TEST REPORT

OVE-directive R25

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

Report reference number..... :	**PVAT2101WDG0266-R1**
Date of issue.....:	2022-05-31
Total number of pages.....:	158
Testing laboratory name..... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
Address.....:	No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China
Accreditation.....:	Certificate # 2951.01
Applicant's name..... :	**FSP TECHNOLOGY INC.**
Address.....:	No.22, Jianguo East Road, Taoyuan City, Taiwan 330.
Test specification	
Standard.....:	Tor Erzeuger Typ A:2019-12 OVE-directive R25:2020-03
Test Report Form No.....:	TOR Erzeuger Typ A VER.1
TRF Originator.....:	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF.....:	Dated 2022-03-01
Test item description.....:	Hybrid solar inverter
Trademark.....:	FSP
Model / Type.....:	FSP Power manager 10KW

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

Testing Location :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
Address :	No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China
Tested by (name and signature) :	Ryan He 
Approved by (name and signature) :	Ken Chan 
Manufacturer's name :	**FSP TECHNOLOGY INC.**
Manufacturer address :	No.22, Jianguo East Road, Taoyuan City, Taiwan 330.
Factory's name :	**VOLTRONIC POWER TECHNOLOGY CORP.**
Factory address :	1-4F, Building 5, YuSheng Industrial Park, No.467, Section Xixiang, National Highway 107, Xixiang, Bao An District, Shenzhen, China.

Document History

Date	Internal reference	Modification / Change / Status	Revision
2021-02-20	Jack Shi	This is a copy test report, the test results refer to the original test report PVAT200119N030-R1.	0
2022-05-31	Ryan He	Update report version; Add table 5.4; Remove model "FSP103PV-230TH-48"; Amend typos.	R1

Supplementary information:

Test items particulars	
Equipment mobility ..... :	Permanent connection
Operating condition ..... :	Continuous
Class of equipment..... :	Class I
Protection against ingress of water . :	IP20 according to EN 60529
Mass of equipment [kg] ..... :	Approximately 45kg
Test case verdicts	
Test case does not apply to the test object ..... :	N/A
Test item does meet the requirement ..... :	P(ass)
Test item does not meet the requirement ..... :	F(ail)
Testing	
Date of receipt of test item..... :	2020-01-19
Date(s) of performance of test..... :	2020-01-19 to 2020-09-10

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 Tor Erzeuger Typ A / OVE Directive R25. This report must not be reproduced in part or in full without the written approval of the issuing testing laboratory.

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

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

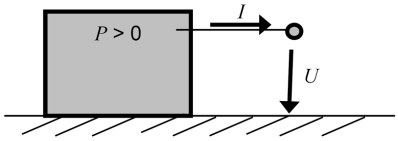
Conformity statements are decided in accordance with IEC GUIDE 115:2021 Procedure 2 (accuracy method), unless otherwise normatively specified or contractually agreed.

- "P_{rE}" for the rated active power:
  $P_{rE} = U_n \times I_r \times \cos \varphi$ (single-Phase); $P_{rE} = \sqrt{3}\ U_n \times I_r \times \cos \varphi$ (three-Phase)
- "P_{ref}" for the momentary power
- "ΔP_{E60}" in [%] = $(P_{Setpoint} - P_{E60}) / P_{rE}$
- "ΔQ_{E60}" in [%] = $(Q_{expected} - Q_{E60}) / P_{Emax}$
- "$_{E0,2}$" for gliding average values over 200 milliseconds
- "$_{E60}$" for gliding average values over 60 seconds
- "$_{E600}$" for gliding average values over 10 minutes
- "(c)" for over-excited
- "(i)" for under-excited

Active and reactive power:

The regarded system of the voltage and current vectors is the load view (Figure 2):

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



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

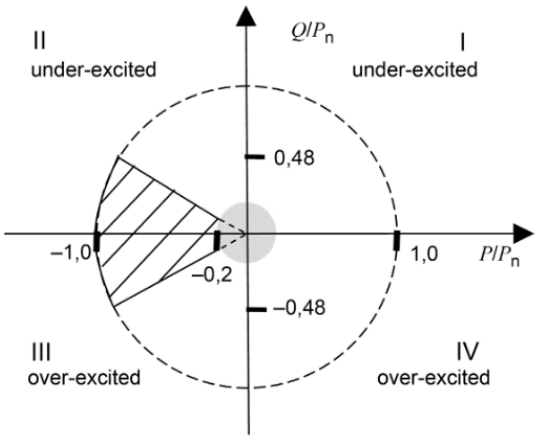
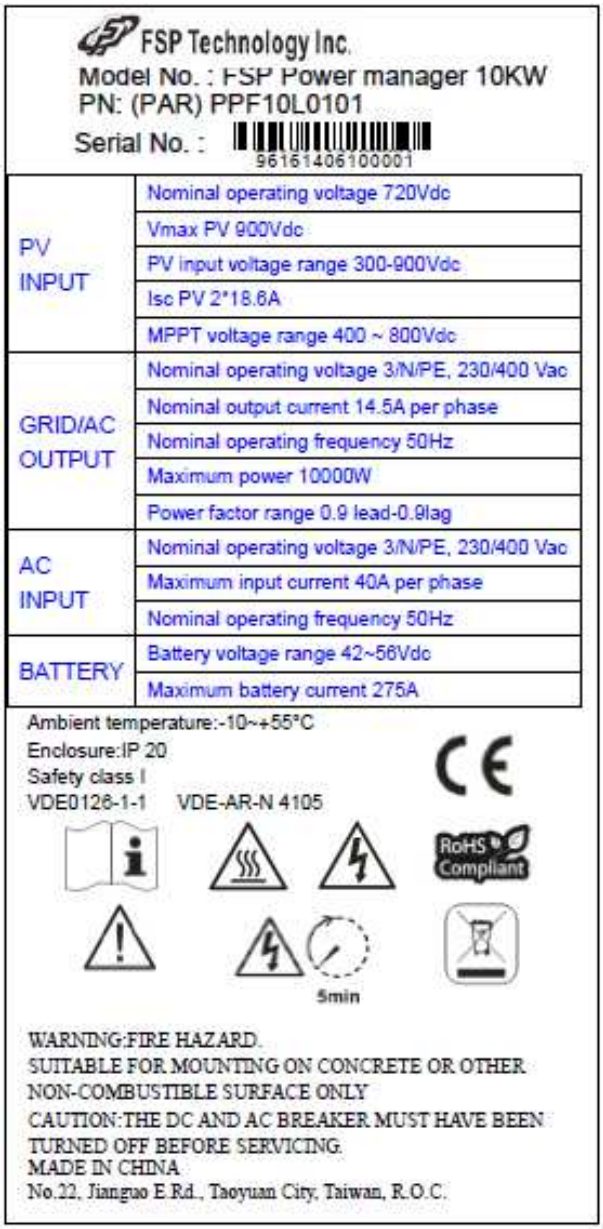


Figure 1

This Test Report consists of the following documents:

Copy of marking plate



Note:

Example 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 two relays. This assures that the opening of the output circuit will also operate in case of one error.

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

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

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

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

Description of the electrical circuit:

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

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

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

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

The unit provides two relays in series in all output conductors. When single fault applied to one relay, alarm an error code in display panel, another redundant relay provides basic insulation maintained between the PV array and the mains. All the relays are tested before each start up. Both CPU can switch of the relays.

Block diagram of the utility interactive inverter:

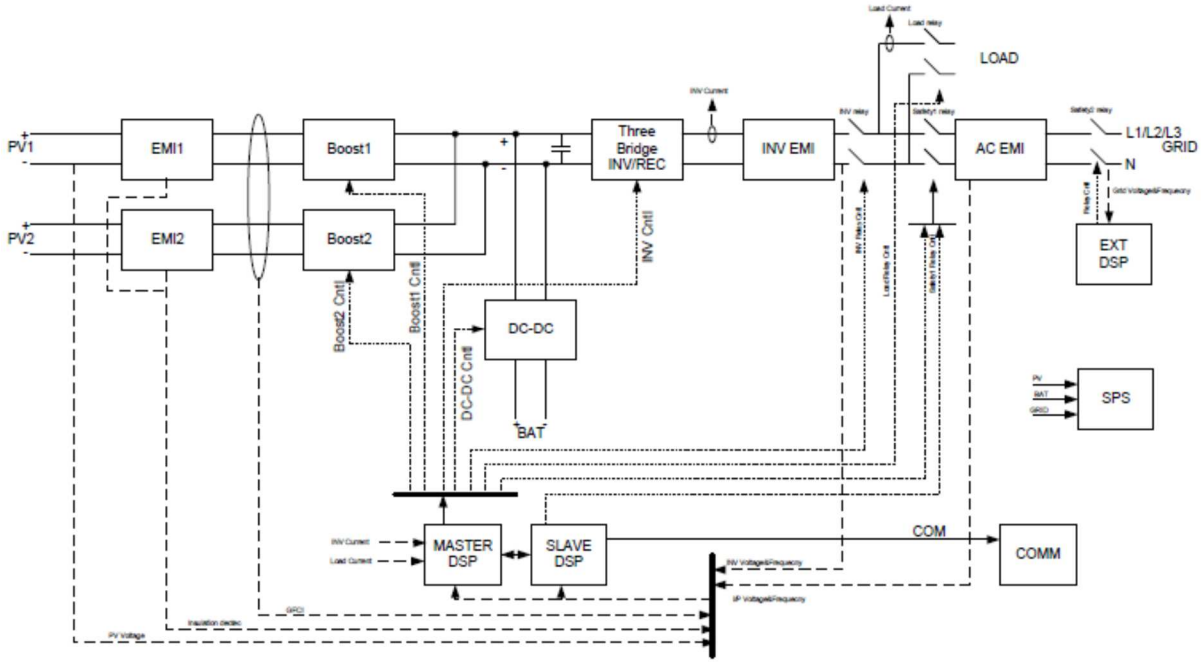


Figure 2 – Block diagram

Description of the remote control in a typical installation:

The PV inverter may be assemble with modbus card for communication with PCs to internet and received the DNO signal and direction. One modbus card can be used in one PV inverter at the same time, up to 31 PV inverters can be monitored from one computer. The cables length between two ports should not be over 1500m.

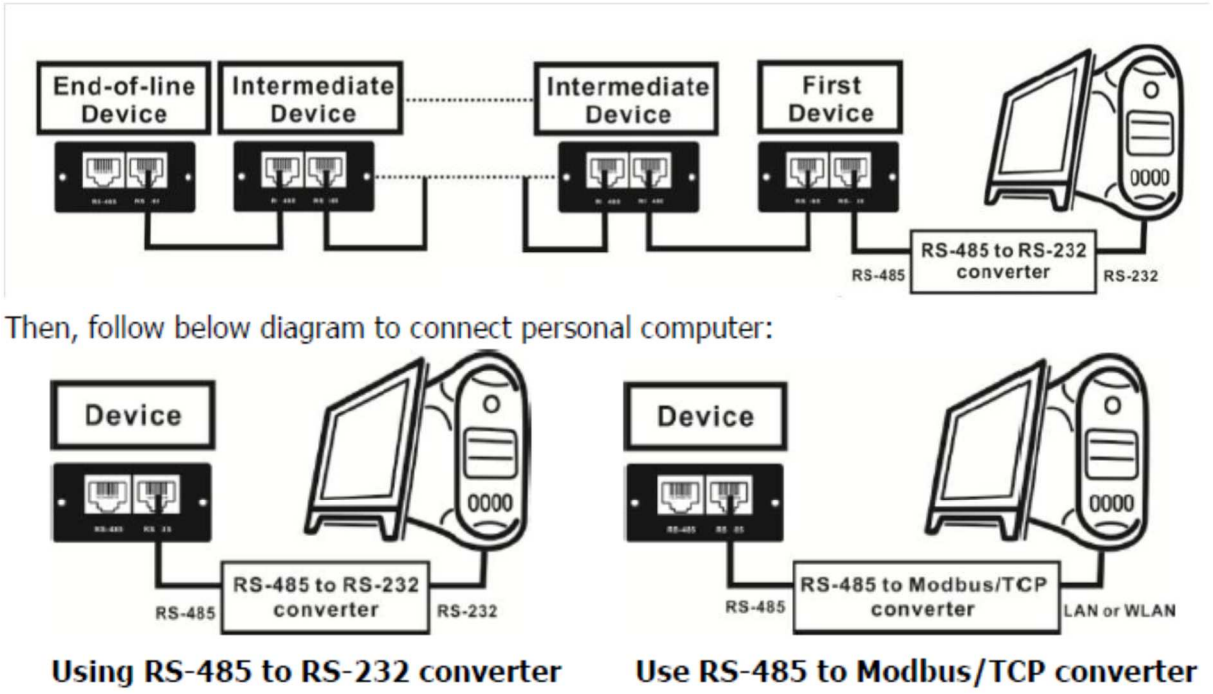
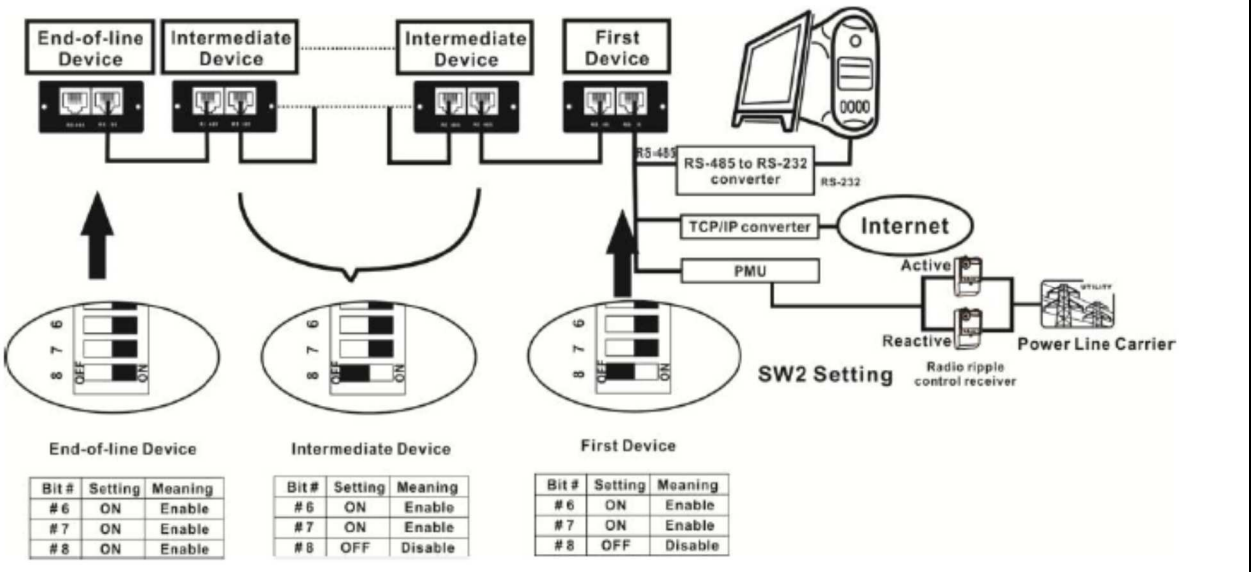


Figure 3 – Scheme of an installation

Description of the connection to the ripple control receiver:



Bit #	Setting	Meaning
#6	ON	Enable
#7	ON	Enable
#8	ON	Enable

Bit #	Setting	Meaning
#6	ON	Enable
#7	ON	Enable
#8	OFF	Disable

Bit #	Setting	Meaning
#6	ON	Enable
#7	ON	Enable
#8	OFF	Disable

Figure 4 – Connection of the ripple control receiver in an installation

Differences of the models in the series: N/A
The product was tested on: The product(s) with serial number xxx, xxx and xxx was/were tested on Hardware: 00G Software: 00G

Test Results

OVE directive R25		
Clause	**Requirement – Test**	**Verdict**
5.1	Evidence of permissible network perturbations	**P**
5.2	Evidence of symmetry behaviour of inverters	**P**
5.3	Evidence of the behaviour of the generating unit on the network	**P**
5.4	NS-protection	**P**
5.5	Connecting conditions and synchronization	**P**
5.6	Evidence dynamic grid support	**P**
5.7	Test of Ancillary Unit	**N/A**

OVE directive R25		
Clause	**Requirement – Test**	**Verdict**
5.1	**Evidence of permissible network perturbations**	
5.1.1	General	**P**
5.1.2	Rapid voltage changes	**P**
5.1.3	Flicker	**P**
5.1.4	Harmonics and interharmonics	**P**

5.1.1	General	P
The electrical installations of the customer system shall be planned, constructed and operated so that reactions to the network operator's network and to the systems of other customers are permanently reduced to a permissible minimum. Should interfering reactions on the network operator's network occur nonetheless, the customer shall apply measures to his system that are to be coordinated with the network operator. The network operator is entitled to disconnect the power generation system concerned from the network until the deficiencies are corrected. System perturbations are defined as: - Rapid voltage changes - Flicker - Harmonics, interharmonics and higher frequencies (up to 9 kHz)		

5.1.2	**Rapid voltage changes** These tests serve to demonstrate the requirements of TOR D2, Section 9.2.3	**P**

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

The following cases must be tested (where applicable).

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

  Note: For PV-plants the inverter is the generator
- Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)

If the manufacturer knows more critical cases (e.g. different cos φ parameters) then these additional have to be tested

Test conditions:

Frequency: 50Hz ± 0,5%

THD of the voltage supply: ≤3%

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

Test:

FSP POWER MANAGER 10KW

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

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	4,522	4,364	2,569	2,253	4,303	4,510	3,320	1,691	2,936
Single period effective values of the voltage [V]	234,05	232,81	231,47	229,32	230,79	230,59	229,03	229,38	230,41
k_i value [1]	0,312	0,301	0,177	0,155	0,297	0,311	0,229	0,117	0,202
k_{imax} value [1]	0,312								

Unfavourable case when switching the generator step (not necessary for electronic inverter)

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

Switch-on for nominal capacity

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	4,094	1,959	2,974	4,323	3,437	2,575	1,315	4,410	4,530
Single period effective values of the voltage [V]	230,30	232,73	232,34	231,68	230,25	230,12	230,50	229,06	230,00
k_i value [1]	0,282	0,135	0,205	0,298	0,237	0,178	0,091	0,304	0,312
k_{imax} value [1]	0,312								

5.1.2	**Rapid voltage changes** These tests serve to demonstrate the requirements of TOR D2, Section 9.2.3	**P**

Switch-off for nominal capacity

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	10,139	10.388	10.366	10,310	9,628	8,888	11,310	11,117	10,462
Single period effective values of the voltage [V]	235,01	233,81	235,93	230,71	231,92	230,51	232,71	232,39	230,83
k_i value [1]	0,699	0,716	0,715	0,711	0,664	0,613	0,780	0,767	0,722
k_{imax} value [1]	0,780								

Grid Frequency [Hz]	50,0
Grid voltage [V]	230,0
Rated current I_r [A]	14,5
Highest k_{imax} value for all switching operations [1]	0,780

Note:

Limits:

k_{imax} = 1,2 for synchronous generators with fine synchronization, converter; (electronic inverter)

k_{imax} = 4 for asynchronous generators, which are switched on at 95% to 105% of their synchronous speed, if no further details are available regarding the type of current limitation. With regard to short-term compensation processes, the condition mentioned below for very short voltage changes must also be observed.

k_{imax} = 8 for asynchronous generators that are powered up by the network if I_a is unknown.

(I_a = starting current)

The test results base on the test report " PVDE190903N004"issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-01-16.

5.1.3	**Flicker** These tests serve to demonstrate the requirements of TOR D2, Section 9.2.4.	**P**

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)

Test conditions:

Voltage: 86% U_n to 109% U_n

Frequency: 50Hz ± 0,5%

THD of the voltage supply: ≤3%

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

Test:

FSP POWER MANAGER 10KW

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

Grid impedance DIN EN 61000-3-3 (VDE 0838-3) [Ω]:	R_A = 0,24Ω jX_A = 0,15Ω
Grid impedance DIN EN 61000-3-11 (VDE 0838-11) [Ω]:	--
Output voltage of the impedance network [V]	230

Flicker to:	Result:		
	P_{lt}	P_{st}	dc%
DIN EN 61000-3-3	0,18	0,18	0,09

Assessment criterion:

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

Determination of the flicker coefficient:

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

where S_k is the short-circuit power of the network standby element (during the determination of the appropriate P_{st} values)

The value for the network standby element must be determined separately with measurements for rated currents > 75 A.

Flicker for rated currents ≤75A to DIN EN 61000-3-3 (VDE 0838-3) / DIN EN 61000-3-11 (VDE 0838-11)

Grid impedance angle ψ_k	32°
Flicker coefficient c(ψ_k)	**3,60**

Assessment criterion:

Long-term flicker strength: P_{lt}≤0,5

Note:

The test results base on the test report " PVDE190903N004"issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-01-16.

5.1.4	Test Harmonics DIN EN 61000-3-2 (≤16 A per Phase)						P
FSP POWER MANAGER 10KW							
Phase	**L1**		**L2**		**L3**		
Power Level	**100%**		**100%**		**100%**		
AC Power [W]	3399		3331		3325		
AC Voltage [V]	230,81		230,75		230,69		
AC Current [A]	14,726		14,438		14,412		
Frequency [Hz]	50,00		50,00		50,00		
THD [%]	3,103		3,173		3,140		
Harmonic	**Current Magnitude (A)**	**% of Funda-mental**	**Current Magnitude (A)**	**% of Funda-mental**	**Current Magnitude (A)**	**% of Funda-mental**	**Harmonic Current Limits (A)**
1st	14,718	99,950	14,430	99,948	14,405	99,949	--
2nd	0,301	2,043	0,246	1,705	0,294	2,038	1,080
3rd	0,168	1,138	0,260	1,801	0,177	1,226	2,300
4th	0,064	0,431	0,062	0,432	0,064	0,447	0,430
5th	0,205	1,395	0,171	1,187	0,200	1,389	1,140
6th	0,033	0,227	0,031	0,213	0,035	0,240	0,300
7th	0,064	0,437	0,095	0,660	0,063	0,434	0,770
8th	0,022	0,151	0,021	0,144	0,023	0,158	0,263
9th	0,037	0,251	0,040	0,274	0,039	0,271	0,400
10th	0,019	0,131	0,018	0,125	0,020	0,137	0,184
11th	0,028	0,192	0,044	0,303	0,027	0,188	0,330
12th	0,021	0,145	0,020	0,140	0,023	0,162	0,153
13th	0,026	0,176	0,039	0,272	0,027	0,185	0,210
14th	0,022	0,147	0,022	0,149	0,023	0,161	0,131
15th	0,034	0,233	0,023	0,159	0,033	0,230	0,150
16th	0,024	0,160	0,020	0,136	0,023	0,157	0,115
17th	0,037	0,254	0,052	0,359	0,036	0,248	0,132
18th	0,028	0,192	0,023	0,157	0,029	0,203	0,102
19th	0,037	0,248	0,028	0,197	0,035	0,245	0,188
20th	0,031	0,208	0,029	0,202	0,032	0,225	0,092
21th	0,044	0,302	0,046	0,318	0,043	0,297	0,107
22th	0,033	0,225	0,029	0,200	0,031	0,218	0,084
23th	0,047	0,317	0,048	0,333	0,047	0,328	0,098
24th	0,040	0,270	0,031	0,217	0,040	0,278	0,077
25th	0,050	0,337	0,050	0,343	0,048	0,330	0,090

5.1.4	Test Harmonics DIN EN 61000-3-2 (≤16 A per Phase)						P
FSP POWER MANAGER 10KW							
26th	0,040	0,268	0,039	0,267	0,045	0,309	0,071
27th	0,056	0,380	0,056	0,389	0,053	0,367	0,080
28th	0,043	0,293	0,038	0,266	0,041	0,284	0,066
29th	0,056	0,380	0,054	0,374	0,056	0,386	0,078
30th	0,043	0,295	0,030	0,210	0,041	0,283	0,061
31th	0,055	0,376	0,064	0,443	0,056	0,391	0,073
32th	0,041	0,280	0,038	0,262	0,041	0,287	0,057
33th	0,048	0,327	0,042	0,289	0,044	0,306	0,068
34th	0,036	0,247	0,031	0,212	0,036	0,248	0,054
35th	0,043	0,295	0,048	0,334	0,042	0,288	0,064
36th	0,030	0,204	0,026	0,178	0,030	0,211	0,051
37th	0,041	0,275	0,039	0,268	0,041	0,287	0,061
38th	0,029	0,197	0,024	0,168	0,029	0,198	0,048
39th	0,031	0,208	0,034	0,238	0,031	0,212	0,058
40th	0,025	0,171	0,021	0,143	0,025	0,176	0,046

PV-curve simulated according to	
Voltage of defined MPP [V]	700,0
Current of defined MPP [A]	15,7
FFU of PV curve [1]	0,68
Impedance [Ω] Line Neutral	 $R_A = 0,24\ jX_A = 0,15$ $R_N = 0,16\ jX_N = 0,10$

Note:

The test results base on the test report " PVDE190903N004"issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-01-16.

5.1.4	Test Harmonics DIN EN 61000-4-7 (≥75 A per Phase)										P
FSP POWER MANAGER 10KW											
Harmonics											
P/ P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100
Order	I_h [%]										
1	5,55	10,66	20,97	30,08	40,40	50,73	61,23	71,55	81,74	92,44	99,58
2	0,93	0,91	0,90	0,86	0,85	0,82	0,82	0,81	0,81	0,80	0,81
3	1,75	1,82	1,72	1,54	1,42	1,34	1,29	1,30	1,30	1,30	1,32
4	0,26	0,27	0,26	0,25	0,25	0,25	0,24	0,24	0,24	0,24	0,24
5	0,78	0,97	1,36	1,42	1,37	1,26	1,18	1,12	1,06	1,03	1,14
6	0,10	0,12	0,17	0,16	0,21	0,21	0,21	0,20	0,20	0,17	0,16
7	0,74	0,60	0,69	0,89	0,94	0,87	0,77	0,70	0,66	0,77	0,78
8	0,20	0,10	0,16	0,10	0,15	0,19	0,22	0,20	0,19	0,14	0,15
9	0,50	0,73	0,30	0,55	0,69	0,70	0,67	0,67	0,70	0,77	0,76
10	0,17	0,15	0,14	0,08	0,13	0,18	0,20	0,21	0,18	0,17	0,15
11	0,23	0,65	0,31	0,40	0,49	0,58	0,61	0,63	0,65	0,65	0,71
12	0,20	0,15	0,11	0,08	0,09	0,14	0,17	0,17	0,16	0,15	0,15
13	0,24	0,38	0,36	0,23	0,26	0,41	0,45	0,48	0,52	0,54	0,60
14	0,09	0,17	0,11	0,06	0,07	0,10	0,13	0,14	0,12	0,13	0,13
15	0,35	0,35	0,52	0,29	0,18	0,19	0,29	0,37	0,44	0,49	0,54
16	0,10	0,11	0,13	0,07	0,06	0,06	0,09	0,10	0,10	0,11	0,11
17	0,30	0,45	0,57	0,37	0,22	0,10	0,20	0,28	0,34	0,41	0,45
18	0,09	0,06	0,14	0,08	0,06	0,05	0,07	0,08	0,09	0,09	0,09
19	0,40	0,35	0,50	0,42	0,21	0,11	0,17	0,25	0,29	0,34	0,38
20	0,08	0,04	0,13	0,10	0,06	0,04	0,06	0,06	0,07	0,08	0,08
21	0,43	0,38	0,54	0,56	0,31	0,19	0,11	0,16	0,21	0,28	0,33
22	0,09	0,04	0,11	0,09	0,07	0,04	0,05	0,06	0,07	0,08	0,07
23	0,39	0,37	0,48	0,52	0,28	0,16	0,11	0,16	0,21	0,26	0,29
24	0,07	0,05	0,10	0,09	0,07	0,04	0,04	0,05	0,06	0,07	0,07
25	0,43	0,40	0,49	0,54	0,34	0,21	0,13	0,12	0,16	0,21	0,25
26	0,06	0,05	0,09	0,08	0,08	0,04	0,03	0,04	0,05	0,06	0,06
27	0,41	0,42	0,44	0,52	0,38	0,23	0,15	0,13	0,14	0,19	0,21
28	0,05	0,05	0,07	0,07	0,07	0,04	0,03	0,04	0,04	0,05	0,06
29	0,34	0,35	0,33	0,40	0,31	0,18	0,13	0,11	0,11	0,13	0,15
30	0,04	0,05	0,04	0,05	0,07	0,04	0,03	0,03	0,03	0,04	0,04
31	0,29	0,29	0,27	0,33	0,28	0,17	0,12	0,10	0,09	0,10	0,11
32	0,04	0,04	0,02	0,04	0,06	0,04	0,03	0,03	0,03	0,03	0,04

33	0,25	0,25	0,23	0,27	0,24	0,16	0,12	0,11	0,10	0,09	0,10
34	0,04	0,03	0,02	0,03	0,05	0,04	0,03	0,03	0,03	0,03	0,03
35	0,18	0,19	0,17	0,19	0,19	0,13	0,10	0,09	0,08	0,08	0,08
36	0,03	0,02	0,03	0,02	0,04	0,03	0,02	0,03	0,02	0,03	0,03
37	0,14	0,14	0,13	0,12	0,13	0,09	0,06	0,06	0,05	0,04	0,04
38	0,02	0,01	0,03	0,02	0,03	0,03	0,02	0,02	0,02	0,02	0,02
39	0,12	0,12	0,11	0,09	0,11	0,08	0,05	0,05	0,04	0,04	0,04
40	0,02	0,01	0,03	0,02	0,03	0,03	0,02	0,02	0,02	0,02	0,03
41	0,09	0,09	0,10	0,08	0,10	0,09	0,06	0,06	0,06	0,06	0,06
42	0,02	0,01	0,03	0,01	0,03	0,03	0,02	0,02	0,02	0,02	0,02
43	0,08	0,08	0,08	0,06	0,09	0,08	0,05	0,05	0,05	0,05	0,05
44	0,02	0,01	0,03	0,01	0,02	0,03	0,02	0,02	0,02	0,02	0,02
45	0,07	0,06	0,06	0,03	0,07	0,06	0,04	0,04	0,04	0,04	0,04
46	0,01	0,01	0,02	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02
47	0,06	0,06	0,07	0,05	0,09	0,09	0,07	0,07	0,07	0,06	0,06
48	0,01	0,01	0,02	0,01	0,02	0,03	0,02	0,02	0,02	0,02	0,02
49	0,04	0,04	0,05	0,03	0,06	0,06	0,05	0,05	0,05	0,06	0,06
50	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02
THC [%]	2,66	2,86	2,96	2,93	2,72	2,53	2,43	2,42	2,43	2,52	2,64
THDU50 [%]	1,48	1,48	1,43	1,38	1,29	1,22	1,2	1,18	1,12	0,99	0,87
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100
f [Hz]	I_h [%]										
75	0,30	0,32	0,40	0,47	0,59	0,68	0,79	0,91	1,02	1,16	1,29
125	0,20	0,20	0,23	0,25	0,30	0,35	0,40	0,45	0,49	0,53	0,57
175	0,17	0,16	0,16	0,16	0,20	0,22	0,24	0,26	0,28	0,30	0,34
225	0,20	0,18	0,18	0,18	0,19	0,22	0,24	0,27	0,29	0,30	0,33
275	0,17	0,19	0,20	0,19	0,20	0,20	0,20	0,21	0,21	0,22	0,25
325	0,20	0,19	0,20	0,21	0,19	0,19	0,21	0,22	0,23	0,23	0,24
375	0,16	0,15	0,17	0,19	0,19	0,17	0,16	0,15	0,15	0,16	0,16
425	0,21	0,22	0,19	0,24	0,22	0,19	0,18	0,18	0,18	0,17	0,18
475	0,09	0,14	0,11	0,14	0,19	0,20	0,18	0,18	0,19	0,19	0,18
525	0,13	0,26	0,19	0,24	0,32	0,31	0,26	0,23	0,21	0,20	0,19
575	0,11	0,10	0,12	0,11	0,18	0,19	0,16	0,15	0,15	0,14	0,14
625	0,17	0,13	0,19	0,15	0,27	0,30	0,26	0,22	0,20	0,18	0,16
675	0,11	0,08	0,13	0,10	0,16	0,19	0,17	0,15	0,13	0,12	0,12
725	0,14	0,09	0,17	0,13	0,22	0,25	0,23	0,19	0,16	0,13	0,12

775	0,05	0,07	0,08	0,08	0,10	0,13	0,12	0,10	0,09	0,09	0,10
825	0,10	0,08	0,12	0,14	0,17	0,21	0,19	0,16	0,14	0,12	0,10
875	0,05	0,05	0,07	0,06	0,06	0,08	0,08	0,08	0,08	0,10	0,11
925	0,08	0,09	0,07	0,13	0,16	0,19	0,19	0,18	0,17	0,15	0,14
975	0,05	0,05	0,05	0,06	0,06	0,08	0,08	0,08	0,07	0,08	0,08
1025	0,06	0,09	0,06	0,10	0,16	0,17	0,19	0,18	0,18	0,17	0,15
1075	0,05	0,04	0,05	0,06	0,08	0,09	0,10	0,09	0,08	0,07	0,07
1125	0,07	0,08	0,06	0,08	0,16	0,16	0,17	0,17	0,16	0,15	0,14
1175	0,05	0,05	0,05	0,06	0,07	0,08	0,09	0,08	0,08	0,07	0,06
1225	0,07	0,07	0,05	0,06	0,14	0,15	0,14	0,14	0,13	0,12	0,10
1275	0,07	0,06	0,06	0,07	0,07	0,06	0,07	0,07	0,07	0,06	0,06
1325	0,05	0,05	0,07	0,05	0,11	0,13	0,12	0,12	0,11	0,11	0,10
1375	0,06	0,05	0,05	0,07	0,07	0,07	0,07	0,08	0,08	0,07	0,07
1425	0,04	0,04	0,06	0,05	0,06	0,10	0,10	0,09	0,10	0,10	0,10
1475	0,04	0,04	0,04	0,05	0,05	0,06	0,07	0,07	0,08	0,08	0,08
1525	0,03	0,03	0,04	0,04	0,05	0,07	0,07	0,06	0,07	0,07	0,07
1575	0,04	0,04	0,04	0,04	0,04	0,06	0,06	0,07	0,08	0,08	0,08
1625	0,03	0,03	0,03	0,04	0,04	0,05	0,05	0,04	0,04	0,05	0,04
1675	0,05	0,04	0,04	0,05	0,04	0,05	0,06	0,06	0,06	0,07	0,07
1725	0,03	0,02	0,02	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,05
1775	0,04	0,04	0,04	0,04	0,03	0,04	0,05	0,06	0,07	0,08	0,08
1825	0,03	0,02	0,02	0,02	0,03	0,03	0,02	0,03	0,04	0,04	0,04
1875	0,03	0,03	0,02	0,03	0,02	0,02	0,03	0,03	0,04	0,05	0,05
1925	0,02	0,02	0,02	0,02	0,02	0,03	0,02	0,02	0,03	0,04	0,05
1975	0,02	0,02	0,02	0,03	0,02	0,02	0,02	0,03	0,03	0,04	0,04
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100
f [kHz]	I_h [%]										
2,1	0,13	0,13	0,13	0,11	0,15	0,13	0,10	0,10	0,11	0,11	0,13
2,3	0,09	0,09	0,10	0,08	0,12	0,12	0,09	0,09	0,09	0,09	0,10
2,5	0,06	0,07	0,07	0,06	0,10	0,10	0,09	0,08	0,09	0,09	0,09
2,7	0,05	0,04	0,05	0,04	0,06	0,08	0,08	0,06	0,06	0,07	0,07
2,9	0,03	0,03	0,03	0,03	0,04	0,06	0,06	0,05	0,05	0,05	0,05
3,1	0,03	0,03	0,03	0,03	0,03	0,05	0,05	0,05	0,04	0,04	0,05
3,3	0,03	0,03	0,03	0,02	0,03	0,04	0,05	0,06	0,05	0,05	0,05
3,5	0,03	0,03	0,03	0,04	0,02	0,03	0,04	0,04	0,04	0,03	0,04
3,7	0,04	0,03	0,03	0,03	0,02	0,03	0,04	0,05	0,04	0,04	0,04

3,9	0,03	0,03	0,03	0,03	0,02	0,02	0,03	0,03	0,03	0,03	0,03
4,1	0,03	0,03	0,03	0,03	0,03	0,02	0,03	0,03	0,04	0,03	0,03
4,3	0,03	0,03	0,03	0,03	0,03	0,02	0,02	0,03	0,03	0,03	0,03
4,5	0,02	0,02	0,02	0,02	0,03	0,02	0,02	0,02	0,03	0,02	0,03
4,7	0,03	0,03	0,02	0,02	0,03	0,02	0,02	0,02	0,03	0,03	0,03
4,9	0,02	0,02	0,02	0,02	0,03	0,02	0,02	0,02	0,03	0,03	0,03
5,1	0,02	0,02	0,02	0,02	0,03	0,02	0,02	0,02	0,02	0,02	0,03
5,3	0,02	0,02	0,02	0,03	0,03	0,03	0,02	0,02	0,02	0,03	0,03
5,5	0,02	0,02	0,02	0,03	0,03	0,03	0,02	0,02	0,02	0,02	0,03
5,7	0,02	0,02	0,02	0,02	0,03	0,02	0,02	0,02	0,02	0,02	0,03
5,9	0,03	0,03	0,03	0,03	0,03	0,03	0,02	0,02	0,02	0,02	0,03
6,1	0,02	0,03	0,03	0,03	0,02	0,02	0,02	0,02	0,02	0,02	0,03
6,3	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03
6,5	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03
6,7	0,02	0,02	0,02	0,02	0,01	0,02	0,01	0,02	0,01	0,01	0,03
6,9	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,03
7,1	0,02	0,02	0,01	0,01	0,01	0,02	0,01	0,01	0,02	0,02	0,03
7,3	0,06	0,06	0,06	0,06	0,07	0,07	0,07	0,08	0,08	0,08	0,09
7,5	0,04	0,05	0,05	0,05	0,05	0,05	0,06	0,07	0,08	0,09	0,10
7,7	0,04	0,04	0,04	0,05	0,05	0,05	0,06	0,06	0,07	0,08	0,09
7,9	0,05	0,06	0,05	0,05	0,05	0,06	0,06	0,06	0,07	0,07	0,07
8,1	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,06
8,3	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,07
8,5	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,06
8,7	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,04	0,07
8,9	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,07	0,09

PV-curve simulated according to	
Voltage of defined MPP [V]	700
Current of defined MPP [A]	15,7
FFU of PV curve [1]	0,68
Impedance [Ω] Line Neutral	 R_A = 0,15 jX_A= 0,15 R_N = 0,01 jX_N= 0,01

Note:

The normalization current is 14,5 A.

The harmonics, interharmonics and higher frequencies are maximum values of all three phases.

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.

The test results base on the test report " PVDE190903N004"issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-01-16.

OVE directive R25		
Clause	**Requirement – Test**	**Verdict**
5.2	**Evidence of symmetry behaviour of inverters**	
5.2.1	General	**P**
5.2.2	Calculation of the asymmetry of three-phase inverters	**P**
5.2.2 a)	Failure of single inverter modules	**N/A**
5.2.2 b)	Power drop of single inverter modules	**N/A**

5.2.1	General	P
These tests serve to prove the requirements according to TOR Erzeuger, 6.1.1. These tests are not applicable for direct connected rotating machines! This test is necessary only for electronic inverters!		
Note: The tests of the “symmetry characteristics of three-phase inverter modules” were performed on the unit with the highest output power. Here is the maximum asymmetry given.		

5.2.2	Calculation of asymmetry					P
Setting values	cos φ = 1	1,00				
	cos φ over-excited	0,90				
	cos φ under-excited	0,90				
Test:						
FSP POWER MANAGER 10KW						
1-min mean value	L1	L2	L3	L1 – L2	L2 – L3	L3 – L1
a) cos φ = 1 at 100 % P_{rE} ± 5 % P_{Emax}						
S_{E60} [kVA]	3,333	3,030	3,030	0,030	0,000	-0,030
	3,334	3,304	3,304	0,029	0,001	-0,030
	3,333	3,303	3,303	0,030	0,000	-0,030
	3,333	3,304	3,303	0,029	0,001	-0,030
	3,332	3,303	3,303	0,029	0,000	-0,030
cos φ_{E60}	0,999					
max. asymmetry [kVA]	0,030					
b) maximum under-excited (i) at 100 % P_{rE} ± 5 % P_{Emax}						
S_{E60} [kVA]	3,365	3,320	3,313	0,045	0,007	-0,052
	3,365	3,320	3,313	0,045	0,008	-0,052
	3,367	3,322	3,315	0,045	0,008	-0,052
	3,364	3,319	3,312	0,045	0,008	-0,052
	3,369	3,325	3,317	0,044	0,007	-0,051
cos φ_{E60}	-0,893					
max. asymmetry [kVA]	-0,052					
c) maximum over-excited (c) at 100 % P_{rE} ± 5 % P_{Emax}						
S_{E60} [kVA]	3,308	3,296	3,307	0,012	-0,011	-0,001
	3,304	3,292	3,303	0,012	-0,011	-0,001
	3,304	3,292	3,303	0,012	-0,011	-0,001
	3,306	3,294	3,305	0,012	-0,011	-0,001
	3,304	3,292	3,303	0,012	-0,011	-0,001
cos φ_{E60}	0,900					
max. asymmetry [kVA]	0,012					
d) cos φ = 1 at 50 % P_{rE} ± 5 % P_{Emax}						
S_{E60} [kVA]	1,695	1,686	1,685	0,010	0,001	-0,011
	1,695	1,685	1,684	0,010	0,001	-0,011
	1,696	1,686	1,685	0,010	0,001	-0,011
	1,695	1,685	1,685	0,010	0,001	-0,011
	1,695	1,686	1,685	0,010	0,001	-0,011

5.2.2	Calculation of asymmetry					P
Setting values	cos φ = 1			1,00		
	cos φ over-excited			0,90		
	cos φ under-excited			0,90		
Test:						
FSP POWER MANAGER 10KW						
1-min mean value	L1	L2	L3	L1 – L2	L2 – L3	L3 – L1
cos φ_{E60}	0,998					
max. asymmetry [kVA]	-0,011					
e) maximum under-excited (i) at 50 % P_{rE} ± 5 % P_{Emax}						
S_{E60} [kVA]	1,891	1,876	1,860	0,014	0,016	-0,031
	1,891	1,877	1,861	0,014	0,016	-0,030
	1,892	1,878	1,862	0,014	0,016	-0,030
	1,892	1,878	1,861	0,014	0,016	-0,030
	1,892	1,878	1,861	0,014	0,016	-0,031
cos φ_{E60}	-0,898					
max. asymmetry [kVA]	-0,031					
f) maximum over-excited (c) at 50 % P_{rE} ± 5 % P_{Emax}						
S_{E60} [kVA]	1,859	1,857	1,869	0,002	-0,011	0,010
	1,859	1,858	1,870	0,002	-0,012	0,011
	1,858	1,857	1,869	0,002	-0,012	0,011
	1,860	1,858	1,870	0,002	-0,012	0,011
	1,860	1,859	1,871	0,002	-0,012	0,011
cos φ_{E60}:	0,901					
max. asymmetry [kVA]	-0,012					
Limit:	≤5% S_{Emax} and 3,68kVA					

Test:

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

Assessment criterion:

The test is passed if the maximum value from the above measurements does not exceed ≤5% S_{Emax} and 3,68kVA

Note:

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

The test results base on the test report " PVDE190903N004"issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-01-16.

OVE directive R25		
Clause	**Requirement – Test**	**Verdict**
5.3	**Evidence of the behaviour of the generating unit on the network**	
5.3.1	General	**P**
5.3.2	Measurement of the active and reactive power range	**P**
5.3.3	End of active power feed-in after OFF command via remote (ripple control) interface	**P**
5.3.4	Active power feed-in for PGUs at overfrequency	**P**
5.3.5	Active power feed-in for PGUs at underfrequency	**P**
5.3.6	Voltage-controlled active power limitation P(V)	**P**
5.3.6.1	Voltage-controlled active power limitation P(V) - quasi-stationary behavior	**P**
5.3.6.2	Voltage-controlled active power limitation P(V) - dynamic behavior	**P**
5.3.7	Reactive power setpoint control “fix cos φ”	**P**
5.3.8	Test of the displacement factor/active power characteristic curve cos φ (P)	**P**
5.3.9	Reactive power setpoint control “fix Q”	**P**
5.3.10	Voltage-controlled control functions “Q= f(V)”	**P**
5.3.10.1.1	Voltage-controlled control functions “Q= f(V)” - quasi-stationary behavior	**P**
5.3.10.1.2	Voltage-controlled control functions “Q= f(V)” - dynamic behavior	**P**
5.3.11	Protection of set values	**P**

5.3.1	**General** (these tests are designed to provide evidence that the requirements of Tor Erzeuger section 5 are met and to determine the values for S_{Emax} and P_{Emax})	**P**
Test Condition:	The measurements were performed in the testing laboratory at the grid-simulator. Test voltage between 0,86 Un and 1,09 Un with ±2% Un until the test Test frequency: 50Hz ±0,5%	
Note: If an examination is required for any other requirements, these apply to this test.		

