TEST REPORT

VDE-AR-N 4105

Generators connected to the low-voltage distribution network – Technical requirements for the connection to and parallel operation with low-voltage distribution networks

Report reference number	:	**PVDE190424N048-1**
Date of issue	:	2020-04-22
Total number of pages	:	151
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Applicant's name	:	**Huawei Technologies Co., Ltd.**
Address	:	Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C
Test specification		
Standard	:	VDE-AR-N 4105:2018-11 (tested according to E DIN VDE V 0124-100:2019-09 draft)
Test Report Form No.	:	TEST REPORT VDE-AR-N 4105 VER.0
TRF Originator	:	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF	:	Dated 2019-11-06
Test item description	:	**SOLAR INVERTER**
Trademark	:	HUAWEI

Model / Type .... :	SUN2000-8KTL-M0, SUN2000-10KTL-M0,SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0, SUN2000-20KTL-M0, SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2, SUN2000-20KTL-M2		
Ratings .... :	**SUN2000-8KTL-M0 SUN2000-8KTL-M2**	**SUN2000-10KTL-M0 SUN2000-10KTL-M2**	**SUN2000-12KTL-M0 SUN2000-12KTL-M2**
MPP DC voltage range [V]............... :	160-950		
Input DC voltage range [V] .... :	160-1080		
Input DC current [A] .... :	Max. 22 x 2 strings		
Output AC voltage [V] .... :	230/400, 3(N)~ + PE, 50Hz		
Output AC current [A]...................... :	Max. 13,4	Max. 17,0	Max. 20,0
Nominal Output power [kVA] .... :	8,0	10,0	12,0
Maximum Output power [kVA] .... :	8,8	11,0	13,2
Ratings .... :	**SUN2000-15KTL-M0 SUN2000-15KTL-M2**	**SUN2000-17KTL-M0 SUN2000-17KTL-M2**	**SUN2000-20KTL-M0 SUN2000-20KTL-M2**
MPP DC voltage range [V]............... :	160-950		
Input DC voltage range [V] .... :	160-1080		
Input DC current [A] .... :	Max. 22 x 2 strings		
Output AC voltage [V] .... :	230/400, 3(N)~ + PE, 50Hz		
Output AC current [A]...................... :	Max. 25,2	Max. 28,5	Max. 33,5
Nominal Output power [kVA] .... :	15,0	17,0	20,0
Maximum Output power [kVA] .... :	16,5	18,7	22,0

Testing Location .... :	**Huawei Technologies Co., Ltd.**
Address .... :	Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C
Tested by (name and signature) .... :	Lukes Lin
Approved by (name and signature) .... :	James Huang
Manufacturer's name .... :	**Huawei Technologies Co., Ltd.**
Manufacturer address .... :	Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C
Factory's name 1 .... :	**Huawei Machine Co., Ltd.**
Factory address 1	No. 2 New City Avenue, Songshan Lake Sci. & Tech. Industry Park, 523808, Dongguan, People's Republic of China.
Factory's name 2 .... :	**Huazhi Machine Co.,Ltd**
Factory address 2	Zone A Yingzhan Industrial Park Kengzi Street Pingshan New District SHENZHEN GUANGDONG 518125 CHINA

Document History			
Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2020-04-22	Lukes Lin	Initial report was written	0
Supplementary information:			

Test items particulars	
Equipment mobility.......................... :	Permanent connection
Operating condition......................... :	Continuous
Class of equipment .... :	Class I
Protection against ingress of water.. :	IP65 according to EN 60529
Mass of equipment [kg]................... :	25 kg
Test case verdicts	
Test case does not apply to the test object.............................. :	N/A
Test item does meet the requirement............................... :	P(ass)
Test item does not meet the requirement............................... :	F(ail)
Testing	
Date of receipt of test item............... :	2019-04-24
Date(s) of performance of test......... :	2020-02-25 to 2020-04-21

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
   5.2 Evidence of permissible network perturbations
   5.3 Evidence of symmetry behavior of inverters
   5.4 Evidence of the behavior of the generating unit on the network
   5.5 NS-protection
   5.6 Connecting conditions and synchronization
   5.7 Evidence of $P_{AV,E}$-Control (not implemented till yet in test plan)
   5.8 Evidence dynamic grid support
2. Pictures of the unit – Annex No. 1
3. Test equipment list – Annex No. 2

Copy of marking plates:

Copy of marking plate

Copy of marking plate

General product information:

The Solar converter converts DC voltage into AC voltage.
The input and output are protected by Varistors to Earth. The unit is providing EMC filtering at the output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundant by the high power switching bridge and a two relays. This assures that the opening of the output circuit will also operate in case of one error.

Description of the electrical circuit: (Figure 1):

The internal control is redundant built. It consists of Microcontroller DSP (U3) and MCU (U33).

The DSP (U3) control the relays by switching signals; measures the PV voltage, PV current, Bus voltage, grid voltage, frequency, AC current with injected DC and the array insulation resistance to ground. In addition it tests the current sensors and the RCMU circuit before each start up.

The MCU (U33) is measures the grid voltage, grid frequency, DCI and residual current, also can switch off the relays independently, and communicate with the DSP (U3) each other.

The current is measured by a current sensor. The AC current signal and the injected DC current signal are sent to the DSP (U3). The DSP (U3) 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.

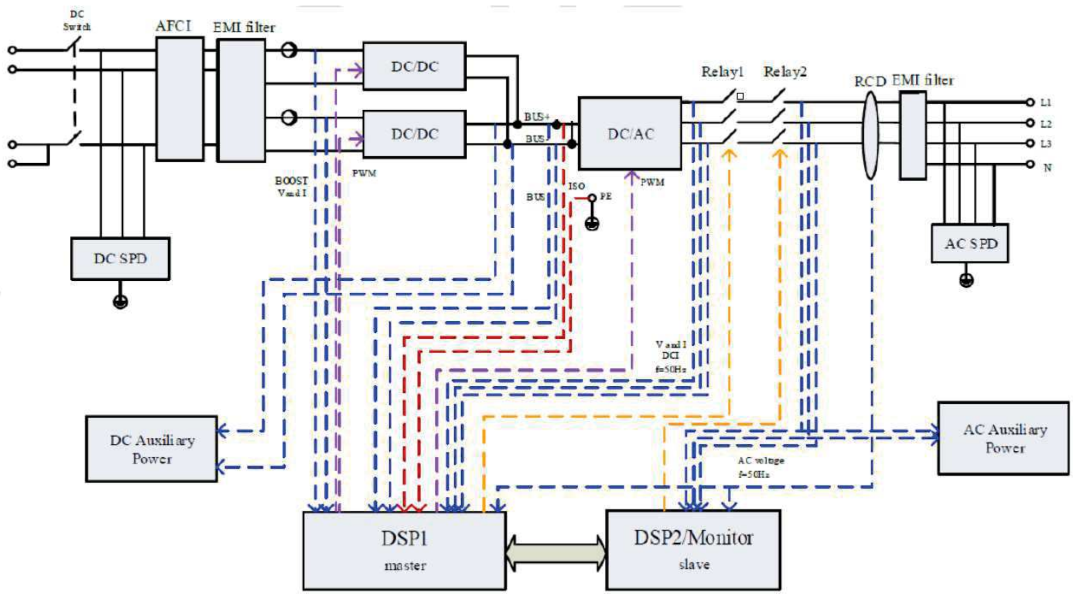


Figure 1 – Block diagram

Differences of the models:

The models SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0 and SUN2000-20KTL-M0 are identical in hardware and software, and the output power derated by software.

The models SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 are identical in hardware, and the output power derated by software.

The model SUN2000-20KTL-M2 and SUN2000-20KTL-M0 are almost identical in hardware except SUN2000-20KTL-M2 has an additional ac auxiliary power supply circuit.

The product was tested on:

Hardware: V100R001
Software: V100R001

Description of the remote control in a typical installation:

Communication port signal definitions

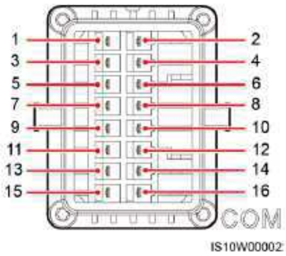


Table 5-3 Signal definitions

Pin	Definition	Function	Description	Pin	Definition	Function	Description
1	485A1-1	RS485 differential signal+	Used to connect to the RS485 signal port on the SUN2000 or SmartLogger1000 A	2	485A1-2	RS485 differential signal+	Used to connect to the RS485 signal port on the SUN2000 or SmartLogger1000 A
3	485B1-1	RS485 differential signal–		4	485B1-2	RS485 differential signal–	
5	PE	Shielding ground	N/A	6	PE	Shielding ground	N/A
7	485A2	RS485 differential signal+	Used to connect to an RS485 signal port on a Smart Power Sensor for export limitation	8	DIN1	Dry contact interface for grid scheduling	Connects to the Ripple Control Device.
9	485B2	RS485 differential signal–		10	DIN2		
11	N/A	N/A	N/A	12	DIN3		
13	GND	Signal ground	N/A	14	DIN4		
15	N/A	N/A	N/A	16	GND		

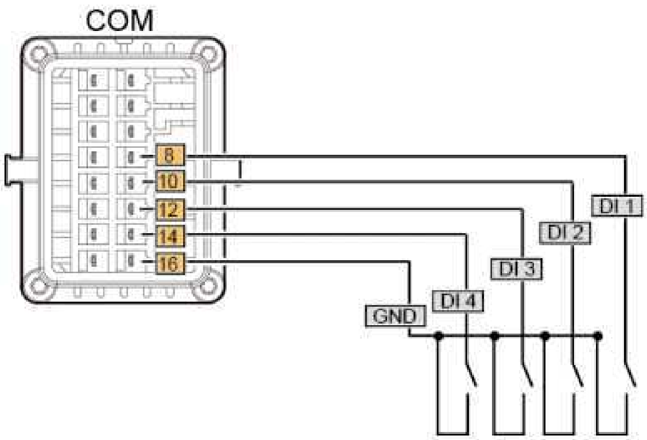
Figure 2 – Scheme of an installation

Description of the connection to the ripple control receiver:

Connecting the Power Grid Scheduling Signal Cable

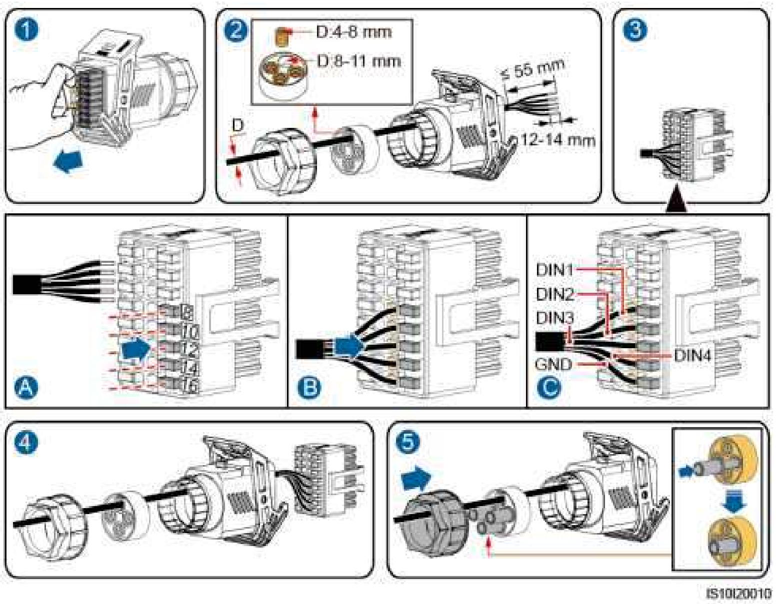
Cable Connection

The following figure shows the cable connections between the inverter and the Ripple Control Device.

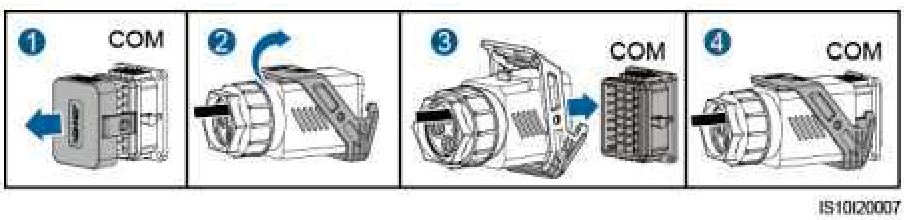


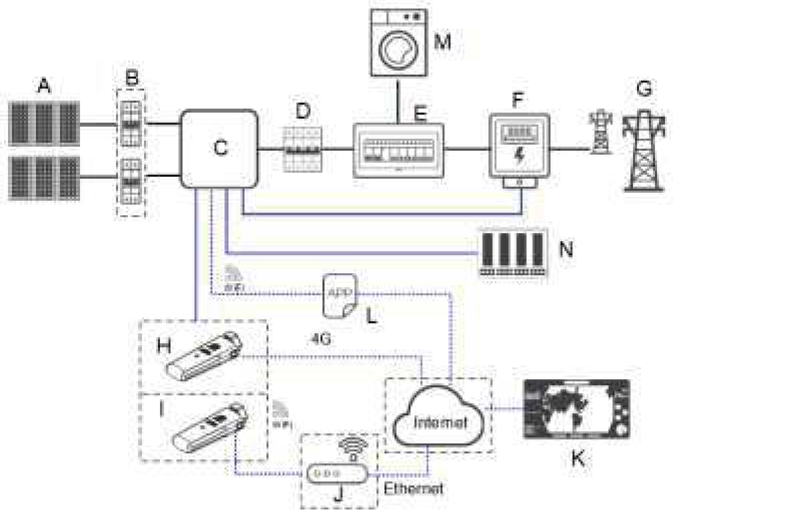
Procedure

Step 1 Connect the signal cable to the signal cable connector.



Step 2 Connect the signal cable to the COM port.





NOTE

— indicates a power cable, — indicates a signal cable, ······ indicates wireless communication.

(A) PV module	(B) DC switch	(C) SUN2000
(D) AC switch	(E) ACDU	(F) Smart Power Sensor
(G) Power grid	(H) 4G Smart Dongle	(I) WLAN Smart Dongle
(J) Router	(K) Remote management system	(L) Local app
(M) Load	(N) Ripple Control Device	

Figure 3 – Connection of the ripple control receiver in an installation

5 Prüfungen E DIN V 0124-100:(2019-09) draft		
Clause	**Test**	**Result**
5.2	Evidence of permissible network perturbations	**P**
5.3	Evidence of symmetry behavior of inverters	**P**
5.4	Evidence of the behavior of the generating unit on the network	**P**
5.5	NS-protection	**P**
5.6	Connecting conditions and synchronization	**P**
5.8	Evidence dynamic grid support	**P**
5.9	Test of Ancillary Unit (not implemented till yet in test plan)	**N/A**

5.2	Evidence of permissible network perturbations E DIN V 0124-100:(2019-09) draft	
Clause	**Test**	**Result**
5.2.1	General	**P**
5.2.2	Rapid voltage changes	**P**
5.2.3	Flicker	**P**
5.2.4	Harmonics and interharmonics	**P**
5.2.4.1	Test: 61000-3-3 / 61000-3-12	**P**
5.2.4.1	Test: 61000-4-7	**P**
5.2.5	Commutation “only for line-commutated inverter”	**N/A**
5.2.6	Feed in of DC current “only for inverter”	**P**

5.2.1 General These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.4 are met.	**P**

Network reactions in the sense of this document according to VDE-AR-N 4100: 2019-04, 5.4 are:

- fast voltage changes;
- flicker;
- Harmonics, interharmonics and super-harmonics (higher frequencies from 2 kHz to 9 kHz);
- Commutation “necessary only for mains-controlled inverter”
- Feed in of direct current “necessary only for inverter”

Note:

5.2.2 Rapid voltage changes These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.4.4.2 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 %

SUN2000-20KTL-M0 L1 Phase:			
Switch-on for any capacity (10% P_{Emax})			
Single period effective values of the current [A]	1,591	1,542	1,609
Single period effective values of the voltage [V]	230,2	230,3	230,3
k_i value	0,050	0,048	0,051
k_{imax} value	0,051		
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	N/A		
Switch-on for nominal capacity			
Single period effective values of the current [A]	1,581	1,627	1,635
Single period effective values of the voltage [V]	230,4	230,3	229,3
k_i value	0,050	0,051	0,051
k_{imax} value	0,051		
SUN2000-20KTL-M0 L2 Phase:			
Switch-on for any capacity (10% P_{Emax})			
Single period effective values of the current [A]	1,775	1,740	1,807
Single period effective values of the voltage [V]	229,4	229,3	229,3
k_i value	0,056	0,055	0,057
k_{imax} value	0,057		
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	N/A		
Switch-on for nominal capacity			
Single period effective values of the current [A]	1,761	1,794	1,790
Single period effective values of the voltage [V]	229,4	229,3	230,3
k_i value	0,055	0,056	0,056
k_{imax} value	0,056		
SUN2000-20KTL-M0 L3 Phase:			
Switch-on for any capacity (10% P_{Emax})			
Single period effective values of the current [A]	1,690	1,852	1,715
Single period effective values of the voltage [V]	230,1	230,2	230,0
k_i value	0,053	0,058	0,054
k_{imax} value	0,058		
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	N/A		
Switch-on for nominal capacity			
Single period effective values of the current [A]	1,735	1,720	1,721
Single period effective values of the voltage [V]	230,0	230,1	230,2
k_i value	0,055	0,054	0,054
k_{imax} value	0,055		
Highest k_{imax} value for all switching operations			
0,058			

Note:
The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0, SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PVAT190424N048 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-07-22.

Switch-on for any capacity (10% P_{Emax}): SUN2000-20KTL-M0

Switch-on for nominal capacity: SUN2000-20KTL-M0

5.2.3 Flicker

These tests are designed to provide evidence that the requirements of VDE-AR-N 4100:2109-04 are met.

Adherence to the thresholds for flicker must be verified as followed:

- For nominal currents ≤ 16 A per conductor to DIN EN 61000-3-3 (VDE 0838-3)
- For nominal currents > 16 A and ≤ 75 A per conductor to DIN EN 61000-3-11 (VDE 0838-11)
- For PGUs and PSUs intended for PGSs with nominal currents > 75 A, the measurements must be conducted as in 5.2.3.2.

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 %

Flicker für Bemessungsströme >75A (bei SCR = 20)

Method: Measurement was carried out according to the procedure in IEC 61400-21.

SUN2000-8KTL-M0				
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker coefficient, $c(\psi_k)$	4,80	3,13	2,55	2,41
Short-term flicker, P_{st}	0,074	0,048	0,039	0,037
SUN2000-10KTL-M0				
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker coefficient, $c(\psi_k)$	3,84	2,51	2,04	1,93
Short-term flicker, P_{st}	0,074	0,048	0,039	0,037
SUN2000-12KTL-M0				
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker coefficient, $c(\psi_k)$	3,20	2,09	1,70	1,61
Short-term flicker, P_{st}	0,074	0,048	0,039	0,037
SUN2000-15KTL-M0				
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker coefficient, $c(\psi_k)$	2,56	1,67	1,36	1,28
Short-term flicker, P_{st}	0,074	0,048	0,039	0,037
SUN2000-17KTL-M0				
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker coefficient, $c(\psi_k)$	2,26	1,47	1,20	1,13
Short-term flicker, P_{st}	0,074	0,048	0,039	0,037

SUN2000-20KTL-M0				
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker coefficient, $c(\psi_k)$	1,92	1,25	1,02	0,96
Short-term flicker, P_{st}	0,074	0,048	0,039	0,037

Note:
The table entries are worst case values.
$S_{k,fic}/S_n$ in the fictitious grid was set to: 20

The test had been performed on the model SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0, SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PVAT190424N048 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-07-22.

5.2.4 **Harmonics and interharmonics** These tests are designed to provide evidence that the requirements of VDE-AR-N 4100:2109-04 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 %

5.2.4.1 Tests	P

Maximum permissible harmonic current as per EN 61000-3-2 Class A

SUN2000-8KTL-M0

Watts(W)	2686	2671	2665
Vrms(V)	231,48	230,70	230,60
Arms(A)	11,616	11,588	11,568
Frequency(Hz)	50,00		
THD* (33% output power)	0,914	1,005	1,055

Harmonics	Current Magnitude (A)			% of Fundamental			Phase	Harmonic Current Limits (A)
	L1	L2	L3	L1	L2	L3		
1st	8,650	8,658	8,639	--	--	--	Three Phase	--
2nd	0,013	0,028	0,024	0,150	0,321	0,278	Three Phase	1,080
3rd	0,017	0,013	0,014	0,201	0,154	0,162	Three Phase	2,300
4th	0,018	0,017	0,019	0,202	0,201	0,216	Three Phase	0,430
5th	0,065	0,075	0,071	0,755	0,867	0,821	Three Phase	1,140
6th	0,020	0,019	0,019	0,225	0,217	0,216	Three Phase	0,300
7th	0,105	0,113	0,098	1,216	1,304	1,136	Three Phase	0,770
8th	0,012	0,011	0,013	0,134	0,125	0,154	Three Phase	0,230
9th	0,014	0,012	0,021	0,164	0,141	0,243	Three Phase	0,400
10th	0,009	0,011	0,010	0,106	0,122	0,116	Three Phase	0,184
11th	0,166	0,174	0,183	1,921	2,013	2,118	Three Phase	0,330
12th	0,009	0,008	0,008	0,099	0,088	0,094	Three Phase	0,153
13th	0,059	0,057	0,065	0,676	0,653	0,755	Three Phase	0,210
14th	0,006	0,006	0,007	0,068	0,069	0,075	Three Phase	0,131
15th	0,014	0,010	0,009	0,160	0,110	0,108	Three Phase	0,150
16th	0,005	0,005	0,005	0,053	0,054	0,057	Three Phase	0,115
17th	0,109	0,106	0,109	1,261	1,221	1,257	Three Phase	0,132
18th	0,004	0,004	0,004	0,050	0,051	0,044	Three Phase	0,102
19th	0,033	0,029	0,030	0,386	0,334	0,345	Three Phase	0,118
20th	0,004	0,004	0,004	0,045	0,047	0,049	Three Phase	0,092
21th	0,012	0,006	0,010	0,136	0,065	0,111	Three Phase	0,107
22th	0,004	0,004	0,000	0,044	0,045	0,000	Three Phase	0,084
23th	0,039	0,035	0,043	0,450	0,408	0,499	Three Phase	0,098
24th	0,005	0,005	0,005	0,057	0,058	0,052	Three Phase	0,077
25th	0,024	0,027	0,025	0,275	0,314	0,291	Three Phase	0,090
26th	0,006	0,005	0,006	0,065	0,062	0,073	Three Phase	0,071
27th	0,009	0,009	0,009	0,109	0,103	0,109	Three Phase	0,083
28th	0,007	0,007	0,007	0,079	0,081	0,084	Three Phase	0,066
29th	0,033	0,033	0,039	0,386	0,385	0,451	Three Phase	0,078
30th	0,005	0,005	0,005	0,059	0,062	0,061	Three Phase	0,061
31th	0,022	0,024	0,019	0,251	0,271	0,225	Three Phase	0,073
32th	0,005	0,005	0,005	0,052	0,054	0,052	Three Phase	0,058
33th	0,005	0,004	0,006	0,059	0,051	0,066	Three Phase	0,068
34th	0,004	0,004	0,004	0,046	0,046	0,050	Three Phase	0,054

35th	0,018	0,016	0,017	0,206	0,188	0,198	Three Phase	0,064
36th	0,003	0,003	0,003	0,038	0,036	0,034	Three Phase	0,051
37th	0,007	0,006	0,007	0,086	0,074	0,082	Three Phase	0,061
38th	0,004	0,004	0,004	0,043	0,047	0,047	Three Phase	0,048
39th	0,005	0,004	0,006	0,053	0,047	0,065	Three Phase	0,058
40th	0,004	0,004	0,004	0,047	0,047	0,051	Three Phase	0,046

Note:
The tests should be based on the limits of the EN 61000-3-2 for less than 16A.

The test had been performed on the model SUN2000-8KTL-M0,the test results are valid for the SUN2000-8KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PVAT190424N048 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-07-22.

SUN2000-10KTL-M0

Harmonics	Current Magnitude (A)			% of Fundamental			Phase	Harmonic Current Limits (A)
Watts(W)					3366		3345	3337
Vrms(V)					231,76		230,83	230,73
Arms(A)					14,532		14,499	14,472
Frequency(Hz)					50,00			
THD* (33% output power)					0,869		0,892	0,953
	L1	L2	L3	L1	L2	L3		
1st	8,650	8,658	8,639	--	--	--	Three Phase	--
2nd	0,013	0,028	0,024	0,150	0,321	0,278	Three Phase	1,080
3rd	0,017	0,013	0,014	0,201	0,154	0,162	Three Phase	2,300
4th	0,018	0,017	0,019	0,202	0,201	0,216	Three Phase	0,430
5th	0,065	0,075	0,071	0,755	0,867	0,821	Three Phase	1,140
6th	0,020	0,019	0,019	0,225	0,217	0,216	Three Phase	0,300
7th	0,105	0,113	0,098	1,216	1,304	1,136	Three Phase	0,770
8th	0,012	0,011	0,013	0,134	0,125	0,154	Three Phase	0,230
9th	0,014	0,012	0,021	0,164	0,141	0,243	Three Phase	0,400
10th	0,009	0,011	0,010	0,106	0,122	0,116	Three Phase	0,184
11th	0,166	0,174	0,183	1,921	2,013	2,118	Three Phase	0,330
12th	0,009	0,008	0,008	0,099	0,088	0,094	Three Phase	0,153
13th	0,059	0,057	0,065	0,676	0,653	0,755	Three Phase	0,210
14th	0,006	0,006	0,007	0,068	0,069	0,075	Three Phase	0,131
15th	0,014	0,010	0,009	0,160	0,110	0,108	Three Phase	0,150
16th	0,005	0,005	0,005	0,053	0,054	0,057	Three Phase	0,115
17th	0,109	0,106	0,109	1,261	1,221	1,257	Three Phase	0,132
18th	0,004	0,004	0,004	0,050	0,051	0,044	Three Phase	0,102
19th	0,033	0,029	0,030	0,386	0,334	0,345	Three Phase	0,118
20th	0,004	0,004	0,004	0,045	0,047	0,049	Three Phase	0,092
21th	0,012	0,006	0,010	0,136	0,065	0,111	Three Phase	0,107
22th	0,004	0,004	0,000	0,044	0,045	0,000	Three Phase	0,084
23th	0,039	0,035	0,043	0,450	0,408	0,499	Three Phase	0,098
24th	0,005	0,005	0,005	0,057	0,058	0,052	Three Phase	0,077
25th	0,024	0,027	0,025	0,275	0,314	0,291	Three Phase	0,090
26th	0,006	0,005	0,006	0,065	0,062	0,073	Three Phase	0,071

27th	0,009	0,009	0,009	0,109	0,103	0,109	Three Phase	0,083
28th	0,007	0,007	0,007	0,079	0,081	0,084	Three Phase	0,066
29th	0,033	0,033	0,039	0,386	0,385	0,451	Three Phase	0,078
30th	0,005	0,005	0,005	0,059	0,062	0,061	Three Phase	0,061
31th	0,022	0,024	0,019	0,251	0,271	0,225	Three Phase	0,073
32th	0,005	0,005	0,005	0,052	0,054	0,052	Three Phase	0,058
33th	0,005	0,004	0,006	0,059	0,051	0,066	Three Phase	0,068
34th	0,004	0,004	0,004	0,046	0,046	0,050	Three Phase	0,054
35th	0,018	0,016	0,017	0,206	0,188	0,198	Three Phase	0,064
36th	0,003	0,003	0,003	0,038	0,036	0,034	Three Phase	0,051
37th	0,007	0,006	0,007	0,086	0,074	0,082	Three Phase	0,061
38th	0,004	0,004	0,004	0,043	0,047	0,047	Three Phase	0,048
39th	0,005	0,004	0,006	0,053	0,047	0,065	Three Phase	0,058
40th	0,004	0,004	0,004	0,047	0,047	0,051	Three Phase	0,046

Note:
The tests should be based on the limits of the EN 61000-3-2 for less than 16A.

The test had been performed on the model SUN2000-10KTL-M0,the test results are valid for the SUN2000-10KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PVAT190424N048 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-07-22.

SUN2000-12KTL-M0

Watts(W)	4033	4007	3998
Vrms(V)	231,83	230,90	230,81
Arms(A)	17,406	17,365	17,331
Frequency(Hz)	50,00		
THD* (33% output power)	0,792	0,763	0,882

Harmonics	Current Magnitude (A)			% of Fundamental			Phase	Harmonic Current Limits (A)
	L1	L2	L3	L1	L2	L3		
1st	17,398	17,355	17,321	99,955	99,943	99,944	Three Phase	--
2nd	0,044	0,030	0,037	0,254	0,171	0,214	Three Phase	1,080
3rd	0,020	0,022	0,020	0,116	0,125	0,114	Three Phase	2,300
4th	0,019	0,018	0,023	0,111	0,103	0,134	Three Phase	0,430
5th	0,093	0,091	0,109	0,533	0,526	0,627	Three Phase	1,140
6th	0,011	0,010	0,013	0,065	0,055	0,075	Three Phase	0,300
7th	0,054	0,043	0,056	0,308	0,247	0,322	Three Phase	0,770
8th	0,014	0,013	0,010	0,079	0,074	0,056	Three Phase	0,230
9th	0,012	0,017	0,019	0,072	0,099	0,107	Three Phase	0,400
10th	0,012	0,014	0,013	0,066	0,080	0,074	Three Phase	0,184
11th	0,015	0,021	0,017	0,084	0,120	0,098	Three Phase	0,330
12th	0,010	0,010	0,012	0,060	0,060	0,071	Three Phase	0,153
13th	0,023	0,032	0,027	0,131	0,183	0,156	Three Phase	0,210
14th	0,014	0,010	0,011	0,079	0,058	0,061	Three Phase	0,131
15th	0,011	0,016	0,014	0,062	0,093	0,083	Three Phase	0,150
16th	0,010	0,012	0,011	0,059	0,067	0,062	Three Phase	0,115
17th	0,017	0,020	0,026	0,097	0,117	0,152	Three Phase	0,132
18th	0,009	0,010	0,010	0,051	0,056	0,058	Three Phase	0,102

19th	0,021	0,024	0,017	0,120	0,141	0,097	Three Phase	0,118
20th	0,011	0,009	0,012	0,065	0,049	0,069	Three Phase	0,092
21th	0,009	0,014	0,009	0,050	0,081	0,054	Three Phase	0,107
22th	0,011	0,010	0,009	0,061	0,060	0,049	Three Phase	0,084
23th	0,018	0,014	0,025	0,103	0,078	0,142	Three Phase	0,098
24th	0,007	0,010	0,011	0,042	0,055	0,063	Three Phase	0,077
25th	0,014	0,010	0,010	0,078	0,058	0,057	Three Phase	0,090
26th	0,008	0,009	0,012	0,044	0,049	0,068	Three Phase	0,071
27th	0,007	0,012	0,008	0,040	0,068	0,046	Three Phase	0,083
28th	0,009	0,009	0,006	0,053	0,052	0,035	Three Phase	0,066
29th	0,018	0,006	0,020	0,104	0,036	0,113	Three Phase	0,078
30th	0,006	0,007	0,008	0,033	0,042	0,049	Three Phase	0,061
31th	0,011	0,007	0,011	0,065	0,039	0,061	Three Phase	0,073
32th	0,005	0,010	0,010	0,030	0,057	0,058	Three Phase	0,058
33th	0,006	0,010	0,008	0,036	0,059	0,044	Three Phase	0,068
34th	0,007	0,008	0,005	0,042	0,047	0,031	Three Phase	0,054
35th	0,015	0,005	0,015	0,084	0,029	0,089	Three Phase	0,064
36th	0,006	0,005	0,007	0,033	0,031	0,042	Three Phase	0,051
37th	0,010	0,006	0,012	0,059	0,035	0,067	Three Phase	0,061
38th	0,005	0,010	0,007	0,029	0,055	0,042	Three Phase	0,048
39th	0,006	0,011	0,008	0,036	0,062	0,047	Three Phase	0,058
40th	0,006	0,008	0,006	0,033	0,044	0,032	Three Phase	0,046

Note:
The tests should be based on the limits of the EN 61000-3-2 for less than 16A.

The test had been performed on the model SUN2000-12KTL-M0,the test results are valid for the SUN2000-12KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PVAT190424N048 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-07-22.

Maximum permissible harmonic current as per EN 61000-3-12								
SUN2000-15KTL-M0								
Watts(W)						5081	5048	5035
Vrms(V)						232,12	231,00	230,95
Arms(A)						21,898	21,862	21,810
Frequency(Hz)						50,00		
THD* (100% output power)						0,696	0,707	0,737
Harmonics	Current Magnitude (A)			% of Fundamental			Phase	Harmonic Current Limits (%)
	L1	L2	L3	L1	L2	L3		
1st	21,873	21,846	21,794	99,885	99,927	99,930	Three Phase	--
2nd	0,036	0,037	0,047	0,165	0,168	0,216	Three Phase	8,000
3rd	0,032	0,042	0,030	0,145	0,194	0,137	Three Phase	21,600
4th	0,018	0,021	0,021	0,081	0,097	0,098	Three Phase	4,000
5th	0,106	0,105	0,119	0,486	0,481	0,544	Three Phase	10,700
6th	0,027	0,018	0,021	0,124	0,084	0,099	Three Phase	2,667
7th	0,058	0,043	0,044	0,263	0,198	0,202	Three Phase	7,200
8th	0,014	0,020	0,018	0,064	0,092	0,084	Three Phase	2,000
9th	0,009	0,022	0,015	0,041	0,100	0,068	Three Phase	3,800
10th	0,014	0,021	0,018	0,066	0,097	0,082	Three Phase	1,600
11th	0,010	0,011	0,010	0,044	0,050	0,048	Three Phase	3,100
12th	0,024	0,017	0,019	0,109	0,077	0,086	Three Phase	1,333
13th	0,012	0,022	0,020	0,055	0,103	0,094	Three Phase	2,000
14th	0,012	0,017	0,016	0,055	0,080	0,074	Three Phase	8,000
15th	0,008	0,012	0,013	0,036	0,055	0,058	Three Phase	N/A
16th	0,012	0,017	0,015	0,054	0,079	0,067	Three Phase	N/A
17th	0,015	0,018	0,017	0,070	0,084	0,079	Three Phase	N/A
18th	0,019	0,014	0,015	0,088	0,062	0,069	Three Phase	N/A
19th	0,017	0,023	0,012	0,080	0,103	0,057	Three Phase	N/A
20th	0,010	0,014	0,013	0,044	0,063	0,059	Three Phase	N/A
21th	0,007	0,014	0,012	0,033	0,062	0,057	Three Phase	N/A
22th	0,009	0,013	0,011	0,043	0,061	0,051	Three Phase	N/A
23th	0,016	0,018	0,021	0,075	0,083	0,097	Three Phase	N/A
24th	0,015	0,011	0,012	0,068	0,049	0,055	Three Phase	N/A
25th	0,017	0,016	0,008	0,079	0,075	0,037	Three Phase	N/A
26th	0,007	0,010	0,009	0,034	0,048	0,043	Three Phase	N/A
27th	0,006	0,011	0,012	0,028	0,050	0,053	Three Phase	N/A
28th	0,007	0,010	0,009	0,033	0,046	0,039	Three Phase	N/A
29th	0,016	0,015	0,019	0,074	0,068	0,087	Three Phase	N/A
30th	0,011	0,009	0,011	0,052	0,040	0,048	Three Phase	N/A
31th	0,017	0,016	0,009	0,078	0,073	0,040	Three Phase	N/A
32th	0,006	0,008	0,007	0,028	0,037	0,033	Three Phase	N/A
33th	0,006	0,006	0,007	0,025	0,028	0,031	Three Phase	N/A
34th	0,006	0,007	0,006	0,026	0,034	0,029	Three Phase	N/A
35th	0,017	0,016	0,019	0,076	0,074	0,088	Three Phase	N/A
36th	0,009	0,006	0,008	0,040	0,028	0,036	Three Phase	N/A
37th	0,018	0,017	0,010	0,080	0,076	0,045	Three Phase	N/A
38th	0,005	0,006	0,006	0,022	0,028	0,026	Three Phase	N/A
39th	0,005	0,005	0,005	0,022	0,023	0,023	Three Phase	N/A
40th	0,005	0,006	0,005	0,023	0,028	0,025	Three Phase	N/A

Note:
The tests should be based on the limits of the EN 61000-3-12 for more than 16A.

The test had been performed on the model SUN2000-15KTL-M0,the test results are valid for the SUN2000-15KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PVAT190424N048 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-07-22.

SUN2000-17KTL-M0

Watts(W)	5742	5708	5689
Vrms(V)	232,37	231,24	231,17
Arms(A)	24,721	24,695	24,617
Frequency(Hz)	50,00		
THD* (100% output power)	0,661	0,685	0,734

Harmonics	Current Magnitude (A)			% of Fundamental			Phase	Harmonic Current Limits (%)
	L1	L2	L3	L1	L2	L3		
1st	24,716	24,689	24,615	99,979	99,975	99,990	Three Phase	--
2nd	0,040	0,037	0,049	0,162	0,151	0,198	Three Phase	8,000
3rd	0,032	0,058	0,052	0,129	0,236	0,213	Three Phase	21,600
4th	0,016	0,012	0,016	0,064	0,048	0,066	Three Phase	4,000
5th	0,125	0,124	0,141	0,506	0,503	0,572	Three Phase	10,700
6th	0,009	0,012	0,011	0,036	0,050	0,043	Three Phase	2,667
7th	0,057	0,040	0,044	0,230	0,161	0,179	Three Phase	7,200
8th	0,011	0,013	0,013	0,044	0,053	0,054	Three Phase	2,000
9th	0,012	0,024	0,015	0,048	0,097	0,062	Three Phase	3,800
10th	0,013	0,013	0,013	0,052	0,054	0,054	Three Phase	1,600
11th	0,013	0,012	0,013	0,053	0,049	0,051	Three Phase	3,100
12th	0,009	0,013	0,011	0,035	0,054	0,046	Three Phase	1,333
13th	0,012	0,022	0,021	0,050	0,091	0,086	Three Phase	2,000
14th	0,011	0,013	0,013	0,045	0,051	0,052	Three Phase	8,000
15th	0,010	0,016	0,015	0,039	0,065	0,062	Three Phase	N/A
16th	0,012	0,012	0,012	0,049	0,048	0,050	Three Phase	N/A
17th	0,016	0,019	0,017	0,066	0,076	0,070	Three Phase	N/A
18th	0,008	0,012	0,011	0,034	0,050	0,046	Three Phase	N/A
19th	0,019	0,021	0,012	0,075	0,086	0,049	Three Phase	N/A
20th	0,011	0,012	0,012	0,044	0,048	0,051	Three Phase	N/A
21th	0,009	0,016	0,013	0,037	0,065	0,054	Three Phase	N/A
22th	0,011	0,010	0,011	0,043	0,040	0,043	Three Phase	N/A
23th	0,016	0,018	0,021	0,064	0,072	0,084	Three Phase	N/A
24th	0,007	0,011	0,010	0,029	0,044	0,039	Three Phase	N/A
25th	0,020	0,018	0,010	0,081	0,073	0,041	Three Phase	N/A
26th	0,009	0,010	0,011	0,038	0,041	0,045	Three Phase	N/A
27th	0,008	0,014	0,013	0,031	0,055	0,053	Three Phase	N/A
28th	0,009	0,008	0,009	0,037	0,033	0,035	Three Phase	N/A
29th	0,016	0,017	0,020	0,066	0,070	0,082	Three Phase	N/A
30th	0,006	0,010	0,009	0,025	0,041	0,038	Three Phase	N/A
31th	0,020	0,017	0,010	0,081	0,067	0,040	Three Phase	N/A
32th	0,008	0,009	0,009	0,033	0,034	0,037	Three Phase	N/A
33th	0,006	0,008	0,008	0,026	0,032	0,031	Three Phase	N/A
34th	0,008	0,006	0,007	0,031	0,026	0,029	Three Phase	N/A
35th	0,017	0,018	0,021	0,070	0,074	0,086	Three Phase	N/A
36th	0,006	0,008	0,006	0,023	0,032	0,026	Three Phase	N/A
37th	0,020	0,017	0,011	0,082	0,070	0,043	Three Phase	N/A
38th	0,007	0,007	0,008	0,027	0,029	0,032	Three Phase	N/A
39th	0,005	0,006	0,006	0,022	0,026	0,023	Three Phase	N/A

40th	0,007	0,006	0,006	0,029	0,023	0,026	Three Phase	N/A

Note:
The tests should be based on the limits of the EN 61000-3-12 for more than 16A.

The test had been performed on the model SUN2000-17KTL-M0,the test results are valid for the SUN2000-17KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PVAT190424N048 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-07-22.

SUN2000-20KTL-M0								
Watts(W)					6673		6680	6630
Vrms(V)					230,56		230,59	230,78
Arms(A)					28,948		28,970	28,750
Frequency(Hz)					50,00			
THD* (100% output power)					0,788		0,880	0,856
Harmonics	Current Magnitude (A)			% of Fundamental			Phase	Harmonic Current Limits (%)
	L1	L2	L3	L1	L2	L3		
1st	28,942	28,963	28,744	99,977	99,976	99,977	Three Phase	--
2nd	0,093	0,098	0,094	0,320	0,338	0,328	Three Phase	8,000
3rd	0,026	0,045	0,063	0,090	0,156	0,218	Three Phase	21,600
4th	0,011	0,021	0,019	0,038	0,073	0,068	Three Phase	4,000
5th	0,169	0,188	0,180	0,583	0,651	0,625	Three Phase	10,700
6th	0,022	0,017	0,018	0,075	0,058	0,061	Three Phase	2,667
7th	0,068	0,087	0,075	0,236	0,302	0,261	Three Phase	7,200
8th	0,010	0,017	0,016	0,035	0,059	0,056	Three Phase	2,000
9th	0,019	0,025	0,022	0,066	0,086	0,075	Three Phase	3,800
10th	0,011	0,012	0,013	0,040	0,041	0,047	Three Phase	1,600
11th	0,038	0,024	0,025	0,132	0,085	0,087	Three Phase	3,100
12th	0,014	0,015	0,013	0,048	0,051	0,044	Three Phase	1,333
13th	0,033	0,034	0,021	0,114	0,117	0,071	Three Phase	2,000
14th	0,010	0,014	0,014	0,036	0,050	0,049	Three Phase	8,000
15th	0,018	0,028	0,023	0,061	0,096	0,081	Three Phase	N/A
16th	0,012	0,014	0,013	0,043	0,048	0,044	Three Phase	N/A
17th	0,027	0,018	0,029	0,094	0,062	0,099	Three Phase	N/A
18th	0,009	0,013	0,013	0,032	0,047	0,044	Three Phase	N/A
19th	0,026	0,022	0,017	0,091	0,076	0,061	Three Phase	N/A
20th	0,013	0,012	0,013	0,046	0,040	0,046	Three Phase	N/A
21th	0,016	0,019	0,018	0,056	0,066	0,062	Three Phase	N/A
22th	0,010	0,016	0,013	0,036	0,057	0,046	Three Phase	N/A
23th	0,022	0,018	0,027	0,075	0,064	0,094	Three Phase	N/A
24th	0,011	0,013	0,014	0,037	0,044	0,048	Three Phase	N/A
25th	0,011	0,011	0,012	0,038	0,039	0,041	Three Phase	N/A
26th	0,011	0,011	0,011	0,037	0,039	0,038	Three Phase	N/A
27th	0,014	0,016	0,015	0,048	0,055	0,051	Three Phase	N/A
28th	0,010	0,013	0,012	0,036	0,043	0,041	Three Phase	N/A
29th	0,016	0,013	0,021	0,055	0,046	0,072	Three Phase	N/A
30th	0,014	0,013	0,014	0,049	0,044	0,050	Three Phase	N/A
31th	0,016	0,017	0,017	0,054	0,058	0,058	Three Phase	N/A
32th	0,011	0,012	0,011	0,039	0,041	0,039	Three Phase	N/A
33th	0,011	0,016	0,014	0,039	0,055	0,047	Three Phase	N/A
34th	0,008	0,013	0,011	0,027	0,044	0,040	Three Phase	N/A
35th	0,015	0,014	0,018	0,052	0,050	0,063	Three Phase	N/A

36th	0,015	0,013	0,016	0,050	0,044	0,057	Three Phase	N/A
37th	0,016	0,017	0,015	0,055	0,058	0,051	Three Phase	N/A
38th	0,011	0,013	0,014	0,040	0,046	0,047	Three Phase	N/A
39th	0,009	0,011	0,011	0,031	0,039	0,037	Three Phase	N/A
40th	0,007	0,011	0,011	0,025	0,037	0,037	Three Phase	N/A

Note:
The tests should be based on the limits of the EN 61000-3-12 for more than 16A.

The test had been performed on the model SUN2000-20KTL-M0,the test results are valid for the SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PVAT190424N048 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-07-22.

5.2.4.2 Additional measurements for PGUs intended for PGSs with nominal currents > 75 A	P

The currents of the interharmonics to 2 kHz must be measured in accordance with DIN EN 61000-4-7 (VDE 0817-4-7), Annex A. The measurements of higher-frequency harmonic currents between 2 kHz and 9 kHz must be conducted in line with DIN EN 61000-4-7 (VDE 0847-4-7), Annex B.

