Phase	N/A
43th	0,004	0,043	Single Phase	N/A
44th	0,001	0,013	Single Phase	N/A
45th	0,003	0,035	Single Phase	N/A
46th	0,001	0,013	Single Phase	N/A
47th	0,003	0,029	Single Phase	N/A
48th	0,001	0,013	Single Phase	N/A
49th	0,002	0,026	Single Phase	N/A
50th	0,001	0,013	Single Phase	N/A
66% Output Power				
Watts (kW)		**3,982**		
VA (kVA)		**3,989**		
Vrms (V)		**220,58**		
Arms (A)		**18,085**		
PF		**0,998**		
Frequency (Hz)		**50,00**		
THD50 (%)		**1,234**		
Harmonics	**Current Magnitude [A]**	**% of Rated Current**	**Phase**	**Harmonic Current Limits [%]**
1st	18,050	66,185	Single Phase	--
2nd	0,034	0,125	Single Phase	1
3rd	0,209	0,765	Single Phase	4
4th	0,006	0,022	Single Phase	1
5th	0,138	0,506	Single Phase	4
6th	0,004	0,016	Single Phase	1
7th	0,117	0,429	Single Phase	4
8th	0,004	0,014	Single Phase	1
9th	0,102	0,373	Single Phase	4
10th	0,004	0,015	Single Phase	1
11th	0,094	0,346	Single Phase	2
12th	0,004	0,014	Single Phase	0,5
13th	0,081	0,296	Single Phase	2
14th	0,004	0,016	Single Phase	0,5
15th	0,062	0,228	Single Phase	2
16th	0,003	0,012	Single Phase	0,5
17th	0,049	0,179	Single Phase	1,5
18th	0,003	0,011	Single Phase	0,375
19th	0,036	0,134	Single Phase	1,5
20th	0,003	0,010	Single Phase	0,375
21th	0,026	0,097	Single Phase	1,5
22th	0,002	0,007	Single Phase	0,375
23th	0,019	0,071	Single Phase	0,6

24th	0,002	0,006	Single Phase	0,15
25th	0,016	0,059	Single Phase	0,6
26th	0,002	0,006	Single Phase	0,15
27th	0,014	0,053	Single Phase	0,6
28th	0,002	0,008	Single Phase	0,15
29th	0,013	0,048	Single Phase	0,6
30th	0,002	0,007	Single Phase	0,15
31th	0,012	0,043	Single Phase	0,6
32th	0,001	0,005	Single Phase	0,15
33th	0,011	0,040	Single Phase	0,6
34th	0,001	0,005	Single Phase	0,15
35th	0,009	0,032	Single Phase	0,3
36th	0,001	0,005	Single Phase	0,075
37th	0,007	0,026	Single Phase	0,3
38th	0,001	0,005	Single Phase	0,075
39th	0,006	0,023	Single Phase	0,3
40th	0,001	0,005	Single Phase	0,075
41th	0,006	0,021	Single Phase	N/A
42th	0,002	0,006	Single Phase	N/A
43th	0,006	0,021	Single Phase	N/A
44th	0,001	0,005	Single Phase	N/A
45th	0,005	0,019	Single Phase	N/A
46th	0,001	0,005	Single Phase	N/A
47th	0,005	0,017	Single Phase	N/A
48th	0,001	0,005	Single Phase	N/A
49th	0,004	0,016	Single Phase	N/A
50th	0,001	0,004	Single Phase	N/A

100% Output Power	
Watts (kW)	**6,018**
VA (kVA)	**6,026**
Vrms (V)	**220,72**
Arms (A)	**27,299**
PF	**0,999**
Frequency (Hz)	**50,00**
THD50 (%)	**1,485**

Harmonics	**Current Magnitude [A]**	**% of Rated Current**	**Phase**	**Harmonic Current Limits [%]**
1st	27,258	99,948	Single Phase	--
2nd	0,039	0,142	Single Phase	1
3rd	0,285	1,046	Single Phase	4
4th	0,008	0,030	Single Phase	1
5th	0,143	0,525	Single Phase	4
6th	0,006	0,023	Single Phase	1
7th	0,106	0,390	Single Phase	4
8th	0,005	0,019	Single Phase	1
9th	0,113	0,413	Single Phase	4
10th	0,004	0,015	Single Phase	1
11th	0,105	0,384	Single Phase	2

12th	0,004	0,014	Single Phase	0,5
13th	0,091	0,333	Single Phase	2
14th	0,003	0,013	Single Phase	0,5
15th	0,078	0,286	Single Phase	2
16th	0,003	0,010	Single Phase	0,5
17th	0,065	0,239	Single Phase	1,5
18th	0,002	0,008	Single Phase	0,375
19th	0,051	0,189	Single Phase	1,5
20th	0,002	0,008	Single Phase	0,375
21th	0,037	0,136	Single Phase	1,5
22th	0,002	0,008	Single Phase	0,375
23th	0,028	0,101	Single Phase	0,6
24th	0,002	0,008	Single Phase	0,15
25th	0,022	0,082	Single Phase	0,6
26th	0,002	0,008	Single Phase	0,15
27th	0,019	0,070	Single Phase	0,6
28th	0,002	0,007	Single Phase	0,15
29th	0,017	0,062	Single Phase	0,6
30th	0,002	0,007	Single Phase	0,15
31th	0,016	0,058	Single Phase	0,6
32th	0,002	0,006	Single Phase	0,15
33th	0,014	0,050	Single Phase	0,6
34th	0,002	0,007	Single Phase	0,15
35th	0,013	0,047	Single Phase	0,3
36th	0,002	0,007	Single Phase	0,075
37th	0,011	0,041	Single Phase	0,3
38th	0,002	0,006	Single Phase	0,075
39th	0,009	0,034	Single Phase	0,3
40th	0,002	0,007	Single Phase	0,075
41th	0,007	0,027	Single Phase	N/A
42th	0,002	0,007	Single Phase	N/A
43th	0,008	0,028	Single Phase	N/A
44th	0,002	0,006	Single Phase	N/A
45th	0,007	0,024	Single Phase	N/A
46th	0,002	0,006	Single Phase	N/A
47th	0,005	0,018	Single Phase	N/A
48th	0,002	0,006	Single Phase	N/A
49th	0,003	0,012	Single Phase	N/A
50th	0,002	0,006	Single Phase	N/A

Note: The harmonics are tested and evaluated according the IEEE1547.1-2005 clause 5.11.1 according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016).

4.6 Harmonic Voltage Limit Test the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016)				P
Vrms (V)		220,72		
Frequency (Hz)		50,00		
THD50 (%)		0,142		
Harmonics	**Voltage Magnitude [V]**	**% of Rated Voltage**	**Phase**	**Limits [%]**
2nd	0,043	0,020	Single Phase	0,2
3rd	0,184	0,083	Single Phase	4
4th	0,006	0,003	Single Phase	0,2
5th	0,132	0,060	Single Phase	4
6th	0,005	0,002	Single Phase	0,2
7th	0,071	0,032	Single Phase	4
8th	0,005	0,002	Single Phase	0,2
9th	0,054	0,025	Single Phase	2
10th	0,006	0,003	Single Phase	0,2
11th	0,058	0,026	Single Phase	0,1
12th	0,007	0,003	Single Phase	0,1
13th	0,056	0,025	Single Phase	0,1
14th	0,005	0,002	Single Phase	0,1
15th	0,056	0,025	Single Phase	0,1
16th	0,007	0,003	Single Phase	0,1
17th	0,050	0,023	Single Phase	0,1
18th	0,006	0,003	Single Phase	0,1
19th	0,048	0,022	Single Phase	0,1
20th	0,005	0,002	Single Phase	0,1
21th	0,045	0,020	Single Phase	0,1
22th	0,007	0,003	Single Phase	0,1
23th	0,040	0,018	Single Phase	0,1
24th	0,008	0,003	Single Phase	0,1
25th	0,042	0,019	Single Phase	0,1
26th	0,012	0,005	Single Phase	0,1
27th	0,038	0,017	Single Phase	0,1
28th	0,011	0,005	Single Phase	0,1
29th	0,037	0,017	Single Phase	0,1
30th	0,010	0,004	Single Phase	0,1
31th	0,039	0,018	Single Phase	0,1
32th	0,008	0,003	Single Phase	0,1
33th	0,037	0,017	Single Phase	0,1
34th	0,011	0,005	Single Phase	0,1
35th	0,033	0,015	Single Phase	0,1
36th	0,008	0,004	Single Phase	0,1
37th	0,029	0,013	Single Phase	0,1
38th	0,008	0,004	Single Phase	0,1
39th	0,029	0,013	Single Phase	0,1
40th	0,009	0,004	Single Phase	0,1
41th	0,025	0,011	Single Phase	N/A
42th	0,010	0,004	Single Phase	N/A

43th	0,025	0,012	Single Phase	N/A
44th	0,007	0,003	Single Phase	N/A
45th	0,024	0,011	Single Phase	N/A
46th	0,007	0,003	Single Phase	N/A
47th	0,020	0,009	Single Phase	N/A
48th	0,006	0,003	Single Phase	N/A
49th	0,016	0,007	Single Phase	N/A
50th	0,006	0,003	Single Phase	N/A
Note: The harmonics are tested and evaluated according the IEEE1547.1-2005 clause 5.11.1 according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016).				

4.7 Power factor(PEA) **3.1, 8.4 Harmonic Regulation (PEA: 2016)**					**P**
Test conditions:					
Output power [kW] **Test AC voltage [V]**	**~10%** **0,604 kW**	**~25%** **1,523 kW**	**~50%** **3,039 kW**	**~75%** **4,538 kW**	**~100%** **6,018 kW**
220	0,9633c	0,9944c	0,9987c	0,9992c	0,9992c

Note:

The PV system shall have a lagging power factor greater than 0,95 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.

Test result refer to table 3.4.1, 8.1.2 1.

