TEST REPORT

DIN VDE V 0124-100

Test requirements for generation units to be connected and operated parallel with the low voltage distribution networks

Report reference number .... :	**PVDE140508N005**
Date of issue .... ……...:	2014-07-21
Total number of pages .... ……...:	79
Testing laboratory name .... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
Address .... :	No. 34, Chenwulu Section, Guantai Rd., Houjie Town, Dongguan City, Guangdong 523942, China
	ACCREDITED Certificate # 2951.01
Applicant's name .... :	**Shenzhen SOFARSOLAR Co., Ltd.**
Address .... :	3A-1, Huake Building, East Technology Park, Qiaoxiang Road, Nanshan District, Shenzhen, China.
Test specification	
Standard .... :	DIN VDE V 0124-100:2012-07
Zertifikate .... :	**Certificate of compliance**
Test report form number. .... :	DIN VDE V 0124-100
Master TRF .... :	Bureau Veritas Consumer Products Services Germany GmbH
Test item description .... :	**Grid connected photovoltaic inverter**
Trademark....................................... :	SOFAR SOLAR
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)....................... :	Corney Zhang
Manufacturer's name..................... :	**Shenzhen SOFARSOLAR Co., Ltd.**
Factory address .... :	No. 8, Fulong road, Qingxi town, Dongguan city, Guangdong, China.

Document History			
Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2014-07-21	James Huang	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]................... :	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 .... :	2014-05-08
Date(s) of performance of test .... :	2014-05-08 to 2014-07-01

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 DIN VDE V 0124-100. This report shall not be reproduced, except in full, without the written approval of the applicant.

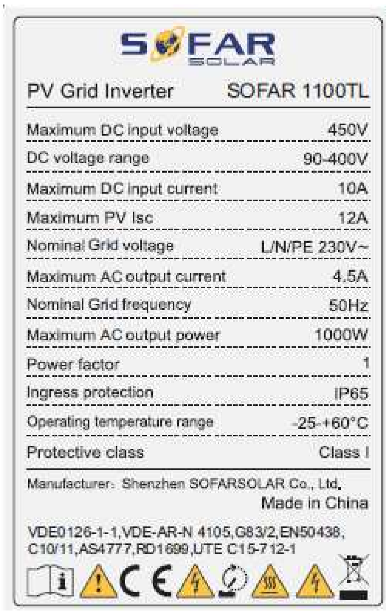
"(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

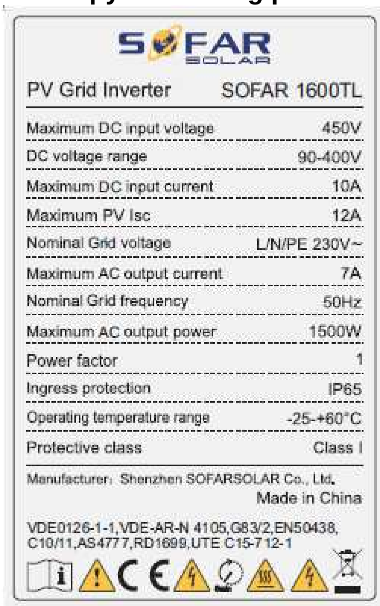
Throughout this report a comma is used as the decimal separator.

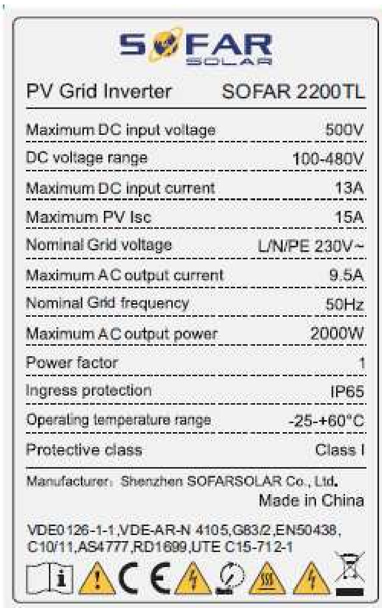
This Test Report consists of the following documents:

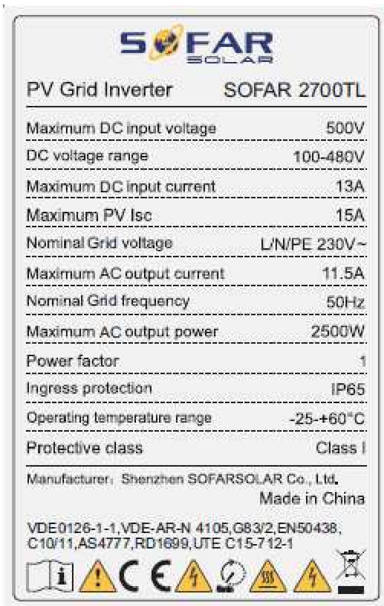
1. Test Report
   - 5.1. Verification of permissible system perturbations
   - 5.3. Verification of the characteristics of the power generation unit on the network
   - 5.4. Testing of NS protection
   - 5.5. Testing of connecting conditions and synchronisation
2. Pictures of the unit – Annex No. 1
3. Test equipment list – Annex No. 2

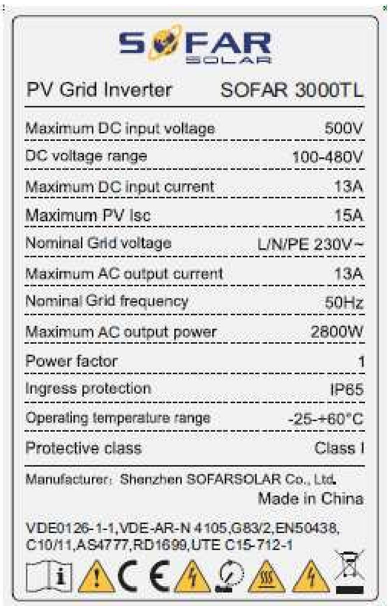
Copy of marking plate











General product information:

The Solar converter converts DC voltage into AC voltage.

The units are single-phase inverter.

The product connected to grid only single or system <3,68kVA used in Germany area.

Description of the power circuit (Figure 1):

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.

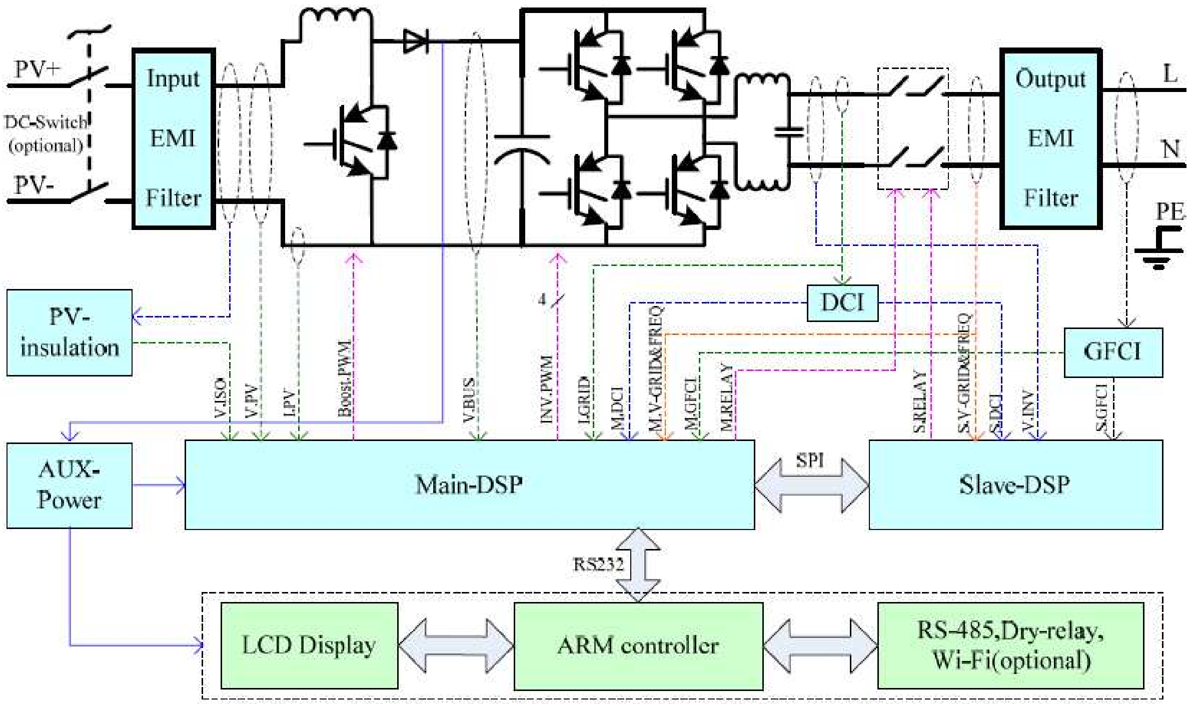


Figure 1 – Block diagram

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.

The product was tested on:

Hardware version: V1.00

Software version: V1.00

Description of the differences of the models within a series:

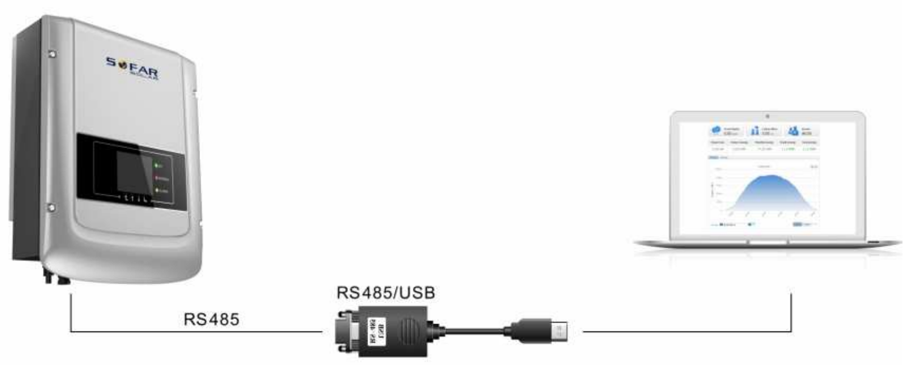
The models SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL, SOFAR 2700TL and SOFAR 3000TL are same as in hardware except the components are in the different table. Identical in software the output power just adjusted by software.

Difference table

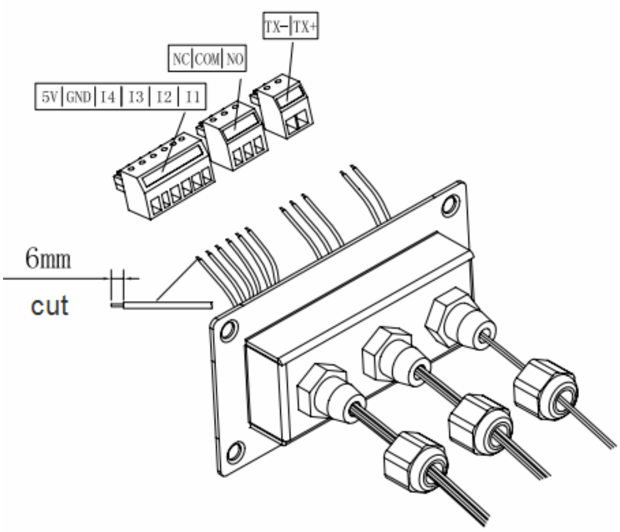
	SOFAR 1100TL	SOFAR 1600TL	SOFAR 2500TL	SOFAR 2700TL	SOFAR 3000TL
Boost inductor	2,6mH	2,6mH	1,9mH	1,9mH	1,9mH
Resistor (RP105, RP108 /RP189,RP109)	220ohm / 10Kohm	220ohm / 10Kohm	200ohm / 7,5Kohm	200ohm / 7,5Kohm	200ohm / 7,5Kohm
BUS capacitor (ECP1, ECP2, ECP3, ECP4)	2 pcs	2 pcs	3 pcs	3 pcs	3 or 4 pcs
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.					

Description of the remote control in a typical installation:

RS485 connection mode:



Type	I/O						Dry contact			RS485	
connector	(6pin)						(3pin)			(2pin)	
label	5V	GND	I4	I3	I2	I1	NC	COM	NO	TX -	TX +
function	source	ground	Input 4	Input 3	Input 2	Input 1	Normally closed	Common ground	Normally open	RS485 differential signal -	RS485 differential signal +



Wi-Fi connection mode:
 **Figure 2 – Scheme of an installation**
Description of the connection to the ripple control receiver: **N/A**

General remarks:

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The following suffixes are used for variables in tables and figures:

- "P_N" for the nominal active power:
  $P_n = U_n \times I_n \times \cos \varphi_n$ (single-Phase); $P_n = \sqrt{3}\, U_n \times I_n \times \cos \varphi_n$ (three-Phase)
- "_E0,2" for gliding average values over 200 milliseconds
- "_E60" for gliding average values over 60 seconds.
- "_E600" for gliding average values over 10 minutes.
- "(c)" for over-excited
- "(i)" for under-excited

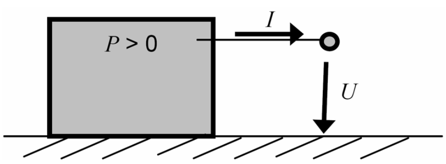
Acronyms:

PGU: power generating unit

PGS: power generating system

The regarded system of the voltage and current vectors is the load view (Figure 3):

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



- If the inverter consumes inductive reactive power the reactive power is marked "inductive" or has a positive sign.
- If the inverter consumes capacitive reactive power the reactive power is marked "capacitive" or has a negative sign.

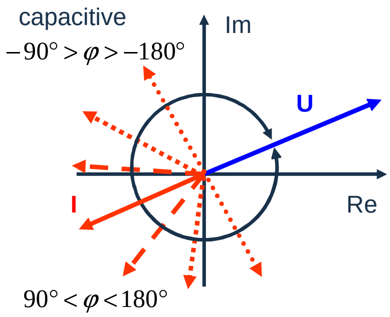


Figure 3

5 Prüfungen DIN VDE V 0124-100:2012-07		
Clause	**Test**	**Result**
5.1	Verification of permissible system perturbations	**P**
5.2	Verification of the symmetry characteristics of three-phase inverter modules	**N/A**
5.3	Verification of the characteristics of the power generation unit on the network	**P**
5.4	Testing of NS protection	**P**
5.5	Testing of connecting conditions and synchronisation	**P**

5.1	**Verification of permissible system perturbations DIN VDE V 0124-100:2012-07**		
Clause	**Test**		**Result**
5.1.1	General		**P**
5.1.2	Rapid voltage changes		**P**
	5.1.2.1	Tests	**P**
	5.1.2.2	Documentation of tests	**P**
5.1.3	Flicker		**P**
	5.1.3.1	Tests	**P**
	5.1.3.2	Documentation of tests	**P**
5.1.4	Harmonics and interharmonics		**P**
	5.1.4.1	Tests	**P**
	5.1.4.2	Additional tests	**N/A**
	5.1.4.3	Documentation of tests	**P**

5.1.1 **General** These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.4 are met.	**P**
The electrical equipment of the customer system has been planned and built, and will be operated, such that system perturbations affecting the network of the network operator and the installations of other customers are limited to a permissible level on a permanent basis. System perturbations are defined as: - Rapid voltage changes - Flicker - Harmonics, interharmonics and higher frequencies (up to 9 kHz)	
Note:	

5.1.2 Rapid voltage changes These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.4.2 are met.	**P**

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

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

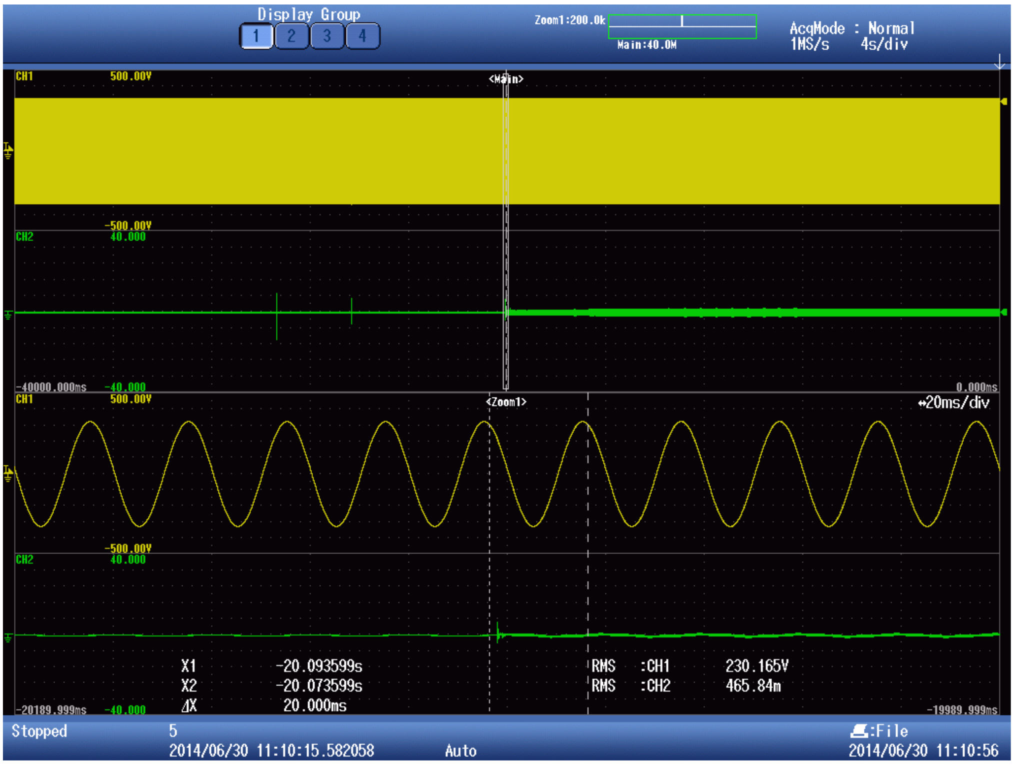
- Switch-on for any capacity
- Unfavourable case when switching the generator step
- Switch-on for nominal capacity

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

Switch-on for any capacity (10% P_{Emax})			
Single period effective values of the current [A]	0,463	0,466	0,445
Single period effective values of the voltage [V]	230,2	230,2	230,2
k_i value	0,04	0,04	0,04
k_{imax} value	0,04		
Unfavourable case when switching the generator step			
Single period effective values of the current [A]	N/A	N/A	N/A
Single period effective values of the voltage [V]	N/A	N/A	N/A
k_i value	N/A	N/A	N/A
k_{imax} value			
Switch-on for nominal capacity			
Single period effective values of the current [A]	0,787	0,475	0,462
Single period effective values of the voltage [V]	230,7	230,2	230,2
k_i value	0,06	0,04	0,04
k_{imax} value	0,06		
Highest k_{imax} value for all switching operations			
0,06			

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.

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



Switch-on for nominal capacity

5.1.3 Flicker

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

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

For power generation systems with rated currents ≤ 75 A, system perturbations are deemed sufficiently limited when the generation units adhere to the thresholds in norms DIN EN 61000-3-3 (VDE 0838-3) and DIN EN 61000-3-11 (VDE 0838-11).

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

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

Flicker to:	Result:		
	P_{lt}	P_{st}	*dc%*
DIN EN 61000-3-3 (SOFAR 1100TL)	0,07	0,07	0,00
DIN EN 61000-3-3 (SOFAR 1600TL)	0,07	0,07	0,00
DIN EN 61000-3-3 (SOFAR 2200TL)	0,07	0,07	0,00
DIN EN 61000-3-3 (SOFAR 2700TL)	0,07	0,07	0,00
DIN EN 61000-3-3 (SOFAR 3000TL)	0,07	0,07	0,00

Assessment criterion:

Long-term flicker strength P_{lt} to DIN EN 61000-3-3 (VDE 0838-3) or DIN EN 61000-3-11 must be ≤ 0,5.

Determination of the flicker coefficient:

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

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

The following applies according to DIN EN 61000-3-3 (≤ 16 A) for the network standby element: S_k = 112148

Flicker to DIN EN 61400-21 (VDE 0127-21) (or FGW TR3)	
SOFAR 1100TL	
Grid impedance angle ψ_k	32°
Flicker coefficient $c(\psi_k)$	7,85
Short-term flicker P_{st}	0,07
SOFAR 1600TL	
Grid impedance angle ψ_k	32°
Flicker coefficient $c(\psi_k)$	5,23
Short-term flicker P_{st}	0,07
SOFAR 2200TL	
Grid impedance angle ψ_k	32°
Flicker coefficient $c(\psi_k)$	3,93
Short-term flicker P_{st}	0,07
SOFAR 2700TL	
Grid impedance angle ψ_k	32°
Flicker coefficient $c(\psi_k)$	3,14
Short-term flicker P_{st}	0,07
SOFAR 3000TL	
Grid impedance angle ψ_k	32°
Flicker coefficient $c(\psi_k)$	2,80
Short-term flicker P_{st}	0,07
Assessment criterion: Long-term flicker strength**:** $P_{lt} \leq 0,5$	
Note:	

5.1.4 **Harmonics and interharmonics** These tests are designed to provide evidence that the requirements of VDE-AR-N 4015, 5.4.4 are met.	**P**

Adherence to the thresholds for harmonic currents must be verified as followed:

- For nominal currents ≤ 16 A per conductor to DIN EN 61000-3-2 (VDE 0838-2)
- For nominal currents > 16 A and ≤ 75 A per conductor to DIN EN 61000-3-12 (VDE 0838-12)
- For PGUs intended for PGSs with nominal currents > 75 A, the measurements must be conducted as in 5.1.4.2.

