TESTING FOR THE VERIFICATION OF COMPLIANCE OF HYBRID INVERTER WITH :

EN 50549-1: 2019+A1:2023:

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)

EN 50549-10: 2022:

REQUIREMENTS FOR GENERATING PLANTS TO BE CONNECTED IN PARALLEL WITH DISTRIBUTION NETWORKS – PART 10: TESTS FOR CONFORMITY ASSESSMENT OF GENERATING UNITS

Test Report Number ..... :	**SUEE250500013551**
Type ..... :	**Hybrid Inverter**
Tested Model ..... :	felicitysolar®
Trade Mark ..... :	**IVGM50KHP3G2**
Variant Models ..... :	IVGM25KHP3G2, IVGM29K9HP3G2, IVGM30KHP3G2, IVGM40KHP3G2

APPLICANT

Name ..... :	**Guangzhou Felicity Solar Technology Co., Ltd.**
Address ..... :	(Airport Baiyun)No.2, 4, 6, 8, 10 and 12 Donghua Huaye Road, Renhe Town, Baiyun District, Guangzhou, Guangdong, P.R. China

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 ..... :	Jojo Shao (Project Engineer)
Reviewed and approved by ..... :	Michael Tong (Technical Reviewer)
Date of issue ..... :	2025/12/11
Number of pages ..... :	121

The testing marked with "(*)" is not under A2LA accreditation. No quantitative general conclusion is referred to the accredited testing.

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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.

Test Report Historical Revision:

Test Report Version	Date	Resume
SUEE250500013551	2025/12/11	First issuance. This report has been revised in accordance with the report No. BL-DG2560064-203, issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701. Added Country / Region: **Sweden**

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1. SCOPE

SGS-CSTC Standards Technical Services Co., Ltd. Suzhou Branch has been contracted by Guangzhou Felicity Solar Technology Co., Ltd. to perform the testing according to the EN 50549 - 10: 2022: 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 following standard have been used for requirements references:

- EN 50549-1:2019+A1:2023. 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

- EN 50549-10: 2022. Requirements for generating plants to be connected in parallel with distribution networks - Part 10: Tests for Conformity Assessment of Generating Units

- The deviations for interface protection for **Sweden** according to EN 50438: 2013.

2. GENERAL INFORMATION

2.1. TESTING PERIOD AND CLIMATIC CONDITIONS

The necessary testing has been performed between November 13th and November 19th of 2025.
All the tests and checks have been performed at climatic conditions:

Temperature	25 ± 5 ºC
Relative Humidity	50 ± 10 %
Pressure	100 ± 10 kPa

2.2. EQUIPMENT UNDER TESTING

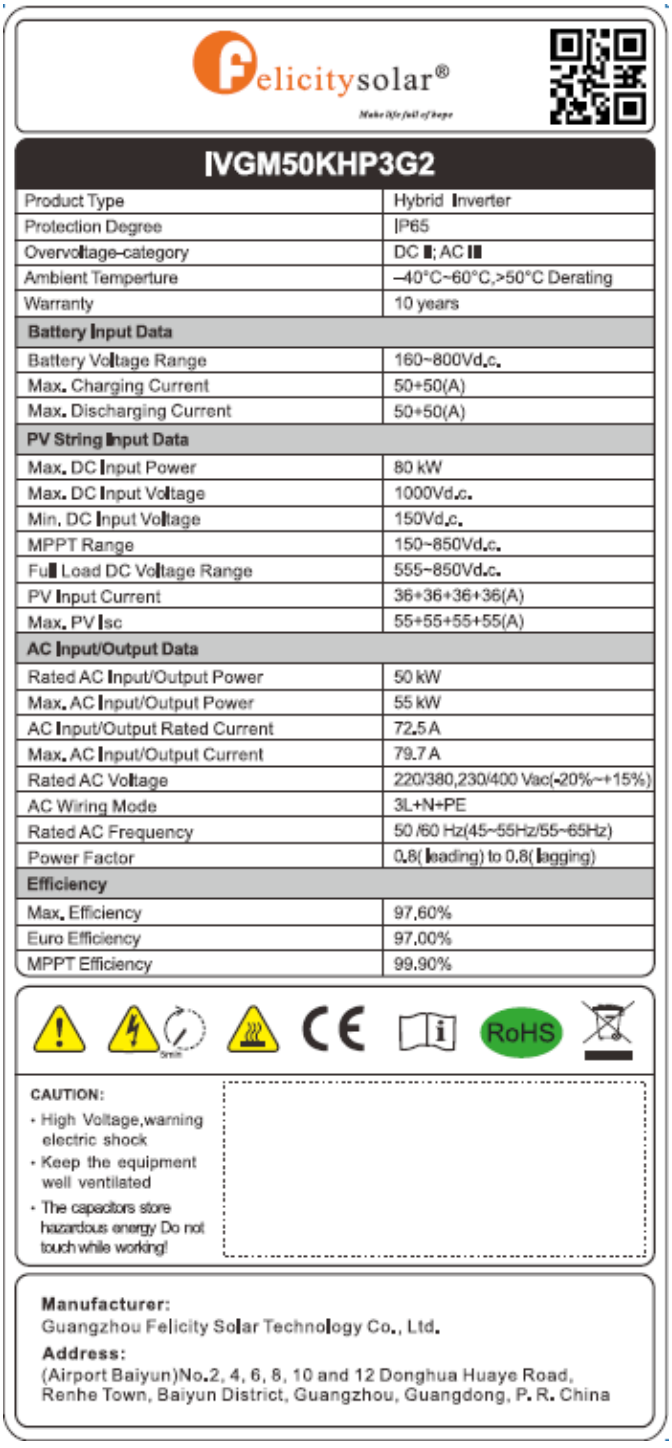
Information within this section has been provided by manufacturer.

Sample Received Date..... : 2025-11-11
Apparatus type ..... : Hybrid Inverter
Installation ..... : Fixed installation
Manufacturer ..... : Guangzhou Felicity Solar Technology Co., Ltd.
Trade mark ..... : Felicitysolar®
Model / Type reference ..... : IVGM50KHP3G2
Serial Number ..... : OHVR10ZR1YDT000C
Software Version ..... : Master: V201, Slave: V101
Rated Characteristics ..... : Refer to page 8

Date of manufacturing: 2025

Test item particulars
Input..... : PV and Battery
Output..... AC, 3L/N/PE
Class of protection against electric shock ... : Class I
Degree of protection against moisture ..... : IP65
Type of connection to the main supply..... : Three phase – Fixed installation
Cooling group ..... : Smart cooling
Modular ..... : No
Internal Transformer..... : No

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 side surface of enclosure and visible after installation

3.Labels of other models are as the same as model **IVGM50KHP3G2**'s except for the parameters of rating.

Equipment Under Testing:

– **IVGM50KHP3G2**

Variant Models:

– IVGM25KHP3G2
– IVGM29K9HP3G2
– IVGM30KHP3G2
– IVGM40KHP3G2

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.

IVGM50KHP3G2, IVGM40KHP3G2, IVGM30KHP3G2, IVGM29K9HP3G2, IVGM25KHP3G2 all models have same PCB layout, communication port, electric circuits, electronic control circuits, and have same software protection designed, the difference lies in the software limiting the output power and the number of MPPT.
Please refer to parameters table, labels and external photos for specific differences.

Model	IVGM25KHP3G2	IVGM29K9HP3G2 IVGM30KHP3G2	IVGM40KHP3G2 IVGM50KHP3G2
MPPT numbers	2	3	4

The above models are identical on topological schematic circuit diagram and control solution codes except for ratings.

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	IVGM25KH P3G2	IVGM29K9 HP3G2	IVGM30KH P3G2	IVGM40KH P3G2	**IVGM50KH P3G2**
Battery Input Data					
Battery Type	LFP (LiFePO4)				
Battery Voltage Range	160 ~ 800 Vd.c.				
Max. Charging Current	50+50 A				
Max. Discharging Current	50+50 A				
Number of battery input	2				
PV String Input Data					
Max. DC Input Power	40 kW	47.84 kW	48 kW	64 kW	80 kW
Max. DC Input Voltage	1000 Vd.c.				
Start-up Voltage	180 V d.c.				
Rated DC Input Voltage	600 V d.c.				
MPPT Voltage Range	150 ~ 850 V d.c.				
Full Load DC Voltage Range	555 ~ 850 Vd.c.	443 ~ 850 Vd.c.	444 ~ 850 Vd.c.		555 ~ 850 Vd.c.
PV Input Current	36+36 A	36+36+36 A		36+36+36+36 A	
Max. PV Isc	55+55 A	55+55+55 A		55+55+55+55 A	
No. of MPP Trackers	2	3		4	
AC Output Data					
Nominal Grid Voltage	230/400 V				
Nominal Grid Frequency	50/60 Hz				
Rated AC Output Power	25 kW	29.9 kW	30 kW	40 kW	50 kW
Max. AC Output Power	27.5 kW	29.9 kW	33 kW	44 kW	55 kW
Rated AC Output Current	36.3 A	43.4 A	43.5 A	58.0 A	72.5 A
Max. AC Output Current	39.9 A	43.4 A	47.9 A	63.8 A	79.7 A
Output Power Factor	0.8(leading) to 0.8(lagging)				
General Data					
Operating temperature range	-40 ºC ~ +65 ºC (＞50ºC derating)				
Protection degree	IP65				
Protective class	Class I				
Cooling method	Smart cooling				

2.3. MANUFACTURER AND FACTORY INFORMATION

Manufacturer Name:

Factory Name ..... : **Guangzhou Felicity Solar Technology Co., Ltd.**

Factory Address ..... : (Airport Baiyun)No.2, 4, 6, 8, 10 and 12 Donghua Huaye Road, Renhe Town, Baiyun District, Guangzhou, Guangdong, P.R. China

Factory Name:

Factory Name ..... : **Guangzhou Felicity Solar Technology Co., Ltd.**

Factory Address ..... : (Airport Baiyun)No.2, 4, 6, 8, 10 and 12 Donghua Huaye Road, Renhe Town, Baiyun District, Guangzhou, Guangdong, P.R. China

2.4. 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	
Nominal active power, **Pn** in kW	50
Design active power, $\mathbf{P_D}$ in kW (1)	49.5
Maximum active power, **Pmax** in kW	55
Maximum apparent power, **Smax** in kVA	55
Rated wind speed (only WT), **vn** in m/s	N/A
Nominal current, **In** in A	72.5
Rated output voltage, (Phase to Neutral) **Un** in Vac	230
Note: Unless otherwise indicated, In this report p.u. values are calculated as follows: -For Active & Reactive Power p.u values are reference to **Smax** -For Currents p.u values, the reference is always **In** -For Voltages p.u values, the reference is always **Un** (1)According to the clause 3.3.2 of the EN 50549-1: 2019, PD=0.9* Pmax= 49.5 kW.	

2.5. TEST EQUIPMENT LIST

From	No.	Equipment Name	Trademark / Model	Equipment No.	Calibration Period
SGS	1	Power analyzer	DEWTRON/ TRIONet	SUZE600302	2025/07/15 to 2026/07/14
	2	Current probe	HIOKI/ CT6873	SUZE600806	2025/07/15 to 2026/07/14
	3	Current probe	HIOKI/ CT6873	SUZE600807	2025/07/15 to 2026/07/14
	4	Current probe	HIOKI/ CT6873	SUZE600808	2025/07/15 to 2026/07/14
	5	Current probe	HIOKI/ CT6873	SUZE600809	2025/07/15 to 2026/07/14
	6	Temperature & Humidity meter	Testo/ 175-H1	SUZE601701	2025/03/17 to 2026/03/16

Note: Voltage direct measurement through power analyzer. All measurement equipment was used inside their corresponding calibration period. Copy of all calibration certificates are available at the laboratory for reference.

2.6. MEASUREMENT UNCERTAINTY

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

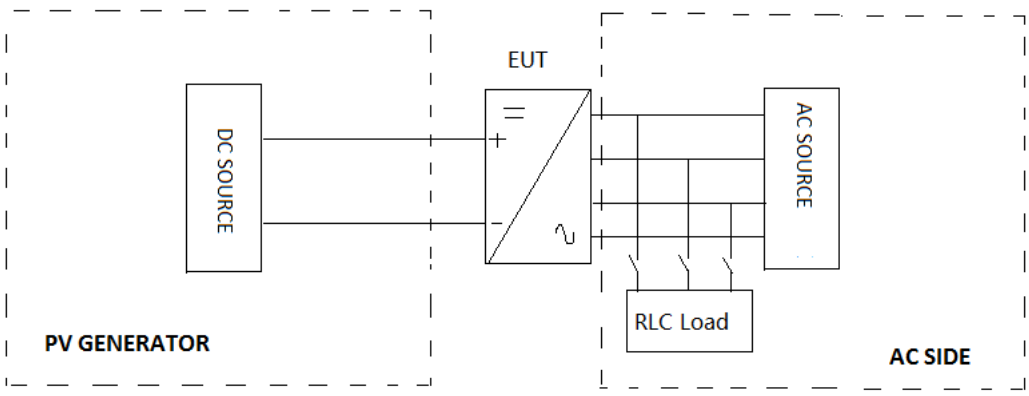
Magnitude	Uncertainty
Voltage measurement	±1.5 %
Current measurement	±2.0 %
Frequency measurement	±0.2 %
Time measurement	±0.2 %
Power measurement	±2.5 %
Phase Angle	±1 º
Temperature	±3 ºC
Note1: Measurement uncertainties showed in this table are maximum allowable uncertainties. The measurement uncertainties 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.	

Data sampling rates have been applied as follows:

Magnitude	Data sampling *(requested by standard)*	Data sampling *(used for testing)*
Voltage measurements	≥ 3 kHz	> 10 kHz
Current measurements	≥ 3 kHz	> 10 kHz
Robustness Requirements	≥ 10 kHz	> 10 kHz

2.7. TEST SET UP

Below is the simplified construction of the test set up.



Different equipment have been used to take measures as shown in chapter 2.5. Current clamps 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	ID.CODE
AC source	WAGO/ WLPA-330150kVA-D-W	0-600 Vac; 0-208 A 150 kVA max. 45-65 Hz	SUZE600101
DC source	EA/PSI 11500-60	1500 V, 60 A max.	SUZE600201
RLC load	KAIXIANG/ AC400V-450.99kVA-RLC	450 kW, 450 kVAr	SUZE660101

2.8. DEFINITIONS

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

3. SUMMARY OF TEST RESULTS

INTERPRETATION KEYS

Test object does meet the requirement ..... :	**P**	Pass
Test object does not meet the requirement ..... :	**F**	Fail
Test specification/standard does not include limits .:	**P***	Performed
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 performed ... :	**N/P**	Not performed

EN 50549-10 section	EN 50549-1 section	Report Section	Standard Requirements Title / Description	Result
5.2	**4.4**	**4.1**	**Normal operating range**	**N/P** (1)
5.2.1	4.4.2	4.1.1	Frequency operating range	N/P (1)
5.2.1	4.4.3	4.1.1	Minimal requirement for active power delivery at underfrequency	N/P (1)
5.2.2	4.4.4	4.1.2	Voltage operating range	N/P (1)
5.3	**4.5**	**4.2**	**Immunity to disturbance**	**N/P** (1)
5.3.1	4.5.2	4.2.1	Rate of change of frequency (ROCOF)	N/P (1)
5.3.2	--	4.2.2	Phase Jump	N/P (1)
5.3.3	4.5.3	4.2.3.1	Under-voltage ride through (UVRT)	N/P (1)
5.3.3	4.5.4	4.2.3.2	Over-voltage ride through (OVRT)	N/P (1)
5.4	**4.6**	**4.3**	**Active response to frequency deviation**	**N/P** (1)
5.4	4.6.1	4.3.1	Power response to overfrequency	N/P (1)
5.4	4.6.2	4.3.2	Power response to underfrequency	N/P (1)
5.5	**4.7**	**4.4**	**Power specification and response to voltage variations**	**N/P** (1)
5.5.1	4.7.2.2	4.4.1	Power capabilities assessment - voltage support by reactive power	N/P (1)
5.5.2	**4.7.2.3**	**4.5**	**Voltage support by reactive power - test to determine the reactive power control modes**	**N/P (1)**
5.5.2.3	--	4.5.1	Verification procedure for Set point control	N/P (1)
5.5.2.4	--	4.5.2	Verification procedure for voltage related control mode for reactive power Q(U)	N/P (1)
5.5.2.5	--	4.5.3	Verification procedure for power related control modes for reactive power	N/P (1)
5.6	4.7.3	4.5.4	Voltage related active power reduction - P(U)	N/P (1)
5.7	**4.8**	**4.6**	**EMC and power quality**	**N/P** (2)
5.7.2.2	4.8	4.6.1	Verification procedure for harmonics, interhamonics and higher frequencies up to 9 kHz	N/P (1)
5.7.2.3	4.8	4.6.2	Verification procedure for flicker and rapid voltage changes	N/P (1)
5.7.2.4	4.8	4.6.3	Verification procedure for DC injection	N/P (1)
5.8	**4.9**	**4.7**	**Interface Protection**	**N/P** (1)
5.8.3	4.9.3	--	Verification procedure for generating plants to be connected to a LV distribution network with Interface protection as internal device	N/P (1)
5.8.3.2	--	4.7.1	Voltage protection (Undervoltage protection [27] and Overvoltage protection [59]);	N/P (1)
5.8.3.2	--	4.7.2	Frequency protection (Underfrequency protection [81<] and Overfrequency protection [81>];	N/P (1)

EN 50549-10 section	EN 50549-1 section	Report Section	Standard Requirements Title / Description	Result
5.8.3.2	--	4.7.3	Immunity to voltage harmonics	P
5.8.3.3	--	4.7.4	Overvoltage 10 min mean protection	N/P (1)
5.8.3.4	--	4.7.5	ROCOF protection.	N/P (1)
5.8.6	4.9.4	4.7.6	Islanding detection	N/P (1)
5.9	**4.10**	**4.8**	**Connection and starting**	**N/P** (1)
5.9.3	4.10.2	4.8.1	Automatic reconnection after tripping	N/P (1)
5.9.4	4.10.3	4.8.2	Starting to generate electrical power	N/P (1)
5.9.7	4.10.4	4.8.3	Synchronisation	P
5.10	**4.11**	**4.9**	**Active power reduction on set point**	**N/P** (1)
5.11	**4.12**	**--**	**Remote information exchange**	**N/A (1)**
5.12	**4.13**	**4.10**	**Requirements regarding single fault tolerance of interface protection system and interface switch**	**N/P** (3)

(1) EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

(2) EN IEC 61000-6-4:2019 & EN 61000-3-12:2011+A1:2019 & EN IEC 61000-3-11:2019 & EN IEC 61000-6-2: 2019: Test Report No. 1811C50185012601, issued by Shenzhen Anbotek Compliance Laboratory Limited, on 2025/08/26. CNAS: L3503.

(3) EN 62109-1 & EN 62109-2 & IEC 62109-1 & IEC 62109-2: Test Report No. 18360SC30021201-M2, issued by Shenzhen Anbotek Compliance Laboratory Limited, on 2025/10/22. CNAS: L3503.

EN 50438: 2013– Requirements for micro-generating plants to be connected in parallel with public low-voltage distribution networks				
REPORT SECTION	**STANDARD SECTION**	**CHAPTER OF THE STANDARD**	**Plant category**	**Result**
4.7.7 (*)	A.20 SE – Sweden	Requirements on voltage and frequency protection	--	P

(*) This test is not under A2LA accreditation. No quantitative general conclusion is referred to the accredited testing.

No deviation from standards.

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 done according to the clause 5.2.1 of the standard,
Applied requirements according to EN 50549-1

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.		

The compliances with the requirements of clause 5.2.1 of the standard are stated in section 5.2.1 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.1.2. Continuous operating voltage range

The test has been done according to the clause 5.2.2 of the standard, the requirement is as follows:

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
The following approaches are considered justified in the verification process of some specific technology:		--
– In case of a PV generating unit, replacing the PV generator by a DC source (e.g. PV Array Simulator) operating at the minimum input voltage (4.2.2).		P
– In case of full converter generating units (Wind or CHP) replacing the generator and if applicable the generator side inverter/rectifier by an AC or if applicable a DC source according 4.2.7.		N/A
– In case of DFIG generating units, replacing the mechanical drive system by a test bench motor (4.2.2).		N/A
– In case of a generating unit connected to the grid through a synchronous generator, the test can be carried out on the generator only (for example at the generator manufacturer testing facility) replacing the mechanical drive system by a test bench motor (4.2.2).	Non-rotating machine evaluated	N/A
verification can be carried out using one of the following methods:		P
– Verification of the generating unit or relevant component using a grid simulator.		P
– Verification of the generating unit or relevant component by using a dedicated prime mover capable of changing the speed of the generating unit or relevant component.		N/A
– Verification of the generating unit or relevant component in island operation with sufficient load.		N/A
– Verification of the generating unit based on relevant components evaluation through documentation and calculation (4.2.13).		N/A
– In case of synchronous generating technology, verification by calculation and numerical simulation according to 4.2.11	Non-rotating machine evaluated	N/A
any available logic function that prevents the generating unit from operating at minimum or maximum operation voltage shall be deactivated. Deactivated logic functions shall be stated in the verification report.	Deactivated Voltage&Frequency trips. QvsV; LVRT.	P
GENERAL TEST CONDITIONS (Using Grid Simulator)		
The voltage operating points shall be adjusted with a maximum error of 0.5 % Un, Uc respectively. The voltage fluctuation during the recording of the test shall not exceed an absolute value of 2 % Un.		P
The verification of the voltage limits can be carried out during the verification of the capability limits and using the correspondent procedures (see 5.5.1).		P
At least 2 verifications shall be conducted, one at each voltage limit	Applied for maximum and minimum voltage.	P
The test shall be carried out with the generating unit operating as follows		P
– at the apparent power for this operating point as stated by the manufacturer;		P

– at an active factor or reactive power set point within normal operation range of the generating unit as stated by the manufacturer; NOTE The active factor or reactive power set point is randomly chosen.		P
– at nominal frequency or in general not exceeding the voltage over frequency (U/f) ratio as stated by the manufacturer (or as stated in the applicable product standard).		P
The followings values shall be used as reference when verifying compliance to the EN 50549-1:2019: – U ≤ 85 % Un – U ≥ 110 % Un		P
Other wither range as declared by manufacturer or grid code.	Indicate limits	N/A
The voltage at the terminals shall be modified in steps according to the following sequence:		P
– The voltage shall be reduced to the minimum voltage and maintained for a minimum of 10 min time. – The voltage shall be increased to its nominal value and maintained for a minimum of 5 min and up to 10min. – The voltage shall be increased to its maximum limit and maintained for a minimum of 10 min time. – The voltage shall be decreased to the voltage nominal value.	Applied sequence	P
GENERAL TEST CONDITIONS (At site)		
Testing a generating unit or component using equipment at site that permits a change in the voltage. Examples are step-up or step-down transformers equipped with on-load tap changer		N/A
It can be expected that the voltage fluctuates during the tests. Permitted voltage deviation during the test shall be within ± 3% Uc , unless differently stated in applicable standards.		N/A
GENERAL TEST CONDITIONS (Using documentation, calculation and if applicable combined with manufacturer tests)		
The verification can be carried out based on documentation, calculation if applicable combined with manufacturer test or product specific test.		N/A
It is expected that the verification in this case would be based on the component (e.g., synchronous generator) rather than on the complete unit.		N/A
The verification process consists in documenting the justification that proves the generating unit or the component is capable to meet the voltage limits requirement.		N/A
The verification process consists in documenting the justification that proves the generating unit or the component is capable to meet the voltage limits requirement. The documentation can include what the expected stress (thermal, mechanical, etc.)		N/A
In case of synchronous generating technology, this includes expected temperature on the windings.		N/A
In case of testing on rotating machine component (e.g. synchronous generator, asynchronous generator etc.), the manufacturer can calculate the expected effect of the voltage variation based on the EN IEC 60034 standard tests. In this case the temperature calculated for stator and rotor coils shall not exceed their correspondent thermal insulation class at voltage limits.		N/A

ACCEPTANCE CRITERIA		
The requirement is considered passed when the generating unit is able to remain in operation and does not disconnect from the system during the test		P
And if the documentation provided shows that the generating unit is expected to run within its operational limits (e.g. temperature on the components does not exceed insulation thermal classes).	Unit Tested	N/A

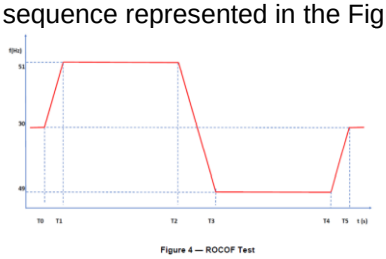
The compliances with the requirements of clause 5.2.2 of the standard are stated in section 5.2.2 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.2. IMMUNITY TO DISTURBANCES

4.2.1. Rate of change of frequency (ROCOF) immunity

The test has been done according to the clause 5.3.1 of the standard, the requirement is as follows:

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
The following approaches are considered justified in the verification process of some specific technology:		--
– In case of a PV generating unit, replacing the PV generator by a DC source (e.g. PV Array Simulator) operating at the minimum input voltage (4.2.2).		P
– In case of full converter generating units (Wind or CHP) replacing the generator and if applicable the generator side inverter/rectifier by an AC or if applicable a DC source according 4.2.2.		N/A
– In case of DFIG generating units, replacing the mechanical drive system by a test bench motor (4.2.2).		N/A
– In case of a generating unit connected to the grid through a synchronous generator, the test can be carried out on the generator only (for example at the generator manufacturer testing facility) replacing the mechanical drive system by a test bench motor (4.2.2).	Non-rotating machine evaluated	N/A
verification can be carried out using one of the following methods:		P
– Verification of the generating unit or relevant component using a grid simulator.		P
– Verification of the generating unit or relevant component in island operation with sufficient load.		N/A
– verification through calculation and numerical simulation (4.2.11).	Non-rotating machine evaluated	N/A
GENERAL TEST CONDITIONS (Using Grid Simulator)		
– The generating unit, connected to a grid simulator, shall be operating between 100 % and 80 % of the nominal power		P
– with an active factor equal to 1.		P
– ROCOF protection function shall be inactive during the test.		P
The ROCOF protection function and correspondent settings shall be tested as described in 5.8.		P
Then the test shall be conducted following the sequence represented in the Figure 4  Figure 4 — ROCOF Test		P
Values according to Table 3	Required Minimum Measurement Time=500ms (0.5s) Required ROCOF Value=2Hz	P

Criteria	Comments	Result
Table 3 — Frequency steps during ROCOF Overfrequency and Underfrequency verifications Step / Frequency / ROCOF associated with time interval T0 / 50 Hz / - T0 to T1 / - / = Required ROCOF Value T1 = T0 + (Required Minimum Measurement Time) / 50 Hz + (Required ROCOF Value) x (Required Minimum Measurement Time) / - T1 to T2 / - / Zero T2 = T0 + (Required Minimum Measurement Time) + 3 s / 50 Hz + (Required ROCOF Value) x (Required Minimum Measurement Time) / - T2 to T3 / - / = - (Required ROCOF Value) T3 = T0 + 3 × (Required Minimum Measurement Time) + 3 s / 50 - (Required ROCOF Value) x (Required Minimum Measurement Time) Hz / - T3 to T4 / - / Zero T4 = T0 + 3 × (Required Minimum Measurement Time) + 6 s / 50 – (Required ROCOF Value) x (Required Minimum Measurement Time) Hz / - T4 to T5 / / = Required ROCOF Value T5 = T0 + 4 × (Required Minimum Measurement Time) + 6 s / 50 Hz / -		
The grid simulator shall increase and decrease the frequency linearly over time.		P
Once the higher, respectively, lower values of frequency have been reached, the frequency shall be maintained for a time period equal or longer than 3 s	30s maintained	P
During the test, the frequency, RMS voltage, RMS current and active and reactive power measured at the output terminals of the generating unit shall be recorded as 10 cycle average values.		P
If the power output of the generating unit has no influence on the capability to cope with the ROCOF variation, the generating unit can be tested at any power within the active power range declared by manufacturer.		P
ACCEPTANCE CRITERIA		
In case of verification using a Grid Simulator, the verification is considered satisfactory if the generating unit operates or unit component remains in operation without disconnection from the grid (no trip).	Immunity tested for a ROCOF of 2Hz/s, as per EN50549-1 for non-synchronous generating technology	P
In case of verification through documentation, calculation or computer-based simulation (e.g. using functional block diagrams representing the unite behaviour) the information shall explicitly provide evidence the unit is capable to cope with the requirements and no malfunction can be expected.		N/A
DOCUMENTATION		
Description of the test carried out and associated results if real test has been carried out to prove compliance.	Described within this table and see chart below	P
Documentation provided by manufacturer if documental assessment has been carried out		N/A
Simulation of the tests and associated results if validated model is used to prove compliance	Applicable according to 5.13 for synchronous	N/A
ROCOF protection settings as set for the generating unit (see 5.7 for ROCOF protection testing).		P
Vector shift protection settings if applicable as set for the generating unit.		N/A

The compliances with the requirements of clause 5.3.1 of the standard are stated in section 5.3.1 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.2.2. Phase Jump

The test has been done according to the clause 5.3.2 of the standard, the requirement is as follows:

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
The following approaches are considered justified in the verification process of some specific technology:		--
– In case of a PV generating unit, replacing the PV generator by a DC source (e.g. PV Array Simulator) operating at the minimum input voltage (4.2.2).		P
– In case of full converter generating units (Wind or CHP) replacing the generator and if applicable the generator side inverter/rectifier by an AC or if applicable a DC source according 4.2.2.		N/A
– In case of DFIG generating units, replacing the mechanical drive system by a test bench motor (4.2.2).		N/A
In case of synchronous generating technology verification of the generating unit based on test by calculation and numerical simulation generating units of synchronous generating technology (see 4.2.11).	Non-rotating machine evaluated	N/A
GENERAL TEST CONDITIONS (Using Grid Simulator)		
There are two different capabilities to be evaluated, these are:		--
Capability 1 vector jumps due to system events with no tripping of protection functions and a recovery of controlled operation as fast as possible after the event.		N/A
Capability 2 During the test a disconnection of the generating unit due to protection tripping is permissible as long as the generating unit is not affected by any damages.		P
For each test, time-series of voltage and current values shall be recorded with a sufficient sampling rate ≥ 10kHz.		P
The measurement is taken at the terminals of the EUT for at least 5 s prior to the phase jump and at least for 10 s after the event.		P
The positive and negative sequence of active power, reactive power, active current, reactive current and voltage shall be calculated from the recorded data.		P
Before the test the EUT is operating at nominal voltage, at a power level above 0.9 Pn and with a unit power factor (cos = 1) at least for 5 min		P
Phase jumps are introduced simultaneously on all phases		P
For three-phase systems phase 1 is used as reference.		P
For capability 1 One test shall be performed with a phase jump at the voltage zero crossing (0°) of the sinewave and the other with a phase jump at the top of the sinewave (+90°).		P

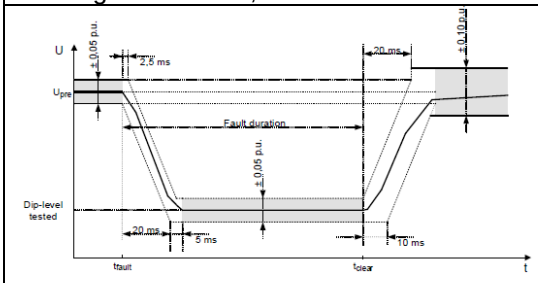
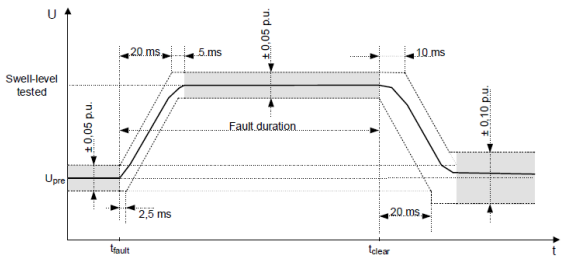
ACCEPTANCE CRITERIA		
The phase jump ride through capability 1 as declared by the manufacturer or as requested by the responsible party or a specific grid code is confirmed		P
The active power and reactive power recovery response times and settling times as declared by the manufacturer or as requested by the responsible party or a specific grid code are confirmed.	Recovery Settling time declared: 10s.	P
The withstand without damage capability as declared by the manufacturer or as requested by the responsible party or a specific grid code is confirmed.	Applied 90º and 180º. Confirmed no trip also.	P
DOCUMENTATION		
The declared capability of the manufacturer	δ1=40º, δ2.1=90º, δ2.2=180º	P
The values of the phase of the voltage before and after the phase jump	Recorded the Phase displacement	N/A
graph representing the currents delivered by the generator as a function of the time, from before the phase jump to at least 200 ms after the phase jump	See charts below	P
ROCOF protection settings as set for the generating unit (see 5.7 for ROCOF protection testing).		P
Vector shift, ROCOF and Frequency protection settings if applicable as set for the generating unit.		P

The compliances with the requirements of clause 5.3.2 of the standard are stated in section 5.3.2 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.2.3. Fault ride through, under-voltage (UVRT) & over-voltage (OVRT)

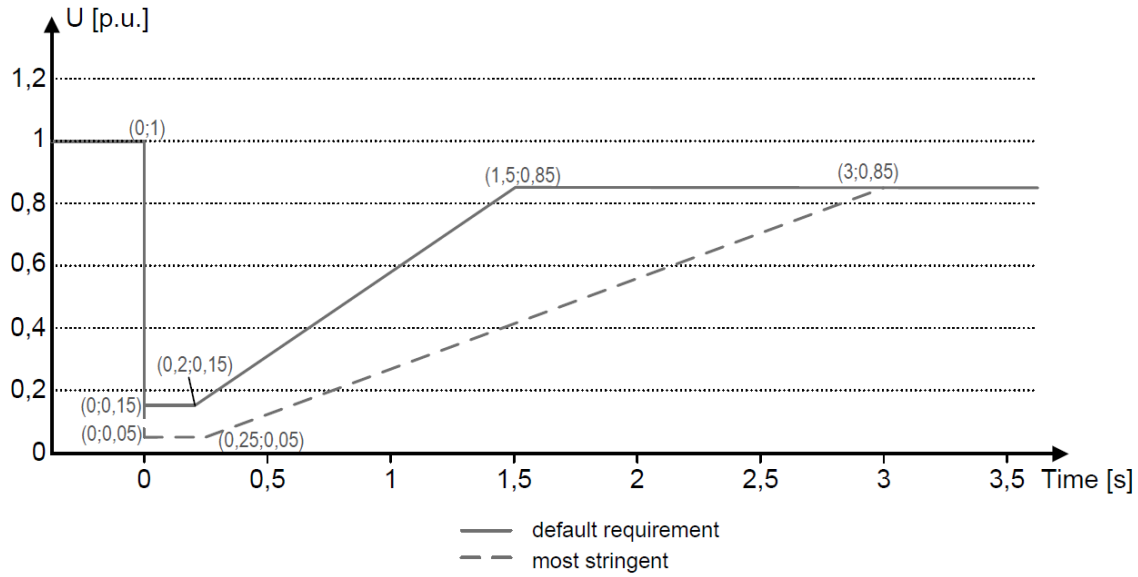
The requirements are defined in the clause 5.3.3 of the standard.

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
The following approaches are considered justified in the verification process of some specific technology:		--
– In case of a PV generating unit, replacing the PV generator by a DC source (e.g. PV Array Simulator) operating at the minimum input voltage (4.2.2).	DC Source	P
In case of Battery generating units, the test shall be done as complete unit test, alternatively by replacing the battery by a battery simulator (see 4.2.2).	DC Source	P
In case of Wind Turbines generating units, the test shall be done as a complete unit test. If multiple tests are conducted to verify the behaviour of the unit in different control modes, these additional tests might be done as test on the electrical generating system as a nacelle test (see 4.2.3).		N/A
In case of generating units using synchronous generating technology, the test shall be done as a complete unit test. If multiple tests are conducted to verify the behaviour of the unit in different control modes, these additional tests might be conducted as tests on the electrical generating system. As an alternative to complete unit tests, simulations using a validated model according to 5.13 may be carried out.	Non-rotating machine evaluated	N/A
GENERAL TEST CONDITIONS		
The test shall be carried out for the generating system operating at two power levels:		P
between 0.1 Pn and 0.5 Pn,		P
above 0.9 Pn		P
the voltage-time characteristic for the undervoltage events shall be within the shape indicated in Figure 5 for UVRT and Figure 6 OVRT,		P
 Figure 5 — Tolerances of the positive sequence voltage for the undervoltage event		P
 Figure 6 — Tolerances of the positive sequence voltage for the overvoltage event		P

Criteria	Comments	Result
To define the effect of the generating unit on the voltage magnitude, the short circuit power of the test setup shall be in the range of 2 times to 40 times the nominal power of the generating unit.		P
The X/R ratio of the test impedance shall be at least 3.		P
In case of two-phase faults voltage drop a phase jump applied according to annex A		P
Measure at least 5s prior and 10s after the fault.		P
For each test case two consecutive tests shall be passed successfully.		P
for test of inverters with specified DC input voltage range:		P
The two consecutive tests as specified above shall be conducted with different DC input voltages – One test near the minimum DC input voltage, between 0 % ~ 20 % of the voltage range. – One test near the maximum DC input voltage, between 80 % ~ 100 % of the voltage range.	Two consecutive tests have been performed at different DC voltages.	P
Operating modes during grid faults evaluated		
Voltage support during faults: In case of faults generating plants shall have the capability to provide additional reactive current. The additional reactive current in the positive sequence ΔIQ1 is set by the gradient k1 as ΔIQ1 = k1ΔU1. The additional reactive current in the negative sequence ΔIQ2 is set by the gradient k2 as ΔIQ2 = k2ΔU2.	The Manufacturer didn't claim reactive current support capability	N/A
Active power priority: The generating plant shall be able to give priority to active current injection.		N/A
Reactive current limitation: The generating plant shall be able to limit the reactive current to a value specified by the DSO and the responsible party.	The Manufacturer didn't claim reactive current support capability	N/A
Zero current threshold: The generating plant shall have the capability to reduce the current as fast as technically feasible down to or below 10 % of the rated current when the voltage falls below a configured zero current thresholds. As long as the voltage remains above or once it recovers above this threshold voltage support during faults and voltage steps is provided according to Voltage support during faults.		P
ACCEPTANCE CRITERIA (5.3.3.6 Immunity)		
No trip occurred during the tests.		P
The active power recovery time after fault is equal or less the time maximum recovery time.	Maximum 1s	P
ACCEPTANCE CRITERIA (5.3.3.8 Voltage support during faults)		
Acceptance criteria (immunity) applies		P
Accuracy for positive and negative sequence current as required in the grid code. (i.e Kset between +0.2 and -0.1). calculated from tfualt+100ms and tclear-20ms)	The Manufacturer didn't claim reactive current support capability	N/A
Dynamic of response and settling time as required of the applicable grid code (30 ms response time, 60 ms settling time)		P

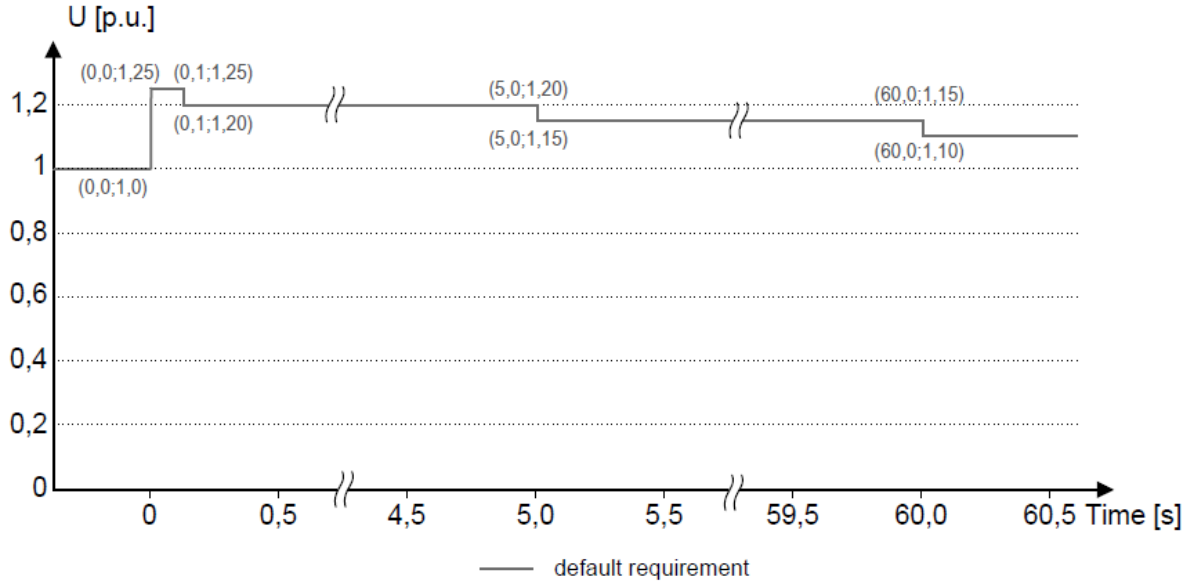
ACCEPTANCE CRITERIA (5.3.3.8 Active power priority)		
Acceptance criteria (immunity) applies		P
Accuracy for positive and negative sequence reactive current according to the active power configuration		N/A
Dynamic of response and settling time as required of the applicable grid code (30 ms response time, 60 ms settling time)		P
ACCEPTANCE CRITERIA (5.3.3.8 Reactive current limitation)		
Acceptance criteria (immunity) applies		P
Accuracy for positive and negative sequence reactive current according to the reactive current configuration	The Manufacturer didn't claim reactive current support capability	N/A
Dynamic of response and settling time as required of the applicable grid code (30 ms response time, 60 ms settling time)		P
ACCEPTANCE CRITERIA (5.3.3.7 Zero current mode)		
Acceptance criteria (immunity) applies		P
The EUT reduced its current as fast as technically feasible below 10 % of rated current.		P
A response time below 30 ms and a settling time below 60 ms is considered sufficient.		P
The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		P
DOCUMENTATION		
Test setup (test with complete generating system or at a test bench, type of test equipment).		P
Operating mode of generating system including a description and the applied setting of all relevant parameters.	Zero current mode.	P
Depending on the test equipment all different test states and the test sequence.	See charts below	P
For each conducted test:		P
Times when the different events of the test sequences start to occur.		P
Trip / no trip of the generating system under the test.		P
Response times (rise time plus dead time) of the reactive and active current of positive and negative sequence [ms] during the fault, after the fault.	The Manufacturer didn't claim reactive current support capability	N/A
Settling times of the reactive and active current of positive and negative sequence during the fault, after the fault.	The Manufacturer didn't claim reactive current support capability	N/A
Steady-state reactive current and active current of positive and negative sequence – Before the fault, measured as average in steady-state [p.u.] – Injection during fault, measured as average in steady-state [p.u.] – After the fault measured as average in steady-state [p.u.]	The Manufacturer didn't claim reactive current support capability	N/A
Steady-state ratio of change in reactive current to the change in voltage of positive and negative sequence during the fault (ΔI / ΔU = k)	The Manufacturer didn't claim reactive current support capability	N/A

UVRT Voltage profile applied



From figure 6 EN 50549-1: applied most stringment requirement

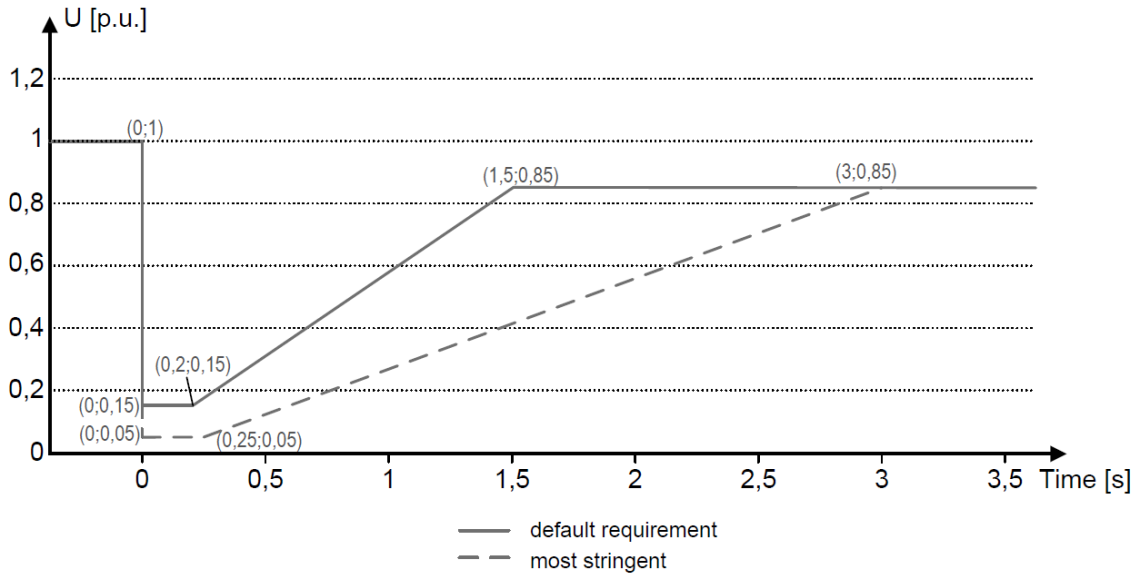
OVRT Voltage profile applied



From figure 8 EN 50549-1:

4.2.3.1. Under-voltage ride through (UVRT)

The requirements are defined in the clause 5.3.3 of the standard.
The test uses the most stringent line in the following figure.