5.2.1 Voltage monitoring **3.7, 12.3 Under and Over Voltage Protection (PEA:2016)** **3.10, 12.5 Response to utility recovery (PEA:2016)**	**P**

First Level (Phase to Neutral)

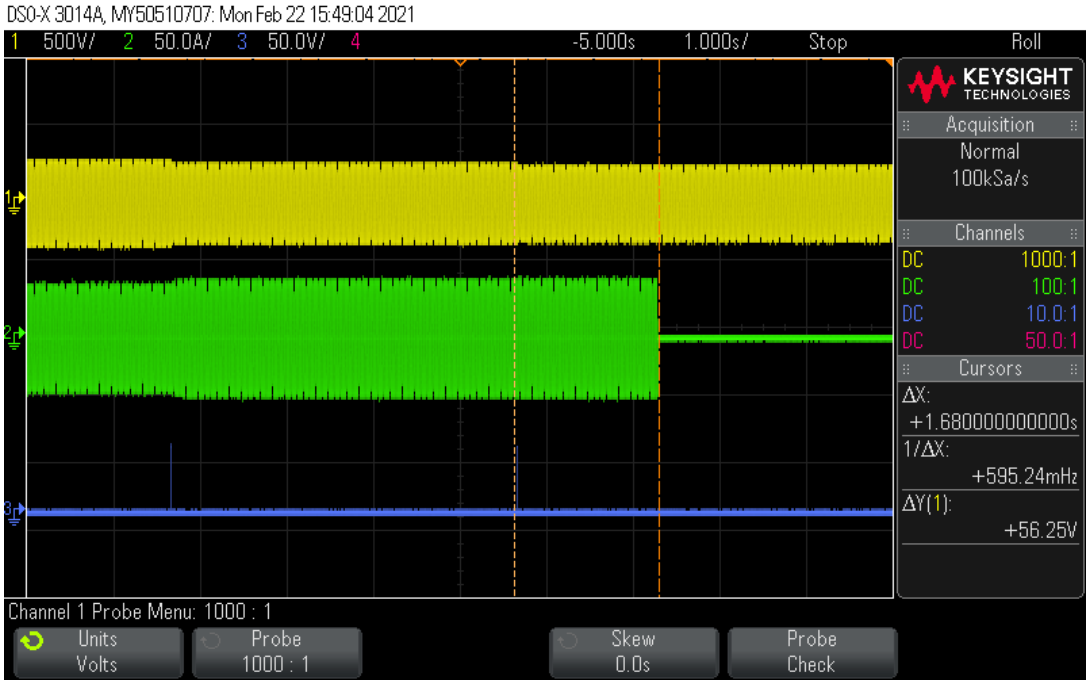
Test conditions:	Output power: 6KW Frequency: 50Hz			
	Under Voltage		**Over Voltage**	
		Voltage [V]		Voltage [V]
Set value		**198V**		**242V**
Measured trip value		196,8		242,1
		196,9		242,2
		196,9		242,1
Parameter		Time [s]		Time [s]
Limit		**<= 2,0s**		**<= 1,0s**
Disconnetion time	220V to 203V (4s min) to **193V**	1,680	220V to 237V (2s min) **to 247V**	0,640
		1,680		0,640
		1,680		0,650
Reconnection time	20s - 5min	72s	20s - 5min	71s

Second Level (Phase to Neutral)				
Test conditions:	Output power:6KW Frequency: 50Hz			
	Under Voltage		**Over Voltage**	
Parameter		Voltage [V]		Voltage [V]
Set value		**110V**		**264V**
Measured trip value		108,9		264,2
		108,9		264,1
		108,8		264,1
Parameter		Time [s]		Time [s]
Limit		**<= 0,3s**		**<= 0,16s**
Disconnection time	220V to 203V (0.6s min) to 105V	0,192	220V to 237V (0.32s min) to 269V	0,090
		0,178		0,088
		0,176		0,090
Reconnection time	20s - 5min	70s	20s - 5min	69s

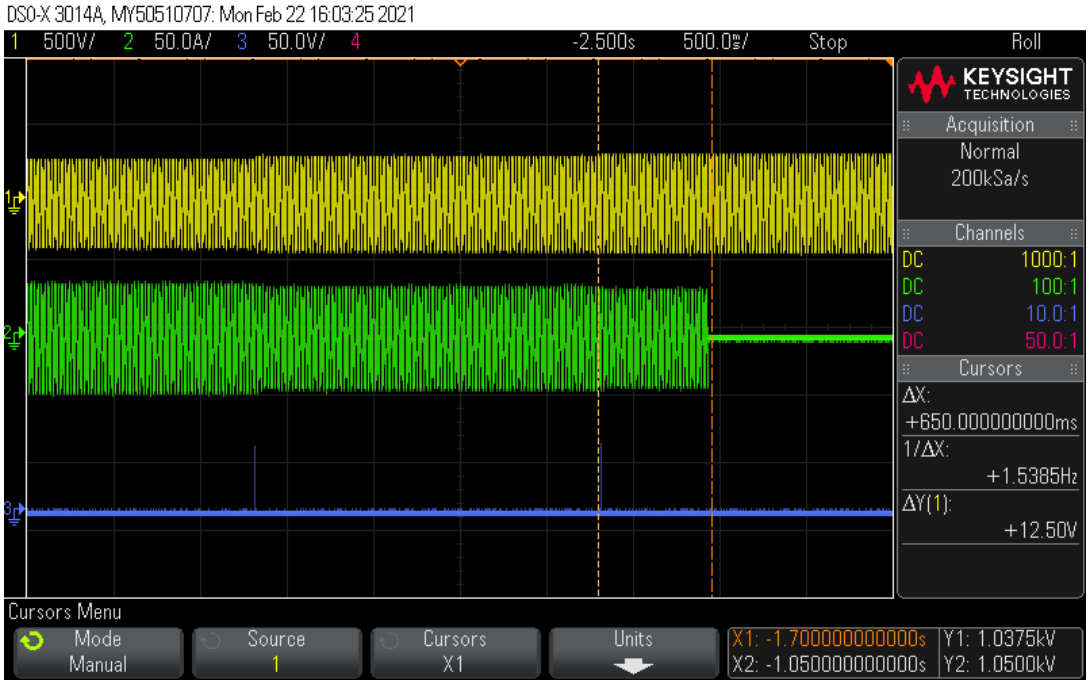
Note:
Note:
The tests are according PEA 8/9/2556. The voltage settings of the EUT are set for the tests as stated to 198V, 110V for undervoltage and 242V, 264V for overvoltage.

Response to utility recovery is according to the appropriate IEEE or IEC standard test methods.