Test conditions:

Voltage: 86% U_n to 109% U_n

Frequency: 50 Hz ± 0,5%

THD of the voltage supply: ≤ 3 %

Voltage rise of the PGU at 100 P_{Emax} %: ≤ 3 %

5.1.4.1 Tests								P
SOFAR 1100TL								
Maximum permissible harmonic current as per EN 61000-3-2 Class A								
Harmonics	2nd	3rd	5th	7th	9th	11th	13th	15 th ≤ n ≤ 39 th
Limit	1,08A	2,3A	1,14A	0,77A	0,4A	0,33A	0,21A	0,15 * (15/n)
Test value	See below							

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	4.2795			2	0.0095	1.0800	99.1
3	0.0632	2.3000	97.3	4	0.0045	0.4300	99.0
5	0.0096	1.1400	99.2	6	0.0031	0.3000	99.0
7	0.0061	0.7700	99.2	8	0.0022	0.2300	99.0
9	0.0036	0.4000	99.1	10	0.0023	0.1840	98.8
11	0.0021	0.3300	99.4	12	0.0023	0.1533	98.5
13	0.0019	0.2100	99.1	14	0.0018	0.1314	98.6
15	0.0015	0.1500	99.0	16	0.0016	0.1150	98.6
17	0.0014	0.1324	99.0	18	0.0018	0.1022	98.3
19	0.0015	0.1184	98.8	20	0.0016	0.0920	98.3
21	0.0017	0.1071	98.4	22	0.0013	0.0836	98.4
23	0.0014	0.0978	98.6	24	0.0012	0.0767	98.4
25	0.0015	0.0900	98.3	26	0.0014	0.0708	98.0
27	0.0012	0.0833	98.6	28	0.0011	0.0657	98.3
29	0.0012	0.0776	98.5	30	0.0010	0.0613	98.4
31	0.0010	0.0726	98.7	32	0.0011	0.0575	98.1
33	0.0011	0.0682	98.4	34	0.0013	0.0541	97.6
35	0.0011	0.0643	98.3	36	0.0012	0.0511	97.7
37	0.0009	0.0608	98.5	38	0.0012	0.0484	97.6
39	0.0009	0.0577	98.5	40	0.0015	0.0460	96.8

SOFAR 1600TL								
Maximum permissible harmonic current as per EN 61000-3-2 Class A								
Harmonics	2nd	3rd	5th	7th	9th	11th	13th	15 th ≤ n ≤ 39 th
Limit	1,08A	2,3A	1,14A	0,77A	0,4A	0,33A	0,21A	0,15 * (15/n)
Test value	See below							

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	6.5184			2	0.0041	1.0800	99.6
3	0.0868	2.3000	96.2	4	0.0033	0.4300	99.2
5	0.0255	1.1400	97.8	6	0.0032	0.3000	98.9
7	0.0156	0.7700	98.0	8	0.0034	0.2300	98.5
9	0.0095	0.4000	97.6	10	0.0035	0.1840	98.1
11	0.0045	0.3300	98.6	12	0.0036	0.1533	97.6
13	0.0043	0.2100	97.9	14	0.0030	0.1314	97.7
15	0.0039	0.1500	97.4	16	0.0026	0.1150	97.8
17	0.0047	0.1324	96.4	18	0.0022	0.1022	97.9
19	0.0057	0.1184	95.2	20	0.0022	0.0920	97.6
21	0.0058	0.1071	94.6	22	0.0018	0.0836	97.9
23	0.0060	0.0978	93.9	24	0.0017	0.0767	97.7
25	0.0061	0.0900	93.2	26	0.0015	0.0708	97.9
27	0.0063	0.0833	92.4	28	0.0014	0.0657	97.9
29	0.0063	0.0776	91.9	30	0.0013	0.0613	97.9
31	0.0064	0.0726	91.2	32	0.0013	0.0575	97.8
33	0.0064	0.0682	90.6	34	0.0014	0.0541	97.4
35	0.0066	0.0643	89.7	36	0.0013	0.0511	97.5
37	0.0066	0.0608	89.2	38	0.0011	0.0484	97.8
39	0.0066	0.0577	88.6	40	0.0010	0.0460	97.9

SOFAR 2200TL								
Maximum permissible harmonic current as per EN 61000-3-2 Class A								
Harmonics	2^{nd}	3^{rd}	5^{th}	7^{th}	9^{th}	11^{th}	13^{th}	15 th ≤ n ≤ 39 th
Limit	1,08A	2,3A	1,14A	0,77A	0,4A	0,33A	0,21A	0,15 * (15/n)
Test value	See below							

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	8.7596			2	0.0024	1.0800	99.8
3	0.1216	2.3000	94.7	4	0.0016	0.4300	99.6
5	0.0136	1.1400	98.8	6	0.0024	0.3000	99.2
7	0.0072	0.7700	99.1	8	0.0033	0.2300	98.5
9	0.0044	0.4000	98.9	10	0.0028	0.1840	98.5
11	0.0029	0.3300	99.1	12	0.0020	0.1533	98.7
13	0.0039	0.2100	98.1	14	0.0015	0.1314	98.9
15	0.0029	0.1500	98.0	16	0.0012	0.1150	99.0
17	0.0035	0.1324	97.4	18	0.0010	0.1022	99.1
19	0.0043	0.1184	96.4	20	0.0010	0.0920	98.9
21	0.0040	0.1071	96.2	22	0.0008	0.0836	99.1
23	0.0032	0.0978	96.7	24	0.0007	0.0767	99.0
25	0.0031	0.0900	96.5	26	0.0008	0.0708	98.8
27	0.0028	0.0833	96.6	28	0.0007	0.0657	98.9
29	0.0021	0.0776	97.2	30	0.0006	0.0613	99.0
31	0.0018	0.0726	97.6	32	0.0006	0.0575	98.9
33	0.0016	0.0682	97.7	34	0.0006	0.0541	99.0
35	0.0015	0.0643	97.7	36	0.0006	0.0511	98.9
37	0.0013	0.0608	97.9	38	0.0007	0.0484	98.5
39	0.0010	0.0577	98.3	40	0.0007	0.0460	98.5

SOFAR 2700TL								
Maximum permissible harmonic current as per EN 61000-3-2 Class A								
Harmonics	2^{nd}	3^{rd}	5^{th}	7^{th}	9^{th}	11^{th}	13^{th}	15 th ≤ n ≤ 39 th
Limit	1,08A	2,3A	1,14A	0,77A	0,4A	0,33A	0,21A	0,15 * (15/n)
Test value	See below							

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	10.7939			2	0.0056	1.0800	99.5
3	0.1149	2.3000	95.0	4	0.0044	0.4300	99.0
5	0.0251	1.1400	97.8	6	0.0038	0.3000	98.7
7	0.0160	0.7700	97.9	8	0.0037	0.2300	98.4
9	0.0086	0.4000	97.9	10	0.0040	0.1840	97.8
11	0.0047	0.3300	98.6	12	0.0040	0.1533	97.4
13	0.0049	0.2100	97.7	14	0.0033	0.1314	97.5
15	0.0045	0.1500	97.0	16	0.0029	0.1150	97.5
17	0.0059	0.1324	95.6	18	0.0024	0.1022	97.7
19	0.0067	0.1184	94.4	20	0.0022	0.0920	97.6
21	0.0066	0.1071	93.8	22	0.0018	0.0836	97.8
23	0.0070	0.0978	92.9	24	0.0018	0.0767	97.6
25	0.0074	0.0900	91.8	26	0.0016	0.0708	97.7
27	0.0076	0.0833	90.9	28	0.0015	0.0657	97.7
29	0.0077	0.0776	90.1	30	0.0013	0.0613	97.9
31	0.0082	0.0726	88.7	32	0.0013	0.0575	97.8
33	0.0082	0.0682	88.0	34	0.0015	0.0541	97.1
35	0.0087	0.0643	86.4	36	0.0016	0.0511	96.8
37	0.0090	0.0608	85.2	38	0.0015	0.0484	96.9
39	0.0093	0.0577	83.9	40	0.0018	0.0460	96.1

SOFAR 3000TL								
Maximum permissible harmonic current as per EN 61000-3-2 Class A								
Harmonics	2nd	3rd	5th	7th	9th	11th	13th	15 th ≤ n ≤ 39 th
Limit	1,08A	2,3A	1,14A	0,77A	0,4A	0,33A	0,21A	0,15 * (15/n)
Test value	See below							

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	11.9330			2	0.0137	1.0800	98.7
3	0.1150	2.3000	95.0	4	0.0035	0.4300	99.2
5	0.0366	1.1400	96.8	6	0.0021	0.3000	99.3
7	0.0108	0.7700	98.6	8	0.0042	0.2300	98.2
9	0.0053	0.4000	98.7	10	0.0033	0.1840	98.2
11	0.0069	0.3300	97.9	12	0.0039	0.1533	97.4
13	0.0106	0.2100	94.9	14	0.0033	0.1314	97.5
15	0.0115	0.1500	92.4	16	0.0029	0.1150	97.5
17	0.0135	0.1324	89.8	18	0.0025	0.1022	97.6
19	0.0154	0.1184	87.0	20	0.0024	0.0920	97.4
21	0.0149	0.1071	86.1	22	0.0019	0.0836	97.7
23	0.0149	0.0978	84.7	24	0.0018	0.0767	97.7
25	0.0152	0.0900	83.1	26	0.0020	0.0708	97.2
27	0.0147	0.0833	82.4	28	0.0017	0.0657	97.4
29	0.0129	0.0776	83.4	30	0.0017	0.0613	97.3
31	0.0120	0.0726	83.4	32	0.0014	0.0575	97.5
33	0.0120	0.0682	82.5	34	0.0013	0.0541	97.5
35	0.0109	0.0643	83.0	36	0.0013	0.0511	97.5
37	0.0099	0.0608	83.7	38	0.0013	0.0484	97.3
39	0.0091	0.0577	84.2	40	0.0013	0.0460	97.1

Note:
The tests should be based on the limits of the EN61000-3-2 for less than 16A.
Covered by EMC Report 13.7.6.8

5.2 Verification of the symmetry characteristics of three-phase inverter modules DIN VDE V 0124-100:2012-07			
Clause	**Test**		**Result**
5.2.1	General		**N/A**
5.2.2	Test in the test laboratory:		**N/A**
	5.2.2.1	Calculation of asymmetry	**N/A**
	5.2.2	Additional tests for communicatively coupled inverter modules	**N/A**
	5.2.2.1	Failure of individual inverter modules	**N/A**
	5.2.2.2	Power drop of individual inverter modules	**N/A**
5.2.3	Tests in the field		**N/A**

5.3 Verification of the characteristics of the power generation unit on the network DIN VDE V 0124-100:2012-07			
Clause	**Test**		**Result**
5.3.1	General		**P**
5.3.2	Measurement of the active reactive power range		**P**
5.3.3	Active power reduction by specifying setpoints		**N/A**
	5.3.3.1	Setpoint control	**N/A**
	5.3.3.2	Measurement of setting accuracy	**N/A**
	5.3.3.3	Measurement of setting time	**N/A**
5.3.4	Active power feed-in for overfrequency		**P**
	5.3.4.1.1	Test cycle for adjustable/conditionally adjustable PGUs	**P**
	5.3.4.1.2	Test cycle for all PGUs (adjustable, conditionally adjustable and non-adjustable PGUs)	**P**
5.3.5	Active power feed-in for underfrequency		**P**
5.3.6	Reactive power output		**P**
	5.3.6.1	Tests of the cos φ setting accuracy	**P**
	5.3.6.4	Test for a displacement factor/ active power characteristic curve cos φ (P)	**N/A**

5.3.1 General (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.7 are met)		**P**
Test Condition:	The measurements were performed in the testing laboratory. at the grid-simulator: U_N = between 86 % Un and 109% Un until the test Frequency: 50 Hz +/- 0,5%	
Note: If an examination is required for any other requirements, these apply to this test.		

5.3.2 Measurement of the active power and reactive power range (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.7.5 are met)		**P**

Setting values	cos φ = 1:	1
	cos φ max. over-excited:	N/A
	cos φ max. under-excited:	N/A

Test: SOFAR 1100TL		
600 s mean value	U_n	1,09 U_n
a) cos φ 1 at 100% P_{Emax}		
U [V]:	230,51	250,78
$P_{Emax600\ a)}$ [kW]	1,015	1,015
$S_{Emax600\ a)}$ [kVa]	1,015	1,015
cos $\varphi_{Emax600}$	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax600\ b)}$ [kW]	N/A	N/A
$S_{Emax600\ b)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax600-under-excited}$	N/A	N/A
c) maximum over-excited (c) at 100% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax600\ c)}$ [kW]	N/A	N/A
$S_{Emax600\ c)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax600-over-excited}$	N/A	N/A
d) maximum under-excited (i) at 20-30% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax60\ d)}$ [kW]	N/A	N/A
$S_{Emax60\ d)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax60-over-excited}$	N/A	N/A
e) maximum over-excited (c) at 20-30% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax60\ e)}$[kW]	N/A	N/A
$S_{Emax60\ e)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax60-over-excited}$	N/A	N/A

$S_{Emax600}$ and $P_{Emax\ 600}$	
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	1,015 kVA
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	1,015 kW

Test: SOFAR 1600TL		
600 s mean value	U_n	1,09 U_n
a) cos φ 1 at 100% P_{Emax}		
U [V]:	230,64	250,88
$P_{Emax600\ a)}$ [kW]	1,509	1,515
$S_{Emax600\ a)}$ [kVa]	1,510	1,516
cos $\varphi_{Emax600}$	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax600\ b)}$ [kW]	N/A	N/A
$S_{Emax600\ b)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax600\text{-}under\text{-}excited}$	N/A	N/A
c) maximum over-excited (c) at 100% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax600\ c)}$ [kW]	N/A	N/A
$S_{Emax600\ c)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax600\text{-}over\text{-}excited}$	N/A	N/A
d) maximum under-excited (i) at 20-30% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax60\ d)}$ [kW]	N/A	N/A
$S_{Emax60\ d)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax60\text{-}over\text{-}excited}$	N/A	N/A
e) maximum over-excited (c) at 20-30% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax60\ e)}$[kW]	N/A	N/A
$S_{Emax60\ e)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax60\text{-}over\text{-}excited}$	N/A	N/A
$S_{Emax600}$ and $P_{Emax\ 600}$		
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	1,516 kVA	
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	1,515 kW	

Test: SOFAR 2200TL		
600 s mean value	U_n	1,09 U_n
a) cos φ 1 at 100% P_{Emax}		
U [V]:	230,76	250,76
$P_{Emax600\ a)}$ [kW]	1,993	2,025
$S_{Emax600\ a)}$ [kVa]	1,994	2,026
cos $\varphi_{Emax600}$	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax600\ b)}$ [kW]	N/A	N/A
$S_{Emax600\ b)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax600\text{-under-excited}}$	N/A	N/A
c) maximum over-excited (c) at 100% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax600\ c)}$ [kW]	N/A	N/A
$S_{Emax600\ c)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax600\text{-over-excited}}$	N/A	N/A
d) maximum under-excited (i) at 20-30% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax60\ d)}$ [kW]	N/A	N/A
$S_{Emax60\ d)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax60\text{-over-excited}}$	N/A	N/A
e) maximum over-excited (c) at 20-30% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax60\ e)}$[kW]	N/A	N/A
$S_{Emax60\ e)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax60\text{-over-excited}}$	N/A	N/A
$S_{Emax600}$ and $P_{Emax\ 600}$		
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	2,026 kVA	
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	2,025 kW	

Test: SOFAR 2700TL		
600 s mean value	U_n	1,09 U_n
a) cos φ 1 at 100% P_{Emax}		
U [V]:	230,07	250,75
$P_{Emax600\ a)}$ [kW]	2,510	2,513
$S_{Emax600\ a)}$ [kVa]	2,511	2,514
cos $\varphi_{Emax600}$	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax600\ b)}$ [kW]	N/A	N/A
$S_{Emax600\ b)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax600\text{-}under\text{-}excited}$	N/A	N/A
c) maximum over-excited (c) at 100% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax600\ c)}$ [kW]	N/A	N/A
$S_{Emax600\ c)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax600\text{-}over\text{-}excited}$	N/A	N/A
d) maximum under-excited (i) at 20-30% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax60\ d)}$ [kW]	N/A	N/A
$S_{Emax60\ d)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax60\text{-}over\text{-}excited}$	N/A	N/A
e) maximum over-excited (c) at 20-30% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax60\ e)}$[kW]	N/A	N/A
$S_{Emax60\ e)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax60\text{-}over\text{-}excited}$	N/A	N/A
$S_{Emax600}$ and $P_{Emax\ 600}$		
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	2,514 kVA	
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	2,513 kW	

Test: SOFAR 3000TL		
600 s mean value	U_n	1,09 U_n
a) cos φ 1 at 100% P_{Emax}		
U [V]:	230,79	250,72
$P_{Emax600\ a)}$ [kW]	2,849	2,844
$S_{Emax600\ a)}$ [kVa]	2,850	2,845
cos $\varphi_{Emax600}$	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax600\ b)}$ [kW]	N/A	N/A
$S_{Emax600\ b)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax600\text{-}under\text{-}excited}$	N/A	N/A
c) maximum over-excited (c) at 100% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax600\ c)}$ [kW]	N/A	N/A
$S_{Emax600\ c)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax600\text{-}over\text{-}excited}$	N/A	N/A
d) maximum under-excited (i) at 20-30% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax60\ d)}$ [kW]	N/A	N/A
$S_{Emax60\ d)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax60\text{-}over\text{-}excited}$	N/A	N/A
e) maximum over-excited (c) at 20-30% P_{Emax}		
U [V]:	N/A	N/A
$P_{Emax60\ e)}$[kW]	N/A	N/A
$S_{Emax60\ e)}$ [kVa]	N/A	N/A
cos $\varphi_{Emax60\text{-}over\text{-}excited}$	N/A	N/A
$S_{Emax600}$ and $P_{Emax\ 600}$		
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	2,850 kVA	
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	2,849 kW	

Test:

The PGU is operated in all of the following, possible operating points. Every operating point must be retained for at least 600s after the transient effect has faded. During the measurements, there may be no power limitation by the primary energy source.

a) For cos φ, the maximum active power possible in this range is set.
b) For maximum under-excited operation, the maximum active power possible in this operating point is set
c) For maximum over-excited operation, the maximum active power possible in this operating point is set.
d) For maximum under-excited operation, the power set to 20-30% P_{Emax}.
e) For maximum over-excited operation, the power set to 20-30% P_{Emax}.

The operating points d) and e) must be retained for at least 60 s.

Assessment criterion:

$S_{Emax600}$ and $P_{Emax\ 600}$ are determined by the highest value measured.

$S_{Emax600} = max(S_{Emax600a)}, S_{Emax600b)}, S_{Emax600c)})$

$P_{Emax600} = max(P_{Emax600a)}, P_{Emax600b)}, P_{Emax600c)})$

Note:

The maximum settable cos φ must be set.

