TEST REPORT

EN 50438

Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks

Report reference number ..... :	**PV180903N026**
Date of issue ..... ……..:	2018-09-29
Total number of pages ..... ……..:	66
Testing laboratory name ..... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
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Applicant's name ..... :	**Shenzhen SOFAR SOLAR Co., Ltd.**
Address ..... :	5/F,Building 4, Antongda Industrial Park, No.1 Liuxian Avenue,Xin'an Street,Bao'an District, Shenzhen City, Guangdong Province,P.R. China.
Test specification	
Standard ..... :	EN 50438:2013
	with deviations according the national network and system protection for Poland
Certificate ..... :	**Certificate of compliance**
Test report form number. ..... :	EN 50438:2013
Master TRF ..... :	Bureau Veritas Consumer Products Services Germany GmbH
Test item description ..... :	**Grid connected photovoltaic inverter**
Trademark ..... :	
Model / Type ..... :	SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL, SOFAR 2700TL, SOFAR 3000TL

Ratings ..... :	**SOFAR 1100TL**	**SOFAR 1600TL**	**SOFAR 2200TL**	**SOFAR 2700TL**	**SOFAR 3000TL**
MPP DC voltage range [V] ..... :	110-380	165-380	170-450	210-450	230-450
Input DC voltage range [V] ..... :	90-400, max. 450		100-480, max. 500		
Input DC current [A] ..... :	Max.10		Max.13		
Output AC voltage [V] ..... :	230V, 50Hz				
Output AC current [A] ..... :	Max.4,5	Max.7,0	Max.9,5	Max.11,5	Max.13,0
Output power [W] ..... :	1000	1500	2000	2500	2800

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) ..... :	James Huang 
Approved by (name and signature) ..... :	Ted Wu 
Manufacturer's name ..... :	**Shenzhen SOFAR SOLAR Co., Ltd.**
Manufacturer address ..... :	5/F,Building 4, Antongda Industrial Park, No.1 Liuxian Avenue,Xin'an Street,Bao'an District, Shenzhen City, Guangdong Province,P.R. China.
Factory's name ..... :	**Dongguan SOFAR SOLAR Co.,Ltd**
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Document History

Date	Internal reference	Modification / Change / Status	Revision
2018-09-29	James Huang	1, This test report is based on the original test report PV140508N005-2. 2, Update to the new standard version EN 50438:2013	--

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]..... :	SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL: 11kg SOFAR 2700TL, SOFAR 3000TL: 12kg

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..... :	1) 2014-05-08 2) 2018-09-03
Date(s) of performance of test..... :	1) 2014-05-08 to 2014-07-01 2) 2018-09-03 to 2018-09-29

General remarks:

The test result presented in this report relate only to the object(s) tested. The report shall state compliance of the tested objects with the requirements of EN 50438. This report shall not be reproduced in part or in full without the written approval of the issuing testing laboratory.

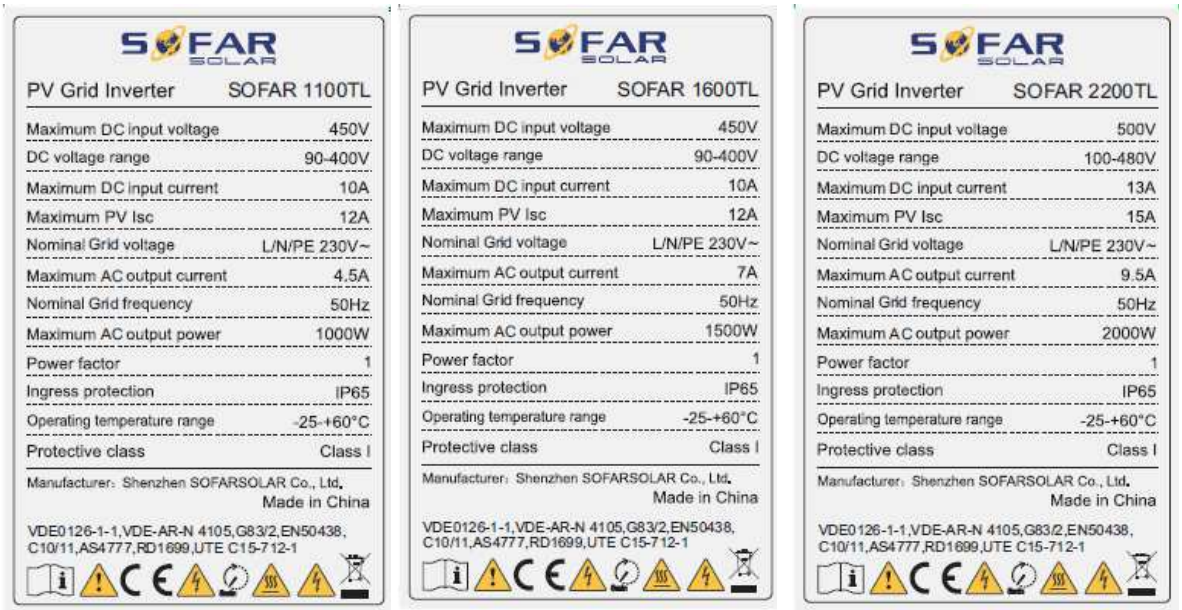
”(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

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

This Test Report consists of the following documents:

1. Test Report
   - 4.2. Normal operating range
   - 4.3 / 4.4. Reactive power capability and control modes
   - 4.5. Voltage control by active power
   - 4.6. Interface protection
   - 4.7. Connection and starting to generate electrical power
   - 4.8. Power quality
2. Pictures of the unit – Annex 1
3. Test equipment list – Annex 2

Copy of marking plate



PV Grid Inverter	SOFAR 1100TL
Maximum DC input voltage	450V
DC voltage range	90-400V
Maximum DC input current	10A
Maximum PV Isc	12A
Nominal Grid voltage	L/N/PE 230V~
Maximum AC output current	4.5A
Nominal Grid frequency	50Hz
Maximum AC output power	1000W
Power factor	1
Ingress protection	IP65
Operating temperature range	-25-+60°C
Protective class	Class I

Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.
Made in China

VDE0126-1-1,VDE-AR-N 4105,G83/2,EN50438, C10/11,AS4777,RD1699,UTE C15-712-1

PV Grid Inverter	SOFAR 1600TL
Maximum DC input voltage	450V
DC voltage range	90-400V
Maximum DC input current	10A
Maximum PV Isc	12A
Nominal Grid voltage	L/N/PE 230V~
Maximum AC output current	7A
Nominal Grid frequency	50Hz
Maximum AC output power	1500W
Power factor	1
Ingress protection	IP65
Operating temperature range	-25-+60°C
Protective class	Class I

Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.
Made in China

VDE0126-1-1,VDE-AR-N 4105,G83/2,EN50438, C10/11,AS4777,RD1699,UTE C15-712-1

PV Grid Inverter	SOFAR 2200TL
Maximum DC input voltage	500V
DC voltage range	100-480V
Maximum DC input current	13A
Maximum PV Isc	15A
Nominal Grid voltage	L/N/PE 230V~
Maximum AC output current	9.5A
Nominal Grid frequency	50Hz
Maximum AC output power	2000W
Power factor	1
Ingress protection	IP65
Operating temperature range	-25-+60°C
Protective class	Class I

Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.
Made in China

VDE0126-1-1,VDE-AR-N 4105,G83/2,EN50438, C10/11,AS4777,RD1699,UTE C15-712-1

PV Grid Inverter	SOFAR 2700TL
Maximum DC input voltage	500V
DC voltage range	100-480V
Maximum DC input current	13A
Maximum PV Isc	15A
Nominal Grid voltage	L/N/PE 230V~
Maximum AC output current	11.5A
Nominal Grid frequency	50Hz
Maximum AC output power	2500W
Power factor	1
Ingress protection	IP65
Operating temperature range	-25-+60°C
Protective class	Class I

Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.
Made in China

VDE0126-1-1,VDE-AR-N 4105,G83/2,EN50438, C10/11,AS4777,RD1699,UTE C15-712-1

PV Grid Inverter	SOFAR 3000TL
Maximum DC input voltage	500V
DC voltage range	100-480V
Maximum DC input current	13A
Maximum PV Isc	15A
Nominal Grid voltage	L/N/PE 230V~
Maximum AC output current	13A
Nominal Grid frequency	50Hz
Maximum AC output power	2800W
Power factor	1
Ingress protection	IP65
Operating temperature range	-25-+60°C
Protective class	Class I

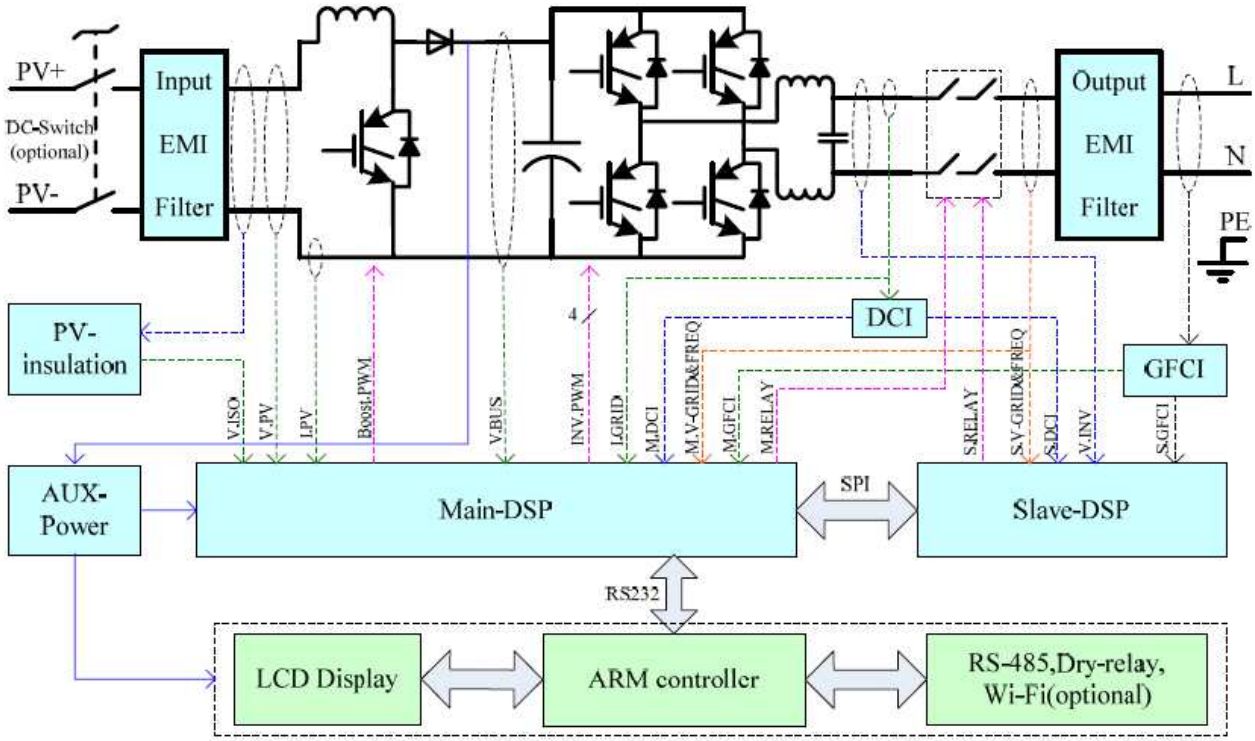
Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.
Made in China

VDE0126-1-1,VDE-AR-N 4105,G83/2,EN50438, C10/11,AS4777,RD1699,UTE C15-712-1

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 PV input and output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundantly by the high power switching bridge and two relays. This assures that the opening of the output circuit will also operate in case of a single error.



The internal control is redundant built. It consists of Microcontroller Master DSP (UC34) and Slave DSP (UC35).

The Master DSP control the relays (RYP2-RYP5) by switching signals; measures the PV voltage, PV current, Bus voltage, grid voltage and 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 (UC35) is measures the grid voltage, AC current, grid frequency and residual current, also can switch off the relays (RYP2-RYP5) independently, and communicate with Master DSP (UC34) 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 (UC34). The Master DSP (UC34) 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.

Differences of the models

The models SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL, SOFAR 2700TL and SOFAR 3000TL are same as in hardware except the components are in the difference table. Identical in software the output power just adjusted by software.

Difference table					
	SOFAR 1100TL	SOFAR 1600TL	SOFAR 2500TL	SOFAR 2700TL	SOFAR 3000TL
Boost inductor	2,6mH	2,6mH	1,9mH	1,9mH	1,9mH
Resistor (RP105, RP108 /RP189,RP109)	220ohm / 10Kohm	220ohm / 10Kohm	200ohm / 7,5Kohm	200ohm / 7,5Kohm	200ohm / 7,5Kohm
BUS capacitor (ECP1, ECP2, ECP3, ECP4)	2 pcs	2 pcs	3 pcs	3 pcs	3 or 4 pcs
Inverter inductor	3,4mH	2,3mH	2,1mH	1,5mH	1,3mH
Resistor (RP118, RP119, RC18 /RP120, RP121,RC22)	499 Ω, 200 Ω, 200 Ω	1 KΩ, 200 Ω, 100 Ω	1 KΩ, 330 Ω, 330 Ω	2 KΩ, 100 Ω, 100 Ω	2 KΩ, 100 Ω, 100 Ω
DC switch and Wi-Fi module are optional.					

The product was tested on:

Hardware version: V1.00
Software version: V1.00

Default interface protection settings according EN 50438:2013:			
Parameter	**Max. disconnection time**	**Min. operate time**	**Trip value**
Over voltage – stage 1 [a]	3 s	-	230V +10% (253 V)
Over voltage – stage 2	0,2 s	0,1 s	230V +15% (264,5 V)
Under voltage	1,5 s	1,2 s	230V -15% (195,5V)
Over frequency	0,5 s	0,3 s	52 Hz
Under frequency	0,5 s	0,3 s	47,5 Hz
Reconnection settings for voltage		$0,85\ U_n \le U \le 1,10\ U_n$	
Reconnection settings for frequency		47,5 Hz ≤ f ≤ 50,05 Hz	
Reconnection time		≥ 60 s	
Active power gradient after reconnection		10 % P_n / min	
Permanent DC-injection		0,5% of rated inverter output current or 20mA	
Loss of mains according EN 62116		Inverter shall disconnect within 2 s.	
The stated currents and voltages are 'true r.m.s.'-values. The voltages in this table are - phase-to-neutral in 230 V single phase systems and 230/400 V systems, - phase-to-phase in a multiphase 230 V system.			
[a] Over voltage – stage1: 10 min-mean-value corresponding to EN 50160. Tolerances on trip values: - Voltage: ± 1% of U_n - Frequency: ± 0.05% Hz - Disconnection time : ± 10%			

EN 50438:2013, clause 4: Tests			
Clause	**Test requirement**	**Test procedure acc. to Annex D**	**Result**
4.2	Normal operating range	D.3.1 / D.3.2 / D.3.3	**P**
4.3 / 4.4	Reactive power capability and control modes	D.3.4	**P**
4.5	Voltage control by active power	D.3.5 (under consideration)	**P**
4.6	Interface protection	Functional safety / D.2.3 / D. 2.4 / D.2.5 / D.3.7	**P**
4.7	Connection and starting to generate electric power	D.3.6	**P**
4.8	Power quality	D.3.8 / D.3.9 / D.3.10	**P**

EN 50438:2013: Interface protection			
Clause	**Test requirement**	**Test procedure acc. to Annex D**	**Result**
4.6	Interface protection	Functional safety / D.2.3 / D.2.4 / D.2.5	**P**

4.6.3 Single fault tolerance of the interface protection system			P
	Ambient temperature [°C] :	23,8	—
	Model/type of power supply :	DC : 62150H-1000S AC : 61512	—
	Manufacturer of power supply :	Chroma	—
	Rated markings of power supply :	DC: 0-1000V, 15kW AC: 0-300V, 18kW	—

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
PV voltage detect UC1C Pin 9	Open	230V 12,63 A	450V 6,62A	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID09. (PV voltage over range)
PV current detect UC1B Pin 5	Open	230V 12,63 A	450V 6,6A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID14. (PV current over range)
GFCI detect UC2D Pin 12-13	Short	230V 12,63 A	450V 6,62A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID12. (GFCI fault)
GFCI detect UC2C Pin 10	Short	230V 12,63 A	450V 6,62A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID52. (GFCI fault)
Grid voltage detect UC2A Pin 3	Open	230V 12,64 A	450V 6,67A	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID15. (Grid current or voltage over range)
Grid voltage detect RC17	Open	230V 12,63 A	450V 6,62A	2 Min.	--	230V 0,17A	450V 0,01A	PV inverter disconnected from grid immediately, error message: ID02, ID49, ID70. (Grid current or voltage under range)
Grid voltage detect RC25	Open	230V 12,64 A	450V 6,62A	2 Min.	--	230V 0,18A	450V 0,01A	PV inverter disconnected from grid immediately, error message: ID55. (Relay fault)
Bus voltage detect RP3	Open	230V 12,61 A	450V 6,63A	2 Min.	--	230V 0,6A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID23. (Bus voltage zero fault)
Bus voltage detect UC1A Pin2-3	Short	230V 12,56 A	450V 6,65A	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID66. (Bus voltage over range)

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
Bus voltage detect RC82	Short	230V 12,56 A	450V 6,69A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID25. (Bus voltage under range)
ISO detect RC105	Open before start	230V 0,17A	450V 0,18A	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter can not start up, error message: ID56. (ISO fault)
AC current detect RC22	Open	230V 12,56	450V 6,68	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID15. (AC current over range), QP2， QP6，QP9， RP26， RP28， RP11 damaged.
AC current detect RC21	Open	230V 12,62 A	450V 6,63A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID15. (AC current over range).
DC current detect RC33	Open	230V 12,67 A	450V 6,69A	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID28. (DC current over range).
DC current detect RC37	Open	230V 12,54 A	450V 6,67A	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID28. (DC current over range).
DC current detect RC42	Open	230V 12,62 A	450V 6,66A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID51. (DC current fault).
AC current detect RC61	Open	230V 12,66 A	450V 6,7A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID15, ID65. (AC voltage or current over range).
AC current detect RC80	Open	230V 12,67 A	450V 6,8A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID15, ID65. (AC voltage or current over range).
GFCI detect RP70	Open	230V 12,63 A	450V 6,66A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID12. (GFCI fault).
GFCI detect RP80	Open	230V 12,63 A	450V 6,66	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID12. (GFCI fault).
GFCI detect UP7A Pin2-3	Short	230V 12,56 A	450V 6,67A	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID12. (GFCI fault).