Under Voltage First Level single phase

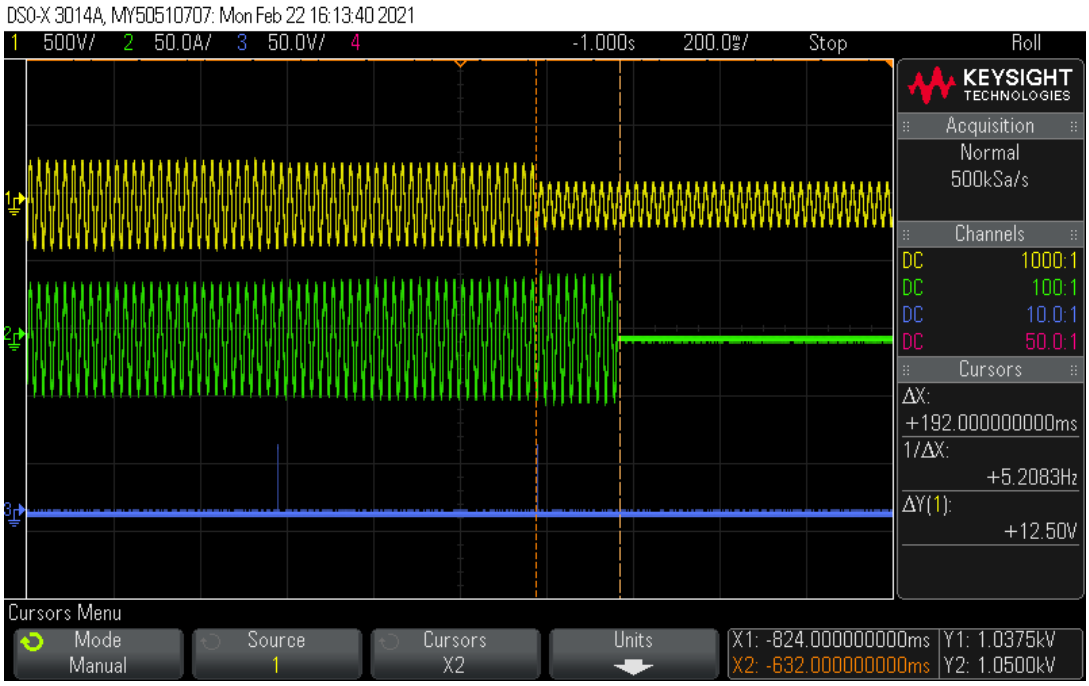


Over voltage First Level single phase

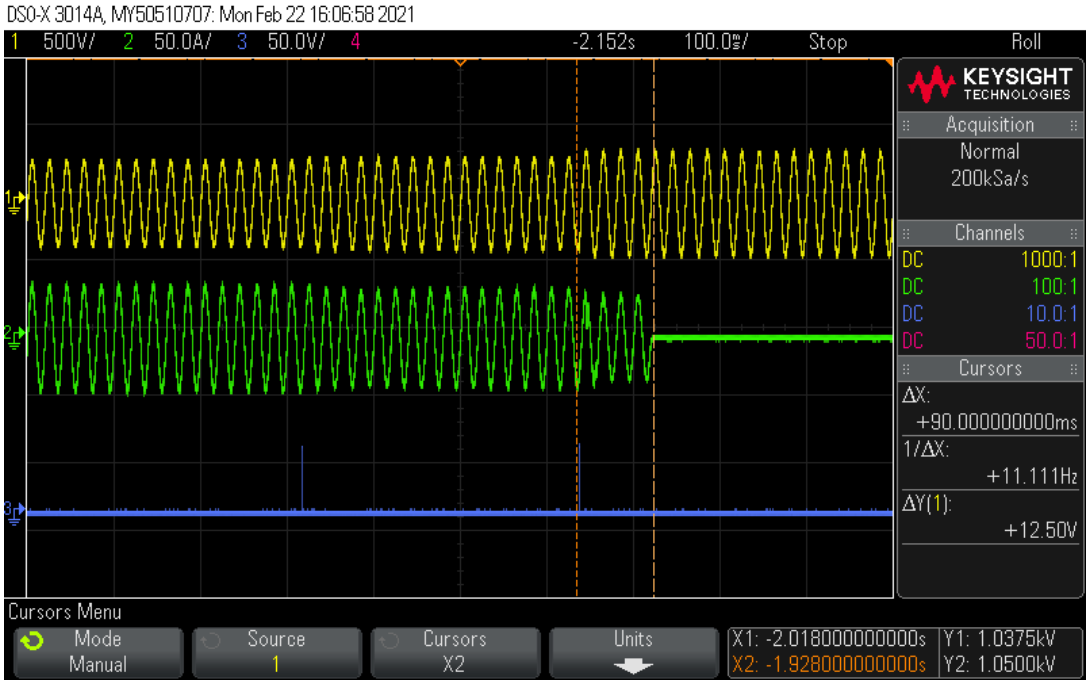


Note:
CH1: grid voltage(500V/div); CH2: Current of EUT; CH3: trip signal

Under Voltage Second Level single phase

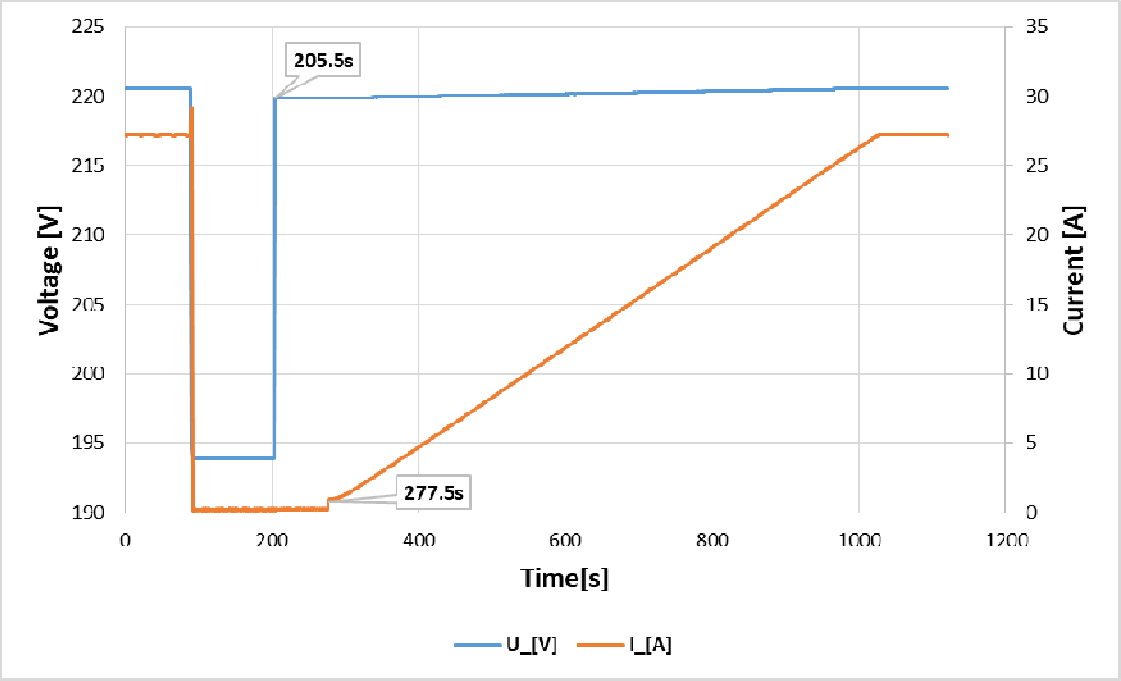


Over voltage Second Level single phase

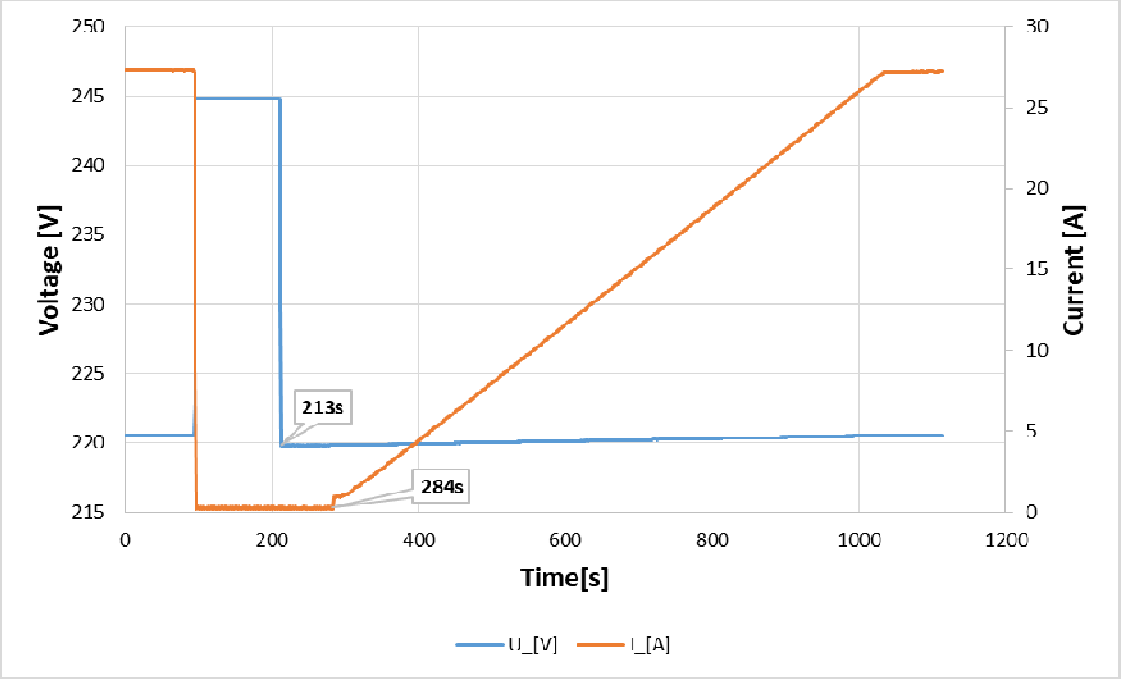


Note:
CH1: grid voltage(500V/div); CH2: Current of EUT; CH3: trip signal

Reconnection after Under Voltage First Level

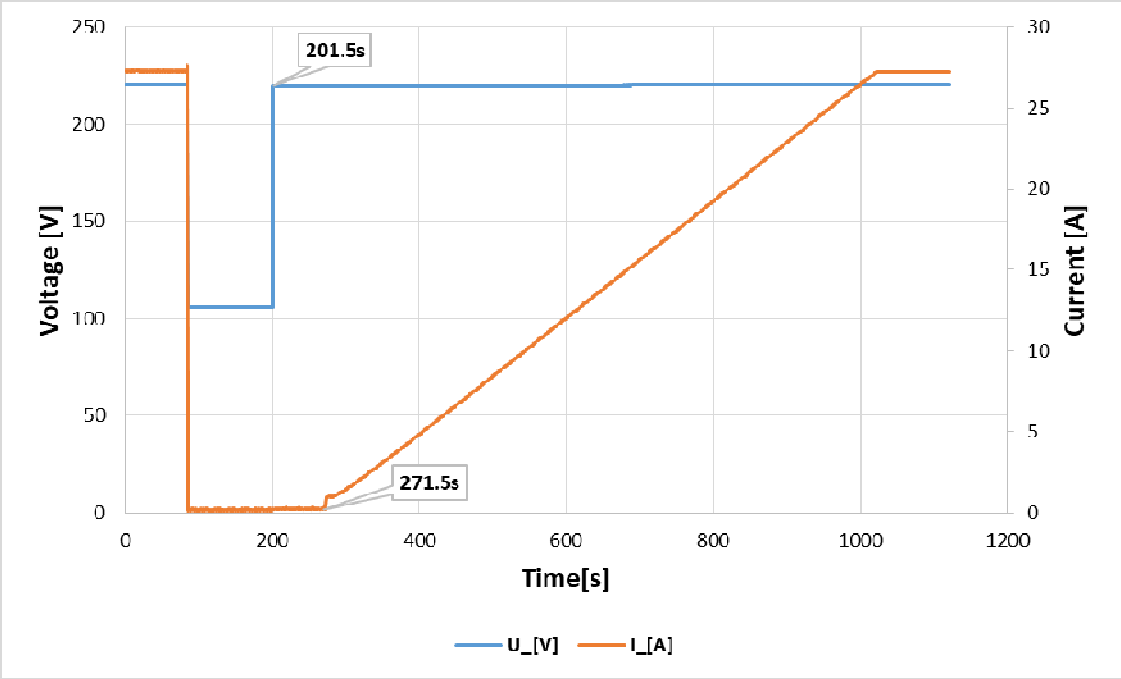


Reconnection after Over Voltage First Level

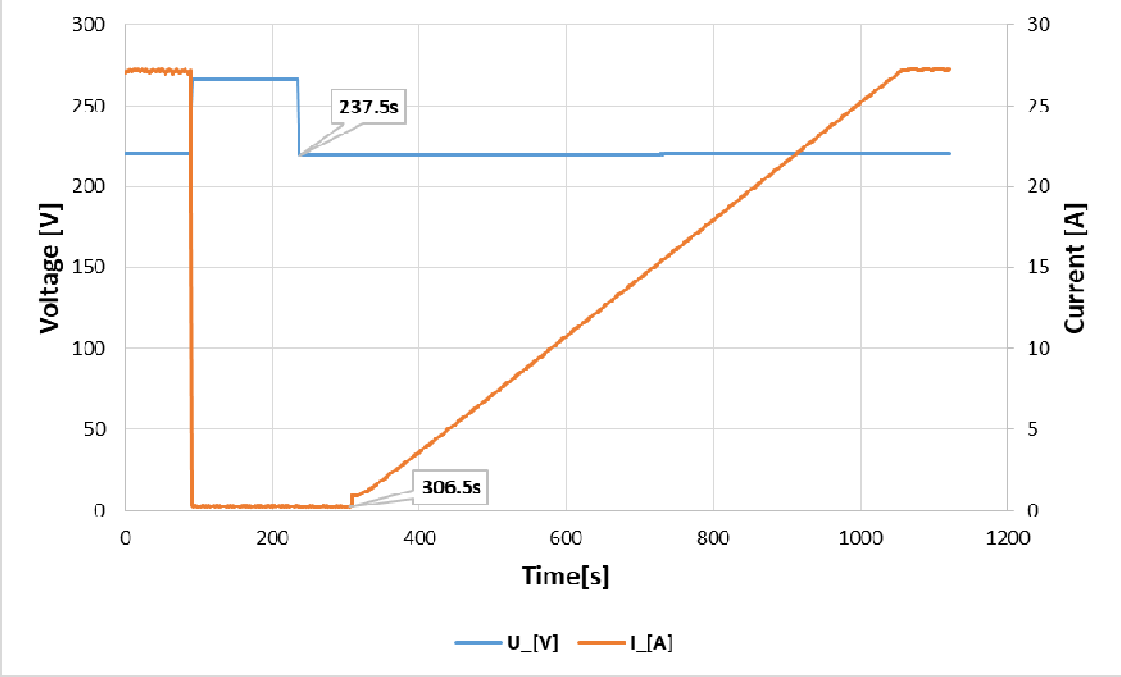


Note:
U: grid voltage; I: Current of EUT;

Reconnection after Under Voltage Second Level



Reconnection after Over Voltage Second Level



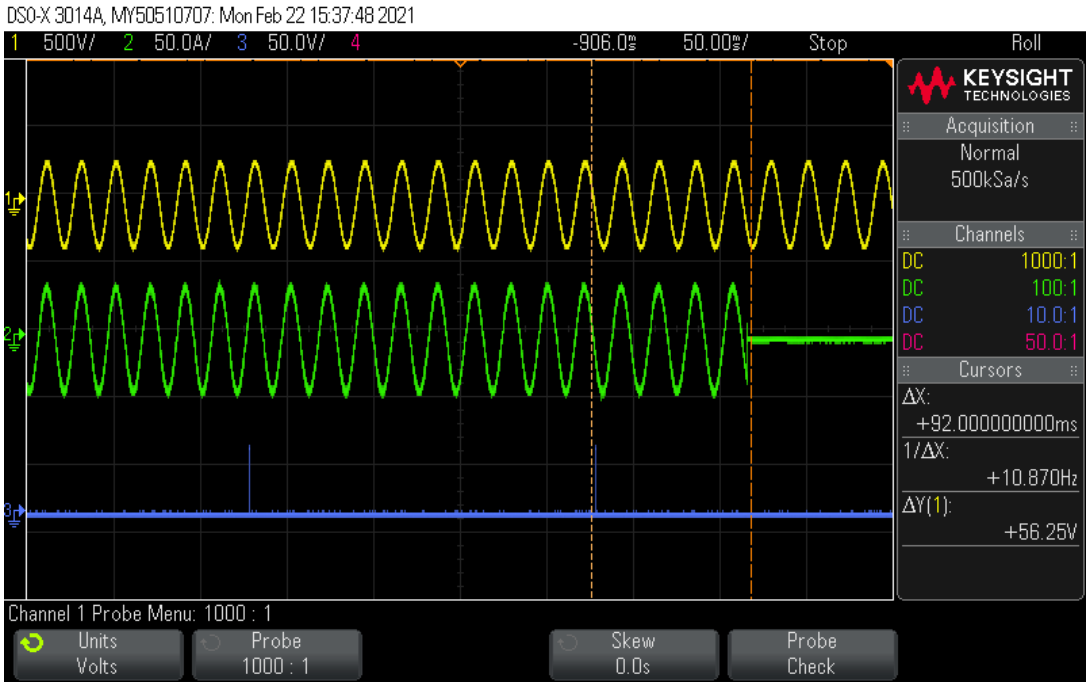
Note:
U: grid voltage; I: Current of EUT;

5.2.2 Frequency monitoring					**P**
IEC 61727 **8.2 Under and Over Frequency Protection (PEA:2016)** **3.10, 12.5 Response to utility recovery (PEA:2016)**					
