TEST REPORT

TOR Erzeuger Typ A

Test Technical and organisational rules for operators and users of networks

TOR producers: connection and parallel operation of type A power generation sites and micro-generation plants

(maximum capacity of 250 kW and rated voltage of 110 kV)

Report reference number.............. :	**PV2105WDG0066-1**
Date of issue......................................:	2021-11-30
Total number of pages......................:	128
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
Accrediation ....:	ilac-MRA; A2LA ACCREDITED Certificate # 2951.01
Applicant's name .... :	**KOSTAL Solar Electric GmbH**
Address..:	Hanferstr. 6 79108 Freiburg Germany
Test specification	
Standard ....:	TOR Erzeuger Typ A Version 1.1 (tested according to OVE-Richtlinie R 25:2020-03)
Test Report Form No. ....:	TOR Erzeuger Typ A VER.0
TRF Originator ....:	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF...:	Dated 2020-05-12
Test item description.......................:	**Grid-Tied Solar Inverter**
Trademark ....:	**KOSTAL**

Ratings ....:	PIKO CI 30
Input DC voltage range [V] ....:	180-1000
MPP DC voltage range [V] ....:	180-960
Input DC current [A]..........................:	75 (2*37.5)
Output AC voltage [V].......................:	3/N/PE, 230/400, 50Hz
Nominal output AC current [A] ....:	43,5
Max. Output AC current [A] ....:	Max. 3*48,0
Initial short-current AC current $I_{k''}$[A]. :	Max. 48,0
Nominal Output power [kW] ....:	30,0
Maximum Output power [kVA] ....:	33,0

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) ....:	Colin Chen
Approved by (name and signature) ....:	Ken Chan
Manufacturer's name .... :	**Shenzhen Senergy Technology Co., Ltd**
Manufacturer address...................... **:**	Room 405, Building A, Co-talent Creative Park,No.2, LiuXianRoad, Block 68, Xin an Street, Bao' an District, ShenZhen.
Factory's name .... :	**APD Shenzhen DK Inc**
Factory address .... **:**	No.1,Fengwei Road,Dakang Community,Yuanshan Street,Long Gang District, Shenzhen City,China

Document History			
Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2021-11-30	Colin Chen	This is a copy report. The test data and result was based on previous test report PV2105WDG0066 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2021-08-05.	0
Supplementary information:			

Test items particulars

Equipment mobility ....:	Permanent connection
Operating condition ....:	Continuous
Class of equipment..........................:	Class I
Protection against ingress of water ..:	IP65 according to EN 60529
Mass of equipment [kg] ....:	41kg

Test case verdicts

Test case does not apply to the test object ....:	N/A
Test item does meet the requirement ....:	P(ass)
Test item does not meet the requirement ....:	F(ail)

Testing

Date of receipt of test item................:	2021-06-01
Date(s) of performance of test..........:	2021-06-01 to 2021-07-06

General remarks:

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

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

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

This is a copy report. The test data and result was based on previous test report PV2105WDG0066 issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2021-08-05.

This Test Report consists of the following documents:

1. Test Report
   - 5.1 Evidence of permissible network perturbations
   - 5.2 Evidence of symmetry behavior of inverters
   - 5.3 Evidence of the behavior of the generating unit on the network
   - 5.4 NS-protection
   - 5.5 Connecting conditions and synchronization
   - 5.6 Evidence dynamic grid support
   - 5.7 Test o Ancillary Unit
2. Pictures of the unit – Annex No. 1
3. Test equipment list – Annex No. 2

Copy of marking plate

Note:The artwork below may be only a draft. The use of certification marks on a product must beauthorized by the respective NCBs that own these marks

General product information:

The Photovoltaic grid-interactive inverter converts DC voltage, generated by photovoltaic modules, into AC voltage.

The units are three-phases inverter.
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 (transformer). The output is switched off redundant by the high power switching bridge and a two relays. This assures that the opening of the output circuit will also operate in case of one error.

Description of the power circuit :
The internal control is redundant built. It consists of master DSP(U3) and slave DSP(U2).

The master DSP (U3) can control the relays, measures voltage, and frequency, AC current with injected DC, insulation resistance and residual current, In addition it tests the array insulation resistance and the RMCU circuit before each start up.

The slave DSP (U2) is using for sample the grid voltage and current, also can open the relays independently and communicate with master DSP (U3).

The unit provides two relays in series on all-phases. 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 start up. Both DPSs can open the relays.

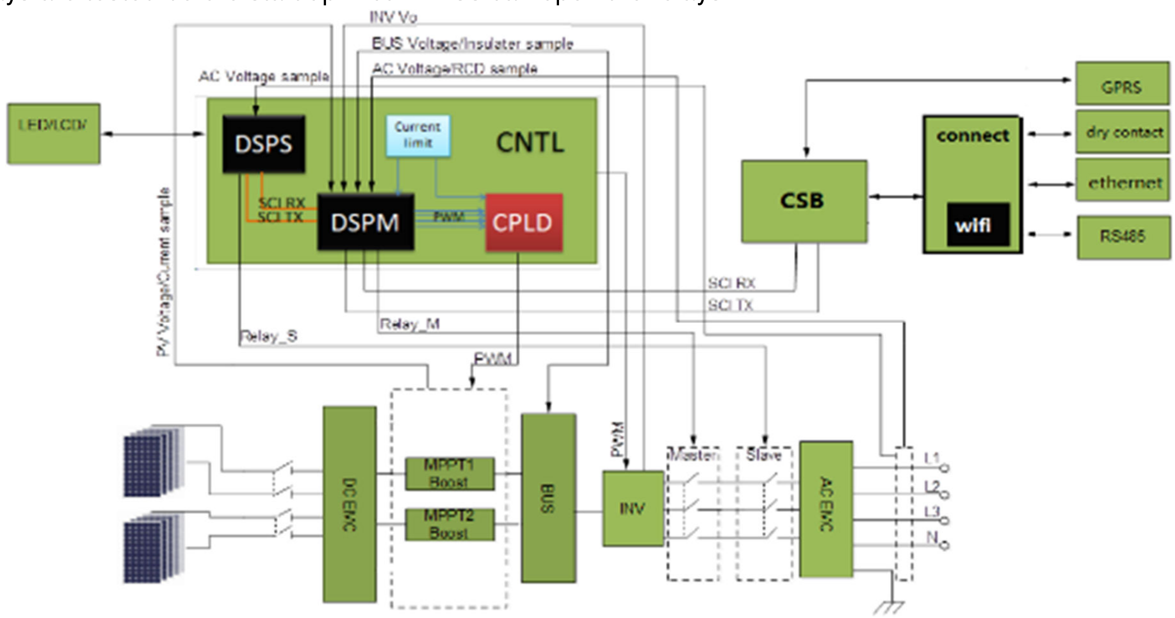


Figure 1 – Block diagram

Differences of the models in the series:

Single model

The product was tested on:

Software version: 3001

Hardware version: V00

Description of the remote control in a typical installation:

The Following information show inverter's interface to connect WIFI,GPRS and RS485 accessory:

WIFI:

The system connects to a WIFI module monitors over an WIFI port,the WIFI module implements communication with Cloud server thtough wireless network to monitor PV inverter's data status.

GPRS:

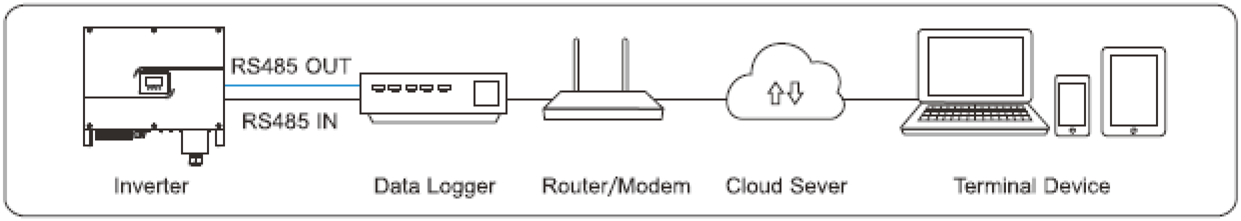
The system connects to a WIFI module monitors over an WIFI port,the GPRS module implements. communication with Cloud server through wireless network to monitor PV inverter's data status

RS485:

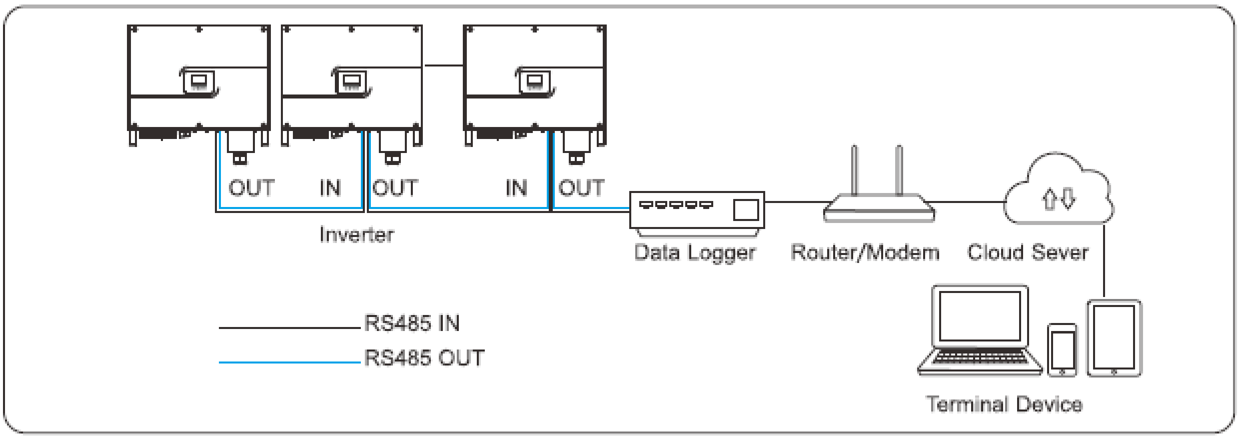
The system connects to an RS485 switching module monitors over an RS485 port, the RS485 switching module monitors PV inverter's data status through collecting and uploading data to Cloud server. The device number should be single inverter, as shown in mode (1) .

It connects to the "RS485 IN" port of a data collector over an RS485 bus, the device number should be less than 20 pieces, as shown in mode (2).

RS485 communication mode (1).



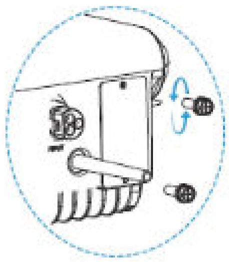
RS485 communication mode (2)



WIFI Installation Guide

1

Remove the metal plate as shown in below Figure.

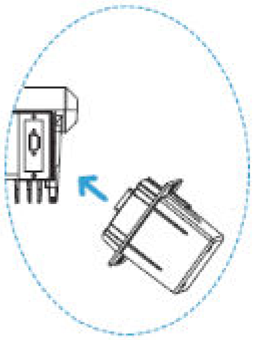


3

Open APP and choose "Bluetooth", click BLExxxx to login. Then click the function list and choose Setting.

2

Take out WIFI module from fitting bag, and connect the exposed WIFI interface to DB9 terminal, and check that the connection is well with an appropriate force.



4

Click switch user, enter password 'admin' to login with administrator account.

Click WIFI Setting to enter WIFI router name & password.

1

5

WIFI module need 10 to 15 seconds to connect with WIFI router.
After WIFI Setting finish, APP will show the result: "WIFI Connected" means connection successful. "WIFI Setting Failed" means connection failed.
If WIFI connection failed, repeat step 4 & 5.

7

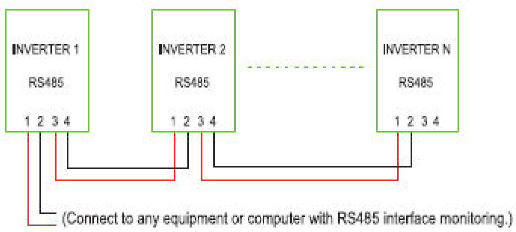
Bind the cloud account using APP referring to the appendix.

6

Register a cloud account refer to appendix (Referring to appendix).

RS485 Installation Guide

Connecting RS485 interface is shown in below picture.

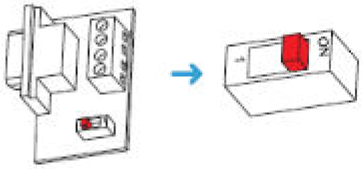


2

1

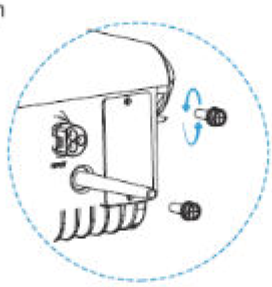
Check the red switch.

Turn the red switch to "1" for these interfaces from No.1 to No.N-1, and yet turn the red switch to "ON" for No. N interface, referring to below Figure.



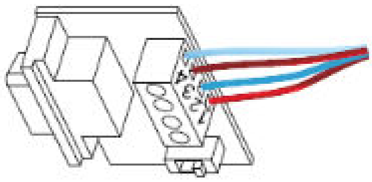
2

Remove the metal plate as shown in below Figure.



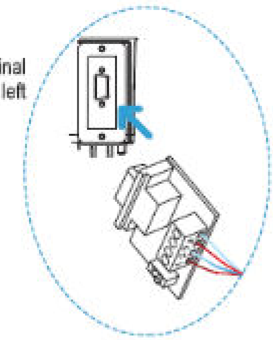
3

Remove the four locking nuts on TB1, and tighten the nuts after connecting the wires (The removed length of the insulation layer from the cable is 0.5mm).



4

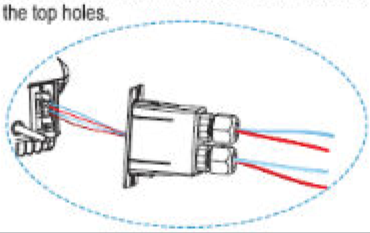
Connect RS485 board to DB9 terminal with component side facing the left (see below Figure).



3

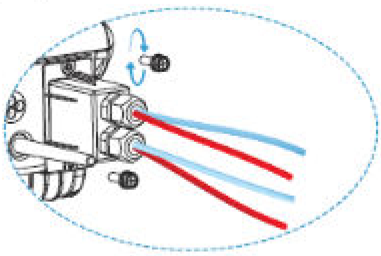
5

Remove the two waterproof connectors on the cover; Tidy up these wires as follows: wires from the 1st and 2nd holes of TB1 come out through the bottom holes, and these from the 3rd and 4th holes of TB1 come out through the top holes.



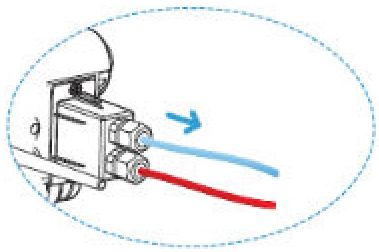
6

Lock the metal cover, and tighten the screws.



7

Tighten the waterproof connector.



8

Login APP referring to the appendix, and connect inverter.

4

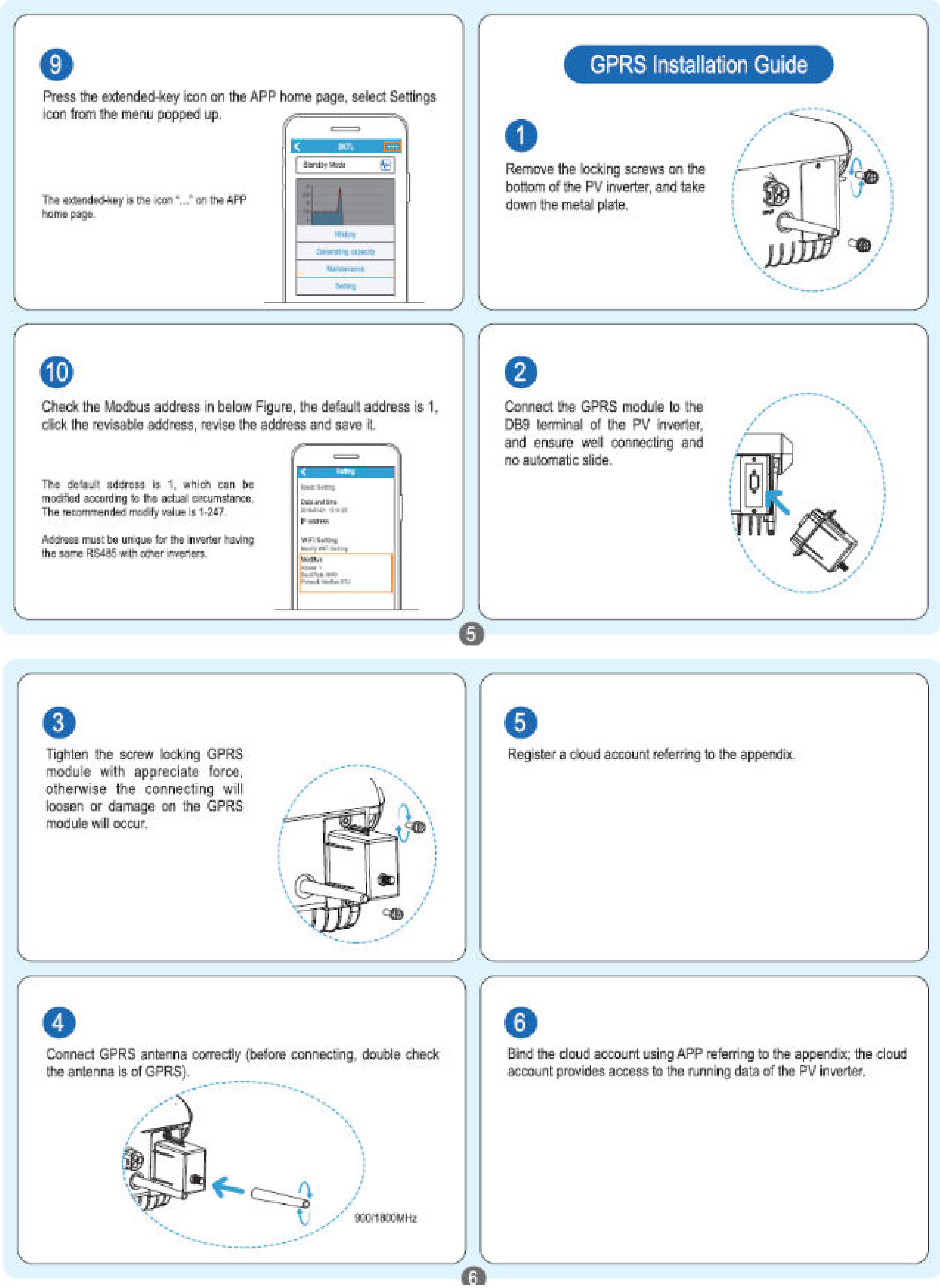


Figure 2 –Scheme of an installation

Description of the connection to the ripple control receiver:

As shown below ,signal control receiver sends grid operator command signal to Data Logger through dry contact signal line

Each Data Logger can carry up to 20 inverters via RS485 bus wih 9600 baud rate. The cable length is recommended that should not longer than 1000m.

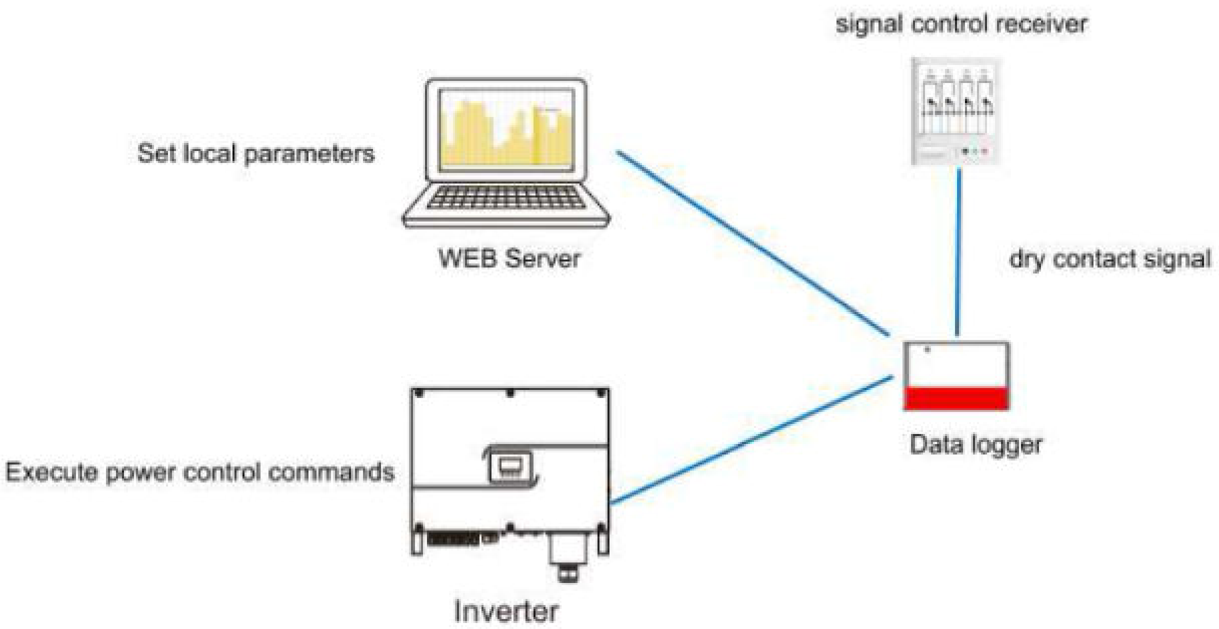


Figure 3– Connection of the ripple control receiver in an installation

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 VDE-AR-N 4105 / DIN VDE V 0124-100. This report must not be reproduced in part or in full without the written approval of the issuing testing laboratory.

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"(see appended table)" refers to a table appended to the report.

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

"P_{rE}" for the rated active power:

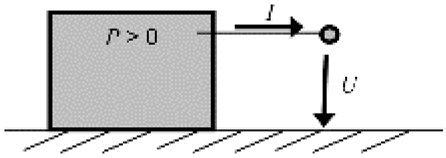
P_{rE} = Un x I_r x cos φn (single-Phase); P_{rE} = √ 3 Un x I_r x cos φn (three-Phase)

- "P_{ref}" for the momentary power
- "ΔP_{E60}" in [%] = ($P_{Setpoint}$ - P_{E60}) / P_{rE}
- "ΔQ_{E60}" in [%] = ($Q_{expected}$ - Q_{E60}) / P_{Emax}
- "(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.

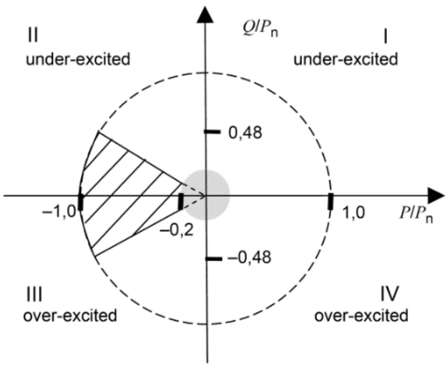


Figure 5

OVE-Richtlinie R 25:2020-03		
Clause	**Test**	**Result**
5.1	**Evidence of permissible network perturbations**	**P**
5.2	**Evidence of symmetry behavior of inverters**	**P**
5.3	**Evidence of the behavior 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**

Evidence of permissible network perturbations

Clause	Test	Result
5.1.1	General	**P**
5.1.2	Rapid voltage changes	**P**
	Tests	**P**
	Documentation of tests	**P**
5.1.3	Flicker	**P**
	Tests	**P**
	Documentation of tests	**P**
5.1.4	Harmonics and interharmonics	**P**
	Tests	**P**
	Additional tests	**P**
	Documentation of tests	**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	P

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

The following three cases must be tested (where applicable).

- Switch-on for any capacity
- Unfavourable case when switching the generator step
- Switch-on for nominal capacity
- 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: 50 Hz ± 0,5%
THD of the voltage supply: ≤ 3 %
Voltage rise of the PGU at 100 P_{Emax} %: ≤ 3 %

Test: PIKO CI 30

Switch-on for any capacity (10% PEmax)

Phase	L1			L2			L3		
Single period effective values of the current [A]	2,168	2,077	2,021	3,555	3,595	3,439	2,578	2,583	2,514
Single period effective values of the voltage [V]	229,53	229,63	229,65	229,53	229,48	229,48	229,83	229,78	229,78
k_i value [1]	0,050	0,048	0,046	0,023	0,083	0,079	0,059	0,059	0,058
k_{imax} value [1]	0,083								

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]	1,787	2,219	2,194	2,987	2,426	2,274	2,445	3,302	3,337
Single period effective values of the voltage [V]	229,90	229,91	229,95	229,47	229,66	229,66	229,76	229,69	229,75
k_i value [1]	0,041	0,051	0,050	0,069	0,056	0,052	0,056	0,076	0,077
k_{imax} value [1]	0,077								

Switch-off for nominal capacity									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	29,049	32,471	30,172	30,115	31,285	30,661	29,603	30,614	30,198
Single period effective values of the voltage [V]	228,76	228,25	228,88	230,18	229,57	228,85	228,28	229,18	229,54
k_i value [1]	0,668	0,747	0,694	0,693	0,720	0,705	0,681	0,704	0,695
k_{imax} value [1]	0,747								

Grid Frequency [Hz]	50,0
Grid voltage [V]	230,0
Rated current I_r [A]	43,478
Highest k_{imax} value for all switching operations [1]	0,747

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)

5.1.3 Flicker These tests are designed to provide evidence that the requirements of TOR D2 are met.	**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: 50 Hz ± 0,5%

THD of the voltage supply: ≤ 3 %

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

Flicker to DIN EN 61000-3-3 (VDE 0838-3) or DIN EN 61000-3-11 (VDE 0838-11) for generator units ≤ 75 A			
Grid impedance DIN EN 61000-3-3 (VDE 0838-3) [Ω]:	R_A = 0,24Ω jX_A = 0,15Ω / R_N = 0,16Ω jX_N = 0,10Ω (Rn and jXn only for single-phase units used!)		
Grid impedance DIN EN 61000-3-11 (VDE 0838-11) [Ω]:	R_A = 0,15Ω jX_A= 0,15Ω / R_N = 0,01Ω jX_N= 0,01Ω (Rn and jXn only for single-phase units used!)		
Output voltage of the impedance network [V]	230Vac		
Flicker to:	Result:		
	P_{lt}	P_{st}	dc%
DIN EN 61000-3-11: PIKO CI 30	0,41	0,45	0,16

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	45°
DIN EN 61000-3-11: PIKO CI 30	10,202

Assessment criterion:

Long-term flicker strength: $P_{lt} \leq 0,5$

Determination of the flicker coefficient:

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

The following applies according to DIN EN 61000-3-3 (≤ 16 A) for the network standby element: S_k = 560739
The following applies according to DIN EN 61000-3-11 (> 16 A and ≤ 75 A) for the network standby element: S_k = 748119

Note:

5.1.4.1	Test Harmonics DIN EN 61000-3-12 (≥16 A and ≤75 A per Phase)			P
PIKO CI 30				
Phase	**L1**	**L2**	**L3**	
Power Level	**33%**			
AC Power [kW]	**3,285**	**3,251**	**3,284**	
AC Voltage [V]	**230,19**	**230,17**	**230,11**	
AC Current [A]	**14,292**	**14,141**	**14,287**	
Frequency [Hz]	**50,00**			
THD [%]	**1,887**	**1,870**	**1,895**	

Harmonic	Current Magnitude (A):L1	Current Magnitude (A):L2	Current Magnitude (A) :L3	% of rated current:L1	% of rated current:L2	% of rated current:L3	Harmonic Current Limits (%)
1st	14,292	14,141	14,287	--	--	--	--
2nd	0,048	0,025	0,044	0,111	0,058	0,101	8,000
3rd	0,081	0,105	0,103	0,186	0,241	0,236	21,600
4th	0,044	0,033	0,048	0,102	0,076	0,112	4,000
5th	0,532	0,520	0,533	1,223	1,197	1,226	10,700
6th	0,031	0,035	0,035	0,072	0,080	0,081	2,667
7th	0,515	0,509	0,518	1,185	1,170	1,192	7,200
8th	0,032	0,033	0,033	0,075	0,077	0,077	2,000
9th	0,064	0,055	0,031	0,146	0,127	0,070	3,800
10th	0,031	0,035	0,035	0,070	0,081	0,081	1,600
11th	0,206	0,209	0,167	0,474	0,481	0,384	3,100
12th	0,032	0,031	0,028	0,073	0,072	0,063	1,333
13th	0,137	0,133	0,170	0,314	0,306	0,392	2,000
14th	0,027	0,038	0,036	0,062	0,087	0,083	N/A
15th	0,041	0,038	0,028	0,094	0,087	0,064	N/A
16th	0,026	0,035	0,036	0,059	0,081	0,084	N/A
17th	0,114	0,130	0,107	0,263	0,300	0,246	N/A
18th	0,026	0,026	0,026	0,061	0,059	0,059	N/A
19th	0,105	0,108	0,130	0,241	0,248	0,298	N/A
20th	0,015	0,021	0,021	0,035	0,049	0,047	N/A
21th	0,026	0,019	0,013	0,060	0,043	0,030	N/A
22th	0,013	0,017	0,017	0,029	0,040	0,039	N/A
23th	0,074	0,076	0,063	0,171	0,175	0,145	N/A
24th	0,013	0,012	0,012	0,030	0,027	0,027	N/A
25th	0,053	0,040	0,063	0,121	0,091	0,144	N/A
26th	0,014	0,018	0,017	0,033	0,041	0,040	N/A

5.1.4.1	Test Harmonics DIN EN 61000-3-12 (≥16 A and ≤75 A per Phase)						P
PIKO CI 30							
27th	0,024	0,017	0,014	0,055	0,038	0,032	N/A
28th	0,013	0,017	0,017	0,029	0,038	0,039	N/A
29th	0,033	0,042	0,028	0,077	0,096	0,064	N/A
30th	0,012	0,011	0,010	0,029	0,026	0,023	N/A
31th	0,034	0,033	0,047	0,078	0,075	0,109	N/A
32th	0,010	0,016	0,014	0,024	0,037	0,032	N/A
33th	0,017	0,012	0,011	0,040	0,027	0,026	N/A
34th	0,010	0,015	0,015	0,023	0,035	0,034	N/A
35th	0,038	0,044	0,033	0,088	0,101	0,076	N/A
36th	0,012	0,010	0,010	0,028	0,022	0,023	N/A
37th	0,036	0,026	0,043	0,083	0,060	0,100	N/A
38th	0,011	0,016	0,016	0,025	0,037	0,036	N/A
39th	0,019	0,014	0,010	0,043	0,031	0,023	N/A
40th	0,012	0,016	0,016	0,027	0,037	0,037	N/A

PV-curve simulated according to	
Voltage of defined MPP [V]	800Vdc
Current of defined MPP [A]	41,3A
FFU of PV curve [1]	**1**
Impedance [Ω]	
Line	R_A = 0,24 jX_A = 0,15
Neutral	R_N = 0,16 jX_N = 0,10
Note:	

5.1.4.1	Test Harmonics DIN EN 61000-3-12 (≥16 A and ≤75 A per Phase)	P
PIKO CI 30		

Phase	L1	L2	L3
Power Level	66%		
AC Power [kW]	6,591	6,534	6,578
AC Voltage [V]	230,42	230,40	230,34
AC Current [A]	28,655	28,406	28,599
Frequency [Hz]	50,00		
THD [%]	1,901	1,994	1,972

Harmonic	Current Magnitude (A):L1	Current Magnitude (A):L2	Current Magnitude (A) :L3	% of rated current:L1	% of rated current:L2	% of rated current:L3	Harmonic Current Limits (%)
1st	28,655	28,406	28,599	--	--	--	--
2nd	0,060	0,026	0,058	0,138	0,059	0,134	8,000
3rd	0,112	0,188	0,153	0,257	0,432	0,351	21,600
4th	0,056	0,034	0,061	0,129	0,077	0,139	4,000
5th	0,431	0,464	0,470	0,992	1,067	1,082	10,700
6th	0,038	0,038	0,042	0,088	0,088	0,097	2,667
7th	0,543	0,556	0,555	1,249	1,278	1,277	7,200
8th	0,030	0,035	0,037	0,068	0,080	0,085	2,000
9th	0,085	0,071	0,037	0,195	0,163	0,084	3,800
10th	0,031	0,036	0,034	0,070	0,084	0,078	1,600
11th	0,277	0,297	0,241	0,638	0,683	0,555	3,100
12th	0,032	0,032	0,029	0,075	0,074	0,068	1,333
13th	0,233	0,227	0,265	0,536	0,522	0,610	2,000
14th	0,029	0,044	0,040	0,066	0,102	0,093	N/A
15th	0,042	0,041	0,034	0,098	0,095	0,079	N/A
16th	0,028	0,039	0,036	0,065	0,091	0,084	N/A
17th	0,125	0,128	0,108	0,288	0,294	0,249	N/A
18th	0,029	0,028	0,025	0,066	0,065	0,057	N/A
19th	0,090	0,079	0,105	0,206	0,181	0,242	N/A
20th	0,017	0,024	0,022	0,038	0,055	0,051	N/A
21th	0,026	0,019	0,014	0,061	0,045	0,032	N/A
22th	0,013	0,017	0,017	0,030	0,040	0,039	N/A
23th	0,053	0,055	0,040	0,122	0,127	0,093	N/A
24th	0,013	0,011	0,011	0,029	0,026	0,025	N/A
25th	0,040	0,032	0,053	0,093	0,075	0,122	N/A
26th	0,012	0,017	0,016	0,029	0,039	0,037	N/A

5.1.4.1	Test Harmonics DIN EN 61000-3-12 (≥16 A and ≤75 A per Phase)						P
PIKO CI 30							
27th	0,022	0,015	0,013	0,050	0,034	0,030	N/A
28th	0,013	0,017	0,017	0,029	0,040	0,040	N/A
29th	0,033	0,040	0,028	0,077	0,093	0,065	N/A
30th	0,013	0,012	0,010	0,031	0,027	0,022	N/A
31th	0,032	0,028	0,044	0,074	0,064	0,102	N/A
32th	0,012	0,016	0,014	0,027	0,037	0,033	N/A
33th	0,018	0,012	0,011	0,042	0,028	0,026	N/A
34th	0,010	0,015	0,016	0,023	0,035	0,037	N/A
35th	0,031	0,037	0,027	0,072	0,085	0,062	N/A
36th	0,011	0,010	0,011	0,026	0,024	0,024	N/A
37th	0,032	0,025	0,040	0,073	0,058	0,093	N/A
38th	0,009	0,015	0,014	0,021	0,034	0,033	N/A
39th	0,016	0,011	0,010	0,036	0,026	0,023	N/A
40th	0,011	0,015	0,015	0,024	0,033	0,035	N/A

PV-curve simulated according to	
Voltage of defined MPP [V]	800Vdc
Current of defined MPP [A]	41,3A
FFU of PV curve [1]	**1**
Impedance [Ω] Line Neutral	 R_A = 0,24 jX_A = 0,15 R_N = 0,16 jX_N = 0,10
Note:	

5.1.4.1	Test Harmonics DIN EN 61000-3-12 (≥16 A and ≤75 A per Phase)			P
PIKO CI 30				
Phase	L1	L2	L3	
Power Level	100%			
AC Power [kW]	9,907	9,826	9,882	
AC Voltage [V]	230,65	230,64	230,56	
AC Current [A]	43,030	42,676	42,928	
Frequency [Hz]	50,00			
THD [%]	1,960	2,159	2,099	

Harmonic	Current Magnitude (A):L1	Current Magnitude (A):L2	Current Magnitude (A) :L3	% of rated current:L1	% of rated current:L2	% of rated current:L3	Harmonic Current Limits (%)
1st	43,030	42,676	42,928	--	--	--	--
2nd	0,084	0,060	0,075	0,192	0,137	0,173	8,000
3rd	0,183	0,306	0,222	0,420	0,704	0,510	21,600
4th	0,062	0,045	0,081	0,142	0,105	0,187	4,000
5th	0,365	0,447	0,464	0,840	1,027	1,066	10,700
6th	0,049	0,047	0,056	0,112	0,107	0,128	2,667
7th	0,632	0,653	0,648	1,453	1,502	1,490	7,200
8th	0,035	0,047	0,048	0,080	0,107	0,109	2,000
9th	0,111	0,096	0,049	0,255	0,220	0,112	3,800
10th	0,037	0,043	0,042	0,084	0,098	0,096	1,600
11th	0,225	0,235	0,173	0,518	0,541	0,399	3,100
12th	0,035	0,033	0,030	0,081	0,077	0,070	1,333
13th	0,195	0,192	0,227	0,448	0,442	0,522	2,000
14th	0,032	0,052	0,046	0,073	0,119	0,105	N/A
15th	0,038	0,034	0,032	0,088	0,079	0,074	N/A
16th	0,029	0,050	0,042	0,068	0,114	0,096	N/A
17th	0,124	0,129	0,110	0,284	0,298	0,252	N/A
18th	0,031	0,027	0,025	0,072	0,062	0,057	N/A
19th	0,094	0,094	0,115	0,215	0,216	0,265	N/A
20th	0,018	0,024	0,023	0,042	0,055	0,054	N/A
21th	0,024	0,021	0,013	0,056	0,048	0,029	N/A
22th	0,014	0,018	0,018	0,032	0,042	0,041	N/A
23th	0,068	0,070	0,057	0,157	0,161	0,132	N/A
24th	0,012	0,011	0,010	0,027	0,025	0,023	N/A
25th	0,049	0,042	0,062	0,113	0,097	0,142	N/A
26th	0,013	0,017	0,016	0,029	0,038	0,036	N/A

