TESTING FOR THE VERIFICATION OF COMPLIANCE OF MICROINVERTER WITH:

EN 50549-1: 2019:

REQUIREMENTS FOR GENERATING PLANTS TO BE CONNECTED IN PARALLEL WITH DISTRIBUTION NETWORKS - PART 1: CONNECTION TO A LV DISTRIBUTION NETWORK - GENERATING PLANTS UP TO AND INCLUDING TYPE B

(REQUIREMENTS FOR PLANTS TYPE B)

Test Report Number ....:	SUEE240500006451
Type ....:	Microinverter
Tested Mark ....:	ABSAAR®
Trade Models ....:	AB800A
Variant Models ....:	AB400A, AB600A

APPLICANT

Name...:	D&W The Motion Corporation GmbH&Co.KG
Address ....:	Dückerweg 21, 44867 Bochum, Germany

TESTING LABORATORY

Name...:	**SGS-CSTC Standards Technical Services Co., Ltd. Suzhou Branch**
Address ....:	1/F., Building 12, Xinxing Industry Park, No.78, Xinglin Street, Suzhou Industrial Park, Suzhou, Jiangsu, China

Conducted (tested) by .... :	Horace Hao (Project Engineer)	Horace Hao
Approved by ....:	Colin Chen (Technical Reviewer)	[signature]
Date of issue ....:	2024/05/30	
Number of pages ....:	148	

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Data Provided By The Client:

The following data has been provided by the applicant:

1. Any information regarding technical characteristics of the equipment (ratings, operation modes, software and hardware versions, dimensions and weight).
2. Equipment operation & construction information (manuals, electrical diagrams, information about components, operation procedures).
3. Documental information (brand and models names, address or other information about applicant, company or manufacturer).
4. Other information remarked within this report.

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Test Report Historical Revision:

Test Report Version	Date	Resume
SUEE240500006451	2024/05/30	First issuance. **Remarks:** According to the declaration from the applicant, the only difference between the EUT (test samples in this report) and testing sample of report SUEE240400004851, which was issued by SGS-CSTC Standards Technical Services Co., Ltd. Suzhou Branch as below: -Update applicant, manufacturer, trademark, models name, label, appearance and equipment type ect. After evaluation, no clause needs to retest. All test data originate from the report SUEE240400004851, SGS-CSTC Standards Technical Services Co., Ltd. Suzhou Branch.

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1. SCOPE

SGS-CSTC Standards Technical Services Co., Ltd. Suzhou Branch has been contracted by D&W The Motion Corporation GmbH&Co.KG, in order to perform the testing according to the EN 50549 – 1: 2019: Requirements for generating plants to be connected in parallel with distribution networks - part 1: connection to a LV distribution network - generating plants up to and including type B.

The tests offered at this test report evaluate the EUT compliance with the requirements of **Type B.**

2. GENERAL INFORMATION

2.1. Testing Period and Climatic conditions

The necessary testing has been performed between November 16th of 2023, February 17th and April 10th of 2024.
All the tests and checks have been performed at climatic conditions:

Temperature	25 ± 5 ºC
Relative Humidity	50 ± 10 %
Pressure	96 ± 10 kPa

2.2. Equipment under Testing

Apparatus type .... : Microinverter

Installation .... : Fixed installation

Manufacturer .... : D&W The Motion Corporation GmbH&Co.KG

Trade mark .... : ABSAAR®

Model / Type reference .... : AB800A

Serial Number .... : WWA2344068

Software Version .... : DH01.001-000-000

Rated Characteristics .... : DC Input: MPPT 33~55 Vdc (60 Vdc max.), 14 A*2 Maximum.
AC Output: 230 Vac, 50 Hz, 3.48 A, 800 W.

Date of manufacturing: 2023

Test item particulars

Input ....: DC

Output .... AC, L/N/PE

Class of protection against electric shock...: Class I

Degree of protection against moisture ....: IP67

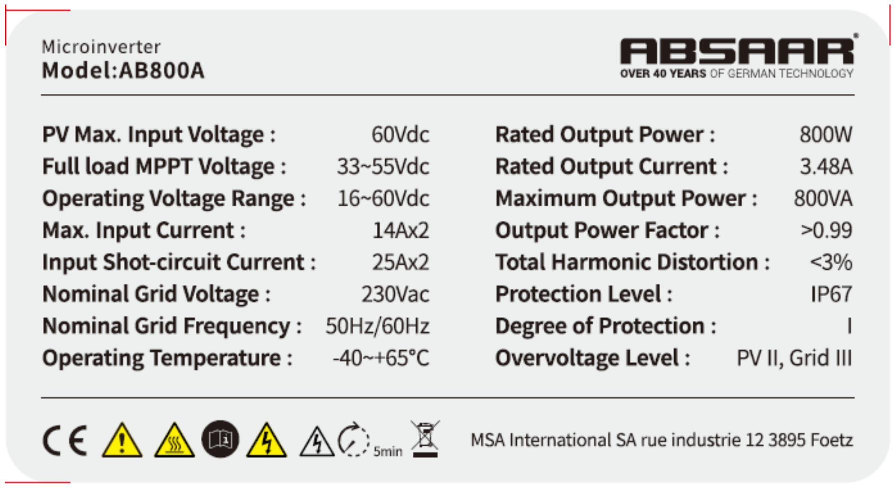
Type of connection to the main supply ....: Single phase – Fixed installation

Cooling group..: Natural Cooling

Modular ....: No

Internal Transformer ....: Yes

Copy of marking plate (representative):



Note:

1.The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.

2.Label is attached on the back of enclosure and visible after installation

3.Labels of other models are as the same with **AB800A**’s except for the parameters of rating.

Equipment Under Testing:

– **AB800A**

Variant models:

- AB400A
- AB600A

The variant models have been included in this test report without tests because the following features don´t change regarding to the tested model:

- Same connection system and hardware topology.
- Same control algorithm.
- Output power within 1/√10 and 2 times of the rated output power of the EUT or Modular inverters.
- Same Firmware Version.

The models of AB400A, AB600A and AB800A are identical on topological schematic circuit diagram and control solution codes.

The results obtained apply only to the particular sample tested that is the subject of the present test report.

The most unfavorable result values of the verifications and tests performed are contained herein.

Throughout this report a point (~~comma~~) is used as the decimal separator.

Following table shows the full ratings of all the models referenced in this report, marked in **bold letters** is the one subjected to testing:

Model	AB400A	AB600A	**AB800A**
PV Input			
Number of MPPT Trackers	2		
Max. Input Voltage	60 Vdc		
Start-up Operating Voltage	30 Vdc		
Operating Voltage Range	16V-60 Vdc		
MPPT Voltage Range	33V-55 Vdc		
Max. Input Current	7 A * 2	12 A * 2	14 A * 2
Max. Short Current	15 A * 2	20 A * 2	25 A * 2
AC Output			
Nominal Grid Voltage	L/N/PE, 230Vac		
Nominal Grid Frequency	50 Hz		
Rated AC Power	400 W	600 W	800 W
Max. AC Power	400 VA	600 VA	800 VA
Rated AC Current	1.74 A	2.60 A	3.48 A
Output Power Factor	>0.99		
General Data			
Operating temperature range	-40 ºC ~ +65 ºC		
Protection degree	IP67		
Protective class	Class I		
Altitude	Max. 2000m		
Cooling method	Natural Cooling		
Topology	Transformer		

2.3. Reference Values

The values presented in the following table have been used for calculation of referenced values (p.u.; %) through the report.

Reference Values for the EUT	
Rated power, **Pn** in W	800
Design active power, **P_D** in W (1)	720
Maximun apparent power, **S max** in VA	800
Rated wind speed (only WT), **vn** in m/s	N/A
Rated current, **In** in A	3.48
Rated output voltage, (Line to Neutral) **Un** in Vac	230
Note: In this report p.u. values are calculated as follows: -For Active & Reactive Power p.u values are reference to **Sn** -For Currents p.u values, the reference is always **In** -For Voltages p.u values, the reference is always **Un**	

(1) Manufacturer's declaration**:** P_D equals to 0.9 times of Rated AC Output power, according to measured $P_D \approx 0.9Pn$ (720 W)

2.4. TEST EQUIPMENT LIST

From	No.	Equipment Name	Trademark / Model No.	Equipment No.	Calibration Period
SGS	1	Power analyzer	ZLG/PA6004H-P0004-2159	SUZE600303	2023/11/05 to 2024/11/04
	2	Digital Oscilloscope	Tektronix / MSO46 4-BW-500	ATC550903	2023/07/13 to 2024/07/12
	3	Oscilloscope probe	Tektronix/C188090	ATC550904	2023/08/08 to 2024/08/07
	4	Current probe	HIOKI/CT6873	SUZE600807	2023/09/08 to 2024/09/07
	5	Current probe	HIOKI/CT6873	SUZE600808	2023/09/08 to 2024/09/07
	6	Voltage probe	CYBERTEK/ CP1000A	SUZE600801	2023/09/08 to 2024/09/07
	7	Voltage probe	CYBERTEK/ CP1000A	SUZE600802	2023/09/08 to 2024/09/07
	8	Temperature & Humidity meter	Testo/ 175-H1	SUZE601701	2023/05/09 to 2024/05/08
	9	Power analyzer	DEWTRON/ TRIONet	SUZE600302	2023/08/10 to 2024/08/09

Note: Voltage direct measurement through power analyzer, the voltage probes and current probe were used with the digital oscilloscope. All measurement equipment was used inside their corresponding calibration period. Copy of all calibration certificates are available at the laboratory for reference.

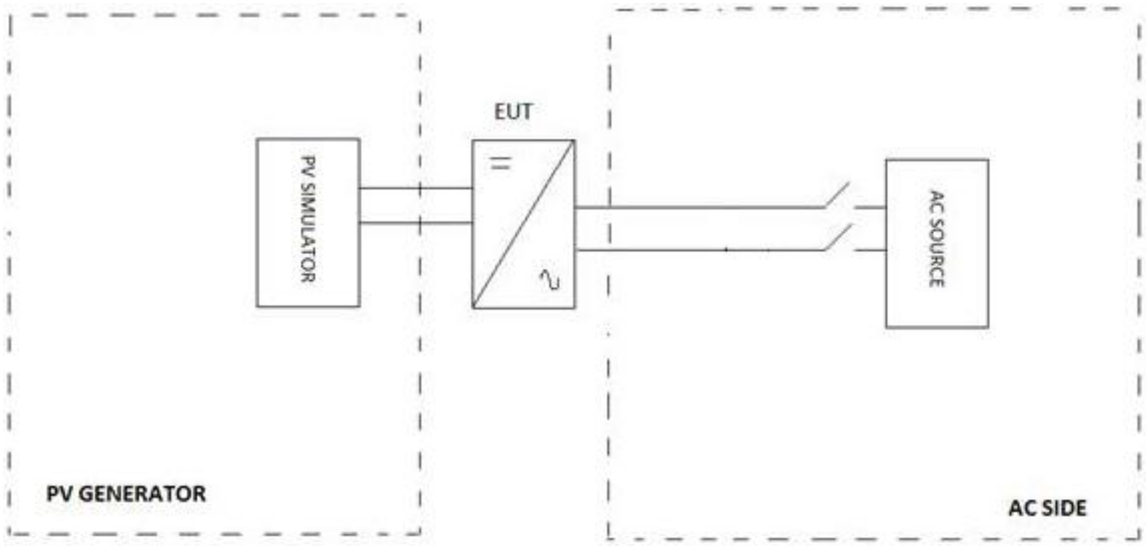
2.5. MEASUREMENT UNCERTAINTY

Associated uncertainties through measurements showed in this report are the maximum allowable uncertainties.

Magnitude	Uncertainty
Voltage measurement	±1.5 %
Current measurement	±2.0 %
Frequency measurement	±0.2 %
Time measurement	±0.2 %
Power measurement	±2.5 %
Phase Angle	±1 º
Temperature	±3 ºC
Note1: Measurement uncertainties showed in this table are maximum allowable uncertainties. The measurement uncertainties associated with other parameters measured during the tests are in the laboratory at disposal of the petitioner. Note2: Where the standard requires lower uncertainties that those in this table. Most restrictive uncertainty has been considered.	

2.6. TEST SET UP OF THE DIFFERENT STANDARD

Below is the simplified construction of the test set up.



Different equipments have been used to take measures as shown in chapter 2.4. Current clamps and vltage probes have been connected to the inverter input / output for all the tests.

All the tests described in the following pages have used this specified test setup.

The test bench used includes:

EQUIPMENT	TRADEMARK / MODEL	RATED CHARACTERISTICS	OWNER / ID.CODE
AC source	WAGO / WLPA-330150kVA-D-W	60 kVA max. 45-65 Hz	SUZE600101
DC source	EA/PSI 11500-60	1500V, 60A max.	SUZE600201
RLC load	KAIXIANG / AC400V-450.99kVA-RLC	450 kW, 450kvar	SUZE660101

2.7. FACTORY INFORMATION

Factory Name...: Shenzhen Donnergy Technology Co., Ltd

Factory Address..: 6F Building 8, Xianan Third Industrial Zone, Shangcun Community, Gongming Street, Guangming District, Shenzhen, China

2.8. DEFINITIONS

EUT	Equipment Under Testing	Hz	Hertz
A	Ampere	V	Volt
Un	Nominal Voltage	p.u	Per unit
In	Nominal Current	Pn	Rated Active Power
Ia	Active Current	Qn	Rated Reactive Power
Ir	Reactive Current	Sn	Rated Apparent Power
MV	Medium Voltage	THC	Total Harmonic Current
LV	Low Voltage	TDD	Total Demand Distortion
UVRT	Under-Voltage Ride Through	I_h	Harmonic Current
OVRT	Over-Voltage Ride Through	Plt	Severity of Flicker Long-Term
Pst	Severity of Flicker Short-Term	ms	Millisecond
dc	Maximum Variation of Voltage	s	Second
d max	Maximum Absolute Value of	min	Minute
	Voltage Variation	P	Active Power
fn	Nominal frequency	Q	Reactive Power
IGBT	Insulated-Gate Bipolar Transistor	PF	Power Factor
RMS	Root Mean Square	Nr.	Number
$S_{k,fic}$	Short-circuit apparent power	POC	Point of Connection
AC	Alternating Current	Meas.	Measured
DC	Direct Current	Des.	Desired
DSO	Distribution System Operator	PGU	Power Generating Unit
EESS	Electrical energy storage system	P_D	Design active power
EES	Electrical energy storage	P_M	Momentary active power
Pmax	Maximum active power	Smax	Maximum apparent power
P_A	Available active power		

3. RESUME OF TEST RESULTS

INTERPRETATION KEYS

Test object does meet the requirement.................: **P** Pass
Test object does not meet the requirement ....: **F** Fails
Test case does not apply to the test object...........: **N/A** Not applicable
To make a reference to a table or an annex.........: See additional sheet
To indicate that the test has not been realized.....: **N/R** Not realized

EN 50549-1:2019 – Requirements for plant category Type B have been considered.				
REPORT SECTION	**STANDARD SECTION**	**CHAPTER OF THE STANDARD**	**Plant category**	**Result**
4.1	4.4	Normal operating range	--	--
4.1.1	4.4.2	Operating frequency range	≥A	P
4.1.2	4.4.3	Minimal requirement for active power delivery at underfrequency	≥A	P
4.1.3	4.4.4	Continuous operating voltage range	≥A	P
4.2	4.5	Immunity to disturbances	≥A	P
4.2.1	4.5.2	Rate of change of frequency (ROCOF) immunity	≥A	P
4.2.2	4.5.3	Under-voltage ride through (UVRT)	B	P
4.2.3	4.5.4	Over-voltage ride through (OVRT)	≥A	P
4.3	4.6	Active response to frequency deviation	≥A	P
4.3.1	4.6.1	Power response to overfrequency	≥A	P
4.3.2	4.6.2	Power response to underfrequency	≥A	N/A
4.4	4.7	Power response to voltage changes	≥A	P
4.4.1 and 4.4.2	4.7.2	Voltage support by reactive power	≥A	P
4.4.3	4.7.3	Voltage related active power reduction	≥A	P
4.4.4	4.7.4	Short circuit current requirements on generating plants	B	N/A
4.5	4.8	EMC and power quality	≥A	N/R (1)
4.5.1	4.8	Harmonic emissions	≥A	P
4.5.2	4.8	Flicker and voltage fluctuations	≥A	P
4.6	4.9	Interface protection	≥A	P
4.6.1	4.9.3	Requirements on voltage and frequency protection	≥A	P
4.6.2	4.9.4	Means to detect island situation	≥A	P
4.6.3	4.9.5	Digital input to the interface protection	≥A	P
4.7	4.10	Connection and starting to generate electrical power	≥A	P
4.7.1	4.10.2	Automatic reconnection after tripping	≥A	P
4.7.2	4.10.3	Starting to generate electrical power	≥A	P
4.7.3	4.10.4	Synchronization	≥A	P
4.8	4.11	Ceasing and reduction of active power on set point	≥A	P
4.8.1	4.11.1	Ceasing active power	≥A	P
4.8.2	4.11.2	Reduction of active power on set point	B	P
4.9	4.13 & 4.3	Requirements regarding single fault tolerance of interface protection system and interface switch	≥A	N/R (2)

Note: Decision Rule of Statements of conformity evaluated according to Guidelines ILAC G8:09/2019 and IEC 115:2023 (4.3.3 / 4.4) & ISO/IEC Guide 98-4 (8.3.12).
Decision Rules used: Binary Statement for Simple Acceptance (Guard Band with respect to the limit w=0).
Specific Risk: Probability of False Accept or Reject lower than 50 %, (PFA / PFR < 50 %)
Measurement uncertainty is not applied when statements of conformity is the simple acceptance.
For more information see ILAC G8/09 & 115 Guidelines.

The compliances with these requirements are stated in the following test reports:

(1) EN IEC 61000-6-3: 2021; EN IEC 61000-6-1: 2019: Test Report no.GZCR231100125005C02 , issued by SGS-SCTS Standards Technical Services Co., Ltd. Guangzhou Branch, on May 28 of 2024. NVLAP LAB CODE 200611-0.

(2) IEC 62109-1: 2010 and IEC 62109-2: 2011: Test Report no. GZES240100138501 and GZES240100138502, issued by SGS-SCTS Standards Technical Services Co., Ltd. Guangzhou Branch, on February 19 of 2024. GAC ATL 0032.

Conclusion: From the test results on the submitted sample, we conclude that it complies with the requirements of the standard.

4. TEST RESULTS

4.1. NORMAL OPERATING RANGE

4.1.1. Operating frequency range

The test has been performed according to the clause 4.4.2 of the standard, the requirement is as follows:

Table 1 — Minimum time periods for operation in underfrequency and overfrequency situations

Frequency Range	Time period for operation Minimum requirement	Time period for operation stringent requirement
47,0 Hz – 47,5 Hz	not required	20 s
47,5 Hz – 48,5 Hz	30 min [a]	90 min
48,5 Hz – 49,0 Hz	30 min [a]	90 min [a]
49,0 Hz – 51,0 Hz	Unlimited	Unlimited
51,0 Hz – 51,5 Hz	30 min [a]	90 min
51,5 Hz – 52,0 Hz	not required	15 min

[a] Respecting the legal framework, it is possible that longer time periods are required by the responsible party in some synchronous areas.

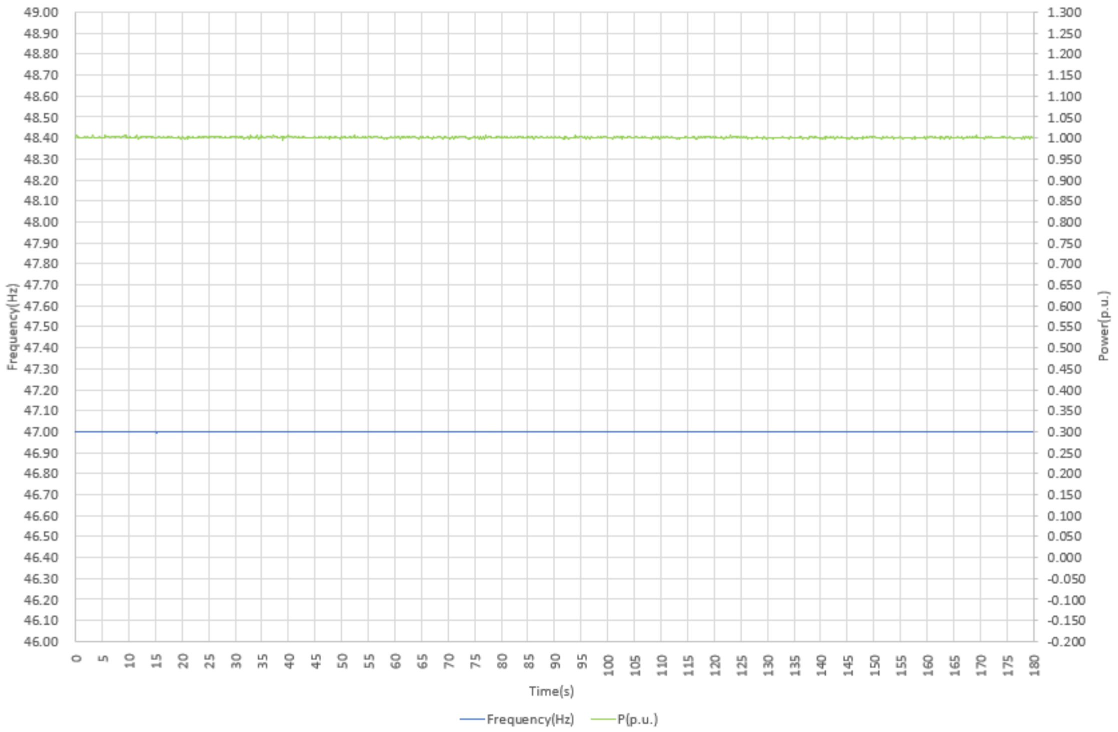
“Time period for operation, stringent requirement” (second column of the table) has been considered for this test.

In order to verify this function, parameter settings as in the following table have been considered to perform the test. Time requirements considered are the “stringent requirement” according to Table 1 of the standard:

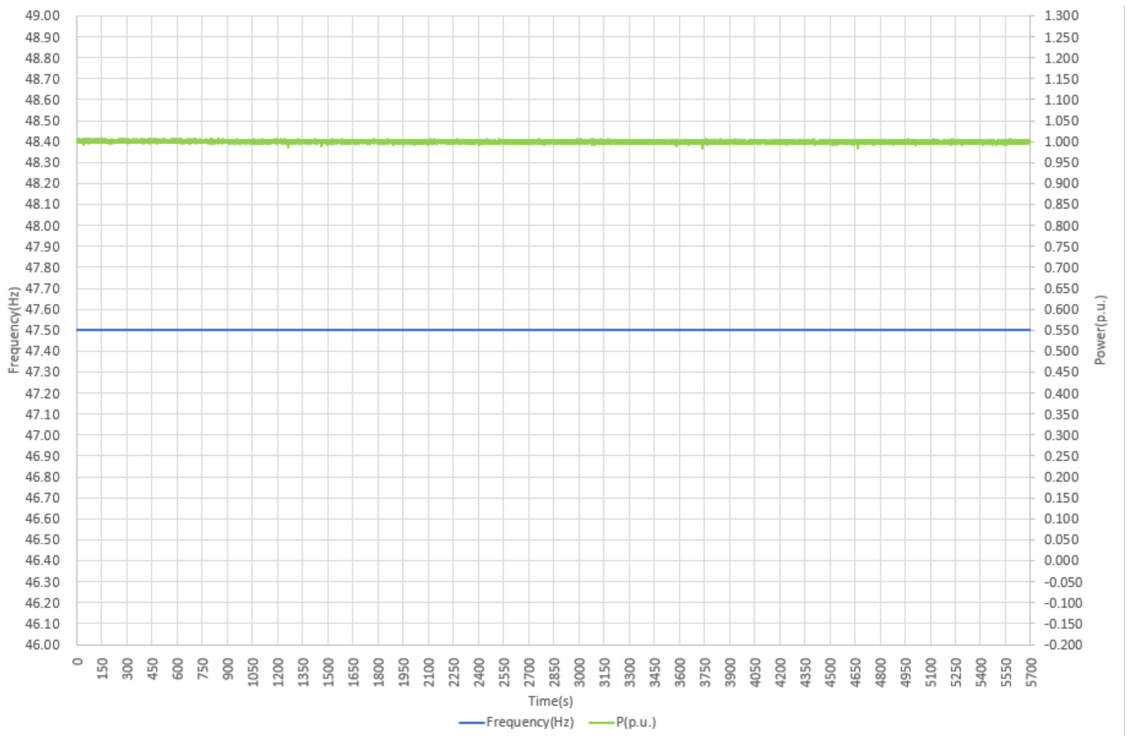
Steps	f (Hz) Setting	Time requirement	f Measured (Hz)	Time Measured (min)	Power measured (p.u.)
1	47.00	>20 s	47.00	3.00	1.002
2	47.50	>90 min	47.50	95.00	1.000
3	48.50	>90 min	48.50	100.00	1.007
4	50.00	Unlimited	50.00	2.83	1.006
5	51.50	>90 min	51.50	95.00	0.999
6	52.00	>15 min	52.00	16.50	1.003

Test results are represented at diagrams below.

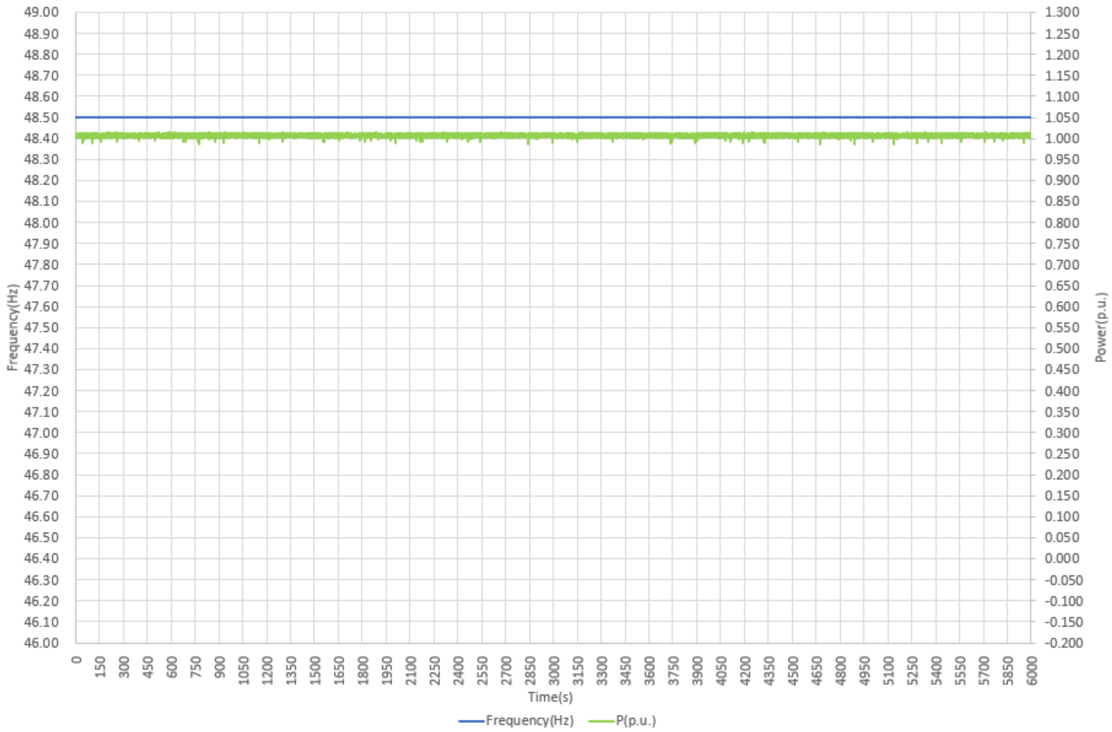
Test 1 - 47.0 Hz



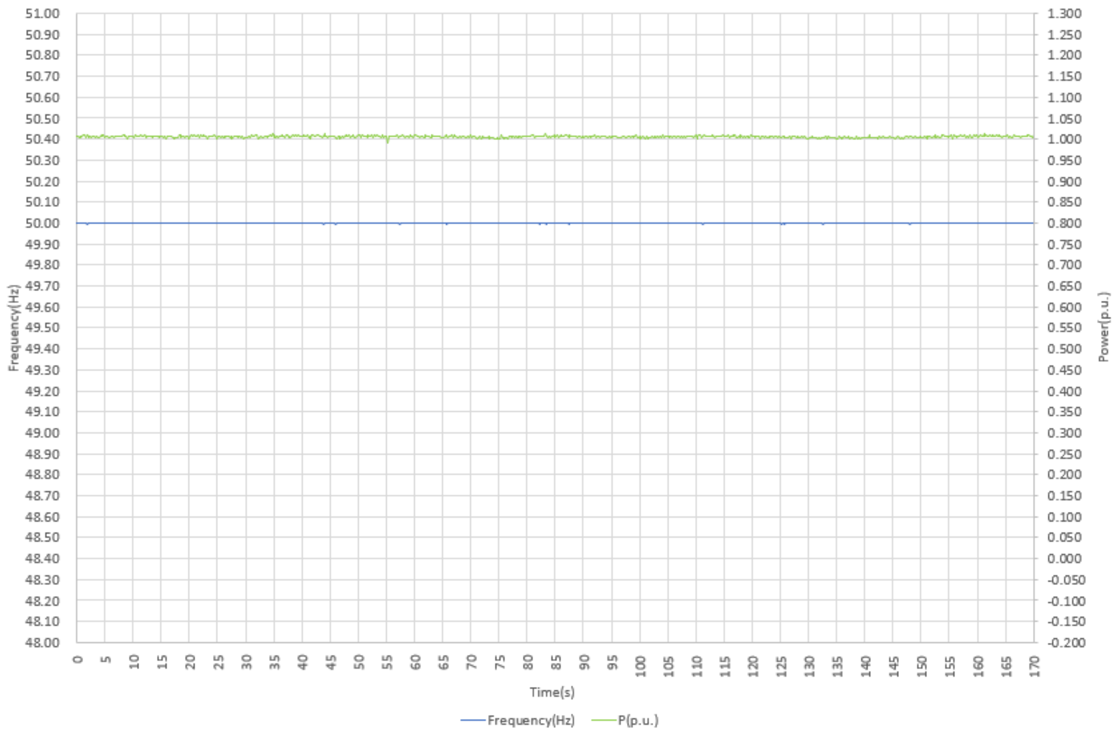
Test 2 - 47.5 Hz



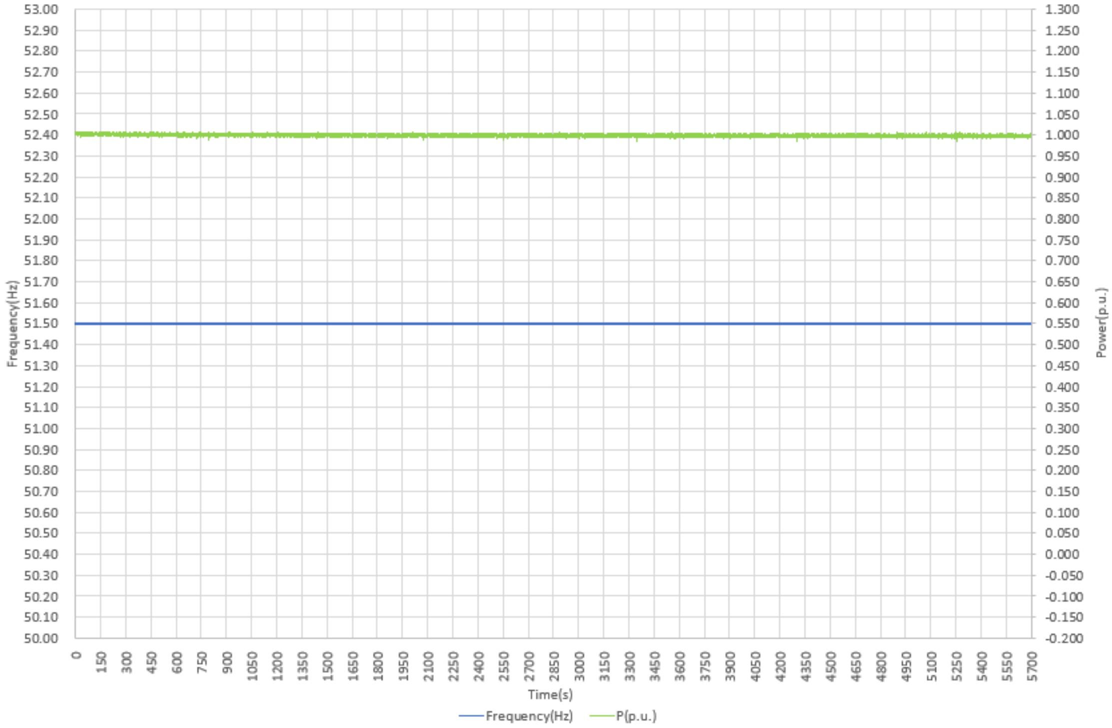
Test 3 - 48.5 Hz



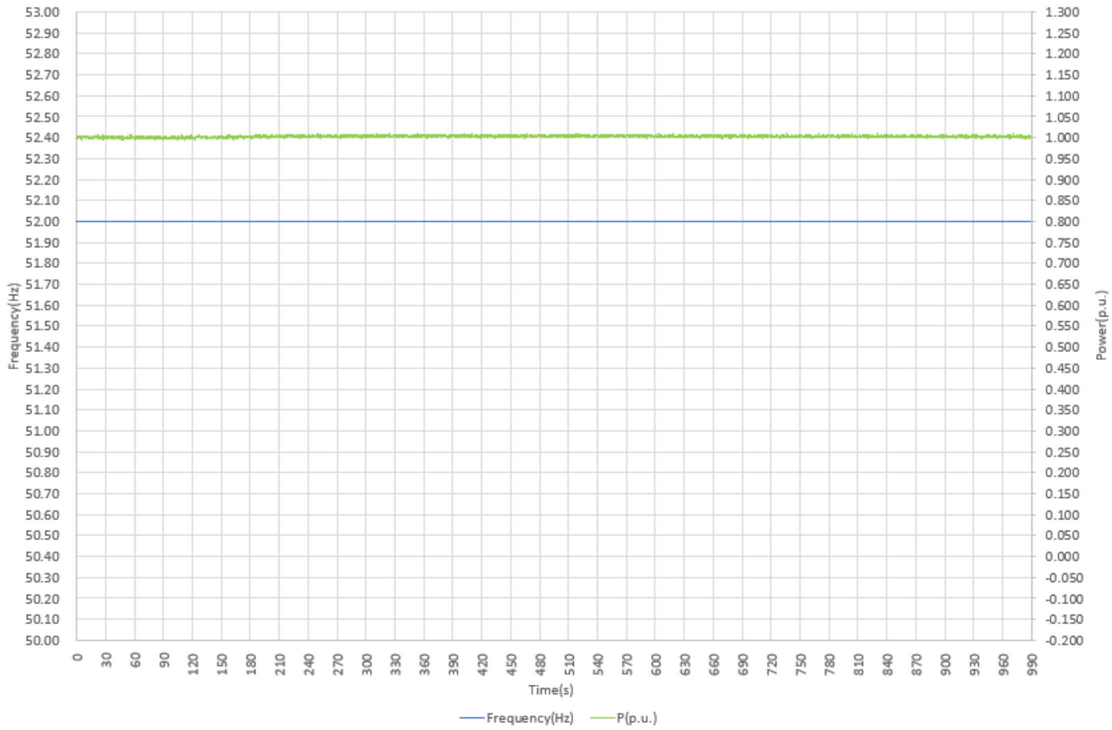
Test 4 - 50.0 Hz



Test 5 - 51.5 Hz



Test 6 - 52.0 Hz



4.1.2. Minimal requirement for active power delivery at underfrequency

The test has been performed according to the clause 4.4.3 of the standard, the requirement is as follows:

A generating plant shall be resilient to the reduction of frequency at the point of connection while reducing the maximum active power as little as possible.

The admissible active power reduction due to underfrequency is limited by the full line in Figure 5 of the standard and is characterized by a maximum allowed reduction rate of 10 % of Pmax per 1 Hz for frequencies below 49.5 Hz.

It is possible that a more stringent power reduction characteristic is required by the responsible party. Nevertheless this requirement is expected to be limited to an admissible active power reduction represented by the dotted line in Figure 5 which is characterised by a reduction rate of 2 % of the maximum power Pmax per 1 Hz for frequencies below 49 Hz.

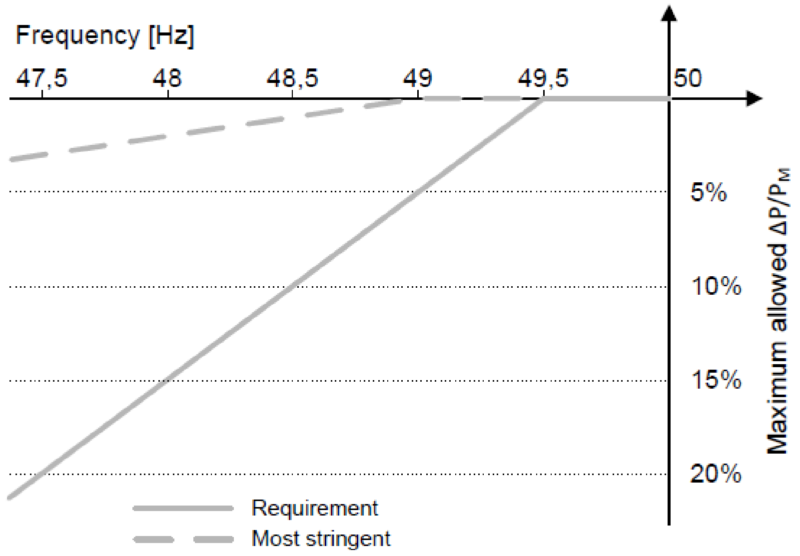


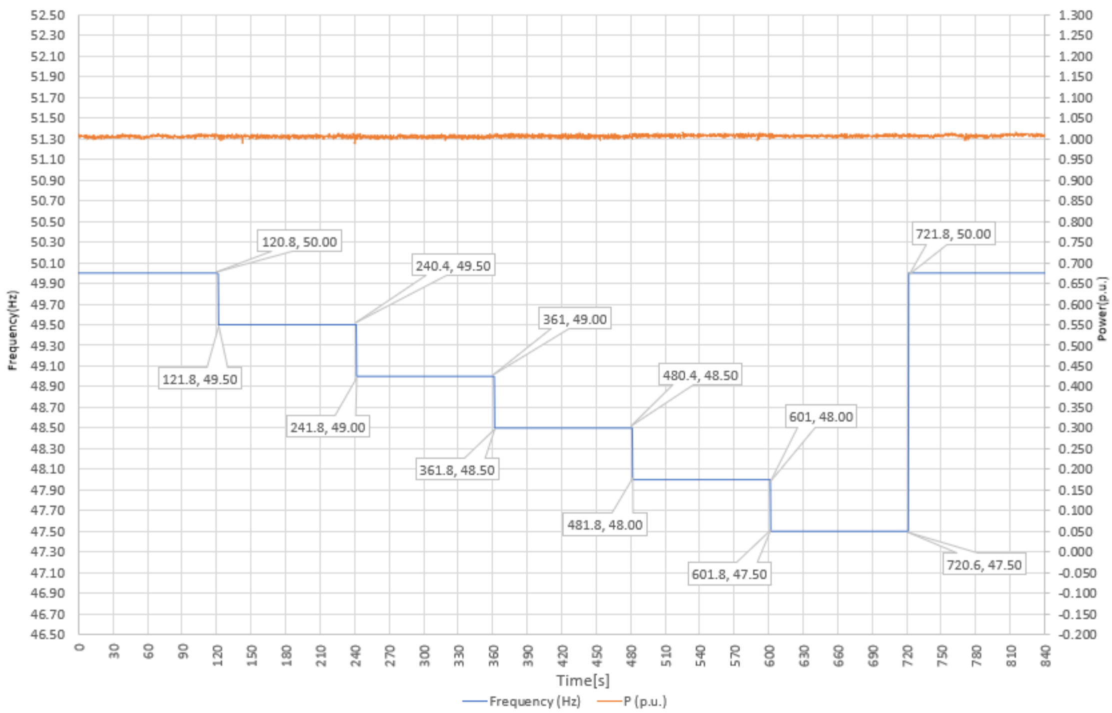
Figure 5 — Maximum allowable power reduction in case of underfrequency

As defined by manufacturer, the power will not reduce when the frequency is below 49.5 Hz.

Step	f (Hz) Setting	f meas. (Hz)	Time start (s)	Time end (s)	Time meas. (s)	Time (s)	P desired (p.u.)	P meas. (p.u.)	P deviation (p.u.)
1	50.00 ± 0.05	50.00	0.0	120.8	120.8	>60	1.000	1.006	+0.006
2	49.50 ± 0.05	49.50	121.8	240.4	118.6	>60	1.000	1.006	+0.006
3	49.00 ± 0.05	49.00	241.8	361.0	119.2	>60	1.000	1.005	+0.005
4	48.50 ± 0.05	48.50	361.8	480.4	118.6	>60	1.000	1.006	+0.006
5	48.00 ± 0.05	48.00	481.8	601.0	119.2	>60	1.000	1.008	+0.008
6	47.50 ± 0.05	47.50	601.8	720.6	118.8	>60	1.000	1.007	+0.007
7	50.00 ± 0.05	50.00	721.8	840.0	118.2	>60	1.000	1.008	+0.008

Test results are represented at diagrams below.

Active power delivery at underfrequency



4.1.3. Continuous operating voltage range

The test has been performed according to the clause 4.4.4 of the standard, the requirement is as follows:

The generating plant shall be capable of operating continuously when the voltage at the point of connection stays within the range of 85%Un to 110%Un.

In order to verify this function, the parameter setting is as follows to perform the test:

Step	V desired (p.u.)	P desired (p.u.)	V meas. (p.u.)	P meas. (p.u.)	Time start (s)	Time end (s)	Time meas. (s)
1	1.000	1.000	1.000	1.000	0.0	299.8	299.8
2	0.850	1.000	0.850	0.850 (1)	301.2	600.4	299.2
3	1.000	1.000	1.000	1.001	601.2	899.2	298.0
4	1.100	1.000	1.100	0.988	901.2	1200.0	298.8

(1) Active power reduction is allowed due to current limitation.

Test results are represented at diagrams below.

Continuous operating voltage range

4.2. IMMUNITY TO DISTURBANCES

4.2.1. Rate of change of frequency (ROCOF) immunity

The test has been performed according to the clause 4.5.2 of the standard, the requirement is as follows:

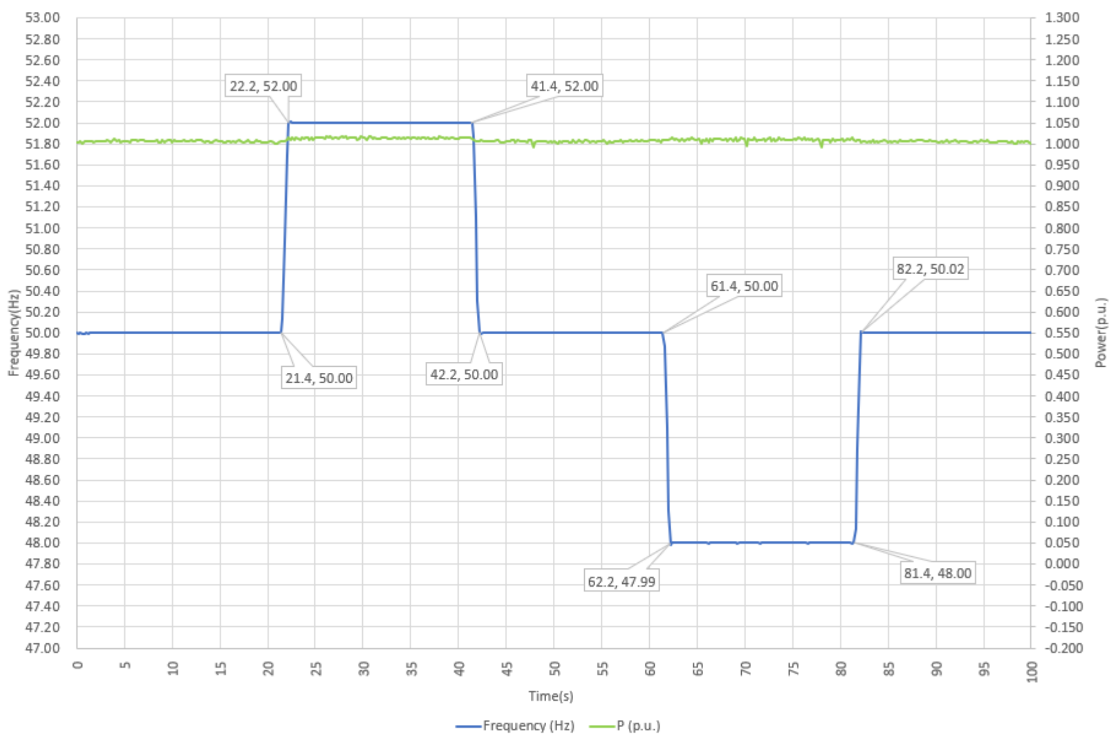
- **Non-synchronous generating technology: at least 2 Hz/s**

The ROCOF immunity is defined with a sliding measurement window of 500 ms as follows:

Steps	f (Hz)	ROCOF requirement (Hz/s)	Step time	Measured frequency (Hz)	Measured step change time (s)	ROCOF meas. (Hz/s)	Discon-nection
1	50.00 ± 0.05	N/A	>10 s	50.00	--	--	No
2	52.00 ± 0.05	>2	>10 s	52.00	0.8	+2.5	No
3	50.00 ± 0.05	>2	>10 s	50.00	0.8	-2.5	No
4	48.00 ± 0.05	>2	>10 s	48.00	0.8	-2.5	No
5	50.00 ± 0.05	>2	>10 s	50.00	0.8	+2.5	No

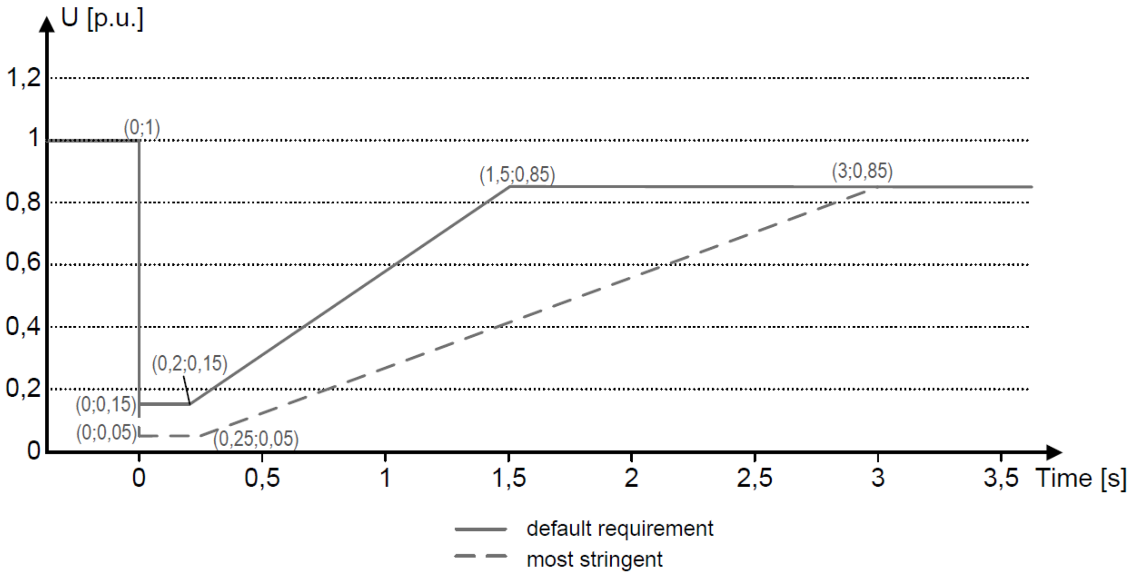
Test results are represented at diagrams below.

Rate of change of frequency (ROCOF) immunity



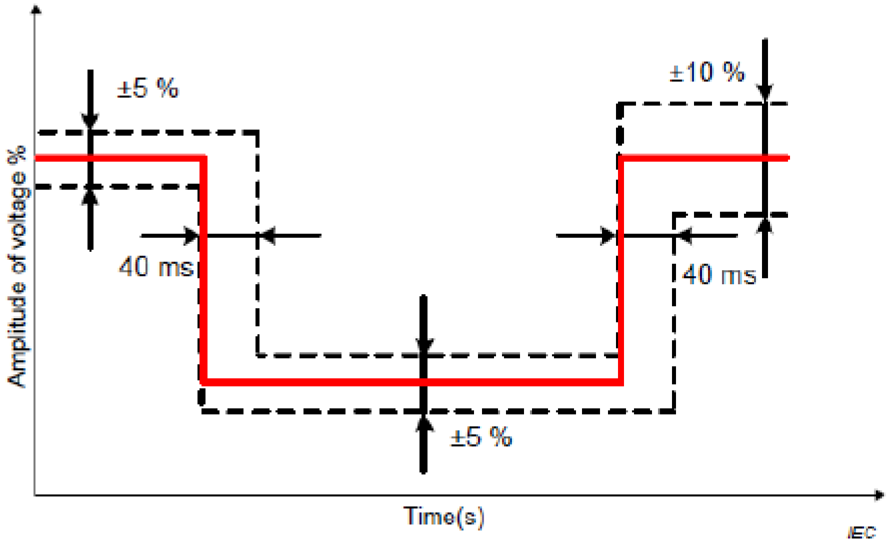
4.2.2. Under-voltage ride through (UVRT)

The requirements are defined in the clause 4.5.3 of the standard.
The test uses the most stringent line in the following figure.



4.2.2.1. No load Test

It is not specified in the reference standard, but following tolerances have been applied. Tolerances for drop depth and duration during no-load tests shall not exceed the values shown in the next figure:



The tolerance for voltage magnitude is ±5%Un for the period before and during the voltage drop. The tolerance for voltage magnitude is ±10%Un during the period after voltage is recovered.
The tolerance range for both drop duration and rise time prefers 40 ms.

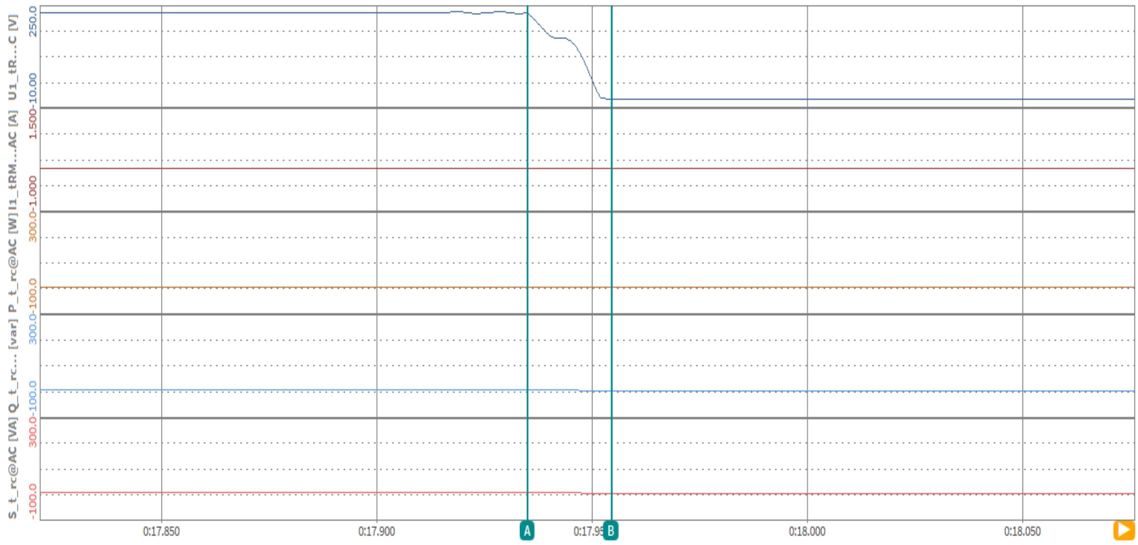
Test results of different no-load cases performed are offered below:

No Load								
Phase type	**Residual voltage desired (%Un)**	**Voltage before fault (%Un)**	**Voltage drop time (ms)**	**Residual voltage Measured (%Un)**	**Dip time desired (ms)**	**Dip time measured (ms)**	**Power recovery time (ms)**	**Voltage after recovery (%Un)**
1 ph	0.0-5.0	100.2	19	3.0	≥ 250	259	--	99.4
1 ph	25.0	100.2	18	25.0	≥ 938	978	--	100.4
1 ph	50.0	100.0	19	50.1	≥ 1797	1810	--	99.7
1 ph	75.0	100.2	17	75.0	≥ 2656	2703	--	100.1

Test results are graphically represented in the following pages.

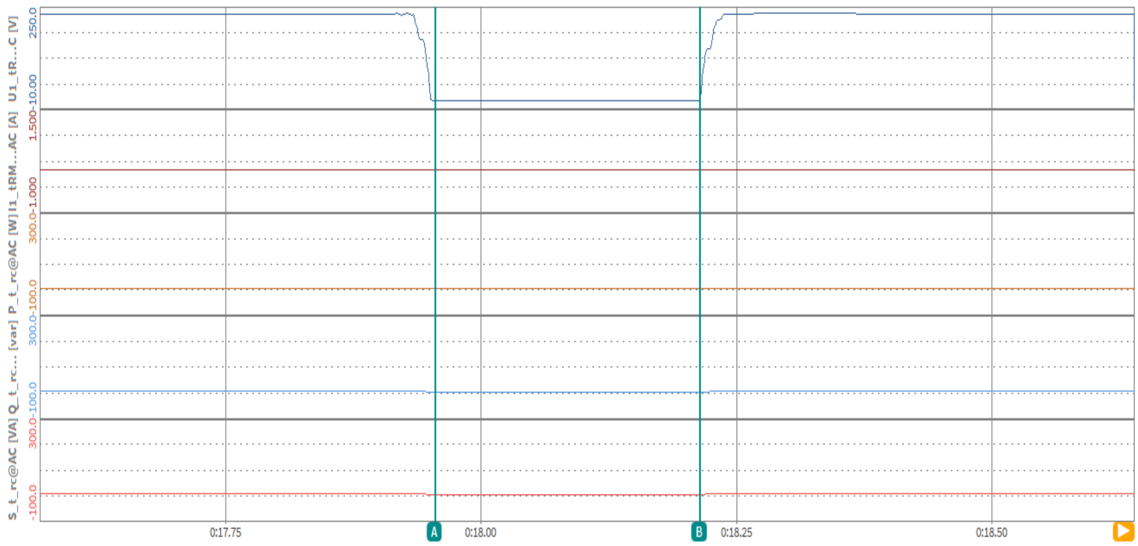
L-N fault	
No Load	Residual voltage: 0~5 %Un

Voltage DropTime



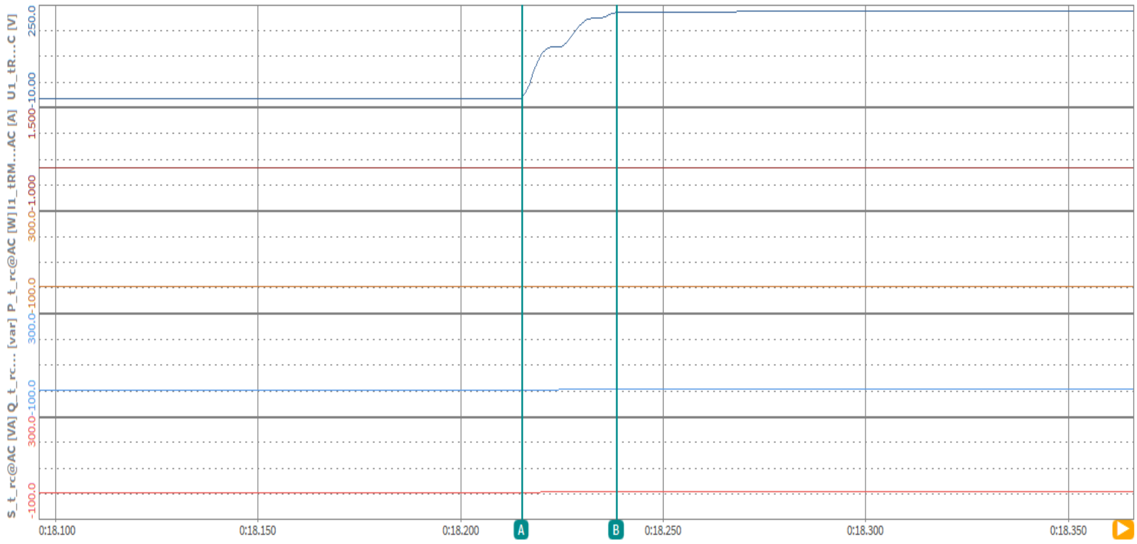
时间 [s]	A 0:17.93509505	B 0:17.95451091	间隔 0.01941586
U1_tRMS_rc@AC [V]	230.3522	7.005990	-223.3462
I1_tRMS_rc@AC [A]	0.018632	0.019045	4.127e-4
P_t_rc@AC [W]	0.144148	-0.010078	-0.154226
Q_t_rc@AC [var]	4.289526	0.133047	-4.156480
S_t_rc@AC [VA]	4.291948	0.133428	-4.158520

Dip Time



时间 [s]	A 0:17.95494978	B 0:18.21409001	间隔 0.25914023
U1_tRMS_rc@AC [V]	7.005990	6.965839	-0.040150
I1_tRMS_rc@AC [A]	0.019045	0.018689	-3.560e-4
P_t_rc@AC [W]	-0.010078	-3.911e-3	6.167e-3
Q_t_rc@AC [var]	0.133047	0.130125	-2.922e-3
S_t_rc@AC [VA]	0.133428	0.130184	-3.244e-3

Voltage Recovery time

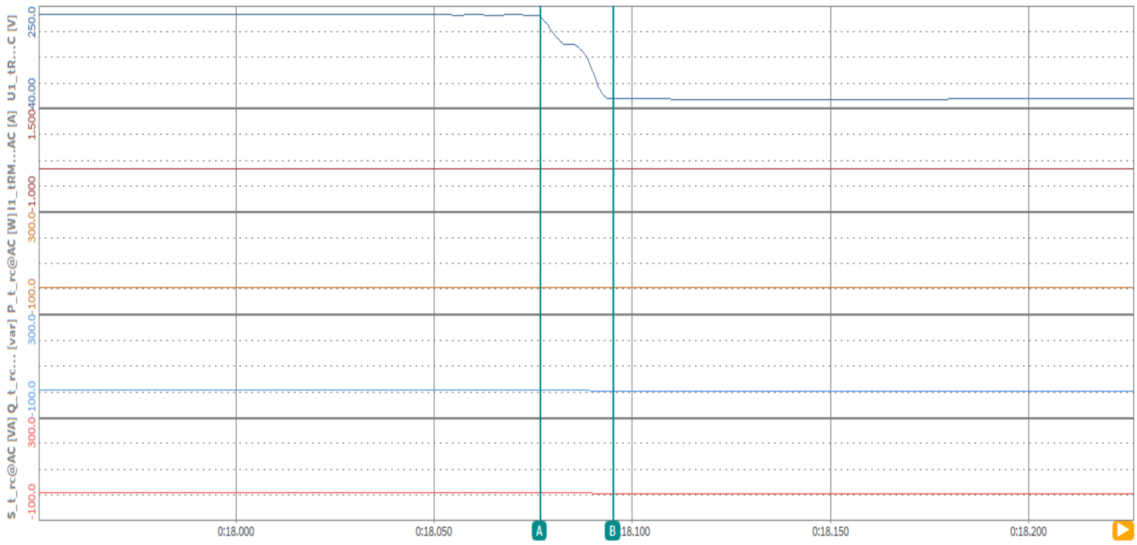


时间 [s]	A 0:18.2151407	B 0:18.2385620	间隔 0.0234213
U1_tRMS_rc@AC [V]	7.005925	228.5468	221.5408
I1_tRMS_rc@AC [A]	0.018540	0.018833	2.934e-4
P_t_rc@AC [W]	-4.829e-3	-0.047126	-0.042298
Q_t_rc@AC [var]	0.129800	4.304053	4.174253
S_t_rc@AC [VA]	0.129890	4.304311	4.174421

L-N fault

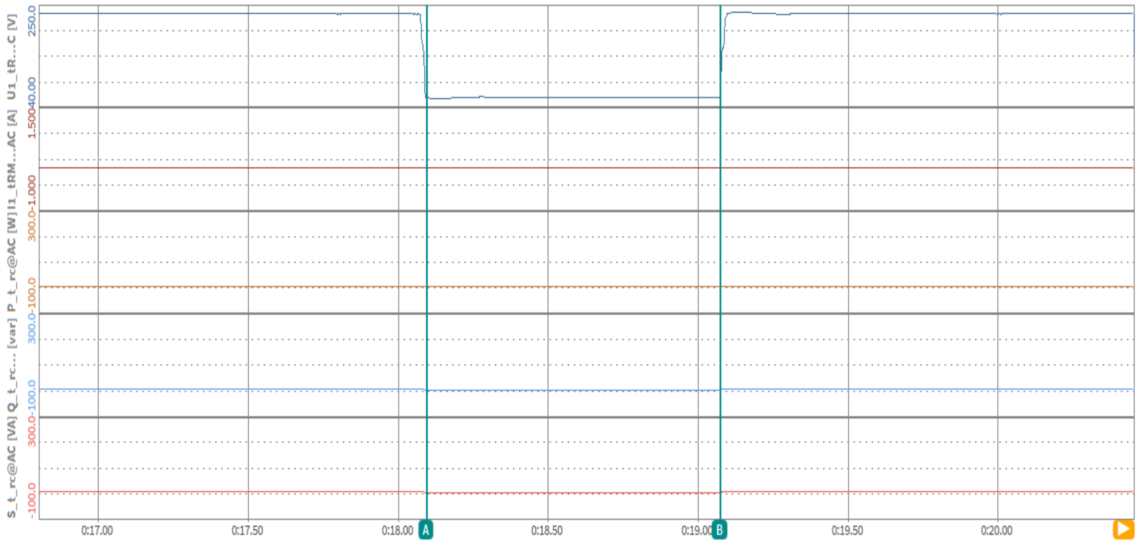
No Load	Residual voltage: 25 %Un

Voltage Drop Time



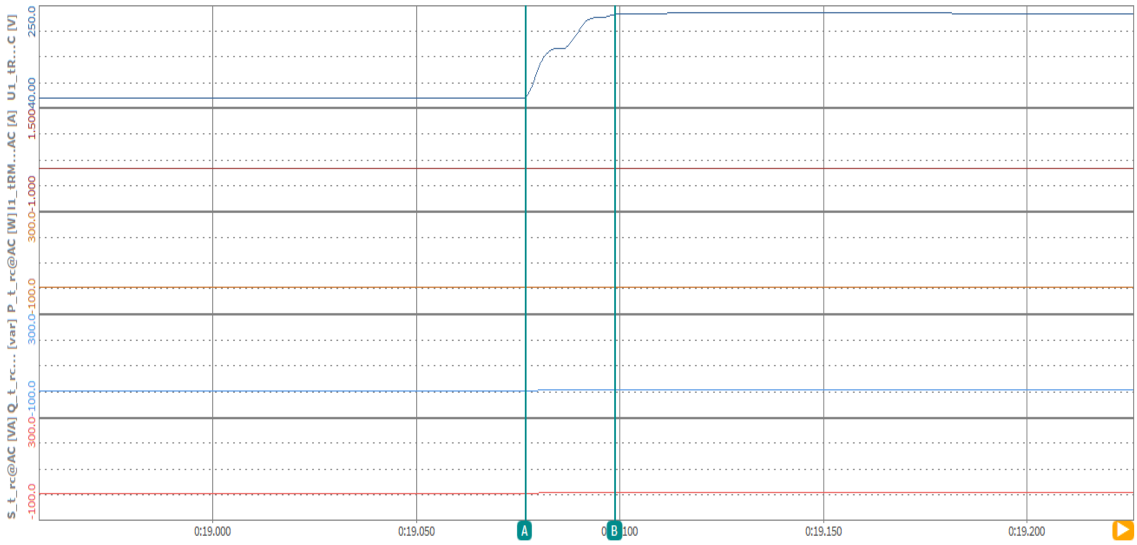
时间 [s]	A 0:18.0767290	B 0:18.0952026	间隔 0.0184736
U1_tRMS_rc@AC [V]	230.3665	57.61111	-172.7554
I1_tRMS_rc@AC [A]	0.019376	0.018871	-5.051e-4
P_t_rc@AC [W]	0.041021	-0.043106	-0.084127
Q_t_rc@AC [var]	4.463450	1.086333	-3.377117
S_t_rc@AC [VA]	4.463638	1.087188	-3.376451

