TESTING FOR THE VERIFICATION OF COMPLIANCE OF PV INVERTER WITH :

ENGINEERING RECOMMENDATION G99 ISSUE 1-AMENDMENT 8, 01 SEPTEMBER 2021,

REQUIREMENTS FOR THE CONNECTION OF GENERATION EQUIPMENT IN PARALLEL WITH PUBLIC DISTRIBUTION NETWORKS ON OR AFTER 27 APRIL 2019

Test Report Number ..... :	**GZES240300433001**
Type ..... :	Hybrid Inverter
Tested Model..... :	**ED5000A**
Variant Models ..... :	ED4600A

APPLICANT

Hired by ..... :	Huizhou Foryou Optoelectronics Technology Co., Ltd
Address ..... :	Building 6, B Area, No.1 North Shangxia Road, Dongjiang High-Tech Industry Park, Huizhou, Guangdong, China

TESTING LABORATORY

Name ..... :	SGS-CSTC Standards Technical Services Co., Ltd. Guangzhou Branch
Address ..... :	198 Kezhu Road, Science City, Economic & Technology Development Area, Guangzhou, Guangdong, China
Conducted (tested) by ..... :	Doris Tao (Project Engineer)
Approved by ..... :	Colin Chen (Technical Reviewer)
Date of issue..... :	2024-05-16
Number of pages ..... :	96

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Test Report Historical Revision:

Test Report Version	Date	Resume
GZES24030043301	2024-05-16	First issuance **Remarks:** According to the declaration from the applicant, the only difference between the EUT (test samples in this report) and testing sample of report GZES220801676701, which was issued by SGS-CSTC Standards Technical Services Co., Ltd. Guangzhou Branch as below: -Update applicant, manufacturer, trademark, models name, label, appearance and equipment type ect. After evaluation, no clause needs to retest. All test data originate from the report GZES220801676701, which was issued by SGS-CSTC Standards Technical Services Co., Ltd. Guangzhou Branch.

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1 SCOPE

SGS-CSTC Standards Technical Services Co., Ltd. Guangzhou Branch has been contract by Huizhou Foryou Optoelectronics Technology Co., Ltd, in order to perform the testing according the“ENGINEERING RECOMMENDATION G99 ISSUE 1-AMENDMENT 8, 1 September 2021, REQUIREMENTS FOR THE CONNECTION OF GENERATION EQUIPMENT IN PARALLEL WITH PUBLIC DISTRIBUTION NETWORKS ON OR AFTER 27 APRIL 2019”.

Note: This standard details connection process, technical and compliance requirements for Type A, Type B, Type C and Type D Power Generating Modules. The tests offered at this test report evaluate the EUT compliance with the requirements of **Type A** defined as below:

Type A
A Power Generating Module with a Connection Point below 110 kV and a Registered Capacity of 0.8 kW or greater but less than 1 MW.

Type B
A Power Generating Module with a Connection Point below 110 kV and Registered Capacity of 1 MW or greater but less than 10 MW.

Type C
A Power Generating Module with a Connection Point below 110 kV and a Registered Capacity of 10 MW or greater but less than 50 MW.

Type D
A Power Generating Module with a Connection Point at or greater than 110 kV, and/or with a Registered Capacity of 50 MW or greater.

2 GENERAL INFORMATION

2.1 TESTING PERIOD AND CLIMATIC CONDITIONS

The necessary testing has been performed along between the 16th of September of 2022 and 11th of April of 2023.

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

SITE TEST

Name.....:	**Dongguan BALUN Testing Technology Co., Ltd.**
Address .....:	Room 104, 204, 205, Building 1, No. 6, Industrial South Road, Songshan Lake District, Dongguan, Guangdong, China.

2.2 EQUIPMENT UNDER TESTING

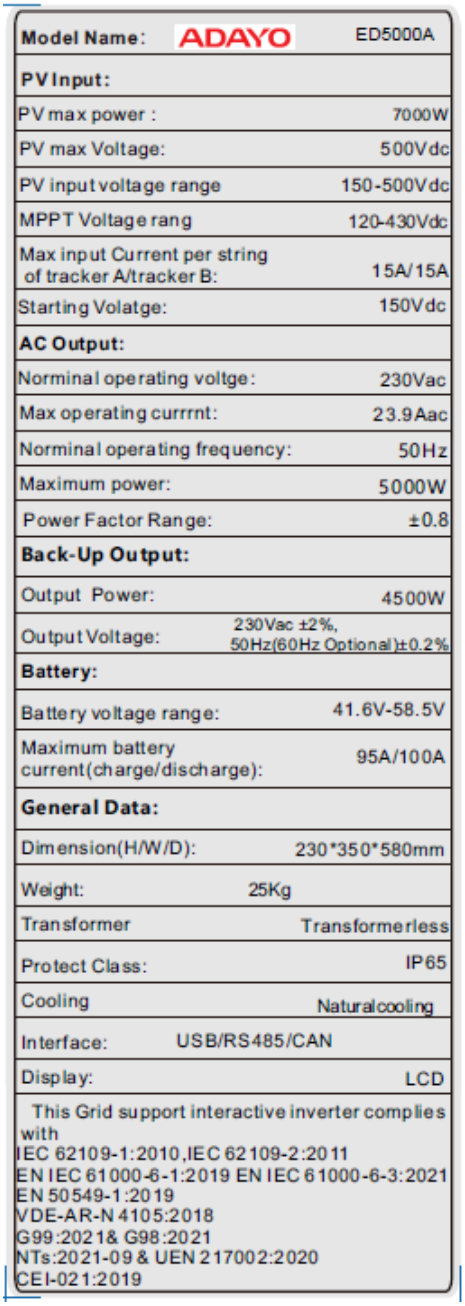
Apparatus type ..... :	Hybrid Inverter
Installation ..... :	Fixed installation
Manufacturer ..... :	**Huizhou Foryou Optoelectronics Technology Co., Ltd**
Address ..... :	Building 6, B Area, No.1 North Shangxia Road, Dongjiang High-Tech Industry Park, Huizhou, Guangdong, China
Trade mark..... :	ADAYO
Model / Type reference ..... :	**ED5000A**
Serial Number ..... :	DN22222222
Software Version..... :	GA01.001-001-001
Rated Characteristics..... :	DC input: 150-500 V, Max. 2× 15 A AC output: L/N/PE 230 V, 50 Hz, 21.7 A (23.9 A), 5000 W

Date of manufacturing: 2022

Test item particulars

Input ..... :	DC
Output.....	AC, L/N/PE
Class of protection against electric shock... :	Class I
Degree of protection against moisture ..... :	IP 65
Type of connection to the main supply ..... :	Single phase – Fixed installation
Cooling group..... :	Natural Cooling
Modular ..... :	No
Internal Transformer..... :	No

Copy of marking plate (representative):



Model Name: ADAYO	ED5000A
PV Input:	
PV max power :	7000W
PV max Voltage:	500Vdc
PV input voltage range	150-500Vdc
MPPT Voltage rang	120-430Vdc
Max input Current per string of tracker A/tracker B:	15A/15A
Starting Volatge:	150Vdc
AC Output:	
Norminal operating voltge:	230Vac
Max operating currrnt:	23.9Aac
Norminal operating frequency:	50Hz
Maximum power:	5000W
Power Factor Range:	±0.8
Back-Up Output:	
Output Power:	4500W
Output Voltage:	230Vac ±2%, 50Hz(60Hz Optional)±0.2%
Battery:	
Battery voltage range:	41.6V-58.5V
Maximum battery current(charge/discharge):	95A/100A
General Data:	
Dimension(H/W/D):	230*350*580mm
Weight:	25Kg
Transformer	Transformerless
Protect Class:	IP65
Cooling	Naturalcooling
Interface:	USB/RS485/CAN
Display:	LCD
This Grid support interactive inverter complies with IEC 62109-1:2010,IEC 62109-2:2011 EN IEC 61000-6-1:2019 EN IEC 61000-6-3:2021 EN 50549-1:2019 VDE-AR-N 4105:2018 G99:2021& G98:2021 NTs:2021-09 & UEN 217002:2020 CEI-021:2019	

Note:

1. The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.
2. Label is attached on the side surface of enclosure and visible after installation.
3. Labels of other models are as the same with **ED5000A**'s except the parameters of rating.
4. As declared by the applicant, the importer (and manufacturer, if it is different)'s name, registered trade name or registered trade mark and the postal address will be marked on the products before being place on the market. The contact details shall be in a language easily understood by end-users and market surveillance authorities.