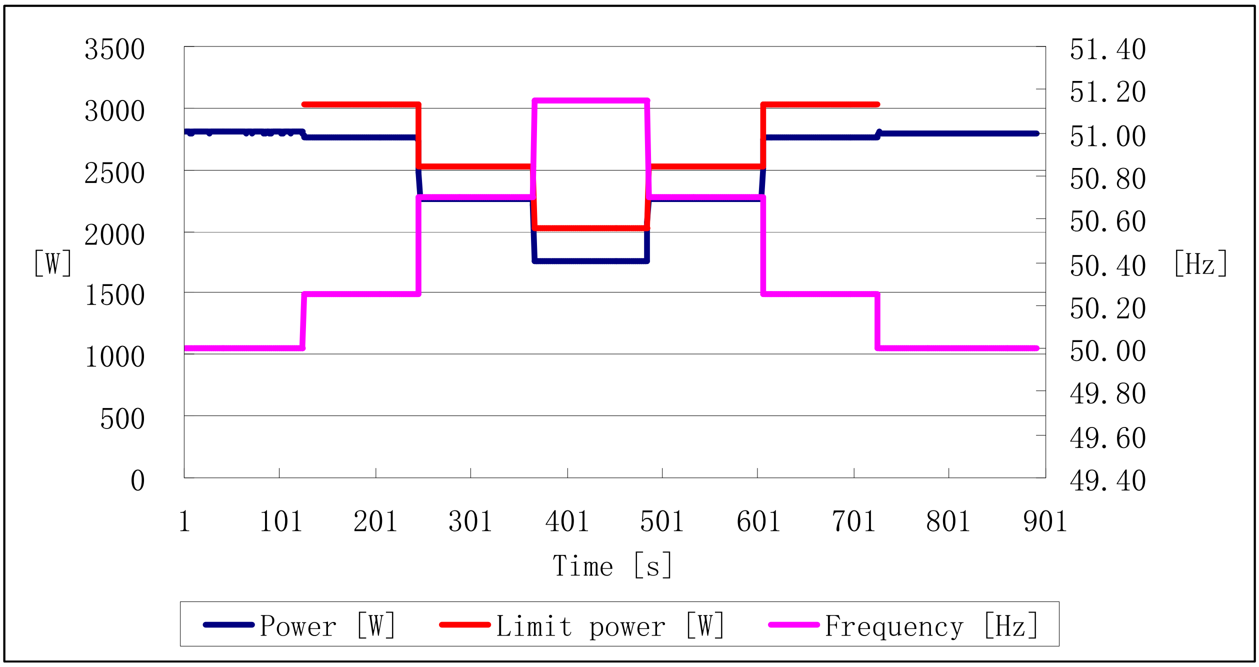
No specification:	PGU ≤ 3,68 kVA not in PGS > 3,68 kVA
φ 0,95 (i) and (c):	PGU > 3,68 kVA and ≤ 13,8 kVA not in PGS > 13,8 kVA and for PGU ≤ 3,68 kVA also in PGS ≤ 13,8 kVA
φ 0,90 (i) and (c):	PGU > 13,8 kVA and for PGU ≤ 13,8 kVA also in PGS > 13,8 kVA

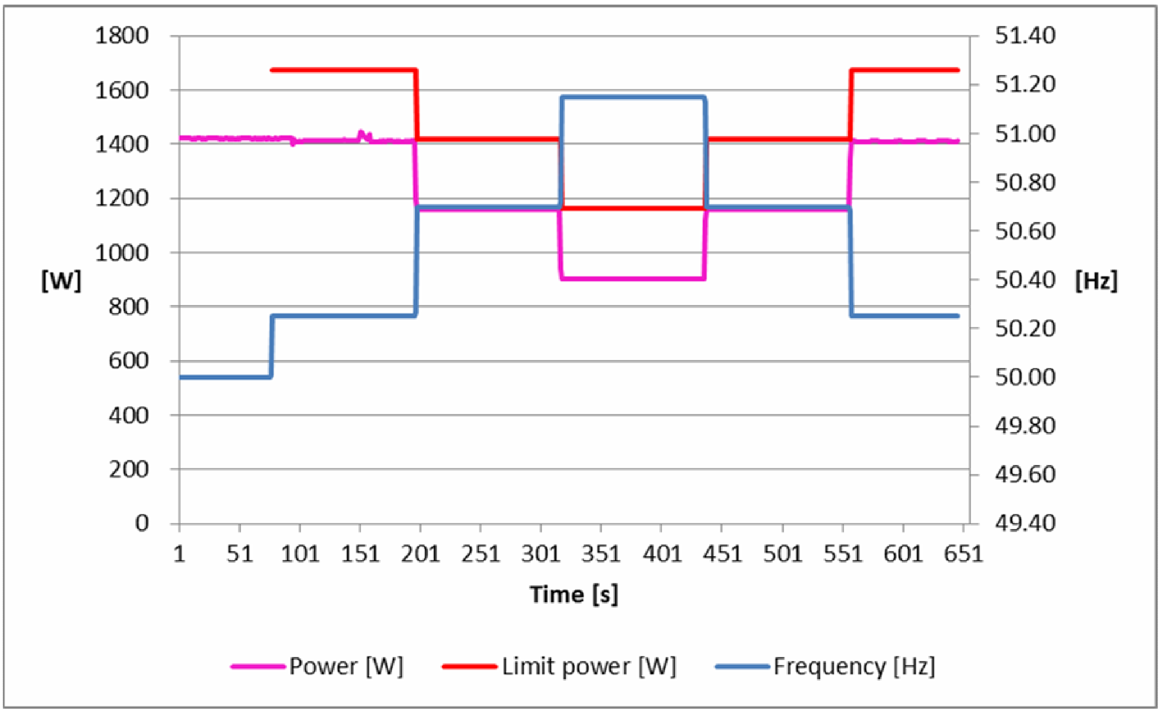
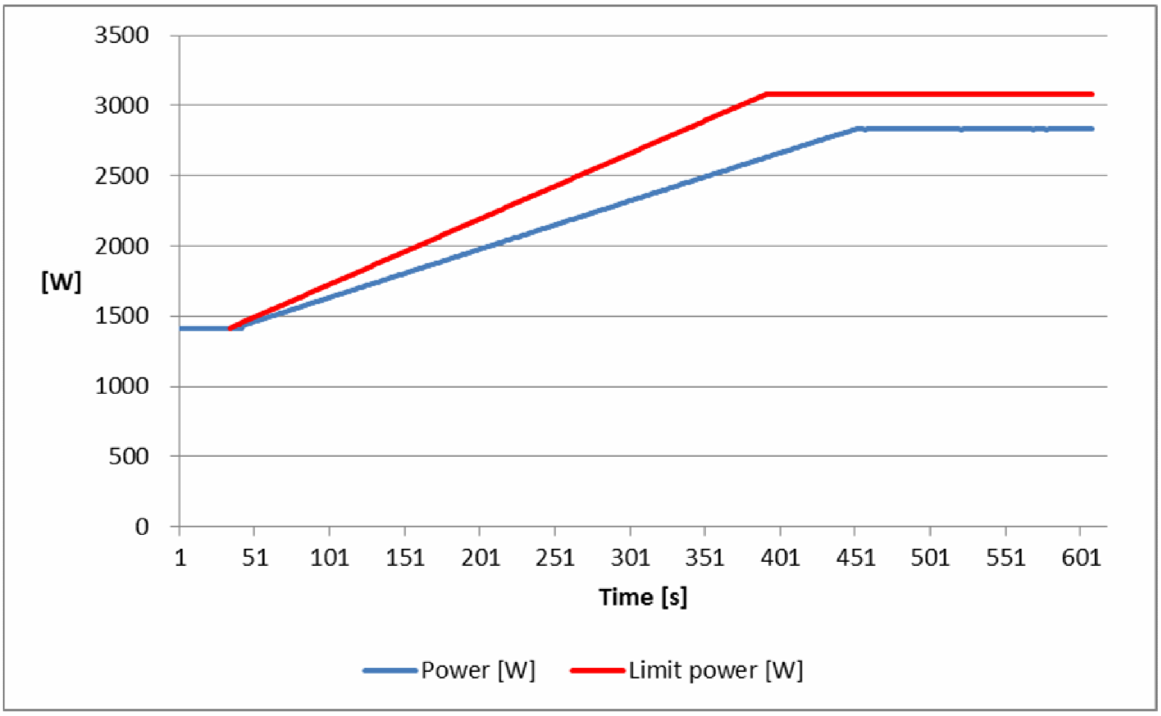
5.3.4 Active power feed-in for overfrequency

(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.7.3.3 are met)

5.3.4.1.1 Test cycle for adjustable/conditionally adjustable PGUs	**P**

Test:							
1-min mean value	a) 50,00 Hz	b) 50,25 Hz	c) 50,70 Hz	d) 51,15 Hz	e) 50,70 Hz	f) 50,25 Hz	g) 50,00 Hz
1. Measurement a) to g): Active power output > 80% P_{Emax}							
Frequency [Hz]:	50,00	50,25	50,70	51,15	50,70	50,25	50,00
$P_{setpoint}$ [kW]:	N/A	2,747	2,243	1,738	2,243	2,747	N/A
P_{E60} [kW]:	2,803	2,761	2,262	1,761	2,262	2,762	2,790
$\Delta P_{E60}/P_{Setpoint}$ [%]:	N/A	0,50	0,68	0,80	0,69	0,51	N/A
2. Measurement a) to g): Active power output 40% and 60% after freezing > 80% P_{Emax}							
Frequency [Hz]:	50,00	50,25	50,70	51,15	50,70	50,25	N/A
$P_{setpoint}$ [kW]:	N/A	1,393	1,137	0,881	1,137	1,393	N/A
P_{E60} [kW]:	1,421	1,415	1,158	0,903	1,157	1,411	N/A
$\Delta P_{E60}/P_{Setpoint}$ [%]:	N/A	0,81	0,73	0,78	0,73	0,65	N/A
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 10 % of P_{Emax}						
Graph of Measurement 1.: Active power output > 80% P_{Emax}							

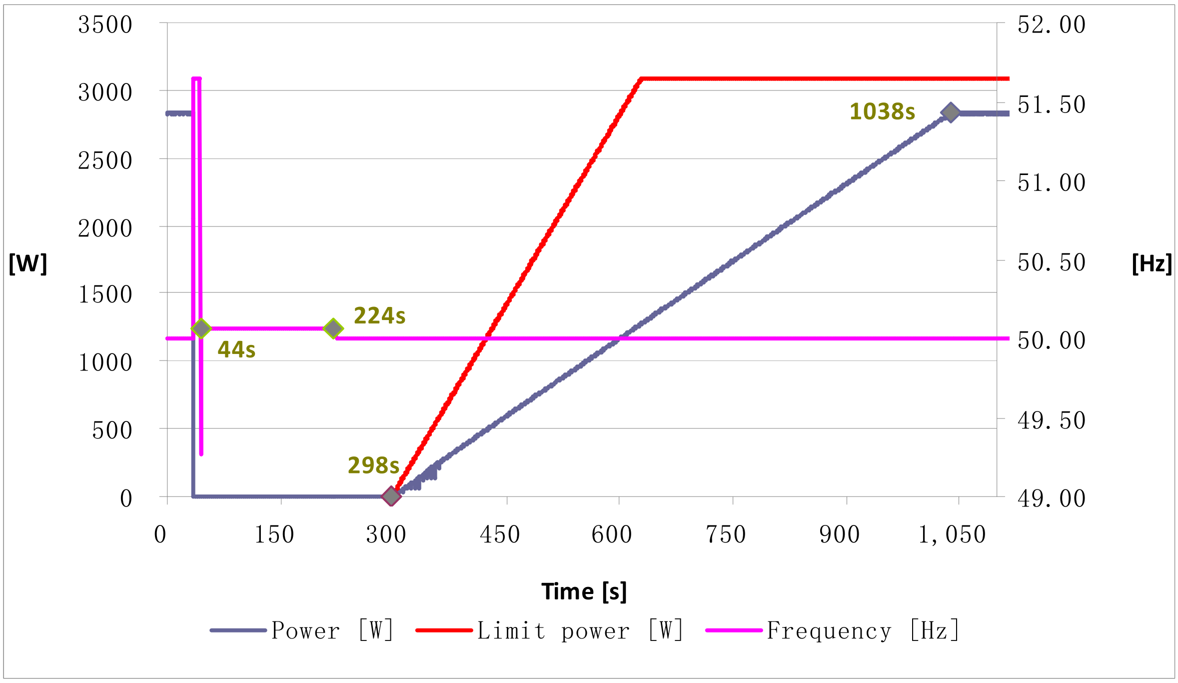


Graph of Measurement 2.:Active power output 40% and 60% after freezing > 80% P_{Emax}

Graph of power gradient:


Test: The test is conducted for two powers. First, the test must start at a power > 80% P_{Emax} ("Measurement 1"), and in a second test, for a power between 40% to 60% P_{Emax} ("Measurement 2"). In the second test, after freezing of the PM, the available active power output must be increased to a value > 80% P_{Emax}, 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 PGU is again feeding in with the active power output available.
Assessment criterion: For f=50,2 Hz, the value of the PM active power currently being generated is "frozen". a) For adjustable PGUs when: 1) the active power reduces between measuring points b) and f) given above with a gradient of 40% PM per Hz for a decreasing frequency (or rises for a frequency decreasing again). 2) the maximum active power gradient occurring in point g) is lower than 10% of maximum active power P_{Emax} every minute, and 3) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from P_{Emax} by more than ± 10%. b) For conditionally adjustable PGUs 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. The PGU must have disconnected from the network no later than 200ms after frequency h) is reached.
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.

5.3.4.1.2 Test cycle for all PGUs (adjustable, conditionally adjustable and non-adjustable)	P

Graph of frequency g) to j):



Test:

1-min mean value	g) 50,00 ± 0,01 Hz	h) 51,65 ± 0,05 Hz	i) 50,06 Hz ± 0,01 Hz	j) 50,00 Hz ± 0,01 Hz

1) g) 50,00 ± 0,01 Hz to h) 51,65 ± 0,05 Hz

Disconnection time [ms]:	176	Limit [ms]:	200

Test:
Following tests a) to g), frequency h) 51,65 Hz ± 0,05 Hz must be set for at least 200ms. Afterwards, frequency i) 50,06 Hz ± 0,01 Hz is enabled and kept for at least 3 minutes.
Afterwards, frequency j) 50,00 Hz ± 0,01 Hz is enabled and kept until transient oscillation of the active power at the earliest.

Assessment criterion:
The PGU must have disconnected from the network no later than 200ms after frequency h) is reached.

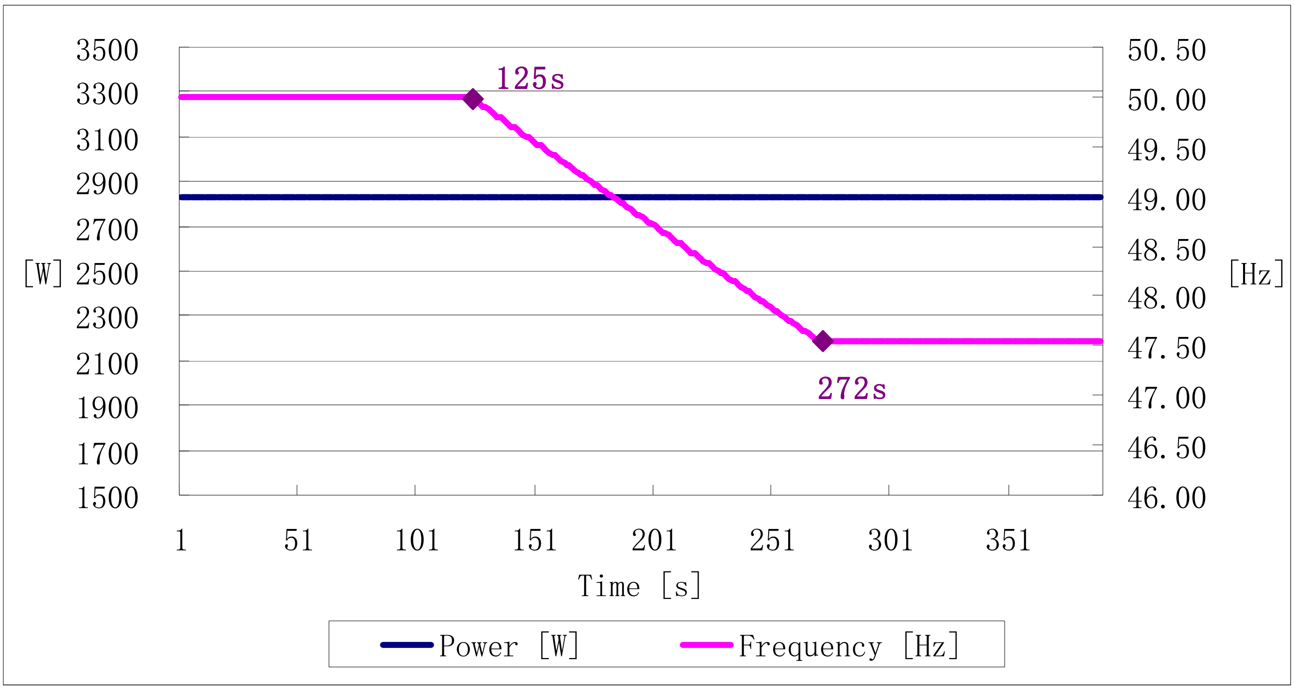
Thereafter, also whilst frequency i) is being held, there may be no resynchronisation or active power feed-in, i.e. not on the characteristic curve as tested before in a) to g).

a) For adjustable PGUs when:
- ab) the maximum active power gradient occurring in point j) is lower than 10% of maximum active power P_{Emax} every minute, and
- ac) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from P_{Emax} by more than ± 10%.

b) For conditionally adjustable PGUs
- ba) when they behave as in a) within their adjustment range, and
- bb) 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.

5.3.5 Active power feed-in for underfrequency			P
Graph of frequency a) to b):			



Test:		
	Switch to:	
1-min mean value	a) 50 ± 0,01 [Hz]	b) - 2,4 to - 2,5 [Hz]
Frequency [Hz]:	50,00	47,55
P_{E60} [kW]:	2,830	2,830
$\Delta P_{a)}/P_{b)}$ [%]:	0	

Test:
Operating point b) must be kept for at least 1 minute.
The test must be carried out at 100% P_{Emax}.

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

Assessment criterion:
The test is passed when the PGU does not disconnect from the network on a network frequency change and continues to feed in 100% P_{Emax} .

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.

5.3.6 Reactive power output

(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.7.5 are met)

The PGU has:
- passed for use for the adjustable cos φ range
- not passed for use for the adjustable cos φ range
- limitations for use in PGSs > 3,68 kVA or ≤ 13,8 kVA

5.3.6.1 Tests of the cos φ setting accuracy — P

SOFAR 1100TL

Setting values	cos φ over-excited:	N/A
	cos φ under-excited:	N/A

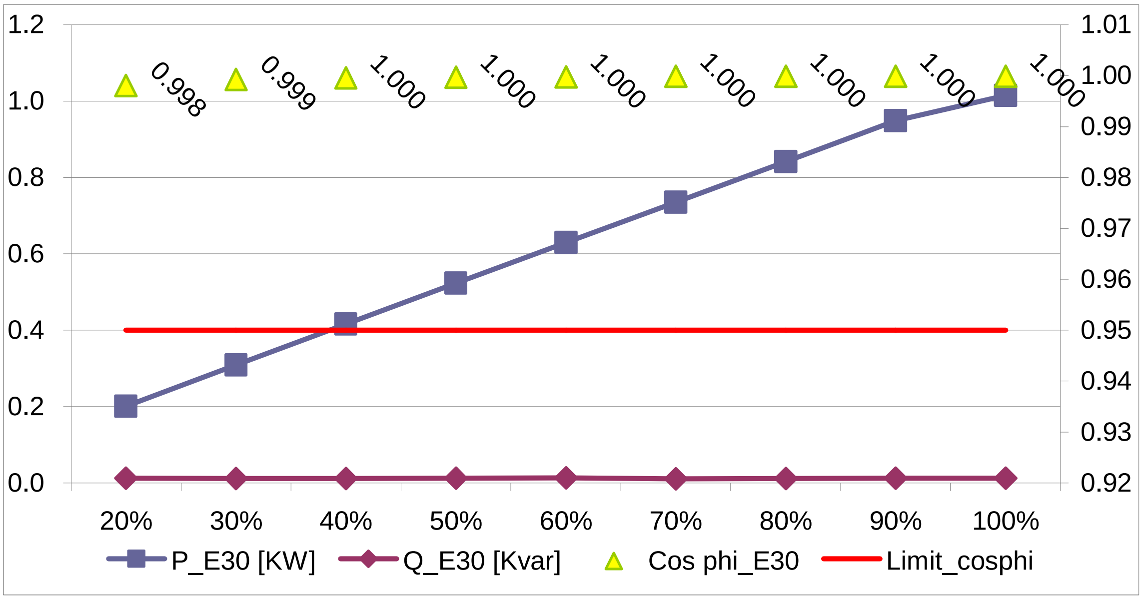
a) PGUs used in PGSs < 3,68 kVA

Test: oder von 20-100% Pemax (ist auch richtig)