5.1.4.1	Test Harmonics DIN EN 61000-3-12 (≥16 A and ≤75 A per Phase)						P
PIKO CI 30							
27th	0,019	0,014	0,012	0,044	0,033	0,027	N/A
28th	0,013	0,016	0,016	0,029	0,038	0,037	N/A
29th	0,036	0,039	0,029	0,082	0,090	0,068	N/A
30th	0,014	0,011	0,010	0,032	0,026	0,023	N/A
31th	0,031	0,023	0,039	0,072	0,052	0,090	N/A
32th	0,012	0,017	0,014	0,029	0,040	0,033	N/A
33th	0,017	0,013	0,011	0,040	0,030	0,026	N/A
34th	0,011	0,015	0,016	0,026	0,035	0,036	N/A
35th	0,027	0,032	0,022	0,061	0,073	0,050	N/A
36th	0,009	0,009	0,009	0,021	0,021	0,021	N/A
37th	0,027	0,019	0,035	0,063	0,043	0,081	N/A
38th	0,012	0,015	0,014	0,027	0,034	0,032	N/A
39th	0,017	0,012	0,012	0,040	0,028	0,027	N/A
40th	0,012	0,016	0,015	0,027	0,037	0,035	N/A

PV-curve simulated according to	
Voltage of defined MPP [V]	800Vdc
Current of defined MPP [A]	41,3A
FFU of PV curve [1]	**1**
Impedance [Ω] Line Neutral	 R_A = 0,24 jX_A = 0,15 R_N = 0,16 jX_N = 0,10
Note:	

5.1.4.2	Test Harmonics DIN EN 61000-4-7 (≥75 A per Phase)	P

PIKO CI 30

Harmonics

P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
Order	I_h [%]											
1	3,176	12,113	20,158	32,520	40,580	50,768	60,525	70,593	80,627	92,652	100,960	100,960
2	0,290	0,336	0,330	0,325	0,323	0,342	0,417	0,400	0,406	0,383	0,392	0,417
3	0,198	0,155	0,155	0,206	0,231	0,263	0,304	0,363	0,424	0,479	0,516	0,516
4	0,342	0,305	0,330	0,332	0,335	0,339	0,359	0,362	0,360	0,349	0,355	0,362
5	1,019	0,910	0,706	0,608	0,411	0,322	0,329	0,478	0,707	0,855	1,078	1,078
6	0,087	0,075	0,075	0,077	0,078	0,082	0,086	0,085	0,082	0,090	0,107	0,107
7	1,344	1,400	1,293	1,399	1,439	1,466	1,506	1,459	1,481	1,397	1,268	1,506
8	0,112	0,072	0,053	0,050	0,052	0,058	0,060	0,059	0,062	0,062	0,066	0,112
9	0,118	0,118	0,126	0,137	0,144	0,143	0,147	0,160	0,184	0,181	0,212	0,212
10	0,064	0,051	0,051	0,056	0,048	0,044	0,039	0,037	0,039	0,040	0,047	0,064
11	0,326	0,423	0,260	0,416	0,505	0,544	0,531	0,495	0,472	0,485	0,467	0,544
12	0,045	0,038	0,028	0,027	0,030	0,030	0,035	0,037	0,038	0,033	0,031	0,045
13	0,418	0,375	0,327	0,314	0,413	0,480	0,468	0,422	0,417	0,386	0,344	0,480
14	0,035	0,029	0,032	0,024	0,019	0,022	0,032	0,032	0,038	0,034	0,037	0,038
15	0,071	0,064	0,062	0,050	0,069	0,077	0,077	0,067	0,084	0,075	0,091	0,091
16	0,050	0,034	0,019	0,022	0,020	0,017	0,016	0,017	0,023	0,023	0,024	0,050
17	0,172	0,211	0,313	0,258	0,198	0,263	0,286	0,301	0,289	0,291	0,275	0,313
18	0,030	0,033	0,017	0,015	0,014	0,015	0,019	0,021	0,022	0,021	0,019	0,033
19	0,144	0,286	0,265	0,253	0,166	0,223	0,254	0,272	0,267	0,261	0,257	0,286
20	0,036	0,031	0,020	0,019	0,021	0,018	0,016	0,021	0,025	0,025	0,025	0,036
21	0,066	0,076	0,062	0,072	0,053	0,065	0,080	0,080	0,084	0,080	0,085	0,085
22	0,027	0,023	0,017	0,020	0,015	0,014	0,016	0,018	0,017	0,017	0,017	0,027
23	0,117	0,161	0,125	0,204	0,139	0,127	0,157	0,184	0,189	0,192	0,183	0,204
24	0,027	0,029	0,024	0,023	0,021	0,016	0,015	0,017	0,018	0,019	0,018	0,029
25	0,130	0,124	0,138	0,167	0,144	0,120	0,127	0,156	0,166	0,168	0,174	0,174
26	0,023	0,024	0,026	0,024	0,023	0,018	0,016	0,016	0,016	0,017	0,018	0,026
27	0,056	0,061	0,058	0,059	0,059	0,053	0,057	0,063	0,062	0,059	0,057	0,063
28	0,029	0,022	0,018	0,019	0,017	0,019	0,016	0,015	0,014	0,015	0,016	0,029
29	0,133	0,145	0,131	0,107	0,133	0,104	0,071	0,102	0,116	0,128	0,133	0,145
30	0,028	0,022	0,018	0,019	0,020	0,021	0,022	0,022	0,022	0,021	0,022	0,028
31	0,120	0,127	0,125	0,105	0,128	0,106	0,075	0,100	0,114	0,124	0,134	0,134
32	0,026	0,022	0,020	0,020	0,019	0,021	0,022	0,021	0,021	0,020	0,020	0,026

5.1.4.2	Test Harmonics DIN EN 61000-4-7 (≥75 A per Phase)										P
PIKO CI 30											
Harmonics											
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
33	0,063	0,057	0,051	0,045	0,055	0,047	0,037	0,045	0,048	0,045	0,048	0,063
34	0,031	0,018	0,015	0,015	0,013	0,015	0,015	0,013	0,014	0,013	0,014	0,031
35	0,134	0,101	0,085	0,088	0,086	0,088	0,056	0,060	0,077	0,096	0,103	0,134
36	0,022	0,016	0,014	0,014	0,013	0,014	0,013	0,013	0,013	0,013	0,014	0,022
37	0,107	0,118	0,100	0,098	0,077	0,091	0,066	0,069	0,084	0,098	0,108	0,118
38	0,026	0,018	0,015	0,016	0,014	0,014	0,015	0,013	0,012	0,013	0,015	0,026
39	0,053	0,057	0,052	0,051	0,037	0,043	0,032	0,035	0,040	0,043	0,044	0,057
40	0,026	0,018	0,016	0,015	0,014	0,015	0,016	0,014	0,013	0,013	0,013	0,026
THC [A]	1,635	1,640	1,556	1,584	1,560	1,582	1,602	1,634	1,689	1,702	1,725	1,725
THDU40 [%]	0,578	0,593	0,585	0,549	0,532	0,539	0,550	0,505	0,520	0,490	0,492	0,593

5.1.4.2	Interharmonics										P
PIKO CI 30												
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
f [Hz]	I_h [%]											
75	0,060	0,076	0,054	0,066	0,059	0,064	0,067	0,057	0,062	0,062	0,114	0,114
125	0,063	0,056	0,052	0,054	0,055	0,058	0,061	0,058	0,059	0,062	0,076	0,076
175	0,065	0,063	0,062	0,062	0,073	0,083	0,084	0,074	0,074	0,082	0,090	0,090
225	0,078	0,074	0,073	0,075	0,080	0,088	0,093	0,088	0,087	0,093	0,112	0,112
275	0,074	0,082	0,084	0,085	0,092	0,097	0,104	0,098	0,099	0,111	0,117	0,117
325	0,061	0,073	0,077	0,079	0,091	0,102	0,102	0,100	0,099	0,107	0,122	0,122
375	0,055	0,075	0,078	0,081	0,088	0,094	0,095	0,092	0,092	0,099	0,105	0,105
425	0,047	0,058	0,063	0,065	0,075	0,086	0,081	0,081	0,082	0,089	0,090	0,090
475	0,043	0,049	0,055	0,058	0,060	0,070	0,068	0,067	0,069	0,071	0,080	0,080
525	0,039	0,041	0,063	0,062	0,063	0,055	0,056	0,058	0,059	0,066	0,067	0,067
575	0,038	0,040	0,042	0,044	0,046	0,052	0,057	0,053	0,051	0,049	0,052	0,057
625	0,034	0,034	0,058	0,057	0,056	0,041	0,039	0,040	0,042	0,044	0,044	0,058
675	0,033	0,033	0,032	0,032	0,033	0,036	0,045	0,041	0,036	0,038	0,040	0,045
725	0,031	0,029	0,031	0,031	0,032	0,031	0,032	0,033	0,037	0,039	0,039	0,039
775	0,030	0,031	0,030	0,030	0,033	0,033	0,033	0,033	0,035	0,036	0,040	0,040
825	0,030	0,028	0,026	0,027	0,027	0,027	0,027	0,029	0,030	0,032	0,034	0,034
875	0,029	0,029	0,027	0,030	0,032	0,031	0,029	0,030	0,031	0,032	0,035	0,035
925	0,030	0,029	0,027	0,029	0,029	0,030	0,029	0,030	0,032	0,034	0,036	0,036
975	0,030	0,028	0,028	0,029	0,028	0,028	0,028	0,028	0,030	0,031	0,032	0,032
1025	0,030	0,027	0,026	0,026	0,025	0,026	0,027	0,028	0,029	0,030	0,031	0,031
1075	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,031	0,035	0,035
1125	0,028	0,026	0,026	0,025	0,024	0,023	0,024	0,024	0,025	0,025	0,025	0,028
1175	0,036	0,036	0,032	0,030	0,033	0,034	0,033	0,030	0,029	0,030	0,032	0,036
1225	0,030	0,028	0,028	0,026	0,026	0,026	0,026	0,026	0,027	0,026	0,027	0,030
1275	0,037	0,034	0,031	0,030	0,030	0,033	0,032	0,031	0,031	0,030	0,032	0,037
1325	0,031	0,029	0,028	0,027	0,026	0,027	0,027	0,027	0,027	0,027	0,028	0,031
1375	0,033	0,033	0,033	0,034	0,036	0,036	0,037	0,036	0,036	0,036	0,036	0,037
1425	0,031	0,029	0,028	0,027	0,027	0,026	0,025	0,025	0,025	0,024	0,025	0,031
1475	0,053	0,063	0,049	0,056	0,064	0,071	0,080	0,079	0,082	0,078	0,076	0,082
1525	0,031	0,029	0,028	0,027	0,028	0,028	0,028	0,029	0,029	0,029	0,028	0,031
1575	0,049	0,060	0,046	0,052	0,059	0,065	0,074	0,074	0,079	0,074	0,072	0,079
1625	0,037	0,039	0,037	0,036	0,034	0,033	0,032	0,031	0,030	0,029	0,030	0,039
1675	0,033	0,031	0,031	0,031	0,033	0,035	0,036	0,037	0,039	0,039	0,039	0,039
1725	0,034	0,035	0,035	0,032	0,031	0,031	0,031	0,030	0,030	0,028	0,027	0,035

5.1.4.2	Interharmonics										P
PIKO CI 30											
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
1775	0,031	0,032	0,031	0,030	0,031	0,032	0,029	0,028	0,028	0,029	0,030	0,032
1825	0,032	0,028	0,026	0,023	0,022	0,023	0,023	0,023	0,023	0,022	0,023	0,032
1875	0,029	0,035	0,032	0,031	0,030	0,030	0,029	0,030	0,030	0,031	0,030	0,035
1925	0,036	0,035	0,033	0,032	0,030	0,030	0,029	0,028	0,027	0,026	0,026	0,036
1975	0,032	0,034	0,029	0,030	0,032	0,033	0,032	0,032	0,033	0,034	0,035	0,035

5.1.4.2	Higher Frequencies											P
PIKO CI 30												
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
f [kHz]	I_h [%]											
2,1	0,157	0,162	0,143	0,138	0,119	0,142	0,132	0,109	0,115	0,127	0,133	0,162
2,3	0,124	0,110	0,113	0,106	0,108	0,107	0,111	0,089	0,084	0,090	0,095	0,124
2,5	0,108	0,108	0,109	0,095	0,085	0,079	0,089	0,093	0,093	0,095	0,103	0,109
2,7	0,140	0,139	0,100	0,091	0,078	0,065	0,060	0,062	0,069	0,090	0,105	0,140
2,9	0,126	0,120	0,102	0,090	0,065	0,062	0,051	0,050	0,045	0,040	0,060	0,126
3,1	0,167	0,156	0,122	0,097	0,065	0,063	0,054	0,051	0,045	0,044	0,050	0,167
3,3	0,161	0,152	0,104	0,099	0,089	0,089	0,074	0,076	0,074	0,065	0,061	0,161
3,5	0,124	0,104	0,091	0,085	0,082	0,077	0,067	0,063	0,062	0,055	0,051	0,124
3,7	0,115	0,099	0,092	0,080	0,072	0,066	0,051	0,052	0,050	0,048	0,048	0,115
3,9	0,077	0,071	0,060	0,062	0,057	0,058	0,060	0,054	0,057	0,052	0,048	0,077
4,1	0,058	0,065	0,058	0,057	0,053	0,053	0,055	0,048	0,049	0,045	0,041	0,065
4,3	0,049	0,048	0,048	0,046	0,037	0,036	0,037	0,031	0,036	0,034	0,032	0,049
4,5	0,044	0,051	0,041	0,042	0,045	0,042	0,040	0,036	0,039	0,039	0,034	0,051
4,7	0,043	0,040	0,044	0,043	0,042	0,041	0,034	0,031	0,031	0,032	0,030	0,044
4,9	0,043	0,039	0,041	0,039	0,038	0,036	0,033	0,032	0,032	0,033	0,031	0,043
5,1	0,044	0,044	0,041	0,043	0,041	0,046	0,042	0,043	0,041	0,040	0,039	0,046
5,3	0,047	0,047	0,045	0,044	0,043	0,042	0,039	0,037	0,036	0,036	0,036	0,047
5,5	0,042	0,045	0,041	0,039	0,037	0,037	0,036	0,033	0,033	0,032	0,033	0,045
5,7	0,048	0,054	0,048	0,050	0,051	0,049	0,049	0,048	0,046	0,043	0,044	0,054
5,9	0,054	0,054	0,054	0,052	0,052	0,051	0,048	0,044	0,042	0,041	0,042	0,054
6,1	0,059	0,054	0,053	0,053	0,051	0,049	0,044	0,041	0,040	0,036	0,039	0,059
6,3	0,065	0,064	0,061	0,060	0,058	0,062	0,059	0,052	0,050	0,045	0,047	0,065
6,5	0,085	0,083	0,076	0,077	0,078	0,073	0,061	0,054	0,054	0,052	0,051	0,085
6,7	0,115	0,107	0,095	0,093	0,083	0,080	0,074	0,064	0,059	0,055	0,057	0,115
6,9	0,169	0,167	0,146	0,139	0,137	0,136	0,118	0,098	0,090	0,082	0,076	0,169

5.1.4.2	Higher Frequencies										P
7,1	0,287	0,266	0,244	0,237	0,202	0,190	0,151	0,128	0,123	0,108	0,097	0,287
7,3	0,209	0,209	0,224	0,218	0,217	0,228	0,188	0,145	0,129	0,116	0,108	0,228
7,5	0,188	0,181	0,164	0,152	0,183	0,195	0,171	0,153	0,153	0,153	0,147	0,195
7,7	0,094	0,094	0,100	0,114	0,136	0,123	0,125	0,127	0,130	0,136	0,136	0,136
7,9	0,054	0,054	0,059	0,077	0,091	0,101	0,084	0,072	0,078	0,093	0,105	0,105
8,1	0,045	0,048	0,043	0,048	0,049	0,052	0,053	0,053	0,062	0,070	0,076	0,076
8,3	0,038	0,037	0,036	0,037	0,039	0,043	0,036	0,037	0,044	0,052	0,059	0,059
8,5	0,028	0,027	0,026	0,029	0,034	0,033	0,031	0,032	0,039	0,047	0,049	0,049
8,7	0,025	0,024	0,025	0,027	0,028	0,027	0,026	0,026	0,029	0,037	0,046	0,046
8,9	0,026	0,026	0,025	0,026	0,026	0,027	0,030	0,034	0,039	0,049	0,059	0,059

PV-curve simulated according to	
Voltage of defined MPP [V]	800Vdc
Current of defined MPP [A]	41,3A
FFU of PV curve [1]	1
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 43,5A.

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.

5.2 Evidence of symmetry behavior of inverters		
Clause	**Test**	**Result**
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	**P**
5.2.2_b)	Power drop of single inverter modules	**P**

5.2.1 General	P
These tests serve to prove the requirements according to TOR Erzeuger, 6.1.1: These tests are not valid for direct connected rotating machines!	
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: PIKO CI 30						
1-min mean value	L1	L2	L3	L1 – L2	L2 – L3	L3 – L1
a) cos φ = 1 at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	10,639	10,609	10,659	0,031	-0,050	0,019
	10,639	10,608	10,659	0,031	-0,051	0,020
	10,640	10,608	10,658	0,033	-0,051	0,018
	10,640	10,608	10,659	0,032	-0,051	0,019
	10,639	10,609	10,659	0,030	-0,050	0,020
cos φ_{E60}:	1,000					
max. asymmetry [kVA]:	0,051					
b) maximum under-excited (i) at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	10,697	10,701	10,746	-0,004	-0,045	0,049
	10,692	10,700	10,745	-0,008	-0,045	0,052
	10,694	10,699	10,747	-0,006	-0,047	0,053
	10,695	10,698	10,748	-0,004	-0,050	0,053
	10,696	10,699	10,748	-0,004	-0,049	0,053
cos φ_{E60}:	0,797					
max. asymmetry [kVA]:	0,053					
c) maximum over-excited (c) at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	10,619	10,674	10,739	-0,056	-0,065	0,120
	10,617	10,673	10,738	-0,056	-0,065	0,121
	10,615	10,670	10,736	-0,055	-0,066	0,121
	10,615	10,671	10,737	-0,056	-0,066	0,122
	10,617	10,670	10,738	-0,053	-0,068	0,121
cos φ_{E60}:	0,798					
max. asymmetry [kVA]:	0,122					
d) cos φ = 1 at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	5,042	5,035	5,012	0,007	0,023	-0,030
	5,042	5,033	5,012	0,009	0,022	-0,030
	5,042	5,033	5,011	0,008	0,022	-0,030
	5,042	5,033	5,011	0,009	0,023	-0,031
	5,041	5,033	5,010	0,008	0,023	-0,031
cos φ_{E60}:	0,999					
max. asymmetry [kVA]:	0,031					

e) maximum under-excited (i) at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	6,284	6,327	6,267	-0,042	0,059	-0,017
	6,286	6,328	6,269	-0,042	0,059	-0,017
	6,285	6,327	6,269	-0,041	0,058	-0,017
	6,286	6,327	6,270	-0,041	0,057	-0,016
	6,284	6,326	6,269	-0,042	0,057	-0,015
cos φ_{E60}:	0,796					
max. asymmetry [kVA]:	0,059					
f) maximum over-excited (c) at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	6,292	6,265	6,206	0,027	0,059	-0,086
	6,291	6,266	6,206	0,026	0,060	-0,085
	6,293	6,266	6,205	0,027	0,062	-0,088
	6,291	6,265	6,206	0,025	0,059	-0,085
	6,292	6,266	6,206	0,025	0,061	-0,086
cos φ_{E60}:	0,800					
max. asymmetry [kVA]:	0,088					
Limit [kVA]:	≤ 5 % S_{Emax} and 3,68 kVA					

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

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

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

5.3 Evidence of the behavior of the generating unit on the network		
Clause	**Test**	**Result**
5.3.1	General	**P**
5.3.2	Measurement of the active power and reactive power range	**P**
5.3.3	End of active power feed-in after OFF command via telecontrol 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 SEmax and PEmax)		**P**
Test Condition:	The measurements were performed in the testing laboratory. at the grid-simulator: U_N = between 86 % Un and 109% Un until the test Frequency: 50 Hz +/- 0,5%	
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	Q	0		
	Q max. over-excited:	43,6% S_n		
	Qmax. under-excited:	43,6% S_n		

Test: PIKO CI 30			
60 s mean value	0,86 U_n	U_n	1,09U_n
a) Q=0 at 100% P_{Emax}			
U [V]:	198,04	230,90	251,03
$P_{Emax60\ a)}$ [kW]	29,250	29,805	29,906
$Q_{Emax60\ a)}$ [kVar]	0,243	0,297	0,330
$S_{Emax60\ a)}$ [kVA]	29,266	29,823	29,926
cos φ_{Emax60}	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}			
U [V]:	198,55	230,84	250,95
$P_{Emax60\ b)}$ [kW]	24,941	29,685	29,802
$Q_{Emax60\ b)}$ [kVar]	-14,397	-14,110	-13,982
$S_{Emax60\ b)}$ [kVA]	28,884	32,953	32,991
cos $\varphi_{Emax60-under-excited}$	0,864	0,901	0,903
c) maximum over-excited (c) at 100% P_{Emax}			
U [V]:	198,73	230,95	251,14
$P_{Emax60\ c)}$ [kW]	24,959	29,716	29,833
$Q_{Emax60\ c)}$ [kVar]	14,473	14,385	14,401
$S_{Emax60\ c)}$ [kVA]	28,950	33,125	33,218
cos $\varphi_{Emax60-over-excited}$	0,862	0,897	0,898
d) maximum under-excited (i) at 20-30% P_{Emax}			
U [V]:	--	230,25	--
$P_{Emax60\ b)}$ [kW]	--	8,823	--
$Q_{Emax60\ b)}$ [kVar]	--	-14,475	--
$S_{Emax60\ b)}$ [kVA]	--	17,014	--
cos $\varphi_{Emax60-under-excited}$	--	0,519	--
e) maximum over-excited (c) at 20-30% P_{Emax}			
U [V]:	--	230,33	--
$P_{Emax60\ c)}$ [kW]	--	8,879	--
$Q_{Emax60\ c)}$ [kVar]	--	14,306	--
$S_{Emax60\ c)}$ [kVA]	--	16,889	--
cos $\varphi_{Emax60-over-excited}$	--	0,526	--
f) maximum under-excited (i) at 10-20% P_{Emax}			
U [V]:	--	230,09	--
$P_{Emax60\ b)}$ [kW]	--	5,795	--
$Q_{Emax60\ b)}$ [kVar]	--	-14,491	--

$S_{Emax60\ b)}$ [kVA]	--	15,682	--
cos $\varphi_{Emax60\text{-}under\text{-}excited}$	--	0,370	--
g) maximum over-excited (c) at 10-20% P_{Emax}			
U [V]:	--	230,24	--
$P_{Emax60\ c)}$ [kW]	--	5,855	--
$Q_{Emax60\ c)}$ [kVar]	--	14,301	--
$S_{Emax60\ c)}$ [kVA]	--	15,504	--
cos $\varphi_{Emax60\text{-}over\text{-}excited}$	--	0,378	--
h) maximum under-excited (i) at 0-10% P_{Emax}			
U [V]:	--	229,97	--
$P_{Emax60\ b)}$ [kW]	--	2,645	--
$Q_{Emax60\ b)}$ [kVar]	--	-14,502	--
$S_{Emax60\ b)}$ [kVA]	--	14,835	--
cos $\varphi_{Emax60\text{-}under\text{-}excited}$	--	0,178	--
i) maximum over-excited (c) at 0-10% P_{Emax}			
U [V]:	--	230,15	--
$P_{Emax60\ c)}$ [kW]	--	2,720	--
$Q_{Emax60\ c)}$ [kVar]	--	14,294	--
$S_{Emax60\ c)}$ [kVA]	--	14,617	--
cos $\varphi_{Emax60\text{-}over\text{-}excited}$	--	0,186	--

S_{Emax60} and $P_{Emax\ 60}$	
S_{Emax60}= max($S_{Emax60\ a)}$, $S_{Emax60\ b)}$, $S_{Emax60\ c)}$) [KVA]	33,218
$P_{Emax\ 60}$= max($P_{Emax60\ a)}$, $P_{Emax60\ b)}$, $P_{Emax60\ c)}$)[KW]	29,906

Test:

*Für Test d – I wird jeweils die Testspannung bei welcher die höchste Wirkleistung erzielt wurde verwendet.
* For test d - I, the test voltage at which the highest active power was achieved is taken!

The EZE 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 <u>under-excited</u> 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 <u>overexcited</u> 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 <u>under-excited</u> 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 <u>overexcited</u> 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 <u>under-excited</u> 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:

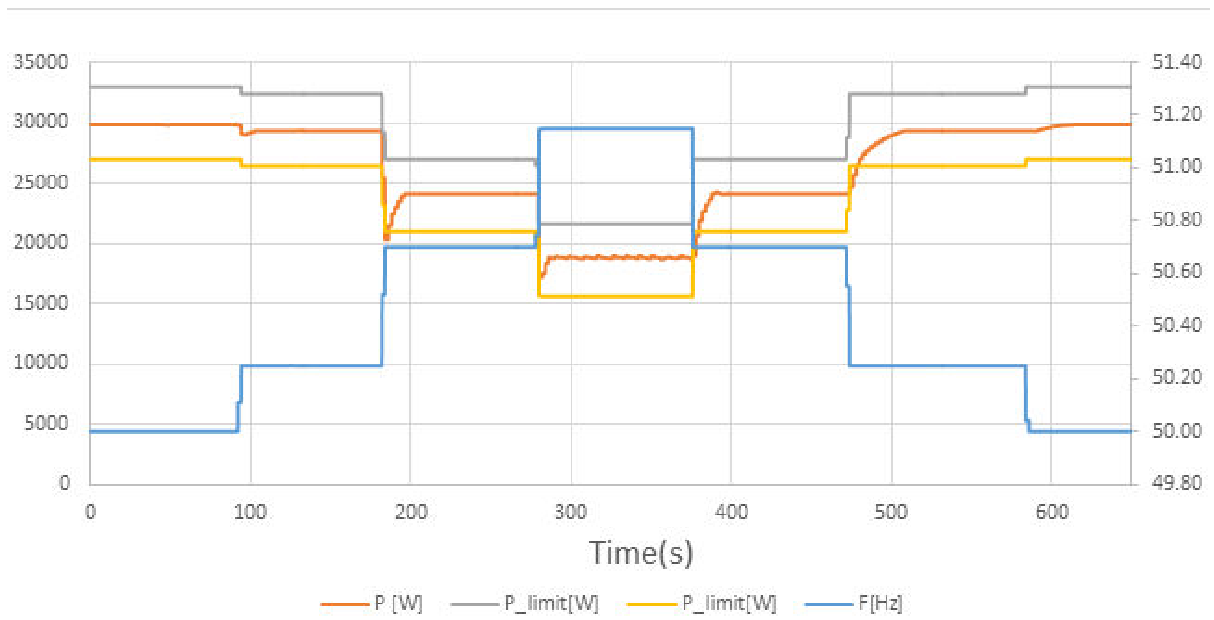
Q=31,2 (φ 0,95) (i) and (c): PGU ≤ 3,68 kVA
Q=43,6 (φ 0,90) (i) and (c): PGU > 3,68 kVA

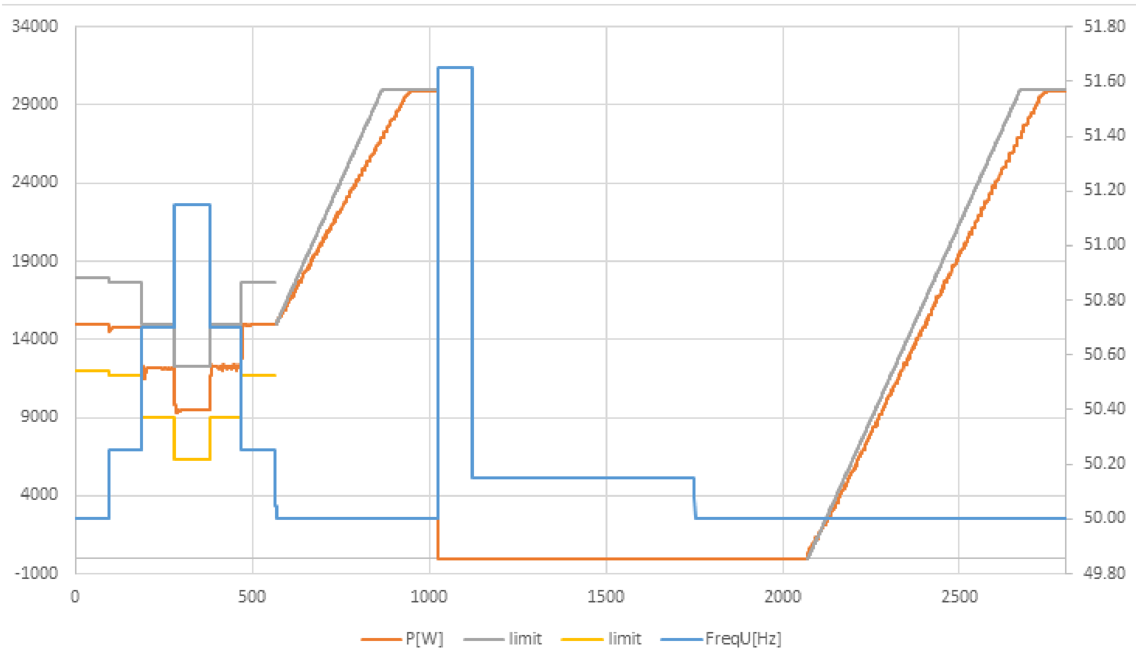
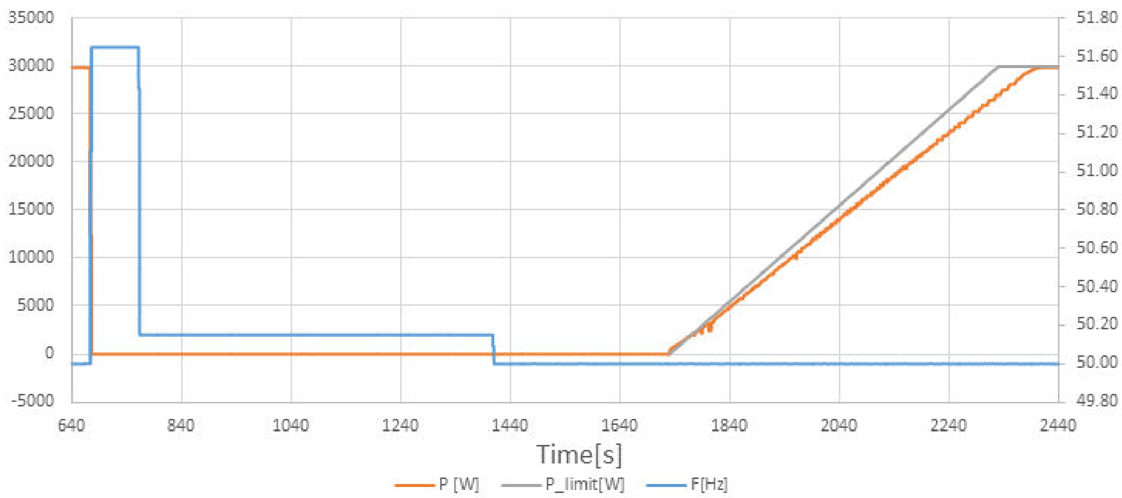
5.3.3.1 End of active power feed-in after OFF command via telecontrol interface		P
Graph of the setting accuracy:		
Test:		
1-min mean value / P_n/P [%]	30	<5
$P_{Setpoint}$[kW]:	9,000	1,500
P_{E60} [kW]:	9,100	1,523
T_0[s]:	2,2	
Limit T_0:	5s	
Test: The setpoint signal must be reduced from 30% to <5% P_{Emax}:		
Assessment criterion: The test is passed if the EZE ends the active power feed within 5 s. The criterion is an active power feed-in <5% Pn A separation of the EZE 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 that the requirements of TOR Erzeuger, 5.5.2)

Test cycle for adjustable PGUs										**P**
Test:										
Test 1: 100% PEmax; start frequency 50,20Hz; droop setting = 5%										
1-min mean value	50,00	50,25	50,70	51,15	50,70	50,25	50,00	51,65	50,15	50,00
Frequency [Hz]:	50,00	50,25	50,70	51,15	50,70	50,25	50,00	51,65	50,15	50,00
$P_{setpoint}$ [kW]:	N/A	29,40	24,00	18,60	24,00	29,40	N/A	0	0	30,00
P_{E60} [kW]:	29,870	29,335	24,062	18,822	24,040	29,161	29,875	0.020	0.010	29,980
$\Delta P_{E60}/P_{Setpoint}$ [%]:	N/A	-0,22%	0,26%	1,19%	0,17%	-0,81%	N/A	N/A	N/A	N/A
Test 2: Measurement: Active power output 40% and 60% after freezing > 80% P_{Emax};										
Frequency [Hz]:	50,00	50,25	50,70	51,15	50,70	50,25	50,00	51,65	50,15	50,00
$P_{setpoint}$ [kW]:	15,00	14,70	12,00	9,30	12,00	14,70	30,00	0	0	30,00
P_{E60} [kW]:	14,997	14,734	12,112	9,524	12,230	14,936	29,877	0.020	0.010	29,980
$\Delta P_{E60}/P_{Setpoint}$ [%]:	N/A	0,23%	0,94%	2,40%	1,92%	1,60%	N/A	N/A	N/A	N/A
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 5 % of P_{Emax}									

Graph Test 1@ 100% Pemax



Graph Test2 @ 40-60% Pemax

Gradient Test 1


Assessment criterion:
For f=50,2 Hz, the value of the PM active power currently being generated is "frozen". a) For adjustable PGUs when: 1) the active power reduces between measuring points b) and f) given above with a gradient of 40% PM per Hz for a decreasing frequency (or rises for a frequency decreasing again). 2) the maximum active power gradient occurring in point g) is lower than 10% of maximum active power P_{Emax} every minute, and 3) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from P_{Emax} by more than ± 10%. b) For conditionally adjustable PGUs 1) when they behave as in a) within their adjustment range, and 2) when, outside the adjustable range, the power fed in on leaving the adjustment range remains constant until shutdown. Shutdown must be no later than at 51,5 Hz. c) for non-regulated EZE, if - a switch-off between 50.2 Hz and 51.5 Hz takes place within 1 s; - The connection time in point j) corresponds to the manufacturer's information on the random generator.
Note:

5.3.4.1.2 Test cycle for all PGUs (adjustable, conditionally adjustable and non-adjustable)				P
Test:				
1-min mean value	g) 50,00 ± 0,01 Hz	h) 51,65 ± 0,05 Hz	i) 50,06 Hz ± 0,01 Hz	j) 50,00 Hz ± 0,01 Hz
1) g) 50,00 ± 0,01 Hz to h) 51,65 ± 0,05 Hz				

Disconnection time [ms]:	136	Limit [ms]:	200

Test:

Following tests a) to g), frequency h) 51,65 Hz ± 0,05 Hz must be set for at least 200ms. Afterwards, frequency i) 50,06 Hz ± 0,01 Hz is enabled and kept for at least 7 minutes.

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

Assessment criterion:

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

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

a) For adjustable PGUs when:

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

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

b) For conditionally adjustable PGUs

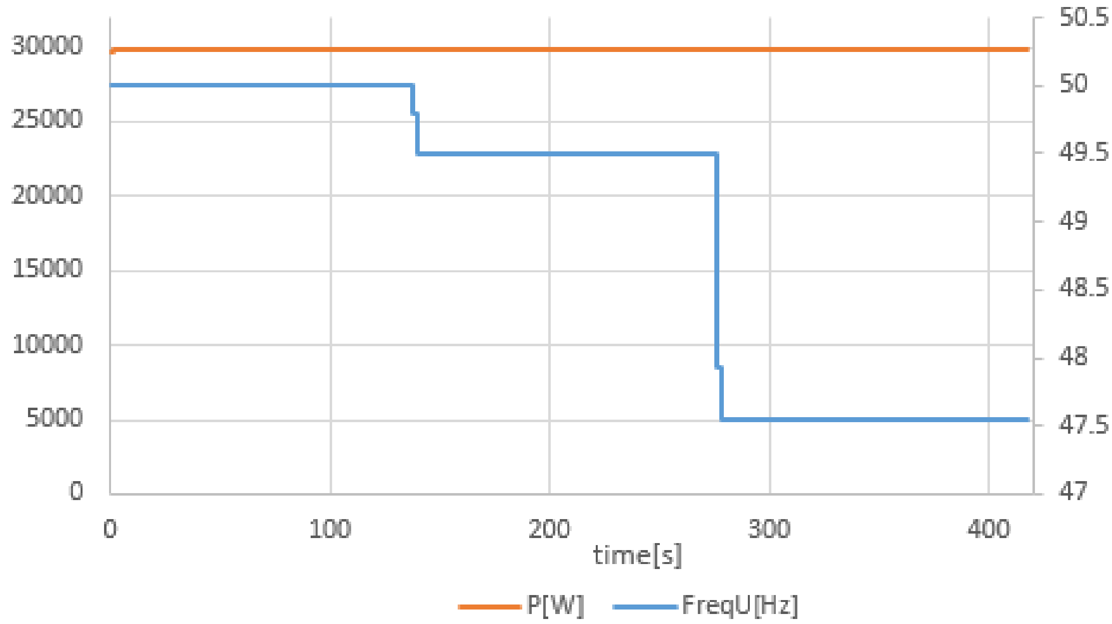
ba) when they behave as in a) within their adjustment range, and

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

Note:

5.3.5 Active power feed-in for underfrequency	P

Graph of frequency a) to b):



Test:

1-min mean value	a) 50 ± 0,01 [Hz]	b) -0,5[Hz]	c)- 2,4 to - 2,5 [Hz]
Frequency [Hz]:	50,00	49,50	47,55
P_{E60} [kW]:	29,874	29,872	29,864
$\Delta P_{b}/P_{c)}$ [%]:	<0,1%		

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 50 ± 0,01 Hz, thereafter the frequency is reduced to -0,5 Hz and after 1 minute reduce to - 2,4 to - 2,5 Hz. A 1-min mean value is recorded both before and after the frequency change.

