TEST REPORT

EN 50549-1:2019

Requirements for generating plants to be connected in parallel with distribution networks - Part 1-1: Connection to a LV distribution network - Generating plants up to and including Type B

Report reference number .... :	**20TH0160-EN50549-1_0**
Date of issue .... :	2019-12-16
Total number of pages .... :	105
Testing laboratory name .... :	**Bureau Veritas Consumer Products Services Germany GmbH**
Address .... :	Businesspark A96 86842 Türkheim Germany
Accrediation .... :	DAkkS Deutsche Akkreditierungsstelle D-PL-12024-03-03
Applicant's name .... :	**AISWEI New Energy Technology(Jiangsu) Co.,Ltd**
Address .... :	Building 9,No.198 Xiangyang Road,215011 Suzhou,P.R.China
Test specification	
Standard.. :	EN 50549-1:2019 with deviations according the national network and system protection for Poland
Certificate...................................... :	**Certificate of compliance**
Test report form number. .... :	EN 50549-1
Master TRF .... :	Bureau Veritas Consumer Products Services Germany GmbH
Test item description..................... :	**PV inverter**
Trademark....................................... :	Solplanet
Model / Type .... :	ASW3000-S, ASW3680-S, ASW4000-S, ASW5000-S

Ratings ....:	**ASW3000-S**	**ASW3680-S**	**ASW4000-S**	**ASW5000-S**
MPP DC input voltage [V] .... :	80-550Vdc			
Input DC voltage range [V]............... :	80-580Vdc			
Input DC current [A] .... :	2 x 12A			
Output AC voltage [V] .... :	220/230Vac, 50/60Hz			
Output AC current [A]....................... :	Max.15,0	Max.16,0	Max.20,0	Max.22,7
Nominal Output power [KW] .... :	3,000	3,680	4,000	5,000
Max.Output apparent power [KVA] .. :	3,000	3,680	4,000	5,000

Testing Location ....:	**AISWEI New Energy Technology(Jiangsu) Co.,Ltd**
Address ....:	Building 9,No.198 Xiangyang Road,215011 Suzhou,P.R.China
Tested by (name and signature) ....:	Weizhao Zheng
Approved by (name and signature) ....:	Georg Loritz
Manufacturer's name ....:	**AISWEI New Energy Technology(Jiangsu) Co.,Ltd**
Manufacturer address ....:	Building 9,No.198 Xiangyang Road,215011 Suzhou,P.R.China
Factory's name ....:	**AISWEI New Energy Technology (Yangzhong) Co., Ltd**
Factory address ....:	No.588 Gangxing Road,Yangzhong, Jiangsu P.R.Chna

Document History

Date	Internal reference	Modification / Change / Status	Revision
2019-12-16	Weizhao Zheng	Initial report was written	0

Supplementary information:

Test items particulars	
Equipment mobility.......................... :	Permanent connection
Operating condition......................... :	Continuous
Class of equipment .... :	Class I
Protection against ingress of water.. :	IP65 according to EN 60529
Mass of equipment [kg]................... :	12kg
Test case verdicts	
Test case does not apply to the test object.............................. :	N/A
Test item does meet the requirement............................... :	P(ass)
Test item does not meet the requirement............................... :	F(ail)
Testing	
Date of receipt of test item.............. :	2019-11-01
Date(s) of performance of test......... :	2019-11-14 to 2019-12-13

General remarks:

The test result presented in this report relate only to the object(s) tested. The report shall state compliance of the tested objects with the requirements of EN 50549-1. This report shall not be reproduced in part or in full without the written approval of the issuing testing laboratory.

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

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

This Test Report consists of the following documents:

1. Test Report
   - 4.4 Normal operating range
   - 4.5 Immunity to disturbances
   - 4.6 Active response to frequency deviation
   - 4.7 Power response to voltage variations and voltage changes
   - 4.8 EMC and power quality
   - 4.9 Interface protection
   - 4.10 Connection and starting to generate electrical power
   - 4.11 Ceasing and reduction of active power on set point
   - 4.13 Requirements regarding single fault tolerance of interface protection system and interface switch
2. Annex No. 3 – Pictures of the unit
3. Annex No. 4 – Test equipment list

Copy of marking plate

Model: ASW3000-S

Max. input voltage	d.c. 580V
MPP voltage range	d.c. 80-550V
Max. input current	d.c. 2×12A
Isc PV(absolute maximum)	d.c. 2×18A
Rated grid voltage	a.c. 220/230V
Rated grid frequency	50/60Hz
Max. AC output active power	3000W
Max. AC output apparent power	3000VA
Max. continuous output current	a.c. 15A
Adjustable cos(φ)	0.8ind...0.8cap
Operating temperature range	-25...+60°C
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)

Supported DRM0, DRM5, DRM6, DRM7, DRM8

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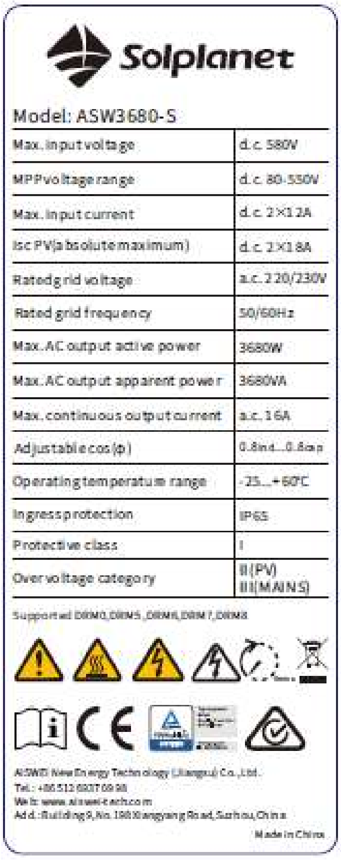

Model: ASW3680-S

Max. input voltage	d.c. 580V
MPP voltage range	d.c. 80-550V
Max. input current	d.c. 2×12A
Isc PV(absolute maximum)	d.c. 2×18A
Rated grid voltage	a.c. 220/230V
Rated grid frequency	50/60Hz
Max. AC output active power	3680W
Max. AC output apparent power	3680VA
Max. continuous output current	a.c. 16A
Adjustable cos(φ)	0.8ind...0.8cap
Operating temperature range	-25...+60°C
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)

Supported DRM0, DRM5, DRM6, DRM7, DRM8

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Model: ASW4000-S

Max. input voltage	d.c. 580V
MPP voltage range	d.c. 80-550V
Max. input current	d.c. 2×12A
Isc PV(absolute maximum)	d.c. 2×18A
Rated grid voltage	a.c. 220/230V
Rated grid frequency	50/60Hz
Max. AC output active power	4000W
Max. AC output apparent power	4000VA
Max. continuous output current	a.c. 20A
Adjustable cos(φ)	0.8ind...0.8cap
Operating temperature range	-25...+60°C
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)

Supported DRM0, DRM5, DRM6, DRM7, DRM8

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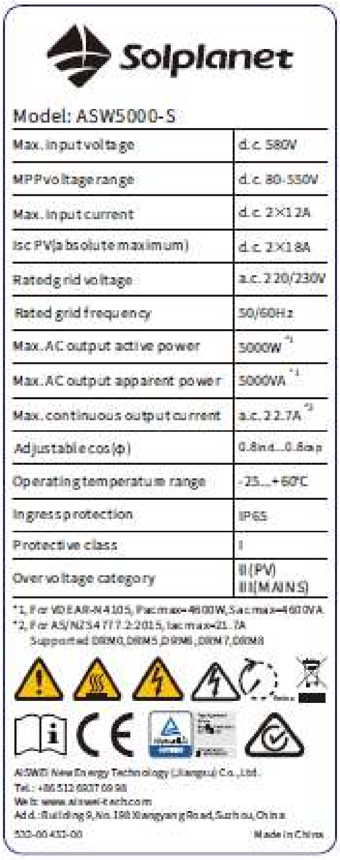

Model: ASW5000-S

Max. input voltage	d.c. 580V
MPP voltage range	d.c. 80-550V
Max. input current	d.c. 2×12A
Isc PV(absolute maximum)	d.c. 2×18A
Rated grid voltage	a.c. 220/230V
Rated grid frequency	50/60Hz
Max. AC output active power	5000W *1
Max. AC output apparent power	5000VA *1
Max. continuous output current	a.c. 22.7A *2
Adjustable cos(φ)	0.8ind...0.8cap
Operating temperature range	-25...+60°C
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)

*1, For VDE AR-N 4105, Pacmax=4600W, Sacmax=4600VA
*2, For AS/NZS 4777.2:2015, Iacmax=21.7A
Supported DRM0, DRM5, DRM6, DRM7, DRM8

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General product information:

The Solar converter converts DC voltage into AC voltage.

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

This unit is a single-phase inverter, that it is combine with operation mode. The inverter is able to generate power from solar modules to feed the grid(utility), also feed in the power to grid from the PV array.

The Solar converter provides with PV array of input.

The input of Solar converter can be supplied from PV array only.

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

Description of the electrical circuit:
The internal control is redundant built. It consists of Microcontroller Master DSP(U705) and Slave DSP(U710).

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

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

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

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

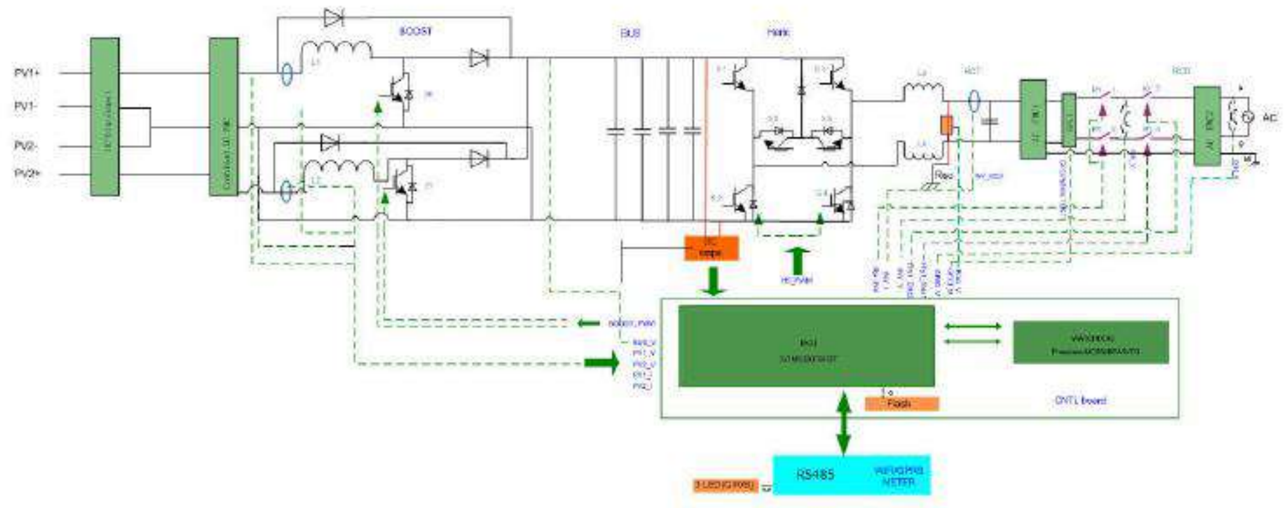

Figure 1 – Block diagram

Differences of the models:

The models ASW3000-S, ASW3680-S, ASW4000-S and ASW5000-S are identical in hardware and software, and the output power derated by software.

The product was tested on:

Hardware: V1.0
Software: V1.0

All tests were performed on EUT of ASW5000-S. Tests of the EUT of ASW5000-S applicable for the models ASW3000-S, ASW3680-S and ASW4000-S were performed on the concerned models and a statement is given at the relevant test.

General remarks:

The test results presented in this report relate only to the object(s) tested.
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"(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.

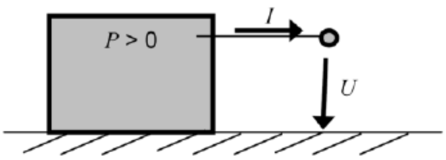
The following suffixes are used for variables in tables and figures:

- "P_n" for the nominal active power:
  $P_n = U_n \times I_n \times \cos \varphi_n$ (single-Phase); $P_n = \sqrt{3}\, U_n \times I_n \times \cos \varphi_n$ (three-Phase)
- "P_M" for the momentary power
- "(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.

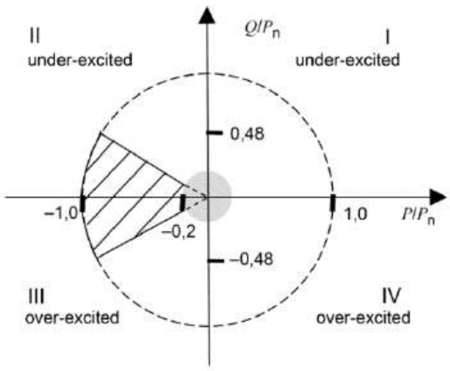


Figure 2

Default interface protection settings according EN 50549-1:2019:			
Parameter	**Max. disconnection time**	**Min. operate time**	**Trip value**
Over voltage – stage 1	3 s	0,1 s	230V +10% (253 V)
Over voltage – stage 2	0,2 s	0,1 s	230V +15% (264,5 V)
Under voltage	1,5 s	1,2 s	230V -15% (195,5V)
Over frequency	0,5 s	0,3 s	52 Hz
Under frequency	0,5 s	0,3 s	47,5 Hz
An explicit Loss of Mains functionality shall be included. Established methods such as, but not limited to, Rate of Change of Frequency, Vector Shift or Source Impedance Measurement may be used. Where Source Impedance is measured, this shall be achieved by purely passive means, Any implementation which involves the injection of pulses onto the distribution network, shall not be permitted.			
ROCOF (where used)		2 s	2 Hz/s
Reconnection settings for voltage		$0,85\ U_n \le U \le 1,10\ U_n$	
Reconnection settings for frequency		49,5 Hz ≤ f ≤ 50,2 Hz	
Reconnection time		≥ 60 s	
Active power gradient after reconnection		10 % P_n / min	
Permanent DC-injection		0,5% of rated inverter output current or 20mA	
Loss of mains according EN 62116		Inverter shall disconnect within 2 s.	
The stated currents and voltages are ‘true r.m.s.’-values. The voltages in this table are - phase-to-neutral in 230 V single phase systems and 230/400 V systems, - phase-to-phase in a multiphase 230 V system.			
Tolerances on trip values: - Voltage: ± 1% of U_n - Frequency: ± 0,05 Hz - Disconnection time : ± 10%			

The following deviations for Poland, have been applied according the EN 50549-1:2019:		
Parameter	**operate time**	**Trip value**
ROCOF (where used)	5 s	0,4 Hz/s
An explicit Loss of Mains functionality shall be included. Established methods such as, but not limited to, Rate of Change of Frequency, Vector Shift or Source Impedance Measurement may be used. Where Source Impedance is measured, this shall be achieved by purely passive means, Any implementation which involves the injection of pulses onto the distribution network, shall not be permitted.		
The stated currents and voltages are ‘true r.m.s.’-values. The voltages in this table are - phase-to-neutral in 230 V single phase systems and 230/400 V systems, - phase-to-phase in a multiphase 230 V system.		
Tolerances on trip values: - Voltage: ± 1% of U_n - Frequency: ± 0,05 Hz - Disconnection time : ± 10%		

EN 50549:2019, clause 4: Tests		
Clause	**Test requirement (According to table C.1)**	**Result**
4.4	Normal operating range	**P**
4.5	Immunity to disturbances	**P**
4.6	Active response to frequency deviation	**P**
4.7	Power response to voltage variations and voltage changes	**P**
4.8	EMC and power quality	**P**
4.9	Interface protection	**P**
4.10	Connection and starting to generate electrical power	**P**
4.11	Ceasing and reduction of active power on set point	**P**
4.12	Remote information exchange	**N/A**
4.13	Requirements regarding single fault tolerance of interface protection system and interface switch	**P**

EN 50549-1:2019: Normal operating range			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.4.2	Power response to over-frequency	EN 50438, Annex D.3.1	**P**
4.4.3	Power response to under-frequency	G99/1-4, clause A.7.3.2	**P**
4.4.4	Continuous operating voltage range	EN 50438, Annex D.3.1	**P**

4.4.2	**Operating frequency range**			**P**
4.4.4	**Continuous operating voltage range**			

Setting values	Over-voltage [V]:	253
	Under-voltage [V]:	195,5
	Over-frequency [Hz]:	51,5
	Under-frequency [Hz]:	47,5

- Test 1: U = 195,5 V; f = 47,5 Hz; P = 1,00 S_n; cosφ = 1
- Test 2: U = 195,5 V; f = 48,5 Hz; P = 1,00 S_n; cosφ = 1
- Test 3: U = 253,0 V; f = 51,5 Hz; P = 1,00 S_n; cosφ = 1
- Test 4: U = 230,0 V; f = 50,0 Hz; Voltage Phase jumps Change +20 degrees P = 1,00 S_n; cosφ = 1
- Test 5: U = 230,0 V; f = 50,0 to 50,5 Hz;RoCoF=1Hz/s; P = 1,00 S_n; cosφ = 1

Test result:

Test sequence	Voltage [V]	Frequency [Hz]	Output power [kW]	Cos φ
Test1	195,50	47,50	4,431	0,9999
Test2	195,64	48,50	4,435	0,9999
Test3	253,28	51,50	5,002	0,9999
Test4	230,66	50,00	5,023	0,9999
Test5	230,60	50,50	4,997	0,9980

Note:

Test method refer clause D.3.1 of EN 50438:2013.

During the tests the interface protection was disabled.

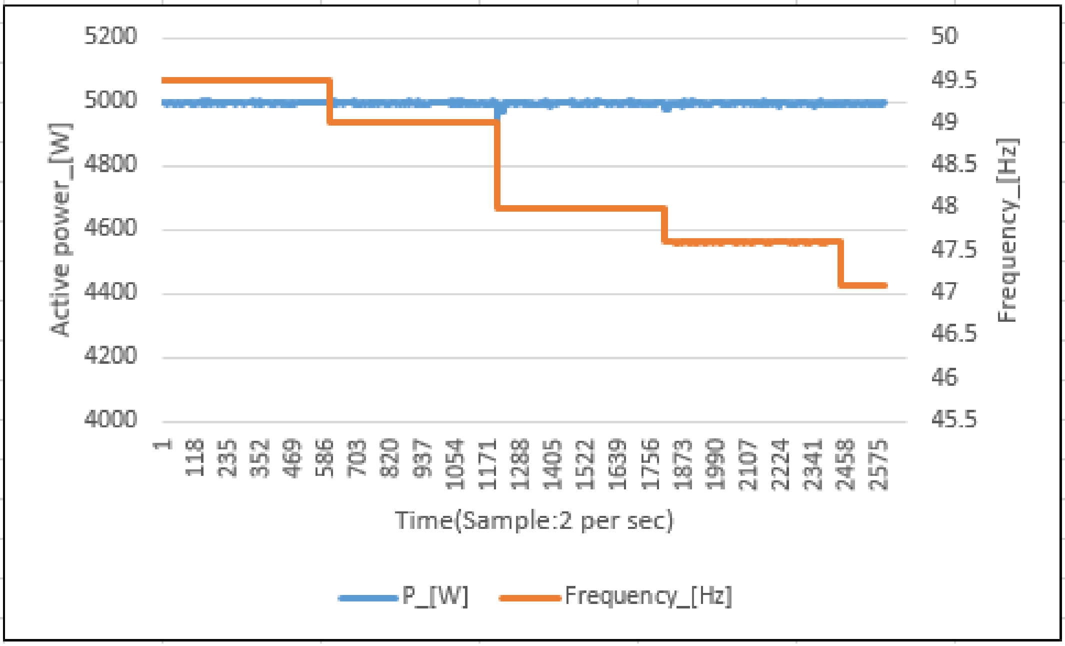
Operation at reduced power is allowed during test 1, equal to the maximum power that can be supplied on reaching the maximum output current limit (P ≥ 0,85 S_n).

During the sequence of test 3, automatic adjustment to reduce power in the case of over-frequency was disabled.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

4.4.3	Minimal requirement for active power delivery at under-frequency	P

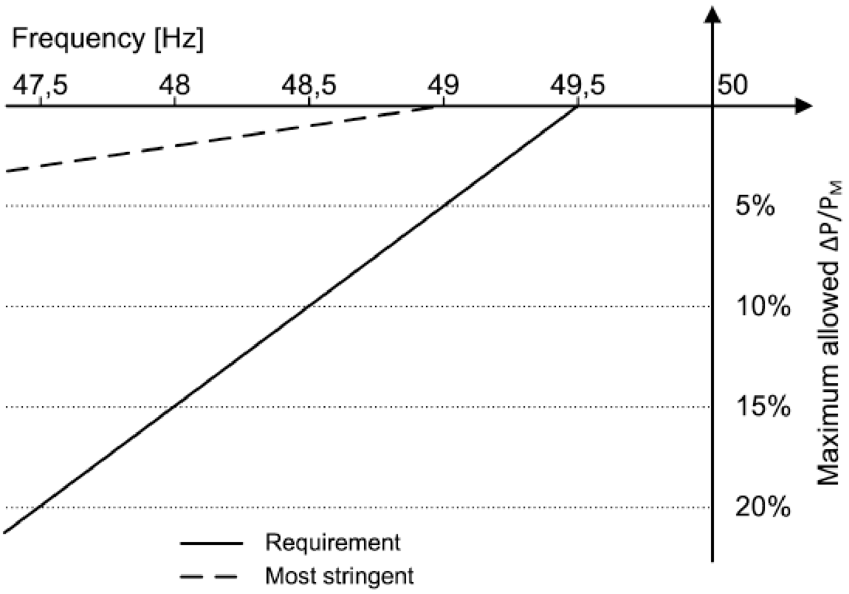
Graph of frequency a) to b) to c) to d) to e):



Test result:

	Switch to:				
5-min mean value (each)	a) 49,50 Hz	b) 49,00 Hz	c) 48,00 Hz	d) 47,60 Hz	e) 47,10 Hz
Frequency [Hz]:	49,50	49,00	48,00	47,60	47,10
Active power [kW]:	4,997	4,996	4,994	4,995	4,995
$\Delta P/P_n$ [%] :	0,060	0,080	0,120	0,100	0,100

Assessment criterion:
Test method refer clause A.7.3.2 of G99/1-4 The frequency should then be set to 49,5 Hz for 5 minutes. The output should remain at 100% of registered Capacity. The frequency should then be set to 49,0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The Active Power output must not be below 99% of registered Capacity. The frequency should then be set to 48,0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The Active Power output must not be below 97% of registered Capacity. The frequency should then be set to 47,6 Hz and once the output has stabilised, held at this frequency for 5 minutes. The Active Power output must not be below 96.2% of registered Capacity. The frequency should then be set to 47,1 Hz and held at this frequency for 20s. The Active Power output must not be below 95,0% of registered Capacity and the Synchronous Power Generating Module must not trip in less than the 20s of the test.



Maximum allowable power reduction in case of under-frequency

Note:

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

EN 50549-1:2019: Immunity to disturbances			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.5.2	Rate of change of frequency (RoCoF) immunity	G99/1-4:2019, clause A.7.1.2.6	**P**
4.5.3	Low voltage ride through (LVRT)	VDE V 0124-100:2019-02 (Draft), clause 5.8.3.	**P**
4.5.4	High voltage ride through (HVRT)	VDE V 0124-100:2019-02 (Draft), clause 5.8.3.	**P**

4.5.2	**Rate of change of frequency (ROCOF) immunity**			**P**

	Start Frequency	**Change**	**End Frequency**	**Confirm no trip**
Positive Frequency drift	49Hz	+2Hz/sec	51Hz	No trip
Negative Frequency drift	51Hz	-2Hz/sec	49Hz	No trip

Note:

Test method refer clause A.7.1.2.6 of G99/1-4:2019.

Hold for 10 s

Manufacturers considering new designs should allow for the RoCoF where stability is required to be increased to, up to 2Hz per second, as proposed in the new European network codes, which are expected to come into force over the period 2014/2015. Under these conditions RoCoF will cease to be an effective loss of mains protection and is unlikely to be permitted in future revisions of this document.

For the step change test the SSEG should be operated with a measureable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 seconds to complete the test. The SSEG should not trip during this test.

For frequency drift tests the SSEG should be operated with a measureable output at the start frequency and then the frequency changed in a ramp function at 0,95Hz per second to the end frequency. On reaching the end frequency it should be maintained for a period of at least10 seconds. The SSEG should not trip during this test.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

4.5.2	Rate of change of frequency (ROCOF) immunity (Poland settings)			P

	Start Frequency	Change	End Frequency	Confirm no trip
Positive Frequency drift	49Hz	+0,4Hz/sec	51Hz	No trip
Negative Frequency drift	51Hz	-0,4Hz/sec	49Hz	No trip

Note:

Test method refer clause A.7.1.2.6 of G99/1-4:2019.

Hold for 10 s

Manufacturers considering new designs should allow for the RoCoF where stability is required to be increased to, up to 0,4Hz per second, as proposed in the new European network codes, which are expected to come into force over the period 2014/2015. Under these conditions RoCoF will cease to be an effective loss of mains protection and is unlikely to be permitted in future revisions of this document.

For the step change test the SSEG should be operated with a measureable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 seconds to complete the test. The SSEG should not trip during this test.

For frequency drift tests the SSEG should be operated with a measureable output at the start frequency and then the frequency changed in a ramp function at 0,95Hz per second to the end frequency. On reaching the end frequency it should be maintained for a period of at least10 seconds. The SSEG should not trip during this test.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

4.5.3 4.5.4	**Low voltage ride through (LVRT)** **High voltage ride through (HVRT)**	**P**

General:

If the voltage on the generator terminals falls below <0.8 U_n and if the generator terminals exceed the voltage of> 1.15 U_n (start of fault), generator must pass through voltage dips without any current being drawn into the grid Network operator (limited dynamic network support).
This requirement is met if, for a voltage dip below 0.8 U_n or at a voltage increase above 1.15 U_n, the injected current of the generating unit (s) and / or the memory 60 ms after occurrence of this voltage dip in any outer conductor 20% of the rated current I_r and does not exceed> 10% I_r after 100 ms.

After the voltage returned to continuous operating voltage range of -15% U_n to +10% U_n, 90 % of pre fault power or available power whichever is the smallest shall be resumed as fast as possible, but at the latest within 1 s unless the DSO and the responsible party requires another value.

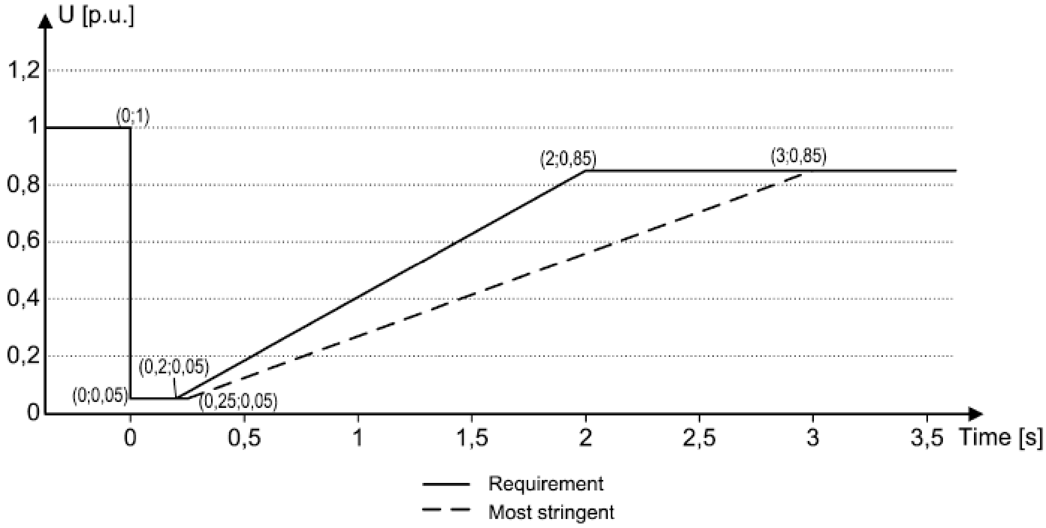


Figure 6 — Low voltage ride through capability for non-synchronous generating technology

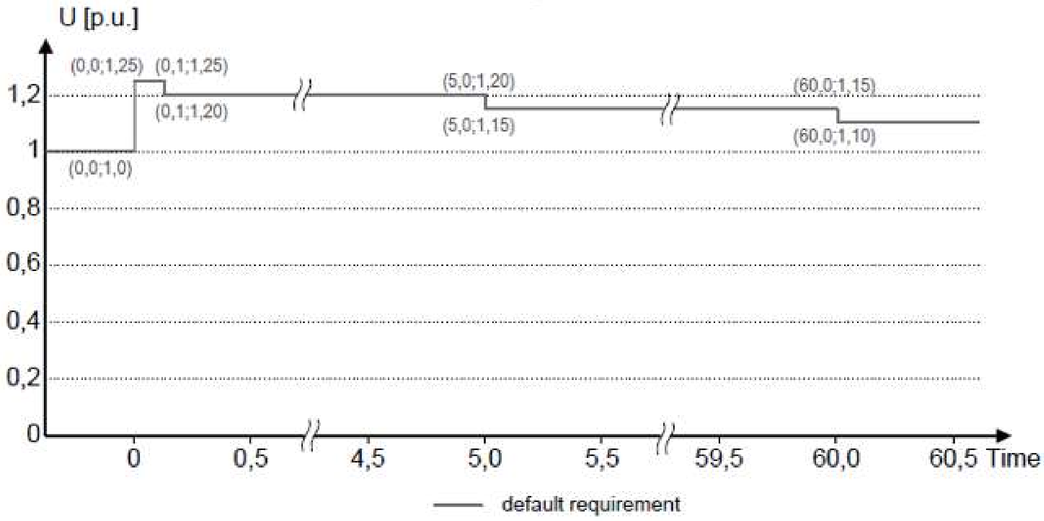


Figure 8 — Over-voltage ride through capability

Test	Drop depth requirement [p.u. U_n]	Symmetry	Fault duration [ms]	Output power level		k-factor	Test no.
				P set point (P_{rE} / p.u.)	Q set point (Q / p.u.)		
1.A.1	0,03	Symmetrical	250	1,0	0,00	0	1.A.1
1.A.2				0,2			1.A.2
1.D.1		Asymmetrical		1,0			1.D.1
1.D.2				0,2			1.D.2
1.B.1		Single phase*		1,0			1.B.1
1.B.2				0,2			1.B.2
2.A.1	0,31	Symmetrical	1300	1,0	0,00	0	2.A.1
2.A.2				0,2			2.A.2
2.D.1		Asymmetrical		1,0			2.D.1
2.D.2				0,2			2.D.2
2.B.1		Single phase*		1,0			2.B.1
2.B.2				0,2			2.B.2
3.A.1	0,82	Symmetrical	3000	1,0	0,00	0	3.A.1
3.A.2				0,2			3.A.2
3.D.1		Asymmetrical		1,0			3.D.1
3.D.2				0,2			3.D.2
3.B.1		Single phase*		1,0			3.B.1
3.B.2				0,2			3.B.2
OV1	1,25	Symmetrical	100	1,0	0,00	0	OV1
OV2	1,20		5000	1,0			OV2
OV3	1,15		60000	1,0			OV3

Note:

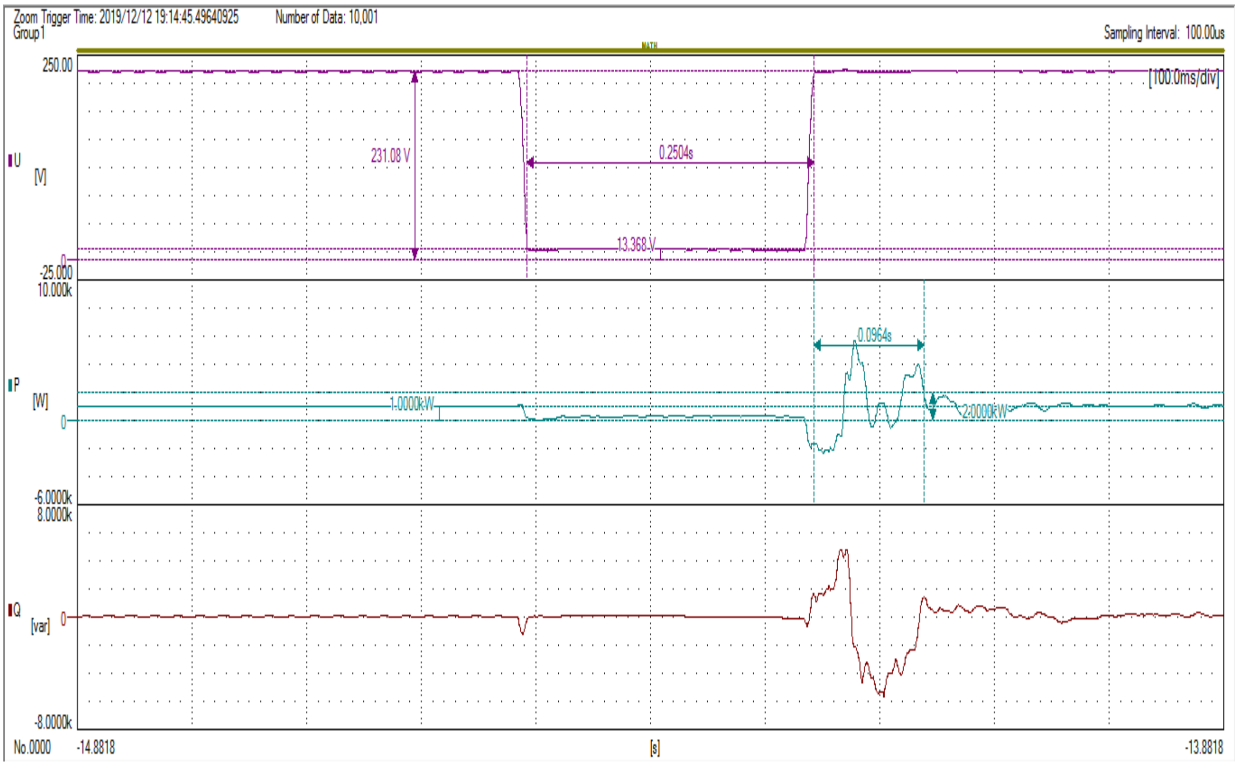
For every kind of voltage dip a test without load has to be performed in order to prove that the test condition was fulfilled. The voltage has to drop to AT LEAST the defined depth level. An exception can be considered in case no current is supplied during dips.