Equipment Under Testing:

- **ED5000A**

The variants models are:

- **ED4600A**

The models of ED5000A and ED4600A are identical on topological schematic circuit diagram and control solution codes except for input/output rating.

The variants 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 or the EUT or Modular inverters.
- Same Firmware Version.

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

Model	**ED4600A**	**ED5000A**
PV Input		
Max. input voltage	500 Vdc	
Start-up operating voltage	150 Vdc	
Rated input voltage	360 Vdc	
MPPT operating voltage range	150-500 Vdc	
Full power MPPT voltage range	150-430 Vdc	
Max. input current	15 A/15 A	15 A/15 A
Max. short current	19.8 A/19.8 A	19.8 A/19.8 A
Battery Input		
operating voltage range	41.6V-58.5 Vdc	
Maximum battery charge current	95 A	95 A
Maximum battery discharge current)	100 A	100 A
AC Output		
Nominal grid voltage	L/N/PE, 230 V	
Nominal grid frequency	50 Hz	
Rated AC power	4600 W	5000 W
Max. AC power	5060 VA	5500 VA
Rated AC current	20.0 A	21.7 A
Max. AC current	22.0 A	23.9 A
Output power factor	1 default (adjustable+/-0.8)	
General Data		
Operating temperature range	-30 ºC ~ +60 ºC	
Protection degree	IP65	
Protective class	Class I	
Cooling method	Natural Cooling	
Topology	Transformerless	

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 MANUFACTURER AND FACTORY INFORMATION

Manufacturer Name ..... :	**Huizhou Foryou Optoelectronics Technology Co., Ltd**
Manufacturer Address ..... :	Building 6, B Area, No.1 North Shangxia Road, Dongjiang High-Tech Industry Park, Huizhou, Guangdong, China
Factory Name ..... :	**Shenzhen Donnergy Power Technology Co. Ltd .**
Factory Address..... :	A305, Zongtai E-commerce Science and Innovation Park, Shiyan Street, Baoan District, Shenzhen, China.

2.4 TEST EQUIPMENT LIST

From	No.	Equipment Name	Trademark / Model No.	Equipment No.	Calibration Period
Balun	1	Power analyzer	ZLG/ PA6000H	BZ-DGD- L059	2022/10/13 to 2023/10/12
	2	Current probe	HIOKI/ CT6863-05	BZ-DGD- L026-1	2022/02/23 to 2023/02/22 2023/02/20 to 2024/02/19
	3	Current probe	HIOKI/ CT6863-05	BZ-DGD- L026-2	2022/02/23 to 2023/02/22 2023/02/20 to 2024/02/19
	4	Current probe	HIOKI/ CT6863-05	BZ-DGD- L026-4	2022/02/23 to 2023/02/22 2023/02/20 to 2024/02/19
	5	Voltage probe	CYBERTEK/ VP5200A	BZ-DGD-L241-1	2022/03/01 to 2023/02/28 2023/03/09 to 2024/03/08
	6	Voltage probe	CYBERTEK/ VP5200A	BZ-DGD-L241-2	2022/03/01 to 2023/02/28 2023/03/09 to 2024/03/08
	7	Voltage probe	CYBERTEK/ VP5200A	BZ-DGD-L241-3	2022/03/01 to 2023/02/28 2023/03/09 to 2024/03/08
	8	Temperature & Humidity meter	CEM/ DT-322	BZ-DGD-L005	2022/03/01 to 2023/02/28 2023/03/13 to 2024/03/12
	9	Digital oscilloscope	TEKTRONIX/ MS04054B	BZ-DGD-L064	2022/03/01 to 2023/02/28 2023/03/07 to 2024/03/06
	10	Power Analyzer	DEWETRON / TRIONet	BZ-DGD-L305	2022/08/18 to 2023/08/17
SGS	11	True RMS Multimeter	Fluke/187	GZE012-16	2022/05/21 to 2023/05/20

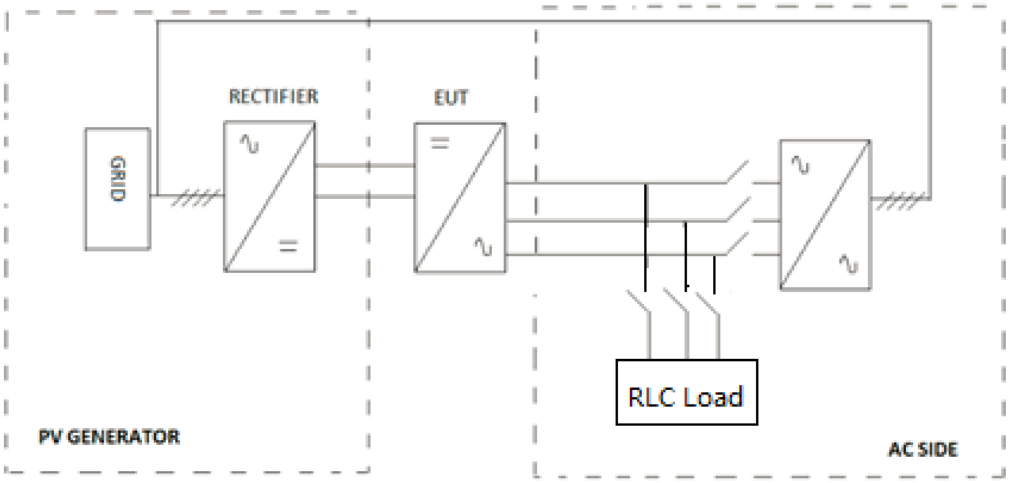
2.5 MEASUREMENT UNCERTAINTY

Associated uncertainties through measurements showed in this 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 equipment has been used to take measures as it shows 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	KEWELL / KACM-75-33	60 kVA max. 45-65 Hz	BZ-DGD-L193
PV source	CHROMA / Chroma 6215011-1000s	15 kVA max.	BZ-DGD-L009
RLC load	QunLing / ACTL-3820	68 kW,68 kvar	BZ-DGD-L063

2.7 DEFINITIONS

EUT	Equipment Under Testing	Hz	Hertz
A	Ampere	V	Volt
VAr	Volt-Ampere reactive	W	Watt
EMC	Electromagnetic Compatibility	p.u	Per unit
Un	Nominal Voltage	Pn	Nominal Active Power
In	Nominal Current	Qn	Nominal Reactive Power
Ia	Active Current	Sn	Nominal Apparent Power
Ir	Reactive Current	THD	Total Harmonic Distortion
I_h	Harmonic Current	TDD	Total Demand Distortion
PWHD	Partial Weighted Harmonic Distortion	PLT	Severity of Flicker Long-Term
		d(t)	Variation of Voltage
PST	Severity of Flicker Short-Term	OV	Over Voltage
d max	Maximum Absolute Value of Voltage Variation	OF	Over Frequency
UV	Under Voltage	UF	Under Frequency

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 performed ..... **N/P** Not performed