Test conditions:	Any output power level				
	Under frequency		**Over frequency**		
Parameter		Frequency [Hz]		Frequency [Hz]	
Output Voltage		U_N		U_N	
Set value		**47,00Hz**		**52,00Hz**	
Measured trip value(V)		46,94		52,01	
		46,97		52,01	
		46,96		52,01	
		Time [s]		Time [s]	
Limit		**<= 0,1s**		**<= 0,1s**	
Disconnection time(ms)	50,0Hz to 47,2 Hz (0,2s min) to 46,5 Hz	0,092	50,0 Hz to 51,80 Hz (0,2s min) to 52,5Hz	0,066	
		0,084		0,091	
		0,072		0,072	
Reconnection time (Sec)	20s – 5min	71s	20s-5min	75s	

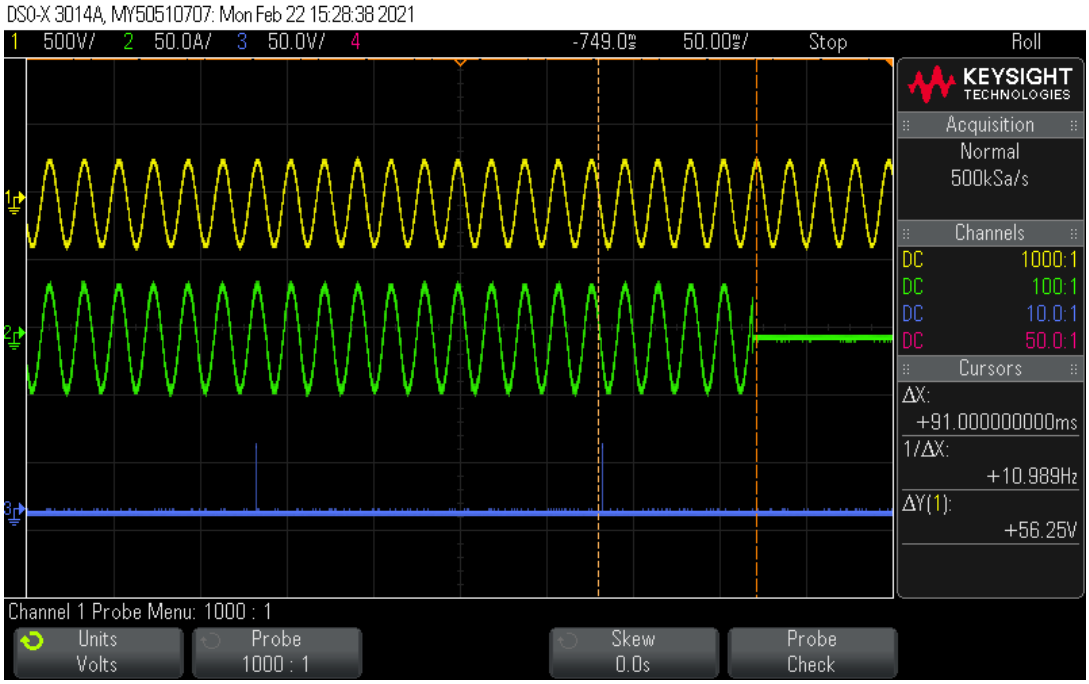
Note:
The frequency which inverter stops feeding power to electrical system in each test must be in the range of the frequency trip setting +/- 0,1Hz and the time it takes to cut off the power must be within 0.1 second.

The tests are performed according the IEEE 1547.1-2005, annex A.
Response to utility recovery is according to the appropriate IEEE or IEC standard test methods.