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
PV voltage detect RP115	Open	230V 12,62A	450V 6,67A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, no display, and reconnect to grid, error message: ID56. (ISO fault).
PV voltage detect RP115	Short	230V 12,63A	450V 6,63A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID09. (PV voltage over range)
ISO detect RP99	Open before start	230V 0,16A	450V 0,02A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter can not start up, error message: ID56. (ISO fault).
Relay detect RYP2 Pin3-4	Short before start	230V 0,16A	450V 0,02A	2 Min.	--	230V 016A	450V 0,02A	PV inverter can not start up, error message: ID55, ID77. (Relay fault).
Relay detect RYP3 Pin3-4	Short before start	230V 0,16A	450V 0,02A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter can not start up, error message: ID55, ID77. (Relay fault).
Relay detect RYP4 Pin3-4	Short before start	230V 0,16A	450V 0,02A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter can not start up, error message: ID55, ID77. (Relay fault).
Relay detect RYP5 Pin3-4	Short before start	230V 0,16A	450V 0,02A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter can not start up, error message: ID55, ID77. (Relay fault).
Grid voltage detect RP150	Open	230V 0,62A	450V 6,67A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID02. (Grid voltage under range)
Grid voltage detect RP150	Short	230V 12,64A	450V 6,66A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID01. (Grid voltage over range)
Grid voltage detect RP135	Short	230V 12,64A	450V 6,67A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID01. (Grid voltage over range)
Grid voltage detect RP135	Open	230V 12,61A	450V 6,66A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID02. (Grid voltage under range)
Loss of control CC100	Short	230V 12,61A	450V 6,67A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: DSP communicate fail
Loss of control XLC	Short	230V 12,63A	450V 6,65A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: DSP communicate fail

component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
Communication microcontroller defect UC34 Pin 31	Open	230V 12,64A	450V 6,66A	2 Min.	--	230V 0.16A	450V 0.02A	PV inverter disconnected from grid immediately, error message: ID 53 (SPI Communication fault)
Communication microcontroller defect UC34 Pin 37	Open	230V 12,64A	450V 6,66A	2 Min.	--	230V 0.17A	450V 0.02A	PV inverter disconnected from grid immediately, error message: ID 53 (SPI Communication fault)
Communication microcontroller defect UC34 Pin 44	Open	230V 12,63A	450V 6,66A	2 Min.	--	230V 0.17A	450V 0.02A	PV inverter disconnected from grid immediately, error message: ID 53 (SPI Communication fault)
Communication microcontroller defect UC34 Pin 47	Open	230V 12,64A	450V 6,67A	2 Min.	--	230V 0.17A	450V 0.02A	PV inverter disconnected from grid immediately, error message: ID 53 (SPI Communication fault)

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

The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

The tes results refer to the original test report PV140508N005-2 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch on July 22, 2014.

Addendum – Shutdown device	
Each active phase can be switched. (L and N)	P
If no galvanic separation between AC and DC (PV): Two relays in series on each active phase are necessary to fulfil the basic insulation or simple separation based on the PV working voltage.	P

D.2.3 Interface protection: Over- /under-voltage (default settings) **D.3.6.2 Connection after trip of interface protection**	**P**

Test conditions			Output power: 6030W Frequency: 50+/-0,2Hz		
Phase	Limit [V]	Trip value [V]	Voltage step [V]	Disconnection time [s]	Limit [s]
L1	110% of Un = 253,0 (stage 1)*	253,2	230,0 to 258,0	1,515	t ≤ 3
		253,5	230,0 to 258,0	1,523	
		253,7	230,0 to 258,0	1,530	
		253,5	230,0 to 258,0	1,529	
		253,4	230,0 to 258,0	1,524	
	115% of Un = 264,5 (stage 2)**	264,2	259V to 269V	0,162	0,1 ≤ t ≤ 0,2
		264,2	259V to 269V	0,156	
		264,2	259V to 269V	0,156	
		264,2	259V to 269V	0,152	
		264,2	259V to 269V	0,168	
	85% of Un = 195,5**	195,3	200V to 190V	1,415	1,2 ≤ t ≤ 1,5
		195,3	200V to 190V	1,410	
		195,3	200V to 190V	1,416	
		195,3	200V to 190V	1,412	
		195,3	200V to 190V	1,420	

Note:

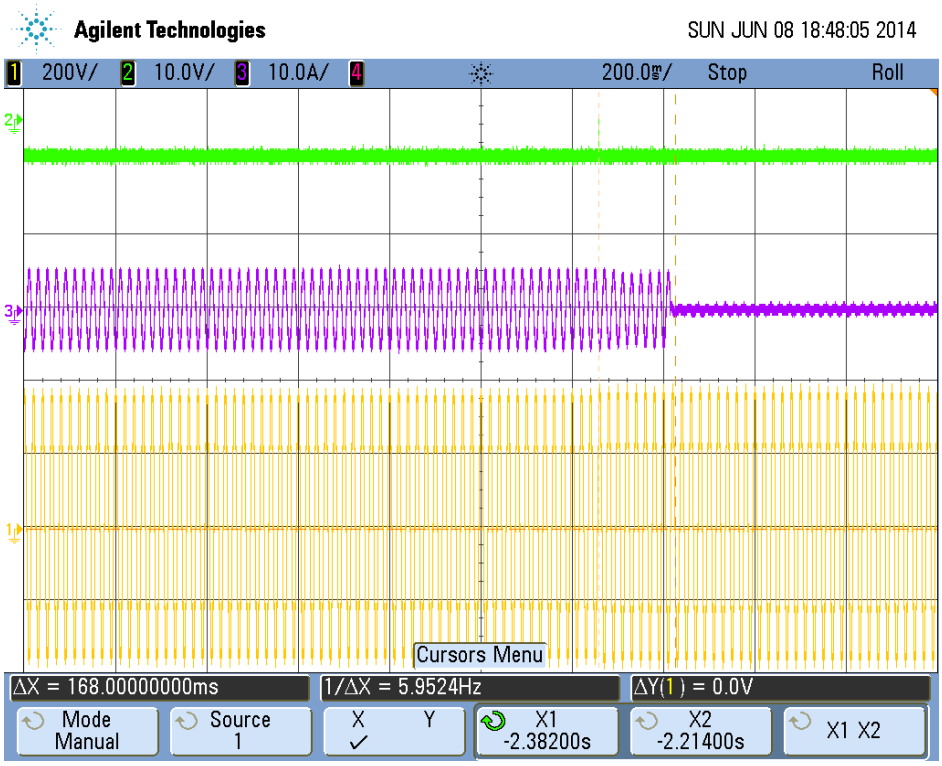
*Over-voltage – stage 1: 10-min-value corresponding to EN 50160.
The calculation of the 10 min value shall comply with the 10 min aggregation of EN 61000-4-30, class S. The function shall be based on the calculation of the square root of the arithmetic mean of the squared input values over 10 min. In deviation from EN 61000-4-30, a moving window shall be used. The calculation of a new 10-min value at least every 3 s is sufficient, which is then to be compared with the trip value.
Tolerances on disconnection time are ± 10 % .

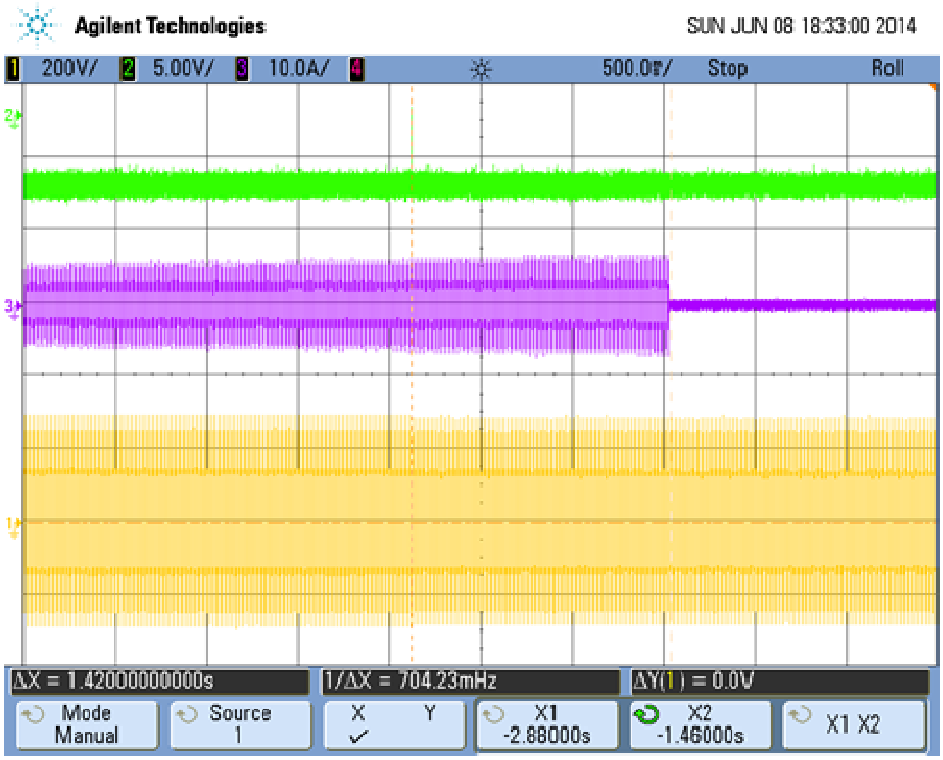
The trip values were evaluated by varying the applied voltage from U_n down to $U_{th\text{-}low}$ - 2% of U_n in steps of 0,5% of U_n for under-voltage testing as well as from U_n up to $U_{th\text{-}high}$ + 2% of U_n in steps of 0.5% of U_n for over-voltage testing. Lower and upper threshold voltage shall not fall or rise below or above 2,3V of the trip value itself. The disconnection time was measured by application of a negative voltage step from U_n to the operate value - 5% of U_n as well as positive voltage step from U_n to the operate value + 5% of U_n.

The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

** The tes results refer to the original test report PV140508N005-2 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch on July 22, 2014.

Scope pictures of the disconnection time_L1 Phase
Over-voltage – stage 1

Over-voltage – stage 2


Under-voltage


4.2.2 Over-voltage-stage 1: 10-min-vale corresponding to EN 50160.				P
Setting values of the protection:	Trip value Setting [V]	253		
	Setting $T_{disconnection\ trip\ value}$ [s]	600		
	Setting $T_{disconnection}$ [ms]	140		
Test:				
		Disconnection time [s]	Limit [s]	
a)	The voltage is set to 100% U_n and held for 600 s. Thereafter the voltage is set to 112% U_n. Disconnection must take place within 600 s.			
	Phase 1:	490 s	600 s	
	Phase 2:	--		
	Phase 3:	--		
b)	The voltage is set to U_n for 600 s and then to 108% U_n for 600 s. No disconnection should take place.			
	Phase 1:	No disconnection	Disconnection should not take place.	
	Phase 2:	--		
	Phase 3:	--		
c)	The voltage is set to 106 % U_n and held for 600 s. Thereafter the voltage is set to 114 % U_n. The disconnection should last for half the period as in Point a)*			
	Phase 1:	320 s	300 s	
	Phase 2:	--		
	Phase 3:	--		

Test:
a) This test serves as proof of the measurement accuracy and the maximum set time.
b) This test serves as proof of the measurement accuracy.
c) This test serves as proof of the correct formation of the 1 minute running mean value.

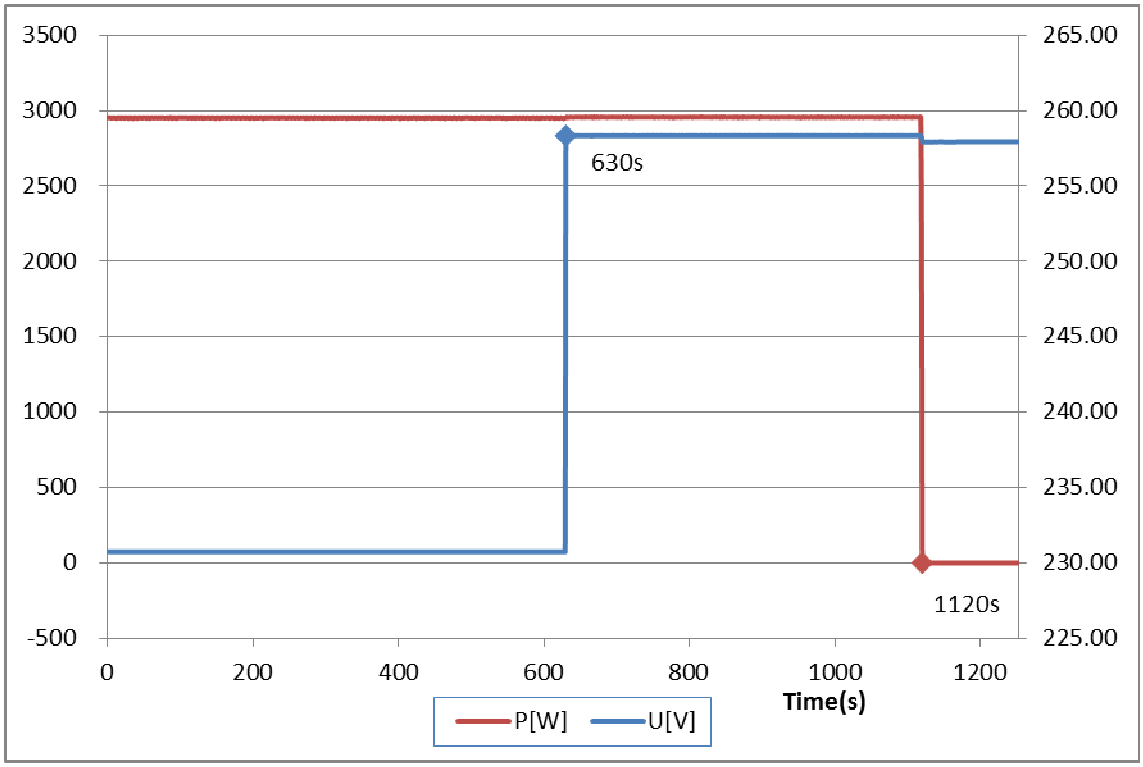
Assessment criterion:
The permitted tolerance between setting value and trip value of the voltage may not exceed ± 1 % of U_N.

Limit values:
Rise-in voltage protection 1,1 U_N after a max. 60 s, the switch off after 200 ms.

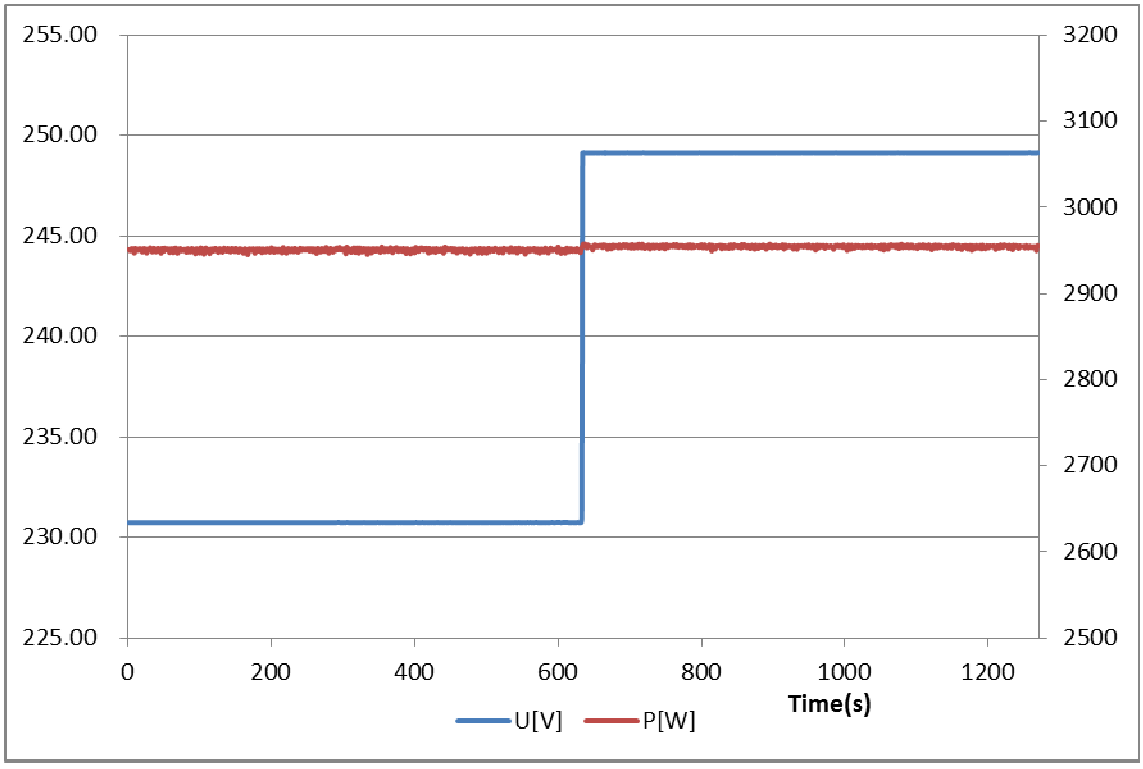
Note:
If only one integrated protection is used for the power generation systems, the value of the rise-in voltage protection of 1,1 U_N may not be changed.