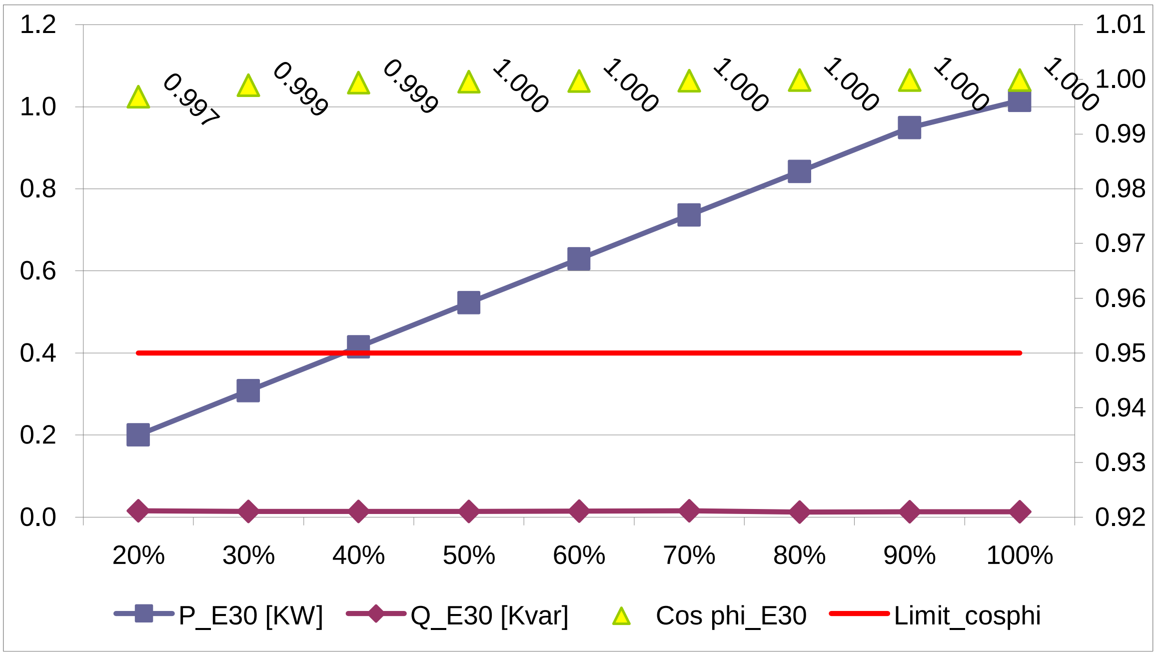
30 s mean value	U_n		$1{,}09\ U_n$	
Active power	S_{Emax}	40 – 60 %P_{Emax}	S_{Emax}	40 – 60 %P_{Emax}
a) no specification of cos φ				
U [V]:	230,30	230,18	250,90	250,79
P_{E30} [kW]:	1,015	0,523	1,015	0,522
Q_{E30} [kVAr]:	0,013	0,013	0,013	0,014
cos $\varphi_{E30\text{-over-excited}}$:	1,000	1,000	1,000	1,000

P_n/P [%]	10	20	30	40	50	60	70	80	90	100
30 s mean value	no specification of cos φ @ U_n									
U [V]:	N/A	230,09	230,12	230,15	230,18	230,20	230,23	230,26	230,28	230,30
P_{E30} [kW]:	N/A	0,201	0,308	0,416	0,523	0,629	0,736	0,842	0,949	1,015
Q_{E30} [kVAr]:	N/A	0,013	0,012	0,012	0,013	0,013	0,011	0,012	0,012	0,013
cos $\varphi_{E30\text{-over-excited}}$:	N/A	0,998	0,999	1,000	1,000	1,000	1,000	1,000	1,000	1,000
	no specification of cos φ @ $U_{1,09}$									
U [V]:	N/A	250,71	250,74	250,76	250,79	250,81	250,84	250,86	250,88	250,90
P_{n30} [kW]:	N/A	0,200	0,308	0,414	0,522	0,629	0,735	0,842	0,949	1,015
Q_{E30} [kVAr].	N/A	0,016	0,014	0,014	0,014	0,015	0,016	0,013	0,013	0,013
cos $\varphi_{E30\text{-over-excited}}$:	N/A	0,997	0,999	0,999	1,000	1,000	1,000	1,000	1,000	1,000
Limit cos φ_{E30}:	cos φ= 0,95 (c) to cos φ= 0,95 (i)									

Graph of no specification of cos φ @ U_n

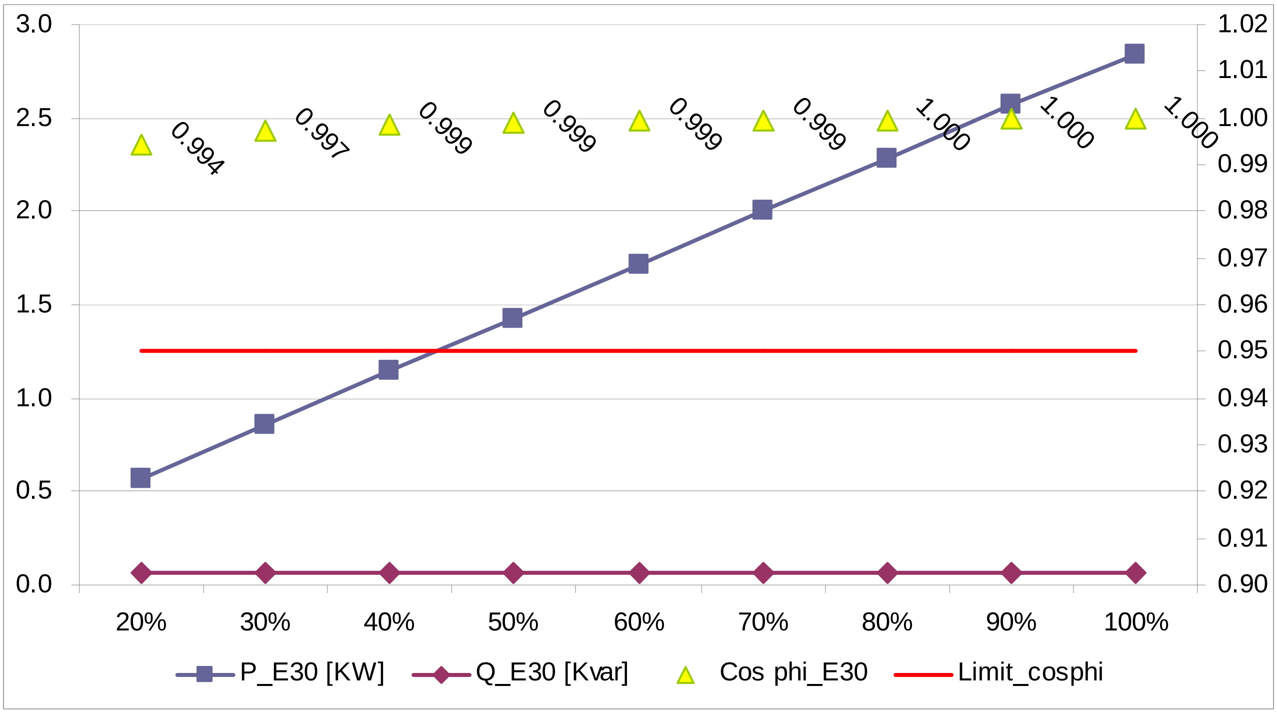


Graph of no specification of cos φ @ $U_{1,09}$

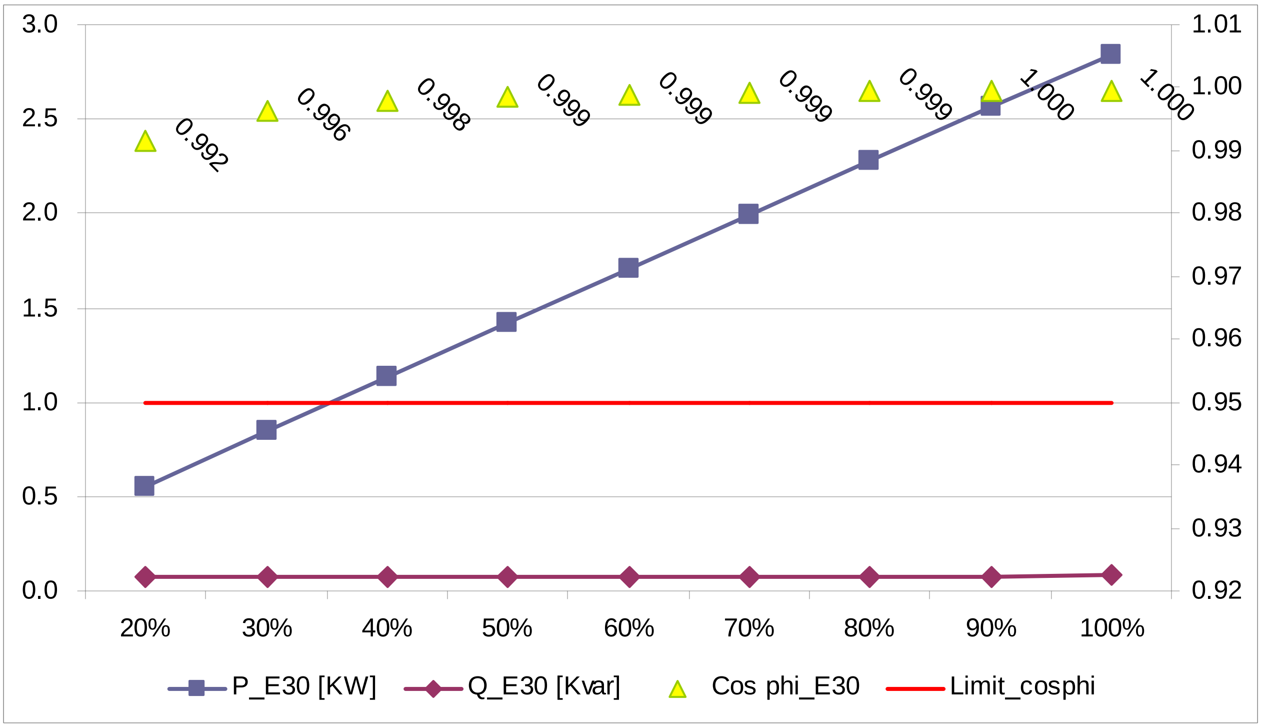


SOFAR 3000TL										
Setting values	cos φ over-excited:				N/A					
	cos φ under-excited:				N/A					
a) PGUs used in PGSs < 3,68 kVA										
Test: oder von 20-100% Pemax (ist auch richtig)										
30 s mean value	U_n					$1,09\ U_n$				
Active power	S_{Emax}		$40 – 60\ \%P_{Emax}$			S_{Emax}		$40 – 60\ \%P_{Emax}$		
a) no specification of cos φ										
U [V]:	230,65		230,38			251,66		251,35		
P_{E30} [kW]:	2,838		1,429			2,846		1,423		
Q_{E30} [kVAr]:	0,069		0,063			0,081		0,075		
$\cos \varphi_{E30\text{-over-excited}}$:	1,000		0,999			1,000		0,999		
P_n/P [%]	10	20	30	40	50	60	70	80	90	100
30 s mean value	no specification of cos φ @ U_n									
U [V]:	N/A	230,19	230,26	230,31	230,38	230,46	230,51	230,59	230,58	230,65
P_{E30} [kW]:	N/A	0,565	0,854	1,142	1,429	1,716	2,001	2,285	2,566	2,838
Q_{E30} [kVAr]:	N/A	0,061	0,062	0,062	0,063	0,064	0,065	0,065	0,067	0,069
$\cos \varphi_{E30\text{-over-excited}}$:	N/A	0,994	0,997	0,999	0,999	0,999	1,000	1,000	1,000	1,000
	no specification of cos φ @ $U_{1,09}$									
U [V]:	N/A	251,16	251,22	251,29	251,35	251,41	251,48	251,54	251,60	251,66
P_{n30} [kW]:	N/A	0,555	0,845	1,135	1,423	1,710	1,994	2,278	2,563	2,846
Q_{E30} [kVAr].	N/A	0,073	0,073	0,074	0,075	0,076	0,077	0,078	0,079	0,081
$\cos \varphi_{E30\text{-over-excited}}$:	N/A	0,992	0,996	0,998	0,999	0,999	0,999	0,999	1,000	1,000
Limit cos φ_{E30}:	cos φ= 0,95 (c) to cos φ= 0,95 (i)									

Graph of no specification of cos φ @ U_n



Graph of no specification of cos φ @ $U_{1,09}$



Test:

a) With no specification of cos φ, the active power must be adjust between 40 % P_{Emax} and 60 % P_{Emax} and to S_{Emax}

b) & c) For cos φ 0,95 over-excited and φ 0,95 under-excited, the active power must be adjust between 40 % P_{Emax} and 60 % P_{Emax} and to S_{Emax}

d) & e) For cos φ 0,90 over-excited and φ 0,90 under-excited, the active power must be adjust between 40 % P_{Emax} and 60 % P_{Emax} and to S_{Emax}

For measurements a) to c), there may be no power limitation by the primary energy source.

Assessment criterion:

a) Applicable for PGUs ≤ 3,68 kVA that cannot be used in PGSs > 3,68 kVA:

The test is passed when all operating points of a) of the PGU lie in range cos φ= 0,95 over-excited to cos φ= 0,95 under-excited.

b) and c) For PSUs > 3,68 kVA and ≤ 13,8 kVA that cannot be used in PGSs > 13,8 kVA, and for PGUs ≤ 3,68 kVA that can be used in PGSs ≤ 13,8 kVA, the following applies:

The test is passed when all measurement points of b) lie within range cos φ= 0,94 to 0,96 over-excited and of c) in range cos φ= 0,94 to 0,96.

d) and e) For PGUs > 13,8 kVA and for PGUs ≤ 13,8kVA also in PGSs > 13,8 kVA

The test is passed when all measurement points of d) lie within range cos φ= 0,89 to 0,91 over-excited and of e) in range cos φ= 0,89 to 0,91.

Note:

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.

5.4 Testing of NS protection **5.5 Testing of connecting conditions and synchronisation** **DIN VDE V 0124-100:2012-07**			
Clause	**Test**		**Result**
5.4.1	General These tests are designed to provide evidence that the requirements of VDE-AR-N 4105 are met		**P**
5.4.2	Central NS protection		**N/A**
5.4.3	Integrated NS protection		**P**
5.4.4	Interface switch		
	5.4.4.1 General		**P**
	5.4.4.2 Integrated interface switch		**P**
5.4.5	Protection devices for the interface switch		
	5.4.5.1	General	**P**
	5.4.5.2	Functional safety	**P**
	5.4.5.3	Voltage control	**P**
	5.4.5.3.3	Measurement of the rise-in voltage protection as a running 10-min mean value	**P**
	5.4.5.4	Frequency measurement	**P**
	5.4.5.5	Reporting NS protection	**P**
5.4.6	Islanding detection		**P**
5.5	Connecting conditions and synchronisation		**P**
	5.5.2	Short interruption	**P**

5.4.2 **Central NS protection** (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.2 are met)	**N/A**
NS protection provides the possibility for sealing or Password protection is given for protection functions. The interface switch is triggered when the switch in the "NS protection interface switch" circuit is actuated (only relevant for external NS protection). Actuation of the interface switch is displayed on the power generation unit. Display is provided by warning light or display text .	

5.4.3 **Integrated NS protection** (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.3 are met)	**P**
Password protection is given for protection function U >.	

5.4.4 Interface switch	
5.4.4.1 General (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.4.1 are met)	**P**
The interface switch consists of two electrical break devices connected in series and is therefore designed with redundancy. See 5.4.5.2 Functional safety for the test for single-fault tolerance and fault finding with subsequent disconnection for the entire functional chain. An all-pole galvanic break device is provided.	
Note: For synchronous machines, the break device for synchronisation is designed three pole instead of four pole.	

5.4.4.2 Integrated interface switch (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.4.3 are met)	**P**

The galvanically separated inverter has a galvanic separating break device

The inverter that is not galvanically separated has two independent galvanically separating breaking devices

See 5.4.5.2 Functional safety for the test for single-fault tolerance of the interface switch

The interface switch is short-circuit proof for the maximum short-circuit current of the power generation unit.

max. short-circuit current of the power generation unit= 13 A, 230 Vac
max. switching current relay= (1) 31 A, 277 Vac;
(2) 31 A, 250 Vac.

Datasheet of the relay:

(1)

CONTACT DATA

Contact arrangement	1A
Contact resistance	100mΩ max.(at 1A 6VDC)
Contact material	$AgSnO_2$
Contact rating	Resistive: 26A 250VAC Inductive: 31A 250VAC (cosφ=0.8) 0.1s:10s
Max. switching voltage	277VAC
Max. switching current	31A
Max. switching power	7750VA
Mechanical endurance	1×10^6OPS
Electrical endurance	3×10^4OPS (See approval reports for more details)

CHARACTERISTICS

Insulation resistance		1000MΩ (at 500VDC)
Dielectric strength	Between coil & contacts	4500VAC 1min
	Between open contacts	2500VAC 1min
Surge voltage (between coil & contacts)		10kV (1.2/50μs)
Operate time (at nomi. volt.)		20ms max.
Release time (at nomi. volt.)		10ms max.
Temperature rise (at nomi. volt.)		95K max. (Contact load current 31A, rated voltage excitation, at 60°C)
		70K max. (Contact load current 31A, 80% of rated voltage excitation, at 85°C)
Shock resistance	Functional	196m/s²
	Destructive	980m/s²
Vibration resistance		10Hz to 55Hz 1.5mm DA
Ambient temperature		-40°C to 60°C (Apply rated voltage to coil) -40°C to 85°C (Apply holding voltage to coil, which is 45% to 80% that of rated voltage)
Humidity		5% to 85% RH
Termination		PCB
Unit weight		Approx. 21g
Construction		Flux proofed

Notes: The data shown above are initial values.

COIL

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

Notes: 1) The coil holding voltage is the voltage of coil after being applied rated voltage for 100ms.
2) By lower coil holding voltage, the purpose of saving power consumption could be achieved. The magnetic system is designed for this reduced holding power. When the holding voltage was lowered to 35% that of rated voltage, the power consumption could be decreased to approx.170mW. Continuous operation without power reduction is not permitted for ambient temperatures of > 23°C!