STANDAARD CLAUSE	STANDARD REQUIREMENTS		RESULT
	G99 Issue 1 Amendment 8 01 September 2021		
	TEST	REMARKS	
Annex A 2-3 (1)	Operating Range		P
A.7.1.5	Harmonics		P
A.7.1.4.3	Voltage fluctuations and Flicker		P
A.7.1.4.4	DC injection		P
A.7.1.4.2	Power Factor		P
A.7.1.2.3	Frequency tests		P
A.7.1.2.2	Voltage tests:		P
A.7.1.2.4	Loss of Mains test		P
A.7.1.2.6	Loss of Mains Protection, Vector Shift Stability test.		P
	Loss of Mains Protection, RoCoF Stability test		P
A.7.1.3	Limited Frequency Sensitive Mode – Over frequency test		P
Annex A 2-3 (10)	Re-connection timer.		P
A.7.1.5	Fault level contribution		P
A.7.1.7	Self-Monitoring solid state switching	No solid state switching devices	N/A
Para 15.2.1	Wiring functional tests		N/A
Annex A 2-3 (14)	Logic Interface (input port)		P
Annex A 2-3 (15)	Cyber security		P

4 TEST RESULTS

4.1 OPERATING RANGE

Two tests should be carried with the Power Generating Module operating at Registered Capacity and connected to a suitable test supply or grid simulation set. The power supplied by the primary source shall be kept stable within ± 5 % of the apparent power value set for the entire duration of each test sequence.
Frequency, voltage and Active Power measurements at the output terminals of the Power Generating Module shall be recorded every second. The tests will verify that the Power Generating Module can operate within the required ranges for the specified period of time.
The Interface Protection shall be disabled during the tests.
The evaluation of this point has been made according to Annex A.7.2.2.
In case of a PV Power Park Module the PV primary source replaced by a DC source.

Test 1:

Voltage = 85% of nominal (195.5 V)

Frequency = 47 Hz

Power factor = 1

Period of test 20 s

Test 2:

Voltage = 85% of nominal (195.5 V)

Frequency = 47.5 Hz

Power factor = 1

Period of test 90 minutes

Test 3:

Voltage = 110% of nominal (253 V).

Frequency = 51.5 Hz

Power factor = 1

Period of test 90 minutes

Test 4:

Voltage = 110% of nominal (253 V).

Frequency = 52.0 Hz

Power factor = 1

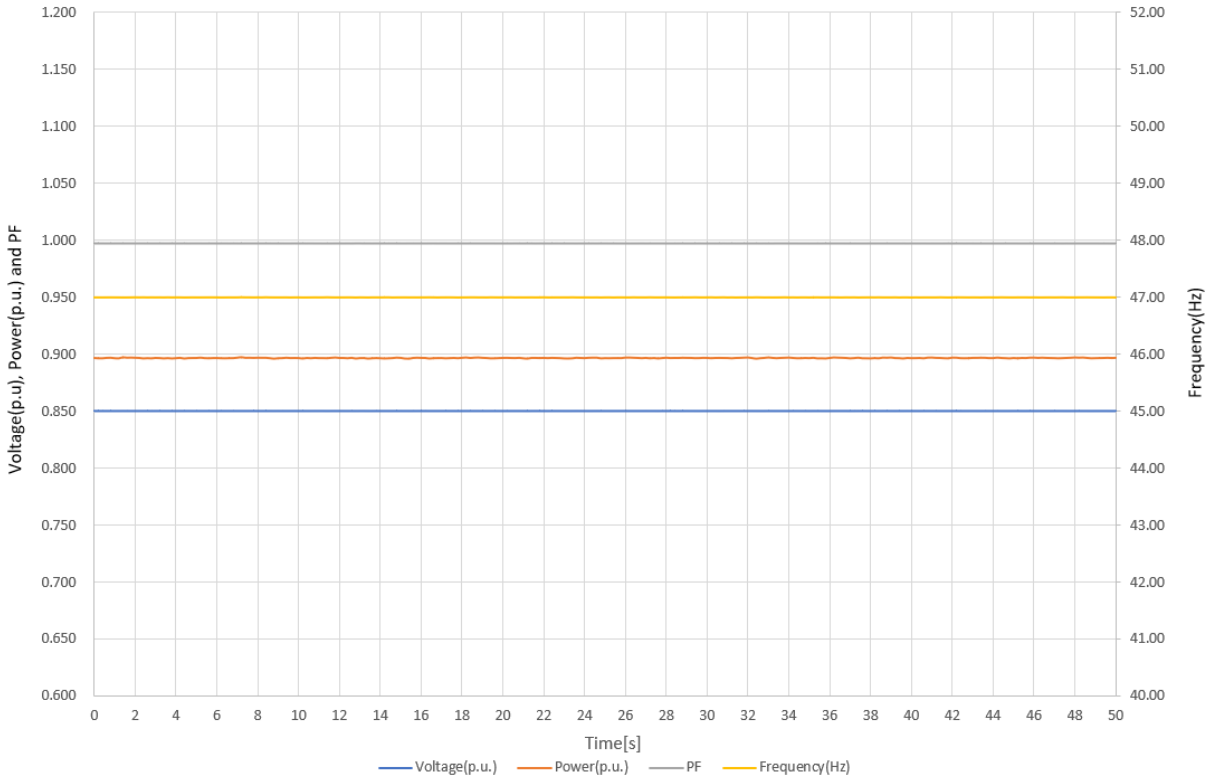
Period of test 15 minutes

Test 5
Voltage = 100% of nominal (230 V),
Frequency = 50.0 Hz,
Power Factor = 1,
Period of test = 90 minutes

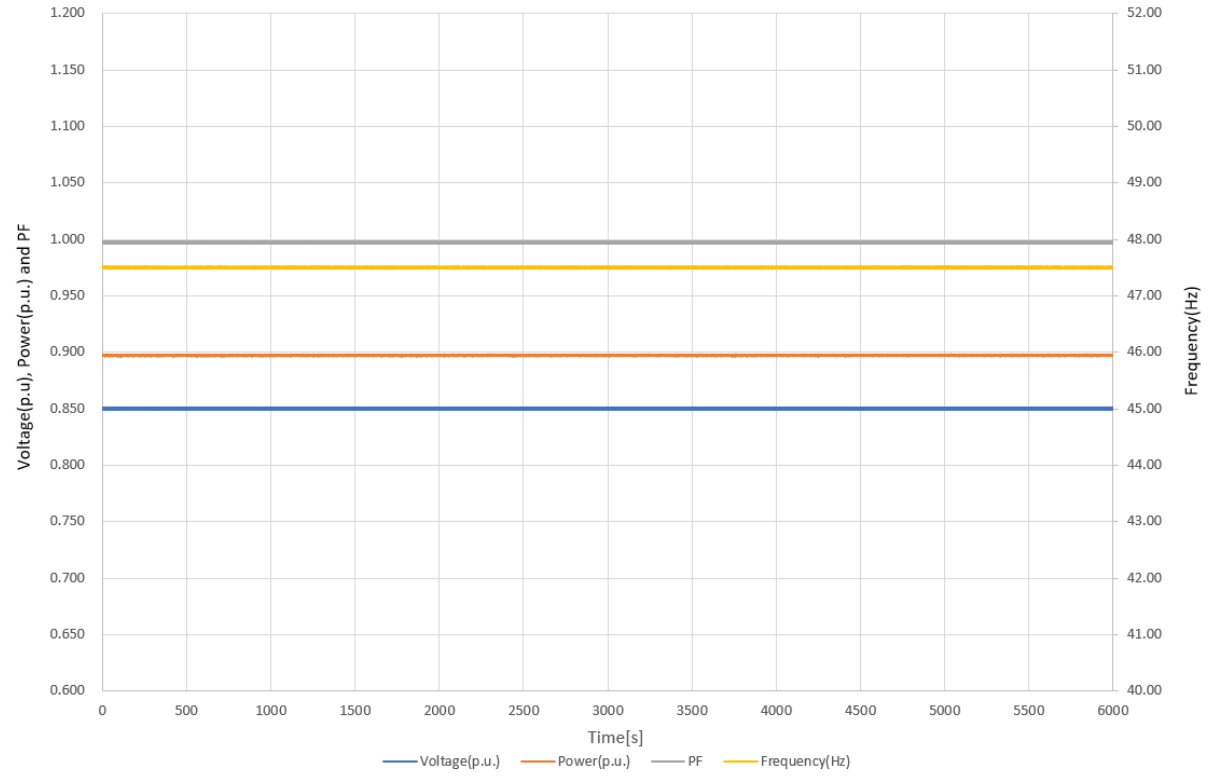
Test 6 RoCoF withstand
Confirm that the **Power Generating Module** is capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1 Hzs-1 as measured over a period of 500 ms.