Under Frequency:

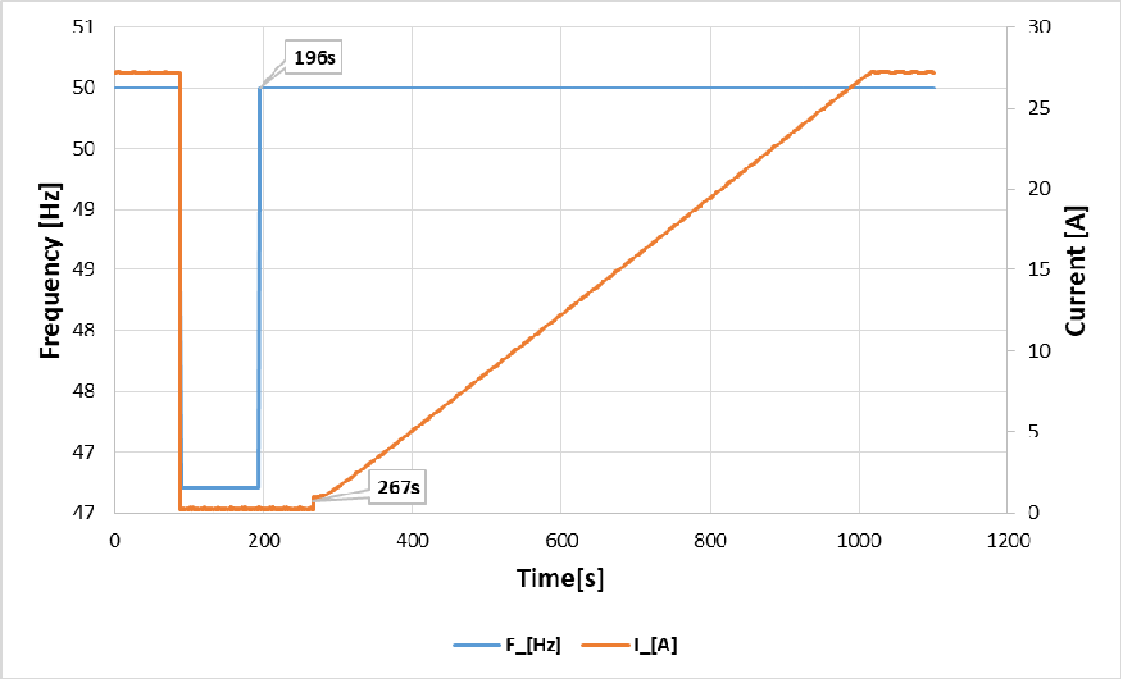


Over Frequency:

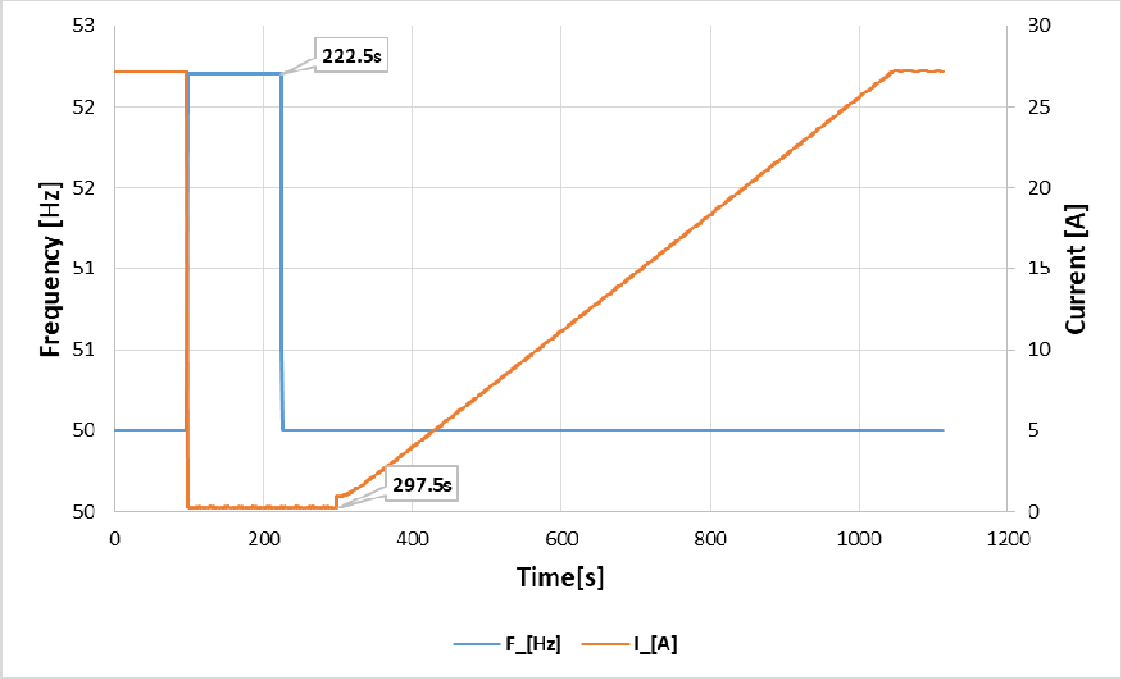


Note:
CH1: grid voltage(500V/div); CH2: Current of EUT(50A/div); CH3: trip signal

Reconnection after Under Frequency:



Reconnection after Over Frequency:



Note:
U: grid voltage; I: Current of EUT;

6.1 Islanding protection
3.9, 12.4 Anti-Islanding (PEA:2016)

Test circuit and parameters

Parameter	Symbol	Units
EUT DC Input		
DC voltage	V_{DC}	V
DC Current	I_{DC}	A
DC Power	P_{DC}	W
EUT AC ouput		
AC voltage	V_{EUT}	V
AC current	I_{EUT}	A
Real power	P_{EUT}	W
Reactive power	Q_{EUT}	VAr
Test Load		
Resistive load current	I_R	A
Inductive load current	I_L	A
Capacitive load current	I_C	A
AC (utility) power source		
Utility real power	P_{AC}	W
Utility reactive power	Q_{AC}	VAr
Utility current	I_{AC}	A

Block diagram test circuit IEC 62116:2008

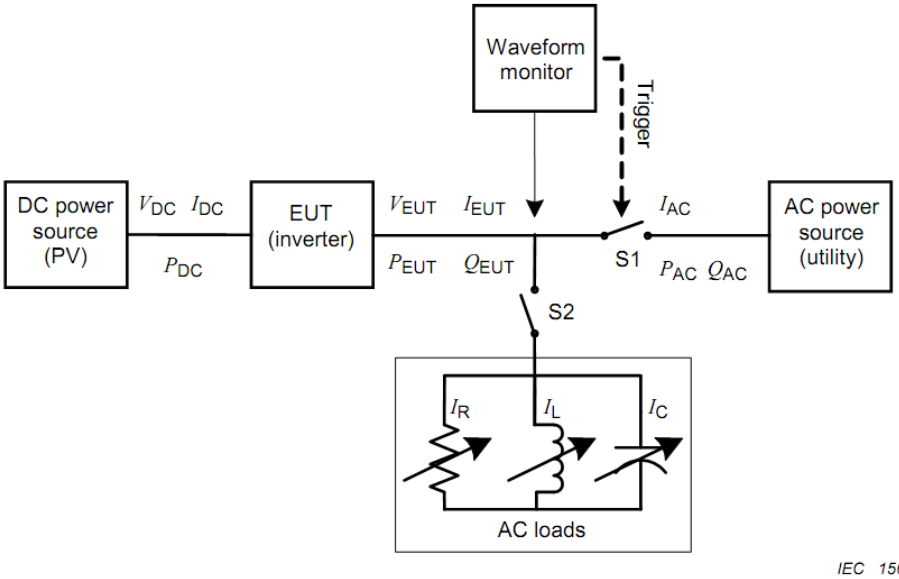


Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

6.1 Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%) **3.9, 12.4 Anti-Islanding (PEA:2016)**	**P**

Test conditions	Frequency: 50+/-0,1Hz U_N=220+/-3Vac Distortion factor of chokes < 2% Quality = 1
Disconnection limit	1s

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} (W per phase)	Actual Q_f	V_{DC} (V)	Remarks4)
1	100	100	0	0	494	6000	1,000	440	Test A at BL
2	100	100	-5	-5	428	6000	1,026	440	Test A at IB
3	100	100	-5	0	480	6000	1,053	440	Test A at IB
4	100	100	-5	+5	372	6000	1,079	440	Test A at IB
5	100	100	0	-5	476	6000	0,975	440	Test A at IB
6	100	100	0	+5	398	6000	1,025	440	Test A at IB
7	100	100	+5	-5	434	6000	0,928	440	Test A at IB
8	100	100	+5	0	490	6000	0,952	440	Test A at IB
9	100	100	+5	+5	472	6000	0,976	440	Test A at IB

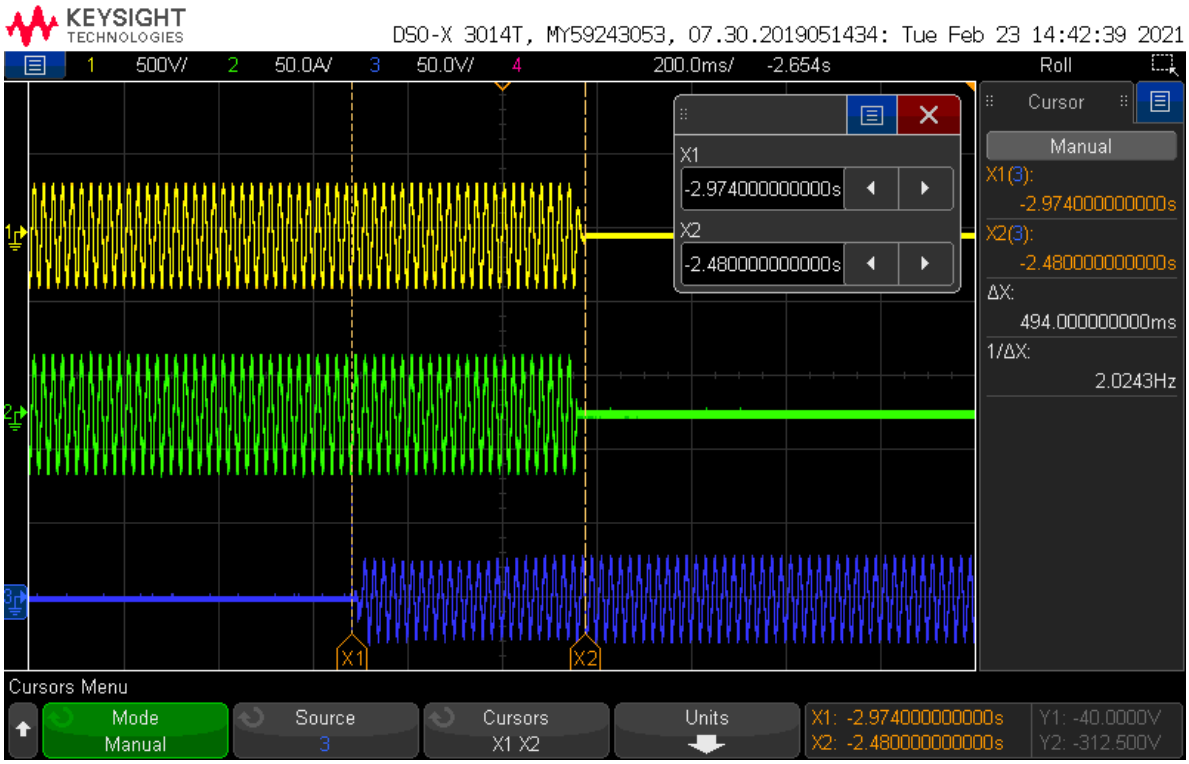
Parameter at 0% per phase	L= 25,68 mH	R= 8,07 Ω	C= 394,60 µF
IAC fundamental current(A)	237mA		

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 P_{AC} 0% and Q_{AC} 0% reactive load No. 1



Attention:
All relays are direct coupled and open directly by receiving the islanding signal from the controller.