COIL DATA at 23°C

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

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

SAFETY APPROVAL RATINGS

UL/CUL	$AgSnO_2$	26A 277VAC at 75°C 22A 277VAC at 85°C
VDE	$AgSnO_2$	26A 277VAC at 75°C 22A 277VAC at 85°C 31A 250VAC COSØ =0.8 0.1s:10s

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

(2)

LF-G (ALFG)

RATING

■ Coil data

Nominal coil voltage	Pick-up voltage (at 20°C 68°F) (Initial)	Drop-out voltage (at 20°C 68°F) (Initial)	Nominal operating current [±10%] (at 20°C 68°F)	Coil resistance [±10%] (at 20°C 68°F)	Nominal operating power	Max. applied voltage (at 20°C 68°F)
9V DC	70%V or less of nominal voltage	10%V or more of nominal voltage	155mA	58Ω	1,400mW	120%V of nominal voltage
12V DC			117mA	103Ω		
18V DC			78mA	230Ω		
24V DC			59mA	410Ω		

■ Specifications

Characteristics	Item		Specifications		
			Standard type	High capacity type	
			Contact Gap 1.5 mm .059 inch type Contact Gap 1.8 mm .071 inch type	Contact Gap 1.5 mm .059 inch type	Contact Gap 1.8 mm .071 inch type
Contact	Arrangement		1 Form A		
	Contact resistance (Initial)		Max. 100 mΩ (By voltage drop 6 V DC 1A)		
	Contact material		$AgSnO_2$ type		
Rating	Nominal switching capacity		22A 250V AC	31A 250V AC	33A 250V AC
	Max. switching power		5,500VA	7,750VA	8,250VA
	Max. switching voltage		250V AC		
	Max. switching current		22A (AC)	31A (AC)	33A (AC)
	Nominal operating power		1,400mW		
	Min. switching capacity (Reference value)*1		100mA 5V DC		
Electrical characteristics	Insulation resistance (Initial)		Min. 1,000MΩ (at 500V DC) Measurement at same location as "Breakdown voltage" section.		
	Breakdown voltage (Initial)	Between open contacts	2,500 Vrms for 1 min. (Detection current: 10 mA)		
		Between contact and coil	4,000 Vrms for 1 min. (Detection current: 10 mA)		
	Surge breakdown voltage*2 (Between contact and coil) (Initial)		6,000 V		
	Temperature rise*3 (coil)		Max. 95°C 203°F (By resistive method, nominal coil voltage applied to the coil; contact carrying current: 22A, at 60°C 140°F) Max. 70°C 158°F (By resistive method, 80%V of nominal coil voltage applied to the coil; contact carrying current: 22A, at 85°C 185°F)	Max. 95°C 203°F (By resistive method, nominal coil voltage applied to the coil; contact carrying current: 31A, at 60°C 140°F) Max. 70°C 158°F (By resistive method, 80%V of nominal coil voltage applied to the coil; contact carrying current: 31A, at 85°C 185°F)	Max. 95°C 203°F (By resistive method, nominal coil voltage applied to the coil; contact carrying current: 33A, at 60°C 140°F) Max. 70°C 158°F (By resistive method, 80%V of nominal coil voltage applied to the coil; contact carrying current: 33A, at 85°C 185°F)
	Coil holding voltage*4		35 to 120%V (contact carrying current: 22A, at 20°C 68°F) 45 to 80%V (contact carrying current: 22A, at 85°C 185°F)	35 to 120%V (contact carrying current: 31A, at 20°C 68°F) 45 to 80%V (contact carrying current: 31A, at 85°C 185°F)	35 to 120%V (contact carrying current: 33A, at 20°C 68°F) 45 to 80%V (contact carrying current: 33A, at 85°C 185°F)
	Operate time (at 20°C 68°F)		Max. 20 ms (at nominal coil voltage excluding contact bounce time.)		
	Release time (at 20°C 68°F)		Max. 10 ms (at nominal coil voltage excluding contact bounce time, without diode)		
Mechanical characteristics	Shock resistance	Functional	Min. 100 m/s² (Half-wave pulse of sine wave: 11 ms; detection time: 10µs.)		
		Destructive	Min. 1,000 m/s² (Half-wave pulse of sine wave: 6 ms.)		
	Vibration resistance	Functional	10 to 55 Hz at double amplitude of 1.5 mm (Detection time: 10µs.)		
		Destructive	10 to 55 Hz at double amplitude of 1.5 mm		
Expected life	Mechanical		Contact Gap 1.5 mm .059 inch type: Min. 10^6 (at 180 times/min.) Contact Gap 1.8 mm .071 inch type: Min. 5×10^5 (at 180 times/min.)		
	Electrical	Resistive load	22A 250V AC, Min. 3×10^4 (at 20 times/min.)	—	—
		Inductive load	Destructive: 22A 250V AC (cosφ = 0.8), Min. 3×10^4 (on:off = 0.1s:10s) Over load: 35A 250V AC (cosφ = 0.8), Min. 50 (on:off = 0.1s:10s)	Destructive: 31A 250V AC (cosφ = 0.8), Min. 3×10^4 (on:off = 0.1s:10s) Over load: 47A 250V AC (cosφ = 0.8), Min. 50 (on:off = 0.1s:10s)	Destructive: 33A 250V AC (cosφ = 0.8), Min. 3×10^4 (on:off = 0.1s:10s) Over load: 50A 250V AC (cosφ = 0.8), Min. 50 (on:off = 0.1s:10s)
Conditions	Conditions for operation, transport and storage*5		Ambient temperature: –40°C to +60°C –40°F to +140°F (When nominal coil voltage applied) –40°C to +85°C –40°F to +185°F (Coil holding voltage is when 45 to 80%V of nominal coil voltage is applied.) Humidity: 5 to 85% R.H. (Not freezing and condensing at low temperature) Air pressure: 86 to 106 kPa		
Unit weight			Approx. 23 g .81 oz		

Note:

(1) Relay manufacture: HONGFA, type number: HF161F-W, Max. release time: 10ms

(2) Relay manufacturer: Panasonic, type number: ALFG2P, Max. release time: 10ms.

5.4.5 Protection devices for the interface switch	
5.4.5.1 General (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.5.1 are met)	**P**
Test condition:	The measurements were performed in the testing laboratory. at the grid-simulator: U_N = between 86 % Un and 109% Un until the test Frequency: 50 Hz +/- 0,5%
Note: If an examination is required for any other requirements, these apply to this test.	

5.4.5.2 Functional safety								**P**
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 6,62 A	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 6,62 A	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 6,62 A	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 6,67 A	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 6,62 A	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 6,62 A	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 6,63 A	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 6,65 A	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID66. (Bus voltage over range)
Bus voltage detect RC82	Short	230V 12,56 A	450V 6,69 A	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 0,17 A	450V 0,18 A	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 6,63 A	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 6,69 A	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 6,67 A	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 6,66 A	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 6,66 A	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 6,67 A	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID12. (GFCI fault).
PV voltage detect RP115	Open	230V 12,62 A	450V 6,67 A	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 12,63 A	450V 6,63 A	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 0,16 A	450V 0,02 A	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 0,16 A	450V 0,02 A	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 0,16 A	450V 0,02 A	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 0,16 A	450V 0,02 A	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 0,16 A	450V 0,02 A	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 0,62 A	450V 6,67 A	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 12,64 A	450V 6,66 A	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 12,64 A	450V 6,67 A	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 12,61 A	450V 6,66 A	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 12,61 A	450V 6,67 A	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 12,63 A	450V 6,65 A	2 Min.	--	230V 0,16A	450V 0,02A	PV inverter disconnected from grid immediately, error message: DSP communicate fail
Communication microcontroller defect UC34 Pin 31	Open	230V 12,64 A	450V 6,66 A	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 12,64 A	450V 6,66 A	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 12,63 A	450V 6,66 A	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 12,64 A	450V 6,67 A	2 Min.	--	230V 0,17A	450V 0,02A	PV inverter disconnected from grid immediately, error message: ID 53 (SPI Communication fault)

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

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.

5.4.5.3 Voltage control	P

Integrated NS protection single phase ≤30kVA		
Setting values of the NS protection:	Setting U< [V]:	184,0 V
	Setting U>>[V]:	264,5 V
	Setting $T_{disconnection}$ [ms]:	140 ms

Operating time of the monitoring device:

	Under voltage:			Over voltage:		
L1 to N:						
Step [V to V]:	230,0 V to 177,1 V			230,0 V to 271,4 V		
Limit [V]:	184,0 V			264,5 V		
Measurement [V:]	184,0 V	184,0 V	184,0 V	264,2 V	264,1 V	264,1 V
Limit [ms]:	200 ms			200 ms		
Disconnection time [ms]:	167 ms	168 ms	163 ms	152 ms	181 ms	186 ms

Test:

To measure the disconnection time a step of 77%$_n$ is taken from the nominal voltage and of 118%$_n$ from the nominal voltage for undervoltage and undervoltage.

The voltages should be measured per phase conductor, in which current is fed between the line conductor and the neutral conductor.

Assessment criterion:

The permitted tolerance between setting value and trip value of the voltage may not exceed ± 1% of U_n.

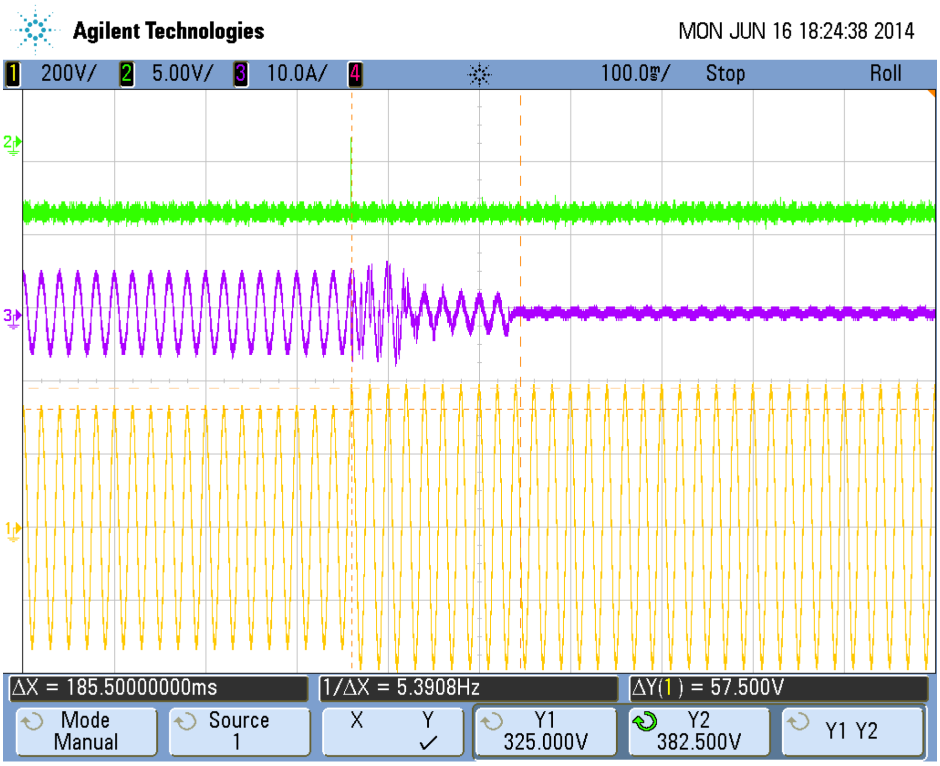
Limit values:

Voltage drop protection U <		0.8 U_n	200 ms
Rise-in voltage protection	U>>	1.15 U_n	200 ms

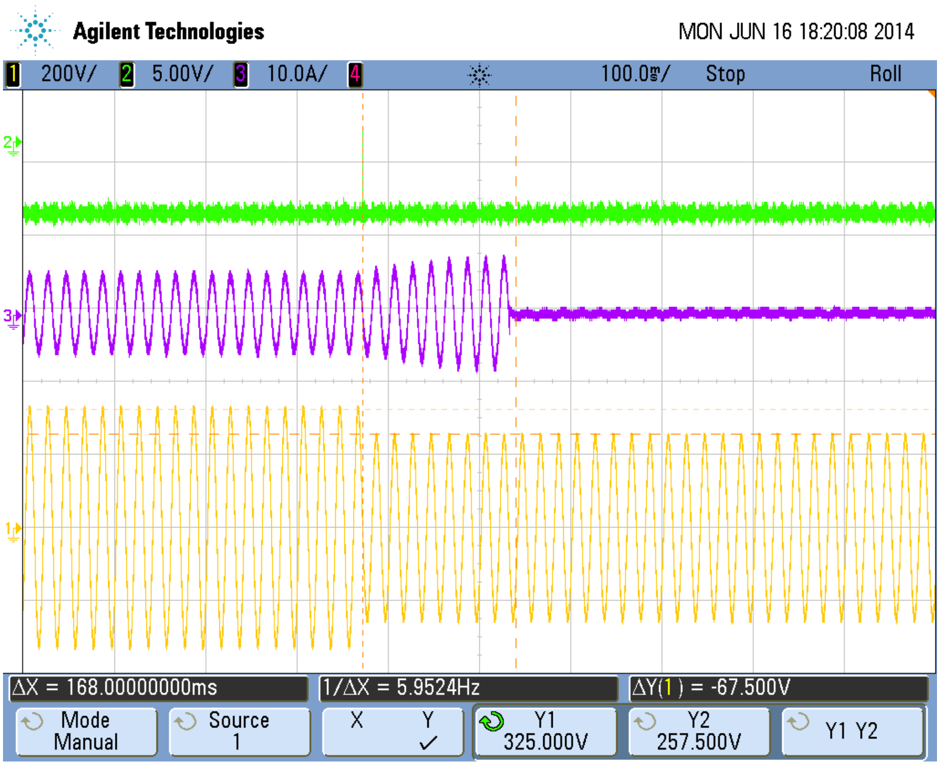
Note:

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.

Under voltage:



Over voltage:



5.4.5.3.3 Measuring the rise-in voltage protection as a running 10-minute mean value			**P**
Test:			
		Disconnection time:	Limit:
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:	500 s	600 s
	Phase 2:	N/A	
	Phase 3:	N/A	
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 disconnected	Disconnection should not take place.
	Phase 2:	N/A	
	Phase 3:	N/A	
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:	283 s	300 s
	Phase 2:	N/A	
	Phase 3:	N/A	

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 10 minute running mean value.

Assessment criterion:

The permitted tolerance between setting value and trip value of the voltage may not exceed ± 1 % of Un.

Limit values:

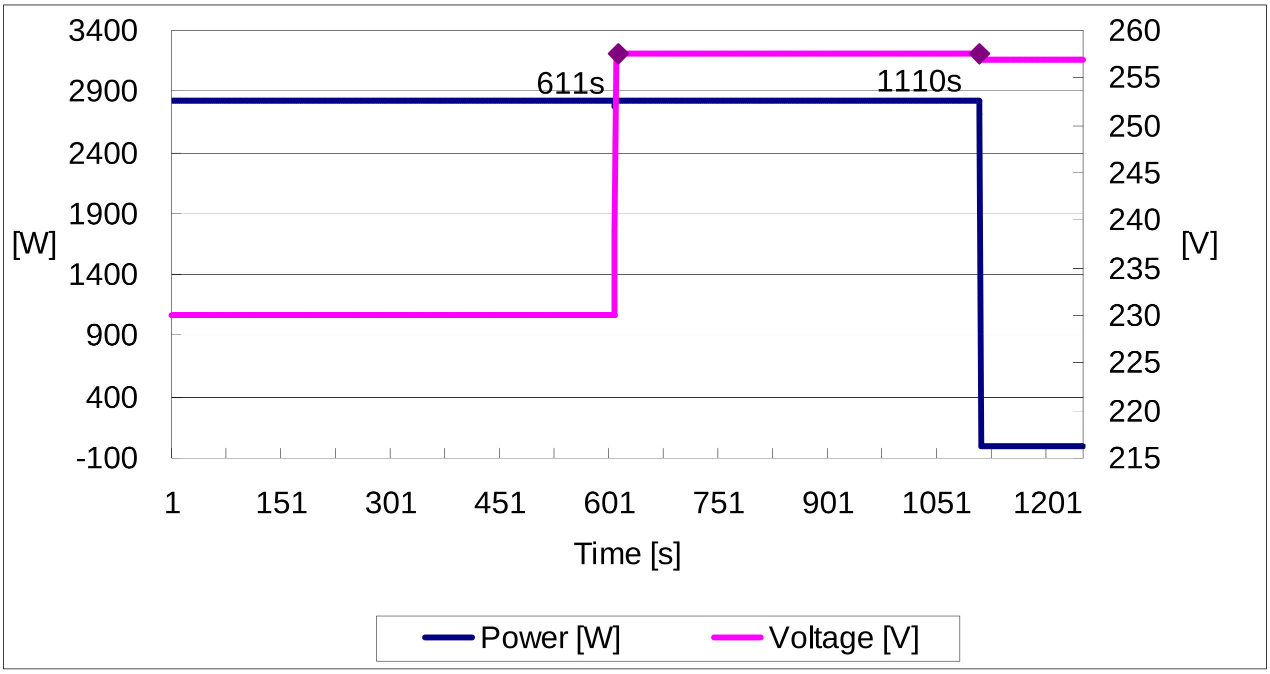
Rise-in voltage protection U> 1,1 U_n after a max. 600 s, the switch off after 200 ms.

Note:

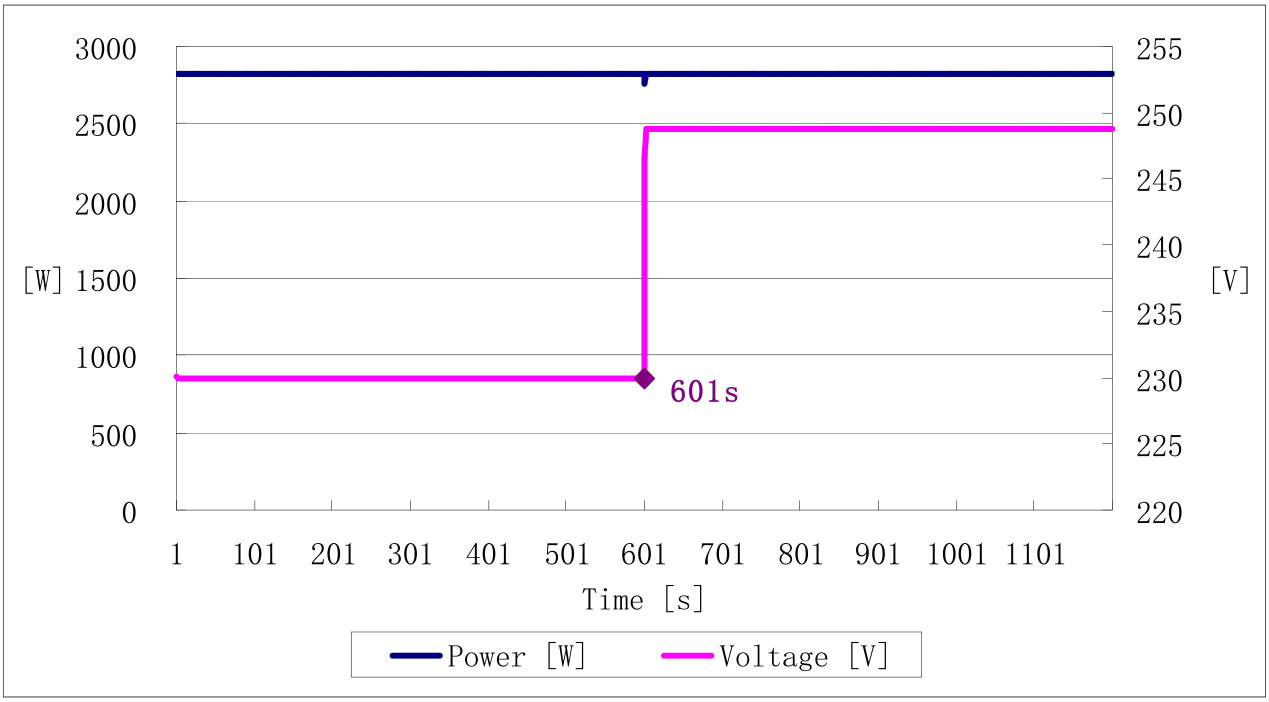
If only one integrated NS protection is used for the power generation systems ≤30kVA, the value of the rise-in voltage protection U> of 1,1 U_n may not be changed.

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.

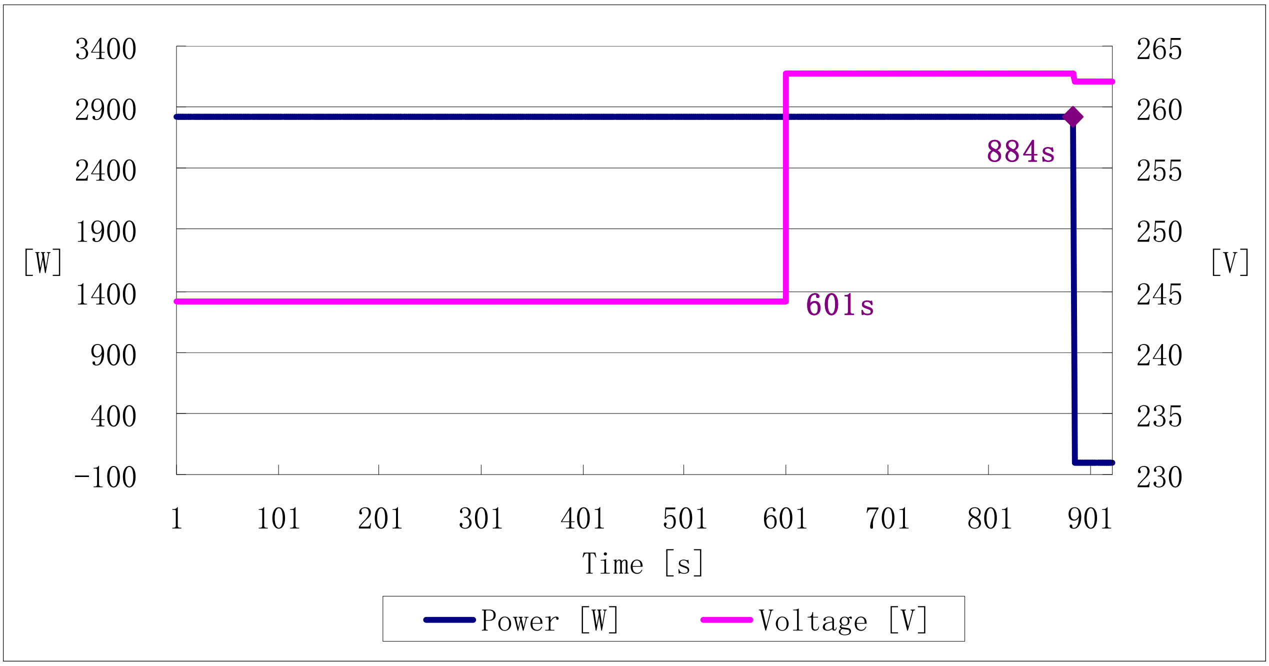
a) Voltage set to 112 % U_n:



b) Voltage set to 108% U_n:



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



5.4.5.4 Frequency measurement						**P**
Setting values of the NS protection:	Setting f< [Hz]:		47,5 Hz			
	Setting f>[Hz]:		51,5 Hz			
	Setting $T_{disconnection}$ [ms]		140 ms			
Operating time of the monitoring device						
	Under frequency			**Over frequency**		
Ramp [Hz to Hz]:	48,00 Hz -> 47,00 Hz			51,00 Hz -> 52,00 Hz		
Limit [Hz]:	47,50 Hz			51,50 Hz		
Measurement [Hz]:	47,50 Hz	47,50 Hz	47,50 Hz	51,52 Hz	51,52 Hz	51,52 Hz
Limit [ms]:	200 ms			200 ms		
Disconnection time [ms]:	166 ms	158 ms	164 ms	174 ms	163 ms	176 ms

Test:

The measuring is performed at a continuous change of frequency of 1 Hz/s. The trip value was determined manually by reducing the frequency in 10 mHz steps. When the trip value is known (e.g. 47,50 Hz), the grid simulator is programmed to run from e.g. 48,00 Hz to 47,00 Hz with 1 Hz/s. The disconnection time is calculated by the measured time minus the 500 ms from 48,00 Hz to 47,50 Hz.