Test results are graphically shown in following pages.

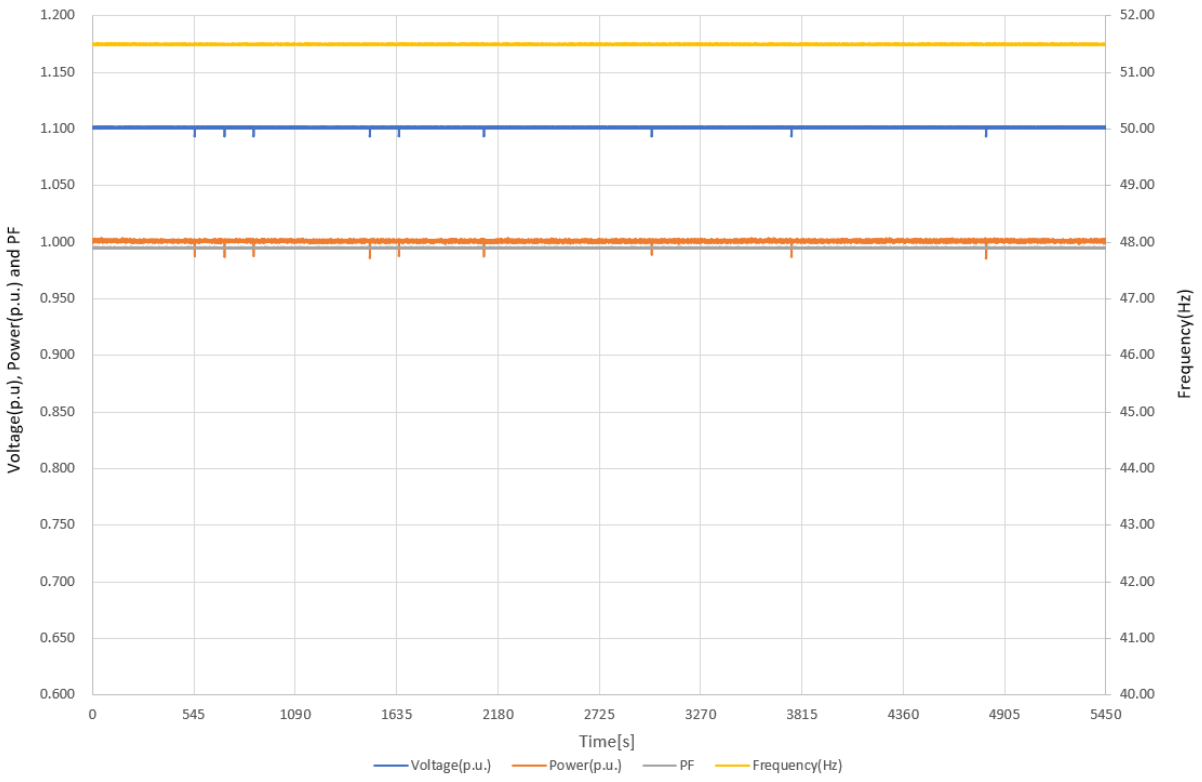
Test 1



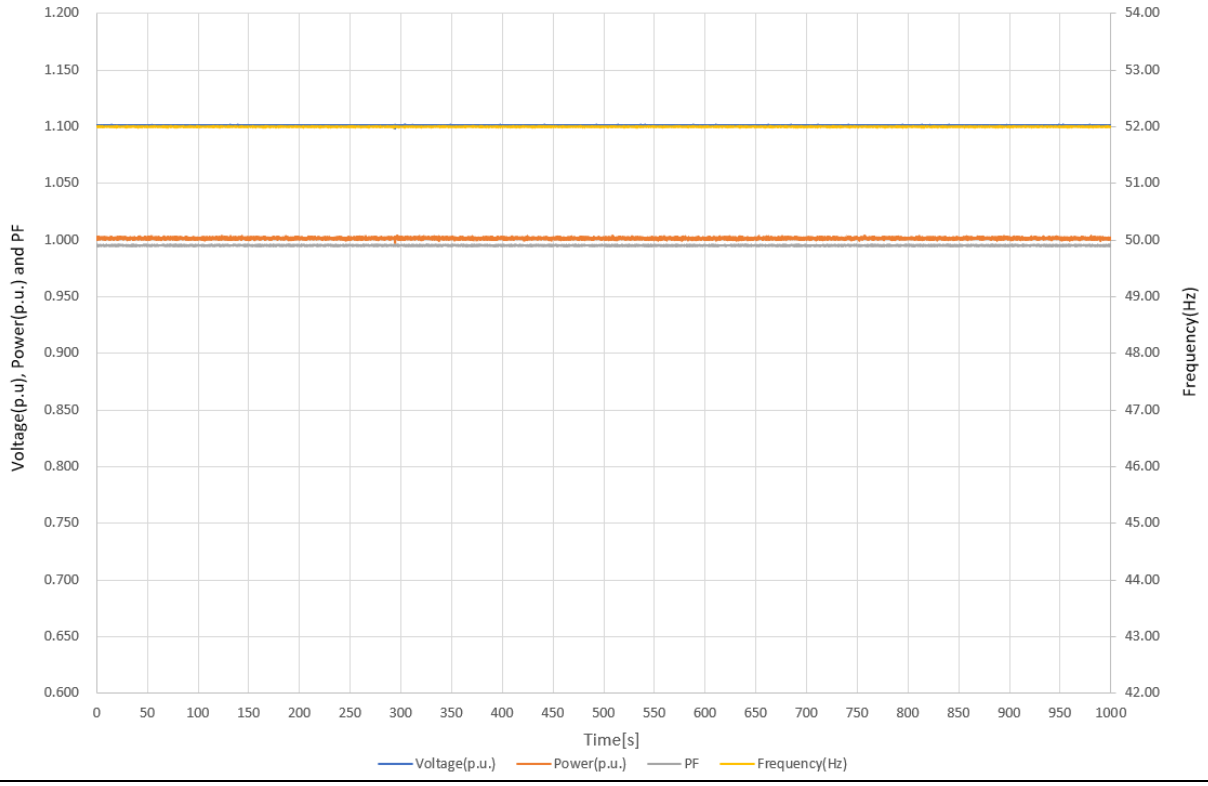
Test 2



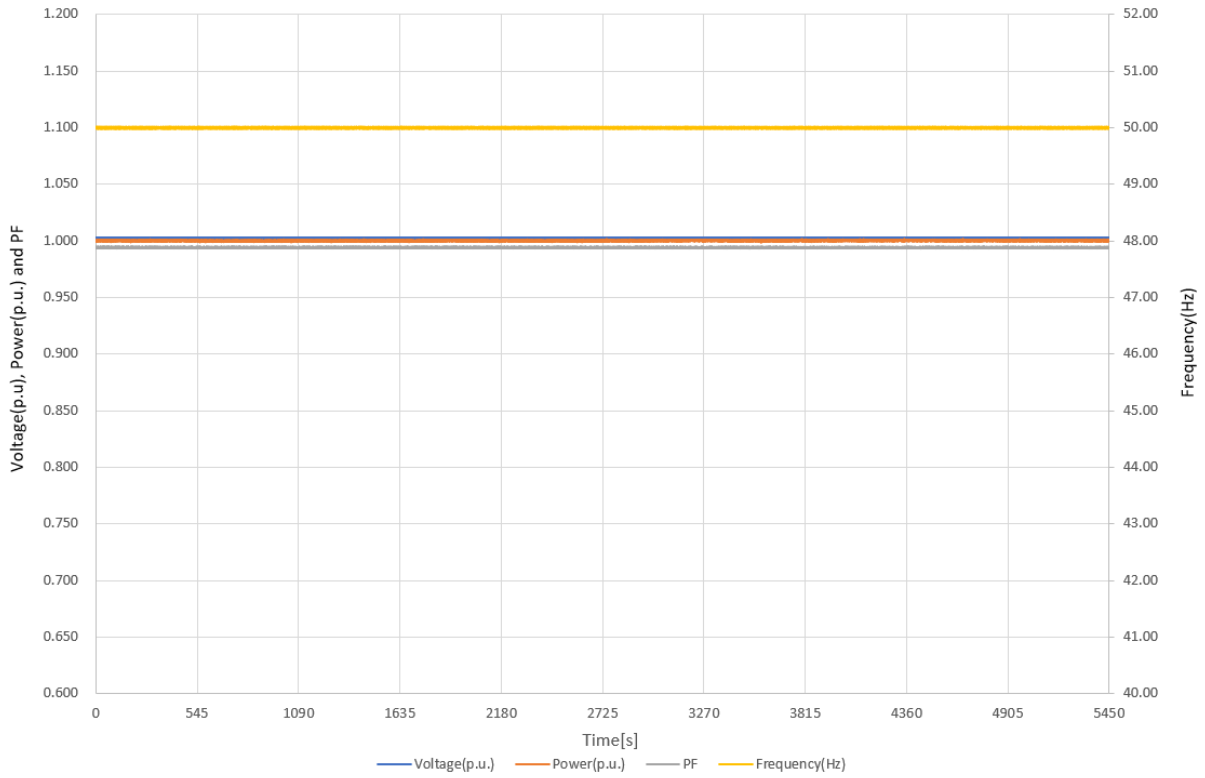
Test 3


Voltage(p.u), Power(p.u.) and PF
Frequency(Hz)
Time[s]
Voltage(p.u.)
Power(p.u.)
PF
Frequency(Hz)

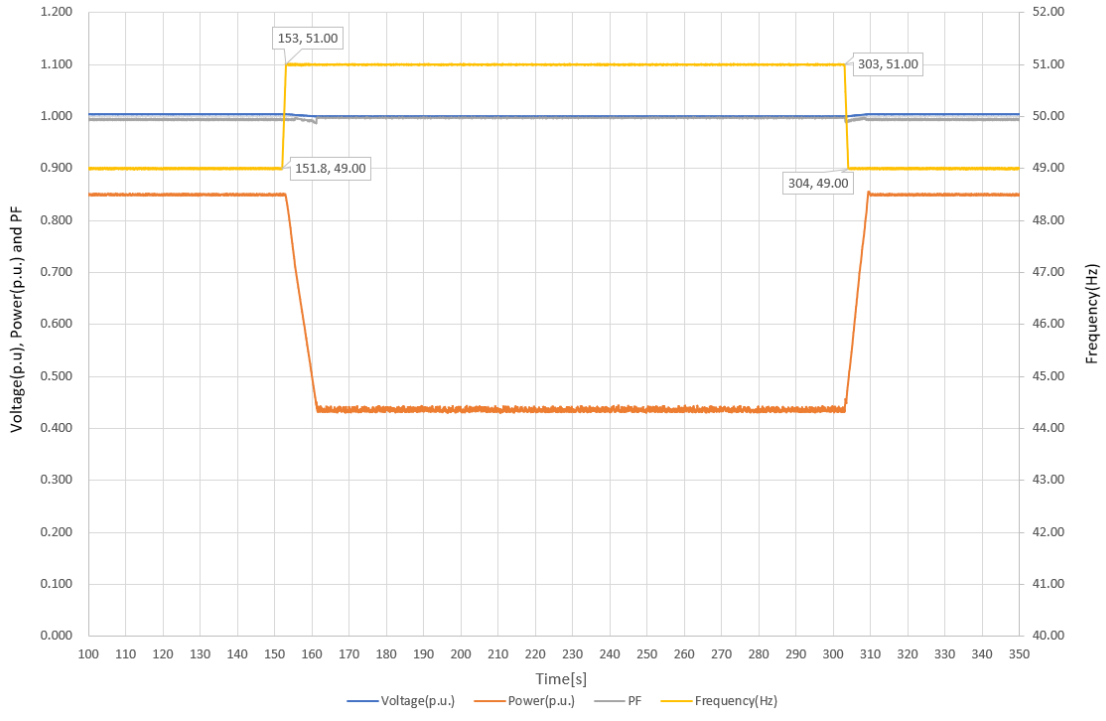
Test 4


Voltage(p.u), Power(p.u.) and PF
Frequency(Hz)
Time[s]
Voltage(p.u.)
Power(p.u.)
PF
Frequency(Hz)

Test 5


Voltage(p.u), Power(p.u.) and PF
Frequency(Hz)
Time[s]
Voltage(p.u.)
Power(p.u.)
PF
Frequency(Hz)

Test 6


153, 51.00
303, 51.00
151.8, 49.00
304, 49.00
Voltage(p.u), Power(p.u.) and PF
Frequency(Hz)
Time[s]
Voltage(p.u.)
Power(p.u.)
PF
Frequency(Hz)

4.2 POWER QUALITY

4.2.1 Harmonics