Assessment criterion:

<u>For synchronous EZE:</u>

- The test is passed if the EZE 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% Pn per Hz from operating point b) to c).

<u>For non-synchronous EZE:</u>

- The test is passed if the EZE 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% Pn 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.

5.3.6.1.1 Voltage-controlled active power limitation P(V) - quasi-stationary behavior	**P**

Test: PIKO CI 30

$Vac_{setpoint}$[%Un]	Vac expected [V]	Vac measured [V]	Power[kW]
100	230,0	230,7	29,83
109	250,7	250,7	29,92
110	253,0	252,9	29,93
111	255,3	255,0	15,51
112	257,6	257,5	0,32
113	259,9	259,7	0,30
112	257,6	257,4	0,33
111	255,3	255,3	14,91
110	253,0	253,0	29,89
109	250,7	250,7	29,92
100	230,0	230,7	29,82

Test:

Operate at 100% P / activation threshold: 110%U_n

Start at 100%U_n→jump to 109% than increase the voltage in 1% steps up 113% →decrease the voltage in 1% steps up to 109% →back to 100% U_n

Every voltage point must held for 60 seconds.

Assessment criterion:

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

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

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.

5.3.6.1.2	Voltage-controlled active power limitation P(V) - dynamic behavior	P

Test: PIKO CI 30

$Vac_{setpoint}$[%Un]	Vac expected [V]	Vac measured [V]	Power[kW]
100	230,0	230,70	29,641
109	250,7	251,40	29,714
113	259,9	260,30	-0,083
109	250,7	251,30	30,255
100	230,0	230,50	29,670

Set value Tau =:	5s

Test:

Operate at 100% P / activation threshold: 110%U_n / Tau=

Start at 100%U_n→jump to 109% →to 113% → to 109% →back to 100% U_n

Every voltage point must held for at 60 seconds.

* The test time must be minimum 10 times Tau in s but at least 60s

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% Pn as well as for the time +3 seconds.

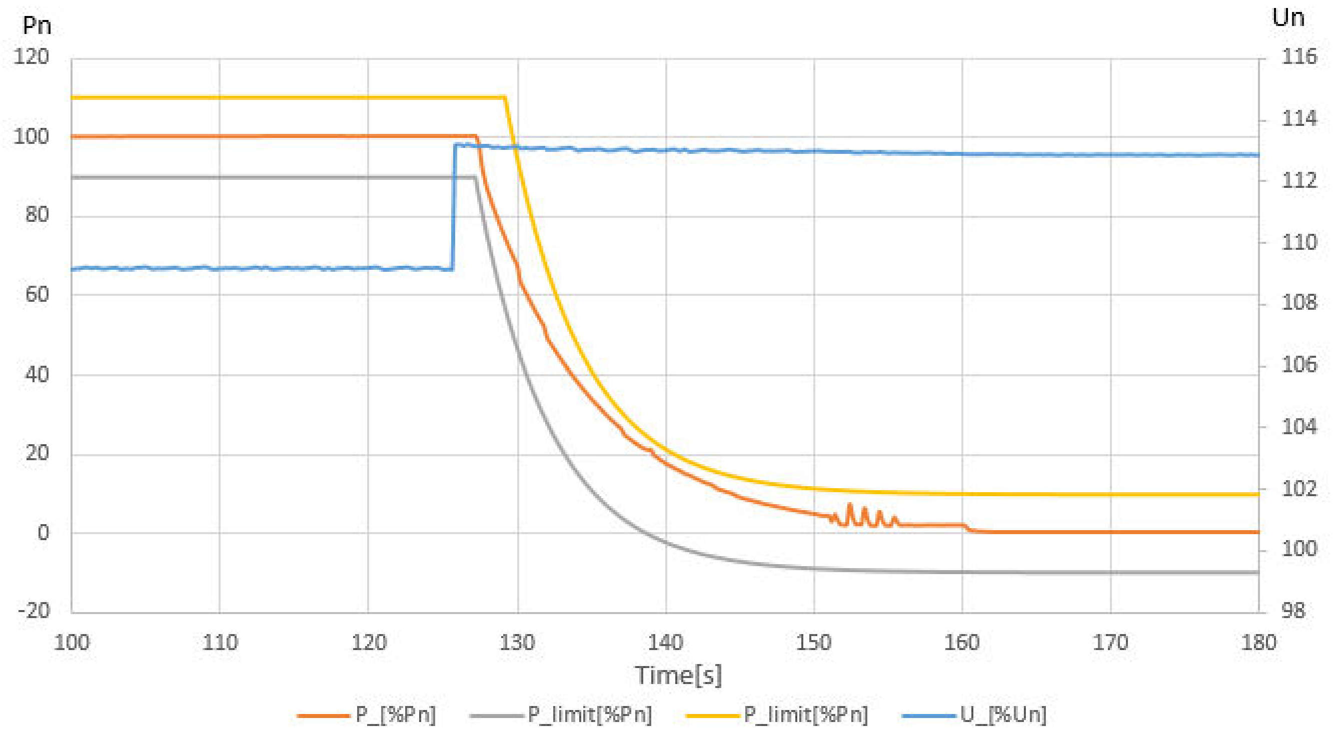
The tolerance bands are calculated according to Table 2.

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

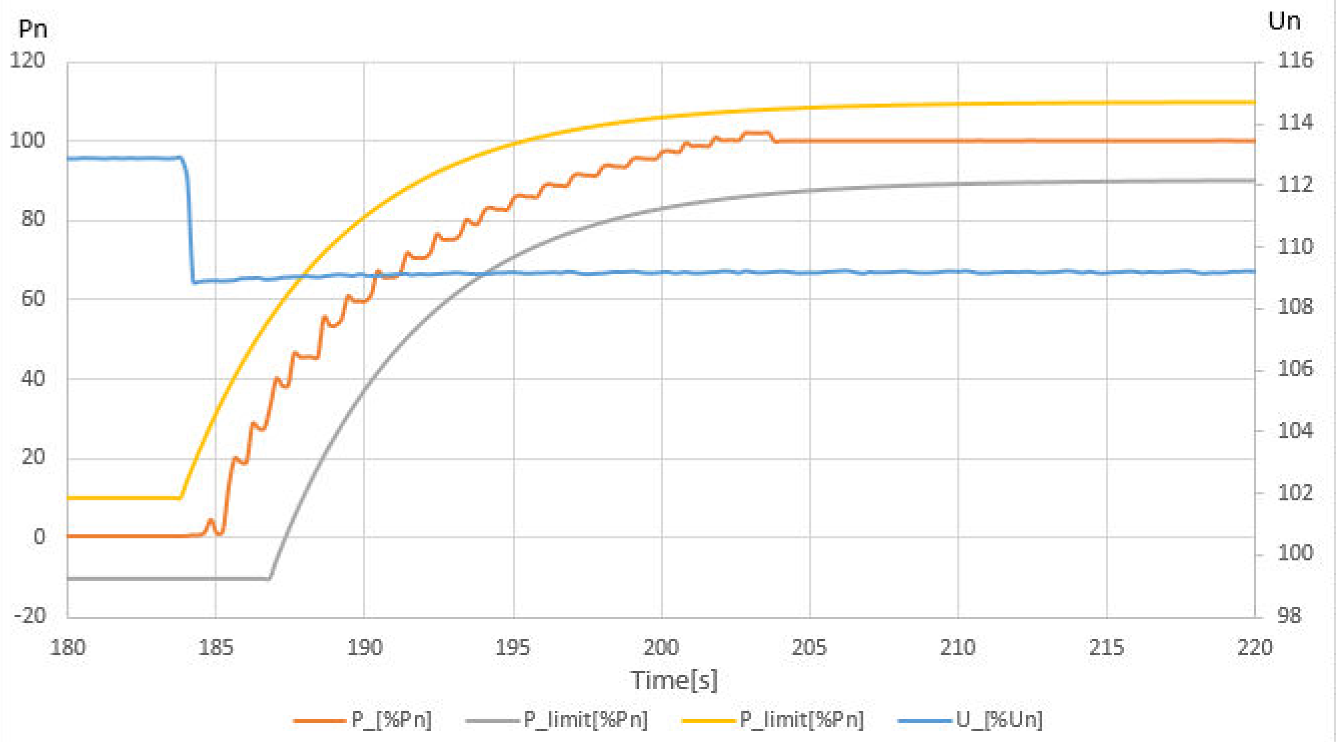
increase in active power $P_2 > P_1$	Upper Tolerance band:	for all *t*: $P_2 - (P_2 - P_1)\, e^{(-t / Tau)} + 0{,}10\, P_n$
	lower Tolerance band:	for *t* < 3 Second: $P_1 - 0{,}10\, P_n$ für t ≥ 3 Second: P2 – (P2 – P1) e([–t+3 Seconds] / Tau) - 0,10 Pn
drop in active power $P_2 < P_1$	Upper Tolerance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

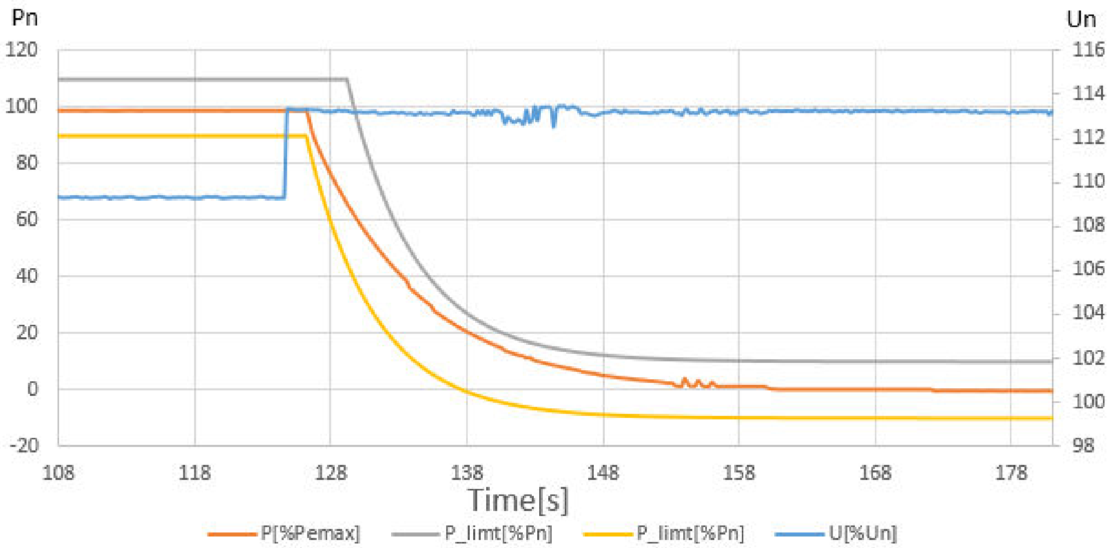
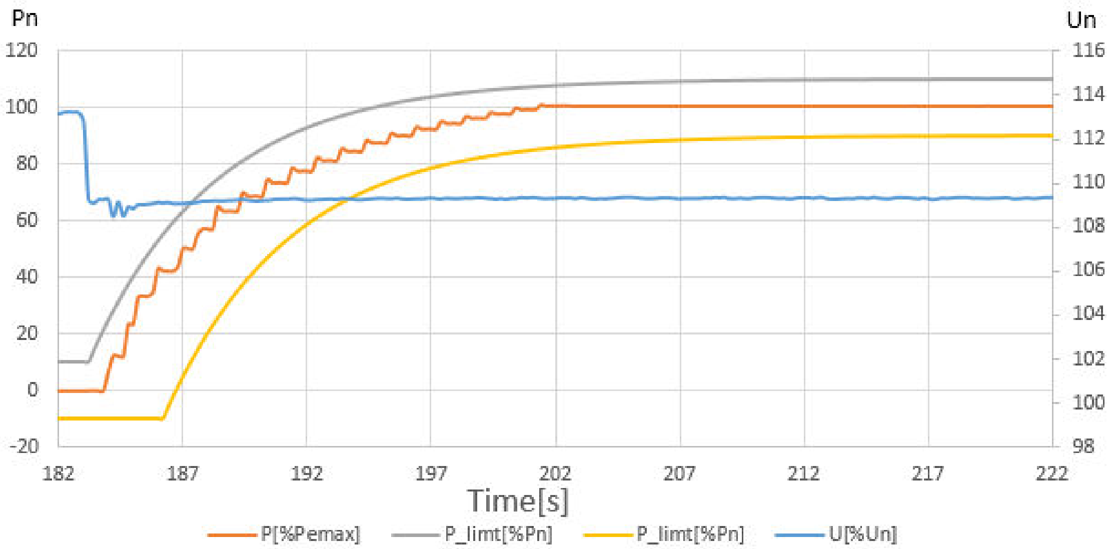
Note:

Graph of Voltage-controlled active power limitation P(V), form 109%Un to 113%Un test by SE 17KTL-D3



Graph of Voltage-controlled active power limitation P(V), form 113%Un to 109%Un test by SE 17KTL-D3



Graph of Voltage-controlled active power limitation P(V), form 109%Un to 113%Un test by PIKO CI 30

Graph of Voltage-controlled active power limitation P(V), form 113%Un to 109%Un test by PIKO CI 30


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.

5.3.7.1 Test — P

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

Test: PIKO CI 30						
60 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]:	209,58	209,96	230,56	230,96	251,12	250,95
P_{E600} [kW]:	14,932	27,508	14,985	29,717	15,032	29,834
Q_{E600} [kVar]:	7,266	12,660	7,255	14,494	7,303	14,065
S_{E600} [kVA]:	16,649	30,365	16,698	33,175	16,765	33,071
cos $φ_{E600\text{-over-excited}}$	0,897	0,906	0,897	0,896	0,897	0,902
b) cos φ 0,9 under-excited						
U [V]:	209,36	209,85	230,55	230,81	251,14	250,99
P_{E600} [kW]:	14,918	27,061	14,972	29,658	29,833	29,778
Q_{E600} [kVar]:	-7,132	-12,969	-7,094	-14,174	14,401	-14,182
S_{E600} [kVA]:	16,584	30,098	16,621	32,956	33,218	33,055
cos $φ_{E600\text{-under-excited}}$:	0,900	0,899	0,901	0,900	0,898	0,901
Limit cos $φ_{E30}$:	cos φ= 0,89 to 0,91 (c) and cos φ= 0,89 to 0,91 (i)					

Test:

**applies for Units $ΣS_{Emax}$ ≤ 3.68 kVA

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

*applies for Units $ΣS_{Emax}$ ≥ 3.68 kVA

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

Assessment criterion:

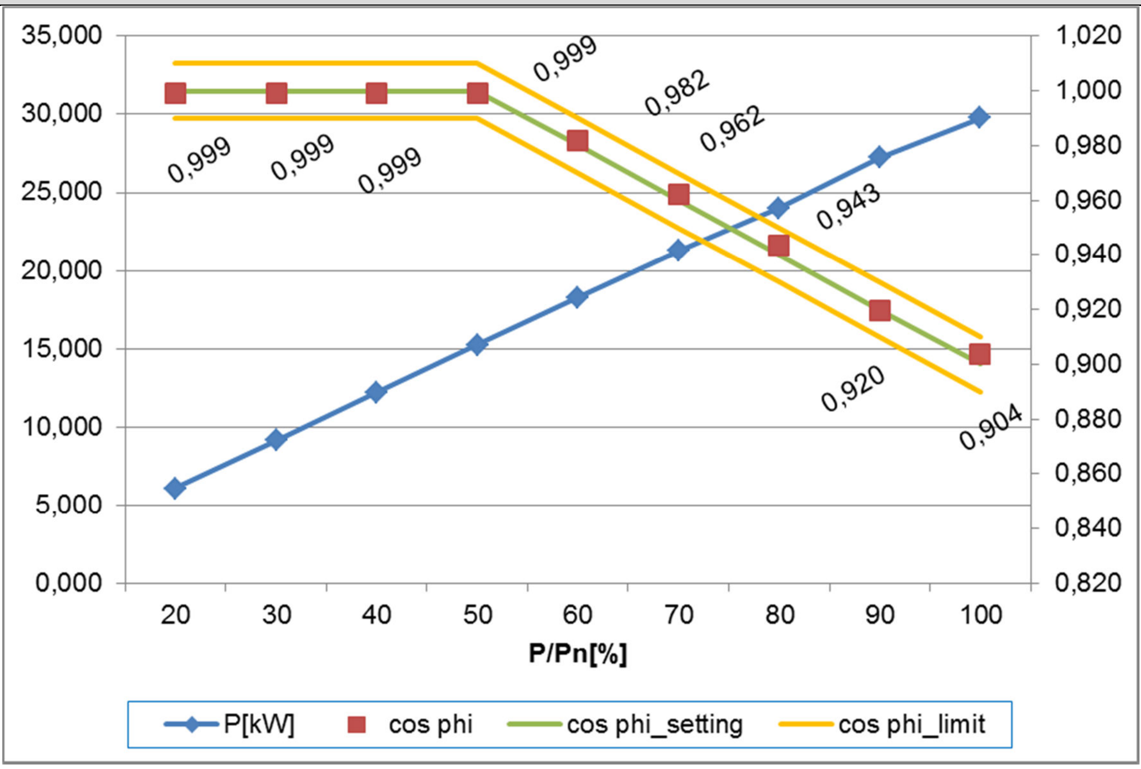
The test is passed if all cos φ values (30 s mean) do not deviate from the specification by more than ± 0.01.

For EZE 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 Un.

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 a): PIKO CI 30									
P_{Emax}/P [%]	20	30	40	50	60	70	80	90	100
30 s mean value	20% to 100% P_{Emax}								
U [V]:	230,04	230,08	230,10	230,11	230,07	230,07	230,10	230,16	230,19
P_{E30} [kW]:	6,071	9,152	12,203	15,242	18,258	21,266	24,000	27,225	29,758
P_{E30} of P_{Emax} [%]:	20,24	30,51	40,68	50,81	60,86	70,89	80,00	90,75	99,19
Q_{E30} [kVar]:	0,218	0,195	0,198	0,201	-3,520	-6,029	-8,434	-11,630	-14,099
cos $φ_{E30}$:	0,999	0,999	0,999	0,999	0,982	0,962	0,943	0,920	0,904
cos $φ_{setpoint}$ of P_{E30}:	1,00	1,00	1,00	1,00	0,98	0,96	0,94	0,92	0,90
Limit cos φ $_{E30}$:	cos $φ_{setpoint}$ ± 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]:	230,19	230,19	230,18	230,23	230,14	230,13	230,07	230,05	230,01
P_{E30} [kW]:	29,758	27,218	23,730	21,259	18,251	15,239	12,195	9,145	6,078
P_{E30} of P_{Emax} [%]:	99,19	90,73	79,10	70,86	60,84	50,80	40,65	30,48	20,26
Q_{E30} [kVar]:	-14,099	-11,630	-8,443	-6,031	-3,524	0,194	0,192	0,190	0,191
cos $φ_{E30}$:	0,904	0,920	0,942	0,962	0,982	0,999	0,999	0,999	0,999
cos $φ_{setpoint}$ of P_{E30}:	0,90	0,92	0,94	0,96	0,98	1,00	1,00	1,00	1,00
Limit cos φ $_{E30}$:	cos $φ_{setpoint}$ ± 0,01								
Test b):									
P_{Emax}/P_n [%]	20			50			100		
30 s mean value	20% to 50% to 100% P_{Emax}								
U [V]:	230,02			230,38			230,65		
P_{E30} [kW]:	5,917			14,904			30,116		
P_{E30} of P_{Emax} [%]:	19,72			49,68			100,39		
Q_{E30} [kVar]:	0,224			0,251			-14,213		
cos $φ_{E30}$:	0,999			1,000			0,910		
cos $φ_{setpoint}$ of P_{E30}:	1,00			1,00			0,90		
T_0[s]:	<1s				<1s				
30 s mean value	100% to 50% to 20% P_{Emax}								
U [V]:	230,58			230,34			229,96		
P_{E30} [kW]:	29,762			15,003			5,958		
P_{E30} [%]:	99,21			50,01			19,86		

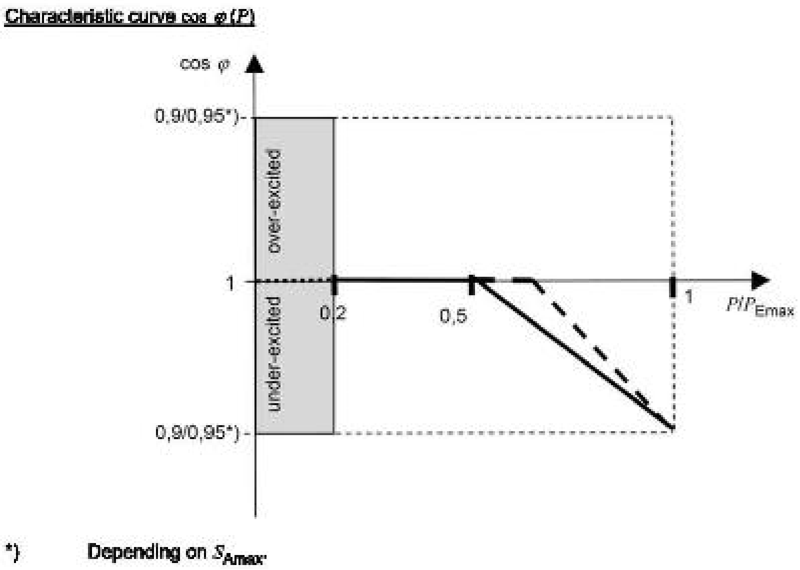
Q_{E30} [kVar]:	-13,905	0,129	0,219
cos $φ_{E30}$:	0,912	0,998	0,999
cos $φ_{setpoint}$ of P_{E30}:	0,90	1,00	1,00
T_0 [s]:	<1s		<1s
Limit T_0 [s]:	10 s		
Limit cos φ $_{E30}$:	cos $φ_{setpoint}$ ± 0,02		
Graph of cos φ(P): Test a)			



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 30 s mean value.



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_n.

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 10 s.

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.

5.3.9.1 Test	P

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

Test: PIKO CI 30

60 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]:	209,61	210,03	230,49	230,95	250,83	251,14
P_{E600} [kW]:	14,814	26,669	14,890	29,716	14,845	29,833
Q_{E600} [kVar]:	14,340	14,438	14,313	14,385	14,496	14,401
cos $φ_{E600-over-excited}$	0,717	0,877	0,719	0,897	0,713	0,898
$Q_{setpoint}$ [kVar]:	14,388	14,388	14,388	14,388	14,388	14,388
ΔQ/Sn%]	-0,15	0,15	-0,23	-0,01	0,33	0,04
b) under-excited						
U [V]:	209,33	209,99	230,37	230,84	250,93	250,95
P_{E600} [kW]:	14,663	26,632	14,740	29,685	14,801	29,802
Q_{E600} [kVar]:	-14,207	-14,206	-14,159	-14,110	-14,192	-13,982
cos $φ_{E600-under-excited}$:	0,716	0,880	0,719	0,901	0,720	0,903
$Q_{setpoint}$ [kVar]:	-14,388	-14,388	-14,388	-14,388	-14,388	-14,388
ΔQ/Sn%]	0,55	0,55	0,69	0,84	0,59	1,23
Limit cos $φ_{E30}$:	± 4% S_n					

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 EZE 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_n to ± 10% P_n. 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

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% Pn**

Voltage steps	U_step [Un%]	U_meas [V]	U_meas [Un%]	P_{30s} [kW]	Q tol_under [kVar]	Q_{30s} [kVar]	Q tol_upper [kVar]	Q tol_under [Sn%]	Q_{30s} [Sn%]	Q tol_upper [Sn%]
1	100	230,26	100,11	29,71	-1,32	0,98	1,32	-4,00	2,97	4,00
2	101	232,37	101,03	29,72	-1,32	1,00	1,32	-4,00	3,03	4,00
3	102	234,76	102,07	29,73	-1,32	1,02	1,32	-4,00	3,09	4,00
4	103	237,05	103,06	29,73	-1,32	1,04	1,32	-4,00	3,15	4,00
5	104	239,34	104,06	29,76	-1,32	1,05	1,32	-4,00	3,18	4,00
6	105	241,48	104,99	29,62	-1,32	-0,99	1,32	-4,00	3,00	4,00
7	106	243,87	106,03	29,60	-6,12	-5,40	-3,48	-18,53	-16,36	-10,53
8	107	246,07	106,99	29,58	-10,91	-9,48	-8,27	-33,07	-28,73	-25,07
9	108	248,47	108,03	29,54	-15,71	-14,22	-13,07	-47,60	-43,09	-39,60
10	109	250,67	108,99	29,55	-15,71	-14,61	-13,07	-47,60	-44,27	-39,60
11	110	253,10	110,04	29,60	-15,71	-14,61	-13,07	-47,60	-44,27	-39,60
12	111	255,32	111,01	29,59	-15,71	-14,61	-13,07	-47,60	-44,27	-39,60
13	112	257,72	112,05	-0,07	-1,32	-0,59	1,32	-4,00	-1,78	4,00
14	113	259,80	112,96	-0,07	-1,32	-0,45	1,32	-4,00	-1,36	4,00
15	112	257,41	111,92	-0,07	-1,32	-0,45	1,32	-4,00	-1,36	4,00
16	111	255,32	111,01	29,60	-15,71	-14,61	-13,07	-47,60	-44,27	-39,60
17	110	253,11	110,05	29,61	-15,71	-14,62	-13,07	-47,60	-44,30	-39,60
18	109	250,69	108,99	29,56	-15,71	-14,62	-13,07	-47,60	-44,30	-39,60
19	108	248,36	107,98	29,54	-15,71	-14,63	-13,07	-47,60	-44,33	-39,60
20	107	245,94	106,93	29,56	-10,91	-10,05	-8,27	-33,07	-30,45	-25,07
21	106	243,77	105,99	29,59	-6,12	-5,81	-3,48	-18,53	-17,61	-10,53
22	105	241,40	104,96	29,63	-1,32	1,43	1,32	-4,00	4,33	4,00
23	104	239,32	104,05	29,74	-1,32	1,08	1,32	-4,00	3,27	4,00
24	103	237,06	103,07	29,72	-1,32	1,04	1,32	-4,00	3,15	4,00
25	102	234,76	102,07	29,72	-1,32	1,02	1,32	-4,00	3,09	4,00
26	101	232,38	101,03	29,70	-1,32	1,00	1,32	-4,00	3,03	4,00
27	100	230,28	100,12	29,69	-1,32	0,99	1,32	-4,00	3,00	4,00
28	99	227,79	99,04	29,68	-1,32	0,98	1,32	-4,00	2,97	4,00
29	98	225,50	98,04	29,67	-1,32	0,97	1,32	-4,00	2,94	4,00
30	97	223,21	97,05	29,66	-1,32	0,96	1,32	-4,00	2,91	4,00
31	96	220,93	96,05	29,64	-1,32	0,96	1,32	-4,00	2,91	4,00
32	95	218,59	95,04	29,62	2,28	2,66	4,92	6,90	8,06	14,90
33	94	216,27	94,03	29,59	5,87	6,51	8,51	17,80	19,73	25,80
34	93	214,04	93,06	28,68	9,47	10,40	12,11	28,70	31,52	36,70
35	92	211,54	91,98	26,91	13,07	13,68	15,71	39,60	41,45	47,60
36	91	209,41	91,05	26,24	13,07	14,53	15,71	39,60	44,03	47,60
37	90	207,18	90,08	25,89	13,07	14,60	15,71	39,60	44,24	47,60
38	89	204,82	89,05	25,52	13,07	14,60	15,71	39,60	44,24	47,60
39	88	202,47	88,03	25,15	13,07	14,61	15,71	39,60	44,27	47,60
40	87	200,22	87,05	24,79	13,07	14,60	15,71	39,60	44,24	47,60
41	86	197,84	86,02	24,42	13,07	14,50	15,71	39,60	43,94	47,60
42	85	195,59	85,04	24,06	13,07	14,51	15,71	39,60	43,97	47,60

43	86	197,84	86,02	24,41	13,07	14,51	15,71	39,60	43,97	47,60
44	87	200,19	87,04	24,78	13,07	14,50	15,71	39,60	43,94	47,60
45	88	202,44	88,02	25,14	13,07	14,50	15,71	39,60	43,94	47,60
46	89	204,79	89,04	25,51	13,07	14,50	15,71	39,60	43,94	47,60
47	90	207,14	90,06	25,88	13,07	14,49	15,71	39,60	43,91	47,60
48	91	209,39	91,04	26,23	13,07	14,49	15,71	39,60	43,91	47,60
49	92	211,62	92,01	26,91	13,07	13,97	15,71	39,60	42,33	47,60
50	93	214,17	93,12	28,63	9,47	10,92	12,11	28,70	33,09	36,70
51	94	216,50	94,13	29,71	5,87	7,38	8,51	17,80	22,36	25,80
52	95	218,72	95,09	29,63	2,28	3,15	4,92	6,90	9,55	14,90
53	96	220,98	96,08	29,64	-1,32	1,08	1,32	-4,00	3,27	4,00
54	97	223,21	97,05	29,66	-1,32	0,96	1,32	-4,00	2,91	4,00
55	98	225,50	98,04	29,67	-1,32	0,97	1,32	-4,00	2,94	4,00
56	99	227,79	99,04	29,69	-1,32	0,98	1,32	-4,00	2,97	4,00
57	100	230,28	100,12	29,69	-1,32	0,99	1,32	-4,00	3,00	4,00

Test: 5.3.10.1.1 **a) to n) 20% Pn**

Voltage steps	U_step [Un%]	U_meas [V]	U_meas [Un%]	P_{30s} [kW]	Q tol_under [kVar]	Q_{30s} [kVar]	Q tol_upper [kVar]	Q tol_under [Sn%]	Q_{30s} [Sn%]	Q tol_upper [Sn%]
1	100	230,16	100,07	6,00	-1,32	0,05	1,32	-4,00	0,15	4,00
2	101	232,46	101,07	6,00	-1,32	0,05	1,32	-4,00	0,15	4,00
3	102	234,76	102,07	6,00	-1,32	0,05	1,32	-4,00	0,15	4,00
4	103	237,06	103,07	6,00	-1,32	0,05	1,32	-4,00	0,15	4,00
5	104	239,36	104,07	6,00	-1,32	0,05	1,32	-4,00	0,15	4,00
6	105	241,63	105,06	6,00	-1,32	-0,01	1,32	-4,00	-0,03	4,00
7	106	243,83	106,01	5,96	-6,12	-4,83	-3,48	-18,53	-14,64	-10,53
8	107	246,10	107,00	5,90	-10,91	-9,41	-8,27	-33,07	-28,52	-25,07
9	108	248,50	108,04	5,82	-15,71	-13,68	-13,07	-47,60	-41,45	-39,60
10	109	250,27	108,81	5,81	-15,71	-14,32	-13,07	-47,60	-43,39	-39,60
11	110	252,80	109,91	5,81	-15,71	-14,33	-13,07	-47,60	-43,42	-39,60
12	111	255,22	110,97	5,81	-15,71	-14,35	-13,07	-47,60	-43,48	-39,60
13	112	257,76	112,07	-0,07	-1,32	-0,59	1,32	-4,00	-1,78	4,00
14	113	259,81	112,96	-0,07	-1,32	-0,45	1,32	-4,00	-1,36	4,00
15	112	257,41	111,92	-0,07	-1,32	-0,45	1,32	-4,00	-1,36	4,00
16	111	255,23	110,97	5,81	-15,71	-14,36	-13,07	-47,60	-43,52	-39,60
17	110	252,80	109,91	5,81	-15,71	-14,34	-13,07	-47,60	-43,45	-39,60
18	109	250,27	108,81	5,81	-15,71	-14,32	-13,07	-47,60	-43,39	-39,60
19	108	248,42	108,01	5,81	-15,71	-14,02	-13,07	-47,60	-42,48	-39,60
20	107	245,95	106,94	5,89	-10,91	-9,99	-8,27	-33,07	-30,27	-25,07
21	106	243,68	105,95	5,95	-6,12	-5,42	-3,48	-18,53	-16,42	-10,53
22	105	241,52	105,01	6,00	-1,32	-0,45	1,32	-4,00	-1,36	4,00
23	104	239,35	104,07	6,00	-1,32	0,03	1,32	-4,00	0,09	4,00
24	103	237,06	103,07	6,00	-1,32	0,05	1,32	-4,00	0,15	4,00
25	102	234,76	102,07	6,00	-1,32	0,05	1,32	-4,00	0,15	4,00
26	101	232,46	101,07	6,00	-1,32	0,04	1,32	-4,00	0,12	4,00
27	100	230,17	100,07	6,00	-1,32	0,04	1,32	-4,00	0,12	4,00
28	99	227,87	99,07	5,99	-1,32	0,04	1,32	-4,00	0,12	4,00
29	98	225,58	98,08	5,99	-1,32	0,04	1,32	-4,00	0,12	4,00
30	97	223,28	97,08	5,99	-1,32	0,04	1,32	-4,00	0,12	4,00
31	96	220,98	96,08	5,99	-1,32	0,04	1,32	-4,00	0,12	4,00
32	95	218,37	94,95	5,98	2,28	3,95	4,92	6,90	11,97	14,90
33	94	216,19	94,00	5,94	5,87	7,25	8,51	17,80	21,97	25,80

34	93	214,05	93,07	5,88	9,47	10,49	12,11	28,70	31,79	36,70
35	92	211,52	91,97	5,79	13,07	14,24	15,71	39,60	43,15	47,60
36	91	209,35	91,02	5,78	13,07	14,57	15,71	39,60	44,15	47,60
37	90	207,00	90,00	5,77	13,07	14,56	15,71	39,60	44,12	47,60
38	89	204,73	89,01	5,76	13,07	14,52	15,71	39,60	44,00	47,60
39	88	202,46	88,03	5,76	13,07	14,47	15,71	39,60	43,85	47,60
40	87	200,20	87,04	5,75	13,07	14,43	15,71	39,60	43,73	47,60
41	86	197,83	86,01	5,75	13,07	14,37	15,71	39,60	43,55	47,60
42	85	195,57	85,03	5,74	13,07	14,31	15,71	39,60	43,36	47,60
43	86	197,83	86,01	5,75	13,07	14,36	15,71	39,60	43,52	47,60
44	87	200,19	87,04	5,75	13,07	14,41	15,71	39,60	43,67	47,60
45	88	202,46	88,02	5,76	13,07	14,46	15,71	39,60	43,82	47,60
46	89	204,72	89,01	5,76	13,07	14,51	15,71	39,60	43,97	47,60
47	90	206,99	90,00	5,77	13,07	14,56	15,71	39,60	44,12	47,60
48	91	209,35	91,02	5,78	13,07	14,57	15,71	39,60	44,15	47,60
49	92	211,60	92,00	5,78	13,07	14,56	15,71	39,60	44,12	47,60
50	93	214,17	93,12	5,87	9,47	10,96	12,11	28,70	33,21	36,70
51	94	216,31	94,05	5,93	5,87	7,69	8,51	17,80	23,30	25,80
52	95	218,61	95,05	5,97	2,28	4,43	4,92	6,90	13,42	14,90
53	96	221,02	96,09	5,99	-1,32	0,51	1,32	-4,00	1,55	4,00
54	97	223,27	97,08	5,99	-1,32	0,04	1,32	-4,00	0,12	4,00
55	98	225,57	98,07	5,99	-1,32	0,04	1,32	-4,00	0,12	4,00
56	99	227,87	99,07	5,99	-1,32	0,04	1,32	-4,00	0,12	4,00
57	100	230,12	100,05	6,00	-1,32	0,04	1,32	-4,00	0,12	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%Un**

Voltage steps	U_step [Un%]	U_meas [V]	U_meas [Un%]	P_{30s} [kW]	Q tol_under [kVar]	Q_{30s} [kVar]	Q tol_upper [kVar]	Q tol_under [Sn%]	Q_{30s} [Sn%]	Q tol_upper [Sn%]
1	91	209,34	91,02	0,37	-0,59	0,89	2,05	-1,80	2,70	6,20
2	91	209,49	91,08	1,28	2,19	3,31	4,83	6,63	10,03	14,63
3	91	209,51	91,09	2,77	5,67	6,93	8,31	17,17	21,00	25,17
4	91	209,56	91,12	4,27	9,15	10,60	11,79	27,74	32,12	35,74
5	91	209,55	91,11	5,77	12,48	14,24	15,12	37,83	43,15	45,83
6	91	209,37	91,03	4,26	9,16	11,20	11,80	27,75	33,94	35,75
7	91	209,35	91,02	2,76	5,67	7,55	8,31	17,18	22,88	25,18
8	91	209,30	91,00	1,27	2,19	3,82	4,83	6,63	11,58	14,63
9	91	209,26	90,98	0,37	-0,59	1,10	2,05	-1,79	3,33	6,21

Test: 5.3.10.1.1 **o) to z) Test@109%Un**

Voltage steps	U_step [Un%]	U_meas [V]	U_meas [Un%]	P_{30s} [kW]	Q tol_under [kVar]	Q_{30s} [kVar]	Q tol_upper [kVar]	Q tol_under [Sn%]	Q_{30s} [Sn%]	Q tol_upper [Sn%]
1	109	250,75	109,02	0,11	-2,03	-1,03	0,61	-6,16	-3,12	1,84
2	109	250,62	108,97	1,35	-4,90	-3,48	-2,26	-14,85	-10,55	-6,85
3	109	250,66	108,98	2,88	-8,26	-7,11	-5,62	-25,04	-21,55	-17,04
4	109	250,66	108,98	4,46	-11,82	-10,77	-9,18	-35,81	-32,64	-27,81
5	109	250,67	108,99	5,98	-15,21	-14,51	-12,57	-46,09	-43,97	-38,09
6	109	250,75	109,02	4,43	-11,64	-11,41	-9,00	-35,26	-34,58	-27,26
7	109	250,80	109,04	2,89	-8,25	-7,67	-5,61	-25,01	-23,24	-17,01
8	109	250,76	109,03	1,34	-4,90	-4,07	-2,26	-14,85	-12,33	-6,85
9	109	250,82	109,05	0,10	-2,03	-1,27	0,61	-6,16	-3,85	1,84

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:

To check the behavior of the Q (U) control, the time constant or the response time of the Q (U) control must be determined according to a filter of the first order (PT1 element) with a time constant **Tau of 5s**. Overvoltage protection Ueff> may be used in the tests of voltage-dependent control functions can be deactivated.