5.3.2	**Measurement of the active power and reactive power range** (these tests are designed to provide evidence that the requirements of TOR Erzeuger, section 5.3.3 are met)		**P**
Setting values	cos φ = 1 [1]:	1	
	Q = 43,6% over-excited:	0,9c	
	Q = 43,6% under-excited:	0,9i	

Test:			
FSP POWER MANAGER 10KW			
60 s mean value	0,86 U_n	U_n	1,09 U_n
a) cos φ 1 at 100% P_{Emax}			
U [V]	198,44	230,56	251,24
$P_{Emax60\ a)}$ [kW]	9,768	9,824	9,841
$S_{Emax60\ a)}$ [kVA]	0,377	0,387	0,405
$Q_{Emax60\ a)}$ [kVar]	9,775	9,832	9,850
cos φ_{Emax60}	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}			
U [V]	198,35	230,53	251,21
$P_{Emax60\ b)}$ [kW]	8,884	8,941	8,956
$S_{Emax60\ b)}$ [kVA]	-4,373	-4,451	-4,506
$Q_{Emax60\ b)}$ [kVar]	9,901	9,988	10,026
cos $\varphi_{Emax60\text{-}under\text{-}excited}$	0,897	0,895	0,893
c) maximum over-excited (c) at 100% P_{Emax}			
U [V]	198,46	230,64	251,25
$P_{Emax60\ c)}$ [kW]	8,790	8,819	8,839
$S_{Emax60\ c)}$ [kVA]	4,457	4,453	4,409
$Q_{Emax60\ c)}$ [kVar]	9,856	9,879	9,878
cos $\varphi_{Emax60\text{-}over\text{-}excited}$	0,892	0,893	0,895
d) maximum under-excited (i) at 20-30% P_{Emax}			
U [V]	--	230,25	--
$P_{Emax60\ d)}$ [kW]	--	2,913	--
$S_{Emax60\ d)}$ [kVA]	--	-4,531	--
$Q_{Emax60\ d)}$ [kVar]	--	5,387	--
cos $\varphi_{Emax60\text{-}under\text{-}excited}$	--	0,543	--
e) maximum over-excited (c) at 20-30% P_{Emax}			
U [V]	--	230,37	--
$P_{Emax60\ e)}$ [kW]	--	2,986	--
$S_{Emax60\ e)}$ [kVA]	--	4,319	--
$Q_{Emax60\ e)}$ [kVar]	--	5,251	--

5.3.2	**Measurement of the active power and reactive power range** (these tests are designed to provide evidence that the requirements of TOR Erzeuger, section 5.3.3 are met)		**P**
Setting values	cos φ = 1 [1]:	1	
	Q = 43,6% over-excited:	0,9c	
	Q = 43,6% under-excited:	0,9i	

Test:			
FSP POWER MANAGER 10KW			
$\cos \varphi_{Emax60\text{-over-excited}}$	--	0,569	--
f) maximum under-excited (i) at 10-20% P_{Emax}			
U [V]	--	230,50	--
$P_{Emax60\ f)}$ [kW]	--	1,696	--
$S_{Emax60\ f)}$ [kVA]	--	-3,889	--
$Q_{Emax60\ f)}$ [kVar]	--	4,243	--
$\cos \varphi_{Emax60\text{-under-excited}}$	--	0,400	--
g) maximum over-excited (c) at 10-20% P_{Emax}			
U [V]	198,01	230,24	250,93
$P_{Emax60\ g)}$ [kW]	1,907	1,927	1,933
$S_{Emax60\ g)}$ [kVA]	4,377	4,331	4,300
$Q_{Emax60\ g)}$ [Var]	4,774	4,741	4,715
$\cos \varphi_{Emax60\text{-over-excited}}$	0,400	0,407	0,411
h) maximum under-excited (i) at 0-10% P_{Emax}			
U [V]	197,95	230,16	250,87
$P_{Emax60\ h)}$ [W]	0,911	0,927	0,927
$S_{Emax60\ h)}$ [VA]	-4,466	-4,517	-4,550
$Q_{Emax60\ h)}$ [Var]	4,558	4,611	4,644
$\cos \varphi_{Emax60\text{-under-excited}}$	0,201	0,202	0,201
i) maximum over-excited (c) at 0-10% P_{Emax}			
U [V]	--	230,46	--
$P_{Emax60\ i)}$ [W]	--	0,768	--
$S_{Emax60\ i)}$ [VA]	--	3,913	--
$Q_{Emax60\ i)}$ [Var]	--	3,988	--
$\cos \varphi_{Emax60\text{-over-excited}}$	--	0,193	--

S_{Emax60} and $P_{Emax\ 60}$	
S_{Emax60}= max($S_{Emax60\ a)}$, $S_{Emax60\ b)}$, $S_{Emax60\ c)}$) [VA]	10,026
$P_{Emax\ 60}$= max($P_{Emax60\ a)}$, $P_{Emax60\ b)}$, $P_{Emax60\ c)}$) [W]	9,841

Test:
* For test d - l, the test voltage at which the highest active power was achieved is taken!

5.3.2	**Measurement of the active power and reactive power range** (these tests are designed to provide evidence that the requirements of TOR Erzeuger, section 5.3.3 are met)	**P**

Setting values	cos φ = 1 [1]:	1
	Q = 43,6% over-excited:	0,9c
	Q = 43,6% under-excited:	0,9i

Test:

FSP POWER MANAGER 10KW

The PGU is operated in all possible of the following operating points, whereby each operating point must be kept for at least 1 minutes after the settling process has subsided. During the partial measurements a) to c) below, the primary energy source must not limit the output.

Measurement points a-c has to be performed at U_n, 0,86U_n and 1,09 U_n

a) With 0,86 Un, Un and 1,09 Un, the maximum possible active power must be set under the specification of a cos *(φ)* 1.

b) With 0,86 Un, Un and 1,09 Un, the maximum possible active power with maximum under-excited operation must be set (Q = 43,6%/S_n.)

c) At 0,86 Un, Un and 1,09 Un, the maximum possible active power with maximum overexcited operation must be set(Q = 43,6%/S_n.)

d) With 0,86 Un*, Un* and 1,09 Un*, the 20-30% active power which was determined values from a) with maximum under-excited operation must be set (Q =43,6%/S_n.)

e) At 0,86 Un*, Un* and 1,09 Un*, the 20-30% possible active power which was determined values from a) with maximum overexcited operation must be set(Q =43,6%/S_n.)

f) With 0,86 Un*, Un* and 1,09 Un*, the 10-20% active power which was determined values from a) with maximum under-excited operation must be set (Q =43,6%/S_n.)

g) At 0,86 Un*, Un* and 1,09 Un*, the 10-20% possible active power which was determined values from a) with maximum overexcited operation must be set(Q =43,6%/S_n.)

h) With 0,86 Un*, Un* and 1,09 Un*, the 0-10% active power which was determined values from a) with maximum under-excited operation must be set (Q =43,6%/S_n.)

i) At 0,86 Un*, Un* and 1,09 Un*, the 0-10% possible active power which was determined values from a) with maximum overexcited operation must be set(Q =43,6%/S_n.)

Assessment criterion:

S_{Emax60} and $P_{Emax\ 60}$ are determined by the highest value measured.

$S_{Emax60} = \max(S_{Emax60a)}, S_{Emax60b)}, S_{Emax60c)})$

$P_{Emax60} = \max(P_{Emax60a)}, P_{Emax60b)}, P_{Emax60c)})$

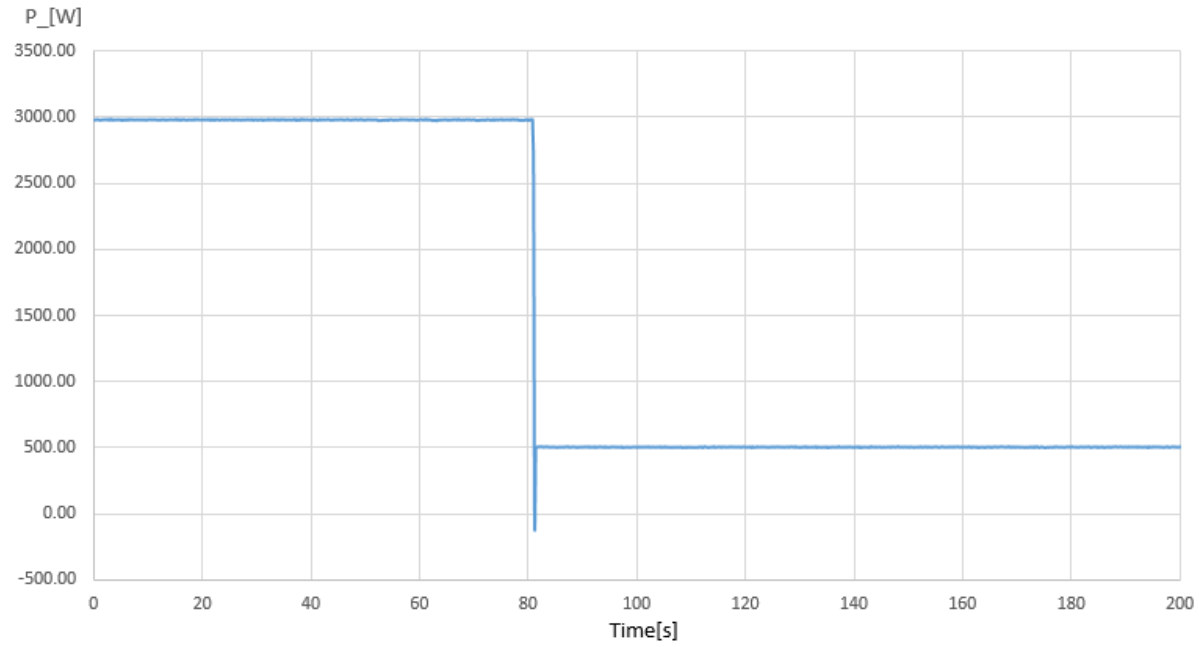
Note:

Q = 31,2 (φ 0,95)	(i) and (c):	PGU ≤ 3,68 kVA
Cos phi = (φ) 0,90	(i) and (c):	PGU ≤ 3,68 kVA (only Inverter)
Q = 43,6 (φ 0,90)	(i) and (c):	PGU > 3,68 kVA (only Inverter)

5.3.3.1	**End of active power feed-in after OFF command via remote (ripple control) interface** These tests serve to demonstrate the requirements of Tor Erzeuger, Section 5.4.1	**P**

Test:		
FSP POWER MANAGER 10KW		
1-min mean value / P_{rE}/P [%]	30	<5
$P_{Setpoint}$[W]	3,000	0,500
P_{E60} [W]	2,943	0,499
T_0[s]	1,6 s	
Limit		
T_0 [s]	5	P

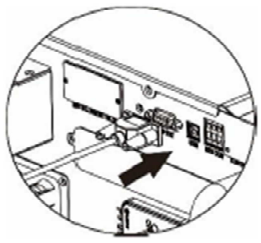
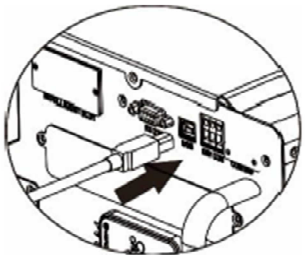
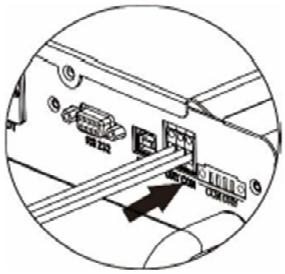
Graph of active power



Picture of used interface + Manual description.

9. Communication

The inverter is equipped with several communication ports and it is also equipped with a slot for alternative communication interfaces in order to communicate with a PC with corresponding software. This intelligent slot is suitable to install with SNMP card and Modbus card. Follow below procedure to connect communication wiring and install the software.

For RS232 port, you should use a DB9 cable as follows:	For USB port, you should use a USB cable as follows:
	
For Dry contact port, please remove insulation sleeve 8 mm for three conductors and insert three cables into ports	For SNMP or MODBUS card, you should use RJ45 cables as follows:
	

Please install monitoring software in your computer. Detailed information is listed in the next chapter. After software is installed, you may initial the monitoring software and extract data through communication port.

Test:

Interface used: RS-232 communication port.

The setpoint signal is reduced from 30% to <5% P_{rE}.

For this test, the PGU is operated with an effective power of at least 20% P_{rE}.

The command to terminate the active power feed is then given via the provided interface (input port) and the time until the actual termination of the active power feed is measured.

Assessment criterion:

The test is passed if the PGU ends the active power feed within 5s. The criterion is an active power feed-in <5% P_{rE}.

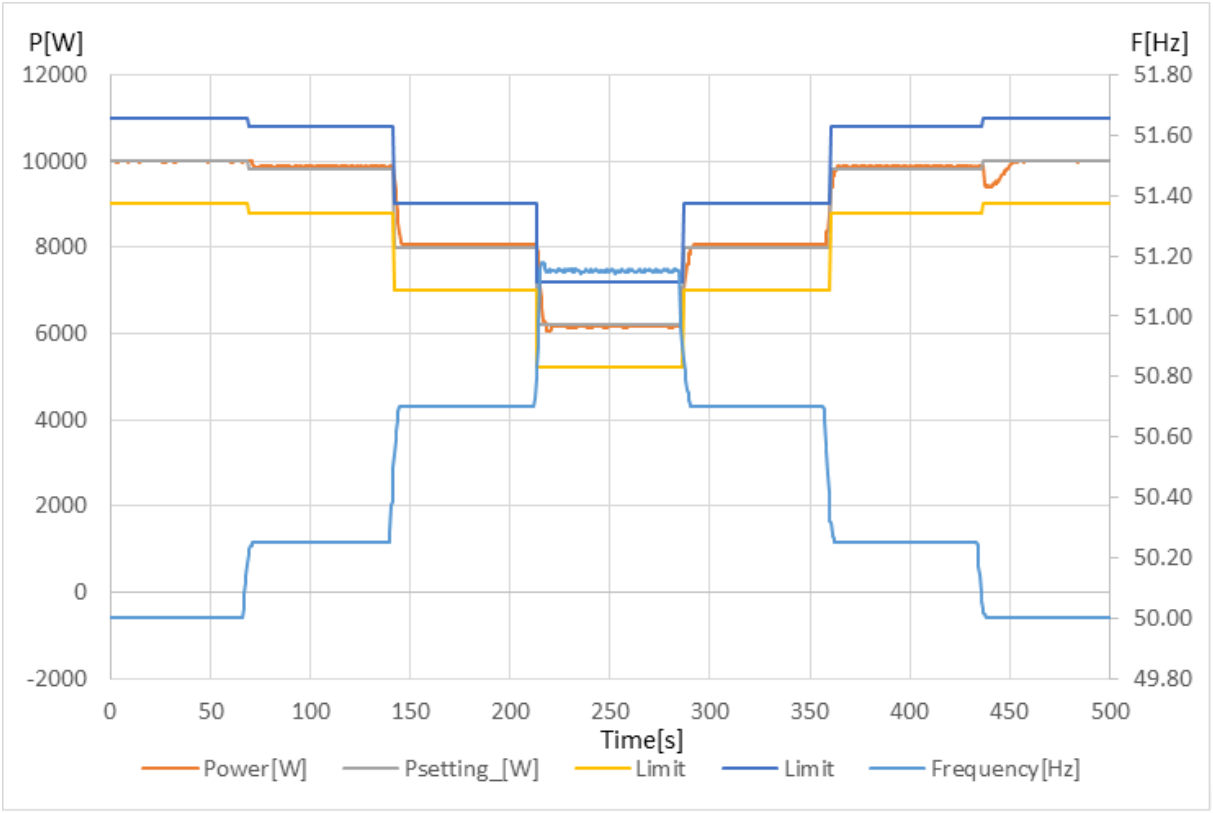
A separation of the PGU from the network is permitted, but not mandatory

Note:

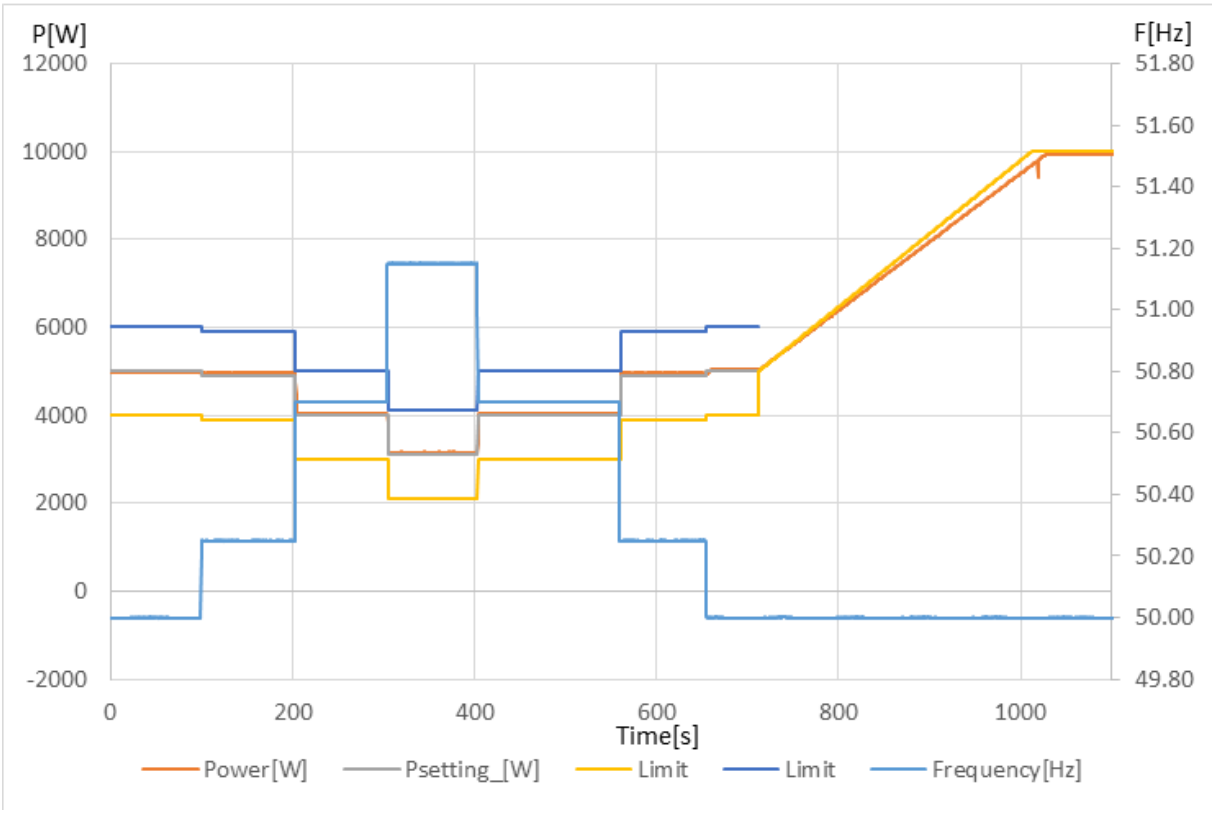
5.3.4	**Active power feed-in for PGUs at overfrequency** (these tests are designed to provide evidence of the requirements of TOR Erzeuger, 5.1.3 and 5.5.2)						**P**
Test cycle for adjustable PGUs:							
FSP POWER MANAGER 10KW							
Test 1:							
1-min mean value	50,00	50,25	50,70	51,15	50,70	50,25	50,00
Expected active power output [% P_{Emax}]:	100	98	80	62	80	98	100
Measurement: 100% P_{Emax}; start frequency 50,20Hz; droop s setting = 5% (40% P_{ref}/Hz)							
Frequency [Hz]	50,00	50,25	50,70	51,15	50,70	50,25	50,00
$P_{setpoint}$ [kW]	10,000	9,800	8,000	6,200	8,000	9,800	10,000
P_{E60} [kW]	9,993	9,863	8,064	6,156	8,060	9,863	9,934
ΔP_{E60} [%]	0,19	1,73	1,74	1,21	1,62	1,70	1,80
Available DC-power [%]	100						
Test 2:							
Measurement: Active power output 40% and 60% after freezing > 80% P_{Emax} droop s setting = 5% (40% P_{ref}/Hz)							
Frequency [Hz]	50,00	50,25	50,70	51,15	50,70	50,25	50,00
$P_{setpoint}$ [kW]	5,000	4,900	4,000	3,100	4,000	4,900	10,000
P_{E60} [kW]	4,968	4,962	4,050	3,147	4,049	4,960	9,944
ΔP_{E60} [%]	0,64	1,25	1,00	0,94	0,99	1,19	1,13
Available DC-power [%]	40 – 60		100				
Limit							
ΔP_{E60} in %	≤ +5% of P_{Emax}						P
DC setting values:							

PV-curve simulated according to	
Voltage of defined MPP [V]	700
Current of defined MPP [A]	15,7
FFU of PV curve [1]	0,68
P_{DC} [kW]	11,0

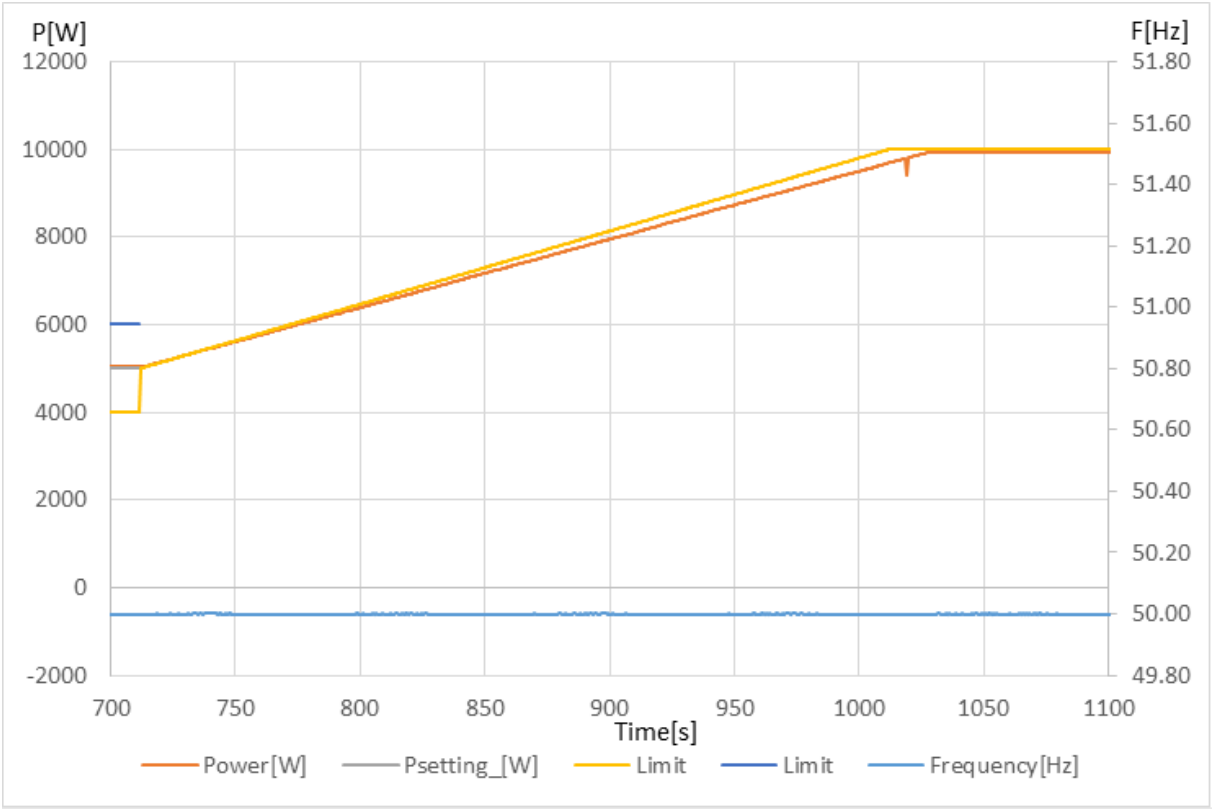
Graph Test 1@ 100% P_{Emax}



Graph Test2 @ 40-60% P_{Emax}



Gradient Test 2



Assessment criterion:

For f = 50,2 Hz, the value of the P_{ref} active power currently being generated is "frozen".

a) For adjustable PGUs when:

P_{ref} 1) the active power reduces between measuring points b) and f) given above with a gradient of 40% per Hz for a decreasing frequency (or rises for a frequency decreasing again).

2) the maximum active power gradient occurring in point g) is lower than 10% of maximum active power P_{Emax} every minute, and

3) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from P_{Emax} by more than ±10%.

b) For conditionally adjustable PGUs

1) when they behave as in a) within their adjustment range, and

2) when, outside the adjustable range, the power fed in on leaving the adjustment range remains constant until shutdown. Shutdown must be no later than at 51,5Hz.

c) for non-regulated EZE, if

- a switch-off between 50,2Hz and 51,5Hz takes place within 1s;
- The connection time in point j) corresponds to the manufacturer's information on the random generator

Note:

The even distribution of the switch-off frequency in a maximum of 0,1 Hz steps between the end of the controllable range (at least 50,2Hz) and 51,5Hz must be proven by a manufacturer's declaration.

Note:

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

Test:

FSP POWER MANAGER 10KW

1-min mean value	g) 50,00Hz ± 0,01Hz	h) 51,65Hz ± 0,05Hz	i) 50,15Hz ± 0,01Hz	j) 50,00Hz ± 0,01Hz
1) g) 50,00Hz ± 0,01Hz to h) 51,65Hz ± 0,05Hz				

Disconnection time [ms]:	166	Limit [ms]:	200

Test:

Following tests a) to g), frequency h) 51,65Hz ± 0,05Hz must be set for at least 0,2s. Afterwards, frequency i) 50,15Hz ±0,01Hz is enabled and kept for at least 7 minutes.

Afterwards, frequency j) 50,00Hz ± 0,01Hz is enabled and kept until transient oscillation of the active power at the earliest.

Assessment criterion:

The PGU must have disconnected from the network no later than 0,2s after frequency h) is reached.

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

a) For adjustable PGUs when:

ab) the maximum active power gradient occurring in point j) is lower than 10% of maximum active power P_{Emax} every minute, and

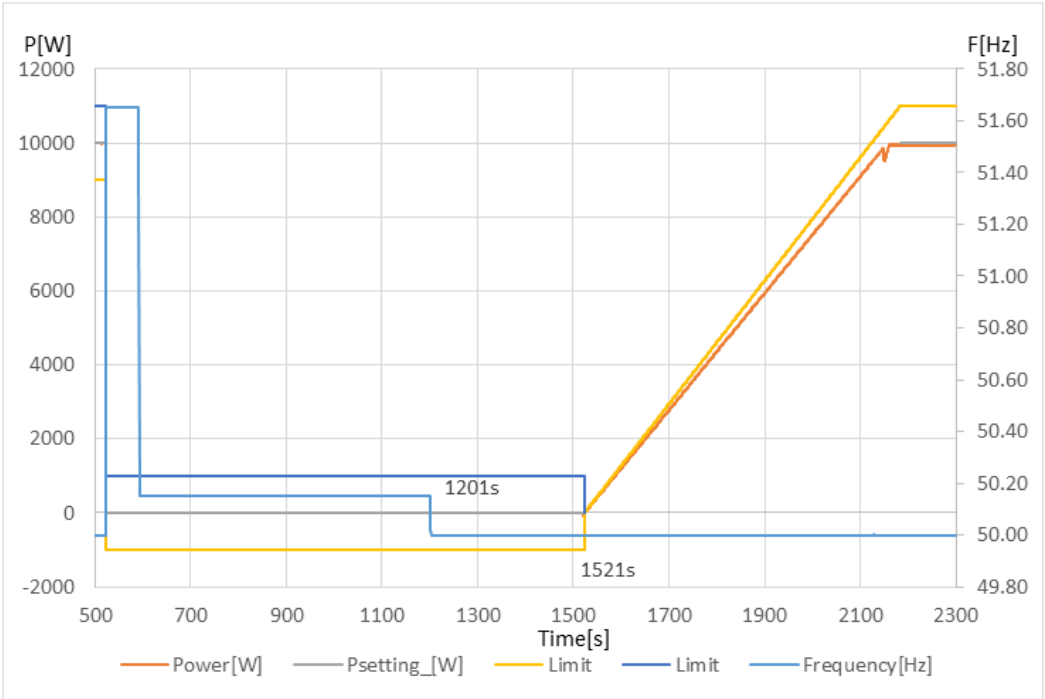
ac) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from P_{Emax} by more than ±10%.

b) For conditionally adjustable PGUs

ba) when they behave as in a) within their adjustment range, and

bb) when, outside the adjustable range, the power fed in on leaving the adjustment range remains constant until shutdown. Shutdown must be no later than at 51,5Hz.

Graph:



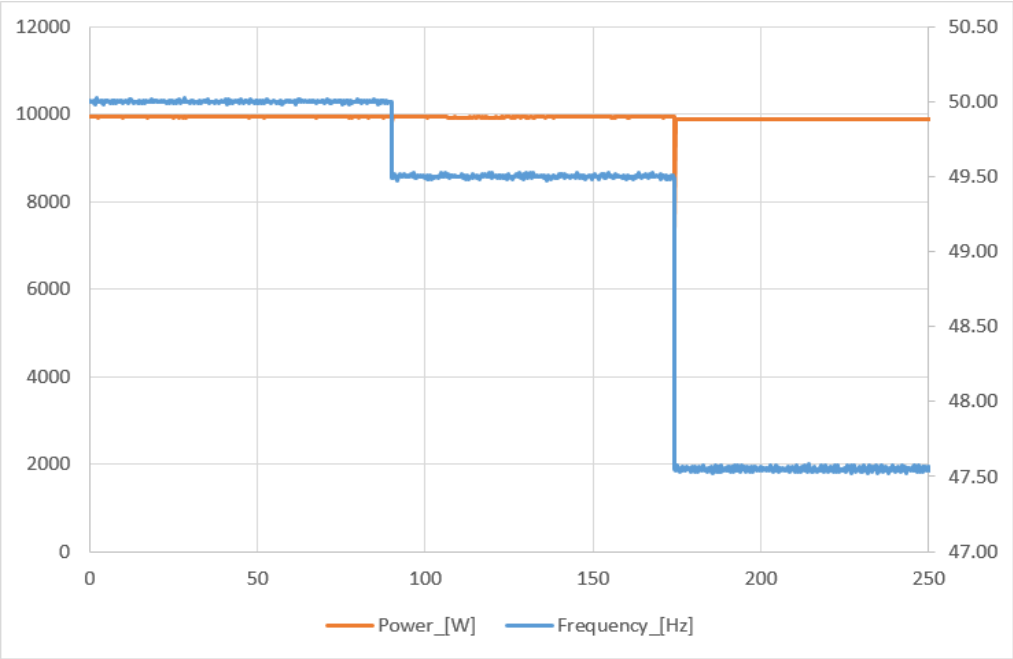
Note:

5.3.5	**Active power feed-in for underfrequency** (these tests are designed to provide evidence of the requirements of TOR Erzeuger, 5.1.5)	**P**

Test:

FSP POWER MANAGER 10KW

Graph of frequency a) to c):



For non-synchronous EZE:

1-min mean value	a) 50 ± 0,01 [Hz]	b) -0,50[Hz]	c)- 2,4 to - 2,5 [Hz]
Frequency [Hz]:	50,00	49,50	47,55
P_{E60} [kW]:	9,933	9,930	9,883
$\Delta P_b/P_{c)}$ [%]:	<0,15%		

Test:

Operating point b) and c) must be kept for at least 1 minute.

The test must be carried out at 100% P_{Emax}.

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

Assessment criterion:

For synchronous PGU:

- The test is passed if the PGU does not reduce the power when the grid frequency changes from operating point a) to b) and the power drops by a maximum of 10% P_{rE} per Hz from operating point b) to c).

For non-synchronous PGU:

- The test is passed if the PGU changes from operating point a) to b) when the network frequency changes does not reduce the power and from operating point b) to c) the power drops by a maximum of 2% P_{rE} per Hz.

Note:

5.3.6	**Voltage-controlled active power limitation P(V)** The test serves as verification of the active power reduction mode at over voltage according to TOR Erzeuger, 5.3.6.	**P**
5.3.6.1.1	**Voltage-controlled active power limitation P(V) - <u>quasi-stationary behavior</u>**	**P**

Test:

FSP POWER MANAGER 10KW

$Vac_{setpoint}$ [%Un]	$Vac_{expected}$ [V]	$Vac_{measured}$ [V]	$P_{,tol\_under}$ [kW]	Power [kW]	$P_{,tol\_upper}$ [kW]
100	230,0	230,66	9,0	9,938	11,0
109	250,7	251,23	9,0	9,947	11,0
110	253,0	253,52	9,0	9,142	11,0
111	255,3	255,66	4,0	4,731	6,0
112	257,6	257,80	-1,0	0,356	1,0
113	259,9	260,07	-1,0	-0,090	1,0
112	257,6	257,80	-1,0	0,136	1,0
111	255,3	255,24	4,0	5,011	6,0
110	253,0	253,16	9,0	9,226	11,0
109	250,7	250,80	9,0	9,883	11,0
100	230,0	230,54	9,0	9,945	11,0

Setting values :

Time constant Tau= 5s

Active delay = 0s (not active)

Activation threshold = 110% Un

Assessment criterion:

The quasi-steady-state behavior test has been passed, if

- the active power values measured according to 5.3.6.2.1 (30s mean values) in stationary operation are within the tolerance band of ±10% P_{rE} and ±1% Un of the specified P(V) characteristic

Note:

The test was performed with no delay. The delay is adjustable in the range from 0s to 3s.

5.3.6	**Voltage-controlled active power limitation P(V)**The test serves as verification of the active power reduction mode at over voltage according to TOR Erzeuger, 5.3.6.	**P**
5.3.6.1.2	**Voltage-controlled active power limitation P(V) - <u>dynamic behavior</u>**	**P**

Test:

FSP POWER MANAGER 10KW

$Vac_{setpoint}$ [%Un]	$Vac_{expected}$ [V]	$Vac_{measured}$ [V]	$P_{,tol\_under}$ [kW]	Power [kW]	$P_{,tol\_upper}$ [kW]
100	230,0	230,38	9,0	10,008	11,0
109	250,7	250,64	9,0	9,991	11,0
113	259,9	259,52	-1,0	-0,093	1,0
109	250,7	250,64	9,0	9,988	11,0
100	230,0	229,98	9,0	10,005	11,0

Set value Tau	5 s

Assessment criterion:

The dynamic behavior test is passed if

- The determined time course of the active power during the measurement according to 5.3.6.2.2 within the entire measurement period is within the tolerance bands that result from the behavior of an equivalent PT1 element (1st order filter). Permissible tolerances for the active power values are ±10% P_{rE} as well as for the time +3 seconds.

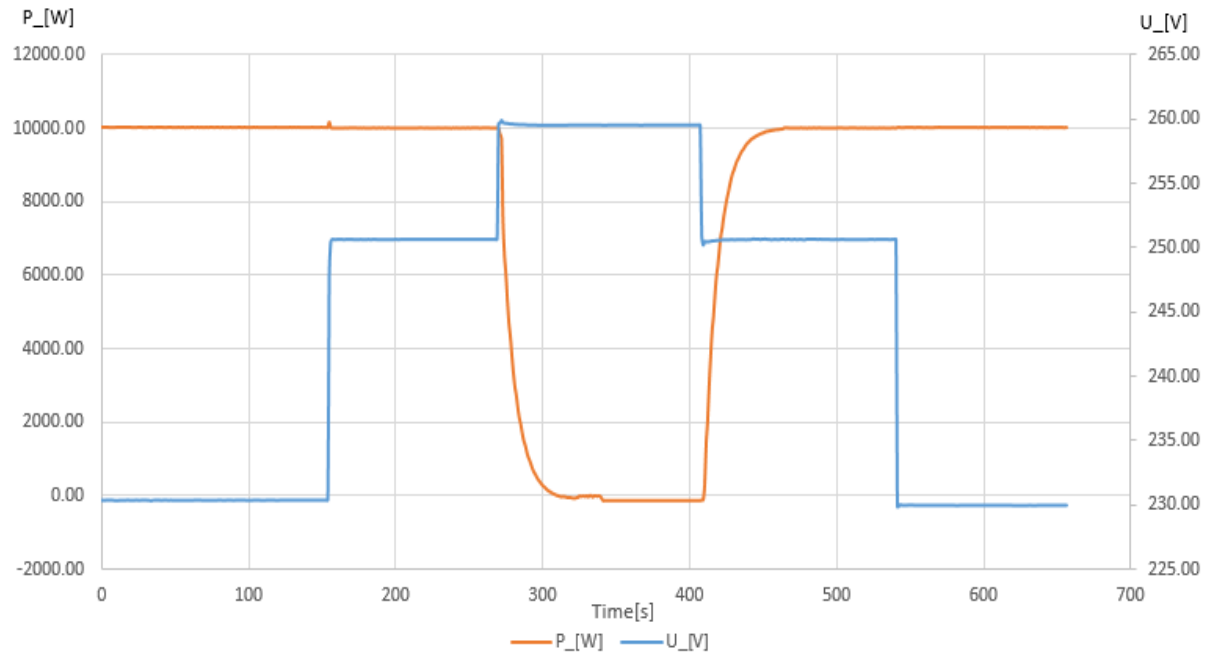
The tolerance bands are calculated according to Table 2.

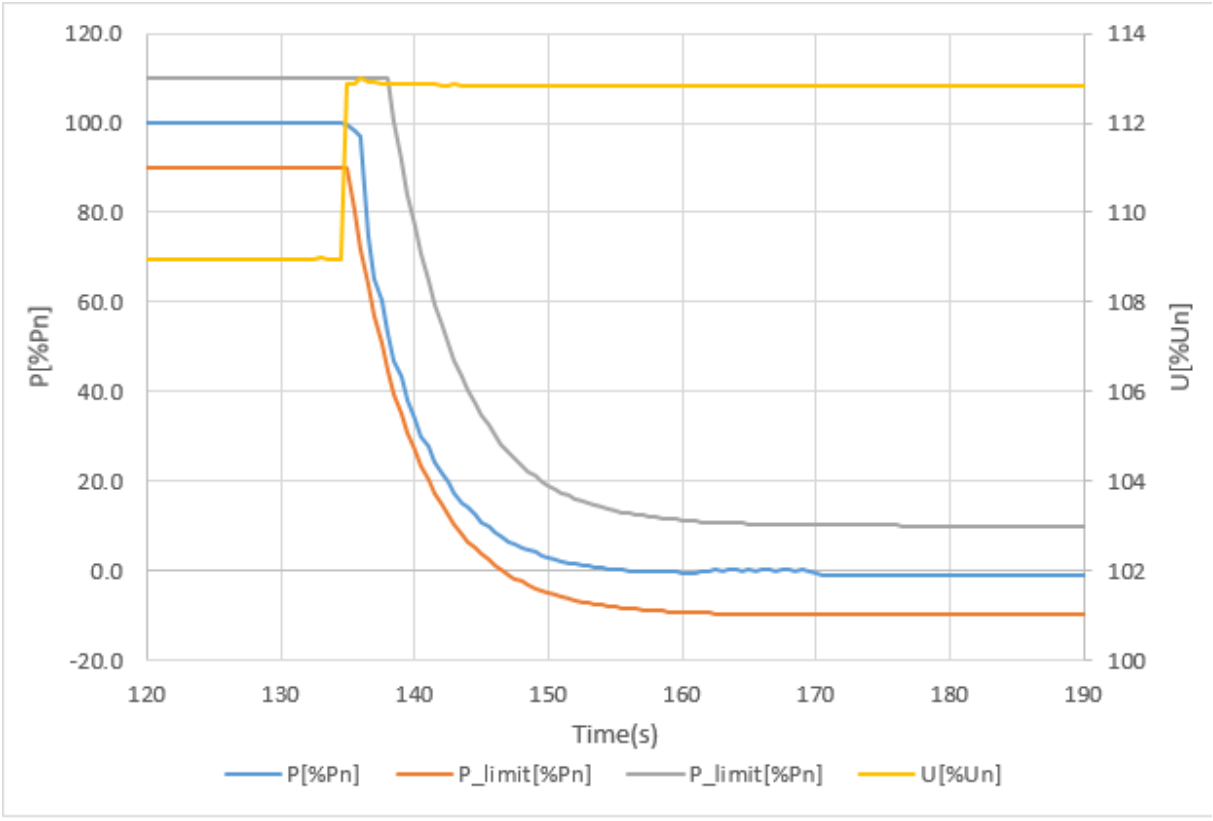
- There are no discontinuities in the characteristic curve, power fluctuations or a shutdown of the PGU;
- A reduction of the active power down to a power of <10% P_{rE} or to that of the manufacturer specified minimum performance is possible

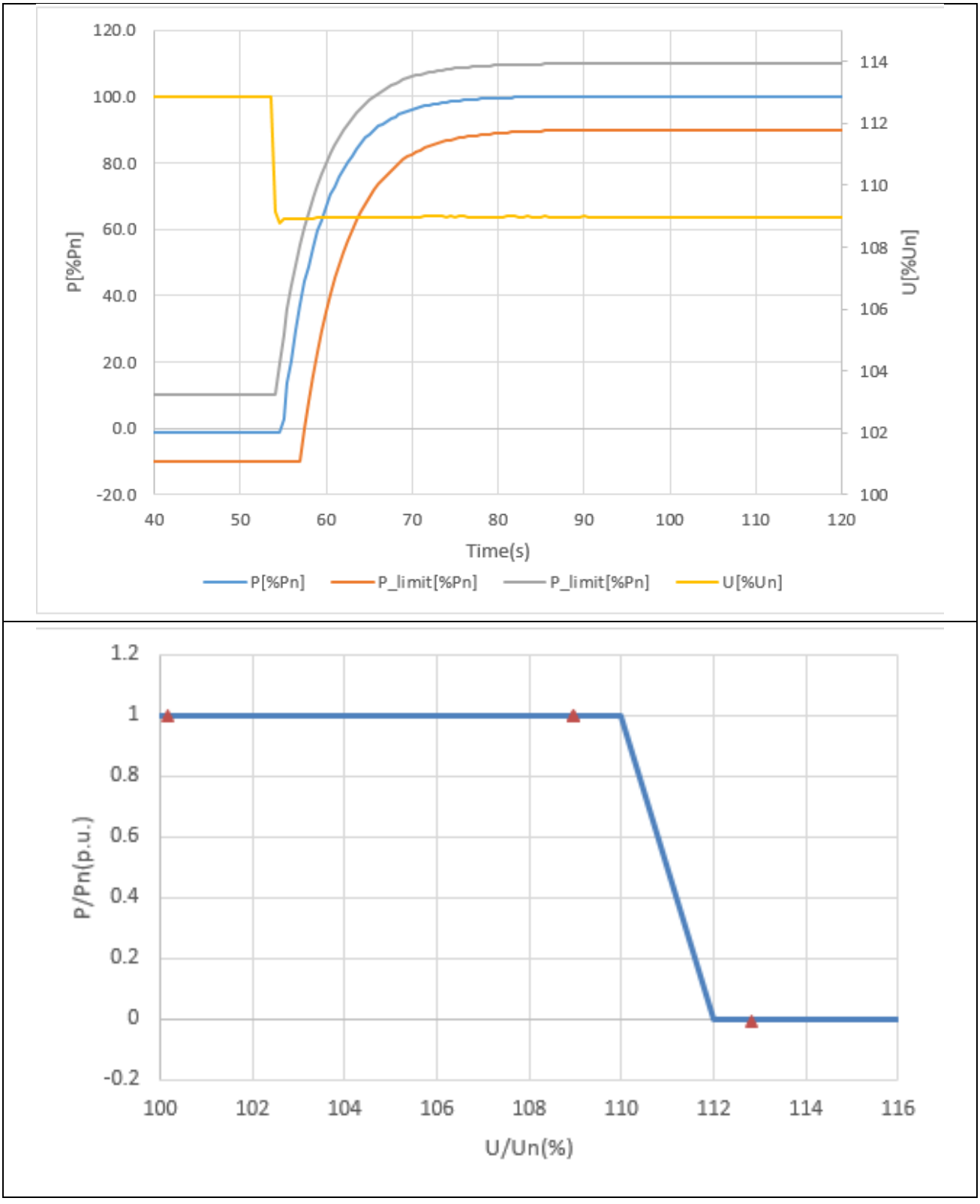
increase in active power $P_2 > P_1$	Upper Tolerance band:	for all *t*: $P_2 - (P_2 - P_1)\, e^{(-t / Tau)} + 0{,}10\ PrE$
	Lower Tolerance band:	for *t* < 3 Second: $P_1 - 0{,}10\ PrE$ für t ≥ 3 Second: P2 – (P2 – P1) e([–t+3 Seconds] / Tau) - 0,10 P_{rE}
drop in active power $P_2 < P_1$	Upper Tolerance band:	for *t* < 3 Second: $P_1 + 0{,}10\ PrE$ for t ≥ 3 Second: P2 – (P2 – P1) e([–t+3 Seconds] / Tau) + 0,10 PrE
	Lower Tolerance band:	for all *t*: $P_2 - (P_2 - P_1)\, e^{(-t / Tau)} - 0{,}10\ PrE$

Note:

Graph of Voltage-controlled active power limitation P(V)






120.0
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
P[%Pn]
114
112
110
108
106
104
102
100
U[%Un]
40
50
60
70
80
90
100
110
120
Time(s)
P[%Pn]
P_limit[%Pn]
P_limit[%Pn]
U[%Un]
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
P/Pn(p.u.)
100
102
104
106
108
110
112
114
116
U/Un(%)

5.3.7	**Reactive power setpoint control "fix cos φ"** The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4.	**P**

5.3.7.1

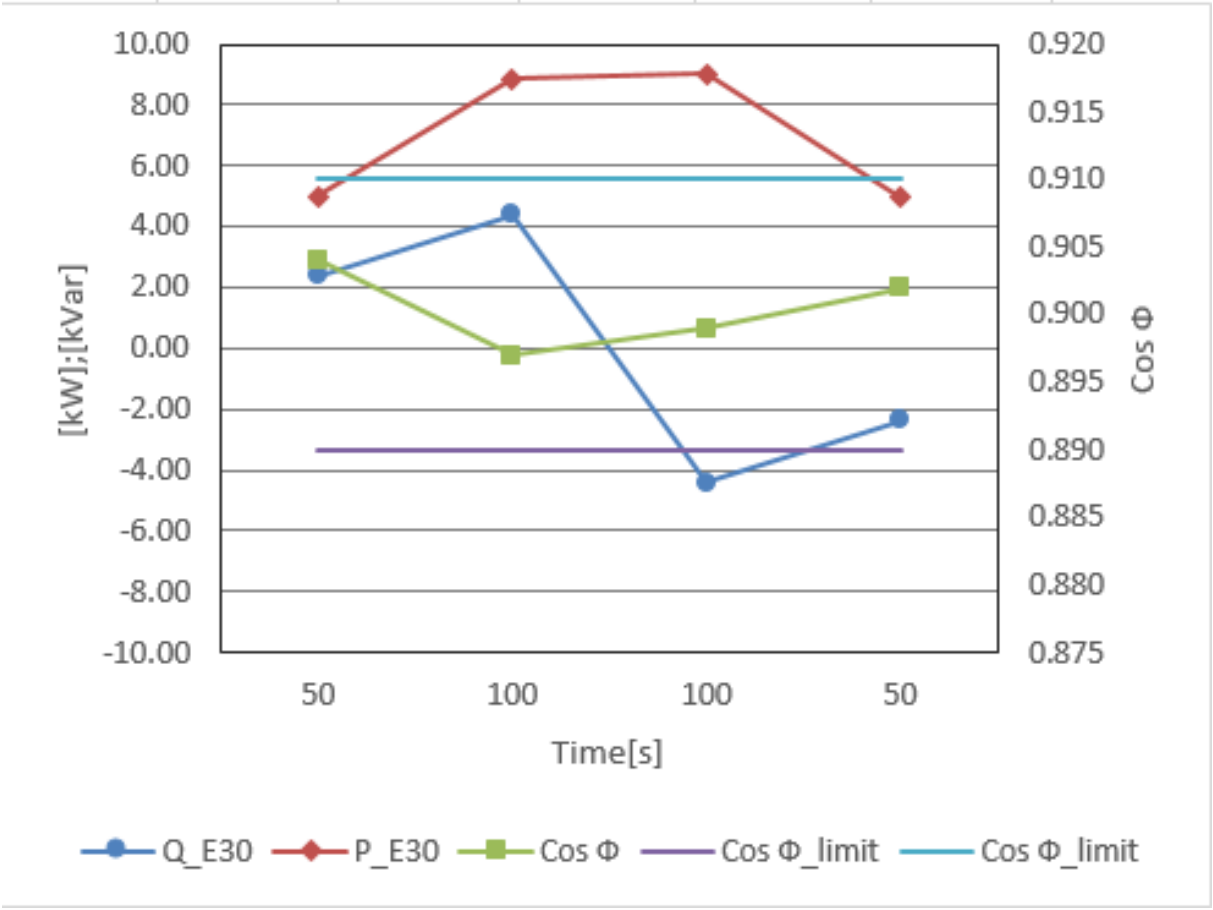
Setting values	cos φ under-excited:	0,90
	cos φ over-excited:	0,90

Test:

FSP POWER MANAGER 10KW

30 s mean value	0,91U_n		U_n		1,09 U_n	
Active power	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}
a) cos φ 0,9 over-excited						
U [V]	209,65	209,41	230,42	230,61	251,04	251,22
P_{E30} [W]	4,979	8,286	4,994	8,876	4,997	8,863
Q_{E30} [VAr]	2,400	3,987	2,366	4,379	2,332	4,322
$\cos \varphi_{E30\text{-over-excited}}$	0,901	0,901	0,904	0,897	0,906	0,899
$\cos \varphi_{setpoint}$	0,90	0,90	0,90	0,90	0,90	0,90
Δcos φ	0,001	0,001	0,004	-0,003	0,006	-0,001
b) cos φ 0,9 under-excited						
U [V]	209,64	209,81	230,33	230,55	251,03	251,20
P_{E30} [W]	4,959	8,302	4,972	9,039	4,974	9,000
Q_{E30} [VAr]	-2,347	-3,962	-2,377	-4,394	-2,411	-4,439
$\cos \varphi_{E30\text{-over-excited}}$	0,904	0,902	0,902	0,899	0,900	0,897
$\cos \varphi_{setpoint}$	0,90	0,90	0,90	0,90	0,90	0,90
Δcos φ	0,004	0,002	0,002	-0,001	0,000	-0,003
Limit						
$\cos \varphi_{E30}$	cos φ= 0,89 to 0,91 (c) and cos φ= 0,89 to 0,91 (i)					

Graph P/Q/U/cos φ



Test:

**applies for Units $\Sigma S_{Emax} \leq 3{,}68$ kVA

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}

*applies for Units $\Sigma S_{Emax} \geq 3{,}68$ kVA

For cos φ 0,90 over-excited and cos φ 0,90 under-excited, the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax}

Assessment criterion:

The test is passed if all cos φ values (30s mean) do not deviate from the specification by more than ±0,01.