Harmonics (SUN2000-8KTL-M0)

P/P_n [%]	5	10	20	30	40	50	60	70	80	90	100
Order	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
1	3,867	9,858	19,985	30,104	40,311	54,961	60,270	70,350	80,425	93,325	101,597
2	0,277	0,443	0,520	0,406	0,462	0,585	0,623	0,588	0,611	0,624	0,618
3	0,344	0,242	0,312	0,324	0,307	0,300	0,250	0,240	0,208	0,167	0,152
4	0,149	0,233	0,320	0,211	0,324	0,321	0,324	0,349	0,373	0,402	0,402
5	0,368	0,436	0,427	0,749	0,728	0,608	0,472	0,515	0,617	0,739	0,778
6	0,084	0,141	0,319	0,281	0,232	0,227	0,233	0,189	0,214	0,211	0,181
7	0,451	0,610	0,881	0,860	0,812	0,633	0,618	0,717	0,810	0,860	0,863
8	0,066	0,115	0,175	0,131	0,110	0,162	0,204	0,232	0,224	0,203	0,175
9	0,073	0,071	0,137	0,194	0,170	0,189	0,236	0,241	0,210	0,172	0,178
10	0,128	0,266	0,316	0,291	0,349	0,381	0,402	0,379	0,362	0,355	0,360
11	0,306	0,406	0,436	0,472	0,432	0,486	0,444	0,368	0,349	0,378	0,401
12	0,194	0,416	0,594	0,373	0,580	0,554	0,598	0,601	0,634	0,620	0,550
13	0,220	0,187	0,234	0,331	0,262	0,121	0,181	0,199	0,219	0,231	0,241
14	0,118	0,257	0,402	0,315	0,465	0,415	0,366	0,303	0,320	0,336	0,332
15	0,106	0,172	0,167	0,295	0,260	0,307	0,280	0,240	0,225	0,237	0,246
16	0,145	0,307	0,488	0,399	0,373	0,454	0,472	0,422	0,387	0,378	0,389
17	0,169	0,178	0,375	0,227	0,317	0,232	0,246	0,372	0,339	0,288	0,251
18	0,167	0,377	0,638	0,455	0,570	0,597	0,638	0,598	0,553	0,514	0,481
19	0,198	0,318	0,193	0,293	0,239	0,259	0,276	0,232	0,233	0,236	0,260
20	0,104	0,217	0,372	0,289	0,295	0,423	0,442	0,392	0,370	0,350	0,337
21	0,089	0,115	0,191	0,142	0,200	0,251	0,197	0,182	0,175	0,174	0,174
22	0,056	0,068	0,150	0,186	0,161	0,128	0,125	0,228	0,264	0,264	0,250
23	0,097	0,166	0,170	0,188	0,180	0,129	0,137	0,139	0,153	0,146	0,142
24	0,072	0,108	0,156	0,079	0,227	0,134	0,179	0,125	0,180	0,199	0,191
25	0,120	0,226	0,141	0,166	0,163	0,183	0,202	0,156	0,150	0,143	0,127
26	0,065	0,109	0,129	0,148	0,188	0,167	0,205	0,189	0,214	0,252	0,265
27	0,064	0,068	0,090	0,108	0,136	0,144	0,124	0,142	0,126	0,143	0,183
28	0,099	0,192	0,299	0,267	0,253	0,263	0,262	0,255	0,217	0,186	0,152
29	0,064	0,096	0,162	0,132	0,155	0,138	0,112	0,107	0,125	0,132	0,136
30	0,128	0,274	0,373	0,308	0,439	0,389	0,388	0,409	0,409	0,396	0,376
31	0,089	0,137	0,063	0,109	0,134	0,140	0,056	0,104	0,091	0,115	0,131
32	0,084	0,173	0,245	0,173	0,250	0,258	0,290	0,278	0,264	0,253	0,244
33	0,068	0,087	0,094	0,112	0,140	0,118	0,140	0,100	0,109	0,109	0,115
34	0,078	0,114	0,147	0,177	0,186	0,177	0,186	0,155	0,182	0,211	0,216
35	0,096	0,136	0,185	0,170	0,152	0,115	0,105	0,123	0,133	0,139	0,127
36	0,057	0,081	0,228	0,121	0,144	0,146	0,161	0,136	0,105	0,115	0,100
37	0,092	0,099	0,090	0,117	0,151	0,160	0,183	0,153	0,154	0,142	0,107
38	0,062	0,087	0,139	0,140	0,113	0,146	0,174	0,120	0,103	0,121	0,118
39	0,062	0,074	0,125	0,091	0,111	0,106	0,115	0,102	0,086	0,081	0,087
40	0,059	0,094	0,109	0,094	0,126	0,125	0,120	0,153	0,147	0,138	0,151
41	0,217	0,175	0,191	0,138	0,151	0,225	0,240	0,212	0,209	0,210	0,184
42	0,090	0,162	0,192	0,097	0,170	0,159	0,158	0,190	0,199	0,194	0,186
43	0,240	0,278	0,201	0,227	0,247	0,236	0,232	0,245	0,251	0,233	0,190

44	0,087	0,135	0,098	0,120	0,166	0,151	0,153	0,186	0,183	0,171	0,150
45	0,057	0,045	0,076	0,074	0,071	0,063	0,061	0,058	0,063	0,065	0,075
46	0,066	0,098	0,177	0,135	0,116	0,142	0,140	0,135	0,120	0,110	0,113
47	0,199	0,166	0,121	0,146	0,187	0,144	0,158	0,184	0,191	0,203	0,203
48	0,064	0,099	0,199	0,101	0,151	0,195	0,201	0,174	0,154	0,143	0,142
49	0,205	0,259	0,257	0,173	0,194	0,176	0,177	0,251	0,296	0,299	0,236
50	0,061	0,084	0,128	0,136	0,109	0,114	0,128	0,113	0,093	0,098	0,105
THC [%]	1,086	1,458	1,969	1,730	1,817	1,763	1,779	1,770	1,844	1,897	1,855
THDU50 [%]	0,191	0,238	0,228	0,207	0,236	0,249	0,255	0,258	0,266	0,271	0,270

Interharmonics at continuous operation (SUN2000-8KTL-M0)

P/P$_n$ [%]	5	10	20	30	40	50	60	70	80	90	100
f [Hz]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]
75	0,055	0,063	0,069	0,098	0,094	0,092	0,090	0,095	0,092	0,100	0,091
125	0,053	0,063	0,081	0,077	0,083	0,086	0,093	0,104	0,103	0,101	0,096
175	0,052	0,060	0,066	0,088	0,093	0,094	0,101	0,110	0,097	0,099	0,098
225	0,055	0,066	0,078	0,083	0,084	0,094	0,099	0,097	0,093	0,102	0,095
275	0,048	0,056	0,069	0,080	0,073	0,080	0,080	0,088	0,088	0,089	0,088
325	0,052	0,062	0,074	0,091	0,090	0,091	0,096	0,097	0,094	0,089	0,094
375	0,054	0,062	0,063	0,074	0,071	0,086	0,092	0,095	0,088	0,100	0,096
425	0,054	0,062	0,071	0,096	0,088	0,079	0,086	0,096	0,100	0,097	0,094
475	0,061	0,065	0,072	0,089	0,094	0,095	0,093	0,102	0,099	0,108	0,105
525	0,059	0,069	0,088	0,102	0,091	0,100	0,100	0,109	0,110	0,119	0,115
575	0,054	0,063	0,073	0,081	0,082	0,083	0,084	0,086	0,093	0,090	0,090
625	0,058	0,065	0,075	0,093	0,091	0,101	0,100	0,107	0,107	0,113	0,118
675	0,060	0,062	0,084	0,094	0,094	0,091	0,094	0,091	0,087	0,091	0,088
725	0,061	0,067	0,086	0,105	0,104	0,091	0,094	0,102	0,110	0,111	0,103
775	0,071	0,065	0,085	0,088	0,092	0,100	0,101	0,104	0,097	0,102	0,103
825	0,063	0,065	0,091	0,115	0,118	0,102	0,097	0,104	0,104	0,098	0,094
875	0,058	0,059	0,075	0,079	0,084	0,097	0,094	0,097	0,104	0,105	0,102
925	0,061	0,058	0,076	0,113	0,098	0,087	0,084	0,085	0,091	0,086	0,089
975	0,068	0,054	0,086	0,092	0,083	0,093	0,090	0,085	0,085	0,097	0,097
1025	0,063	0,058	0,089	0,096	0,101	0,094	0,095	0,094	0,096	0,099	0,094
1075	0,078	0,052	0,074	0,084	0,085	0,086	0,090	0,086	0,080	0,087	0,084
1125	0,065	0,057	0,075	0,079	0,086	0,097	0,086	0,084	0,089	0,085	0,082
1175	0,059	0,049	0,065	0,079	0,074	0,068	0,064	0,072	0,074	0,074	0,068
1225	0,061	0,048	0,065	0,084	0,082	0,074	0,072	0,069	0,072	0,070	0,070
1275	0,072	0,051	0,058	0,073	0,072	0,071	0,071	0,066	0,065	0,071	0,071
1325	0,063	0,052	0,059	0,090	0,090	0,068	0,067	0,064	0,072	0,069	0,066
1375	0,077	0,050	0,061	0,066	0,075	0,068	0,063	0,060	0,064	0,065	0,064
1425	0,062	0,054	0,063	0,076	0,072	0,063	0,058	0,056	0,062	0,060	0,064
1475	0,058	0,049	0,058	0,067	0,078	0,062	0,059	0,058	0,063	0,065	0,062
1525	0,058	0,048	0,057	0,077	0,067	0,061	0,057	0,058	0,066	0,069	0,071
1575	0,069	0,050	0,064	0,069	0,083	0,068	0,068	0,060	0,062	0,068	0,072
1625	0,057	0,049	0,061	0,073	0,076	0,064	0,062	0,060	0,074	0,075	0,071
1675	0,073	0,049	0,064	0,065	0,068	0,059	0,053	0,053	0,055	0,061	0,063
1725	0,056	0,049	0,056	0,073	0,075	0,060	0,059	0,060	0,061	0,059	0,057
1775	0,052	0,044	0,053	0,055	0,063	0,057	0,058	0,056	0,059	0,060	0,057

1825	0,052	0,043	0,051	0,095	0,078	0,052	0,050	0,051	0,050	0,053	0,052
1875	0,061	0,048	0,060	0,059	0,066	0,055	0,057	0,053	0,055	0,060	0,065
1925	0,049	0,043	0,055	0,080	0,072	0,055	0,053	0,051	0,054	0,051	0,050
1975	0,064	0,044	0,053	0,055	0,064	0,052	0,050	0,048	0,054	0,054	0,054

Higher Frequencies components (SUN2000-8KTL-M0)											
P/P_n [%]	5	10	20	30	40	50	60	70	80	90	100
f [kHz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
2,1	0,341	0,360	0,372	0,298	0,379	0,384	0,383	0,399	0,415	0,403	0,350
2,3	0,232	0,220	0,271	0,237	0,284	0,283	0,287	0,290	0,294	0,289	0,266
2,5	0,238	0,297	0,314	0,267	0,267	0,272	0,273	0,322	0,349	0,346	0,293
2,7	0,266	0,323	0,333	0,370	0,333	0,287	0,267	0,271	0,304	0,318	0,301
2,9	0,187	0,273	0,343	0,321	0,341	0,271	0,261	0,249	0,249	0,265	0,268
3,1	0,168	0,257	0,267	0,274	0,253	0,212	0,203	0,198	0,194	0,188	0,187
3,3	0,233	0,419	0,415	0,404	0,385	0,362	0,271	0,255	0,242	0,244	0,229
3,5	0,189	0,345	0,362	0,353	0,377	0,287	0,267	0,256	0,248	0,241	0,232
3,7	0,184	0,339	0,401	0,389	0,430	0,412	0,359	0,326	0,298	0,264	0,239
3,9	0,191	0,333	0,468	0,478	0,524	0,550	0,507	0,466	0,431	0,426	0,451
4,1	0,126	0,192	0,236	0,297	0,334	0,332	0,343	0,323	0,301	0,282	0,304
4,3	0,116	0,182	0,272	0,211	0,266	0,261	0,282	0,283	0,268	0,233	0,210
4,5	0,113	0,147	0,155	0,166	0,168	0,182	0,186	0,192	0,180	0,165	0,156
4,7	0,082	0,099	0,091	0,105	0,106	0,109	0,110	0,110	0,113	0,112	0,110
4,9	0,076	0,075	0,091	0,089	0,093	0,090	0,092	0,091	0,090	0,087	0,086
5,1	0,073	0,075	0,070	0,073	0,074	0,076	0,081	0,081	0,082	0,081	0,078
5,3	0,068	0,065	0,062	0,069	0,070	0,072	0,067	0,069	0,074	0,075	0,072
5,5	0,065	0,059	0,061	0,065	0,065	0,066	0,066	0,066	0,066	0,071	0,069
5,7	0,061	0,058	0,057	0,062	0,060	0,060	0,058	0,058	0,058	0,060	0,061
5,9	0,059	0,055	0,055	0,060	0,059	0,058	0,057	0,057	0,057	0,058	0,058
6,1	0,058	0,053	0,054	0,059	0,059	0,058	0,056	0,057	0,056	0,057	0,057
6,3	0,058	0,053	0,053	0,059	0,057	0,055	0,055	0,054	0,055	0,055	0,056
6,5	0,057	0,053	0,052	0,057	0,055	0,055	0,054	0,054	0,054	0,054	0,054
6,7	0,056	0,053	0,053	0,056	0,056	0,055	0,053	0,053	0,054	0,054	0,054
6,9	0,056	0,054	0,053	0,056	0,056	0,055	0,053	0,054	0,053	0,054	0,054
7,1	0,056	0,052	0,052	0,056	0,055	0,054	0,052	0,053	0,053	0,053	0,052
7,3	0,057	0,054	0,053	0,055	0,056	0,054	0,052	0,053	0,053	0,053	0,053
7,5	0,057	0,054	0,053	0,056	0,056	0,054	0,054	0,053	0,054	0,053	0,052
7,7	0,056	0,053	0,052	0,056	0,055	0,054	0,052	0,052	0,052	0,052	0,052
7,9	0,056	0,053	0,053	0,055	0,056	0,054	0,053	0,053	0,053	0,053	0,053
8,1	0,056	0,052	0,052	0,055	0,056	0,054	0,052	0,053	0,053	0,052	0,052
8,3	0,055	0,052	0,052	0,054	0,054	0,054	0,052	0,052	0,052	0,052	0,052
8,5	0,055	0,052	0,052	0,054	0,055	0,054	0,052	0,052	0,052	0,052	0,052
8,7	0,055	0,052	0,052	0,054	0,055	0,053	0,052	0,052	0,052	0,052	0,052

8,9	0,055	0,052	0,052	0,054	0,055	0,054	0,052	0,052	0,052	0,052	0,052

Harmonics (SUN2000-10KTL-M0)

P/P_n [%]	5	10	20	30	40	50	60	70	80	90	100
Order	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
1	2,784	9,904	20,033	30,171	40,211	53,458	60,319	70,422	84,746	90,505	101,570
2	0,180	0,270	0,296	0,356	0,413	0,421	0,429	0,446	0,458	0,439	0,412
3	0,280	0,296	0,409	0,410	0,389	0,371	0,339	0,315	0,294	0,258	0,250
4	0,106	0,184	0,171	0,147	0,216	0,216	0,207	0,210	0,205	0,218	0,244
5	0,298	0,314	0,471	0,616	0,497	0,439	0,470	0,591	0,664	0,694	0,749
6	0,092	0,252	0,226	0,232	0,188	0,173	0,168	0,190	0,210	0,227	0,216
7	0,366	0,598	0,738	0,679	0,494	0,527	0,590	0,663	0,679	0,689	0,723
8	0,044	0,082	0,160	0,225	0,231	0,221	0,193	0,212	0,182	0,168	0,153
9	0,059	0,107	0,101	0,138	0,123	0,170	0,190	0,175	0,159	0,149	0,143
10	0,078	0,197	0,257	0,269	0,348	0,319	0,272	0,288	0,297	0,274	0,286
11	0,209	0,110	0,269	0,175	0,258	0,216	0,126	0,108	0,130	0,145	0,159
12	0,097	0,237	0,324	0,379	0,420	0,494	0,508	0,474	0,407	0,417	0,387
13	0,189	0,218	0,245	0,201	0,272	0,290	0,184	0,184	0,208	0,202	0,219
14	0,053	0,129	0,150	0,220	0,256	0,246	0,220	0,221	0,246	0,257	0,241
15	0,053	0,062	0,065	0,101	0,141	0,168	0,124	0,104	0,082	0,075	0,083
16	0,068	0,150	0,218	0,173	0,143	0,152	0,172	0,168	0,168	0,145	0,137
17	0,146	0,224	0,306	0,267	0,178	0,259	0,240	0,187	0,167	0,173	0,186
18	0,077	0,203	0,287	0,351	0,344	0,331	0,286	0,301	0,289	0,266	0,233
19	0,112	0,143	0,101	0,098	0,167	0,170	0,121	0,165	0,185	0,182	0,196
20	0,054	0,102	0,180	0,257	0,197	0,184	0,157	0,136	0,142	0,156	0,155
21	0,057	0,053	0,068	0,062	0,091	0,106	0,125	0,113	0,083	0,064	0,070
22	0,068	0,161	0,197	0,175	0,191	0,246	0,259	0,239	0,218	0,221	0,235
23	0,055	0,092	0,107	0,107	0,108	0,096	0,081	0,088	0,086	0,067	0,072
24	0,058	0,129	0,177	0,196	0,211	0,226	0,234	0,220	0,224	0,243	0,277
25	0,081	0,169	0,121	0,137	0,098	0,109	0,107	0,121	0,123	0,129	0,149
26	0,043	0,077	0,097	0,096	0,138	0,197	0,214	0,185	0,171	0,159	0,164
27	0,049	0,047	0,059	0,068	0,060	0,095	0,091	0,107	0,086	0,064	0,062
28	0,051	0,104	0,181	0,130	0,122	0,114	0,122	0,130	0,132	0,133	0,156
29	0,039	0,059	0,097	0,080	0,077	0,086	0,105	0,090	0,089	0,088	0,109
30	0,060	0,138	0,219	0,266	0,255	0,258	0,241	0,243	0,230	0,211	0,213
31	0,060	0,104	0,074	0,059	0,067	0,065	0,077	0,097	0,105	0,108	0,096
32	0,047	0,099	0,131	0,221	0,173	0,170	0,189	0,198	0,192	0,182	0,174
33	0,047	0,053	0,058	0,083	0,054	0,036	0,054	0,046	0,038	0,041	0,044
34	0,052	0,072	0,114	0,079	0,096	0,100	0,120	0,128	0,110	0,077	0,079
35	0,058	0,041	0,100	0,101	0,093	0,093	0,094	0,078	0,069	0,096	0,097
36	0,051	0,091	0,135	0,123	0,095	0,095	0,118	0,107	0,108	0,106	0,128
37	0,084	0,147	0,140	0,141	0,124	0,121	0,134	0,148	0,175	0,170	0,144
38	0,047	0,066	0,060	0,065	0,048	0,057	0,075	0,067	0,070	0,071	0,092
39	0,043	0,040	0,043	0,058	0,052	0,054	0,051	0,054	0,044	0,046	0,048
40	0,061	0,117	0,158	0,141	0,133	0,124	0,114	0,129	0,117	0,109	0,111
41	0,173	0,195	0,186	0,139	0,122	0,185	0,217	0,209	0,240	0,244	0,223
42	0,061	0,128	0,169	0,222	0,194	0,215	0,216	0,206	0,193	0,200	0,205
43	0,204	0,294	0,271	0,211	0,126	0,107	0,082	0,124	0,150	0,144	0,107
44	0,050	0,068	0,089	0,145	0,123	0,142	0,152	0,150	0,146	0,143	0,150
45	0,044	0,052	0,052	0,070	0,063	0,056	0,052	0,044	0,041	0,036	0,038
46	0,049	0,082	0,105	0,082	0,053	0,070	0,078	0,067	0,061	0,071	0,096
47	0,168	0,209	0,281	0,248	0,200	0,192	0,198	0,245	0,261	0,260	0,231
48	0,047	0,084	0,122	0,115	0,117	0,128	0,129	0,127	0,128	0,132	0,133

49	0,145	0,110	0,109	0,145	0,137	0,151	0,156	0,144	0,120	0,109	0,153
50	0,050	0,085	0,111	0,114	0,106	0,087	0,061	0,076	0,073	0,066	0,081
THC [%]	0,813	1,092	1,371	1,387	1,321	1,331	1,354	1,399	1,455	1,480	1,504
THDU40 [%]	0,186	0,228	0,233	0,237	0,236	0,246	0,254	0,265	0,274	0,276	0,276

Interharmonics at continuous operation (SUN2000-10KTL-M0)

P/Pn [%]	5	10	20	30	40	50	60	70	80	90	100
f [Hz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
75	0,050	0,040	0,068	0,065	0,067	0,067	0,061	0,068	0,068	0,062	0,062
125	0,040	0,043	0,062	0,063	0,068	0,066	0,063	0,064	0,066	0,067	0,074
175	0,040	0,045	0,054	0,065	0,068	0,070	0,070	0,071	0,070	0,071	0,081
225	0,042	0,045	0,061	0,064	0,067	0,066	0,066	0,066	0,068	0,074	0,080
275	0,038	0,044	0,056	0,062	0,062	0,062	0,064	0,063	0,063	0,072	0,080
325	0,042	0,047	0,061	0,073	0,079	0,078	0,078	0,079	0,080	0,087	0,092
375	0,041	0,044	0,057	0,059	0,065	0,066	0,065	0,063	0,061	0,066	0,075
425	0,041	0,045	0,063	0,068	0,073	0,072	0,071	0,074	0,075	0,079	0,079
475	0,045	0,047	0,062	0,070	0,074	0,077	0,080	0,079	0,074	0,076	0,079
525	0,046	0,047	0,074	0,066	0,068	0,072	0,072	0,071	0,070	0,073	0,075
575	0,041	0,045	0,063	0,063	0,073	0,071	0,069	0,069	0,071	0,073	0,070
625	0,046	0,047	0,061	0,071	0,070	0,070	0,072	0,071	0,072	0,078	0,084
675	0,046	0,044	0,056	0,059	0,064	0,065	0,067	0,064	0,062	0,064	0,069
725	0,044	0,044	0,059	0,059	0,063	0,070	0,070	0,068	0,071	0,077	0,079
775	0,053	0,041	0,056	0,059	0,059	0,066	0,067	0,067	0,070	0,075	0,081
825	0,051	0,041	0,068	0,064	0,066	0,068	0,067	0,068	0,070	0,074	0,081
875	0,046	0,040	0,054	0,054	0,053	0,055	0,056	0,055	0,057	0,065	0,077
925	0,050	0,040	0,062	0,064	0,067	0,068	0,069	0,073	0,079	0,083	0,080
975	0,054	0,038	0,054	0,054	0,053	0,054	0,055	0,053	0,056	0,061	0,066
1025	0,047	0,039	0,060	0,063	0,064	0,062	0,057	0,063	0,065	0,066	0,068
1075	0,058	0,038	0,051	0,049	0,052	0,055	0,056	0,056	0,056	0,059	0,059
1125	0,054	0,036	0,052	0,049	0,046	0,051	0,052	0,050	0,050	0,051	0,055
1175	0,048	0,037	0,048	0,049	0,050	0,051	0,050	0,050	0,052	0,053	0,052
1225	0,052	0,035	0,045	0,047	0,043	0,047	0,048	0,047	0,050	0,055	0,065
1275	0,056	0,035	0,044	0,045	0,048	0,046	0,046	0,048	0,050	0,050	0,054
1325	0,046	0,036	0,049	0,044	0,044	0,047	0,048	0,047	0,051	0,055	0,063
1375	0,059	0,036	0,039	0,044	0,043	0,048	0,051	0,049	0,051	0,052	0,057
1425	0,052	0,032	0,049	0,046	0,045	0,044	0,046	0,047	0,048	0,050	0,050
1475	0,047	0,035	0,042	0,044	0,042	0,041	0,040	0,039	0,039	0,040	0,044
1525	0,048	0,034	0,048	0,046	0,045	0,042	0,044	0,046	0,051	0,051	0,049
1575	0,055	0,032	0,043	0,044	0,042	0,041	0,043	0,043	0,046	0,047	0,049
1625	0,043	0,033	0,045	0,052	0,047	0,044	0,039	0,043	0,044	0,042	0,041
1675	0,055	0,033	0,035	0,036	0,035	0,035	0,035	0,035	0,036	0,036	0,038
1725	0,047	0,031	0,039	0,039	0,036	0,037	0,040	0,040	0,042	0,044	0,043
1775	0,040	0,033	0,040	0,038	0,036	0,035	0,034	0,035	0,036	0,036	0,039
1825	0,042	0,030	0,041	0,042	0,037	0,037	0,038	0,037	0,040	0,043	0,050
1875	0,050	0,031	0,034	0,039	0,037	0,035	0,035	0,038	0,039	0,039	0,040
1925	0,037	0,033	0,039	0,037	0,034	0,038	0,039	0,037	0,041	0,043	0,045
1975	0,048	0,028	0,034	0,036	0,031	0,037	0,037	0,037	0,038	0,038	0,039

Higher Frequencies components (SUN2000-10KTL-M0)											
P/P_n [%]	5	10	20	30	40	50	60	70	80	90	100
f [kHz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
2,1	0,284	0,360	0,355	0,337	0,274	0,315	0,341	0,332	0,364	0,369	0,351
2,3	0,194	0,240	0,328	0,297	0,246	0,249	0,261	0,280	0,303	0,309	0,286
2,5	0,173	0,175	0,201	0,228	0,218	0,224	0,229	0,216	0,213	0,221	0,250
2,7	0,190	0,203	0,277	0,270	0,248	0,251	0,251	0,245	0,246	0,250	0,264
2,9	0,136	0,217	0,211	0,190	0,176	0,191	0,208	0,201	0,180	0,166	0,195
3,1	0,129	0,226	0,283	0,263	0,209	0,198	0,199	0,201	0,221	0,239	0,242
3,3	0,165	0,338	0,343	0,307	0,237	0,211	0,200	0,197	0,205	0,220	0,237
3,5	0,118	0,232	0,221	0,308	0,231	0,239	0,212	0,215	0,218	0,228	0,243
3,7	0,135	0,292	0,344	0,334	0,298	0,297	0,294	0,287	0,250	0,222	0,244
3,9	0,137	0,266	0,271	0,426	0,422	0,398	0,412	0,411	0,374	0,349	0,371
4,1	0,096	0,166	0,175	0,247	0,285	0,275	0,287	0,290	0,290	0,298	0,312
4,3	0,081	0,116	0,186	0,168	0,147	0,156	0,169	0,189	0,206	0,183	0,187
4,5	0,085	0,117	0,118	0,124	0,118	0,109	0,114	0,114	0,117	0,098	0,112
4,7	0,063	0,079	0,080	0,081	0,081	0,083	0,085	0,090	0,097	0,097	0,093
4,9	0,059	0,066	0,068	0,068	0,071	0,071	0,072	0,071	0,074	0,073	0,073
5,1	0,056	0,059	0,060	0,058	0,058	0,056	0,056	0,057	0,060	0,057	0,059
5,3	0,052	0,047	0,052	0,050	0,050	0,051	0,050	0,052	0,053	0,054	0,057
5,5	0,048	0,046	0,048	0,048	0,046	0,047	0,048	0,047	0,048	0,049	0,048
5,7	0,044	0,044	0,046	0,047	0,045	0,046	0,046	0,047	0,047	0,046	0,048
5,9	0,043	0,043	0,046	0,044	0,044	0,044	0,043	0,045	0,046	0,045	0,046
6,1	0,041	0,042	0,044	0,044	0,044	0,043	0,043	0,044	0,043	0,043	0,045
6,3	0,042	0,042	0,045	0,043	0,043	0,043	0,043	0,043	0,043	0,044	0,044
6,5	0,041	0,042	0,044	0,043	0,042	0,043	0,041	0,042	0,042	0,043	0,043
6,7	0,041	0,042	0,044	0,043	0,042	0,043	0,042	0,042	0,042	0,042	0,042
6,9	0,041	0,042	0,044	0,043	0,042	0,043	0,042	0,042	0,042	0,042	0,043
7,1	0,040	0,042	0,044	0,043	0,042	0,043	0,042	0,043	0,042	0,042	0,042
7,3	0,041	0,042	0,045	0,043	0,042	0,042	0,041	0,041	0,041	0,041	0,042
7,5	0,042	0,042	0,044	0,043	0,041	0,042	0,041	0,042	0,041	0,041	0,042
7,7	0,041	0,042	0,043	0,042	0,041	0,042	0,041	0,041	0,041	0,041	0,042
7,9	0,041	0,042	0,043	0,042	0,042	0,042	0,041	0,042	0,041	0,042	0,042
8,1	0,041	0,041	0,043	0,043	0,042	0,042	0,041	0,042	0,041	0,041	0,042
8,3	0,040	0,041	0,043	0,042	0,041	0,042	0,041	0,041	0,041	0,041	0,041
8,5	0,041	0,041	0,043	0,042	0,041	0,042	0,041	0,041	0,041	0,041	0,042
8,7	0,041	0,041	0,043	0,042	0,041	0,042	0,040	0,041	0,041	0,041	0,042
8,9	0,040	0,041	0,043	0,042	0,041	0,042	0,041	0,042	0,041	0,041	0,042

Harmonics (SUN2000-12KTL-M0)											
P/P_n [%]	5	10	20	30	40	50	60	70	80	90	100
Order	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
1	3,271	10,223	21,091	34,285	42,190	52,321	60,406	73,420	84,340	91,695	101,650
2	0,150	0,168	0,201	0,282	0,352	0,395	0,426	0,464	0,497	0,520	0,612

3	0,212	0,197	0,237	0,235	0,202	0,199	0,220	0,212	0,234	0,244	0,242
4	0,051	0,051	0,093	0,089	0,085	0,106	0,114	0,113	0,113	0,115	0,145
5	0,246	0,226	0,385	0,240	0,271	0,312	0,365	0,427	0,462	0,477	0,512
6	0,031	0,034	0,057	0,059	0,051	0,064	0,074	0,073	0,075	0,079	0,101
7	0,244	0,246	0,205	0,162	0,088	0,146	0,190	0,246	0,294	0,314	0,258
8	0,023	0,033	0,051	0,075	0,052	0,057	0,060	0,061	0,058	0,064	0,125
9	0,047	0,040	0,044	0,057	0,082	0,116	0,129	0,131	0,123	0,119	0,123
10	0,023	0,020	0,035	0,054	0,051	0,055	0,055	0,061	0,060	0,064	0,115
11	0,177	0,167	0,289	0,268	0,124	0,079	0,064	0,129	0,155	0,170	0,244
12	0,026	0,020	0,047	0,063	0,069	0,060	0,051	0,057	0,061	0,067	0,119
13	0,154	0,148	0,090	0,266	0,153	0,095	0,048	0,066	0,104	0,118	0,094
14	0,026	0,021	0,026	0,041	0,047	0,052	0,055	0,051	0,051	0,059	0,119
15	0,044	0,037	0,041	0,083	0,056	0,060	0,070	0,095	0,102	0,104	0,123
16	0,025	0,023	0,034	0,057	0,062	0,066	0,061	0,054	0,055	0,058	0,090
17	0,110	0,107	0,152	0,084	0,125	0,108	0,080	0,060	0,070	0,098	0,187
18	0,035	0,029	0,033	0,048	0,056	0,061	0,058	0,056	0,060	0,067	0,114
19	0,073	0,067	0,140	0,091	0,102	0,108	0,093	0,066	0,048	0,064	0,108
20	0,031	0,019	0,030	0,040	0,047	0,056	0,058	0,057	0,057	0,057	0,093
21	0,051	0,045	0,049	0,064	0,057	0,063	0,093	0,103	0,087	0,064	0,090
22	0,027	0,025	0,034	0,044	0,059	0,058	0,063	0,061	0,057	0,051	0,076
23	0,039	0,038	0,049	0,036	0,044	0,061	0,055	0,054	0,052	0,064	0,136
24	0,032	0,023	0,036	0,035	0,036	0,043	0,056	0,057	0,056	0,060	0,089
25	0,037	0,038	0,052	0,068	0,043	0,082	0,092	0,070	0,039	0,048	0,100
26	0,033	0,025	0,032	0,053	0,035	0,046	0,052	0,054	0,056	0,055	0,074
27	0,040	0,040	0,054	0,042	0,056	0,052	0,061	0,071	0,068	0,052	0,061
28	0,031	0,027	0,036	0,034	0,042	0,058	0,059	0,060	0,061	0,051	0,055
29	0,039	0,040	0,062	0,073	0,044	0,034	0,062	0,061	0,053	0,061	0,125
30	0,035	0,026	0,043	0,048	0,042	0,047	0,040	0,048	0,054	0,060	0,079
31	0,040	0,045	0,057	0,049	0,070	0,044	0,065	0,080	0,045	0,045	0,101
32	0,033	0,022	0,034	0,034	0,037	0,049	0,051	0,053	0,058	0,057	0,057
33	0,035	0,039	0,046	0,046	0,039	0,053	0,045	0,060	0,065	0,053	0,043
34	0,026	0,026	0,032	0,027	0,031	0,037	0,043	0,055	0,066	0,066	0,090
35	0,060	0,064	0,084	0,069	0,079	0,051	0,036	0,064	0,068	0,050	0,086
36	0,032	0,025	0,028	0,029	0,033	0,038	0,041	0,037	0,046	0,047	0,054
37	0,065	0,071	0,106	0,098	0,063	0,087	0,031	0,073	0,079	0,040	0,073
38	0,032	0,030	0,039	0,030	0,033	0,035	0,035	0,044	0,050	0,053	0,084
39	0,042	0,044	0,045	0,057	0,062	0,074	0,057	0,066	0,095	0,084	0,063
40	0,029	0,038	0,040	0,034	0,030	0,029	0,030	0,031	0,050	0,063	0,102
41	0,173	0,185	0,200	0,240	0,144	0,203	0,081	0,147	0,159	0,104	0,074
42	0,035	0,032	0,032	0,039	0,046	0,043	0,055	0,043	0,045	0,051	0,062
43	0,165	0,195	0,149	0,162	0,180	0,186	0,138	0,130	0,186	0,133	0,087
44	0,036	0,036	0,024	0,027	0,025	0,024	0,026	0,023	0,027	0,037	0,085
45	0,040	0,046	0,056	0,059	0,061	0,042	0,068	0,048	0,060	0,071	0,067
46	0,043	0,047	0,038	0,037	0,036	0,044	0,037	0,036	0,038	0,052	0,086
47	0,139	0,158	0,201	0,170	0,182	0,109	0,139	0,100	0,141	0,116	0,075
48	0,029	0,029	0,020	0,020	0,026	0,033	0,031	0,034	0,027	0,030	0,055
49	0,127	0,149	0,135	0,155	0,146	0,094	0,161	0,105	0,124	0,134	0,070
50	0,027	0,025	0,020	0,023	0,021	0,027	0,027	0,028	0,023	0,023	0,057
THC [%]	0,610	0,595	0,742	0,696	0,643	0,680	0,711	0,769	0,838	0,857	0,987
THDU50 [%]	0,184	0,190	0,212	0,224	0,224	0,227	0,230	0,233	0,243	0,290	0,714

Interharmonics at continuous operation (SUN2000-12KTL-M0)											
P/Pn [%]	5	10	20	30	40	50	60	70	80	90	100
f [Hz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
75	0,033	0,030	0,040	0,049	0,047	0,047	0,044	0,048	0,048	0,048	0,043
125	0,034	0,034	0,041	0,048	0,048	0,051	0,051	0,052	0,051	0,051	0,047
175	0,030	0,032	0,040	0,049	0,048	0,051	0,051	0,050	0,049	0,049	0,047
225	0,034	0,031	0,040	0,051	0,052	0,055	0,053	0,056	0,057	0,055	0,047
275	0,031	0,030	0,035	0,042	0,043	0,042	0,042	0,042	0,044	0,043	0,043
325	0,032	0,030	0,038	0,046	0,046	0,044	0,043	0,044	0,045	0,044	0,044
375	0,032	0,029	0,037	0,048	0,050	0,050	0,049	0,049	0,047	0,046	0,044
425	0,038	0,035	0,041	0,045	0,046	0,047	0,046	0,048	0,049	0,049	0,042
475	0,035	0,036	0,041	0,047	0,050	0,052	0,053	0,052	0,050	0,050	0,044
525	0,038	0,035	0,041	0,046	0,048	0,049	0,049	0,052	0,054	0,054	0,042
575	0,035	0,033	0,038	0,039	0,038	0,039	0,039	0,040	0,041	0,041	0,040
625	0,037	0,033	0,041	0,043	0,043	0,041	0,041	0,041	0,042	0,041	0,039
675	0,038	0,033	0,039	0,045	0,047	0,048	0,048	0,047	0,045	0,044	0,040
725	0,042	0,038	0,043	0,041	0,041	0,042	0,041	0,044	0,046	0,046	0,038
775	0,039	0,041	0,044	0,047	0,048	0,048	0,049	0,049	0,047	0,045	0,041
825	0,043	0,038	0,043	0,044	0,043	0,042	0,042	0,045	0,046	0,045	0,037
875	0,040	0,038	0,040	0,039	0,038	0,037	0,037	0,037	0,038	0,038	0,037
925	0,041	0,036	0,042	0,040	0,038	0,037	0,038	0,038	0,038	0,037	0,036
975	0,044	0,038	0,046	0,045	0,047	0,047	0,045	0,045	0,043	0,043	0,038
1025	0,047	0,041	0,045	0,040	0,039	0,038	0,038	0,040	0,041	0,042	0,034
1075	0,043	0,046	0,051	0,044	0,045	0,045	0,045	0,044	0,042	0,042	0,036
1125	0,044	0,040	0,045	0,037	0,038	0,036	0,037	0,039	0,040	0,039	0,032
1175	0,043	0,039	0,041	0,035	0,034	0,036	0,036	0,035	0,036	0,035	0,034
1225	0,042	0,035	0,043	0,035	0,034	0,033	0,034	0,033	0,034	0,033	0,032
1275	0,047	0,042	0,050	0,043	0,044	0,045	0,044	0,043	0,041	0,040	0,035
1325	0,046	0,040	0,044	0,035	0,035	0,034	0,035	0,036	0,038	0,037	0,030
1375	0,044	0,047	0,054	0,041	0,041	0,043	0,044	0,043	0,040	0,040	0,033
1425	0,041	0,039	0,042	0,033	0,033	0,032	0,032	0,035	0,035	0,035	0,027
1475	0,042	0,038	0,040	0,033	0,032	0,034	0,034	0,035	0,035	0,035	0,031
1525	0,040	0,033	0,039	0,032	0,030	0,031	0,031	0,031	0,030	0,030	0,029
1575	0,045	0,042	0,053	0,046	0,043	0,043	0,043	0,042	0,039	0,039	0,033
1625	0,042	0,036	0,042	0,035	0,032	0,031	0,032	0,033	0,035	0,034	0,026
1675	0,041	0,045	0,051	0,043	0,038	0,039	0,039	0,038	0,035	0,036	0,028
1725	0,037	0,037	0,038	0,034	0,031	0,030	0,030	0,031	0,032	0,032	0,024
1775	0,038	0,033	0,035	0,031	0,031	0,033	0,033	0,032	0,032	0,032	0,028
1825	0,035	0,030	0,035	0,030	0,028	0,028	0,028	0,029	0,028	0,027	0,025
1875	0,040	0,038	0,048	0,049	0,041	0,039	0,038	0,037	0,035	0,036	0,030
1925	0,035	0,032	0,035	0,034	0,030	0,029	0,029	0,031	0,032	0,032	0,023
1975	0,035	0,041	0,045	0,043	0,036	0,035	0,035	0,035	0,032	0,032	0,024

Higher Frequencies components (SUN2000-12KTL-M0)											
P/Pn [%]	5	10	20	30	40	50	60	70	80	90	100
f [kHz]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]
2,1	0,251	0,278	0,258	0,288	0,239	0,277	0,177	0,201	0,246	0,178	0,154
2,3	0,161	0,179	0,216	0,193	0,202	0,134	0,168	0,132	0,167	0,149	0,136
2,5	0,149	0,169	0,156	0,169	0,165	0,136	0,172	0,137	0,143	0,155	0,124
2,7	0,172	0,193	0,146	0,131	0,151	0,181	0,174	0,162	0,150	0,165	0,115
2,9	0,108	0,120	0,088	0,108	0,121	0,122	0,101	0,116	0,100	0,117	0,086
3,1	0,101	0,109	0,093	0,118	0,123	0,105	0,091	0,114	0,092	0,098	0,076
3,3	0,107	0,111	0,132	0,137	0,117	0,116	0,124	0,115	0,113	0,101	0,076
3,5	0,079	0,077	0,098	0,117	0,100	0,094	0,086	0,080	0,082	0,079	0,057
3,7	0,078	0,076	0,098	0,105	0,102	0,098	0,089	0,082	0,087	0,080	0,064
3,9	0,088	0,081	0,097	0,093	0,088	0,090	0,092	0,094	0,089	0,089	0,071
4,1	0,068	0,064	0,075	0,069	0,071	0,074	0,076	0,074	0,071	0,070	0,065
4,3	0,063	0,060	0,066	0,063	0,069	0,072	0,072	0,071	0,065	0,068	0,060
4,5	0,069	0,063	0,064	0,062	0,065	0,071	0,069	0,068	0,071	0,070	0,062
4,7	0,053	0,050	0,050	0,050	0,052	0,051	0,051	0,051	0,051	0,051	0,051
4,9	0,051	0,049	0,048	0,050	0,052	0,050	0,049	0,048	0,050	0,048	0,047
5,1	0,050	0,048	0,046	0,049	0,047	0,047	0,048	0,046	0,046	0,047	0,046
5,3	0,047	0,045	0,044	0,044	0,043	0,045	0,045	0,044	0,043	0,044	0,046
5,5	0,043	0,042	0,042	0,041	0,041	0,040	0,041	0,041	0,040	0,040	0,041
5,7	0,040	0,040	0,038	0,037	0,036	0,036	0,037	0,037	0,037	0,037	0,037
5,9	0,038	0,037	0,038	0,036	0,036	0,036	0,037	0,037	0,036	0,036	0,037
6,1	0,037	0,036	0,035	0,035	0,035	0,035	0,036	0,036	0,036	0,036	0,036
6,3	0,037	0,037	0,036	0,035	0,035	0,035	0,036	0,036	0,036	0,036	0,036
6,5	0,037	0,035	0,035	0,035	0,035	0,034	0,035	0,035	0,035	0,035	0,036
6,7	0,037	0,035	0,034	0,034	0,034	0,035	0,035	0,035	0,035	0,036	0,036
6,9	0,037	0,035	0,034	0,034	0,034	0,035	0,035	0,035	0,035	0,036	0,036
7,1	0,036	0,035	0,034	0,034	0,034	0,034	0,035	0,035	0,035	0,036	0,036
7,3	0,037	0,036	0,035	0,034	0,034	0,034	0,035	0,035	0,035	0,035	0,036
7,5	0,037	0,035	0,034	0,034	0,034	0,035	0,035	0,035	0,035	0,035	0,036
7,7	0,037	0,035	0,034	0,033	0,033	0,034	0,034	0,034	0,034	0,035	0,036
7,9	0,037	0,035	0,034	0,034	0,034	0,034	0,035	0,035	0,035	0,035	0,036
8,1	0,037	0,035	0,034	0,034	0,034	0,034	0,035	0,035	0,035	0,035	0,035
8,3	0,037	0,035	0,034	0,034	0,033	0,033	0,035	0,034	0,035	0,035	0,035
8,5	0,037	0,035	0,033	0,033	0,033	0,034	0,035	0,034	0,034	0,035	0,035
8,7	0,037	0,035	0,033	0,033	0,033	0,034	0,034	0,034	0,035	0,035	0,035
8,9	0,037	0,035	0,034	0,033	0,033	0,033	0,034	0,034	0,034	0,035	0,035

Harmonics (SUN2000-15KTL-M0)											
P/P_n [%]	5	10	20	30	40	50	60	70	80	90	100
Order	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
1	4,740	13,439	20,130	34,789	40,223	51,613	60,356	74,090	80,588	90,521	101,572
2	0,115	0,101	0,162	0,263	0,291	0,336	0,362	0,425	0,479	0,521	0,542
3	0,186	0,199	0,195	0,171	0,156	0,159	0,174	0,188	0,186	0,189	0,222
4	0,042	0,050	0,070	0,060	0,079	0,084	0,080	0,086	0,109	0,112	0,129
5	0,203	0,181	0,251	0,211	0,242	0,313	0,364	0,377	0,398	0,420	0,430
6	0,021	0,028	0,042	0,041	0,049	0,058	0,057	0,068	0,082	0,085	0,081
7	0,236	0,297	0,123	0,077	0,106	0,148	0,190	0,247	0,197	0,225	0,248
8	0,019	0,031	0,053	0,047	0,044	0,047	0,046	0,064	0,097	0,106	0,111
9	0,040	0,045	0,055	0,065	0,090	0,104	0,102	0,096	0,098	0,091	0,094
10	0,018	0,023	0,038	0,045	0,042	0,047	0,048	0,063	0,092	0,093	0,098
11	0,147	0,167	0,274	0,172	0,063	0,063	0,110	0,147	0,188	0,205	0,192
12	0,022	0,021	0,032	0,053	0,047	0,043	0,046	0,065	0,093	0,103	0,106
13	0,136	0,157	0,172	0,155	0,077	0,047	0,060	0,093	0,073	0,091	0,115
14	0,022	0,020	0,032	0,037	0,039	0,041	0,038	0,060	0,094	0,108	0,115
15	0,037	0,046	0,074	0,056	0,047	0,065	0,081	0,088	0,100	0,096	0,106
16	0,019	0,018	0,024	0,052	0,052	0,048	0,042	0,053	0,072	0,085	0,100
17	0,091	0,073	0,068	0,094	0,087	0,062	0,042	0,094	0,143	0,147	0,151
18	0,028	0,020	0,030	0,048	0,048	0,045	0,046	0,061	0,089	0,105	0,113
19	0,067	0,074	0,063	0,072	0,087	0,075	0,030	0,053	0,086	0,104	0,099
20	0,027	0,018	0,029	0,046	0,044	0,046	0,041	0,050	0,073	0,096	0,109
21	0,044	0,034	0,053	0,058	0,045	0,081	0,079	0,062	0,072	0,085	0,096
22	0,021	0,017	0,024	0,052	0,045	0,050	0,044	0,046	0,058	0,068	0,081
23	0,034	0,033	0,036	0,037	0,049	0,046	0,033	0,066	0,106	0,120	0,133
24	0,027	0,021	0,031	0,034	0,032	0,044	0,046	0,054	0,071	0,083	0,099
25	0,029	0,030	0,038	0,047	0,063	0,063	0,039	0,052	0,081	0,097	0,106
26	0,028	0,022	0,038	0,036	0,035	0,041	0,041	0,045	0,058	0,066	0,083
27	0,033	0,032	0,035	0,044	0,040	0,054	0,058	0,050	0,048	0,063	0,084
28	0,023	0,019	0,027	0,031	0,045	0,048	0,048	0,042	0,044	0,046	0,061
29	0,031	0,034	0,037	0,043	0,026	0,049	0,039	0,061	0,099	0,115	0,128
30	0,029	0,020	0,026	0,031	0,037	0,032	0,039	0,049	0,061	0,066	0,080
31	0,034	0,047	0,063	0,060	0,033	0,061	0,054	0,049	0,077	0,090	0,103
32	0,028	0,019	0,030	0,030	0,038	0,043	0,042	0,045	0,046	0,048	0,062
33	0,030	0,034	0,035	0,033	0,044	0,040	0,053	0,049	0,035	0,035	0,054
34	0,021	0,026	0,029	0,024	0,028	0,032	0,048	0,057	0,071	0,063	0,049
35	0,047	0,056	0,072	0,060	0,042	0,037	0,059	0,049	0,068	0,092	0,111
36	0,026	0,023	0,030	0,027	0,030	0,030	0,031	0,038	0,040	0,043	0,052
37	0,059	0,070	0,048	0,048	0,070	0,041	0,063	0,044	0,057	0,081	0,101
38	0,026	0,028	0,028	0,029	0,028	0,027	0,037	0,050	0,067	0,044	0,043
39	0,033	0,042	0,056	0,058	0,059	0,041	0,065	0,074	0,050	0,043	0,065
40	0,034	0,051	0,029	0,025	0,023	0,025	0,029	0,057	0,080	0,070	0,065
41	0,140	0,162	0,197	0,167	0,163	0,084	0,130	0,104	0,063	0,083	0,102
42	0,029	0,032	0,022	0,032	0,033	0,041	0,025	0,041	0,050	0,035	0,023
43	0,168	0,222	0,212	0,193	0,148	0,097	0,130	0,127	0,074	0,078	0,119
44	0,038	0,048	0,023	0,022	0,019	0,020	0,016	0,040	0,067	0,062	0,049
45	0,033	0,044	0,034	0,038	0,028	0,055	0,028	0,059	0,054	0,039	0,036
46	0,045	0,062	0,028	0,034	0,035	0,032	0,027	0,047	0,067	0,064	0,052
47	0,133	0,164	0,127	0,134	0,083	0,090	0,092	0,100	0,063	0,053	0,078
48	0,029	0,036	0,015	0,024	0,027	0,028	0,022	0,029	0,044	0,038	0,028
49	0,126	0,164	0,103	0,093	0,066	0,118	0,066	0,111	0,060	0,054	0,074
50	0,033	0,046	0,020	0,019	0,021	0,022	0,020	0,025	0,044	0,057	0,054

THC [%]	0,513	0,566	0,625	0,532	0,525	0,564	0,624	0,706	0,777	0,844	0,903
THDU50 [%]	0,199	0,221	0,225	0,225	0,226	0,228	0,236	0,412	0,709	0,721	0,737

Interharmonics at continuous operation (SUN2000-15KTL-M0)											
P/P_n [%]	5	10	20	30	40	50	60	70	80	90	100
f [Hz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
75	0,025	0,026	0,034	0,039	0,035	0,041	0,036	0,039	0,034	0,039	0,038
125	0,028	0,025	0,037	0,041	0,040	0,042	0,041	0,041	0,038	0,039	0,038
175	0,025	0,024	0,037	0,041	0,041	0,042	0,040	0,040	0,037	0,038	0,038
225	0,028	0,024	0,036	0,041	0,042	0,042	0,044	0,044	0,038	0,038	0,041
275	0,025	0,021	0,029	0,034	0,034	0,035	0,035	0,035	0,035	0,035	0,034
325	0,026	0,022	0,033	0,037	0,036	0,036	0,035	0,035	0,036	0,036	0,036
375	0,026	0,024	0,033	0,038	0,038	0,037	0,037	0,037	0,034	0,033	0,036
425	0,031	0,024	0,034	0,037	0,039	0,037	0,039	0,039	0,035	0,035	0,039
475	0,029	0,025	0,035	0,040	0,042	0,042	0,041	0,039	0,034	0,036	0,038
525	0,032	0,024	0,035	0,038	0,039	0,039	0,041	0,042	0,034	0,036	0,041
575	0,028	0,022	0,030	0,031	0,032	0,033	0,033	0,033	0,033	0,033	0,031
625	0,031	0,023	0,034	0,034	0,034	0,034	0,033	0,032	0,032	0,032	0,032
675	0,031	0,025	0,033	0,036	0,036	0,036	0,036	0,036	0,032	0,031	0,032
725	0,037	0,025	0,034	0,034	0,034	0,034	0,036	0,036	0,032	0,032	0,036
775	0,033	0,027	0,035	0,039	0,039	0,039	0,038	0,036	0,032	0,033	0,034
825	0,036	0,025	0,034	0,035	0,034	0,033	0,036	0,036	0,030	0,032	0,036
875	0,033	0,023	0,030	0,031	0,030	0,030	0,030	0,030	0,030	0,030	0,029
925	0,036	0,025	0,032	0,032	0,031	0,031	0,030	0,030	0,029	0,029	0,028
975	0,036	0,027	0,033	0,036	0,036	0,035	0,035	0,034	0,030	0,028	0,030
1025	0,041	0,026	0,033	0,033	0,031	0,031	0,032	0,033	0,028	0,029	0,033
1075	0,035	0,030	0,037	0,038	0,037	0,036	0,034	0,033	0,028	0,029	0,031
1125	0,037	0,026	0,032	0,032	0,029	0,029	0,031	0,032	0,026	0,029	0,032
1175	0,035	0,024	0,029	0,028	0,027	0,027	0,028	0,028	0,027	0,028	0,026
1225	0,038	0,026	0,030	0,028	0,028	0,028	0,027	0,027	0,025	0,026	0,025
1275	0,038	0,030	0,037	0,035	0,034	0,033	0,032	0,032	0,028	0,026	0,026
1325	0,041	0,027	0,033	0,030	0,028	0,028	0,029	0,029	0,025	0,026	0,029
1375	0,035	0,035	0,038	0,036	0,035	0,035	0,032	0,032	0,026	0,027	0,027
1425	0,035	0,027	0,030	0,028	0,026	0,027	0,028	0,028	0,022	0,025	0,028
1475	0,034	0,025	0,028	0,026	0,026	0,027	0,028	0,028	0,025	0,026	0,025
1525	0,035	0,026	0,029	0,026	0,027	0,027	0,025	0,024	0,023	0,024	0,024
1575	0,036	0,033	0,040	0,035	0,032	0,032	0,030	0,030	0,026	0,025	0,025
1625	0,038	0,027	0,031	0,027	0,025	0,026	0,028	0,027	0,021	0,022	0,026
1675	0,033	0,038	0,039	0,034	0,031	0,032	0,029	0,028	0,023	0,023	0,023
1725	0,031	0,029	0,029	0,027	0,024	0,024	0,025	0,025	0,019	0,022	0,024
1775	0,030	0,025	0,025	0,024	0,025	0,025	0,025	0,025	0,023	0,023	0,023
1825	0,030	0,027	0,026	0,024	0,023	0,024	0,023	0,022	0,020	0,021	0,021
1875	0,031	0,034	0,038	0,034	0,029	0,029	0,028	0,028	0,024	0,021	0,022
1925	0,032	0,028	0,027	0,026	0,023	0,023	0,025	0,025	0,019	0,020	0,023
1975	0,032	0,042	0,036	0,033	0,029	0,029	0,026	0,026	0,019	0,020	0,021

Higher Frequencies components (SUN2000-15KTL-M0)

P/Pn [%]	5	10	20	30	40	50	60	70	80	90	100
f [kHz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
2,1	0,229	0,281	0,294	0,262	0,221	0,146	0,184	0,168	0,127	0,139	0,168
2,3	0,154	0,192	0,141	0,150	0,103	0,115	0,111	0,128	0,107	0,105	0,104
2,5	0,145	0,186	0,122	0,119	0,105	0,130	0,096	0,126	0,102	0,102	0,116
2,7	0,163	0,204	0,117	0,137	0,146	0,150	0,101	0,134	0,095	0,090	0,100
2,9	0,102	0,125	0,083	0,092	0,098	0,087	0,084	0,088	0,069	0,074	0,082
3,1	0,088	0,100	0,090	0,086	0,084	0,075	0,085	0,077	0,061	0,059	0,069
3,3	0,092	0,101	0,095	0,112	0,091	0,090	0,095	0,084	0,061	0,056	0,057
3,5	0,064	0,073	0,092	0,088	0,075	0,070	0,061	0,065	0,045	0,046	0,048
3,7	0,061	0,066	0,082	0,081	0,079	0,077	0,064	0,065	0,052	0,042	0,045
3,9	0,068	0,066	0,078	0,075	0,071	0,074	0,067	0,073	0,056	0,045	0,042
4,1	0,052	0,050	0,056	0,056	0,059	0,060	0,059	0,057	0,052	0,042	0,039
4,3	0,048	0,048	0,052	0,053	0,058	0,055	0,054	0,054	0,048	0,044	0,037
4,5	0,053	0,048	0,049	0,053	0,057	0,058	0,057	0,056	0,051	0,046	0,040
4,7	0,042	0,040	0,039	0,043	0,041	0,041	0,041	0,041	0,040	0,040	0,036
4,9	0,040	0,040	0,042	0,042	0,041	0,040	0,040	0,039	0,039	0,038	0,038
5,1	0,040	0,039	0,037	0,039	0,038	0,038	0,037	0,038	0,037	0,037	0,036
5,3	0,037	0,036	0,036	0,036	0,036	0,036	0,034	0,035	0,037	0,037	0,037
5,5	0,034	0,034	0,033	0,033	0,033	0,033	0,032	0,032	0,032	0,033	0,034
5,7	0,031	0,032	0,031	0,031	0,030	0,029	0,029	0,030	0,030	0,030	0,031
5,9	0,030	0,030	0,031	0,030	0,030	0,029	0,029	0,029	0,029	0,030	0,031
6,1	0,028	0,030	0,030	0,029	0,029	0,028	0,029	0,029	0,029	0,029	0,030
6,3	0,029	0,030	0,030	0,030	0,029	0,028	0,029	0,029	0,029	0,029	0,029
6,5	0,028	0,029	0,029	0,029	0,029	0,028	0,028	0,028	0,028	0,029	0,029
6,7	0,028	0,029	0,029	0,029	0,029	0,028	0,028	0,028	0,028	0,029	0,028
6,9	0,028	0,029	0,029	0,029	0,029	0,028	0,028	0,028	0,028	0,029	0,028
7,1	0,027	0,028	0,029	0,028	0,029	0,027	0,028	0,028	0,028	0,029	0,028
7,3	0,028	0,029	0,029	0,029	0,029	0,028	0,028	0,028	0,028	0,028	0,028
7,5	0,027	0,029	0,029	0,029	0,028	0,027	0,028	0,028	0,028	0,028	0,028
7,7	0,027	0,028	0,029	0,028	0,028	0,027	0,028	0,028	0,028	0,028	0,028
7,9	0,027	0,029	0,029	0,028	0,028	0,027	0,028	0,028	0,028	0,028	0,028
8,1	0,028	0,028	0,029	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,028
8,3	0,027	0,028	0,029	0,028	0,028	0,027	0,028	0,028	0,028	0,028	0,027
8,5	0,027	0,028	0,028	0,028	0,028	0,027	0,028	0,028	0,028	0,028	0,028
8,7	0,027	0,028	0,028	0,028	0,028	0,027	0,027	0,028	0,028	0,028	0,027
8,9	0,028	0,028	0,029	0,028	0,028	0,027	0,028	0,028	0,028	0,028	0,027

