TESTING FOR THE VERIFICATION OF COMPLIANCE OF PV INVERTER WITH:

EN 50549-1: 2019:

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

(REQUIREMENTS FOR PLANTS TYPE B)

Procedure: PE.T-LE-62

Test Report Number	:	**2221 / 0052**
Type	:	Hybrid Inverter
Tested Model	:	HPS50
Trade Mark	:	ATESS
Variant Models	:	HPS30

APPLICANT

Name	:	SGS Tecnos, S.A. (Certification Body)
Address	:	C/ Trespaderne, 29 - Edificio Barajas 1 28042 Madrid (Spain)

HIRED BY

Name	:	Shenzhen Atess Power Technology Co., Ltd
Address	:	1st Floor of Building 3 at Sector B and 3rd Floor or Building 9, Henglong Industrial Park, Shuitian, Baoan District, Shenzhen, Guangdong Province, P.R. China

TESTING LABORATORY

Name	:	SGS Tecnos, S.A.U. (Electrical Testing Laboratory)
Address	:	C/ Trespaderne, 29 - Edificio Barajas 1 28042 Madrid (Spain)
Conducted (tested) by	:	Roger Hu (Project Engineer)
Approved by	:	Jacobo Tévar (Technical Reviewer)

SGS Tecnos, S.A.
Laboratorio de Ensayos E&E

Date of issue	:	2021/04/05
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Test Report Historical Revision:

Test Report Version	Date	Resume
2221 / 0052	2021/04/05	First issuance

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1. SCOPE

SGS Tecnos, S.A. (Electrical Testing Laboratory) has been contracted by SGS Tecnos, S.A. (Certification Body) to perform the testing according the EN 50549 – 1: 2019: Requirements for generating plants to be connected in parallel with distribution networks - part 1: connection to a LV distribution network - generating plants up to and including type B.

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

2. GENERAL INFORMATION

2.1. TESTING PERIOD AND CLIMATIC CONDITIONS

The necessary testing has been performed along the period 20th November of 2020 and 30th March of 2021.

All the tests and checks have been performed at 25 ± 5 ºC, 96 ± 10 kPa and 50 ± 10 %RH.

SITE TEST

Name ..... : Shenzhen BALUN Technology Co., Ltd.

Address ..... : Room 104, 204, 205, Building 1, No. 6, Industrial South Road, Songshan Lake District, Dongguan, Guangdong, P.R. China

2.2. EQUIPMENT UNDER TESTING

Apparatus type ..... : Hybrid Inverter

Installation ..... : Fixed installation

Manufacturer ..... : Shenzhen Atess Power Technology Co., Ltd.

Trade mark ..... : ATESS

Model / Type reference ..... : HPS50

Serial Number ..... : TMD094602A

Software Version ..... : DSP: HPS30K_150K_HV3_SV4.1.14_APP50549;
LCD: HPS30K_150K_WEINVIEWScreen_HV1.0_SV1.0.8

Rated Characteristics ..... : PV input: 480-800 V_{mppt} (Max. 1000 V input), 136A max;
Battery input: 352-600 Vdc, Charge current 150 Adc, Discharge current 156 Adc;
AC output: 3P/PE, 400 Vac, 50 Hz, 3*72 A, 50 kW

Date of manufacturing: 2020

Test item particulars

Input ..... : DC

Output ..... AC

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

Degree of protection against moisture..... : IP20

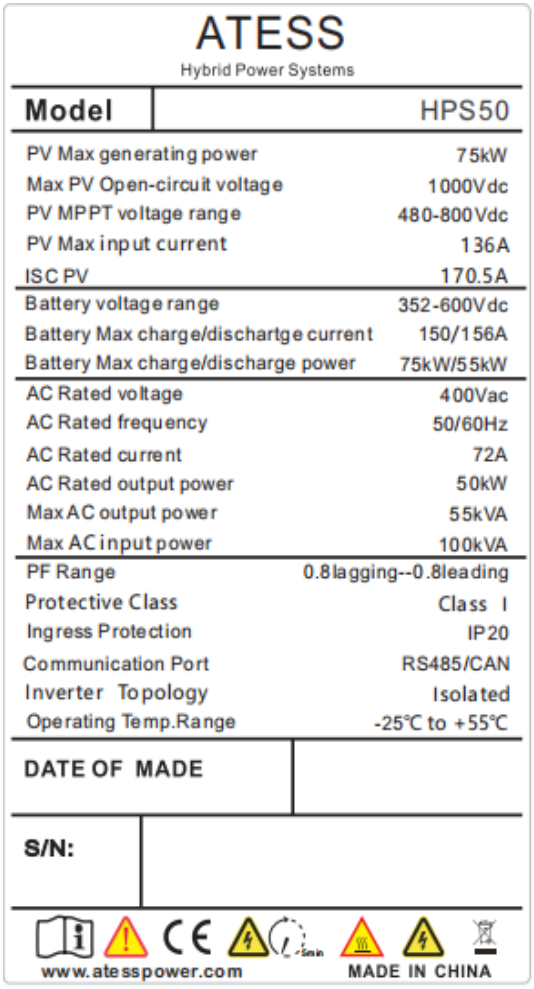
Type of connection to the main supply ..... : Three phase – Fixed installation

Cooling group ..... : Fans

Modular ..... : No

Internal Transformer ..... : Yes

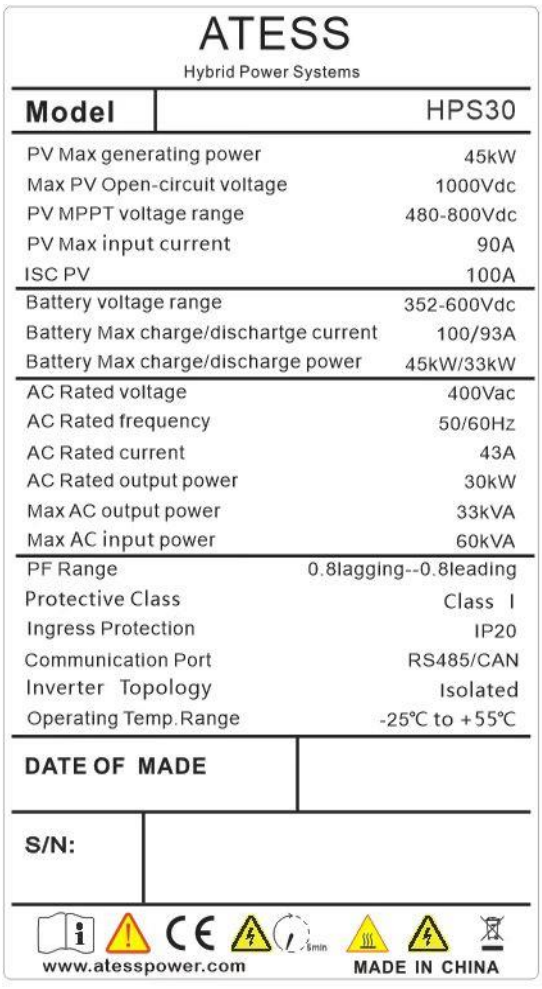
Copy of marking plate (representative):



ATESS
Hybrid Power Systems

Model	HPS50
PV Max generating power	75kW
Max PV Open-circuit voltage	1000Vdc
PV MPPT voltage range	480-800Vdc
PV Max input current	136A
ISC PV	170.5A
Battery voltage range	352-600Vdc
Battery Max charge/dischartge current	150/156A
Battery Max charge/discharge power	75kW/55kW
AC Rated voltage	400Vac
AC Rated frequency	50/60Hz
AC Rated current	72A
AC Rated output power	50kW
Max AC output power	55kVA
Max AC input power	100kVA
PF Range	0.8lagging--0.8leading
Protective Class	Class I
Ingress Protection	IP20
Communication Port	RS485/CAN
Inverter Topology	Isolated
Operating Temp.Range	-25℃ to +55℃
DATE OF MADE	
S/N:	

www.atesspower.com MADE IN CHINA



ATESS
Hybrid Power Systems

Model	HPS30
PV Max generating power	45kW
Max PV Open-circuit voltage	1000Vdc
PV MPPT voltage range	480-800Vdc
PV Max input current	90A
ISC PV	100A
Battery voltage range	352-600Vdc
Battery Max charge/dischartge current	100/93A
Battery Max charge/discharge power	45kW/33kW
AC Rated voltage	400Vac
AC Rated frequency	50/60Hz
AC Rated current	43A
AC Rated output power	30kW
Max AC output power	33kVA
Max AC input power	60kVA
PF Range	0.8lagging--0.8leading
Protective Class	Class I
Ingress Protection	IP20
Communication Port	RS485/CAN
Inverter Topology	Isolated
Operating Temp.Range	-25℃ to +55℃
DATE OF MADE	
S/N:	

www.atesspower.com MADE IN CHINA

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.

Equipment under testing:

- **HPS50**

The variant models are:

- **HPS30**

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

Following table shows the full ratings of the variant models:

Model Number	HPS30	HPS50
PV parameters		
PV rated Power	33 kW	55 kW
Max. PV Power	45 kW	75 kW
Max. PV input voltage	1000 Vd.c.	
PV MPPT voltage range	480-800 Vd.c.	
Battery parameters		
Battery operating voltage range	352-600 Vd.c.	
Max.Battery charge current	100 A	150 A
Max.Battery discharge current	93 A	156 A
Max.Battery charge power	45 kW	75 kW
Max.Battery discharge power	33 kW	55 kW
AC output parameter		
Rated voltage	400 Vac	
Rated current	3*43 A	3*72 A
Rated output power	30 kW	50 kW
Rated frequency	50 Hz	
Frequency Range	45-55 Hz	
Max.output power	33 kVA	55 kVA
Max. input power	60 kVA	100 kVA
Power factor	1 default (+/- 0.8 adjustable)	
Ambient temperature	-25 ºC ~ 55 ºC	
Ingress protection	IP20	
Protective class	Class I	

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.

2.3. REFERENCE VALUES

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

Reference Values: Model HPS50	
Design active power, P_D in kW	50
Rated apparent power, **Sn** in kVA	55
Rated wind speed (only WT), **vn** in m/s	N/A
Rated current (determined), **In** in A	3*72
Rated output voltage, (phase to phase) **Un** in Vac	400
Note: In this report p.u. values are calculated as follows: -For Active & Reactive Power p.u values are reference to**Sn** -For Currents p.u values, the reference is always **In** -For Voltages p.u values, the reference is always **Un**	

2.4. TEST EQUIPMENT LIST

Test date from 20/11/2020 to13/01/2021.

From	No.	Equipment Name	MARK/Model No.	Equipment No.	Equipment calibration due date
BALUN	1	Current clamp	HIOKI / CT6863-05	BZ-DGD-L026-1	2020-03-04 to 2021-03-03
	2	Current clamp	HIOKI / CT6863-05	BZ-DGD-L026-2	2020-03-04 to 2021-03-03
	3	Current clamp	HIOKI / CT6863-05	BZ-DGD-L026-3	2020-03-04 to 2021-03-03
	4	Current clamp	HIOKI / CT6863-05	BZ-DGD-L026-4	2020-03-04 to 2021-03-03
	5	Power analyzer	HIOKI / PW6001-16	BZ-DGD-L025	2020-03-04 to 2021-03-03
	6	Power analyzer	DEWETRON / DEWE2-A4	BZ-DGD-L119	2020-03-04 to 2021-03-03
	7	Temperature and Humidity meter	CEM/DT-322	BZ-DGD-L005	2020-03-07 to 2021-03-06
	8	Power analyzer	ZhiYuan / PA6000H	BZ-DGD-L059	2020-11-18 to 2021-11-17
	9	Power analyzer	DEWEsoft/SIRIUSI-HS-4XIIV-4XLV	BZ-DGD-L163	2020-03-04 to 2021-03-03
SGS	10	True RMS Multimeter	Fluke / 289C	GZE012-53	2020-02-21 to 2021-02-20

Test date in 30/03/2021.

From	No.	Equipment Name	MARK/Model No.	Equipment No.	Equipment calibration due date
BALUN	1	Current clamp	HIOKI / CT6863-05	BZ-DGD-L026-1	2021-03-01 to 2022-02-28
	2	Current clamp	HIOKI / CT6863-05	BZ-DGD-L026-2	2021-03-01 to 2022-02-28
	3	Current clamp	HIOKI / CT6863-05	BZ-DGD-L026-3	2021-03-01 to 2022-02-28
	4	Current clamp	HIOKI / CT6863-05	BZ-DGD-L026-4	2021-03-01 to 2022-02-28
	5	Power analyzer	HIOKI / PW6001-16	BZ-DGD-L025	2021-03-16 to 2022-03-15
	6	Temperature and Humidity meter	CEM/DT-322	BZ-DGD-L005	2021-02-25 to 2022-02-24
SGS	7	True RMS Multimeter	Fluke /187	GZE012-8	2020-12-04 to 2021-12-03

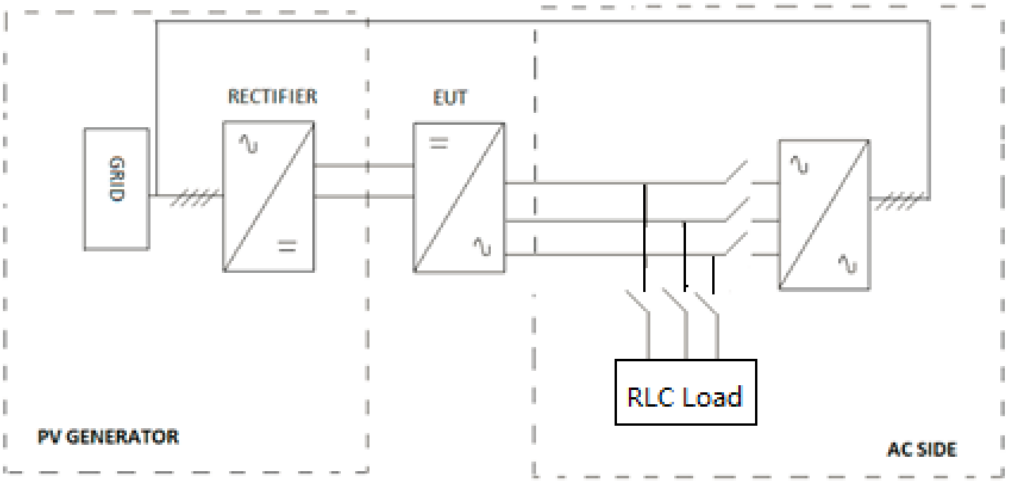
2.5. MEASUREMENT UNCERTAINTY

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

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

2.6. TEST SET UP OF THE DIFFERENT STANDARD

Below is the simplified construction of the test set up.



Different equipments have been used to take measures as shown in chapter 2.3. Current and voltage 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	MARK / MODEL	RATED CHARACTERISTICS	OWNER / ID.CODE
AC source	Wogo / WLPA-33-1000kVA	1000 kVA 5-400 Vrms 44.5-65.5 Hz	--
DC source	Wogo / WDGC-1000kW	0 – 1500 Vdc (0.01 V step) 0 – 1333 A (0.01 A step)	--
RLC load	Qunlin / ACLT3816H	563.3kW, 563.3kVAr	--

2.7. DEFINITIONS

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

3. RESUME OF TEST RESULTS

INTERPRETATION KEYS

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

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

Note: The declaration of conformity has been evaluated taking into account the IEC Guide 115.

The compliances with these requirements are stated in the following test reports:
(*) Test Report no. ES170725041E-1, issued by EMTEK (SHENZHEN) CO., LTD on March 10th, 2020.

(**) Model HPS30

The compliance with these requirements is stated in page 30 to page 35 of the following test report:
IEC 62116:2014: Test Report nº ES200211002P which was issued by EMTEK (SHENZHEN) CO., LTD on Mar 01th, 2020.

Model HPS50

The compliance with these requirements is stated in page 25 to page 31 of the following test report:
IEC 62116:2014: Test Report nº ES190602003P which was issued by EMTEK (SHENZHEN) CO., LTD on Dec 18th, 2019.

(***) **IEC/EN 62109-1: 2010:** Test Report nº ES170725041P-1 which was issued by EMTEK (SHENZHEN) CO., LTD on March 31 th,2020.

4. TEST RESULTS

4.1. NORMAL OPERATING RANGE

4.1.1. Operating frequency range

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

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

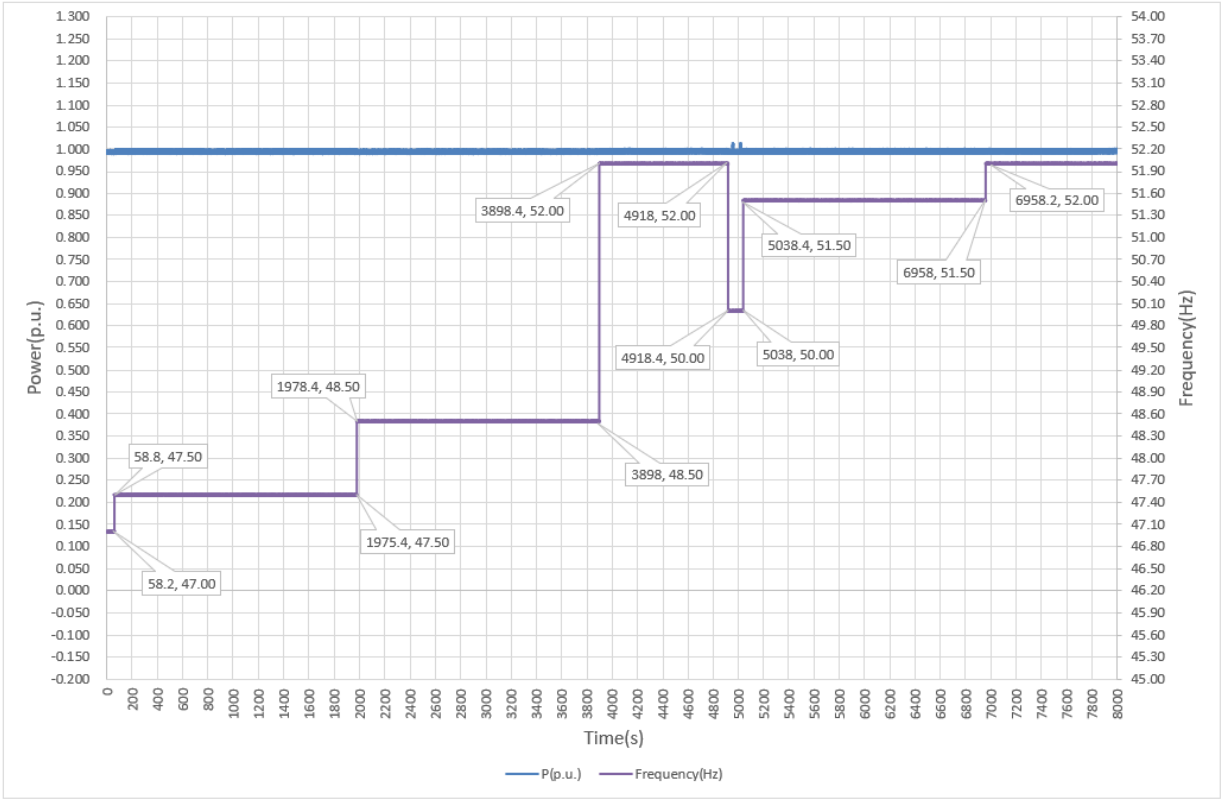
Frequency Range	Time period for operation Minimum requirement	Time period for operation stringent requirement
47,0 Hz – 47,5 Hz	not required	20 s
47,5 Hz – 48,5 Hz	30 min [a]	90 min
48,5 Hz – 49,0 Hz	30 min [a]	90 min [a]
49,0 Hz – 51,0 Hz	Unlimited	Unlimited
51,0 Hz – 51,5 Hz	30 min [a]	90 min
51,5 Hz – 52,0 Hz	not required	15 min
[a] Respecting the legal framework, it is possible that longer time periods are required by the responsible party in some synchronous areas.		

"Time period for operation, Minimum requirement" (first column of the table) has been considered for this test.

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

Steps	f setting (Hz)	Time requirement	f measured (Hz)	Time measured (min)	Power measured (p.u.)
1	47.0	Not required	47.00	0.97	0.994
2	47.5	>30 min	47.50	31.94	0.994
3	48.5	>30 min	48.50	31.99	0.994
4	52.0	Not required	52.00	16.99	0.995
5	50.0	Unlimited	50.00	1.99	0.996
6	51.5	>30 min	51.50	31.99	0.995
7	52.0	Not required	52.00	19.03	0.995

Operating frequency range



4.1.2. Minimal requirement for active power delivery at underfrequency

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

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

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

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

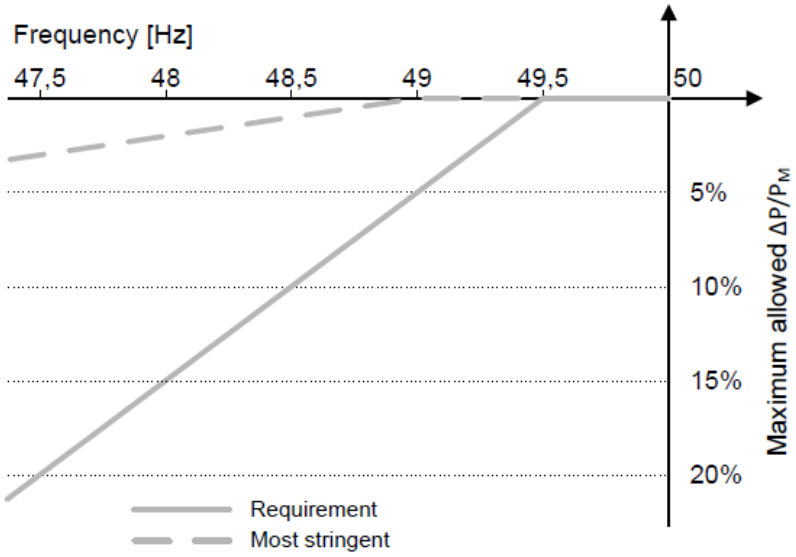
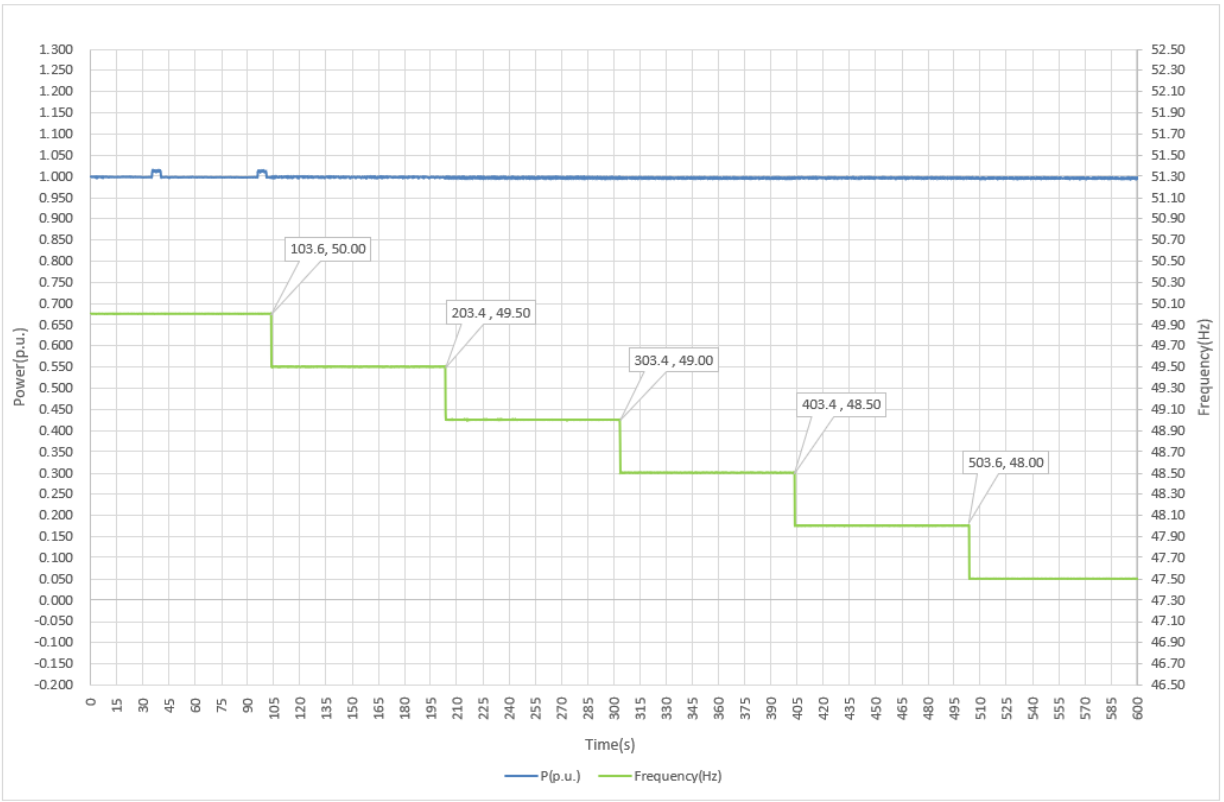


Figure 5 — Maximum allowable power reduction in case of underfrequency

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

Step	f (Hz)	f meas. (Hz)	T (s)	T meas. (s)	P desired (p.u.)	P meas. (p.u.)	P deviation (p.u.)
1	50.00 ± 0.05	50.00	>60	103.6	1.000	0.999	-0.001
2	49.50 ± 0.05	49.50	>60	99.6	1.000	0.998	-0.002
3	49.00 ± 0.05	49.00	>60	99.6	1.000	0.997	-0.003
4	48.50 ± 0.05	48.50	>60	99.6	1.000	0.996	-0.004
5	48.00 ± 0.05	48.00	>60	99.8	1.000	0.996	-0.004
6	47.50 ± 0.05	47.50	>60	96.2	1.000	0.996	-0.004

Active power delivery at underfrequency



4.1.3. Continuous operating voltage range

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

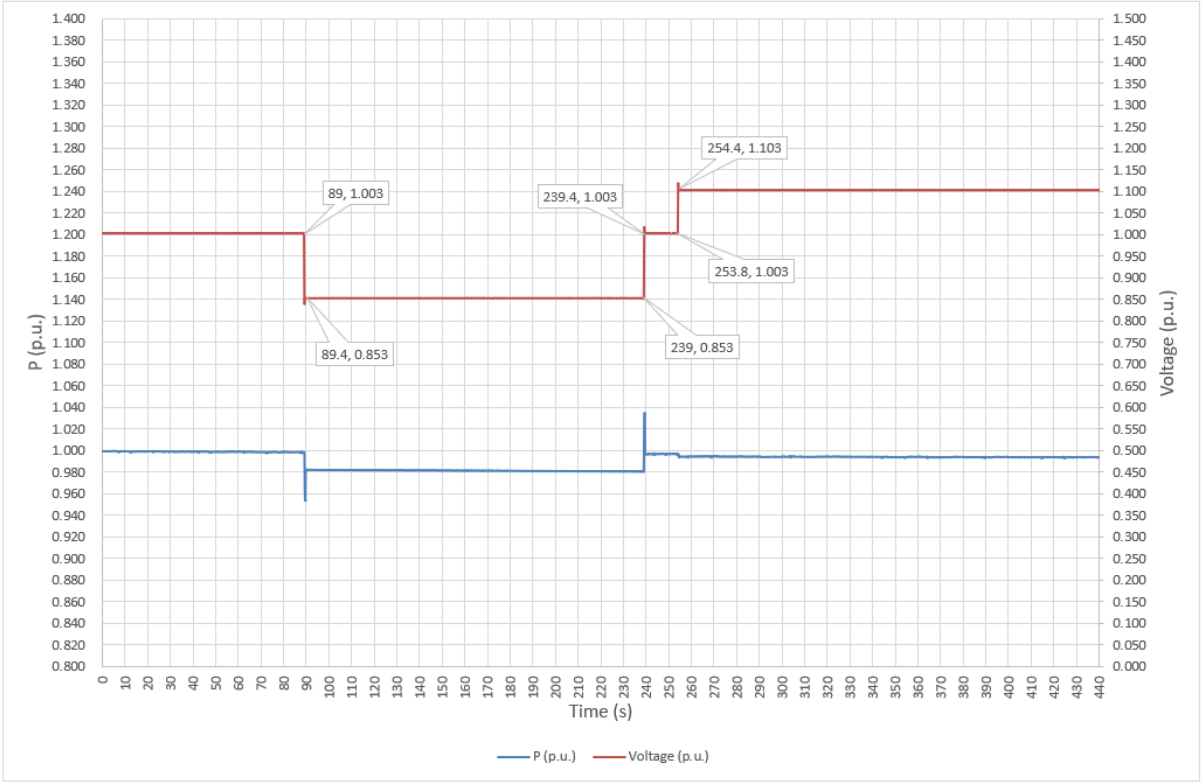
The generating plant shall be capable of operating continuously when the voltage at the point of connection stays within the range of 85 %Un to 110 %Un.

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

Step	V desired (p.u.)	P desired (p.u.)	V meas. (p.u.)	P meas. (p.u.)	Time meas.(s)
1	1.000	1.000	1.003	1.000	89
2	0.850	1.000	0.853	0.981(*)	149.6
3	1.000	1.000	1.003	0.997	14.4
4	1.100	1.000	1.103	0.996	185.6

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

Continuous operating voltage range



4.2. IMMUNITY TO DISTURBANCES

4.2.1. Rate of change of frequency (ROCOF) immunity

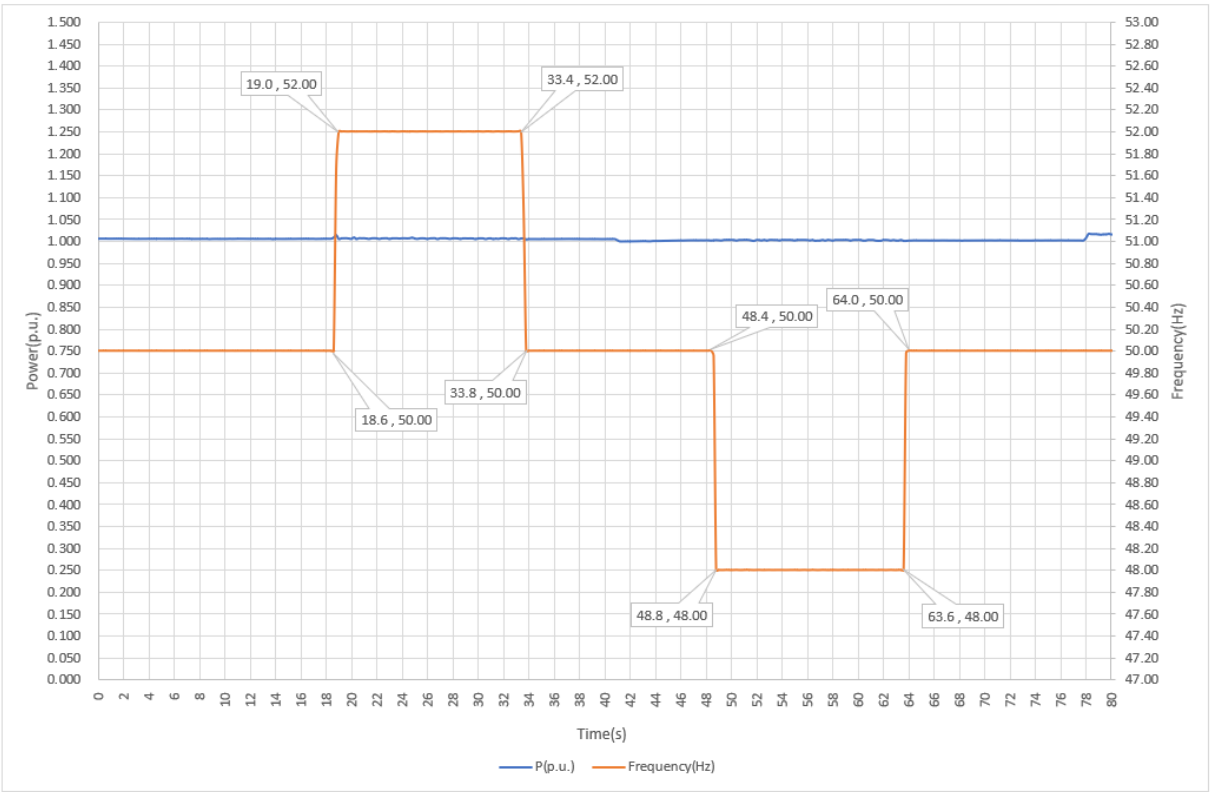
The test has been done according to the clause 4.5.2 of the standard, the requirement is as follows:

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

The ROCOF immunity is defined with a sliding measurement window of 200 ms as follows:

Steps	f (Hz)	ROCOF requirement (Hz/s)	Step time	Measured frequency (Hz)	Measured step change time (s)	ROCOF meas. (Hz/s)	Disconnection
1	50.00 ± 0.05	N/A	>10 s	50.00	--	--	No
2	52.00 ± 0.05	>2	>10 s	52.00	0.4	5.00	No
3	50.00 ± 0.05	>2	>10 s	50.00	0.4	5.00	No
4	48.00 ± 0.05	>2	>10 s	48.00	0.4	5.00	No
5	50.00 ± 0.05	>2	>10 s	50.00	0.4	5.00	No

Rate of change of frequency (ROCOF) immunity



4.2.2. Under-voltage ride through (UVRT)

The requirements are defined in the clause 4.5.3 of the standard.

4.2.1.1. No load Test

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

No Load							
Phase type	**Residual voltage desired (%Un)**	**Voltage measured (%Un)**	**Voltage drop time (ms)**	**Dip time desired (ms)**	**Dip time measured (ms)**	**Power recovery time (ms)**	**Voltage after recovery (%Un)**
1 ph	0-5	4.7	21	≥ 400	474	--	100.2
2 ph		4.5	22		475	--	100.2
3 ph		4.2	21		474	--	100.0
1 ph	25	25.1	23	≥ 1000	1176	--	99.9
2 ph		25.2	21		1173	--	100.0
3 ph		25.3	21		1173	--	100.0
1 ph	50	49.7	21	≥ 1850	1975	--	99.9
2 ph		49.8	21		1972	--	100.0
3 ph		49.8	23		1955	--	100.0
1 ph	75	75.4	21	≥ 3000	3169	--	99.9
2 ph		75.0	21		3150	--	100.0
3 ph		75.0	21		3153	--	100.1

Remark: The virtual neutral line was used in the test.

Test results are graphically represented in the following pages.

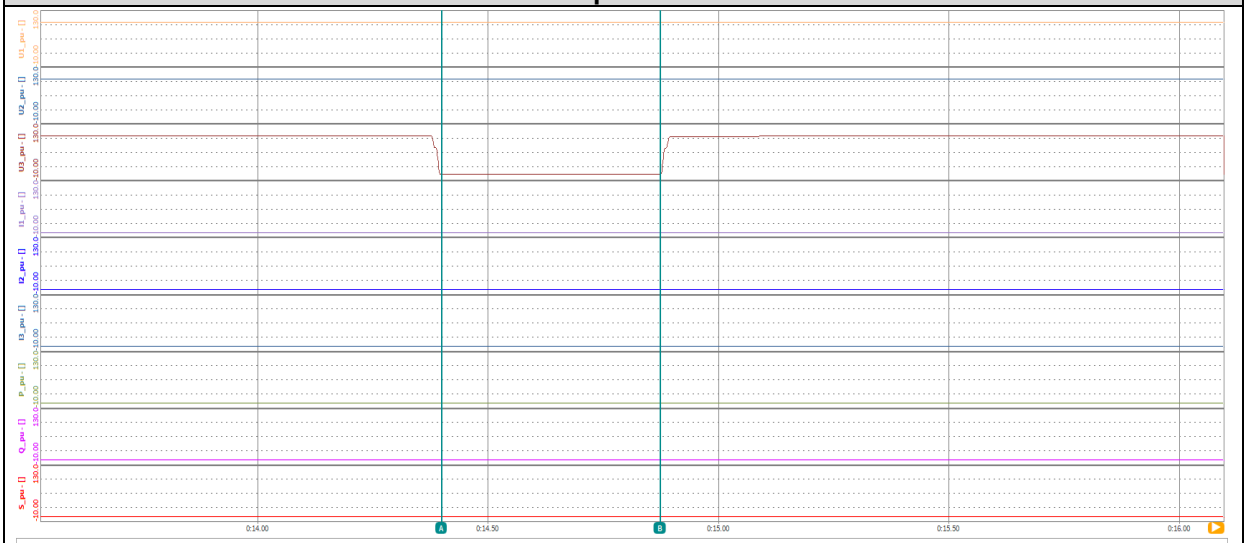
Note: The following test figure the voltage unit of U1_pu, U2_pu and U3_pu are **%Un** , the current unit of I1_pu, I2_pu and I3_pu are **%In** and the power unit is **%Pn**

Single-Phase fault	
No Load	Residual voltage: 0~5 %Un

Voltage DropTime

	A	B	Delta
Time [s]	0:14.3794601	0:14.4000230	0.0205628
U1_pu []	100.2111	100.2059	-5.122e-3
U2_pu []	100.1563	100.1493	-6.913e-3
U3_pu []	100.0356	4.664316	-95.37126
I1_pu []	0.332807	0.331556	-1.252e-3
I2_pu []	0.495215	0.483364	-0.011851
I3_pu []	0.463240	0.353731	-0.109509
P_pu []	-2.019e-3	2.504e-3	4.524e-3
Q_pu []	0.430963	0.277596	-0.153367
S_pu []	0.430968	0.277608	-0.153360

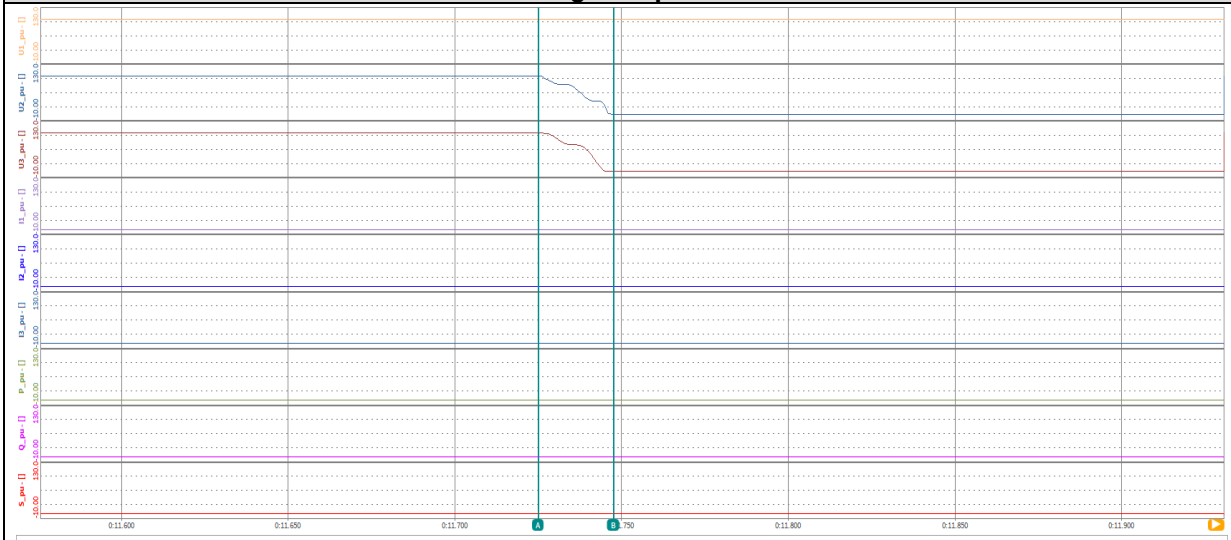
Dip Time



	A	B	Delta
Time [s]	0:14.3997569	0:14.8738307	0.4740738
U1_pu []	100.2059	100.2182	0.012247
U2_pu []	100.1493	100.1299	-0.019458
U3_pu []	4.664316	4.496413	-0.167903
I1_pu []	0.331556	0.334298	2.742e-3
I2_pu []	0.483364	0.493896	0.010533
I3_pu []	0.353731	0.354319	5.883e-4
P_pu []	2.504e-3	4.192e-3	1.687e-3
Q_pu []	0.277596	0.281801	4.205e-3
S_pu []	0.277608	0.281832	4.224e-3

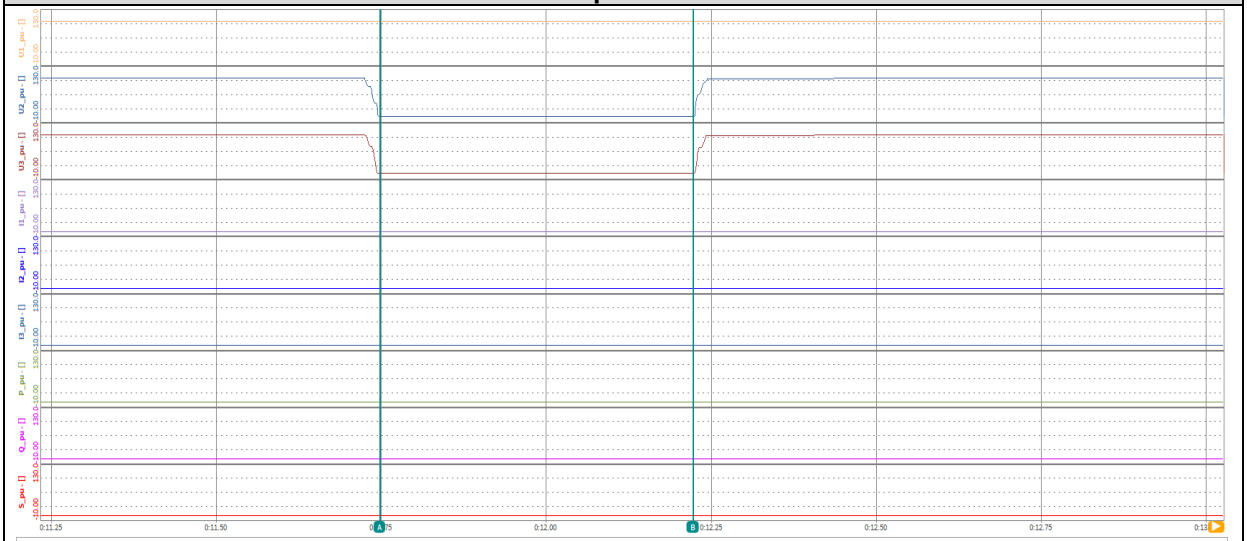
Two-Phase fault	
No Load	Residual voltage: 0~5 %Un

Voltage Drop Time



	A	B	Delta
Time [s]	0:11.7251185	0:11.7476754	0.0225569
U1_pu []	100.2240	100.2272	3.218e-3
U2_pu []	100.1380	4.476367	-95.66168
U3_pu []	100.2511	4.503574	-95.74753
I1_pu []	0.332295	0.330275	-2.020e-3
I2_pu []	0.497518	0.365526	-0.131992
I3_pu []	0.476919	0.354776	-0.122144
P_pu []	-7.095e-3	8.157e-3	0.015253
Q_pu []	0.436396	0.120847	-0.315549
S_pu []	0.436453	0.121122	-0.315332

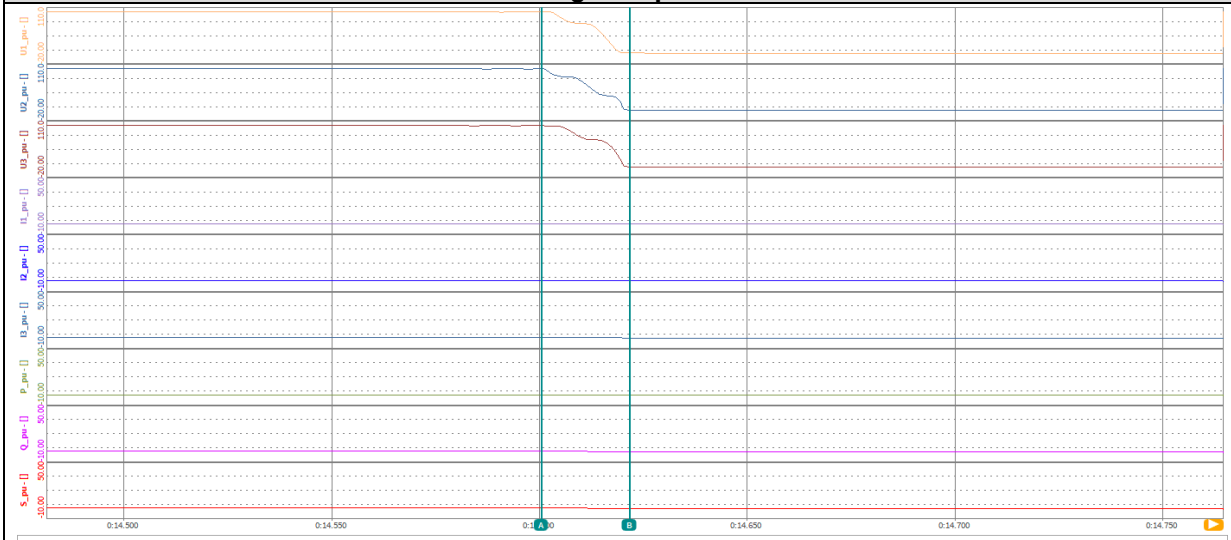
Dip Time



	A	B	Delta
Time [s]	0:11.7481806	0:12.2226928	0.4745123
U1_pu []	100.2272	100.2144	-0.012817
U2_pu []	4.476367	4.473816	-2.551e-3
U3_pu []	4.503574	4.394051	-0.109523
I1_pu []	0.330275	0.332313	2.038e-3
I2_pu []	0.365526	0.362776	-2.749e-3
I3_pu []	0.354776	0.355464	6.888e-4
P_pu []	8.157e-3	5.539e-3	-2.618e-3
Q_pu []	0.120847	0.121499	6.520e-4
S_pu []	0.121122	0.121625	5.032e-4

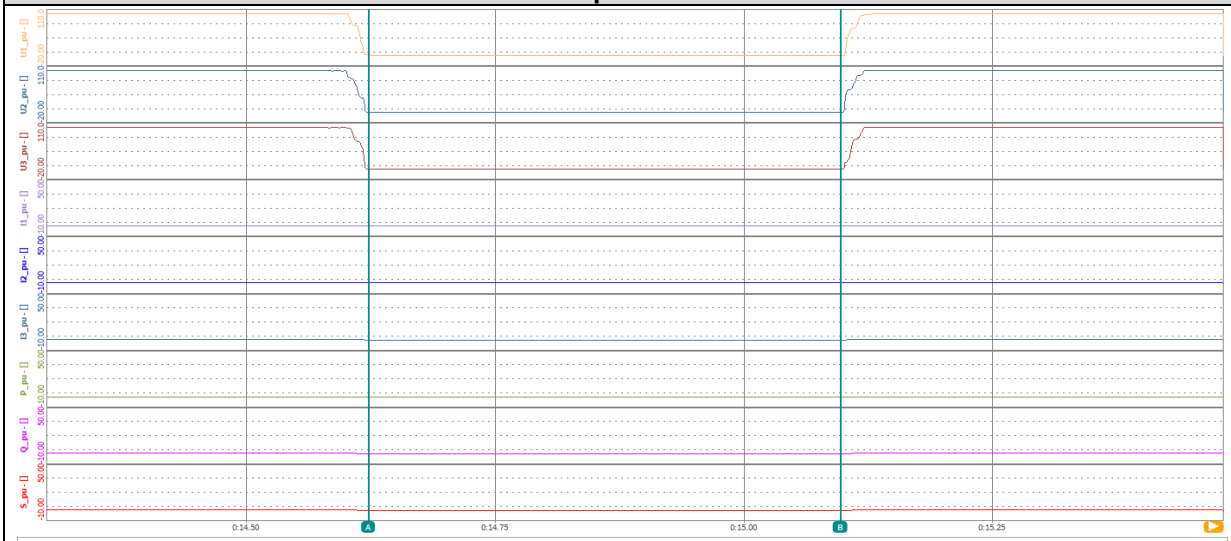
Three-Phase fault	
No Load	Residual voltage: 0~5 %Un

Voltage Drop Time



	A	B	Delta
Time [s]	0:14.6005268	0:14.6217317	0.0212049
U1_pu []	99.47403	4.378048	-95.09598
U2_pu []	99.82440	4.088973	-95.73542
U3_pu []	100.8317	4.093234	-96.73846
I1_pu []	0.478824	0.346318	-0.132506
I2_pu []	0.549856	0.454641	-0.095215
I3_pu []	0.329527	0.091871	-0.237656
P_pu []	-2.624e-3	-1.077e-3	1.547e-3
Q_pu []	0.452480	0.012458	-0.440023
S_pu []	0.452488	0.012504	-0.439984

Dip Time

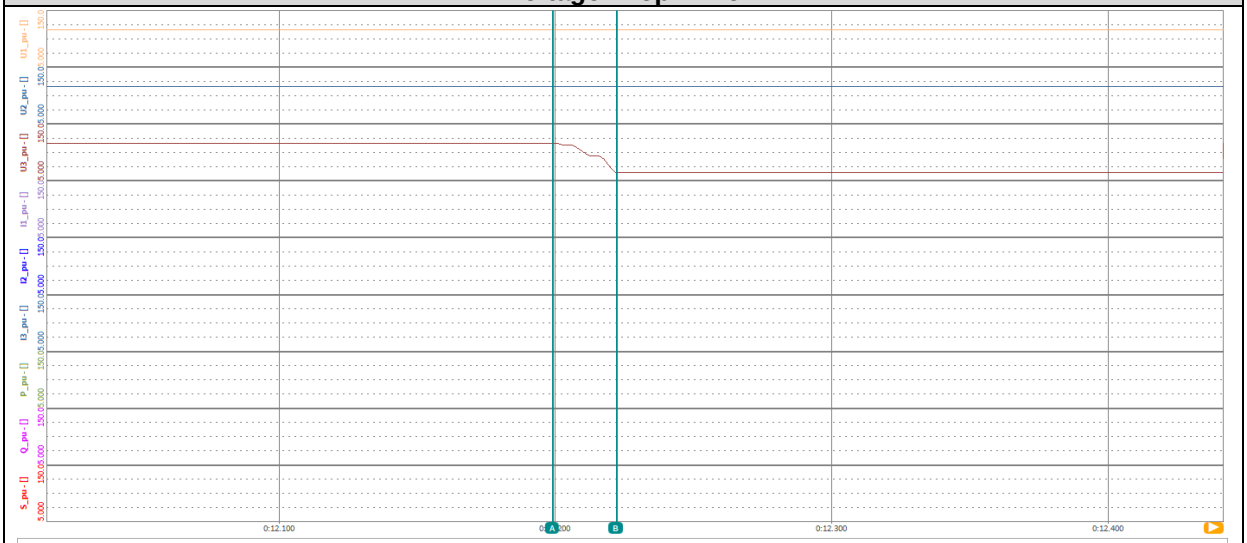


	A	B	Delta
Time [s]	0:14.6229615	0:15.0971139	0.4741524
U1_pu []	4.263892	4.040840	-0.223052
U2_pu []	4.117223	4.007713	-0.109510
U3_pu []	4.108365	3.952392	-0.155973
I1_pu []	0.349983	0.350912	9.295e-4
I2_pu []	0.453001	0.453867	8.658e-4
I3_pu []	0.084003	0.083867	-1.355e-4
P_pu []	-1.062e-3	-5.080e-4	5.539e-4
Q_pu []	0.012296	0.011884	-4.120e-4
S_pu []	0.012342	0.011895	-4.469e-4

Single-Phase fault

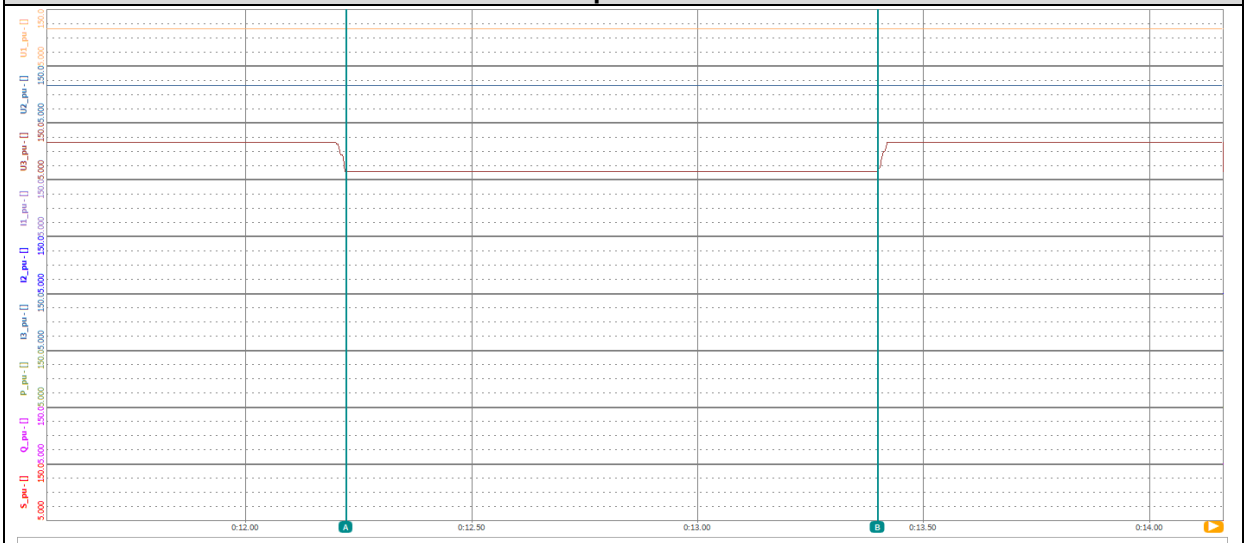
No Load	Residual voltage: 25 %Un

Voltage Drop Time



	A	B	Delta
Time [s]	0:12.19906	0:12.22211	0.02305
U1_pu []	100.0252	99.97490	-0.050334
U2_pu []	100.0648	99.99284	-0.071955
U3_pu []	99.90017	25.05139	-74.84879
I1_pu []	0.474648	0.477348	2.700e-3
I2_pu []	0.553504	0.554482	9.773e-4
I3_pu []	0.334959	0.116920	-0.218039
P_pu []	-5.256e-3	-1.435e-3	3.821e-3
Q_pu []	0.454388	0.353651	-0.100737
S_pu []	0.454418	0.353654	-0.100765

Dip Time

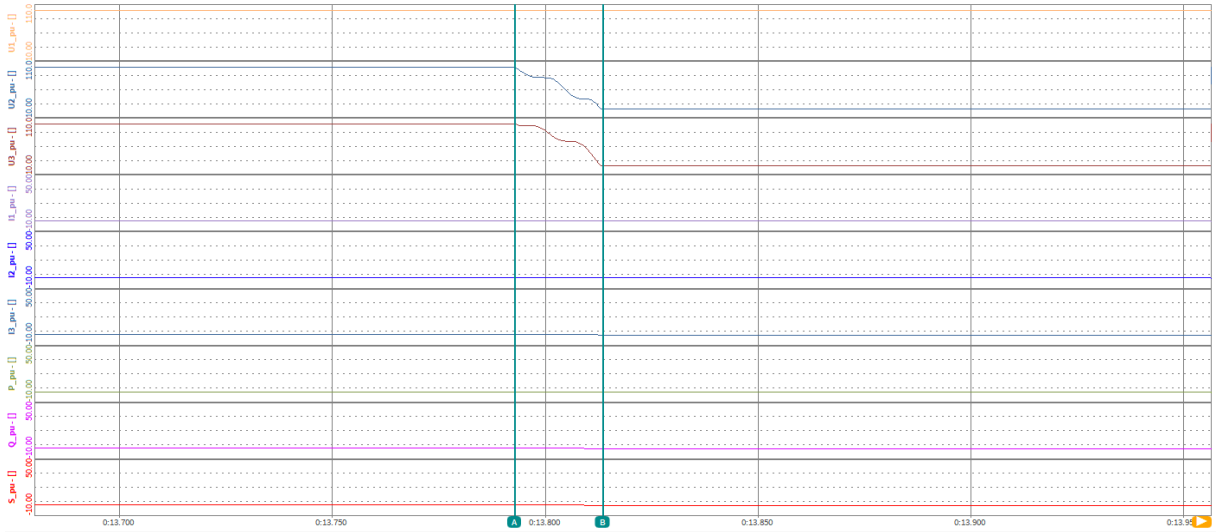


	A	B	Delta
Time [s]	0:12.22282	0:13.39855	1.17573
U1_pu []	99.97490	100.0230	0.048138
U2_pu []	99.99284	100.0539	0.061009
U3_pu []	25.05139	24.98393	-0.067455
I1_pu []	0.477348	0.477731	3.829e-4
I2_pu []	0.554482	0.554580	9.821e-5
I3_pu []	0.116920	0.120131	3.212e-3
P_pu []	-1.435e-3	-4.241e-3	-2.806e-3
Q_pu []	0.353651	0.354219	5.685e-4
S_pu []	0.353654	0.354244	5.909e-4

Two-Phase fault

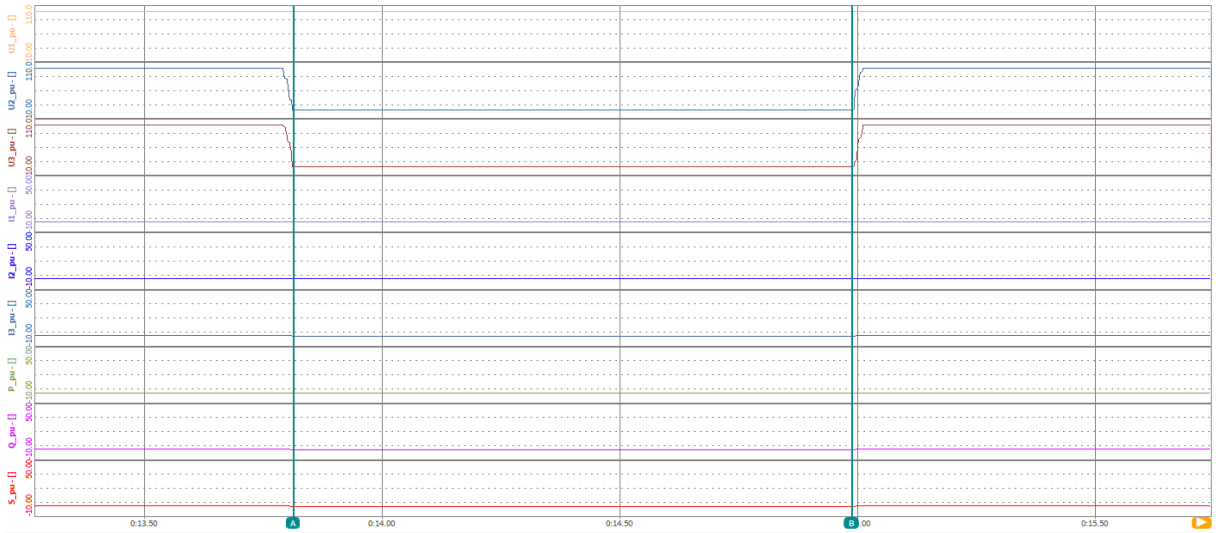
No Load	Residual voltage: 25 %Un

Voltage Drop Time



Time [s]	A 0:13.7929053	B 0:13.8135977	Delta 0.0206924
U1_pu []	100.0217	99.94549	-0.076175
U2_pu []	100.0488	25.15481	-74.89398
U3_pu []	99.91162	25.13252	-74.77909
I1_pu []	0.473060	0.474108	1.048e-3
I2_pu []	0.554567	0.487122	-0.067445
I3_pu []	0.334849	0.147783	-0.187066
P_pu []	-5.796e-3	1.904e-3	7.700e-3
Q_pu []	0.454148	0.211167	-0.242981
S_pu []	0.454185	0.211175	-0.243009

Dip Time

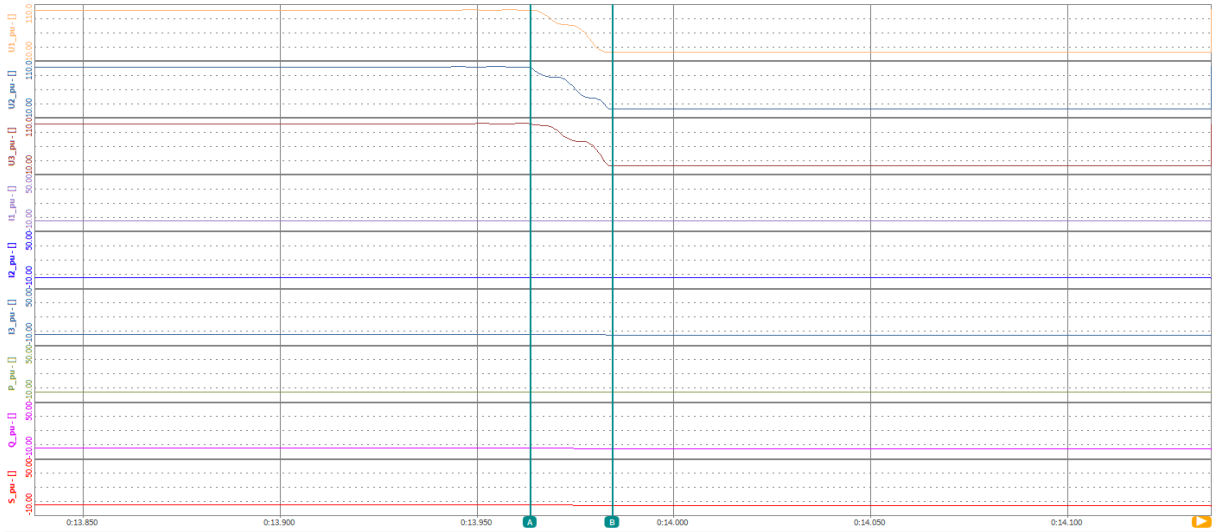


Time [s]	A 0:13.8138723	B 0:14.9873487	Delta 1.1734764
U1_pu []	99.94549	100.1093	0.163806
U2_pu []	25.15481	25.02825	-0.126558
U3_pu []	25.13252	24.99175	-0.140771
I1_pu []	0.474108	0.472427	-1.681e-3
I2_pu []	0.487122	0.456195	-0.030927
I3_pu []	0.147783	0.114075	-0.033708
P_pu []	1.904e-3	-3.567e-3	-5.472e-3
Q_pu []	0.211167	0.205179	-5.988e-3
S_pu []	0.211175	0.205210	-5.965e-3

Three-Phase fault

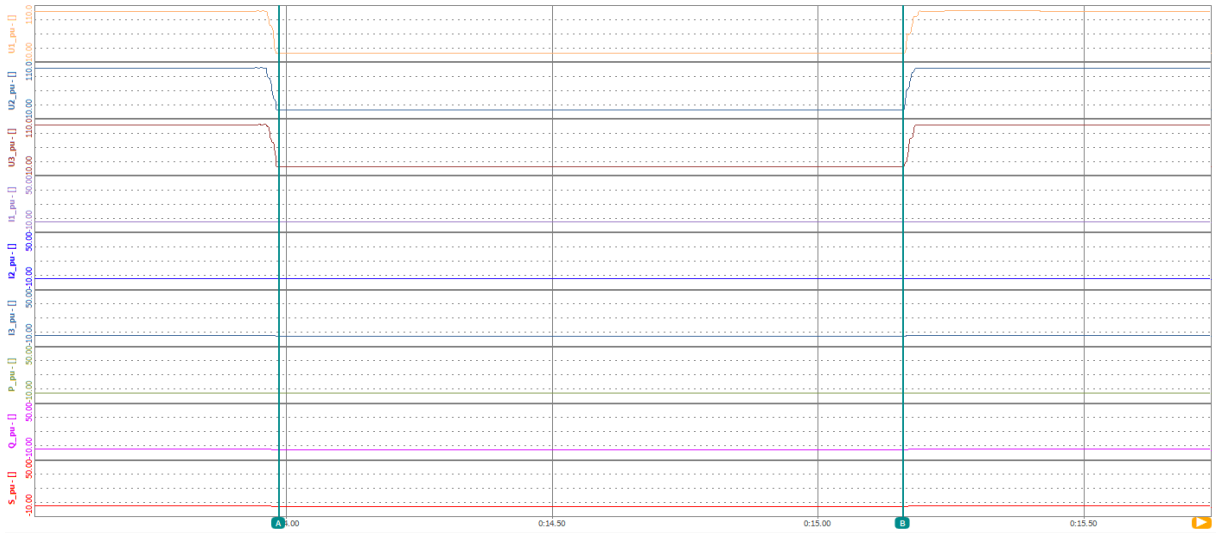
No Load	Residual voltage: 25 %Un

Voltage Drop Time



Time [s]	A 0:13.9635848	B 0:13.9844361	Delta 0.0208513
U1_pu []	99.49808	25.46143	-74.03665
U2_pu []	100.1004	25.21443	-74.88598
U3_pu []	100.3763	25.19025	-75.18603
I1_pu []	0.478894	0.355856	-0.123038
I2_pu []	0.552353	0.495609	-0.056744
I3_pu []	0.330680	0.161986	-0.168694
P_pu []	-3.169e-3	2.010e-3	5.179e-3
Q_pu []	0.453763	0.085435	-0.368328
S_pu []	0.453774	0.085459	-0.368315

Dip Time

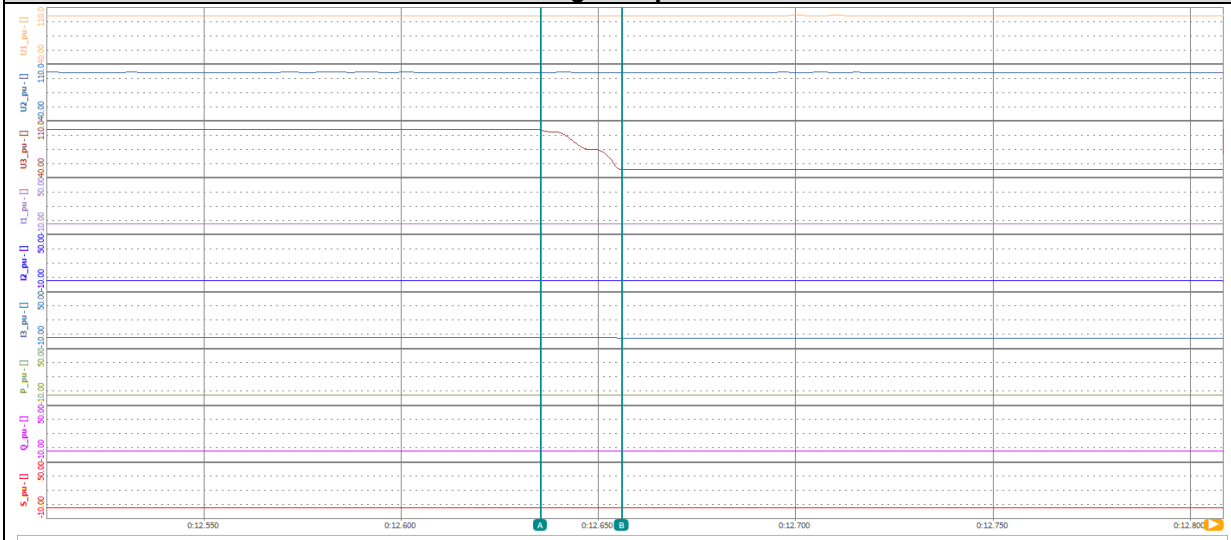


Time [s]	A 0:13.9863036	B 0:15.1590197	Delta 1.1727161
U1_pu []	25.26915	24.95184	-0.317308
U2_pu []	25.15841	25.06674	-0.091670
U3_pu []	25.11229	25.01132	-0.100963
I1_pu []	0.362050	0.361782	-2.677e-4
I2_pu []	0.459739	0.460742	1.003e-3
I3_pu []	0.114918	0.126284	0.011366
P_pu []	-1.083e-3	-3.283e-3	-2.200e-3
Q_pu []	0.078662	0.079048	3.863e-4
S_pu []	0.078670	0.079117	4.470e-4

Single-Phase fault

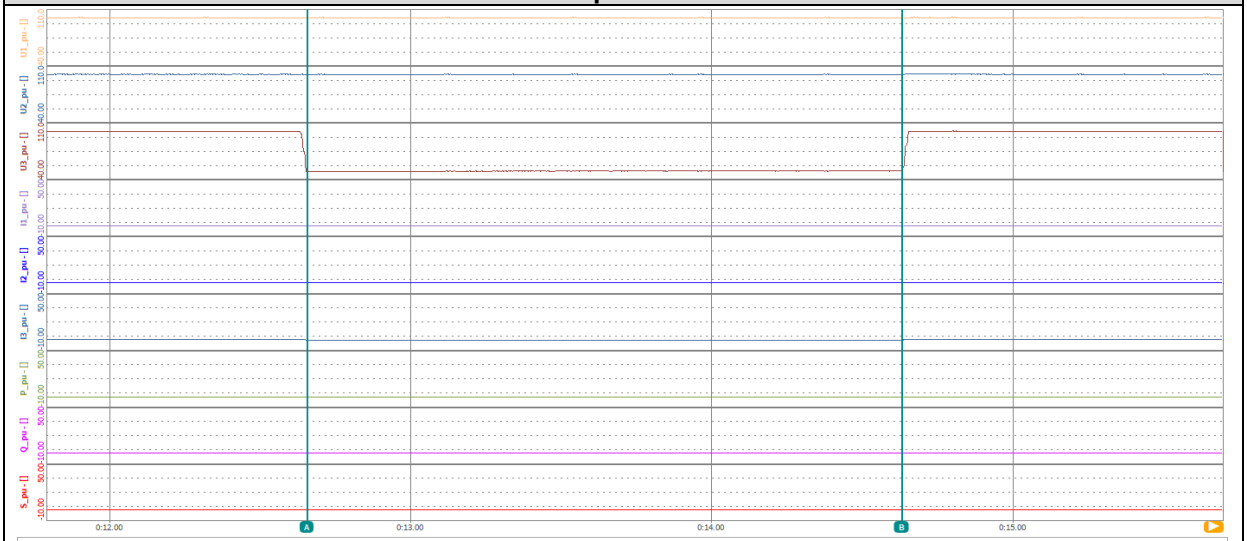
No Load	Residual voltage: 50 %Un

Voltage Drop Time



	A	B	Delta
Time [s]	0:12.6354143	0:12.6559968	0.0205825
U1_pu []	100.0316	99.98946	-0.042128
U2_pu []	100.0631	100.0203	-0.042758
U3_pu []	99.86284	49.69825	-50.16459
I1_pu []	0.474395	0.473664	-7.303e-4
I2_pu []	0.555748	0.557518	1.770e-3
I3_pu []	0.334058	0.184933	-0.149125
P_pu []	-5.658e-3	-1.360e-3	4.298e-3
Q_pu []	0.454712	0.374382	-0.080330
S_pu []	0.454748	0.374385	-0.080363

Dip Time



	A	B	Delta
Time [s]	0:12.6564758	0:14.6314487	1.9749729
U1_pu []	99.98946	100.0191	0.029675
U2_pu []	100.0203	100.0582	0.037835
U3_pu []	49.69825	49.93948	0.241235
I1_pu []	0.473664	0.473674	1.012e-5
I2_pu []	0.557518	0.557215	-3.028e-4
I3_pu []	0.184933	0.186737	1.804e-3
P_pu []	-1.360e-3	-4.713e-3	-3.353e-3
Q_pu []	0.374382	0.374824	4.415e-4
S_pu []	0.374385	0.374853	4.686e-4

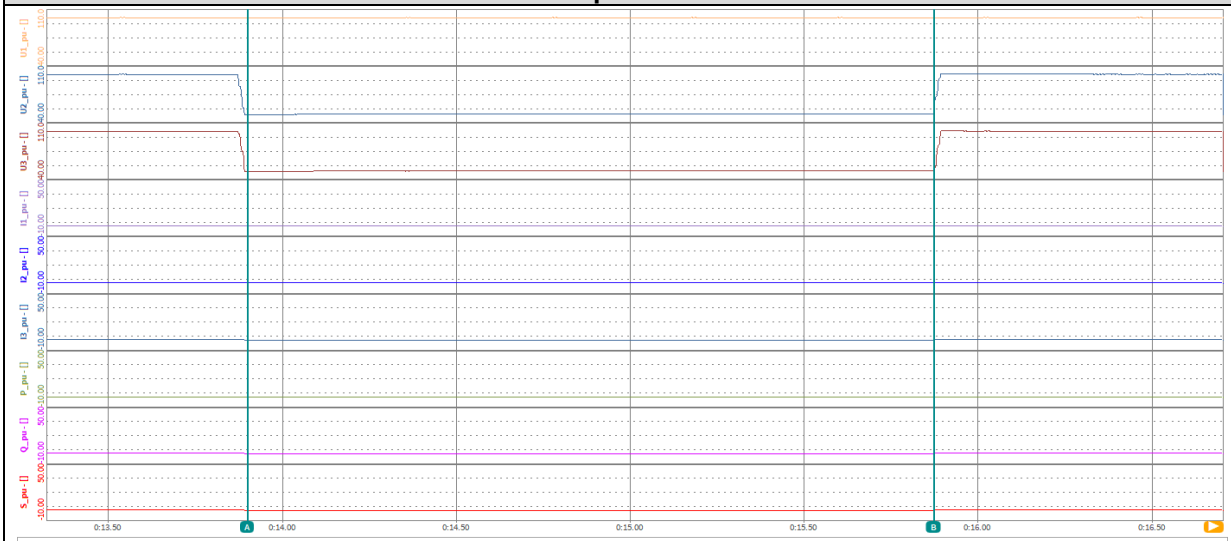
Two-Phase fault

No Load	Residual voltage: 50 %Un

Voltage Drop Time

	A	B	Delta
Time [s]	0:13.8747566	0:13.8953835	0.0206269
U1_pu []	99.99981	99.95090	-0.048908
U2_pu []	100.0463	49.78440	-50.26192
U3_pu []	99.91600	49.79638	-50.11962
I1_pu []	0.476063	0.475652	-4.110e-4
I2_pu []	0.554918	0.479097	-0.075821
I3_pu []	0.333865	0.182548	-0.151317
P_pu []	-5.337e-3	-7.737e-4	4.563e-3
Q_pu []	0.454910	0.268278	-0.186632
S_pu []	0.454941	0.268279	-0.186662

Dip Time

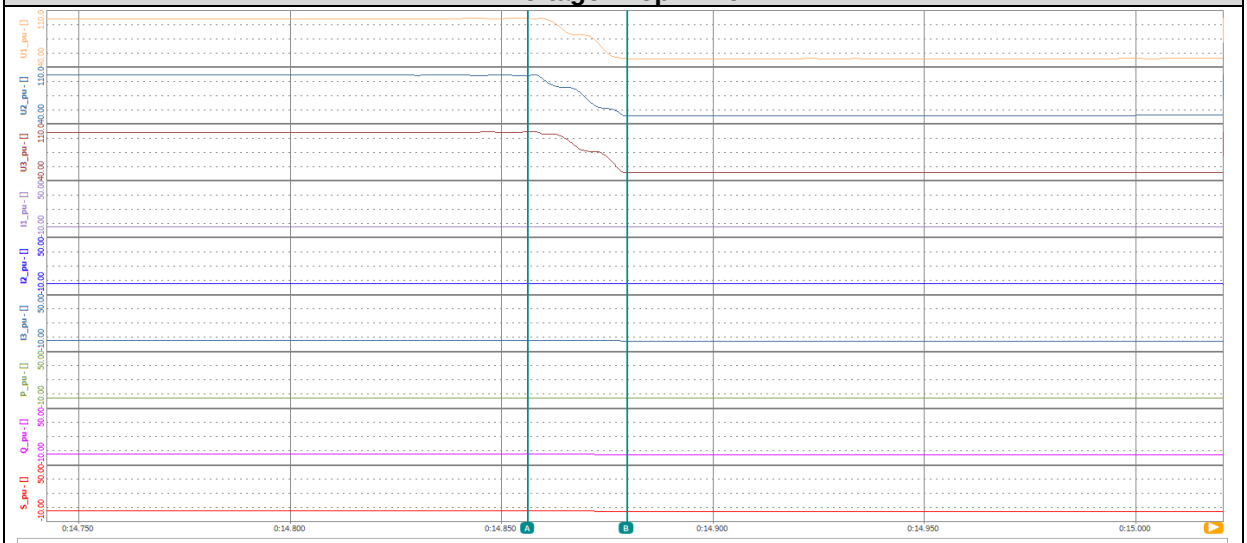


	A	B	Delta
Time [s]	0:13.9010464	0:15.8726948	1.9716484
U1_pu []	99.93001	99.99157	0.061559
U2_pu []	49.80153	50.05449	0.252961
U3_pu []	49.80019	49.99029	0.190108
I1_pu []	0.476811	0.477336	5.256e-4
I2_pu []	0.479116	0.481151	2.035e-3
I3_pu []	0.181561	0.186576	5.015e-3
P_pu []	-1.022e-3	-4.113e-3	-3.091e-3
Q_pu []	0.268499	0.270437	1.938e-3
S_pu []	0.268501	0.270468	1.967e-3

Three-Phase fault

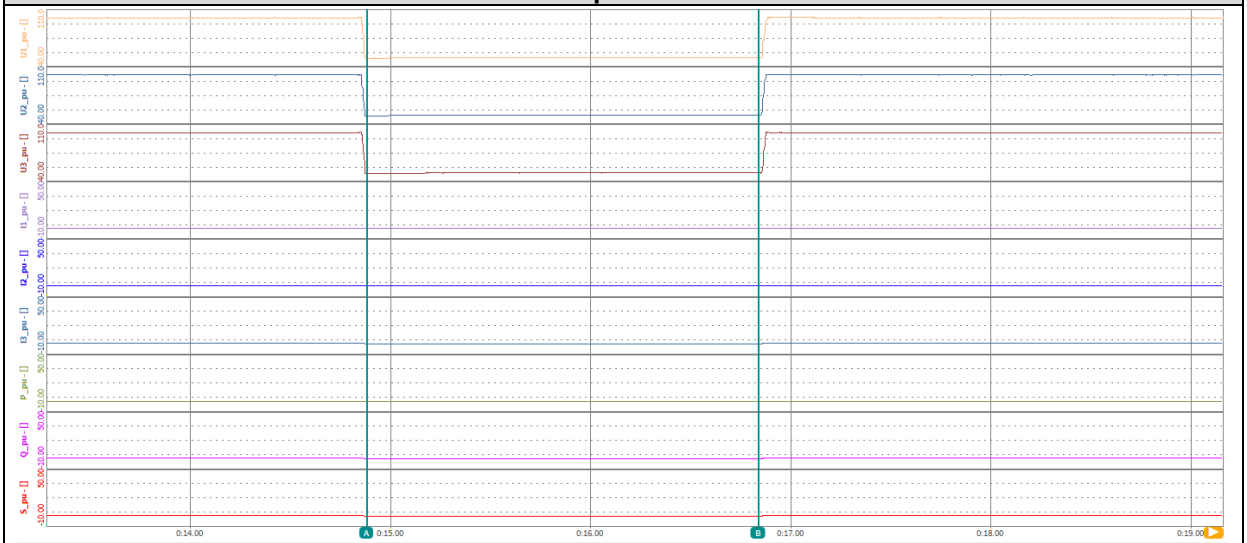
No Load	Residual voltage: 50 %Un

Voltage Drop Time



	A	B	Delta
Time [s]	0:14.85628	0:14.87966	0.02338
U1_pu []	100.1386	50.07292	-50.06571
U2_pu []	99.64608	49.68153	-49.96454
U3_pu []	100.2722	49.73715	-50.53508
I1_pu []	0.476257	0.382736	-0.093521
I2_pu []	0.550972	0.476791	-0.074181
I3_pu []	0.332766	0.180874	-0.151893
P_pu []	-4.744e-3	-2.492e-3	2.252e-3
Q_pu []	0.453179	0.172811	-0.280368
S_pu []	0.453204	0.172829	-0.280375

Dip Time

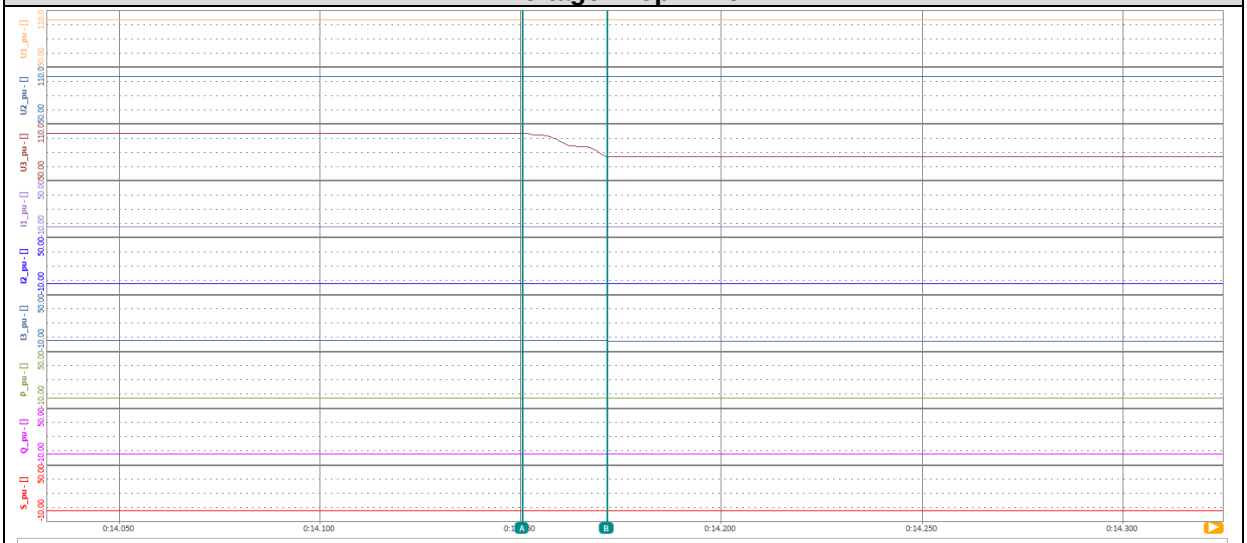


	A	B	Delta
Time [s]	0:14.88390	0:16.83846	1.95456
U1_pu []	49.86741	50.02292	0.155514
U2_pu []	49.84564	50.07612	0.230477
U3_pu []	49.79444	49.94731	0.152876
I1_pu []	0.387548	0.387008	-5.400e-4
I2_pu []	0.476988	0.478998	2.009e-3
I3_pu []	0.178909	0.184195	5.286e-3
P_pu []	-1.240e-3	-3.024e-3	-1.783e-3
Q_pu []	0.173364	0.175126	1.762e-3
S_pu []	0.173368	0.175152	1.784e-3

Single-Phase fault

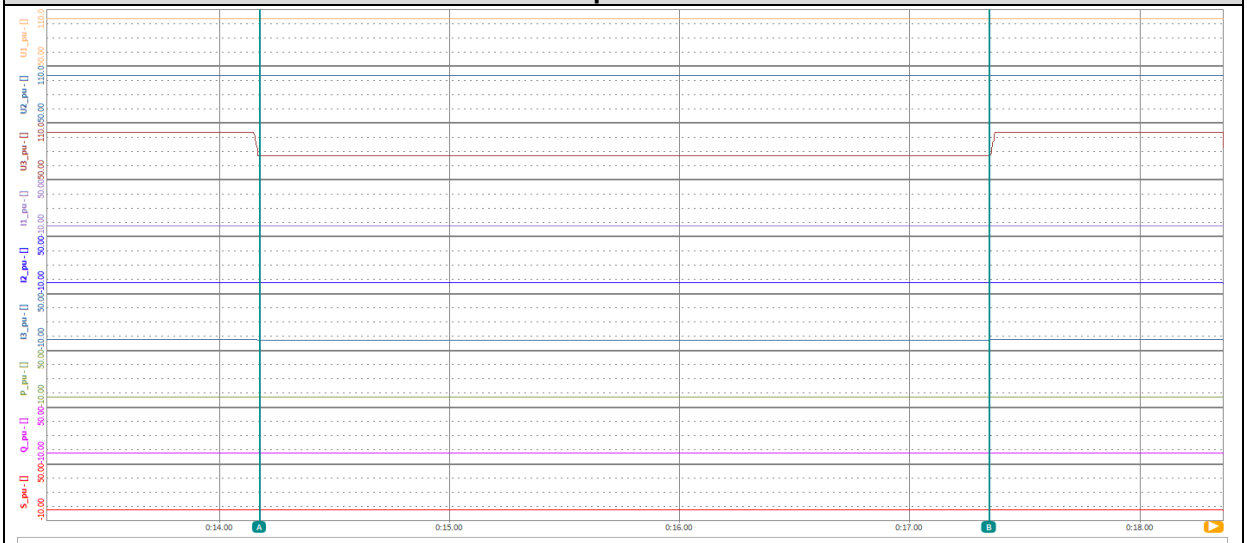
No Load	Residual voltage: 75 %Un

Voltage Drop Time



	A	B	Delta
Time [s]	0:14.1504547	0:14.1715446	0.0210900
U1_pu []	99.95673	99.94626	-0.010475
U2_pu []	100.0298	100.0235	-6.289e-3
U3_pu []	99.87730	75.36401	-24.51328
I1_pu []	0.473478	0.473972	4.939e-4
I2_pu []	0.555162	0.561997	6.835e-3
I3_pu []	0.334198	0.359204	0.025006
P_pu []	-5.669e-3	3.341e-3	9.010e-3
Q_pu []	0.454094	0.435506	-0.018588
S_pu []	0.454129	0.435519	-0.018610

Dip Time

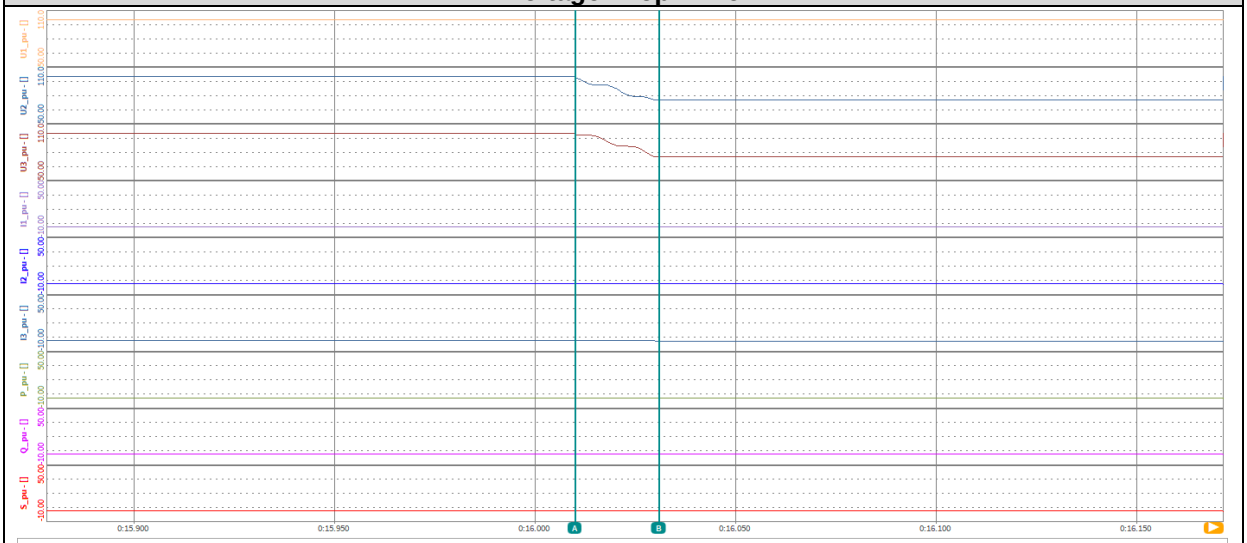


	A	B	Delta
Time [s]	0:14.1754260	0:17.3447975	3.1693715
U1_pu []	99.93989	99.95029	0.010396
U2_pu []	100.0123	100.0439	0.031586
U3_pu []	74.96014	74.92126	-0.038877
I1_pu []	0.473185	0.473649	4.637e-4
I2_pu []	0.554625	0.554814	1.883e-4
I3_pu []	0.253397	0.259087	5.690e-3
P_pu []	-2.366e-3	-5.009e-3	-2.643e-3
Q_pu []	0.405840	0.407496	1.656e-3
S_pu []	0.405847	0.407527	1.680e-3

Two-Phase fault

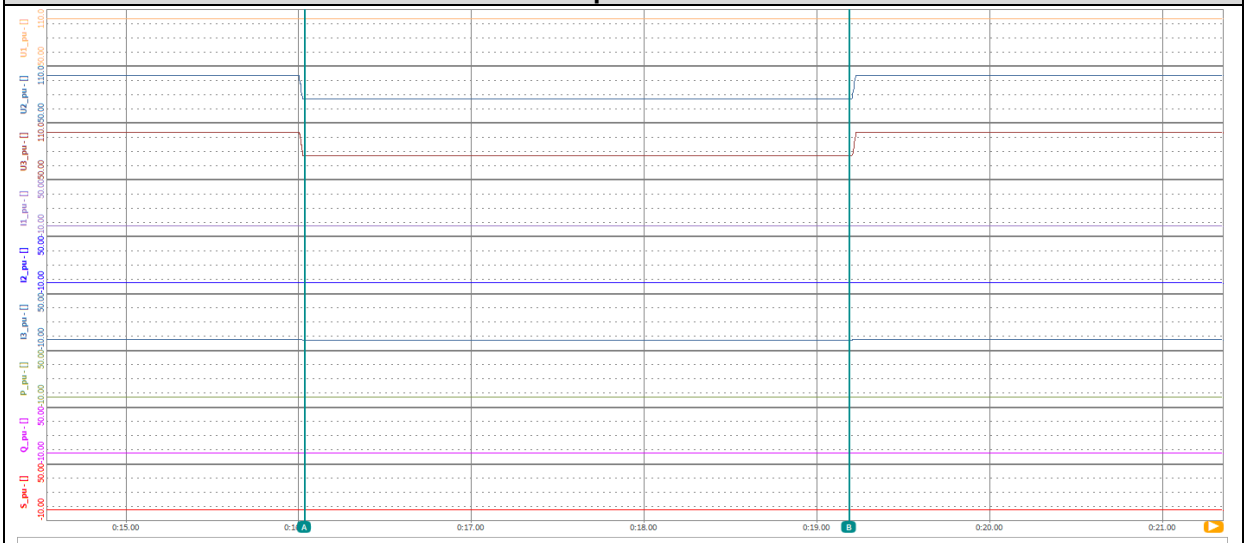
No Load	Residual voltage: 75 %Un

Voltage Drop Time



	A	B	Delta
Time [s]	0:16.0100249	0:16.0309072	0.0208823
U1_pu []	100.0179	100.0007	-0.017189
U2_pu []	100.0870	75.06004	-25.02694
U3_pu []	99.89368	74.94957	-24.94411
I1_pu []	0.474048	0.475905	1.857e-3
I2_pu []	0.553703	0.510748	-0.042955
I3_pu []	0.333519	0.256130	-0.077389
P_pu []	-5.964e-3	-2.626e-3	3.339e-3
Q_pu []	0.453788	0.350405	-0.103383
S_pu []	0.453827	0.350415	-0.103413

Dip Time

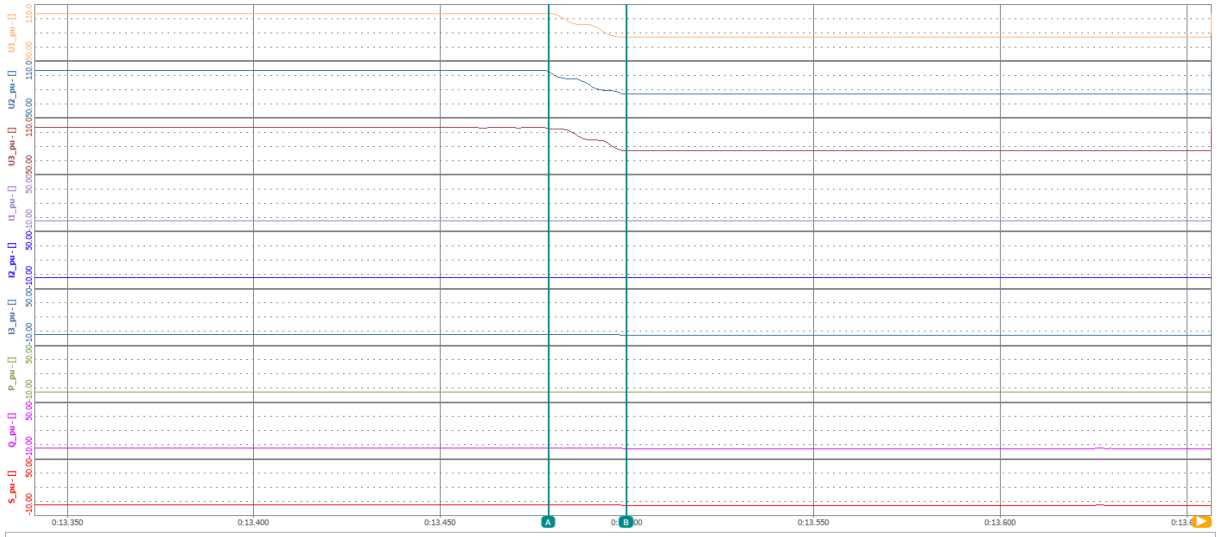


	A	B	Delta
Time [s]	0:16.03699	0:19.18695	3.14997
U1_pu []	99.99999	100.0071	7.085e-3
U2_pu []	75.07102	75.07801	6.986e-3
U3_pu []	74.94255	74.92816	-0.014390
I1_pu []	0.476680	0.474973	-1.707e-3
I2_pu []	0.512166	0.512298	1.315e-4
I3_pu []	0.255625	0.257837	2.213e-3
P_pu []	-2.474e-3	-4.674e-3	-2.200e-3
Q_pu []	0.350905	0.350910	5.066e-6
S_pu []	0.350913	0.350941	2.747e-5

Three-Phase fault

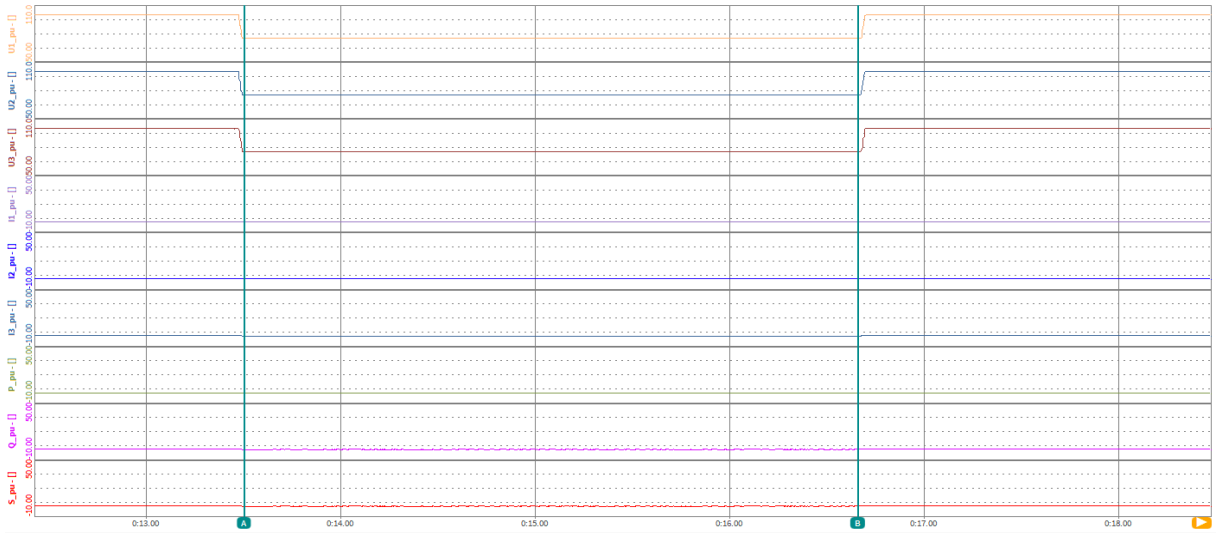
No Load	Residual voltage: 75 %Un

Voltage Drop Time



	A	B	Delta
Time [s]	0:13.47907	0:13.49989	0.02082
U1_pu []	99.89894	75.01259	-24.88635
U2_pu []	99.75449	74.95901	-24.79548
U3_pu []	99.61204	74.90766	-24.70438
I1_pu []	0.475838	0.426890	-0.048948
I2_pu []	0.601089	0.510740	-0.090349
I3_pu []	0.397600	0.254955	-0.142645
P_pu []	8.261e-3	-2.259e-3	-0.010520
Q_pu []	0.490273	0.298007	-0.192266
S_pu []	0.490343	0.298016	-0.192327

Dip Time



	A	B	Delta
Time [s]	0:13.50677	0:16.65942	3.15265
U1_pu []	75.01123	75.03053	0.019306
U2_pu []	74.97716	75.04742	0.070263
U3_pu []	74.89562	74.92804	0.032428
I1_pu []	0.426802	0.424593	-2.209e-3
I2_pu []	0.510193	0.511784	1.591e-3
I3_pu []	0.253168	0.258677	5.509e-3
P_pu []	-1.949e-3	-4.678e-3	-2.729e-3
Q_pu []	0.297423	0.298789	1.366e-3
S_pu []	0.297430	0.298826	1.396e-3

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

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

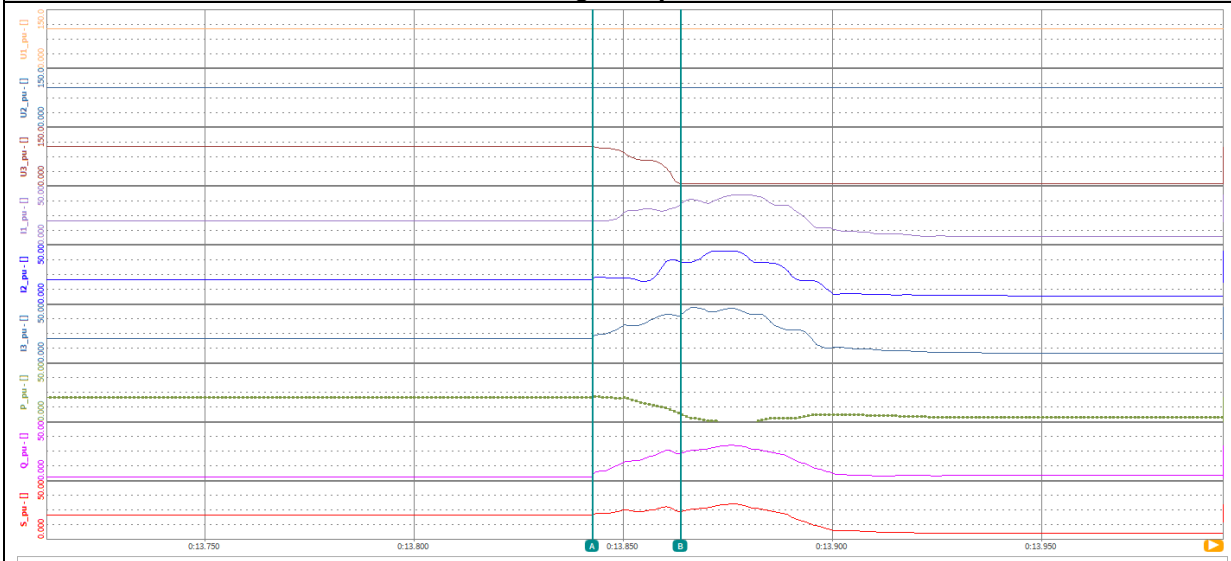
20 %Pn Load							
Phase type	**Residual voltage desired (%Un)**	**Voltage measured (%Un)**	**Voltage drop time (ms)**	**Dip time desired (ms)**	**Dip time measured (ms)**	**Power recovery time (ms)**	**Voltage after recovery (%Un)**
1 ph	0-5	4.0	21	≥ 400	426	21	100.0
2 ph		4.0	23		424	22	99.9
3 ph		4.2	21		425	13	99.9
1 ph	25	25.0	20	≥ 1000	1071	20	99.9
2 ph		25.0	22		1074	20	100.0
3 ph		25.4	21		1072	27	100.0
1 ph	50	49.8	21	≥ 1850	1967	5	99.9
2 ph		49.8	22		1966	20	100.0
3 ph		49.8	23		1970	15	100.0
1 ph	75	74.9	20	≥ 3000	3062	16	99.9
2 ph		75.0	21		3073	11	100.0
3 ph		75.4	20		3074	20	100.0

Remark: The virtual neutral line was used in the test.