The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

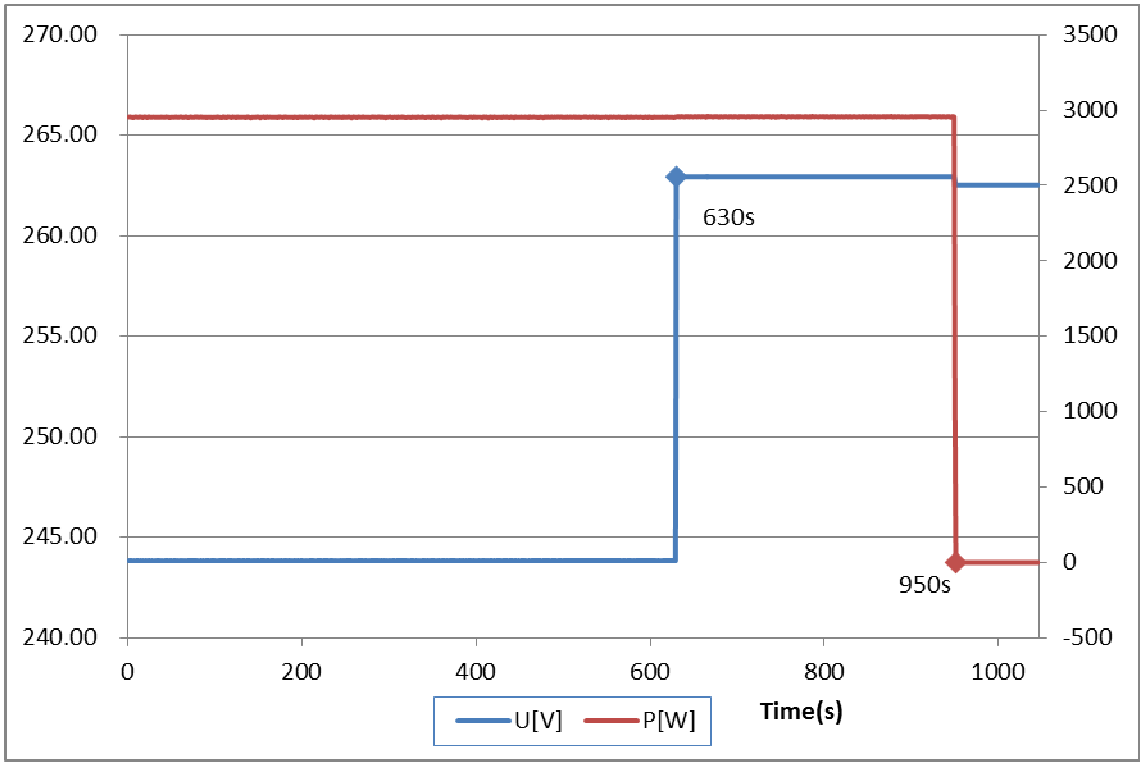
a) Voltage set to 112 % U_n



b) Voltage set to 108% U_n



c) Voltage set to 106 % U_n, thereafter 114% U_n:

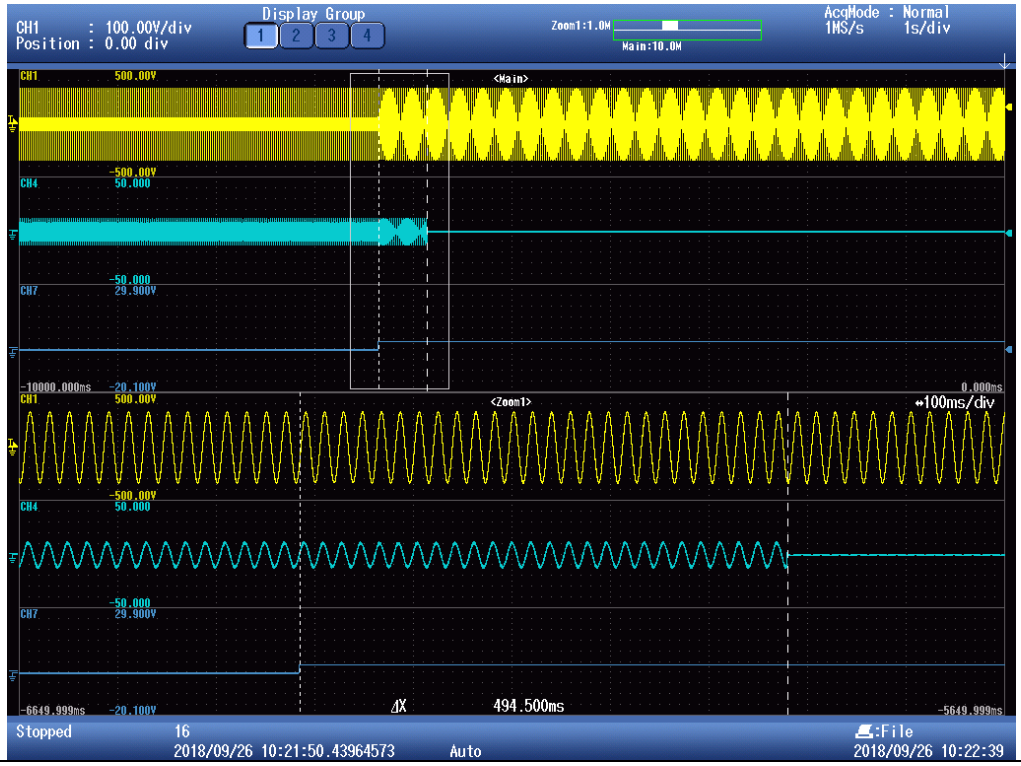


D.2.4 Interface protection: Over- /under-frequency (default settings) **D.3.6.2 Connection after trip of interface protection**					**P**
Test conditions	Output power: 1632W U_n = 230Vac				
	Under-frequency		**Over-frequency**		
Parameter	Frequency	Time	Frequency	Time	
Limit	47,50 Hz	0,3 ≤ t ≤ 0,5 s	52,00 Hz	0,3 ≤ t ≤ 0,5	
Trip value [Hz]	47,50		52,02		
	47,55		52,02		
	47,49		52,02		
	47,50		52,02		
	47,50		52,02		
Disconnection time [s]	50,00 Hz to 47,4Hz	0,491	50,00 Hz to 52,1Hz	0,488	
		0,432		0,490	
		0,426		0,495	
		0,429		0,491	
		0,419		0,494	

Note:

The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

Scope pictures of the disconnection time
Under-frequency

Over-frequency


D.2.5 Loss of Mains (LoM) detection

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

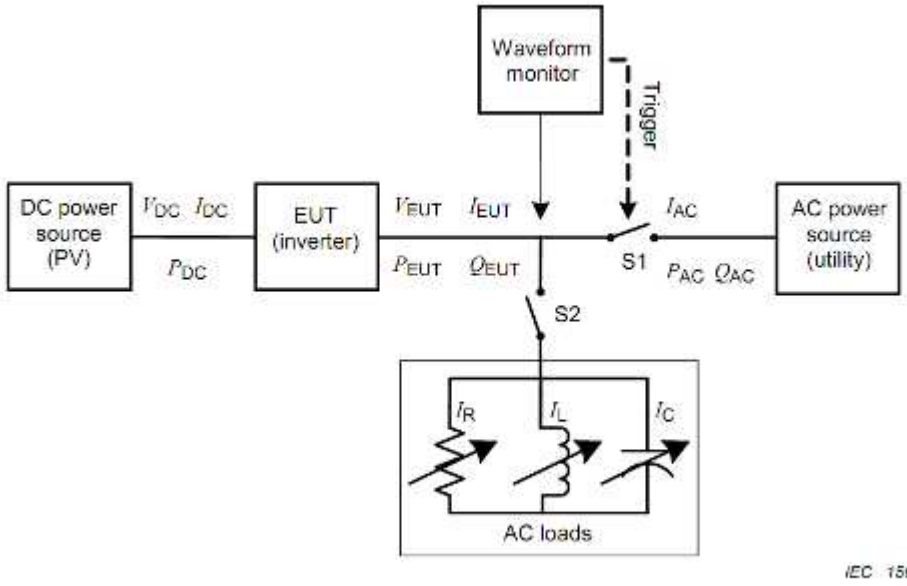


Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

Load imbalance (real, reactive load) for test condition A (EUT output = 100%)	**P**

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% 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]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f [1]	Run on Time [ms]	Remarks 5)
1	100	100	0	0	2800	383	1,073	256	BL
8	100	100	-5	-5	2800	383	1,101	178	IB
9	100	100	-5	0	2800	383	1,129	226	IB
10	100	100	-5	+5	2800	383	1,157	241	IB
13	100	100	0	-5	2800	383	1,046	228	IB
14	100	100	0	+5	2800	383	1,099	113	IB
17	100	100	+5	-5	2800	383	0,996	236	IB
18	100	100	+5	0	2800	383	1,022	181	IB
19	100	100	+5	+5	2800	383	1,047	105	IB

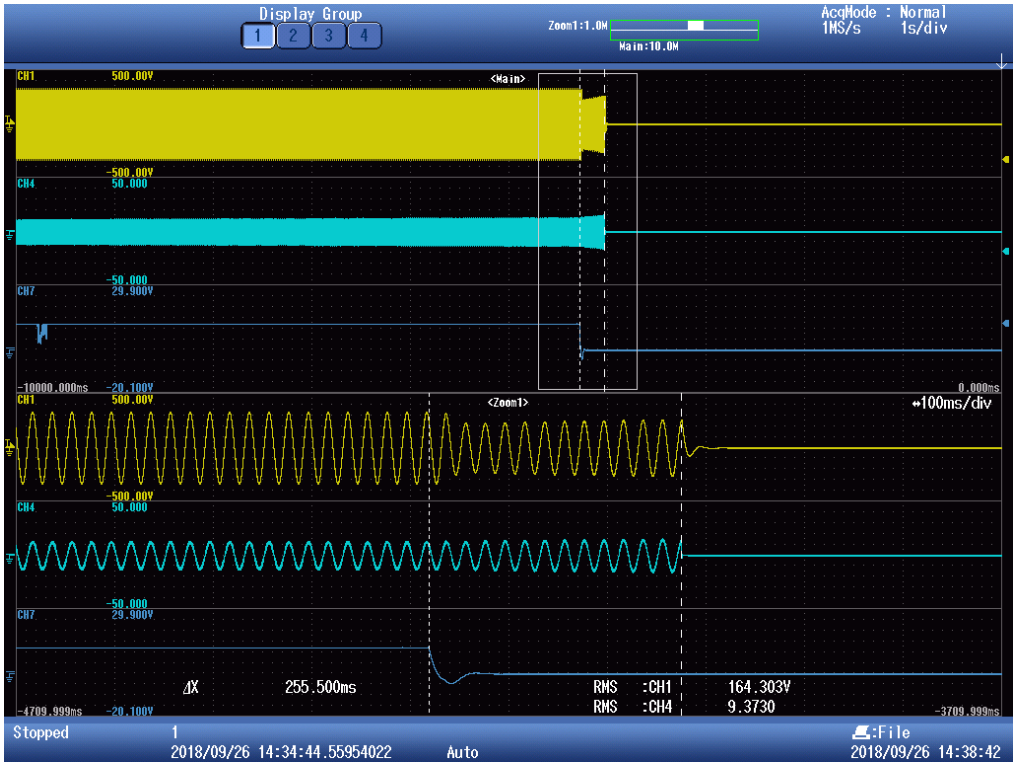
Parameter at 0% per phase	L= 56,05mH	R= 18,89 Ω	C= 180,78 µF

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.
5) BL: Balance condition, IB: Imbalance condition.

Condition A:
EUT output power PEUT = Maximum 6)
EUT input voltage 6) = >75% of rated input voltage range

6) Maximum EUT output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.
7) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % of range =X + 0,75 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.
The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

Scope pictures of the disconnection time
Disconnection at No. 1



Fundamental of I_{AC} at balance condition = 0,032A

Note:
C1: Output voltage
C2: Output current
C3: Trip singal EUT Current

Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %)	**P**

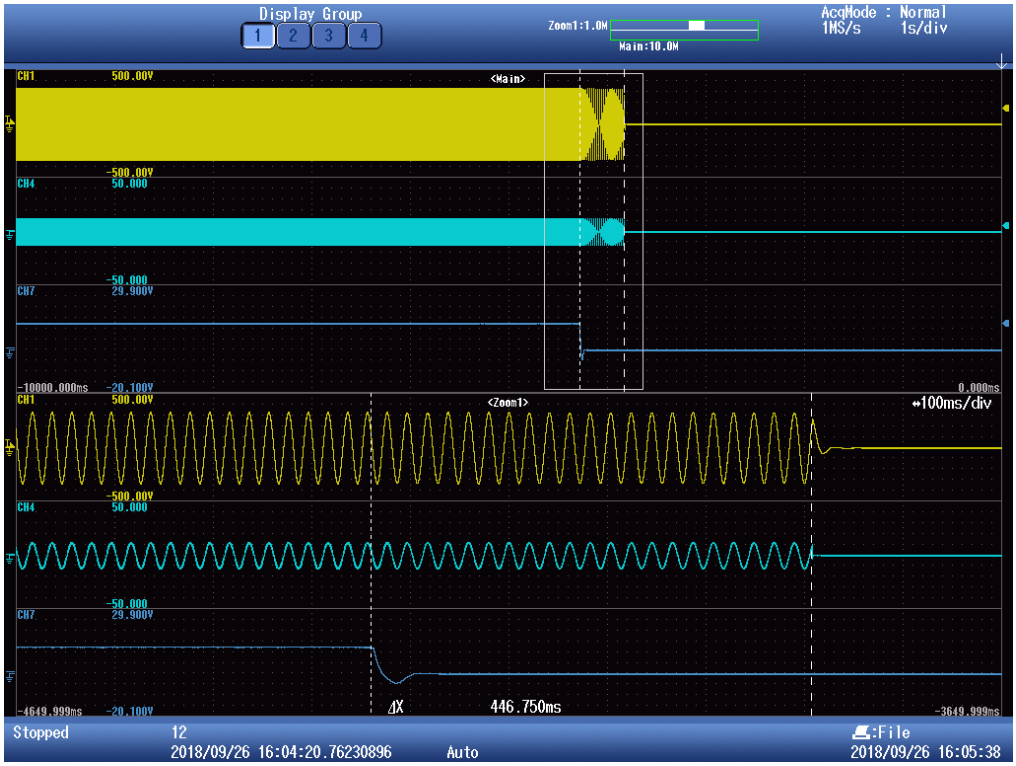
Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	2s

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]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f [1]	Run on Time [ms]	Remarks 5)
1	66	66	0	-5	1820	315	1,068	181	IB
2	66	66	0	-4	1820	315	1,074	245	IB
3	66	66	0	-3	1820	315	1,079	199	IB
4	66	66	0	-2	1820	315	1,085	447	IB
5	66	66	0	-1	1820	315	1,090	264	IB
6	66	66	0	0	1820	315	1,096	251	BL
7	66	66	0	1	1820	315	1,101	313	IB
8	66	66	0	2	1820	315	1,107	297	IB
9	66	66	0	3	1820	315	1,112	285	IB
10	66	66	0	4	1820	315	1,118	287	IB
11	66	66	0	5	1820	315	1,123	228	IB

Parameter at 0% per phase	L= 84,42 mH	R= 29,07 Ω	C= 120,03 µF

Note:
RLC is adjusted to min. +/-1% of the inverter rated output power
1) P_{EUT}: EUT output power
2) P_{AC}: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
3) Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
4) Fundamental of I_{AC} when RLC is adjusted
5) BL: Balance condition, IB: Imbalance condition.
Condition B:
EUT output power P_{EUT} = 50 % – 66 % of maximum
EUT input voltage 6) = 50 % of rated input voltage range, ±10 %
6) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 50 % of range =X + 0,5 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.
The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

Scope pictures of the disconnection time
Disconnection at No. 4



Fundamental of I_{AC} at balance condition = 0,072A

Note:
C1: Output voltage
C2: Output current
C3: Trip singal EUT Current

Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %)	**P**

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% 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]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f [1]	Run on Time [ms]	Remarks 5)
1	33	33	0	-5	940	247	1,021	166	IB
2	33	33	0	-4	940	247	1,026	184	IB
3	33	33	0	-3	940	247	1,032	288	IB
4	33	33	0	-2	940	247	1,037	235	IB
5	33	33	0	-1	940	247	1,042	234	IB
6	33	33	0	0	940	247	1,048	357	BL
7	33	33	0	1	940	247	1,053	265	IB
8	33	33	0	2	940	247	1,058	258	IB
9	33	33	0	3	940	247	1,063	273	IB
10	33	33	0	4	940	247	1,068	156	IB
11	33	33	0	5	940	247	1,073	161	IB

Parameter at 0% per phase	L= 170,93 mH	R= 56,28 Ω	C= 59,28 µF

Note:
RLC is adjusted to min. +/-1% of the inverter rated output power
1) P_{EUT}: EUT output power
2) P_{AC}: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
3) Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
4) Fundamental of I_{AC} when RLC is adjusted
5) BL: Balance condition, IB: Imbalance condition.
Condition B:
EUT output power PEUT = 25 % – 33 % 6) of maximum
EUT input voltage 7) = <20 % of rated input voltage range
6) Or minimum allowable EUT output level if greater than 33 %.
7) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 10 % of range =X + 0,2 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.
The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