*** Single phase = "choose Typ 7 at BV-Lab Studio" ≙ LVRT Typ B**

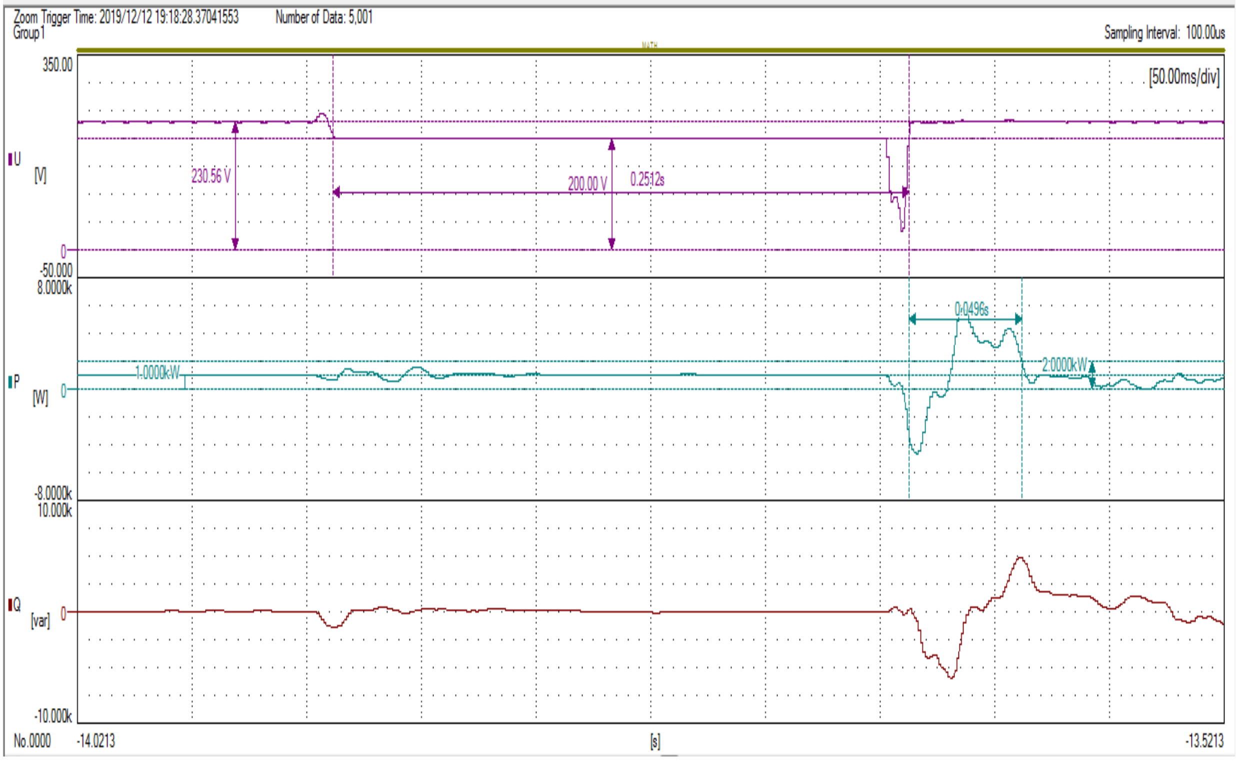
Graph of FRT test one				
Test result:				
List of tests	**Residual amplitude of phase-to-phase voltage [p.u. U_n]**	**Duration limit [ms]**	**Duration [ms]**	**Result**
P_{Emax} in %	20% ±5%			
1.D.1- Asymmetrical fault phase [Phase 1]	0,03	250 ± 20	250,4	Pass
1.D.1- Asymmetrical fault phase [Phase 2]	0,03	250 ± 20	251,2	Pass
1.D.1- Asymmetrical fault phase [Phase 3]	0,03	250 ± 20	257,5	Pass
2.D.1- Asymmetrical fault phase [Phase 1]	0,31	1300 ± 20	1303,2	Pass
2.D.1- Asymmetrical fault phase [Phase 2]	0,31	1300 ± 20	1303,1	Pass
2.D.1- Asymmetrical fault phase [Phase 3]	0,31	1300 ± 20	1303,1	Pass
3.D.1- Asymmetrical fault phase [Phase 1]	0,82	3000 ± 20	3000,0	Pass
3.D.1- Asymmetrical fault phase [Phase 2]	0,82	3000 ± 20	3007,9	Pass
3.D.1- Asymmetrical fault phase [Phase 3]	0,82	3000 ± 20	3000,0	Pass
P_{Emax} in %	100% ±5%			
1.D.2- Asymmetrical fault phase [Phase 1]	0,03	250 ± 20	250,4	Pass
1.D.2- Asymmetrical fault phase [Phase 2]	0,03	250 ± 20	258,3	Pass
1.D.2- Asymmetrical fault phase [Phase 3]	0,03	250 ± 20	255,1	Pass
2.D.2- Asymmetrical fault phase [Phase 1]	0,31	1300 ± 20	1307,1	Pass
2.D.2- Asymmetrical fault phase [Phase 2]	0,31	1300 ± 20	1303,2	Pass
2.D.2- Asymmetrical fault phase [Phase 3]	0,31	1300 ± 20	1303,2	Pass
3.D.2- Asymmetrical fault phase [Phase 1]	0,82	3000 ± 20	3000,0	Pass
3.D.2- Asymmetrical fault phase [Phase 2]	0,82	3000 ± 20	3007,9	Pass
3.D.2- Asymmetrical fault phase [Phase 3]	0,82	3000 ± 20	3000,0	Pass
OV1- Symmetrical fault phase	1,25	100 ± 20	105,5	Pass
OV2- Symmetrical fault phase	1,20	5000 ± 20	5000,0	Pass
OV3- Symmetrical fault phase	1,15	60000 ± 20	60009,9	Pass

Test conditions:
Voltage simulator fall and rise time: < 20ms
Used sample rate: 10 kHz
The test conditions are performed as worst case conditions. The inverter feeds maximal active and reactive power during the complete test.
Note:
The test method refer to clause 5.8.3 of VDE V 0124-100:2019-02 (Draft).
The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

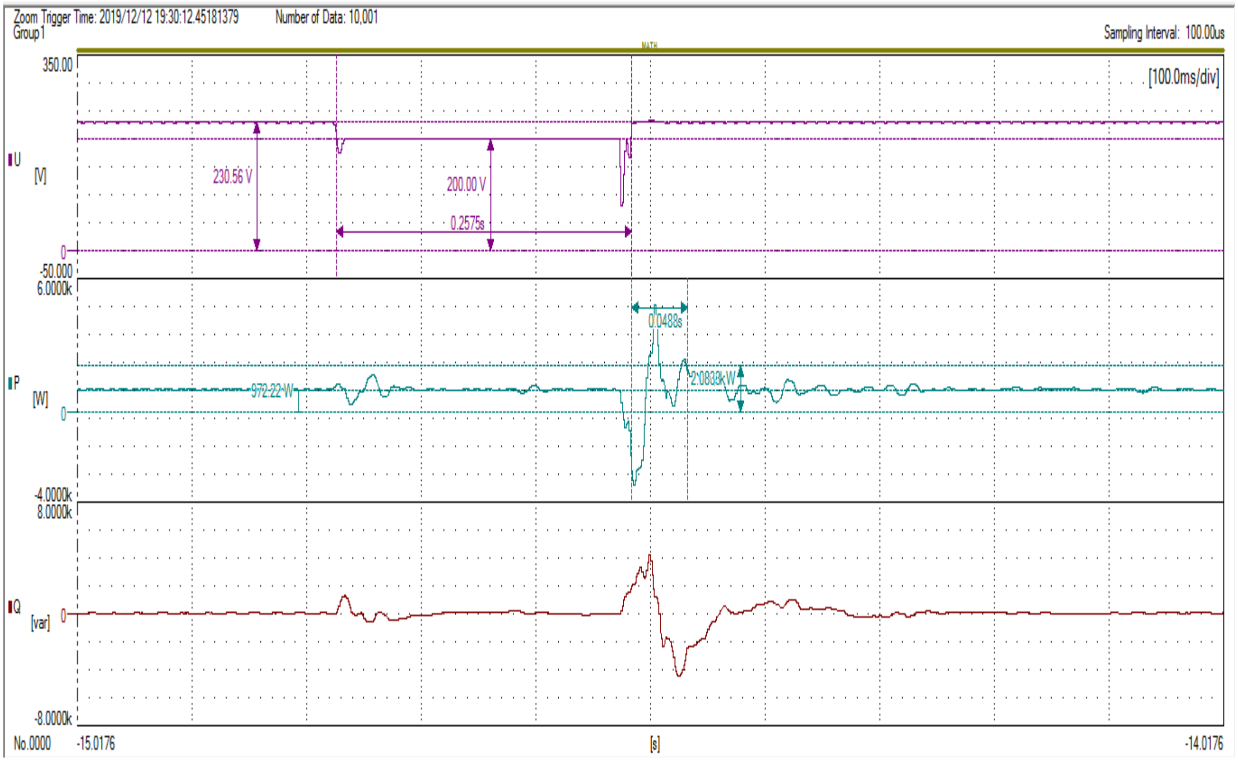
Test 1: 1.D.1- Asymmetrical fault phase [Phase 1]; P = 20% ±5% P_n



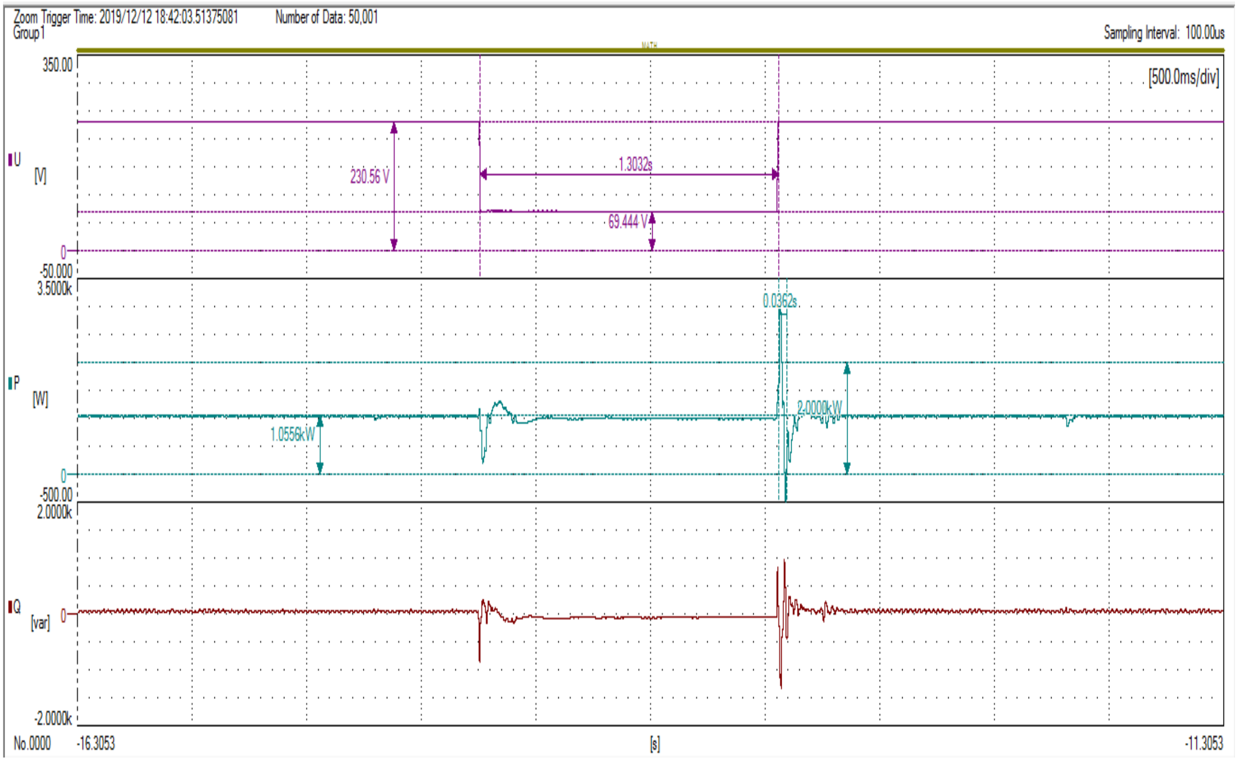
Test 1: 1.D.1- Asymmetrical fault phase [Phase 2]; P = 20% ±5% P_n



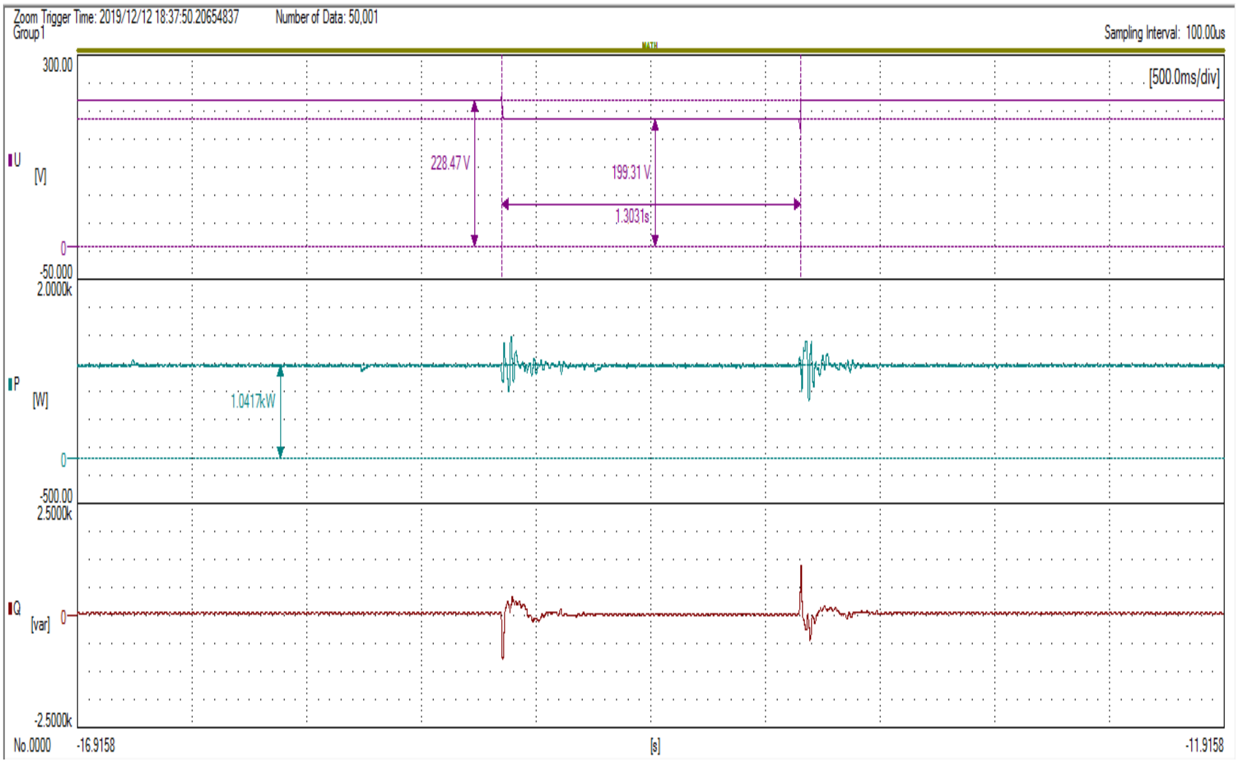
Test 1: 1.D.1- Asymmetrical fault phase [Phase 3]; P = 20% ±5% P_n



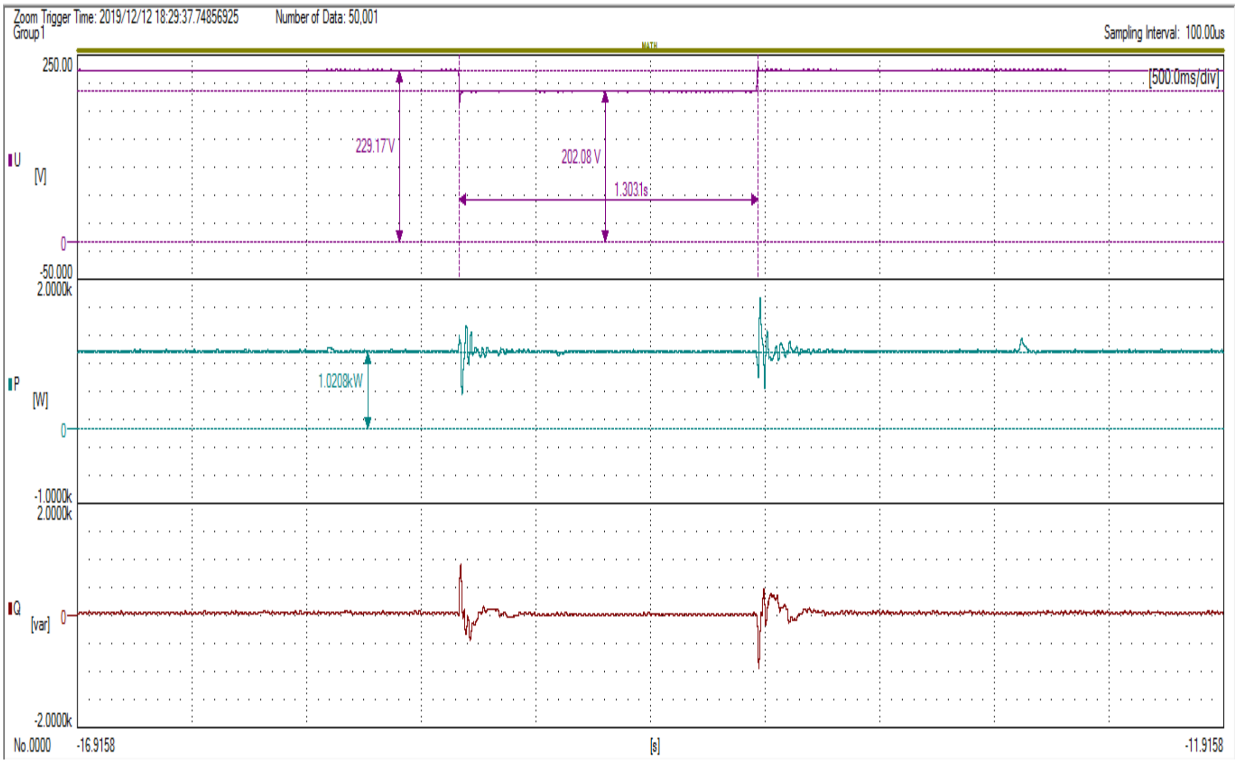
Test 2: 2.D.1- Asymmetrical fault phase [Phase 1]; P = 20% ±5% P_n



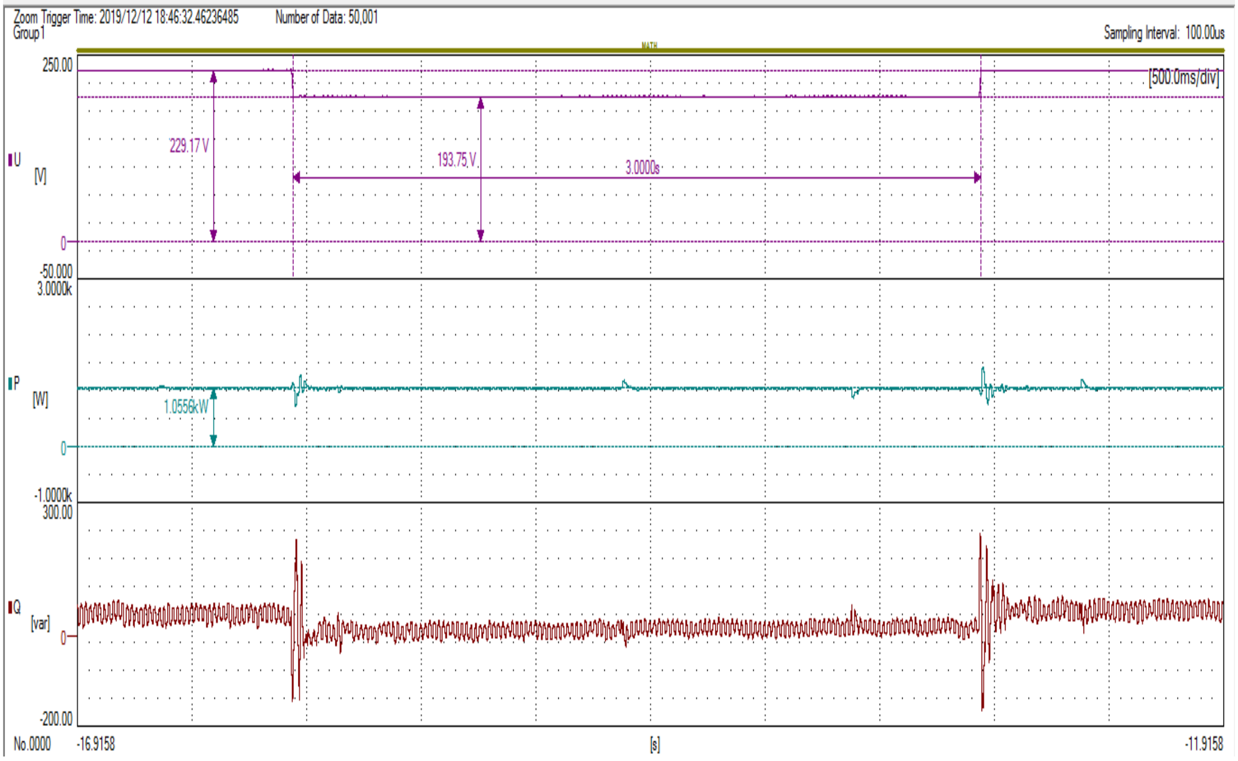
Test 2: 2.D.1- Asymmetrical fault phase [Phase 2]; P = 20% ±5% P_n



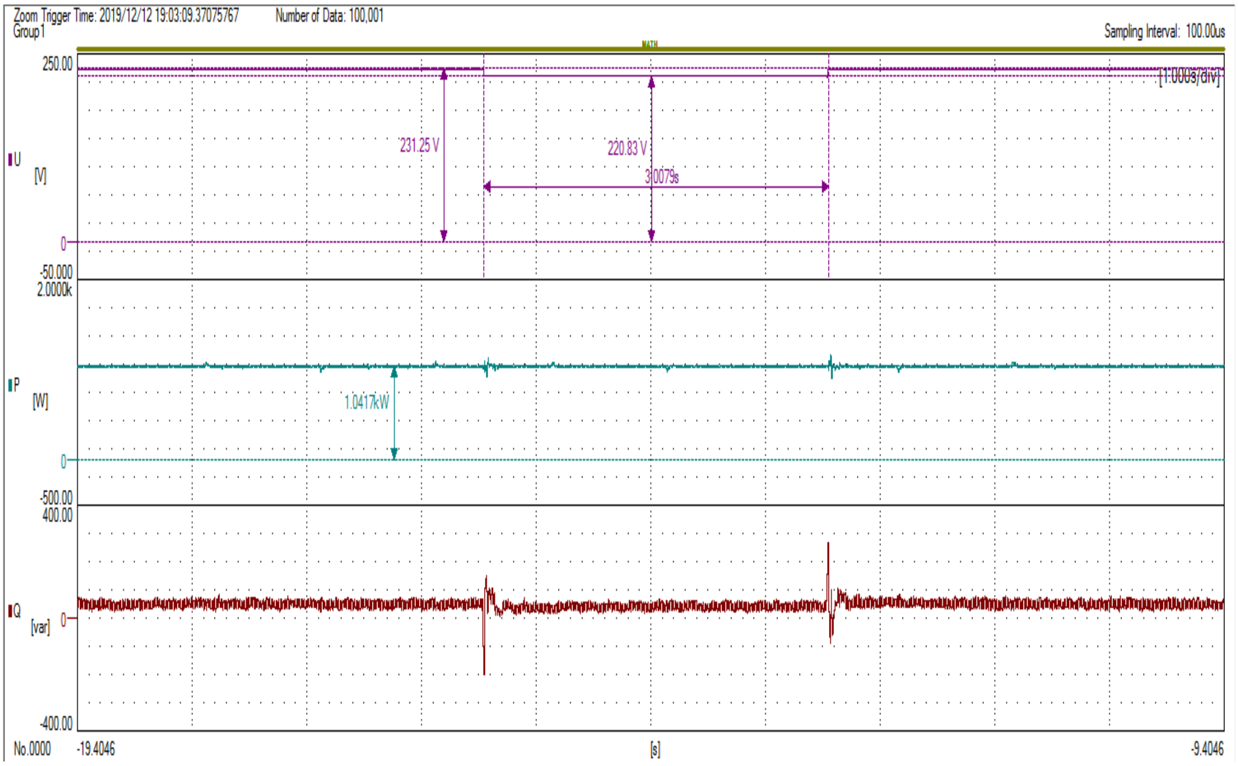
Test 2: 2.D.1- Asymmetrical fault phase [Phase 3]; P = 20% ±5% P_n



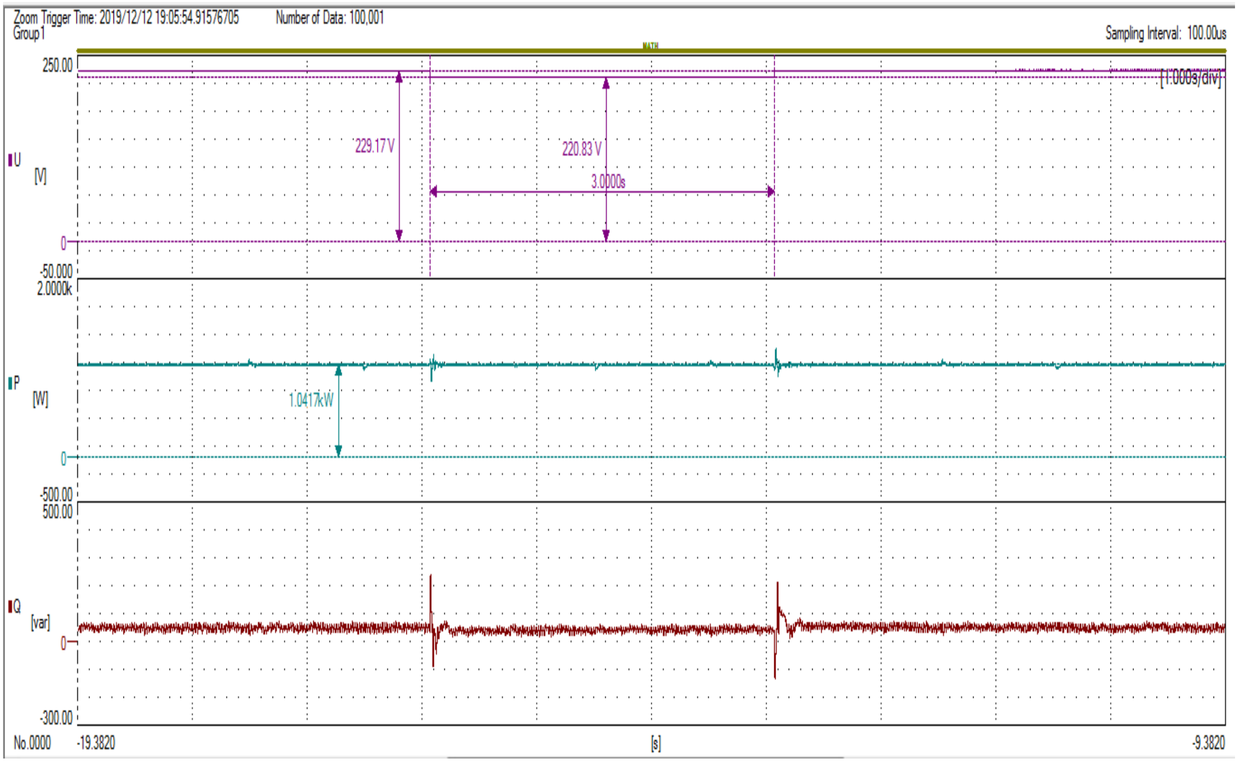
Test 3: 3.D.1- Asymmetrical fault phase [Phase 1]; P = 20% ±5% P_n



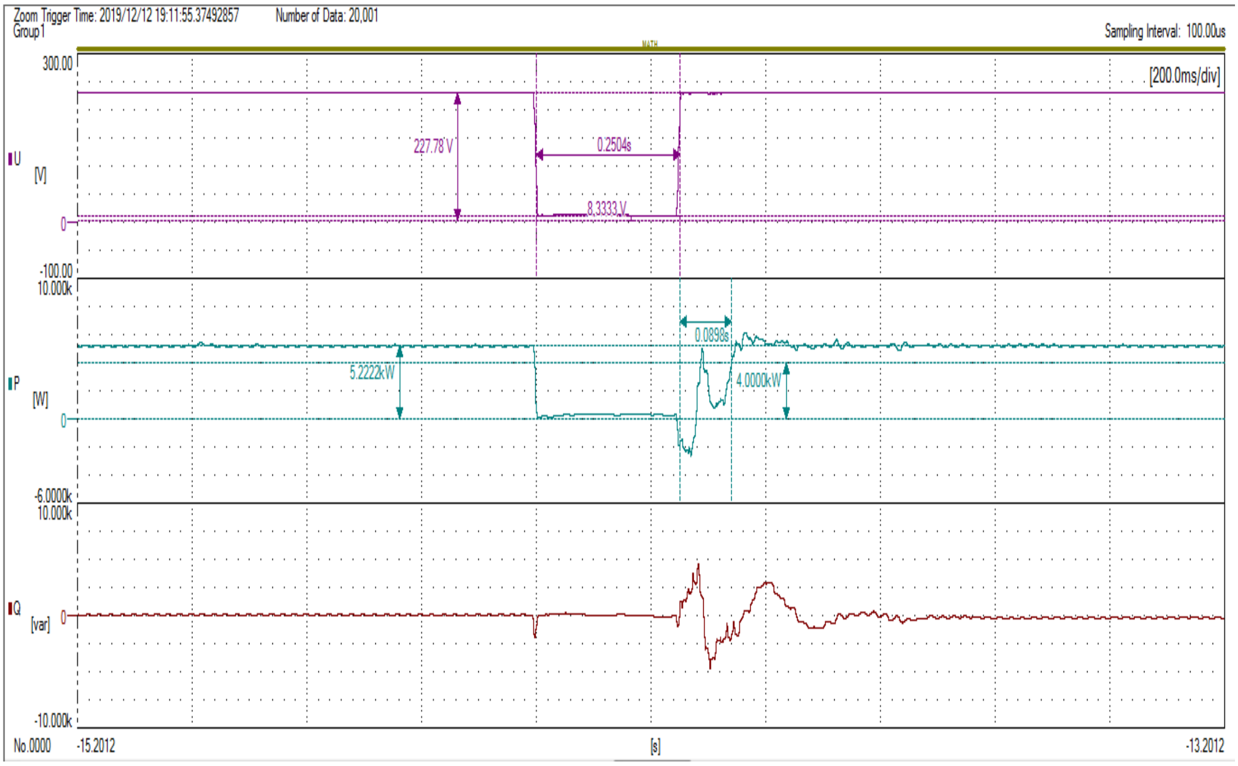
Test 3: 3.D.1- Asymmetrical fault phase [Phase 2]; P = 20% ±5% P_n