Test results are graphically represented at following pages.
Note: The following test figure the voltage unit of U1_pu, U2_pu and U3_pu are **%Un** , the current unit of I1_pu, I2_pu and I3_pu are **%In** and the power unit is **%Pn**

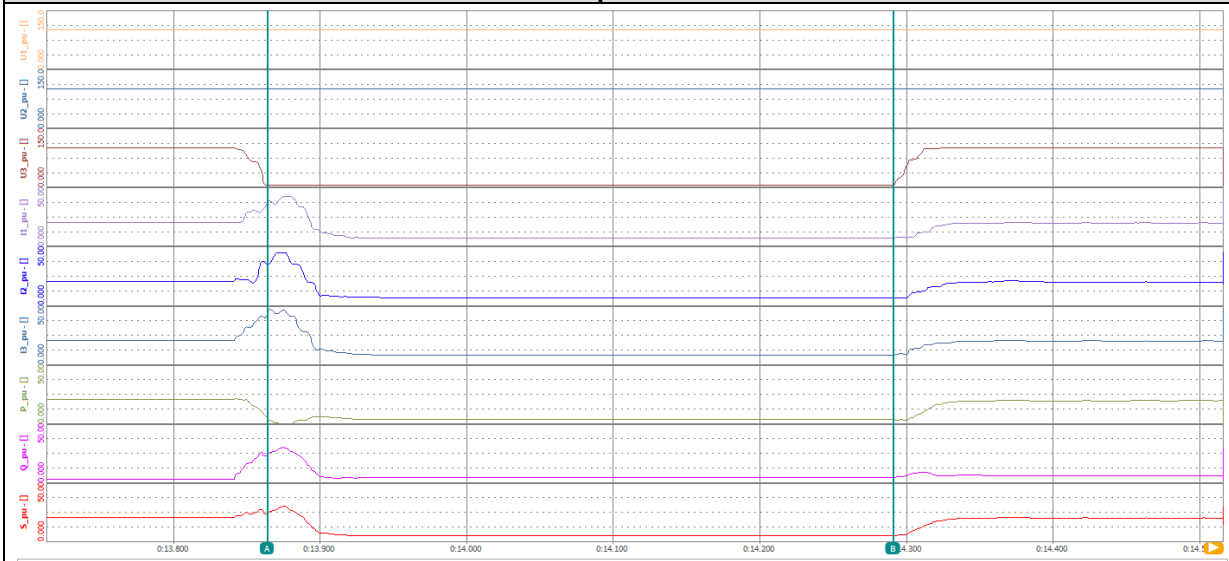
Single-Phase fault	
20%Pn Load	Residual voltage: 0~5%Un

Voltage Drop time



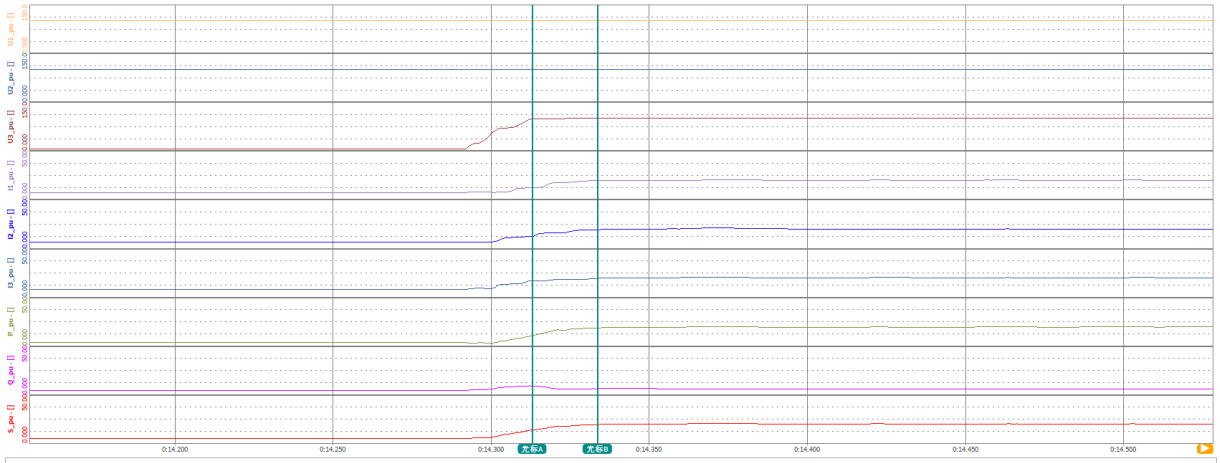
	A	B	Delta
Time [s]	0:13.8426296	0:13.8636874	0.0210578
U1_pu []	100.0191	99.95755	-0.061500
U2_pu []	100.0641	99.96283	-0.101232
U3_pu []	99.85344	3.985156	-95.86828
I1_pu []	20.34498	32.95976	12.61478
I2_pu []	20.39833	35.72810	15.32977
I3_pu []	20.40238	39.52551	19.12313
P_pu []	20.23210	6.380338	-13.85176
Q_pu []	2.430585	22.52574	20.09516
S_pu []	20.37758	23.41191	3.034338

Dip time



	A	B	Delta
Time [s]	0:13.8644219	0:14.2908743	0.4264524
U1_pu []	99.95755	99.98121	0.023658
U2_pu []	99.96283	100.0196	0.056803
U3_pu []	3.985156	3.936058	-0.049098
I1_pu []	32.95976	6.949677	-26.01008
I2_pu []	35.72810	6.047838	-29.68026
I3_pu []	39.52551	7.358116	-32.16739
P_pu []	6.380338	2.688626	-3.691711
Q_pu []	22.52574	3.519571	-19.00617
S_pu []	23.41191	4.429005	-18.98291

Power Recovery time

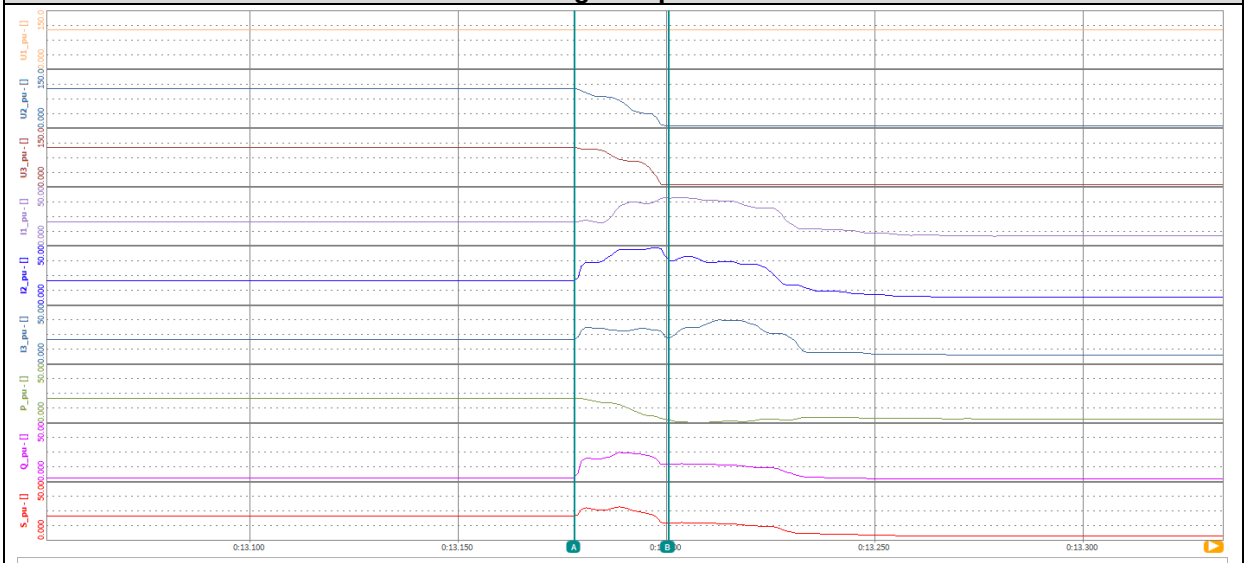


	A	B	间隔
时间 [s]	0:14.3131622	0:14.3337806	0.0206184
U1_pu []	100.0491	100.0998	0.050666
U2_pu []	100.1109	100.1621	0.051183
U3_pu []	95.95730	99.72157	3.764277
I1_pu []	12.18195	19.27933	7.097386
I2_pu []	11.60454	18.63813	7.033588
I3_pu []	16.30487	18.90862	2.603752
P_pu []	9.760686	18.10738	8.346699
Q_pu []	8.812540	5.557234	-3.255306
S_pu []	13.15036	18.94097	5.790611

Two-Phase fault

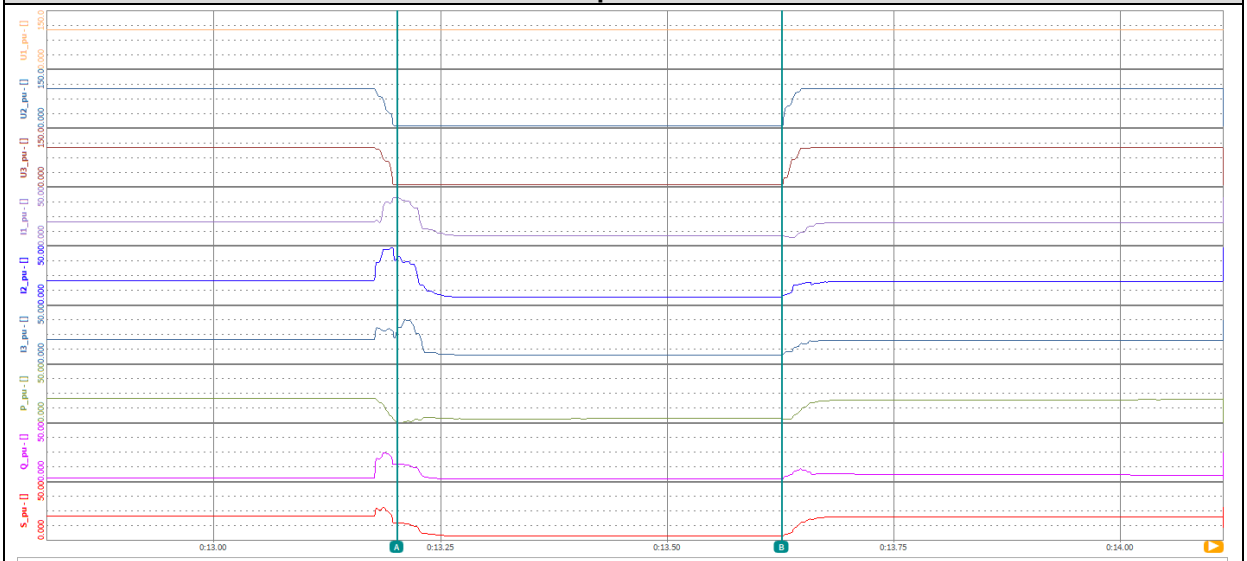
20%Pn Load	Residual voltage: 0~5%Un

Voltage Drop time



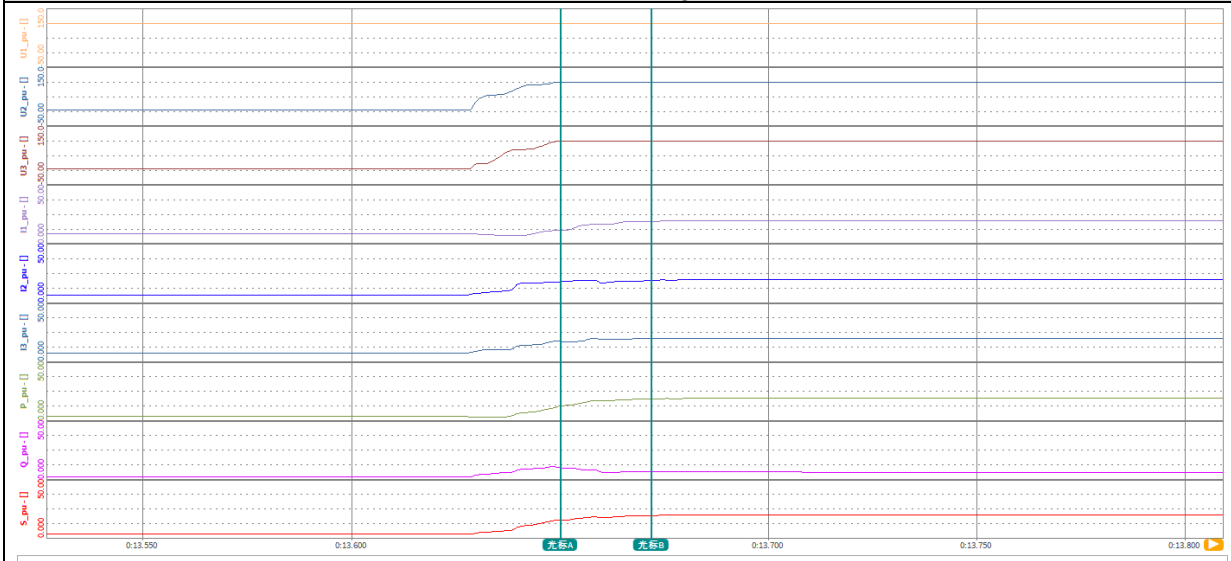
	A	B	Delta
Time [s]	0:13.1778752	0:13.2004670	0.0225918
U1_pu []	100.0131	99.89081	-0.122336
U2_pu []	100.0828	3.945164	-96.13765
U3_pu []	99.85848	4.004070	-95.85441
I1_pu []	20.27718	40.68160	20.40442
I2_pu []	20.31547	40.79806	20.48259
I3_pu []	20.26814	22.46781	2.199672
P_pu []	20.13998	2.366329	-17.77365
Q_pu []	2.411739	14.18611	11.77437
S_pu []	20.28387	14.38212	-5.901747

DipTime



	A	B	Delta
Time [s]	0:13.2025199	0:13.6263268	0.4238069
U1_pu []	99.88090	99.95141	0.070509
U2_pu []	3.983145	3.999252	0.016107
U3_pu []	4.012599	3.958993	-0.053606
I1_pu []	40.99178	8.301449	-32.69033
I2_pu []	37.68188	6.158487	-31.52339
I3_pu []	24.04565	6.817946	-17.22770
P_pu []	0.938682	2.621385	1.682703
Q_pu []	14.43910	1.326447	-13.11265
S_pu []	14.46958	2.937877	-11.53170

Power Recovery time

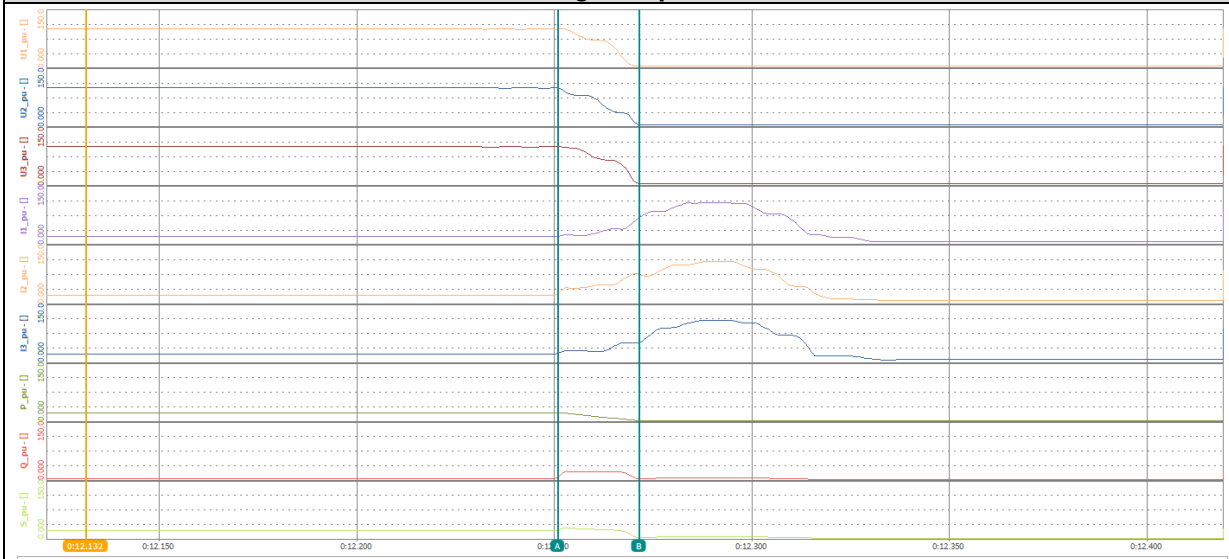


	A	B	间隔
时间 [s]	0:13.6501976	0:13.6720101	0.0218125
U1_pu []	100.0380	100.0880	0.050016
U2_pu []	99.64962	99.95115	0.301527
U3_pu []	98.27797	99.71923	1.441259
I1_pu []	10.99538	18.70217	7.706789
I2_pu []	17.32939	18.78843	1.459045
I3_pu []	16.94556	19.46775	2.522189
P_pu []	11.64319	18.04485	6.401663
Q_pu []	9.415768	5.852915	-3.562853
S_pu []	14.97400	18.97033	3.996331

Three-Phase fault

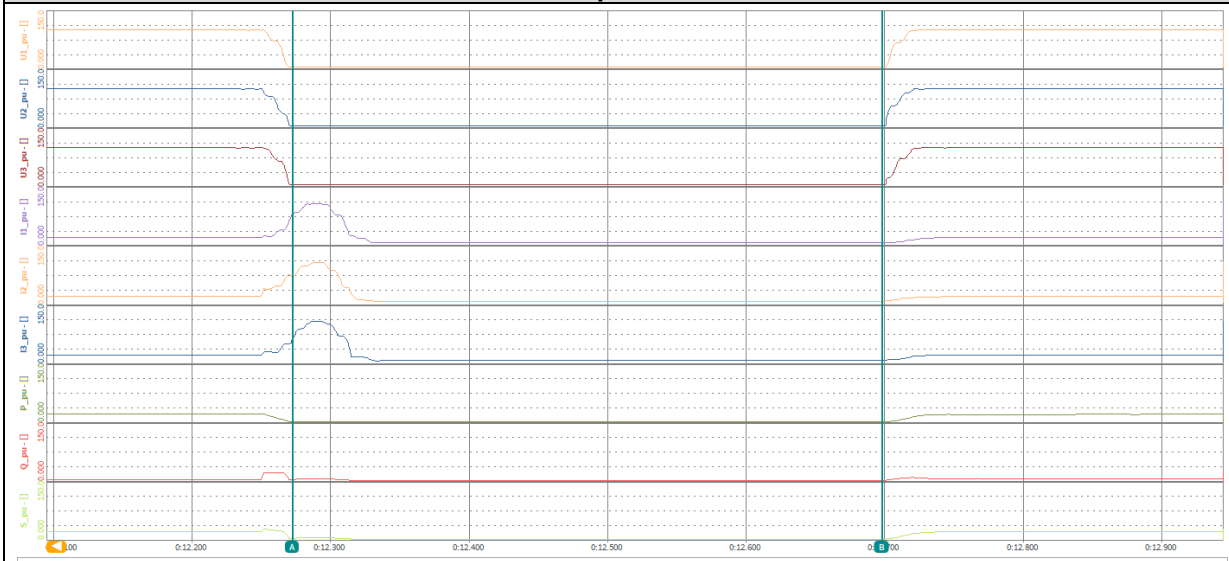
20%Pn Load	Residual voltage: 0~5%Un

Voltage Drop time



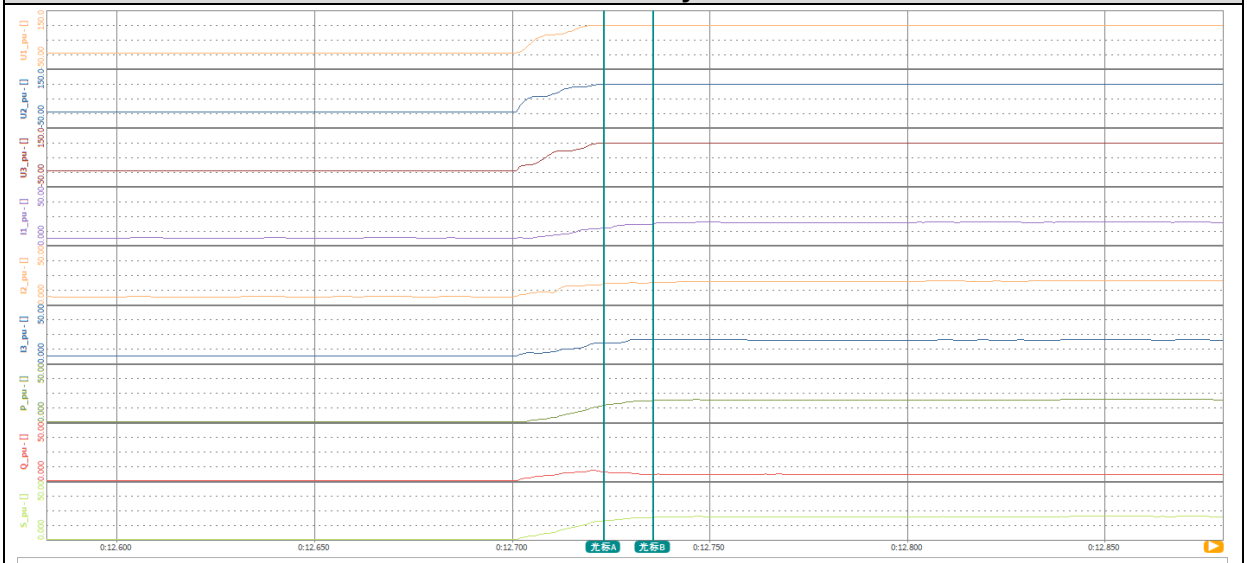
	A	B	Delta
Time [s]	0:12.2509676	0:12.2715158	0.0205482
U1_pu []	99.12384	4.459383	-94.66446
U2_pu []	100.1284	4.019506	-96.10889
U3_pu []	100.7739	4.097592	-96.67629
I1_pu []	20.19769	64.90139	44.70371
I2_pu []	20.34780	75.64024	55.29244
I3_pu []	20.55233	49.15832	28.60600
P_pu []	20.22004	0.180755	-20.03929
Q_pu []	2.456161	2.643452	0.187291
S_pu []	20.36868	2.649625	-17.71905

DipTime



	A	B	Delta
Time [s]	0:12.2727373	0:12.6980911	0.4253538
U1_pu []	4.308813	4.053963	-0.254850
U2_pu []	4.046169	4.026073	-0.020097
U3_pu []	4.133675	3.992815	-0.140860
I1_pu []	72.39604	6.308018	-66.08802
I2_pu []	72.50391	6.281579	-66.22233
I3_pu []	52.51087	6.163361	-46.34751
P_pu []	0.058723	0.224208	0.165485
Q_pu []	2.740594	0.114103	-2.626491
S_pu []	2.741223	0.251572	-2.489651

Power Recovery time

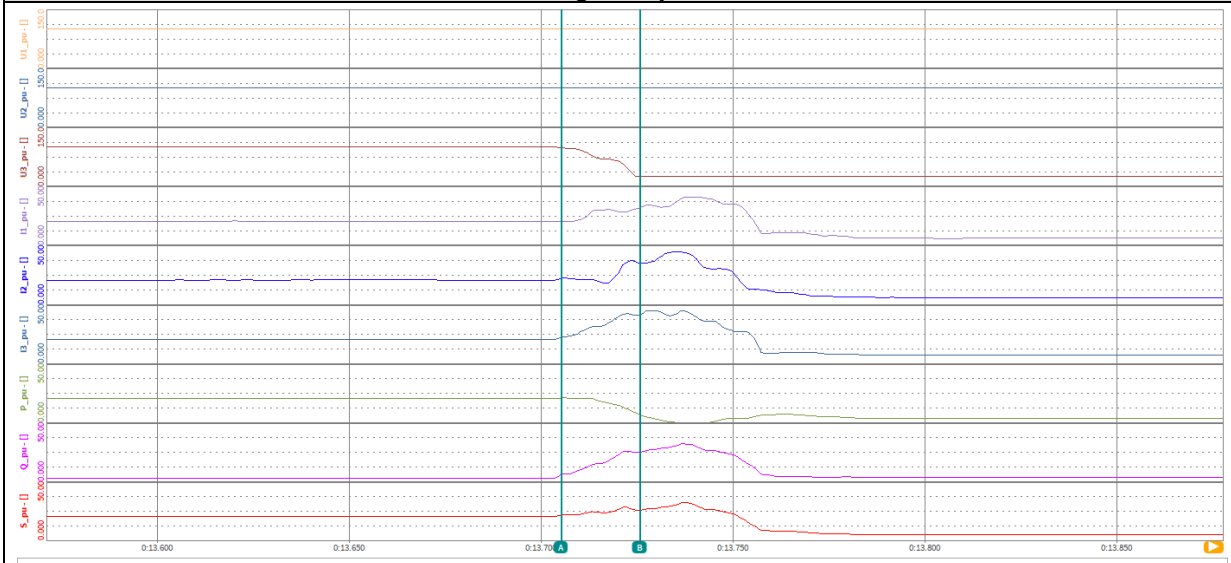


	A	B	间隔
时间 [s]	0:12.7231310	0:12.7356348	0.0125038
U1_pu []	98.25002	100.0672	1.817182
U2_pu []	100.3910	99.86615	-0.524869
U3_pu []	99.07921	99.80126	0.722053
I1_pu []	14.49147	18.21489	3.723423
I2_pu []	16.63677	18.41716	1.780392
I3_pu []	16.82503	20.01628	3.191245
P_pu []	13.76614	18.07391	4.307773
Q_pu []	7.896086	5.407048	-2.489039
S_pu []	15.86993	18.86538	2.995445

Single-Phase fault

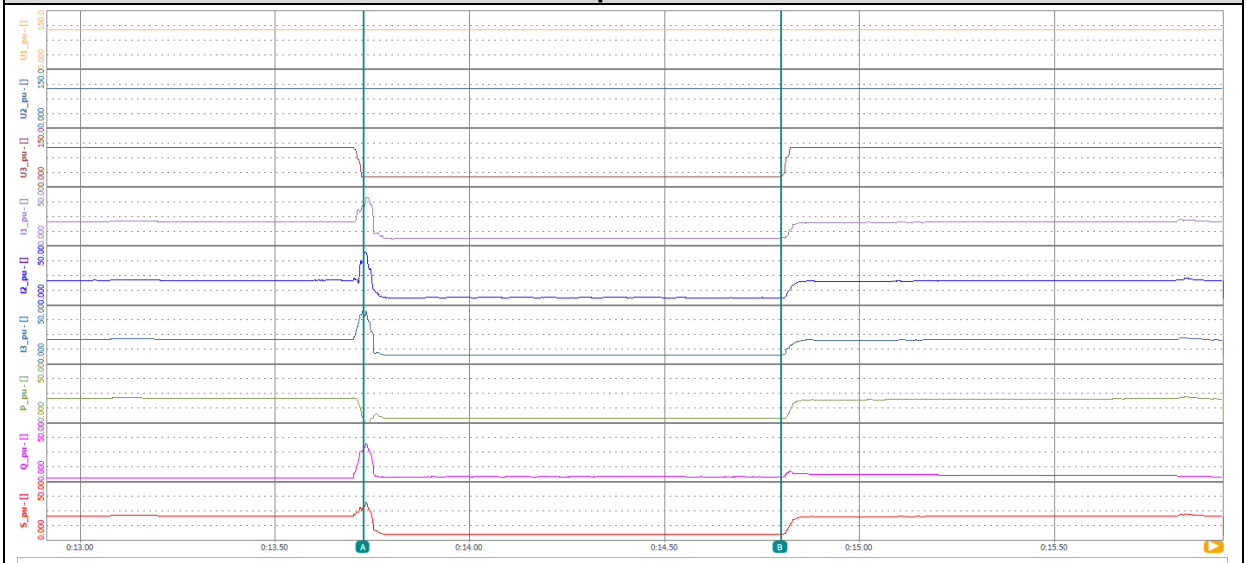
20%Pn Load	Residual voltage: 25%Un

Voltage Drop time



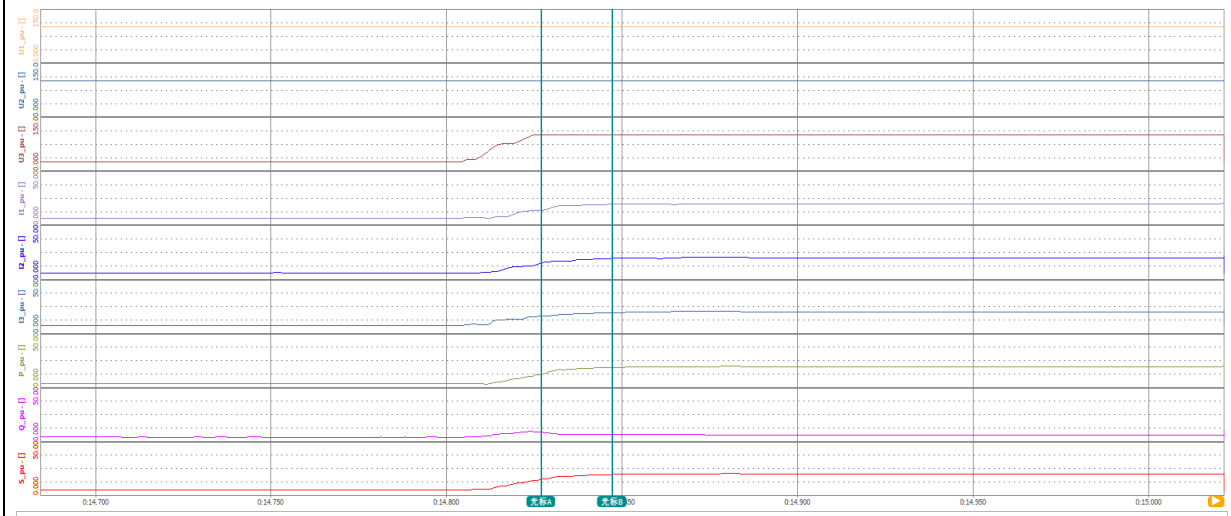
	A	B	Delta
Time [s]	0:13.7052323	0:13.7257096	0.0204773
U1_pu []	100.0195	99.95718	-0.062355
U2_pu []	100.0964	99.97042	-0.126004
U3_pu []	99.39336	25.03086	-74.36250
I1_pu []	20.45730	31.37762	10.92032
I2_pu []	20.81010	35.42118	14.61108
I3_pu []	21.00787	40.79601	19.78813
P_pu []	20.44801	6.798437	-13.64957
Q_pu []	3.370723	24.74526	21.37453
S_pu []	20.72397	25.66216	4.938195

DipTime



	A	B	Delta
Time [s]	0:13.7272091	0:14.7977469	1.0705377
U1_pu []	99.94600	99.99716	0.051157
U2_pu []	99.96300	100.0728	0.109837
U3_pu []	25.04710	24.95952	-0.087580
I1_pu []	33.04447	6.154530	-26.88994
I2_pu []	34.84781	5.567209	-29.28060
I3_pu []	42.31525	6.883583	-35.43166
P_pu []	5.526606	2.965441	-2.561165
Q_pu []	25.56284	3.359717	-22.20312
S_pu []	26.15343	4.481243	-21.67219

Power Recovery time

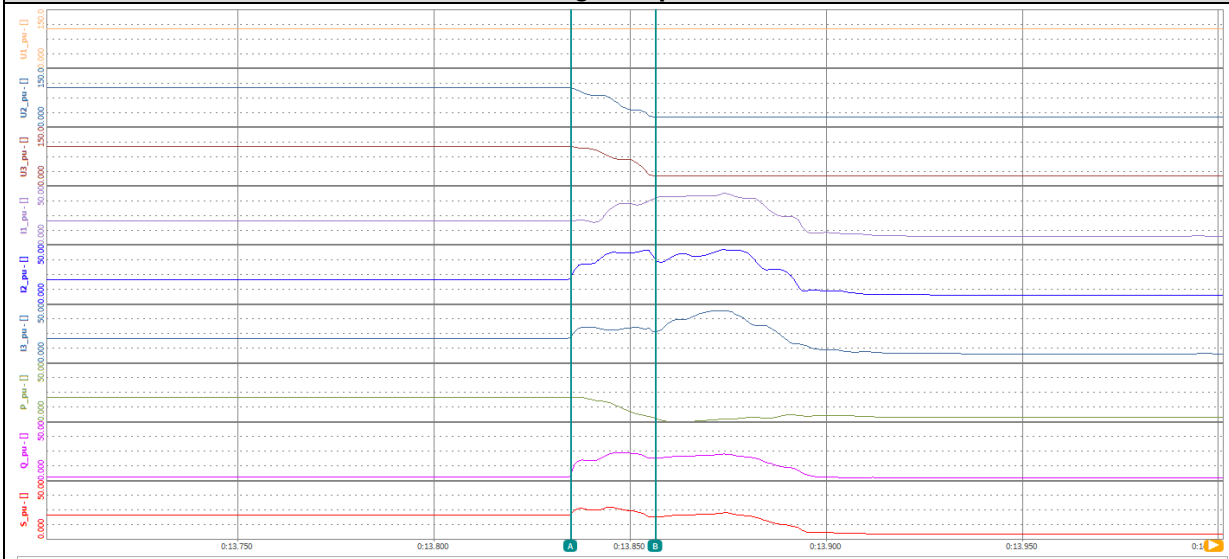


	A	B	间隔
时间 [s]	0:14.8270525	0:14.8472629	0.0202103
U1_pu []	100.0899	100.1081	0.018198
U2_pu []	100.1913	100.3228	0.131504
U3_pu []	99.77254	99.68988	-0.082663
I1_pu []	13.24287	19.04313	5.800253
I2_pu []	14.07439	19.02175	4.947358
I3_pu []	15.66400	18.95143	3.287436
P_pu []	11.55180	18.04371	6.491912
Q_pu []	8.476547	5.993759	-2.482788
S_pu []	14.32815	19.01317	4.685020

Two-Phase fault

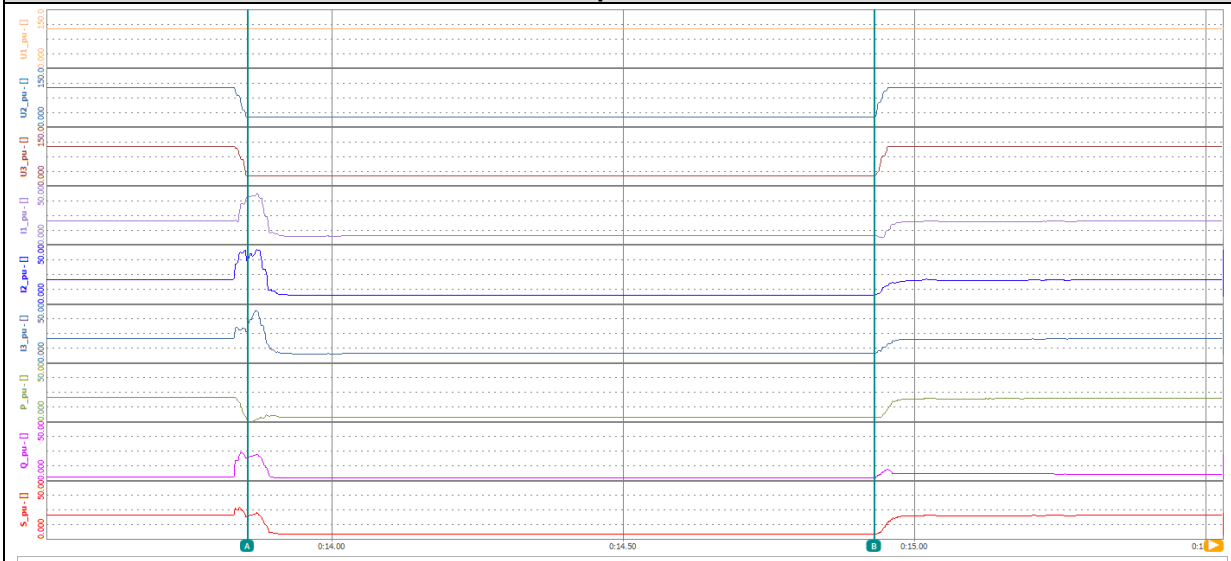
20%Pn Load | Residual voltage: 25%Un

Voltage Drop time



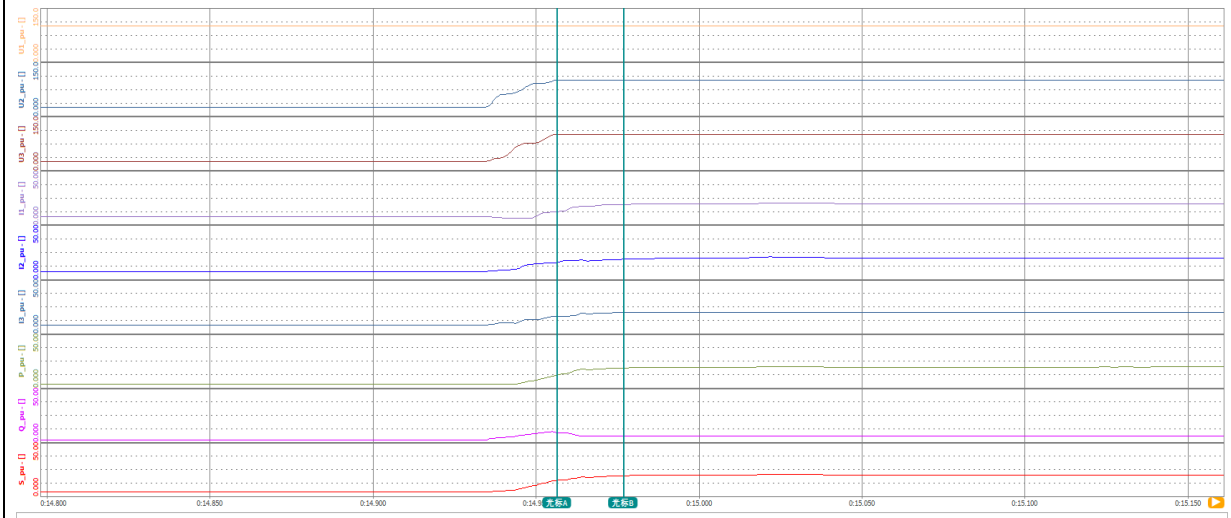
	A	B	Delta
Time [s]	0:13.8349371	0:13.8565214	0.0215843
U1_pu []	100.0263	99.88036	-0.145887
U2_pu []	100.0766	25.04747	-75.02912
U3_pu []	99.91846	25.10494	-74.81352
I1_pu []	20.39360	39.05128	18.65768
I2_pu []	20.42800	40.40008	19.97208
I3_pu []	20.39611	25.92922	5.533103
P_pu []	20.26006	2.674780	-17.58528
Q_pu []	2.447503	18.35051	15.90301
S_pu []	20.40736	18.54442	-1.862938

DipTime



	A	B	Delta
Time [s]	0:13.8566601	0:14.9309045	1.0742444
U1_pu []	99.88036	99.97576	0.095394
U2_pu []	25.04747	25.04696	-5.125e-4
U3_pu []	25.10494	25.01665	-0.088292
I1_pu []	39.05128	7.224215	-31.82706
I2_pu []	40.40008	6.774966	-33.62512
I3_pu []	25.92922	7.127423	-18.80179
P_pu []	2.674780	3.119607	0.444827
Q_pu []	18.35051	1.730590	-16.61992
S_pu []	18.54442	3.567477	-14.97695

Power Recovery time

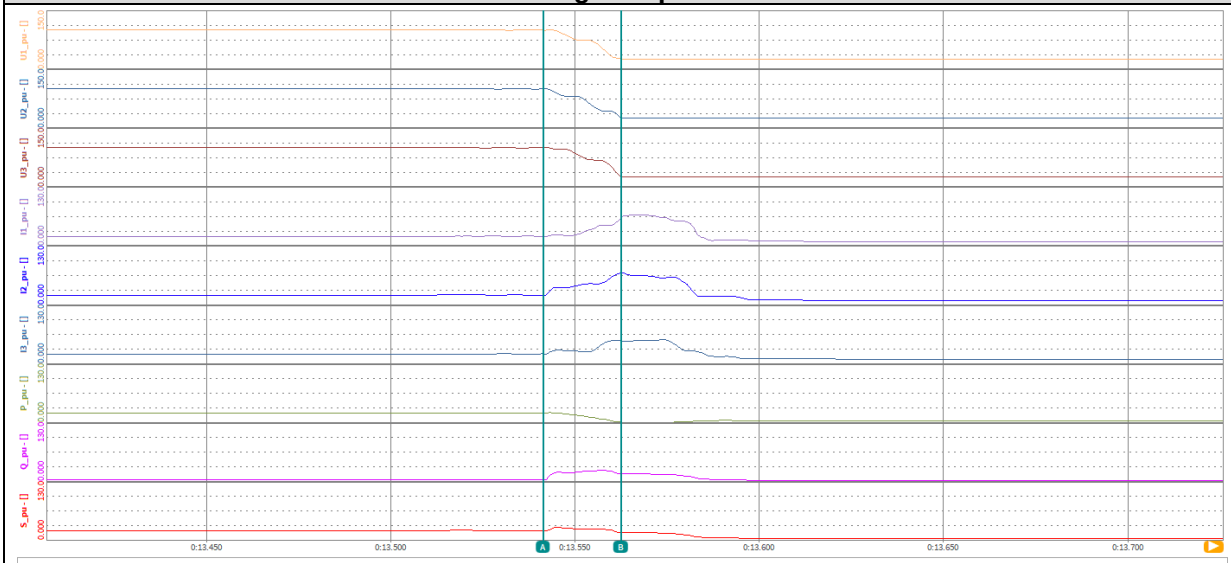


时间 [s]	A 0:14.9565554	B 0:14.9768262	间隔 0.0202708
U1_pu []	100.0931	100.1541	0.061055
U2_pu []	100.0079	99.99256	-0.015345
U3_pu []	99.84244	99.84366	1.221e-3
I1_pu []	11.99680	18.78513	6.788326
I2_pu []	15.01488	18.12404	3.109159
I3_pu []	15.76297	19.26296	3.499988
P_pu []	11.23418	18.02424	6.790062
Q_pu []	8.773327	5.068035	-3.705292
S_pu []	14.25406	18.72320	4.469147

Three-Phase fault

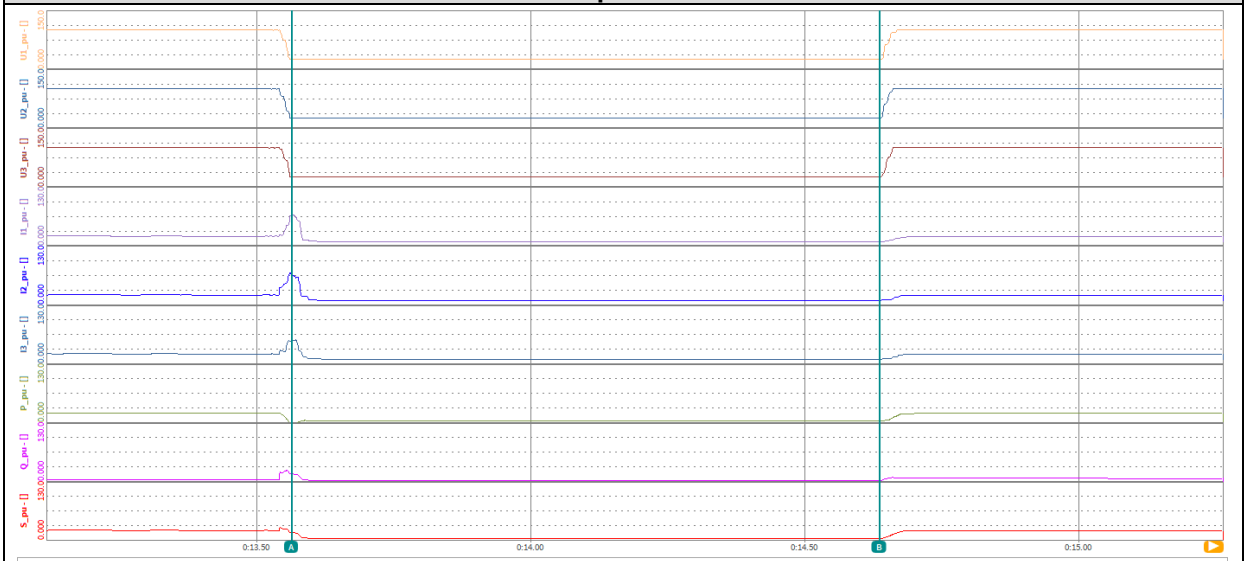
20%Pn Load	Residual voltage: 25%Un

Voltage Drop time



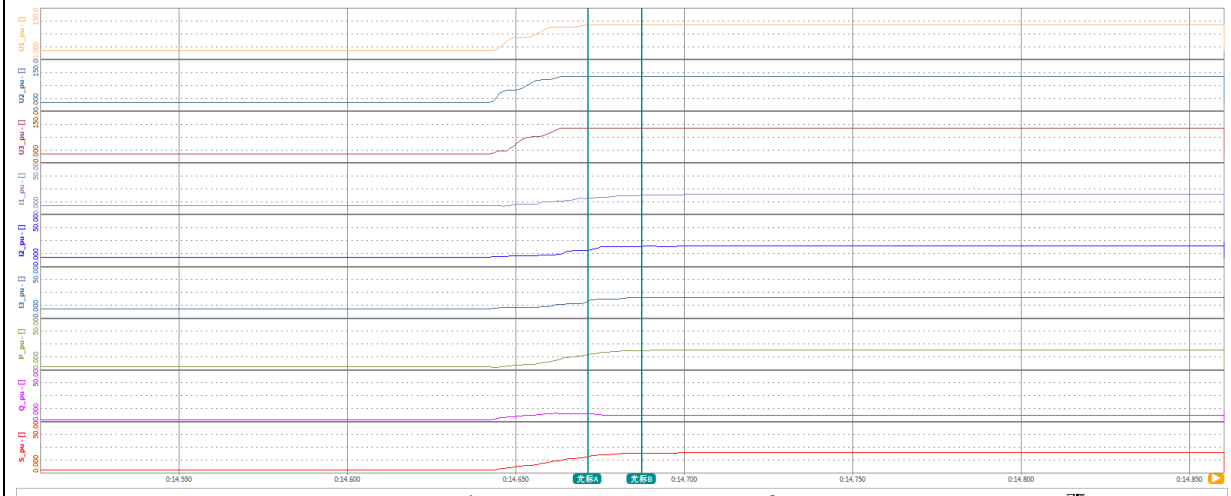
Time [s]	A 0:13.5415440	B 0:13.5626354	Delta 0.0210914
U1_pu []	99.94035	25.47482	-74.46554
U2_pu []	99.58211	25.49457	-74.08754
U3_pu []	100.5714	25.31978	-75.25159
I1_pu []	20.15598	58.37121	38.21523
I2_pu []	20.21807	70.78958	50.57152
I3_pu []	20.37286	49.57256	29.19970
P_pu []	20.11024	-0.569311	-20.67955
Q_pu []	2.422346	15.14568	12.72333
S_pu []	20.25560	15.15637	-5.099227

DipTime



	A	B	Delta
Time [s]	0:13.5646278	0:14.6367016	1.0720738
U1_pu []	25.22060	24.93963	-0.280967
U2_pu []	25.04828	25.06130	0.013021
U3_pu []	25.06077	25.08658	0.025809
I1_pu []	66.54476	8.203867	-58.34089
I2_pu []	65.71900	8.273556	-57.44545
I3_pu []	48.24087	8.215450	-40.02542
P_pu []	-2.549200	2.020759	4.569959
Q_pu []	14.89476	0.400939	-14.49382
S_pu []	15.11133	2.060150	-13.05118

Power Recovery time

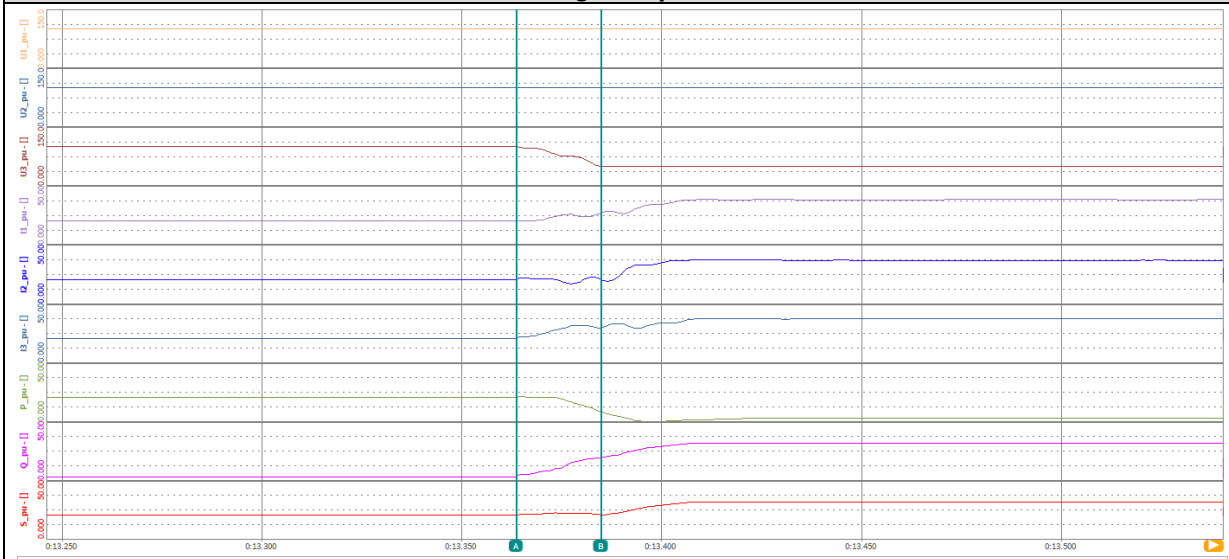


	A	B	间隔
时间 [s]	0:14.6713641	0:14.6873942	0.0160301
U1_pu []	99.07349	99.68475	0.611260
U2_pu []	99.89179	99.93916	0.047375
U3_pu []	99.73547	99.76017	0.024699
I1_pu []	15.10546	18.23129	3.125835
I2_pu []	15.04690	18.93073	3.883829
I3_pu []	14.39154	19.04520	4.653656
P_pu []	13.17238	18.00588	4.833500
Q_pu []	6.710538	5.038396	-1.672143
S_pu []	14.78320	18.69752	3.914319

Single-Phase fault

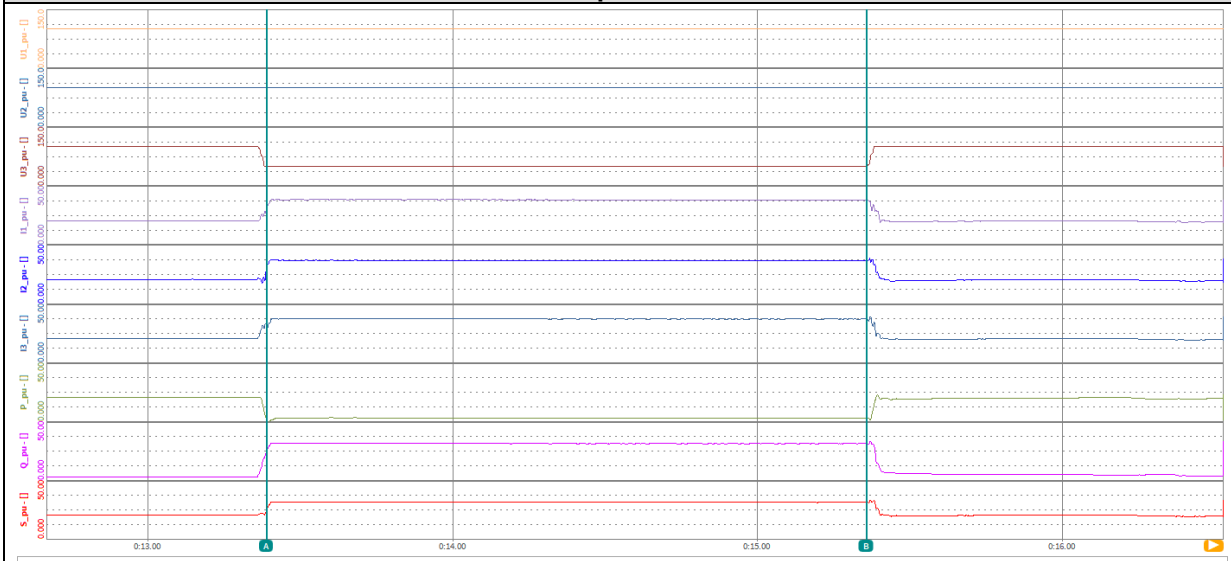
20%Pn Load | Residual voltage: 50%Un

Voltage Drop time



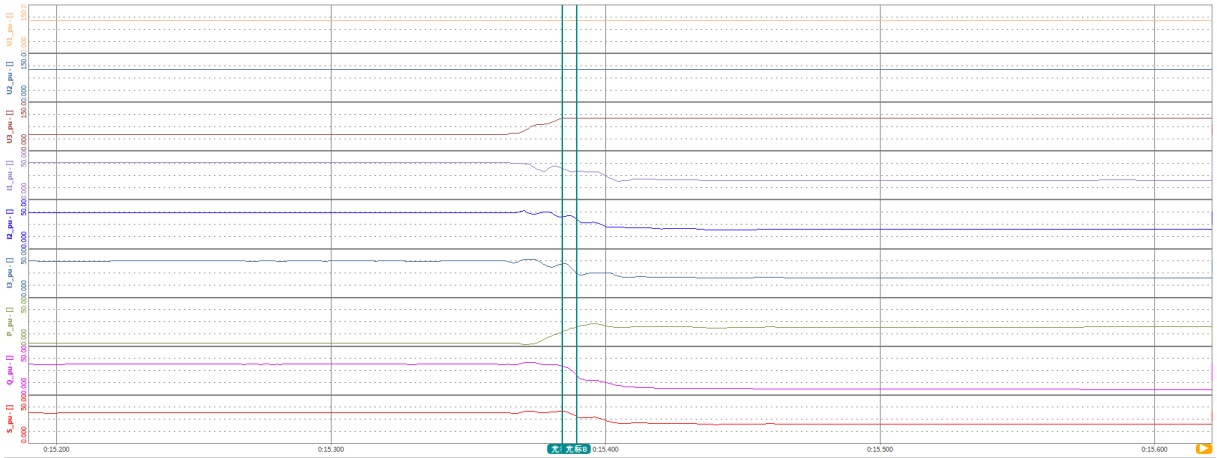
	A	B	Delta
Time [s]	0:13.3636848	0:13.3848739	0.0211891
U1_pu []	100.0311	99.95045	-0.080606
U2_pu []	100.0982	99.97427	-0.123954
U3_pu []	99.90854	49.82188	-50.08666
I1_pu []	20.38001	26.38979	6.009788
I2_pu []	20.38802	20.81121	0.423197
I3_pu []	20.37847	29.12576	8.747288
P_pu []	20.23912	8.416283	-11.82284
Q_pu []	2.432177	18.76342	16.33124
S_pu []	20.38474	20.56453	0.179789

DipTime



	A	B	Delta
Time [s]	0:13.3898599	0:15.3570587	1.9671989
U1_pu []	99.89728	100.0395	0.142212
U2_pu []	99.98418	100.1113	0.127126
U3_pu []	49.81633	50.02920	0.212870
I1_pu []	26.99184	38.32931	11.33746
I2_pu []	23.22769	36.40710	13.17941
I3_pu []	33.18425	36.98041	3.796163
P_pu []	3.964109	2.435242	-1.528867
Q_pu []	21.88363	31.00219	9.118566
S_pu []	22.23977	31.09769	8.857924

Power Recovery time

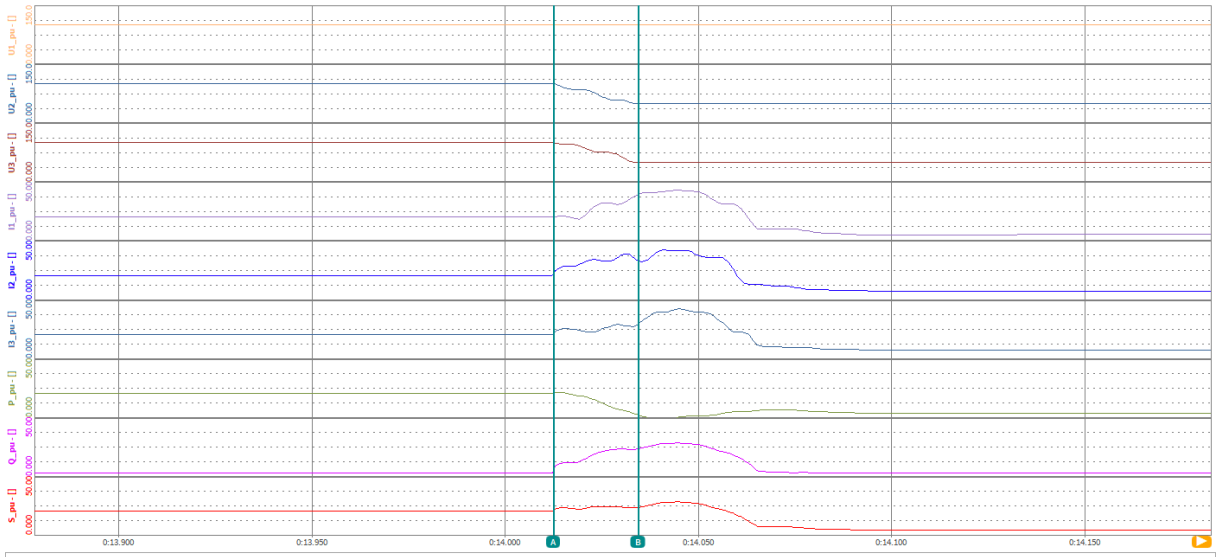


	A	B	间隔
时间 [s]	0:15.3841352	0:15.3894065	0.0052713
U1_pu []	100.1242	100.1270	2.773e-3
U2_pu []	100.2191	100.2251	6.017e-3
U3_pu []	97.70183	100.1400	2.438175
I1_pu []	32.58876	28.42650	-4.162265
I2_pu []	32.41364	32.39645	-0.017191
I3_pu []	33.54591	27.84300	-5.702910
P_pu []	13.53410	18.22367	4.689566
Q_pu []	29.69041	23.33095	-6.359455
S_pu []	32.62962	29.60465	-3.024971

Two-Phase fault

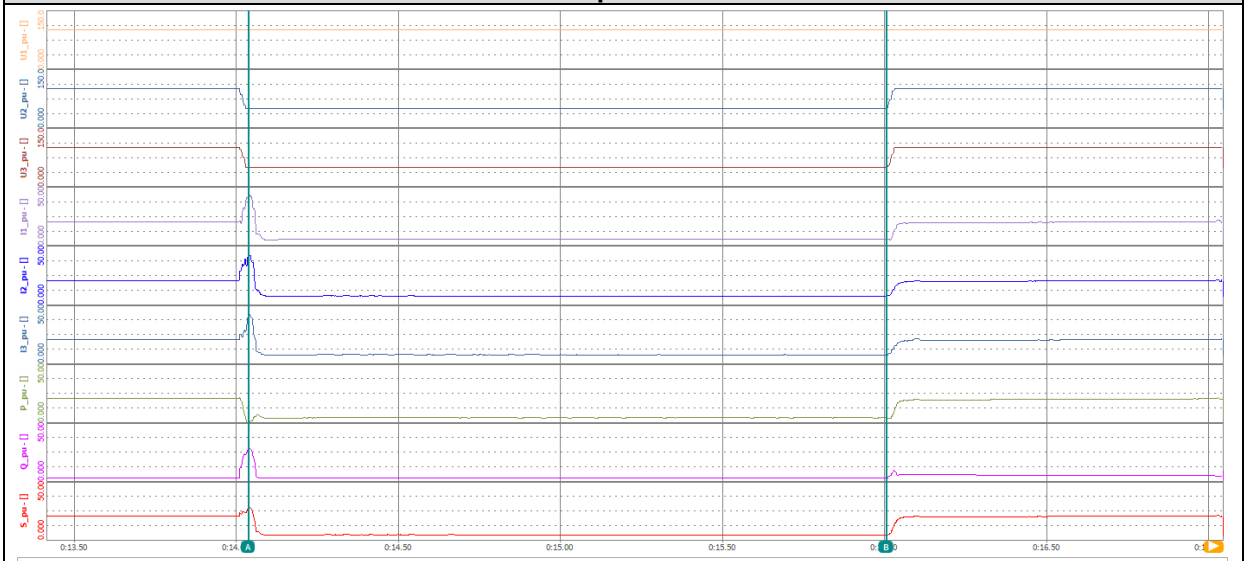
20%Pn Load	Residual voltage: 50%Un

Voltage Drop time



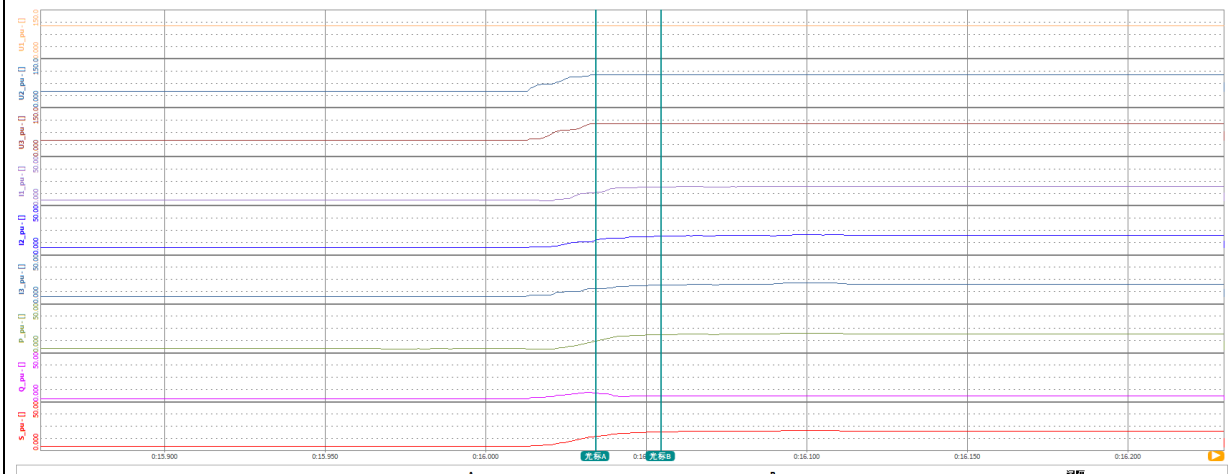
	A	B	Delta
Time [s]	0:14.0125601	0:14.0344705	0.0219104
U1_pu []	100.0456	99.90027	-0.145303
U2_pu []	100.0730	49.74231	-50.33068
U3_pu []	99.87610	49.76423	-50.11187
I1_pu []	20.26924	39.16184	18.89260
I2_pu []	20.33532	33.48363	13.14831
I3_pu []	20.23925	28.34196	8.102706
P_pu []	20.13449	1.910171	-18.22432
Q_pu []	2.432817	23.21571	20.78289
S_pu []	20.28094	23.29416	3.013221

DipTime



	A	B	Delta
Time [s]	0:14.0389034	0:16.0053908	1.9664874
U1_pu []	99.88032	100.0093	0.128977
U2_pu []	49.77292	50.04069	0.267769
U3_pu []	49.75396	49.96278	0.208817
I1_pu []	41.09634	5.120528	-35.97581
I2_pu []	37.12022	6.957614	-30.16261
I3_pu []	37.86402	7.058386	-30.80563
P_pu []	-0.993785	3.365349	4.359135
Q_pu []	26.10169	2.240721	-23.86097
S_pu []	26.12061	4.043069	-22.07754

Power Recovery time

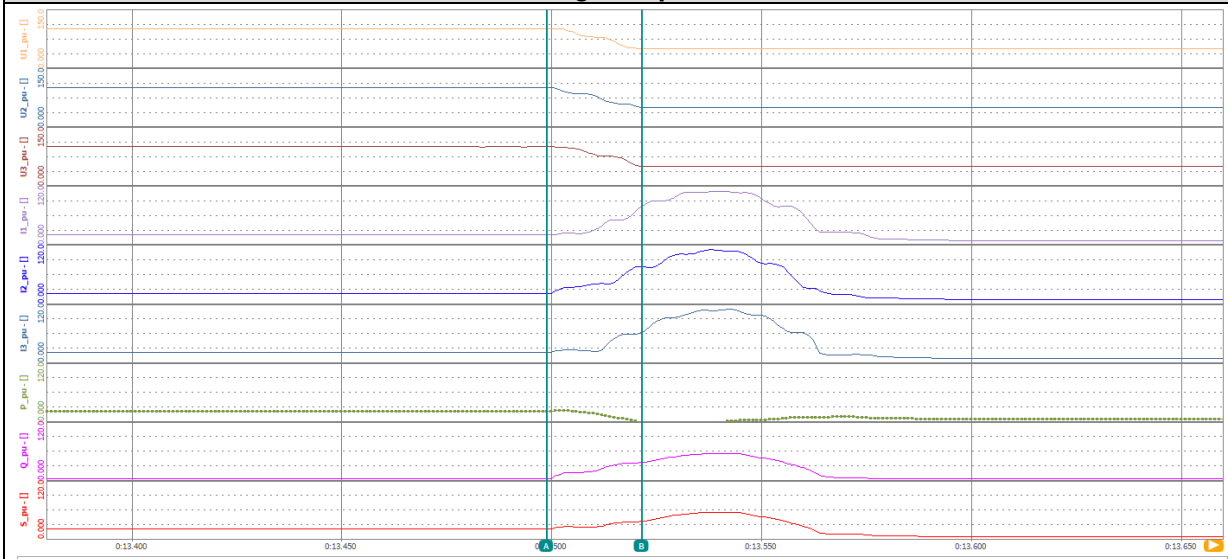


	A	B	间隔
时间 [s]	0:16.0342833	0:16.0545980	0.0203146
U1_pu []	100.0874	100.1412	0.053797
U2_pu []	100.2849	100.3404	0.055569
U3_pu []	100.0664	100.1258	0.059443
I1_pu []	12.60992	18.89292	6.283006
I2_pu []	12.98997	18.52454	5.534566
I3_pu []	14.97606	18.72925	3.753187
P_pu []	10.15822	18.02449	7.866269
Q_pu []	8.959233	5.177414	-3.781820
S_pu []	13.54464	18.75334	5.208698

Three-Phase fault

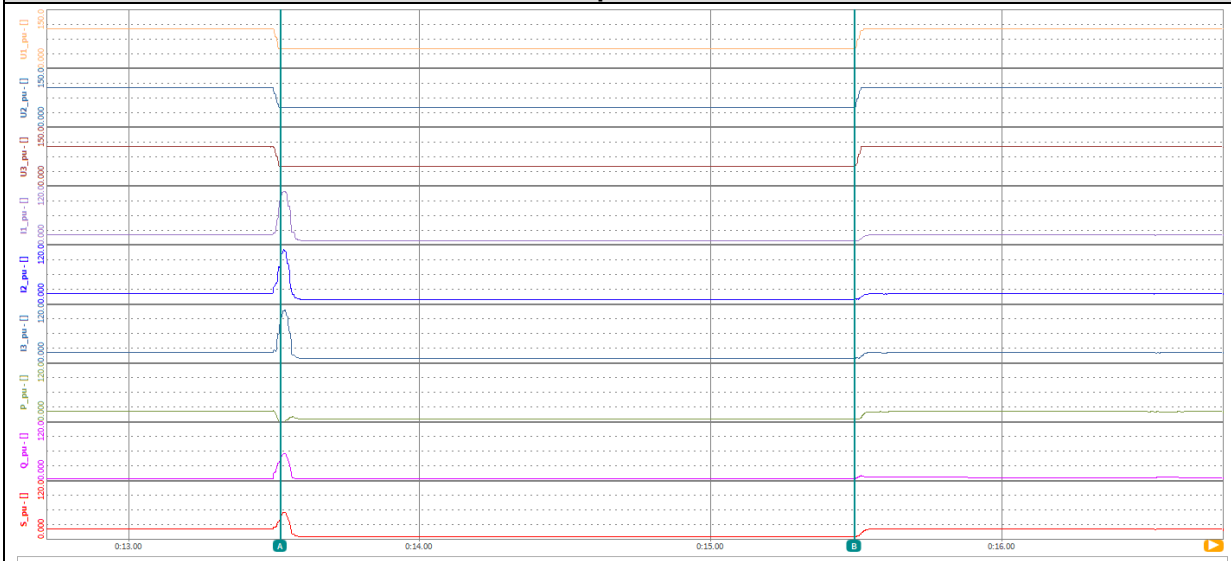
20%Pn Load	Residual voltage: 50%Un

Voltage Drop time



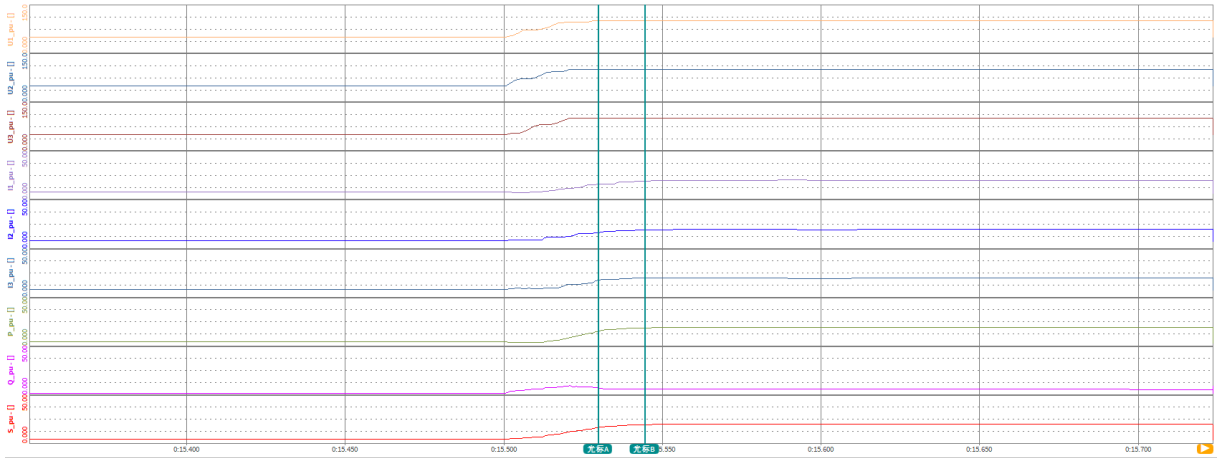
	A	B	Delta
Time [s]	0:13.49883	0:13.52146	0.02264
U1_pu []	100.0057	49.94932	-50.05638
U2_pu []	99.80402	49.70608	-50.09793
U3_pu []	100.2284	49.80947	-50.41888
I1_pu []	20.36474	75.86463	55.49989
I2_pu []	20.43433	75.83790	55.40357
I3_pu []	20.49719	58.71993	38.22274
P_pu []	20.28525	-1.133010	-21.41826
Q_pu []	2.467150	34.92763	32.46048
S_pu []	20.43473	34.94600	14.51127

DipTime



	A	B	Delta
Time [s]	0:13.52355	0:15.49400	1.97045
U1_pu []	49.85423	50.03115	0.176919
U2_pu []	49.74444	49.90990	0.165462
U3_pu []	49.83813	50.12633	0.288195
I1_pu []	85.98609	7.306896	-78.67919
I2_pu []	73.05698	7.444206	-65.61277
I3_pu []	70.51587	7.418881	-63.09699
P_pu []	-3.900231	3.531739	7.431970
Q_pu []	37.91770	1.091788	-36.82591
S_pu []	38.11776	3.696644	-34.42111

Power Recovery time

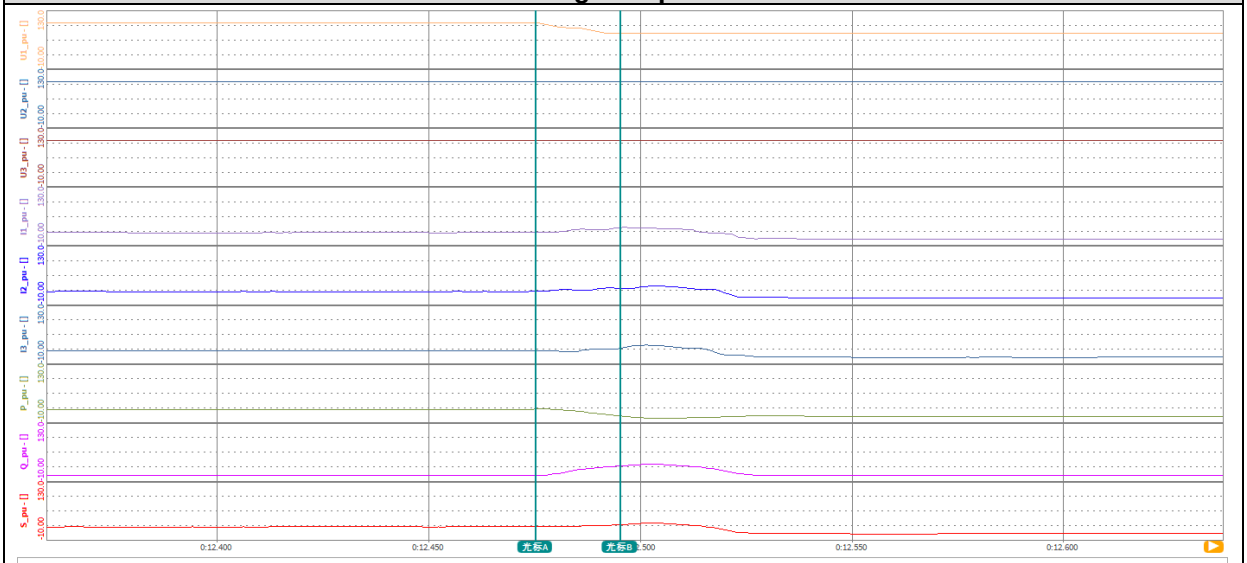


	A	B	间隔
时间 [s]	0:15.5297750	0:15.5444854	0.0147104
U1_pu []	100.5445	100.1140	-0.430484
U2_pu []	100.2515	100.2932	0.041776
U3_pu []	100.1164	100.0853	-0.031055
I1_pu []	15.00068	18.40081	3.400135
I2_pu []	15.46764	18.58543	3.117796
I3_pu []	16.12556	19.11244	2.986876
P_pu []	13.91723	18.02265	4.105420
Q_pu []	6.998345	5.099323	-1.899022
S_pu []	15.57774	18.73016	3.152419

Single-Phase fault

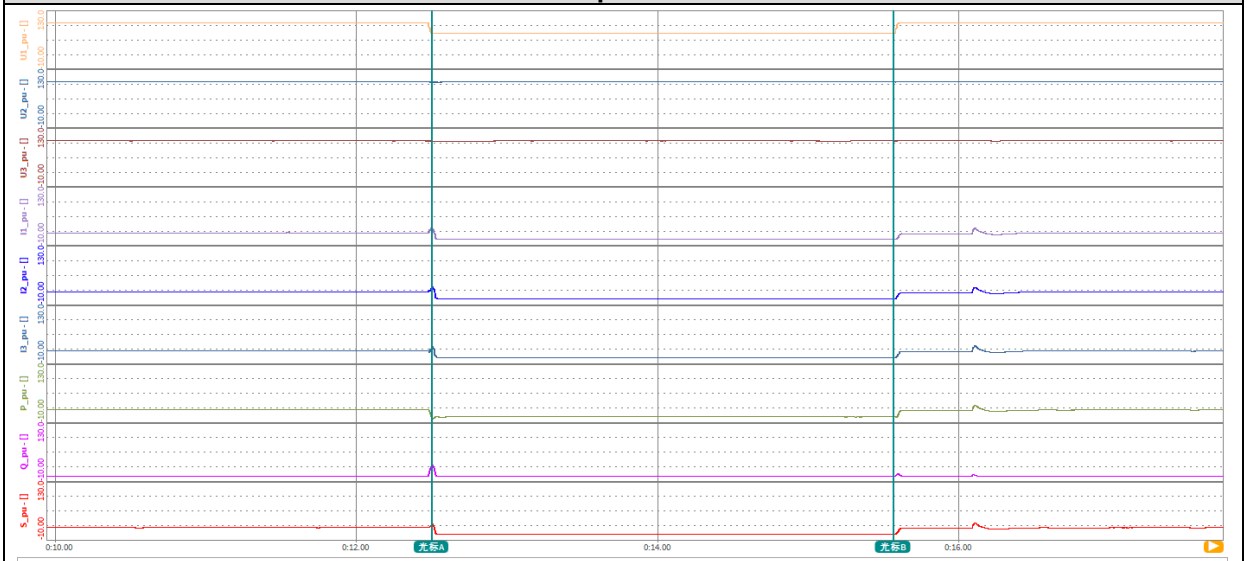
20%Pn Load	Residual voltage: 75%Un

Voltage Drop time



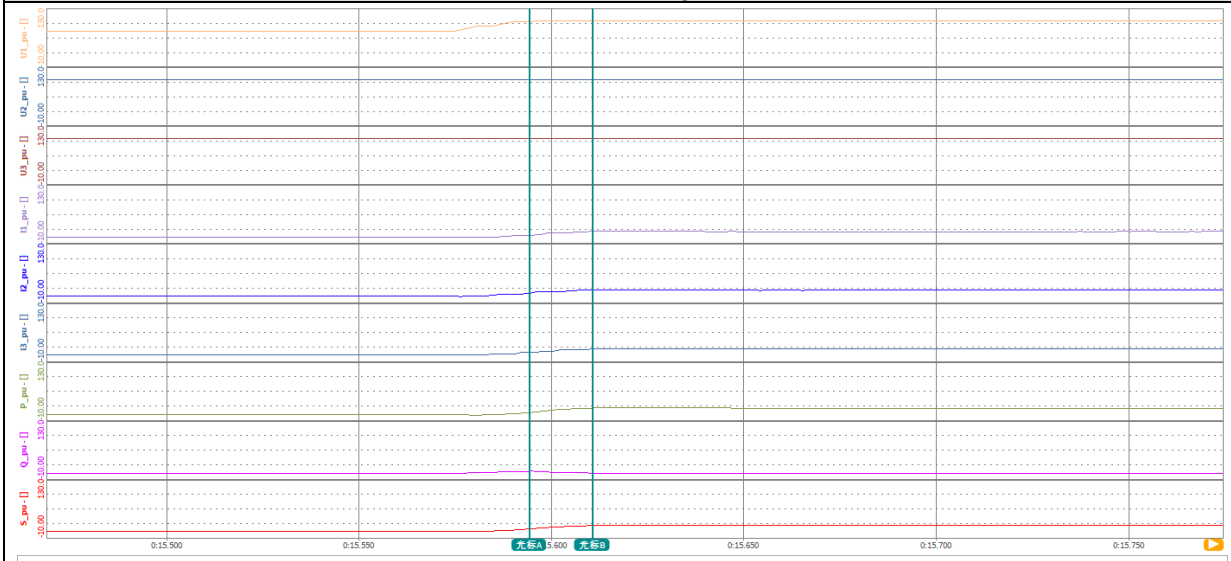
	A	B	间隔
时间 [s]	0:12.475250	0:12.495251	0.020002
U1_pu []	100.2922	75.55186	-24.74030
U2_pu []	100.0244	99.96276	-0.061599
U3_pu []	100.2783	100.0746	-0.203672
I1_pu []	20.48344	31.69641	11.21297
I2_pu []	20.40986	28.52766	8.117805
I3_pu []	20.11630	22.99488	2.878579
P_pu []	20.21505	4.813658	-15.40139
Q_pu []	2.562323	24.69397	22.13165
S_pu []	20.37679	25.15876	4.781969

DipTime



	A	B	间隔
时间 [s]	0:12.502824	0:15.565032	3.062208
U1_pu []	75.32123	75.23602	-0.085210
U2_pu []	99.97988	99.98673	6.853e-3
U3_pu []	100.0847	100.2809	0.196255
I1_pu []	31.58159	4.802683	-26.77891
I2_pu []	32.90144	4.198912	-28.70253
I3_pu []	32.75449	3.744229	-29.01026
P_pu []	-1.159478	3.101039	4.260517
Q_pu []	29.79902	2.290919	-27.50810
S_pu []	29.82156	3.855483	-25.96608

Power Recovery time

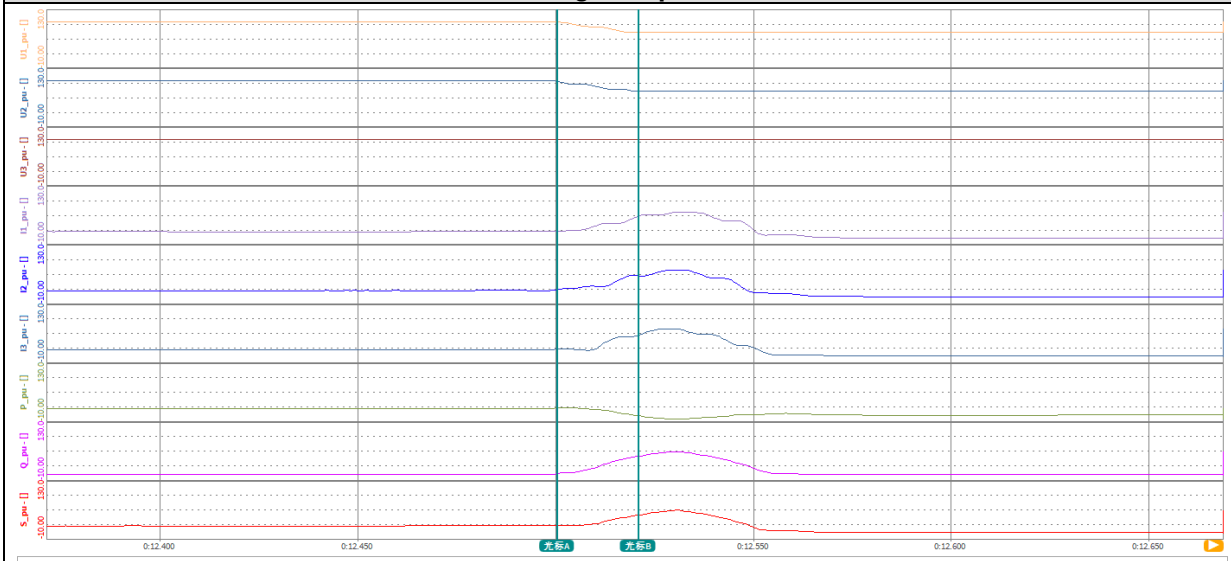


	A	B	间隔
时间 [s]	0:15.594323	0:15.610708	0.016386
U1_pu []	99.51169	100.0277	0.516039
U2_pu []	100.2514	100.3407	0.089330
U3_pu []	100.3721	100.4379	0.065832
I1_pu []	9.224997	18.50255	9.277558
I2_pu []	10.14303	18.38223	8.239205
I3_pu []	11.05648	18.33202	7.275547
P_pu []	6.648570	18.14308	11.49451
Q_pu []	7.667632	3.378450	-4.289182
S_pu []	10.14870	18.45495	8.306254

Two-Phase fault

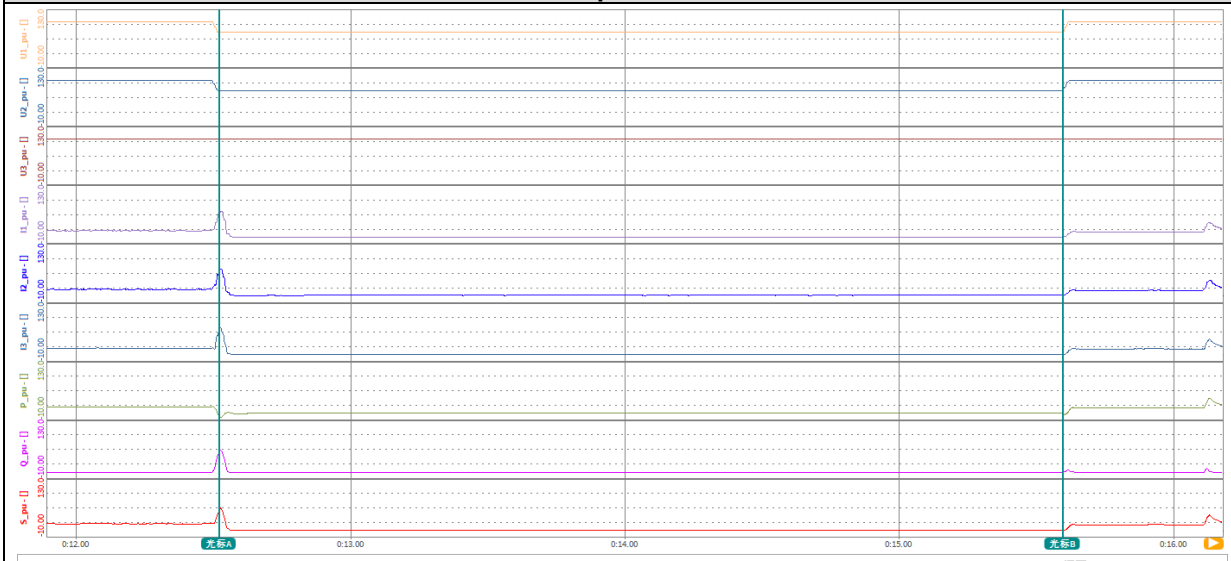
20%Pn Load | Residual voltage: 75%Un

Voltage Drop time



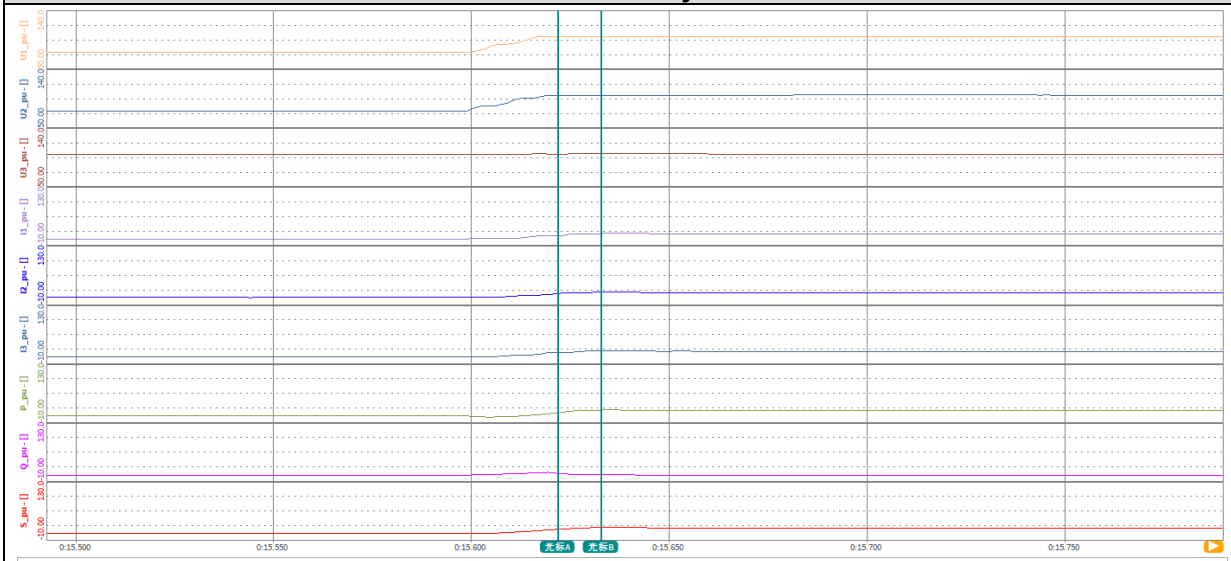
	A	B	间隔
时间 [s]	0:12.500465	0:12.520938	0.020473
U1_pu []	100.1312	75.82328	-24.30794
U2_pu []	100.2302	75.48526	-24.74499
U3_pu []	100.2857	100.2242	-0.061493
I1_pu []	20.35256	55.62213	35.26956
I2_pu []	20.29998	56.38045	36.08047
I3_pu []	20.26738	51.67538	31.40800
P_pu []	20.24442	3.028262	-17.21616
Q_pu []	2.074386	45.40736	43.33297
S_pu []	20.35042	45.50822	25.15780

DipTime



	A	B	间隔
时间 [s]	0:12.521733	0:15.594682	3.072949
U1_pu []	75.73175	75.15234	-0.579416
U2_pu []	75.44867	75.20431	-0.244366
U3_pu []	100.2972	100.2444	-0.052802
I1_pu []	58.41342	5.324374	-53.08904
I2_pu []	55.51067	5.745746	-49.76493
I3_pu []	54.55755	4.374332	-50.18321
P_pu []	1.846955	3.847359	2.000404
Q_pu []	46.91008	1.772007	-45.13807
S_pu []	46.94642	4.235821	-42.71060

Power Recovery time

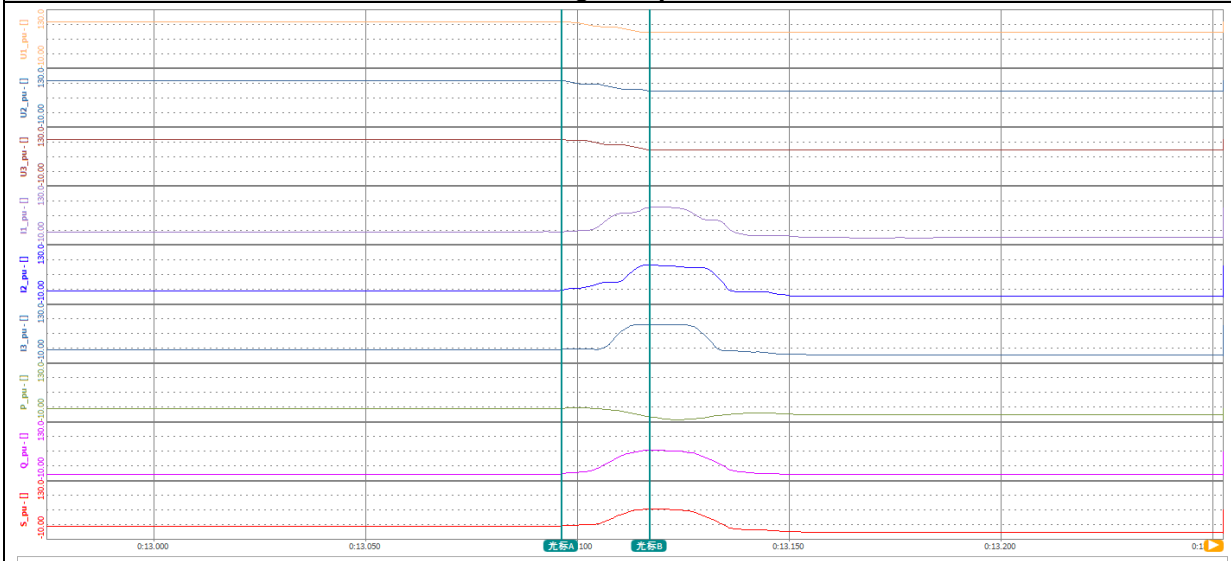


	A	B	间隔
时间 [s]	0:15.621920	0:15.632837	0.010916
U1_pu []	99.88975	100.1052	0.215434
U2_pu []	99.69069	99.91758	0.226885
U3_pu []	100.3595	100.4002	0.040695
I1_pu []	12.96776	18.14466	5.176904
I2_pu []	14.69699	18.55176	3.854769
I3_pu []	15.17885	18.79676	3.617912
P_pu []	11.58208	18.12518	6.543100
Q_pu []	8.352165	3.823464	-4.528701
S_pu []	14.27947	18.52407	4.244598

Three-Phase fault

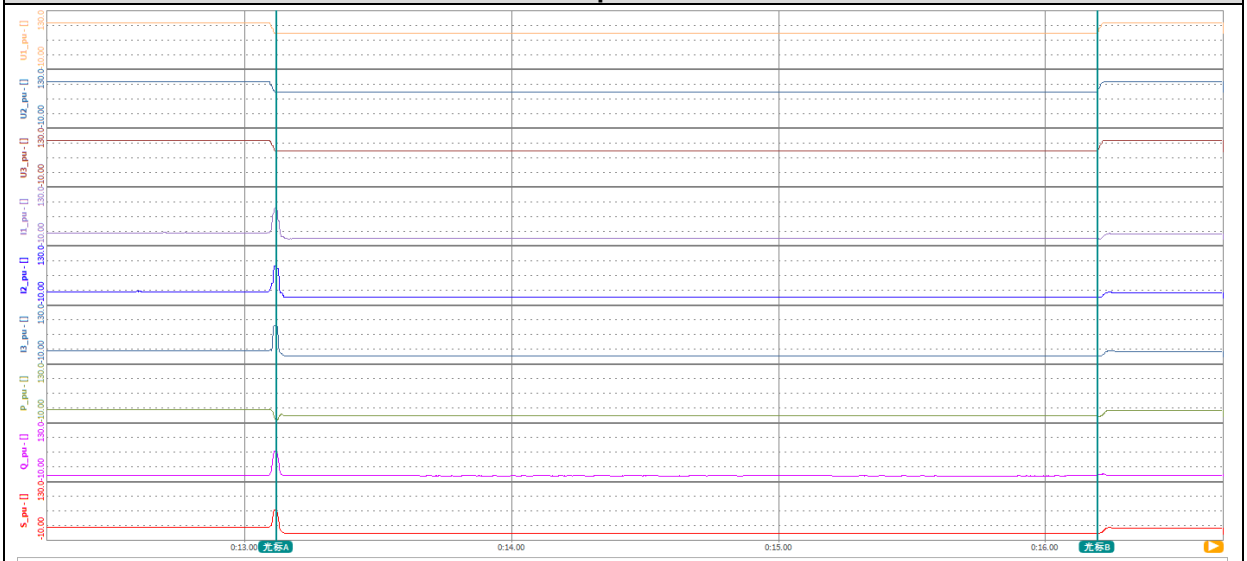
20%Pn Load	Residual voltage: 75%Un

Voltage Drop time



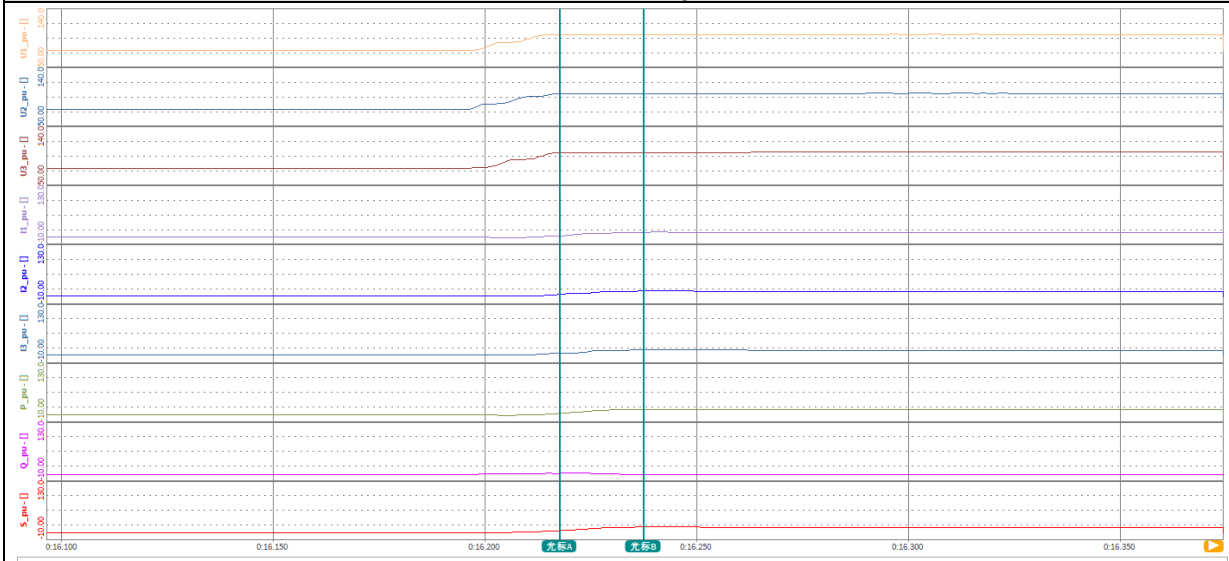
	A	B	间隔
时间 [s]	0:13.096279	0:13.117100	0.020821
U1_pu []	100.1400	75.79963	-24.34038
U2_pu []	100.1780	75.56618	-24.61183
U3_pu []	100.3148	75.60112	-24.71365
I1_pu []	20.26805	78.71773	58.44968
I2_pu []	20.22460	82.56919	62.34460
I3_pu []	20.08405	79.63216	59.54811
P_pu []	20.10911	1.120391	-18.98871
Q_pu []	2.251553	60.74465	58.49309
S_pu []	20.23476	60.75498	40.52022

DipTime



	A	B	间隔
时间 [s]	0:13.119370	0:16.193233	3.073863
U1_pu []	75.72073	75.23408	-0.486649
U2_pu []	75.48947	75.25232	-0.237148
U3_pu []	75.62904	75.22103	-0.408013
I1_pu []	79.65682	6.269375	-73.38744
I2_pu []	81.15451	6.251324	-74.90318
I3_pu []	79.65565	6.194770	-73.46088
P_pu []	-2.289758	4.438343	6.728101
Q_pu []	60.56428	1.526699	-59.03758
S_pu []	60.60755	4.693581	-55.91397

Power Recovery time



	A	B	间隔
时间 [s]	0:16.217641	0:16.237417	0.019775
U1_pu []	99.76700	100.1276	0.360572
U2_pu []	99.48901	99.89868	0.409665
U3_pu []	99.70207	100.0950	0.392934
I1_pu []	8.415576	18.07495	9.659373
I2_pu []	8.581216	18.29620	9.714988
I3_pu []	10.50116	18.54101	8.039850
P_pu []	7.380708	18.03091	10.65020
Q_pu []	5.381677	3.192923	-2.188754
S_pu []	9.134401	18.31143	9.177030

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

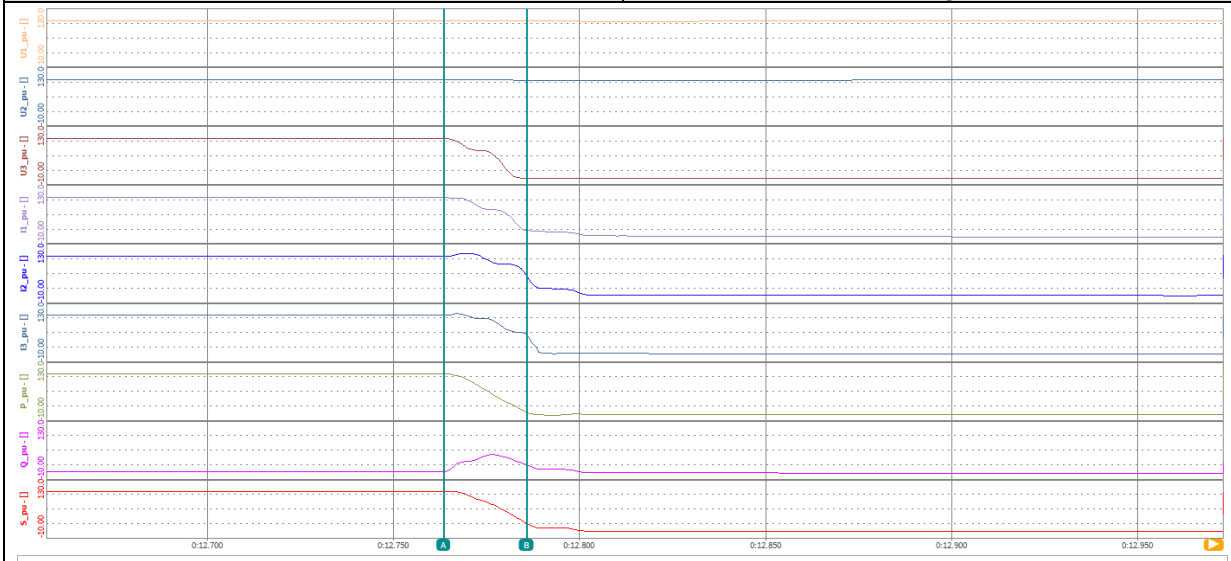
Test results of different no-load cases performed are offered below:

100%Pn Load							
Phase Type	**Residual Voltage Desired (%Un)**	**Voltage Measured (%Un)**	**Voltage Drop Time (ms)**	**Dip Time Desired (ms)**	**Time Measured (ms)**	**Power Recovery Time (ms)**	**Voltage After Recovery (%Un)**
1 ph	0-5%	4.7	22	≥400	425	61	100.4
2 ph		4.7	22		425	62	100.4
3 ph		4.5	20		428	120	100.4
1 ph	25%	25.8	20	≥1000	1023	62	100.3
2 ph		25.9	22		1026	62	100.3
3 ph		25.6	21		1025	60	100.3
1 ph	50%	50.9	21	≥1850	1871	58	100.2
2 ph		50.7	21		1863	58	100.3
3 ph		50.8	21		1868	59	100.3
1 ph	75%	75.4	20	≥3000	3081	61	100.3
2 ph		75.7	20		3074	49	100.4
3 ph		75.4	20		3073	57	100.3

Remark: The virtual neutral line was used in the test.