Harmonics (SUN2000-17KTL-M0)

P/Pn [%]	5	10	20	30	40	50	60	70	80	90	100
Order	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
1	0,152	11,528	20,123	30,151	44,477	50,292	60,356	70,424	84,855	90,498	101,485
2	0,101	0,120	0,154	0,333	0,393	0,386	0,404	0,459	0,491	0,499	0,504

3	0,154	0,126	0,171	0,255	0,227	0,178	0,162	0,129	0,114	0,088	0,099
4	0,037	0,062	0,060	0,141	0,143	0,135	0,145	0,161	0,171	0,165	0,165
5	0,179	0,209	0,153	0,349	0,574	0,635	0,779	0,918	1,032	1,083	1,073
6	0,019	0,038	0,040	0,096	0,110	0,116	0,125	0,154	0,170	0,175	0,183
7	0,178	0,273	0,126	0,443	0,461	0,470	0,497	0,471	0,478	0,498	0,520
8	0,017	0,027	0,051	0,098	0,087	0,090	0,095	0,191	0,210	0,213	0,197
9	0,035	0,068	0,036	0,096	0,078	0,056	0,057	0,098	0,111	0,116	0,124
10	0,017	0,020	0,037	0,223	0,228	0,218	0,210	0,202	0,205	0,213	0,198
11	0,129	0,103	0,204	0,170	0,210	0,218	0,253	0,336	0,339	0,352	0,339
12	0,019	0,023	0,034	0,381	0,384	0,347	0,334	0,360	0,353	0,323	0,298
13	0,111	0,125	0,197	0,108	0,088	0,098	0,105	0,130	0,120	0,120	0,114
14	0,020	0,018	0,027	0,193	0,216	0,185	0,171	0,142	0,136	0,145	0,132
15	0,033	0,037	0,069	0,078	0,067	0,078	0,097	0,142	0,151	0,153	0,170
16	0,018	0,023	0,035	0,191	0,193	0,188	0,194	0,251	0,279	0,284	0,297
17	0,081	0,068	0,048	0,081	0,108	0,120	0,113	0,109	0,104	0,105	0,087
18	0,025	0,021	0,028	0,190	0,205	0,206	0,227	0,185	0,171	0,174	0,195
19	0,055	0,043	0,070	0,142	0,133	0,127	0,123	0,123	0,123	0,106	0,092
20	0,025	0,020	0,024	0,116	0,105	0,120	0,148	0,240	0,286	0,307	0,332
21	0,039	0,044	0,045	0,094	0,074	0,060	0,063	0,103	0,102	0,104	0,104
22	0,019	0,020	0,020	0,125	0,149	0,127	0,117	0,109	0,104	0,099	0,102
23	0,030	0,029	0,032	0,055	0,078	0,068	0,070	0,111	0,133	0,144	0,164
24	0,023	0,019	0,022	0,161	0,159	0,151	0,146	0,129	0,138	0,148	0,151
25	0,026	0,030	0,051	0,054	0,049	0,044	0,049	0,080	0,087	0,086	0,084
26	0,026	0,022	0,035	0,118	0,138	0,129	0,124	0,144	0,153	0,165	0,142
27	0,030	0,029	0,029	0,033	0,054	0,068	0,081	0,077	0,069	0,072	0,087
28	0,022	0,020	0,025	0,113	0,122	0,105	0,110	0,120	0,166	0,183	0,192
29	0,027	0,024	0,033	0,055	0,069	0,073	0,070	0,066	0,074	0,079	0,089
30	0,026	0,024	0,030	0,160	0,186	0,190	0,197	0,183	0,173	0,163	0,160
31	0,026	0,032	0,031	0,062	0,078	0,077	0,077	0,079	0,065	0,068	0,073
32	0,026	0,023	0,026	0,093	0,084	0,084	0,085	0,085	0,104	0,114	0,126
33	0,026	0,028	0,033	0,058	0,047	0,041	0,049	0,046	0,041	0,050	0,071
34	0,017	0,018	0,020	0,056	0,074	0,073	0,071	0,062	0,062	0,065	0,086
35	0,041	0,052	0,059	0,078	0,075	0,076	0,074	0,077	0,092	0,102	0,109
36	0,022	0,019	0,020	0,063	0,061	0,058	0,055	0,044	0,074	0,087	0,107
37	0,044	0,049	0,072	0,067	0,061	0,049	0,071	0,095	0,102	0,103	0,107
38	0,022	0,026	0,022	0,066	0,078	0,074	0,068	0,050	0,059	0,071	0,079
39	0,029	0,032	0,040	0,031	0,038	0,042	0,044	0,037	0,028	0,034	0,047
40	0,018	0,027	0,026	0,069	0,067	0,065	0,077	0,085	0,084	0,088	0,072
41	0,119	0,164	0,157	0,129	0,112	0,120	0,117	0,105	0,113	0,120	0,140
42	0,025	0,022	0,024	0,115	0,126	0,127	0,124	0,112	0,106	0,101	0,088
43	0,106	0,128	0,148	0,092	0,046	0,046	0,071	0,073	0,093	0,100	0,125
44	0,025	0,026	0,021	0,073	0,069	0,068	0,067	0,067	0,066	0,062	0,047
45	0,025	0,035	0,035	0,048	0,042	0,041	0,047	0,048	0,043	0,041	0,053
46	0,028	0,040	0,025	0,045	0,040	0,039	0,045	0,055	0,058	0,061	0,058
47	0,092	0,134	0,113	0,090	0,053	0,026	0,027	0,043	0,062	0,069	0,093
48	0,020	0,020	0,013	0,066	0,061	0,050	0,048	0,043	0,044	0,050	0,065
49	0,082	0,104	0,081	0,139	0,133	0,127	0,144	0,132	0,136	0,145	0,146
50	0,020	0,022	0,016	0,029	0,042	0,042	0,035	0,036	0,050	0,056	0,064
THC [%]	0,434	0,491	0,512	0,964	1,063	1,078	1,175	1,309	1,441	1,505	1,508
THDU50 [%]	0,181	0,205	0,220	0,253	0,274	0,278	0,285	0,738	0,758	0,769	0,784

Interharmonics at continuous operation (SUN2000-17KTL-M0)											
P/P$_n$ [%]	5	10	20	30	40	50	60	70	80	90	100
f [Hz]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]
75	0,021	0,025	0,032	0,049	0,052	0,052	0,053	0,058	0,066	0,061	0,059
125	0,025	0,026	0,032	0,046	0,052	0,050	0,047	0,048	0,058	0,057	0,057
175	0,023	0,026	0,034	0,052	0,050	0,049	0,050	0,051	0,054	0,048	0,053
225	0,026	0,025	0,035	0,052	0,051	0,051	0,051	0,051	0,053	0,055	0,061
275	0,022	0,022	0,028	0,042	0,045	0,046	0,045	0,052	0,051	0,046	0,049
325	0,023	0,024	0,031	0,048	0,058	0,061	0,066	0,060	0,058	0,053	0,057
375	0,024	0,024	0,032	0,052	0,051	0,048	0,048	0,049	0,047	0,044	0,049
425	0,028	0,026	0,030	0,050	0,063	0,060	0,059	0,054	0,051	0,045	0,056
475	0,026	0,027	0,031	0,052	0,055	0,049	0,049	0,050	0,052	0,053	0,058
525	0,028	0,025	0,031	0,056	0,062	0,062	0,058	0,064	0,070	0,074	0,066
575	0,025	0,022	0,028	0,047	0,052	0,050	0,049	0,047	0,049	0,047	0,055
625	0,027	0,024	0,030	0,044	0,056	0,058	0,057	0,060	0,069	0,075	0,063
675	0,028	0,026	0,030	0,054	0,050	0,048	0,050	0,049	0,049	0,051	0,048
725	0,032	0,028	0,029	0,050	0,053	0,048	0,048	0,048	0,056	0,060	0,057
775	0,029	0,029	0,031	0,050	0,051	0,053	0,050	0,047	0,048	0,050	0,049
825	0,032	0,027	0,031	0,056	0,058	0,058	0,059	0,057	0,056	0,058	0,059
875	0,029	0,024	0,027	0,036	0,040	0,040	0,042	0,049	0,051	0,052	0,047
925	0,031	0,026	0,028	0,044	0,056	0,059	0,068	0,062	0,059	0,052	0,049
975	0,032	0,029	0,030	0,039	0,042	0,042	0,044	0,044	0,051	0,054	0,050
1025	0,036	0,030	0,027	0,048	0,056	0,056	0,056	0,051	0,051	0,049	0,047
1075	0,031	0,030	0,030	0,037	0,040	0,039	0,039	0,037	0,036	0,038	0,045
1125	0,033	0,028	0,026	0,035	0,043	0,045	0,044	0,039	0,044	0,051	0,046
1175	0,031	0,026	0,024	0,036	0,043	0,042	0,043	0,039	0,039	0,042	0,038
1225	0,032	0,027	0,025	0,033	0,041	0,043	0,042	0,035	0,040	0,049	0,051
1275	0,034	0,032	0,030	0,036	0,037	0,038	0,040	0,034	0,033	0,036	0,038
1325	0,036	0,031	0,025	0,034	0,036	0,037	0,038	0,033	0,036	0,040	0,038
1375	0,031	0,030	0,029	0,035	0,037	0,038	0,037	0,032	0,033	0,036	0,035
1425	0,031	0,027	0,025	0,032	0,037	0,039	0,043	0,039	0,040	0,043	0,038
1475	0,030	0,026	0,022	0,029	0,029	0,029	0,029	0,028	0,035	0,038	0,036
1525	0,030	0,026	0,023	0,028	0,033	0,036	0,043	0,046	0,048	0,042	0,036
1575	0,032	0,034	0,033	0,029	0,028	0,030	0,032	0,034	0,038	0,040	0,038
1625	0,033	0,028	0,025	0,031	0,034	0,034	0,037	0,035	0,038	0,039	0,035
1675	0,028	0,029	0,031	0,028	0,026	0,026	0,028	0,026	0,027	0,030	0,030
1725	0,028	0,025	0,025	0,029	0,032	0,033	0,032	0,030	0,031	0,033	0,037
1775	0,027	0,024	0,022	0,025	0,028	0,029	0,031	0,031	0,035	0,037	0,032
1825	0,026	0,023	0,022	0,029	0,033	0,034	0,033	0,027	0,028	0,029	0,033
1875	0,027	0,034	0,034	0,030	0,029	0,031	0,033	0,031	0,031	0,034	0,031
1925	0,027	0,025	0,024	0,028	0,028	0,029	0,029	0,024	0,023	0,026	0,028
1975	0,024	0,030	0,030	0,028	0,027	0,027	0,027	0,023	0,023	0,026	0,025

Higher Frequencies components (SUN2000-17KTL-M0)											
P/Pn [%]	5	10	20	30	40	50	60	70	80	90	100
f [kHz]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]
2,1	0,168	0,213	0,217	0,191	0,185	0,191	0,200	0,187	0,192	0,197	0,211
2,3	0,109	0,153	0,127	0,125	0,105	0,090	0,091	0,099	0,107	0,111	0,135
2,5	0,099	0,125	0,103	0,175	0,173	0,161	0,171	0,162	0,162	0,167	0,170
2,7	0,116	0,161	0,102	0,169	0,169	0,164	0,165	0,156	0,154	0,163	0,181
2,9	0,074	0,104	0,065	0,105	0,119	0,126	0,136	0,132	0,139	0,161	0,188
3,1	0,068	0,097	0,068	0,137	0,132	0,125	0,121	0,106	0,122	0,131	0,178
3,3	0,075	0,092	0,109	0,165	0,163	0,165	0,162	0,137	0,134	0,128	0,238
3,5	0,056	0,059	0,076	0,156	0,149	0,148	0,153	0,126	0,117	0,121	0,152
3,7	0,056	0,063	0,071	0,170	0,169	0,164	0,165	0,146	0,141	0,148	0,152
3,9	0,063	0,059	0,068	0,267	0,274	0,278	0,288	0,231	0,213	0,230	0,207
4,1	0,049	0,047	0,048	0,144	0,166	0,174	0,180	0,156	0,174	0,184	0,167
4,3	0,046	0,044	0,044	0,105	0,117	0,132	0,162	0,139	0,152	0,171	0,157
4,5	0,050	0,047	0,041	0,062	0,076	0,083	0,094	0,085	0,104	0,120	0,125
4,7	0,038	0,037	0,035	0,046	0,053	0,059	0,066	0,063	0,069	0,076	0,084
4,9	0,037	0,035	0,036	0,038	0,041	0,043	0,048	0,050	0,060	0,061	0,071
5,1	0,036	0,035	0,034	0,034	0,036	0,037	0,039	0,039	0,048	0,051	0,053
5,3	0,033	0,032	0,031	0,031	0,031	0,032	0,034	0,035	0,040	0,043	0,045
5,5	0,030	0,029	0,029	0,028	0,029	0,030	0,031	0,032	0,036	0,037	0,038
5,7	0,028	0,028	0,027	0,028	0,029	0,030	0,029	0,030	0,034	0,037	0,035
5,9	0,026	0,027	0,026	0,026	0,027	0,027	0,027	0,028	0,030	0,032	0,033
6,1	0,026	0,025	0,025	0,026	0,027	0,027	0,027	0,028	0,030	0,031	0,030
6,3	0,026	0,025	0,025	0,026	0,026	0,026	0,026	0,027	0,028	0,029	0,030
6,5	0,025	0,025	0,024	0,025	0,025	0,025	0,026	0,026	0,027	0,027	0,028
6,7	0,025	0,025	0,024	0,025	0,025	0,025	0,026	0,026	0,027	0,028	0,028
6,9	0,025	0,025	0,024	0,025	0,025	0,025	0,026	0,026	0,027	0,027	0,027
7,1	0,025	0,025	0,024	0,025	0,025	0,025	0,025	0,025	0,025	0,026	0,026
7,3	0,025	0,024	0,024	0,025	0,025	0,025	0,025	0,025	0,026	0,026	0,026
7,5	0,025	0,025	0,024	0,025	0,025	0,025	0,025	0,025	0,025	0,026	0,026
7,7	0,025	0,024	0,024	0,025	0,024	0,024	0,025	0,025	0,025	0,025	0,025
7,9	0,025	0,025	0,024	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025
8,1	0,025	0,025	0,024	0,024	0,025	0,025	0,025	0,024	0,025	0,024	0,025
8,3	0,025	0,024	0,024	0,024	0,024	0,024	0,025	0,024	0,024	0,024	0,025
8,5	0,025	0,024	0,024	0,024	0,025	0,024	0,025	0,025	0,025	0,025	0,025
8,7	0,025	0,025	0,024	0,024	0,024	0,024	0,025	0,024	0,025	0,025	0,025
8,9	0,025	0,025	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024

Harmonics (SUN2000-20KTL-M0)											
P/Pn [%]	5	10	20	30	40	50	60	70	80	90	100
Order	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]	Ih [%]
1	0,175	10,947	24,361	33,869	40,338	50,326	62,601	71,046	80,431	90,444	101,449
2	0,096	0,125	0,189	0,238	0,256	0,258	0,337	0,389	0,373	0,343	0,385
3	0,131	0,143	0,269	0,252	0,227	0,215	0,202	0,179	0,148	0,121	0,150
4	0,032	0,053	0,106	0,090	0,100	0,128	0,151	0,117	0,124	0,121	0,167
5	0,159	0,226	0,329	0,457	0,551	0,681	0,810	0,892	0,954	0,947	0,781
6	0,017	0,050	0,083	0,086	0,086	0,156	0,125	0,088	0,074	0,097	0,119
7	0,152	0,219	0,348	0,378	0,389	0,393	0,373	0,375	0,399	0,422	0,352
8	0,015	0,025	0,052	0,059	0,072	0,116	0,186	0,178	0,166	0,181	0,171
9	0,031	0,053	0,054	0,063	0,054	0,055	0,079	0,080	0,076	0,081	0,087
10	0,015	0,026	0,063	0,077	0,088	0,111	0,180	0,219	0,206	0,217	0,155
11	0,110	0,101	0,154	0,090	0,099	0,105	0,168	0,181	0,236	0,208	0,162
12	0,018	0,033	0,085	0,079	0,103	0,186	0,243	0,275	0,264	0,248	0,142
13	0,095	0,040	0,100	0,114	0,145	0,151	0,153	0,146	0,151	0,150	0,180
14	0,017	0,022	0,056	0,058	0,059	0,091	0,173	0,157	0,144	0,149	0,168
15	0,029	0,029	0,076	0,092	0,083	0,065	0,088	0,076	0,083	0,096	0,109
16	0,015	0,020	0,045	0,056	0,054	0,108	0,192	0,193	0,183	0,170	0,135
17	0,068	0,100	0,095	0,119	0,111	0,102	0,135	0,158	0,184	0,171	0,131
18	0,023	0,035	0,060	0,062	0,070	0,144	0,177	0,221	0,201	0,165	0,175
19	0,047	0,047	0,137	0,107	0,087	0,056	0,066	0,061	0,066	0,066	0,088
20	0,022	0,024	0,050	0,042	0,054	0,089	0,068	0,081	0,079	0,085	0,134
21	0,034	0,031	0,038	0,039	0,034	0,041	0,090	0,088	0,093	0,099	0,091
22	0,017	0,020	0,042	0,055	0,063	0,101	0,110	0,113	0,121	0,138	0,111
23	0,024	0,033	0,042	0,027	0,026	0,024	0,056	0,080	0,094	0,097	0,089
24	0,022	0,024	0,030	0,047	0,059	0,112	0,073	0,059	0,081	0,104	0,120
25	0,022	0,040	0,050	0,070	0,076	0,078	0,095	0,100	0,098	0,086	0,087
26	0,023	0,028	0,034	0,027	0,037	0,067	0,105	0,110	0,133	0,166	0,136
27	0,026	0,028	0,031	0,043	0,040	0,028	0,052	0,065	0,072	0,076	0,084
28	0,019	0,020	0,043	0,058	0,060	0,078	0,088	0,093	0,085	0,081	0,102
29	0,024	0,027	0,077	0,063	0,063	0,045	0,074	0,079	0,088	0,109	0,069
30	0,024	0,024	0,027	0,026	0,033	0,078	0,111	0,150	0,154	0,150	0,085
31	0,023	0,035	0,043	0,035	0,024	0,035	0,068	0,053	0,062	0,067	0,080
32	0,022	0,021	0,026	0,036	0,047	0,066	0,079	0,104	0,117	0,132	0,117
33	0,022	0,027	0,017	0,018	0,023	0,025	0,020	0,035	0,048	0,058	0,064
34	0,015	0,018	0,019	0,026	0,029	0,034	0,038	0,041	0,056	0,059	0,071
35	0,036	0,043	0,034	0,045	0,051	0,062	0,084	0,096	0,083	0,076	0,086
36	0,020	0,023	0,022	0,030	0,050	0,080	0,064	0,046	0,055	0,059	0,064
37	0,038	0,034	0,026	0,042	0,058	0,059	0,076	0,068	0,067	0,070	0,117
38	0,020	0,023	0,025	0,029	0,036	0,050	0,040	0,028	0,030	0,038	0,059
39	0,025	0,036	0,030	0,029	0,035	0,030	0,027	0,037	0,050	0,060	0,046
40	0,016	0,017	0,015	0,021	0,030	0,051	0,043	0,053	0,063	0,060	0,042
41	0,101	0,161	0,129	0,126	0,090	0,074	0,055	0,051	0,050	0,049	0,172
42	0,021	0,019	0,028	0,025	0,034	0,070	0,073	0,080	0,088	0,091	0,064
43	0,091	0,109	0,082	0,071	0,046	0,062	0,100	0,116	0,107	0,120	0,135
44	0,022	0,023	0,018	0,023	0,029	0,038	0,038	0,052	0,073	0,084	0,045
45	0,023	0,024	0,020	0,013	0,015	0,017	0,020	0,016	0,024	0,032	0,040
46	0,025	0,024	0,024	0,020	0,028	0,053	0,048	0,043	0,035	0,022	0,036
47	0,078	0,091	0,057	0,096	0,104	0,112	0,119	0,116	0,106	0,134	0,166
48	0,017	0,013	0,025	0,026	0,032	0,053	0,051	0,059	0,060	0,049	0,044
49	0,069	0,085	0,039	0,060	0,072	0,040	0,034	0,052	0,070	0,085	0,124
50	0,016	0,014	0,024	0,026	0,029	0,050	0,052	0,058	0,057	0,046	0,040

THC [%]	0,375	0,474	0,677	0,758	0,807	0,941	1,108	1,202	1,265	1,262	1,136
THDU50 [%]	0,181	0,211	0,227	0,245	0,256	0,274	0,749	0,768	0,778	0,783	0,780

Interharmonics at continuous operation (SUN2000-20KTL-M0)

P/P$_n$ [%]	5	10	20	30	40	50	60	70	80	90	100
f [Hz]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]	I$_h$ [%]
75	0,018	0,027	0,030	0,028	0,028	0,031	0,038	0,044	0,043	0,045	0,037
125	0,021	0,023	0,031	0,030	0,033	0,037	0,046	0,053	0,048	0,047	0,036
175	0,018	0,022	0,032	0,032	0,034	0,041	0,042	0,050	0,043	0,045	0,037
225	0,021	0,024	0,029	0,029	0,032	0,035	0,035	0,039	0,039	0,046	0,038
275	0,018	0,020	0,029	0,031	0,033	0,035	0,037	0,038	0,032	0,039	0,035
325	0,020	0,023	0,031	0,032	0,036	0,041	0,040	0,042	0,045	0,051	0,039
375	0,021	0,023	0,027	0,029	0,031	0,035	0,033	0,035	0,034	0,035	0,033
425	0,023	0,024	0,031	0,031	0,035	0,040	0,043	0,052	0,053	0,055	0,041
475	0,021	0,024	0,031	0,034	0,036	0,044	0,048	0,054	0,054	0,055	0,040
525	0,024	0,025	0,030	0,031	0,032	0,038	0,043	0,049	0,047	0,050	0,041
575	0,022	0,021	0,030	0,031	0,035	0,036	0,036	0,039	0,048	0,053	0,039
625	0,023	0,024	0,029	0,031	0,035	0,040	0,050	0,054	0,051	0,047	0,037
675	0,025	0,024	0,024	0,026	0,029	0,034	0,032	0,036	0,036	0,039	0,034
725	0,027	0,025	0,026	0,028	0,031	0,037	0,038	0,042	0,040	0,044	0,037
775	0,024	0,027	0,026	0,028	0,030	0,038	0,038	0,042	0,039	0,042	0,035
825	0,027	0,027	0,025	0,028	0,030	0,033	0,029	0,034	0,035	0,043	0,036
875	0,025	0,023	0,025	0,025	0,030	0,031	0,033	0,037	0,037	0,033	0,032
925	0,027	0,024	0,021	0,025	0,028	0,034	0,033	0,037	0,049	0,053	0,036
975	0,029	0,028	0,021	0,024	0,028	0,032	0,029	0,034	0,033	0,032	0,030
1025	0,030	0,027	0,023	0,023	0,026	0,032	0,033	0,042	0,047	0,047	0,034
1075	0,026	0,030	0,021	0,023	0,025	0,030	0,031	0,038	0,038	0,039	0,030
1125	0,028	0,028	0,020	0,021	0,023	0,027	0,029	0,032	0,033	0,031	0,027
1175	0,027	0,024	0,019	0,021	0,025	0,026	0,025	0,027	0,028	0,035	0,028
1225	0,027	0,025	0,018	0,019	0,022	0,026	0,032	0,034	0,029	0,025	0,025
1275	0,030	0,031	0,018	0,019	0,021	0,023	0,022	0,024	0,027	0,035	0,026
1325	0,030	0,028	0,018	0,019	0,022	0,025	0,024	0,027	0,025	0,028	0,025
1375	0,026	0,032	0,017	0,017	0,019	0,024	0,024	0,027	0,028	0,025	0,024
1425	0,026	0,027	0,016	0,015	0,018	0,020	0,023	0,028	0,026	0,028	0,022
1475	0,027	0,024	0,017	0,016	0,019	0,020	0,020	0,022	0,026	0,025	0,022
1525	0,026	0,024	0,015	0,015	0,018	0,022	0,025	0,030	0,036	0,038	0,025
1575	0,029	0,031	0,016	0,016	0,019	0,019	0,019	0,023	0,023	0,022	0,020
1625	0,027	0,026	0,016	0,016	0,019	0,020	0,023	0,027	0,030	0,031	0,022
1675	0,024	0,031	0,016	0,015	0,017	0,019	0,020	0,024	0,024	0,024	0,021
1725	0,024	0,024	0,015	0,014	0,015	0,017	0,019	0,022	0,026	0,022	0,020
1775	0,024	0,021	0,015	0,015	0,016	0,016	0,017	0,020	0,021	0,022	0,019
1825	0,022	0,021	0,014	0,014	0,016	0,018	0,020	0,021	0,021	0,021	0,019
1875	0,024	0,027	0,015	0,014	0,016	0,016	0,018	0,021	0,023	0,023	0,018
1925	0,023	0,021	0,013	0,014	0,015	0,017	0,017	0,019	0,019	0,020	0,018
1975	0,020	0,026	0,014	0,014	0,014	0,016	0,018	0,019	0,018	0,021	0,018

Higher Frequencies components (SUN2000-20KTL-M0)

P/Pn [%]	5	10	20	30	40	50	60	70	80	90	100
f [kHz]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]	I_h [%]
2,1	0,143	0,199	0,159	0,144	0,108	0,118	0,132	0,149	0,147	0,164	0,223
2,3	0,092	0,103	0,074	0,107	0,117	0,135	0,136	0,139	0,131	0,149	0,179
2,5	0,084	0,096	0,064	0,078	0,086	0,082	0,074	0,091	0,104	0,116	0,143
2,7	0,097	0,094	0,162	0,114	0,072	0,103	0,135	0,153	0,136	0,162	0,182
2,9	0,062	0,060	0,125	0,065	0,067	0,091	0,129	0,150	0,154	0,140	0,121
3,1	0,058	0,060	0,100	0,122	0,122	0,095	0,089	0,112	0,124	0,163	0,153
3,3	0,063	0,071	0,174	0,151	0,119	0,104	0,106	0,120	0,116	0,164	0,159
3,5	0,048	0,056	0,122	0,150	0,158	0,109	0,101	0,138	0,131	0,140	0,140
3,7	0,047	0,056	0,139	0,126	0,124	0,142	0,105	0,107	0,104	0,128	0,115
3,9	0,054	0,068	0,242	0,215	0,211	0,247	0,181	0,174	0,146	0,153	0,142
4,1	0,042	0,048	0,114	0,121	0,144	0,176	0,126	0,131	0,154	0,176	0,145
4,3	0,040	0,040	0,091	0,141	0,133	0,087	0,113	0,124	0,126	0,135	0,125
4,5	0,043	0,041	0,079	0,067	0,079	0,080	0,069	0,085	0,095	0,099	0,126
4,7	0,033	0,030	0,036	0,040	0,046	0,045	0,047	0,051	0,060	0,080	0,073
4,9	0,032	0,030	0,032	0,039	0,033	0,042	0,036	0,046	0,048	0,056	0,065
5,1	0,031	0,029	0,033	0,029	0,033	0,033	0,035	0,037	0,043	0,051	0,048
5,3	0,027	0,026	0,025	0,027	0,025	0,028	0,028	0,031	0,032	0,038	0,042
5,5	0,025	0,024	0,023	0,024	0,023	0,025	0,028	0,030	0,031	0,033	0,036
5,7	0,023	0,023	0,025	0,025	0,024	0,025	0,026	0,026	0,026	0,028	0,031
5,9	0,022	0,023	0,022	0,022	0,022	0,022	0,025	0,025	0,025	0,027	0,028
6,1	0,021	0,021	0,021	0,022	0,022	0,023	0,023	0,024	0,024	0,026	0,026
6,3	0,021	0,022	0,022	0,021	0,022	0,022	0,023	0,024	0,025	0,025	0,025
6,5	0,021	0,021	0,021	0,021	0,021	0,022	0,022	0,022	0,023	0,024	0,023
6,7	0,021	0,021	0,021	0,021	0,021	0,021	0,022	0,022	0,022	0,023	0,022
6,9	0,021	0,021	0,021	0,021	0,021	0,022	0,022	0,022	0,022	0,023	0,022
7,1	0,020	0,021	0,021	0,022	0,020	0,021	0,021	0,021	0,021	0,022	0,022
7,3	0,020	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,022	0,021
7,5	0,021	0,021	0,021	0,020	0,021	0,021	0,021	0,021	0,021	0,022	0,021
7,7	0,020	0,021	0,021	0,020	0,021	0,021	0,021	0,021	0,021	0,021	0,021
7,9	0,020	0,020	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021
8,1	0,020	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021
8,3	0,020	0,020	0,020	0,020	0,020	0,021	0,021	0,021	0,021	0,021	0,021
8,5	0,020	0,020	0,020	0,021	0,020	0,021	0,021	0,021	0,021	0,021	0,021
8,7	0,020	0,020	0,020	0,020	0,020	0,021	0,020	0,021	0,021	0,021	0,021
8,9	0,020	0,020	0,020	0,020	0,020	0,021	0,020	0,020	0,020	0,021	0,021

Note:

The normalization current is

- 11,59A (SUN2000-8KTL-M0), 14,49A (SUN2000-10KTL-M0), 17,39A (SUN2000-12KTL-M0)
- 21,74A (SUN2000-15KTL-M0), 24,64A (SUN2000-17KTL-M0), 28,99 A (SUN2000-20KTL-M0)

The stated harmonics are maximum values of all 3 phases.

The test results refer to the original test report PVAT190424N048 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-07-22.

5.2.6 Feed in of DC current	P

Test result:

Protection limit	Tested at four power levels limit 0,5% of $I_{AC;nom}$ (144mA)		
Output power	30% S_{Emax} to 40% S_{Emax}	60% S_{Emax} to 70% S_{Emax}	>95% S_{Emax}
L1 Max, test value [mA]	48,0	86,0	79,0
L1 Average, test value [mA]	38,2	69,6	56,2
L2 Max, test value [mA]	60,0	102,0	90,0
L2 Average, test value [mA]	37,9	68,5	59,0
L3 Max, test value [mA]	48,0	91,0	78,0
L3 Average, test value [mA]	37,1	68,1	60,2

Test:

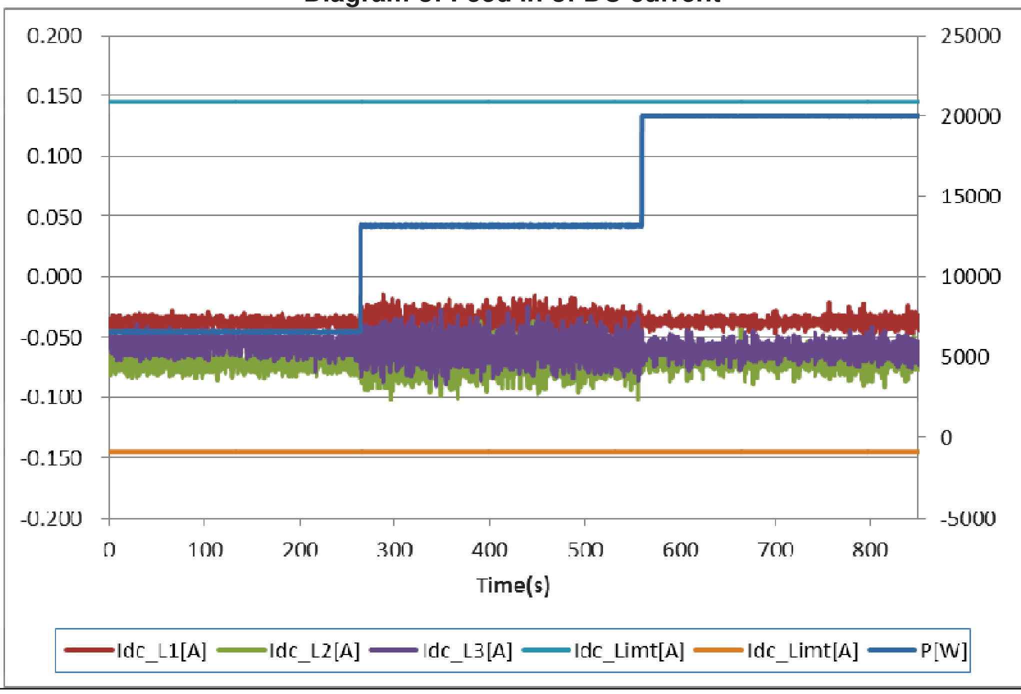
The inverter must be used in the adjustment range Test1, Test2 and Test 3. Each test point shall be held for min 5 minutes and I_{grid}, U_{grid}, I_{dc} of each phase has to be recorded. Measurement of I_{dc} must be done according to VDE AR-N 4100:2019-04 based on DIN EN 61000-4-7 (VDE-0847-4-7) over 10 fundamental periods.

Assessment criterion:

A inverter must not feed more than 0.5% of its rated current or a maximum of 20 mA (the higher value is to be selected) as direct current.

The test had been performed on the model SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0, SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

Diagram of Feed in of DC current



5.3 Evidence of symmetry behavior of inverters E DIN V 0124-100:(2019-09) draft		
Clause	**Test**	**Result**
5.3.1	General	**P**
5.3.2.1	Calculation of the asymmetry of three-phase inverters	**P**
5.3.2.2.1	Failure of single inverter modules	**N/A**
5.3.2.2.2	Power drop of single inverter modules	**N/A**
5.3.2.3.2	Symmetrical operation with a symmetry device	**N/A**

5.3.1 General These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.5 are met.	**P**
These tests serve to prove the requirements according to VDE-AR-N 4100: 2019-04, 5.5: These tests are not valid for direct connected rotating machines.	
Note:	

5.3.2 Test in the test laboratory		**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.		

5.3.2.1 Calculation of the asymmetry of three-phase inverters			P
Setting values	cos φ = 1:	1,00	
	cos φ over-excited:	0,80	
	cos φ under-excited:	0,80	

Test: SUN2000-20KTL-M0						
1-min mean value	L1	L2	L3	L1 – L2	L2 – L3	L3 – L1
a) cos φ = 1 at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	7,337	7,312	7,304	0,025	0,008	-0,033
	7,337	7,313	7,304	0,024	0,008	-0,032
	7,336	7,313	7,305	0,023	0,008	-0,031
	7,334	7,314	7,305	0,020	0,009	-0,029
	7,336	7,313	7,304	0,023	0,009	-0,032
cos $φ_{E60}$:	0,999					
max. asymmetry [kVA]:	0,033					
b) maximum under-excited (i) at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	7,356	7,349	7,339	0,007	0,009	-0,017
	7,357	7,348	7,340	0,008	0,009	-0,017
	7,356	7,349	7,340	0,007	0,008	-0,016
	7,355	7,350	7,340	0,006	0,010	-0,015
	7,356	7,349	7,340	0,006	0,009	-0,016
cos $φ_{E60}$:	0,799					
max. asymmetry [kVA]:	0,017					
c) maximum over-excited (c) at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	7,332	7,325	7,316	0,007	0,009	-0,016
	7,332	7,325	7,316	0,007	0,009	-0,016
	7,333	7,325	7,316	0,008	0,009	-0,017
	7,331	7,326	7,317	0,005	0,009	-0,014
	7,332	7,325	7,316	0,006	0,009	-0,015
cos $φ_{E60}$:	0,799					
max. asymmetry [kVA]:	0,017					
d) cos φ = 1 at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	3,674	3,664	3,659	0,010	0,006	-0,015
	3,674	3,664	3,659	0,010	0,006	-0,015
	3,673	3,665	3,659	0,009	0,006	-0,014
	3,673	3,664	3,659	0,009	0,005	-0,014
	3,674	3,664	3,659	0,010	0,005	-0,015
cos $φ_{E60}$:	0,999					

max. asymmetry [kVA]:	0,015					

e) maximum under-excited (i) at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	4,620	4,613	4,605	0,007	0,008	-0,015
	4,621	4,613	4,605	0,008	0,008	-0,016
	4,621	4,613	4,605	0,008	0,008	-0,016
	4,621	4,612	4,605	0,009	0,007	-0,016
	4,621	4,612	4,605	0,009	0,007	-0,016
cos φ_{E60}:	0,799					
max. asymmetry [kVA]:	0,016					
f) maximum over-excited (c) at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	4,604	4,594	4,587	0,010	0,007	-0,017
	4,604	4,594	4,587	0,010	0,007	-0,017
	4,604	4,594	4,587	0,010	0,007	-0,017
	4,604	4,594	4,587	0,010	0,007	-0,017
	4,605	4,594	4,587	0,010	0,007	-0,018
cos φ_{E60}:	0,799					
max. asymmetry [kVA]:	0,018					
Limit [kVA]:	≤ 5 % S_{Emax} and 4,6 kVA					
Note: The maximum inductive and capacitive values are specified by the manufacturer.						

Test: SUN2000-8KTL-M0						
1-min mean value	L1	L2	L3	L1 – L2	L2 – L3	L3 – L1
a) cos φ = 1 at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	2,639	2,676	2,668	-0,037	0,008	0,029
	2,639	2,676	2,668	-0,037	0,008	0,029
	2,639	2,676	2,668	-0,037	0,008	0,029
	2,639	2,676	2,668	-0,037	0,008	0,029
	2,639	2,676	2,668	-0,037	0,008	0,029
cos φ_{E60}:	0,999					
max. asymmetry [kVA]:	0,037					
b) maximum under-excited (i) at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	2,305	2,352	2,347	-0,047	0,005	0,042
	2,305	2,352	2,347	-0,047	0,005	0,042
	2,305	2,352	2,347	-0,047	0,005	0,042
	2,305	2,352	2,347	-0,047	0,005	0,042
	2,305	2,352	2,347	-0,047	0,005	0,042
cos φ_{E60}:	0,791					
max. asymmetry [kVA]:	0,047					
c) maximum over-excited (c) at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	2,334	2,363	2,349	-0,030	0,014	0,015
	2,334	2,363	2,349	-0,030	0,014	0,015
	2,334	2,363	2,349	-0,030	0,014	0,015
	2,334	2,363	2,349	-0,029	0,014	0,015
	2,333	2,363	2,349	-0,030	0,014	0,015
cos φ_{E60}:	0,808					
max. asymmetry [kVA]:	0,017					
d) cos φ = 1 at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	1,310	1,353	1,338	-0,044	0,015	0,028
	1,310	1,353	1,338	-0,044	0,015	0,028
	1,310	1,353	1,338	-0,044	0,015	0,029
	1,310	1,353	1,338	-0,044	0,015	0,028
	1,310	1,353	1,338	-0,044	0,015	0,029
cos φ_{E60}:	0,999					
max. asymmetry [kVA]:	0,044					

e) maximum under-excited (i) at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	1,318	1,365	1,352	-0,047	0,013	0,034
	1,318	1,365	1,352	-0,047	0,013	0,034

	1,318	1,365	1,352	-0,047	0,013	0,034
	1,318	1,365	1,352	-0,047	0,013	0,034
	1,318	1,365	1,352	-0,047	0,013	0,034
cos φ_{E60}:	0,796					
max. asymmetry [kVA]:	0,047					
f) maximum over-excited (c) at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	1,452	1,490	1,471	-0,038	0,019	0,020
	1,452	1,490	1,472	-0,038	0,019	0,020
	1,452	1,490	1,472	-0,038	0,019	0,020
	1,452	1,490	1,472	-0,038	0,019	0,020
	1,452	1,490	1,471	-0,038	0,019	0,019
cos φ_{E60}:	0,803					
max. asymmetry [kVA]:	0,038					
Limit [kVA]:	≤ 5 % S_{Emax} and 4,6 kVA					

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

Example:

Messung Nr.	**1**	**2**	**3**	**4**	**5**
L1	8	7	9	10	9
L2	9	10	10	10	10
L3	10	10	11	8	8
Rechnung					
|L1 - L2|	1	3	1	0	1
|L2 - L3|	1	0	1	2	2
|L3 – L1|	2	3	2	2	1
Unsymmetrie	2	3	2	2	2
max. Unsymmetrie	**3**				

Assessment criterion:
The test is passed if the maximum value from the above measurements does not exceed 5 % S_{Emax} and 4,6 kVA.

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

The test had been performed on the model SUN2000-8KTL-M0, SUN2000-20KTL-M0, the test results are valid for the SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0, SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

5.4 Evidence of the characteristics of the power generation unit on the network E DIN V 0124-100:(2019-09) draft		
Clause	**Test**	**Result**
5.4.1	General	**P**
5.4.2	Measurement of the active power and reactive power range	**P**
5.4.3.2	Measurement of setting accuracy	**P**
5.4.3.3	Measurement of the power gradient	**P**
5.4.3.4	Measurement Priority Interfaces / Energy Management	**P**
5.4.4	Active power feed-in for PGUs at overfrequency	**P**
5.4.5	Active power feed-in of Storage systems for overfrequency	**P**
5.4.6	Active power feed-in for PGUs at Underfrequency	**P**
5.4.7	Active power feed-in for storage systems at Underfrequency	**P**
5.4.8.1	Tests of the Reactive power / cos φ setting accuracy	**P**
5.4.8.2	Test of the displacement factor/active power characteristic curve cos φ (P)	**P**
5.4.8.3.1	Test of the accuracy of the Q (U) regulation	**P**
5.4.8.3.2	Test of the dynamics of the Q (U) regulation	**P**

5.4.1 **General** (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105:2018-11, 5.7.2.2 are met and to determine the values for SEmax and PEmax)	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%

Designation for under-excited and over-excited:

- "(c)" stands for over-excited.
- "(i)" stands for under-excited.

Note:

If an examination is required for any other requirements, these apply to this test.

The RoCoF requirements of the VDE-AR-N 4105:2018-11, 5.7.1 are not part of the Unit certification.

5.4.2 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	$\cos\varphi = 1$:	1,00
	$\cos\varphi$ max. over-excited:	0,80
	$\cos\varphi$ max. under-excited:	0,80

Test: SUN2000-8KTL-M0					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) $\cos\varphi$ 1 at 100% P_{Emax}					
U [V]:	207,24	218,71	230,18	241,65	250,85
P_{E30} [kW]:	7,992	7,991	7,988	7,993	7,995
Q_{E30} [kVar]:	-0,014	-0,015	-0,017	-0,017	-0,020
S_{E30} [kVA].	7,992	7,991	7,988	7,993	7,995
$\cos\varphi_{E30\text{-over-excited}}$:	0,999	0,999	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,18	218,66	230,14	241,67	250,82
P_{E30} [kW]:	6,661	7,031	7,027	7,029	7,029
Q_{E30} [kVar]:	-5,010	-5,287	-5,287	-5,288	-5,292
S_{E30} [kVA].	8,334	8,797	8,794	8,796	8,798
$\cos\varphi_{E30\text{-over-excited}}$:	0,799	0,800	0,799	0,799	0,799
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,21	218,68	230,17	241,64	250,84
P_{E30} [kW]:	6,673	7,040	7,036	7,038	7,038
Q_{E30} [kVar]:	4,988	5,259	5,256	5,258	5,254
S_{E30} [kVA].	8,331	8,787	8,783	8,785	8,783
$\cos\varphi_{E30\text{-over-excited}}$:	0,801	0,801	0,801	0,801	0,802
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	8,798 kVA				
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	7,995 kW				
Test: SUN2000-10KTL-M0					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) $\cos\varphi$ 1 at 100% P_{Emax}					
U [V]:	207,24	218,71	230,19	230,19	250,89
P_{E30} [kW]:	9,999	9,995	9,988	9,988	9,981
Q_{E30} [kVar]:	-0,026	-0,028	-0,031	-0,031	-0,034
S_{E30} [kVA].	9,999	9,995	9,988	9,988	9,981
$\cos\varphi_{E30\text{-over-excited}}$:	0,999	0,999	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,17	218,64	230,12	241,63	250,83

P_{E30} [kW]:	7,990	7,989	7,985	7,982	7,979
Q_{E30} [kVar]:	-6,025	-6,024	-6,020	-6,021	-6,019
S_{E30} [kVA].	10,007	10,006	10,001	9,998	9,995
cos $\varphi_{E30\text{-over-excited}}$:	0,799	0,799	0,799	0,799	0,799
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,19	218,67	230,15	241,65	250,85
P_{E30} [kW]:	8,003	8,001	7,998	7,995	7,995
Q_{E30} [kVar]:	5,974	5,970	5,961	5,958	5,953
S_{E30} [kVA].	9,986	9,983	9,975	9,971	9,968
cos $\varphi_{E30\text{-over-excited}}$:	0,802	0,802	0,802	0,802	0,802
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	10,007 kVA				
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	9,999 kW				
Test: SUN2000-12KTL-M0					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) cos φ 1 at 100% P_{Emax}					
U [V]:	207,33	218,81	230,28	241,76	250,95
P_{E30} [kW]:	11,985	11,989	11,989	11,989	11,991
Q_{E30} [kVar]:	-0,023	-0,023	-0,024	-0,026	-0,028
S_{E30} [kVA].	11,985	11,989	11,989	11,989	11,991
cos $\varphi_{E30\text{-over-excited}}$:	0,999	0,999	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,25	218,75	230,22	241,71	250,89
P_{E30} [kW]:	9,946	10,493	10,542	10,543	10,546
Q_{E30} [kVar]:	-7,490	-7,900	-7,937	-7,938	-7,940
S_{E30} [kVA].	12,451	13,135	13,196	13,197	13,201
cos $\varphi_{E30\text{-over-excited}}$:	0,799	0,799	0,799	0,799	0,799
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,29	218,78	230,26	241,74	250,92
P_{E30} [kW]:	9,968	10,512	10,552	10,554	10,555
Q_{E30} [kVar]:	7,454	7,860	7,887	7,885	7,883
S_{E30} [kVA].	12,447	13,125	13,174	13,175	13,174
cos $\varphi_{E30\text{-over-excited}}$:	0,801	0,801	0,801	0,801	0,801
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	13,201 kVA				
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	11,991 kW				
Test: SUN2000-15KTL-M0					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) cos φ 1 at 100% P_{Emax}					
U [V]:	207,43	218,90	230,37	241,85	251,03
P_{E30} [kW]:	14,974	14,974	14,971	14,975	14,984

Q_{E30} [kVar]:	-0,041	-0,042	-0,042	-0,044	-0,044
S_{E30} [kVA].	14,975	14,974	14,971	14,975	14,984
cos $φ_{E30-over-excited}$:	0,999	0,999	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,34	218,83	230,30	241,78	250,97
P_{E30} [kW]:	12,523	13,169	13,166	13,166	13,168
Q_{E30} [kVar]:	-9,451	-9,936	-9,931	-9,932	-9,933
S_{E30} [kVA].	15,689	16,497	16,492	16,492	16,494
cos $φ_{E30-over-excited}$:	0,798	0,799	0,799	0,799	0,799
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,38	218,87	230,34	241,82	251,00
P_{E30} [kW]:	12,559	13,187	13,184	13,185	13,189
Q_{E30} [kVar]:	9,383	9,845	9,841	9,842	9,842
S_{E30} [kVA].	15,677	16,457	16,451	16,453	16,456
cos $φ_{E30-over-excited}$:	0,801	0,801	0,802	0,801	0,802
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)			16,497 kVA		
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)			14,984 kW		
Test: SUN2000-17KTL-M0					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) cos φ 1 at 100% P_{Emax}					
U [V]:	207,47	218,94	230,44	241,91	251,09
P_{E30} [kW]:	16,974	16,975	16,966	16,964	16,968
Q_{E30} [kVar]:	-0,034	-0,033	-0,035	-0,037	-0,038
S_{E30} [kVA].	16,974	16,976	16,966	16,965	16,968
cos $φ_{E30-over-excited}$:	0,999	0,999	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,37	218,87	230,36	241,84	251,02
P_{E30} [kW]:	14,151	14,927	14,921	14,922	14,925
Q_{E30} [kVar]:	-10,667	-11,247	-11,241	-11,243	-11,243
S_{E30} [kVA].	17,721	18,690	18,681	18,683	18,686
cos $φ_{E30-over-excited}$:	0,799	0,799	0,799	0,799	0,799
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,42	218,91	230,41	241,88	251,06
P_{E30} [kW]:	14,189	14,938	14,931	14,933	14,936
Q_{E30} [kVar]:	10,619	11,174	11,166	11,163	11,163
S_{E30} [kVA].	17,722	18,654	18,644	18,644	18,646
cos $φ_{E30-over-excited}$:	0,801	0,801	0,801	0,801	0,801
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)			18,690 kVA		
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)			16,975 kW		

Test: SUN2000-20KTL-M0					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) cos φ 1 at 100% P_{Emax}					
U [V]:	207,54	219,02	230,46	241,93	251,11
P_{E30} [kW]:	19,967	19,964	19,951	19,957	19,967
Q_{E30} [kVar]:	-0,061	-0,059	-0,060	-0,060	-0,059
S_{E30} [kVA].	19,967	19,964	19,952	19,957	19,967
cos $\varphi_{E30\text{-over-excited}}$:	0,999	0,999	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,41	218,86	230,33	241,81	250,99
P_{E30} [kW]:	15,457	15,952	15,947	15,947	15,951
Q_{E30} [kVar]:	-11,674	-12,046	-12,042	-12,042	-12,045
S_{E30} [kVA].	19,370	19,989	19,983	19,983	19,988
cos $\varphi_{E30\text{-over-excited}}$:	0,798	0,798	0,798	0,798	0,798
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,47	218,91	230,38	241,86	251,03
P_{E30} [kW]:	15,978	15,976	15,969	15,973	15,980
Q_{E30} [kVar]:	11,937	11,935	11,926	11,928	11,932
S_{E30} [kVA].	19,944	19,942	19,931	19,935	19,944
cos $\varphi_{E30\text{-over-excited}}$:	0,801	0,801	0,801	0,801	0,801
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	19,989 kVA				
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	19,967 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 = 1, 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.