Note:

6.1 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %) **3.9, 12.4 Anti-Islanding (PEA:2016)**	**P**

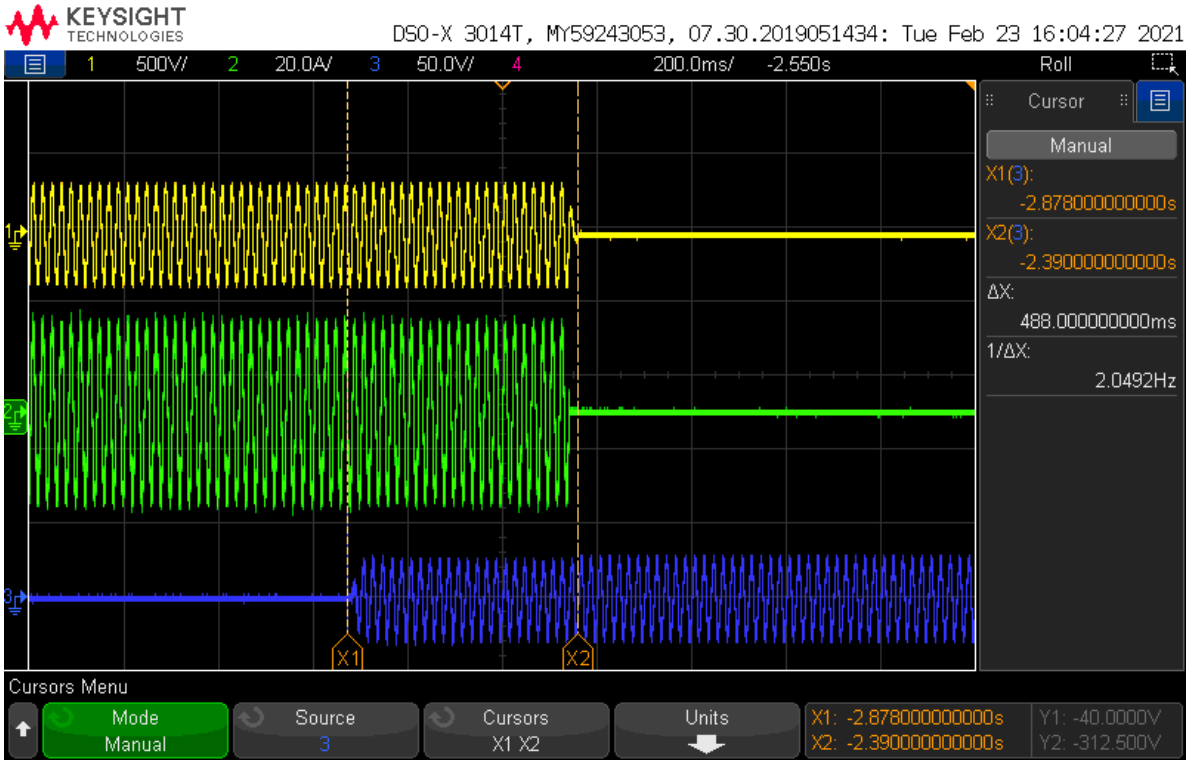
Test conditions	Frequency: 50+/-0,1Hz U_N=220+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	1s

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} (W per phase)	Actual Qf	V_{DC} (V)	Remarks4)
1	66	66	0	-5	408	3960	0,975	280	Test B at IB
2	66	66	0	-4	440	3960	0,980	280	Test B at IB
3	66	66	0	-3	466	3960	0,985	280	Test B at IB
4	66	66	0	-2	420	3960	0,990	280	Test B at IB
5	66	66	0	-1	450	3960	0,995	280	Test B at IB
6	66	66	0	0	488	3960	1,000	280	Test B at BL
7	66	66	0	1	476	3960	1,005	280	Test B at IB
8	66	66	0	2	450	3960	1,010	280	Test B at IB
9	66	66	0	3	484	3960	1,015	280	Test B at IB
10	66	66	0	4	442	3960	1,020	280	Test B at IB
11	66	66	0	5	410	3960	1,025	280	Test B at IB

Parameter at 0% per phase	L= 38,90 mH	R= 12,22 Ω	C= 260,44 µF
IAC fundamental current(A)	196mA		

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, 50 % of range =X + 0,5 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load No. 6



Attention:
All relays are direct coupled and open directly by receiving the islanding signal from the controller.

Note:

6.1 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %) **3.9, 12.4 Anti-Islanding (PEA:2016)**	**P**

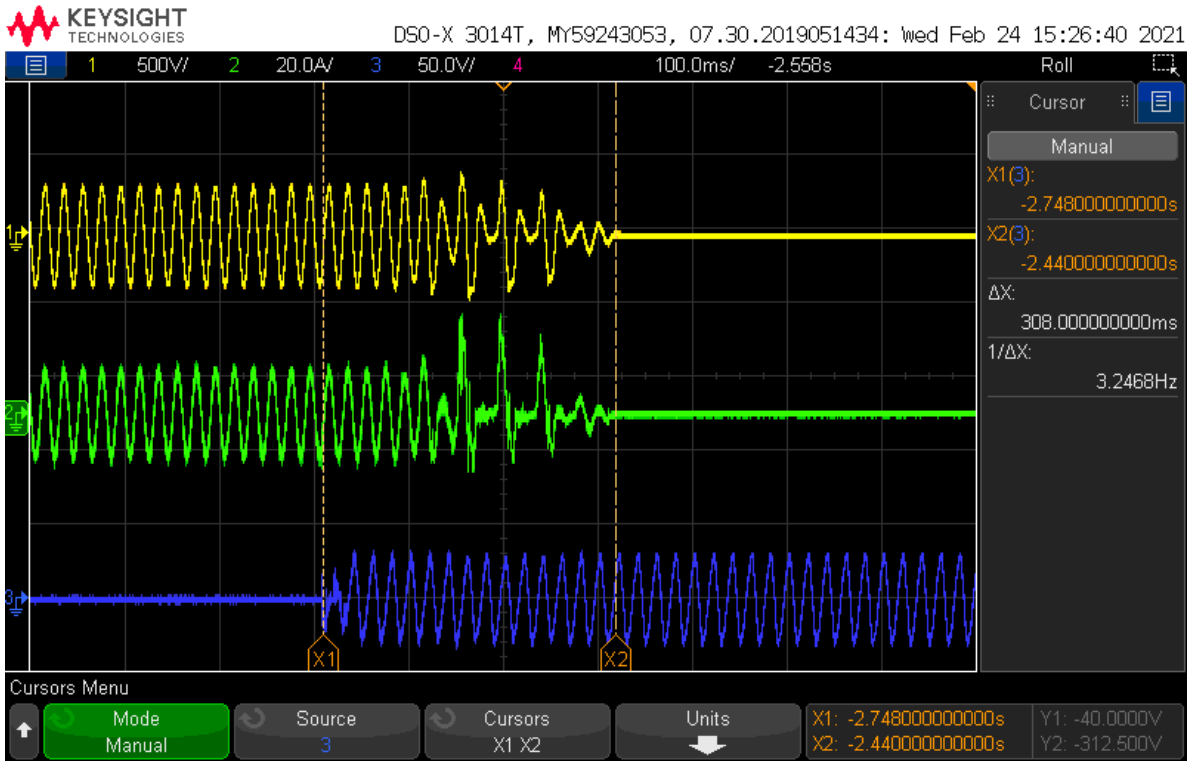
Test conditions	Frequency: 50+/-0,1Hz U_N=220+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	1s

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} (W per phase)	Actual Q_f	V_{DC} (V)	Remarks[4]
1	33	33	0	-5	270	1980	0,975	120	Test C at IB
2	33	33	0	-4	284	1980	0,980	120	Test C at IB
3	33	33	0	-3	250	1980	0,985	120	Test C at IB
4	33	33	0	-2	300	1980	0,990	120	Test C at IB
5	33	33	0	-1	254	1980	0,995	120	Test C at IB
6	33	33	0	0	308	1980	1,000	120	Test C at BL
7	33	33	0	1	278	1980	1,005	120	Test C at IB
8	33	33	0	2	262	1980	1,010	120	Test C at IB
9	33	33	0	3	256	1980	1,015	120	Test C at IB
10	33	33	0	4	290	1980	1,020	120	Test C at IB
11	33	33	0	5	268	1980	1,025	120	Test C at IB

Parameter at 0% per phase	L= 77,81 mH	R= 24,44 Ω	C= 130,22 µF
IAC fundamental current(A)	163mA		

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, 10 % of range =X + 0,1 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load No. 6



Attention:
All relays are direct coupled and open directly by receiving the islanding signal from the controller.