Dip Time



时间 [s]	A 0:18.0950257	B 0:19.0733618	间隔 0.9783361
U1_tRMS_rc@AC [V]	57.61111	57.50113	-0.109978
I1_tRMS_rc@AC [A]	0.018871	0.019348	4.771e-4
P_t_rc@AC [W]	-0.043106	0.012063	0.055170
Q_t_rc@AC [var]	1.086333	1.112481	0.026148
S_t_rc@AC [VA]	1.087188	1.112546	0.025358

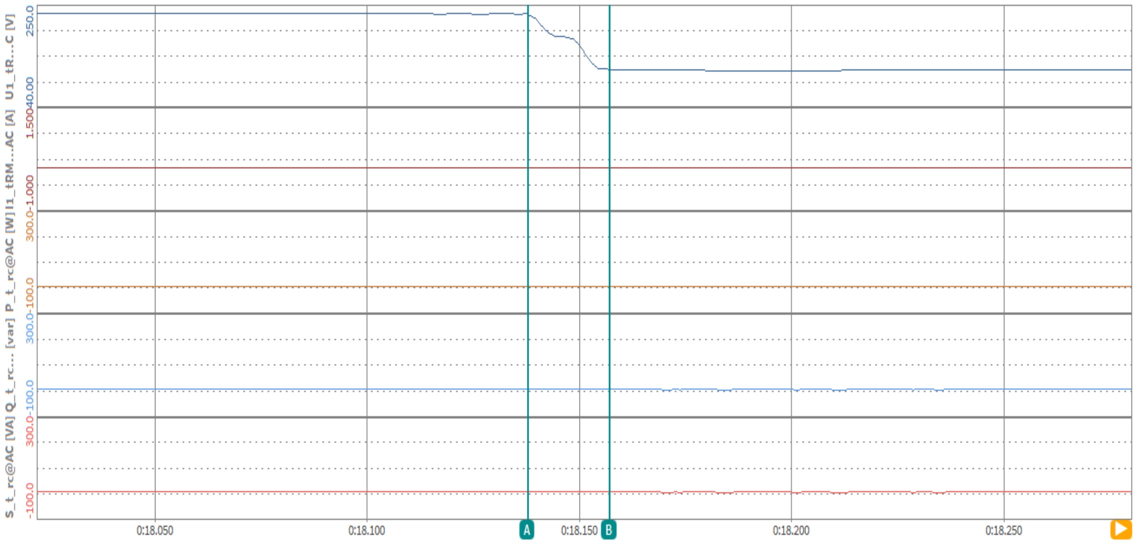
Voltage recovery time



时间 [s]	A 0:19.0767365	B 0:19.0988650	间隔 0.0221285
U1_tRMS_rc@AC [V]	57.69662	230.9868	173.2901
I1_tRMS_rc@AC [A]	0.019183	0.019651	4.681e-4
P_t_rc@AC [W]	-3.128e-3	0.151356	0.154483
Q_t_rc@AC [var]	1.106767	4.536525	3.429758
S_t_rc@AC [VA]	1.106771	4.539049	3.432278

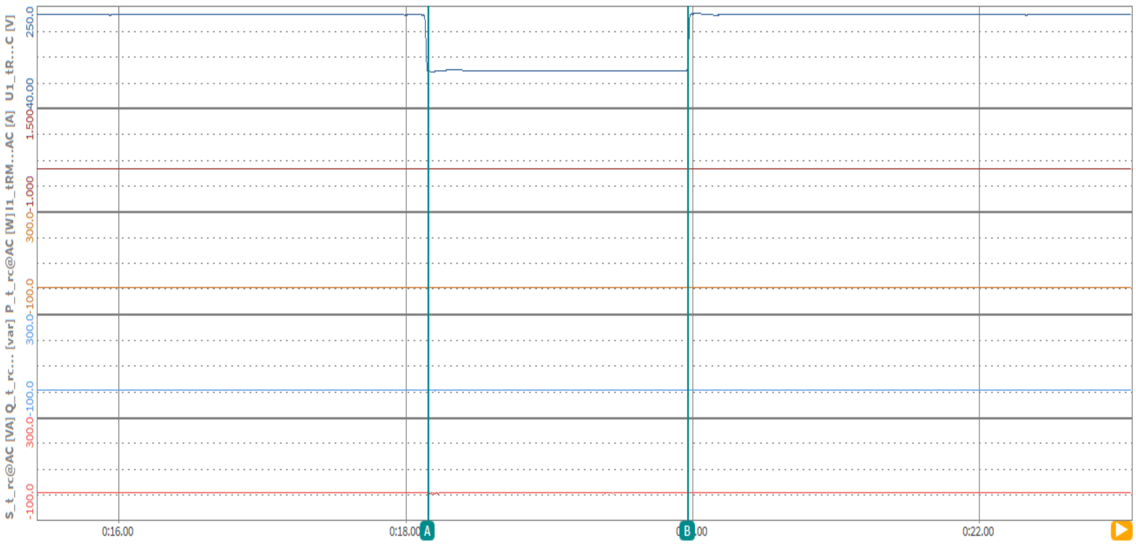
L-N fault	
No Load	Residual voltage: 50 %Un

Voltage Drop Time



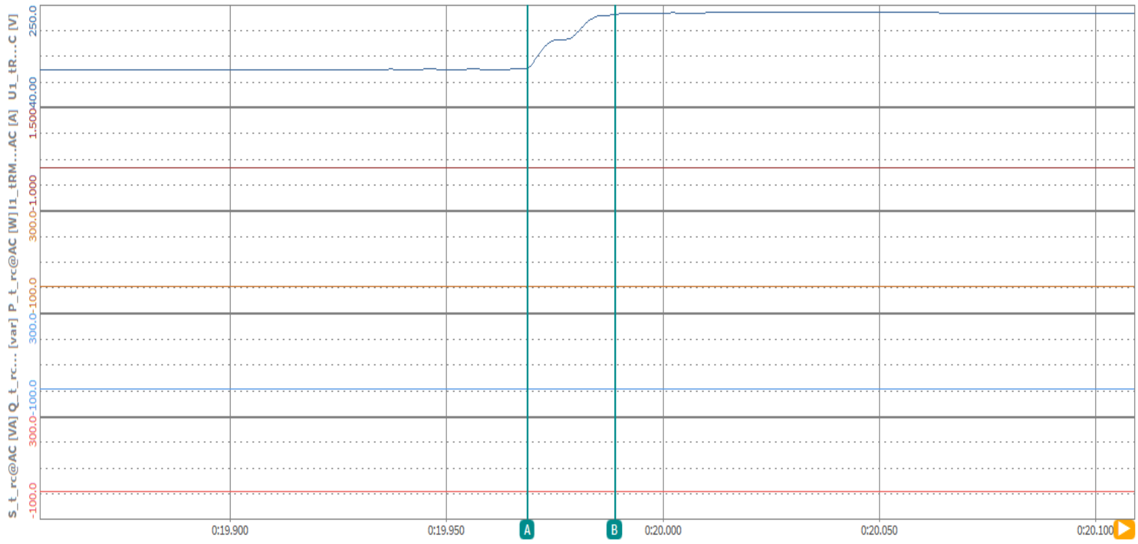
	A	B	间隔
时间 [s]	0:18.13785530	0:18.15714206	0.01928677
U1_tRMS_rc@AC [V]	230.0382	115.3416	-114.6967
I1_tRMS_rc@AC [A]	0.020818	0.020586	-2.325e-4
P_t_rc@AC [W]	-0.043081	-0.109563	-0.066481
Q_t_rc@AC [var]	4.788786	2.371861	-2.416925
S_t_rc@AC [VA]	4.788980	2.374390	-2.414590

Dip Time



	A	B	间隔
时间 [s]	0:18.15631205	0:19.96632391	1.81001186
U1_tRMS_rc@AC [V]	115.7210	115.3972	-0.323799
I1_tRMS_rc@AC [A]	0.020619	0.020793	1.741e-4
P_t_rc@AC [W]	-0.112879	-0.062630	0.050249
Q_t_rc@AC [var]	2.383404	2.398675	0.015272
S_t_rc@AC [VA]	2.386075	2.399493	0.013418

Voltage recovery time

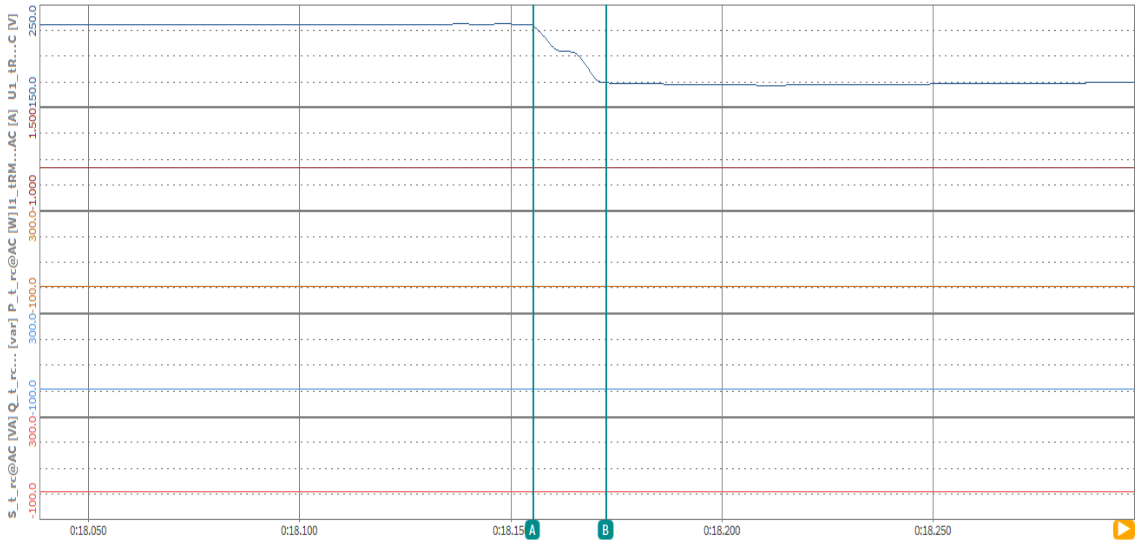


	A	B	间隔
时间 [s]	0:19.96875137	0:19.98892751	0.02017614
U1_tRMS_rc@AC [V]	115.3806	229.4113	114.0308
I1_tRMS_rc@AC [A]	0.020865	0.020056	-8.092e-4
P_t_rc@AC [W]	-0.066091	-0.048285	0.017805
Q_t_rc@AC [var]	2.406502	4.600765	2.194262
S_t_rc@AC [VA]	2.407410	4.601018	2.193609

L-N fault

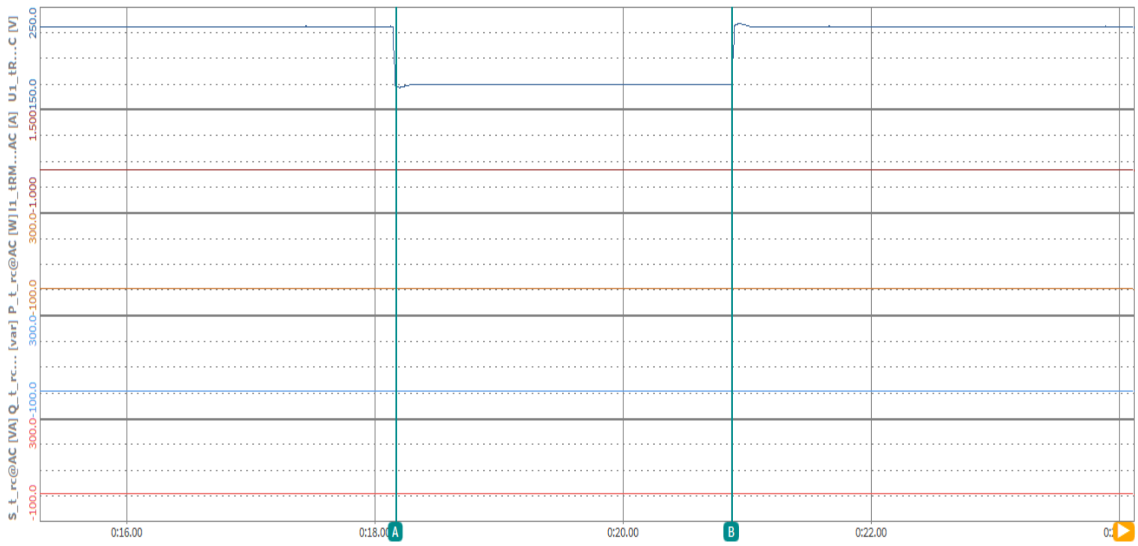
No Load	Residual voltage: 75 %Un

Voltage Drop Time



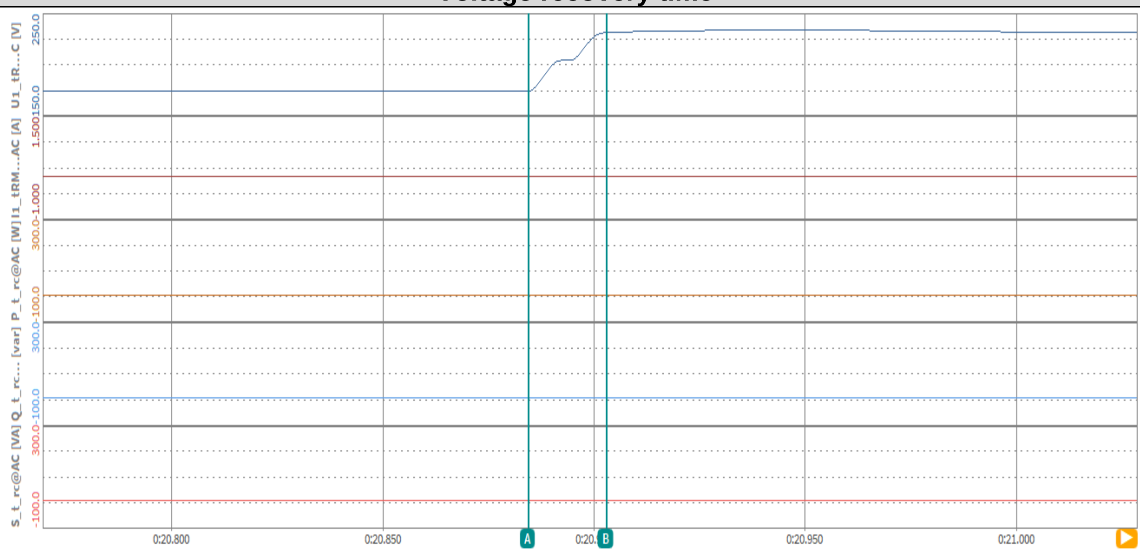
	A	B	间隔
时间 [s]	0:18.15530356	0:18.17264124	0.01733769
U1_tRMS_rc@AC [V]	230.3604	172.5212	-57.83917
I1_tRMS_rc@AC [A]	0.018827	0.019359	5.316e-4
P_t_rc@AC [W]	-0.126058	0.038870	0.164928
Q_t_rc@AC [var]	4.335265	3.339622	-0.995643
S_t_rc@AC [VA]	4.337098	3.339848	-0.997250

Dip Time



	A	B	间隔
时间 [s]	0:18.17278501	0:20.87600615	2.70322114
U1_tRMS_rc@AC [V]	172.5212	172.6087	0.087479
I1_tRMS_rc@AC [A]	0.019359	0.019003	-3.562e-4
P_t_rc@AC [W]	0.038870	0.036117	-2.754e-3
Q_t_rc@AC [var]	3.339622	3.279859	-0.059763
S_t_rc@AC [VA]	3.339848	3.280058	-0.059790

Voltage recovery time



	A	B	间隔
时间 [s]	0:20.88438710	0:20.90284564	0.01845854
U1_tRMS_rc@AC [V]	172.6146	230.3034	57.68877
I1_tRMS_rc@AC [A]	0.019383	0.019479	9.649e-5
P_t_rc@AC [W]	-0.048357	-0.086445	-0.038088
Q_t_rc@AC [var]	3.345429	4.485345	1.139917
S_t_rc@AC [VA]	3.345778	4.486178	1.140400

4.2.2.2. Load Tests: Partial load (20 %Pn)

Test results of different 20%Pn load cases performed are offered below:

20 %Pn Load								
Phase type	Residual voltage desired (%Un)	Voltage before fault (%Un)	Voltage drop time (ms)	Residual voltage Measured (%Un)	Dip time desired (ms)	Dip time measured (ms)	Power recovery time (ms)	Voltage after recovery (%Un)
1 ph	0.0-5.0	100.0	20	3.0	≥ 250	258	138	100.3
1 ph	25.0	100.2	19	25.0	≥ 938	978	186	99.9
1 ph	50.0	99.8	18	50.0	≥ 1797	1808	157	100.0
1 ph	75.0	100.2	18	75.0	≥ 2656	2676	238	99.9

Test results are graphically represented at following pages.

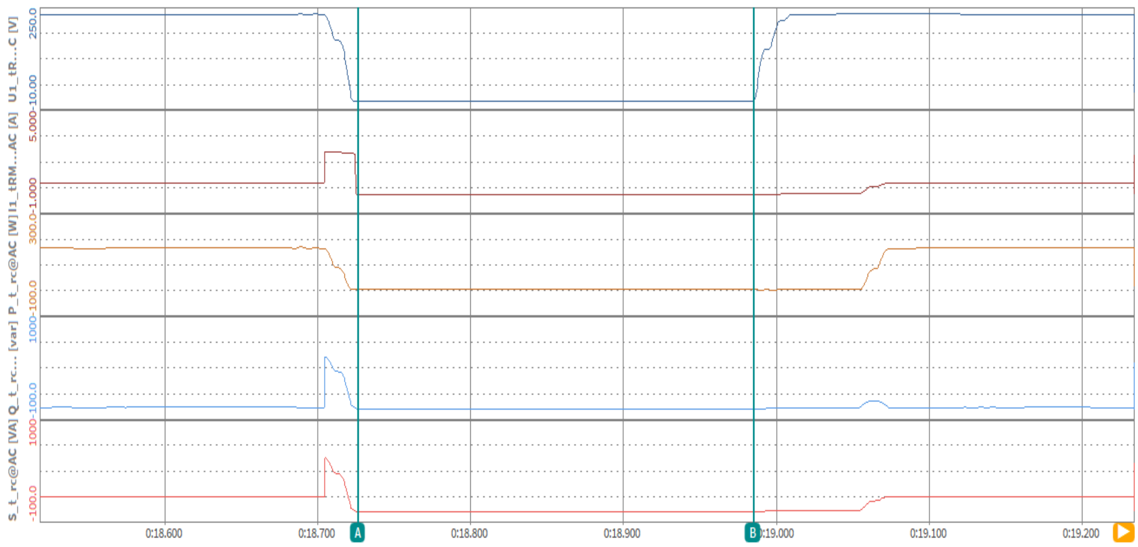
L-N fault

20%Pn Load	Residual voltage: 0~5%Un

Voltage Drop time

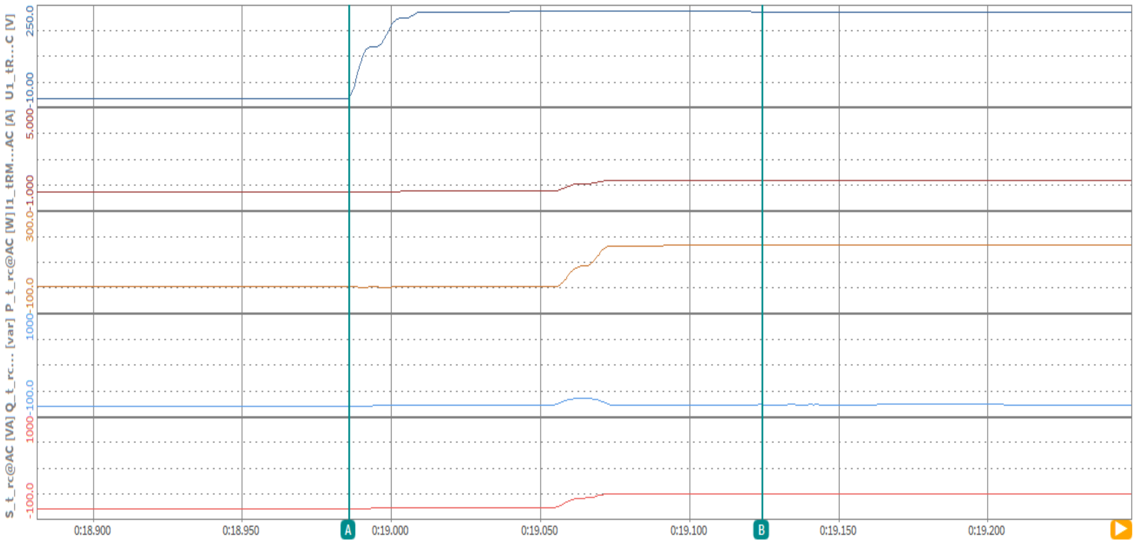
时间 [s]	A 0:18.7064029	B 0:18.7262751	间隔 0.0198721
U1_tRMS_rc@AC [V]	229.9596	6.963996	-222.9956
I1_tRMS_rc@AC [A]	2.563327	0.023753	-2.539574
P_t_rc@AC [W]	164.0200	-2.786e-3	-164.0228
Q_t_rc@AC [var]	566.1824	0.165393	-566.0170
S_t_rc@AC [VA]	589.4616	0.165416	-589.2962

Dip time



时间 [s]	A 0:18.7265806	B 0:18.9848501	间隔 0.2582695
U1_tRMS_rc@AC [V]	6.963996	6.861953	-0.102044
I1_tRMS_rc@AC [A]	0.023753	0.019931	-3.822e-3
P_t_rc@AC [W]	-2.786e-3	-1.827e-3	9.588e-4
Q_t_rc@AC [var]	0.165393	0.136754	-0.028639
S_t_rc@AC [VA]	0.165416	0.136766	-0.028650

Power Recovery time

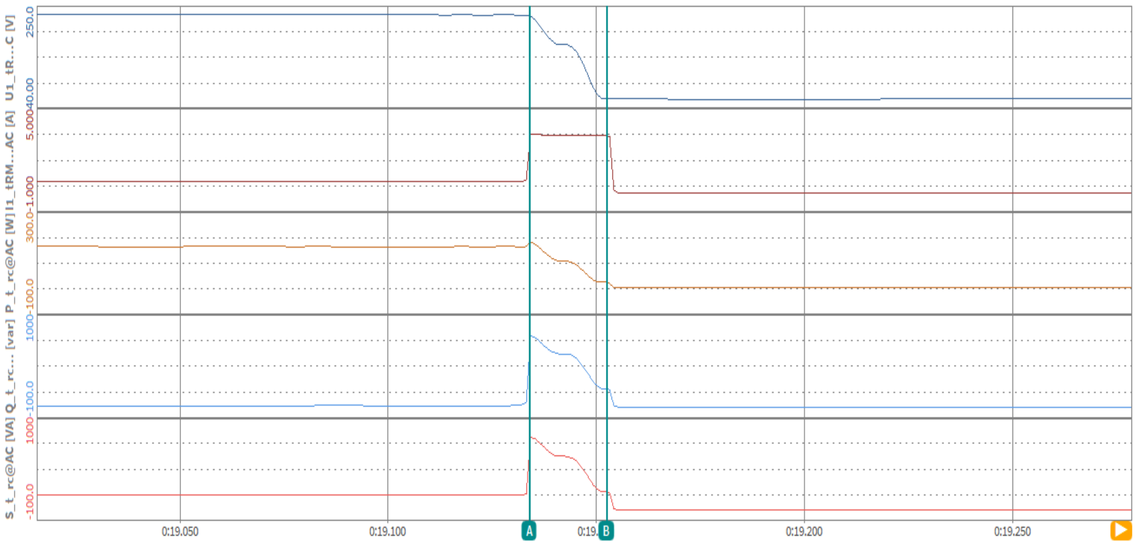


时间 [s]	A 0:18.9857767	B 0:19.1242103	间隔 0.1384337
U1_tRMS_rc@AC [V]	6.891031	230.7578	223.8668
I1_tRMS_rc@AC [A]	0.019807	0.706888	0.687080
P_t_rc@AC [W]	-3.614e-3	162.0366	162.0402
Q_t_rc@AC [var]	0.136446	18.76804	18.63160
S_t_rc@AC [VA]	0.136494	163.1199	162.9834

L-N fault

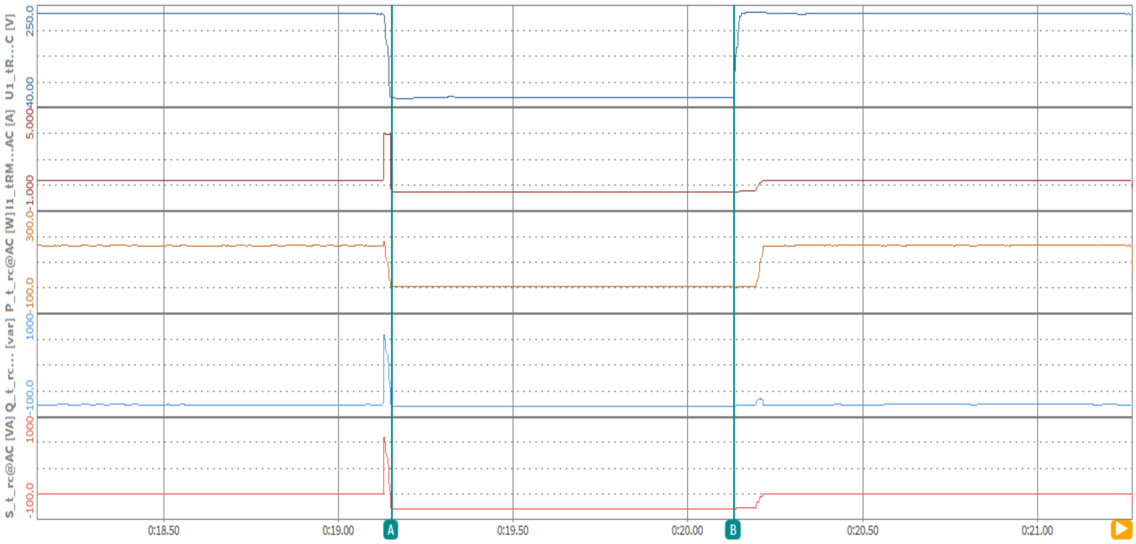
20%Pn Load	Residual voltage: 25%Un

Voltage Drop time



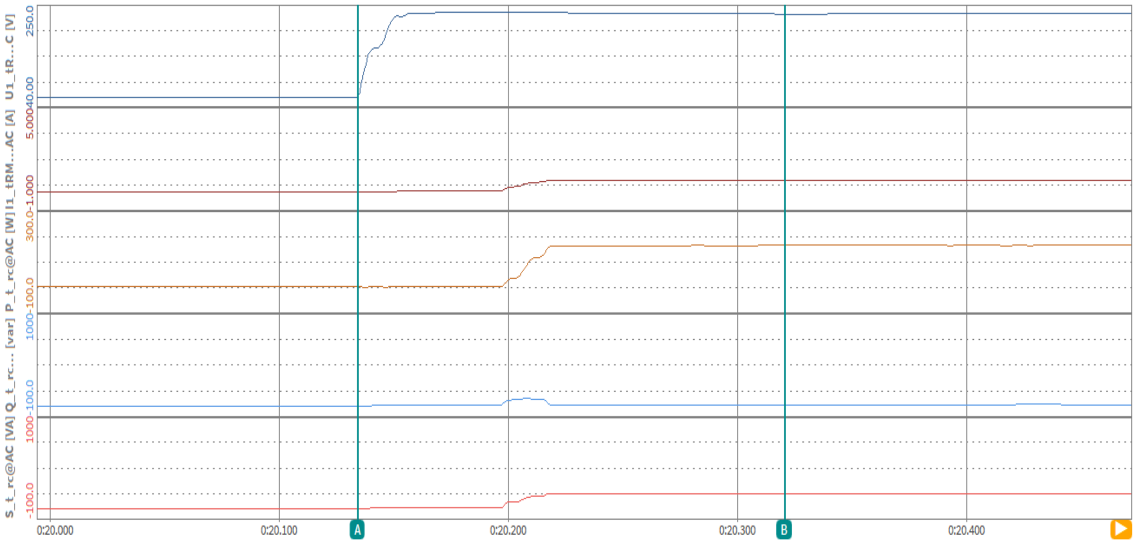
时间 [s]	A 0:19.1340334	B 0:19.1525930	间隔 0.0185595
U1_tRMS_rc@AC [V]	230.3974	57.54622	-172.8512
I1_tRMS_rc@AC [A]	0.740263	3.401532	2.661268
P_t_rc@AC [W]	163.3842	20.64318	-142.7410
Q_t_rc@AC [var]	48.93406	194.6537	145.7197
S_t_rc@AC [VA]	170.5547	195.7453	25.19054

DipTime



时间 [s]	A	B	间隔
	0:19.1526214	0:20.1309611	0.9783398
U1_tRMS_rc@AC [V]	57.54622	57.52131	-0.024906
I1_tRMS_rc@AC [A]	3.401532	0.023652	-3.377879
P_t_rc@AC [W]	20.64318	-2.615e-3	-20.64579
Q_t_rc@AC [var]	194.6537	1.360514	-193.2932
S_t_rc@AC [VA]	195.7453	1.360516	-194.3848

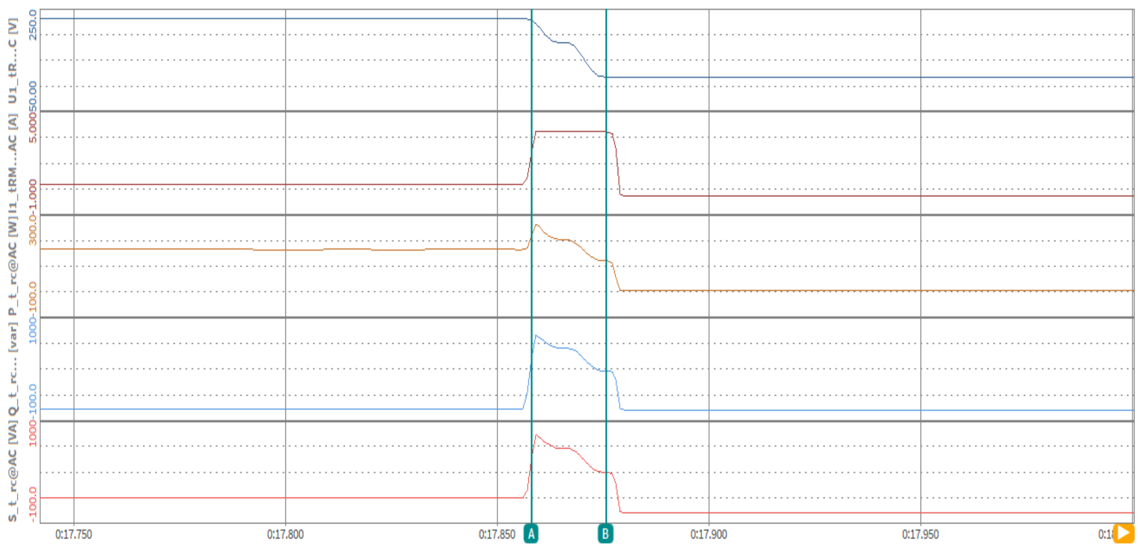
Power Recovery time



时间 [s]	A	B	间隔
	0:20.13431699	0:20.32042128	0.18610429
U1_tRMS_rc@AC [V]	57.71861	229.6781	171.9595
I1_tRMS_rc@AC [A]	0.024426	0.707734	0.683309
P_t_rc@AC [W]	-0.021145	161.7876	161.8087
Q_t_rc@AC [var]	1.409667	15.73703	14.32737
S_t_rc@AC [VA]	1.409826	162.5511	161.1413

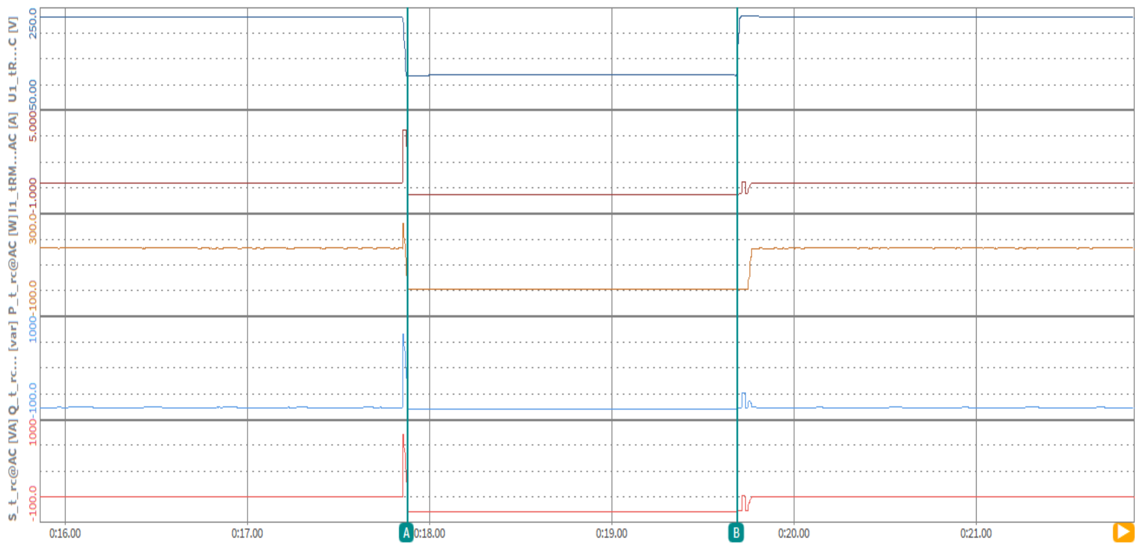
L-N fault	
20%Pn Load	Residual voltage: 50%Un

Voltage Drop time



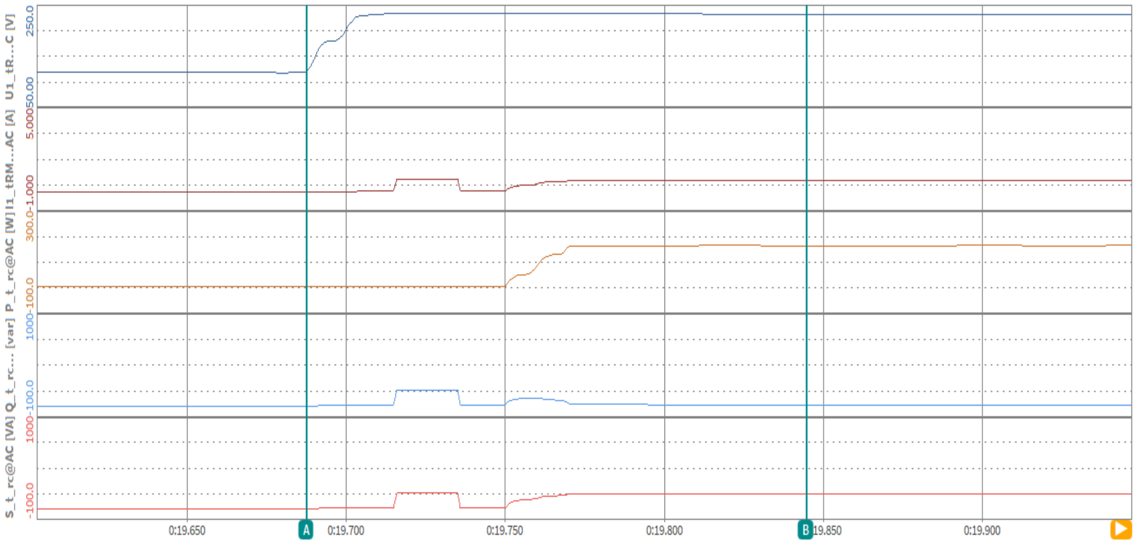
时间 [s]	A 0:17.85811512	B 0:17.87575483	间隔 0.01763971
U1_tRMS_rc@AC [V]	229.5272	114.9849	-114.5423
I1_tRMS_rc@AC [A]	1.097175	3.815746	2.718571
P_t_rc@AC [W]	170.4334	118.0598	-52.37360
Q_t_rc@AC [var]	185.3957	422.5709	237.1752
S_t_rc@AC [VA]	251.8315	438.7531	186.9216

DipTime



时间 [s]	A 0:17.87589165	B 0:19.68421998	间隔 1.80832833
U1_tRMS_rc@AC [V]	114.9849	115.1918	0.206970
I1_tRMS_rc@AC [A]	3.815746	0.033837	-3.781909
P_t_rc@AC [W]	118.0598	4.453e-3	-118.0554
Q_t_rc@AC [var]	422.5709	3.897778	-418.6731
S_t_rc@AC [VA]	438.7531	3.897780	-434.8553

Power Recovery time

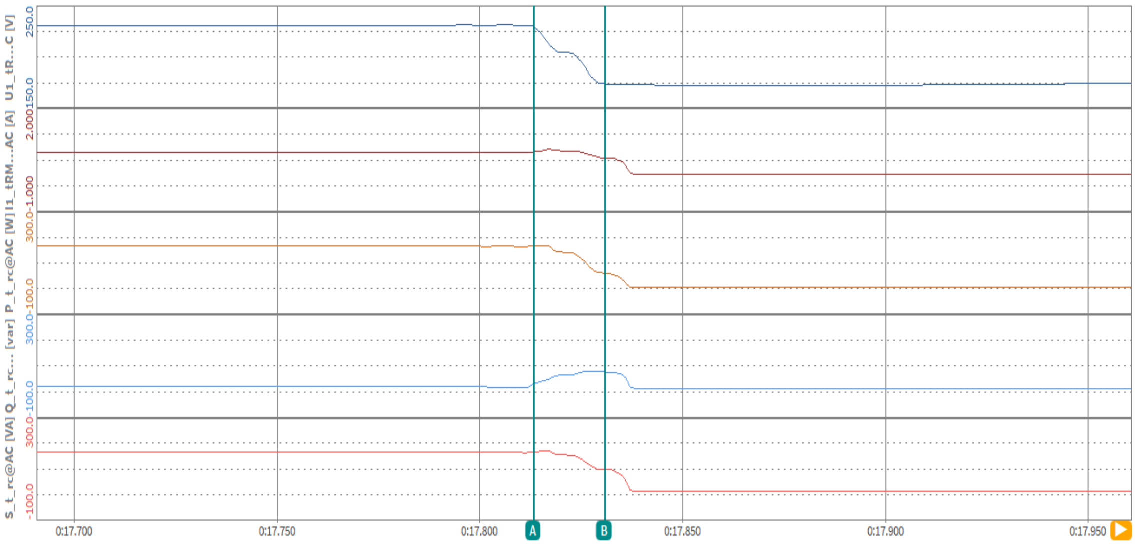


时间 [s]	A 0:19.6876180	B 0:19.8445015	间隔 0.1568835
U1_tRMS_rc@AC [V]	115.8882	229.9892	114.1011
I1_tRMS_rc@AC [A]	0.035192	0.703974	0.668782
P_t_rc@AC [W]	-0.081555	161.0709	161.1525
Q_t_rc@AC [var]	4.077526	16.42623	12.34870
S_t_rc@AC [VA]	4.078341	161.9063	157.8280

L-N fault

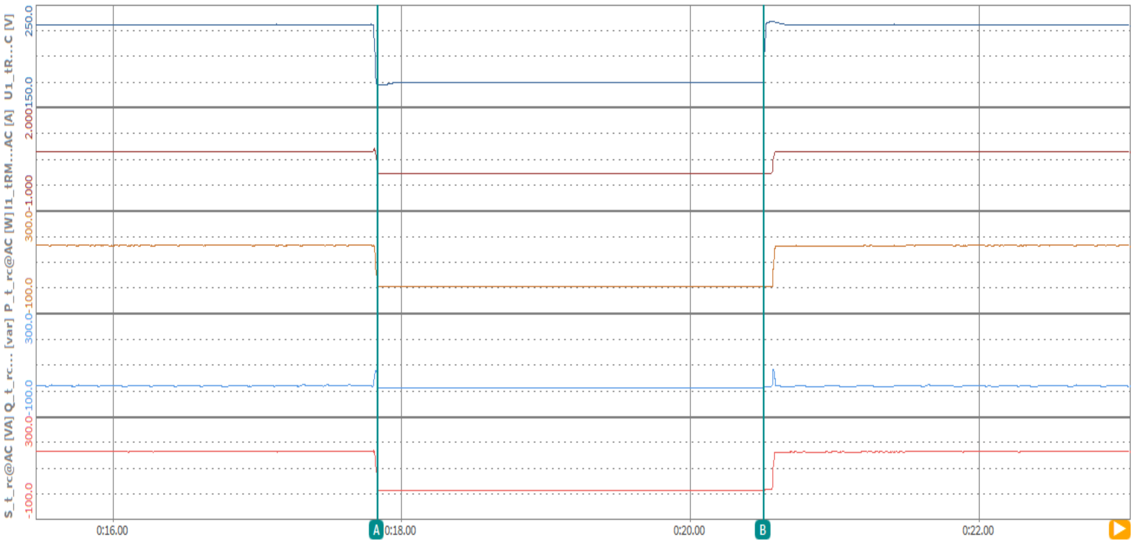
20%Pn Load	Residual voltage: 75%Un

Voltage Drop time



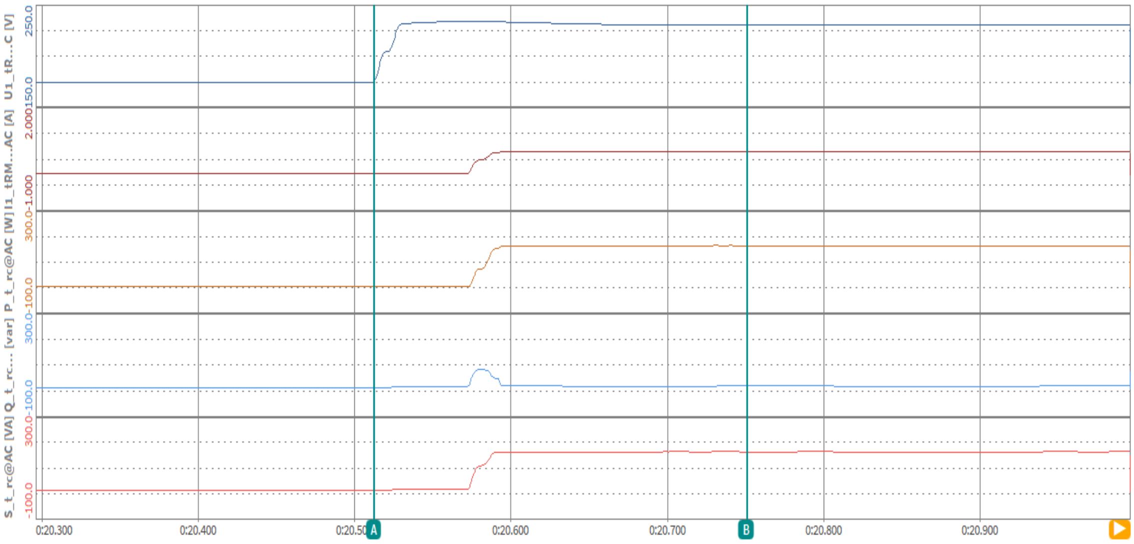
时间 [s]	A 0:17.81329645	B 0:17.83079719	间隔 0.01750073
U1_tRMS_rc@AC [V]	230.4390	172.5601	-57.87897
I1_tRMS_rc@AC [A]	0.705793	0.547056	-0.158736
P_t_rc@AC [W]	161.9278	57.16507	-104.7627
Q_t_rc@AC [var]	15.22733	75.12343	59.89609
S_t_rc@AC [VA]	162.6422	94.40008	-68.24210

DipTime



	A	B	间隔
时间 [s]	0:17.83073506	0:20.50685182	2.67611676
U1_tRMS_rc@AC [V]	172.5601	172.6268	0.066788
I1_tRMS_rc@AC [A]	0.547056	0.045250	-0.501806
P_t_rc@AC [W]	57.16507	-3.594e-3	-57.16866
Q_t_rc@AC [var]	75.12343	7.811443	-67.31199
S_t_rc@AC [VA]	94.40008	7.811444	-86.58863

Power Recovery time



	A	B	间隔
时间 [s]	0:20.51268702	0:20.75074760	0.23806058
U1_tRMS_rc@AC [V]	172.6681	229.8471	57.17899
I1_tRMS_rc@AC [A]	0.045626	0.699158	0.653532
P_t_rc@AC [W]	-0.076744	159.6925	159.7692
Q_t_rc@AC [var]	7.877718	17.96136	10.08364
S_t_rc@AC [VA]	7.878092	160.6994	152.8213

4.2.2.3. Load Tests: Partial load (> 90 %Pn)

Test results of full power cases performed are offered below:

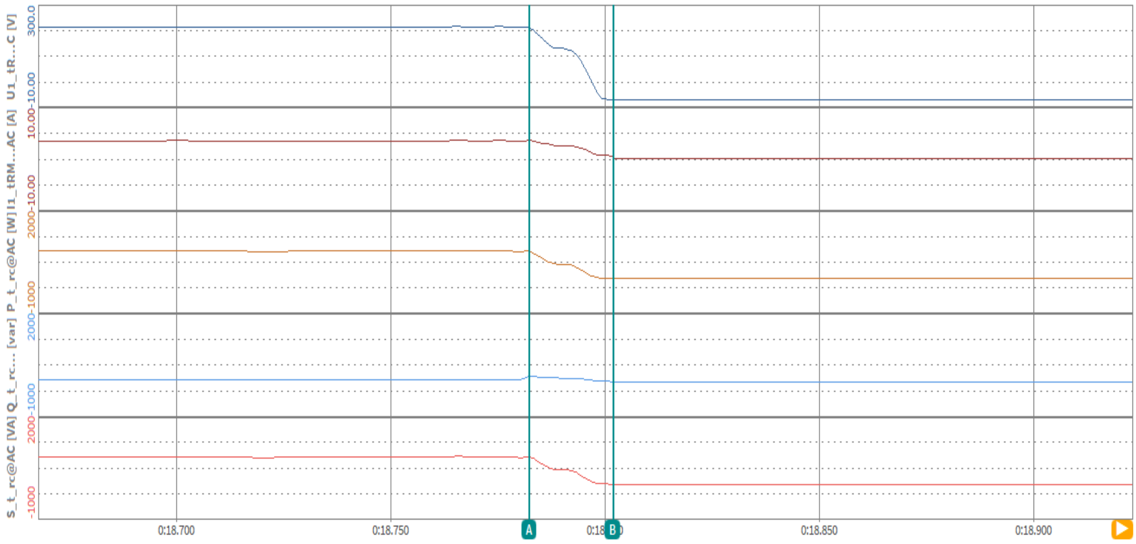
> 90 %Pn Load								
Phase type	Residual voltage desired (%Un)	Voltage before fault (%Un)	Voltage drop time (ms)	Residual voltage Measured (%Un)	Dip time desired (ms)	Dip time measured (ms)	Power recovery time (ms)	Voltage after recovery (%Un)
1 ph	0.0-5.0	100.2	19	3.0	≥ 250	259	736	100.0
1 ph	25.0	100.0	18	25.0	≥ 938	979	273	100.0
1 ph	50.0	100.0	18	50.0	≥ 1797	1810	629	100.0
1 ph	75.0	100.0	18	75.0	≥ 2656	2692	421	100.0

Test results are graphically represented at following pages.

L-N fault

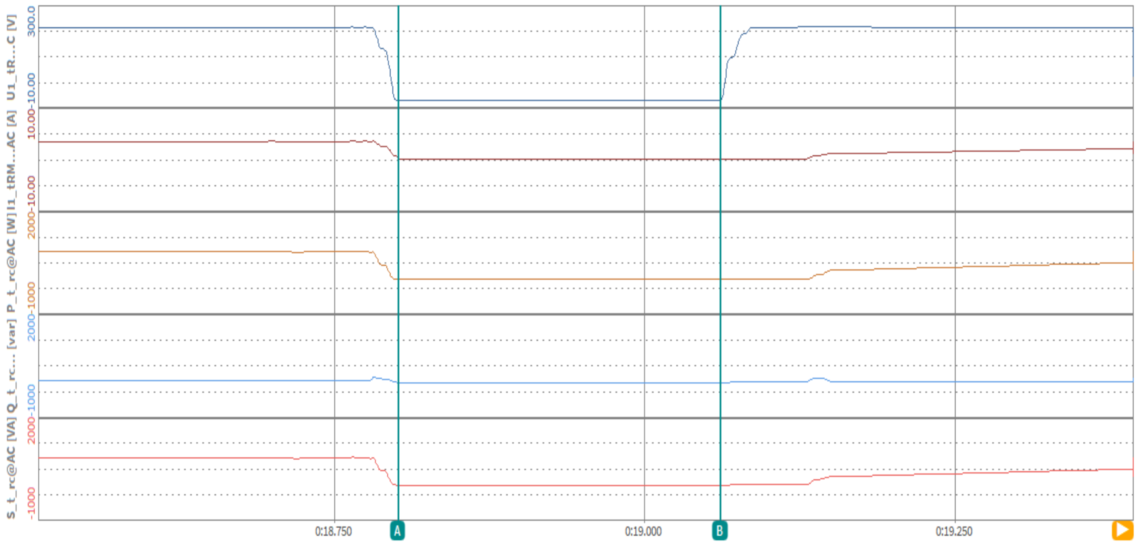
100%Pn Load	Residual voltage: 0~5%Un

Voltage Drop time



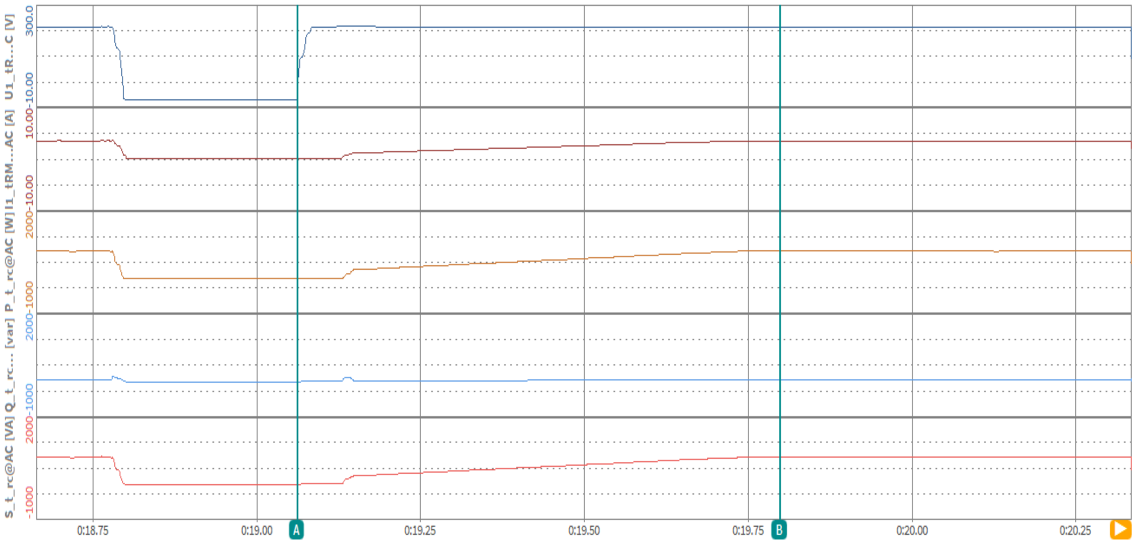
	A	B	间隔
时间 [s]	0:18.7824203	0:18.8018868	0.0194665
U1_tRMS_rc@AC [V]	230.4299	6.959313	-223.4705
I1_tRMS_rc@AC [A]	3.518061	0.469936	-3.048125
P_t_rc@AC [W]	804.4243	-0.203389	-804.6277
Q_t_rc@AC [var]	100.4067	3.264102	-97.14262
S_t_rc@AC [VA]	810.6664	3.270433	-807.3959

DipTime



	A	B	间隔
时间 [s]	0:18.8016545	0:19.0610553	0.2594007
U1_tRMS_rc@AC [V]	6.959313	6.953030	-6.283e-3
I1_tRMS_rc@AC [A]	0.469936	0.018314	-0.451622
P_t_rc@AC [W]	-0.203389	-7.679e-3	0.195709
Q_t_rc@AC [var]	3.264102	0.127109	-3.136993
S_t_rc@AC [VA]	3.270433	0.127341	-3.143092

Power Recovery Time

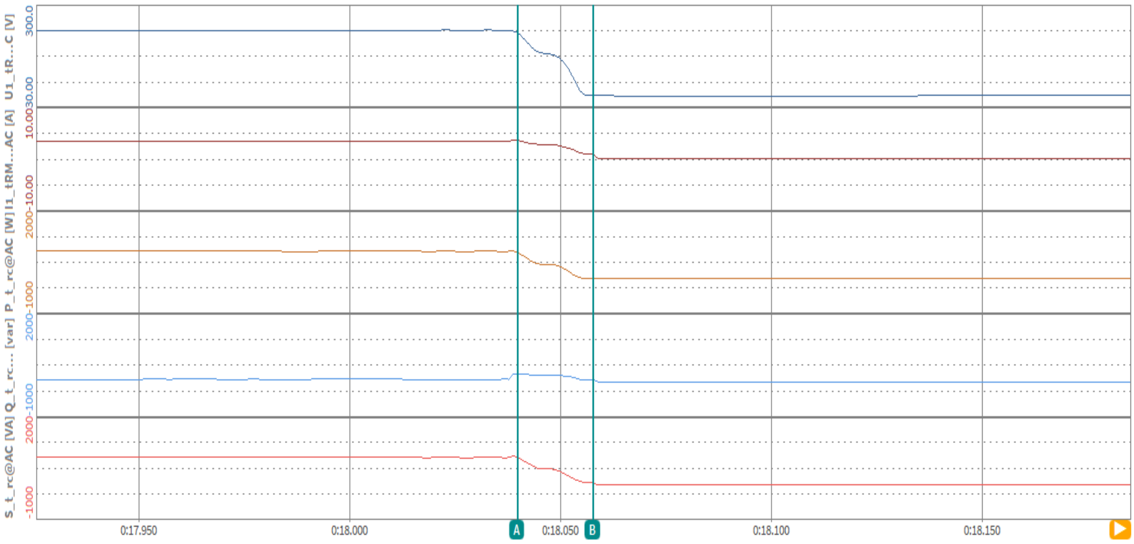


	A	B	间隔
时间 [s]	0:19.06209441	0:19.79824050	0.73614609
U1_tRMS_rc@AC [V]	6.967752	230.0735	223.1057
I1_tRMS_rc@AC [A]	0.018866	3.478077	3.459211
P_t_rc@AC [W]	-9.429e-3	797.3329	797.3424
Q_t_rc@AC [var]	0.131113	67.83505	67.70394
S_t_rc@AC [VA]	0.131452	800.2134	800.0819

L-N fault

100%Pn Load	Residual voltage: 25%Un

Voltage Drop time

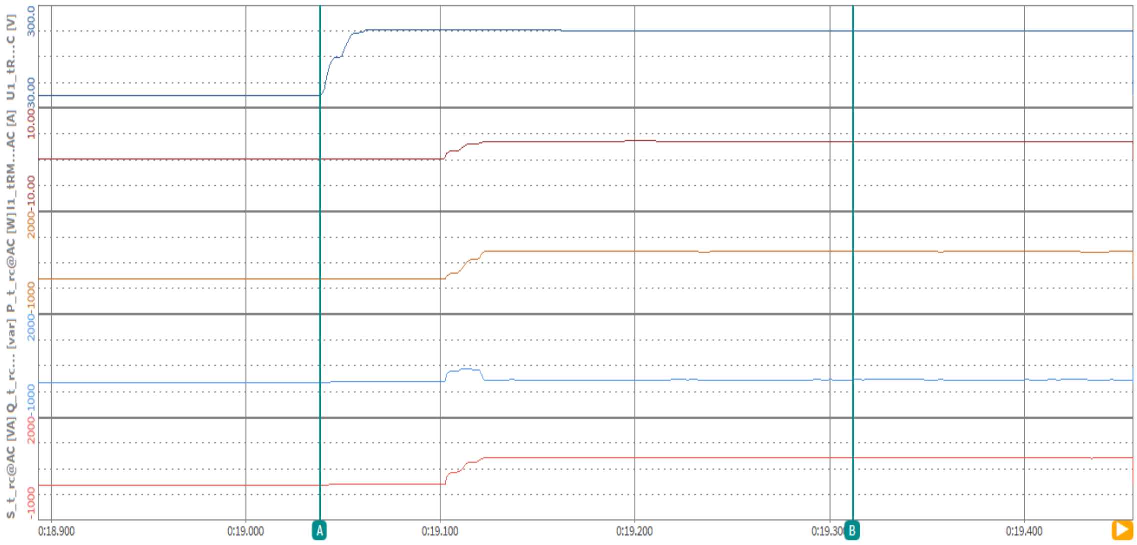


	A	B	间隔
时间 [s]	0:18.03976993	0:18.05771808	0.01794815
U1_tRMS_rc@AC [V]	229.9616	57.47577	-172.4858
I1_tRMS_rc@AC [A]	3.611303	0.947639	-2.663664
P_t_rc@AC [W]	801.0609	2.739065	-798.3218
Q_t_rc@AC [var]	219.0129	54.39735	-164.6155
S_t_rc@AC [VA]	830.4608	54.46626	-775.9946

DipTime

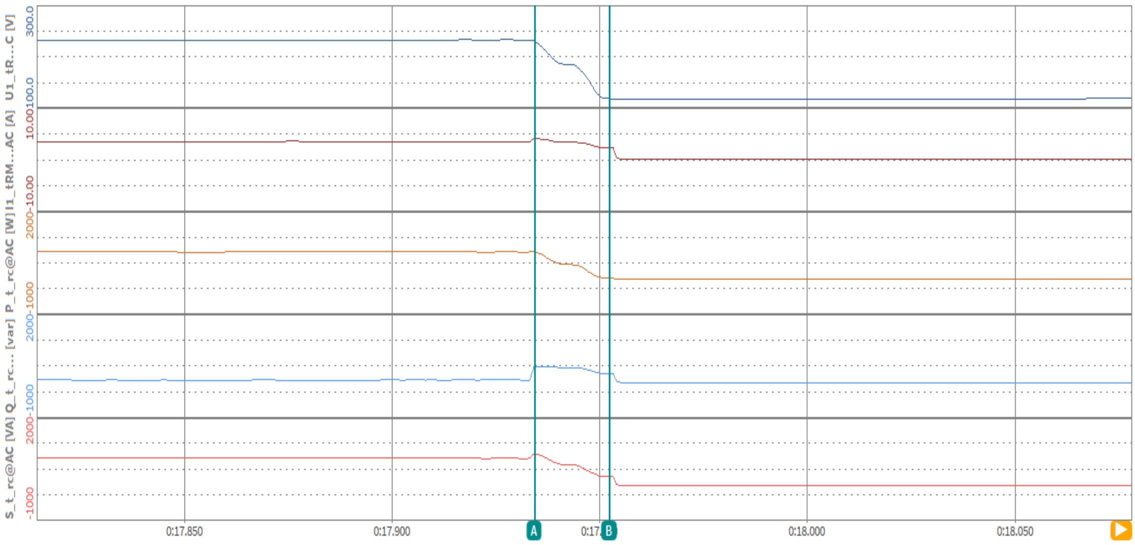
	A	B	间隔
时间 [s]	0:18.05731743	0:19.03638354	0.97906611
U1_tRMS_rc@AC [V]	57.47577	57.40454	-0.071228
I1_tRMS_rc@AC [A]	0.947639	0.022930	-0.924709
P_t_rc@AC [W]	2.739065	3.597e-4	-2.738705
Q_t_rc@AC [var]	54.39735	1.316269	-53.08108
S_t_rc@AC [VA]	54.46626	1.316269	-53.14999

Power Recovery Time



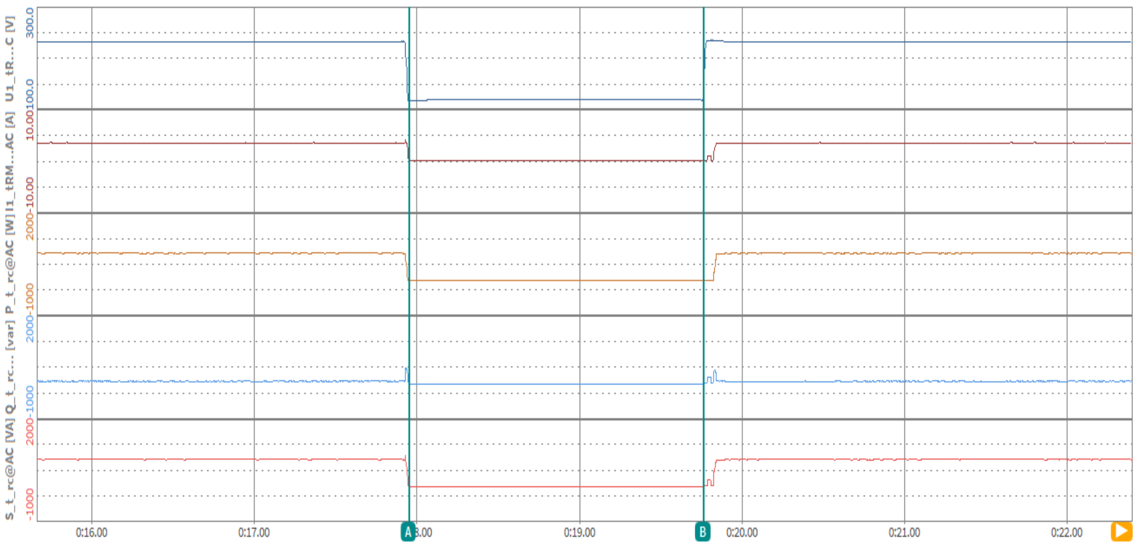
	A	B	间隔
时间 [s]	0:19.0383395	0:19.3117892	0.2734497
U1_tRMS_rc@AC [V]	57.56044	230.0092	172.4487
I1_tRMS_rc@AC [A]	0.022973	3.478631	3.455658
P_t_rc@AC [W]	-0.010447	796.7859	796.7963
Q_t_rc@AC [var]	1.322283	72.93474	71.61246
S_t_rc@AC [VA]	1.322324	800.1170	798.7947