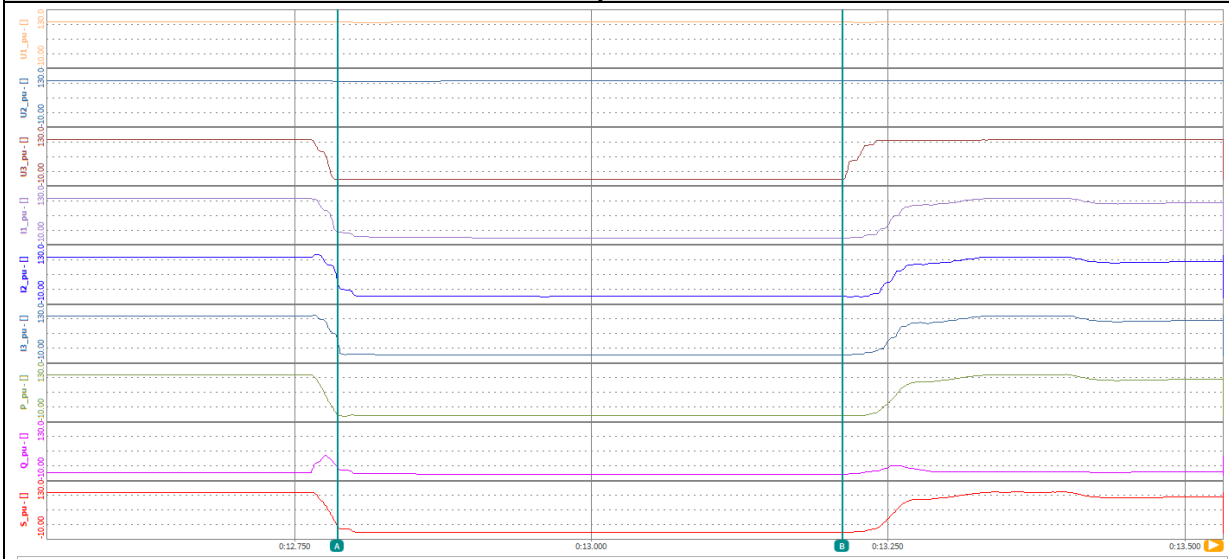
Test results are graphically represented at following pages.
Note: The following test figure the voltage unit of U1_pu, U2_pu and U3_pu are **%Un** , the current unit of I1_pu, I2_pu and I3_pu are **%In** and the power unit is **%Pn**

Single-Phase fault	
Voltage Drop time	
100%Pn Load	Residual voltage: 0~5%Un



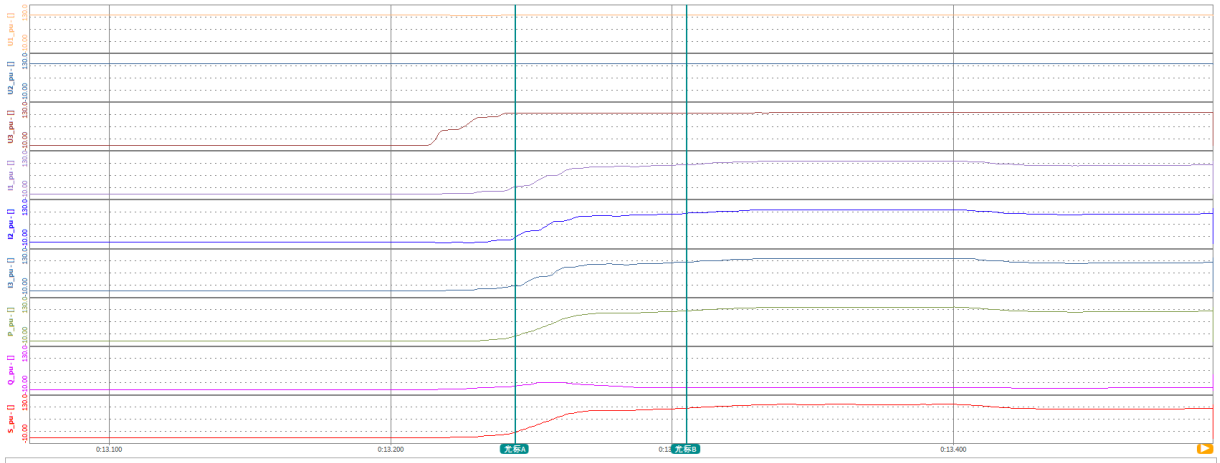
	A	B	Delta
Time [s]	0:12.763668	0:12.785913	0.022245
U1_pu []	100.4943	99.76939	-0.724919
U2_pu []	100.3760	99.43871	-0.937288
U3_pu []	100.4071	4.702800	-95.70434
I1_pu []	99.99559	21.48073	-78.51486
I2_pu []	99.84930	61.10470	-38.74460
I3_pu []	99.88751	57.09119	-42.79632
P_pu []	100.0817	11.38502	-88.69665
Q_pu []	7.143307	25.90082	18.75752
S_pu []	100.3363	28.29260	-72.04366

DipTime



	A	B	Delta
Time [s]	0:12.786112	0:13.211301	0.425189
U1_pu []	99.76939	100.1928	0.423378
U2_pu []	99.43871	100.0844	0.645699
U3_pu []	4.702800	4.795125	0.092325
I1_pu []	21.48073	5.177014	-16.30372
I2_pu []	61.10470	5.799609	-55.30509
I3_pu []	57.09119	6.450641	-50.64055
P_pu []	11.38502	2.526092	-8.858925
Q_pu []	25.90082	2.794401	-23.10642
S_pu []	28.29260	3.766938	-24.52566

Power Recovery Time

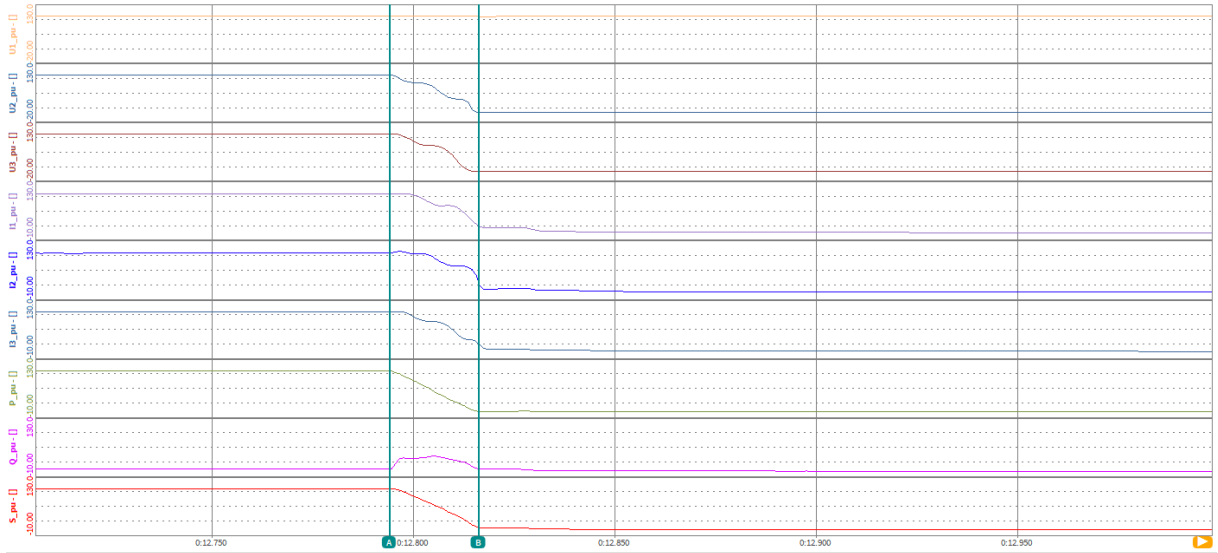


时间 [s]	A 0:13.2441460	B 0:13.3049928	间隔 0.0608467
U1_pu []	100.5243	101.0706	0.546304
U2_pu []	100.2528	100.8882	0.635442
U3_pu []	98.98806	99.51197	0.523914
I1_pu []	22.58183	90.82293	68.24111
I2_pu []	15.68753	90.09885	74.41133
I3_pu []	20.38968	89.54941	69.15973
P_pu []	14.78960	90.16150	75.37190
Q_pu []	12.76554	8.926052	-3.839483
S_pu []	19.53692	90.60227	71.06535

Two-Phase fault

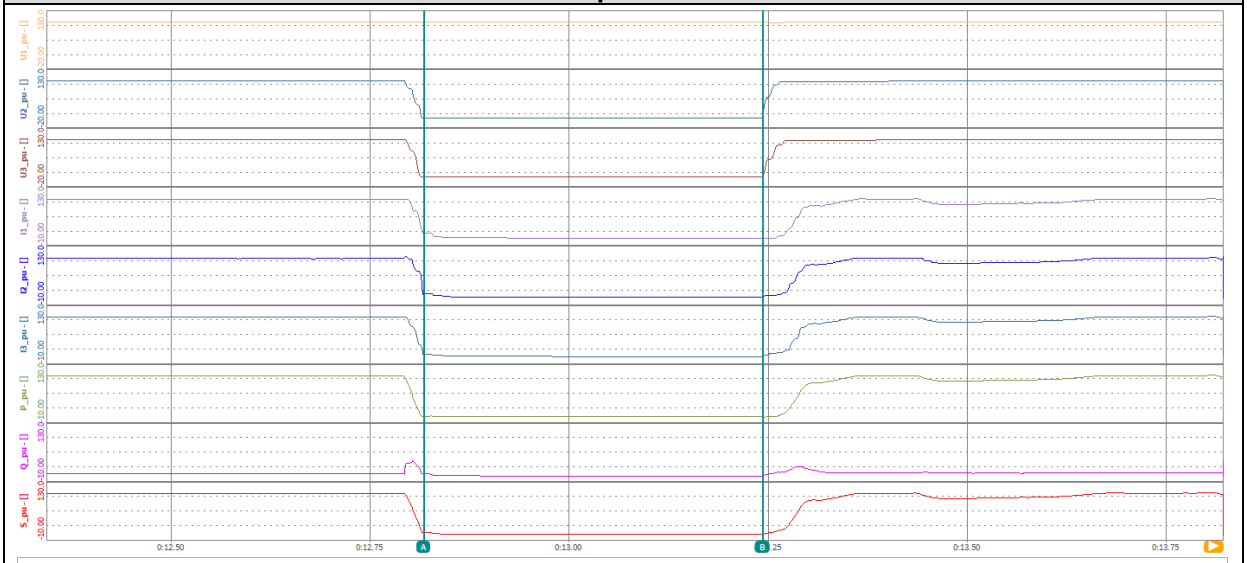
100%Pn Load	Residual voltage: 0~5%Un

Voltage Drop time



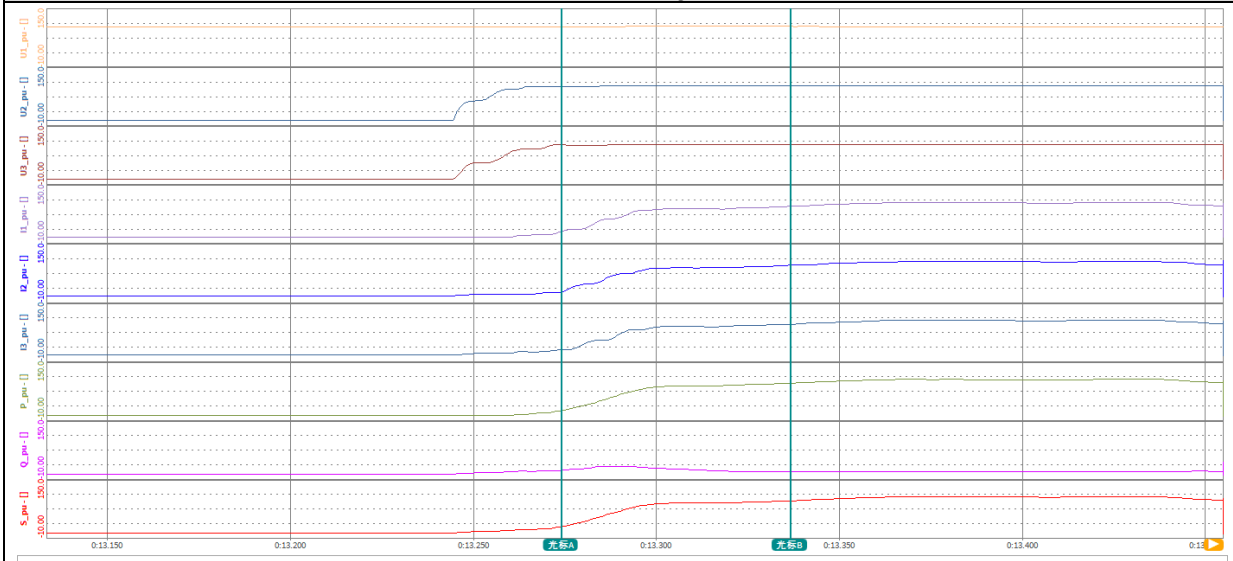
Time [s]	A 0:12.794057	B 0:12.816197	Delta 0.022140
U1_pu []	100.5142	99.77793	-0.736316
U2_pu []	100.3581	4.327835	-96.03024
U3_pu []	100.3961	4.671994	-95.72414
I1_pu []	99.87828	26.75649	-73.12179
I2_pu []	99.81065	45.40623	-54.40442
I3_pu []	99.89813	30.12623	-69.77189
P_pu []	100.0300	3.857603	-96.17240
Q_pu []	7.141463	9.251159	2.109696
S_pu []	100.2846	10.02323	-90.26138

DipTime



	A	B	Delta
Time [s]	0:12.817835	0:13.243098	0.425263
U1_pu []	99.77490	100.1965	0.421561
U2_pu []	4.355142	4.668451	0.313309
U3_pu []	4.655915	4.724046	0.068131
I1_pu []	20.15829	6.912311	-13.24598
I2_pu []	13.94574	6.296434	-7.649301
I3_pu []	12.02642	5.626840	-6.399579
P_pu []	2.463308	2.091014	-0.372294
Q_pu []	6.651953	1.361531	-5.290421
S_pu []	7.093402	2.495217	-4.598185

Power Recovery Time

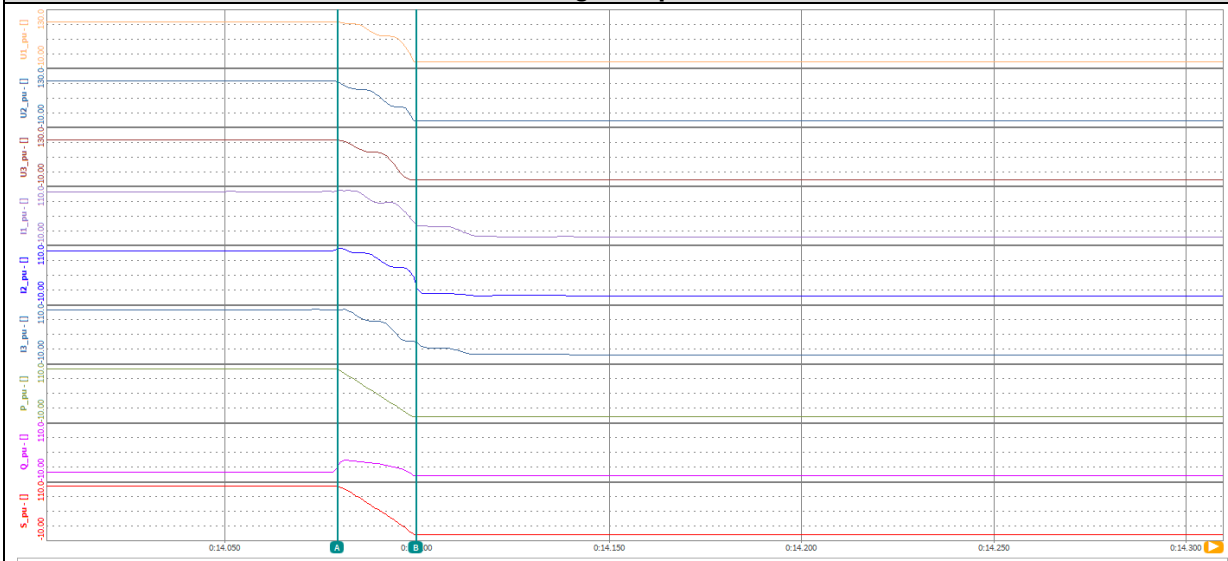


	A	B	间隔
时间 [s]	0:13.2739668	0:13.3365243	0.0625576
U1_pu []	100.4766	101.0515	0.574865
U2_pu []	98.08638	99.31469	1.228306
U3_pu []	99.17494	99.44645	0.271514
I1_pu []	20.49362	91.45504	70.96142
I2_pu []	16.76405	90.74278	73.97873
I3_pu []	21.20961	90.09739	68.88778
P_pu []	14.85681	90.24330	75.38649
Q_pu []	12.40746	9.210387	-3.197074
S_pu []	19.35639	90.71209	71.35570

Three-Phase fault

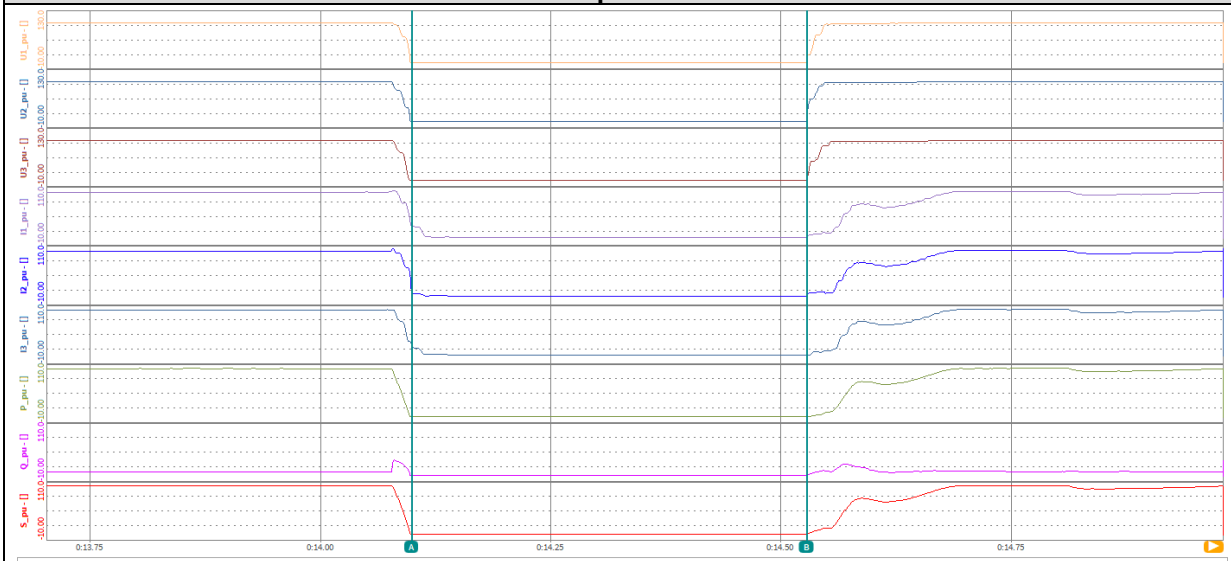
100%Pn Load	Residual voltage: 0~5%Un

Voltage Drop time



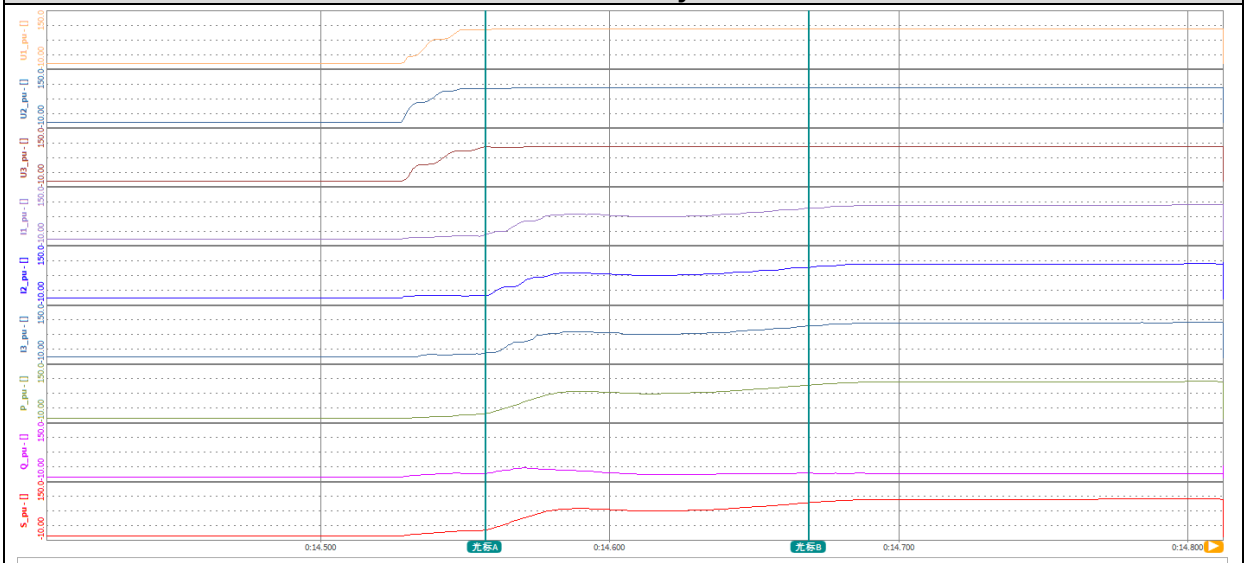
	A	B	Delta
Time [s]	0:14.0794257	0:14.0998624	0.0204367
U1_pu []	100.7822	4.287131	-96.49511
U2_pu []	100.5233	4.227121	-96.29616
U3_pu []	100.0559	4.617942	-95.43794
I1_pu []	100.1306	36.20690	-63.92365
I2_pu []	99.95315	45.33896	-54.61419
I3_pu []	99.57845	34.17415	-65.40430
P_pu []	100.0873	0.583480	-99.50381
Q_pu []	7.136132	1.577877	-5.558254
S_pu []	100.3414	1.682304	-98.65906

DipTime



	A	B	Delta
Time [s]	0:14.0995483	0:14.5282709	0.4287226
U1_pu []	4.287131	4.523085	0.235954
U2_pu []	4.227121	4.473060	0.245939
U3_pu []	4.617942	4.421643	-0.196299
I1_pu []	36.20690	6.305873	-29.90103
I2_pu []	45.33896	6.414433	-38.92452
I3_pu []	34.17415	6.202058	-27.97209
P_pu []	0.583480	0.260244	-0.323236
Q_pu []	1.577877	0.108938	-1.468940
S_pu []	1.682304	0.282125	-1.400179

Power Recovery Time

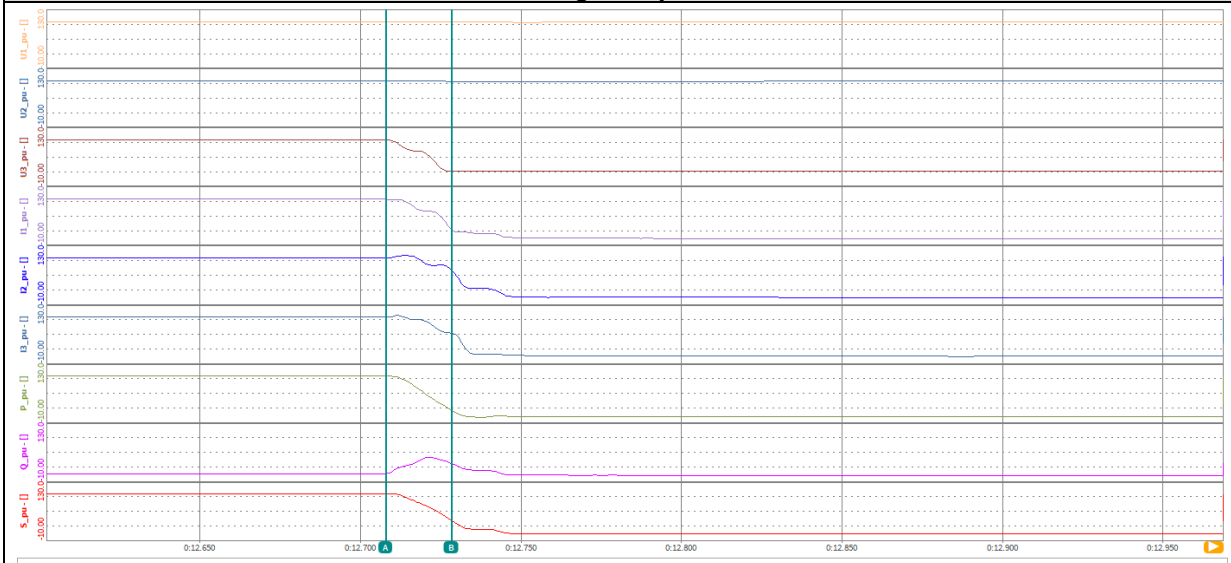


	A	B	间隔
时间 [s]	0:14.5569165	0:14.6689077	0.1119912
U1_pu []	98.01573	100.0194	2.003651
U2_pu []	98.06487	99.83692	1.772050
U3_pu []	98.44515	99.73754	1.292393
I1_pu []	16.12659	92.02142	75.89484
I2_pu []	13.89237	90.43287	76.54051
I3_pu []	16.34662	91.60662	75.26000
P_pu []	12.23240	90.58243	78.35003
Q_pu []	8.979118	10.85296	1.873838
S_pu []	15.17419	91.23027	76.05608

Single-Phase fault

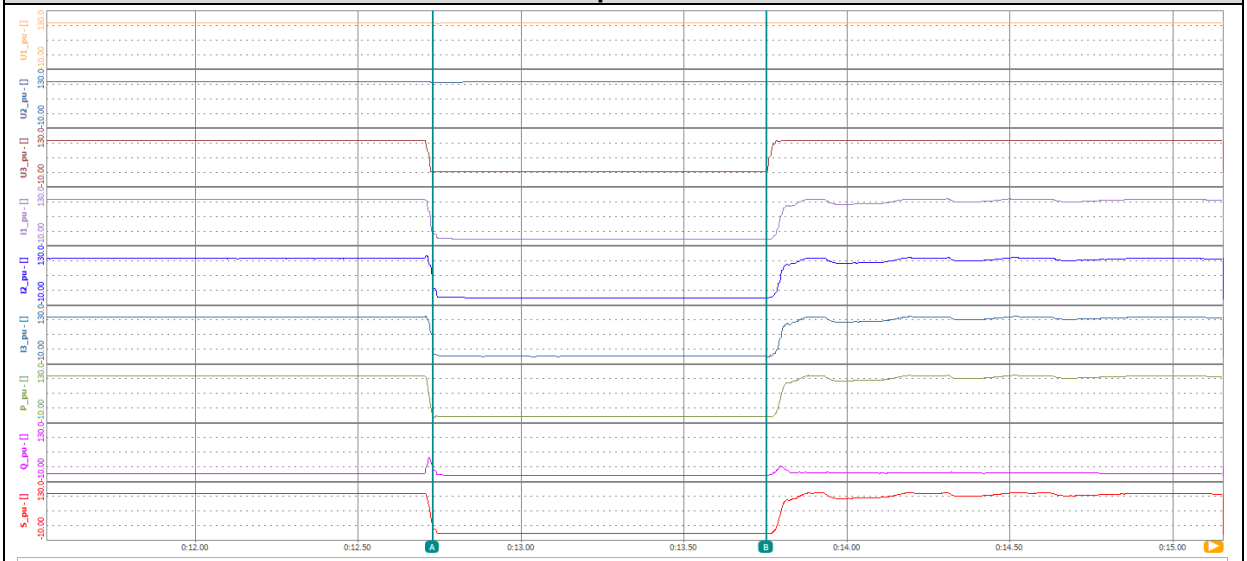
100%Pn Load	Residual voltage: 25%Un

Voltage Drop time



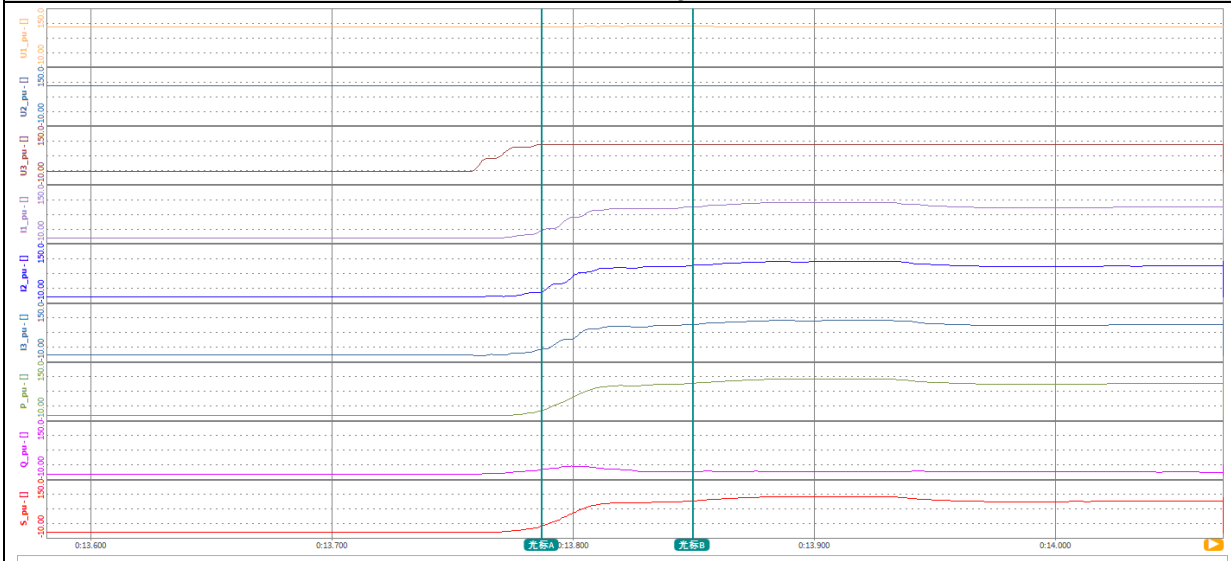
	A	B	Delta
Time [s]	0:12.708050	0:12.728491	0.020441
U1_pu []	100.5085	99.89205	-0.616435
U2_pu []	100.3541	99.60205	-0.752019
U3_pu []	100.4062	25.78857	-74.61766
I1_pu []	99.88904	33.97378	-65.91526
I2_pu []	99.81897	76.98333	-22.83565
I3_pu []	99.88844	62.43540	-37.45304
P_pu []	100.0320	22.78407	-77.24790
Q_pu []	7.159494	35.56642	28.40693
S_pu []	100.2879	42.23842	-58.04944

DipTime



	A	B	Delta
Time [s]	0:12.729681	0:13.752696	1.023015
U1_pu []	99.87973	100.2690	0.389278
U2_pu []	99.51510	100.1487	0.633625
U3_pu []	25.63558	24.85551	-0.780071
I1_pu []	25.89204	4.550334	-21.34171
I2_pu []	70.17947	4.971087	-65.20839
I3_pu []	62.02478	5.740423	-56.28436
P_pu []	18.09035	2.577957	-15.51239
Q_pu []	32.50525	2.592325	-29.91293
S_pu []	37.20016	3.655956	-33.54420

Power Recovery Time

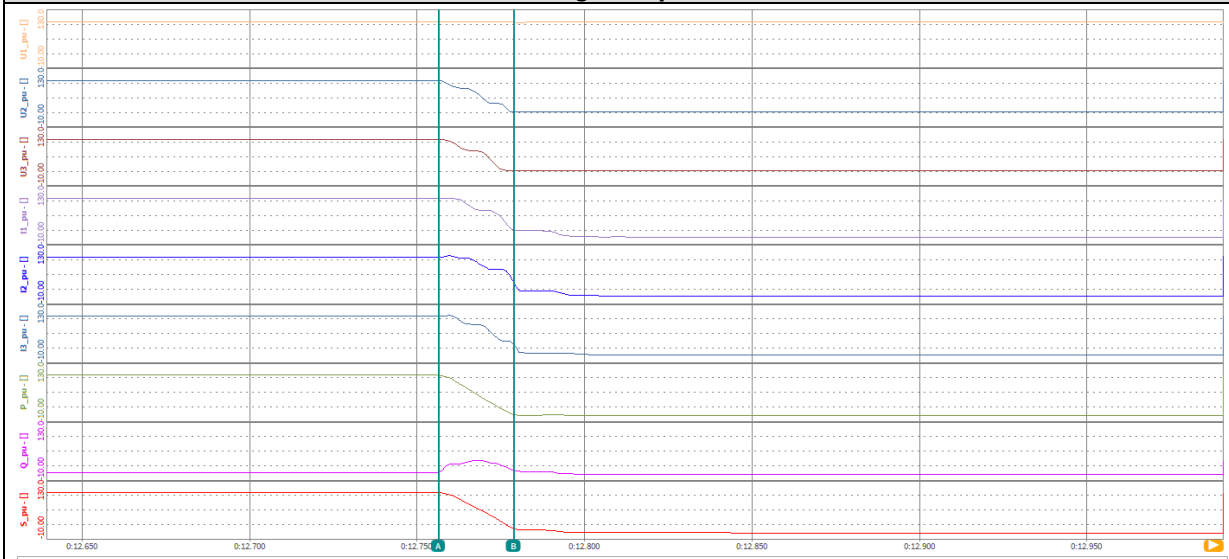


	A	B	间隔
时间 [s]	0:13.7871413	0:13.8496094	0.0624681
U1_pu []	100.5056	101.0622	0.556607
U2_pu []	100.2810	100.9247	0.643768
U3_pu []	100.1119	100.4041	0.292239
I1_pu []	22.43291	90.49123	68.05833
I2_pu []	17.18093	89.96442	72.78349
I3_pu []	22.09729	89.36292	67.26563
P_pu []	14.86124	90.18734	75.32610
Q_pu []	14.31238	9.222078	-5.090300
S_pu []	20.63251	90.65761	70.02510

Two-Phase fault

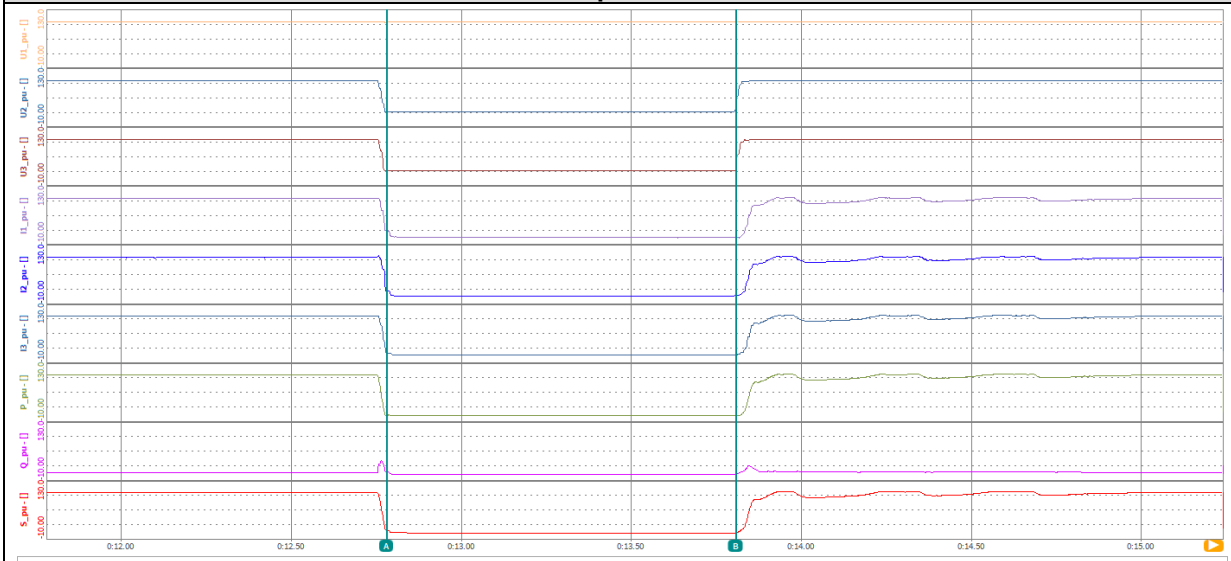
100%Pn Load | Residual voltage: 25%Un

Voltage Drop time



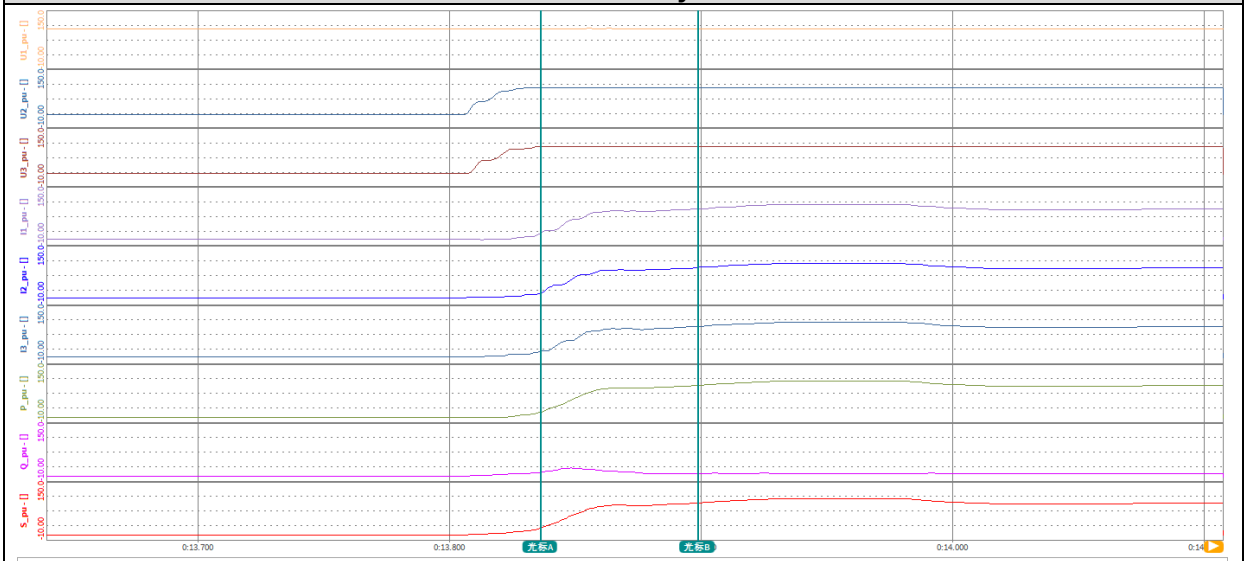
	A	B	Delta
Time [s]	0:12.756530	0:12.778966	0.022436
U1_pu []	100.3911	99.74523	-0.645871
U2_pu []	100.3740	25.87620	-74.49777
U3_pu []	100.5272	25.84032	-74.68690
I1_pu []	99.75567	30.47652	-69.27915
I2_pu []	99.80562	57.48654	-42.31908
I3_pu []	100.0302	39.15890	-60.87125
P_pu []	100.0386	8.028266	-92.01034
Q_pu []	7.153869	16.62764	9.473774
S_pu []	100.2941	18.46433	-81.82975

DipTime



	A	B	Delta
Time [s]	0:12.781755	0:13.807951	1.026196
U1_pu []	99.58948	100.2751	0.685591
U2_pu []	25.70759	25.03218	-0.675414
U3_pu []	25.79668	25.02146	-0.775221
I1_pu []	22.81667	5.719034	-17.09763
I2_pu []	19.91195	6.623875	-13.28808
I3_pu []	13.76386	6.181658	-7.582197
P_pu []	3.121419	2.483982	-0.637437
Q_pu []	9.987770	1.646040	-8.341729
S_pu []	10.46417	2.979869	-7.484298

Power Recovery Time

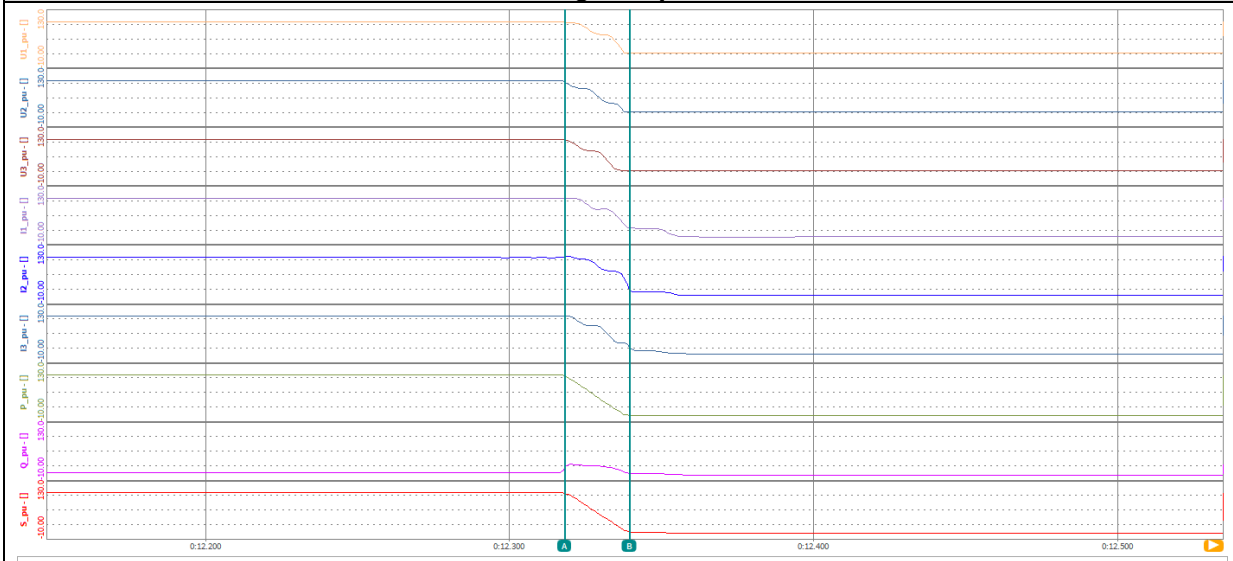


	A	B	间隔
时间 [s]	0:13.8362819	0:13.8987287	0.0624468
U1_pu []	100.3396	100.9827	0.643078
U2_pu []	99.05834	100.1024	1.044013
U3_pu []	100.2880	100.2264	-0.061612
I1_pu []	20.56729	90.50187	69.93457
I2_pu []	17.56008	89.60321	72.04313
I3_pu []	21.52618	89.35139	67.82521
P_pu []	15.32233	89.74256	74.42023
Q_pu []	12.65606	9.203636	-3.452426
S_pu []	19.87334	90.21327	70.33992

Three-Phase fault

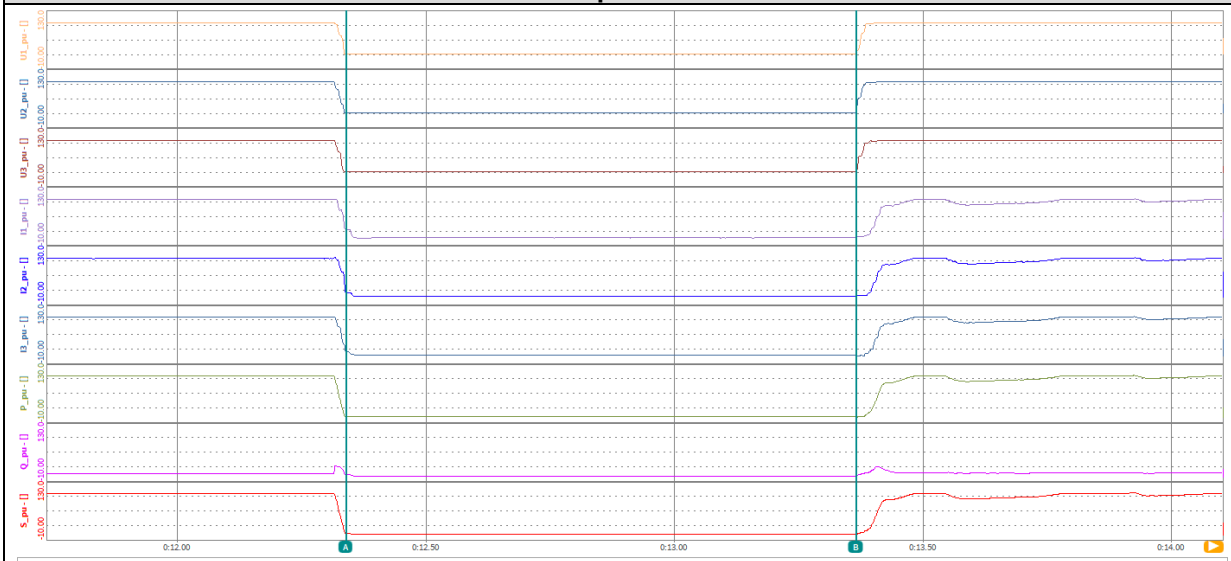
100%Pn Load	Residual voltage: 25%Un

Voltage Drop time



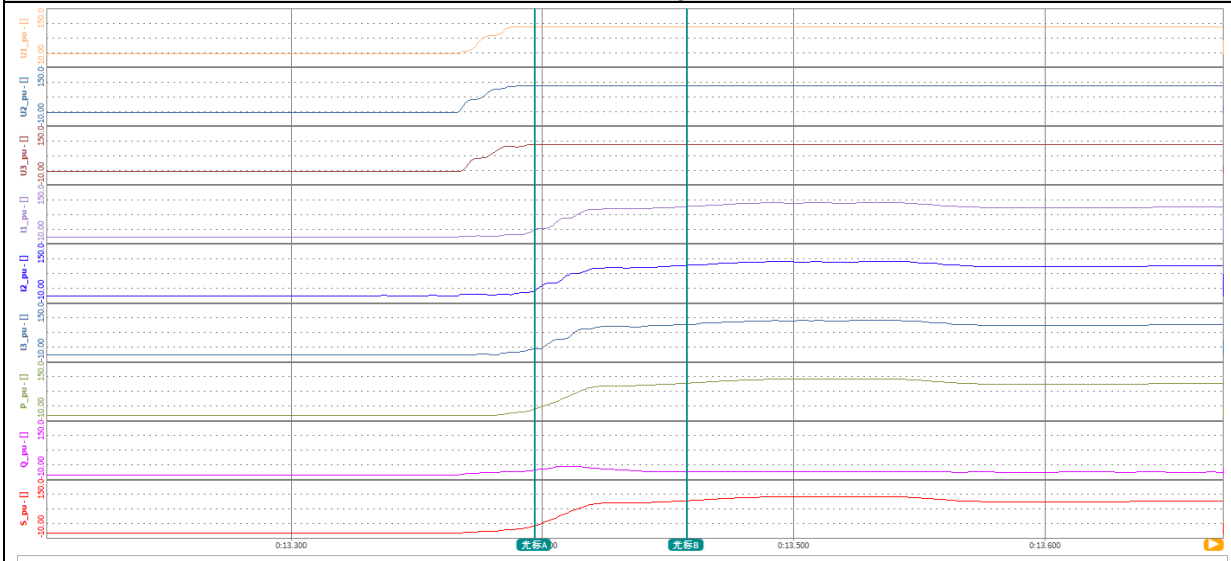
	A	B	Delta
Time [s]	0:12.3182521	0:12.3395576	0.0213055
U1_pu []	100.4014	25.71347	-74.68797
U2_pu []	99.24620	25.54796	-73.69824
U3_pu []	100.2108	25.78836	-74.42241
I1_pu []	100.8240	30.06270	-70.76128
I2_pu []	101.2623	35.84676	-65.41551
I3_pu []	99.75596	33.76156	-65.99440
P_pu []	99.76532	3.838397	-95.92692
Q_pu []	12.65412	7.619389	-5.034730
S_pu []	100.5646	8.531611	-92.03302

DipTime



	A	B	Delta
Time [s]	0:12.3399965	0:13.3652517	1.0252552
U1_pu []	25.71347	25.30776	-0.405715
U2_pu []	25.54796	25.12510	-0.422861
U3_pu []	25.78836	25.22731	-0.561051
I1_pu []	30.06270	7.858228	-22.20447
I2_pu []	35.84676	7.872331	-27.97443
I3_pu []	33.76156	7.853195	-25.90836
P_pu []	3.838397	1.935728	-1.902670
Q_pu []	7.619389	0.428592	-7.190797
S_pu []	8.531611	1.982607	-6.549004

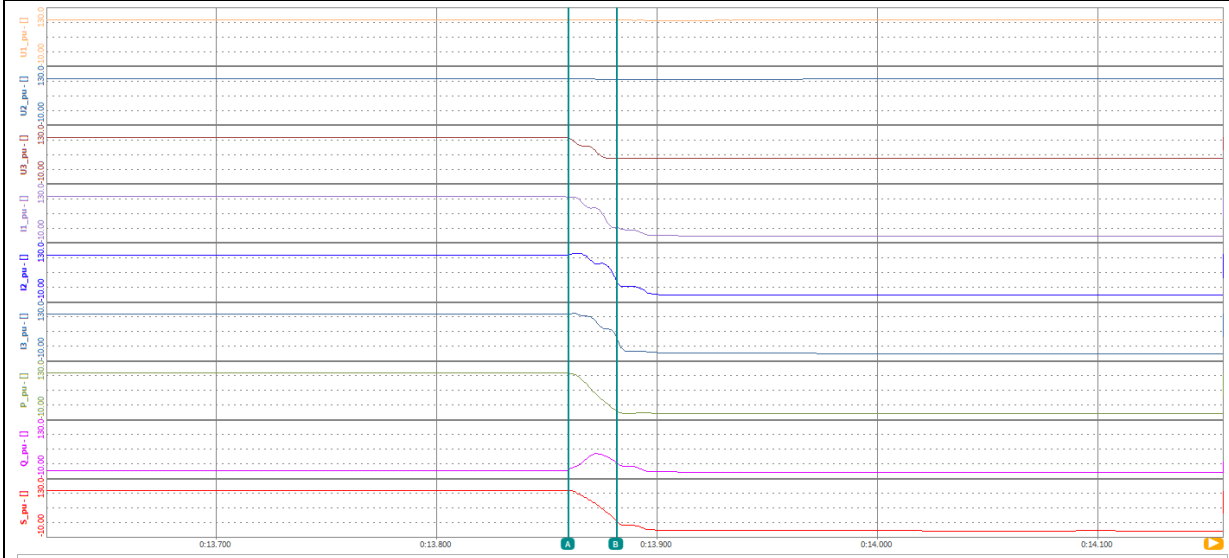
Power Recovery Time



	A	B	间隔
时间 [s]	0:13.3969559	0:13.4574486	0.0604927
U1_pu []	99.46105	100.5412	1.080150
U2_pu []	99.16519	100.3017	1.136514
U3_pu []	100.2501	100.5419	0.291801
I1_pu []	20.98097	90.80579	69.82482
I2_pu []	17.58246	89.95444	72.37198
I3_pu []	21.60788	90.14741	68.53954
P_pu []	15.94171	90.27564	74.33393
Q_pu []	12.05828	8.964745	-3.093530
S_pu []	19.98850	90.71966	70.73117

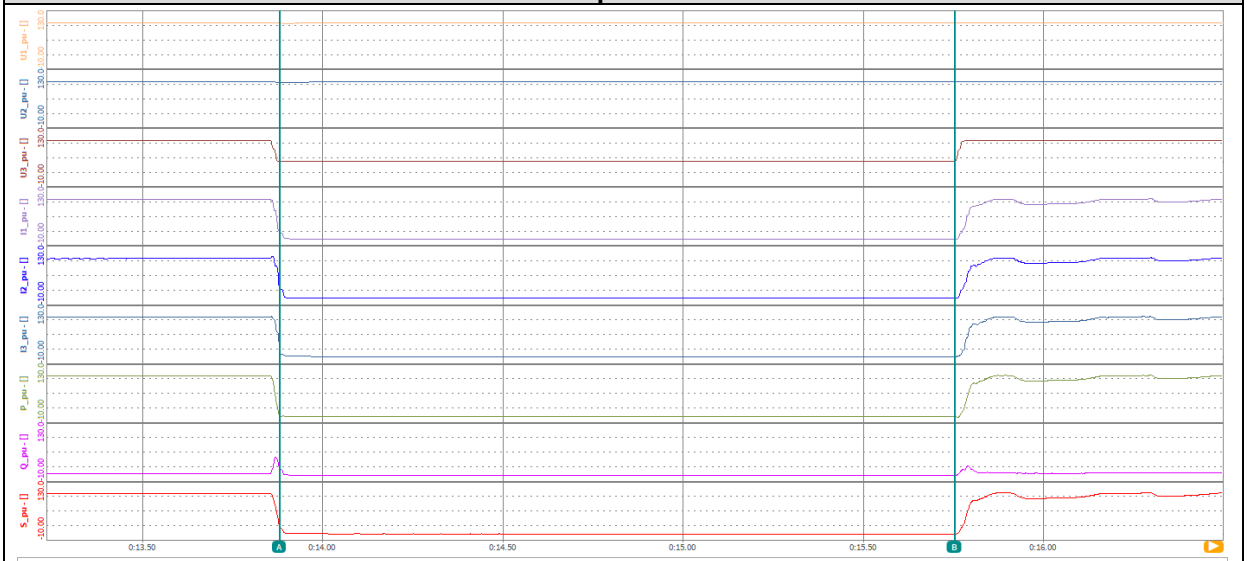
Single-Phase fault	
100%Pn Load	Residual voltage: 50%Un

Voltage Drop time



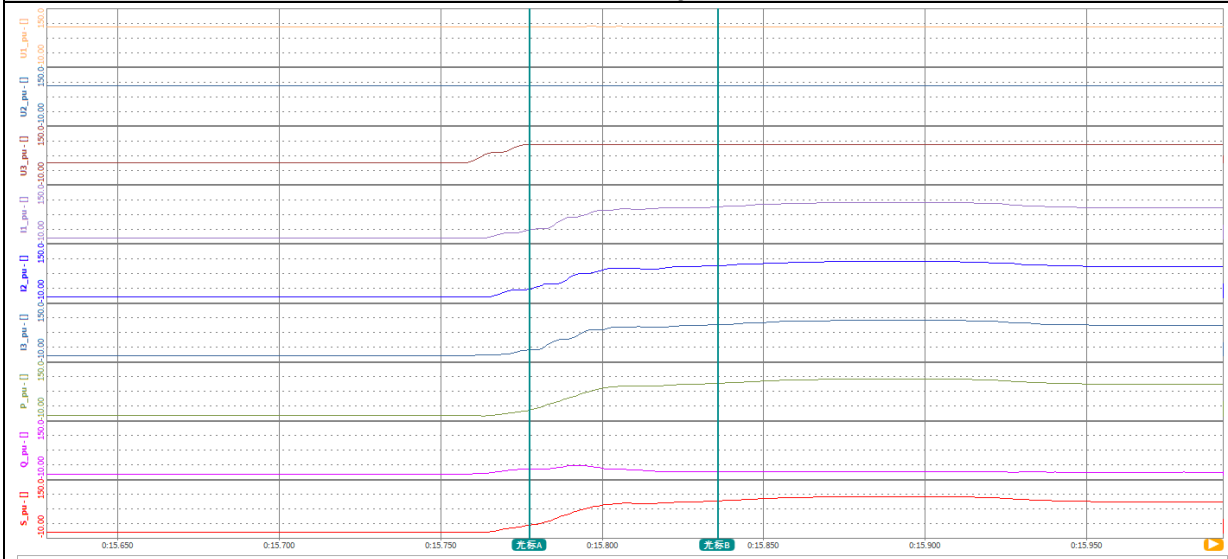
	A	B	Delta
Time [s]	0:13.8599886	0:13.8817808	0.0217921
U1_pu []	100.5193	99.68820	-0.831113
U2_pu []	100.2592	99.44306	-0.816153
U3_pu []	100.0108	50.87542	-49.13536
I1_pu []	99.67807	25.97936	-73.69870
I2_pu []	100.2324	45.42456	-54.80784
I3_pu []	100.1956	53.59933	-46.59624
P_pu []	100.0023	11.94597	-88.05630
Q_pu []	7.697655	30.52534	22.82768
S_pu []	100.2981	32.77961	-67.51849

DipTime



	A	B	Delta
Time [s]	0:13.8817764	0:15.7527072	1.8709308
U1_pu []	99.68820	100.2324	0.544168
U2_pu []	99.44306	100.1204	0.677371
U3_pu []	50.87542	50.17287	-0.702551
I1_pu []	25.97936	3.964811	-22.01455
I2_pu []	45.42456	4.171065	-41.25349
I3_pu []	53.59933	4.847337	-48.75199
P_pu []	11.94597	2.594227	-9.351747
Q_pu []	30.52534	2.390072	-28.13527
S_pu []	32.77961	3.527386	-29.25222

Power Recovery Time

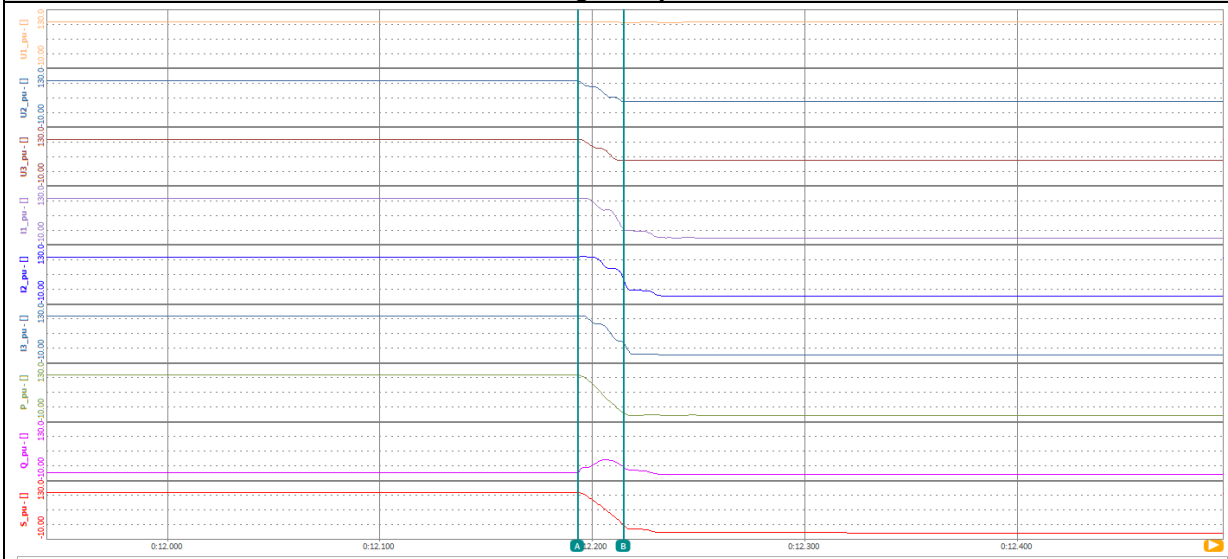


	A	B	间隔
时间 [s]	0:15.7776155	0:15.8357733	0.0581578
U1_pu []	100.4586	101.0081	0.549569
U2_pu []	100.3421	100.8787	0.536638
U3_pu []	99.45663	100.3408	0.884200
I1_pu []	25.23278	89.97684	64.74406
I2_pu []	24.91489	89.65244	64.73756
I3_pu []	20.62472	90.63494	70.01022
P_pu []	16.12867	90.34372	74.21505
Q_pu []	17.25659	8.640800	-8.615794
S_pu []	23.62042	90.75600	67.13558

Two-Phase fault

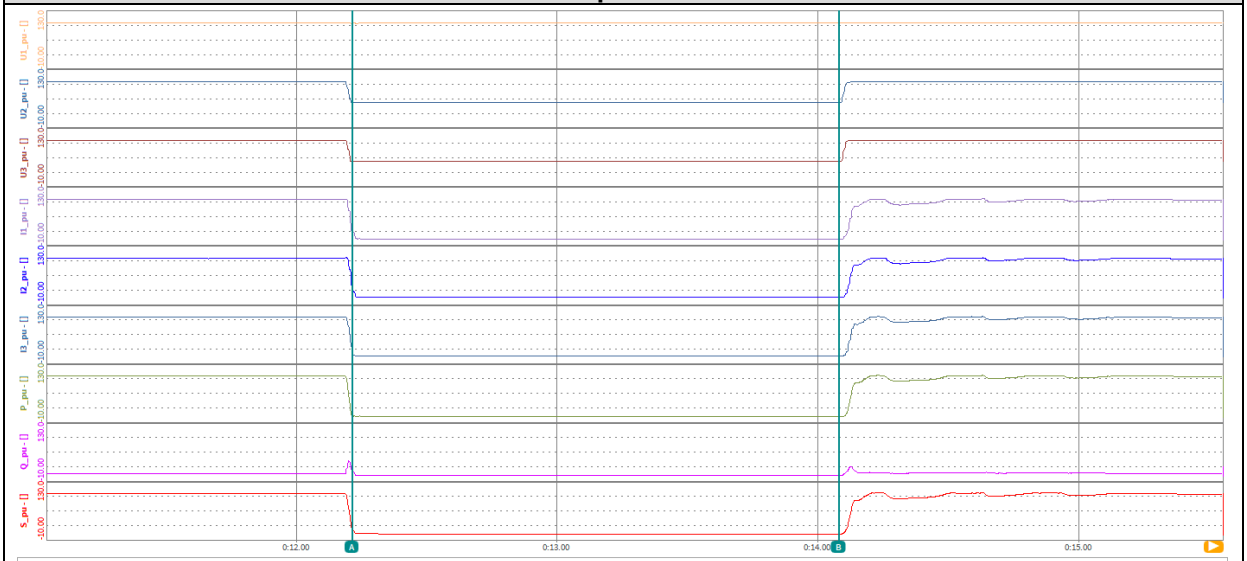
100%Pn Load	Residual voltage: 50%Un

Voltage Drop time



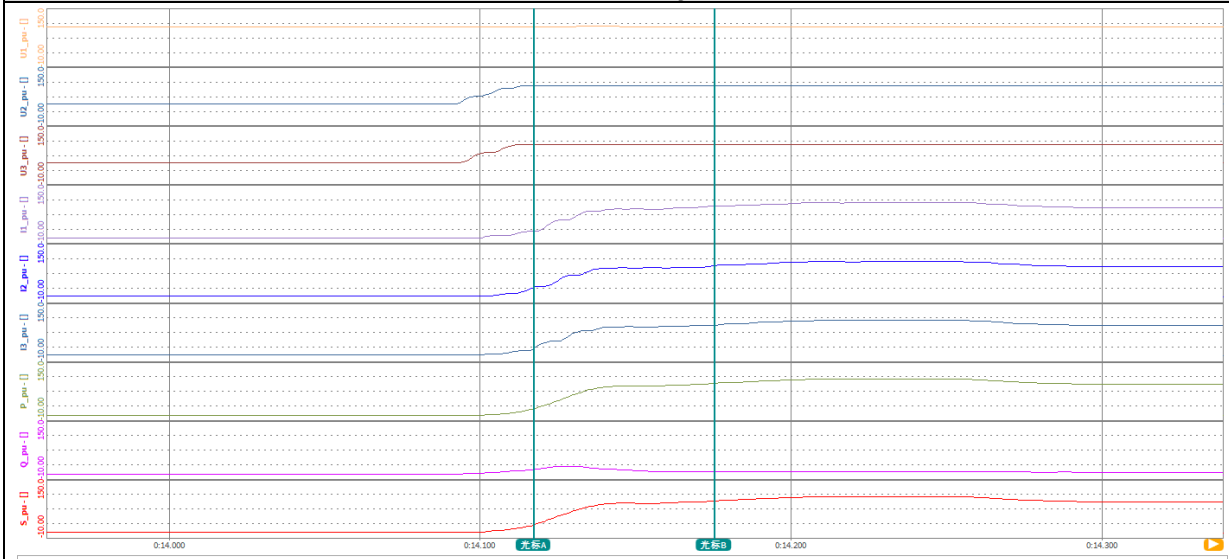
	A	B	Delta
Time [s]	0:12.1931868	0:12.2148110	0.0216242
U1_pu []	100.4865	99.67461	-0.811940
U2_pu []	100.3606	50.62630	-49.73431
U3_pu []	100.4188	50.83320	-49.58556
I1_pu []	99.92417	32.05551	-67.86866
I2_pu []	99.80956	60.16795	-39.64161
I3_pu []	99.88760	40.64056	-59.24704
P_pu []	100.0440	12.61300	-87.43098
Q_pu []	7.095122	24.65087	17.55575
S_pu []	100.2952	27.69030	-72.60495

DipTime



	A	B	Delta
Time [s]	0:12.2157005	0:14.0795685	1.8638680
U1_pu []	99.64921	100.2538	0.604586
U2_pu []	50.57506	50.21691	-0.358144
U3_pu []	50.79693	50.29105	-0.505879
I1_pu []	25.36813	3.869909	-21.49822
I2_pu []	46.49243	5.885968	-40.60646
I3_pu []	37.18834	5.843607	-31.34474
P_pu []	9.049931	2.601140	-6.448790
Q_pu []	20.66643	1.961956	-18.70447
S_pu []	22.56108	3.258098	-19.30298

Power Recovery Time

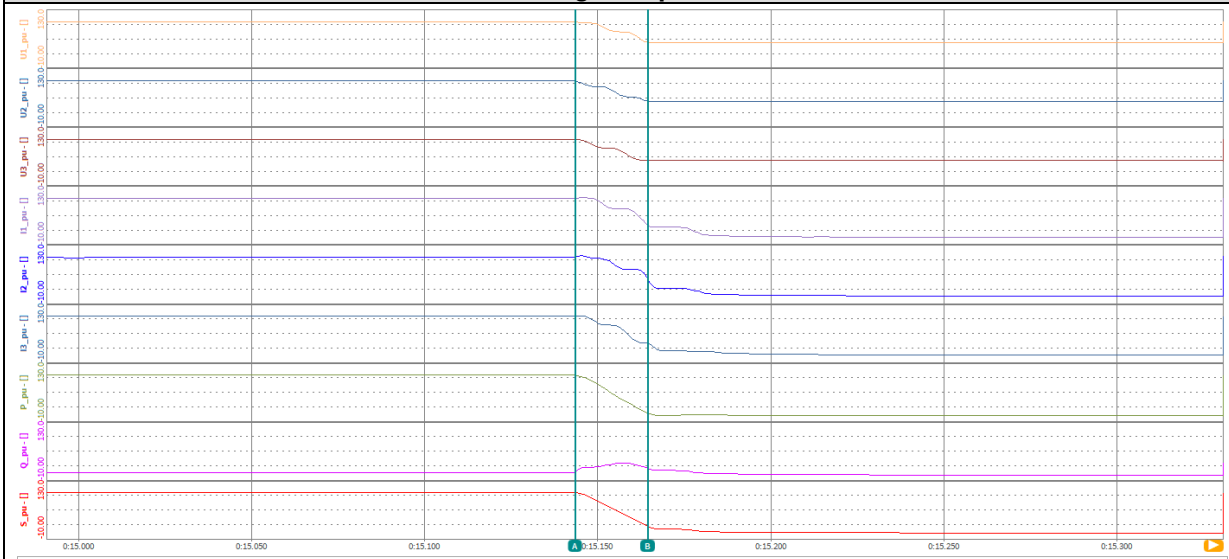


	A	B	间隔
时间 [s]	0:14.1172795	0:14.1752848	0.0580053
U1_pu []	100.5435	100.9927	0.449192
U2_pu []	99.20175	100.3653	1.163509
U3_pu []	99.47061	100.3491	0.878502
I1_pu []	22.61781	92.61743	69.99962
I2_pu []	29.02923	89.68469	60.65546
I3_pu []	22.14340	88.60291	66.45951
P_pu []	19.75243	90.40565	70.65322
Q_pu []	14.53081	8.670255	-5.860551
S_pu []	24.52148	90.82045	66.29898

Three-Phase fault

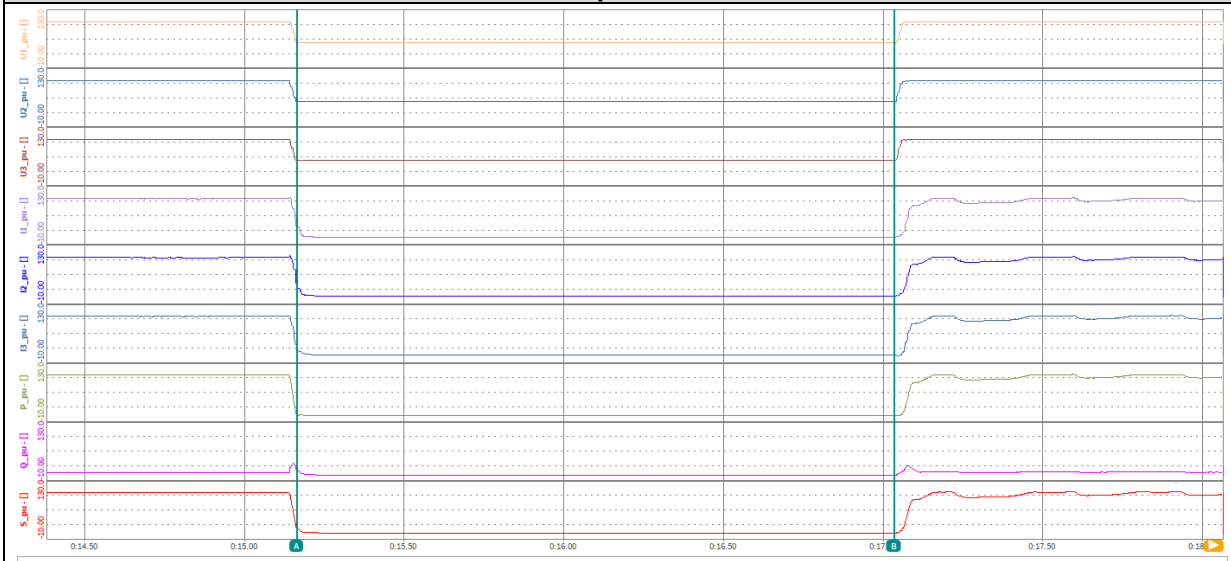
100%Pn Load | Residual voltage: 50%Un

Voltage Drop time



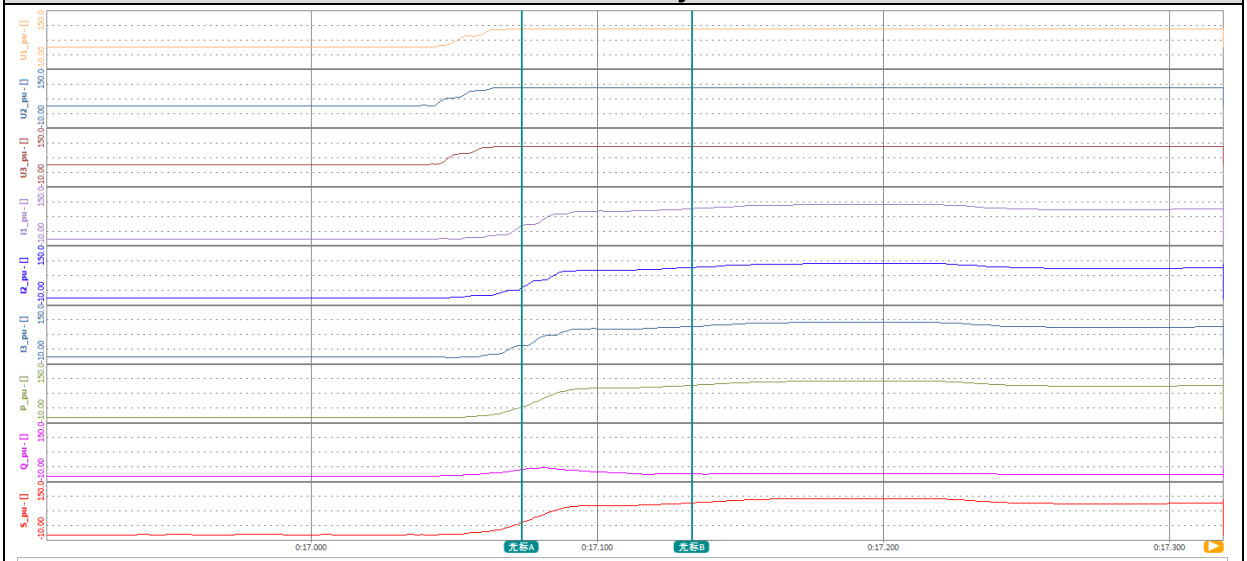
	A	B	Delta
Time [s]	0:15.1436445	0:15.1646120	0.0209676
U1_pu []	100.5053	50.83867	-49.66668
U2_pu []	100.3839	50.69520	-49.68874
U3_pu []	100.4445	50.84215	-49.60232
I1_pu []	99.95976	35.40058	-64.55918
I2_pu []	99.86859	50.08130	-49.78729
I3_pu []	100.0182	36.32880	-63.68938
P_pu []	100.1378	8.720851	-91.41697
Q_pu []	7.156579	18.68371	11.52713
S_pu []	100.3932	20.61878	-79.77444

DipTime



	A	B	Delta
Time [s]	0:15.1652071	0:17.0340111	1.8688040
U1_pu []	50.83867	50.14945	-0.689213
U2_pu []	50.69520	50.11577	-0.579433
U3_pu []	50.84215	50.00951	-0.832639
I1_pu []	35.40058	6.240680	-29.15990
I2_pu []	50.08130	6.364113	-43.71719
I3_pu []	36.32880	6.177506	-30.15129
P_pu []	8.720851	2.935112	-5.785739
Q_pu []	18.68371	1.104769	-17.57894
S_pu []	20.61878	3.136144	-17.48264

Power Recovery Time

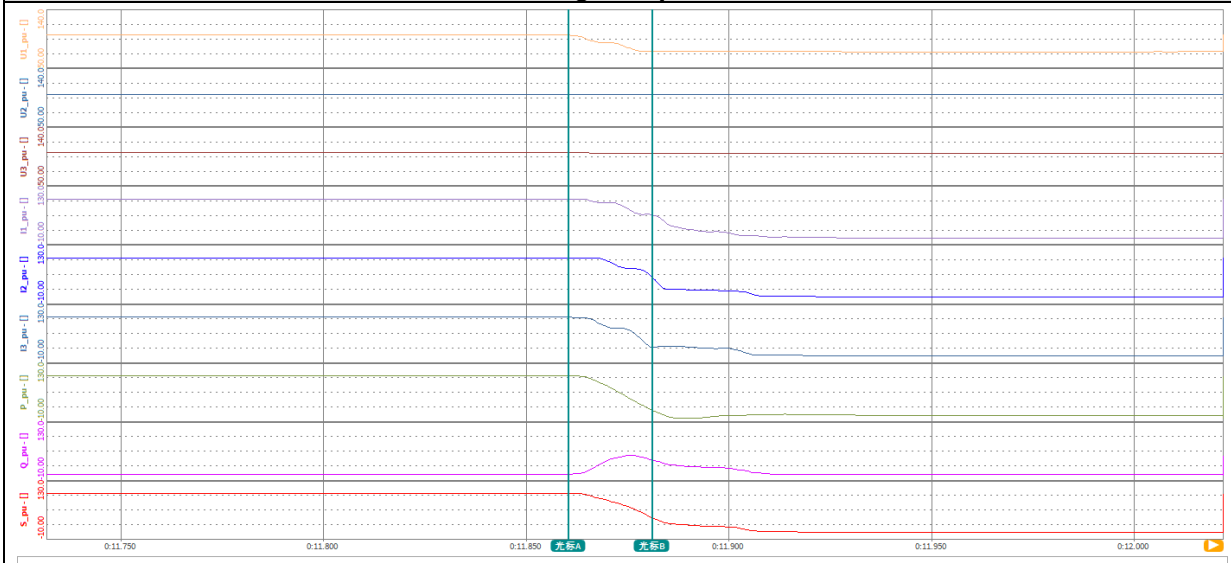


	A	B	间隔
时间 [s]	0:17.0736059	0:17.1330564	0.0594505
U1_pu []	99.52914	100.4961	0.966923
U2_pu []	99.97376	100.2913	0.317502
U3_pu []	98.89788	100.4785	1.580618
I1_pu []	41.82781	90.84245	49.01465
I2_pu []	32.77855	89.60051	56.82196
I3_pu []	37.37002	90.53355	53.16353
P_pu []	31.32162	90.25117	58.92955
Q_pu []	19.92045	9.083242	-10.83721
S_pu []	37.11965	90.70711	53.58746

Single-Phase fault

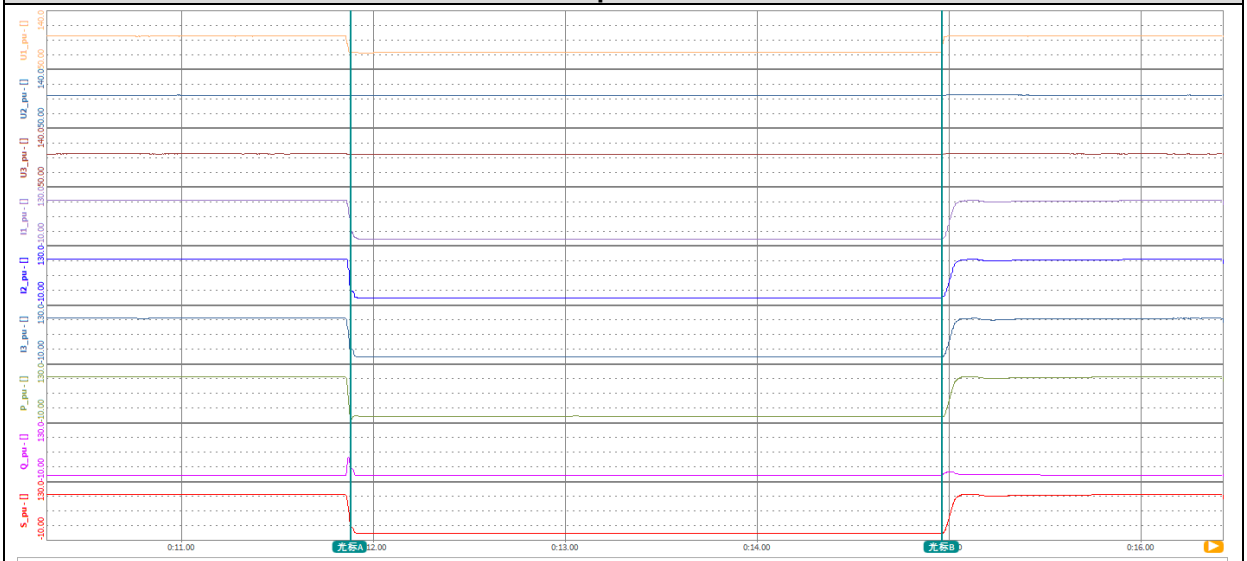
100%Pn Load	Residual voltage: 75%Un

Voltage Drop time



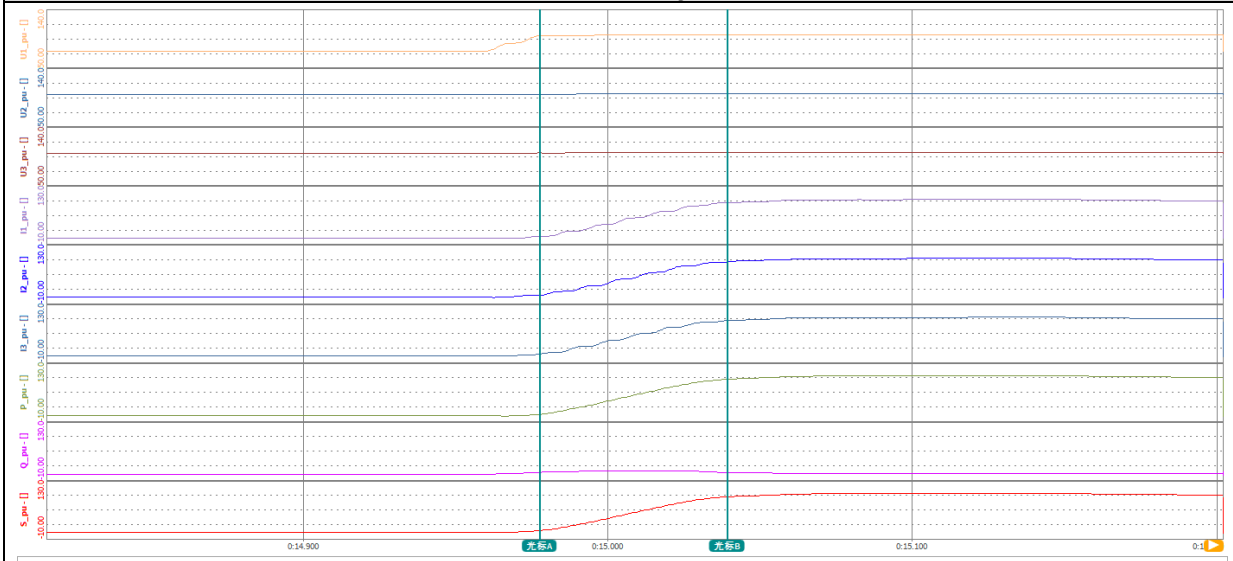
	A	B	间隔
时间 [s]	0:11.860472	0:11.881061	0.020589
U1_pu []	100.3920	75.40335	-24.98870
U2_pu []	100.3216	99.34184	-0.979754
U3_pu []	100.4102	99.80856	-0.601654
I1_pu []	98.07309	61.75446	-36.31863
I2_pu []	98.02609	55.31579	-42.71031
I3_pu []	97.82445	25.97135	-71.85310
P_pu []	98.31280	16.78007	-81.53273
Q_pu []	2.377625	39.02475	36.64712
S_pu []	98.34155	42.47943	-55.86212

DipTime



	A	B	间隔
时间 [s]	0:11.881192	0:14.961700	3.080508
U1_pu []	75.40335	75.46890	0.065546
U2_pu []	99.34184	100.1886	0.846777
U3_pu []	99.80856	100.1031	0.294588
I1_pu []	61.75446	4.824104	-56.93036
I2_pu []	55.31579	4.140228	-51.17556
I3_pu []	25.97135	4.024112	-21.94724
P_pu []	16.78007	3.142141	-13.63793
Q_pu []	39.02475	2.375429	-36.64932
S_pu []	42.47943	3.938999	-38.54043

Power Recovery Time

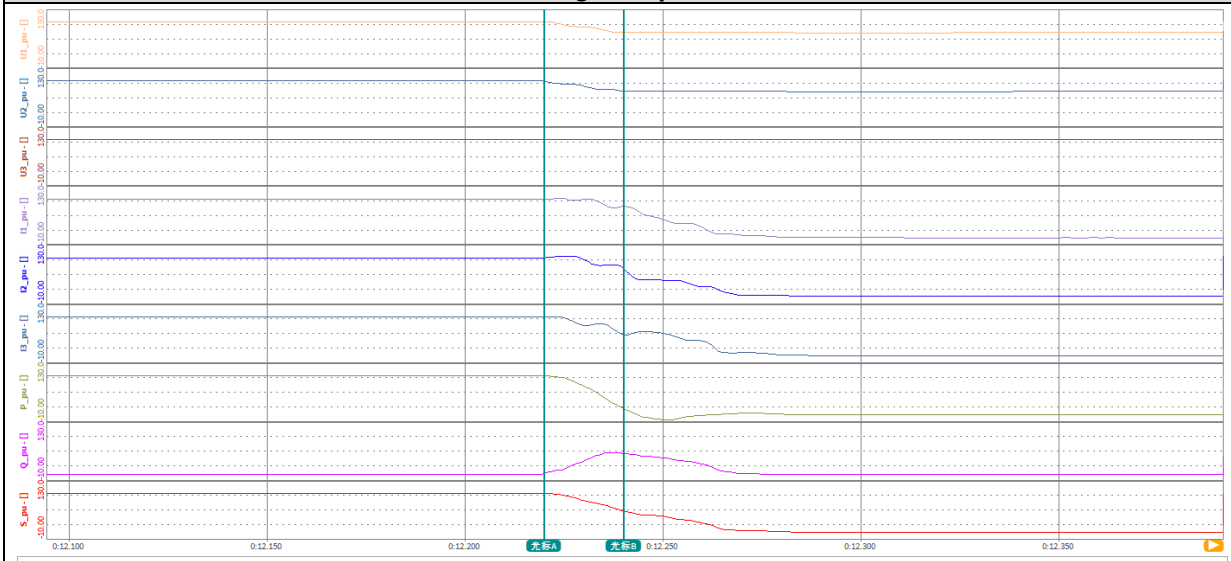


	A	B	间隔
时间 [s]	0:14.977735	0:15.039281	0.061546
U1_pu []	98.67337	100.9462	2.272836
U2_pu []	99.99851	100.8484	0.849875
U3_pu []	100.3514	100.8889	0.537501
I1_pu []	8.619085	89.75505	81.13597
I2_pu []	8.847068	88.84561	79.99854
I3_pu []	7.942024	89.96161	82.01959
P_pu []	4.849751	90.04616	85.19641
Q_pu []	6.908154	7.049361	0.141207
S_pu []	8.440538	90.32167	81.88113

Two-Phase fault

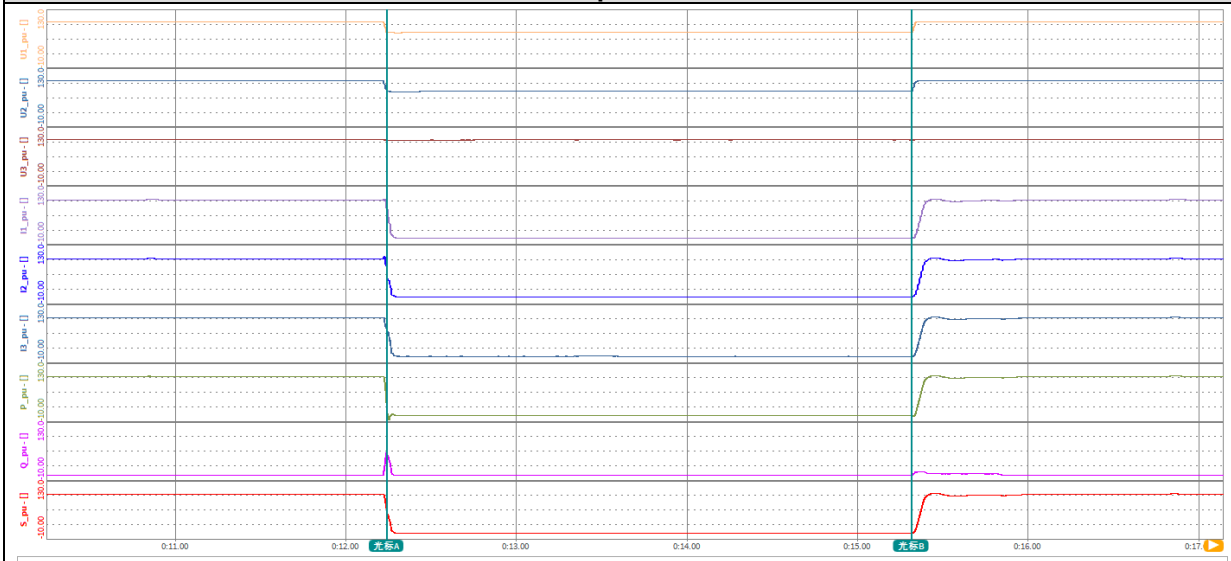
100%Pn Load | Residual voltage: 75%Un

Voltage Drop time



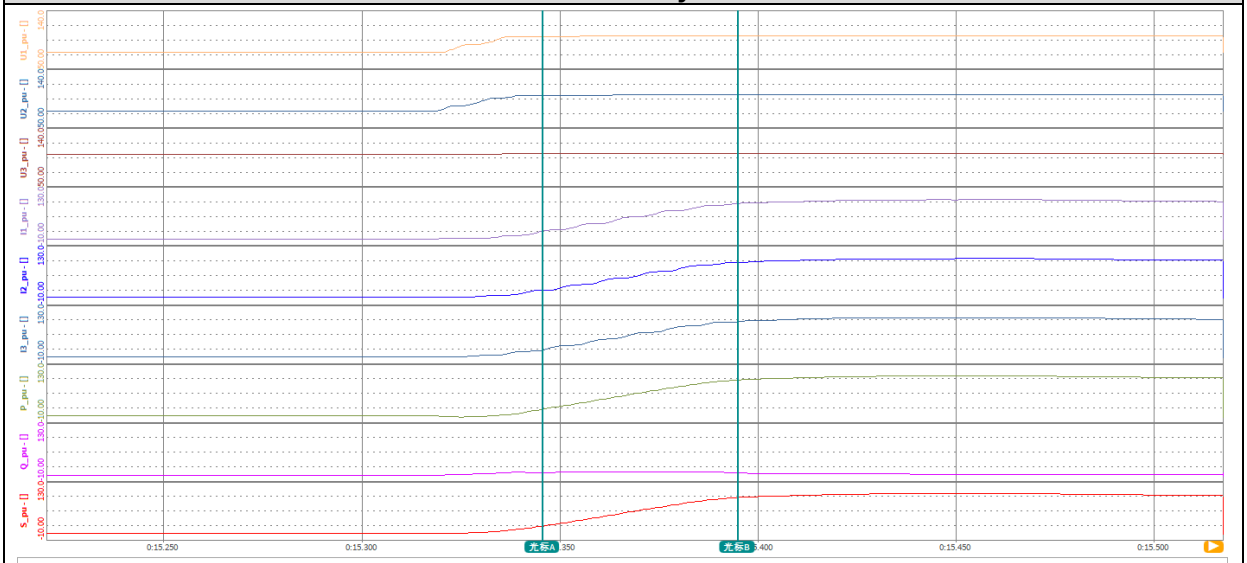
	A	B	间隔
时间 [s]	0:12.220047	0:12.240148	0.020101
U1_pu []	100.2868	75.39575	-24.89105
U2_pu []	100.3825	75.98218	-24.40029
U3_pu []	100.4456	99.83396	-0.611678
I1_pu []	97.92943	79.21139	-18.71805
I2_pu []	98.05698	79.22627	-18.83072
I3_pu []	97.82684	58.82474	-39.00210
P_pu []	98.27380	23.64509	-74.62871
Q_pu []	2.341717	54.65336	52.31165
S_pu []	98.30170	59.54898	-38.75273

DipTime



	A	B	间隔
时间 [s]	0:12.241401	0:15.315086	3.073686
U1_pu []	75.19001	75.19423	4.226e-3
U2_pu []	74.92856	75.24026	0.311704
U3_pu []	99.91381	100.2577	0.343873
I1_pu []	80.79208	5.461348	-75.33073
I2_pu []	63.52020	5.877141	-57.64306
I3_pu []	54.84998	4.584110	-50.26587
P_pu []	15.07821	3.929603	-11.14860
Q_pu []	52.24955	1.922871	-50.32668
S_pu []	54.38168	4.374839	-50.00684

Power Recovery Time

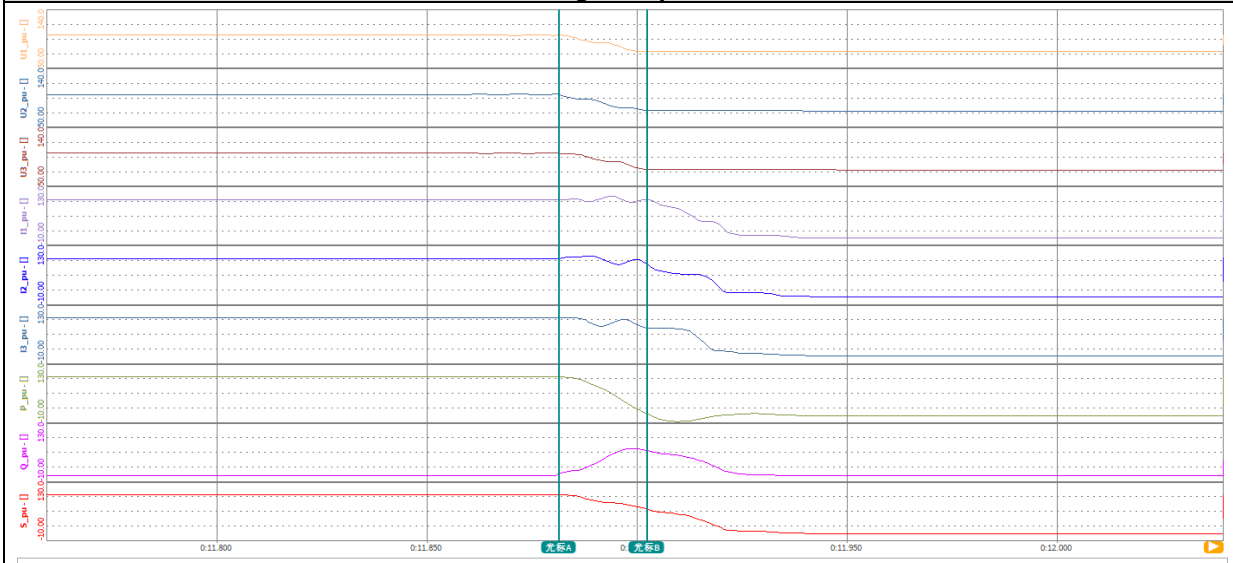


	A	B	间隔
时间 [s]	0:15.345619	0:15.394861	0.049242
U1_pu []	100.0461	100.7642	0.718112
U2_pu []	99.84729	100.8099	0.962624
U3_pu []	100.5019	100.9536	0.451667
I1_pu []	22.81586	89.98669	67.17083
I2_pu []	22.98970	90.84254	67.85284
I3_pu []	19.73524	89.16146	69.42622
P_pu []	19.77254	90.32398	70.55145
Q_pu []	9.349890	8.832144	-0.517746
S_pu []	21.87175	90.75477	68.88302

Three-Phase fault

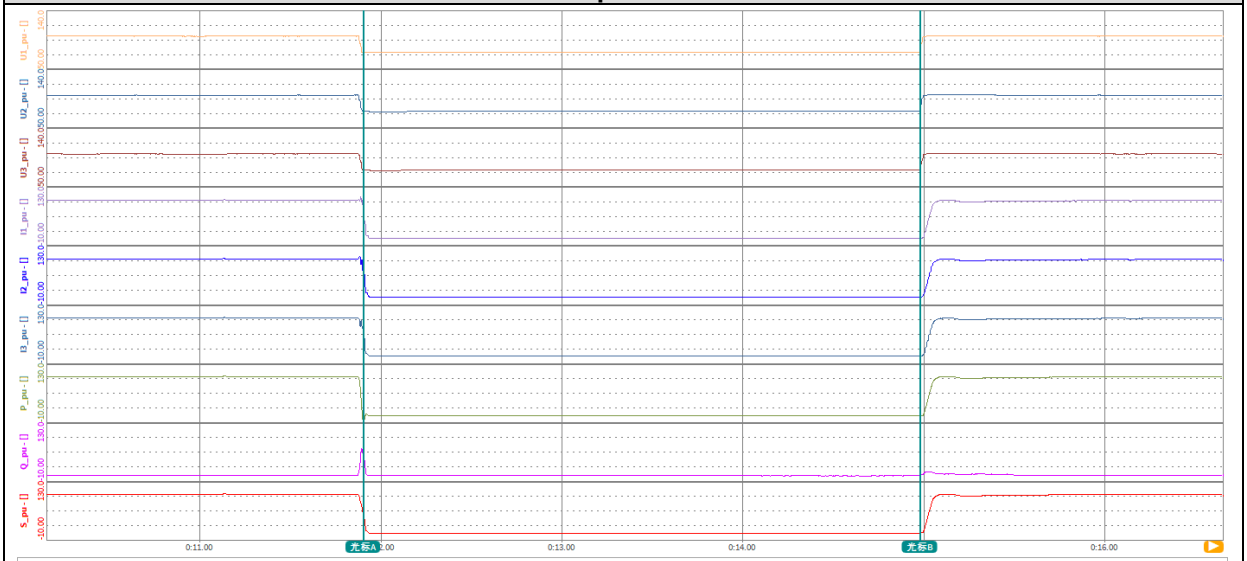
100%Pn Load	Residual voltage: 75%Un

Voltage Drop time



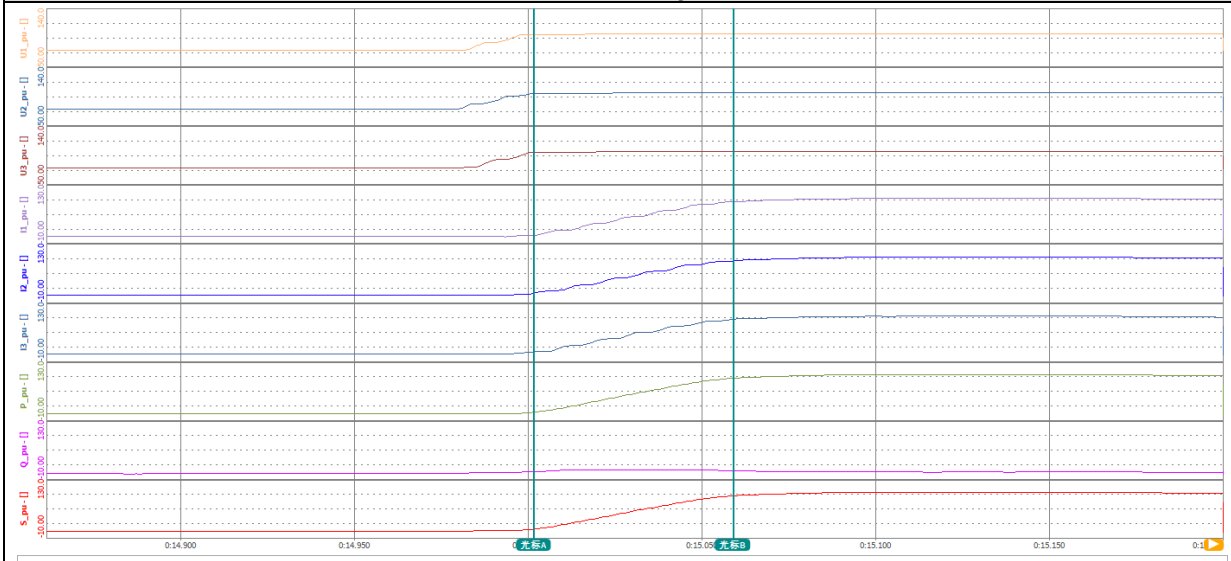
	A	B	间隔
时间 [s]	0:11.88146	0:11.90234	0.02088
U1_pu []	100.3095	75.54867	-24.76084
U2_pu []	100.3787	75.20850	-25.17020
U3_pu []	100.4790	75.36320	-25.11584
I1_pu []	97.92367	99.01923	1.095560
I2_pu []	98.16644	90.82894	-7.337504
I3_pu []	98.05910	75.76915	-22.28995
P_pu []	98.40198	13.18256	-85.21942
Q_pu []	2.400992	65.42542	63.02443
S_pu []	98.43127	66.74028	-31.69098

DipTime



	A	B	间隔
时间 [s]	0:11.90504	0:14.97850	3.07346
U1_pu []	75.28042	75.23179	-0.048636
U2_pu []	75.01963	75.24263	0.223004
U3_pu []	75.38367	75.17632	-0.207347
I1_pu []	92.04009	6.665883	-85.37421
I2_pu []	71.75672	6.623289	-65.13343
I3_pu []	73.60114	6.584725	-67.01641
P_pu []	0.361058	4.733562	4.372505
Q_pu []	59.53325	1.556340	-57.97691
S_pu []	59.53434	4.982852	-54.55149

Power Recovery Time



	A	B	间隔
时间 [s]	0:15.00181	0:15.05907	0.05726
U1_pu []	99.80440	100.9481	1.143732
U2_pu []	99.52836	100.7544	1.226037
U3_pu []	99.73766	100.9341	1.196395
I1_pu []	8.769482	90.62066	81.85118
I2_pu []	10.08871	89.14796	79.05924
I3_pu []	11.65602	89.63839	77.98237
P_pu []	8.223241	90.15857	81.93533
Q_pu []	5.932157	8.851245	2.919088
S_pu []	10.13963	90.59201	80.45237

4.2.3. Over-voltage ride through (OVRT)

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

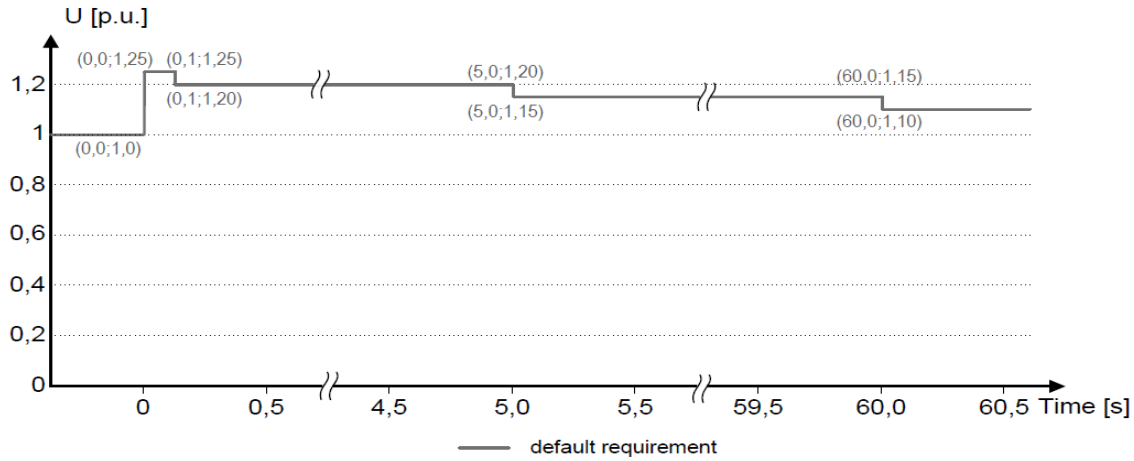
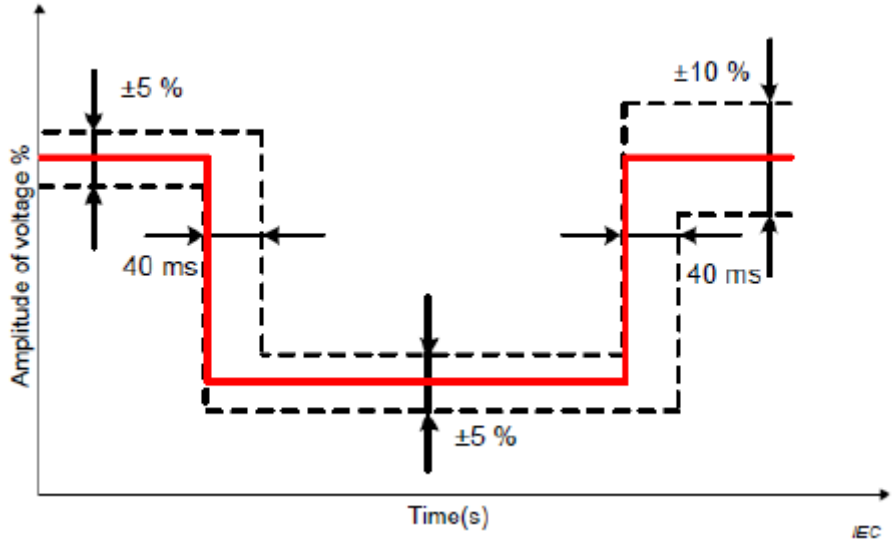


Figure 8 — Over-voltage ride through capability

4.2.3.1 *No load Test*

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



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

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

Single-Phase fault							
Residual voltage Desired (%Un)	Voltage before Recovery (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.0	21	125.0	> 120	131	--	100.0
120.0	100.0	20	120.0	> 5000	5062	--	100.0
115.0	100.0	19	114.9	> 60000	60069	--	100.0

Two-Phase fault							
Residual voltage Desired (%Un)	Voltage before Recovery (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.0	23	124.7	> 120	128	--	100.0
120.0	100.0	20	119.8	> 5000	5060	--	100.0
115.0	100.0	22	115.0	> 60000	60076	--	100.0

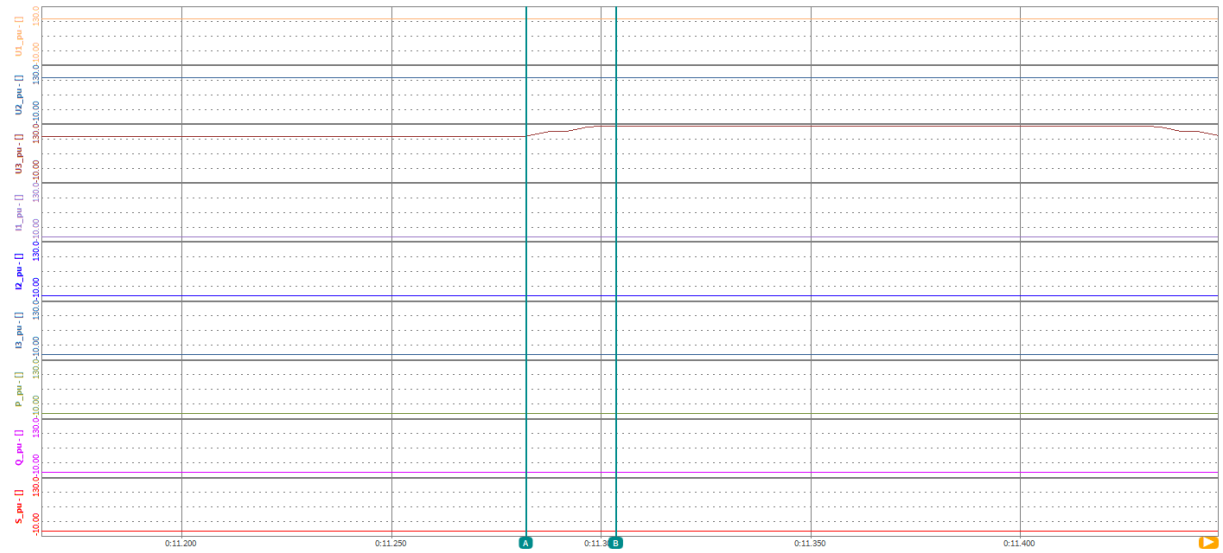
Three-Phase fault							
Residual voltage Desired (%Un)	Voltage before Recovery (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.0	21	124.8	> 120	129	--	100.0
120.0	100.0	20	119.0	> 5000	5049	--	100.0
115.0	100.0	23	115.0	> 60000	60064	--	100.0

Remark: The virtual neutral line was used in the test.