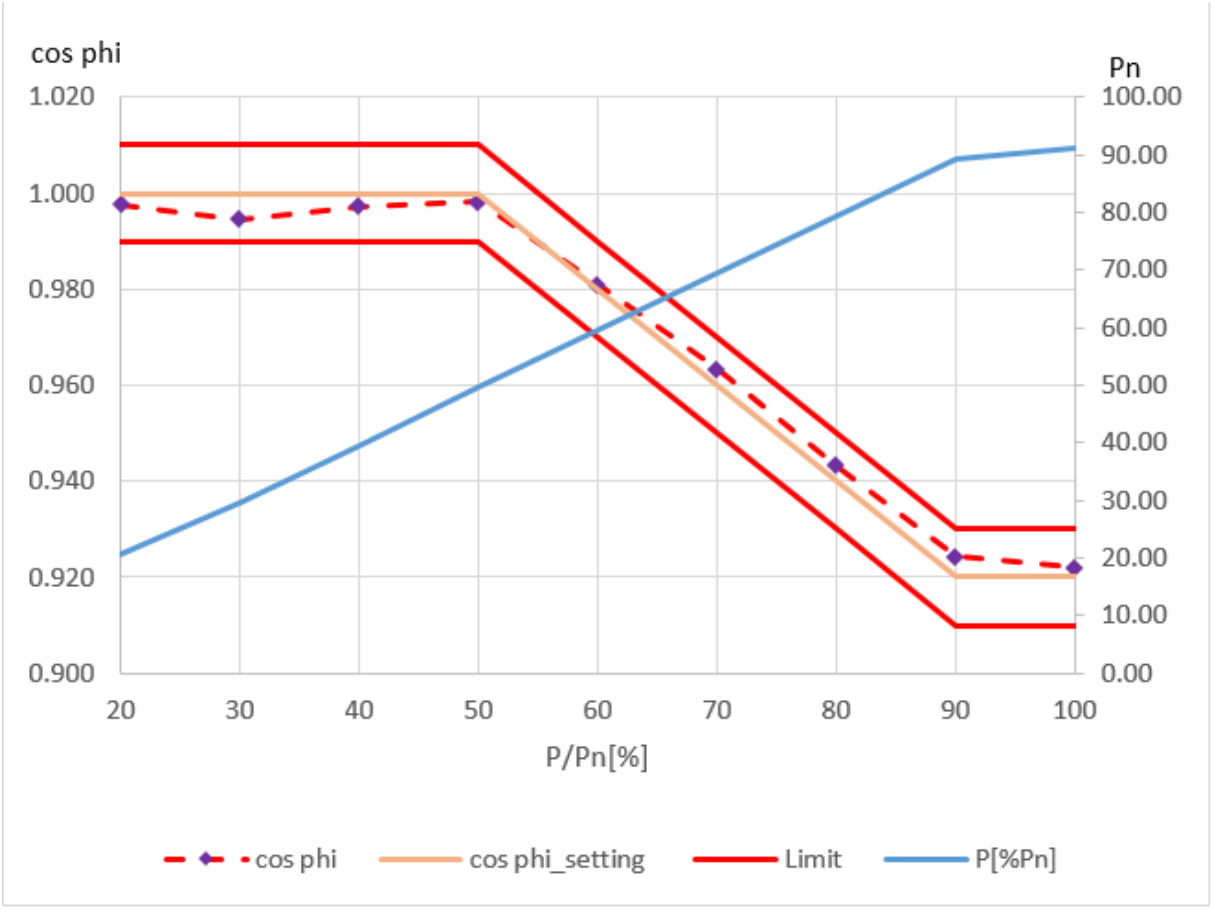
For PGU with generators directly connected to the grid, which cannot regulate reactive power due to the principle, such as asynchronous generators, and therefore use non-controllable fixed capacities, the tolerance band increases from 0,01 to 0,02. This device type is only evaluated at U_n.

Note:

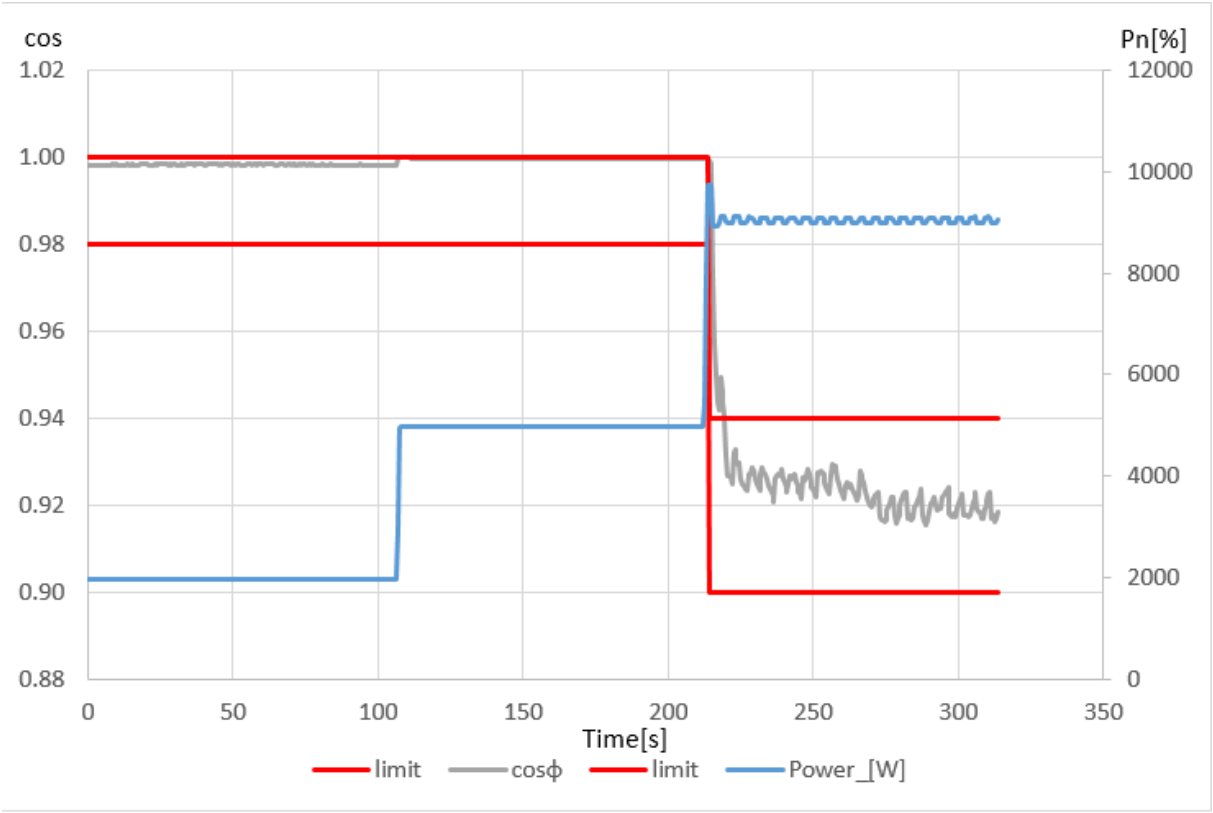
5.3.8	**Test of the displacement factor/active power characteristic curve cos φ (P)** The test serves as verification of the standard cos φ (P) curve according to TOR Erzeuger, 5.3.4.1.	**P**

Test:									
FSP POWER MANAGER 10KW									
Test a):									
P_{Emax}/P [%]	20	30	40	50	60	70	80	90	100
30 s mean value	20% to 100% P_{Emax}								
U [V]	230,11	230,28	230,31	230,35	230,35	230,38	230,40	230,44	230,44
P_{E30} [kW]	2,051	2,956	3,958	4,960	5,957	6,943	7,938	8,935	9,132
P_{E30} of P_{Emax} [%]	20,51	29,56	39,58	49,60	59,57	69,43	79,38	89,35	91,32
Q_{E30} [kVAr]	-0,142	0,307	0,291	0,298	-1,098	-1,921	-2,786	-3,686	-3,831
cos φ_{E30}	0,998	0,995	0,997	0,998	0,981	0,963	0,943	0,924	0,922
cos $\varphi_{setpoint}$ of P_{E30}	1,00	1,00	1,00	1,00	0,98	0,96	0,94	0,92	0,92
Limit									
cos φ $_{E30}$	cos $\varphi_{setpoint}$ ±0,01								
Test a):									
P_{Emax}/P [%]	100	90	80	70	60	50	40	30	20
30 s mean value	100% to 20% P_{Emax}								
U [V]	230,00	230,00	230,00	230,00	230,00	230,00	230,00	230,00	230,10
P_{E30} [kW]	9,132	8,934	7,938	6,941	5,978	4,980	3,971	2,968	2,050
P_{E30} of P_{Emax} [%]	91,32	89,34	79,38	69,41	59,78	49,80	39,71	29,68	20,50
Q_{E30} [kVAr]:	-3,831	-3,749	-2,833	-1,998	-1,233	0,316	0,300	0,311	-0,144
cos φ_{E30}	0,922	0,922	0,942	0,961	0,979	0,998	0,997	0,995	0,998
cos $\varphi_{setpoint}$ of P_{E30}	0,92	0,92	0,94	0,96	0,98	1,00	1,00	1,00	1,00
Limit									
cos φ $_{E30}$	cos $\varphi_{setpoint}$ ±0,01								
Test b):									
P_{Emax}/P_{rE} [%]	20			50			90		
30 s mean value	20% to 50% to 100% P_{Emax}								
U [V]	230,29			230,44			230,58		
P_{E30} [kW]	1,976			4,967			9,048		
P_{E30} of P_{Emax} [%]	19,76			49,67			90,48		
Q_{E30} [kVAr]	-0,114			0,122			-3,798		
cos φ_{E30}	0,998			0,999			0,922		
cos $\varphi_{setpoint}$ of P_{E30}	1,00			1,00			0,92		
T_0 [s]	8,5								
30 s mean value	100% to 50% to 20% P_{Emax}								

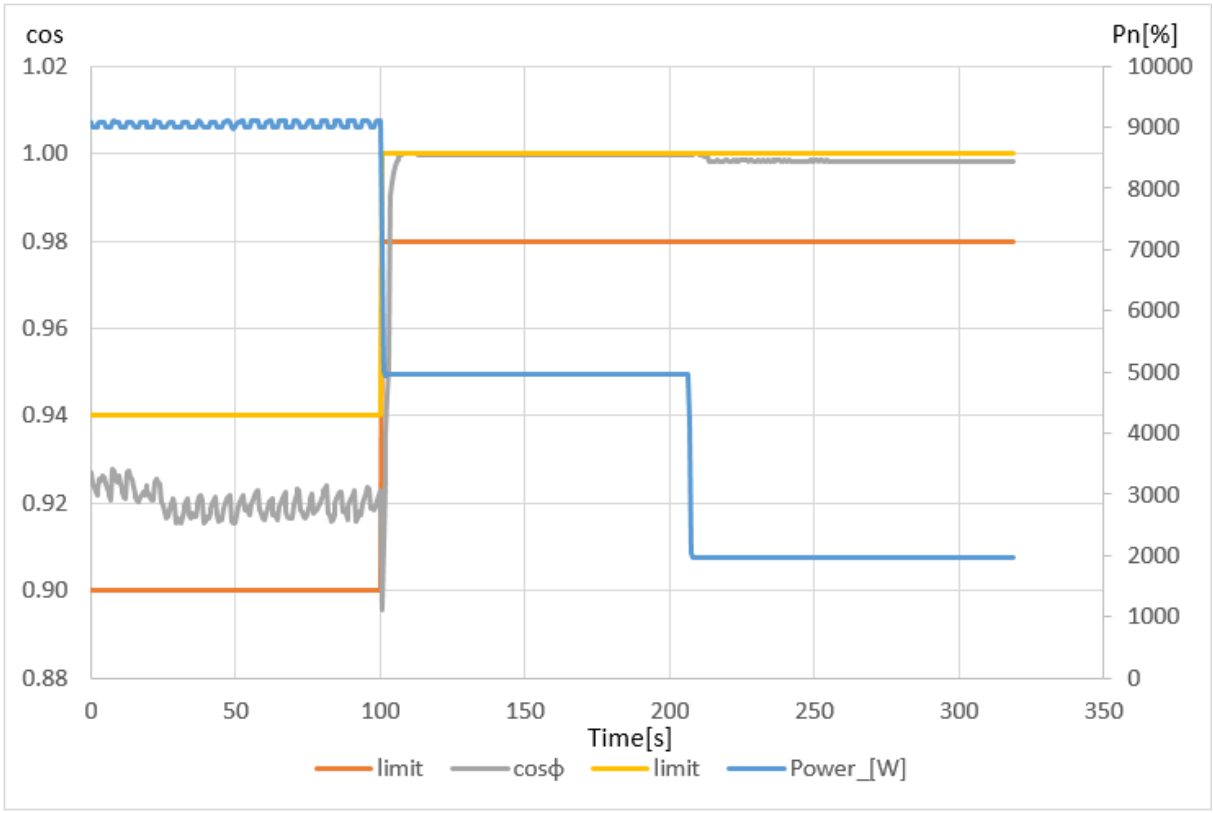
U [V]	230,59	230,45	230,29
P_{E30} [kW]	9,048	4,967	1,975
P_{E30} [%]	90,48	49,67	19,75
Q_{E30} [kVAr]	-3,851	0,119	-0,115
cos φ_{E30}	0,920	0,999	0,998
cos $\varphi_{setpoint}$ of P_{E30}	0,92	1,00	1,00
T_0 [s]	10,0		
Limit:			
T_0 [s]	10 s		
cos φ_{E30}	cos $\varphi_{setpoint}$ ±0,02		
Graph of cos φ(P): Test a)			



Graph of setting (T_0) time: Test b) 20% to 50% to 100%



Graph of setting (T_0) time: Test b) 100% to 50% to 20%

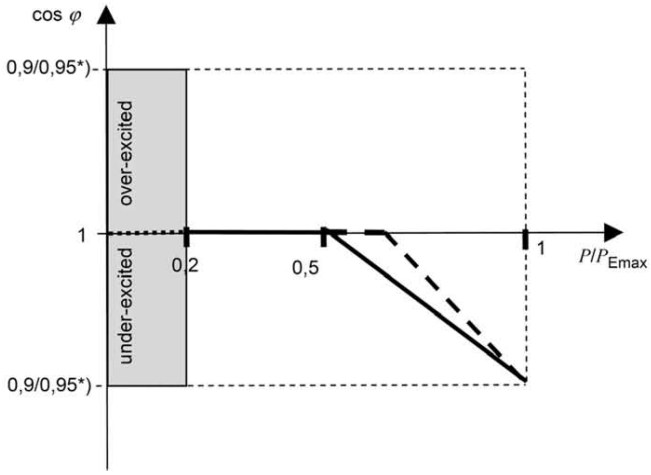


Test:

Test 1: Using the standard characteristic curve increases the active power from 20% P_{Emax} in increments of 10% P_{Emax} to P_{Emax}. The test is carried out in reverse.

Test 2: Using the standard characteristic curve increases the active power from 20% P_{Emax} to 50% P_{Emax} and to P_{Emax}. The test is carried out in reverse. After the PGU has settled, the end value reached is determined as a 30s mean value.

Characteristic curve cos φ (P)



*) Depending on S_{Amax}.

Assessment criterion:

Test 1: cos φ accuracy cos φ (±0,02)

Test 2: cos φ accuracy cos φ (±0,01)

The active power steps must be approached with an accuracy of ±5% P_{rE}.

For the test to be passed, the cos φ setpoint from the active power must be measured at the terminals of the PGU within a settling time of 10s.

Note:

5.3.9	**Reactive power setpoint control "fix Q"** The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4.	**P**

5.3.9.1

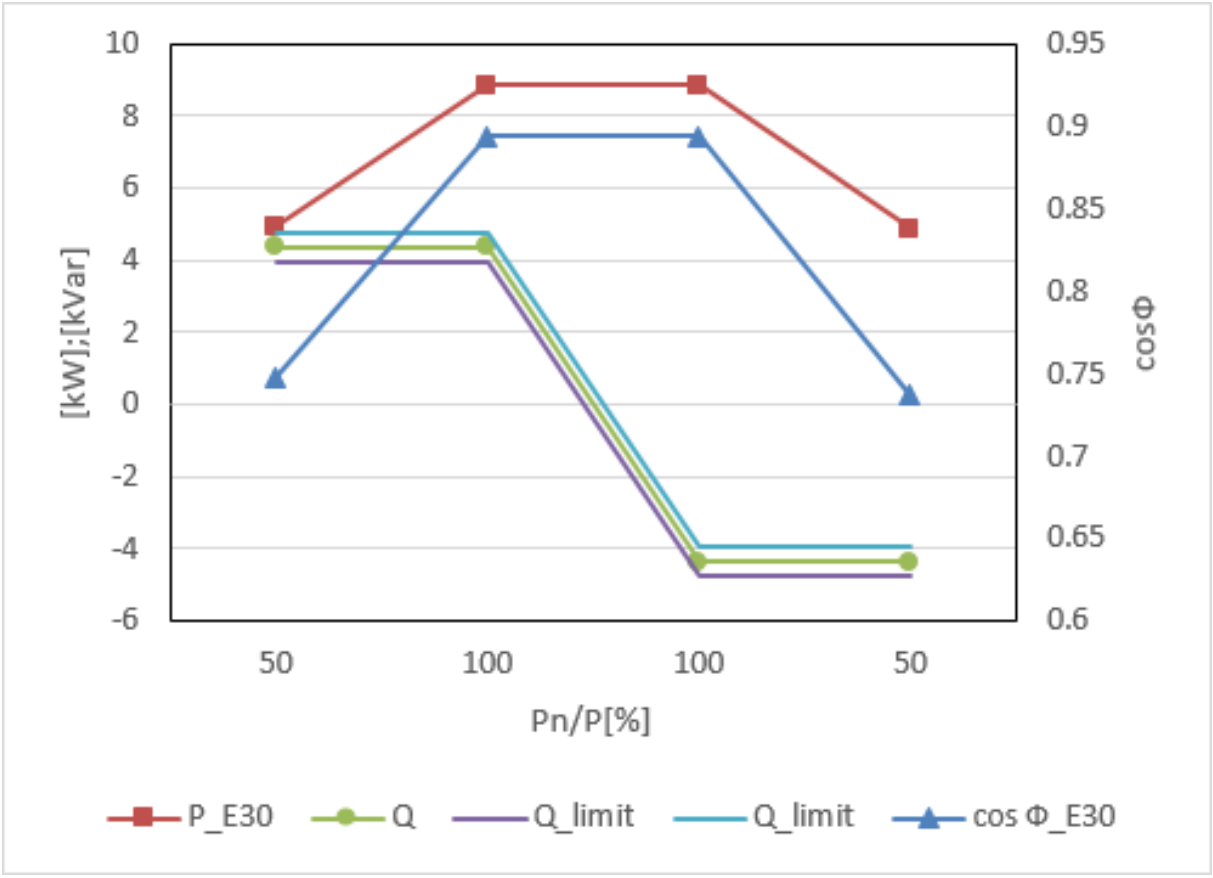
Setting values	Q over-excited:	43,6% S_n
	Q under-excited:	43,6% S_n

Test:

FSP POWER MANAGER 10KW

30 s mean value	0,91U_n		U_n		1,09 U_n	
Active power	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}
a) over-excited						
U [V]	209,66	209,93	230,35	230,62	251,07	251,21
P_{E30} [kW]	4,901	8,795	4,920	8,832	4,929	8,848
Q_{E30} [kVAr]	4,406	4,483	4,365	4,435	4,075	4,393
$Q_{setpoint}$ [kVAr]	4,360	4,360	4,360	4,360	4,360	4,360
ΔQ [VAr]	0,046	0,123	0,005	0,075	-0,295	0,033
cos $\varphi_{E30\text{-over-excited}}$	0,744	0,891	0,748	0,894	0,768	0,896
b) under-excited						
U [V]	209,67	209,85	230,35	230,56	251,03	251,21
P_{E30} [kW]	4,862	8,806	4,879	8,842	4,885	8,858
Q_{E30} [kVAr]	-4,438	-4,392	-4,468	-4,428	-4,500	-4,465
$Q_{setpoint}$ [kVAr]	-4,360	-4,360	-4,360	-4,360	-4,360	-4,360
ΔQ [VAr]	-0,078	-0,032	-0,102	-0,068	-0,140	-0,105
cos $\varphi_{E30\text{-over-excited}}$	0,739	0,895	0,737	0,894	0,735	0,893
Limit						
Q_{E30}	≤ ±4% S_n (electronic inverter)					

Graph P, Q, U



Test:

**applies for inverter ΣS_{Emax} ≤3,68 kVA

For Q = 31,2 over-excited and Q = 31,2 under-excited, the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax}

*applies for inverter ΣS_{Emax} ≥3,68 kVA

For Q = 43,6 over-excited and Q=43,6 under-excited, the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax}

**Q = 31,2 (φ 0,95) (i) and (c): PGU ≤3,68 kVA

*Q = 43,6 (φ 0,90) (i) and (c): PGU >3,68 kVA

Assessment criterion:

The test is passed if all Q values (30 s mean) are not more than ±4% S_n from the specification differ.

In the case of PGU with generators directly connected to the grid, which cannot regulate reactive power due to the principle, such as asynchronous generators, and therefore use non-controllable fixed capacities, the tolerance band extends from ±4% P_{rE} to ±10% P_{rE}. This device type is only used at U_n rated.

Note:

5.3.10	**Voltage-controlled control functions "Q= f(V)"** The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4.2	**P**
5.3.10.1.1	**Test Voltage-controlled control functions "Q= f(V)" - quasi-stationary behavior**	**P**

Test: 5.3.10.1.1 a) to n) 100% P_{rE}

FSP POWER MANAGER 10KW

Voltage steps	$U_{\_step}$ [%]	$U_{\_meas}$ [V]	$U_{\_meas}$ [%]	P_{30s} [kW]	Q $_{tol\_under}$ [kVAr]	Q_{30s} [kVAr]	Q $_{tol\_upper}$ [kVAr]	Q $_{tol\_under}$ [%S_n]	Q_{30s} [%S_n]	Q $_{tol\_upper}$ [%S_n]
1	100	230,00	100,00	10,000	-0,400	0,309	0,400	-4,00	3,09	4,00
2	101	232,00	100,87	10,000	-0,400	0,311	0,400	-4,00	3,11	4,00
3	102	235,00	102,17	10,000	-0,400	0,314	0,400	-4,00	3,14	4,00
4	103	237,00	103,04	10,000	-0,400	0,316	0,400	-4,00	3,16	4,00
5	104	239,00	103,91	10,000	-0,400	0,318	0,400	-4,00	3,18	4,00
6	105	241,00	104,78	10,000	-0,400	0,362	0,400	-4,00	3,62	4,00
7	106	244,00	106,09	9,855	-1,853	-1,640	-1,053	-18,53	-16,40	-10,53
8	107	246,00	106,96	9,489	-3,307	-3,096	-2,507	-33,07	-30,96	-25,07
9	108	248,00	107,83	8,958	-4,760	-4,405	-3,960	-47,60	-44,05	-39,60
10	109	251,00	109,13	8,955	-4,760	-4,403	-3,960	-47,60	-44,03	-39,60
11	110	253,05	110,02	8,949	-4,760	-4,402	-3,960	-47,60	-44,02	-39,60
12	111	255,17	110,95	4,862	-4,760	-4,468	-3,960	-47,60	-44,68	-39,60
13	112	257,67	112,03	-0,093	-0,400	-0,324	0,400	-4,00	-3,24	4,00
14	113	259,97	113,03	-0,122	-0,400	-0,323	0,400	-4,00	-3,23	4,00
15	112	257,66	112,03	-0,113	-0,400	-0,327	0,400	-4,00	-3,27	4,00
16	111	255,22	110,96	4,858	-4,760	-4,469	-3,960	-47,60	-44,69	-39,60
17	110	253,04	110,02	8,950	-4,760	-4,403	-3,960	-47,60	-44,03	-39,60
18	109	251,00	109,13	8,954	-4,760	-4,404	-3,960	-47,60	-44,04	-39,60
19	108	248,00	107,83	8,957	-4,760	-4,404	-3,960	-47,60	-44,04	-39,60
20	107	246,00	106,96	9,474	-3,307	-3,137	-2,507	-33,07	-31,37	-25,07
21	106	244,00	106,09	9,839	-1,853	-1,725	-1,053	-18,53	-17,25	-10,53
22	105	241,00	104,78	10,000	-0,400	0,375	0,400	-4,00	3,75	4,00
23	104	239,00	103,91	10,000	-0,400	0,317	0,400	-4,00	3,17	4,00
24	103	237,00	103,04	10,000	-0,400	0,316	0,400	-4,00	3,16	4,00
25	102	235,00	102,17	10,000	-0,400	0,314	0,400	-4,00	3,14	4,00
26	101	232,00	100,87	10,000	-0,400	0,312	0,400	-4,00	3,12	4,00
27	100	230,00	100,00	10,009	-0,400	0,310	0,400	-4,00	3,10	4,00
28	99	228,00	99,13	10,009	-0,400	0,309	0,400	-4,00	3,09	4,00
29	98	225,00	97,83	10,011	-0,400	0,307	0,400	-4,00	3,07	4,00

5.3.10	**Voltage-controlled control functions "Q= f(V)"** The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4.2	**P**
5.3.10.1.1	**Test Voltage-controlled control functions "Q= f(V)" - quasi-stationary behavior**	**P**

Test: 5.3.10.1.1 a) to n) 100% P_{rE}

FSP POWER MANAGER 10KW

Voltage steps	$U_{\_step}$ [%]	$U_{\_meas}$ [V]	$U_{\_meas}$ [%]	P_{30s} [kW]	Q_{tol_under} [kVAr]	Q_{30s} [kVAr]	Q_{tol_upper} [kVAr]	Q_{tol_under} [%S_n]	Q_{30s} [%S_n]	Q_{tol_upper} [%S_n]
30	97	223,00	96,96	10,017	-0,400	0,304	0,400	-4,00	3,04	4,00
31	96	221,00	96,09	10,020	-0,400	0,321	0,400	-4,00	3,21	4,00
32	95	219,00	95,22	9,959	0,690	1,260	1,490	6,90	12,60	14,90
33	94	216,00	93,91	9,797	1,780	2,283	2,580	17,80	22,83	25,80
34	93	214,00	93,04	9,486	2,870	3,409	3,670	28,70	34,09	36,70
35	92	212,00	92,17	9,133	3,960	4,297	4,760	39,60	42,97	47,60
36	91	209,00	90,87	9,140	3,960	4,298	4,760	39,60	42,98	47,60
37	90	207,00	90,00	9,142	3,960	4,296	4,760	39,60	42,96	47,60
38	89	205,00	89,13	9,147	3,960	4,296	4,760	39,60	42,96	47,60
39	88	202,00	87,83	9,158	3,960	4,295	4,760	39,60	42,95	47,60
40	87	200,00	86,96	9,159	3,960	4,299	4,760	39,60	42,99	47,60
41	86	198,00	86,09	9,165	3,960	4,299	4,760	39,60	42,99	47,60
42	85	195,00	84,78	9,167	3,960	4,298	4,760	39,60	42,98	47,60
43	86	198,00	86,09	9,165	3,960	4,299	4,760	39,60	42,99	47,60
44	87	200,00	86,96	9,160	3,960	4,299	4,760	39,60	42,99	47,60
45	88	202,00	87,83	9,157	3,960	4,299	4,760	39,60	42,99	47,60
46	89	205,00	89,13	9,144	3,960	4,301	4,760	39,60	43,01	47,60
47	90	207,00	90,00	9,142	3,960	4,300	4,760	39,60	43,00	47,60
48	91	209,00	90,87	9,138	3,960	4,303	4,760	39,60	43,03	47,60
49	92	212,00	92,17	9,129	3,960	4,296	4,760	39,60	42,96	47,60
50	93	214,00	93,04	9,490	2,870	3,388	3,670	28,70	33,88	36,70
51	94	216,00	93,91	9,785	1,780	2,325	2,580	17,80	23,25	25,80
52	95	218,00	94,78	9,957	0,690	1,258	1,490	6,90	12,58	14,90
53	96	221,00	96,09	10,019	-0,400	0,324	0,400	-4,00	3,24	4,00
54	97	223,00	96,96	10,016	-0,400	0,305	0,400	-4,00	3,05	4,00
55	98	225,00	97,83	10,011	-0,400	0,308	0,400	-4,00	3,08	4,00
56	99	228,00	99,13	10,008	-0,400	0,309	0,400	-4,00	3,09	4,00
57	100	230,00	100,00	10,007	-0,400	0,311	0,400	-4,00	3,11	4,00

5.3.10.1.1	Test Voltage-controlled control functions “Q= f(V)” - quasi-stationary behavior	P

Test: 5.3.10.1.1 a) to n) 20% P_{rE}

FSP POWER MANAGER 10KW

Voltage steps	$U_{\_step}$ [%]	$U_{\_meas}$ [V]	$U_{\_meas}$ [%]	P_{30s} [kW]	Q_{tol_under} [kVAr]	Q_{30s} [kVAr]	Q_{tol_upper} [kVAr]	Q_{tol_under} [%S_n]	Q_{30s} [%S_n]	Q_{tol_upper} [%S_n]
1	100	229,97	99,99	1,958	-0,400	0,283	0,400	-4,00	2,83	4,00
2	101	232,32	101,01	1,948	-0,400	0,284	0,400	-4,00	2,84	4,00
3	102	234,64	102,02	1,942	-0,400	0,286	0,400	-4,00	2,86	4,00
4	103	236,91	103,00	1,937	-0,400	0,287	0,400	-4,00	2,87	4,00
5	104	239,23	104,01	1,931	-0,400	0,288	0,400	-4,00	2,88	4,00
6	105	241,51	105,00	1,926	-0,400	0,297	0,400	-4,00	2,97	4,00
7	106	243,78	105,99	1,905	-1,853	-1,598	-1,053	-18,53	-15,98	-10,53
8	107	246,07	106,99	1,878	-3,307	-3,040	-2,507	-33,07	-30,40	-25,07
9	108	248,37	107,99	1,842	-4,760	-4,486	-3,960	-47,60	-44,86	-39,60
10	109	250,70	109,00	1,838	-4,760	-4,485	-3,960	-47,60	-44,85	-39,60
11	110	253,12	110,05	1,833	-4,760	-4,485	-3,960	-47,60	-44,85	-39,60
12	111	255,44	111,06	1,828	-4,760	-4,483	-3,960	-47,60	-44,83	-39,60
13	112	257,69	112,04	-0,092	-0,400	-0,323	0,400	-4,00	-3,23	4,00
14	113	259,98	113,03	-0,122	-0,400	-0,322	0,400	-4,00	-3,22	4,00
15	112	257,69	112,04	-0,118	-0,400	-0,323	0,400	-4,00	-3,23	4,00
16	111	255,40	111,04	1,829	-4,760	-4,484	-3,960	-47,60	-44,84	-39,60
17	110	253,13	110,06	1,833	-4,760	-4,484	-3,960	-47,60	-44,84	-39,60
18	109	250,71	109,01	1,838	-4,760	-4,485	-3,960	-47,60	-44,85	-39,60
19	108	248,41	108,00	1,843	-4,760	-4,487	-3,960	-47,60	-44,87	-39,60
20	107	246,11	107,00	1,879	-3,307	-3,044	-2,507	-33,07	-30,44	-25,07
21	106	243,80	106,00	1,905	-1,853	-1,606	-1,053	-18,53	-16,06	-10,53
22	105	241,51	105,00	1,926	-0,400	0,298	0,400	-4,00	2,98	4,00
23	104	239,22	104,01	1,932	-0,400	0,290	0,400	-4,00	2,90	4,00
24	103	236,92	103,01	1,937	-0,400	0,289	0,400	-4,00	2,89	4,00
25	102	234,62	102,01	1,942	-0,400	0,288	0,400	-4,00	2,88	4,00
26	101	232,32	101,01	1,948	-0,400	0,287	0,400	-4,00	2,87	4,00
27	100	230,02	100,01	1,954	-0,400	0,285	0,400	-4,00	2,85	4,00
28	99	227,72	99,01	1,960	-0,400	0,284	0,400	-4,00	2,84	4,00
29	98	225,41	98,01	1,966	-0,400	0,282	0,400	-4,00	2,82	4,00
30	97	223,12	97,01	1,973	-0,400	0,280	0,400	-4,00	2,80	4,00
31	96	220,82	96,01	1,983	-0,400	0,279	0,400	-4,00	2,79	4,00
32	95	218,52	95,01	1,983	0,690	1,285	1,490	6,90	12,85	14,90

5.3.10.1.1	Test Voltage-controlled control functions “Q= f(V)” - quasi-stationary behavior	P

Test: 5.3.10.1.1 a) to n) 20% P_{rE}

FSP POWER MANAGER 10KW

Voltage steps	$U_{\_step}$ [%]	$U_{\_meas}$ [V]	$U_{\_meas}$ [%]	P_{30s} [kW]	Q_{tol_under} [kVAr]	Q_{30s} [kVAr]	Q_{tol_upper} [kVAr]	Q_{tol_under} [%S_n]	Q_{30s} [%S_n]	Q_{tol_upper} [%S_n]
33	94	216,22	94,01	1,971	1,780	2,323	2,580	17,80	23,23	25,80
34	93	213,92	93,01	1,990	2,870	3,372	3,670	28,70	33,72	36,70
35	92	211,61	92,00	2,009	3,960	4,211	4,760	39,60	42,11	47,60
36	91	209,26	90,98	2,018	3,960	4,210	4,760	39,60	42,10	47,60
37	90	206,99	90,00	2,024	3,960	4,210	4,760	39,60	42,10	47,60
38	89	204,68	88,99	2,030	3,960	4,207	4,760	39,60	42,07	47,60
39	88	202,39	88,00	2,036	3,960	4,208	4,760	39,60	42,08	47,60
40	87	200,07	86,99	2,043	3,960	4,207	4,760	39,60	42,07	47,60
41	86	197,76	85,98	2,049	3,960	4,205	4,760	39,60	42,05	47,60
42	85	195,47	84,99	2,056	3,960	4,205	4,760	39,60	42,05	47,60
43	86	197,77	85,99	2,049	3,960	4,204	4,760	39,60	42,04	47,60
44	87	200,07	86,99	2,043	3,960	4,207	4,760	39,60	42,07	47,60
45	88	202,37	87,99	2,036	3,960	4,209	4,760	39,60	42,09	47,60
46	89	204,67	88,98	2,031	3,960	4,207	4,760	39,60	42,07	47,60
47	90	206,97	89,99	2,025	3,960	4,212	4,760	39,60	42,12	47,60
48	91	209,29	90,99	2,018	3,960	4,211	4,760	39,60	42,11	47,60
49	92	211,59	92,00	2,009	3,960	4,212	4,760	39,60	42,12	47,60
50	93	213,88	92,99	1,992	2,870	3,413	3,670	28,70	34,13	36,70
51	94	216,18	93,99	1,972	1,780	2,348	2,580	17,80	23,48	25,80
52	95	218,47	94,99	1,984	0,690	1,285	1,490	6,90	12,85	14,90
53	96	220,77	95,99	1,983	-0,400	0,306	0,400	-4,00	3,06	4,00
54	97	223,09	97,00	1,973	-0,400	0,281	0,400	-4,00	2,81	4,00
55	98	225,41	98,00	1,966	-0,400	0,282	0,400	-4,00	2,82	4,00
56	99	227,73	99,01	1,961	-0,400	0,284	0,400	-4,00	2,84	4,00
57	100	230,02	100,01	1,954	-0,400	0,286	0,400	-4,00	2,86	4,00

5.3.10.1.1	**Test Voltage-controlled control functions "Q= f(V)" - quasi-stationary behavior**	P

Test: 5.3.10.1.1 o) to z) Test@91%U_n

FSP POWER MANAGER 10KW

Voltage steps	$U_{\_step}$ [%]	$U_{\_meas}$ [V]	$U_{\_meas}$ [%]	P_{30s} [kW]	Q_{tol_under} [kVAr]	Q_{30s} [kVAR]	Q_{tol_upper} [kVAr]	Q_{tol_under} [%S_n]	Q_{30s} [%S_n]	Q_{tol_upper} [%S_n]
1	91	209,26	90,98	0,018	-0.400	-0.301	0.400	--	-3,01	--
2	91	209,26	90,98	0,608	0.757	1.107	1.557	7,57	11,07	15,57
3	91	209,26	90,98	1,091	1.781	2.115	2.581	17,81	21,15	25,81
4	91	209,26	90,98	1,548	2.757	3.076	3.557	27,57	30,76	35,57
5	91	209,26	90,98	2,112	3.960	4.209	4.760	39,60	42,09	47,60
6	91	209,26	90,98	1,549	2.758	3.078	3.558	27,58	30,78	35,58
7	91	209,26	90,98	1,091	1.784	2.119	2.584	17,84	21,19	25,84
8	91	209,26	90,98	0,608	0.759	1.108	1.559	7,59	11,08	15,59
9	91	209,26	90,98	0,019	-0.400	-0.302	0.400	--	-3,02	--

Test: 5.3.10.1.1 o) to z) Test@109%U_n

FSP POWER MANAGER 10KW

Voltage steps	$U_{\_step}$ [%]	$U_{\_meas}$ [V]	$U_{\_meas}$ [%]	P_{30s} [kW]	Q_{tol_under} [kVAr]	Q_{30s} [kVAR]	Q_{tol_upper} [kVAr]	Q_{tol_under} [%S_n]	Q_{30s} [%S_n]	Q_{tol_upper} [%S_n]
1	109	250,93	109,10	-0,001	-0.701	0.128	0.099	-7,01	1,28	0,99
2	109	250,92	109,10	0,398	-1.597	-1.243	-0.797	-15,97	-12,43	-7,97
3	109	250,93	109,10	0,881	-2.596	-2.227	-1.796	-25,96	-22,27	-17,96
4	109	250,93	109,10	1,364	-3.610	-3.225	-2.810	-36,10	-32,25	-28,10
5	109	250,93	109,10	1,941	-4.760	-4.414	-3.960	-47,60	-44,14	-39,60
6	109	250,93	109,10	1,364	-3.613	-3.228	-2.813	-36,13	-32,28	-28,13
7	109	250,93	109,10	0,881	-2.599	-2.231	-1.799	-25,99	-22,31	-17,99
8	109	250,92	109,10	0,397	-1.598	-1.244	-0.798	-15,98	-12,44	-7,98
9	109	250,92	109,10	-0,102	-0.720	-0.334	0.080	-7,20	-3,34	0,80

Setting values for the Q(U) characteristic test:

Required voltage points according table 3	Voltage (U/U_n)	Reactive power (Q/S_n)	Time constant Tau
a	0,92	43,6% (over exited)	3s
b	0,96	0,0	
c	1,05	0,0	
d	1,08	43,6% (under exited)	

Assessment criterion:

The examination of inpatient behaviour is passed if

- The 30s mean values of the reactive power values measured in stationary operation measured according to 5.3.10.1.1 are within the tolerance band of ±4% Sn and ±1% Un of the set Q (U) characteristic. - in the power range Pmin up to 20% P_{rE} the time course of the reactive power is constant and when P = 0 the reactive power goes towards 0. Compliance with the tolerance band of ±4% Sn is in this Active power range not required.
Note:

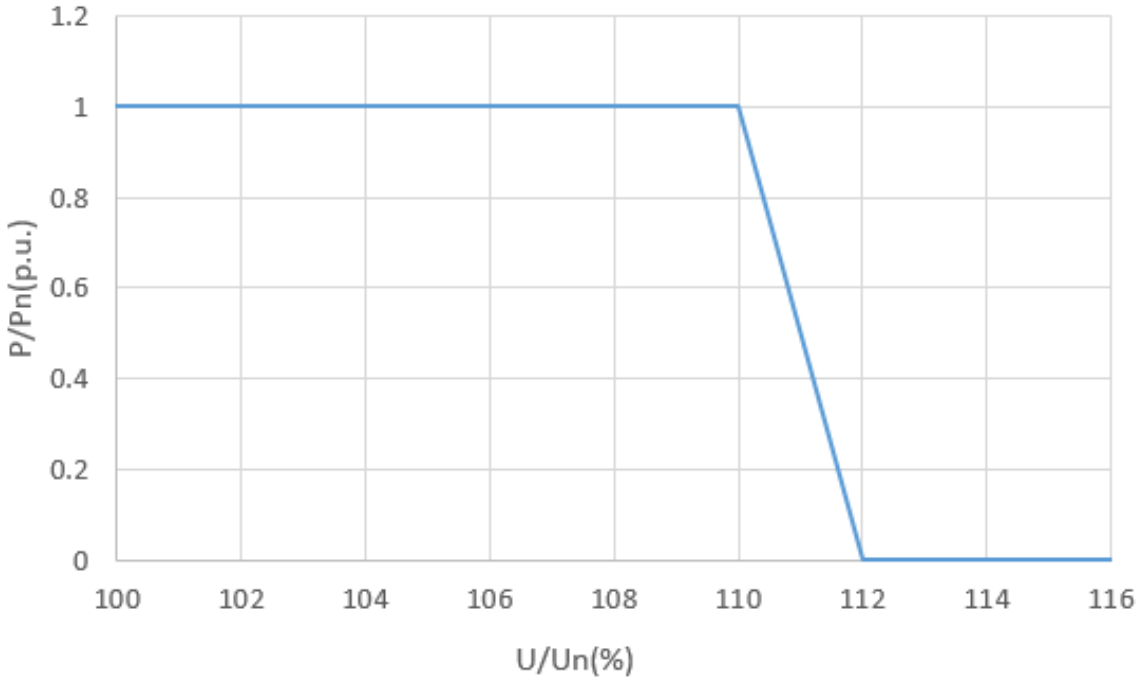
5.3.10.1.2	Test Voltage-controlled control functions "Q= f(V)" - dynamic behavior	P

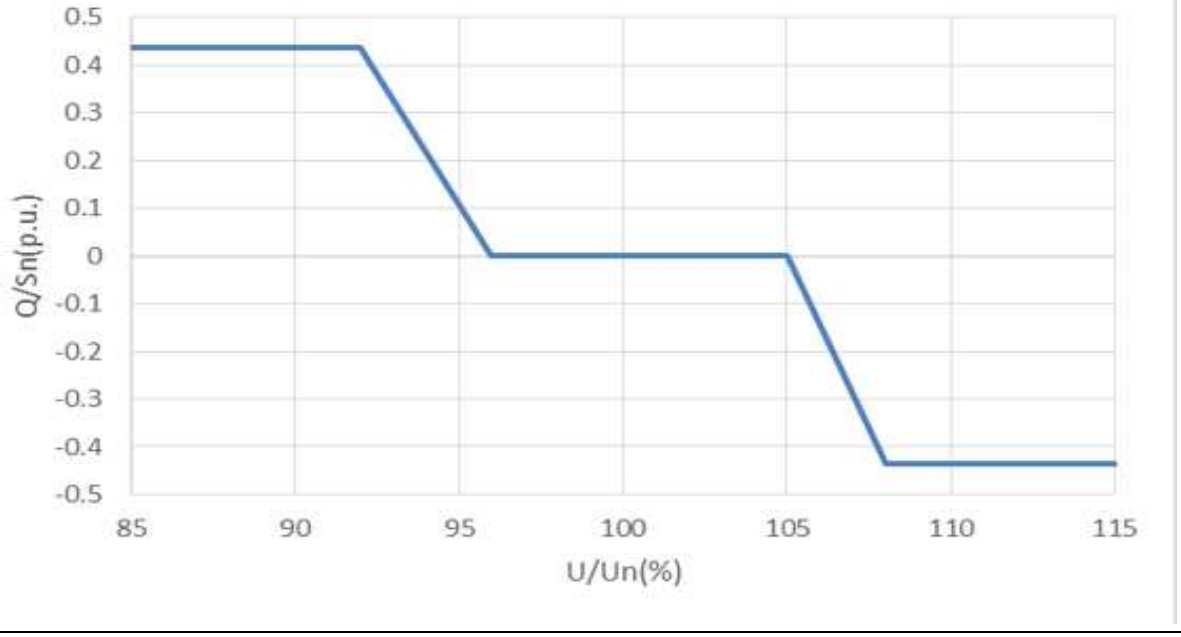
FSP POWER MANAGER 10KW

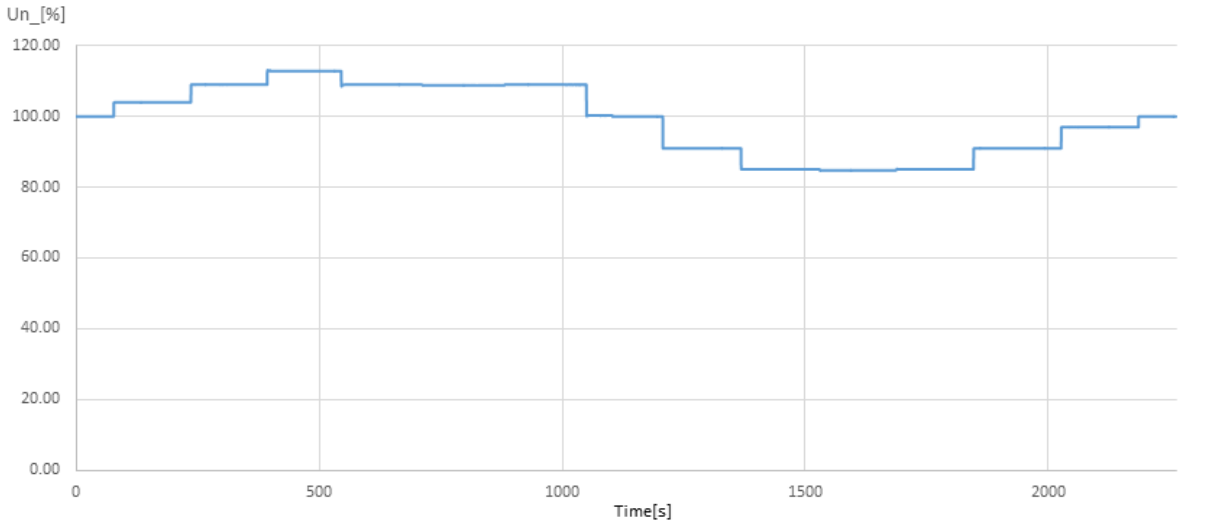
$U_{\_step}$ [%]	$U_{\_meas}$ [V]	$U_{\_meas}$ [%]	P_{tol_under} [kW]	P_{30s} [kW]	P_{tol_upper} [kW]	P_{30s} [%]	Q_{tol_under} [kVAr]	Q_{30s} [kVAr]	Q_{tol_upper} [kVAr]	Q,set [%S_n]	Q_{30s} [%S_n]
100	230,05	100,02	9,0	9,867	11,0	98,67	-0,40	-0,31	0,40	0	-3,13
104	239,23	104,01	9,0	9,846	11,0	98,46	-0,40	-0,31	0,40	0	-3,12
109	250,69	109,00	8,0	8,767	11,0	87,67	-4,76	-4,53	-3,96	-43,6	-1,67
113	259,58	112,86	0,0	-0,063	1,0	-0,63	-0,40	-0,05	0,40	0	-0,50
109	250,69	109,00	8,0	8,761	11,0	87,61	-4,76	-4,53	-3,96	-43,6	-1,67
109	250,32	108,83	0,0	0,034	1,0	0,34	-0,40	-0,06	0,40	0	-0,62
109	250,71	109,00	8,0	8,772	11,0	87,72	-4,76	-4,52	-3,96	-43,6	-1,58
100	230,65	100,28	9,0	9,869	11,0	98,69	-0,40	-0,31	0,40	0	-3,15
91	209,30	91,00	9,0	9,098	11,0	90,98	3,96	4,10	4,76	43,6	-2,59
85	195,65	85,06	9,0	9,129	11,0	91,29	3,96	4,11	4,76	43,6	-2,52
85	195,00	84,78	0,0	0,139	1,0	1,39	-0,40	-0,11	0,40	0	-1,12
85	195,65	85,06	9,0	9,130	11,0	91,30	3,96	4,11	4,76	43,6	-2,48
91	209,31	91,00	9,0	9,113	11,0	91,13	3,96	4,12	4,76	43,6	-2,45
97	223,05	96,98	9,0	9,902	11,0	99,02	-0,40	-0,29	0,40	0	-2,93
100	229,95	99,98	18,0	20,040	22,0	100,20	-0,88	-0,033	0,88	0	-0,15

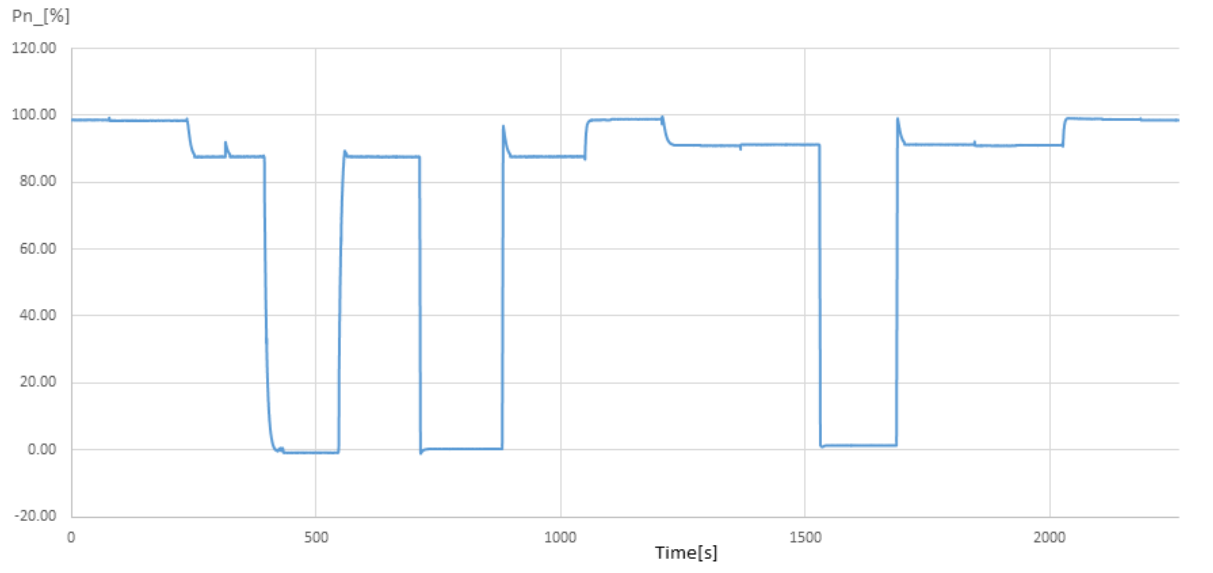
Note:

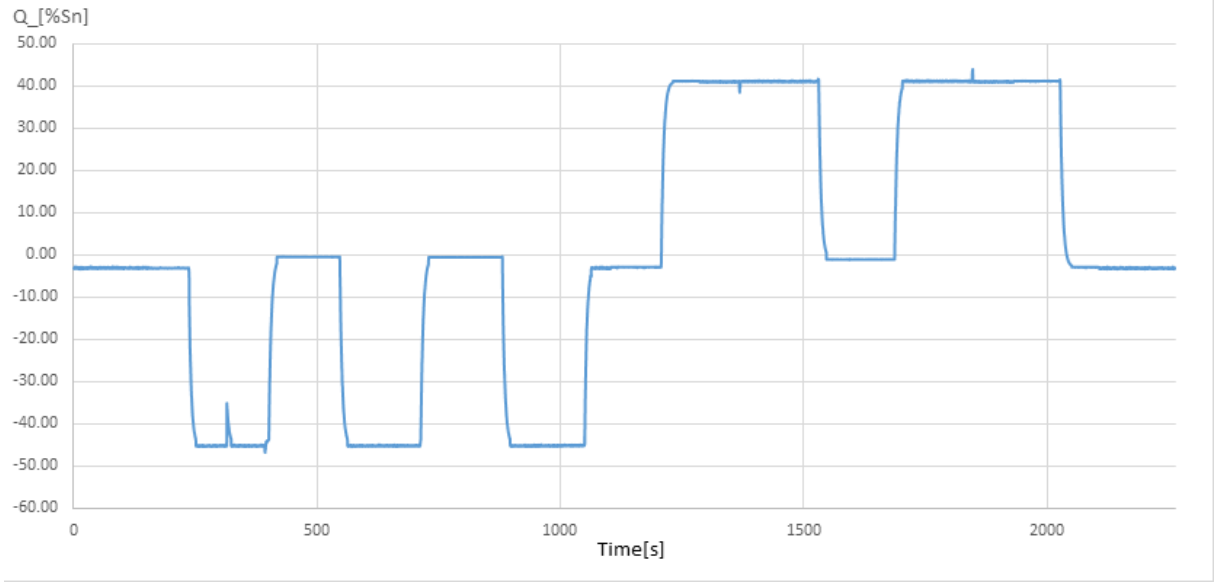
Graph of Q(U)



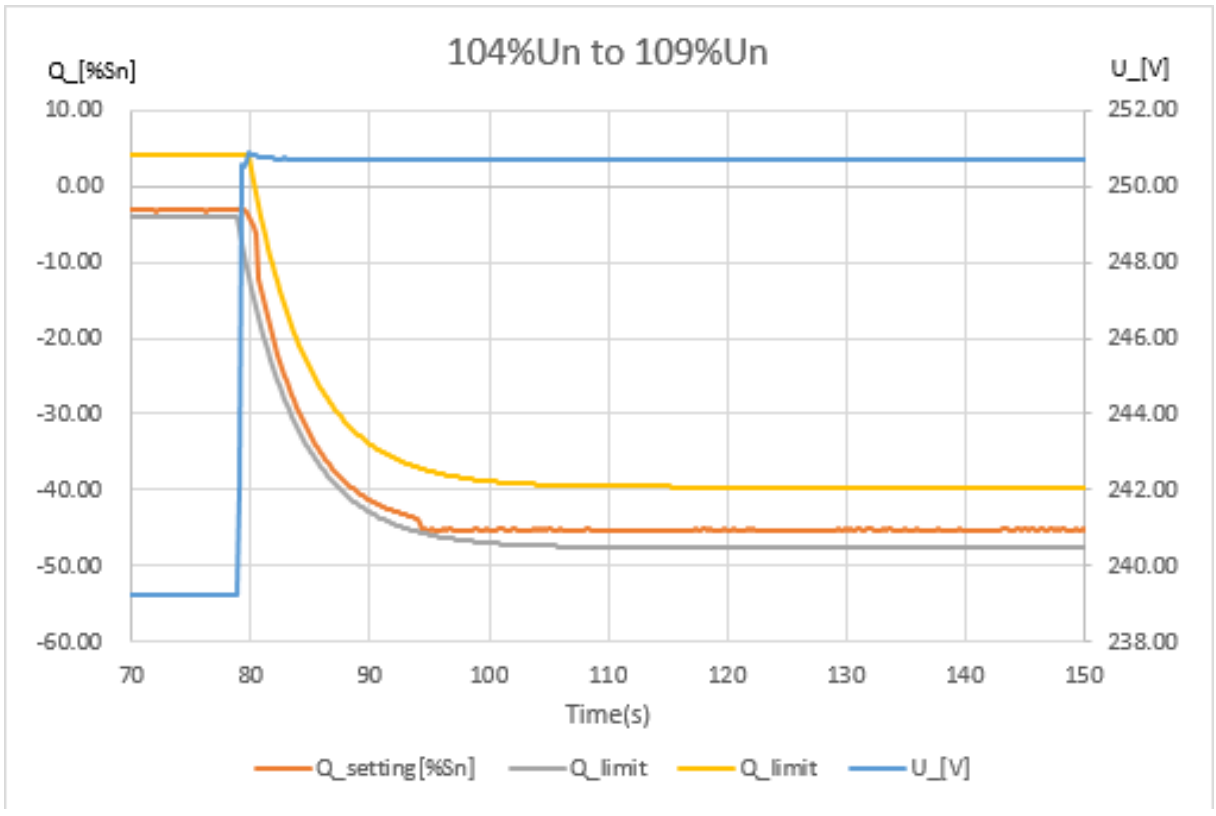

0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
Q/Sn(p.u.)
85
90
95
100
105
110
115
U/Un(%)


Un_[%]
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
500
1000
1500
2000
Time[s]

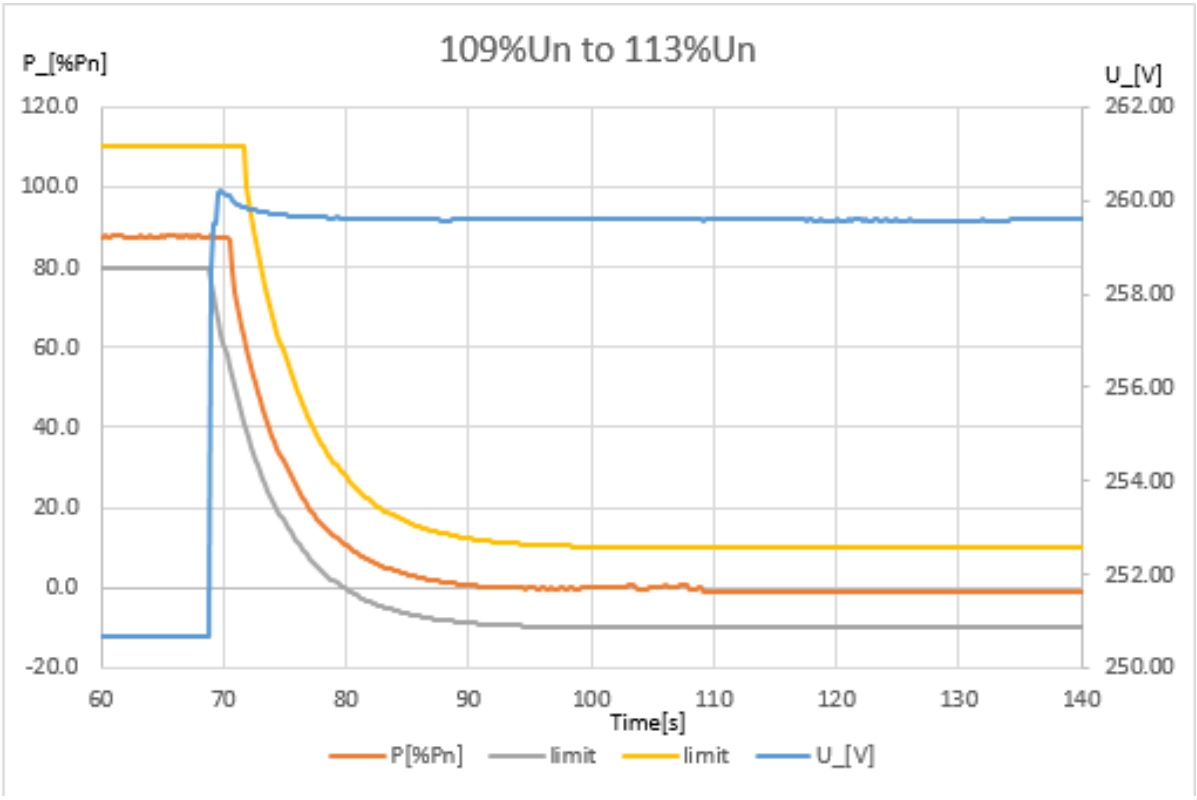

Pn_[%]
120.00
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
0
500
1000
1500
2000
Time[s]