L-N fault	
100%Pn Load	Residual voltage: 50%Un
Voltage Drop time	



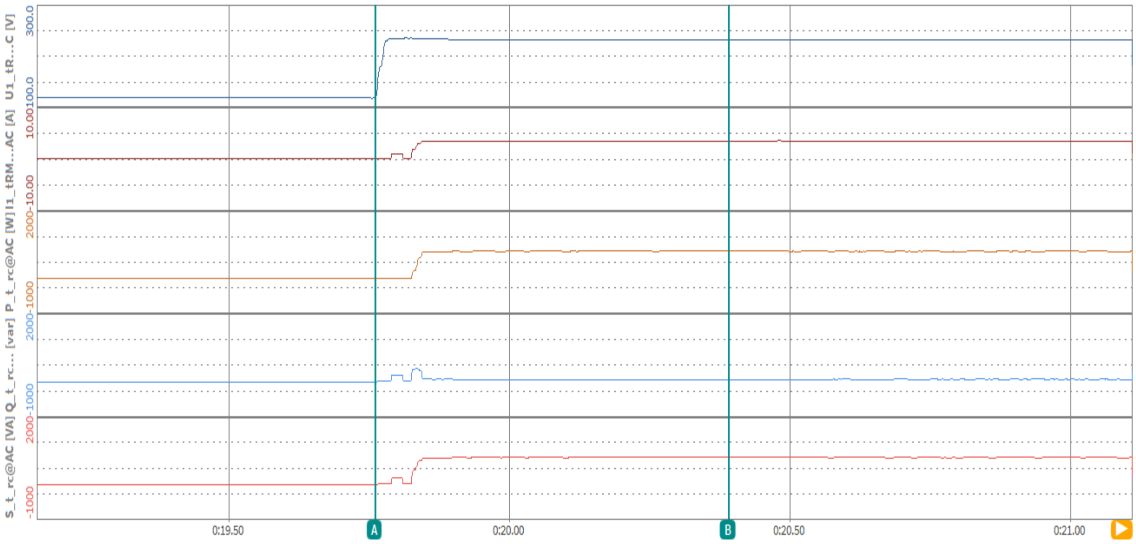
	A	B	间隔
时间 [s]	0:17.93439279	0:17.95242776	0.01803497
U1_tRMS_rc@AC [V]	230.0667	115.0111	-115.0556
I1_tRMS_rc@AC [A]	3.454387	2.232477	-1.221910
P_t_rc@AC [W]	791.4632	22.60386	-768.8593
Q_t_rc@AC [var]	72.08972	255.7628	183.6730
S_t_rc@AC [VA]	794.7396	256.7597	-537.9799

DipTime



	A	B	间隔
时间 [s]	0:17.95265032	0:19.76275783	1.81010750
U1_tRMS_rc@AC [V]	115.0111	115.6987	0.687553
I1_tRMS_rc@AC [A]	2.232477	0.033174	-2.199303
P_t_rc@AC [W]	22.60386	-0.037948	-22.64181
Q_t_rc@AC [var]	255.7628	3.837998	-251.9248
S_t_rc@AC [VA]	256.7597	3.838186	-252.9215

Power Recovery Time

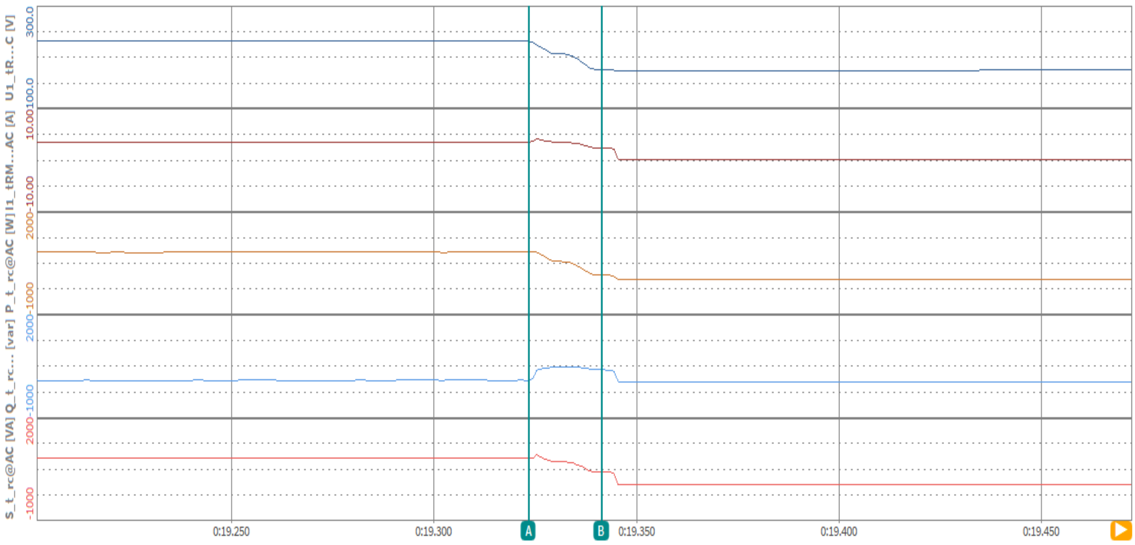


时间 [s]	A 0:19.760941	B 0:20.390011	间隔 0.629070
U1_tRMS_rc@AC [V]	115.2192	230.0584	114.8392
I1_tRMS_rc@AC [A]	0.033134	3.488174	3.455040
P_t_rc@AC [W]	-0.054211	799.3460	799.4002
Q_t_rc@AC [var]	3.817285	70.89639	67.07911
S_t_rc@AC [VA]	3.817670	802.4839	798.6662

L-N fault

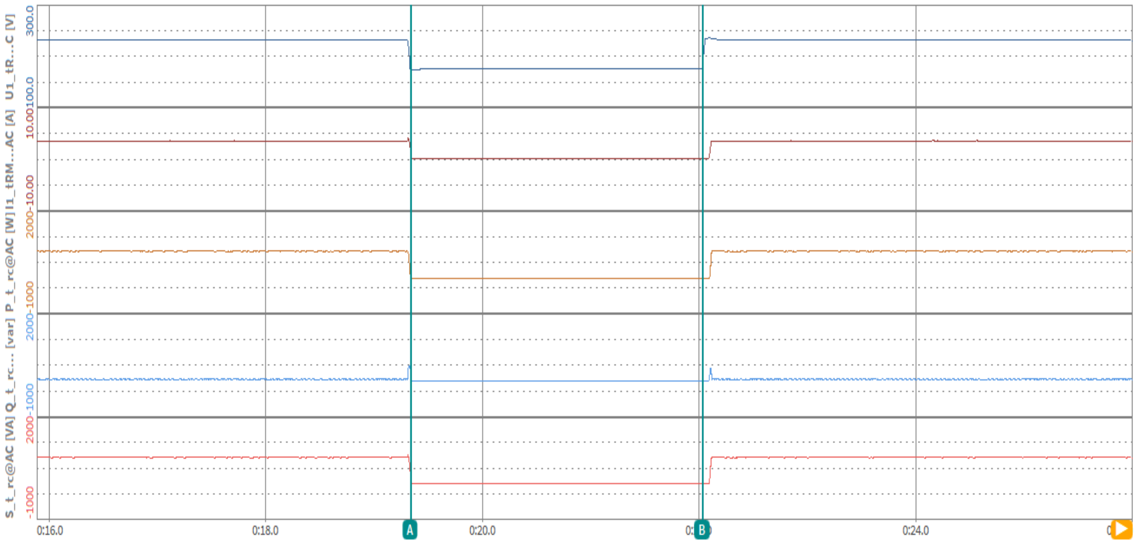
100%Pn Load	Residual voltage: 75%Un

Voltage Drop time



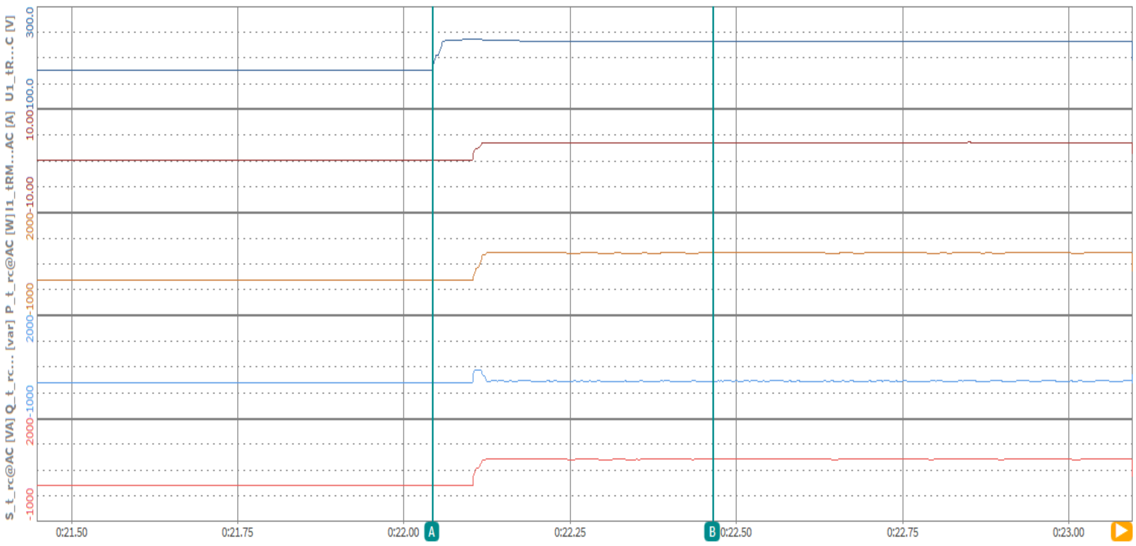
时间 [s]	A 0:19.3234408	B 0:19.3414951	间隔 0.0180543
U1_tRMS_rc@AC [V]	230.0230	172.5105	-57.51257
I1_tRMS_rc@AC [A]	3.490792	2.322895	-1.167898
P_t_rc@AC [W]	799.5894	119.4416	-680.1478
Q_t_rc@AC [var]	73.52382	382.5090	308.9852
S_t_rc@AC [VA]	802.9626	400.7236	-402.2390

DipTime



	A	B	间隔
时间 [s]	0:19.3410030	0:22.0328026	2.6917997
U1_tRMS_rc@AC [V]	172.5105	172.6048	0.094360
I1_tRMS_rc@AC [A]	2.322895	0.045234	-2.277660
P_t_rc@AC [W]	119.4416	-0.080714	-119.5223
Q_t_rc@AC [var]	382.5090	7.807230	-374.7017
S_t_rc@AC [VA]	400.7236	7.807647	-392.9160

Power Recovery Time



	A	B	间隔
时间 [s]	0:22.0431449	0:22.4645739	0.4214289
U1_tRMS_rc@AC [V]	172.6147	230.0514	57.43671
I1_tRMS_rc@AC [A]	0.045520	3.462344	3.416823
P_t_rc@AC [W]	-0.049743	793.2045	793.2543
Q_t_rc@AC [var]	7.857301	72.56697	64.70967
S_t_rc@AC [VA]	7.857458	796.5170	788.6596

4.2.3. Over-voltage ride through (OVRT)

The test has been performed according to the clause 4.5.4 of the standard. The setting of over-voltage ride through capability is as follows:

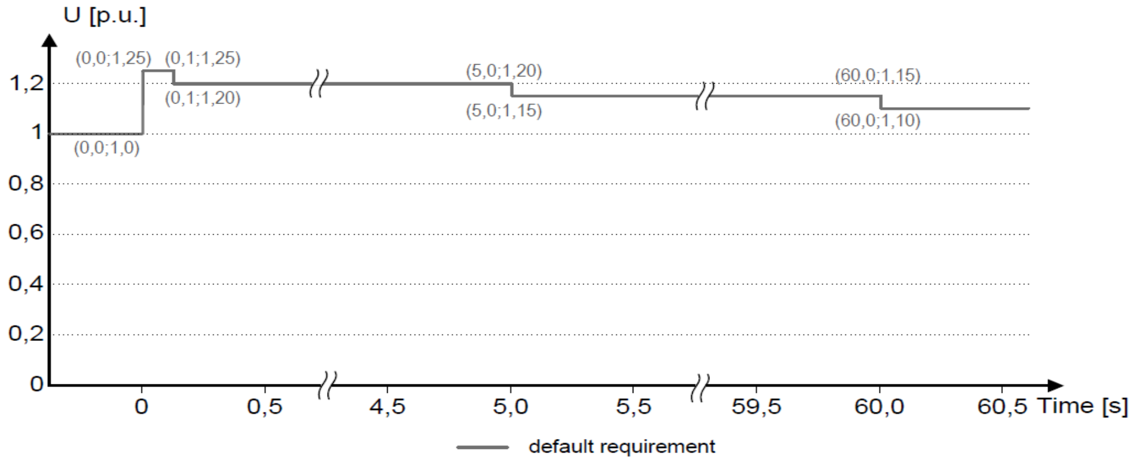
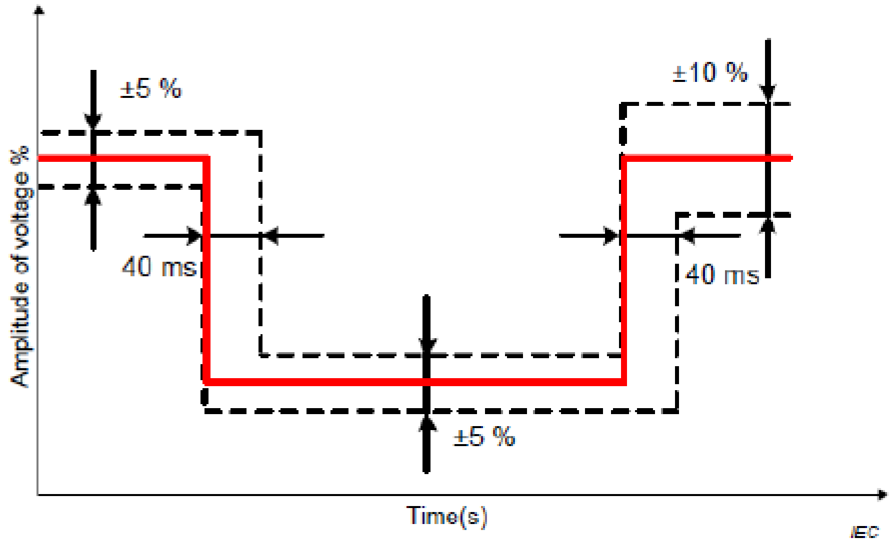


Figure 8 — Over-voltage ride through capability

4.2.3.1 *No load Test*

It is not specified in the reference standard, but following tolerances have been applied. Tolerances for drop depth and duration during no-load tests shall not exceed the values shown in the next figure:



The tolerance for voltage magnitude is ±5%Un for the period before and during the voltage drop. The tolerance for voltage magnitude is ±10%Un during the period after voltage is recovered.
The tolerance range for both drop duration and rise time prefers 40 ms.

Test results of different no-load cases performed are offered below:

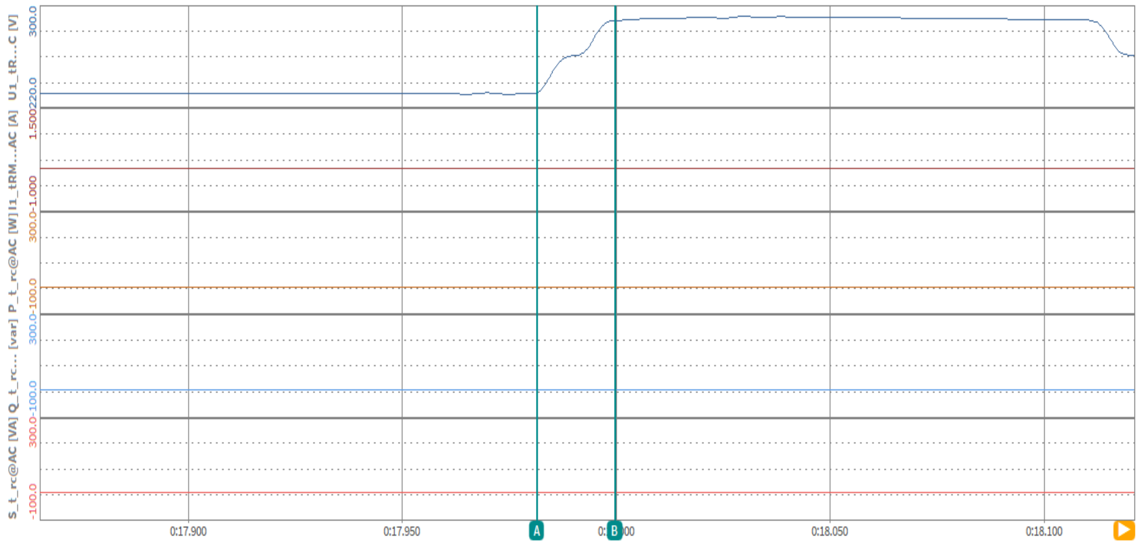
L-N fault							
Residual voltage Desired (%Un)	Voltage before sag (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.0	18	125.0	> 100	112	--	100.2
120.0	100.0	17	120.2	> 5000	5072	--	100.3
115.0	100.1	16	115.1	> 60000	60929	--	100.1

Test results are graphically represented at following pages.

L-N fault

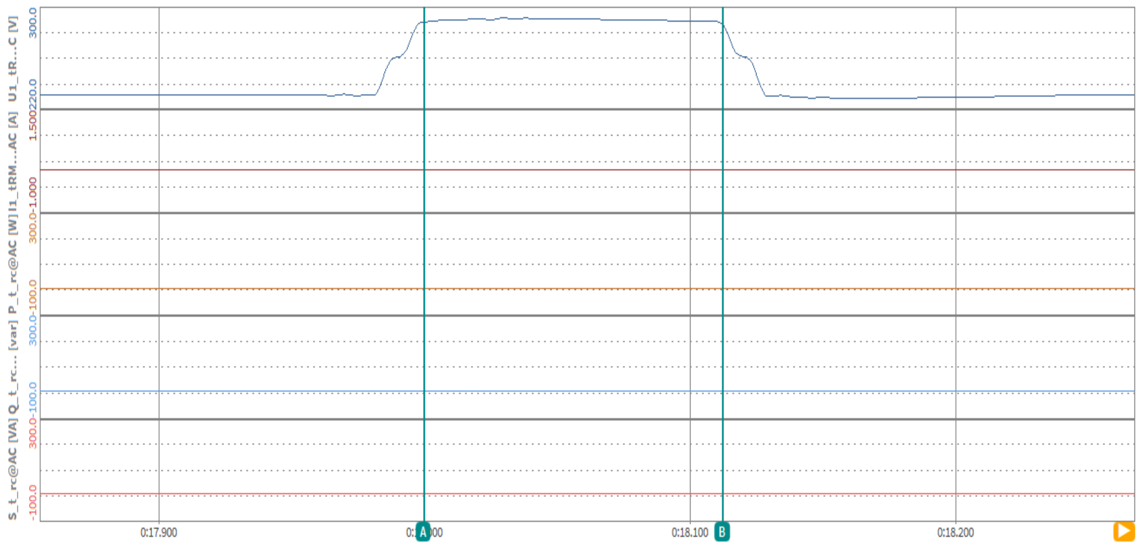
No Load	Residual voltage: 125.0%Un

Voltage Rise time



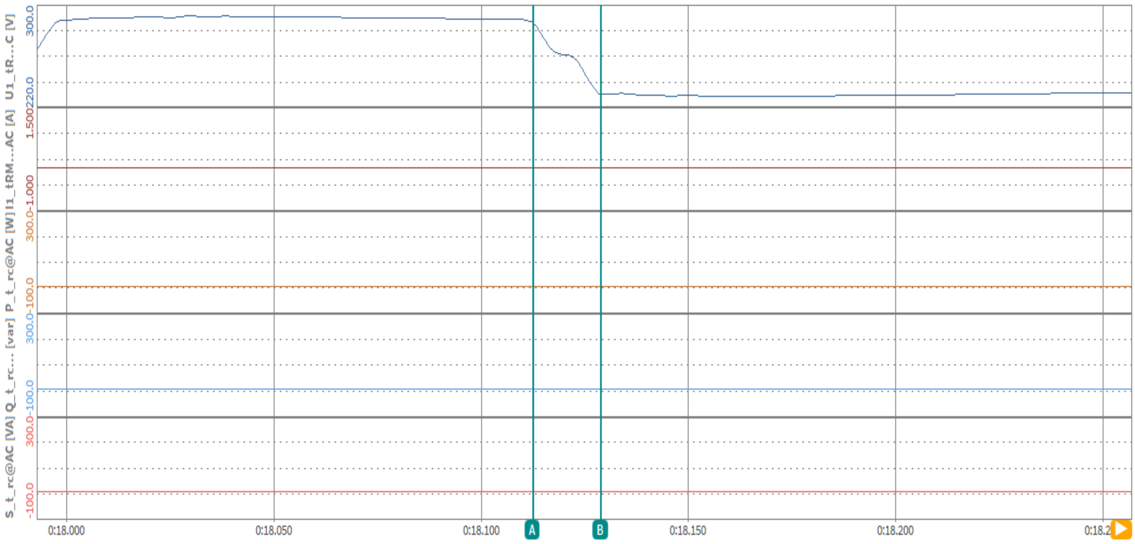
	A	B	间隔
时间 [s]	0:17.98157375	0:17.99984752	0.01827377
U1_tRMS_rc@AC [V]	230.0513	287.4356	57.38429
I1_tRMS_rc@AC [A]	0.019808	0.019296	-5.120e-4
P_t_rc@AC [W]	-1.865e-3	5.758e-3	7.622e-3
Q_t_rc@AC [var]	4.556950	5.546479	0.989529
S_t_rc@AC [VA]	4.556950	5.546482	0.989532

DipTime



	A	B	间隔
时间 [s]	0:17.99975820	0:18.11223146	0.11247326
U1_tRMS_rc@AC [V]	287.4356	287.6895	0.253906
I1_tRMS_rc@AC [A]	0.019296	0.019990	6.937e-4
P_t_rc@AC [W]	5.758e-3	0.102921	0.097164
Q_t_rc@AC [var]	5.546479	5.750045	0.203566
S_t_rc@AC [VA]	5.546482	5.750966	0.204484

Voltage recovery time

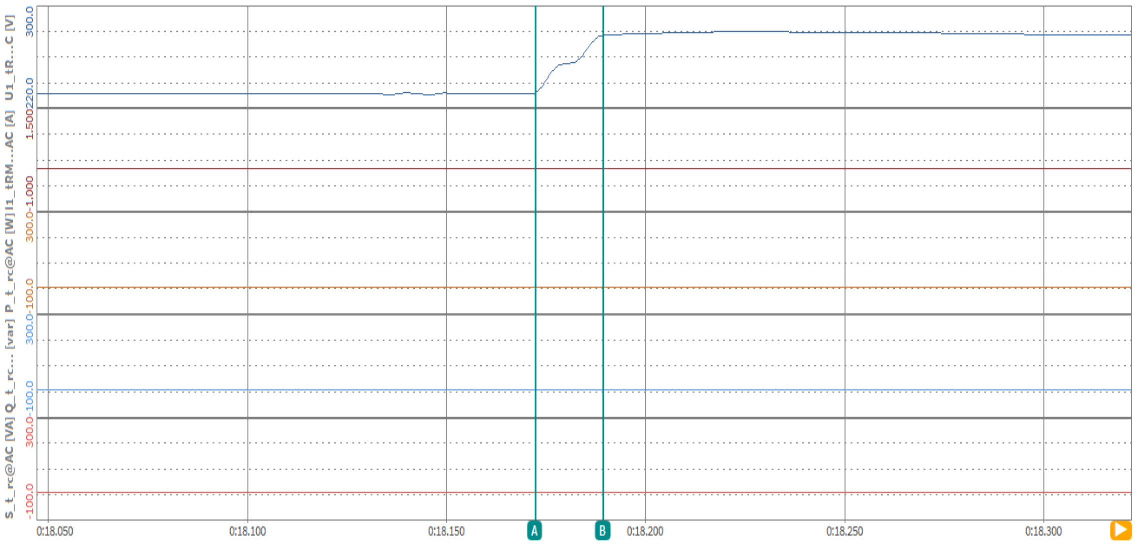


	A	B	间隔
时间 [s]	0:18.11248490	0:18.12892531	0.01644041
U1_tRMS_rc@AC [V]	287.6895	230.3573	-57.33229
I1_tRMS_rc@AC [A]	0.019990	0.019813	-1.768e-4
P_t_rc@AC [W]	0.102921	0.015756	-0.087166
Q_t_rc@AC [var]	5.750045	4.564128	-1.185917
S_t_rc@AC [VA]	5.750966	4.564156	-1.186810

L-N fault

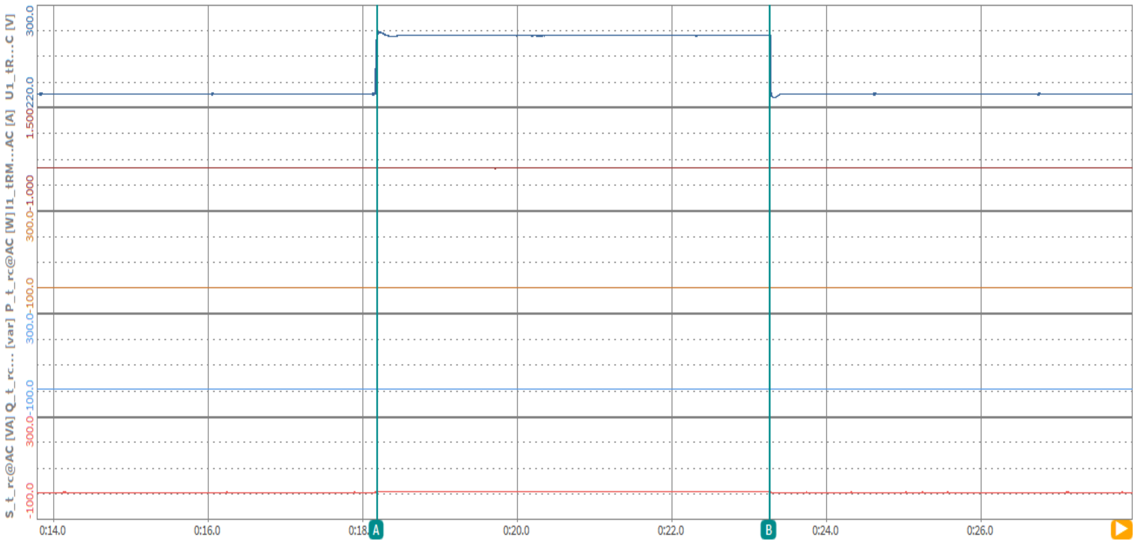
No Load	Residual voltage: 120.0%Un

Voltage Rise time



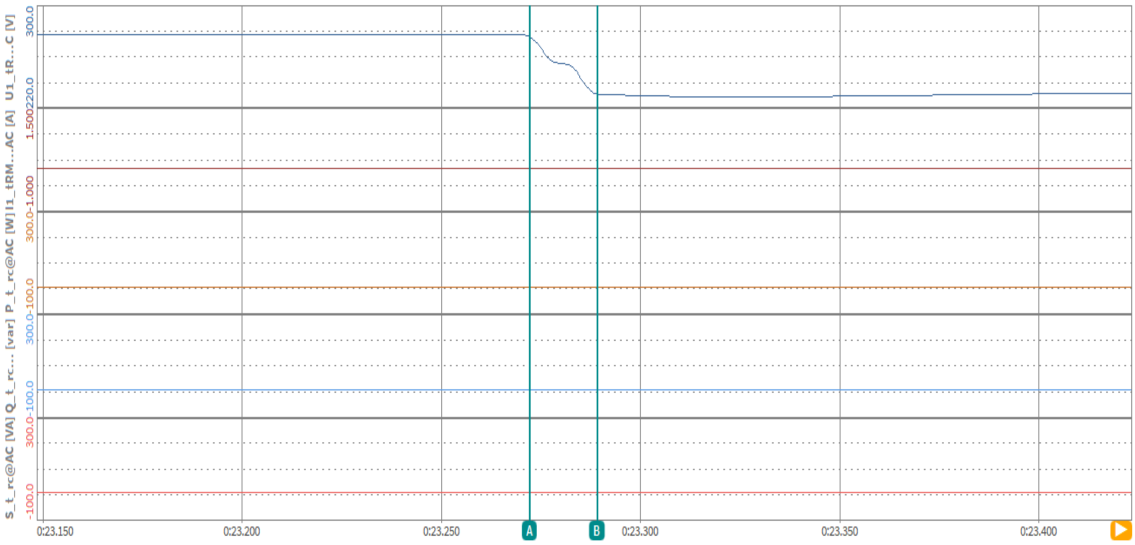
	A	B	间隔
时间 [s]	0:18.17232635	0:18.18945974	0.01713339
U1_tRMS_rc@AC [V]	230.0850	276.4180	46.33301
I1_tRMS_rc@AC [A]	0.021173	0.021331	1.580e-4
P_t_rc@AC [W]	0.021300	-0.024754	-0.046054
Q_t_rc@AC [var]	4.871474	5.896135	1.024661
S_t_rc@AC [VA]	4.871521	5.896187	1.024666

DipTime



	A	B	间隔
时间 [s]	0:18.18980492	0:23.26208661	5.07228169
U1_tRMS_rc@AC [V]	276.4180	275.9498	-0.468170
I1_tRMS_rc@AC [A]	0.021331	0.021214	-1.164e-4
P_t_rc@AC [W]	-0.024754	-0.055549	-0.030795
Q_t_rc@AC [var]	5.896135	5.853827	-0.042308
S_t_rc@AC [VA]	5.896187	5.854091	-0.042096

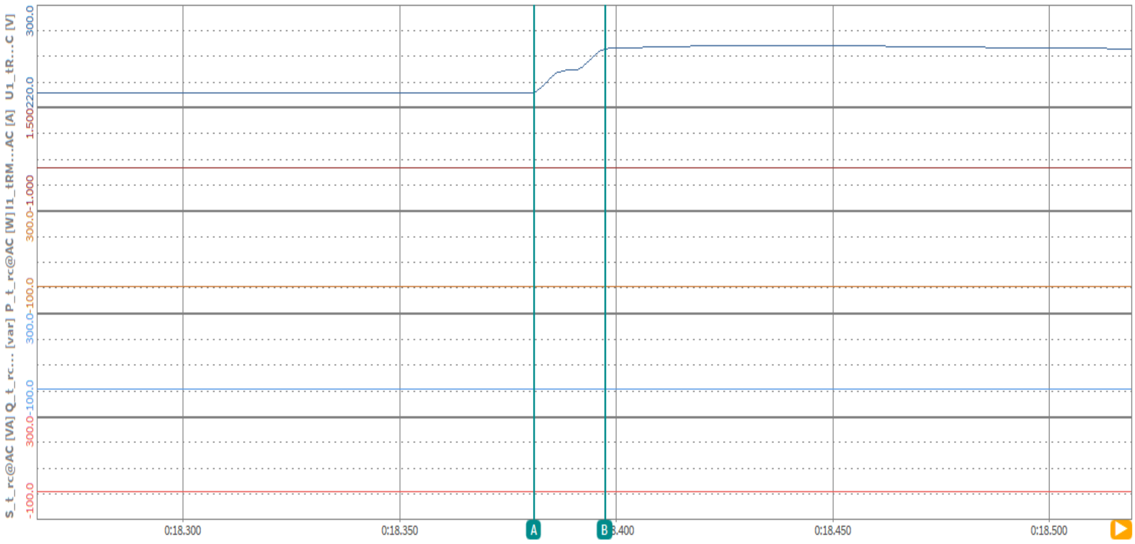
Voltage recovery time



	A	B	间隔
时间 [s]	0:23.27226895	0:23.28922058	0.01695163
U1_tRMS_rc@AC [V]	275.9117	230.6937	-45.21797
I1_tRMS_rc@AC [A]	0.021488	0.020995	-4.935e-4
P_t_rc@AC [W]	0.031879	0.133824	0.101944
Q_t_rc@AC [var]	5.928799	4.841520	-1.087279
S_t_rc@AC [VA]	5.928885	4.843369	-1.085515

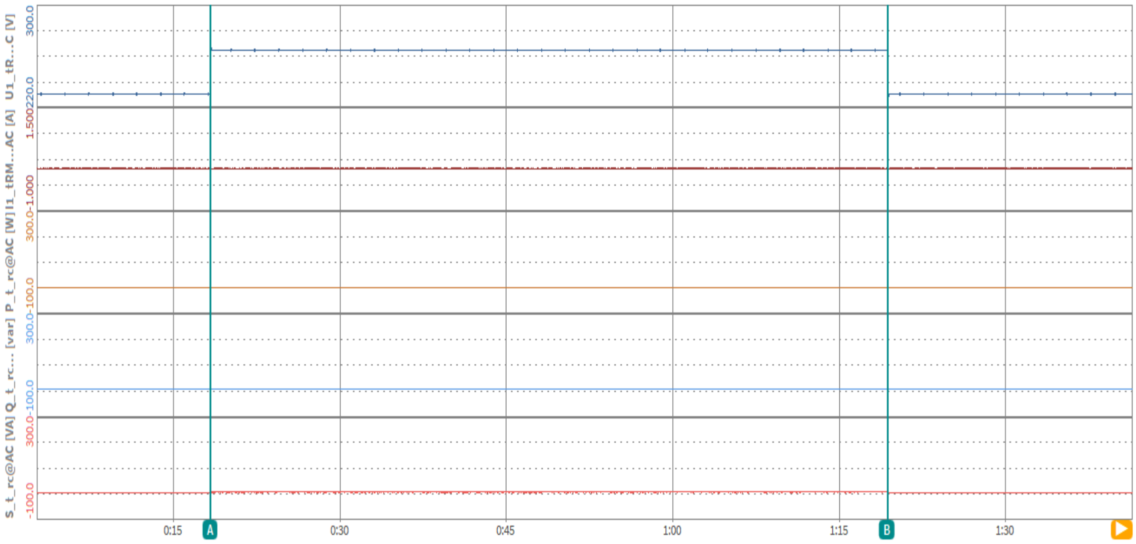
L-N fault	
No Load	Residual voltage: 115.0%Un

Voltage Rise time



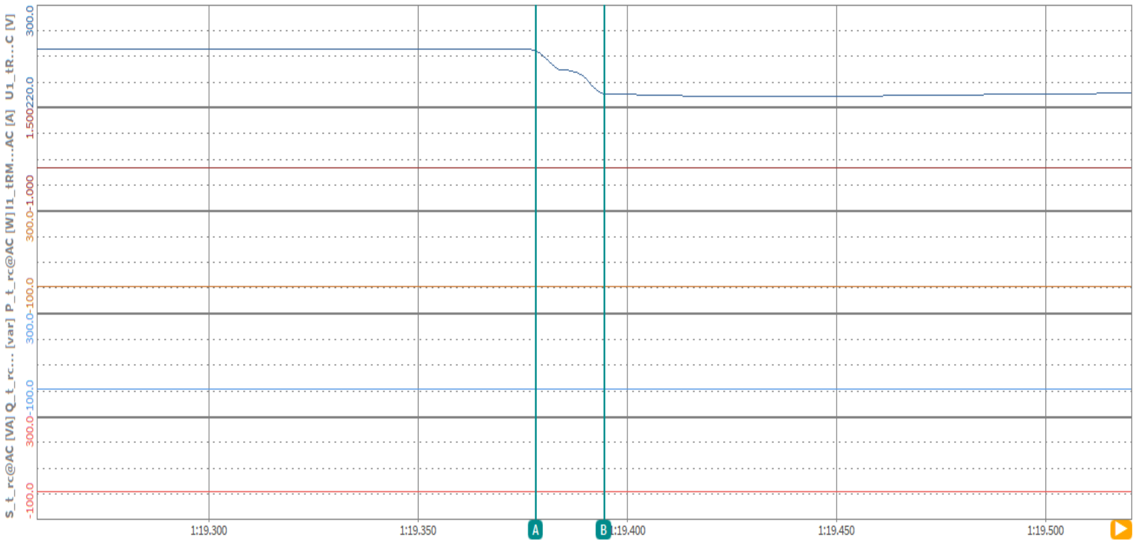
时间 [s]	A 0:18.38107367	B 0:18.39750196	间隔 0.01642829
U1_tRMS_rc@AC [V]	230.2387	264.6546	34.41591
I1_tRMS_rc@AC [A]	0.019336	0.019079	-2.564e-4
P_t_rc@AC [W]	-0.062210	0.043005	0.105215
Q_t_rc@AC [var]	4.451374	5.049220	0.597846
S_t_rc@AC [VA]	4.451809	5.049403	0.597594

DipTime



时间 [s]	A 0:18.3975002	B 1:19.3262686	间隔 1:00.9287684
U1_tRMS_rc@AC [V]	264.6546	264.4737	-0.180878
I1_tRMS_rc@AC [A]	0.019079	0.019855	7.760e-4
P_t_rc@AC [W]	0.043005	0.159885	0.116881
Q_t_rc@AC [var]	5.049220	5.248756	0.199537
S_t_rc@AC [VA]	5.049403	5.251191	0.201788

Voltage recovery time



	A	B	间隔
时间 [s]	1:19.3782639	1:19.3945336	0.0162696
U1_tRMS_rc@AC [V]	264.4139	230.1594	-34.25450
I1_tRMS_rc@AC [A]	0.019737	0.019567	-1.693e-4
P_t_rc@AC [W]	0.127890	-2.980e-3	-0.130869
Q_t_rc@AC [var]	5.217100	4.503618	-0.713482
S_t_rc@AC [VA]	5.218668	4.503619	-0.715048

4.2.3.2 Load Tests: Partial load (20%Pn)

Test results of 20%Pn power cases performed are offered below:

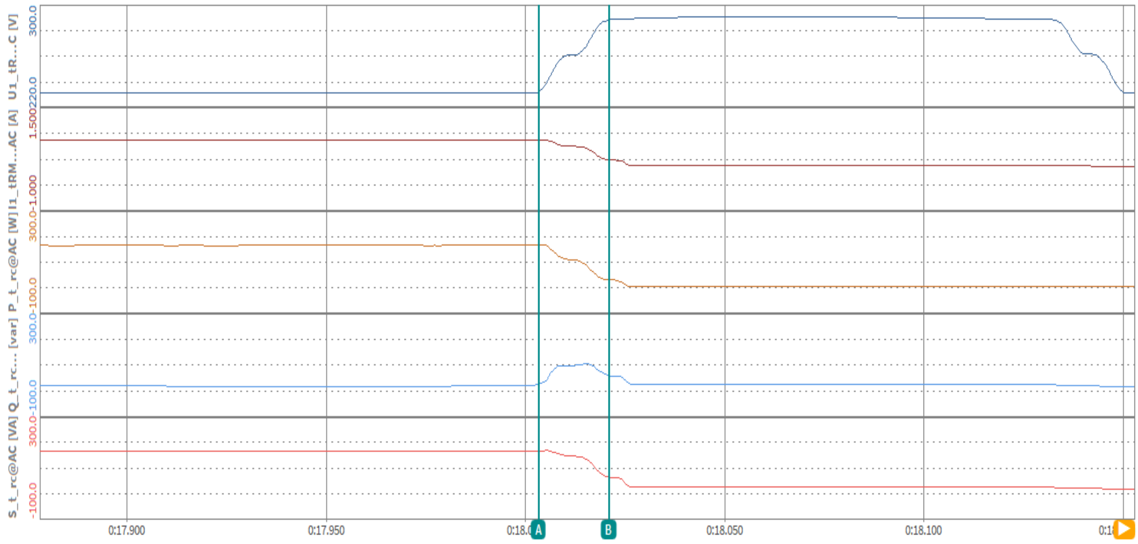
L-N fault							
Residual voltage Desired (%Un)	Voltage before sag (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.0	18	125.1	> 100	113	240	100.1
120.0	100.1	18	120.2	> 5000	5281	243	100.1
115.0	100.0	17	115.0	> 60000	60903	282	100.0

Test results are graphically represented at following pages.

L-N fault

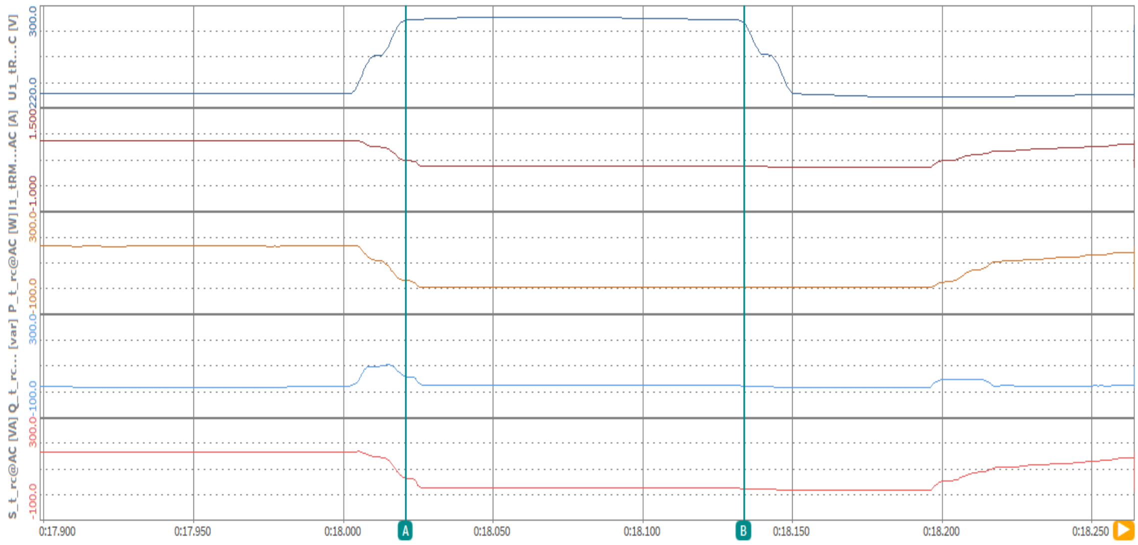
Partial load (20%Pn)	Residual voltage: 125.0%Un

Voltage Rise time



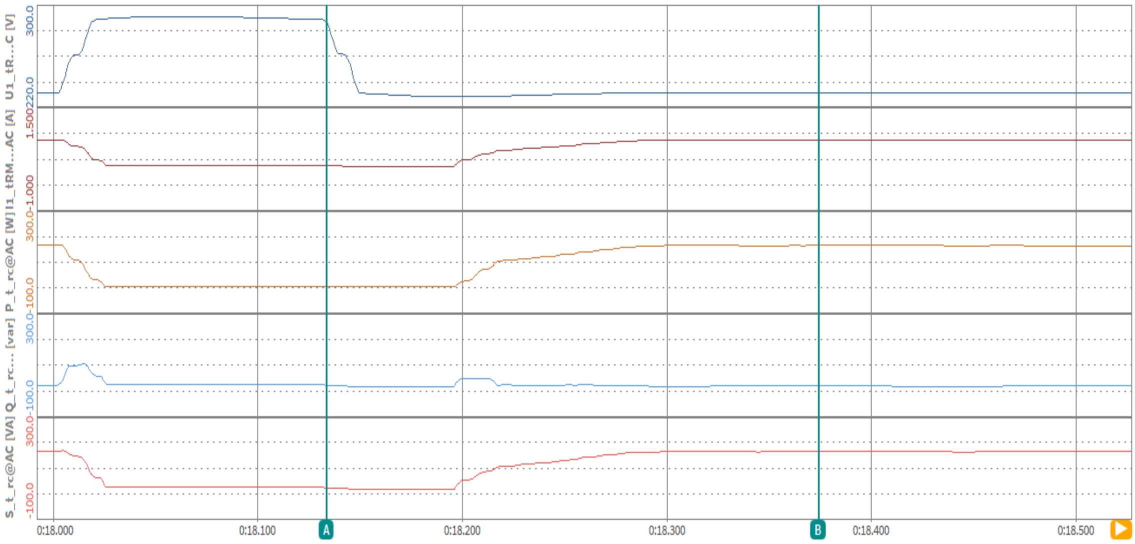
时间 [s]	A 0:18.0033738	B 0:18.0210589	间隔 0.0176851
U1_tRMS_rc@AC [V]	230.0588	287.7035	57.64464
I1_tRMS_rc@AC [A]	0.709315	0.218537	-0.490778
P_t_rc@AC [W]	162.2405	26.11106	-136.1294
Q_t_rc@AC [var]	17.52387	57.19560	39.67173
S_t_rc@AC [VA]	163.1841	62.87388	-100.3102

DipTime



时间 [s]	A 0:18.0209752	B 0:18.1338945	间隔 0.1129193
U1_tRMS_rc@AC [V]	287.7035	287.5248	-0.178619
I1_tRMS_rc@AC [A]	0.218537	0.070621	-0.147916
P_t_rc@AC [W]	26.11106	0.352910	-25.75815
Q_t_rc@AC [var]	57.19560	20.30236	-36.89324
S_t_rc@AC [VA]	62.87388	20.30543	-42.56845

Power Recovery time

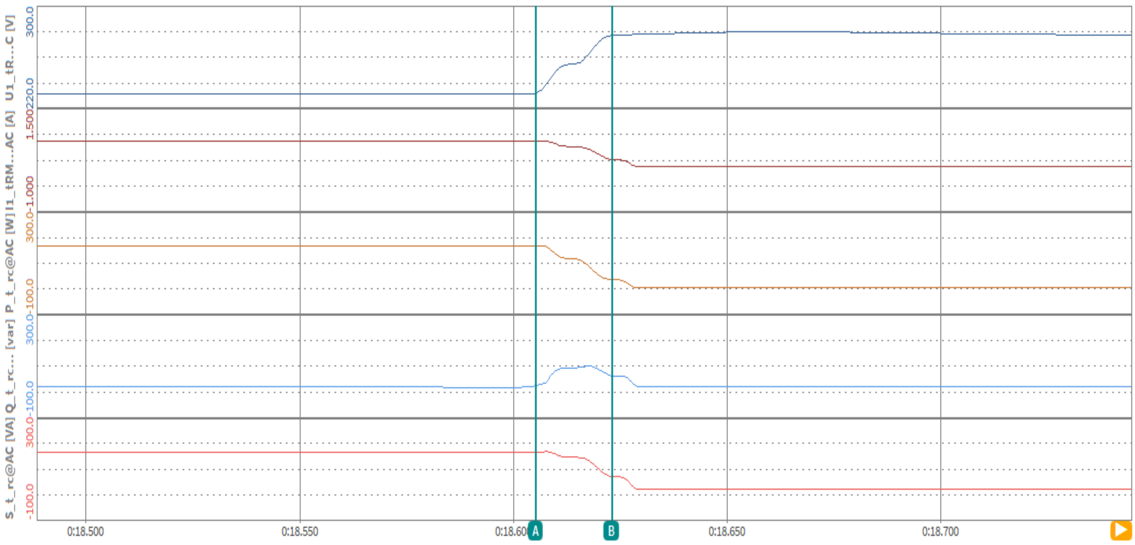


	A	B	间隔
时间 [s]	0:18.1338511	0:18.3741004	0.2402493
U1_tRMS_rc@AC [V]	287.5248	230.2789	-57.24597
I1_tRMS_rc@AC [A]	0.070621	0.705663	0.635041
P_t_rc@AC [W]	0.352910	161.5199	161.1670
Q_t_rc@AC [var]	20.30236	17.81344	-2.488926
S_t_rc@AC [VA]	20.30543	162.4993	142.1938

L-N fault

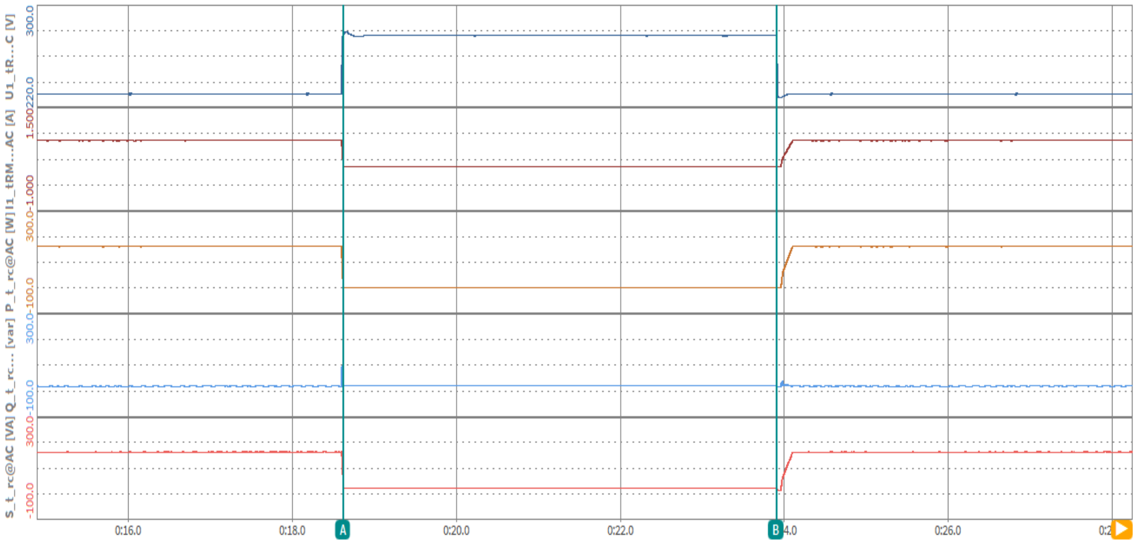
Partial load (20%Pn)	Residual voltage: 120.0%Un

Voltage Rise time



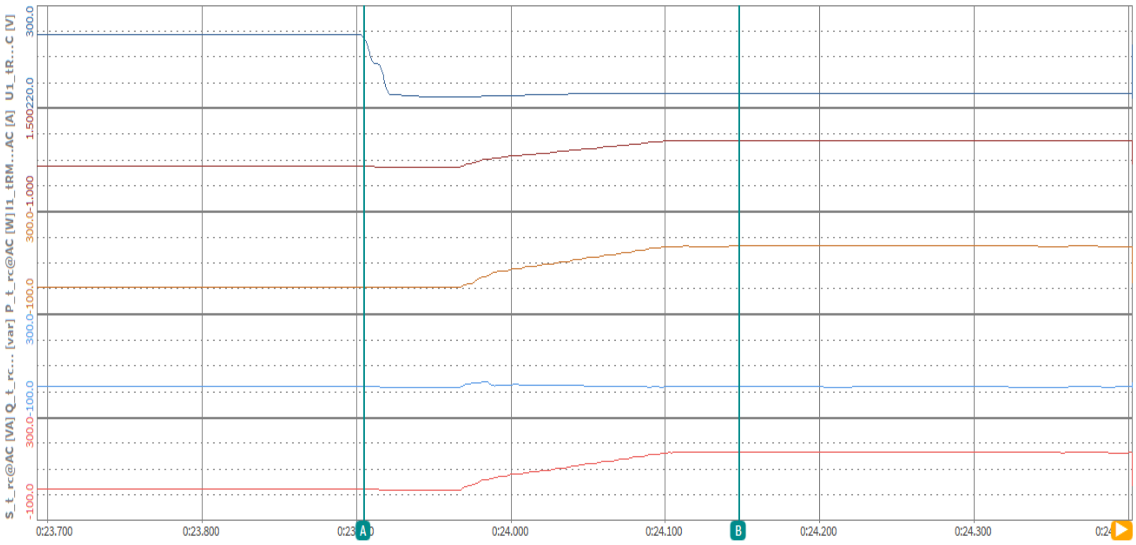
	A	B	间隔
时间 [s]	0:18.6052956	0:18.6230301	0.0177345
U1_tRMS_rc@AC [V]	230.2055	276.5371	46.33165
I1_tRMS_rc@AC [A]	0.710933	0.245833	-0.465100
P_t_rc@AC [W]	162.6162	31.32406	-131.2921
Q_t_rc@AC [var]	18.46136	60.33529	41.87392
S_t_rc@AC [VA]	163.6608	67.98193	-95.67882

DipTime



	A	B	间隔
时间 [s]	0:18.6230327	0:23.9039966	5.2809639
U1_tRMS_rc@AC [V]	276.5371	275.9352	-0.601990
I1_tRMS_rc@AC [A]	0.245833	0.069293	-0.176540
P_t_rc@AC [W]	31.32406	-0.160229	-31.48429
Q_t_rc@AC [var]	60.33529	19.11963	-41.21565
S_t_rc@AC [VA]	67.98193	19.12030	-48.86163

Power Recovery time

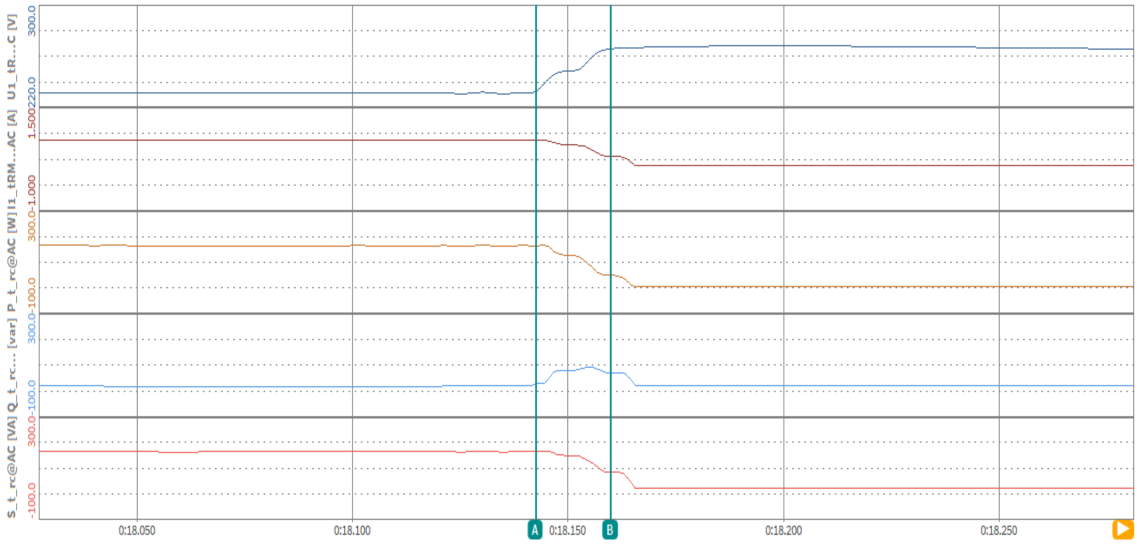


	A	B	间隔
时间 [s]	0:23.90474334	0:24.14751331	0.24276997
U1_tRMS_rc@AC [V]	275.9352	230.2097	-45.72548
I1_tRMS_rc@AC [A]	0.069293	0.705714	0.636421
P_t_rc@AC [W]	-0.160229	161.3679	161.5281
Q_t_rc@AC [var]	19.11963	18.82388	-0.295748
S_t_rc@AC [VA]	19.12030	162.4621	143.3418

L-N fault

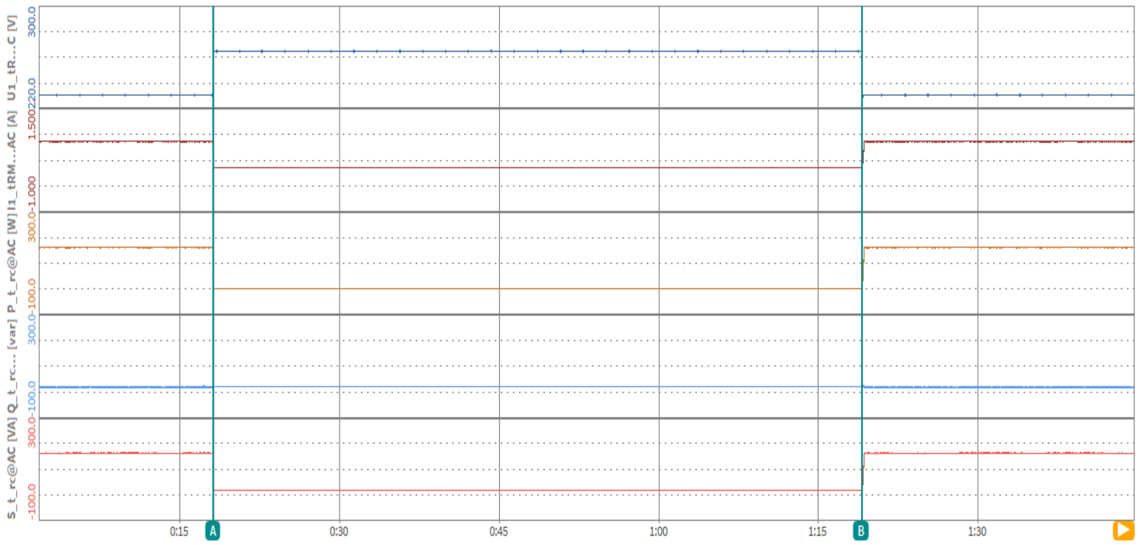
Partial load (20%Pn)	Residual voltage: 115.0%Un

Voltage Rise time



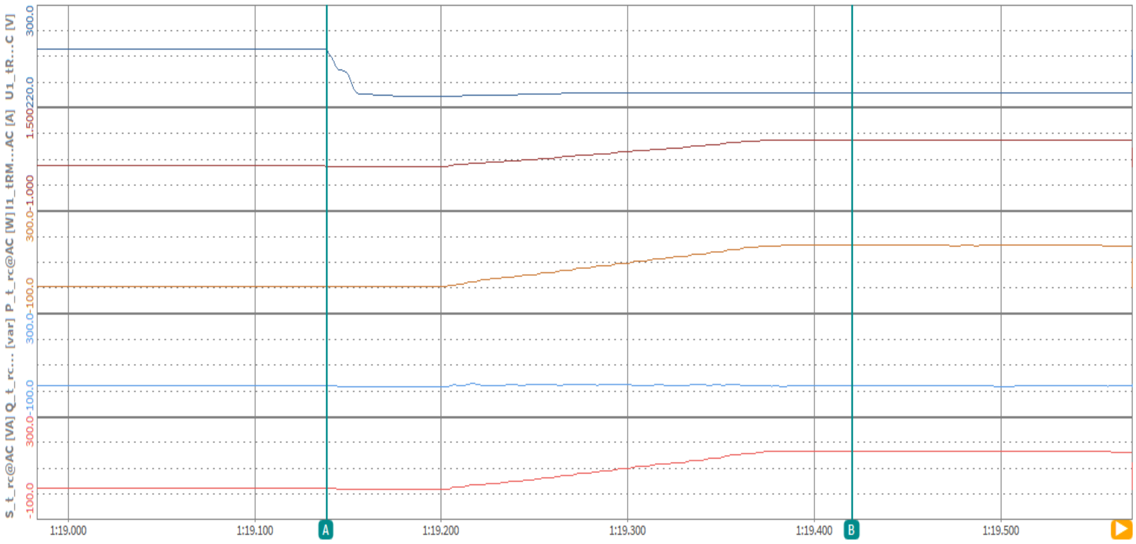
时间 [s]	A 0:18.1425630	B 0:18.1599506	间隔 0.0173876
U1_tRMS_rc@AC [V]	230.0957	264.5118	34.41608
I1_tRMS_rc@AC [A]	0.703366	0.303573	-0.399793
P_t_rc@AC [W]	160.6724	44.01782	-116.6545
Q_t_rc@AC [var]	19.41875	67.15880	47.74005
S_t_rc@AC [VA]	161.8416	80.29865	-81.54293

DipTime



时间 [s]	A 0:18.1599483	B 1:19.0631608	间隔 1:00.9032125
U1_tRMS_rc@AC [V]	264.5118	264.4684	-0.043396
I1_tRMS_rc@AC [A]	0.303573	0.066145	-0.237428
P_t_rc@AC [W]	44.01782	-0.088461	-44.10628
Q_t_rc@AC [var]	67.15880	17.49298	-49.66581
S_t_rc@AC [VA]	80.29865	17.49321	-62.80544

Power Recovery time



	A	B	间隔
时间 [s]	1:19.1386083	1:19.4204145	0.2818062
U1_tRMS_rc@AC [V]	264.4673	230.0707	-34.39661
I1_tRMS_rc@AC [A]	0.066089	0.708116	0.642027
P_t_rc@AC [W]	-0.159503	161.9855	162.1450
Q_t_rc@AC [var]	17.47757	17.39384	-0.083731
S_t_rc@AC [VA]	17.47830	162.9167	145.4384

4.2.3.2 *Load Tests: Full Load (* > 90 %Pn*)*

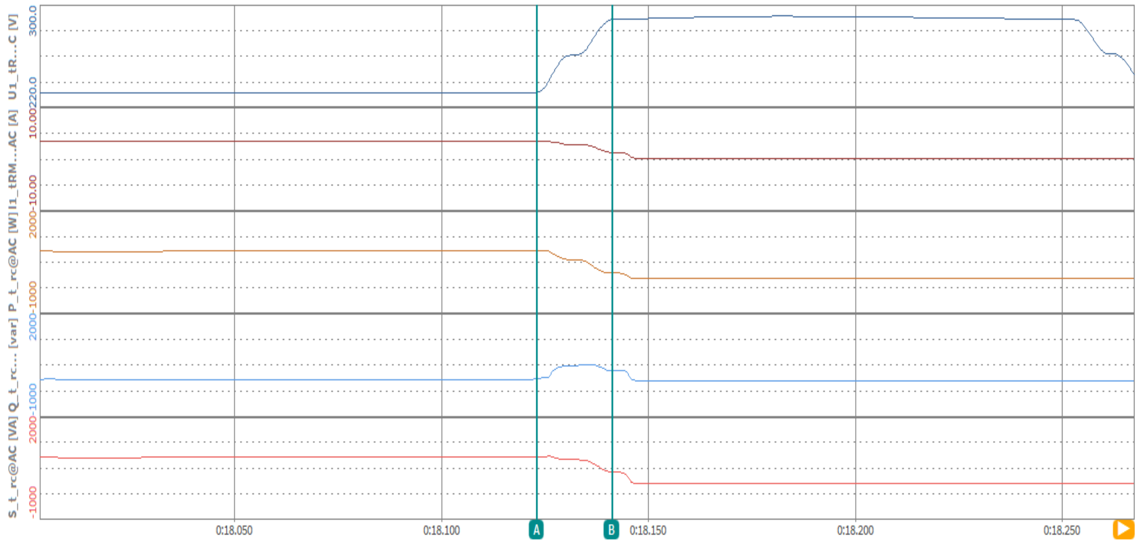
Test results of full power cases performed are offered below:

L-N fault							
Residual voltage Desired (%Un)	Voltage before sag (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.0	18	125.1	> 100	112	875	100.0
120.0	100.0	17	120.0	> 5000	5270	987	100.0
115.0	100.0	18	115.2	> 60000	60947	223	100.1

Test results are graphically represented at following pages.