Test results are graphically represented at following pages.
Note: The following test figure the voltage unit of U1_pu, U2_pu and U3_pu are **%Un** , the current unit of I1_pu, I2_pu and I3_pu are **%In** and the power unit is **%Pn**

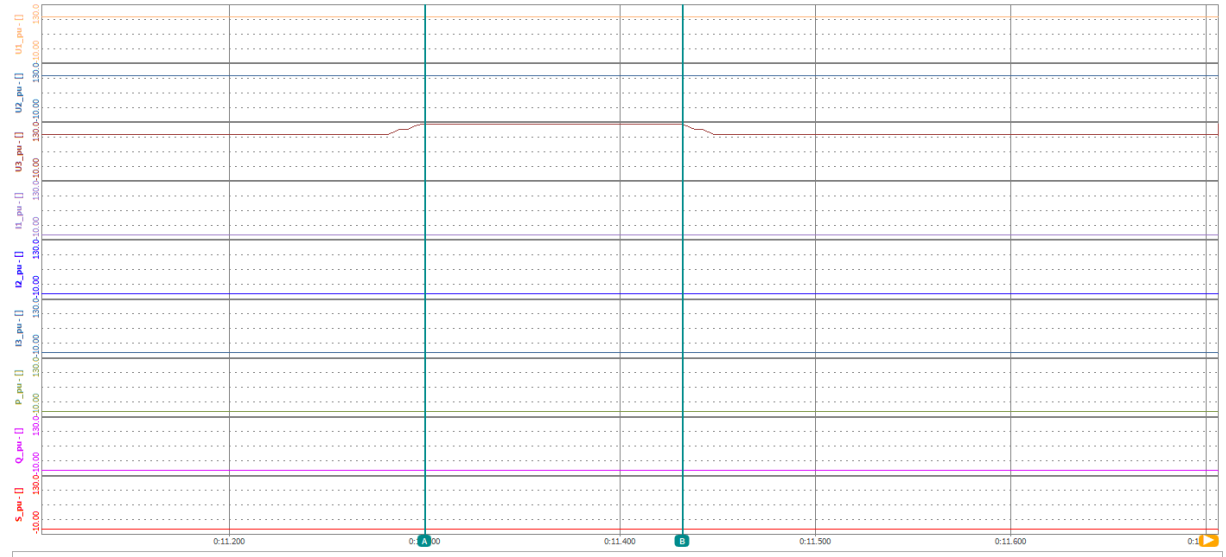
Single-Phase fault	
No Load	Residual voltage: 125.0%Un

Voltage Rise time



Time [s]	A 0:11.2822294	B 0:11.3036685	Delta 0.0214392
U1_pu []	100.2007	100.2062	5.506e-3
U2_pu []	100.1767	100.1660	-0.010721
U3_pu []	100.3945	124.8475	24.45300
I1_pu []	0.331614	0.347828	0.016214
I2_pu []	0.605062	0.596368	-8.694e-3
I3_pu []	0.484136	0.531384	0.047248
P_pu []	-4.701e-3	-0.025509	-0.020808
Q_pu []	0.474796	0.535834	0.061039
S_pu []	0.474819	0.536441	0.061622

DipTime

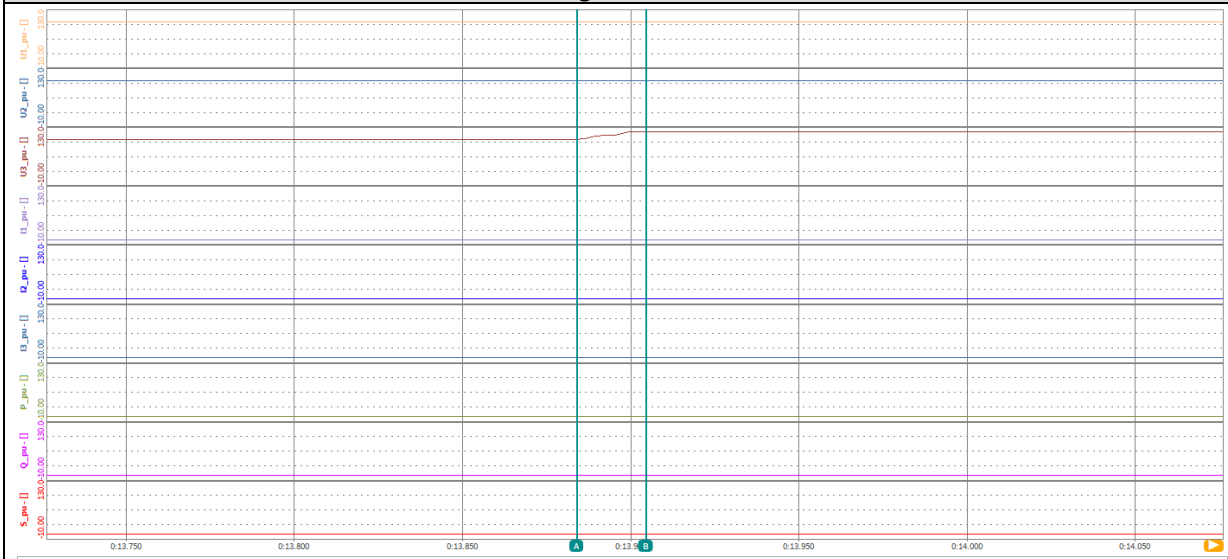


Time [s]	A 0:11.3003455	B 0:11.4320292	Delta 0.1316837
U1_pu []	100.2098	100.2106	8.160e-4
U2_pu []	100.1724	100.1667	-5.705e-3
U3_pu []	124.8132	125.0910	0.277843
I1_pu []	0.348436	0.335898	-0.012539
I2_pu []	0.603422	0.599577	-3.845e-3
I3_pu []	0.534571	0.526074	-8.497e-3
P_pu []	-0.021441	-0.013870	7.571e-3
Q_pu []	0.539856	0.531570	-8.286e-3
S_pu []	0.540282	0.531751	-8.531e-3

Single-Phase fault

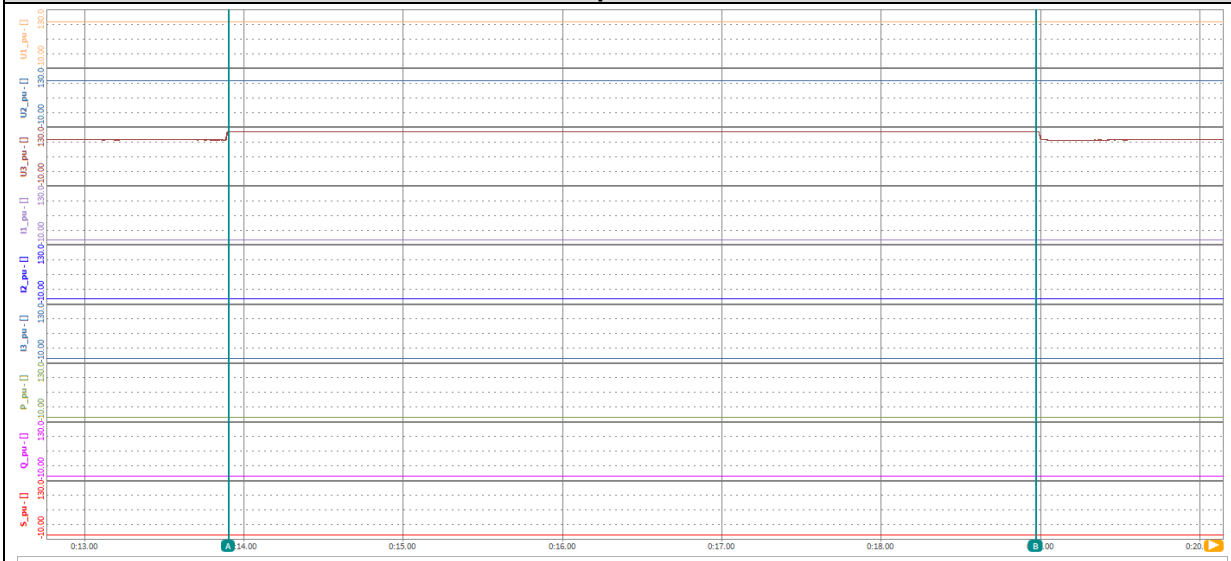
No Load	Residual voltage: 120.0%Un

Voltage Rise time



	A	B	Delta
Time [s]	0:13.8840785	0:13.9046167	0.0205382
U1_pu []	100.2106	100.2095	-1.101e-3
U2_pu []	100.1699	100.1606	-9.374e-3
U3_pu []	100.2562	119.9221	19.66587
I1_pu []	0.331076	0.344599	0.013523
I2_pu []	0.591053	0.608615	0.017562
I3_pu []	0.476522	0.519120	0.042598
P_pu []	-4.962e-3	-0.021234	-0.016272
Q_pu []	0.467165	0.525389	0.058224
S_pu []	0.467191	0.525818	0.058626

DipTime

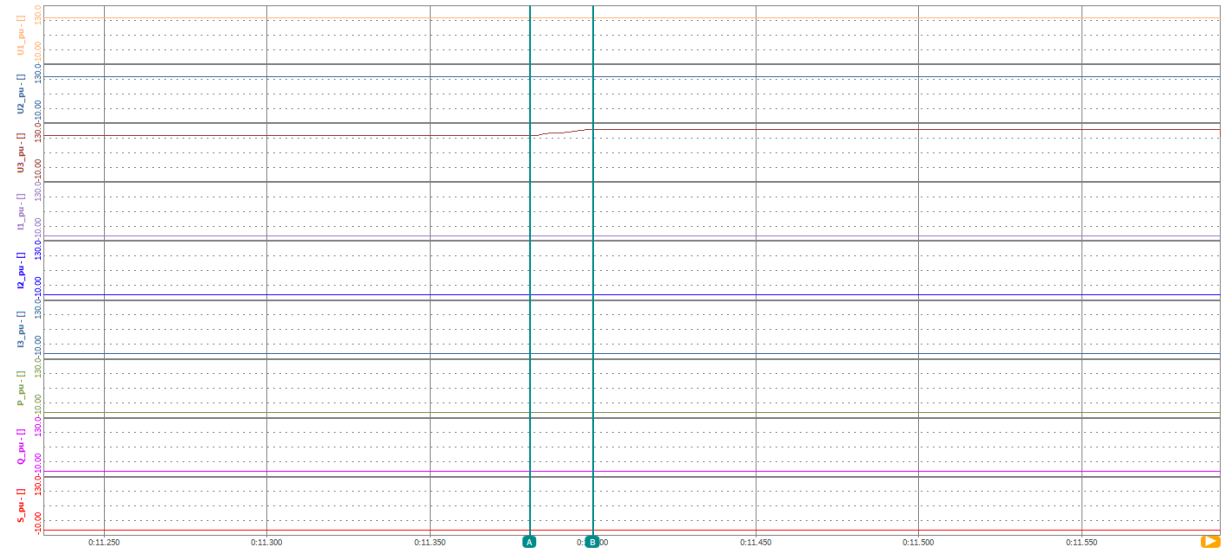


	A	B	Delta
Time [s]	0:13.9070667	0:18.9698057	5.0627390
U1_pu []	100.2051	100.1995	-5.606e-3
U2_pu []	100.1651	100.1646	-5.042e-4
U3_pu []	119.9665	120.2060	0.239497
I1_pu []	0.344765	0.330754	-0.014011
I2_pu []	0.604209	0.587477	-0.016733
I3_pu []	0.519491	0.514783	-4.708e-3
P_pu []	-0.023278	-7.602e-3	0.015676
Q_pu []	0.524115	0.512830	-0.011285
S_pu []	0.524631	0.512886	-0.011745

Single-Phase fault

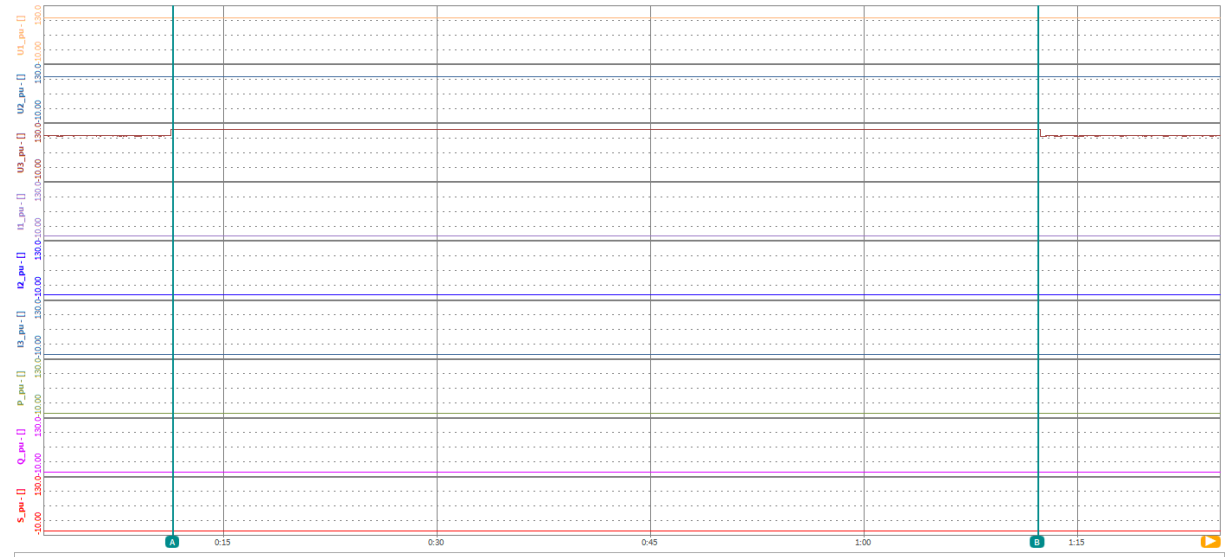
No Load | Residual voltage: 115.0%Un

Voltage Rise time



	A	B	Delta
Time [s]	0:11.38076	0:11.40006	0.01930
U1_pu []	100.2133	100.2170	3.702e-3
U2_pu []	100.1679	100.1645	-3.324e-3
U3_pu []	100.1866	114.9186	14.73203
I1_pu []	0.331303	0.339829	8.526e-3
I2_pu []	0.557305	0.557327	2.217e-5
I3_pu []	0.471296	0.505719	0.034423
P_pu []	-4.077e-3	-0.013363	-9.286e-3
Q_pu []	0.454123	0.493144	0.039021
S_pu []	0.454142	0.493325	0.039183

DipTime

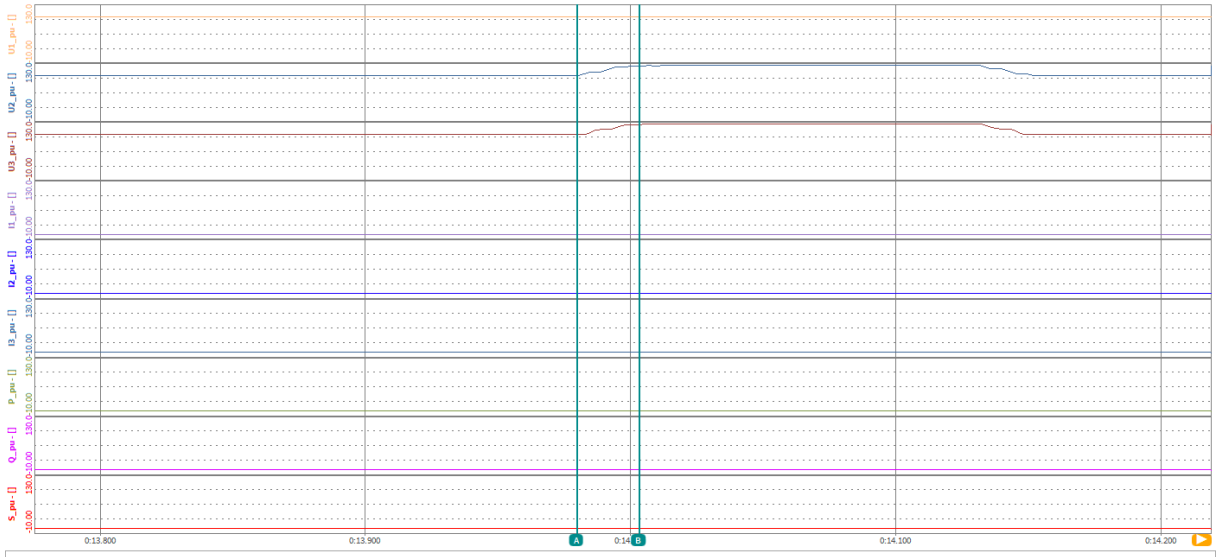


	A	B	Delta
Time [s]	0:11.49332	1:12.18599	1:00.69267
U1_pu []	100.2107	100.1980	-0.012652
U2_pu []	100.1698	100.1552	-0.014635
U3_pu []	115.4769	115.1840	-0.292849
I1_pu []	0.330973	0.330125	-8.475e-4
I2_pu []	0.555915	0.547638	-8.277e-3
I3_pu []	0.507744	0.502833	-4.911e-3
P_pu []	-0.010748	-7.669e-3	3.080e-3
Q_pu []	0.491501	0.486090	-5.412e-3
S_pu []	0.491619	0.486150	-5.469e-3

Two-Phase fault

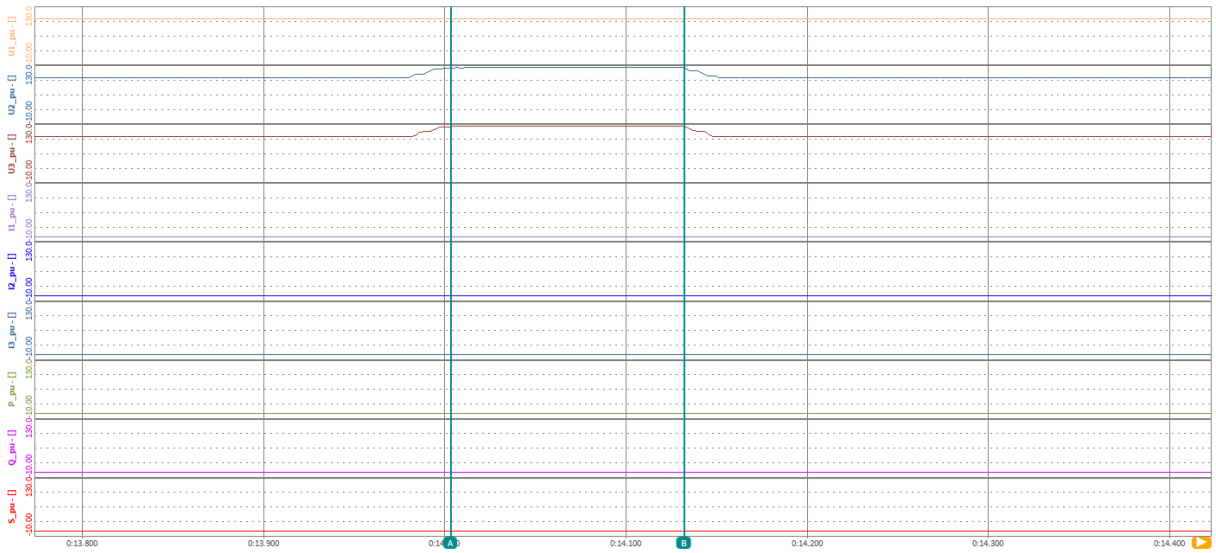
No Load	Residual voltage: 125.0%Un

Voltage Rise time



	A	B	Delta
Time [s]	0:13.97974	0:14.00321	0.02347
U1_pu []	100.2062	100.2074	1.115e-3
U2_pu []	100.1799	124.6737	24.49380
U3_pu []	100.1862	124.7405	24.55432
I1_pu []	0.332534	0.346697	0.014163
I2_pu []	0.596841	0.638180	0.041339
I3_pu []	0.470581	0.532479	0.061898
P_pu []	-0.011843	-0.025311	-0.013469
Q_pu []	0.467380	0.601893	0.134513
S_pu []	0.467530	0.602425	0.134895

DipTime

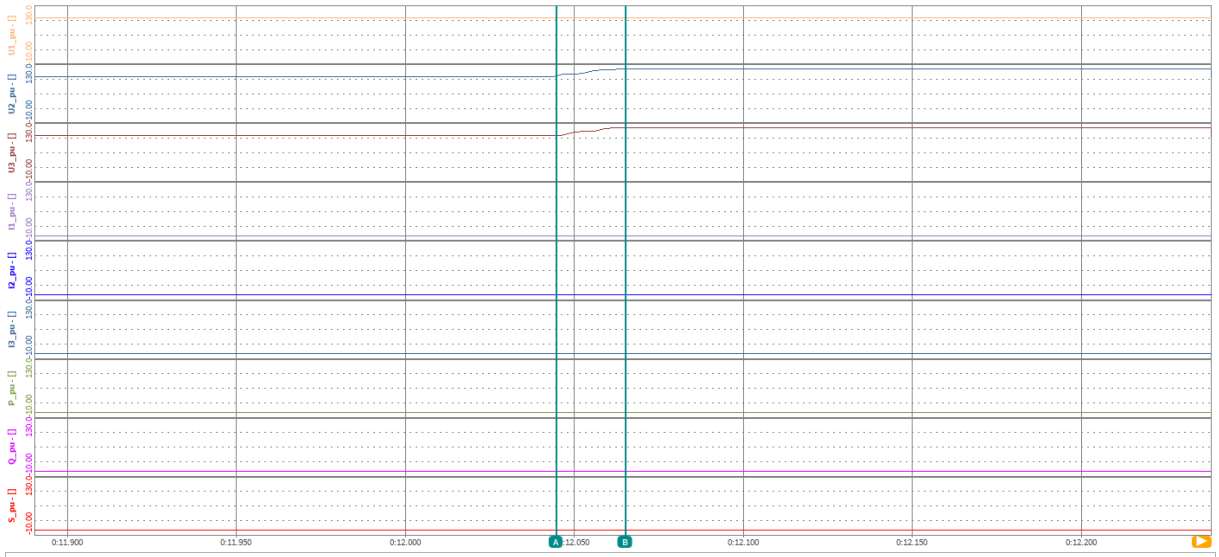


	A	B	Delta
Time [s]	0:14.00356	0:14.13227	0.12870
U1_pu []	100.2049	100.1993	-5.560e-3
U2_pu []	124.6912	125.1507	0.459515
U3_pu []	124.7518	125.2233	0.471589
I1_pu []	0.346826	0.332643	-0.014183
I2_pu []	0.639349	0.647387	8.038e-3
I3_pu []	0.532180	0.526245	-5.935e-3
P_pu []	-0.024641	-7.064e-3	0.017577
Q_pu []	0.602380	0.600791	-1.589e-3
S_pu []	0.602884	0.600833	-2.052e-3

Two-Phase fault

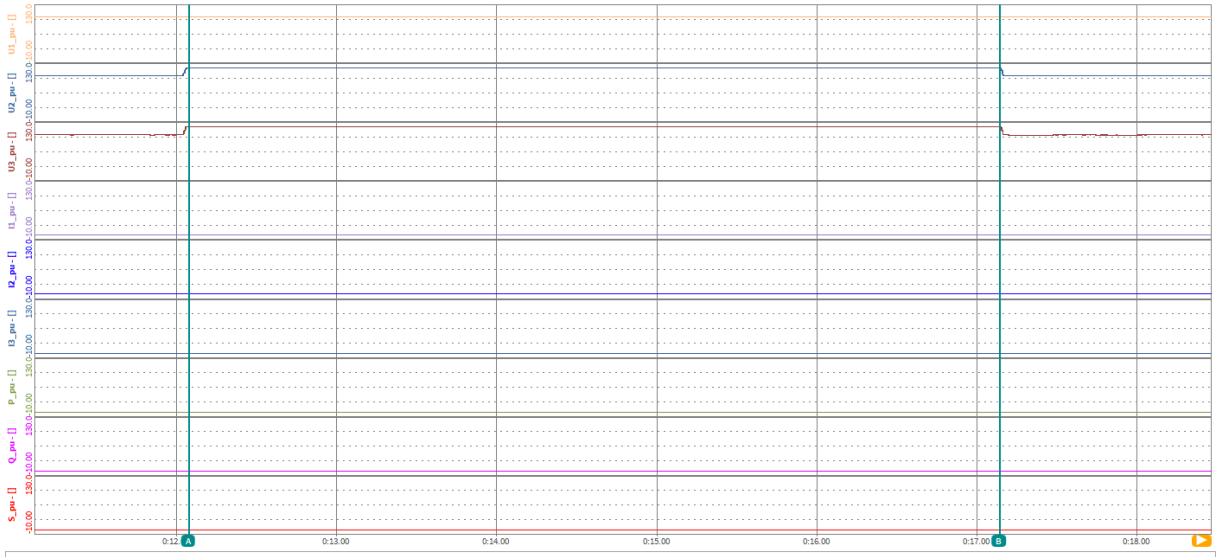
No Load	Residual voltage: 120.0%Un

Voltage Rise time



Time [s]	A 0:12.0446583	B 0:12.0651008	Delta 0.0204425
U1_pu []	100.1950	100.1902	-4.810e-3
U2_pu []	100.7107	119.7894	19.07876
U3_pu []	100.2012	119.8973	19.69606
I1_pu []	0.332174	0.342713	0.010539
I2_pu []	0.541454	0.572413	0.030958
I3_pu []	0.477206	0.525934	0.048728
P_pu []	-0.016464	-0.019792	-3.328e-3
Q_pu []	0.451797	0.552858	0.101061
S_pu []	0.452097	0.553212	0.101115

DipTime

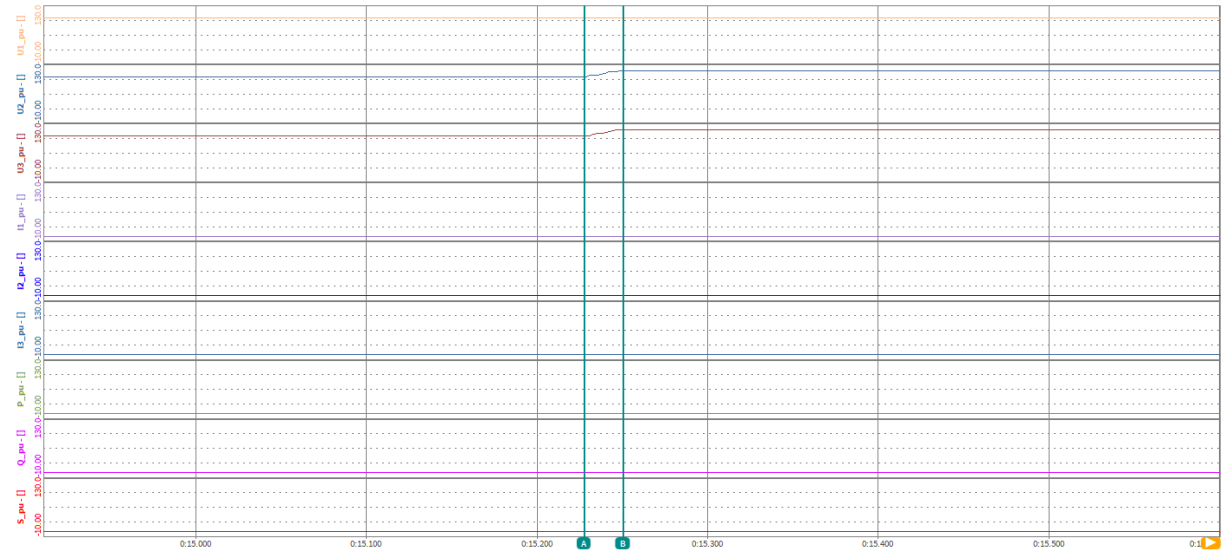


Time [s]	A 0:12.0793068	B 0:17.1400430	Delta 5.0607362
U1_pu []	100.1877	100.1905	2.780e-3
U2_pu []	119.9457	120.1654	0.219673
U3_pu []	120.0496	120.2095	0.159925
I1_pu []	0.331564	0.332658	1.094e-3
I2_pu []	0.597472	0.578740	-0.018732
I3_pu []	0.516804	0.519951	3.147e-3
P_pu []	-6.794e-3	-8.987e-3	-2.193e-3
Q_pu []	0.556375	0.551182	-5.192e-3
S_pu []	0.556416	0.551256	-5.161e-3

Two-Phase fault

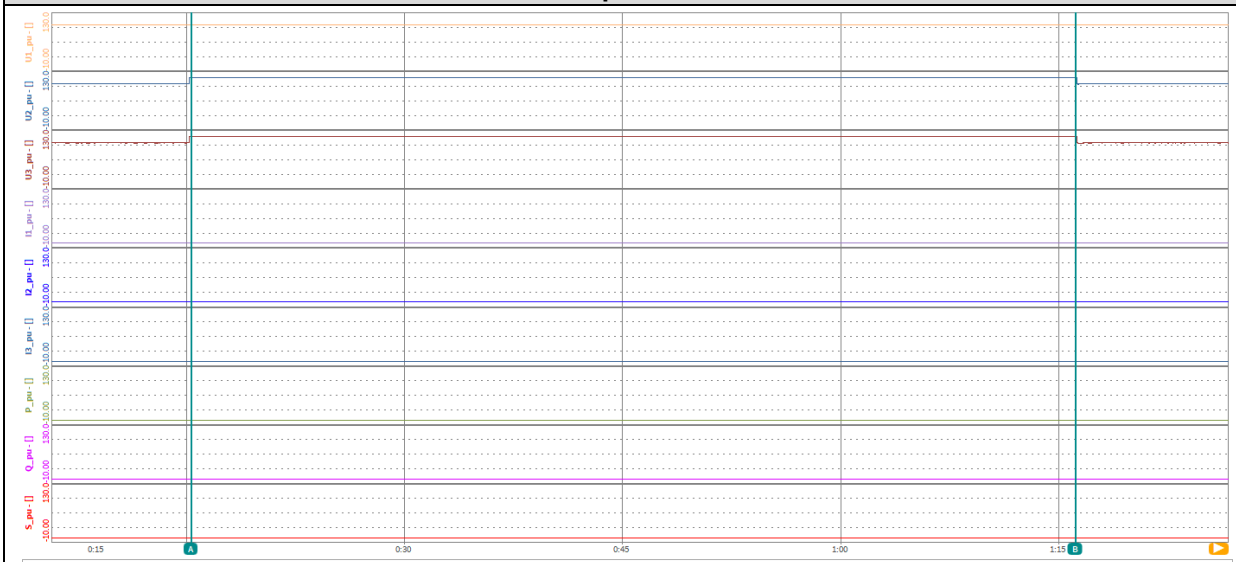
No Load | Residual voltage: 115.0%Un

Voltage Rise time



	A	B	Delta
Time [s]	0:15.2278683	0:15.2506382	0.0227699
U1_pu []	100.2011	100.1994	-1.685e-3
U2_pu []	100.1784	114.9218	14.74333
U3_pu []	100.2030	115.0339	14.83093
I1_pu []	0.331919	0.339454	7.535e-3
I2_pu []	0.530449	0.576343	0.045894
I3_pu []	0.475349	0.510478	0.035129
P_pu []	-5.160e-3	-0.013425	-8.266e-3
Q_pu []	0.446736	0.529729	0.082994
S_pu []	0.446765	0.529899	0.083134

DipTime

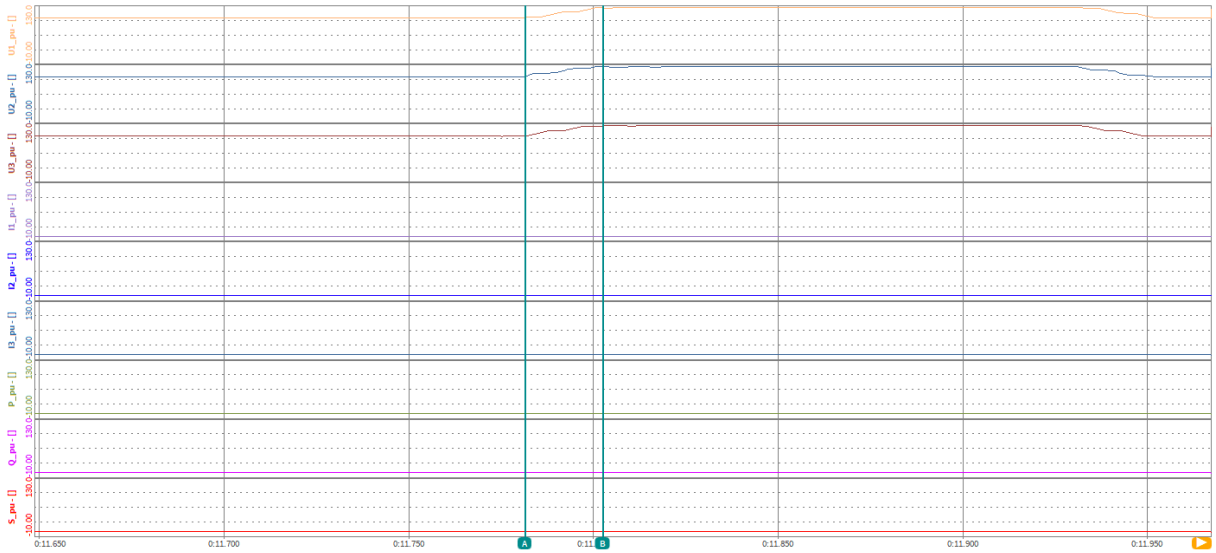


	A	B	Delta
Time [s]	0:15.3613044	1:16.1271225	1:00.7658181
U1_pu []	100.1944	100.2138	0.019392
U2_pu []	115.3993	115.1688	-0.230448
U3_pu []	115.4719	115.1970	-0.274870
I1_pu []	0.333695	0.331446	-2.249e-3
I2_pu []	0.542252	0.539086	-3.166e-3
I3_pu []	0.508443	0.508178	-2.645e-4
P_pu []	-8.165e-3	-9.171e-3	-1.006e-3
Q_pu []	0.515671	0.512725	-2.946e-3
S_pu []	0.515736	0.512807	-2.929e-3

Three-Phase fault

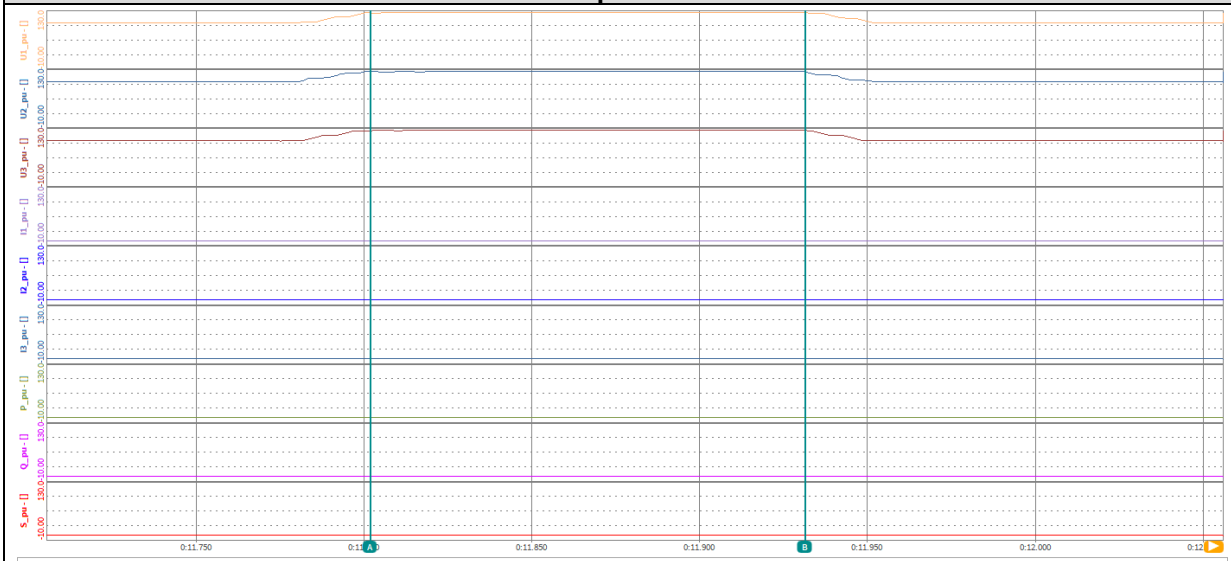
No Load	Residual voltage: 125.0%Un

Voltage Rise time



	A	B	Delta
Time [s]	0:11.78155	0:11.80259	0.02105
U1_pu []	99.92753	124.8056	24.87805
U2_pu []	99.87273	124.8182	24.94544
U3_pu []	100.6618	124.6752	24.01340
I1_pu []	0.331386	0.442876	0.111490
I2_pu []	0.546546	0.590175	0.043628
I3_pu []	0.468421	0.545095	0.076674
P_pu []	-8.611e-3	-0.034517	-0.025906
Q_pu []	0.449423	0.655417	0.205994
S_pu []	0.449506	0.656326	0.206820

DipTime

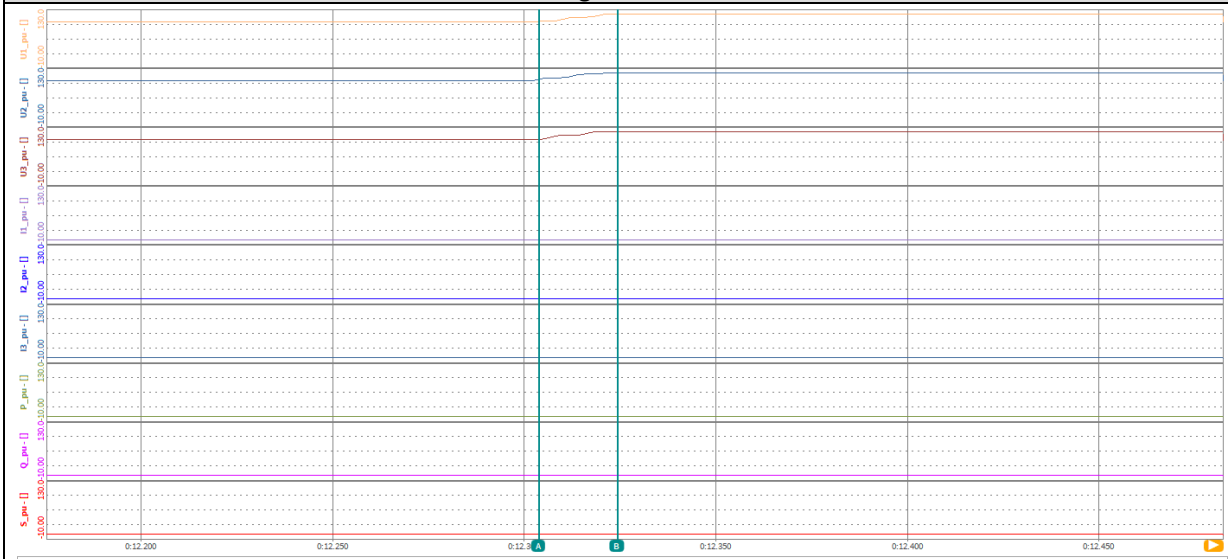


	A	B	Delta
Time [s]	0:11.80205	0:11.93144	0.12939
U1_pu []	124.8056	125.2135	0.407914
U2_pu []	124.8182	125.0950	0.276848
U3_pu []	124.6752	125.4296	0.754408
I1_pu []	0.442876	0.412607	-0.030269
I2_pu []	0.590175	0.582147	-8.027e-3
I3_pu []	0.545095	0.528419	-0.016676
P_pu []	-0.034517	-0.011192	0.023325
Q_pu []	0.655417	0.635792	-0.019626
S_pu []	0.656326	0.635890	-0.020435

Three-Phase fault

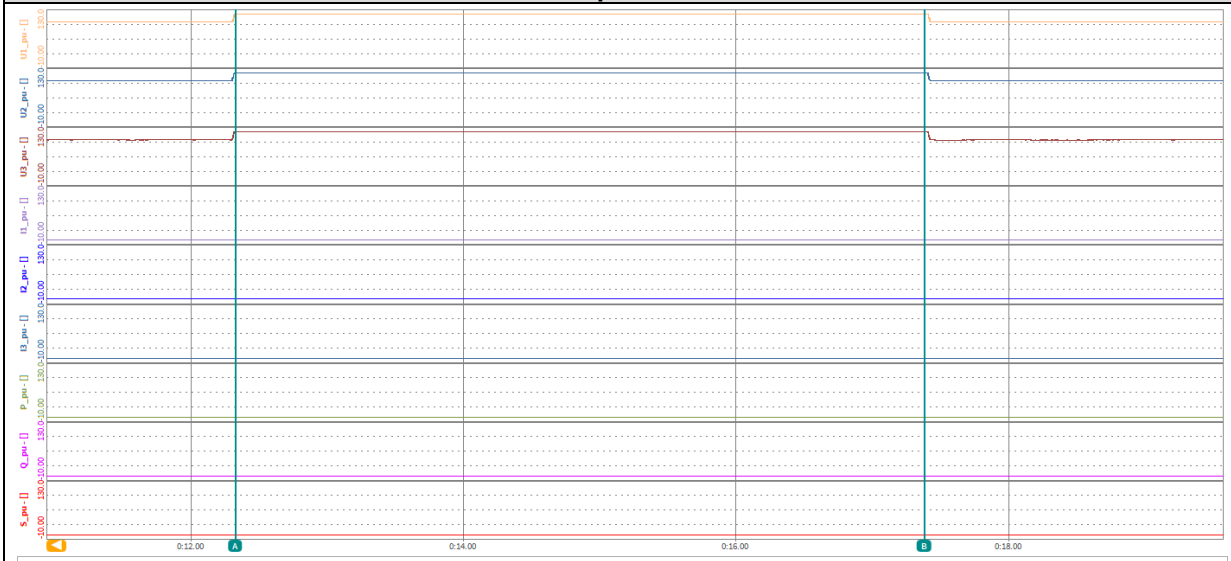
No Load	Residual voltage: 120.0%Un

Voltage Rise time



	A	B	Delta
Time [s]	0:12.30384	0:12.32436	0.02052
U1_pu []	100.4406	119.8594	19.41885
U2_pu []	100.8048	119.9434	19.13859
U3_pu []	100.5652	119.8657	19.30044
I1_pu []	0.347796	0.415567	0.067771
I2_pu []	0.585833	0.596330	0.010497
I3_pu []	0.475163	0.533441	0.058278
P_pu []	-0.016100	-0.027809	-0.011709
Q_pu []	0.472300	0.616963	0.144662
S_pu []	0.472575	0.617589	0.145014

DipTime

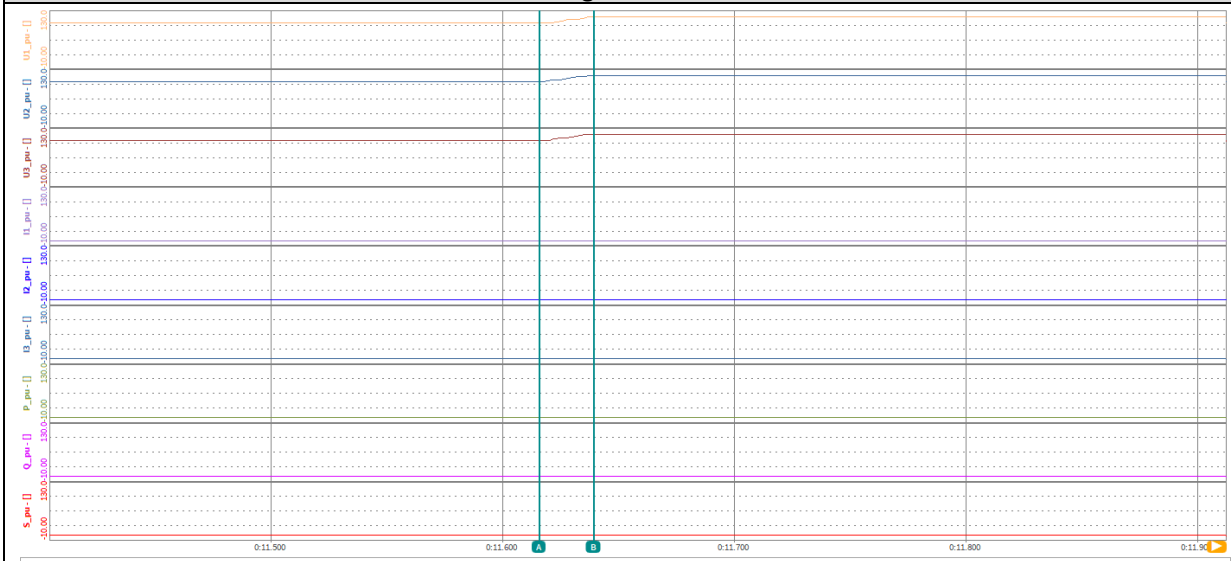


	A	B	Delta
Time [s]	0:12.333435	0:17.383277	5.049842
U1_pu []	120.0481	120.2123	0.164211
U2_pu []	120.0173	120.1736	0.156343
U3_pu []	119.8922	120.2076	0.315379
I1_pu []	0.393574	0.392864	-7.097e-4
I2_pu []	0.604239	0.599800	-4.439e-3
I3_pu []	0.517430	0.516767	-6.628e-4
P_pu []	-0.012618	-3.819e-3	8.799e-3
Q_pu []	0.605878	0.604743	-1.135e-3
S_pu []	0.606009	0.604755	-1.254e-3

Three-Phase fault

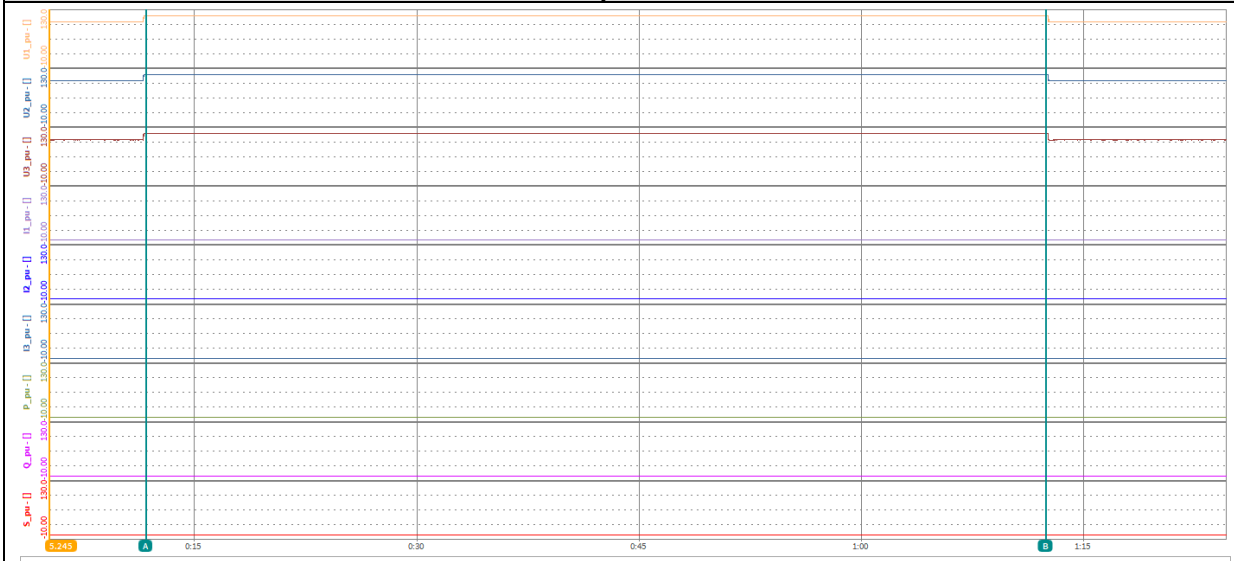
No Load	Residual voltage: 115.0%Un

Voltage Rise time



	A	B	Delta
Time [s]	0:11.61593	0:11.63942	0.02349
U1_pu []	100.0493	115.0128	14.96341
U2_pu []	100.4118	114.9064	14.49455
U3_pu []	100.1552	114.9778	14.82254
I1_pu []	0.330922	0.395698	0.064777
I2_pu []	0.540686	0.547071	6.385e-3
I3_pu []	0.473271	0.510285	0.037014
P_pu []	-3.276e-3	-0.022686	-0.019410
Q_pu []	0.449322	0.556350	0.107027
S_pu []	0.449334	0.556812	0.107478

DipTime



	A	B	Delta
Time [s]	0:11.77050	1:12.41893	1:00.64842
U1_pu []	115.3907	115.1925	-0.198232
U2_pu []	115.3153	115.1715	-0.143738
U3_pu []	115.3627	115.2093	-0.153357
I1_pu []	0.379443	0.377772	-1.671e-3
I2_pu []	0.537505	0.557720	0.020215
I3_pu []	0.507148	0.508142	9.941e-4
P_pu []	-5.833e-3	-3.957e-3	1.876e-3
Q_pu []	0.547544	0.554295	6.750e-3
S_pu []	0.547576	0.554309	6.733e-3

4.2.3.2 Load Tests: Partial load (20%Pn)

Test results of full power cases performed are offered below:

Single-Phase fault							
Residual voltage Desired (%Un)	Voltage before Recovery (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.0	21	124.6	> 120	152	20	100.6
120.0	100.0	20	119.7	> 5000	5076	16	100.5
115.0	100.0	19	114.8	> 60000	60005	17	100.4

Two-Phase fault							
Residual voltage Desired (%Un)	Voltage before Recovery (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.0	21	124.5	> 120	150	37	100.4
120.0	100.0	20	119.6	> 5000	5076	16	100.6
115.0	100.0	20	114.8	> 60000	60007	388	100.2

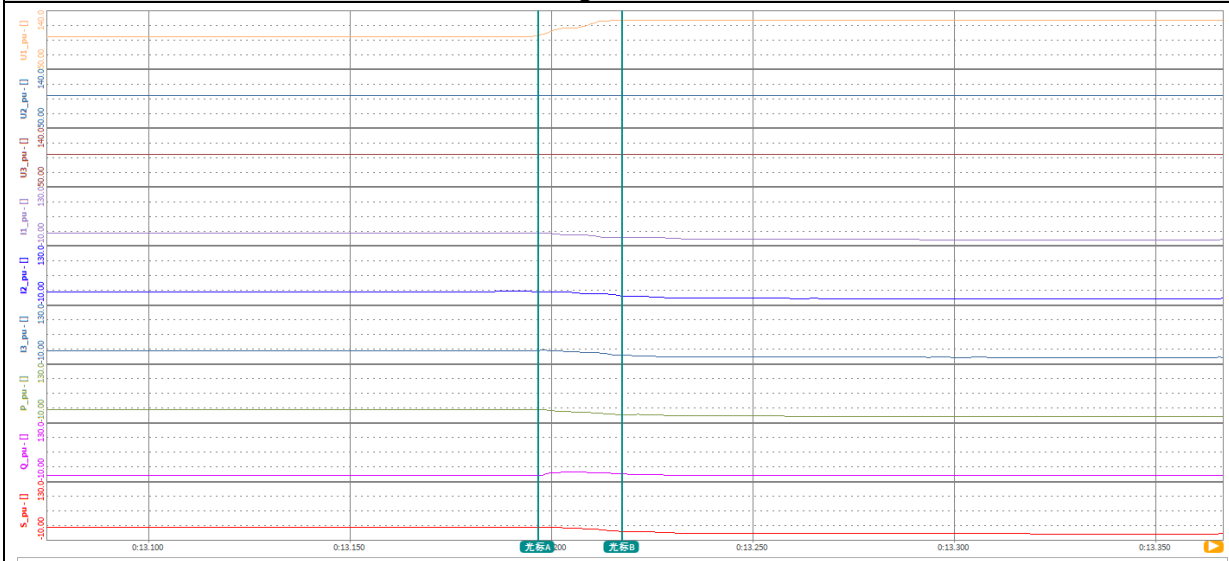
Three-Phase fault							
Residual voltage Desired (%Un)	Voltage before Recovery (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.0	20	124.3	> 120	148	37	100.1
120.0	100.0	21	119.5	> 5000	5056	20	100.5
115.0	100.0	20	114.8	> 60000	60008	408	100.0

Remark: The virtual neutral line was used in the test.

Test results are graphically represented at following pages.
Note: The following test figure the voltage unit of U1_pu, U2_pu and U3_pu are **%Un** , the current unit of I1_pu, I2_pu and I3_pu are **%In** and the power unit is **%Pn**

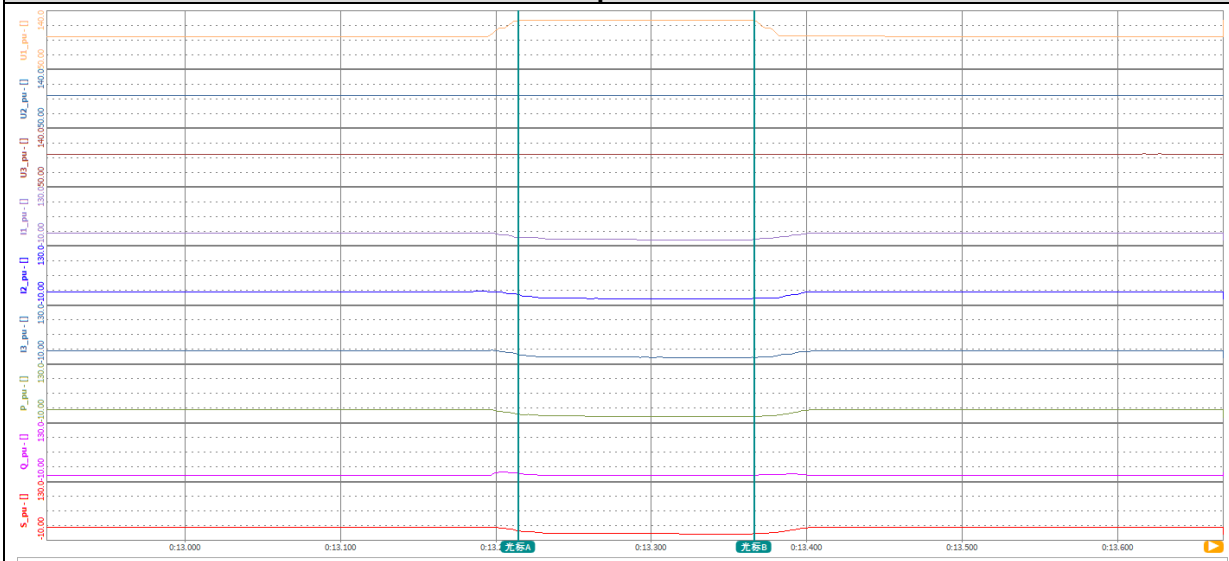
Single-Phase fault	
Partial load (20%Pn)	Residual voltage: 125.0%Un

Voltage Rise time



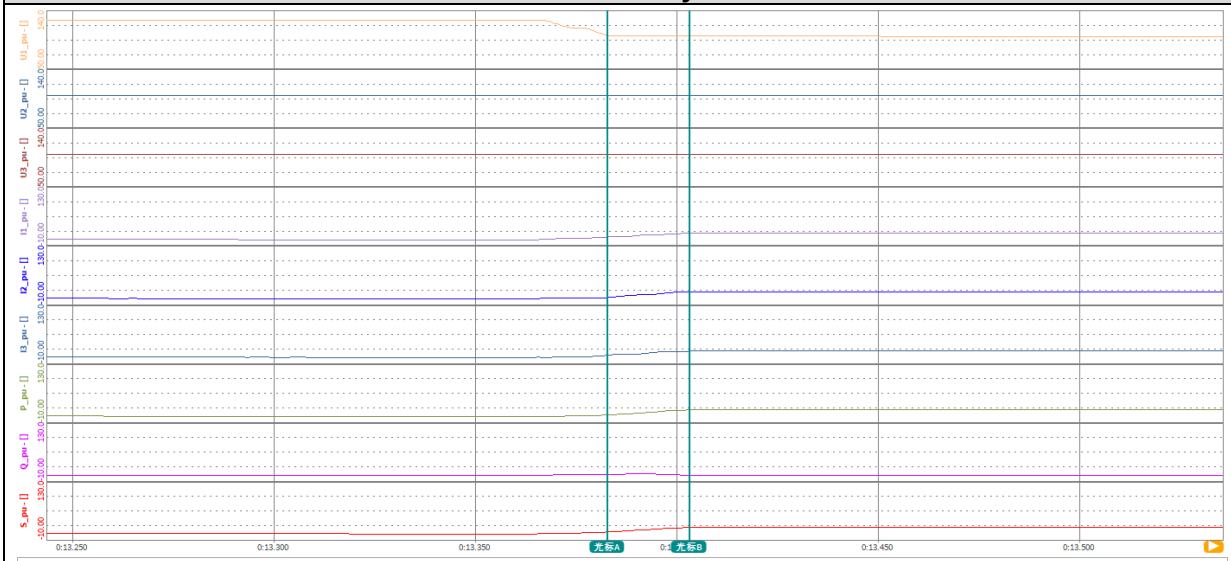
	A	B	间隔
时间 [s]	0:13.1965990	0:13.2174527	0.0208537
U1_pu []	100.0937	124.5818	24.48807
U2_pu []	100.2990	99.97318	-0.325788
U3_pu []	100.1859	99.98491	-0.200965
I1_pu []	20.16138	8.901306	-11.26007
I2_pu []	20.22252	11.14176	-9.080758
I3_pu []	20.12323	8.650049	-11.47318
P_pu []	20.08690	7.391922	-12.69498
Q_pu []	2.208626	7.161780	4.953153
S_pu []	20.20796	10.29231	-9.915653

DipTime



	A	B	间隔
时间 [s]	0:13.2146849	0:13.3663513	0.1516664
U1_pu []	124.2793	124.9388	0.659511
U2_pu []	100.0161	100.1270	0.110918
U3_pu []	100.1433	100.0553	-0.087984
I1_pu []	9.143899	2.985404	-6.158495
I2_pu []	14.37687	3.443767	-10.93310
I3_pu []	12.40487	3.585901	-8.818965
P_pu []	9.785735	1.917100	-7.868635
Q_pu []	8.129389	3.033669	-5.095720
S_pu []	12.72193	3.588652	-9.133282

Power Recovery time

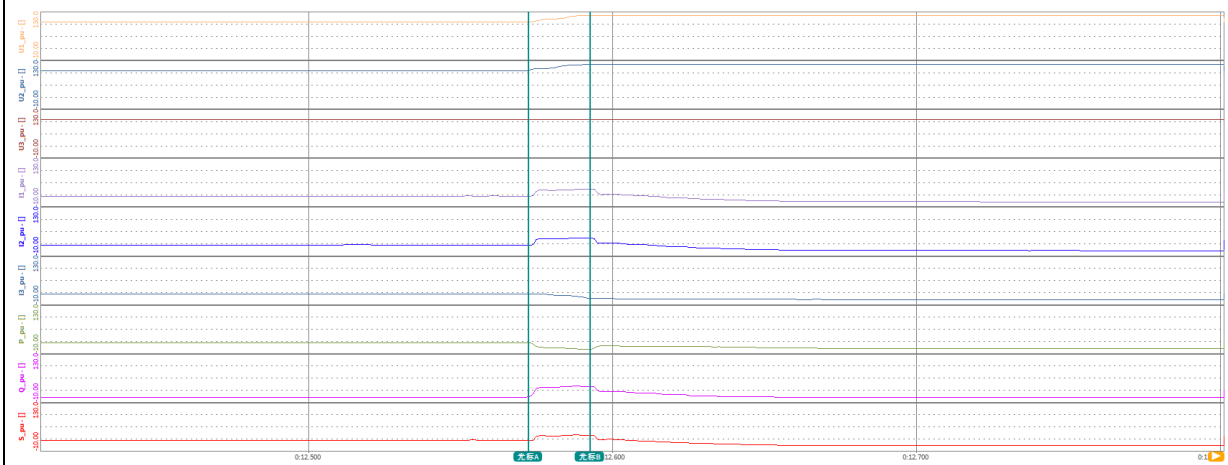


	A	B	间隔
时间 [s]	0:13.3827761	0:13.4030735	0.0202974
U1_pu []	101.7094	100.6278	-1.081576
U2_pu []	100.0771	100.3162	0.239059
U3_pu []	100.1056	100.3062	0.200640
I1_pu []	9.844124	18.97207	9.127948
I2_pu []	5.444762	18.50468	13.05992
I3_pu []	8.292219	17.92407	9.631854
P_pu []	6.326051	18.26185	11.93580
Q_pu []	4.766526	3.225074	-1.541452
S_pu []	7.920776	18.54444	10.62366

Single-Phase fault

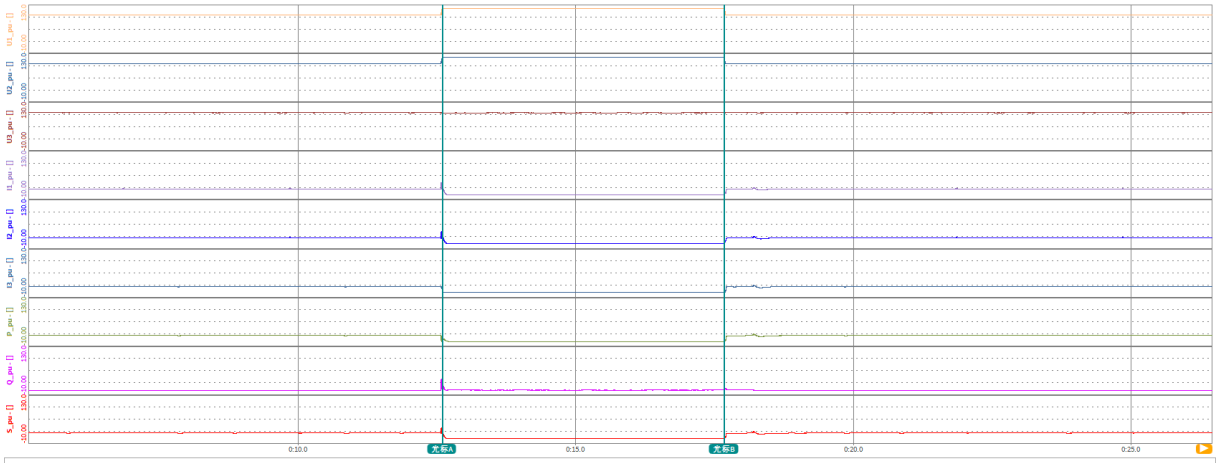
Partial load (20%Pn)	Residual voltage: 120.0%Un

Voltage Rise time



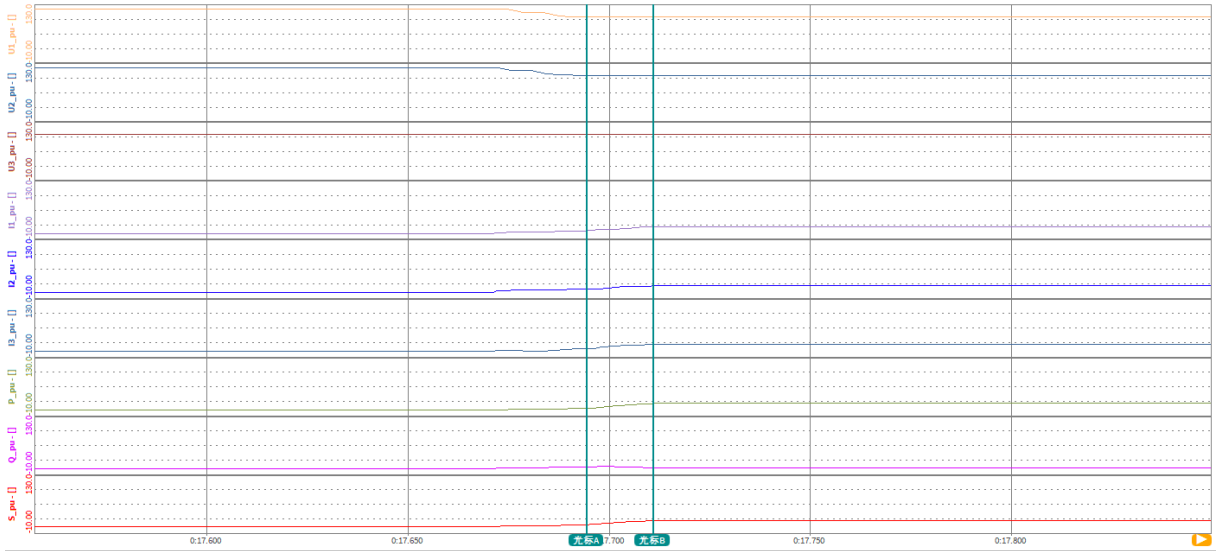
	A	B	间隔
时间 [s]	0:12.57239	0:12.59265	0.02026
U1_pu []	100.3248	119.7097	19.38494
U2_pu []	100.0932	119.4439	19.35064
U3_pu []	100.1311	99.96830	-0.162771
I1_pu []	20.26254	39.40681	19.14427
I2_pu []	20.28127	39.84938	19.56811
I3_pu []	20.11267	7.288304	-12.82437
P_pu []	20.13040	0.261554	-19.86885
Q_pu []	2.250848	34.01813	31.76729
S_pu []	20.25585	34.01914	13.76329

DipTime



时间 [s]	A 0:12.59566	B 0:17.67174	间隔 5.07608
U1_pu []	119.8421	120.2056	0.363464
U2_pu []	119.6974	120.1442	0.446804
U3_pu []	99.97294	100.1619	0.188964
I1_pu []	28.66547	3.272365	-25.39311
I2_pu []	26.19618	3.346687	-22.84949
I3_pu []	7.086718	3.428252	-3.658466
P_pu []	8.442422	2.057395	-6.385027
Q_pu []	22.74871	3.190187	-19.55852
S_pu []	24.26475	3.796072	-20.46868

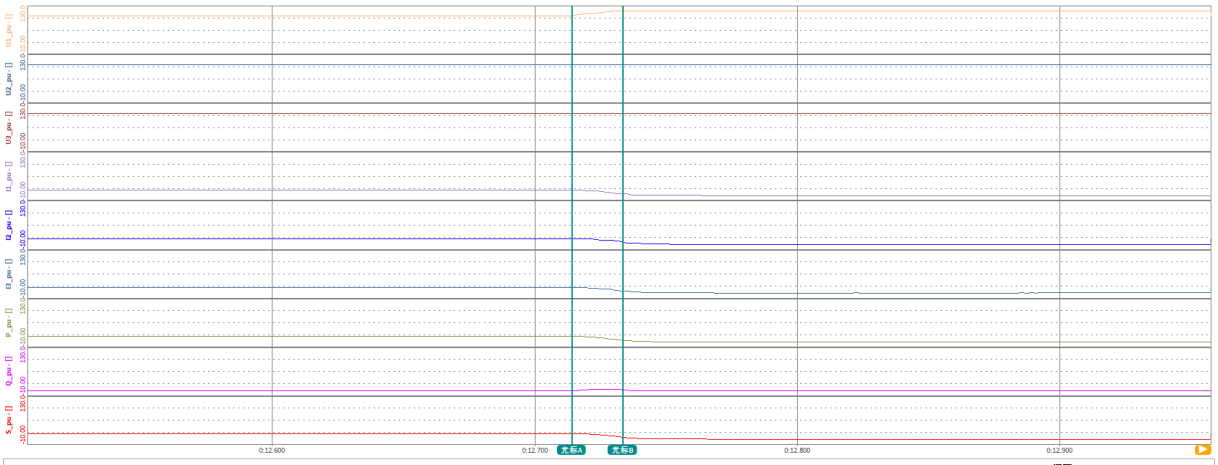
Power Recovery time



时间 [s]	A 0:17.694384	B 0:17.710823	间隔 0.016439
U1_pu []	100.5254	100.4953	-0.030080
U2_pu []	100.5518	100.5720	0.020274
U3_pu []	100.1971	100.4043	0.207208
I1_pu []	8.438061	18.68813	10.25007
I2_pu []	11.13158	18.11163	6.980053
I3_pu []	8.068690	19.24376	11.17507
P_pu []	6.509161	18.03765	11.52849
Q_pu []	6.576848	5.200937	-1.375912
S_pu []	9.253330	18.77250	9.519168

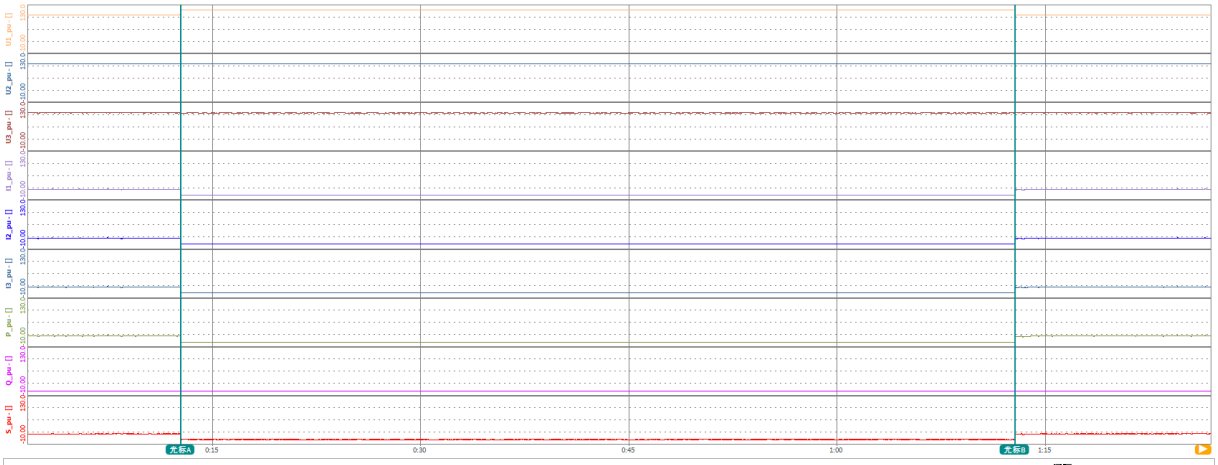
Single-Phase fault	
Partial load (20%Pn)	Residual voltage: 115.0%Un

Voltage Rise time



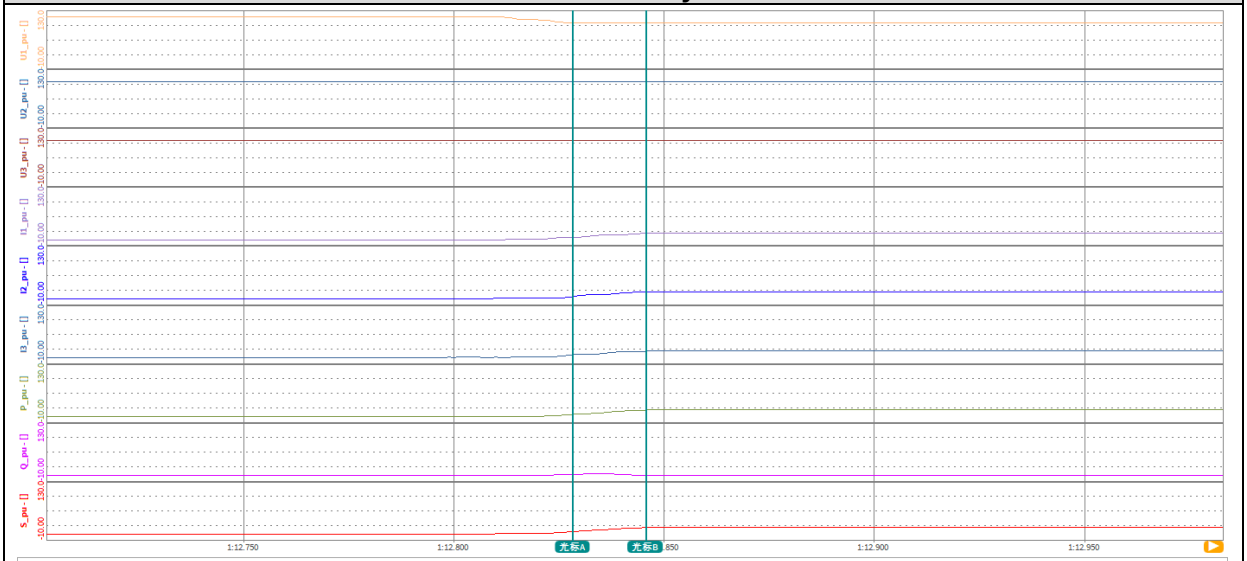
时间 [s]	A 0:12.71417	B 0:12.73355	间隔 0.01937
U1_pu []	100.1912	114.8421	14.65097
U2_pu []	100.3094	100.0013	-0.308015
U3_pu []	100.1736	100.0057	-0.167940
I1_pu []	20.02637	9.319917	-10.70645
I2_pu []	20.02697	11.01316	-9.013811
I3_pu []	20.06591	8.910087	-11.15583
P_pu []	19.95297	8.427295	-11.52567
Q_pu []	2.297242	5.762378	3.465136
S_pu []	20.08478	10.20903	-9.875747

DipTime



时间 [s]	A 0:12.73874	B 1:12.78931	间隔 1:00.05057
U1_pu []	114.8873	115.1793	0.291960
U2_pu []	99.92799	100.1365	0.208561
U3_pu []	99.99766	100.1544	0.156721
I1_pu []	4.976141	2.779490	-2.196651
I2_pu []	6.295985	3.430685	-2.865300
I3_pu []	7.306735	3.547097	-3.759638
P_pu []	5.403210	1.855381	-3.547829
Q_pu []	3.501046	2.844892	-0.656154
S_pu []	6.438323	3.396446	-3.041876

Power Recovery time

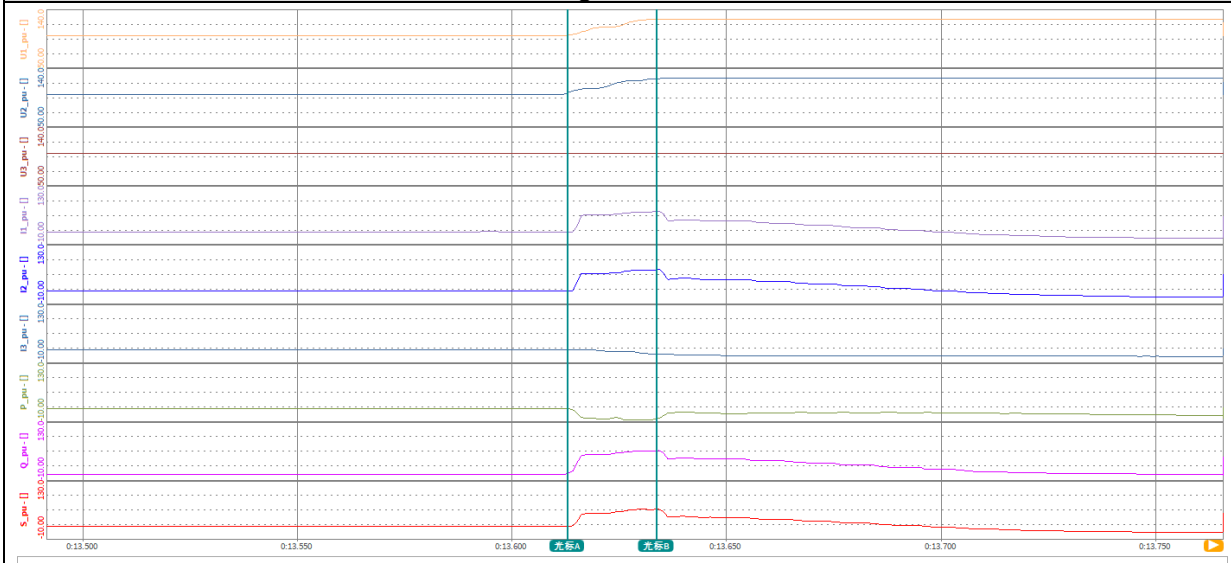


	A	B	间隔
时间 [s]	1:12.828342	1:12.845634	0.017292
U1_pu []	100.4120	100.3602	-0.051734
U2_pu []	100.2001	100.3829	0.182833
U3_pu []	100.2331	100.3566	0.123497
I1_pu []	9.434363	18.46889	9.034532
I2_pu []	6.709744	18.49150	11.78176
I3_pu []	9.830341	17.78905	7.958711
P_pu []	7.177179	18.05577	10.87859
Q_pu []	4.887366	3.080912	-1.806455
S_pu []	8.683217	18.31674	9.633521

Two-Phase fault

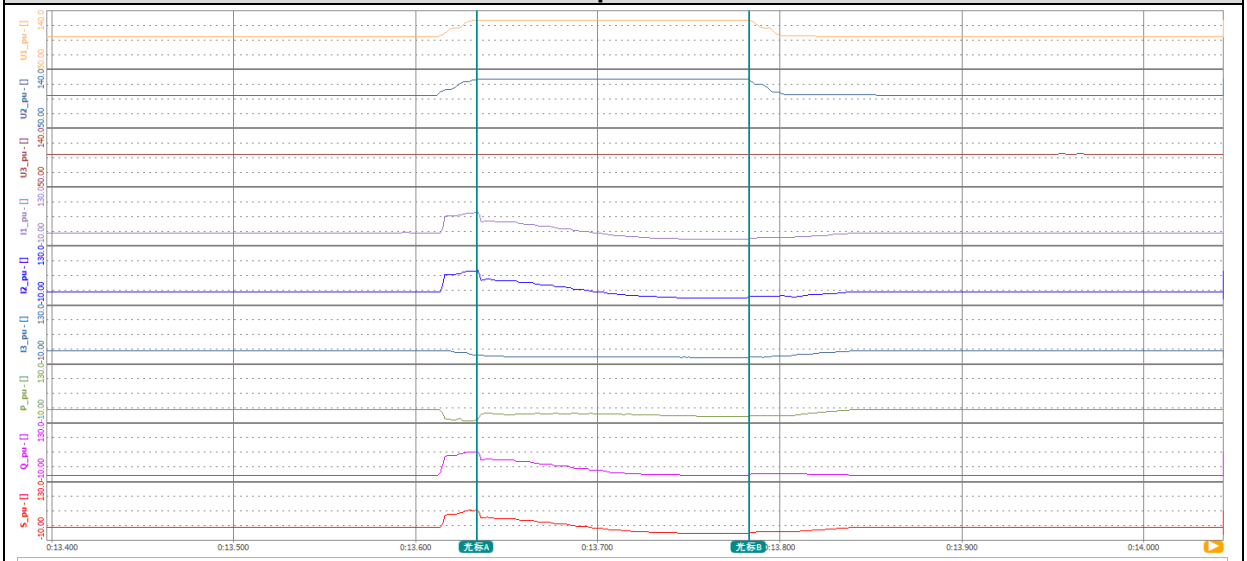
Partial load (20%Pn)	Residual voltage: 125.0%Un

Voltage Rise time



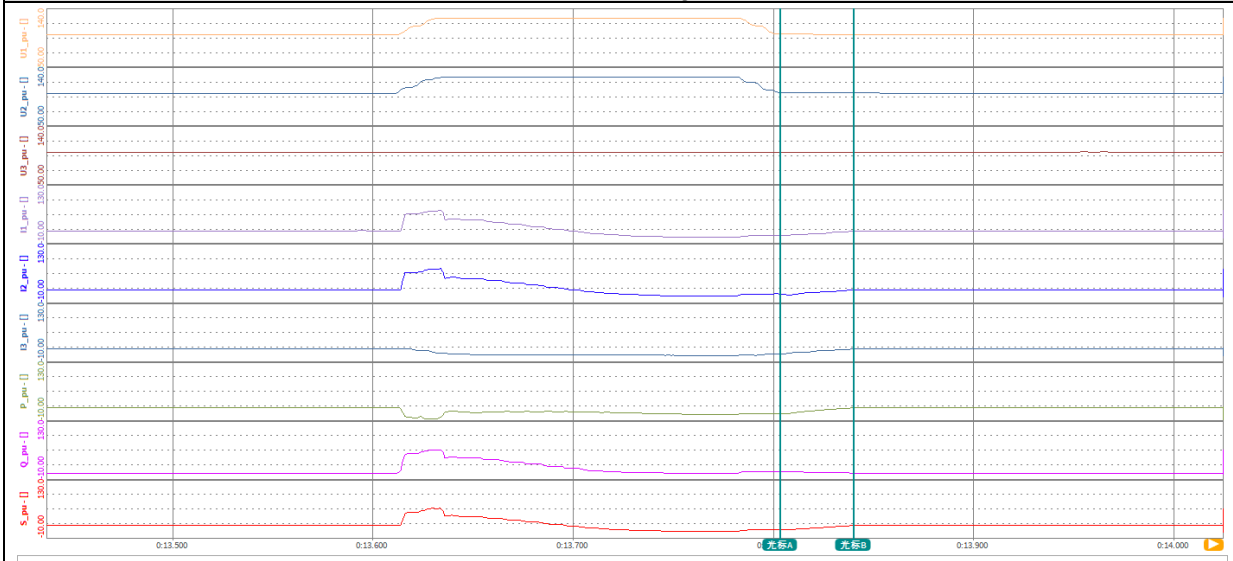
	A	B	间隔
时间 [s]	0:13.6129903	0:13.6337229	0.0207326
U1_pu []	100.1956	124.6249	24.42936
U2_pu []	100.1732	124.3209	24.14770
U3_pu []	100.1782	99.96821	-0.209974
I1_pu []	20.21167	68.61837	48.40670
I2_pu []	20.20029	70.07268	49.87239
I3_pu []	20.13333	8.360327	-11.77301
P_pu []	20.09656	-6.510872	-26.60743
Q_pu []	2.217777	59.97705	57.75927
S_pu []	20.21856	60.32941	40.11085

DipTime



	A	B	间隔
时间 [s]	0:13.6335682	0:13.7830752	0.1495070
U1_pu []	124.6249	124.8438	0.218891
U2_pu []	124.3209	125.2044	0.883577
U3_pu []	99.96821	100.0896	0.121354
I1_pu []	68.61837	4.139095	-64.47927
I2_pu []	70.07268	3.867884	-66.20480
I3_pu []	8.360327	3.421915	-4.938412
P_pu []	-6.510872	3.042429	9.553301
Q_pu []	59.97705	3.286264	-56.69078
S_pu []	60.32941	4.478382	-55.85103

Power Recovery time

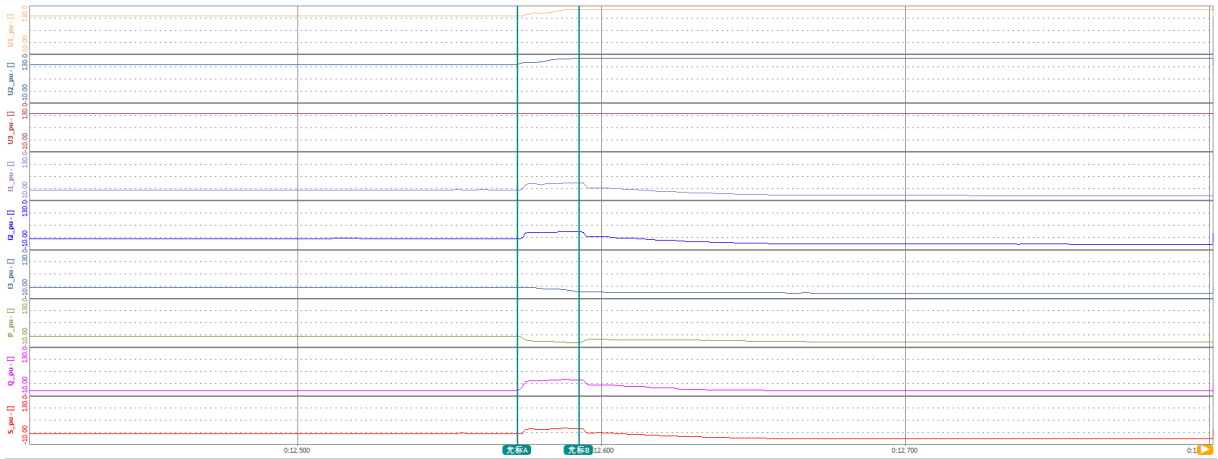


	A	B	间隔
时间 [s]	0:13.8034841	0:13.8400302	0.0365461
U1_pu []	100.4749	100.2561	-0.218818
U2_pu []	100.8670	100.4891	-0.377914
U3_pu []	100.0860	100.3499	0.263844
I1_pu []	9.250113	18.67416	9.424045
I2_pu []	10.18485	18.37655	8.191704
I3_pu []	7.522263	18.37364	10.85138
P_pu []	5.256582	18.21593	12.95934
Q_pu []	7.344720	3.462640	-3.882080
S_pu []	9.031975	18.54211	9.510137

Two-Phase fault

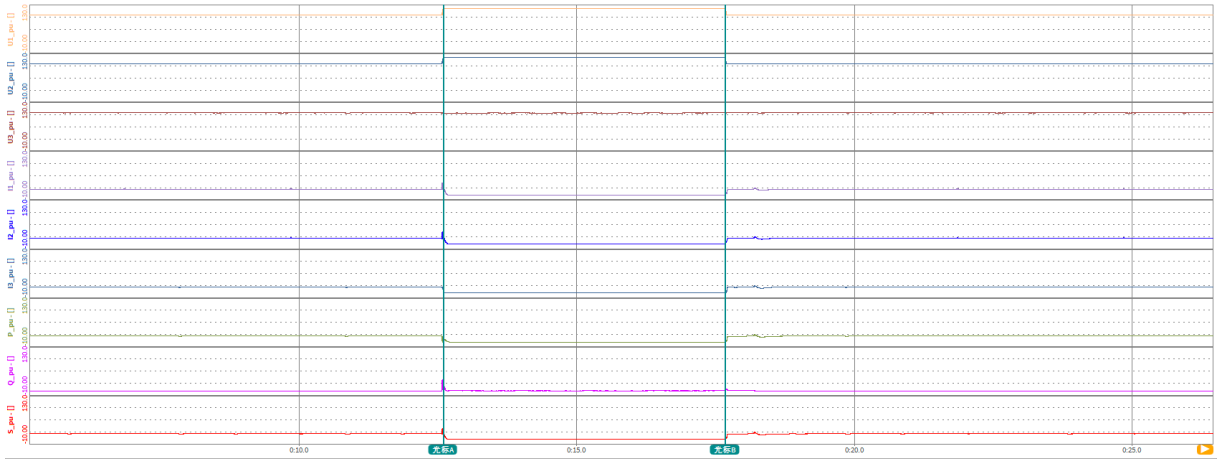
Partial load (20%Pn) | Residual voltage: 120.0%Un

Voltage Rise time



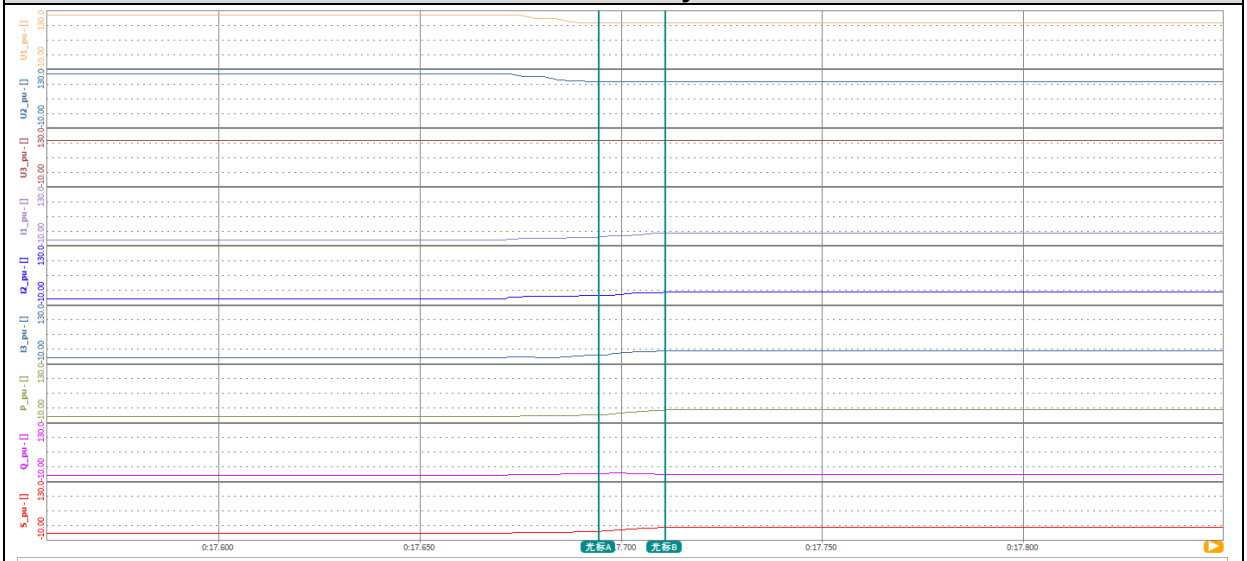
时间 [s]	A 0:12.57239	B 0:12.59265	间隔 0.02026
U1_pu []	100.3248	119.7097	19.38494
U2_pu []	100.0932	119.4439	19.35064
U3_pu []	100.1311	99.96830	-0.162771
I1_pu []	20.26254	39.40681	19.14427
I2_pu []	20.28127	39.84938	19.56811
I3_pu []	20.11267	7.288304	-12.82437
P_pu []	20.13040	0.261554	-19.86885
Q_pu []	2.250848	34.01813	31.76729
S_pu []	20.25585	34.01914	13.76329

DipTime



时间 [s]	A 0:12.59566	B 0:17.67174	间隔 5.07608
U1_pu []	119.8421	120.2056	0.363464
U2_pu []	119.6974	120.1442	0.446804
U3_pu []	99.97294	100.1619	0.188964
I1_pu []	28.66547	3.272365	-25.39311
I2_pu []	26.19618	3.346687	-22.84949
I3_pu []	7.086718	3.428252	-3.658466
P_pu []	8.442422	2.057395	-6.385027
Q_pu []	22.74871	3.190187	-19.55852
S_pu []	24.26475	3.796072	-20.46868

Power Recovery time

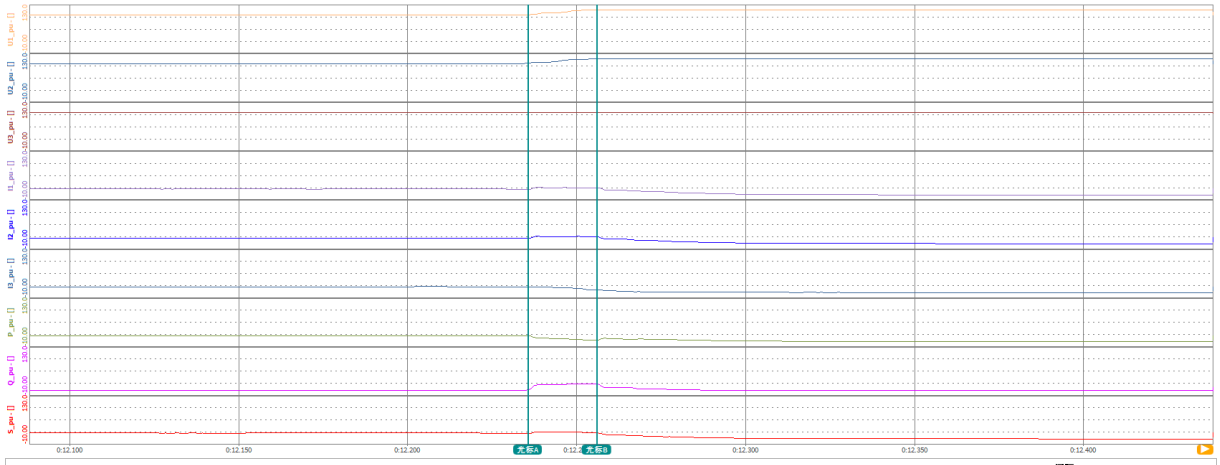


	A	B	间隔
时间 [s]	0:17.694384	0:17.710823	0.016439
U1_pu []	100.5254	100.4953	-0.030080
U2_pu []	100.5518	100.5720	0.020274
U3_pu []	100.1971	100.4043	0.207208
I1_pu []	8.438061	18.68813	10.25007
I2_pu []	11.13158	18.11163	6.980053
I3_pu []	8.068690	19.24376	11.17507
P_pu []	6.509161	18.03765	11.52849
Q_pu []	6.576848	5.200937	-1.375912
S_pu []	9.253330	18.77250	9.519168

Two-Phase fault

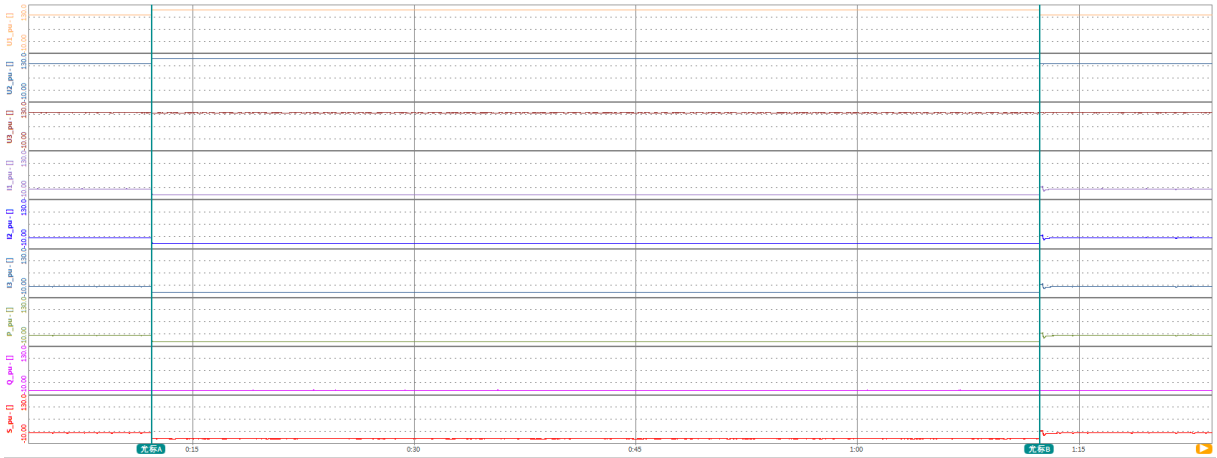
Partial load (20%Pn)	Residual voltage: 115.0%Un

Voltage Rise time



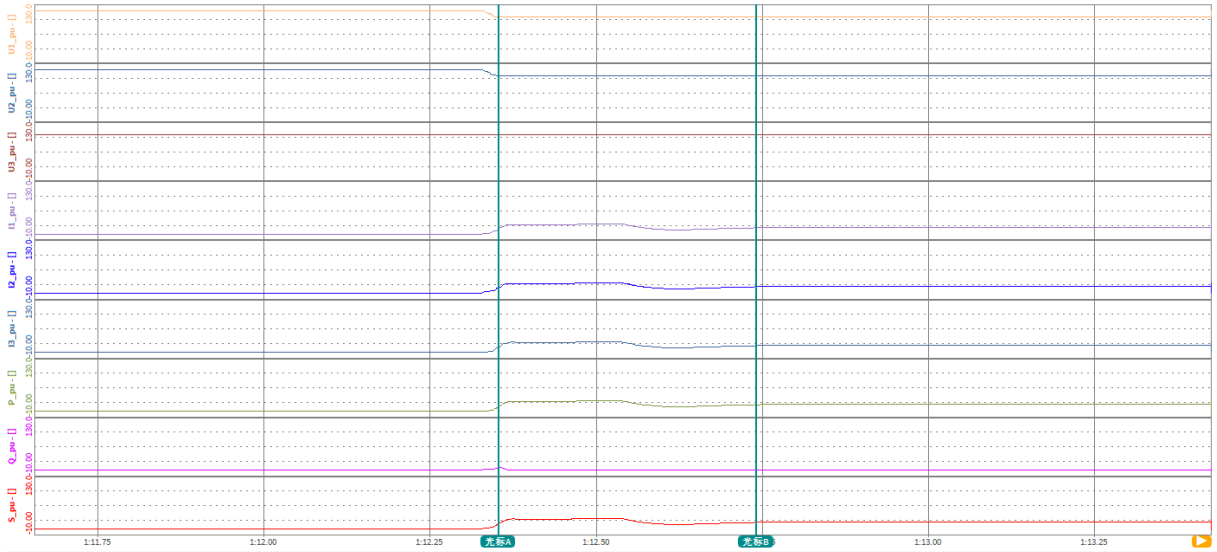
	A	B	间隔
时间 [s]	0:12.235667	0:12.256057	0.020389
U1_pu []	100.2263	114.8236	14.59739
U2_pu []	100.6955	114.6526	13.95707
U3_pu []	100.1926	100.0259	-0.166653
I1_pu []	20.24919	23.24907	2.999884
I2_pu []	19.90366	23.76040	3.856738
I3_pu []	20.07112	10.15315	-9.917966
P_pu []	19.93763	6.423200	-13.51443
Q_pu []	2.910556	20.37594	17.46538
S_pu []	20.14895	21.36437	1.215420

DipTime



	A	B	间隔
时间 [s]	0:12.23913	1:12.31259	1:00.07347
U1_pu []	103.5002	115.1585	11.65833
U2_pu []	105.0674	115.1388	10.07140
U3_pu []	100.1864	100.1978	0.011371
I1_pu []	24.71641	2.913524	-21.80288
I2_pu []	24.52809	3.073318	-21.45477
I3_pu []	19.92268	3.243659	-16.67902
P_pu []	12.72753	1.680719	-11.04681
Q_pu []	20.07636	2.933975	-17.14239
S_pu []	23.77079	3.381276	-20.38951

Power Recovery time

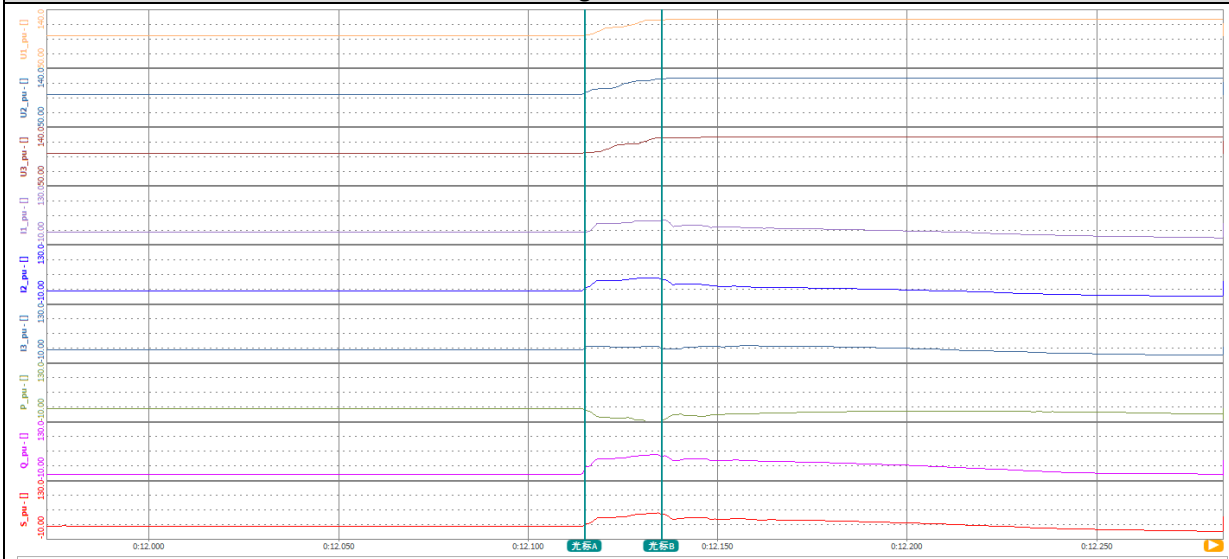


	A	B	间隔
时间 [s]	1:12.353191	1:12.740968	0.387777
U1_pu []	100.5983	100.1863	-0.412014
U2_pu []	100.6186	100.1682	-0.450420
U3_pu []	100.3519	100.2055	-0.146405
I1_pu []	11.45371	18.22336	6.769648
I2_pu []	14.38828	18.21890	3.830623
I3_pu []	13.54165	18.23214	4.690489
P_pu []	11.05604	18.12738	7.071335
Q_pu []	7.204554	2.186919	-5.017635
S_pu []	13.19628	18.25882	5.062542

Three-Phase fault

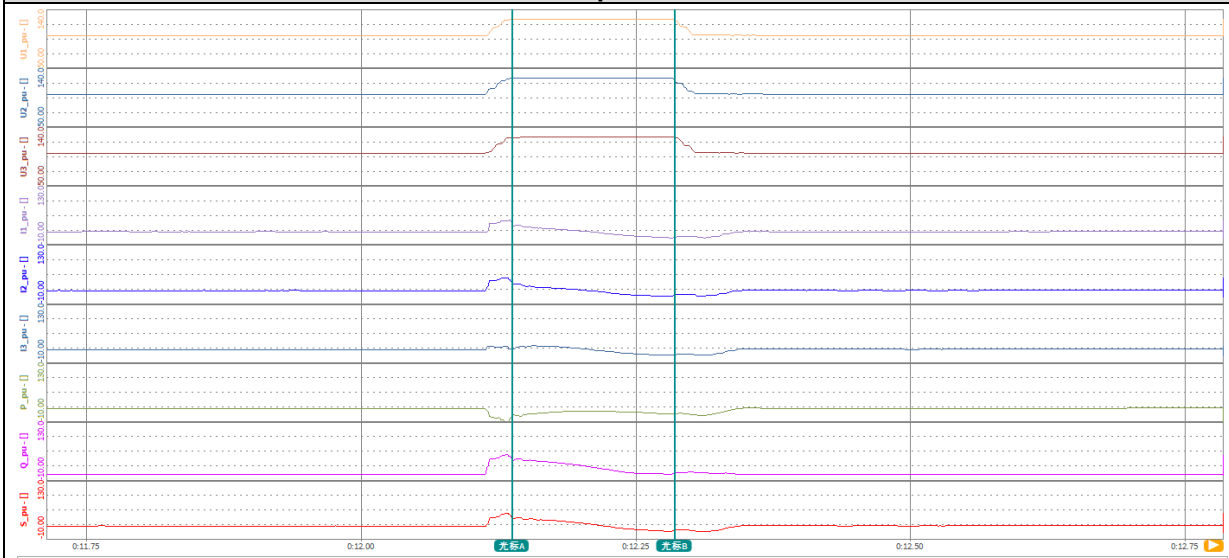
Partial load (20%Pn) | Residual voltage: 125.0%Un

Voltage Rise time



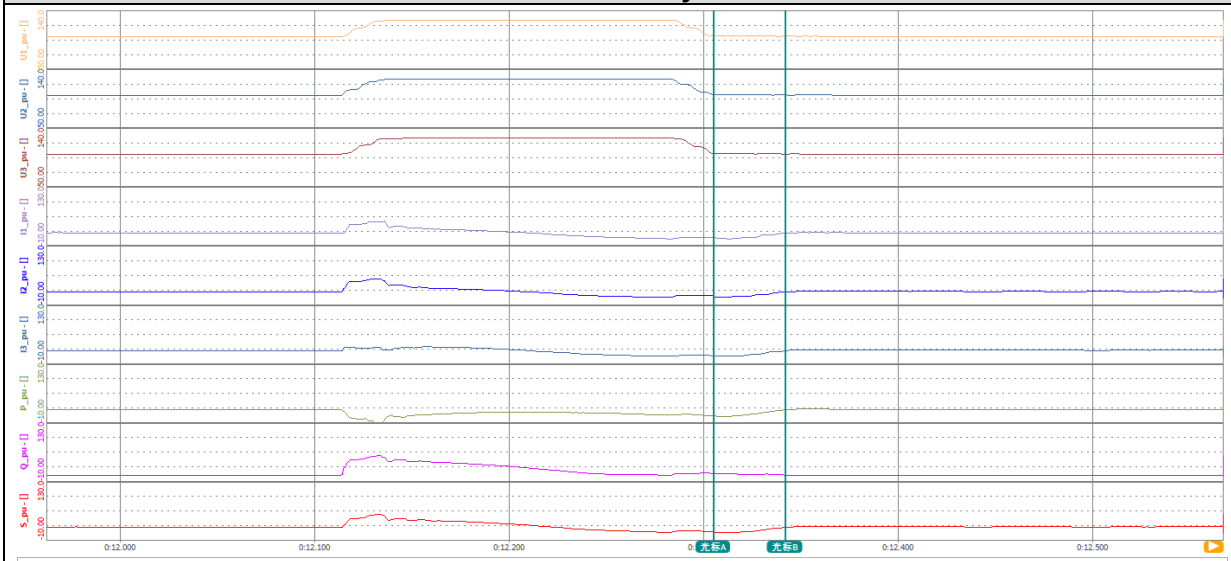
	A	B	间隔
时间 [s]	0:12.1150397	0:12.1352511	0.0202113
U1_pu []	100.1841	124.2547	24.07063
U2_pu []	100.3629	124.3252	23.96236
U3_pu []	100.3331	124.3400	24.00690
I1_pu []	20.24622	46.51803	26.27181
I2_pu []	20.13800	50.70570	30.56770
I3_pu []	20.15556	28.20617	8.050605
P_pu []	19.90496	-14.47348	-34.37844
Q_pu []	3.662411	49.91474	46.25233
S_pu []	20.23909	51.97079	31.73170

DipTime



	A	B	间隔
时间 [s]	0:12.1374928	0:12.2853770	0.1478842
U1_pu []	124.5085	124.9804	0.471868
U2_pu []	124.4751	125.0024	0.527238
U3_pu []	124.3986	125.0485	0.649812
I1_pu []	47.59530	5.556400	-42.03890
I2_pu []	47.34843	6.941175	-40.40726
I3_pu []	20.42478	6.390652	-14.03413
P_pu []	-5.394212	6.344191	11.73840
Q_pu []	47.56355	4.658434	-42.90512
S_pu []	47.86846	7.870818	-39.99764