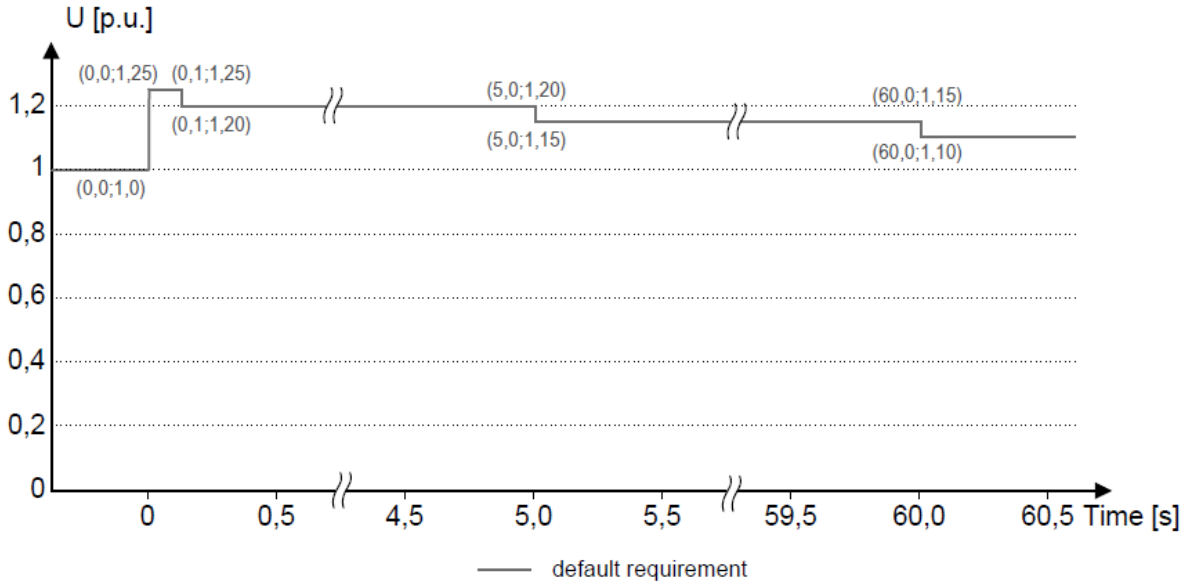


The compliances with the requirements of clause 5.3.3 of the standard are stated in section 5.3.3 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.2.3.2. Over-voltage ride through (OVRT)

The requirements are defined in the clause 5.3.3 of the standard.
The test uses the default line in the following figure.



The compliances with the requirements of clause 5.3.3 of the standard are stated in section 5.3.3 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.3. ACTIVE RESPONSE TO FREQUENCY DEVIATION

4.3.1 Power response to overfrequency

The test has been done according to the clause 5.4.3.2 of the standard.

The following definitions apply to the test of this clause:

Table 6 — Frequency threshold and droop

	Setting (a)	Setting (b)	Setting (c)
frequency threshold f_{th} [Hz]	50,2	50,5	50,2
droop [%]	5	2	12
power level at start of test [% P_n]	100 / 50 [a] / –50 [d]	60 [b]	40 [c]
Intentional delay [s]	0	0	2
Configured deactivation threshold and time f_{stop} [Hz] / t_{stop} [s]	n.a.	50,5 / 1	50,05 / 600

[a] or minimum regulation level +35 % P_{max}, whichever is higher
[b] or minimum regulation level +25 % P_{max}, whichever is higher
[c] or minimum regulation level +15 % P_{max}, whichever is higher
[d] only applicable for EES

The frequency sequence shall be selected according to Table 7:

Table 7 — Frequency points selection (over-frequency)

Frequency point	Value [Hz]
f_1	50 Hz
f_2	50 Hz < f_{stop} < f_2 < f_{th}
f_3	f_{th} < f_3 < f_4
f_4	f_3 < f_4 < f_{max} [a]
f_5	f_{max} [a]

[a] f_{max} as maximum frequencies limits as specified in 5.2.1

Figure 11 describes, on time domain, an example of frequencies sequence test.

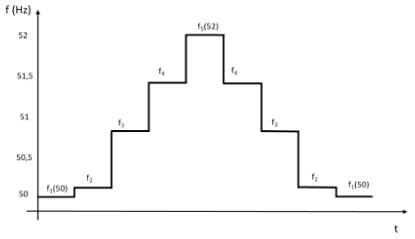
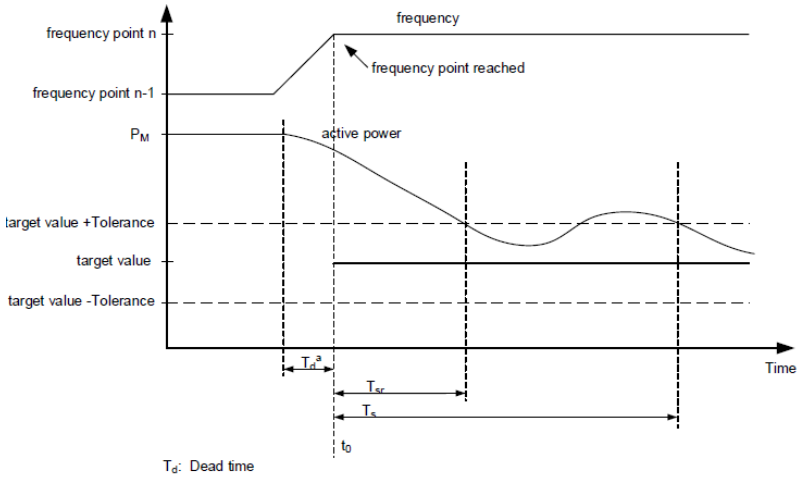


Figure 11 — Example of frequencies sequence test



T_d: Dead time
T_{sr}: Step response time
T_s: Settling time
[a] Negative times are considered as zero

Figure 12 — Example of power reduction

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
The following test setups are adopted		--
Setup n. 1: Tests on electrical generation system (4.2.2) or complete unit (4.2.1), with the grid simulator connected to the output of the generator (power port).	DC Source	P
Setup n. 2: Tests on electrical generation system (4.2.2) or complete unit (4.2.1), with the test signal generator (with full voltage range) connected to the control circuits of the generator according 4.2.8.		N/A
Setup n. 3: Tests on electrical generation system (4.2.2) or complete unit (4.2.1), with modification of the control parameters according 4.2.9.		N/A
During the test procedure, it shall be verified that the settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		P
GENERAL TEST CONDITIONS (frequency threshold and droop)		
The tests can either be carried out: – for specific frequency threshold and droop settings provided by the DSO and the responsible party, Or		P
by testing all three settings (a), (b) and (c) indicated in Table 6 representing the default value and the configuration range according EN 50549-1:2019.		P
As required by table 6 tests have been performed at 100%Pn and 50%Pn		P
The frequency sequence shall be selected according to Table 7 **Table 7 — Frequency points selection (over-frequency)** **Frequency point** / **Value [Hz]** f_1 — 50 Hz f_2 — $50\ Hz < f_{stop} < f_2 < f_{th}$ f_3 — $f_{th} < f_3 < f_4$ f_4 — $f_3 < f_4 < f_{max}$ [a] f_5 — f_{max} [a] [a] f_{max} as maximum frequencies limits as specified in 5.2.1		P
The frequency is changed using a rate of change of frequency not less than 1 Hz/s.		P
In case of fast acting response relative to the increase/decrease of the frequency this procedure might result in negative response time and settling time. If this occurs, a faster rate of change of frequency up to the maximum ride through capability of the generating unit should be applied or Negative times are considered as zero.		P
Tests for synchronous generating technology (Pref = Pmax)		N/A
Test for systems with energy storage (Pref = Pmax)		P
Tests for all other non-synchronous generating technology (Pref = PM)		N/A
During the procedure for setting (a) with power level at start of the test in partial load, of Figure 13, Figure 16 and Figure 19, after the activation of the function, the down regulation is released.		P
ACCEPTANCE CRITERIA		
The active power target value is calculated for each		P

Criteria	Comments	Result
frequency point according to the configured droop setting and Pref setting.		
The step response behaviour is measured as indicated in Figure 12 starting from the instant the frequency reaches the end value of the considered frequency point f2 to f5.		P
For the step response time and the settling time a tolerance band of ± 10 % Pn to the active power target value is considered.		P
Limited to Figure 14, Figure 17 and Figure 19: crossing the frequency threshold value, verify that the dead time of the generation unit is less than (e.g.) 2 s, and that the step response time is less than (e.g.) 30 s.		P
Limited to Figure 15, Figure 18 and Figure 21: crossing the frequency threshold value, verify that the step response time of the generation unit is equal to the intentional delay (e,g., 2s) ± 250 ms.		P
DOCUMENTATION		
1) test setup (test with complete generating system or at a test bench, type of test equipment);		P
2) operating mode of generating system including a description and the applied setting of all relevant parameters		P
For each conducted test		P
1) the dead time, step response time and settling time		P
2) active power response accuracy		P
3) applied ROCOF during the test		P

The compliances with the requirements of clause 5.4.3.2 of the standard are stated in section 5.4.3.2 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.3.2 Power response to underfrequency

The test has been done according to the clause 5.4.3.3 of the standard.

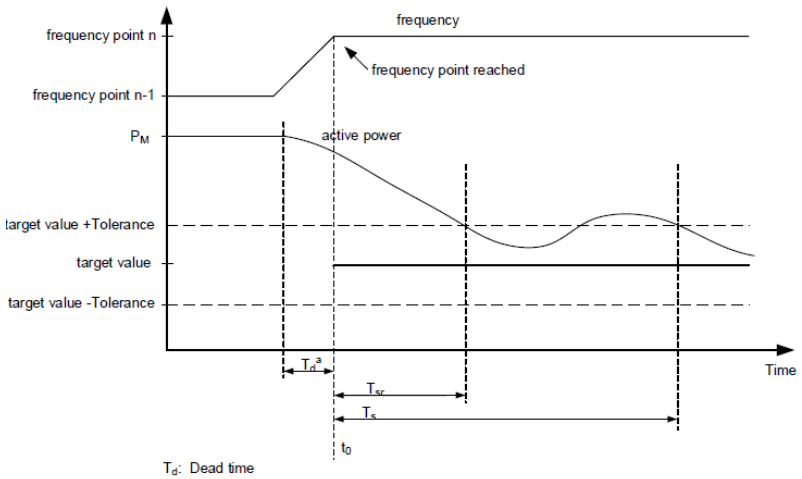
The following definitions apply to the test of this clause:

Table 9 — Frequency threshold and droop

	Setting (a)	Setting (b)	Setting (c)
threshold frequency f_{th} [Hz]	49,8	49,5	49,8
droop [%]	5	2	12
power level at start of test [% P_n]	−50 / 0 [a]	0 [a]	50 [a]
Intentional delay [s]	0	0	2
configured deactivation threshold	No	No	No
P_{ref}	P_{max}	P_{max}	P_{max}
[a] or minimum regulating level, whichever is higher			

Table 10 — Frequency points selection (under-frequency)

Frequency point	Value [Hz]
f_1	50 Hz
f_2	$f_{th} < f_2 < 50$ Hz
f_3	$f_{th} < f_3 < f_4$
f_4	$f_{min} < f_4 < f_3$
f_5	f_{min} [a]
[a] f_{min} as maximum frequencies limits as specified in 5.2.1	



T_d: Dead time
T_{sr}: Step response time
T_s: Settling time
[a] Negative times are considered as zero

Figure 12 — Example of power reduction

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
the following test setups are adopted		--
Setup n. 1: Tests on electrical generation system (4.2.2) or complete unit (4.2.1), with the grid simulator connected to the output of the generator (power port).	DC Source	P
Setup n. 2: Tests on electrical generation system (4.2.2) or complete unit (4.2.1), with the test signal generator (with full voltage range) connected to the control circuits of the generator according 4.2.8.		N/A
Setup n. 3: Tests on electrical generation system (4.2.2) or complete unit (4.2.1), with modification of the control parameters according 4.2.9.		N/A
During the test procedure, it shall be verified that the settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		P
GENERAL TEST CONDITIONS (frequency threshold and droop)		
The tests can either be carried out: – for specific frequency threshold and droop settings provided by the DSO and the responsible party, Or		N/A
by testing all three settings (a), (b) and (c) indicated in Table 9 representing the default value and the configuration range according EN 50549-1:2019.		P
As required by table 9 tests have been performed at -50%Pn and 0%Pn (Instead of 0%Pn minimum regulating level if higher)		P
The frequency sequence shall be selected according to Table 10 **Table 10 — Frequency points selection (under-frequency)** Frequency point / Value [Hz] f_1 / 50 Hz f_2 / $f_{th} < f_2 < 50$ Hz f_3 / $f_{th} < f_3 < f_4$ f_4 / $f_{min} < f_4 < f_3$ f_5 / f_{min} [a] [a] f_{min} as maximum frequencies limits as specified in 5.2.1		P
The frequency is changed using a rate of change of frequency not less than 1 Hz/s.		P
In case of fast acting response relative to the increase/decrease of the frequency this procedure might result in negative response time and settling time. If this occurs, a faster rate of change of frequency up to the maximum ride through capability of the generating unit should be applied or Negative times are considered as zero.	Step increase/decrease of the frequency	P
Test for systems with energy storage (Pref = Pmax)		P
Tests for all other non-synchronous generating technology (Pref = Pmax)		N/A

ACCEPTANCE CRITERIA		
The active power target value is calculated for each frequency point according to the configured droop setting and Pref setting		P
The step response behaviour is measured as indicated in Figure 12 starting from the instant the frequency reaches the end value of the considered frequency point f2 to f5.		P
For the step response time and the settling time a tolerance band of ± 10 % Pn to the active power target value is considered.		P
Limited to Figure 23: crossing the frequency threshold value, verify that the dead time of the generation unit is less than (e.g.) 2 s, and that the step response time is less than (e.g.) 30 s.		P
Limited to Figure 24: crossing the frequency threshold value, verify that the step response time of the generation unit is equal to the intentional delay (e,g., 2s) ± 250 ms.		P
DOCUMENTATION		
1) test setup (test with complete generating system or at a test bench, type of test equipment);		P
2) operating mode of generating system including a description and the applied setting of all relevant parameters		P
For each conducted test		P
1) the dead time, step response time and settling time		P
2) active power response accuracy		P
3) applied ROCOF during the test		P

The compliances with the requirements of clause 5.4.3.3 of the standard are stated in section 5.4.3.3 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.4. POWER SPECIFICATION AND RESPONSE TO VOLTAGE VARIATIONS

4.4.1. Power capabilities assessment - voltage support by reactive power

The tests have been done according to the clause 5.5.1 of the standard.

The aim of this measurement is to determine:
– the values of the rated current, of the maximum active power (Pmax) and of the maximum apparent power (Smax) of the EUT; (**5.5.1.3)**
– the maximum possible underexcited (Qmax under) and overexcited (Qmax over) reactive power capability of the EUT as function of the active power; this includes verification of the reactive power limits valid at maximum active power condition; (**5.5.1.3)**
– the dependency of the reactive power capability to voltage according to **5.5.1.6**.

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
The following test setups are adopted		--
In case of a PV generating unit, replacement of the PV generator by a DC source (e.g a PV array Simulator) (4.2.2).	DC Source	P
In case of full converter generating units (Wind or CHP), replacement of the Generator and the generator side inverter/rectifier by a DC source, if there are no control links with the primary source side (4.2.2).		N/A
In case of a generating unit having batteries as a power supply, replacement of the Battery by a bidirectional DC source operating at the minimum input voltage (4.2.2).	DC Source	P
In case of DFIG generating units, replacement of the mechanical drive system by a test bench motor (4.2.2).		N/A
In case of a generating unit coupled with a synchronous generator, replacement of the mechanical drive system by a test bench motor (4.2.2).		N/A
In case of synchronous generating technology, the test can be conducted as Test by calculation and numerical simulation for generating units of synchronous generating technology according to 4.2.11.		N/A
GENERAL TEST CONDITIONS		
– Measurements shall be sampled during continuous operation only. Measurements shall be recorded and evaluated as 1 min average values. For the determination of the dynamic behaviour, 1 period RMS values shall be evaluated.		P
The active and reactive power shall be calculated based on the positive sequence component of the fundamental of the voltages and currents at the generating unit terminals.		P
The active power, reactive power and the active factor, frequency, RMS voltage, RMS current at the generating unit terminals shall be recorded during tests.		P

The maximum underexcited and overexcited reactive power shall be measured over a period of 1 min for each 10 % of Pn from 0 % to maximum active power as declared by manufacturer.		P
Once the procedure is completed, the operating points with the highest measured value for active power, reactive power and apparent power respectively shall be adjusted once more and maintained for 10 min for the evaluation of Pmax, Smax and Qmax over and Qmax under.		P
The values Pmax, Smax and Qmax over and Qmax under shall be measured over a period of 10 min.		P
The measurements shall be carried out once the set point is reached stabilized. Voltage variation once reached stabilized condition shall not exceed 3 %.		P
The test procedure may either – Reactive power priority mode: conduct all active power levels for one reactive power set point and repeat the process for each reactive power set point Qmax over, Qmax uner, Q = 0; or		P
– Active power priority mode: conduct all reactive power set points Qmax over, Qmax under, Q = 0 for one active power level and repeat the process for each active power level to be tested.		N/A
ACCEPTANCE CRITERIA		
The generating unit is able to meet the reactive power value of the capability curve in overexcited and underexcited condition as declared by the manufacturer. In particular the values are reached and maintained for the specified time.		P
During the test, the generated active power shall be kept stable within ± 5 %*Sn compared to the value set for the entire duration of each test sequence.		P
DOCUMENTATION		
The measured results for Pmax, Smax and Qmax over and Qmax under. For each value the measured data are evaluated and the maximum value over a period of 600 s, 60 s and 0.2 s shall be stated in the report.		P

The compliances with the requirements of clause 5.5.1 of the standard are stated in section 5.5.1 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

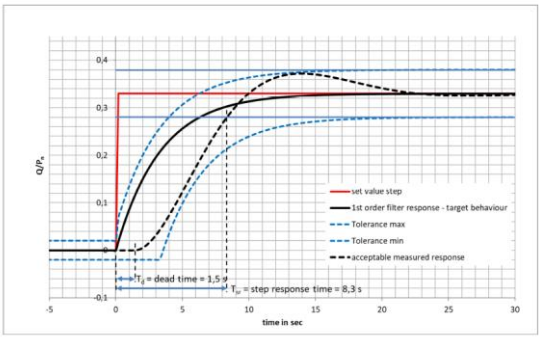
4.5. VOLTAGE SUPPORT BY REACTIVE POWER - TEST TO DETERMINE THE REACTIVE POWER CONTROL MODES

The tests have been done according to the clause 5.5.2 of the standard.

4.5.1. Verification procedure for Set point control

According to the clause 5.5.2.3 of the standard.

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
the following test setups are adopted		--
In case of a PV generating unit, replacement of the PV generator by a DC source (e.g a PV array Simulator) (4.2.2).	DC Source	P
In case of full converter generating units (Wind or CHP), replacement of the Generator and the generator side inverter/rectifier by a DC source, if there are no control links with the primary source side (4.2.2).	DC Source	N/A
In case of a generating unit having batteries as a power supply, replacement of the Battery by a bidirectional DC source operating at the minimum input voltage (4.2.2).	DC Source	P
In case of DFIG generating units, replacement of the mechanical drive system by a test bench motor (4.2.2).		N/A
In case of a generating unit coupled with a synchronous generator, replacement of the mechanical drive system by a test bench motor (4.2.2).		N/A
In case of synchronous generating technology, the test can be conducted as Test by calculation and numerical simulation for generating units of synchronous generating technology according to 4.2.11.		N/A
Voltage, current, active power and reactive power shall be recorded as 10-period RMS values (positive sequence components for 3-phase generating units).		P
GENERAL TEST CONDITIONS (Accuracy)		
The test shall be performed according to what is stipulated below: – Active power equal to 50 % ± 10 % Pn.		P
– If the maximum reactive power operating range according to the measured P-Q diagram (see 4.4.1) can be achieved at different load conditions, the test shall be repeated at that active power conditions.		P
If the response time or time constant of the Q-control can be adjusted, the test may be performed at the default time setting as specified by the manufacturer, or any time setting as suitable for the test and test setup.		P
Power factor control mode additional tests (if specified by the manufacturer)		P
Voltage Set control mode additional tests (if specified by manufacturer)		P
GENERAL TEST CONDITIONS (Dynamic Behaviour)		
The test shall be performed for an active power level, at which at least 90 % of the maximum reactive power operating range according to the measured P-Q diagram (see 4.4.1) can be achieved.		P
If the time constant of the Q-control can be adjusted, the		P

Criteria	Comments	Result
tests shall be performed with the shortest possible time constant (not longer than 3 s).		
and the longest possible time constant. If the time constant is adjustable to values above 60s.		P
it is considered acceptable to test with a time constant of 60s instead of the longest possible setting.		P
Power factor control mode additional tests (if specified by the manufacturer)		P
Voltage Set control mode additional tests (if specified by manufacturer)		P
ACCEPTANCE CRITERIA		
– Reactive power set point control accuracy (static reactive power value) is better than 2 % Smax.		P
In case of cos φ set points, the reactive power accuracy applies for the reactive power set value derived from the cos φ set point and the active power during the measurement.		P
the time response of the reactive power during the measurement is within the tolerance band resulting from the behaviour of an equivalent first order filter element and the configured time constant *tau*. Accepted tolerances are ± 5 %Pn for the reactive power values and 3 s for the time delay deviating from an ideal first order filter response.		P
The tolerance band calculated according to Table 14 (see also Figure 32).  Figure 32 — Example graphical representation of step response behaviour for a step from Q = 0 to Q = 0,33 % P_n with a time constant configured to a value equal to 3,33 s (settling time $3 \times \tau = 10$ s).		P
DOCUMENTATION		
Description of the interface used to provide reactive power set points, all relevant settings of the EUT related to reactive power control.		P

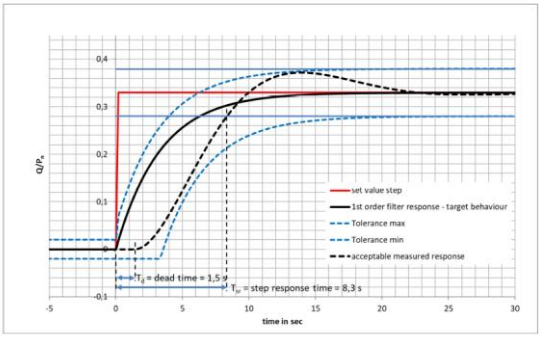
The compliances with the requirements of clause 5.5.2.3 of the standard are stated in section 5.5.2.3 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.5.2. Verification procedure for voltage related control mode for reactive power Q(U)

The tests have been done according to the clause 5.5.2.4 of the standard.

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
the following test setups are adopted		--
In case of a PV generating unit, replacement of the PV generator by a DC source (e.g a PV array Simulator) (4.2.2).	DC Source	P
In case of full converter generating units (Wind or CHP), replacement of the Generator and the generator side inverter/rectifier by a DC source, if there are no control links with the primary source side (4.2.2).	DC Source	N/A
In case of a generating unit having batteries as a power supply, replacement of the Battery by a bidirectional DC source operating at the minimum input voltage (4.2.2).	DC Source	P
In case of DFIG generating units, replacement of the mechanical drive system by a test bench motor (4.2.2).		N/A
In case of a generating unit coupled with a synchronous generator, replacement of the mechanical drive system by a test bench motor (4.2.2).		N/A
In case of synchronous generating technology, the test can be conducted as Test by calculation and numerical simulation for generating units of synchronous generating technology according to 4.2.11.		N/A
If the conformity assessment is conducted for a specific grid code, the EUT control shall be configured as defined in this grid code.		N/A
If the conformity assessment is conducted in general, the configuration shall be chosen in a way that each parameter shall be tested once configured to its minimum and once to its maximum according to the principle given in Table 17 and Table 18.		P
Depending on the used test set up one of the following methods can be used:		P
– utilizing a grid simulator in case of test on the complete generating unit or the electrical generation system or	Grid simulator	P
– simulating to the measurement inputs of the control unit or to measurement sensors of the EUT instead of to the terminals of the EUT		N/A
– modifying the reading of the voltage measurement of the EUT control system, or		N/A
– modifying the threshold parameters and characteristic curve that define the EUT response as a function of the measured voltage.		N/A
GENERAL TEST CONDITIONS		
The relevant values shall be measured as follows: – Voltage, current, active power and reactive power shall be recorded as 10-period RMS values (positive sequence components for 3-phase generating units).		P
– The step response behaviour is measured starting from the instance of the voltage jump. For the step response time and the settling time a tolerance band of ± 5 %Pn to the reactive power set point is considered.		P
– The static reactive power value is measured considering the mean value over 30 s. The		P

Criteria	Comments	Result
measurement starts from the instant the generated power reaches the reactive power target value ± 2 % Pn for the first time.		
ACCEPTANCE CRITERIA		
The test of the accuracy conditions shall be considered passed if:		--
The measured 30-s averages of the reactive power (positive sequence components) during steady-state conditions are within a tolerance band of ± 2 % Smax and ± 1 % Un of the set Q(U) characteristic including correct behaviour related to Lock-in/Lock-out and min cos φ.		P
The test of the dynamic behaviour shall be considered passed if:		--
The tolerance band calculated according to Table 14 (see also Figure 32).  Figure 32 — Example graphical representation of step response behaviour for a step from Q = 0 to Q = 0,33 % P_n with a time constant configured to a value equal to 3,33 s (settling time $3 \times \tau = 10$ s).		P
No discontinuities in the characteristic curve are detected and no oscillations of the reactive power after the end of the transient period of 5 τ as configured and no disconnection of the EUT occur		P
Correct functioning of lock-in and lock-out thresholds if activated: Q(U) is disabled for power levels below the lock-out setting and enabled again if the active power is above lock-in threshold		P
Correct functioning of minimum active factor if activated: The reactive power value is reduced for small active power to maintain the configured minimum active factor. The accuracy requirement for the active factor set point applies.		P
The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		P
DOCUMENTATION		
Description of the interface used to provide reactive power set points, all relevant settings of the EUT related to reactive power control.	Modbus TCP/IP	P

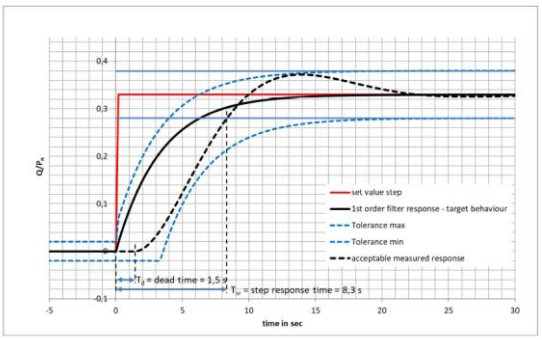
The compliances with the requirements of clause 5.5.2.4 of the standard are stated in section 5.5.2.4 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.5.3. Verification procedure for power related control modes for reactive power

The tests have been done according to the clause 5.5.2.5 of the standard.

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
the following test setups are adopted		--
In case of a PV generating unit, replacement of the PV generator by a DC source (e.g a PV array Simulator) (4.2.2).	DC Source	P
In case of full converter generating units (Wind or CHP), replacement of the Generator and the generator side inverter/rectifier by a DC source, if there are no control links with the primary source side (4.2.2).	DC Source	N/A
In case of a generating unit having batteries as a power supply, replacement of the Battery by a bidirectional DC source operating at the minimum input voltage (4.2.2).	DC Source	P
In case of DFIG generating units, replacement of the mechanical drive system by a test bench motor (4.2.2).		N/A
In case of a generating unit coupled with a synchronous generator, replacement of the mechanical drive system by a test bench motor (4.2.2).		N/A
In case of synchronous generating technology, the test can be conducted as Test by calculation and numerical simulation for generating units of synchronous generating technology according to 4.2.11.		N/A
If the conformity assessment is conducted for a specific grid code, the EUT control shall be configured as defined in this grid code.		N/A
If the conformity assessment is conducted in general, the configuration shall be chosen in a way that each parameter shall be tested once configured to its minimum and once to its maximum according to the principle given in Table 17		P
and Table 18.		N/A
Depending on the used test set up one of the following methods can be used:		P
– utilizing a grid simulator in case of test on the complete generating unit or the electrical generation system or	Grid simulator	P
– simulating to the measurement inputs of the control unit or to measurement sensors of the EUT instead of to the terminals of the EUT		N/A
– modifying the reading of the voltage measurement of the EUT control system, or		N/A
– modifying the threshold parameters and characteristic curve that define the EUT response as a function of the measured voltage.		N/A
GENERAL TEST CONDITIONS		
The relevant values shall be measured as follows: – Voltage, current, active power and reactive power		P

Criteria	Comments	Result
shall be recorded as 10-period RMS values (positive sequence components for 3-phase generating units).		
– The step response behaviour is measured starting from the instance of the voltage jump. For the step response time and the settling time a tolerance band of ± 5 %Pn to the reactive power set point is considered.		P
– The static reactive power value is measured considering the mean value over 30 s. The measurement starts from the instant the generated power reaches the reactive power target value ± 2 % Pn for the first time.		P
ACCEPTANCE CRITERIA		
The test of the accuracy conditions shall be considered passed if:		--
The measured 30-s averages of the reactive power during steady-state conditions are within a tolerance band of ± 2 % Smax around the reactive power set point resulting from the measured active power and the given cos φ (P) or Q (P) characteristic.		P
The test of the dynamic behaviour shall be considered passed if:		--
The tolerance band calculated according to Table 14 (see also Figure 32).  Figure 32 — Example graphical representation of step response behaviour for a step from Q = 0 to Q = 0,33 % P_n with a time constant configured to a value equal to 3,33 s (settling time $3 \times \tau = 10$ s).		P
No discontinuities in the characteristic curve are detected and no oscillations of the reactive power after the end of the transient period of 5 τ as configured and no disconnection of the EUT occur		P
Correct functioning of lock-in and lock-out thresholds if activated.		P
The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		P
DOCUMENTATION		
Description of the interface used to provide reactive power set points, all relevant settings of the EUT related to reactive power control.	Modbus TCP/IP	P

The compliances with the requirements of clause 5.5.2.5 of the standard are stated in section 5.5.2.5 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.5.4. Voltage related active power reduction - P(U)

The test has been done according to the clause 5.6 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 compliances with the requirements of clause 5.6 of the standard are stated in section 5.6 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.6. EMC AND POWER QUALITY

According to clause 5.7 of the standard, this part is divided on EMC and Power Quality.

Regarding EMC requirements as per 5.7.1 all electric and electronic equipment to be installed under the scope of this standard shall be in compliance with relative standards for Electromagnetic Compatibility, according to the requirements established in Directive 2014/30/EU or 2014/53/EU, whichever applies.

Regarding Power Quality the following evaluations have been performed as per 5.7.2 of the standard.

4.6.1 Verification procedure for harmonics, interhamonics and higher frequencies up to 9 kHz

The test has been done according to the clause 5.7.2.1 of the standard EN 61000-3-2 for units with rated current ≤ 16A; EN 61000-3-12 for units with rated current > 16A and ≤ 75A; Or for units with rated current > 75A EN 61000-4-7

The compliances with the requirements of clause 5.7.2.1 of the standard are stated in section 5.7.2.2 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.6.2 Verification procedure for flicker and rapid voltage changes

The test has been done according to the clause 5.7.2.3 of the standard.

4.6.2.1 Flickers

Following standards have been used for verification:
– EN 61000-3-3 for devices with a rated current of 16 A.
– EN IEC 61000-3-11 for devices with a rated current of 16 A and 75 A
– EN IEC 61000-3-11 also used for determining flickers for units with a rated current > 75 A

The compliances with the requirements of clause 5.7.2.3 of the standard are stated in section 5.7.2.3.2 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.6.2.2 Rapid voltage changes

The rapid voltage changes test has been measured according to chapter 5.2.2 of VDE V 0124-100:2020-06, at the required conditions. The maximum voltage change shall not exceed a value of $\Delta U_a \leq 3\%$ according to chapter 5.3 of VDE AR-N 4105:2018-11 and it is calculated as follows:

$$\Delta u_a = k_{imax} \cdot \frac{S_{rE}}{S_{kV}}$$

- S_{rE} is the rated apparent power of inverter.
- S_{kV} is the network short circuit power.

k_{imax} is calculated as the ratio of the highest current occurring during a switching operation (e.g. starting or connecting current or the highest breaking current under normal operating conditions) to the normal generator current I_{rE}.

The four following cases (if applicable) according to VDE-AR-N 4105: 2018-11, Appendix E.5 must each be tested three times.

The compliances with the requirements of clause 5.7.2.3 of the standard are stated in section 5.7.2.3.4 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.6.3 Verification procedure for DC injection

Tests performed according 5.7.2.4 of the standard.

Criteria	Comments	Result
GENERAL TEST CONDITIONS & ACCEPTANCE CRITERIA		
The supply voltage shall meet the following conditions: – Mains voltage: nominal value ± 1 % – Network frequency: 50Hz ± 0.2Hz – THD of the mains voltage: < 2.5 % (with the inverter off) – When using network simulators: DC component of the voltage < 0.1 %		P
For each operating point wait 5 min, or for reaching a stable operating temperature (depending on the event that occurs later).	Equipment worked for 3h before test.	P
The DC currents generated into the grid are then recorded in all phases for at least 5 min.		P
The measurement of DC currents takes place over 10 fundamental oscillation periods according to EN 61000-4-7.	Max and Avg values calculated from 10 fundamental period values	P
Also measure and record the RMS current and the inverter output RMS voltage.		P
Calculate the average value of the DC current on each phase. The average shall be calculated considering the modulus (unsigned) of the value of each sample recorded during each observation period of 5 min (on the 3 levels of power).		P
This test is passed if the DC current in the test above for all 5 min average values calculated is lower than 0.5 % of nominal current or 20 mA whatever is the higher value.	0.5 % of nominal current	P

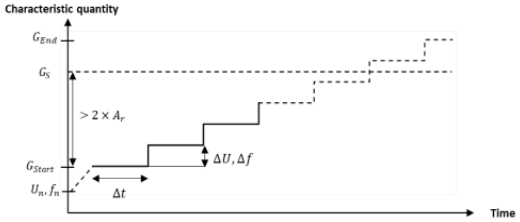
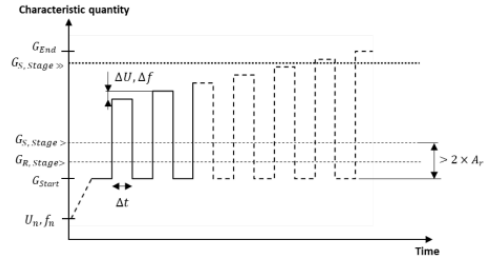
The compliances with the requirements of clause 5.7.2.4 of the standard are stated in section 5.7.2.4 of following test report:

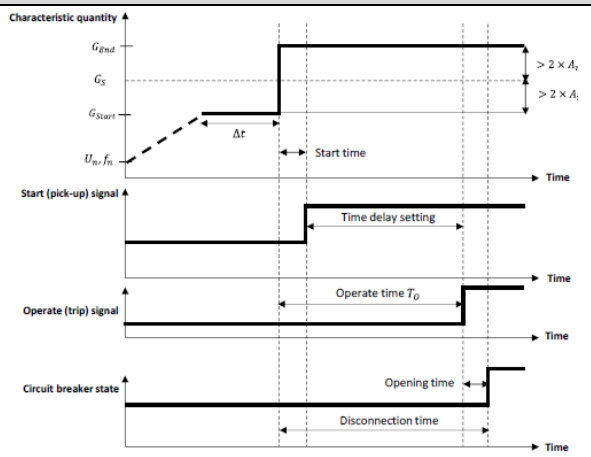
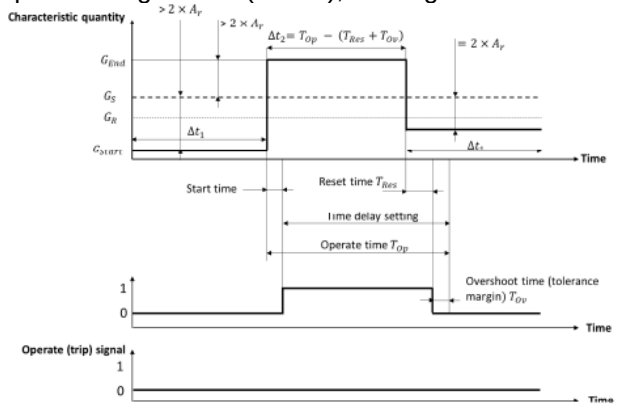
EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.7. INTERFACE PROTECTION

The test has been done according to the clause 5.8.3 of the standard.