The examination of inpatient behaviour is passed if

- The 30 s 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% Pn 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.

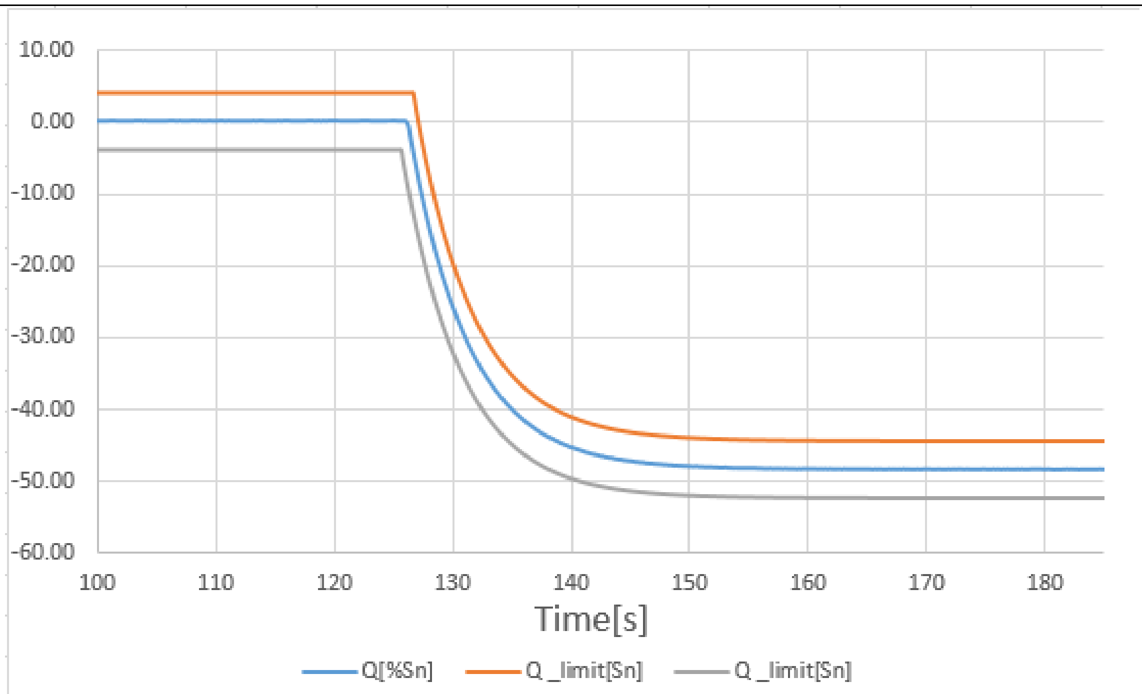
Note:

5.3.10 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

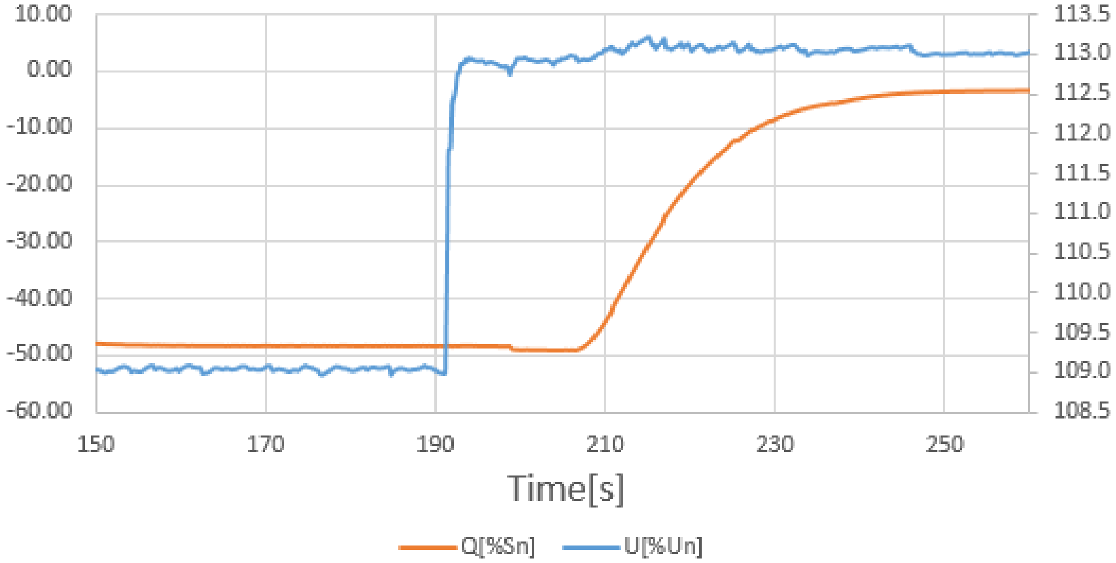
5.3.10.1.2 Test Voltage-controlled control functions "Q= f(V)" - dynamic behavior | P

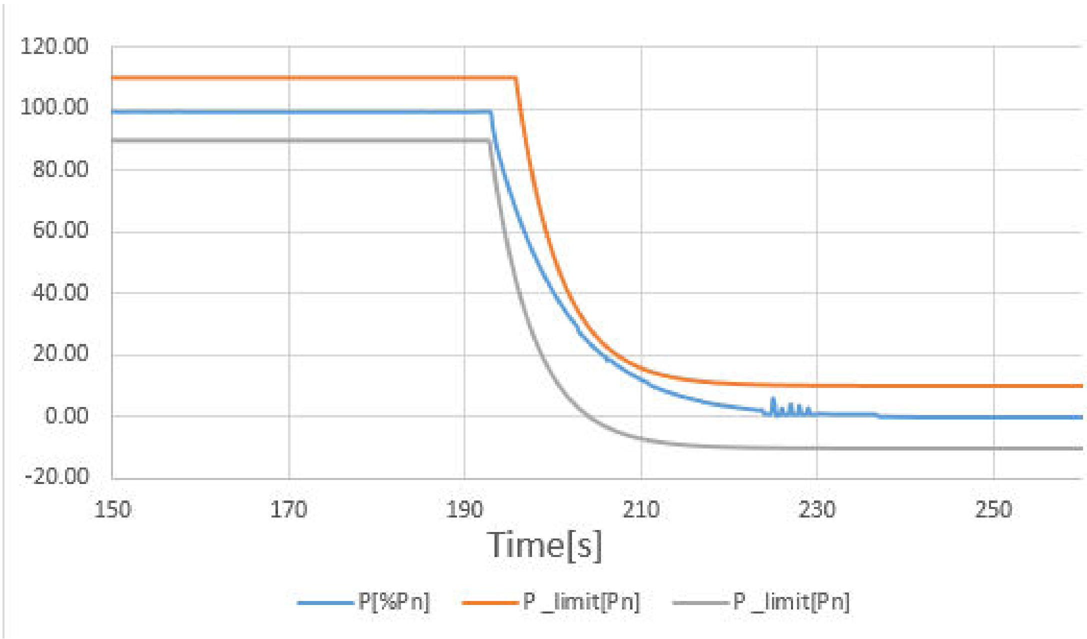
U_{step} [%]	U_{meas} [V]	U_{meas} [%]	P_{tol_under} [kW]	P_{30s} [kW]	P_{tol_upper} [kW]	P_{30s} [%]	Q_{tol_under} [kVar]	Q_{30s} [kVar]	Q_{tol_upper} [kVar]	Q,set [Sn%]	Q_{30s} [Sn %]
100	230,16	100,07	27,0	29,75	33,0	99,17	-1,32	0,05	1,32	0	0,14
104	239,42	104,09	27,0	29,82	33,0	99,41	-1,32	0,05	1,32	0	0,14
109	250,96	109,12	27,0	29,71	33,0	99,02	-15,71	-14,42	-13,07	-43,6	-43,69
113	259,97	113,03	0,0	0,15	8,0	0,50	-1,32	-1,39	1,32	0	-4,22
109	250,82	109,05	27,0	29,67	33,0	98,91	-15,71	-14,54	-13,07	-43,6	-44,06
109	250,79	109,04	0,0	0,11	6,0	0,37	-1,32	-1,04	1,32	0	-3,15
109	250,45	108,89	27,0	29,70	33,0	98,99	-15,71	-14,54	-13,07	-43,6	-44,06
100	230,02	100,01	27,0	29,74	33,0	99,14	-1,32	0,04	1,32	0	0,11
91	209,58	91,12	--	26,31	--	87,70	13,07	14,48	15,71	43,6	43,86
85	195,74	85,10	--	24,13	--	80,43	13,07	14,52	15,71	43,6	43,99
85	195,39	84,95	0,0	0,20	8,0	0,65	-1,32	-0,86	1,32	0	-2,60
85	195,78	85,12	--	24,14	--	80,45	13,07	14,51	15,71	43,6	43,96
91	209,71	91,18	--	26,31	--	87,69	13,07	14,48	15,71	43,6	43,87
97	223,31	97,09	27,0	29,69	33,0	98,97	-1,32	0,04	1,32	0	0,12
100	230,20	100,09	27,0	29,71	33,0	99,04	-1,32	0,03	1,32	0	0,10

Graph of Q(U): Test steps form 2 to 3

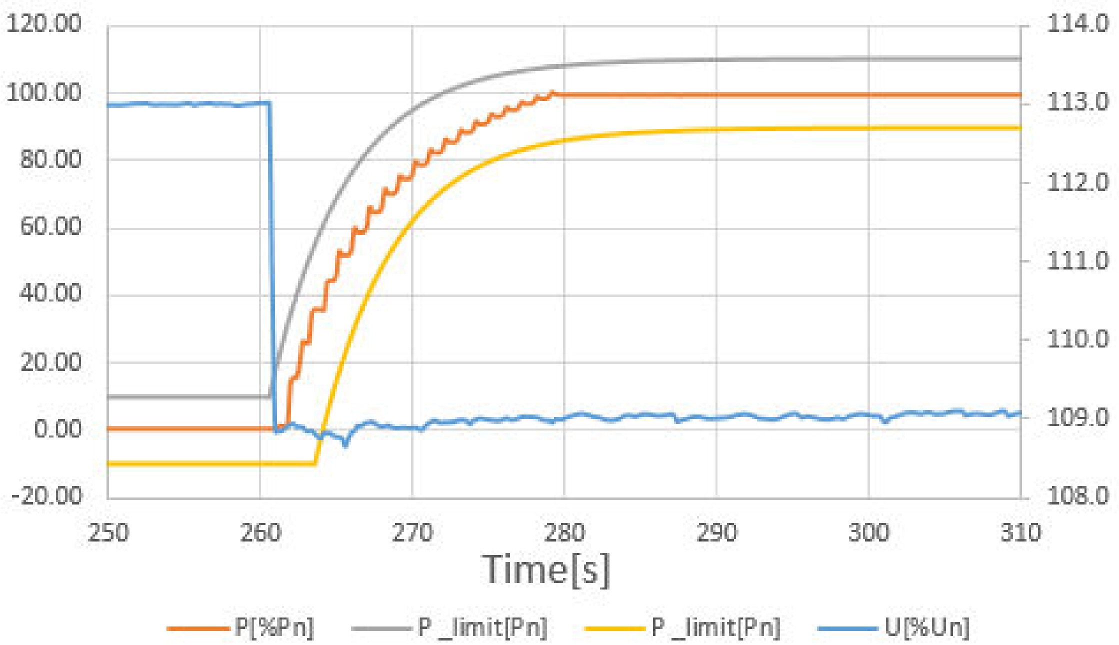


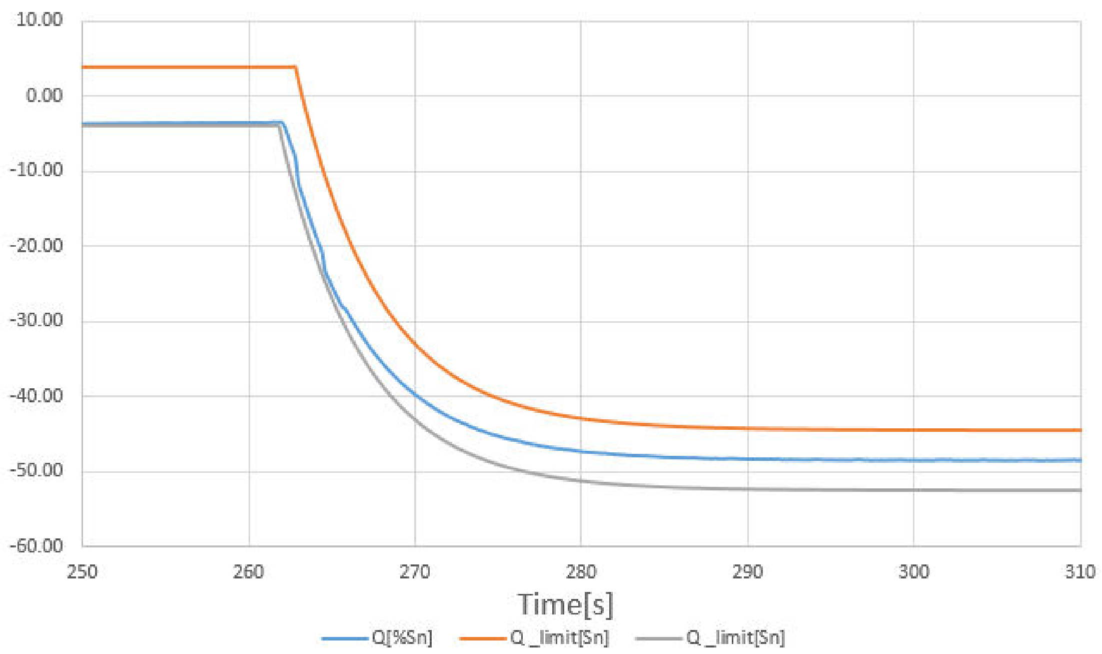
Graph of Q(U): Test steps form 3 to 4

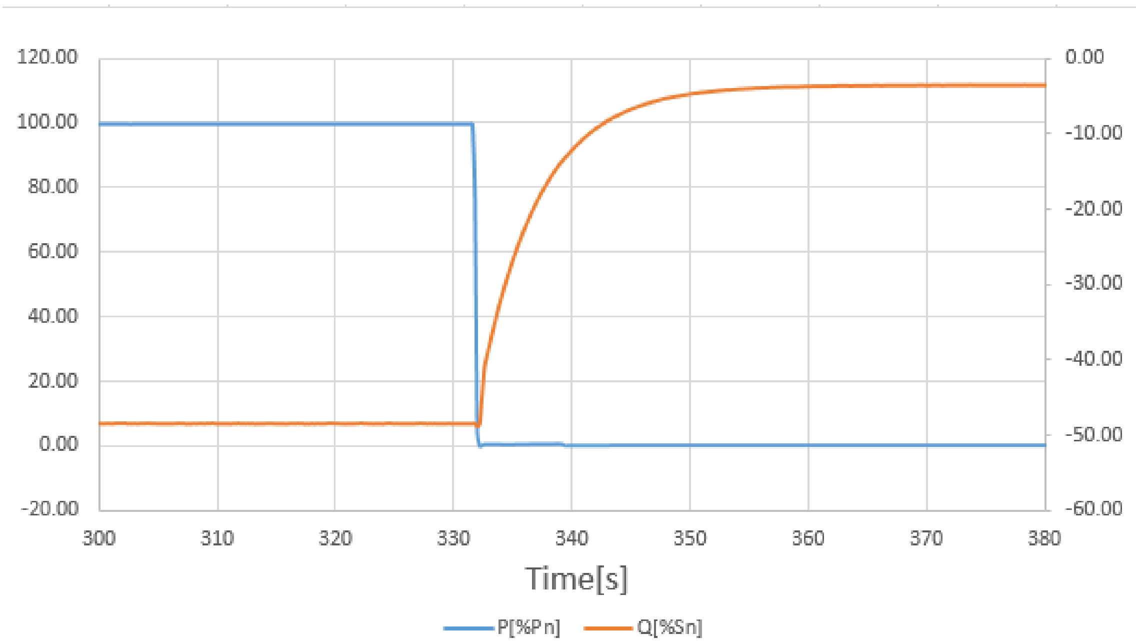
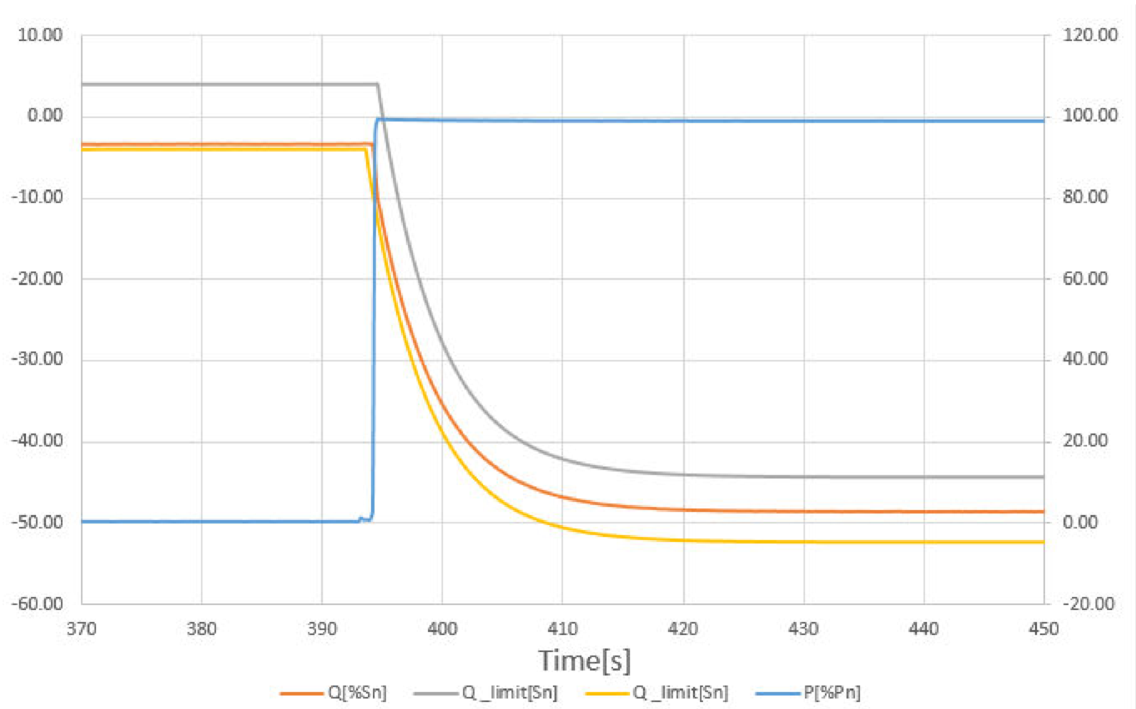




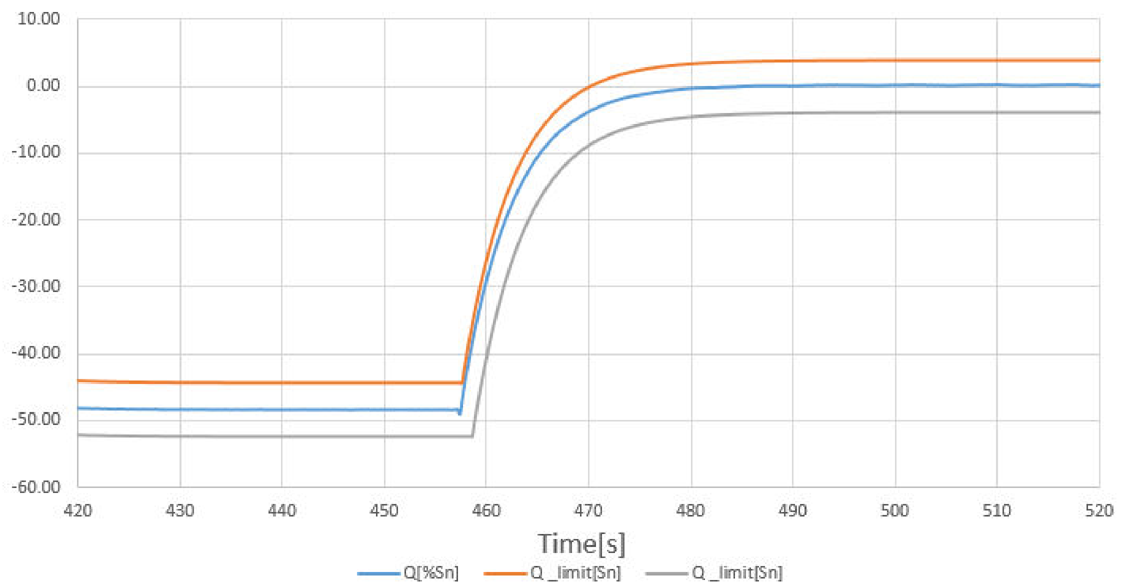
Graph of Q(U): Test steps form 4 to 5



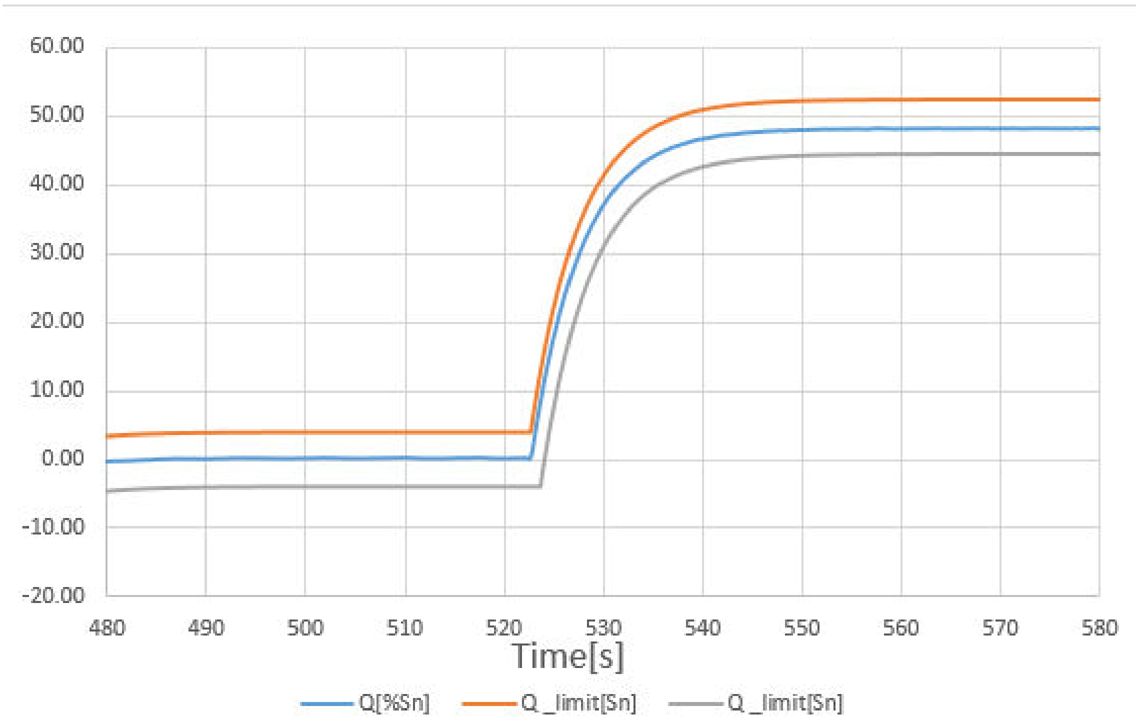


Graph of Q(U): Test steps form 5 to 6

Graph of Q(U): Test steps form 6 to 7


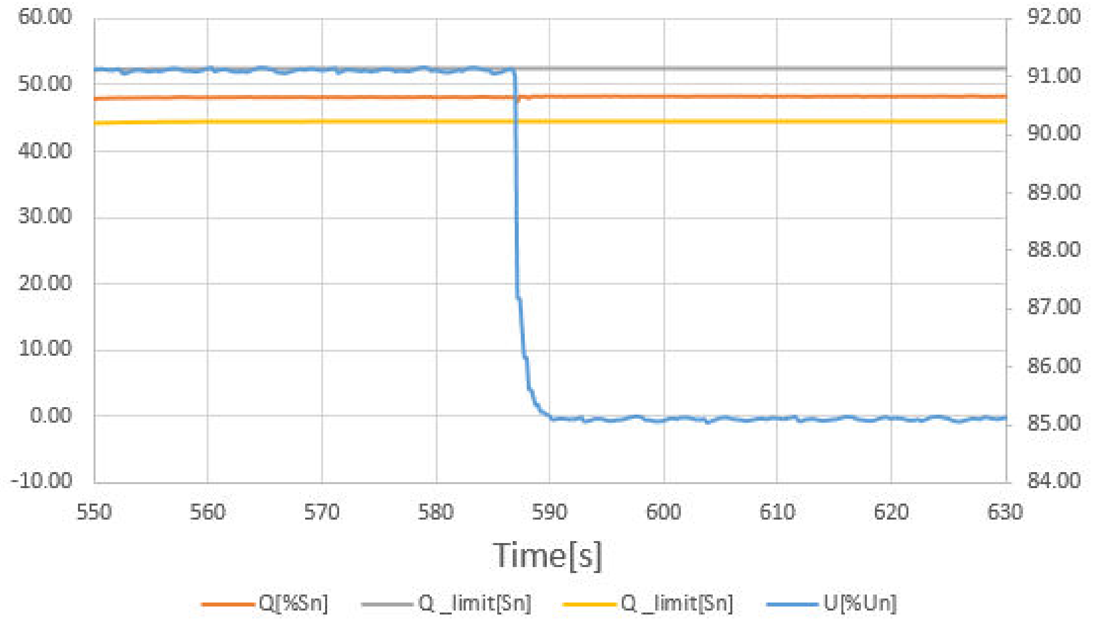
Graph of Q(U): Test steps form 7 to 8



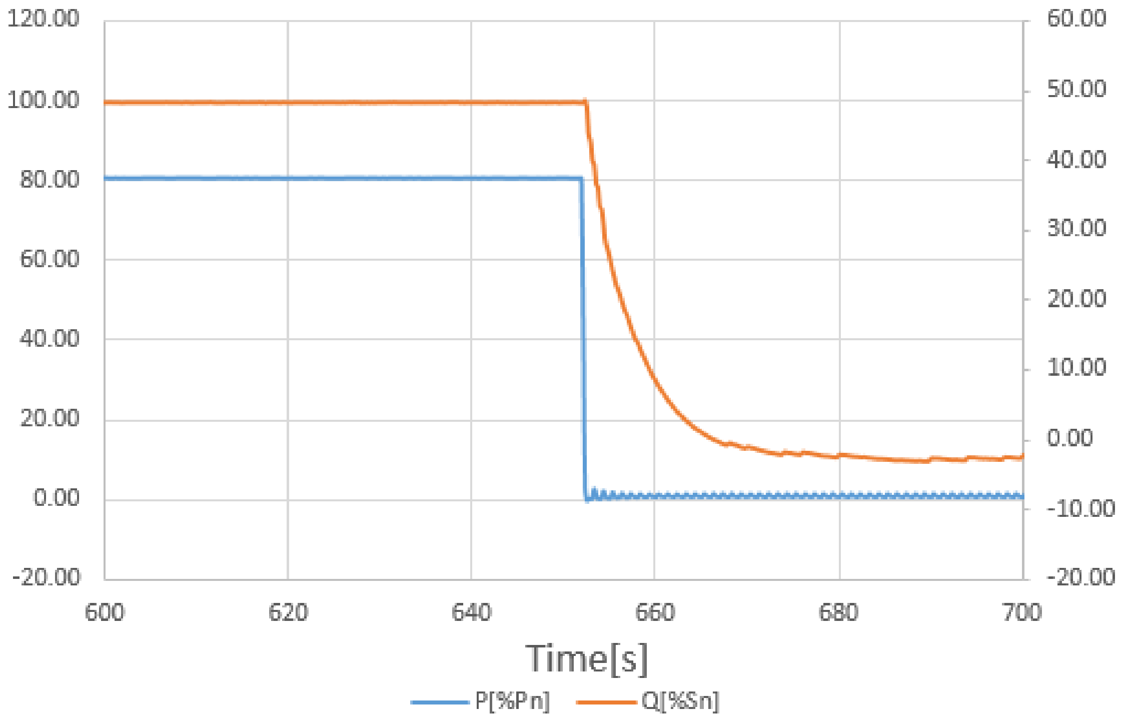
Graph of Q(U): Test steps form 8 to 9



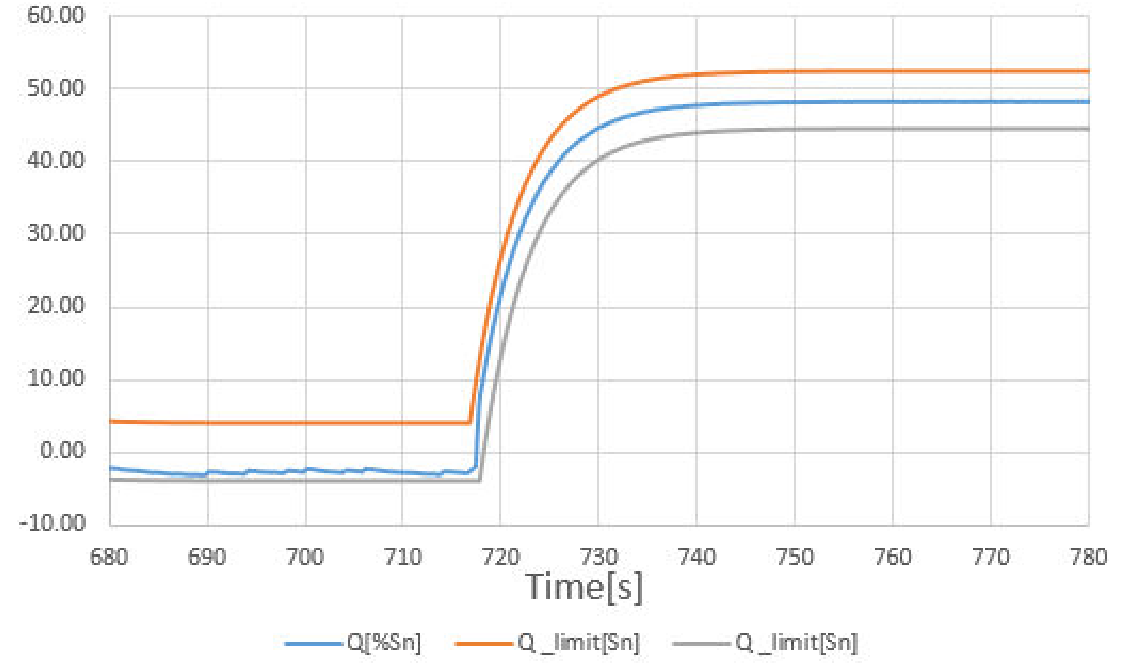
Graph of Q(U): Test steps form 9 to 10



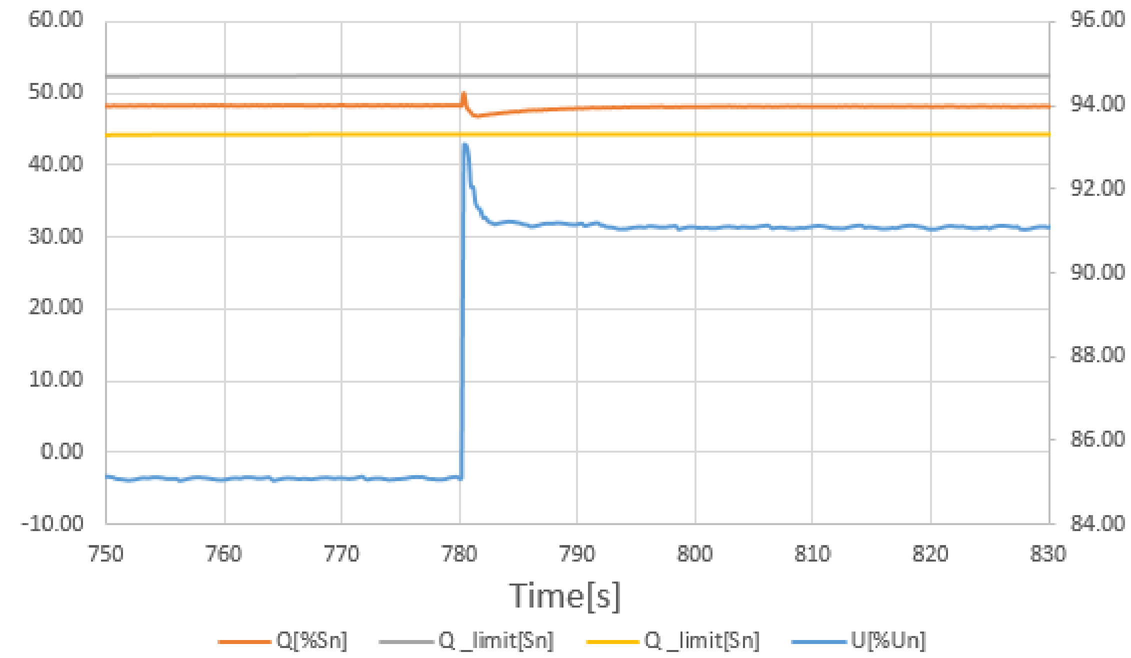
Graph of Q(U): Test steps form 10 to 11



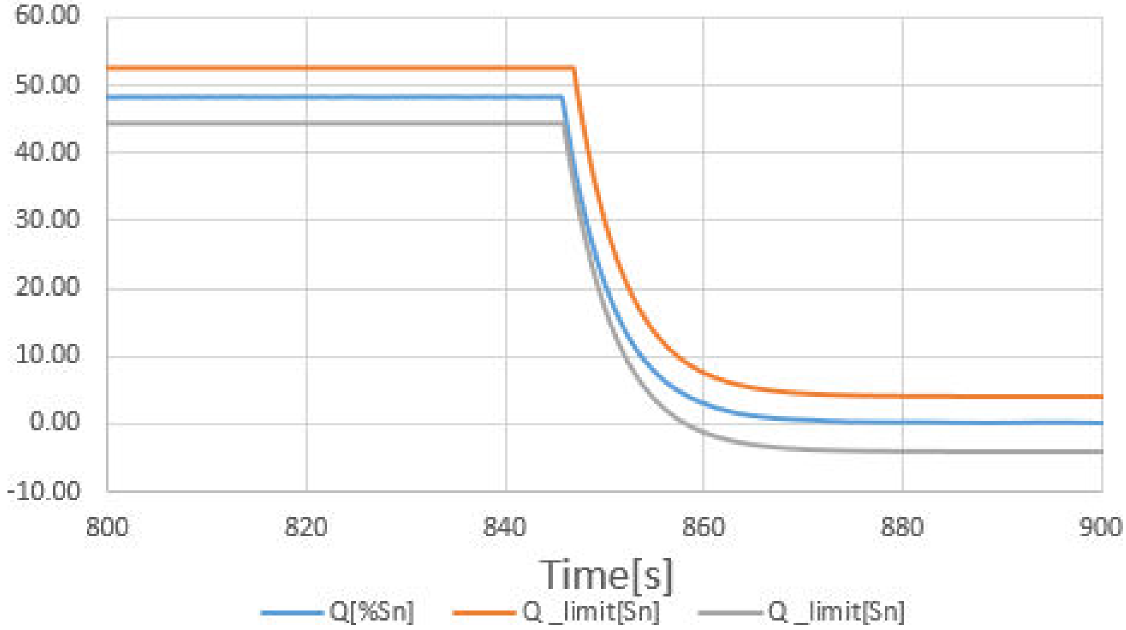
Graph of Q(U): Test steps form 11 to 12



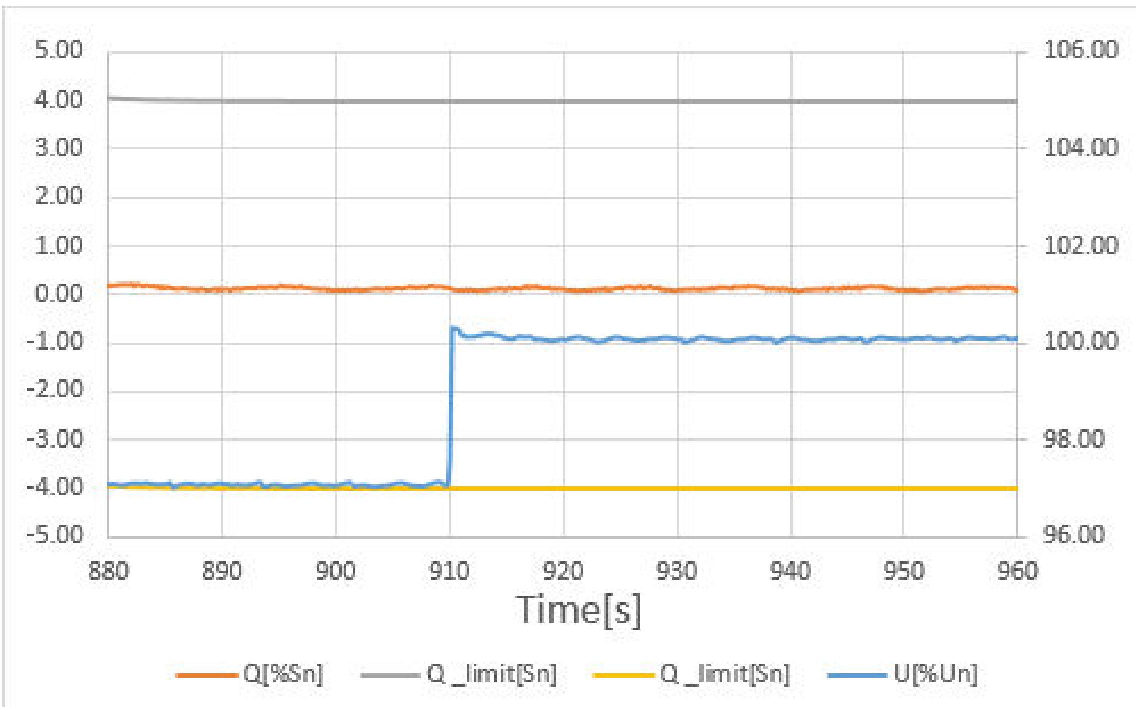
Graph of Q(U): Test steps form 12 to 13



Graph of Q(U): Test steps form 13 to 14



Graph of Q(U): 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 customer can not change any values.	