Power Recovery time

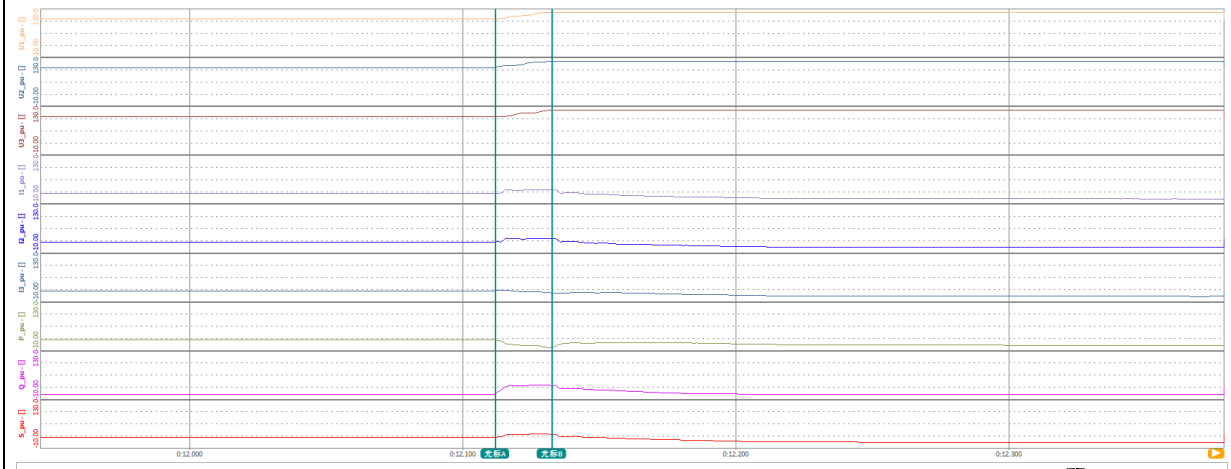


	A	B	间隔
时间 [s]	0:12.3050155	0:12.3418697	0.0368541
U1_pu []	100.5439	100.3972	-0.146750
U2_pu []	100.4969	100.4988	1.818e-3
U3_pu []	100.4220	100.2589	-0.163163
I1_pu []	8.858946	19.52396	10.66502
I2_pu []	10.75728	18.50260	7.745327
I3_pu []	7.639035	18.70813	11.06910
P_pu []	4.934187	18.58701	13.65282
Q_pu []	7.681501	3.863589	-3.817912
S_pu []	9.129713	18.98432	9.854605

Three-Phase fault

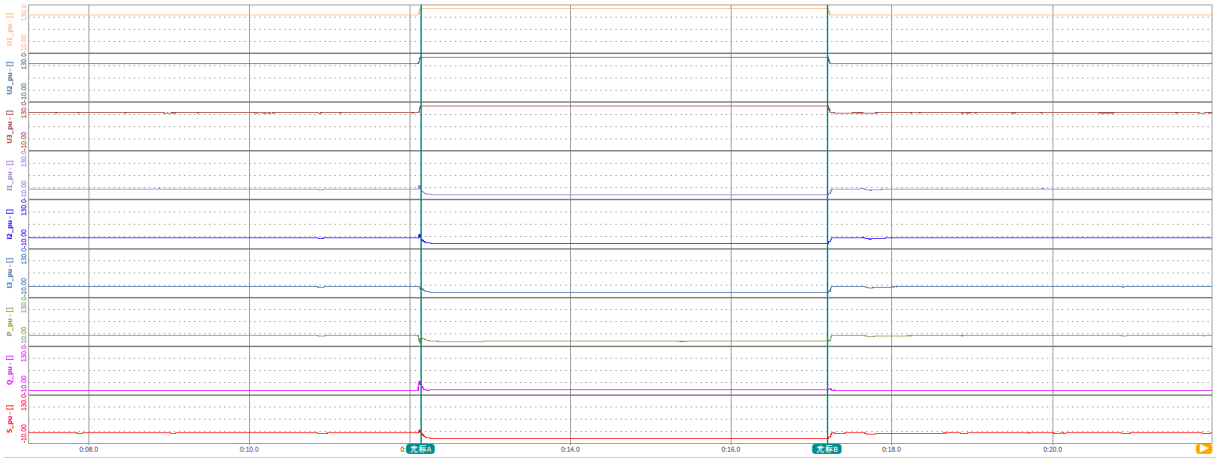
Partial load (20%Pn)	Residual voltage: 120.0%Un

Voltage Rise time



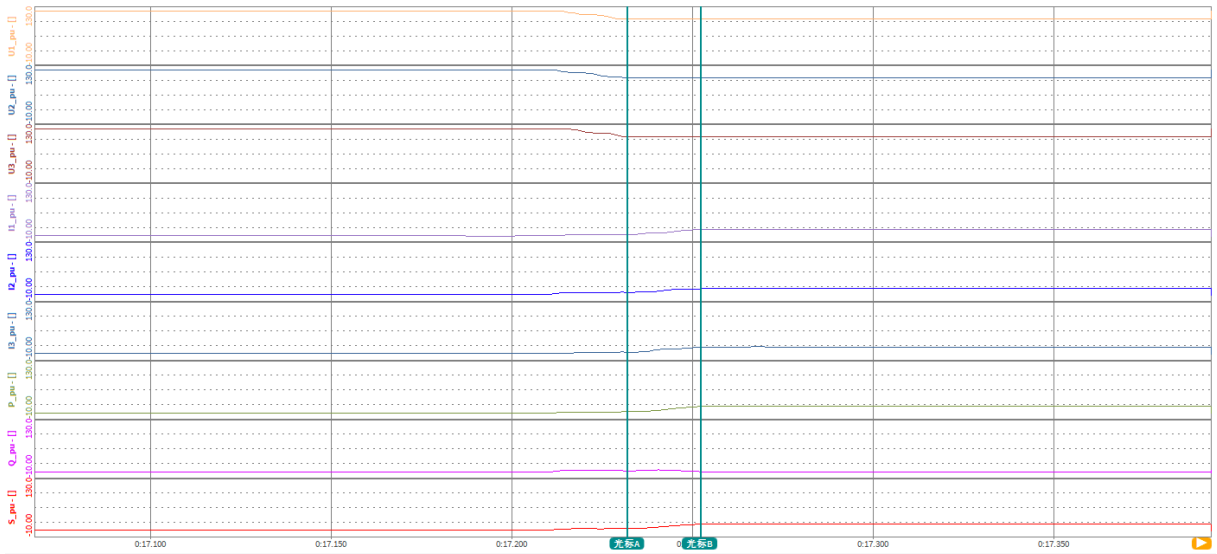
	A	B	间隔
时间 [s]	0:12.11194	0:12.13266	0.02072
U1_pu []	100.1844	119.5664	19.38206
U2_pu []	100.1791	119.3858	19.20669
U3_pu []	100.1713	119.4724	19.30108
I1_pu []	20.12333	29.46039	9.337065
I2_pu []	20.18914	29.57827	9.389132
I3_pu []	20.13894	14.32029	-5.818652
P_pu []	20.05816	-2.842623	-22.90078
Q_pu []	2.271686	29.07663	26.80495
S_pu []	20.18638	29.21526	9.028871

DipTime



	A	B	间隔
时间 [s]	0:12.13862	0:17.19552	5.05690
U1_pu []	119.8160	120.2030	0.386963
U2_pu []	119.8297	120.1177	0.288033
U3_pu []	119.5898	119.9371	0.347356
I1_pu []	20.76598	3.521938	-17.24405
I2_pu []	20.98224	3.757718	-17.22453
I3_pu []	13.17767	3.683302	-9.494372
P_pu []	9.839708	2.944551	-6.895157
Q_pu []	19.59602	3.253694	-16.34233
S_pu []	21.92770	4.388270	-17.53943

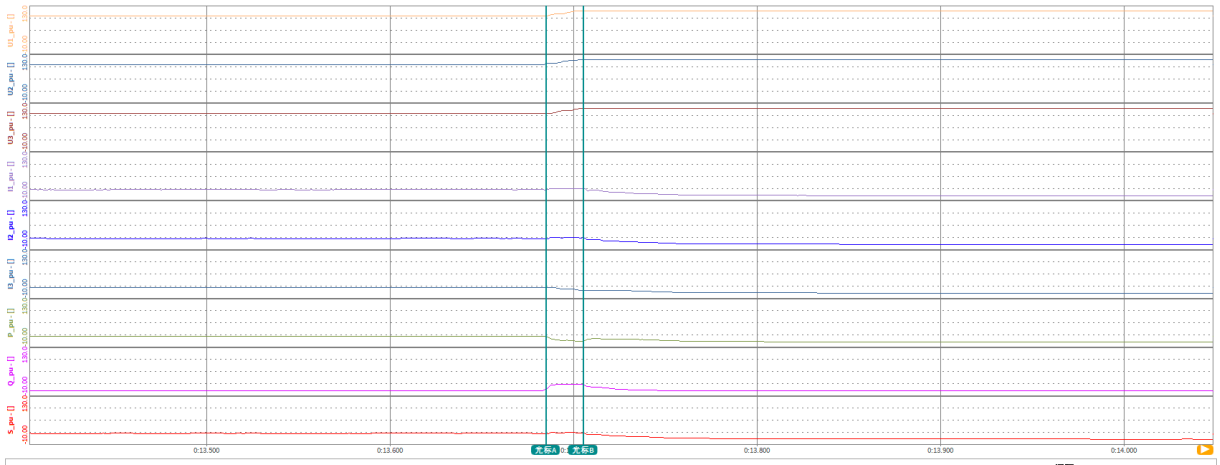
Power Recovery time



	A	B	间隔
时间 [s]	0:17.232087	0:17.252195	0.020108
U1_pu []	100.4762	100.4905	0.014264
U2_pu []	100.5218	100.5574	0.035626
U3_pu []	100.4555	100.4648	9.295e-3
I1_pu []	6.878630	18.29461	11.41598
I2_pu []	9.249329	18.08606	8.836727
I3_pu []	7.593068	19.51686	11.92379
P_pu []	5.779276	18.34699	12.56771
Q_pu []	5.452676	3.749817	-1.702858
S_pu []	7.945546	18.72627	10.78072

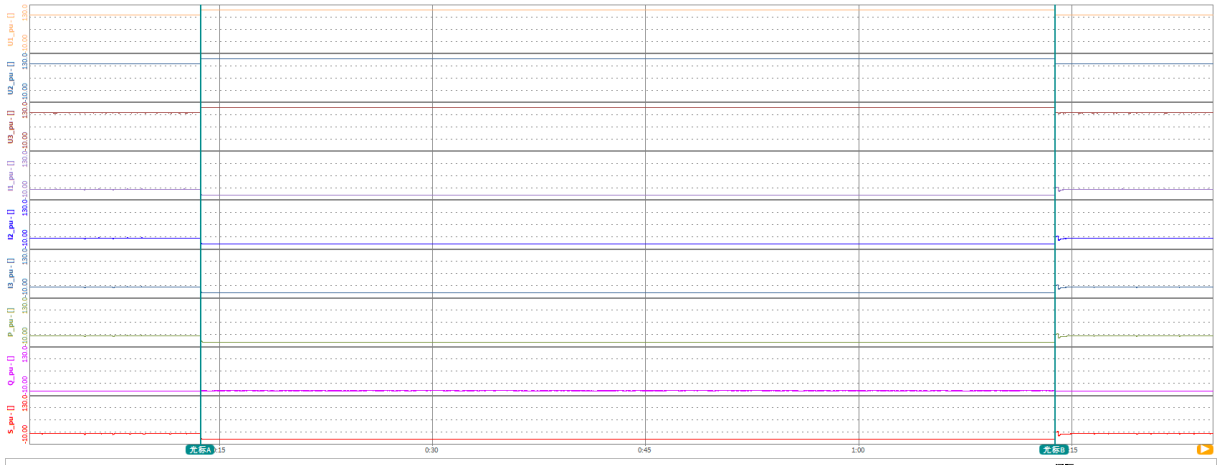
Three-Phase fault	
Partial load (20%Pn)	Residual voltage: 115.0%Un

Voltage Rise time



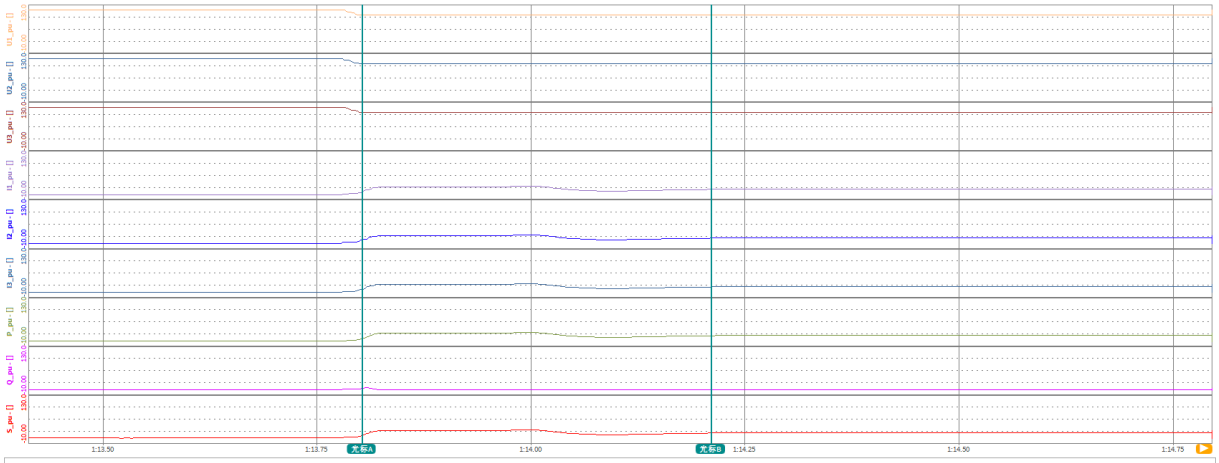
	A	B	间隔
时间 (s)	0:13.685093	0:13.705395	0.020302
U1_pu []	100.2319	114.7700	14.53810
U2_pu []	101.5875	114.6970	13.10950
U3_pu []	100.7284	114.7668	14.03846
I1_pu []	20.22282	23.28947	3.066652
I2_pu []	19.41747	22.23054	2.813071
I3_pu []	19.95942	10.87225	-9.087173
P_pu []	18.99867	4.481870	-14.51680
Q_pu []	6.355186	21.09747	14.74229
S_pu []	20.03342	21.56828	1.534861

DipTime



	A	B	间隔
时间 (s)	0:13.704595	1:13.780237	1:00.075641
U1_pu []	114.6087	115.0344	0.425733
U2_pu []	114.5518	115.1996	0.647782
U3_pu []	114.6368	115.2330	0.596168
I1_pu []	23.21403	3.153314	-20.06072
I2_pu []	22.10227	3.245029	-18.85724
I3_pu []	11.05519	3.301482	-7.753711
P_pu []	3.850394	1.926476	-1.923918
Q_pu []	21.18533	3.186225	-17.99910
S_pu []	21.53239	3.723350	-17.80904

Power Recovery time



时间 [s]	A 1:13.8026000	B 1:14.2101683	间隔 0.4075684
U1_pu []	100.5194	100.2294	-0.290010
U2_pu []	100.5435	100.1725	-0.370968
U3_pu []	100.5293	100.2019	-0.327480
I1_pu []	8.059584	18.23607	10.17648
I2_pu []	10.47692	18.19922	7.722295
I3_pu []	10.69735	18.19757	7.500227
P_pu []	8.072186	18.10346	10.03127
Q_pu []	5.550657	2.289082	-3.261575
S_pu []	9.796427	18.24761	8.451181

4.2.3.2 *Load Tests: Full Load (100%Pn)*

Test results of full power cases performed are offered below:

Single-Phase fault							
Residual voltage Desired (%Un)	Voltage before Recovery (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.3	20	124.5	> 120	148	61	100.3
120.0	100.3	20	119.5	> 5000	5050	74	100.3
115.0	100.4	20	114.5	> 60000	60001	64	99.9

Two-Phase fault							
Residual voltage Desired (%Un)	Voltage before Recovery (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.3	20	124.3	> 120	145	94	100.3
120.0	100.3	20	119.3	> 5000	5062	78	100.3
115.0	100.4	20	114.3	> 60000	6001	72	99.9

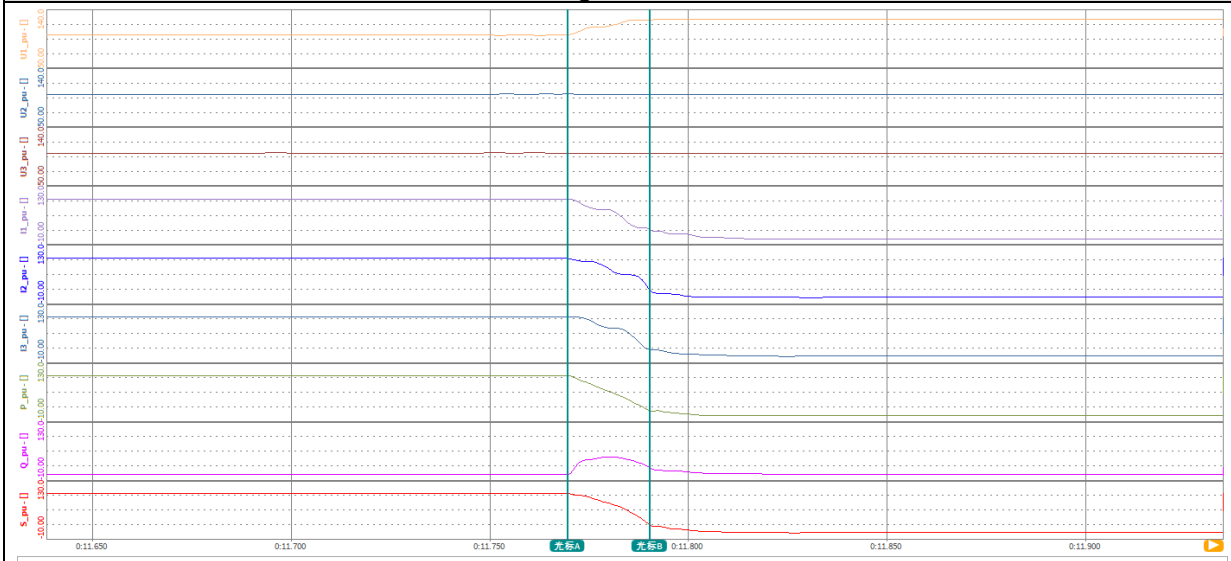
Three-Phase fault							
Residual voltage Desired (%Un)	Voltage before Recovery (%Un)	Voltage Rise time (ms)	Residual voltage Measured (%Un)	DipTime (ms)		Power Recovery time (ms)	Voltage after Recovery (%Un)
				Desired	Meas.		
125.0	100.3	21	124.3	> 120	146	86	100.3
120.0	100.3	20	119.3	> 5000	5050	92	100.3
115.0	100.4	20	114.5	> 60000	6004	76	99.9

Remark: The virtual neutral line was used in the test.

Test results are graphically represented at following pages.
Note: The following test figure the voltage unit of U1_pu, U2_pu and U3_pu are **%Un** , the current unit of I1_pu, I2_pu and I3_pu are **%In** and the power unit is **%Pn**

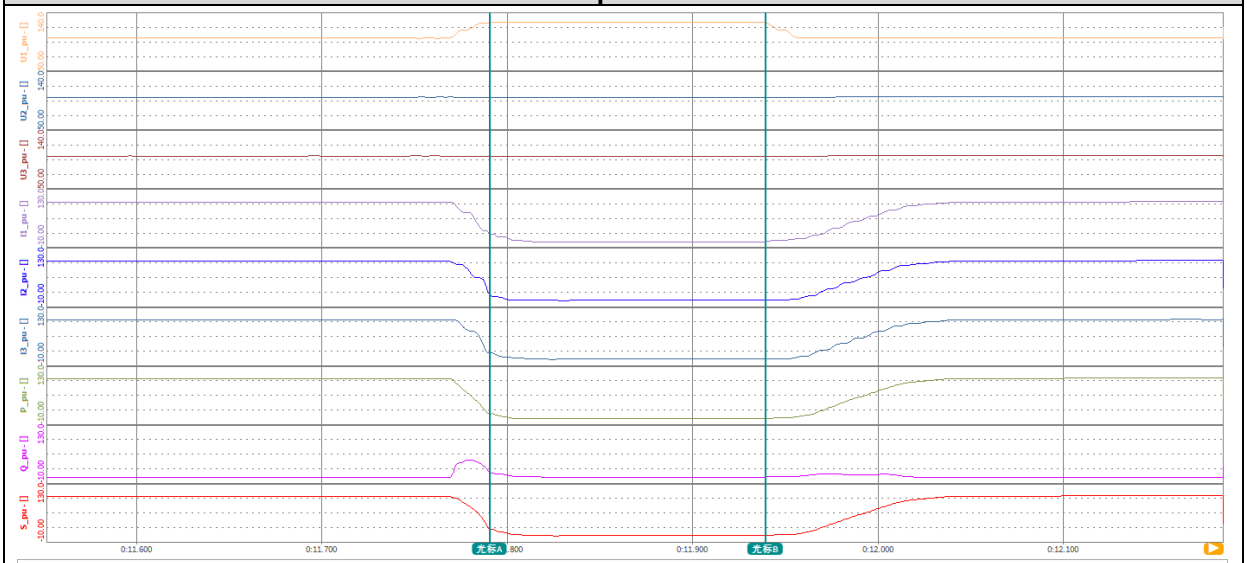
Single-Phase fault	
Partial load (20%Pn)	Residual voltage: 125.0%Un

Voltage Rise time



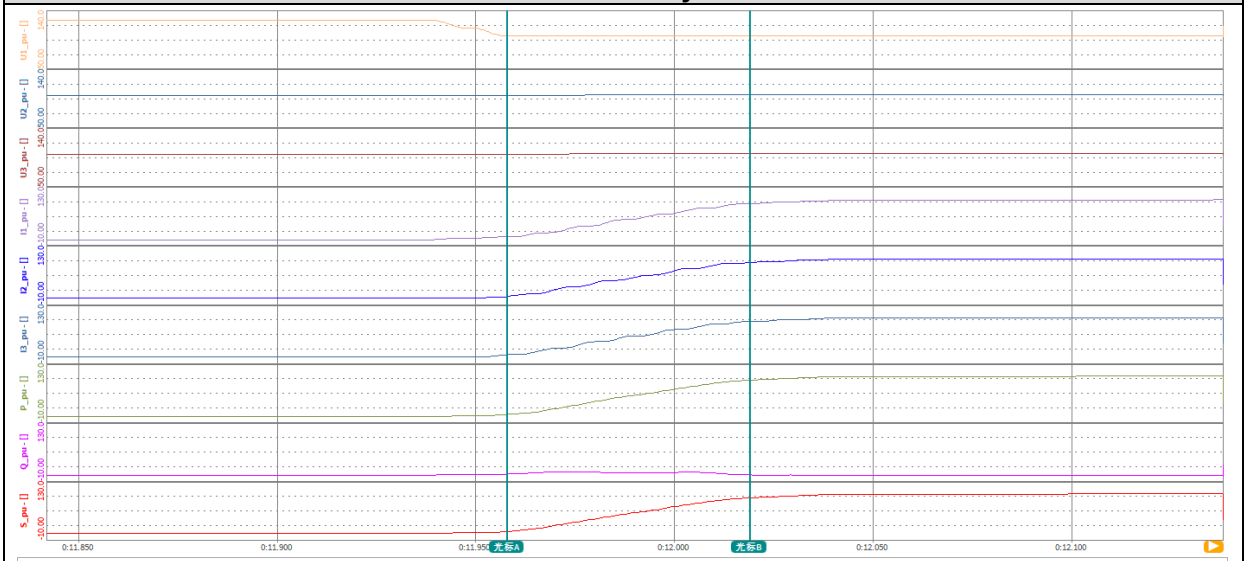
时间 [s]	A 0:11.7696659	B 0:11.7903223	间隔 0.0206564
U1_pu []	100.4999	124.5320	24.03213
U2_pu []	100.4175	99.53755	-0.879981
U3_pu []	100.3192	99.76772	-0.551433
I1_pu []	97.89409	29.58552	-68.30856
I2_pu []	97.91222	35.69512	-62.21709
I3_pu []	97.92855	23.06209	-74.86645
P_pu []	98.26416	20.12355	-78.14061
Q_pu []	3.167622	24.61507	21.44745
S_pu []	98.31520	31.79401	-66.52119

DipTime



时间 [s]	A 0:11.7907918	B 0:11.9394756	间隔 0.1486838
U1_pu []	124.4890	124.8180	0.329019
U2_pu []	99.47897	99.87815	0.399177
U3_pu []	99.76633	99.97391	0.207579
I1_pu []	25.86992	3.045409	-22.82451
I2_pu []	20.77837	3.791540	-16.98683
I3_pu []	19.35879	4.068402	-15.29039
P_pu []	15.69115	2.288022	-13.40312
Q_pu []	18.24319	3.139972	-15.10322
S_pu []	24.06296	3.885160	-20.17780

Power Recovery time

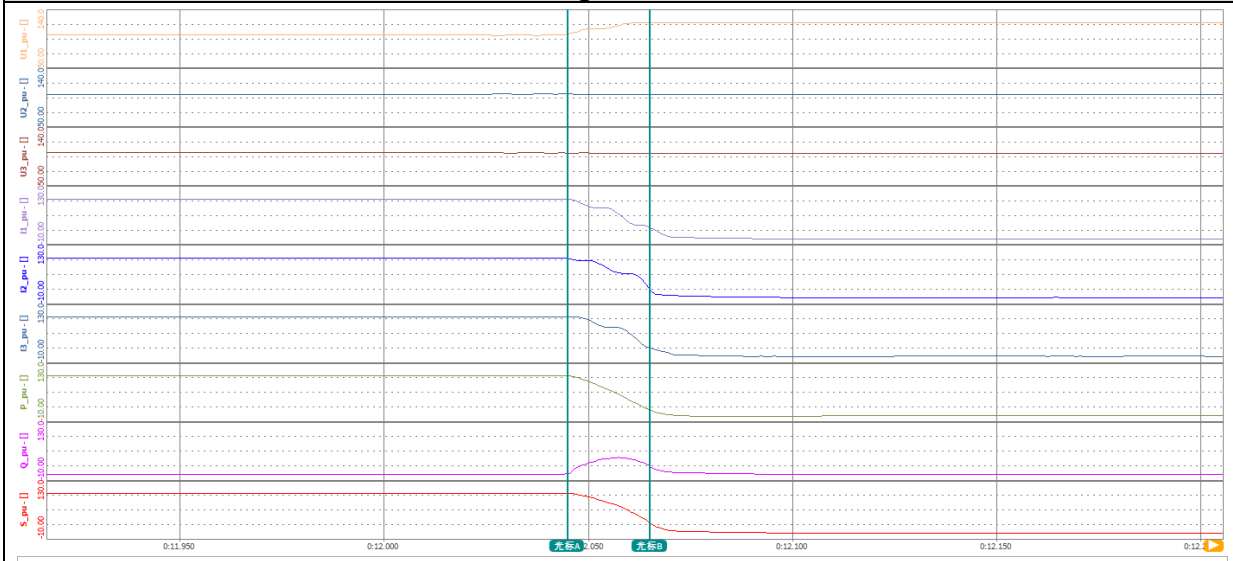


	A	B	间隔
时间 [s]	0:11.9578631	0:12.0188583	0.0609952
U1_pu []	100.4703	100.4603	-9.951e-3
U2_pu []	99.89828	100.7065	0.808198
U3_pu []	100.0571	100.7093	0.652207
I1_pu []	10.17800	89.50722	79.32922
I2_pu []	7.164757	89.62625	82.46149
I3_pu []	9.771075	90.25939	80.48832
P_pu []	7.108971	90.28136	83.17239
Q_pu []	5.605833	3.755712	-1.850120
S_pu []	9.053333	90.35945	81.30611

Single-Phase fault

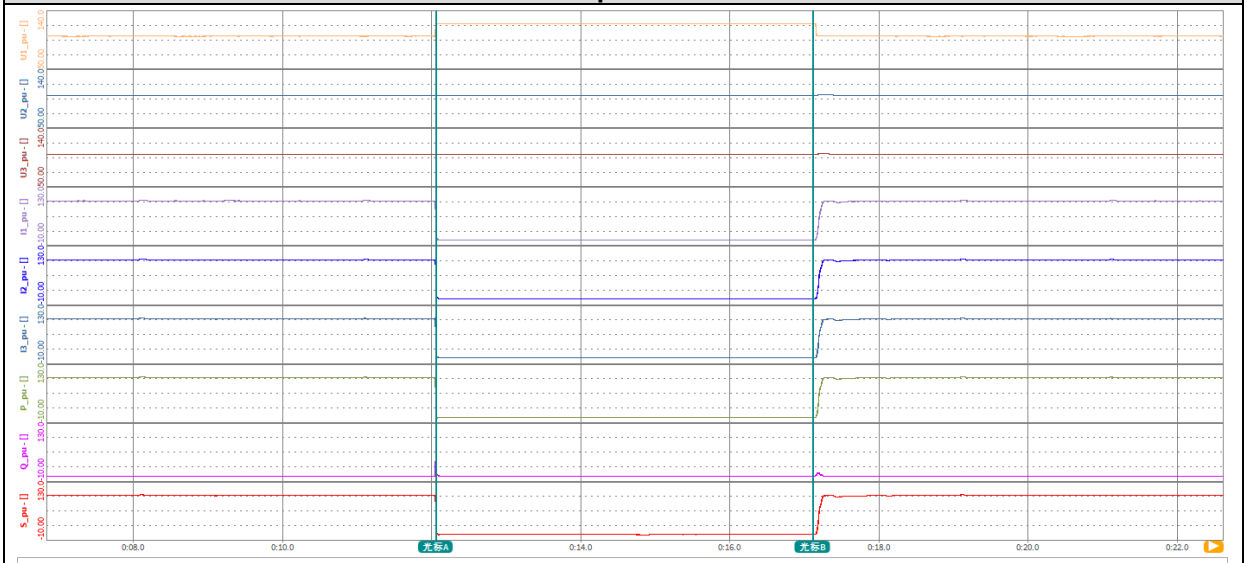
Partial load (20%Pn)	Residual voltage: 120.0%Un

Voltage Rise time



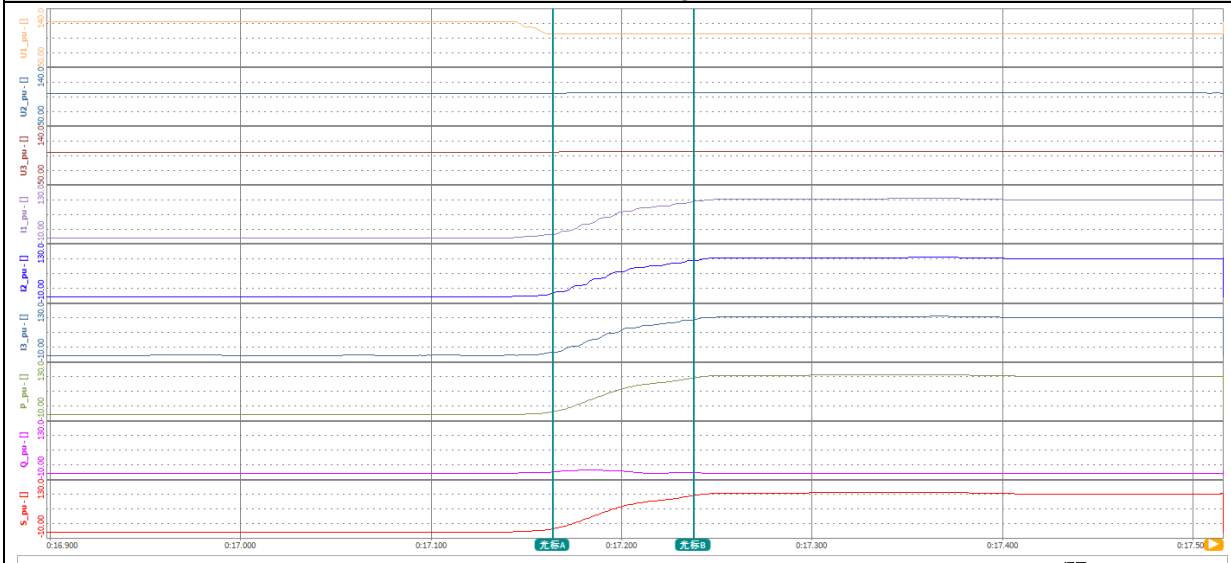
	A	B	间隔
时间 [s]	0:12.04485	0:12.06510	0.02024
U1_pu []	100.7448	119.5302	18.78534
U2_pu []	100.4420	99.47246	-0.969543
U3_pu []	100.3205	99.73645	-0.584047
I1_pu []	97.93853	33.94674	-63.99178
I2_pu []	97.86684	32.82796	-65.03888
I3_pu []	98.20872	25.51240	-72.69632
P_pu []	98.42775	19.07874	-79.34901
Q_pu []	3.692063	26.79361	23.10155
S_pu []	98.49697	32.89218	-65.60479

DipTime



	A	B	间隔
时间 [s]	0:12.06217	0:17.11302	5.05085
U1_pu []	119.3104	120.3163	1.005966
U2_pu []	99.71722	100.1105	0.393325
U3_pu []	99.92572	100.2232	0.297513
I1_pu []	36.74579	2.911773	-33.83402
I2_pu []	58.50608	3.293823	-55.21226
I3_pu []	48.90781	3.634271	-45.27354
P_pu []	33.80689	1.814740	-31.99215
Q_pu []	37.31406	2.970608	-34.34345
S_pu []	50.35122	3.481062	-46.87016

Power Recovery time

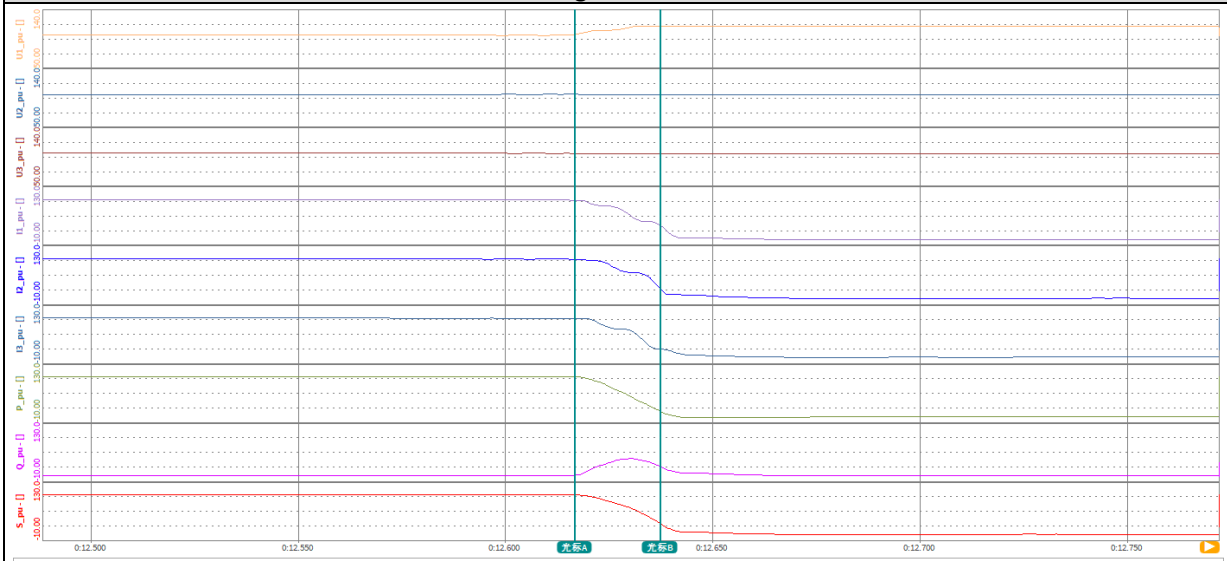


	A	B	间隔
时间 [s]	0:17.16387	0:17.23778	0.07391
U1_pu []	100.7216	100.8288	0.107157
U2_pu []	100.2287	100.8711	0.642475
U3_pu []	100.3467	100.8970	0.550258
I1_pu []	10.24729	89.97911	79.73183
I2_pu []	9.901996	90.94144	81.03945
I3_pu []	11.17961	88.97296	77.79335
P_pu []	8.812800	90.59432	81.78152
Q_pu []	5.686339	5.195625	-0.490713
S_pu []	10.48808	90.74319	80.25510

Single-Phase fault

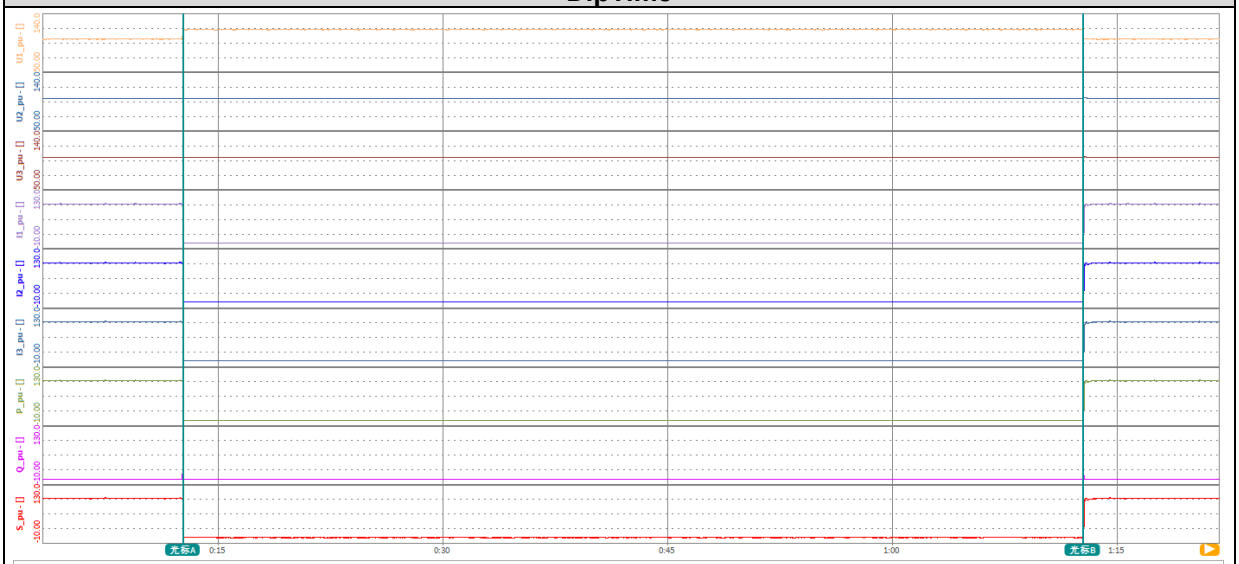
Partial load (20%Pn) | Residual voltage: 115.0%Un

Voltage Rise time



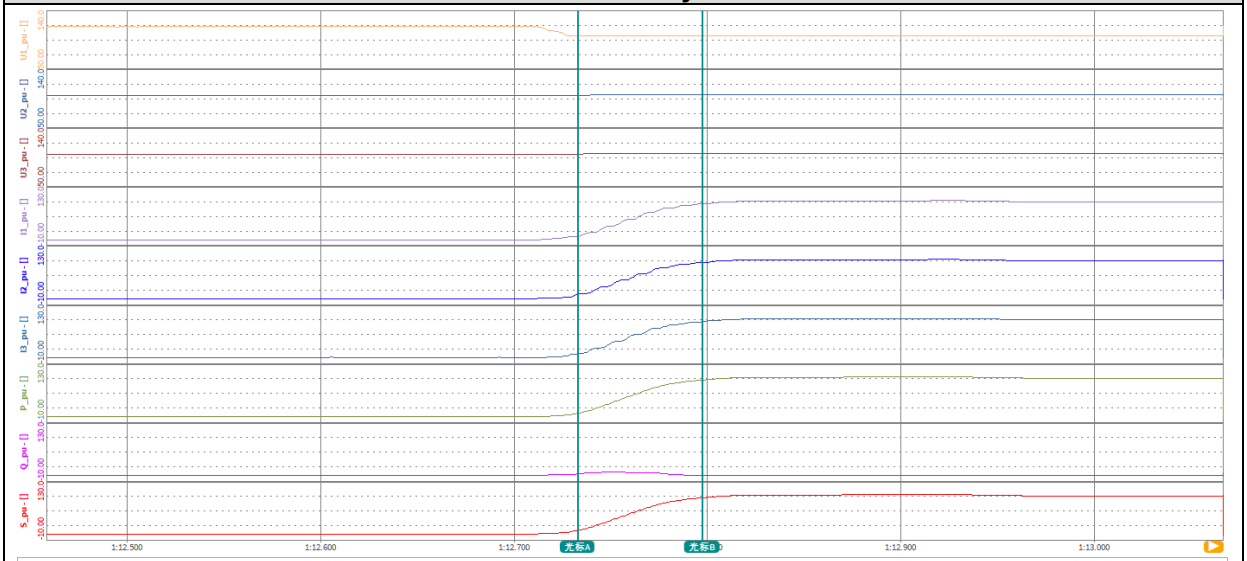
	A	B	间隔
时间 [s]	0:12.61677	0:12.63731	0.02054
U1_pu []	100.5474	114.5256	13.97826
U2_pu []	100.4283	99.41286	-1.015439
U3_pu []	100.3046	99.72467	-0.579973
I1_pu []	97.54677	41.18474	-56.36203
I2_pu []	97.59802	31.16149	-66.43654
I3_pu []	97.54410	23.01274	-74.53136
P_pu []	97.93274	18.52457	-79.40817
Q_pu []	3.021190	28.14991	25.12872
S_pu []	97.97933	33.69833	-64.28100

DipTime



	A	B	间隔
时间 [s]	0:12.66624	1:12.67834	1:00.01210
U1_pu []	114.6342	115.3421	0.707875
U2_pu []	99.46919	100.1039	0.634686
U3_pu []	99.65128	100.2186	0.567295
I1_pu []	2.753052	2.750978	-2.074e-3
I2_pu []	3.747283	3.434710	-0.312573
I3_pu []	3.622307	3.426742	-0.195564
P_pu []	1.330967	1.876207	0.545241
Q_pu []	3.234535	2.773518	-0.461017
S_pu []	3.497669	3.348515	-0.149154

Power Recovery time

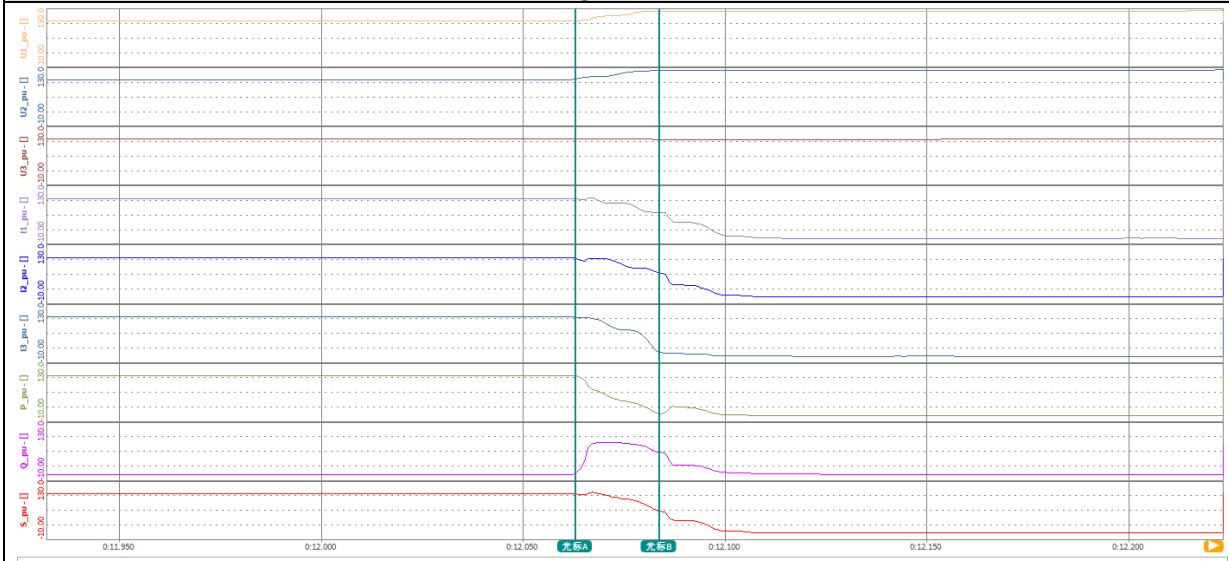


	A	B	间隔
时间 [s]	1:12.73302	1:12.79740	0.06438
U1_pu []	100.6126	100.9000	0.287376
U2_pu []	100.2328	100.8568	0.623998
U3_pu []	100.3462	100.8988	0.552554
I1_pu []	10.36202	90.14645	79.78443
I2_pu []	10.20057	89.75605	79.55549
I3_pu []	11.61007	88.82319	77.21312
P_pu []	9.278405	90.30915	81.03074
Q_pu []	5.461946	3.263706	-2.198240
S_pu []	10.76669	90.36810	79.60141

Two-Phase fault

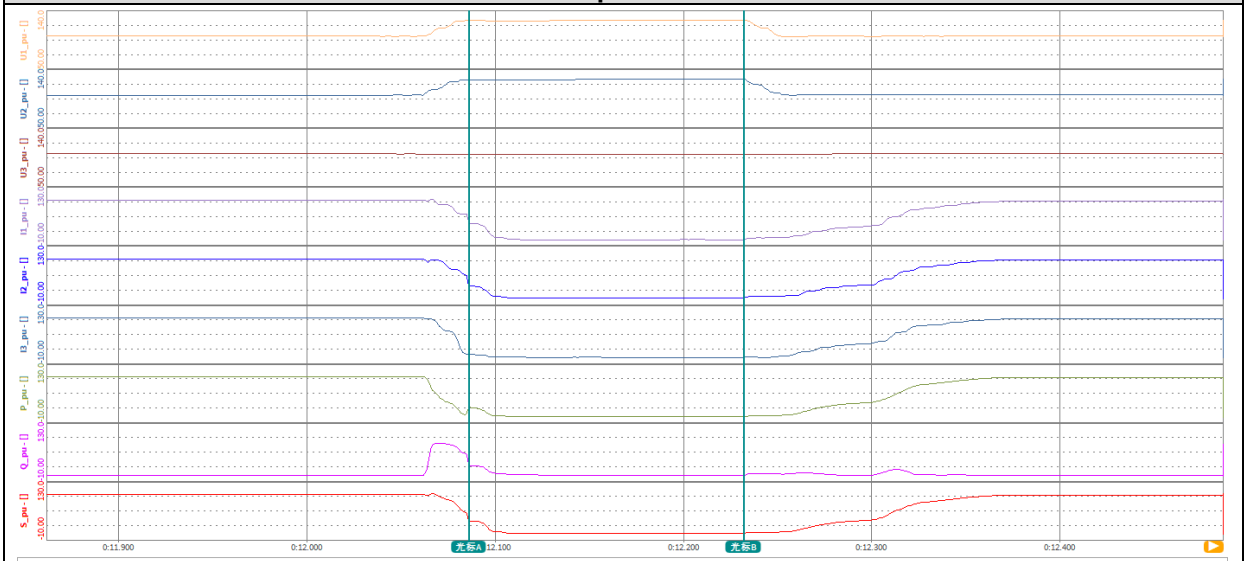
Partial load (20%Pn)	Residual voltage: 125.0%Un

Voltage Rise time



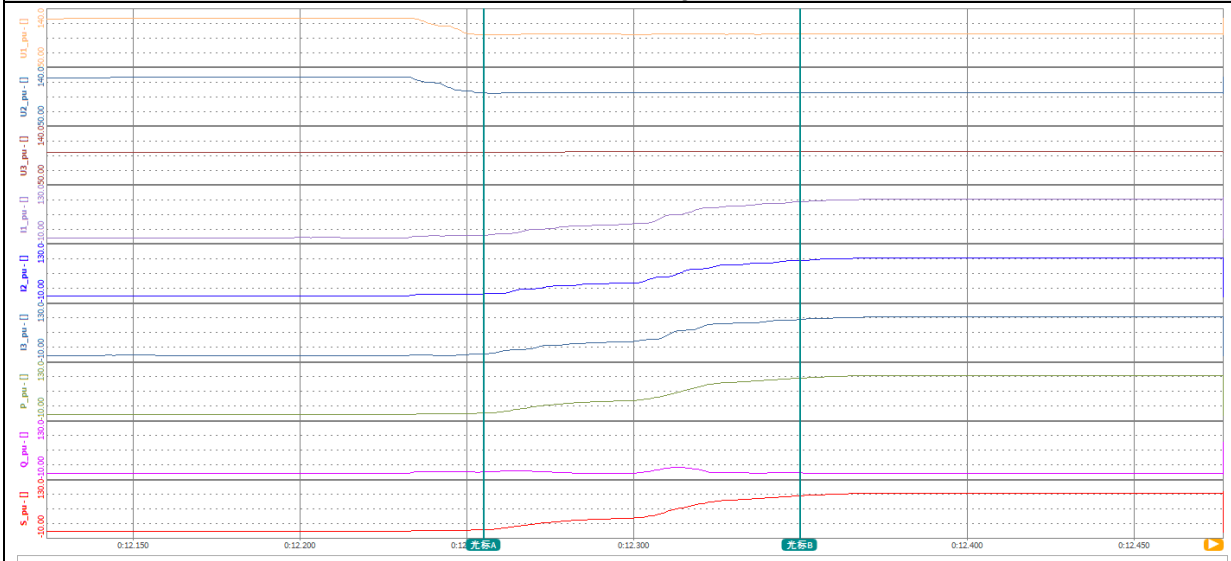
	A	B	间隔
时间 [s]	0:12.0629008	0:12.0836555	0.0207547
U1_pu []	100.4924	124.4772	23.98481
U2_pu []	100.2368	123.9629	23.72604
U3_pu []	100.3192	99.59743	-0.721734
I1_pu []	98.15714	66.06009	-32.09706
I2_pu []	98.02607	63.17186	-34.85422
I3_pu []	97.95884	14.97416	-82.98468
P_pu []	98.35649	9.055033	-89.30146
Q_pu []	2.569774	57.77918	55.20941
S_pu []	98.39006	58.48443	-39.90564

DipTime



	A	B	间隔
时间 [s]	0:12.0863268	0:12.2320456	0.1457188
U1_pu []	124.5866	124.6949	0.108245
U2_pu []	124.2204	124.7842	0.563779
U3_pu []	99.57667	99.97730	0.400636
I1_pu []	64.59261	3.533311	-61.05930
I2_pu []	58.85463	3.627508	-55.22712
I3_pu []	11.82220	3.431831	-8.390368
P_pu []	10.45304	2.375021	-8.078016
Q_pu []	54.11819	3.367967	-50.75022
S_pu []	55.11846	4.121156	-50.99731

Power Recovery time

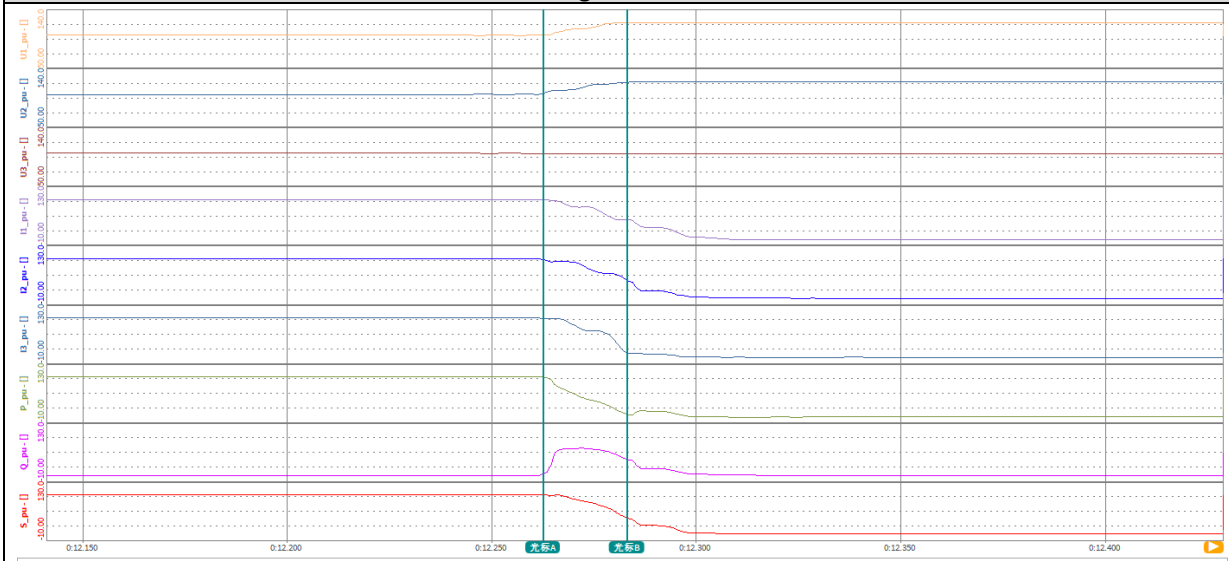


	A	B	间隔
时间 [s]	0:12.2550419	0:12.3497299	0.0946880
U1_pu []	100.3457	100.4731	0.127398
U2_pu []	100.3879	100.5203	0.132367
U3_pu []	99.96078	100.7514	0.790618
I1_pu []	7.770345	90.64632	82.87597
I2_pu []	9.652623	89.81809	80.16546
I3_pu []	7.025867	89.31698	82.29111
P_pu []	5.816346	90.37052	84.55418
Q_pu []	5.737693	3.780223	-1.957470
S_pu []	8.170129	90.44955	82.27943

Two-Phase fault

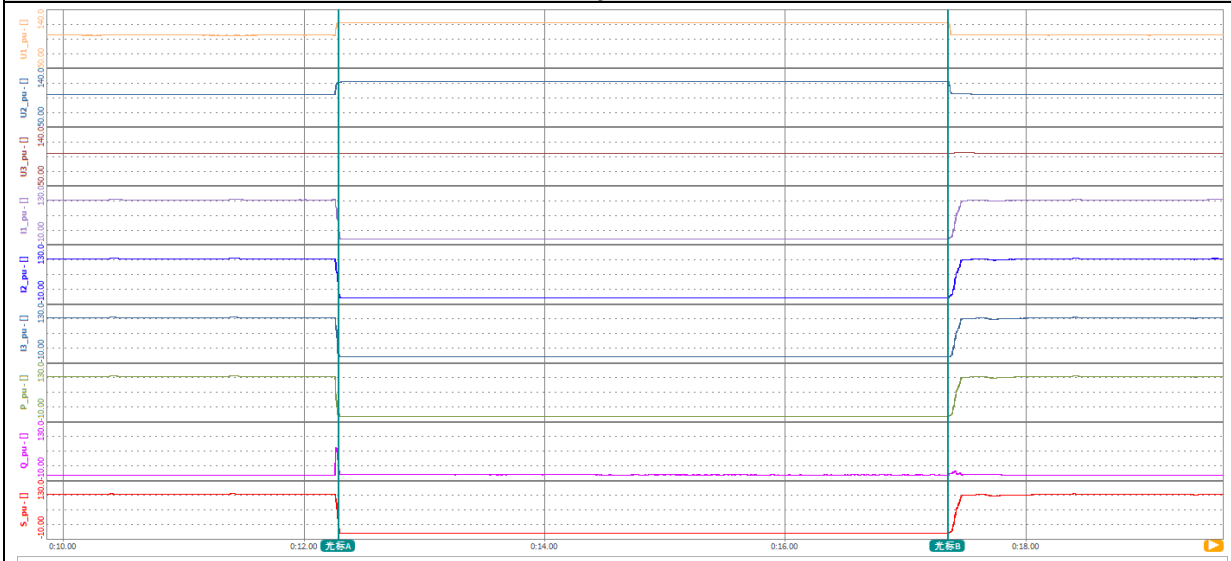
Partial load (20%Pn) | Residual voltage: 120.0%Un

Voltage Rise time



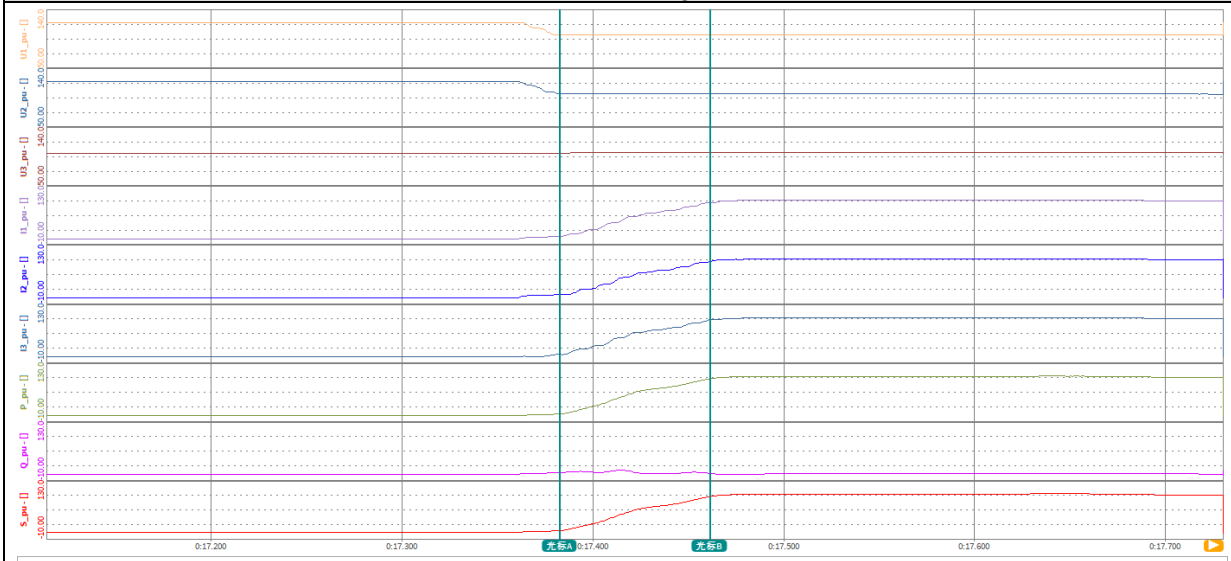
	A	B	间隔
时间 [s]	0:12.26265	0:12.28317	0.02052
U1_pu []	100.5357	119.5205	18.98483
U2_pu []	100.2390	119.0580	18.81906
U3_pu []	100.3448	99.61442	-0.730412
I1_pu []	98.35242	50.94663	-47.40578
I2_pu []	98.18896	49.90881	-48.28015
I3_pu []	98.15635	17.53910	-80.61725
P_pu []	98.56998	10.06702	-88.50296
Q_pu []	2.402026	44.81098	42.40895
S_pu []	98.59924	45.92787	-52.67137

DipTime



	A	B	间隔
时间 [s]	0:12.28879	0:17.35127	5.06248
U1_pu []	119.6240	120.1588	0.534801
U2_pu []	119.3752	120.1347	0.759516
U3_pu []	99.59323	100.3255	0.732302
I1_pu []	31.67494	3.149016	-28.52592
I2_pu []	21.90713	3.145908	-18.76122
I3_pu []	11.01583	3.448364	-7.567467
P_pu []	16.07992	1.975487	-14.10443
Q_pu []	19.14841	3.097989	-16.05042
S_pu []	25.00451	3.674246	-21.33026

Power Recovery time

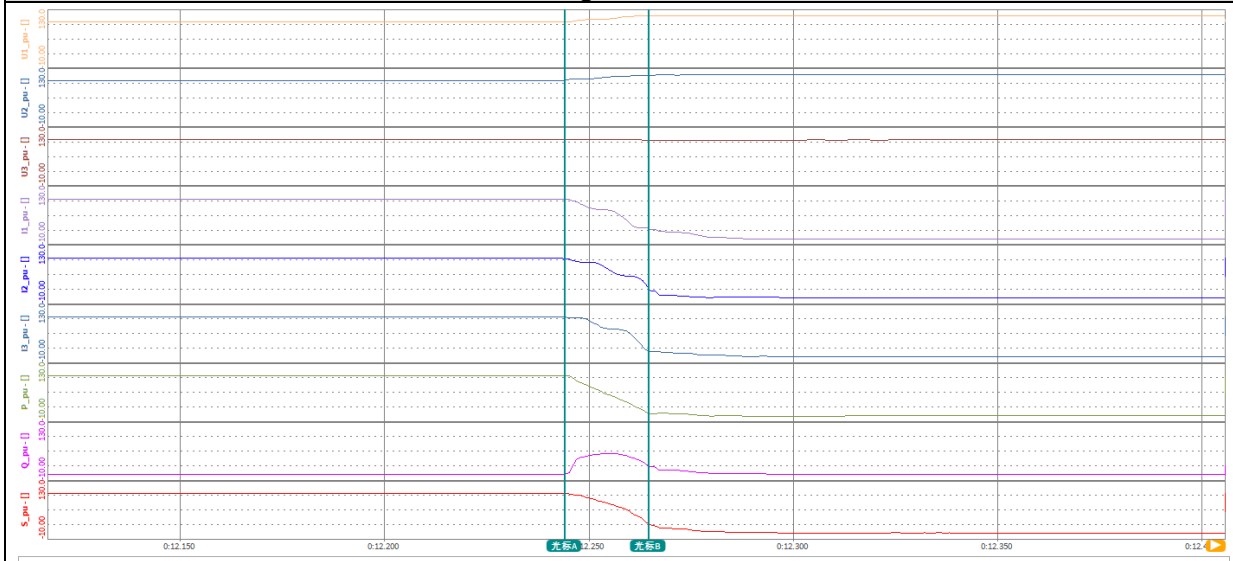


	A	B	间隔
时间 [s]	0:17.38283	0:17.46139	0.07856
U1_pu []	100.6435	100.9197	0.276224
U2_pu []	100.5826	100.7008	0.118136
U3_pu []	100.2989	100.9424	0.643490
I1_pu []	7.967400	90.21496	82.24756
I2_pu []	10.52923	88.36441	77.83518
I3_pu []	7.868998	90.57259	82.70359
P_pu []	6.354038	90.30480	83.95077
Q_pu []	6.137129	5.704799	-0.432330
S_pu []	8.833920	90.48482	81.65090

Two-Phase fault

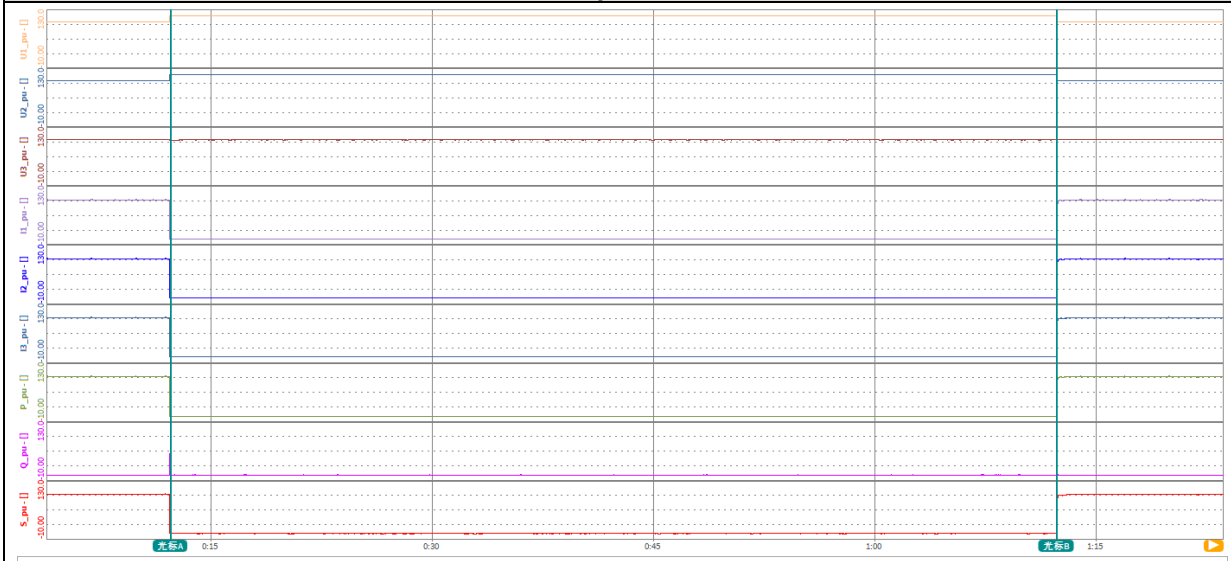
Partial load (20%Pn)	Residual voltage: 115.0%Un

Voltage Rise time



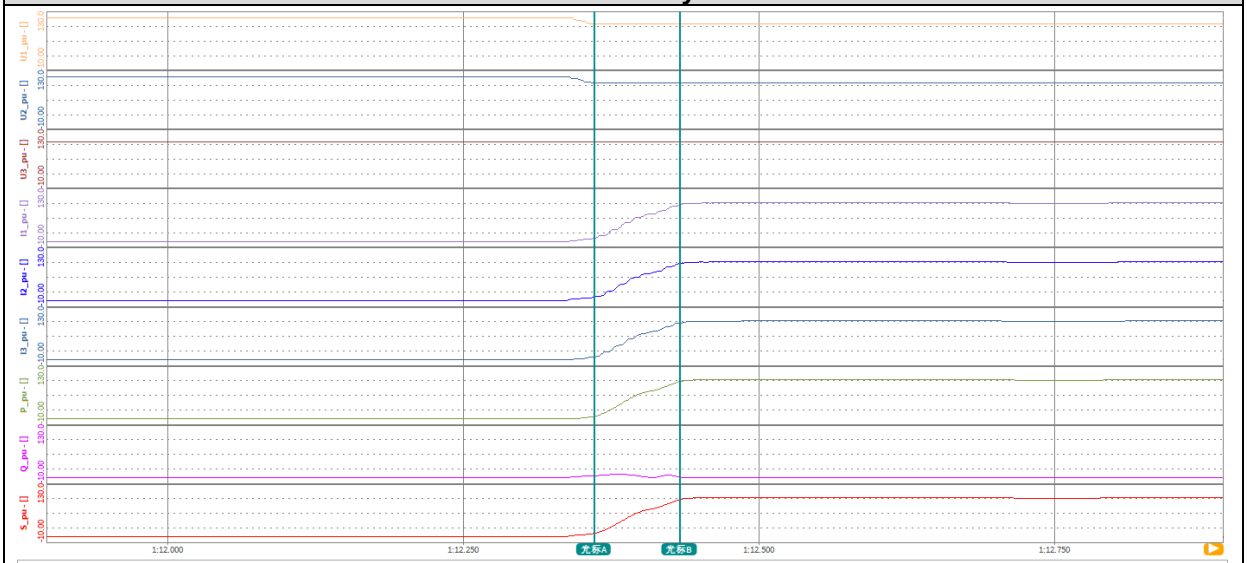
	A	B	间隔
时间 [s]	0:12.24403	0:12.26456	0.02053
U1_pu []	100.3949	114.5146	14.11971
U2_pu []	100.2955	114.1497	13.85426
U3_pu []	100.3810	99.57012	-0.810898
I1_pu []	98.06312	28.88550	-69.17762
I2_pu []	98.11182	33.53307	-64.57875
I3_pu []	98.01743	20.01207	-78.00535
P_pu []	98.38405	11.34984	-87.03421
Q_pu []	2.440975	28.23128	25.79030
S_pu []	98.41433	30.42736	-67.98697

DipTime



	A	B	间隔
时间 [s]	0:12.30854	1:12.32587	1:00.01733
U1_pu []	114.7255	115.3445	0.618976
U2_pu []	114.7824	114.9296	0.147227
U3_pu []	99.69052	100.2059	0.515389
I1_pu []	2.930624	3.034118	0.103494
I2_pu []	3.348928	3.014876	-0.334051
I3_pu []	3.380729	3.309650	-0.071080
P_pu []	1.401100	1.701602	0.300502
Q_pu []	3.235101	2.974760	-0.260342
S_pu []	3.525473	3.427046	-0.098427

Power Recovery time

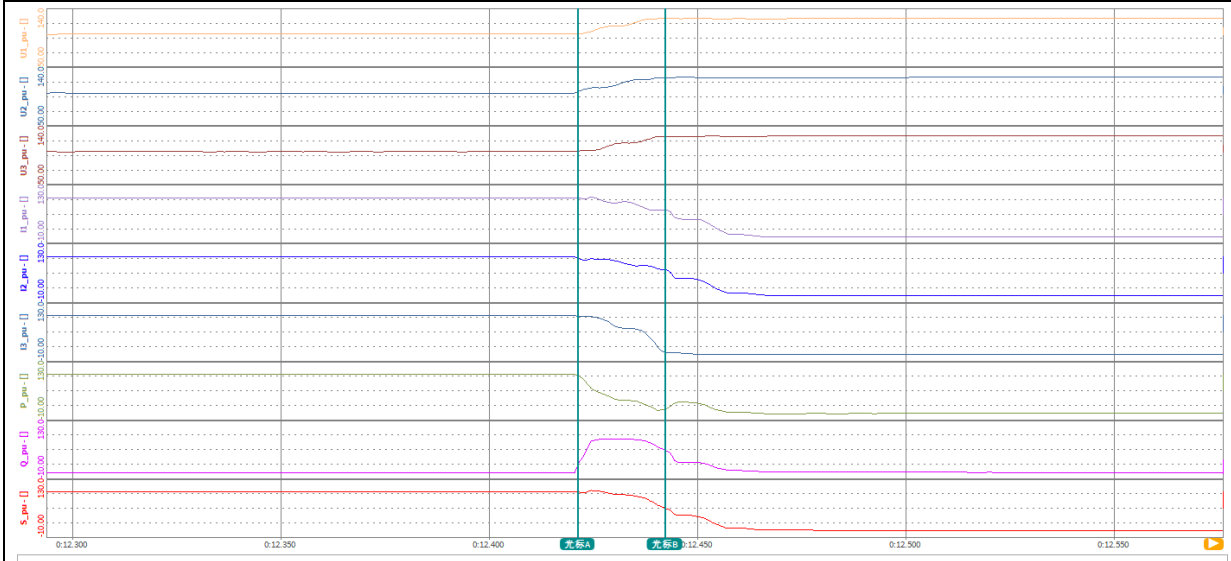


	A	B	间隔
时间 [s]	1:12.36075	1:12.43315	0.07239
U1_pu []	100.4779	100.8107	0.332807
U2_pu []	100.3742	100.6325	0.258225
U3_pu []	100.2734	100.8920	0.618611
I1_pu []	9.813048	88.55278	78.73973
I2_pu []	10.22833	91.33217	81.10384
I3_pu []	9.748000	90.65495	80.90695
P_pu []	7.736203	90.74150	83.00530
Q_pu []	6.284396	5.040229	-1.244167
S_pu []	9.967068	90.88137	80.91430

Three-Phase fault

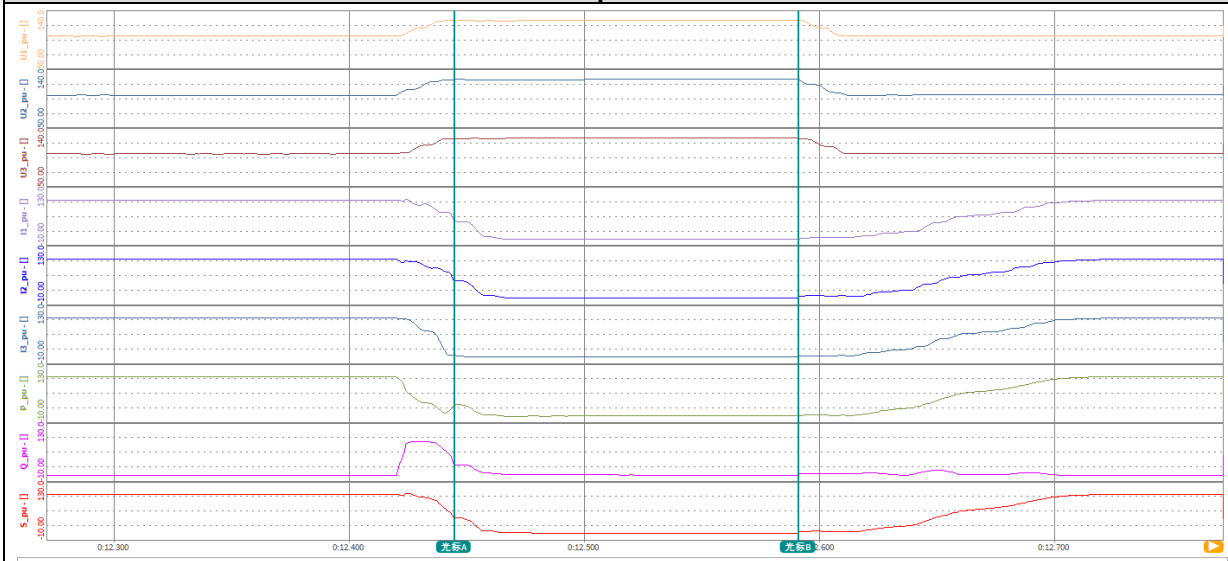
Partial load (20%Pn) | Residual voltage: 125.0%Un

Voltage Rise time



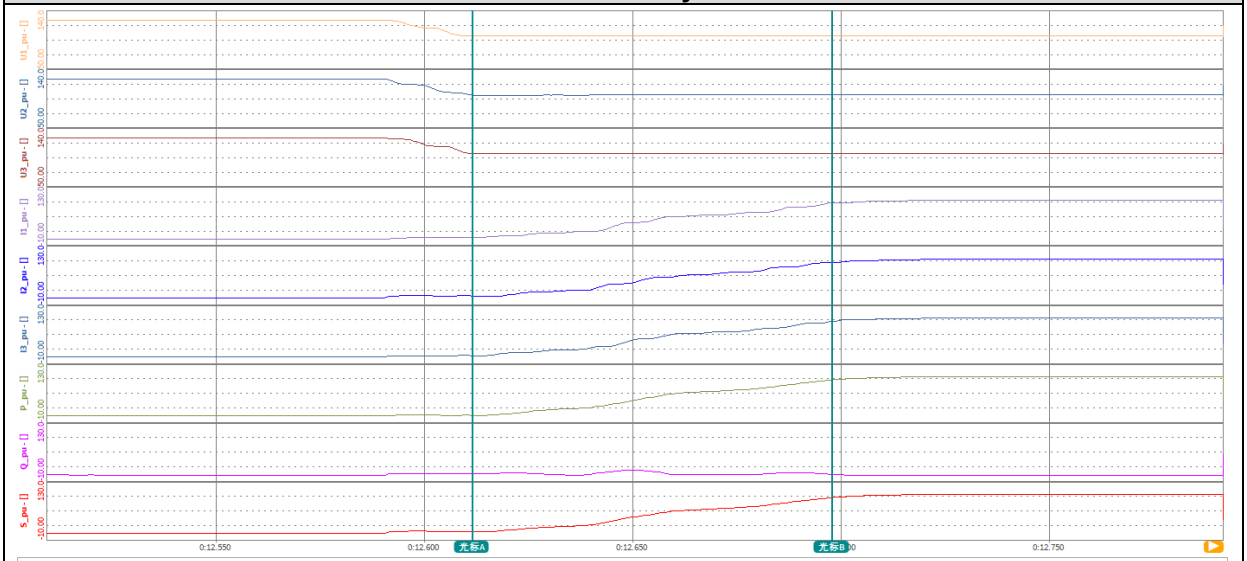
	A	B	间隔
时间 [s]	0:12.4213112	0:12.4422457	0.0209344
U1_pu []	100.3913	124.5738	24.18250
U2_pu []	100.3038	123.9806	23.67673
U3_pu []	100.3793	124.3206	23.94125
I1_pu []	98.03936	68.84763	-29.19173
I2_pu []	98.01989	67.33835	-30.68154
I3_pu []	97.73699	13.84929	-83.88770
P_pu []	98.25559	12.08610	-86.16950
Q_pu []	2.313296	60.97034	58.65704
S_pu []	98.28282	62.15670	-36.12612

DipTime



	A	B	间隔
时间 [s]	0:12.4446233	0:12.5908637	0.1462405
U1_pu []	124.5848	124.8297	0.244910
U2_pu []	124.3791	124.8942	0.515070
U3_pu []	124.3905	125.0610	0.670524
I1_pu []	64.34405	4.187596	-60.15646
I2_pu []	60.05504	4.218479	-55.83656
I3_pu []	7.905594	4.339161	-3.566433
P_pu []	21.28507	4.075360	-17.20971
Q_pu []	50.60321	3.400197	-47.20301
S_pu []	54.89754	5.307532	-49.59000

Power Recovery time

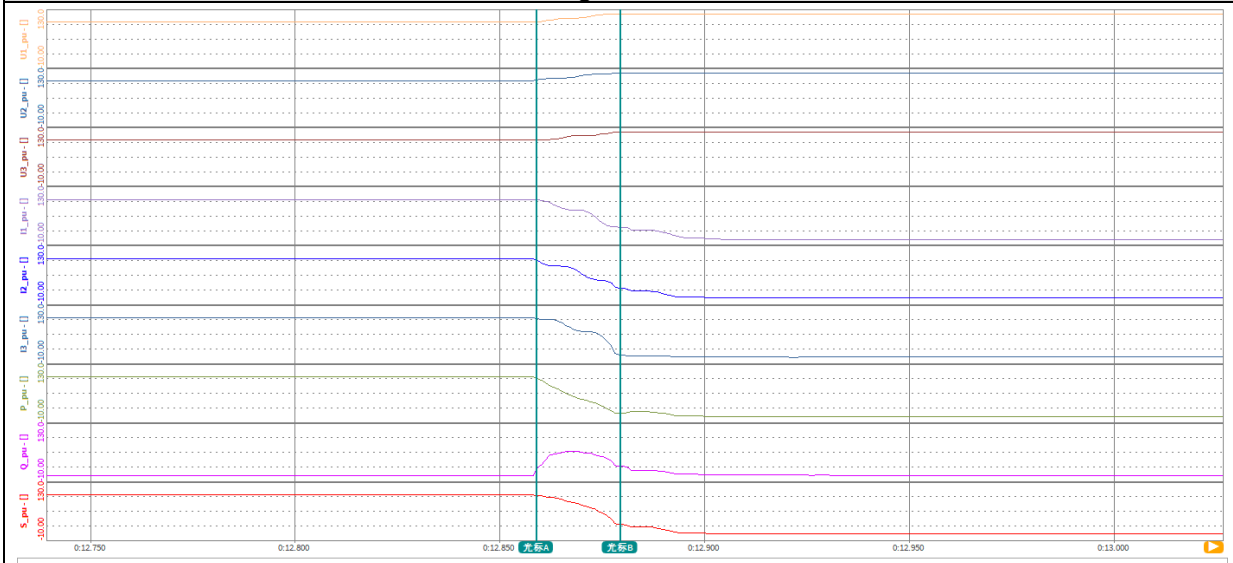


	A	B	间隔
时间 [s]	0:12.6114849	0:12.6977922	0.0863073
U1_pu []	100.4714	100.7404	0.269026
U2_pu []	100.7654	100.6412	-0.124193
U3_pu []	100.7377	100.6856	-0.052165
I1_pu []	8.576763	91.94285	83.36608
I2_pu []	10.65490	89.85253	79.19762
I3_pu []	8.429754	89.56652	81.13677
P_pu []	5.889508	90.92166	85.03215
Q_pu []	7.174028	5.327510	-1.846518
S_pu []	9.281863	91.07760	81.79574

Three-Phase fault

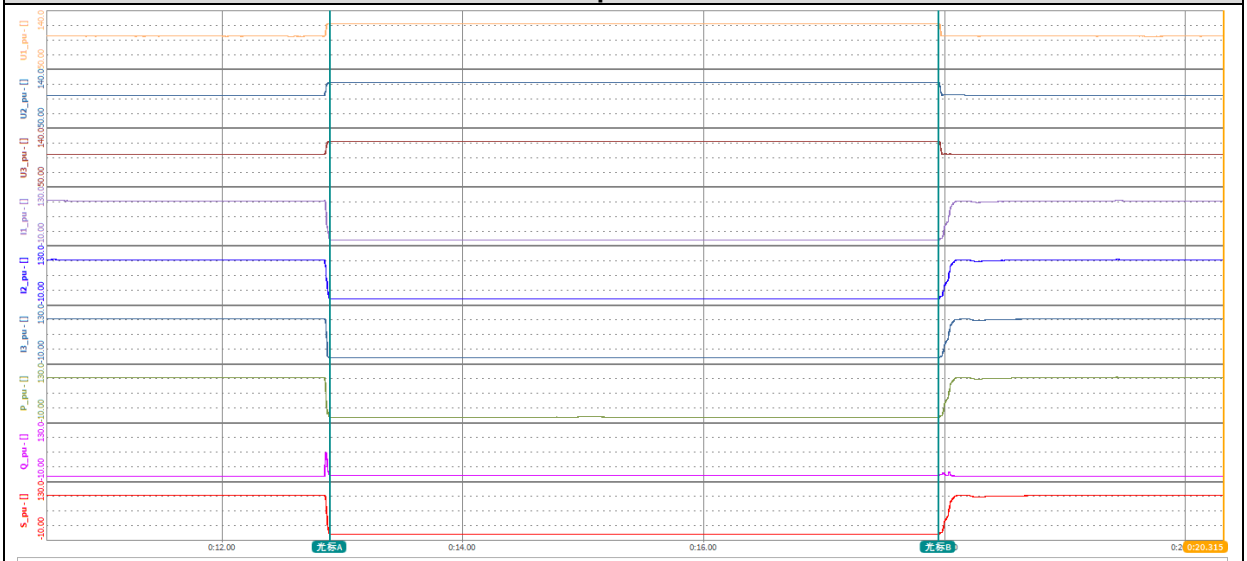
Partial load (20%Pn)	Residual voltage: 120.0%Un

Voltage Rise time



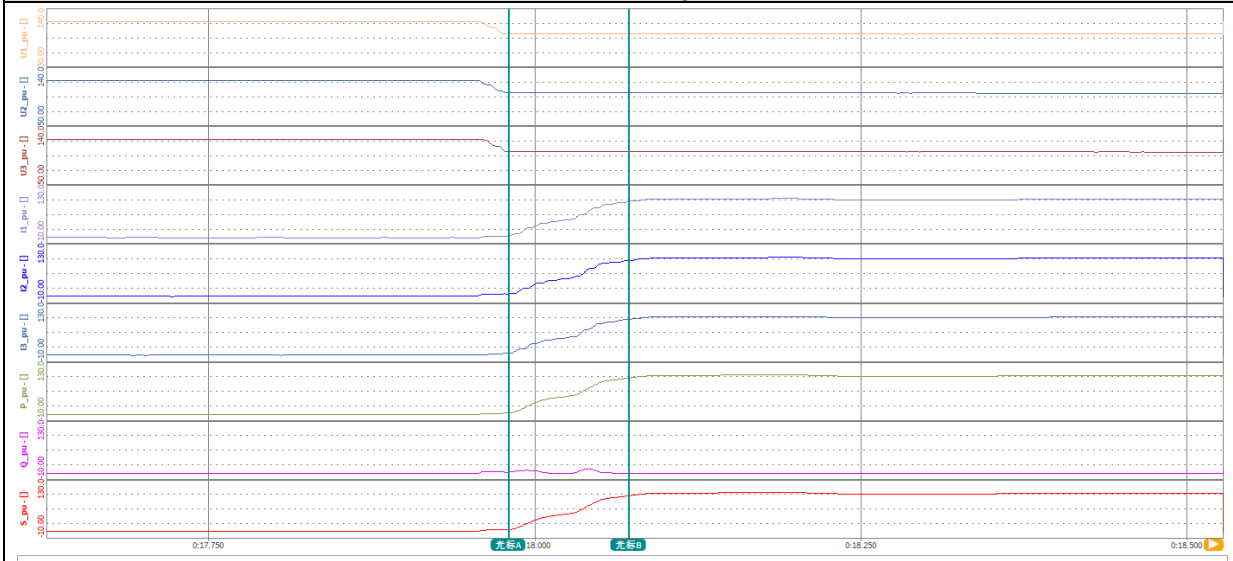
	A	B	间隔
时间 [s]	0:12.85896	0:12.87943	0.02047
U1_pu []	100.4213	119.2936	18.87230
U2_pu []	100.3495	119.2037	18.85422
U3_pu []	100.3888	119.2674	18.87862
I1_pu []	98.11352	34.04536	-64.06816
I2_pu []	98.04164	30.33765	-67.70399
I3_pu []	98.03081	12.09505	-85.93577
P_pu []	98.40013	11.64842	-86.75172
Q_pu []	2.837557	28.08086	25.24331
S_pu []	98.44104	30.40100	-68.04004

DipTime



	A	B	间隔
时间 [s]	0:12.89672	0:17.94756	5.05085
U1_pu []	119.5615	120.0413	0.479842
U2_pu []	119.2808	120.0959	0.815125
U3_pu []	119.5209	120.2355	0.714616
I1_pu []	7.077244	3.541895	-3.535349
I2_pu []	6.172614	3.643431	-2.529183
I3_pu []	4.140964	3.626543	-0.514421
P_pu []	3.606030	2.814102	-0.791928
Q_pu []	5.911537	3.289866	-2.621670
S_pu []	6.924574	4.329248	-2.595326

Power Recovery time

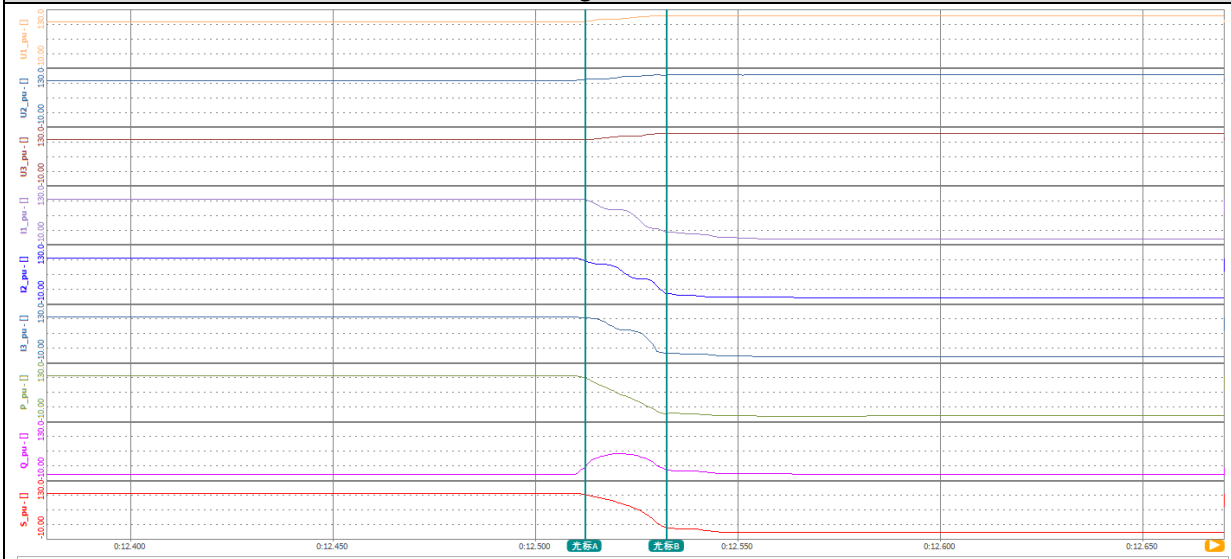


	A	B	间隔
时间 [s]	0:17.98003	0:18.07208	0.09204
U1_pu []	100.5356	100.7070	0.171389
U2_pu []	100.4533	100.6438	0.190469
U3_pu []	100.4714	100.6343	0.162964
I1_pu []	7.166883	89.36022	82.19334
I2_pu []	9.366876	90.59623	81.22936
I3_pu []	7.808693	89.57026	81.76156
P_pu []	6.026733	90.38595	84.35922
Q_pu []	5.491441	3.027372	-2.464070
S_pu []	8.153370	90.43664	82.28327

Three-Phase fault

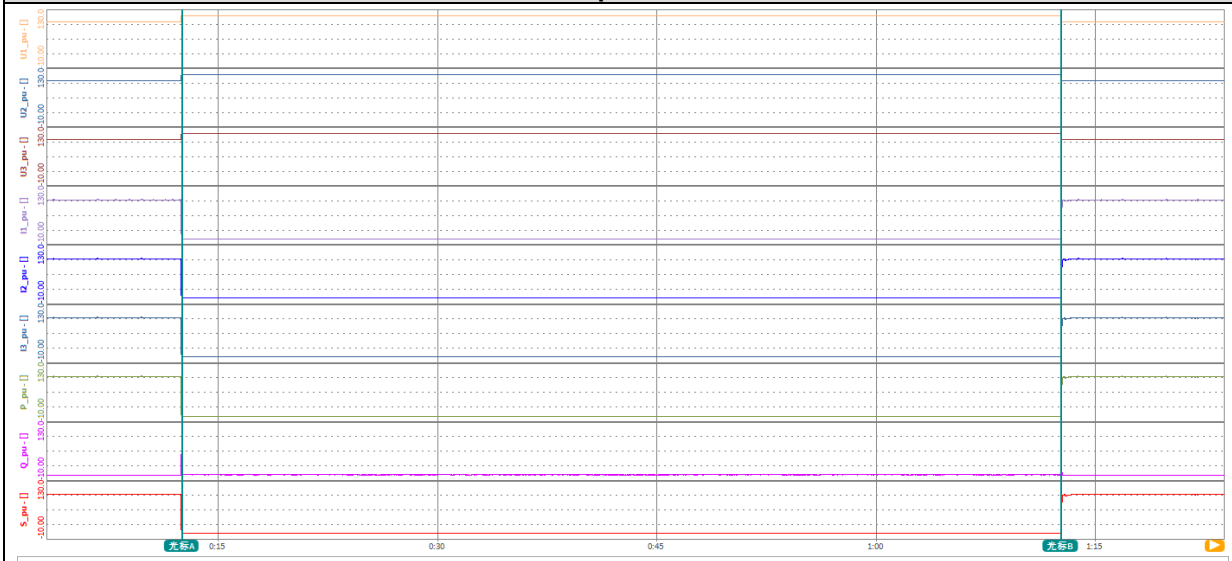
Partial load (20%Pn) | Residual voltage: 115.0%Un

Voltage Rise time



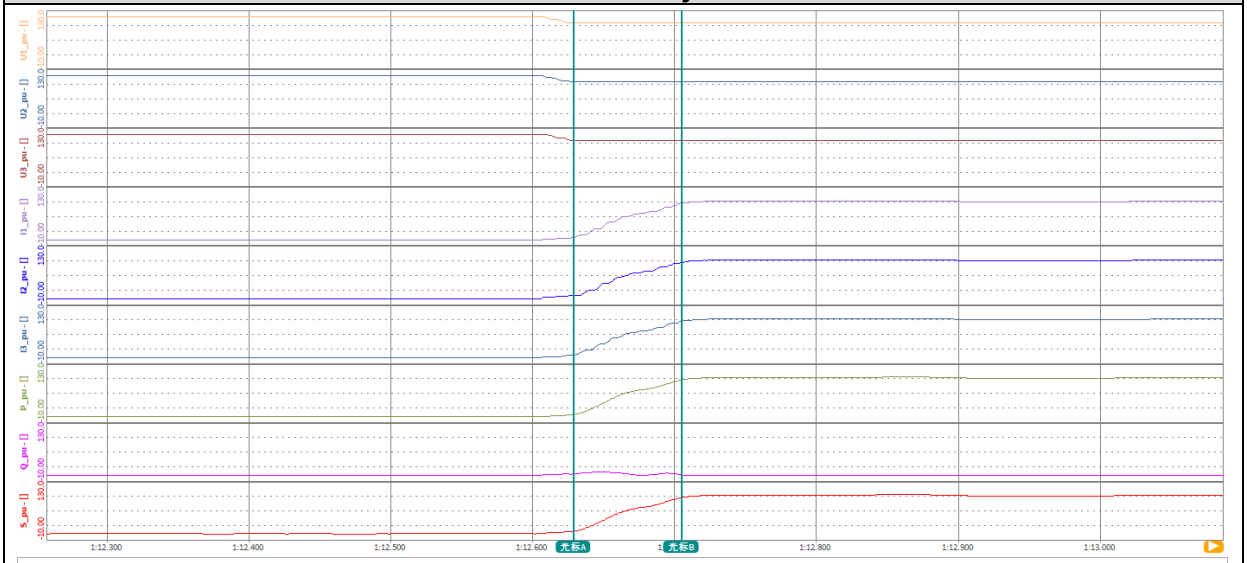
	A	B	间隔
时间 [s]	0:12.51224	0:12.53248	0.02024
U1_pu []	100.5145	114.5609	14.04642
U2_pu []	102.0897	114.2692	12.17952
U3_pu []	100.9997	114.4642	13.46451
I1_pu []	98.50897	20.13374	-78.37522
I2_pu []	95.52329	13.15438	-82.36890
I3_pu []	96.28725	10.30504	-85.98221
P_pu []	97.14005	7.235158	-89.90490
Q_pu []	12.40042	14.97451	2.574086
S_pu []	97.92834	16.63080	-81.29755

DipTime



	A	B	间隔
时间 [s]	0:12.56526	1:12.60597	1:00.04070
U1_pu []	114.7277	115.2112	0.483425
U2_pu []	114.6630	115.0609	0.397843
U3_pu []	114.9477	115.1795	0.231881
I1_pu []	2.982770	2.991332	8.562e-3
I2_pu []	3.532058	3.304828	-0.227230
I3_pu []	3.248428	3.134750	-0.113678
P_pu []	1.280422	1.797535	0.517113
Q_pu []	3.509029	3.141985	-0.367044
S_pu []	3.735340	3.619834	-0.115506

Power Recovery time



	A	B	间隔
时间 [s]	1:12.62883	1:12.70489	0.07606
U1_pu []	100.5151	100.8848	0.369760
U2_pu []	100.4487	100.7035	0.254762
U3_pu []	100.5011	100.7282	0.227110
I1_pu []	7.869439	91.29654	83.42710
I2_pu []	10.35558	88.86169	78.50611
I3_pu []	9.361432	89.80590	80.44446
P_pu []	7.283381	90.57955	83.29617
Q_pu []	5.686143	4.344832	-1.341312
S_pu []	9.240122	90.68369	81.44357

4.3. ACTIVE RESPONSE TO FREQUENCY DEVIATION

4.3.1. Power response to overfrequency

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

- Test 1：P = 100 %Pn; f1 = 50.2 Hz; droop = 12 %; f-stop deactivated, with delay of 2 s (*)
- Test 2：P = 100 %; f1 = 52 Hz; droop = 2 %; function deactivated
- Test 3：P = 50 %; f1 = 51 Hz; droop = 5 %; f-stop deactivated, no delay
- Test 4：P = 100 %, f1 = 50.2 Hz; droop = 5 %; f-stop = 50.1 Hz (hysteresis), no delay

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

Note:

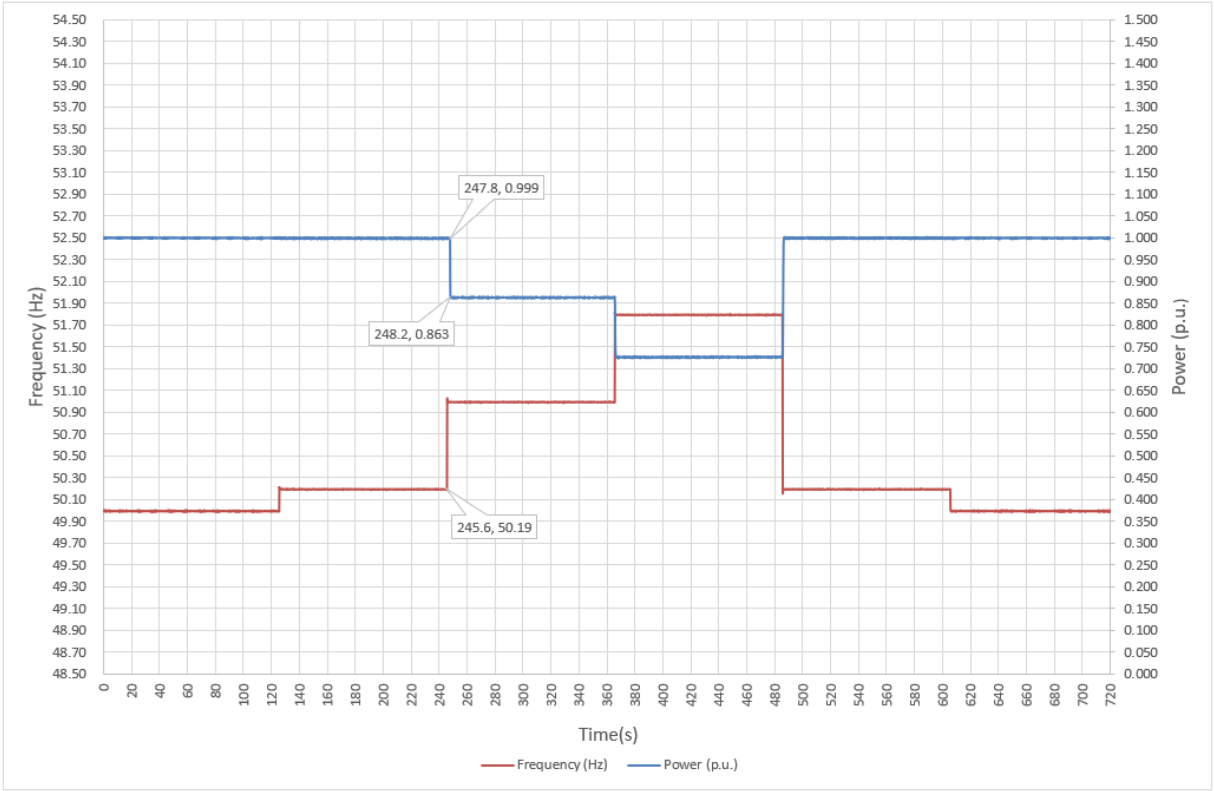
(1) The activation and deactivation of the function and its settings can be field adjustable through SunSpec Dashboard interface, under the menu of Freq_watt_param, ModEna = 0 indicating function deactivation, while ModEna = 1 indicating function activation; means to setting the parameter are protected by key of the SunSpec Dashboard.

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

Test results are offered at the table below.