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
For interface protections as internal device the verification process can be conducted as:		--
Test on complete generating unit (4.2.1);		P
Test on the electrical generation system (4.2.2);		N/A
Test at limited power (4.2.5);		P
Test on stopped generating unit (4.2.6);		N/A
Simulated input test, in this case the test with simulated input shall include the complete measurement chain of the interface protection (4.2.8).		N/A
In case of re-testing of previously tested generating unit with similar ratings and hardware components in application of 4.5 the test may be performed as Test of the real generating unit control unit in a simulated environment according 4.2.12. The valid response of the C-HIL model shall be demonstrated based on the results of the initial tests performed on the complete generating unit or electrical generating system.		N/A
For interface protections as dedicated device the verification process can be conducted as: – Component test on an independent component (4.2.7);		N/A
Verification of the function and the settings range, according:		P
Assess the performance over the entire setting range: settings Used, 0 %; 30 %; 60 %; 100 % of maximum setting for the range. Or		P
verify a specific setting, as associated to specific technical requirements (e.g. grid codes)		P
The test of an integrated interface protection without test terminal block shall be carried out on a network simulator that emulates a power network which the EUT is connected to.	No Terminal Block	N/A
The test of an interface protection as dedicated device or integrated device with test terminal block can alternatively be tested with a relay tester or on a network simulator.		N/A
GENERAL TEST CONDITIONS		
Before each test the interface protection shall be operated at symmetrical nominal voltage and nominal frequency until all protection functions are in reset condition but at least 10 s.		P
Each test shall be performed 3 times to ensure the repeatability of results.	On results tables below, it is shown the most unfavorable result of the 3 repetitions performed for each test.	P
In case of three-phase interface protection, a symmetric three-phase system, all phase to neutral and all phase to phase voltages shall be tested.	Protection system is used in a 3 phase system where a neutral conductor is present.	P
If a protection system does only feature phase-phase evaluation, only the phase-phase protection principle shall be tested.		N/A

Criteria	Comments	Result
In case of single-phase interface protection, protection is tested for the active phase only.		N/A
SPECIFIC VOLTAGE TESTS CONDITIONS		
During the test it shall be ensured that no voltage other than the voltage defined as characteristic quantity exceeds one of the setting value. To achieve this:		P
– the protection functions not currently tested may be deactivated;		P
– for tests related to phase to neutral protection function, a voltage system defined as described in Figure 38a), which apply for the undervoltage protection of the phase A to neutral N voltage, may be used;		P
– for tests related to phase to phase protection function, a voltage system defined as described in Figure 38b), which apply for the undervoltage protection of the phase A to phase C voltage, may be used.		P
ACCURACY TEST CONDITIONS		
The test method shall be based on a voltage or frequency ramp (Ramp), see Figure 39 applicable for an overvoltage/frequency.  Figure 39 — Ramp signal test (*Ramp*)		P
When testing the second protection stage (> >), there is a risk of operation (tripping) due to the first protection stage (>). This may be prevented by temporarily deactivating the first protection stage or		P
By a pulse ramp as shown in Figure 40.  Figure 40 — Pulsed ramp test signal (testing of second stage > >)		N/A
START, OPERATE AND DISCONNECTION TIMES TEST CONDITIONS		
These durations shall be determined with a jump signal test (jump), see Figure		P

Criteria	Comments	Result
 41 Figure 41 — Jump signal test (*jump*)		
RESET TIME AND RESET RATIO TEST CONDITIONS		
Evidence of compliance with the requirement related to the reset time and the reset ratio shall be based on a non-operation signal test (NOP), see Figure 42  Figure 42 — Non-operation signal test (*NOP*)		P
ACCEPTANCE CRITERIA ACCURACY, TIMES & RESET RATIO		
1)Tests with ramp signal (Ramp), are considered passed if for all tests the difference between the setting value and measured value is less than the required accuracy for the voltage and for the frequency.	Considered limits from EN 50549-1:2019. Voltage measurement accuracy of 1 % Un; Frequency accuracy of 0.05 Hz.	P
2)Tests with jump signal (Jump), are considered passed if the operate time is equal to or below the configured time delay setting plus the start time as stated in the product documentation.		P
3) For criteria 1) and 2) it is ensured that no voltage other than the voltage to be tested exceeds one of the setting values		P
4) For tests with non-operation signal (NOP) the relay does not operate.		P
5) If the interface protection operates the interface switch opens.		P
6) The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		P
ACCEPTANCE CRITERIA OVERVOLTAGE 10 MIN MEAN PROTECTION		

Criteria	Comments	Result
The test is considered passed if		--
1) For tests U10M 1 and U10M 3 if the operation occurs between T1 and T2 after the jump, see Figure 43		P
2) For tests U10M 2 if no operation occurred within and after 600 s, see Figure 43.		P
3) The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		P
ACCEPTANCE CRITERIA ROCOF protection		
The test is considered passed if		--
1) For test item RVAL POS 2 and RVAL NEG 2, the protection function operates, and operate time is equal to or below the configured time delay setting plus the start time as stated in the product documentation.		P
2) For test item RVAL POS 1, RVAV NEG 1, NOP POS and NOP NEG, the protection function does not operate.		P
3) If the interface protection operates the interface switch opens.		P
4) The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		P

4.7.1 Voltage protection

The compliances with the requirements of clause 5.8.3 of the standard are stated in section 5.8.3.2 & 5.8.3.2.4 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.7.2 Frequency protection

The compliances with the requirements of clause 5.8.3 of the standard are stated in section 5.8.3.2 & 5.8.3.2.4 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.7.3 Immunity to voltage harmonics

Tests performed according 5.8.3.2.6 of the standard.

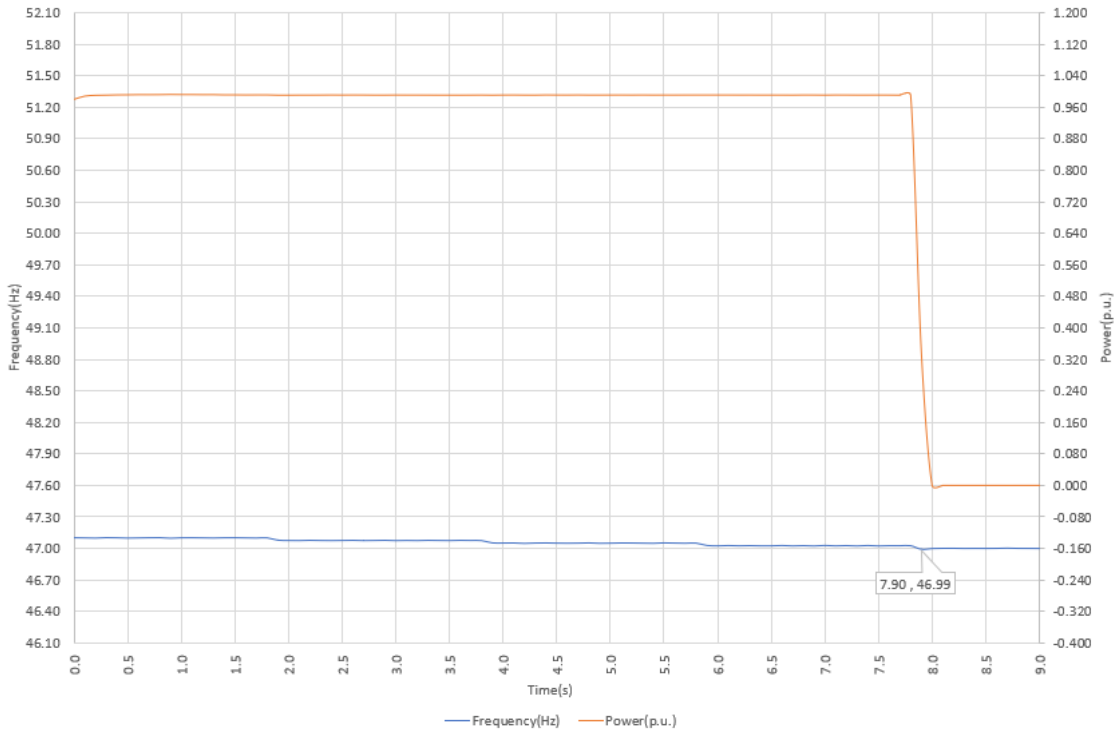
Table C.1 — EN IEC 60255-181:2019 Table 26 – Superimposed harmonics

Order of harmonics	Harmonics percentage H_k
2	3 %
3	6 %
4	1,5 %
5	8 %
6	1 %
7	7 %
8	1 %
9	2,5 %
10	1 %
11	5 %
12	1 %
13	4,5 %
14	1 %
15	2 %
16	1 %
17	4 %
18	1 %
19	3,5 %
20	1 %
21	1,75 %
22	1 %
23	2,8 %
24	1 %
25	2,6 %
26 to 40	1 %

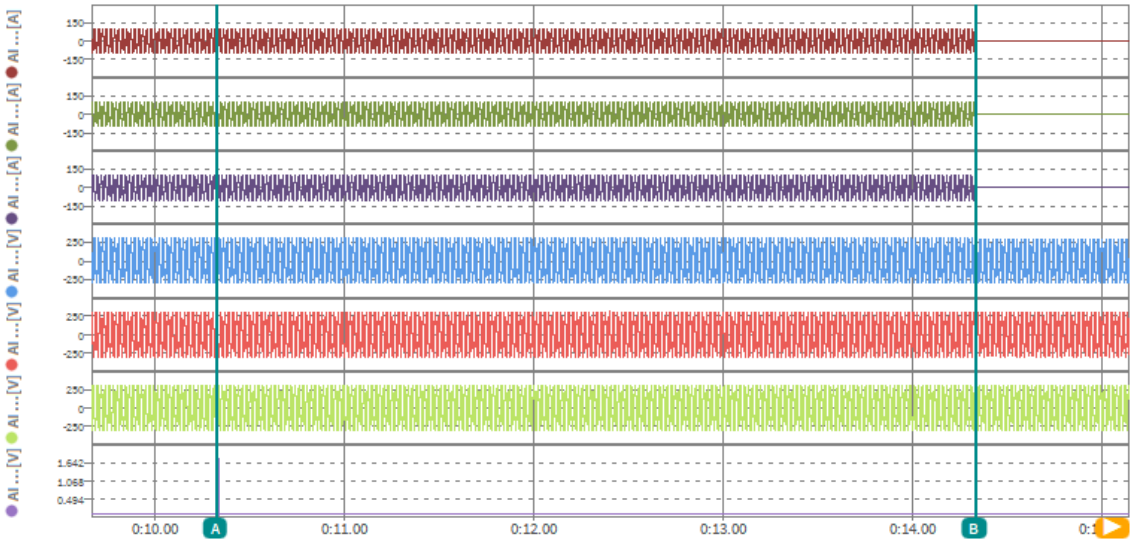
4.7.3.1 The test item f < 1 shall be repeated under the voltage conditions as described in EN 60255-181:2019, Table 26

Trip Value						
Test Condition	**Fault type**	**f_{set} (Hz)**	**f_{start} (Hz)**	**f_{step} (Hz)**	**Step Time (ms)**	**Meas f (Hz)**
f < 1	3-Phase (L123)	47.00	47.10	0.025	300	46.99
Trip Time						
Test Condition	**Fault type**	**T_{set} (ms)**	**f_{start} (Hz)**	**f_{step} (Hz)**	**Step Time (ms)**	**Meas Time (Hz)**
f < 1	3-Phase (L123)	4000	47.10	0.200	8000	3999

Trip Value



Trip Time

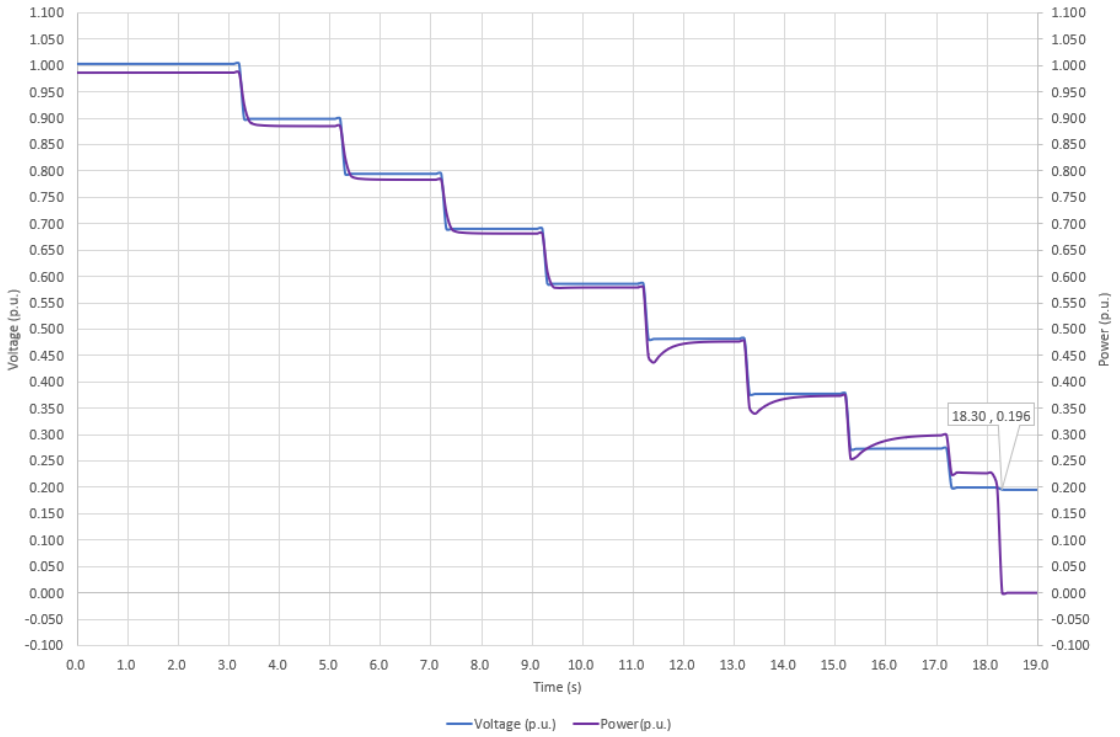


	A	B	间隔
时间 [s]	0:10.33090	0:14.33050	3.99960
AI 1/I1 [A]	51.07067	-2.105741	-53.17641
AI 1/I2 [A]	56.30660	0.348323	-55.95827
AI 1/I3 [A]	-102.4474	0.279516	102.7269
AI 1/U1 [V]	167.2088	-28.95317	-196.1620
AI 1/U2 [V]	185.9548	-264.4925	-450.4473
AI 1/U3 [V]	-310.3937	269.0572	579.4509
AI 1/U4 [V]	-4.985e-3	-5.939e-3	-9.537e-4

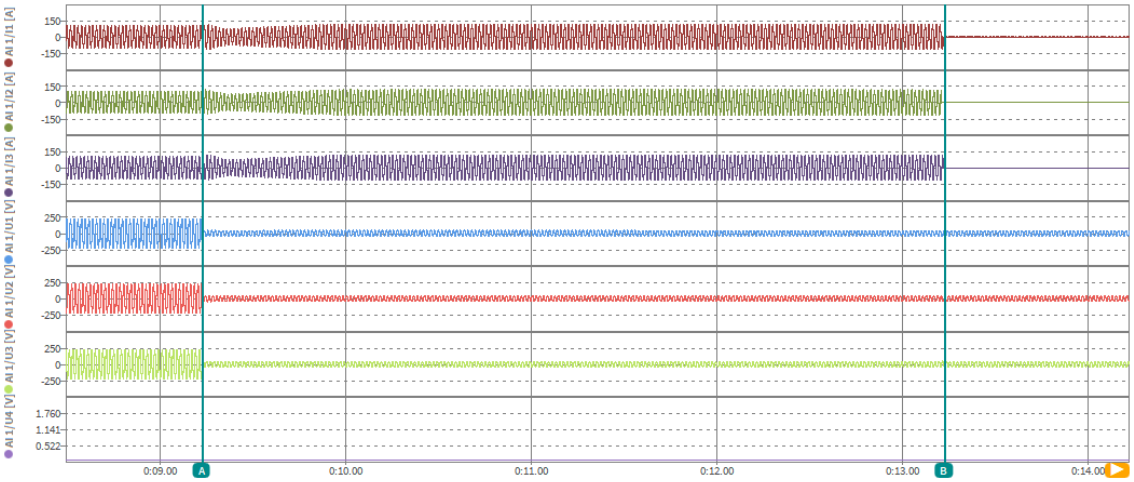
4.7.3.2 The test item U < 1 shall be repeated under the voltage conditions as described in EN 61000-4-13:2002, able 8 class 3.

Trip Value						
Test Condition	**Fault type**	**V_{set} (%Un)**	**V_{start} (%Un)**	**V_{step} (%Un)**	**Step Time (ms)**	**Meas V (%Un)**
U < 1	3-Phase (L123)	20.0	22.0	0.5	300	19.6
Trip Time						
Test Condition	**Fault type**	**T_{set} (ms)**	**V_{start} (%Un)**	**V_{step} (%Un)**	**Step Time (ms)**	**Meas Time (ms)**
U < 1	3-Phase (L123)	4000	22.0	4.0	8000	3997

Trip Value



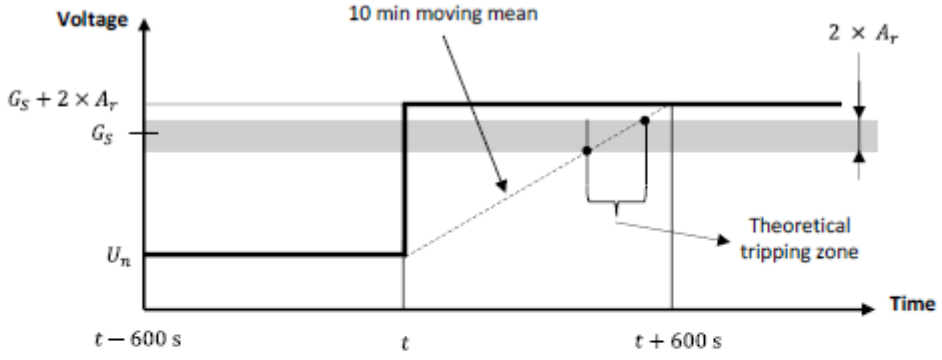
Trip Time



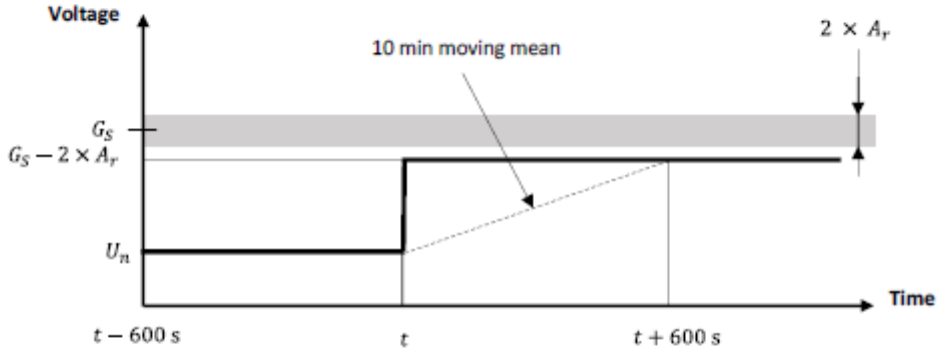
	A	B	间隔
时间 [s]	9.22926	0:13.22596	3.99670
AI 1/I1 [A]	-80.50445	-0.111131	80.39332
AI 1/I2 [A]	94.32006	-0.010259	-94.33032
AI 1/I3 [A]	-17.28764	-5.156e-3	17.28249
AI 1/U1 [V]	-167.3571	15.75532	183.1124
AI 1/U2 [V]	221.7198	33.18835	-188.5314
AI 1/U3 [V]	-93.21892	-42.85943	50.35949
AI 1/U4 [V]	-0.020721	-0.025251	-4.530e-3

4.7.4 Overvoltage 10 min mean protection

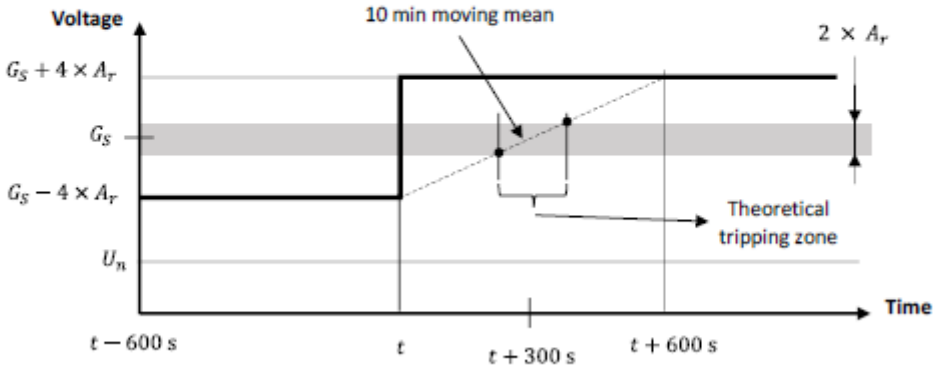
Test performed according 5.8.3.3 of the standard



Test U10M 1



Test U10M 2



Test U10M 3

The compliances with the requirements of clause 5.8.3.3 of the standard are stated in section 5.8.3.3 & 5.8.3.2.4 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.7.5 ROCOF protection

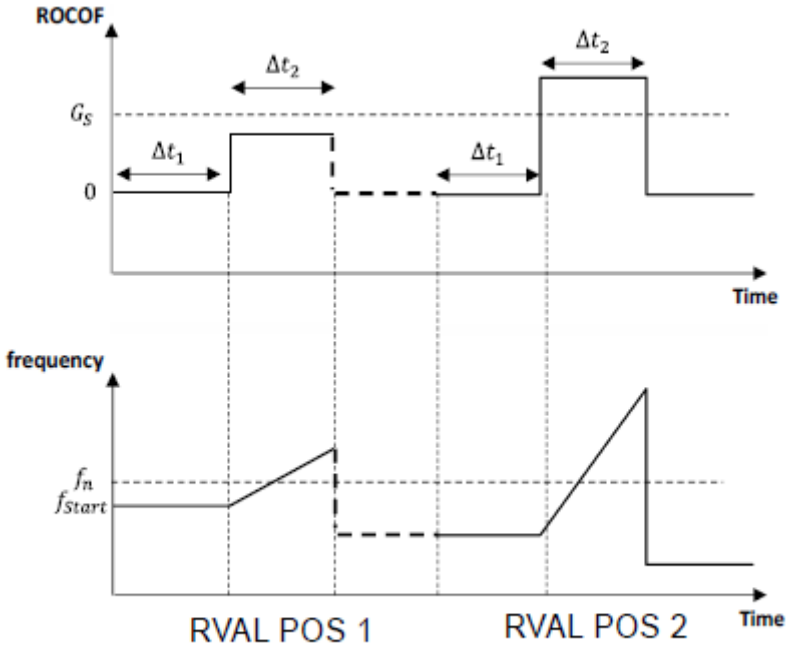


Figure 44 — ROCOF jump tests sequence (2 tests)

The compliances with the requirements of clause 5.8.3.4 of the standard are stated in section 5.8.3.4 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.7.6 Means to detect island situation

The test has been done according to the clause 5.8.6 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.

The compliances with the requirements of clause 5.8.6 of the standard are stated in section 5.8.6 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.7.7. Requirements on voltage and frequency protection (Country / Region included in the default settings: Sweden) (*)

Add test **A.20 SE – Sweden** for interface protection according to Annex A of the standard EN 50438: 2013 as following:

(*) This test is not under A2LA accreditation. No quantitative general conclusion is referred to the accredited testing.

Parameter	Time(s)	Setting
Over-voltage (stage 2)	60	230 V + 11 %
Over-voltage (stage 1)	0.2	230 V + 15 %
Under-voltage (stage 1)	0.2	230 V – 15 %
Over-frequency	0.5	51.0 Hz
Under frequency	0.5	47.0 Hz
Loss of Mains (LoM)	0.15	--

The minimum required accuracy is:

- for frequency measurement ± 0.05 Hz;
- for voltage measurement ± 1 % of Un

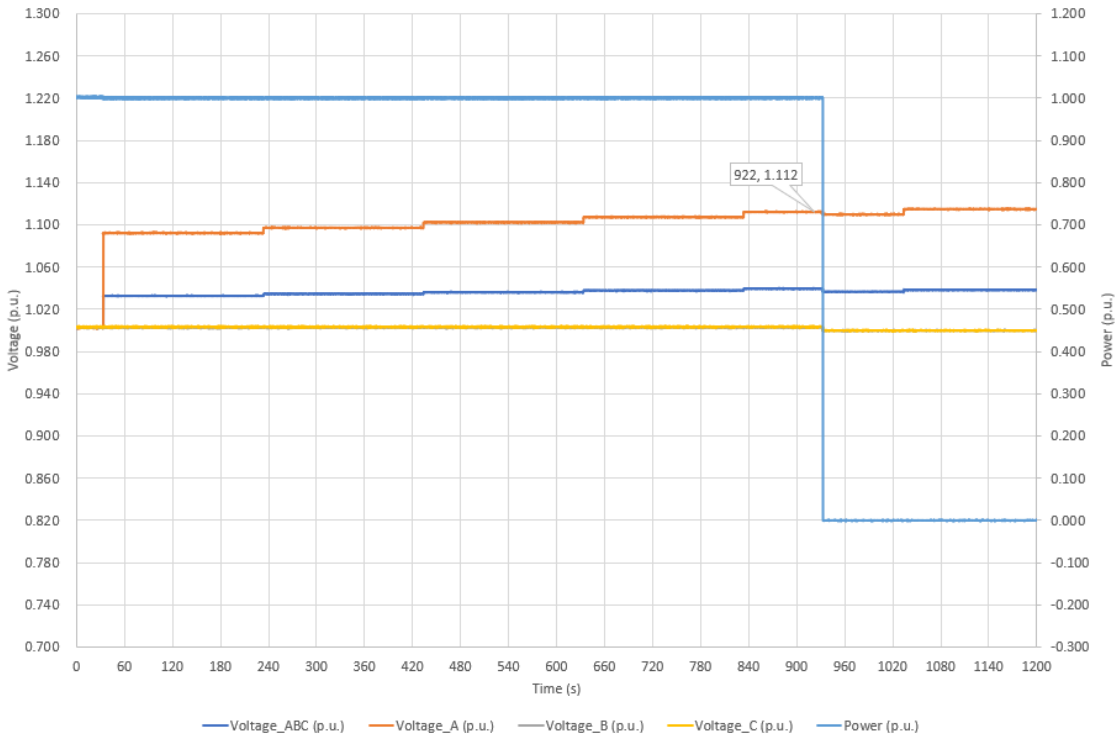
4.7.7.1 Overvoltage protection (Country / Region: Sweden)

Overvoltage of 111%Un (stage 2)				
Phase A				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	255.3	255.8	255.8	255.8
Trip time [s]	< 60.000	59.912	59.923	59.640
Phase B				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	255.3	255.8	255.8	255.8
Trip time [s]	< 60.000	59.813	59.780	59.976
Phase C				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	255.3	256.0	256.0	256.0
Trip time [s]	< 60.000	59.898	59.716	59.911
Phase ABC				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	255.3	255.8	255.8	255.8
Trip time [s]	< 60.000	59.813	59.774	59.923

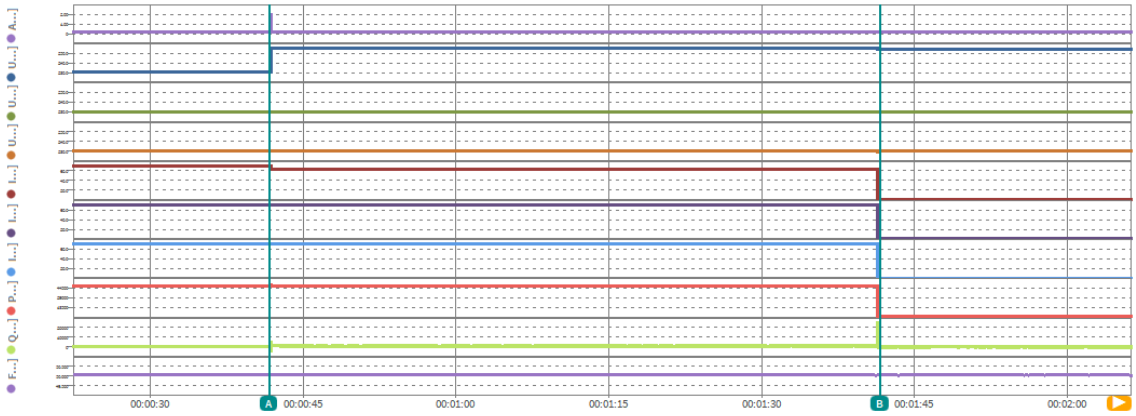
Test results are represented at diagrams below.

Phase A Test 1

Trip Value



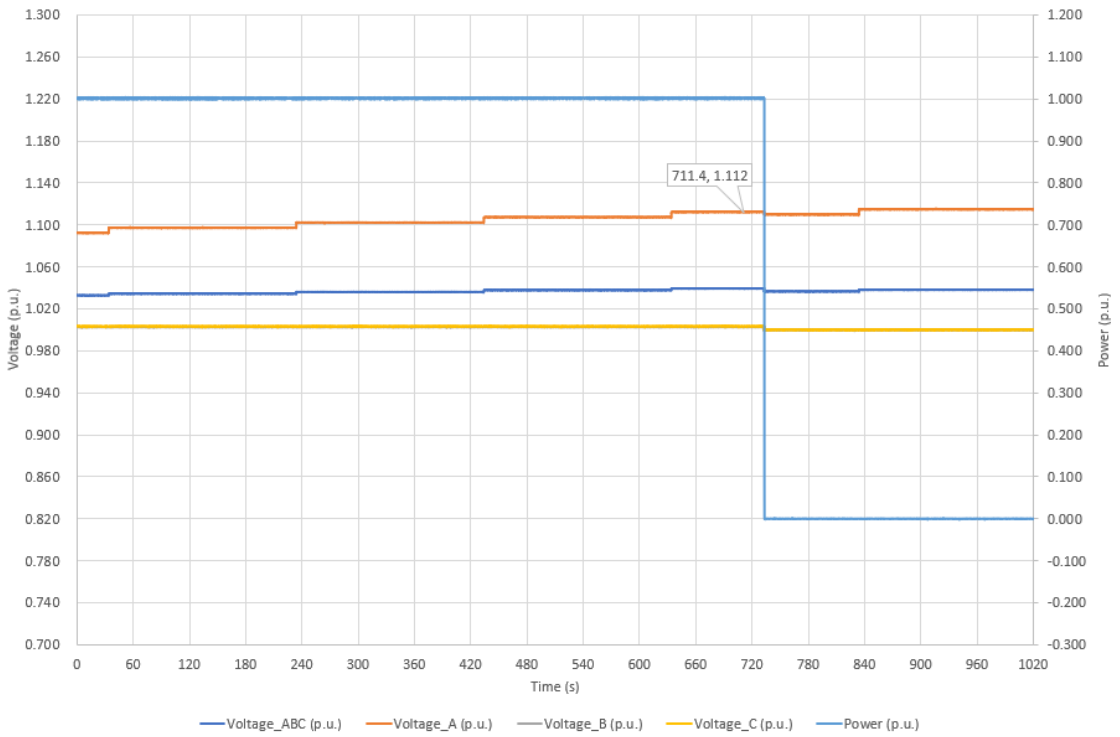
Trip Time



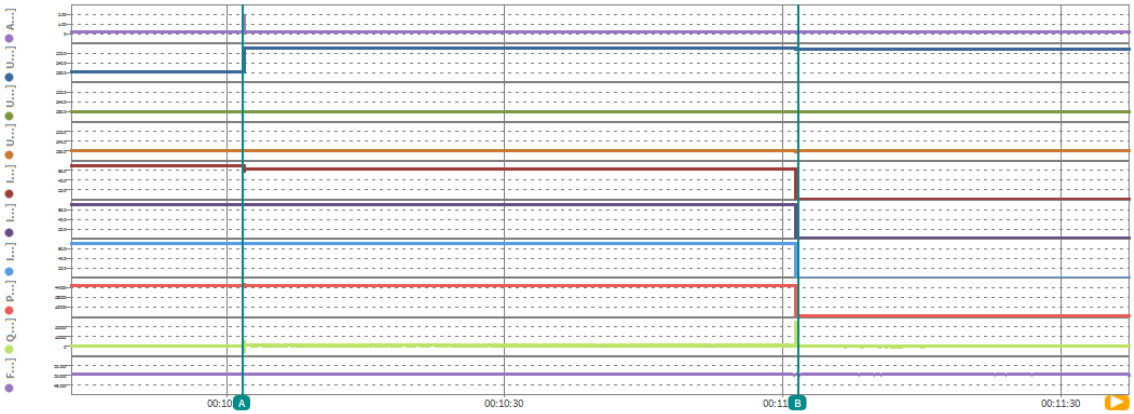
	A	B	间隔
时间 [s]	0:41.745	1:41.658	0:59.912
AI 1/U4 [V]	0.166893	0.163794	-3.099e-3
U1_tRMS_rc@Grid [V]	230.5438	255.2204	24.67664
U2_tRMS_rc@Grid [V]	230.5752	229.9355	-0.639648
U3_tRMS_rc@Grid [V]	230.7065	229.9404	-0.766052
I1_tRMS_rc@Grid [A]	72.33347	0.396801	-71.93667
I2_tRMS_rc@Grid [A]	72.43681	0.235896	-72.20091
I3_tRMS_rc@Grid [A]	72.32877	0.074200	-72.25457
P_t_rc@Grid [W]	50056.17	-0.966666	-50057.14
Q_t_rc@Grid [var]	933.3774	172.5713	-760.8061
F_fund@Grid [Hz]	50.00042	50.00006	-3.586e-4

Phase A Test 2

Trip Value



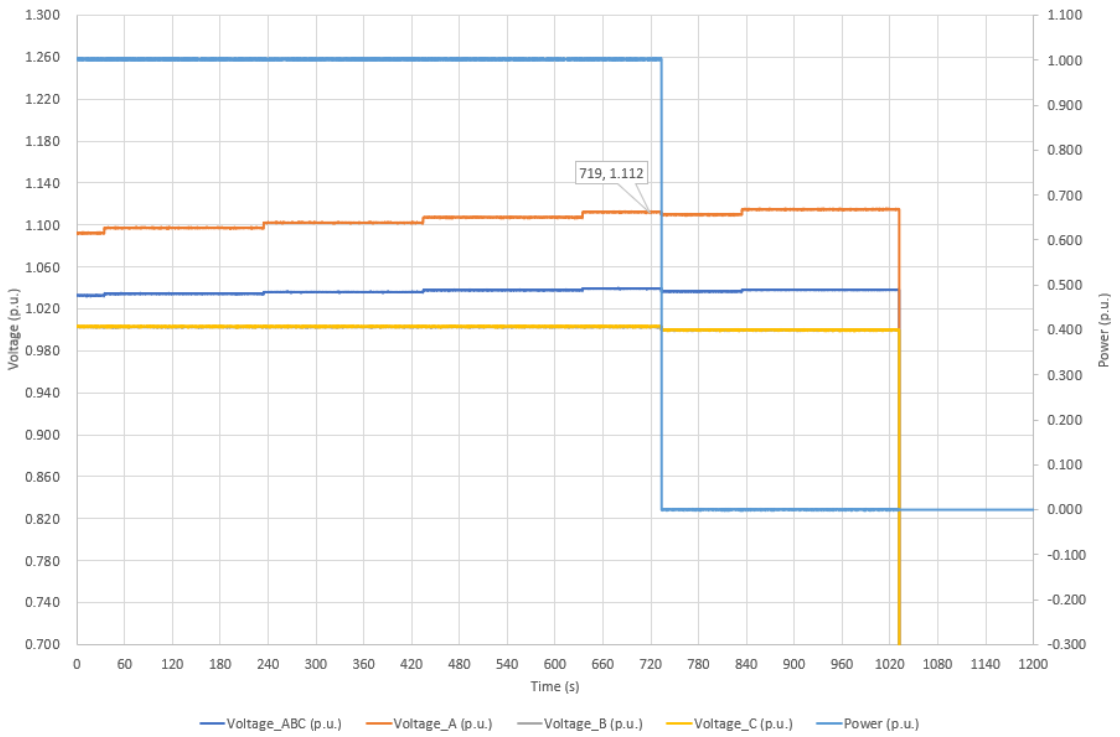
Trip Time



时间 [s]	A 00:10:01.743	B 00:11:01.666	间隔 0:59.923
AI 1/U4 [V]	0.170231	0.170946	7.153e-4
U1_tRMS_rc@Grid [V]	230.5594	255.2310	24.67165
U2_tRMS_rc@Grid [V]	230.5846	229.9366	-0.648026
U3_tRMS_rc@Grid [V]	230.7146	229.9505	-0.764145
I1_tRMS_rc@Grid [A]	72.35070	0.376171	-71.97453
I2_tRMS_rc@Grid [A]	72.45087	0.206590	-72.24428
I3_tRMS_rc@Grid [A]	72.36221	0.069128	-72.29308
P_t_rc@Grid [W]	50073.50	-0.143355	-50073.64
Q_t_rc@Grid [var]	934.1588	-159.4092	-1093.568
F_fund@Grid [Hz]	50.00045	50.00027	-1.793e-4

Phase A Test 3

Trip Value



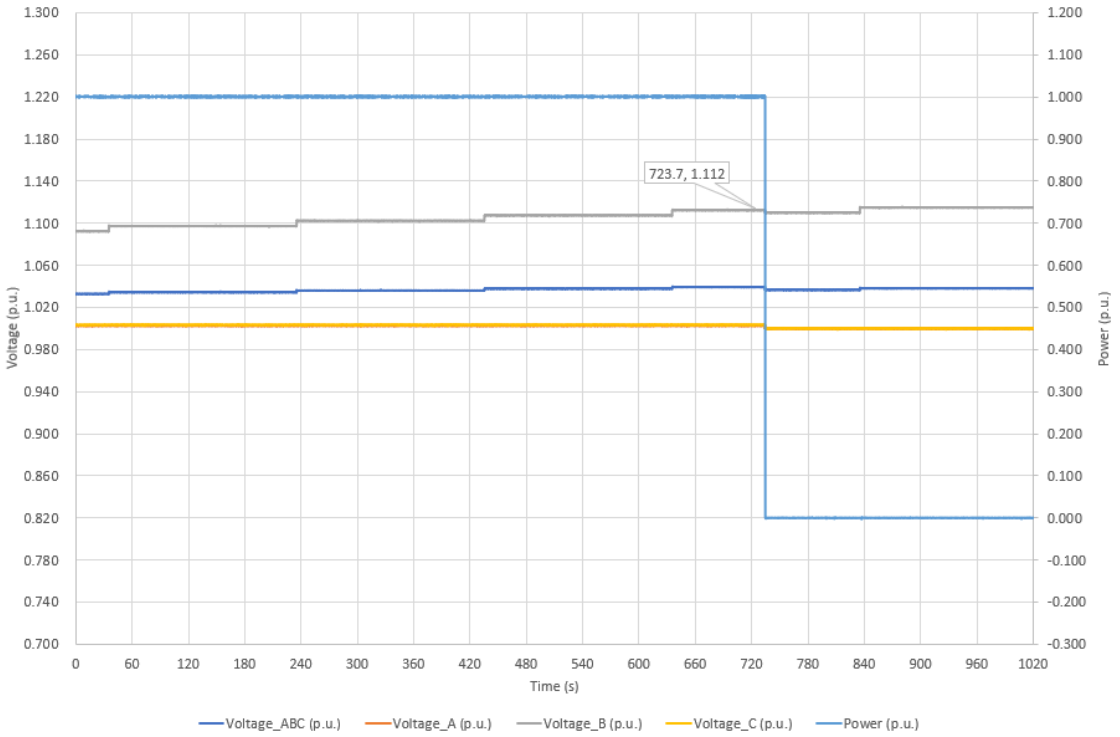
Trip Time



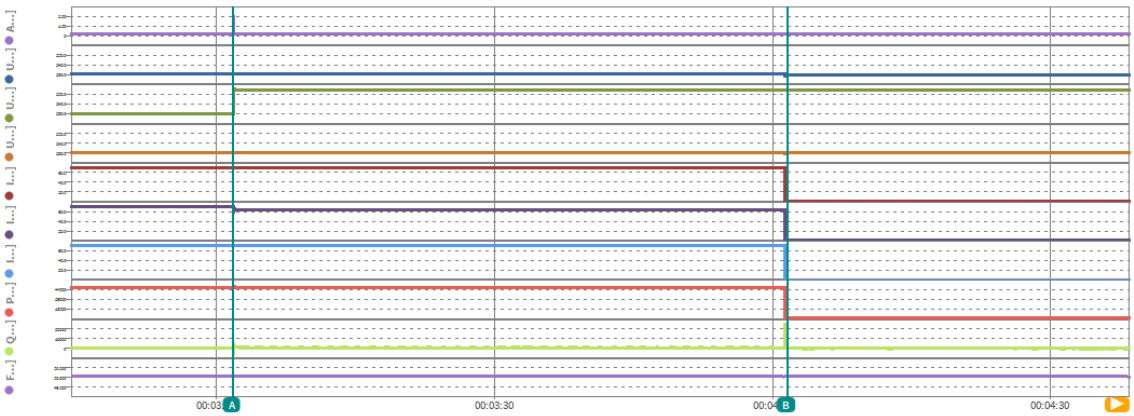
时间 [s]	A 00:19:21.840	B 00:20:21.480	间隔 0:59.640
AI 1/U4 [V]	0.176668	0.168085	-8.583e-3
U1_tRMS_rc@Grid [V]	230.5560	255.2010	24.64494
U2_tRMS_rc@Grid [V]	230.5978	229.9023	-0.695526
U3_tRMS_rc@Grid [V]	230.7184	229.9061	-0.812332
I1_tRMS_rc@Grid [A]	72.38571	0.390131	-71.99558
I2_tRMS_rc@Grid [A]	72.48315	0.205957	-72.27719
I3_tRMS_rc@Grid [A]	72.39088	0.073909	-72.31697
P_t_rc@Grid [W]	50096.62	-0.513626	-50097.13
Q_t_rc@Grid [var]	933.7953	163.9030	-769.8923
F_fund@Grid [Hz]	50.00033	50.00054	2.098e-4