Scope pictures of the disconnection time
Disconnection at No. 6

Fundamental of I_{AC} at balance condition = 0,101A

Note:
C1: Output voltage
C2: Output current
C3: Trip singal EUT Current

EN 50438:2013: Normal operating range			
Clause	**Test requirement**	**Test procedure acc. to Annex D**	**Result**
4.2	Normal operating range	D.3.1 / D.3.2 / D.3.3	**P**

D.3.1 Operating range			P
Setting values	Over-voltage [V]:	253,0	
	Under-voltage [V]:	195,5	
	Over-frequency [Hz]:	52,00	
	Under-frequency [Hz]:	47,50	

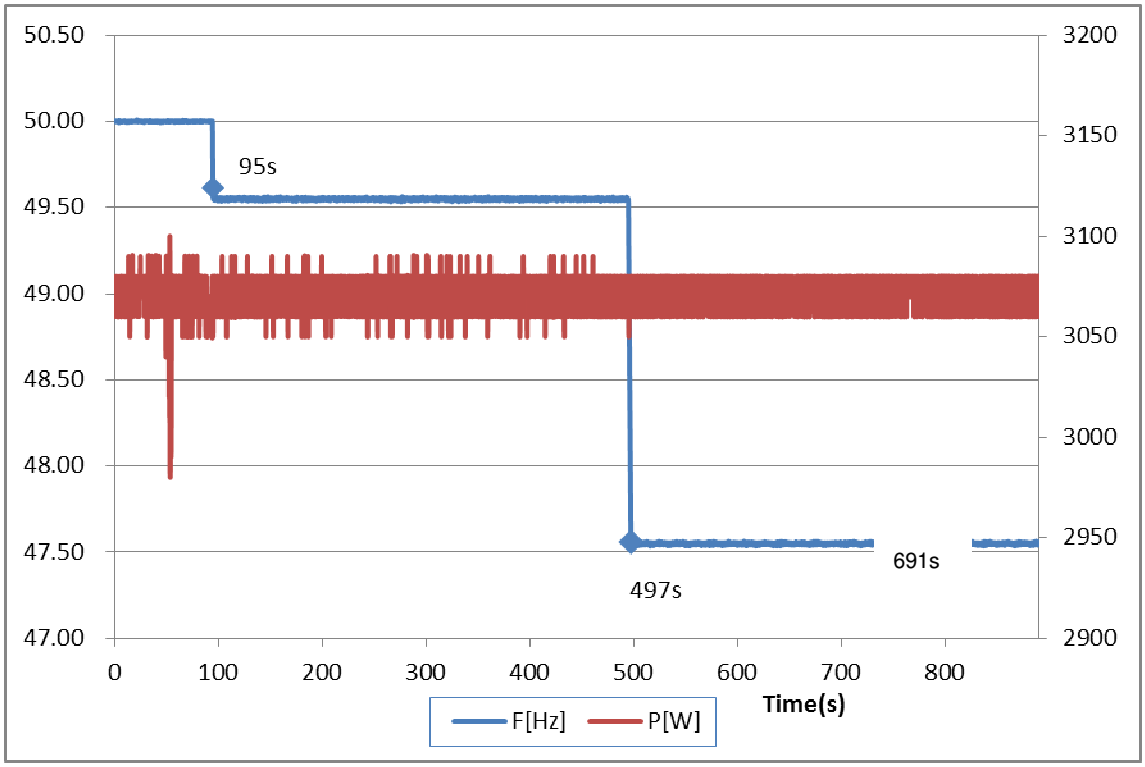
- Test 1: U = 195,5 V; f = 47,5 Hz; P = 1,00 Sn; cosφ = 1
- Test 2: U = 253,0 V; f = 51,5 Hz; P = 1,00 Sn; cosφ = 1

Test sequence	Voltage [V]	Frequency [Hz]	Output power [W]	Cos φ [1]
1	195,58	47,50	2902	0,9993
2	253,65	51,50	3048	0,9992

Note:
During the tests the interface protection was disabled.
Operation at reduced power is allowed during test 1, equal to the maximum power that can be supplied on reaching the maximum output current limit (P ≥ 0,85 Sn).
During the sequence of test 2, automatic adjustment to reduce power in the case of over-frequency was disabled.
The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

D.3.2 Active power feed-in for under-frequency	P

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



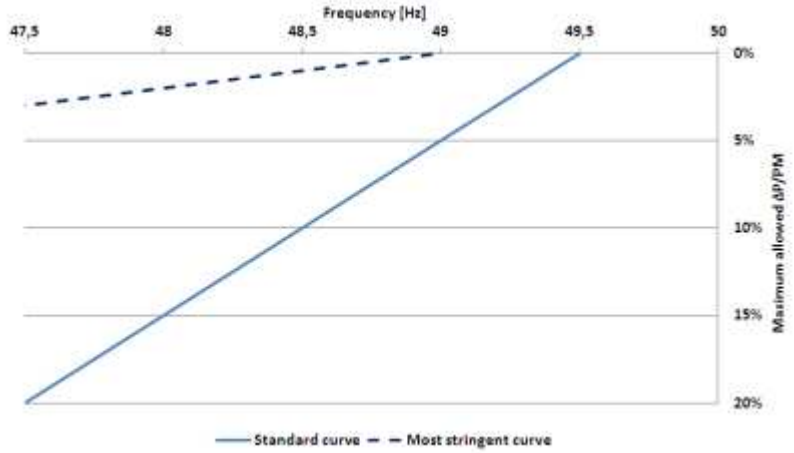
Test:

	Switch to:		
5-min mean value (each)	a) 50 ± 0,01 [Hz]	b) – 0,4 to – 0,5 [Hz]	c) – 2,4 to – 2,5 [Hz]
Frequency [Hz]:	50,00	49,55	47,55
Active power [W]:	3071	3071	3071
$\Delta P/P_M$ [%] per 1 Hz:			0,01

Test:
Operating points b) and c) must be kept for at least 5 minutes.
The test must be carried out at 100% P_n.

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

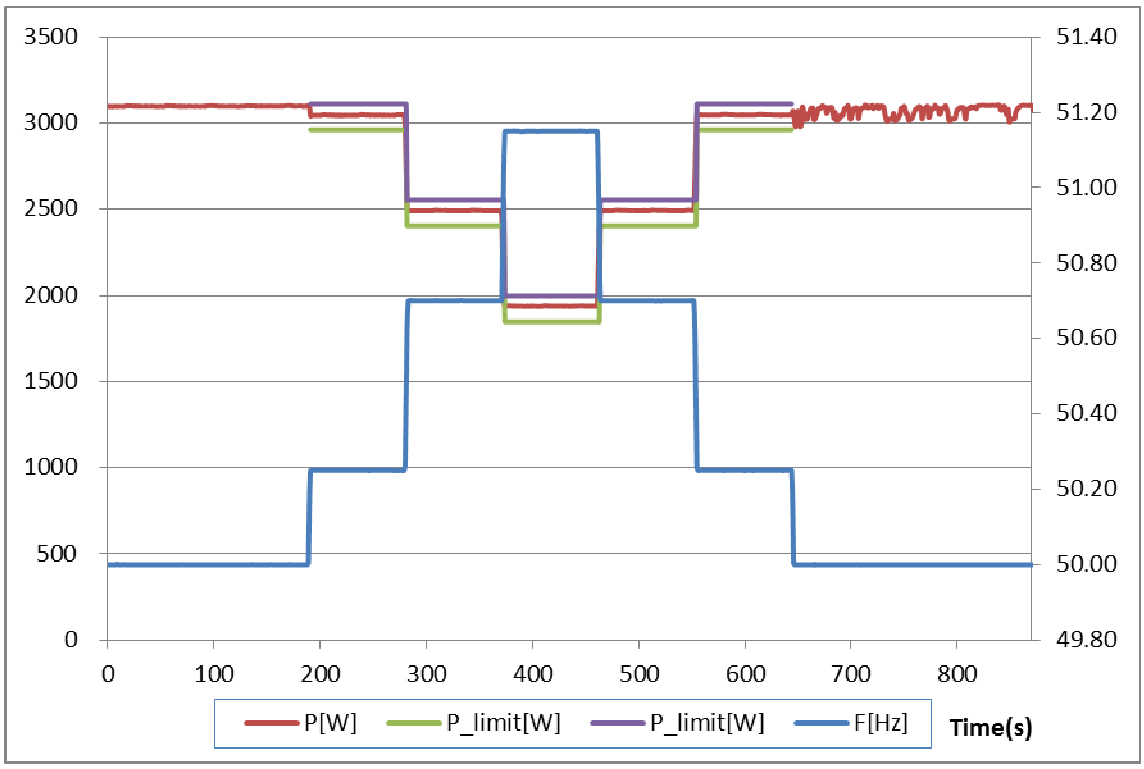
Assessment criterion:
The test is passed when the micro-generator
- does not disconnect from the network on a network frequency change at the operating points a) to c),
- continues to feed in 100% P_n in b) and
- the power reduction in point c) is less or equal to the power reduction of 10 % P_M per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



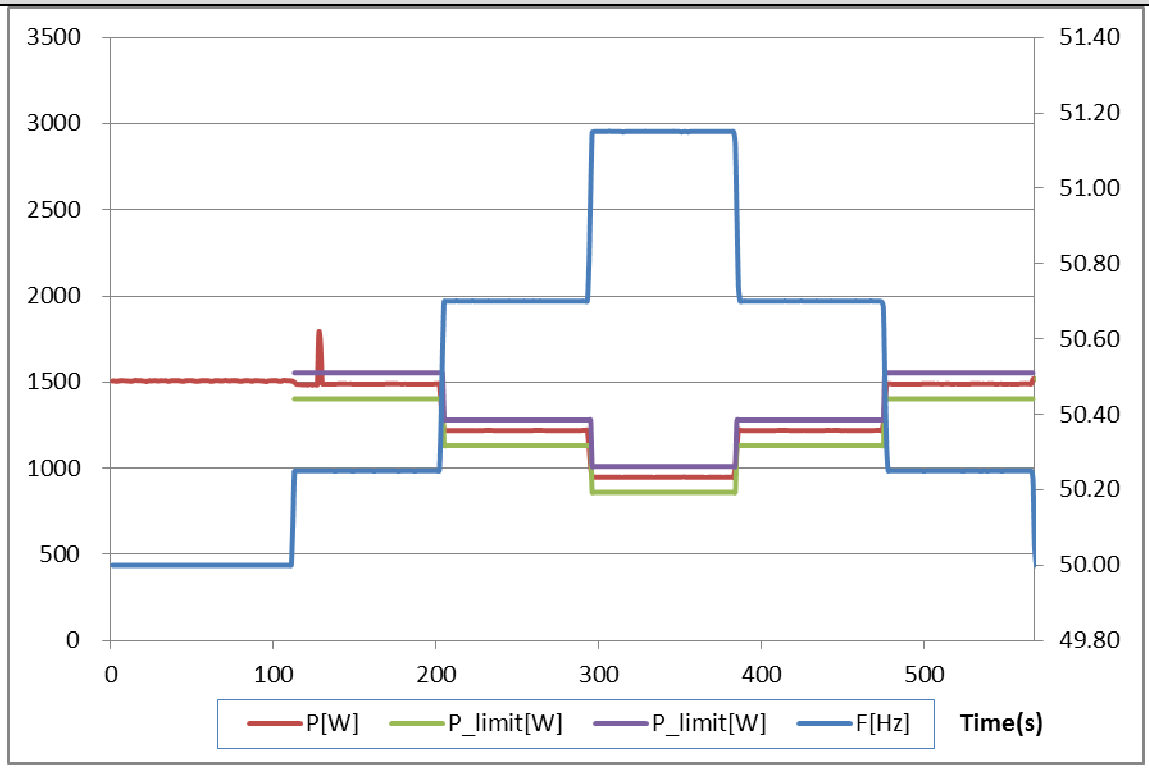
Maximum allowable power reduction in case of under-frequency

Note:
The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

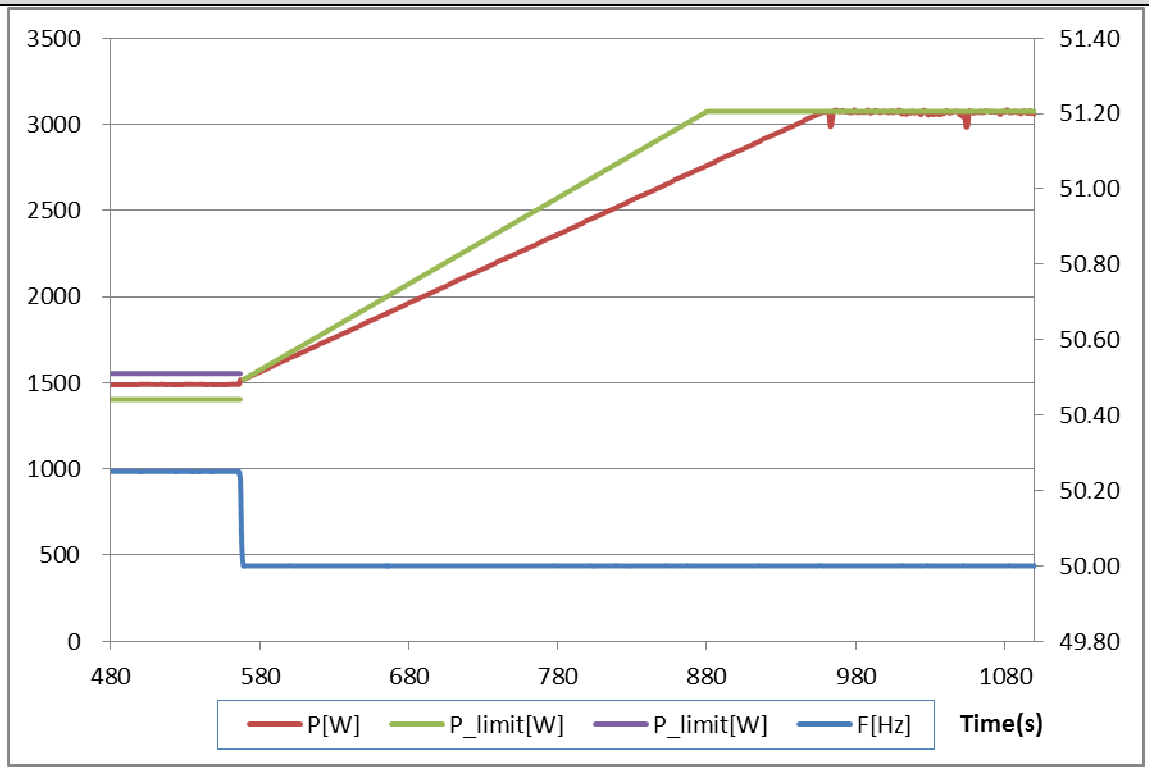
D.3.3 Power response to over-frequency							**P**
Test: $P_{M\ 100\%}$= 10854 W, $P_{M\ 50\%}$= 5451 W							
1-min mean value [Hz]:	a) 50,00	b) 50,25	c) 50,70	d) 51,15	e) 50,70	f) 50,25	g) 50,00
1. Measurement a) to g): Active power output > 80% P_n							
Frequency [Hz]:	50,00	50,20	50,70	51,15	50,70	50,20	50,00
P [W]:	N/A	3,037	2,479	1,922	2,479	3,307	N/A
P_{E60} [W]:	3,099	3,046	2,492	1,938	2,493	3,048	3,080
△P/P [%]:	N/A	0,28	0,43	0,54	0,45	0,36	N/A
2. Measurement a) to g): Active power output 40% and 60% after freezing > 80% P_n							
Frequency [Hz]:	50,00	50,20	50,70	51,15	50,70	50,20	50,00
P [W]:	N/A	1,478	1,206	0,935	1,206	1,478	N/A
P_{E60} [W]:	1,508	1,495	1,220	0,948	1,220	1,490	10,750
△P/P [%]:	N/A	0,58	0,44	0,43	0,45	0,39	N/A
Limit | P-P_{E60} | :	**+ 10 % of P_M**						
Graph of Measurement 1.: Active power output > 80% P_n							



Graph of Measurement 2.:Active power output 40% and 60% after freezing > 80% P_{Emax}



Graph of power gradient:



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

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

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

a) For adjustable micro-generators when:
1) the active power reduces between measuring points b) and f) given above with the set gradient P_M per Hz for a increasing frequency (or rises for a frequency decreasing again).
2) the maximum active power gradient occurring in point is less than the configured maximum active power per minute
3) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from P_n by more than ± 10%.
4) the settling time is equal or below 2 s with an intentional delay set to zero
b) For partly adjustable micro-generators
1) when they behave as in a) within their adjustment range, and
2) when, outside the adjustable range, the power fed in on leaving the adjustment range remains constant until shutdown. Shutdown must be no later than at 51,5 Hz.

Note:
The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

EN 50438:2013: Reactive power output capability			
Clause	**Test requirement**	**Test procedure acc. to Annex D**	**Result**
4.3 / 4.4	Reactive power capability and control modes	D.3.4	**P**

D.3.4.1 Test of no controllable reactive power			P
SOFAR 1100TL			
Test voltage / Output power	211,6 V	230 V	248,4 V
25% P_N	0,994c	0,991c	0,987c
50% P_N	0,998c	0,998c	0,997c
75% P_N	0,999c	0,999c	0,999c
100% P_N	0,999c	0,999c	0,999c
Limit:	>0,95	>0,95	>0,95
SOFAR 3000TL			
Test voltage / Output power	211,6 V	230 V	248,4 V
25% P_N	0,994c	0,991c	0,987c
50% P_N	0,998c	0,998c	0,997c
75% P_N	0,999c	0,999c	0,999c
100% P_N	0,999c	0,999c	0,999c
Limit:	>0,95	>0,95	>0,95

Note:
When operating at the 25%, 50%, 75% and 100% rated power the micro-generator operates at a power factor within the range 0,95 lagging to 0,95 leading relative to the voltage waveform.