For Power Generating Modules of Registered Capacity of less than 75 A per phase (ie 50 kW) the test requirements are specified in Annex A.7.1.5. These tests should be carried out as specified in BS EN 61000-3-12 The results need to comply with the limits of Table 2 of BS EN 61000-3-12 for single phase equipment and Table 3 of BS EN 610000-3-12 for three phase equipment.

Power Generating Modules with emissions close to the limits laid down in BS EN 61000-3-12 may require the installation of a transformer between 2 and 4 times the rating of the Power Generating Module in order to accept the connection to a Distribution Network.

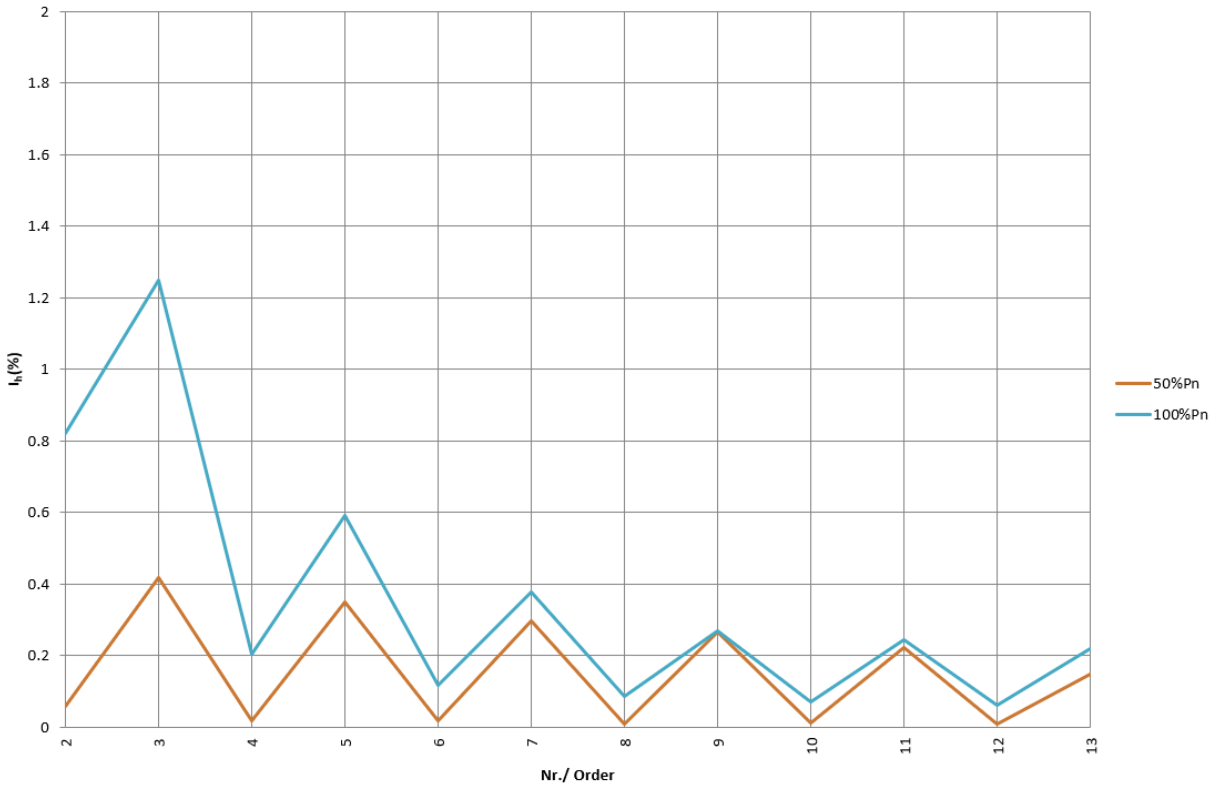
For Power Generating Modules of Registered Capacity of greater than 75 A per phase (ie 50 kW) the installation must be designed in accordance with EREC G5.