Phase B Test 1

Trip Value



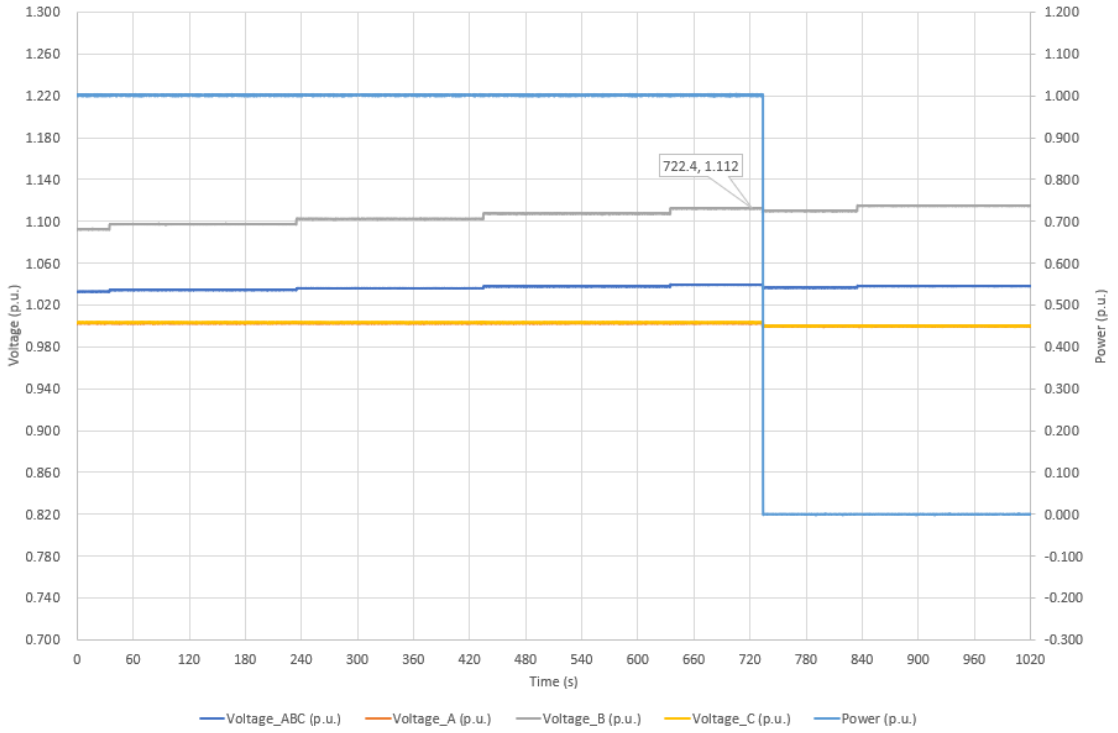
Trip Time



时间 [s]	A 3:01.750	B 4:01.562	间隔 0:59.813
AI 1/U4 [V]	0.168800	0.171900	3.099e-3
U1_tRMS_rc@Grid [V]	230.5528	229.8954	-0.657440
U2_tRMS_rc@Grid [V]	230.5682	255.2294	24.66121
U3_tRMS_rc@Grid [V]	230.7023	229.9209	-0.781403
I1_tRMS_rc@Grid [A]	72.35955	0.386717	-71.97283
I2_tRMS_rc@Grid [A]	72.41705	0.210551	-72.20649
I3_tRMS_rc@Grid [A]	72.34146	0.068697	-72.27276
P_t_rc@Grid [W]	50060.44	-0.984078	-50061.42
Q_t_rc@Grid [var]	931.9188	-158.4353	-1090.354
F_fund@Grid [Hz]	50.00023	50.00068	4.501e-4

Phase B Test 2

Trip Value



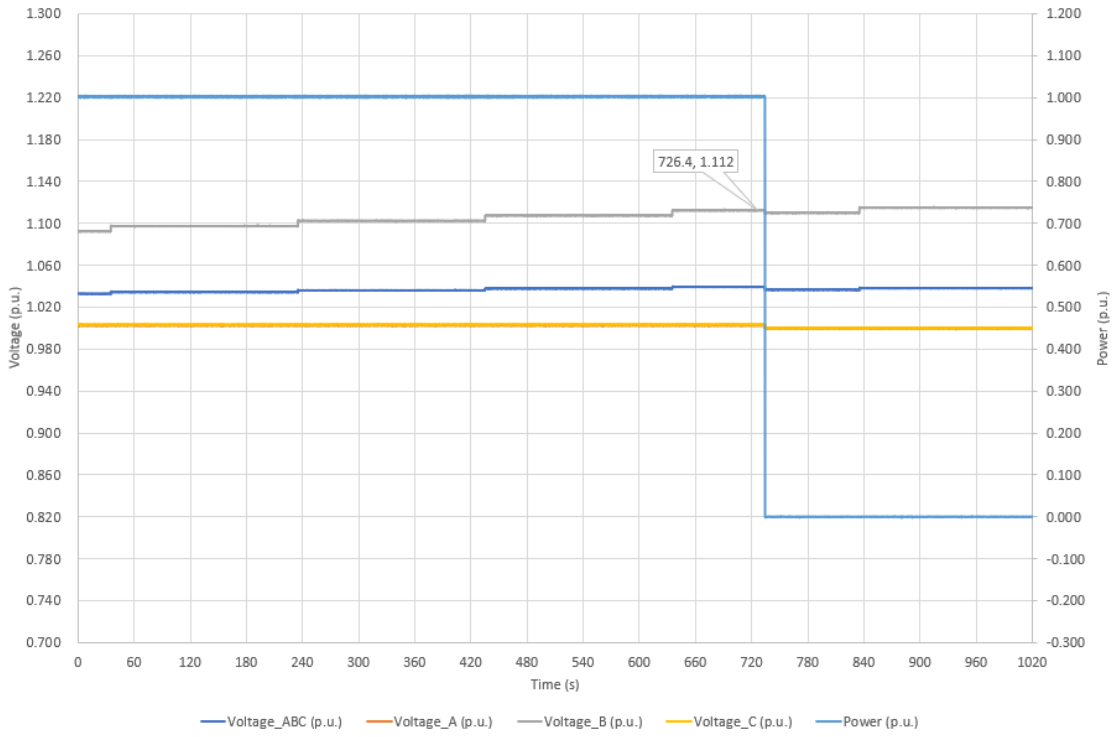
Trip Time



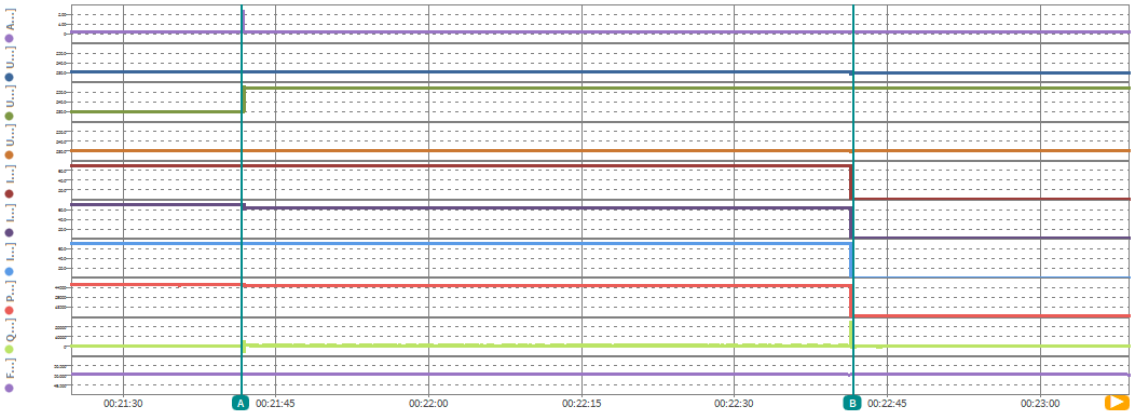
时间 [s]	A 00:12:21.746	B 00:13:21.525	间隔 0:59.780
AI 1/U4 [V]	0.169754	0.166178	-3.576e-3
U1_tRMS_rc@Grid [V]	230.5462	229.9013	-0.644882
U2_tRMS_rc@Grid [V]	230.5857	255.2204	24.63470
U3_tRMS_rc@Grid [V]	230.7099	229.9227	-0.787109
I1_tRMS_rc@Grid [A]	72.36097	0.379282	-71.98169
I2_tRMS_rc@Grid [A]	72.47845	0.215001	-72.26345
I3_tRMS_rc@Grid [A]	72.36288	0.065729	-72.29715
P_t_rc@Grid [W]	50081.22	1.522757	-50079.70
Q_t_rc@Grid [var]	930.7697	-157.1753	-1087.945
F_fund@Grid [Hz]	50.00044	50.00033	-1.068e-4

Phase B Test 3

Trip Value



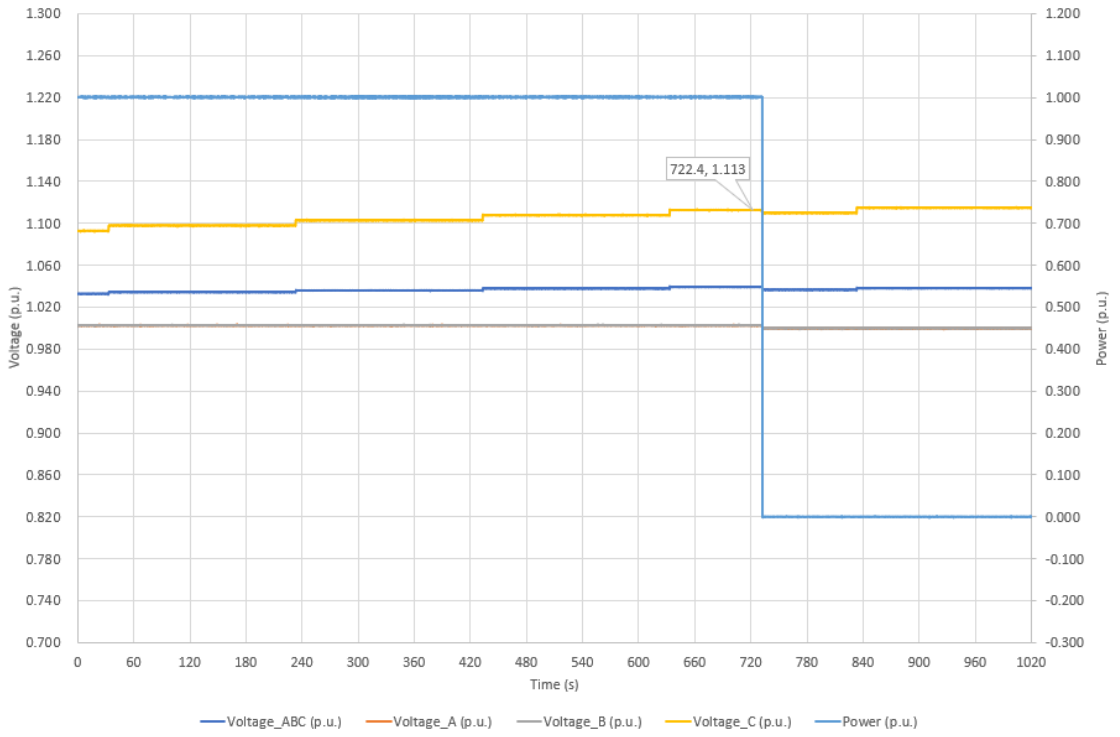
Trip Time



时间 [s]	A 00:21:41.655	B 00:22:41.632	间隔 0:59.976
AI 1/U4 [V]	0.174522	0.171900	-2.623e-3
U1_tRMS_rc@Grid [V]	230.5695	229.9154	-0.654037
U2_tRMS_rc@Grid [V]	230.5895	255.2590	24.66953
U3_tRMS_rc@Grid [V]	230.7216	229.9478	-0.773788
I1_tRMS_rc@Grid [A]	72.38018	0.395234	-71.98495
I2_tRMS_rc@Grid [A]	72.46694	0.200018	-72.26692
I3_tRMS_rc@Grid [A]	72.36839	0.105893	-72.26250
P_t_rc@Grid [W]	50087.07	0.411810	-50086.66
Q_t_rc@Grid [var]	931.2978	166.2760	-765.0218
F_fund@Grid [Hz]	50.00037	50.00015	-2.213e-4

Phase C Test 1

Trip Value



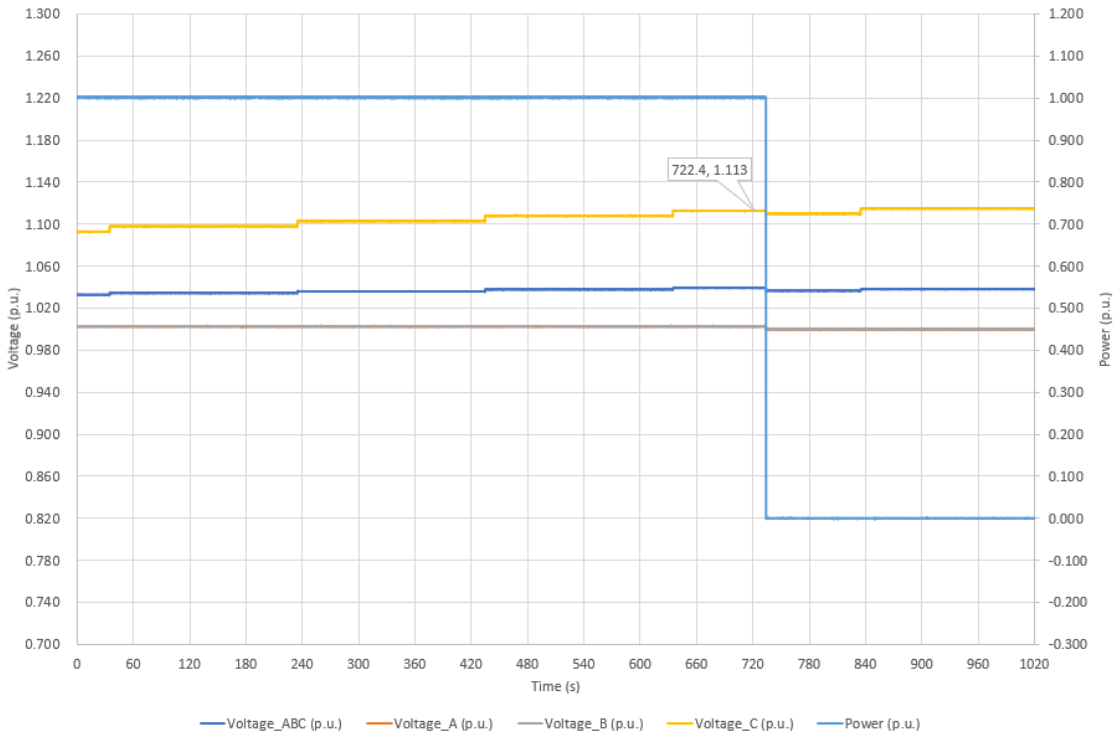
Trip Time



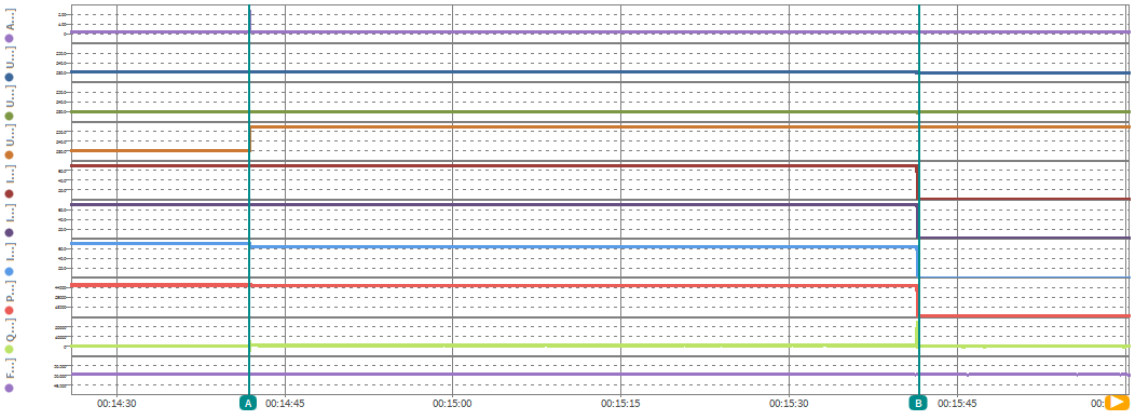
时间 [s]	A 5:21.684	B 6:21.582	间隔 0:59.898
AI 1/U4 [V]	0.170469	0.169039	-1.431e-3
U1_tRMS_rc@Grid [V]	230.5506	229.8940	-0.656555
U2_tRMS_rc@Grid [V]	230.5703	229.9273	-0.642975
U3_tRMS_rc@Grid [V]	230.6920	255.2235	24.53145
I1_tRMS_rc@Grid [A]	72.34000	0.386370	-71.95363
I2_tRMS_rc@Grid [A]	72.43938	0.226892	-72.21248
I3_tRMS_rc@Grid [A]	72.35268	0.072954	-72.27973
P_t_rc@Grid [W]	50062.94	0.505430	-50062.43
Q_t_rc@Grid [var]	930.2346	159.6117	-770.6229
F_fund@Grid [Hz]	50.00051	50.00028	-2.327e-4

Phase C Test 2

Trip Value



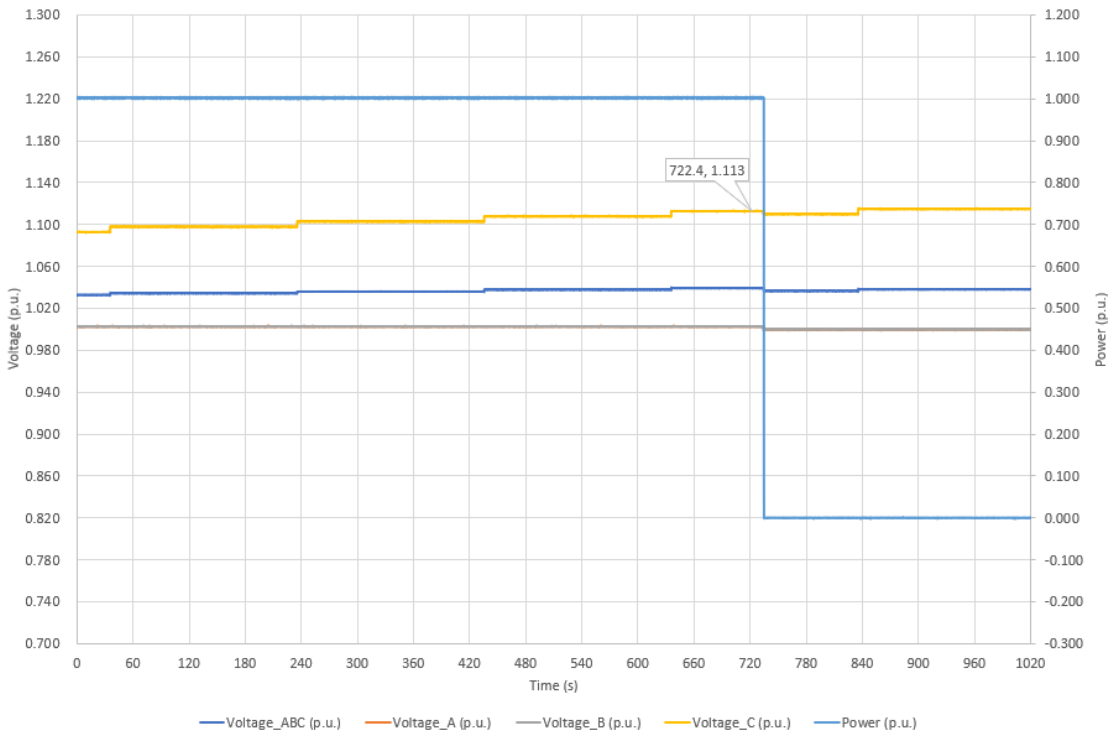
Trip Time



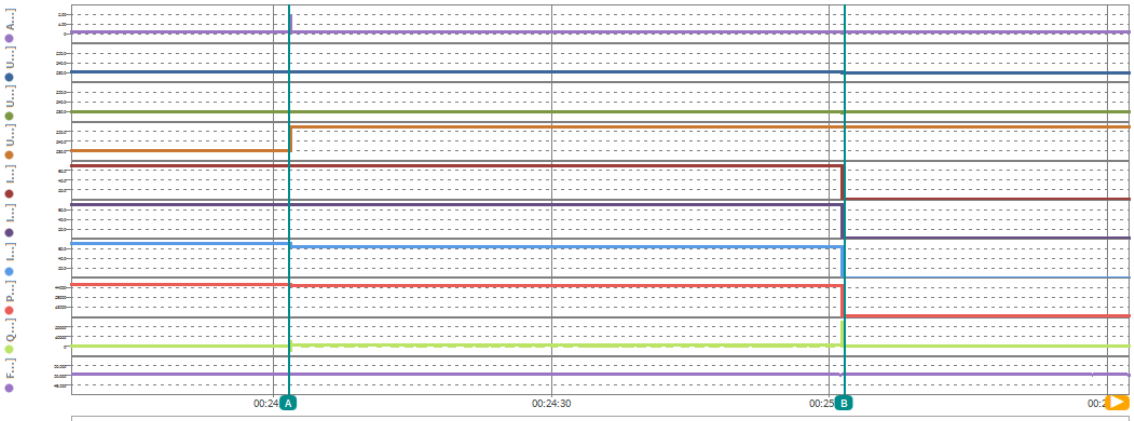
时间 [s]	A 00:14:41.847	B 00:15:41.563	间隔 0:59.716
AI 1/U4 [V]	0.169754	0.170469	7.153e-4
U1_tRMS_rc@Grid [V]	230.5561	229.9058	-0.650314
U2_tRMS_rc@Grid [V]	230.5860	229.9330	-0.653015
U3_tRMS_rc@Grid [V]	230.7042	255.2229	24.51871
I1_tRMS_rc@Grid [A]	72.36898	0.391104	-71.97788
I2_tRMS_rc@Grid [A]	72.45661	0.212708	-72.24390
I3_tRMS_rc@Grid [A]	72.38355	0.098622	-72.28493
P_t_rc@Grid [W]	50083.14	-1.233968	-50084.37
Q_t_rc@Grid [var]	930.2206	163.9915	-766.2291
F_fund@Grid [Hz]	50.00043	50.00040	-3.052e-5

Phase C Test 3

Trip Value



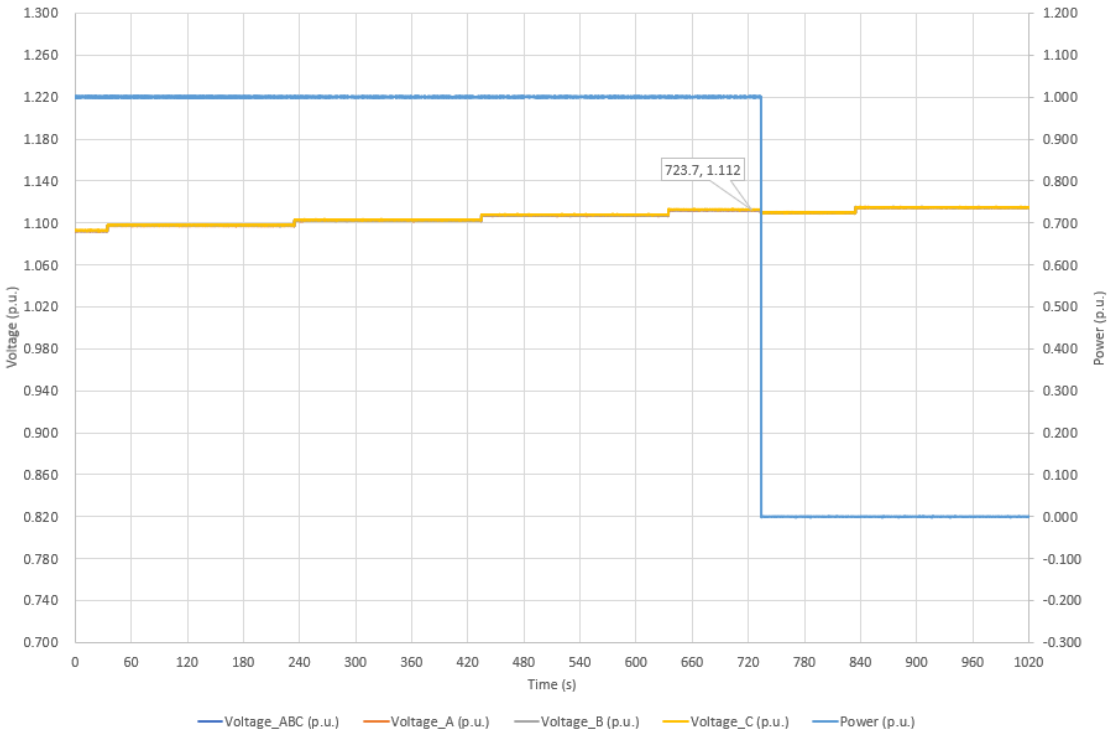
Trip Time



时间 [s]	A 00:24:01.739	B 00:25:01.649	间隔 0:59.911
AI 1/U4 [V]	0.172853	0.167608	-5.245e-3
U1_tRMS_rc@Grid [V]	230.5644	229.9264	-0.637985
U2_tRMS_rc@Grid [V]	230.6056	229.9478	-0.657730
U3_tRMS_rc@Grid [V]	230.7278	255.2404	24.51265
I1_tRMS_rc@Grid [A]	72.38687	0.381833	-72.00504
I2_tRMS_rc@Grid [A]	72.48993	0.223381	-72.26655
I3_tRMS_rc@Grid [A]	72.39150	0.071602	-72.31990
P_t_rc@Grid [W]	50100.51	1.865243	-50098.64
Q_t_rc@Grid [var]	930.1652	157.4241	-772.7411
F_fund@Grid [Hz]	50.00045	50.00029	-1.602e-4

Phase ABC Test 1

Trip Value



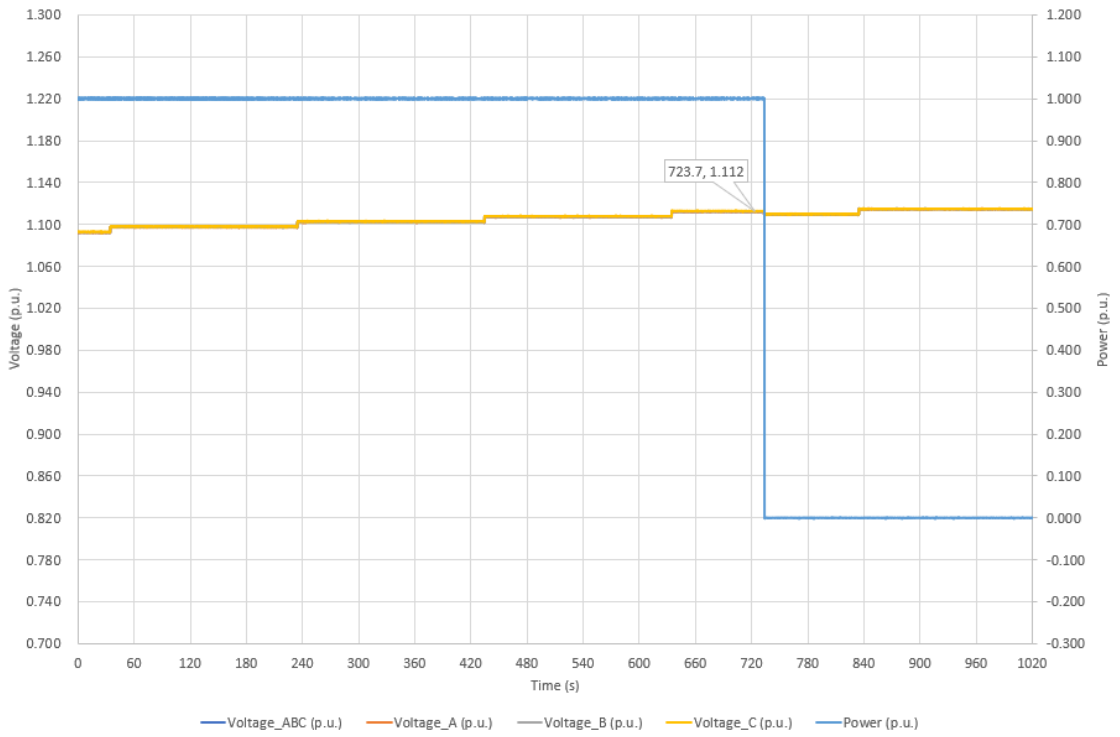
Trip Time



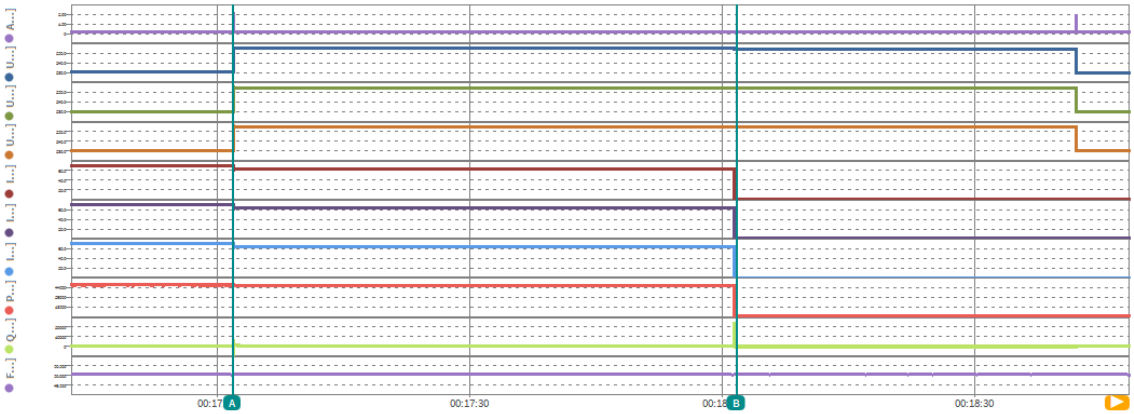
时间 [s]	A 7:41.689	B 8:41.502	间隔 0:59.813
AI 1/U4 [V]	0.166178	0.170946	4.768e-3
U1_tRMS_rc@Grid [V]	230.5589	255.1922	24.63333
U2_tRMS_rc@Grid [V]	230.5769	255.2113	24.63438
U3_tRMS_rc@Grid [V]	230.7118	255.2110	24.49918
I1_tRMS_rc@Grid [A]	72.36568	0.389205	-71.97647
I2_tRMS_rc@Grid [A]	72.42865	0.214282	-72.21437
I3_tRMS_rc@Grid [A]	72.34351	0.054520	-72.28899
P_t_rc@Grid [W]	50066.63	-0.785229	-50067.41
Q_t_rc@Grid [var]	939.0856	167.9215	-771.1641
F_fund@Grid [Hz]	50.00033	50.00031	-2.289e-5

Phase ABC Test 2

Trip Value



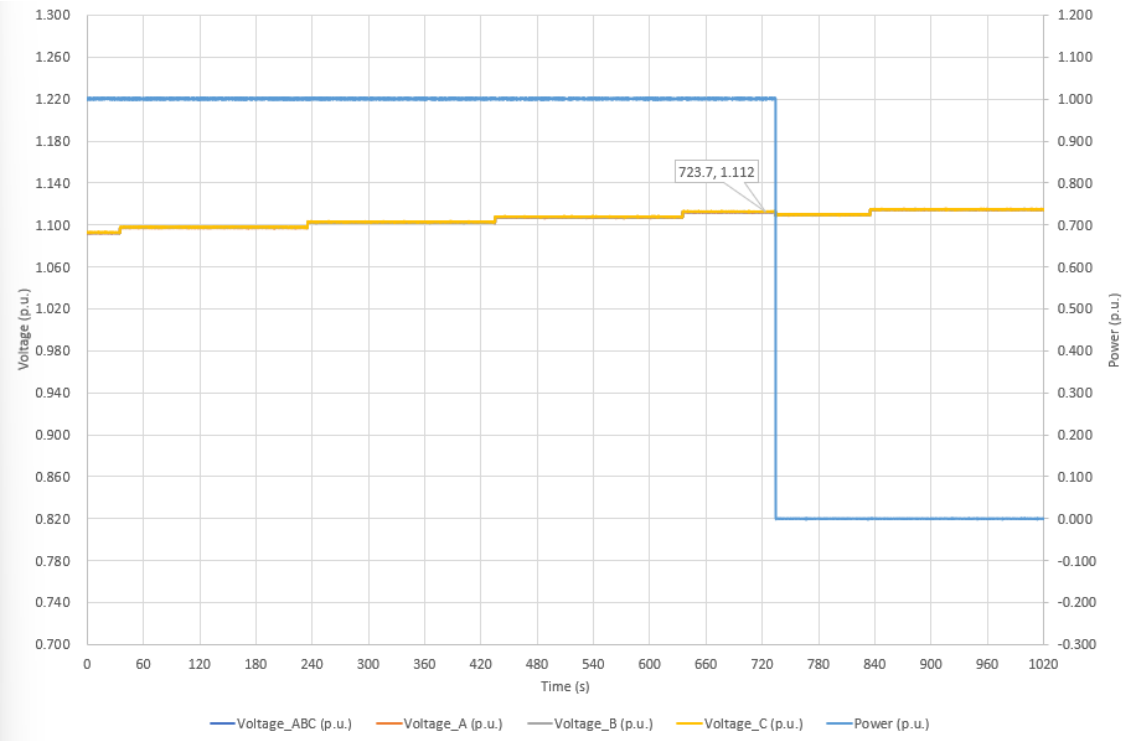
Trip Time



时间 [s]	A 00:17:01.908	B 00:18:01.681	间隔 0:59.774
AI 1/U4 [V]	0.171900	0.172138	2.384e-4
U1_tRMS_rc@Grid [V]	255.9236	255.2288	-0.694748
U2_tRMS_rc@Grid [V]	255.8400	255.2476	-0.592377
U3_tRMS_rc@Grid [V]	255.9258	255.2456	-0.680161
I1_tRMS_rc@Grid [A]	65.72926	0.378342	-65.35092
I2_tRMS_rc@Grid [A]	66.33018	0.206535	-66.12365
I3_tRMS_rc@Grid [A]	65.27881	0.076139	-65.20267
P_t_rc@Grid [W]	50460.38	1.135019	-50459.25
Q_t_rc@Grid [var]	1951.751	-168.7116	-2120.463
F_fund@Grid [Hz]	49.99856	50.00019	1.629e-3

Phase ABC Test 3

Trip Value



Trip Time



时间 [s]	A 00:26:21.748	B 00:27:21.671	间隔 0:59.923
AI 1/U4 [V]	0.173807	0.168324	-5.484e-3
U1_tRMS_rc@Grid [V]	230.5800	255.2212	24.64114
U2_tRMS_rc@Grid [V]	230.5905	255.2557	24.66524
U3_tRMS_rc@Grid [V]	230.7208	255.2530	24.53221
I1_tRMS_rc@Grid [A]	72.38970	0.377615	-72.01209
I2_tRMS_rc@Grid [A]	72.47462	0.203756	-72.27087
I3_tRMS_rc@Grid [A]	72.40999	0.078730	-72.33126
P_t_rc@Grid [W]	50101.26	-0.319998	-50101.58
Q_t_rc@Grid [var]	939.6573	-168.4809	-1108.138
F_fund@Grid [Hz]	50.00043	50.00036	-7.248e-5

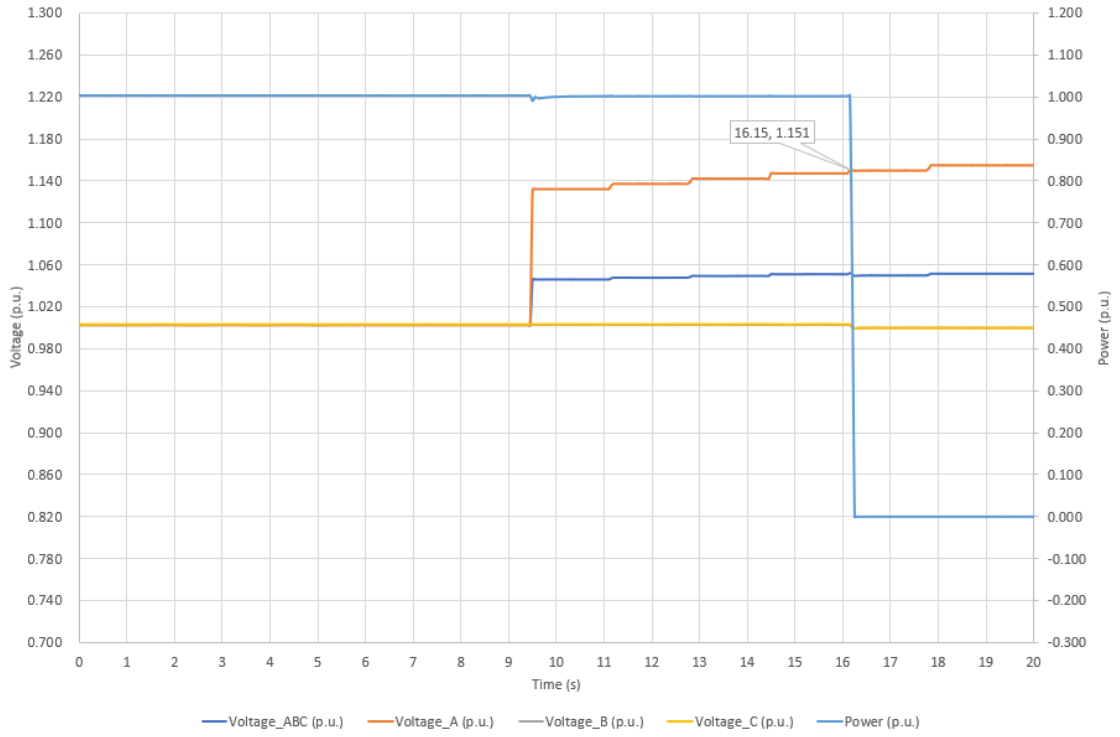
4.7.7.2 Overvoltage protection (Country / Region: Sweden)

Overvoltage of 115%Un (stage 1)				
Phase A				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	264.5	264.7	264.7	264.5
Trip time [s]	< 0.200	0.101	0.102	0.122
Phase B				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	264.5	264.5	264.7	264.7
Trip time [s]	< 0.200	0.120	0.145	0.124
Phase C				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	264.5	264.7	264.7	264.7
Trip time [s]	< 0.200	0.101	0.121	0.101
Phase ABC				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	264.5	264.7	264.7	264.7
Trip time [s]	< 0.200	0.103	0.127	0.100

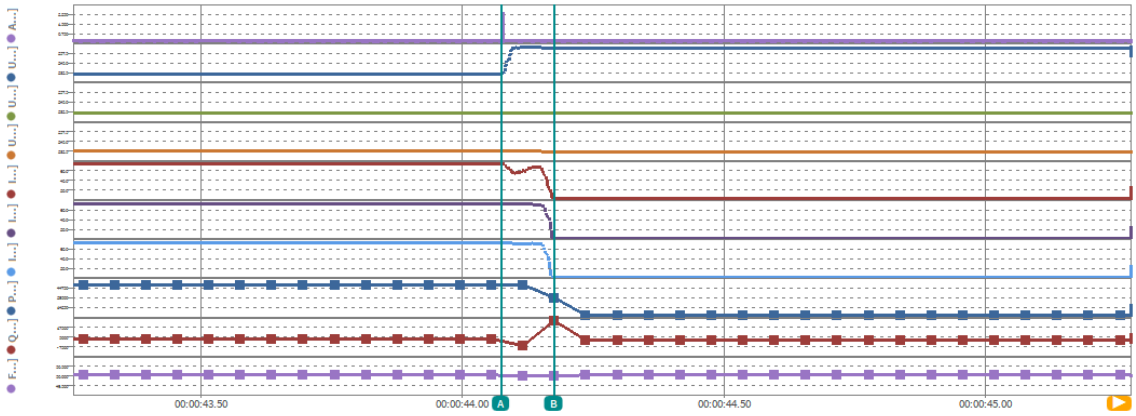
Test results are represented at diagrams below.