Assessment criterion:

The setting value and the trip value of the frequency may not vary by more than ±0.1 % f_n .

For frequencies of between 47,5 Hz and 51,5 Hz (±0,1% f_n) automatic disconnection from the network as a result of a deviation in frequency is not permitted.

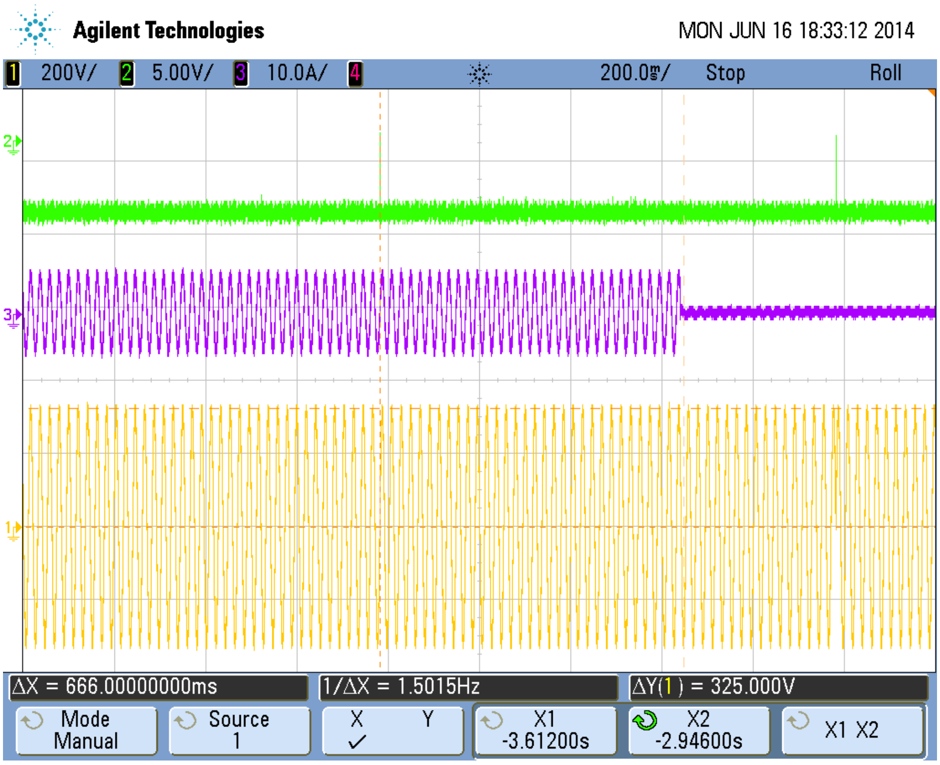
Limit values:

Frequency decrease protection	f<	47,5 Hz	200 ms
Frequency increase protection	f<	51,5 Hz	200 ms

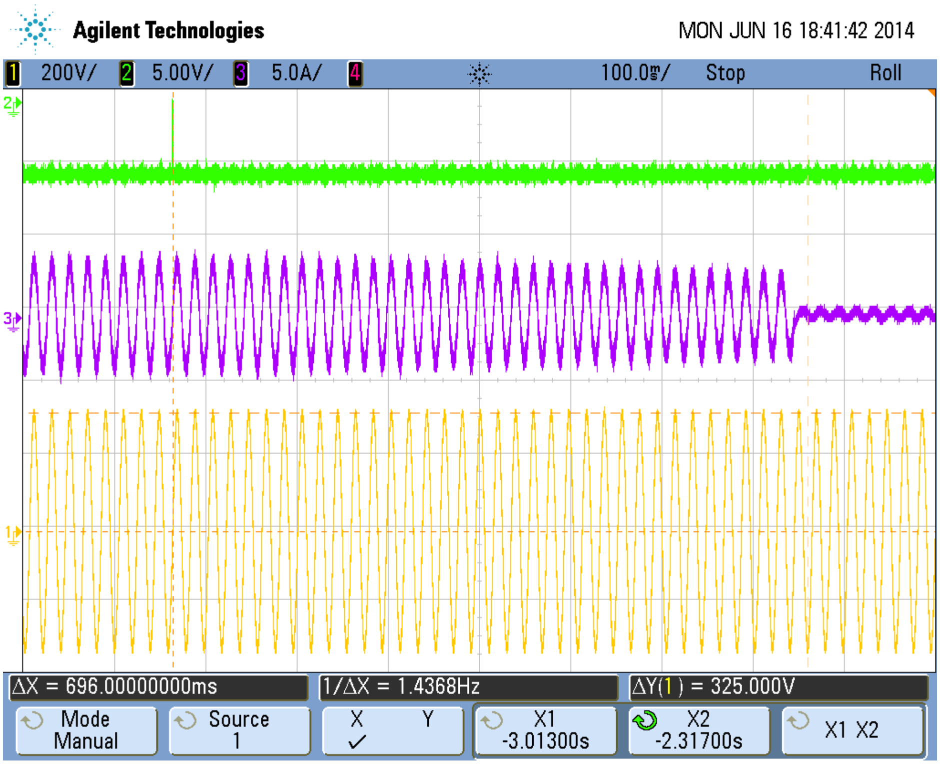
Note:

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.

Under frequency:



Over frequency:



5.4.5.5 Reporting NS protection	P
The last 5 dated failure reports on the NS protection can be read. An interruption in the supply voltage of ≤ 3s does not result in any loss of failure reports. Central NS protection: It is possible to read the setting values and the failure reports of the NS protection independently of the operational state and without any additional aids. Integrated NS protection: It is possible to read out the values of the NS protection via the data interface, if the values are not directly readable.	
Note:	

5.4.6 Islanding detection
(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.5.3 are met)

For power generation systems, islanding detection must be carried out using one of the following processes:

a) active method, e.g. by means of frequency – shift process (oscillating circuit)

b) passive method with the help of the three-phase voltage control (only possible for power generation systems without converters or for single-phase generation units with converters).

(see 5.4.5.3 3-phase voltage control)

With the passive process, it is important to provide evidence that the power generation unit can be set not equal to 120°.

5.4.6.1 Active method (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, D.1 are met)			**P**
Test condition:	Frequency: 50+/-0,01 Hz U_N = 230+/-1% V_{ac} RLC consumes inverter real power within +/-3% Distortion factor of chokes <3% Quality Q>2		
Disconnection limit:	5 s		
Output power: / Osc. parameter	25%	50%	100%
- 5%	0,158	0,204	0,180
- 4%	0,146	0,128	0,071
- 3%	0,202	0,108	0,104
- 2%	0,235	0,384	0,391
- 1%	0,420	0,394	0,452
0%	0,489	0,378	0,468
+1%	0,422	0,431	0,485
+2%	0,130	0,115	0,109
+3%	0,190	0,202	0,111
+4%	0,167	0,203	0,140
+5%	0,170	0,048	0,100
Parameter at 0%	L=120,02 mH R=76,12 Ω C=84,66 uF	L=59,48 mH R=37,84 Ω C=169,75 uF	L=29,87 mH R=18,93 Ω C=338,59 uF

Test:

The capacitors and the chokes of the resonant circuit were adjusted in order to reach a quality of >2. $P_{QC}+P_{QL}=-P_{Q,WR}$. The resistors of the resonant circuit consumed the real power of the inverter (P_{WR}) within +/-3%.

$$L = \frac{U^2}{2 \cdot \pi \cdot 50Hz \cdot P \cdot Q} \qquad C = \frac{P \cdot Q}{2 \cdot \pi \cdot 50Hz \cdot U^2}$$

Assessment criterion:

Limit values:

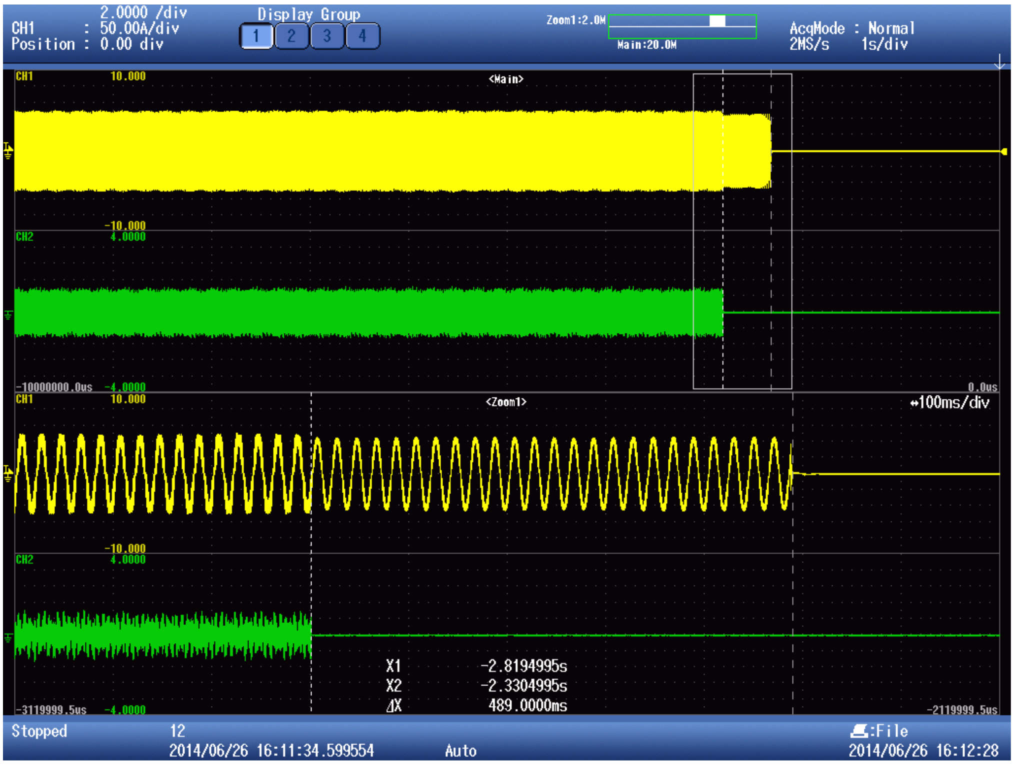
Quality factor Q > 2

Disconnection t ≤ 5 s

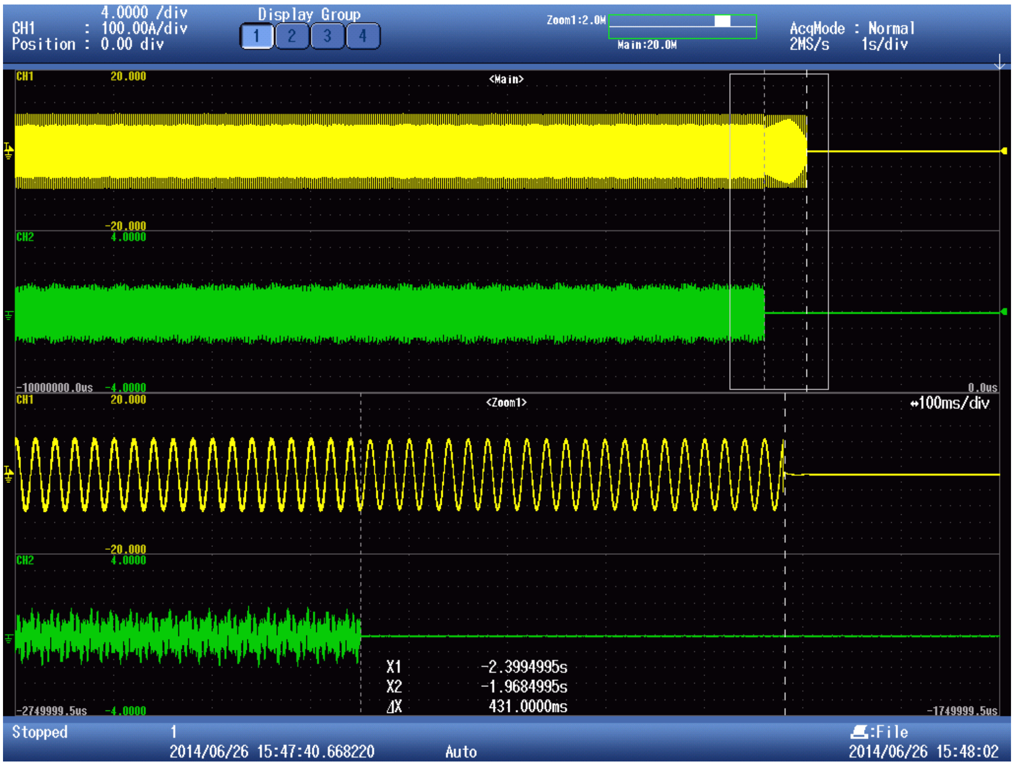
Note:

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.

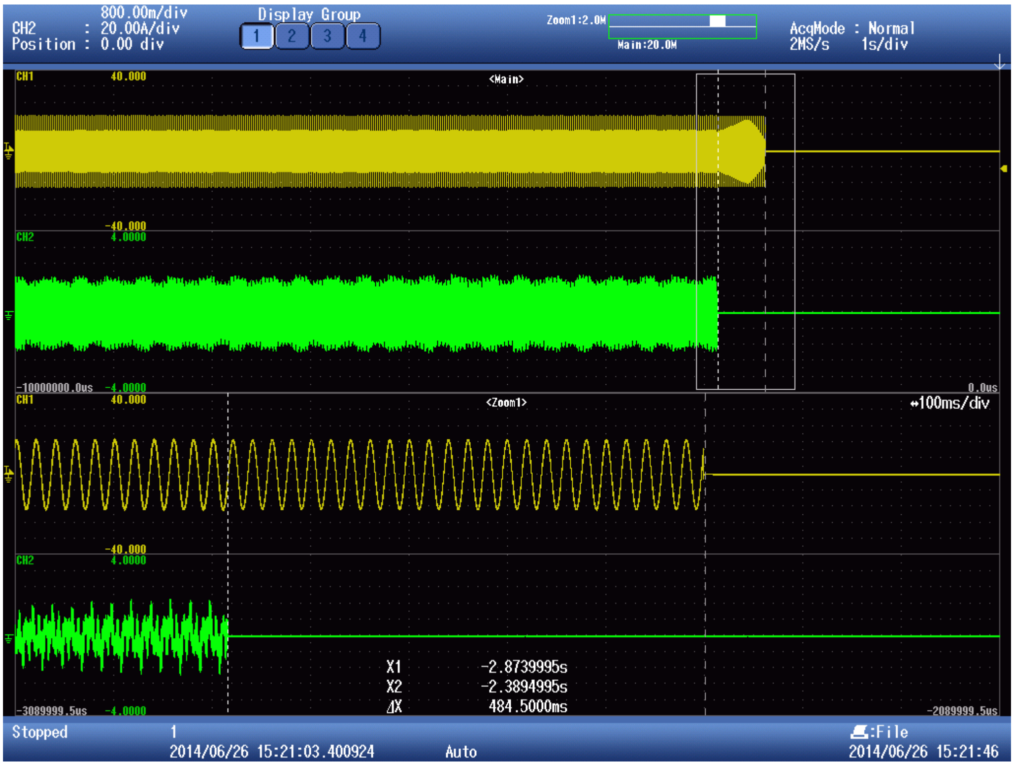
Oscillating circuit test: 25% output power



Oscillating circuit test: 50% output power



Oscillating circuit test: 100% output power



5.4.6.1 Passive method	N/A
Three-phase voltage control is permitted for islanding detection, as the currents of the power generation unit are controlled independently, so that arbitrary phase relationships can develop.	
Test: The test is performed according to the voltage disconnection testing clause 5.4.5.3.1 a). The test is passed, if the current follows without phase displacement of the voltage on the displaced phase. For test results, see clause 5.4.5.3.1 a) above.	
Note:	

5.5 Testing of connecting conditions and synchronisation DIN VDE V 0124-100:2012-07		
Clause	**Test**	**Result**
5.5	Connecting conditions and synchronisation	**P**
	5.5.2 Short interruption	**P**

5.5	Connecting conditions and synchronisation (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 8.3.1 are met)		P
Setting values of the NS protection:	Setting $T_{reconnection\ 60s}$ [s]:	60 s	
	Setting f< [Hz]:	47,5 Hz	
	Setting f> [Hz]:	51,5 Hz	
	Setting V< [V]:	184,0 V	
	Setting V>> [V]:	264,5 V	

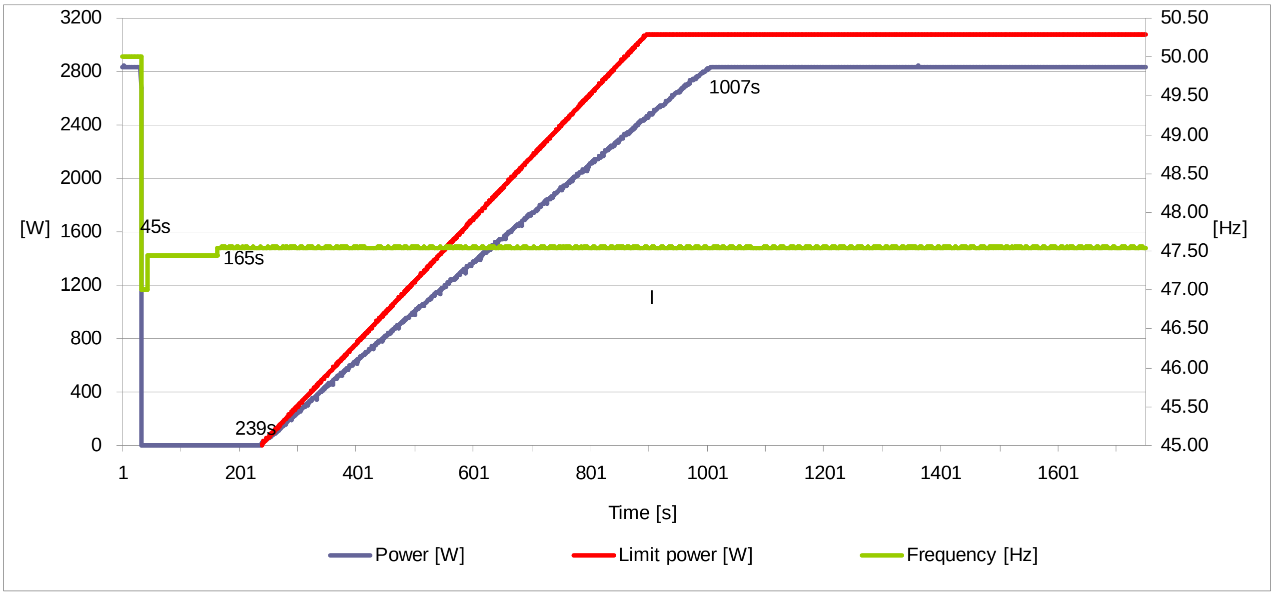
Test:			
	f_{ist}	**Reset time:**	**Limit:**
Connecting conditions for frequencies:			
a)	47,45 Hz	No reconnection	No resetting allowed
	Switch to:		
b)	≥ 47,55 Hz	74 s	≥ 60 s
c)	50,06 Hz	No reconnection	No resetting allowed
	Switch to:		
d)	≥ 50,0 Hz	74 s	≥ 60 s
Connecting conditions for voltages:			
e)	84%	No reconnection	No resetting allowed
	Switch to:		
f)	≥ 86%	74 s	≥ 60 s
g)	111 %	No reconnection	No resetting allowed
	Switch to:		
h)	≤ 109%	74 s	≥ 60 s

Test:
see points a) to h) for the test process.
The measurement was carried out with a programmable AC source.
e.g. connecting conditions for frequencies: Point a) and b). The AC source was programmed in such a way that the first step of 230 V / 50 Hz to 200 V / 47,0 Hz resulted in a faulty disconnection. Thereafter the voltage and frequency for 100 s is set to 215 V / 47,45 Hz. Switching on again is not permitted. After a lapse of 100 s the voltage is set to 230 V / 47,55 Hz. Setting again after 60 s is permitted.