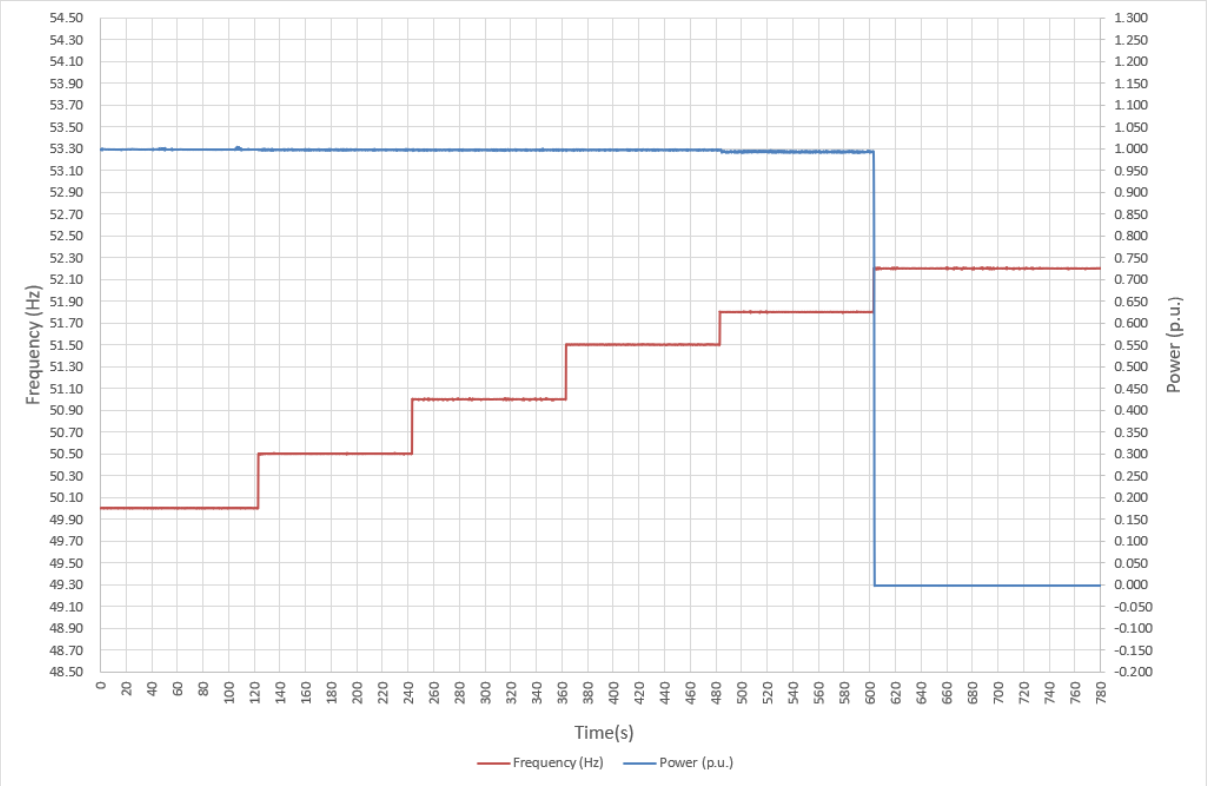
Test 1					
Step	**f (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	100.0	49.99	100.0	0.0
2	50.20 ± 0.05 Hz	100.0	50.19	99.9	-0.1
3	51.00 ± 0.05 Hz	86.7	50.99	86.3	-0.4
4	51.80 ± 0.05 Hz	73.3	51.79	72.7	-0.6
5	50.20 ± 0.05 Hz	100.0	50.20	99.8	-0.2
6	50.00 ± 0.05 Hz	100.0	49.99	100.0	0.0
Time delay setting from step 2 to step 3					
Time reference of change (s)			245.6		
End of delay (s)			247.8		
Delay time (s)			2.20		
End of change (s)			248.2		
Response time (s)			0.40		

P vs f chart for Test 1



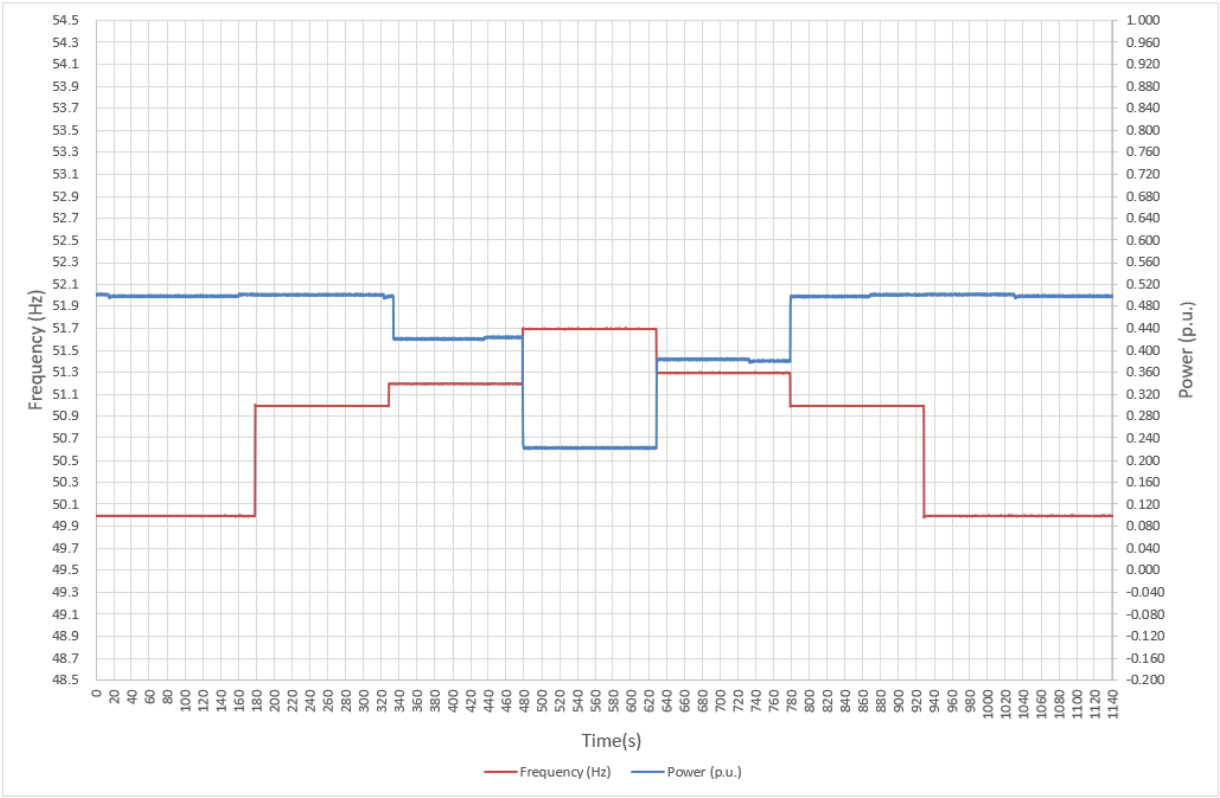
Test 2					
Step	**f (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	100.0	50.00	99.9	-0.1
2	50.50 ± 0.05 Hz	100.0	50.50	99.7	-0.3
3	51.00 ± 0.05 Hz	100.0	51.00	99.7	-0.3
4	51.50 ± 0.05 Hz	100.0	51.50	99.7	-0.3
5	51.80 ± 0.05 Hz	100.0	51.80	99.3	-0.7
6	52.20 ± 0.05 Hz	0.0	52.20	-0.2	-0.2

P vs f chart for Test 2



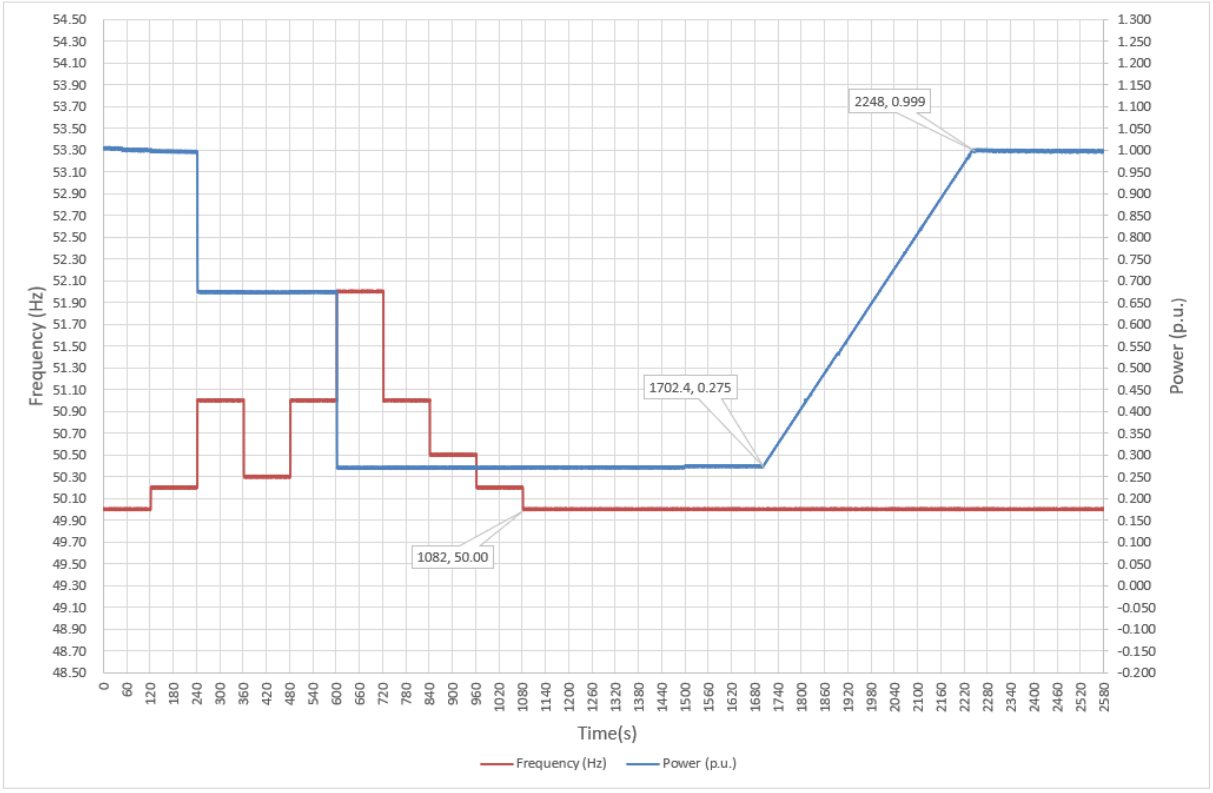
Test 3					
Step	**f (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	50.0	49.99	49.9	-0.1
2	51.00 ± 0.05 Hz	50.0	50.99	50.1	0.1
3	51.20 ± 0.05 Hz	42.0	51.19	42.4	0.4
4	51.70 ± 0.05 Hz	22.0	51.69	22.3	0.3
5	51.30 ± 0.05 Hz	38.0	51.29	38.2	0.2
6	51.00 ± 0.05 Hz	50.0	50.99	49.9	-0.1
7	50.00 ± 0.05 Hz	50.0	49.99	50.0	0.0

P vs f chart for Test 3



Test 4					
Step	**f (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	100.0	50.00	100.2	0.2
2	50.20 ± 0.05 Hz	100.0	50.20	99.7	-0.3
3	51.00 ± 0.05 Hz	68.0	51.00	67.5	-0.5
4	50.30 ± 0.05 Hz	68.0	50.30	67.3	-0.7
5	51.00 ± 0.05 Hz	68.0	51.00	67.4	-0.6
6	52.00 ± 0.05 Hz	28.0	52.00	27.1	-0.9
7	51.00 ± 0.05 Hz	28.0	51.00	27.1	-0.9
8	50.50 ± 0.05 Hz	28.0	50.50	27.1	-0.9
9	50.20 ± 0.05 Hz	28.0	50.20	27.1	-0.9
10	50.00 ± 0.05 Hz	100.0	50.00	99.8	-0.2
Reconnection Time(s)		620.4		Power ramp gradient (%Pn/min)	8.0

P vs f chart for Test 4



4.3.2. Power response to underfrequency

The test has been done according to the clause 4.6.2 of the standard. This test has been perform to show the capability of the inverter, although it is only mandatory for Energy Storage Systems according to the standard. The following definitions apply to the test to verify the clause:

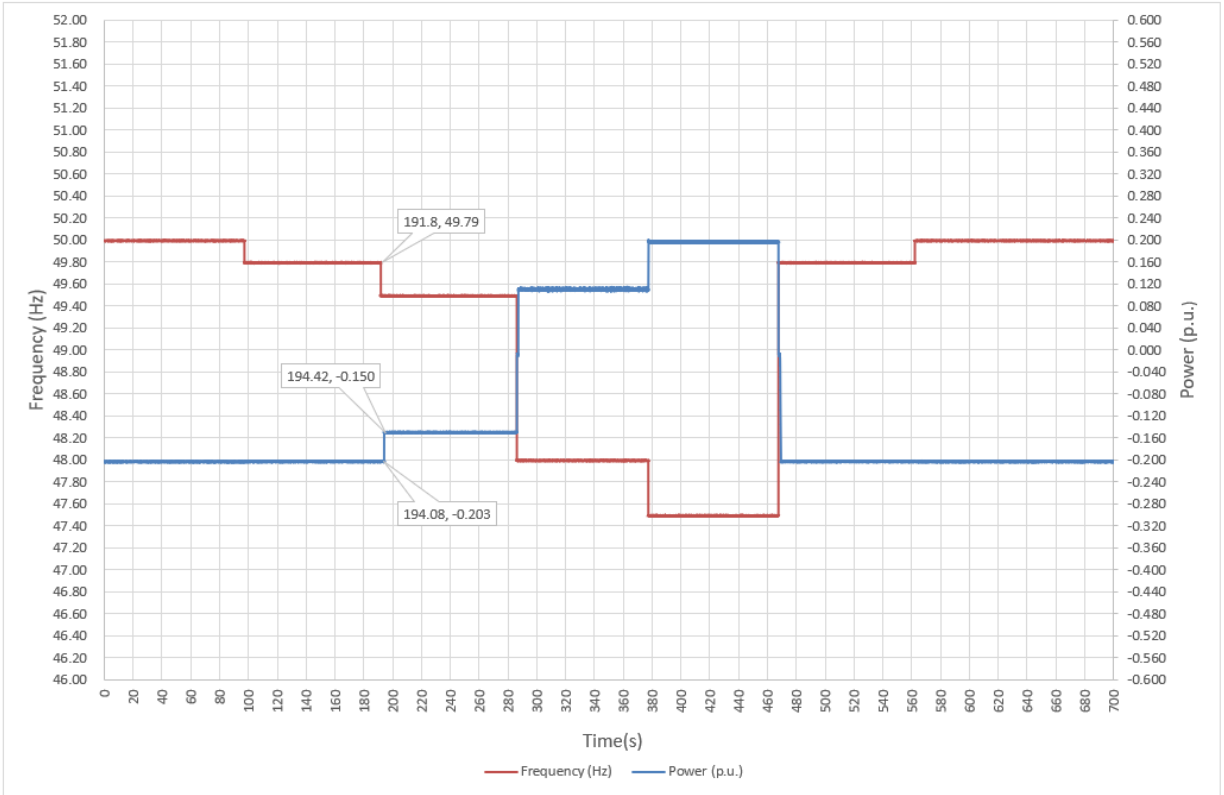
- Test 1： P_M = -20 %Pn; f1 = 49.8 Hz; droop = 12 %; f-stop deactivated, with delay of 2 s (*)
- Test 2： P_M = -20 %Pn; f1 = 48 Hz; droop = 2 %; f-stop deactivated, no delay
- Test 3： P_M = 50 %Pn; f1 = 49.8 Hz; droop = 5 %; f-stop deactivated, no delay

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

Test results are offered at the table below.

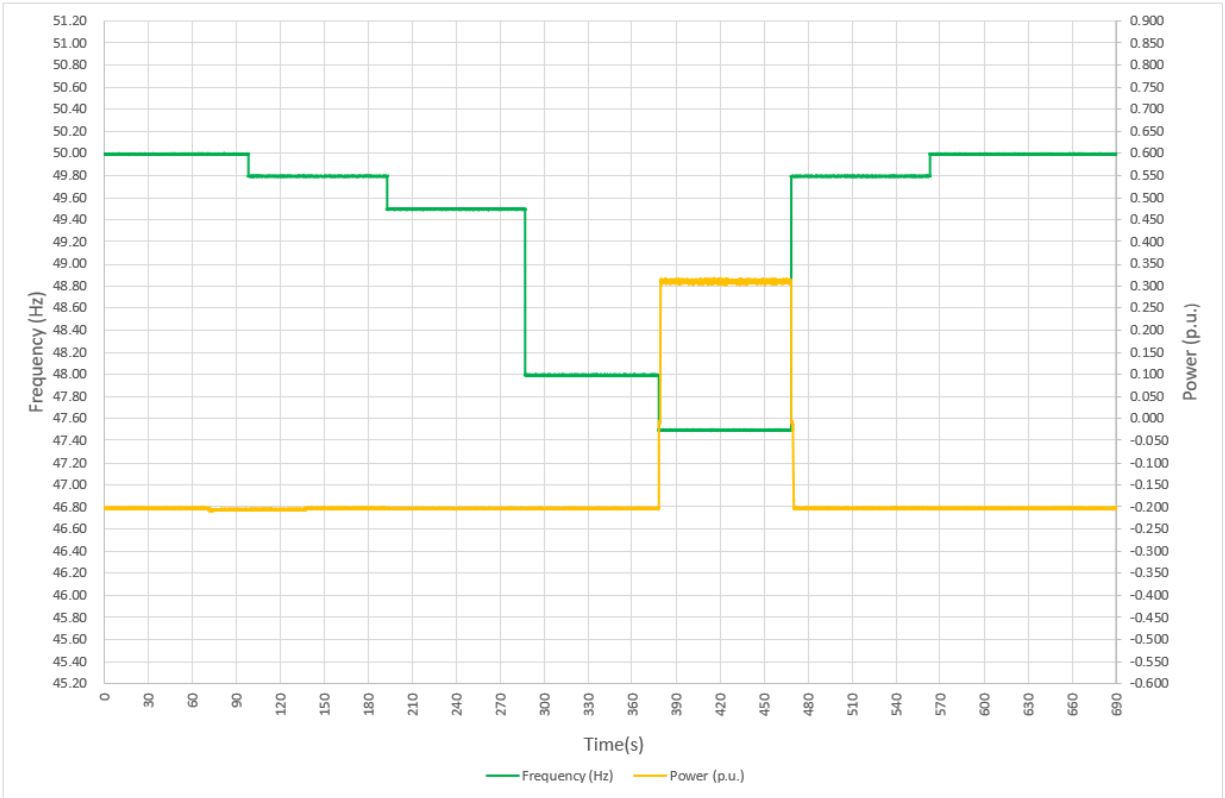
Test 1					
Step	**f (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	-20.0	49.99	-20.3	-0.3
2	49.80 ± 0.05 Hz	-20.0	49.79	-20.3	-0.3
3	49.50 ± 0.05 Hz	-15.0	49.49	-15.1	-0.1
4	48.00 ± 0.05 Hz	10.0	48.00	10.8	0.8
5	47.50 ± 0.05 Hz	18.3	47.50	19.6	1.3
6	49.80 ± 0.05 Hz	-20.0	49.79	-19.9	0.1
7	50.00 ± 0.05 Hz	-20.0	49.99	-20.3	-0.3
Time delay setting from step 2 to step 3					
Time reference of change (s)			191.80		
End of delay (s)			193.80		
Delay time (s)			2.28		
End of change (s)			193.94		
Response time (s)			0.34		

P vs f chart for Test 1



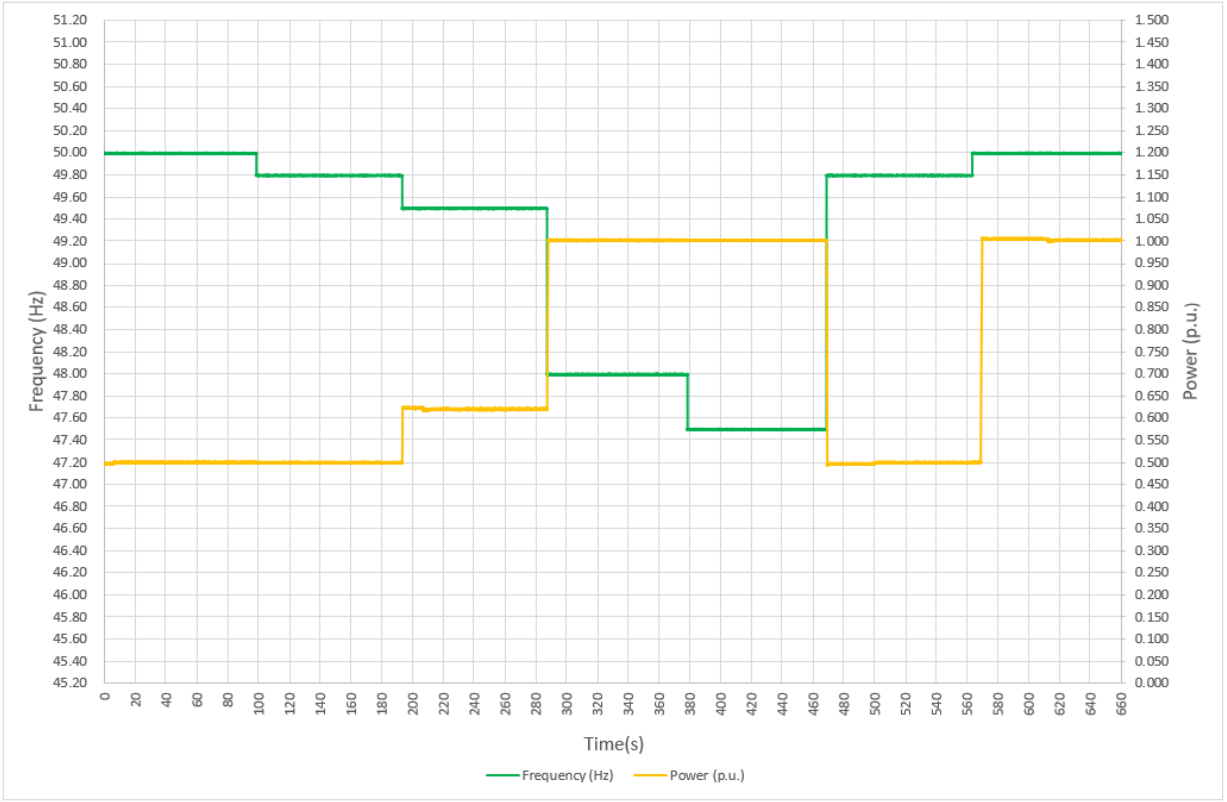
Test 2					
Step	**f (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	-20.0	49.99	-20.4	-0.4
2	49.80 ± 0.05 Hz	-20.0	49.79	-20.4	-0.4
3	49.50 ± 0.05 Hz	-20.0	49.49	-20.3	-0.3
4	48.00 ± 0.05 Hz	-20.0	47.99	-20.3	-0.3
5	47.50 ± 0.05 Hz	30.0	47.49	30.7	0.7
6	49.80 ± 0.05 Hz	-20.0	49.79	-20.0	0.0
7	50.00 ± 0.05 Hz	-20.0	49.99	-20.3	-0.3

P vs f chart for Test 2



Test 3					
Step	**f (Hz)**	**P desired (%Pn)**	**Frequency meas. (Hz)**	**P meas. (%Pn)**	**P deviation (%Pn) (within ±10 %)**
1	50.00 ± 0.05 Hz	50.0	49.99	49.9	-0.1
2	49.80 ± 0.05 Hz	50.0	49.79	49.9	-0.1
3	49.50 ± 0.05 Hz	62.0	49.49	62.0	0.0
4	48.00 ± 0.05 Hz	100.0	47.99	100.0	0.0
5	47.50 ± 0.05 Hz	100.0	47.49	100.1	0.1
6	49.80 ± 0.05 Hz	50.0	49.79	49.9	-0.1
7	50.00 ± 0.05 Hz	100.0	49.99	97.6	-2.4

P vs f chart for Test 3



4.4. POWER RESPONSE TO VOLTAGE CHANGES

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

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

4.4.1. Setpoint control modes

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

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

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

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

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

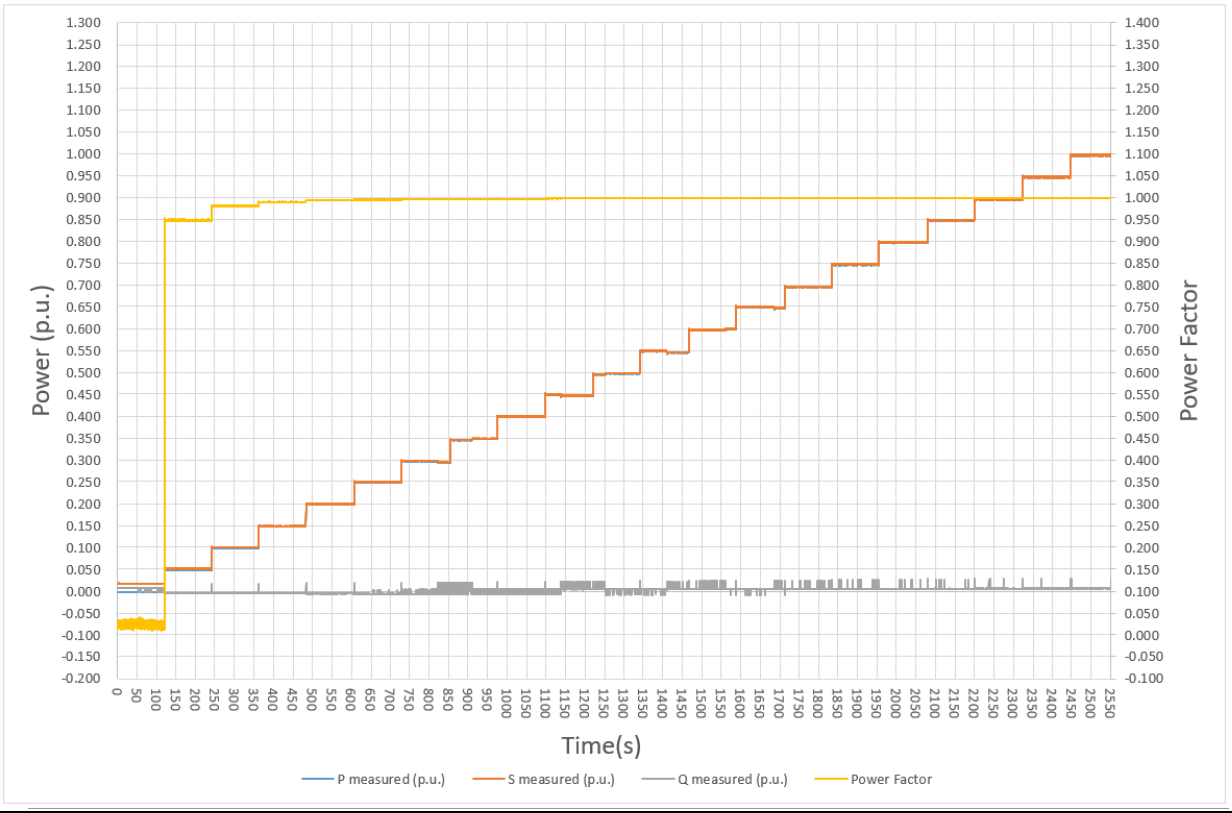
Test results are offered at tables below.

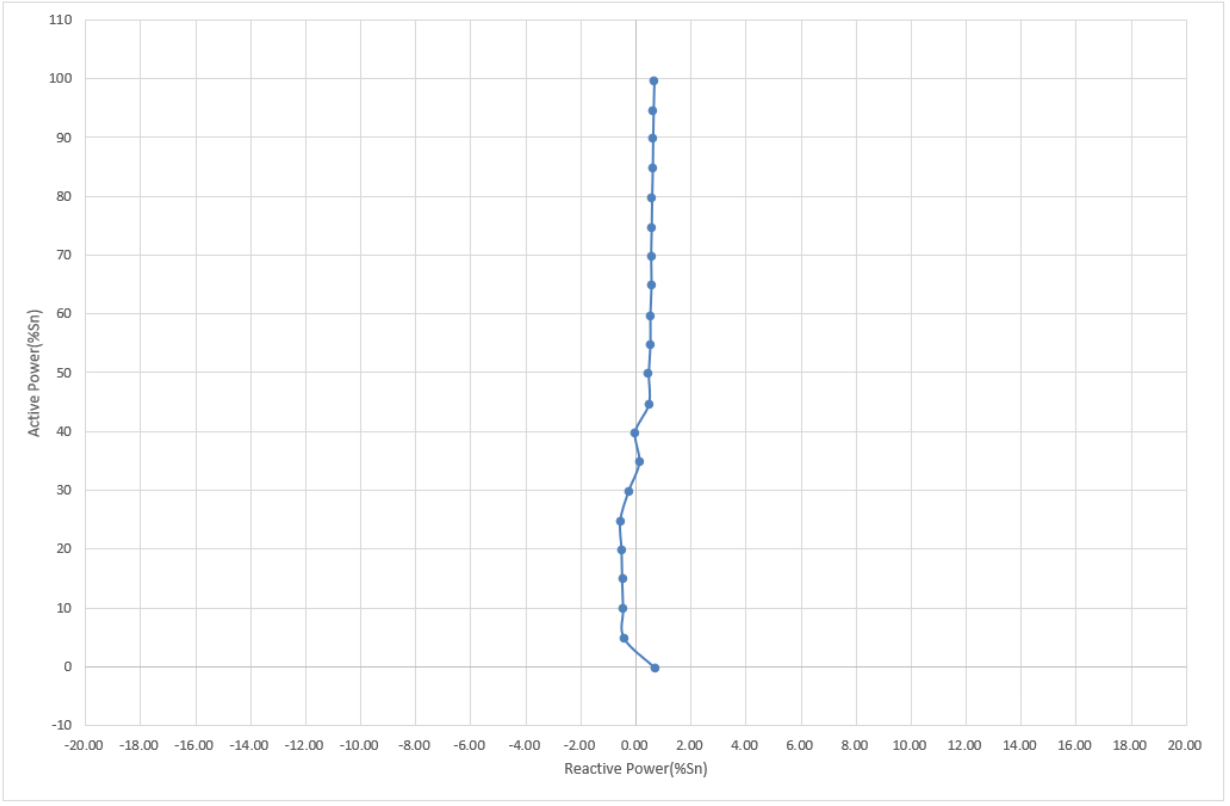
Rectangular Curve (Q = 0 %Sn)						
P desired (%Sn)	**Power DC (kW)**	**P measured (%Sn)**	**Q desired (%Sn)**	**Q measured (%Sn)**	**Q deviation (%Sn)**	**Power Factor (cos φ)**
0(*)	0.4	-0.3	--	0.7	--	0.025
5(*)	3.1	4.9	--	-0.4	--	0.947
10(*)	5.7	9.8	0.0	-0.5	-0.5	0.982
15	8.2	14.8	0.0	-0.5	-0.5	0.991
20	10.8	19.9	0.0	-0.5	-0.5	0.994
25	13.4	24.8	0.0	-0.6	-0.6	0.996
30	16.0	29.8	0.0	-0.3	-0.3	0.997
35	18.6	34.7	0.0	0.1	0.1	0.998
40	21.2	39.9	0.0	0.0	0.0	0.998
45	23.9	44.7	0.0	0.5	0.5	0.998
50	26.5	49.9	0.0	0.5	0.5	0.999
55	29.1	54.8	0.0	0.5	0.5	0.999
60	31.8	59.7	0.0	0.5	0.5	0.999
65	34.4	64.9	0.0	0.5	0.5	0.999
70	37.1	69.7	0.0	0.5	0.5	0.999
75	39.8	74.7	0.0	0.6	0.6	0.999
80	42.5	79.7	0.0	0.6	0.6	0.999
85	45.1	84.7	0.0	0.6	0.6	0.999
90	47.8	89.7	0.0	0.6	0.6	0.999
95	50.5	94.7	0.0	0.6	0.6	0.999
100	53.2	99.7	0.0	0.7	0.7	0.999

(*) No tolerance of reactive power was defined when active power level below 10%Sn

Test results are represented at diagrams below.

Rectangular Curve (Q = 0 %Sn)





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

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

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

Test results are offered at tables below.

Rectangular Curve (Q = 48.4 %Sn / Inductive)						
P desired (%Sn)	**Power DC (kW)**	**P measured (%Sn)**	**Q desired (%Sn)**	**Q measured (%Sn)**	**Q deviation (%Sn)**	**Power Factor (cos φ)**
0(*)	1.1	-0.5	--	49.2	--	-0.009
5(*)	4.2	5.6	--	49.1	--	0.113
10(*)	6.2	9.5	--	49.1	--	0.189
15	9.3	15.5	48.4	49.1	0.6	0.301
20	11.3	19.8	48.4	49.0	0.6	0.373
25	14.4	25.6	48.4	49.0	0.5	0.461
30	16.4	29.6	48.4	48.9	0.5	0.516
35	19.5	35.9	48.4	48.9	0.4	0.590
40	21.6	39.7	48.4	48.8	0.4	0.629
45	24.7	45.7	48.4	48.8	0.4	0.682
50	26.8	49.8	48.4	48.8	0.4	0.712
55	30.0	55.8	48.4	48.8	0.3	0.751
60	32.1	59.8	48.4	48.7	0.3	0.774
65	35.2	65.8	48.4	48.7	0.2	0.803
70	37.3	69.9	48.4	48.6	0.2	0.819
75	40.5	75.9	48.4	48.6	0.2	0.841
80	42.6	79.9	48.4	48.6	0.2	0.853
85	45.8	85.9	48.4	48.5	0.1	0.870
90	48.0	89.9	48.4	48.5	0.1	0.879
95	51.2	95.9	48.4	48.4	0.0	0.892
100	53.3	99.8	48.4	48.4	0.0	0.899

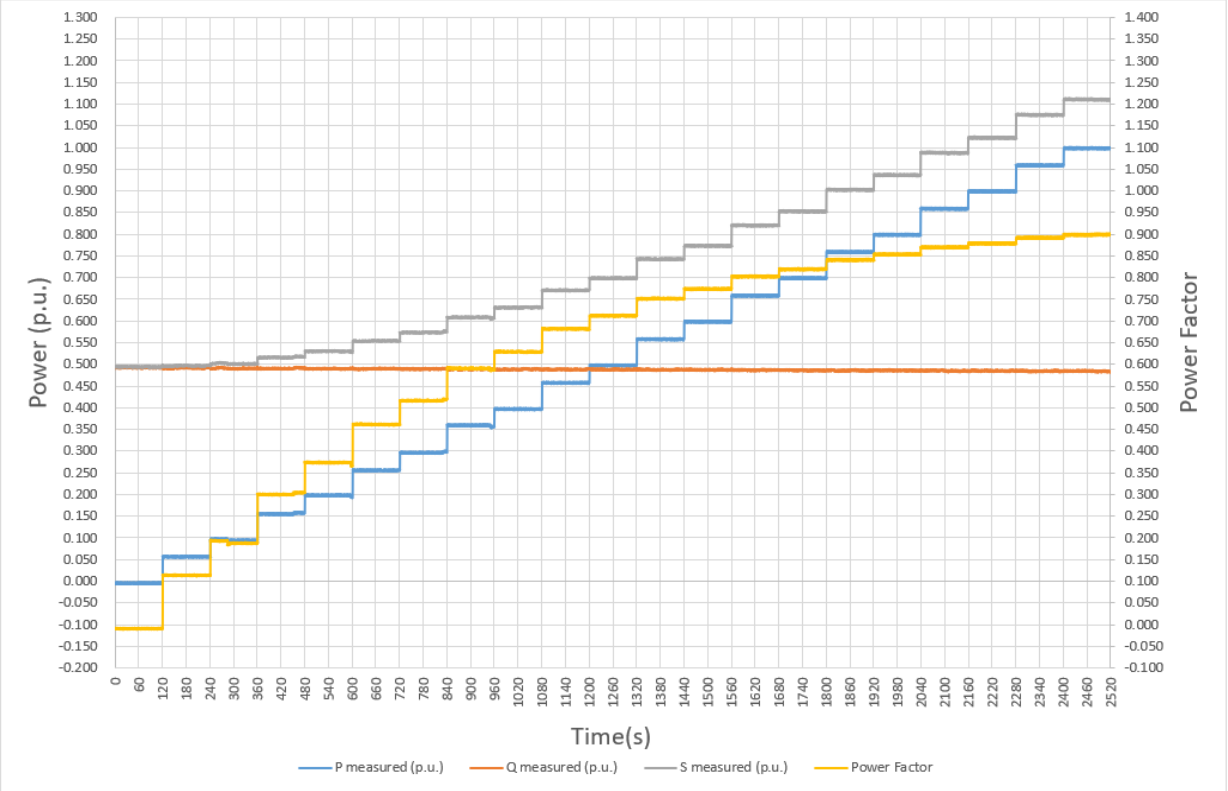
(*) No tolerance of reactive power was defined when active power level below 10%Sn

Rectangular Curve (Q = 48.4 %Sn / Capacitive)						
P desired (%Sn)	**Power DC (kW)**	**P measured (%Sn)**	**Q desired (%Sn)**	**Q measured (%Sn)**	**Q deviation (%Sn)**	**Power Factor (cos φ)**
0(*)	0.9	-1.9	--	-49.3	--	-0.039
5(*)	3.9	4.3	--	-49.2	--	0.086
10(*)	7.0	10.5	--	-49.3	--	0.209
15	9.0	14.4	-48.4	-49.4	-1.0	0.279
20	12.1	20.4	-48.4	-49.5	-1.0	0.380
25	14.1	24.7	-48.4	-49.5	-1.1	0.446
30	17.2	30.5	-48.4	-49.5	-1.1	0.524
35	19.3	34.5	-48.4	-49.5	-1.1	0.571
40	22.4	40.5	-48.4	-49.6	-1.1	0.632
45	24.4	44.6	-48.4	-49.5	-1.1	0.668
50	27.6	50.6	-48.4	-49.6	-1.1	0.713
55	29.7	54.6	-48.4	-49.6	-1.1	0.740
60	32.8	60.7	-48.4	-49.6	-1.1	0.773
65	34.9	64.7	-48.4	-49.6	-1.2	0.793
70	38.1	70.7	-48.4	-49.6	-1.2	0.817
75	40.2	74.7	-48.4	-49.6	-1.2	0.832
80	43.4	80.7	-48.4	-49.7	-1.2	0.851
85	45.5	84.7	-48.4	-49.7	-1.3	0.862
90	48.7	90.7	-48.4	-49.7	-1.3	0.876
95	50.9	94.7	-48.4	-49.7	-1.3	0.885
100	54.1	100.7	-48.4	-49.8	-1.3	0.896

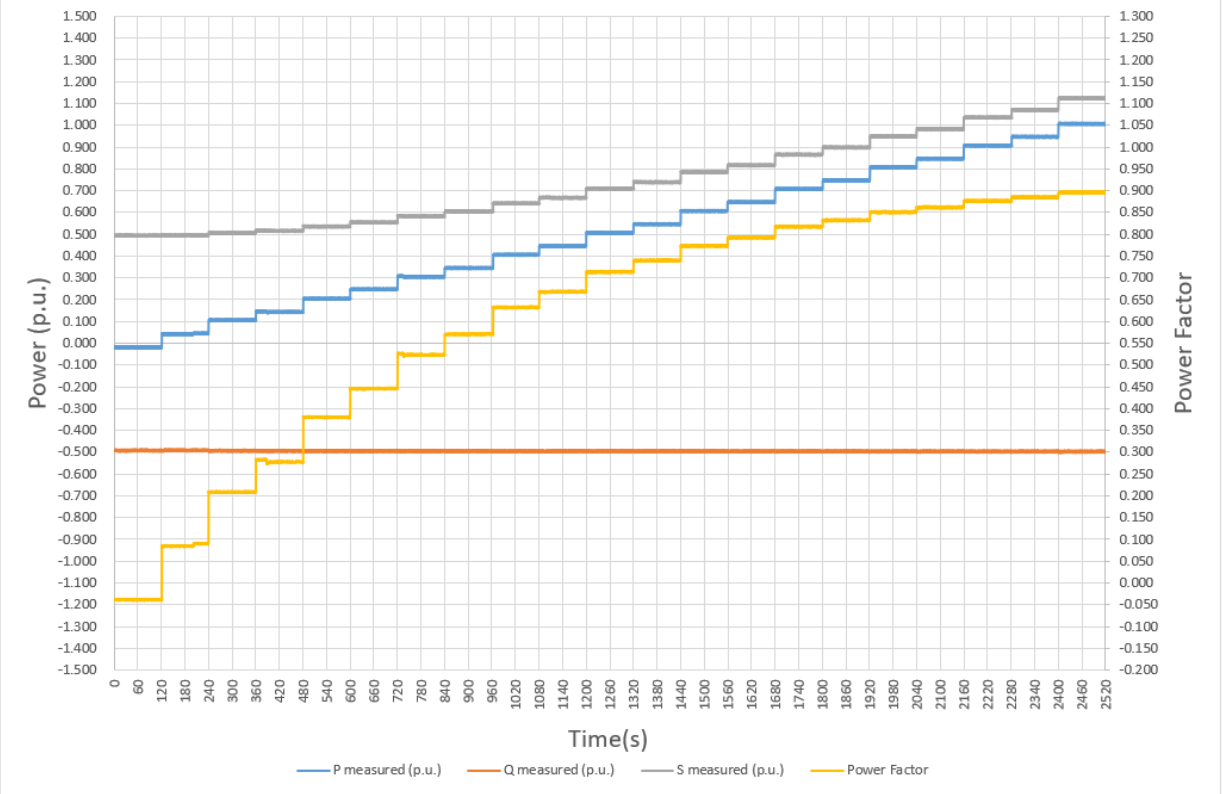
(*) No tolerance of reactive power was defined when active power level below 10%Sn

Test results are represented at diagrams below.

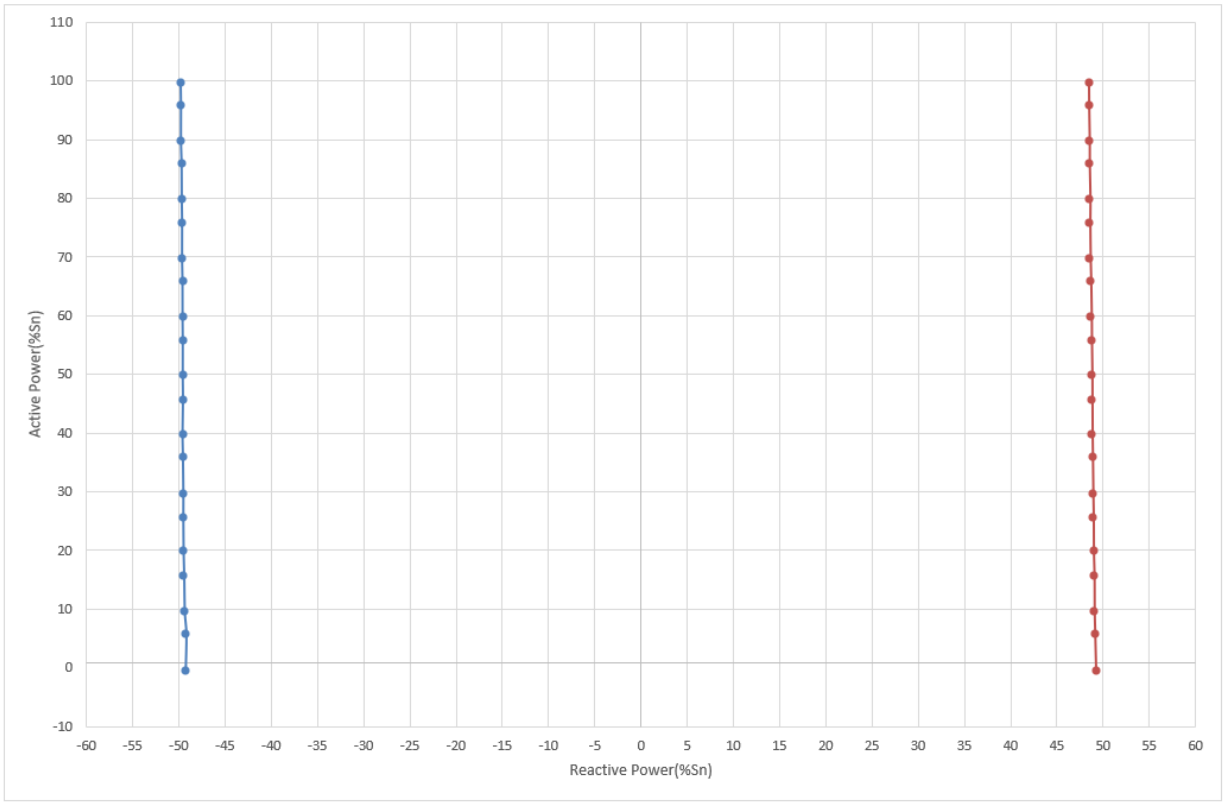
Rectangular Curve (Q = 48.4 %Sn / Inductive)



Rectangular Curve (Q = 48.4 %Sn / Capacitive)



Rectangular Curve (Capacitive vs Inductive)



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

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

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

Test results are offered at the tables below.

Triangular Curve (PF = 0.8 / inductive)						
P desired (%Sn)	**Power DC (kW)**	**P measured (%Sn)**	**Q measured (%Sn)**	**Power factor desired (cos φ)**	**Power factor measured (cos φ)**	**Power factor deviation (cos φ)**
0(*)	0.2	-1.1	-0.1	--	-0.505	--
5(*)	3.4	5.1	3.0	--	0.794	--
10(*)	5.5	9.1	5.9	--	0.802	--
15	8.6	15.2	10.4	0.800	0.805	0.005
20	10.7	19.3	13.5	0.800	0.805	0.005
25	13.8	25.4	18.1	0.800	0.806	0.006
30	15.9	29.7	21.4	0.800	0.805	0.005
35	19.1	35.8	25.9	0.800	0.806	0.006
40	21.3	39.7	28.9	0.800	0.805	0.005
45	24.5	45.7	33.4	0.800	0.804	0.004
50	26.6	49.7	36.4	0.800	0.804	0.004
55	29.8	55.8	40.9	0.800	0.804	0.004
60	32.0	59.8	43.9	0.800	0.804	0.004
65	35.2	65.9	48.4	0.800	0.804	0.004
70	37.4	69.9	51.4	0.800	0.804	0.004
75	40.7	75.9	55.9	0.800	0.804	0.004
80	42.9	80.0	58.9	0.800	0.804	0.004
85	46.2	86.0	63.3	0.800	0.804	0.004
90	48.4	90.0	66.3	0.800	0.804	0.004
95 (**)	49.4	91.7	67.0	0.800	0.807	0.007
100 (**)	49.3	91.6	66.9	0.800	0.807	0.007

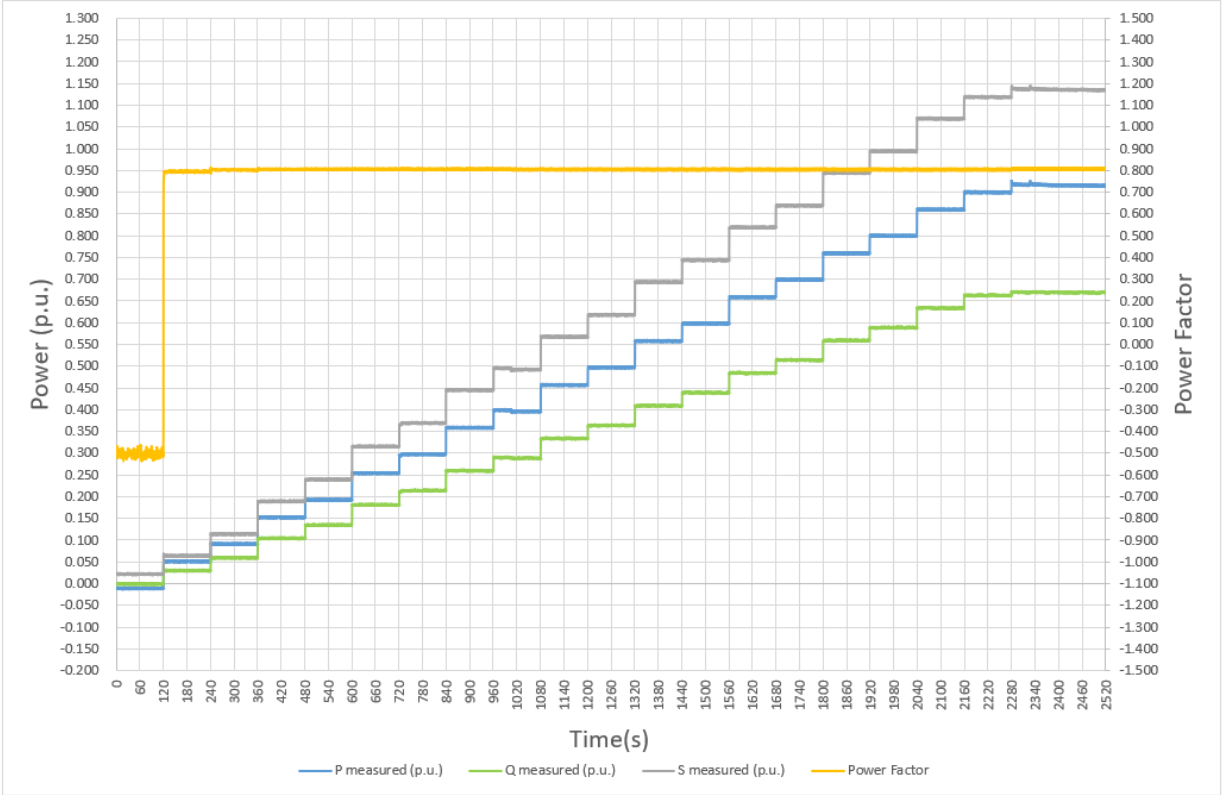
(*) No tolerance of Power Factor was defined when active power level below 10%Sn
(**) The desired value of active power has not been reached due to power factor is 0.8 of the inverter.

Triangular Curve (PF = 0.8 / Capacitive)						
P desired (%Sn)	**Power DC (kW)**	**P measured (%Sn)**	**Q measured (%Sn)**	**Power factor desired (cos φ)**	**Power factor measured (cos φ)**	**Power factor deviation (cos φ)**
0(*)	-0.4	-0.8	3.3	--	-0.199	--
5(*)	2.6	5.3	-3.2	--	0.793	--
10(*)	5.6	11.2	-7.9	--	0.794	--
15	7.6	15.2	-11.0	0.800	0.793	-0.007
20	10.6	21.1	-15.8	0.800	0.793	-0.007
25	12.5	24.9	-18.7	0.800	0.793	-0.007
30	15.6	31.1	-23.5	0.800	0.793	-0.007
35	17.5	35.0	-26.6	0.800	0.792	-0.008
40	20.4	40.9	-31.2	0.800	0.792	-0.008
45	22.5	45.1	-34.4	0.800	0.793	-0.007
50	25.4	50.8	-39.0	0.800	0.791	-0.009
55	27.4	54.7	-42.1	0.800	0.791	-0.009
60	30.3	60.7	-46.8	0.800	0.791	-0.009
65	32.3	64.7	-49.9	0.800	0.791	-0.009
70	35.3	70.6	-54.5	0.800	0.790	-0.010
75	37.3	74.6	-57.6	0.800	0.791	-0.009
80	40.3	80.5	-62.3	0.800	0.790	-0.010
85	42.2	84.4	-65.3	0.800	0.790	-0.010
90	45.2	90.3	-69.9	0.800	0.790	-0.010
95	47.1	94.3	-72.9	0.800	0.790	-0.010
100	49.2	98.5	-74.1	0.800	0.798	-0.002

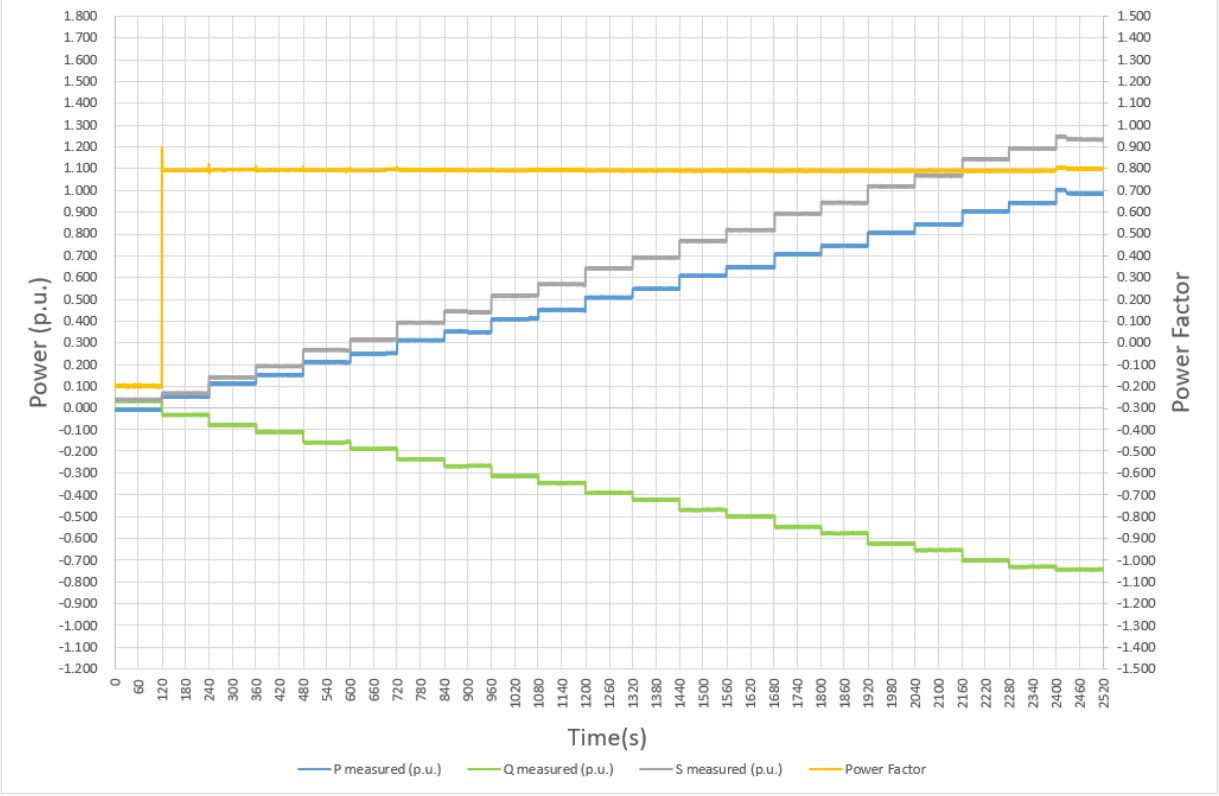
(*) No tolerance of Power Factor was defined when active power level below 10%Sn

Test results are represented at the diagrams below.

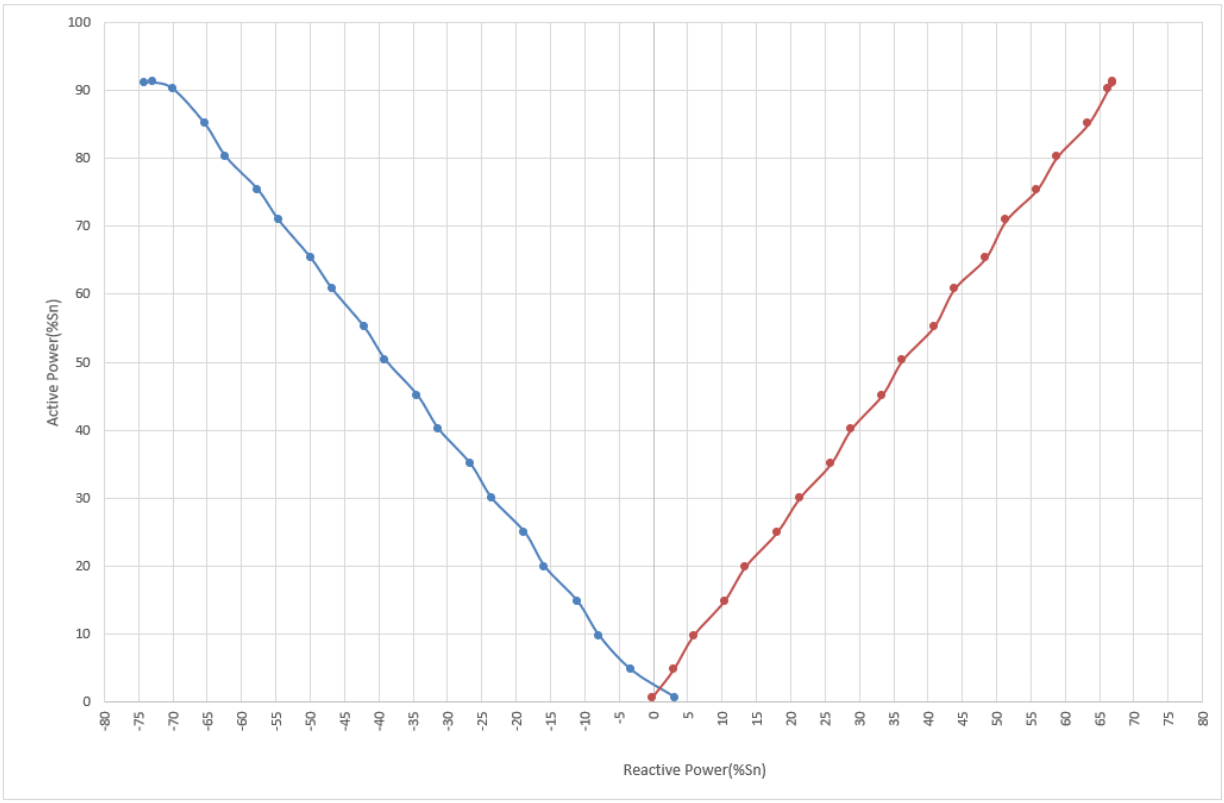
Triangular Curve (PF = 0.8 / Inductive)



Triangular Curve (PF = 0.8 / Capacitive)



Triangular Curve (Inductive vs Capacitive)



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

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

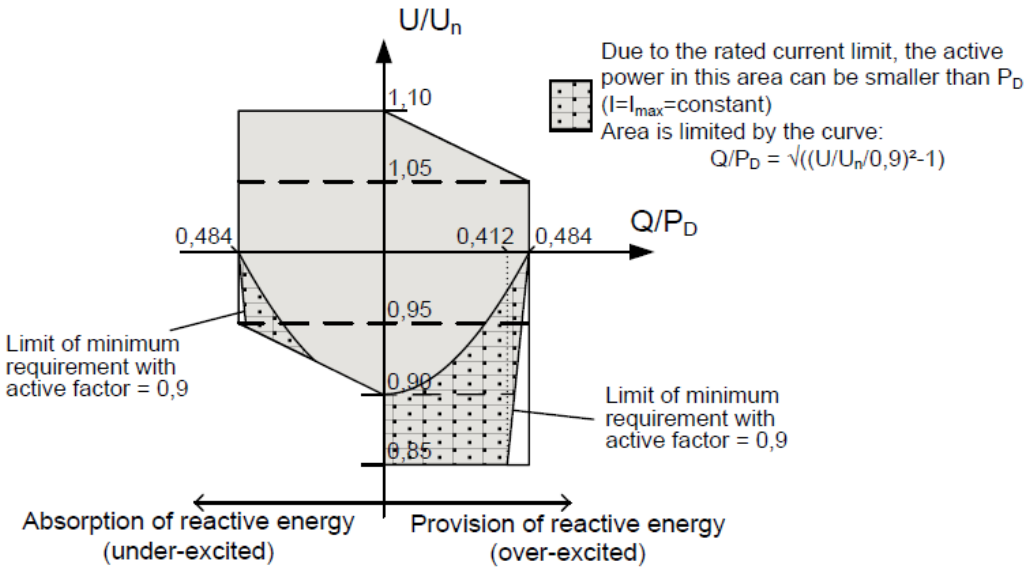


Figure 13 — Reactive power capability at active power P_D in the voltage range (positive sequence component of the fundamental)

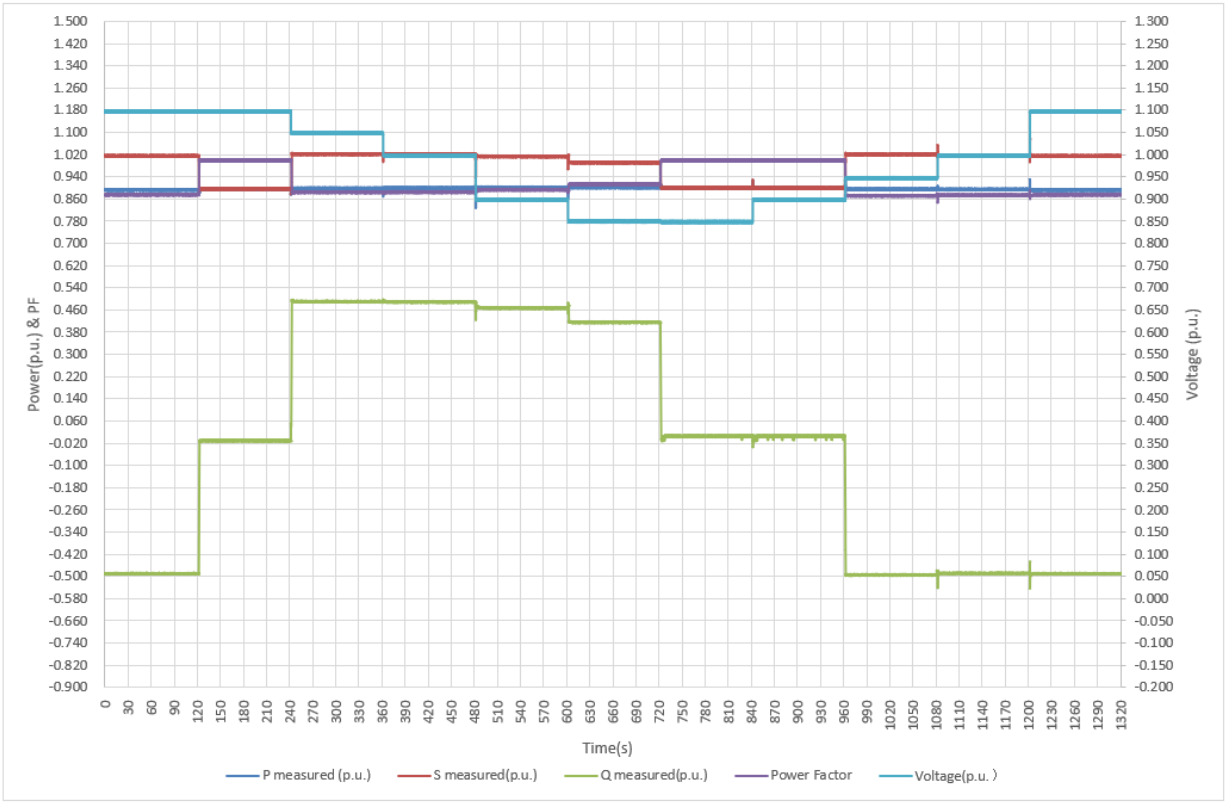
Allowed tolerance for reactive power measurements is to be considered inside ±2 %Sn (±2.2 %PD)

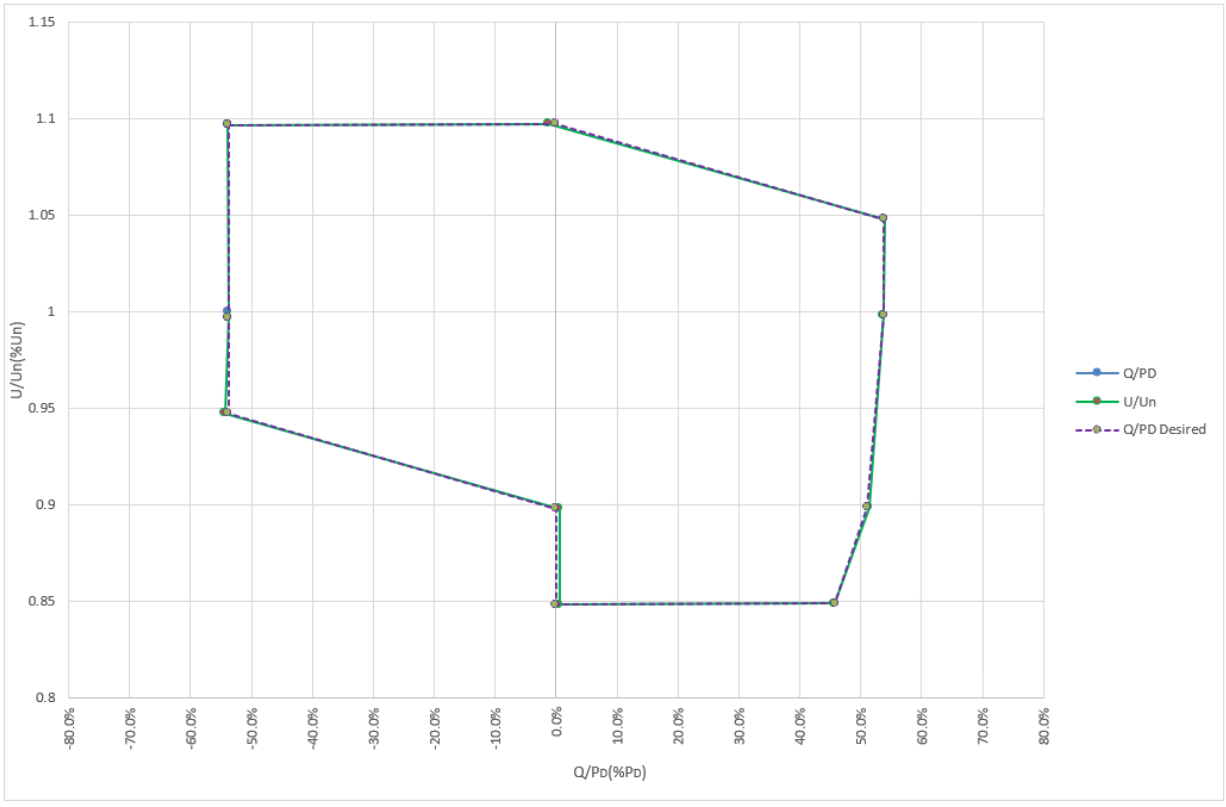
Test results are offered at the tables below.

Reactive power capability at active power PD in the voltage range								
Step	**Voltage desired (p.u.)**	**Voltage meas. (p.u.)**	**P desired (%Sn)**	**P meas. (%Sn)**	**Q meas. (%PD)**	**Q desired (%PD)**	**Q devation (%PD)**	**Power Factor measured (cos φ)**
1	1.100	1.097	90.0	89.2	-54.4	-53.8	-0.6	0.875
2	1.100	1.097	90.0	89.5	-1.2	0.0	-1.2	0.999
3	1.050	1.048	90.0	89.8	54.5	53.8	0.7	0.884
4	1.000	0.998	90.0	102.1	54.3	53.8	0.5	0.885
5	0.900	0.899	90.0	101.3	51.9	51.1	0.8	0.893
6	0.850	0.849	90.0	99.1	46.2	45.8	0.4	0.913
7	0.850	0.848	90.0	90.0	0.5	0.0	0.5	0.999
8	0.900	0.898	90.0	90.0	0.5	0.0	0.5	0.999
9	0.950	0.947	90.0	102.1	-54.9	-53.8	-1.2	0.871
10	1.000	0.997	90.0	101.7	-54.3	-53.8	-0.5	0.874
11	1.100	1.097	90.0	101.5	-54.5	-53.8	-0.7	0.875

Note: PD = 0.9 Pn a declared by manufacturer, while voltage operating range is at 0.85Un ~ 1.1Un.

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





4.4.2. Voltage related control mode

4.4.2.1. Voltage related control mode Q(U)

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

Note: The activation and deactivation of the function and its settings can be field adjustable through SunSpec Dashboard interface, under the menu of Volt_var, ModEna = 0 indicating function deactivation, while ModEna = 1 indicating function activation; means to setting the parameter are protected by key of the SunSpec Dashboard.

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

- U1 = 0.93, Qmax
- U2 = 0.96, Q= 0.1 p.u.
- U3 = 1.04, Q= - 0.1 p.u.
- U4 = 1.07, -Qmax

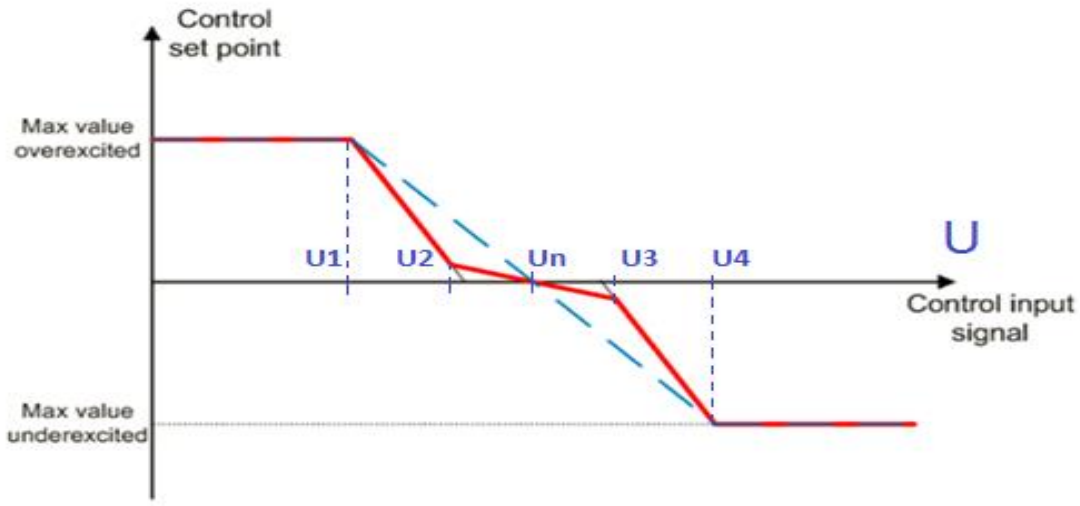


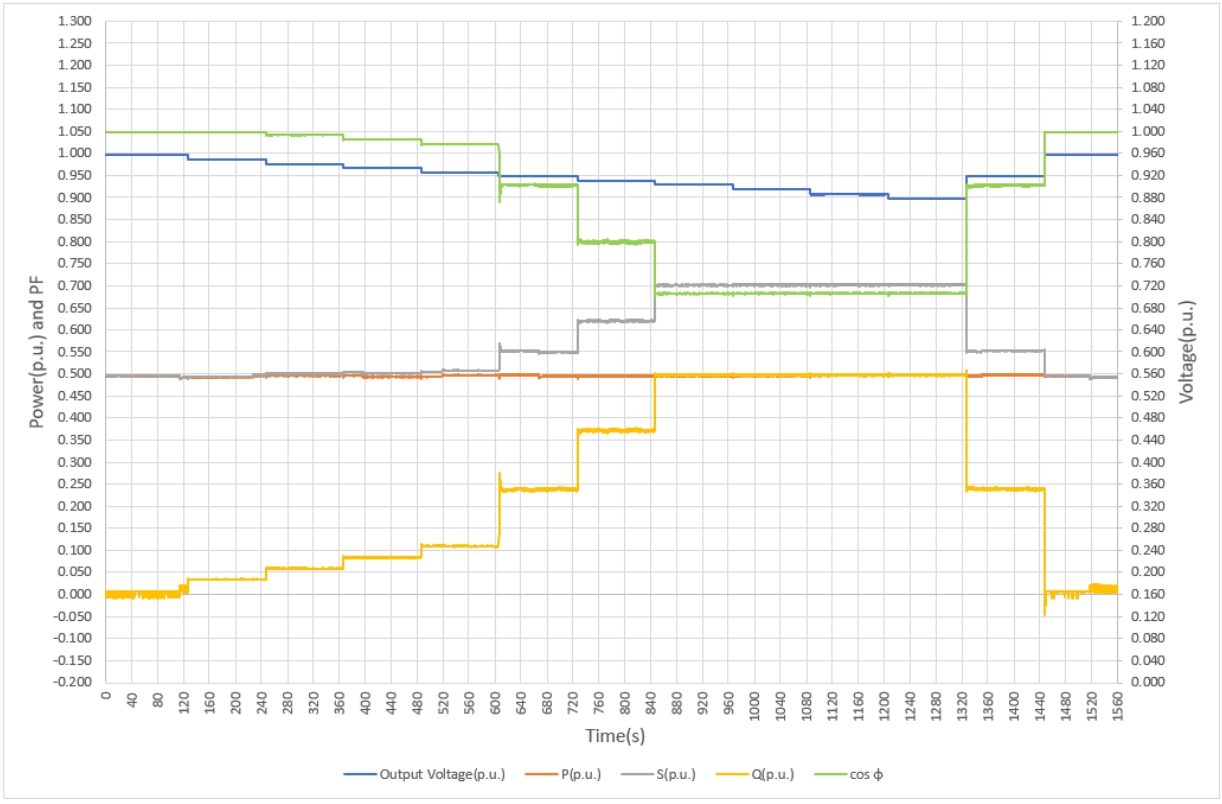
Figure 16 — Example characteristics for Q respectively cos φ control mode

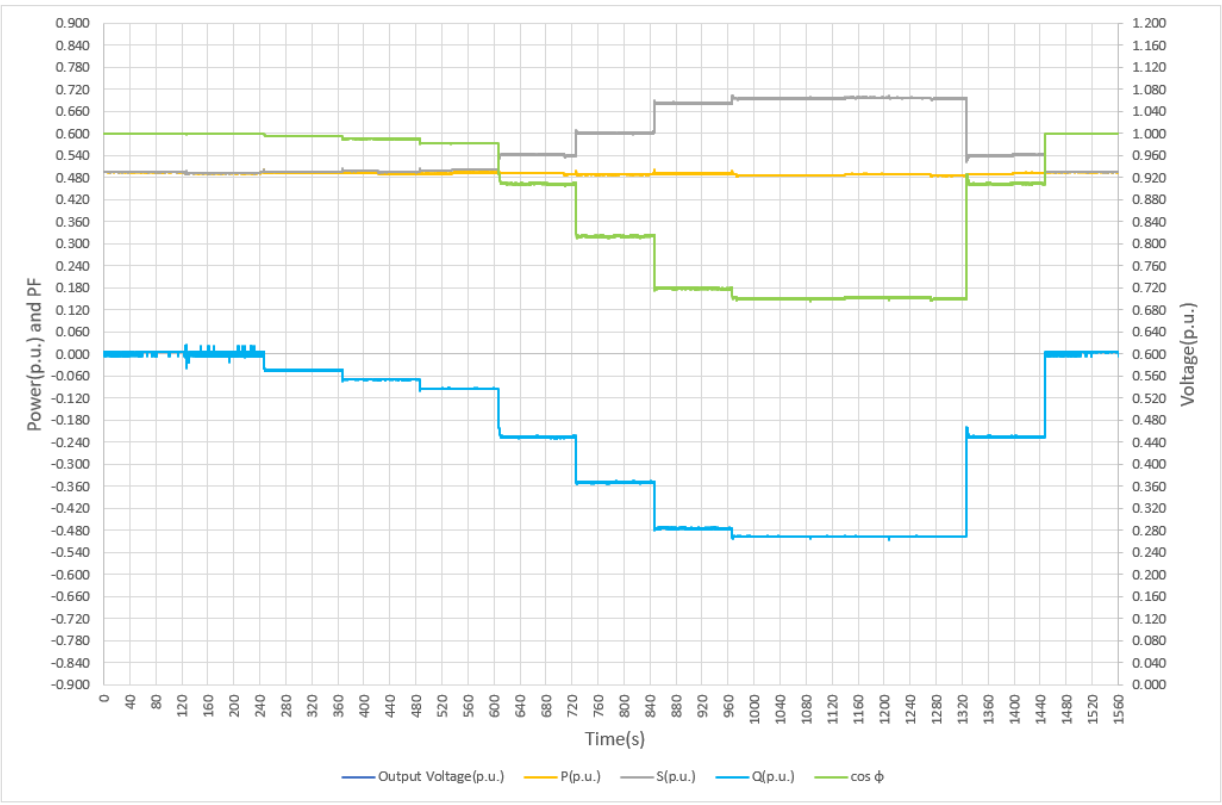
Test results are offered at the tables below.

P/Pn setpoint (%)	U setpoint	P measured (p.u.)	V measured (p.u.)	Q measured (p.u.)	Q desired (p.u.)	ΔQ (< ±0.05 p.u.)	Power Factor measured (cos φ)
50	1.000 Un	0.495	0.997	0.004	0.000	0.004	0.999
50	0.990 Un	0.493	0.987	0.035	0.025	0.010	0.997
50	0.980 Un	0.496	0.977	0.060	0.050	0.010	0.993
50	0.970 Un	0.494	0.967	0.085	0.075	0.010	0.986
50	0.960 Un	0.497	0.957	0.110	0.100	0.010	0.976
50	0.950 Un	0.496	0.947	0.238	0.228	0.010	0.902
50	0.940 Un	0.495	0.938	0.372	0.356	0.016	0.799
50	0.930 Un	0.495	0.928	0.497	0.484	0.013	0.706
50	0.920 Un	0.496	0.918	0.497	0.484	0.013	0.706
50	0.910 Un	0.496	0.908	0.498	0.484	0.014	0.706
50	0.900 Un	0.496	0.898	0.497	0.484	0.013	0.706
50	0.950 Un	0.498	0.948	0.239	0.228	0.011	0.901
50	1.000 Un	0.494	0.997	0.006	0.000	0.006	0.999

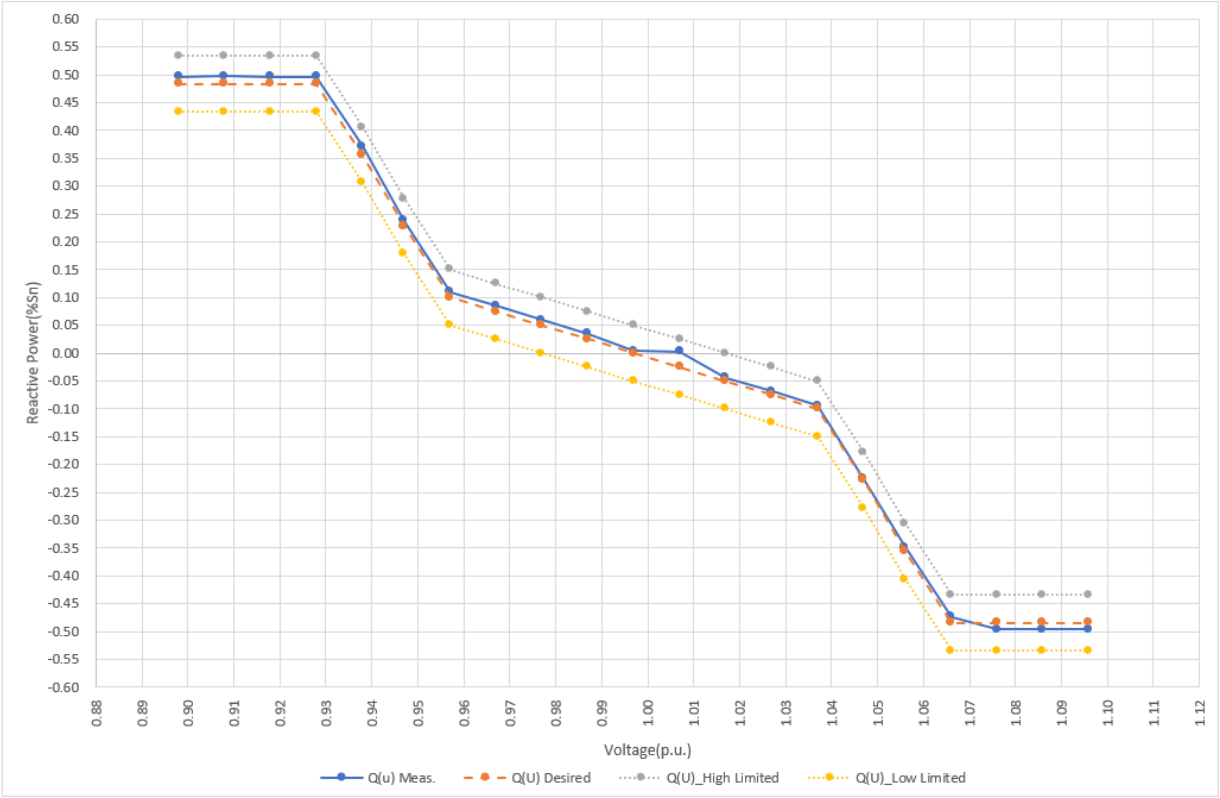
P/Pn setpoint (%)	U setpoint	P measured (p.u.)	V measured (p.u.)	Q measured (p.u.)	Q desired (p.u.)	ΔQ (< ±0.05 p.u.)	Power Factor measured (cos φ)
50	1.000 Un	0.495	0.997	0.005	0.000	0.005	0.999
50	1.010 Un	0.492	1.007	0.003	-0.025	0.028	0.999
50	1.020 Un	0.494	1.017	-0.044	-0.050	0.006	0.996
50	1.030 Un	0.492	1.027	-0.069	-0.075	0.006	0.990
50	1.040 Un	0.493	1.037	-0.094	-0.100	0.006	0.982
50	1.050 Un	0.493	1.047	-0.226	-0.228	0.002	0.909
50	1.060 Un	0.489	1.056	-0.349	-0.356	0.007	0.814
50	1.070 Un	0.491	1.066	-0.474	-0.484	0.010	0.719
50	1.080 Un	0.487	1.076	-0.496	-0.484	-0.012	0.700
50	1.090 Un	0.489	1.086	-0.496	-0.484	-0.012	0.702
50	1.100 Un	0.488	1.096	-0.496	-0.484	-0.012	0.701
50	1.050 Un	0.491	1.047	-0.225	-0.228	0.003	0.909
50	1.000 Un	0.495	0.997	0.005	0.000	0.005	0.999

Voltage related control mode - Q(U)





Voltage vs Reactive Power



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

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

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

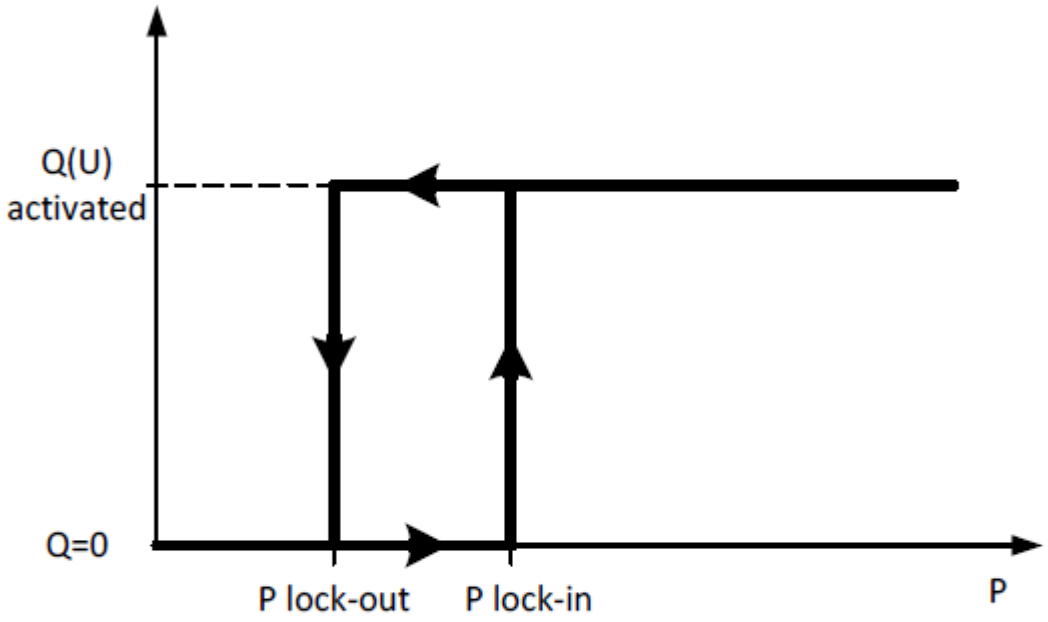


Figure 14 – Example of lock-in and lock-out values for Q(U) mode

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

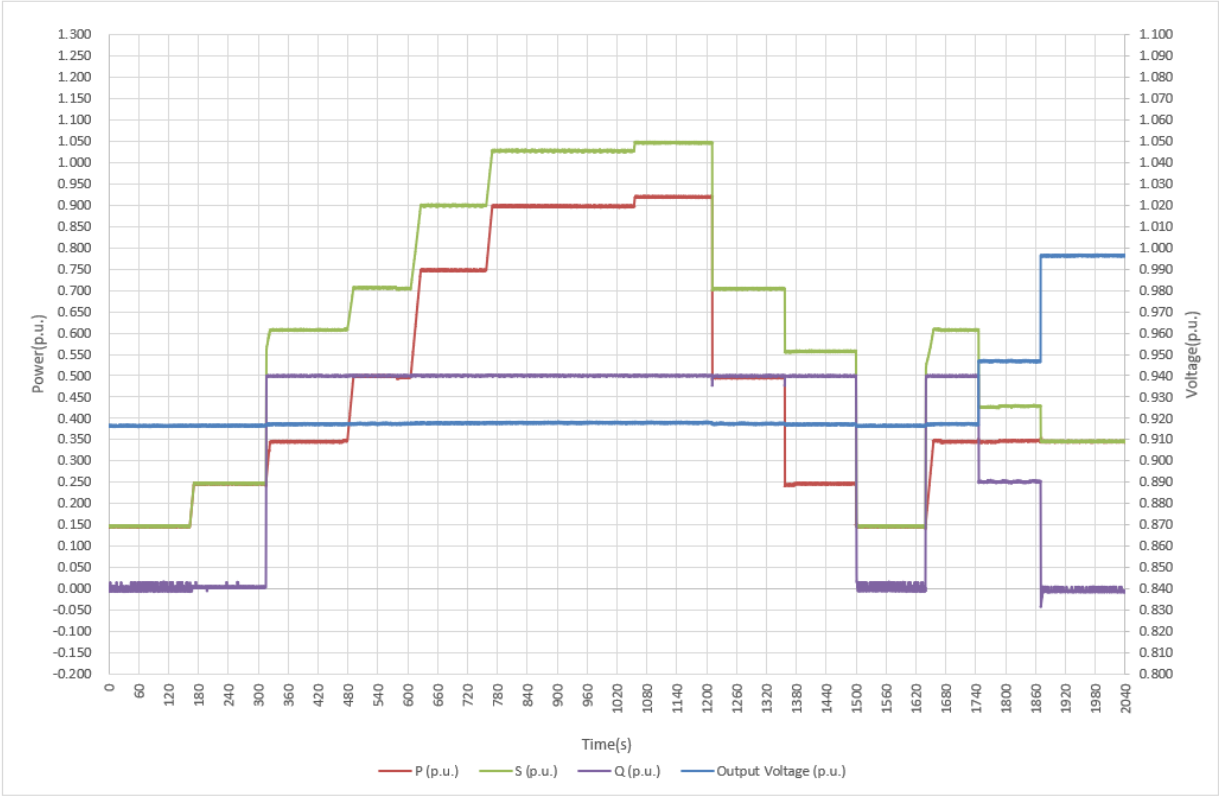
- U1 = 0.93, Qmax
- U2 = 0.96, Q= 0.1 p.u.
- U3 = 1.04, Q= - 0.1 p.u.
- U4 = 1.07, -Qmax

P lock-in = 30 %, P lock-out = 20 %

Test results are offered at the tables below.

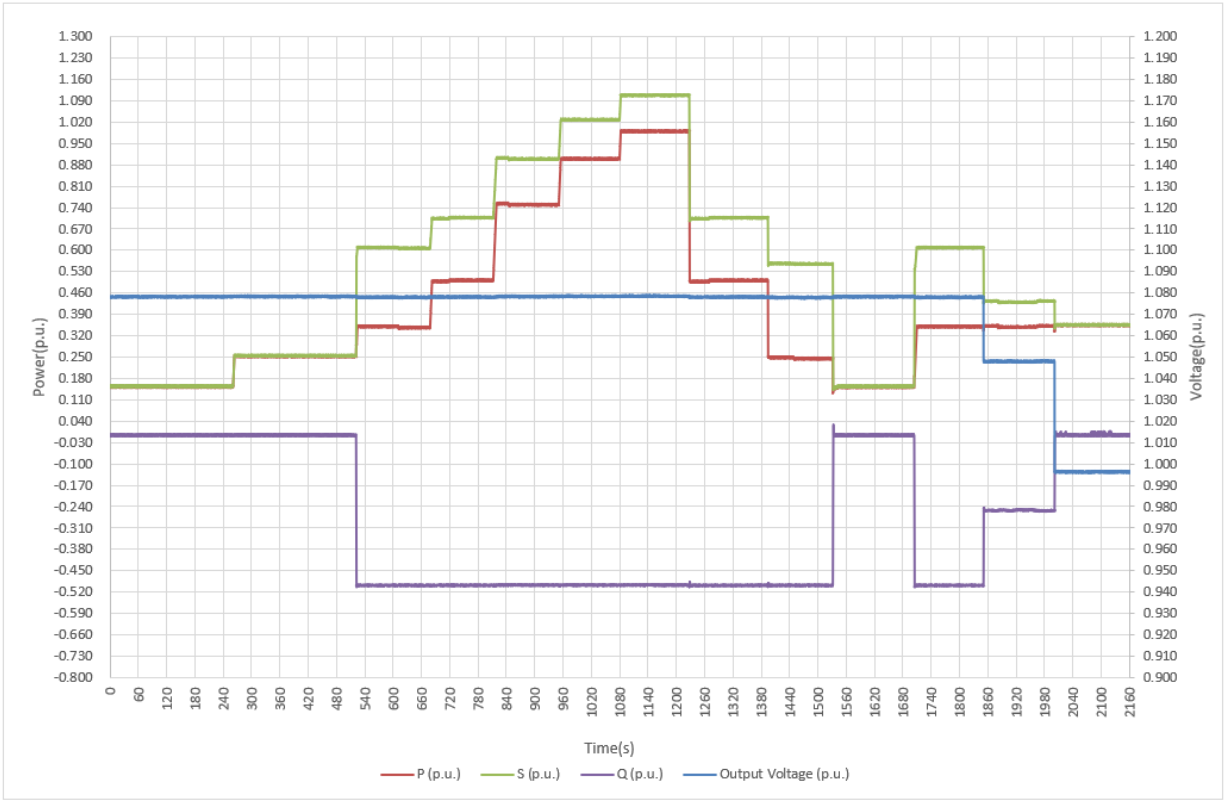
Reactive power injection in relation with the Voltage (inductive)						
P/Pn setpoint (%Pn)	**U setpoint (p.u.)**	**P meas. (p.u.)**	**V meas. (p.u.)**	**Q meas. (p.u.)**	**Q desired (p.u.)**	**ΔQ (< ±0.05 p.u.)**
<20	0.920	0.146	0.916	0.002	0.000	0.002
25	0.920	0.247	0.917	0.004	0.000	0.004
35	0.920	0.345	0.917	0.500	0.484	0.015
50	0.920	0.499	0.917	0.500	0.484	0.016
75	0.920	0.748	0.918	0.500	0.484	0.016
90	0.920	0.898	0.918	0.500	0.484	0.016
100	0.920	0.919	0.918	0.500	0.484	0.016
50	0.920	0.496	0.917	0.500	0.484	0.016
25	0.920	0.247	0.917	0.500	0.484	0.015
<20	0.920	0.146	0.917	0.002	0.000	0.002
35	0.920	0.345	0.917	0.500	0.484	0.015
35	0.950	0.347	0.947	0.251	0.242	0.010
35	1.000	0.345	0.996	-0.005	0.000	-0.005

Reactive power injection in relation with the Voltage (inductive)



Reactive power injection in relation with the Voltage (capacitive)						
P/Pn setpoint (%Pn)	U setpoint (p.u.)	P meas. (p.u.)	V meas. (p.u.)	Q meas. (p.u.)	Q desired (p.u.)	ΔQ (< ±0.05 p.u.)
<20	1.080	0.153	1.078	-0.006	0.000	-0.006
25	1.080	0.253	1.078	-0.006	0.000	-0.006
35	1.080	0.347	1.078	-0.498	-0.484	-0.014
50	1.080	0.502	1.078	-0.498	-0.484	-0.014
75	1.080	0.749	1.078	-0.497	-0.484	-0.013
90	1.080	0.900	1.079	-0.497	-0.484	-0.013
100	1.080	0.990	1.079	-0.497	-0.484	-0.013
50	1.080	0.501	1.078	-0.498	-0.484	-0.014
25	1.080	0.246	1.078	-0.498	-0.484	-0.014
<20	1.080	0.152	1.078	-0.006	0.000	-0.006
35	1.080	0.350	1.078	-0.498	-0.484	-0.014
35	1.050	0.350	1.048	-0.252	-0.242	-0.010
35	1.000	0.355	0.996	-0.005	0.000	-0.005

Reactive power injection in relation with the Voltage (capacitive)



4.4.2.3 Static accuracy

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

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

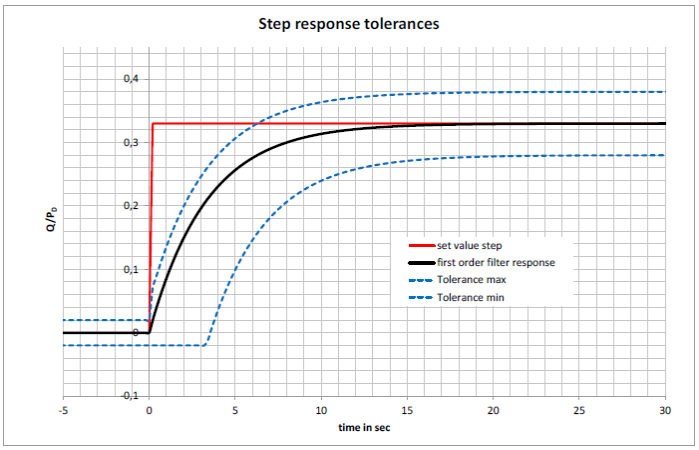
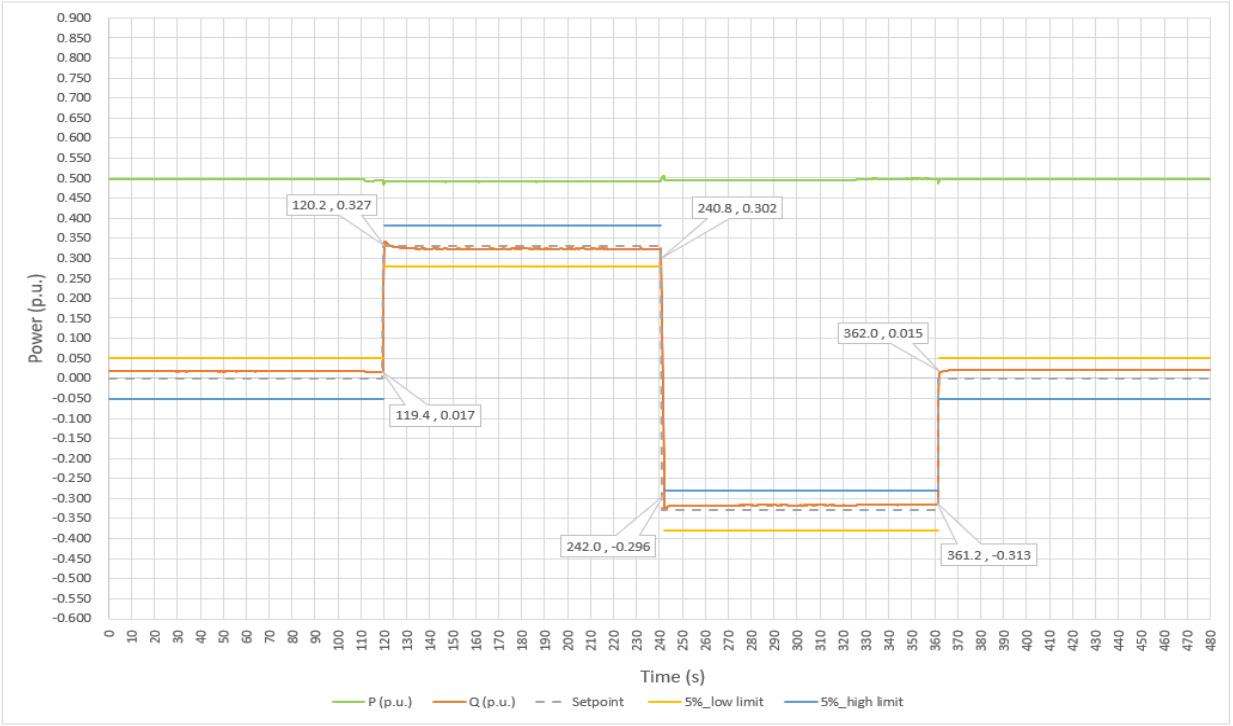


Figure 15 — Example of dynamic control response and tolerance band for a step from Q=0 to Q= 33%P_D with τ=3,33s

Test results are offered at the tables below.

%Pn	Steps	Time measured (s)
50	Q = 0 → Q = 33 %Sn (Inductive)	t = 0.8
	Q = 33 %Sn (Inductive) → Q = 33 %Sn (Capacitive)	t = 1.2
	Q = 33 %Sn (Capacitive) → Q = 0	t = 0.8

Reactive power injection dynamic control response and tolerance band

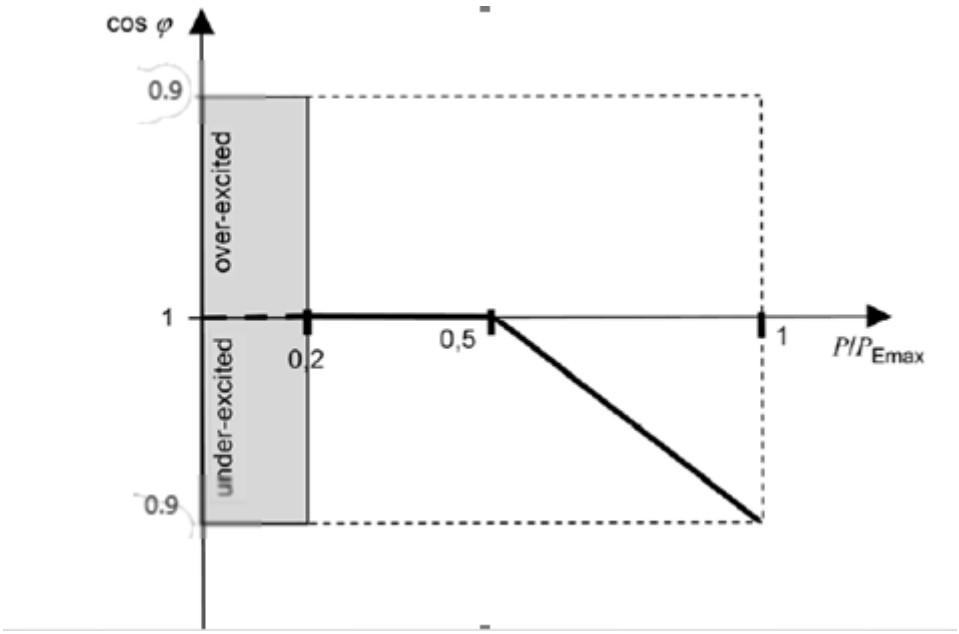


4.4.2.4 Power related control mode

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

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

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

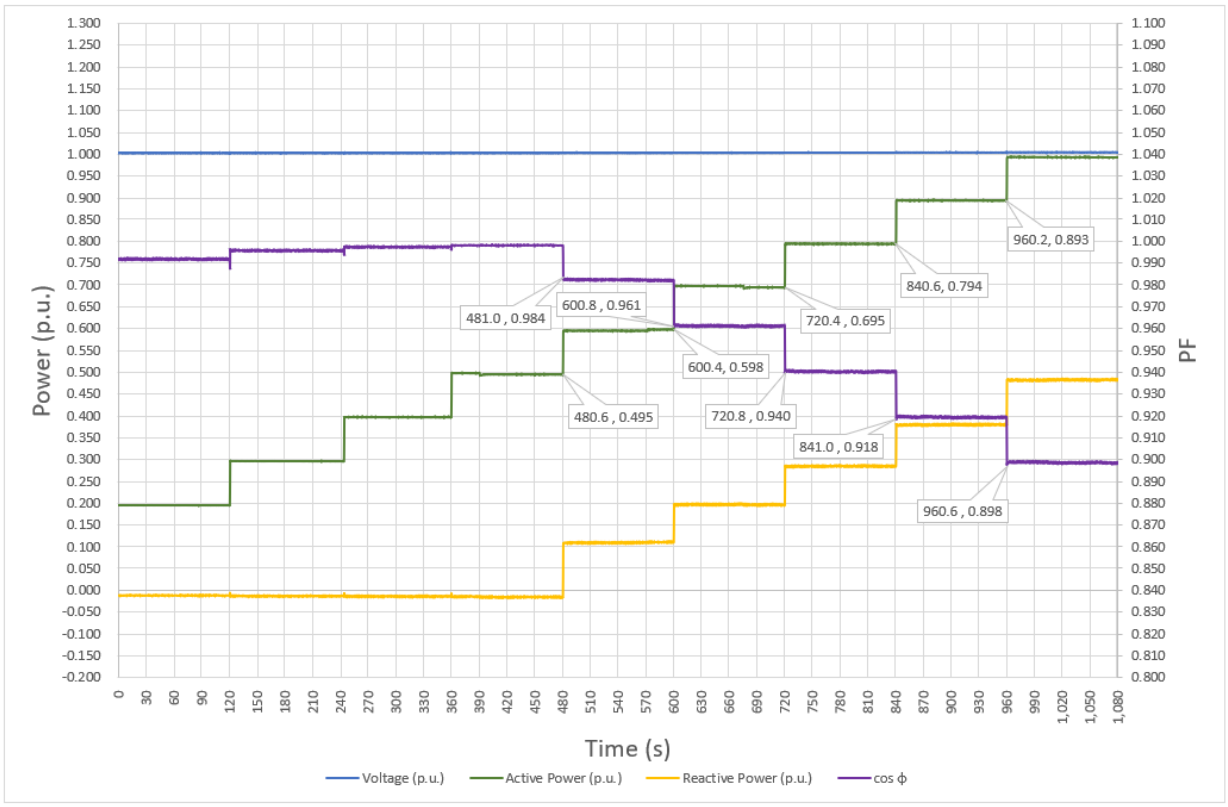


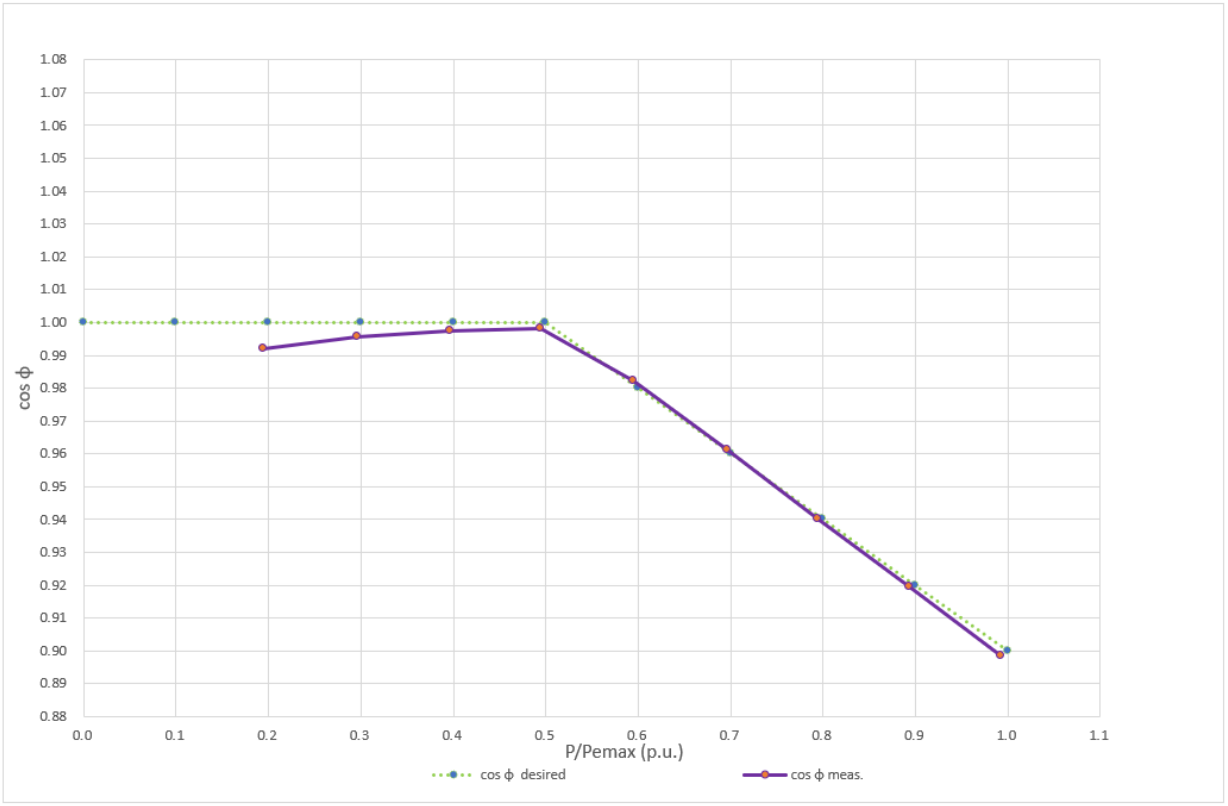
Resulting from a change in active power output a new cos φ set point is defined according to the set characteristic. The response to a new cos φ set value shall be as fast as technically feasible to allow the change in reactive power to be in synchrony with the change in active power. The new reactive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

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

Setting cos φ(P) with the standard characteristic curve (20 %Pn to 100 %Pn)						
Active Power setting ($\%P_{Emax}$)	**Active Power measured (p.u.)**	**Reactive Power measured (p.u.)**	**cos φ measured**	**Desired cos φ**	**Δ cos φ (<0.01)**	**Transient period (<10s)**
20	0.195	-0.012	0.992	1.000	-0.008	
30	0.296	-0.013	0.996	1.000	-0.004	--
40	0.397	-0.014	0.997	1.000	-0.003	--
50	0.495	-0.015	0.998	1.000	-0.002	--
60	0.595	0.109	0.982	0.980	0.002	0.4
70	0.696	0.197	0.961	0.960	0.001	0.4
80	0.794	0.285	0.940	0.940	0.000	0.4
90	0.894	0.380	0.919	0.920	-0.001	0.4
100	0.993	0.483	0.899	0.900	-0.001	0.6

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



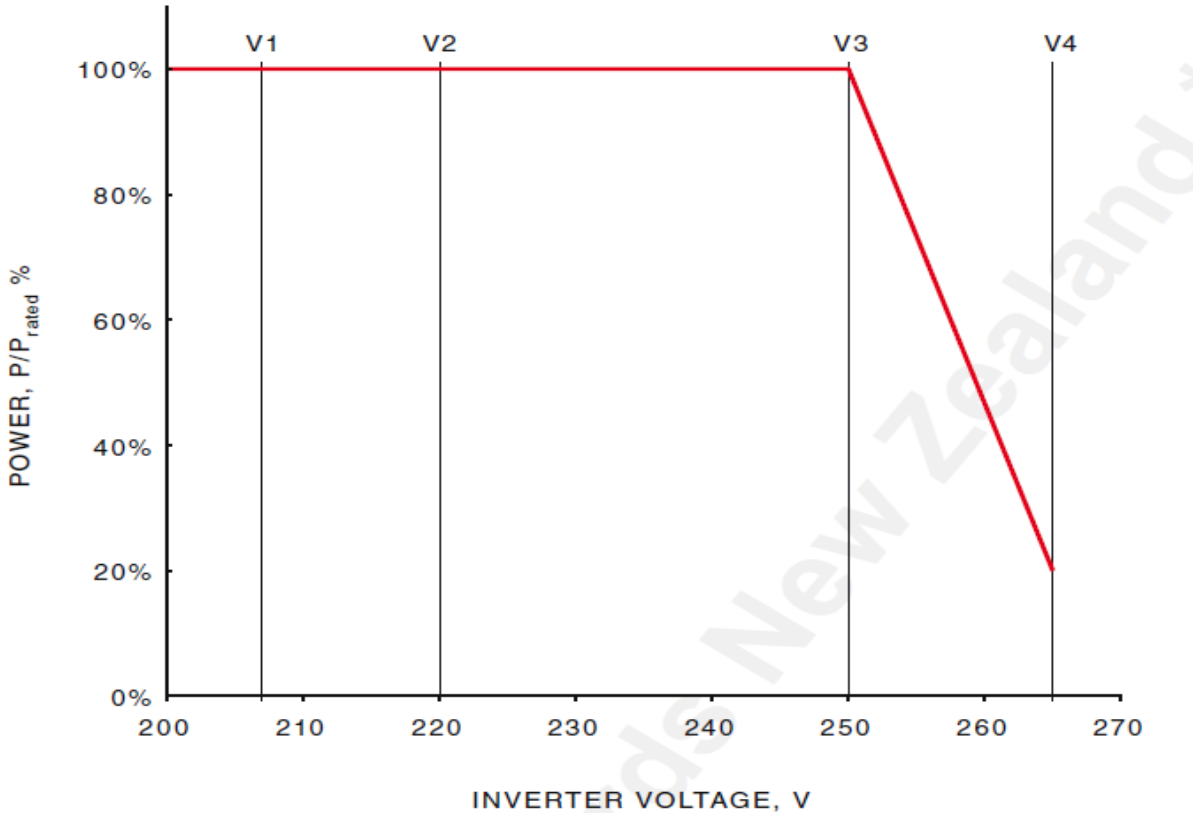


4.4.3. Voltage related active power reduction (Volt-Watt)

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

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

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



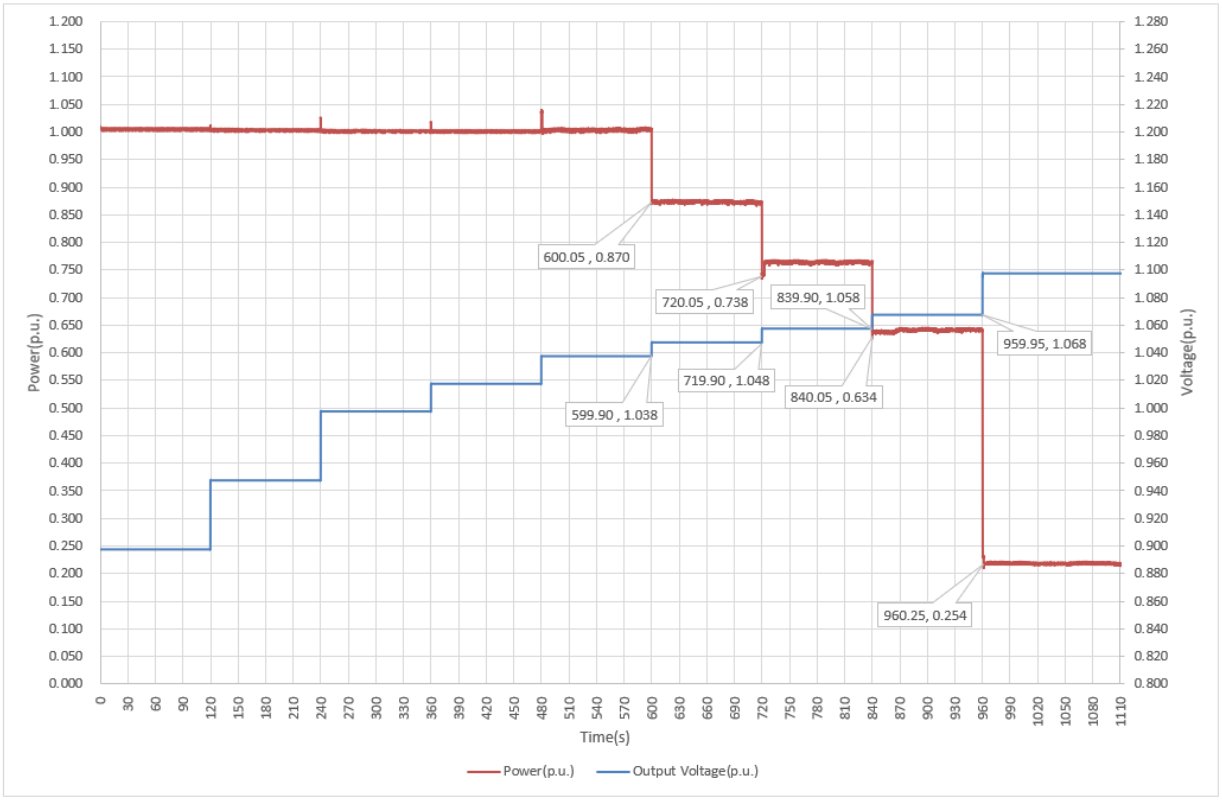
Test 1 and Test 2 setpoint as following:

Reference	Test 1 Set points		Test 2 Set points	
	Volt. (%Un)	Power (%Pn)	Volt. (%Un)	Power (%Pn)
V1	90.0%	100%	90.0%	100%
V2	95.6%	100%	95.6%	100%
V3	104.0%	100%	108.7%	100%
V4	110.0%	20%	115.2%	20%

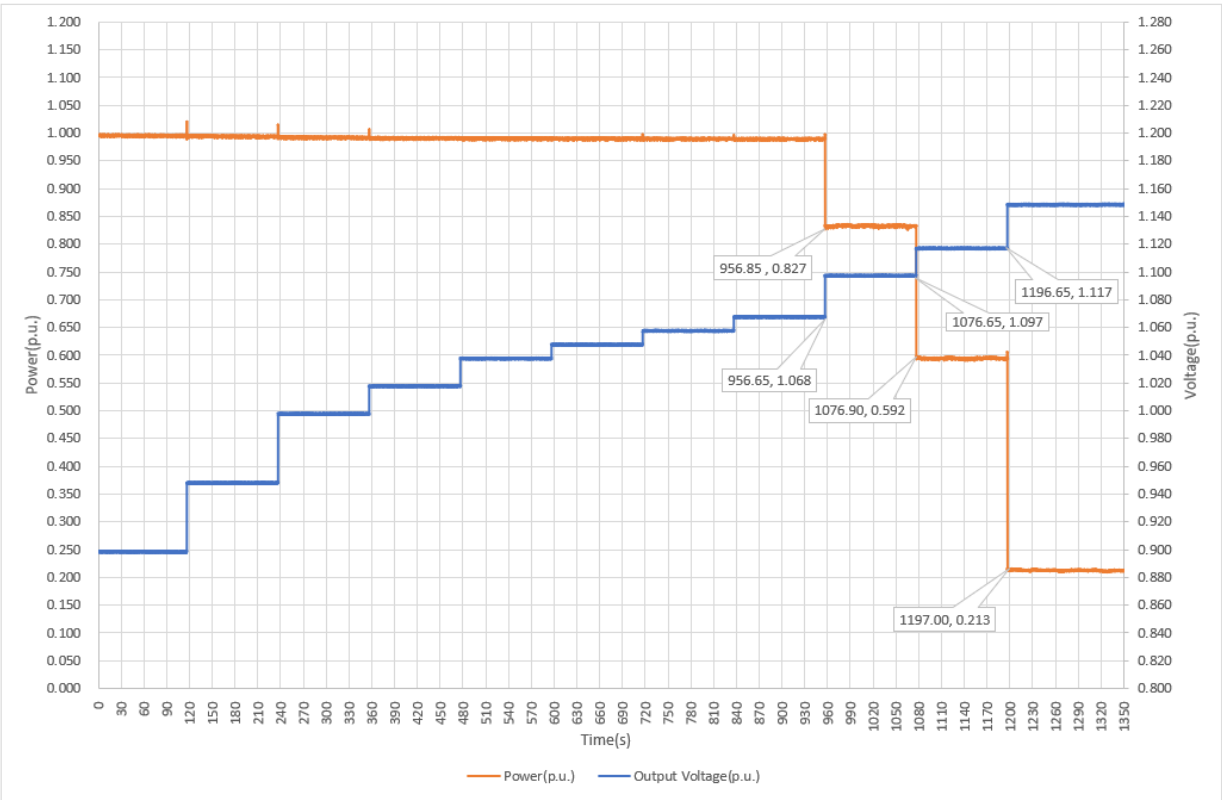
Test results are offered at tables below.