Phase A Test 1

Trip Value



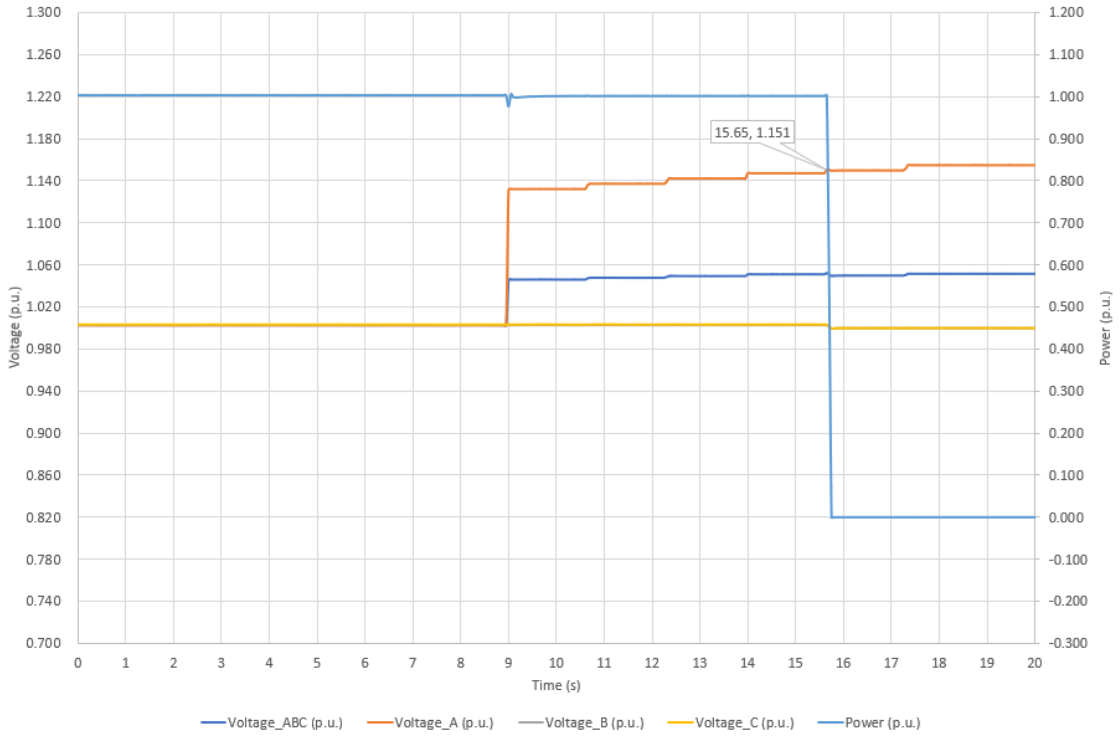
Trip Time



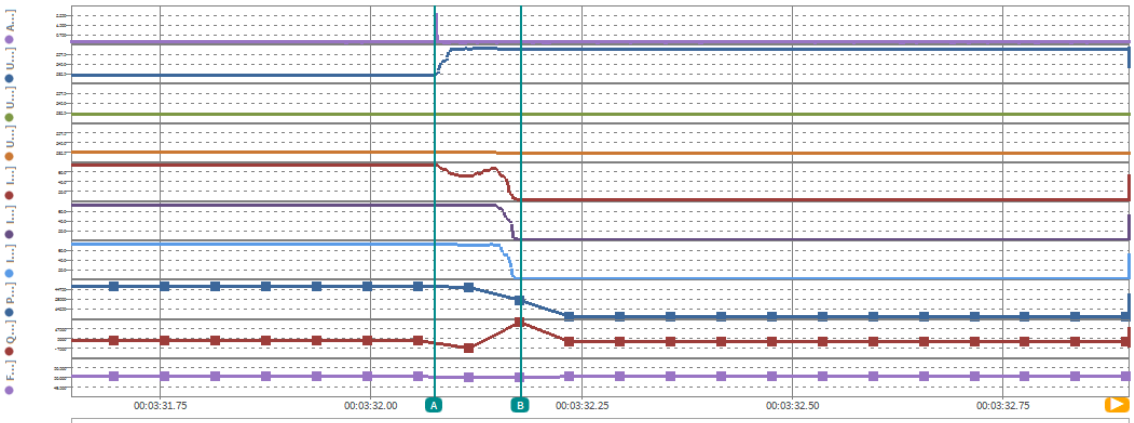
	A	B	间隔
时间 [s]	0:44.075	0:44.176	0.101
AI 1/U4 [V]	0.171423	0.171661	2.384e-4
U1_tRMS_rc@Grid [V]	230.5863	264.5378	33.95146
U2_tRMS_rc@Grid [V]	230.6178	229.8934	-0.724335
U3_tRMS_rc@Grid [V]	230.7475	229.9190	-0.828430
I1_tRMS_rc@Grid [A]	72.41473	2.137628	-70.27710
I2_tRMS_rc@Grid [A]	72.53336	2.302799	-70.23056
I3_tRMS_rc@Grid [A]	72.42917	0.924744	-71.50442
P_t@Grid [W]	50130.23	48682.73	-1447.496
Q_t@Grid [var]	936.2179	-7393.917	-8330.135
F_fund@Grid [Hz]	50.00032	49.99342	-6.901e-3

Phase A Test 2

Trip Value



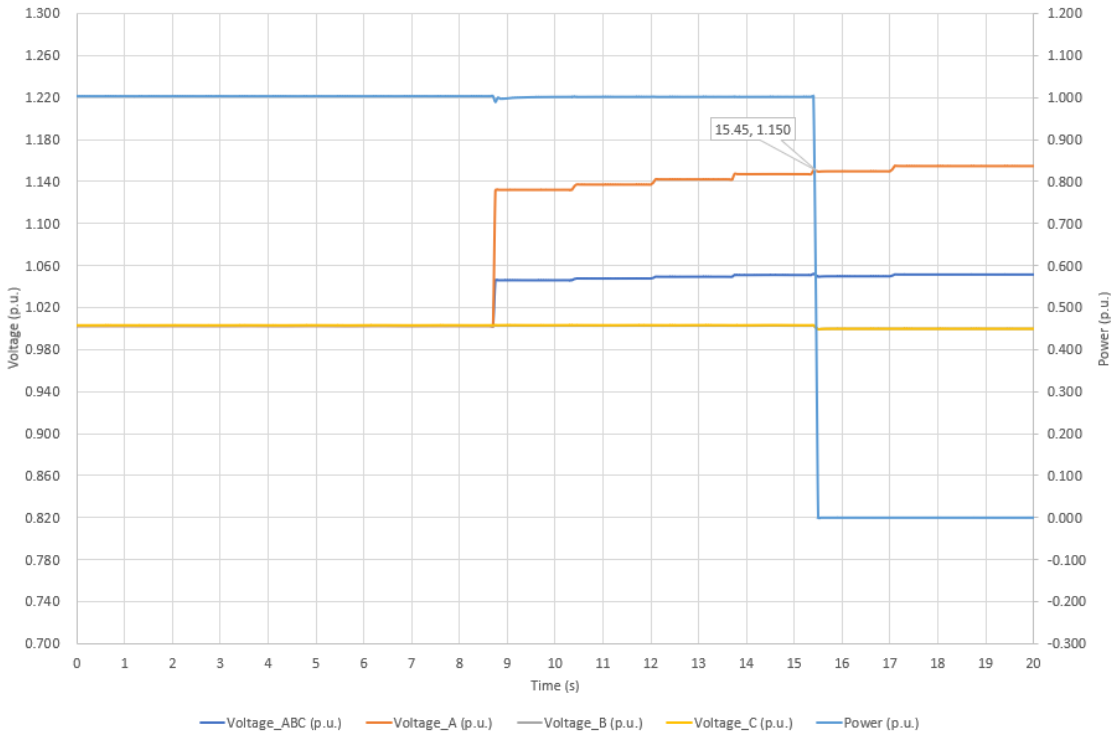
Trip Time



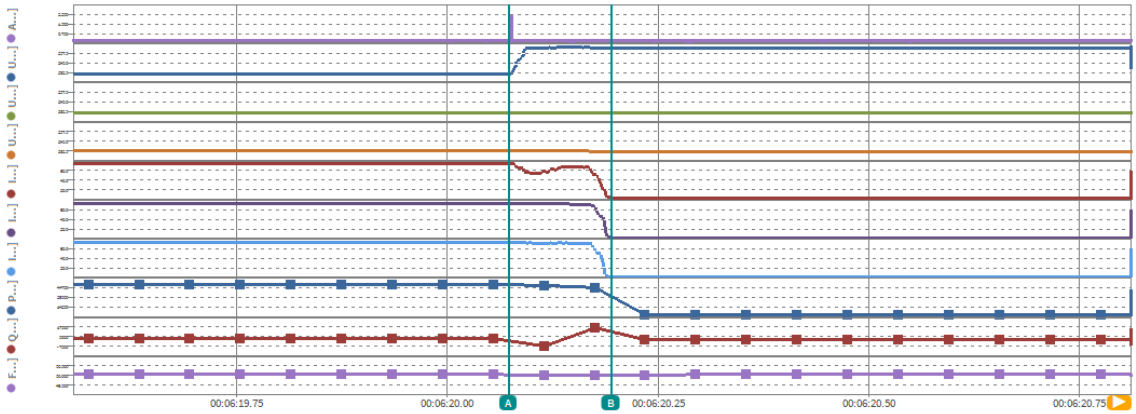
时间 [s]	A 3:32.076	B 3:32.178	间隔 0.102
AI 1/U4 [V]	0.176668	0.179768	3.099e-3
U1_tRMS_rc@Grid [V]	230.5760	264.5788	34.00284
U2_tRMS_rc@Grid [V]	230.6123	229.8400	-0.772324
U3_tRMS_rc@Grid [V]	230.7385	229.8442	-0.894318
I1_tRMS_rc@Grid [A]	72.44019	0.392564	-72.04763
I2_tRMS_rc@Grid [A]	72.54911	0.214112	-72.33500
I3_tRMS_rc@Grid [A]	72.44816	0.090124	-72.35803
P_t@Grid [W]	50140.13	27107.54	-23032.59
Q_t@Grid [var]	940.5131	25014.50	24073.99
F_fund@Grid [Hz]	50.00047	49.97703	-0.023438

Phase A Test 3

Trip Value



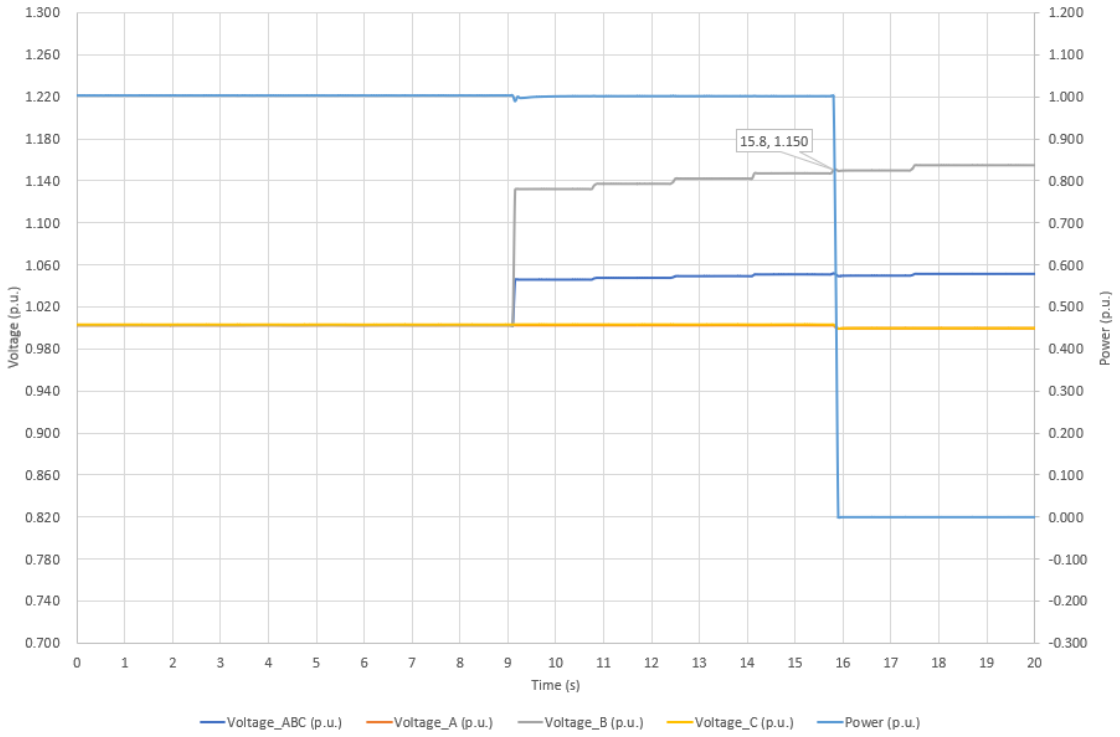
Trip Time



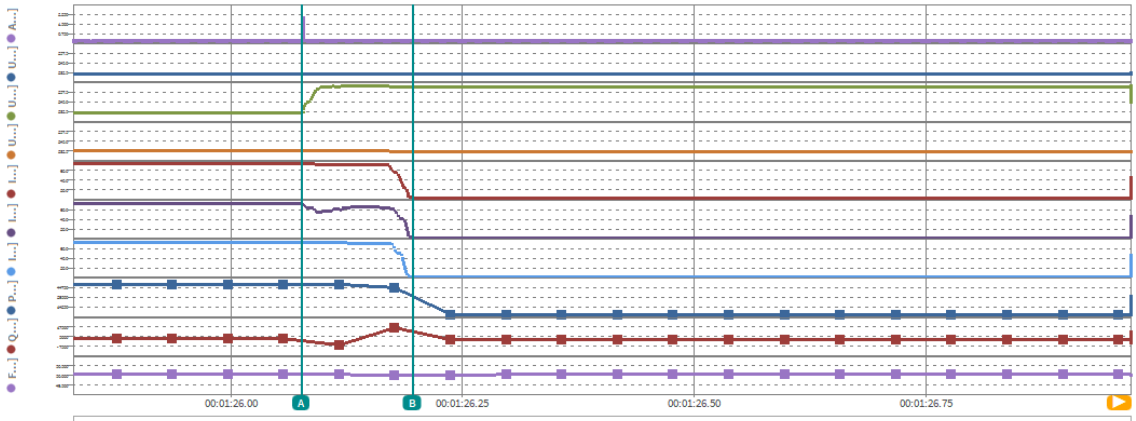
时间 [s]	A 6:20.073	B 6:20.195	间隔 0.122
AI 1/U4 [V]	0.177145	0.178099	9.537e-4
U1_tRMS_rc@Grid [V]	230.5785	264.3175	33.73903
U2_tRMS_rc@Grid [V]	230.6142	229.8877	-0.726440
U3_tRMS_rc@Grid [V]	230.7465	229.9049	-0.841614
I1_tRMS_rc@Grid [A]	72.44525	1.726825	-70.71843
I2_tRMS_rc@Grid [A]	72.55270	1.586543	-70.96615
I3_tRMS_rc@Grid [A]	72.44891	0.282871	-72.16604
P_t@Grid [W]	50143.15	44828.77	-5314.375
Q_t@Grid [var]	940.1867	16002.63	15062.44
F_fund@Grid [Hz]	50.00051	49.98182	-0.018692

Phase B Test 1

Trip Value



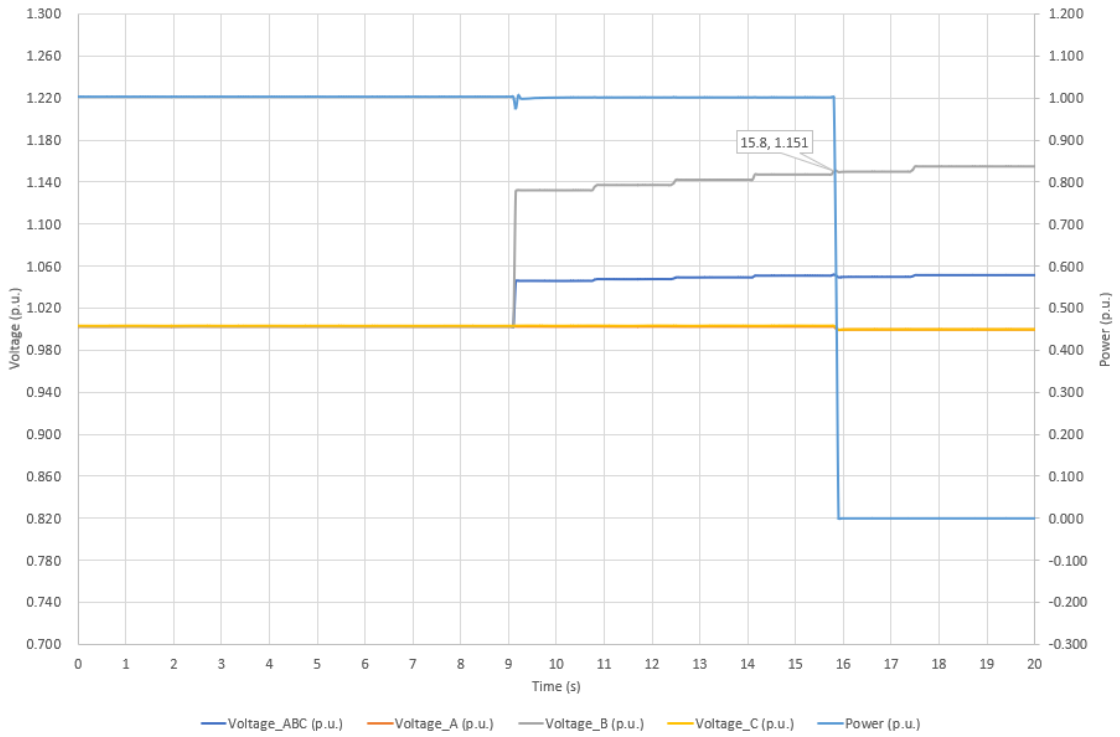
Trip Time



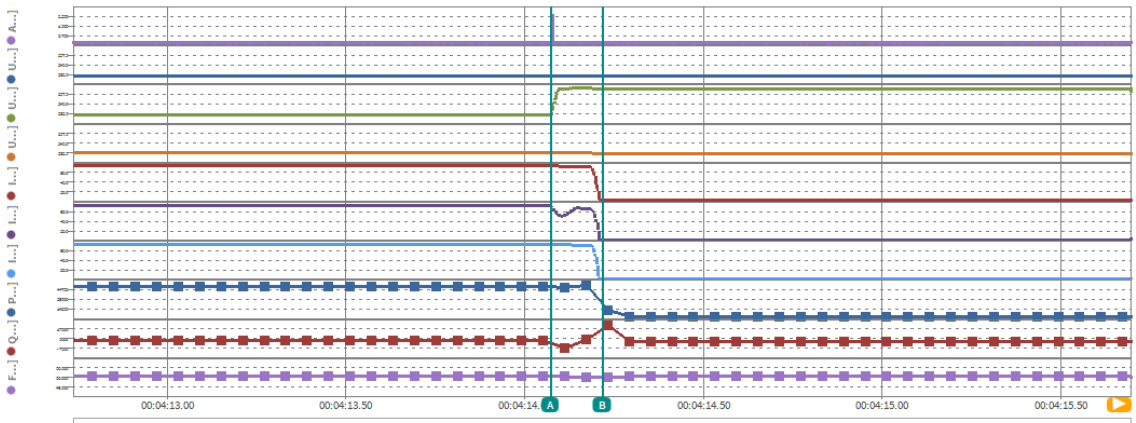
时间 [s]	A 1:26.077	B 1:26.197	间隔 0.120
AI 1/U4 [V]	0.173807	0.173807	0.000000
U1_tRMS_rc@Grid [V]	230.5766	229.8326	-0.743988
U2_tRMS_rc@Grid [V]	230.6183	264.3876	33.76932
U3_tRMS_rc@Grid [V]	230.7473	229.9059	-0.841385
I1_tRMS_rc@Grid [A]	72.42428	1.738915	-70.68536
I2_tRMS_rc@Grid [A]	72.54359	1.833281	-70.71031
I3_tRMS_rc@Grid [A]	72.44534	0.365079	-72.08026
P_t@Grid [W]	50133.90	44906.93	-5226.969
Q_t@Grid [var]	940.7349	15848.08	14907.34
F_fund@Grid [Hz]	50.00046	49.97592	-0.024540

Phase B Test 2

Trip Value



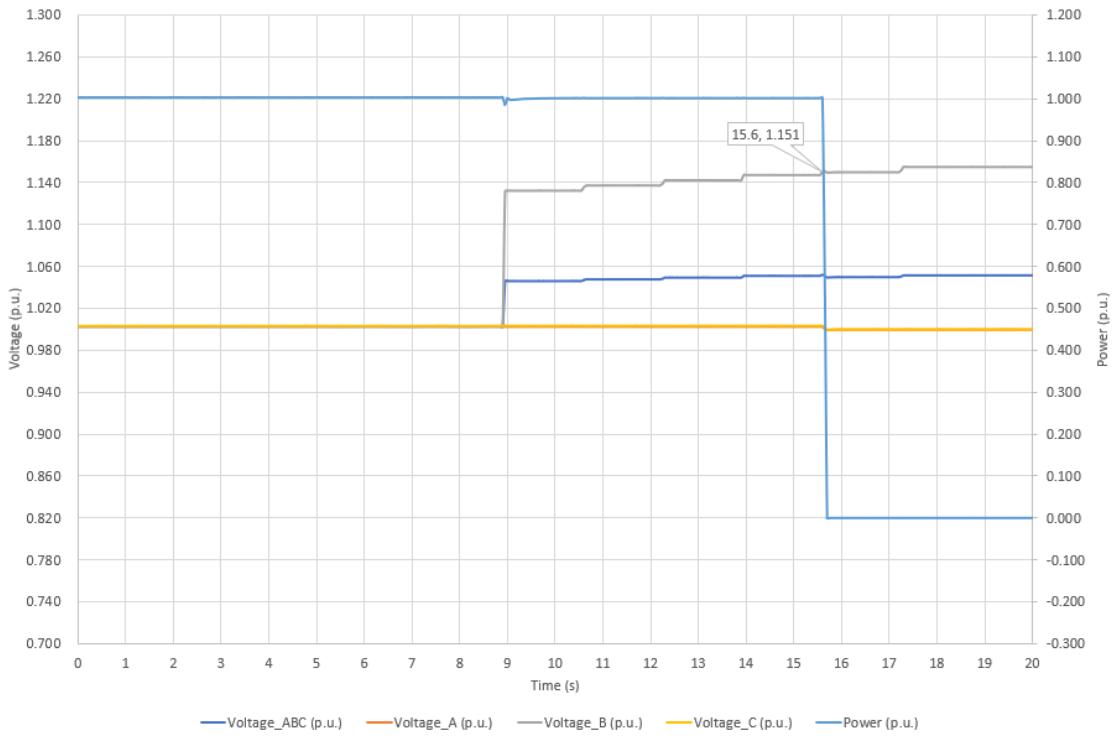
Trip Time



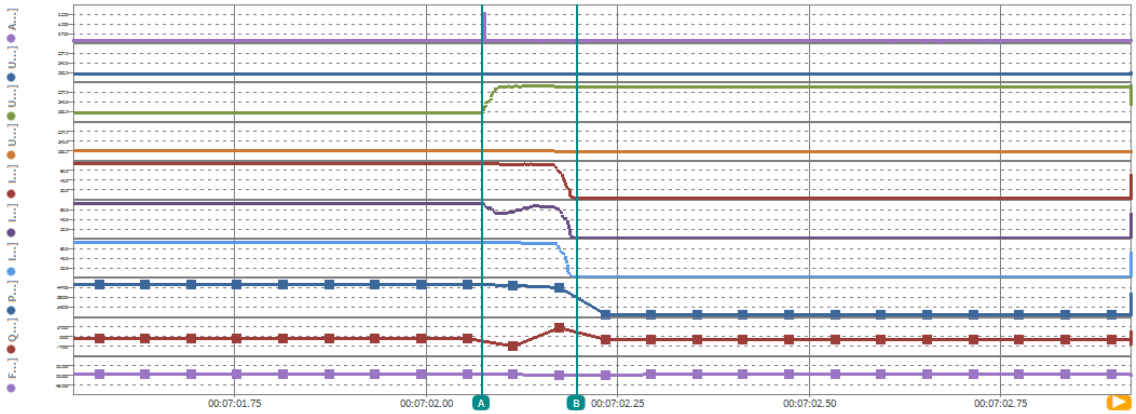
时间 [s]	A 4:14.074	B 4:14.219	间隔 0.145
AI 1/U4 [V]	0.172853	0.177860	5.007e-3
U1_tRMS_rc@Grid [V]	230.5831	229.8177	-0.765305
U2_tRMS_rc@Grid [V]	230.6205	264.3489	33.72844
U3_tRMS_rc@Grid [V]	230.7507	229.8575	-0.893280
I1_tRMS_rc@Grid [A]	72.43755	0.404085	-72.03347
I2_tRMS_rc@Grid [A]	72.54320	0.189624	-72.35357
I3_tRMS_rc@Grid [A]	72.44312	0.097440	-72.34568
P_t@Grid [W]	50140.07	50430.50	290.4258
Q_t@Grid [var]	939.2553	3345.603	2406.348
F_fund@Grid [Hz]	50.00046	49.99970	-7.629e-4

Phase B Test 3

Trip Value



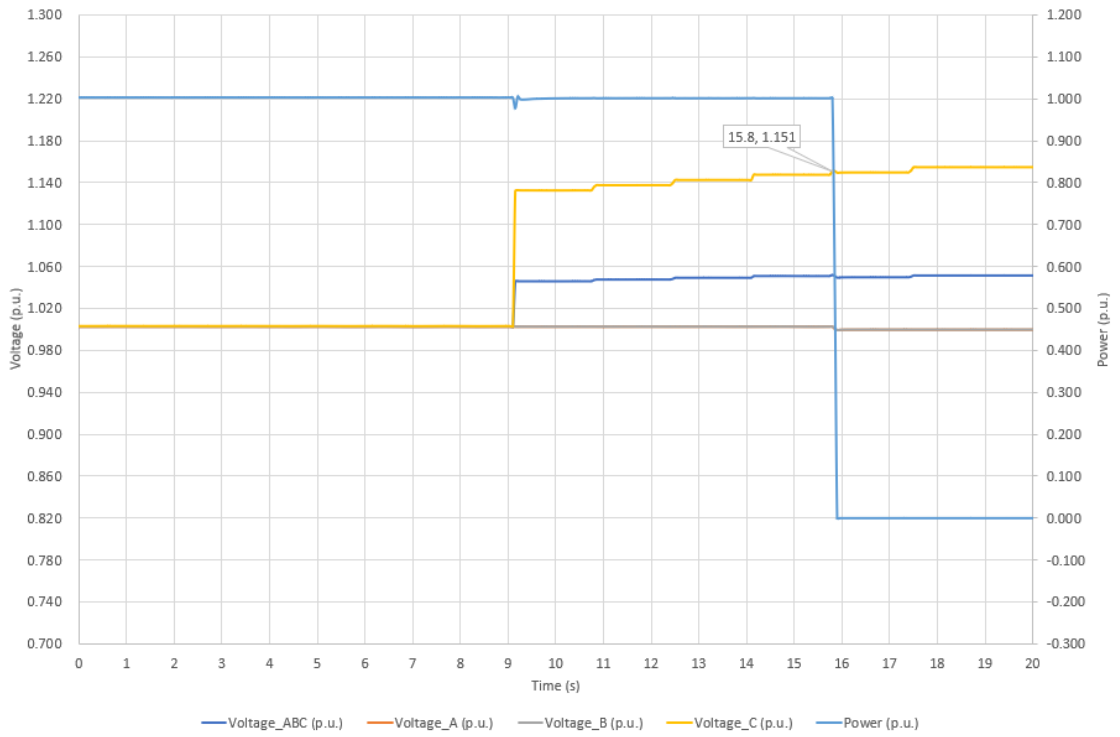
Trip Time



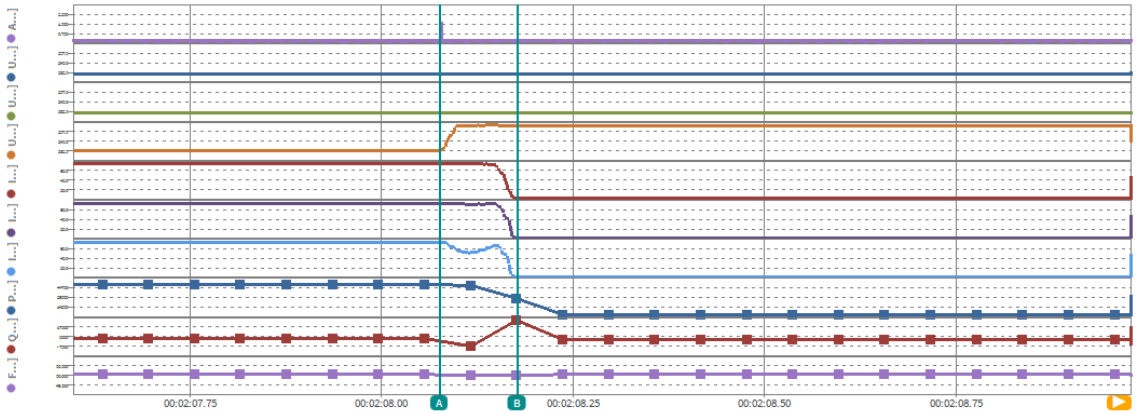
时间 [s]	A 7:02.073	B 7:02.197	间隔 0.124
AI 1/U4 [V]	0.174999	0.176907	1.907e-3
U1_tRMS_rc@Grid [V]	230.5712	229.8053	-0.765961
U2_tRMS_rc@Grid [V]	230.6105	264.3919	33.78143
U3_tRMS_rc@Grid [V]	230.7312	229.8481	-0.883148
I1_tRMS_rc@Grid [A]	72.45234	0.551585	-71.90075
I2_tRMS_rc@Grid [A]	72.54388	0.371467	-72.17241
I3_tRMS_rc@Grid [A]	72.45774	0.101473	-72.35627
P_t@Grid [W]	50144.96	44946.93	-5198.023
Q_t@Grid [var]	936.2767	16017.80	15081.53
F_fund@Grid [Hz]	50.00025	49.97586	-0.024391

Phase C Test 1

Trip Value



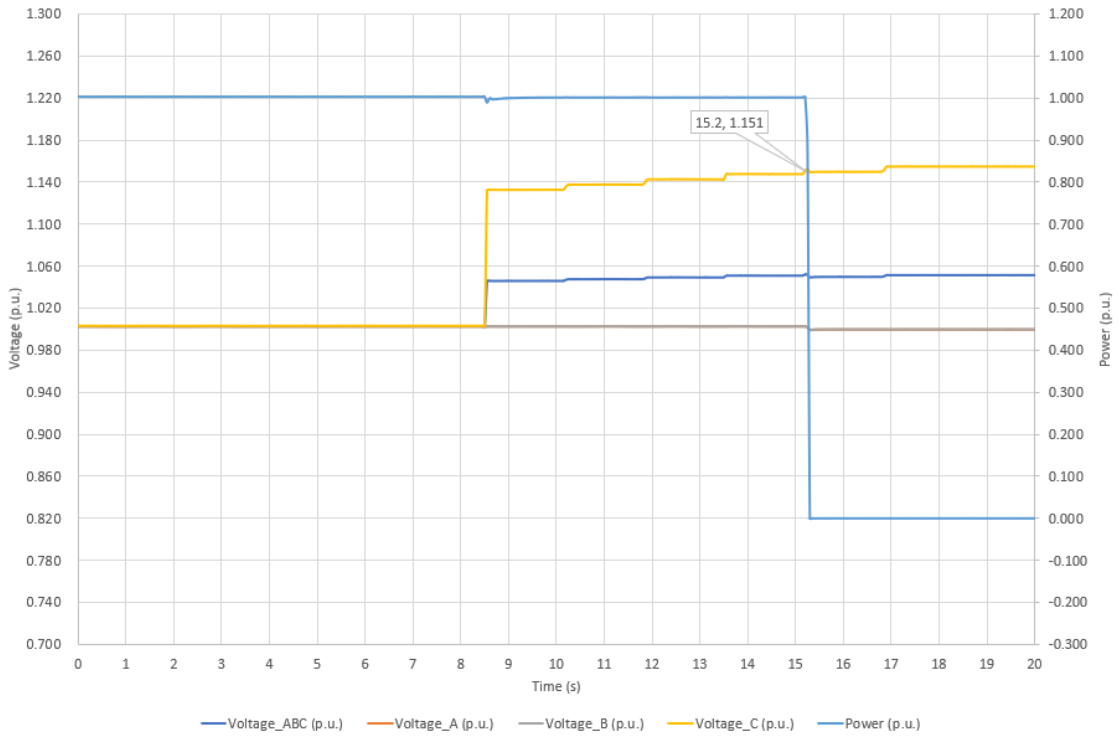
Trip Time



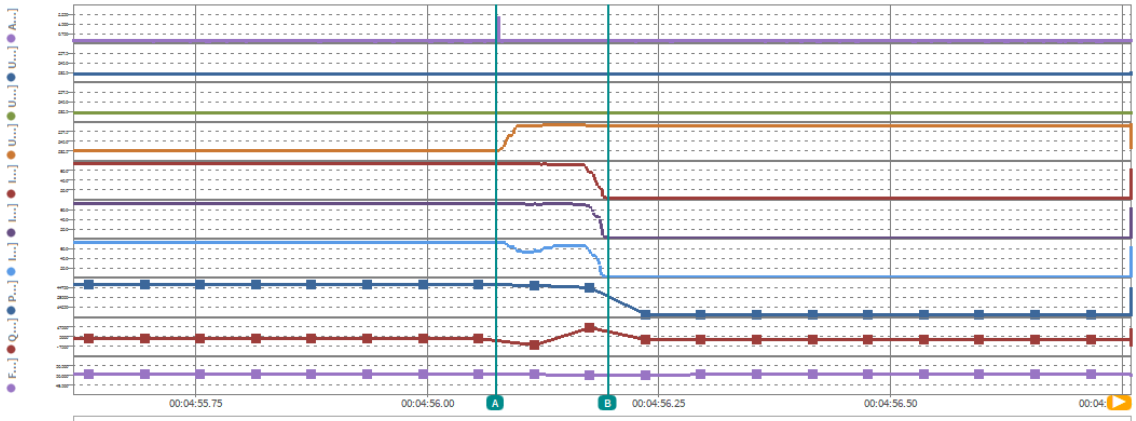
时间 [s]	A 2:08.076	B 2:08.178	间隔 0.101
AI 1/U4 [V]	0.176430	0.178099	1.669e-3
U1_tRMS_rc@Grid [V]	230.5769	229.8039	-0.772995
U2_tRMS_rc@Grid [V]	230.6190	229.8762	-0.742737
U3_tRMS_rc@Grid [V]	230.7445	264.3478	33.60338
I1_tRMS_rc@Grid [A]	72.42741	0.876589	-71.55082
I2_tRMS_rc@Grid [A]	72.53691	0.707873	-71.82904
I3_tRMS_rc@Grid [A]	72.44463	0.092994	-72.35163
P_t@Grid [W]	50134.38	48098.70	-2035.676
Q_t@Grid [var]	942.1480	-8336.591	-9278.739
F_fund@Grid [Hz]	50.00030	49.99997	-3.319e-4

Phase C Test 2

Trip Value



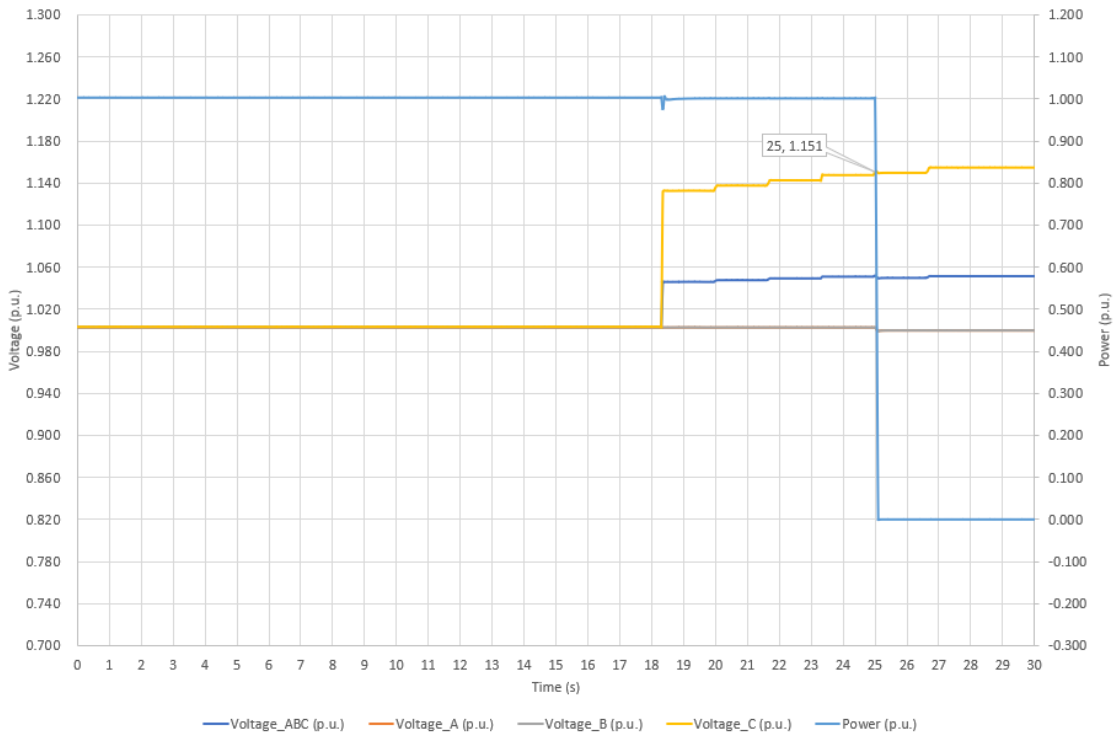
Trip Time



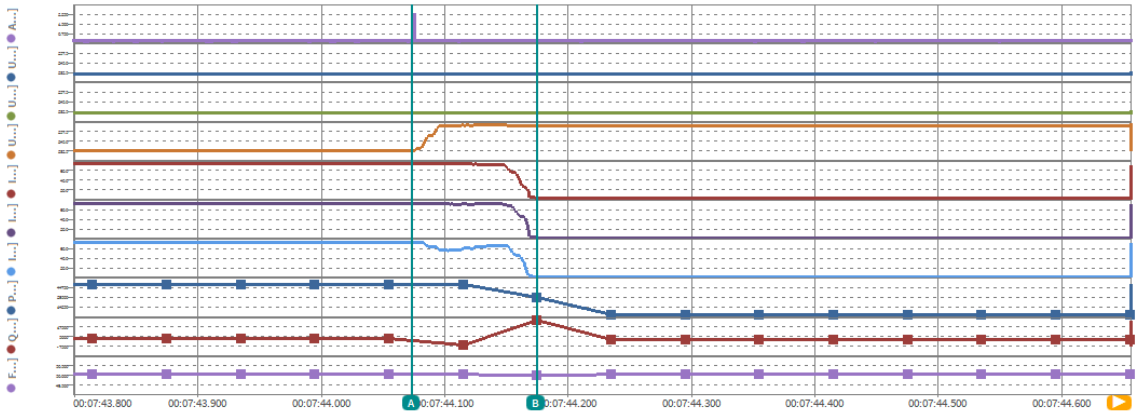
时间 [s]	A 4:56.074	B 4:56.195	间隔 0.121
AI 1/U4 [V]	0.179052	0.178814	-2.384e-4
U1_tRMS_rc@Grid [V]	230.5844	229.8322	-0.752106
U2_tRMS_rc@Grid [V]	230.6115	229.8810	-0.730499
U3_tRMS_rc@Grid [V]	230.7418	264.3826	33.64076
I1_tRMS_rc@Grid [A]	72.43238	1.539841	-70.89254
I2_tRMS_rc@Grid [A]	72.54543	1.403170	-71.14226
I3_tRMS_rc@Grid [A]	72.44919	0.192313	-72.25688
P_t@Grid [W]	50140.27	44861.34	-5278.930
Q_t@Grid [var]	944.6169	16054.89	15110.27
F_fund@Grid [Hz]	50.00047	49.97692	-0.023548

Phase C Test 3

Trip Value



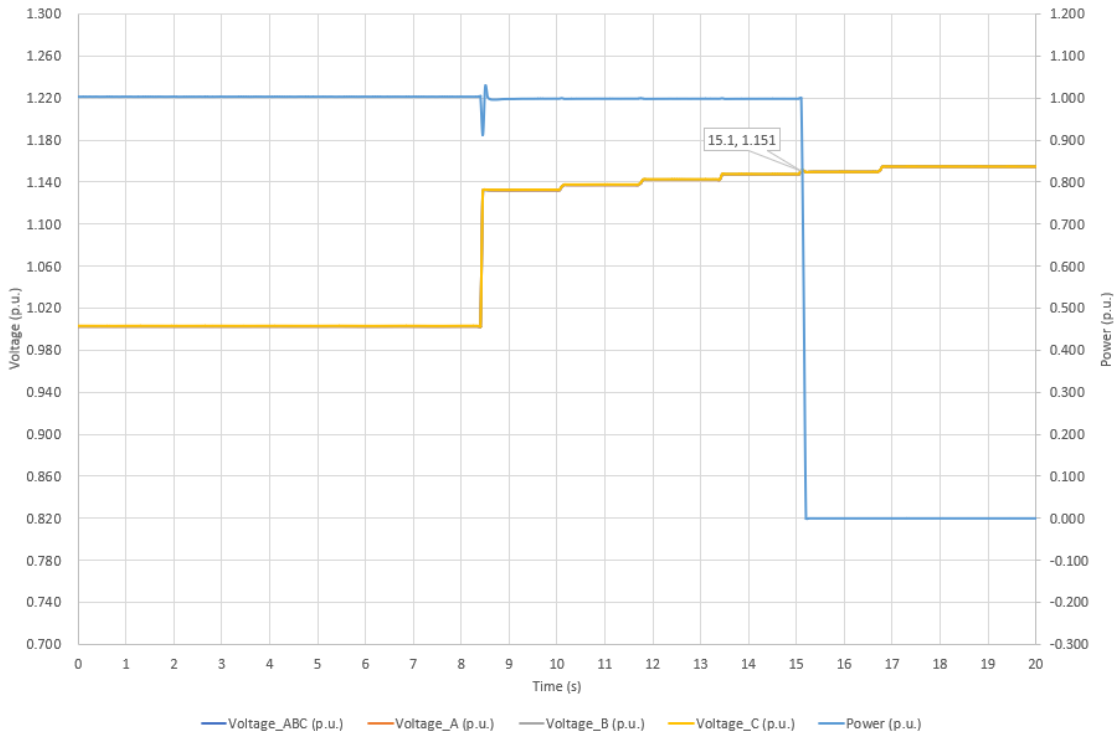
Trip Time



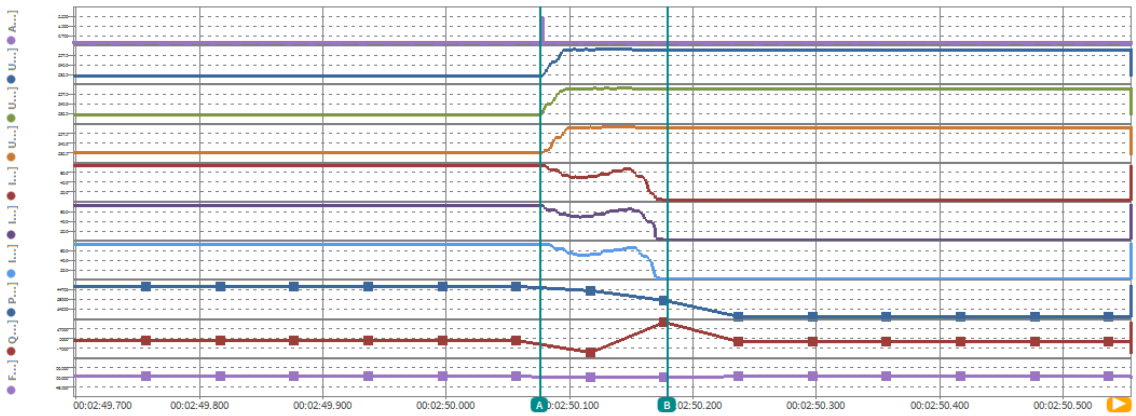
时间 [s]	A 7:44.073	B 7:44.174	间隔 0.101
AI 1/U4 [V]	0.175476	0.175238	-2.384e-4
U1_tRMS_rc@Grid [V]	230.5807	229.8261	-0.754623
U2_tRMS_rc@Grid [V]	230.6185	229.8883	-0.730209
U3_tRMS_rc@Grid [V]	230.7457	264.3826	33.63692
I1_tRMS_rc@Grid [A]	72.44947	1.351086	-71.09838
I2_tRMS_rc@Grid [A]	72.54639	1.198516	-71.34787
I3_tRMS_rc@Grid [A]	72.45370	0.093728	-72.35998
P_t@Grid [W]	50145.88	49040.97	-1104.910
Q_t@Grid [var]	937.1494	-7012.984	-7950.134
F_fund@Grid [Hz]	50.00057	50.00025	-3.166e-4