The tests had been performed on the SOFAR 1100TL and SOFAR 3000TL are valid for the SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

D.3.4.2.1 Test of controllable reactive power	P

Test result: SOFAR 3000TL

Inductive reactive power absorbation

Power-BIN	Active power [W]	Reactive power [Var]	Power factor (cos φ)	DC power [W]
0% -10%	300	226	0,7983	317
10% -20%	556	416	0,8005	578
20% -30%	838	630	0,7991	866
30% -40%	1135	861	0,7967	1172
40% -50%	1434	1055	0,8055	1480
50% -60%	1741	1285	0,8045	1798
60% -70%	2046	1515	0,8036	2116
70% -80%	2357	1749	0,8030	2440
80% -90%	2553	1895	0,8030	2646
90% -100%*	2556	1894	0,8034	2650

Capacitive reactive power supply

Power-BIN	Active power [W]	Reactive power [Var]	Power factor (cos φ)	DC power [W]
0% -10%	299	-221	0,8036	317
10% -20%	555	-417	0,7997	579
20% -30%	836	-614	0,8057	866
30% -40%	1133	-851	0,7996	1172
40% -50%	1432	-1066	0,8023	1481
50% -60%	1738	-1286	0,8039	1798
60% -70%	2044	-1507	0,8050	2116
70% -80%	2355	-1732	0,8055	2441
80% -90%	2451	-1805	0,8052	2543
90% -100%*	2453	-1808	0,8050	2546

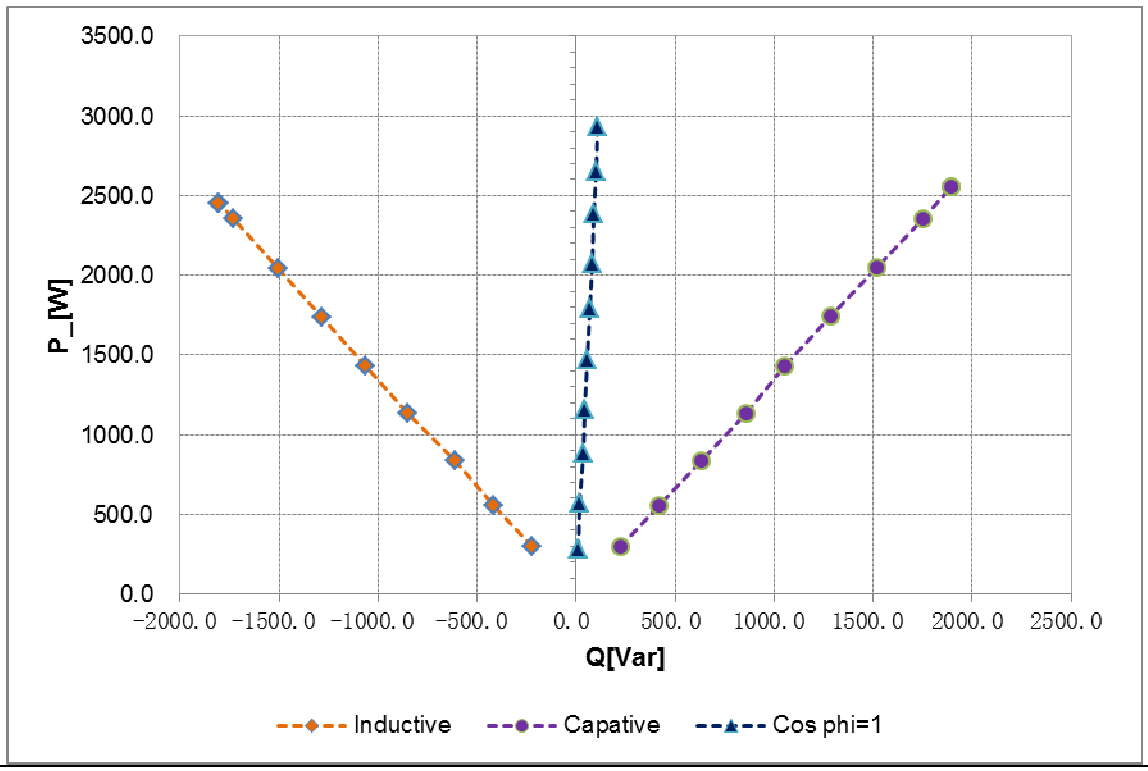
Reactive power supply with set point cos φ =1

Power-BIN	Active power [W]	Reactive power [Var]	Power factor (cos φ)	DC power [W]
0% -10%	286	11	0,9992	283
10% -20%	574	19	0,9993	576
20% -30%	884	33	0,9991	892
30% -40%	1162	45	0,9991	1176
40% -50%	1471	57	0,9991	1495
50% -60%	1793	70	0,9991	1826
60% -70%	2074	79	0,9991	2118
70% -80%	2386	90	0,9991	2441
80% -90%	2649	99	0,9991	2713
90% -100%	2934	110	0,9991	3013

Note:
The inverter was power derated of 10% of the nominal output power.
The nominal output power limited by Smax. and cos φ (+,-0,8), so under 100% condition P<Prated

The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

SOFAR 3000TL



EN 50438:2013: Voltage control by active power			
Clause	**Test requirement**	**Test procedure acc. to Annex D**	**Result**
4.5	Voltage control by active power	D.3.5 (under consideration)	**N/A**

EN 50438:2013: Connection and starting to generate electric power			
Clause	**Test requirement**	**Test procedure acc. to Annex D**	**Result**
4.7	Connection and starting to generate electric power	D.3.6	**P**

D.3.6 Connection and starting to generate electrical power		P
Setting value	Min. voltage for connected to grid :	197,8 V
	Max. voltage for connected to grid :	250,7 V
	Min. Frequency for connected to grid :	47,55 Hz
	Max. Frequency for connected to grid :	50,05 Hz
	Observation time (≥60s) :	60 s

Test:

	Voltage conditions	
a) Start up for voltage range	<84% Un for twice of observation time	>111% Un for twice of observation time
Connection:	No connection	No connection
Limit	No connection allowed	
b) In voltage range at start-up	≥84% Un within twice setting observation time	≤111% Un within twice setting observation time
Reconnection time [s]	78,7 s	121,6 s
Limit:	Connected after setting observation time (≥60s)	
Gradient:	For adjustable micro generators 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. For non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min. For recorded gradient see diagram below.	
c) In voltage range after voltage failture	≥84% Un for twice of setting observation time	≤111% Un for twice of setting observation time
Reconnection time [s]	79,0 s	85,8 s
Limit:	Reconnection after setting observation time (≥60s)	
Gradient:	For adjustable micro generators 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. For non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min. For recorded gradient see diagram below.	

	Frequency conditions	
d) Start up for frequency range	<47.45 Hz for twice of setting observation time	>50.15 Hz for twice of setting observation time
Connection:	No connection	No connection
Limit	No connection allowed	
e) In frequency range at start-up	≥47.45 Hz within twice of setting observation time	≤50.10 Hz within twice of setting observation time
Reconnection time [s]	75,4 s	78,8 s
Limit:	Connected after setting delay time(≥60s)	
Gradient:	For adjustable micro generators 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. For non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min. For recorded gradient see diagram below.	
f) In frequency range after frequency failture	≥47.45 Hz for twice of setting observation time	≤50.10 Hz for twice of setting observation time
Reconnection time [s]	75,4 s	79,6 s
Limit:	Reconnection after setting observation time (≥60s)	
Gradient:	For adjustable micro generators 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. For non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min. For recorded gradient see diagram below.	

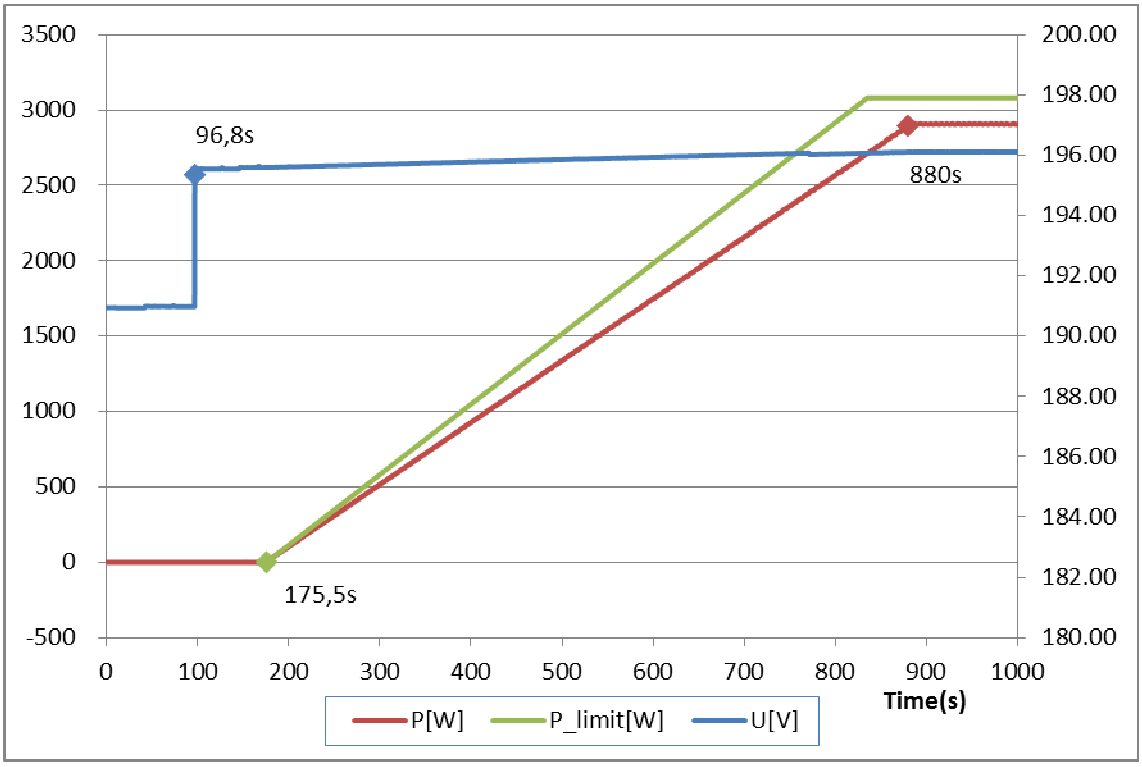
Test:
Test condition b) and c): voltage within the limits of 85% to 110%Vn.
Test condition e) and f): frequency within the limits of 47,50Hz to 51,10Hz.

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 2 % deviating from the operate value.

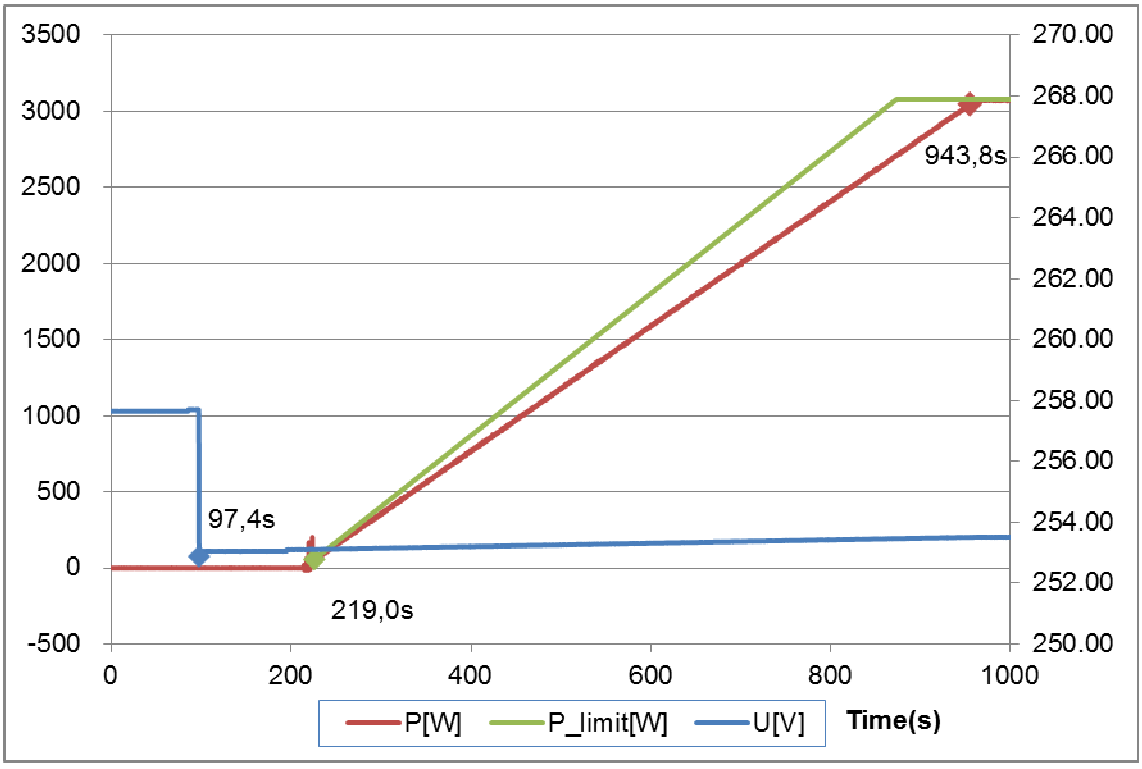
Assessment criterion:
a) the micro generator connects respectively starts generating electrical power only in the permitted range of voltage and frequency and
b) for adjustable micro generators the maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute and
c) for non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min.

The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

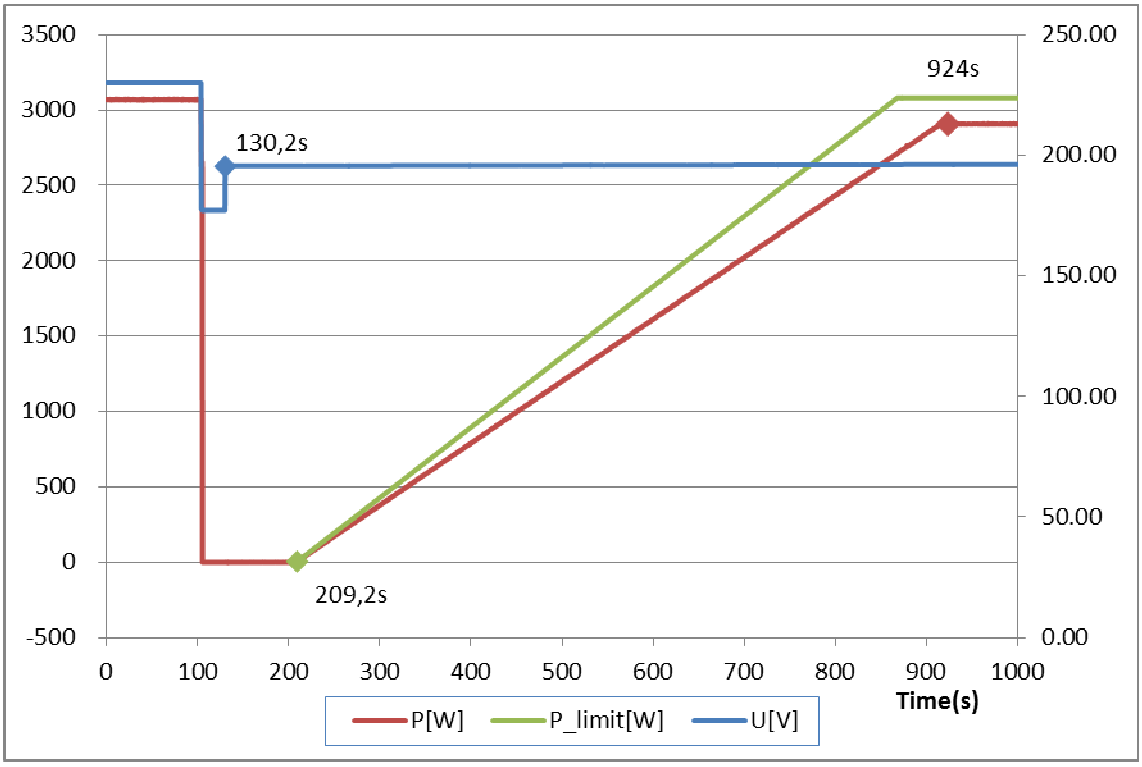
Under voltage a) to b)



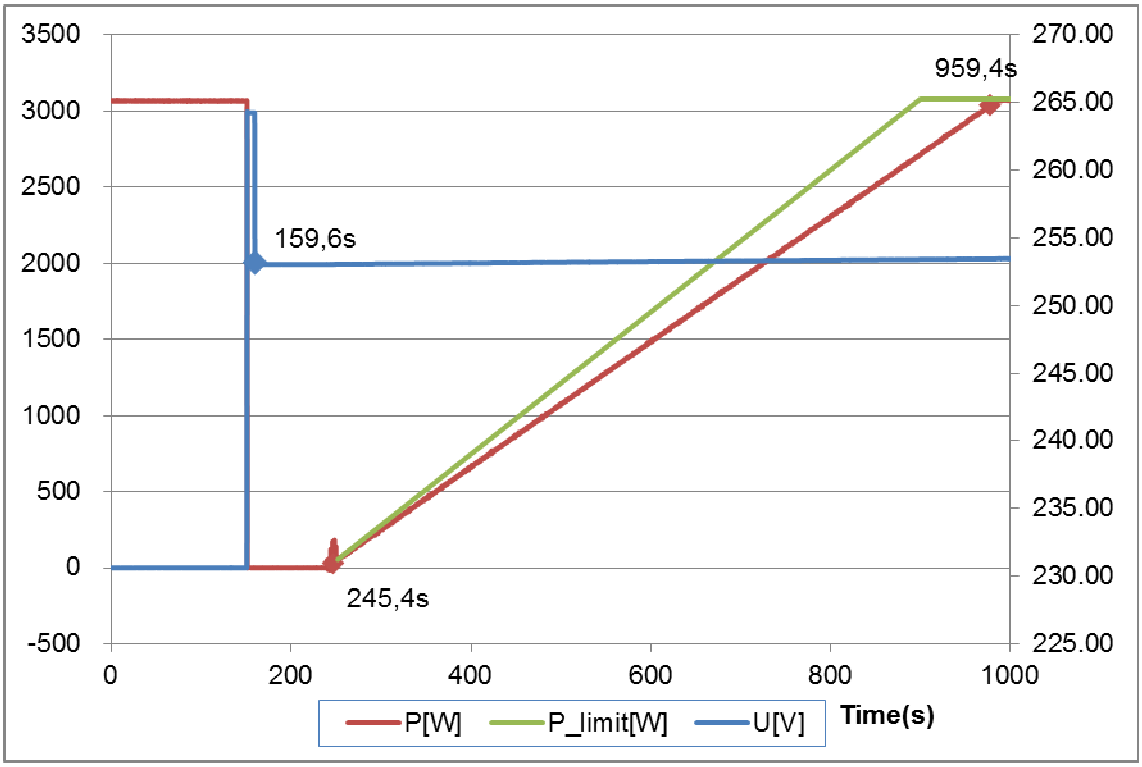
Over voltage a) to b)