Volt-Watt TEST 1					
V setting (p.u.)	**V meas. (p.u.)**	**P desired (p.u.)**	**P meas. (p.u.)**	**P deviation (p.u.)**	**Response time (s)**
0.900	0.898	1.000	1.006	1.000	--
0.950	0.947	1.000	1.004	1.000	--
1.000	0.997	1.000	1.002	1.000	--
1.020	1.018	1.000	1.002	1.000	--
1.040	1.038	1.000	1.004	1.000	--
1.050	1.047	0.867	0.873	0.867	0.15
1.060	1.057	0.771	0.764	0.771	0.15
1.070	1.068	0.657	0.642	0.657	0.15
1.100	1.098	0.200	0.218	0.200	0.15
Volt-Watt TEST 2					
V setting (p.u.)	**V meas. (p.u.)**	**P desired (p.u.)**	**P meas. (p.u.)**	**P deviation (p.u.)**	**Response time (s)**
0.900	0.898	1.000	0.996	1.000	--
0.950	0.948	1.000	0.995	1.000	--
1.000	0.998	1.000	0.993	1.000	--
1.020	1.018	1.000	0.992	1.000	--
1.040	1.038	1.000	0.991	1.000	--
1.050	1.048	1.000	0.991	1.000	--
1.060	1.058	1.000	0.990	1.000	--
1.070	1.068	1.000	0.990	1.000	--
1.100	1.097	0.840	0.834	0.840	0.20
1.120	1.117	0.594	0.595	0.594	0.25
1.152	1.148	0.200	0.213	0.200	0.35

Volt-Watt Test 1



Vatt-Watt Test 2



4.4.4. Short circuit current requirements on generating plants

The following clauses describe the required short circuit current contribution for generating plants taking into account the connection technology of the generating modules.

Generating modules classified as type B modules according to COMMISSION REGULATION 2016/631 shall comply with the requirements of 4.7.4.2 and 4.7.4.3. Generating modules classified as type A according to COMMISSION REGULATION 2016/631 should comply with these requirements. The actual behaviour of type A modules shall be specified in the connection agreement.

4.4.4.1 Generating plant with non-synchronous generating technology

4.4.4.1.1 Voltage support during faults and voltage steps

The requirements are stated in clause 4.7.4.2.1 of the standard.

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

4.4.4.1.2 Zero current mode for converter connected generating technology

The requirements are stated in clause 4.7.4.2.2 of the standard.

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

4.4.4.1.3 Induction generator based units

The requirements are stated in clause 4.7.4.2.3 of the standard.

The EUT is no voltage support during faults and voltage steps. This clause is not applicable.

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

The requirements are stated in clause 4.7.4.3 of the standard.

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

4.5. EMC AND POWER QUALITY

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

The compliances with these requirements are stated in the following test reports:
Test Report no. ES170725041E-1, issued by EMTEK (SHENZHEN) CO., LTD on March 10th, 2020.

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

4.5.1. Harmonic emissions

The test has been done according to the clause 4.8 of the standard EN 61000-3-12

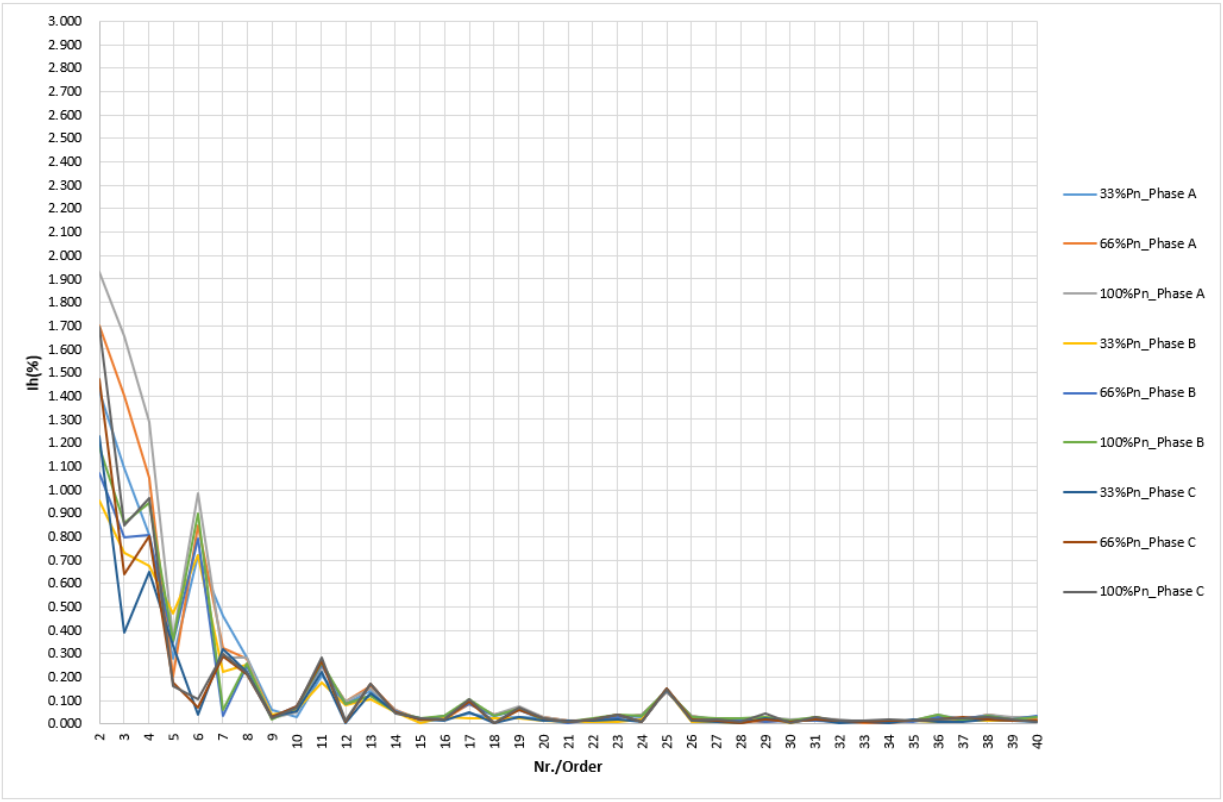
Below are the measured values of current harmonics.

Phase A				
P_{bin} (%)	33	66	100	LIMIT
Nr. / Order	I_h (%)	I_h (%)	I_h (%)	(%)
2	1.424	1.702	1.928	8.000
3	1.091	1.401	1.657	--
4	0.805	1.053	1.290	4.000
5	0.281	0.201	0.367	10.700
6	0.722	0.846	0.987	2.700
7	0.460	0.326	0.283	7.200
8	0.285	0.280	0.283	2.000
9	0.062	0.035	0.026	--
10	0.028	0.060	0.052	1.600
11	0.210	0.249	0.242	3.100
12	0.085	0.097	0.096	1.300
13	0.140	0.163	0.151	2.000
14	0.052	0.059	0.059	--
15	0.024	0.019	0.012	--
16	0.018	0.018	0.023	--
17	0.047	0.088	0.095	--
18	0.025	0.040	0.040	--
19	0.030	0.065	0.075	--
20	0.022	0.028	0.027	--
21	0.008	0.012	0.016	--
22	0.009	0.014	0.014	--
23	0.013	0.027	0.028	--
24	0.023	0.037	0.041	--
25	0.144	0.135	0.136	--
26	0.019	0.037	0.032	--
27	0.011	0.017	0.018	--
28	0.012	0.015	0.017	--
29	0.020	0.010	0.029	--
30	0.007	0.022	0.019	--
31	0.022	0.014	0.026	--
32	0.009	0.012	0.019	--
33	0.011	0.006	0.009	--
34	0.006	0.004	0.010	--
35	0.014	0.016	0.013	--
36	0.011	0.036	0.041	--
37	0.017	0.013	0.020	--
38	0.014	0.039	0.041	--
39	0.021	0.024	0.029	--
40	0.021	0.025	0.028	--
THD (%)	2.206	2.656	3.089	**13.000**
PWHD (%)	0.883	1.036	1.105	**22.000**

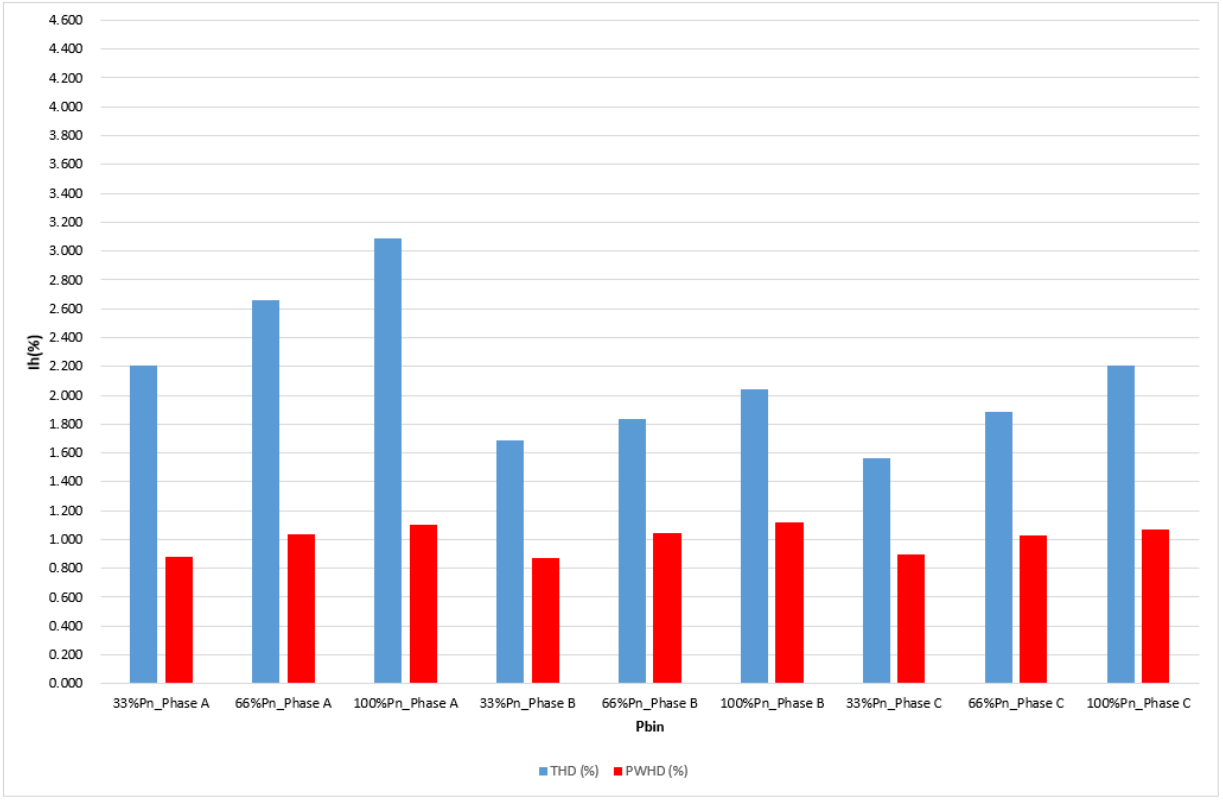
Phase B				
P_{bin} (%)	33	66	100	LIMIT (%)
Nr. / Order	I_h (%)	I_h (%)	I_h (%)	
2	0.953	1.072	1.181	8.000
3	0.729	0.798	0.856	--
4	0.675	0.805	0.945	4.000
5	0.473	0.348	0.357	10.700
6	0.722	0.791	0.897	2.700
7	0.221	0.037	0.060	7.200
8	0.252	0.246	0.259	2.000
9	0.040	0.027	0.022	--
10	0.060	0.075	0.073	1.600
11	0.178	0.253	0.263	3.100
12	0.082	0.087	0.083	1.300
13	0.104	0.122	0.119	2.000
14	0.052	0.055	0.049	--
15	0.004	0.018	0.024	--
16	0.028	0.035	0.033	--
17	0.026	0.088	0.105	--
18	0.027	0.036	0.034	--
19	0.025	0.058	0.066	--
20	0.016	0.021	0.021	--
21	0.008	0.005	0.011	--
22	0.012	0.021	0.023	--
23	0.011	0.032	0.037	--
24	0.019	0.033	0.033	--
25	0.147	0.143	0.145	--
26	0.009	0.028	0.029	--
27	0.010	0.022	0.025	--
28	0.006	0.017	0.024	--
29	0.029	0.011	0.029	--
30	0.004	0.016	0.015	--
31	0.030	0.015	0.032	--
32	0.012	0.008	0.007	--
33	0.009	0.010	0.011	--
34	0.007	0.012	0.013	--
35	0.013	0.011	0.013	--
36	0.007	0.030	0.038	--
37	0.015	0.025	0.013	--
38	0.015	0.033	0.036	--
39	0.015	0.020	0.021	--
40	0.016	0.033	0.028	--
THD (%)	1.685	1.839	2.043	**13.000**
PWHD (%)	0.873	1.048	1.115	**22.000**

Phase C				
P_{bin}(%)	33	66	100	LIMIT
Nr. / Order	I_h (%)	I_h (%)	I_h (%)	(%)
2	1.227	1.472	1.695	8.000
3	0.391	0.640	0.849	--
4	0.648	0.803	0.964	4.000
5	0.335	0.175	0.159	10.700
6	0.042	0.072	0.104	2.700
7	0.322	0.291	0.297	7.200
8	0.221	0.213	0.217	2.000
9	0.029	0.029	0.025	--
10	0.054	0.075	0.071	1.600
11	0.221	0.270	0.282	3.100
12	0.005	0.011	0.014	1.300
13	0.129	0.172	0.173	2.000
14	0.048	0.049	0.046	--
15	0.021	0.019	0.023	--
16	0.014	0.022	0.021	--
17	0.052	0.097	0.107	--
18	0.003	0.005	0.006	--
19	0.030	0.060	0.069	--
20	0.017	0.025	0.025	--
21	0.014	0.011	0.010	--
22	0.014	0.021	0.020	--
23	0.018	0.038	0.040	--
24	0.008	0.011	0.010	--
25	0.153	0.151	0.145	--
26	0.012	0.019	0.015	--
27	0.007	0.013	0.019	--
28	0.006	0.007	0.010	--
29	0.026	0.020	0.045	--
30	0.009	0.007	0.006	--
31	0.019	0.018	0.028	--
32	0.003	0.017	0.013	--
33	0.008	0.009	0.013	--
34	0.004	0.016	0.021	--
35	0.021	0.017	0.015	--
36	0.010	0.021	0.018	--
37	0.009	0.028	0.027	--
38	0.018	0.020	0.028	--
39	0.013	0.015	0.019	--
40	0.008	0.016	0.011	--
THD (%)	1.565	1.882	2.205	**13.000**
PWHD (%)	0.898	1.025	1.066	**22.000**

Current Harmonics



THD and PWHD



4.5.2. Flicker and voltage fluctuations

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

The measurements of voltage fluctuations have been measured at 33%, 66% and 100% of the nominal power value of the inverter according to the standard IEC 61000-3-11:2017.

The flicker test result as following:

33 %Pn				
Pbin (%)	**Limit**	**Phase A**	**Phase B**	**Phase C**
PST	≤ 1.0	0.261	0.275	0.264
PLT	≤ 0.65	0.250	0.266	0.235
dc	≤ 3.30 %	0.081 %	0.028 %	0.051%
dmax	4 %	0.542 %	0.354 %	0.472 %

66 %Pn				
Pbin (%)	**Limit**	**Phase A**	**Phase B**	**Phase C**
PST	≤ 1.0	0.461	0.460	0.226
PLT	≤ 0.65	0.284	0.286	0.204
dc	≤ 3.30 %	0.090 %	0.054 %	0.067 %
dmax	4 %	0.592 %	0.360 %	0.486 %

100%Pn				
Pbin (%)	**Limit**	**Phase A**	**Phase B**	**Phase C**
PST	≤ 1.0	0.249	0.261	0.231
PLT	≤ 0.65	0.241	0.248	0219
dc	≤ 3.30 %	0.040 %	0.045 %	0.047 %
dmax	4 %	0.449 %	0.347 %	0.412 %

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

33 %Pn

Phase A

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	0.006	Pass	-0.345	Pass	0.0	Pass	0.247	Pass		
2	0.021	Pass	0.529	Pass	0.0	Pass	0.259	Pass		
3	0.044	Pass	0.542	Pass	0.0	Pass	0.261	Pass		
4	-0.029	Pass	-0.469	Pass	0.0	Pass	0.251	Pass		
5	0.000	Pass	0.000	Pass	0.0	Pass	0.246	Pass		
6	-0.033	Pass	-0.466	Pass	0.0	Pass	0.245	Pass		
7	-0.045	Pass	0.510	Pass	0.0	Pass	0.254	Pass		
8	0.009	Pass	-0.480	Pass	0.0	Pass	0.249	Pass		
9	0.027	Pass	-0.467	Pass	0.0	Pass	0.247	Pass		
10	-0.030	Pass	-0.330	Pass	0.0	Pass	0.244	Pass		
11	0.056	Pass	0.466	Pass	0.0	Pass	0.252	Pass		
12	0.081	Pass	0.475	Pass	0.0	Pass	0.243	Pass		
Result		Pass		Pass		Pass		Pass	0.250	Pass

Phase B

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	-0.023	Pass	-0.329	Pass	0.0	Pass	0.255	Pass		
2	-0.013	Pass	0.339	Pass	0.0	Pass	0.260	Pass		
3	0.025	Pass	0.354	Pass	0.0	Pass	0.268	Pass		
4	-0.025	Pass	0.333	Pass	0.0	Pass	0.276	Pass		
5	0.006	Pass	0.314	Pass	0.0	Pass	0.265	Pass		
6	0.017	Pass	-0.308	Pass	0.0	Pass	0.275	Pass		
7	0.007	Pass	0.312	Pass	0.0	Pass	0.269	Pass		
8	-0.012	Pass	0.343	Pass	0.0	Pass	0.275	Pass		
9	0.014	Pass	0.302	Pass	0.0	Pass	0.262	Pass		
10	-0.028	Pass	-0.318	Pass	0.0	Pass	0.261	Pass		
11	0.025	Pass	-0.316	Pass	0.0	Pass	0.262	Pass		
12	0.022	Pass	0.312	Pass	0.0	Pass	0.260	Pass		
Result		Pass		Pass		Pass		Pass	0.266	Pass

Phase C

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	0.000	Pass	-0.439	Pass	0.0	Pass	0.216	Pass		
2	-0.004	Pass	-0.439	Pass	0.0	Pass	0.264	Pass		
3	-0.002	Pass	-0.422	Pass	0.0	Pass	0.235	Pass		
4	-0.006	Pass	-0.411	Pass	0.0	Pass	0.216	Pass		
5	0.035	Pass	-0.414	Pass	0.0	Pass	0.217	Pass		
6	0.044	Pass	-0.472	Pass	0.0	Pass	0.242	Pass		
7	0.030	Pass	-0.414	Pass	0.0	Pass	0.246	Pass		
8	0.000	Pass	0.386	Pass	0.0	Pass	0.248	Pass		
9	0.051	Pass	-0.416	Pass	0.0	Pass	0.238	Pass		
10	0.000	Pass	-0.390	Pass	0.0	Pass	0.228	Pass		
11	0.045	Pass	0.422	Pass	0.0	Pass	0.242	Pass		
12	0.047	Pass	0.390	Pass	0.0	Pass	0.222	Pass		
Result		Pass		Pass		Pass		Pass	0.235	Pass

66 %Pn

Phase A

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	-0.069	Pass	-0.523	Pass	0.0	Pass	0.461	Pass		
2	-0.079	Pass	-0.536	Pass	0.0	Pass	0.233	Pass		
3	-0.076	Pass	0.592	Pass	0.0	Pass	0.239	Pass		
4	0.000	Pass	-0.522	Pass	0.0	Pass	0.228	Pass		
5	-0.090	Pass	0.535	Pass	0.0	Pass	0.269	Pass		
6	0.017	Pass	-0.497	Pass	0.0	Pass	0.254	Pass		
7	0.000	Pass	0.492	Pass	0.0	Pass	0.276	Pass		
8	-0.038	Pass	0.521	Pass	0.0	Pass	0.249	Pass		
9	0.014	Pass	0.480	Pass	0.0	Pass	0.278	Pass		
10	-0.075	Pass	0.488	Pass	0.0	Pass	0.248	Pass		
11	-0.052	Pass	-0.506	Pass	0.0	Pass	0.249	Pass		
12	0.000	Pass	0.494	Pass	0.0	Pass	0.247	Pass		
Result		Pass		Pass		Pass		Pass	0.284	Pass

Phase B

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	-0.034	Pass	-0.344	Pass	0.0	Pass	0.460	Pass		
2	0.011	Pass	-0.312	Pass	0.0	Pass	0.221	Pass		
3	0.028	Pass	-0.323	Pass	0.0	Pass	0.214	Pass		
4	-0.032	Pass	-0.360	Pass	0.0	Pass	0.240	Pass		
5	-0.043	Pass	-0.350	Pass	0.0	Pass	0.263	Pass		
6	-0.014	Pass	-0.321	Pass	0.0	Pass	0.266	Pass		
7	0.012	Pass	-0.330	Pass	0.0	Pass	0.282	Pass		
8	-0.054	Pass	-0.327	Pass	0.0	Pass	0.258	Pass		
9	0.021	Pass	-0.338	Pass	0.0	Pass	0.279	Pass		
10	-0.040	Pass	-0.340	Pass	0.0	Pass	0.265	Pass		
11	-0.017	Pass	-0.347	Pass	0.0	Pass	0.250	Pass		
12	-0.012	Pass	-0.317	Pass	0.0	Pass	0.257	Pass		
Result		Pass		Pass		Pass		Pass	0.286	Pass

Phase C

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	-0.034	Pass	-0.464	Pass	0.0	Pass	0.189	Pass		
2	-0.012	Pass	0.449	Pass	0.0	Pass	0.178	Pass		
3	-0.021	Pass	0.475	Pass	0.0	Pass	0.175	Pass		
4	-0.018	Pass	0.427	Pass	0.0	Pass	0.186	Pass		
5	0.067	Pass	-0.481	Pass	0.0	Pass	0.205	Pass		
6	-0.039	Pass	-0.469	Pass	0.0	Pass	0.211	Pass		
7	-0.056	Pass	-0.465	Pass	0.0	Pass	0.216	Pass		
8	-0.029	Pass	0.486	Pass	0.0	Pass	0.210	Pass		
9	0.020	Pass	0.465	Pass	0.0	Pass	0.219	Pass		
10	-0.032	Pass	0.438	Pass	0.0	Pass	0.208	Pass		
11	-0.025	Pass	-0.419	Pass	0.0	Pass	0.209	Pass		
12	-0.024	Pass	0.454	Pass	0.0	Pass	0.226	Pass		
Result		Pass		Pass		Pass		Pass	0.204	Pass

100 %Pn

Phase A

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	0.000	Pass	0.000	Pass	0.0	Pass	0.247	Pass		
2	0.000	Pass	0.000	Pass	0.0	Pass	0.236	Pass		
3	0.000	Pass	0.000	Pass	0.0	Pass	0.237	Pass		
4	-0.032	Pass	-0.306	Pass	0.0	Pass	0.235	Pass		
5	0.000	Pass	0.000	Pass	0.0	Pass	0.219	Pass		
6	0.000	Pass	0.000	Pass	0.0	Pass	0.246	Pass		
7	0.000	Pass	0.000	Pass	0.0	Pass	0.244	Pass		
8	0.000	Pass	0.000	Pass	0.0	Pass	0.239	Pass		
9	0.000	Pass	0.000	Pass	0.0	Pass	0.249	Pass		
10	0.040	Pass	-0.449	Pass	0.0	Pass	0.241	Pass		
11	0.000	Pass	0.000	Pass	0.0	Pass	0.249	Pass		
12	0.000	Pass	0.000	Pass	0.0	Pass	0.244	Pass		
Result		Pass		Pass		Pass		Pass	0.241	Pass

Phase B

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	-0.024	Pass	-0.312	Pass	0.0	Pass	0.250	Pass		
2	0.045	Pass	0.347	Pass	0.0	Pass	0.242	Pass		
3	0.015	Pass	0.306	Pass	0.0	Pass	0.233	Pass		
4	-0.013	Pass	-0.302	Pass	0.0	Pass	0.250	Pass		
5	-0.021	Pass	-0.330	Pass	0.0	Pass	0.250	Pass		
6	0.022	Pass	0.314	Pass	0.0	Pass	0.252	Pass		
7	0.023	Pass	0.342	Pass	0.0	Pass	0.233	Pass		
8	-0.034	Pass	-0.318	Pass	0.0	Pass	0.243	Pass		
9	0.006	Pass	0.333	Pass	0.0	Pass	0.250	Pass		
10	0.000	Pass	0.000	Pass	0.0	Pass	0.251	Pass		
11	-0.018	Pass	-0.317	Pass	0.0	Pass	0.254	Pass		
12	0.028	Pass	0.333	Pass	0.0	Pass	0.261	Pass		
Result		Pass		Pass		Pass		Pass	0.248	Pass

Phase C

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	0.000	Pass	0.393	Pass	0.0	Pass	0.209	Pass		
2	0.000	Pass	-0.412	Pass	0.0	Pass	0.222	Pass		
3	0.000	Pass	0.378	Pass	0.0	Pass	0.207	Pass		
4	0.000	Pass	-0.368	Pass	0.0	Pass	0.220	Pass		
5	0.023	Pass	0.394	Pass	0.0	Pass	0.228	Pass		
6	0.000	Pass	0.403	Pass	0.0	Pass	0.211	Pass		
7	0.036	Pass	-0.412	Pass	0.0	Pass	0.229	Pass		
8	0.000	Pass	-0.354	Pass	0.0	Pass	0.227	Pass		
9	0.047	Pass	-0.411	Pass	0.0	Pass	0.212	Pass		
10	0.042	Pass	-0.388	Pass	0.0	Pass	0.220	Pass		
11	0.000	Pass	0.382	Pass	0.0	Pass	0.231	Pass		
12	0.000	Pass	0.360	Pass	0.0	Pass	0.203	Pass		
Result		Pass		Pass		Pass		Pass	0.219	Pass

4.6. INTERFACE PROTECTION

4.6.1. Requirements on voltage and frequency protection

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

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

4.6.1.1 Undervoltage protection

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

Undervoltage threshold stage 1 [27 <]:

- Threshold (0.2 – 1) Un adjustable by steps of 0.01 Un
- Operate time (0.1 – 100) s adjustable in steps of 0.1 s

Undervoltage threshold stage 2 [27 <<]:

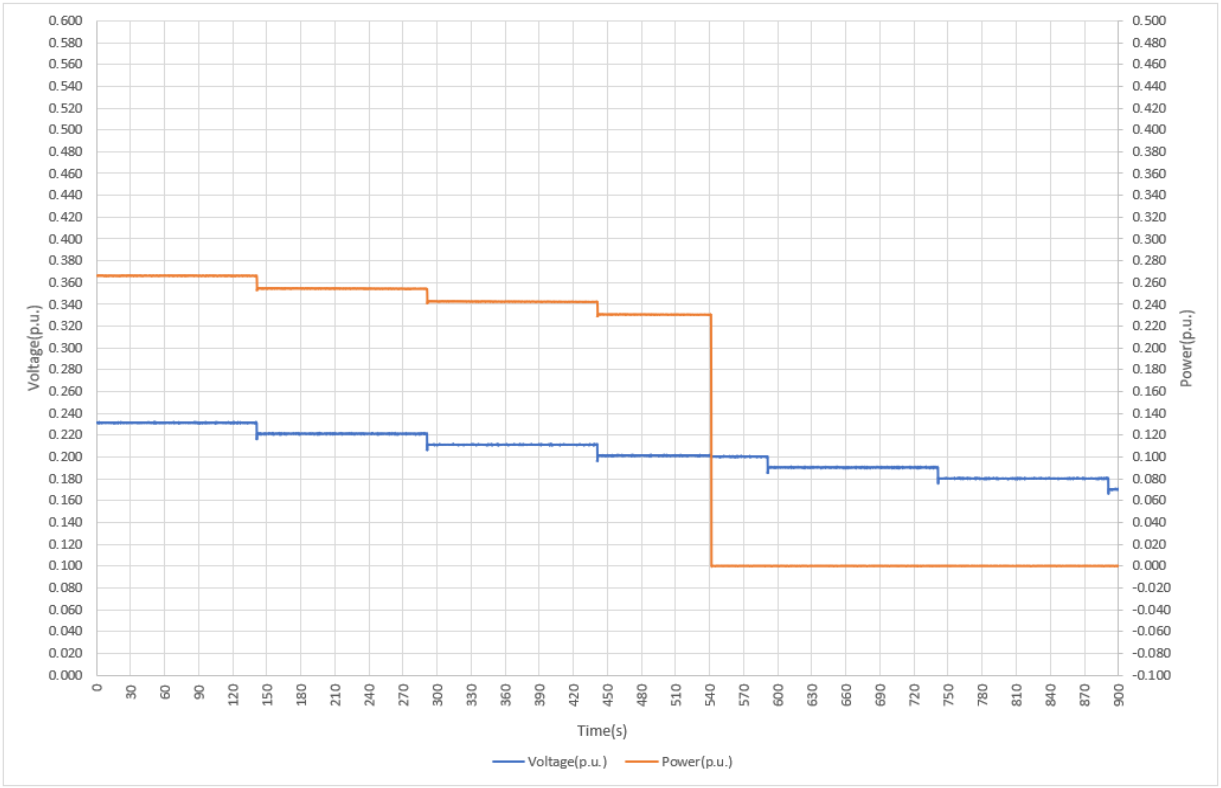
- Threshold (0.2 – 1) Un adjustable by steps of 0.01 Un
- Operate time (0.1 – 5) s adjustable in steps of 0.05 s

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

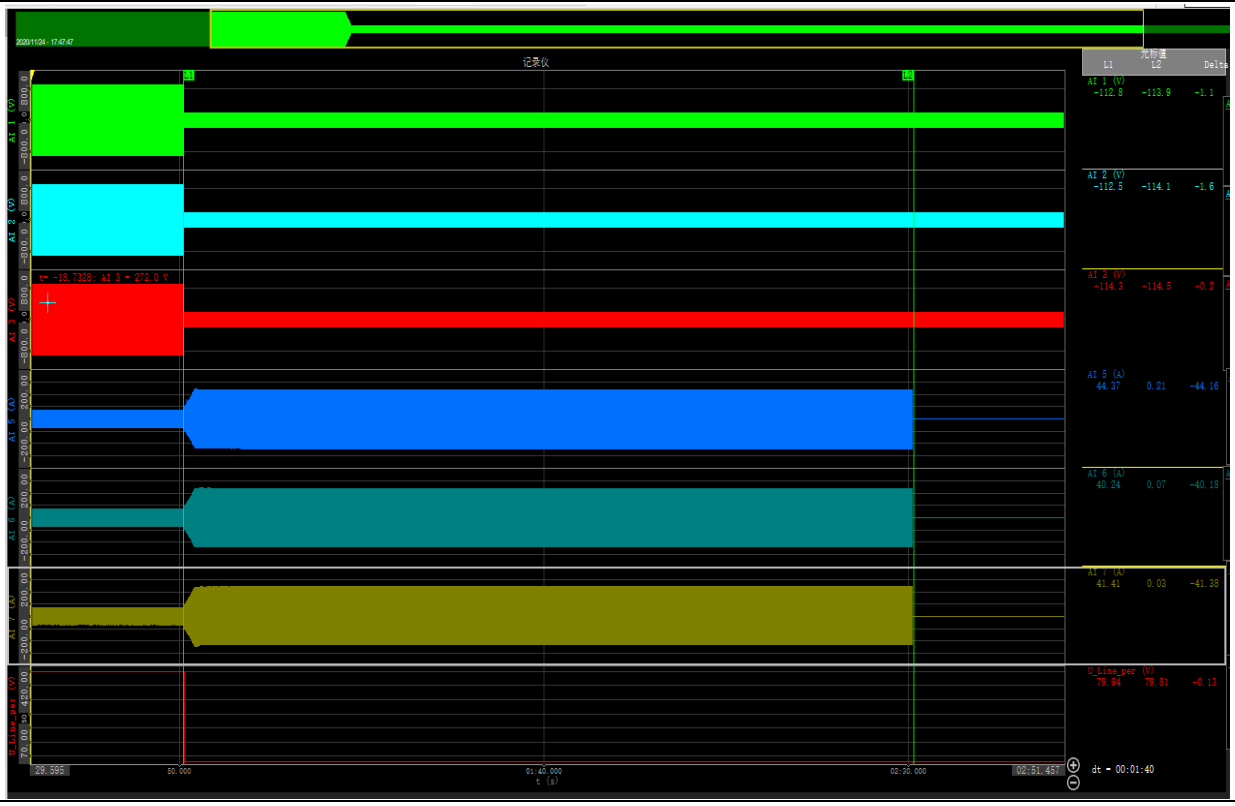
The following definitions apply to the test to verify the clause:

Undervoltage	Test No.	Voltage setting (p.u.)	Voltage meas. (p.u.)	Voltage deviation (p.u.)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
Stage 1 [27 <]	1	0.200	0.201	0.001	100.000	100.000	0.000
	2	1.000	0.998	-0.002	0.100	0.128	0.028
Stage 2 [27 <<]	3	0.200	0.201	0.001	5.000	5.016	0.016
	4	1.000	0.997	-0.003	0.100	0.127	0.027

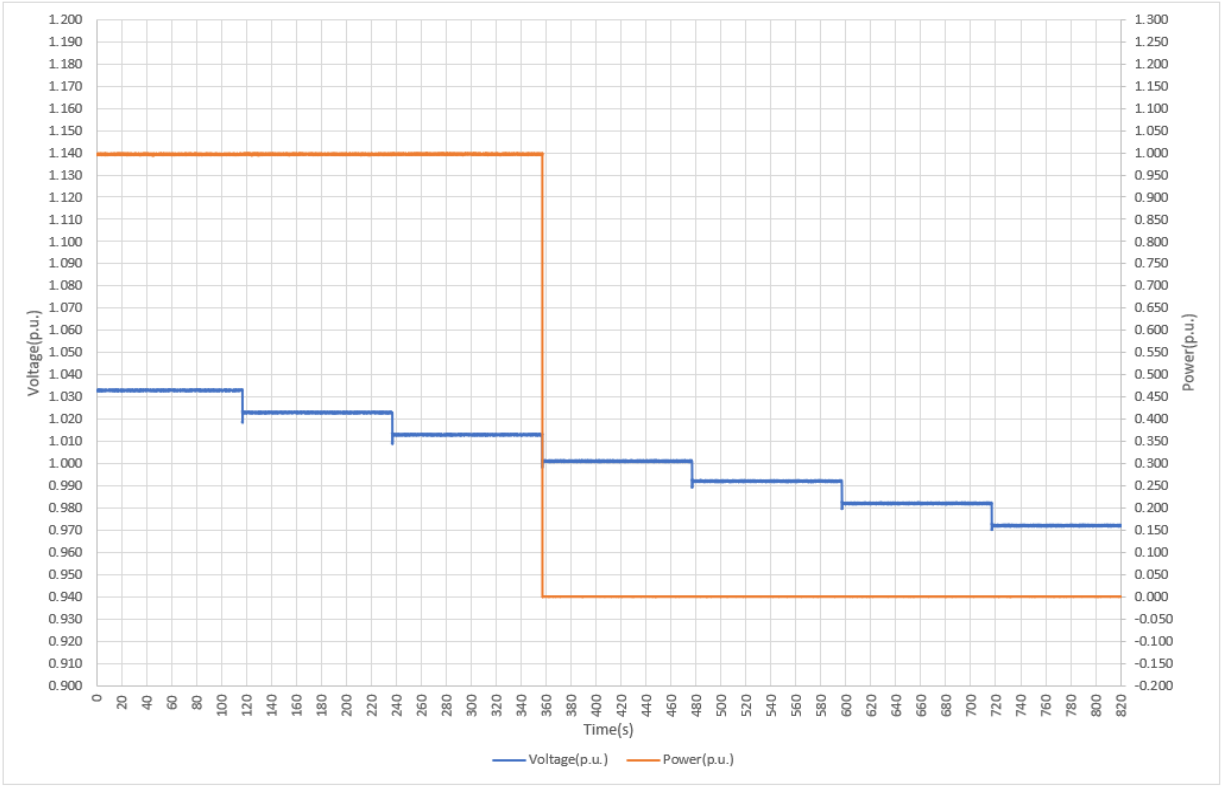
Undervoltage - Test 1: Trip value



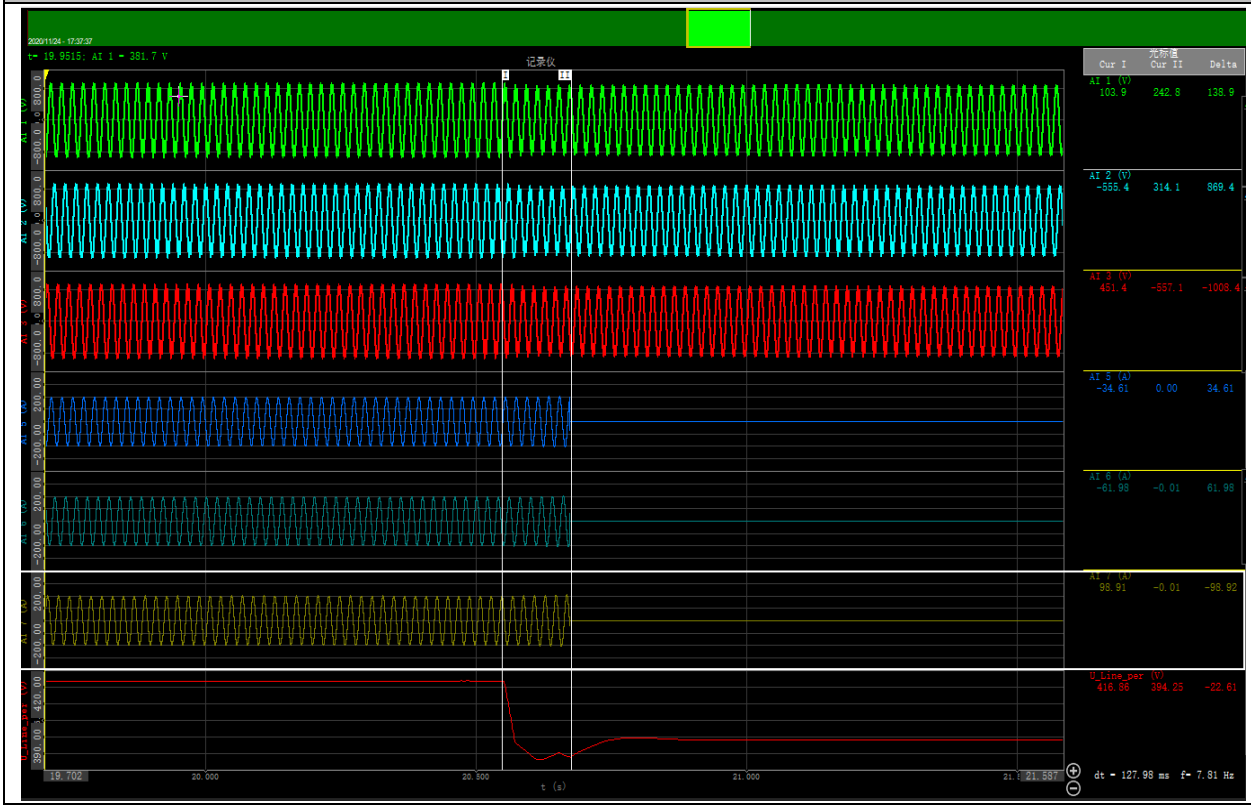
Undervoltage - Test 1: Trip time



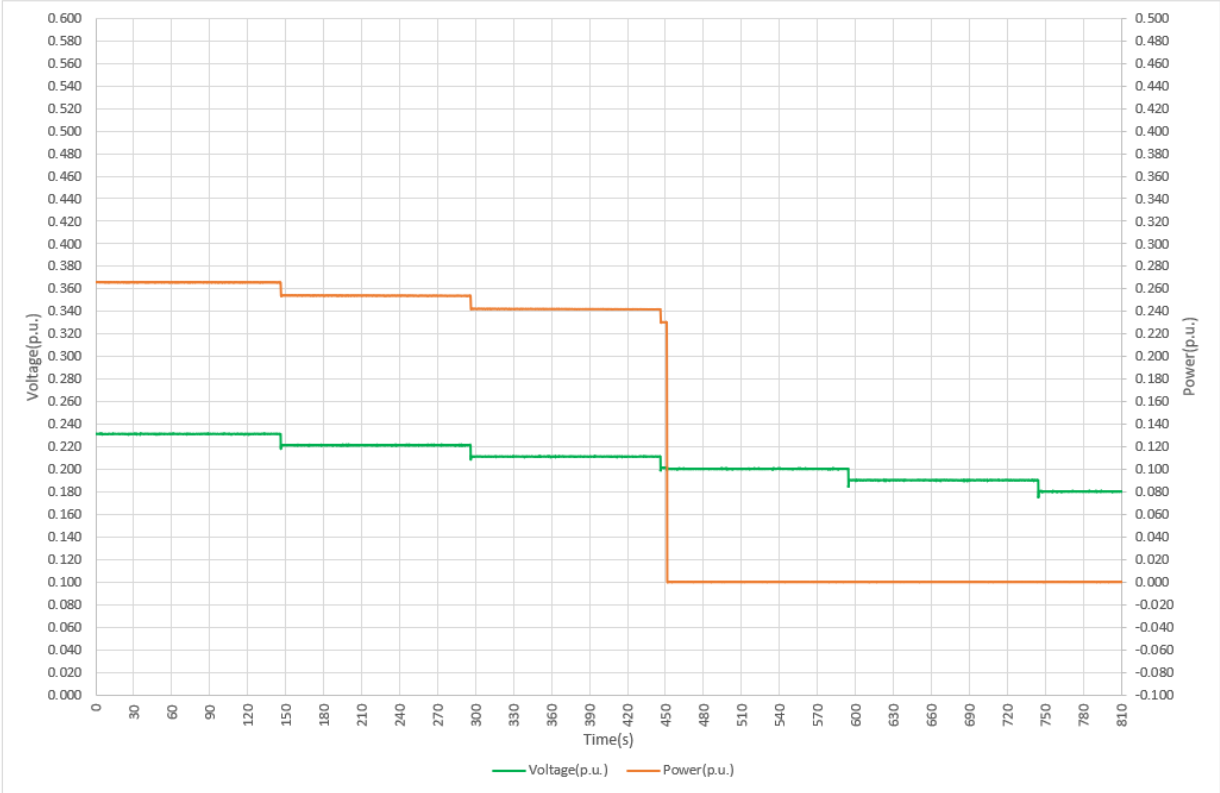
Under voltage - Test 2: Trip value



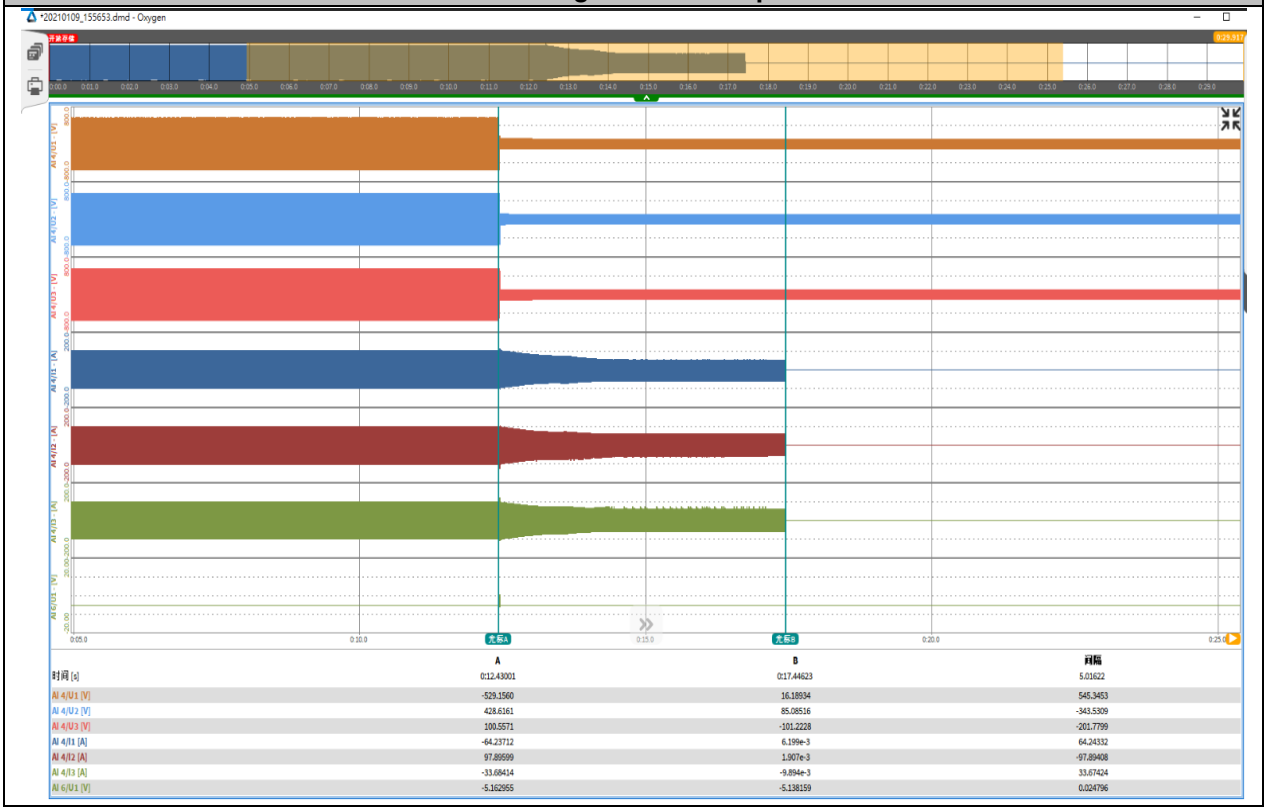
Under voltage - Test 2: Trip time



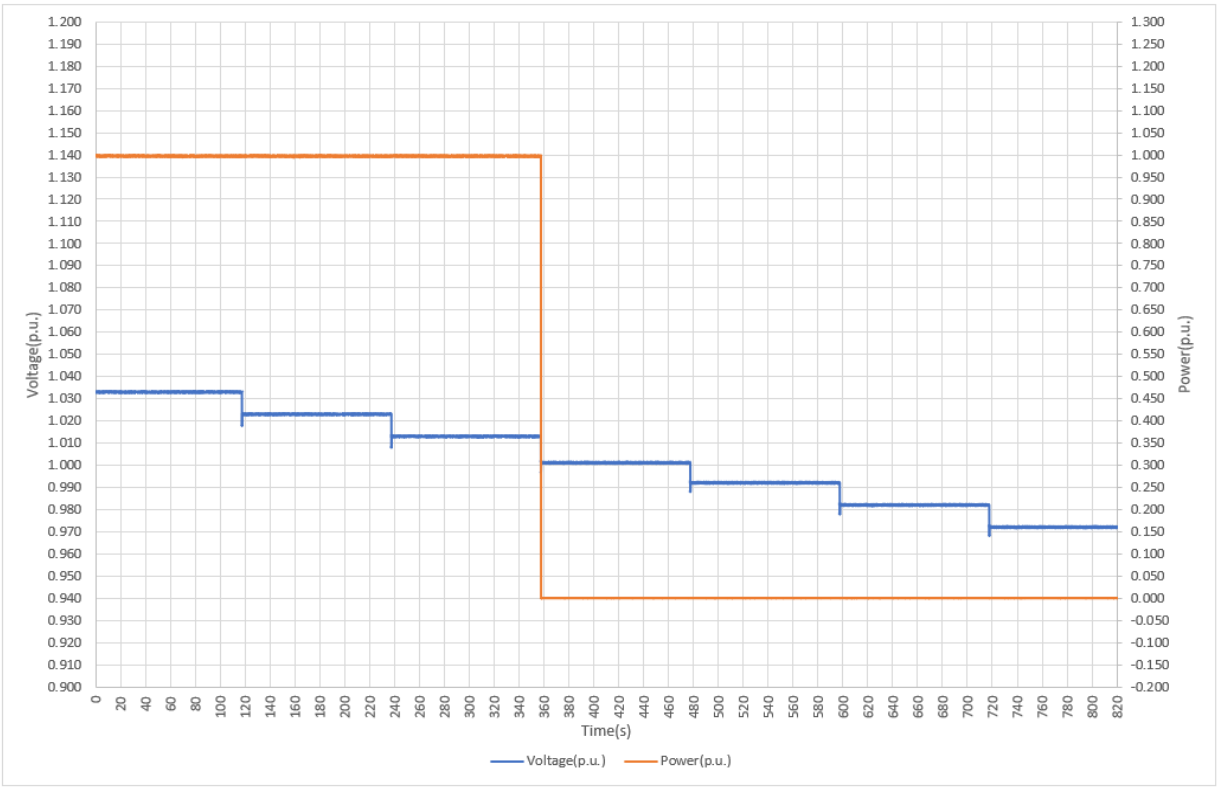
Undervoltage - Test 3: Trip value



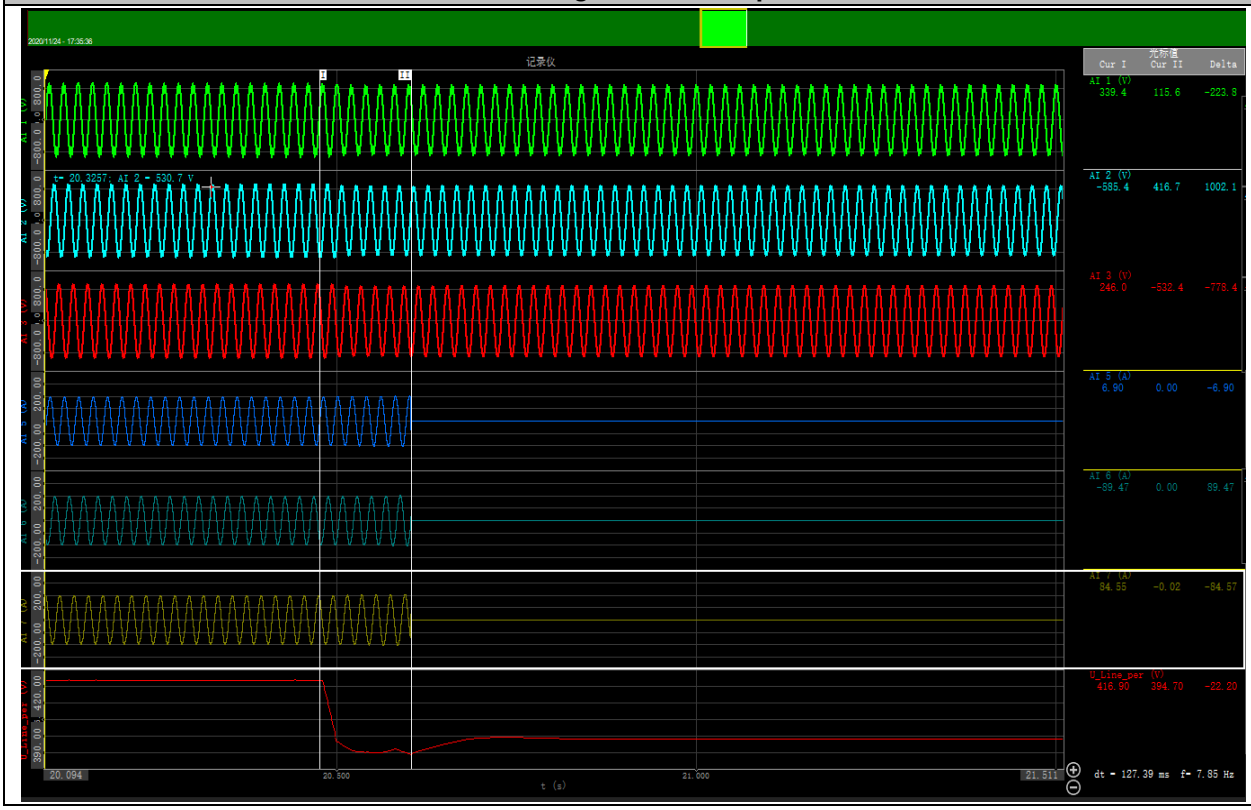
Undervoltage - Test 3: Trip time



Undervoltage - Test 4: Trip value



Undervoltage - Test 4: Trip time



4.6.1.2 Overvoltage protection

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

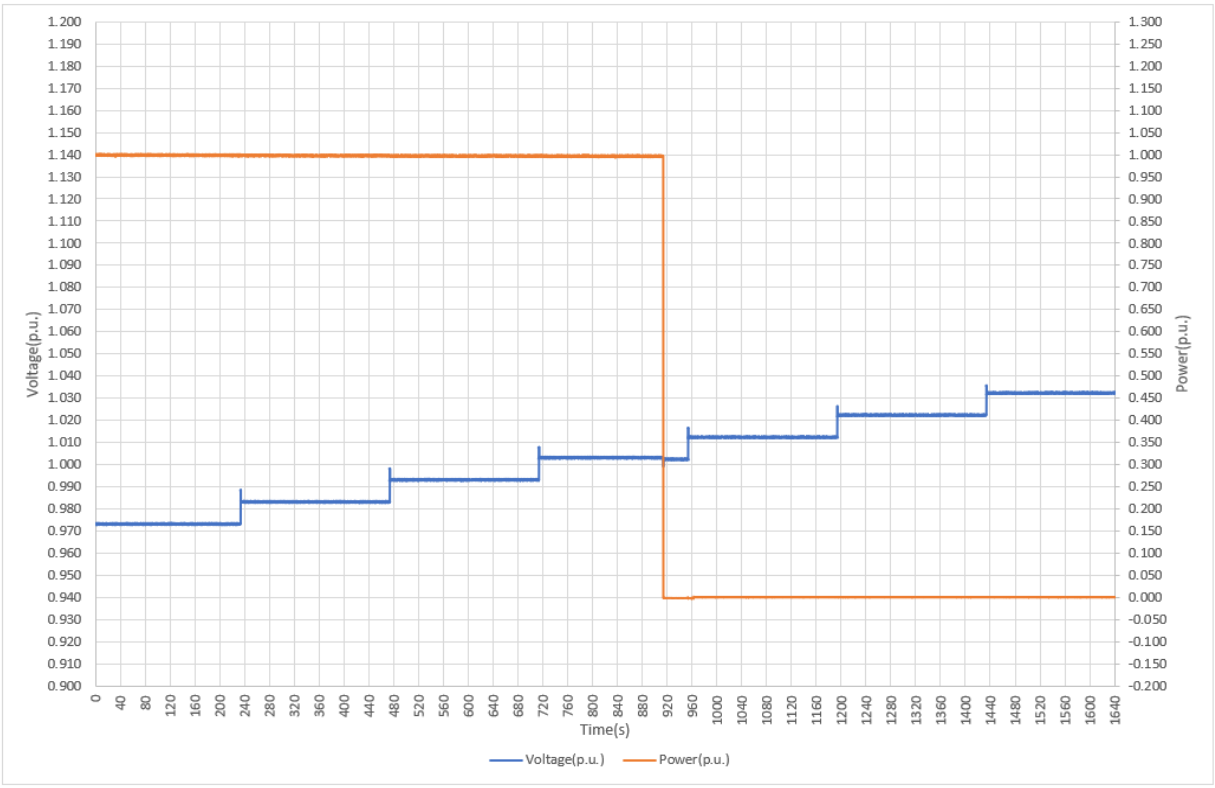
Overvoltage threshold stage 1 [59 >]:
- Threshold (1.0 – 1.2) *Un* adjustable by steps of 0.01 *Un*
- Operate time (0.1 – 100) s adjustable in steps of 0.1 s

Overvoltage threshold stage 2 [59 > >]:
- Threshold (1.0 – 1.30) *Un* adjustable by steps of 0.01 *Un*
- Operate time (0.1 – 5) s adjustable in steps of 0.05 s

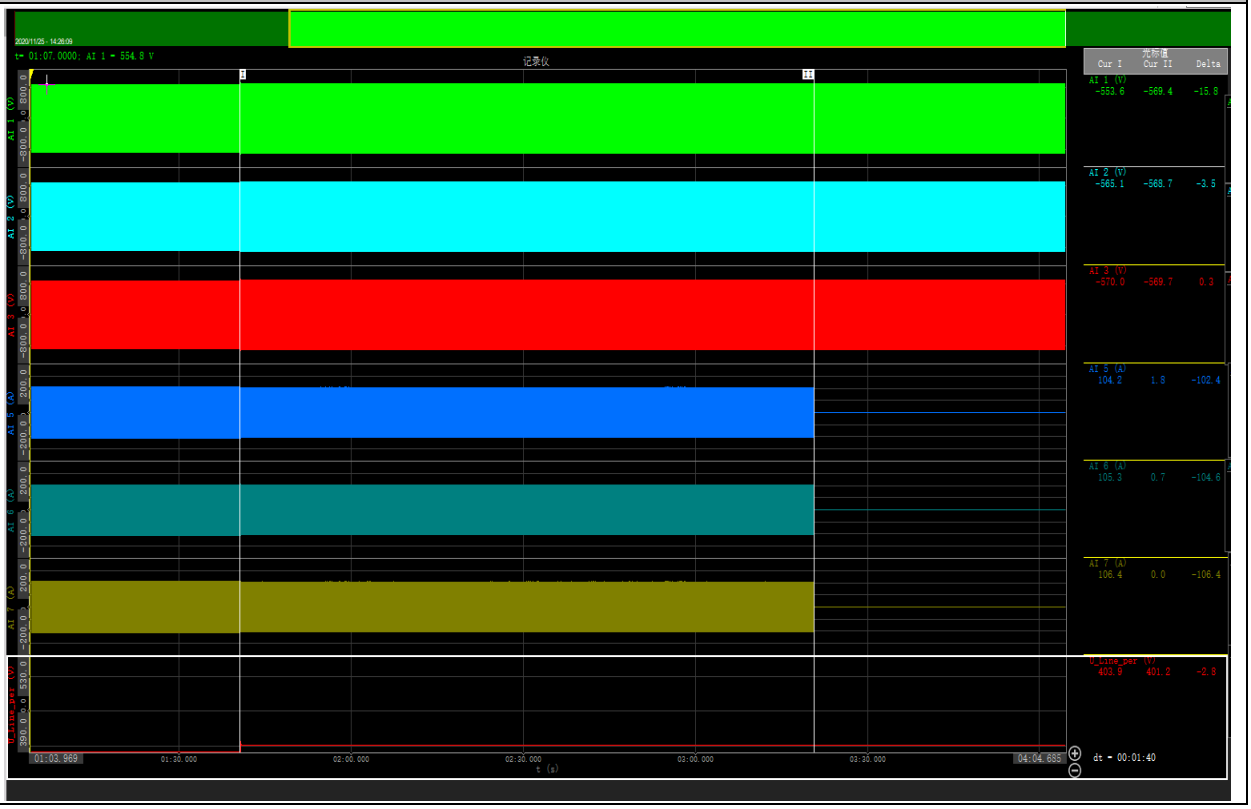
The following definitions apply to the test to verify the clause:

Overvoltage	Test No.	Voltage setting (p.u.)	Voltage meas. (p.u.)	Voltage deviation (p.u.)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
Stage 1 [59 >]:	1	1.000	1.003	0.003	100.000	100.000	0.000
	2	1.200	1.205	0.005	0.100	0.125	0.025
Stage 2 [59 > >]	3	1.000	1.006	0.006	5.000	5.037	0.037
	4	1.300	1.305	0.005	0.100	0.127	0.027

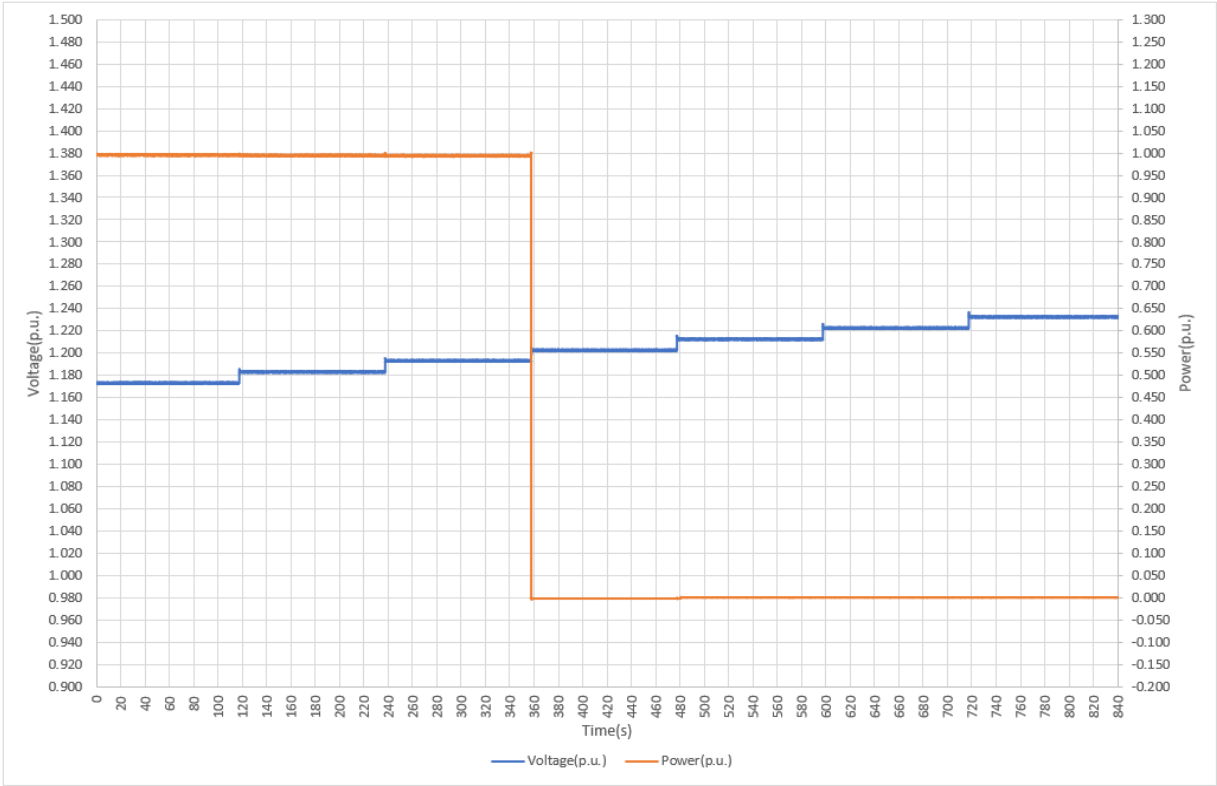
Overvoltage - Test 1: Trip value



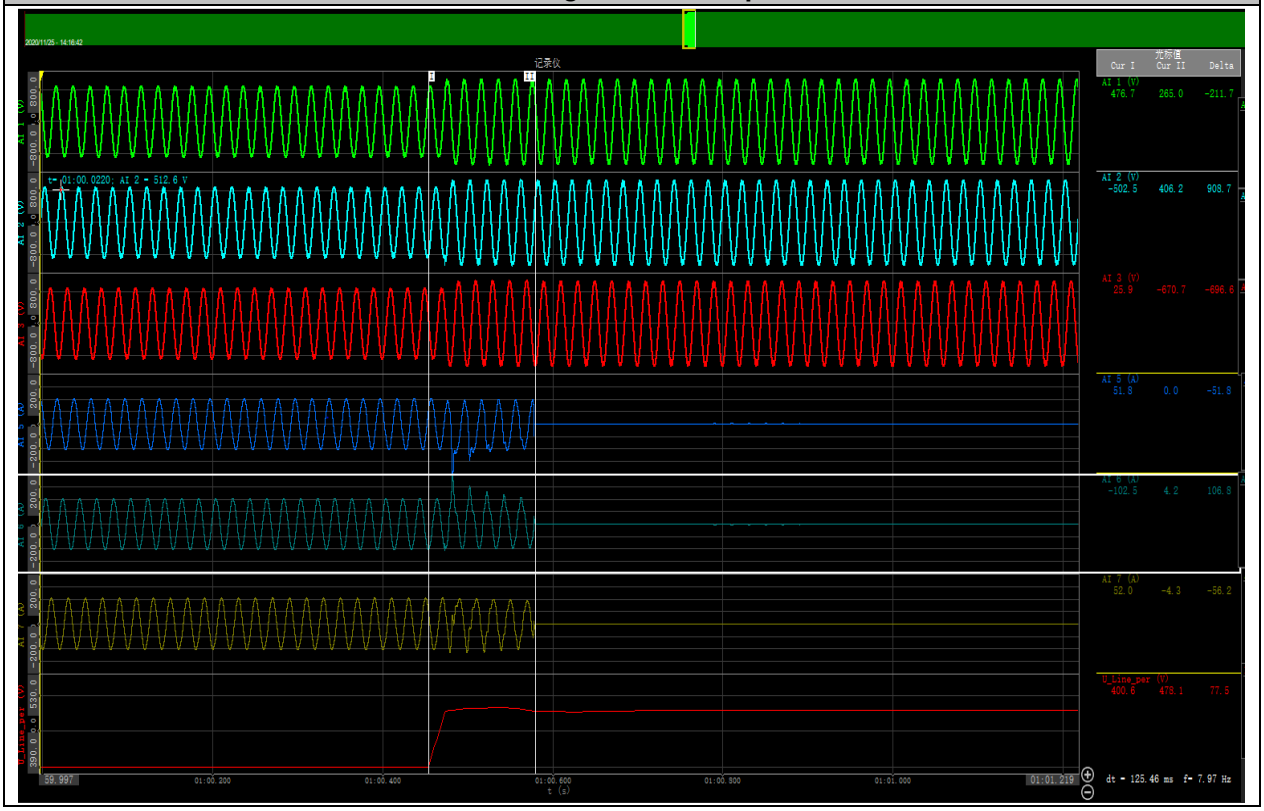
Overvoltage - Test 1: Trip time



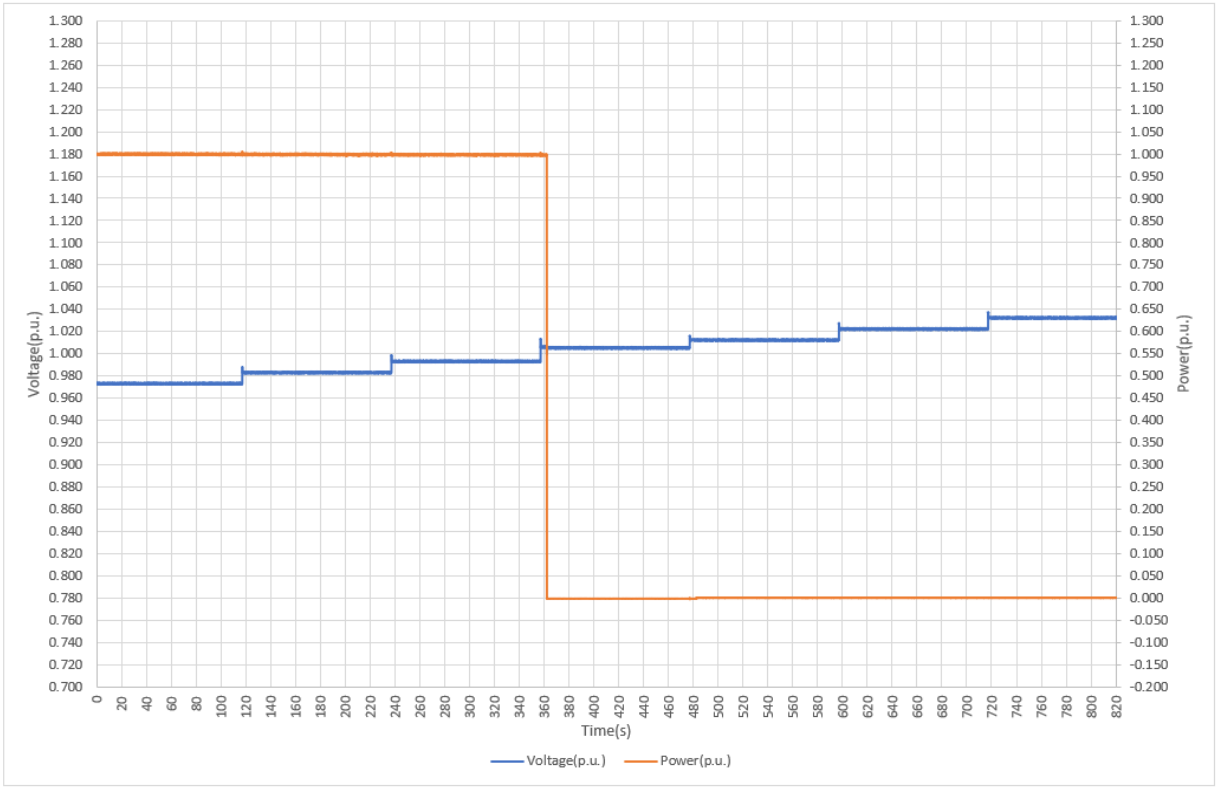
Overvoltage - Test 2: Trip value



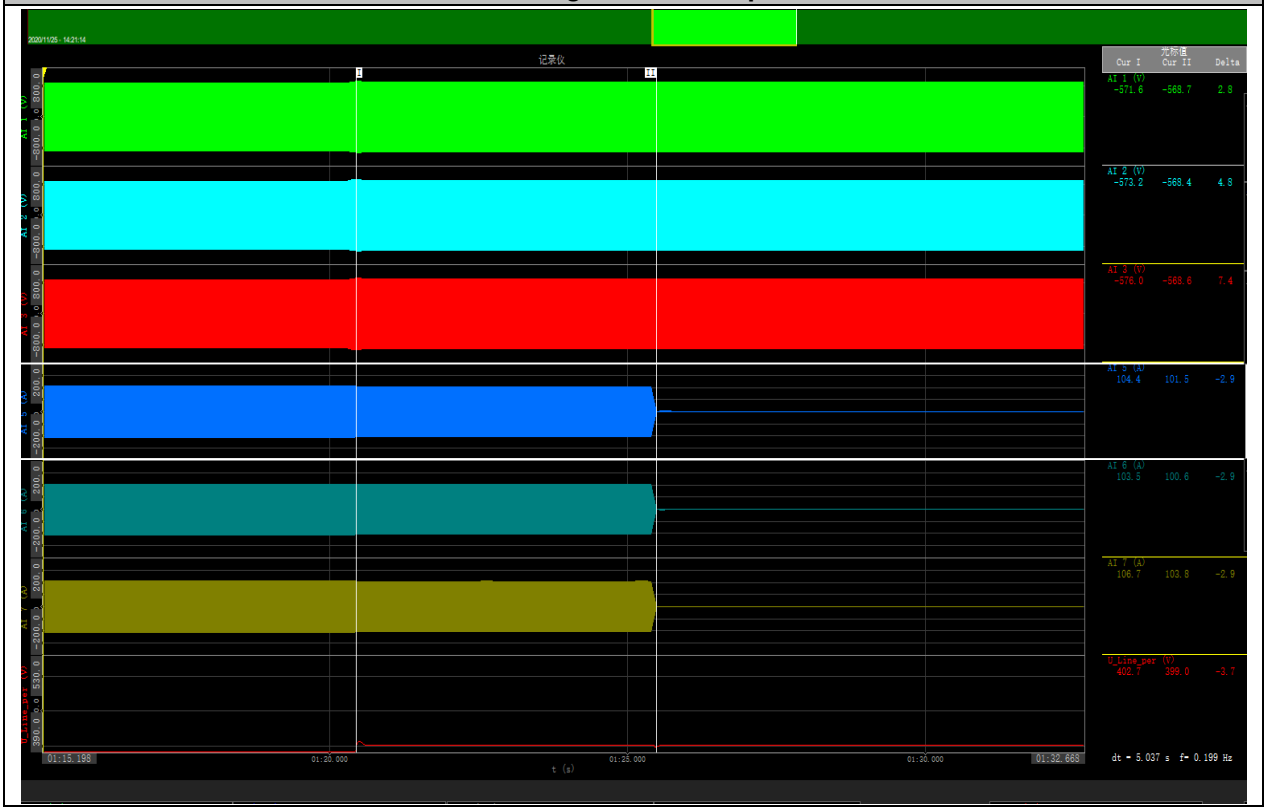
Overvoltage - Test 2: Trip time



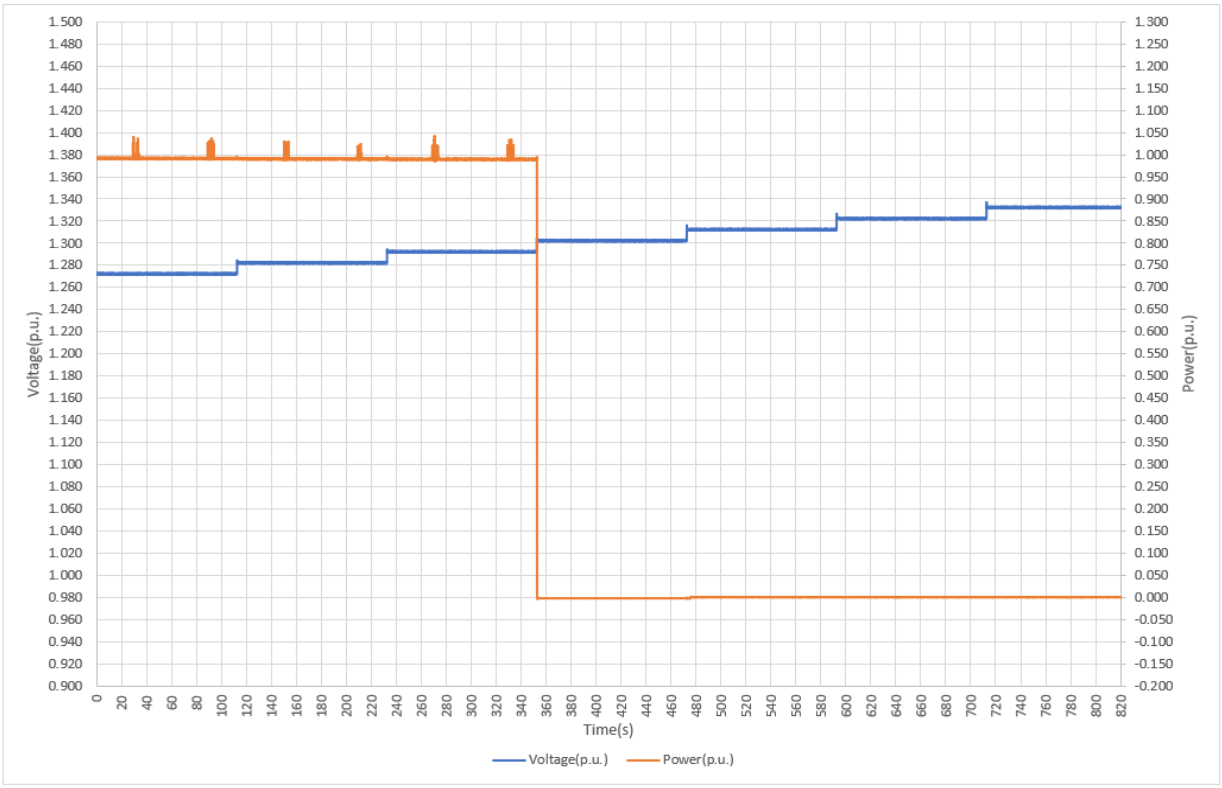
Overvoltage - Test 3: Trip value



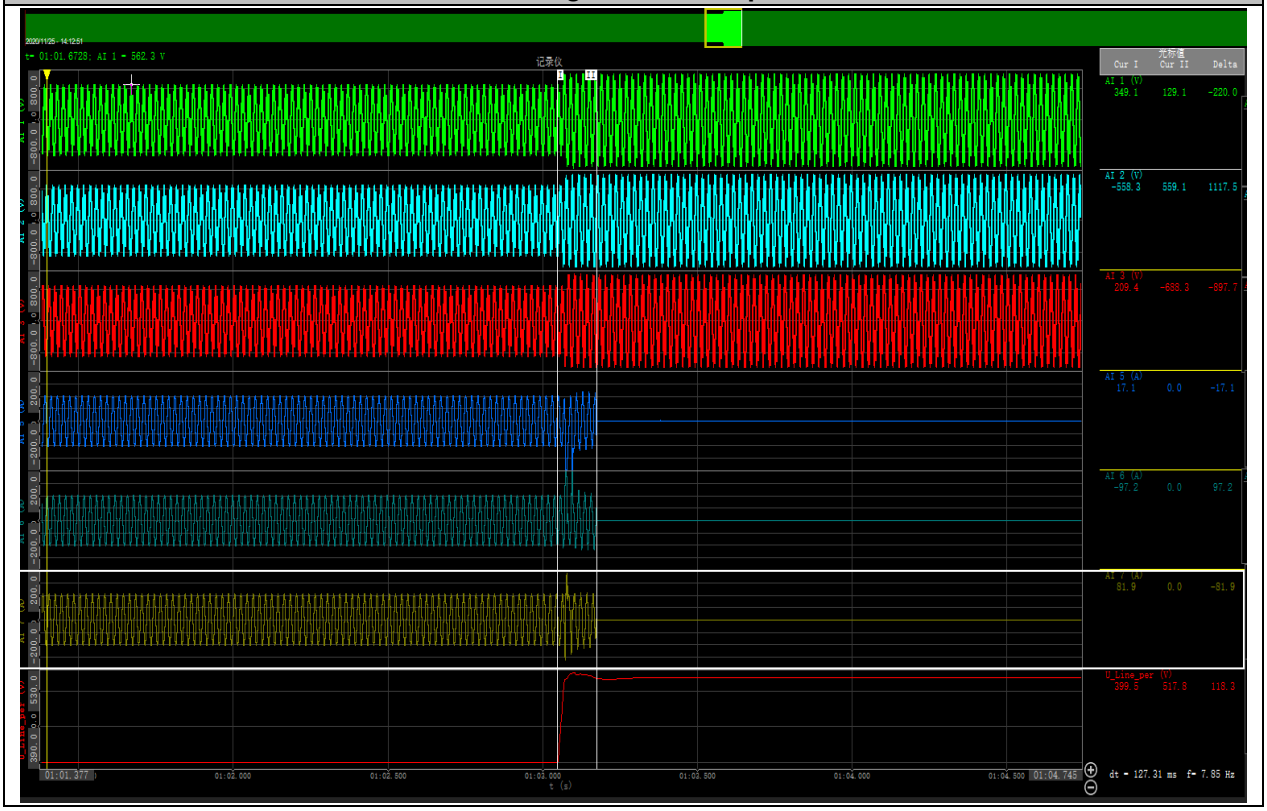
Overvoltage - Test 3: Trip time



Overvoltage - Test 4: Trip value



Overvoltage - Test 4: Trip time



4.6.1.3 Overvoltage 10 min mean protection

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

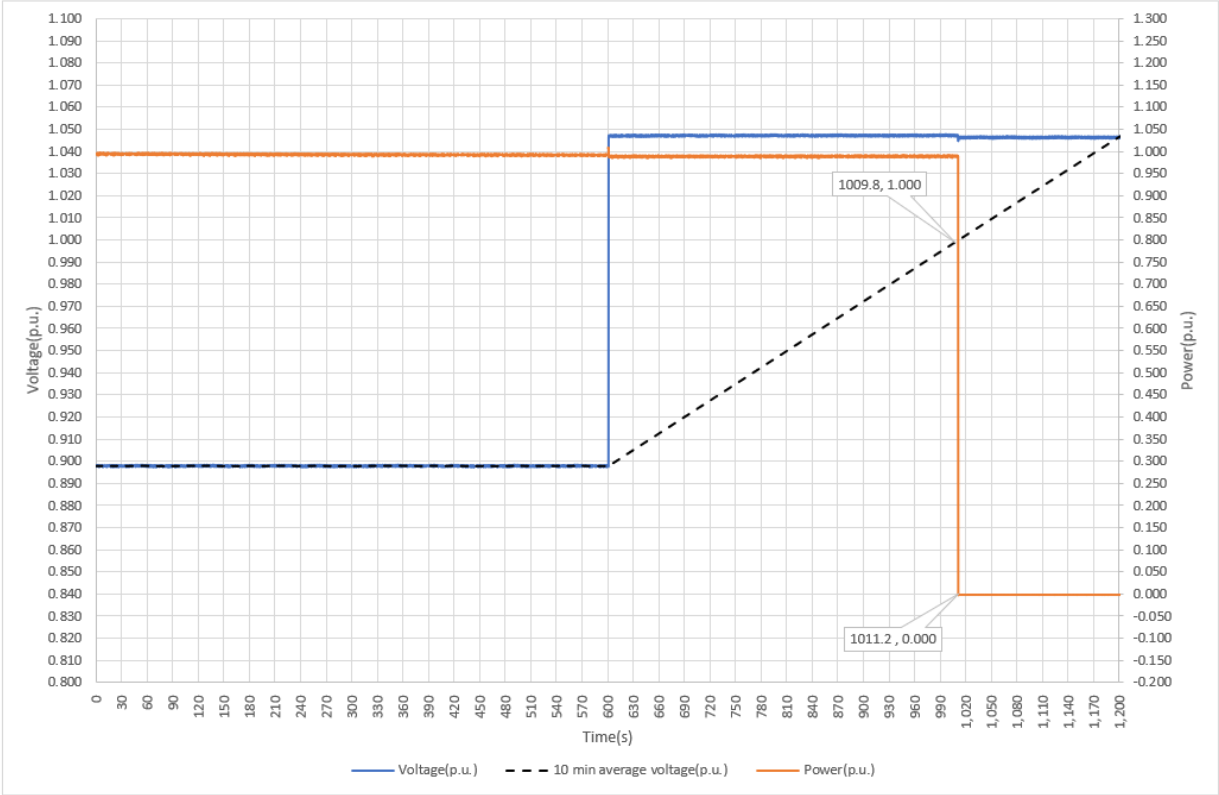
- Threshold (1.0 – 1.15) *Un* adjustable by steps of 0.01 *Un*
- Start time ≤ 3s not adjustable
- Time delay setting = 0 ms

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

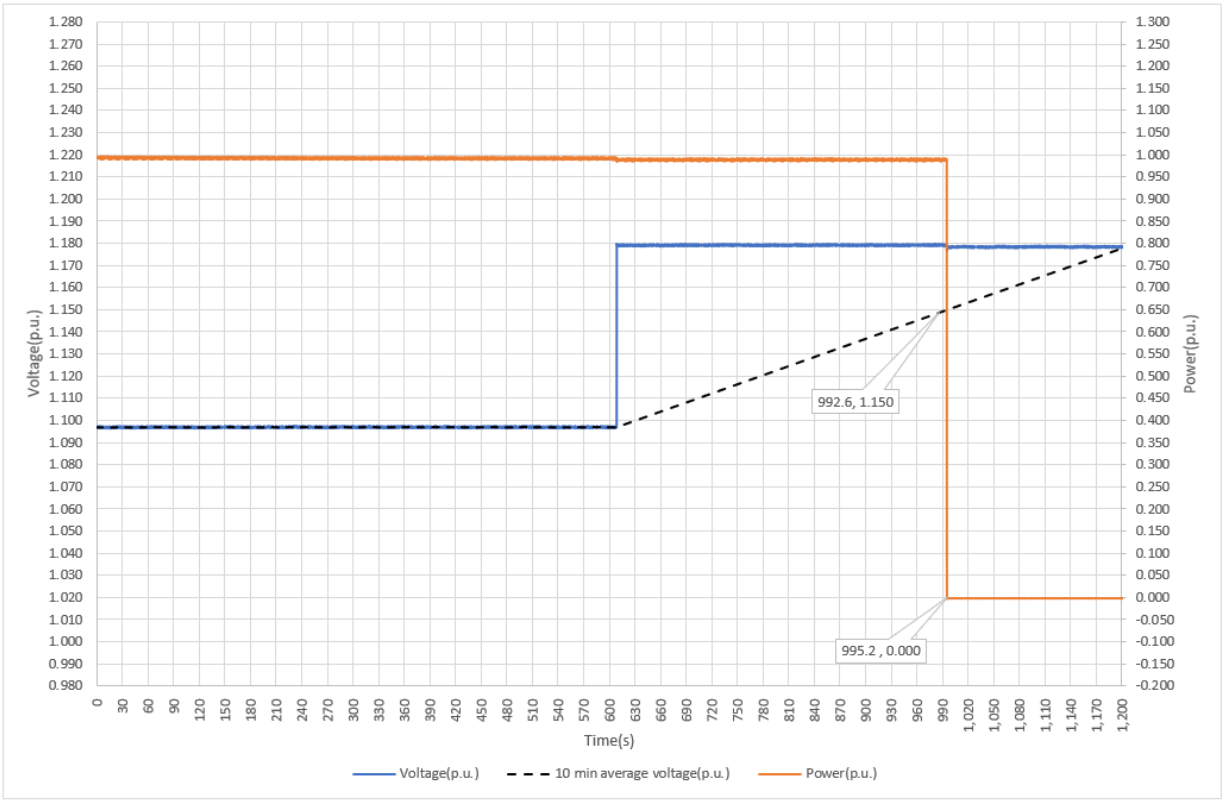
Test No.	Voltage setting (p.u.)	Voltage meas. (p.u.)	Voltage deviation (p.u.)	Trip time meas. (s)	Trip time limited
1	1.000	1.000	0.000	1.4	≤ 3s
2	1.150	1.150	0.000	2.6	≤ 3s

Note: The trip voltage accuracy tolerance is ±0.01 Un

Overvoltage 10 min mean protection - Test 1



Overvoltage 10 min mean protection - Test 2



4.6.1.4 Underfrequency protection

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

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

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

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

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

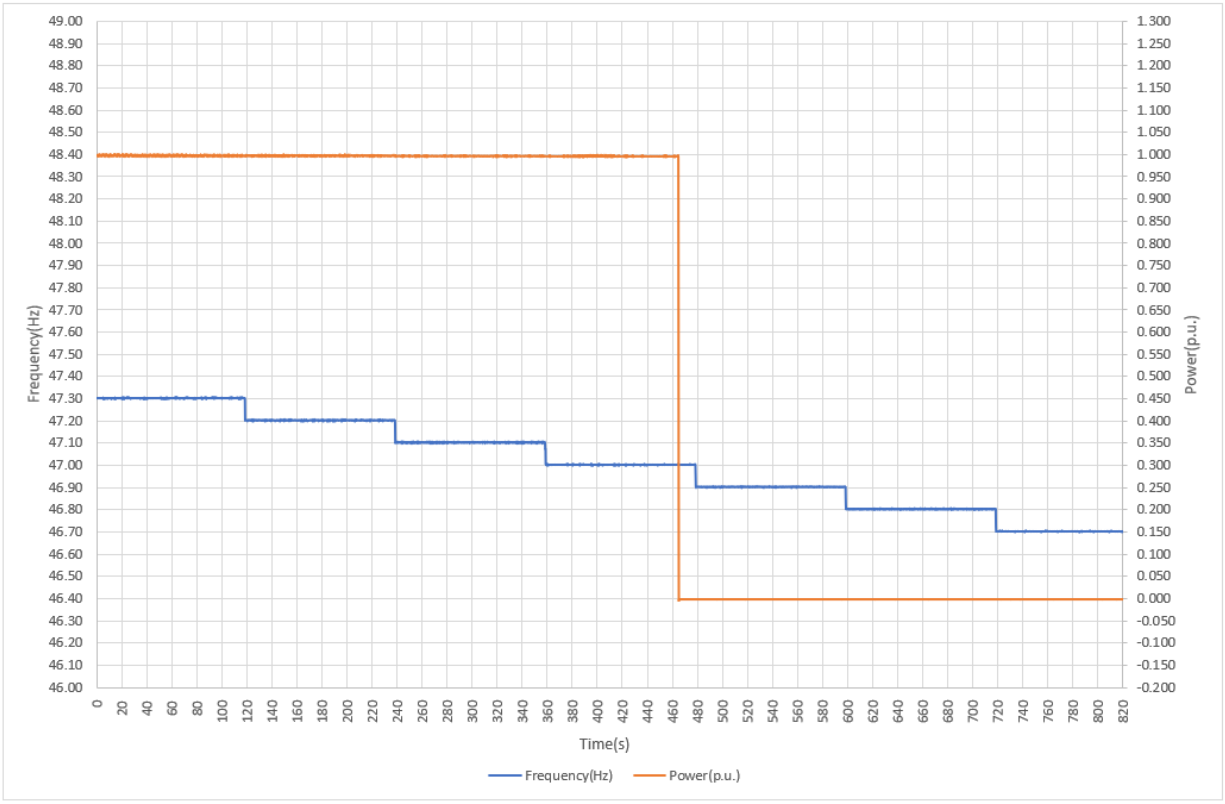
Under 0.2 Un the frequency protection is inhibited. Disconnection may only happen based on undervoltage protection.