Phase ABC Test 1

Trip Value



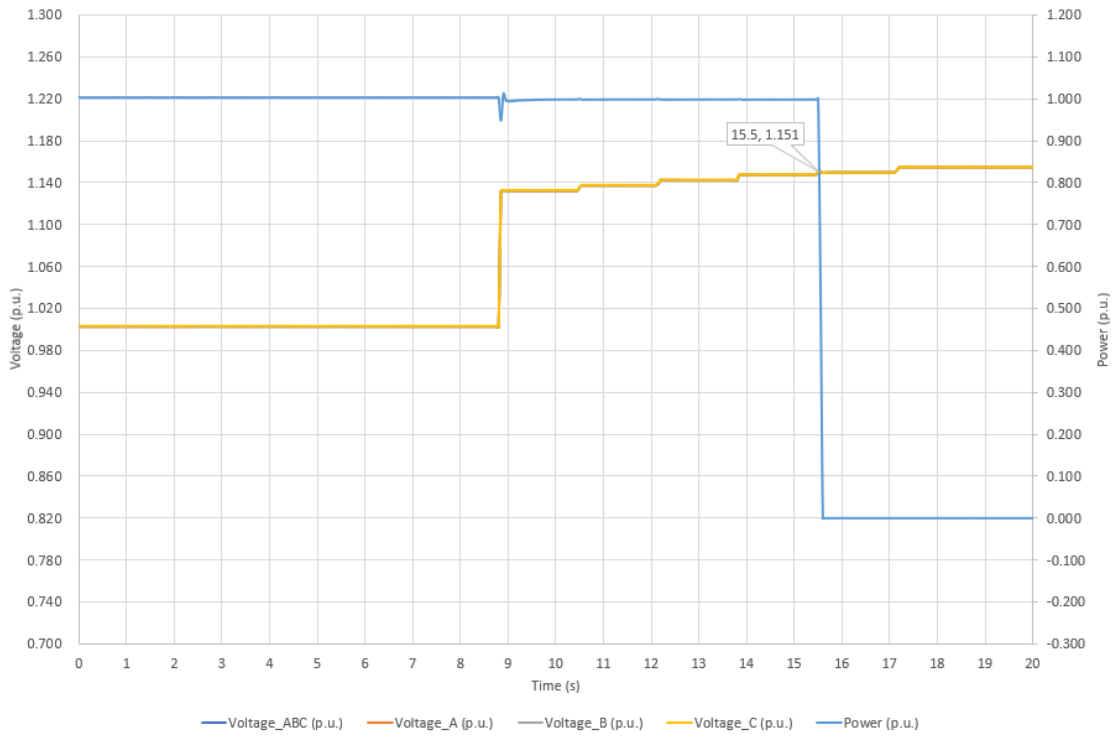
Trip Time



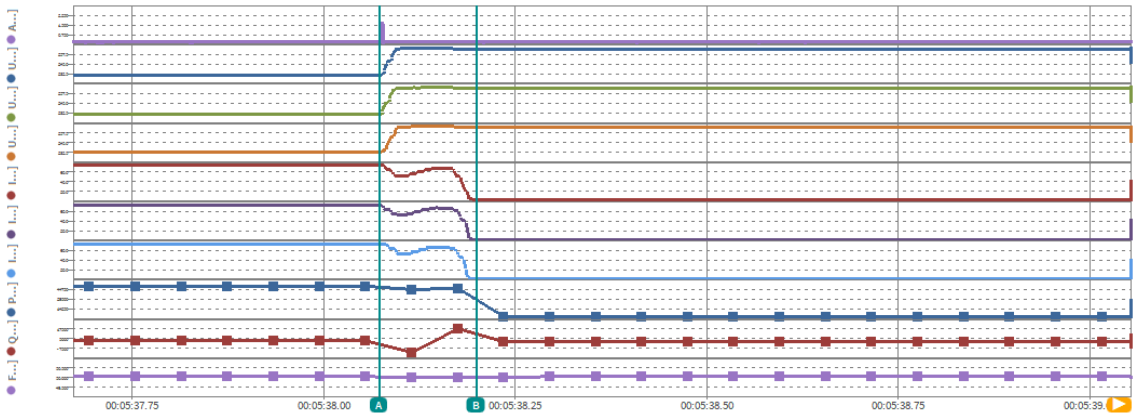
	A	B	间隔
时间 [s]	2:50.076	2:50.180	0.103
AI 1/U4 [V]	0.174761	0.177622	2.861e-3
U1_tRMS_rc@Grid [V]	230.5748	264.5268	33.95204
U2_tRMS_rc@Grid [V]	230.6132	264.3192	33.70599
U3_tRMS_rc@Grid [V]	230.7421	264.3140	33.57196
I1_tRMS_rc@Grid [A]	72.43768	0.384710	-72.05297
I2_tRMS_rc@Grid [A]	72.53188	0.200604	-72.33127
I3_tRMS_rc@Grid [A]	72.44093	0.070361	-72.37057
P_t@Grid [W]	50136.33	27380.18	-22756.15
Q_t@Grid [var]	937.2041	25532.98	24595.77
F_fund@Grid [Hz]	50.00043	49.97684	-0.023590

Phase ABC Test 2

Trip Value



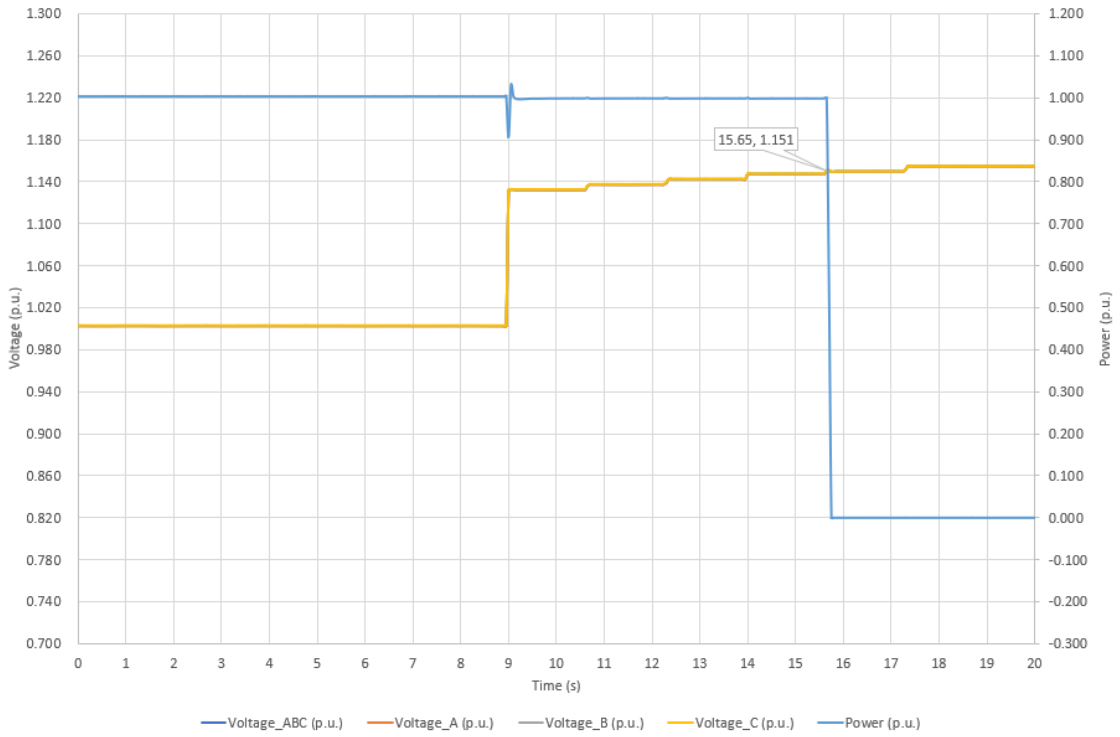
Trip Time



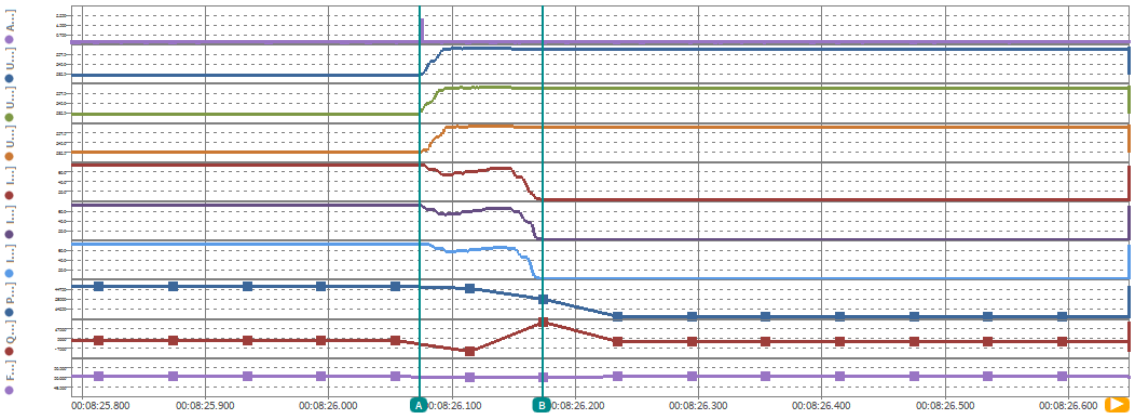
时间 [s]	A 5:38.073	B 5:38.200	间隔 0.127
AI 1/U4 [V]	0.179529	0.177145	-2.384e-3
U1_tRMS_rc@Grid [V]	230.5790	264.5363	33.95728
U2_tRMS_rc@Grid [V]	230.6152	264.3204	33.70515
U3_tRMS_rc@Grid [V]	230.7431	264.3202	33.57710
I1_tRMS_rc@Grid [A]	72.43630	0.407869	-72.02843
I2_tRMS_rc@Grid [A]	72.54555	0.193230	-72.35232
I3_tRMS_rc@Grid [A]	72.44949	0.067179	-72.38231
P_t@Grid [W]	50141.43	46012.21	-4129.219
Q_t@Grid [var]	942.0828	16863.49	15921.40
F_fund@Grid [Hz]	50.00035	49.98110	-0.019253

Phase ABC Test 3

Trip Value



Trip Time



	A	B	间隔
时间 [s]	8:26.074	8:26.174	0.100
AI 1/U4 [V]	0.174761	0.174046	-7.153e-4
U1_tRMS_rc@Grid [V]	230.5804	264.4777	33.89725
U2_tRMS_rc@Grid [V]	230.6009	264.3493	33.74834
U3_tRMS_rc@Grid [V]	230.7261	264.3684	33.64235
I1_tRMS_rc@Grid [A]	72.45160	1.474278	-70.97732
I2_tRMS_rc@Grid [A]	72.54518	1.364745	-71.18044
I3_tRMS_rc@Grid [A]	72.44383	0.102818	-72.34101
P_t@Grid [W]	50143.61	46230.61	-3913.000
Q_t@Grid [var]	946.0651	-12486.23	-13432.30
F_fund@Grid [Hz]	50.00039	49.99379	-6.599e-3

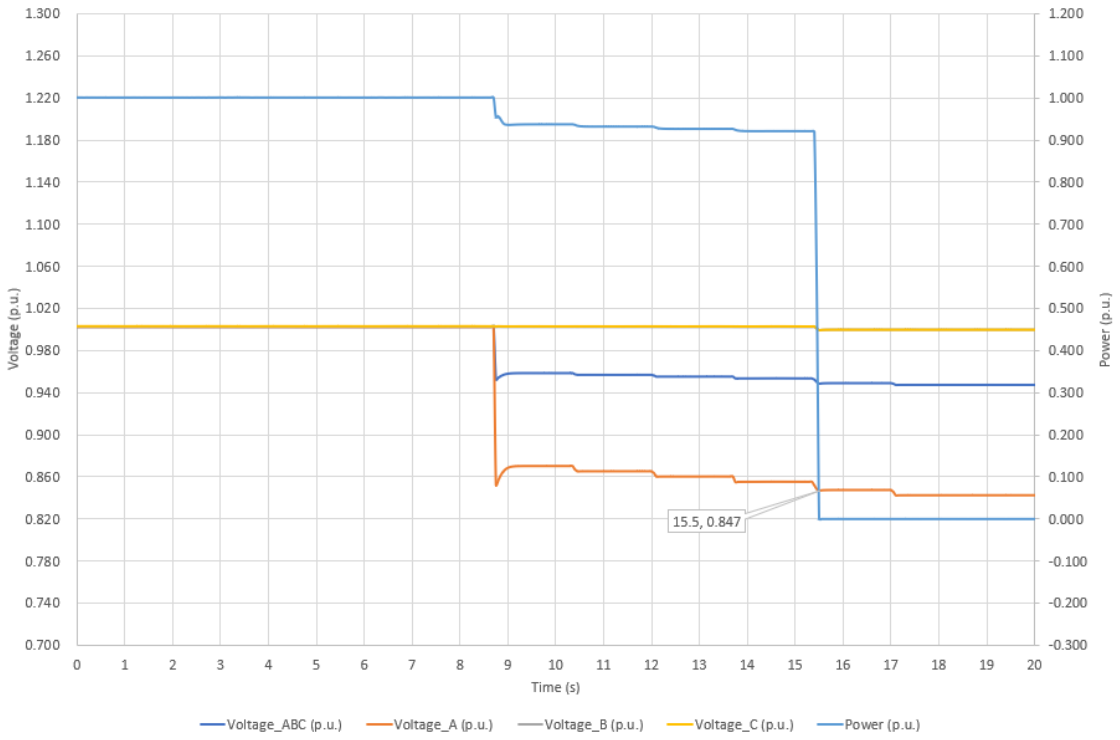
4.7.7.3 Undervoltage protection (Country / Region: Sweden)

Overvoltage of 85%Un				
Phase A				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	195.5	194.8	195.3	194.8
Trip time [s]	< 0.200	0.108	0.106	0.098
Phase B				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	195.5	194.8	194.8	194.8
Trip time [s]	< 0.200	0.118	0.105	0.112
Phase C				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	195.5	194.8	194.8	194.8
Trip time [s]	< 0.200	0.111	0.109	0.091
Phase ABC				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [V]	195.5	195.0	195.0	194.8
Trip time [s]	< 0.200	0.101	0.105	0.097

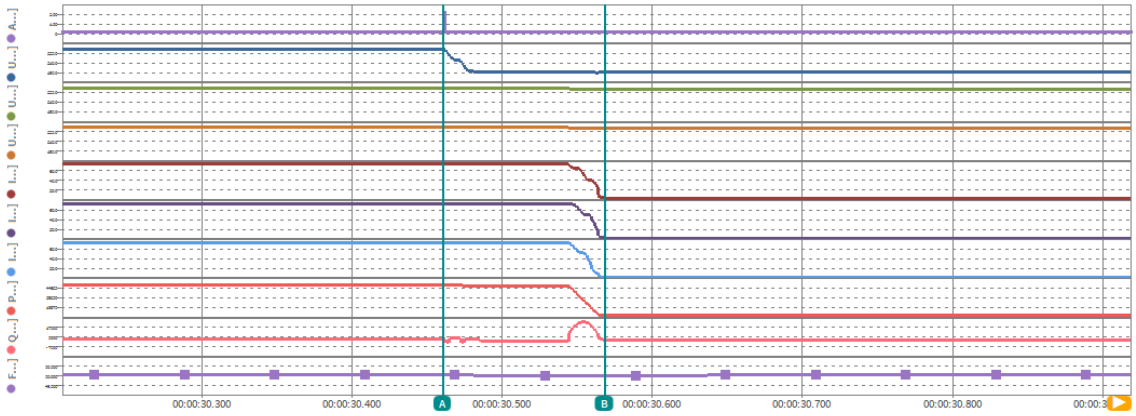
Test results are represented at diagrams below.

Phase A Test 1

Trip Value



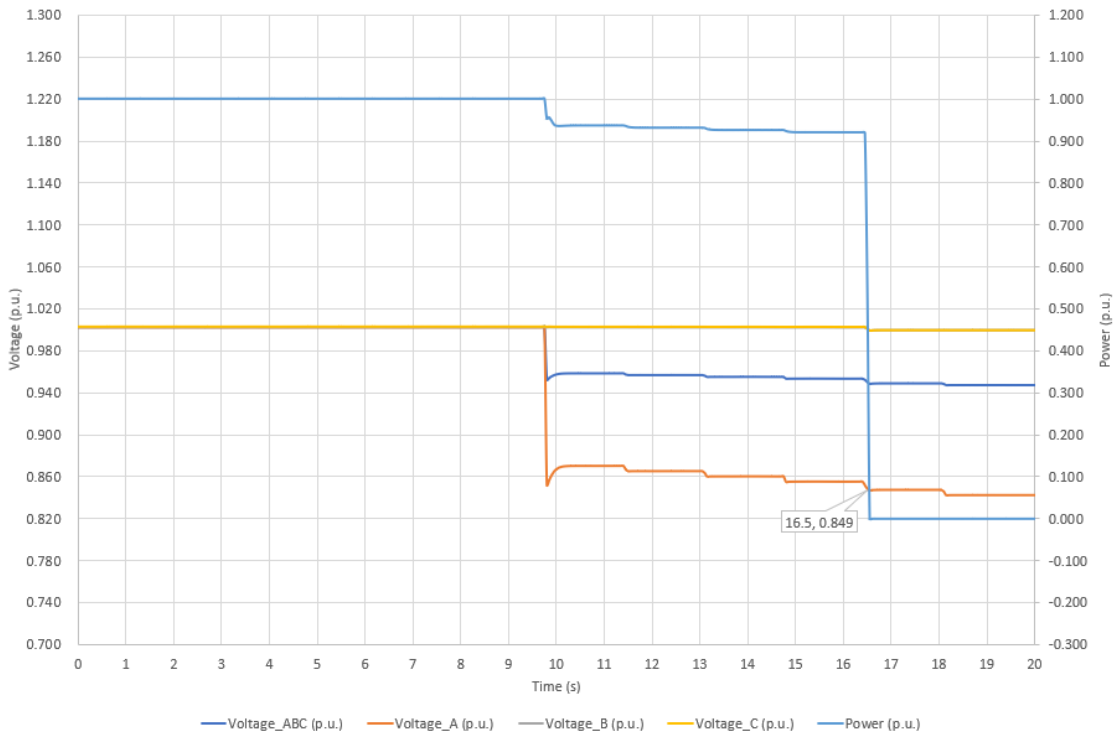
Trip Time



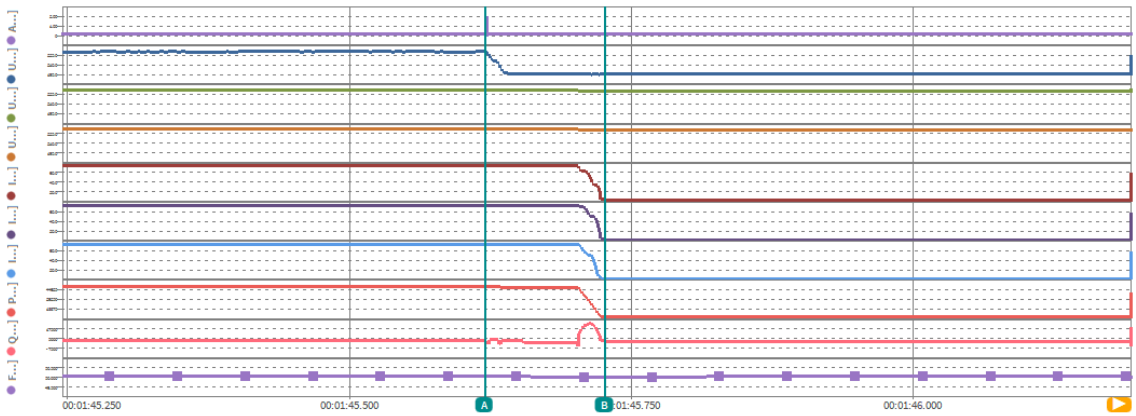
时间 [s]	A 0:30.461	B 0:30.569	间隔 0.108
AI 1/U4 [V]	0.166178	0.170708	4.530e-3
U1_tRMS_rc@Grid [V]	230.5828	194.8568	-35.72598
U2_tRMS_rc@Grid [V]	230.6153	229.8956	-0.719727
U3_tRMS_rc@Grid [V]	230.7486	229.8879	-0.860641
I1_tRMS_rc@Grid [A]	72.38479	1.731090	-70.65370
I2_tRMS_rc@Grid [A]	72.49298	1.417660	-71.07532
I3_tRMS_rc@Grid [A]	72.38492	0.427011	-71.95791
P_t_rc@Grid [W]	50102.70	-65.86805	-50168.57
Q_t_rc@Grid [var]	933.3520	758.5385	-174.8135
F_fund@Grid [Hz]	50.00033	49.99430	-6.031e-3

Phase A Test 2

Trip Value



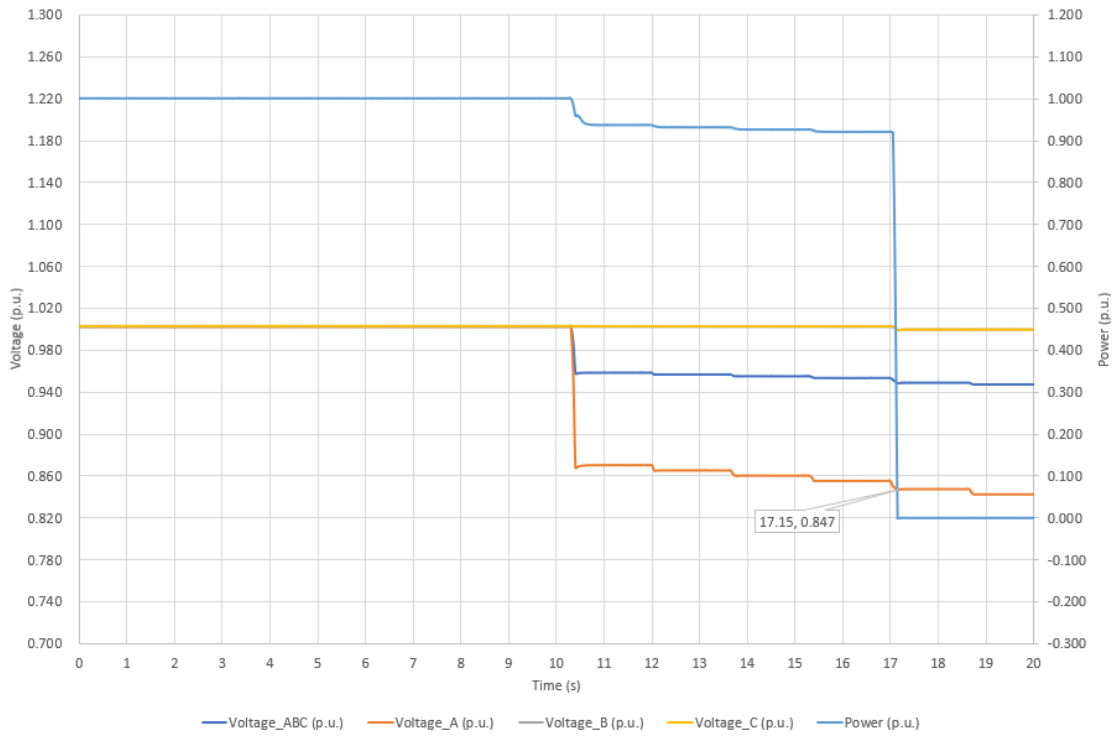
Trip Time



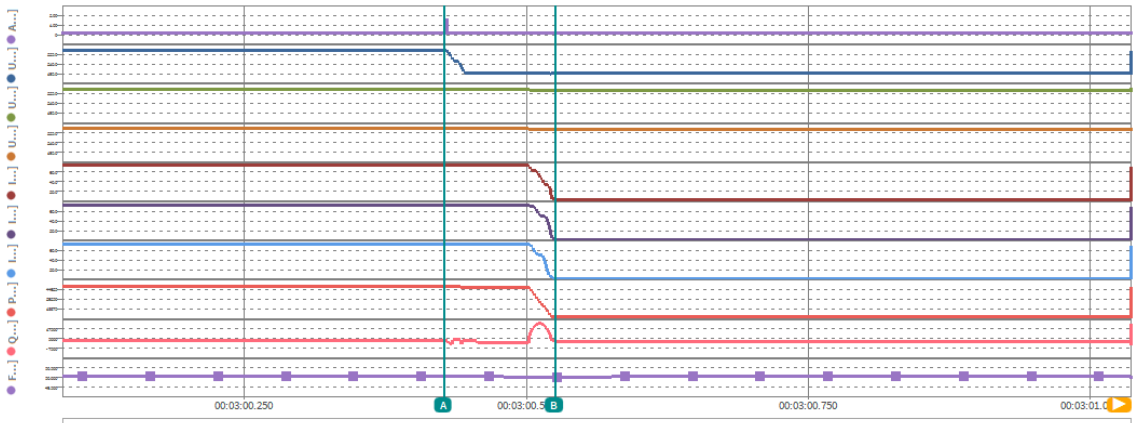
时间 [s]	A 1:45.620	B 1:45.727	间隔 0.106
AI 1/U4 [V]	0.163794	0.166178	2.384e-3
U1_tRMS_rc@Grid [V]	230.5729	194.8338	-35.73917
U2_tRMS_rc@Grid [V]	230.6079	229.8951	-0.712799
U3_tRMS_rc@Grid [V]	230.7279	229.9003	-0.827637
I1_tRMS_rc@Grid [A]	72.38962	1.867108	-70.52251
I2_tRMS_rc@Grid [A]	72.49210	2.011662	-70.48043
I3_tRMS_rc@Grid [A]	72.41084	0.528011	-71.88282
P_t_rc@Grid [W]	50106.62	-99.93128	-50206.55
Q_t_rc@Grid [var]	945.5267	942.3531	-3.173584
F_fund@Grid [Hz]	50.00027	49.96987	-0.030399

Phase A Test 3

Trip Value



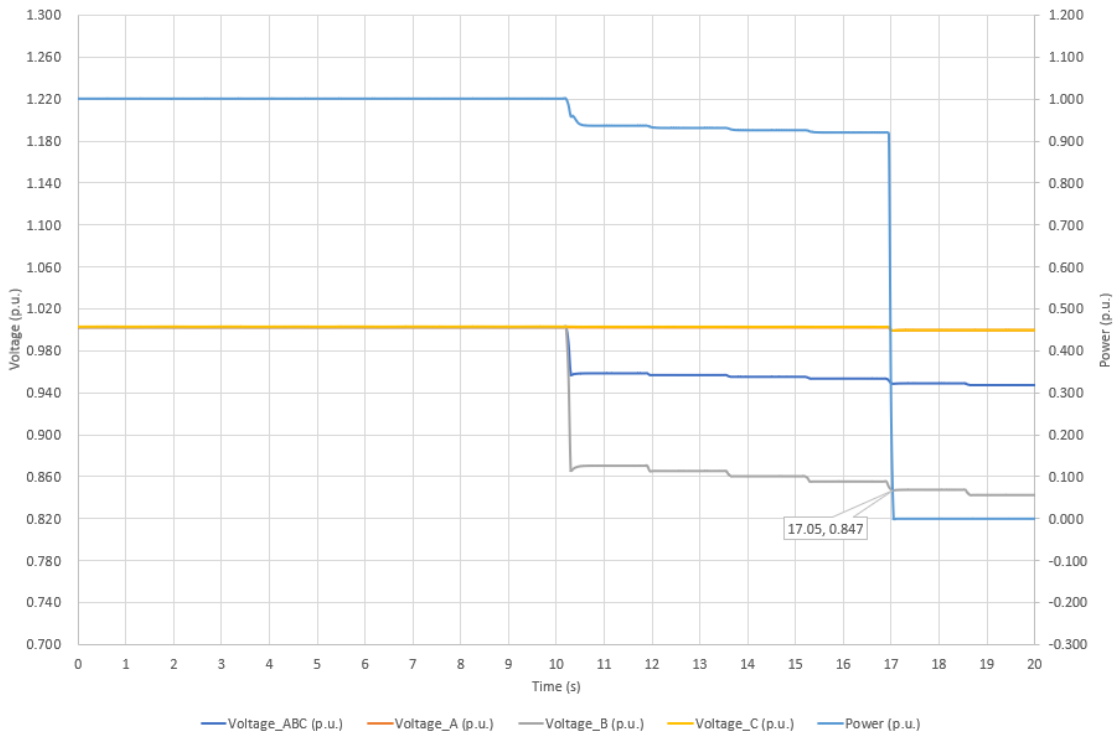
Trip Time



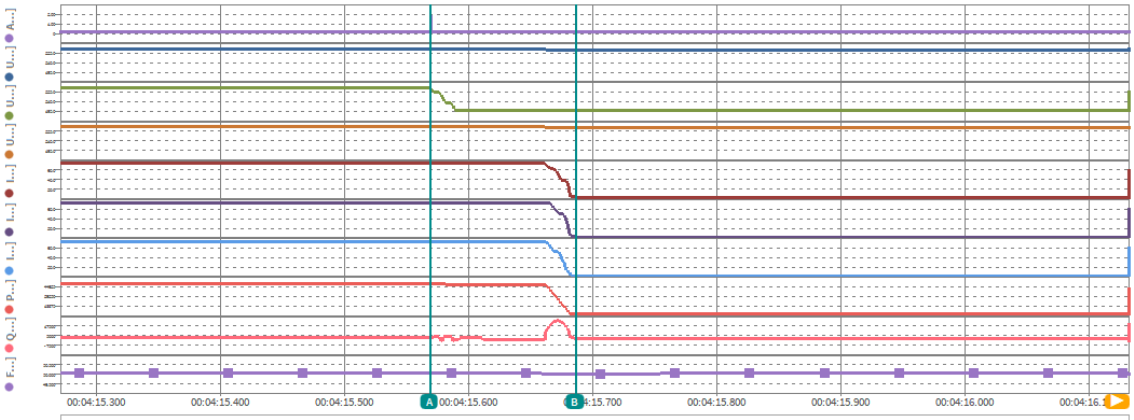
时间 [s]	A 3:00.427	B 3:00.525	间隔 0.098
AI 1/U4 [V]	0.171423	0.169516	-1.907e-3
U1_tRMS_rc@Grid [V]	230.5821	194.8736	-35.70857
U2_tRMS_rc@Grid [V]	230.6102	229.8951	-0.715073
U3_tRMS_rc@Grid [V]	230.7399	229.9111	-0.828796
I1_tRMS_rc@Grid [A]	72.39602	1.825089	-70.57093
I2_tRMS_rc@Grid [A]	72.50195	2.107895	-70.39405
I3_tRMS_rc@Grid [A]	72.39767	0.701912	-71.69576
P_t_rc@Grid [W]	50109.15	-88.28694	-50197.44
Q_t_rc@Grid [var]	938.9724	997.7353	58.76294
F_fund@Grid [Hz]	50.00035	50.00632	5.970e-3

Phase B Test 1

Trip Value



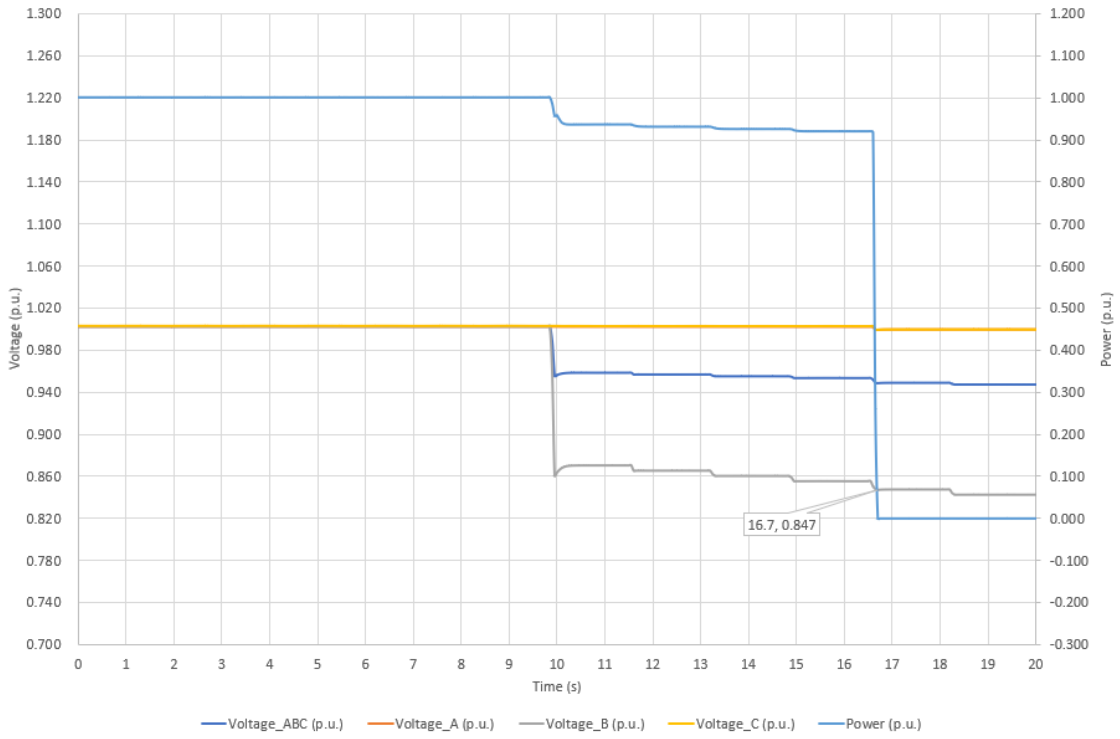
Trip Time



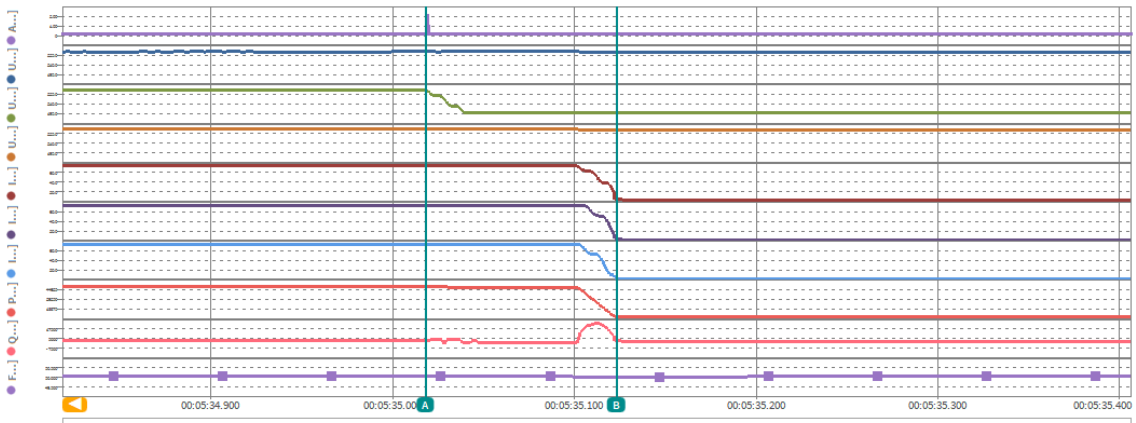
时间 [s]	A 4:15.569	B 4:15.687	间隔 0.118
AI 1/U4 [V]	0.164986	0.163555	-1.431e-3
U1_tRMS_rc@Grid [V]	230.5756	229.8582	-0.717361
U2_tRMS_rc@Grid [V]	230.5940	194.8791	-35.71494
U3_tRMS_rc@Grid [V]	230.7166	229.8755	-0.841110
I1_tRMS_rc@Grid [A]	72.40740	2.031428	-70.37597
I2_tRMS_rc@Grid [A]	72.49437	1.436129	-71.05824
I3_tRMS_rc@Grid [A]	72.41323	0.365748	-72.04748
P_t_rc@Grid [W]	50110.31	-47.89601	-50158.21
Q_t_rc@Grid [var]	937.6212	829.5068	-108.1144
F_fund@Grid [Hz]	50.00047	50.00040	-6.866e-5

Phase B Test 2

Trip Value



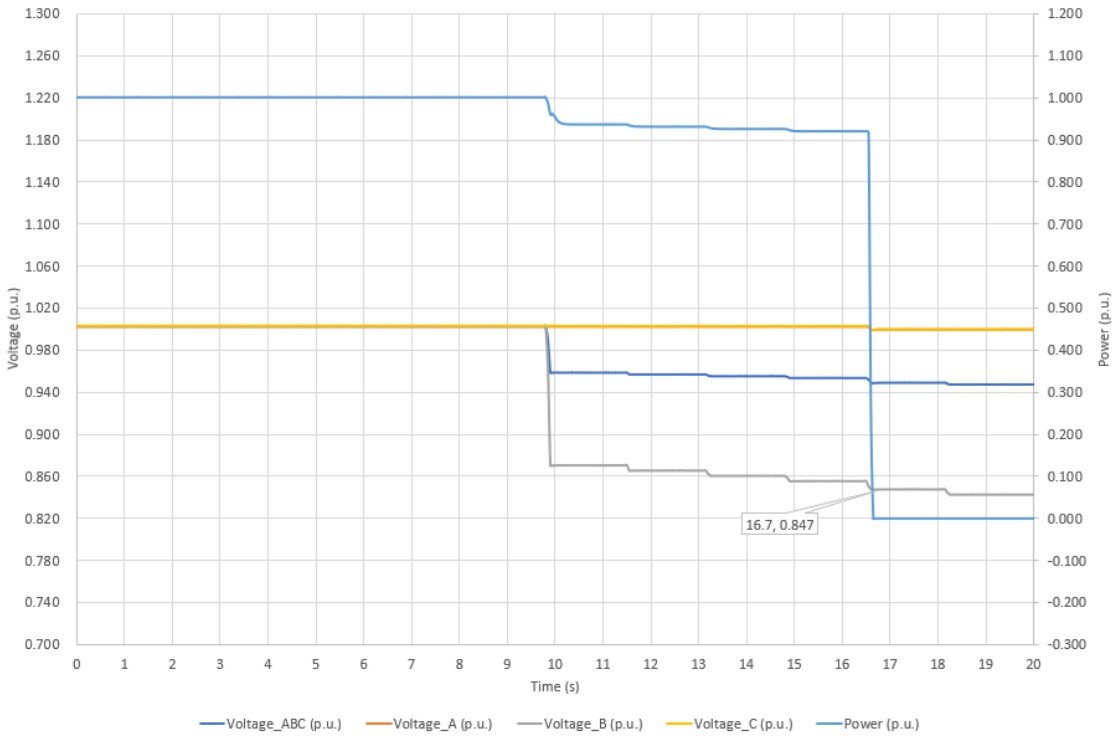
Trip Time



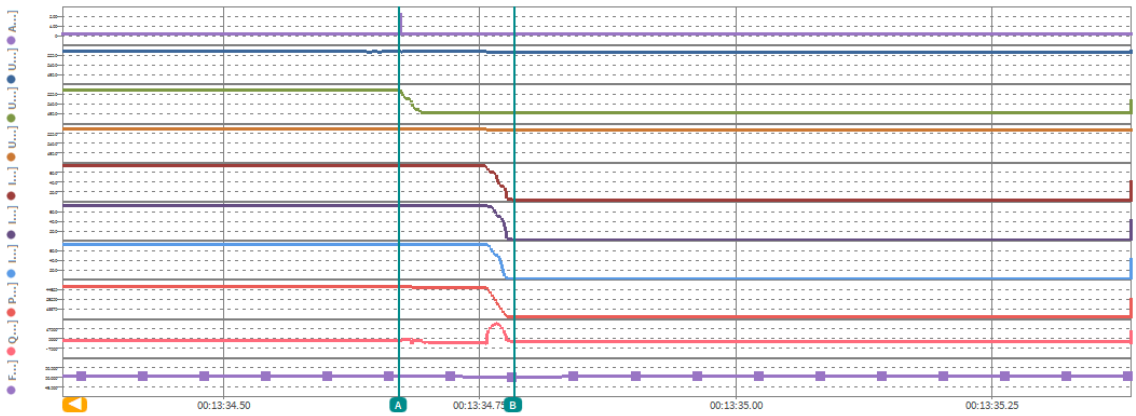
时间 [s]	A 5:35.019	B 5:35.123	间隔 0.105
AI 1/U4 [V]	0.165224	0.168562	3.338e-3
U1_tRMS_rc@Grid [V]	230.5720	229.8307	-0.741333
U2_tRMS_rc@Grid [V]	230.6090	194.9027	-35.70633
U3_tRMS_rc@Grid [V]	230.7293	229.8631	-0.866211
I1_tRMS_rc@Grid [A]	72.39108	2.881281	-69.50979
I2_tRMS_rc@Grid [A]	72.49564	2.228692	-70.26694
I3_tRMS_rc@Grid [A]	72.40768	1.178257	-71.22943
P_t_rc@Grid [W]	50107.36	-1.205954	-50108.57
Q_t_rc@Grid [var]	934.7119	1367.422	432.7101
F_fund@Grid [Hz]	50.00031	50.00082	5.112e-4