5.4 Testing of NS protection		
Clause	**Test**	**Result**
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)	**N/A**
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**
5.4.3	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%)	**P**
	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT ouput = 66%)	**P**
	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT ouput = 33%)	**P**

5.5 Connecting conditions and synchronization		
Clause	**Test**	**Result**
5.5	Connecting conditions and synchronization	
5.5.1	Test	**P**

5.6 Evidence dynamic grid support		
Clause	**Test**	**Result**
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 Testing of NS protection

5.4.1.1.1 Voltage control (non-synchronous systems)							P
Integrated NS protection multi phase ≤30kVA (phase to neutral)							
Setting values of the NS protection:	Setting U< [V]:		184,0				
	Setting U>>[V]:		264,5				
	Setting $T_{disconnection}$ [ms]		/				
Operating time of the monitoring device:							
L1 to N:							
	Under voltage 1:			**Over voltage 1:***			
Step [V to V]:	230,0 V to 177,1 V			230,0 V to 259,9 V			
Limit [V]:	184,0 V			255,3 V			
Measurement [V:]	185,3	184,3	185,0	--	--	--	
Limit [ms]:	≤ 1600 ms			≤ 60000 ms			
Disconnection time [ms]:	1535,0	1550,0	1535,0	--	--	--	
	Under voltage 2:			**Over voltage 2:**			
Step [V to V]:	230,0 V to 50,6 V			230,0 V to 271,4 V			
Limit [V]:	57,5 V			264,5 V			
Measurement [V:]	58,2	57,3	56,6	264,6	264,5	264,7	
Limit [ms]:	≤ 600 ms			≤ 200 ms			
Disconnection time [ms]:	540,0	532,5	550,0	123,0	133,0	127,0	
L2 to N:							
	Under voltage 1:			**Over voltage 1:***			
Step [V to V]:	230,0 V to 177,1 V			230,0 V to 259,9 V			
Limit [V]:	184,0 V			255,3 V			
Measurement [V:]	183,3	182,3	184,5	--	--	--	
Limit [ms]:	≤ 1600 ms			≤ 60000 ms			
Disconnection time [ms]:	1542,5	1537,5	1545,0	--	--	--	
	Under voltage 2:			**Over voltage 2:**			
Step [V to V]:	230,0 V to 50,6 V			230,0 V to 271,4 V			
Limit [V]:	57,5 V			264,5 V			
Measurement [V:]	56,9	57,3	58,4	264,0	264,3	264,1	
Limit [ms]:	≤ 600 ms			≤ 200 ms			
Disconnection time [ms]:	555,0	545,0	540,0	131,0	131,0	133,0	

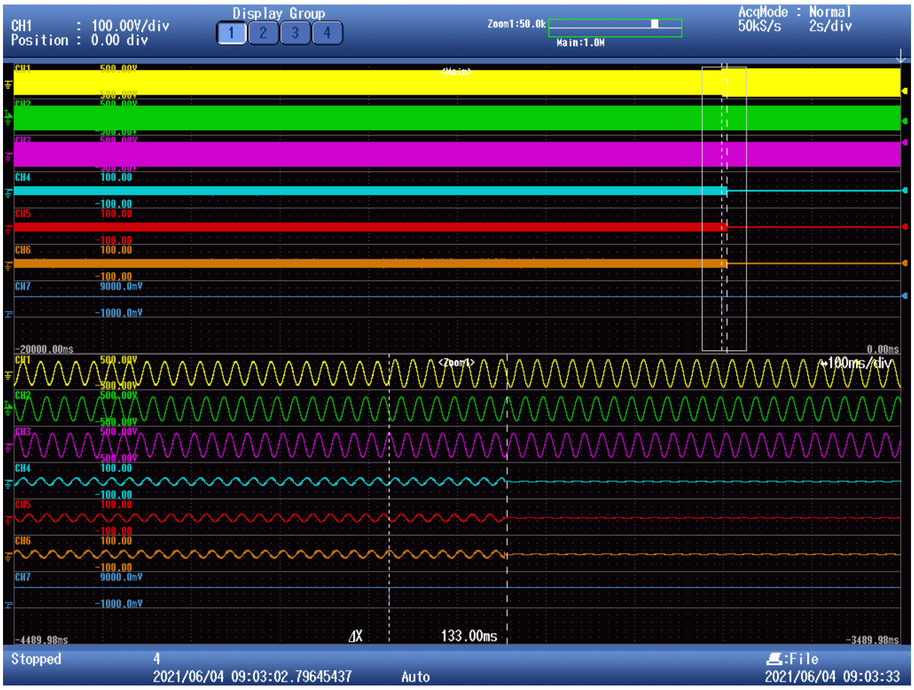
L3 to N:						
	Under voltage 1:			**Over voltage 1:***		
Step [V to V]:	230,0 V to 177,1 V			230,0 V to 259,9 V		
Limit [V]:	184,0 V			255,3 V		
Measurement [V:]	186,0	185,4	184,4	--	--	--
Limit [ms]:	≤ 1600 ms			≤ 60000 ms		
Disconnection time [ms]:	1530,0	1542,5	1547,5	--	--	--
	Under voltage 2:			**Over voltage 2:**		
Step [V to V]:	230,0 V to 50,6 V			230,0 V to 271,4 V		
Limit [V]:	57,5 V			264,5 V		
Measurement [V:]	58,7	57,6	58,8	266,4	265,3	264,7
Limit [ms]:	≤ 600 ms			≤ 200 ms		
Disconnection time [ms]:	530,0	540,0	540,0	120,0	138,0	130,0

Note:
*** N/A if 5.4.1.1.2 Measuring the rise-in voltage protection as a running 10-minute mean value is used**
The permitted tolerance between setting value and trip value of the voltage may not exceed ± 1% of U_n.
The disconnection time includes disconnect time + operate time of the integrated relay.

Under voltage 2 L1 to N:

Under voltage 1 L1 to N:

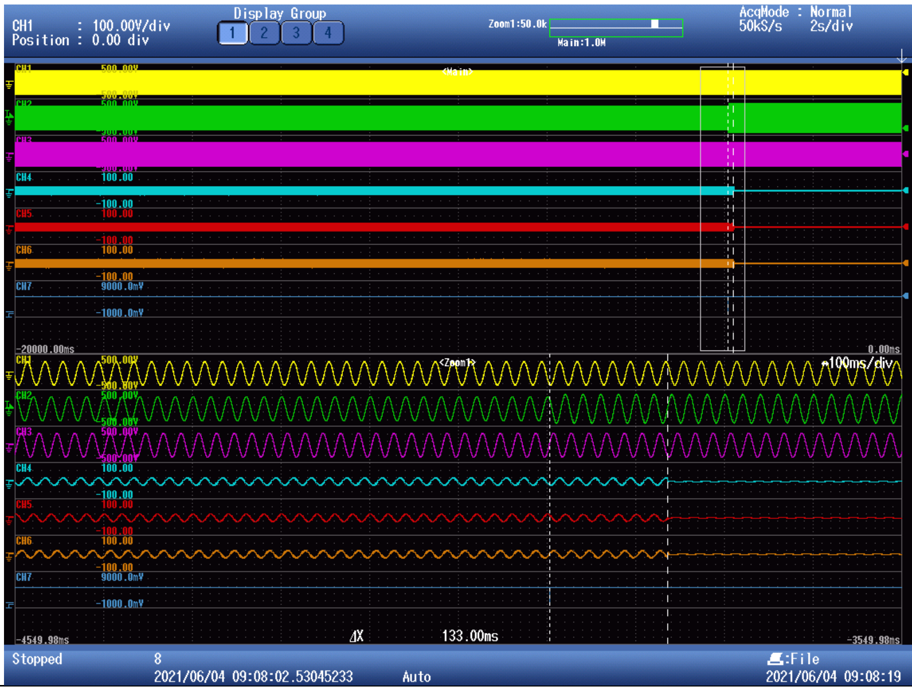
Over voltage L1 to N:



Under voltage 2 L2 to N

Under voltage 1 L2 to N

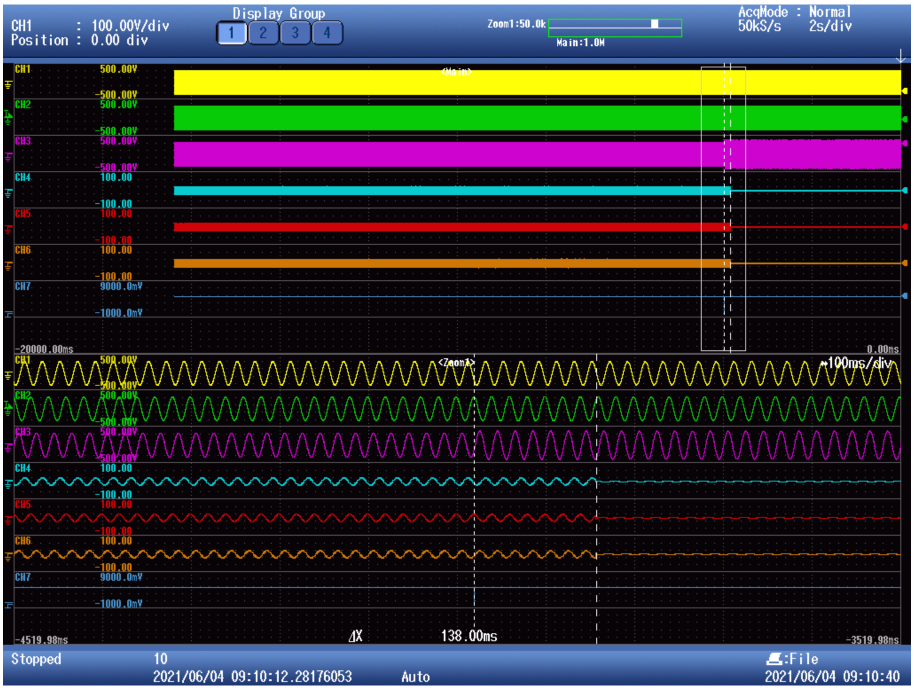
Over voltage L2 to N:



Under voltage 2 L3 to N:

Under voltage 1 L3 to N:

Over voltage L3 to N:



5.4.1.1.2 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]	/	
		Setting $T_{disconnection}$ [ms]	/	
Test:				
		Disconnection time:	Limit:	
a)	The voltage is set to 100% U_n and held for 600 s. Thereafter the voltage is set to 113% U_n. Disconnection must take place within 600 s.			
	Phase 1:	540 s	≤ 600 s	
	Phase 2:	485 s		
	Phase 3:	538 s		
b)	The voltage is set to U_n for 600 s and then to 109% U_n for 600 s. No disconnection should take place.			
	Phase 1:	No disconnection	Disconnection should not take place.	
	Phase 2:	No disconnection		
	Phase 3:	No disconnection		
c)	The voltage is set to 107 % U_n and held for 600 s. Thereafter the voltage is set to 115 % U_n. Disconnection must take place within 300 s or about 50 % of the disconnection time measured in point a).*			
	Phase 1:	342 s	The disconnection time should be about 50 % of the value measured in a). *	
	Phase 2:	254 s		
	Phase 3:	349 s		

Note:
*If the setting value is set to 600 s, then the disconnection time can be in the range between 225 s and 375 s.

→default threshold: 111% Un. If the threshold is not adjustable than set to 110%Un

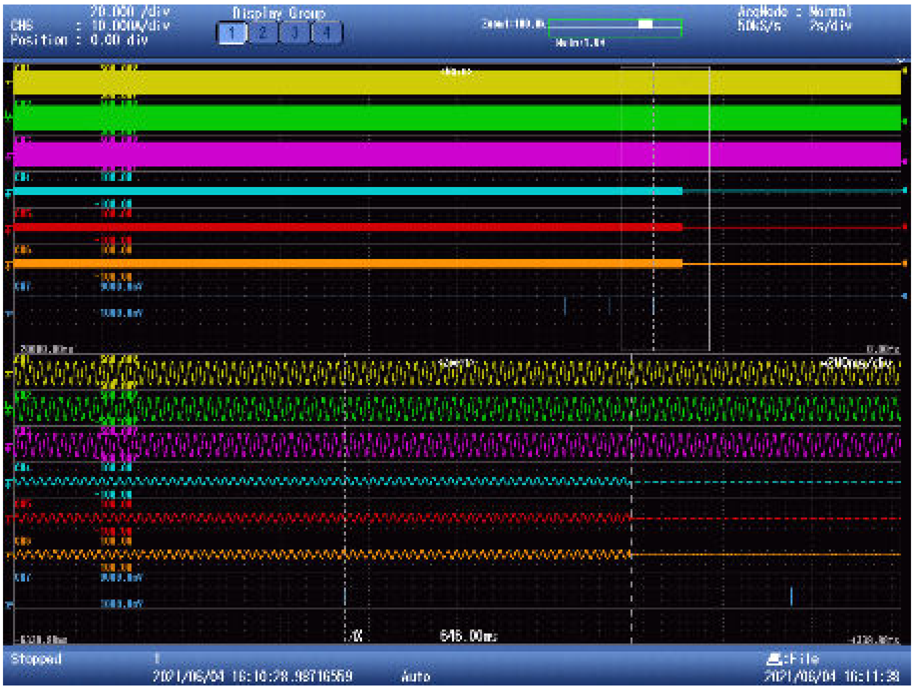
5.4.2.1 Frequency measurement						P
Setting values of the NS protection:	Setting f< [Hz]:		47,50			
	Setting f>[Hz]:		51,50			
	Setting $T_{disconnection}$ [ms]		/			
Operating time of the monitoring device						
	Under frequency:			**Over frequency:**		
Ramp [Hz to Hz]:	47,0 Hz -> 48,0 Hz			51,0 Hz -> 52,0 Hz		
Limit [Hz]:	47,50 Hz			51,50 Hz		
Measurement [Hz]:	47,51	47,49	47,50	51,49	51,49	51.51
Limit [ms]:	≤ 200 ms			≤ 200 ms		
Disconnection time [ms]:	136,0	146,0	138,0	42,0	146,0	113,0

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

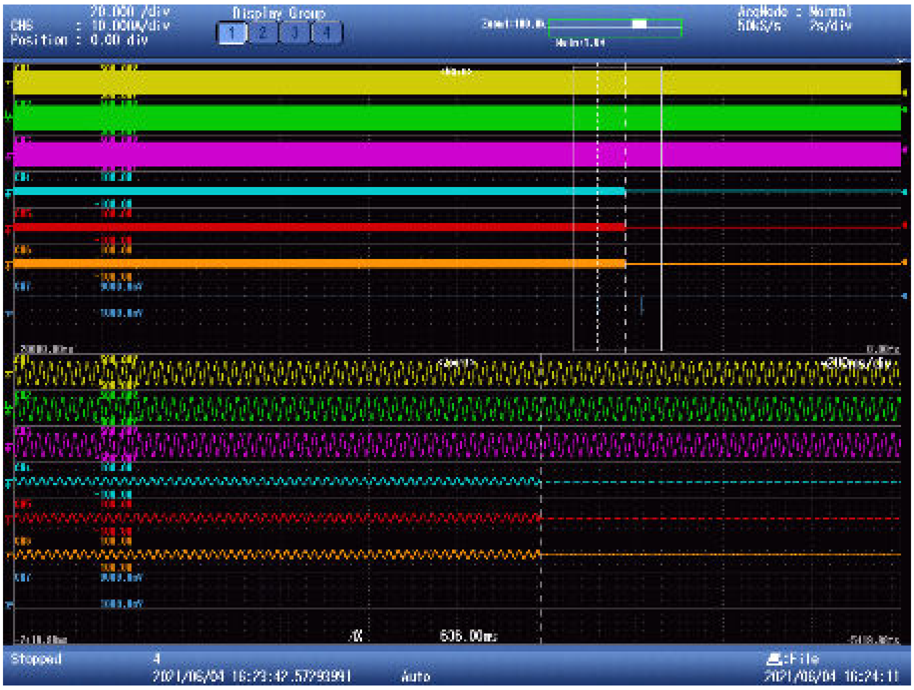
To determine the switch-off time, a ramp must be run at 1 Hz / s

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

Under frequency:



Over frequency:



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

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

No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6,1,d) 1)	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [kW per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks5)
1	100	100	0	0	0,166	9,91	768	1,021	395	BL
2	100	100	-5	-5	1,930	9,91	768	1,019	63	IB
3	100	100	-5	0	2,092	9,91	768	1,047	35	IB
4	100	100	-5	+5	2,146	9,91	768	1,075	36	IB
5	100	100	0	-5	0,218	9,91	768	0,995	44	IB
6	100	100	0	+5	0,218	9,91	768	1,046	28	IB
7	100	100	+5	-5	2,030	9,91	768	0,948	49	IB
8	100	100	+5	0	1,980	9,91	768	0,972	34	IB
9	100	100	+5	+5	2,030	9,91	768	0,996	36	IB

Parameter at 0% per phase	L= 18,10 mH	R= 5,81 Ω	C= 559,68 µF

Note:

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

1) P_{EUT}: EUT output power

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

3) Q_{AC}: Reactive power flow at S1 in Figure 1, Positive means power from EUT to utility, Nominal is the 0 % test condition value,

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

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

Condition A:

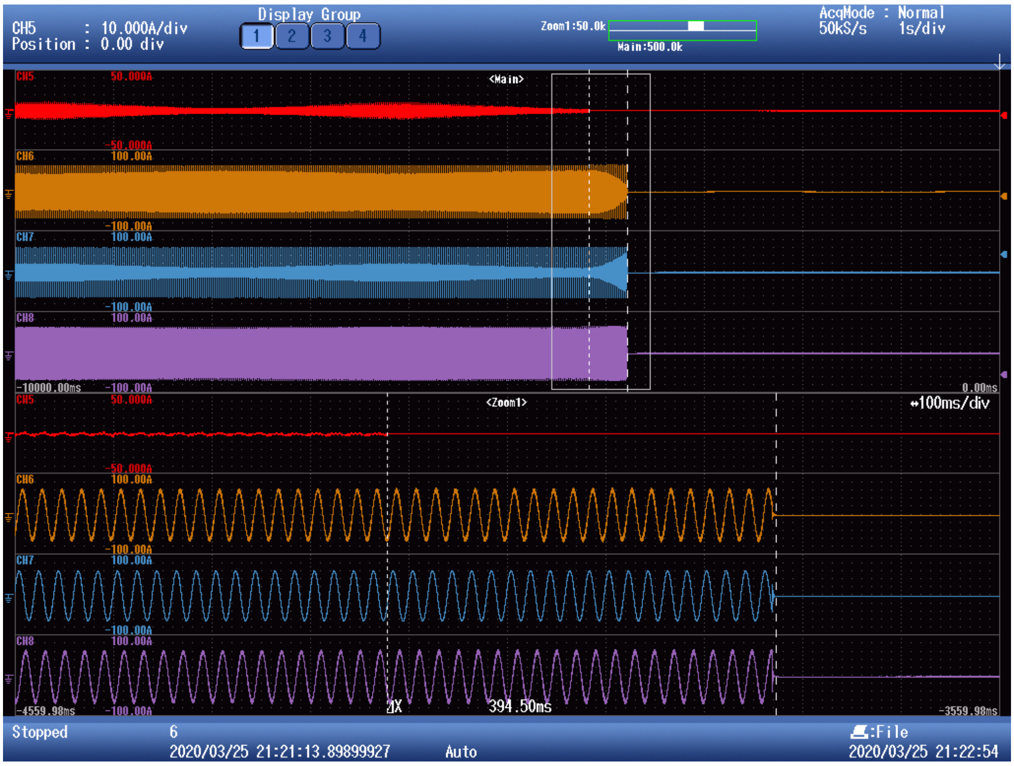
EUT output power P_{EUT} = Maximum 6)

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

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

7) Based on EUT rated input operating range, For example, If range is between X volts and Y volts, 75 % of range =X + 0,75 × (Y – X), Y shall not exceed 0,8 × EUT maximum system voltage (i,e,, maximum allowable array open circuit voltage), In any case, the EUT should not be operated outside of its allowable input voltage range,

Scope pictures of the disconnection time
Disconnection at No. 1



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

Test : SUN2000-40KTL-M3

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

No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6,1,d) 1)	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks5)
1	66	66	0	-5	0,244	6,68	640	0,992	28	BL
2	66	66	0	-4	0,222	6,68	640	0,997	31	IB
3	66	66	0	-3	0,203	6,68	640	1,002	25	IB
4	66	66	0	-2	0,187	6,68	640	1,008	47	IB
5	66	66	0	-1	0,174	6,68	640	1,013	45	IB
6	66	66	0	0	0,151	6,68	640	1,018	49	IB
7	66	66	0	1	0,157	6,68	640	1,023	323	IB
8	66	66	0	2	0,152	6,68	640	1,028	32	IB
9	66	66	0	3	0,151	6,68	640	1,033	45	IB
10	66	66	0	4	0,153	6,68	640	1,038	49	IB
11	66	66	0	5	0,157	6,68	640	1,043	45	IB

Parameter at 0% per phase	L= 24,76 mH	R= 7,92 Ω	C= 409,18 µF

Note:

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

1) P_{EUT}: EUT output power

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

3) Q_{AC}: Reactive power flow at S1 in Figure 1, Positive means power from EUT to utility, Nominal is the 0 % test condition value,

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

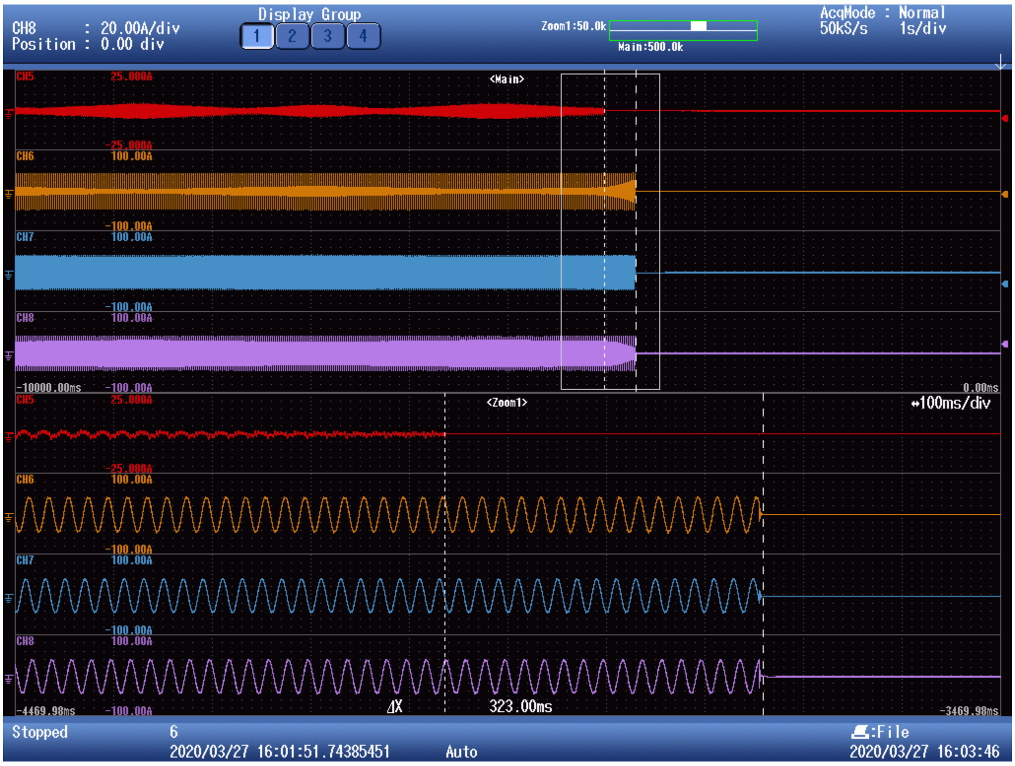
5) BL: Balance condition, IB: Imbalance condition,

Condition B:

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

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

6) Based on EUT rated input operating range, For example, If range is between X volts and Y volts, 50 % of range =X + 0,5 × (Y – X), Y shall not exceed 0,8 × EUT maximum system voltage (i,e,, maximum allowable array open circuit voltage), In any case, the EUT should not be operated outside of its allowable input voltage range,

Scope pictures of the disconnection time
Disconnection at No. 7


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

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

No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6,1,d) 1)	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [W per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks5)
1	33	33	0	-5	0,119	3,35	512	0,982	38	IB
2	33	33	0	-4	0,119	3,35	512	0,987	40	IB
3	33	33	0	-3	0,120	3,35	512	0,992	36	IB
4	33	33	0	-2	0,123	3,35	512	0,997	28	IB
5	33	33	0	-1	0,128	3,35	512	1,002	53	IB
6	33	33	0	0	0,119	3,35	512	1,007	43	BL
7	33	33	0	1	0,141	3,35	512	1,012	42	IB
8	33	33	0	2	0,150	3,35	512	1,017	40	IB
9	33	33	0	3	0,161	3,35	512	1,022	49	IB
10	33	33	0	4	0,173	3,35	512	1,027	174	IB
11	33	33	0	5	0,186	3,35	512	1,032	60	IB

Parameter at 0% per phase	L= 49,92 mH	R= 15,79 Ω	C= 202,99 µF

Note:

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

1) P_{EUT}: EUT output power

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

3) Q_{AC}: Reactive power flow at S1 in Figure 1, Positive means power from EUT to utility, Nominal is the 0 % test condition value,

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

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

Condition B:

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

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

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

7) Based on EUT rated input operating range, For example, If range is between X volts and Y volts, 20 % of range =X + 0,2 × (Y – X), Y shall not exceed 0,8 × EUT maximum system voltage (i,e,, maximum allowable array open circuit voltage), In any case, the EUT should not be operated outside of its allowable input voltage range.

Scope pictures of the disconnection time
Disconnection at No. 10

5.5 Testing of connecting conditions and synchronisation

5.5.1 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 EZE 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**
Setting values of the NS protection:	Setting $T_{reconnection\ 60s}$ 1) [s]:	300	
	Setting f< [Hz]:	47,5	
	Setting f> [Hz]:	51,5	
	Setting V< [V]:	184	
	Setting V>> [V]:	264,5	

Test:

	f_{ist}		**Reset time:**	**Limit:**
Connecting conditions for frequencies:				
a)	47,45 Hz		No reconnected	No resetting allowed
	Switch to:			
b)	≥ 47,55 Hz		322 s	≥ 300 s
c)	50,15 Hz		No reconnected	No resetting allowed
	Switch to:			
d)	≥ 50,05 Hz		312 s	≥ 300 s
Connecting conditions for voltages:				
e)	84%		No reconnected	No resetting allowed
	Switch to:			
f)	≥ 86%	L1	326 s	≥ 300 s
		L2	329 s	
		L3	327 s	
g)	110 %		No reconnected	No resetting allowed
	Switch to:			
h)	≤ 108%	L1	324 s	≥ 300 s
		L2	317 s	
		L3	319 s	

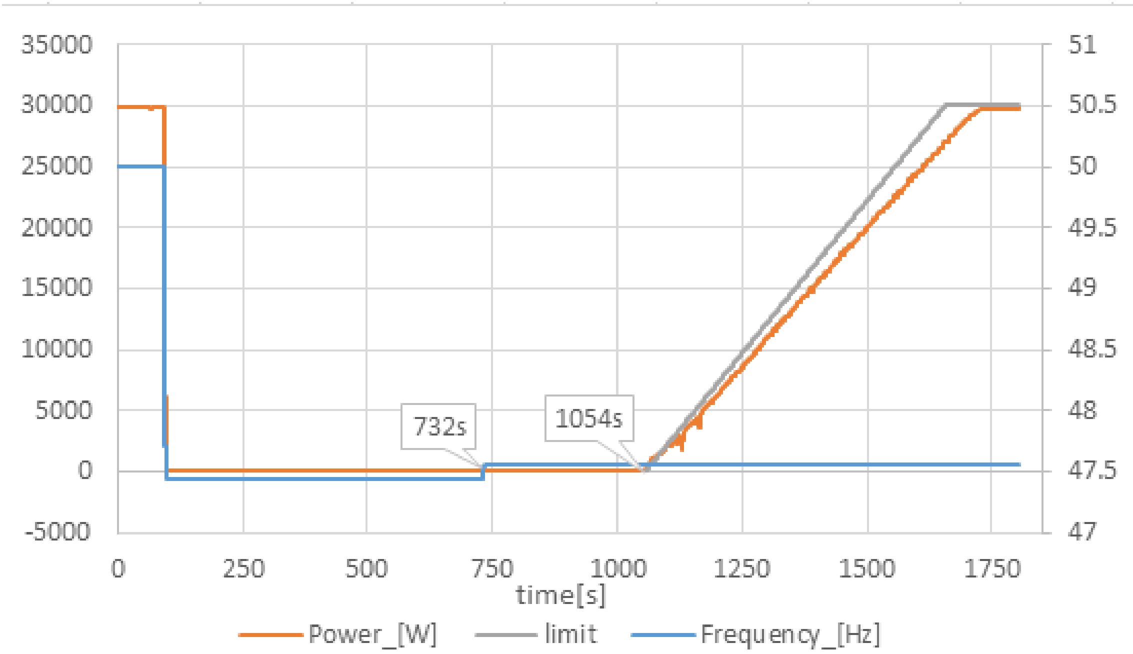
Note:

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

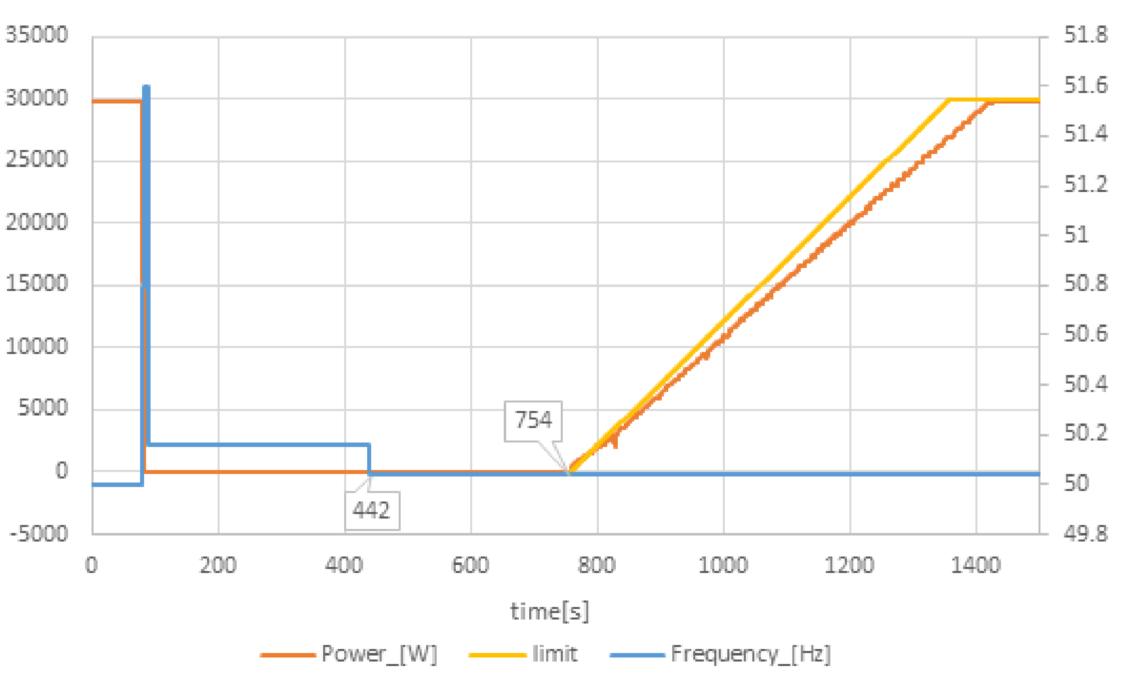
≥ 60 s ≙ restart and if no error was produced

≥300s ≙ if an error was produced

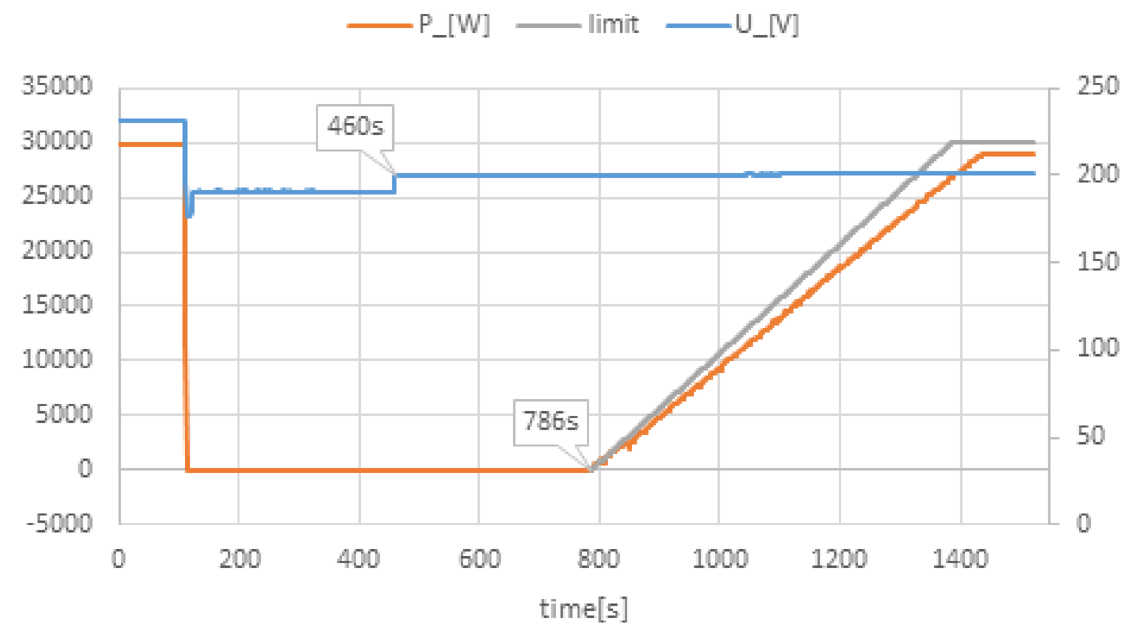
a) 47,50 Hz to b) ≥ 47,55 Hz:



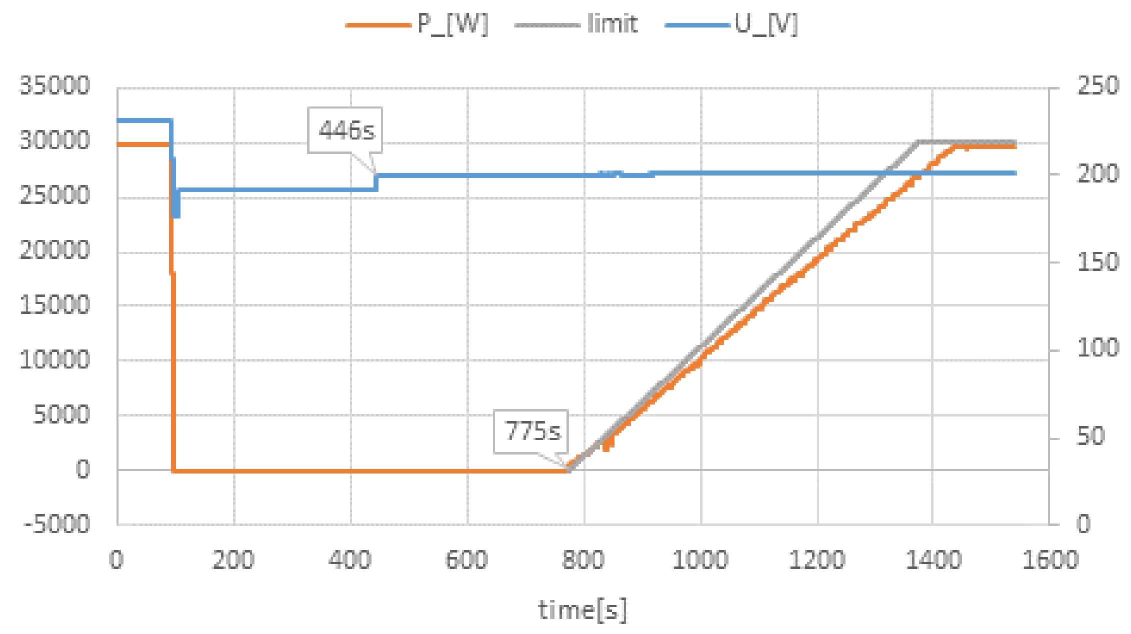
c) 50,15 Hz to d) ≤ 50,05 Hz:



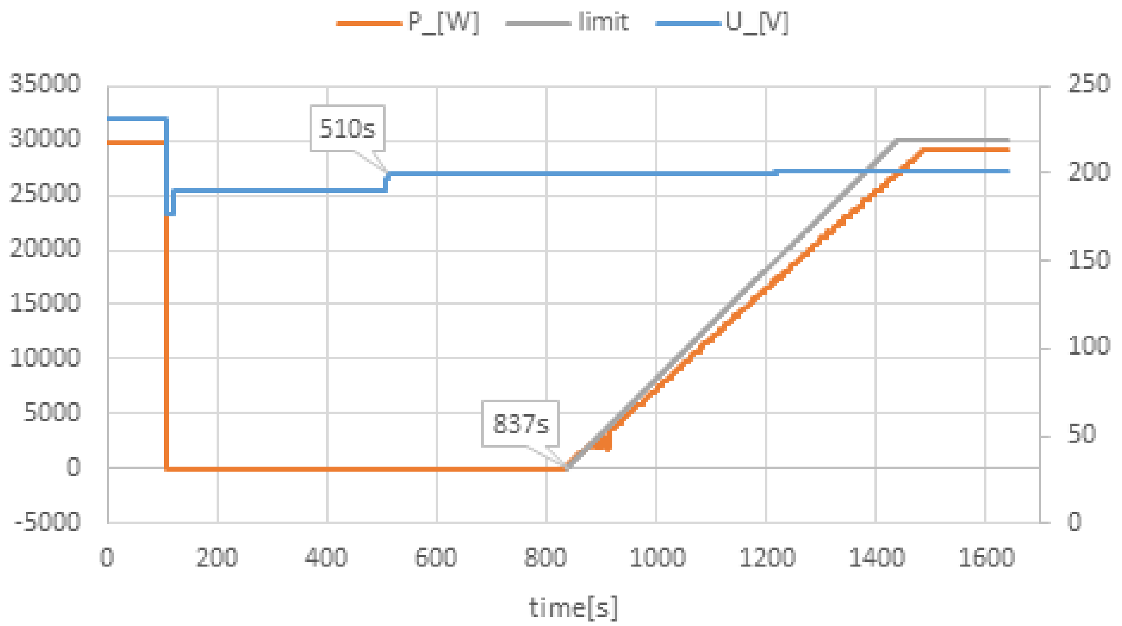
e) 84 % U_n to f) ≥ 86 % U_n test by L1



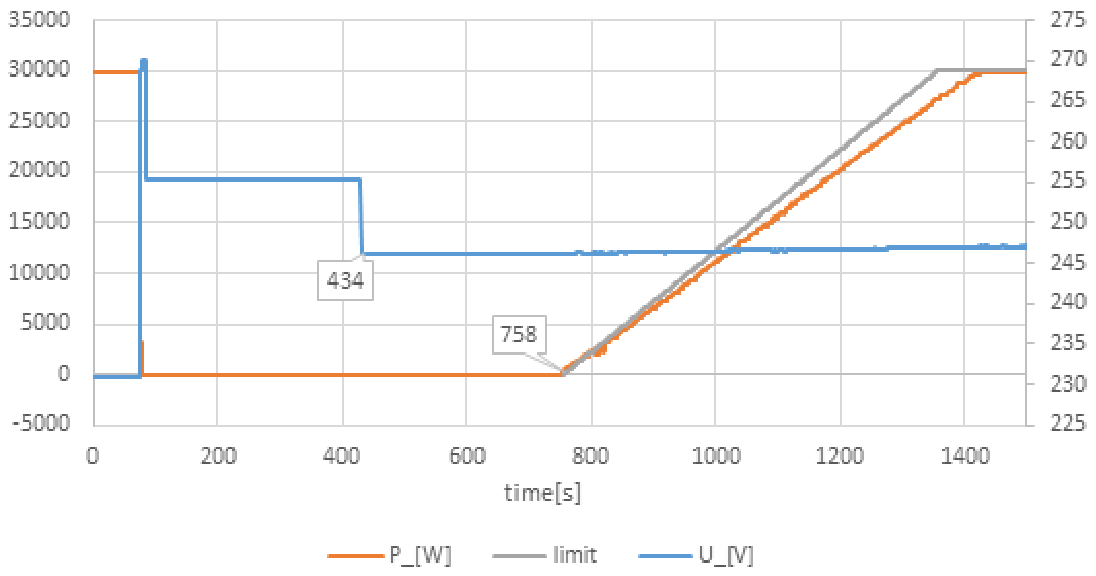
e) 84 % U_n to f) ≥ 86 % U_n test by L2



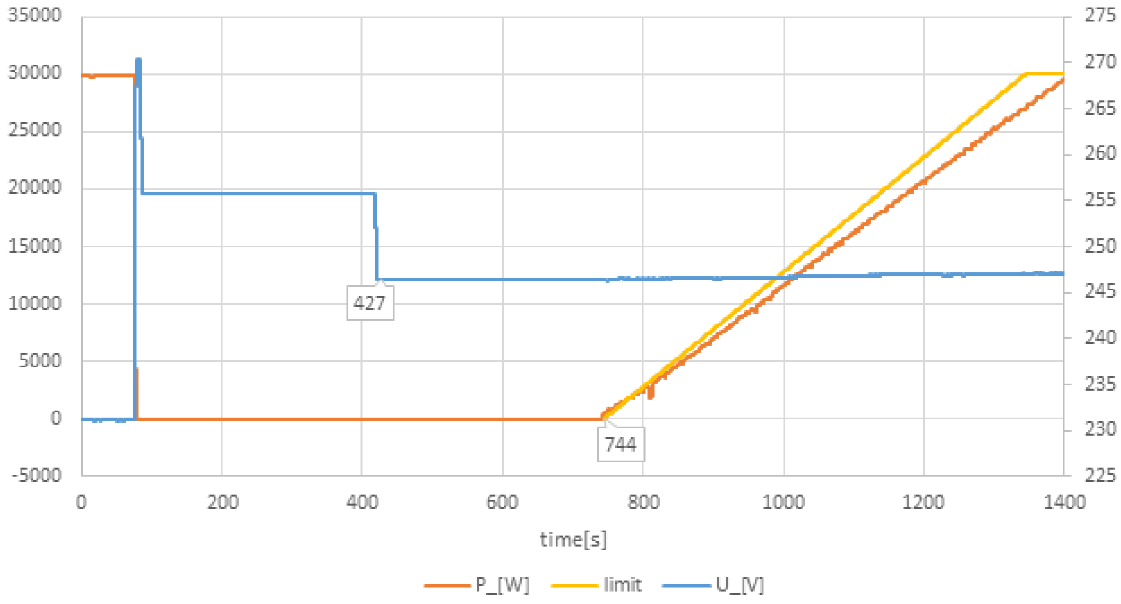
e) 84 % U_n to f) ≥ 86 % U_n test by L3



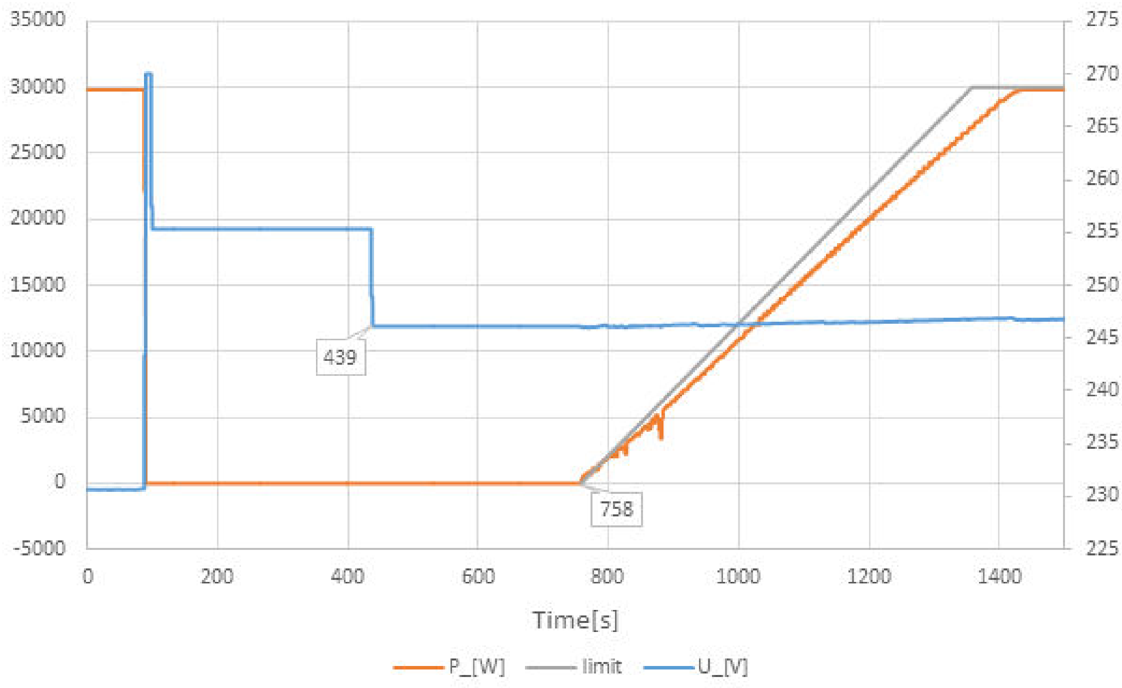
g) 110 % U_n to h) ≤ 108 % U_n test by L1



g) 110 % U_n to h) ≤ 108 % U_n test by L2



g) 110 % U_n to h) ≤ 108 % U_n test by L3



5.6 Testing of the dynamic grid support

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 (EZE) or a storage system.

For inverter(3-phase Inverters)	P

Load definition		
	requirement	Used for testing
Full load	P_n ±2%P_n	100%P_n
Partial load	0,2·P_n ~ 0,6·P_n	0,3P_n

Test	Voltage Fault depth [p.u. U_n]	Fault type	Fault duration [ms]	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)	≥ 150 (at U=0,15) ≥ 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)	≥ 840 (at U=0,50) ≥ 1020 (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)	≥ 60000	full load	(0 - ±10%) 0	3.1	☒	☒
				partial load		3.2	☒	☒
		2-phase (type D1)		full load		3.3	☒	☒
				partial load		3.4	☒	☒

No load test

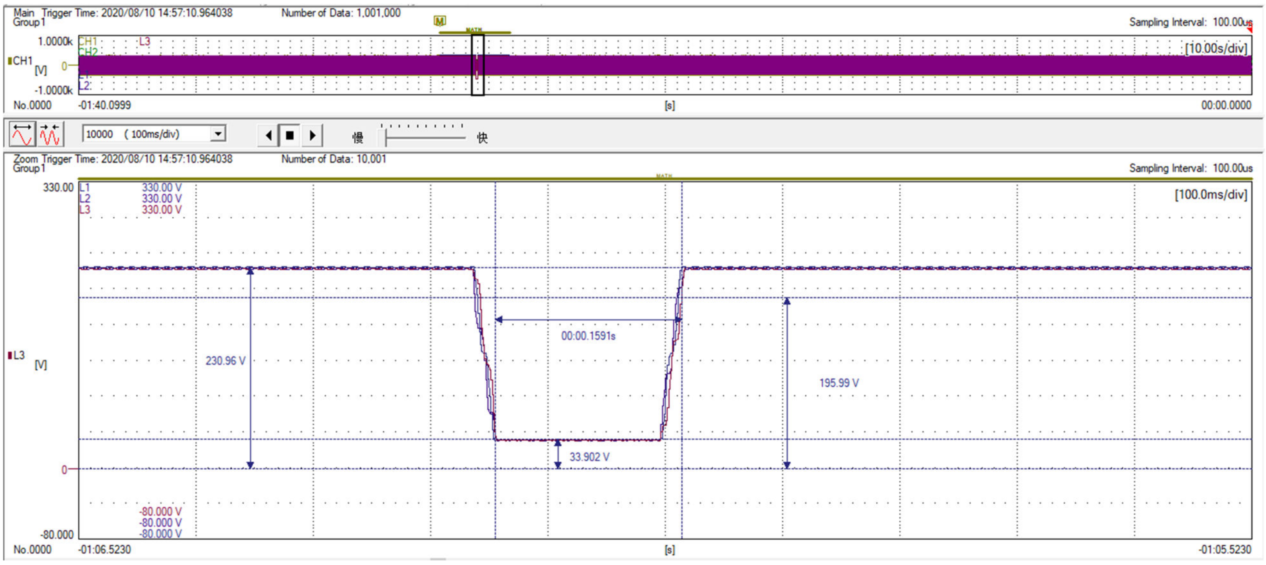
Test	Voltage Fault depth [p.u. U_n]	Fault type	Fault duration [ms]	Load / P-setpoint	Q-setpoint [%P_{rE}]	Test No.	Test 1	Test 2
0	0,15 … 0,25 typical: 0,15	3-phase (type A)	≥ 150 (at U=0,15) ≥ 250 (at U=0,25)	No load	0	0.1.1	☒	
		2-phase (type D1)				0.1.2	☒	
		2-phase (type D2)				0.1.3	☒	
	0,50 … 0,60 typical: 0,50	3-phase (type A)	≥ 840 (at U=0,50) ≥ 1020 (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)	≥ 60000			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 60 s.

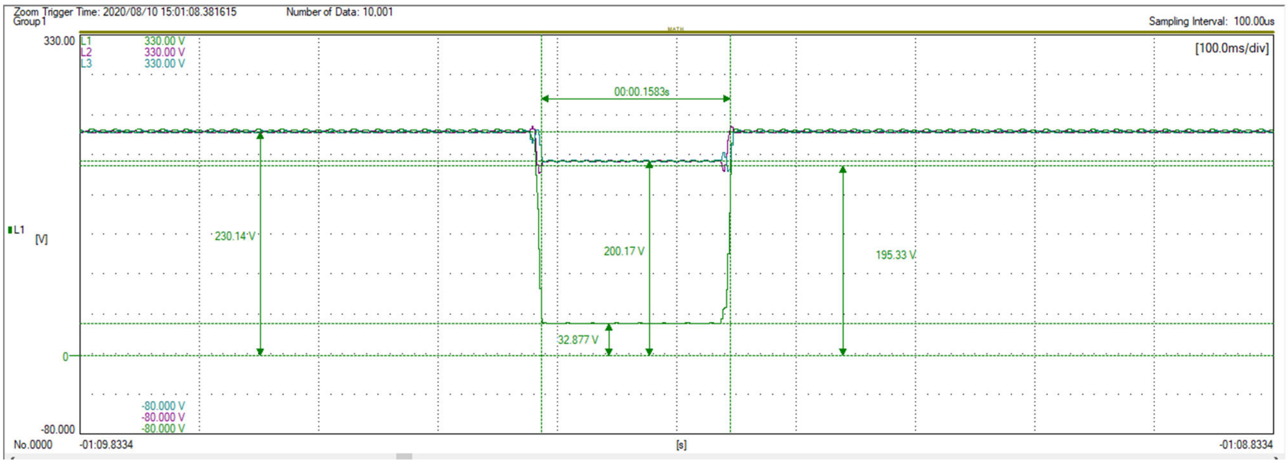
Behavior during the network fault
- No separation of the EZE from the grid during the break-in. If the EZE disconnects from the network, the time of the disconnection must be documented.
- Non-synchronous units and memories must not feed in either an active or a reactive current during a network fault 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 60 ms after the occurrence of this voltage dip / increase
in no phase conductor does not exceed 20% of the rated current Ir and after 100 ms no more than 10% Ir.

Behavior after the end of the error
- No separation of the EZE within 60 s after the end of the fault;
- Synchronous units: Start-up time of the active power maximum 6 s;
- Non-synchronous units and memory: Rise time of the active power maximum 1 s.

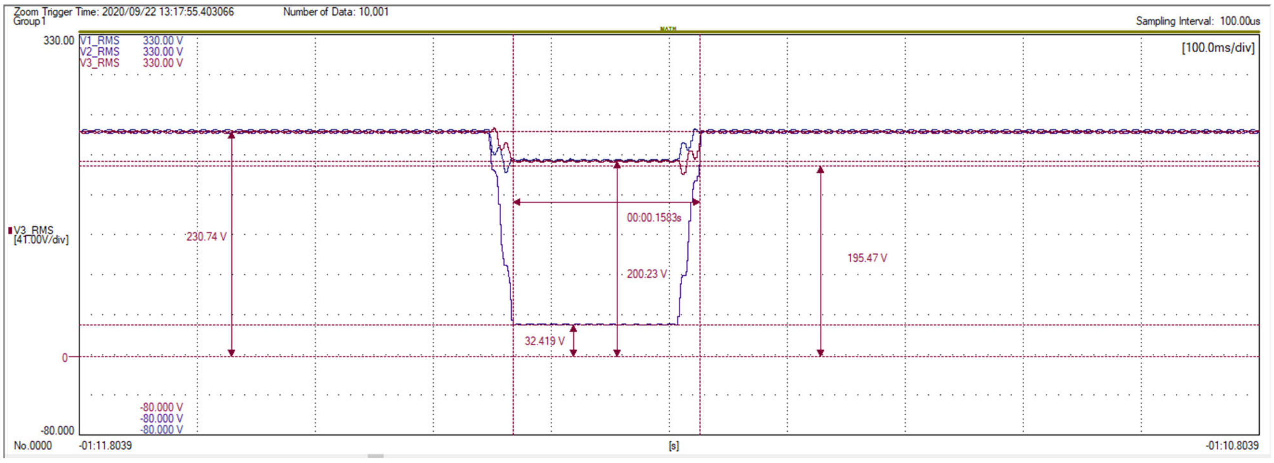
Test 0.1.1



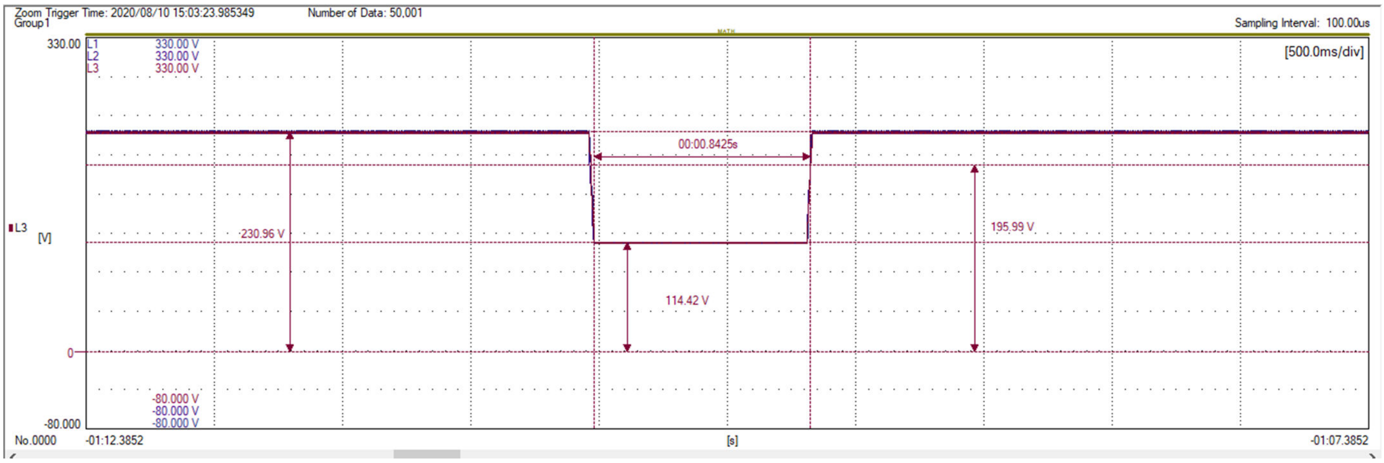
Test 0.1.2



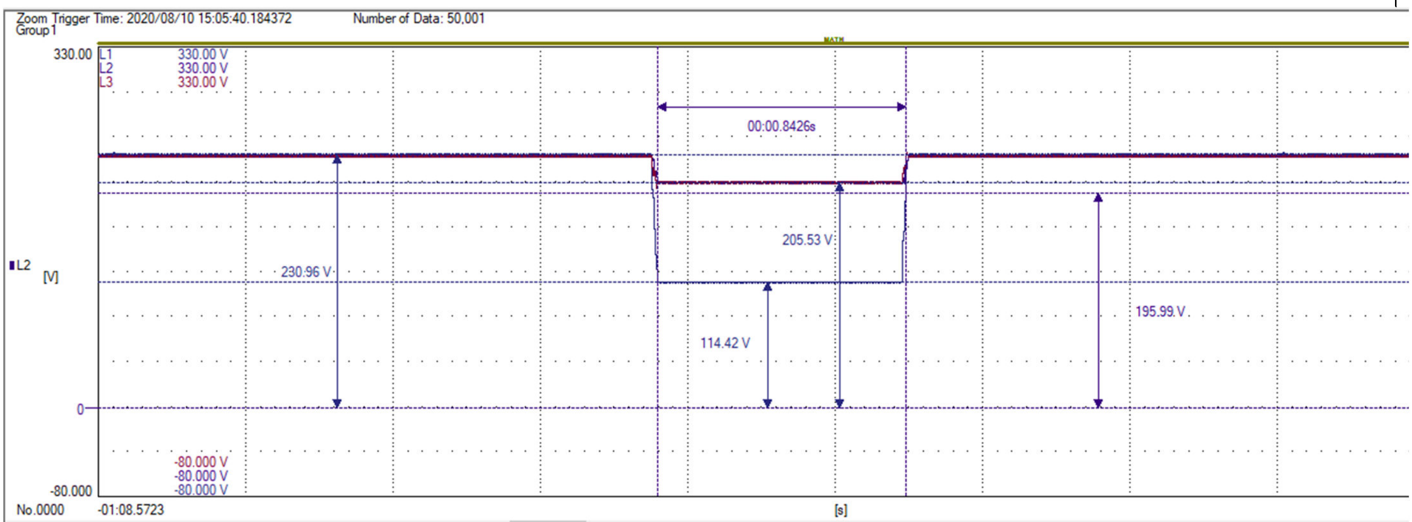
Test 0.1.3



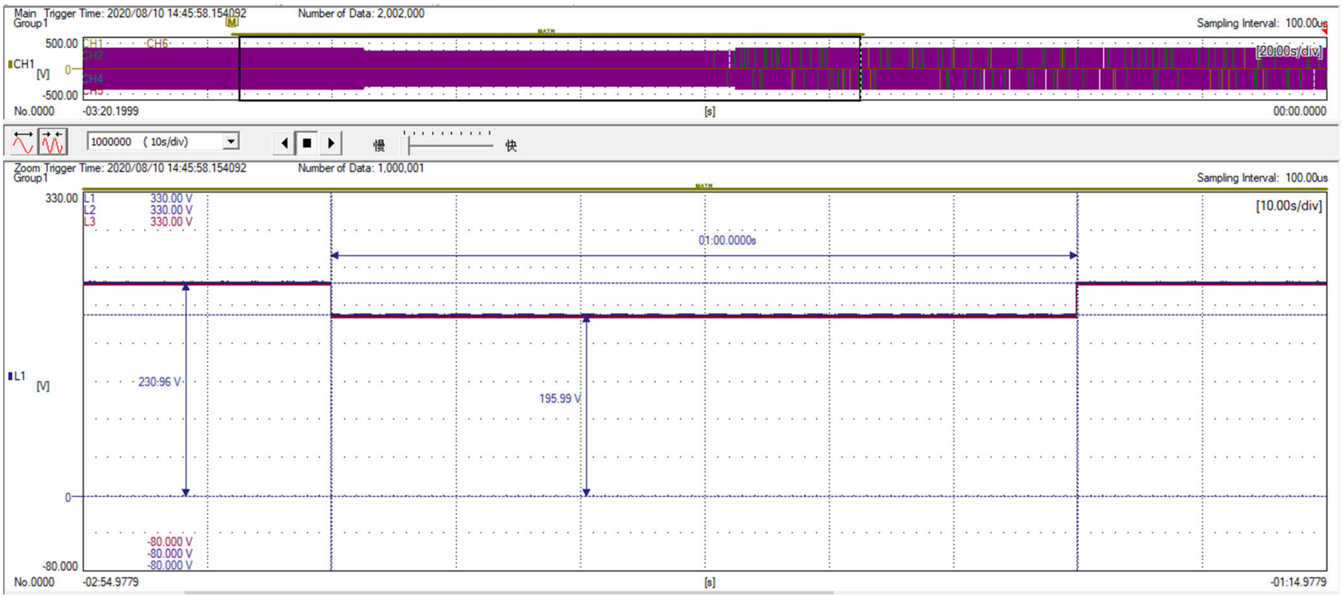
Test 0.2.1



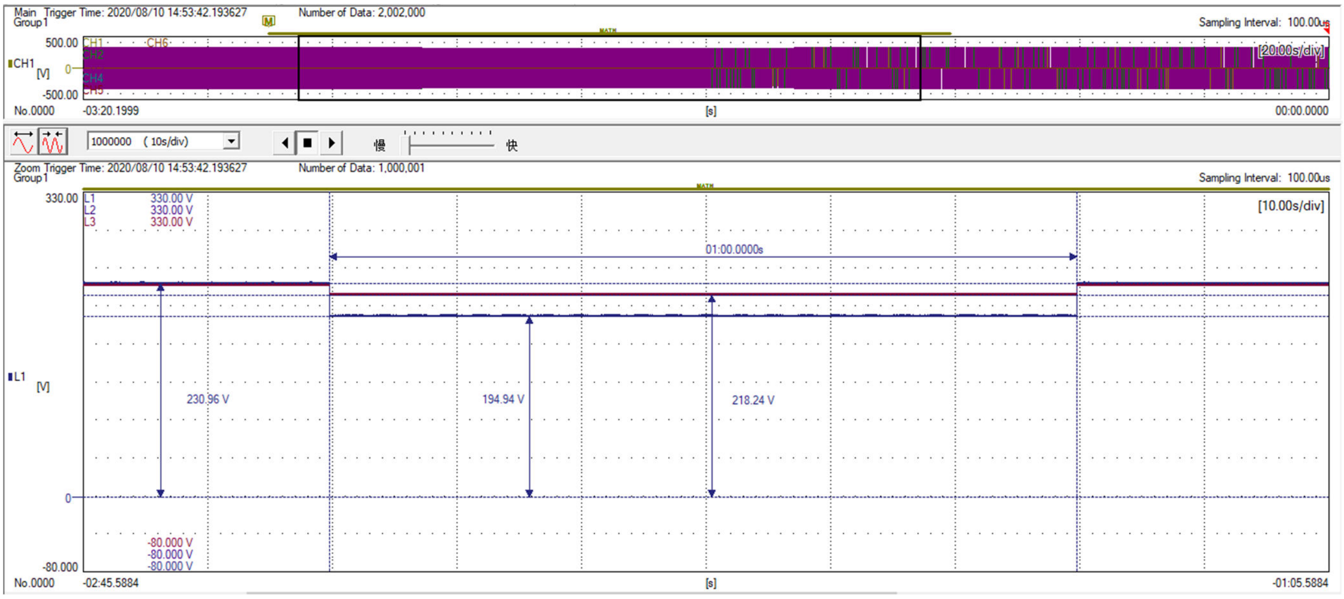
Test 0.2.2



Test 0.3.1



Test 0.3.2



Graph of FRT test one				
Test result:				
List of tests	**Residual amplitude of phase-to-phase voltage [p.u. U_n]**	**Duration limit [ms]**	**Duration [ms]**	**Result**
P_{Emax} in %	30% ±5%			
1.A.1- Symmetrical	0,15	150 ± 20	158	Pass
1.D.1- Asymmetrical	0,15	150 ± 20	158	Pass
2.A.1- Symmetrical	0,50	850 ± 20	855	Pass
2.D.1- Asymmetrical	0,50	850 ± 20	858	Pass
3.A.1- Symmetrical	0,85	60000 ± 20	60002	Pass
3.D.1- Asymmetrical	0,85	60000 ± 20	60002	Pass
P_{Emax} in %	100% ±5%			
1.A.1- Symmetrical	0,15	150 ± 20	157	Pass
1.D.1- Asymmetrical	0,15	150 ± 20	158	Pass
1.D.2- Asymmetrical	0,15	150 ± 20	159	Pass
2.A.1- Symmetrical	0,50	850 ± 20	858	Pass
2.D.1- Asymmetrical	0,50	850 ± 20	854	Pass
3.A.1- Symmetrical	0,85	60000 ± 20	60002	Pass
3.D.1- Asymmetrical	0,85	60000 ± 20	60002	Pass
Note:				

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.1
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	15:27:40
	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]	160
	6	Fault occurrence ($t1$)	Total	–	[ms]	31639
	7	Fault clearance ($t2$)	Total	–	[ms]	31796
	8	Fault duration determined from test	Total	–	[ms]	156,72
	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.]	1,002
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,991
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,995
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,995
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,021
	16		Total	t_1-10 s to t_1	[p.u.]	0,021
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,150
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,040
	20		Phase 2	t_1+60 ms	[p.u.]	0,041
	21		Phase 3	t_1+60 ms	[p.u.]	0,041
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,040
	23		Phase 2	t_1 +100 ms	[p.u.]	0,041
	24		Phase 3	t_1 +100 ms	[p.u.]	0,040
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,006
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,006
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,000
	28	Active power	Positive sequence	t_2+3 s to $t2$+10 s	[p.u.]	0,996
	29		Total	t_2+3 s to $t2$+10 s	[p.u.]	0,996
	30	Response time active power	Positive sequence	-	[s]	0,133
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,021
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,021
	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

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.2
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	15:15:37
	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]	160
	6	Fault occurrence (*t1*)	Total	–	[ms]	26041
	7	Fault clearance (*t2*)	Total	–	[ms]	26197
	8	Fault duration determined from test	Total	–	[ms]	156,32
	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.]	1,000
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,299
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,299
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,299
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,016
	16		Total	t_1-10 s to t_1	[p.u.]	0,016
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,150
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,040
	20		Phase 2	t_1+60 ms	[p.u.]	0,041
	21		Phase 3	t_1+60 ms	[p.u.]	0,040
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,040
	23		Phase 2	t_1 +100 ms	[p.u.]	0,041
	24		Phase 3	t_1 +100 ms	[p.u.]	0,040
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,006
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,006
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,001
	28	Active power	Positive sequence	t_2+3 s to *t2*+10 s	[p.u.]	0,300
	29		Total	t_2+3 s to *t2*+10 s	[p.u.]	0,300
	30	Response time active power	Positive sequence	-	[s]	0,113
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,016
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,016
	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

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.3
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	15:22:41
	3	Type of fault (number of affected phases)	–	–	–	D(1)
	4	Drop depth setpoint	Phase	–	[p.u]	0,15
	5	Drop duration setpoint	Total	–	[ms]	160
	6	Fault occurrence (*t*1)	Total	–	[ms]	27479
	7	Fault clearance (*t*2)	Total	–	[ms]	27635
	8	Fault duration determined from test	Total	–	[ms]	156,34
	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			0,464
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,000
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,991
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,996
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,996
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,021
	16		Total	t_1-10 s to t_1	[p.u.]	0,021
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,150
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,048
	20		Phase 2	t_1+60 ms	[p.u.]	0,041
	21		Phase 3	t_1+60 ms	[p.u.]	0,043
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,048
	23		Phase 2	t_1 +100 ms	[p.u.]	0,041
	24		Phase 3	t_1 +100 ms	[p.u.]	0,044
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,019
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,019
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,000
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,996
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,996
	30	Response time active power	Positive sequence	-	[s]	0,168
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,021
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,021
	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

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.3.a
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	15:25:06
	3	Type of fault (number of affected phases)	–	–	–	D(1)
	4	Drop depth setpoint	Phase	–	[p.u]	0,15
	5	Drop duration setpoint	Total	–	[ms]	160
	6	Fault occurrence (*t*1)	Total	–	[ms]	30848
	7	Fault clearance (*t*2)	Total	–	[ms]	31006
	8	Fault duration determined from test	Total	–	[ms]	157,48
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,151
	10		Positive sequence			0,464
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,000
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,991
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,996
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,996
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,021
	16		Total	t_1-10 s to t_1	[p.u.]	0,023
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,151
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,042
	20		Phase 2	t_1+60 ms	[p.u.]	0,050
	21		Phase 3	t_1+60 ms	[p.u.]	0,047
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,041
	23		Phase 2	t_1 +100 ms	[p.u.]	0,049
	24		Phase 3	t_1 +100 ms	[p.u.]	0,045
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,019
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,019
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,000
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,996
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,996
	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.]	0,021
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,021
	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

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.4
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	15:19:03
	3	Type of fault (number of affected phases)	–	–	–	D(1)
	4	Drop depth setpoint	Phase	–	[p.u]	0,15
	5	Drop duration setpoint	Total	–	[ms]	160
	6	Fault occurrence (*t*1)	Total	–	[ms]	29867
	7	Fault clearance (*t*2)	Total	–	[ms]	30026
	8	Fault duration determined from test	Total	–	[ms]	158,62
	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			0,464
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,997
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,299
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,299
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,299
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,016
	16		Total	t_1-10 s to t_1	[p.u.]	0,016
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,150
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,048
	20		Phase 2	t_1+60 ms	[p.u.]	0,041
	21		Phase 3	t_1+60 ms	[p.u.]	0,043
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,050
	23		Phase 2	t_1 +100 ms	[p.u.]	0,044
	24		Phase 3	t_1 +100 ms	[p.u.]	0,045
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,020
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,020
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,998
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,299
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,299
	30	Response time active power	Positive sequence	-	[s]	0,161
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,016
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,016
	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

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.1
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	15:30:27
	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]	860
	6	Fault occurrence (*t1*)	Total	–	[ms]	31669
	7	Fault clearance (*t2*)	Total	–	[ms]	32533
	8	Fault duration determined from test	Total	–	[ms]	864,38
	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			0,501
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,001
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,991
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,995
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,995
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,021
	16		Total	t_1-10 s to t_1	[p.u.]	0,021
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,499
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,045
	20		Phase 2	t_1+60 ms	[p.u.]	0,043
	21		Phase 3	t_1+60 ms	[p.u.]	0,046
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,046
	23		Phase 2	t_1 +100 ms	[p.u.]	0,045
	24		Phase 3	t_1 +100 ms	[p.u.]	0,048
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,021
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,021
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,000
	28	Active power	Positive sequence	t_2+3 s to *t2*+10 s	[p.u.]	0,995
	29		Total	t_2+3 s to *t2*+10 s	[p.u.]	0,995
	30	Response time active power	Positive sequence	-	[s]	0,143
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,021
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,021
	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

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.2
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	15:44:33
	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]	860
	6	Fault occurrence (*t*1)	Total	–	[ms]	33215
	7	Fault clearance (*t*2)	Total	–	[ms]	34079
	8	Fault duration determined from test	Total	–	[ms]	864,36
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,500
	10		Positive sequence			0,501
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,997
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,299
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,299
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,299
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,016
	16		Total	t_1-10 s to t_1	[p.u.]	0,016
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,500
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,045
	20		Phase 2	t_1+60 ms	[p.u.]	0,043
	21		Phase 3	t_1+60 ms	[p.u.]	0,046
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,047
	23		Phase 2	t_1 +100 ms	[p.u.]	0,045
	24		Phase 3	t_1 +100 ms	[p.u.]	0,049
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,021
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,021
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,000
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,300
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,300
	30	Response time active power	Positive sequence	-	[s]	0,129
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,016
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,016
	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

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.3
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	15:33:33
	3	Type of fault (number of affected phases)	–	–	–	D(1)
	4	Drop depth setpoint	Phase	–	[p.u]	0,5
	5	Drop duration setpoint	Total	–	[ms]	860
	6	Fault occurrence (*t*1)	Total	–	[ms]	31724
	7	Fault clearance (*t*2)	Total	–	[ms]	32587
	8	Fault duration determined from test	Total	–	[ms]	863,78
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,500
	10		Positive sequence			0,674
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,000
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,991
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,995
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,995
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,021
	16		Total	t_1-10 s to t_1	[p.u.]	0,021
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,500
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,043
	20		Phase 2	t_1+60 ms	[p.u.]	0,036
	21		Phase 3	t_1+60 ms	[p.u.]	0,042
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,041
	23		Phase 2	t_1 +100 ms	[p.u.]	0,036
	24		Phase 3	t_1 +100 ms	[p.u.]	0,040
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,020
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,021
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,000
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,996
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,996
	30	Response time active power	Positive sequence	-	[s]	0,143
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,021
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,021
	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