Note:

PEA:2016 additional test	P
3.4 Reactive power control(PEA:2016)	**P**

Test conditions:	Output: 220 Vac,50Hz

P (setting)	P(kW)ind	P(kW)cap	Q(kVar)ind, max	Q(kVar)cap, max	PFind, max	PFcap, max
0%	0,295	0,296	-0,129	0,236	0,9104	0,7818
10%	0,601	0,603	-0,290	0,290	0,9007	0,9012
20%	1,213	1,215	-0,584	0,588	0,9009	0,9002
30%	1,821	1,823	-0,873	0,893	0,9017	0,8981
40%	2,425	2,428	-1,150	1,201	0,9036	0,8963
50%	3,027	3,031	-1,479	1,464	0,8985	0,9005
60%	3,625	3,630	-1,785	1,725	0,8972	0,9032
70%	4,218	4,224	-2,054	1,997	0,8990	0,9041
80%	4,808	4,815	-2,365	2,272	0,8973	0,9044
90%	5,369	5,401	-2,659	2,547	0,8961	0,9044
100%	5,367	5,541	-2,660	2,598	0,8960	0,9054

Note:

PEA:2016 additional test	P
3.4.1, 8.1.2 1) A fixed displacement factor cosφ	**P**

Test conditions:	Output: 220 Vac,50Hz

P (setting)	PF (setting)	P(kW)	Q(kVar)	PF
0%	0,90 lagging	0,295	-0,129	0,9104
10%	0,90 lagging	0,601	-0,290	0,9007
20%	0,90 lagging	1,213	-0,584	0,9009
30%	0,90 lagging	1,821	-0,873	0,9017
40%	0,90 lagging	2,425	-1,150	0,9036
50%	0,90 lagging	3,027	-1,479	0,8985
60%	0,90 lagging	3,625	-1,785	0,8972
70%	0,90 lagging	4,218	-2,054	0,8990
80%	0,90 lagging	4,808	-2,365	0,8973
90%	0,90 lagging	5,369	-2,659	0,8961
100%	0,90 lagging	5,367	-2,660	0,8960

P (setting)	PF (setting)	P(kW)	Q(kVar)	PF
0%	0,90 leading	0,296	0,236	0,7818
10%	0,90 leading	0,603	0,290	0,9012
20%	0,90 leading	1,215	0,588	0,9002
30%	0,90 leading	1,823	0,893	0,8981
40%	0,90 leading	2,428	1,201	0,8963
50%	0,90 leading	3,031	1,464	0,9005
60%	0,90 leading	3,630	1,725	0,9032
70%	0,90 leading	4,224	1,997	0,9041
80%	0,90 leading	4,815	2,272	0,9044
90%	0,90 leading	5,401	2,547	0,9044
100%	0,90 leading	5,541	2,598	0,9054

P (setting)	PF (setting)	P(kW)	Q(kVar)	PF
0%	1,00	0,243	0,081	0,9484
10%	1,00	0,627	0,080	0,9920
20%	1,00	1,221	0,127	0,9946
30%	1,00	1,818	0,177	0,9952

40%	1,00	2,423	0,179	0,9973
50%	1,00	3,025	0,168	0,9985
60%	1,00	3,625	0,162	0,9990
70%	1,00	4,220	0,169	0,9992
80%	1,00	4,815	0,174	0,9993
90%	1,00	5,404	0,164	0,9995
100%	1,00	5,991	-0,173	0,9995
Note:				

PEA:2016 additional test	N/A
3.4.2, 8.1.2 2) A variable reactive power depending on the voltage Q(U) (PEA:2016) (Power generation system is greater than 500kW)	**N/A**

The purpose of the test is to ensure that the converter complies with the methods for automatically supplying reactive power according to the standard characteristic curve Q(U) indicated in 1.5.

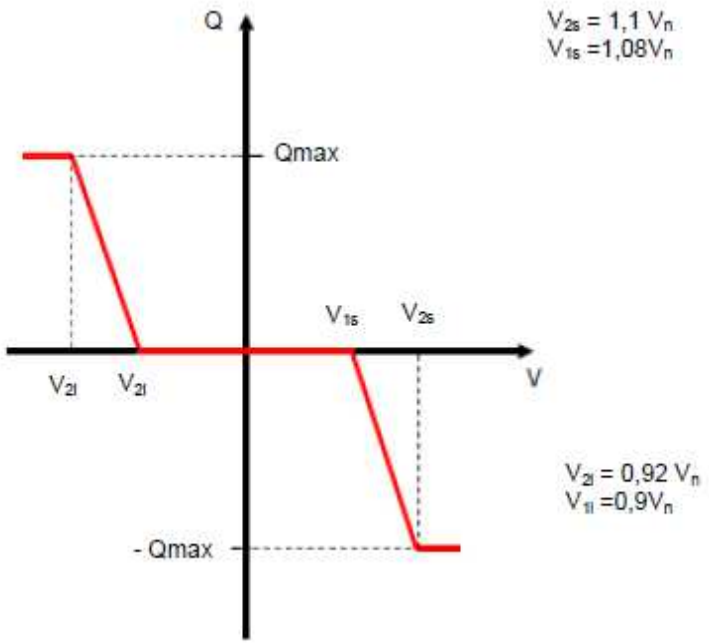
Activation must be at the Distributor's request, when the Operating Regulations are issued. The Distributor shall also specify the values of the parameters that uniquely characterise the curve, i.e.: V1i, V2i, V1s and V1s as well as the lock-in value of active power (default value P = 0,2 P_n).

The parameters V1i, V2i, V1s and V1s should be set in the range between 0,9 and 1,1 with 0,01 V_n steps. In order to facilitate execution of the type tests, the characterising parameters are conventionally set as follows:

V1s =1,08 V_n; V2s = 1,1 V_n

V1i =0,92 V_n; V2i = 0,9 V_n

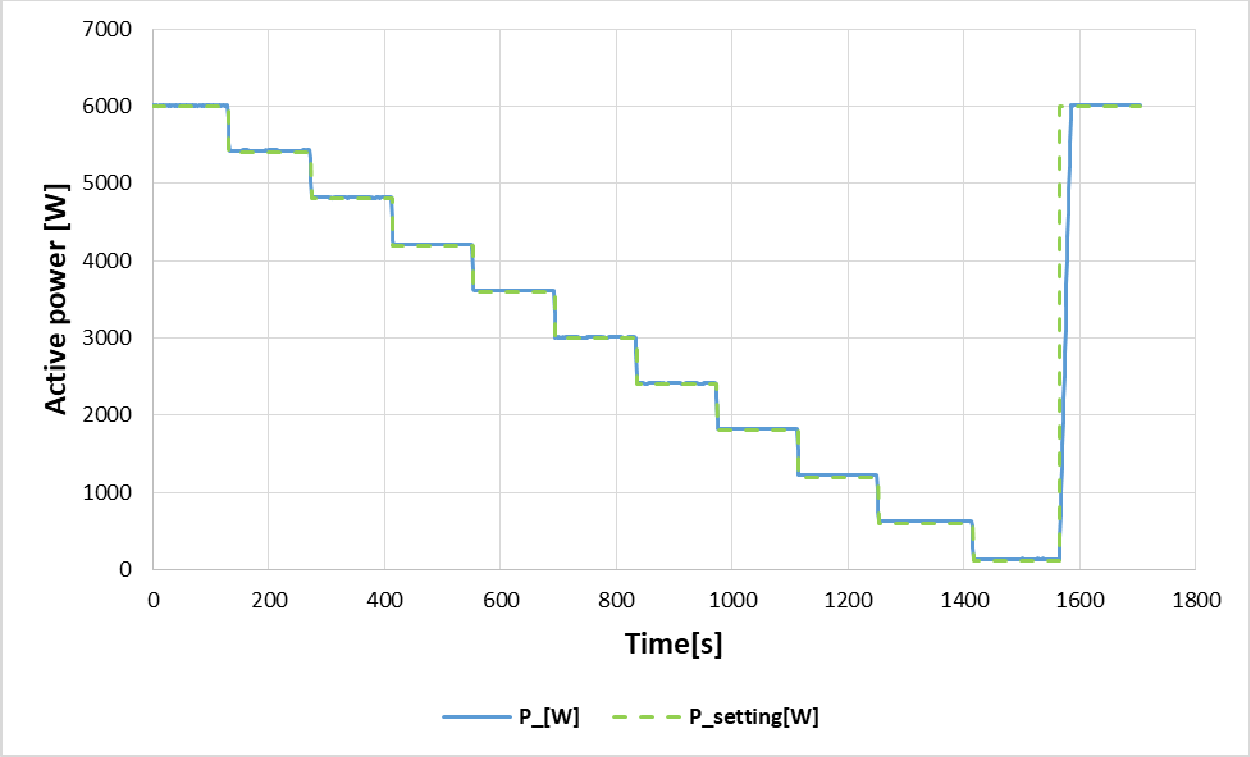
and the active power lock-in value (default value P = 0,2 P_n).