Phase B Test 3

Trip Value



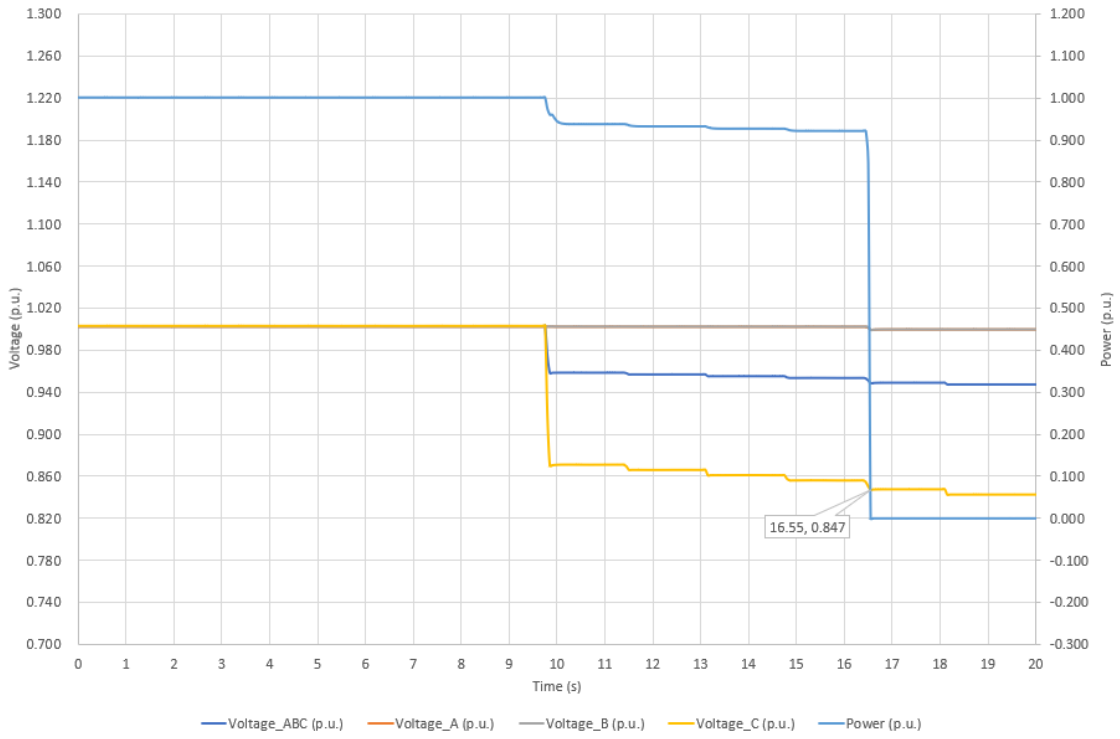
Trip Time



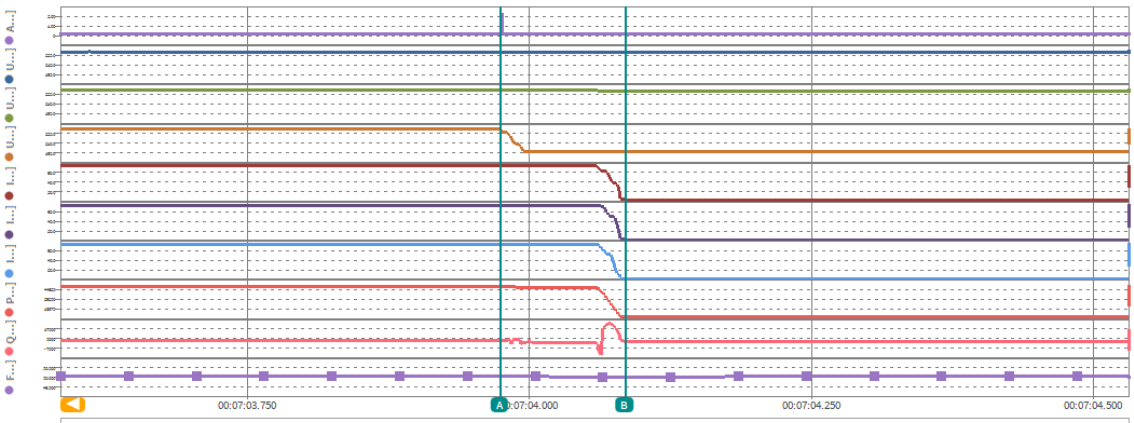
时间 [s]	A 00:13:34.672	B 00:13:34.784	间隔 0.112
AI 1/U4 [V]	0.165463	0.168085	2.623e-3
U1_tRMS_rc@Grid [V]	230.5721	229.8252	-0.746964
U2_tRMS_rc@Grid [V]	230.6131	194.9170	-35.69614
U3_tRMS_rc@Grid [V]	230.7415	229.8707	-0.870880
I1_tRMS_rc@Grid [A]	72.39912	1.175547	-71.22358
I2_tRMS_rc@Grid [A]	72.49944	0.977965	-71.52147
I3_tRMS_rc@Grid [A]	72.40547	0.100091	-72.30538
P_t_rc@Grid [W]	50110.66	-56.72359	-50167.39
Q_t_rc@Grid [var]	940.7371	480.4634	-460.2737
F_fund@Grid [Hz]	50.00030	50.00056	2.594e-4

Phase C Test 1

Trip Value



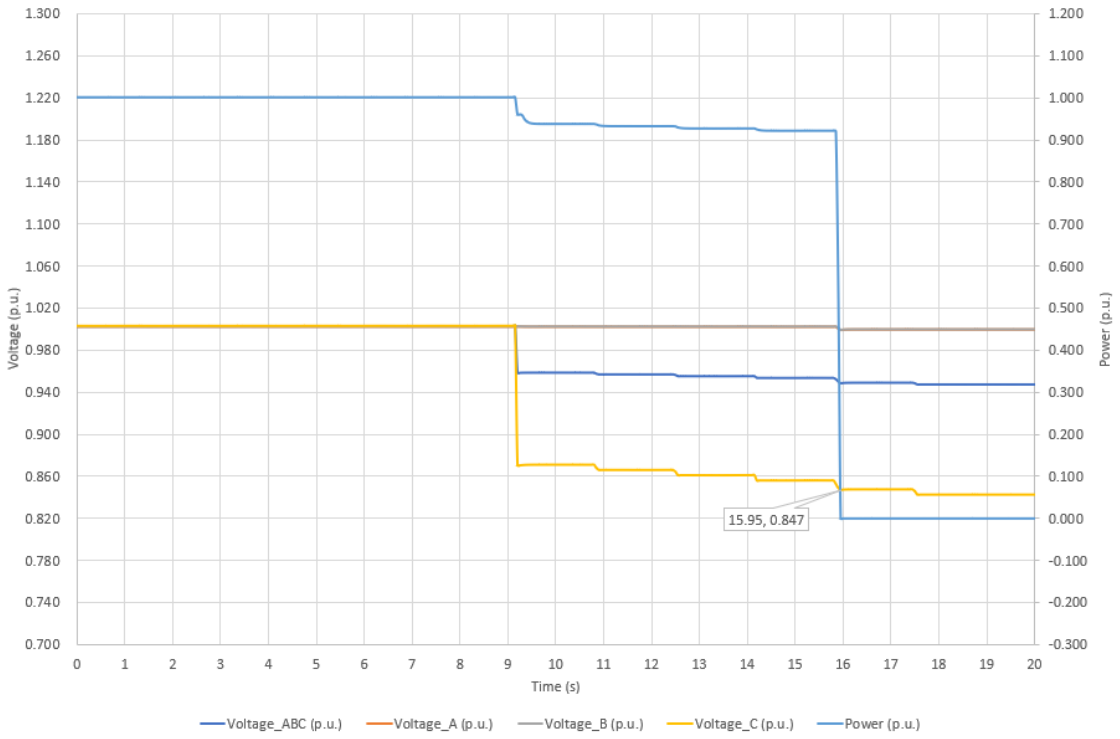
Trip Time



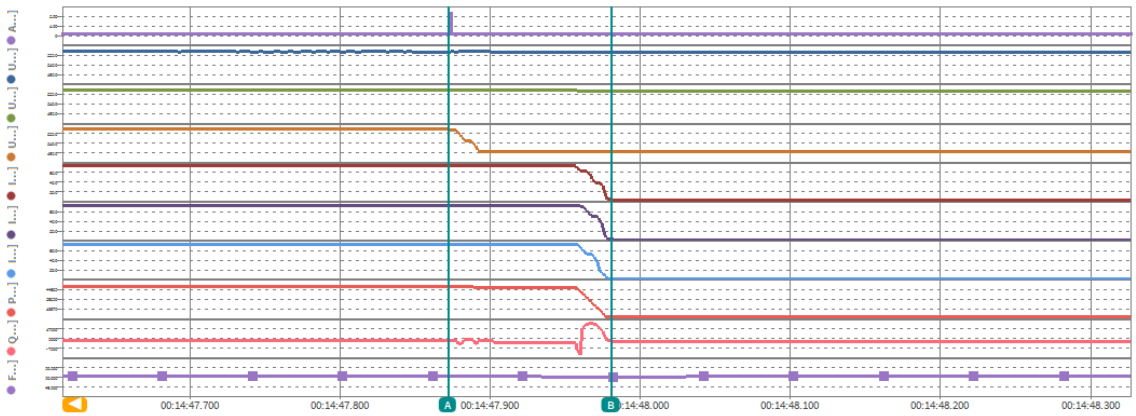
时间 [s]	A 7:03.974	B 7:04.085	间隔 0.111
AI 1/U4 [V]	0.164509	0.167131	2.623e-3
U1_tRMS_rc@Grid [V]	230.5647	229.8564	-0.708298
U2_tRMS_rc@Grid [V]	230.6045	229.8912	-0.713333
U3_tRMS_rc@Grid [V]	230.7210	194.9041	-35.81693
I1_tRMS_rc@Grid [A]	72.40658	2.275857	-70.13072
I2_tRMS_rc@Grid [A]	72.49889	1.912569	-70.58632
I3_tRMS_rc@Grid [A]	72.39301	0.395737	-71.99728
P_t_rc@Grid [W]	50106.81	-122.4560	-50229.26
Q_t_rc@Grid [var]	936.5635	1032.699	96.13544
F_fund@Grid [Hz]	50.00031	49.97193	-0.028378

Phase C Test 2

Trip Value



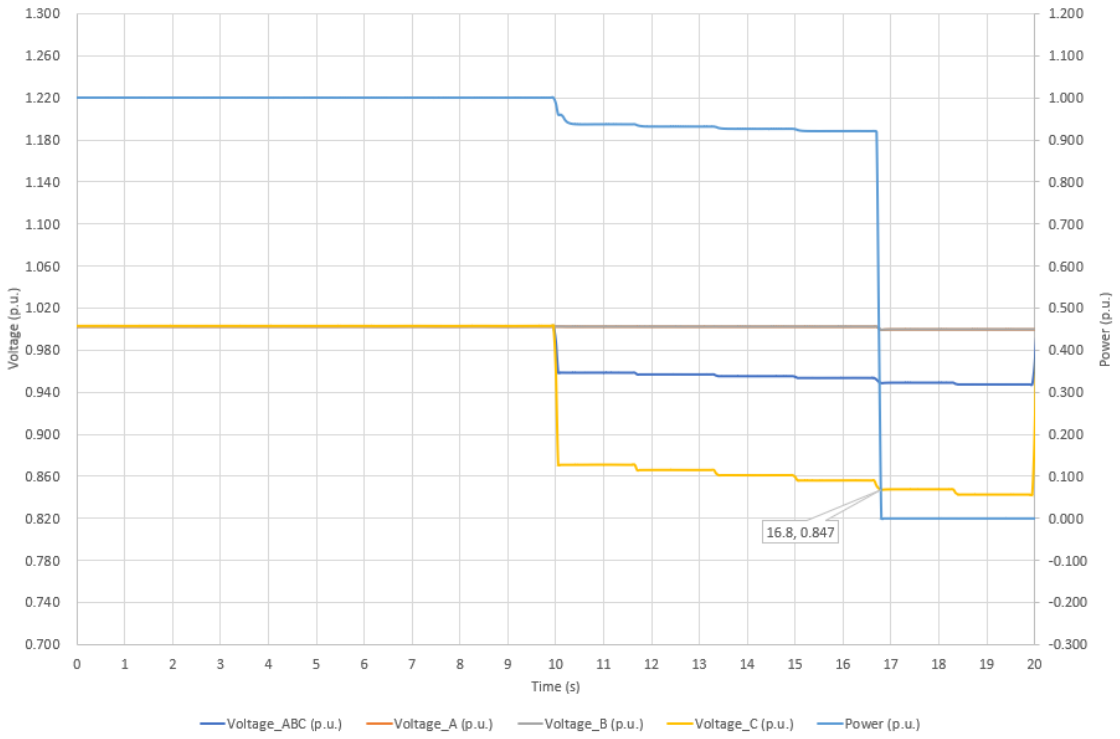
Trip Time



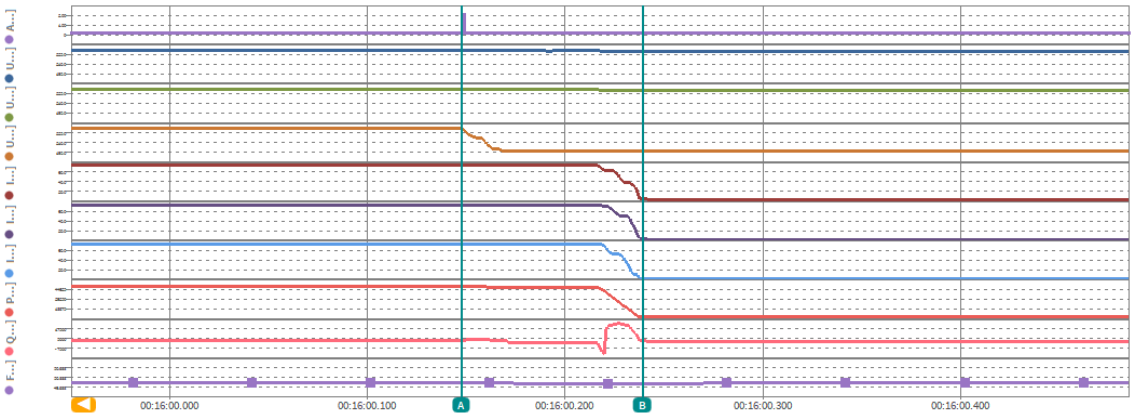
时间 [s]	A 00:14:47.872	B 00:14:47.981	间隔 0.109
AI 1/U4 [V]	0.163555	0.165939	2.384e-3
U1_tRMS_rc@Grid [V]	230.5695	229.8626	-0.706879
U2_tRMS_rc@Grid [V]	230.6084	229.8958	-0.712524
U3_tRMS_rc@Grid [V]	230.7310	194.9123	-35.81874
I1_tRMS_rc@Grid [A]	72.42014	2.199831	-70.22031
I2_tRMS_rc@Grid [A]	72.51039	2.010961	-70.49943
I3_tRMS_rc@Grid [A]	72.39607	0.418389	-71.97768
P_t_rc@Grid [W]	50114.47	-99.04745	-50213.52
Q_t_rc@Grid [var]	946.1417	1044.835	98.69348
F_fund@Grid [Hz]	50.00041	50.00026	-1.488e-4

Phase C Test 3

Trip Value



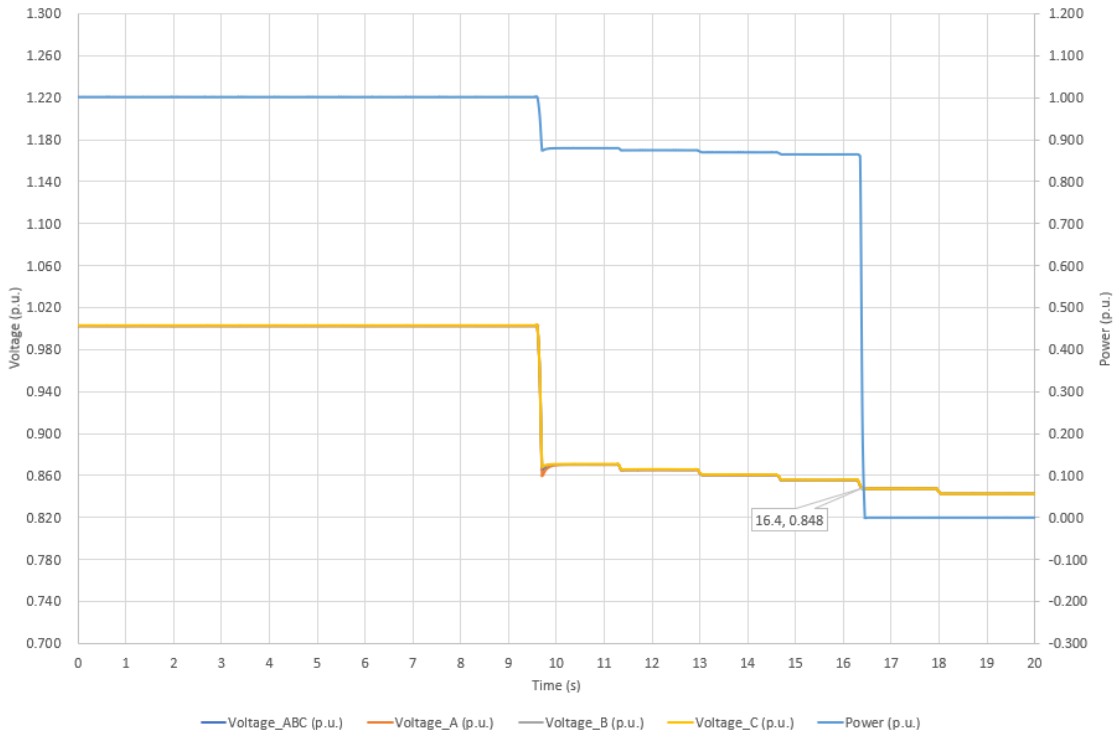
Trip Time



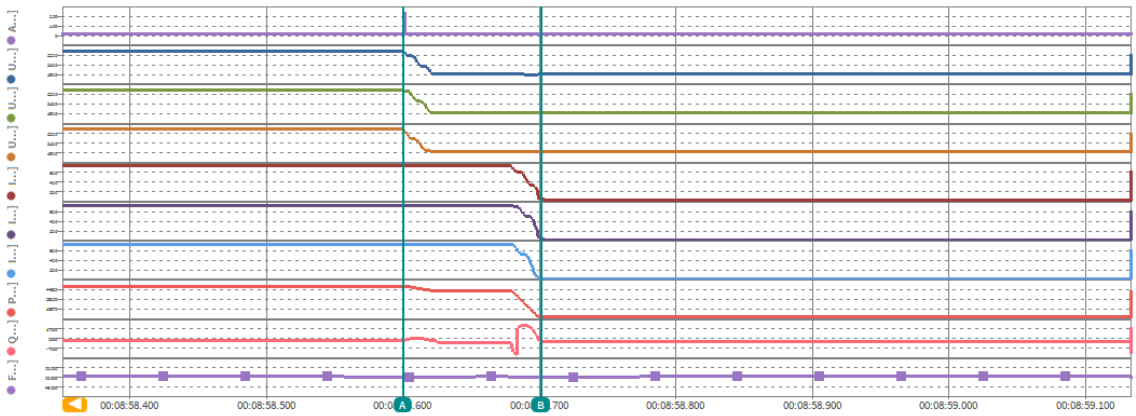
时间 [s]	A 00:16:00.148	B 00:16:00.239	间隔 0.091
AI 1/U4 [V]	0.166416	0.165939	-4.768e-4
U1_tRMS_rc@Grid [V]	230.5786	229.8758	-0.702850
U2_tRMS_rc@Grid [V]	230.5940	229.8854	-0.708618
U3_tRMS_rc@Grid [V]	230.7206	194.9143	-35.80624
I1_tRMS_rc@Grid [A]	72.41324	2.227764	-70.18547
I2_tRMS_rc@Grid [A]	72.49295	2.119977	-70.37297
I3_tRMS_rc@Grid [A]	72.43977	0.560766	-71.87901
P_t_rc@Grid [W]	50117.98	-76.92793	-50194.91
Q_t_rc@Grid [var]	936.6202	1106.090	169.4700
F_fund@Grid [Hz]	50.00035	49.97257	-0.027782

Phase ABC Test 1

Trip Value



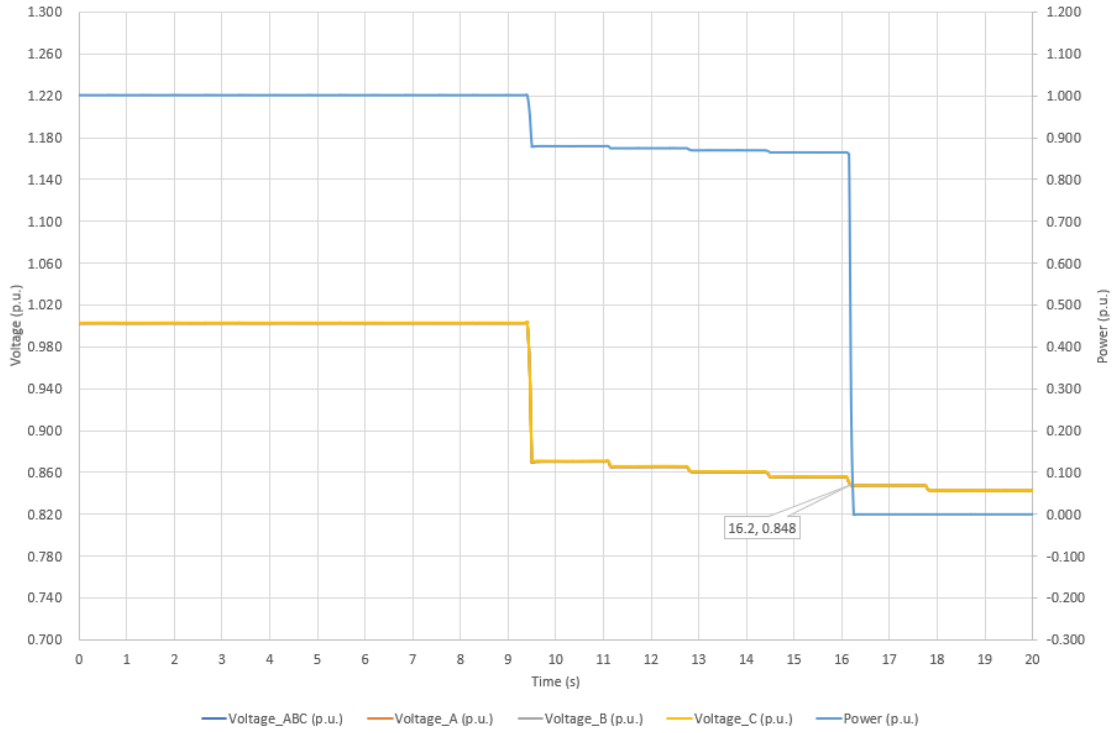
Trip Time



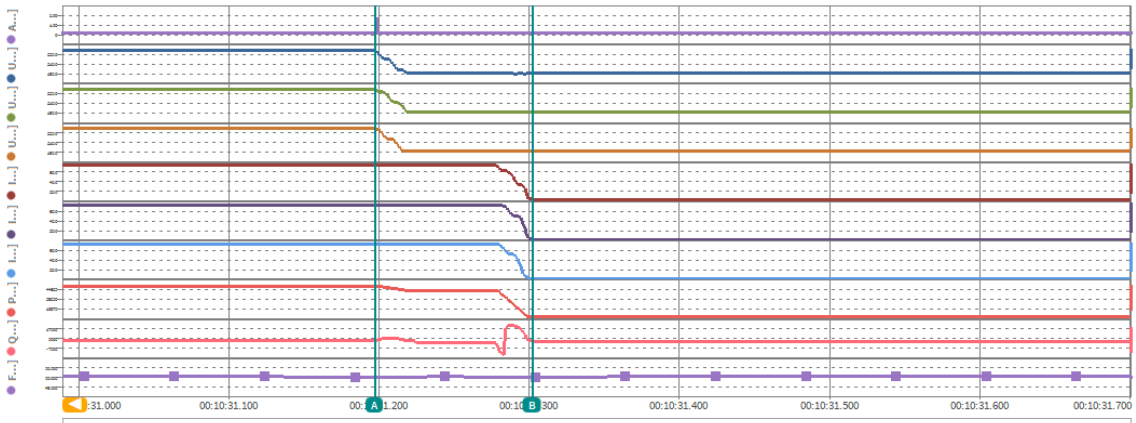
时间 [s]	A 8:58.601	B 8:58.702	间隔 0.101
AI 1/U4 [V]	0.166893	0.165463	-1.431e-3
U1_tRMS_rc@Grid [V]	230.5798	194.7584	-35.82141
U2_tRMS_rc@Grid [V]	230.5936	194.8980	-35.69556
U3_tRMS_rc@Grid [V]	230.7155	194.9190	-35.79648
I1_tRMS_rc@Grid [A]	72.40767	1.904849	-70.50282
I2_tRMS_rc@Grid [A]	72.48101	2.149752	-70.33126
I3_tRMS_rc@Grid [A]	72.40216	1.013574	-71.38859
P_t_rc@Grid [W]	50104.76	-65.18309	-50169.94
Q_t_rc@Grid [var]	946.6680	985.3792	38.71118
F_fund@Grid [Hz]	50.00035	50.01399	0.013638

Phase ABC Test 2

Trip Value



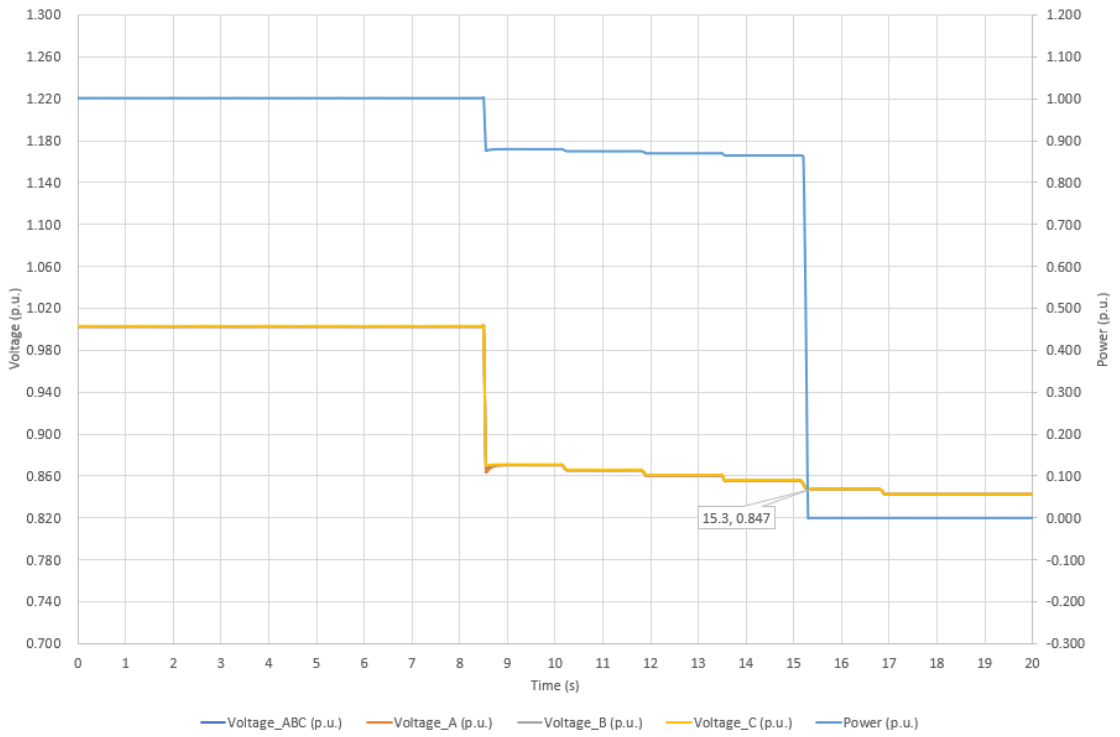
Trip Time



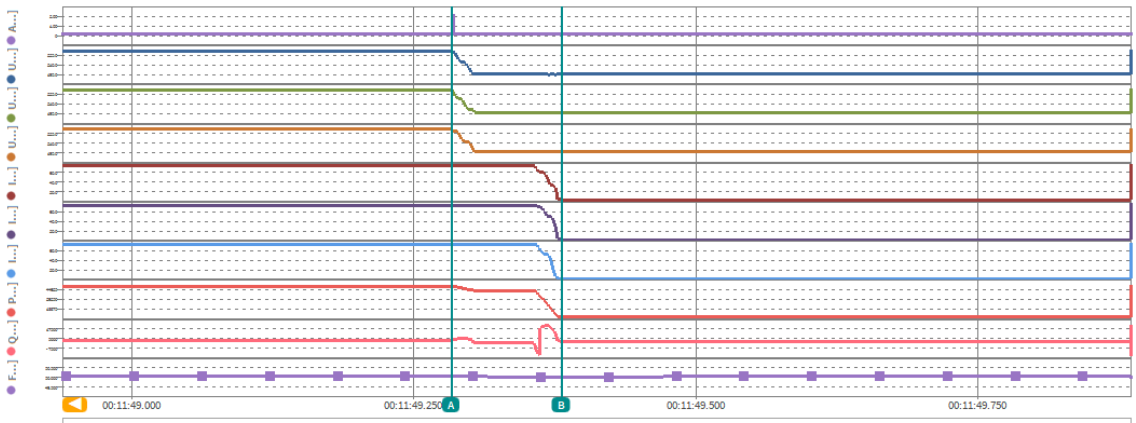
时间 [s]	A 00:10:31.198	B 00:10:31.302	间隔 0.105
AI 1/U4 [V]	0.167131	0.164986	-2.146e-3
U1_tRMS_rc@Grid [V]	230.5848	194.7833	-35.80150
U2_tRMS_rc@Grid [V]	230.6015	194.8924	-35.70917
U3_tRMS_rc@Grid [V]	230.7265	194.9285	-35.79803
I1_tRMS_rc@Grid [A]	72.40591	1.822999	-70.58291
I2_tRMS_rc@Grid [A]	72.49943	1.701604	-70.79782
I3_tRMS_rc@Grid [A]	72.42427	0.366000	-72.05827
P_t_rc@Grid [W]	50115.52	-65.77370	-50181.29
Q_t_rc@Grid [var]	942.6061	755.2045	-187.4017
F_fund@Grid [Hz]	49.99978	50.00697	7.191e-3

Phase ABC Test 3

Trip Value



Trip Time



时间 [s]	A 00:11:49.284	B 00:11:49.381	间隔 0.097
AI 1/U4 [V]	0.165463	0.168562	3.099e-3
U1_tRMS_rc@Grid [V]	230.5829	194.7865	-35.79642
U2_tRMS_rc@Grid [V]	230.6046	194.8989	-35.70570
U3_tRMS_rc@Grid [V]	230.7369	194.9335	-35.80336
I1_tRMS_rc@Grid [A]	72.41087	1.824549	-70.58632
I2_tRMS_rc@Grid [A]	72.49454	1.792866	-70.70167
I3_tRMS_rc@Grid [A]	72.40344	0.507156	-71.89629
P_t_rc@Grid [W]	50111.53	-60.64818	-50172.18
Q_t_rc@Grid [var]	944.2497	801.3951	-142.8546
F_fund@Grid [Hz]	50.00039	49.97104	-0.029350

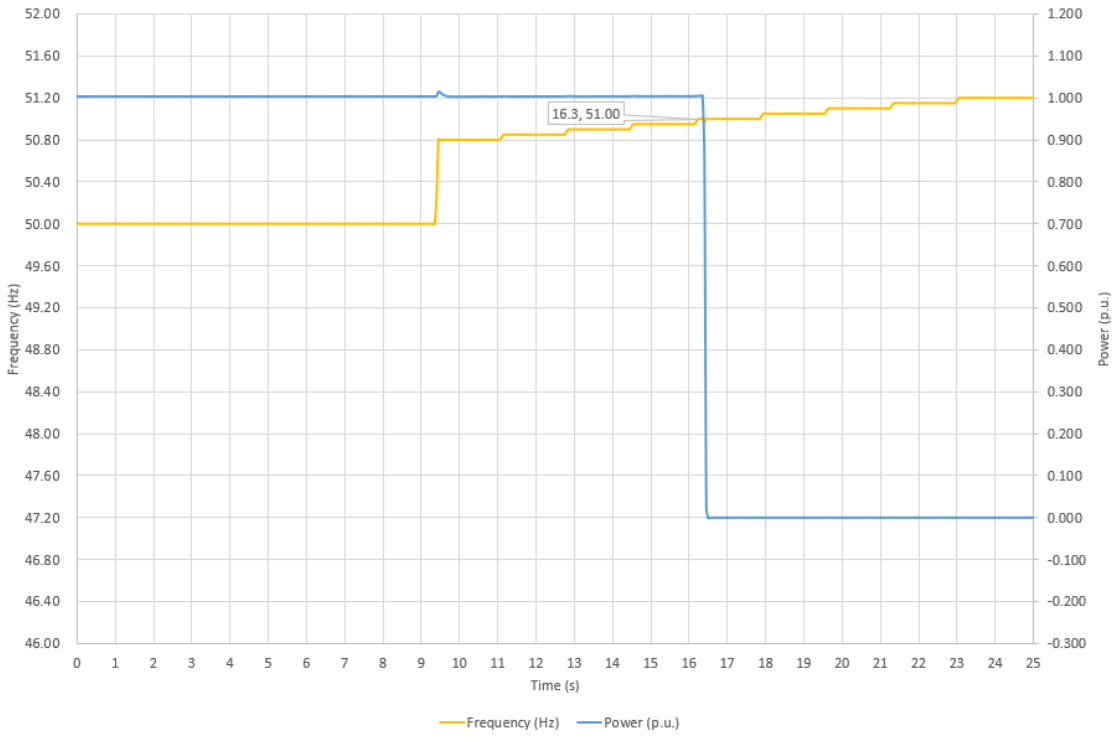
4.7.7.4 Overfrequency protection (Country / Region: Sweden)

51.0 Hz				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [Hz]	51.00	51.00	51.00	51.00
Trip time [s]	< 0.500	0.488	0.481	0.491

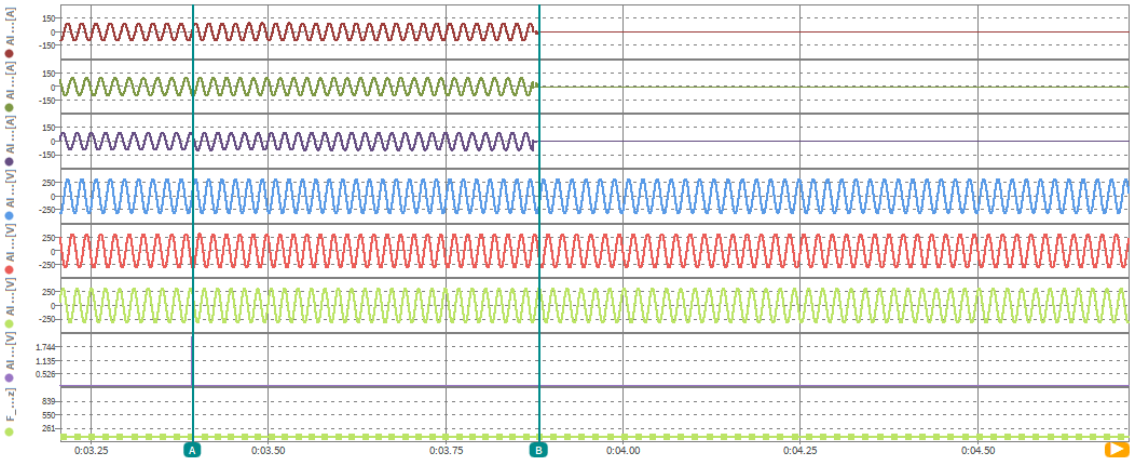
Test results are represented at diagrams below.