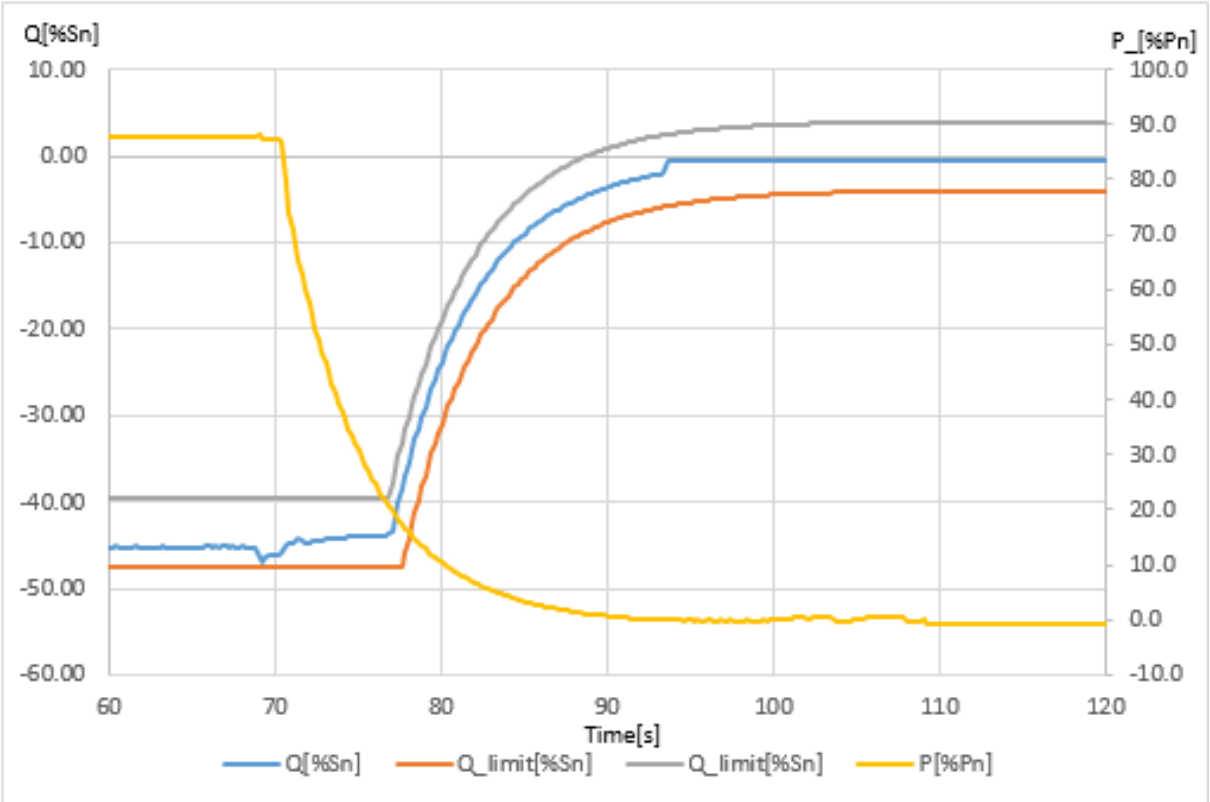


Test steps form 2 to 3

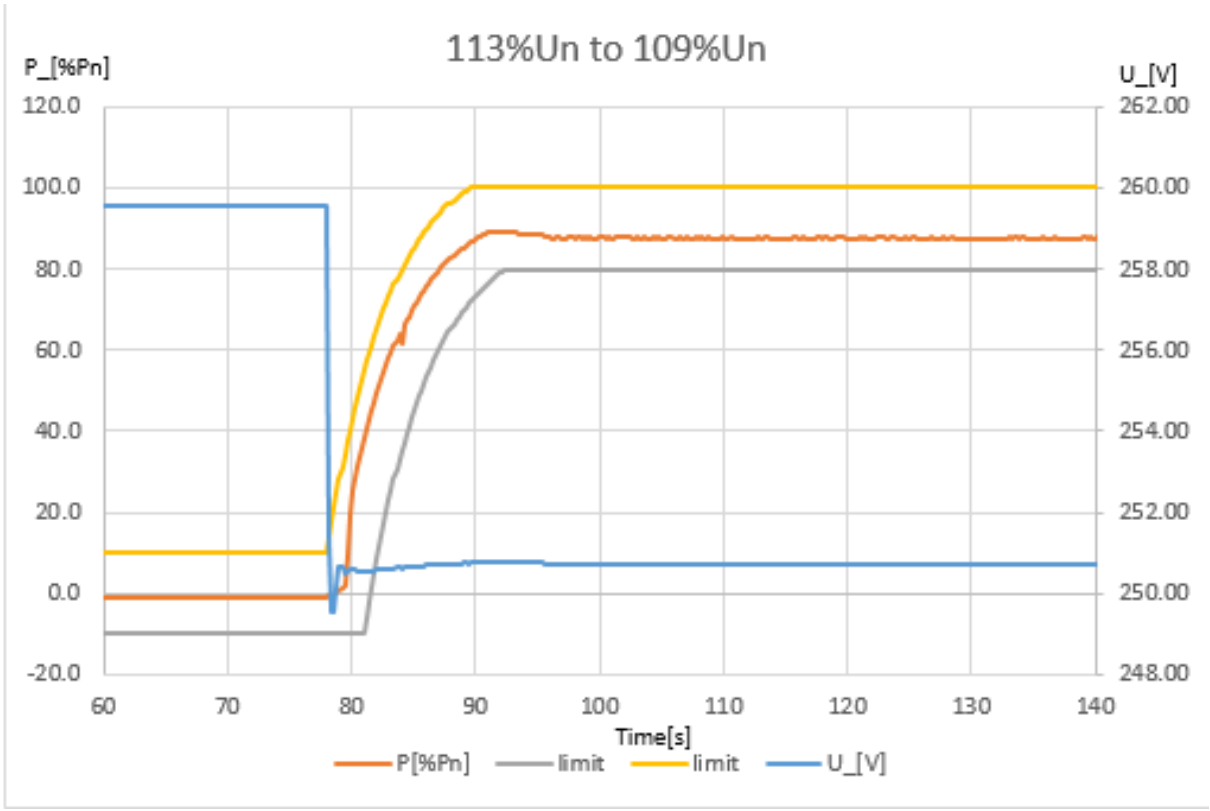


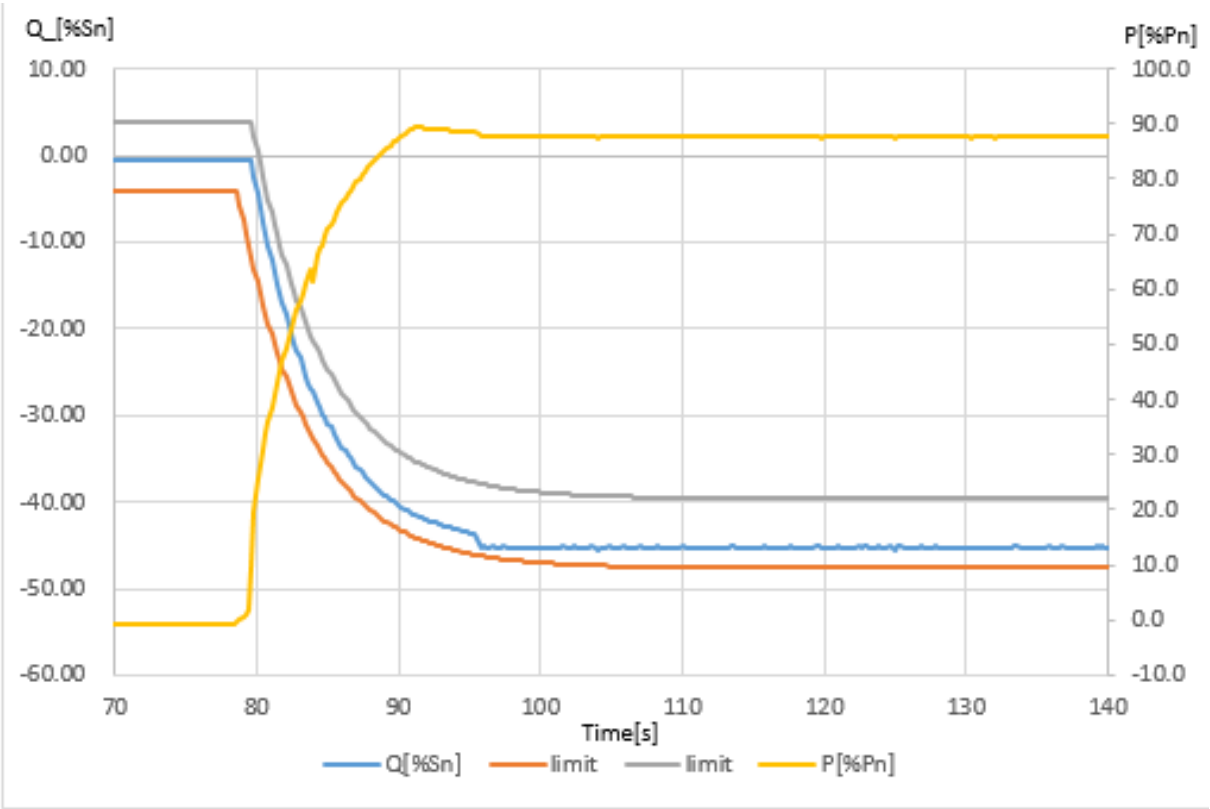
Test steps form 3 to 4



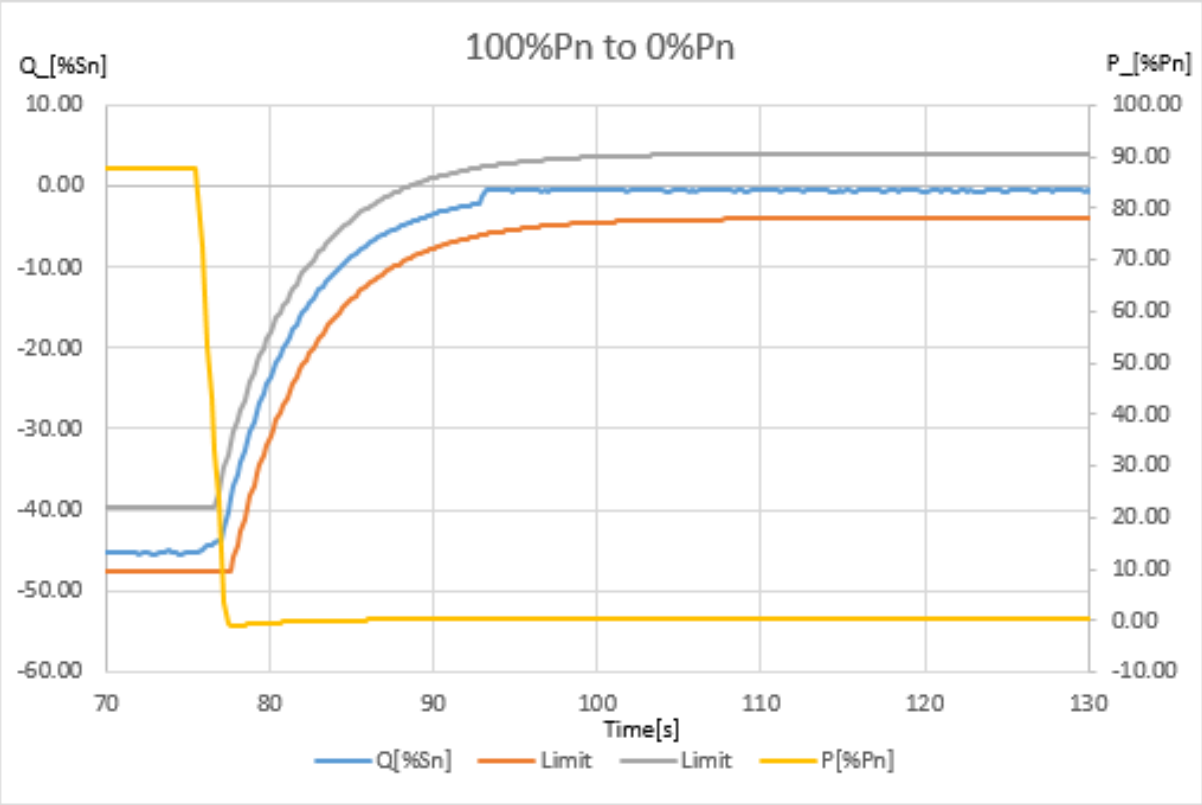


Test steps form 4 to 5

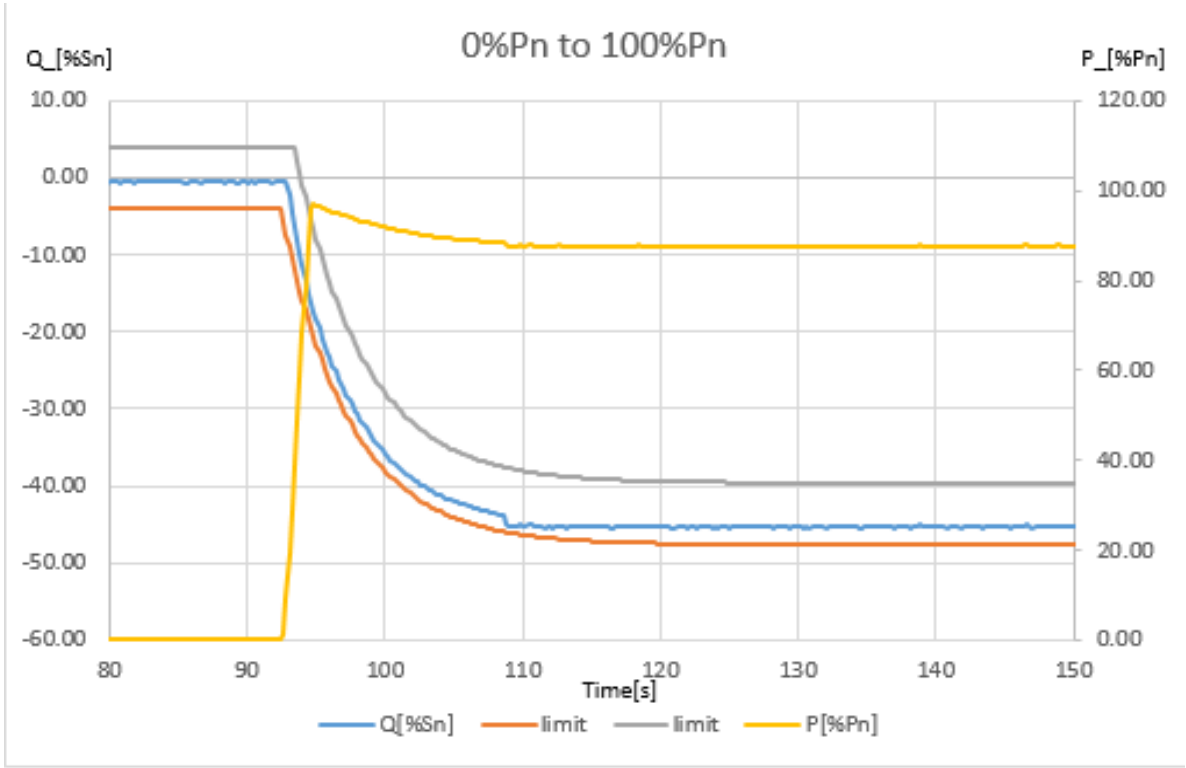




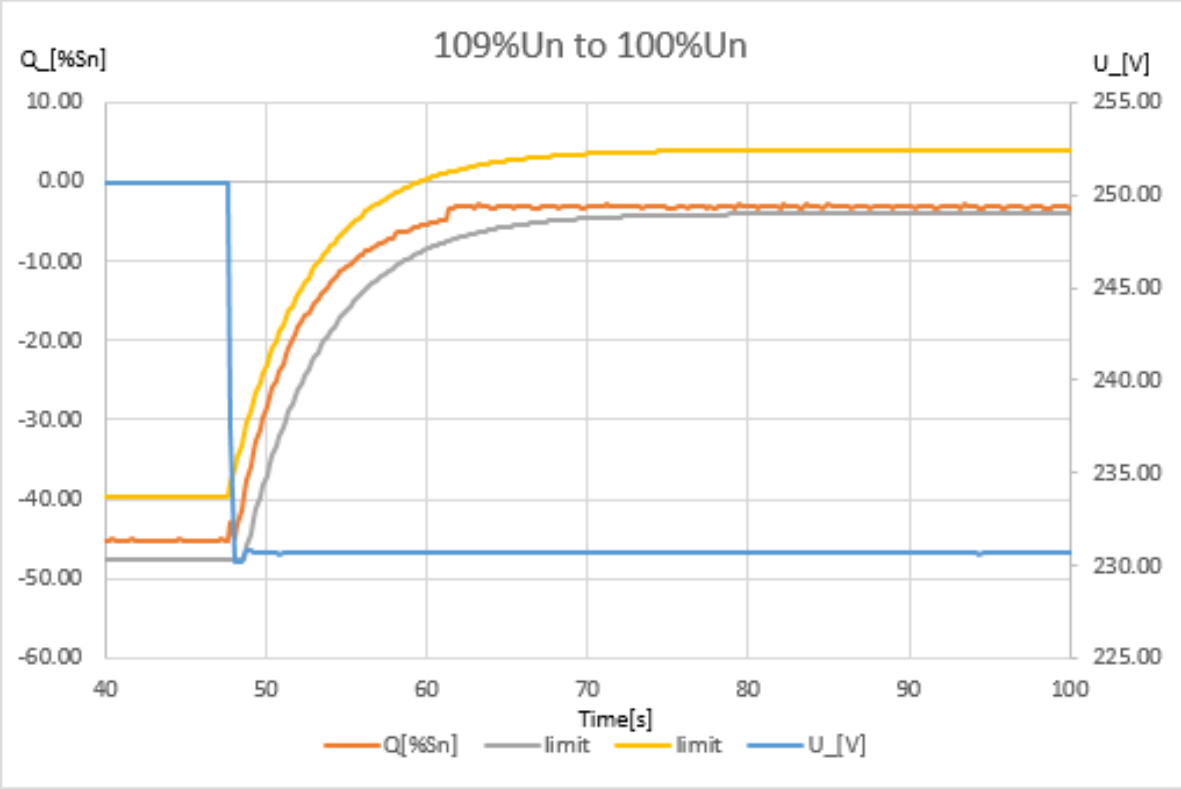
Test steps form 5 to 6



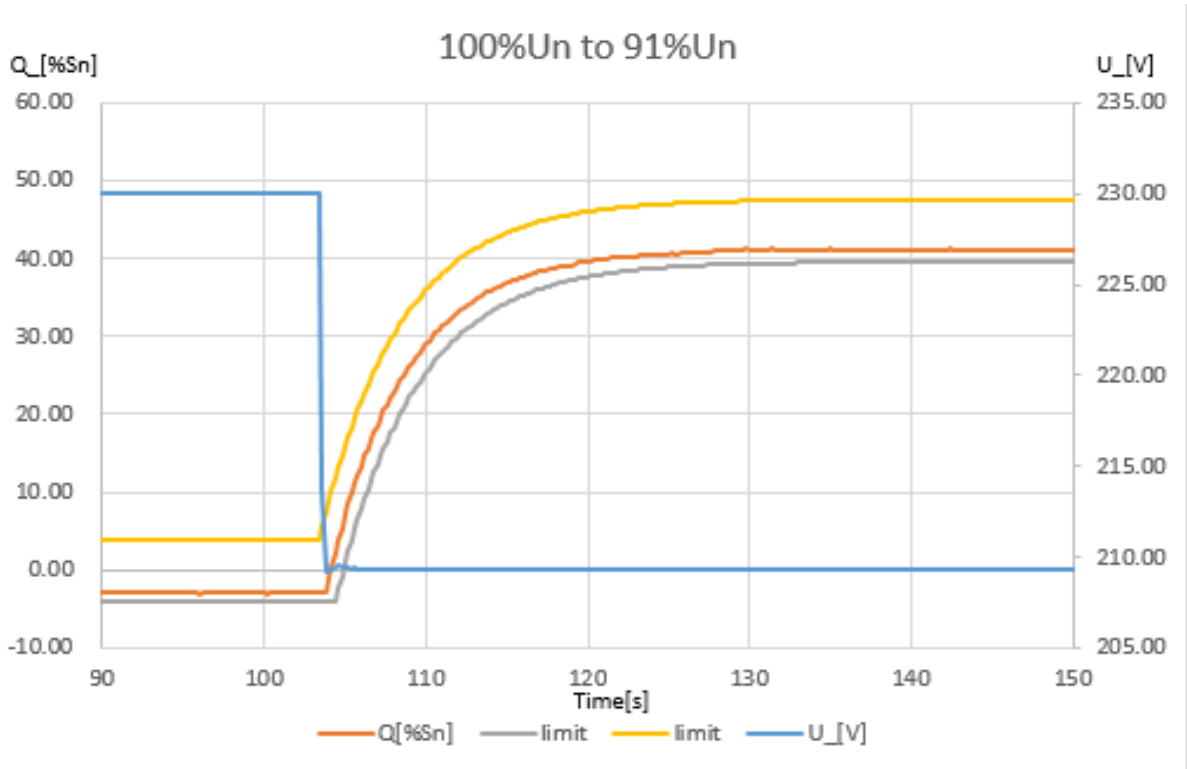
Test steps form 6 to 7



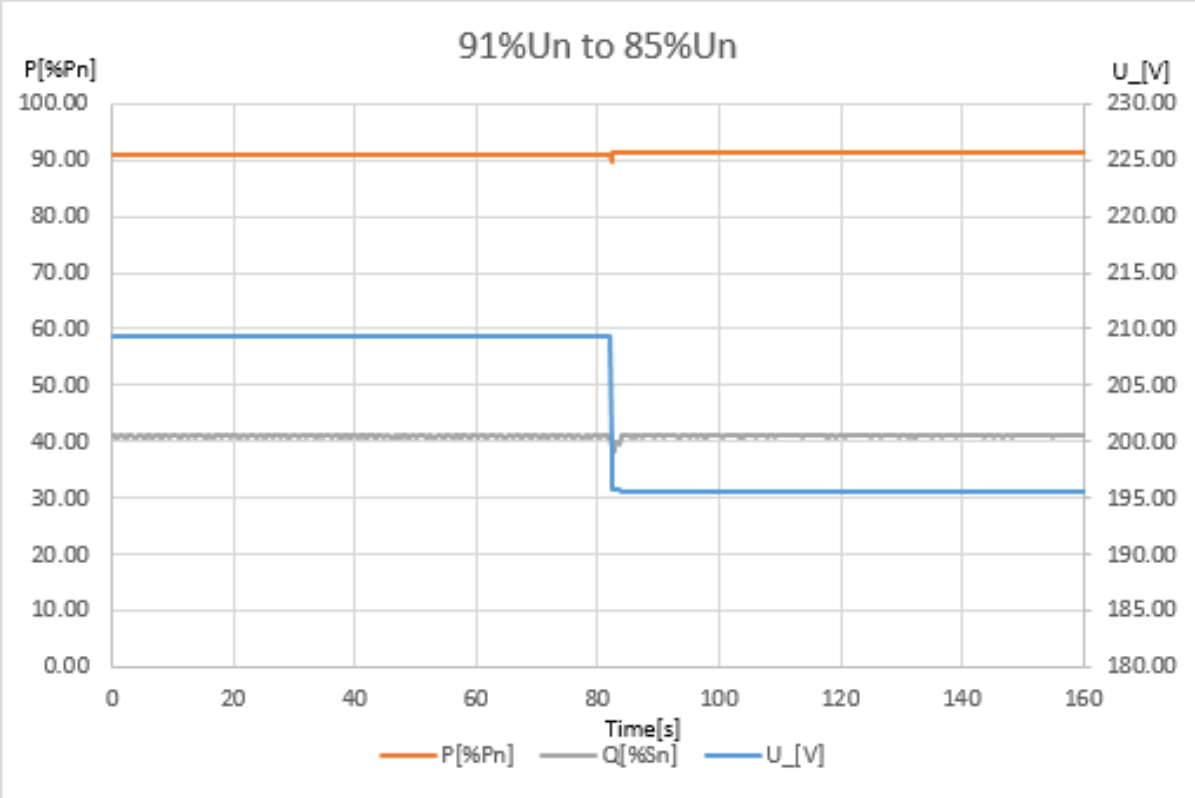
Test steps form 7 to 8



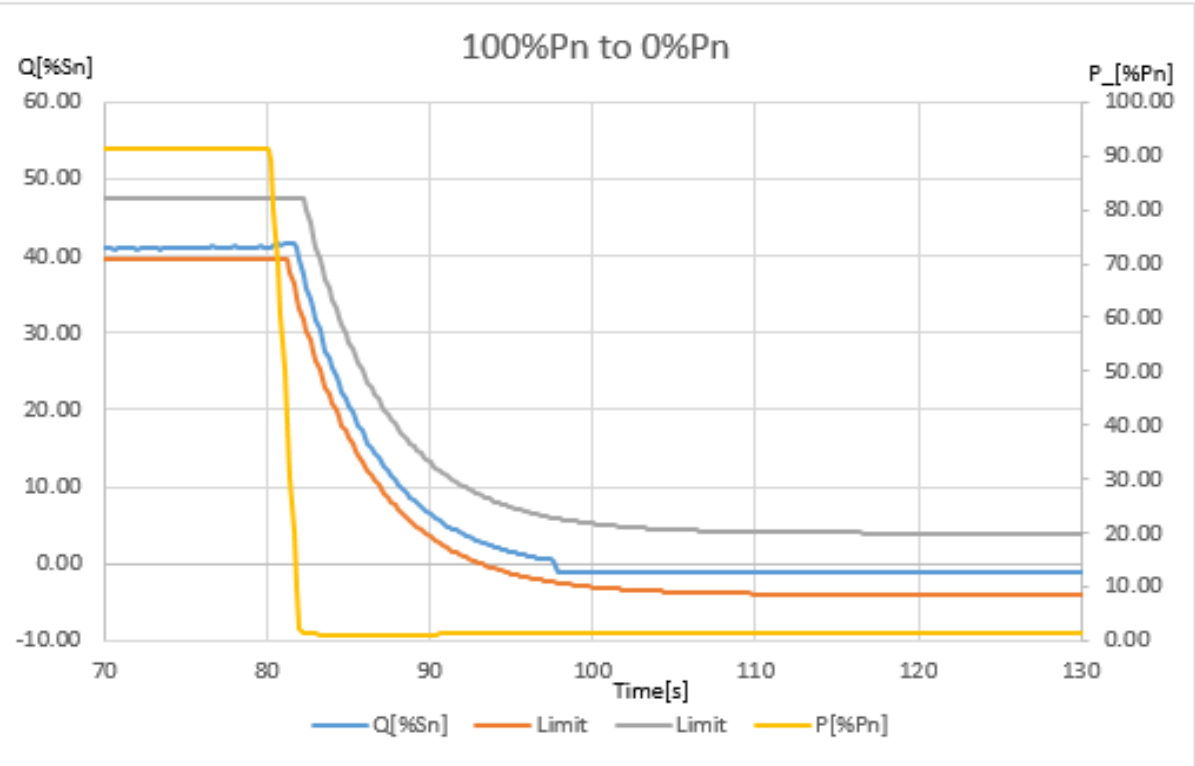
Test steps form 8 to 9



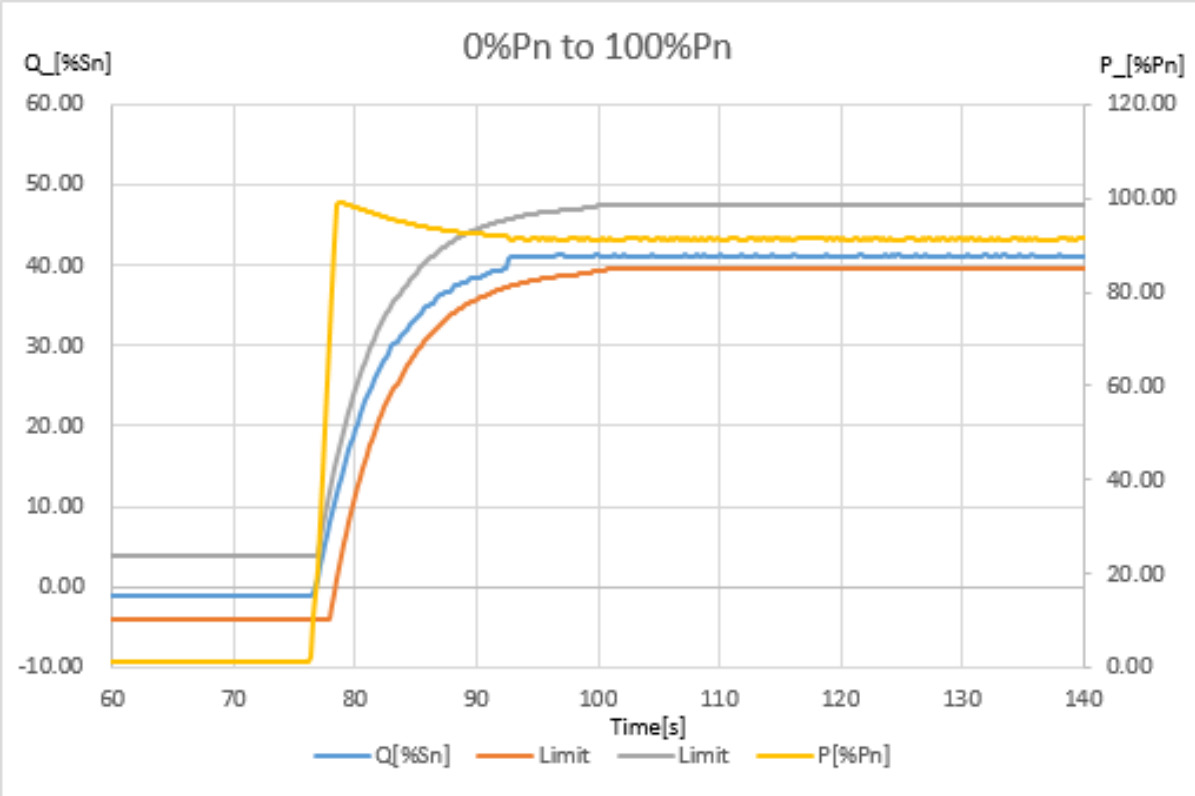
Test steps form 9 to 10



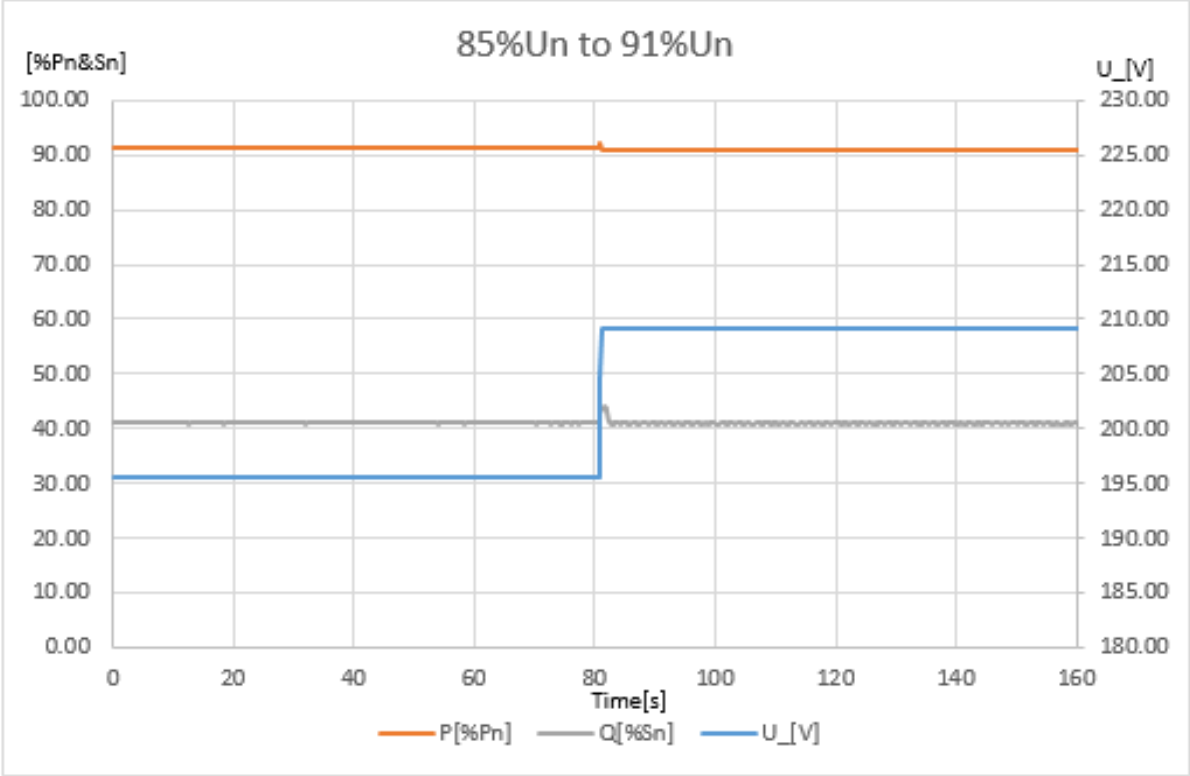
Test steps form 10 to 11



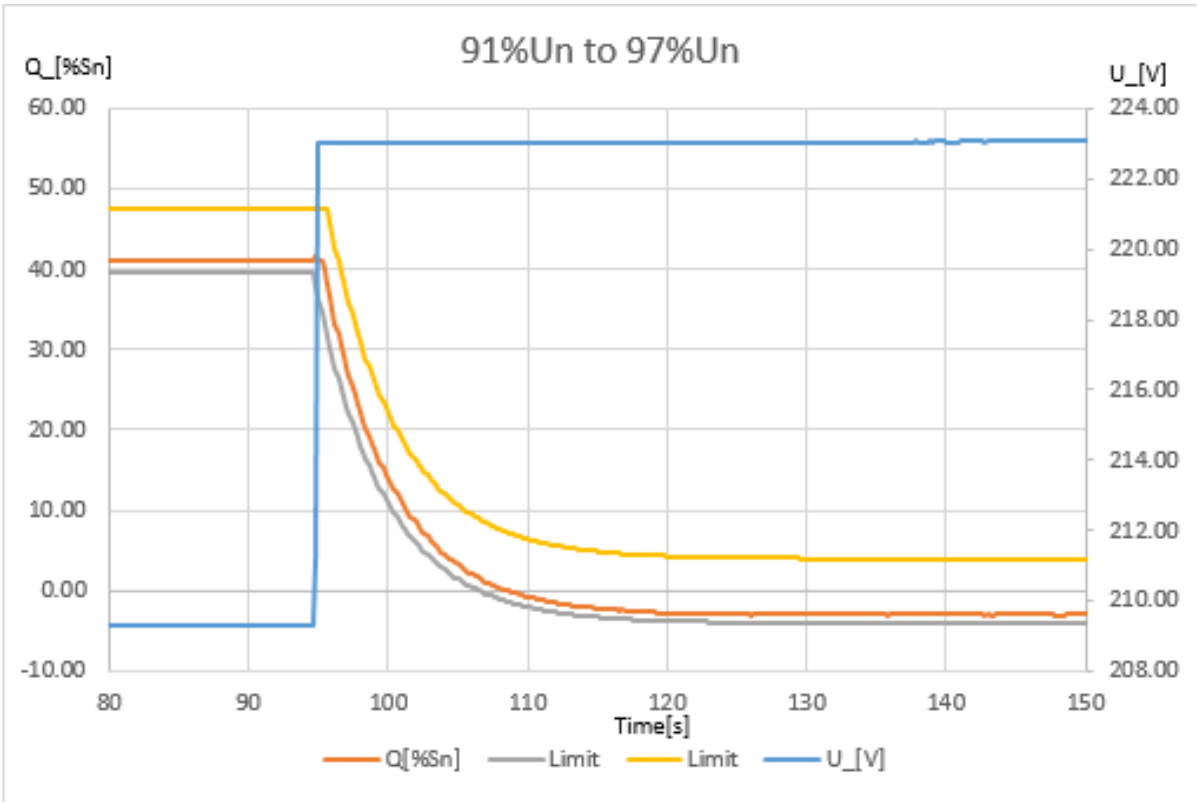
Test steps form 11 to 12



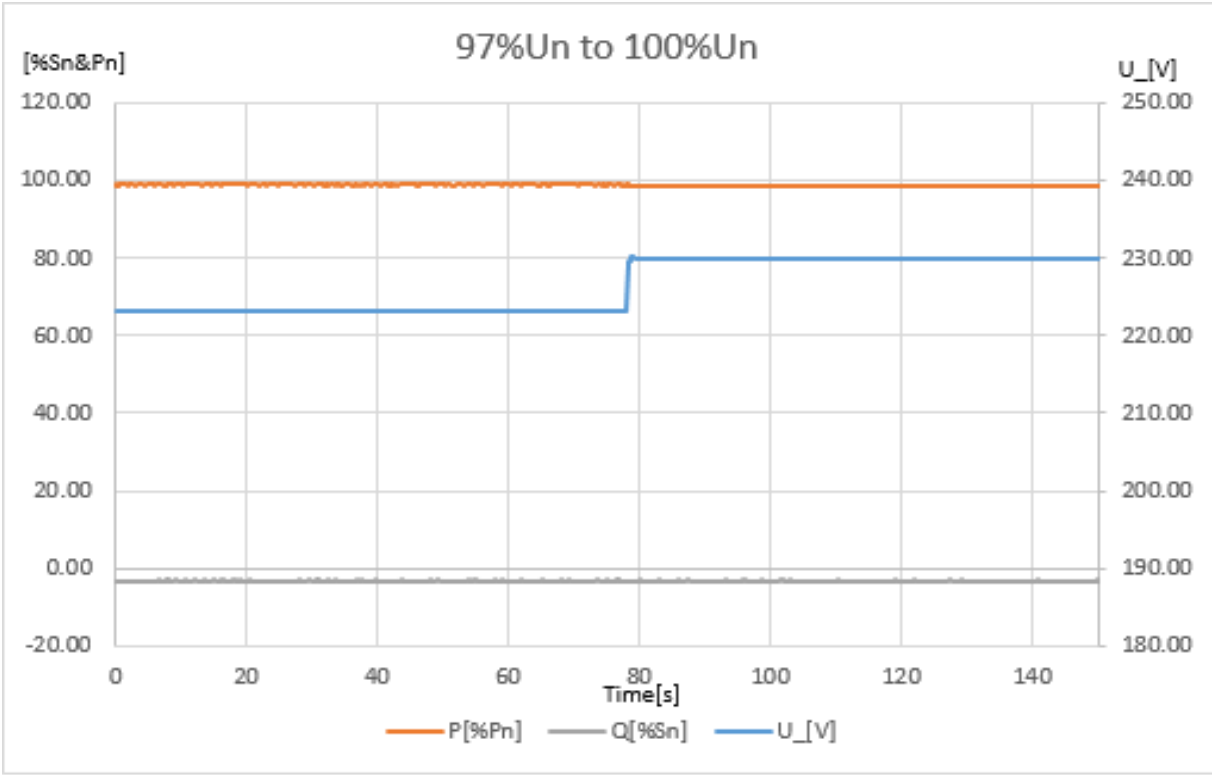
Test steps form 12 to 13



Test steps form 13 to 14



Test steps form 14 to 15



5.3.11	**Protection of set values** The test serves as evidence of the requirements according to TOR Erzeuger, 6.2.3
All parameters are password protected. The behaviour of the system on the mains concerning settings by software updates is not changed.	

OVE directive R25		
Clause	**Test**	**Result**
5.4	**NS protection**	
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	**P**
5.4	Central NS-protection (VDE AR-N 4105 / VDE 0124-100)	**N/A**
5.4	Integrated NS protection (VDE AR-N 4105 / VDE 0124-100)	**P**
5.4	Interface switch (VDE AR-N 4105 / VDE 0124-100)	**N/A**
5.4	Integrated interface switch (VDE AR-N 4105 / VDE 0124-100)	**P**
5.4	Check of setting values (TOR Erzeuger Typ A)	**P**
5.4.1.1.1	Voltage control Single Phase	**P**
5.4.1.1.1	Voltage control Multi Phase (Phase to N)	**P**
5.4.1.1.1	Voltage control Multi Phase (Phase to Phase)	**P**
5.4.1.1.2	Measuring the rise-in voltage protection as a running 10-minute mean value	**P**
5.4.2.1	Frequency measurement	**P**
5.4	Reporting NS protection (VDE AR-N 4105 / VDE 0124-100)	**P**
5.4	Constructional characteristics of NS protection (VDE AR-N 4105 / VDE 0124-100)	**P**
5.4.3	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT output = 100%)	**P**
	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT output = 66%)	**P**
	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT output = 33%)	**P**
5.5	**Connecting conditions and synchronization**	
5.5.1	Test	**P**
5.6	**Evidence dynamic grid support**	
5.6.1	General	**P**
5.6.3	Test	**P**
5.7	**Test of Ancillary Unit**	
5.7.1	General	**N/A**
5.7.2	Test	**N/A**

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
Mis-wiring with phase	Revesed before start up	230V 0.01A	800V 0.05A	2min	--	230V 0.01A	800V 0.05A	Inverter can not start up. No damage. No hazard.
PV + to PV -	Revesed before start up	230V 0.01A	800V 0.05A	2min	--	230V 0.01A	800V 0.05A	Inverter can not start up. No damage. No hazard.
Battery + to Battery -	Revesed	230V 0.01A	48V 0.05A	2min	--	230V 0.01A	48V 0.05A	DC breaker turned off immediatery. No damage. No hazard.
Battery + to Battery -	Short	230V 0.01A	48V 0.05A	2min	--	230V 0.01A	48V 0.05A	DC breaker turned off immediatery. No damage. No hazard.
Battery	Over charge	230V 44.7A	48V 200A	7hours	--	230V 44.7A	48V 200A	After 7 hours testing, no high temperature. No damage. No hazard.
Battery	Over discharge	230V 43A	48V 218A	7hours	--	230V 43A	48V 218A	Ater testing, no high temperature. No damage. No hazard.
Output	Overload	230V 47.3A	47.4V 251.4A	3.4 hours	--	230V 47.3A	47.4V 251.4A	Inverter normal working, no high temperature. No damage. No hazard.
71-000292-00G PV SPS Q8 (PinD&PinS)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. D69&Q7 damage. No hazard.
71-000292-00G PV SPS Q8 (PinD&PinG)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. Q7&Q8 damage. No hazard.
71-000292-00G PV SPS C94	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. No damage. No hazard.
71-000292-00G PV SPS U21(Pin3&Pin4)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. No damage. No hazard.

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
71-000292-00G PV SPS U21(Pin1)	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. CE1, C11 damage. No hazard.
71-000292-00G GRID SPS Rec1(Pin2&Pin3)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. REC1, REC2 damage. No hazard.
71-000292-00G GRID SPS C74	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. REC1, REC2 damage. No hazard.
71-000292-00G GRID SPS Q18 (PinD&PinS)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. REC1, REC2, Q14 damage. No hazard.
71-000292-00G GRID SPS Q18 (PinD&PinG)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. REC1, REC2, Q14, Q18 damage. No hazard.
71-000292-00G GRID SPS U22(Pin1)	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. CE3, C24 damage. No hazard.
71-000292-00G BAT SPS CE6	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. F2 damage. No hazard.
71-000292-00G BAT SPS Q12(Pin2&Pin3)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. R212, R213, U7 damage. No hazard.
71-000292-00G BAT SPS	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately.

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
C25								No damage. No hazard.
71-000292-00G BAT SPS Q6 (PinD&PinS)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. F2 damage. No hazard.
71-000292-00G BAT SPS Q6 (PinD&PinG)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. Q6, F2 damage. No hazard.
71-000292-00G BUS SOFT STAR D67	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. IGBT18, IGBT21, D24 damage. No hazard.
71-000292-00G BUS SOFT STAR C110	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. IGBT1, IGBT4 damage. No hazard.
71-000292-00G BUS SOFT STAR Q10(PinD&PinS)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. F2 damage. No hazard.
71-000292-00G BUS SOFT STAR Q10(PinD&PinG)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. F2, Q10, R245 damage. No hazard.
71-000292-00G BUS SOFT STAR U17(Pin3&Pin4)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. No damage. No hazard.
71-000292-00G DC fan (near SPS board)	Blocked	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. No damage. No hazard.
71-000292-00G DC fan (near ventilation)	Blocked	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Inverter disconnect from grid immediately. No damage. No hazard.

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
Ventilation	Blanket wrapped	230V 43A	800V 2x6.25A	2min	--	230V 38.695A	800V 11.589A	The PCE power droped to 8.9KW. No damage. No hazard.
71-000293-00G Output current sensor defect CT3(Pin8)	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Error message:"05 ERROR" (Inverter current exceed the upper limit); Inverter was disconnect from grid immediately.
71-000293-00G Output current sensor defect CT2(Pin9)	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.05A	Error message:"05 ERROR" (Inverter current exceed the upper limit); Inverter was disconnect from grid immediately.
71-000293-00G Relay defect RY7(Pin3&Pin4)	Short before start up	230V 0,01A	800V 0.02A	10min	--	230V 0.01A	800V 0.02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY5(Pin3&Pin4)	Short before start up	230V 0,01A	800V 0.02A	10min	--	230V 0.01A	800V 0.02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY2(Pin3&Pin4)	Short before start up	230V 0,01A	800V 0.02A	10min	--	230V 0.01A	800V 0.02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY1(Pin3&Pin4)	Short before start up	230V 0,01A	800V 0.02A	10min	--	230V 0.01A	800V 0.02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY9(Pin3&Pin4)	Short before start up	230V 0,01A	800V 0.02A	10min	--	230V 0.01A	800V 0.02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
71-000293-00G Relay defect RY8(Pin3&Pin4)	Short before start up	230V 0,01A	800V 0.02A	10min	--	230V 0.01A	800V 0.02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY6(Pin3&Pin4)	Short before start up	230V 0,01A	800V 0.02A	10min	--	230V 0.01A	800V 0.02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Relay defect RY4(Pin3&Pin4)	Short before start up	230V 0,01A	800V 0.02A	10min	--	230V 0.01A	800V 0.02A	Error message:"07 ERROR" (relay work abnormal)', Inverter does not start up.
71-000293-00G Grid voltage monitoring R93	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R89	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R13	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R17	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
71-000293-00G Grid voltage monitoring R8	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R4	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R92	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R88	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R18	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R16	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R7	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)';

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
								PV inverter was disconnected from grid immediately.
71-000293-00G Grid voltage monitoring R3	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000297-00G Isolation monitoring defect R56	Open before start up	230V 0,01A	800V 0.02A	2min	--	230V 0.01A	800V 0.02A	Error message:"13 ERROR" (insulation resistance); Inverter does not start up.
71-000297-00G Isolation monitoring R68	Open before start up	230V 0,01A	800V 0.02A	2min	--	230V 0.01A	800V 0.02A	Error message:"13 ERROR" (insulation resistance); Inverter does not start up.
71-000297-00G Isolation monitoring defect R82	Open before start up	230V 0,01A	800V 0.02A	2min	--	230V 0.01A	800V 0.02A	Error message:"13 ERROR" (insulation resistance); Inverter does not start up.
71-000297-00G Isolation monitoring defect R89	Open before start up	230V 0,01A	800V 0.02A	2min	--	230V 0.01A	800V 0.02A	Error message:"13 ERROR" (insulation resistance); Inverter does not start up.
71-000297-00G Isolation monitoring defect R158	Open before start up	230V 0,01A	800V 0.02A	2min	--	230V 0.01A	800V 0.02A	Error message:"13 ERROR" (insulation resistance); Inverter does not start up.
71-000368-00G Grid voltage monitoring defect R1	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
71-000368-00G Grid voltage monitoring defect R 5	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R9	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R13	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R17	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R21	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G RELAY Board R25	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R29	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)';

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
								PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R33	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R37	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R41	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R45	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R2	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R6	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
71-000368-00G Grid voltage monitoring defect R10	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R14	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R18	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R22	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R26	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R30	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R34	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)';

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
								PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R38	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R42	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G Grid voltage monitoring defect R46	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR" (Line voltage is different)'; PV inverter was disconnected from grid immediately.
71-000368-00G DSP lost of control C73	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Inverter was shut down immediately.
71-500375-00G DSP lost of control XL1	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Shutdown immediately, No breakdown
71-500375-00G DSP lost of control C12	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Shutdown immediately, No breakdown
71-500375-00G DSP lost of control C72	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Shutdown immediately, No breakdown
71-500375-00G DSP lost of control XL3	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Shutdown immediately, No breakdown
71-500375-00G	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message: "17 ERROR" (Comminication

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
DSPs communication defect R528								loss between master CPU and slave CPU)', PV inverter was disconnected from grid immediately.
71-500375-00G DSPs communication defect R527	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message: "17 ERROR" (Comminication loss between master CPU and slave CPU)', PV inverter was disconnected from grid immediately.
71-500375-00G Inverter voltage monitoring defect U10(Pin5&Pin6)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Inverter voltage monitoring defect R75	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Inverter voltage monitoring defect U10(Pin9&Pin10)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Inverter voltage monitoring defect R84	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:"36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Grid frequency monitoring defect R93	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message: "04 warning" (Line frequency LOW)',

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
								PV inverter was disconnected from grid immediately.
71-500375-00G Grid frequency monitoring defect U4(Pin8&Pin9)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message: “04 warning” (Line frequency LOW)’, PV inverter was disconnected from grid immediately.
71-500375-00G Grid voltage monitoring defect U11(Pin2&Pin3)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:”36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Grid voltage monitoring defect R101	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:”36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Grid voltage monitoring defect U11(Pin5&Pin6)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:”36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Grid voltage monitoring defect R106	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:”36 ERROR(Line voltage is different), PV inverter was disconnected from grid immediately.
71-500375-00G Gird frequency monitoring defect U81(Pin5&Pin6)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message: “04 warning” (Line frequency LOW)’, PV inverter was disconnected from grid immediately.

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	Functional safety (VDE AR-N 4105 / VDE 0124-100)	P

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
71-500375-00G Gird frequency monitoring defect R119	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message: “04 warning” (Line frequency LOW)’, PV inverter was disconnected from grid immediately.
71-500375-00G Gird frequency monitoring defect U81(Pin2&Pin3)	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message: “04 warning” (Line frequency LOW)’, PV inverter was disconnected from grid immediately.
71-500375-00G Gird frequency monitoring defect R126	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message: “04 warning” (Line frequency LOW)’, PV inverter was disconnected from grid immediately.
71-500375-00G Isolation detection defect U14(Pin9&Pin10)	Short before start-up	230V 0A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:”13 ERROR” (Solar insulation resistance too low)’, PV inverter was disconnected from grid immediately.
71-500375-00G Isolation detection defect R182	Open before start-up	230V 0A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:”13 ERROR” (Solar insulation resistance too low)’, PV inverter was disconnected from grid immediately.
71-500375-00G Isolation detection defect U14(Pin12&Pin13)	Short before start-up	230V 0A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:”13 ERROR” (Solar insulation resistance too low)’, PV inverter was disconnected from grid immediately.

5.4	NS protection	P
The test serves as verification of the reactive power mode according to TOR Erzeuger, 5.3.4. The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1).		
5.4	**Functional safety (VDE AR-N 4105 / VDE 0124-100)**	**P**

FSP POWER MANAGER 10KW

Component No.	Fault	Test condition:		Test time: [min]	Fuse no.[A]	Fault condition:		Result:
		AC	DC			AC	DC	
71-500375-00G Isolation detection defect R187	Open before start-up	230V 0A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message:”13 ERROR” (Solar insulation resistance too low)’, PV inverter was disconnected from grid immediately.
71-500375-00G Residual current monitoring defect R25	Open	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message: “16 ERROR” (GFCI Over), No hazard, PV inverter was disconnected from grid immediately.
71-500375-00G Residual current monitoring defect C52	Short	230V 43A	800V 2x6.25A	2min	--	230V 0.01A	800V 0.02A	Error message: “16 ERROR” (GFCI Over), No hazard, PV inverter was disconnected from grid immediately.

Note:

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

Assessment criterion:

The NS protection must send a shutdown command to the coupling switch.

If the error is detected, the device is switched off within 10 s after error detection.

If the auxiliary voltage fails with the central NS protection or if the control fails with the integrated NS protection, the switch-off command must be given immediately.

5.4	Integrated NS protection (VDE AR-N 4105 / VDE 0124-100)	P
The integrated NS protection is tested in connection with the examination of the entire NS protection chain and switch.		
Note: For test results see Functional safety.		

5.4	**Integrated interface switch (VDE AR-N 4105 / VDE 0124-100)**	**P**
	Test (functional chain integrated NS-protection and integrated interface switch)	**P**
Following monitoring options of an interface switch are valid (a) or (b) or (c):		
(a) Use of an interface switch in which a control voltage must be constantly applied when switched on and which switches off automatically when this voltage is not present. The operational switch-on and switch-off processes is monitored		
The disconnection of the control voltage leads to the instantaneous disconnection of the interface switch.		N/A
A simulated defect during the closing and opening of the interface switch leads to an instantaneous shutdown of the PGU. A restart is not possible.		N/A
A simulated defect of the interface switch after the NS protection as operated leads to an instantaneous shutdown of the PGU. A restart is not possible.		N/A
The switch-off time of the whole reaction chain is within 0,2s.		N/A
(b) The interface switch is switched on and off at least once a day by the NS protection and the proper functioning of the coupling switch is monitored.		
A simulated defect of the interface switch during the daily test leads to an instantaneous shutdown of the PGU. A restart is not possible.		N/A
A simulated defect of the interface switch after the NS protection has operated leads to an instantaneous shutdown of the PGU. A restart is not possible.		N/A
A function for daily switching on and off is available and explained by a manufacturer's declaration.		N/A
(c) Use of the integrated coupling switch and the integrated NA protection for PV and battery converters according to DIN EN 62109 (VDE 0126-14-1).		
The integrated interface switch and NS protection is comply with DIN EN 62109 (VDE 0126-14-1). See IEC 62109-2 test report " LD140506N039-R3"issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-01-16.		P
Note: See test results 5.5.2.1 functional safety.		
The inverter has a galvanic separating break device. The interface switch is short-circuit proof for the maximum short-circuit current of the power generation unit.		
Max. initial short-circuit current of the PGU (power generation unit)	= 14,5 A, 230 Vac	
Max. switching current relay	= 40 A, 277 Vac	

Datasheet of the relay (interface protection relay / Interface switch):

REVISION:A/1 DATE SUBMITTED:2015/01/20

HATF901ASDC12-1-2-4421 40 Amp

c UL us
File No.:E75887

File No.:R 50194653

RoHS Compliant

FEATURES

- The minimum air gap between the two contacts is 2.0mm
- 4000VAC high dielectric strength between contacts and coil

CONTACT RATINGS

Contact Arrangement	1A
Contact Resistance	50mΩ (1A 24VDC)
Contact Material	AgSnO
Contact Rating(Resistive)	40A/277VAC, 30A/28VDC
Max. Switching Voltage	277VAC/28VDC
Max. Switching Current	40A
Max. Switching Power	11080VA/840W
Mechanical Life	1×10^7 operations
Electrical Life	5×10^4 operations

ORDERING INFORMATION

HAT F 901 A S DC12 - 1 - 2 - 4421

- Model
- F:Class F
- 901:PCB Pins Only
- A:SPST-NO
- S:Sealed
- Coil Voltage
- Without Pin 6
- Contact Gap:2=2mm
- Customer Code

CHARACTERISTICS

Insulation Resistance		1000MΩ (at 500VDC)
Dielectric Strength	Between coil & contacts	4000VAC 1min
	Between open contacts	1500VAC 1min
Operate time (at nom. volt.)		≤15ms
Release time (at nom. volt.)		≤10ms
Humidity		98% RH, 40°C
Ambient temperature		-40°C~+105°C
Shock Resistance	Functional	98m/s²
	Destructive	980m/s²
Vibration resistance		10Hz to 55Hz 1.5mm DA
Unit weight		Approx. 36g
Construction		Sealed

Notes:1) The data shown above are initial values.
2) Please find coil temperature curve in the characteristic curved below.

COIL DATA at 25°C

Nominal Voltage VDC	Pick-up Voltage (Max.) VDC	Drop-out Voltage (Min.) VDC	Max. Allowable Voltage VDC	Coil Resistance Ω±10%
12	9.00	1.20	15.6	155

COIL

Coil Power	Approx. 900mW

SAFETY APPROVAL RATINGS

UL&CUL	NO	1HP/120VAC, 2HP/277VAC, 2HP/240VAC 20A/277VAC Ballast, 30A/120VAC Ballast 40A/277VAC Resistive Load *
TüV		40/240VAC(NO), 40/240VAC(NC) 6×10^3 operations* 20A/240VAC/14VDC, 15A/240VAC/14VDC

***Note: If you need this rating, please contact our company.**
For the additional ratings, please contact our company.

This datasheet is for customers' reference. All the specifications are subject to change without notice.

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RELAYS

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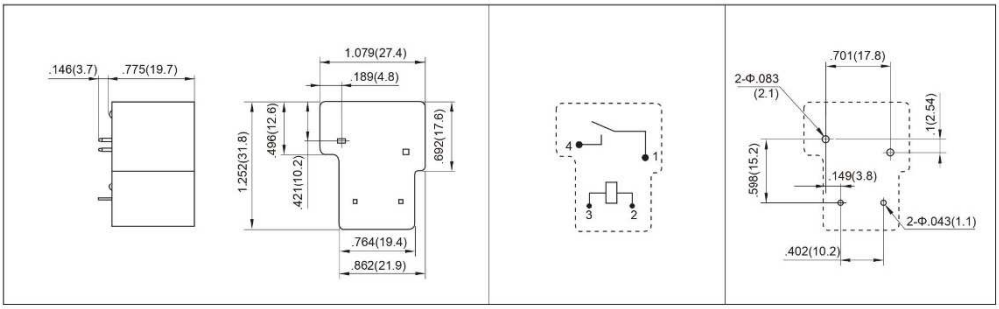
REVISION:A/1 DATE SUBMITTED:2015/01/20

HATF901ASDC12-1-2-4421 40 Amp

OUTLINE DIMENSIONS, WIRING DIAGRAM AND PC BOARD LAYOUT. Unit: inch(mm)

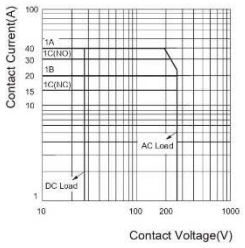
Outline Dimensions | Wiring Diagram (Bottom view) | PCB Layout (Bottom view)



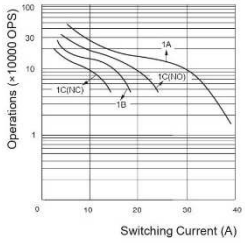
Remark: 1) In case of no tolerance shown in outline dimension: outline dimension ≤1mm,tolerance should be ±0.2mm; outline dimension >1mm and ≤5mm,tolerance should be ±0.3mm;outline dimension >5mm, tolerance should be ±0.4mm.
2) The tolerance without indicating for PCB layout is always ±0.1mm.

CHARACTERISTIC CURVES

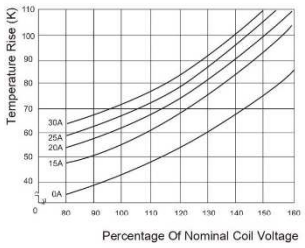
MAXIMUM SWITCHING POWER



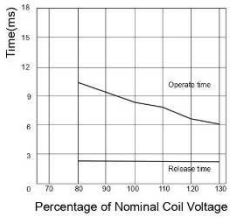
ENDURANCE CURVE



COIL TEMPERATURE RISE



OPERATE TIME / RELEASE TIME



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RELAYS

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5.4	Check of setting values (TOR Erzeuger)	P
	Test	P

FSP POWER MANAGER 10KW

Setting values check TOR Erzeuger Typ A

PGU type	Description	Parameter name	Set value in p.u.	Set value L-N	Set value L-L
	nominal voltage	U_n	1	230,0 V	400 V
	Nominal frequency	f_n	1	50 Hz	50 Hz
Name of country setting in inverter “Austria” (Parameter setup name in manual or software)					
Inverter with limited dynamihc grid support according to Tor Erzeuger Typ A 5.2.2.1	Excitation threshold U>>	AU>>	1,15	264,5V	458,1V
	Delay time U>>	tU>>	-	0,1s	0,1s
	Excitation threshold U>	AU>	1,11	255,3V	442,2V
	Delay time U> * 1)	tU>	-	0,1s *1)	0,1s *1)
	Excitation threshold U<	AU<	0,8	184,0 V	318,7V
	Delay time U<	tU<	-	1,5s	1,5s
	Excitation threshold U<<	AU<<	0,25	57,5V	99,6V
	Delay time U<<	tU<<	-	0,5s	0,5s
	Excitation threshold f>	Af>	1,03	51,5Hz	51,5Hz
	Delay time f>	tf>	-	0,1s	0,1s
	Excitation threshold f<	Af<	0,95	47,5Hz	47,5Hz
	Delay time f<	tf<	-	0,1s	0,1s

*1) 10-min mean value

Factory settings correspond to the values stated.	Yes
There are no factory settings. The information on the setting values in the instructions manual correspond to those stated.	No
External NS protection: settings and delay times are password protected settable	N/A
External NS protection: It is possible to read the setting values without a tool	N/A
Integrated NS protection: the setting values are visible via a data interface or display	Yes

Assessment criterion:

The exam is passed if the following points are met:

The setting values that can be changed according to Tor Erzeuger Typ A and can be set within the specified limits and are protected against unauthorized access.

5.4.1.1.1	Voltage control (Inverters with automatic disconnection device)					P
NS protection single phase ≤30kVA (phase to neutral)						
Setting values of the NS protection:	Setting	Value [V]	Time [ms]	Setting	Value [V]	Time [ms]
				U>>	264,5	100
	U<	184,0	1500	U<<	57,5	500
Operating time of the monitoring device:						
L1 to N:						
	Under voltage 1:			**Over voltage 1:**		
Step [V to V]	230,0 to 177,1			230,0 to 271,4		
Limit [V]	184,0			264,5		
Measurement [V]	184,2	184,5	184,4	264,4	264,3	264,4
Deviation trip setting and value [V]	0,2	0,5	0,4	-0,1	-0,2	-0,1
Limit [ms]	1500 ± 100			100 ± 100		
Disconnection time [ms]	1582	1596	1596	197	193	197
Deviation trip setting and time [ms]	82	96	96	97	93	97
	Under voltage 2:					
Step [V to V]	230,0 to 50,6					
Limit [V]	57,5					
Measurement [V]	56,9	56,8	57,0			
Deviation trip setting and value [V]	-0,6	-0,7	-0,5			
Limit [ms]	500 ± 100					
Disconnection time [ms]	536	539	542			
Deviation trip setting and time [ms]	36	39	42			
L2 to N:						
	Under voltage 1:			**Over voltage 1:**		
Step [V to V]	230,0 to 177,1			230,0 to 271,4		
Limit [V]	184,0			264,5		
Measurement [V]	185,2	185,0	185,2	264,8	264,5	264,6
Deviation trip setting and value [V]	1,2	1,0	1,2	0,3	0,0	0,1
Limit [ms]	1500 ± 100			100 ± 100		
Disconnection time [ms]	1598	1598	1596	199	199	197
Deviation trip setting and time [ms]	98	98	96	99	99	97
	Under voltage 2:					
Step [V to V]	230,0 to 50,6					
Limit [V]	57,5					
Measurement [V]	57,9	57,8	57,9			
Deviation trip setting and value [V]	0,4	0,3	0,4			

5.4.1.1.1	Voltage control (Inverters with automatic disconnection device)					P
NS protection single phase ≤30kVA (phase to neutral)						
Setting values of the NS protection:	Setting	Value [V]	Time [ms]	Setting	Value [V]	Time [ms]
				U>>	264,5	100
	U<	184,0	1500	U<<	57,5	500
Operating time of the monitoring device:						
Limit [ms]	500 ± 100					
Disconnection time [ms]	553	554	555			
Deviation trip setting and time [ms]	53	54	55			
L3 to N:						
	Under voltage 1:			**Over voltage 1:**		
Step [V to V]	230,0 to 177,1			230,0 to 271,4		
Limit [V]	184,0			264,5		
Measurement [V]	185,1	185,3	185,3	264,6	264,4	264,5
Deviation trip setting and value [V]	1,1	1,3	1,3	0,1	-0,1	0,0
Limit [ms]	1500 ± 100			100 ± 100		
Disconnection time [ms]	1596	1588	1588	187	199	199
Deviation trip setting and time [ms]	96	88	88	87	99	99
	Under voltage 2:					
Step [V to V]	230,0 to 50,6					
Limit [V]	57,5					
Measurement [V]	56,8	56,8	56,9			
Deviation trip setting and value [V]	-0,7	-0,7	-0,6			
Limit [ms]	500 ± 100					
Disconnection time [ms]	555	556	556			
Deviation trip setting and time [ms]	55	56	56			

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

5.4.1.1.2	Measuring the rise-in voltage protection as a running 10-minute mean value		P
Setting values of the NS protection:	Setting U> [V]	255,3	
	Setting $T_{disconnection\ U>}$ [s]	600	
	Setting $T_{disconnection}$ [ms]	100	
Operating time of the monitoring device:			
FSP POWER MANAGER 10KW			
L1-N:	**Over voltage 10-minute mean value (a):**		
Ramp [start V to stop V]	230,0 → 259,9		
Step size [V]	29,9		
Step length [s]	>600,2		
Limit for disconnection [s]	600		
Measurement [s]	529,5		
Deviation trip setting and time [s]	-70,5		
L1-N:	**Over voltage 10-minute mean value (b):**		
Ramp [start V to stop V]	230,0 → >250,7		
Step size [V]	20,7		
Step length [s]	>600,2		
Limit for reconnection [s]	no disconnection (also after 600s)		
Measurement [s]	N/A, no disconnection		
Deviation trip setting and time [s]	N/A, no disconnection		
L1-N:	**Over voltage 10-minute mean value (c):**		
Ramp [start V to stop V]	246,1 → >264,5		
Step size [V]	18,4		
Step length [s]	>600,2		
Limit for disconnection[s]	225 – 375		
Measurement [s]	279,0		
Deviation trip setting and time [s]	-21,0		
L2-N:	**Over voltage 10-minute mean value (a):**		
Ramp [start V to stop V]	230,0 → 259,9		
Step size [V]	29,9		
Step length [s]	>600,2		
Limit for disconnection [s]	600		
Measurement [s]	520,5		

5.4.1.1.2	Measuring the rise-in voltage protection as a running 10-minute mean value	P
Deviation trip setting and time [s]	-79,5	
L2-N:	**Over voltage 10-minute mean value (b):**	
Ramp [start V to stop V]	230,0 → >250,7	
Step size [V]	20,7	
Step length [s]	>600,2	
Limit for reconnection [s]	no disconnection (also after 600s)	
Measurement [s]	N/A, no disconnection	
Deviation trip setting and time [s]	N/A, no disconnection	
L2-N:	**Over voltage 10-minute mean value (c):**	
Ramp [start V to stop V]	246,1 → >264,5	
Step size [V]	18,4	
Step length [s]	>600,2	
Limit for disconnection[s]	225 – 375	
Measurement [s]	276,0	
Deviation trip setting and time [s]	-24,0	
L3-N:	**Over voltage 10-minute mean value (a):**	
Ramp [start V to stop V]	230,0 → 259,9	
Step size [V]	29,9	
Step length [s]	>600,2	
Limit for disconnection [s]	600	
Measurement [s]	528,0	
Deviation trip setting and time [s]	-72,0	
L3-N:	**Over voltage 10-minute mean value (b):**	
Ramp [start V to stop V]	230,0 → >250,7	
Step size [V]	20,7	
Step length [s]	>600,2	
Limit for reconnection [s]	no disconnection (also after 600s)	
Measurement [s]	N/A, no disconnection	
Deviation trip setting and time [s]	N/A, no disconnection	
L3-N:	**Over voltage 10-minute mean value (c):**	
Ramp [start V to stop V]	246,1 → >264,5	

5.4.1.1.2	Measuring the rise-in voltage protection as a running 10-minute mean value	P
Step size [V]	18,4	
Step length [s]	>600,2	
Limit for disconnection[s]	225 – 375	
Measurement [s]	290,0	
Deviation trip setting and time [s]	-10,0	
Note: *If the setting value is set to 600s, then the disconnection time can be in the range between 225s and 375s. →default threshold: 111% Un. If the threshold is not adjustable than set to 110%Un.		

5.4.2.1	Frequency measurement						P
Setting values of the NS protection:		Setting f< [Hz]			47,50		
		Setting f>[Hz]			51,50		
		Setting $T_{disconnection}$ [ms]			100		
Operating time of the monitoring device							
		Under frequency:			**Over frequency:**		
Ramp [Hz to Hz]		48,00 -> 47,00			51,00 -> 52,00		
Limit [Hz]		47,50			51,50		
Measurement [Hz]		47,51	47,50	47,50	51,51	51,50	51,50
Deviations setting and trip value [Hz]		0,01	0,00	0,00	0,01	0,00	0,00
Limit [ms]		100 ± 100			100 ± 100		
Disconnection time [ms]		110	112	122	85	88	85
Deviation trip setting and time [ms]		10	12	22	-15	-12	-15
Test: Testing of the frequency over protection f> and of the under frequency protection f<. To determine the switch-off time, a ramp must be run at 1Hz/s							
Note: The setting value and the trip value of the frequency may not vary by more than ±0,1% f_n . A total tripping time of the individual protective functions including the intrinsic time of the switching device in the decoupling point of maximum 0,2 s must be achievable be achievable.							