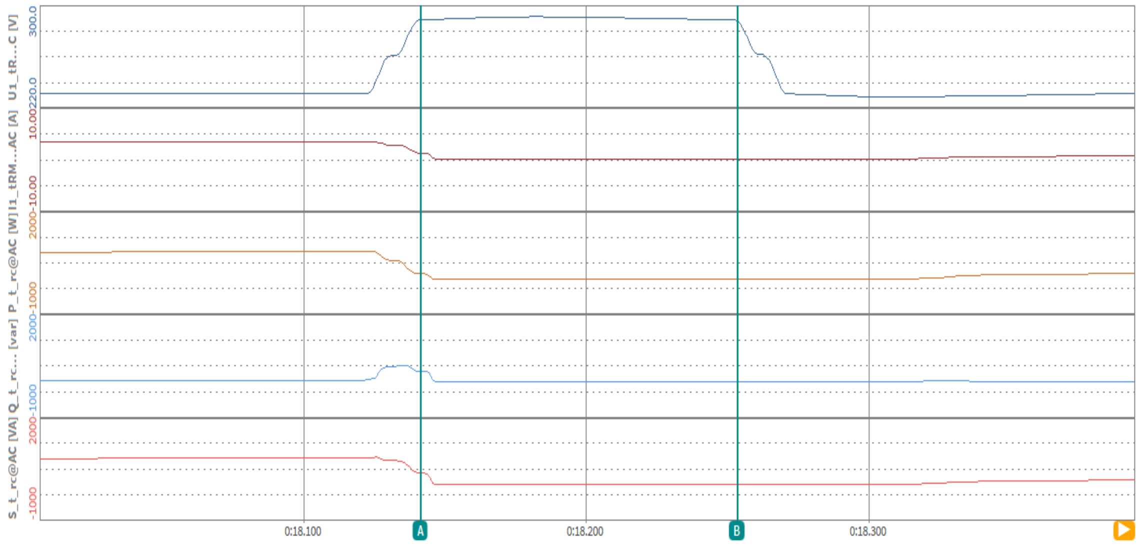
L-N fault	
Partial load (100%Pn)	Residual voltage: 125.0%Un

Voltage Rise time



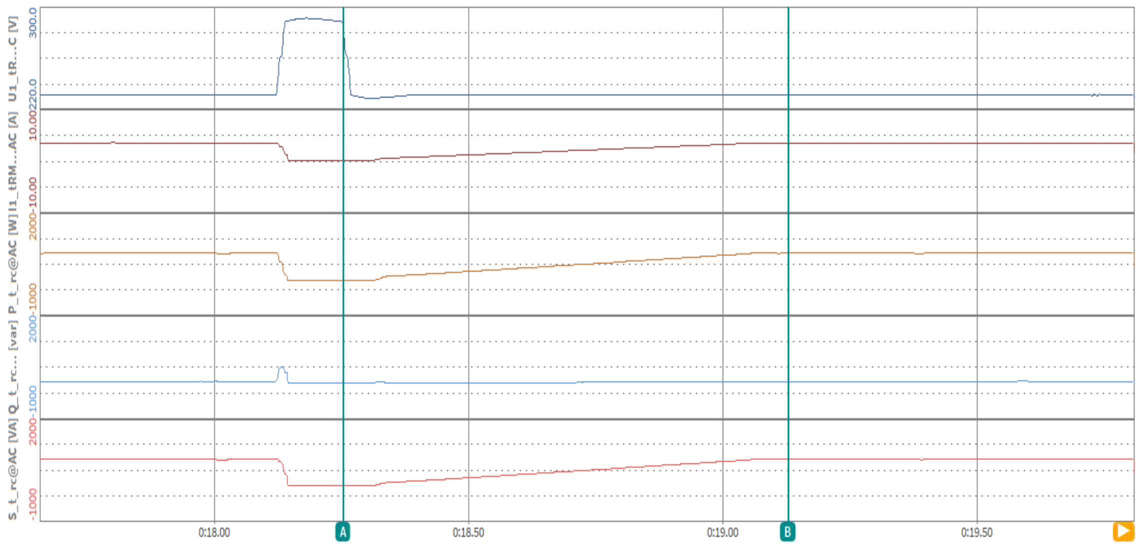
	A	B	间隔
时间 [s]	0:18.12305151	0:18.14119614	0.01814463
U1_tRMS_rc@AC [V]	230.0619	287.7606	57.69862
I1_tRMS_rc@AC [A]	3.475606	1.244609	-2.230997
P_t_rc@AC [W]	796.6180	144.8084	-651.8096
Q_t_rc@AC [var]	69.04589	327.5690	258.5231
S_t_rc@AC [VA]	799.6047	358.1493	-441.4554

DipTime



	A	B	间隔
时间 [s]	0:18.14150144	0:18.25340814	0.11190670
U1_tRMS_rc@AC [V]	287.7606	288.0327	0.272095
I1_tRMS_rc@AC [A]	1.244609	0.071718	-1.172891
P_t_rc@AC [W]	144.8084	5.845e-3	-144.8026
Q_t_rc@AC [var]	327.5690	20.65719	-306.9118
S_t_rc@AC [VA]	358.1493	20.65719	-337.4921

Power Recovery time

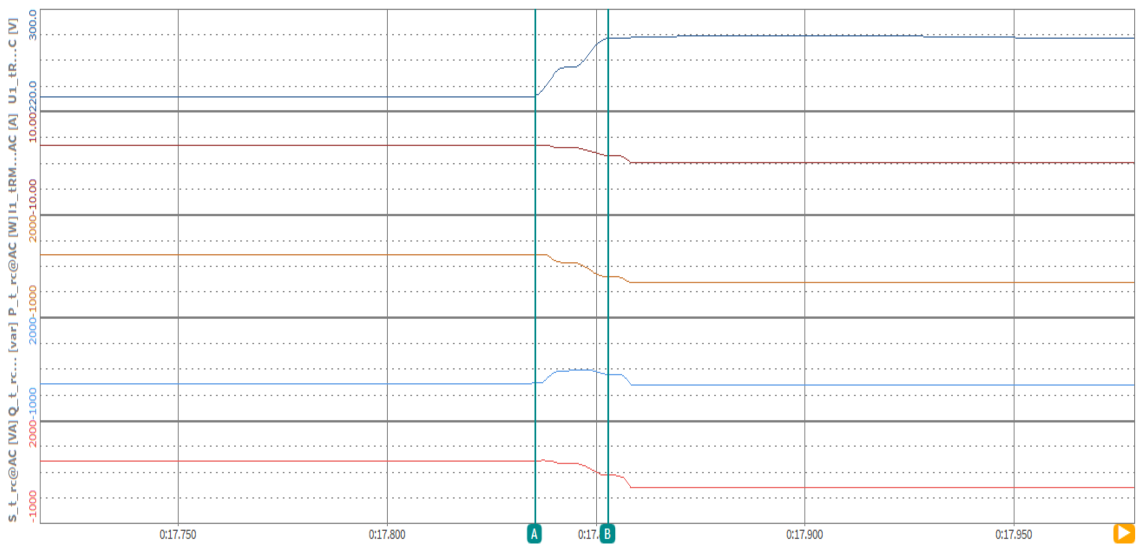


	A	B	间隔
时间 [s]	0:18.25371483	0:19.12835015	0.87463532
U1_tRMS_rc@AC [V]	288.0327	230.0752	-57.95744
I1_tRMS_rc@AC [A]	0.071718	3.489628	3.417910
P_t_rc@AC [W]	5.845e-3	800.0930	800.0871
Q_t_rc@AC [var]	20.65719	66.80357	46.14638
S_t_rc@AC [VA]	20.65719	802.8770	782.2198

L-N fault

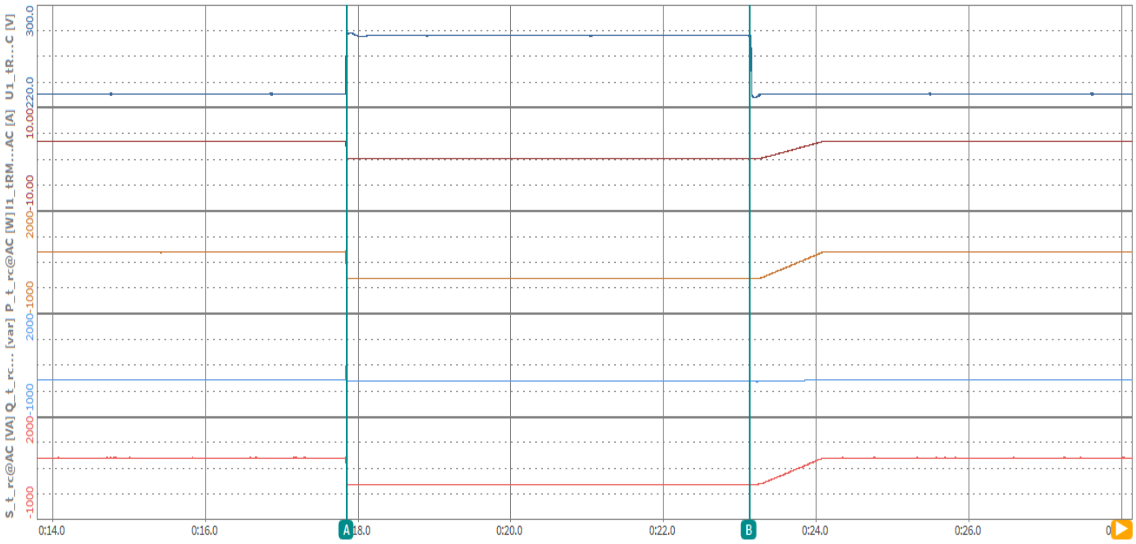
Partial load (100%Pn)	Residual voltage: 120.0%Un

Voltage Rise time



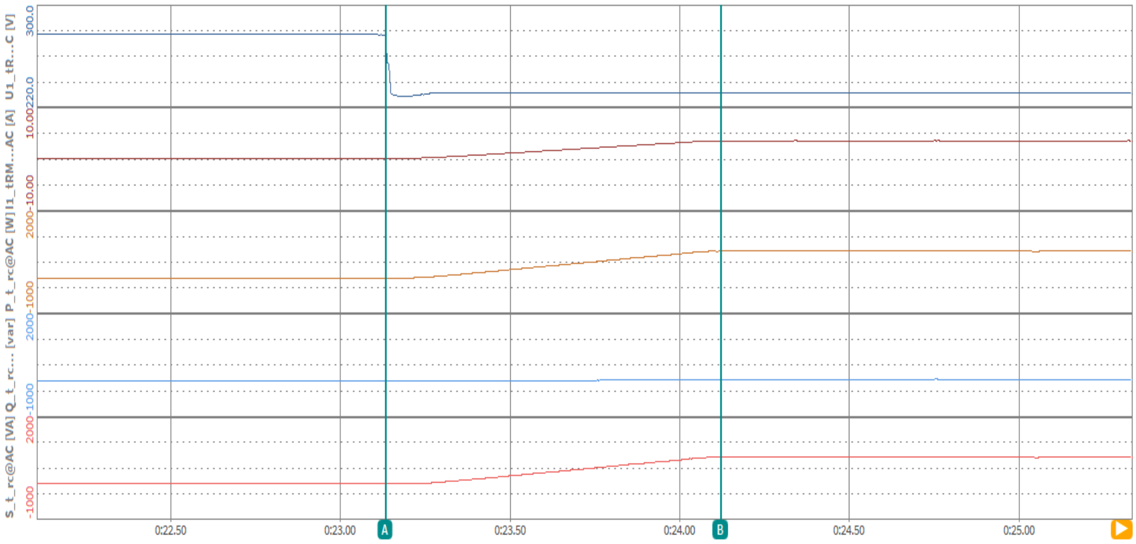
	A	B	间隔
时间 [s]	0:17.83539616	0:17.85288065	0.01748449
U1_tRMS_rc@AC [V]	230.0755	276.1056	46.03009
I1_tRMS_rc@AC [A]	3.507266	1.395256	-2.112010
P_t_rc@AC [W]	804.0944	171.5915	-632.5029
Q_t_rc@AC [var]	67.66158	344.9127	277.2511
S_t_rc@AC [VA]	806.9361	385.2381	-421.6980

DipTime



	A	B	间隔
时间 [s]	0:17.85264184	0:23.12311274	5.27047090
U1_tRMS_rc@AC [V]	276.1056	276.5182	0.412537
I1_tRMS_rc@AC [A]	1.395256	0.068361	-1.326895
P_t_rc@AC [W]	171.5915	-0.137717	-171.7292
Q_t_rc@AC [var]	344.9127	18.90261	-326.0101
S_t_rc@AC [VA]	385.2381	18.90311	-366.3350

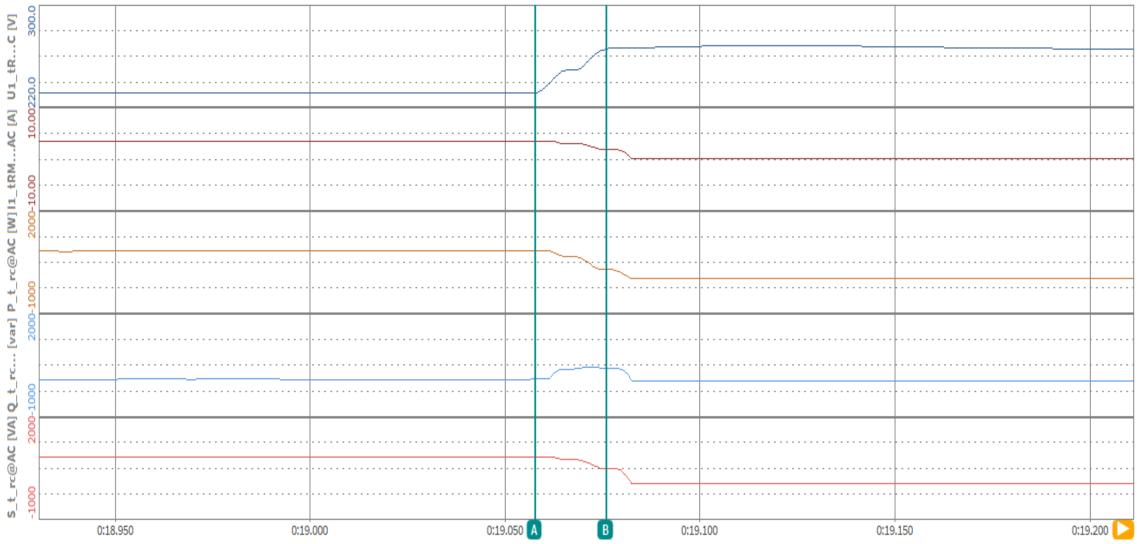
Power Recovery time



	A	B	间隔
时间 [s]	0:23.1339344	0:24.1210249	0.9870905
U1_tRMS_rc@AC [V]	276.6277	230.0791	-46.54858
I1_tRMS_rc@AC [A]	0.068536	3.469577	3.401041
P_t_rc@AC [W]	-0.048042	795.3338	795.3818
Q_t_rc@AC [var]	18.95879	68.48844	49.52965
S_t_rc@AC [VA]	18.95885	798.2772	779.3184

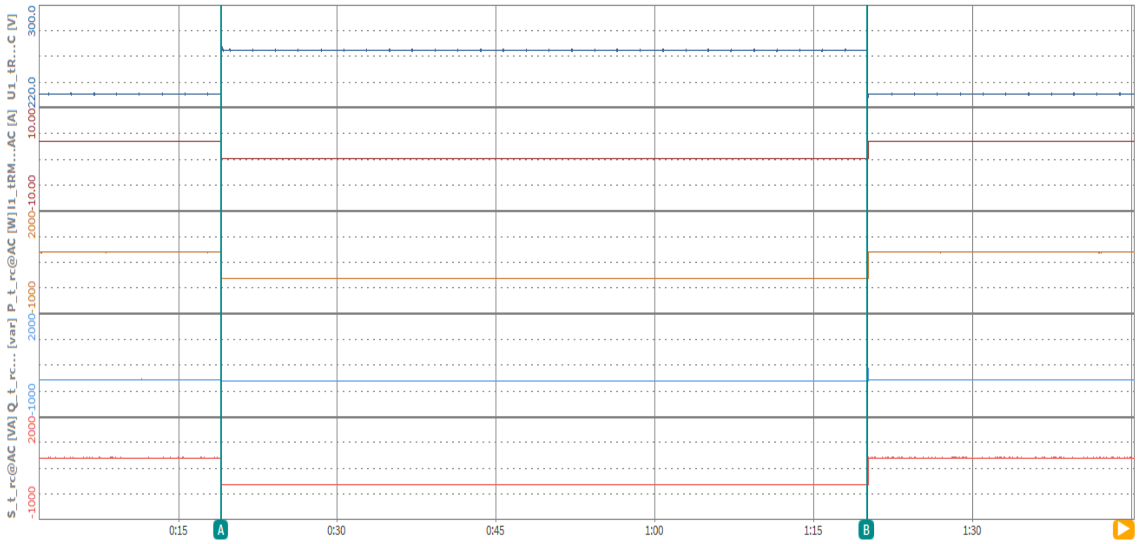
L-N fault	
Partial load (100%Pn)	Residual voltage: 115.0%Un

Voltage Rise time



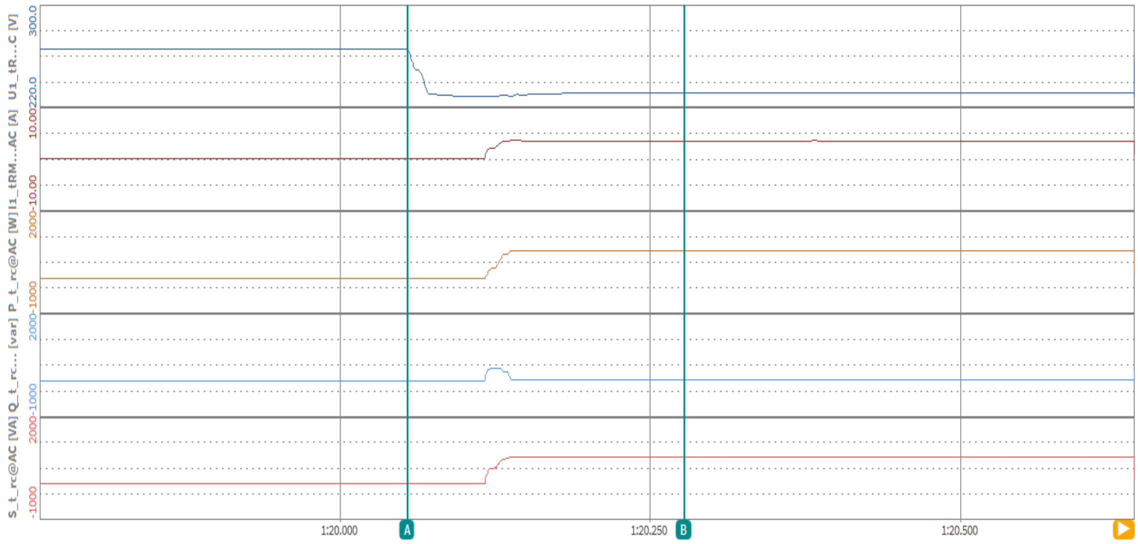
时间 [s]	A 0:19.0576578	B 0:19.0758681	间隔 0.0182102
U1_tRMS_rc@AC [V]	230.0294	264.9280	34.89862
I1_tRMS_rc@AC [A]	3.466322	1.742890	-1.723433
P_t_rc@AC [W]	794.0464	246.6007	-547.4457
Q_t_rc@AC [var]	72.57177	390.3744	317.8026
S_t_rc@AC [VA]	797.3559	461.7403	-335.6156

DipTime



时间 [s]	A 0:19.0765306	B 1:20.0231015	间隔 1:00.9465709
U1_tRMS_rc@AC [V]	264.9280	264.4584	-0.469543
I1_tRMS_rc@AC [A]	1.742890	0.066391	-1.676498
P_t_rc@AC [W]	246.6007	-0.031662	-246.6324
Q_t_rc@AC [var]	390.3744	17.55773	-372.8166
S_t_rc@AC [VA]	461.7403	17.55776	-444.1825

Power Recovery time



	A	B	间隔
时间 [s]	1:20.05458370	1:20.27739806	0.22281436
U1_tRMS_rc@AC [V]	264.4560	230.3006	-34.15543
I1_tRMS_rc@AC [A]	0.066040	3.479489	3.413449
P_t_rc@AC [W]	-7.800e-3	798.3892	798.3970
Q_t_rc@AC [var]	17.46477	68.56969	51.10492
S_t_rc@AC [VA]	17.46477	801.3284	783.8636

4.3. ACTIVE RESPONSE TO FREQUENCY DEVIATION

4.3.1. Power response to overfrequency

The test has been performed according to the clause 4.6.1 of the standard. The following definitions apply to the test to verify the clause:

- Test 1: P = 100 %Pn; f1 = 50.2 Hz; droop = 12 %; f-stop deactivated, with delay of 2 s (1)
- Test 2: P = 100 %; f1 = 52.0 Hz; droop = 2 %; function deactivated
- Test 3: P = 50 %; f1 = 51.0 Hz; droop = 5 %; f-stop deactivated, no delay
- Test 4: P = 100 %, f1 = 50.2 Hz; droop = 5 %; f-stop = 50.1 Hz (hysteresis), no delay

(1) The intentional delay is only active for the activation of the function, once the function is operating, the established control loop is not intentionally delayed.

Note:

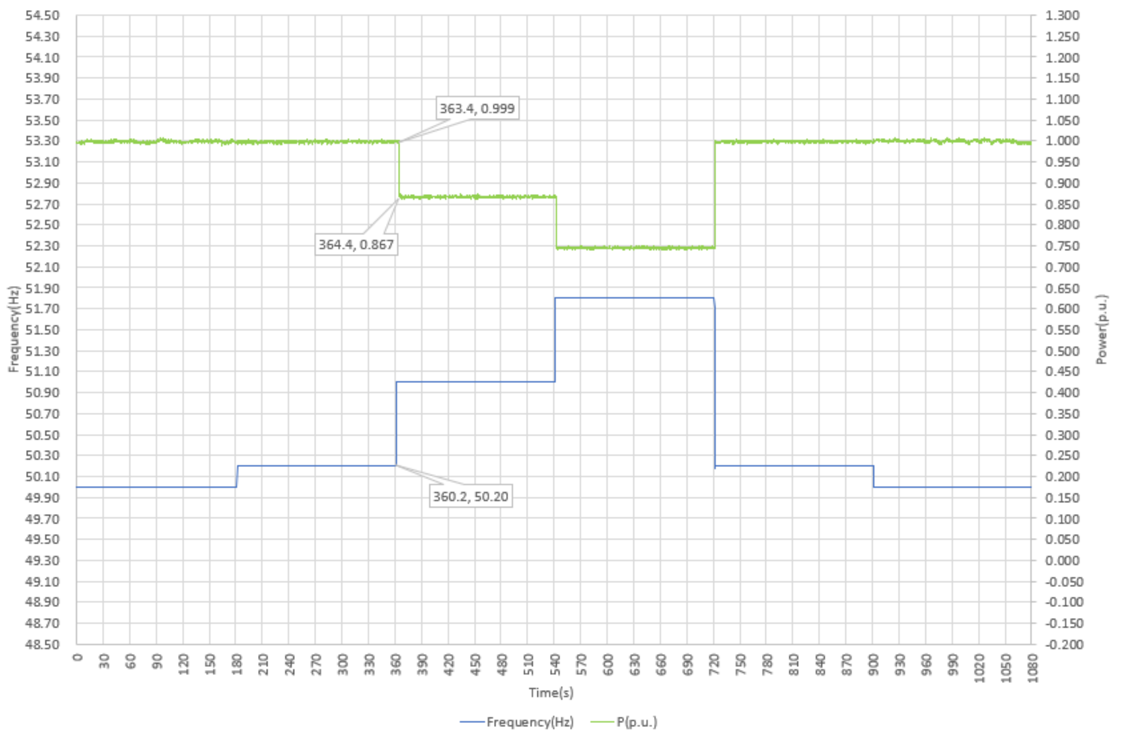
Threshold for discconnection overfrequency protection is set at 52.0 Hz at each test items.

Test results are offered at the table below.

Test 1					
Step	**Frequency (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	100.0	50.00	99.9	-0.1
2	50.20 ± 0.05 Hz	100.0	50.20	99.8	-0.2
3	51.00 ± 0.05 Hz	86.7	51.00	86.7	0.0
4	51.80 ± 0.05 Hz	73.3	51.80	74.5	+1.2
5	50.20 ± 0.05 Hz	100.0	50.20	99.8	-0.2
6	50.00 ± 0.05 Hz	100.0	50.00	100.0	0.0
Time delay setting from step 2 to step 3					
Time reference of change (s)			360.2		
End of delay (s)			363.4		
Delay time (s)			3.2		
End of change (s)			364.4		
Change time (s)			1.0		

Test results are represented at diagrams below.

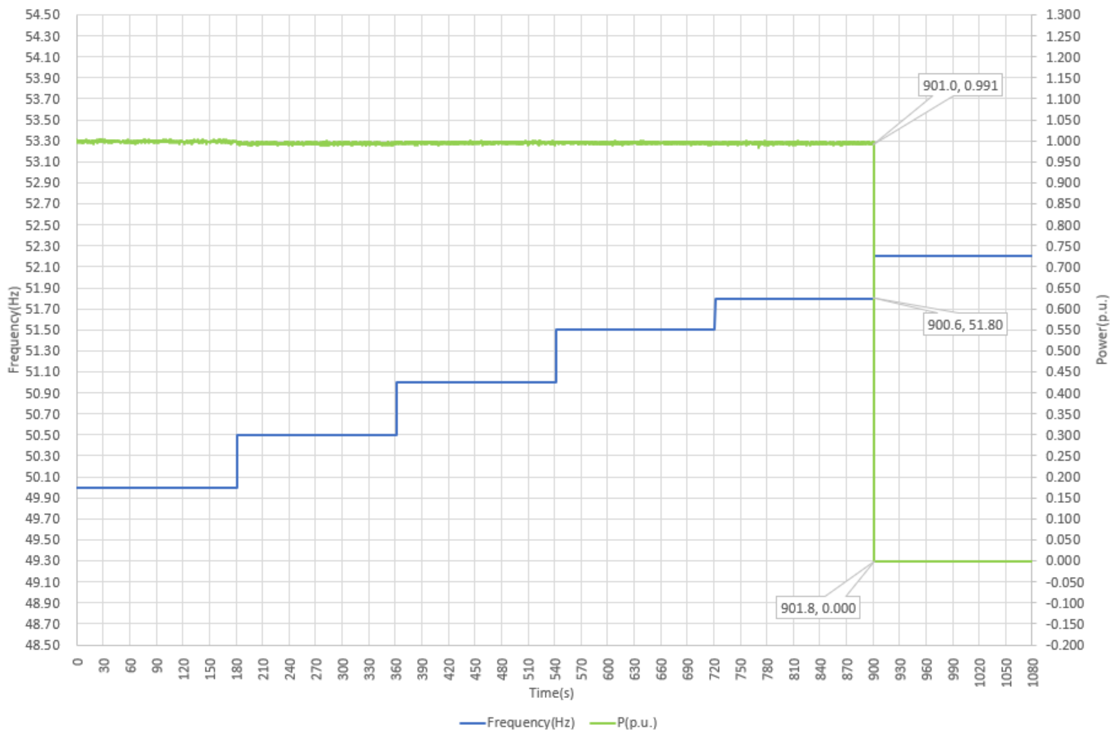
P vs F chart for Test 1



Test 2					
Step	**f (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	100.0	50.00	99.8	-0.2
2	50.50 ± 0.05 Hz	100.0	50.50	99.3	-0.7
3	51.00 ± 0.05 Hz	100.0	51.00	99.5	-0.5
4	51.50 ± 0.05 Hz	100.0	51.50	99.5	-0.5
5	51.80 ± 0.05 Hz	100.0	51.80	99.4	-0.6
6	52.20 ± 0.05 Hz	0.0	52.20	0.0	0.0

Test results are represented at diagrams below.

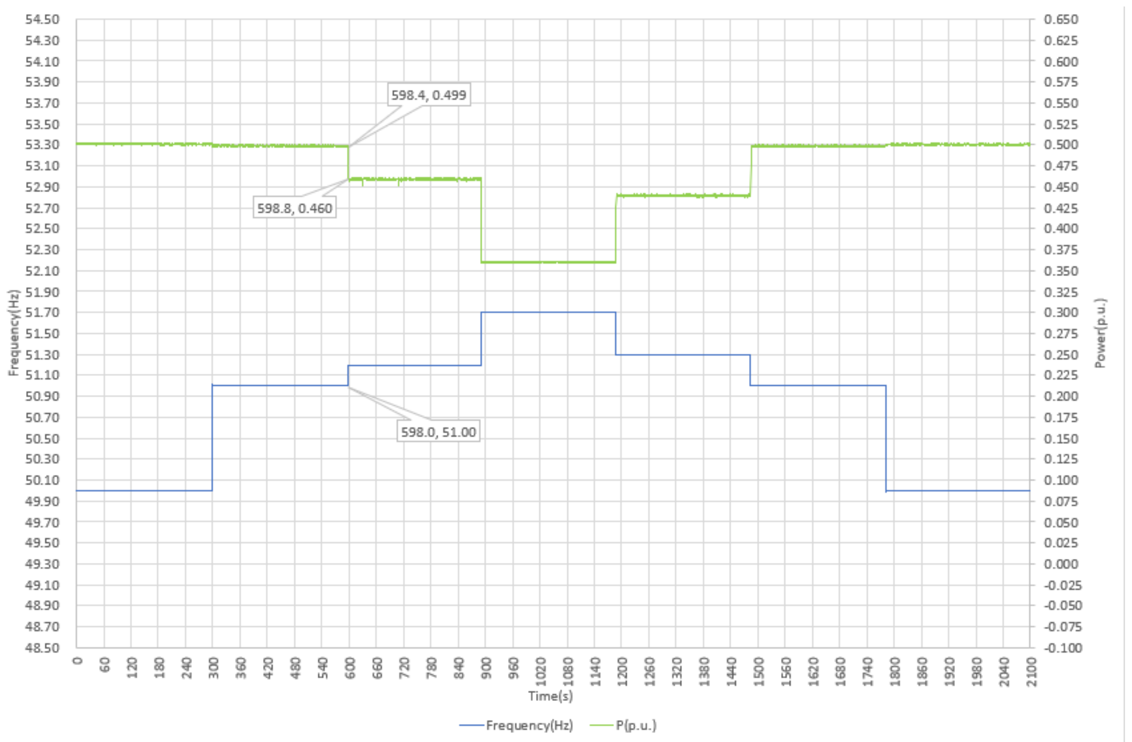
P vs F chart for Test 2



Test 3					
Step	**Frequency (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	50.0	50.00	50.1	+0.1
2	51.00 ± 0.05 Hz	50.0	51.00	49.9	-0.1
3	51.20 ± 0.05 Hz	46.0	51.20	45.9	-0.1
4	51.70 ± 0.05 Hz	36.0	51.70	36.0	0.0
5	51.30 ± 0.05 Hz	44.0	51.30	43.9	-0.1
6	51.00 ± 0.05 Hz	50.0	51.00	49.9	-0.1
7	50.00 ± 0.05 Hz	50.0	50.00	50.0	0.0
Time delay setting from step 2 to step 3					
Time reference of change (s)			598.0		
End of delay (s)			598.4		
Delay time (s)			0.4		
End of change (s)			598.8		
Change time (s)			0.4		

Test results are represented at diagrams below.

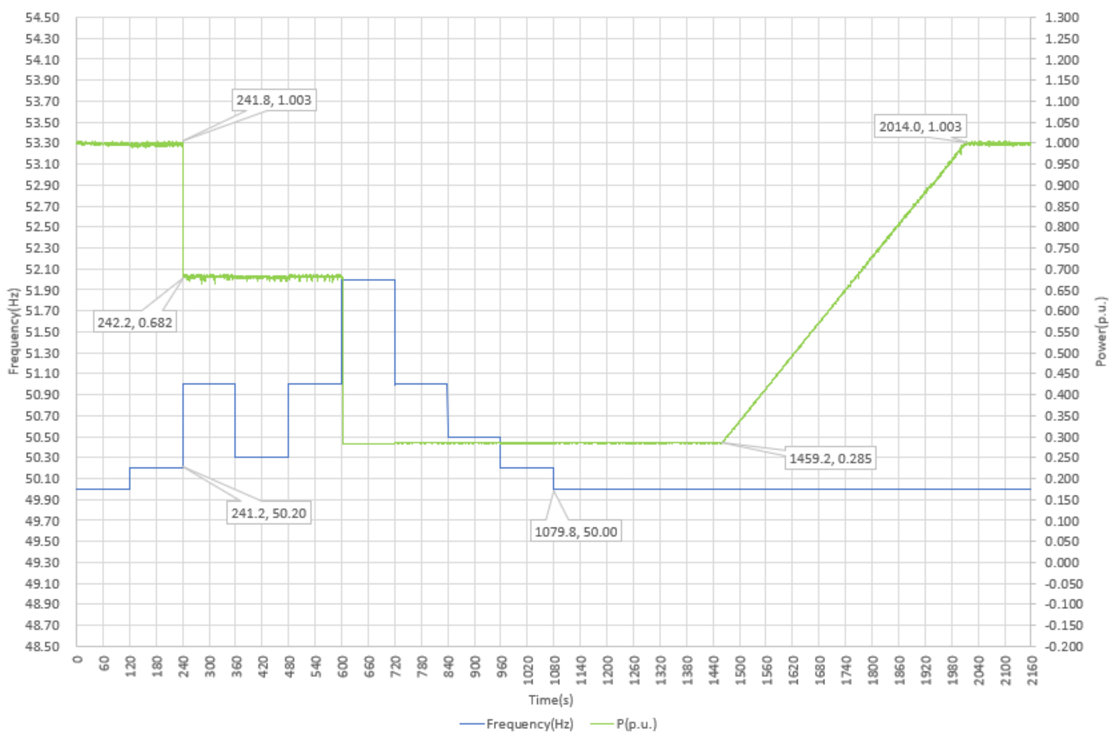
P vs F chart for Test 3



Test 4					
Step	**Frequency (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	100.0	50.00	99.8	-0.2
2	50.20 ± 0.05 Hz	100.0	50.20	99.7	-0.3
3	51.00 ± 0.05 Hz	68.0	51.00	68.2	+0.2
4	50.30 ± 0.05 Hz	68.0	50.30	68.0	0.0
5	51.00 ± 0.05 Hz	68.0	51.00	68.2	+0.2
6	52.00 ± 0.05 Hz	28.0	52.00	28.3	+0.3
7	51.00 ± 0.05 Hz	28.0	51.00	28.5	+0.5
8	50.50 ± 0.05 Hz	28.0	50.50	28.5	+0.5
9	50.20 ± 0.05 Hz	28.0	50.20	28.4	+0.4
10	50.00 ± 0.05 Hz	100.0	50.00	99.8	-0.2
Time delay setting from step 2 to step 3					
Time reference of change (s)			241.2		
End of delay (s)			241.8		
Delay time (s)			0.6		
End of change (s)			242.2		
Change time (s)			0.4		
Recovery Time (s)			379.4		
Power ramp gradient (%Pn/min)			7.8		

Test results are represented at diagrams below.

P vs F chart for Test 4



4.3.2. Power response to underfrequency

This test has not been performed to show the capability of the inverter, because it is only mandatory for Energy Storage Systems according to the clause 4.6.2 of the standard.

4.4. POWER RESPONSE TO VOLTAGE CHANGES

The generating unit shall be capable of operating in the control modes specified below within the limits specified in 4.7.2.2. The control modes are exclusive, only one mode may be active at a time.

- Q setpoint mode
- Q (U)
- Cos φ setpoint mode
- Cos φ (P)

4.4.1. Setpoint control modes

The test has been performed according to the clause 4.7.2.3.2 of the standard. The following definitions apply to the test to verify the clause:

- Test 1: Q Zero (Q = 0 % P_D)
- Test 2: Rectangular Curve (Q = ±43.6%Sn =±48.4%PD)
- Test 3: Triangular Curve (PF = ±0.8)
- Test 4: Reactive power capability at active power P_D in the voltage range (0.85Un ~ 1.1Un)

4.4.1.1. Test 1: Q Zero (Q = 0 % P_D)

This test verifies the capability of the inverter to provide a fixed value of reactive power. In addition, it is verified the Q control mode.

When the measurement is equal to or greater than 10% Sn, the allowable tolerance of reactive power measurement should be within ±2% Smax or ±2.2% P_D.

Test results are offered at tables below.

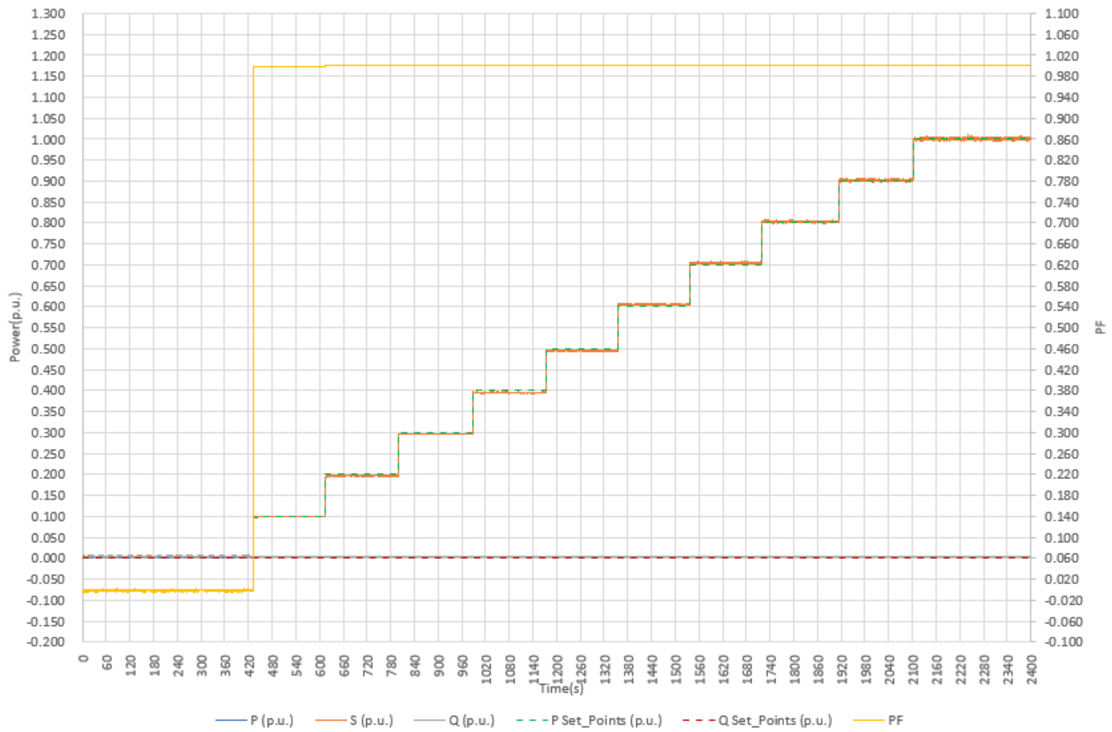
Rectangular Curve (Q=0% P_D)					
P Desired (%Sn)	P measured (%Sn)	Q desired (%P_D)	Q measured (%P_D)	Q deviation (±2.2% P_D)	Power Factor (cos φ)
0.0	0.0	--	+0.5	-- (1)	--
10.0	9.8	0.0	+0.4	+0.4	0.999
20.0	19.6	0.0	+0.4	+0.4	1.000
30.0	29.7	0.0	+0.4	+0.4	1.000
40.0	39.5	0.0	+0.4	+0.4	1.000
50.0	49.5	0.0	+0.4	+0.4	1.000
60.0	60.5	0.0	+0.4	+0.4	1.000
70.0	70.5	0.0	+0.4	+0.4	1.000
80.0	80.3	0.0	+0.4	+0.4	1.000
90.0	90.2	0.0	+0.4	+0.4	1.000
100.0	100.1	0.0	+0.4	+0.4	1.000

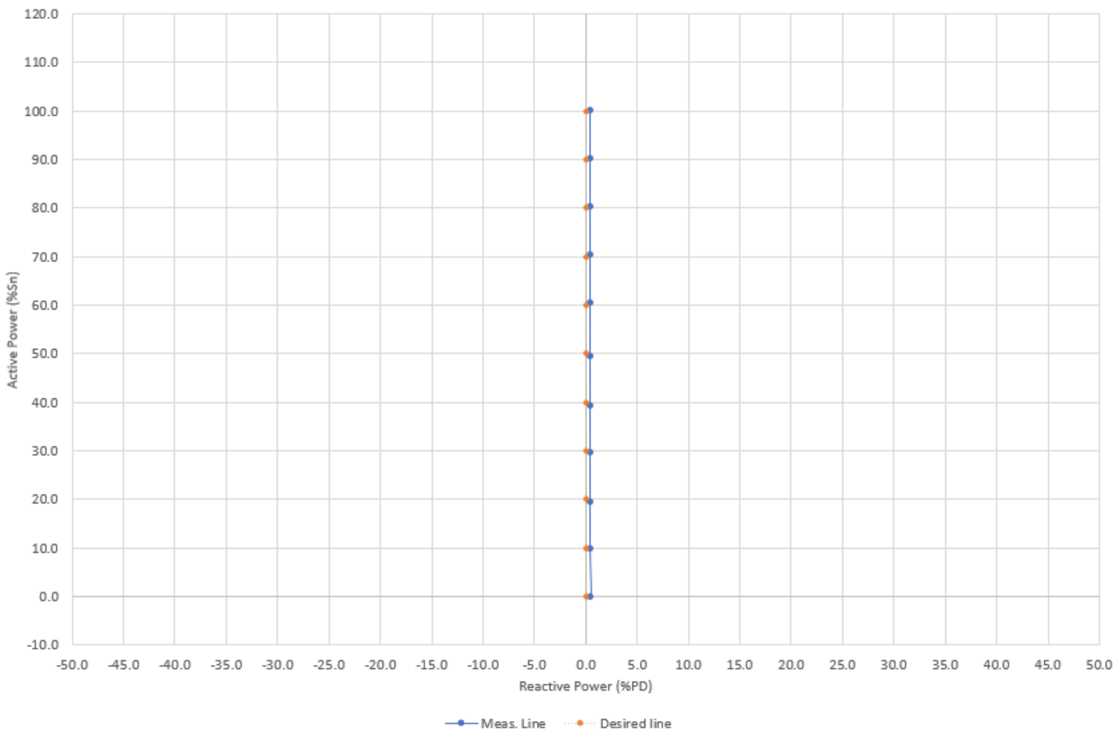
(1) The reactive power accuracy is ±2%Smax, which is not suitable for power below 10%Pn.

Note: Pn is with respect to Sn , Qn is according to measured PD ≈ 0.9 Pn (720 W)

Test results are represented at diagrams below.

Q = 0 %P_D





4.4.1.2. Test 2: Rectangular Curve (Q = ±43.6%Sn =±48.4%P_D)

This test verifies the capability of the inverter to provide a fixed value of reactive power. In addition, it is verified the Q control mode.

When the measurement is equal to or greater than 10% Sn, the allowable tolerance of reactive power measurement should be within ±2% Smax or ±2.2% P_D.

Test results are offered at tables below.

Rectangular Curve (Q=48.4 %P_D / Capacitive)					
P Desired (%Sn)	P measured (%Sn)	Q desired (%P_D)	Q measured (%P_D)	Q Deviation (±2.2%P_D)	Power Factor (cos φ)
0	0.1	--(1)	-48.7	--(1)	0.001
10	10.7	-48.4	-48.7	-0.3	0.215
20	20.4	-48.4	-48.7	-0.3	0.389
30	30.4	-48.4	-48.7	-0.3	0.532
40	40.3	-48.4	-48.7	-0.3	0.640
50	50.3	-48.4	-48.7	-0.3	0.721
60	60.3	-48.4	-48.7	-0.3	0.780
70	70.1	-48.4	-48.7	-0.3	0.823
80	80.0	-48.4	-48.7	-0.3	0.856
90	90.2	-48.4	-48.7	-0.3	0.899
100	90.2 (2)	-48.4	-48.7	-0.3	0.899

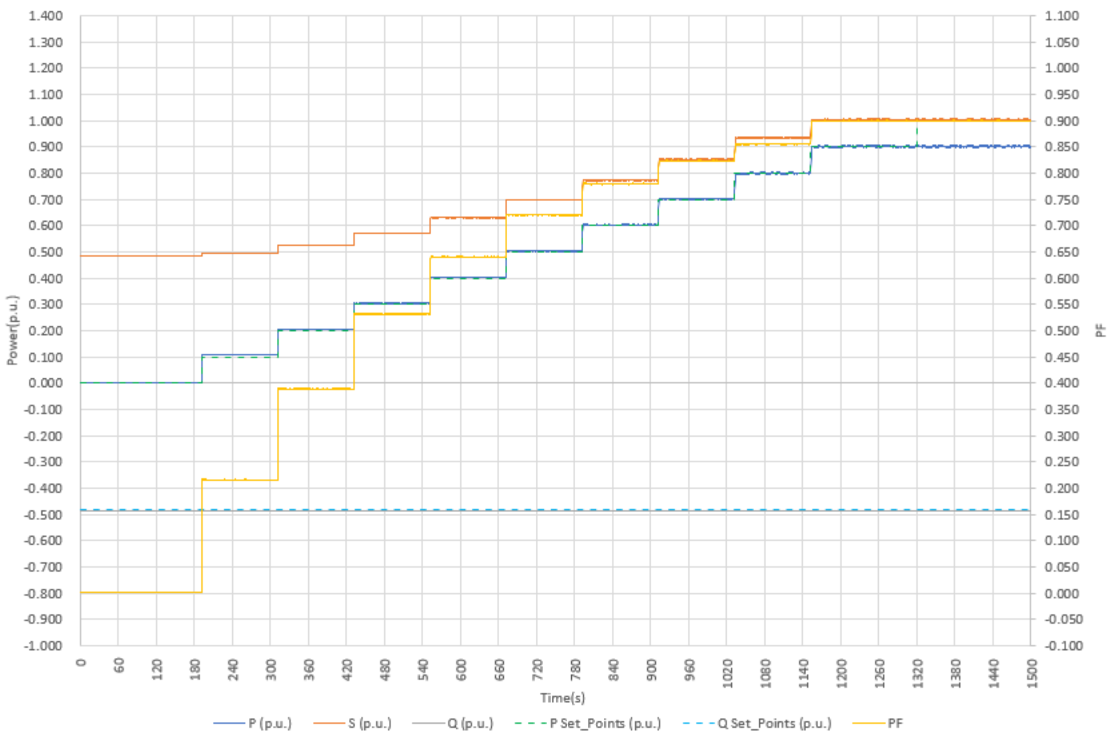
Rectangular Curve (Q=48.4 %P_D / Inductive)					
P Desired (%Sn)	P measured (%Sn)	Q desired (%P_D)	Q measured (%P_D)	Q Deviation (±2.2%P_D)	Power Factor (cos φ)
0	0.1	--(1)	+48.4	--(1)	0.002
10	10.7	+48.4	+48.4	0.0	0.238
20	20.4	+48.4	+48.4	0.0	0.424
30	30.4	+48.4	+48.4	0.0	0.572
40	40.3	+48.4	+48.4	0.0	0.679
50	50.3	+48.4	+48.4	0.0	0.756
60	60.2	+48.4	+48.4	0.0	0.810
70	70.1	+48.4	+48.4	0.0	0.849
80	80.0	+48.4	+48.4	0.0	0.878
90	90.0	+48.4	+48.4	0.0	0.900
100	90.0 (2)	+48.4	+48.4	0.0	0.900

(1) The reactive power accuracy is ±2.2%P_D, which is not suitable for power below 10%Sn.
(2) Test performed in reactive power priority mode. Working in this mode, the inverter can't output the desired active power due to current limitation, so don't consider the deviation value.

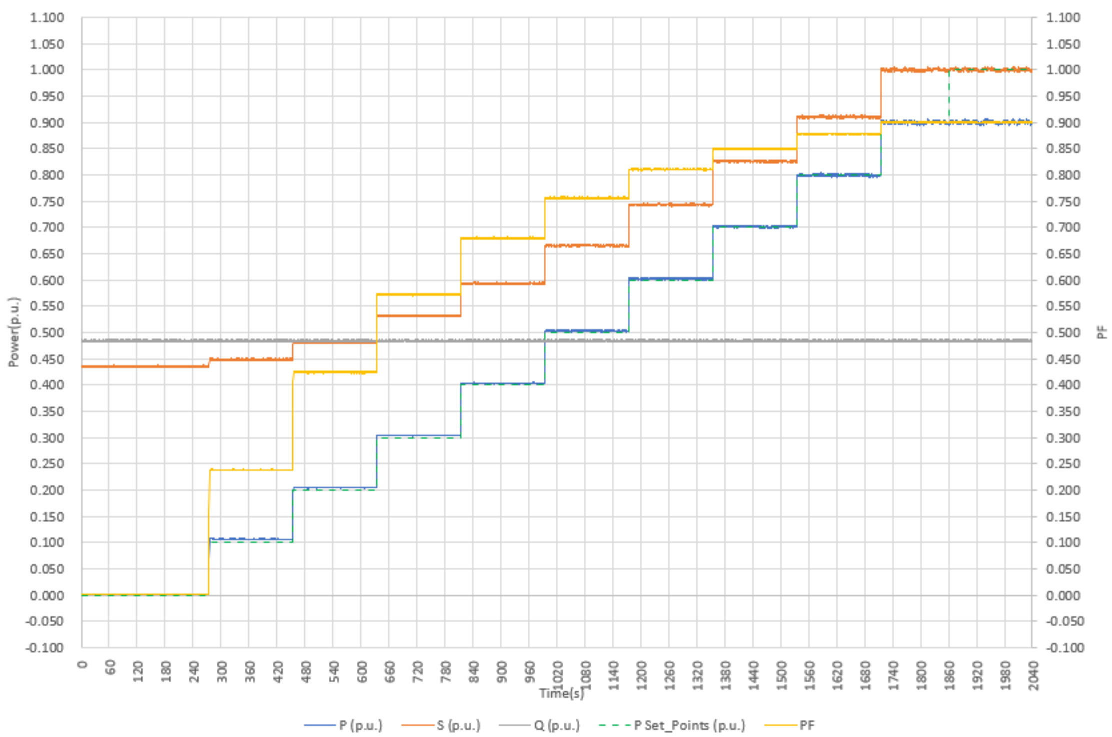
Note: Pn is with respect to Sn , Qn is according to measured PD ≈ 0.9 Pn (720 W)

Test results are represented at diagrams below.
Supplementary information: p.u. values for P and S are given in reference to Sn, p.u. values for Q are given in reference to P_D.

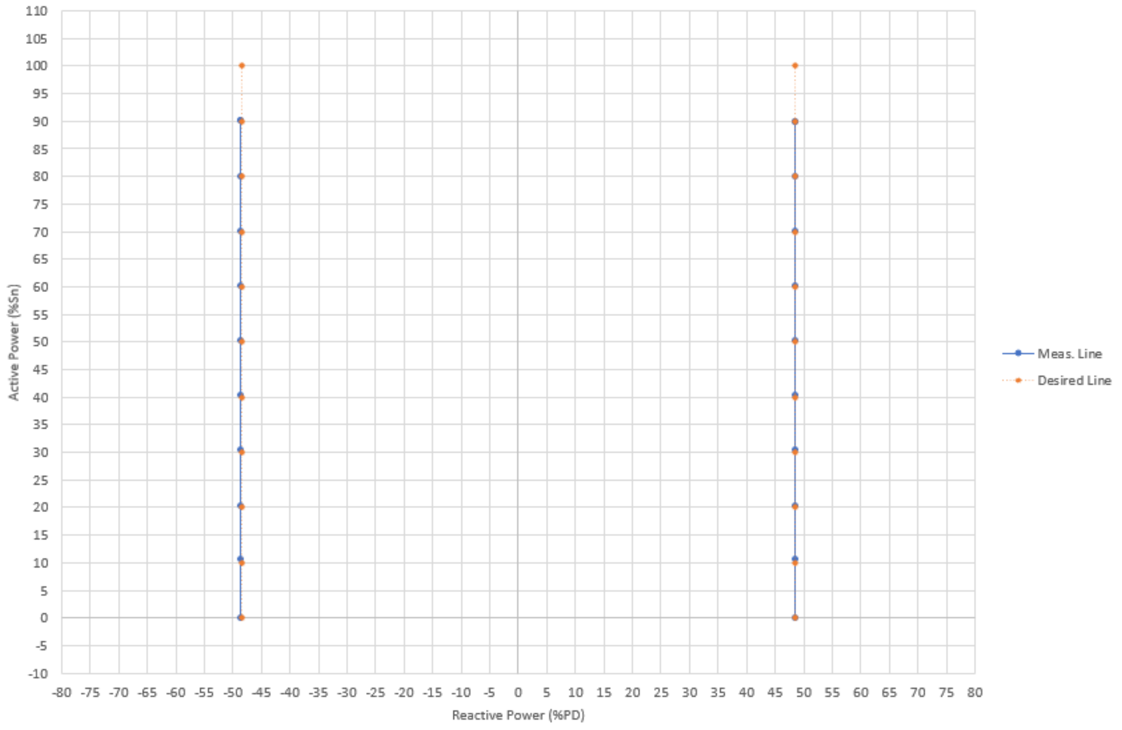
Rectangular Curve (Q = 48.4 %P_D / Capacitive)



Rectangular Curve (Q = 48.4 %P_D / Inductive)



Rectangular Curve (Capacitive vs Inductive)



4.4.1.3. Test 3: Triangular Curve (PF = ±0.8)

This test verifies the capability of the inverter to provide a fixed value of power factor. In addition, it is verified the PF control mode.

When the measurement is equal to or greater than 1colin0% Sn, the allowable tolerance of reactive power measurement should be within ±2% Smax.

Test results are offered at the tables below.

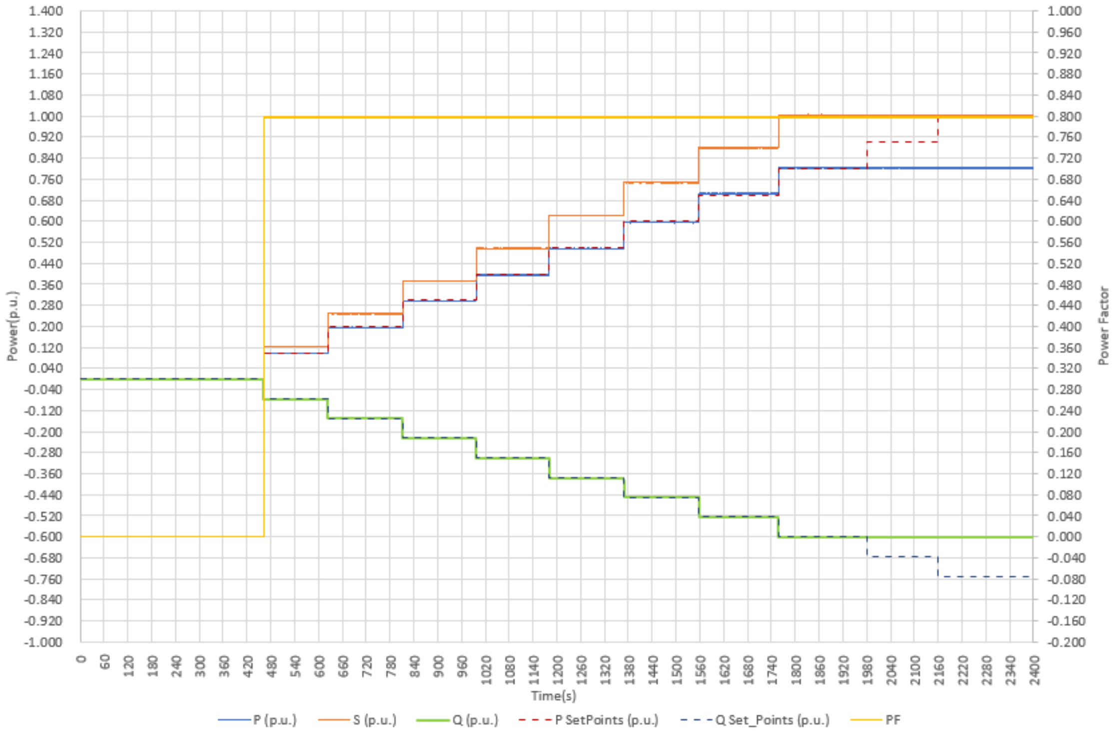
Triangular Curve (PF = 0.8 / Capacitive)						
P desired (%Sn)	P measured (%Sn)	Q measured (%Sn)	Q desired (%Sn) (3)	Q deviation (±2%Sn)	Power factor measured (cos φ)	Power factor deviation (cos φ)
0	0.0	0.0	0.0	--(1)	--(1)	--(1)
10	9.8	-7.5	-7.5	+0.0	0.798	-0.002
20	19.7	-15.1	-15.0	+0.1	0.798	-0.002
30	29.7	-22.6	-22.5	+0.1	0.798	-0.002
40	39.5	-30.0	-30.0	+0.0	0.798	-0.002
50	49.6	-37.6	-37.5	+0.1	0.798	-0.002
60	59.6	-45.1	-45.0	+0.1	0.798	-0.002
70	70.5	-52.5	-52.5	+0.0	0.798	-0.002
80	80.2	-60.0	-60.0	+0.0	0.798	-0.002
90	80.3 (2)	-60.0	-67.5	--(2)	0.798	-0.002
100	80.3 (2)	-60.0	-75.0	--(2)	0.798	-0.002

Triangular Curve (PF = 0.8 / Inductive)						
P desired (%Sn)	P measured (%Sn)	Q measured (%Sn)	Q desired (%Sn) (3)	Q deviation (±2%Sn)	Power factor measured (cos φ)	Power factor deviation (cos φ)
0	0.0	0.4	0.0	--(1)	--(1)	--(1)
10	9.8	+7.4	+7.5	-0.1	0.799	-0.001
20	19.7	+14.8	+15.0	-0.2	0.799	-0.001
30	29.7	+22.3	+22.5	-0.2	0.799	-0.001
40	39.5	+29.7	+30.0	-0.3	0.799	-0.001
50	49.6	+37.3	+37.5	-0.2	0.799	-0.001
60	59.7	+44.9	+45.0	-0.1	0.799	-0.001
70	69.4	+52.3	+52.5	-0.2	0.799	-0.001
80	79.4	+59.7	+60.0	-0.3	0.799	-0.001
90	80.3 (2)	+60.4	+67.5	--(2)	0.799	-0.001
100	80.3 (2)	+60.5	+75.0	--(2)	0.799	-0.001

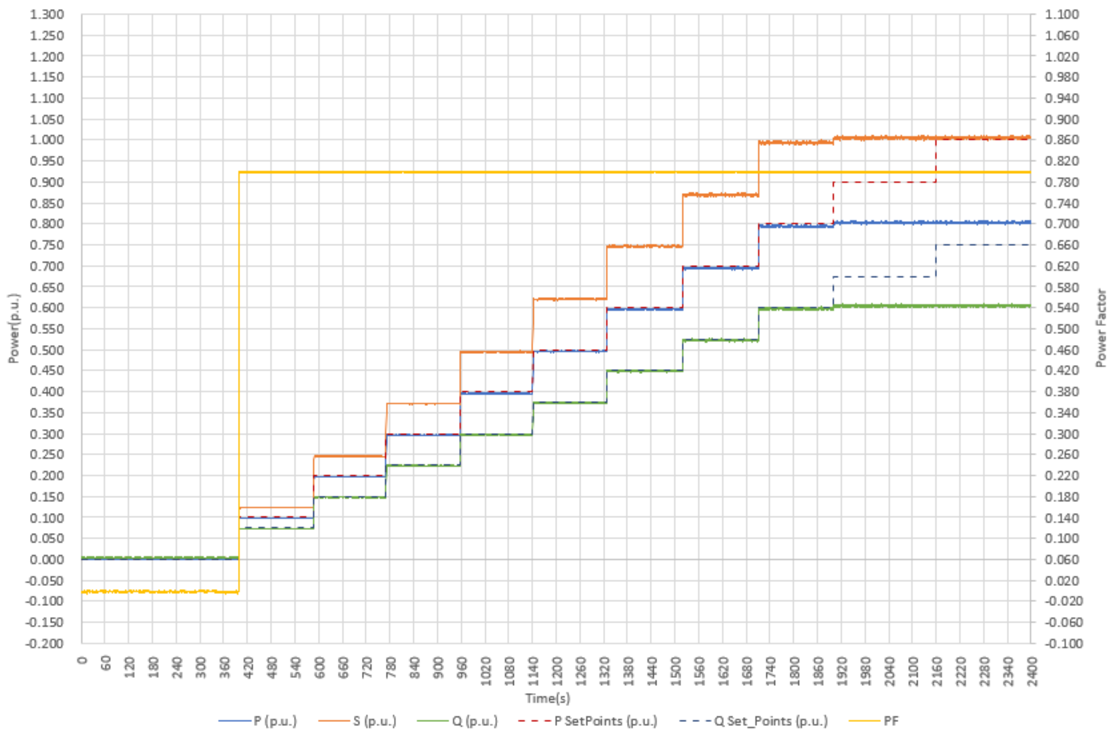
(1) The reactive power accuracy is ±2%Sn, which is not suitable for power below 10%Sn.
(2) Test performed in reactive power priority mode. Working in this mode, the inverter can't output the desired active power due to current limitation, so don't consider the deviation value.
(3) Q desired value is calculated from the desired power and fixed power factor (PF = 0.8).

Test results are represented at the diagrams below.

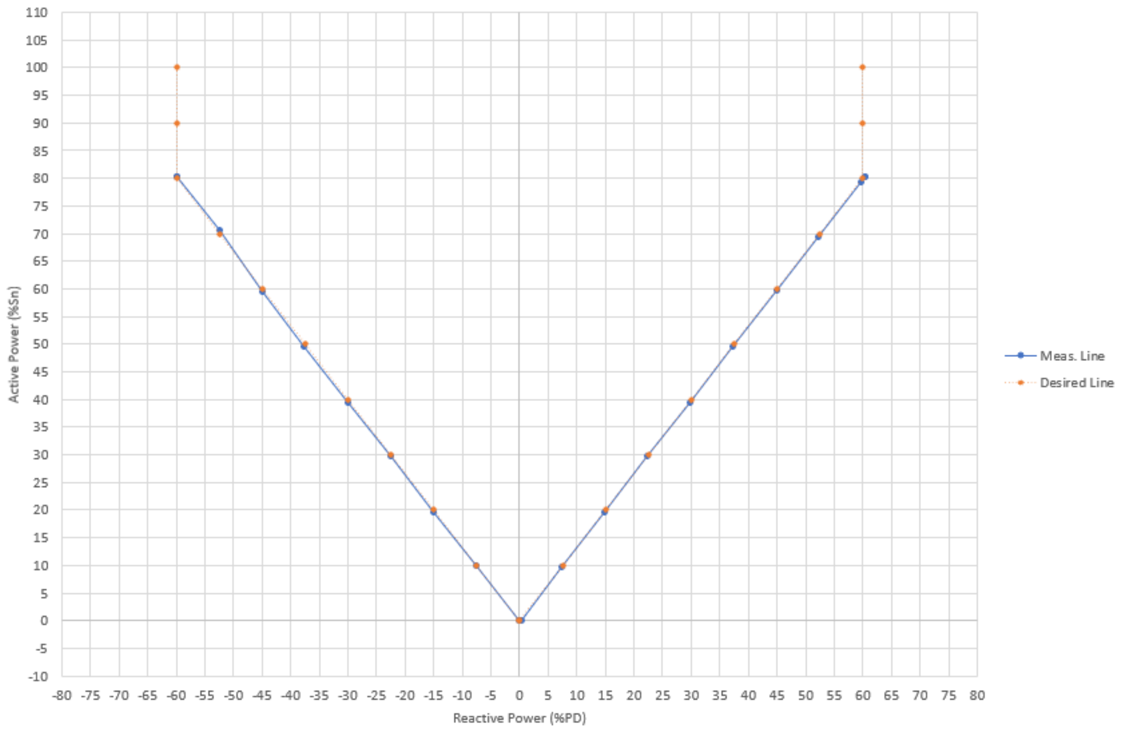
Triangular Curve (PF = 0.8 / Capacitive)



Triangular Curve (PF = 0.8 / inductive)



Triangular Curve (Inductive vs Capacitive)



4.4.1.4. Test 4: Reactive power capability at active power P_D in the voltage range (0.85Un~1.1Un)

This test verifies the capability of the inverter to provide reactive power capability at active power P_D in the voltage range, as the Figure 13 of standard:

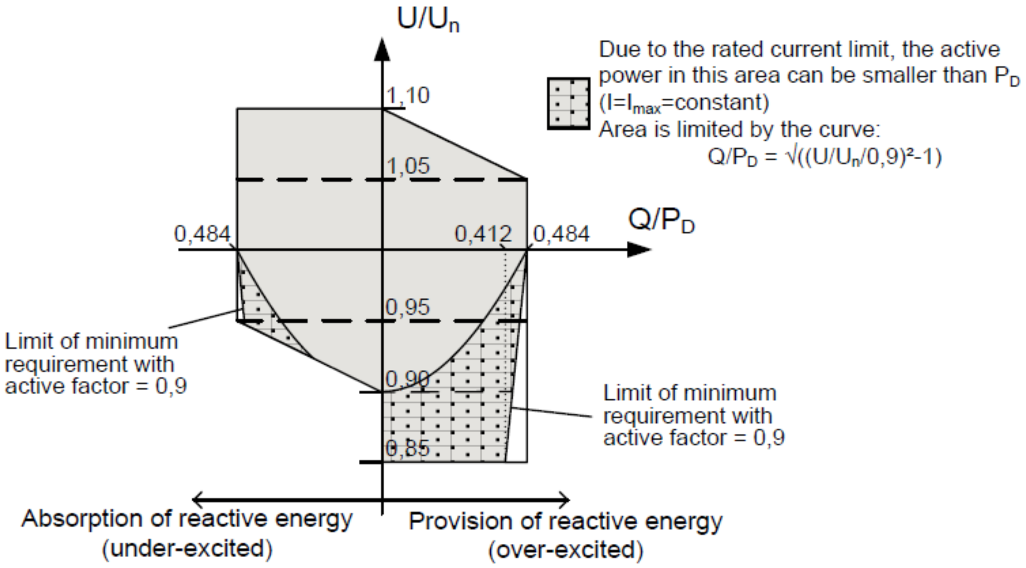


Figure 13 — Reactive power capability at active power P_D in the voltage range (positive sequence component of the fundamental)

Allowed tolerance for reactive power measurements is to be considered inside ±2% Sn or ±2.2 % P_D

Test results are offered at the tables below.