Assessment criterion:

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

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

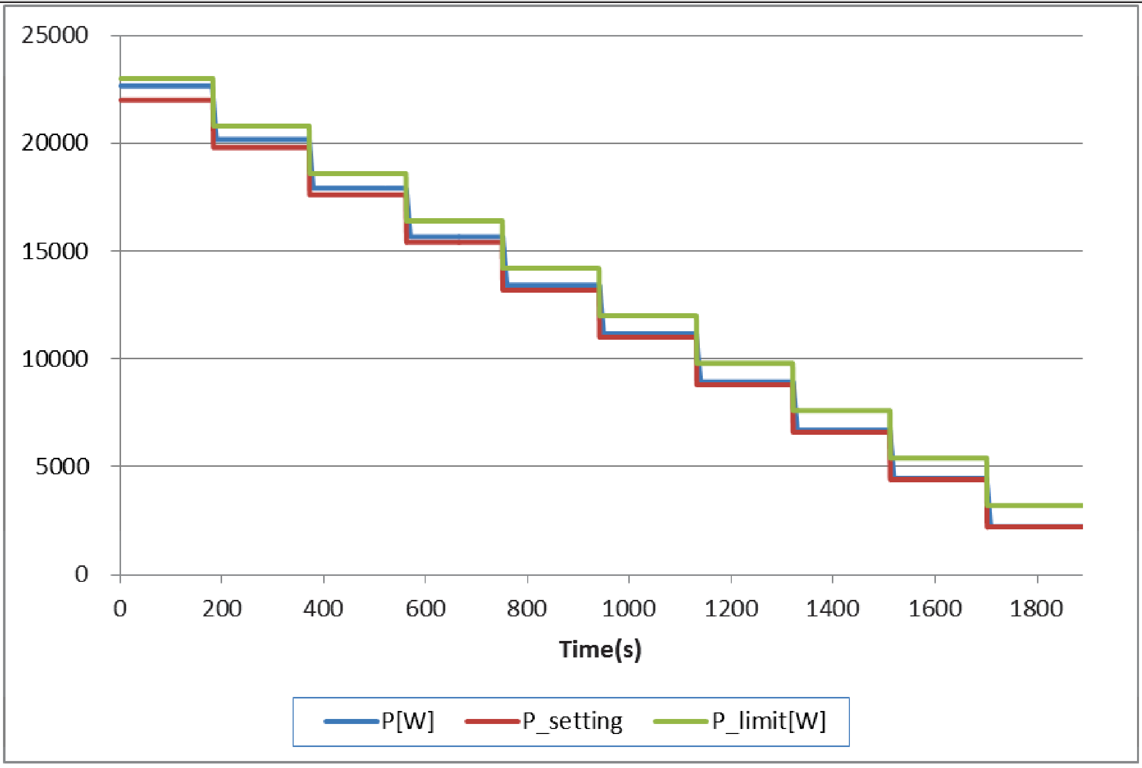
$P_{Emax600}$ = max($P_{Emax600a)}$, $P_{Emax600b)}$, $P_{Emax600c)}$)

Note:

The test had been performed on the model SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

5.4.3.2 Measurement of setting accuracy — P

Graph of the setting accuracy:



Test:

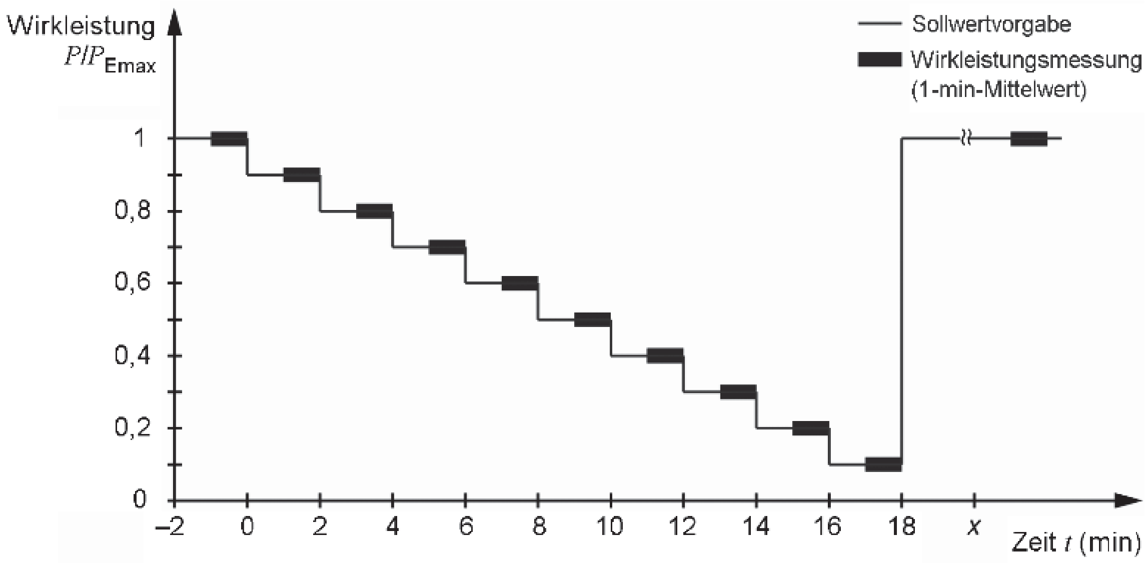
1-min mean value / P_n/P [%]	100	90	80	70	60	50	40	30	20	10
$P_{Setpoint}$[kW]:	22,000	19,800	17,600	15,400	13,200	11,000	8,800	6,600	4,400	2,200
P_{E60} [kW]:	22,660	20,175	17,914	15,666	13,422	11,169	8,931	6,701	4,460	2,220
$\Delta P_{E60}/P_{Setpoint}$ [%]:	3,00	1,70	1,43	1,21	1,01	0,77	0,60	0,46	0,27	0,09
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 5 % of P_{Emax}									

Test:

The setpoint signal must be reduced from 100% to 10% P_{Emax}:

a) for adjustable PGUs in increments of 10% P_{Emax}. 1 minute must elapse after every change to the setpoint setting so that the PGU can settle at the new setpoint. Then the active power of the PGU must be measured as a 1-min mean value.

b) For all other PGUs, in line with their adjustable steps. 1 minutes must elapse after the setpoint setting is changed so that the PGU can settle at the new setpoint. Then the active power of the PGU must be measured as a 1-min mean value.



Assessment criterion:

a) for adjustable PGUs:

- no network disconnection
- the active power value does not exceed the setpoint by more than 5% PEmax
- the power gradient determined according 5.4.3.3 not be less than 0.33% PrE/s and not more than 0.66% PrE/s.

Note:

The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

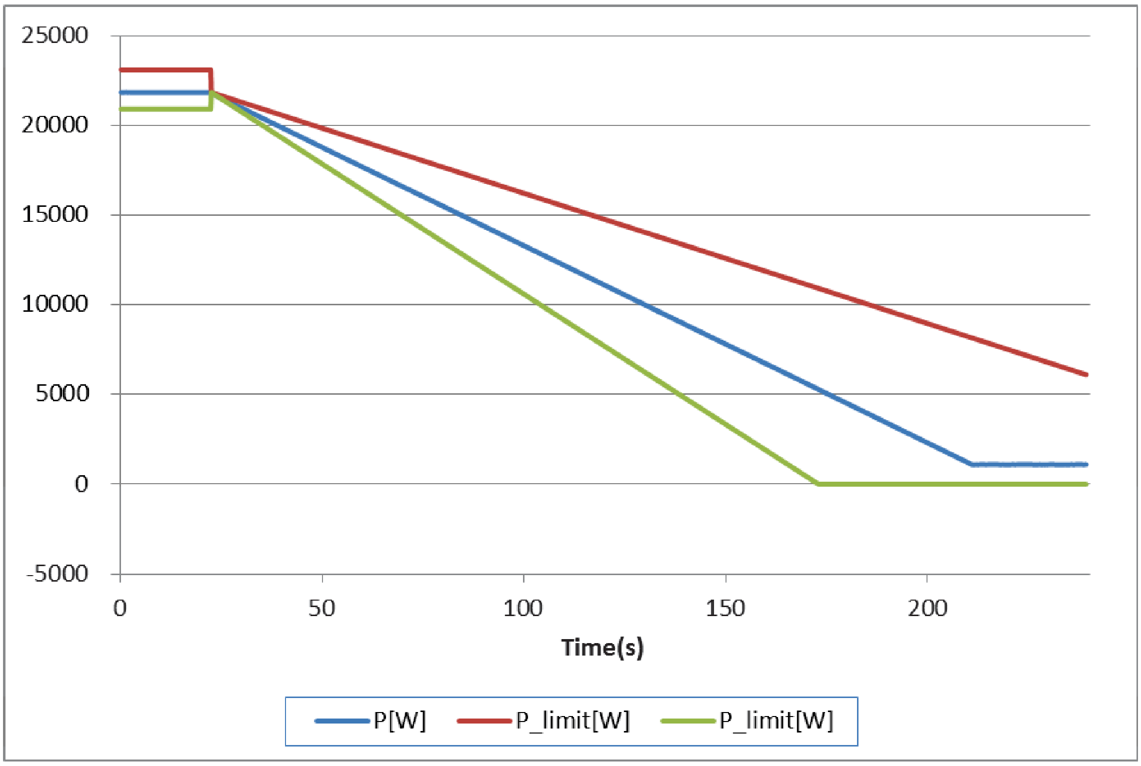
5.4.3.3 Measurement of the power gradient				P
Test:				
$P_{Setpoint}$	100% to 5% P_{Emax}		5% to 100% P_{Emax}	
$P_{Setpoint}$[kW]:	22,000	1,100	1,100	22,000
P_{E60} [kW]:	21,837	1,095	1,095	21,873
$\Delta P_{E60}/P_{Setpoint}$ [%]:	-1,634	-0,053	-0,048	-1,268
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 5 % of PEmax			
Gradient[P_{rE}/s.]:				
Limit Gradient [P_{rE}/s.]:	0,33 to 0,66			

Test:
The measurement of the power gradient takes place :
- Via a setpoint change from 100% to 5% of the rated effective power PrE at time t0. If the technical performance is> 5%, this should be specified.
- Via a setpoint change from 5% to 100% of the rated effective power PrE at time t0. Is the technical Performance> 5%, this should be specified

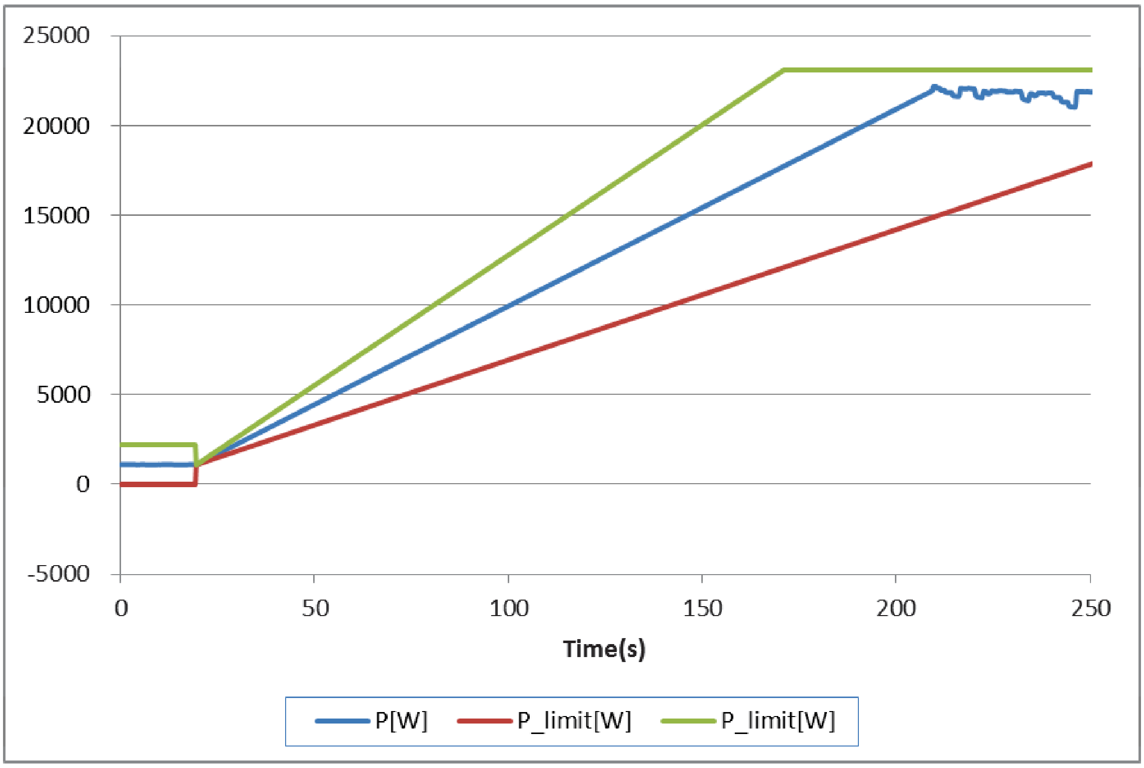
Assessment criterion:
a) for adjustable PGUs:
- no network disconnection
- the active power value does not exceed the setpoint by more than 5% PEmax
- the power gradient determined according 5.4.3.3 not be less than 0.33% PrE/s and not more than 0.66% PrE/s.

Note:
The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

Graph of power gradient: 100% to 5% P_{Emax}



Graph of power gradient: 5% to 100% P_{Emax}



5.4.4	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

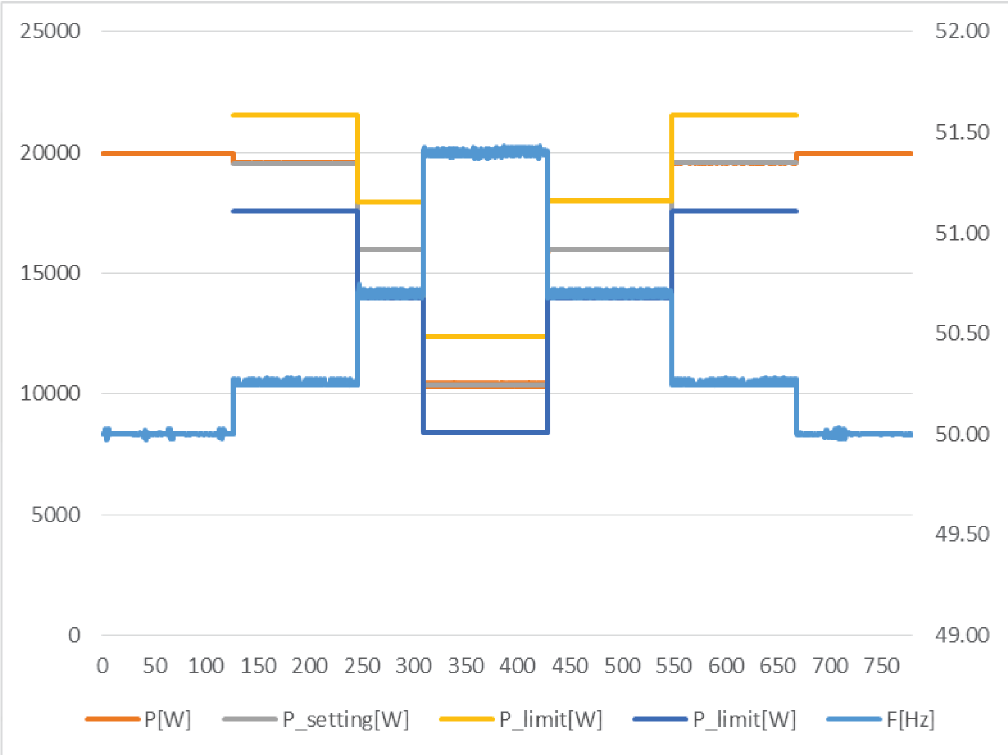
Test:

f [Hz]	a) 50,00	b) 50,25	c) 50,70	d) 51,40	e) 50,70	f) 50,25	g) 50,00	h) 51,65	i) 50,15	j) 50,00
Test 1:										
Frequency [Hz]:	50,00	50,25	50,70	51,41	50,70	50,25	50,00	51,65	50,15	50,00
$P_{setpoint}$ [% P_{Emax}]:	100,00	98,00	80,00	52,00	80,00	98,00	100,00	0,00	0,00	100,00
P_{E60} [% P_{Emax}]:	99,85	97,85	79,88	51,95	79,88	97,84	99,84	0,00	0,00	98,59
$\Delta P_{E60}/P_{Setpoint}$ [% P_{Emax}]:	-0,15	-0,15	-0,12	-0,05	-0,12	-0,16	-0,16	0,00	0,00	-1,41

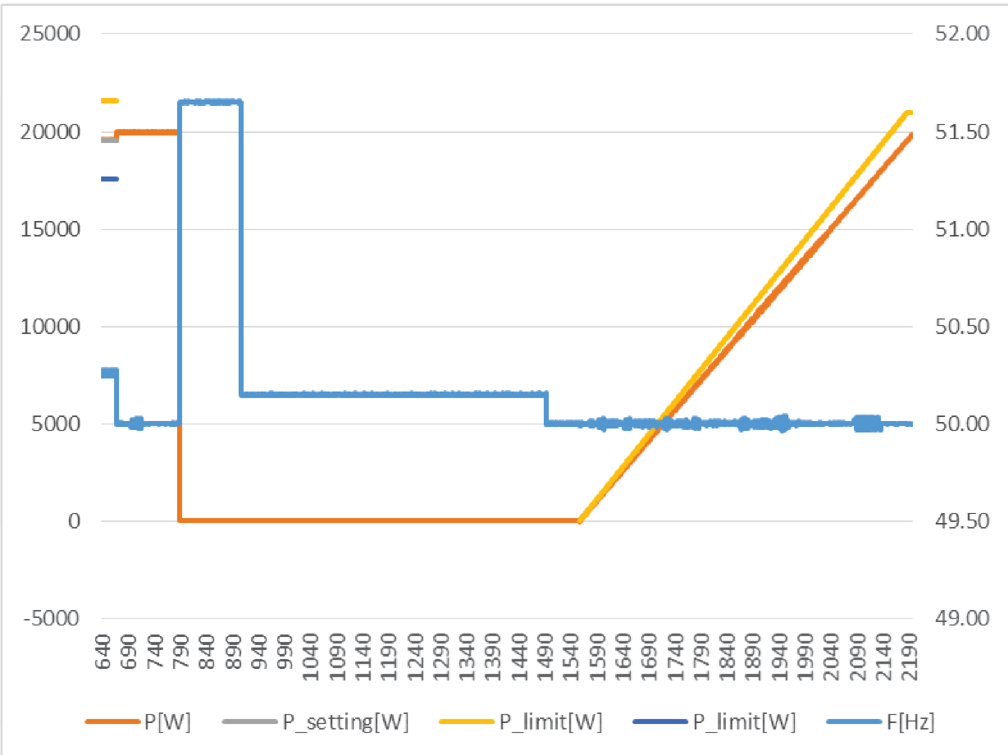
Test 2:

f [Hz]	a) 50,00	b) 50,50	c) 50,70	d) 51,40	e) 50,70	f) 50,40	g) 50,00
Frequency [Hz]:	50,00	50,50	50,70	51,40	50,70	50,40	50,00
$P_{setpoint}$ [% P_{Emax}]:	60,00	60,00	58,00	51,00	58,00	60,00	100,00
P_{E60} [% P_{Emax}]:	59,89	59,75	57,78	50,66	57,78	59,84	99,83
$\Delta P_{E60}/P_{Setpoint}$ [% P_{Emax}]:	-0,11	-0,25	-0,22	-0,33	-0,22	-0,16	-0,17
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 10 % of P_{Emax}						

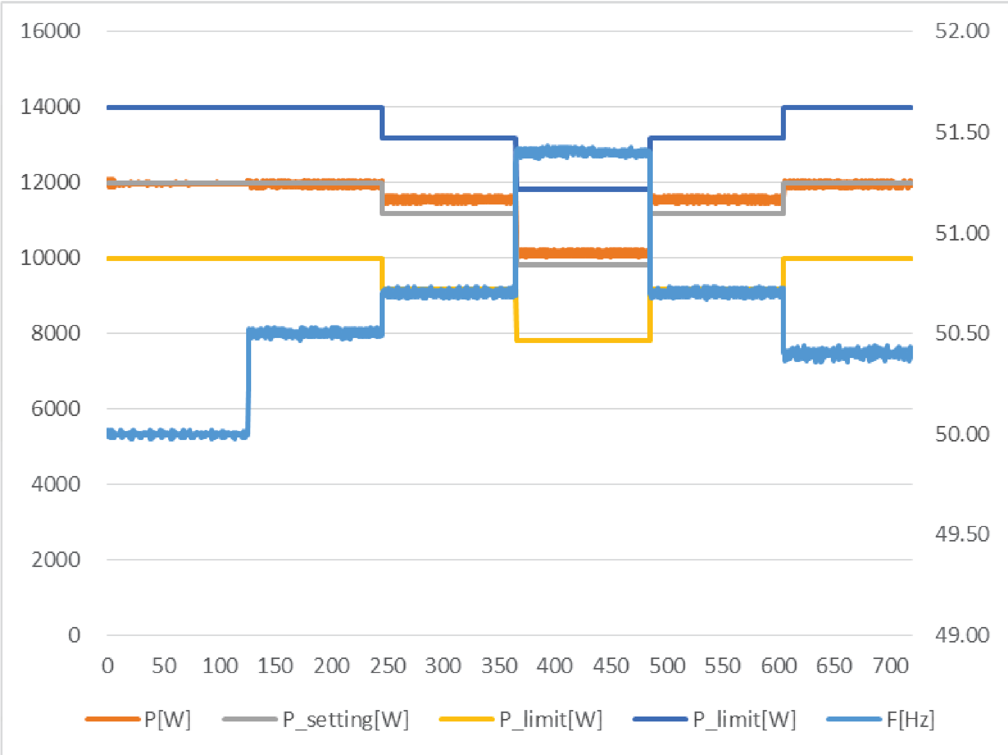
Graph of Test 1:



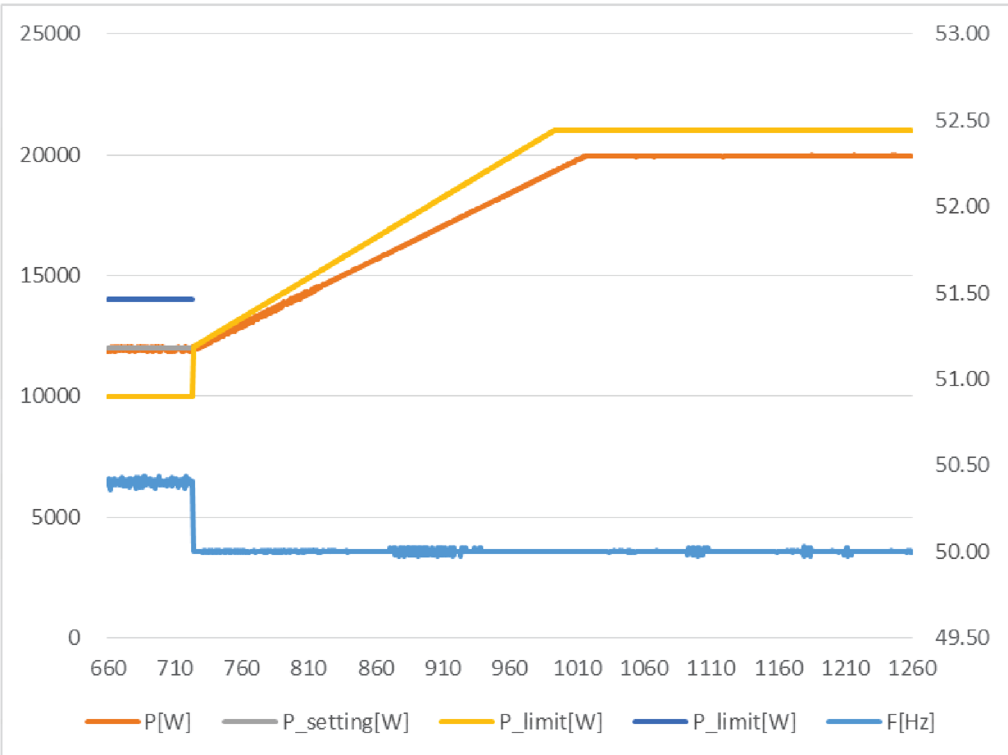
Graph of Test 1:



Graph of Test 2:



Graph of Test 1:



Tests:
The test is conducted for two powers.
Test1:
First, the test must start at a power > 100% PEmax ("Measurement 1") Start of the Power reduction at 50,20Hz s =5% (40% Pref/Hz), the rise of the active power gradient must be recorded.
Test2:
In a second test, for a power 60% PEmax ("Measurement 2"). Start of the Power reduction at 50,50Hz s =12% (16,67% Pref/Hz). After freezing of the PM, the available active power output must be increased to a value 100% PEmax, and after the network frequency of 50,2 Hz is raised above, the rise of the active power gradient must be recorded.

Assessment criterion:
The test is regarded as passed:
a) for controllable PGU if:
- The active power reduces between measuring points 5.4.4.1 a) to g) and j), the expected active power output, after settling, adjusts with a deviation ≤ ± 10% PEmax.
In the measurement points h) and i) shall no active power be given.
- The initial time delay TV of the frequency-dependent adaptation of the active power output ≤ 2 s.
- The response time of the adaptation of the active power output is a maximum of 8 s (type 1 units and type 2 units with rotating machines) or 2 s (all other type 2 units)
- the settling time of the adaptation of the active power output is a maximum time of 30 s (for type 1 units and for type 2 units with rotating machines) or respectively a maximum time of 20 s (for all other generation units type 2) and
- The connection time at point j) is at least 60 s and the power is then increased with a gradient of ≤ 10% PEmax / min.
- In the case of generating units with combustion engines or gas turbines, if the criteria for response time and settling time are not met, the test shall be passed, even if the adaptation of active power output occurs with a power gradient of at least 66% PEmax per min (corresponding to 1.11% PEmax per s).

b) for conditionally adjustable PGU, if:
- they behave as described in a) inside their control range and
- outside the control range, the power supplied when leaving the control range remains constant until it is switched off
- the connection time in j) and where appropriate in g) corresponds to the manufacturer's information on the random number generator;

NOTE: The Uniform distribution of the disconnection frequency in maximum increments of 0.1 Hz between the end of the control range (at least 50.2 Hz) and 51.5 Hz shall be proofed by a manufacturer's declaration.
c) for non-adjustable EZE, if
- a disconnection takes place between 50.2 Hz and 51.5 Hz;
- the connection time in j) and where appropriate in g) corresponds to the manufacturer's information on the random number generator;

NOTE The Uniform distribution of the disconnection frequency in maximum increments of 0.1 Hz between 50.2 Hz and 51.5 Hz shall be proofen by a manufacturer's declaration.
d) for linear generators with SEmax ≤ 4.6 kVA,
- if they disconnect from the mains at a frequency ≥ 50.2 Hz and their maximum upper frequency limit (as specified by the manufacturer), but at the latest when they exceed 51.5 Hz.
- the connection time in j) and where appropriate in g) corresponds to the manufacturer's information on the random number generator;

Subsequently no more resynchronisation/active power feed-in is permitted, also while the frequency 5.4.4.1 i) is maintained (i.e no running on the characteristic curve as previously tested in a) at g).

Note:
The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-

8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

5.4.6	**Active power feed-in for PGUs at Underfrequency** (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105:2018-11 5.7.4.3. and VDE-AR-N 4105:2018-11 8.3.1. are met)	**P**

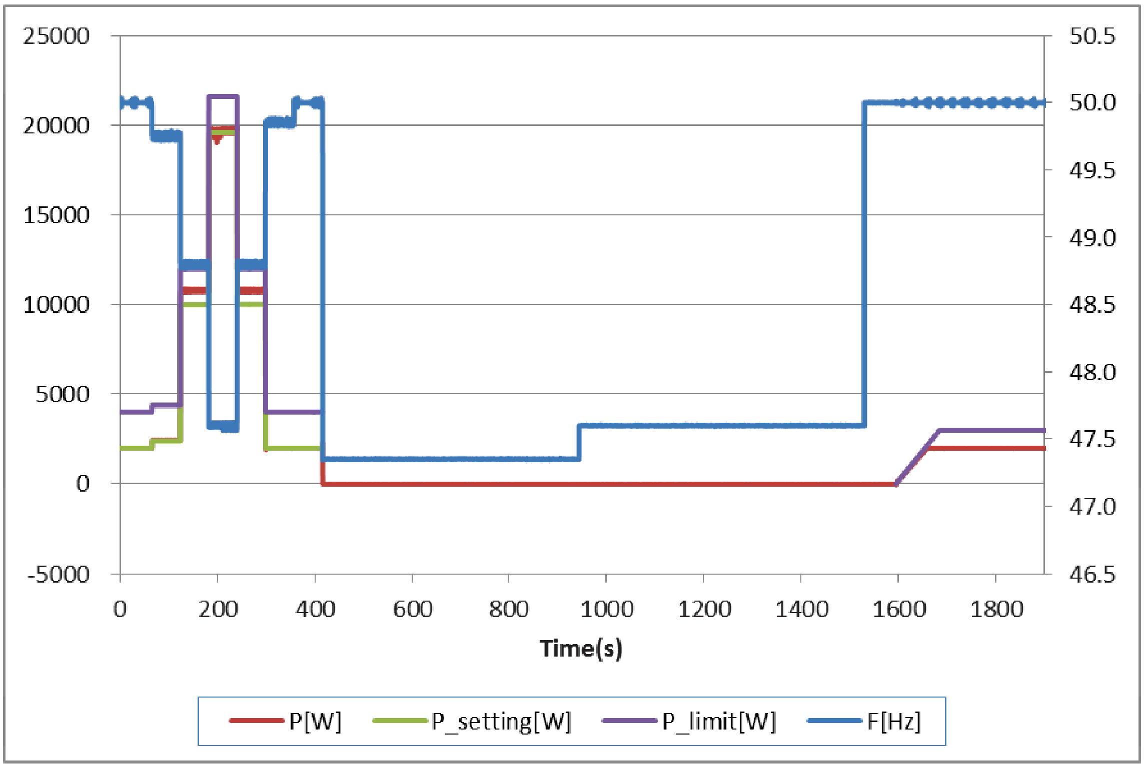
Test:

f [Hz]	a) 50,00	b) 49,75	c) 48,80	d) 47,60	e) 48,80	f) 49,85	g) 50,00	h) 47,35	i) 47,60	j) 50,00
Test 1:										
Frequency [Hz]:	50,00	49,75	48,80	47,60	48,80	49,85	50,00	47,35	47,60	50,00
$P_{setpoint}$ [% P_{Emax}]:	10,00	12,00	50,00	98,00	50,00	10,00	10,00	0,00	0,00	10,00
P_{E60} [% P_{Emax}]:	9,99	12,17	53,94	97,52	53,92	9,99	9,98	0,00	0,00	9,99
$\Delta P_{E60}/P_{Setpoint}$ [% P_{Emax}]:	-0,01	0,17	3,94	-0,48	3,92	-0,01	-0,02	0,00	0,00	-0,01

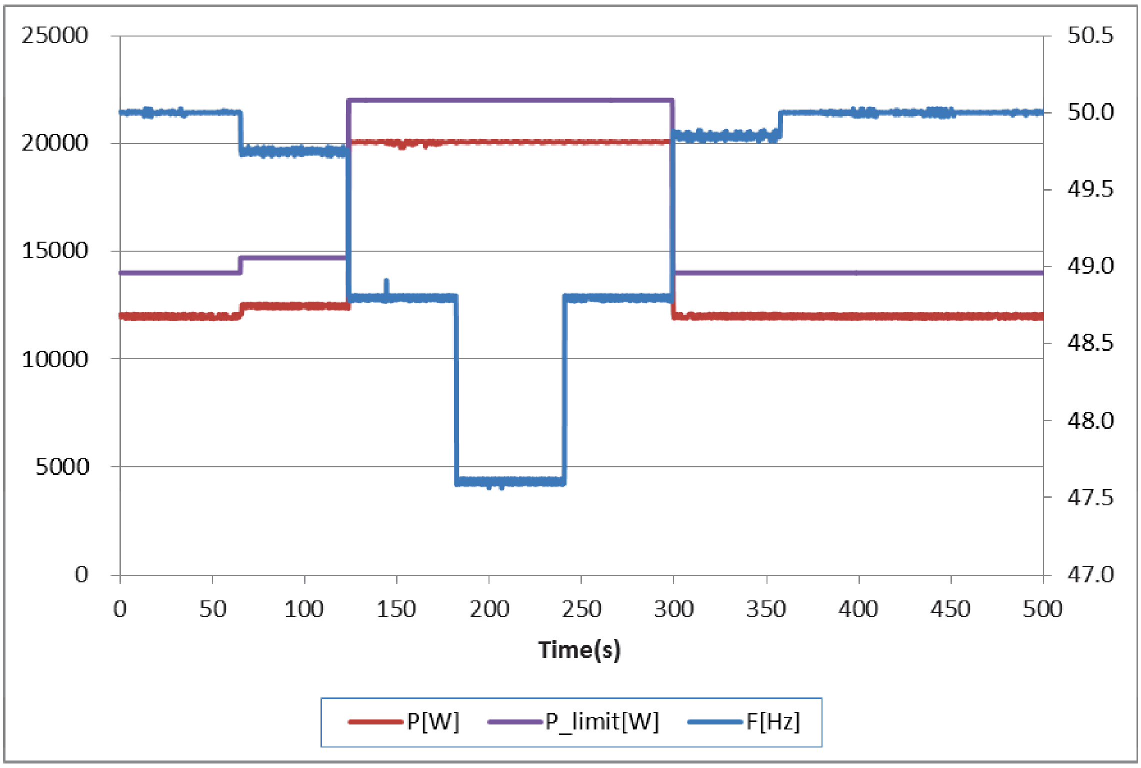
Test 2:

f [Hz]	a) 50,00	b) 49,75	c) 48,80	d) 47,60	e) 48,80	f) 49,85	g) 50,00
Frequency [Hz]:	50,00	49,75	48,80	47,60	48,80	49,85	50,00
$P_{setpoint}$ [% P_{Emax}]:	60,00	62,00	100,00	100,00	100,00	60,00	60,00
P_{E60} [% P_{Emax}]:	59,87	62,36	100,19	100,37	100,35	60,03	59,94
$\Delta P_{E60}/P_{Setpoint}$ [% P_{Emax}]:	-0,13	0,36	0,19	0,37	0,35	0,03	-0,06
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 10 % of P_{Emax}						

Graph of Test 1:



Graph of Test 2:



Tests:
The test is conducted for two powers.
In both tests, the following measuring points a) to j) must be approached with an accuracy of ± 10 mHz. The measuring points a) to h) and j) are to be approached for at least 60 s or until the maximum power is reached after a shutdown. The measuring point i) must be started for at least 10 min. The specified initial active power must be maintained with a tolerance of ± 5% PEmax. The deviation must be taken into account during the evaluation.
Start of the increase of active power at 49,8Hz s =5% (40% Pref/Hz), the rise of the active power gradient must be recorded.
Test1:
First, the test must start at a power > 10% PEmax ("Measurement 1")
Note: Testing is only valid for adjustable PGUs
Test2:
First, the test must start at a power > 60% PEmax ("Measurement 2")
Note: If the technical minimum line is above 60% PEmax, this must be taken into account accordingly. In the case of non-controllable EZE, this test is omitted.

Assessment criterion:
The test is regarded as passed:
a) for controllable PGU if:
- The active power reduces between measuring points 5.4.4.1 a) to g) and j), the expected active power output, after settling, adjusts with a deviation ≤ ± 10% P_{Emax}. Deviations according to VDE-AR-N 4105: 2018-11, 5.7.4.3, Figure 13 and due to the technical restrictions described are permissible. In the measuring points h) and i) no active power may be delivered,
- The initial time delay T_V of the frequency-dependent adaptation of the active power output ≤ 2 s.
- The response time of the adaptation of the active power output is a maximum of 8 s (type 1 units and type 2 units with rotating machines) or 2 s (all other type 2 units)
- the settling time of the adaptation of the active power output is a maximum time of 30 s (for type 1 units and for type 2 units with rotating machines) or respectively a maximum time of 20 s (for all other generation units type 2) and
- The connection time at point j) is at least 60 s and the power is then increased with a gradient of ≤ 10% P_{Emax} / min.
- In the case of generating units with combustion engines or gas turbines, if the criteria for response time and settling time are not met, the test shall be passed, even if the adaptation of active power output occurs with a power gradient of at least 66% P_{Emax} per min (corresponding to 1.11% P_{Emax} per s).

b) for conditionally adjustable PGU, if:
- they behave as descripted in a) inside their control range and
- no disconnection takes place between 49,8 Hz and 47,5 Hz;
- the connection time in j) corresponds to the manufacturer's information on the random number generator;

NOTE: The Uniform distribution of the disconnection frequency in maximum increments of 0.1 Hz between the end of the control range (at least 50.2 Hz) and 51.5 Hz shall be proofed by a manufacturer's declaration.

c) for non-adjustable EZE, if
- no disconnection takes place between 49,8 Hz and 47,5 Hz;
- the connection time in j) corresponds to the manufacturer's information on the random number generator;

NOTE The Uniform distribution of the disconnection frequency in maximum increments of 0.1 Hz between 50.2 Hz and 51.5 Hz shall be proofen by a manufacturer's declaration.

d) for linear generators with S_{Emax} ≤ 4.6 kVA,
- if they disconnect from the mains at a frequency ≤ 49,8 Hz and their maximum upper frequency limit (as specified by the manufacturer), but at the latest when they exceed 47.5 Hz.

the connection time in j) corresponds to the manufacturer's information on the random number generator;
Subsequently no more resynchronisation/active power feed-in is permitted, also while the frequency 5.4.4.1 i) is maintained (i.e no running on the characteristic curve as previously tested in a) at g).

Note:
The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-

8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

5.4.8 Static voltage stability / reactive power supply

The test serves as verification of the reactive power mode according to VD-AR-N 4105: 2018-11, 5.7.2 of the EZE in normal operation.

The PGU has:
applies for PGUs Type 2 - only inverter $\Sigma S_{Emax} \geq 4.6$ kVA

5.4.8.1 Tests of the Reactive power / cos φ setting accuracy — P

Setting values		
Setting values	cos φ over-excited:	0,90
	cos φ under-excited:	0,90

Test: SUN2000-8KTL-M0

30 s mean value	$0{,}90U_n$		U_n		$1{,}1\ U_n$	
	S_{Emax}	40 – 60 $\%P_{Emax}$	S_{Emax}	40 – 60 $\%P_{Emax}$	S_{Emax}	40 – 60 $\%P_{Emax}$
cos φ (1)						
U [V]:	207,17	207,64	230,14	230,64	253,12	253,64
P_{E30} [kW]:	7,994	4,051	7,991	4,052	7,998	4,053
Q_{E30} [kVar]:	-0,023	-0,106	-0,027	-0,127	-0,029	-0,153
S_{E30} [kVA].	7,994	4,052	7,991	4,054	7,998	4,055
cos $\varphi_{E30\text{-over-excited}}$:	0,999	0,999	0,999	0,999	0,999	0,999
$Q_{setpoint}$ [kVar]:	0,000	0,000	0,000	0,000	0,000	0,000
$\Delta Q/P_{Emax}$[%]	-0,29	-1,32	-0,34	-1,59	-0,36	-1,91
cos φ (c)						
U [V]:	207,15	207,65	230,14	230,65	253,12	253,65
P_{E30} [kW]:	6,671	4,060	7,039	4,062	7,042	4,065
Q_{E30} [kVar]:	4,975	3,036	5,248	3,023	5,244	2,989
S_{E30} [kVA].	8,322	5,070	8,780	5,064	8,780	5,045
cos $\varphi_{E30\text{-over-excited}}$:	0,802	0,801	0,802	0,802	0,802	0,806
$Q_{setpoint}$ [kVar]:	4,993	3,042	5,268	3,038	5,268	3,027
$\Delta Q/P_{Emax}$[%]	-0,23	-0,07	-0,25	-0,19	-0,30	-0,48
cos φ (i)						
U [V]:	207,14	207,61	230,13	230,62	253,11	253,62
P_{E30} [kW]:	6,675	4,034	7,027	4,035	7,027	4,035
Q_{E30} [kVar]:	-5,031	-3,039	-5,297	-3,058	-5,302	-3,084
S_{E30} [kVA].	8,359	5,050	8,801	5,063	8,803	5,079
cos $\varphi_{E30\text{-over-excited}}$:	0,799	0,799	0,799	0,797	0,798	0,794
$Q_{setpoint}$ [kVar]:	-5,015	-3,030	-5,280	-3,038	-5,282	-3,047

$\Delta Q/P_{Emax}$[%]	-0,20	-0,11	-0,21	-0,25	-0,25	-0,46
Limit ΔQ:	± 4% P_{Emax}					
Test: SUN2000-20KTL-M0						
30 s mean value	$0{,}90U_n$		U_n		1,1 U_n	
	S_{Emax}	40 – 60 %P_{Emax}	S_{Emax}	40 – 60 %P_{Emax}	S_{Emax}	40 – 60 %P_{Emax}
cos φ (1)						
U [V]:	207,54	207,83	230,46	230,76	251,11	251,40
P_{E30} [kW]:	19,967	9,994	19,951	10,008	19,967	10,004
Q_{E30} [kVar]:	-0,061	-0,050	-0,060	-0,055	-0,059	-0,052
S_{E30} [kVA].	19,967	9,994	19,952	10,008	19,967	10,004
cos $\varphi_{E30\text{-over-excited}}$:	0,999	0,999	0,999	0,999	0,999	0,999
$Q_{setpoint}$ [kVar]:	0,000	0,000	0,000	0,000	0,000	0,000
$\Delta Q/P_{Emax}$[%]	-0,28	-0,23	-0,27	-0,25	-0,27	-0,24
cos φ (c)						
U [V]:	207,47	207,69	230,38	230,79	251,03	251,42
P_{E30} [kW]:	15,978	7,778	15,969	9,993	15,980	10,028
Q_{E30} [kVar]:	11,937	5,787	11,926	7,435	11,932	7,449
S_{E30} [kVA].	19,944	9,695	19,931	12,456	19,944	12,492
cos $\varphi_{E30\text{-over-excited}}$:	0,801	0,803	0,801	0,802	0,801	0,803
$Q_{setpoint}$ [kVar]:	11,967	5,817	11,959	7,473	11,966	7,495
$\Delta Q/P_{Emax}$[%]	-0,135	-0,135	-0,146	-0,173	-0,155	-0,208
cos φ (i)						
U [V]:	207,41	207,62	230,33	230,72	250,99	251,36
P_{E30} [kW]:	15,457	7,673	15,947	9,879	15,951	9,976
Q_{E30} [kVar]:	-11,674	-5,820	-12,042	-7,500	-12,045	-7,568
S_{E30} [kVA].	19,370	9,631	19,983	12,403	19,988	12,522
cos $\varphi_{E30\text{-over-excited}}$:	0,798	0,797	0,798	0,797	0,798	0,797
$Q_{setpoint}$ [kVar]:	-11,622	-5,779	-11,990	-7,442	-11,993	-7,513
$\Delta Q/P_{Emax}$[%]	-0,24	-0,19	-0,24	-0,26	-0,24	-0,25
Limit ΔQ:	± 4% P_{Emax}					

Test:

applies for PGUs Type 2 - only inverter $\Sigma S_{Emax} \leq 4.6$ kVA

a)and b) For cos φ 0,95 over-excited and φ 0,95 under-excited, the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax} and a second time,
for cos φ 0,975 over-excited and φ 0,975 under-excited, the active power will be measured at a value between 40% P_{Emax} and 60% and S_{Emax}

applies for PGUs Type 2 - only inverter $\Sigma S_{Emax} \geq 4.6$ kVA

c) and d) For cos φ 0,90 over-excited and φ 0,90 under-excited, the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax} and a second time,
for cos φ 0,95 over-excited and φ 0,95 under-excited, the active power will be measured at a value between 40% P_{Emax} and 60% and S_{Emax}

applies PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells $\Sigma S_{Emax} \leq 4.6$ kVA

e) without specification of the cos φ the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax}.

applies for PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells $\Sigma S_{Emax} \geq 4.6$ kVA

f) and g) For cos φ 0,95 over-excited and cos φ 0,95 under-excited, the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax} and a second time,
for cos φ 0,975 over-excited and φ 0,975 under-excited, the active power will be measured at a value between 40% P_{Emax} and 60% and S_{Emax}

applies for PGUs Type 2 Asynchronous generators:

h) without specification of the cos φ the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax}

Assessment criterion:

applies for PGUs Type 2 - only inverter ΣSEmax ≤ 4.6 kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0.95 and one time at 0,975 and the measured apparent power of the fundamental. The test is passed if all the Q 60 s mean values of the fundamental component for a) are in the range of Q set point ± 4% P_{Emax} overexcited and for b) in the range of Q set point ± 4% P_{Emax} under-excited. In addition, a setting of the cos φ must be possible within a step size of at least 0.01.

applies for PGUs Type 2 - only inverter ΣSEmax ≥ 4.6 kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0.90 and one time at 0,95 and the measured apparent power of the fundamental. The test is passed if all the Q 60 s mean values of the fundamental component for a) are in the range of Q set point ± 4% P_{Emax} overexcited and for c) in the range of Q set point ± 4% P_{Emax} under-excited. In addition, a setting of the cos φ must be possible within a step size of at least 0.01.

applies for PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells ΣSEmax ≤ 4.6 kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0.95 and one time at 0,975 and the measured apparent power of the fundamental. The test is passed if all the Q 60 s mean values of the fundamental from e) are in the range Q maximal overexcited till Q minimal under-excited.

applies for PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells ΣSEmax ≥ 4.6 kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0.95 and one time at 0,975 and the measured apparent power of the fundamental. The test is passed if all the Q 60 s mean values of the fundamental component for a) are in the range of Q set point ± 4% P_{Emax} overexcited and for f) in the range of Q set point ± 4% P_{Emax} under-excited. In addition, a setting of the cos φ must be possible within a step size of at least 0.01.

applies for PGUs Type 1 Asynchronous generators:

The test is passed if the cos φ Q 60 s mean values of h) is in the range cos φ = 0,95 underexcited ±0,02.