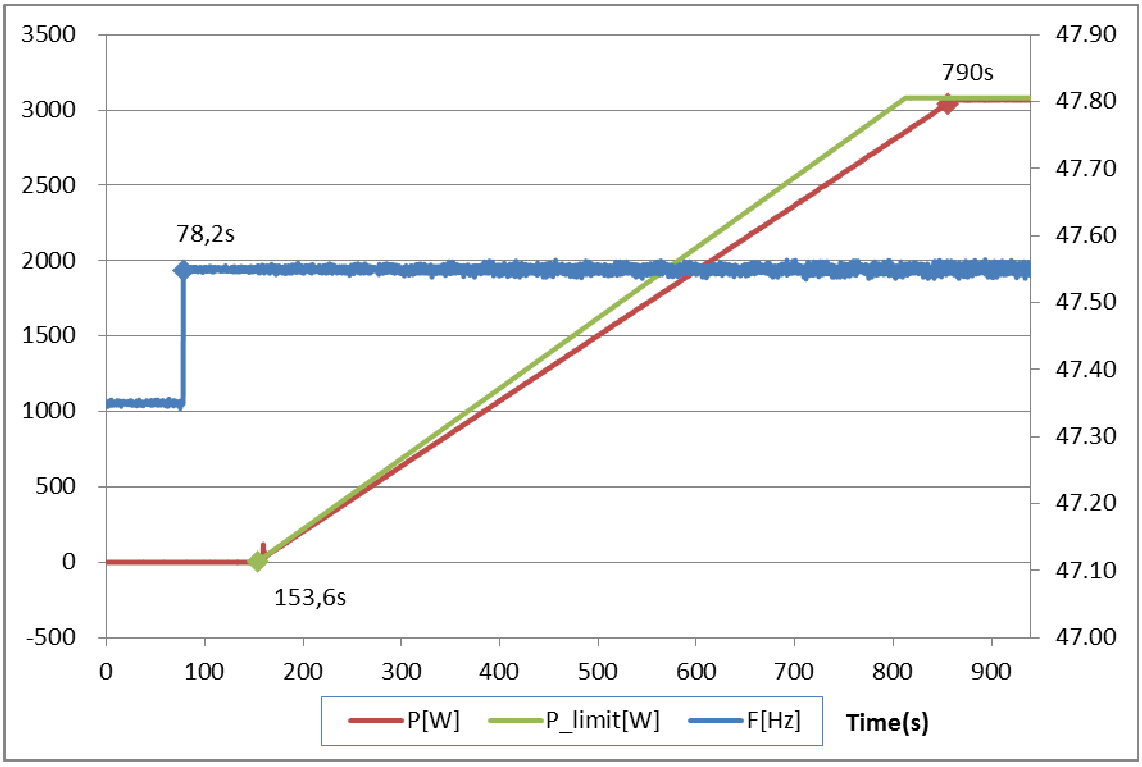
Under voltage c)



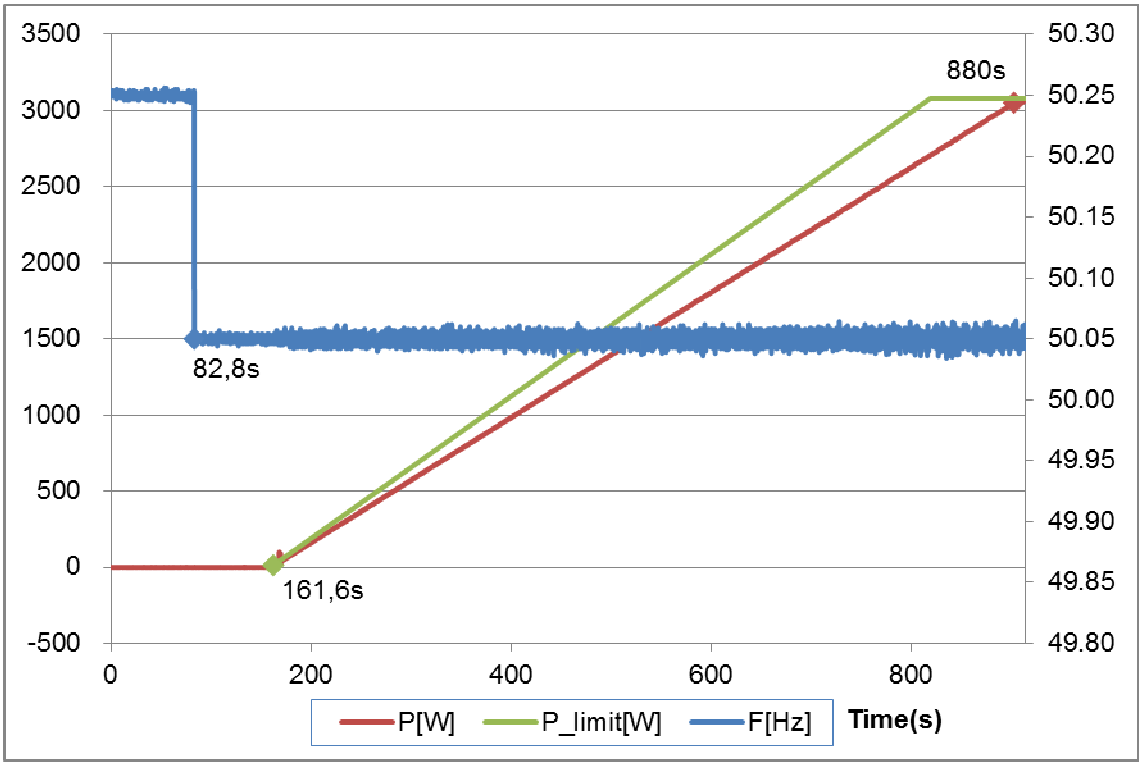
Over voltage c)



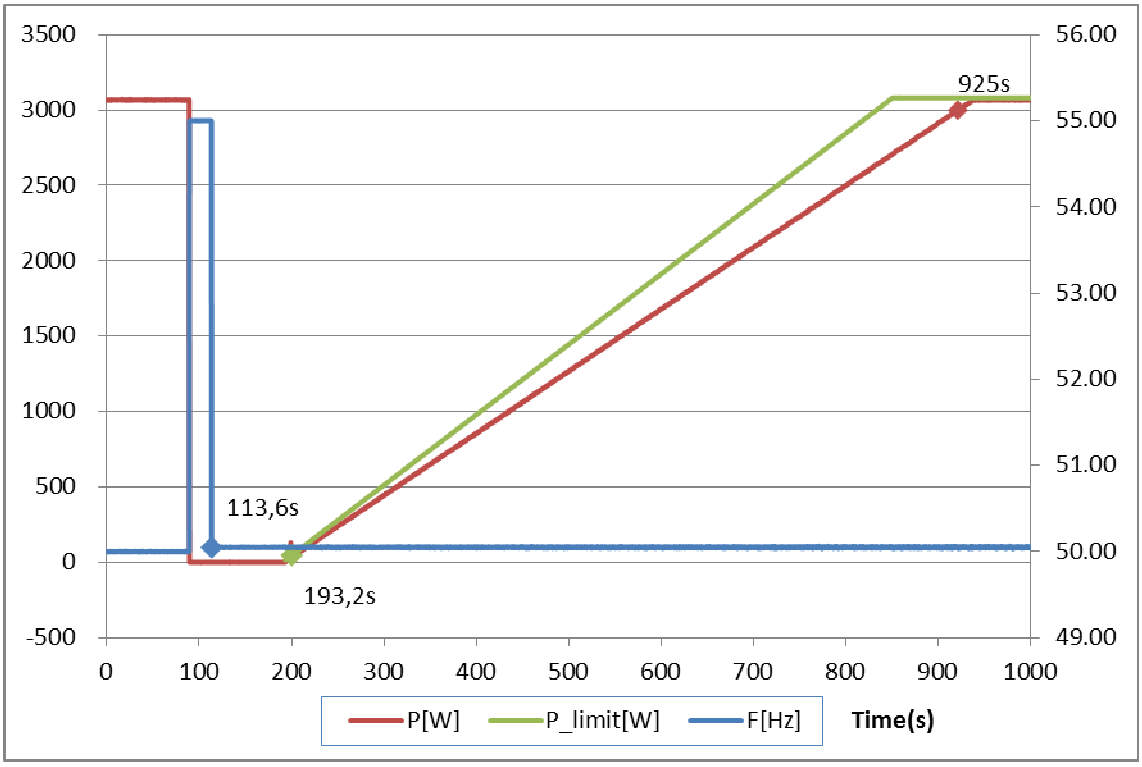
Under frequency d) to e)



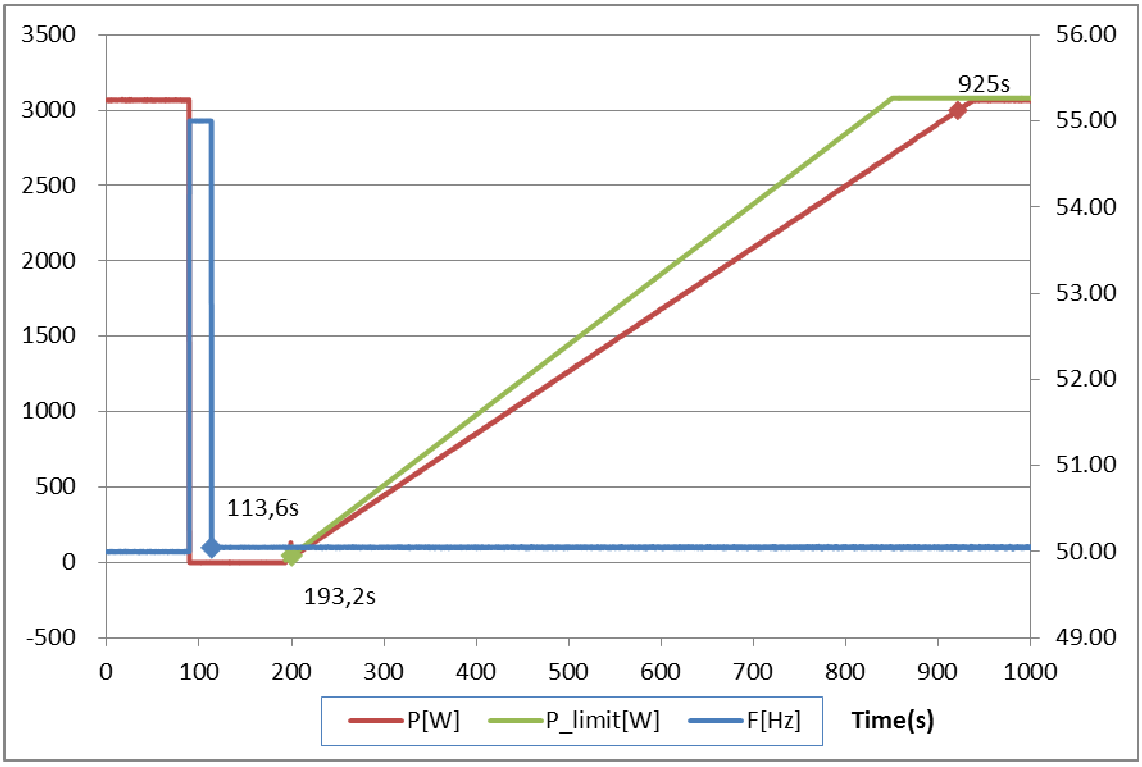
Over frequency d) to e)



Under frequency f)



Over frequency f)



EN 50438:2013: Short circuit current contribution			
Clause	**Test requirement**	**Test procedure acc. to Annex D**	**Result**
4.7	Short circuit current contribution	D.3.7	**P**

D.3.7 Short circuit Current Contribution					P
For a directly coupled generator			For an electronic inverter		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	Ip	N/A	20ms	27	14,6
Initial Value of aperiodic current	A	N/A	100ms	27	11,1
Initial symmetrical short-circuit current*	Ik	N/A	250ms	--	--
Decaying (aperiodic) component of short circuit current*	iDC	N/A	500ms	--	--
Reactance/Resistance Ratio of source*	X/R	N/A	Time to trip	0,052	In seconds

Note:
The values of voltage and current should be recorded for a period of up to 1 second when the changeover switch should be returned to the normal position. The voltage and current at relevant times shall be recorded in the type test report (Appendix 4) including the time taken for the Inverter to trip.

The tests had been performed on the SOFAR 3000TL is valid for the SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

EN 50438:2013: Power quality			
Clause	**Test requirement**	**Test procedure acc. to Annex D**	**Result**
4.8	Power quality	D.3.8 / D.3.9 / D.3.10	**P**

D.3.8 Harmonic current emission (EN 61000-3-2) (SOFAR 1100TL)	P

Watts [W]	1,017
Vrms [V]	230,07
Arms [A]	4,419
Frequency [Hz]	50,00

Harmonic order n	Current Magnitude [A] at 100% rated output power	% of Fundamental	Harmonic current limit EN61000-3-2 [%]
1st	4,418	--	--
2nd	0,002	0,036	1
3rd	0,080	1,799	4
4th	0,001	0,032	1
5th	0,010	0,224	4
6th	0,001	0,032	1
7th	0,006	0,140	4
8th	0,002	0,036	1
9th	0,004	0,091	2
10th	0,002	0,043	0,5
11th	0,003	0,059	2
12th	0,002	0,043	0,5
13th	0,002	0,045	2
14th	0,002	0,041	0,5
15th	0,002	0,041	1
16th	0,002	0,034	0,5
17th	0,002	0,034	1
18th	0,001	0,029	0,5
19th	0,002	0,036	1
20th	0,001	0,032	0,5
21th	0,002	0,048	0,6
22th	0,001	0,025	0,5
23th	0,002	0,034	0,6
24th	0,001	0,023	0,5
25th	0,002	0,041	0,6
26th	0,001	0,018	0,5
27th	0,002	0,034	0,6
28th	0,001	0,023	0,5
29th	0,002	0,041	0,6
30th	0,001	0,014	0,5
31th	0,001	0,032	0,6
32th	0,001	0,018	0,5
33th	0,002	0,036	0,6
34th	0,001	0,014	0,5
35th	0,001	0,032	0,6
36th	0,001	0,014	0,5
37th	0,002	0,036	0,6
38th	0,001	0,016	0,5
39th	0,001	0,029	0,6

40th	0,001	0,014	0,5
THD_{50}	--	1,83	5

D.3.8 Harmonic current emission (EN 61000-3-2) (SOFAR 3000TL)			**P**
Watts [W]		2,804	
Vrms [V]		229,99	
Arms [A]		12,189	
Frequency [Hz]		50,00	
Harmonic order n	Current Magnitude [A] at 100% rated output power	% of Fundamental	Harmonic current limit EN61000-3-2 [%]
1st	12,188	--	--
2nd	0,008	0,066	1
3rd	0,158	1,296	4
4th	0,006	0,051	1
5th	0,032	0,259	4
6th	0,003	0,025	1
7th	0,014	0,113	4
8th	0,003	0,025	1
9th	0,005	0,044	2
10th	0,004	0,034	0,5
11th	0,006	0,048	2
12th	0,004	0,030	0,5
13th	0,012	0,099	2
14th	0,004	0,033	0,5
15th	0,010	0,084	1
16th	0,003	0,026	0,5
17th	0,013	0,106	1
18th	0,002	0,020	0,5
19th	0,014	0,113	1
20th	0,003	0,021	0,5
21th	0,015	0,120	0,6
22th	0,002	0,015	0,5
23th	0,014	0,112	0,6
24th	0,002	0,013	0,5
25th	0,013	0,109	0,6
26th	0,002	0,016	0,5
27th	0,013	0,107	0,6
28th	0,002	0,014	0,5
29th	0,012	0,098	0,6
30th	0,001	0,011	0,5
31th	0,011	0,088	0,6
32th	0,001	0,010	0,5
33th	0,009	0,077	0,6
34th	0,001	0,010	0,5
35th	0,009	0,075	0,6
36th	0,001	0,009	0,5

37th	0,008	0,065	0,6
38th	0,001	0,011	0,5
39th	0,008	0,063	0,6
40th	0,001	0,010	0,5
THD_{50}	--	1,38	5
The tests had been performed on the SOFAR 1100TL and SOFAR 3000TL are valid for the SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.			