5.4	Reporting NS protection (VDE AR-N 4105 / VDE 0124-100)	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.

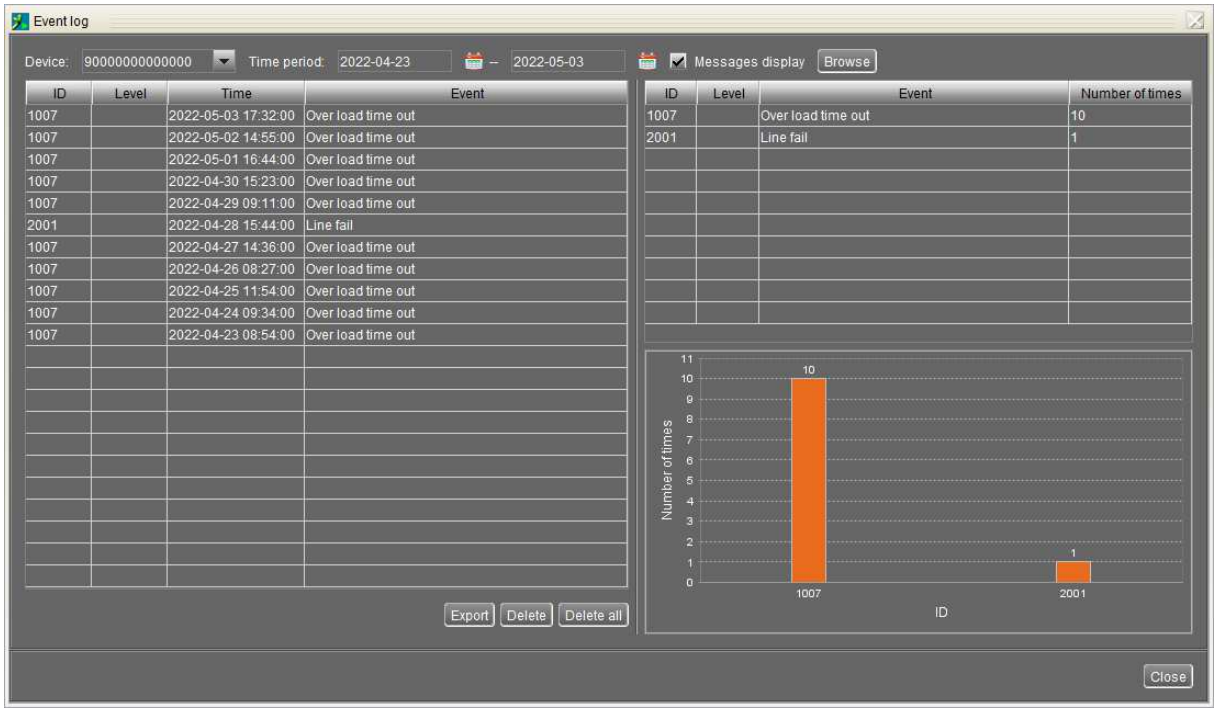
Central NS protection:

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.

Picture of 5 last dated failure:



Assessment criterion:

At least the last 5 error messages including time stamps that were recorded before the voltage interruption and at least 5 error messages including time stamps that were recorded after the voltage interruption must be documented.

Note:

5.4	**Constructional characteristics of NS protection (VDE AR-N 4105 / VDE 0124-100)**	**P**
	General	**P**
These tests serve to demonstrate the requirements of VDE-AR-N 4105: 2018-11, 6.5.2.		
	Test	**P**
Type of NS protection: Internal		
NS-protection is sealed or a password protection is used (or both)		Yes
adjustability of U> and the time delays for U< and U<< is given		Yes
All other protective functions are either permanently protected or protected from unauthorized access by additional, separate protection (example password)		Yes

5.4.3	Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (PGU output = 100%)	P

Test conditions	Frequency: 50 ±1% f_n U_n = 230 ±1%U_n Distortion factor of chokes ≤2%
Disconnection limit	2s (IEC 62116)

FSP POWER MANAGER 10KW

No	P_{PGU} [1] [% of PGU 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_{PGU} [kW per phase]	V_{DC} [V]	Q_f [1]	Run on Time [s]	Remarks [5]
1	100	100	0	0	0,208	3,333	615	1,006	0,174	BL
32	100	100	-10	-10	--	--	--	--	--	IB
33	100	100	-10	-5	--	--	--	--	--	IB
34	100	100	-10	0	--	--	--	--	--	IB
35	100	100	-10	+5	--	--	--	--	--	IB
36	100	100	-10	+10	--	--	--	--	--	IB
37	100	100	-5	-10	--	--	--	--	--	IB
4	100	100	-5	-5	1,319	3,333	615	1,032	0,160	IB
5	100	100	-5	0	1,399	3,333	615	1,059	0,123	IB
6	100	100	-5	+5	1,385	3,333	615	1,085	0,154	IB
38	100	100	-5	+10	--	--	--	--	--	IB
39	100	100	0	-10	--	--	--	--	--	IB
7	100	100	0	-5	0,677	3,333	615	0,981	0,159	IB
8	100	100	0	+5	0,686	3,333	615	1,031	0,130	IB
40	100	100	0	+10	--	--	--	--	--	IB
41	100	100	+5	-10	--	--	--	--	--	IB
9	100	100	+5	-5	0,438	3,333	615	0,934	0,168	IB
10	100	100	+5	0	0,417	3,333	615	0,958	0,123	IB
11	100	100	+5	+5	0,430	3,333	615	0,982	0,155	IB
42	100	100	+5	+10	--	--	--	--	--	IB
43	100	100	+10	-10	--	--	--	--	--	IB
44	100	100	+10	-5	--	--	--	--	--	IB
45	100	100	+10	0	--	--	--	--	--	IB
46	100	100	+10	+5	--	--	--	--	--	IB
47	100	100	+10	+10	--	--	--	--	--	IB

Parameter at 0% per phase	L= 51,98 mH	R= 16,43 Ω	C= 194,92 µF

5.4.3	**Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (PGU output = 100%)**	**P**

Note:

RLC is adjusted to min. +/-1% of the inverter rated output power

1) P_{PGU}: PGU output power

2) P_{AC}: Real power flow at S1 in Figure 1. Positive means power from PGU to utility. Nominal is the 0 % test condition value.

3) Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from PGU 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:

PGU output power P_{PGU} = Maximum 6)

PGU input voltage 6) ≥ 75% of rated input voltage range

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

7) Based on PGU 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 × PGU maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the PGU should not be operated outside of its allowable input voltage range.

The test results base on the test report " PVDE190903N004"issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-01-16.

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

Test conditions	Frequency: 50 ±1% f_n U_n = 230 ±1%U_n Distortion factor of chokes ≤2%
Disconnection limit	2s (IEC 62116)

No	P_{PGU} 1) [% of PGU 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_{PGU} [kW per phase]	V_{DC} [V]	Q_f [1]	Run on Time [s]	Remarks 5)
12	66	66	0	-5	0,470	2,200	510	0,966	0,194	BL
13	66	66	0	-4	0,463	2,200	510	0,971	0,197	IB
14	66	66	0	-3	0,456	2,200	510	0,976	0,179	IB
15	66	66	0	-2	0,450	2,200	510	0,981	0,205	IB
16	66	66	0	-1	0,446	2,200	510	0,986	0,112	IB
2	66	66	0	0	0,305	2,200	510	0,991	0,214	IB
17	66	66	0	1	0,439	2,200	510	0,996	0,193	IB
18	66	66	0	2	0,437	2,200	510	1,001	0,217	IB
19	66	66	0	3	0,436	2,200	510	1,006	0,152	IB
20	66	66	0	4	0,435	2,200	510	1,010	0,182	IB
21	66	66	0	5	0,436	2,200	510	1,015	0,149	IB

Parameter at 0% per phase	L= 76,20 mH	R= 23,72 Ω	C= 132,98 µF

Note:

RLC is adjusted to min. +/-1% of the inverter rated output power

1) P_{PGU}: PGU output power

2) P_{AC}: Real power flow at S1 in Figure 1. Positive means power from PGU to utility. Nominal is the 0 % test condition value.

3) Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from PGU 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:

PGU output power P_{PGU} = 50 % – 66 % of maximum

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

6) Based on PGU 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 × PGU maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the PGU should not be operated outside of its allowable input voltage range.

The test results base on the test report " PVDE190903N004"issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-01-16.

5.4.3	Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (PGU output = 25 % – 33 %)	P

Test conditions	Frequency: 50 ±1% f_n U_n = 230 ±1%U_n Distortion factor of chokes ≤2%
Disconnection limit	2s (IEC 62116)

No	P_{PGU} [1] [% of PGU 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_{PGU} [kW per phase]	V_{DC} [V]	Q_f [1]	Run on Time [s]	Remarks [5]
22	33	33	0	-5	0,229	1,100	384	0,994	0,169	BL
23	33	33	0	-4	0,226	1,100	384	0,999	0,184	IB
24	33	33	0	-3	0,224	1,100	384	1,004	0,167	IB
25	33	33	0	-2	0,222	1,100	384	1,010	0,167	IB
26	33	33	0	-1	0,220	1,100	384	1,015	0,124	IB
3	33	33	0	0	0,218	1,100	384	1,020	0,180	IB
27	33	33	0	1	0,218	1,100	384	1,025	0,271	IB
28	33	33	0	2	0,218	1,100	384	1,030	0,179	IB
29	33	33	0	3	0,218	1,100	384	1,035	0,190	IB
30	33	33	0	4	0,219	1,100	384	1,040	0,146	IB
31	33	33	0	5	0,220	1,100	384	1,045	0,137	IB

Parameter at 0% per phase	L= 163,45 mH	R= 52,38 Ω	C= 61,99 µF

Note:

RLC is adjusted to min. +/-1% of the inverter rated output power

[1] P_{PGU}: PGU output power

[2] P_{AC}: Real power flow at S1 in Figure 1. Positive means power from PGU to utility. Nominal is the 0 % test condition value.

[3] Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from PGU 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:

PGU output power P_{PGU} = 25 % – 33 % [6] of maximum

PGU input voltage [7] < 20 % of rated input voltage range

[6] Or minimum allowable PGU output level if greater than 33 %.

[7] Based on PGU 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 × PGU maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the PGU should not be operated outside of its allowable input voltage range.

The test results base on the test report " PVDE190903N004"issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2020-01-16.

5.5	**Connecting conditions and synchronisation** The connection and synchronization are carried out or monitored by at least one suitable device. This device can be implemented in the control of the PGU or in the automatic activation point (integrated or external) and is according to the TOR generator, section 5.5.2. set and check as follows:	**P**

Connecting conditions for frequencies:			
	f_{ist}	**Reset time:**	**Limit:**
a)	<47,45Hz	No reconnection	No resetting allowed
	Switch to:		
b)	≥47,55Hz	316,0 s	≥300s
c)	>50,15Hz	No reconnection	No resetting allowed
	Switch to:		
d)	≤50,05Hz	319,5 s	≥300s
Connecting conditions for voltages: Phase 1			
	U_n	**Reset time:**	**Limit:**
e)	<84%	No reconnection	No resetting allowed
	Switch to:		
f)	≥86%	317,0 s	≥300s
g)	>110%	No reconnection	No resetting allowed
	Switch to:		
h)	≤108%	314.5 s	≥300s
Connecting conditions for voltages: Phase 2			
	U_n	**Reset time:**	**Limit:**
e)	<84%	No reconnection	No resetting allowed
	Switch to:		
f)	≥86%	319,0 s	≥300s
g)	>110%	No reconnection	No resetting allowed
	Switch to:		
h)	≤108%	312,5 s	≥300s
Connecting conditions for voltages: Phase 3			
	U_n	**Reset time:**	**Limit:**
e)	<84%	No reconnection	No resetting allowed
	Switch to:		
f)	≥86%	321,0 s	≥300s
g)	>110%	No reconnection	No resetting allowed
	Switch to:		
h)	≤108%	310 s	≥300s

Note:

The test is passed if the PGU or the automatic disconnection point can only be switched on within the tolerance bands according to the TOR Erzeuger, Section 5.5.2 and after the voltage and frequency have remained within the tolerance bands after 300s at the earliest.

≥60s ≙ restart and if no error was produced

≥300s ≙ if an error was produced.

5.6	Testing of the dynamic grid support	P
5.6.1	General	
These tests serve to demonstrate the requirements of the requirements regarding robustness and dynamic network support according to TOR producers, Section 5.2. The aim of these tests is to determine whether the test specimen is able to drive through voltage dips undamaged and to behave accordingly. The device under test can be a generation unit (PGU) or a storage system.		

5.6.3	Testing of the dynamic grid support	P
For PGUs asynchronous generator/inverter(1-phase and 3-phase Inverters)		

Load definition		
	requirement	Used for testing
Full load	P_{rE} ±2% P_{rE}	100% P_{rE}
Partial load	0,2·P_{rE} ~ 0,6·P_{rE}	0,3 P_{rE}

Test:

FSP POWER MANAGER 10KW

Test	Voltage Fault depth [p.u. U_n]	Fault type	Fault duration [s]	Load / P-setpoint	Q-setpoint [%P_{rE}]	Test No.	Test 1	Test 2
1	0,15 … 0,25 typical: 0,15	3-phase (type A)	≥0,150 (at U=0,15) ≥0,250 (at U=0,25)	full load	(0 - ±10%) 0	1.1	☒	☒
				partial load		1.2	☒	☒
		2-phase (type D1)		full load		1.3	☒	☒
		2-phase (type D2)		full load		1.3.a	☒	☒
		2-phase (type D1)		partial load		1.4	☒	☒
2	0,50 … 0,60 typical: 0,50	3-phase (type A)	≥0,840 (at U=0,50) ≥1,020 (at U=0,60)	full load	(0 - ±10%) 0	2.1	☒	☒
				partial load		2.2	☒	☒
		2-phase (type D1)		full load		2.3	☒	☒
				partial load		2.4	☒	☒
3	0,85 … 0,90 typical: 0,85	3-phase (type A)	≥60,000	full load	(0 - ±10%) 0	3.1	☒	☒
				partial load		3.2	☒	☒
		2-phase (type D1)		full load		3.3	☒	☒
				partial load		3.4	☒	☒

5.6.3	Testing of the dynamic grid support							P
No load test								
0	0,15 … 0,25 typical: 0,15	3-phase (type A)	≥0,150 (at U=0,15) ≥0,250 (at U=0,25)	No load	0	0.1.1	☒	
		2-phase (type D1)				0.1.2	☒	
		2-phase (type D2)				0.1.3	☒	
	0,50 … 0,60 typical: 0,50	3-phase (type A)	≥0,840 (at U=0,50) ≥1,020 (at U=0,60)			0.2.1	☒	
		2-phase (type D1)				0.2.2	☒	
	0,85 … 0,90 typical: 0,85	3-phase (type A)	≥60,000			0.3.1	☒	
		2-phase (type D1)				0.3.2	☒	

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 60s.

Behavior during the network fault

- No separation of the EZE from the grid during the break-in. If the EZE disconnects from the network, the time of the disconnection must be documented.

- Non-synchronous units and memories must not feed in either an active or a reactive current during a network fault and a voltage at the terminals of the EZE below 0,8 Un. This

The requirement is met if, in the event of a voltage dip or the current fed in by the generating unit and / or the memory 0,06s after the occurrence of this voltage dip / increase

in no phase conductor does not exceed 20% of the rated current Ir and after 0,1s no more than 10% Ir.

Behavior after the end of the error

- No separation of the EZE within 60s after the end of the fault;

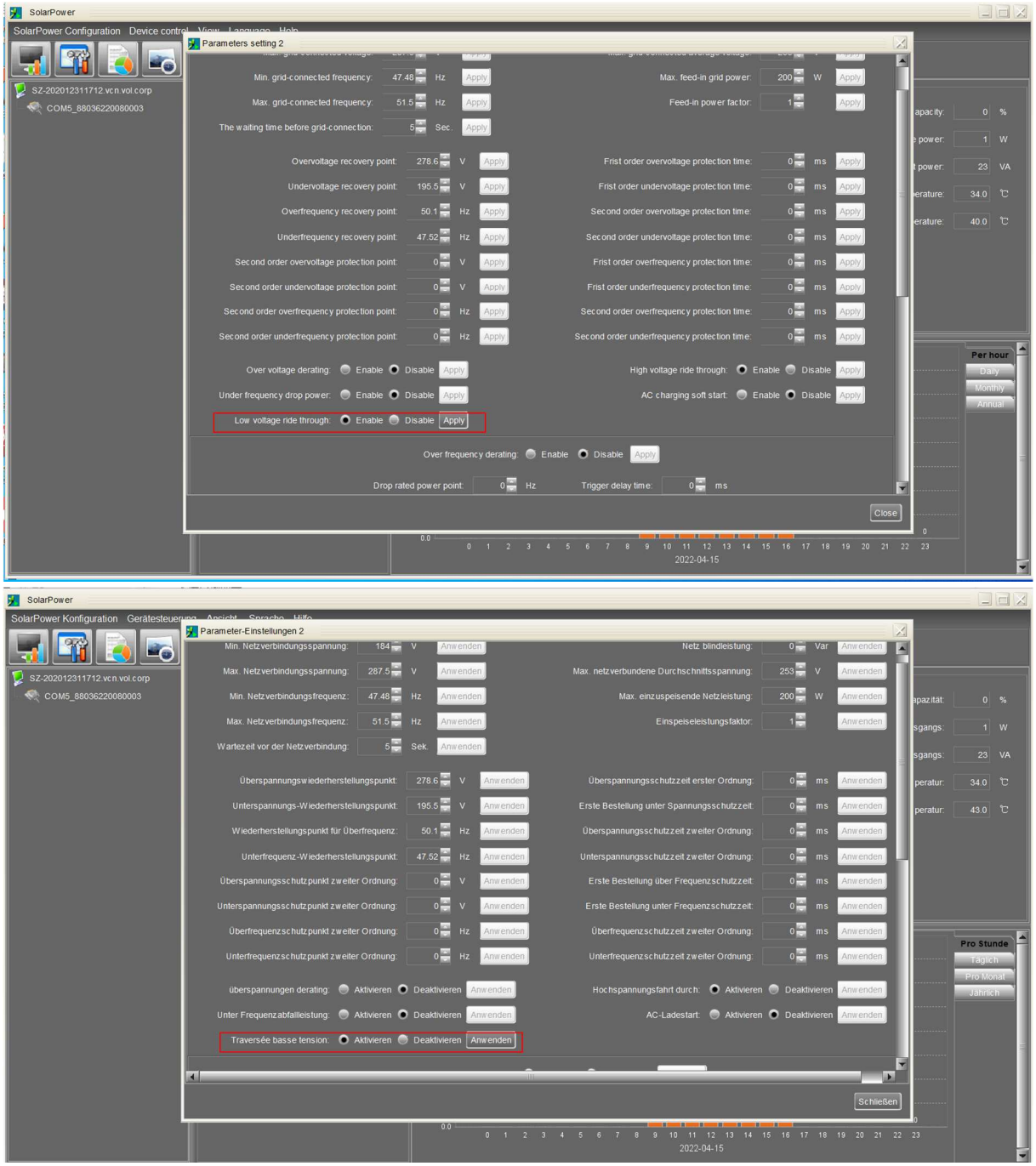
- Synchronous units: Start-up time of the active power maximum 6s;

- Non-synchronous units and memory: Rise time of the active power maximum 1s.

The disconnect device (N/A protection) was disabled during the tests.

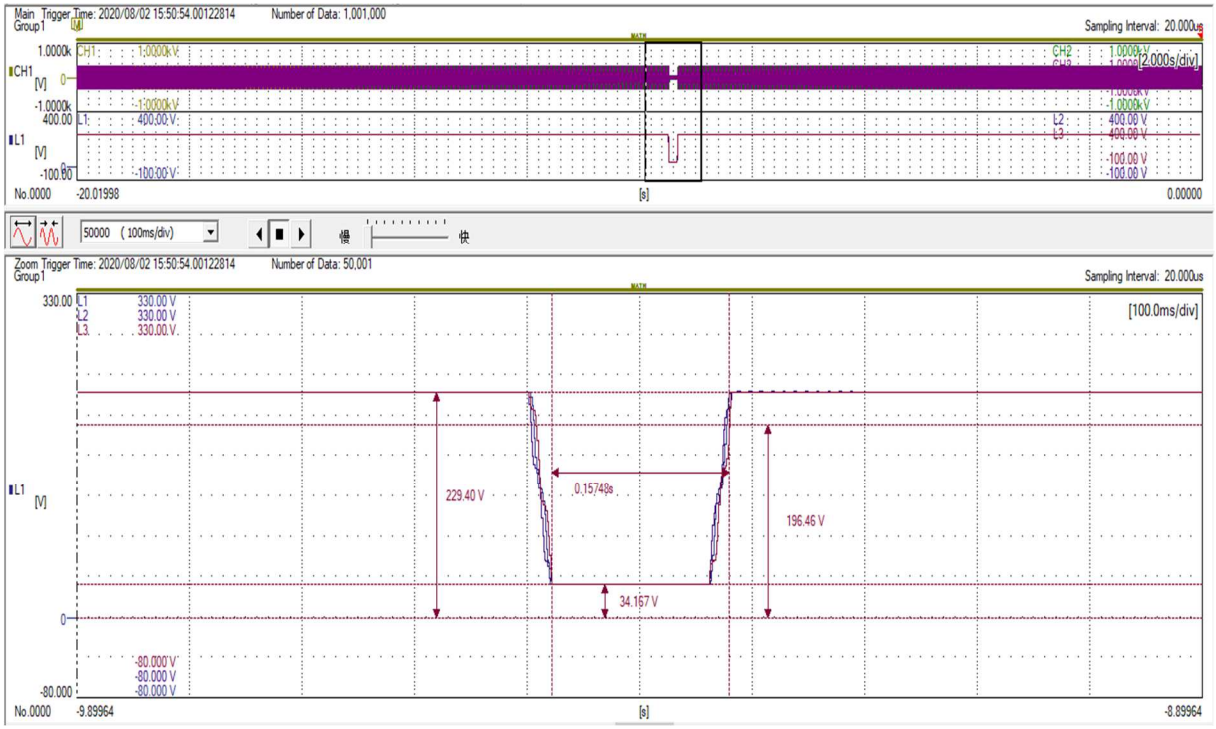
The PGU is set to “LVRT Zero Current Mode” during FRT testing, the below are the setting screenshots for English version and Germany version.

5.6.3	Testing of the dynamic grid support	P

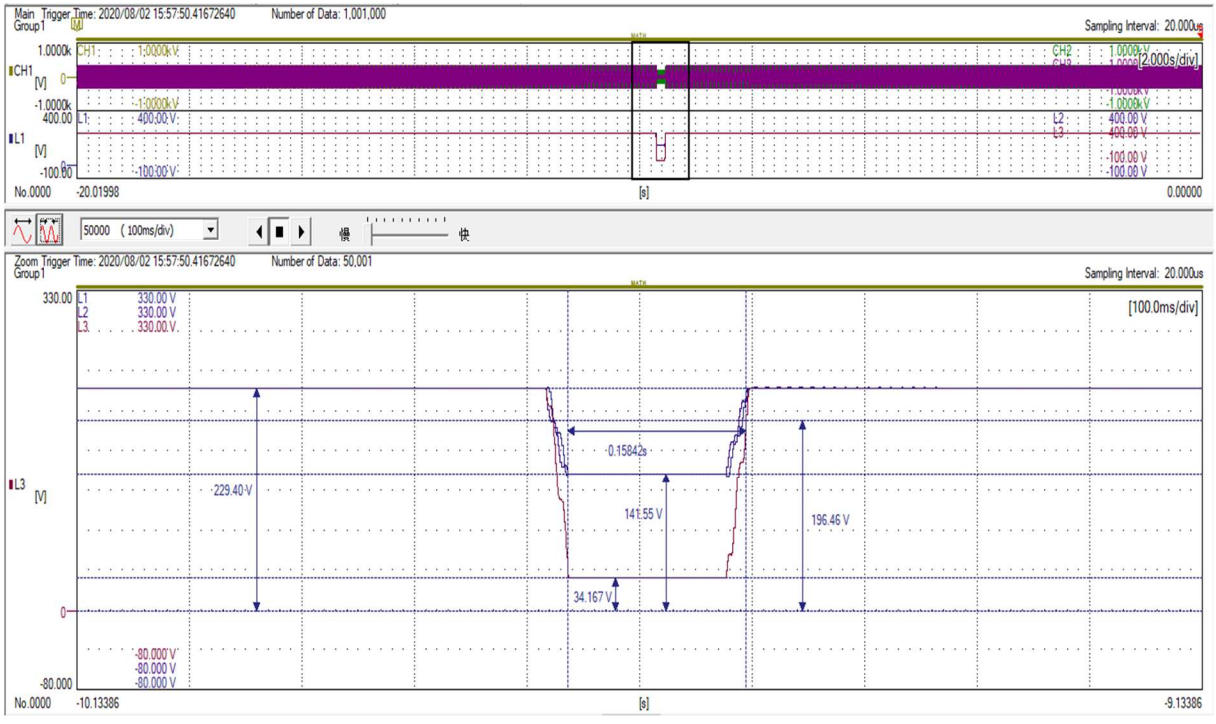


5.6.3	Testing of the dynamic grid support	P

No load test 0.1.1

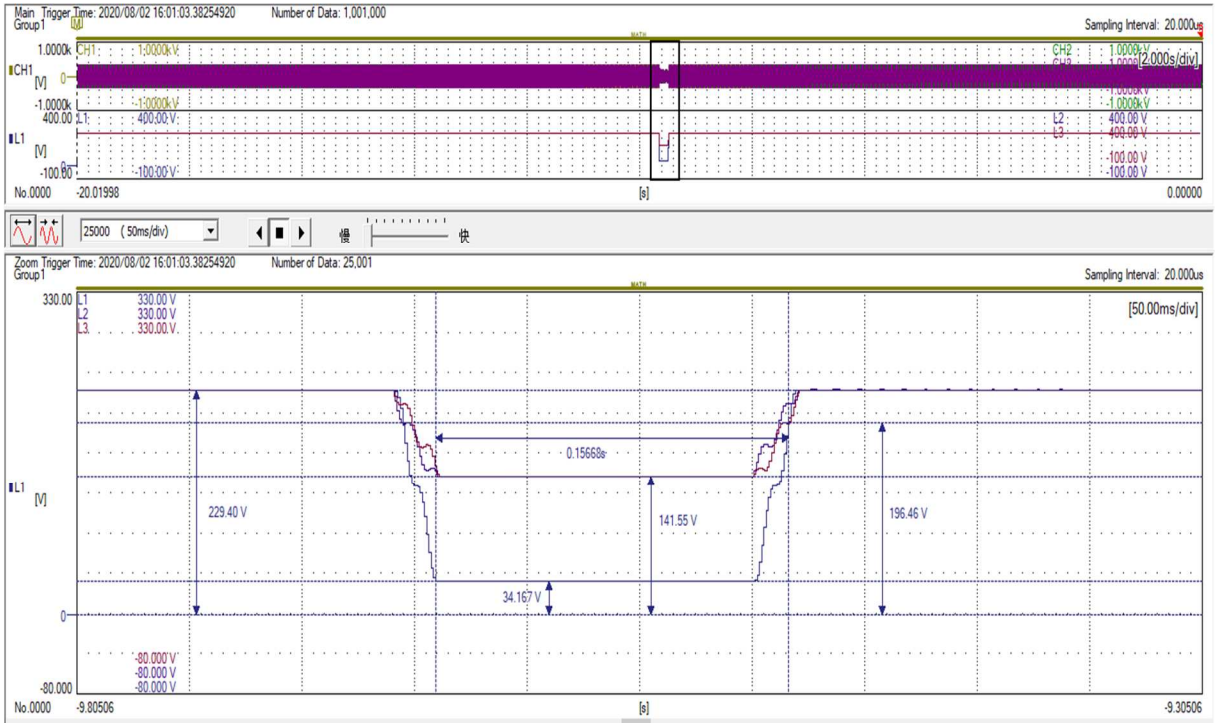


No load test 0.1.2

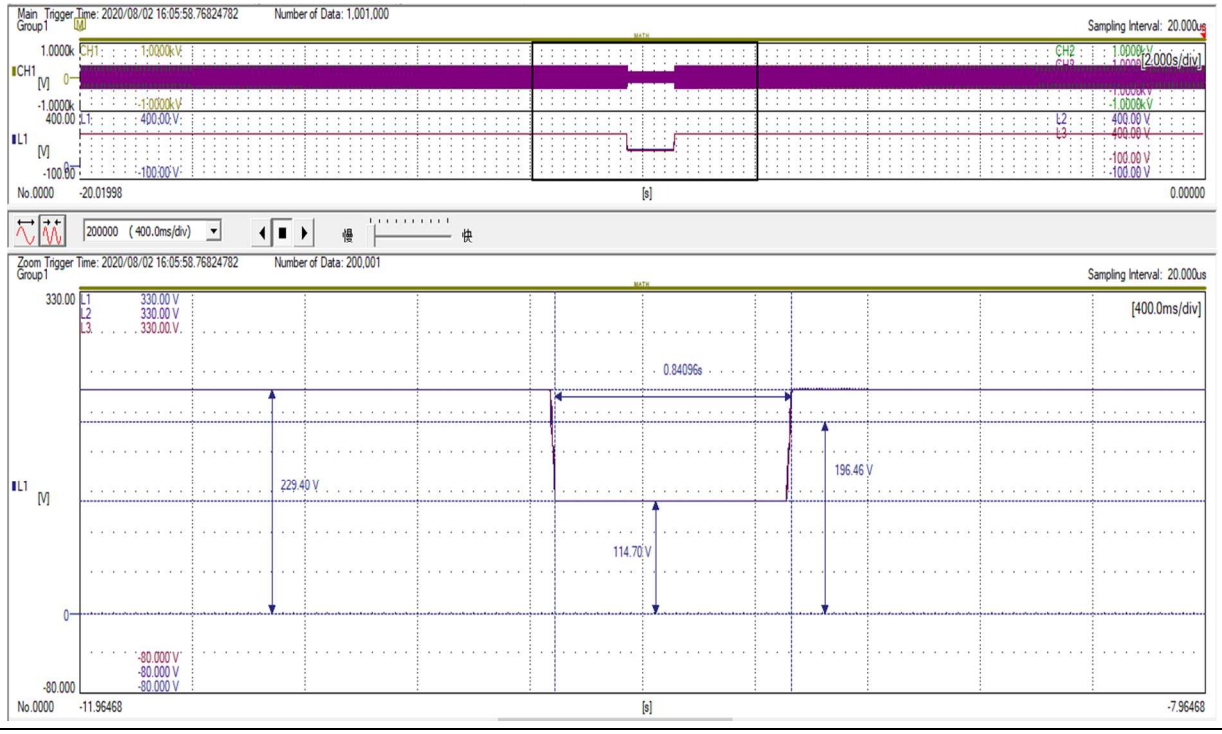


5.6.3	Testing of the dynamic grid support	P

No load test 0.1.3

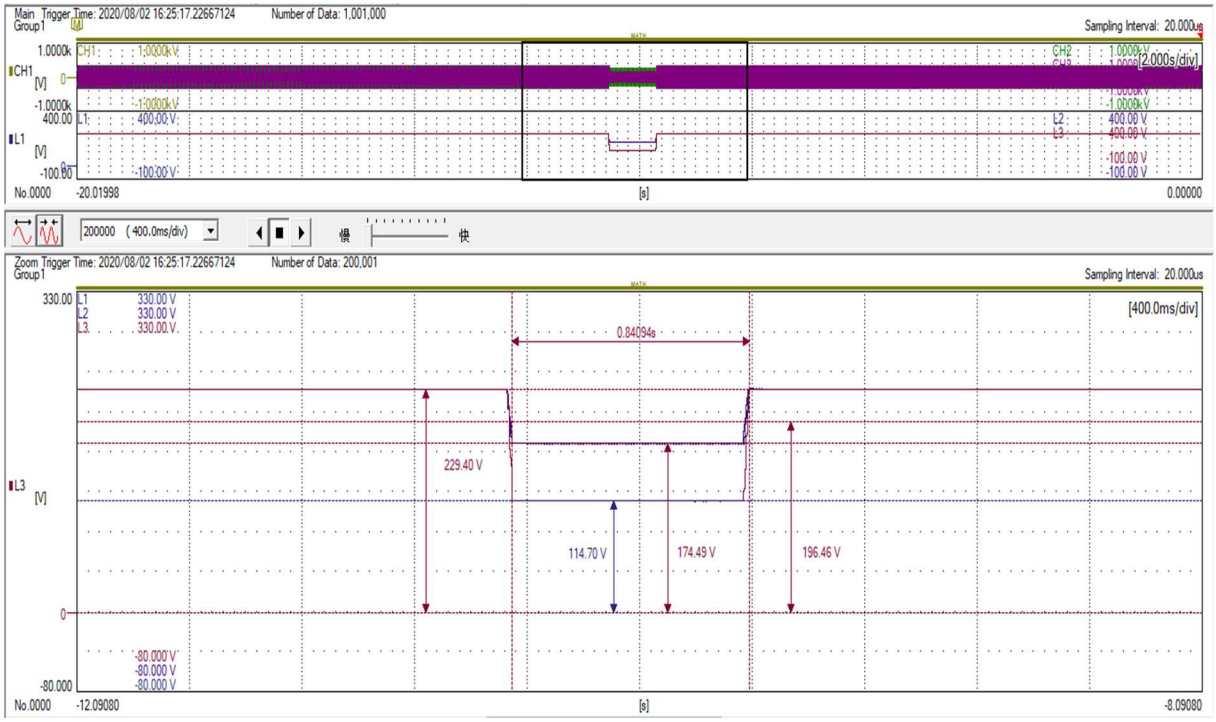


No load test 0.2.1

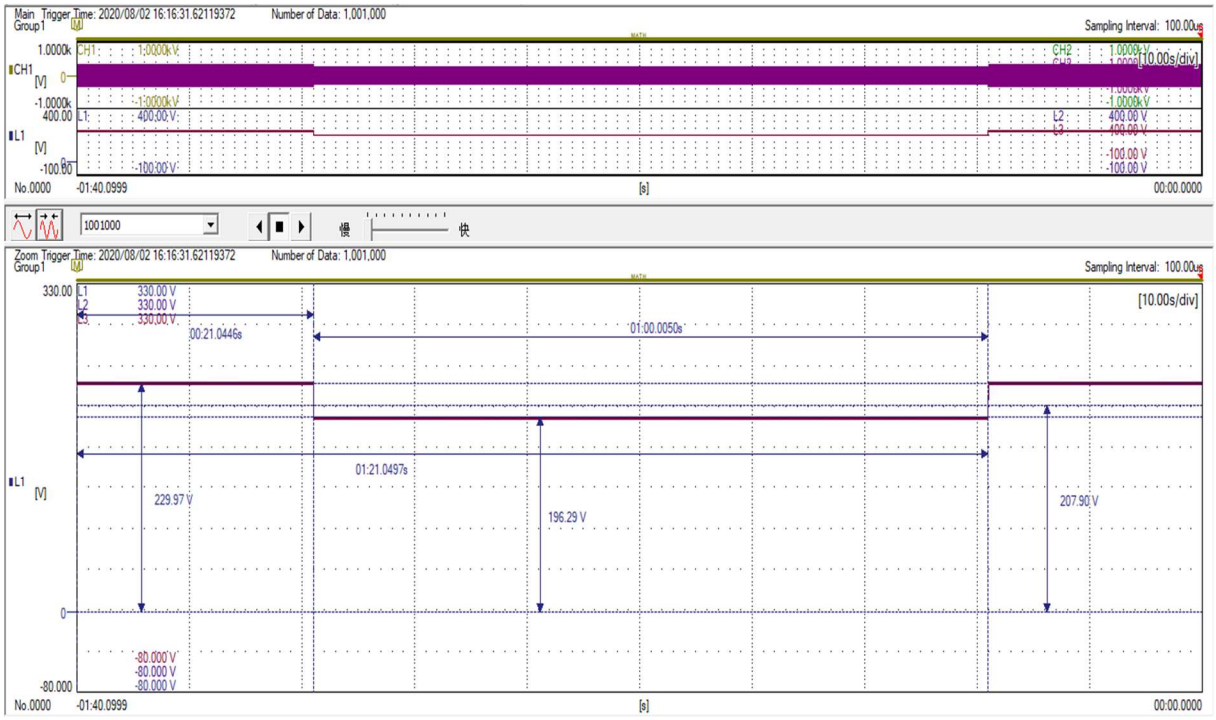


5.6.3	Testing of the dynamic grid support	P

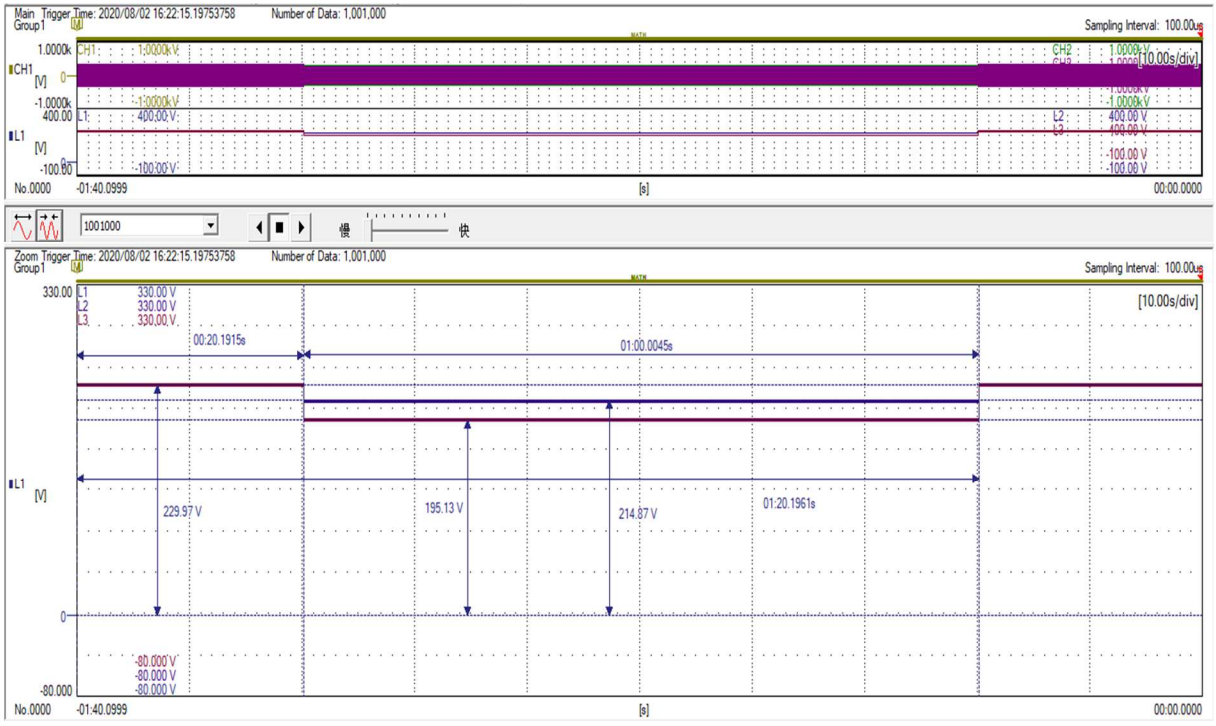
No load test 0.2.2



No load test 0.3.1



5.6.3	Testing of the dynamic grid support	P
	No load test 0.3.2	

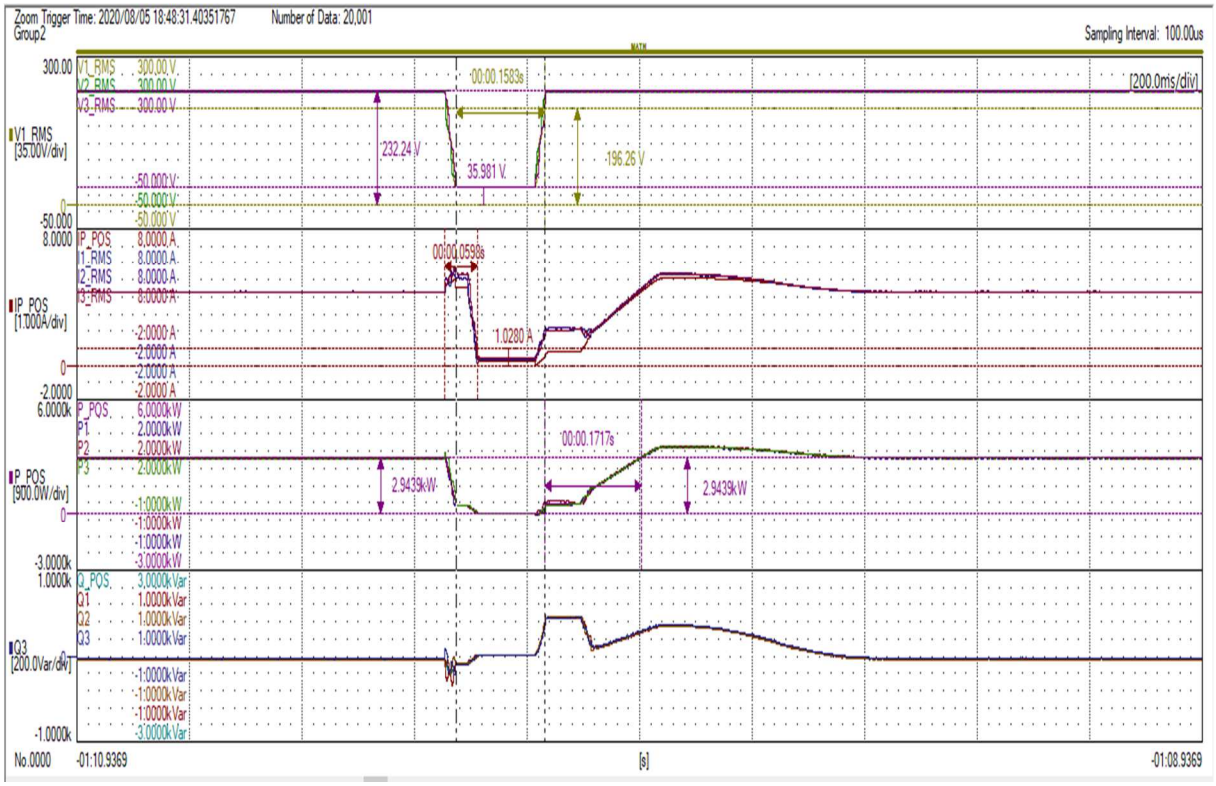


5.6.3	Testing of the dynamic grid support	P

Load tests 1.1

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.1
	1	Date	–	–	[dd.mm.yyyy]	05.08.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	18:51:54
	3	Type of fault (number of affected phases)	–	–	–	A(3)
	4	Drop depth setpoint	Phase	–	[p.u]	0,15
	5	Drop duration setpoint	Total	–	[ms]	150
	6	Fault occurrence ($t1$)	Total	–	[ms]	303007
	7	Fault clearance ($t2$)	Total	–	[ms]	304582
	8	Fault duration determined from test	Total	–	[ms]	157,5
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,149
	10		Positive sequence			0,150
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,99
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,99
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,99
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,04
	16		Total	t_1-10 s to t_1	[p.u.]	0,04
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,15
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,03
	20		Phase 2	t_1+60 ms	[p.u.]	0,03
	21		Phase 3	t_1+60 ms	[p.u.]	0,03
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,03
	23		Phase 2	t_1 +100 ms	[p.u.]	0,03
	24		Phase 3	t_1 +100 ms	[p.u.]	0,03
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,00
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,00
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	30	Response time active power	Positive sequence	-	[s]	0,836
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,05
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,05

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

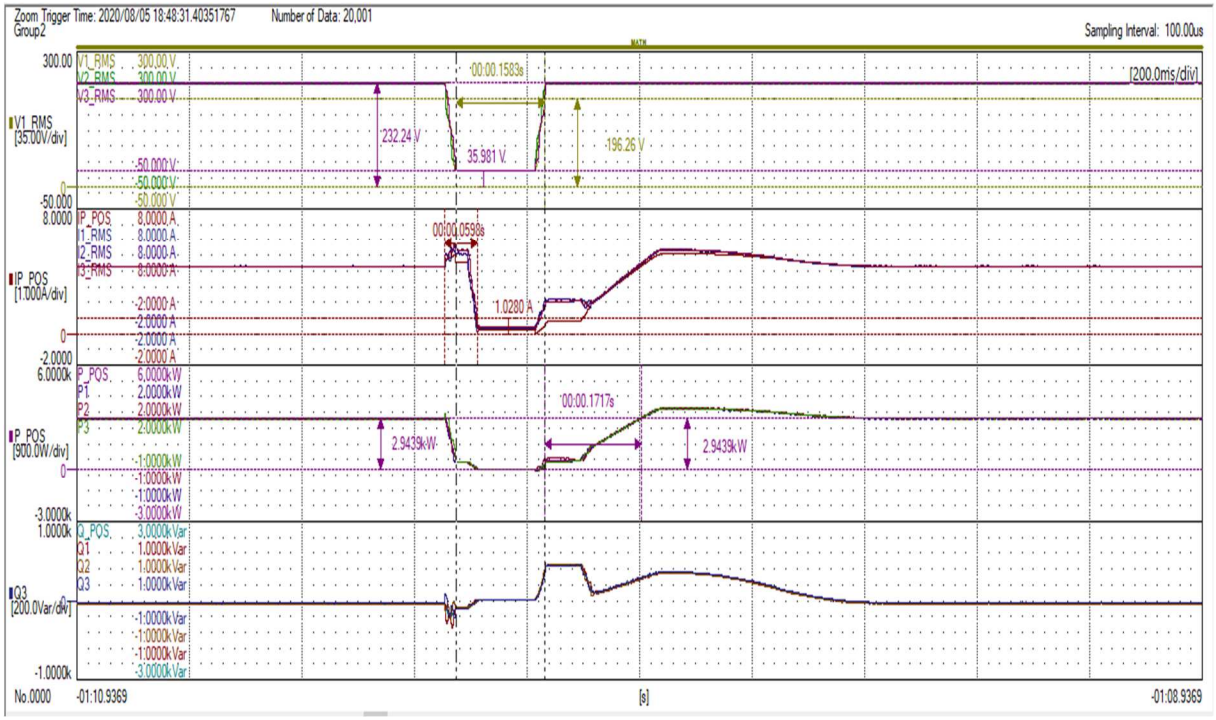


5.6.3	Testing of the dynamic grid support	P

Load tests 1.2

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.2
	1	Date	–	–	[dd.mm.yyyy]	05.08.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	18:48:31
	3	Type of fault (number of affected phases)	–	–	–	A(3)
	4	Drop depth setpoint	Phase	–	[p.u]	0,15
	5	Drop duration setpoint	Total	–	[ms]	150
	6	Fault occurrence ($t1$)	Total	–	[ms]	298367
	7	Fault clearance ($t2$)	Total	–	[ms]	299950
	8	Fault duration determined from test	Total	–	[ms]	158,3
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,150
	10		Positive sequence			0,150
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,29
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,29
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,29
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,03
	16		Total	t_1-10 s to t_1	[p.u.]	0,03
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,15
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,03
	20		Phase 2	t_1+60 ms	[p.u.]	0,03
	21		Phase 3	t_1+60 ms	[p.u.]	0,03
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,03
	23		Phase 2	t_1 +100 ms	[p.u.]	0,03
	24		Phase 3	t_1 +100 ms	[p.u.]	0,03
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,00
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,00
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	30	Response time active power	Positive sequence	-	[s]	0,172
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,03
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,03