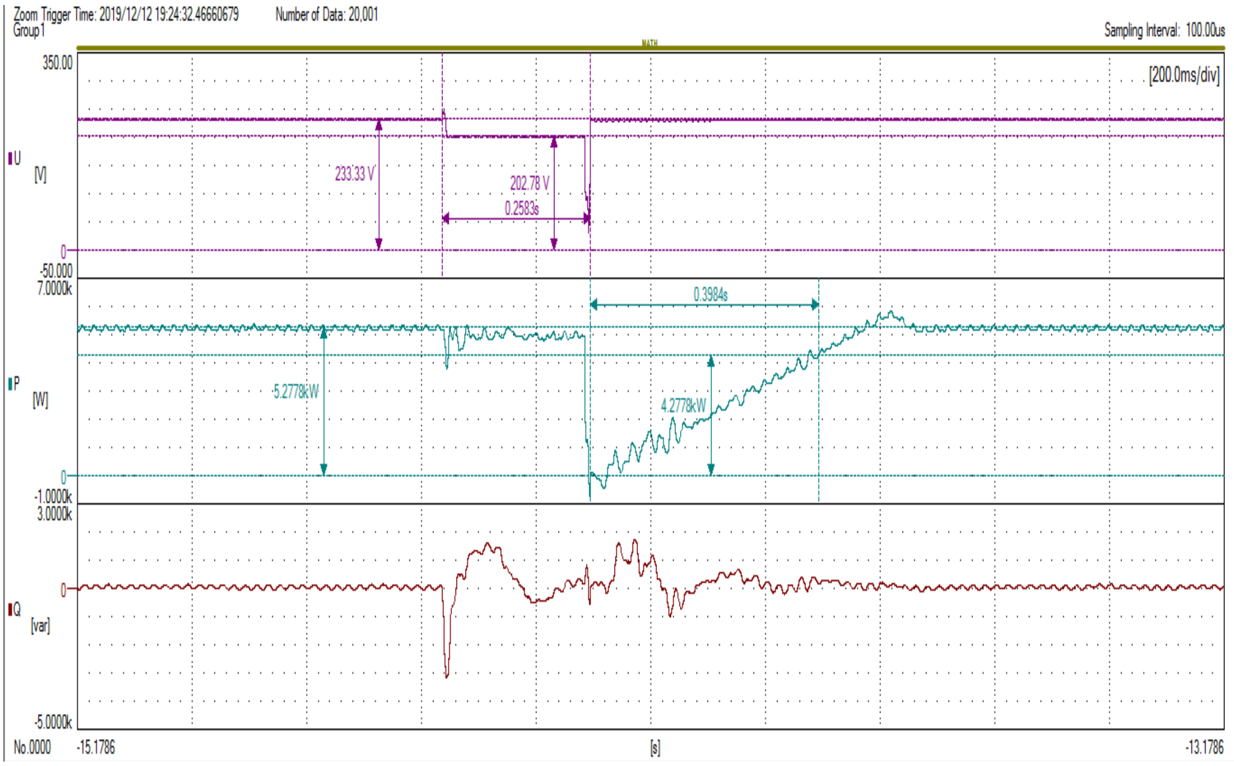
Test 3: 3.D.1- Asymmetrical fault phase [Phase 3]; P = 20% ±5% P_n



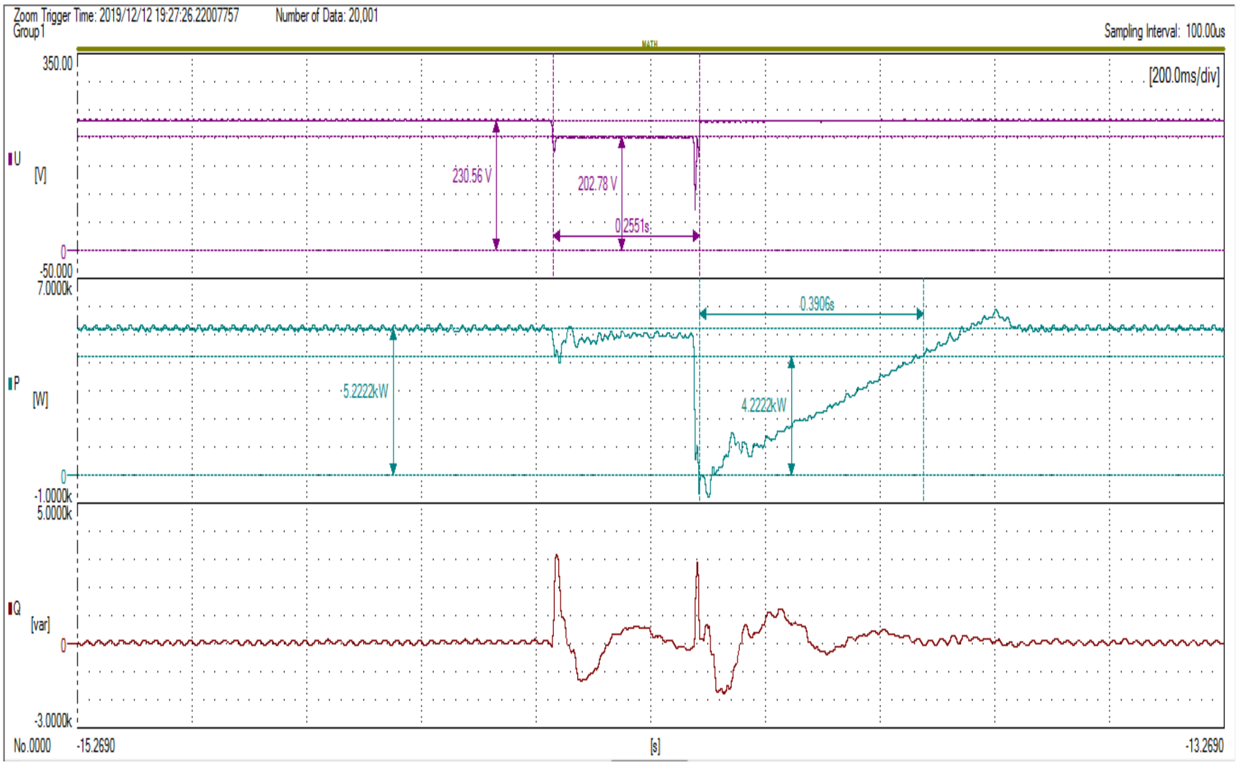
Test 1: 1.D.2- Asymmetrical fault phase [Phase 1]; P = 100% ±5% P_n



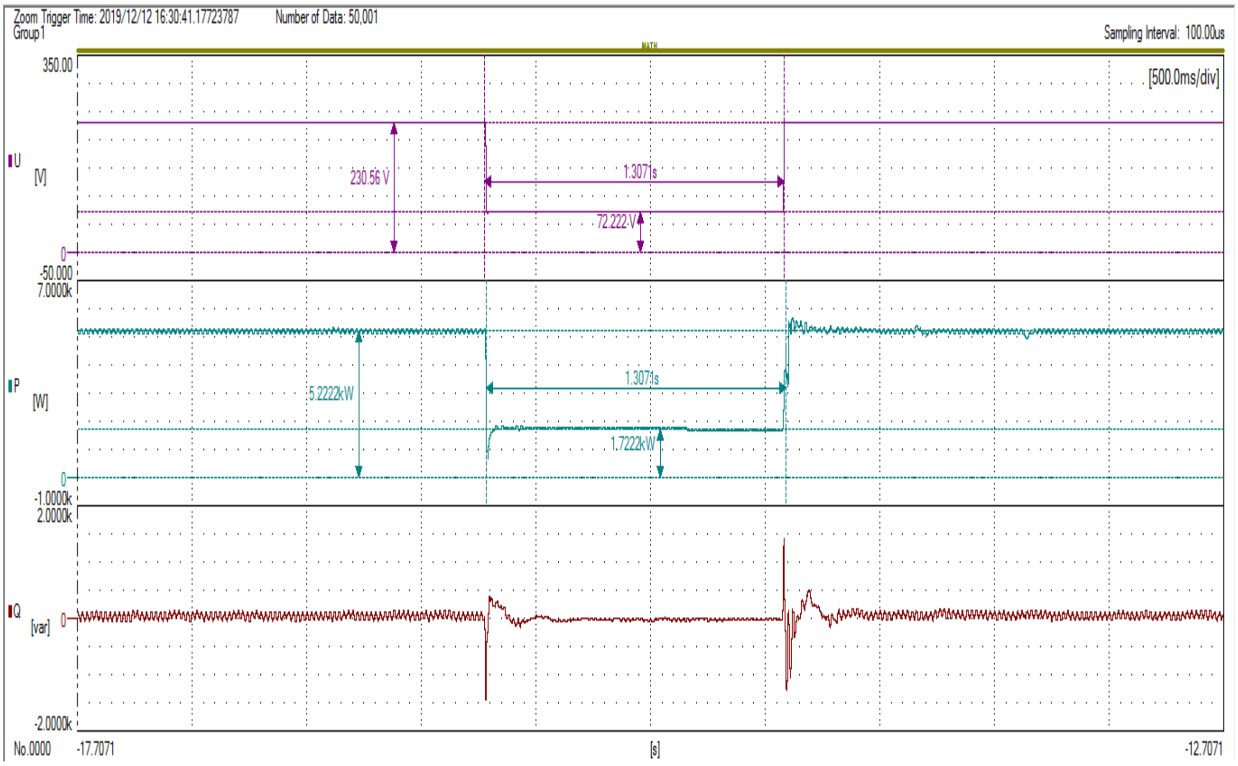
Test 1: 1.D.2- Asymmetrical fault phase [Phase 2]; P = 100% ±5% P_n



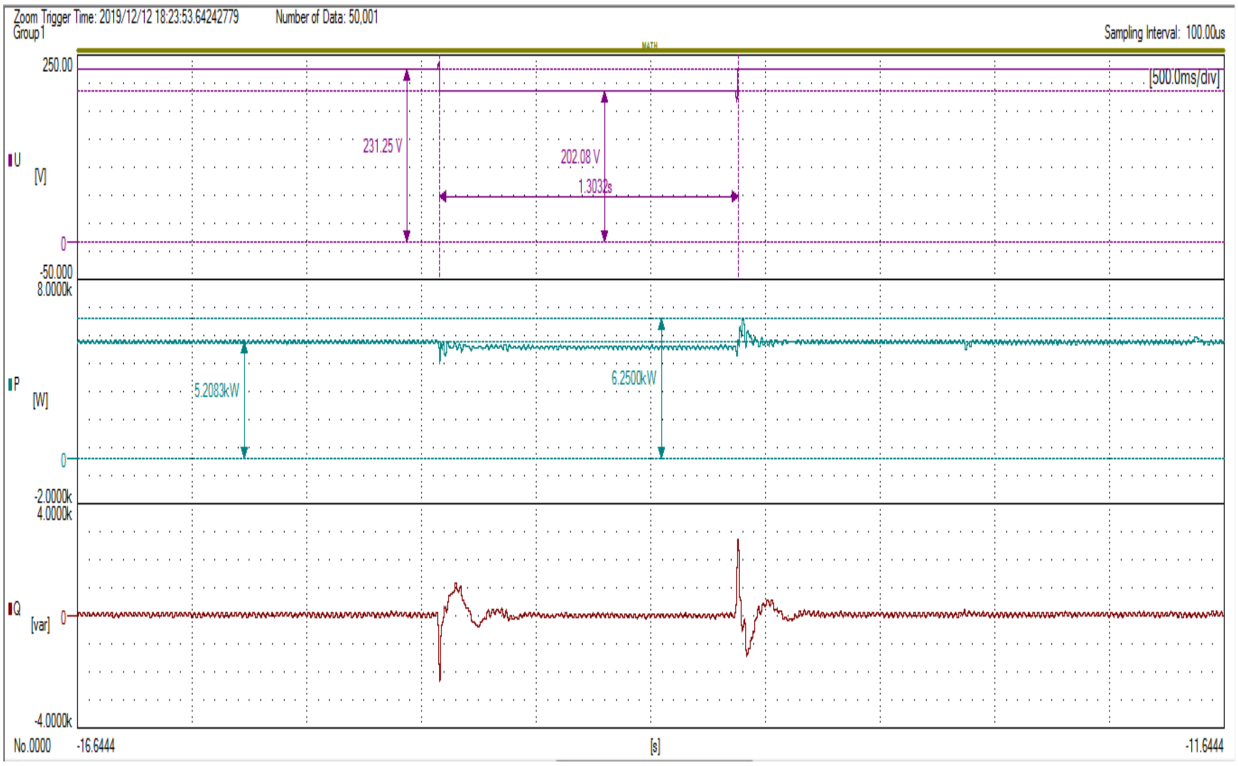
Test 1: 1.D.2- Asymmetrical fault phase [Phase 3]; P = 100% ±5% P_n



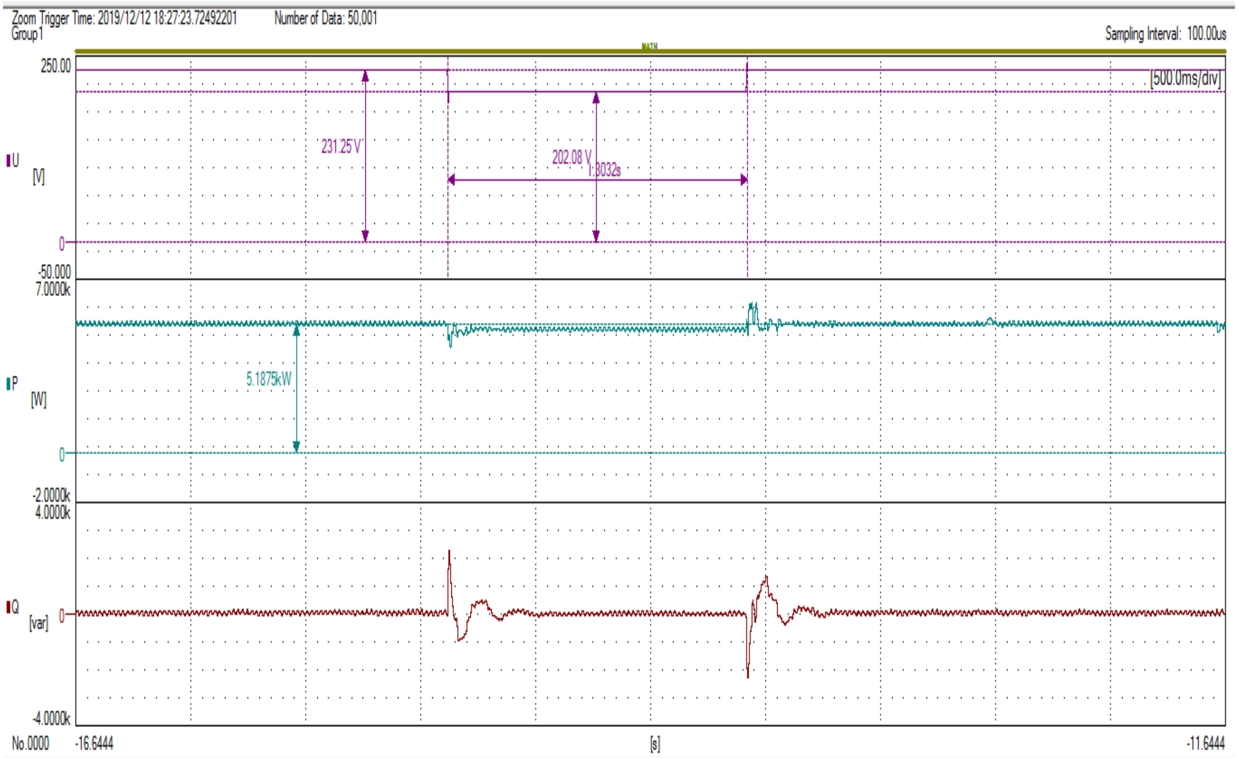
Test 2: 2.D.2- Asymmetrical fault phase [Phase 1]; P = 100% ±5% P_n



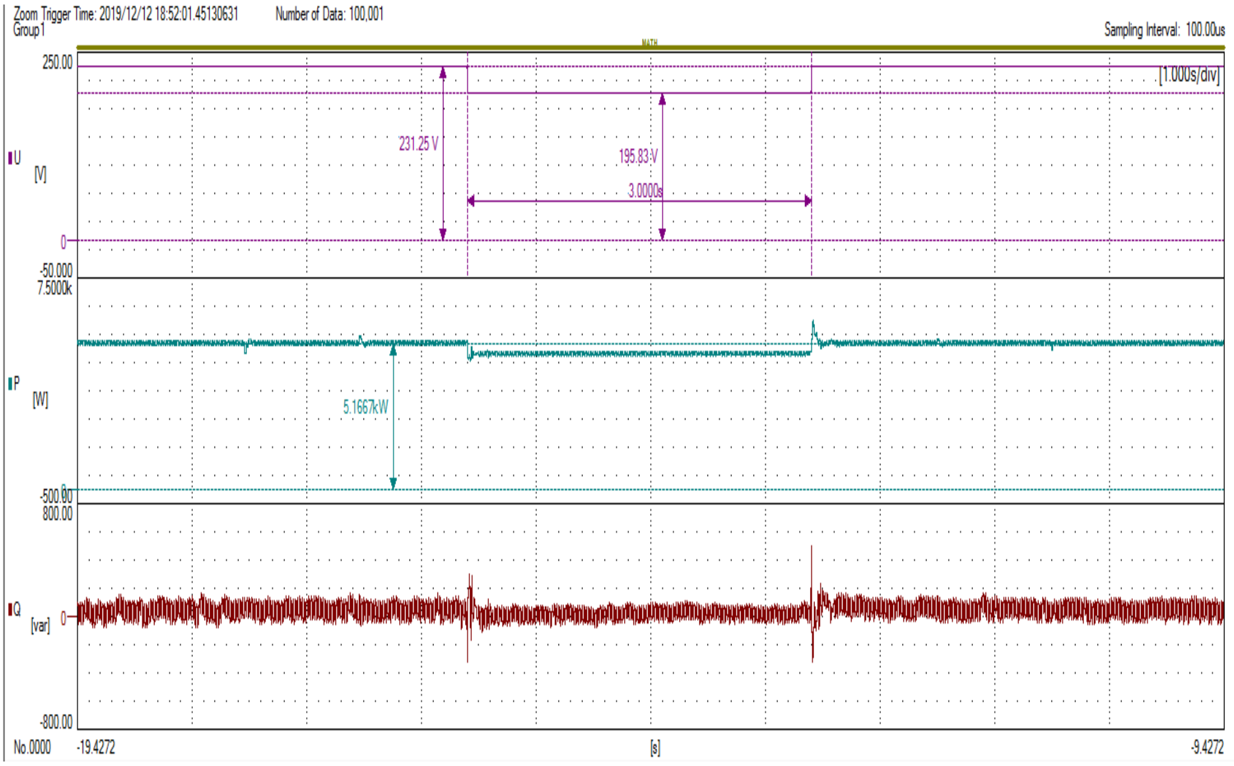
Test 2: 2.D.2- Asymmetrical fault phase [Phase 2]; P = 100% ±5% P_n



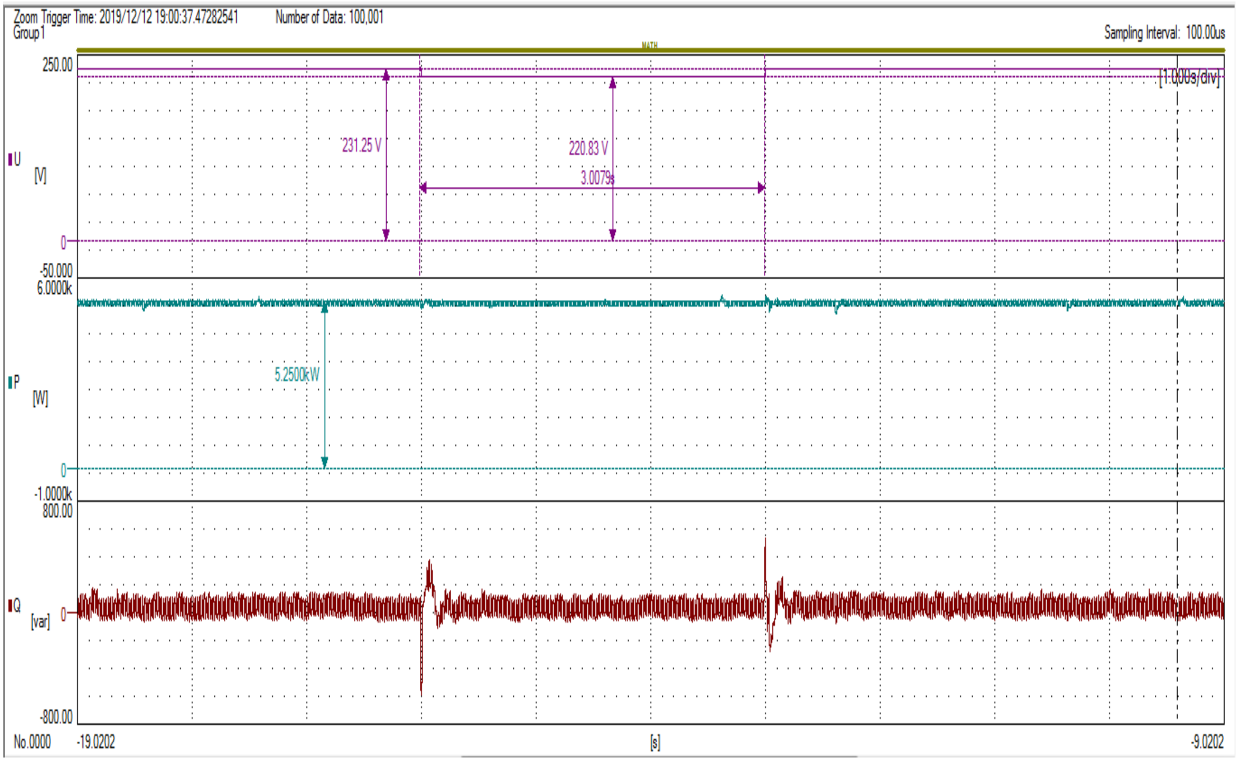
Test 2: 2.D.2- Asymmetrical fault phase [Phase 3]; P = 100% ±5% P_n



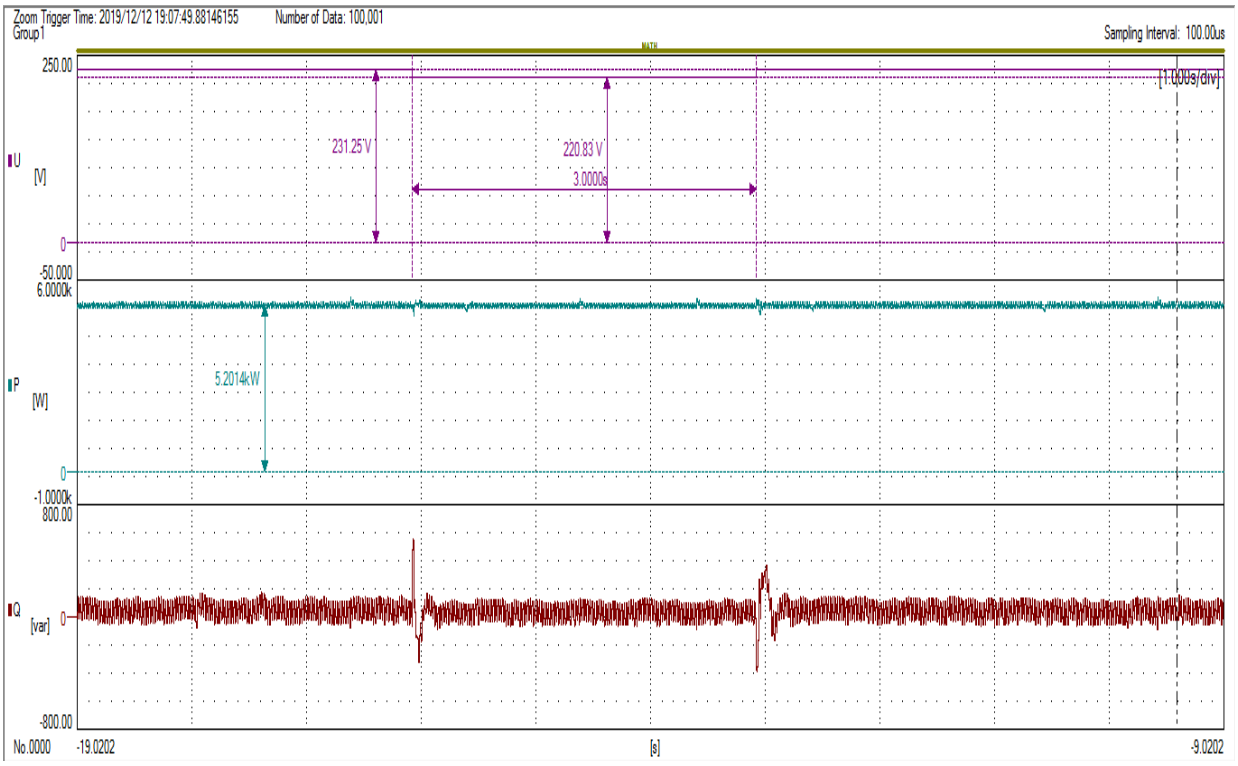
Test 3: 3.D.2- Asymmetrical fault phase [Phase 1]; P = 100% ±5% P_n



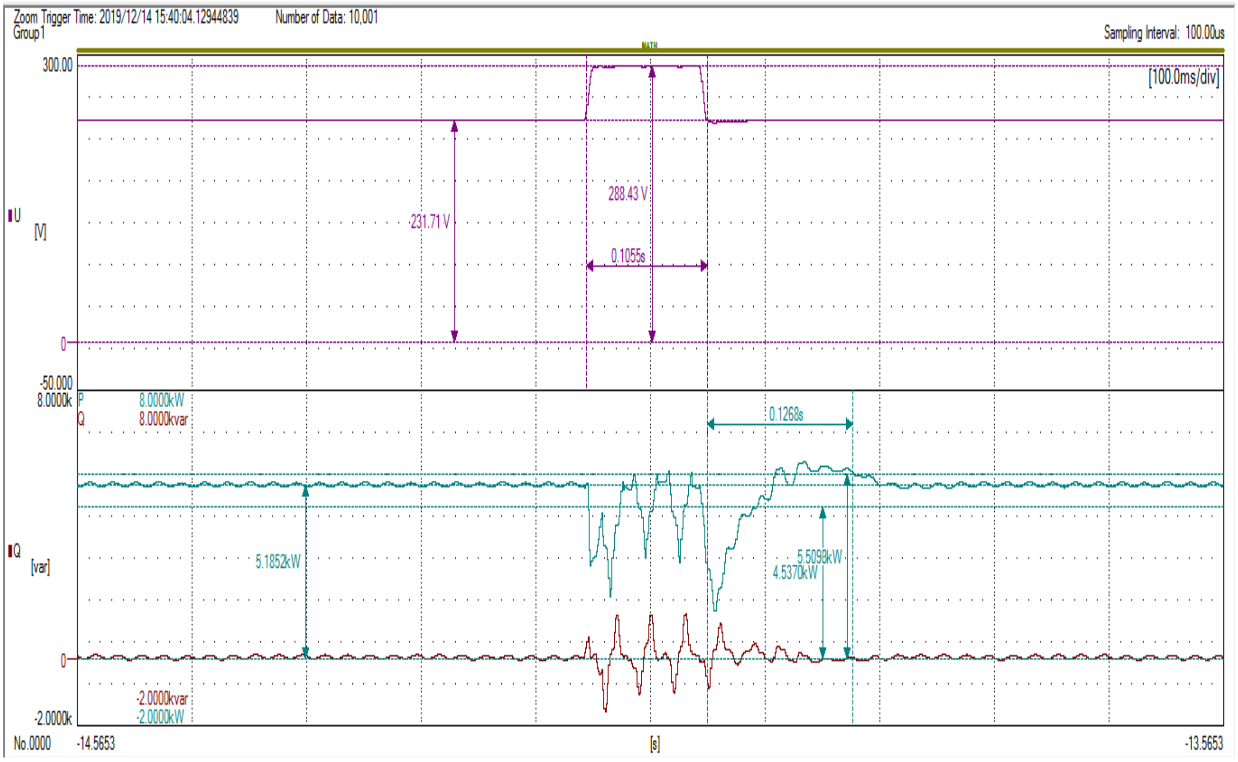
Test 3: 3.D.2- Asymmetrical fault phase [Phase 2]; P = 100% ±5% P_n



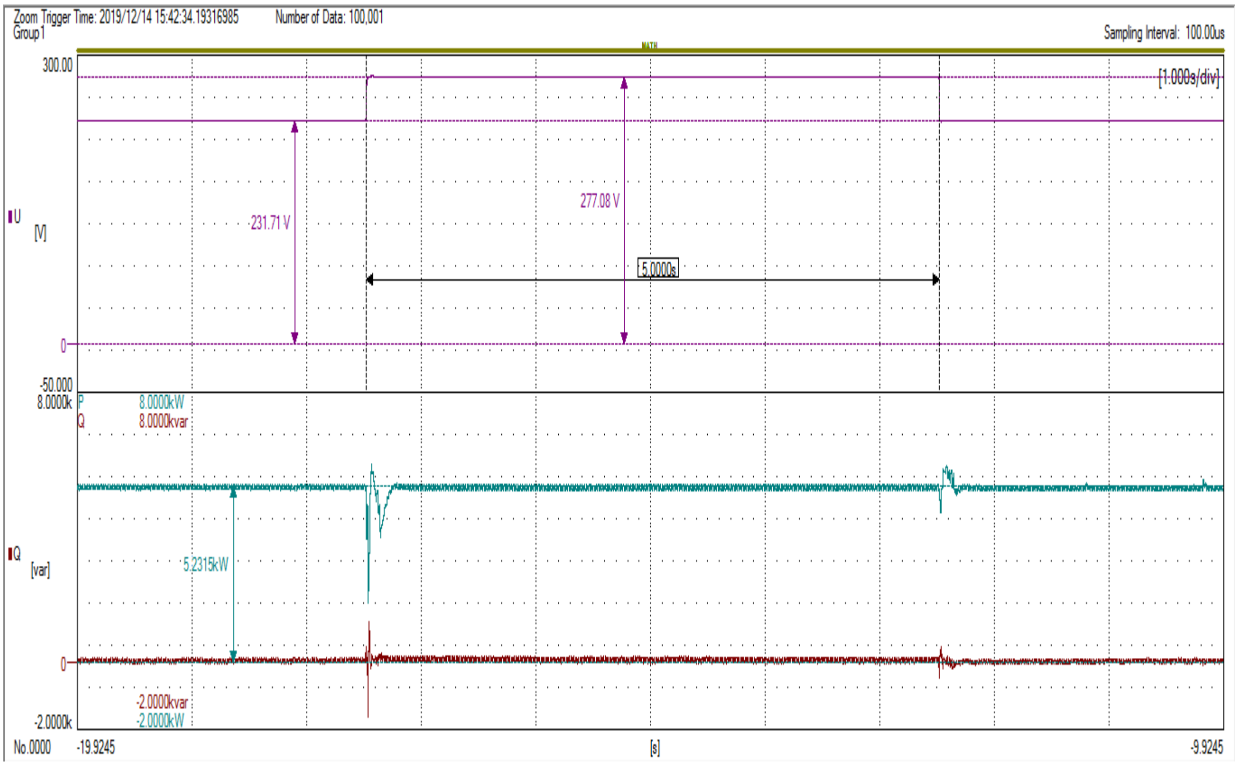
Test 3: 3.D.2- Asymmetrical fault phase [Phase 3]; P = 100% ±5% P_n