Test 1

Trip Value



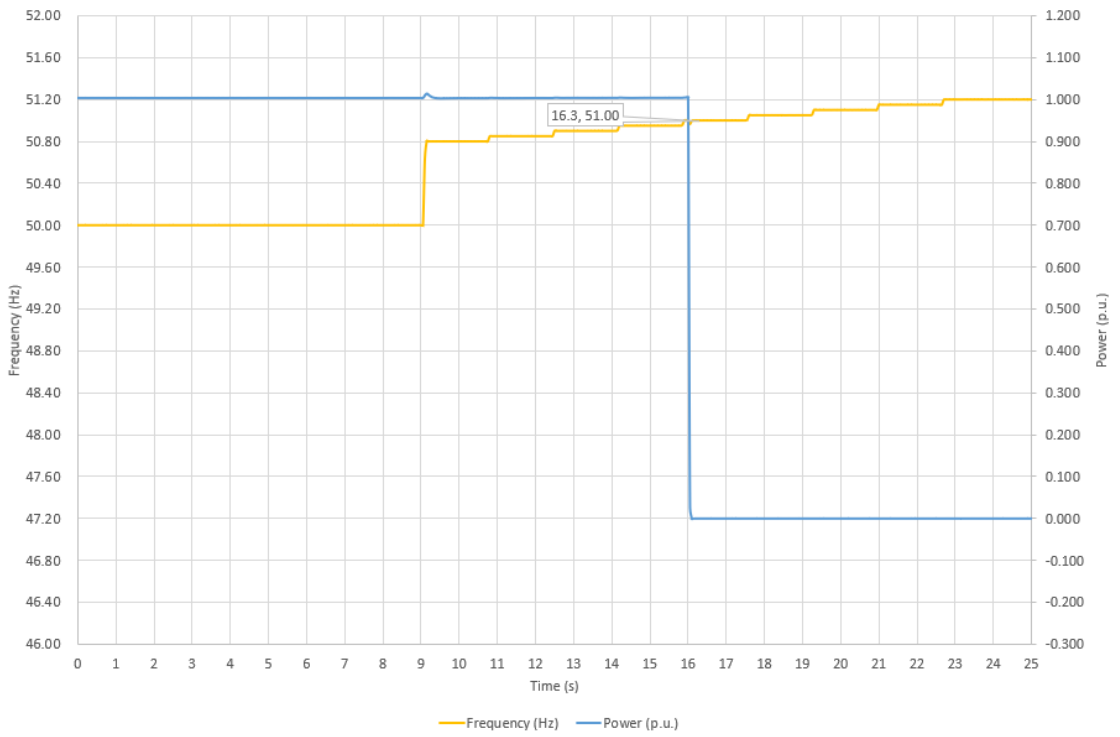
Trip Time



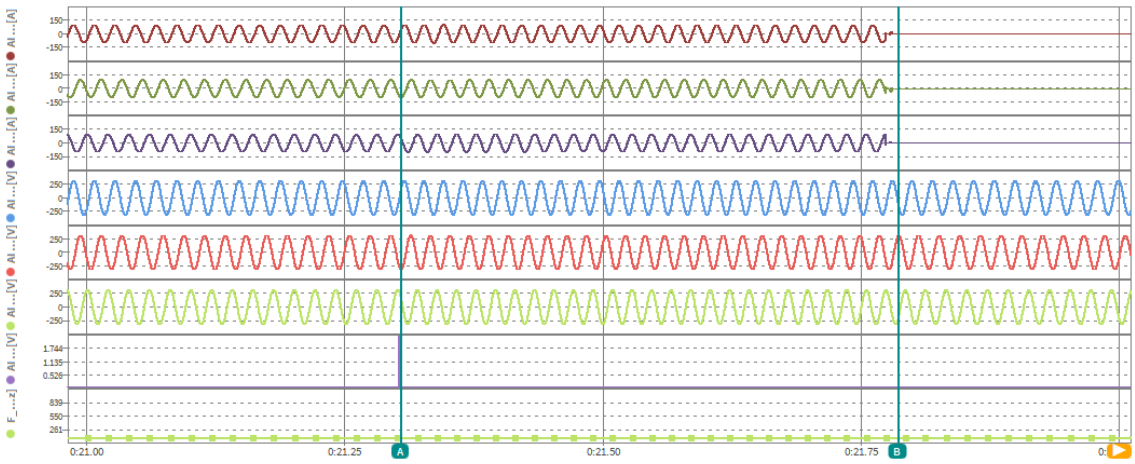
	A	B	间隔
时间 [s]	3.39478	3.88238	0.48760
AI 1/I1 [A]	25.27616	-0.274686	-25.55084
AI 1/I2 [A]	-97.51202	0.208609	97.72063
AI 1/I3 [A]	70.89767	-0.076682	-70.97435
AI 1/U1 [V]	91.80227	-213.1172	-304.9195
AI 1/U2 [V]	-316.5455	-105.5884	210.9571
AI 1/U3 [V]	226.8127	319.0891	92.27634
AI 1/U4 [V]	-0.013092	-9.515e-3	3.576e-3
F_fund@INV [Hz]	50.03796	53.00271	2.964748

Test 2

Trip Value



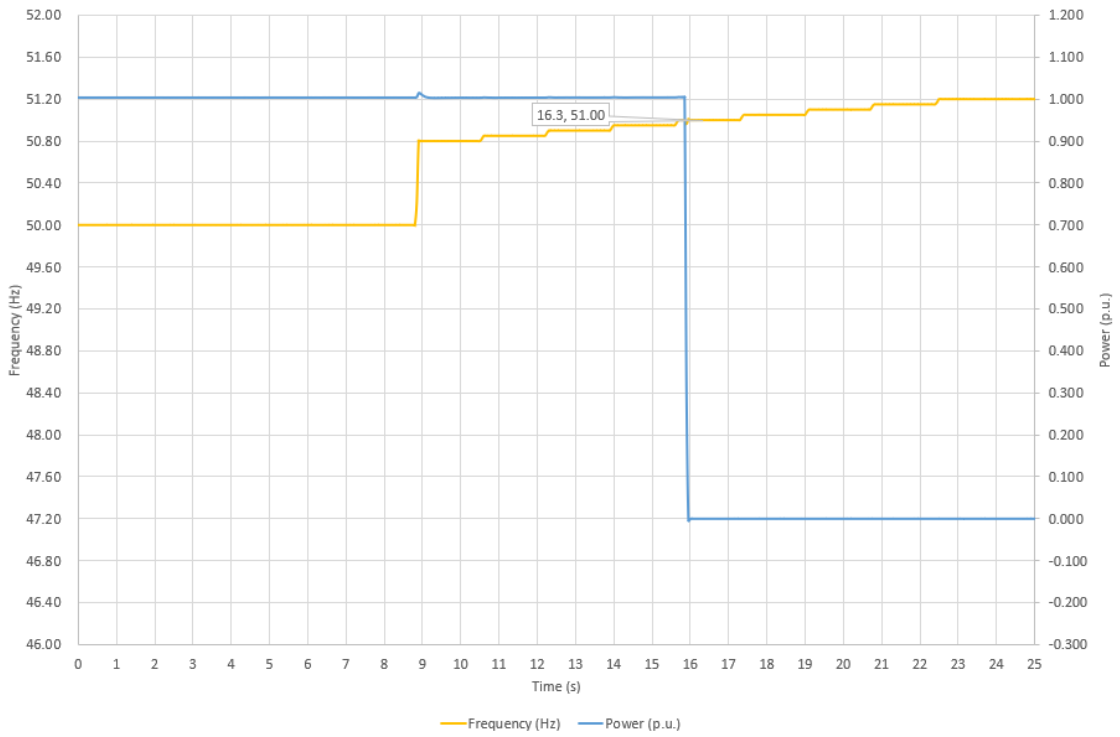
Trip Time



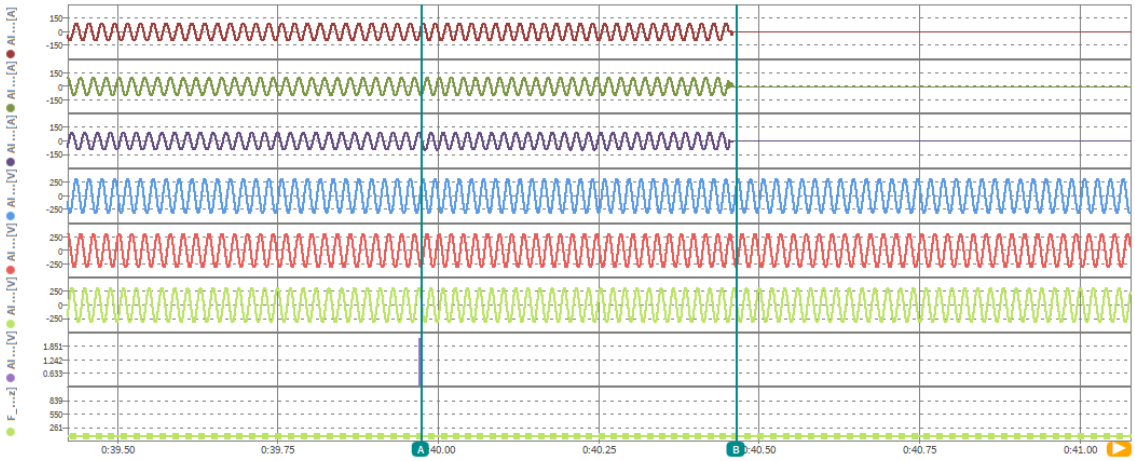
	A	B	间隔
时间 [s]	0:21.30488	0:21.78568	0.48080
AI 1/I1 [A]	32.84309	0.114413	-32.72867
AI 1/I2 [A]	-99.03933	-0.089414	98.94992
AI 1/I3 [A]	65.97385	-0.175387	-66.14924
AI 1/U1 [V]	112.5766	-74.69568	-187.2723
AI 1/U2 [V]	-321.3546	311.1882	632.5429
AI 1/U3 [V]	209.4301	-236.4231	-445.8533
AI 1/U4 [V]	-0.012138	-0.011661	4.768e-4
F_fund@INV [Hz]	50.03767	52.92352	2.885849

Test 3

Trip Value



Trip Time



	A	B	间隔
时间 [s]	0:39.97388	0:40.46478	0.49090
AI 1/I1 [A]	2.760859	-0.297098	-3.057957
AI 1/I2 [A]	-90.36948	0.060790	90.43027
AI 1/I3 [A]	84.23004	0.108331	-84.12171
AI 1/U1 [V]	18.46829	51.27040	32.80211
AI 1/U2 [V]	-291.0841	-303.4370	-12.35294
AI 1/U3 [V]	273.2448	252.1273	-21.11745
AI 1/U4 [V]	0.152848	-0.013330	-0.166178
F_fund@INV [Hz]	50.03783	52.89232	2.854488

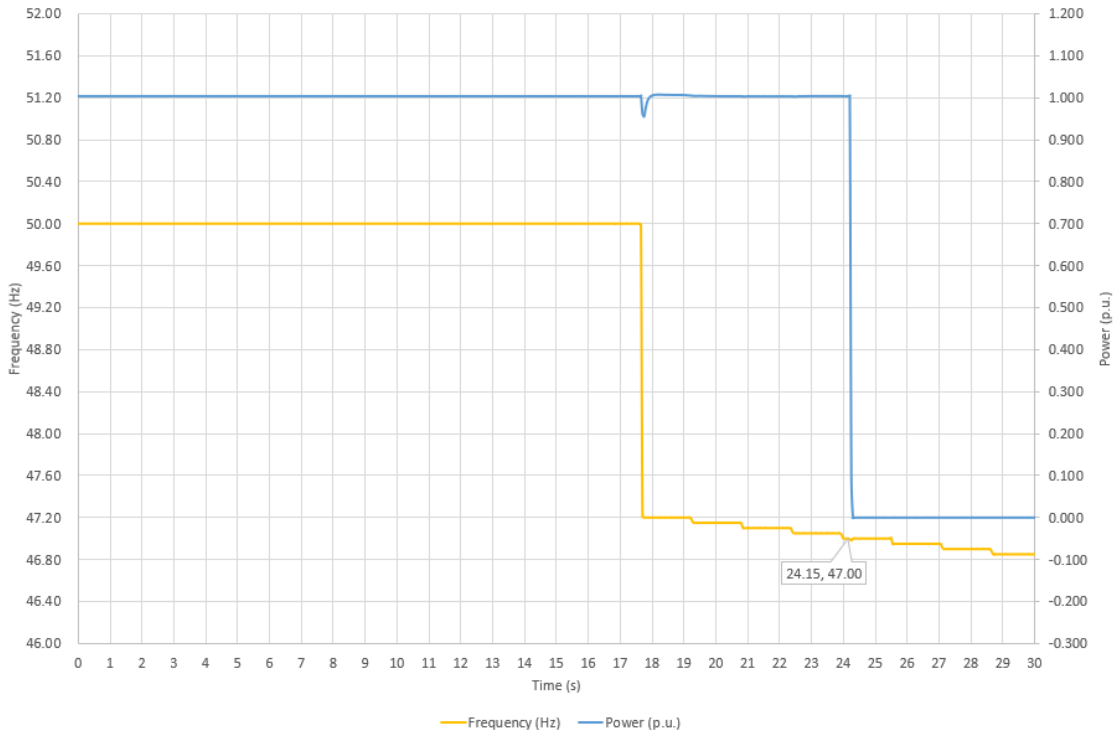
4.7.7.5 Underfrequency protection (Country / Region: Sweden)

47.0 Hz				
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**
Trip value [Hz]	47.00	47.00	47.00	47.00
Trip time [s]	< 0.500	0.482	0.489	0.485

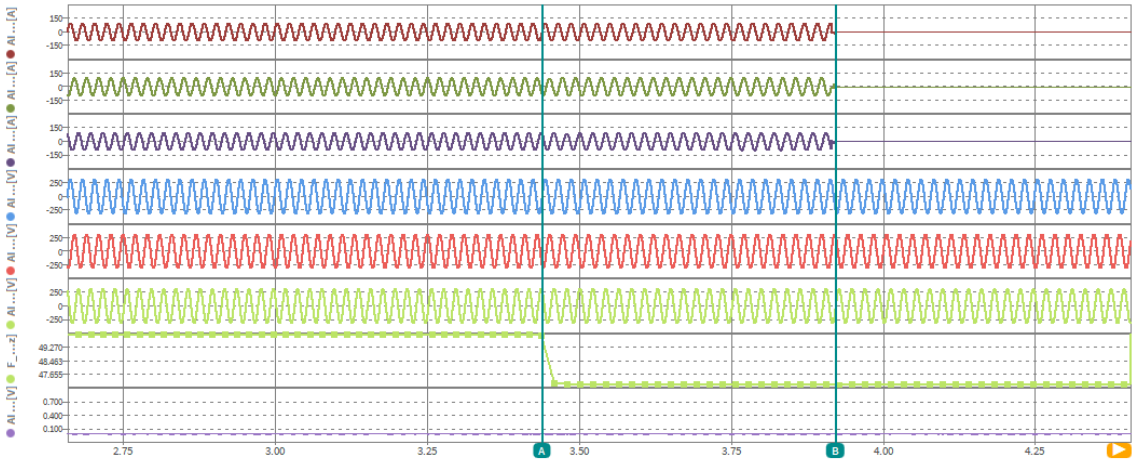
Test results are represented at diagrams below.

Test 1

Trip Value



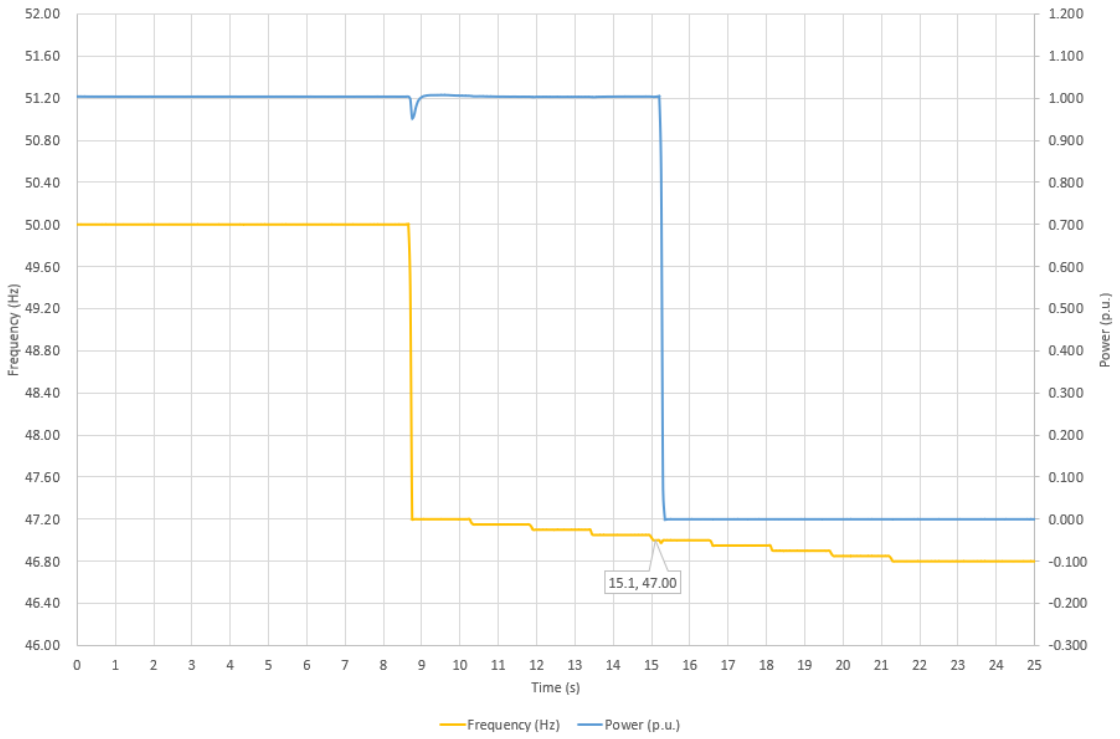
Trip Time



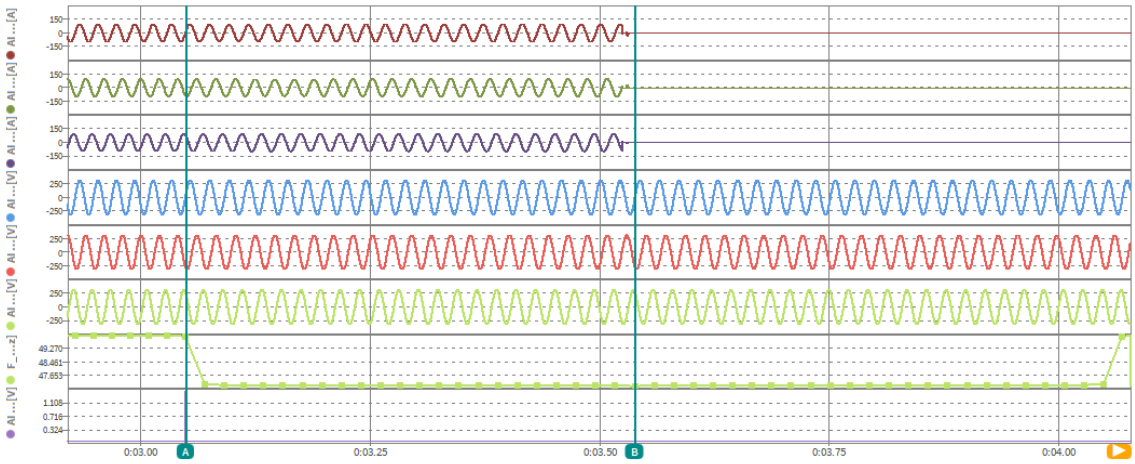
	A	B	间隔
时间 [s]	3.440200	3.922000	0.481800
AI 1/I1 [A]	-11.07648	0.115843	11.19232
AI 1/I2 [A]	-81.72775	2.316e-4	81.72799
AI 1/I3 [A]	91.71591	-0.205428	-91.92133
AI 1/U1 [V]	-36.86891	-229.6423	-192.7734
AI 1/U2 [V]	-261.5481	311.8184	573.3664
AI 1/U3 [V]	299.8516	-82.14915	-382.0007
F_fund@INV [Hz]	49.99991	46.99612	-3.003788
AI 1/U4 [V]	-0.015953	-0.012853	3.099e-3

Test 2

Trip Value



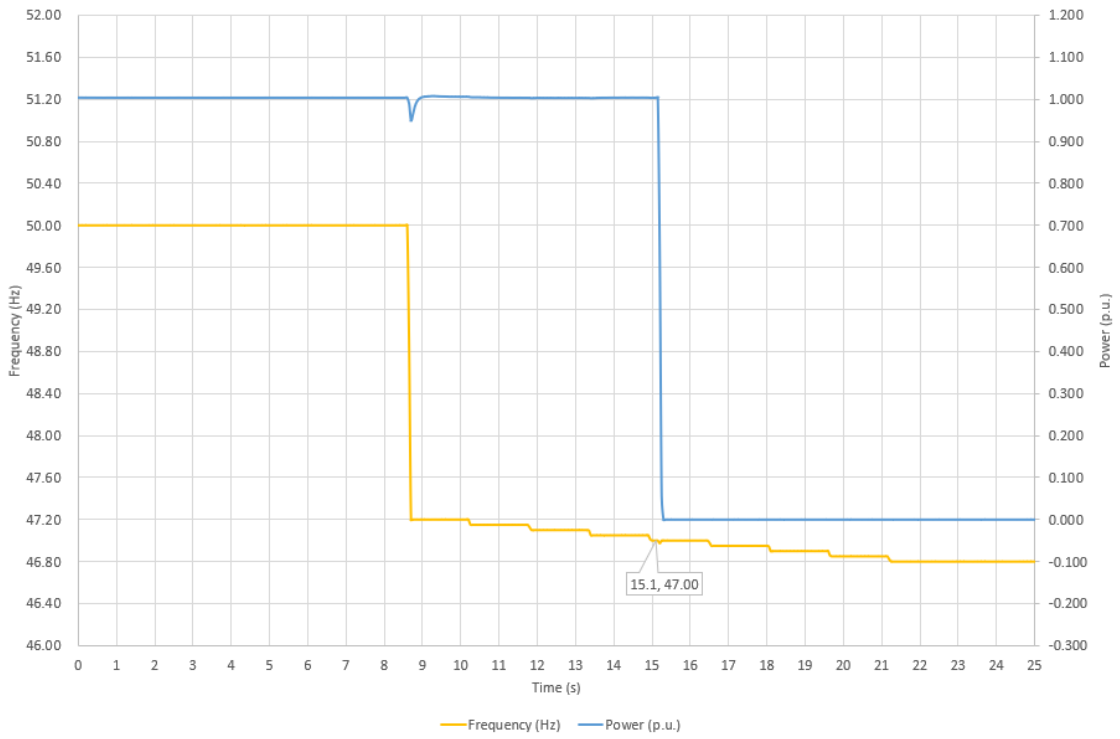
Trip Time



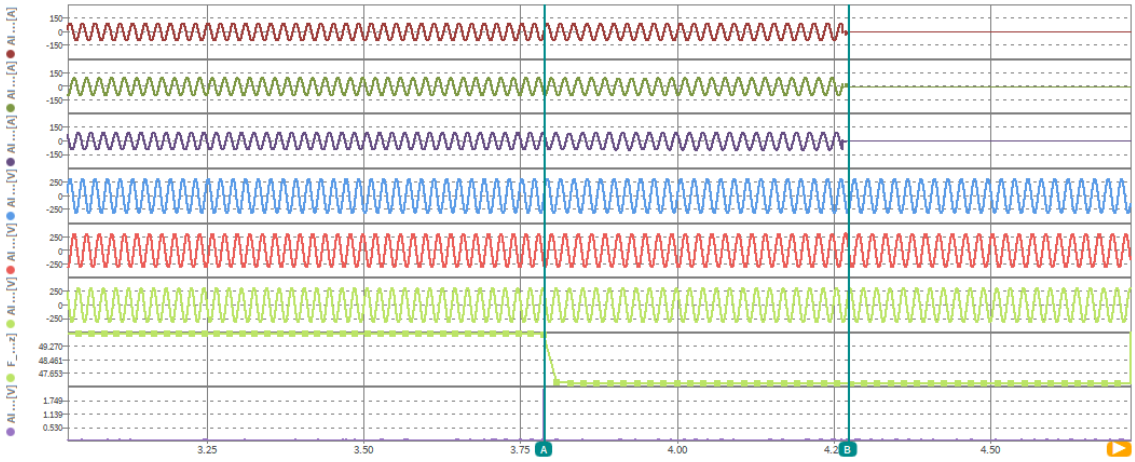
	A	B	间隔
时间 [s]	3.050100	3.538700	0.488600
AI 1/I1 [A]	-15.01658	-0.300912	14.71567
AI 1/I2 [A]	-79.21816	0.125640	79.34380
AI 1/I3 [A]	93.08586	-0.011832	-93.09769
AI 1/U1 [V]	-49.96953	-120.2422	-70.27269
AI 1/U2 [V]	-253.7220	-201.3683	52.35362
AI 1/U3 [V]	304.7065	321.6166	16.91008
F_fund@INV [Hz]	50.00016	47.00182	-2.998341
AI 1/U4 [V]	-0.011184	-0.015237	-4.053e-3

Test 3

Trip Value



Trip Time



	A	B	间隔
时间 [s]	3.788120	4.272820	0.484700
AI 1/I1 [A]	-20.45682	-0.077753	20.37907
AI 1/I2 [A]	-75.80973	0.145667	75.95540
AI 1/I3 [A]	94.68803	-0.223548	-94.91158
AI 1/U1 [V]	-65.58190	-325.2248	-259.6429
AI 1/U2 [V]	-243.5062	163.8386	407.3448
AI 1/U3 [V]	309.9548	161.6062	-148.3486
F_fund@INV [Hz]	50.00034	47.00376	-2.996578
AI 1/U4 [V]	-0.012615	-0.012853	-2.384e-4

4.8. CONNECTION AND STARTING

Tests performed according 5.9 of the standard.

4.8.1 Automatic reconnection after tripping

Table 32 — Default parameter automatic reconnection after tripping according to EN 50549-1:2019 and EN 50549-2:2019

Parameter	Range	Default setting
Lower frequency	47,0Hz – 50,0 Hz	49,5 Hz
Upper frequency	50,0 Hz – 52,0 Hz	50,2 Hz
Lower voltage	50 %U_n – 100 %U_n	85 % U_n[a] / 90 % U_c[b]
Upper voltage	100 % – 120 % U_n	110 %U_n[a] / 110 %U_c[b]
Observation time	10 s – 600 s	60 s
Active power increase gradient	6 % – 3000 %/min	10 %/min

[a] In case of EN 50549-1:2019
[b] In case of EN 50549-2:2019

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
This test shall be performed as		--
Test on complete generating unit (4.2.1);		P
Test on the electrical generation system (4.2.2);		N/A
as component test on an independent component according to 4.2.7 (e.g. synchronizer) or,		N/A
as simulated input test according to 4.2.8 or,		P
as test by changing a control parameter according to 4.2.9.		N/A
In case of re-testing of previously tested generating unit with similar ratings and hardware components in application of 4.5 the test may be performed as Test of the real generating unit control unit in a simulated environment according 4.2.12. The valid response of the C-HIL model shall be demonstrated based on the results of the initial tests performed on the complete generating unit or electrical generating system.		N/A
If using synchronization settings different from EN 50549-1:2019, the procedures to be followed are the same adapting the values accordingly.		N/A
GENERAL TEST CONDITIONS		
Initial Status for test: the generator is disconnected and ready to reconnect or offline with its system on and logics enabled. A trip of Interface Protection associated to voltage or frequency shall be simulated.		P
Procedure as stated on section 5.9.3.1 for Frequency range verification & Voltage range verification		P
The reconnection time, the duration from the adjustment of the voltage into the reconnection range until the instant the EUT reconnects, shall be recorded for each test sequence.		P
During the test the active power measured at the output terminals of the generating unit shall be recorded at a rate of at least 1 sample per second.		P

Criteria	Comments	Result
At least one of the tests shall be conducted so that the output power after synchronization will reach a value equal to or above 80 % Pmax; and the ramp to last at least 12 min to demonstrate the ramp rate.		P
The other tests, Step 2) according to procedure shall be kept for at least 2 min. This		P
ACCEPTANCE CRITERIA		
The test is considered passed, if the following is fulfilled:		--
The generating unit does not start reconnection process when it is out of voltage band or frequency band;	Settings from EN 50549-1:2019	P
The generating unit does not connect before the end of observation time after the interface protection trip provided voltage or frequency are constantly within the permitted band during observation time;		P
The active power ramp-up rate, evaluated for each minute, stays below 11 %/min, Or		P
for non-adjustable or partly adjustable generating units, the connection happens at 1 min to 10 min (randomized value) or later. The randomization can be done via the manufacturer's portfolio and has to be documented.	Configurable setting.	N/A
Products that do have different setups implemented to fulfil different requirements for specific settings can be additionally evaluated:		N/A
– It is evaluated that the relevant setup has the correct values programmed.		N/A
– The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		N/A

The compliances with the requirements of clause 5.9.3 of the standard are stated in section 5.9.3 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.8.2 Starting to generate electrical power

Table 33 — Default parameter starting to generate electrical power according to EN 50549-1:2019 and EN 50549-2:2019

Parameter	Range	Default setting
Lower frequency	47,0Hz – 50,0 Hz	49,5 Hz
Upper frequency	50,0 Hz – 52,0 Hz	50,1 Hz
Lower voltage	50 %U_n – 100 %U_n	85 % U_n [a] / 90 % U_c [b]
Upper voltage	100 % – 120 % U_n	110 %U_n [a] / 110 %U_c [b]
Observation time	10 s – 600 s	60 s
Active power increase gradient	6 % – 3000 %/min	disabled
[a] In case of EN 50549-1:2019 [b] In case of EN 50549-2:2019		

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
The procedures to be followed are the one described "Automatic reconnection after tripping interface protection", but		P
instead of tripping the generator via interface protection the generator is switched off via its control system, Or		N/A
via turning off source power or,		P
for example for synchronous generating unit, before initiating the automatic paralleling sequence, the voltage or the frequency are already simulated out of the permissible band.		N/A
ACCEPTANCE CRITERIA		
The test is considered passed, if the following is fulfilled:		P
The generating unit does not start reconnection process when it is out of voltage band or frequency band;	Settings from EN 50549-1:2019	P
The generating unit does not connect before the end of observation time after the interface protection trip provided voltage or frequency are constantly within the permitted band during observation time;		P
The active power ramp-up rate, evaluated for each minute, stays below 11 %/min, Or		P
for non-adjustable or partly adjustable generating units, the connection happens at 1 min to 10 min (randomized value) or later. The randomization can be done via the manufacturer's portfolio and has to be documented.	Configurable setting.	N/A
Products that do have different setups implemented to fulfil different requirements for specific settings can be additionally evaluated:		N/A
– It is evaluated that the relevant setup has the correct values programmed.		N/A
– The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		N/A

The compliances with the requirements of clause 5.9.4 of the standard are stated in section 5.9.4 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.8.3 Synchronisation

The test has the aim to verify the generators have smooth connection to the grid.

For inverter-based generators this topic is considered with the switching current factor dealt with in 5.7.2.3.

The recording shall start at least 5 s before the synchronization or switching-on of the generating unit to the grid (where switching corresponds to connect the generating unit to the grid).

Different requirements and therefore different tests shall be considered for inverter based generating units switching on the grid and for directly coupled generators to be synchronized to the grid. As explained above, inverter-based generators do not have to be tested again.

For a synchronous generator the evaluation can be made by visual inspection of the settings present on the synchronizing unit. As an alternative an evaluation can be carried out by considering the differences in voltage, frequency and phase angle measured at the generator terminals and on the grid (for example by using a synchro check relay).

Test Result



	A	B	间隔
时间 [s]	7.98764	0:13.08094	5.09330
AI 1/I1 [A]	0.040503	-0.279455	-0.319958
AI 1/I2 [A]	-0.268228	0.073665	0.341892
AI 1/I3 [A]	0.073045	0.083059	0.010014
AI 1/U1 [V]	276.6206	8.493808	-268.1267
AI 1/U2 [V]	8.570678	-285.8605	-294.4312
AI 1/U3 [V]	-286.1141	276.8802	562.9943

4.9. ACTIVE POWER REDUCTION ON SET POINT

Tests performed according 5.10 of the standard.

Criteria	Comments	Result
CONDITIONS DURING MEASUREMENTS		
The assessment shall be performed:		--
In case of a primary energy source that individually adjusts the level of its generated power without requiring any control device (e.g. PV panels or electrical batteries not equipped with battery management system BMS), the tests shall be done as complete unit test or, alternatively, by replacing the primary energy source by an electrical source.		P
In case of a primary energy source which requires a suitable control device to adjust the level of its generated power (e.g. electrical batteries equipped with BMS, fuel cells or electromechanical primary energy source), the tests shall be done as complete unit test. In this case it is considered in general not justified replacing the primary energy source by an electrical source.		N/A
In case of a primary energy source which requires a suitable control device to adjusts the level of its generated power (e.g. electrical batteries equipped with BMS, fuel cells or electromechanical primary energy source), with the generator equipped with a converter absorbing constant power from the primary source regardless the amount of power delivered to the mains, the tests shall be done as complete unit test or, alternatively, by replacing the primary energy source by an electrical source. The test can be carried out as a component test, if the condition is fulfilled as described in 4.2.4.		N/A
In case of a primary energy converter which is controlled on the primary energy source and its controller, irrespective of the electrical generation system (e.g. a reciprocating engine coupled with a synchronous generator or a gas turbine coupled with a generator), the test can be conducted as Test on the primary energy converter or as Simulated input test according to 4.2.4 and 4.2.8.		N/A
In case of re-testing of previously tested generating unit with similar ratings and hardware components in application of 4.5 the test may be performed as Test of the real generating unit control unit in a simulated environment according 4.2.12. The valid response of the C-HIL model shall be demonstrated based on the results of the initial tests performed on the complete generating unit or electrical generating system.		N/A
verification can be carried out using one the following methods:		P
– Verification of the generating unit or component using a grid simulator.		P
– Verification of the generating unit or component at site.		N/A

4.9.1. Verification of the accuracy

According 5.10.3.2 of the standards.

Criteria	Comments	Result
GENERAL TEST CONDITIONS		
Procedure according 5.10.3.2.1 of the standards.		P
ACCEPTANCE CRITERIA		
The test is considered passed, if the following is fulfilled:		P
– for power set point reduction all average values recorded are within the tolerance range ± 5 %Pn around the power reduction set point.		P
– for power set point increase all average values recorded are below the tolerance maximum +5 %Pn above the power reduction set point.		P
If a specific grid code specifies a different tolerance band, the method can be adapted accordingly. All modifications shall be stated in the report.		N/A
Test results shall be reported as 1 min average data.		P
Test results shall also be presented in a graph. The graph shall show set point values and active power output as measured during operation		P

The compliances with the requirements of clause 5.10.3.2 of the standard are stated in section 5.10.3.2 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.9.2. Verification of dynamic behaviour

According 5.10.3.3 of the standards.

Criteria	Comments	Result
GENERAL TEST CONDITIONS		
Procedure according 5.10.3.3.1 of the standard.	Refer to test results below.	P
For the step response time and the settling time a tolerance band of ± 5 % Pn to the reactive power set point is considered		P
ACCEPTANCE CRITERIA		
The test is considered passed, if the following is fulfilled:		--
1) the settling time measured during the test has the value stated in EN 50549-1:2019 or settling time values as defined by the relevant party or as defined by the manufacturer; And		P
2) the slope equals or exceeds that corresponding to a (0,33*Pn/s) slope and does not exceed that corresponding to a (0,66*Pn/s) slope as defined by the relevant party or a slope as defined by the manufacturer;		P
3) the settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).		P
Test results shall be reported as 1 min average data.		P
Test results shall also be presented in a graph. The graph shall show set point values and active power output as measured during operation		P

The compliances with the requirements of clause 5.10.3.3 of the standard are stated in section 5.10.3.3 of following test report:

EN 50549-1:2019+A1:2023 & EN 50549-10:2022: Report No. BL-DG2560064-203 on 2025/10/20 which was issued by Dongguan BALUN Testing Technology Co., Ltd. CNAS: L14701.

4.10. REQUIREMENTS REGARDING SINGLE FAULT TOLERANCE

Requirements regarding single fault tolerance of interface protection system and interface switch according to 5.12 of the standard is applicable only when appliyin EN 505049-1

According to 5.12.3 of the standard.

1) Information on indepedant mechanism:

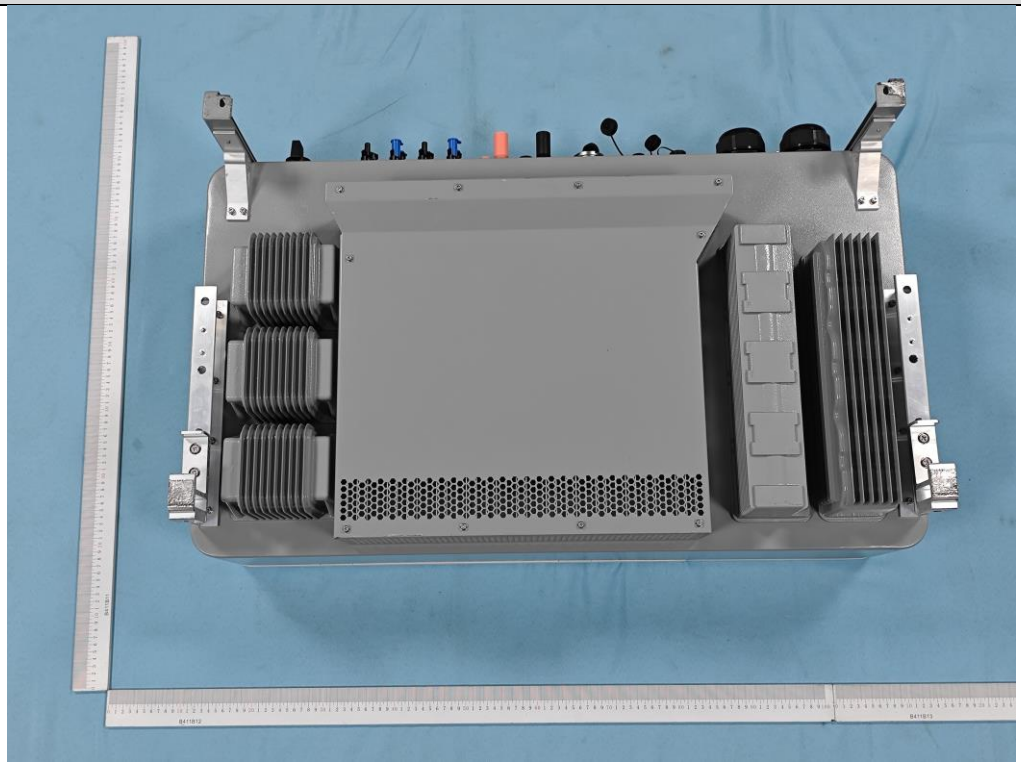
The output is switched off redundant by the high-power switching bridge and relays, model: HF172F-200, rated: 830Vac,200A.

2) Proof of conformity according to EN 62109-1 & EN 62109-2 & IEC 62109-1 & IEC 62109-2:

EN 62109-1 & EN 62109-2 & IEC 62109-1 & IEC 62109-2: Test Report No. 18360SC30021201-M2, issued by Shenzhen Anbotek Compliance Laboratory Limited, on 2025/10/22. CNAS: L3503.

5. PICTURES

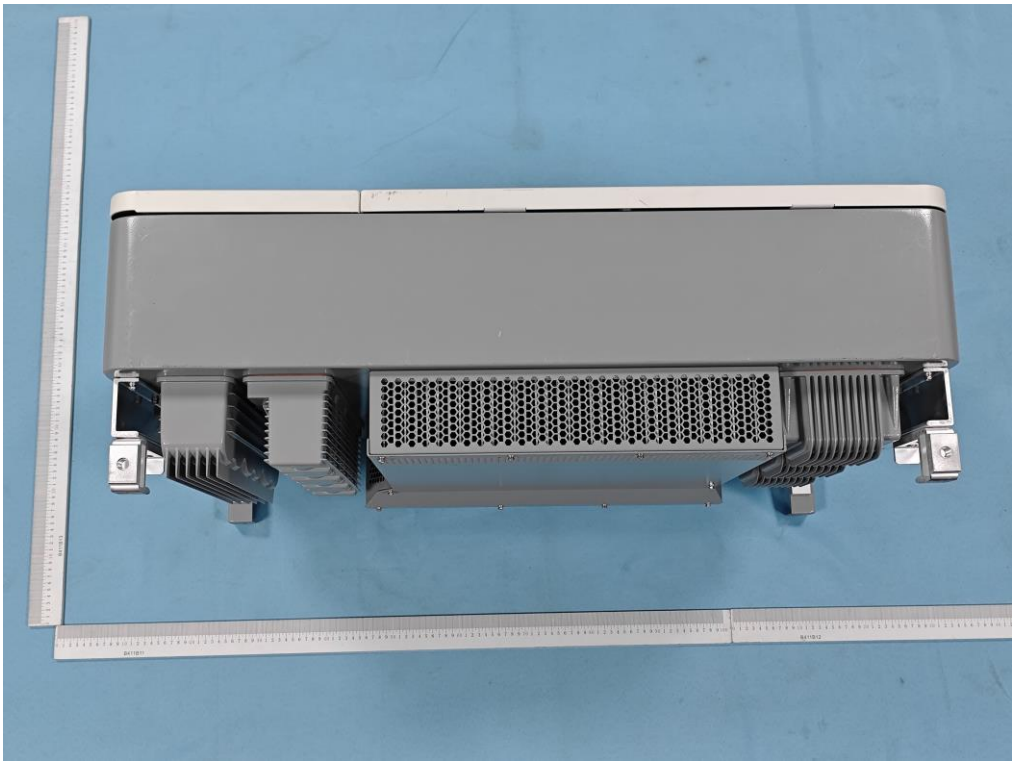
Front view

Back view


Left view

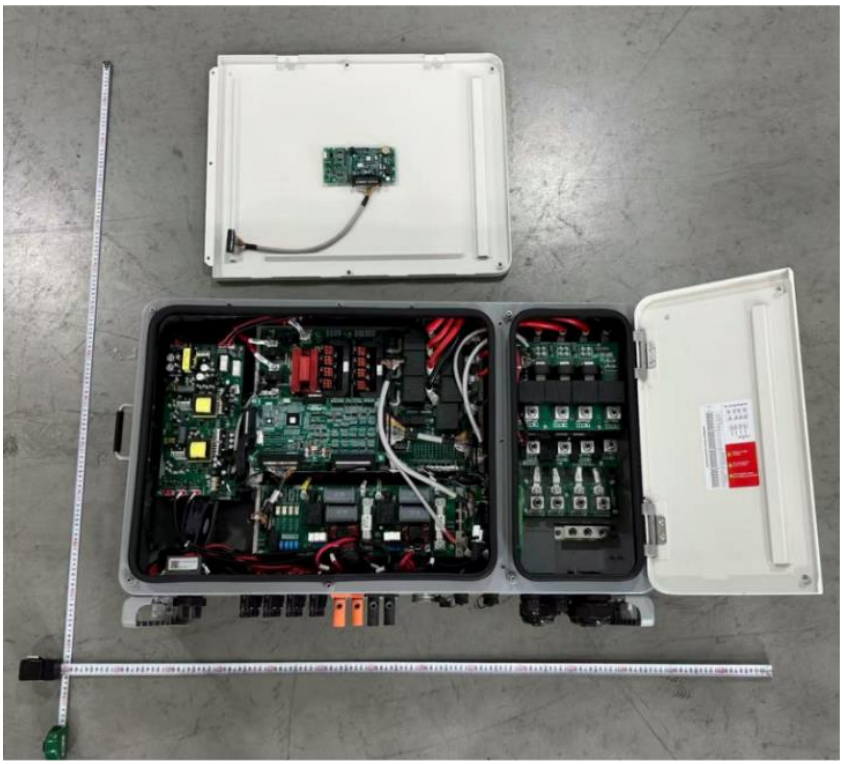
Right view


Top view



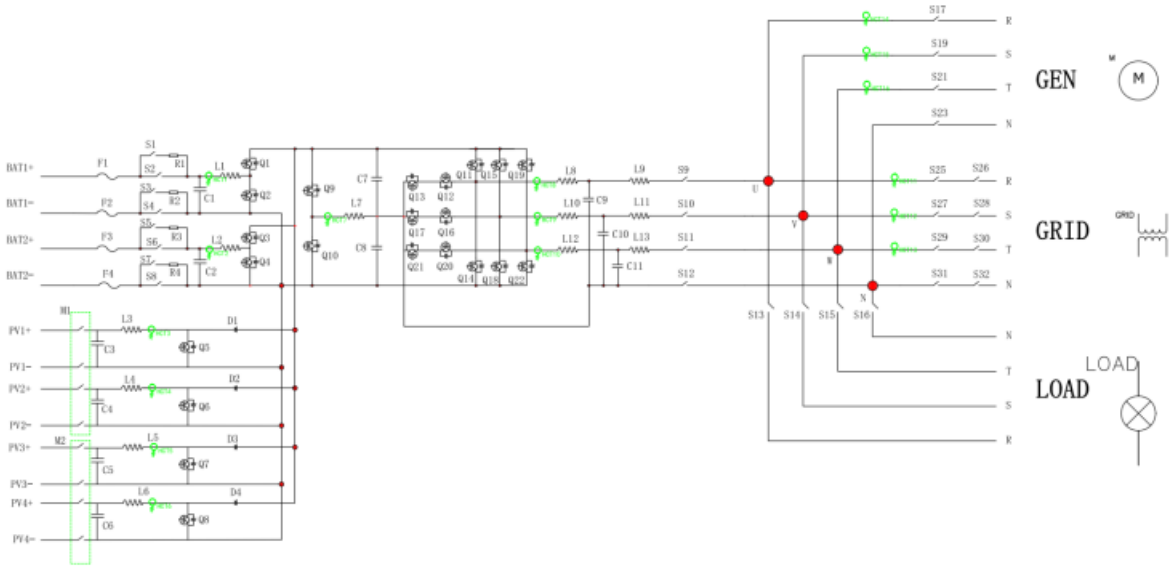
Bottom view



Internal view


Serial Number and Software Version
SN is: OHVR10ZR1YDT000C Software version: Master: V201, Slave: V101

6. ELECTRICAL SCHEME

Electrical Scheme under test


----------End of Report----------