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

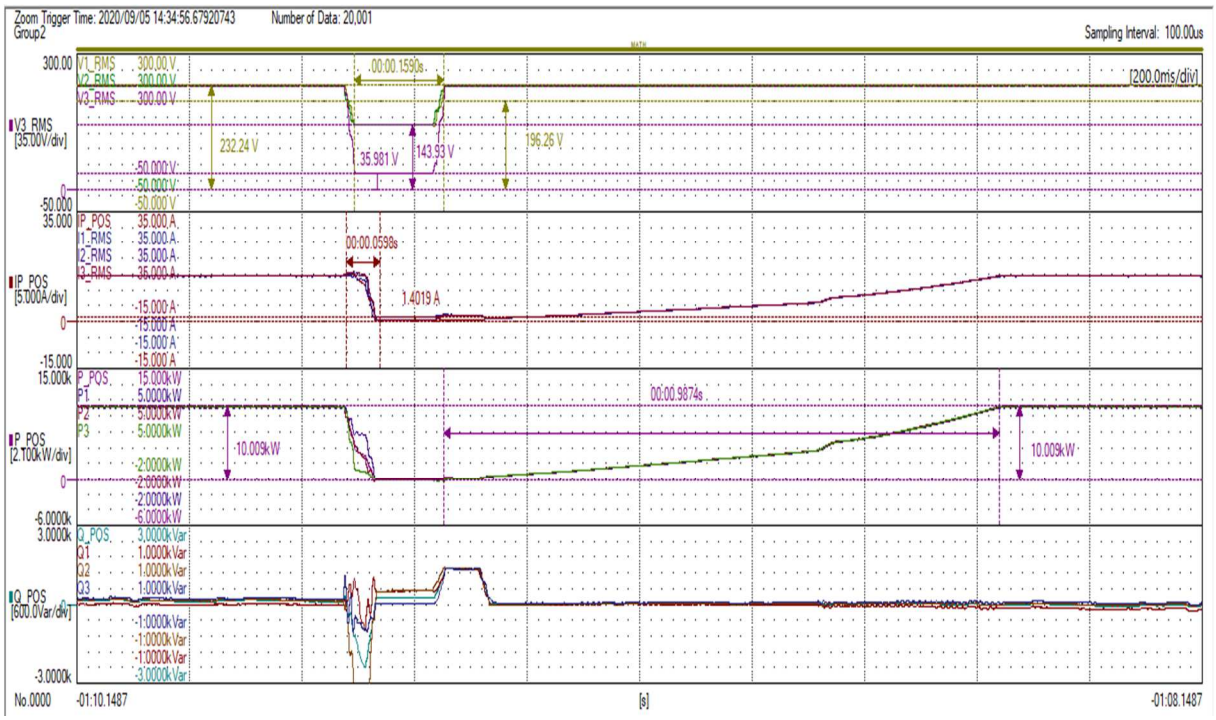


5.6.3	Testing of the dynamic grid support	P

Load tests 1.3

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.3
	1	Date	–	–	[dd.mm.yyyy]	05.09.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	14:34:56
	3	Type of fault (number of affected phases)	–	–	–	D1(2)
	4	Drop depth setpoint	Phase	–	[p.u]	0,15
	5	Drop duration setpoint	Total	–	[ms]	150
	6	Fault occurrence ($t1$)	Total	–	[ms]	304441
	7	Fault clearance ($t2$)	Total	–	[ms]	306031
	8	Fault duration determined from test	Total	–	[ms]	159,0
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,150
	10		Positive sequence			0,429
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,99
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,99
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,99
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,03
	16		Total	t_1-10 s to t_1	[p.u.]	0,03
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,15
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,09
	20		Phase 2	t_1+60 ms	[p.u.]	0,09
	21		Phase 3	t_1+60 ms	[p.u.]	0,02
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,09
	23		Phase 2	t_1 +100 ms	[p.u.]	0,09
	24		Phase 3	t_1 +100 ms	[p.u.]	0,03
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,02
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,01
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	30	Response time active power	Positive sequence	-	[s]	0,987
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,02
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,03

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

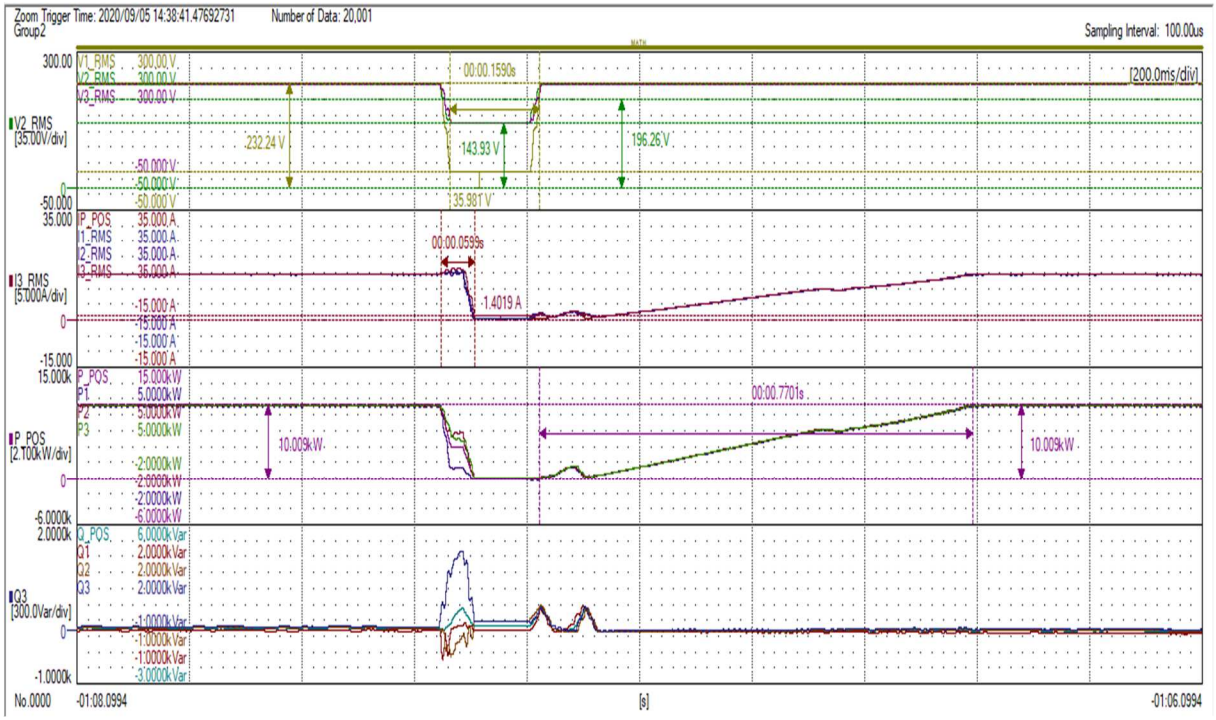


5.6.3	Testing of the dynamic grid support	P

Load tests 1.3.a

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.3a
	1	Date	–	–	[dd.mm.yyyy]	05.09.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	14:38:41
	3	Type of fault (number of affected phases)	–	–	–	D2(2)
	4	Drop depth setpoint	Phase	–	[p.u]	0,15
	5	Drop duration setpoint	Total	–	[ms]	150
	6	Fault occurrence ($t1$)	Total	–	[ms]	326633
	7	Fault clearance ($t2$)	Total	–	[ms]	328223
	8	Fault duration determined from test	Total	–	[ms]	159,0
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,150
	10		Positive sequence			0,429
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,99
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,99
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,99
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,03
	16		Total	t_1-10 s to t_1	[p.u.]	0,04
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,15
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,09
	20		Phase 2	t_1+60 ms	[p.u.]	0,09
	21		Phase 3	t_1+60 ms	[p.u.]	0,02
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,09
	23		Phase 2	t_1 +100 ms	[p.u.]	0,09
	24		Phase 3	t_1 +100 ms	[p.u.]	0,03
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,02
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,03
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	30	Response time active power	Positive sequence	-	[s]	0,770
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,02
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,03

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

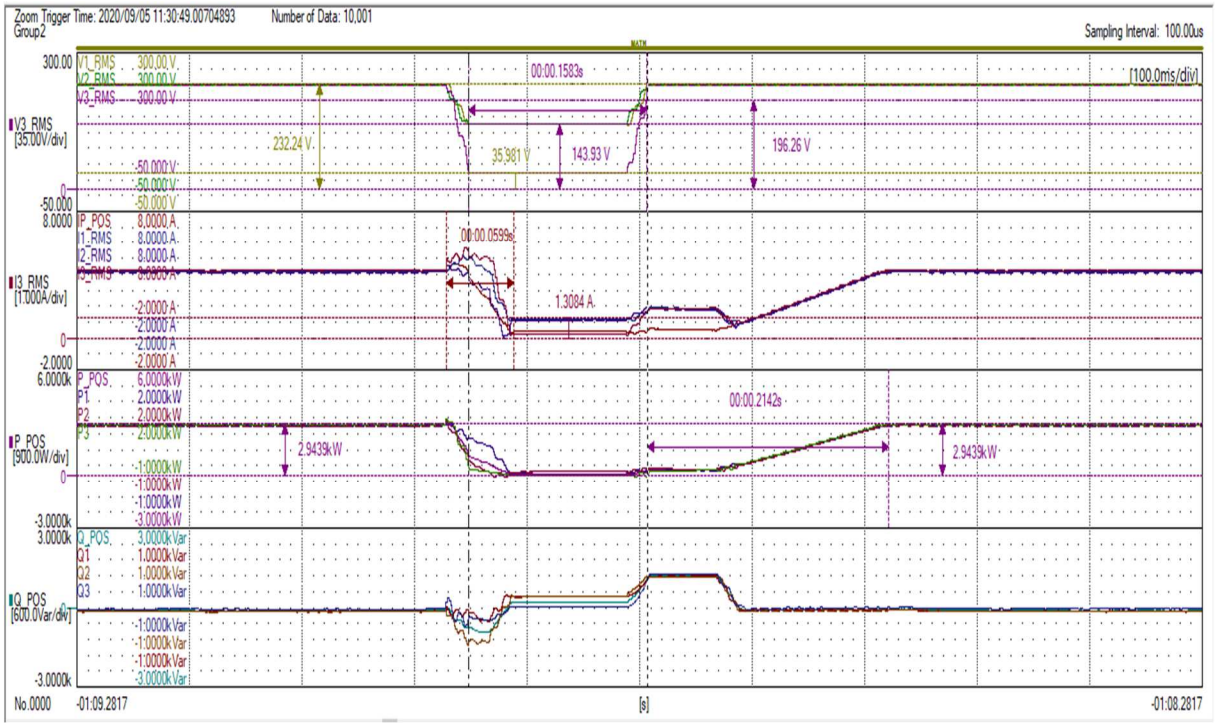


5.6.3	Testing of the dynamic grid support	P

Load tests 1.4

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.4
	1	Date	–	–	[dd.mm.yyyy]	05.09.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	11:30:49
	3	Type of fault (number of affected phases)	–	–	–	D1(2)
	4	Drop depth setpoint	Phase	–	[p.u]	0,15
	5	Drop duration setpoint	Total	–	[ms]	150
	6	Fault occurrence ($t1$)	Total	–	[ms]	311666
	7	Fault clearance ($t2$)	Total	–	[ms]	313249
	8	Fault duration determined from test	Total	–	[ms]	158,3
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,150
	10		Positive sequence			0,429
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,29
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,29
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,29
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,03
	16		Total	t_1-10 s to t_1	[p.u.]	0,03
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,15
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,08
	20		Phase 2	t_1+60 ms	[p.u.]	0,08
	21		Phase 3	t_1+60 ms	[p.u.]	0,02
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,08
	23		Phase 2	t_1 +100 ms	[p.u.]	0,08
	24		Phase 3	t_1 +100 ms	[p.u.]	0,02
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,02
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,01
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	30	Response time active power	Positive sequence	-	[s]	0,214
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,03
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,03

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

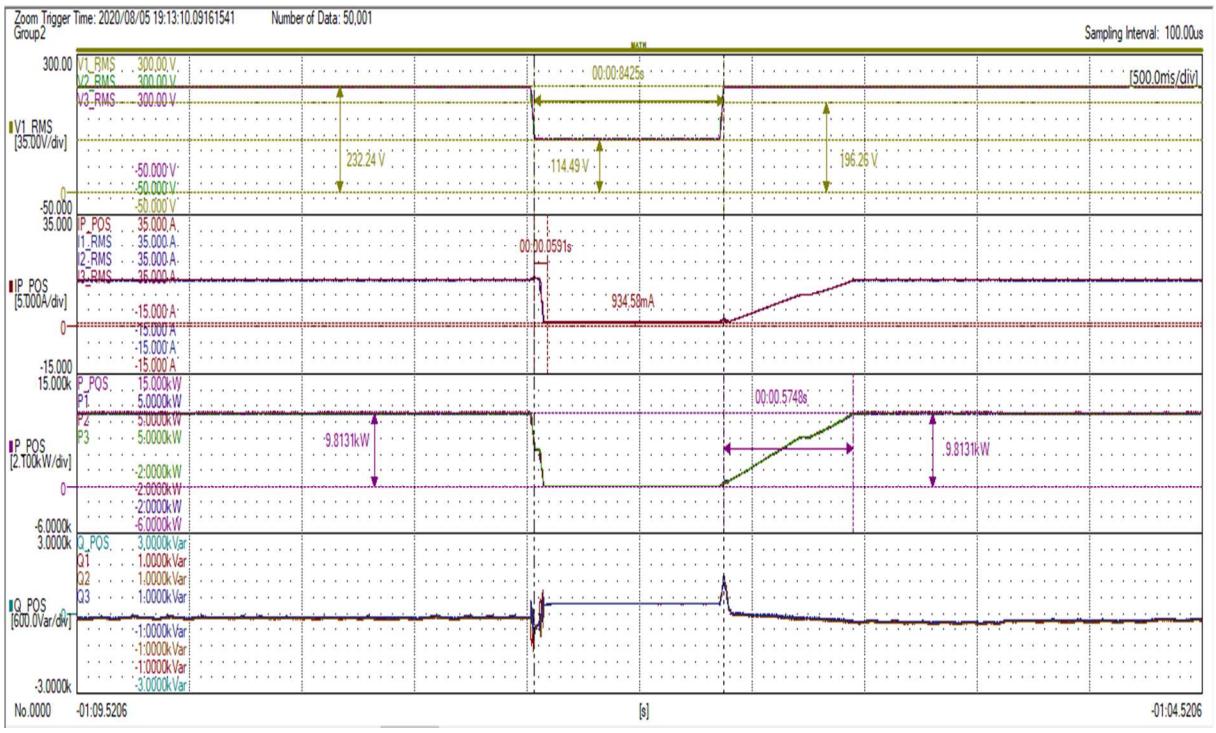


5.6.3	Testing of the dynamic grid support	P

Load tests 2.1

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.1
	1	Date	–	–	[dd.mm.yyyy]	05.08.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	19:13:10
	3	Type of fault (number of affected phases)	–	–	–	A(3)
	4	Drop depth setpoint	Phase	–	[p.u]	0,5
	5	Drop duration setpoint	Total	–	[ms]	840
	6	Fault occurrence ($t1$)	Total	–	[ms]	326111
	7	Fault clearance ($t2$)	Total	–	[ms]	334536
	8	Fault duration determined from test	Total	–	[ms]	842,5
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,498
	10		Positive sequence			0,499
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,99
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,99
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,99
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,04
	16		Total	t_1-10 s to t_1	[p.u.]	0,04
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,50
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,09
	20		Phase 2	t_1+60 ms	[p.u.]	0,09
	21		Phase 3	t_1+60 ms	[p.u.]	0,09
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,09
	23		Phase 2	t_1 +100 ms	[p.u.]	0,09
	24		Phase 3	t_1 +100 ms	[p.u.]	0,09
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,03
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,03
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	30	Response time active power	Positive sequence	-	[s]	0,575
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,05
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,05

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

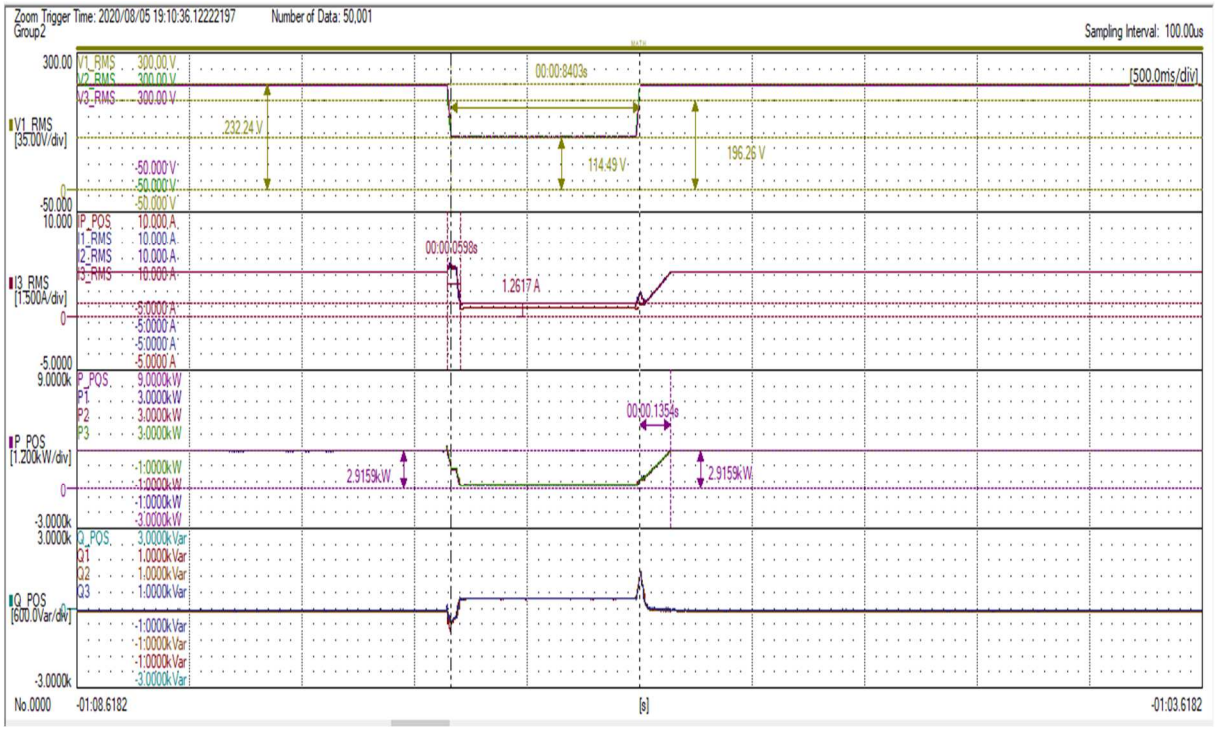


5.6.3	Testing of the dynamic grid support	P

Load tests 2.2

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.2
	1	Date	–	–	[dd.mm.yyyy]	05.08.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	19:10:36
	3	Type of fault (number of affected phases)	–	–	–	A(3)
	4	Drop depth setpoint	Phase	–	[p.u]	0,50
	5	Drop duration setpoint	Total	–	[ms]	840
	6	Fault occurrence ($t1$)	Total	–	[ms]	331419
	7	Fault clearance ($t2$)	Total	–	[ms]	339822
	8	Fault duration determined from test	Total	–	[ms]	840,3
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,498
	10		Positive sequence			0,499
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,29
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,29
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,29
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,03
	16		Total	t_1-10 s to t_1	[p.u.]	0,03
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,50
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,09
	20		Phase 2	t_1+60 ms	[p.u.]	0,09
	21		Phase 3	t_1+60 ms	[p.u.]	0,09
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,09
	23		Phase 2	t_1 +100 ms	[p.u.]	0,09
	24		Phase 3	t_1 +100 ms	[p.u.]	0,09
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,03
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,03
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	30	Response time active power	Positive sequence	-	[s]	0,135
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,03
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,03

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

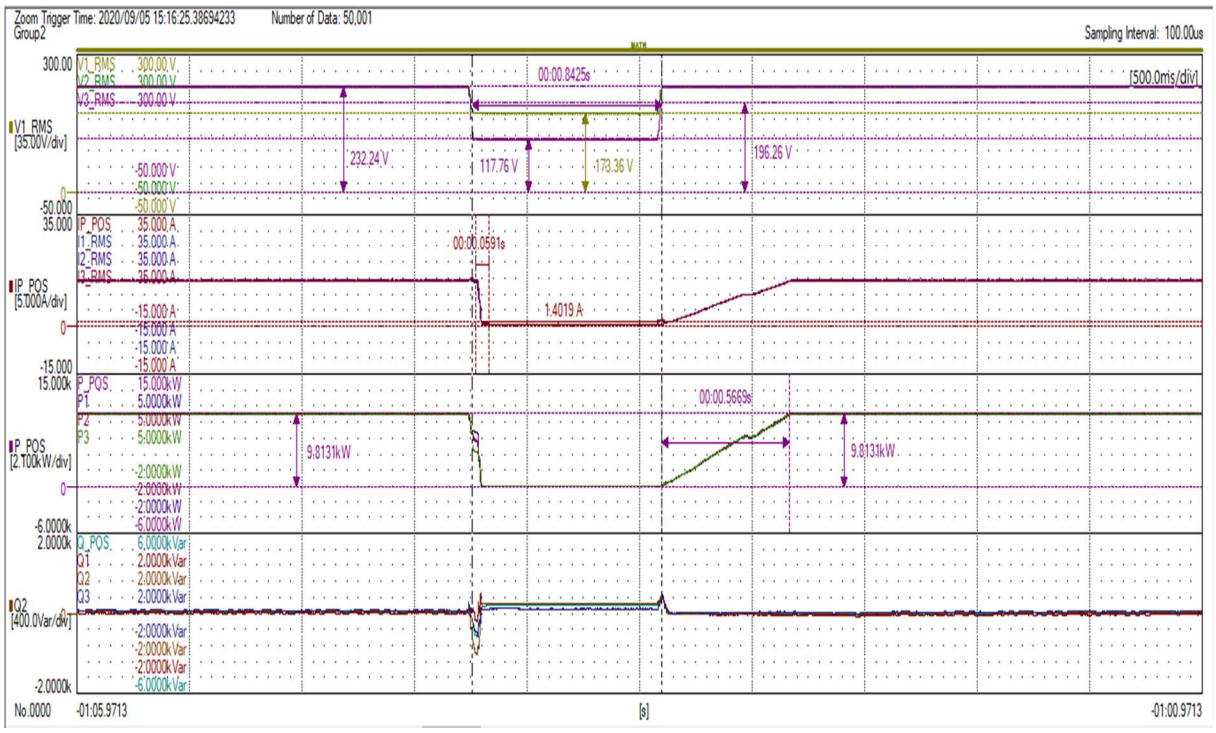


5.6.3	Testing of the dynamic grid support	P

Load tests 2.3

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.3
	1	Date	–	–	[dd.mm.yyyy]	05.09.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	15:16:25
	3	Type of fault (number of affected phases)	–	–	–	D1(2)
	4	Drop depth setpoint	Phase	–	[p.u]	0,50
	5	Drop duration setpoint	Total	–	[ms]	840
	6	Fault occurrence ($t1$)	Total	–	[ms]	358847
	7	Fault clearance ($t2$)	Total	–	[ms]	367272
	8	Fault duration determined from test	Total	–	[ms]	842,5
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,499
	10		Positive sequence			0,655
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,98
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,98
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,98
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,03
	16		Total	t_1-10 s to t_1	[p.u.]	0,03
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,50
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,10
	20		Phase 2	t_1+60 ms	[p.u.]	0,10
	21		Phase 3	t_1+60 ms	[p.u.]	0,08
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,10
	23		Phase 2	t_1 +100 ms	[p.u.]	0,10
	24		Phase 3	t_1 +100 ms	[p.u.]	0,08
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,02
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,02
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,98
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,98
	30	Response time active power	Positive sequence	-	[s]	0,567
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,02
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,03

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

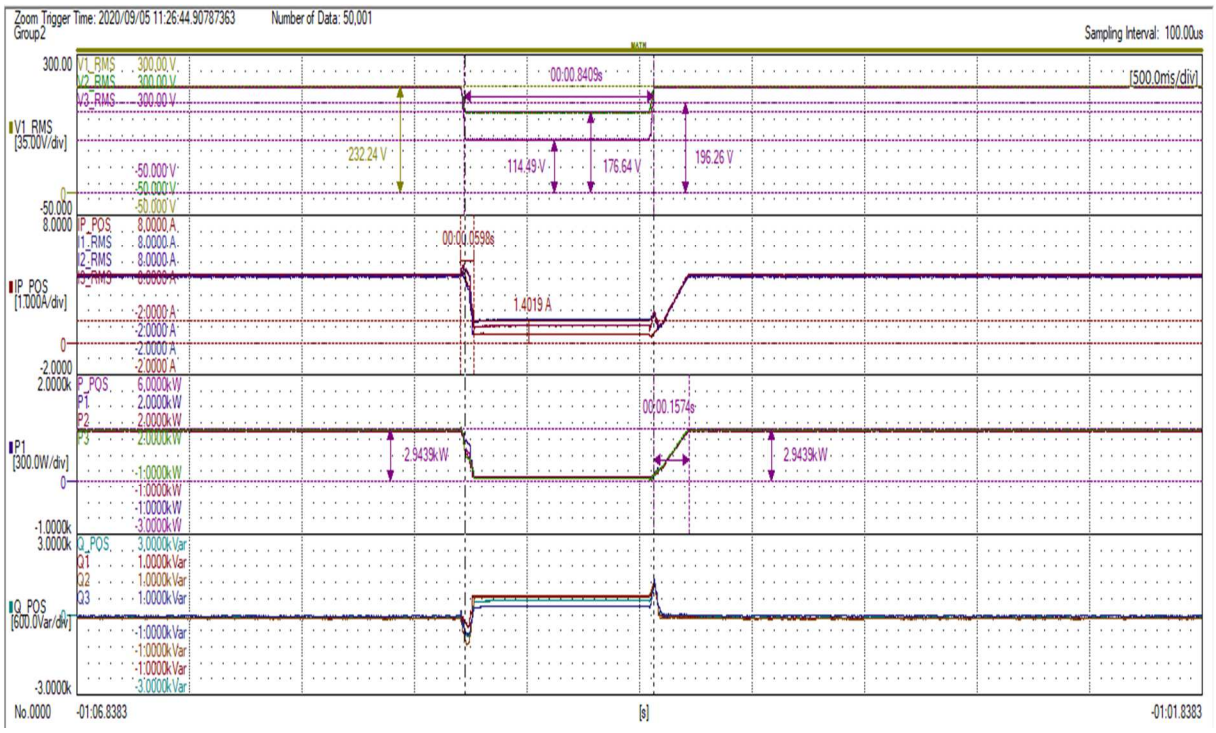


5.6.3	Testing of the dynamic grid support	P

Load tests 2.4

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.4
	1	Date	–	–	[dd.mm.yyyy]	05.09.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	11:26:44
	3	Type of fault (number of affected phases)	–	–	–	D1(2)
	4	Drop depth setpoint	Phase	–	[p.u]	0,5
	5	Drop duration setpoint	Total	–	[ms]	840
	6	Fault occurrence ($t1$)	Total	–	[ms]	349843
	7	Fault clearance ($t2$)	Total	–	[ms]	358252
	8	Fault duration determined from test	Total	–	[ms]	840,9
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,499
	10		Positive sequence			0,663
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,29
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,29
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,29
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,03
	16		Total	t_1-10 s to t_1	[p.u.]	0,03
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,50
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,10
	20		Phase 2	t_1+60 ms	[p.u.]	0,09
	21		Phase 3	t_1+60 ms	[p.u.]	0,07
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,10
	23		Phase 2	t_1 +100 ms	[p.u.]	0,09
	24		Phase 3	t_1 +100 ms	[p.u.]	0,07
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,03
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,03
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	30	Response time active power	Positive sequence	-	[s]	0,157
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,03
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,03

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

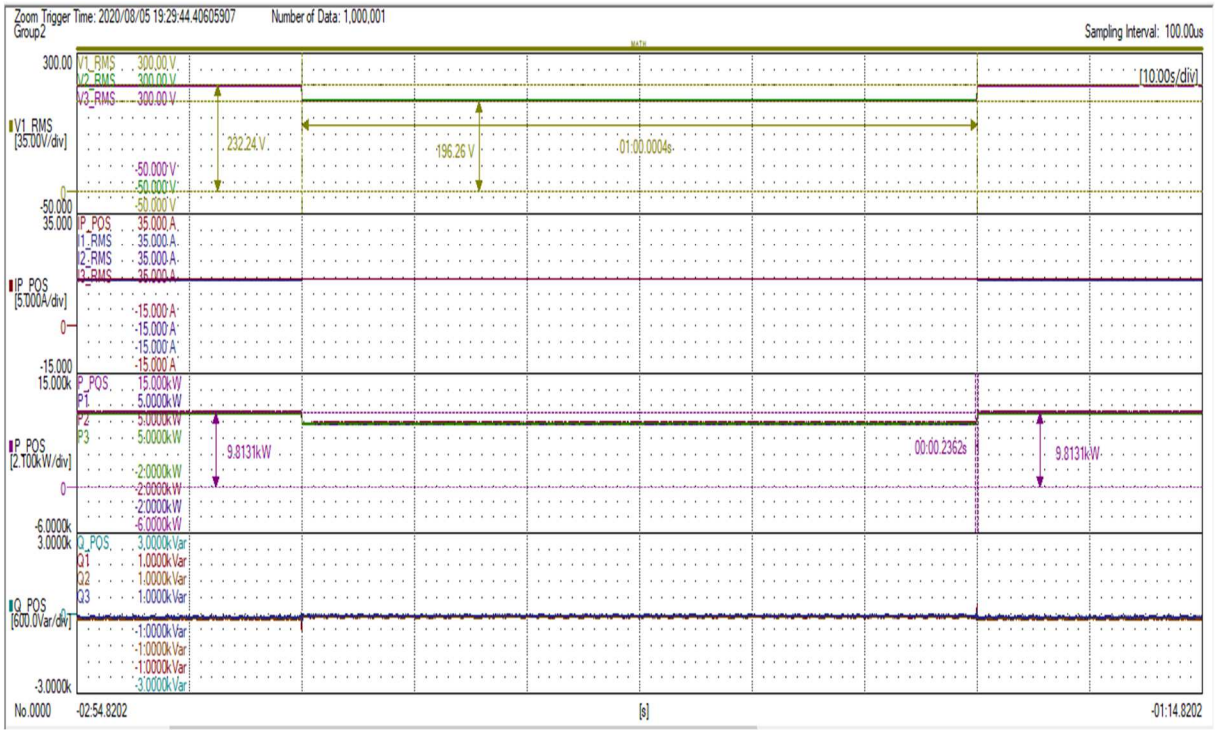


5.6.3	Testing of the dynamic grid support	P

Load tests 3.1

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.1
	1	Date	–	–	[dd.mm.yyyy]	05.08.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	19:29:44
	3	Type of fault (number of affected phases)	–	–	–	A(3)
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence ($t1$)	Total	–	[ms]	453889
	7	Fault clearance ($t2$)	Total	–	[ms]	1053893
	8	Fault duration determined from test	Total	–	[ms]	60000,4
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,850
	10		Positive sequence			0,851
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,99
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,99
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,99
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,04
	16		Total	t_1-10 s to t_1	[p.u.]	0,04
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,85
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,99
	20		Phase 2	t_1+60 ms	[p.u.]	1,00
	21		Phase 3	t_1+60 ms	[p.u.]	1,00
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,99
	23		Phase 2	t_1 +100 ms	[p.u.]	1,01
	24		Phase 3	t_1 +100 ms	[p.u.]	1,00
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,85
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,85
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	30	Response time active power	Positive sequence	-	[s]	0,236
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,04
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,04

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

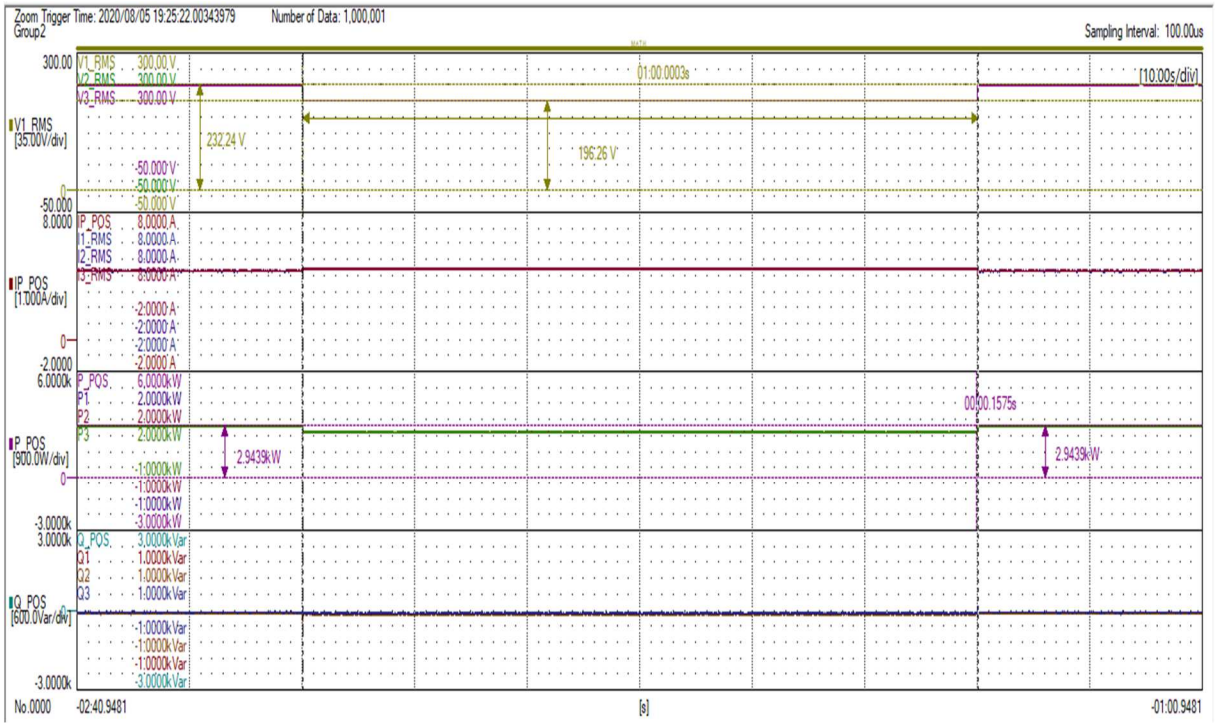


5.6.3	Testing of the dynamic grid support	P

Load tests 3.2

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.2
	1	Date	–	–	[dd.mm.yyyy]	05.08.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	19:25:22
	3	Type of fault (number of affected phases)	–	–	–	A(3)
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence ($t1$)	Total	–	[ms]	593158
	7	Fault clearance ($t2$)	Total	–	[ms]	1193161
	8	Fault duration determined from test	Total	–	[ms]	60000,3
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,848
	10		Positive sequence			0,848
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,29
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,29
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,29
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,03
	16		Total	t_1-10 s to t_1	[p.u.]	0,03
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,85
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,30
	20		Phase 2	t_1+60 ms	[p.u.]	0,30
	21		Phase 3	t_1+60 ms	[p.u.]	0,30
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,30
	23		Phase 2	t_1 +100 ms	[p.u.]	0,30
	24		Phase 3	t_1 +100 ms	[p.u.]	0,30
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,26
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,26
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	30	Response time active power	Positive sequence	-	[s]	0,158
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,03
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,03

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

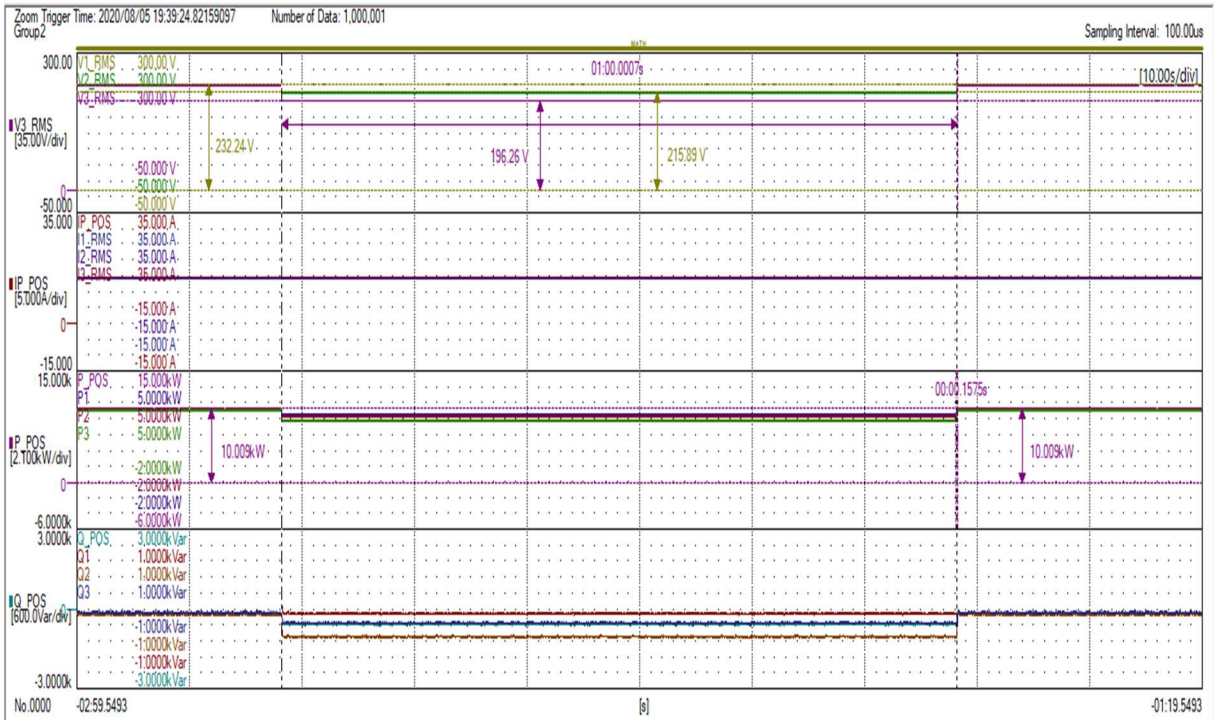


5.6.3	Testing of the dynamic grid support	P

Load tests 3.3

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.3
	1	Date	–	–	[dd.mm.yyyy]	05.08.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	19:39:24
	3	Type of fault (number of affected phases)	–	–	–	D1(2)
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence ($t1$)	Total	–	[ms]	388693
	7	Fault clearance ($t2$)	Total	–	[ms]	988700
	8	Fault duration determined from test	Total	–	[ms]	60000,7
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,850
	10		Positive sequence			0,903
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,99
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,99
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,99
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,04
	16		Total	t_1-10 s to t_1	[p.u.]	0,04
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,85
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,99
	20		Phase 2	t_1+60 ms	[p.u.]	0,98
	21		Phase 3	t_1+60 ms	[p.u.]	0,99
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,99
	23		Phase 2	t_1 +100 ms	[p.u.]	0,98
	24		Phase 3	t_1 +100 ms	[p.u.]	0,99
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,89
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,89
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,99
	30	Response time active power	Positive sequence	-	[s]	0,158
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,04
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,04

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes

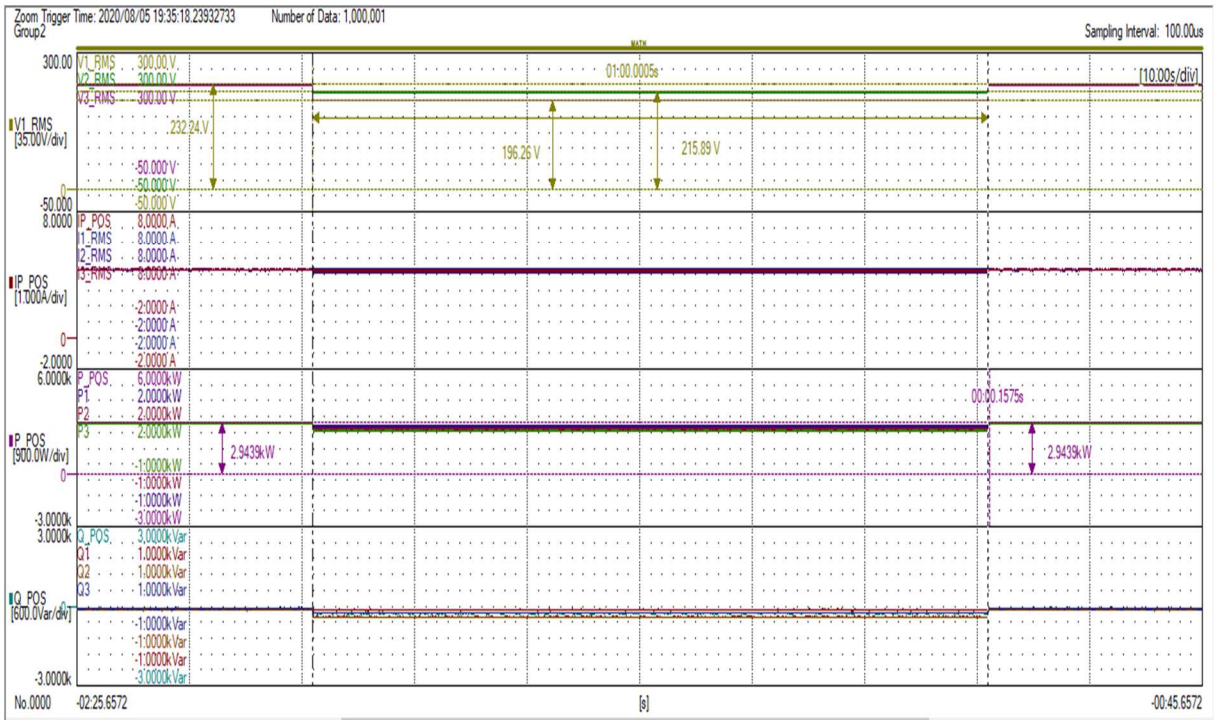


5.6.3	Testing of the dynamic grid support	P

Load tests 3.4

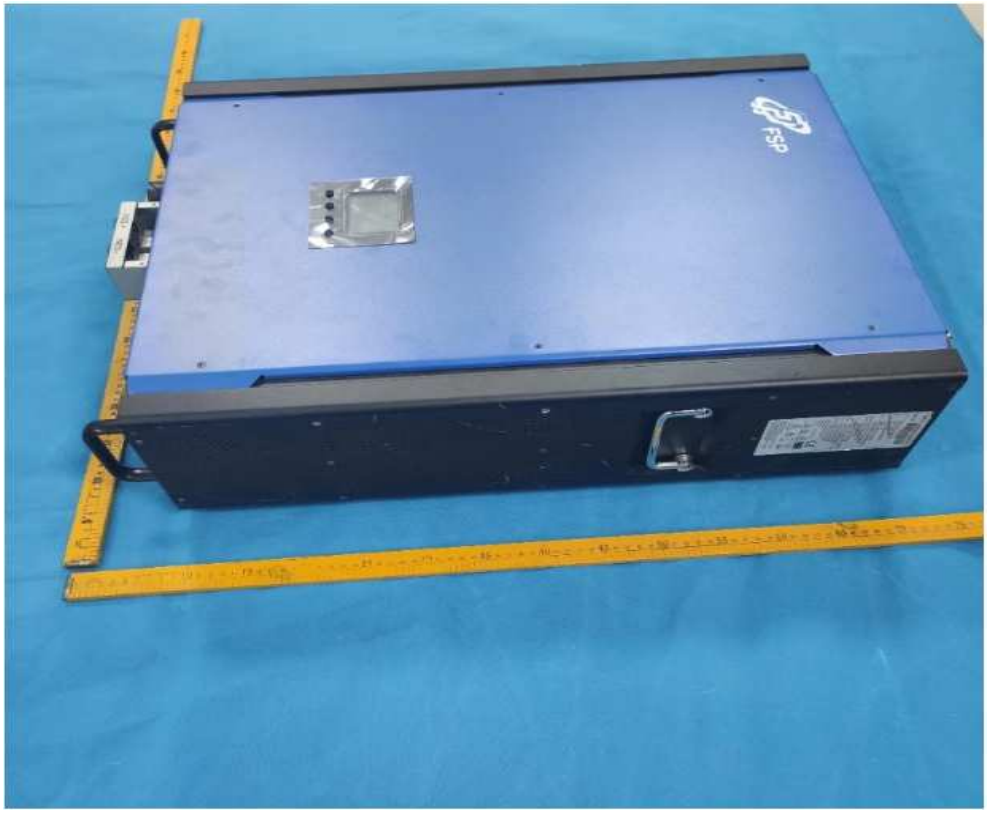
	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.4
	1	Date	–	–	[dd.mm.yyyy]	05.08.2020
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	19:35:18
	3	Type of fault (number of affected phases)	–	–	–	D1(2)
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence ($t1$)	Total	–	[ms]	755125
	7	Fault clearance ($t2$)	Total	–	[ms]	1355130
	8	Fault duration determined from test	Total	–	[ms]	60000,5
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,848
	10		Positive sequence			0,900
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,00
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,29
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,29
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,29
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,03
	16		Total	t_1-10 s to t_1	[p.u.]	0,03
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,00
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,85
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,30
	20		Phase 2	t_1+60 ms	[p.u.]	0,29
	21		Phase 3	t_1+60 ms	[p.u.]	0,30
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,30
	23		Phase 2	t_1 +100 ms	[p.u.]	0,28
	24		Phase 3	t_1 +100 ms	[p.u.]	0,29
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,26
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,26
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,00
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,29
	30	Response time active power	Positive sequence	-	[s]	0,158
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,03
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,03