Note:

The test had been performed on the model SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

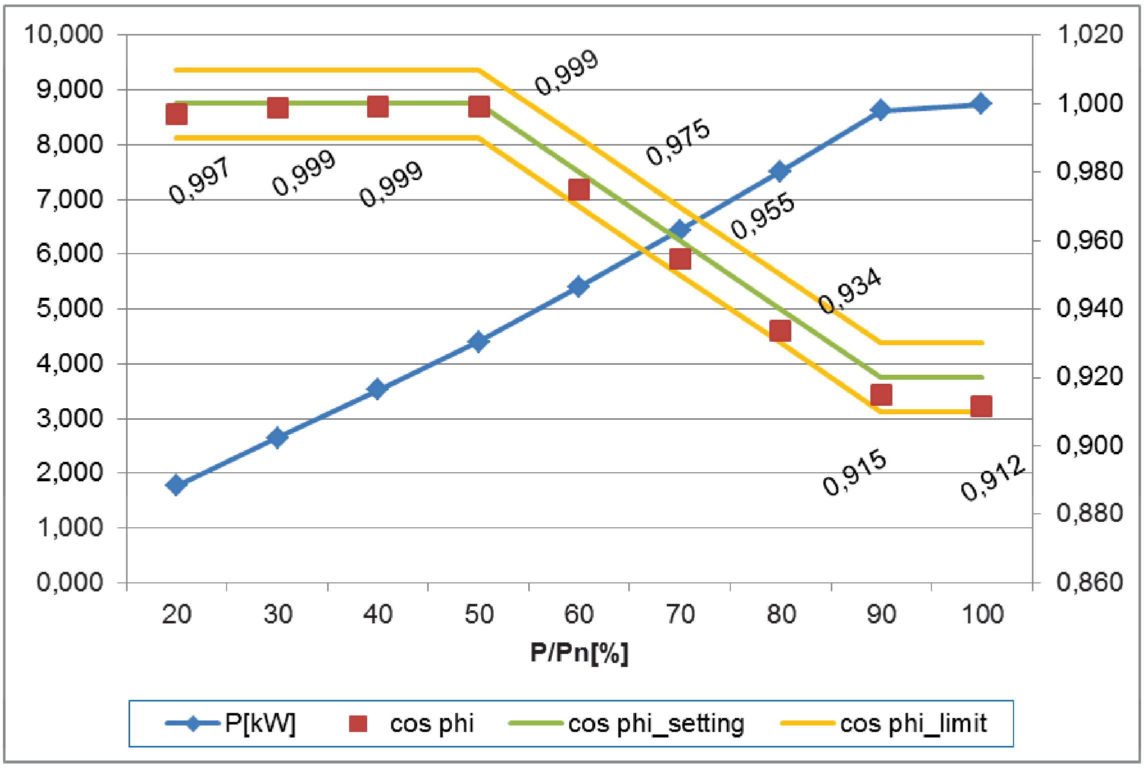
5.4.8.2 Test of the displacement factor/active power characteristic curve cos φ (P) The test serves as verification of the standard cos φ (P) curve according to VDE-AR-N 4105:2018-11, 5.7.2.4.	P

Test c): supply-dependent PGUs - Accuracy (characteristic curve): SUN2000-8KTL-M0										
P_{Emax}/P [%]	10	20	30	40	50	60	70	80	90	100
30 s mean value	20% to 100% P_{Emax}									
U [V]:	--	230,21	230,28	230,34	230,41	230,47	230,53	230,59	230,65	230,65
P_{E30} [kW]:	--	1,768	2,646	3,523	4,399	5,271	6,144	7,018	7,891	7,970
P_{E30} of P_{Emax} [%]:	--	20,09	30,07	40,04	49,99	59,90	69,82	79,74	89,67	90,56
Q_{E30} [kVar]:	--	-0,123	-0,124	-0,128	-0,180	-1,206	-1,911	-2,691	-3,481	-3,590
S_{E30} [kVA].	--	1,773	2,649	3,525	4,403	5,407	6,435	7,516	8,625	8,741
cos φ_{E30}:	--	0,997	0,999	0,999	0,999	0,975	0,955	0,934	0,915	0,912
cos $\varphi_{setpoint}$ of P_{E30}:	--	1,00	1,00	1,00	1,00	0,98	0,96	0,94	0,92	0,92
$Q_{setpoint}$ [kVar]:	--	0	0	0	0	-1,076	-1,802	-2,564	-3,380	-3,426
$\Delta Q/P_{Emax}$[%]	--	-1,402	-1,410	-1,450	-2,043	-1,481	-1,242	-1,444	-1,148	-1,864
Limit ΔQ:	± 4% P_{Emax}									
P_{Emax}/P [%]	100	90	80	70	60	50	40	30	20	10
30 s mean value	100% to 20% P_{Emax}									
U [V]:	230,65	230,65	230,58	230,52	230,46	230,41	230,34	230,28	230,22	--
P_{E30} [kW]:	7,970	7,890	7,017	6,144	5,271	4,400	3,523	2,647	1,768	--
P_{E30} of P_{Emax} [%]:	90,56	89,66	79,74	69,82	59,90	49,99	40,04	30,07	20,09	--
Q_{E30} [kVar]:	-3,590	-3,513	-2,722	-1,934	-1,217	-0,178	-0,127	-0,124	-0,123	--
S_{E30} [kVA].	8,741	8,637	7,527	6,441	5,410	4,403	3,526	2,649	1,773	--
cos φ_{E30}:	0,912	0,914	0,932	0,954	0,974	0,999	0,999	0,999	0,997	--
cos $\varphi_{setpoint}$ of P_{E30}:	0,92	0,92	0,94	0,96	0,98	1,00	1,00	1,00	1,00	--
$Q_{setpoint}$ [kVar]:	-3,426	-3,385	-2,568	-1,804	-1,077	0	0	0	0	--
$\Delta Q/P_{Emax}$[%]	-1,865	-1,456	-1,750	-1,478	-1,601	-2,028	-1,441	-1,408	-1,403	--
Limit ΔQ:	± 4% P_{Emax}									

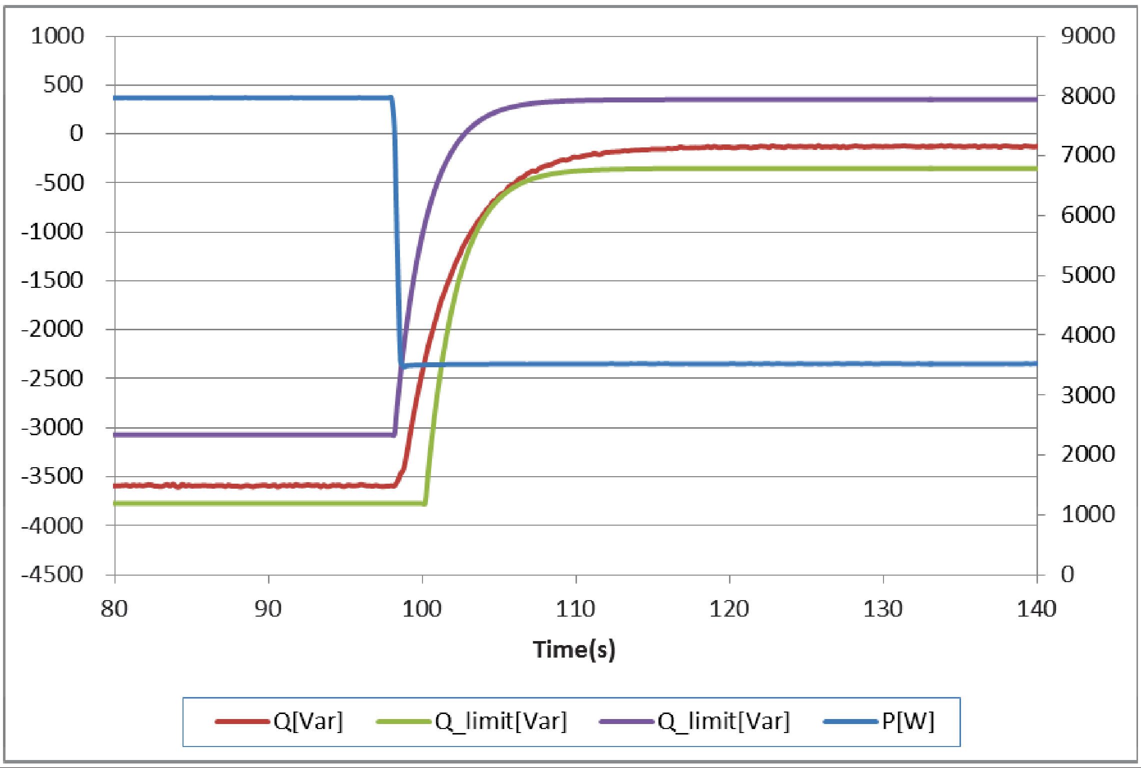
Test d): supply-dependent PGUs - Dynamic: SUN2000-8KTL-M0				
P_{Emax}/P_n [%]	100	40	100	75
30 s mean value	100% to 40% to 100% to 75% P_{Emax}			
U [V]:	230,65	230,34	230,65	230,55
P_{E30} [kW]:	7,969	3,523	7,970	6,581
P_{E30} of P_{Emax} [%]:	90,56	40,04	90,56	74,78
Q_{E30} [kVar]:	-3,591	-0,127	-3,591	-2,308

S_{E30} [kVA].	8,741	3,526	8,741	6,974
cos φ_{E30}:	0,912	0,999	0,912	0,944
cos $\varphi_{setpoint}$ of P_{E30}:	0,92	1,00	0,92	0,95
$Q_{setpoint}$ [kVar]:	-3,426	0	-3,426	-2,178
$\Delta Q/P_{Emax}$[%]	-1,874	-1,446	-1,880	-1,482
Limit ΔQ:	± 4% P_{Emax}			

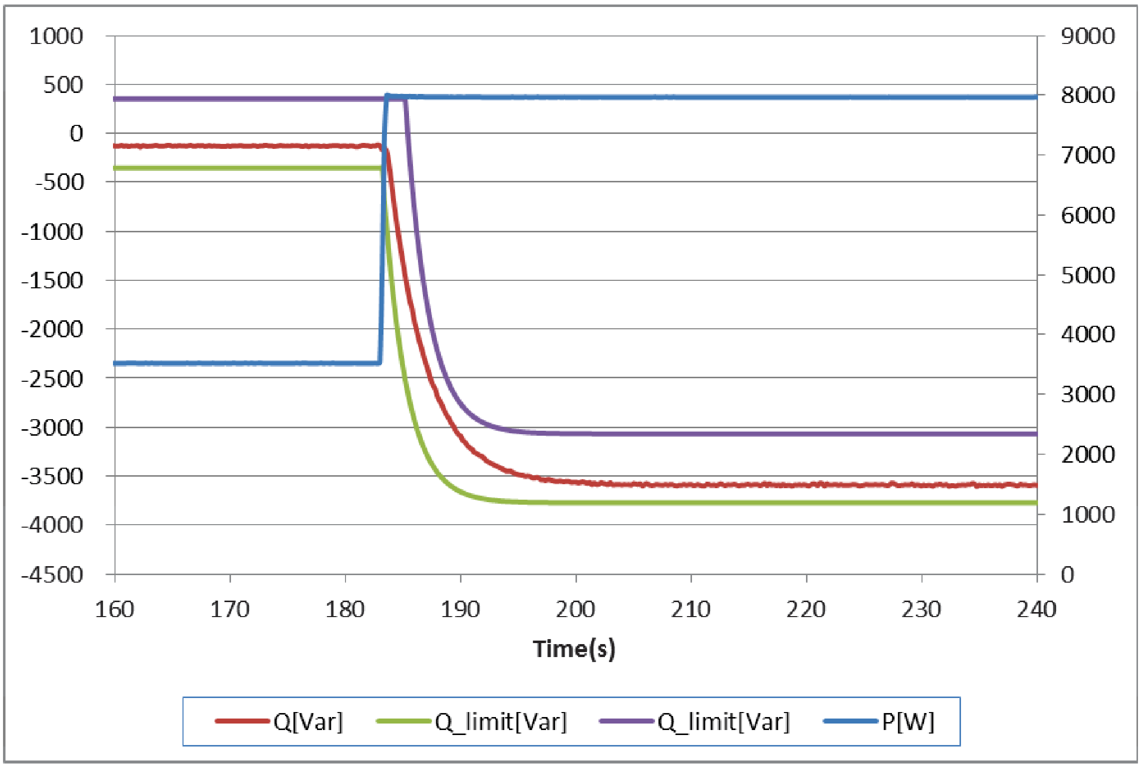
Graph of cos φ(P): Test c)



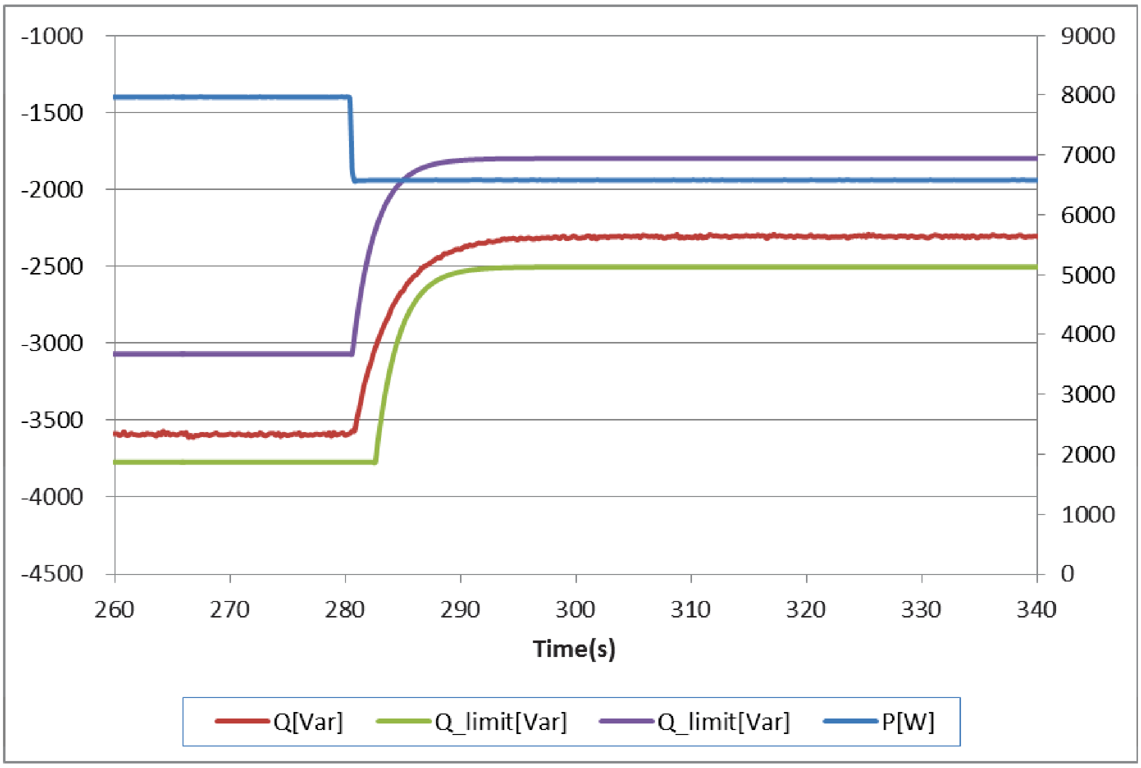
Graph of Test d): 100% to 40% P_{Emax}



Graph of Test d): 40% to 100% P_{Emax}



Graph of Test d): 100% to 75% P_{Emax}

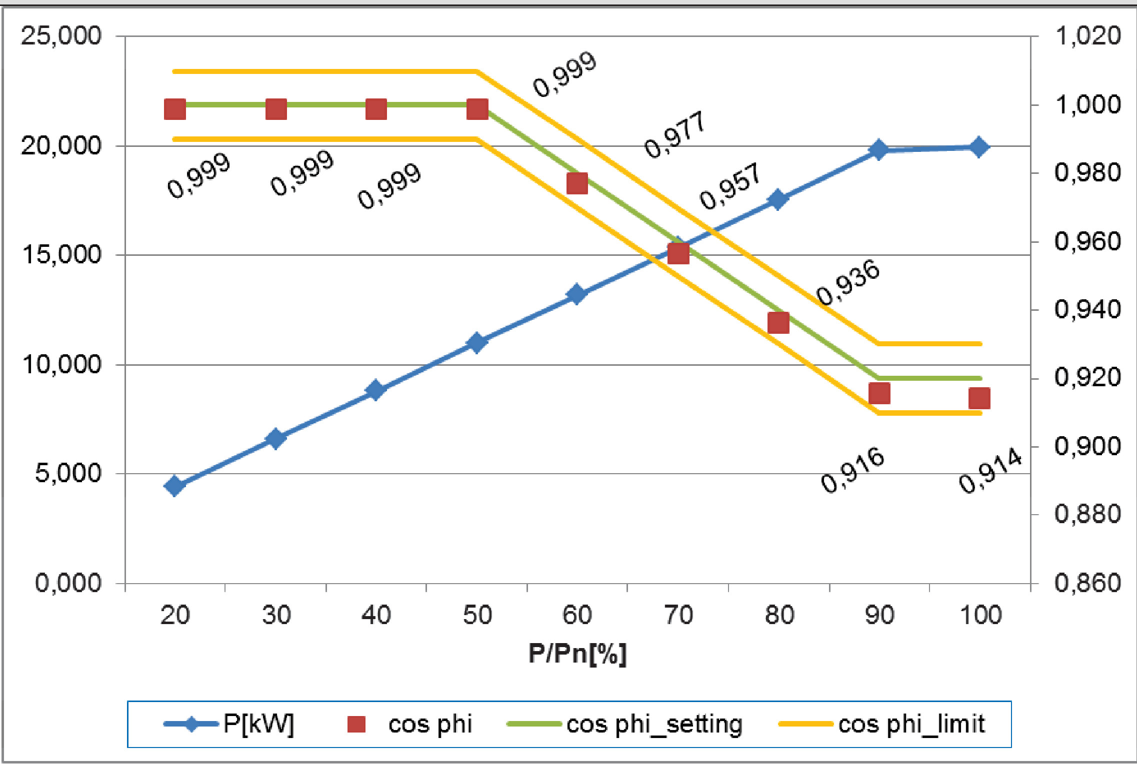


Test c): supply-dependent PGUs - Accuracy (characteristic curve): SUN2000-20KTL-M0										
P_{Emax}/P [%]	10	20	30	40	50	60	70	80	90	100
30 s mean value	20% to 100% P_{Emax}									
U [V]:	--	230,57	230,72	230,86	231,04	231,17	231,30	231,43	231,55	231,57
P_{E30} [kW]:	--	4,417	6,611	8,804	10,997	13,182	15,368	17,558	19,813	19,951
P_{E30} of P_{Emax} [%]:	--	20,08	30,05	40,02	49,99	59,92	69,85	79,81	90,06	90,68
Q_{E30} [kVar]:	--	-0,137	-0,146	-0,156	-0,270	-2,861	-4,675	-6,578	-8,683	-8,842
S_{E30} [kVA].	--	4,419	6,612	8,806	11,001	13,489	16,063	18,749	21,632	21,822
cos φ_{E30}:	--	0,999	0,999	0,999	0,999	0,977	0,957	0,936	0,916	0,914
cos $\varphi_{setpoint}$ of P_{E30}:	--	1,00	1,00	1,00	1,00	0,98	0,96	0,94	0,92	0,92
$Q_{setpoint}$ [kVar]:	--	0	0	0	0	-2,684	-4,498	-6,397	-8,478	-8,553
$\Delta Q/P_{Emax}$[%]	--	-0,625	-0,664	-0,710	-1,228	-0,803	-0,807	-0,823	-0,929	-1,315
Limit ΔQ:	± 4% P_{Emax}									
P_{Emax}/P [%]	100	90	80	70	60	50	40	30	20	10
30 s mean value	100% to 20% P_{Emax}									
U [V]:	231,57	231,56	231,44	231,31	231,18	231,04	230,88	230,73	230,58	--
P_{E30} [kW]:	19,951	19,753	17,561	15,373	13,185	10,999	8,805	6,610	4,416	--
P_{E30} of P_{Emax} [%]:	90,68	89,78	79,82	69,88	59,93	50,00	40,02	30,05	20,07	--
Q_{E30} [kVar]:	-8,841	-8,648	-6,594	-4,678	-2,855	-0,261	-0,156	-0,146	-0,137	--
S_{E30} [kVA].	21,822	21,563	18,758	16,069	13,491	11,002	8,807	6,612	4,419	--
cos φ_{E30}:	0,914	0,916	0,936	0,957	0,977	0,999	0,999	0,999	0,999	--
cos $\varphi_{setpoint}$ of P_{E30}:	0,92	0,92	0,94	0,96	0,98	1,00	1,00	1,00	1,00	--
$Q_{setpoint}$ [kVar]:	-8,552	-8,451	-6,400	-4,499	-2,685	0	0	0	0	--
$\Delta Q/P_{Emax}$[%]	-1,313	-0,895	-0,881	-0,811	-0,773	-1,187	-0,709	-0,663	-0,623	--
Limit ΔQ:	± 4% P_{Emax}									

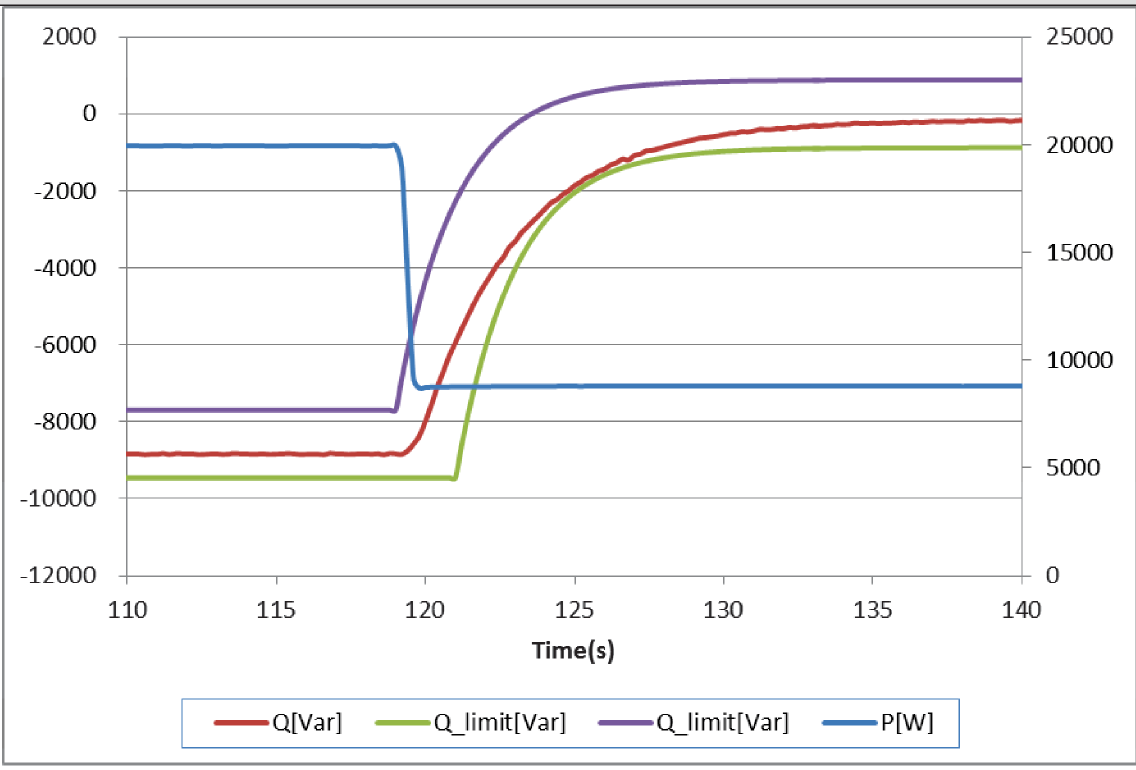
Test d): supply-dependent PGUs - Dynamic: SUN2000-20KTL-M0				
P_{Emax}/P_n [%]	100	40	100	75
30 s mean value	100% to 40% to 100% to 75% P_{Emax}			
U [V]:	231,52	230,87	231,52	231,35
P_{E30} [kW]:	19,945	8,803	19,946	16,462
P_{E30} of P_{Emax} [%]:	90,66	40,01	90,66	74,83
Q_{E30} [kVAr]:	-8,836	-0,157	-8,827	-5,604
S_{E30} [kVA].	21,815	8,804	21,812	17,390
cos φ_{E30}:	0,914	0,999	0,914	0,947
cos $\varphi_{setpoint}$ of P_{E30}:	0,92	1,00	0,92	0,95
$Q_{setpoint}$ [kVAr]:	-8,550	0	-8,549	-5,430

ΔQ/P_{Emax}[%]	-1,302	-0,715	-1,267	-0,789
Limit ΔQ:	± 4% P_{Emax}			

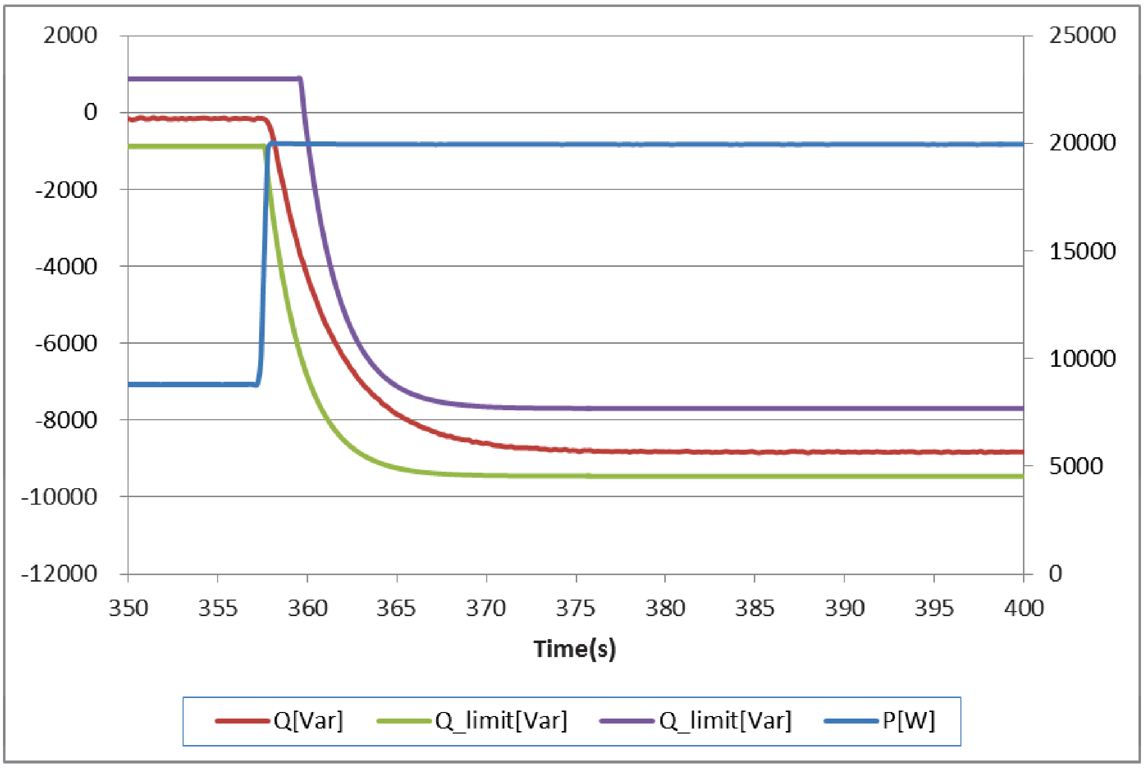
Graph of cos φ(P): Test c)



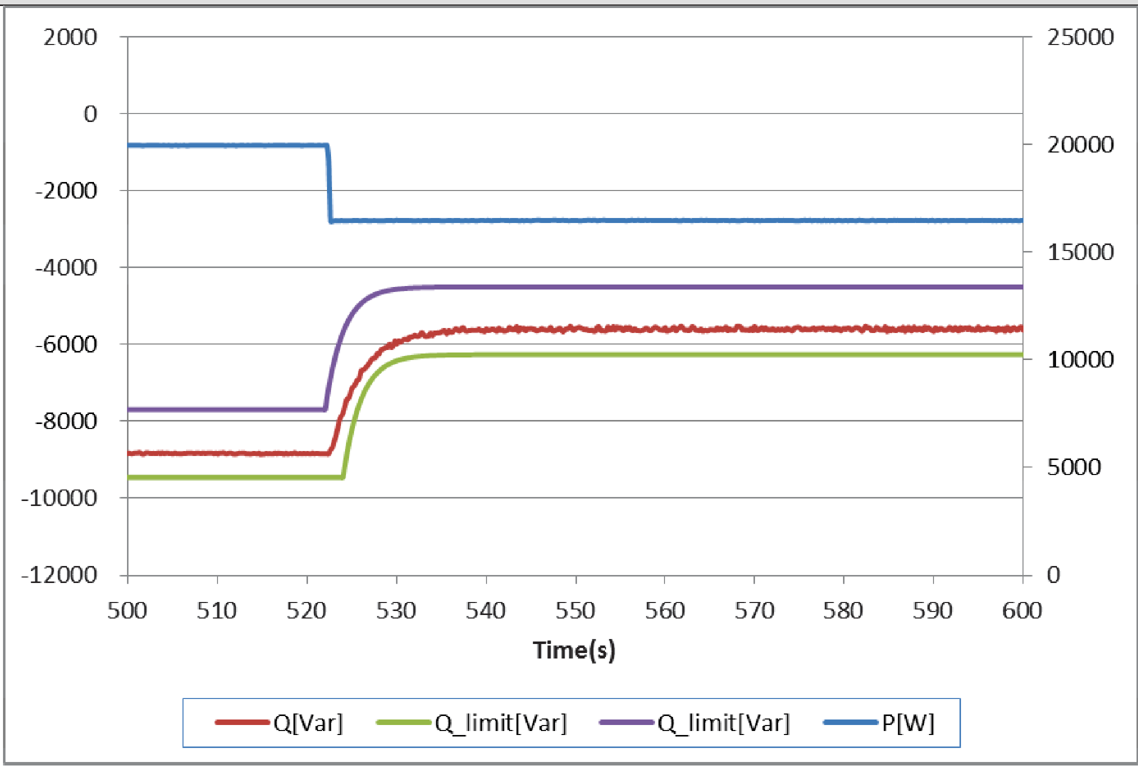
Graph of Test d): 100% to 40% P_{Emax}



Graph of Test d): 40% to 100% P_{Emax}



Graph of Test d): 100% to 75% P_{Emax}



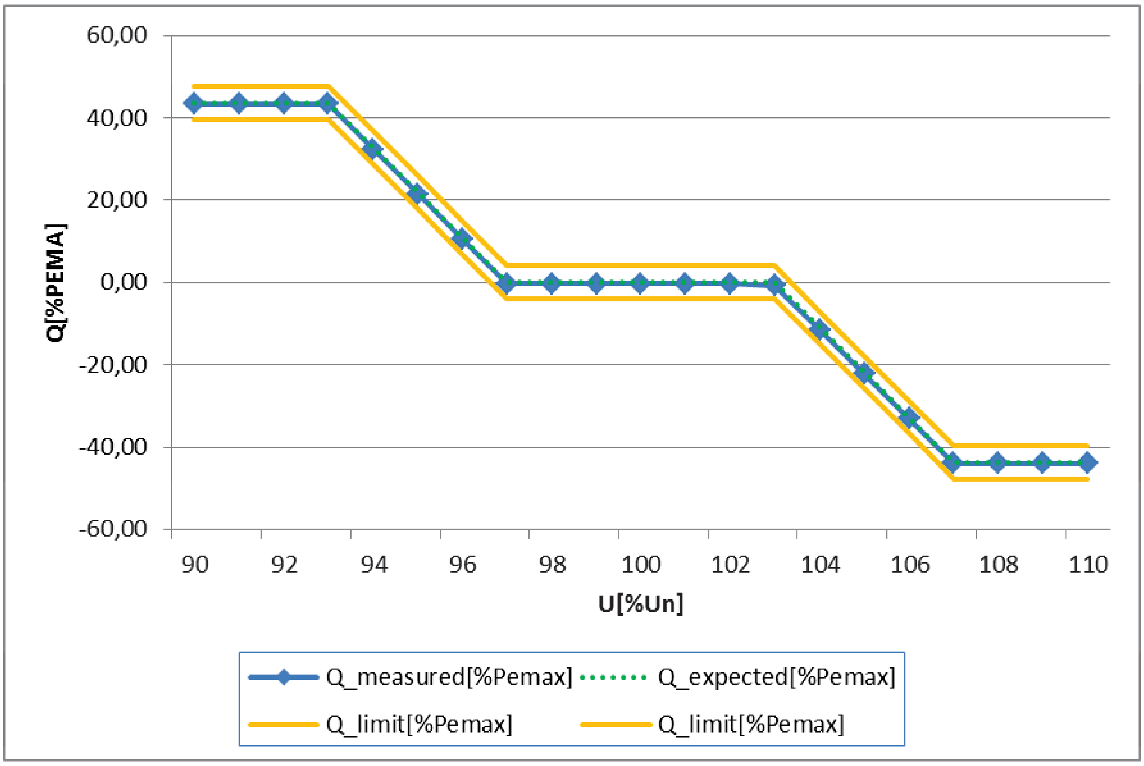
Assessment criterion: Test 5.4.8.2 a) and c) are passed if the maximum deviation between the reactive power setpoint (calculated from the characteristic) and the reactive power actual value at the generator terminals for all calculated reactive power values is a maximum of ± 4.0% relative to P_{Emax}. Test 5.4.8.2 (b) is regarded as passed if the PGU demonstrably complies with the performance gradient requirements of VDE-AR-N 4105: 2018-11 in Section 5.7.4.2. Test 5.4.8.2 d) is passed if the step response of the reactive power in the test steps c) and e) exhibits the PT1 behavior according to VDE-AR-N 4105: 2018-11 Section 5.7.2.5 and for test step d) the power gradient between the Limits of VDE-AR-N 4105: 2018-11 Section 5.7.4.2.
Note: The test had been performed on the model SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

5.4.8.3 Test the reactive power-voltage characteristic Q (U) The validation of the Q (U) regulation according to VDE-AR-N 4105: 2018-05, 5.7.2.4 is divided into two partial tests, so that on the one hand the accuracy and on the other hand the dynamics of the Q (U) control is checked. For all inverter-coupled systems, only the inverter must be tested.	**P**
5.4.8.3.1 Test of the reactive power-voltage characteristic Q (U): SUN2000-8KTL-M0	**P**

Vac [% U_n] Set point	Vac_L1 [V] measured	Vac_L2 [V] measured	Vac_L3 [V] measured	P [kW] measured	Q [kVar] measured	Q [kVar] expected	ΔQ [% P_{Emax}]
100	230,13	230,13	230,15	7,992	-0,026	0,000	-0,29
99	227,84	227,84	227,85	7,992	-0,025	0,000	-0,29
98	225,54	225,54	225,56	7,992	-0,025	0,000	-0,29
97	223,11	223,11	223,12	7,993	0,012	0,000	0,14
96	220,92	220,92	220,94	7,995	0,926	0,959	-0,38
95	218,65	219,36	218,28	7,997	1,841	1,918	-0,88
94	216,36	216,36	215,58	7,999	2,949	2,878	0,81
93	214,06	214,46	213,68	7,739	3,791	3,837	-0,52
92	211,57	211,98	211,22	7,620	3,810	3,837	-0,31
91	209,43	210,22	209,45	7,535	3,810	3,837	-0,30
90	207,16	207,57	206,77	7,420	3,810	3,837	-0,30
91	209,47	210,26	209,48	7,536	3,810	3,837	-0,30
92	211,77	212,17	211,38	7,627	3,809	3,837	-0,32
93	214,08	214,08	213,70	7,725	3,809	3,837	-0,32
94	216,37	216,37	215,60	7,998	2,934	2,878	0,64
95	218,83	218,84	218,48	7,996	1,871	1,918	-0,54
96	220,96	220,97	220,99	7,993	0,905	0,959	-0,62
97	223,26	223,27	223,28	7,990	-0,025	0,000	-0,29
98	225,56	225,57	225,58	7,990	-0,026	0,000	-0,29
99	227,85	227,87	227,88	7,989	-0,026	0,000	-0,30
100	230,15	230,17	230,18	7,989	-0,026	0,000	-0,30
101	232,45	232,47	232,48	7,989	-0,026	0,000	-0,30
102	234,75	234,76	234,77	7,989	-0,027	0,000	-0,30
103	237,13	237,14	237,15	7,990	-0,085	0,000	-0,97
104	239,34	239,36	239,37	7,988	-1,029	-0,959	-0,79
105	241,64	241,66	241,66	7,987	-1,982	-1,918	-0,73
106	245,14	243,95	243,96	7,987	-3,103	-2,878	-2,56
107	246,23	246,25	246,25	7,905	-3,861	-3,837	-0,28
108	248,53	248,55	248,55	7,905	-3,862	-3,837	-0,28

109	250,83	250,85	250,84	7,906	-3,862	-3,837	-0,29
110	253,13	253,15	253,14	7,906	-3,862	-3,837	-0,29
109	250,83	250,84	250,84	7,906	-3,862	-3,837	-0,29
108	248,53	248,55	248,55	7,906	-3,861	-3,837	-0,28
107	246,23	246,25	246,25	7,905	-3,861	-3,837	-0,28
106	243,93	243,95	243,95	7,987	-2,938	-2,878	-0,68
105	241,64	241,66	241,29	7,987	-1,962	-1,918	-0,49
104	239,34	239,36	239,36	7,988	-1,031	-0,959	-0,81
103	237,04	237,06	236,76	7,989	-0,036	0,000	-0,41
102	234,75	234,76	234,76	7,989	-0,027	0,000	-0,31
101	232,45	232,46	232,47	7,989	-0,027	0,000	-0,31
100	230,15	230,16	230,17	7,989	-0,026	0,000	-0,29
Limit ΔQ:	± 4% P_{Emax}						

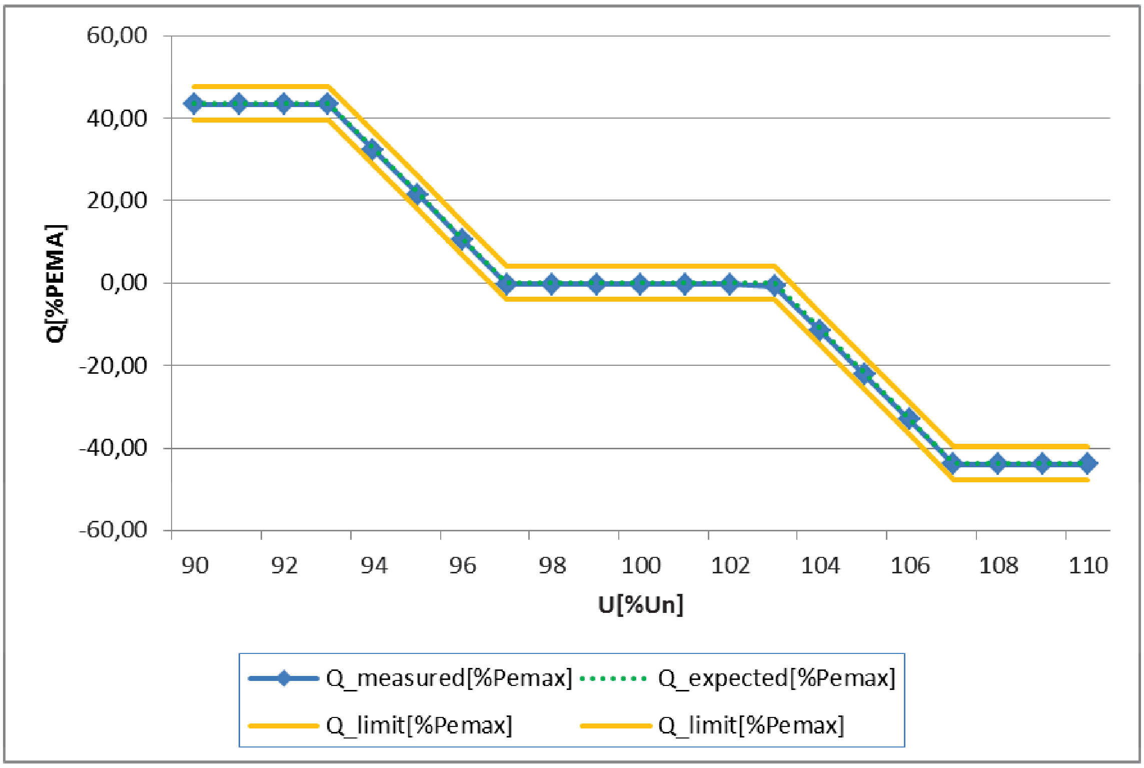
Graph of characteristic Q (U):



5.4.8.3.1	Test of the reactive power-voltage characteristic Q (U): SUN2000-20KTL-M0						P
Vac [% U_n] Set point	Vac_L1 [V] measured	Vac_L2 [V] measured	Vac_L3 [V] measured	P [kW] measured	Q [kVar] measured	Q [kVar] expected	ΔQ [% P_{Emax}]
100	229,94	230,41	229,53	19,965	-0,057	0,000	-0,26
99	227,69	228,16	227,23	19,964	-0,057	0,000	-0,26
98	225,37	225,83	224,90	19,965	-0,058	0,000	-0,26
97	223,11	223,57	222,63	19,969	-0,043	0,000	-0,19
96	220,80	221,25	220,29	19,975	2,300	2,398	-0,45
95	218,32	218,96	217,85	19,975	4,780	4,796	-0,07
94	215,92	216,48	215,45	19,925	7,260	7,194	0,30
93	213,72	214,37	213,34	19,237	9,528	9,592	-0,29
92	212,00	212,26	211,22	19,011	9,529	9,592	-0,29
91	209,12	209,75	208,70	18,135	9,532	9,592	-0,27
90	206,98	207,62	206,63	17,456	9,534	9,592	-0,27
91	209,11	209,75	208,76	17,994	9,531	9,592	-0,28
92	211,68	212,07	211,35	18,995	9,528	9,592	-0,29
93	213,54	214,10	213,03	19,219	9,497	9,592	-0,43
94	216,04	216,68	215,60	19,949	7,109	7,194	-0,39
95	218,32	218,96	217,98	19,963	4,691	4,796	-0,48
96	220,70	221,27	220,28	19,961	2,287	2,398	-0,50
97	223,07	223,55	222,65	19,957	-0,060	0,000	-0,27
98	225,36	225,84	224,94	19,956	-0,060	0,000	-0,27
99	227,55	228,13	227,23	19,954	-0,059	0,000	-0,27
100	229,88	230,43	229,51	19,954	-0,059	0,000	-0,27
101	232,14	232,72	231,82	19,954	-0,060	0,000	-0,27
102	234,86	235,37	234,90	11,866	0,028	0,000	0,13
103	236,73	237,31	236,40	19,957	-0,134	0,000	-0,61
104	239,12	239,60	238,79	19,955	-2,559	-2,398	-0,73
105	241,51	241,89	241,08	19,953	-4,956	-4,796	-0,73
106	244,20	244,19	243,37	19,950	-7,461	-7,194	-1,22
107	246,29	246,48	245,65	19,745	-9,645	-9,592	-0,24
108	248,78	248,77	247,94	19,747	-9,646	-9,592	-0,24
109	251,07	250,77	250,34	19,749	-9,646	-9,592	-0,25
110	253,37	253,37	252,62	19,750	-9,647	-9,592	-0,25
109	251,17	251,16	250,42	19,748	-9,646	-9,592	-0,24
108	248,78	248,77	248,04	19,746	-9,646	-9,592	-0,25
107	246,49	245,78	245,65	19,774	-9,585	-9,592	0,03

106	244,20	244,19	243,36	19,948	-7,470	-7,194	-1,26
105	241,41	241,60	240,98	19,951	-4,785	-4,796	0,05
104	239,12	239,60	238,69	19,953	-2,535	-2,398	-0,62
103	236,73	237,31	236,40	19,956	-0,137	0,000	-0,62
102	234,43	235,02	234,11	19,955	-0,060	0,000	-0,27
101	232,74	233,02	232,81	19,956	-0,060	0,000	-0,27
100	229,95	230,42	229,52	19,956	-0,059	0,000	-0,27
Limit ∆Q:	± 4% P_{Emax}						

Graph of characteristic Q (U):



Test:

The verification of the accuracy of the Q (U) control of the reactive power-voltage characteristic Un shown in VDE-AR-N 4105: 2018-11, 5.7.2.4, Figure 7 is effected by a slow variation of the line voltage U_n in the range 90% U_n to 110% U_n. Depending on the type of EZE (single- or three-phase), the voltage changes must be carried out simultaneously or symmetrically on all phases.

a) In order to check the stationary accuracy, the permissible voltage range shall be passed through within steps, with a step size of 1% U_n, but not greater than 2% U_n.

1. Pass the voltage range from 100% U_n down to the under voltage range to 90% U_n.
2. Pass the voltage range from 90% U_n up to the over voltage range to 110% U_n.
3. Pass the voltage range from 110% U_n down to the Nominal Voltage U_n.

The procedure is analogous to Figure 3 in Section 5.4.3.2.

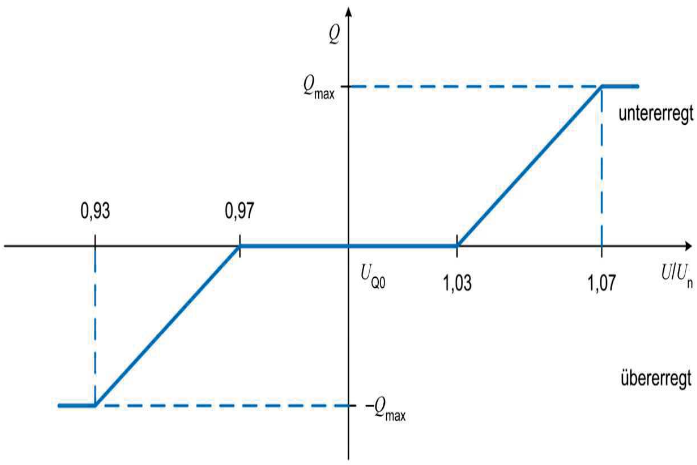


Bild 7 – Standard-$Q(U)$-Kennlinie

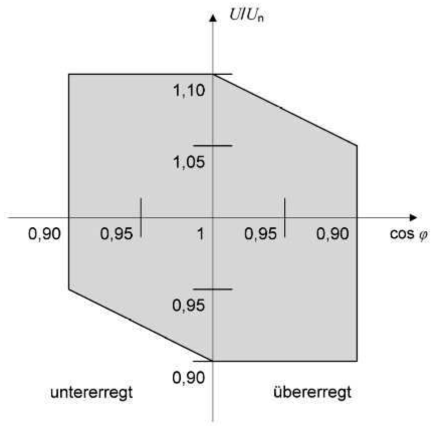


Bild 3 – Anforderungen an Erzeugungseinheiten bezüglich der Blindleistungsbereitstellung an den Generatorklemmen
($\sum S_{Emax} > 4{,}6$ kVA)

The voltages are to be set with a maximum deviation of 0.25% U_n.

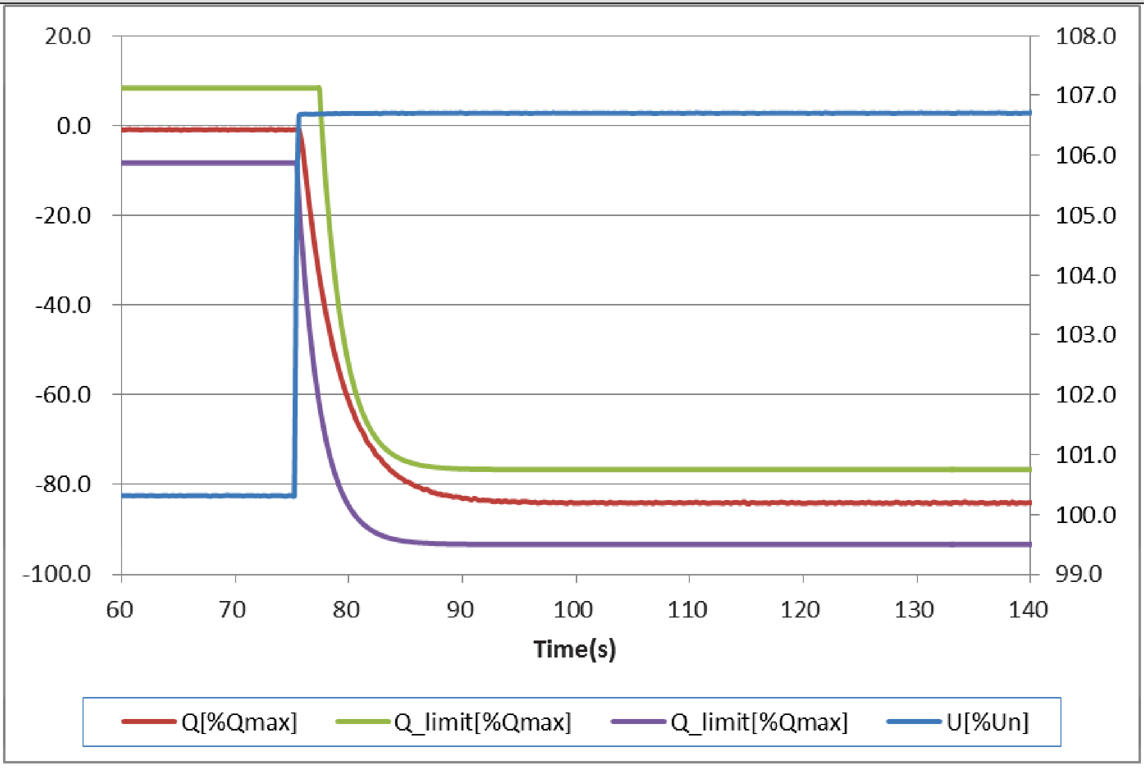
Assessment criterion:

In order to pass the Q (U) accuracy test, the measured stationary value pairs U_{PGU} and Q_{PGU}, under taking account to the correct sign in the consumer metering system, must be within VDE-AR-N 4105: 2018-11, in 5.7.2.4, Figure 7 Q (U) shown characteristic. The stationary value pairs U_{PGU} and Q_{PGU} are determined by averaging over 30 seconds at the end of the respective measuring section analogously to Chapter 5.4.3.2. The permissible deviations are with the maximum measuring error of the voltage of 1% U_n stated in VDE-AR-N 4105: 2018-11 and a setting accuracy of 4% P_{EMax} at

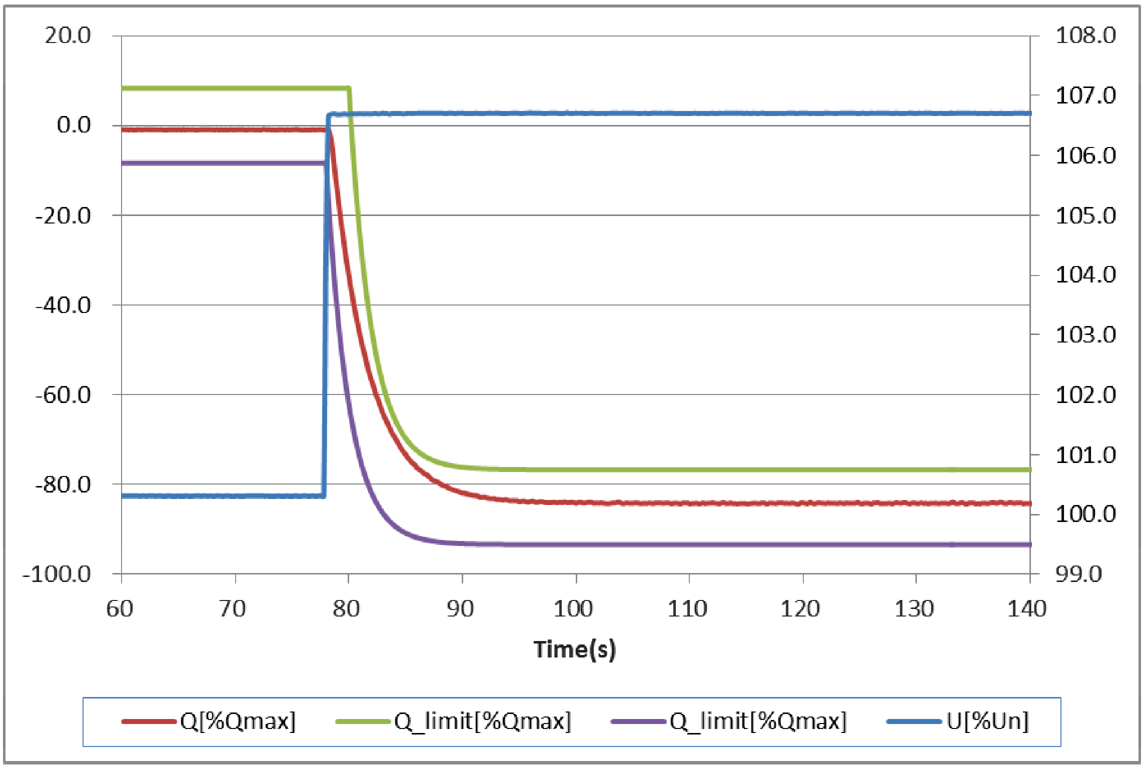
$$Q_{EZE,tol} = \pm(0.01 \cdot U_{N,Y} \cdot k_{QU} + 0.04 \cdot P_{EMax}) = \pm 0{,}25 \cdot P_{EMax} \cdot (\sin(\arccos(\varphi_{min})) + 0.16).$$

5.4.8.3.2 Test of the dynamics of the Q (U) regulation			P
Voltage jump Vac [% U_n]	Q [kVar] measured	Q [%Qmax] measured	T=3τmeasured
100 to 106,4	-8,066	-84,1	10,2s
	-8,071	-84,1	10,2s
	-8,065	-84,1	10,2s
100 to 93,6	8,495	88,6	9,8s
	8,474	88,4	9,8s
	8,452	88,1	9,8s