PEA:2016 additional test	P
3.5, 12.1 Active power control (PEA:2016)	**P**

Setpoint in power bin [%]	$P_{setpoint}$ [kW]	P_{60} [kW]	Decrease time (s)
100%	6,000	6,009	
90%	5,400	5,426	2s
80%	4,800	4,814	2s
70%	4,200	4,211	2s
60%	3,600	3,609	2s
50%	3,000	3,008	2s
40%	2,400	2,412	2s
30%	1,800	1,816	2s
20%	1,200	1,222	2s
10%	0,600	0,630	2s
2%	0,120	0,140	2s

Graph of the setting accuracy



Note:

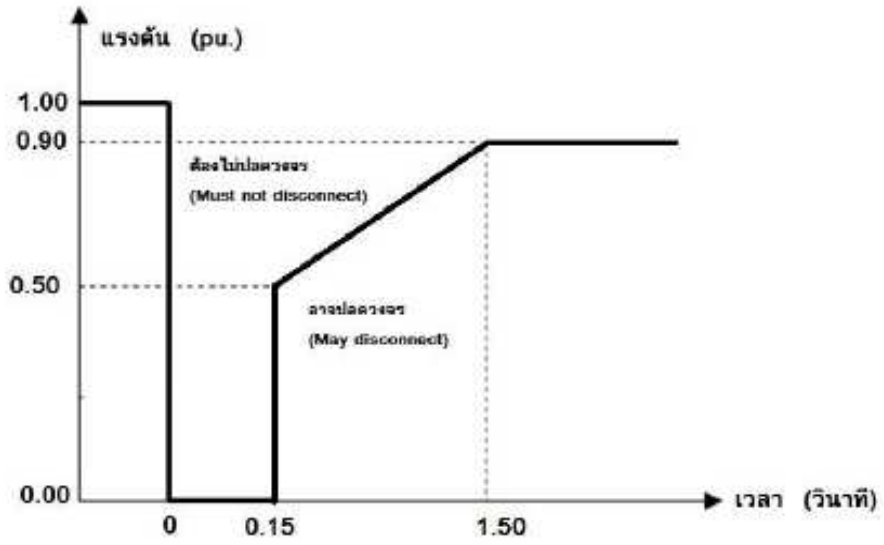
PEA:2016 additional test	N/A
3.6, 12.2 Low voltage fault Ride through capability (PEA:2016) (Power generation system is greater than 500kW)	N/A

Test List	V(V/V_n)	Duration time (Sec)
Test P>0,9P_n*		
Three-phase faults	0,7-0,8V_n	---
	0,3-0,5V_n	---
	0-0,05V_n	---
Phase to phase faults	0,7-0,8V_n	---
	0,3-0,5V_n	---
	0-0,05V_n	---
Single phase to ground faults	0,7-0,8V_n	---
	0,3-0,5V_n	---
	0-0,05V_n	---
Test P=0,3P_n		
Three-phase faults	0,7-0,8V_n	---
	0,3-0,5V_n	---
	0-0,049V_n	---
Phase to phase faults	0,7-0,8V_n	---
	0,3-0,5V_n	---
	0-0,049V_n	---
Single phase to ground faults	0,7-0,8V_n	---
	0,3-0,5V_n	---
	0-0,049V_n	---
Test P=0,1 Pn		
Three-phase faults	0,7-0,8V_n	---
	0,3-0,5V_n	---
	0-0,049V_n	---
Phase to phase faults	0,7-0,8V_n	---
	0,3-0,5V_n	---
	0-0,049V_n	---

Single phase to ground faults	0,7-0,8V_n	---
	0,3-0,5V_n	---
	0-0,049V_n	---

Note:
The PGS must not disconnected from gird while the PCC voltage dip period less than below curve limit.

a) install and connect the PGS and recommendation of the technical requirements of the equipment manufacturer .
b) Check all parameters of power supply in normal conditions, the operation of power system equipment .
c) testing by simulation the voltage . (I try to short-circuit in the power network) in the electricity network to balance the pressure between 70-80%V_n , 30-50%V_n, and less than 5 percent of the normal operating pressure .
d) Record the maximum time power system can still connect to the electricity network as shown on above table.



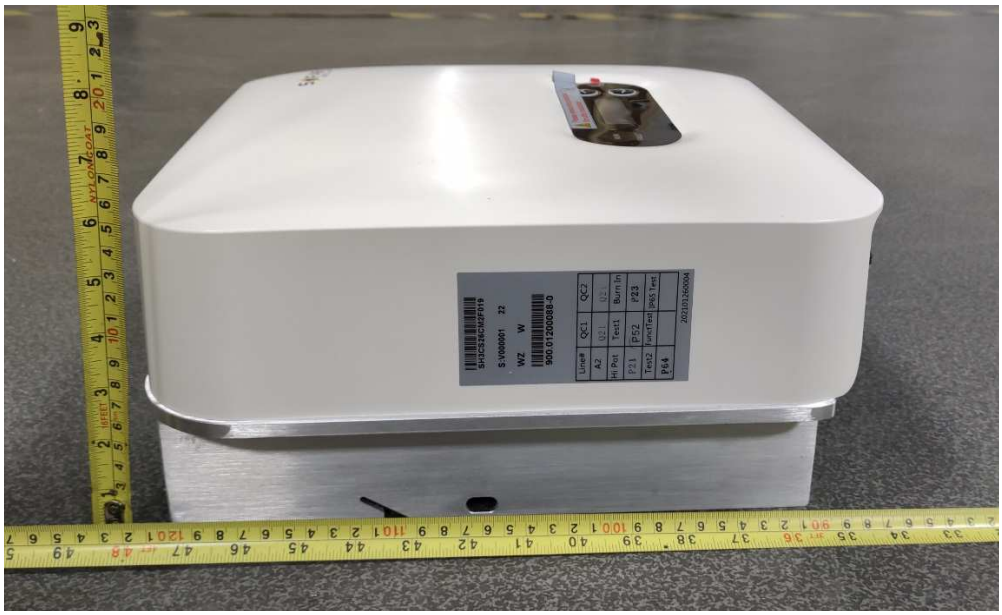
Annex 1

Pictures of the unit

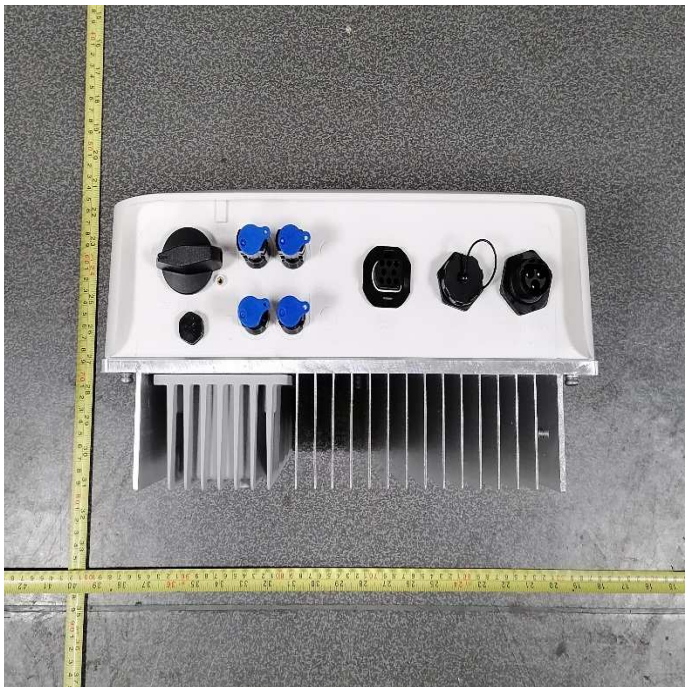
The full pictures refer to PHOTO DOCUMENT
Project No.: 200526N020-1
Date: 20210311

Enclosure front view

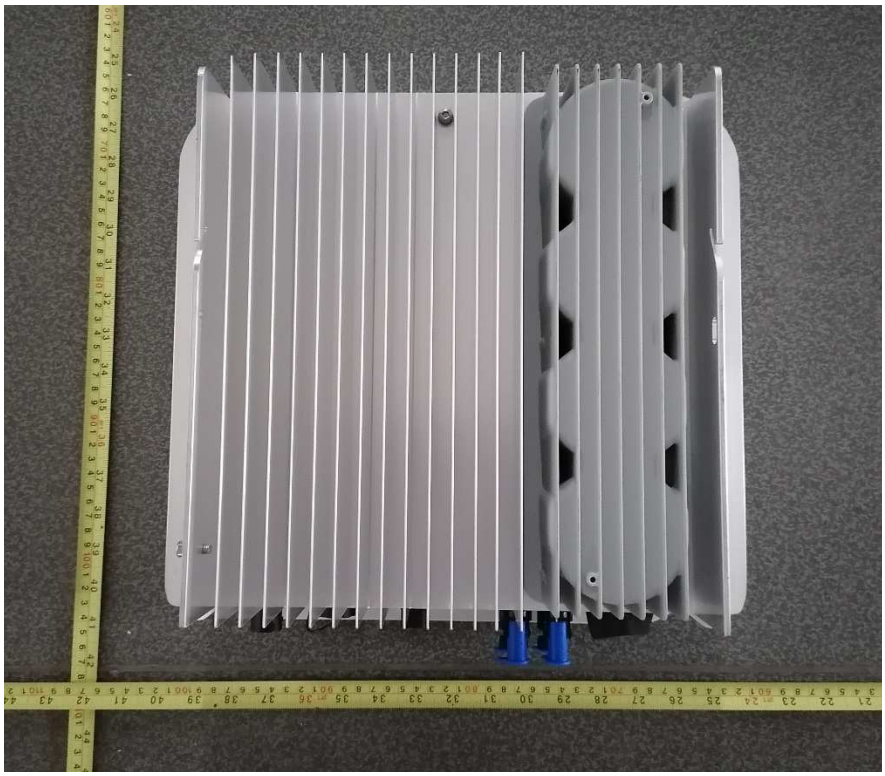
Enclosure side view



Enclosure teminal view



Enclosure rear view



Annex 2
Test equipment list

Testing Location: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Dates of performance test: 2021-01-21 to 2021-03-08

Equipment	Internal No.	Manufacturer	Type	Serial No.	Next Calibration date
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	Jun, 16, 2021
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040016DG	Chroma	62150H-1000S	62150EF00490	
	A7040017DG	Chroma	620028	620028EF00120	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 23, 2021
Oscilloscope	//	KEYSIGHT	DSOX3014T	MY59243036	Jan. 04, 2022
Oscilloscope probel	A4089008DG	Tektronix	TPP1000	C008230	Aug. 10, 2021
	A4089010DG	Tektronix	TPP1000	C008228	Aug. 10, 2021
	A4089011DG	Tektronix	TPP1000	C008229	Aug. 10, 2021
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Sep. 02, 2021
	A1060008DG	YOKOGAWA	CT200	1130700017	Sep. 02, 2021
	A1060012DG	YOKOGAWA	CT200	1130700018	Sep. 02, 2021