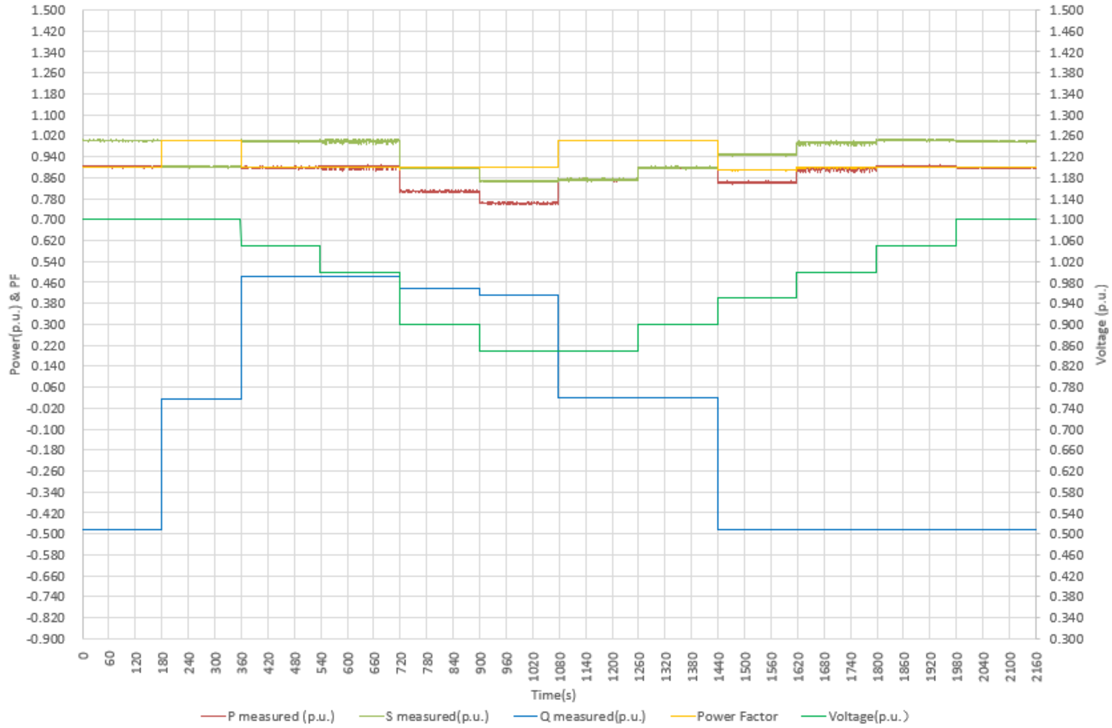
Reactive power capability at active power P_D in the voltage range								
Step	Voltage desired (p.u.)	Voltage meas. (p.u.)	P desired (%Sn)	P meas. (%Sn)	Q meas. (%P_D)	Q desired (%P_D)	Q devation (±2.2%P_D)	Power Factor measured (cos φ)
1	1.100	1.100	90.0	90.1	-48.5	-48.4	-0.1	0.900
2	1.100	1.100	90.0	90.1	+1.5	0.0	+1.5	1.000
3	1.050	1.050	90.0	89.9	+48.2	+48.4	-0.2	0.901
4	1.000	1.000	90.0	90.2	+48.2	+48.4	-0.2	0.901
5	0.900	0.900	90.0	80.8 (1)	+43.6	+43.6	-0.0	0.900
6	0.850	0.850	90.0	76.3 (1)	+41.1	+41.2	-0.1	0.900
7	0.850	0.850	90.0	85.2 (1)	+2.0	0.0	+2.0	1.000
8	0.900	0.900	90.0	89.8	+2.0	0.0	+2.0	1.000
9	0.950	0.950	90.0	84.3	-48.3	-48.4	+0.1	0.889
10	1.000	1.000	90.0	89.5	-48.3	-48.4	+0.1	0.899
11	1.050	1.050	90.0	90.4	-48.3	-48.4	+0.1	0.901
12	1.100	1.100	90.0	89.8	-48.3	-48.4	+0.1	0.900

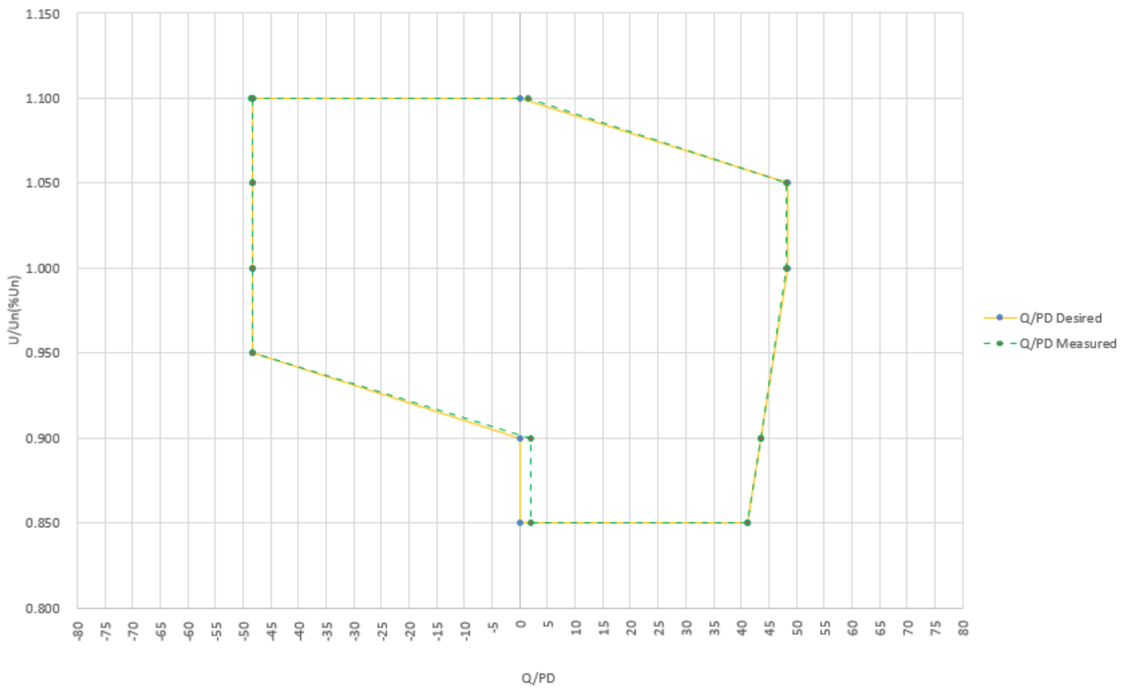
(1) Since the working mode is reactive power priority, the active power cannot reach the expected value due to current limitation.

Note: Pn is with respect to Sn , Qn is according to measured PD ≈ 0.9 Pn (720 W)

Test results are represented at diagrams below.

Reactive power capability at active power P_D in the voltage range (0.85Un~1.00Un)





4.4.2. Voltage related control mode

4.4.2.1. Voltage related control mode Q(U)

The test has been performed according to the clause 4.7.2.3.3 of the standard.

Note: This feature is optional, enabling and disabling the feature and its settings can be modified or adjusted through the manufacturer's guidelines.

Setting the characteristic as following to prove configurability of the inverter:

- U1 = 0.93, Qmax=43.6%Pn=48.4%P_D
- U2 = 0.96, Q= 9.0%Pn=10.0% P_D
- U3 = 1.04, Q= - 9.0%Pn=-10.0% P_D
- U4 = 1.07, -Qmax= - 43.6%Pn= - 48.4%P_D

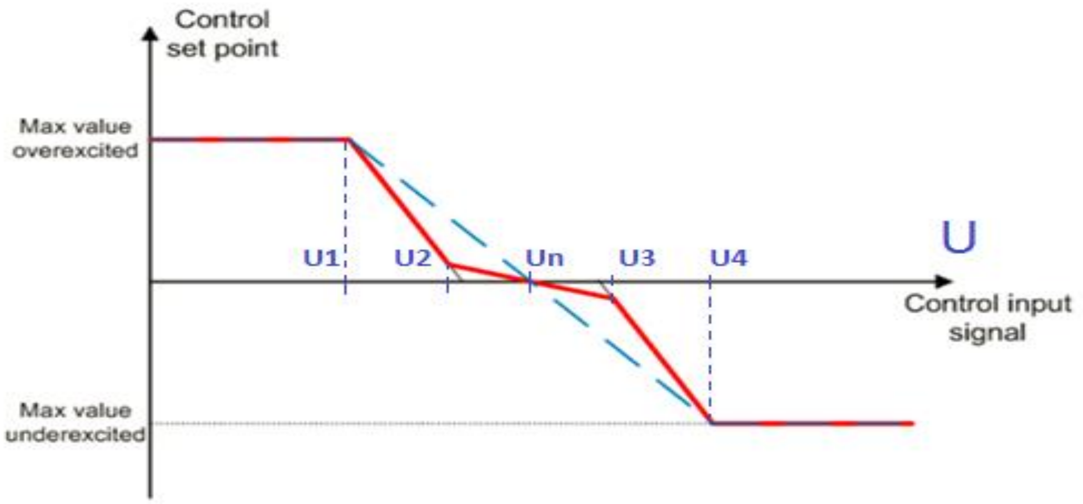


Figure 16 — Example characteristics for Q respectively cos φ control mode

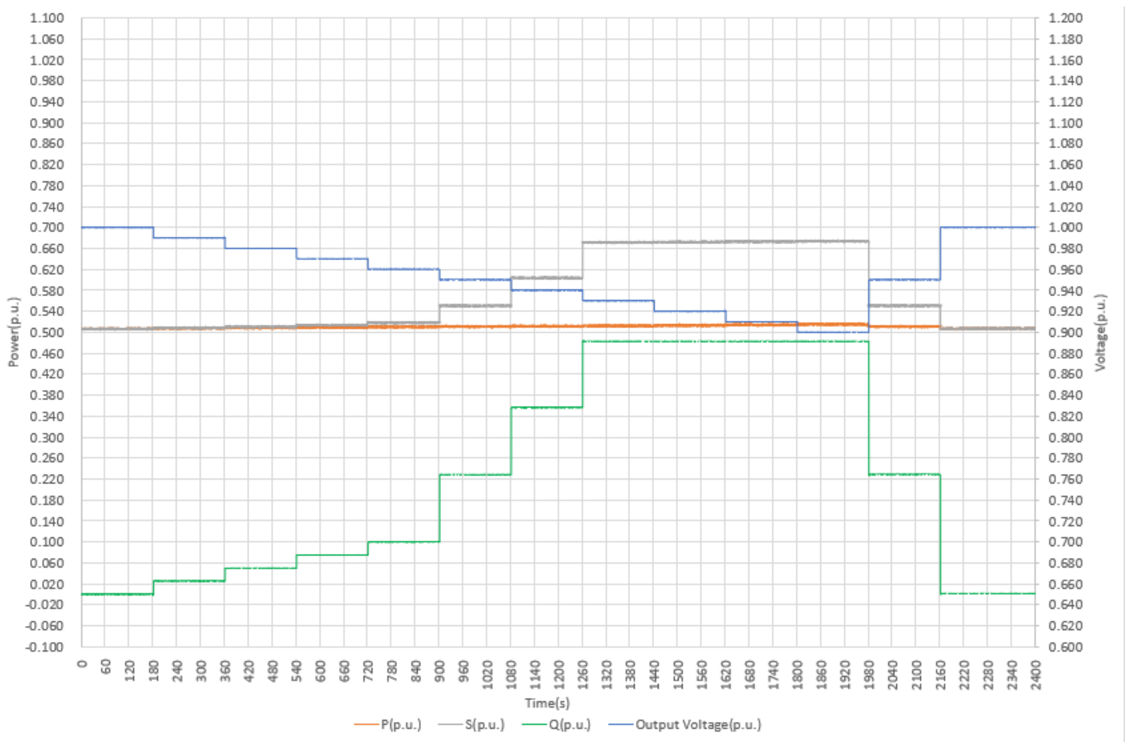
Test results are offered at the tables below.

Undervoltage Test						
P/Pn setpoint (%)	**U setpoint**	**P measured (%Sn)**	**V measured (p.u.)**	**Q measured (%P_D)**	**Q desired (%P_D)**	**ΔQ (p.u.) (±2.2%P_D)**
50	1.000 Un	50.7	1.000	+0.0	0.0	+0.0
50	0.990 Un	50.8	0.990	+2.5	+2.5	+0.0
50	0.980 Un	50.8	0.980	+5.0	+5.0	-0.0
50	0.970 Un	50.9	0.970	+7.5	+7.5	+0.0
50	0.960 Un	51.0	0.960	+10.0	+10.0	-0.0
50	0.950 Un	51.1	0.950	+22.8	+22.8	+0.0
50	0.940 Un	51.2	0.940	+35.6	+35.6	+0.0
50	0.930 Un	51.2	0.930	+48.2	+48.4	-0.2
50	0.920 Un	51.3	0.920	+48.2	+48.4	-0.2
50	0.910 Un	51.4	0.910	+48.2	+48.4	-0.2
50	0.900 Un	51.5	0.900	+48.2	+48.4	-0.2
50	0.950 Un	51.1	0.950	+22.8	+22.8	+0.0
50	1.000 Un	50.7	1.000	+0.2	0.0	+0.2

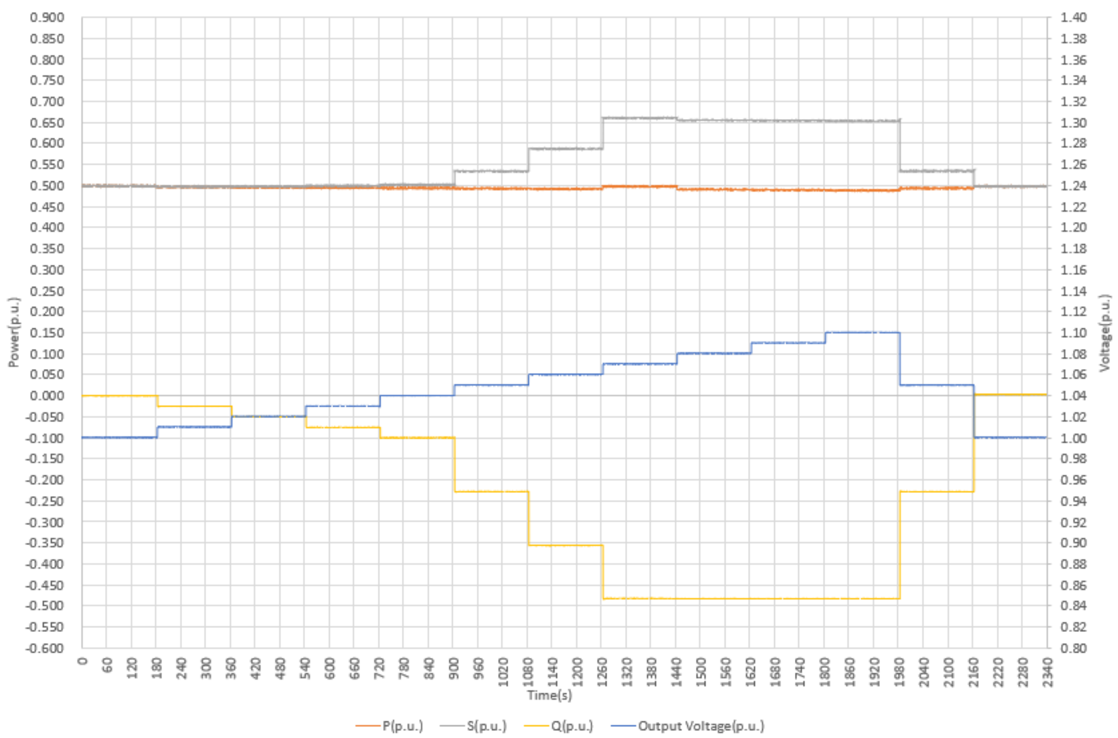
Overvoltage Test						
P/Pn setpoint (%)	**U setpoint**	**P measured (%Sn)**	**V measured (p.u.)**	**Q measured (%P_D)**	**Q desired (%P_D)**	**ΔQ (p.u.) (±2.2%P_D)**
50	1.000 Un	49.9	1.000	0.0	0.0	-0.0
50	1.010 Un	49.6	1.010	-2.5	-2.5	-0.0
50	1.020 Un	49.5	1.020	-5.0	-5.0	-0.0
50	1.030 Un	49.4	1.030	-7.5	-7.5	-0.0
50	1.040 Un	49.3	1.040	-10.0	-10.0	-0.0
50	1.050 Un	49.3	1.050	-22.8	-22.8	+0.0
50	1.060 Un	49.2	1.060	-35.6	-35.6	-0.0
50	1.070 Un	49.7	1.070	-48.2	-48.4	+0.2
50	1.080 Un	49.0	1.080	-48.3	-48.4	+0.1
50	1.090 Un	48.9	1.090	-48.3	-48.4	+0.1
50	1.100 Un	48.8	1.100	-48.3	-48.4	+0.1
50	1.050 Un	49.3	1.050	-22.8	-22.8	-0.0
50	1.000 Un	49.8	1.000	+0.3	0.0	+0.3

Test results are represented at diagrams below.
Supplementary information: p.u. values for P and S are given in reference to Sn, p.u. values for Q are given in reference to P_D.

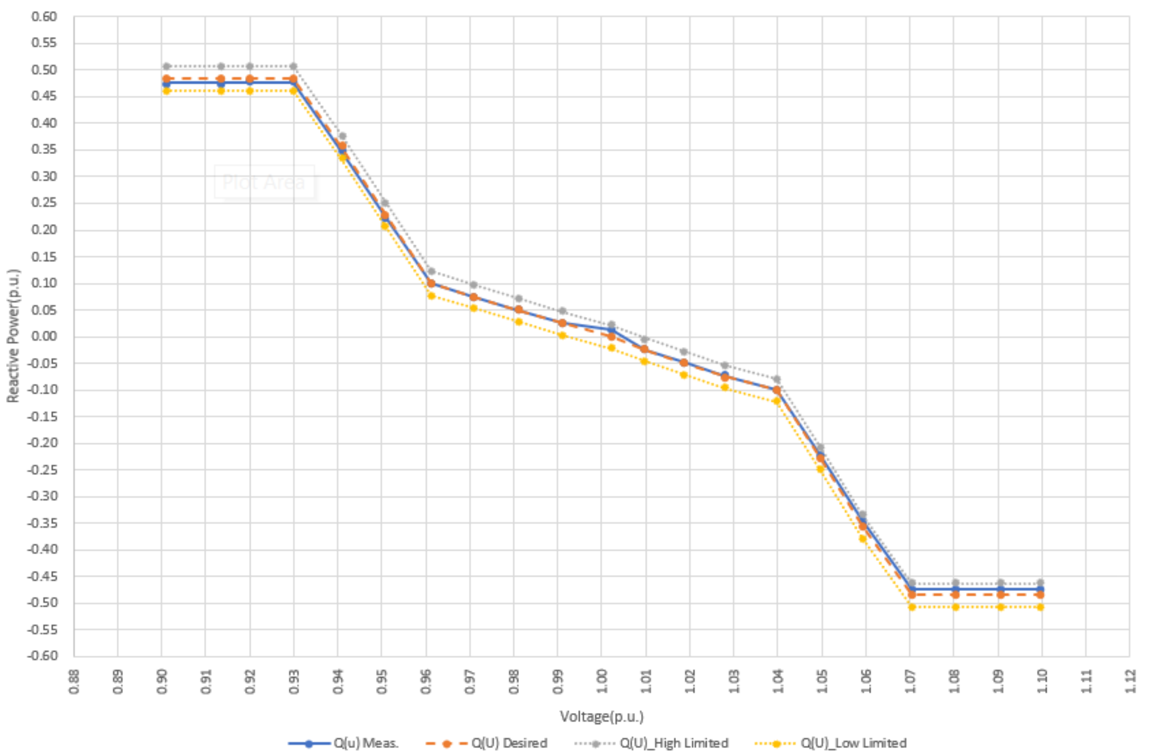
Voltage related control mode - Q(U) of Undervoltage Test



Voltage related control mode - Q(U) of Overvoltage Test



Voltage vs Reactive Power



4.4.2.2 Voltage related control mode Q(U) with lock-in/lock-out function

The test has been performed according to the clause 4.7.2.3.3 of the standard.

Two active power levels shall be configurable both at least in the range of 0 % to 100 % of P_D. The lock-in value turns the Q(U) mode on, the lock-out value turns Q(U) off. If lock-in is larger than lock-out a hysteresis is given. See also Figure 14 in the standard.

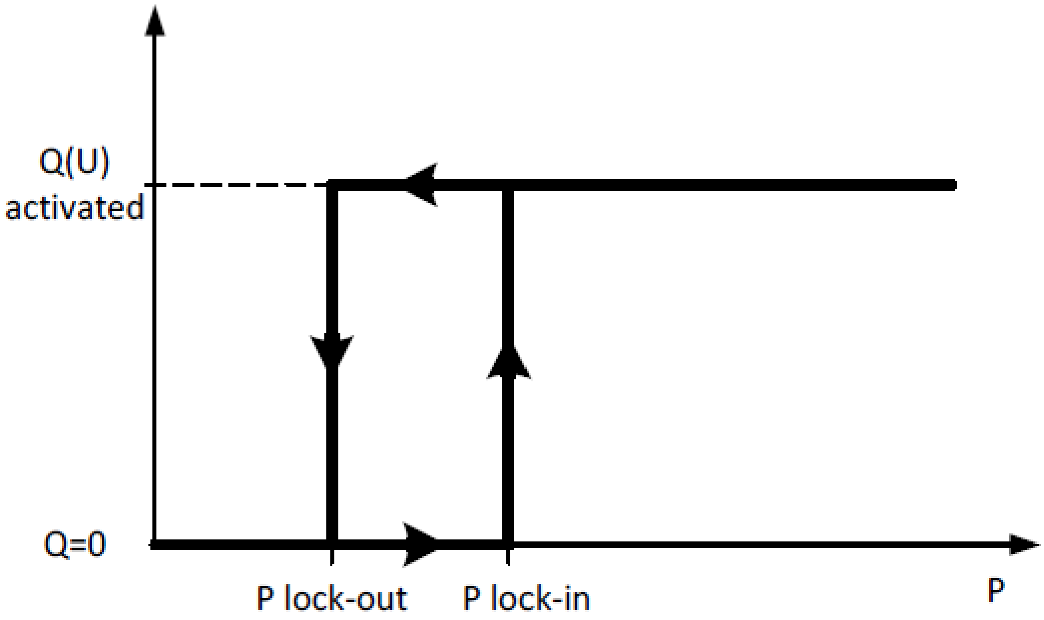


Figure 14 – Example of lock-in and lock-out values for Q(U) mode

Setting the characteristic as following to prove configurability of the inverter:

- U1 = 0.93, Qmax= 43.6%Pn= 48.4%P_D
- U2 = 0.96, Q= 9.0%Pn= 10.0% P_D
- U3 = 1.04, Q= - 9.0%Pn= -10.0% P_D
- U4 = 1.07, -Qmax= - 43.6%Pn=- 48.4%P_D

P lock-in = 30%Pn=33.3%P_D, P lock-out = 20%Pn=22.2%P_D

Test results are offered at the tables below.

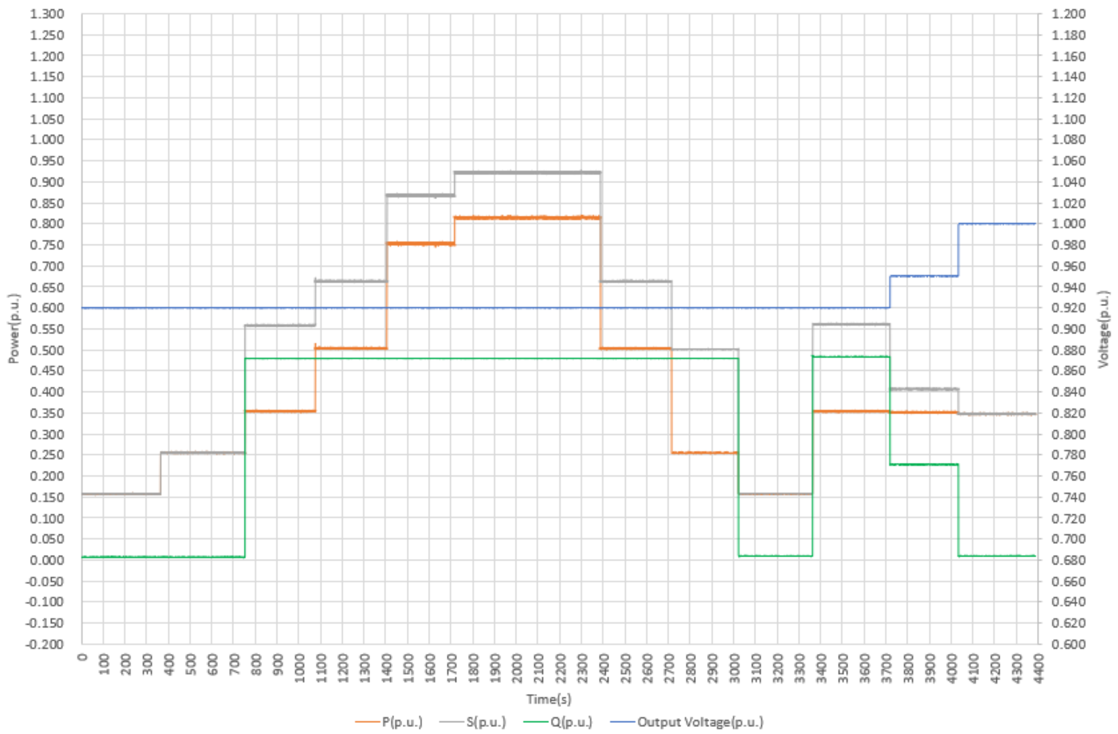
Reactive power injection in relation with the Voltage (Inductive)						
P/Pn setpoint (%Pn)	U setpoint (p.u.)	P measured (%Sn)	V measured (p.u.)	Q measured (%P_D)	Q desired (%P_D)	ΔQ (p.u.) (±2.2%P_D)
<20.0	0.920	15.7	0.920	+0.7	0.0	+0.7
25.0	0.920	25.5	0.920	+0.7	0.0	+0.7
35.0	0.920	35.4	0.920	+48.0	+48.4	-0.4
50.0	0.920	50.4	0.920	+48.0	+48.4	-0.4
75.0	0.920	75.3	0.920	+48.0	+48.4	-0.4
90.0	0.920	81.5 (1)	0.920	+48.0	+48.4	-0.4
100.0	0.920	81.5 (1)	0.920	+48.0	+48.4	-0.4
50.0	0.920	50.4	0.920	+48.0	+48.4	-0.4
25.0	0.920	25.5	0.920	+48.0	+48.4	-0.4
<20.0	0.920	15.7	0.920	+1.0	0.0	+1.0
35.0	0.920	35.4	0.920	+48.4	+48.4	0.0
35.0	0.950	35.2	0.950	+22.7	+22.8	-0.1
35.0	1.000	34.8	1.000	+1.0	0.0	+1.0

(1) Since the working mode is reactive power priority, the active power cannot reach the expected value due to current limitation.

Test results are represented at diagrams below.

Supplementary information: p.u. values for P and S are given in reference to Sn, p.u. values for Q are given in reference to P_D.

Reactive power injection in relation with the Voltage (Inductive)

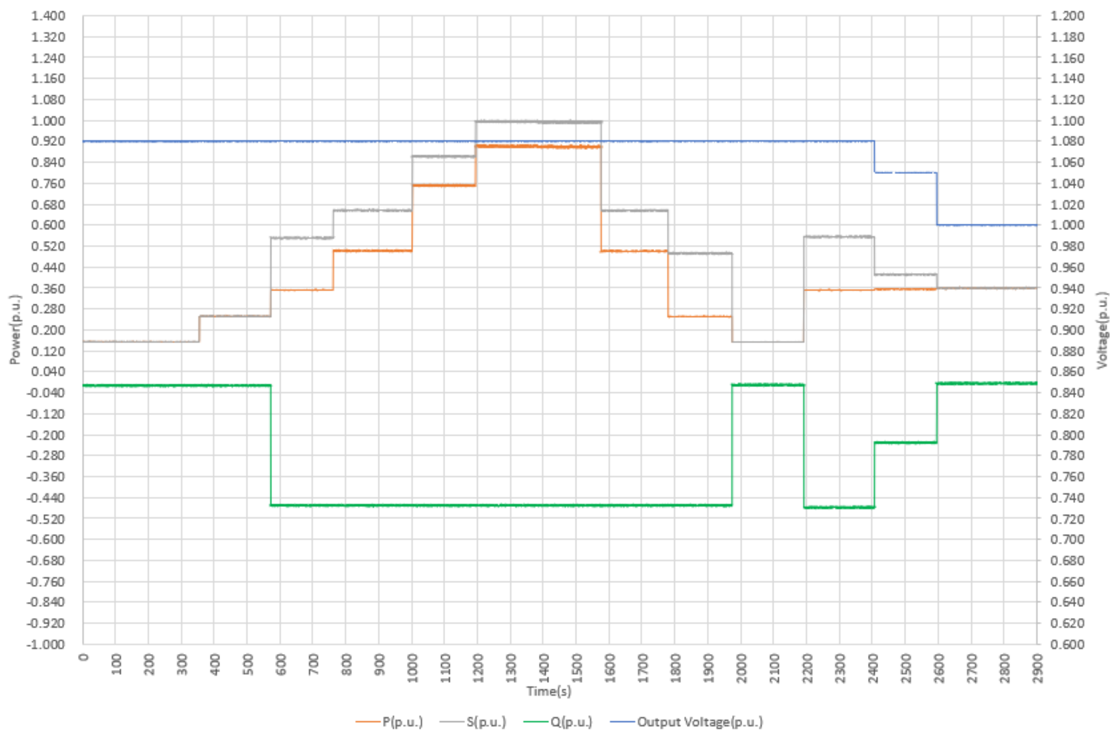


Reactive power injection in relation with the Voltage (Capacitive)						
P/Pn setpoint (%Pn)	U setpoint (p.u.)	P measured (%Sn)	V measured (p.u.)	Q measured (% P_D)	Q desired (% P_D)	ΔQ (p.u.) (±2.2% P_D)
<20.0	1.080	15.4	1.080	-1.3	0.0	-1.3
25.0	1.080	25.2	1.080	-1.3	0.0	-1.3
35.0	1.080	35.3	1.080	-47.0	-48.4	+1.4
50.0	1.080	50.2	1.080	-47.0	-48.4	+1.4
75.0	1.080	75.1	1.080	-47.0	-48.4	+1.4
90.0	1.080	90.1	1.080	-47.0	-48.4	+1.4
100.0	1.080	87.4	1.080	-47.0	-48.4	+1.4
50.0	1.080	50.1	1.080	-47.0	-48.4	+1.4
25.0	1.080	25.2	1.080	-47.0	-48.4	+1.4
<20.0	1.080	15.4	1.080	-1.0	0.0	-1.0
35.0	1.080	35.2	1.080	-47.8	-48.4	+0.6
35.0	1.050	35.5	1.050	-23.1	-22.8	-0.3
35.0	1.000	36.0	1.000	-0.4	0.0	-0.4

(1) Since the working mode is reactive power priority, the active power cannot reach the expected value due to current limitation.

Test results are represented at diagrams below.
Supplementary information: p.u. values for P and S are given in reference to Sn, p.u. values for Q are given in reference to P_D.

Reactive power injection in relation with the Voltage (Capacitive)



4.4.2.3 Static accuracy

The test has been performed according to the clause 4.7.2.3.3 of the standard.

The dynamics of the control shall correspond with a first order filter having a time constant that is configurable in the range of 3 s to 60 s.

The dynamic accuracy shall be in accordance with Figure 15 in the standard with a maximum tolerance of ±5 %P_D plus a time delay of up to 3 seconds deviating from an ideal first order filter response.

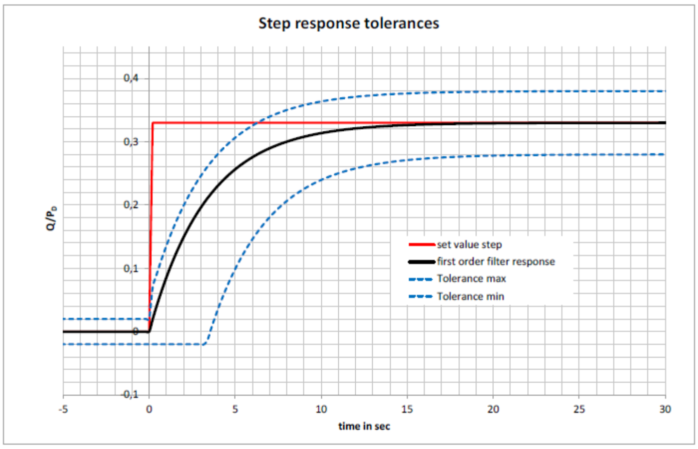


Figure 15 — Example of dynamic control response and tolerance band for a step from Q=0 to Q= 33%P_D with τ=3,33s

Note: Figure 15 – Is from Q=0 to Q= 33% P_D.

The response time is adjustable from 2 s to 60s by settings, which is more stringent than the standard's requirement, from 3s to 60s.

Test results are offered at the tables below.

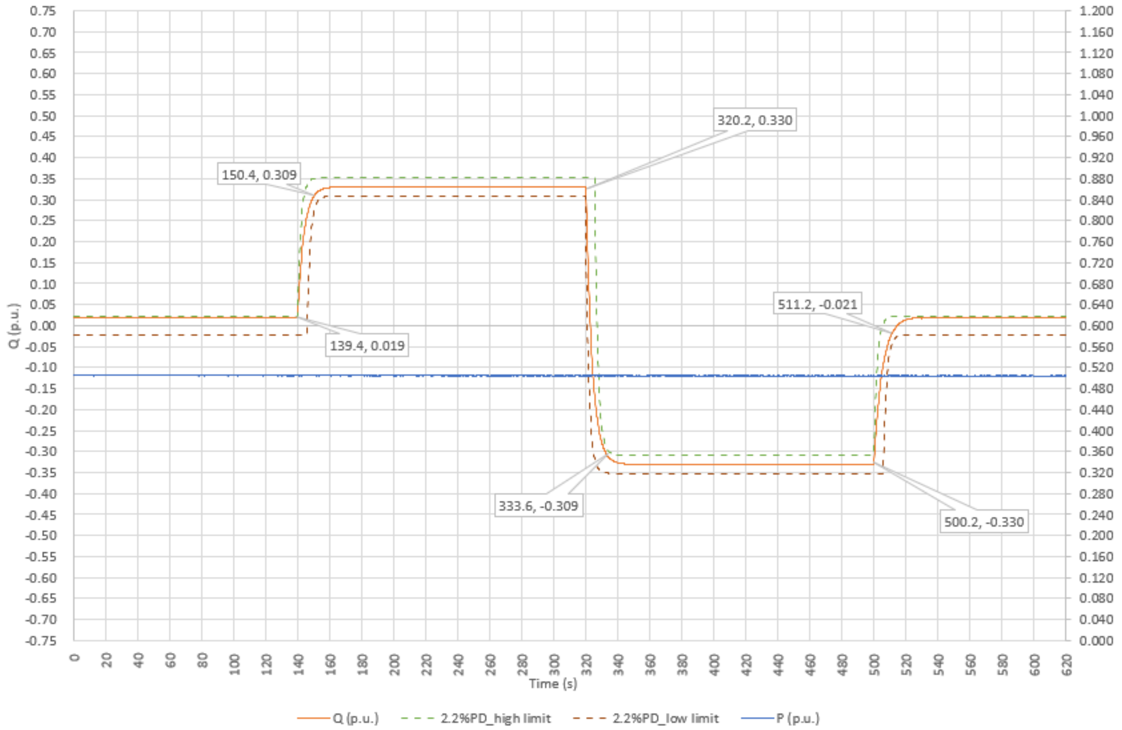
Setting time = 2 s				
%Pn	**Steps**	**Time measured (s)**	**Q Measured (%P_D)**	**Δ Q (%Sn) < ±2.2%P_D**
50	Q = 0 → Q = 33%P_D (Inductive)	11.0	+33.0	0.0
	Q = 33%P_D (Inductive) → Q = 33%P_D(Capacitive)	13.4	-33.0	0.0
	Q = -33%P_D (Capacitive) → Q = 0	11.0	+1.9	+1.9

Setting time = 60 s				
%Pn	**Steps**	**Time measured (s)**	**Q Measured (%P_D)**	**Δ Q (%Sn) <±2.2%P_D**
50	Q = 0 → Q = 33%Sn (33%P_D)(Inductive)	178.2	+33.0	0.0
	Q = 33%Sn (33%P_D) (Inductive) → Q = - 33%Sn (33%P_D) (Capacitive)	228.2	-33.0	0.0
	Q = -33%Sn (-33%P_D) (Capacitive) → Q = 0	147.6	+1.8	+1.8

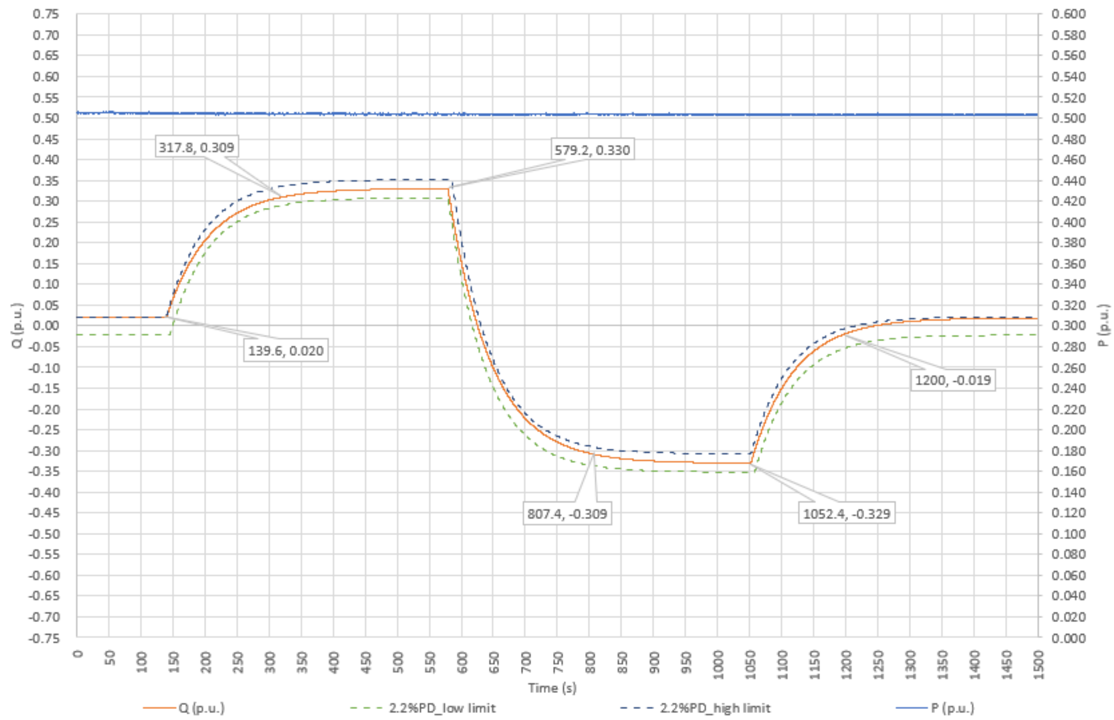
Test results are represented at diagrams below.

Supplementary information: p.u. values for P and S are given in reference to Sn, p.u. values for Q are given in reference to P_D.

Reactive power injection dynamic control response and tolerance band (Setting time = 2 s)



Reactive power injection dynamic control response and tolerance band (Setting time = 60 s)

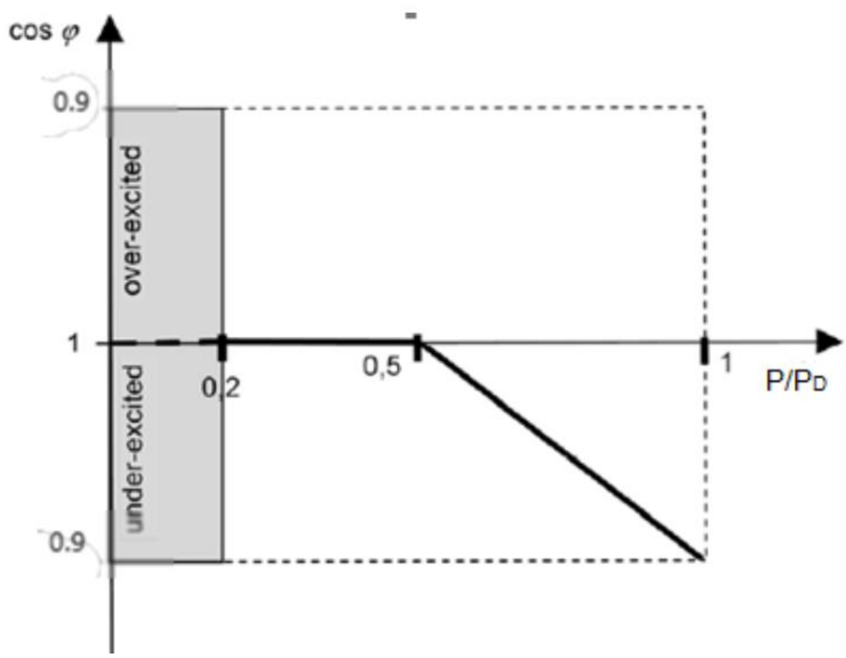


4.4.2.4 Power related control mode

The test has been performed according to the clause 4.7.2.3.4 of the standard.

The power related control mode cos φ (P) controls the cos φ of the output as a function of the active power output.

For power related control modes, a characteristic defined by the manufacturer as follows:



Resulting from a change in active power output a new cos φ set point is defined according to the set characteristic. The response to a new cos φ set value shall be as fast as technically feasible to allow the change in reactive power to be in synchrony with the change in active power. The new reactive power set value shall be reached at the latest within 10 s after the end value of the active power is reached. The static accuracy of each cos φ set point shall be according to 4.7.2.2.

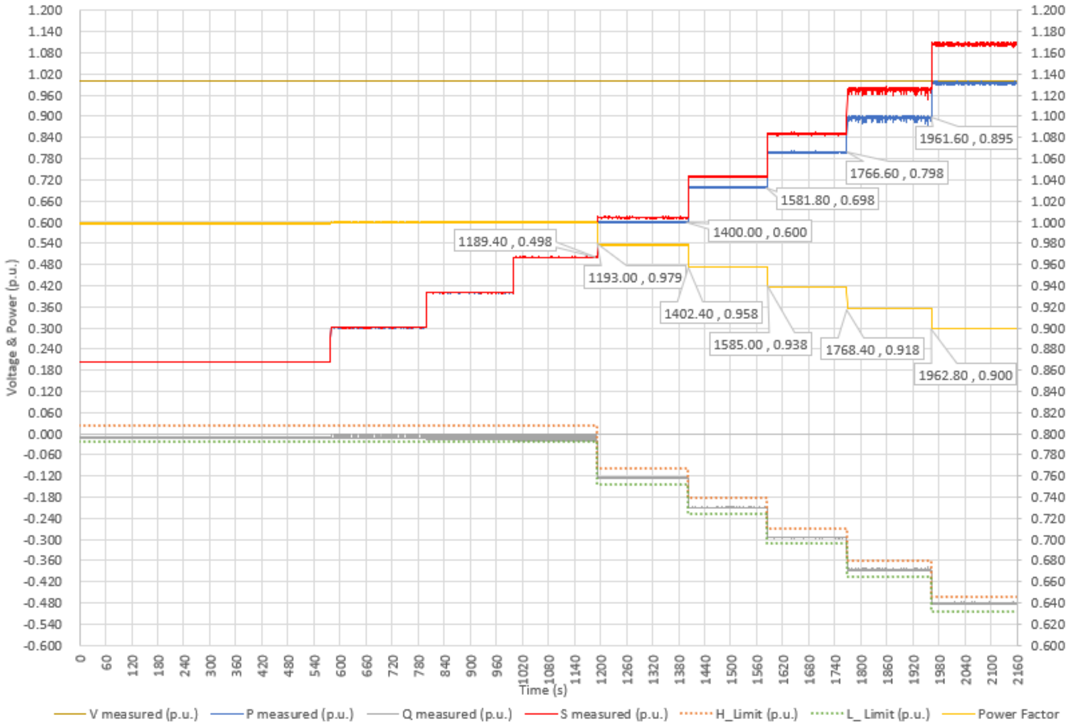
The results are offered in the table below (Note: 10 %Pn has not been measured in the following test):

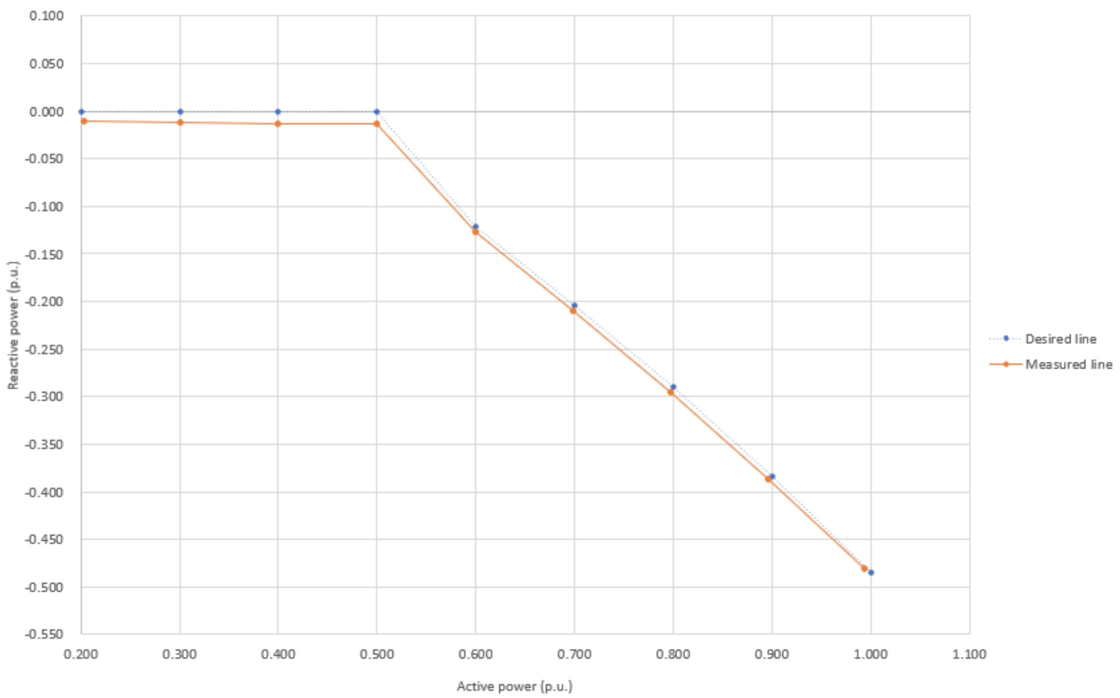
Setting cos φ(P) with the standard characteristic curve (20 $\%P_D$ to 100 $\%P_D$)							
Active Power setting ($\%P_D$)	Active Power measured ($\%P_D$)	Reactive Power measured ($\%P_D$)	cos φ measured	Desired cos φ	Desired Q ($\%P_D$)	Δ Q ($\%P_D$) (±2.2)	Transient period (<10s)
20	20.3	-1.0	0.999	1.000	0.0	-1.0	
30	30.1	-1.2	0.999	1.000	0.0	-1.2	--
40	40.0	-1.3	0.999	1.000	0.0	-1.3	--
50	50.0	-1.3	0.999	1.000	0.0	-1.3	--
60	60.0	-12.7	0.978	0.980	-12.2	-0.5	3.60
70	69.9	-20.9	0.958	0.960	-20.4	-0.5	2.40
80	79.8	-29.5	0.938	0.940	-29.0	-0.5	3.20
90	89.6	-38.7	0.918	0.920	-38.3	-0.4	1.80
100	99.4	-48.1	0.900	0.900	-48.4	+0.3	1.20

Note: The desired Q is calculated from $Q = -\sqrt{(S^2 - P^2)}$.

Test results are represented at diagrams below.

Setting cos φ(P) with standard characteristic curve (20 %P_D to 100 %P_D)



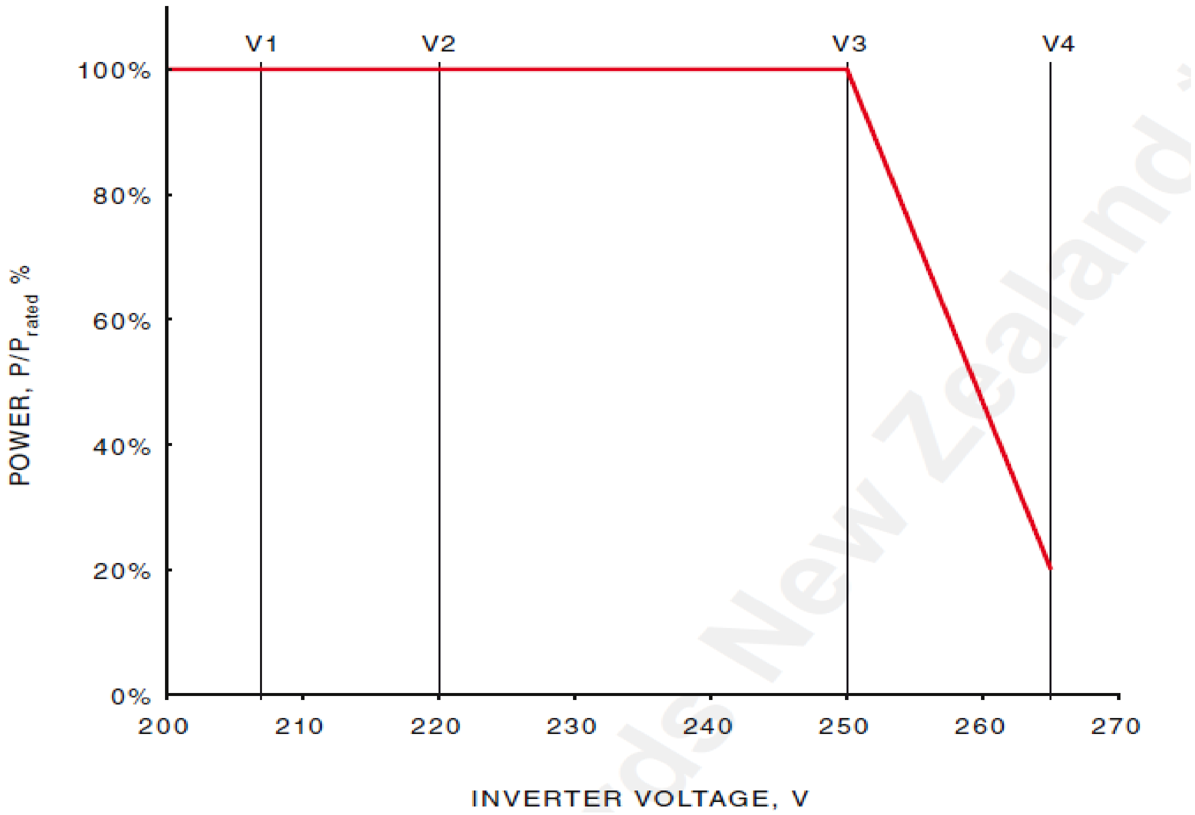


4.4.3. Voltage related active power reduction (Volt-Watt)

The test has been performed according to the clause 4.7.3 of the standard.

The final implemented logic can be chosen by the manufacturer. Nevertheless, this logic shall not cause steps or oscillations in the output power. The power reduction caused by such a function may not be faster than an equivalent of a time constant tau = 3 s (= 33 %/s at a 100 % change).

The following parameters have been set by the manufacturer for this test:



Test 1 and Test 2 setpoint as following:

Reference	Test 1 Set points		Test 2 Set points	
	Volt.(%Un)	Power(%Pn)	Volt.(%Un)	Power(%Pn)
V1	90.0%	100.0%	90.0%	100.0%
V2	95.6%	100.0%	95.6%	100.0%
V3	104.0%	100.0%	108.7%	100.0%
V4	110.0%	20.0%	115.2%	20.0%

Test results are offered at tables below.

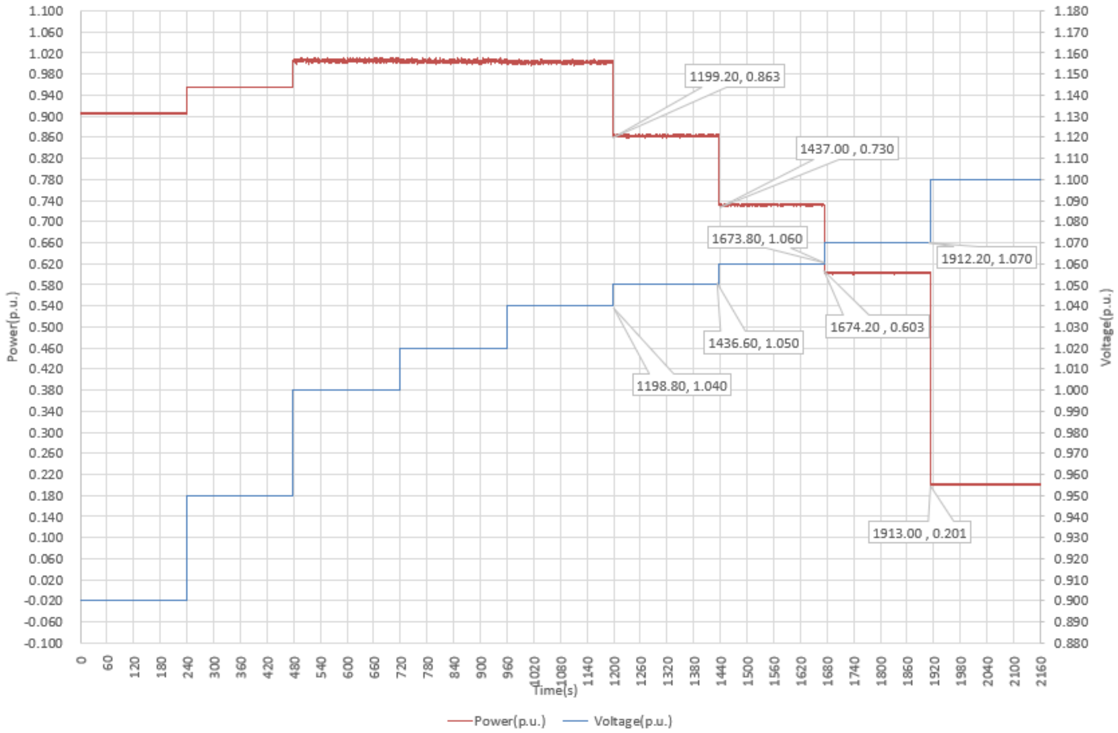
Volt-Watt TEST 1					
V setting (p.u.)	V meas. (p.u.)	P desired (p.u.)	P meas. (p.u.)	P deviation (p.u.)	Response time (s)
0.900	0.900	1.000	0.905 (1)	--	--
0.950	0.950	1.000	0.956 (1)	--	--
1.000	1.000	1.000	1.006	+0.006	--
1.020	1.020	1.000	1.005	+0.005	--
1.040	1.040	1.000	1.003	+0.003	--
1.050	1.050	0.867	0.863	-0.004	0.4
1.060	1.060	0.733	0.732	-0.001	0.4
1.070	1.070	0.600	0.603	+0.003	0.4
1.100	1.100	0.200	0.201	+0.001	0.8

Volt-Watt TEST 2					
V setting (p.u.)	V meas. (p.u.)	P desired (p.u.)	P meas. (p.u.)	P deviation (p.u.)	Response time (s)
0.900	0.900	1.000	0.905 (1)	--	--
0.950	0.950	1.000	0.955 (1)	--	--
1.000	1.000	1.000	1.005	+0.005	--
1.020	1.020	1.000	1.004	+0.004	--
1.040	1.040	1.000	1.001	+0.001	--
1.050	1.050	1.000	1.001	+0.001	--
1.060	1.060	1.000	0.999	-0.001	--
1.070	1.070	1.000	0.999	-0.001	--
1.100	1.100	0.840	0.837	-0.003	0.8
1.120	1.120	0.594	0.596	+0.002	0.8
1.152	1.152	0.200	0.204	+0.004	0.8

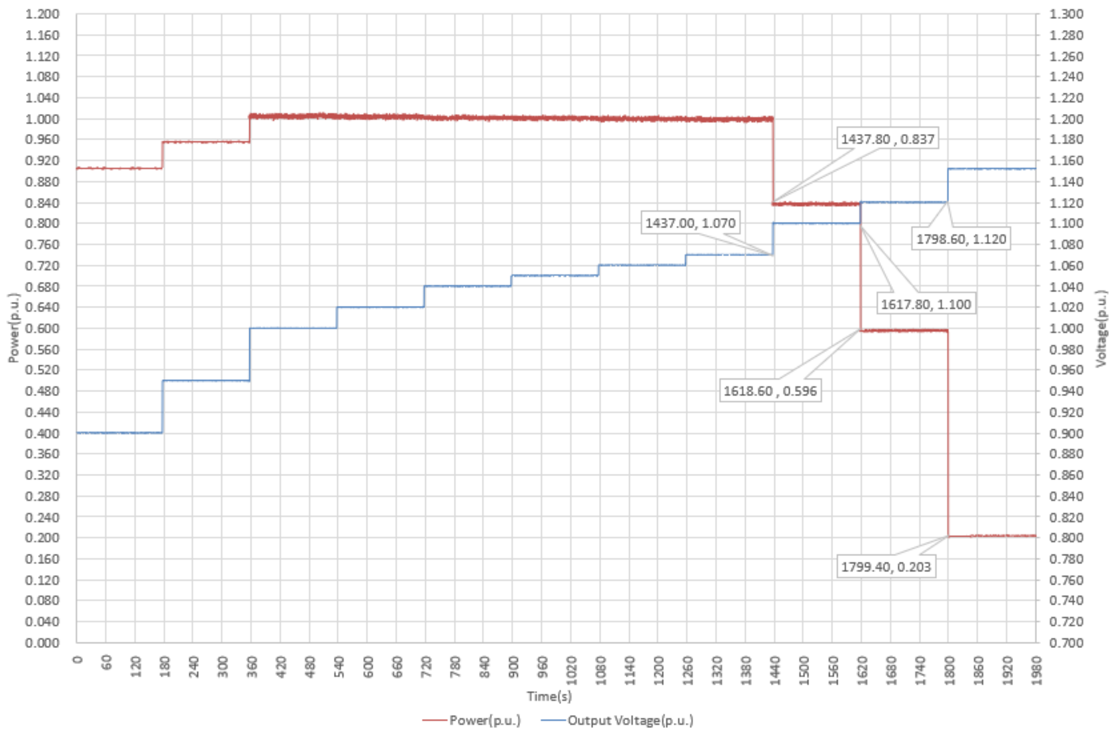
(1) The active power cannot reach the expected value due to current limitation.

Test results are represented at diagrams below.

Volt-Watt Test 1



Vatt-Watt Test 2



4.4.4. Short circuit current requirements on generating plants

The tests of the chapter 4.7.4 of the standard describe the required short circuit current contribution for generating plants taking into account the connection technology of the generating modules.

These tests are considered optional for Type A and Type B generating units connected to LV distribution grids, thus they have not been performed.

4.4.4.1 Generating plant with non-synchronous generating technology

4.4.4.1.1 Voltage support during faults and voltage steps

The requirements are stated in clause 4.7.4.2.1 of the standard.

The EUT is classified as Type A and B. This is no voltage support during faults and voltage steps.

4.4.4.1.2 Zero current mode for converter connected generating technology

The requirements are stated in clause 4.7.4.2.2 of the standard.

The EUT is classified as Type A and B. Refer to Section 4.2.2 and 4.2.3 of this report. During UVRT and OVRT, the EUT is always work at zero current mode.

4.4.4.1.3 Induction generator based units

The requirements are stated in clause 4.7.4.2.3 of the standard.

In general, no voltage support during faults and voltage steps is required from generating plants connected in LV distribution networks as the additional reactive current is expected to interfere with grid protection equipment. This clause is not applicable.

4.4.4.2 Generating plant with synchronous generating technology - Synchronous generator based units

The requirements are stated in clause 4.7.4.3 of the standard.

The EUT is with non-synchronous generating technology. This clause is not applicable.

4.5. EMC AND POWER QUALITY

As required in clause 4.8 of the standard, all electric and electronic equipment to be installed under the scope of this standard shall be in compliance with relative standards for Electromagnetic Compatibility.

The compliances with these requirements are stated in the following EMC test reports:

EN IEC 61000-6-3: 2021; EN IEC 61000-6-1: 2019: Test Report no. GZCR231100125005C02 , issued by SGS-SCTS Standards Technical Services Co., Ltd. Guangzhou Branch, on May 28 of 2024. NVLAP LAB CODE 200611-0.

Note: Aside of EMC evidence of compliances, the harmonic and flicker content has been measured just to provide further information of the tested unit, and the results are stated in the following items 4.5.1 and 4.5.2 of the report.