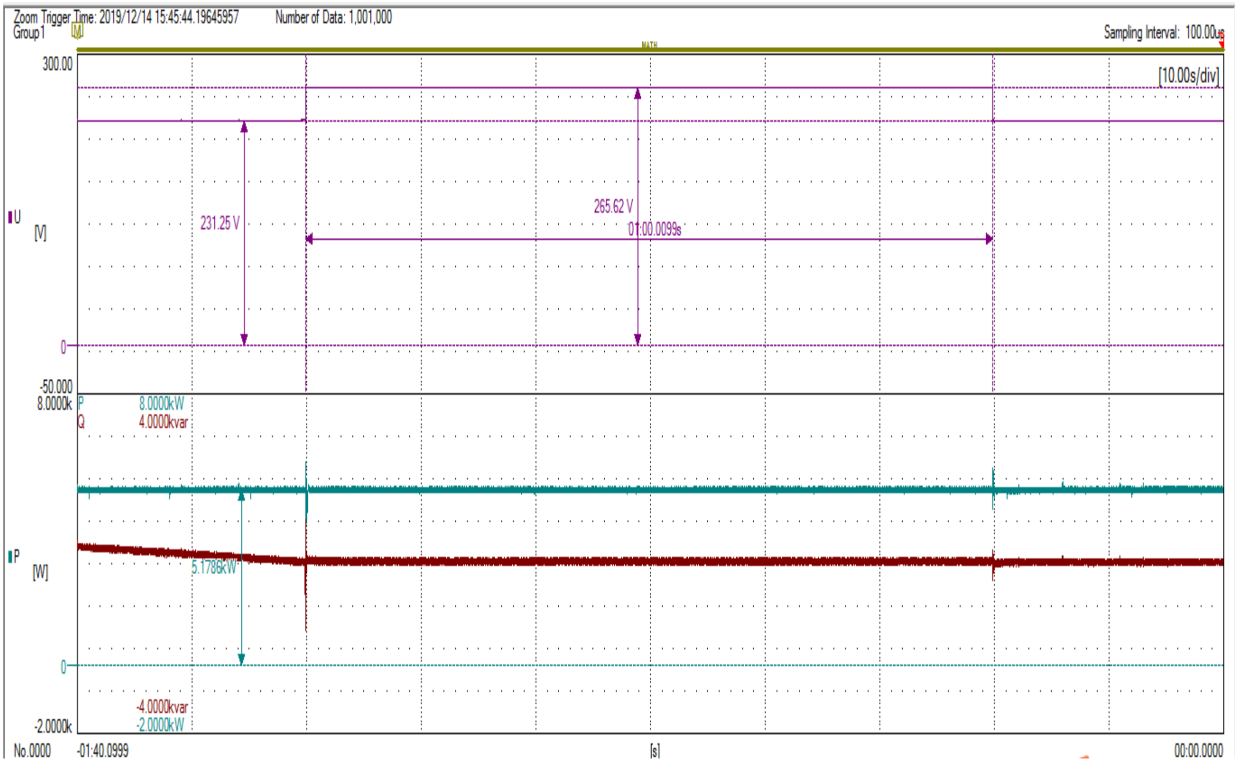
Test OV1- Symmetrical fault phase; P = 100% ±5% P_n



Test OV2- Symmetrical fault phase; P = 100% ±5% P_n

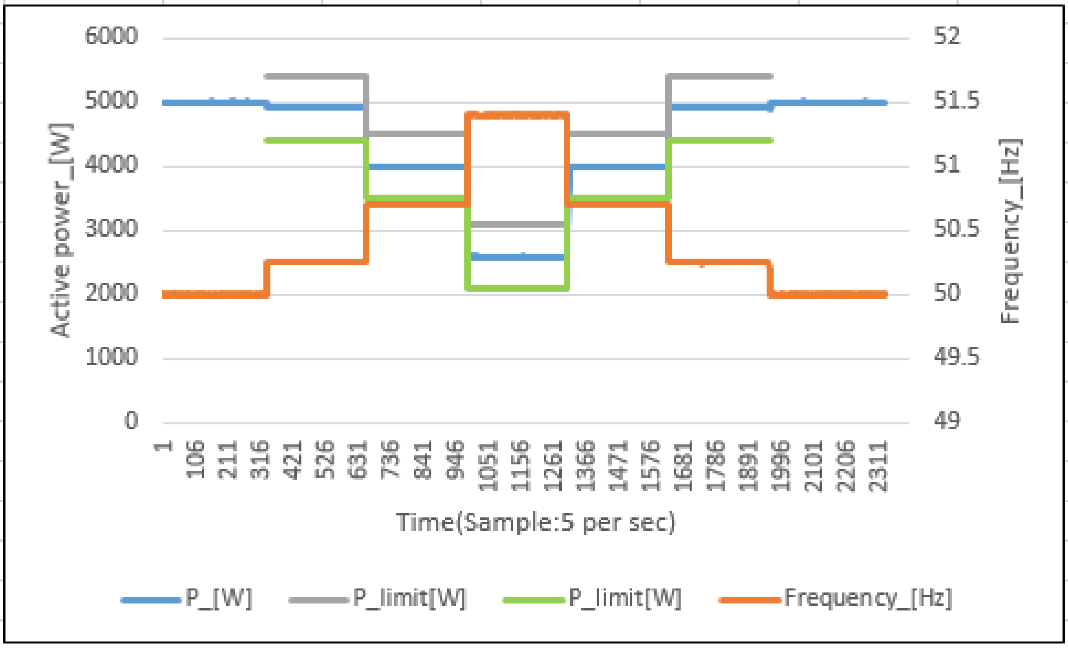


Test OV3- Symmetrical fault phase; P = 100% ±5% P_n



EN 50549-1:2019: Active response to frequency deviation			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.6.1	Power response to over-frequency	VDE V 0124-100:2019-02 (Draft), clause 5.4.4	**P**
4.6.2	Power response to under-frequency	VDE V 0124-100:2019-02 (Draft), clause 5.4.6	**N/A**

4.6.1	**Power response to over-frequency**						**P**
Test result:							
1-min mean value [Hz]:	a) 50,00	b) 50,25	c) 50,70	d) 51,40	e) 50,70	f) 50,25	g) 50,00
1. Measurement a) to g): Active power output =100% P_{Emax} s=5% (40% P_{ref} / Hz), threshold frequency for start/return: 50,2Hz							
Frequency [Hz]:	50,00	50,25	50,70	51,40	50,70	50,25	50,00
P_M [kW]:	N/A	4,900	4,000	2,600	4,000	4,900	N/A
P_{E60} [kW]:	4,996	4,907	3,990	2,589	3,990	4,909	4,996
$\Delta P_{E60}/P_M$ [%]:	N/A	-0,14	0,20	0,22	0,20	-0,18	N/A
Test result:							
1-min mean value [Hz]:	a) 50,00	b) 50,25	c) 50,70	d) 51,40	e) 50,70	f) 50,25	g) 50,00
2. Measurement a) to g): Active power output 60% after freezing = 100% P_{Emax} s=5% (40% P_{ref} / Hz), threshold frequency for start/return: 50,2Hz							
Frequency [Hz]:	50,00	50,25	50,70	51,40	50,70	50,25	50,00
P_M [kW]:	N/A	2,940	2,400	1,560	2,400	2,940	N/A
P_{E60} [kW]:	3,008	2,955	2,398	1,567	2,398	2,955	5,016
$\Delta P_{E60}/P_M$ [%]:	N/A	-0,30	0,04	-0,14	0,04	-0,30	N/A
Limit $\Delta P/P_{1min}$:	± 10 % of P_{Emax}						
Graph of Measurement 1.: Active power output > 80% P_{Emax}							



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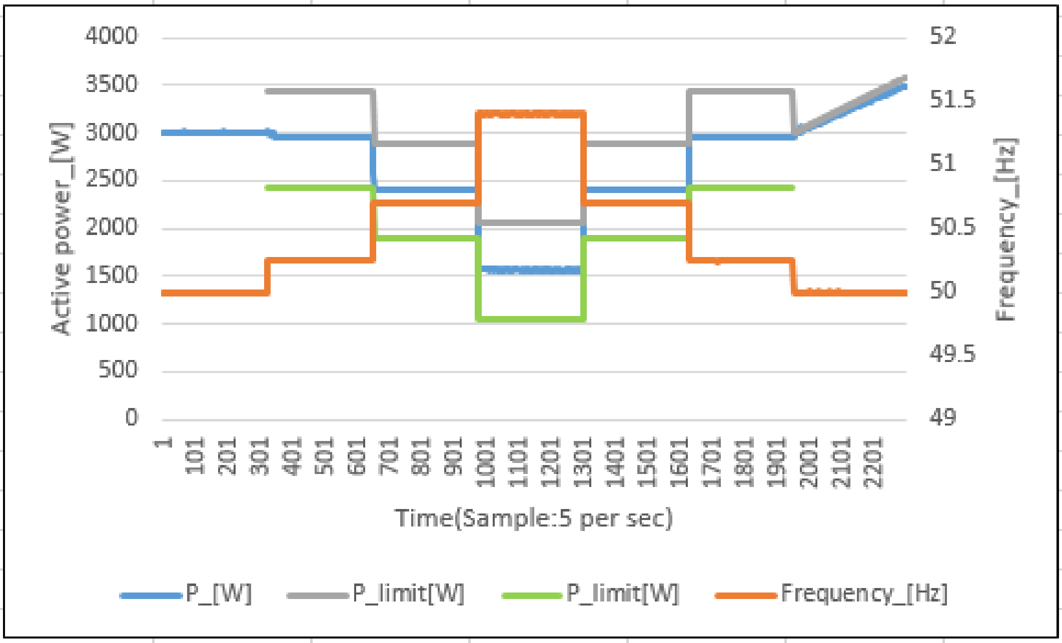
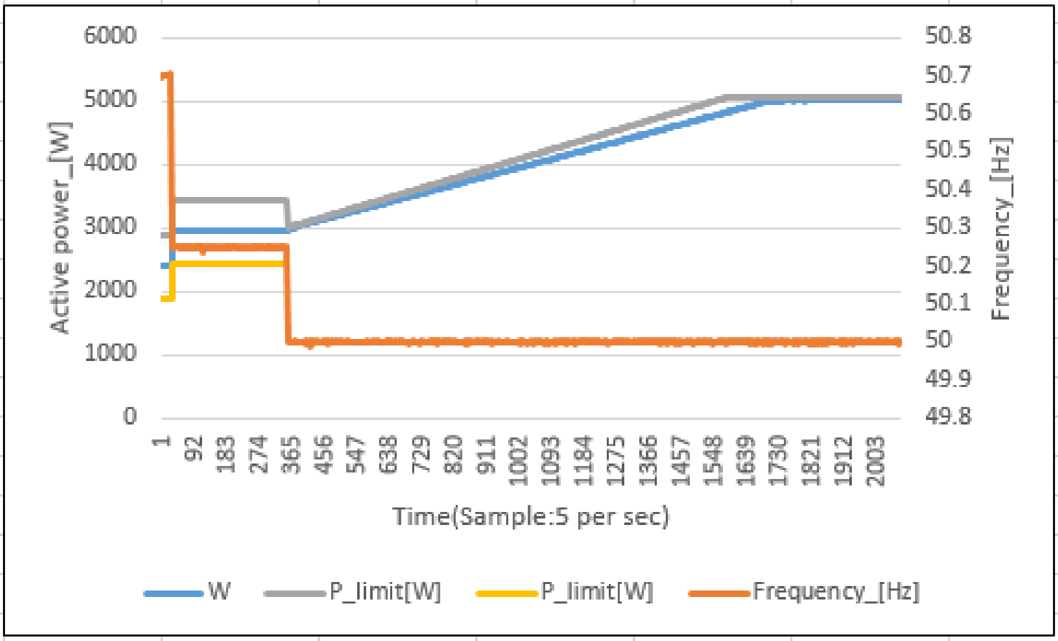
Graph of Measurement 2.:Active power output 40% and 60% after freezing > 80% P_n



Graph of power gradient:



Test:

The test is conducted for two powers. First, the test must start at a power =100% P_{Emax} ("Measurement 1"), and in a second test, for a power 60% P_{Emax} ("Measurement 2"). In the second test, after freezing of the P_M, the available active power output must be increased to a value =100% P_{Emax}, and after the network frequency of 50,2 Hz is fallen below, the rise of the active power gradient must be recorded.

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

Assessment criterion:

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

a) For adjustable micro-generators when:

1) the active power reduces between measuring points b) and f) given above with the set gradient P_M per Hz for a increasing frequency (or rises for a frequency decreasing again).

2) the maximum active power gradient occurring in point is less than the configured maximum active power per minute

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

4) the settling time is equal or below 2 s with an intentional delay set to zero

b) For partly adjustable micro-generators

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

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

Note:

The test method refer to clause 5.4.4 of VDE V 0124-100:2019-02 (Draft).

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

EN 50549-1:2019: Power response to voltage variations and voltage changes			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.7.2.2	Capabilities	--	**P**
4.7.2.3.2	Fix control modes <u>(cos φ setpoint mode)</u>	FGW TG3, Revision 25, clause 4.2.2	**P**
4.7.2.3.2	Fix control modes <u>(Q setpoint mode, 48,43%)</u>	EN 50438:2013, Annex D.3.4.2.1	**P**
4.7.2.2	Q Response time	CEI 0-21:2019-04, Annex B.1.2.4	**P**
4.7.2.3.3	Voltage related control modes (Q (U) controls)	CEI 0-21:2019-04, Annex B.1.2.6	**P**
4.7.2.3.4	Power related control modes (cos φ (P) curve)	VDE V 0124-100:2012, clause 5.3.6.4	**P**
4.7.3	Voltage related active power reduction (P(U) function)	CEI 0-21:2019-04, Annex B.1.3.1	**P**

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4.7.2 4.7.2.2 4.7.2.3.2	Voltage support by reactive power Capabilities Fix control modes (cos φ setpoint mode)			P
Test result:				
PF = 0,8 / Inducitive reactive power supply				
Rating power [%}	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage [V]
5%	0,242	-0,183	0,7977	229,85
10%	0,478	-0,351	0,8065	229,94
20%	0,985	-0,732	0,8023	230,22
30%	1,494	-1,119	0,8003	230,23
40%	1,995	-1,501	0,7991	230,24
50%	2,496	-1,882	0,7985	230,11
60%	2,993	-2,260	0,7980	230,29
70%	3,480	-2,632	0,7975	230,18
80%	3,983	-3,012	0,7976	230,18
90%	3,981	-3,030	0,7957	230,17
100%	3,976	-3,031	0,7951	230,17
PF = 0,8 / Capacitive reactive power supply				
Rating power [%}	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage [V]
5%	0,249	0,186	0,8007	229,06
10%	0,481	0,358	0,8017	229,96
20%	0,985	0,734	0,8016	230,24
30%	1,497	1,112	0,8027	230,53
40%	1,999	1,483	0,8030	230,41
50%	2,503	1,857	0,8030	230,45
60%	2,999	2,224	0,8032	230,50
70%	3,495	2,591	0,8033	230,42
80%	3,989	2,955	0,8035	230,56
90%	4,034	2,997	0,8027	230,59
100%	4,028	2,995	0,8024	230,60
Cos phi=1 no reactive power supply				
Rating power [%}	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage [V]
5%	0,243	-0,014	0,9982	230,27
10%	0,484	-0,014	0,9995	229,95
20%	0,998	-0,012	0,9999	229,70
30%	1,502	-0,016	0,9999	229,98
40%	2,013	-0,019	0,9999	230,04
50%	2,519	-0,023	0,9999	229,79
60%	3,022	-0,026	0,9999	230,10
70%	3,524	-0,030	0,9999	230,15
80%	4,024	-0,033	0,9999	230,22
90%	4,522	-0,036	0,9999	230,08

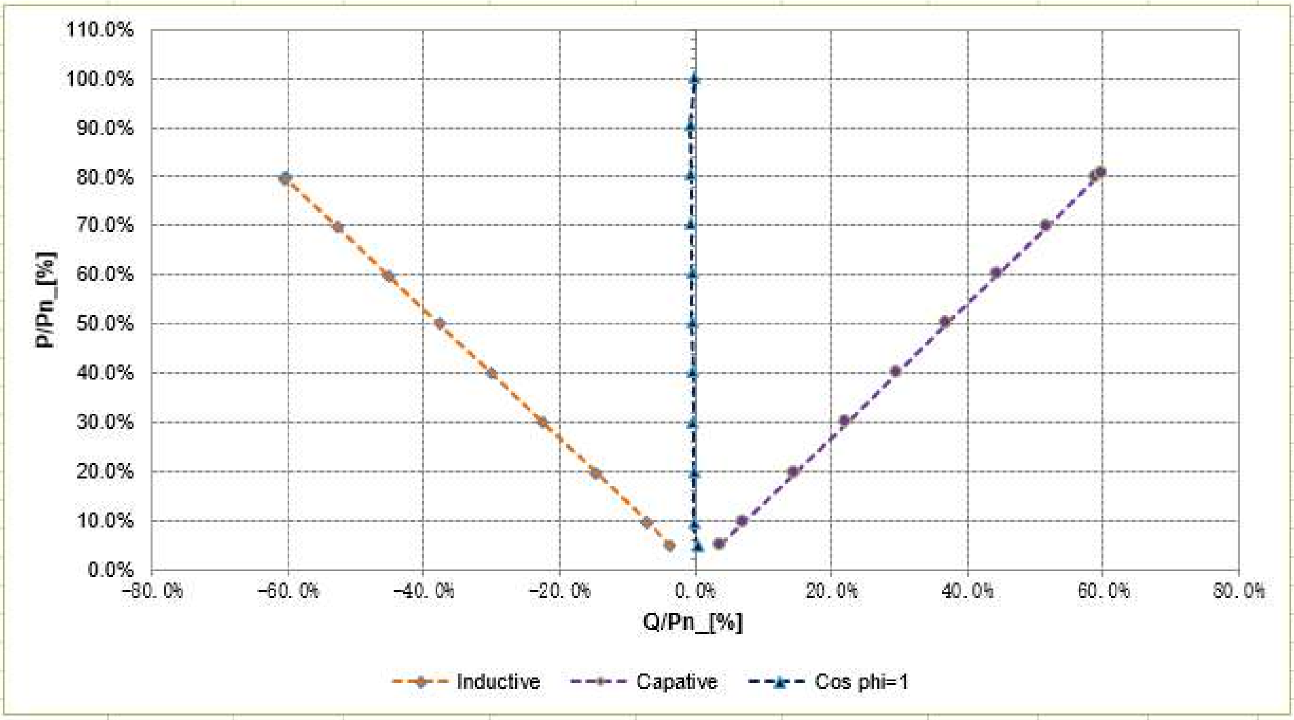
100%	5,007	-0,007	0,9999	230,33

Assessment criterion:

The power factor resulting in each of the measurement points between 20 % and 90 % of the nominal power is equal to or lower than 0,90 both in over excited and under excited operation.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Diagram



4.7.2	Voltage support by reactive power	P
4.7.2.2	Capabilities	
4.7.2.3.2	Fix control modes (Q setpoint mode, 48,43%)	

Test result:

Inducitive reactive power supply				
Rating power [%}	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage [V]
5%	0,247	-2,939	0,0836	229,75
10%	0,483	-2,903	0,1642	229,96
20%	0,941	-3,045	0,2952	229,57
30%	1,452	-3,047	0,4302	229,89
40%	1,962	-3,050	0,5409	229,61
50%	2,468	-3,022	0,6326	229,77
60%	2,978	-3,025	0,7015	230,10
70%	3,481	-3,026	0,7547	229,24
80%	3,983	-3,029	0,7960	229,55
90%	3,981	-3,030	0,7957	229,55
100%	3,974	-3,032	0,7950	229,55
Capacitive reactive power supply				
Rating power [%}	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage [V]
5%	0,243	2,899	0,0843	229,59
10%	0,500	3,009	0,1637	229,68
20%	1,007	2,918	0,3258	230,32
30%	1,457	3,080	0,4274	229,88
40%	1,969	3,075	0,5391	229,31
50%	2,479	3,041	0,6318	229,63
60%	2,985	3,036	0,7010	229,94
70%	3,488	3,031	0,7548	230,25
80%	3,984	3,026	0,7964	230,56
90%	4,026	3,022	0,7997	230,59
100%	4,020	3,021	0,7994	230,58
Cos phi=1 no reactive power supply				
Rating power [%}	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage [V]
5%	0,242	-0,012	0,9987	230,27
10%	0,484	-0,014	0,9995	229,95
20%	0,998	-0,012	0,9999	229,70
30%	1,502	-0,016	0,9999	229,98
40%	2,013	-0,019	0,9999	230,04
50%	2,519	-0,023	0,9999	229,79
60%	3,022	-0,026	0,9999	230,10
70%	3,524	-0,030	0,9999	230,15
80%	4,024	-0,033	0,9999	230,22
90%	4,522	-0,036	0,9999	230,08
100%	5,007	-0,007	0,9999	230,33

Assessment criterion:

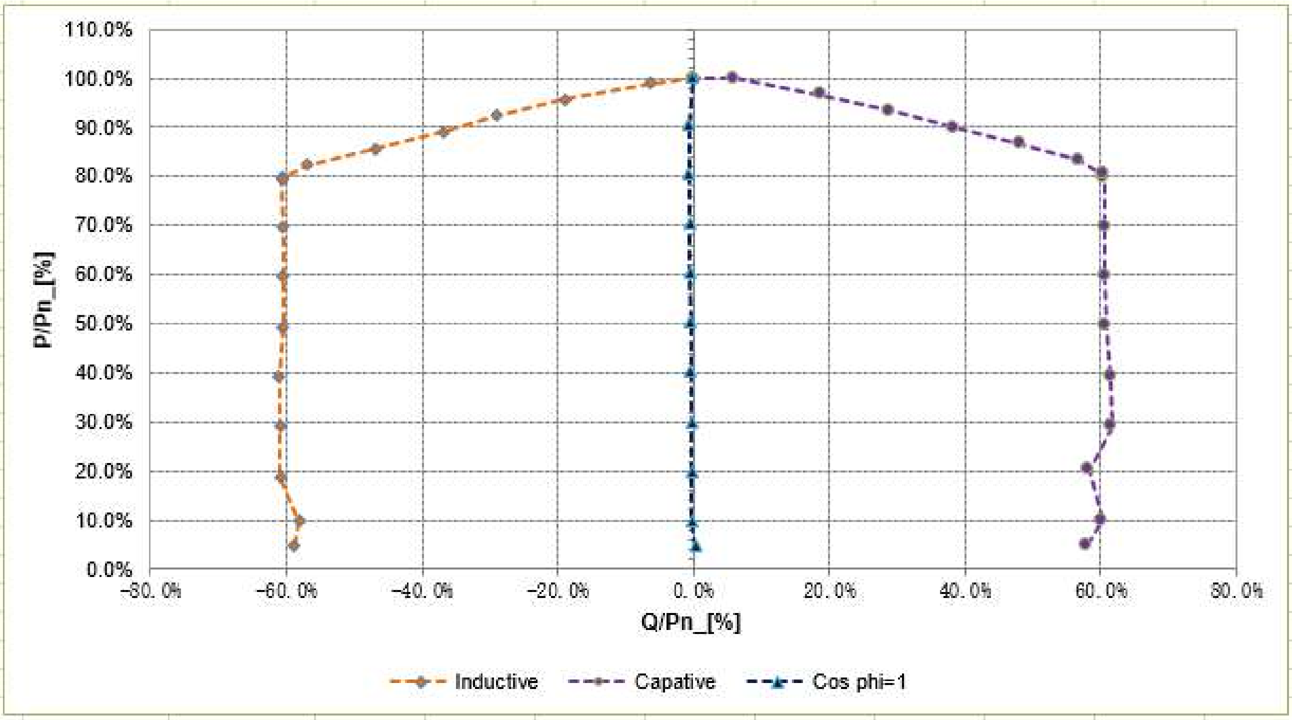
The power factor resulting in each of the measurement points between 20 % and 90 % of the nominal power is equal to or lower than 0,90 both in over excited and under excited operation,

The test method refer to clause CEI0-21 / EN 50438:2013, Annex D,3,4,2,1,

Generating plants must meet the reactive power requirement regardless of the number of feeding phases under normal steady-state operating conditions in the voltage tolerance band +10%U_n and -15%U_n.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Diagram



4.7.2.2 Capabilities Q Response time	P

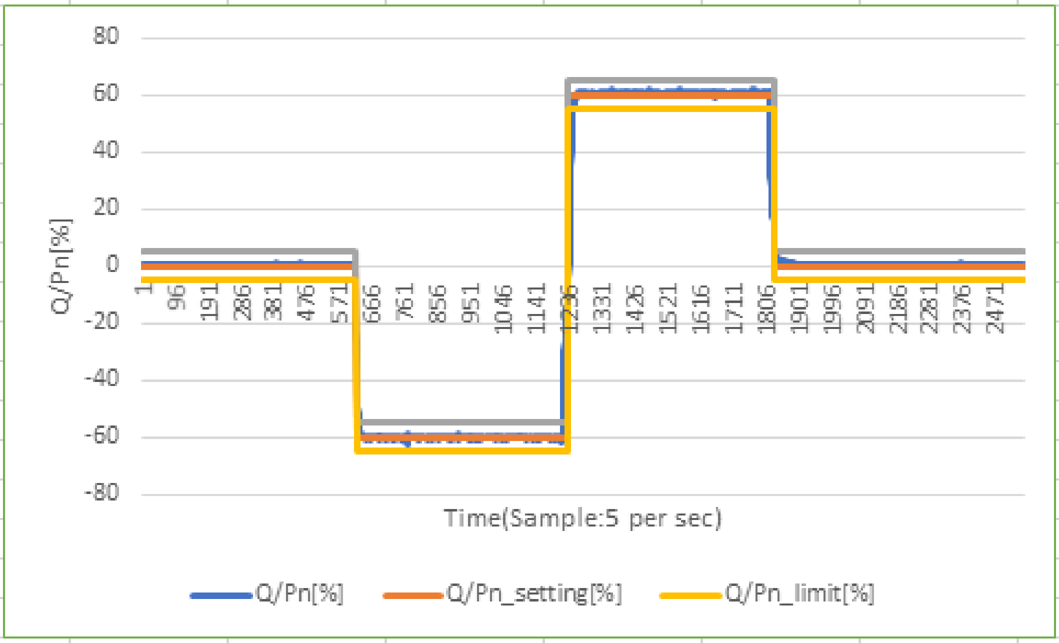
Reaction time

Test result:

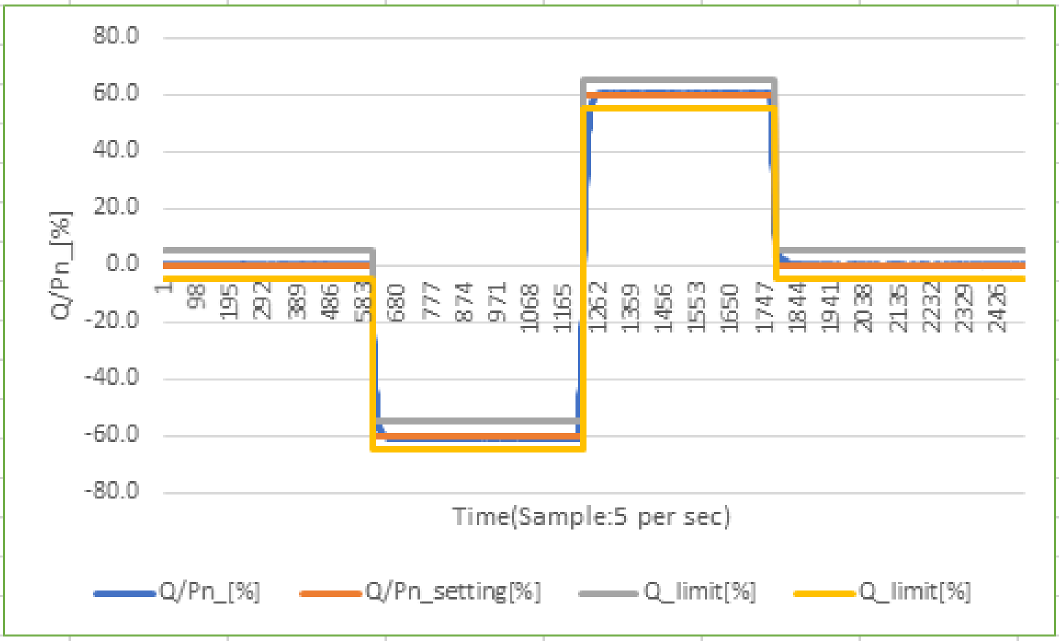
		Time	Result
1,	Reaction time Q=0 to Qmin (50% test)	4,6 s	P
2,	Reaction time Qmin to Qmax (50% test)	7,6 s	P
3,	Reaction time Qmax to Q=0 (50% test)	4,0 s	P
4,	Reaction time Q=0 to Qmin (100% test)	6,4 s	P
5,	Reaction time Qmin to Qmax (100% test)	9,0 s	P
6,	Reaction time Qmax to Q=0 (100% test)	4,4 s	P

Test result:

Graph 50%Pn



Graph 100%Pn



Assessment criterion:

DC source should be set to 50%(test1) and 100%(test2) output power micro-generator,

Starting with Q=0 then Qmin≤ -0,4843 Pn to to Qmax≥ 0,4843 Pn, and then back to Q=0 in doing so each point must be kept for at least 2 minute,

The total tolerance is ΔQ ≤ ±5,0% of Pn or Δcosφ ≤ ±0,01

The maximum response time is 10s.