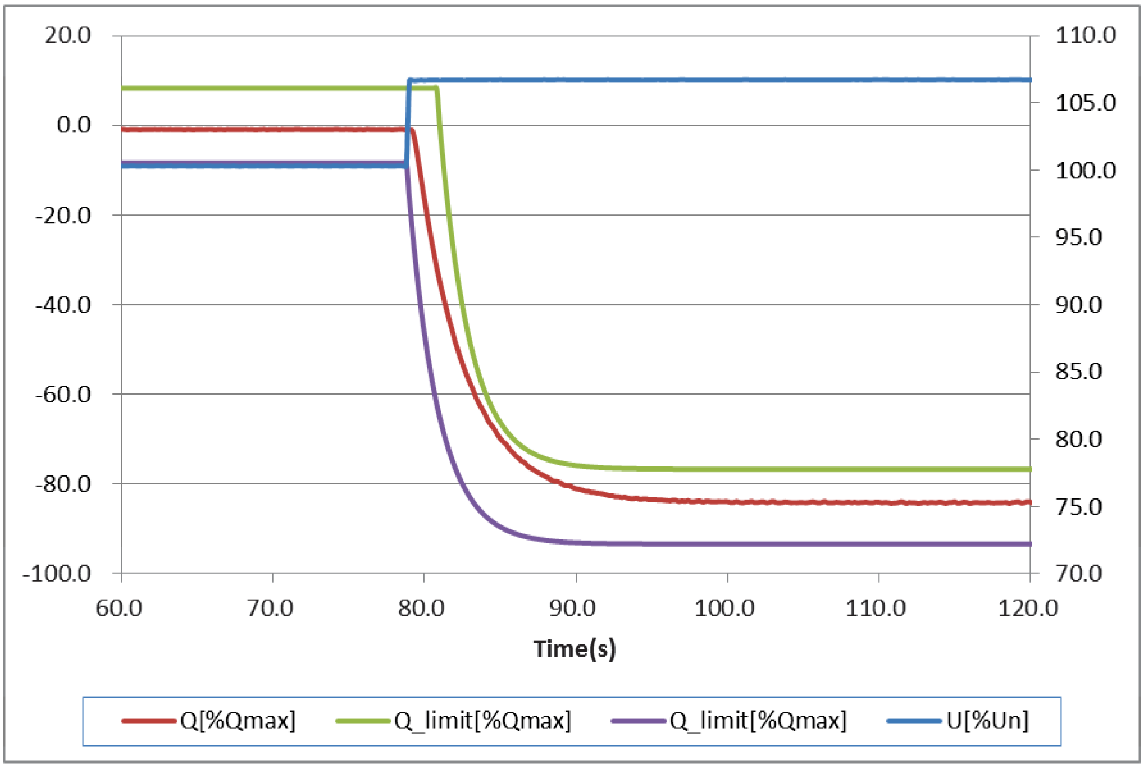
Graph of 100% U_n to 106,4% U_n: Test 1



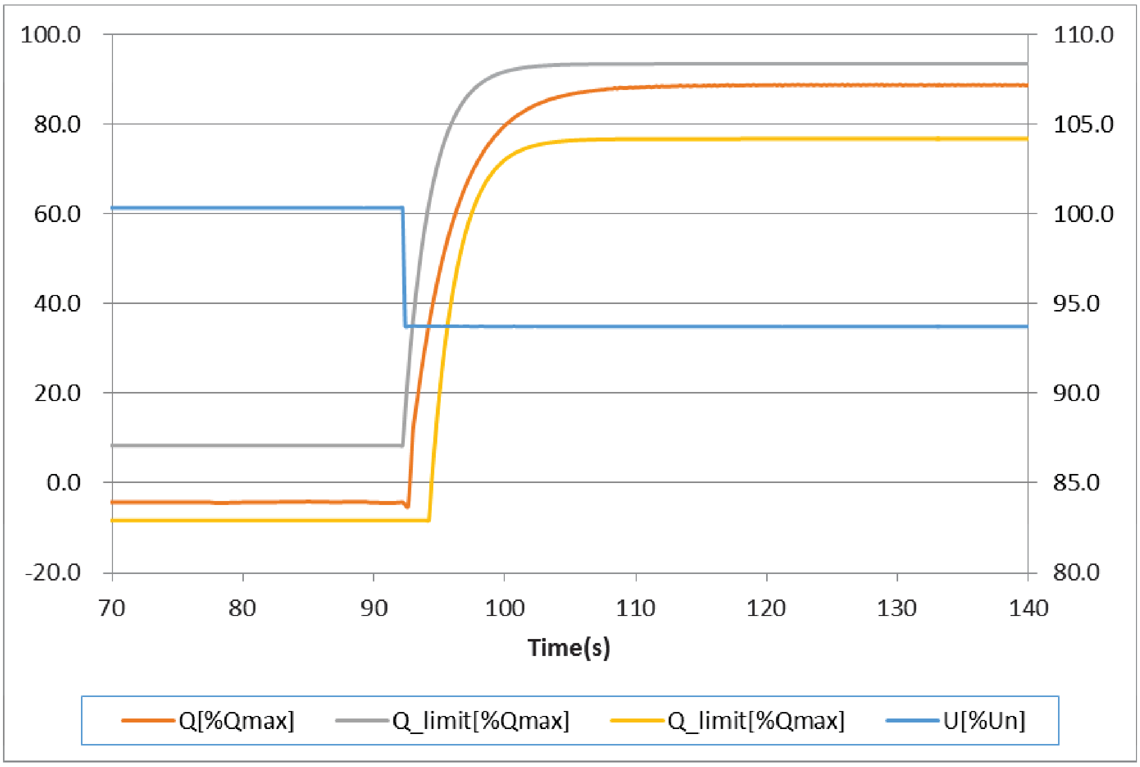
Graph of 100% U_n to 106,4% U_n: Test 2



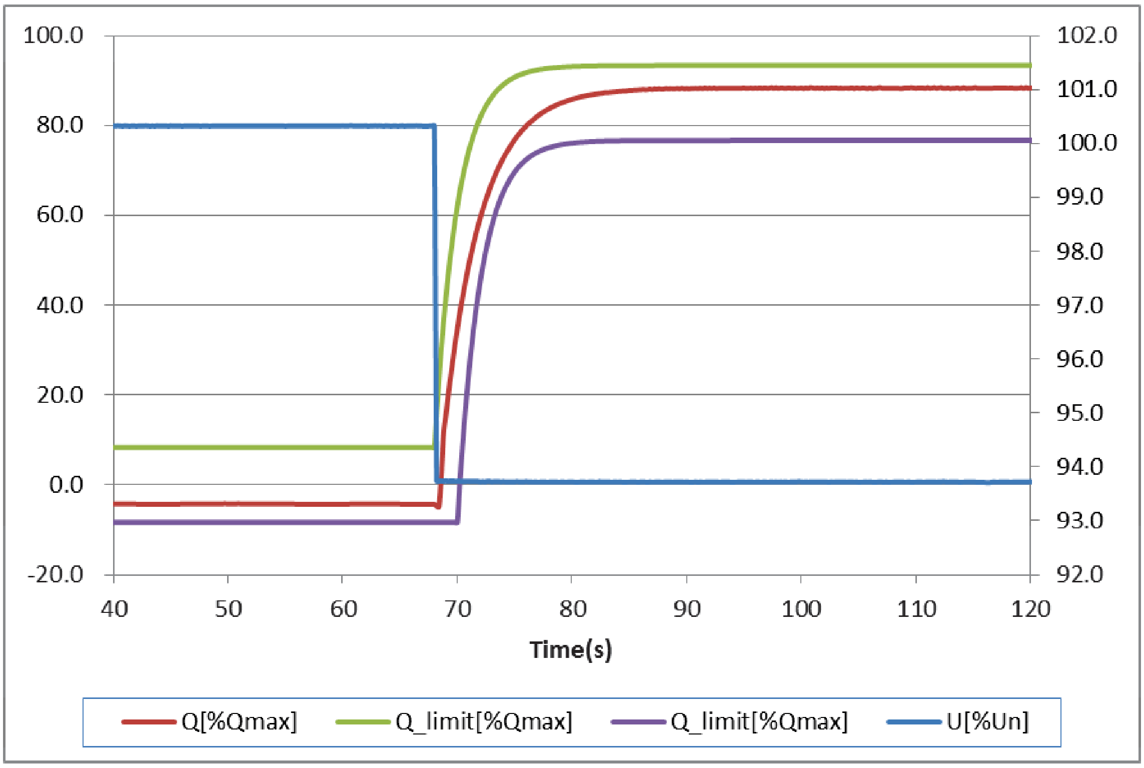
Graph of 100% U_n to 106,4% U_n: Test 3



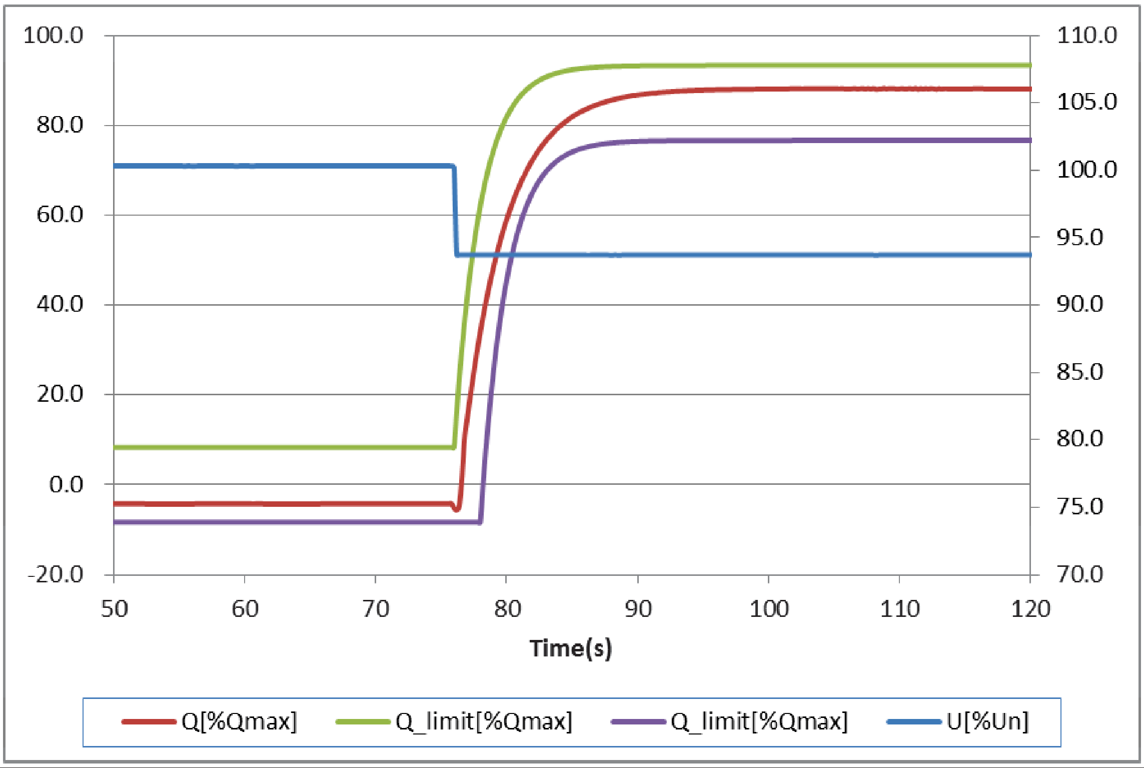
Graph of 100% U_n to 93,6% U_n: Test 1



Graph of 100% U_n to 93,6% U_n: Test 2



Graph of 100% U_n to 93,6% U_n: Test 3



5.5 Testing of NS protection

E DIN V 0124-100:(2019-09) draft

Clause	Test	Result
5.5.1	General	P
5.5.2.1	Functional safety	P
5.5.4	Integrated NS-protection	P
5.5.6	Section switch	P
5.5.6.2	Central section switch	N/A
5.5.6.3	Integrated section switch	P
5.5.7.2	Voltage control Single Phase	N/A
5.5.7.2	Voltage control Multi Phase (Phase to N)	P
5.5.7.2	Voltage control Multi Phase (Phase to Phase)	N/A
5.5.7.2.1.3	Measuring the rise-in voltage protection as a running 10-minute mean value	P
5.5.7.2.1.9	Frequency measurement	P
5.5.8	Reporting of NS protection	P
5.5.9	Constructional characteristics of NS protection	P
5.5.10.2	Passive Islanding Protection	N/A
5.5.10.3	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%)	P
5.5.10.3	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT ouput = 66%)	P
5.5.10.3	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT ouput = 33%)	P

5.5.2.1 **Functional safety**								P
Component No.	Fault	Test condition:		Test time	Fuse no.	Fault condition		Result
		AC	DC			AC	DC	
Relay defect K4 Pin 1-pin 2	s-c*	230V <0,1 A	850V <0,1 A	10 min.	--	230V <0,1A	850V <0,1A	PCE can't start up. Error message: alarm grid relay abnormal No hazard, no damage, no reconnection.
Relay defect K3 Pin 1-pin 2	s-c*	230V <0,1 A	850V <0,1 A	10 min.	--	230V <0,1A	850V <0,1A	PCE can't start up. Error message: alarm grid relay abnormal No hazard, no damage, no reconnection.
Relay defect K6 Pin 1-pin 2	s-c*	230V <0,1 A	850V <0,1 A	10 min.	--	230V <0,1A	850V <0,1A	PCE can't start up. Error message: alarm grid relay abnormal No hazard, no damage, no reconnection.
Relay defect K5 Pin 1-pin 2	s-c*	230V <0,1 A	850V <0,1 A	10 min.	--	230V <0,1A	850V <0,1A	PCE can't start up. Error message: alarm grid relay abnormal No hazard, no damage, no reconnection.
Relay defect K8 Pin 1-pin 2	s-c*	230V <0,1 A	850V <0,1 A	10 min.	--	230V <0,1A	850V <0,1A	PCE can't start up. Error message: alarm grid relay abnormal No hazard, no damage, no reconnection.
Relay defect K7 Pin 1-pin 2	s-c*	230V <0,1 A	850V <0,1 A	10 min.	--	230V <0,1A	850V <0,1A	PCE can't start up. Error message: alarm grid relay abnormal No hazard, no damage, no reconnection.
Relay defect C4063	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm grid relay abnormal No hazard, no damage, no reconnection.
Relay defect Q230	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm grid relay abnormal No hazard, no damage, no reconnection.

Monitoring grid voltage phase defect D13 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D21 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm grid over voltage,unballence No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D15 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm PE wire connection abnormal No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect R305	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm grid over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect R308	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm 3 phase voltage unballance No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D55 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D55 pin3 to pin1	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D54 pin3 to pin1	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D54 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.

Monitoring grid voltage phase defect D57 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D57 pin3 to pin1	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D56 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D56 pin3 to pin1	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D59 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D59 pin3 to pin1	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D14 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D14 pin3 to pin1	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect D13 pin3 to pin1	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.

Monitoring grid voltage phase defect D12 pin3 to pin1	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect R109	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect R363	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring grid voltage phase defect R110	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm ABC phase over voltage No hazard, no damage, no reconnection.
Monitoring PV voltage defect D26 pin2 to pin3	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm BOOSTA input voltage over voltage No hazard, no damage, no reconnection.
Monitoring PV voltage defect R134	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm BOOSTA input voltage over voltage No hazard, no damage, no reconnection.
Monitoring PV voltage defect R136	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm BOOSTA input voltage over voltage No hazard, no damage, no reconnection.
Monitoring PV voltage defect R369	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm BOOSTA input voltage over voltage No hazard, no damage, no reconnection.
Monitoring PV voltage defect R176	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm BOOSTA input voltage over voltage No hazard, no damage, no reconnection.

Monitoring BUS voltage defect C432	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm bus over voltage No hazard, no damage, no reconnection.
Monitoring BUS voltage defect C429	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm bus over voltage No hazard, no damage, no reconnection.
Monitoring BUS voltage defect D5 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm bus over voltage, bus voltage unballance No hazard, no damage, no reconnection.
Monitoring BUS voltage defect D5 pin3 to pin1	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm bus over voltage, bus voltage unballance No hazard, no damage, no reconnection.
Monitoring BUS voltage defect D6 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm bus over voltage No hazard, no damage, no reconnection.
Frequency measurement defect C396	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm under frequency, grid fault. No hazard, no damage, no reconnection.
Frequency measurement defect C393	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm under frequency, grid fault. No hazard, no damage, no reconnection.
Frequency measurement defect C389	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm under frequency, grid fault. No hazard, no damage, no reconnection.
Grid current measurement defect D19 pin3 to pin2	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm inverter over current No hazard, no damage, no reconnection.

Grid current measurement defect U23 pin7 to agnd	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm positive bus voltage over voltage No hazard, no damage, no reconnection.
Grid current measurement defect C352	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm inverter circuit abnormal No hazard, no damage, no reconnection.
Grid current measurement defect C353	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm inverter circuit abnormal No hazard, no damage, no reconnection.
Grid current measurement defect C354	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm inverter circuit abnormal No hazard, no damage, no reconnection.
Grid current measurement defect C355	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm inverter over current No hazard, no damage, no reconnection.
PV Current measurement defect R517	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm boost input over current No hazard, no damage, no reconnection.
PV Current measurement defect R518	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm boost input over current No hazard, no damage, no reconnection.
RCMU measurement defect D9	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm RCD fault No hazard, no damage, no reconnection.
RCMU measurement defect R402	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm RCD fault No hazard, no damage, no reconnection.

RCMU measurement defect R4795	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm RCD fault No hazard, no damage, no reconnection.
RCMU measurement defect D10	o-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm RCD fault No hazard, no damage, no reconnection.
PV insulation measurement defect D28 pin2 to pin3	s-c*	230V <0,1 A	850V <0,1 A	10 min.	--	230V <0,1A	850V <0,1A	PCE can't start up. Error message: Unit can't power on, alarm, ISO fault. No hazard, no damage, no reconnection.
PV insulation measurement defect R589	s-c*	230V <0,1 A	850V <0,1 A	10 min.	--	230V <0,1A	850V <0,1A	PCE can't start up. Error message: Unit can't power on, alarm, ISO fault. No hazard, no damage, no reconnection.
PV insulation measurement defect D70 pin2 to pin3	s-c*	230V <0,1 A	850V <0,1 A	10 min.	--	230V <0,1A	850V <0,1A	PCE can't start up. Error message: Unit can't power on, alarm, ISO fault. No hazard, no damage, no reconnection.
Loss of control DSP failure +1,2V	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. No hazard, no damage, no reconnection.
Loss of control DSP failure +3,3V	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. No hazard, no damage, no reconnection.
Loss of control DSP failure +5V	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. No hazard, no damage, no reconnection.
Loss of control Inverter voltage detector X1	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. No hazard, no damage, no reconnection.
Communication microcontroller defect C285	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm control circuit fault No hazard, no damage, no reconnection.
Communication microcontroller defect R122 pin 1 to GND	s-c	230V 29,0 A	850V 23,5 A	10 min.	--	230V <0,1A	850V <0,1A	PCE shutdown immediately. Error message: alarm control circuit fault No hazard, no damage, no reconnection.

Note:
The errors in the control circuit simulate that the safety is even ensured during a single fault.
s-c: short circuit; o-c: open circuit
* Before start-up.

The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PVAT190424N048 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-07-22.

5.5.7.2 Voltage control						P
Integrated NS protection multi phase ≤30kVA (phase to neutral)						
Setting values of the NS protection:	Setting U< [V]:		184			
	Setting U>>[V]:		287,5			
	Setting $T_{disconnection}$ [ms]		/			
Operating time of the monitoring device:						
L1 to N:						
	Under voltage 1:			**Over voltage 1:**		
Step [V to V]:	230,0 V to 177,1 V			230,0 V to 294,5 V		
Limit [V]:	184,0 V			287,5 V		
Measurement [V:]	184,4	184,4	184,3	288,9	288,9	288,9
Limit [ms]:	≤ 3100 ms			≤ 200 ms		
Disconnection time [ms]:	3077	3091	3090	173	172	175
	Under voltage 2:					
Step [V to V]:	230,0 V to 96,6 V					
Limit [V]:	103,5 V					
Measurement [V:]	103,4	103,2	103,3			
Limit [ms]:	≤ 400 ms					
Disconnection time [ms]:	344	306	335			
L2 to N:						
	Under voltage 1:			**Over voltage 1:**		
Step [V to V]:	230,0 V to 177,1 V			230,0 V to 294,5 V		
Limit [V]:	184,0 V			287,5 V		
Measurement [V:]	185,0	185,0	185,0	289,7	289,6	289,7
Limit [ms]:	≤ 3100 ms			≤ 200 ms		
Disconnection time [ms]:	3087	3082	3079	183	191	176
	Under voltage 2:					
Step [V to V]:	230,0 V to 96,6 V					
Limit [V]:	103,5 V					
Measurement [V:]	103,6	103,7	103,5			
Limit [ms]:	≤ 400 ms					
Disconnection time [ms]:	379	393	389			

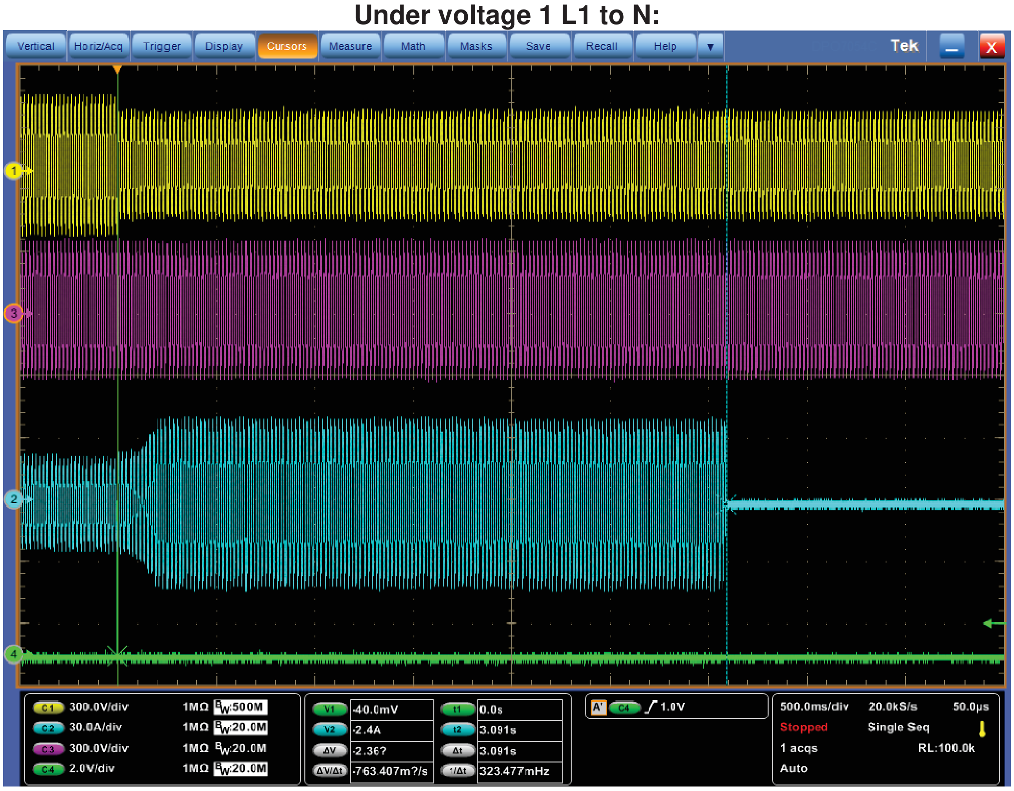
L3 to N:						
	Under voltage 1:			**Over voltage 1:**		
Step [V to V]:	230,0 V to 177,1 V			230,0 V to 294,5 V		
Limit [V]:	184,0 V			287,5 V		
Measurement [V:]	184,9	184,9	184,8	287,5	287,6	287,5
Limit [ms]:	≤ 3100 ms			≤ 200 ms		
Disconnection time [ms]:	3080	3091	3083	181	184	181
	Under voltage 2:					
Step [V to V]:	230,0 V to 96,6 V					
Limit [V]:	103,5 V					
Measurement [V:]	103,1	103,2	103,2			
Limit [ms]:	≤ 400 ms					
Disconnection time [ms]:	382	393	396			

Note:
The permitted tolerance between setting value and trip value of the voltage may not exceed ± 1% of U_n.
The disconnection time includes disconnect time + operate time of the integrated relay. Therefore limit is give with +100ms according to Table 2 set values of the NS-protection according to VDE AR-N 4105:2018.

The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

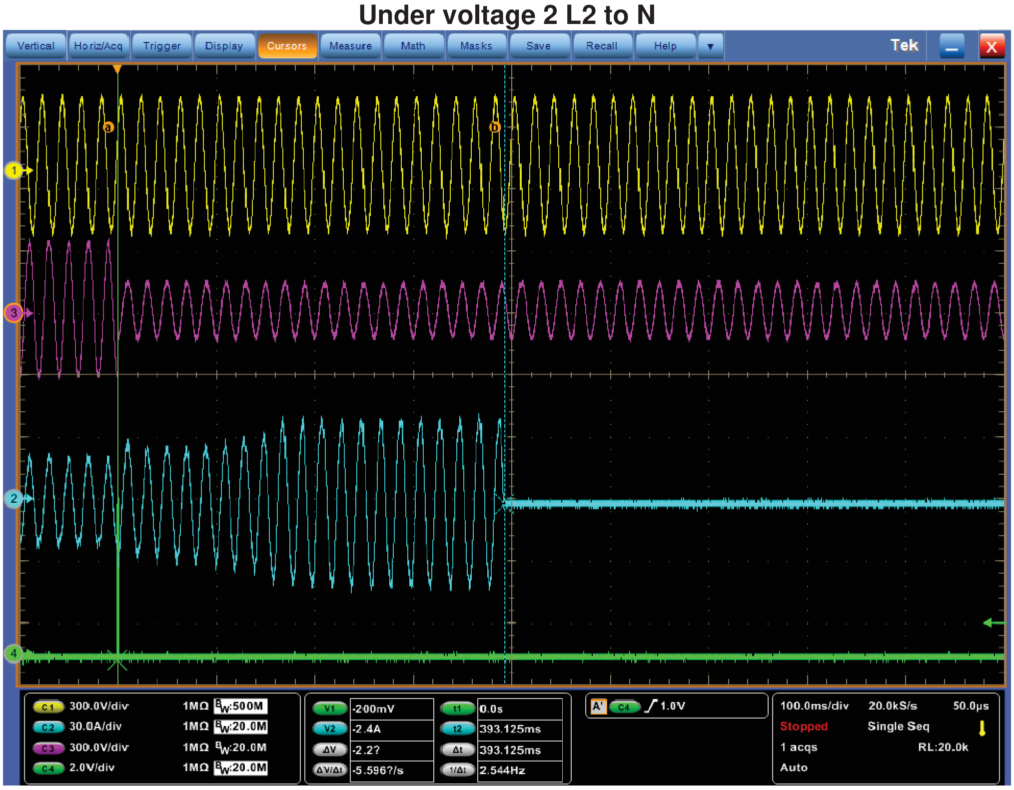
Under voltage 2 L1 to N:

Under voltage 1 L1 to N:

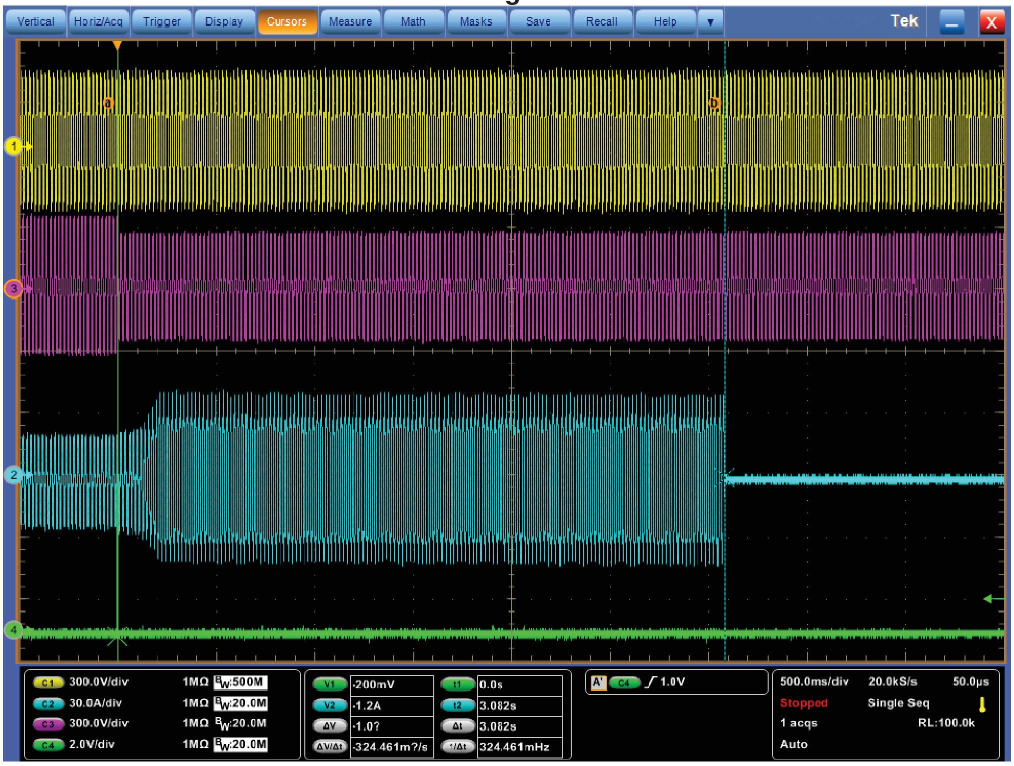


Over voltage L1 to N:

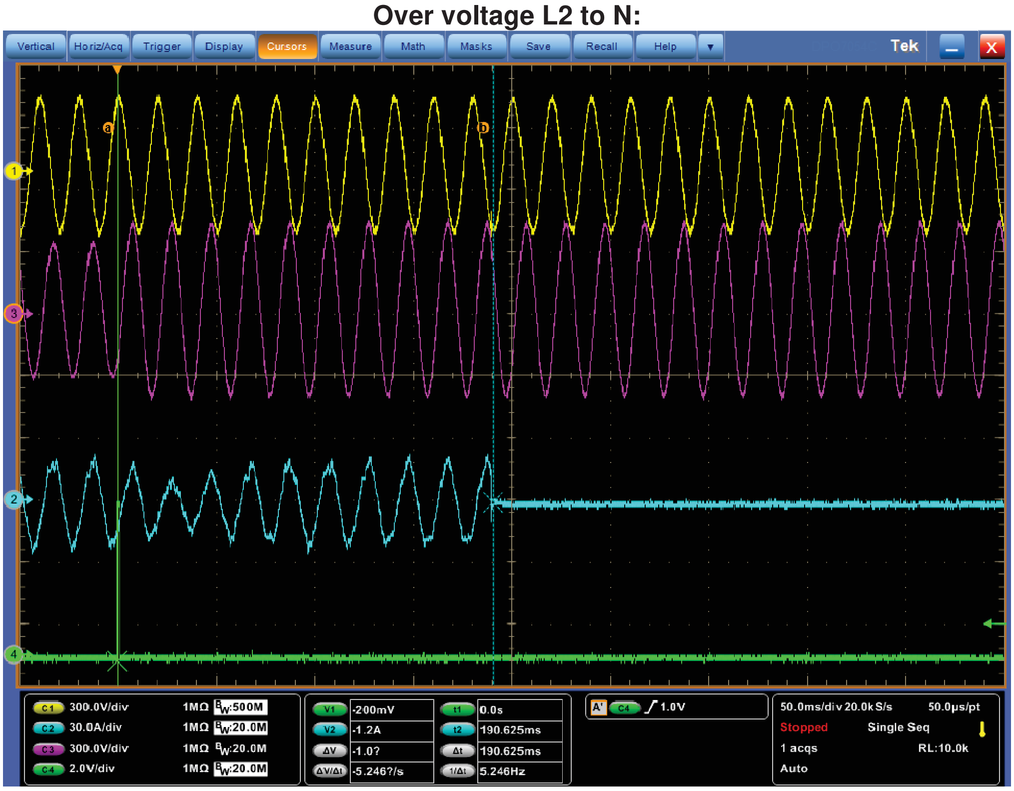
Under voltage 2 L2 to N



Under voltage 1 L2 to N

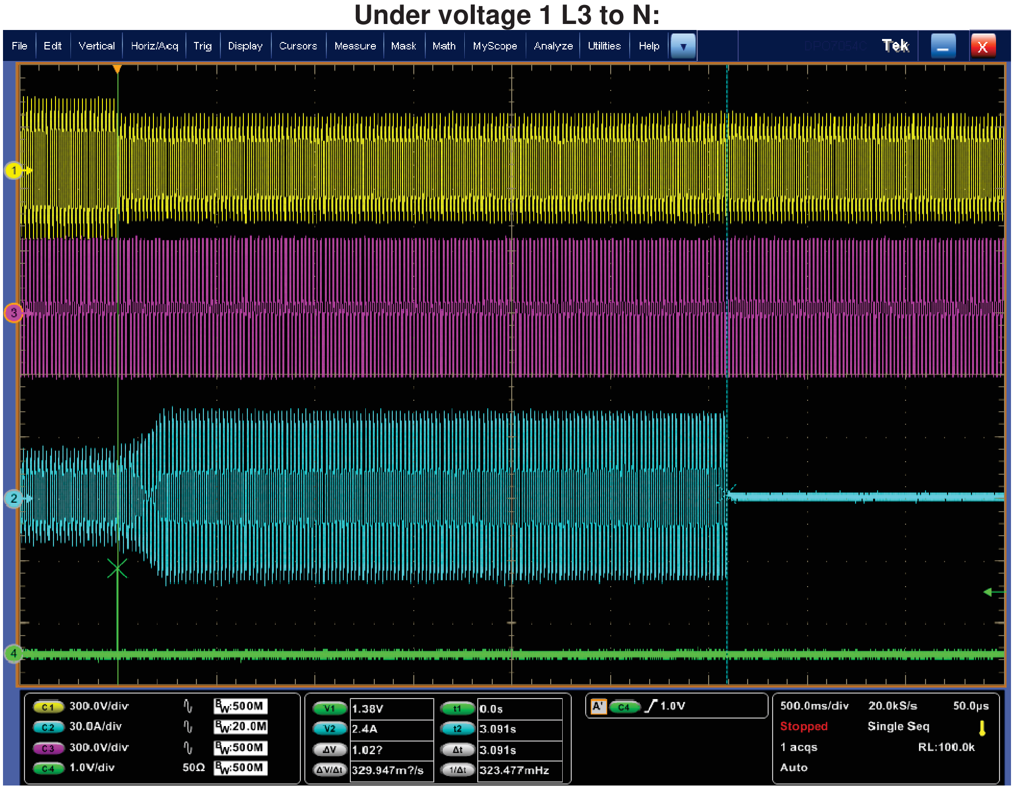


Over voltage L2 to N:



Under voltage 2 L3 to N:

Under voltage 1 L3 to N:



Over voltage L3 to N:

5.5.7.2.1.3 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:	490 s	600 s
	Phase 2:	498 s	
	Phase 3:	504 s	
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:	No disconnected	
	Phase 3:	No disconnected	
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:	288 s	300 s
	Phase 2:	287 s	
	Phase 3:	293 s	

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:

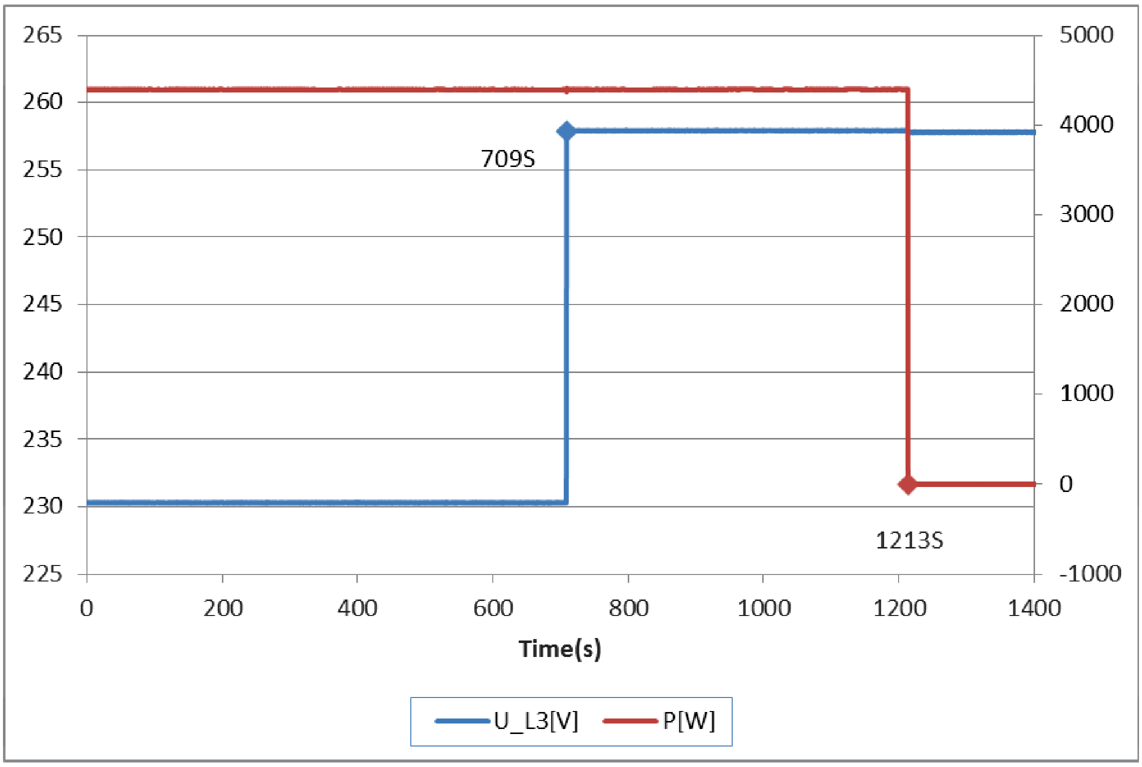
Rise-in voltage protection U> 1,1 U_n after a max. 600 s, the switch off after 200 ms.

Note:

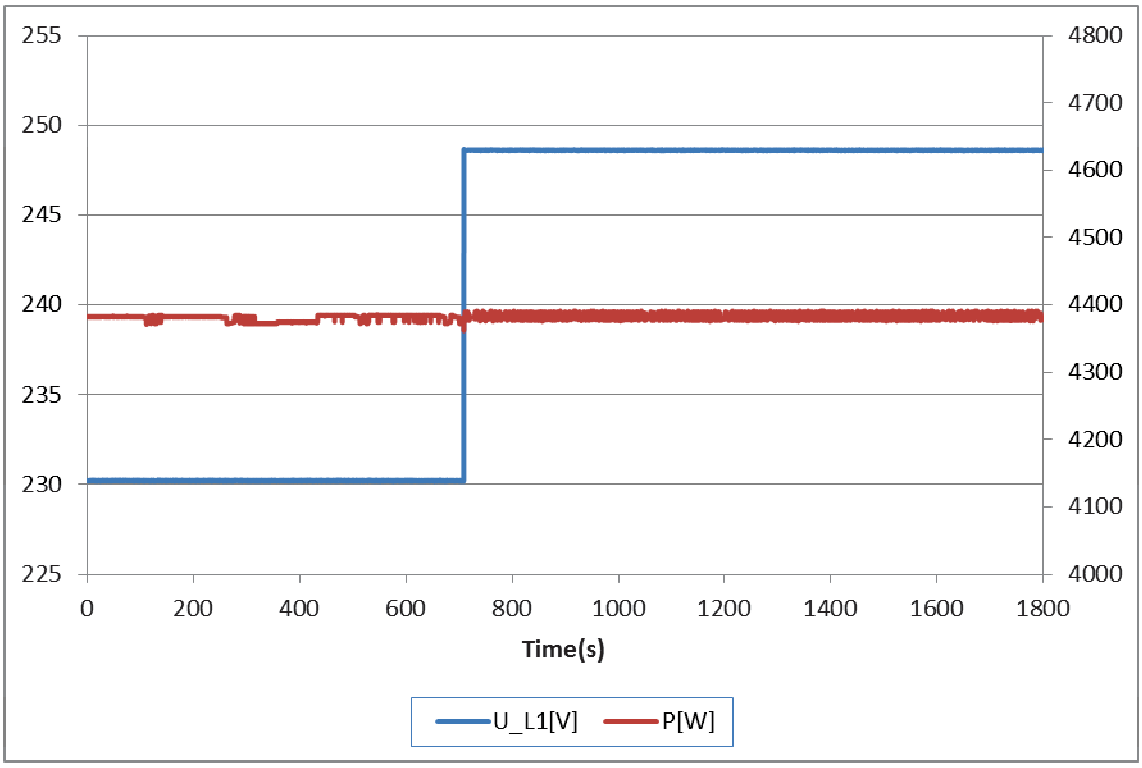
If only one integrated NS protection is used for the power generation systems ≤30kVA, the value of the rise-in voltage protection U> of 1,1 U_n may not be changed.

The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

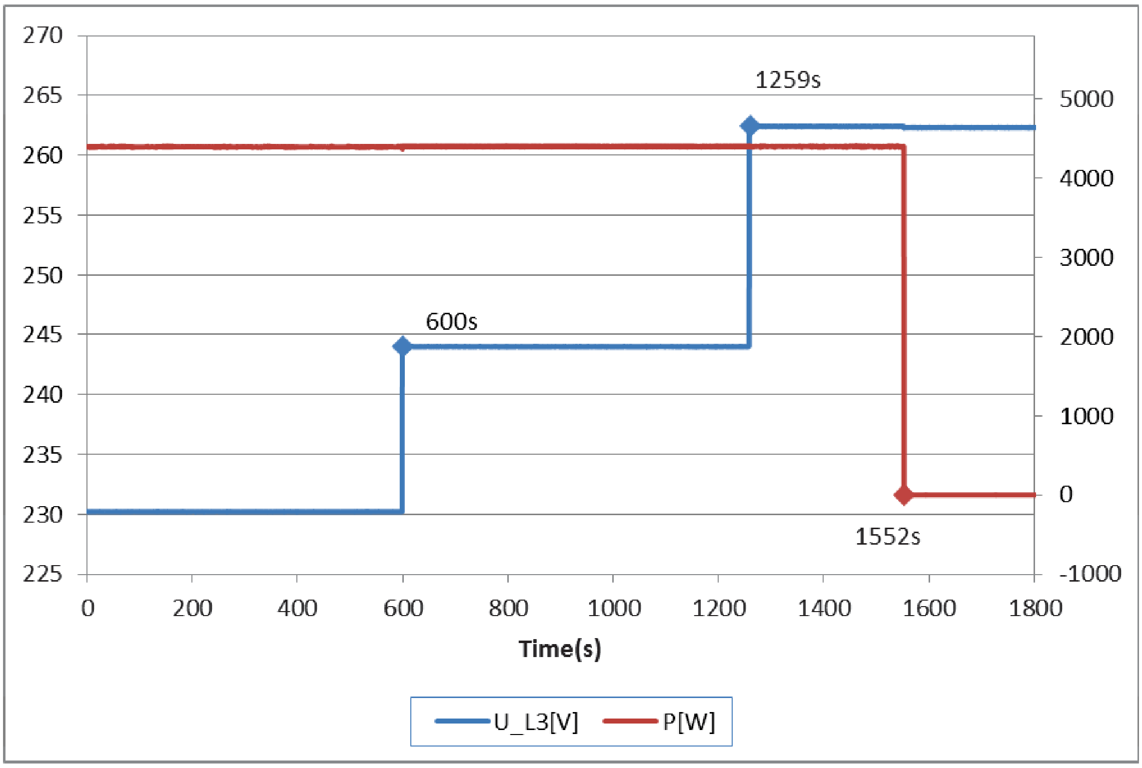
Graph of test a) Voltage set to 112 % Uₙ:



Graph of test b) Voltage set to 108 % Uₙ:



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



5.5.7.2.1.9 Frequency measurement						**P**
Setting values of the NS protection:	Setting f< [Hz]:		47,50			
	Setting f>[Hz]:		51,50			
	Setting $T_{disconnection}$ [ms]		/			
Operating time of the monitoring device						
	Under frequency:			**Over frequency:**		
Jump [Hz to Hz]:	47,70 Hz -> 47,30 Hz			51,30 Hz -> 51,70 Hz		
Limit [Hz]:	47,50 Hz			51,50 Hz		
Measurement [Hz]:	47,50	47,50	47,50	51,49	51,50	51,49
Limit [ms]:	≤ 200 ms			≤ 200 ms		
Disconnection time [ms]:	179	181	178	178	169	173

Test:
Testing of the frequency over protection f> and of the under frequency protection f <.

a) The frequency must be set to f_n 50.0 Hz and kept. A jump to 51.3 Hz must be performed and held for 60 sec. Afterwards, a jump to 51.7 Hz must be performed and held.
b) The frequency must be set to f_n 50.0 Hz and kept. A jump to 47,7 Hz must be performed and held for 60 sec. Afterwards, a jump to 47,3 Hz must be performed and held.

Assessment criteria:
The Test is passed if

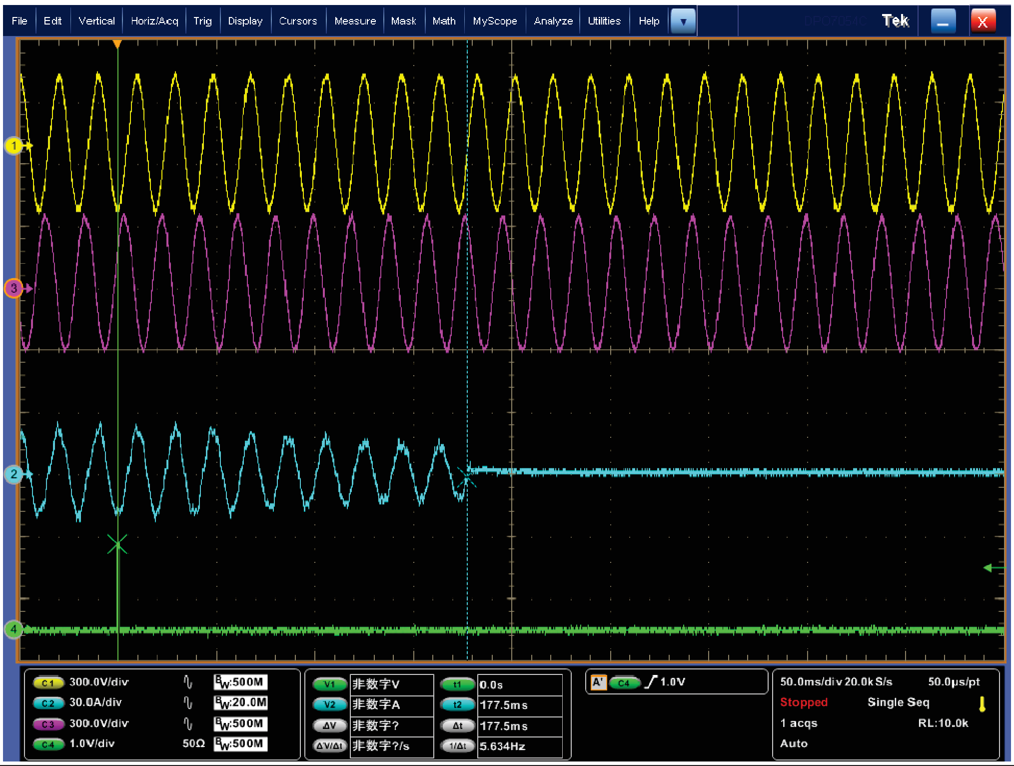
a) after the jump to 51.3 Hz no shutdown has taken place and after the jump to 51.7 Hz, a shutdown within 200ms is done.
b) after the jump to 47,7 Hz no shutdown has taken place and after the jump to 47,3 Hz, a shutdown within 200ms is done

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

The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

Under frequency:

Over frequency:



5.5.8 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:	

5.5.10 **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°.

5.5.10.3 Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%)	**P**

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality = 1
Disconnection limit	2s (IEC 62116)

No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6,1,d) 1)	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks5)
1	100	100	0	0	0,132	6667	688	1,001	385,6	BL
2	100	100	-10	-10	2,869	6667	688	1,055	193,5	IB
3	100	100	-10	-5	2,990	6667	688	1,084	265,1	IB
4	100	100	-10	0	3,031	6667	688	1,112	567,9	IB
5	100	100	-10	+5	2,991	6667	688	1,139	251,7	IB
6	100	100	-10	+10	2,871	6667	688	1,166	198,8	IB
7	100	100	-5	-10	1,428	6667	688	0,999	190,9	IB
8	100	100	-5	-5	1,542	6667	688	1,027	254,1	IB
9	100	100	-5	0	1,581	6667	688	1,053	482,2	IB
10	100	100	-5	+5	1,544	6667	688	1,080	236,6	IB
11	100	100	-5	+10	1,430	6667	688	1,105	179,4	IB
12	100	100	0	-10	0,278	6667	688	0,949	184,9	IB
13	100	100	0	-5	0,169	6667	688	0,975	222,7	IB
14	100	100	0	+5	0,168	6667	688	1,026	301,3	IB
15	100	100	0	+10	0,275	6667	688	1,050	219,1	IB
16	100	100	+5	-10	1,720	6667	688	0,904	204,0	IB
17	100	100	+5	-5	1,617	6667	688	0,929	271,1	IB
18	100	100	+5	0	1,581	6667	688	0,953	434,4	IB
19	100	100	+5	+5	1,615	6667	688	0,977	249,1	IB
20	100	100	+5	+10	1,718	6667	688	1,000	189,8	IB
21	100	100	+10	-10	3,164	6667	688	0,863	180,1	IB
22	100	100	+10	-5	3,064	6667	688	0,887	237,9	IB
23	100	100	+10	0	3,031	6667	688	0,910	419,7	IB
24	100	100	+10	+5	3,063	6667	688	0,932	227,6	IB

25	100	100	+10	+10	3,161	6667	688	0,954	209,8	IB

Parameter at 0% per phase	L= 25,23 mH	R= 7,93 Ω	C= 401,57 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 A:

EUT output power P_{EUT} = Maximum [6)]

EUT input voltage [6)] = >75% of rated input voltage range

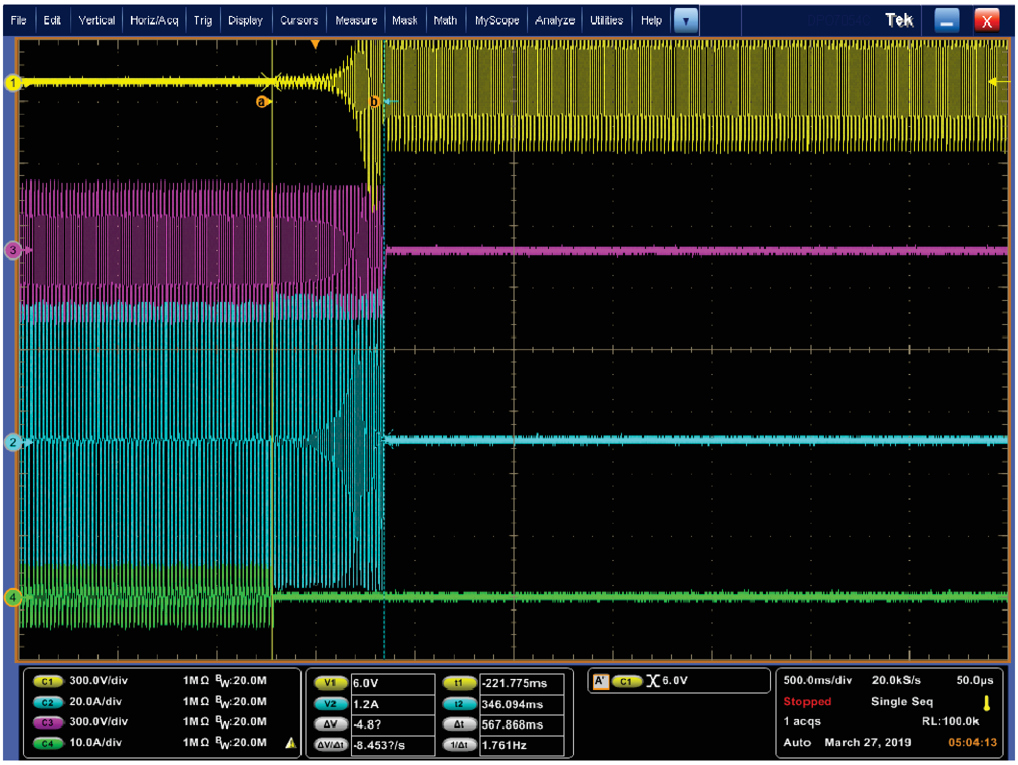
6) Maximum EUT output power condition should be achieved using the maximum allowable input power, Actual output power may exceed nominal rated output,

7) Based on EUT rated input operating range, For example, If range is between X volts and Y volts, 75 % 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 test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PV190424N048-1 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-05-23.