5.6.3		Testing of the dynamic grid support				P
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn´t disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	yes



Annex No. 1
Pictures of the unit

Enclosure front



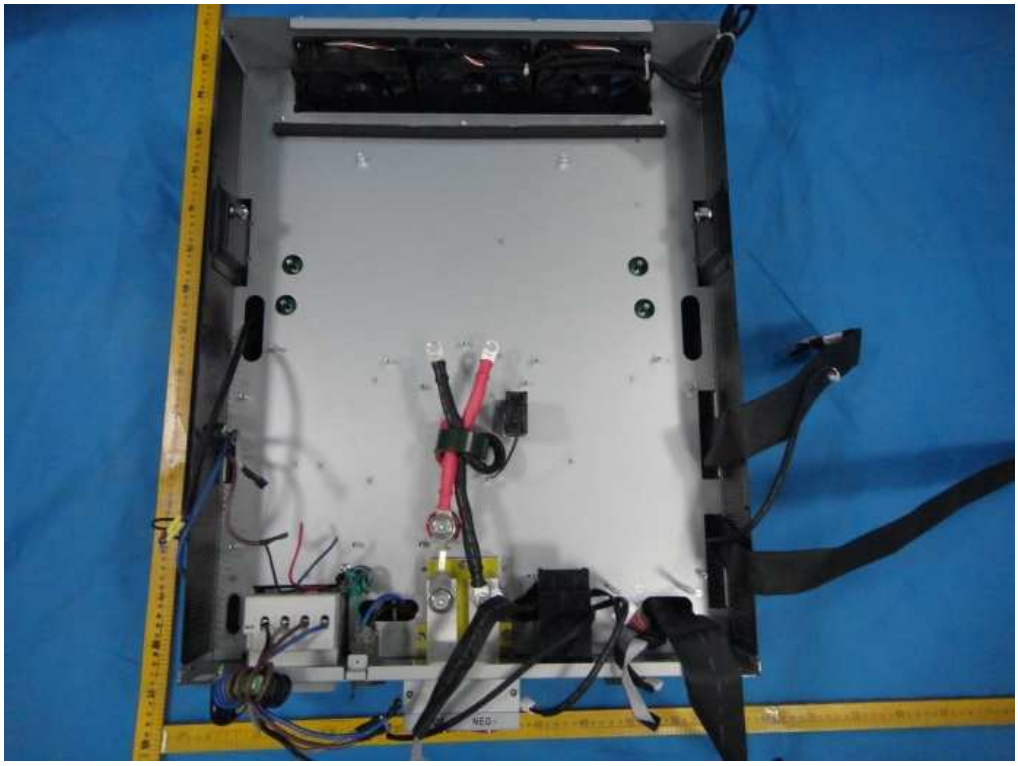
Enclosure rear view

Enclosure Bottom view

Internal view-1:

Internal view 2:

Internal view 3:



Internal view 4:

Internal view 5:

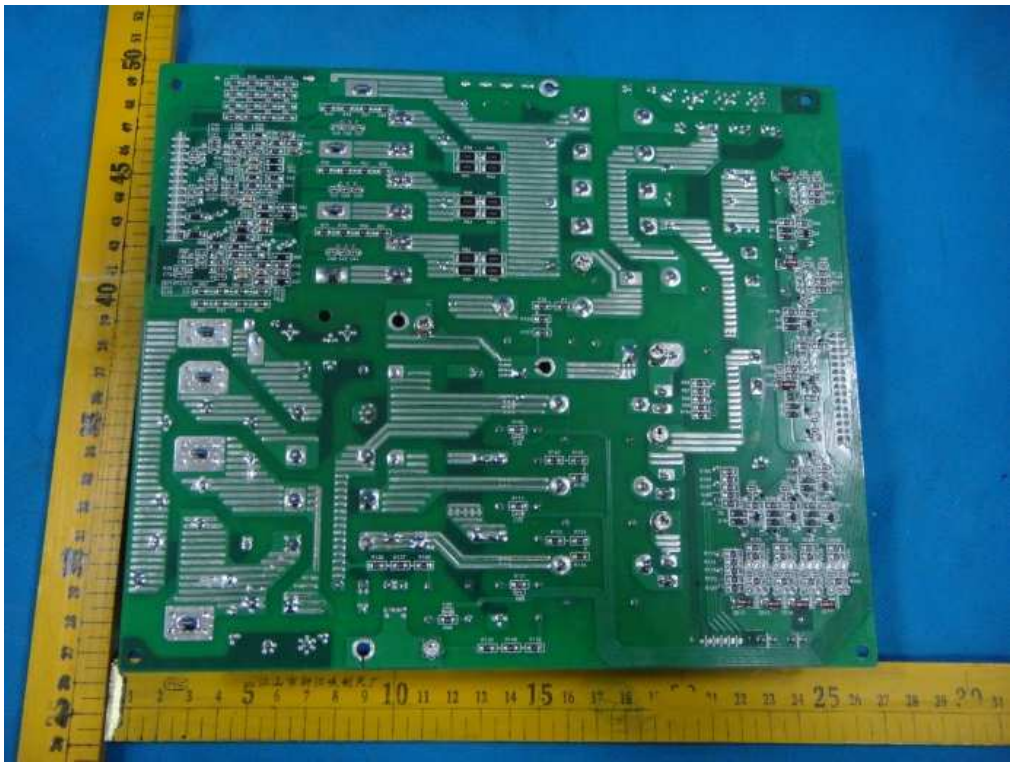
Internal view 6:

Internal view 7:

Internal view 8:

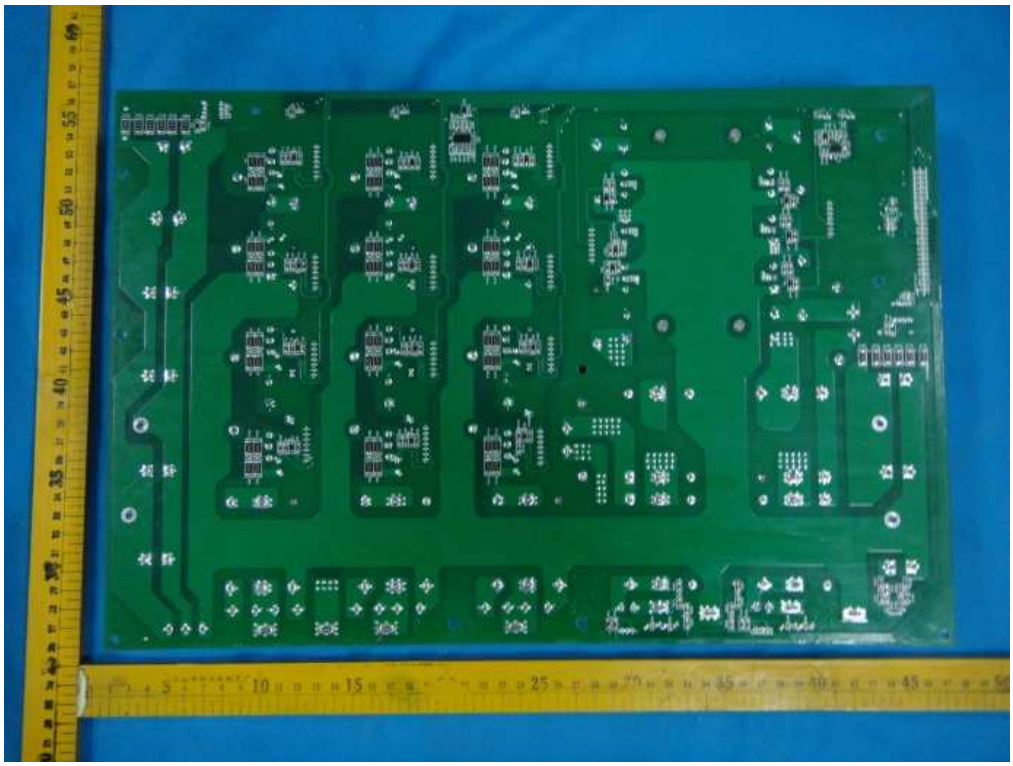
Grid board component side view:

Grid board solder side view:

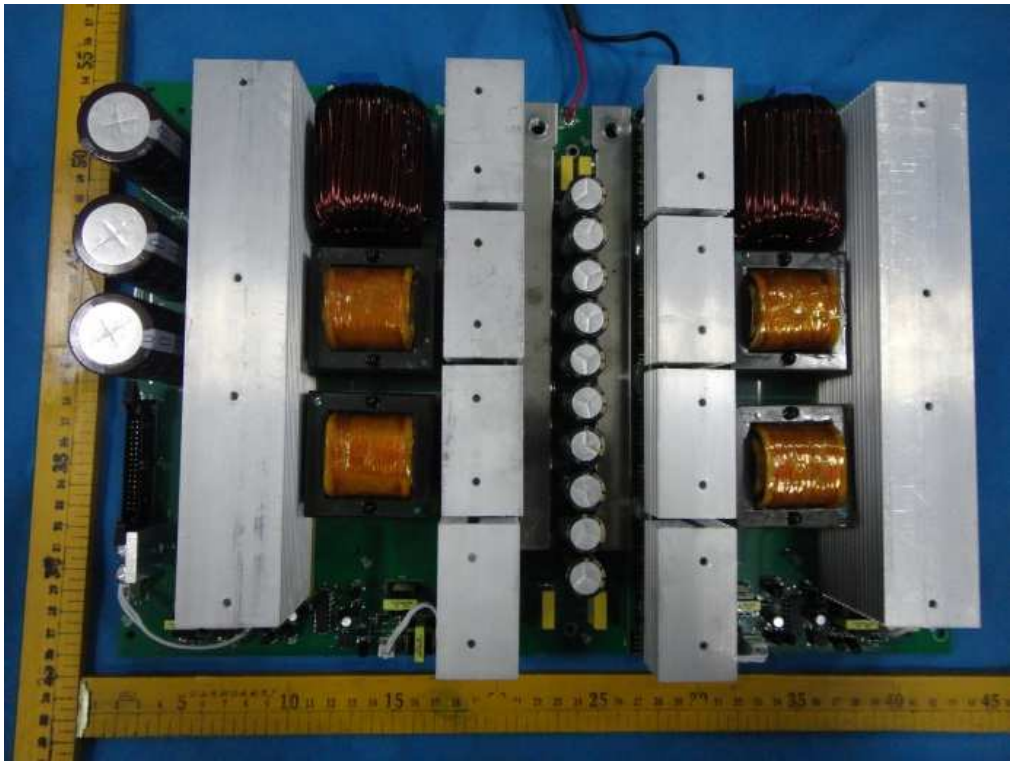


Inverter board component side view:

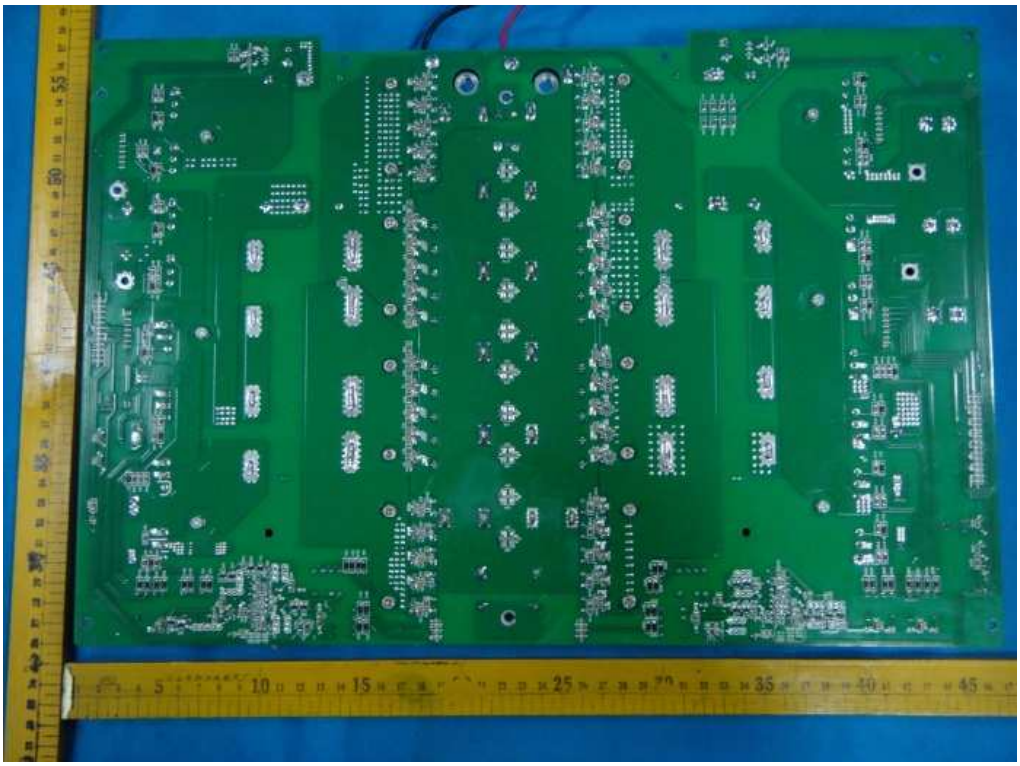
Inverter board solder side view:



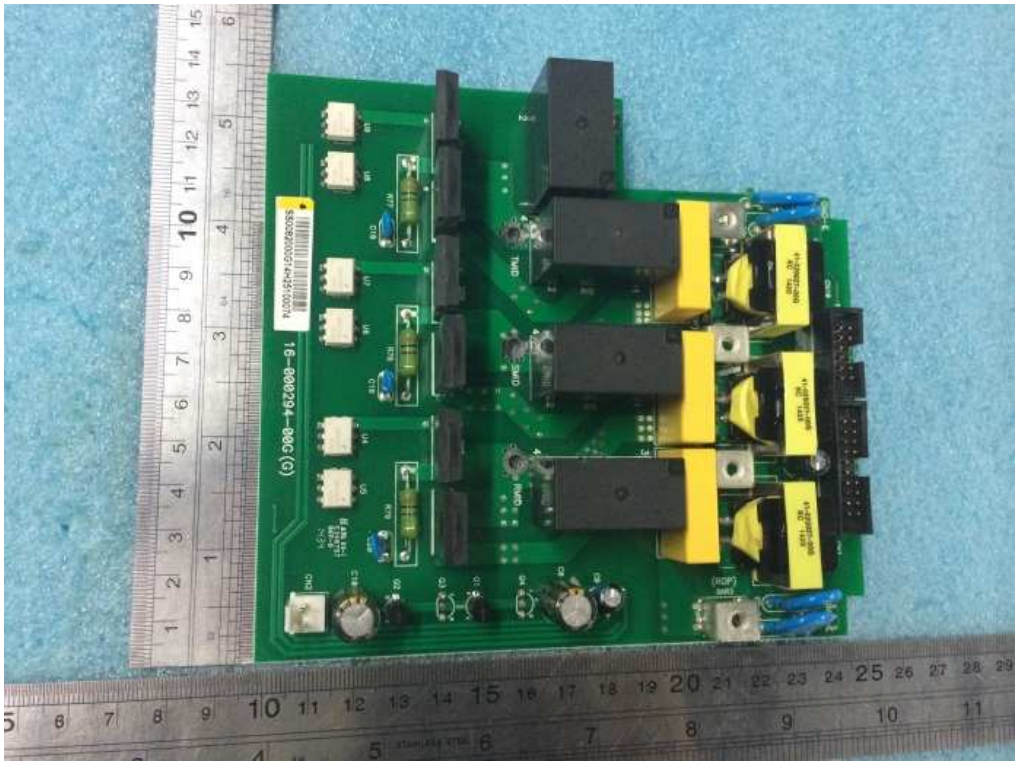
DC-DC board component side view:



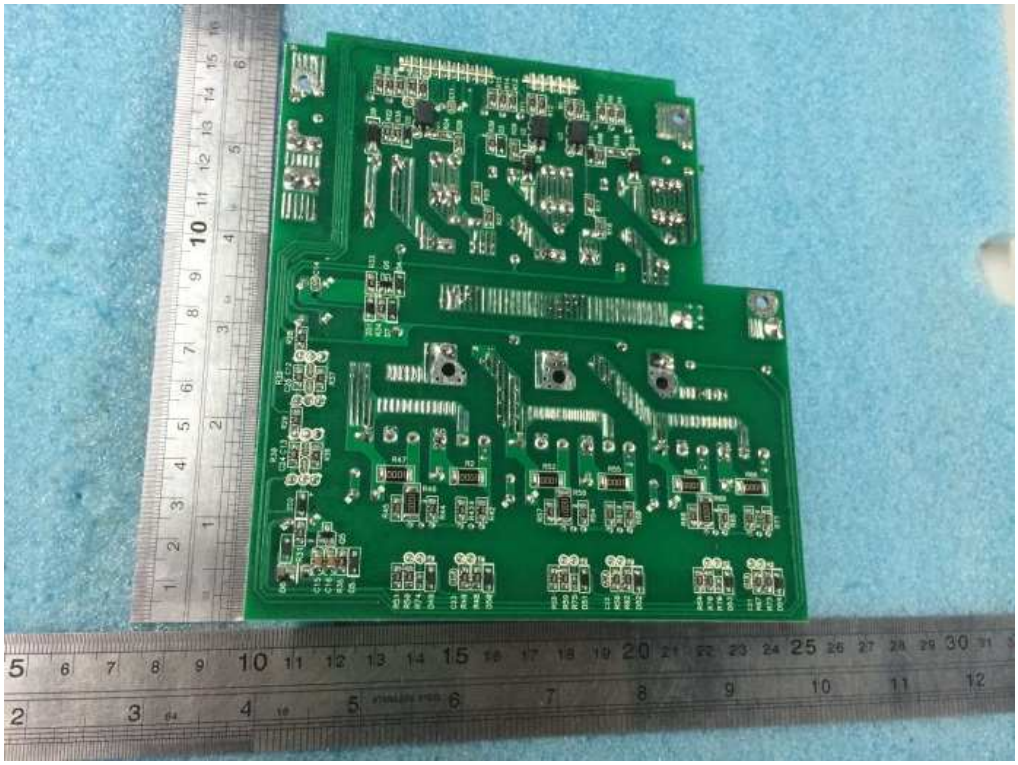
DC-DC board solder side view:



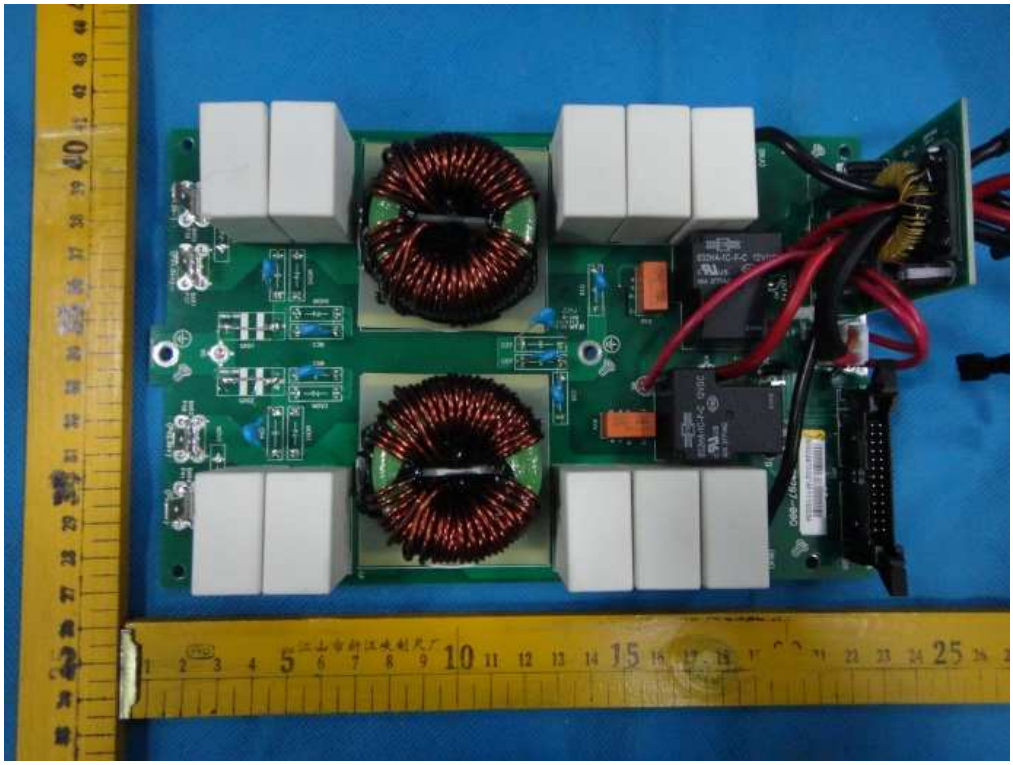
OP board component side view:



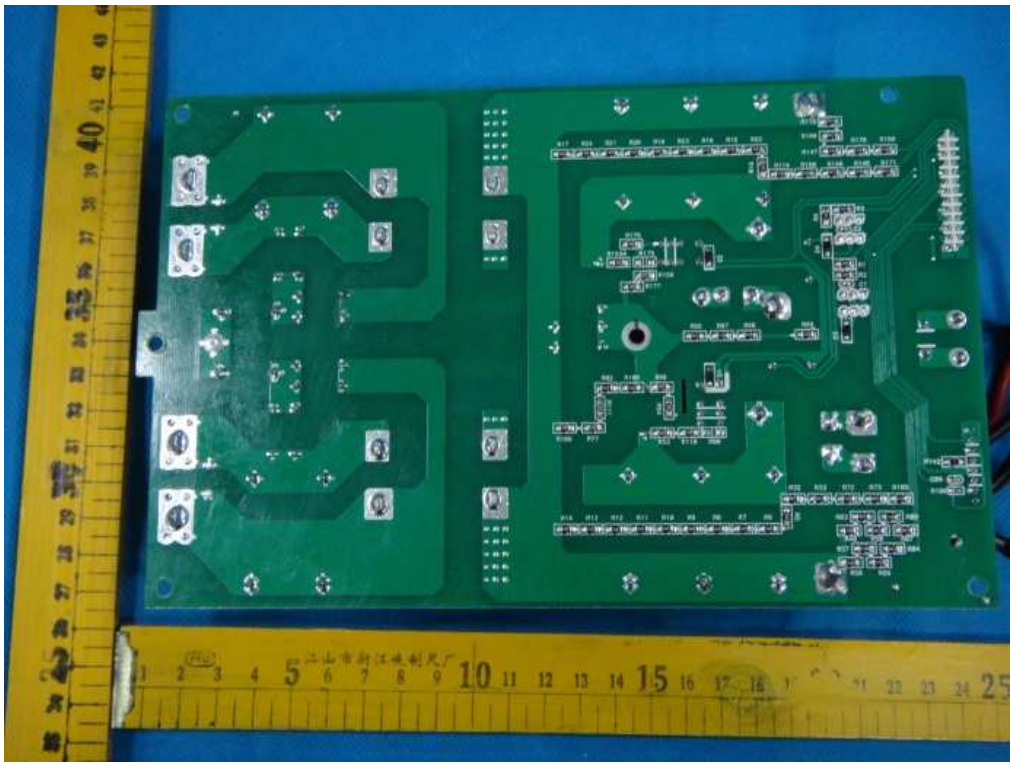
OP board solder side view:



PV side EMI board component side view:



PV side EMI board solder side view:

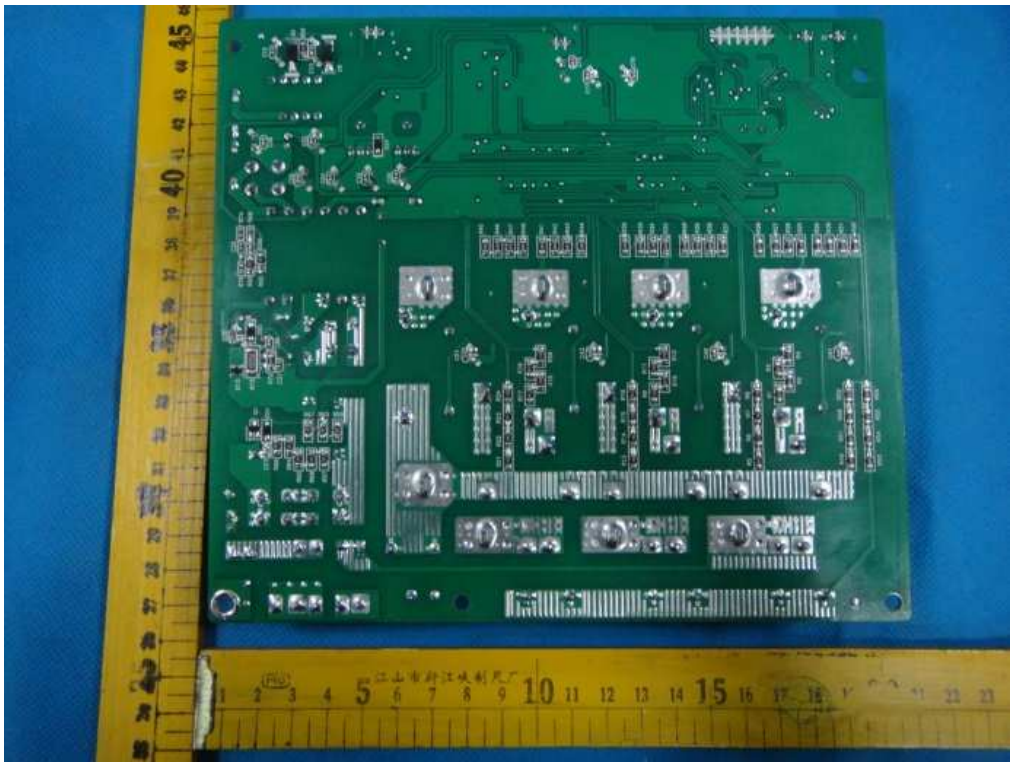


SPS board component side view:

SPS board solder side view:

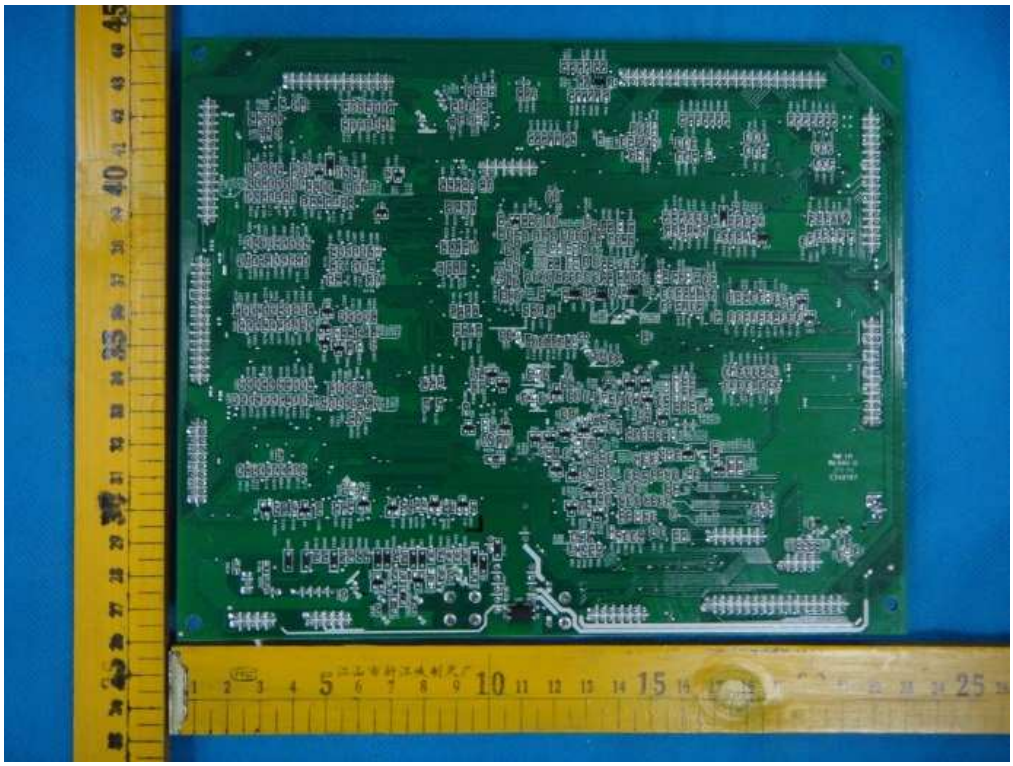
Relay board component side view:

Relay board solder side view:

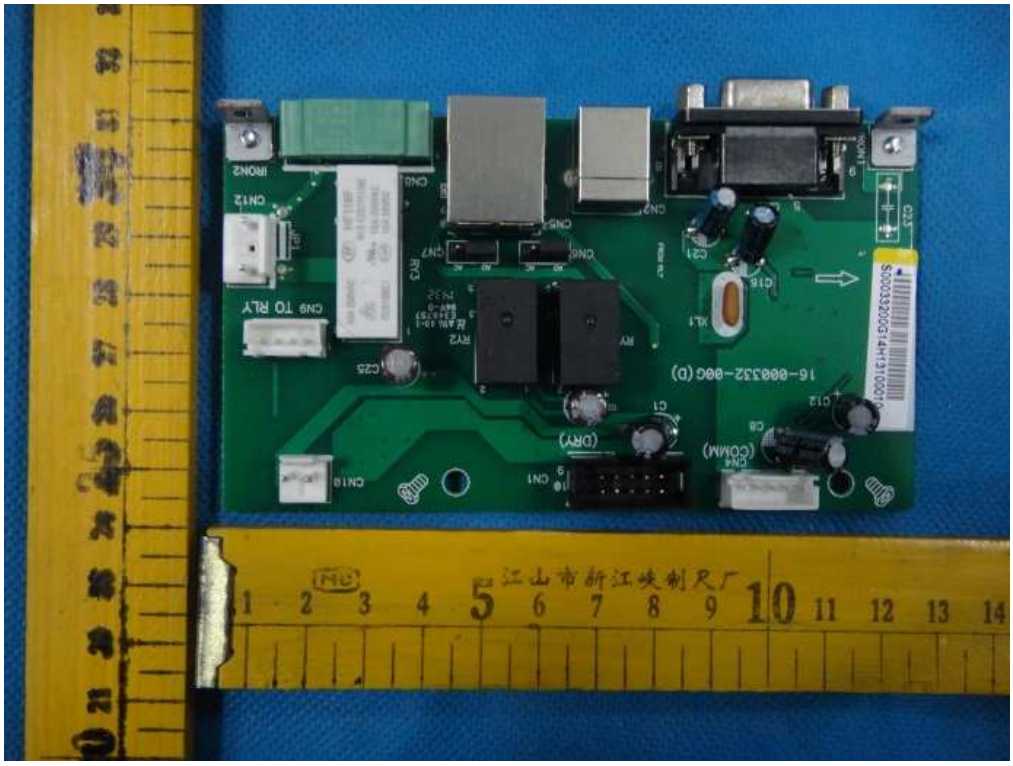


Control board component side view:

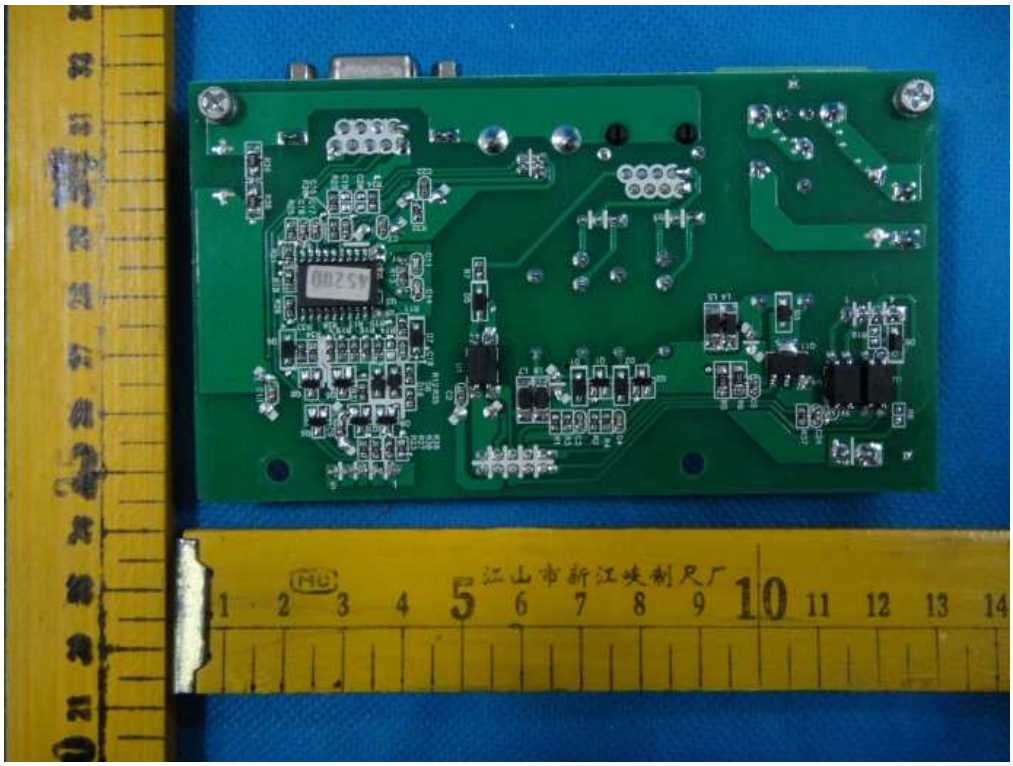
Control board solder side view:



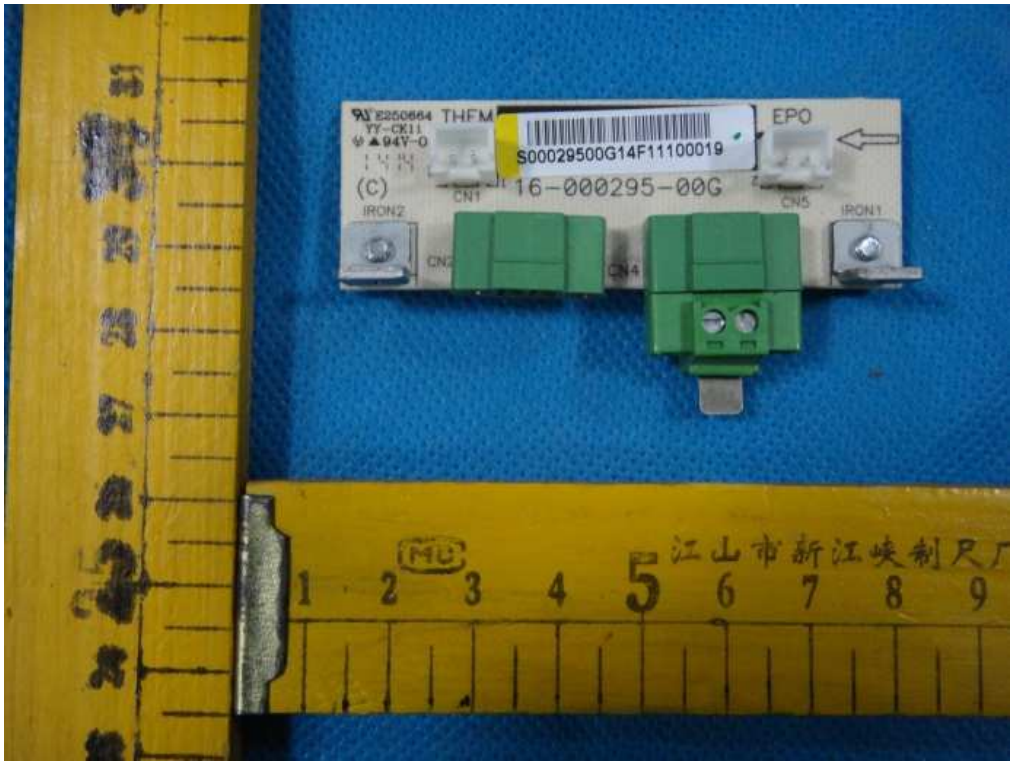
COM board component side view:



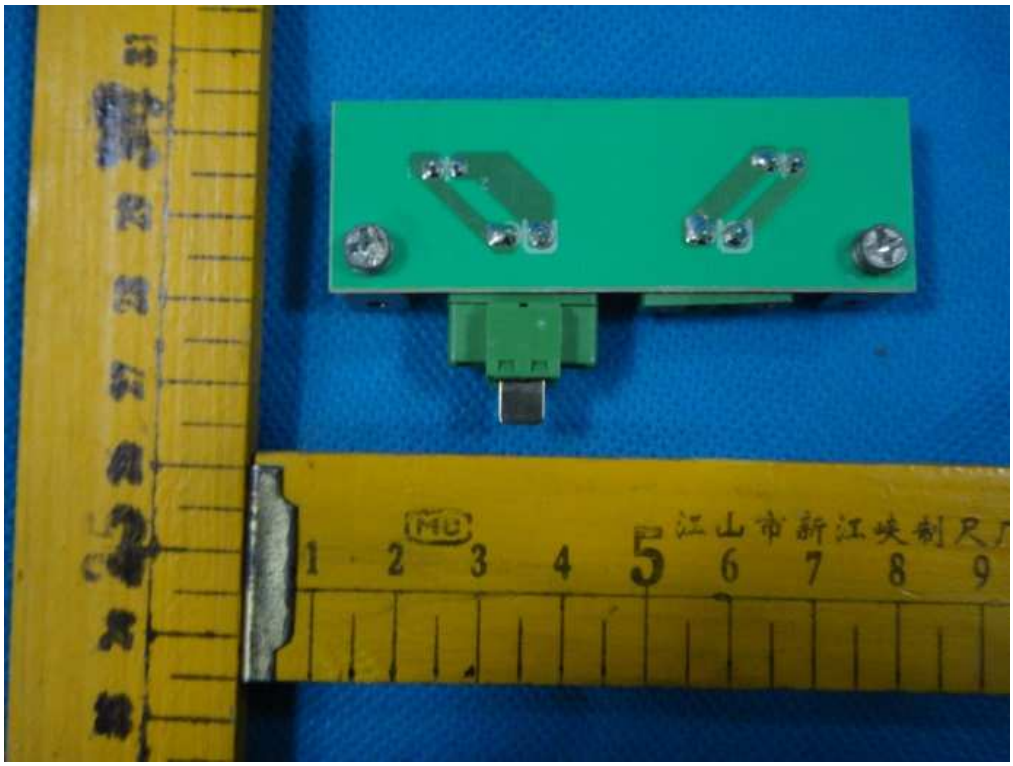
COM board solder side view:



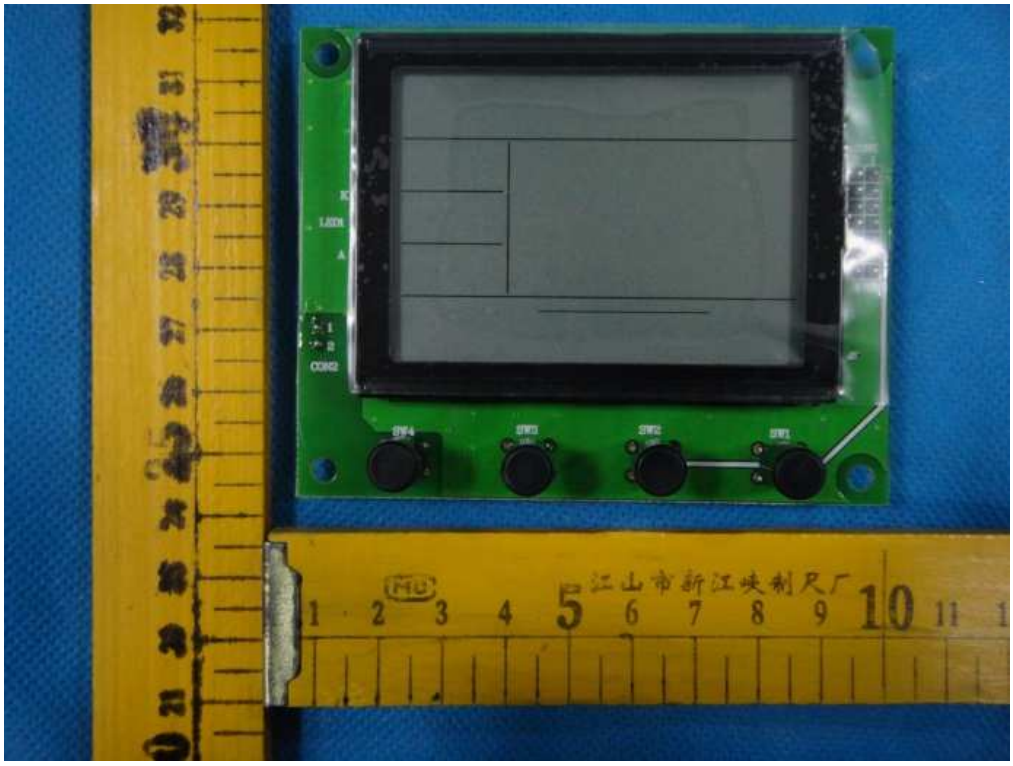
EPO board component side view:



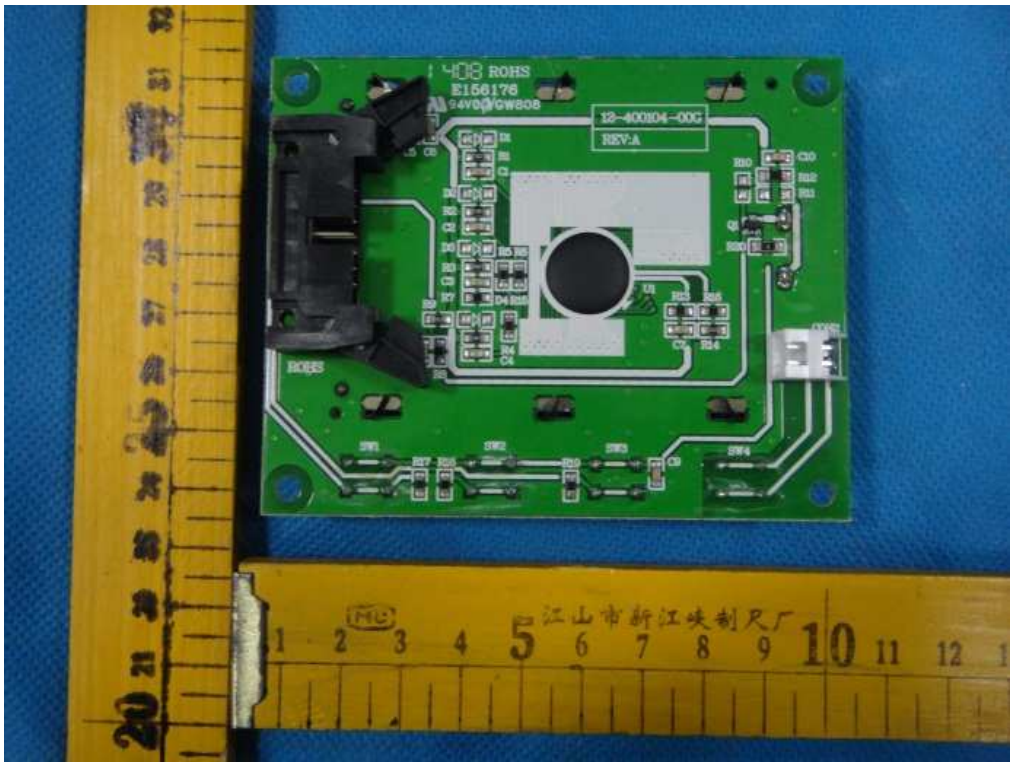
EPO board solder side view:



LCD board component side view:



LCD board solder side view:



Annex No. 2
Test Equipment list

Testing Location: **Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**

Date(s) of performance test: **2020-01-19 to 2020-09-10**

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

--End of Test Report--