D.3.9 Voltage fluctuation and flicker					**P**
	Maximum permissible voltage fluctuation (expressed as a percentage of nominal voltage at 100 % power) and flicker as per EN 61000-3-11				
Value	**Pst**	**Plt 2 hours**	**d(t) 500ms**	**dc**	**dmax**
Limit	1,0	0,65	3,3%	3,3%	4%
Test value	See below				

SOFAR 1100TL

No.	dc[%]	dmax[%]	d(t)[ms]	Pst
1	0.00	0.00	0.00	0.07
2	0.00	0.00	0.00	0.07
3	0.00	0.00	0.00	0.07
4	0.00	0.00	0.00	0.07
5	0.00	0.00	0.00	0.07
6	0.00	0.00	0.00	0.07
7	0.00	0.00	0.00	0.07
8	0.00	0.00	0.00	0.07
9	0.00	0.00	0.00	0.07
10	0.00	0.00	0.00	0.07
11	0.00	0.00	0.00	0.07
12	0.00	0.00	0.00	0.07

Plt
0.07

SOFAR 3000TL

No.	dc[%]	dmax[%]	d(t)[ms]	Pst
1	0.00	0.00	0.00	0.07
2	0.00	0.00	0.00	0.07
3	0.00	0.00	0.00	0.07
4	0.00	0.00	0.00	0.07
5	0.00	0.00	0.00	0.07
6	0.00	0.00	0.00	0.07
7	0.00	0.00	0.00	0.07
8	0.00	0.00	0.00	0.07
9	0.00	0.00	0.00	0.07
10	0.00	0.00	0.00	0.07
11	0.00	0.00	0.00	0.07
12	0.00	0.00	0.00	0.07

Plt
0.07

Note:
Mains Impedance according EN61000-3-3 / EN61000-3-11: Rmax =0,24Ω; jXmax=0,15Ω @50Hz (|Zmax| =0,283Ω)
Bei Einphasigen Invertern Zmax sowie Rn und jxn angeben Rn =0,16Ω; jXn=0,1Ω

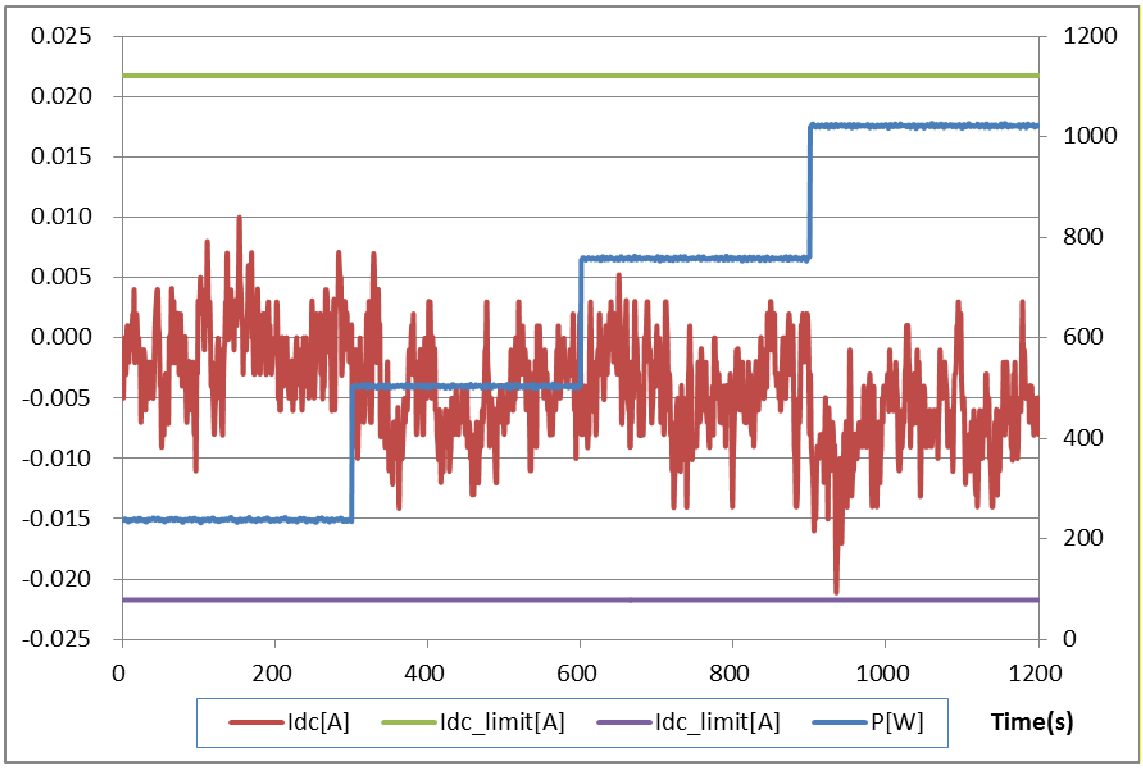
Calculation of the maximum permissible grid impedance at the point of common coupling based on dc:
Zmax = Zref * 3,3% / dc(Pn)
The tests should be based on the limits of the EN61000-3-3 for less than 16A and on EN 61000-3-11 for more than 16A.

The tests had been performed on the SOFAR 1100TL and SOFAR 3000TL are valid for the SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

D.3.10 DC-Injection	P

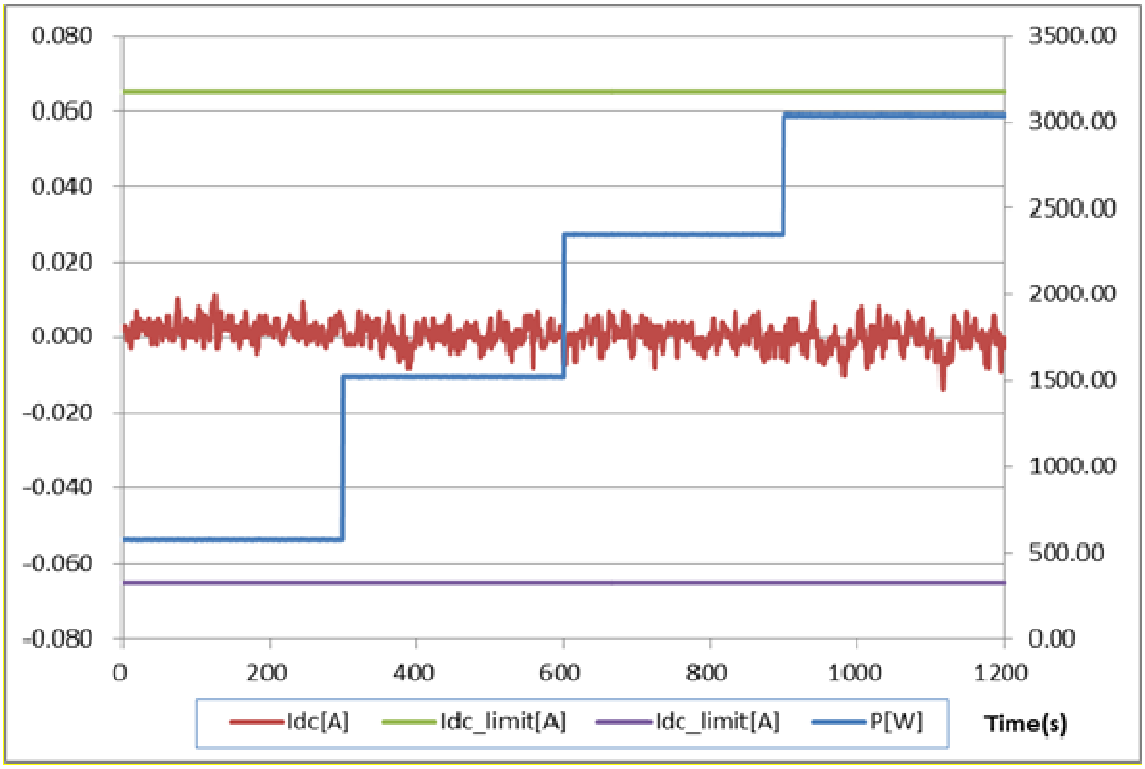
SOFAR 1100TL

Protection limit	Tested at four power levels limit 0,5% of IAC;nom			
Output power	~20%	~50%	75%	~100%
Abs. Max. test value [A]	-0,011	-0,014	-0,014	-0,021
Abs. Ave. test value [A]	-0,001	-0,005	-0,004	-0,007



SOFAR 3000TL

Protection limit	Tested at four power levels limit 0,5% of IAC;nom			
Output power	~20%	~50%	75%	~100%
Abs. Max. test value [A]	0,011	-0,008	-0,008	-0,014
Abs. Ave. test value [A]	0,002	0,001	0,000	-0,001



Note:
The internal temperature of the EUT must be stabilized. No temperature drift of more than 2K within 1 hour is allowed.

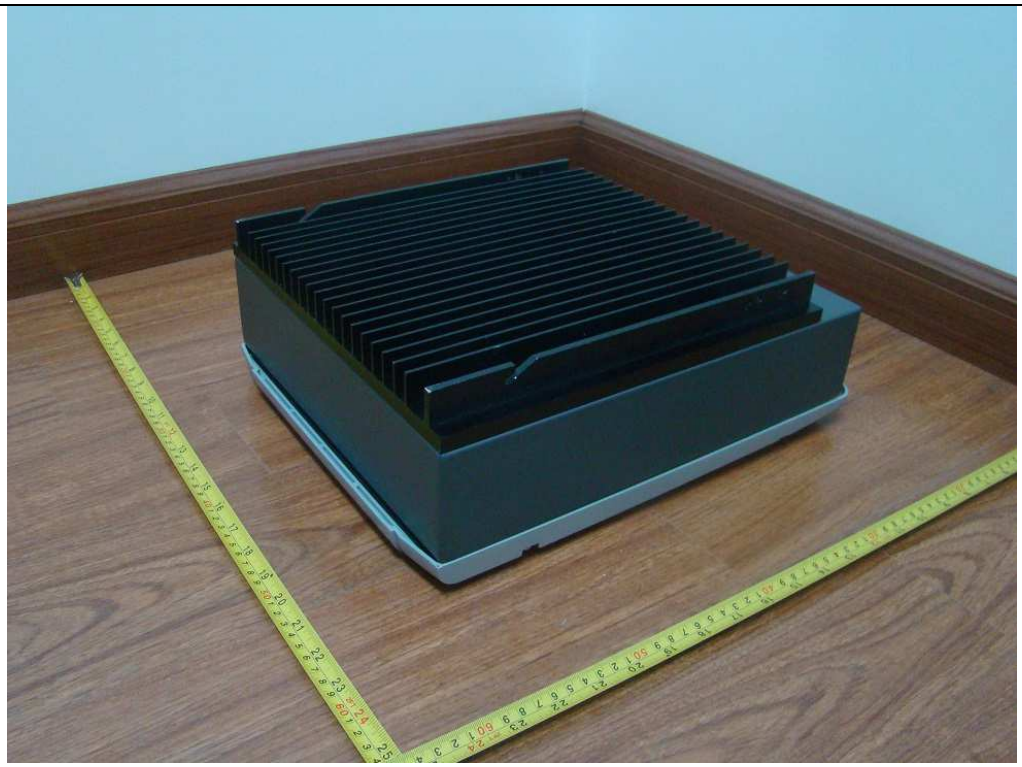
The tests had been performed on the SOFAR 1100TL and SOFAR 3000TL are valid for the SOFAR 1600TL, SOFAR 2200TL and SOFAR 2700TL, since it is same as in hardware and just power derated by software.