Measures have been repeated at 50%P_n and 100%P_n.

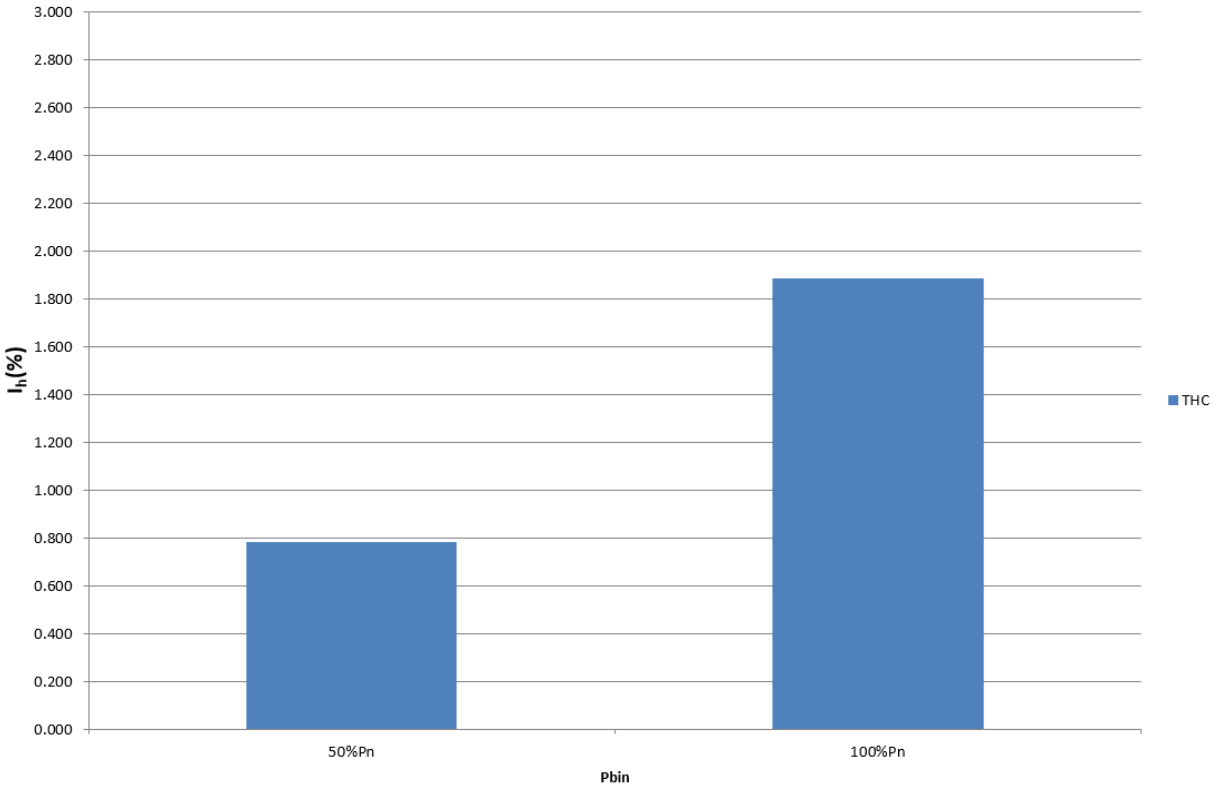
Following tables show the test results:

Power Generating Module rating per phase (rpp)			5	kVA	Harmonic % = Measured Value (A) x 23/rating per phase (kVA)	
Phase A						
Harmonic	At 45-55% of **Registered Capacity**		100% of **Registered Capacity**		Limit in BS EN 61000-3-12	
	Measured Value MV in Amps	(%)	Measured Value MV in Amps	(%)	1 Phase	3 Phase
2	0.012	0.056	0.179	0.822	8%	8%
3	0.091	0.417	0.271	1.249	21.6%	Not stated
4	0.004	0.017	0.044	0.203	4%	4%
5	0.076	0.348	0.129	0.592	10.7%	10.7%
6	0.004	0.016	0.025	0.115	2.67%	2.67%
7	0.065	0.297	0.082	0.377	7.2%	7.2%
8	0.002	0.009	0.018	0.085	2%	2%
9	0.058	0.266	0.059	0.270	3.8%	Not stated
10	0.002	0.010	0.015	0.071	1.6%	1.6%
11	0.048	0.222	0.053	0.244	3.1%	3.1%
12	0.002	0.009	0.013	0.060	1.33%	1.33%
13	0.032	0.148	0.048	0.219	2%	2%
THD	--	0.782	--	1.334	23%	13%
PWHD	--	1.281	--	1.936	23%	22%

Current Harmonics



THD



4.2.2 Voltage fluctuations and Flicker

These tests should be undertaken in accordance with EREC G98 Annex A1 A.1.3.3 (Inverter connected) or Annex A2 A.2.3.3 (Synchronous).

The measurements of voltage fluctuations have been measured according to the standard, at 100 % of the nominal power value of the inverter.

The test impedance is recorded in the table below:

Test Impedance	R	0.24	Ω	X	0.15	Ω
Standard Impedance	R	0.24	Ω	X	0.15	Ω
Maximum Impedance	R	0.24	Ω	X	0.15	Ω

Starting operation and Stopping operation			
Pbin (%)	**100%**		
	Limit	**Starting measured values**	**Stopping measured values**
PST	≤ 1	0.052	0.047
PLT	≤ 0.65	0.050	0.050
dc	≤ 3.30%	0.025	0.040
d(t)	≤ 3.30%	0.000	0.000
dmax	4%	0.280	0.274

As it can be seen in the next screenshots, this test has two steps:

1. Starting operation
2. Stopping operation

All values are the most unfavorable of the two steps.

Starting operation and Stopping operation
100% Pn

Running operation 2 hours		
Pbin (%)	100%	
	Limit	Measured values
PST	≤ 1	0.250
PLT	≤ 0.65	0.213
dc	≤ 3.30%	0.220
d(t)	≤ 3.30%	0.000
dmax	4%	0.431

As it can be seen in the next screenshots is running operation. The values took of Pst and Plt are the most unfavorable of the twelve steps.