4.5.1. Harmonic emissions

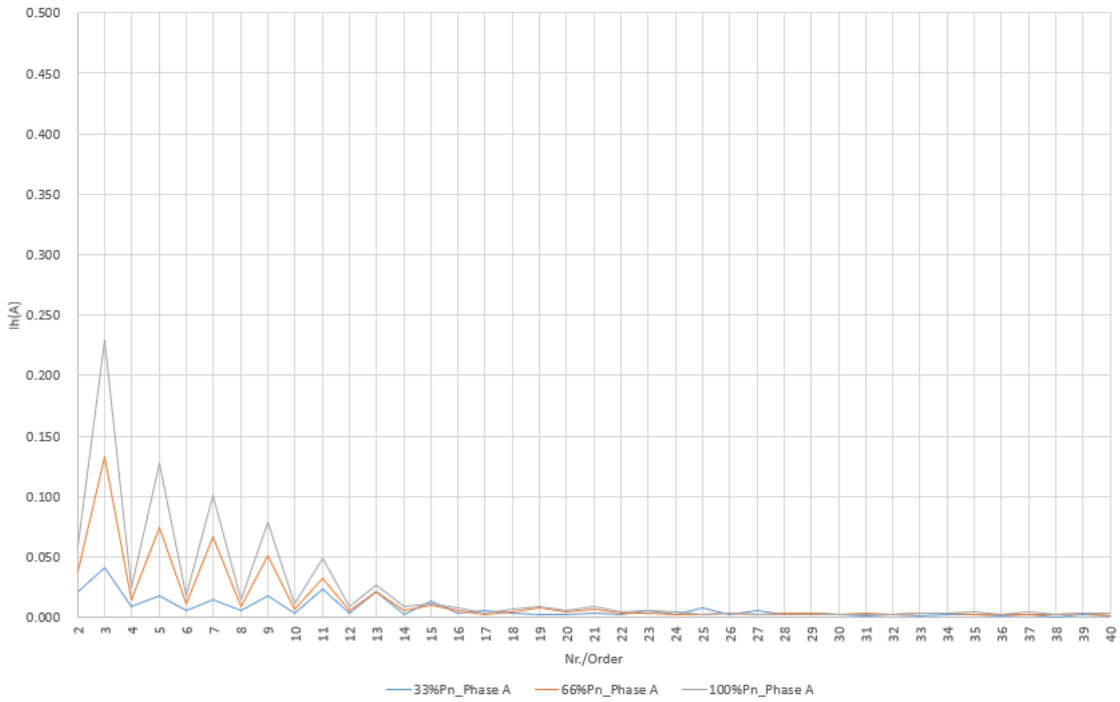
The test has been performed according to the clause 4.8 of the standard EN 61000-3-2:2011-05.

Below are the measured values of current harmonics.

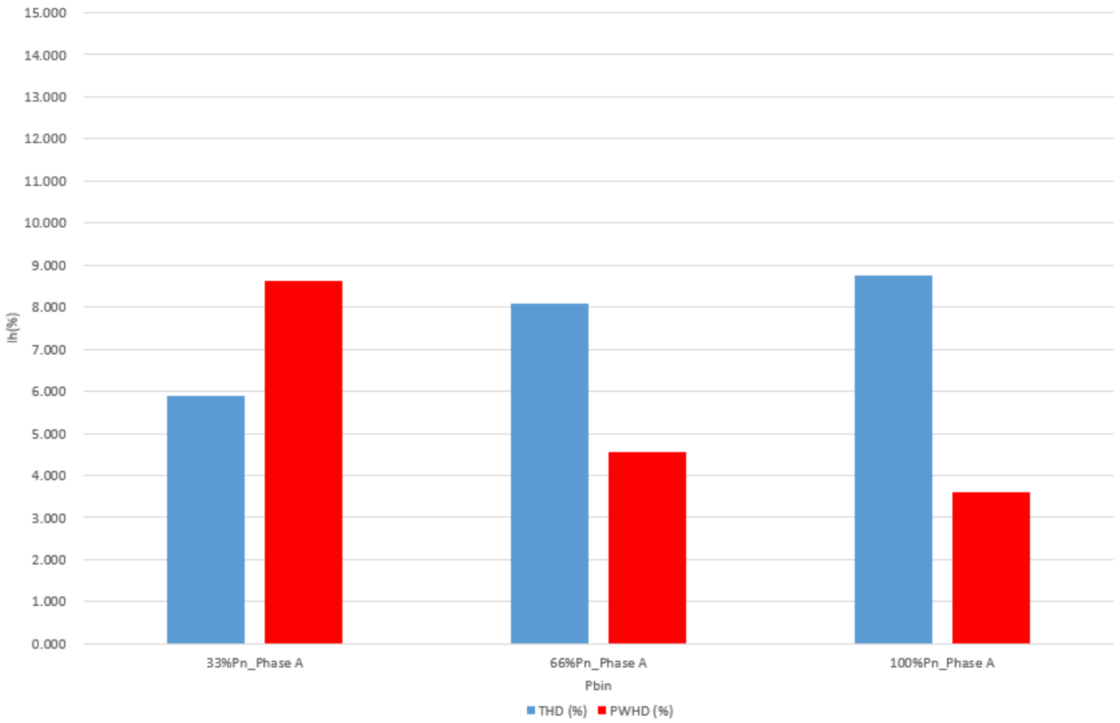
Pn (%)	33	66	100	Limit (A)
Nr./Order	I_h (A)	I_h (A)	I_h (A)	
2	0.021	0.038	0.059	1.080
3	0.041	0.133	0.230	2.300
4	0.009	0.015	0.024	0.430
5	0.018	0.075	0.127	1.140
6	0.006	0.011	0.018	0.300
7	0.014	0.067	0.101	0.770
8	0.005	0.009	0.014	1.000
9	0.018	0.051	0.079	0.400
10	0.004	0.007	0.011	0.800
11	0.023	0.032	0.049	0.330
12	0.003	0.005	0.010	0.667
13	0.021	0.022	0.027	0.210
14	0.003	0.006	0.009	0.571
15	0.013	0.010	0.011	1.000
16	0.003	0.006	0.008	0.500
17	0.005	0.003	0.003	0.882
18	0.003	0.005	0.007	0.444
19	0.003	0.008	0.009	0.789
20	0.003	0.004	0.006	0.400
21	0.004	0.007	0.009	0.714
22	0.003	0.003	0.005	0.364
23	0.006	0.004	0.006	0.652
24	0.002	0.003	0.004	0.333
25	0.008	0.002	0.002	0.600
26	0.002	0.003	0.003	0.308
27	0.006	0.002	0.002	0.556
28	0.002	0.004	0.003	0.286
29	0.004	0.004	0.003	0.517
30	0.002	0.002	0.002	0.267
31	0.001	0.003	0.002	0.484
32	0.003	0.002	0.003	0.250
33	0.001	0.003	0.003	0.455
34	0.002	0.003	0.004	0.235
35	0.002	0.003	0.005	0.429
36	0.001	0.003	0.003	0.222
37	0.003	0.003	0.004	0.405
38	0.001	0.003	0.002	0.211
39	0.003	0.004	0.004	0.385
40	0.001	0.002	0.003	0.200
THD (%)	5.900	8.073	8.765	13.000
PWHD(%)	8.626	4.561	3.611	22.000

Test results are represented at diagrams below.

Current Harmonics



THD and PWHD



4.5.2. Flicker and voltage fluctuations

The test has been performed according to the clause 4.8 of the standard.

The measurements of voltage fluctuations have been measured at 33%, 66% and 100% of the nominal power value of the inverter according to the standard IEC 61000-3-3:2017.

The flicker test result as following:

33 %Pn		
Item	**Limit**	**L-N**
P_{ST}	≤ 1.000	0.133
P_{LT}	≤ 0.650	0.058
dc [%]	≤ 3.300	0.000
dmax [%]	4.000	0.000

66 %Pn		
Item	**Limit**	**L-N**
P_{ST}	≤ 1.000	0.015
P_{LT}	≤ 0.650	0.014
dc [%]	≤ 3.300	0.000
dmax [%]	4.000	0.000

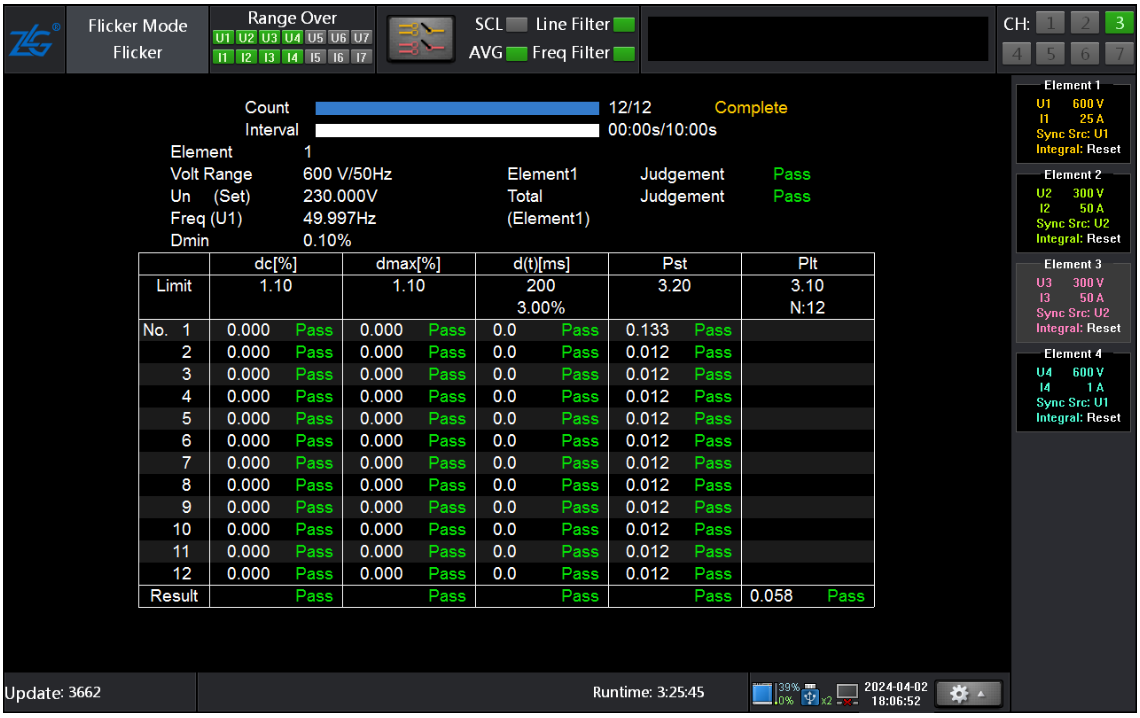
100 %Pn		
Item	**Limit**	**L-N**
P_{ST}	≤ 1.000	0.017
P_{LT}	≤ 0.650	0.017
dc [%]	≤ 3.300	0.000
dmax [%]	4.000	0.000

As it can be seen in the next screenshots, this test has 12 steps. The values took of Pst, Plt, dc and dmax are the most unfavorable of the 12 steps.

Test results are represented at diagrams below.

33 %Pn

L-N



Count 12/12 Complete
Interval 00:00s/10:00s
Element 1
Volt Range 600 V/50Hz
Un (Set) 230.000V
Freq (U1) 49.997Hz
Dmin 0.10%
Element1 Judgement Pass
Total (Element1) Judgement Pass

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	1.10		1.10		200 3.00%		3.20		3.10 N:12	
No. 1	0.000	Pass	0.000	Pass	0.0	Pass	0.133	Pass		
2	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
3	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
4	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
5	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
6	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
7	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
8	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
9	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
10	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
11	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
12	0.000	Pass	0.000	Pass	0.0	Pass	0.012	Pass		
Result		Pass		Pass		Pass		Pass	0.058	Pass

Update: 3662 Runtime: 3:25:45 2024-04-02 18:06:52

66 %Pn

L-N

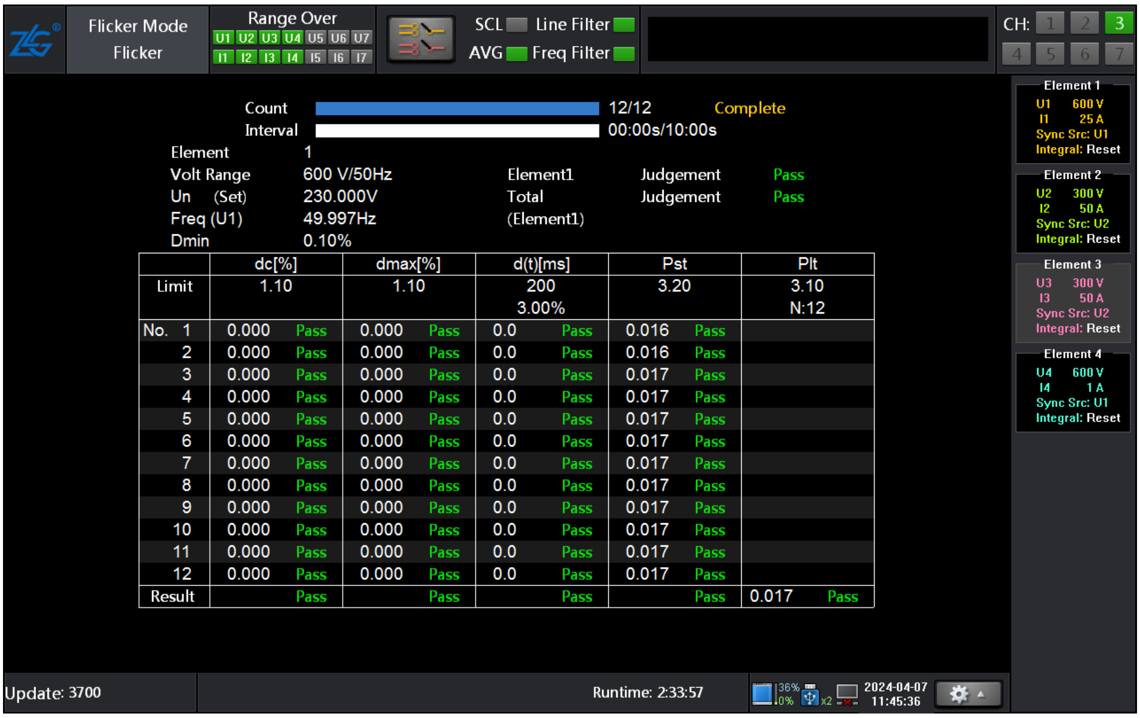
Count 12/12 Complete
Interval 00:00s/10:00s
Element 1
Volt Range 600 V/50Hz
Un (Set) 230.000V
Freq (U1) 43.101Hz
Dmin 0.10%
Element1 Judgement Pass
Total (Element1) Judgement Pass

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	1.10		1.10		200 3.00%		3.20		3.10 N:12	
No. 1	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
2	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
3	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
4	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
5	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
6	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
7	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
8	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
9	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
10	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
11	0.000	Pass	0.000	Pass	0.0	Pass	0.014	Pass		
12	0.000	Pass	0.000	Pass	0.0	Pass	0.015	Pass		
Result		Pass		Pass		Pass		Pass	0.014	Pass

Update: 5262 Runtime: 2:57:24 2024-04-03 17:33:27

100 %Pn

L-N



	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	1.10		1.10		200 3.00%		3.20		3.10 N:12	
No. 1	0.000	Pass	0.000	Pass	0.0	Pass	0.016	Pass		
2	0.000	Pass	0.000	Pass	0.0	Pass	0.016	Pass		
3	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
4	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
5	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
6	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
7	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
8	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
9	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
10	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
11	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
12	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
Result		Pass		Pass		Pass		Pass	0.017	Pass

4.6. INTERFACE PROTECTION

4.6.1. Requirements on voltage and frequency protection

The test has been performed according to the clause 4.9.3 of the standard. The minimum required accuracy for protection is:

- For frequency measurement ±0.05 Hz;
- For voltage measurement ±1 %Un.
- The reset time shall be ≤50 ms.
- The interface protection relay shall not conduct continuous starting and disengaging operations of the interface protection relay. Therefore, a reasonable reset ratio shall be implemented which shall not be zero but be below 2 % of nominal value for voltage and below 0.2 Hz for frequency.

4.6.1.1 Undervoltage protection

Undervoltage protection may be implemented with two completely independent protection thresholds, each one able to be activated or not. The standard adjustment ranges are as follows.

Undervoltage threshold stage 1 [27 <]:
- Threshold (0.2 – 1.0) Un adjustable by steps of 0.01 Un
- Operate time (0.1 – 100) s adjustable in steps of 0.1 s

Undervoltage threshold stage 2 [27 <<]:
- Threshold (0.2 – 1.0) Un adjustable by steps of 0.01 Un
- Operate time (0.1 – 5) s adjustable in steps of 0.05 s

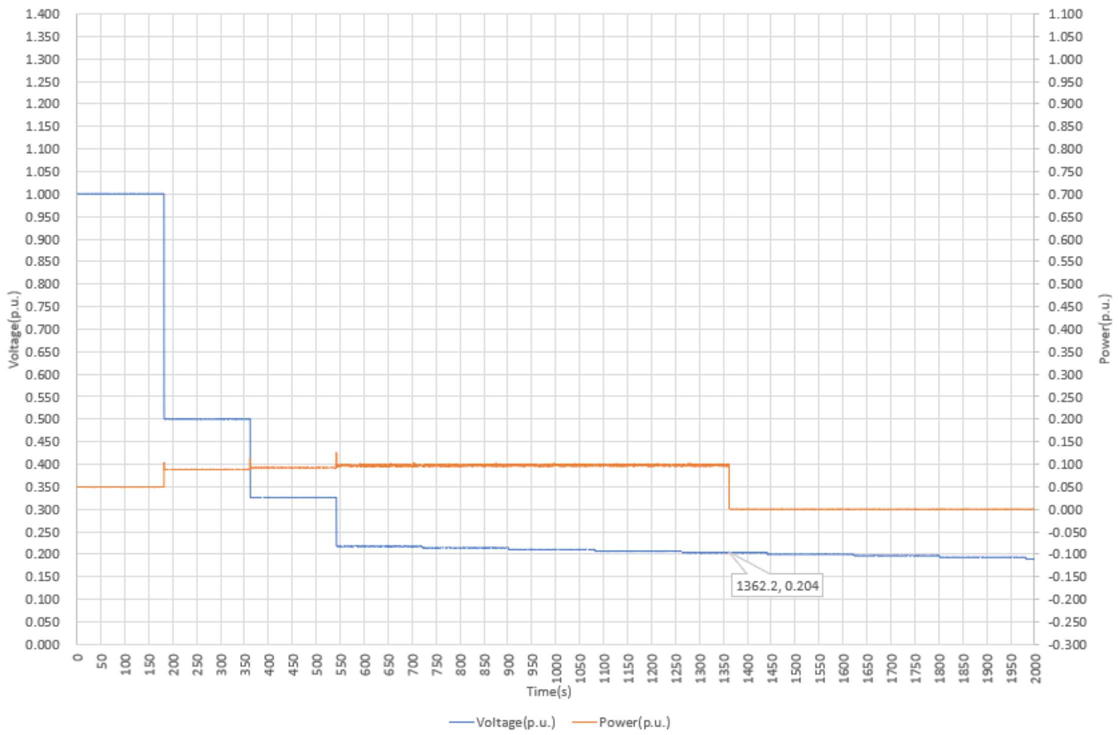
The undervoltage threshold stage 2 is not applicable for micro-generating plants.

The following definitions apply to the test to verify the clause:

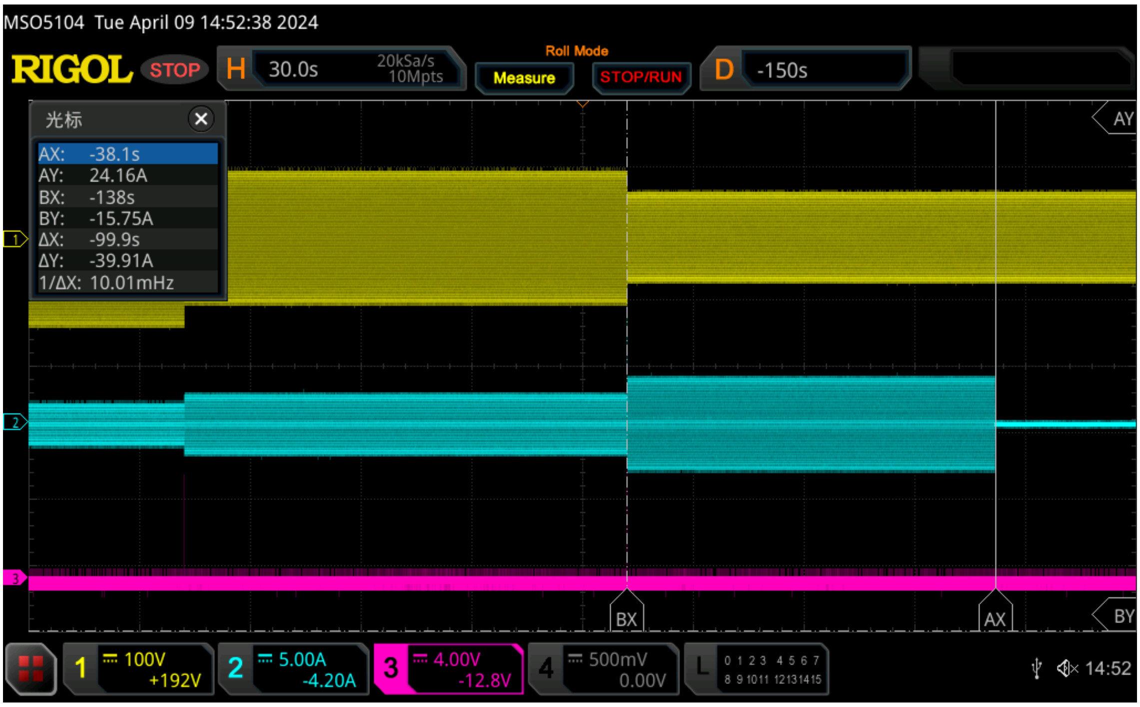
Undervoltage	Test No.	Voltage setting (p.u.)	Voltage meas. (p.u.)	Voltage deviation (p.u.)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
Stage 1 [27 <]	1	0.200	0.204	+0.004	100.000	99.900	-0.100
	2	1.000	1.000	+0.000	0.100	0.043	-0.057
Stage 2 [27 <<]	3	0.200	0.200	0.000	5.000	4.980	-0.020
	4	1.000	1.002	+0.002	0.100	0.027	-0.073

Test results are represented at diagrams below.

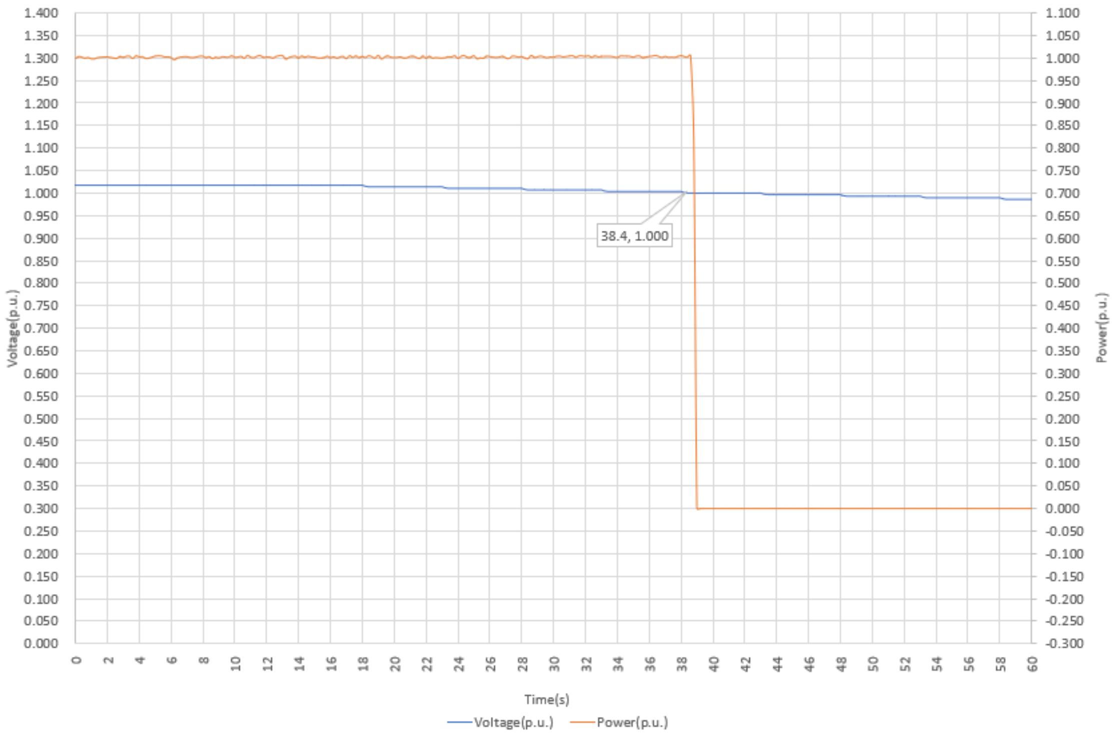
Undervoltage - Test 1: Trip value



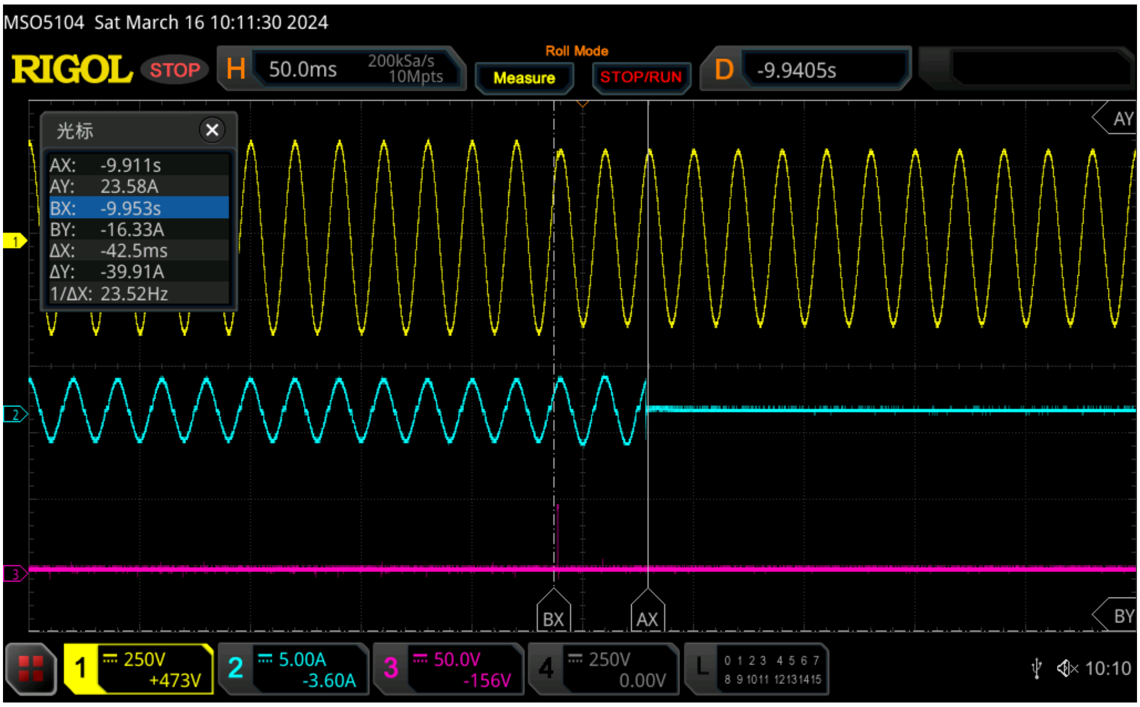
Undervoltage - Test 1: Trip time



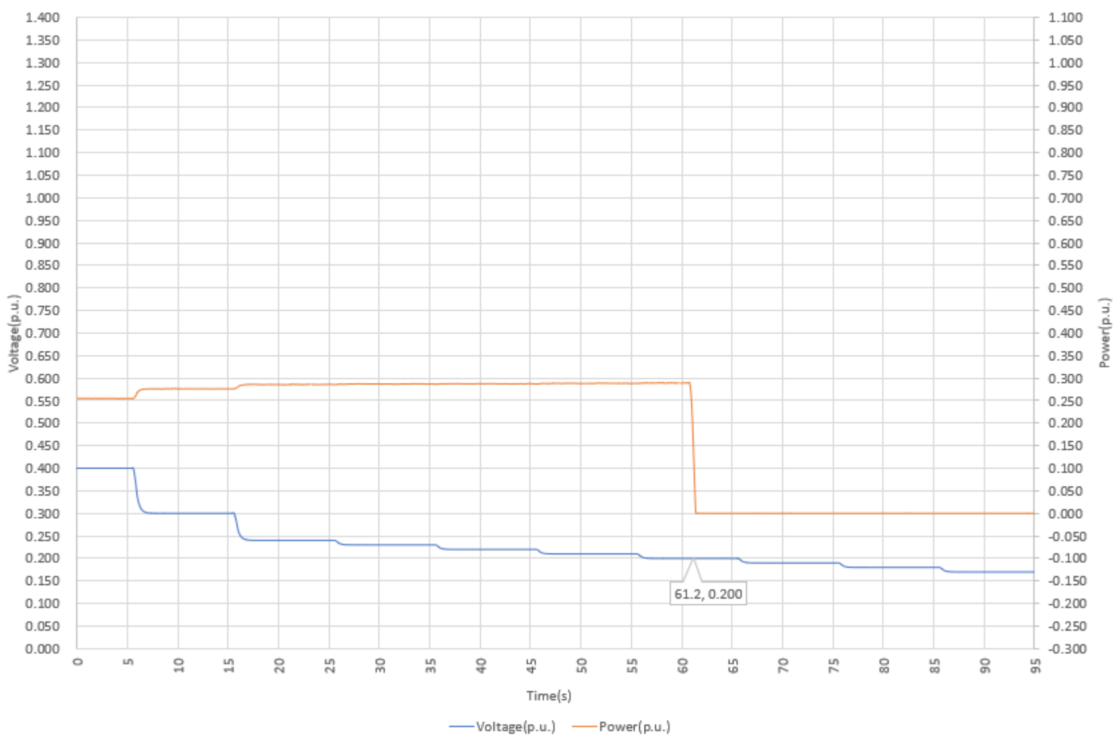
Under voltage - Test 2: Trip value



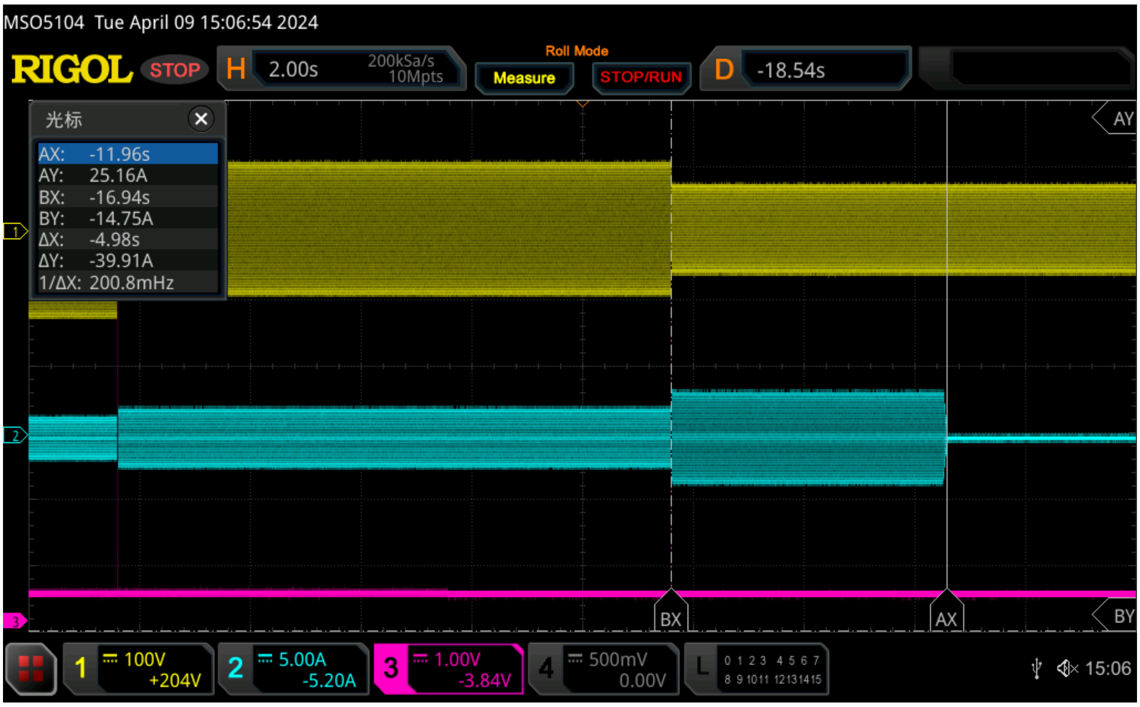
Under voltage - Test 2: Trip time



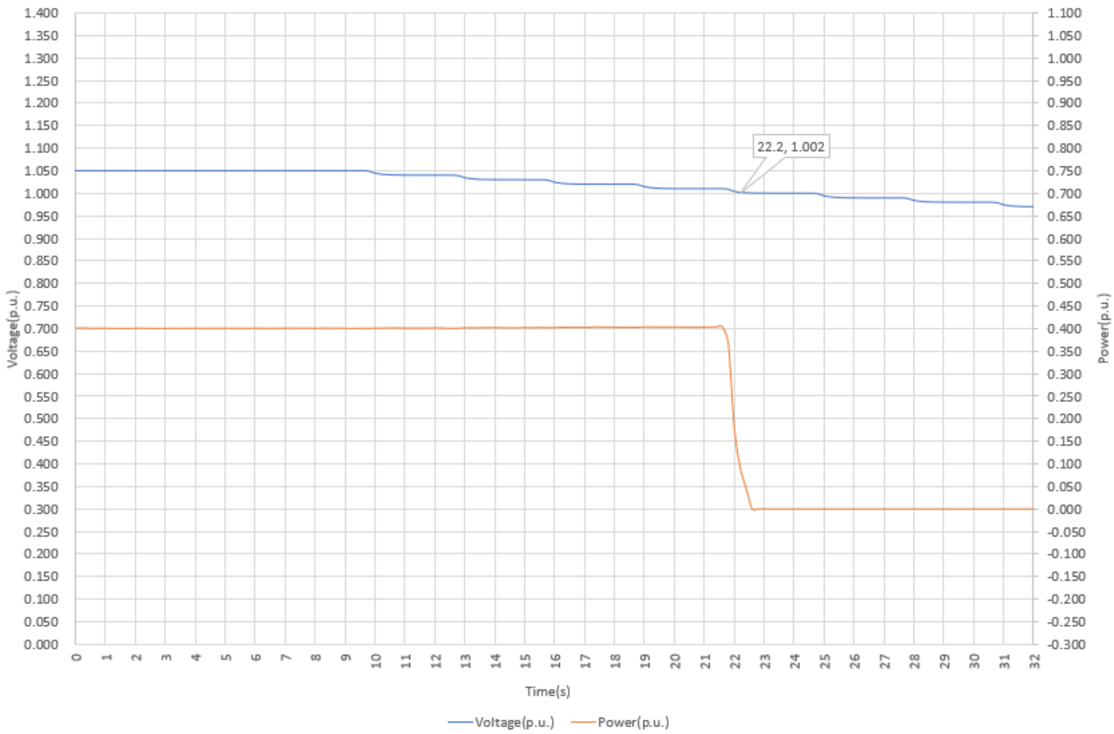
Under voltage - Test 3: Trip value



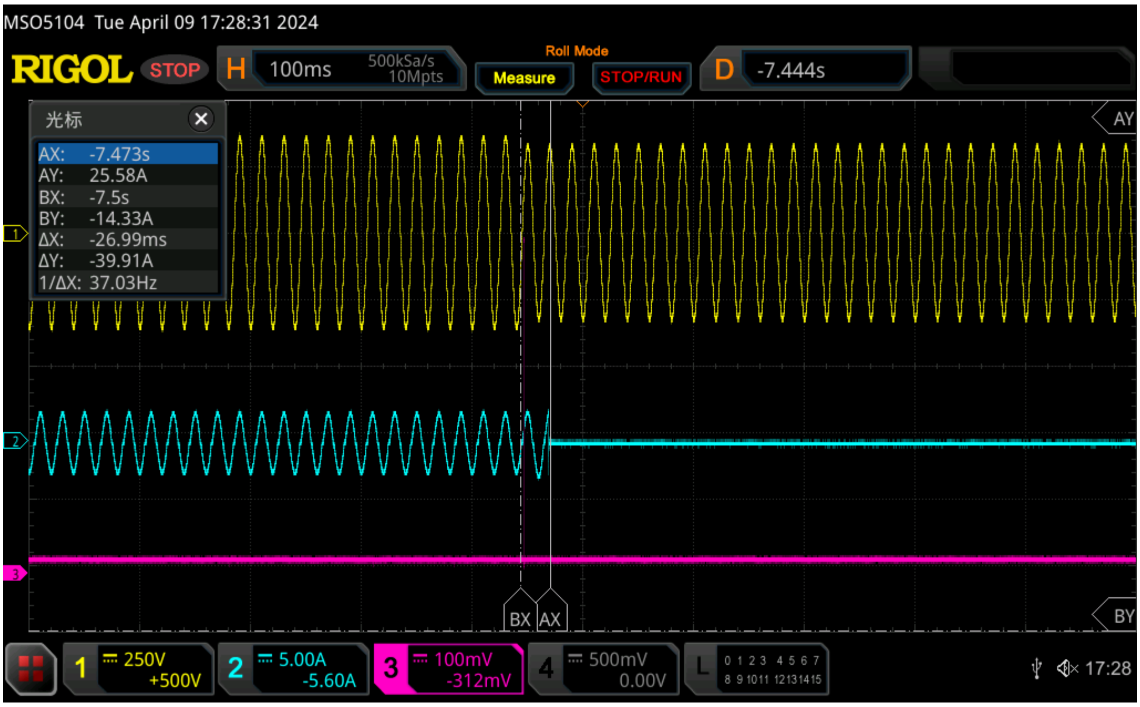
Under voltage - Test 3: Trip time



Under voltage - Test 4: Trip value



Under voltage - Test 4: Trip time



4.6.1.2 Overvoltage protection

Overvoltage protection may be implemented with two completely independent protection thresholds, each one able to be activated or not. The standard adjustment ranges are as follows.

Overvoltage threshold stage 1 [59 >]:
- Threshold (1.0 – 1.2) Un adjustable by steps of 0.01 *Un*
- Operate time (0.1 – 100) s adjustable in steps of 0.1 s

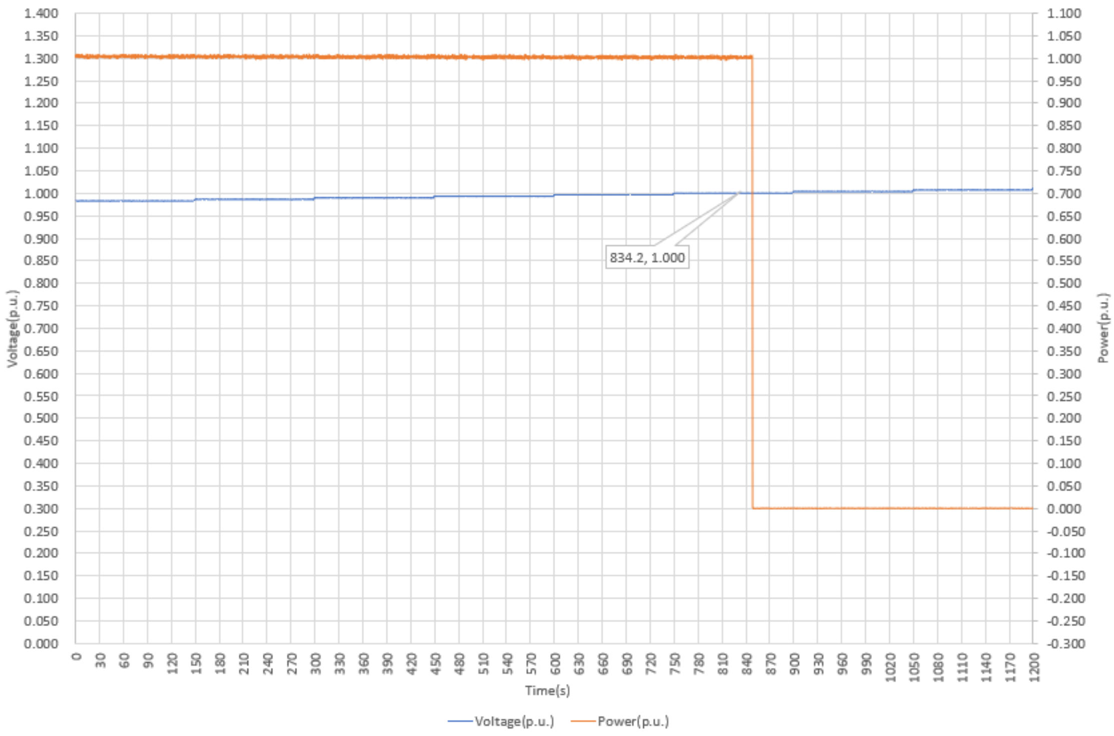
Overvoltage threshold stage 2 [59 > >]:
- Threshold (1.0 – 1.3) Un adjustable by steps of 0.01 *Un*
- Operate time (0.1 – 5) s adjustable in steps of 0.05 s

The following definitions apply to the test to verify the clause:

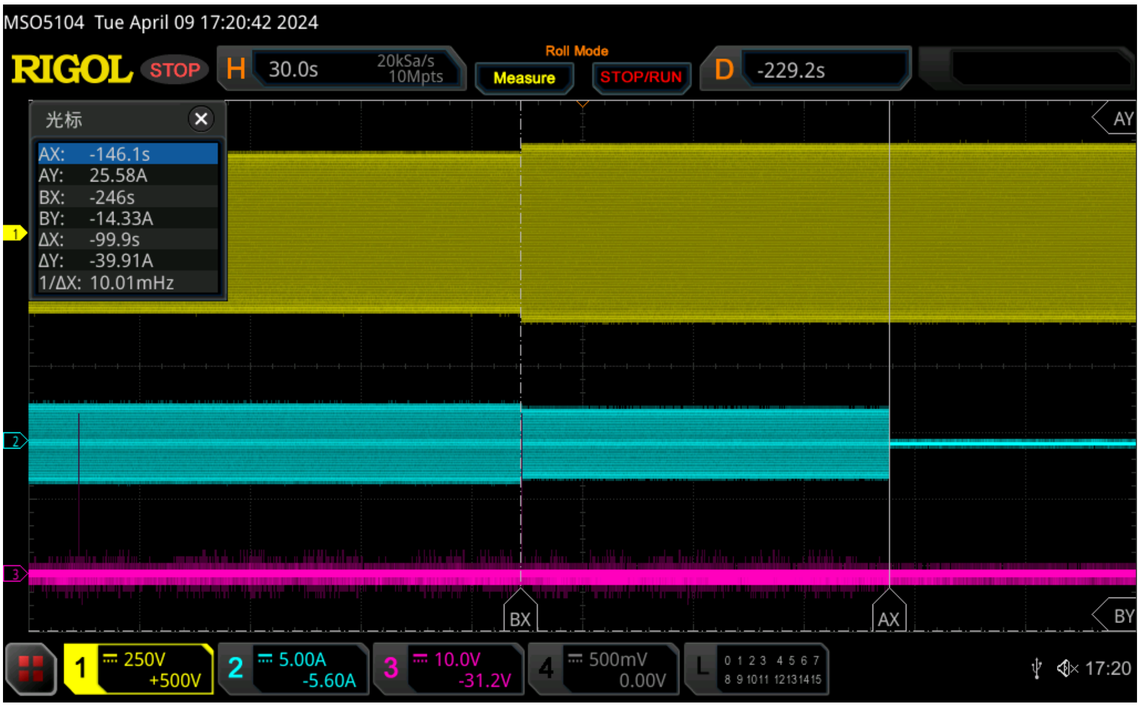
Overvoltage	Test No.	Voltage setting (p.u.)	Voltage meas. (p.u.)	Voltage deviation (p.u.)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
Stage 1 [59 >]:	1	1.000	1.000	0.000	100.000	99.900	-0.100
	2	1.200	1.200	0.000	0.100	0.026	-0.074
Stage 2 [59 > >]	3	1.000	1.000	0.000	5.000	4.980	-0.020
	4	1.300	1.300	0.000	0.100	0.012	-0.088

Test results are represented at diagrams below.

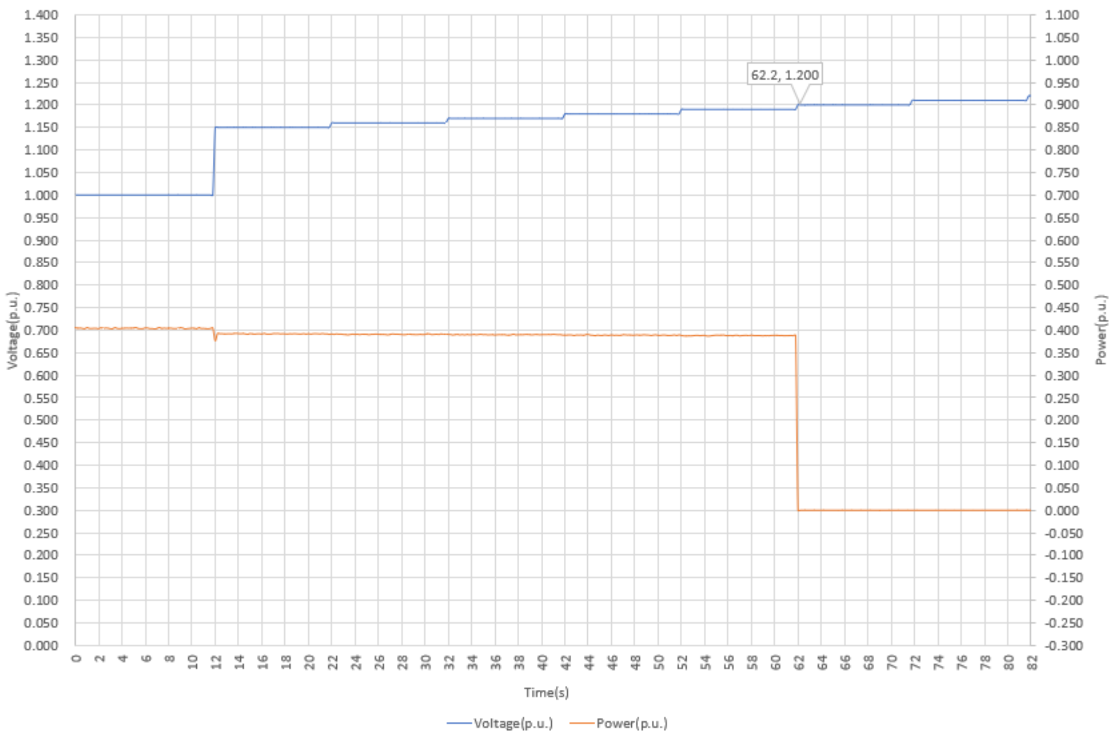
Overvoltage - Test 1: Trip value



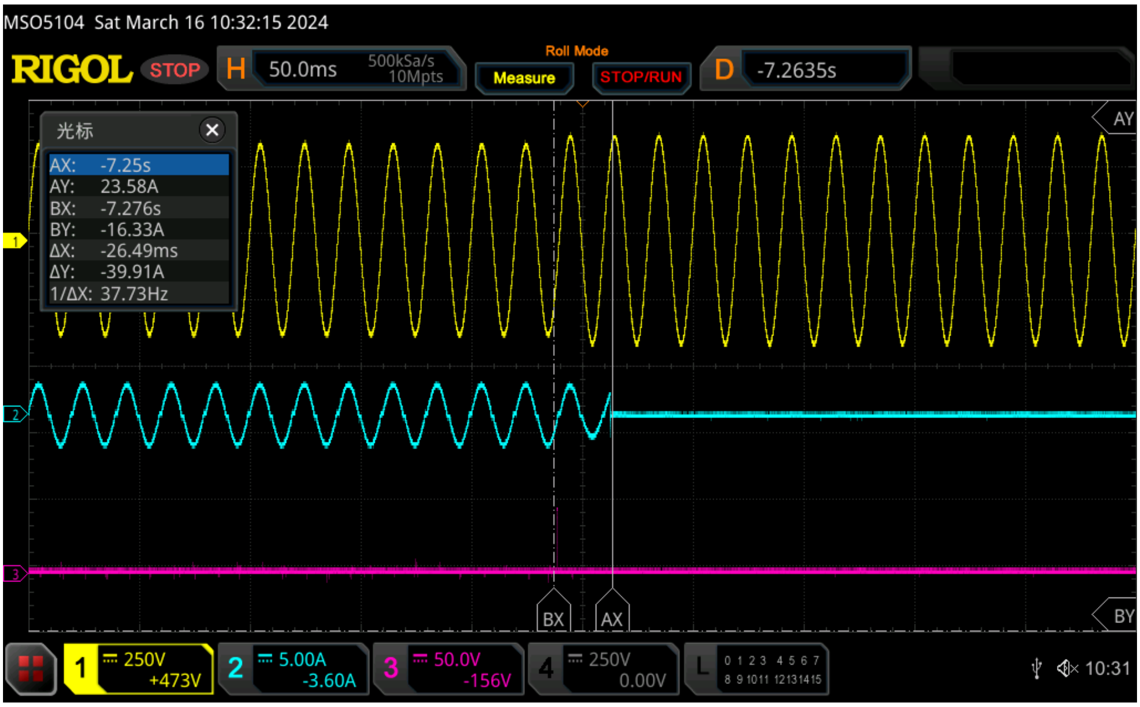
Overvoltage - Test 1: Trip time



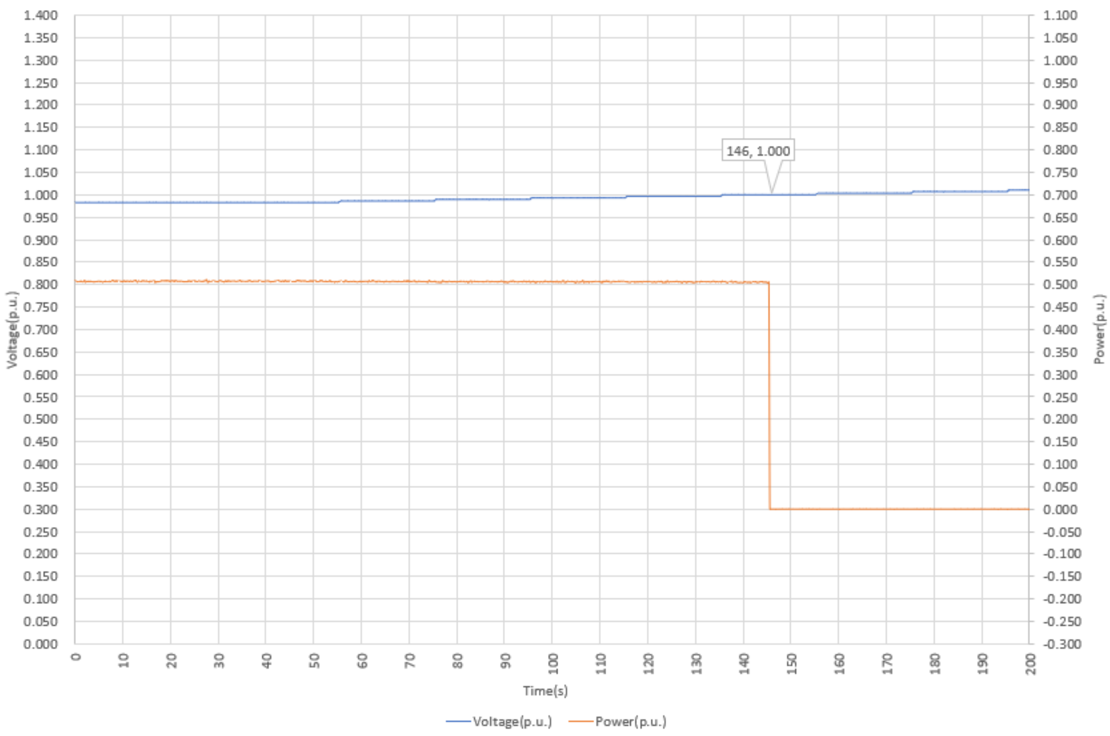
Overvoltage - Test 2: Trip value



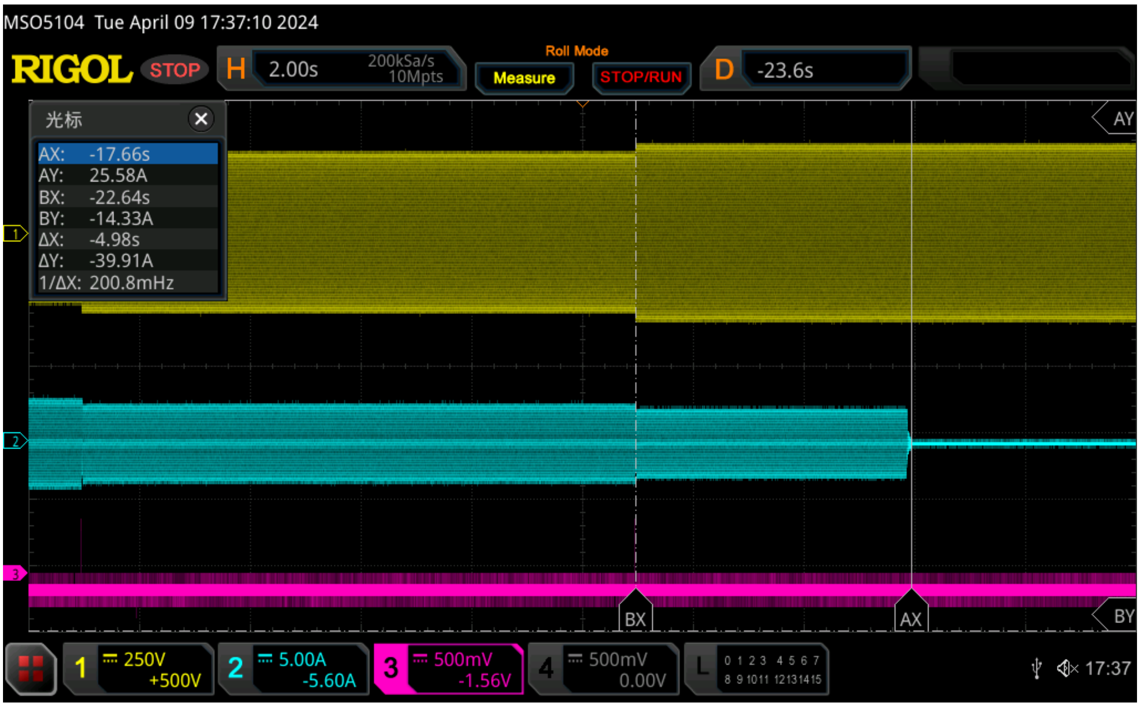
Overvoltage - Test 2: Trip time



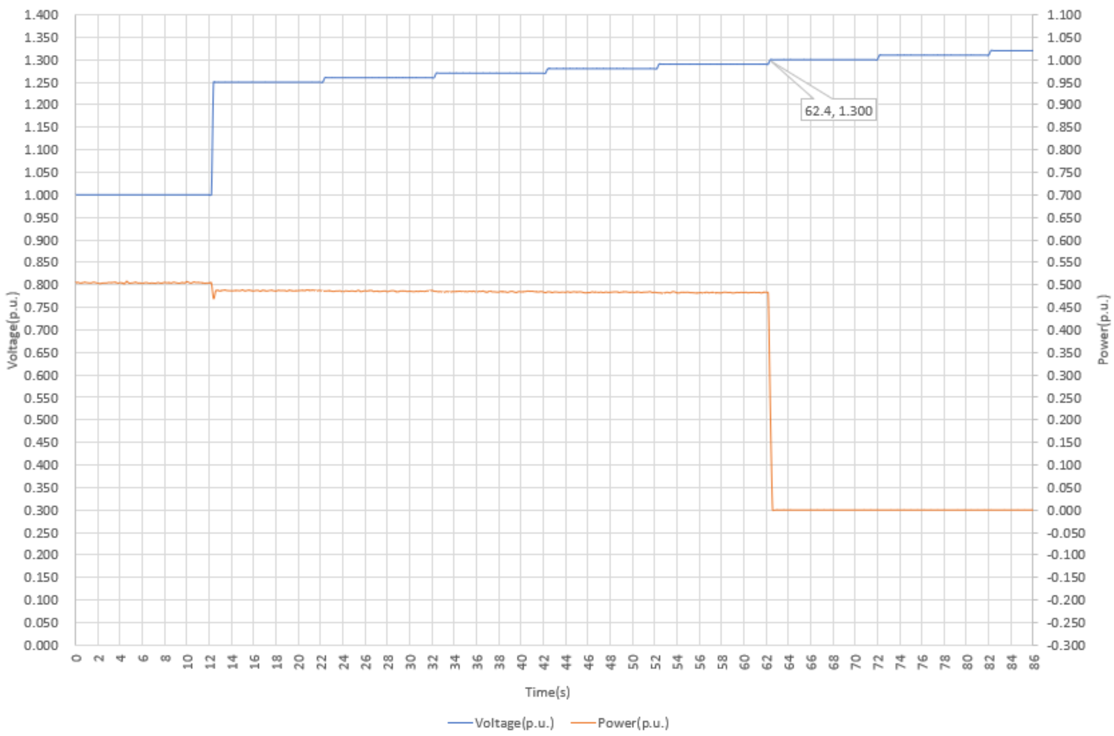
Overvoltage - Test 3: Trip value



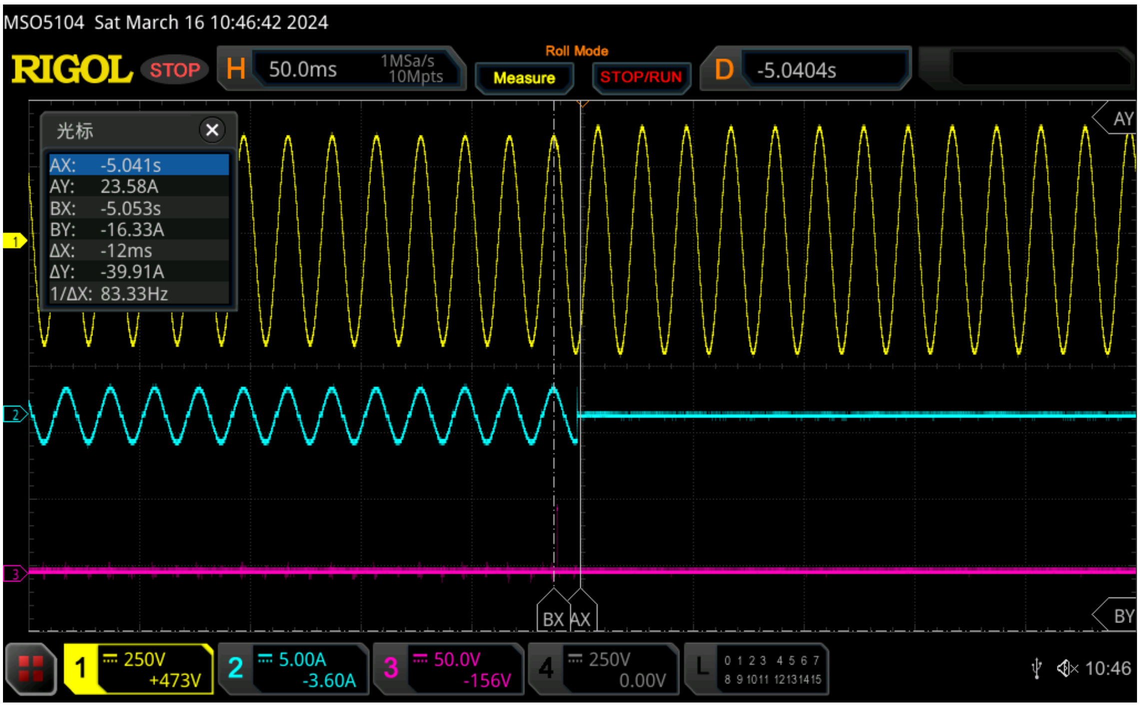
Overvoltage - Test 3: Trip time



Overvoltage - Test 4: Trip value



Overvoltage - Test 4: Trip time



4.6.1.3 Overvoltage 10 min mean protection

The function shall be based on the calculation of the square root of the arithmetic mean of the squared input values over 10 min. The calculation of a new 10 min value at least every 3 s is sufficient, which is then to be compared with the threshold value.

- Threshold (1.0 – 1.15) *Un* adjustable by steps of 0.01 *Un*
- Start time ≤ 3s not adjustable
- Time delay setting = 0 ms

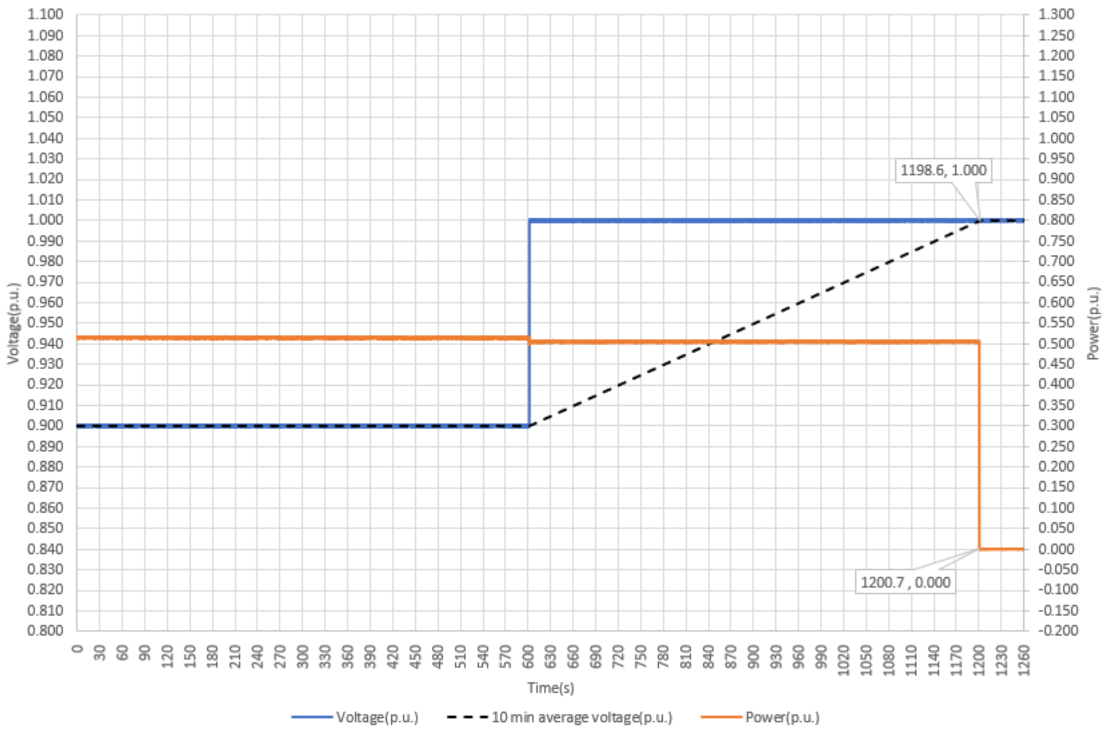
The following definitions apply to the test to verify the clause:

Test No.	Voltage setting (p.u.)	Voltage meas. (p.u.)	Voltage deviation (p.u.)	Trip time meas. (s)	Trip time limited
1	1.000	1.000	0.000	2.1	≤ 3.0s
2	1.150	1.150	0.000	1.6	≤ 3.0s

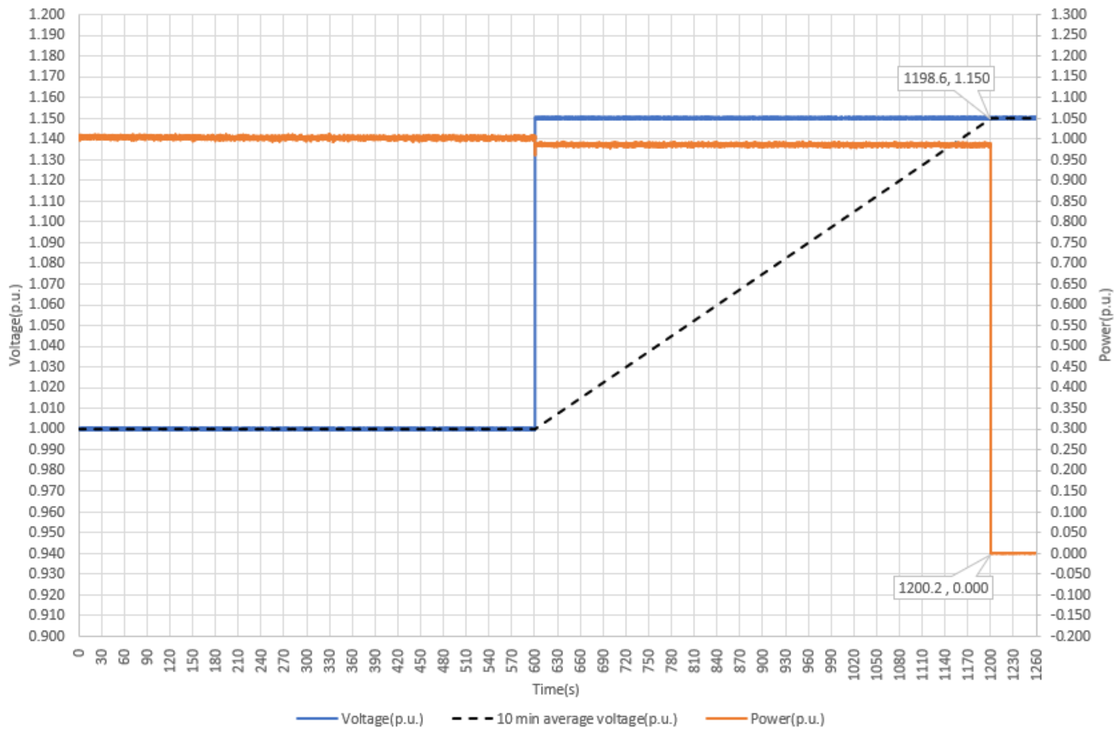
Remark: The trip voltage accuracy tolerance is ±0.01 Un.