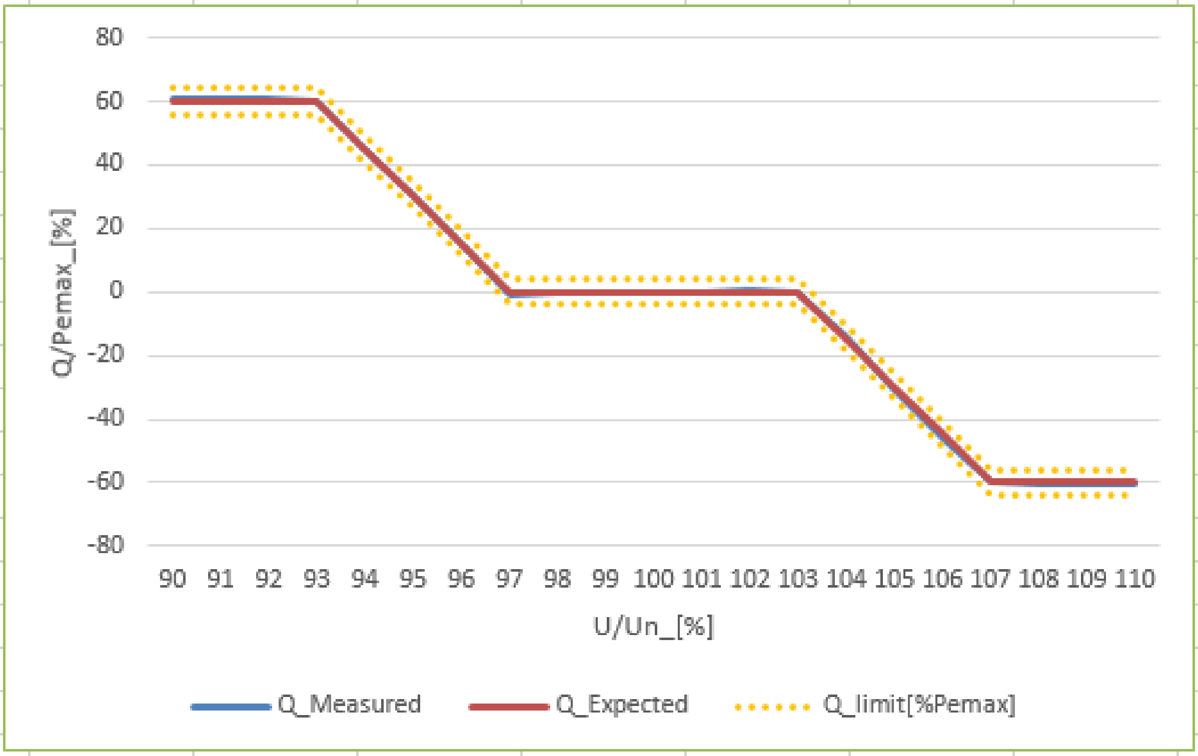
The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

4.7.2.2 4.7.2.3.3	Capabilities Voltage related control modes (Q (U) controls)	P

Test of the reactive power-voltage characteristic Q (U)					P
Vac [% U_n] Set point	Vac_L1 [V] measured	P [kW] measured	Q [kVar] measured	Q [kVar] expected	ΔQ [% P_{Emax}]
100	230,14	5,019	0,010	0	0,200
99	227,72	5,018	0,008	0	0,160
98	225,44	5,015	0,007	0	0,140
97	223,09	5,012	0,006	0	0,120
96	220,67	4,971	0,688	0,750	-1,240
95	218,33	4,729	1,417	1,500	-1,660
94	216,17	4,338	2,209	2,250	-0,820
93	213,76	3,763	2,983	3,000	-0,340
92	211,62	3,669	3,027	3,000	0,540
91	209,29	3,598	3,029	3,000	0,580
90	207,12	3,538	3,030	3,000	0,600
91	209,33	3,603	3,030	3,000	0,600
92	211,65	3,672	3,029	3,000	0,580
93	213,76	3,751	3,007	3,000	0,140
94	216,17	4,302	2,247	2,250	-0,060
95	218,33	4,702	1,513	1,500	0,260
96	220,70	4,964	0,740	0,750	-0,200
97	223,10	5,011	-0,042	0	-0,840
98	225,45	5,018	0,005	0	0,100
99	227,72	5,020	0,007	0	0,140
100	230,14	5,022	0,008	0	0,160
101	232,40	5,029	0,008	0	0,160
102	234,60	5,030	0,011	0	0,220
103	236,88	5,031	0,008	0	0,160
104	239,08	4,987	-0,734	-0,750	0,320
105	241,47	4,800	-1,538	-1,500	-0,760
106	243,73	4,489	-2,287	-2,250	-0,740
107	246,08	4,052	-2,996	-3,000	0,080
108	248,59	4,042	-3,014	-3,000	-0,280
109	250,88	4,044	-3,015	-3,000	-0,300
110	253,23	4,046	-3,015	-3,000	-0,300
109	250,85	4,044	-3,015	-3,000	-0,300
108	248,57	4,043	-3,015	-3,000	-0,300

107	246,10	4,041	-3,014	-3,000	-0,280
106	243,72	4,473	-2,320	-2,250	-1,400
105	241,46	4,788	-1,577	-1,500	-1,540
104	239,06	4,980	-0,788	-0,750	-0,760
103	236,87	5,026	0,051	0	1,020
102	234,59	5,026	0,011	0	0,220
101	232,39	5,023	0,010	0	0,200
100	230,41	5,022	0,009	0	0,180
Limit ∆Q:	± 4% P_{Emax}				

Graph of characteristic Q (U):



Test:

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

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

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

The procedure is analogous to Figure 3 in Section 5.4.3.2.

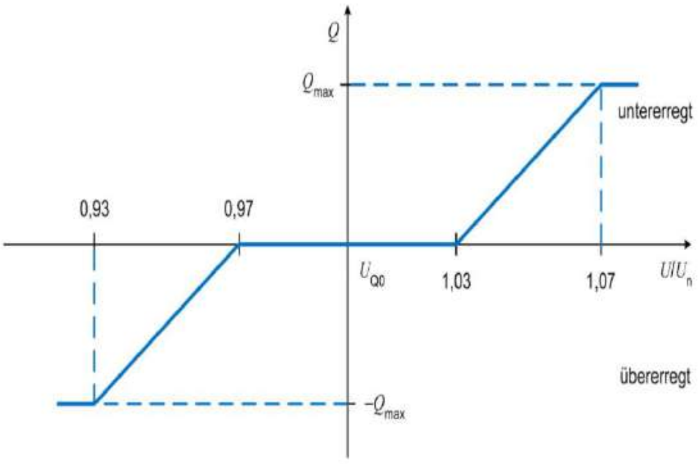


Bild 7 – Standard-Q(U)-Kennlinie

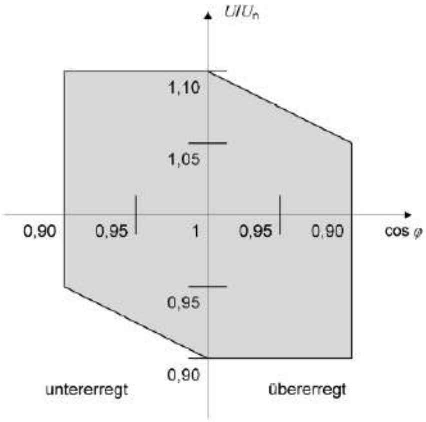


Bild 3 – Anforderungen an Erzeugungseinheiten bezüglich der Blindleistungsbereitstellung an den Generatorklemmen
($\sum S_{Emax} > 4{,}6$ kVA)

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

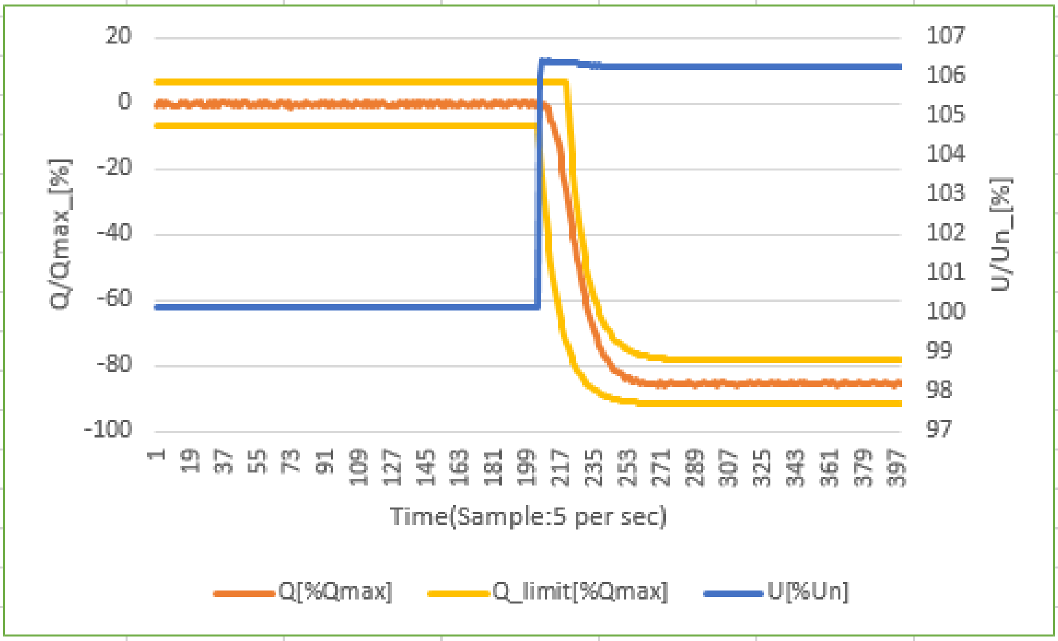
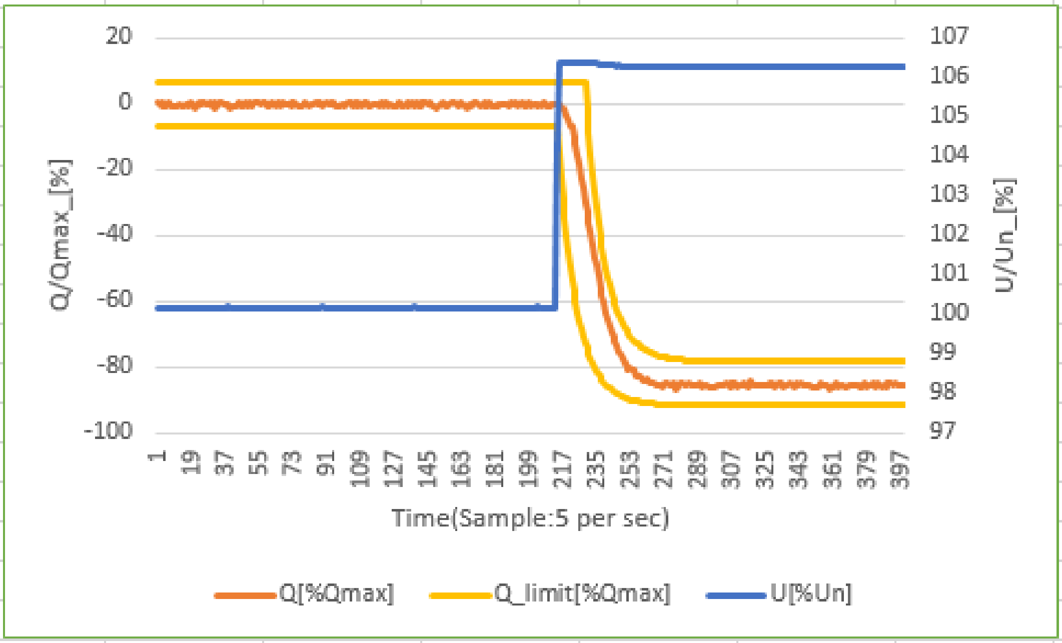
Assessment criterion:

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

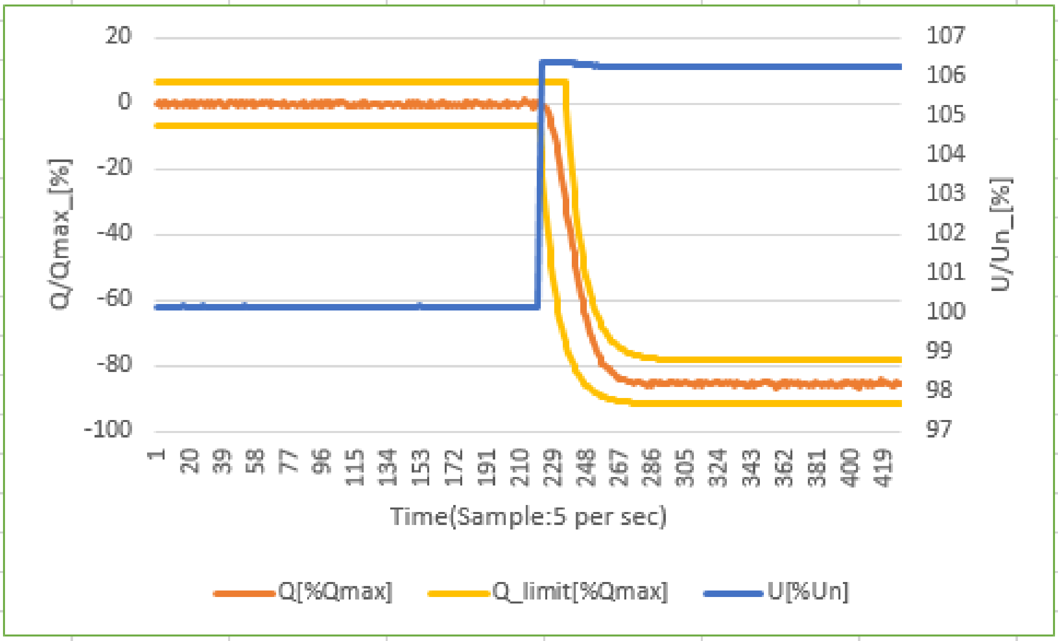
$$Q_{EZE,tol} = \pm(0.01 \cdot \mathrm{U_{N,Y}} \cdot \mathrm{k_{QU}} + 0.04 \cdot P_{EMax}) = \pm 0{,}25 \cdot P_{EMax} \cdot (\sin(\arccos(\varphi_{min})) + 0.16).$$

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

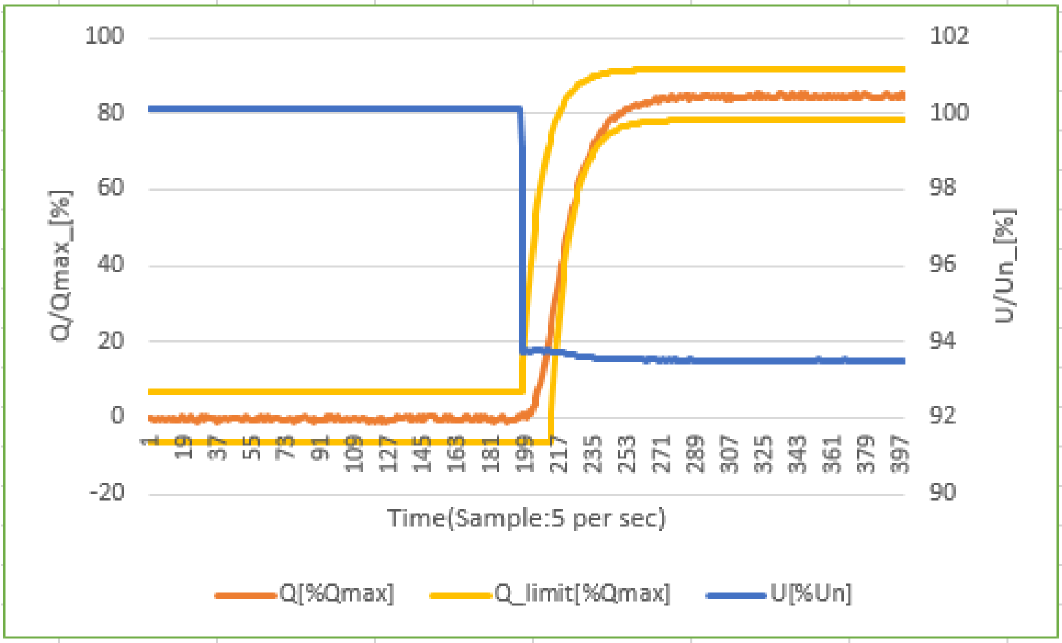
Test of the dynamics of the Q (U) regulation			**P**
Voltage jump Vac [% U_n]	Q [kVar] measured	Q [%Qmax] measured	T=3τmeasured
1.0—>1.064 ($\Delta U_{ind,Y}$)	-2,564	-85,467	7,8 s
	-2,568	-85,600	7,8 s
	-2,566	-85,533	7,6 s
1.0—>0,936 ($\Delta U_{cap,Y}$)	2,535	84,500	10,8 s
	2,537	84,567	10,2 s
	2,541	84,700	10,4 s
Note: The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.			

Q (U) jumps-1: 1.0—>1.064 (∆Uind,Y)

Q (U) jumps-2: 1.0—>1.064 (∆Uind,Y)


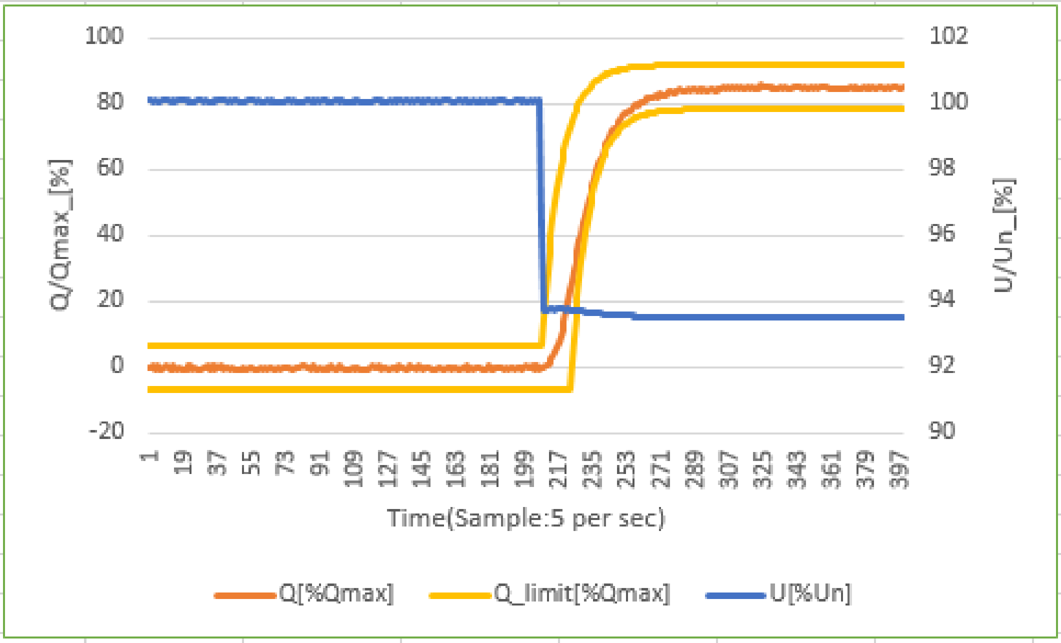
Q (U) jumps-3: 1.0—>1.064 (∆Uind,Y)



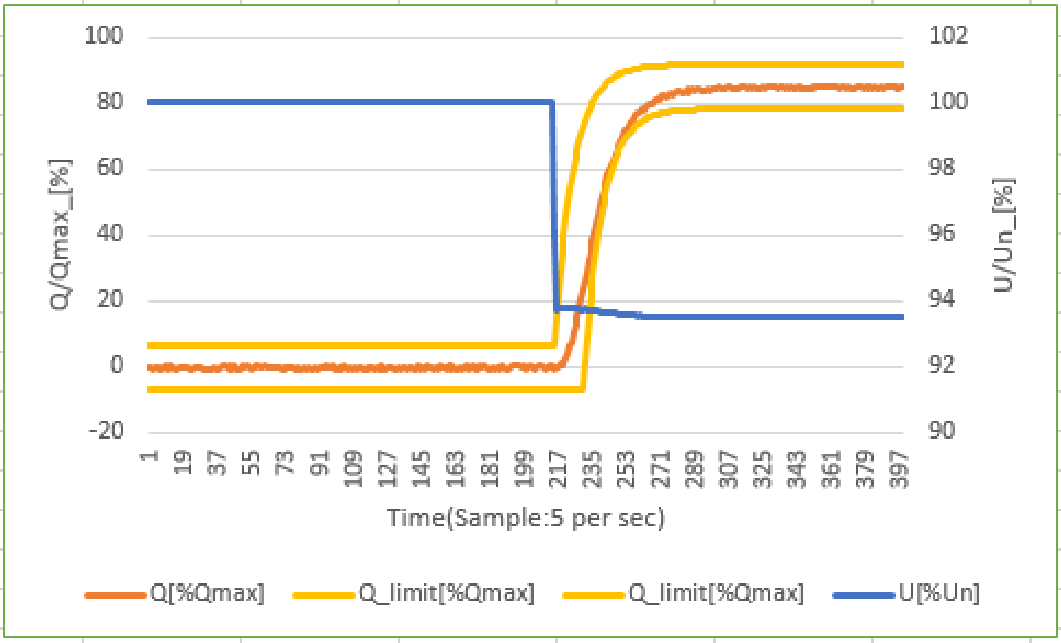
Q (U) jumps-1: 1.0—>0,936 (∆Ucap,Y)



Q (U) jumps-2: 1.0—>0,936 (∆Ucap,Y)



Q (U) jumps-3: 1.0—>0,936 (∆Ucap,Y)



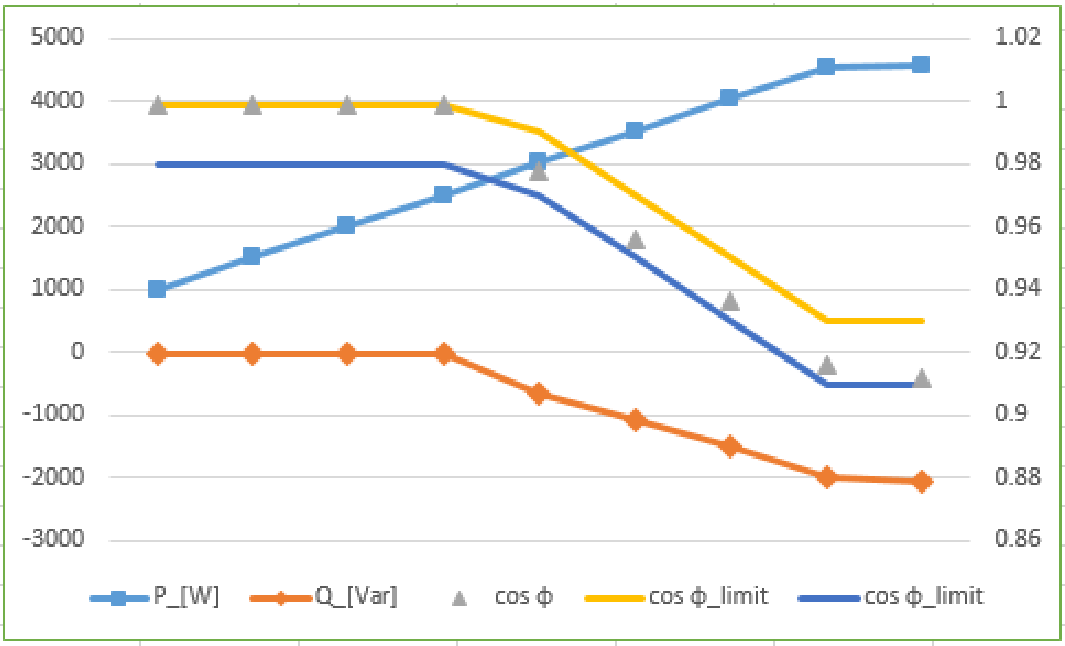
4.7.2.2 **4.7.2.3.4**	**Capabilities** **Power related Control mode (cos φ (P) curve)**	**P**

Test result:										
Test a):										
P_{Emax}/P [%]	10	20	30	40	50	60	70	80	90	100
30 s mean value	20% to 100% P_{Emax}									
U [V]:	N/A	230,06	230,34	230,65	230,96	230,12	230,40	230,69	230,63	230,60
P_{E30} [kW]:	N/A	1,000	1,509	2,017	2,516	3,024	3,528	4,026	4,520	4,575
P_{E30} of P_{Emax} [%]:	N/A	20,00	30,18	40,34	50,32	60,48	70,56	80,52	90,40	91,50
Q_{E30} [kVAr]:	N/A	-0,021	-0,017	-0,014	-0,022	-0,652	-1,074	-1,509	-1,973	-2,056
cos $φ_{E30}$:	N/A	0,999	0,999	0,999	0,999	0,978	0,956	0,936	0,916	0,912
cos $φ_{setpoint}$ of P_{E30}:	N/A	1,000	1,000	1,000	1,000	0,980	0,960	0,940	0,920	0,920
Limit cos φ $_{E30}$:	cos $φ_{setpoint}$ ± 0,01									

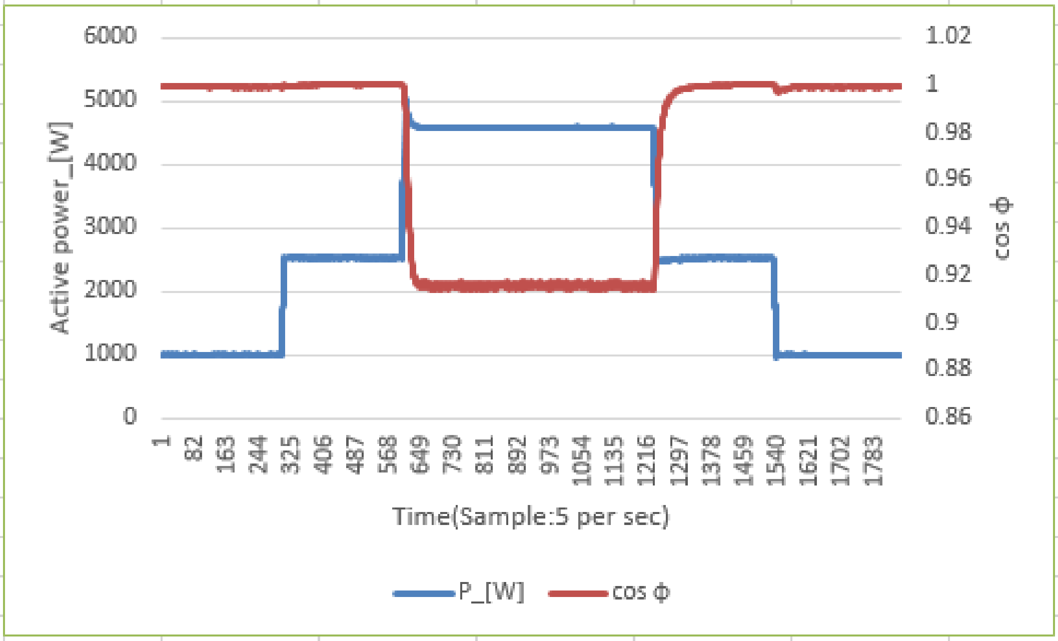
Test b):			
P_{Emax}/P_n [%]	20	50	100
30 s mean value	20% to 50% to 100% P_{Emax}		
U [V]:	229,53	230,23	230,98
P_{E30} [kW]:	1,000	2,524	4,586
P_{E30} of P_{Emax} [%]:	20,00	50,48	91,72
Q_{E30} [kVAr]:	0,041	-0,018	-2,011
cos φ $_{E30}$:	0,999	0,999	0,916
cos $φ_{setpoint}$ of P_{E30}:	1,000	1,000	0,920
T_0[s]:	1,4s		1,6s
P_{Emax}/P_n [%]	100	50	20
30 s mean value	100% to 50% to 20% P_{Emax}		
U [V]:	230,89	229,73	229,43
P_{E30} [kW]:	4,585	2,519	0,994
P_{E30} [%]:	91,70	50,38	19,88
Q_{E30} [kVAr]:	-2,012	-0,053	-0,043
cos φ $_{E30}$:	0,916	0,999	0,999
cos $φ_{setpoint}$ of P_{E30}:	0,920	1,000	1,000
T_0 [s]:	5,4s		1,2s
Limit T_0 [s]:	10 s		
Limit cos φ $_{E30}$:	cos $φ_{setpoint}$ ± 0,02		

Test result:

Graph of cos φ(P): Test a)



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

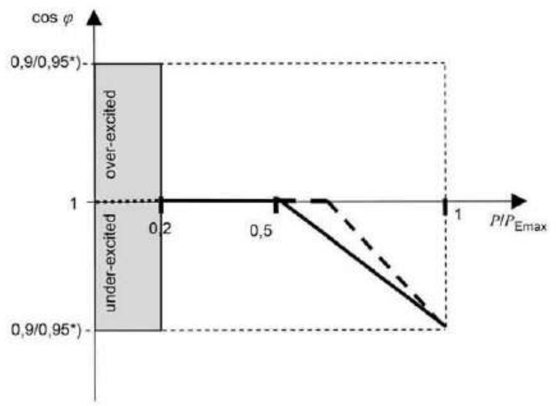


Test:

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

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

Characteristic curve cos φ (P)



*) Depending on S_{Amax}.

Assessment criterion:

Test 1: cos φ accuracy cos φ (±0,01)

Test 2: cos φ accuracy cos φ (±0,02)

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:

The test method refer to clause 5,3,6,4 of VDE V 0124-100:2012-07.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

4.7.3	Voltage related active power reduction (P(U) function)	P

Test result:	
Test:	
5-min mean value / P/ P_n [%]	100% to 20%
Settling time [s]:	8,8s
P_{E60} [%]:	19,7
$\Delta P_{E60}/P_{Setpoint}$ [%]:	20 % or less of P_{Emax}
Limit settling time:	600s

Test:

a) Set the voltage to 2% Vn lower than the activation threshold stated by the manufacturer,

b) Set the voltage to 112%Vn, The inverter now has to reduce its output power to value lower than 20%Pn within 5min,

c) Set the voltage back to 2%Vn lower than the activation threshold, Check that the active power will return to the value consistent with the power available from the primary source or simulated.

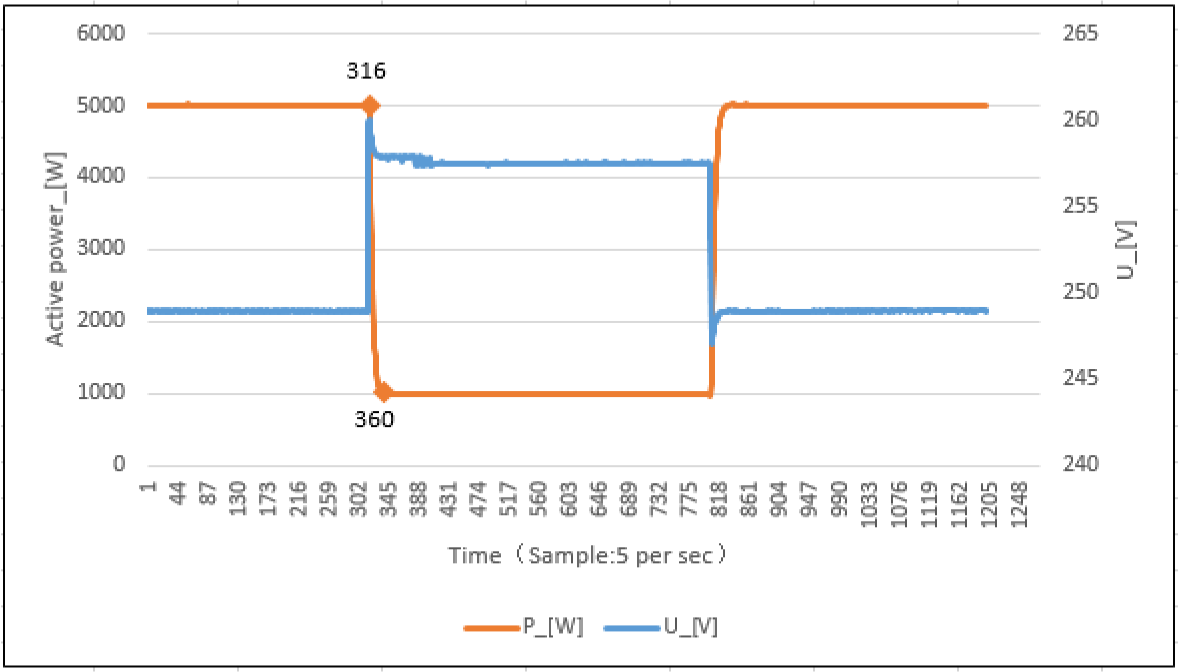
The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Assessment criterion:

for adjustable PGUs:

- no network disconnection
- the active power value does not exceed the setpoint of 20% P_{Emax}
- the setting time determind is equal or less than 600s.

Graph:



EN 50549-1:2019: Power quality			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.8	EMC and power quality	--	**P**
	Harmonic current emission	EN 61000-3-2, EN 61000-3-12	**P**
	Harmonic current emission	EN 61000-4-7	**N/A**
	Switching operations	IEC 61400-21	**P**
	Voltage fluctuation and flicker	EN 61000-3-3, EN 61000-3-11	**P**
	Flicker and voltage fluctuations	IEC 61400-21	**P**
	DC injection	EN 50438, Annex D,3,10	**P**
	Immunity to voltage dips and short interruptions	G59/3-4:2018-05, clause 13.8.4.5	**P**
	Unbalance	BDEW TG3, Revision 25, clause 4.3.5	**N/A**

4.8	EMC and power quality Harmonic current emission (EN 61000-3-12)	P

Test result:

Watts [kW]	5,019
Vrms [V]	230,18
Arms [A]	21,813
Frequency [Hz]	50,00
THD50* (100% output power)	0,656%

Harmonic order n	Current Magnitude [A] at 100% rated output power	% of Fundamental	Phase	Harmonic Current Limits [%]
1st	21,806	100,303	Single-phase	-
2nd	0,043	0,198	Single-phase	8
3rd	0,072	0,332	Single-phase	21,6
4th	0,012	0,054	Single-phase	4
5th	0,077	0,352	Single-phase	10,7
6th	0,009	0,041	Single-phase	2,667
7th	0,011	0,049	Single-phase	7,2
8th	0,008	0,035	Single-phase	2
9th	0,047	0,216	Single-phase	3,8
10th	0,009	0,041	Single-phase	1,6
11th	0,020	0,092	Single-phase	3,1
12th	0,012	0,053	Single-phase	1,333
13th	0,030	0,136	Single-phase	2
14th	0,014	0,063	Single-phase	8
15th	0,026	0,118	Single-phase	N/A
16th	0,013	0,061	Single-phase	N/A
17th	0,029	0,132	Single-phase	N/A
18th	0,012	0,056	Single-phase	N/A
19th	0,027	0,124	Single-phase	N/A
20th	0,011	0,052	Single-phase	N/A
21th	0,020	0,093	Single-phase	N/A
22th	0,010	0,045	Single-phase	N/A
23th	0,017	0,080	Single-phase	N/A
24th	0,009	0,043	Single-phase	N/A
25th	0,016	0,073	Single-phase	N/A
26th	0,008	0,038	Single-phase	N/A
27th	0,014	0,064	Single-phase	N/A
28th	0,008	0,036	Single-phase	N/A
29th	0,013	0,059	Single-phase	N/A
30th	0,007	0,033	Single-phase	N/A
31th	0,011	0,053	Single-phase	N/A
32th	0,007	0,030	Single-phase	N/A
33th	0,010	0,048	Single-phase	N/A
34th	0,006	0,027	Single-phase	N/A
35th	0,009	0,041	Single-phase	N/A
36th	0,006	0,029	Single-phase	N/A
37th	0,009	0,042	Single-phase	N/A
38th	0,007	0,032	Single-phase	N/A
39th	0,010	0,046	Single-phase	N/A
40th	0,005	0,024	Single-phase	N/A

Note:

The tests should be based on the limits of the EN61000-3-2 for less than 16A and on EN 61000-3-12 for more than 16A.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

4.8	EMC and power quality Switching operation (Refer IEC 61400-21)			P
Test result:				
Max, number of switching operations, N_{10}	10			
Max, number of switching operations, N_{120}	120			
Case of switching operation	Cut-in at 10%P_{Emax}			
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker step factor, $k_f(\psi_k)$	0,04	0,03	0,02	0,02
Voltage change factor, $k_u(\psi_k)$	1,29	1,22	0,60	1,28
Maximum inrush current factor k_{imax}	0,03			
Case of switching operation	Cut-in at 100%P_{Emax}			
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker step factor, $k_f(\psi_k)$	0,13	0,08	0,07	0,06
Voltage change factor, $k_u(\psi_k)$	3,81	3,82	3,80	3,78
Maximum inrush current factor k_{imax}	0,03			
Case of switching operation	Service disconnection at rated power			
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker step factor, $k_f(\psi_k)$	0,51	0,33	0,27	0,26
Voltage change factor, $k_u(\psi_k)$	3,32	3,45	3,40	3,27
Maximum inrush current factor k_{imax}	0,47			
Worst case over all switching operations, k_{imax}	0,47			
Note: $S_{k,fic}/S_n$ in the fictitious grid was set to: 38 The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.				