Scope pictures of the disconnection time
Disconnection at No, 4



5.5.10.3 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %)	P

Test :

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	2s (IEC 62116)

No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6,1,d) 1)	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks5)
1	66	66	0	-5	0,144	4400	512	0,977	252,6	IB
2	66	66	0	-4	0,136	4400	512	0,982	267,7	IB
3	66	66	0	-3	0,129	4400	512	0,987	284,4	IB
4	66	66	0	-2	0,125	4400	512	0,992	323,7	IB
5	66	66	0	-1	0,122	4400	512	0,997	325,0	IB
6	66	66	0	0	0,121	4400	512	1,002	362,4	BL
7	66	66	0	+1	0,122	4400	512	1,007	317,9	IB
8	66	66	0	+2	0,125	4400	512	1,012	261,5	IB
9	66	66	0	+3	0,130	4400	512	1,017	291,6	IB
10	66	66	0	+4	0,137	4400	512	1,022	261,5	IB
11	66	66	0	+5	0,146	4400	512	1,027	243,1	IB

Parameter at 0% per phase	L= 38,19 mH	R= 12,02 Ω	C= 265,29 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

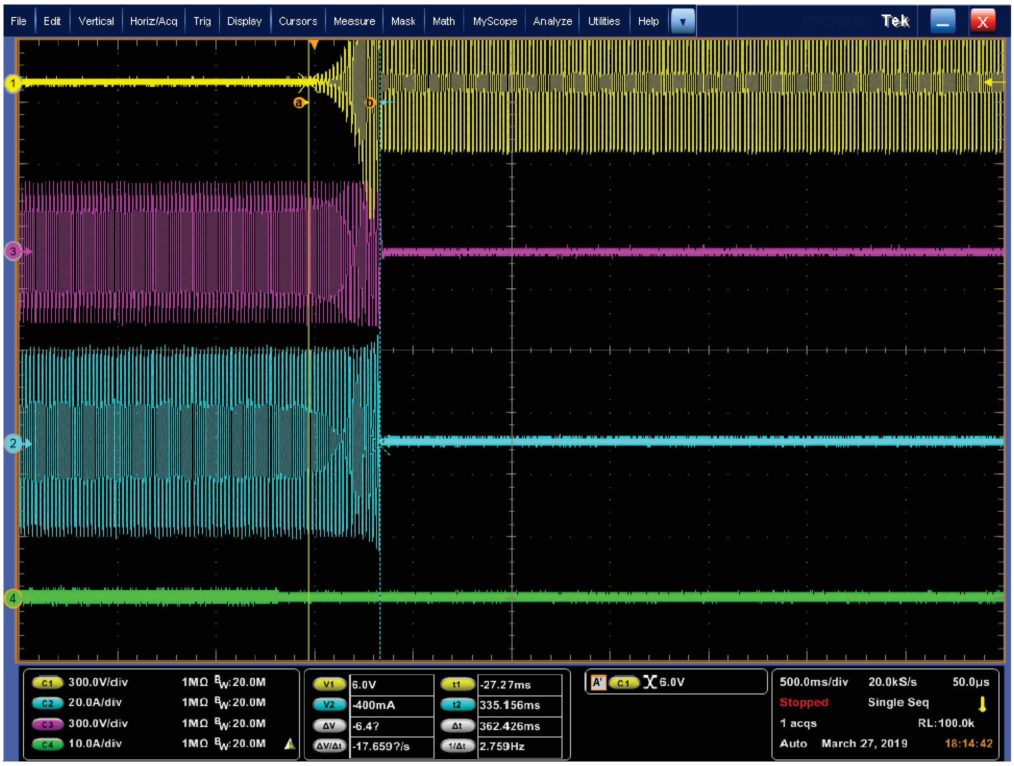
EUT input voltage 6) = 50 % of rated input voltage range, ±10 %

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 test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PV190424N048-1 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-05-23.

Scope pictures of the disconnection time
Disconnection at No, 6



5.5.10.3 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (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 (IEC 62116)

No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6,1,d) 1)	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks5)
1	33	33	0	-5	0,120	2200	301	0,978	236,7	IB
2	33	33	0	-4	0,116	2200	301	0,983	260,5	IB
3	33	33	0	-3	0,113	2200	301	0,988	279,6	IB
4	33	33	0	-2	0,111	2200	301	0,993	327,7	IB
5	33	33	0	-1	0,109	2200	301	0,998	367,9	IB
6	33	33	0	0	0,109	2200	301	1,003	279,8	BL
7	33	33	0	+1	0,110	2200	301	1,008	394,1	IB
8	33	33	0	+2	0,111	2200	301	1,013	282,4	IB
9	33	33	0	+3	0,114	2200	301	1,018	327,8	IB
10	33	33	0	+4	0,117	2200	301	1,023	274,7	IB
11	33	33	0	+5	0,122	2200	301	1,028	272,3	IB

Parameter at 0% per phase	L= 76,31 mH	R= 24,05 Ω	C= 132,78 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,

4) Fundamental of I_{AC} when RLC is adjusted

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

Condition B:

EUT output power P_{EUT} = 25 % – 33 % 6) of maximum

EUT input voltage 7) = <20 % of rated input voltage range

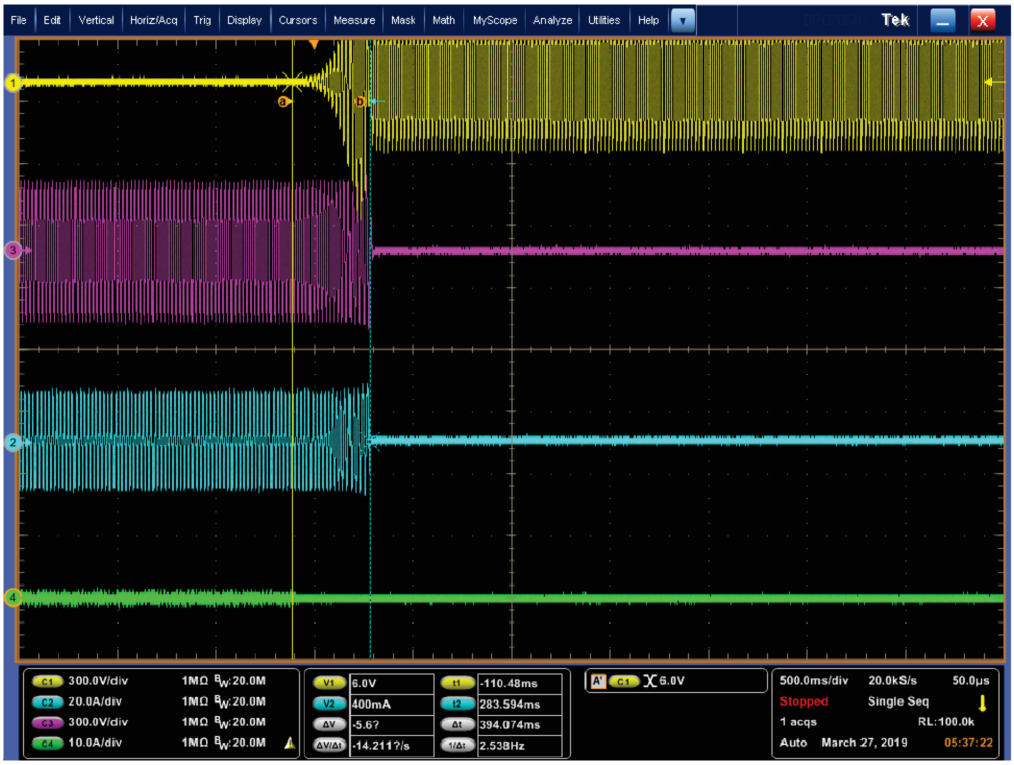
6) Or minimum allowable EUT output level if greater than 33 %,

7) Based on EUT rated input operating range, For example, If range is between X volts and Y volts, 20 % 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 test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

The test results refer to the original test report PV190424N048-1 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2019-05-23.

Scope pictures of the disconnection time
Disconnection at No, 7

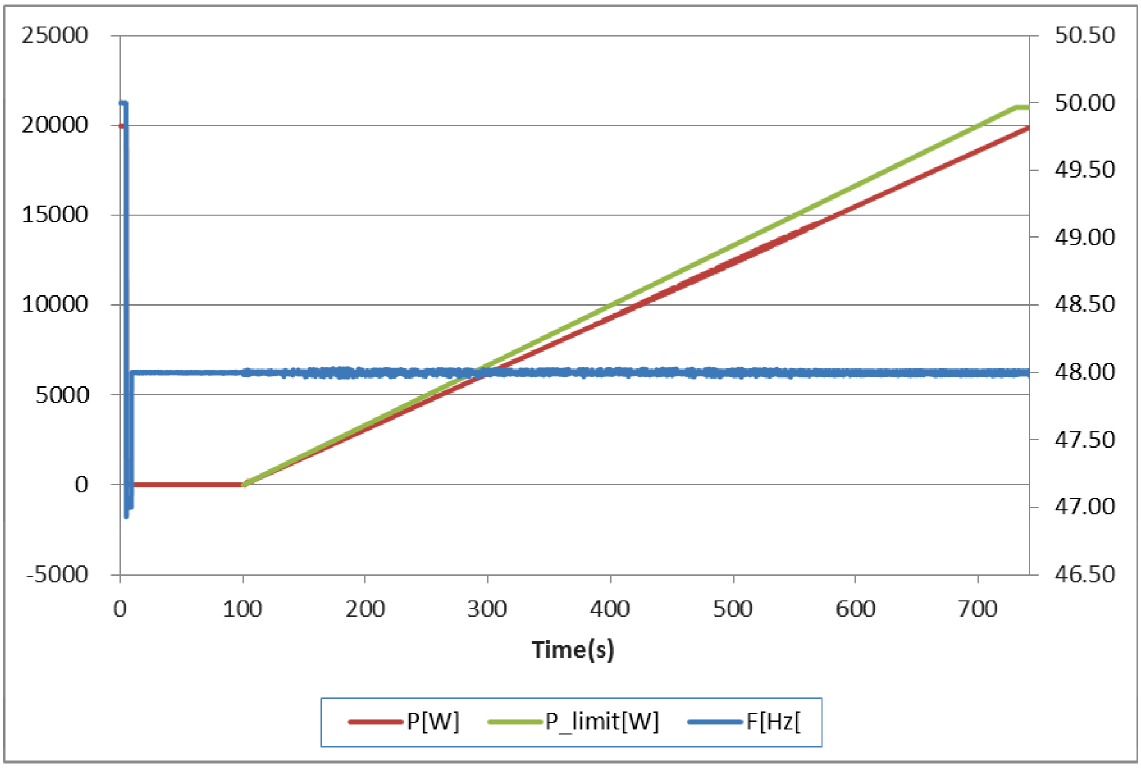


5.6 Connecting conditions and synchronization E DIN V 0124-100:(2019-09) draft		
Clause	**Test**	**Result**
5.6.1	General	**P**
5.6.2	Test	**P**

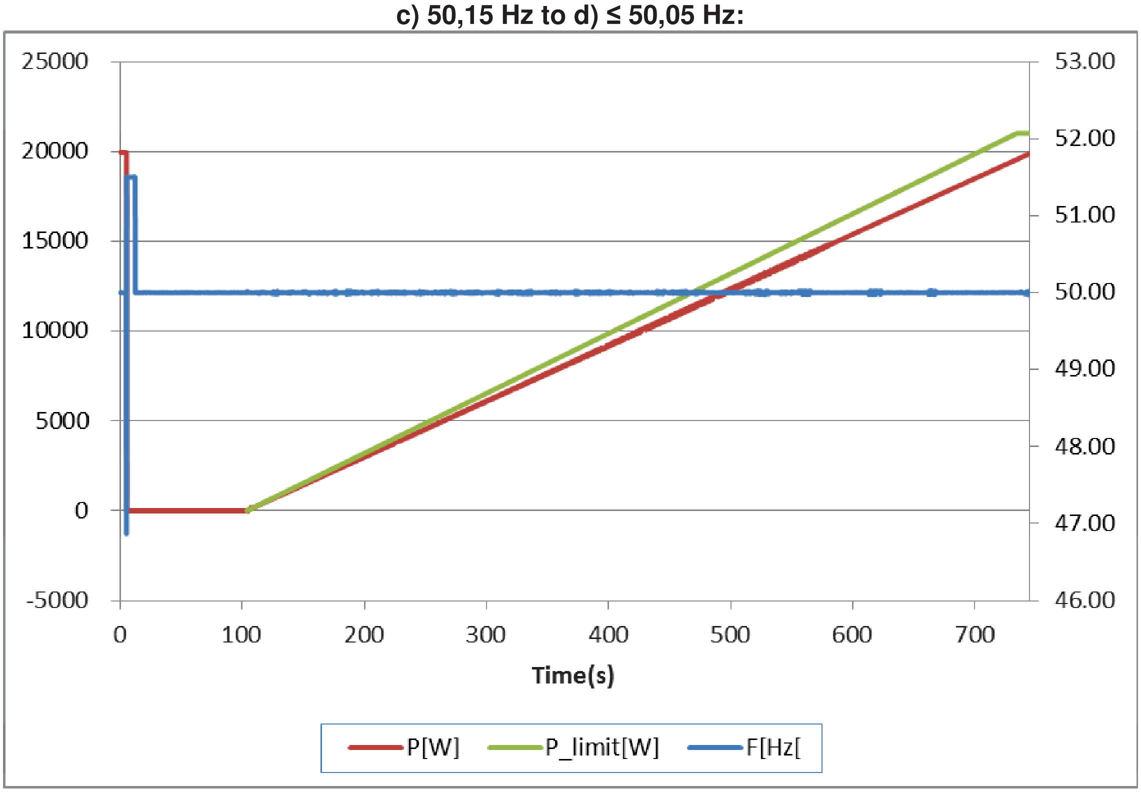
5.6	Connecting conditions and synchronisation			P
Setting values of the NS protection:	Setting $T_{reconnection\ 60s}$ [s]:	60		
	Setting f< [Hz]:	47,5		
	Setting f> [Hz]:	50,1		
	Setting V< [V]:	195,5		
	Setting V>> [V]:	253,0		
Test:				
	f_{ist}	**Reset time:**	**Limit:**	
Connecting conditions for frequencies:				
a)	47,45 Hz	No reconnected.	No resetting allowed	
	Switch to:			
b)	≥ 47,55 Hz	91,0 s	≥ 60 s	
c)	> 50,15 Hz	No reconnected.	No resetting allowed	
	Switch to:			
d)	≤ 50,05 Hz	91,4 s	≥ 60 s	
Connecting conditions for voltages: L1 phase				
e)	84%	No reconnected.	No resetting allowed	
	Switch to:			
f)	≥ 86%	131,0 s	≥ 60 s	
g)	111 %	No reconnected.	No resetting allowed	
	Switch to:			
h)	≤ 109%	86,2 s	≥ 60 s	
Connecting conditions for voltages: L2 phase				
e)	84%	No reconnected.	No resetting allowed	
	Switch to:			
f)	≥ 86%	129,2 s	≥ 60 s	
g)	111 %	No reconnected.	No resetting allowed	
	Switch to:			
h)	≤ 109%	90,6 s	≥ 60 s	
Connecting conditions for voltages: L3 phase				
e)	84%	No reconnected.	No resetting allowed	
	Switch to:			
f)	≥ 86%	86,2 s	≥ 60 s	
g)	111 %	No reconnected.	No resetting allowed	
	Switch to:			
h)	≤ 109%	88,0 s	≥ 60 s	

Note:
The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

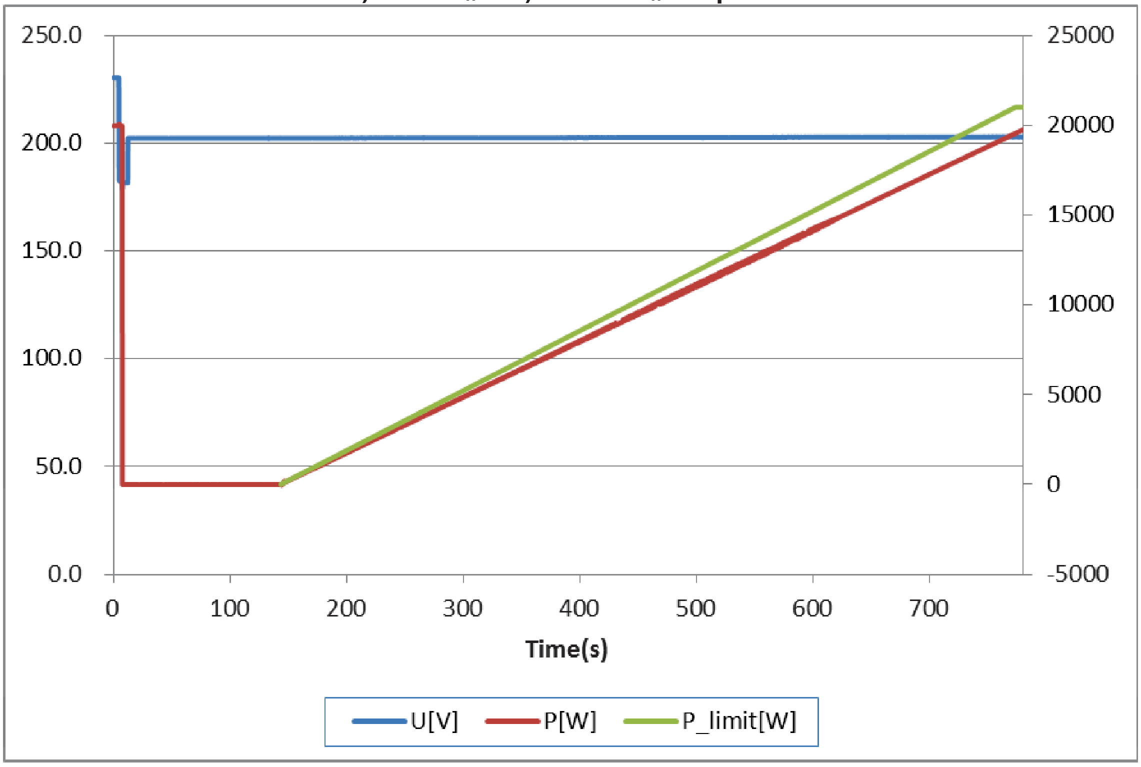
a) 47,50 Hz to b) ≥ 47,55 Hz:



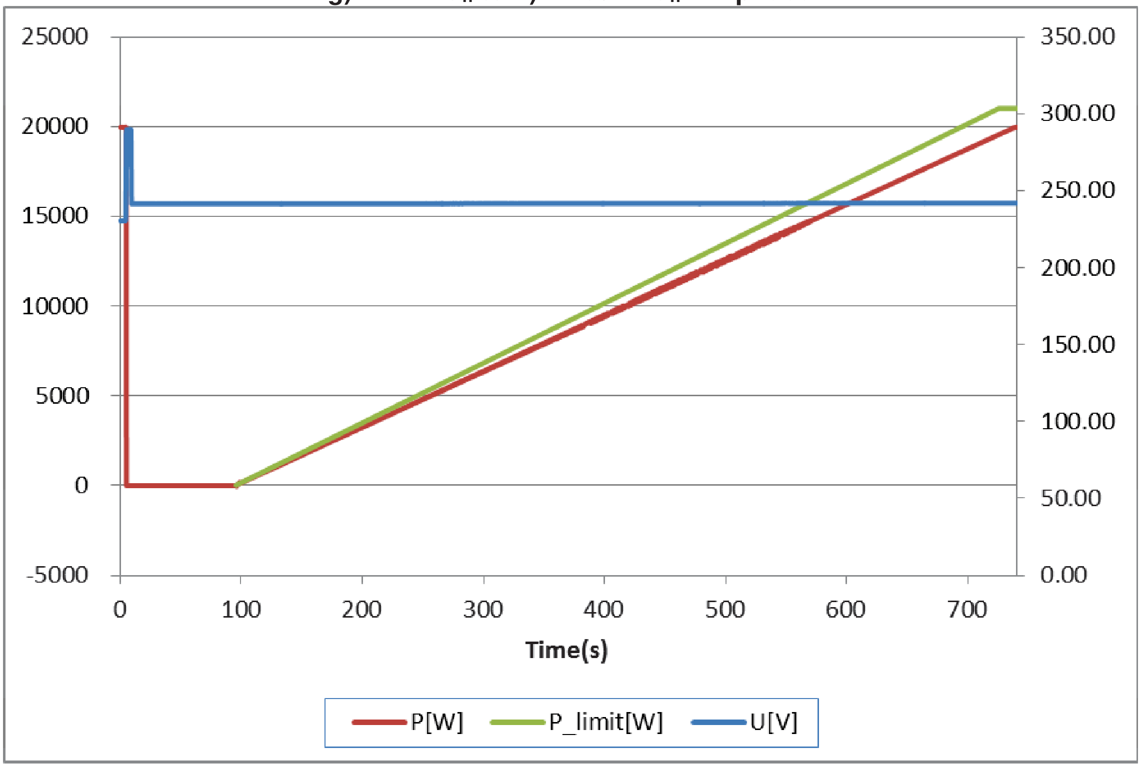
c) 50,15 Hz to d) ≤ 50,05 Hz:



e) 84 % U_n to f) ≥ 86 % U_n: L1 phase



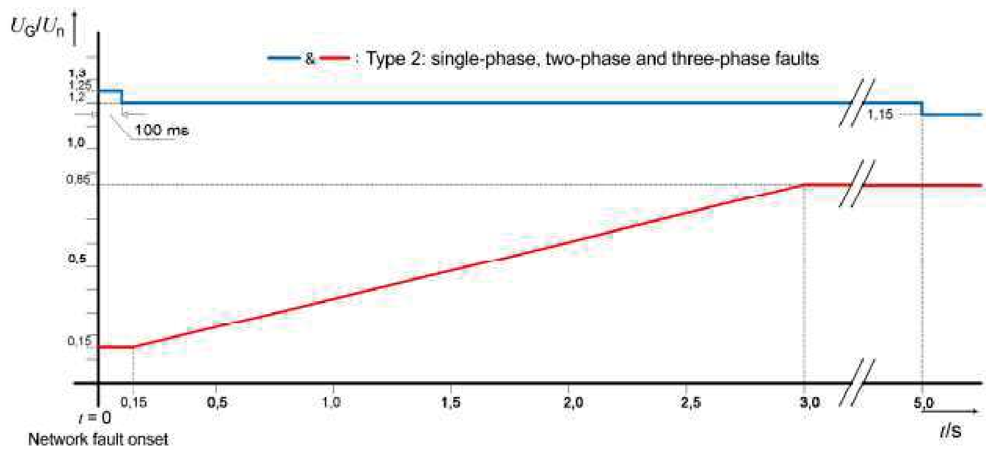
g) 111 % U_n to h) ≤ 109 % U_n: L1 phase



5.8 Evidence dynamic grid support E DIN V 0124-100:(2019-09) draft		
Clause	**Test**	**Result**
5.8.1	General	**P**
5.8.3	Testing of the dynamic grid support PGU Type 1	**N/A**
5.8.3	Testing of the dynamic grid support PGU Type 2	**P**

5.8.3 Testing of the dynamic grid support	P
For PGUs Type 2 and storage systems	

General:



Key

&	FRT curve for single-phase, two-phase and three-phase network faults
UG	r.m.s. value of the actual voltage at the generator terminals

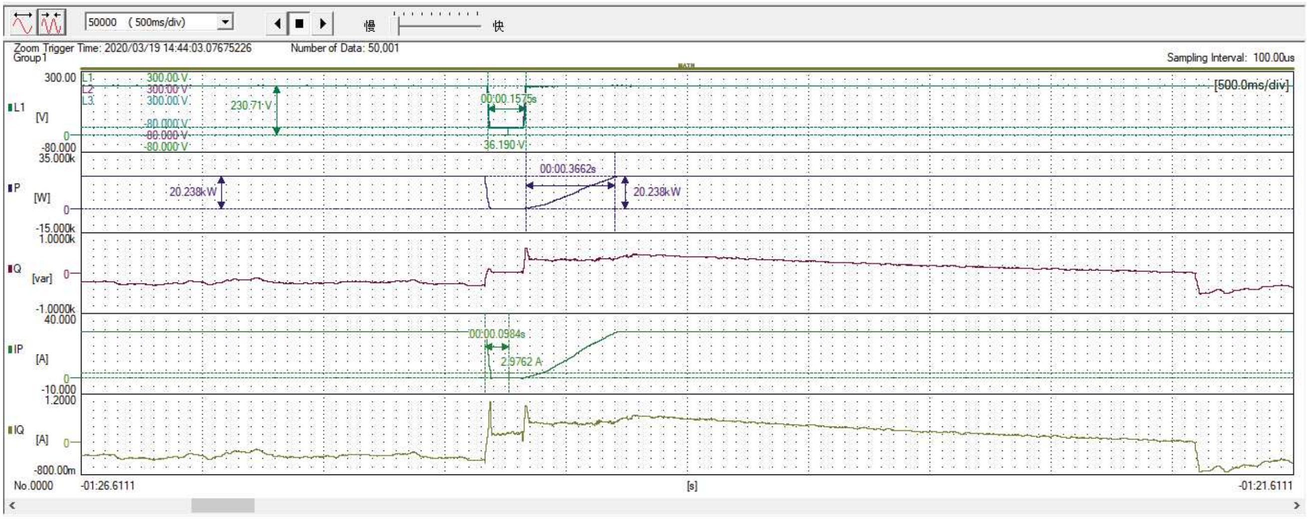
Test	Voltage dip to (U_n / p.u.)	Dip type	duration (ms) (2)*	P set point (P_{rE} / p.u.)	Q set point (Q / p.u.)	Comment	Test ref. No.	Result
1	0,15 to 0,25	A	for 0,15 ≥ 150 / for 0,25 ≥ 250	1	0 to ± 0,1	Symetric	1.1	P
				0,2 to 0,6			1.2	P
		D		1		Asymetric (ph-2-ph + Dy5-Trafo)	1.5	P
				0,2 to 0,6			1.6	P
2	0,50 to 0,60	A	for 0,50 ≥ 1500 / for 0,60 ≥ 1500	1	Max. over exceeded	Symetric	2.1	P
				0,2 to 0,6			2.2	P
		D		1		Asymetric (ph-2-ph + Dy5-Trafo)	2.5	P
				0,2 to 0,6			2.6	P
3	0,50 to 0,60	A	for 0,50 ≥ 1500 / for 0,60 ≥ 1500	1	Max. under exceeded	Symetric	3.1	P
				0,2 to 0,6			3.2	P
		D		1		Asymetric (ph-2-ph + Dy5-Trafo)	3.5	P
				0,2 to 0,6			3.6	P
4	0,85 to 0,90	A	≥ 60000	1	0 to ± 0,1	Symetric	4.1	P
				0,2 to 0,6			4.2	P
		D		1		Asymetric (ph-2-ph + Dy5-Trafo)	4.5	P
				0,2 to 0,6			4.6	P
5	1,20 to 1,25	A	≥ 100	1	0 to ± 0,1	Symetric	5.1	P
				0,2 to 0,6			5.2	P
		D		1		Asymetric (ph-2-ph + Dy5-Trafo)	5.5	P
				0,2 to 0,6			5.6	P
6	1,15 to 1,20	A	≥ 5000	1	0 to ± 0,1	Symetric	6.1	P
				0,2 to 0,6			6.2	P
		D		1		Asymetric (ph-2-ph + Dy5-Trafo)	6.5	P
				0,2 to 0,6			6.6	P

Test	Voltage dip to (U_n / p.u.)	Dip type	duration (ms) (2)*	P set point (P_{rE} / p.u.)	Q set point (Q / p.u.)	Comment	Test ref. No.	Result
7	1,10 to 1,15	A	≥ 60000	1	0 to ± 0,1	Symetric	7.1	P
				0,2 to 0,6			7.2	P
		D		1		Asymetric (ph-2-ph + Dy5-Trafo)	7.5	P
				0,2 to 0,6			7.6	P

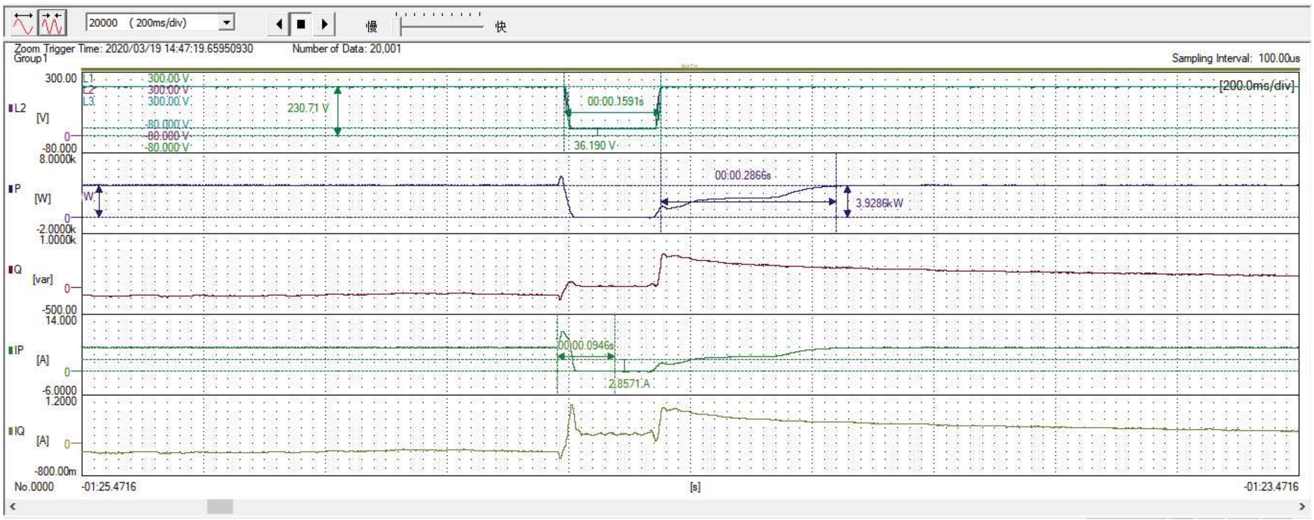
Graph of FRT test one				
Test result:				
List of tests	**Residual amplitude of phase-to-phase voltage [p.u. U_n]**	**Duration limit [ms]**	**Duration [ms]**	**Result**
P_{Emax} in %	20% ±5%			
1.A.1- Symmetrical	0,15	150 ± 20	159	Pass
1.D.1- Asymmetrical	0,15	250 ± 20	252	Pass
2.A.1- Symmetrical	0,50	1500 ± 20	1512	Pass
2.D.1- Asymmetrical	0,50	1500 ± 20	1511	Pass
3.A.1- Symmetrical	0,50	1500 ± 20	1496	Pass
3.D.1- Asymmetrical	0,50	1500 ± 20	1512	Pass
4.A.1- Symmetrical	0,85	60000 ± 20	60000	Pass
4.D.1- Asymmetrical	0,85	60000 ± 20	60001	Pass
5.A.1- Symmetrical	1,25	100 ± 20	110	Pass
5.D.1- Asymmetrical	1,25	100 ± 20	107	Pass
6.A.1- Symmetrical	1,20	5000 ± 20	5007	Pass
6.D.1- Asymmetrical	1,20	5000 ± 20	5007	Pass
7.A.1- Symmetrical	1,15	60000 ± 20	60001	Pass
7.D.1- Asymmetrical	1,15	60000 ± 20	60000	Pass
P_{Emax} in %	100% ±5%			
1.A.1- Symmetrical	0,15	150 ± 20	158	Pass
1.D.1- Asymmetrical	0,15	250 ± 20	250	Pass
2.A.1- Symmetrical	0,50	1500 ± 20	1505	Pass
2.D.1- Asymmetrical	0,50	1500 ± 20	1511	Pass
3.A.1- Symmetrical	0,50	1500 ± 20	1512	Pass
3.D.1- Asymmetrical	0,50	1500 ± 20	1511	Pass
4.A.1- Symmetrical	0,85	60000 ± 20	60003	Pass
4.D.1- Asymmetrical	0,85	60000 ± 20	60000	Pass
5.A.1- Symmetrical	1,25	100 ± 20	109	Pass
5.D.1- Asymmetrical	1,25	100 ± 20	109	Pass
6.A.1- Symmetrical	1,20	5000 ± 20	5002	Pass
6.D.1- Asymmetrical	1,20	5000 ± 20	5008	Pass
7.A.1- Symmetrical	1,15	60000 ± 20	60001	Pass
7.D.1- Asymmetrical	1,15	60000 ± 20	60000	Pass

Test conditions: Voltage simulator fall and rise time: < 20ms Used sample rate: 10 kHz
Note: At lease The recording must begin at least 10 s before the error occurs. After a faulty declaration (Voltage in the range 0,85 $U_n \leq U \leq 1,1\ U_n$), the recording must continue for at least another 60 s. Behavior during the network error: No disconnection of the PGU during the voltage drops the grid. If the PGU disconnects from the grid, the time of disconnection must be documented. • Type 1 units have to support the line voltage during a line fault principle by supplying a suitable active and reactive current. It is not permitted that the increase in the voltage due to the reactive current supply cause the overvoltage limit curve (cf. VDE-AR-N 4105:2018-11) to be exceeded during a network fault and / or after a network fault. • Asynchronous generators must remain connected to the grid during the tests shown and principle, may supply an active and reactive current. • Type 2 units and storage systems are not allowed to inject neither active or reactive current during a line voltage at the PGUs terminals below 0.8 Un and above 1.15 Un. This requirement is met if, in the event of a under-/ under voltage dip, the injected current of the generating unit and / or the storage systems does not exceed 20% of the rated current Ir and no more than 10% Ir after 60 ms after the occurrence of this under-/ under voltage dip in any phase. Behavior after the end of the error: • Not disconnection of the PGU within 60 s after the end of the fault. • Type 1 units and asynchronous machines: Reaction time of active power maximum 6 s, Reaction time of reactive power as fast as possible. Type 2 units and storage systems: Reaction time of active power up to 1 s, Reaction time of reactive power according to PT1 behavior with 3 tau = 10 s in accordance with VDE-AR-N 4105: 2018-11, 5.7.2.5 The test had been performed on the model SUN2000-20KTL-M0, the test results are valid for the SUN2000-8KTL-M0, SUN2000-10KTL-M0, SUN2000-12KTL-M0, SUN2000-15KTL-M0, SUN2000-17KTL-M0,SUN2000-8KTL-M2, SUN2000-10KTL-M2, SUN2000-12KTL-M2, SUN2000-15KTL-M2, SUN2000-17KTL-M2 and SUN2000-20KTL-M2 except current sampling circuit and the output power derated by software.

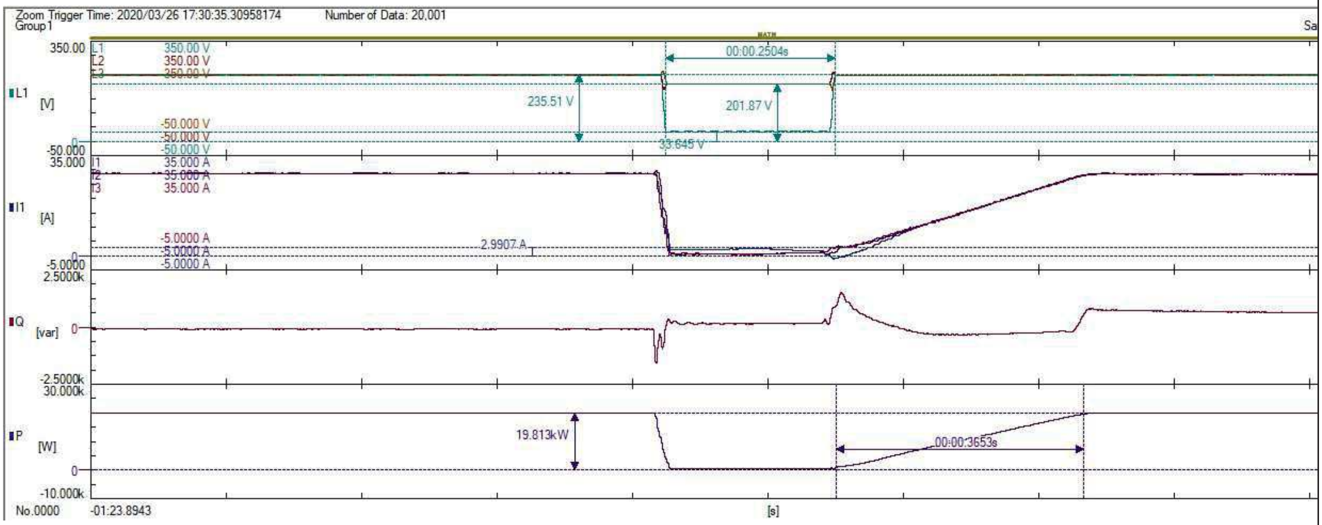
Test 1.A.1-Symmetrical fault (U/U_{nom} =0,15); P = 100% P_n



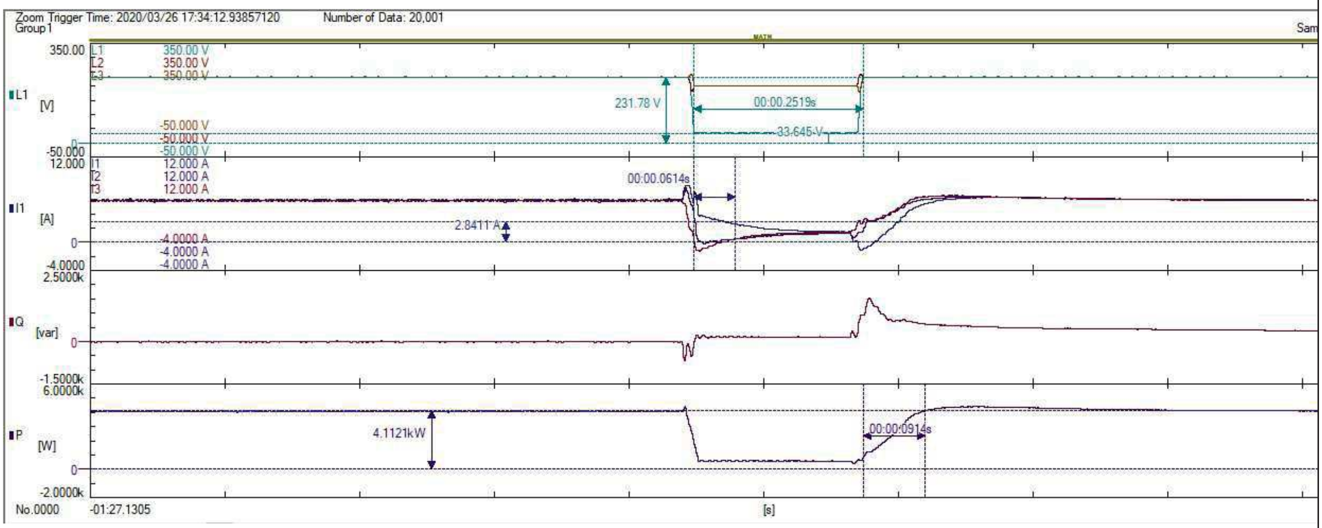
Test 1.A.2-Symmetrical fault (U/U_{nom} =0,15); P = 20%P_n



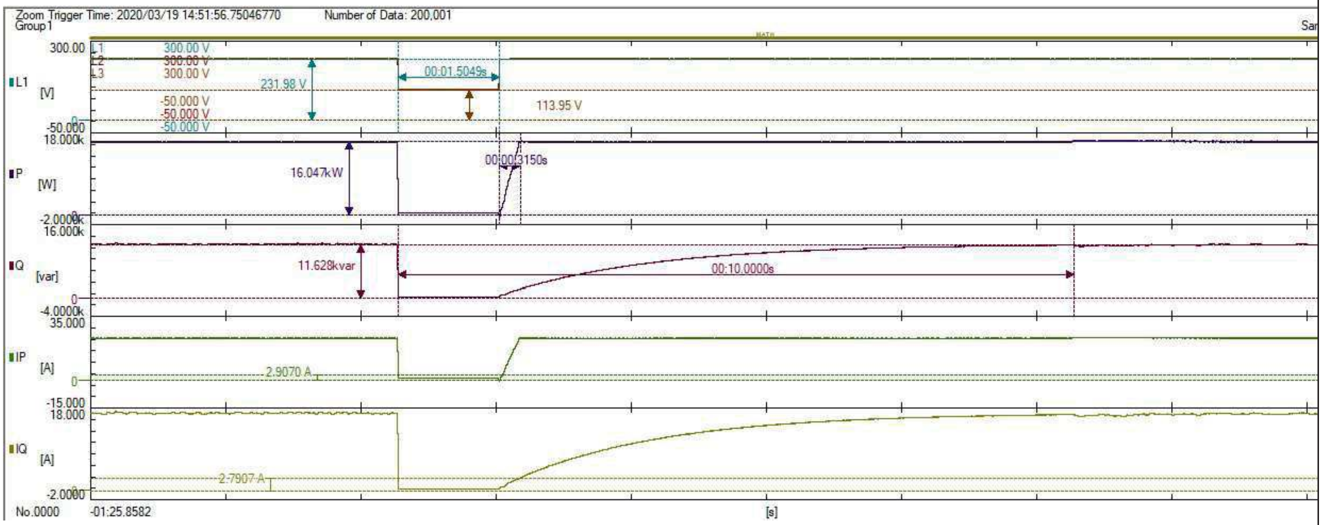
Test 1.D.1-Asymmetrical fault (U/U_{nom} =0,15); P = 100% P_n



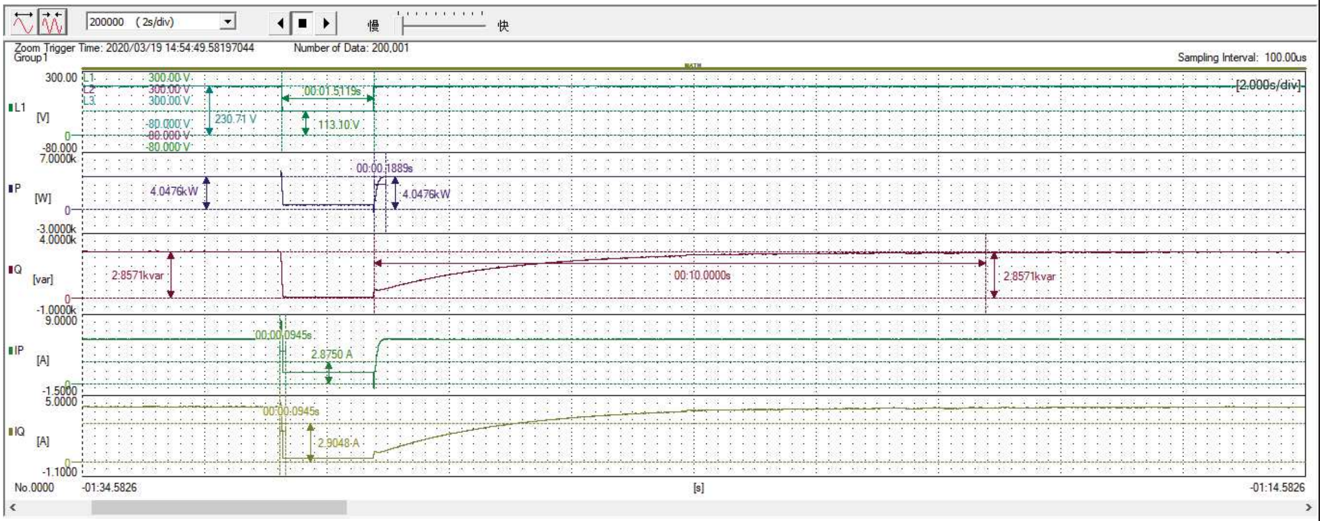
Test 1.D.2-Asymmetrical fault (U/U_{nom} =0,15); P = 20%P_n

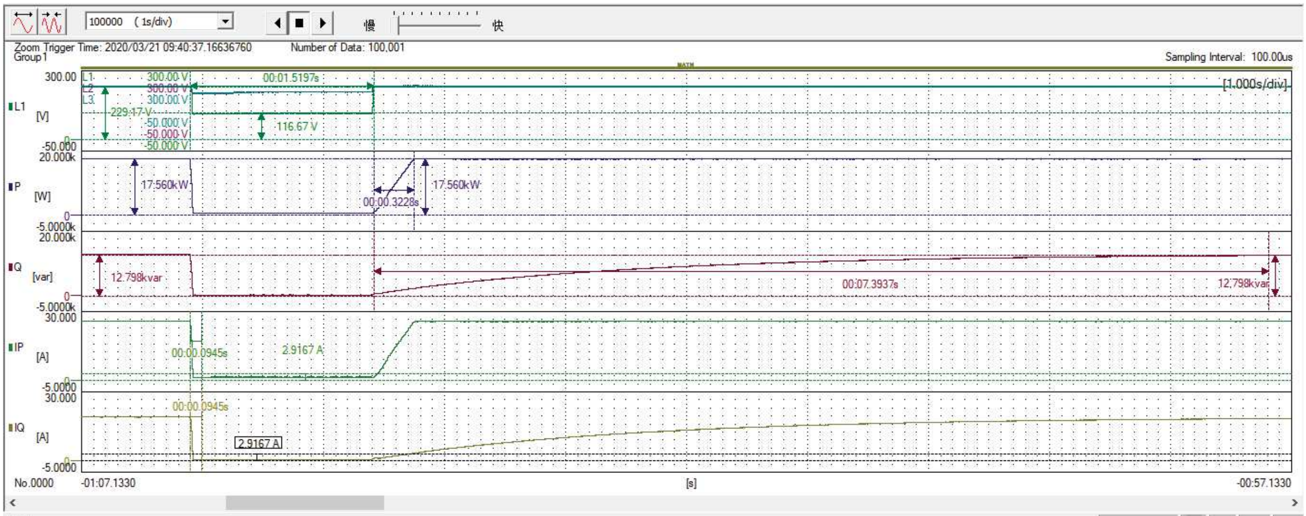
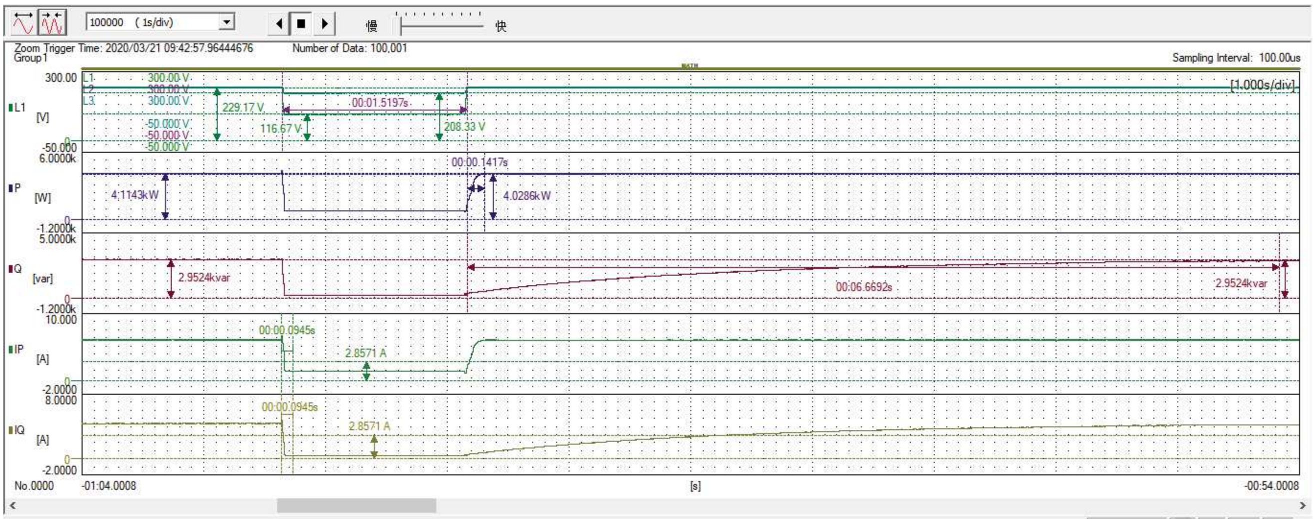


Test 2.A.1-Symmetrical fault (U/U$_{nom}$ =0,50); P =100% P$_n$

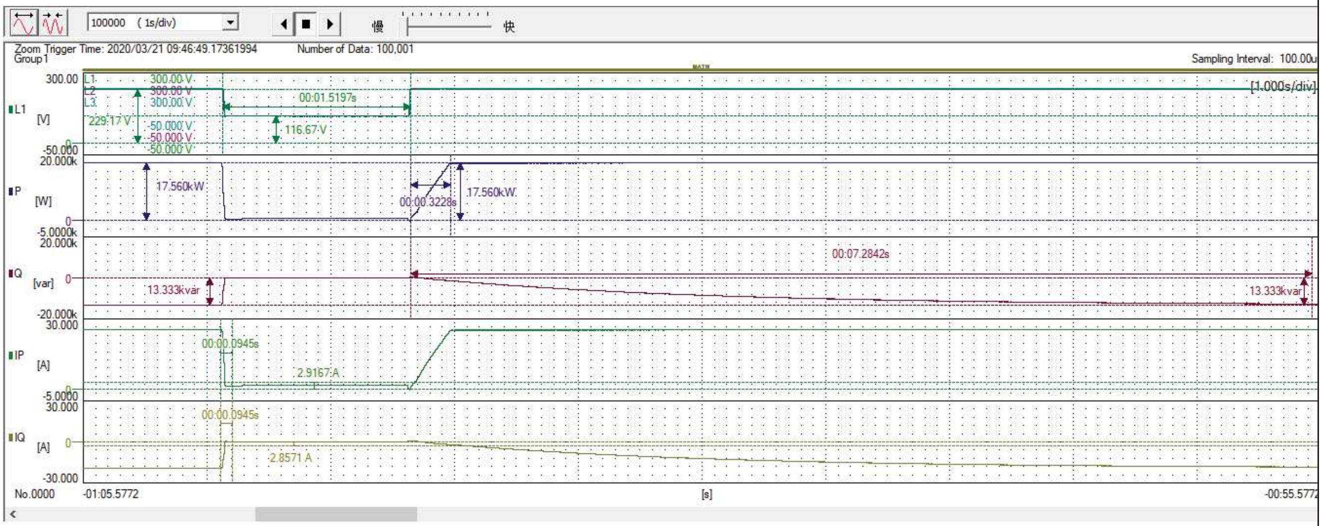


Test 2. A.2-Symmetrical fault (U/U$_{nom}$ =0,50); P = 20% P$_n$

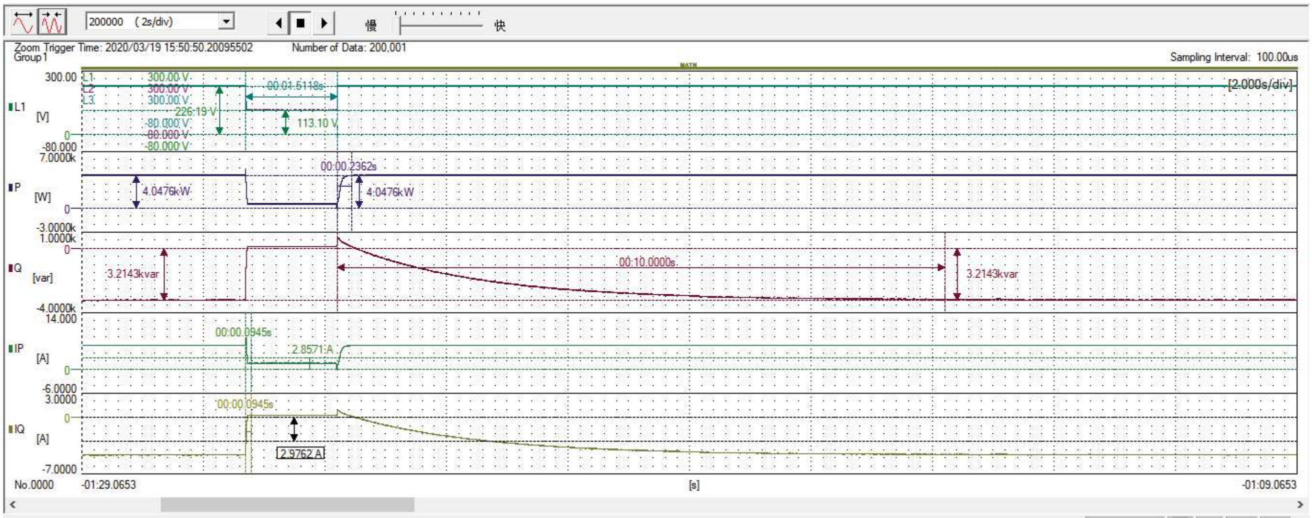


Test 2.D.1-Asymmetrical fault (U/U_{nom} =0,50); P = 100% P_n

Test 2.D.2-Asymmetrical fault (U/U_{nom} =0,50); P = 20% P_n


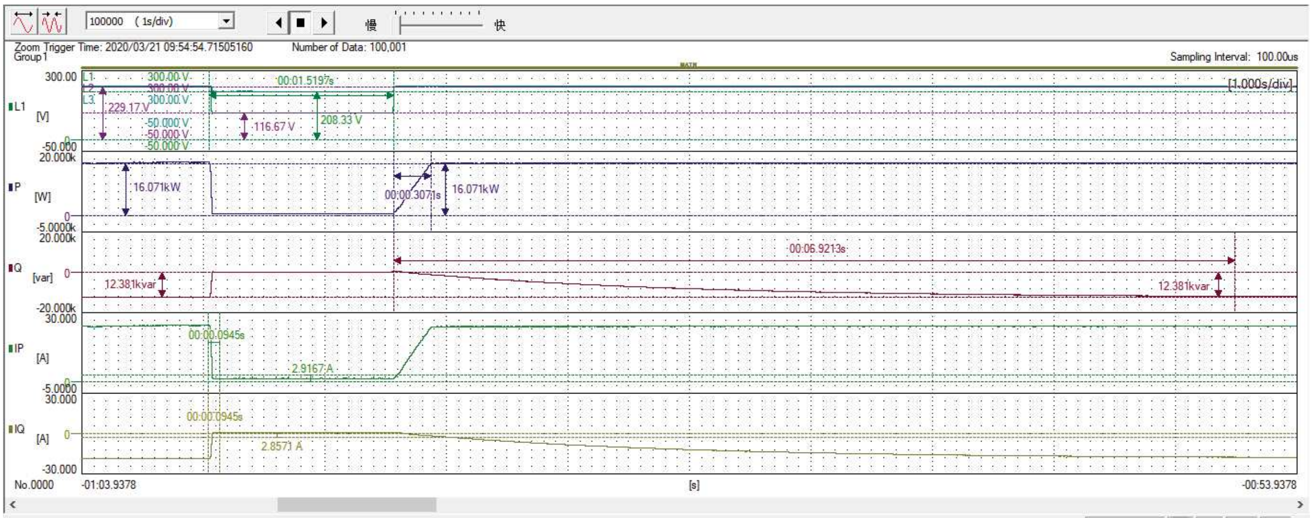
Test 3.A.1-Symmetrical fault (U/U_{nom} =0,50); P =100% P_n