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

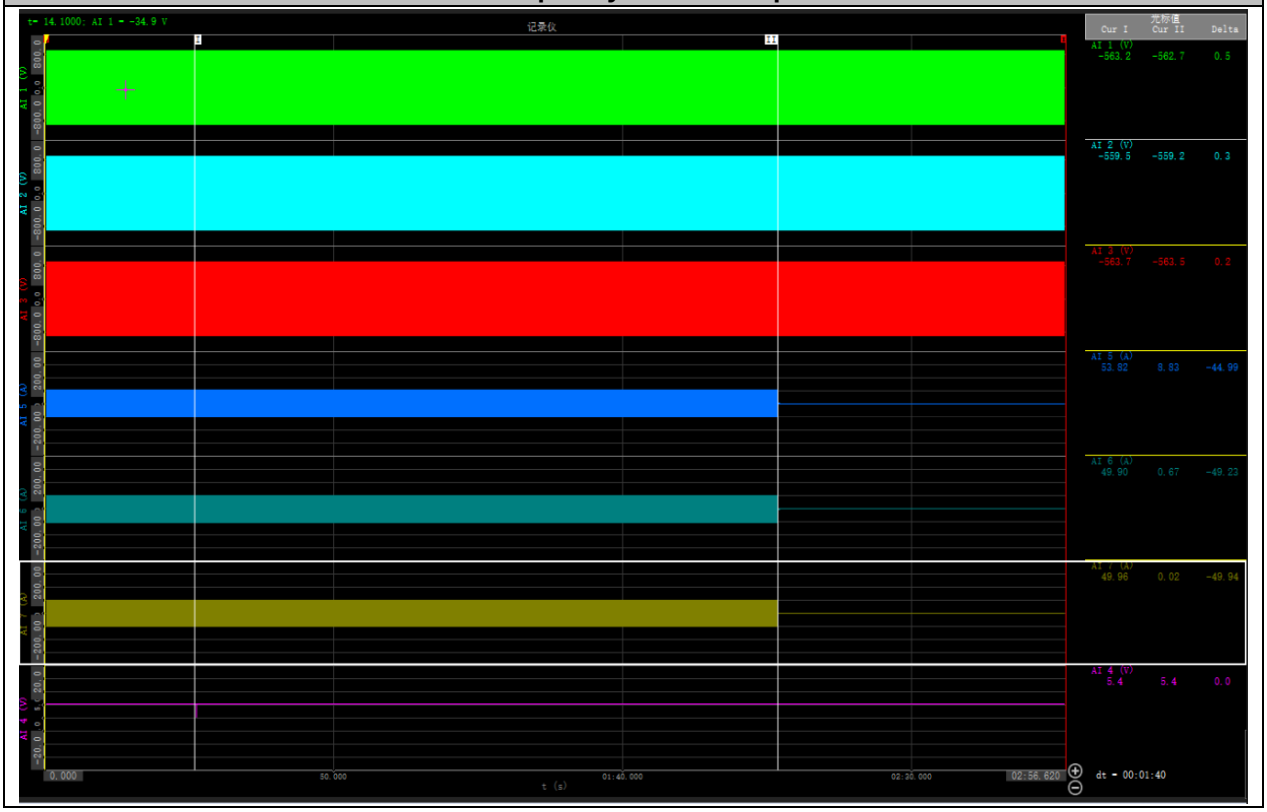
Under frequency	Test No.	Frequency setting (Hz)	Frequency meas. (Hz)	Frequency deviation (Hz)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
Stage 1 [81 <]	1	47.00	47.00	0.00	100.000	100.000	0.000
	2	50.00	49.99	-0.01	0.100	0.121	0.021
Stage 2 [81 < <]	3	47.00	47.00	0.00	5.000	5.005	0.005
	4	50.00	49.99	-0.01	0.100	0.126	0.026

Voltage protection threshold setting (Un)	Test No.	Frequency setting (Hz)	Voltage setting (%Un)	Voltage meas. (Un)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
0.18	5	47.00	0.21	0.21	5.000	5.000	0.000
	6	47.00	1.19	1.18	5.000	5.000	0.000
	7	47.00	0.19	0.19	Not protected	--	--
		47.00	0.17	0.17	5.000	4.950	-0.050

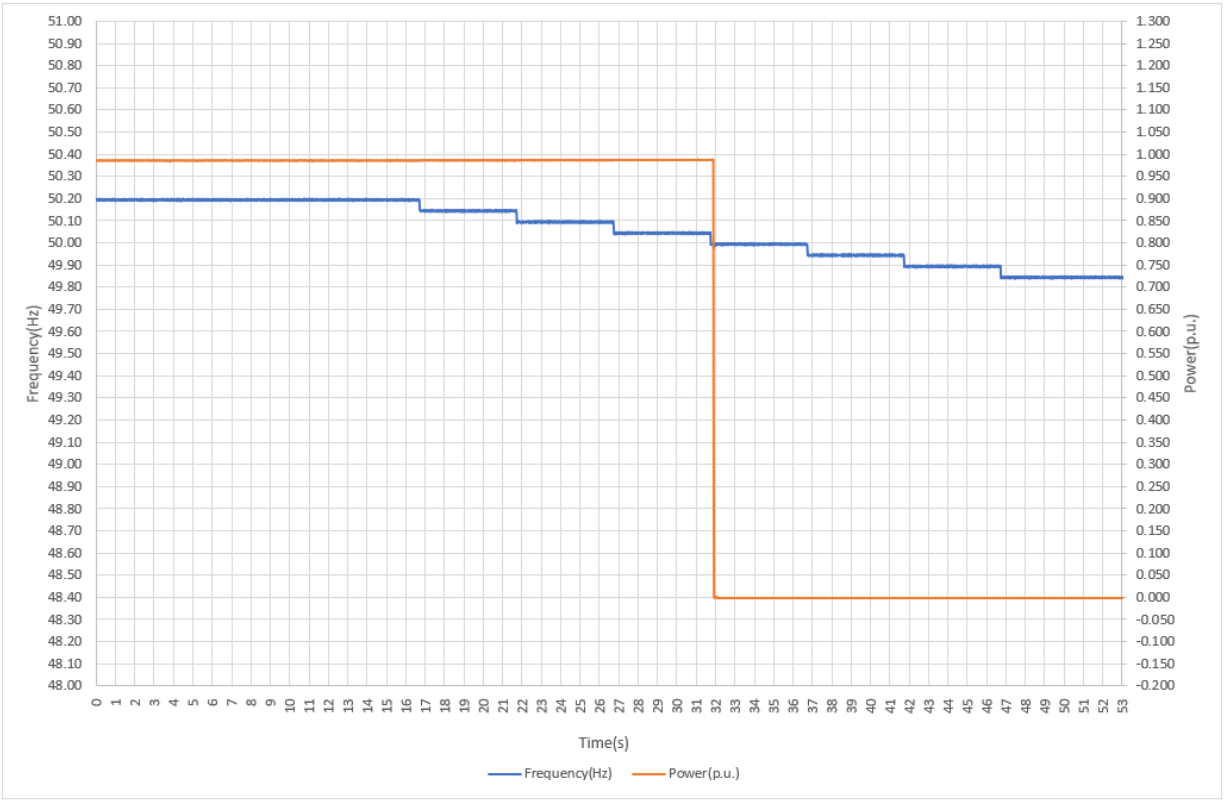
Underfrequency - Test 1: Trip value



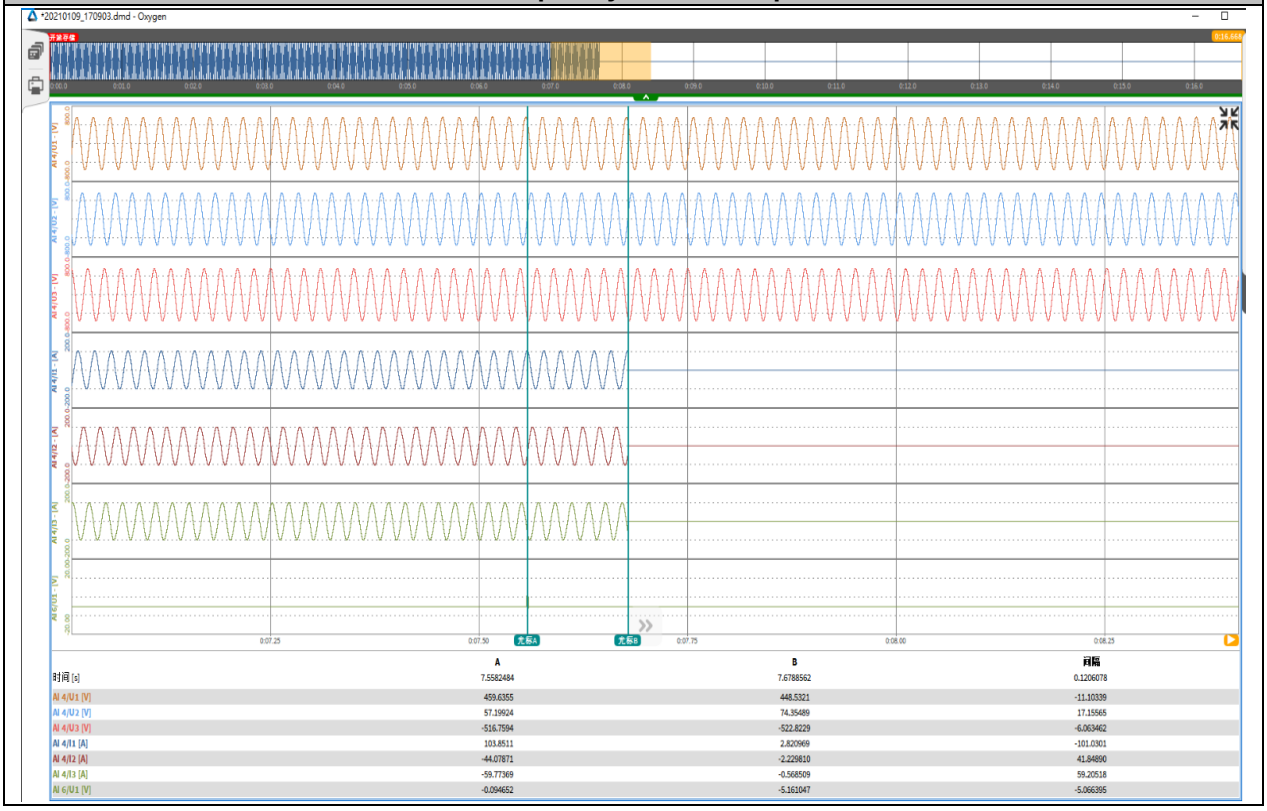
Underfrequency - Test 1: Trip time



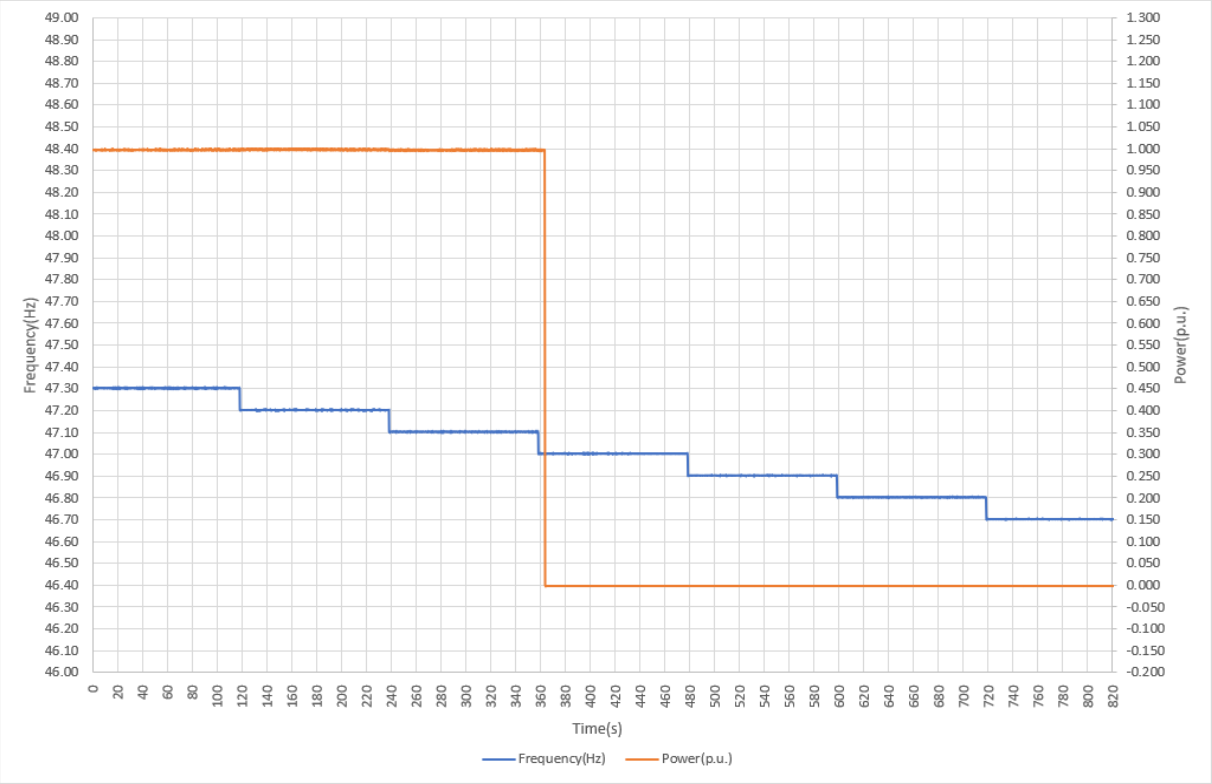
Underfrequency - Test 2: Trip value



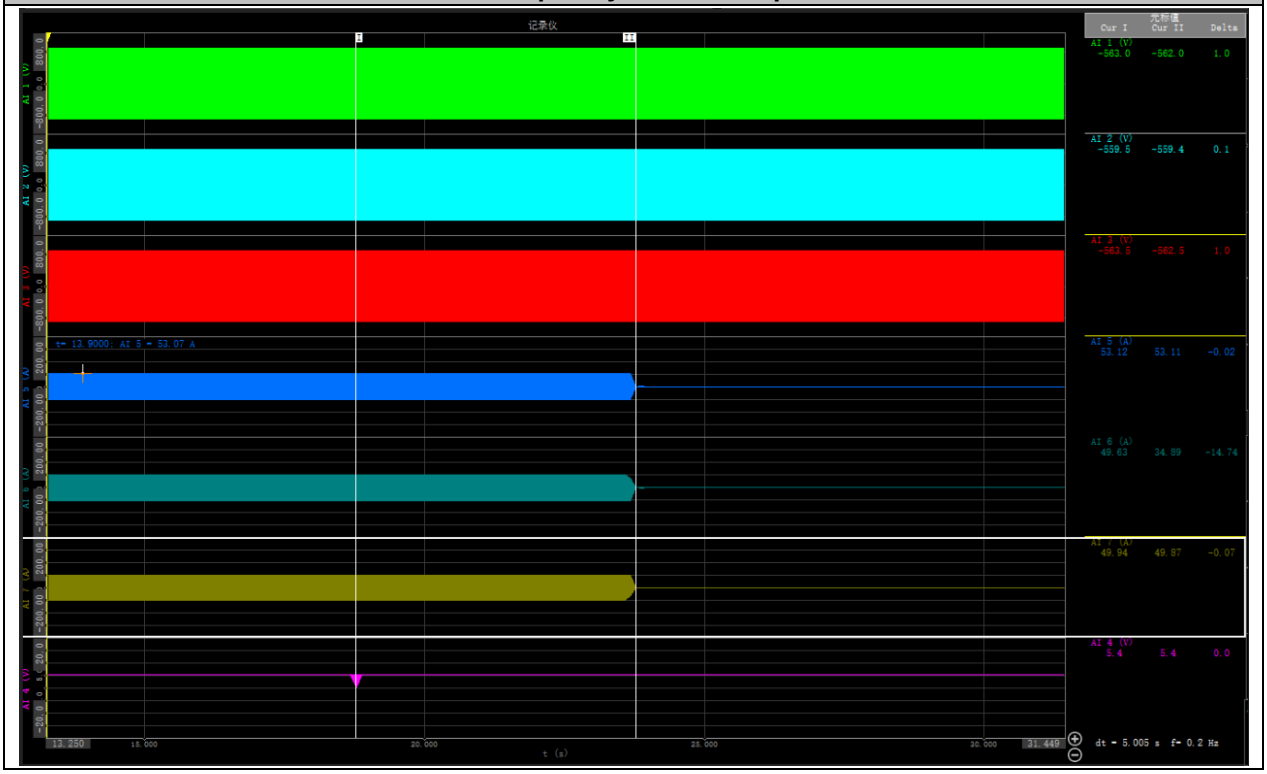
Underfrequency - Test 2: Trip time



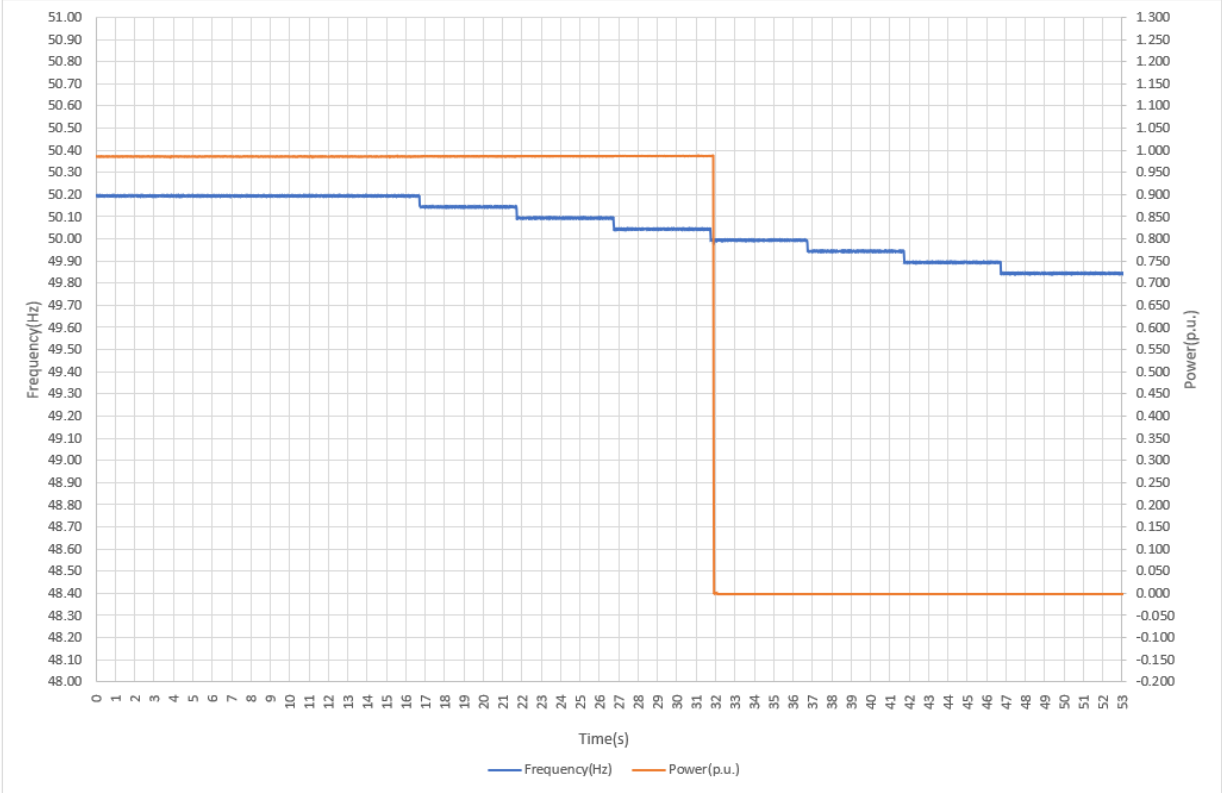
Underfrequency - Test 3: Trip value



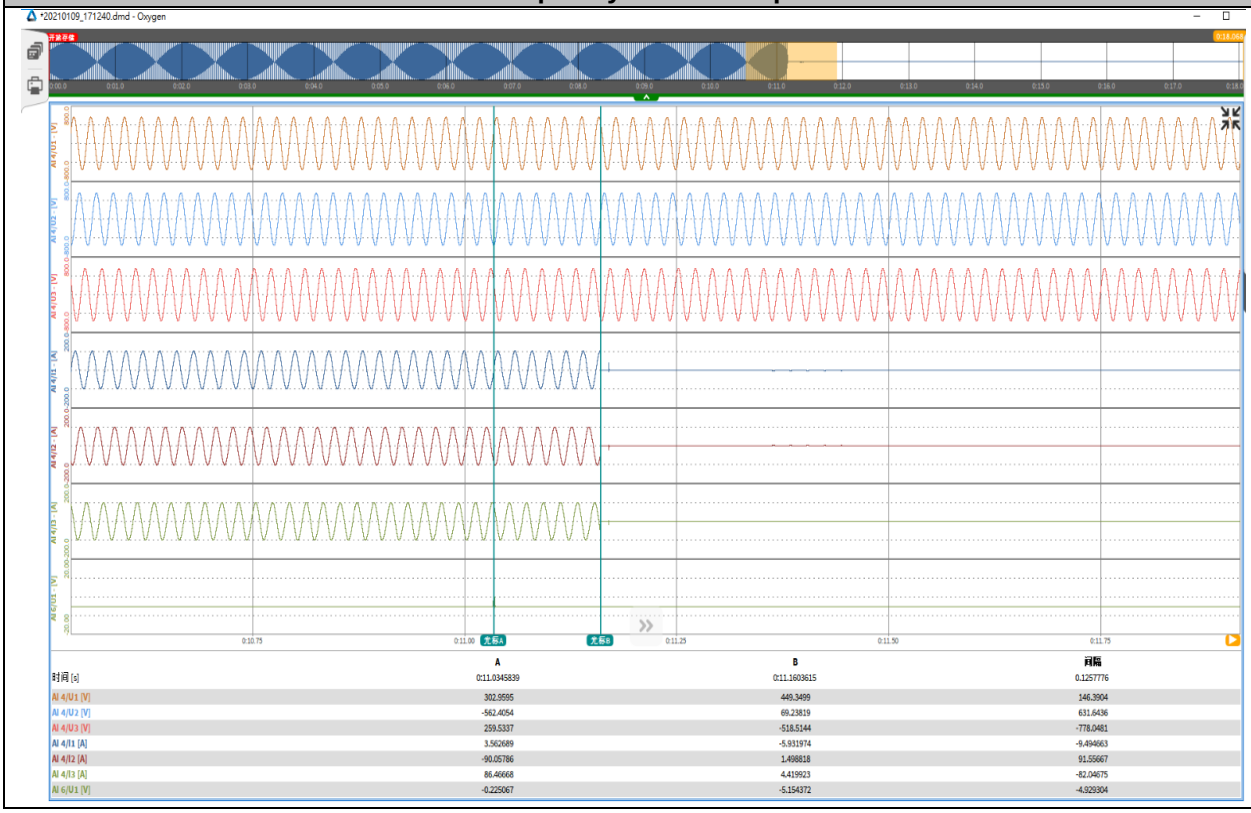
Underfrequency - Test 3: Trip time



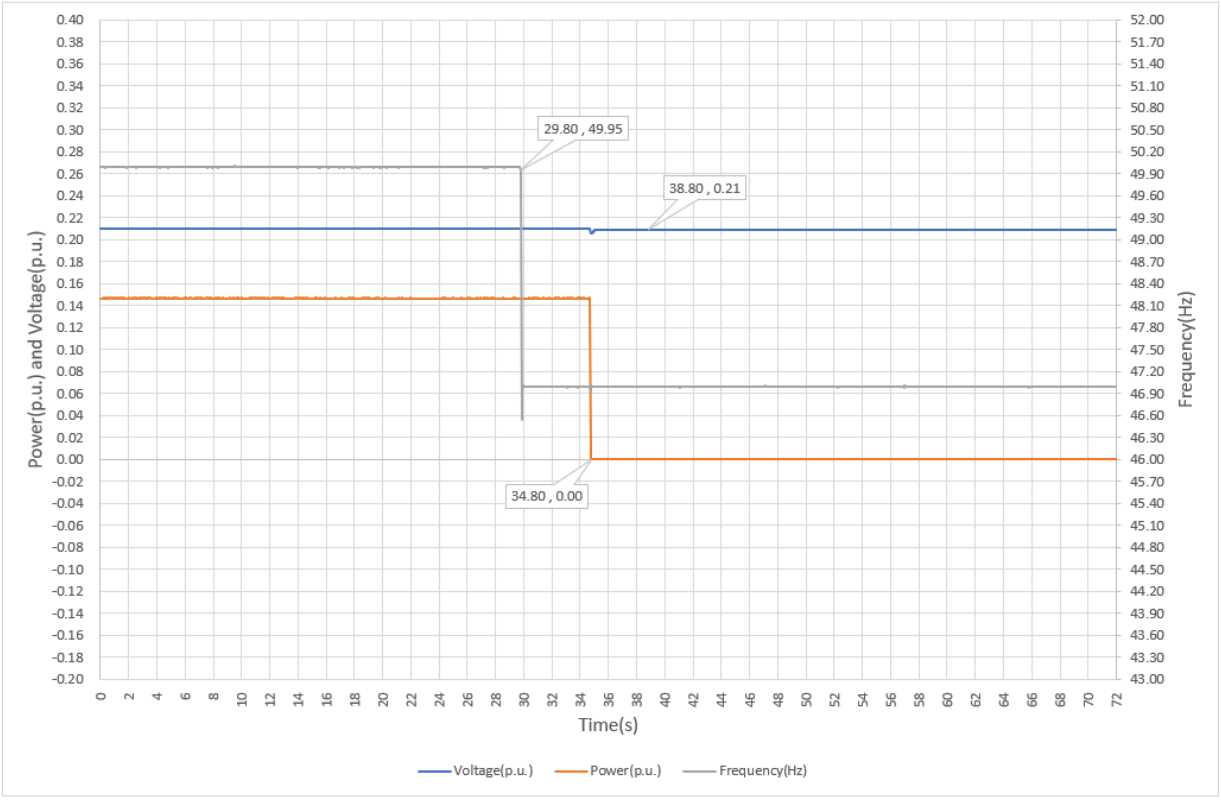
Underfrequency - Test 4: Trip value



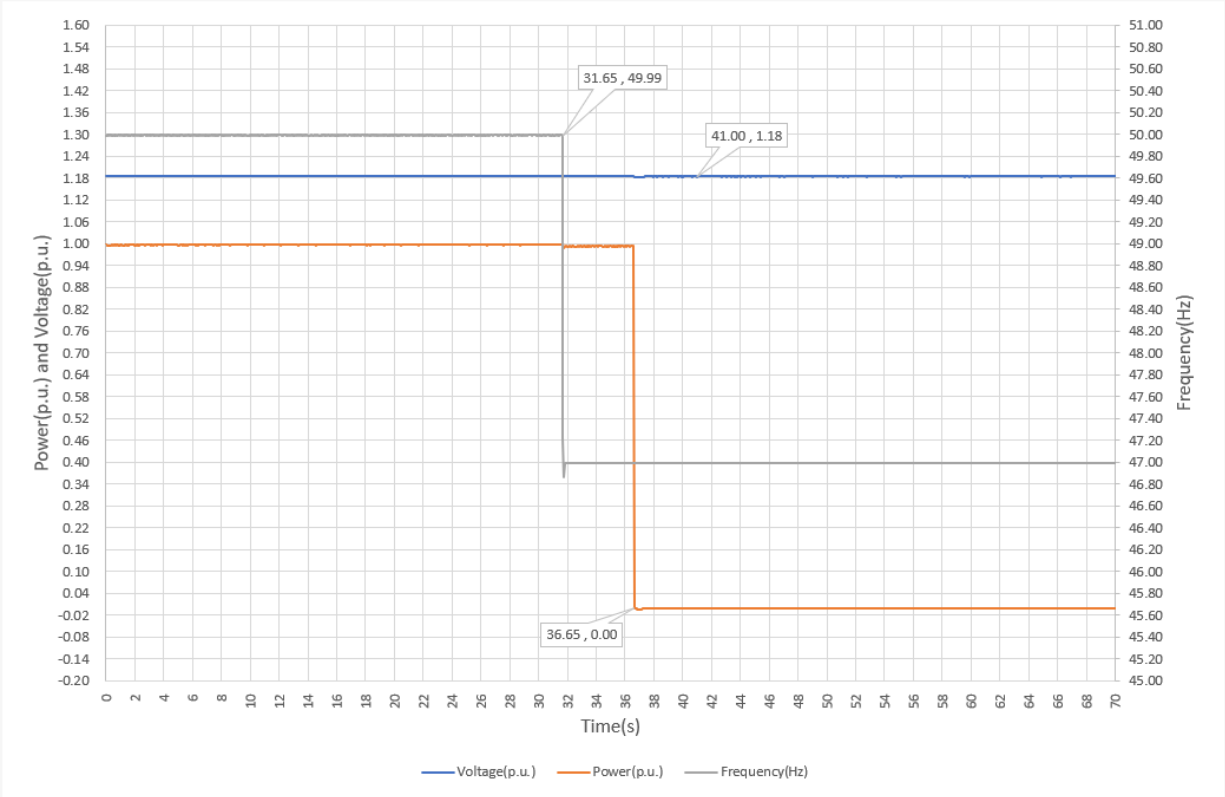
Underfrequency - Test 4: Trip time



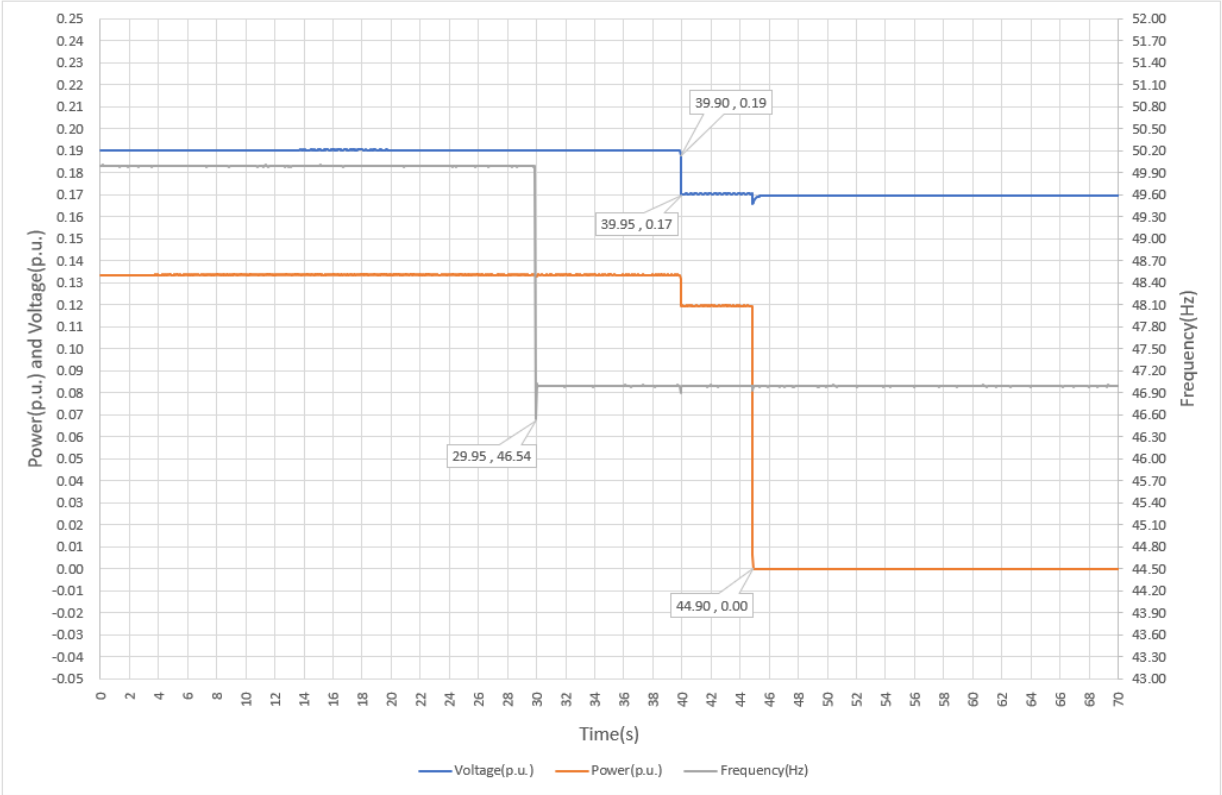
Test 5:Underfrequency 47Hz and Voltage 21%Un



Test 6:Underfrequency 47Hz and Voltage 119%Un



Test 7:Underfrequency 47Hz and Voltage 19%Un to 17%Un



4.6.1.5 Overfrequency protection

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

Overfrequency threshold stage 1 [81 >]:

- Threshold (50.0 – 52.0) Hz adjustment by steps of 0.1 Hz
- Operate time (0.1 – 100) s adjustable in steps of 0.1 s

Overfrequency threshold stage 2 [81 > >]:

- Threshold (50.0 – 52.0) Hz adjustment by steps of 0.1 Hz
- Operate time (0.1 - 5) s adjustable in steps of 0.05 s

In order to use narrow frequency thresholds for islanding detection (see4.9.3.3) it may be required to have the ability to activate and deactivate a stage by an external signal.

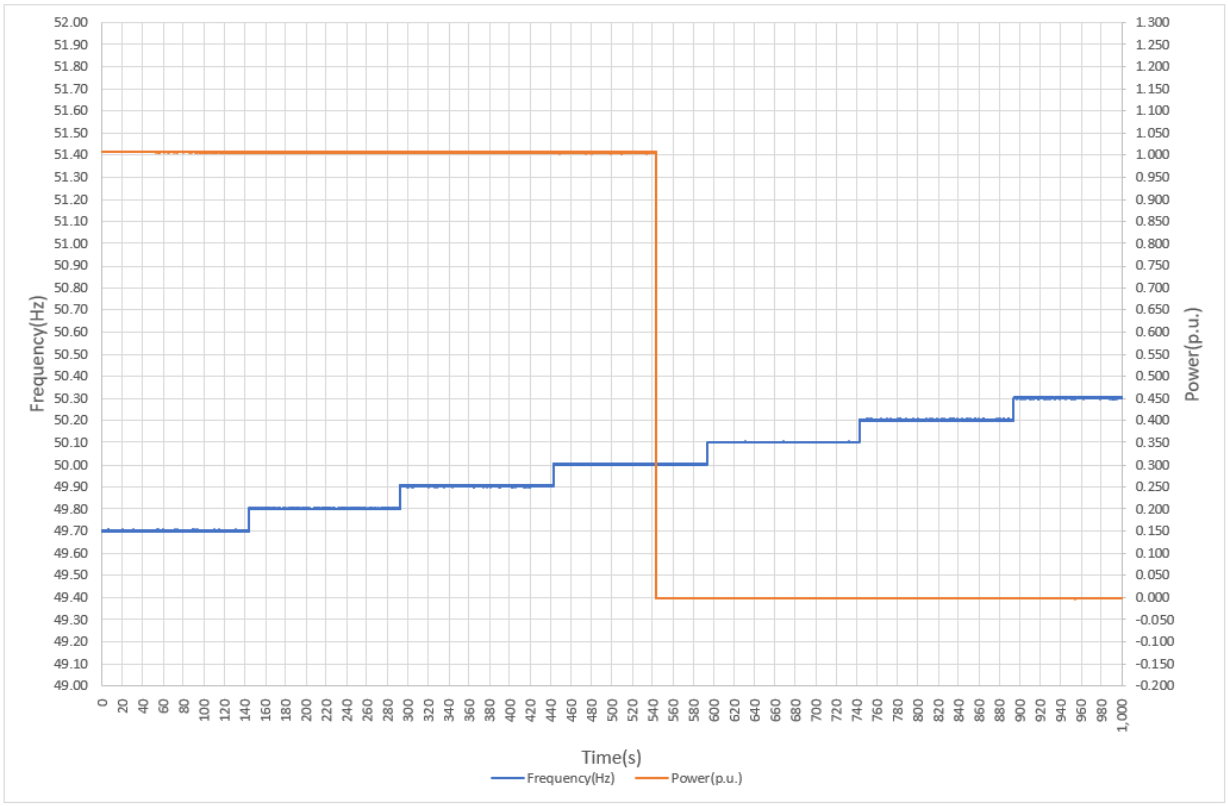
The frequency protection shall function correctly in the input voltage range between 20 %Un and 120 %Un and shall be inhibited for input voltages of less than 20 %Un.

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

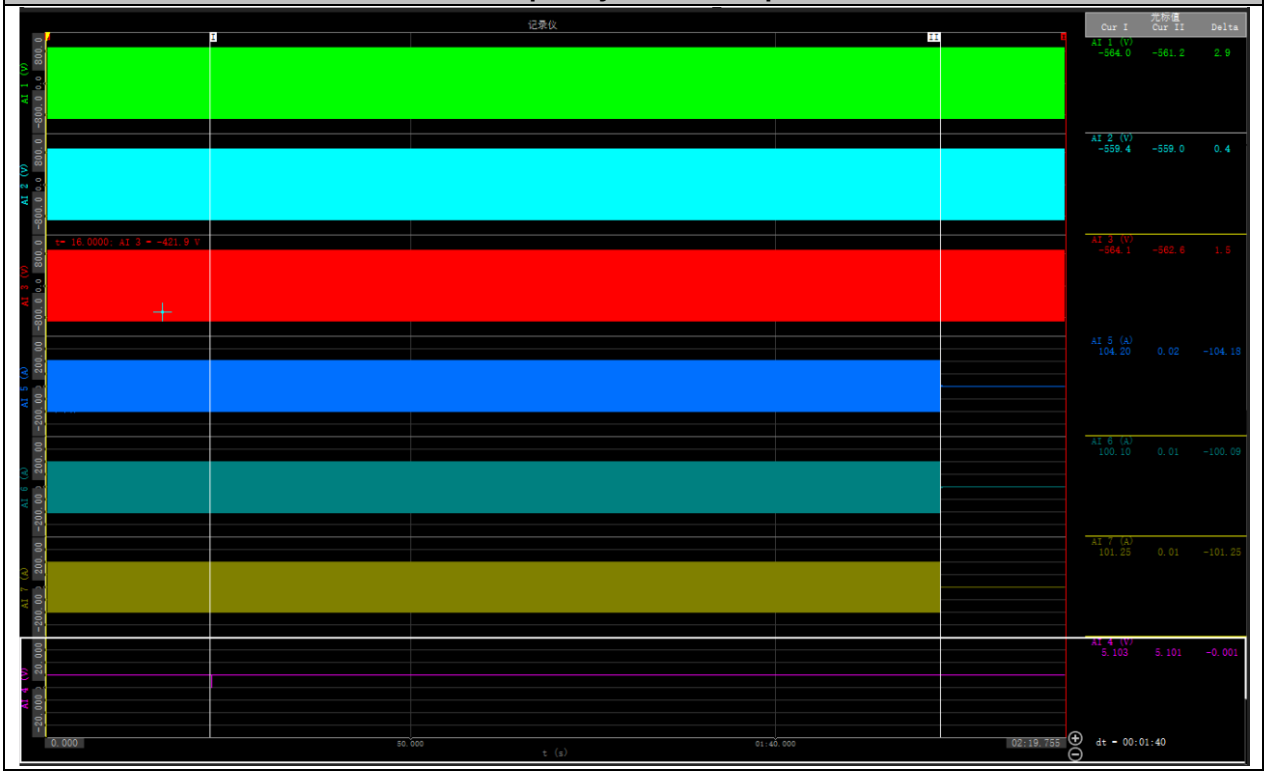
Over frequency	Test No.	Frequency setting (Hz)	Frequency meas. (Hz)	Frequency deviation (Hz)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
Stage 1 [81 >]	1	50.00	50.00	0.00	100.000	100.000	0.000
	2	52.00	52.00	0.00	0.100	0.112	0.012
Stage 2 [81 > >]	3	50.00	50.00	0.00	5.000	5.003	0.003
	4	52.00	52.00	0.00	0.100	0.098	0.012

Voltage protection threshold setting (Un)	Test No.	Frequency setting (Hz)	Voltage setting (%Un)	Voltage meas. (Un)	Trip time setting (s)	Trip time meas. (s)	Trip time deviation (s)
0.18	5	52.00	0.21	0.21	5.000	4.950	-0.050
	6	52.00	1.19	1.19	5.000	4.950	-0.050
	7	52.00	0.19	0.19	Not protected	--	--
		52.00	0.17	0.17	5.000	4.950	-0.050

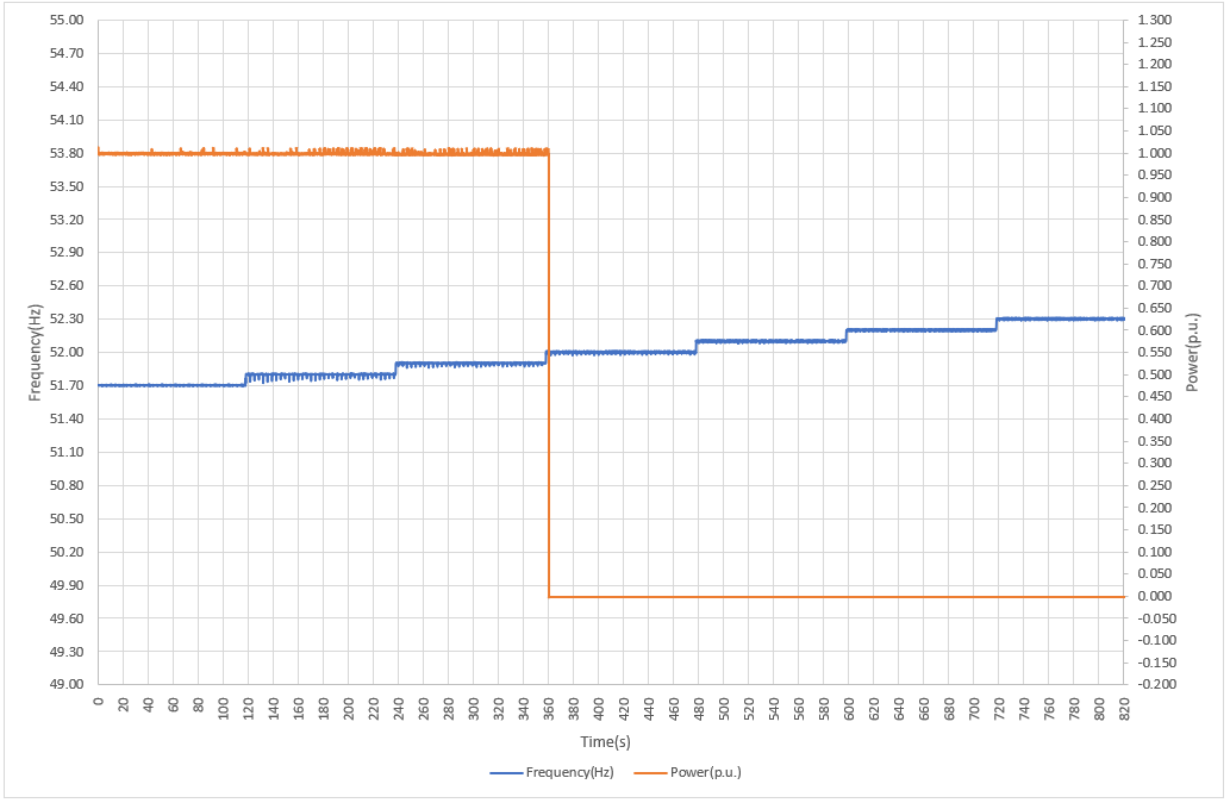
Overfrequency - Test 1: Trip value



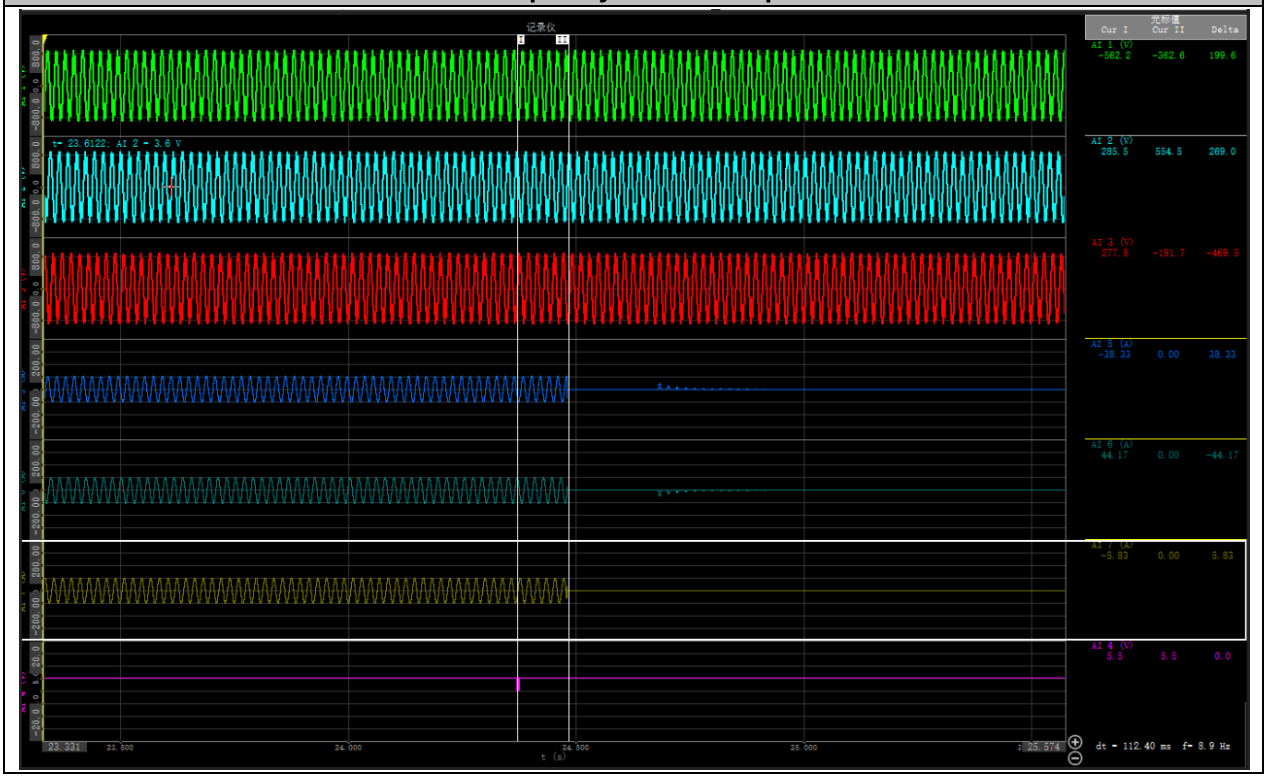
Overfrequency - Test 1: Trip time



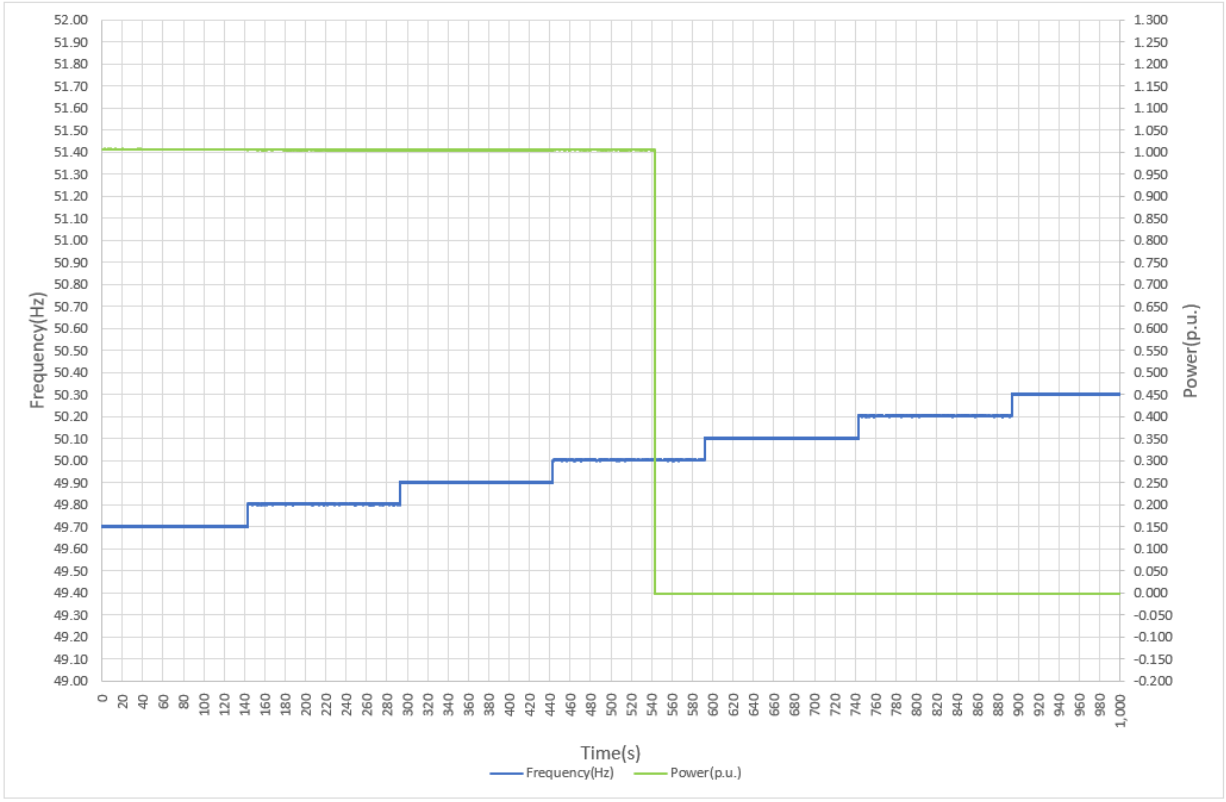
Overfrequency - Test 2: Trip value



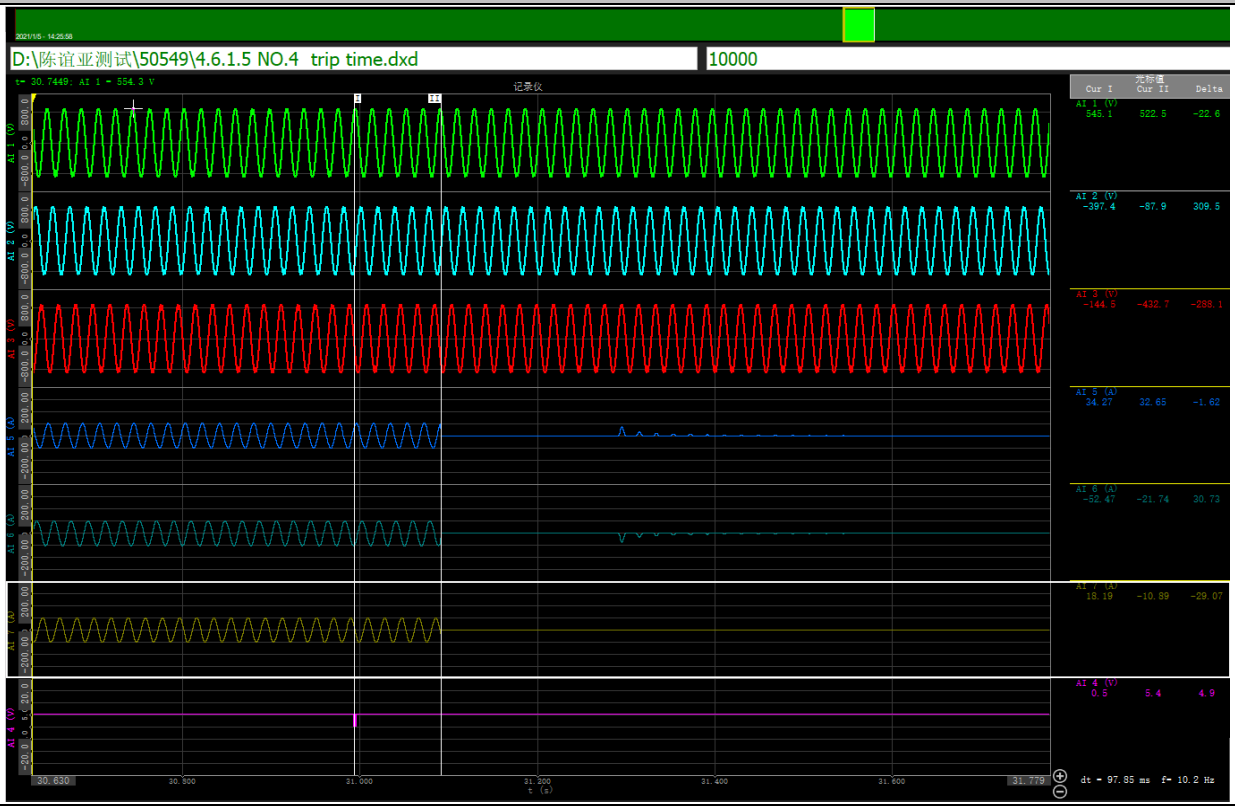
Overfrequency - Test 2: Trip time



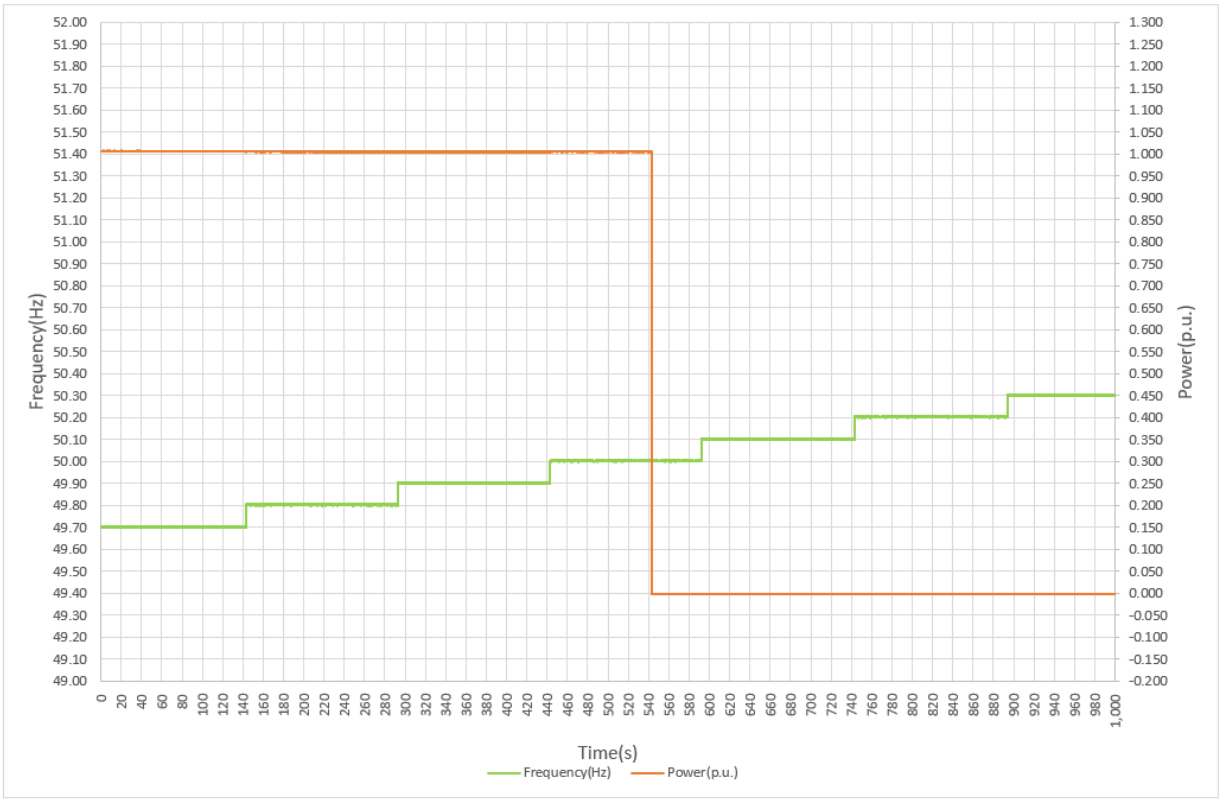
Overfrequency - Test 3: Trip value



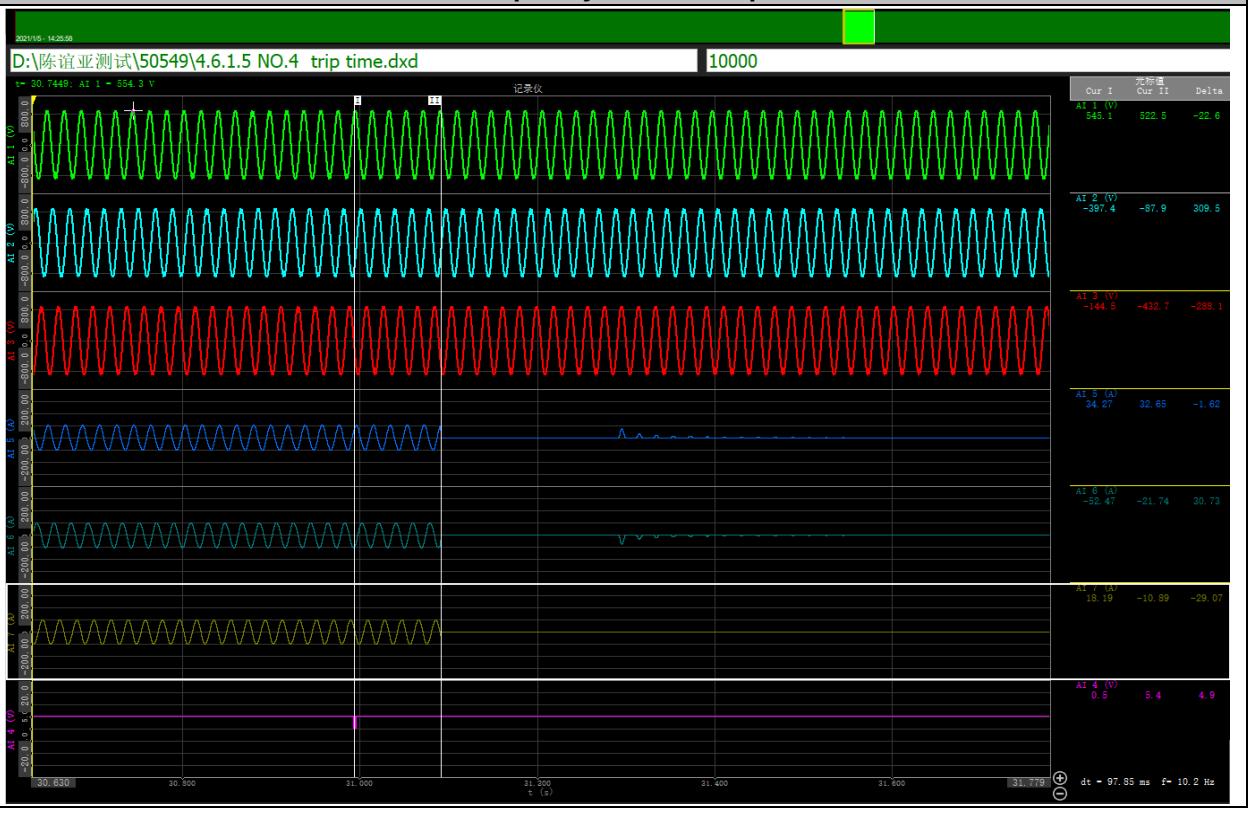
Overfrequency - Test 3: Trip time



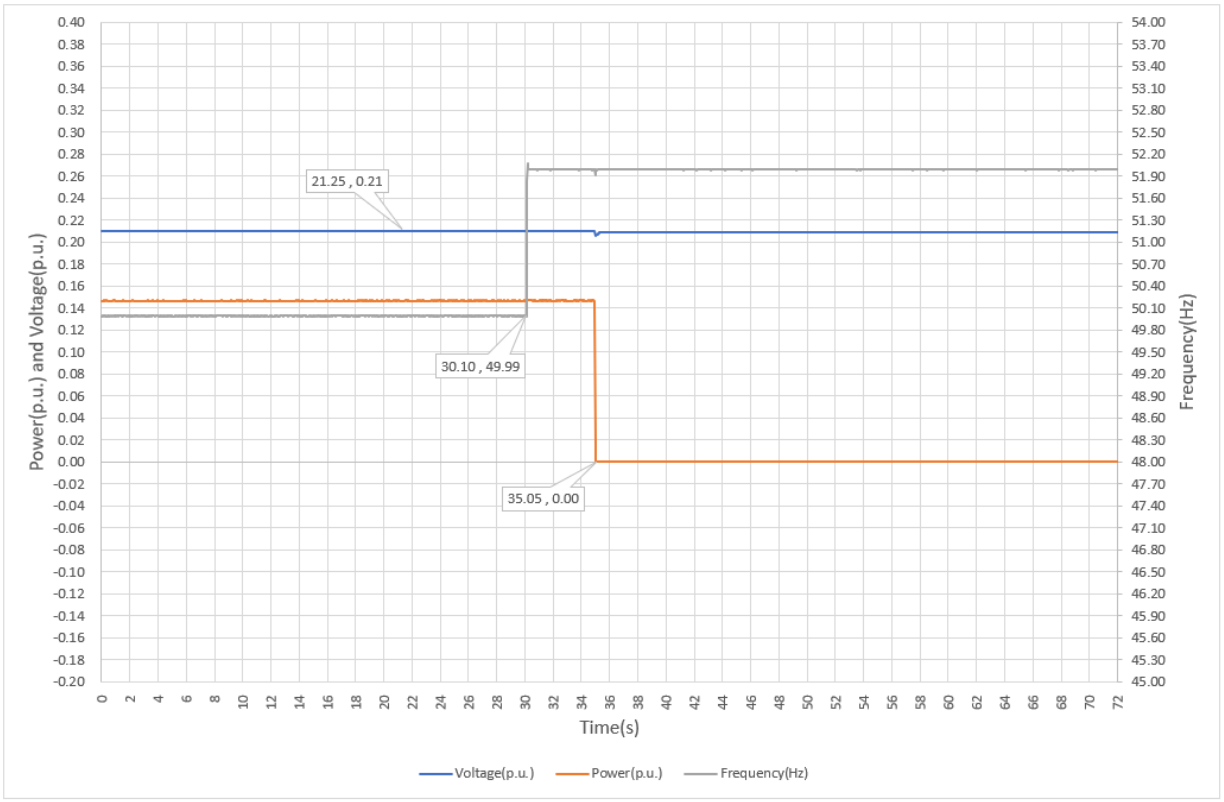
Overfrequency - Test 4: Trip value



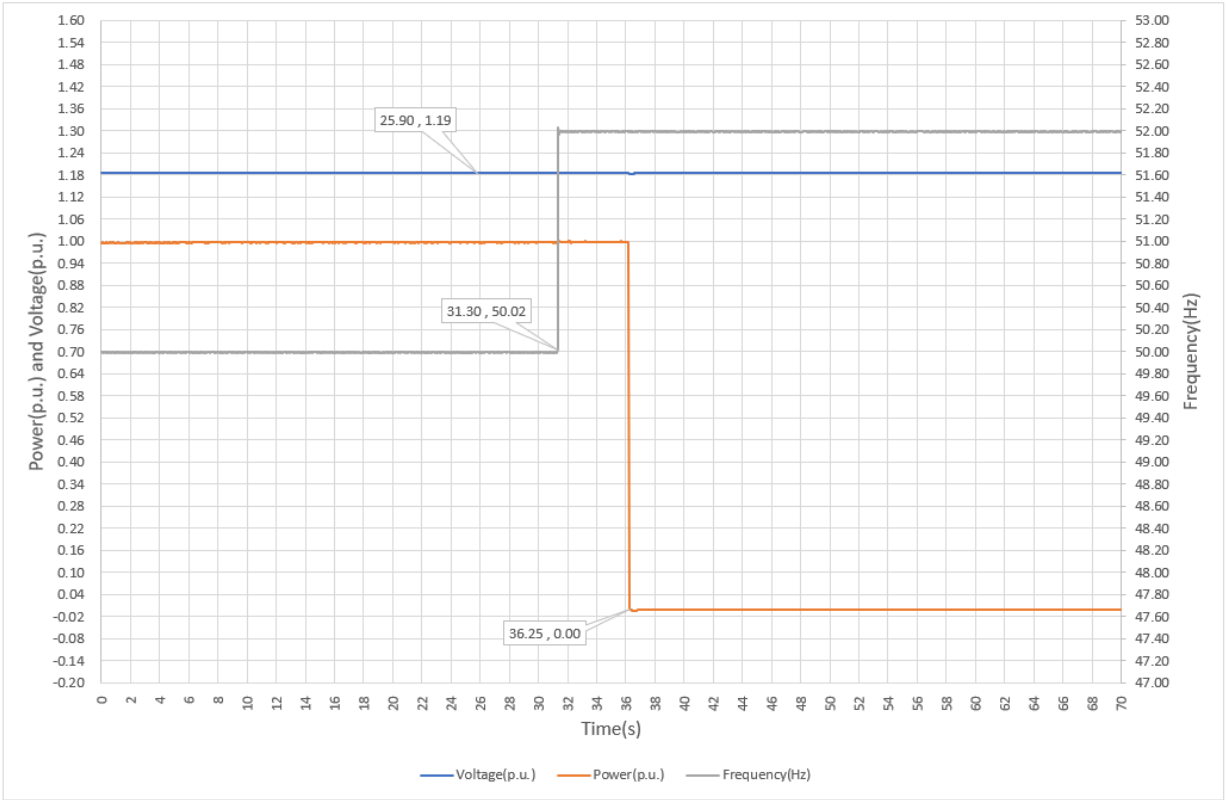
Overfrequency - Test 4: Trip time



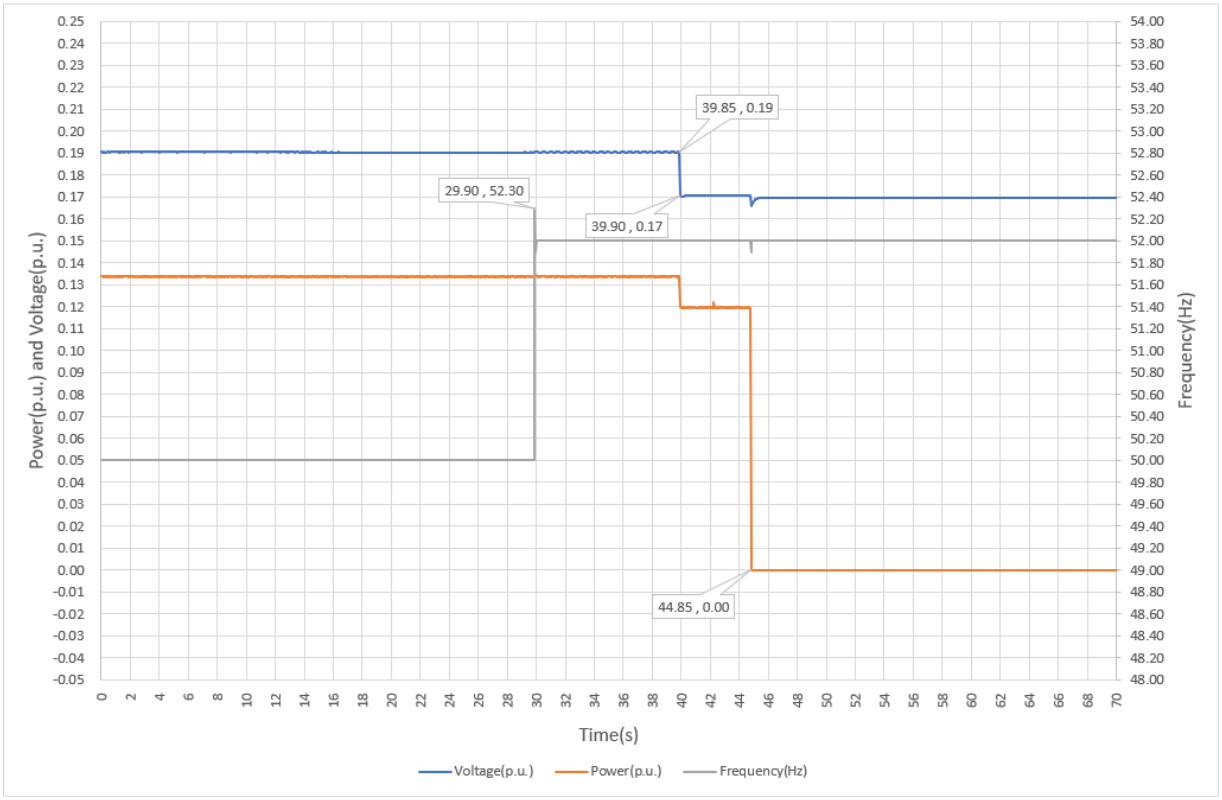
Test 5:Underfrequency 52Hz and Voltage 21%Un



Test 6:Underfrequency 52Hz and Voltage 119%Un



Test 7:Underfrequency 52Hz and Voltage 19%Un to 17%Un



4.6.2. Means to detect island situation

According to the test requirements of standard 4.9.4, these methods have passed the EN 62116 photovoltaic inverter resonance circuit test.

Model HPS30
The compliance with these requirements is stated in page 30 to page 35 of the following test report:

IEC 62116:2014: Test Report nº ES200211002P which was issued by EMTEK (SHENZHEN) CO., LTD on Mar 01th, 2020.

Model HPS50
The compliance with these requirements is stated in page 25 to page 31 of the following test report:

IEC 62116:2014: Test Report nº ES190602003P which was issued by EMTEK (SHENZHEN) CO., LTD on Dec 18th, 2019.

4.6.3. Digital input to the interface protection

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

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

4.7. CONNECTION AND STARTING TO GENERATE ELECTRICAL POWER

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

4.7.1. Automatic reconnection after tripping

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

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

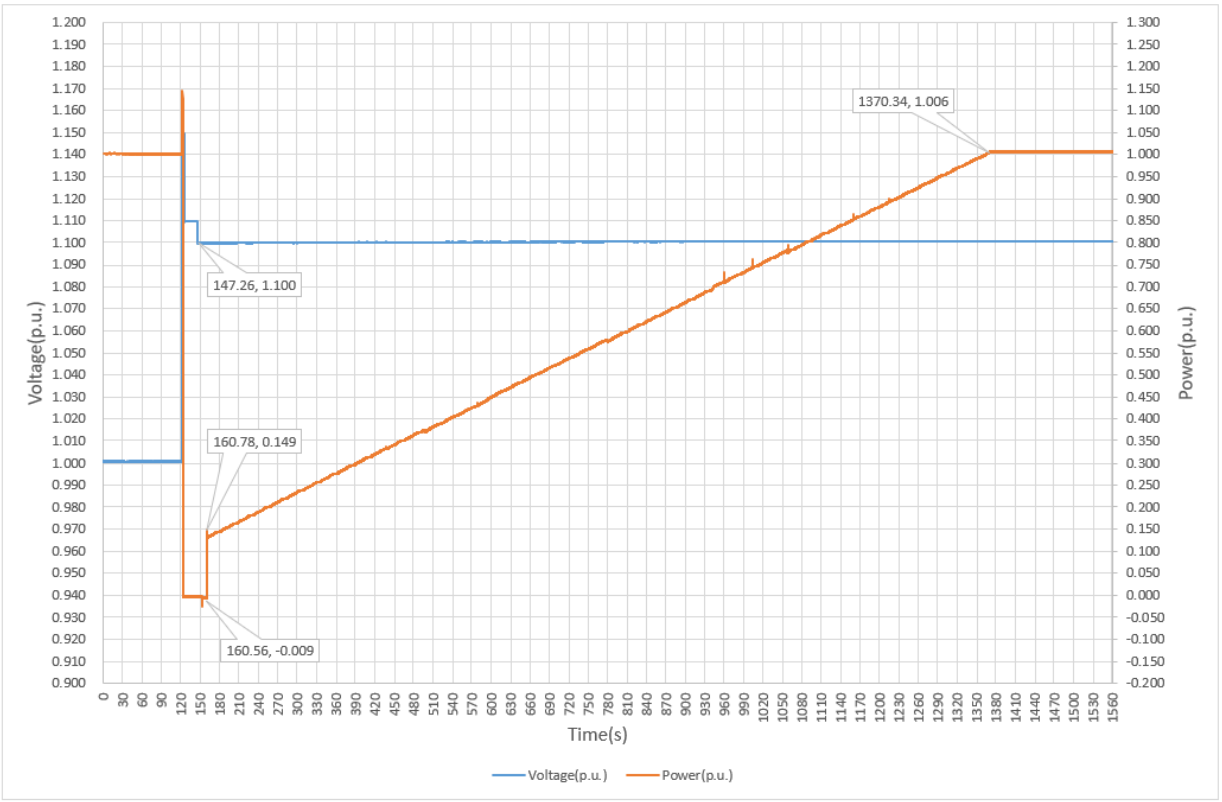
Table 3 — Automatic reconnection after tripping

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

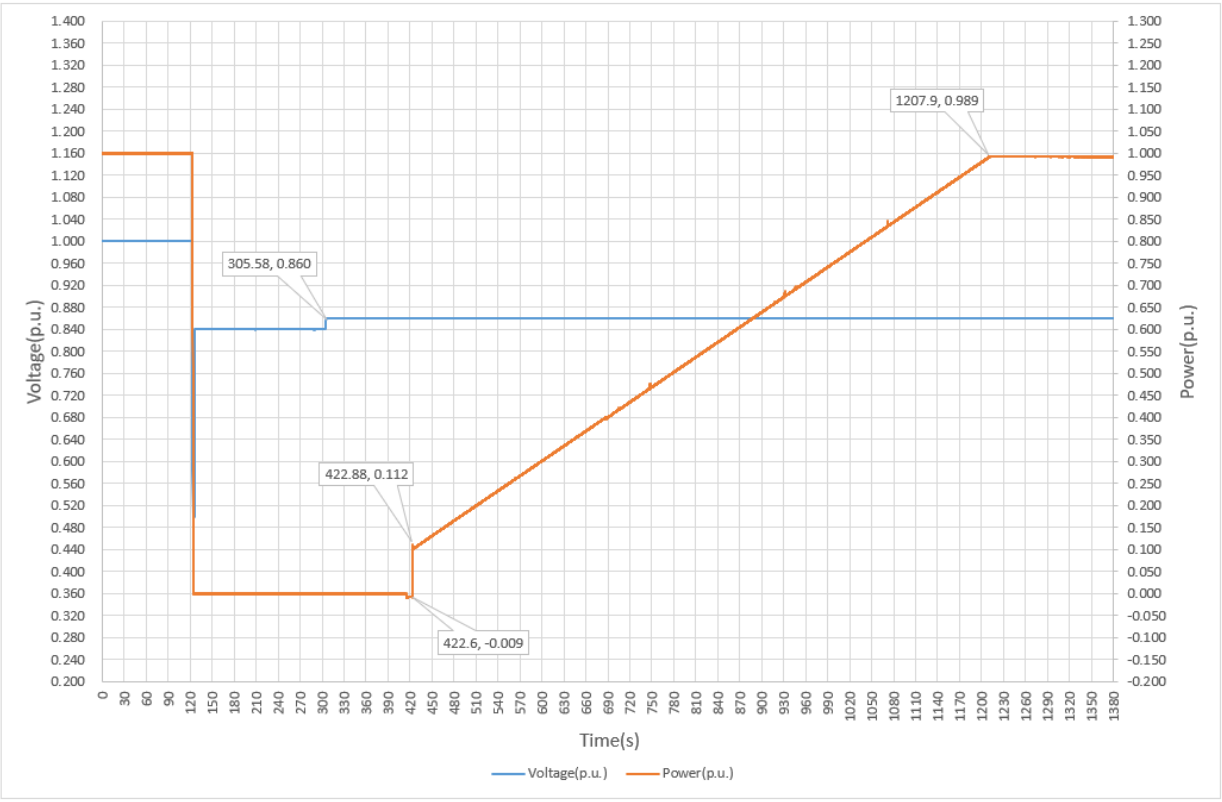
The following definitions apply to the test to verify the clause:

Disconnection Setting		Reconnection Setting		Setting Reconnection time (s)	Meas. Reconnection time (s)	Setting gradient (%Pn/min)	Meas. gradient (%Pn/min)
U= 115 %Un	Yes	U = 110 %Un	Yes	10.0	13.3	4.0	4.4
U = 50 %Un	Yes	U = 85 %Un	Yes	90.0	117.0	6.0	6.7
f = 52.00 Hz	Yes	f = 50.20 Hz	Yes	600.0	624.9	3000.0	2899
f = 48.00 Hz	Yes	f = 49.50 Hz	Yes	60.0	81.7	10.0	10.1

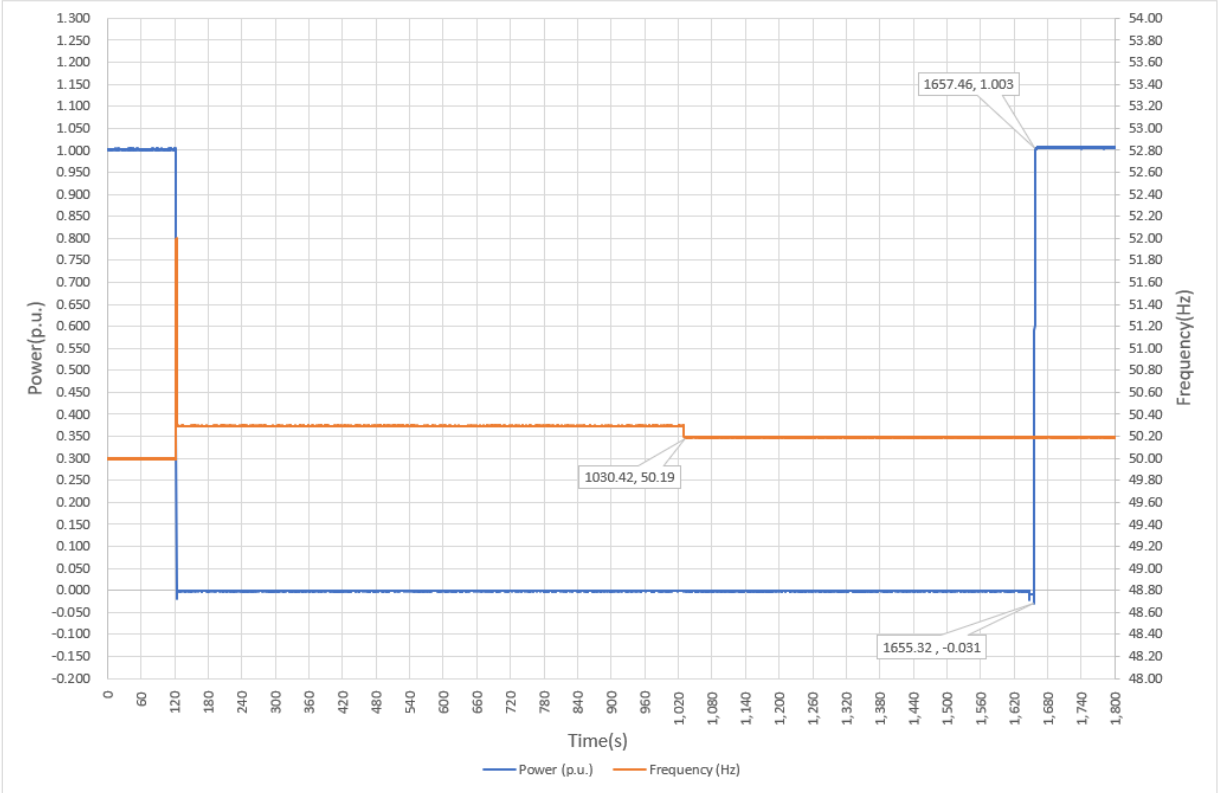
Overvoltage re-connection



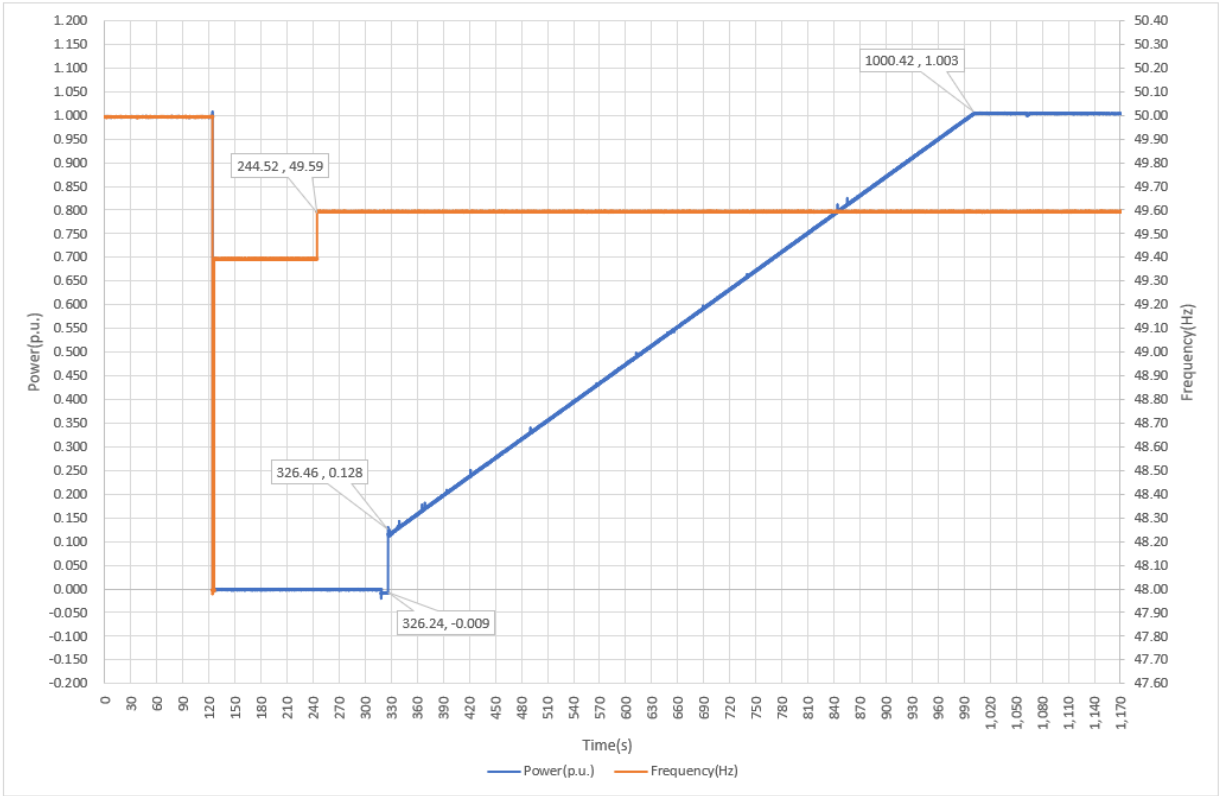
Undervoltage re-connection



Overfrequency re-connection



Underfrequency re-connection



4.7.2. Starting to generate electrical power

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

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

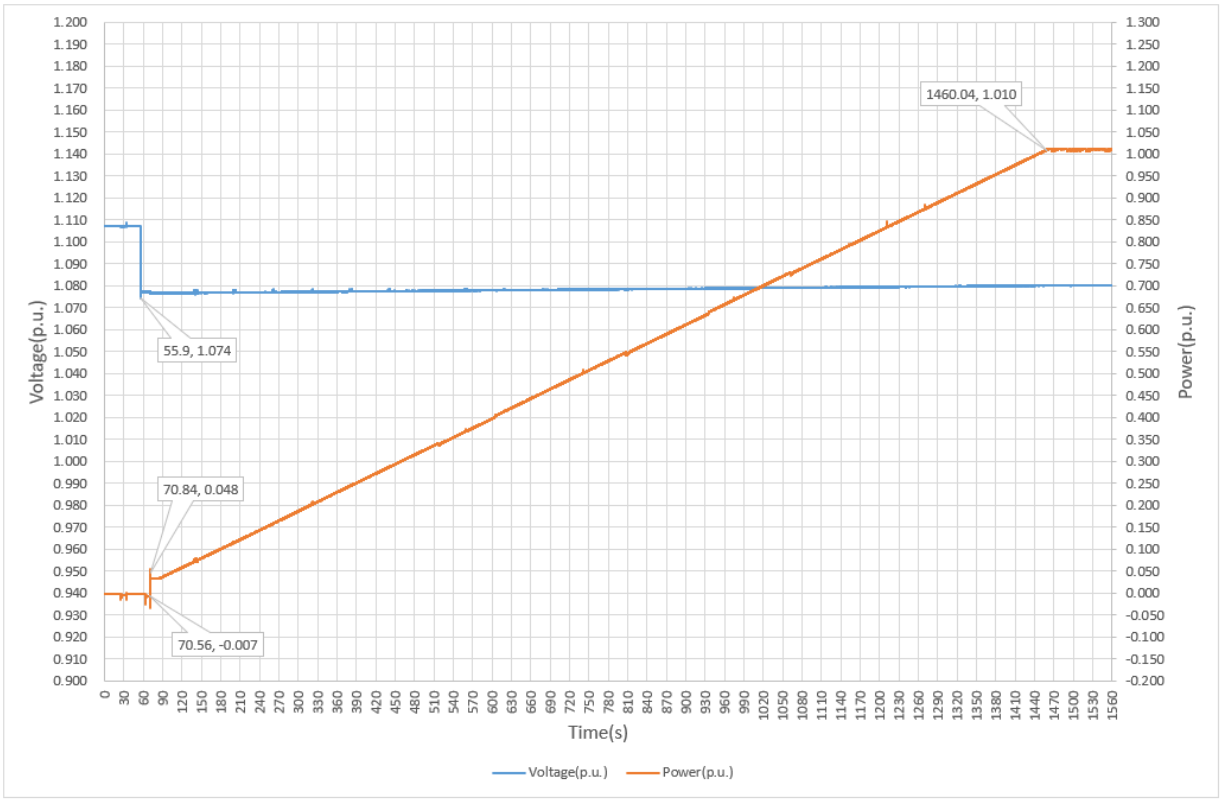
Table 4 — Starting to generate electrical power

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

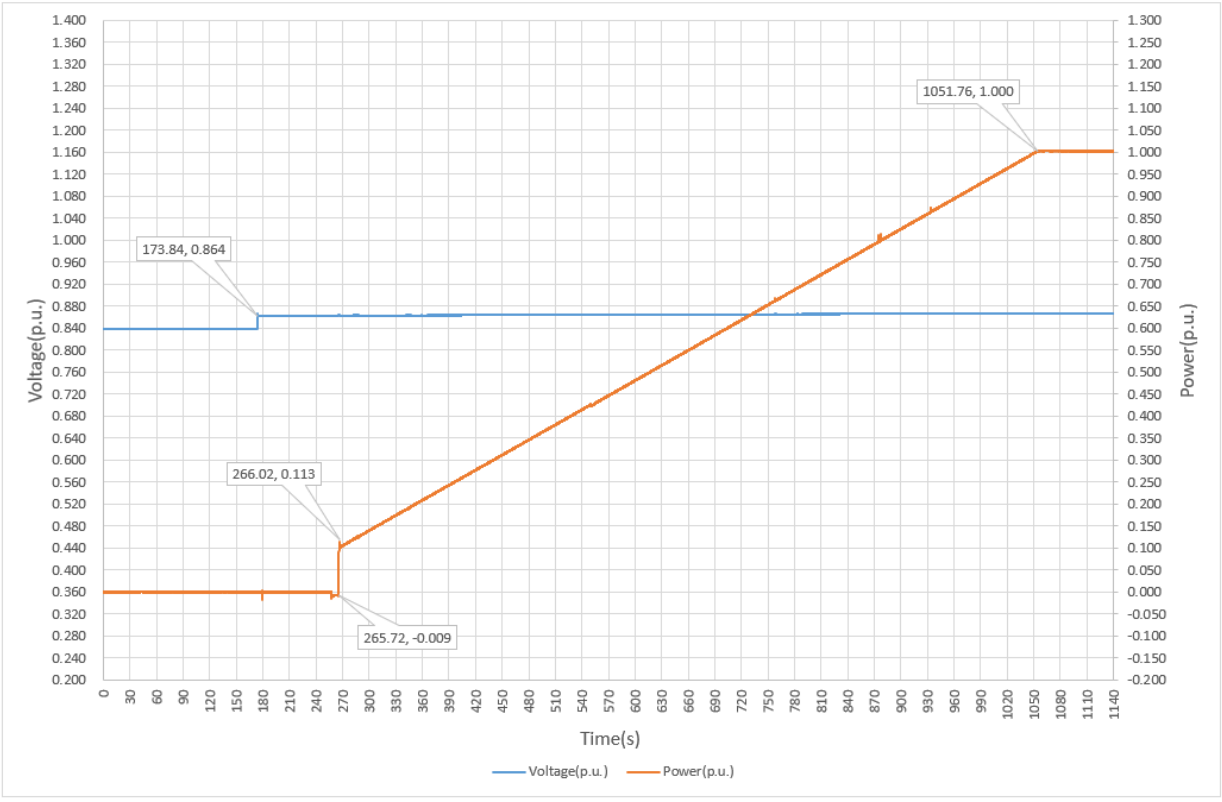
The following definitions apply to the test to verify the clause:

Connection		Setting Connection time (s)	Meas. Connection time (s)	Setting gradient (%Pn/min)	Meas. gradient (%Pn/min)
U < 110 %Un	Yes	10	14.7	4.0	4.2
85 % < U	Yes	60	91.9	6.0	6.8
f < 50.10 Hz	Yes	600	622.3	3000.0	2811.1
49.50 < f	Yes	60	81.7	10.0	9.9

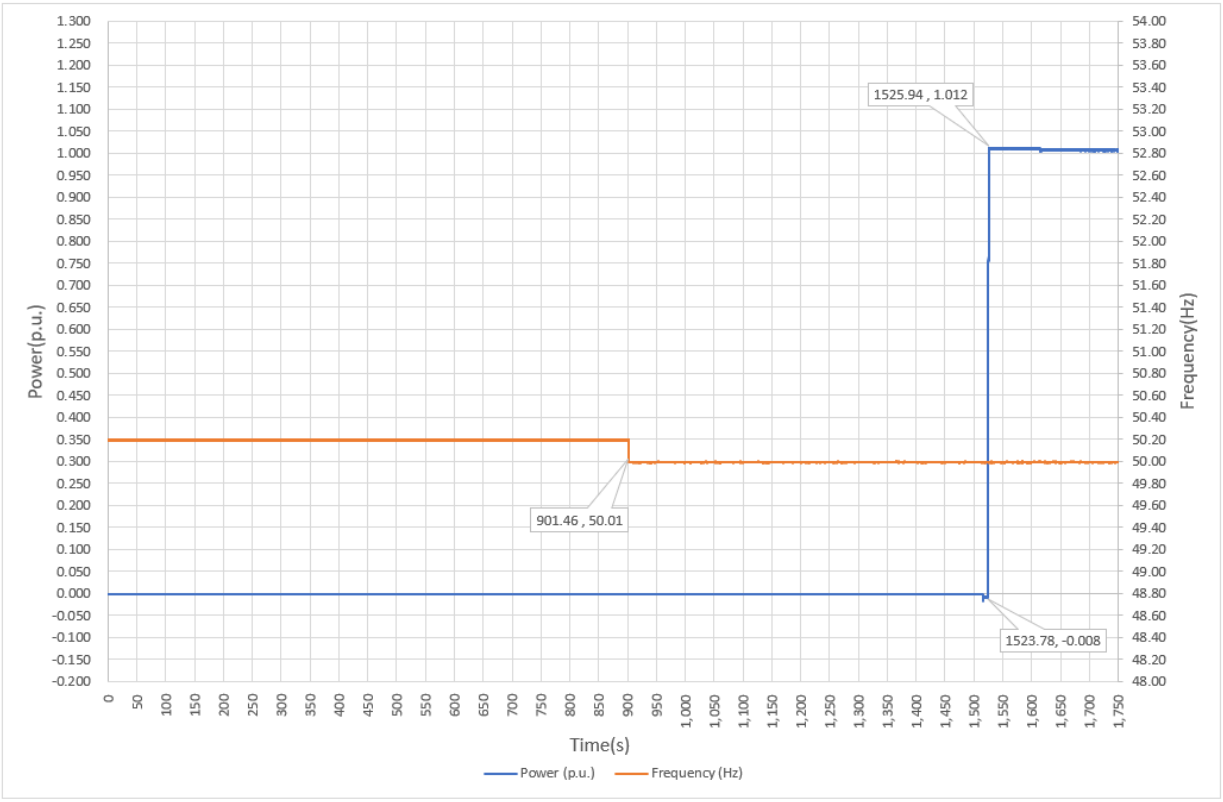
Overvoltage Connection



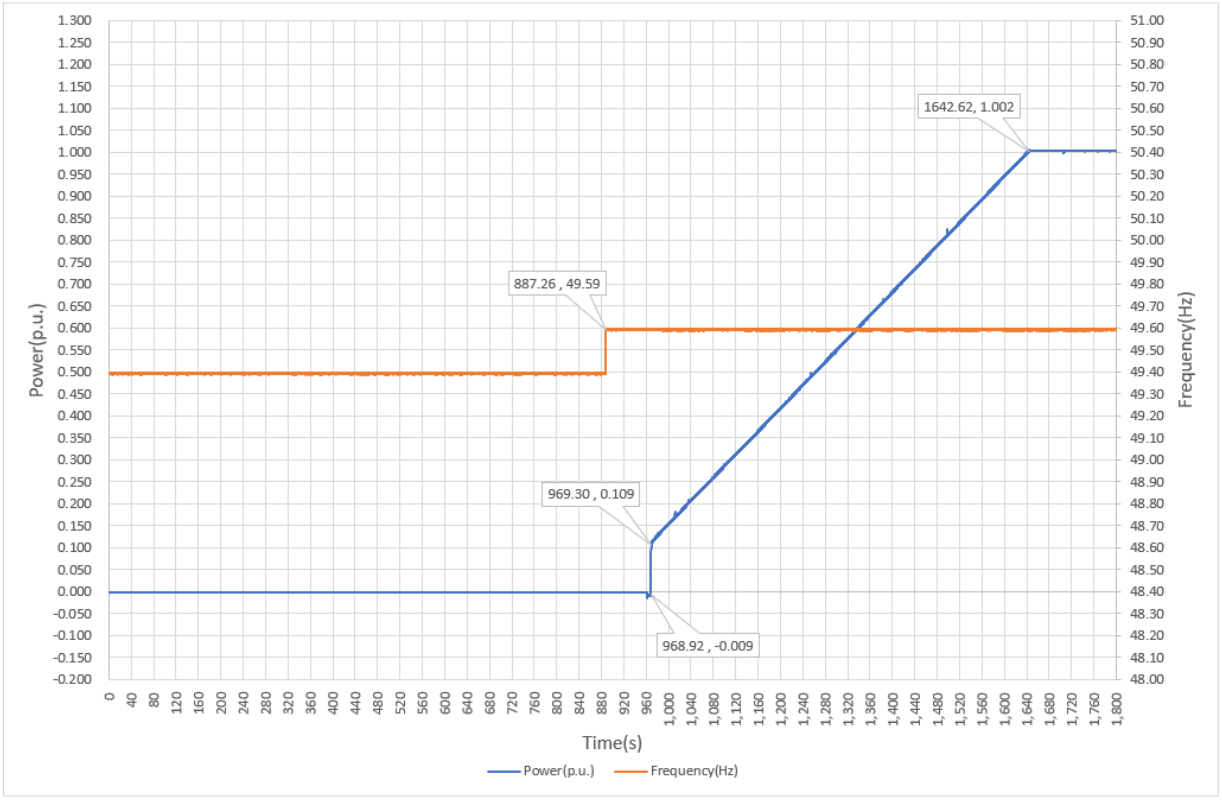
Undervoltage Connection



Overfrequency Connection



Underfrequency reconnection



4.7.3. Synchronization

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

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

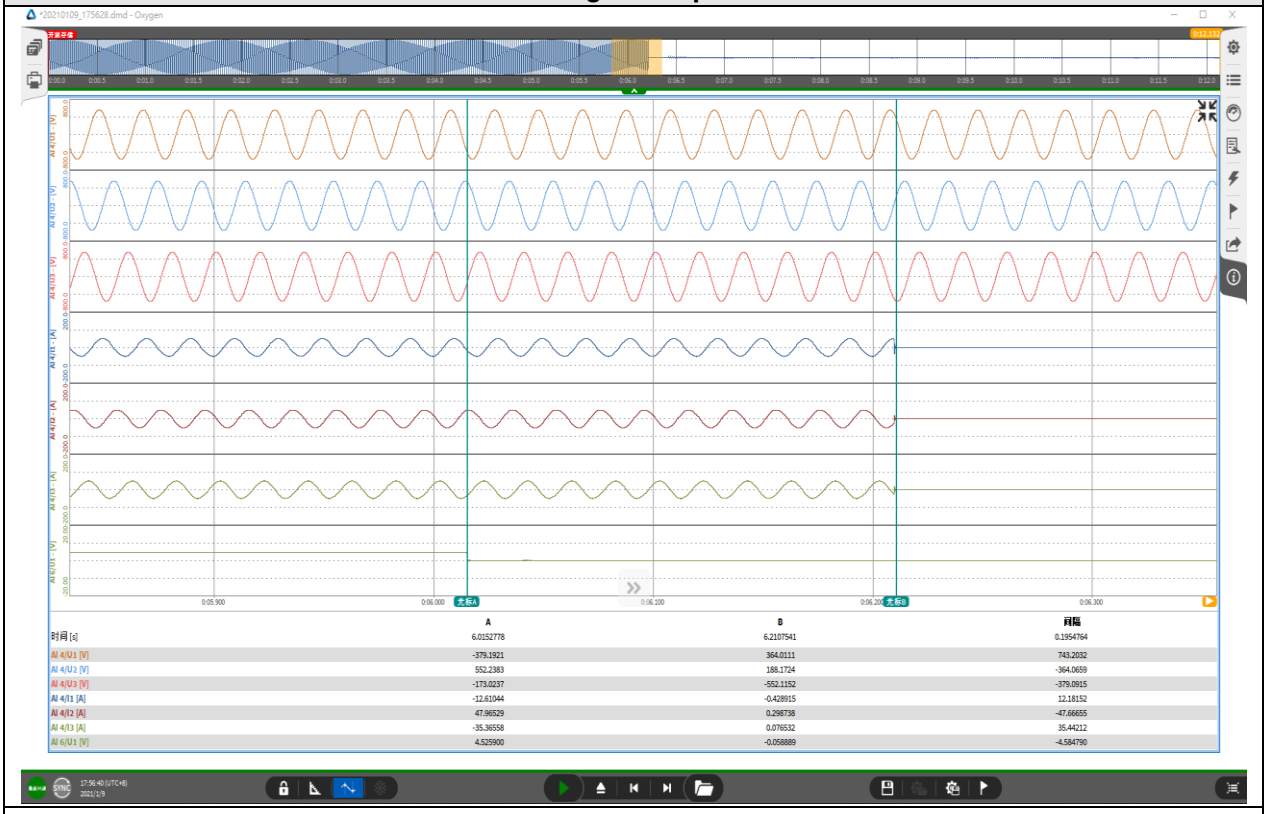
4.8. CEASING AND REDUCTION OF ACTIVE POWER ON SET POINT

4.8.1. Ceasing active power

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

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

Ceasing active power



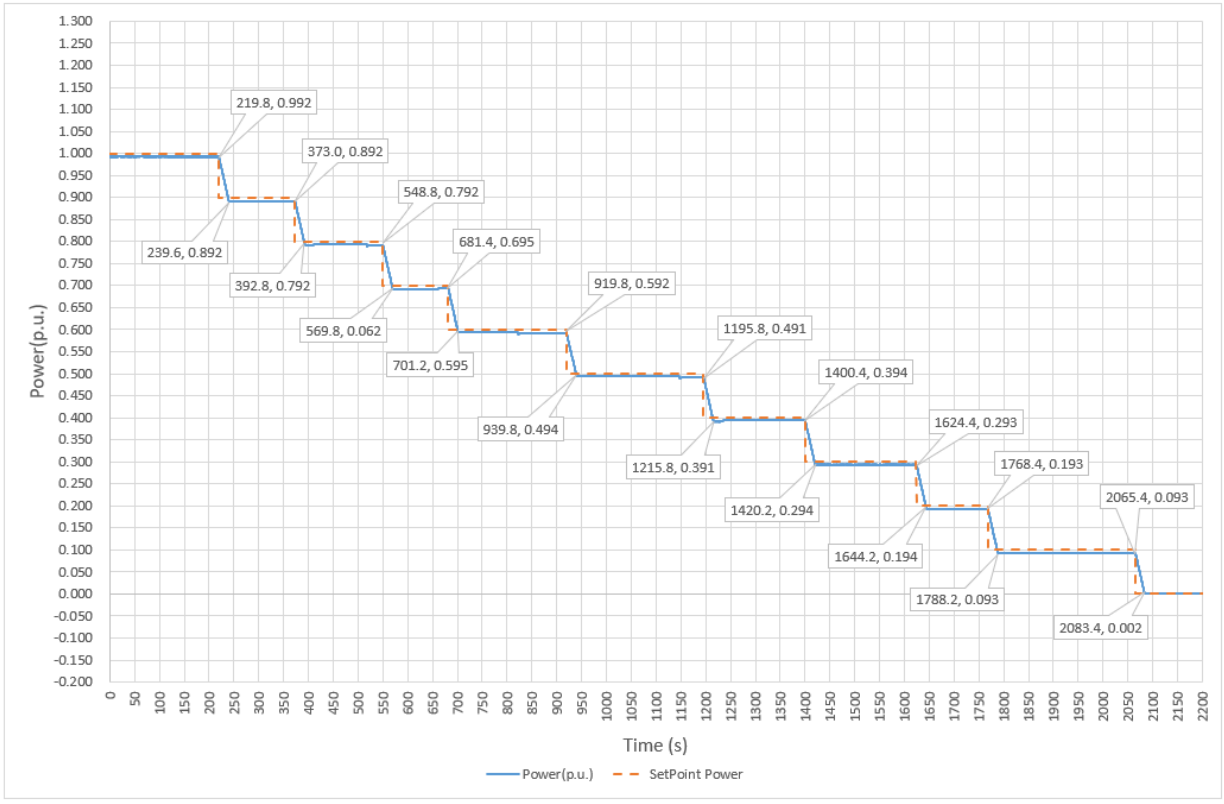
Tested ceasing active power time: 195 ms

4.8.2. Reduction of active power on set point

Test requirements according to the clause 4.11.2 of the standard.

Active Power step ($\%P_n$)	Setpoint value		Actual value		Deviation <±5%		Gradient 0.66%Pn/s to 0.33%Pn/s
	(kW)	(%Pn)	(kW)	($\%P_n$)	(kW)	($\%P_n$)	(%Pn/s)
100%	50.00	100.00	49.61	99.23	-0.39	-0.77	--
90%	45.00	90.00	44.62	89.23	-0.38	-0.77	0.51
80%	40.00	80.00	39.71	79.42	-0.29	-0.58	0.51
70%	35.00	70.00	34.64	69.28	-0.36	-0.72	0.49
60%	30.00	60.00	29.67	59.34	-0.33	-0.66	0.51
50%	25.00	50.00	24.70	49.39	-0.30	-0.61	0.49
40%	20.00	40.00	19.70	39.40	-0.30	-0.60	0.51
30%	15.00	30.00	14.69	29.37	-0.31	-0.63	0.51
20%	10.00	20.00	9.68	19.36	-0.32	-0.64	0.50
10%	5.00	10.00	4.65	9.30	-0.35	-0.70	0.51
0%	0.00	0.00	0.09	0.17	0.09	0.17	0.52

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



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

The requriments is from clause 4.13 of the standard.

The compliance with these requirements is stated in section 4.4 in page 63 to 64 page of the following test report:

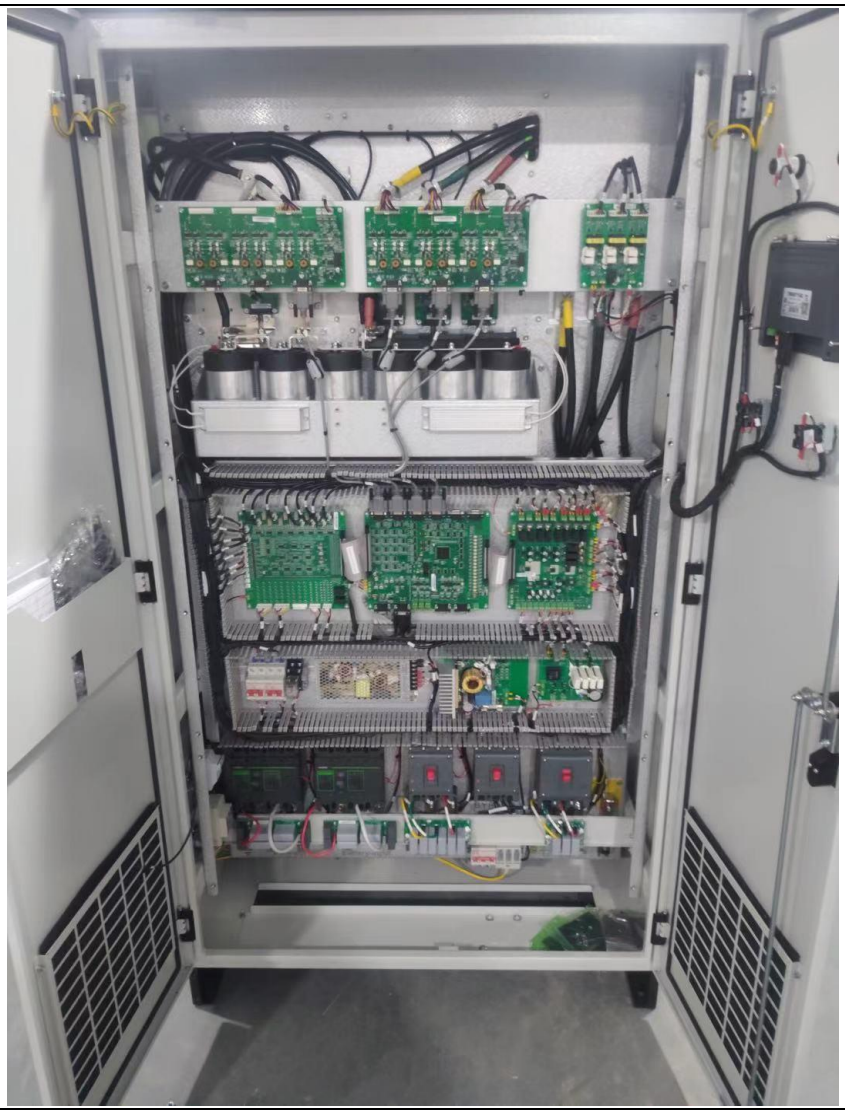
IEC/EN 62109-1: 2010: Test Report nº ES170725041P-1 which was issued by EMTEK (SHENZHEN) CO., LTD on March 31 th,2020.

5. PICTURES

Front


Back side

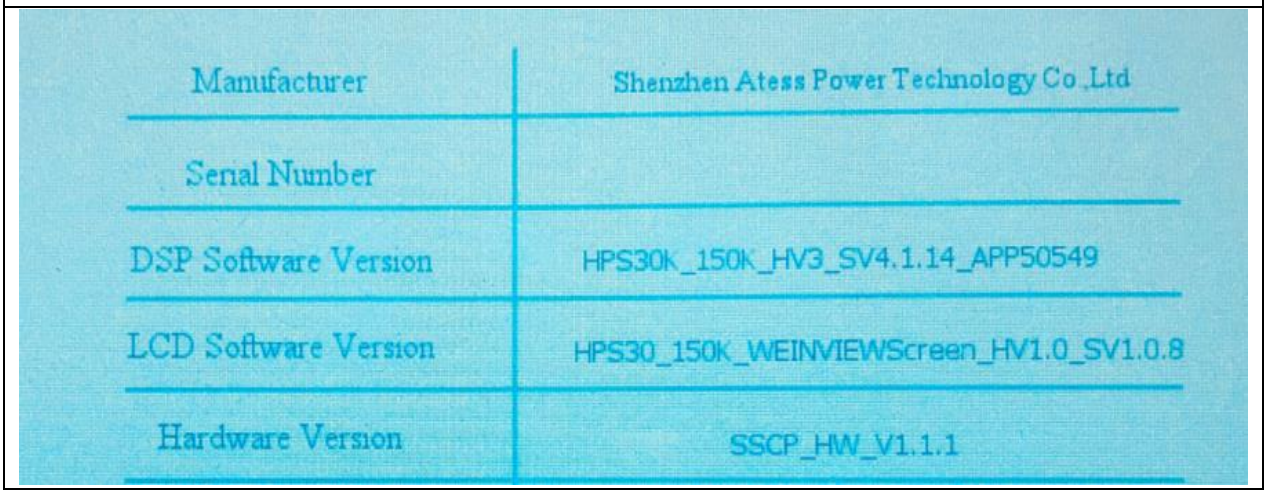

Side view


Internal of Front side


Internal of Back side


Serial Number

Software Version



6. ELECTRICAL SCHEME