Diagram of measured voltage, current, apparent active and reactive power at cut in at 10%P_{Emax}

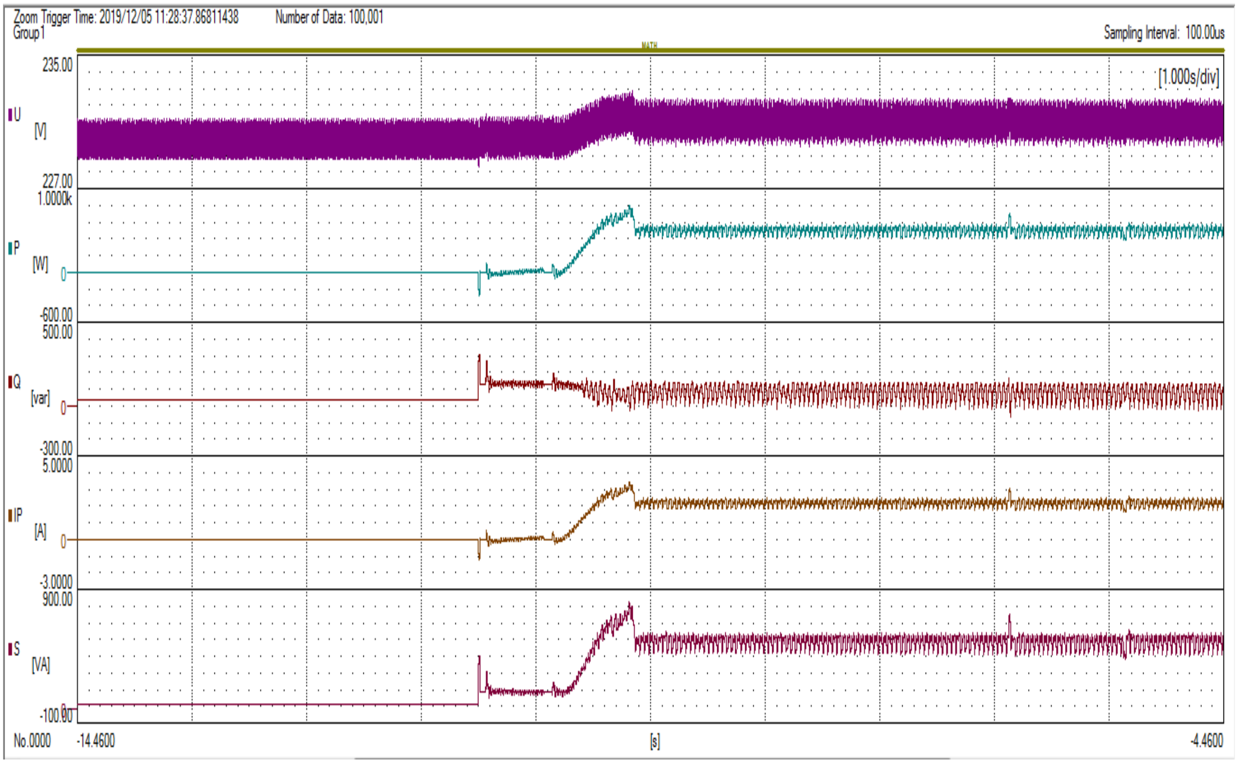


Diagram of measured voltage, current, apparent active and reactive power at cut in at 100%P_{Emax}

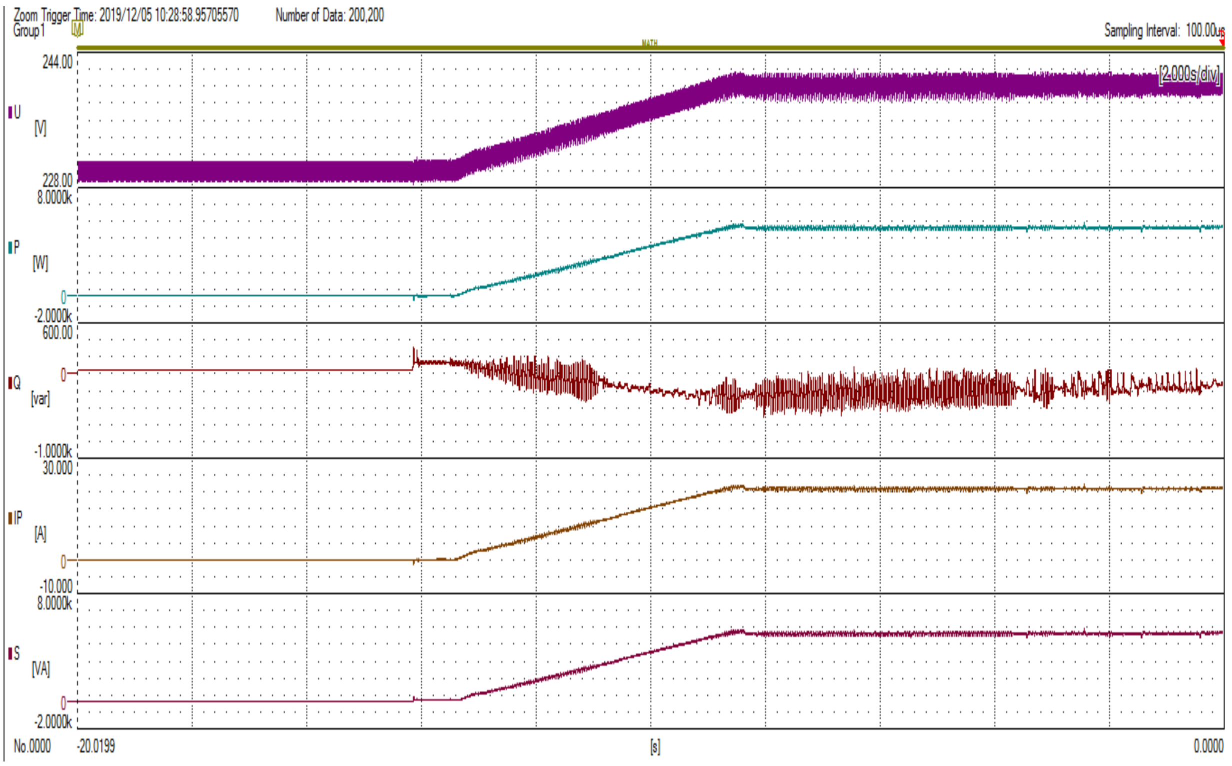
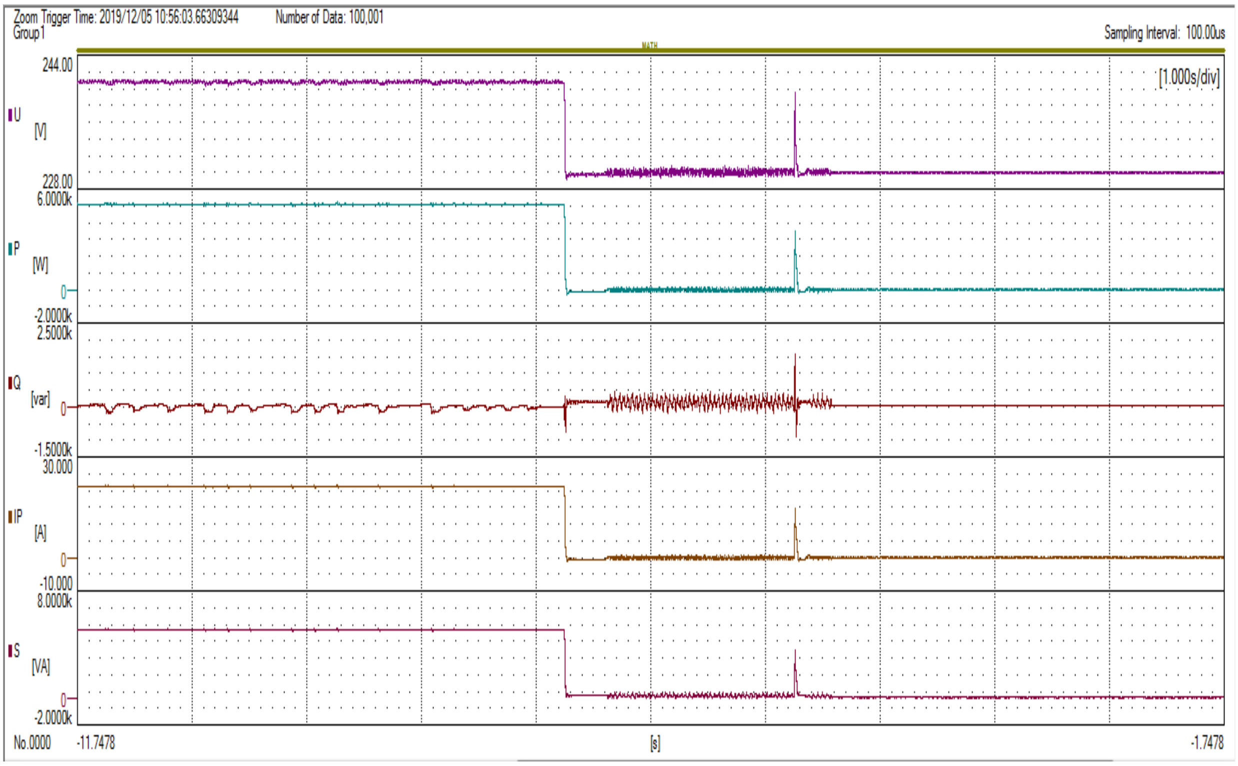


Diagram of measured voltage, current, apparent active and reactive power at service disconnection



4.8	**Voltage fluctuation and flicker**				**P**
Test result:					
Test conditions:	Maximum permissible voltage fluctuation (expressed as a percentage of nominal voltage at 100 % power) and flicker as per EN 61000-3-3 and/or EN 61000-3-11.				
Test:					
Value	**P_{st}**	**P_{lt} 2 hours**	**d(t) $_{500ms}$**	**d_c**	**d_{max}**
Limit	1,0	0,65	3,3%	3,3%	4%
Test value	See below				
inverter >16A					

No.	dc[%]	dmax[%]	d(t)[ms]	Pst
1	0.06	0.37	0.00	0.25
2	0.04	1.83	0.00	0.71
3	0.03	0.43	0.00	0.23
4	0.05	0.42	0.00	0.25
5	0.04	1.91	0.00	0.70
6	0.05	0.44	0.00	0.23
7	0.05	0.37	0.00	0.25
8	0.04	1.87	0.00	0.71
9	0.05	0.43	0.00	0.24
10	0.05	1.08	0.00	0.38
11	0.05	1.90	0.00	0.68
12	0.05	0.42	0.00	0.24

Plt
0.50

Note:

*The stationary deviance of dc% is more relevant than the dynamic deviance of dmax at starting and stopping,
Mains Impedance according EN61000-3-3:**Rmax = 0,24Ω; jXmax= 0,15Ω @50Hz (|Zmax| = 0,283/0,4717Ω) for single phase inverter use also R_n = 0,16Ω; jX_n= 0,1Ω**
Calculation of the maximum permissible grid impedance at the point of common coupling based on dc:**Z_{max} = Z_{ref} * 3,3% / d_c(P_n)**
The tests should be based on the limits of the EN 61000-3-3 for less than 16A and on EN 61000-3-11 for more than 16A.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

4.8	EMC and power quality Flicker and voltage fluctuations	P

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

Test result:

Grid impedance angle, ψ_k	30°	50°	70°	85°
Operating point, P_a/P_{Emax} [%]	Flicker coefficient, $c(\psi_k)$			
0	5,631	3,675	2,996	2,826
10	4,022	2,625	2,140	2,019
20	5,631	3,675	2,996	2,826
30	5,631	3,675	2,996	2,826
40	4,022	2,625	2,140	2,019
50	3,218	2,100	1,712	1,615
60	3,218	2,100	1,712	1,615
70	3,620	2,363	1,926	1,817
80	5,229	3,413	2,782	2,624
90	12,066	7,876	6,420	6,056
100	8,848	5,775	4,708	4,441
Max, Flicker coefficient, $c(\psi_k)$	12,066	7,876	6,420	6,056
Max, Short-term flicker, P_{st}	0,318	0,208	0,169	0,160

Reactive power setpoint during testing [kVar]	0

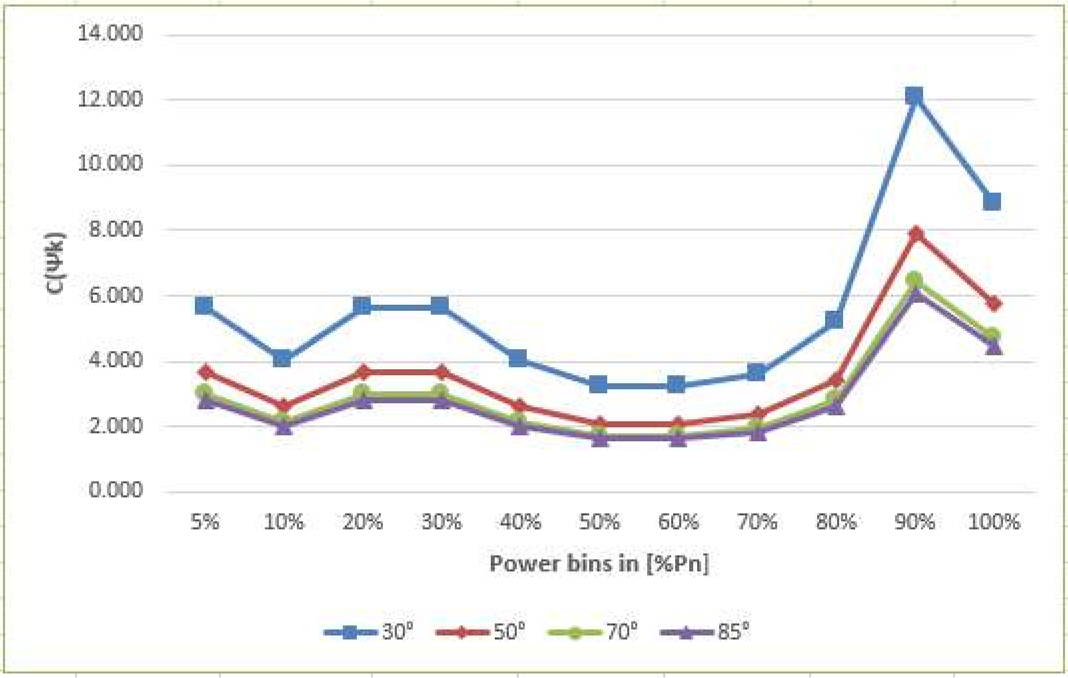
P [%P_{Emax}]	0	10	20	30	40	50	60	70	80	90	100
Number of data sets	1	1	1	1	1	1	1	1	1	1	1

Note:

The table entries are worst case values.

$S_{k,fic}/S_n$ in the fictitious grid was set to: 38.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Maximum Flicker coefficients c(ψ_k) vs, power bins


4.8	EMC and power quality DC-Injection	P

Test result:

Protection limit	Tested at four power levels limit 0,5% of $I_{AC;nom}$ (108,7mA)			
Output power	~20%	~50%	70%	~100%
Max, test value [mA]	-40	-49	-58	-97

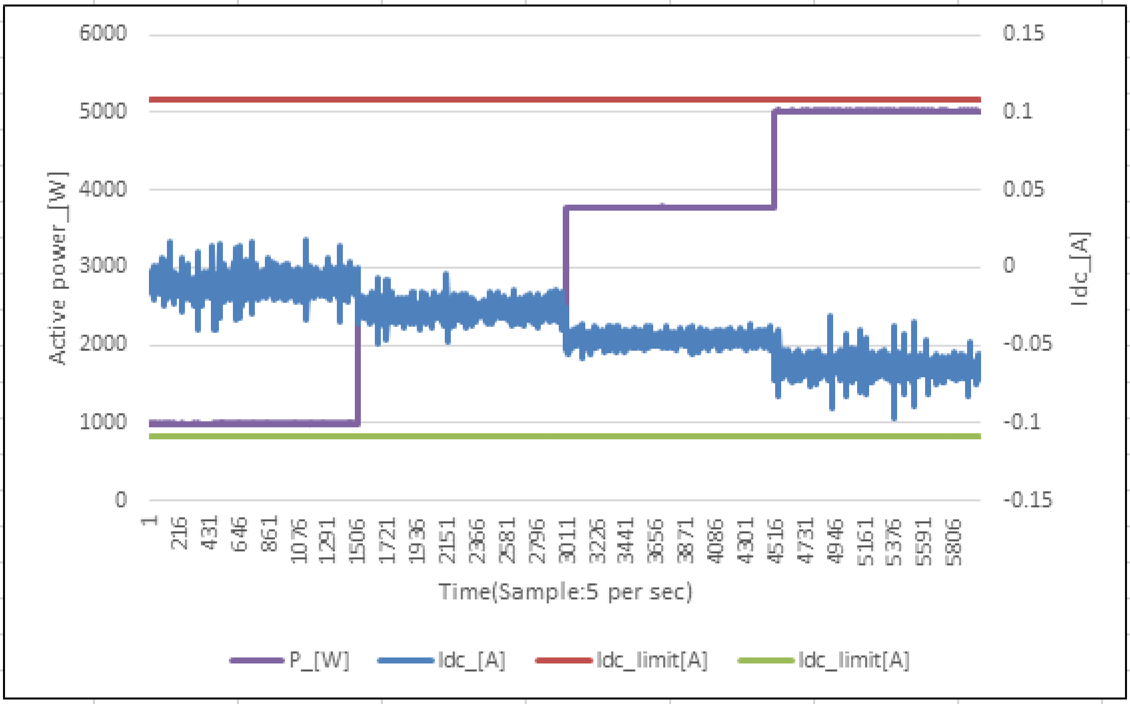
Note:

Test method and setting value refer Annex D,3,10 of EN 50438:2013,

Testing must be performed according to WI 10,4,-03,doc rev D, The internal temperature of the EUT must be stabilized, No temperature drift of more than 2K within 1 hour is allowed.

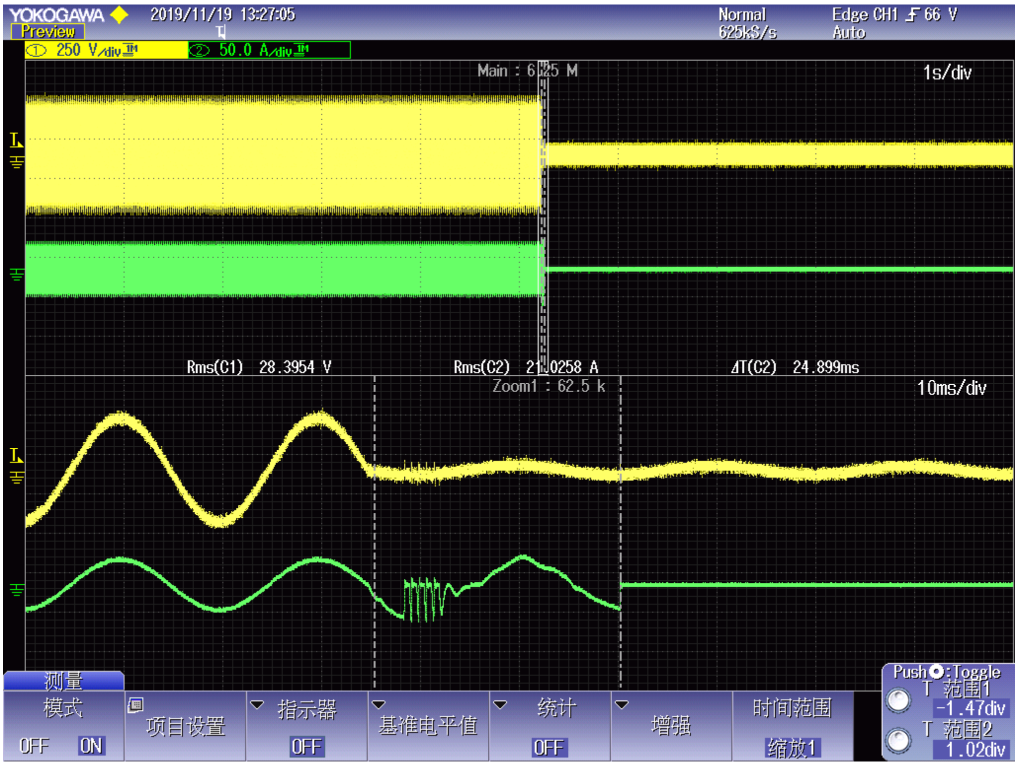
The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Diagram of permanent dc-injection



4.8	**Immunity to voltage dips and short interruptions**				**P**
For a directly coupled SSEG			For a Inverter SSEG		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	I_p	N/A	20ms	30,03	21,332
Initial Value of aperiodic current	A	N/A	100ms	20,89	9,880
Initial symmetrical short-circuit current*	I_k	N/A	250ms	N/A	N/A
Decaying (aperiodic) component of short circuit current*	i_{DC}	N/A	500ms	N/A	N/A
Reactance/Resistance Ratio of source*	X/R	N/A	Time to trip	0,0249	In seconds

Diagram



Note:

For rotating machines and linear piston machines the test should produce a 0s – 2s plot of the short circuit current as seen at the Generating Unit terminals,

* Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

EN 50549-1:2019: Interface protection			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.9.3	Requirements on voltage and frequency protection	CEI 0-21:2019-04, Annex A.3.1 to A.3.4	**P**
4.9.3.1	Undervoltage protection	EN 50438, Annex D.2.3	**P**
	Overvoltage protection	EN 50438, Annex D.2.3	**P**
	Overvoltage 10 min mean protection	EN 50160	**P**
	Underfrequency protection	EN 50438, Annex D.2.4	**P**
	Overfrequency protection	EN 50438, Annex D.2.4	**P**
4.9.4.2	Loss of Mains (LoM) detection	IEC 62116:2014	**P**

4.9.3	**Requirements on voltage and frequency protection Checklist**	**P**
Several points to check		
Clause 4.9.3.1 to 4.9.3.6	All thresholds must be adjustable	**P**

Voltage values

Threshold	Stage 1 [27 <]		Stage 2 [27 <<]	
	Operate voltage	Operate time	Operate voltage	Operate time
Range	0,2-1,0 U_n	0,1-100s	0,2-1,0 U_n	0,1-5s
Steps	0,01 U_n	0,1 s	0,01 U_n	0,05s

Threshold	Stage 1 [59 >]		Stage 2 [59 >>]		Overvoltage 10 min mean protection	
	Operate voltage	Operate time	Operate voltage	Operate time	Operate voltage	Operate time
Range	1,0-1,2 U_n	0,1-100s	1,0-1,3 U_n	0,1-5s	1,0-1,15 U_n	3s not adjustable
Steps	0,01 U_n	0,1s	0,01 U_n	0,05s	0,01 U_n	--

Frequency values

Threshold	Stage 1 [81 <]		Stage 2 [81 <<]	
	Operate frequency	Operate time	Operate frequency	Operate time
Range	47,0-50,0Hz	0,1-100s	47,0-50,0Hz	0,1-5s
Steps	0,1 Hz	0,1 s	0,1 Hz	0,05s

Threshold	Stage 1 [81 >]		Stage 2 [81 >>]	
	Operate frequency	Operate time	Operate frequency	Operate time
Range	50,0-52,0Hz	0,1-100s	50,0-52,0Hz	0,1-5s
Steps	0,1 Hz	0,1 s	0,1 Hz	0,05s

4.9.2.6	Insensitive against 40ms frequency transients, so that the unit will not trip	**P**

Note:

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

4.9.3 4.9.3.1	**Requirements on voltage and frequency protection** **General (Interface protection: Over/under voltage)** **(Setting value refer EN 50438 for default settings)**			**P**
Test conditions		Output power: 10,0kW Frequency: 50+/-0,2Hz		
Limit [V]	**Trip value [V]**	**Voltage step [V]**	**Disconnection time [s]**	**Limit [s]**
Stage 1 110% of U_n = 253,0	252,6	230 to 258	2,005	≤3,0s
	252,6	230 to 258	2,005	
	252,6	230 to 258	2,005	
	252,6	230 to 258	2,000	
	252,6	230 to 258	2,000	
Stage 2 115% of U_n = 264,5	264,5	230 to 269	0,137	0,1s ≤ t ≤ 0,2s
	264,5	230 to 269	0,135	
	264,5	230 to 269	0,135	
	264,5	230 to 269	0,135	
	264,5	230 to 269	0,135	
Stage1 85% of U_n = 195,5	195,6	230 to 190	1,314	1,2s ≤ t ≤ 1,5s
	195,6	230 to 190	1,312	
	195,6	230 to 190	1,310	
	195,6	230 to 190	1,312	
	195,6	230 to 190	1,310	

Note:

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

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Scope pictures of the disconnection time
Over-voltage - Stage 1

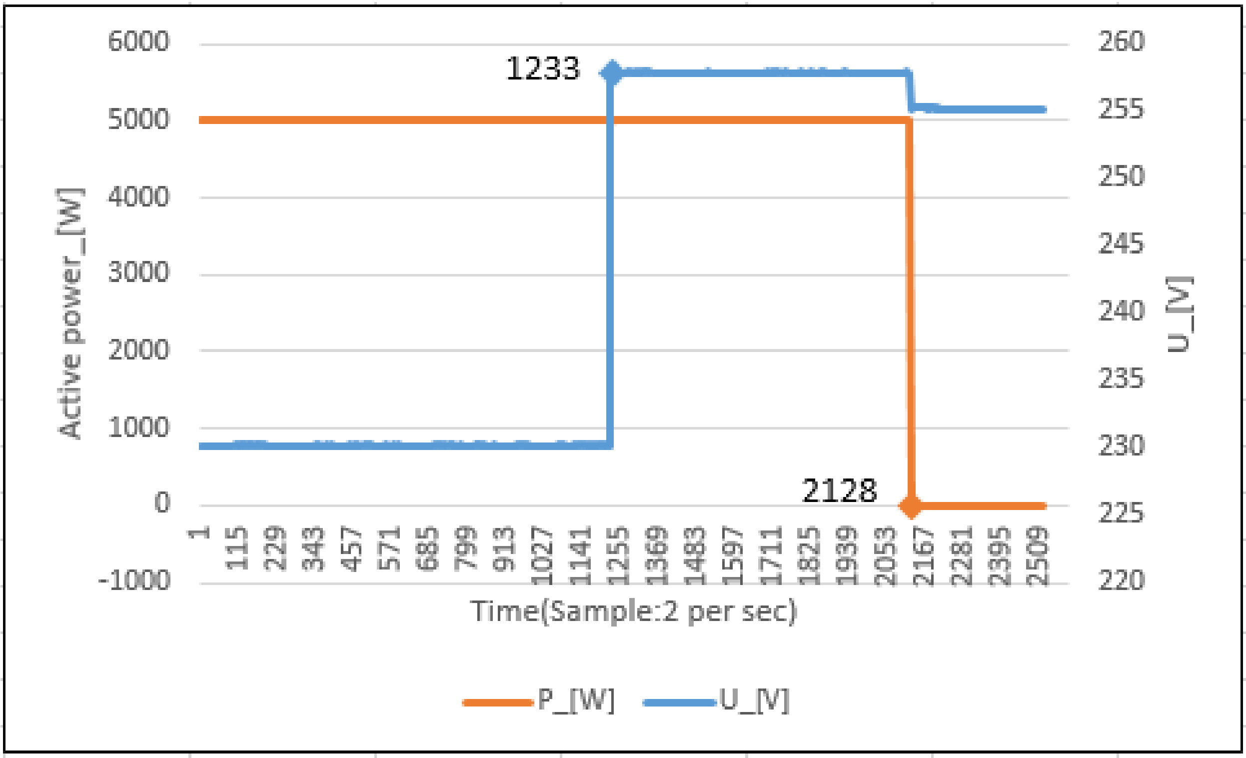
Over-voltage - Stage 2


Under-voltage

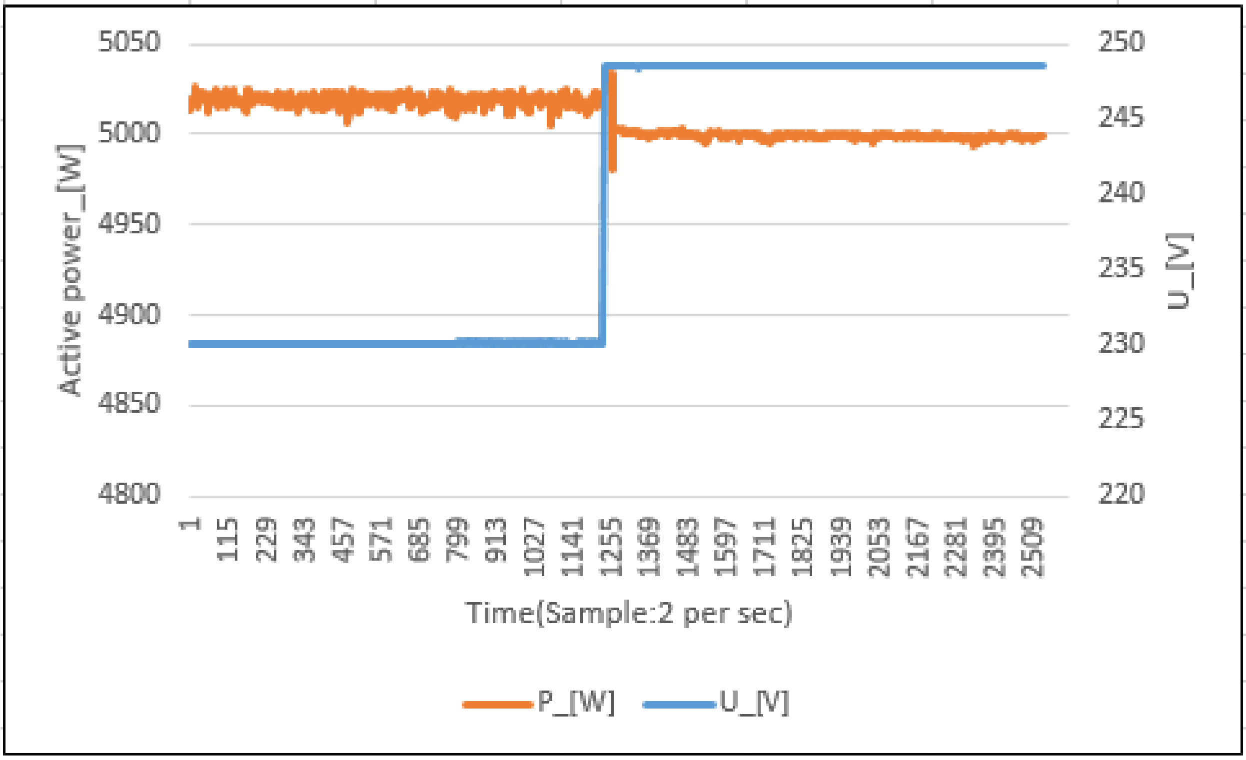

<table>
<tr><td colspan="3">4.9.3
4.9.3.1</td><td colspan="2">Requirements on voltage and frequency protection
General
(Maximum voltage 10 min mean protection according to EN 50160)
(Setting value refer EN 50438 for default settings)</td><td>P</td></tr>
<tr><td colspan="2" rowspan="3">Setting values of the protection:</td><td>Trip value Setting [V]</td><td colspan="3">253</td></tr>
<tr><td>Setting $T_{disconnection\ trip\ value}$ [s]</td><td colspan="3">600</td></tr>
<tr><td>Setting $T_{disconnection}$ [ms]</td><td colspan="3">200</td></tr>
<tr><td colspan="6">Test result:</td></tr>
<tr><td colspan="2"></td><td colspan="2">Disconnection time [s]</td><td colspan="2">Limit [s]</td></tr>
<tr><td rowspan="4">a)</td><td colspan="5">The voltage is set to 100% U_n and held for 600 s, Thereafter the voltage is set to 112% U_n, Disconnection must take place within 600 s,</td></tr>
<tr><td>Phase 1:</td><td colspan="2">447,5 s</td><td colspan="2" rowspan="3">≤ 600 s</td></tr>
<tr><td>Phase 2:</td><td colspan="2">N/A</td></tr>
<tr><td>Phase 3:</td><td colspan="2">N/A</td></tr>
<tr><td rowspan="4">b)</td><td colspan="5">The voltage is set to U_n for 600 s and then to 108% U_n for 600 s, No disconnection should take place,</td></tr>
<tr><td>Phase 1:</td><td colspan="2">No Disconnection</td><td colspan="2" rowspan="3">Disconnection should not take place,</td></tr>
<tr><td>Phase 2:</td><td colspan="2">N/A</td></tr>
<tr><td>Phase 3:</td><td colspan="2">N/A</td></tr>
<tr><td rowspan="4">c)</td><td colspan="5">The voltage is set to 106 % U_n and held for 600 s, Thereafter the voltage is set to 114 % U_n, The disconnection should last for half the period as in Point a)*</td></tr>
<tr><td>Phase 1:</td><td colspan="2">255,5 s</td><td colspan="2" rowspan="3">The disconnection time should be about 50 % of the value measured in a), *</td></tr>
<tr><td>Phase 2:</td><td colspan="2">N/A</td></tr>
<tr><td>Phase 3:</td><td colspan="2">N/A</td></tr>
<tr><td colspan="6">Test:
a) This test serves as proof of the measurement accuracy and the maximum set time,
b) This test serves as proof of the measurement accuracy,
c) This test serves as proof of the correct formation of the 1 minute running mean value,</td></tr>
<tr><td colspan="6">Assessment criterion:
The permitted tolerance between setting value and trip value of the voltage may not exceed ± 1 % of U_N,