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.4
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	15:50:44
	3	Type of fault (number of affected phases)	–	–	–	D(1)
	4	Drop depth setpoint	Phase	–	[p.u]	0,5
	5	Drop duration setpoint	Total	–	[ms]	860
	6	Fault occurrence (*t*1)	Total	–	[ms]	31635
	7	Fault clearance (*t*2)	Total	–	[ms]	32499
	8	Fault duration determined from test	Total	–	[ms]	864,36
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,500
	10		Positive sequence			0,674
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,998
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,991
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,299
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,299
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,016
	16		Total	t_1-10 s to t_1	[p.u.]	0,016
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,500
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,042
	20		Phase 2	t_1+60 ms	[p.u.]	0,036
	21		Phase 3	t_1+60 ms	[p.u.]	0,040
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,041
	23		Phase 2	t_1 +100 ms	[p.u.]	0,036
	24		Phase 3	t_1 +100 ms	[p.u.]	0,040
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,020
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,021
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,997
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,299
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,299
	30	Response time active power	Positive sequence	-	[s]	0,189
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,016
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,016
	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

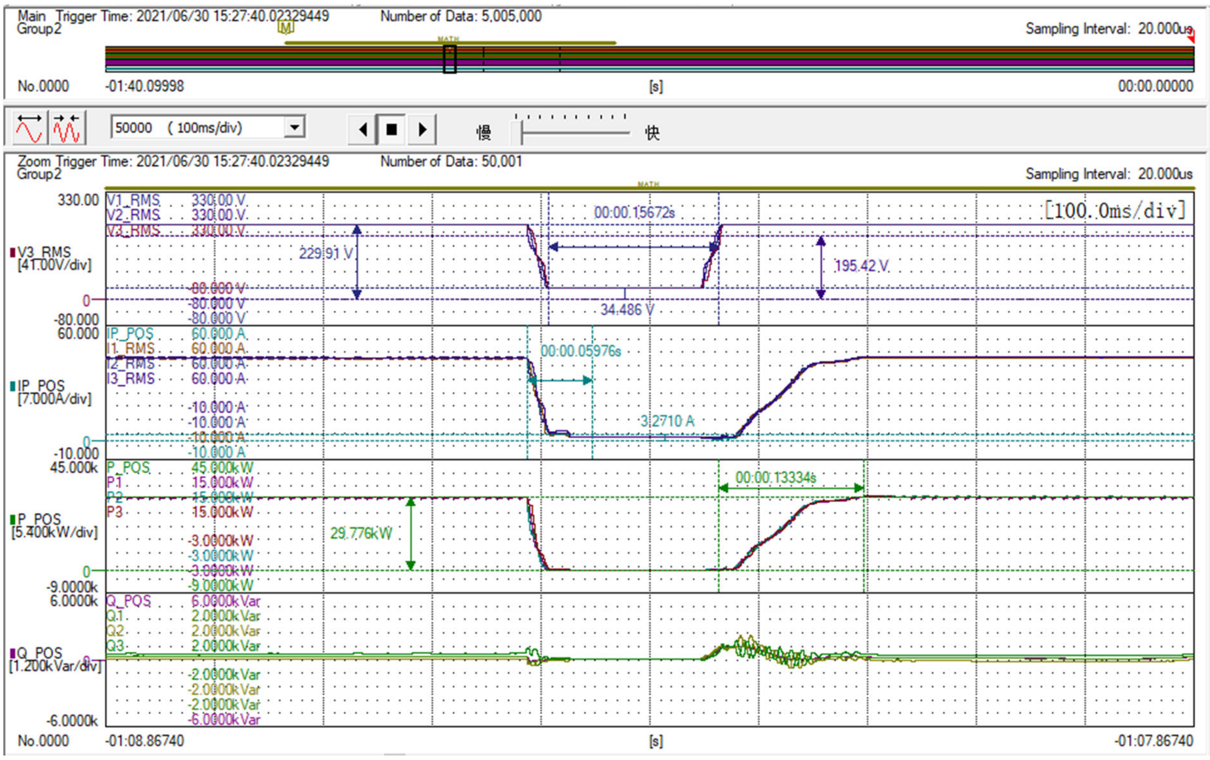
	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.1
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	16:21:50
	3	Type of fault (number of affected phases)	–	–	–	A(3)
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60020
	6	Fault occurrence (*t*1)	Total	–	[ms]	51559
	7	Fault clearance (*t*2)	Total	–	[ms]	111575
	8	Fault duration determined from test	Total	–	[ms]	60016,25
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,854
	10		Positive sequence			0,856
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,001
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,991
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,995
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,995
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,020
	16		Total	t_1-10 s to t_1	[p.u.]	0,020
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,854
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	1,140
	20		Phase 2	t_1+60 ms	[p.u.]	1,161
	21		Phase 3	t_1+60 ms	[p.u.]	1,164
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	1,139
	23		Phase 2	t_1 +100 ms	[p.u.]	1,161
	24		Phase 3	t_1 +100 ms	[p.u.]	1,163
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,979
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,979
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,000
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,987
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,987
	30	Response time active power	Positive sequence	-	[s]	0,230
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,020
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,020
	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

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.2
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	16:05:54
	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]	60020
	6	Fault occurrence (*t*1)	Total	–	[ms]	69963
	7	Fault clearance (*t*2)	Total	–	[ms]	129979
	8	Fault duration determined from test	Total	–	[ms]	60016,15
	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.]	0,998
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,299
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,299
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,299
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,016
	16		Total	t_1-10 s to t_1	[p.u.]	0,016
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,850
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	0,345
	20		Phase 2	t_1+60 ms	[p.u.]	0,352
	21		Phase 3	t_1+60 ms	[p.u.]	0,354
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	0,345
	23		Phase 2	t_1 +100 ms	[p.u.]	0,352
	24		Phase 3	t_1 +100 ms	[p.u.]	0,353
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,298
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,298
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,998
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,299
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,299
	30	Response time active power	Positive sequence	-	[s]	0,230
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,016
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,016
	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

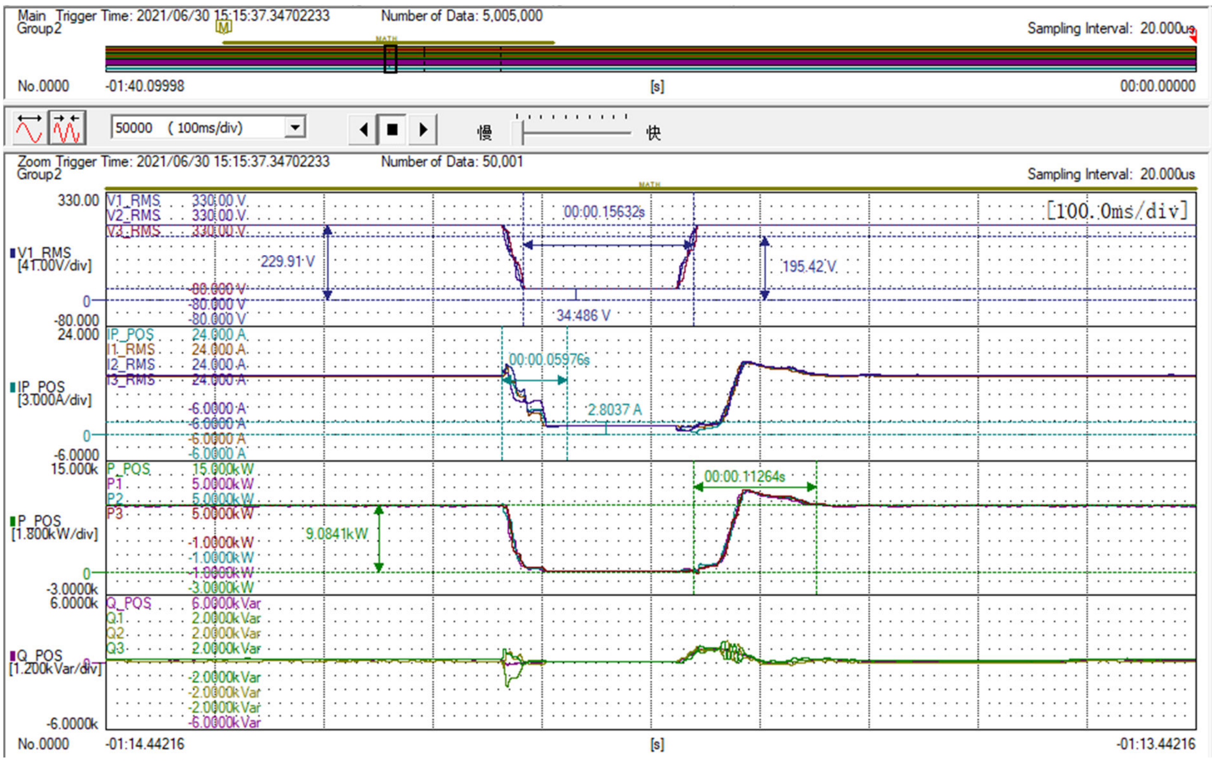
	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.3
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	16:17:59
	3	Type of fault (number of affected phases)	–	–	–	D(1)
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60020
	6	Fault occurrence (*t*1)	Total	–	[ms]	63768
	7	Fault clearance (*t*2)	Total	–	[ms]	123786
	8	Fault duration determined from test	Total	–	[ms]	60017,95
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,854
	10		Positive sequence			0,909
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,000
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,991
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,996
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,996
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,020
	16		Total	t_1-10 s to t_1	[p.u.]	0,020
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,854
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	1,074
	20		Phase 2	t_1+60 ms	[p.u.]	1,105
	21		Phase 3	t_1+60 ms	[p.u.]	1,097
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	1,074
	23		Phase 2	t_1 +100 ms	[p.u.]	1,105
	24		Phase 3	t_1 +100 ms	[p.u.]	1,096
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,980
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,980
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,000
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,983
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,982
	30	Response time active power	Positive sequence	-	[s]	0,230
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,020
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,020
	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

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.4
	1	Date	–	–	[dd.mm.yyyy]	30.06.2021
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	16:12:45
	3	Type of fault (number of affected phases)	–	–	–	D(1)
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60020
	6	Fault occurrence (*t*1)	Total	–	[ms]	62410
	7	Fault clearance (*t*2)	Total	–	[ms]	122425
	8	Fault duration determined from test	Total	–	[ms]	60015,30
	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			0,905
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,998
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,299
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,299
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,299
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,016
	16		Total	t_1-10 s to t_1	[p.u.]	0,016
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	1,000
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,850
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	1,074
	20		Phase 2	t_1+60 ms	[p.u.]	1,105
	21		Phase 3	t_1+60 ms	[p.u.]	1,097
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	1,074
	23		Phase 2	t_1 +100 ms	[p.u.]	1,105
	24		Phase 3	t_1 +100 ms	[p.u.]	1,096
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,298
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,299
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,998
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,299
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,299
	30	Response time active power	Positive sequence	-	[s]	0,230
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,016
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,016
	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