Test results are represented at diagrams below.

Overvoltage 10 min mean protection - Test 1



Overvoltage 10 min mean protection - Test 2



4.6.1.4 Underfrequency protection

Underfrequency protection may be implemented with two completely independent protection thresholds, each one able to be activated or not. The standard adjustment ranges are as follows.

Underfrequency threshold stage 1 [81 <]:
- Threshold (47.0 – 50.0) Hz adjustment by steps of 0.1 Hz
- Operate time (0.1 – 100) s adjustable in steps of 0.1 s

Underfrequency threshold stage 2 [81 <<]:
- Threshold (47.0 – 50.0) Hz adjustment by steps of 0.1 Hz
- Operate time (0.1 – 5) s adjustable in steps of 0.05 s

In order to use narrow frequency thresholds for islanding detection (see 4.9.3.3) it may be required to have the ability to activate and deactivate a stage by an external signal.

The frequency protection shall function correctly in the input voltage range between 20 % Un and 120 % Un and shall be inhibited for input voltages of less than 20 % Un.

Under 0.2 Un the frequency protection is inhibited. Disconnection may only happen based on undervoltage protection.

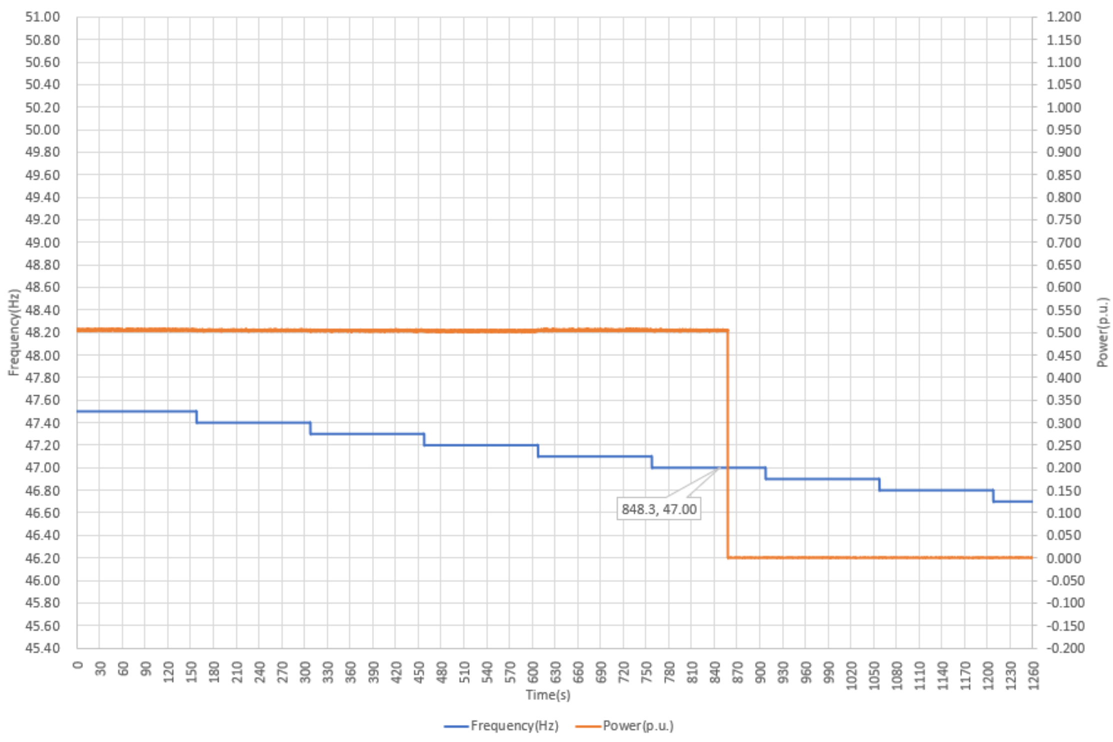
The following definitions apply to the test to verify the clause:

Under frequency	Test No.	Frequency setting (Hz)	Frequency meas. (Hz)	Frequency deviation (Hz)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
Stage 1 [81 <]	1	47.00	47.00	0.00	100.000	99.9	-0.100
	2	50.00	50.00	0.00	0.100	0.040	-0.060
Stage 2 [81 < <]	3	47.00	47.00	0.00	5.000	4.960	-0.040
	4	50.00	50.00	0.00	0.100	0.039	-0.061

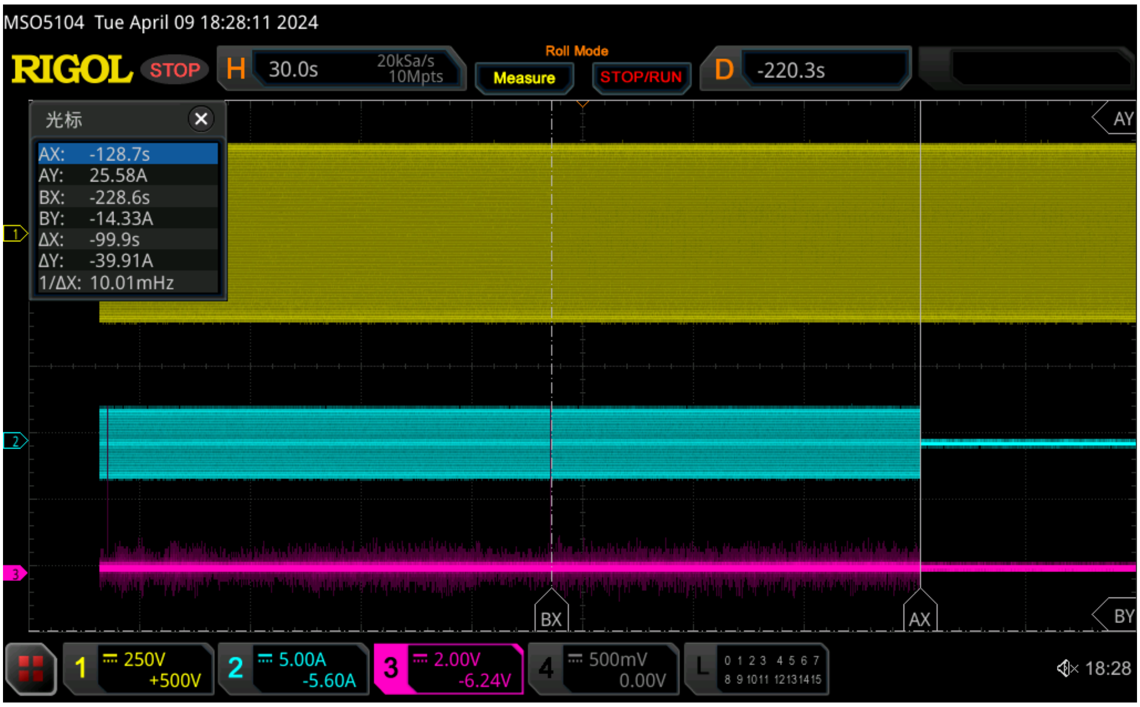
Voltage protection threshold setting (p.u.)	Test No.	Frequency setting (Hz)	Voltage setting (p.u.)	Trip value meas. (Hz)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
0.18 & 1.22	5	47.00	0.210	47.00	5.000	4.940	-0.060
	6	47.00	1.190	47.00	5.000	4.980	-0.020
	7	47.00	0.190	--	Not protected	--	--
		47.00	0.170	47.00	5.000	4.920	-0.080
	8	47.00	1.210	--	Not protected	--	--
		47.00	1.230	47.00	5.000	4.980	-0.020

Test results are represented at diagrams below.

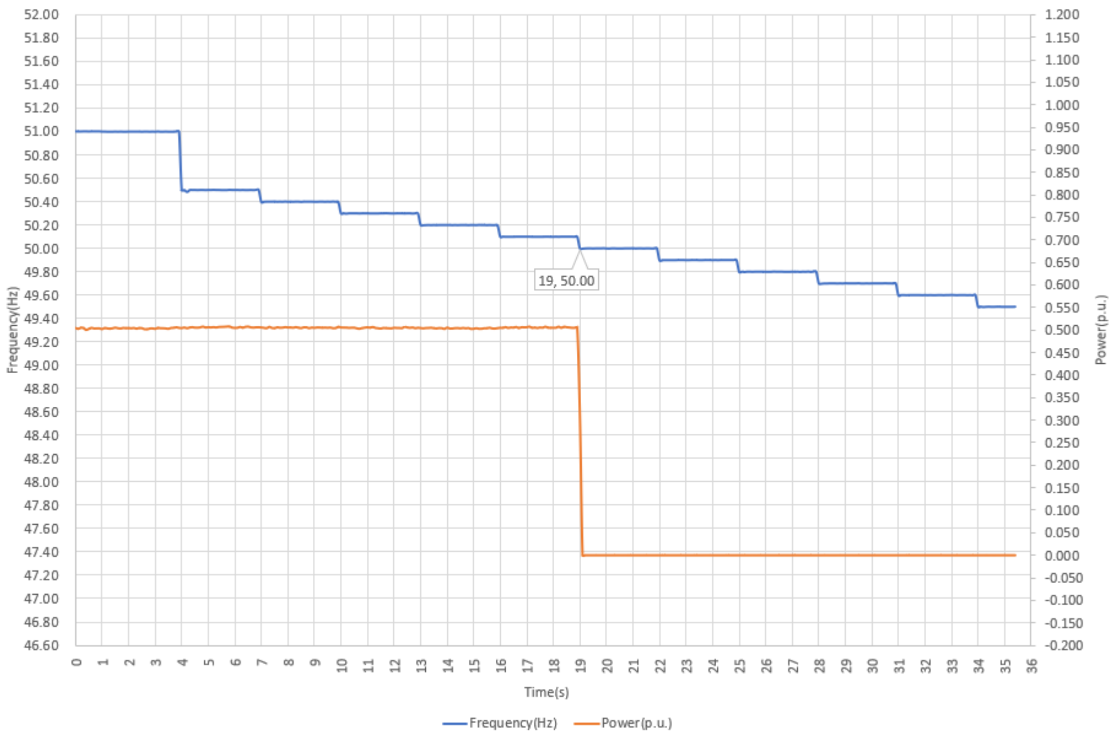
Underfrequency - Test 1: Trip value



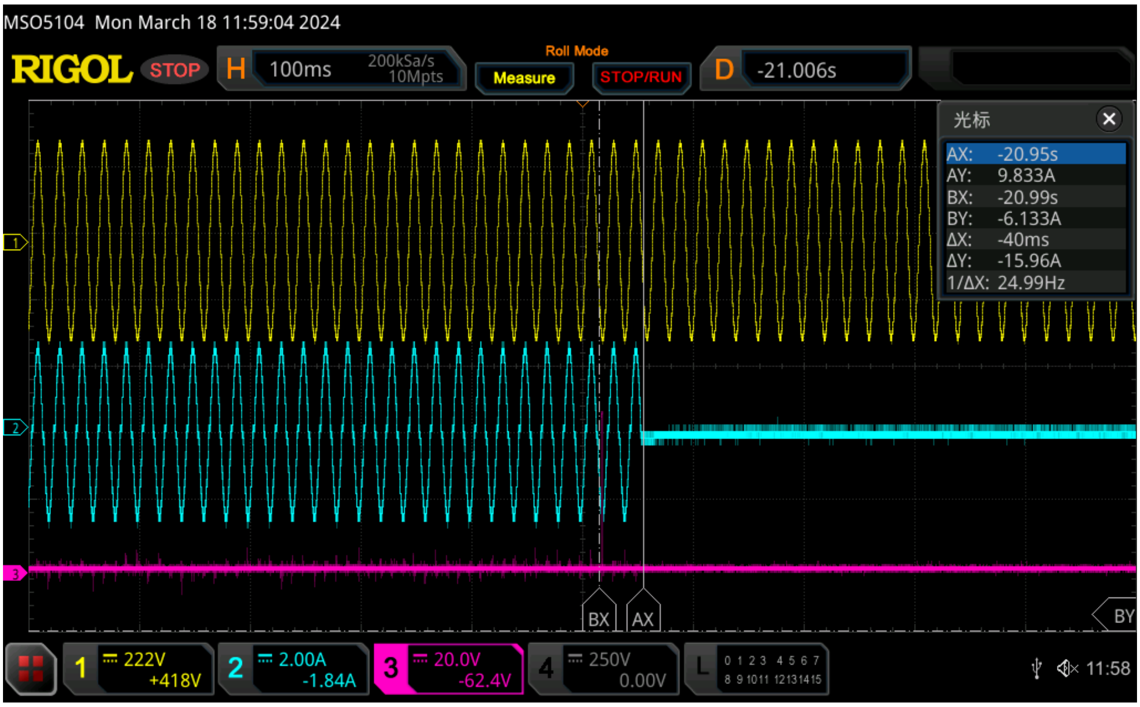
Underfrequency - Test 1: Trip time



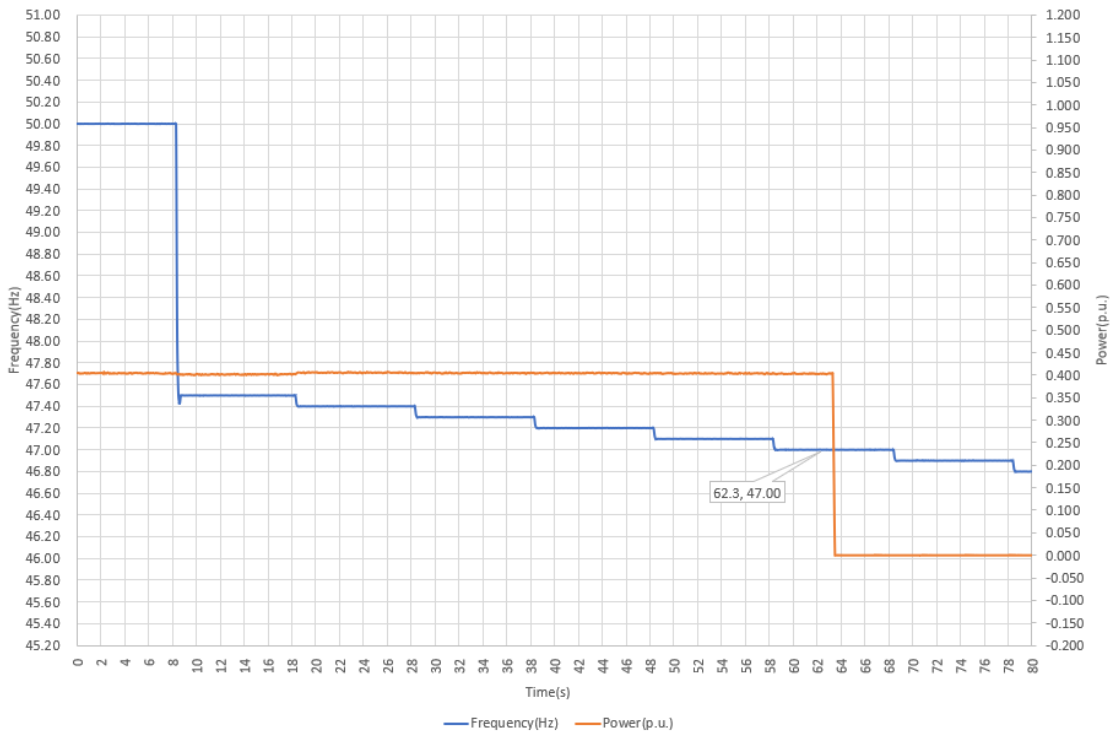
Underfrequency - Test 2: Trip value



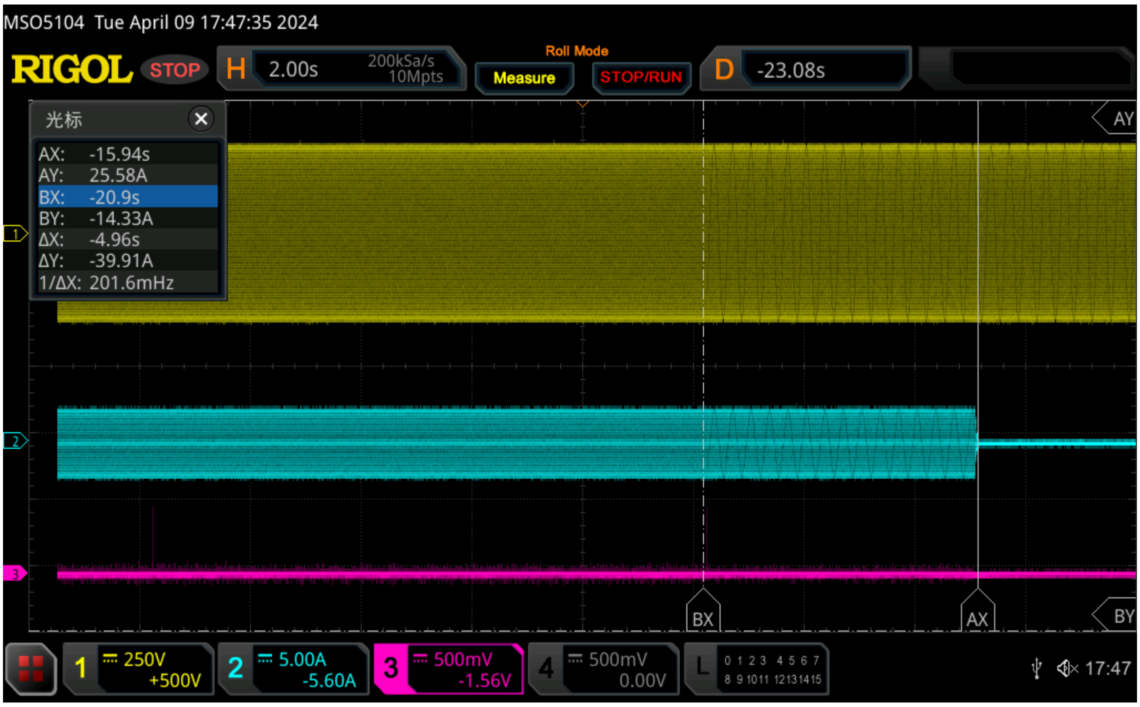
Underfrequency - Test 2: Trip time



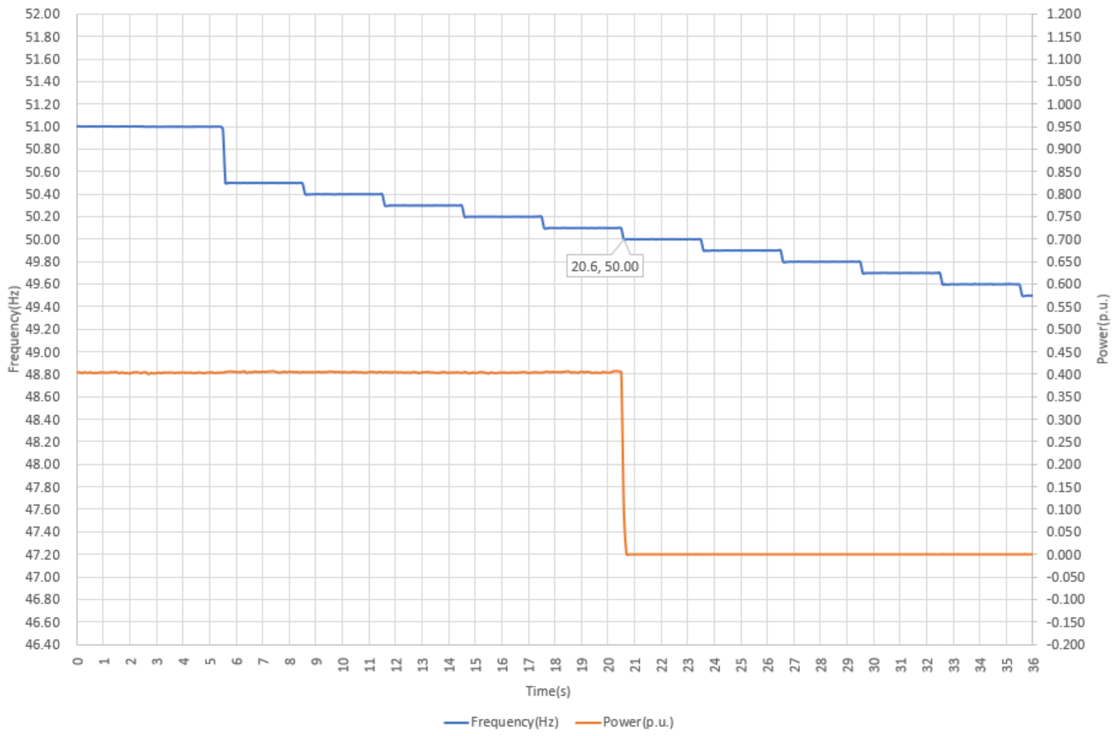
Underfrequency - Test 3: Trip value



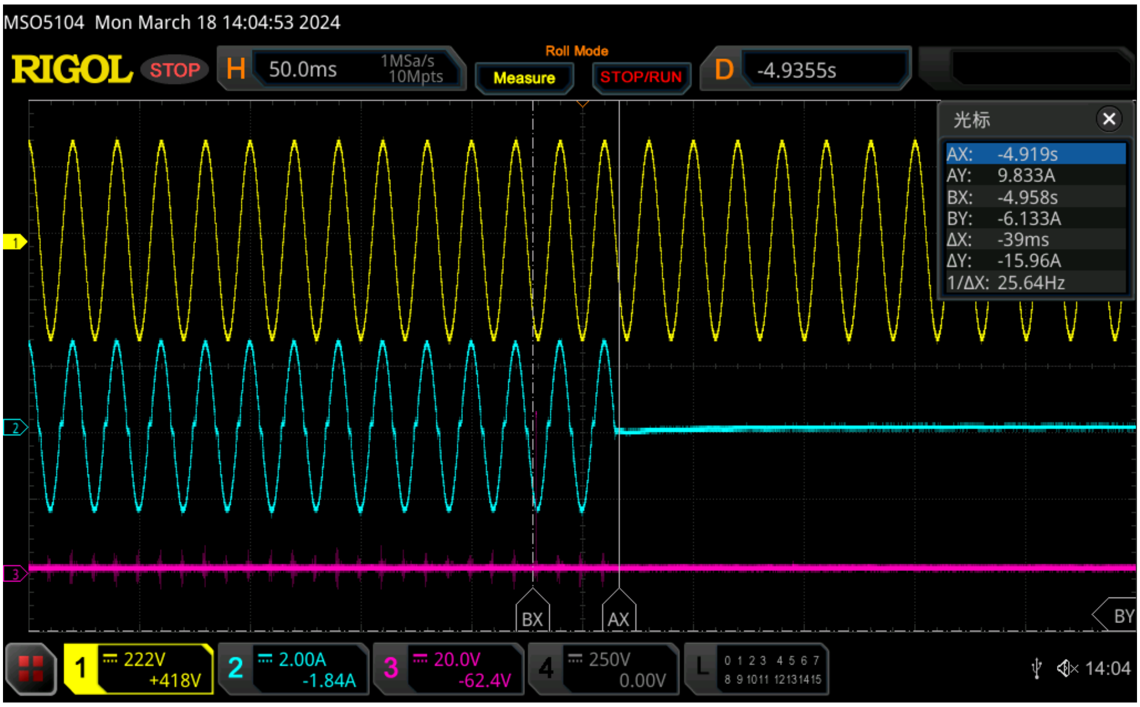
Underfrequency - Test 3: Trip time



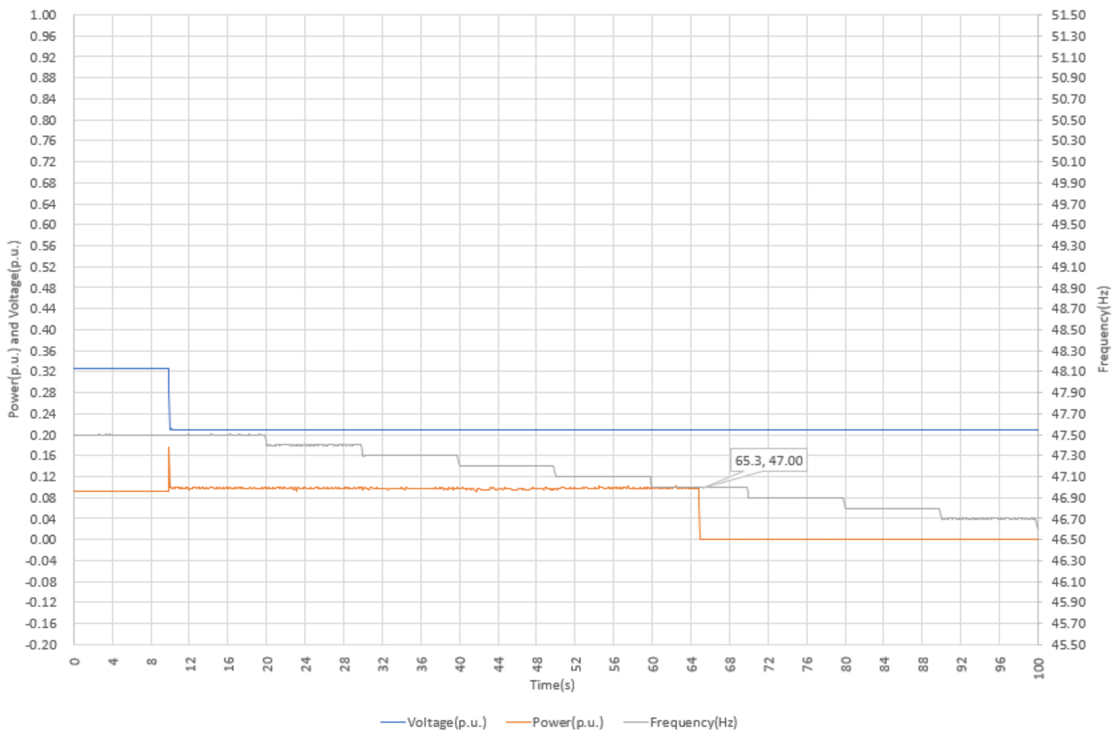
Underfrequency - Test 4: Trip value



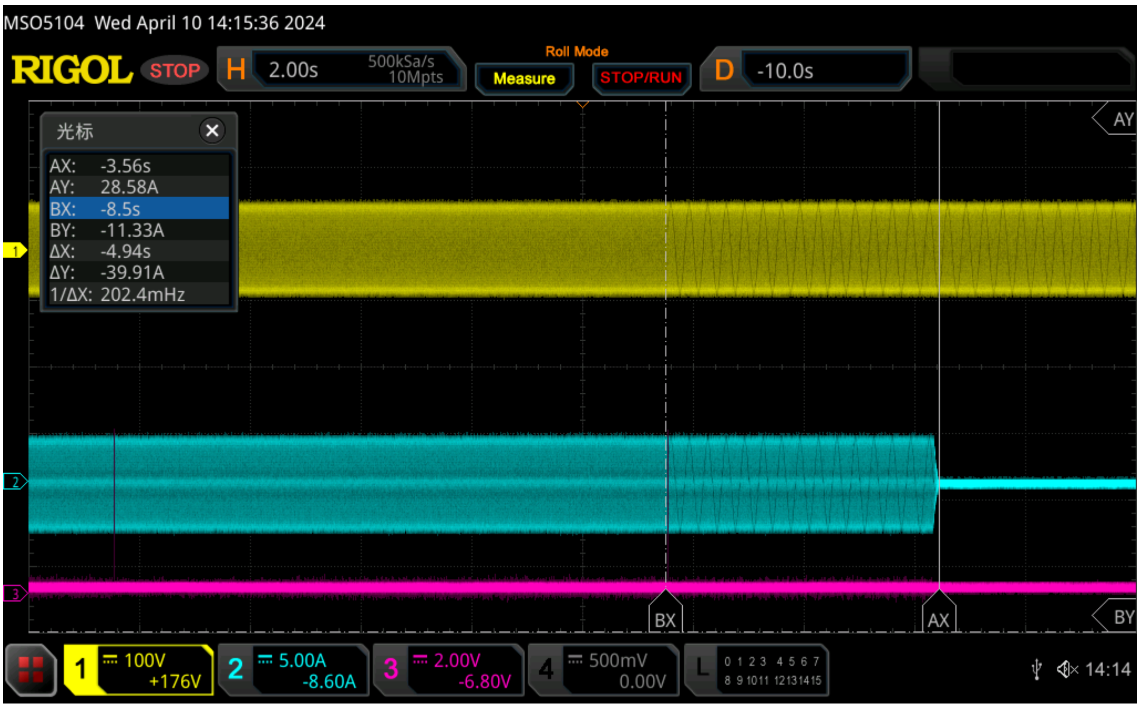
Underfrequency - Test 4: Trip time



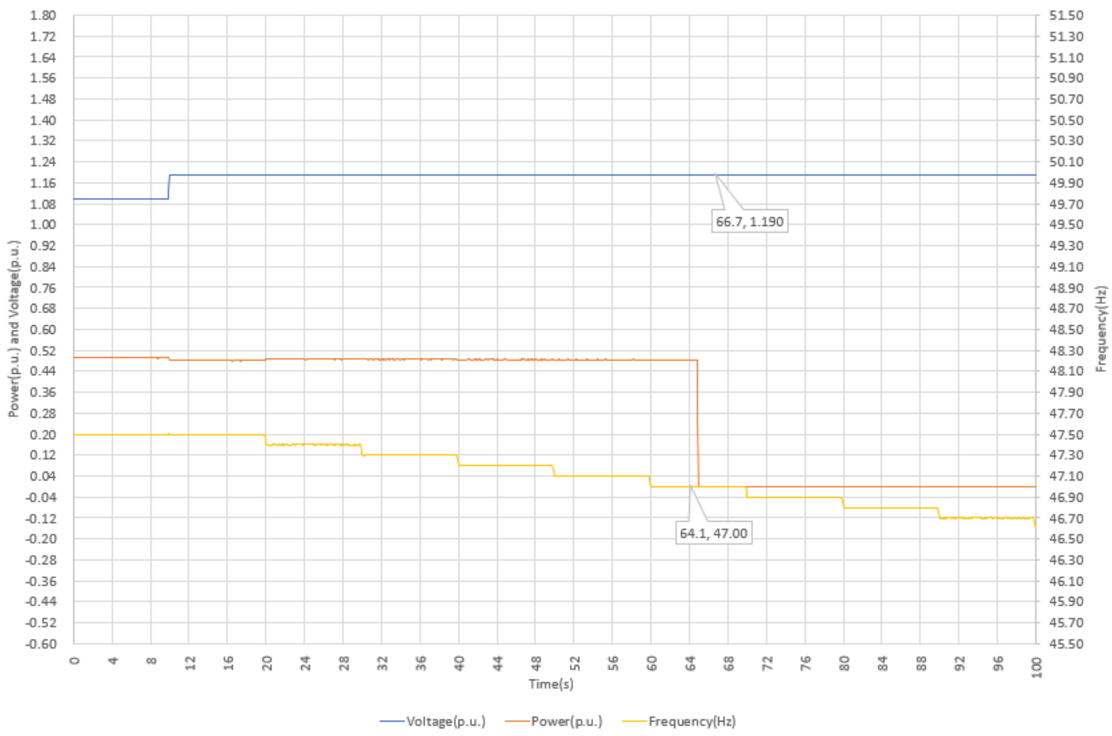
Underfrequency - Test 5: Trip value



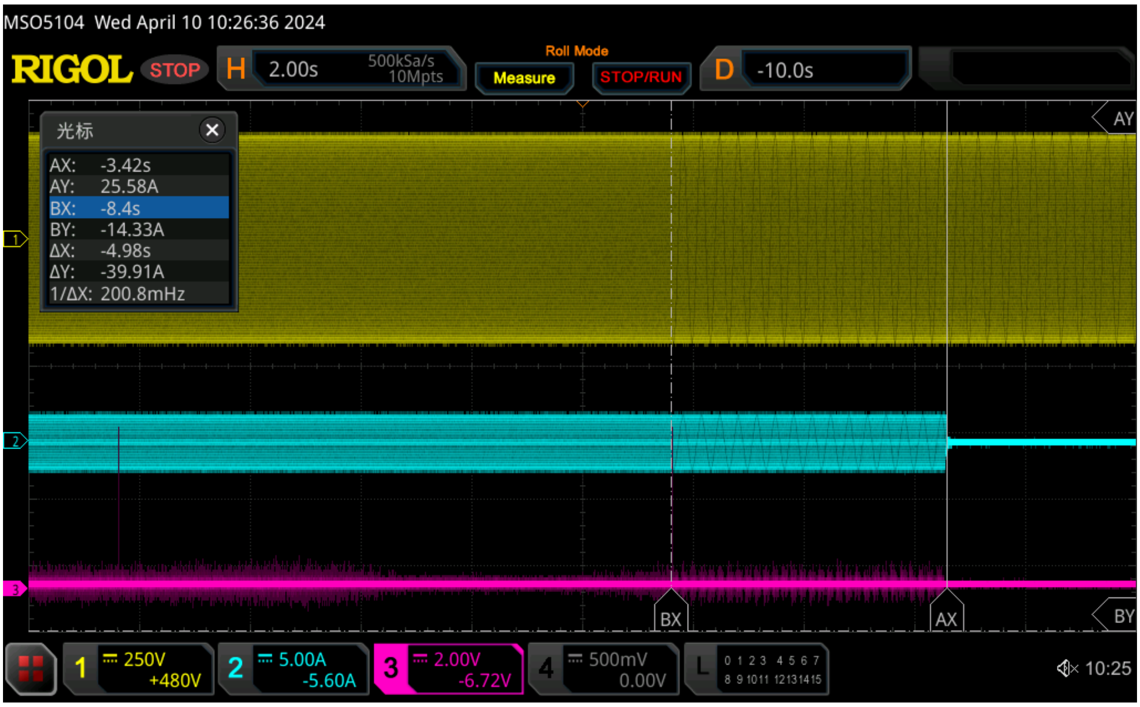
Underfrequency - Test 5: Trip time



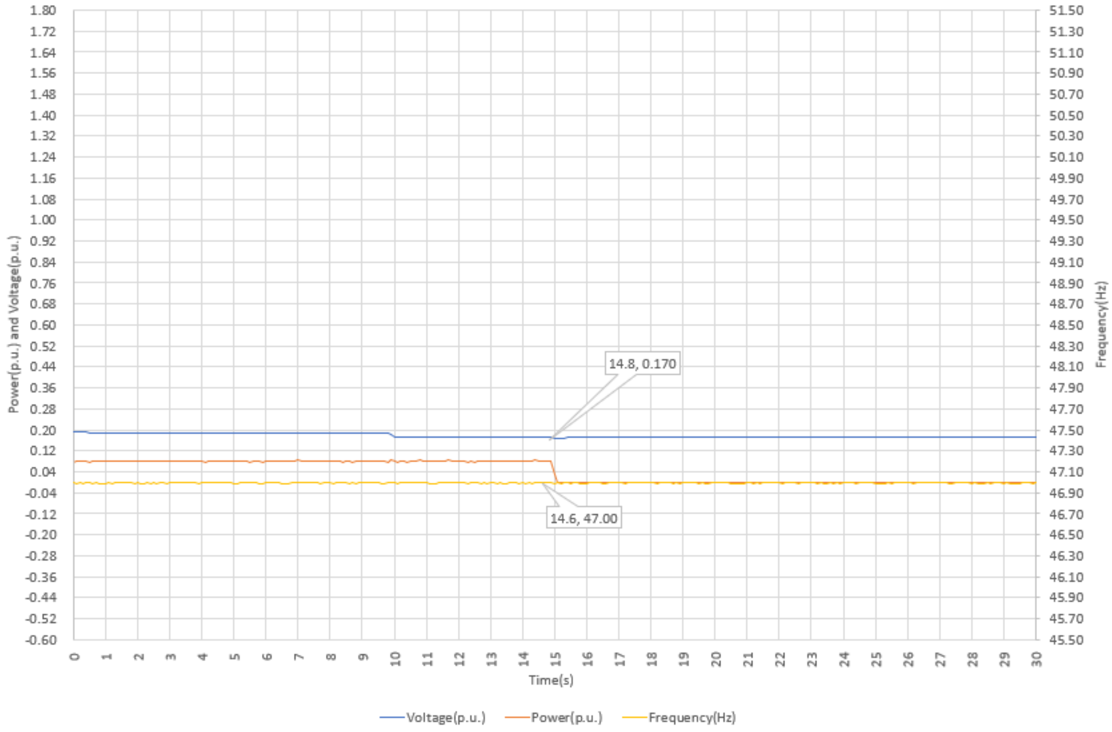
Underfrequency - Test 6: Trip value



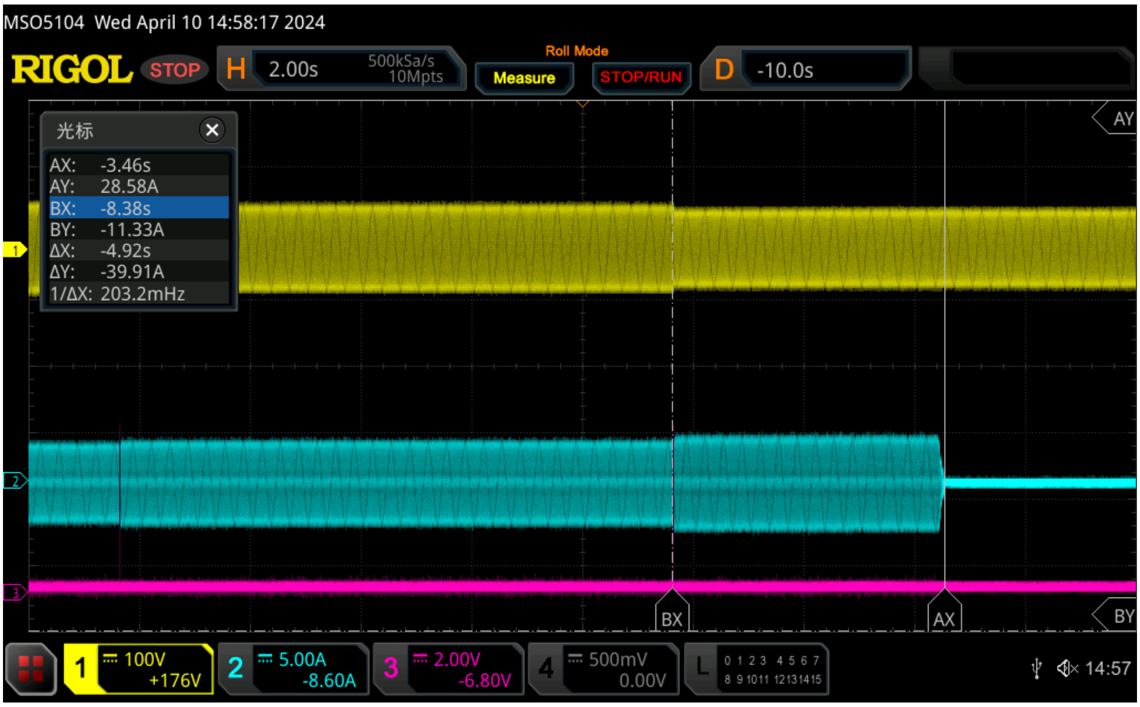
Underfrequency - Test 6: Trip time



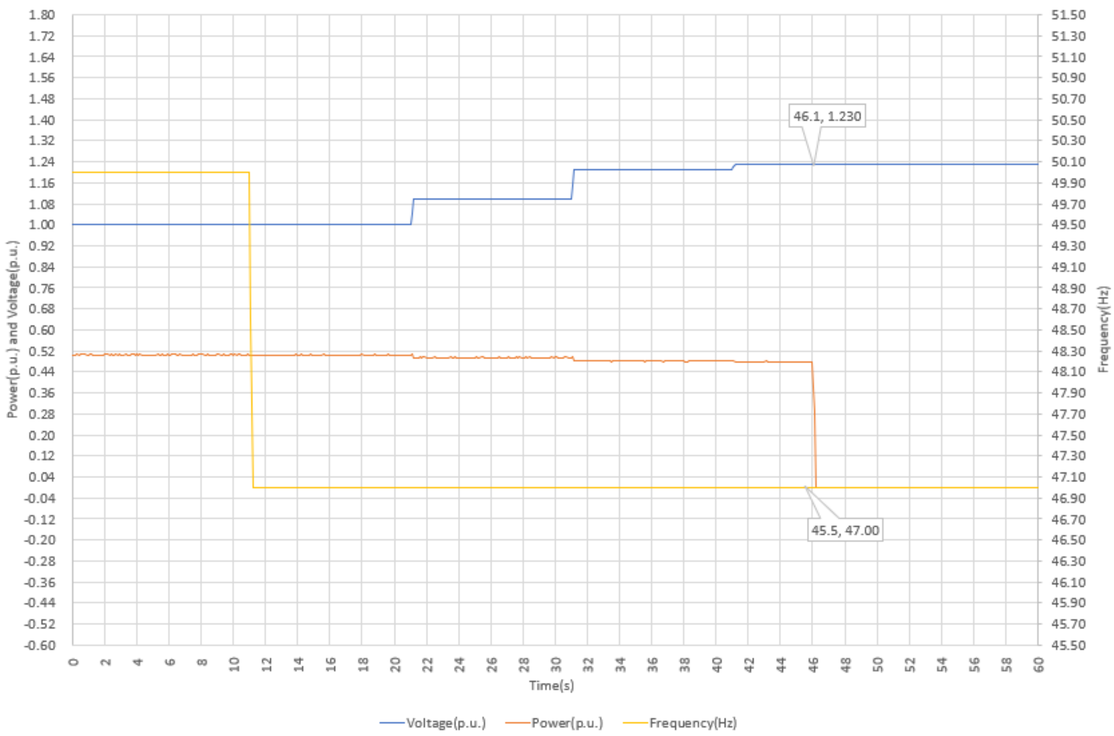
Underfrequency - Test 7: Trip value



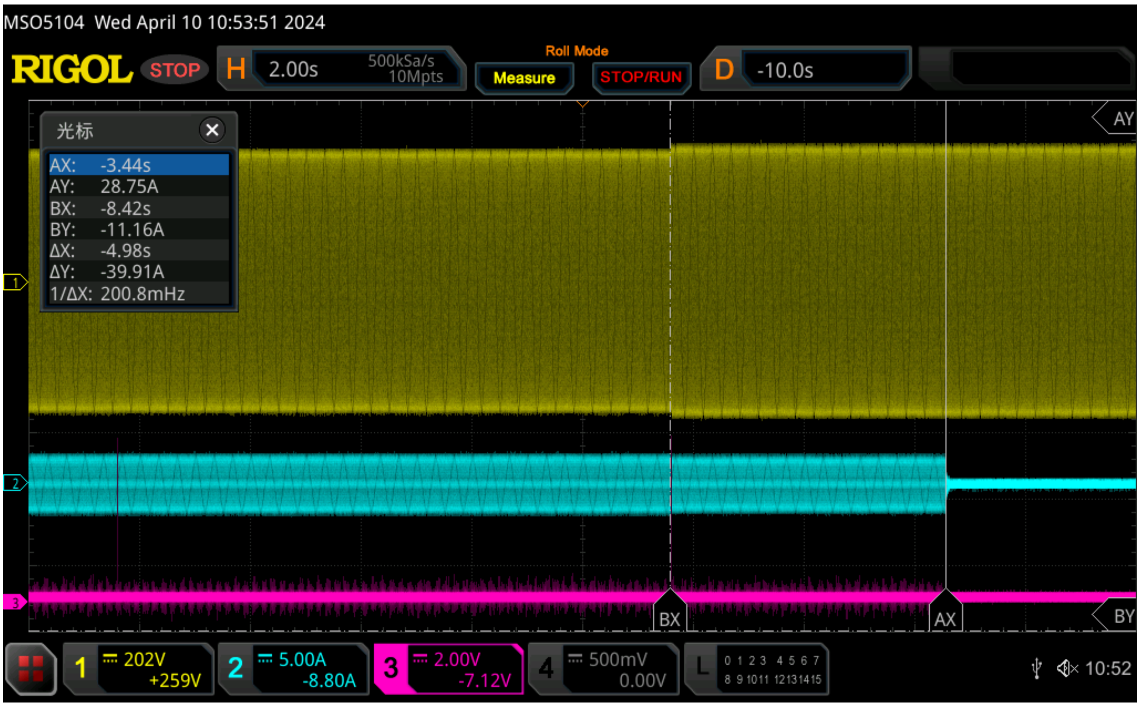
Underfrequency - Test 7: Trip time



Underfrequency - Test 8: Trip value



Underfrequency - Test 8: Trip time



4.6.1.5 Overfrequency protection

Overfrequency protection may be implemented with two completely independent protection thresholds, each one able to be activated or not. The standard adjustment ranges are as follows.

Overfrequency threshold stage 1 [81 >]:
- Threshold (50.0 – 52.0) Hz adjustment by steps of 0.1 Hz
- Operate time (0.1 – 100) s adjustable in steps of 0.1 s

Overfrequency threshold stage 2 [81 > >]:
- Threshold (50.0 – 52.0) Hz adjustment by steps of 0.1 Hz
- Operate time (0.1 - 5) s adjustable in steps of 0.05 s

In order to use narrow frequency thresholds for islanding detection (see 4.9.3.3) it may be required to have the ability to activate and deactivate a stage by an external signal.

The frequency protection shall function correctly in the input voltage range between 20 %Un and 120 %Un and shall be inhibited for input voltages of less than 20 %Un.

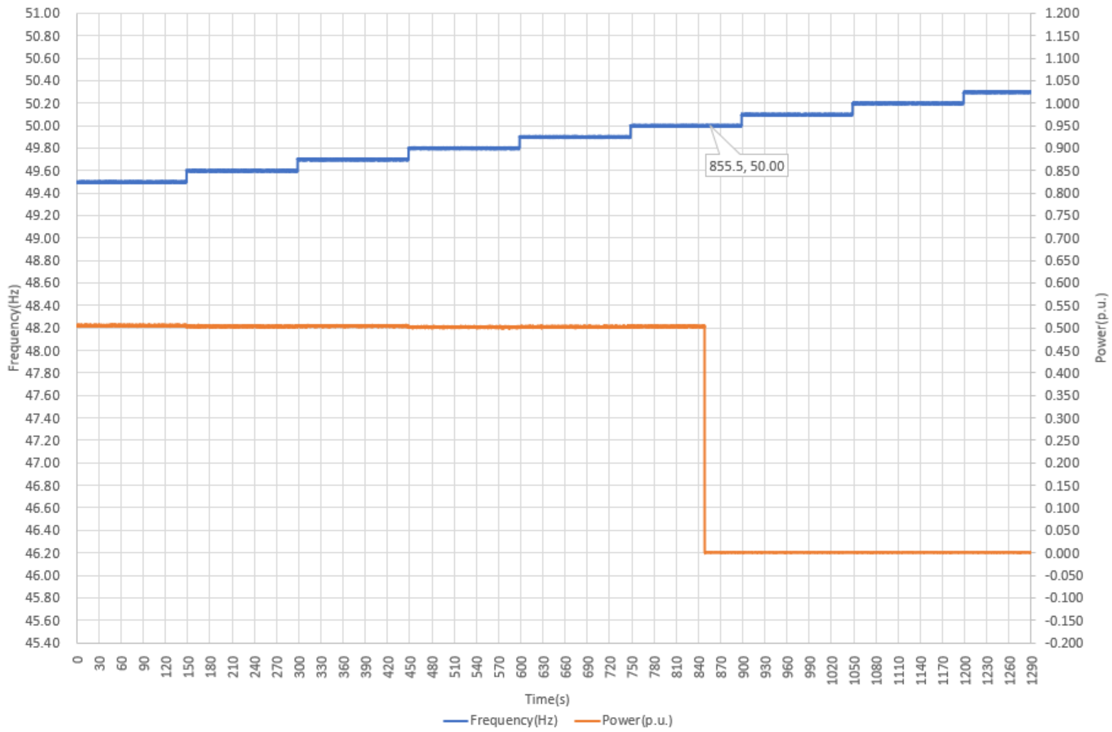
The following definitions apply to the test to verify the clause:

Over frequency	Test No.	Frequency setting (Hz)	Frequency meas. (Hz)	Frequency deviation (Hz)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
Stage 1 [81 >]	1	50.00	50.00	0.00	100.000	99.900	-0.100
	2	52.00	52.00	0.00	0.100	0.034	-0.066
Stage 2 [81 > >]	3	50.00	50.00	0.00	5.000	4.980	-0.020
	4	52.00	52.00	0.00	0.100	0.048	-0.052

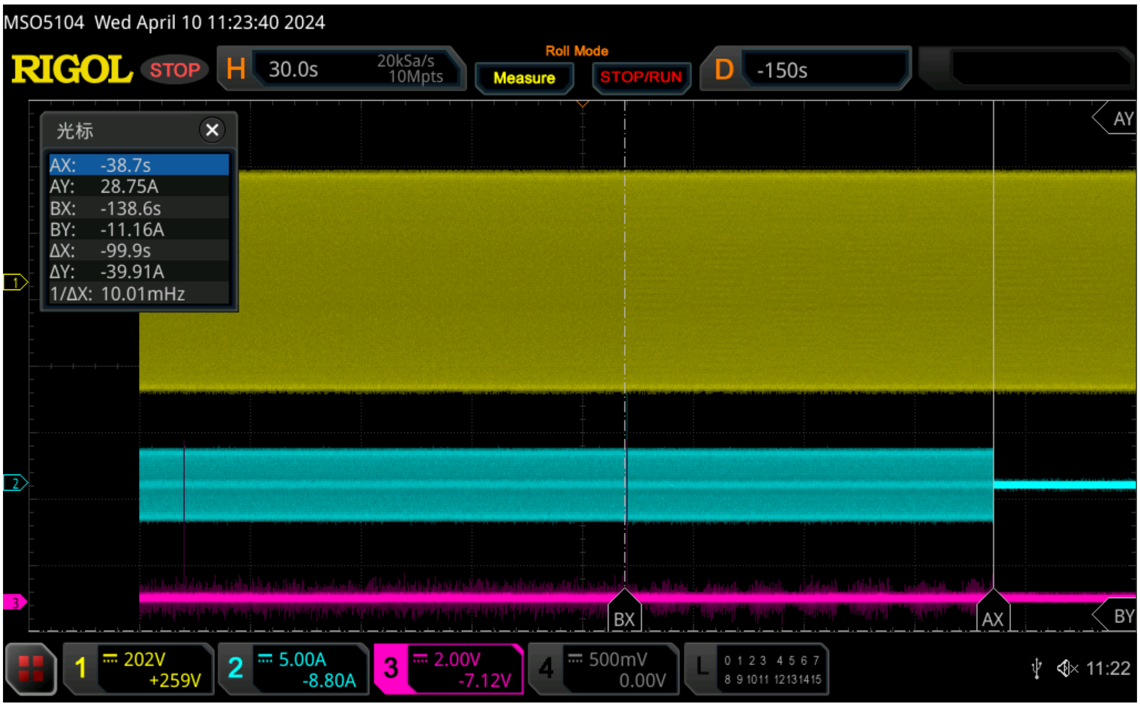
Voltage protection threshold setting (p.u.)	Test No.	Frequency setting (Hz)	Voltage setting (p.u.)	Trip value meas. (Hz)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
0.21 & 1.22	5	52.00	0.210	52.00	5.000	4.980	-0.020
	6	52.00	1.190	52.00	5.000	4.980	-0.020
	7	52.00	0.190	--	Not protected	--	--
		52.00	0.170	52.00	5.000	4.960	-0.040
	8	52.00	1.210	--	Not protected	--	--
		52.00	1.230	52.00	5.000	4.980	-0.020

Test results are represented at diagrams below.