<u>Limit values:</u>
Rise-in voltage protection 1,1 U_N after a max, 600 s, the switch off after 200 ms,</td></tr>
<tr><td colspan="6">Note:
If only one integrated protection is used for the power generation systems, the value of the rise-in voltage protection of 1,1 U_N may not be changed,
*If the setting value is set to 600 s, then the disconnection time can be in the range between 225 s and 375 s.
The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.</td></tr>
</table>

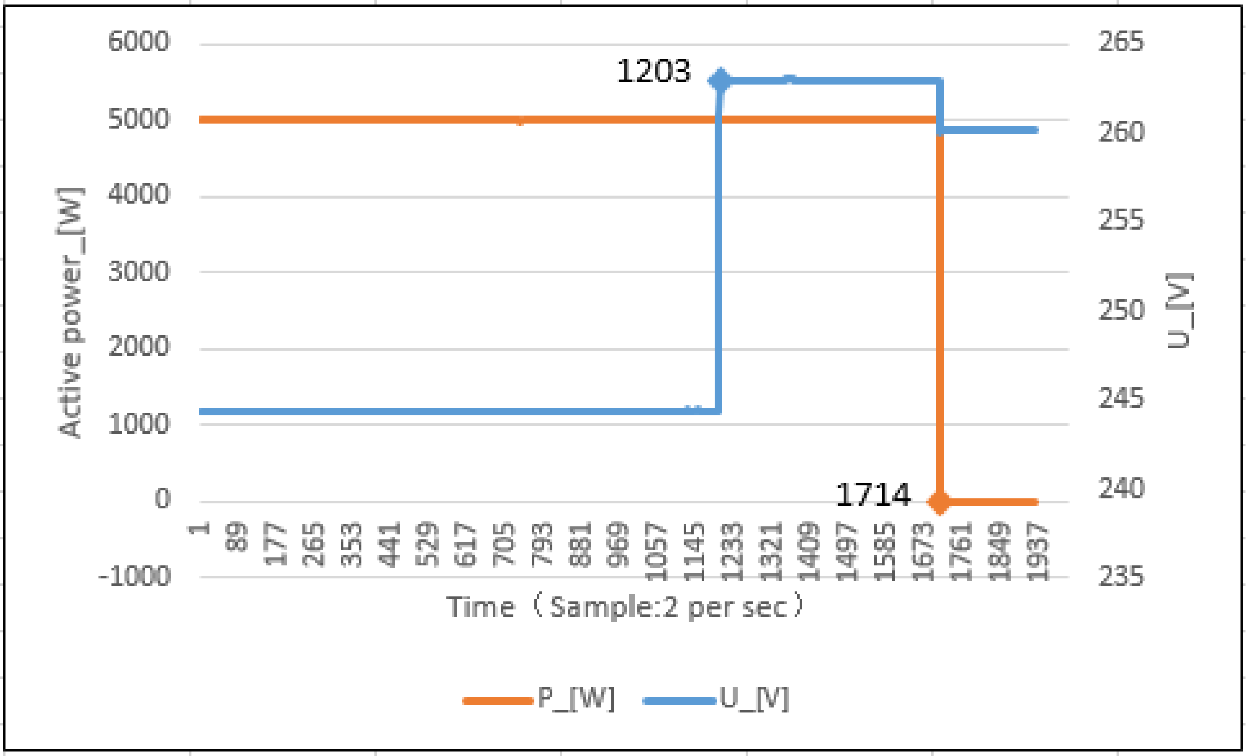
a) Voltage set to 112 % U_n:



b) Voltage set to 108% U_n:



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



4.9.3 4.9.3.1	**Requirements on voltage and frequency protection** **General (Interface protection: Over/under frequency)** **(Setting value refer EN 50438 Default setting)**				**P**

Test conditions	Output power: 5,0kW U_n = 230Vac			
	Under-frequency		**Over-frequency**	
Parameter	**Frequency**	**Time**	**Frequency**	**Time**
Limit	47,50 Hz	0,3 ≤ t ≤ 0,5 s	52,00 Hz	0,3 ≤ t ≤ 0,5 s
Trip value [Hz]	47,48		52,02	
	47,48		52,02	
	47,48		52,02	
	47,48		52,02	
	47,48		52,02	
Disconnection time [s]	50,00 Hz to 47,40 Hz	0,430	50,00 Hz to 52,10 Hz	0,415
		0,415		0,415
		0,415		0,425
		0,420		0,425
		0,410		0,430

Note:

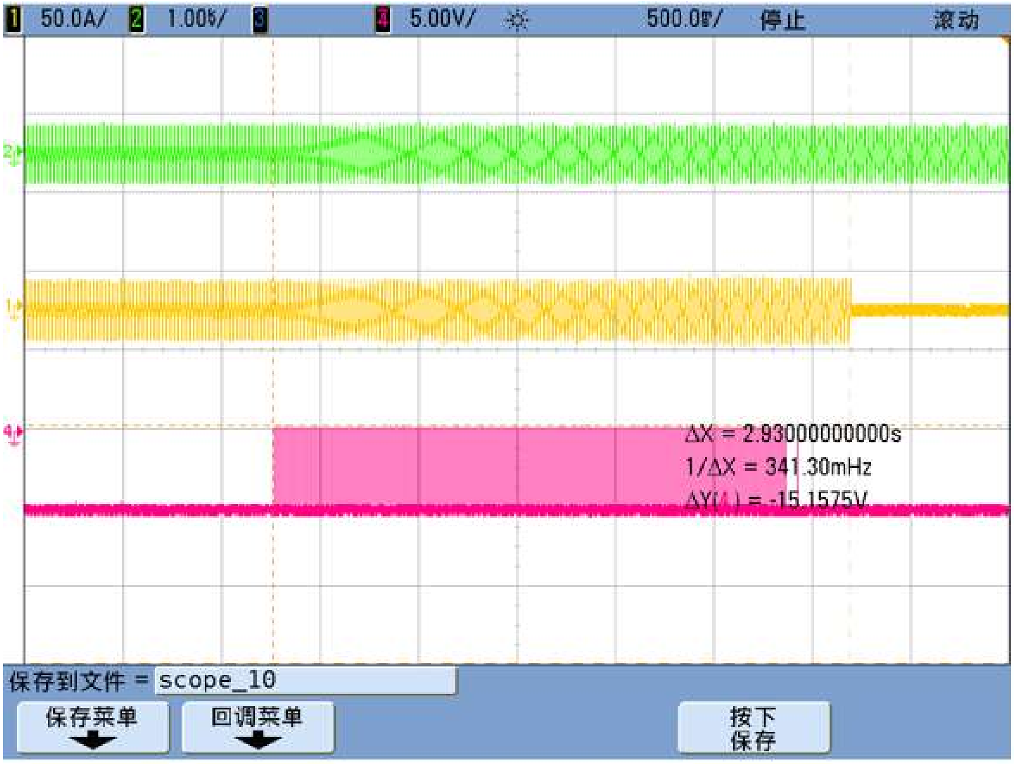
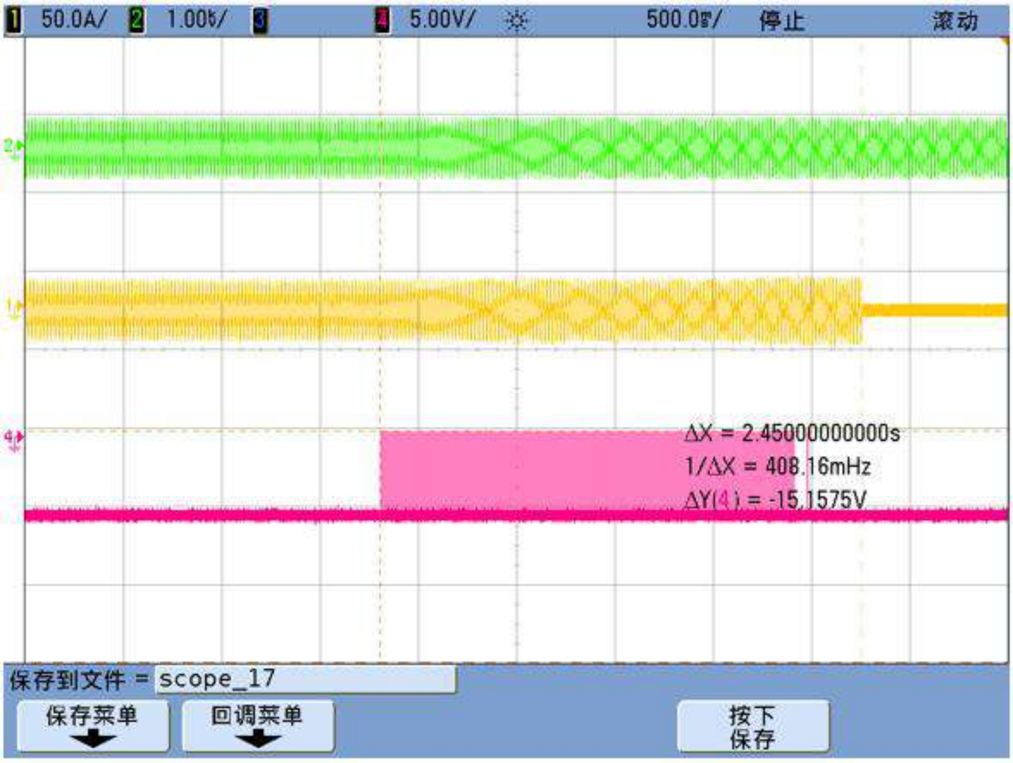
For under-frequency testing the applied frequency is varied from f_n down to f_{th-low} -0,1 Hz in steps of 0,025 Hz with a time duration per step exceeding the configured disconnection time, The operate value is the value of the applied frequency at switch the protection function trips and shall be within f_{th-low} ± 0,05 Hz,

For over-frequency testing the applied frequency is varied from f_n up to $f_{th-high}$ + 0,1 Hz in steps of 0,025 Hz with a time duration per step exceeding the configured disconnection time, The operate value is the value of the applied frequency at which the protection function trips and shall be within $f_{th-high}$ ± 0,05 Hz,

The disconnection time was measured by applying a negative or positive frequency ramp from f_n to the operate value -0,1 Hz or +0,1 Hz, e,g, from 50 Hz to 47,4 Hz, The time elapsed between the application of the frequency ramp and the opening of the interface switch was calculated by the measured time minus the 2500 ms from 50,0 Hz to 47,5 Hz,

The oscilloscope pictures below show the measured worst case disconnection times.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Scope pictures of the disconnection time
Under-frequency

Over-frequency


4.9.4.2 Loss of Mains (LoM) detection		
Test circuit and parameters		
Parameter	**Symbol**	**Units**
EUT DC Input DC voltage DC Current DC Power	 V_{DC} I_{DC} P_{DC}	 V A W
EUT AC ouput AC voltage AC current Real power Reactive power	 V_{EUT} I_{EUT} P_{EUT} Q_{EUT}	 V A W VAr
Test Load Resistive load current Inductive load current Capacitive load current	 I_R I_L I_C	 A A A
AC (utility) power source Utility real power Utility reactive power Utility current	 P_{AC} Q_{AC} I_{AC}	 W VAr A

Block diagram test circuit IEC 62116:2014

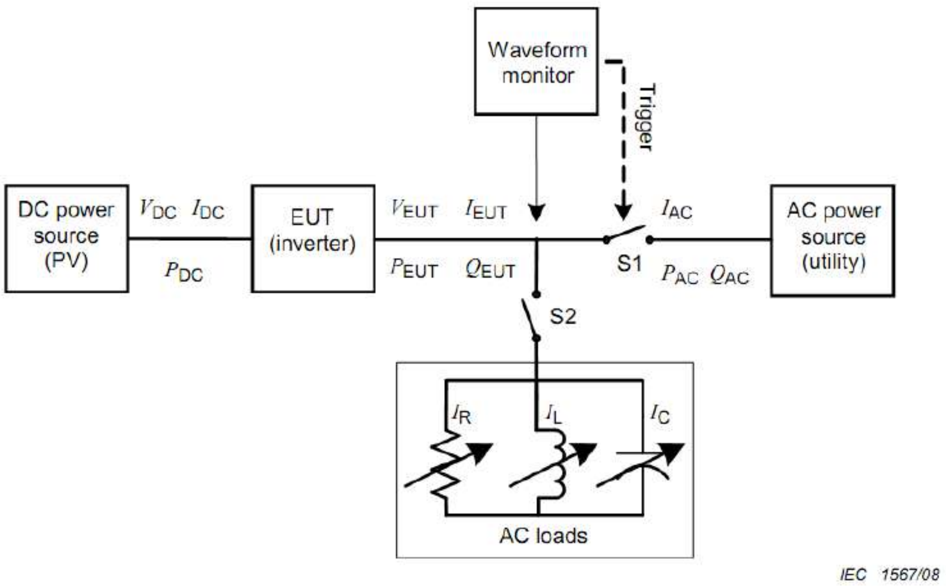


Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

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

Test result:

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]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks 5)
1	100	100	0	0	0,025	5,000	368	1,000	457	BL
2	100	100	-5	-5	1,083	5,000	368	1,026	384	IB
3	100	100	-5	0	1,112	5,000	368	1,053	366	IB
4	100	100	-5	+5	1,083	5,000	368	1,079	316	IB
5	100	100	0	-5	0,052	5,000	368	0,975	298	IB
6	100	100	0	+5	0,052	5,000	368	1,025	327	IB
7	100	100	+5	-5	1,138	5,000	368	0,928	300	IB
8	100	100	+5	0	1,112	5,000	368	0,952	405	IB
9	100	100	+5	+5	1,138	5,000	368	0,976	333	IB

Parameter at 0% per phase	L= 33,68 mH	R= 10,58 Ω	C= 300,86 µF

Note:

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

1) P_{EUT}: EUT output power

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

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

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

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

Condition A:

EUT output power P_{EUT} = Maximum 6)

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

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

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

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Scope pictures of the disconnection time
Disconnection at No, 1


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

Test result:

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]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks 5)
1	66	66	0	-5	0,084	3,300	272	0,975	223	IB
2	66	66	0	-4	0,090	3,300	272	0,980	232	IB
3	66	66	0	-3	0,095	3,300	272	0,985	240	IB
4	66	66	0	-2	0,099	3,300	272	0,990	249	IB
5	66	66	0	-1	0,101	3,300	272	0,995	341	IB
6	66	66	0	0	0,032	3,300	272	1,000	405	BL
7	66	66	0	+1	0,101	3,300	272	1,005	378	IB
8	66	66	0	+2	0,099	3,300	272	1,010	370	IB
9	66	66	0	+3	0,095	3,300	272	1,015	330	IB
10	66	66	0	+4	0,090	3,300	272	1,020	353	IB
11	66	66	0	+5	0,084	3,300	272	1,025	325	IB

Parameter at 0% per phase	L= 51,27 mH	R= 16,11 Ω	C= 197,60 µF

Note:

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

1) P_{EUT}: EUT output power

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

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

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

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

Condition B:

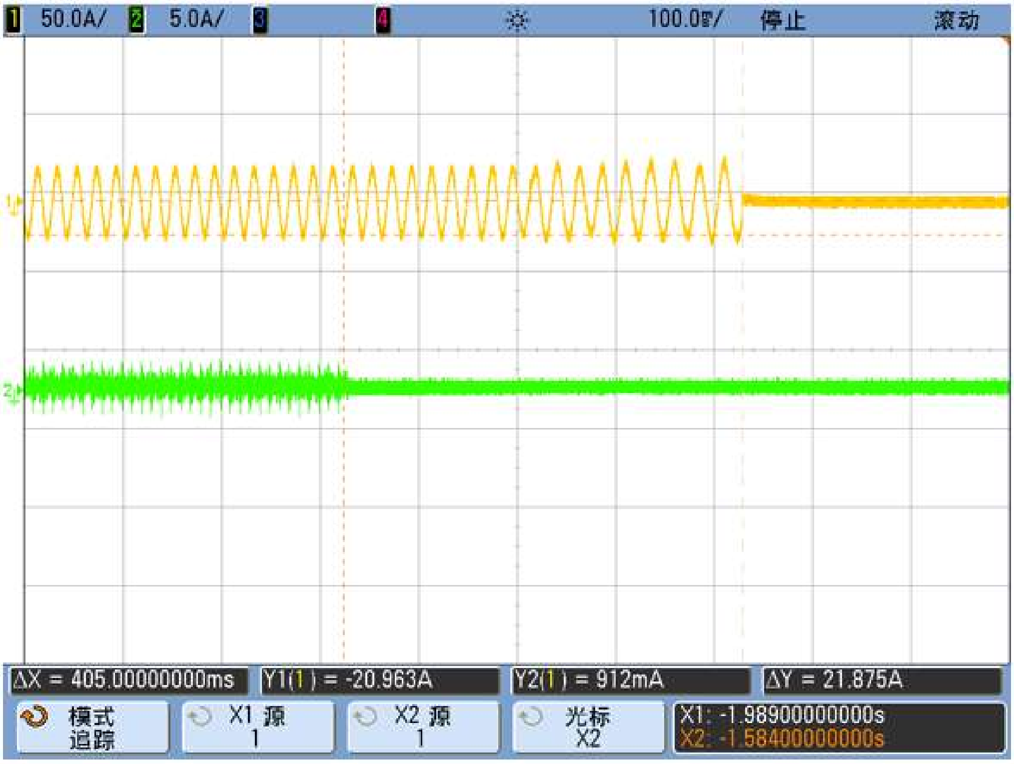
EUT output power P_{EUT} = 50 % – 66 % of maximum

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

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

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Scope pictures of the disconnection time
Disconnection at No, 6



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

Test result:

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]	Remarks 5)
1	33	33	0	-5	0,157	1,620	157	0,975	214	IB
2	33	33	0	-4	0,160	1,620	157	0,980	218	IB
3	33	33	0	-3	0,162	1,620	157	0,985	220	IB
4	33	33	0	-2	0,164	1,620	157	0,990	223	IB
5	33	33	0	-1	0,165	1,620	157	0,995	302	IB
6	33	33	0	0	0,035	1,620	157	1,000	463	BL
7	33	33	0	+1	0,165	1,620	157	1,005	372	IB
8	33	33	0	+2	0,164	1,620	157	1,010	342	IB
9	33	33	0	+3	0,162	1,620	157	1,015	315	IB
10	33	33	0	+4	0,160	1,620	157	1,020	310	IB
11	33	33	0	+5	0,157	1,620	157	1,025	294	IB

Parameter at 0% per phase	L= 103,94 mH	R= 32,65 Ω	C= 97,48 µF

Note:

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

1) P_{EUT}: EUT output power

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

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

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

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

Condition B:

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

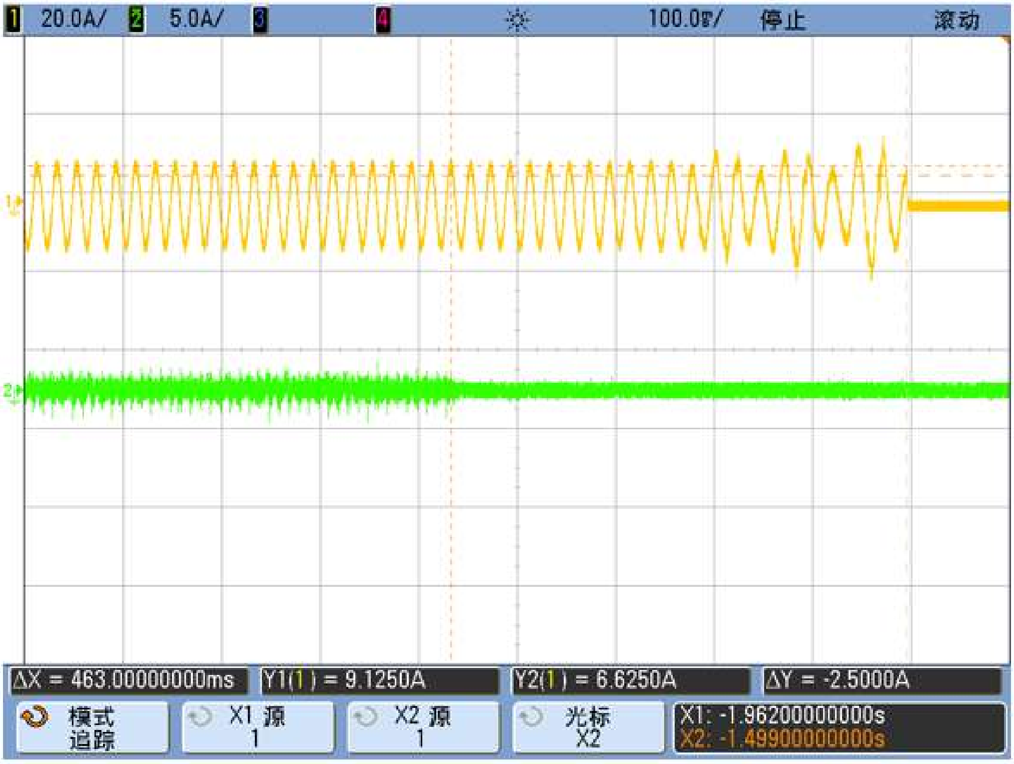
EUT input voltage 7) = <20 % of rated input voltage range

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

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

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Scope pictures of the disconnection time
Disconnection at No, 6



EN 50549-1:2019: Connection and starting to generate electrical power			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.10.2	Automatic reconnection after trippin	EN 50438, Annex D.3.6	**P**
4.10.3	Starting to generate electrical power	EN 50438, Annex D.3.6	**P**

4.10 **4.10.2** **4.10.3**	**Connection and starting to generate electrical power** **Automatic reconnection after tripping** **Starting to generate electrical power**		**P**
Setting value	Min, voltage for connected to grid :	196	
	Max, voltage for connected to grid :	253	
	Min, Frequency for connected to grid :	49,5	
	Max, voltage for connected to grid :	50,1	
	Observation time (≥60s) :	60	
Test result:			

	Voltage conditons	
a) Start up for voltage range	<84% Un for twice of observation time	>111% Un for twice of observation time
Connection:	No connection	No connection
Limit	No connection allowed	
b) In voltage range at start-up	≥84% Un within twice setting observation time	≤111% Un within twice setting observation time
Reconnection time [s]	65,2 s	65,2 s
Limit:	Connected after setting observation time (≥60s)	
Gradient:	The maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute Max gradient: disable, For recorded gradient see diagram below,	
c) In voltage range after voltage failture	≥84% Un for twice of setting observation time	≤111% Un for twice of setting observation time
Reconnection time [s]	76,0 s	68,4 s
Limit:	Reconnection after setting observation time (≥60s)	
Gradient:	For adjustable micro generators the maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute Max gradient: 10%P_{Emax}/min, For non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min, For recorded gradient see diagram below,	

	Frequency conditions	
d) Start up for frequency range	<49,45 Hz for twice of setting observation time	>50,15 Hz for twice of setting observation time
Connection:	No connection	No connection
Limit	No connection allowed	
e) In frequency range at start-up	≥49,45 Hz within twice of setting observation time	≤50,15 Hz within twice of setting observation time
Reconnection time [s]	65,2 s	65,0 s
Limit:	Connected after setting delay time(≥60s)	
Gradient:	The maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute Max gradient: disable, For recorded gradient see diagram below,	
f) In frequency range after frequency failture	≥49,45 Hz for twice of setting observation time	≤50,25 Hz for twice of setting observation time
Reconnection time [s]	68,0 s	69,4 s
Limit:	Reconnection after setting observation time (≥60s)	
Gradient:	For adjustable micro generators the maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute Max gradient: 10%Pn/min, For non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min, For recorded gradient see diagram below,	

Test:

Test condition b) and c): voltage within the limits of 85% to 110%U_n,

Test condition e): frequency within the limits of 49,50Hz to 50,1Hz,

Test condition f): frequency within the limits of 49,50Hz to 50,2Hz,

In order to avoid continuous starting and disengaging operations of the interface protection relay, the disengaging value of frequency and voltage functions shall be above 2 % deviating from the operate value,

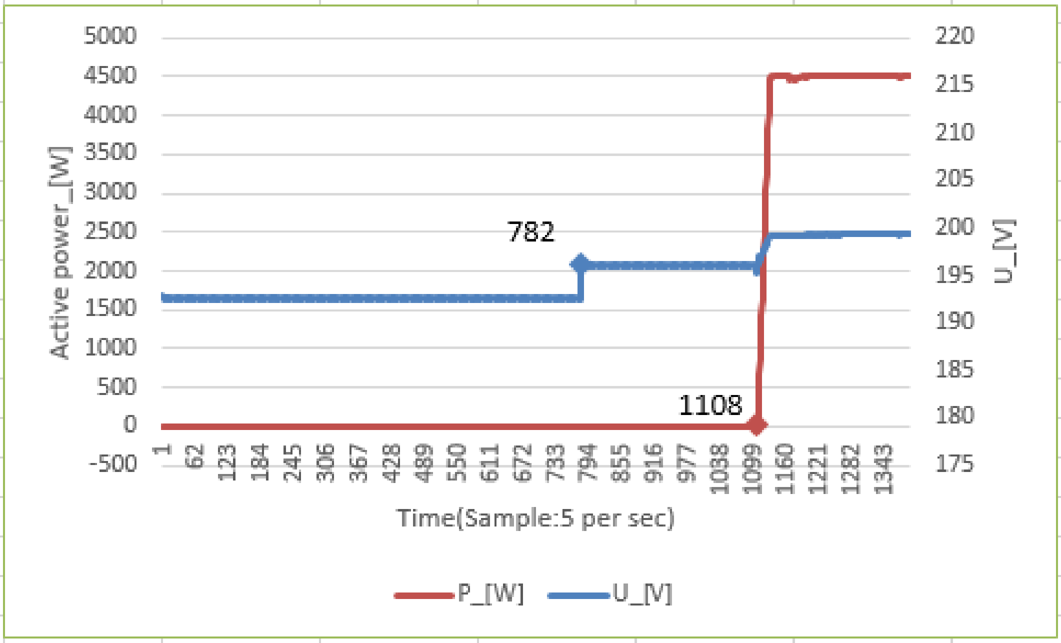
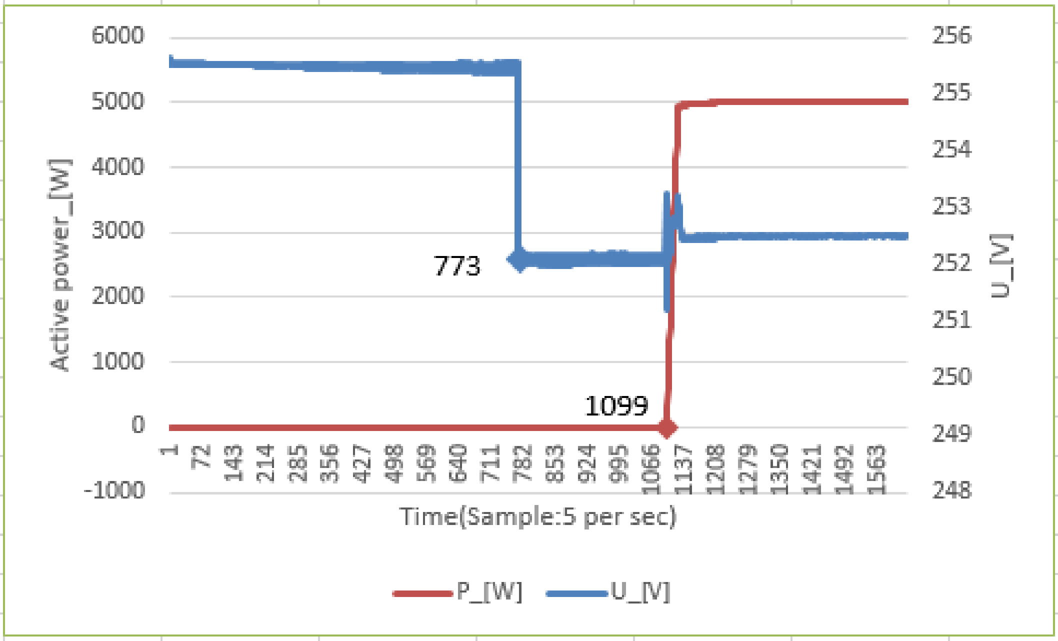
The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Assessment criterion:

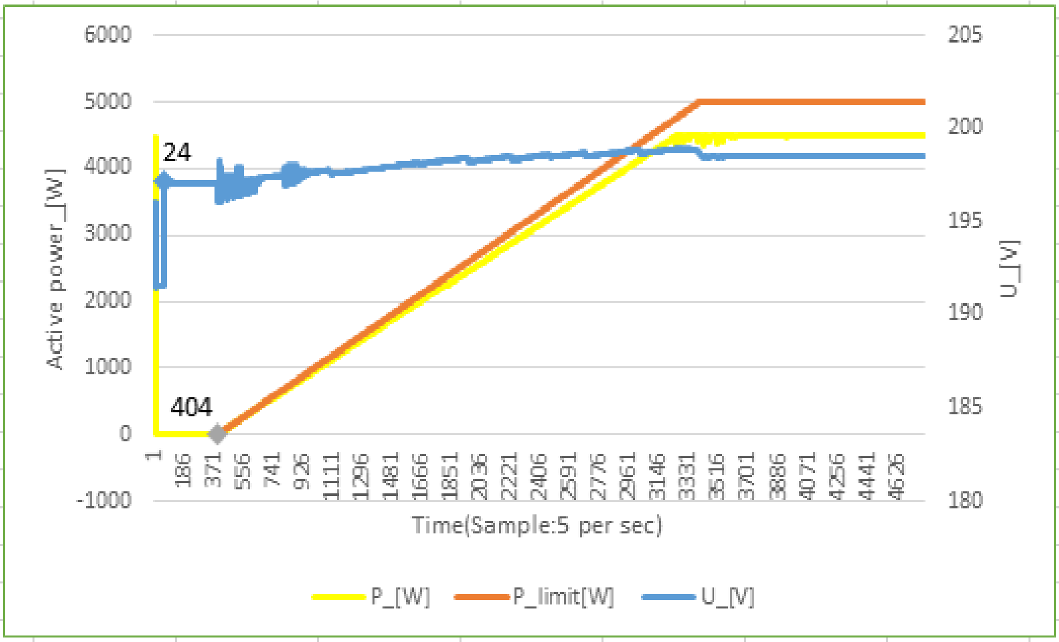
a) the micro generator connects respectively starts generating electrical power only in the permitted range of voltage and frequency and

b) for adjustable micro generators the maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute and

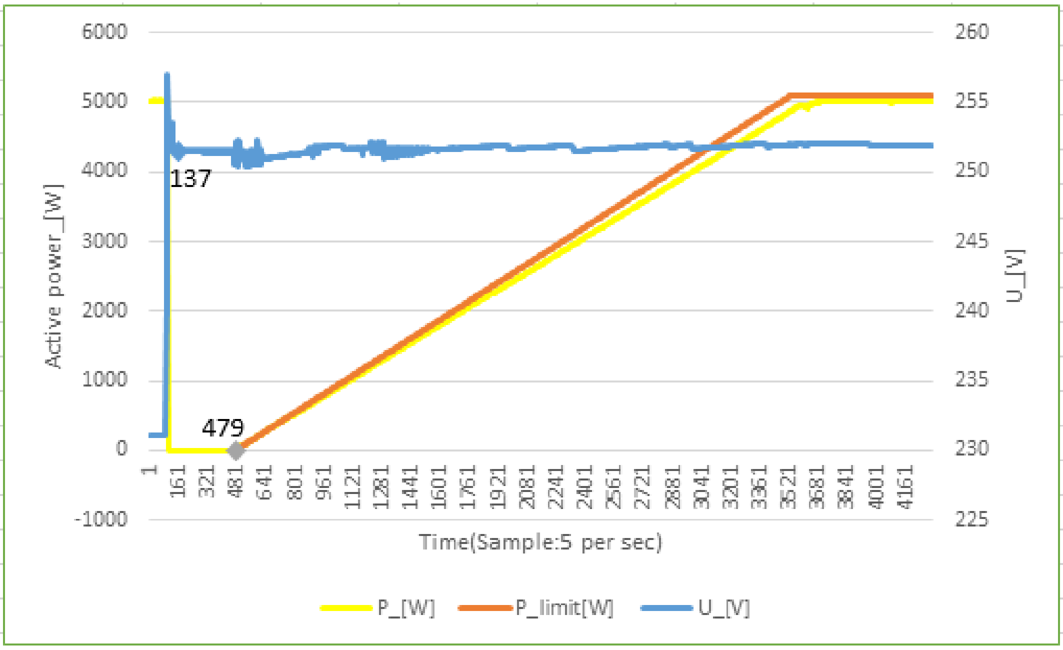
c) for non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min.