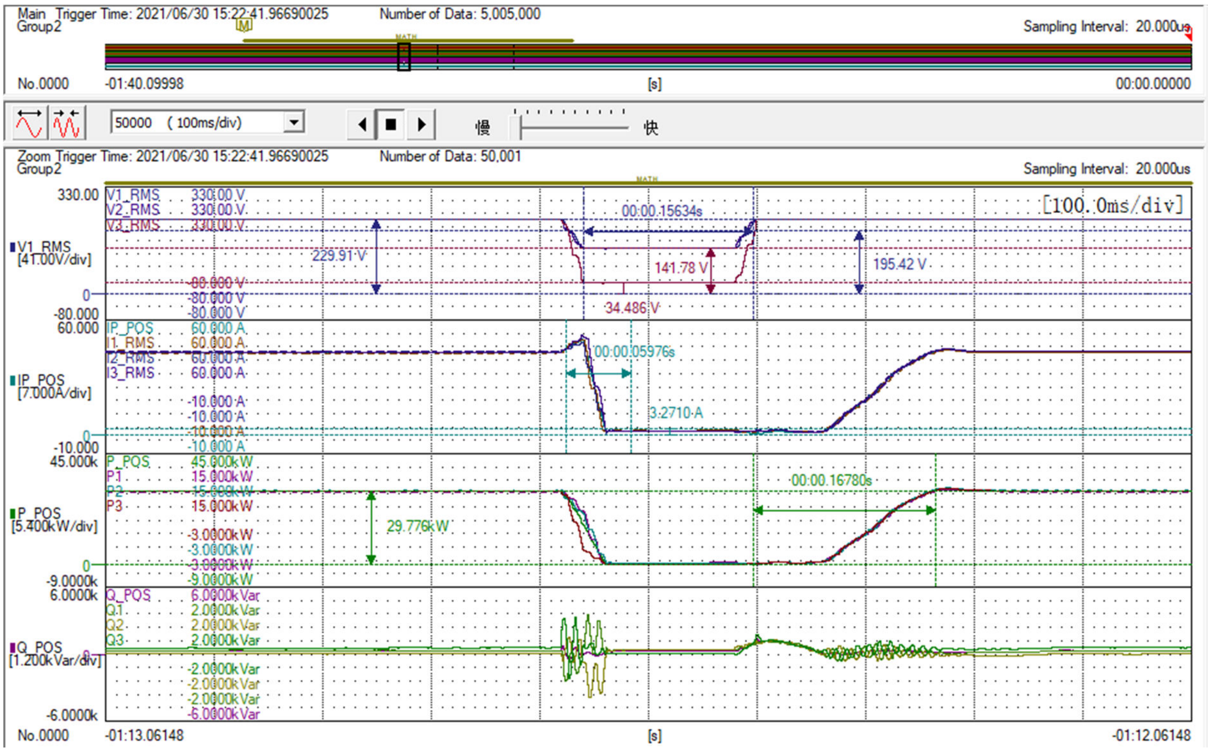
Test No.1.1



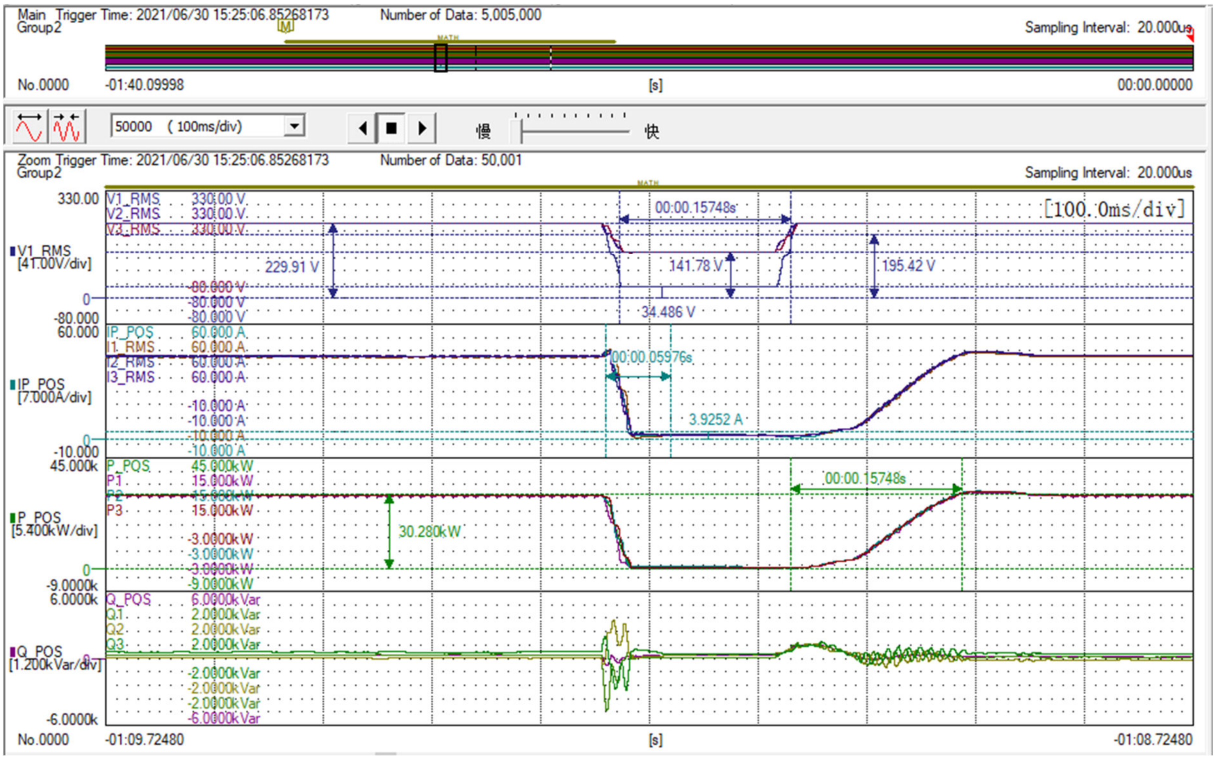
Test No.1.2



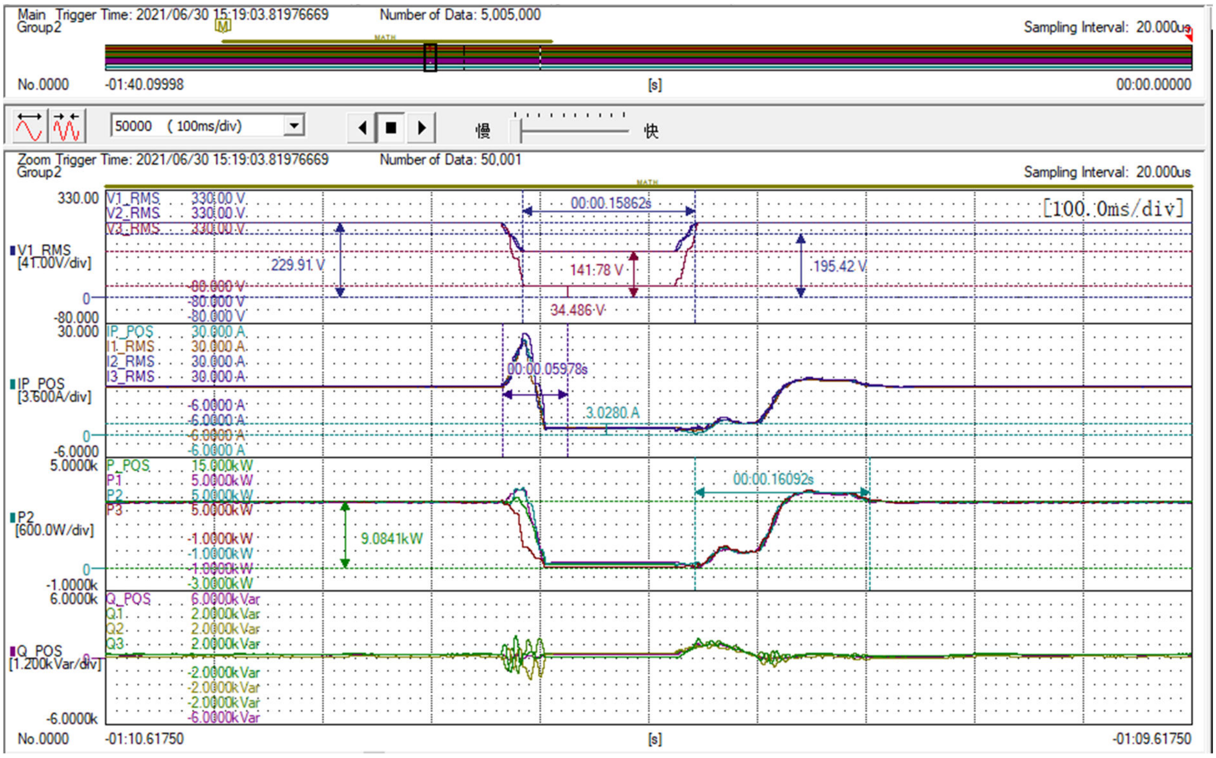
Test No.1.3



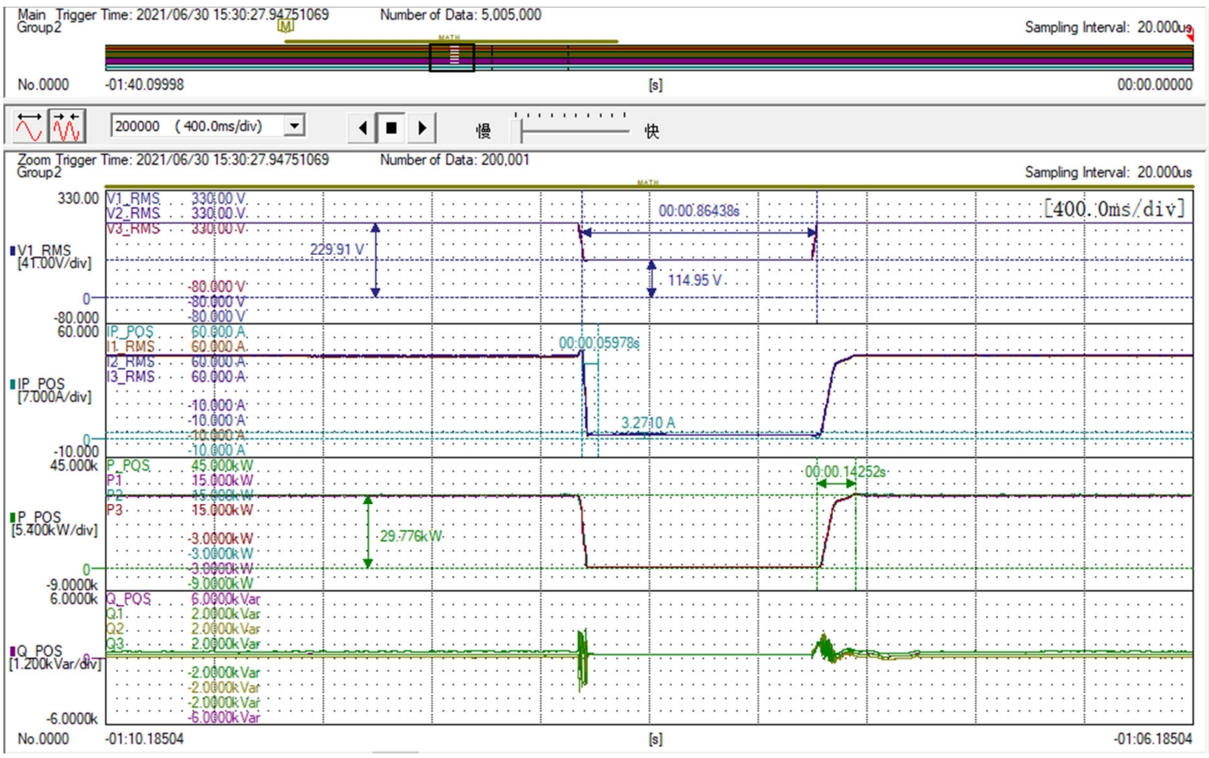
Test No.1.3.a



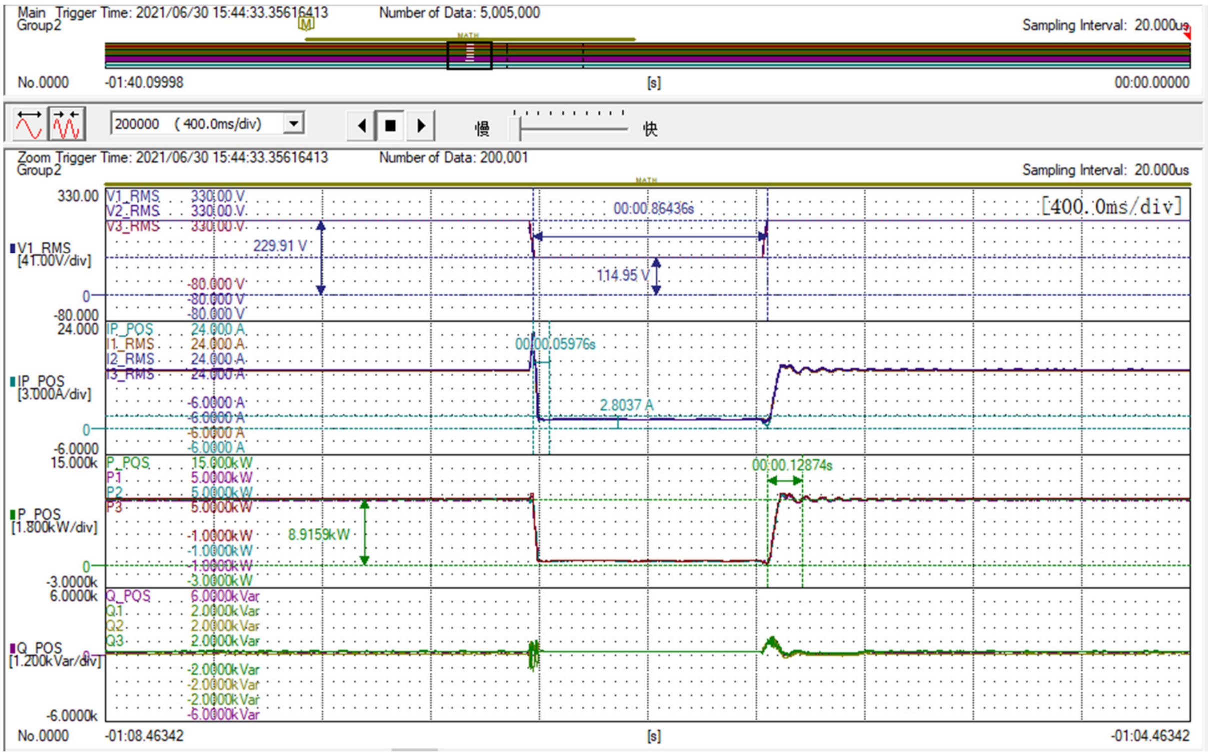
Test No.1.4



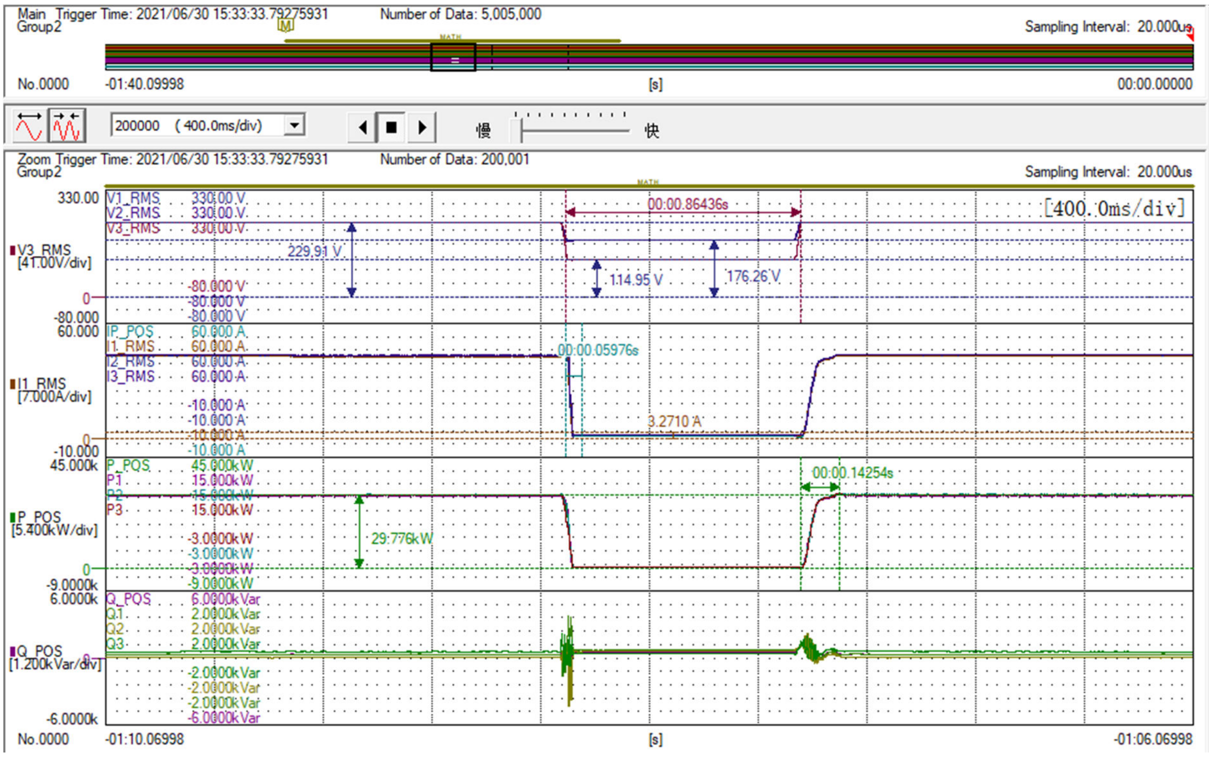
Test No.2.1



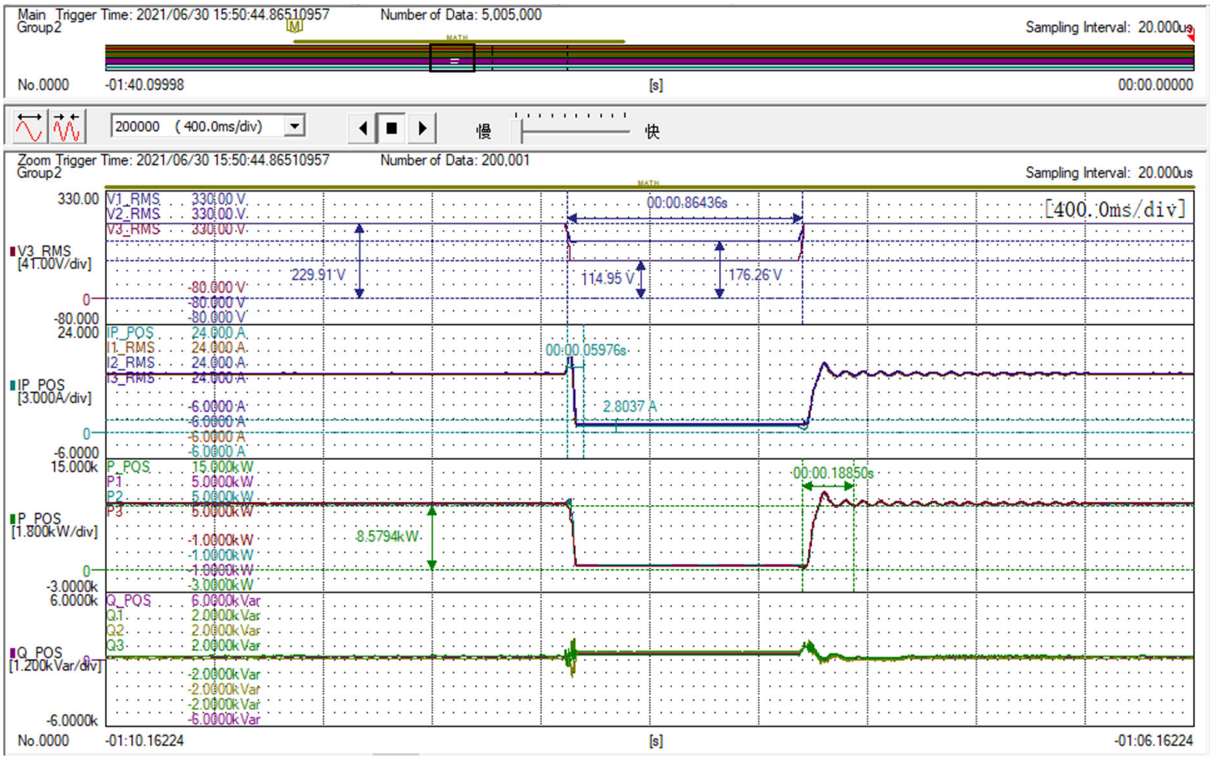
Test No.2.2



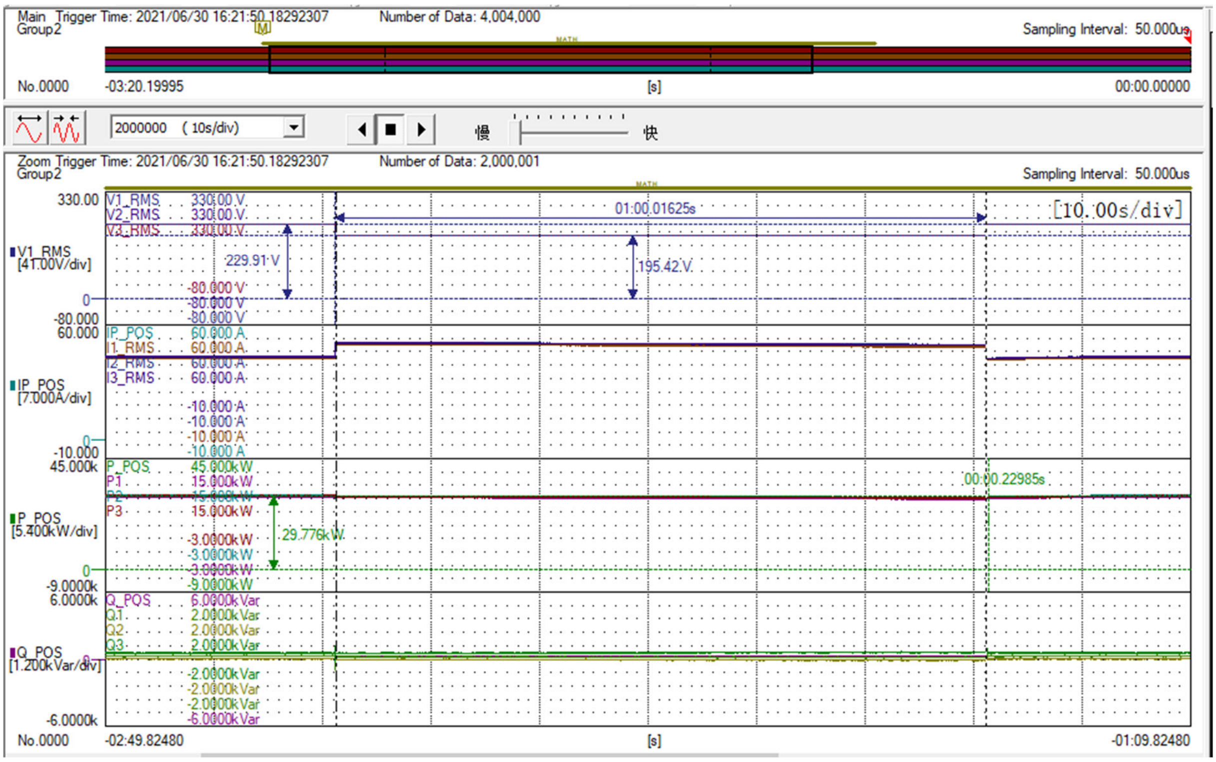
Test No.2.3



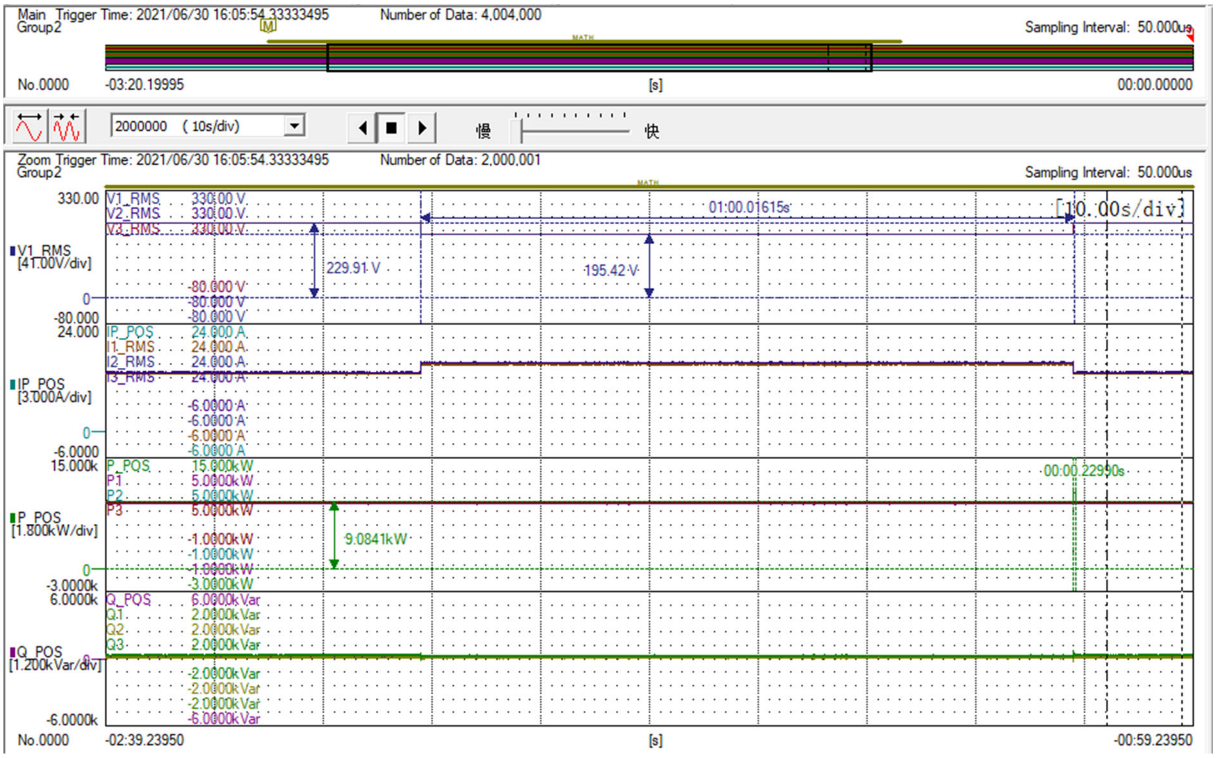
Test No.2.4



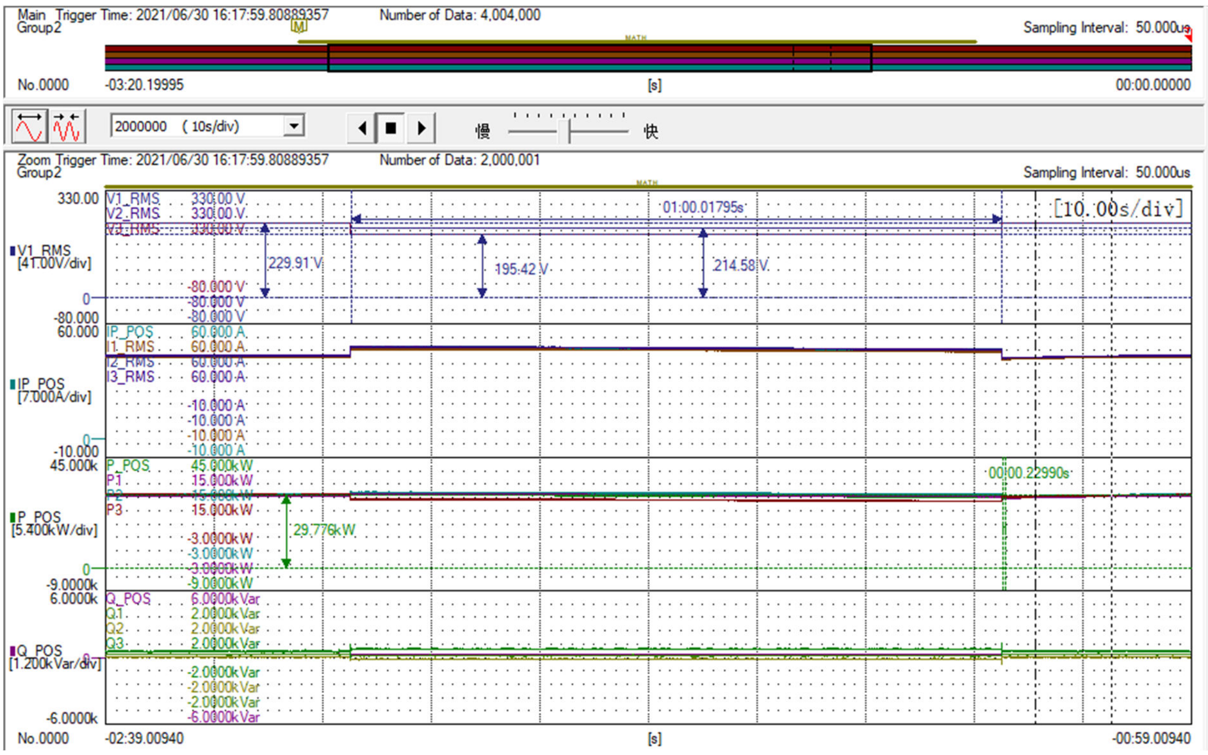
Test No.3.1



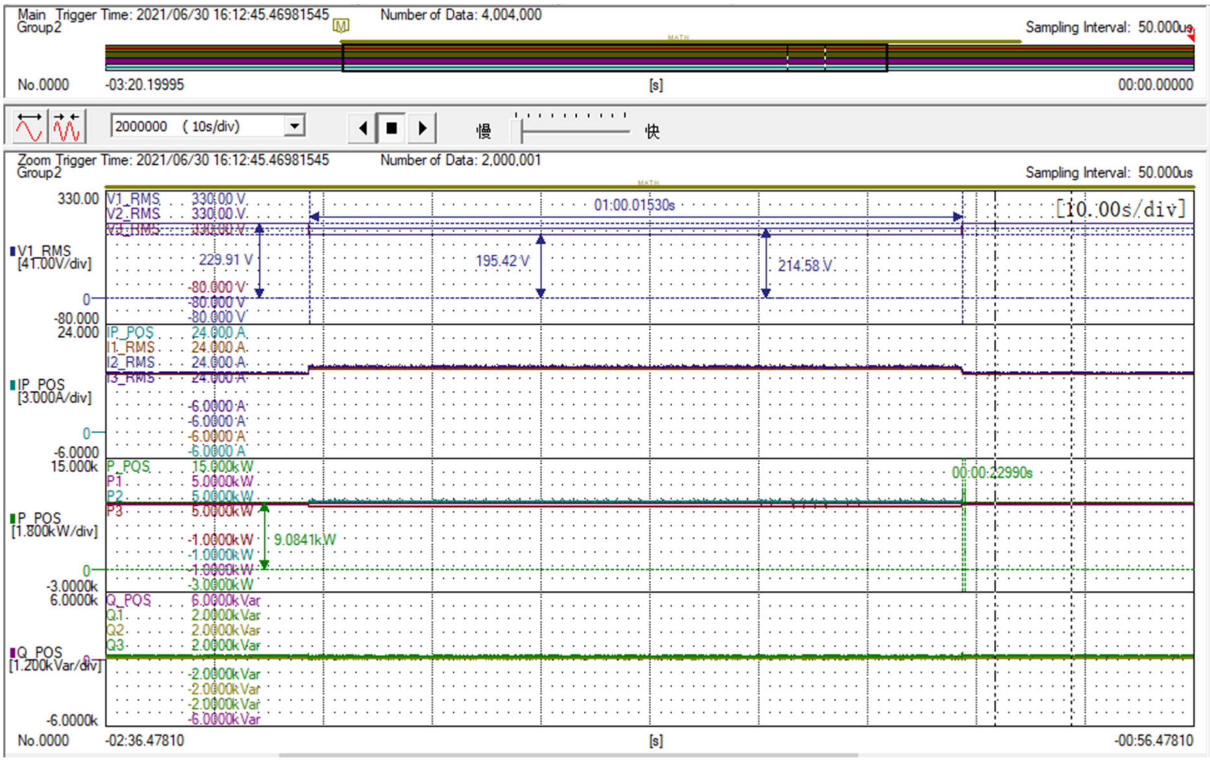
Test No.3.2



Test No.3.3



Test No.3.4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No.0000
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[s]
00:00.00000
2000000 (10s/div)
慢
快
Zoom Trigger Time: 2021/06/30 16:12:45.46981545
Group2
Number of Data: 2,000,001
Sampling Interval: 50.000us
01:00.01530s
[10.00s/div]
229.91 V
195.42 V
214.58 V
V1_RMS [41.00V/div]
IP_POS [3.000A/div]
P_POS [1.800kW/div]
00:00:22990s
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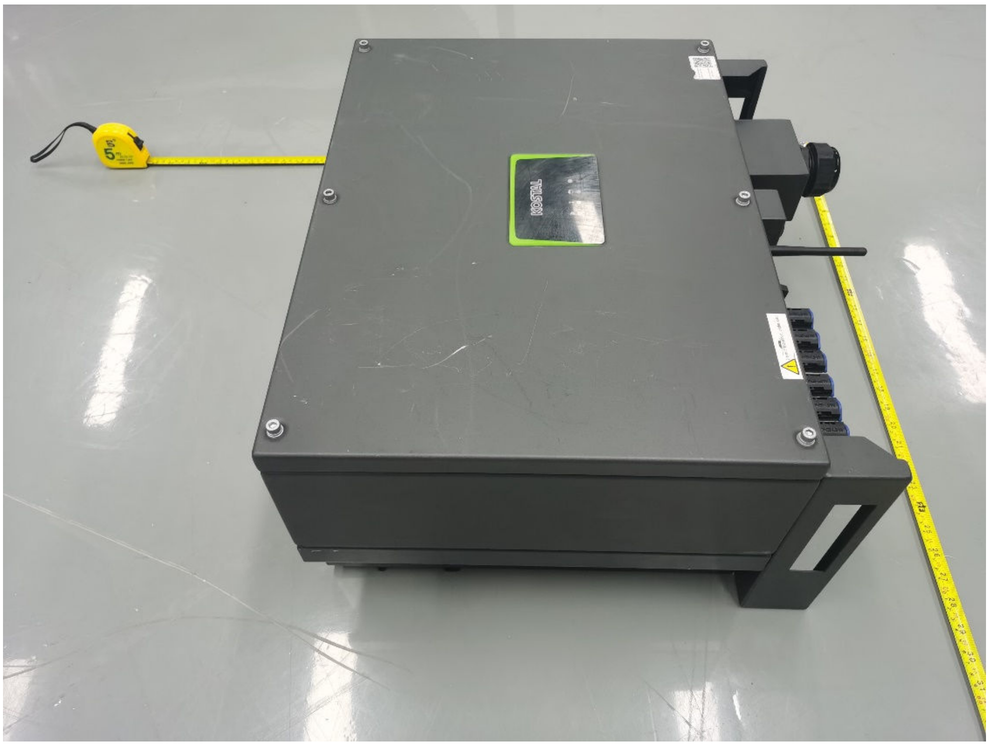
-02:36.47810
[s]
-00:56.47810

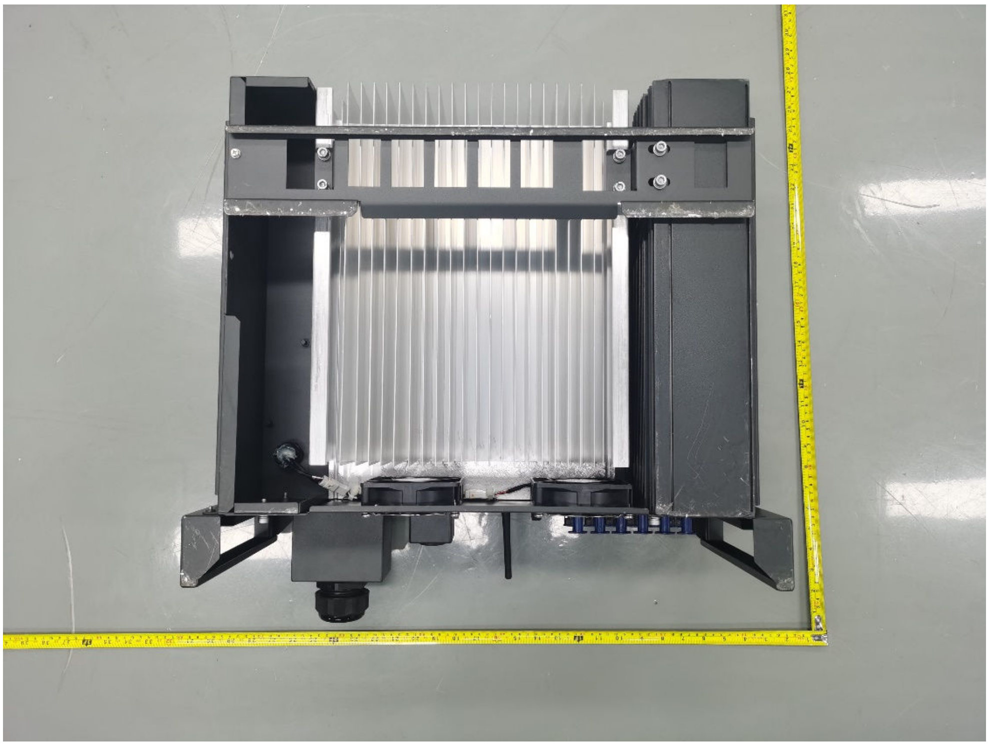
Annex 1

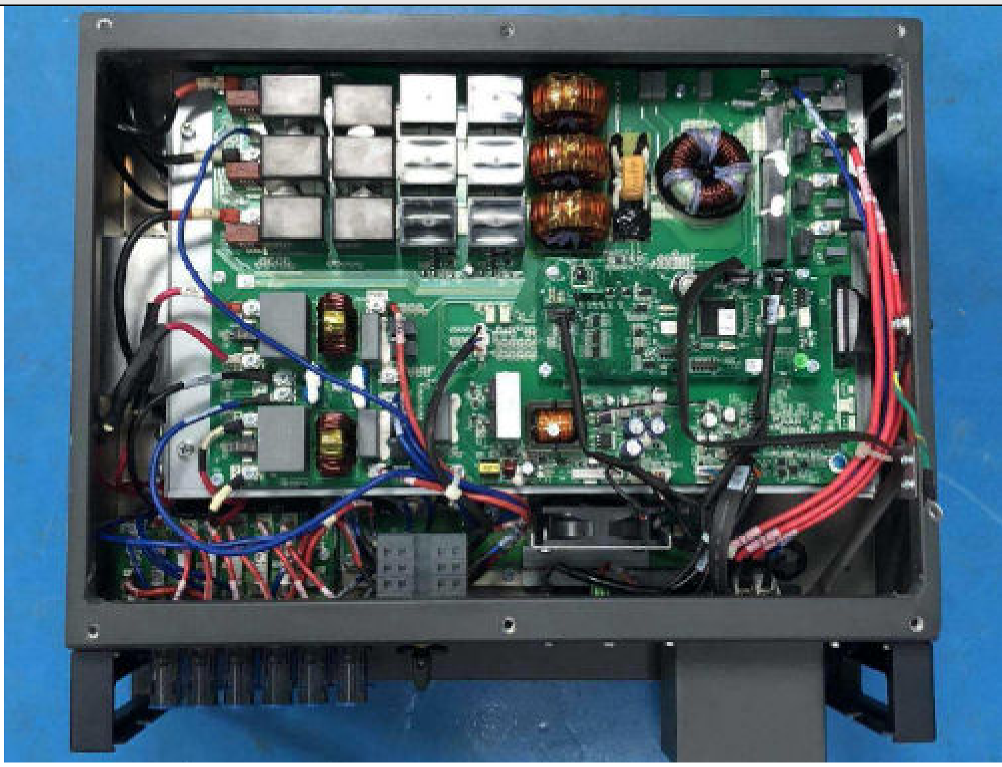
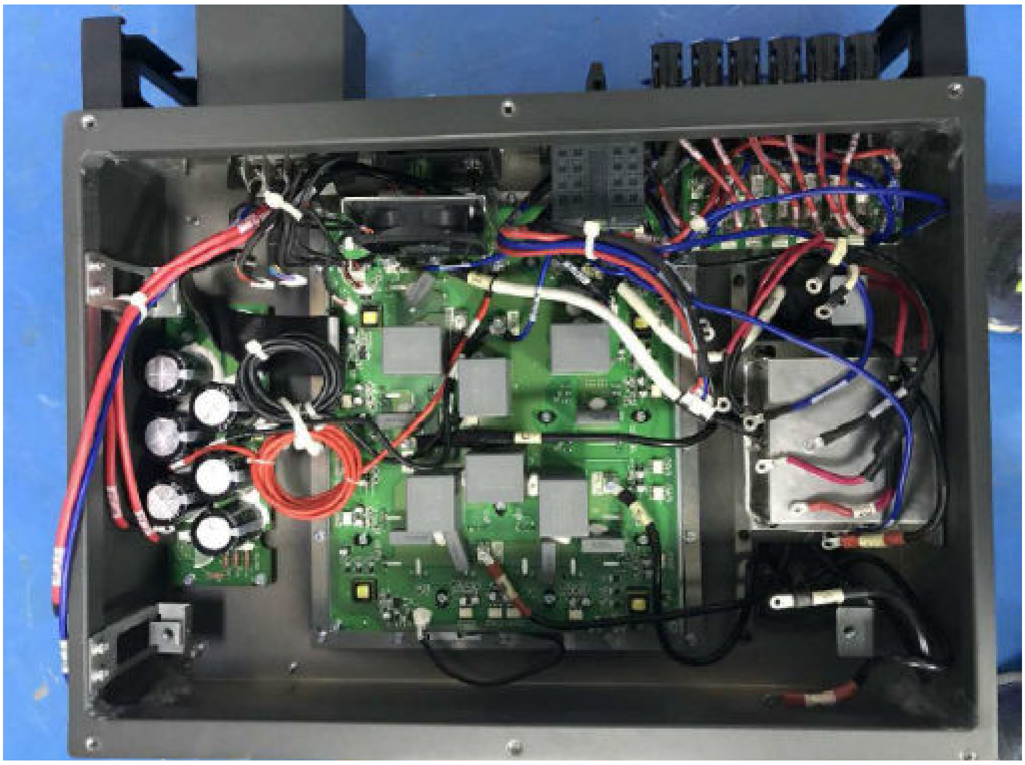
Pictures of the unit

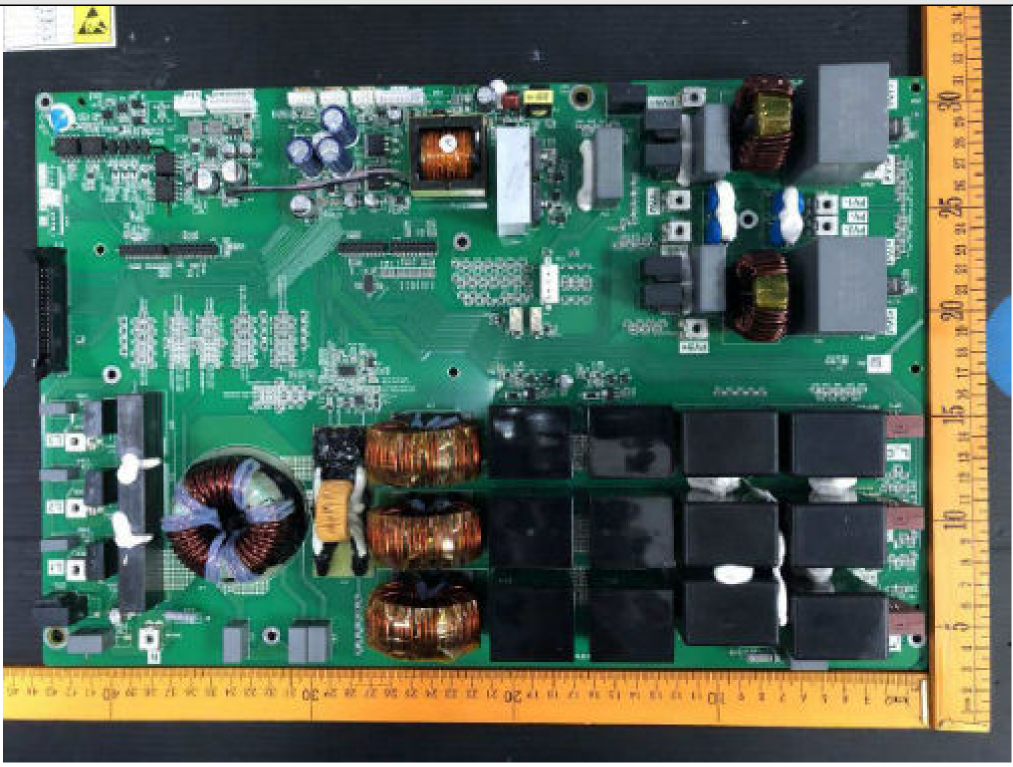
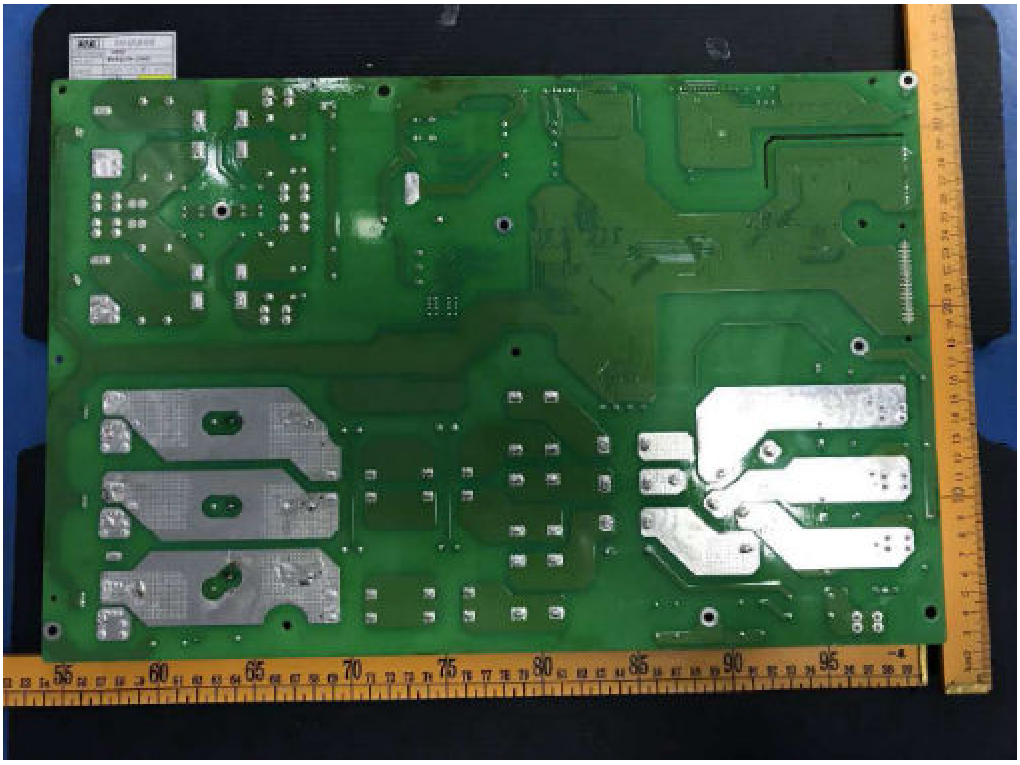
Enclosure front view

Enclosure top view


Enclosure side view-1

Enclosure side view-2

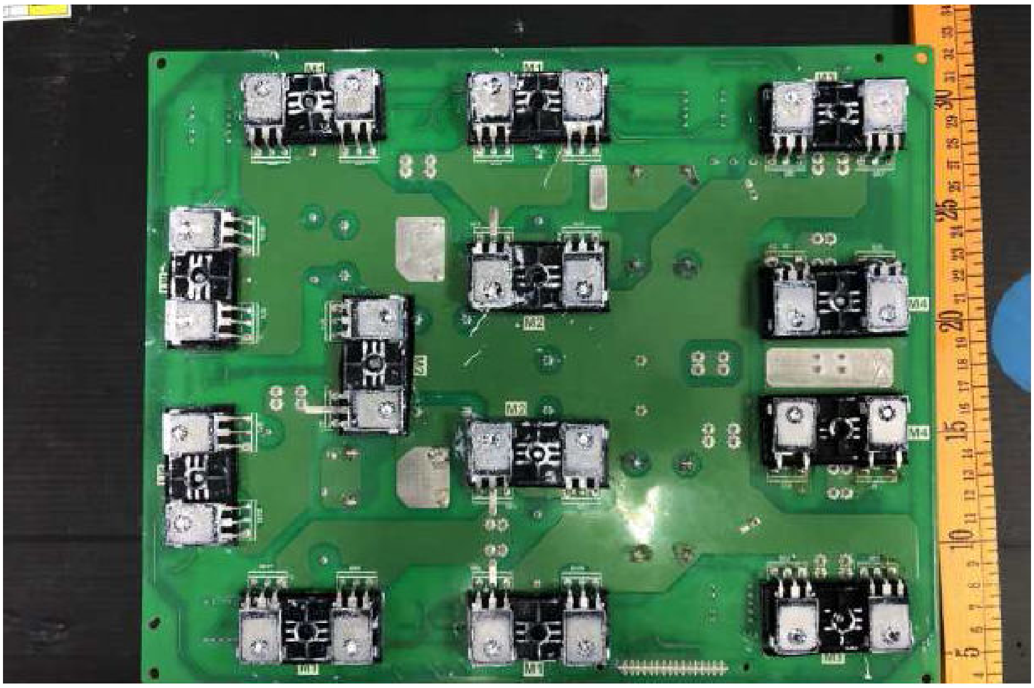

Enclosure bear view

AC output terminal:

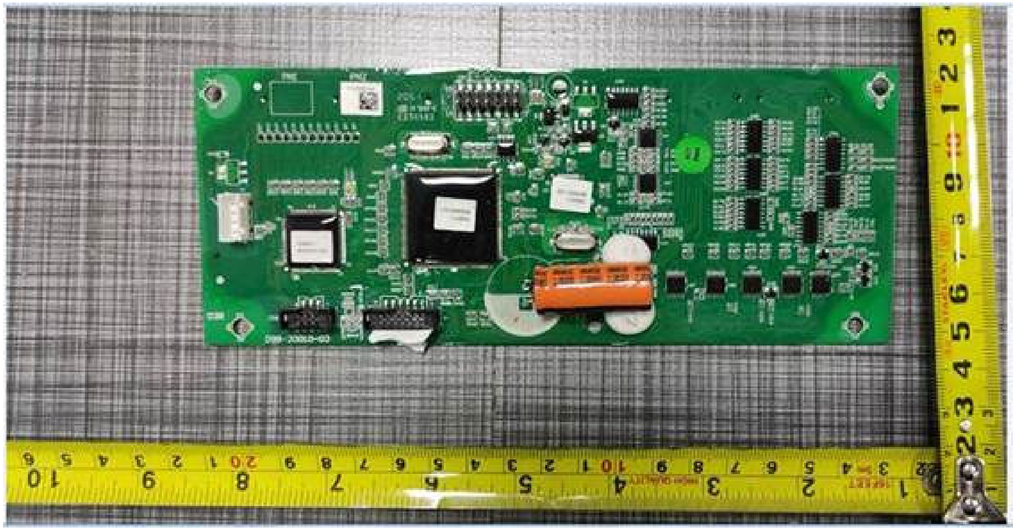
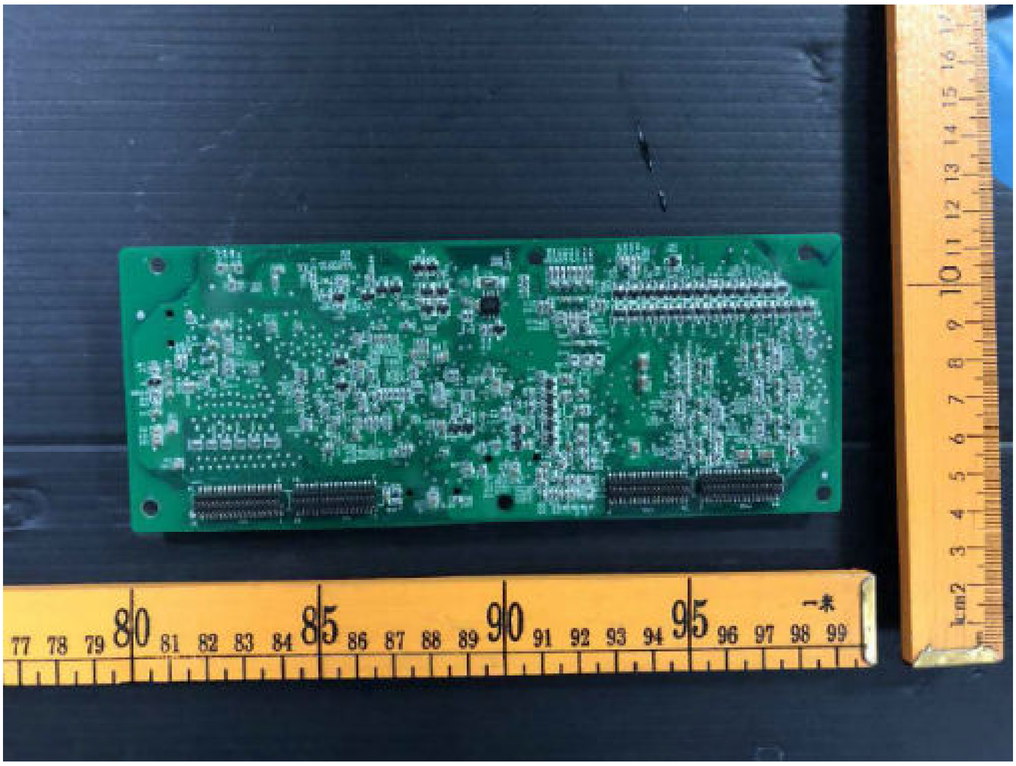

Internal view-1

Internal view-2


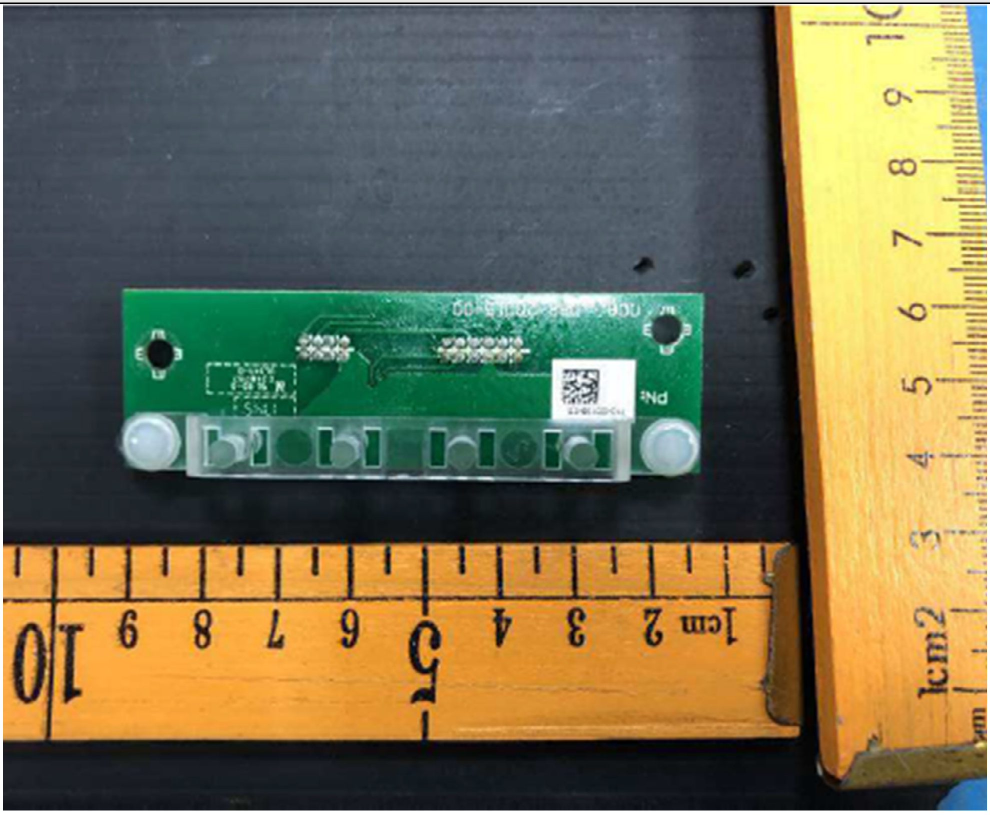
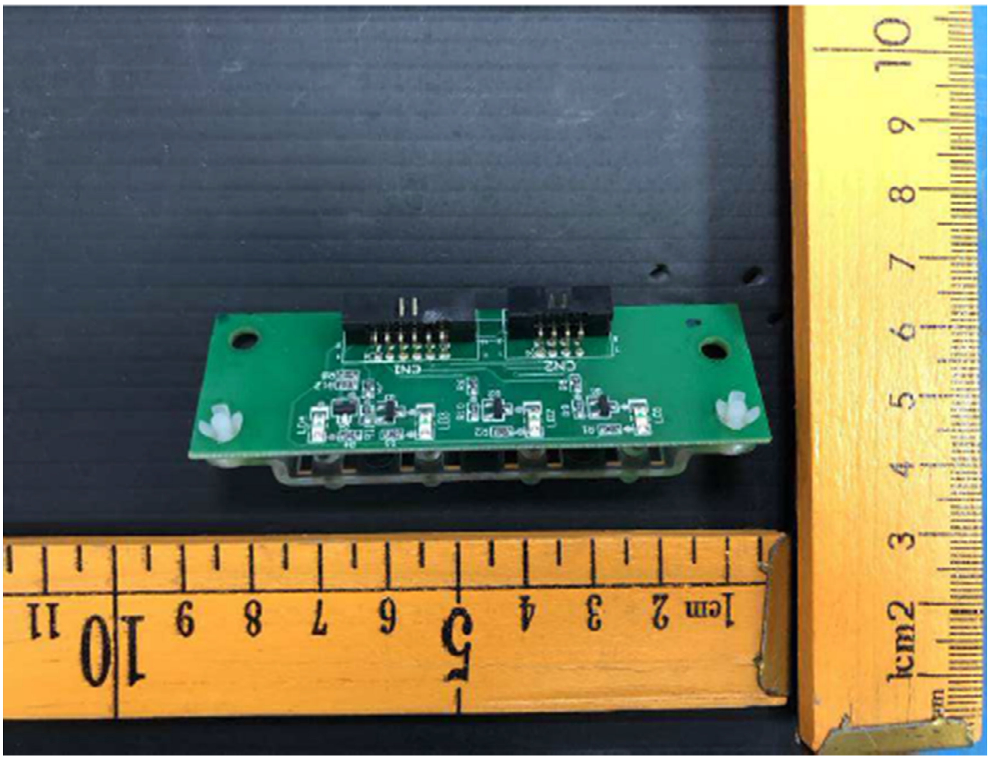
Interface board component side view

Interface board solder side view


Power board component side view

Power board solder side view

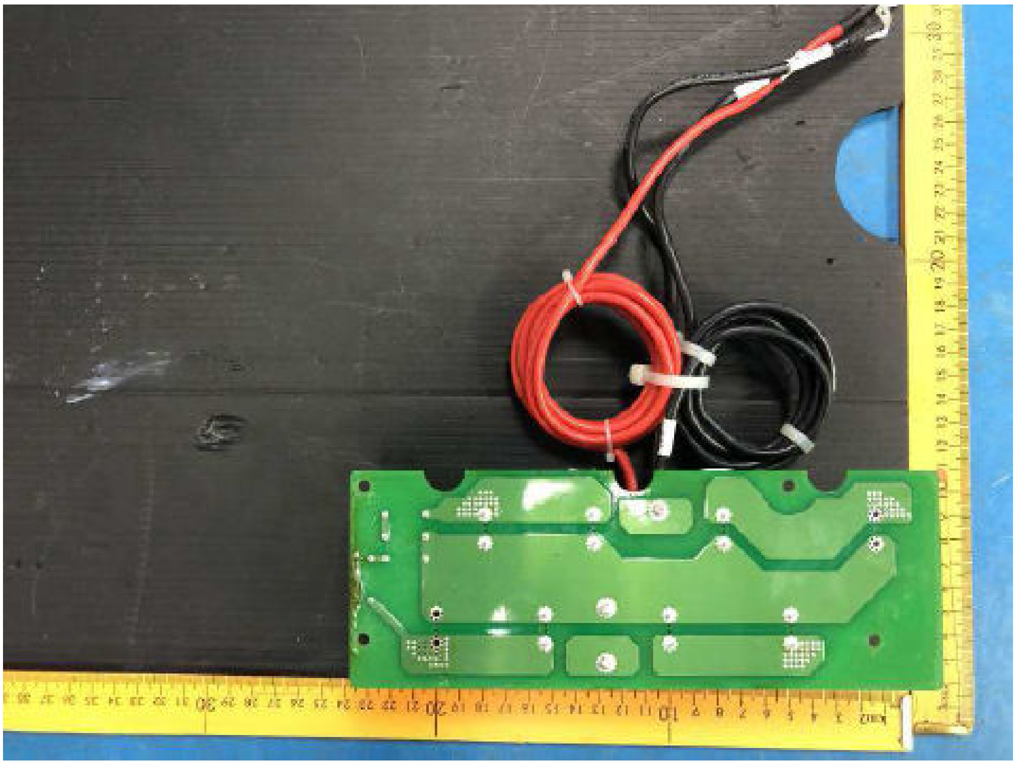


Control board component side view：

Control board solder side view：


Button board component side view：

Button board solder side view：


Bus board component side view

Bus board solder side view



Annex No. 2

Test Equipment list

Test location: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Date(s) of performance test: 2021-06-01 to 2021-07-06

Equipment	Internal no.:	Manufacturer:	Type:	Serial no.:	Last Calibration
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	July. 18, 2020
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040016DG	Chroma	62150H-1000S	62150EF00490	
	A7040017DG	Chroma	620028	620028EF00120	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 24, 2020
Oscilloscope probel	A1490008DG	YOKOGAWA	701901	//	Sep. 23, 2020
	A1490009DG	YOKOGAWA	701901	//	Sep. 23, 2020
	A1490010DG	YOKOGAWA	701901	//	Sep. 23, 2020
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Sep. 03, 2020
	A1060008DG	YOKOGAWA	CT200	1130700017	Sep. 03, 2020
	A1060009DG	YOKOGAWA	CT200	1130700019	Sep. 03, 2020
	A10600010DG	YOKOGAWA	CT200	1130700016	Sep. 03, 2020
	A10600011DG	YOKOGAWA	CT200	1130700011	Sep. 03, 2020
	A10600012DG	YOKOGAWA	CT200	1130700018	Sep. 03, 2020
Temp. & Humi. Recorder	A7440034DG	HUATO	S580-TH	HT20103923	Jan. 28, 2021

---End of test report---