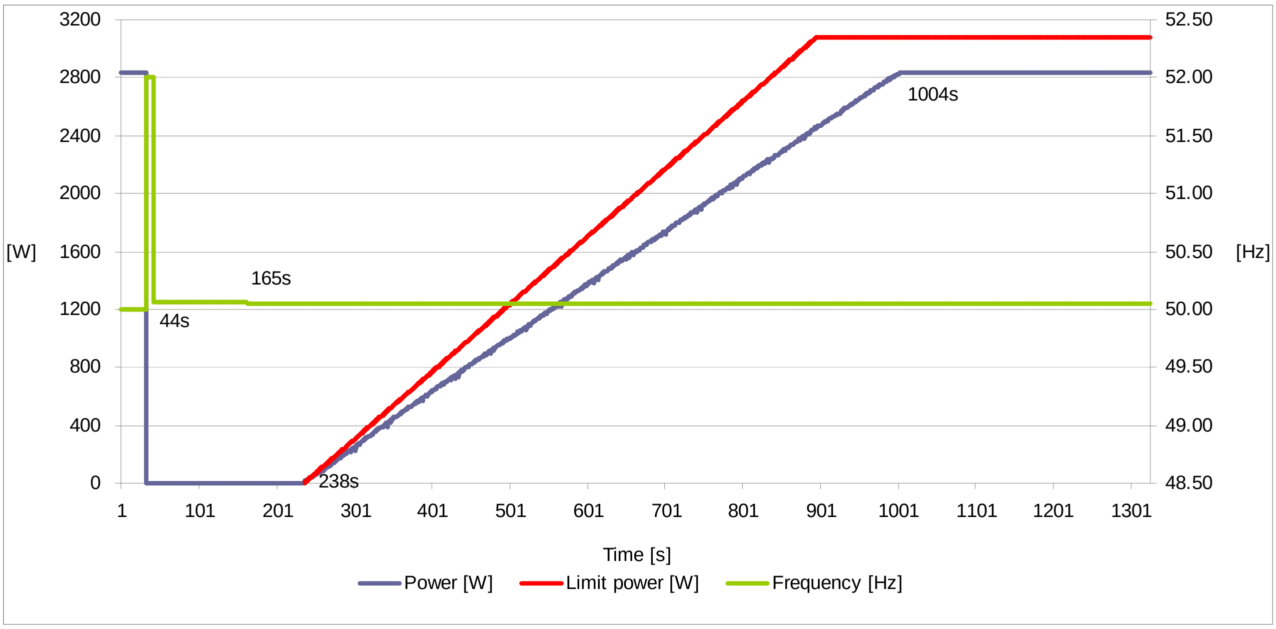
Assessment criterion:
After actuating the NS protection it should be checked that the system can only be switched within the tolerance ranges ((80% $U_n \leq U \leq$ 110% U_n) and (47,5 Hz ≤ f ≤ 50,05Hz)) at the earliest after 60 s after voltage and frequency has remained within the tolerance ranges.

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.

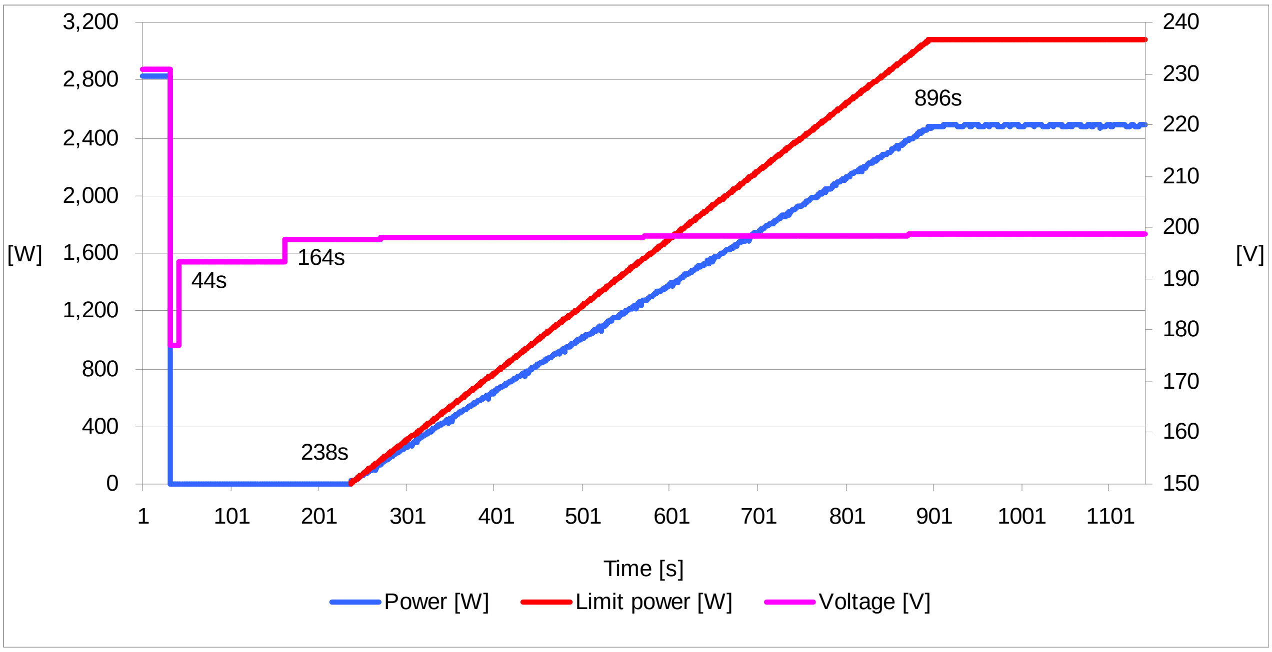
a) 47,50 Hz to b) ≥ 47,55 Hz:



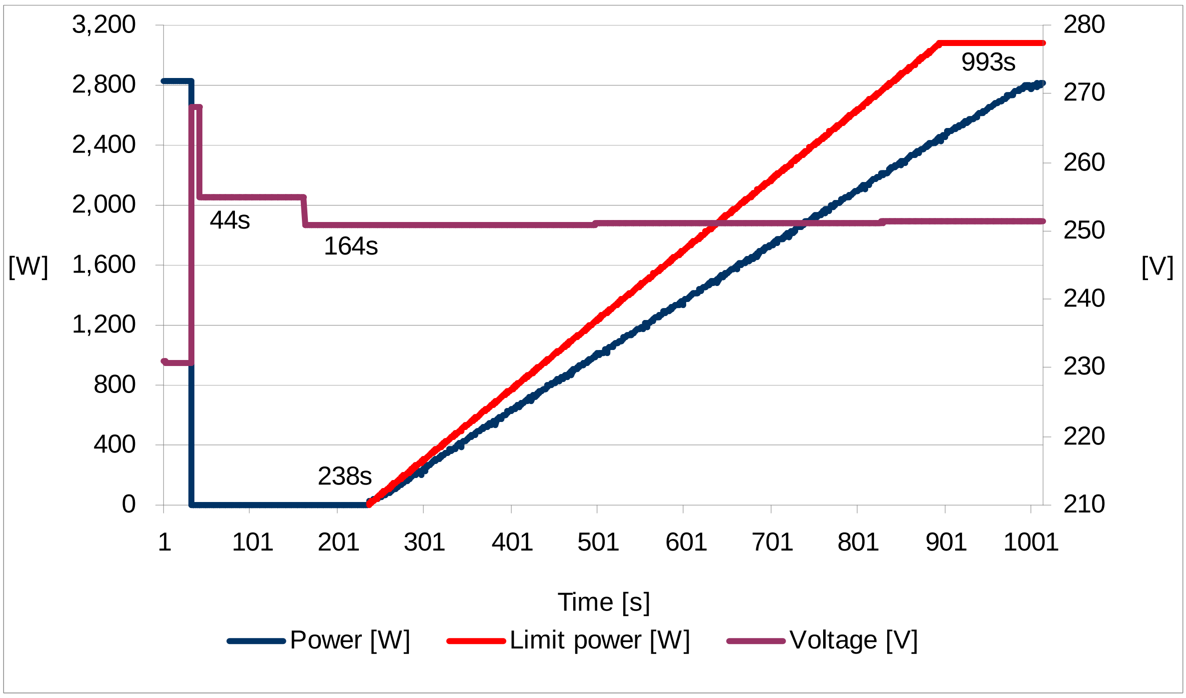
c) 50,10 Hz to d) ≤ 50,00 Hz:



e) 84 % U_n to f) ≥ 86 % U_n:



g) 111 % U_n to h) ≤ 109 % U_n:



5.5.2 Short interruption			P
Setting values of the NS protection:	Setting $T_{disconnection\ 5s}$ [s]:	60 s	
	Setting $T_{reconnection\ 60s}$ [s]:	60 s	
	Setting V< [V]:	184 V	
	Step 1:	**Step 2:**	
Step [V to V]	230 V to 177,1 V	230 V to 177,1 V	
Jump Duration [s]:	2 s	4 s	
Limit [s]:	≥ 5 s	≥ 60 s	
Reconnection Time [s]:	74 s	74 s	

Test:
After providing evidence of a short interruption the network voltage is reduced from the nominal voltage with a surge of 77% U_n. A surge to the nominal voltage takes place after 2 s.
After providing evidence of a short interruption the network voltage is reduced from the nominal voltage with a surge of 77% U_n. A surge to the nominal voltage takes place after 4 s.

Assessment criterion:

Limit values:

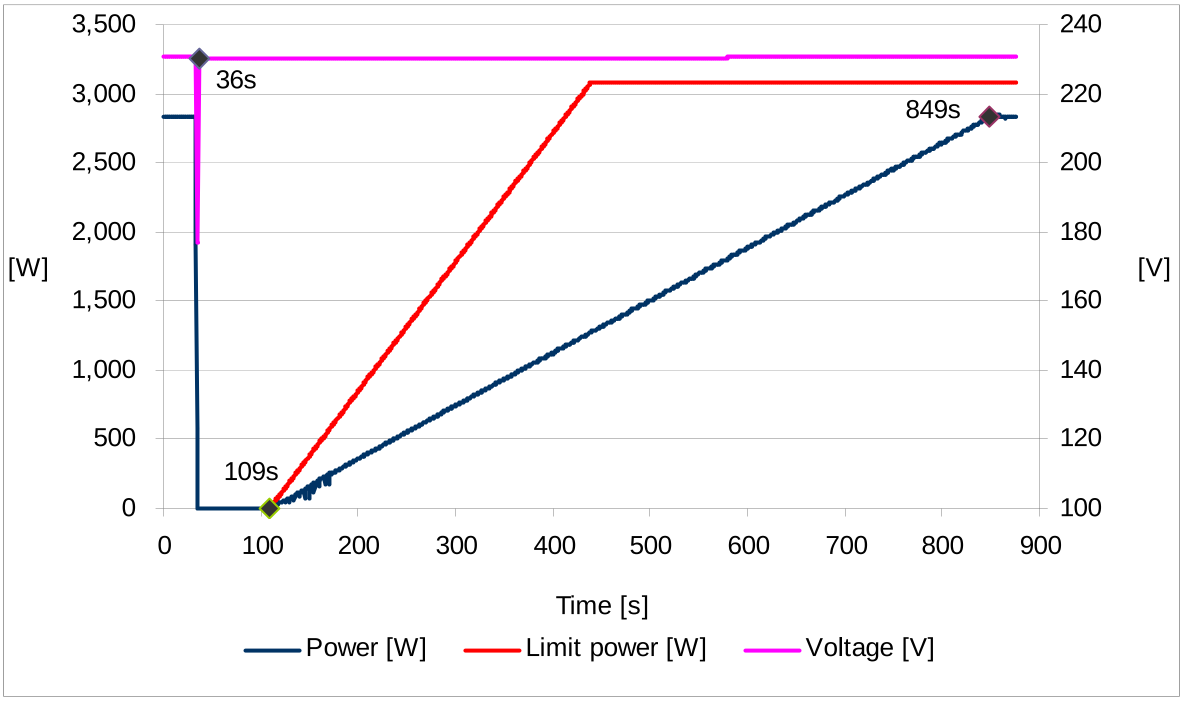
Short interruption ≤ 2 s Reset time ≥ 5 s
Short interruption ≥ 3 s Reset time ≥ 60 s

Note:
A short interruption is characterised by exceeding or not reaching the NS protection settings for the network frequency and/or network voltage for a maximum period of 3 seconds.

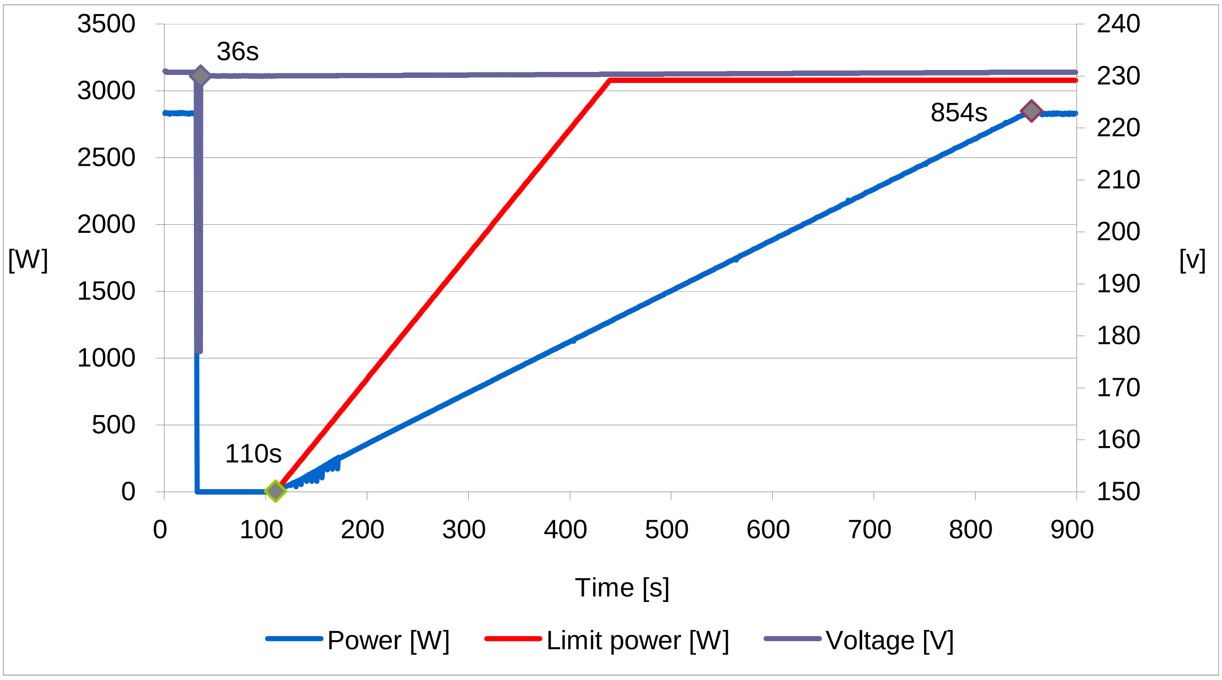
A ramp of 10% P_n is not necessary after short interruptions.

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.

Step 1: 230 V to 177,1 V in 2 s:



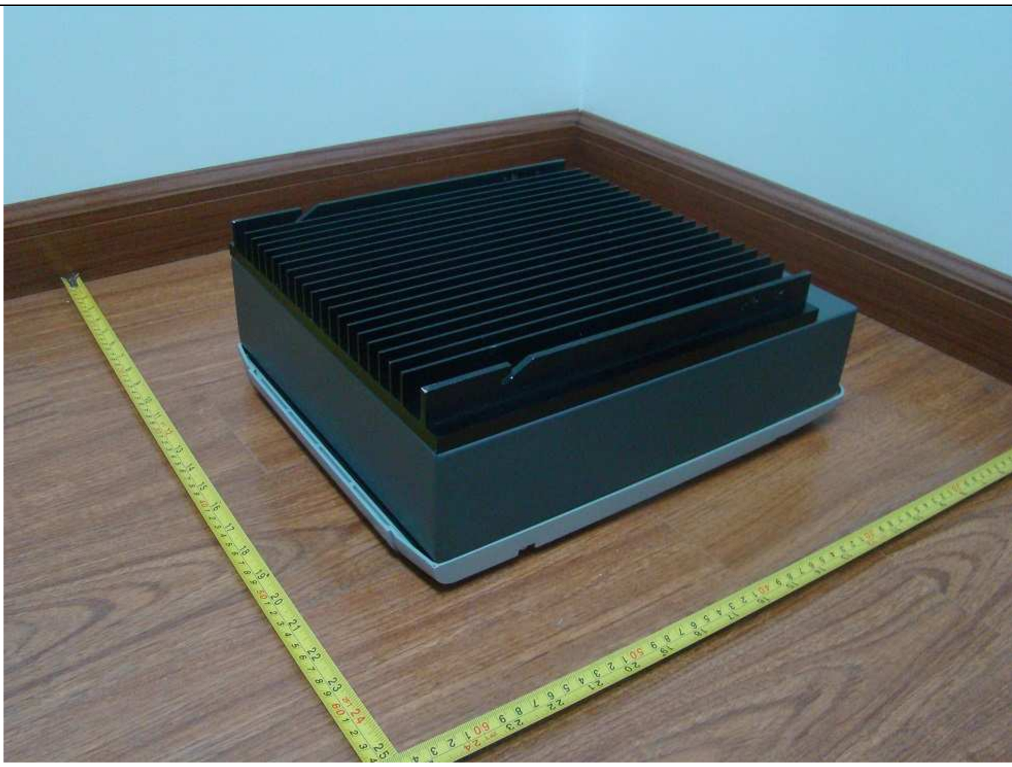
Step 2: 230 V to 177,1 V in 4 s:



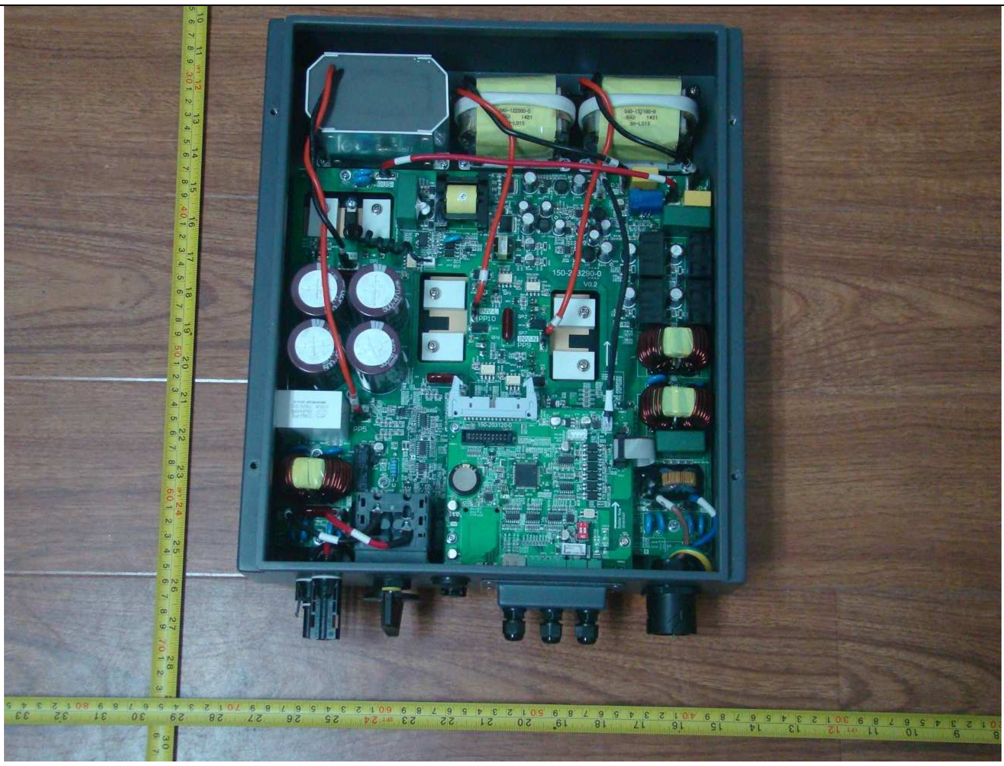
Annex No. 1

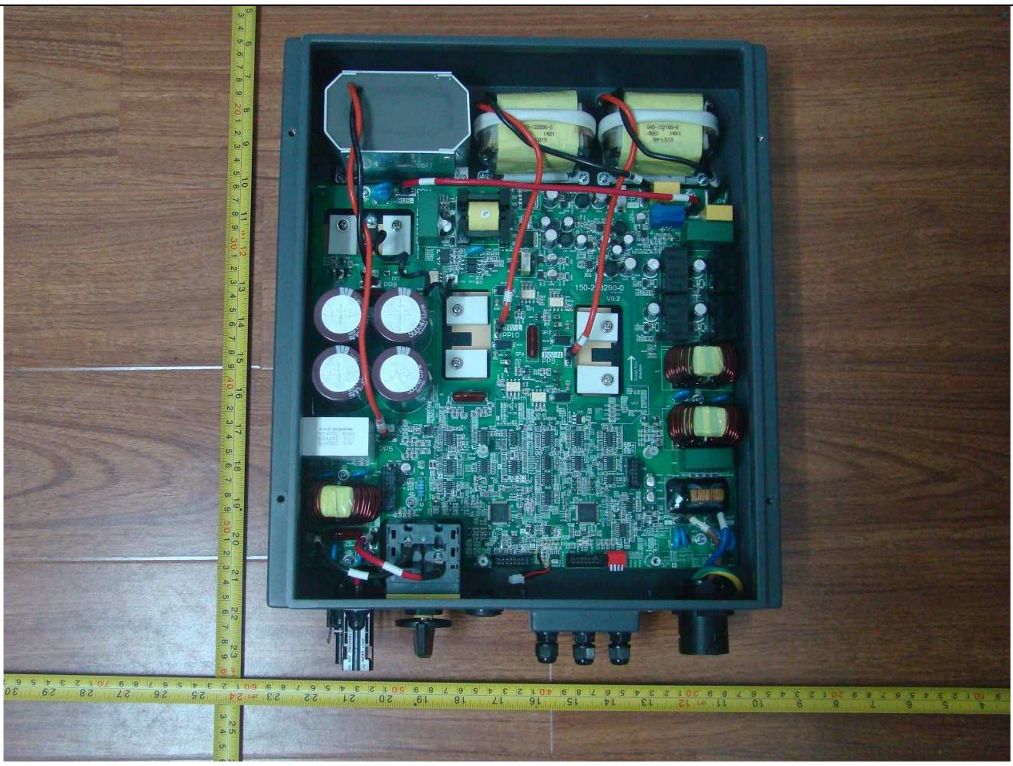
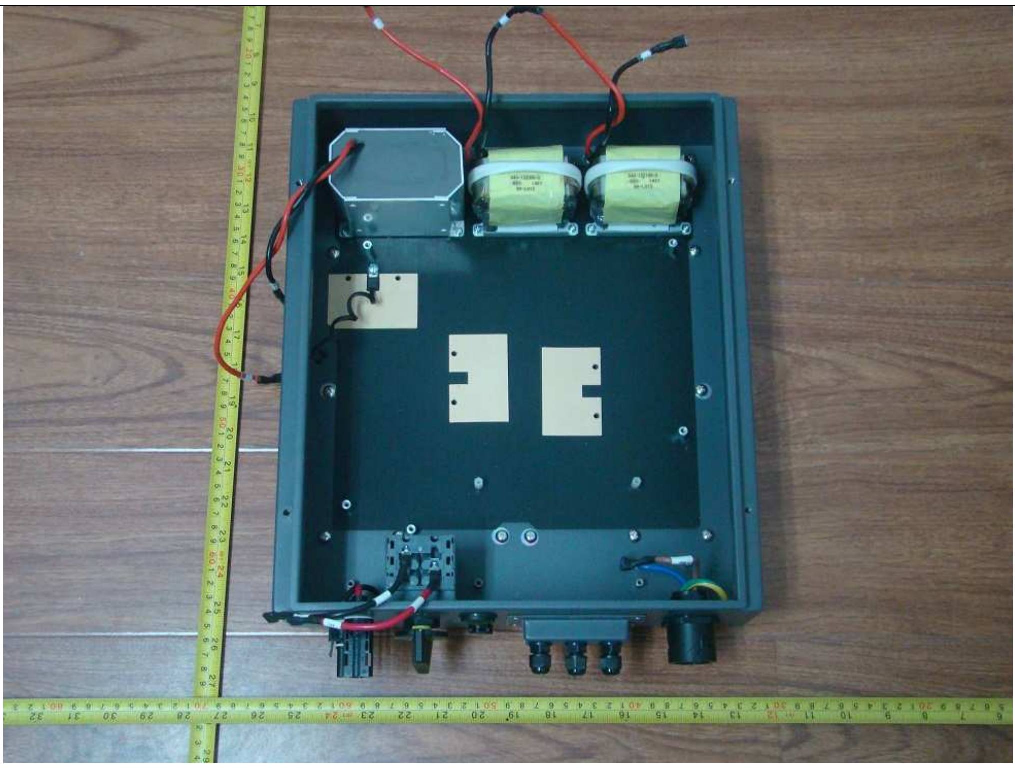
Pictures of the unit

Enclosure front view

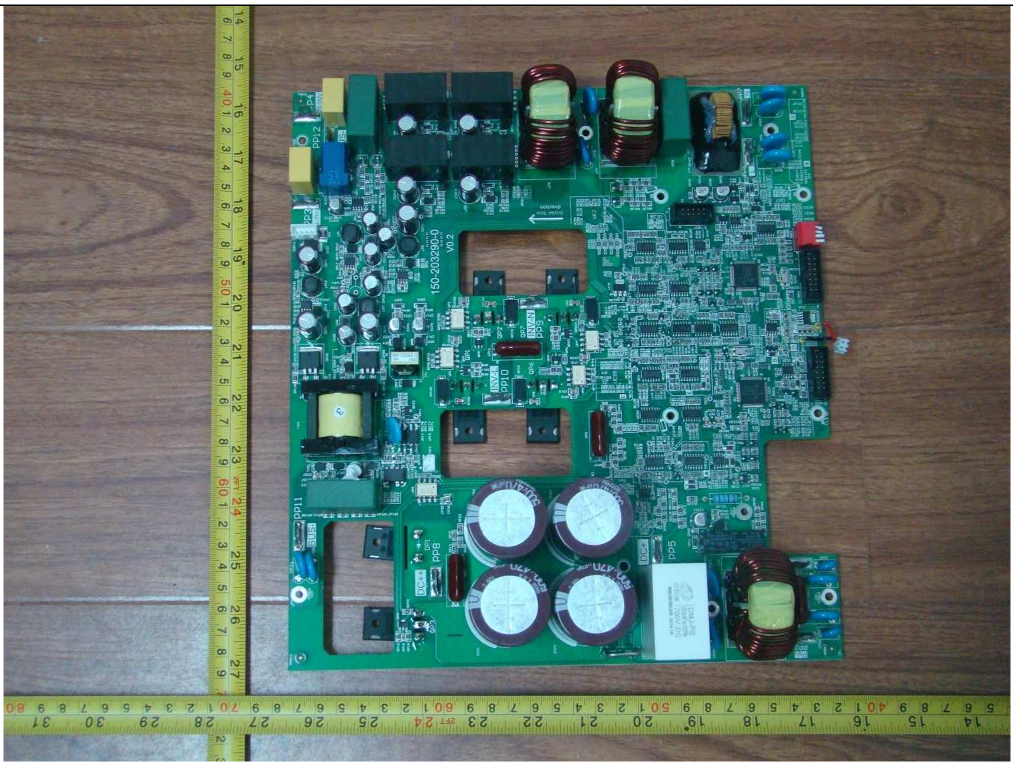
Enclosure rear view


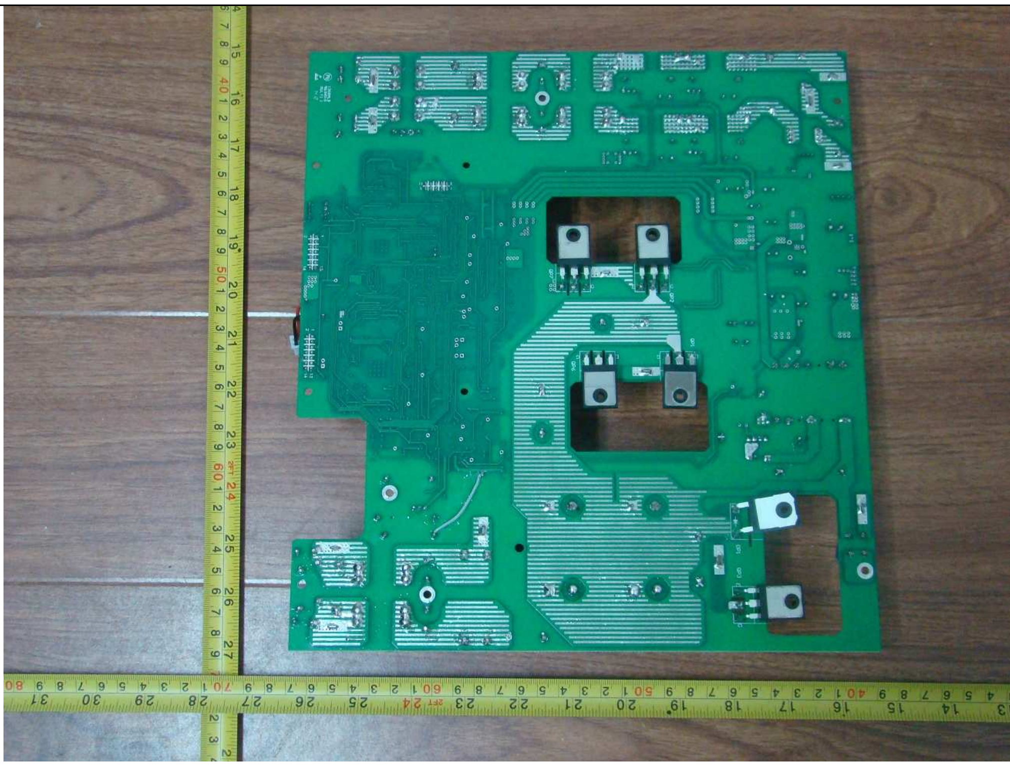
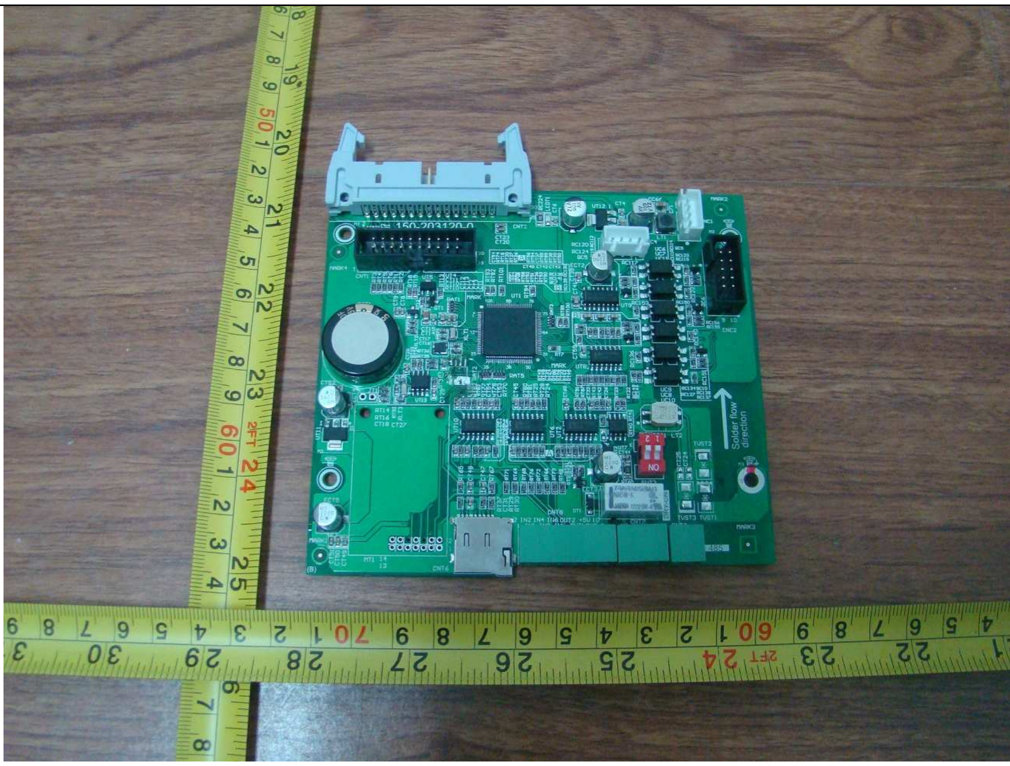
Enclosure bottom view

Internal view-1


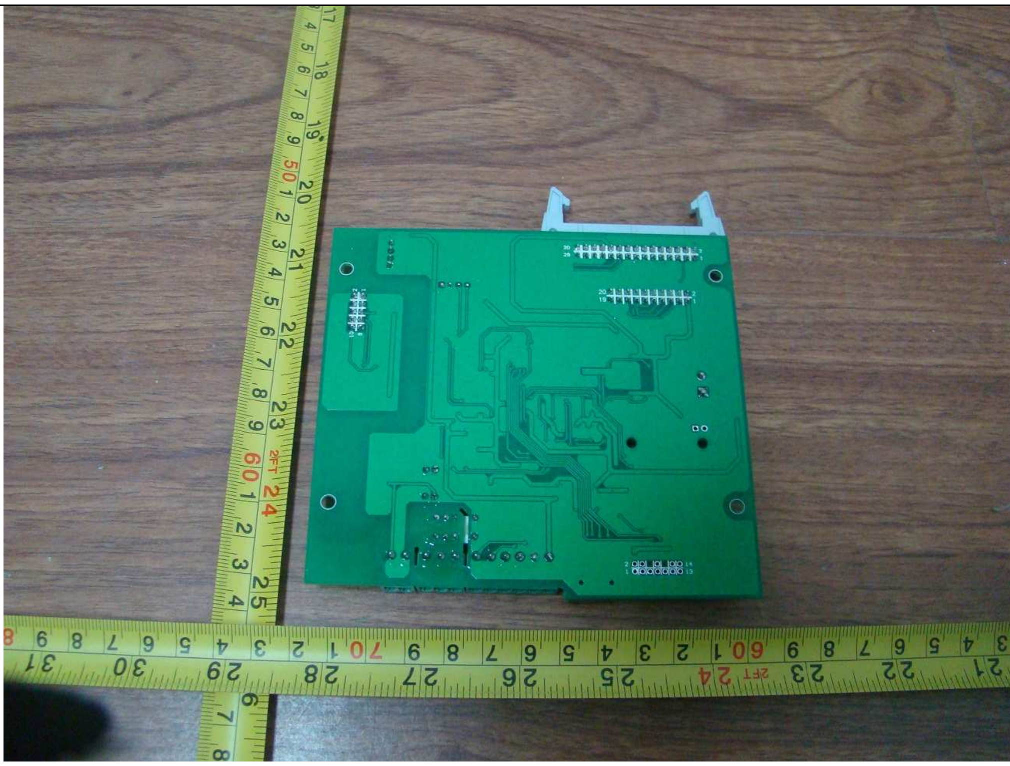
Internal view-2

Internal view-3


Internal view-4

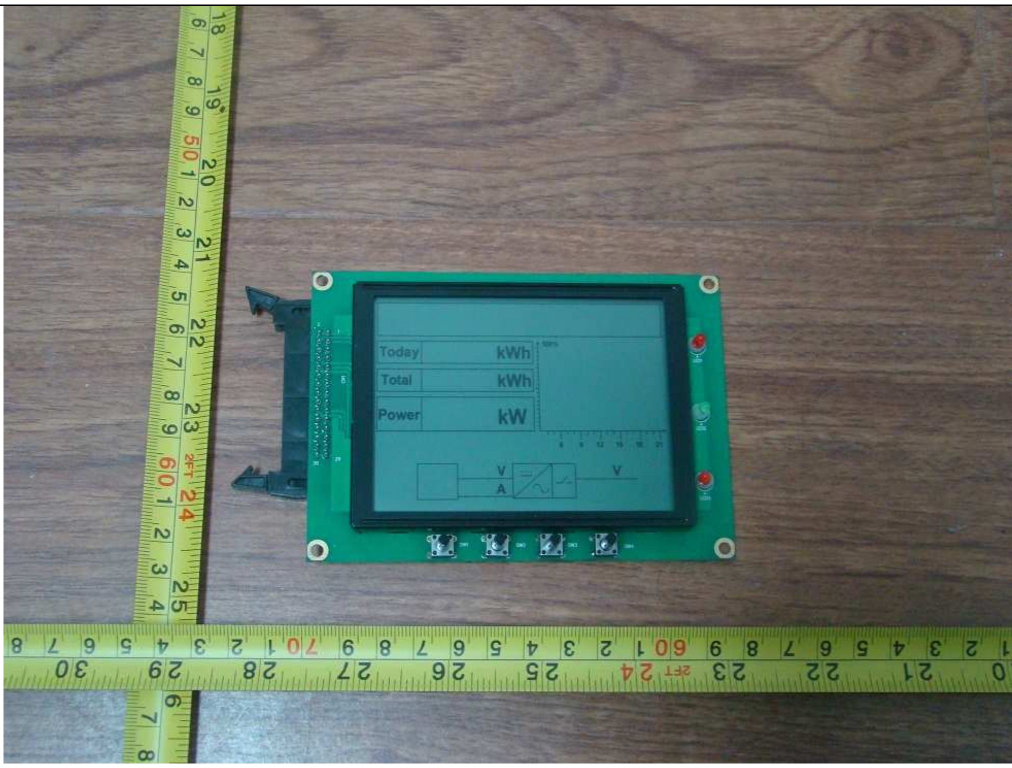
Main power board component side view


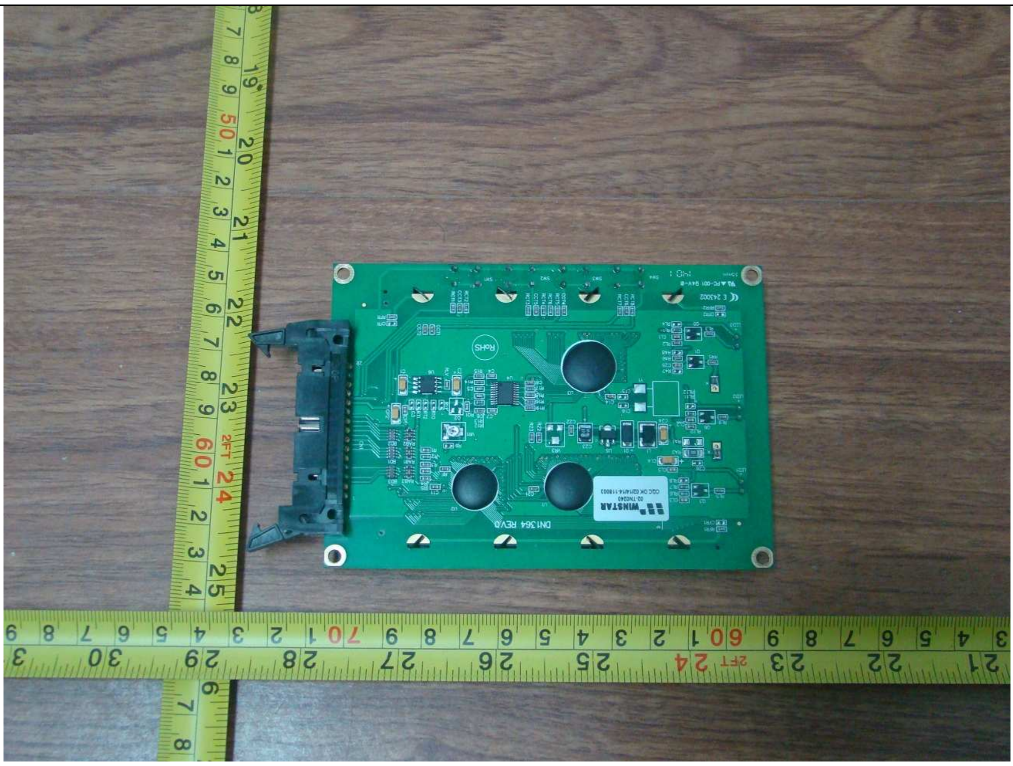
Main power board solder side view

Control board component side view


Control board solder side view



Display board component side view



Display board solder side view


Annex No. 2

Test Equipment list

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
AC Source	A7040020DG	Chroma	61512	61512000438	Monitored by Power Analyzer
DC Simulation Power Supply	A7040015DG	Chroma	62150H-1000S	62150EF00488	Monitored by Power Analyzer
DC Simulation Power Supply	A7040016DG	Chroma	62150H-1000S	62150EF00490	Monitored by Power Analyzer
Four Channel Digital Phosphor Oscilloscope	A4089003DG	Tektronix	DPO4104B	C010624	Oct. 17, 2013
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Jan 20, 2014
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	Monitored by Power Analyzer
Oscilloscope probel	A4089010DG	Tektronix	TPP1000	C008228	Dec. 20, 2013
Oscilloscope probel	A4089011DG	Tektronix	TPP1000	C008229	Dec. 20, 2013
LCR Hitester	A1060006DG	HIOKI	3535	120112505	Mar. 06, 2014