Graph of the gradual power supply : Test b) for ≥ 84% U_n

Graph of the gradual power supply : Test b) for ≤ 111% U_n


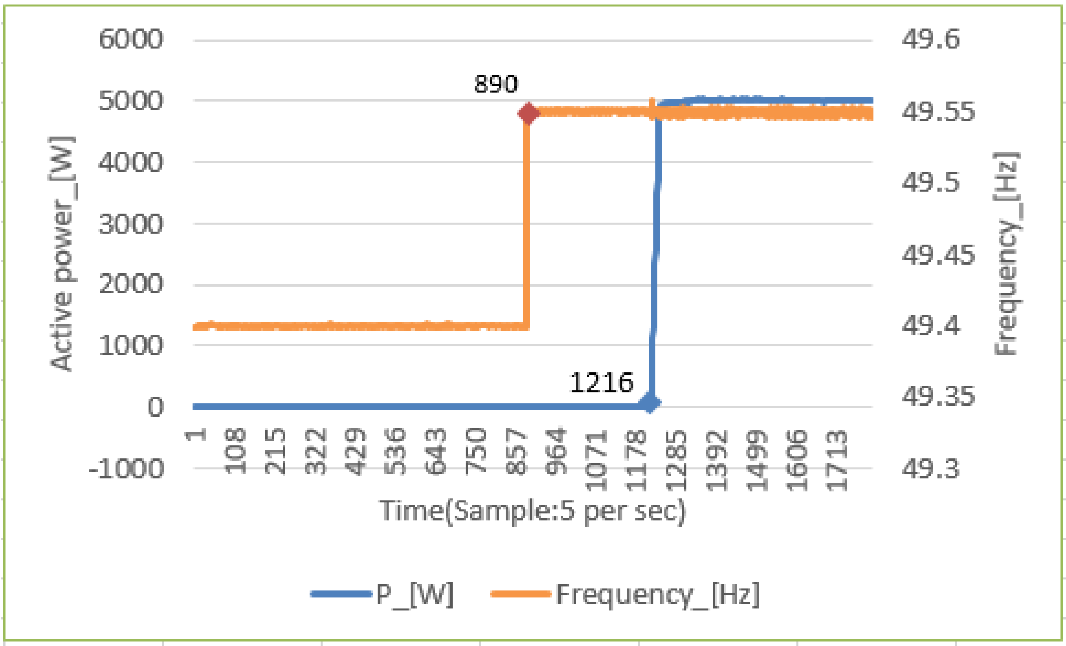
Graph of the gradual power supply : Test c) for ≥ 84% U_n



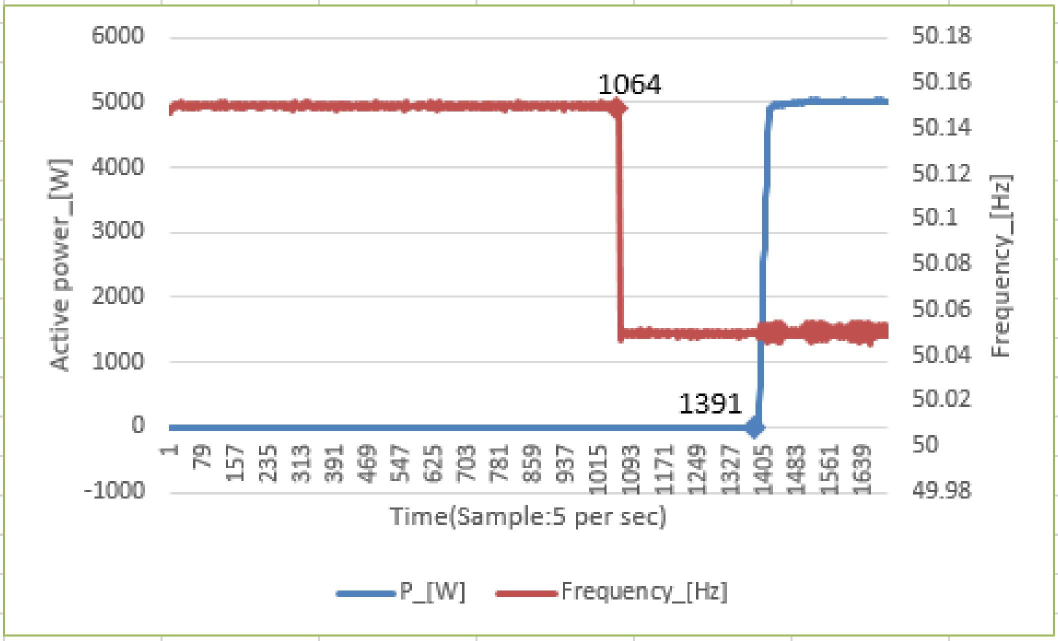
Graph of the gradual power supply : Test c) for ≤ 111% U_n



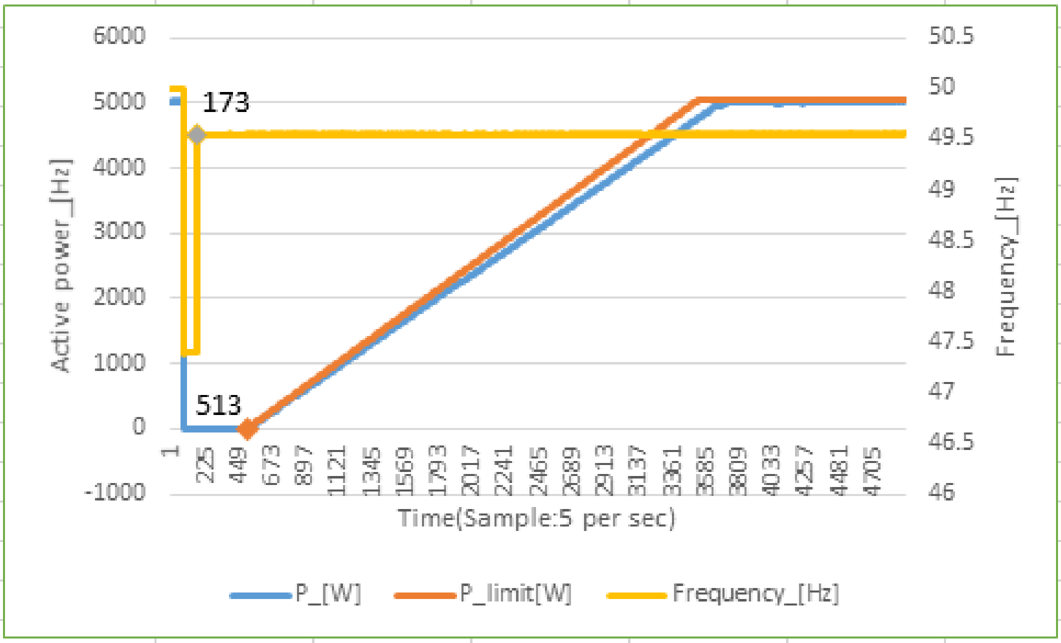
Graph of the gradual power supply : Test e) for ≥ 49,45Hz



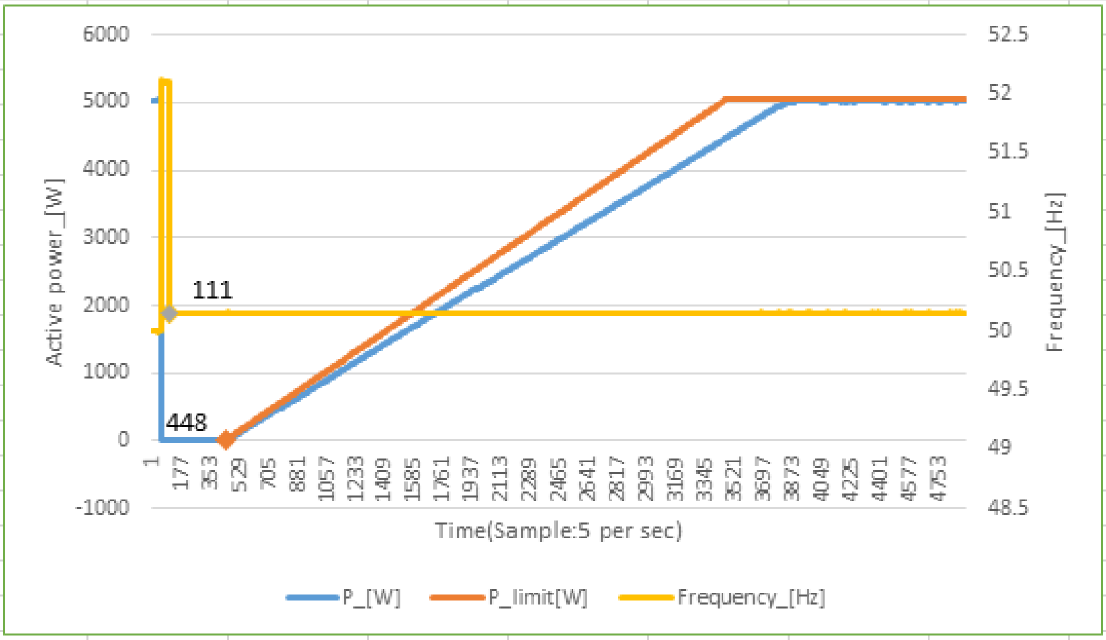
Graph of the gradual power supply : Test e) for ≤ 50,15Hz



Graph of the gradual power supply : Test f) for ≥ 49,45Hz



Graph of the gradual power supply : Test f) for ≤ 50,25Hz



EN 50549-1:2019: Ceasing and reduction of active power on set point			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.11.1	Ceasing active power	CEI 0-21:2019-04, Annex A.4.3.3.2	**P**
4.11.2	Reduction of active power on a set point	FGW TG3, Revision 25, clause 4.1.2	**P**

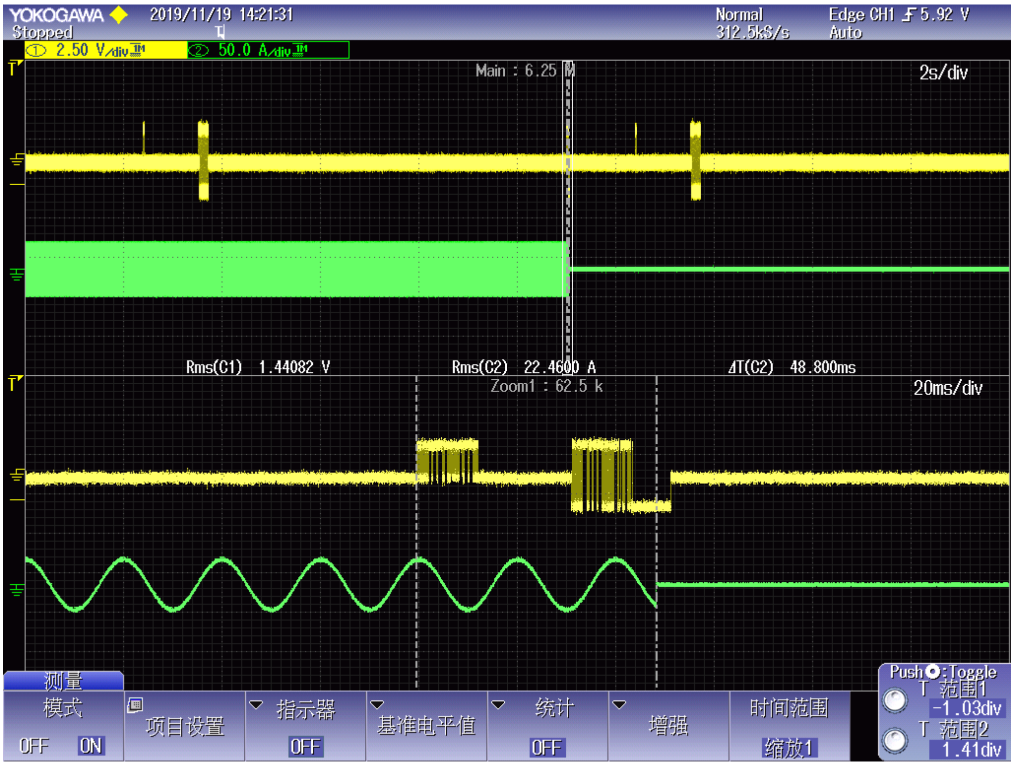
4.11.1	**Ceasing active power**	**P**
Operating time of the monitoring device		
Test:	Remote tripping signal for the external disconnection	
Limit [s]:	5 s	
Reaction time of the tripping value [s]:	0,049 s	

Note:

The test method refer to Annex A,4,3,2 of CEI 0-21:2019-04,
Generating plants shall be equipped with a logic interface (input port) in order to cease active power output within five seconds following an instruction being received at the input port, If required by the DSO, this includes remote operation.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Graph



4.11.2	**Reduction of active power on set point**			**P**

Test result:

Setpoint power bin [% P_{Emax}]	P_{set} [kW]	P_{60} [kW]	Deviation [% P_{Emax}]
100%	5,000	5,024	0,48
90%	4,500	4,506	0,12
80%	4,000	3,998	-0,04
70%	3,500	3,493	-0,14
60%	3,000	2,989	-0,22
50%	2,500	2,487	-0,26
40%	2,000	2,003	0,06
30%	1,500	1,495	-0,10
20%	1,000	0,986	-0,28
10%	0,500	0,477	-0,46
5%	0,250	0,235	-0,30

	Setpoint power bin [% P_{Emax}]	Deviation [% P_{Emax}]
Max, deviation	10%	0,48
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 5 % of P_{Emax}	

Test:

The setpoint signal must be reduced from 100% to 0% P_{Emax}:

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

b) For all other PGUs, in line with their adjustable steps, 5 minutes must elapse after the setpoint setting is changed so that the PGU can settle at the new setpoint, Then the active power of the PGU must be measured as a 1-min mean value,

Assessment criterion:

a) for adjustable PGUs:

- no network disconnection
- the active power value does not exceed the setpoint by more than 5% P_{Emax}
- the setting time determined this way is ≤ 1min

b) For all other PGUs:

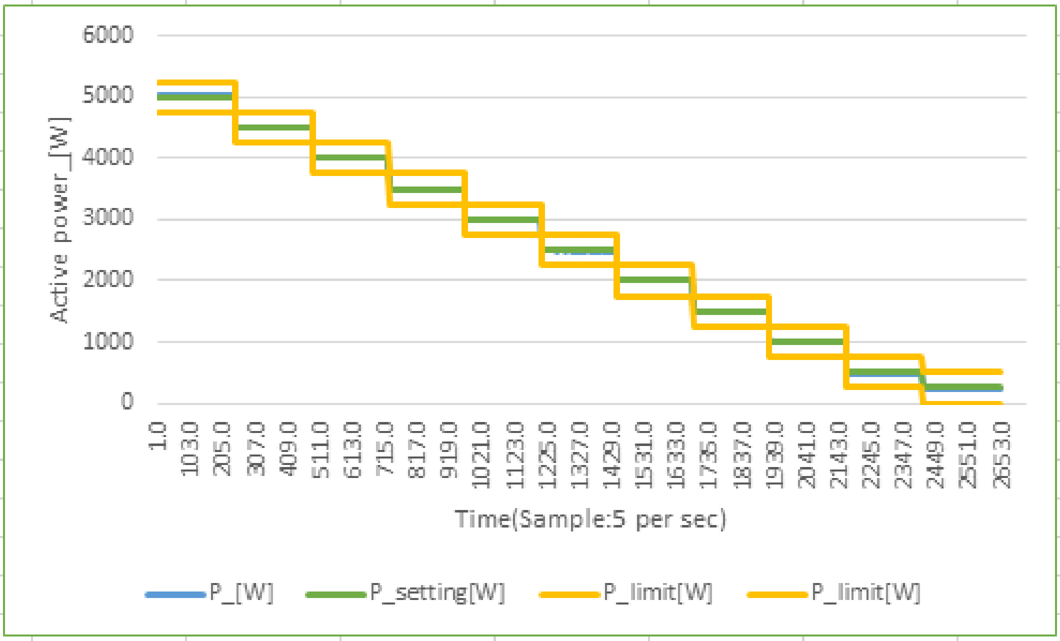
- the active power value does not exceed the setpoint by more than 5% P_{Emax} or
- the setpoint is fallen below within 5 minutes or the PGU has switched off

Note:

The setting time is ≤ 1min, See below “Graph of the setting accuracy”.

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Graph of active power on set point



EN 50549-1:2019			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.13	Requirements regarding single fault tolerance of interface protection system and interface switch	VDE V 0124-100:2019-02 (Draft), clause 5.5.2	**P**

4.13	Requirements regarding single fault tolerance of interface protection system and interface switch	P

Component No,	Fault	Test condition		Test time	Fuse No,	Fault condition		Result
		AC	DC			AC	DC	
Bus Voltage detector (R119)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start. No error code.No harzard happened.
Iverter Voltage detector (R238)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start. Error 3 Relay check fail.No harzard happened.
Grid/AC Voltage detector (R201)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start.Error 34 AC voltage check fail. No harzard happened.
Grid/AC Voltage detector (R212)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start.Error 34 AC voltage check fail. No harzard happened.
Grid/AC Voltage detector (R248)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start.Error 34 AC voltage check fail. No harzard happened.
Grid/AC Current detector (R223)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start. No error code.No harzard happened.
DC isolation device function detector (R620)	o-c before start up	230V 0,01A	487V 0,01A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 38 ISO check fail. No harzard happened.
DC isolation device function detector (Q601 D-S)	s-c before start up	230V 0,01A	487V 0,01A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 38 ISO check fail. No harzard happened.
DC isolation device function detector (R605)	o-c before start up	230V 0,01A	487V 0,01A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 38 ISO check fail. No harzard happened.
DC isolation device function detector (R618)	o-c before start up	230V 0,01A	487V 0,01A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 38 ISO check fail. No harzard happened.
DC isolation device function detector (R639)	o-c before start up	230V 0,01A	487V 0,01A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 38 ISO check fail. No harzard happened.

Component No,	Fault	Test condition		Test time	Fuse No,	Fault condition		Result
		AC	DC			AC	DC	
DC isolation device function detector (R615)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 38 ISO check fail. No harzard happened.
Residual current detector (R275)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 9 GFCI check fail. No harzard happened.
Residual current detector (R226)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 9 GFCI check fail. No harzard happened.
Residual current detector (R227)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 9 GFCI check fail. No harzard happened.
Residual current detector (R228)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 9 GFCI check fail. No harzard happened.
Relay 201	s-c before start up	230V 0,01A	487V 0,01A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 3 Relay check fail. No harzard happened.
Relay 202	s-c before start up	230V 0,01A	487V 0,01A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 3 Relay check fail. No harzard happened.
Relay 203	s-c before start up	230V 0,01A	487V 0,01A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 3 Relay check fail. No harzard happened.
Relay 204	s-c before start up	230V 0,01A	487V 0,01A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 3 Relay check fail. No harzard happened.
Relay function detector (Q405 D-S)	s-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE didn't start. Error 3 Relay check fail. No harzard happened.
Inverter drive (R301)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start.Error 4 DCI protestion. No harzard happened.
Inverter drive (R309)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start.Error 4 DCI protestion. No harzard happened.

Component No,	Fault	Test condition		Test time	Fuse No,	Fault condition		Result
		AC	DC			AC	DC	
Inverter drive (R313)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start.Error 4 DCI protestion. No harzard happened.
Main CPU oscillator (R749)	s-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start.No error code. No harzard happened.
MainCPU and slave CPU communicatio n (R792)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start.No error code. No harzard happened.
MainCPU and slave CPU communicatio n (R765)	o-c	230V 21,7A	380V 13,2A	30min	-	230V 0,01A	487V 0,01A	The PCE shut down.The PCE didn't start.No error code. No harzard happened.
The errors in the control circuit simulate that the safety is even under one error ensured,								
Addendum – Shutdown device								
Each active phase can be switched, (L and N)								Yes
If no galvanic separation between AC and DC (PV): Two relays in series on each active phase are necessary to fulfil the basic insulation or simple separation based on the PV working voltage,								Two relays in series on each active phase

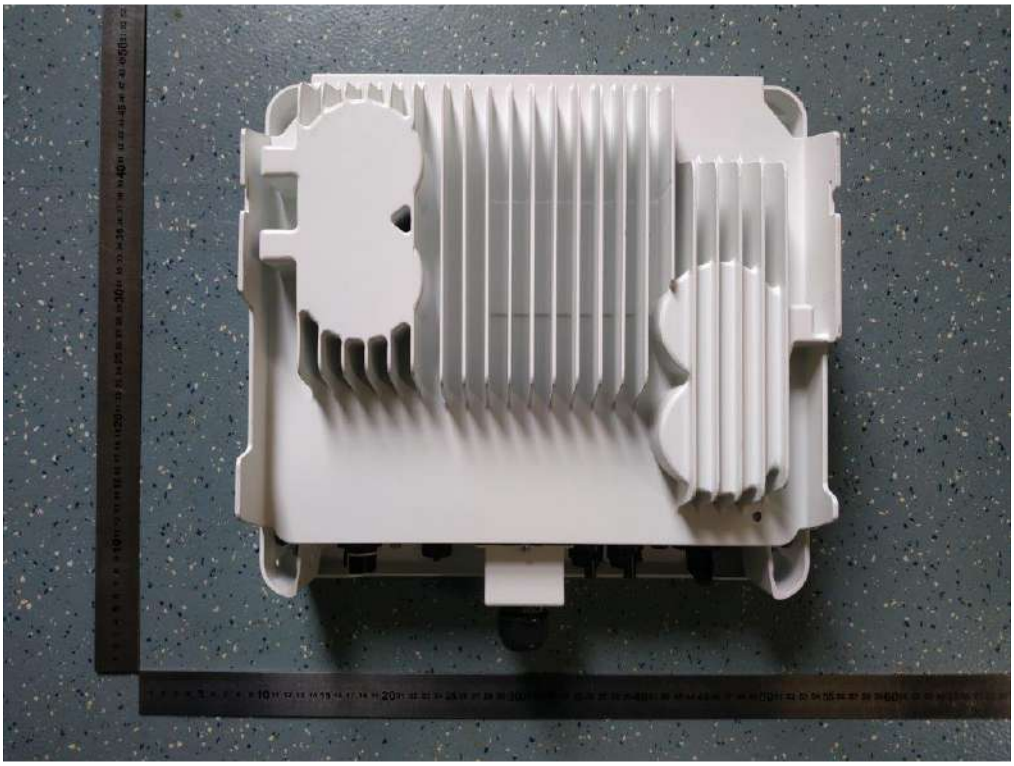
Note:

The test had been performed on the model ASW5000-S, the test results are valid for the ASW3000-S, ASW3680-S, ASW4000-S since it is identical in hardware and software.

Annex No, 3
Pictures of the unit

Enclosure front view

Enclosure rear view

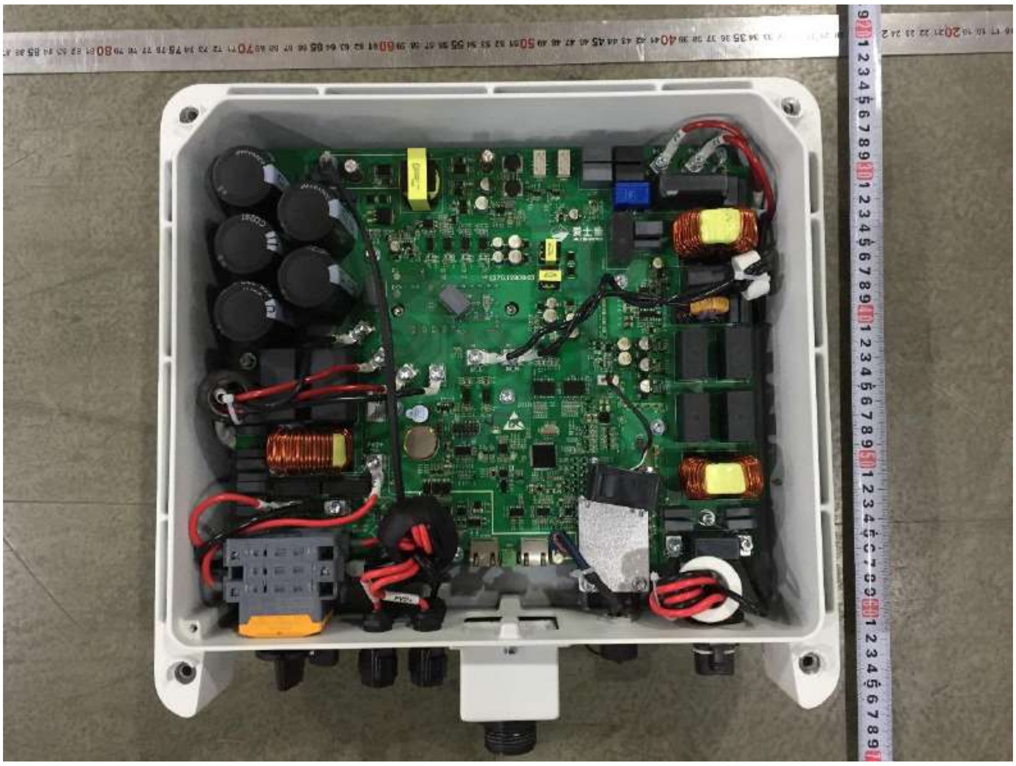


Enclosure Bottom view

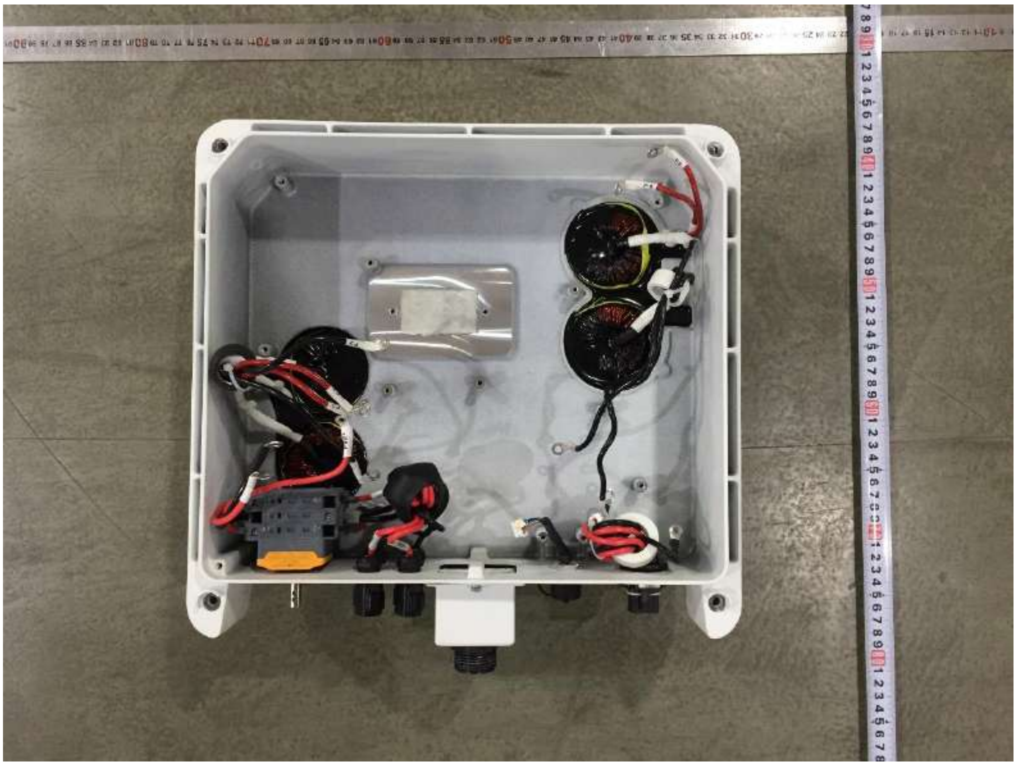
Enclosure side view-1

Enclosure side view-2

Internal view 1



Internal view 2



Main board -component side view

Main board-solder side view

Annex No, 4

Test Equipment list

Date(s) of performance test: 2019-11-14 to 2019-12-13

Equipment	Internal No,	Manufacturer	Type	Serial No,	Calibration is valid to
Power analyzer	SCGJ296	YOKOGAWA	WT1800	//	Feb. 14, 2020
Oscilloscope	SCGJ417	YOKOGAWA	DLM2024	//	Feb. 14, 2020
	SCGT208	Agilent	DSO7014B	//	Feb. 14, 2020
AC Source	656038001333	CHROMA	6560	//	Monitored by Power analyzer
DC Simulation Power supply	62150EF01095	CHROMA	62150H-1000S	//	
	62150EF01095	CHROMA	62150H-600S	//	
RLC load	93V002581	Qunling	ACTL-3803H	//	
AC/DC Current probel	ZSCGJ0161	Tektronix	A622	//	Feb. 14, 2020
Differential probel	P5200A	Tektronix	P5200A	//	Feb. 14, 2020
Multi-meter	SCGJ334	Fluke	F287	//	Feb. 14, 2020