Annex 1

Pictures of the unit

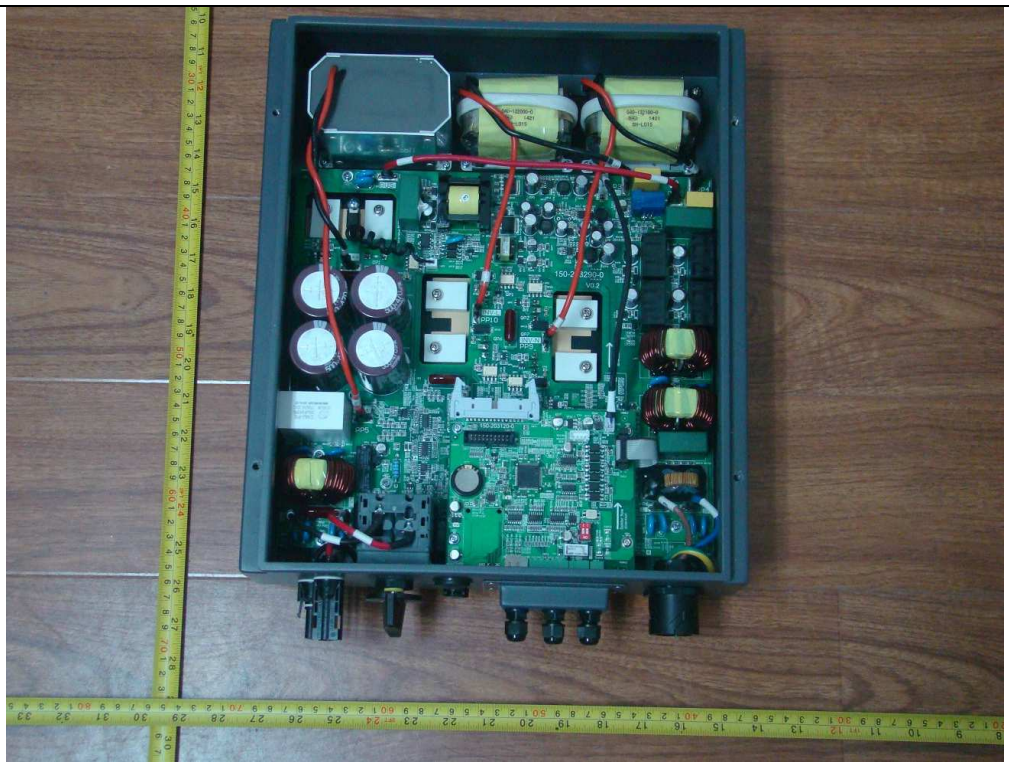
Enclosure front view

Enclosure rear view

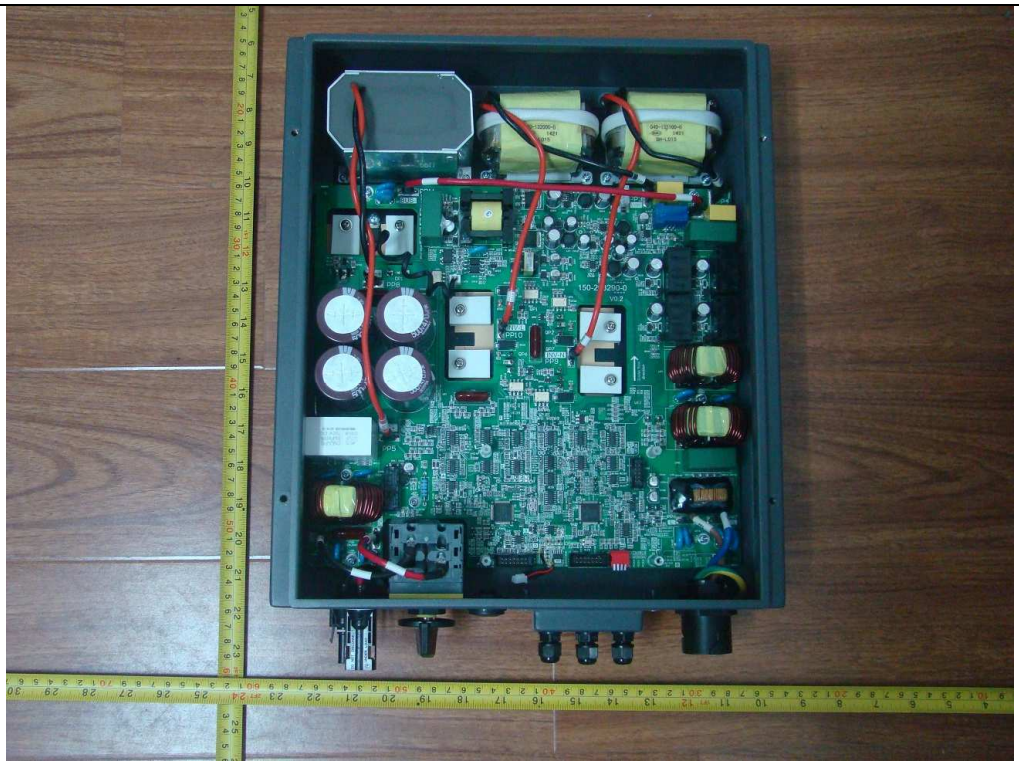


Enclosure bottom view

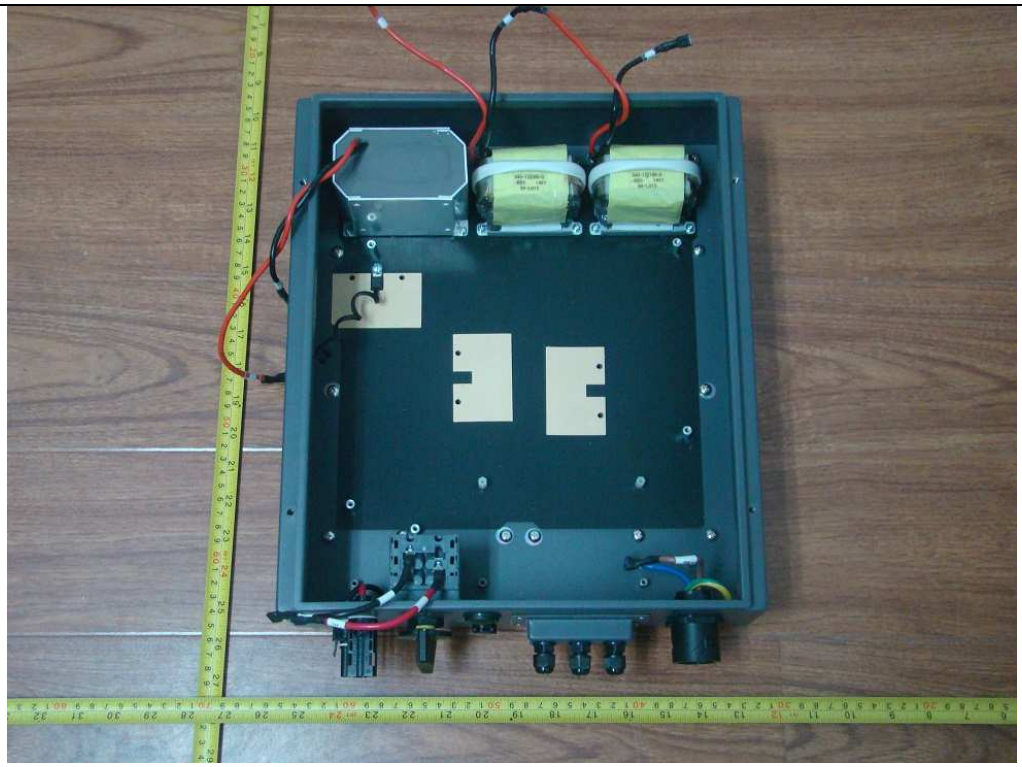
Internal view-1



Internal view-2

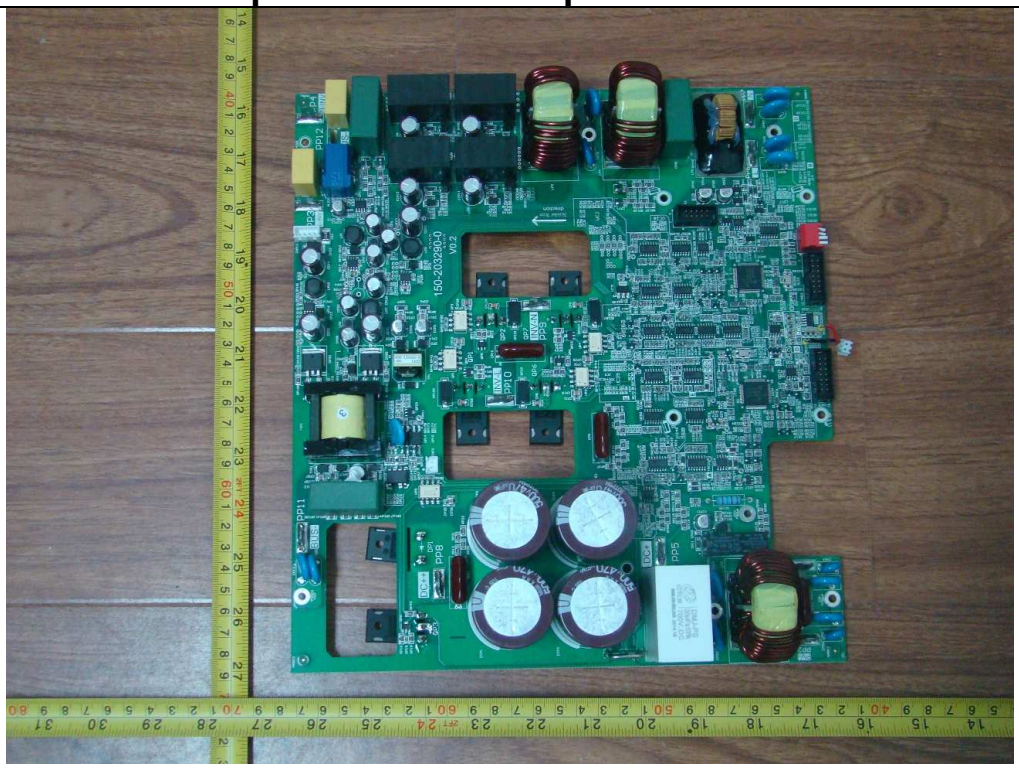


Internal view-3

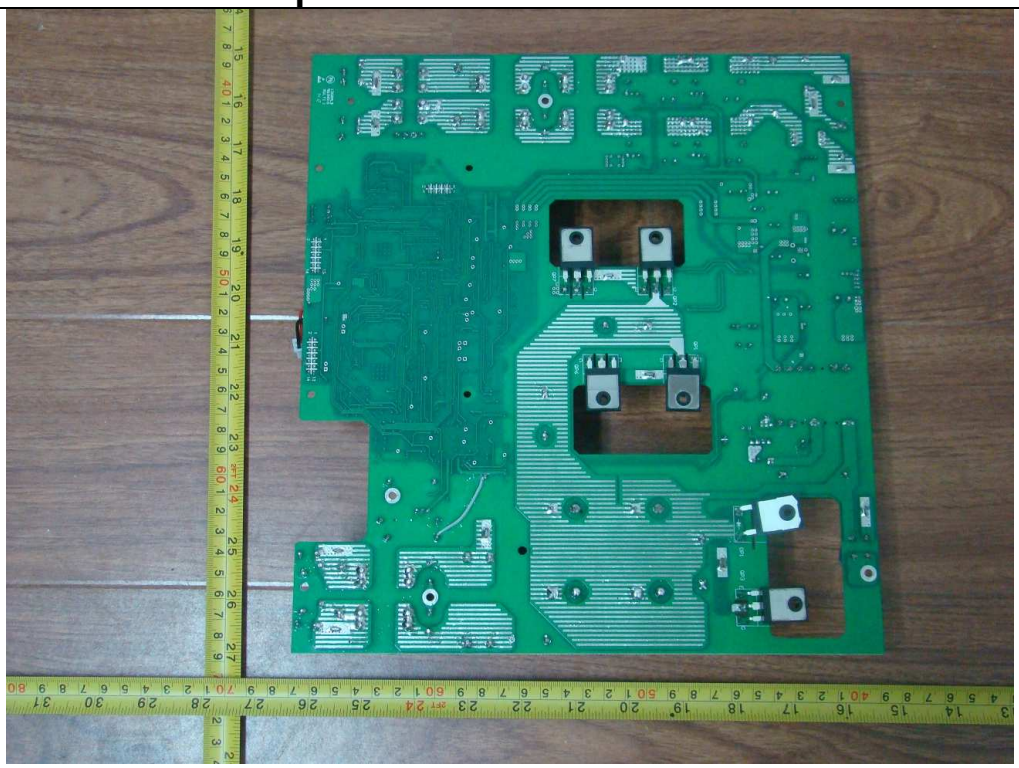


Internal view-4

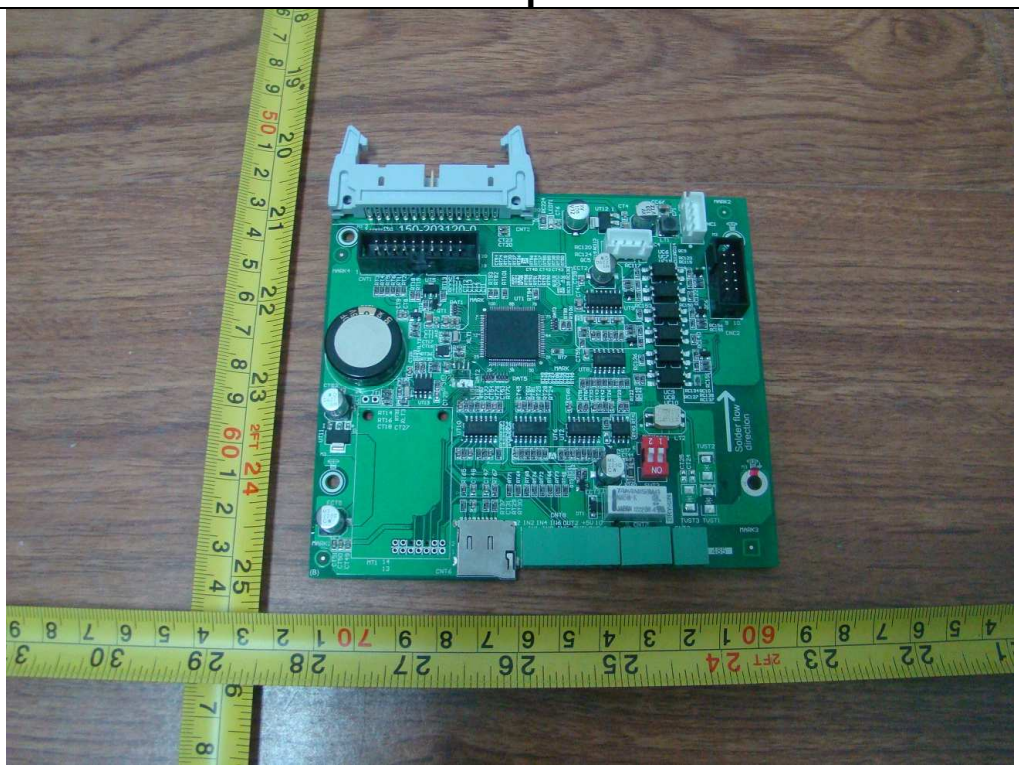
Main power board component side view



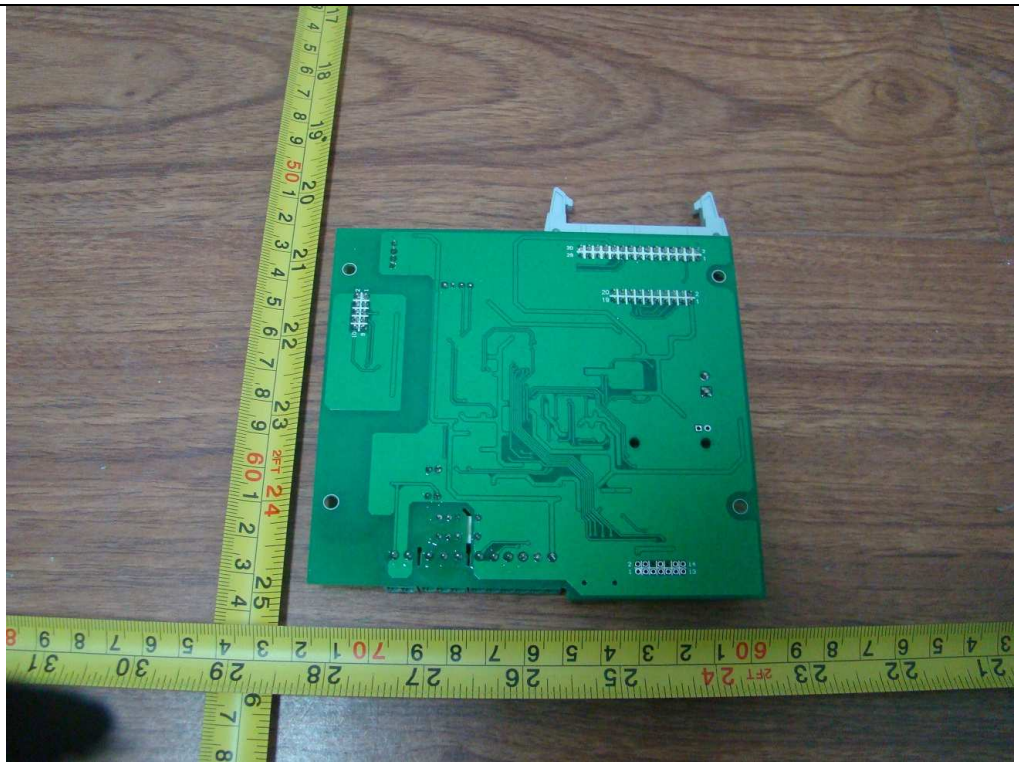
Main power board solder side view



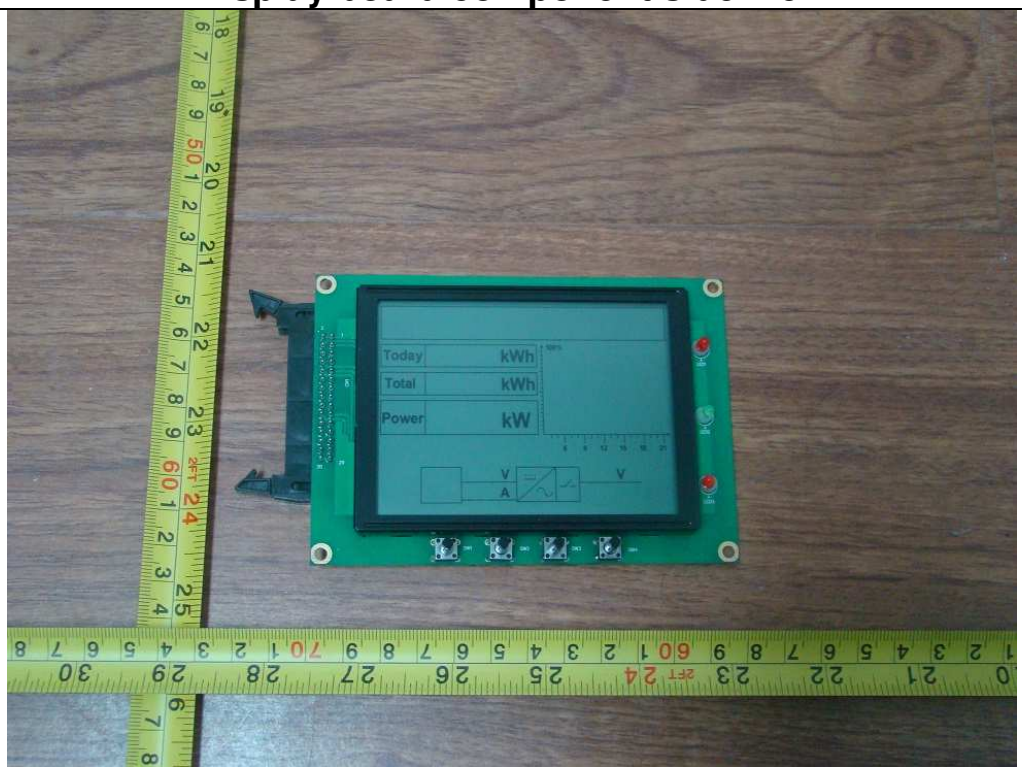
Control board component side view



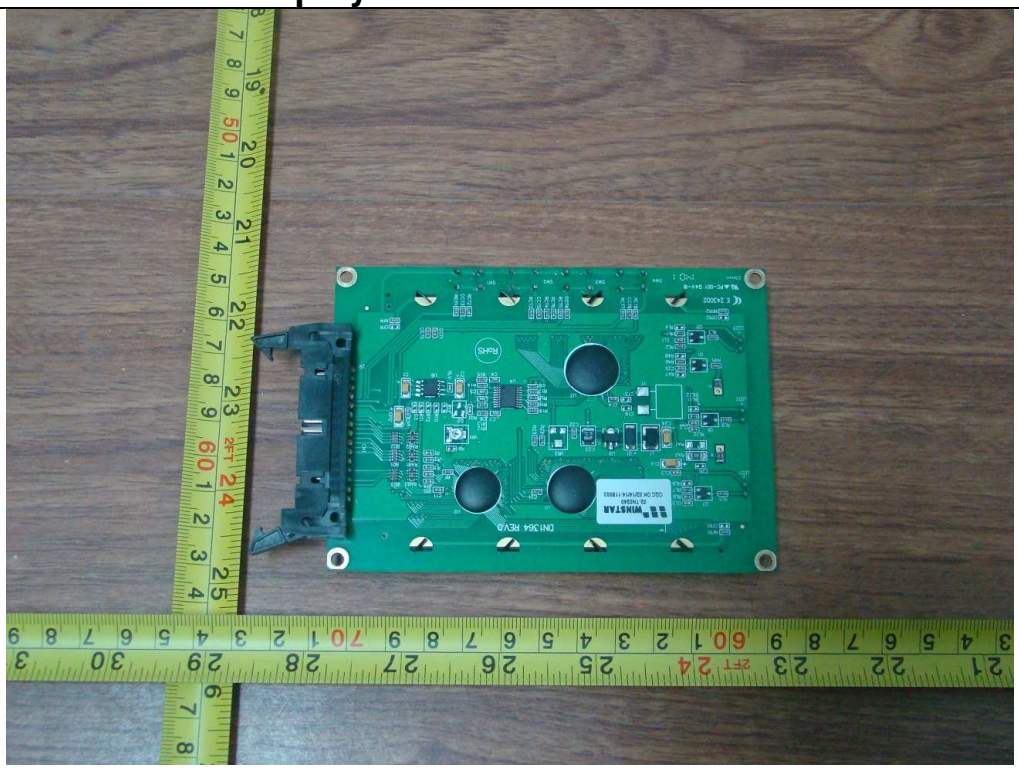
Control board solder side view



Display board component side view



Display board solder side view



Annex 2

Test Equipment list

Test location: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Dates of performance test: 2014-05-08 to 2014-07-01

Equipment	Internal No.	Manufacturer	Type	Serial No.	Last Calibration
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	Mar. 12, 2014
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040015DG	Chroma	62150H-1000S	62150EF00488	
	A7040016DG	Chroma	62150H-1000S	62150EF00490	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Four Channel Digital Phosphor Oscilloscope	A4089003DG	Tektronix	DPO4104B	C010624	Oct. 17, 2013
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Jan 20, 2014
Oscilloscope probel	A4089010DG	Tektronix	TPP1000	C008228	Dec. 20, 2013
	A4089011DG	Tektronix	TPP1000	C008229	Dec. 20, 2013
LCR Hitester	A1060006DG	HIOKI	3535	120112505	Mar. 06, 2014

Test location: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Dates of performance test: 2018-09-03 to 2018-09-29

Equipment	Internal No.	Manufacturer	Type	Serial No.	Last Calibration
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	Jan. 12, 2018
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040015DG	Chroma	62150H-1000S	62150EF00488	
	A7040016DG	Chroma	62150H-1000S	62150EF00490	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850-H-HC	91N726247	Sep. 07, 2018
Isolation voltage probe	A1490008DG	YOKOGAWA	701901	//	Oct. 25, 2017
	A1490011DG	YOKOGAWA	701901	//	Oct. 25, 2017
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Nov. 28, 2017
	A1060008DG	YOKOGAWA	CT200	1130700017	Nov. 22, 2017