Running operation

100% Pn

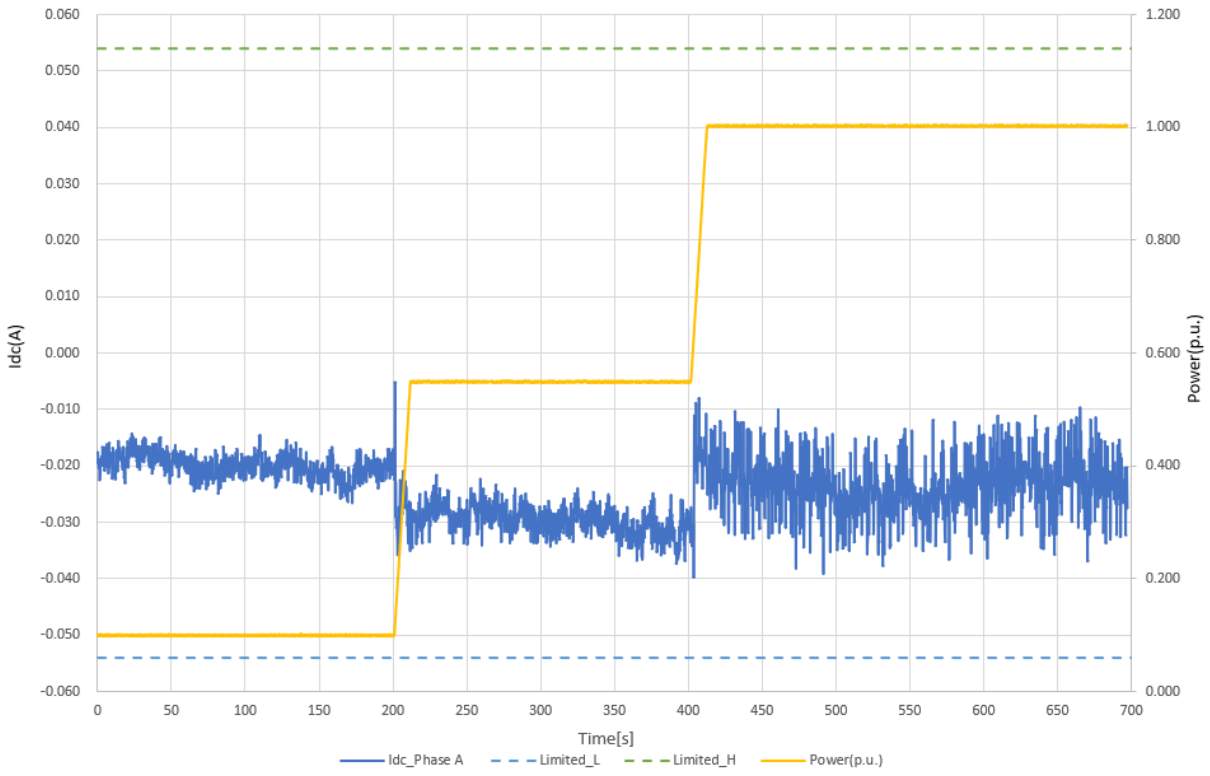
4.2.3 DC Injection

The tests should be carried out on a single Generating Unit. Tests are to be carried out at three defined power levels ±5%. At 230 V a 6 kW three phase Inverter has a current output of 26A so DC limit is 65 mA. These tests should be undertaken in accordance with Annex A.7.1.4.4.

Following tables show the test results:

DC injection			
Test power level	10%	55%	100%
Recorded value in Amps	0.020	0.030	0.024
as % of rated AC current	0.092	0.138	0.110
Limit	0.25%	0.25%	0.25%

DC injection test result



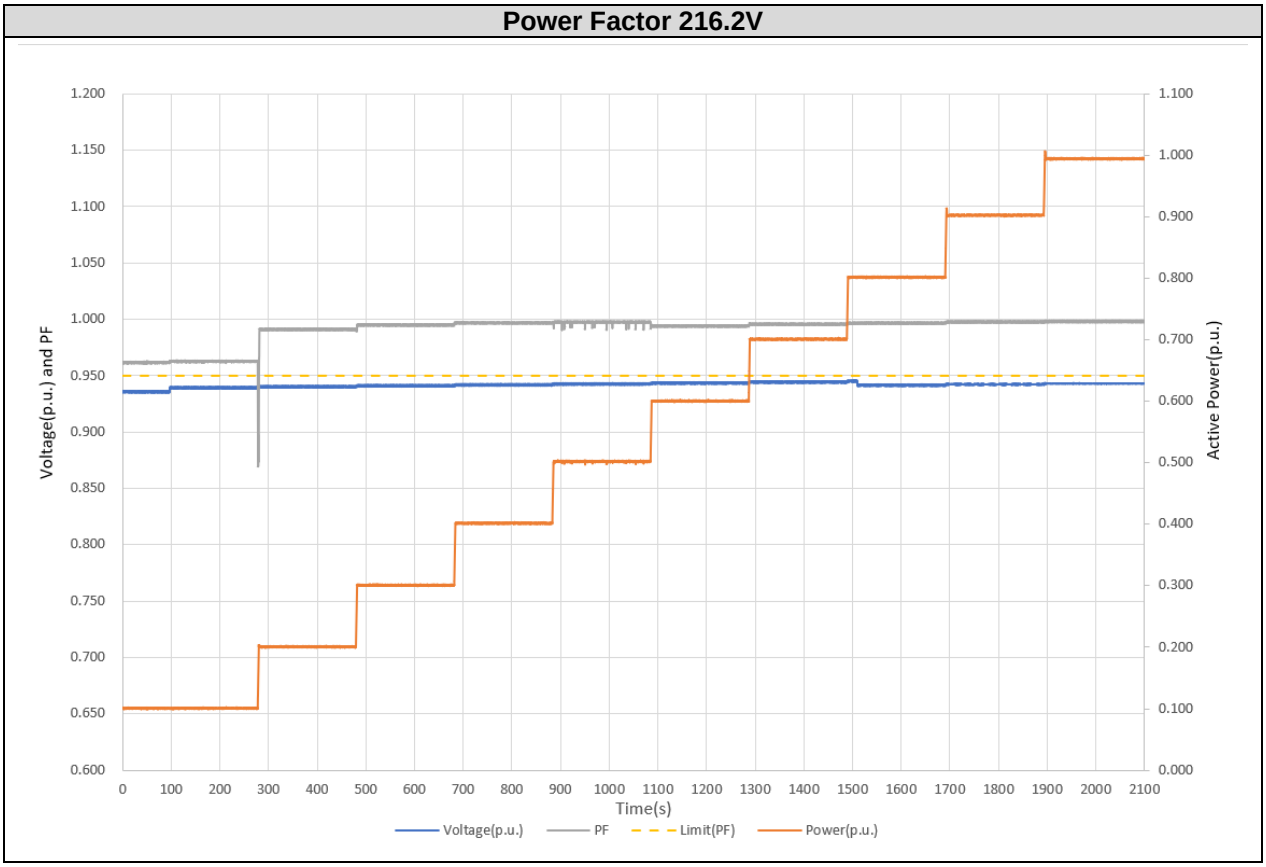
4.2.4 Power Factor

The tests should be carried out on a single Power Generating Module. Tests are to be carried out at three voltage levels and at Registered Capacity. Voltage to be maintained within ±1.5% of the stated level during the test. These tests should be undertaken in accordance with Annex A.7.1.4.2.