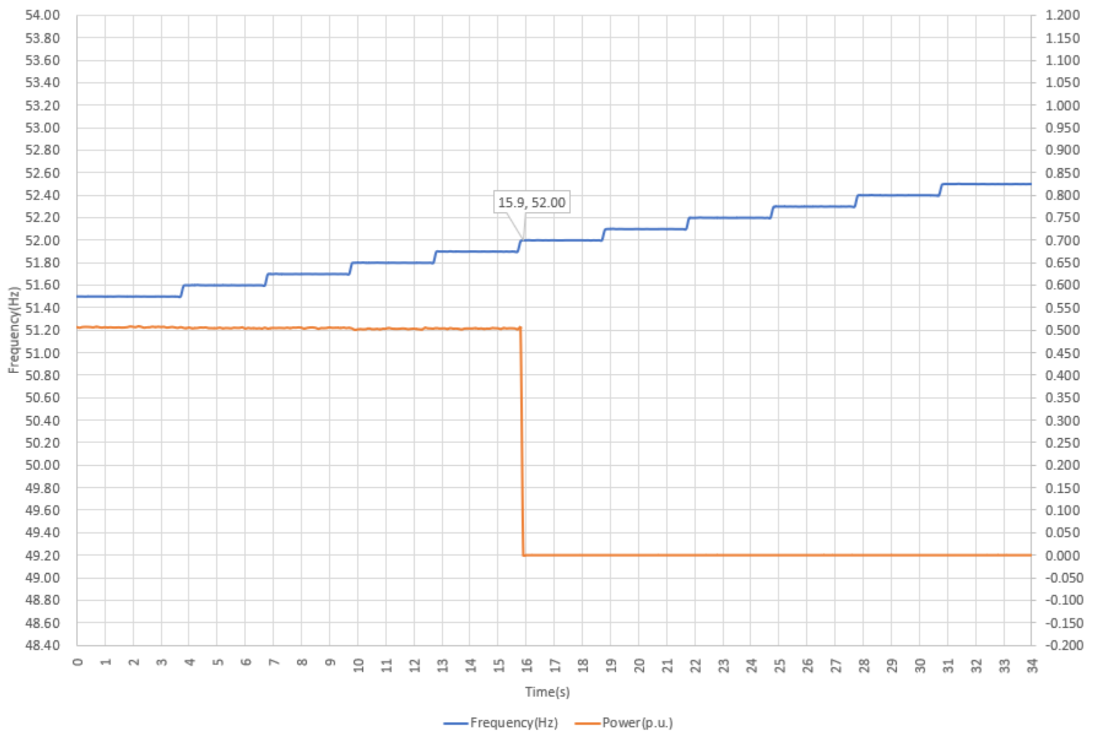
Over frequency - Test 1: Trip value



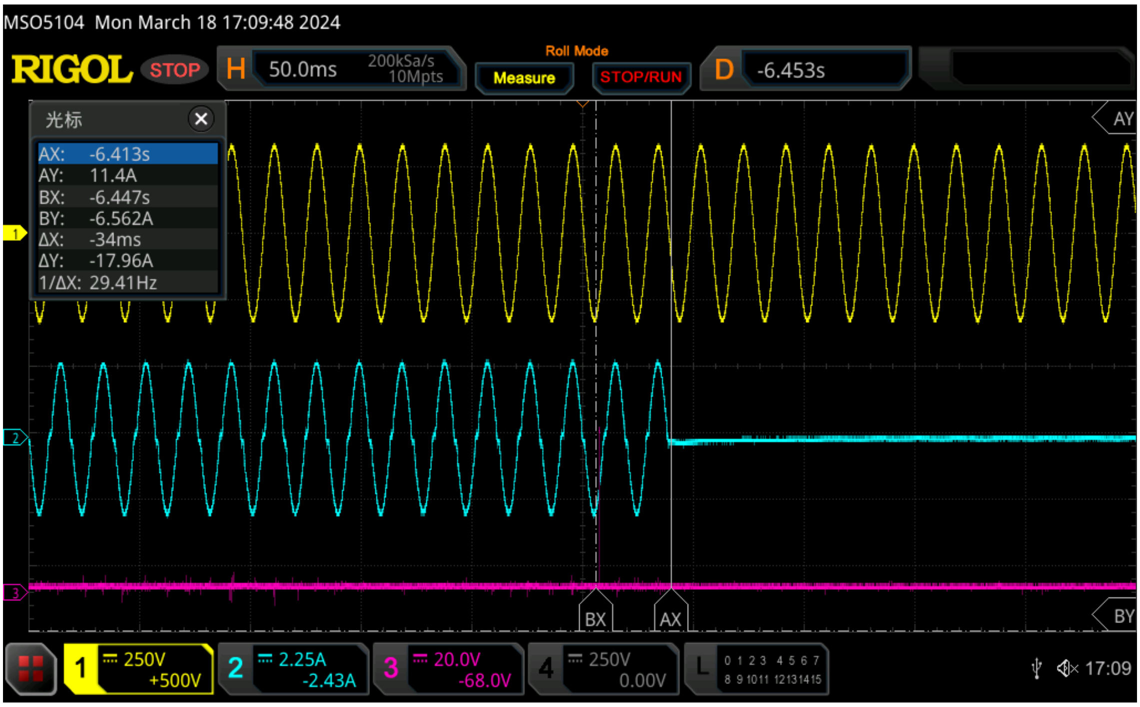
Over frequency - Test 1: Trip time



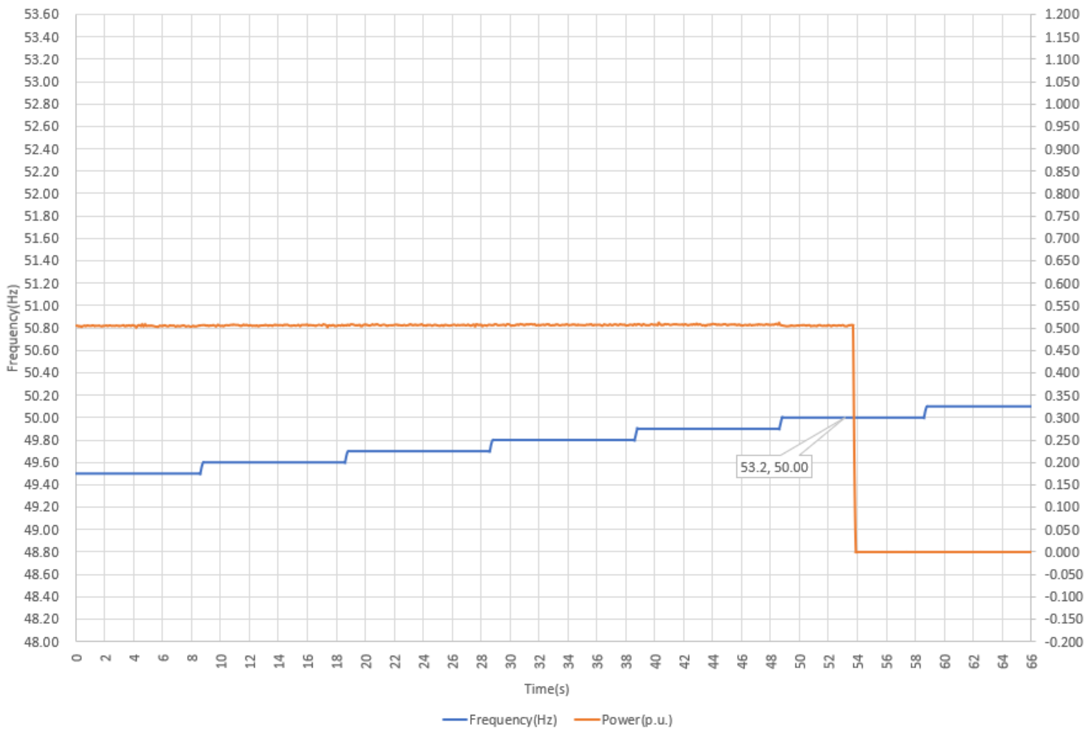
Over frequency - Test 2: Trip value



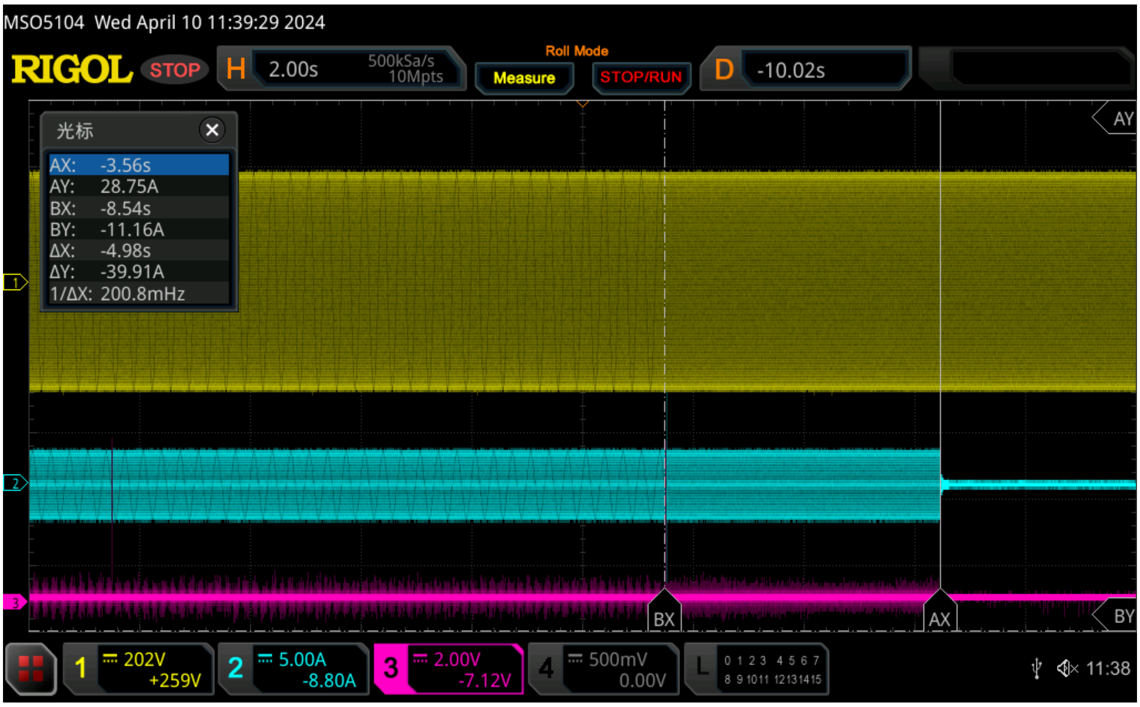
Over frequency - Test 2: Trip time



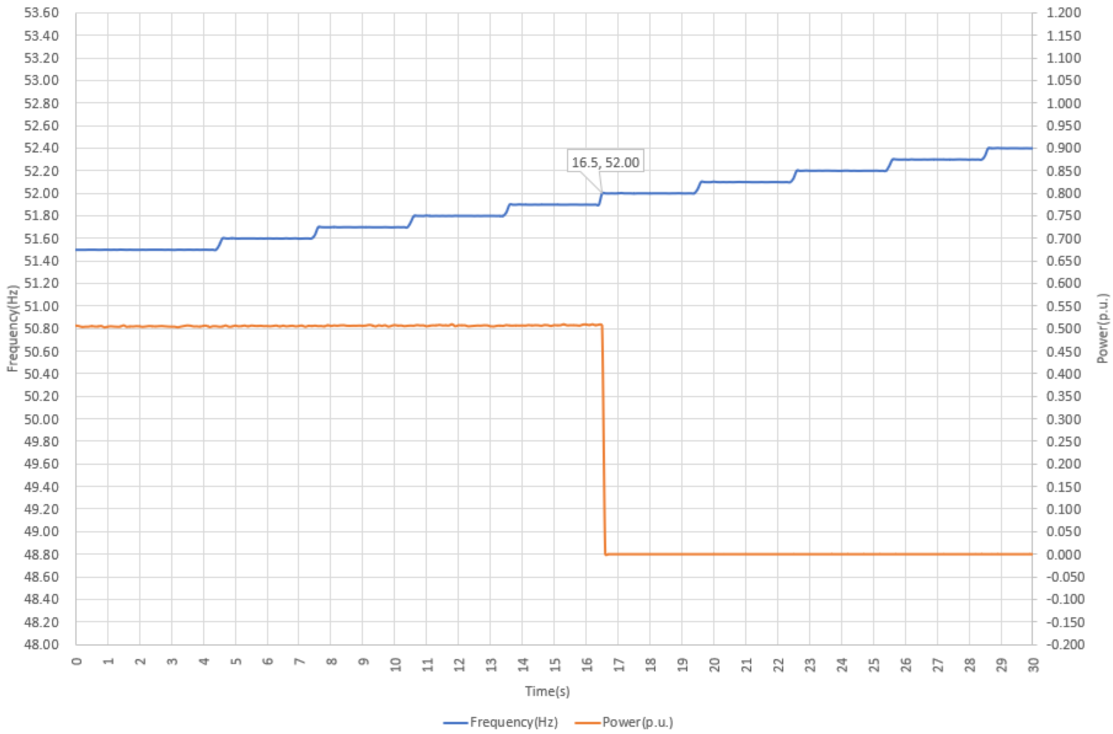
Over frequency - Test 3: Trip value



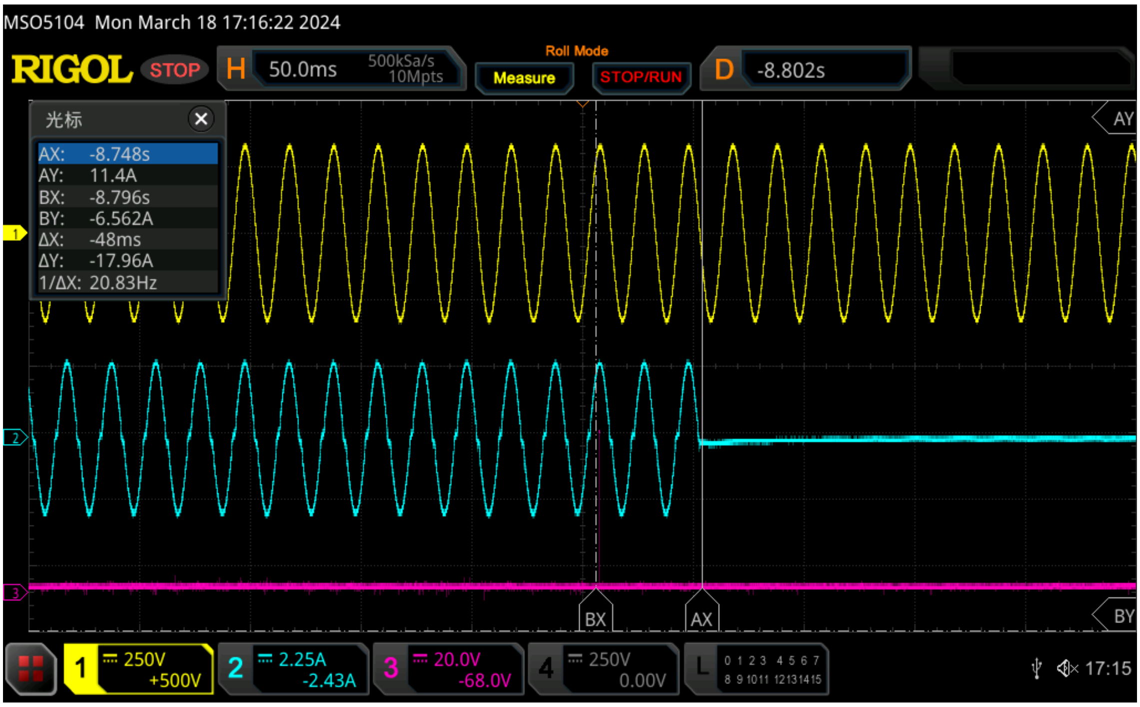
Over frequency - Test 3: Trip time



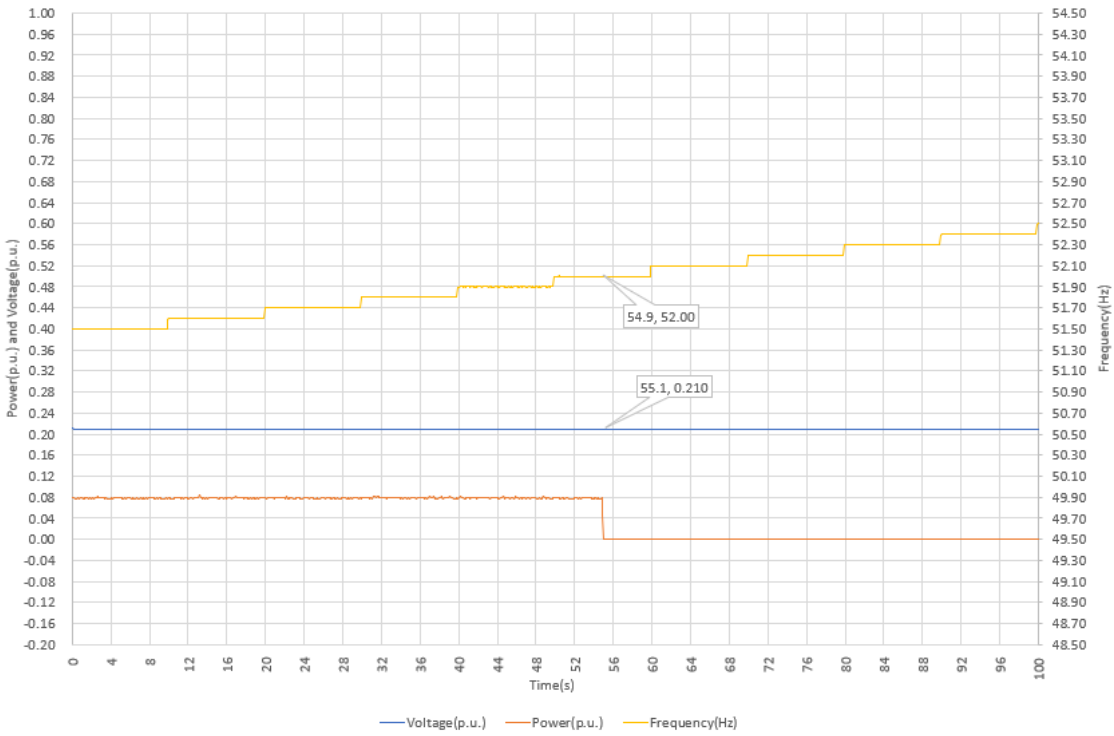
Over frequency - Test 4: Trip value



Over frequency - Test 4: Trip time

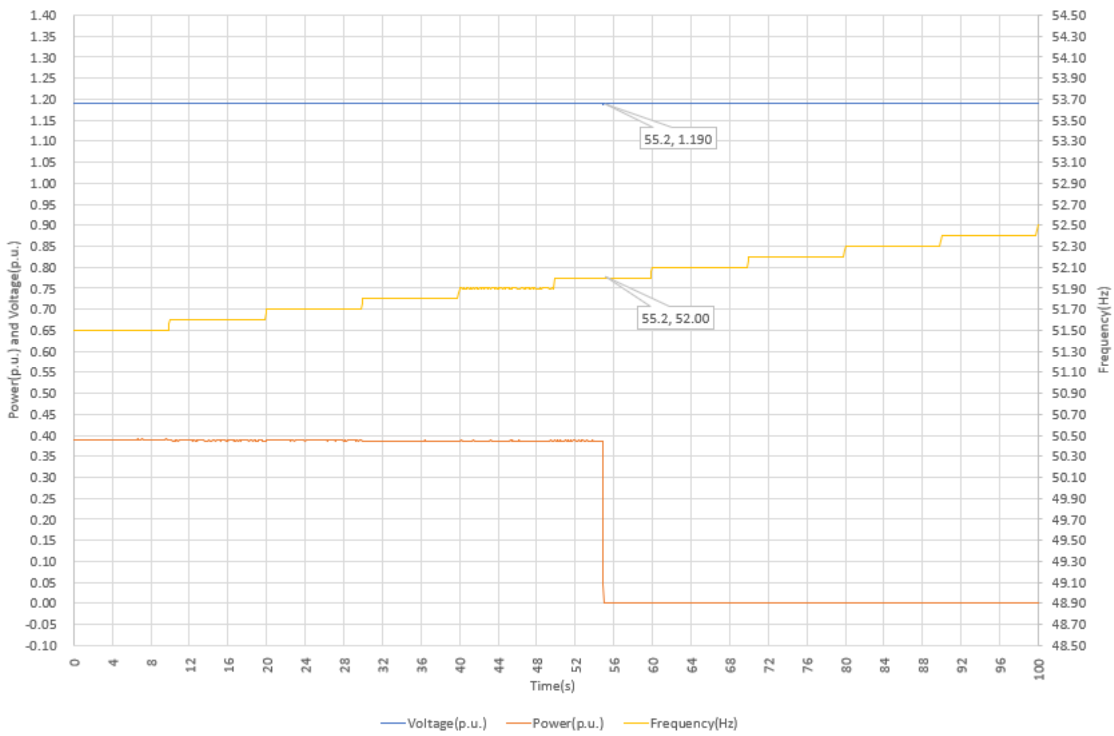


Over frequency - Test 5: Trip value

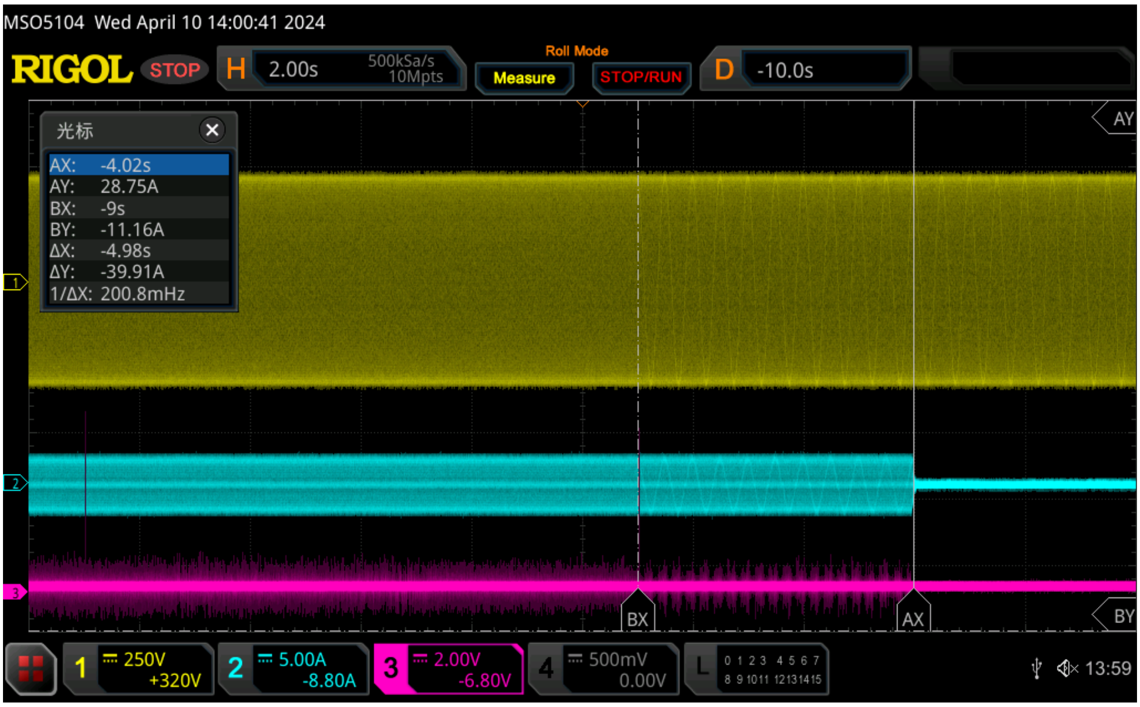


Over frequency - Test 5: Trip time

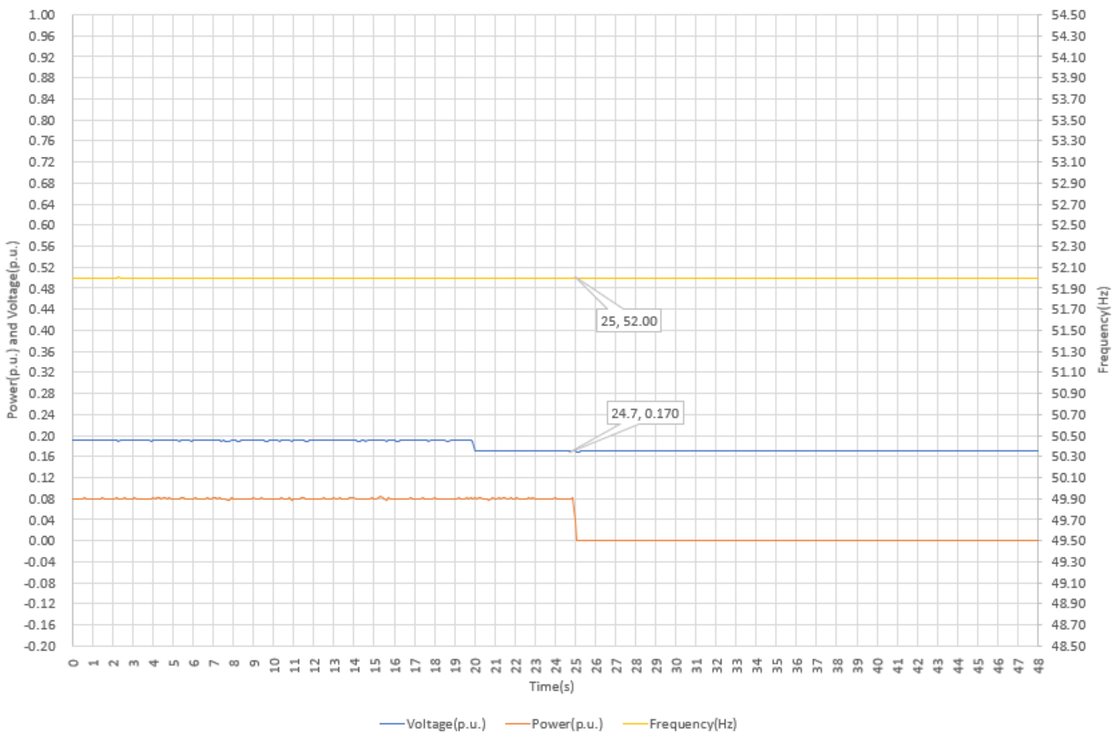
Over frequency - Test 6: Trip value



Over frequency - Test 6: Trip time

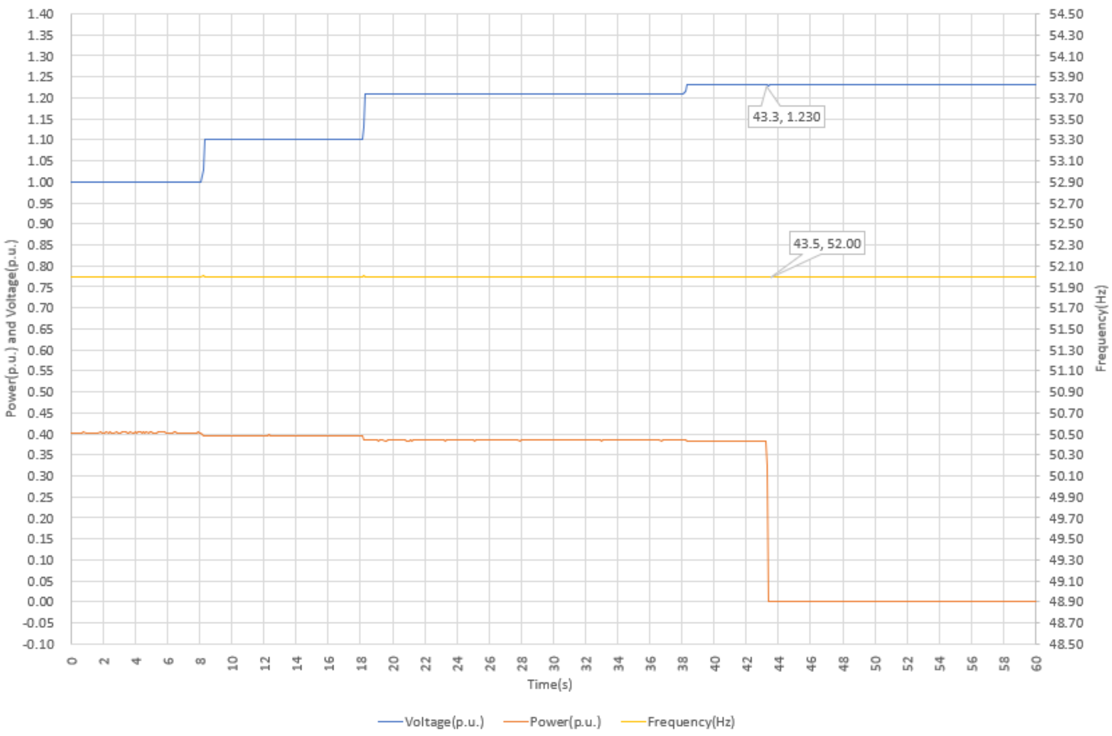


Over frequency - Test 7: Trip value

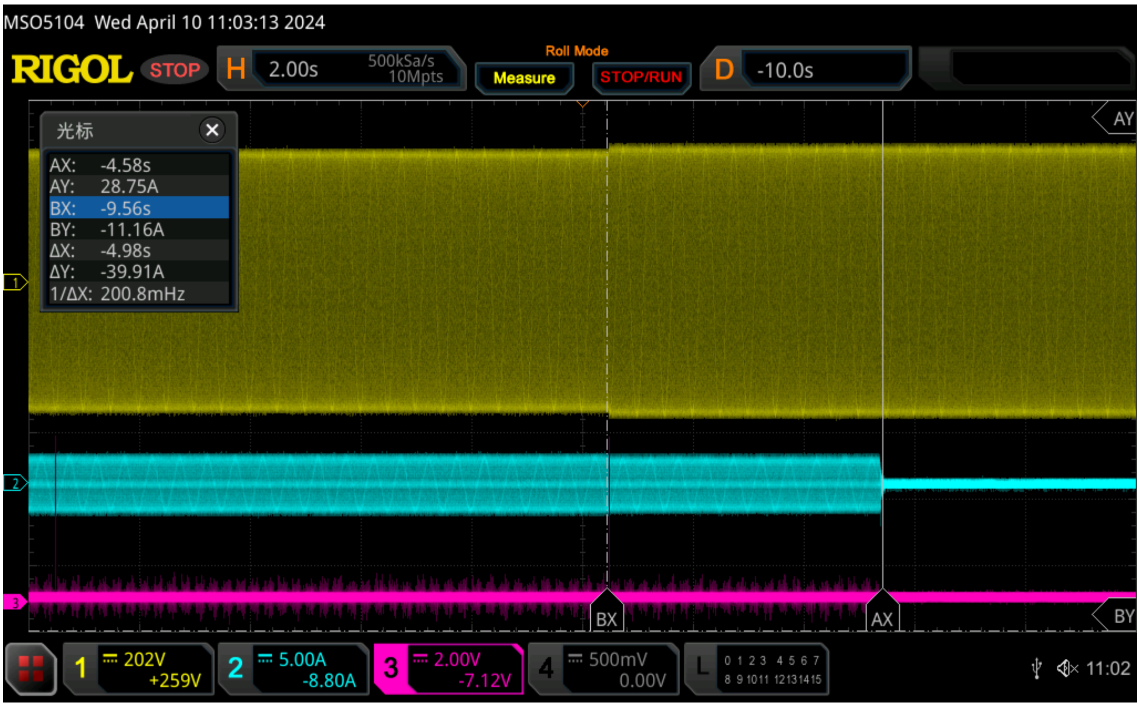


Over frequency - Test 7: Trip time

Over frequency - Test 8: Trip value



Over frequency - Test 8: Trip time



4.6.2. Means to detect island situation

The test has been performed according to the clause 4.9.4 of the standard.

This protection device is also able to detect islanded situations and disconnect the equipment from the grid. Active methods tested with a resonant circuit used for detecting islanding situations.

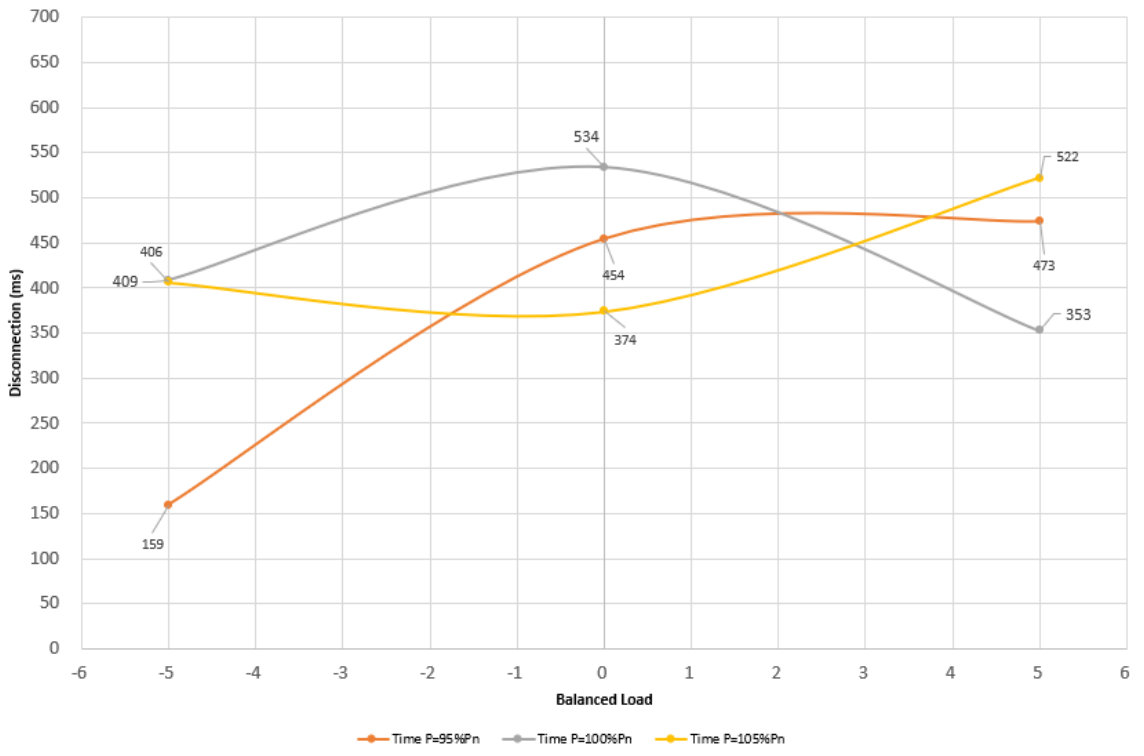
The compliances with these requirements are stated in the according to EN 62116. An EUT is considered to comply with the requirements for islanding protection when each case of recorded run-on time is less than 2 s or meets the requirements of local codes.

Table: tested condition and run-on time									
No.	P_{EUT} (% of EUT rating)	Reactive load (% of normial)	P_{AC}	Q_{AC}	Run-on time (ms)	P_{EUT} (KW)	Actual Q_f	V_{DC} (Vd.c.)	Which load is selected to be adjusted (R or L)
Test condtion A									
1	100	100	0	0	534	0.76	1.00	45	--
2	100	100	-5	-5	159	0.72	1.03	45	R/L
3	100	100	-5	0	454	0.72	1.05	45	R
4	100	100	-5	+5	473	0.72	1.08	45	R/L
5	100	100	0	-5	409	0.75	0.98	45	L
6	100	100	0	+5	353	0.76	1.03	45	L
7	100	100	+5	-5	406	0.79	0.94	45	R/L
8	100	100	+5	0	374	0.79	0.96	45	R
9	100	100	+5	+5	522	0.79	0.99	45	R/L
10	100	100	-10	+10	--	--	--	--	R/L
11	100	100	-5	+10	--	--	--	--	R/L
12	100	100	0	+10	--	--	--	--	L
13	100	100	+10	+10	--	--	--	--	R/L
14	100	100	+10	+5	--	--	--	--	R/L
15	100	100	+10	0	--	--	--	--	R
16	100	100	+10	-5	--	--	--	--	R/L
17	100	100	+10	-10	--	--	--	--	R/L
18	100	100	+5	-10	--	--	--	--	R/L
19	100	100	+5	10	--	--	--	--	R/L
20	100	100	0	-10	--	--	--	--	L
21	100	100	-5	-10	--	--	--	--	R/L
22	100	100	-10	-10	--	--	--	--	R/L
23	100	100	-10	-5	--	--	--	--	R/L
24	100	100	-10	0	--	--	--	--	R/L
25	100	100	-10	+5	--	--	--	--	R/L
Test condtion B									
10	66	66	0	0	493	0.50	1.00	41	--
11	66	66	0	-5	451	0.50	0.98	41	L
12	66	66	0	-4	466	0.50	0.99	41	L
13	66	66	0	-3	517	0.50	0.99	41	L
14	66	66	0	-2	450	0.50	0.99	41	L
15	66	66	0	-1	446	0.50	1.00	41	L
16	66	66	0	1	458	0.50	1.01	41	L
17	66	66	0	2	502	0.50	1.03	41	L
18	66	66	0	3	299	0.50	1.03	41	L
19	66	66	0	4	427	0.50	1.04	41	L
20	66	66	0	5	126	0.50	1.04	41	L
21	66	66	0	6	--	--	--	--	L

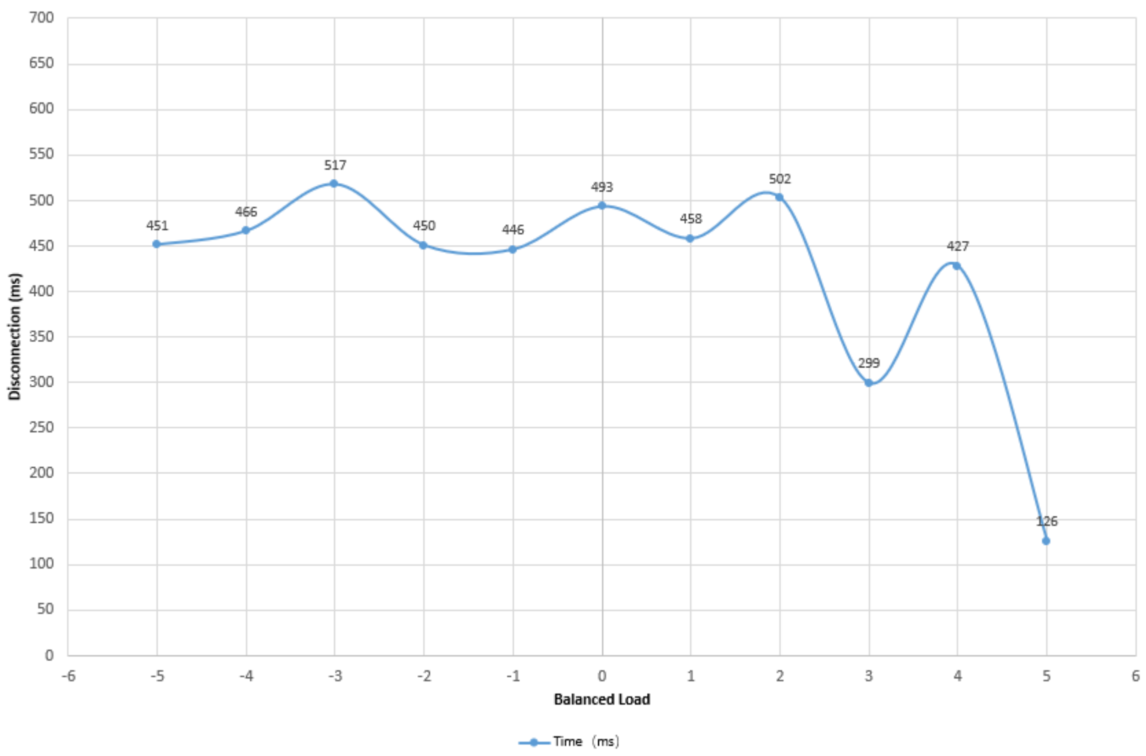
Table: tested condition and run-on time									
No.	P_{EUT} (% of EUT rating)	Reactive load (% of normial)	P_{AC}	Q_{AC}	Run-on time (ms)	P_{EUT} (KW)	Actual Q_f	V_{DC} (Vd.c.)	Which load is selected to be adjusted (R or L)
Test condition C									
22	33	33	0	0	492	0.25	1.00	35	--
23	33	33	0	-5	421	0.25	0.97	35	L
24	33	33	0	-4	632	0.25	0.98	35	L
25	33	33	0	-3	534	0.25	0.99	35	L
26	33	33	0	-2	464	0.25	0.99	35	L
27	33	33	0	-1	430	0.25	0.99	35	L
28	33	33	0	1	170	0.25	1.07	35	L
29	33	33	0	2	109	0.25	1.07	35	L
30	33	33	0	3	137	0.25	1.08	35	L
31	33	33	0	4	155	0.25	1.08	35	L
32	33	33	0	5	152	0.25	1.08	35	L

Remark:
For test condition A:
If any of the recorded run-on times are longer than the one recorded for the rated balance condition, then the non-shaded parameter combinations also require testing.
For test condition B and C:
If run-on times are still increasing at the 95 % or 105 % points, additional 1 % increments are taken until run-on times begin decreasing.

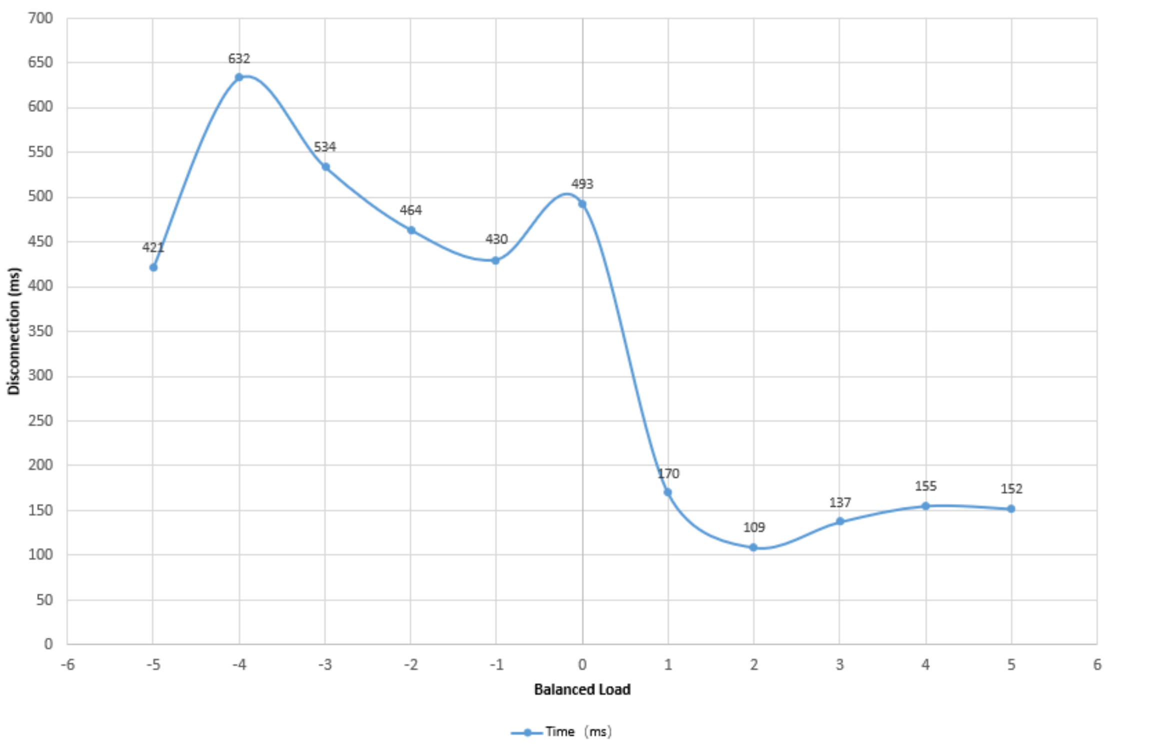
Test Condition A



Test Condition B



Test Condition C



4.6.3. Digital input to the interface protection

The test has been performed according to the clause 4.9.5 of the standard.

The interface protection shall have at least two configurable digital inputs, EUT used active methods tested with a resonant circuit and ROCOF to comply to the clause.

4.7. CONNECTION AND STARTING TO GENERATE ELECTRICAL POWER

The test has been performed according to the clause 4.10 of the standard.

4.7.1. Automatic reconnection after tripping

The test has been performed according to the clause 4.10.2 of the standard.

The frequency range, the voltage range, the observation time shall be adjustable in the range according to Table 3 column 2. If no settings are specified by the DSO and the responsible party, the default settings for the reconnection after tripping of the interface protection are according to Table 3 column 3.

Table 3 — Automatic reconnection after tripping

Parameter	Range	Default setting
Lower frequency	47,0Hz – 50,0Hz	49,5Hz
Upper frequency	50,0Hz – 52,0Hz	50,2Hz
Lower voltage	50% – 100%U_n	85 % U_n
Upper voltage	100% – 120% U_n	110 % U_n
Observation time	10s – 600s	60s
Active power increase gradient	6% – 3000%/min	10%/min

The following definitions apply to the test to verify the clause:

Disconnection Setting		Reconnection Setting		Setting Reconnection time (s)	Meas. Reconnection time (s)	Setting gradient (%Pn/min)	Meas. gradient (%Pn/min)
U= 115 %Un	Yes	U = 110 %Un	Yes	60.0	75.6	6.0	4.88
U = 84 %Un	Yes	U = 85 %Un	Yes	10.0	13.4	10.0	7.79
f = 52.00 Hz	Yes	f = 50.20 Hz	Yes	600.0	600.9	3000.0	1332.00 (1)
f = 47.50 Hz	Yes	f = 49.50 Hz	Yes	100.0	109.8	10.0	7.64

(1) This is the maximum gradient which can be measured for the setting of 3000.0 %Pn/min.

Note: See section 4.7.2 for the test result graph.

4.7.2. Starting to generate electrical power

The test has been performed according to the clause 4.10.3 of the standard.

The frequency range, the voltage range, the observation time shall be adjustable in the range according to Table 4 column 2. If no settings are specified by the DSO and the responsible party, the default settings for connection or starting to generate electrical power due to normal operational startup or activity are according to Table 4 column 3.

Table 4 — Starting to generate electrical power

Parameter	Range	Default setting
Lower frequency	47,0Hz – 50,0Hz	49,5Hz
Upper frequency	50,0Hz – 52,0Hz	50,1Hz
Lower voltage	50% – 100% U_n	85 % U_n
Upper voltage	100% – 120% U_n	110 % U_n
Observation time	10s – 600s	60s
Active power increase gradient	6% – 3000%/min	disabled

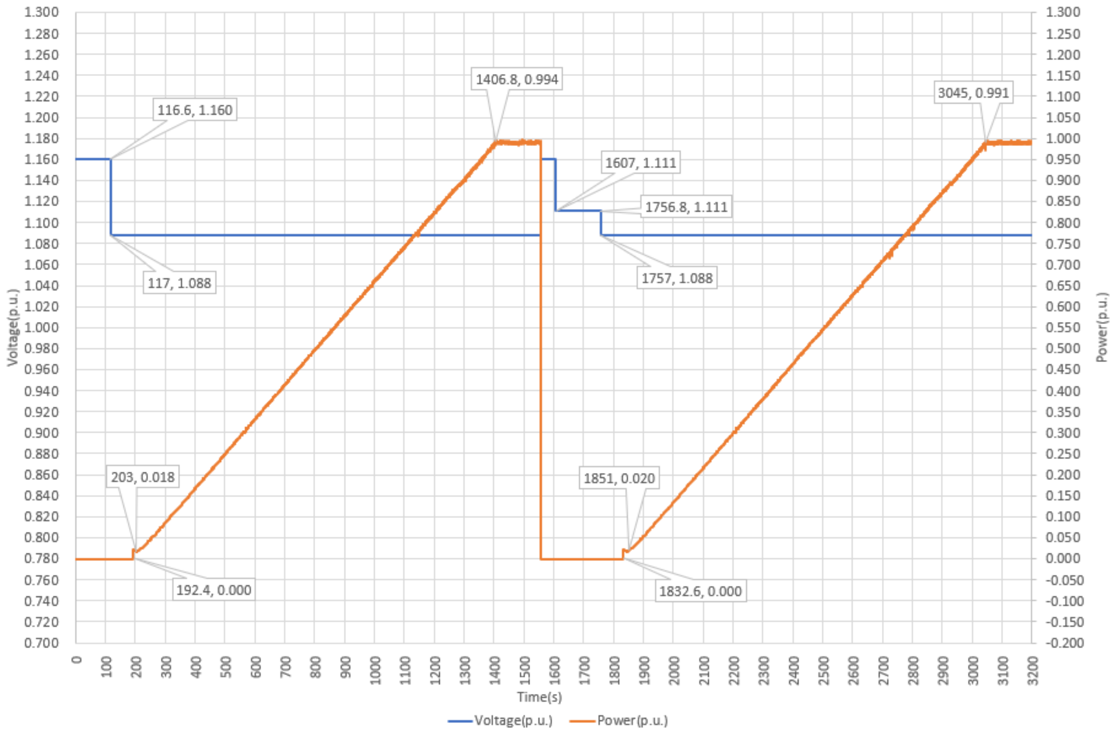
The following definitions apply to the test to verify the clause:

Connection		Setting Connection time (s)	Meas. Connection time (s)	Setting gradient (%Pn/min)	Meas. gradient (%Pn/min)
U < 110 %Un	Yes	60.0	75.4	6.0	4.86
85 % < U	Yes	10.0	13.6	10.0	7.79
f < 50.10 Hz	Yes	600.0	601.1	3000.0	1336.00 (1)
49.50 < f	Yes	100.0	115.8	10.0	7.70

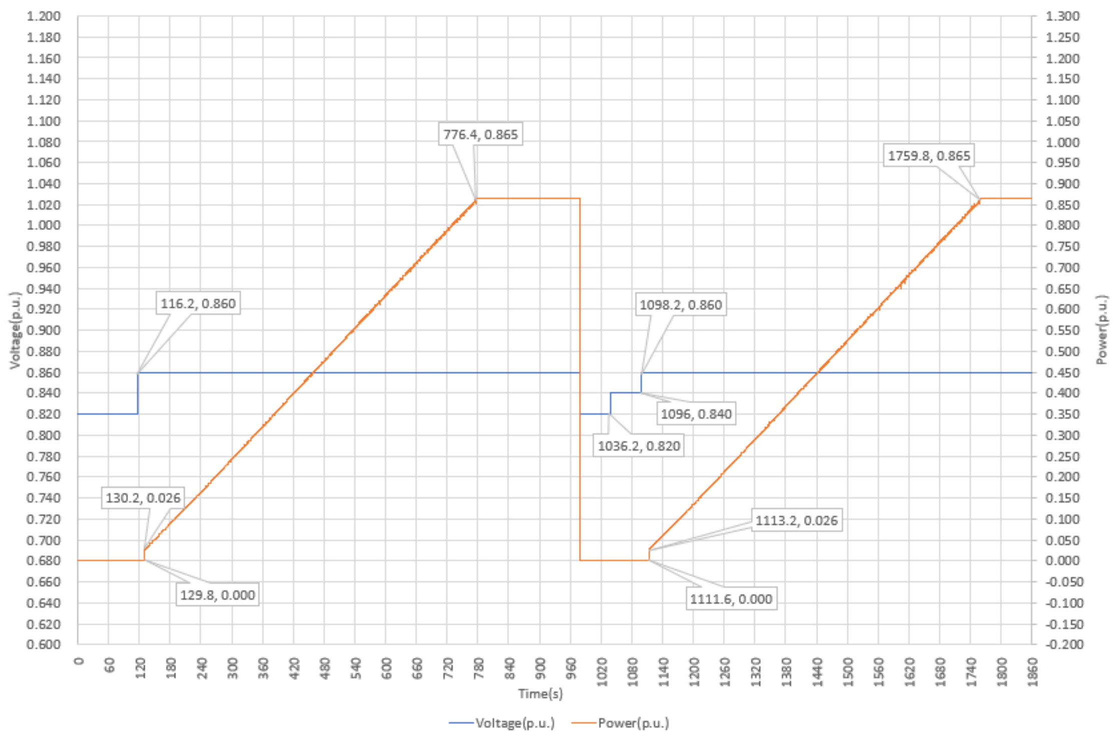
(1) This is the maximum gradient which can be measured for the setting of 3000.0 %Pn/min.

Test results are represented at diagrams below.

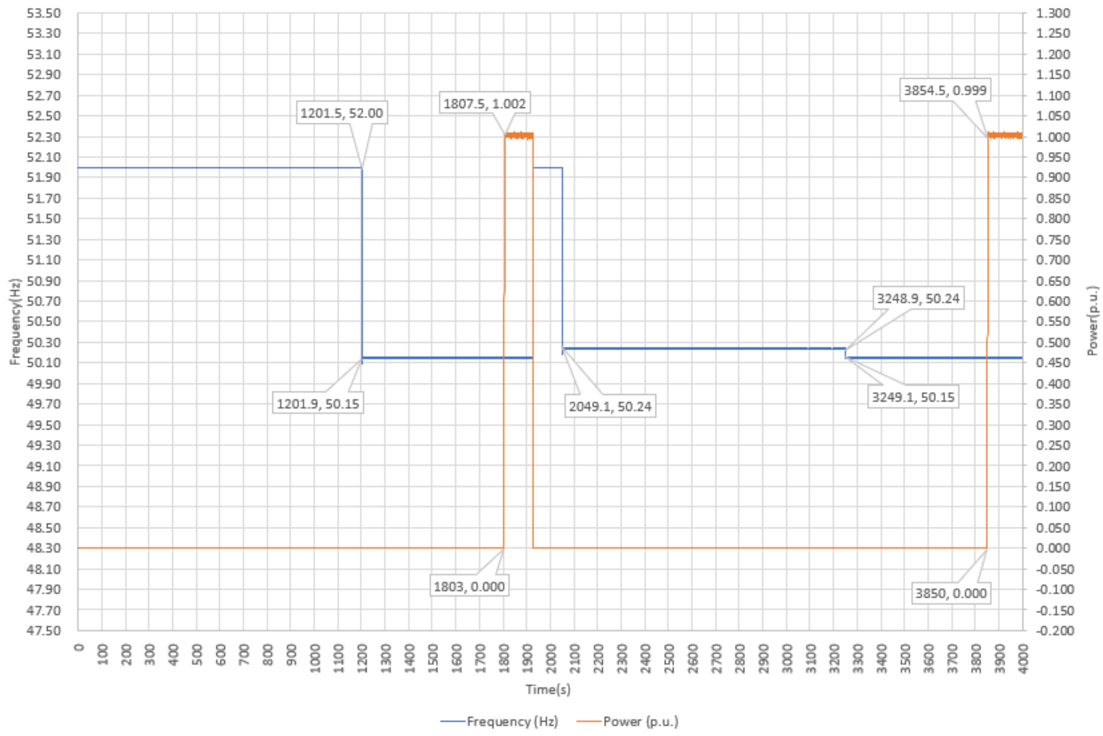
Overvoltage Connection and Reconnection



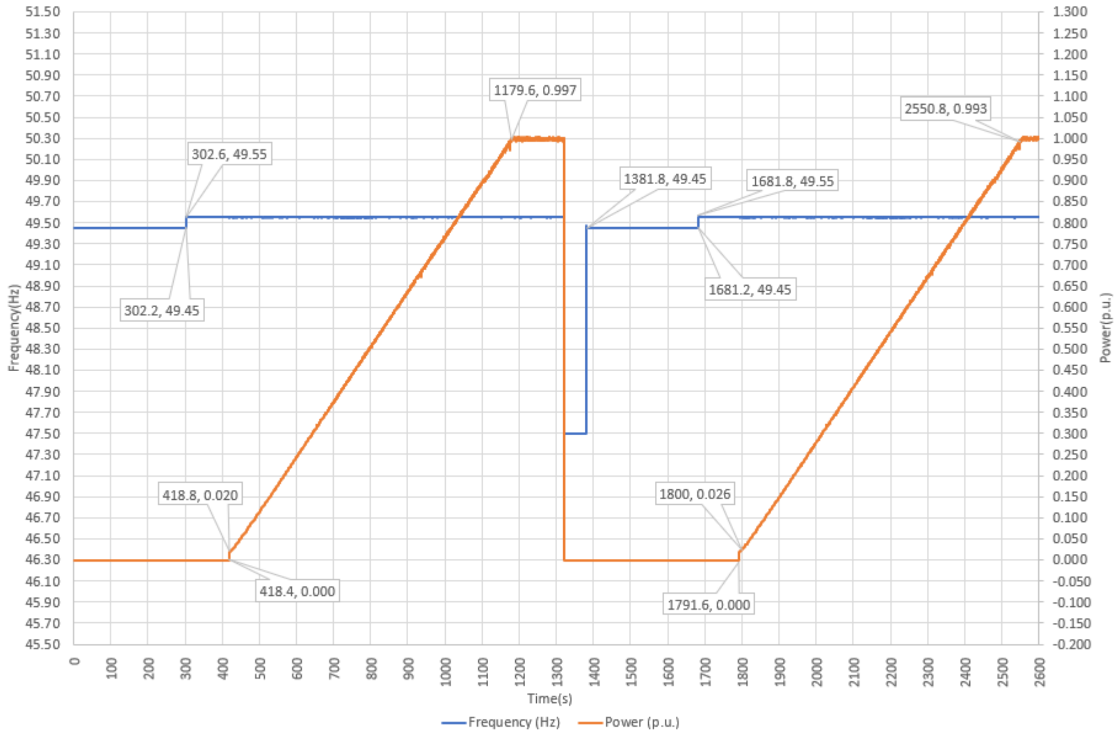
Undervoltage Connection and Reconnection



Overfrequency Connection and Reconnection



Underfrequency Connection and Reconnection



4.7.3. Synchronization

The requirements are from clause 4.10.4 of the standard. Synchronizing a generating plant/unit with the distribution network shall be fully automatic.

The EUT is fully automatic in the connection to the distribution network.

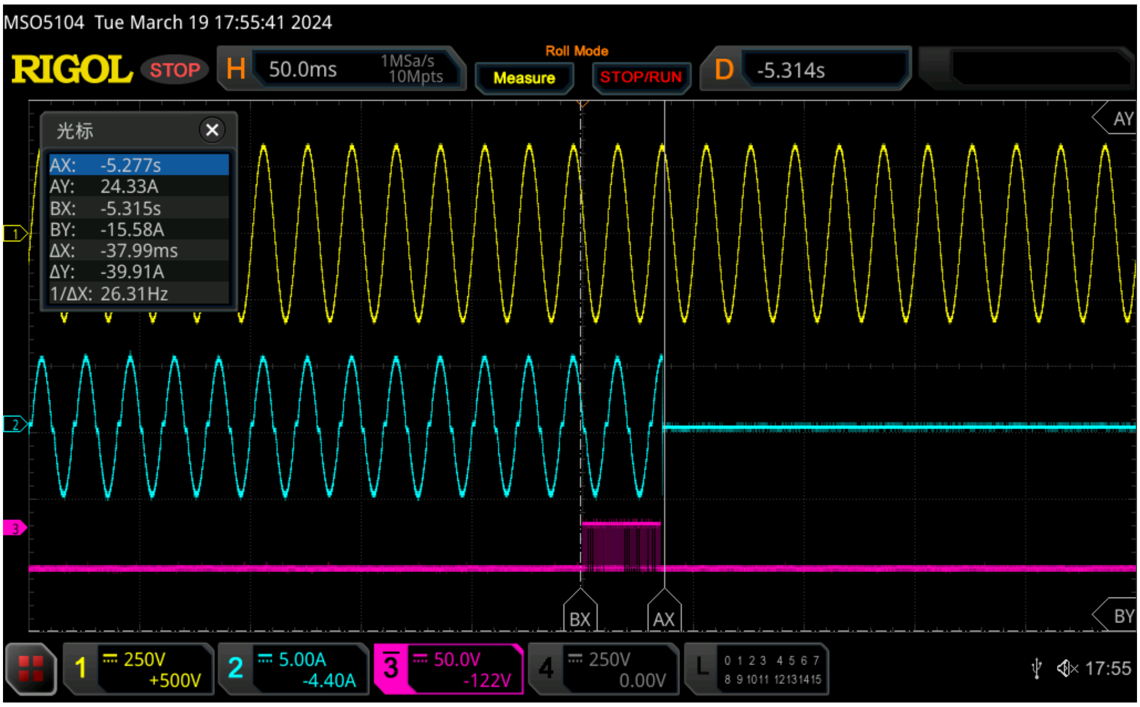
4.8. CEASING AND REDUCTION OF ACTIVE POWER ON SET POINT

4.8.1. Ceasing active power

The test has been performed according to the clause 4.11.1 of the standard.

Generating plants with a maximum capacity of 0.8 kW or more shall be equipped with a logic interface (input port) in order to cease active power output within 5 seconds following an instruction being received at the input port. If required by the DSO and the responsible party, this includes remote operation.

Ceasing active power



Tested ceasing active power time: 0.038 s

CH1: Output Voltage; CH2: Output current ; CH3: Trip signal;

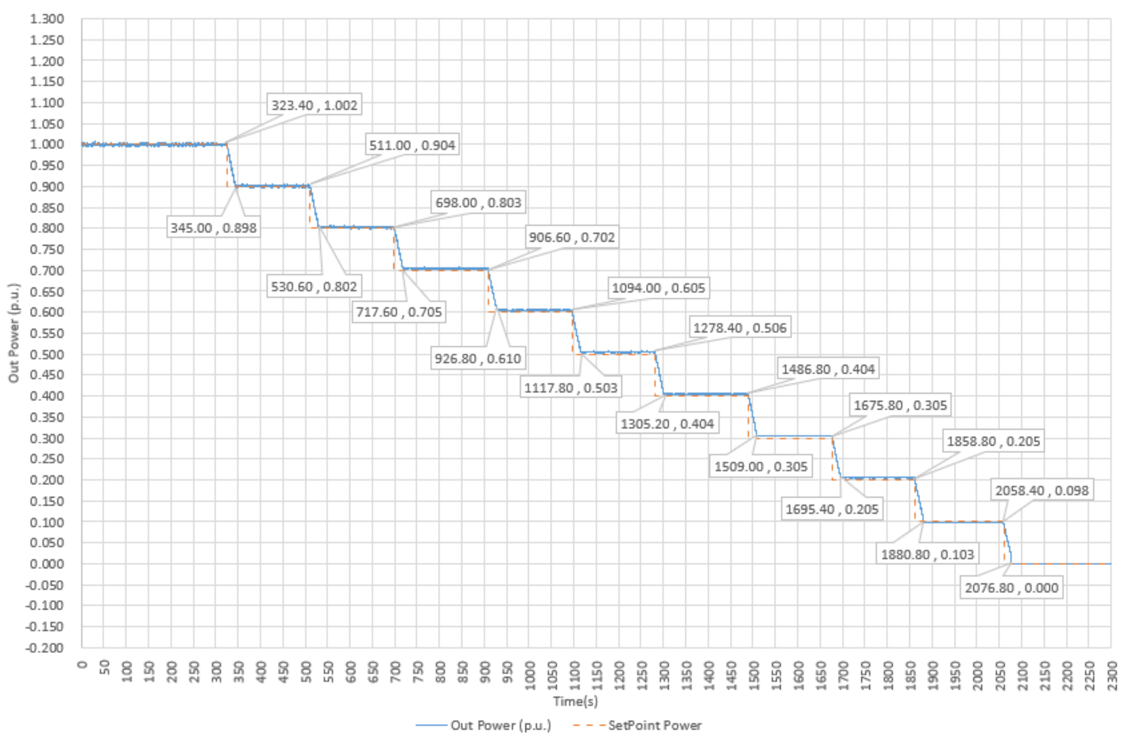
4.8.2. Reduction of active power on set point

Test requirements according to the clause 4.11.2 of the standard.

Active Power step (%P_n)	Setpoint value		Actual value		Deviation <±5% P_n		Gradient 0.66%Pn/s to 0.33%Pn/s
	(kW)	(%Pn)	(kW)	(%P_n)	(kW)	(%P_n)	(%Pn/s)
100	0.800	100	0.800	100.0	0.000	0.0	--
90	0.720	90	0.721	90.1	+0.001	+0.1	-0.48
80	0.640	80	0.642	80.2	+0.002	+0.2	-0.52
70	0.560	70	0.563	70.4	+0.003	+0.4	-0.50
60	0.480	60	0.483	60.4	+0.003	+0.4	-0.46
50	0.400	50	0.404	50.5	+0.004	+0.5	-0.43
40	0.320	40	0.324	40.5	+0.004	+0.5	-0.38
30	0.240	30	0.244	30.5	+0.004	+0.5	-0.45
20	0.160	20	0.164	20.5	+0.004	+0.5	-0.51
10	0.080	10	0.078	9.8	-0.002	-0.2	-0.47
0	0.000	0	0.000	0.0	0.000	0.0	-0.53

Test results are represented at diagrams below.

Output power reduction by steps (100 %Pn to 0 %Pn)



4.9. REQUIREMENTS REGARDING SINGLE FAULT TOLERANCE OF INTERFACE PROTECTION SYSTEM AND INTERFACE SWITCH

The requeriments are from clause 4.3.2 and 4.13 of the standard.

1) The compliances with the requirements of clause 4.3.2 are met with the following structure:

The output is switched off redundantly by the high-power switching bridge and relays, model: HF115F/012-2HS4AF , rated: 8A/250Vac.

2) The compliances with the requirements of clause 4.13 are stated in section 4.4 and 4.4.4 of the following test report:

IEC 62109-1: 2010 and IEC 62109-2: 2011: Test Report no. GZES240100138501 and GZES240100138502, issued by SGS-SCTS Standards Technical Services Co., Ltd. Guangzhou Branch, on February 19 of 2024. GAC ATL 0032.

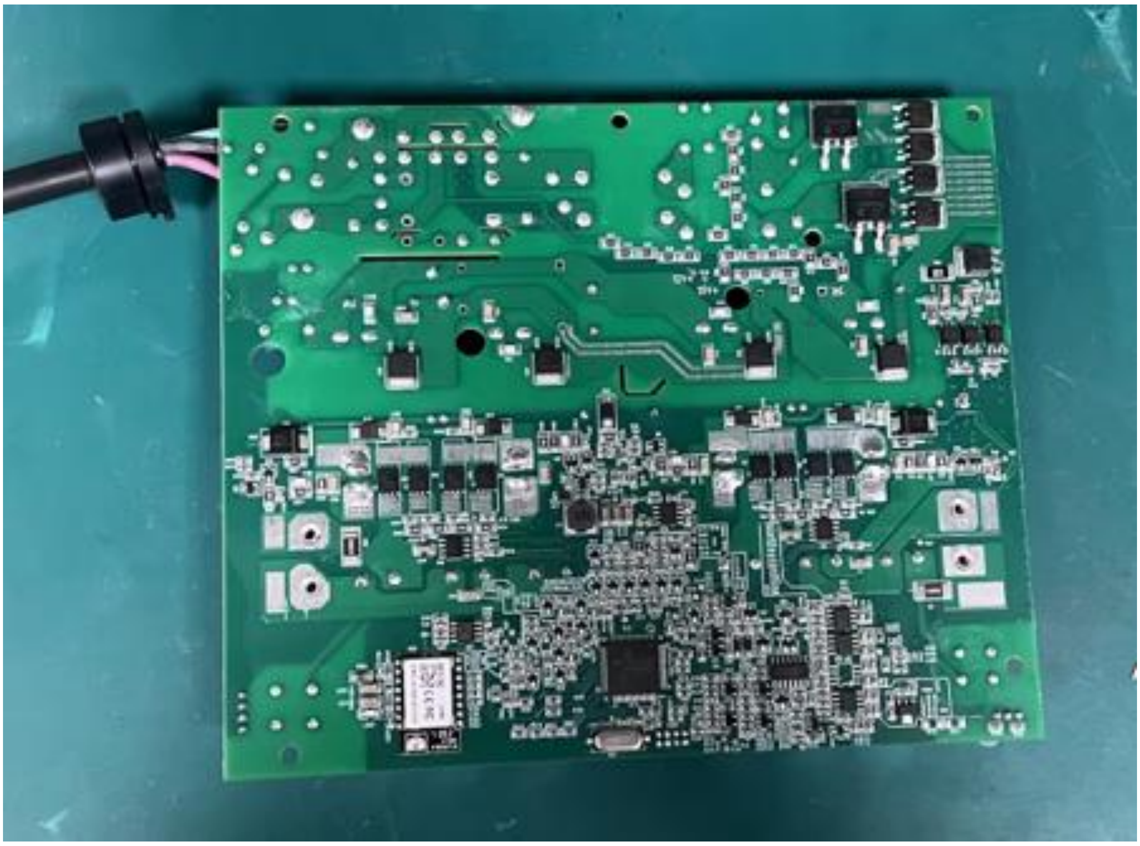
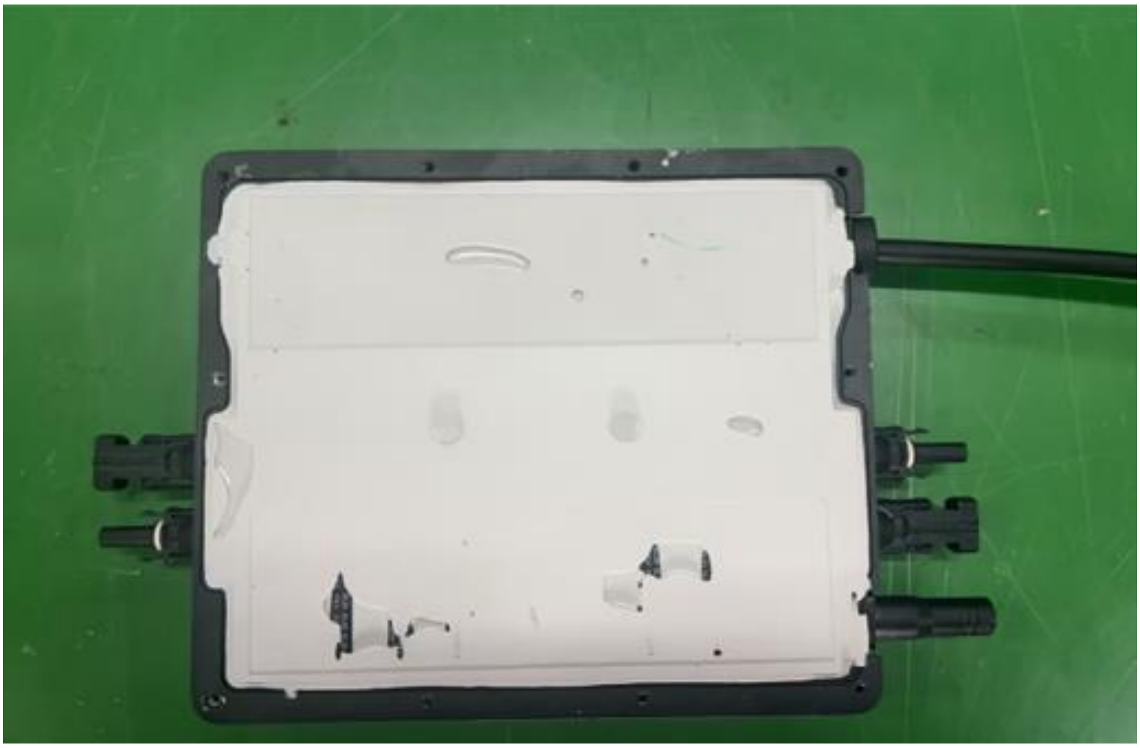
5. PICTURES

Front view

Back view

Internal view

Front view of main board

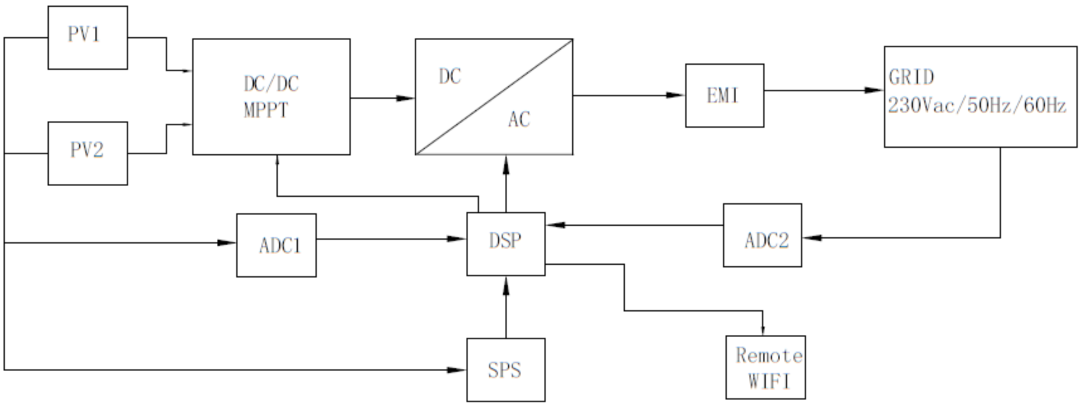

Back view of main board

After gluing


Serial Number

Software Version
DH01.001-000-000

6. ELECTRICAL SCHEME

Electrical Scheme of EUT



---End of Report---