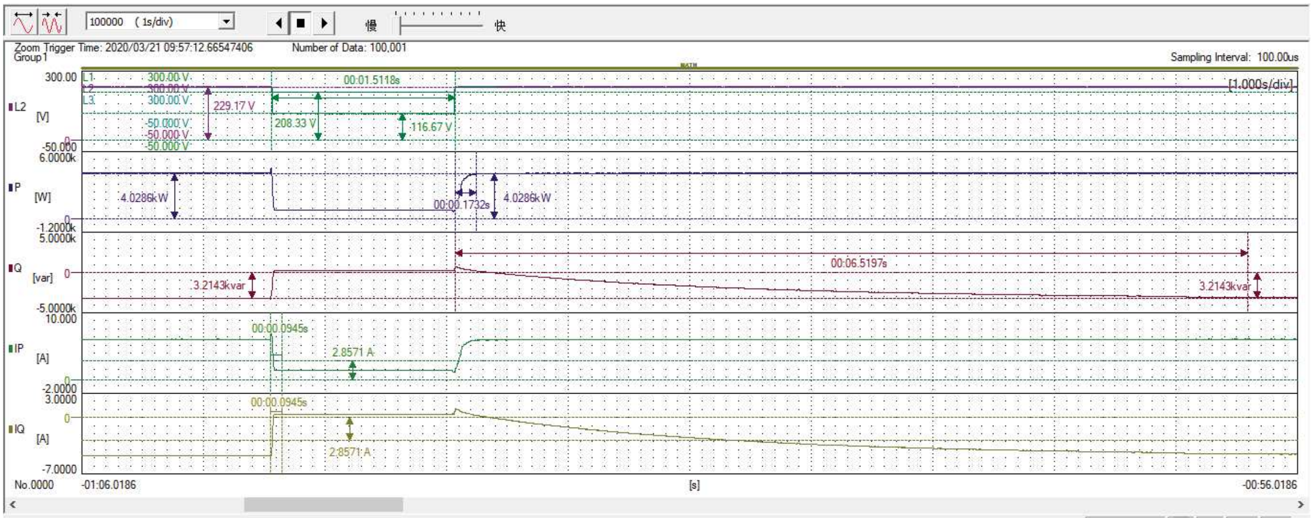
Test 3. A.2-Symmetrical fault (U/U_{nom} =0,50); P = 20% P_n



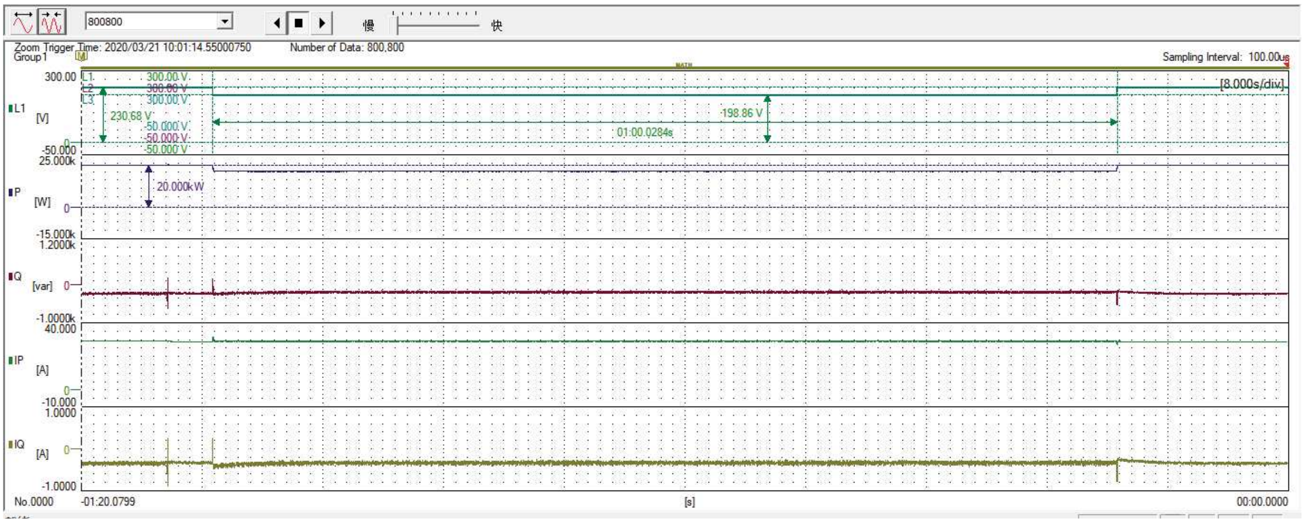
Test 3.D.1-Asymmetrical fault (U/U_{nom} =0,50; P = 100% P_n



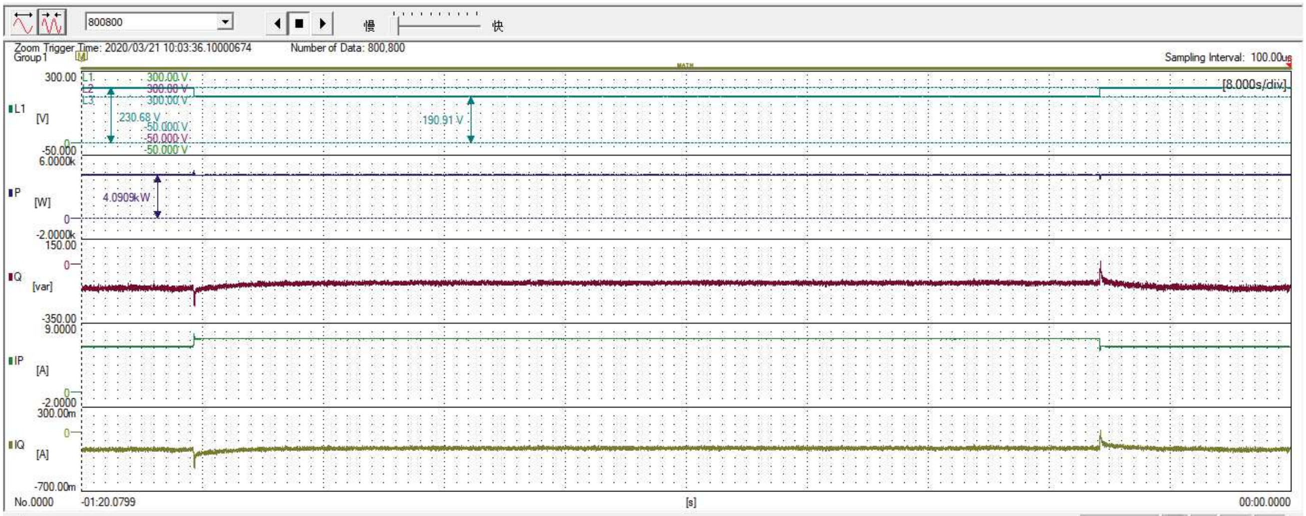
Test 3.D.2-Asymmetrical fault (U/U_{nom} =0,50); P = 20% P_n



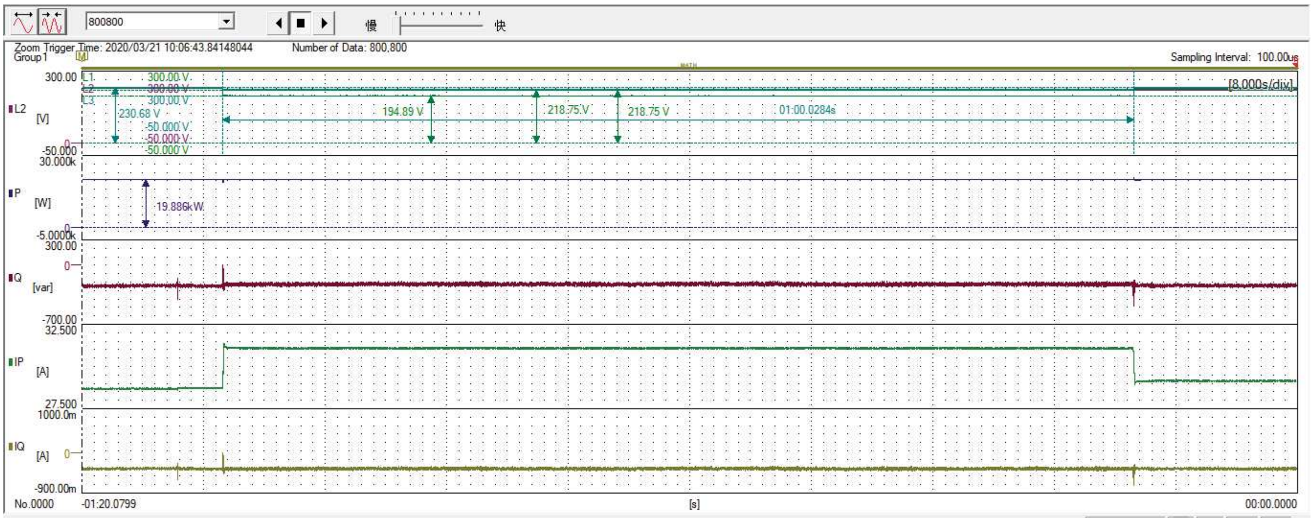
Test 4.A.1-Symmetrical fault (U/U$_{nom}$ =0,85); P =100% P$_n$



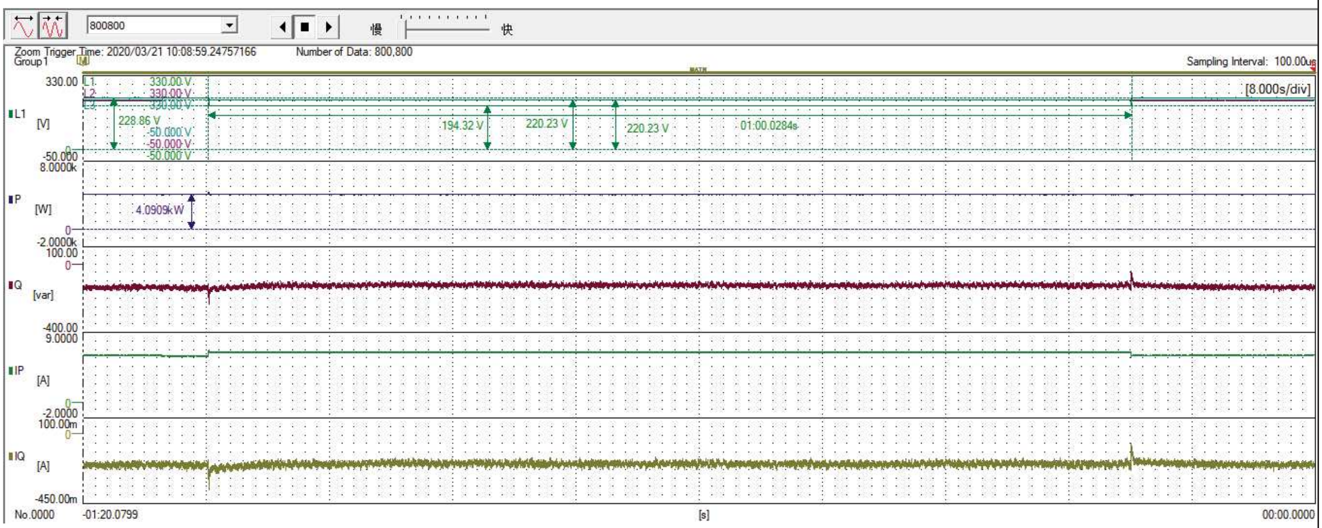
Test 4. A.2-Symmetrical fault (U/U$_{nom}$ =0,85); P = 20% P$_n$



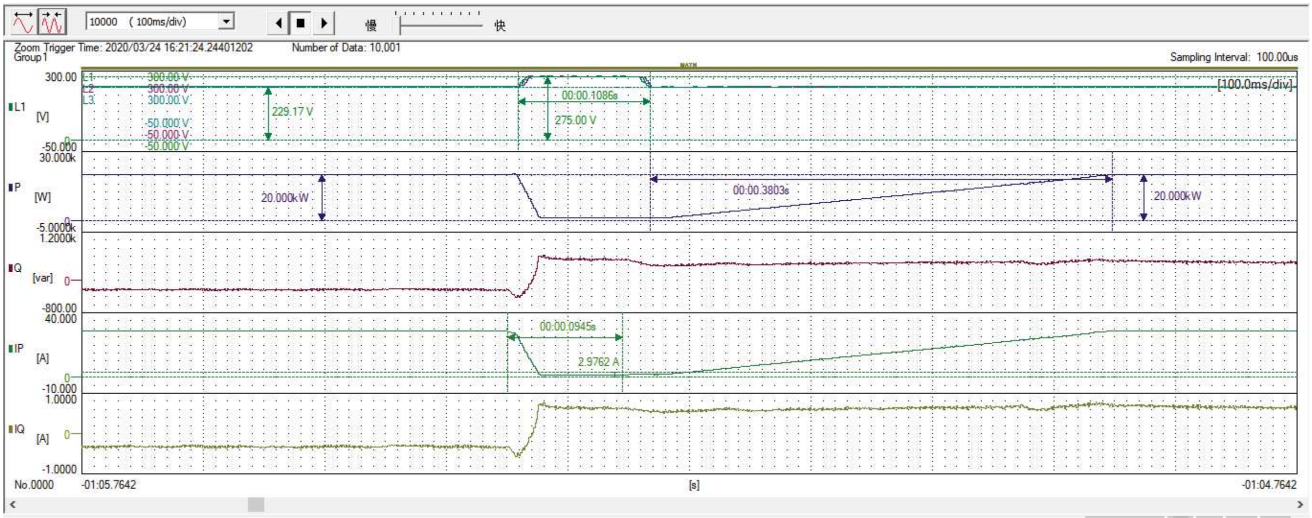
Test 4.D.1-Asymmetrical fault (U/U_{nom} =0,85); P = 100% P_n



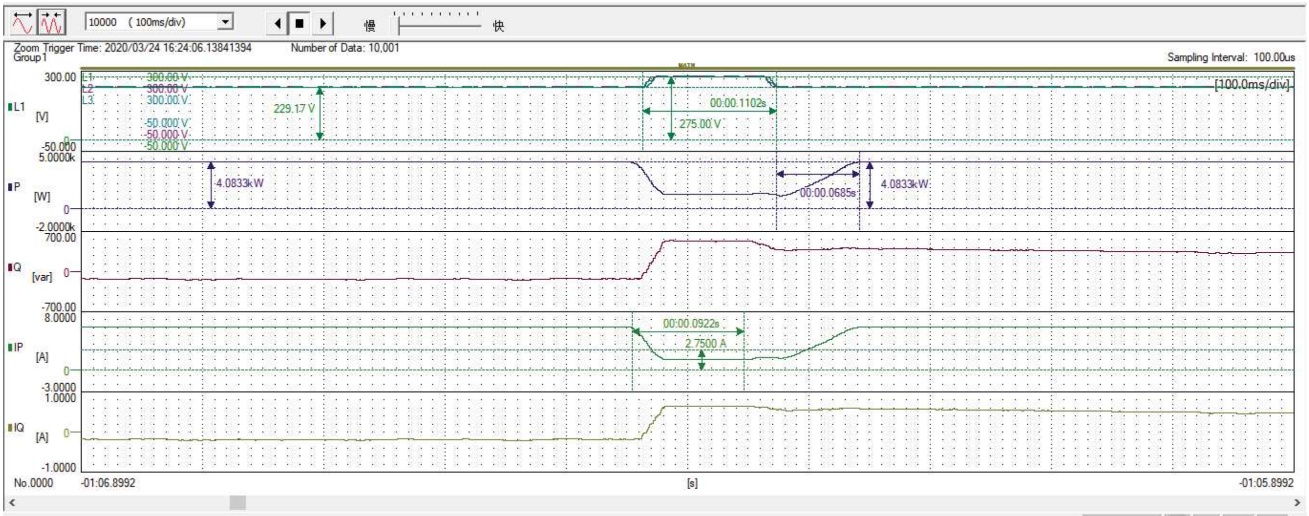
Test 4.D.2-Asymmetrical fault (U/U_{nom} =0,85); P = 20% P_n



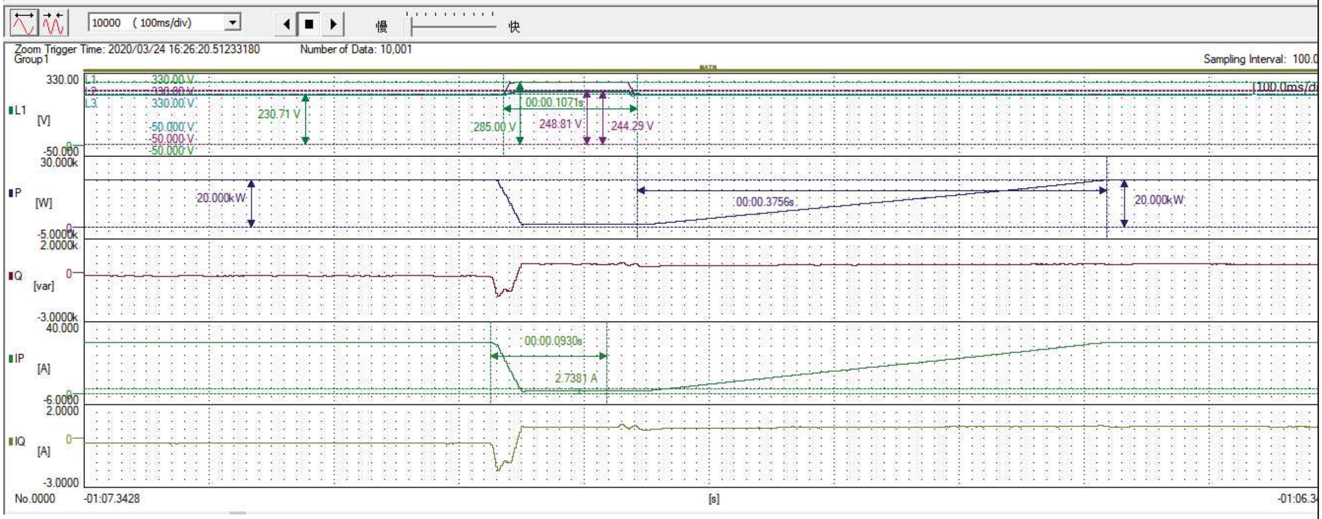
Test 5.A.1-Symmetrical fault (U/U_{nom} =1,25); P =100% P_n



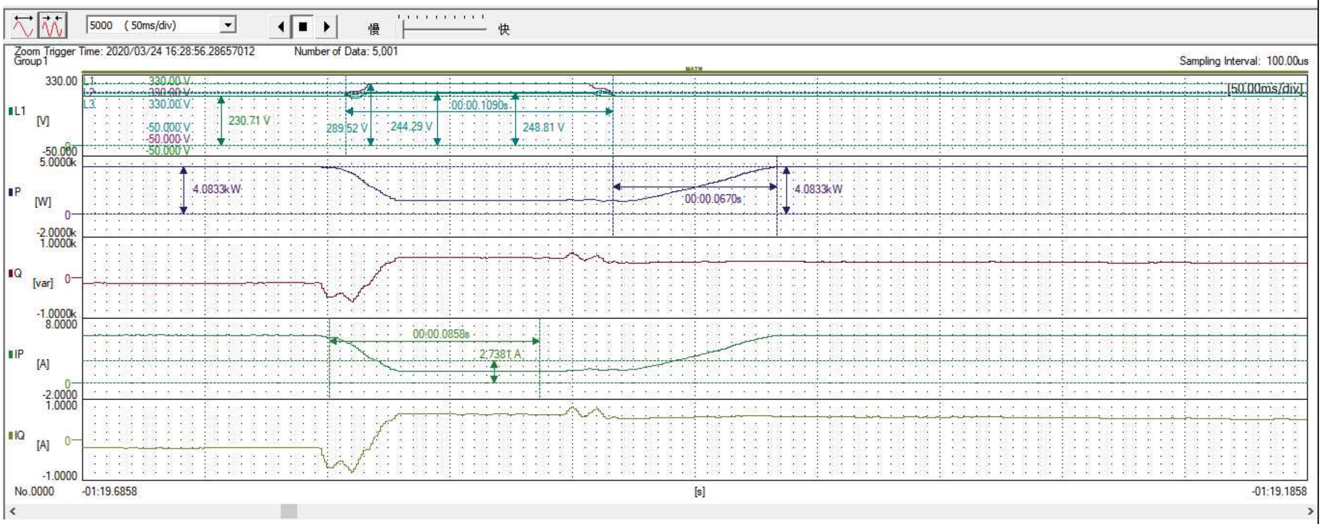
Test 5. A.2-Symmetrical fault (U/U_{nom} =1,25); P = 20% P_n



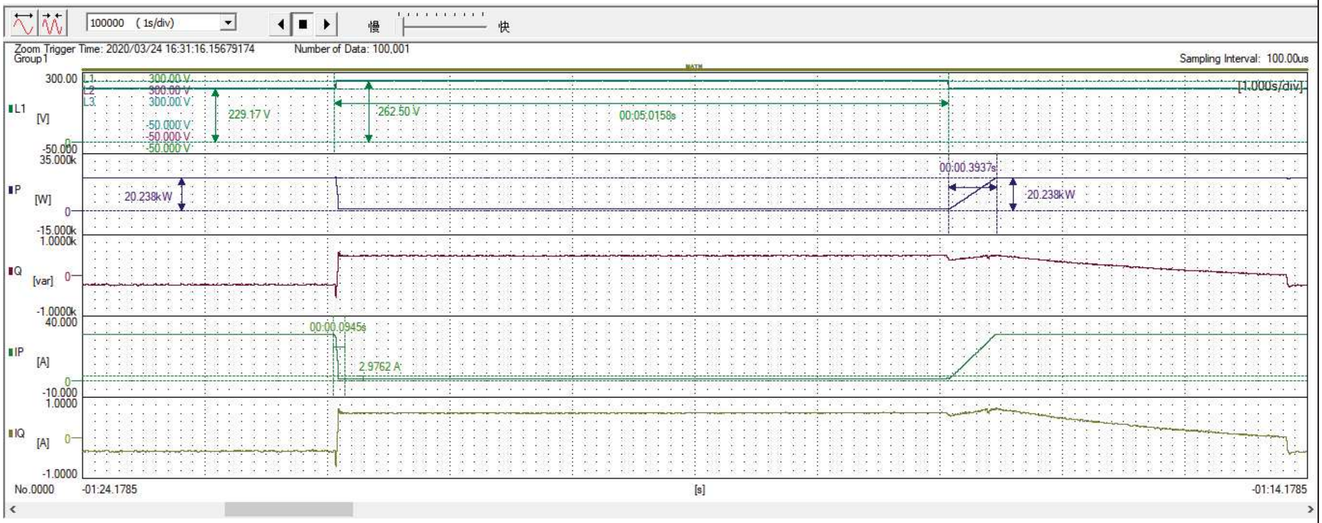
Test 5.D.1-Asymmetrical fault (U/U_{nom} =1,25); P = 100% P_n



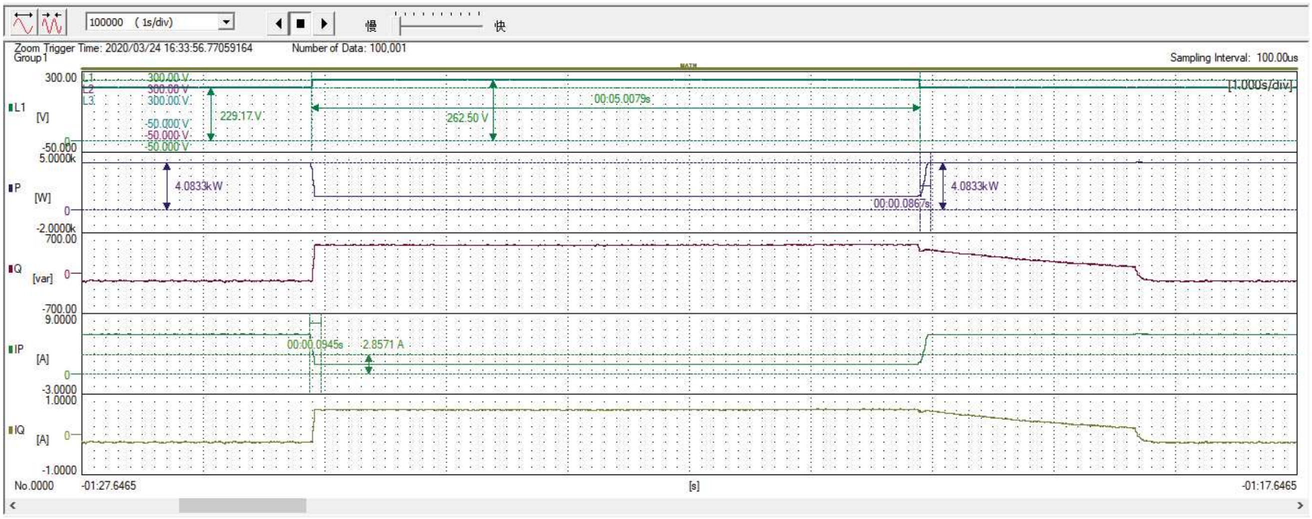
Test 5.D.2-Asymmetrical fault (U/U_{nom} =1,25); P = 20% P_n



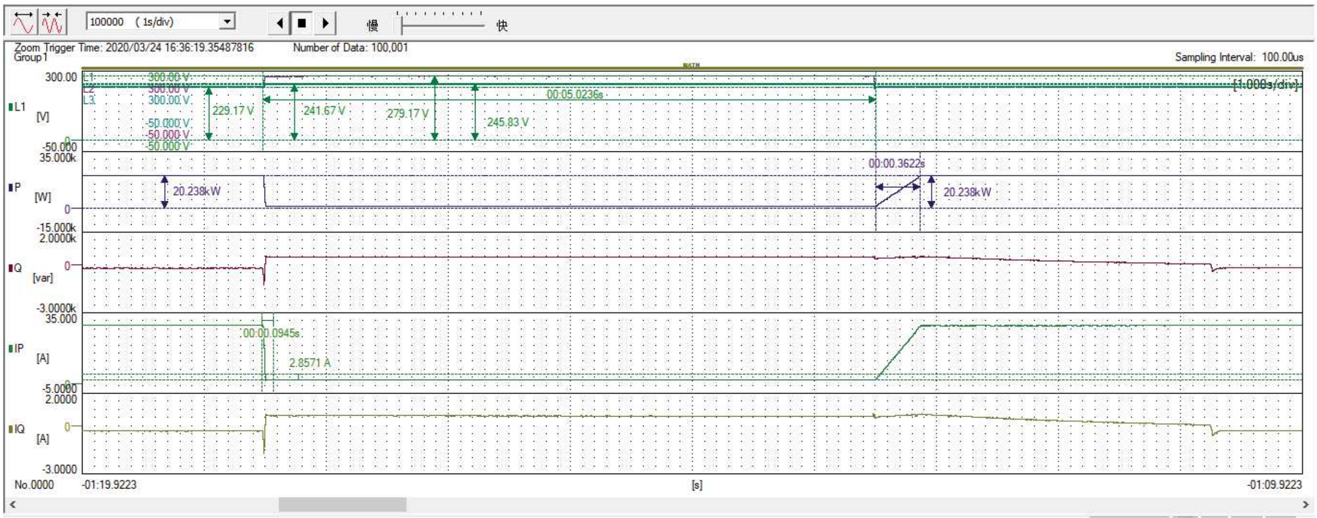
Test 6.A.1-Symmetrical fault (U/U_{nom} =1,20); P =100% P_n



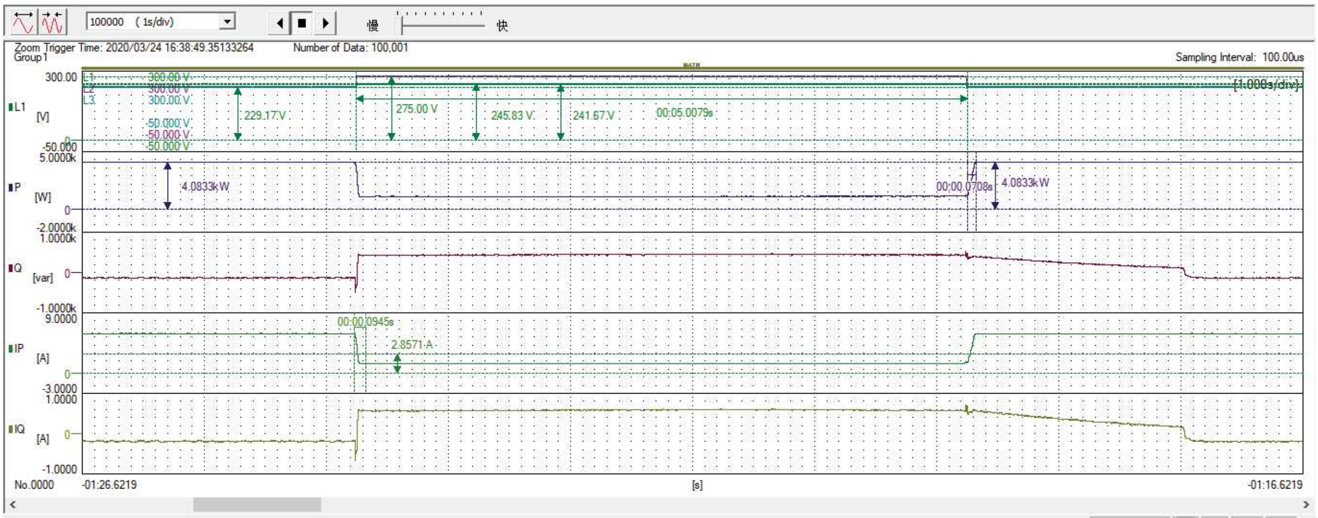
Test 6. A.2-Symmetrical fault (U/U_{nom} =1,20); P = 20% P_n



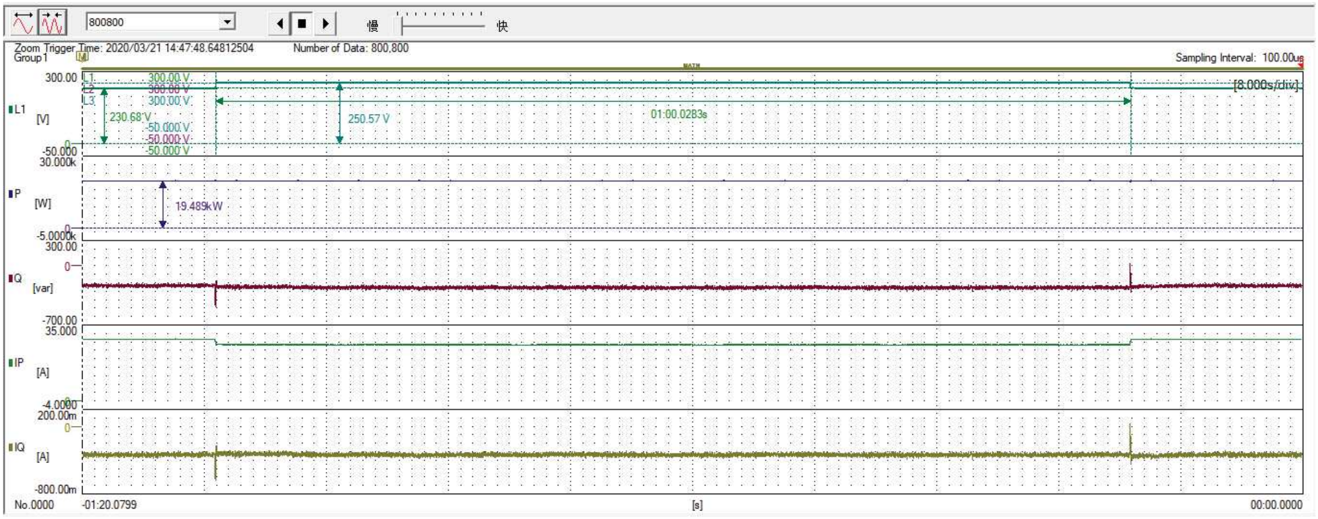
Test 6.D.1-Asymmetrical fault (U/U_{nom} =1,20); P = 100% P_n



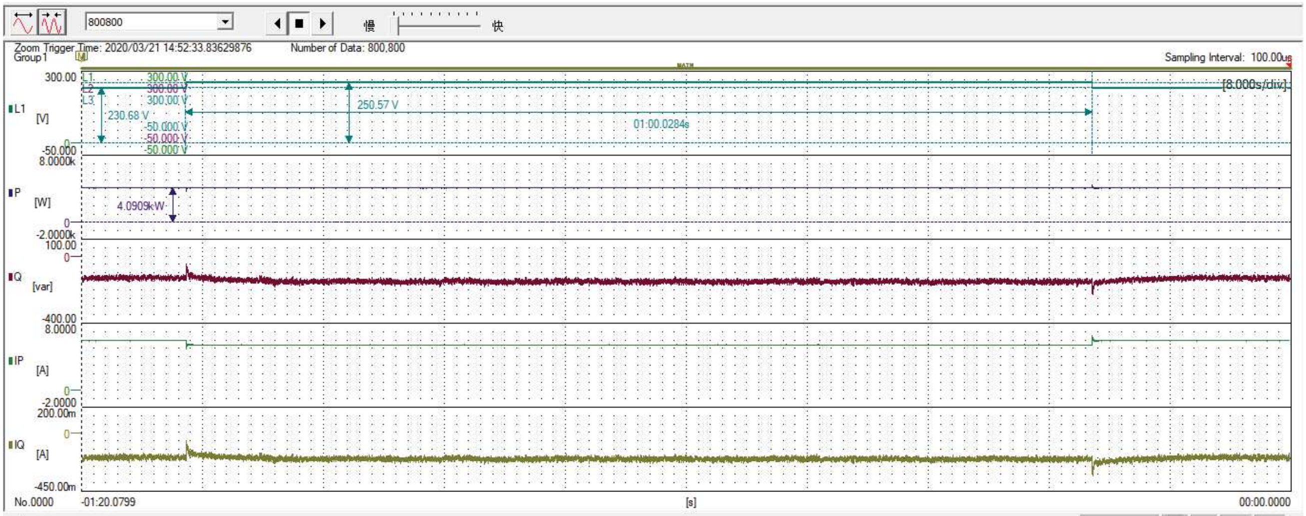
Test 6.D.2-Asymmetrical fault (U/U_{nom} =1,20); P = 20% P_n



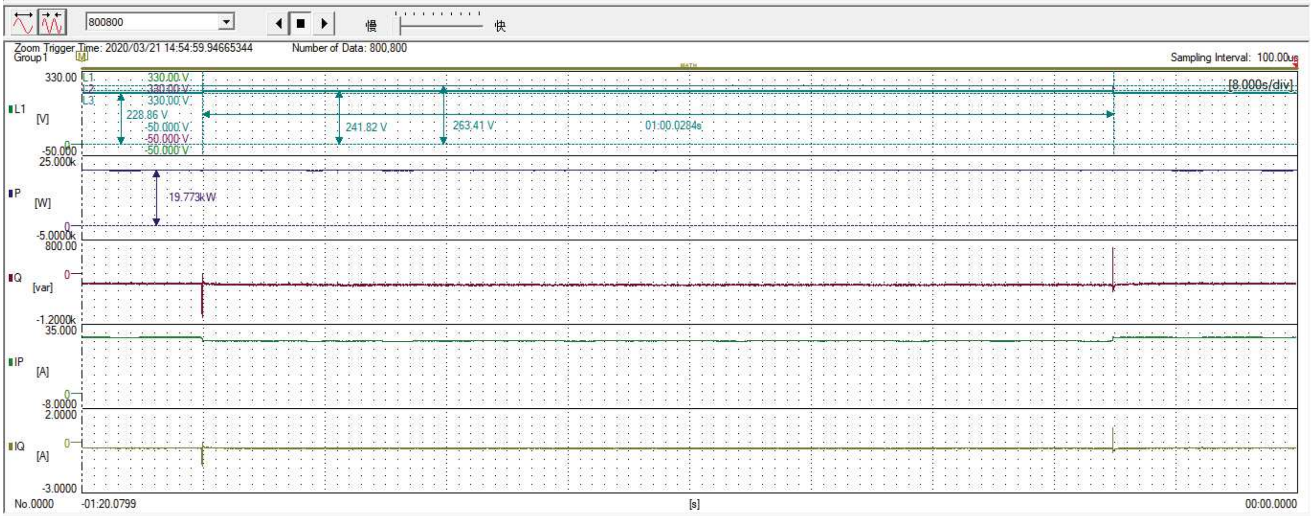
Test 7.A.1-Symmetrical fault (U/U$_{nom}$ =1,15); P =100% P$_n$



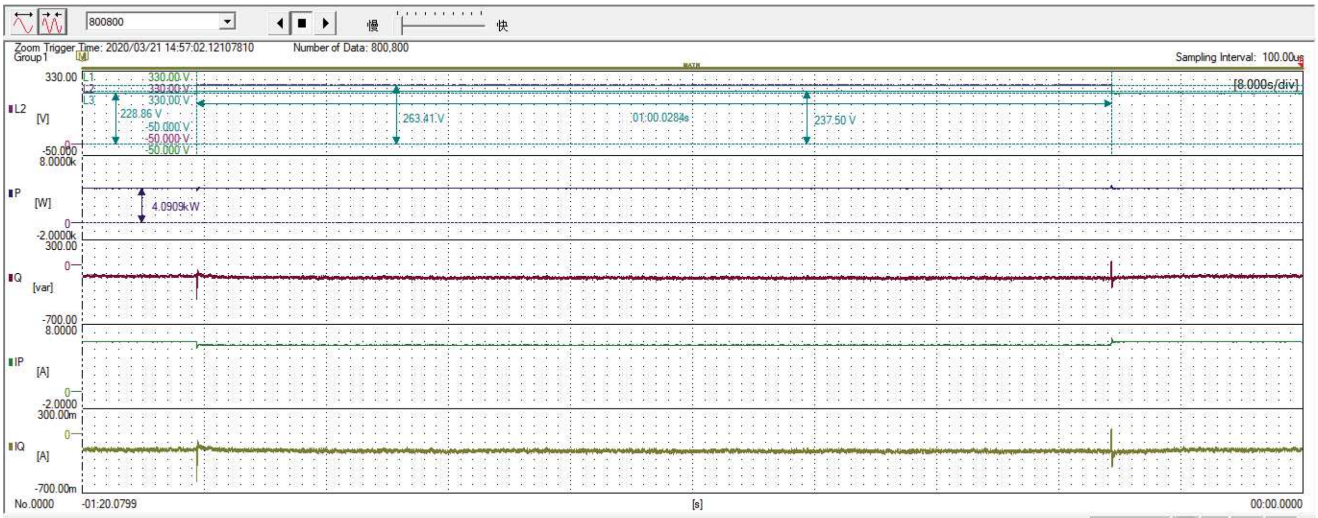
Test 7. A.2-Symmetrical fault (U/U$_{nom}$ =1,15); P = 20% P$_n$



Test 7.D.1-Asymmetrical fault (U/U_{nom} =1,15); P = 100% P_n



Test 7.D.2-Asymmetrical fault (U/U_{nom} =1,15); P = 20% P_n



Annex No. 1

Pictures of the unit

The full pictures refer to PHOTO DOCUMENT
Project No.: 190424N048-R1
Date: 20200409

Bureau Veritas Shenzhen Co., Ltd.
Dongguan Branch

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Tel: +86 769 8998 2098
Fax: +86 769 8599 1080
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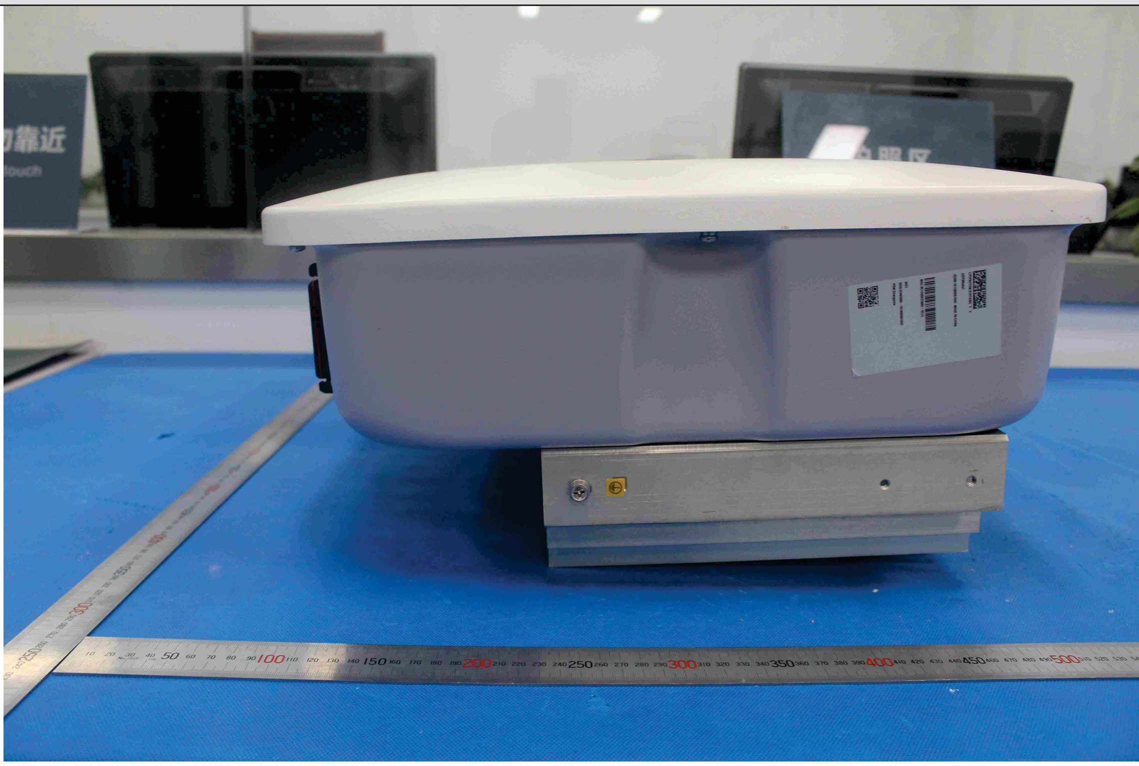
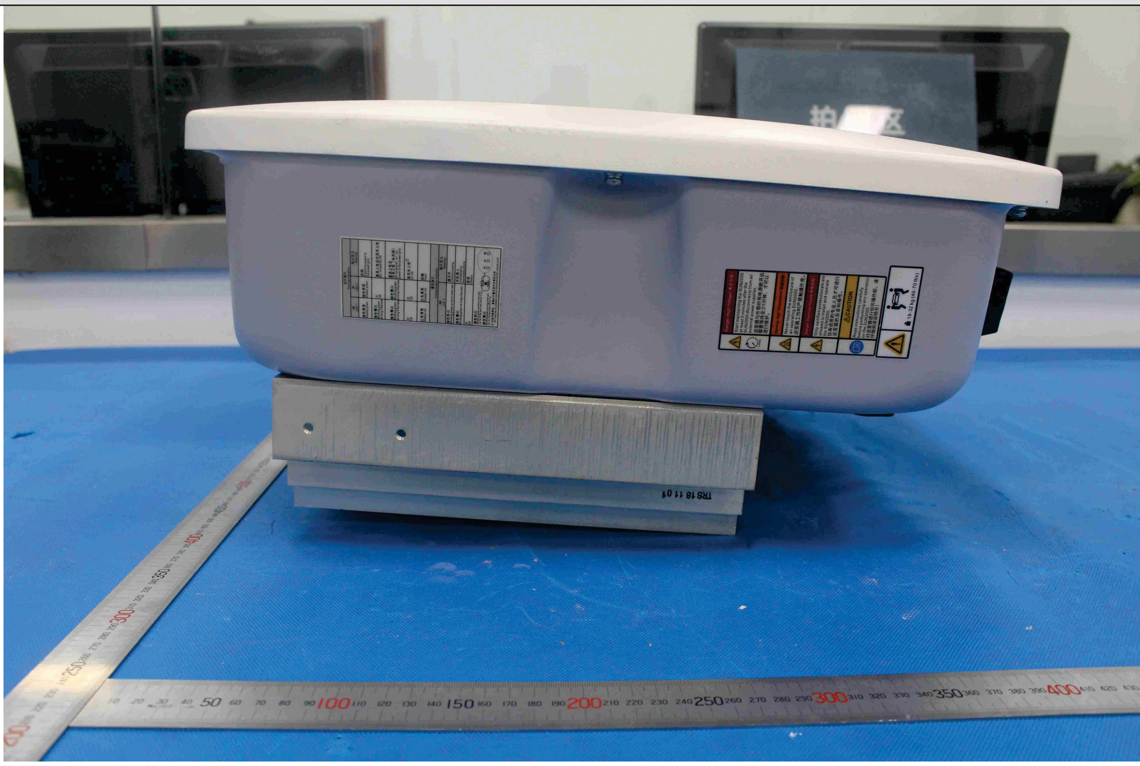
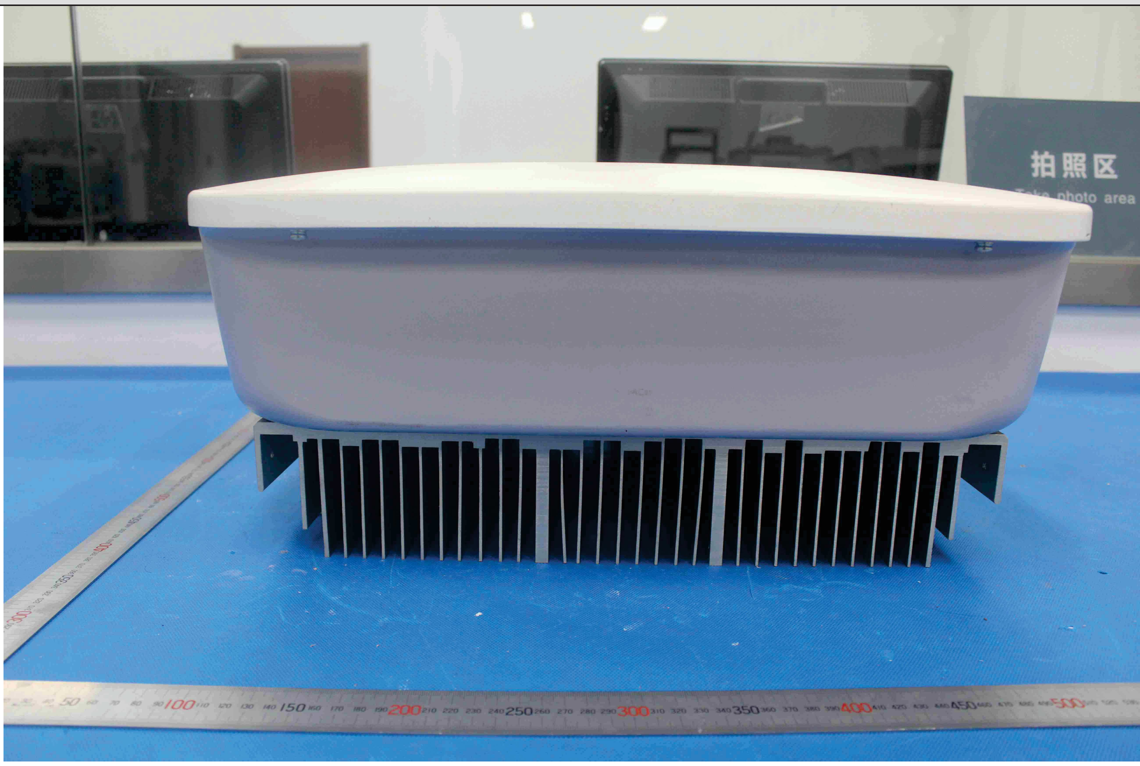
Enclosure front view

Enclosure side view


Enclosure side view

Enclosure top view


Enclosure bottom view

Enclosure rear view

Annex No. 2

Test Equipment list

Date(s) of performance test: 2020-02-25 to 2020-04-21

Equipment	Internal No.	Manufacturer	Type	Serial No.	Last Calibration
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	Sep. 12, 2019
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
AC Source	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040016DG	Chroma	62150H-1000S	62150EF00490	
DC Simulation Power Supply	A7040017DG	Chroma	620028	620028EF00120	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 24, 2019
Oscilloscope probel	A1490008DG	YOKOGAWA	701901	//	Sep. 20, 2019
Oscilloscope probel	A1490009DG	YOKOGAWA	701901	//	Sep. 20, 2019
Oscilloscope probel	A1490010DG	YOKOGAWA	701901	//	Sep. 20, 2019
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Sep. 12, 2019
Current transducer	A1060008DG	YOKOGAWA	CT200	1130700017	Sep. 12, 2019
Current transducer	A1060009DG	YOKOGAWA	CT200	1130700019	Sep. 12, 2019