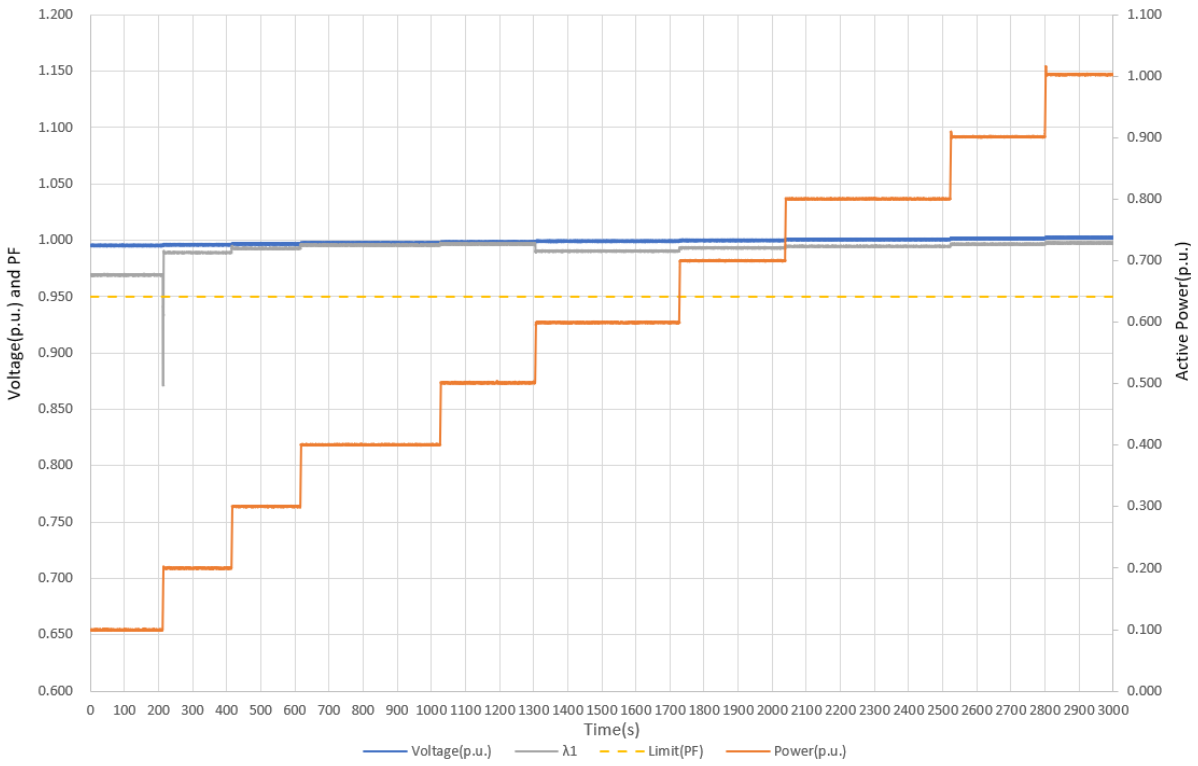
The following table shows the test results at required voltage levels:

Volatge	0.94 (p.u.)	1.00(p.u.)	1.10 (p.u.)
Measured Volatge value (V)	216.6	229.8	253.7
Measured Power Factor value (cos φ)	0.996	0.995	0.995
Power Factor Limit	>0.95	>0.95	>0.95

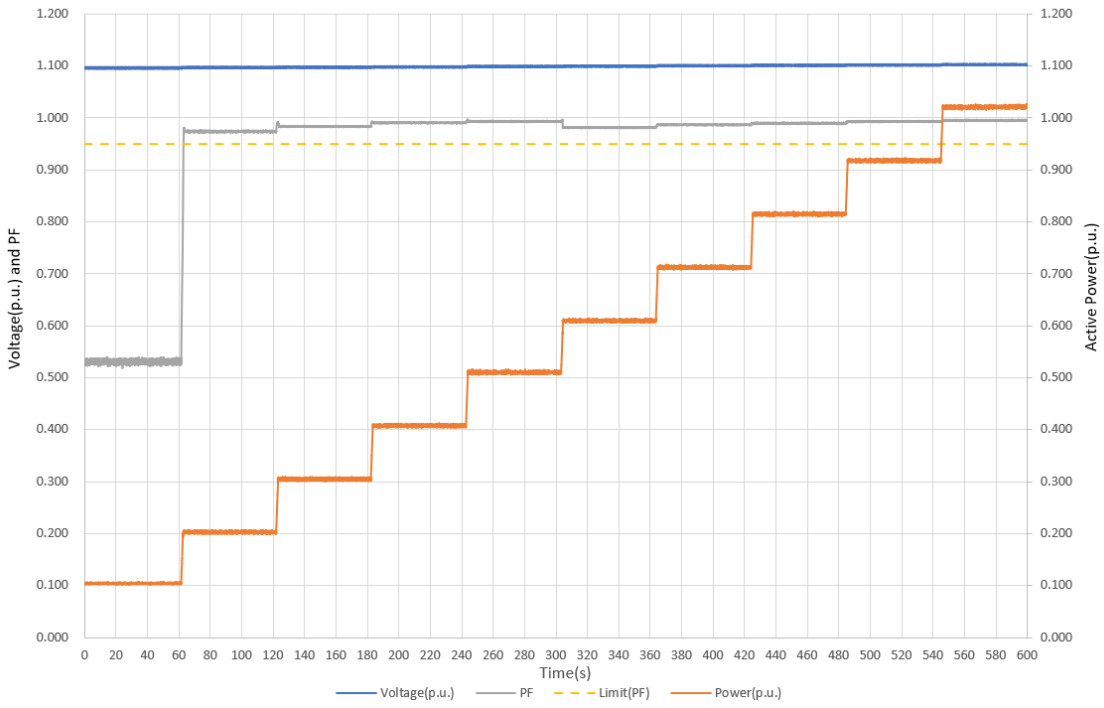
Test results are graphically shown below.



Power Factor 230V



Power Factor 253V



4.3 PROTECTION

4.3.1 Frequency tests

These tests should be carried out in accordance with Annex A.7.1.2.3.

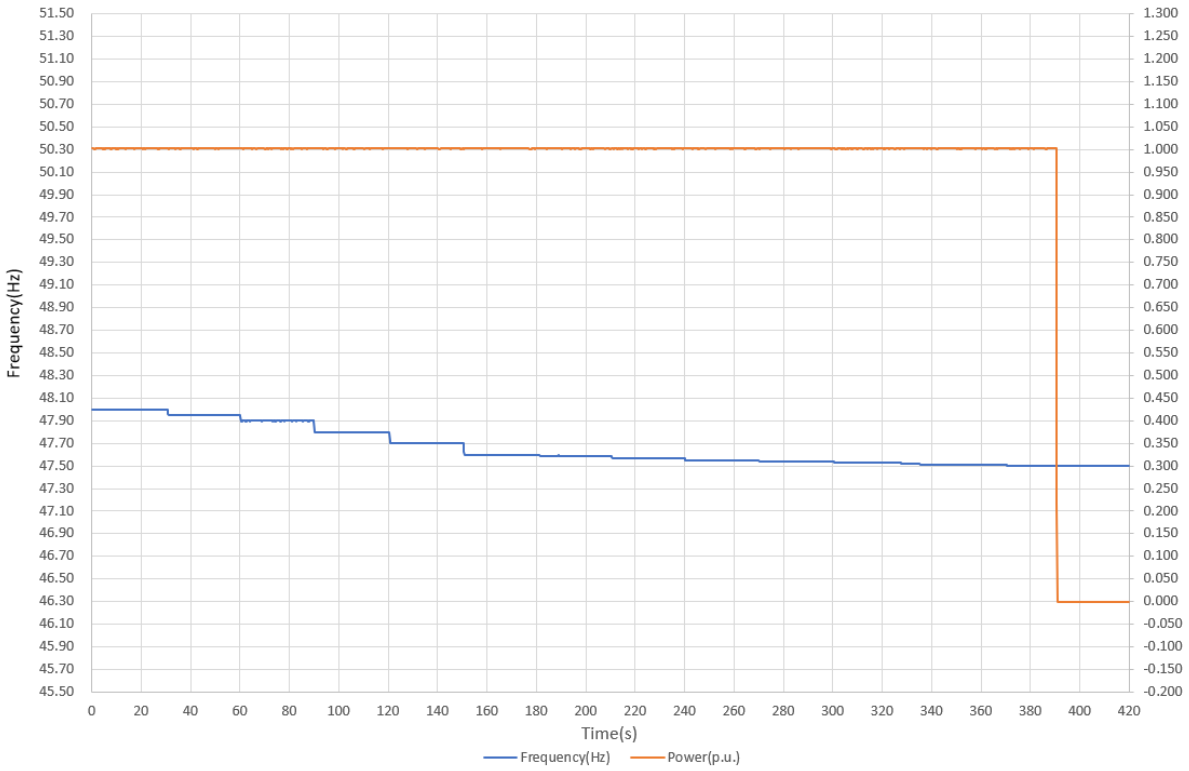
To establish a trip frequency, the test frequency should be applied in a slow ramp rate of less than 0.1 Hz/s, or if this is not possible in steps of 0.05 Hz for a duration that is longer than the trip time delay.

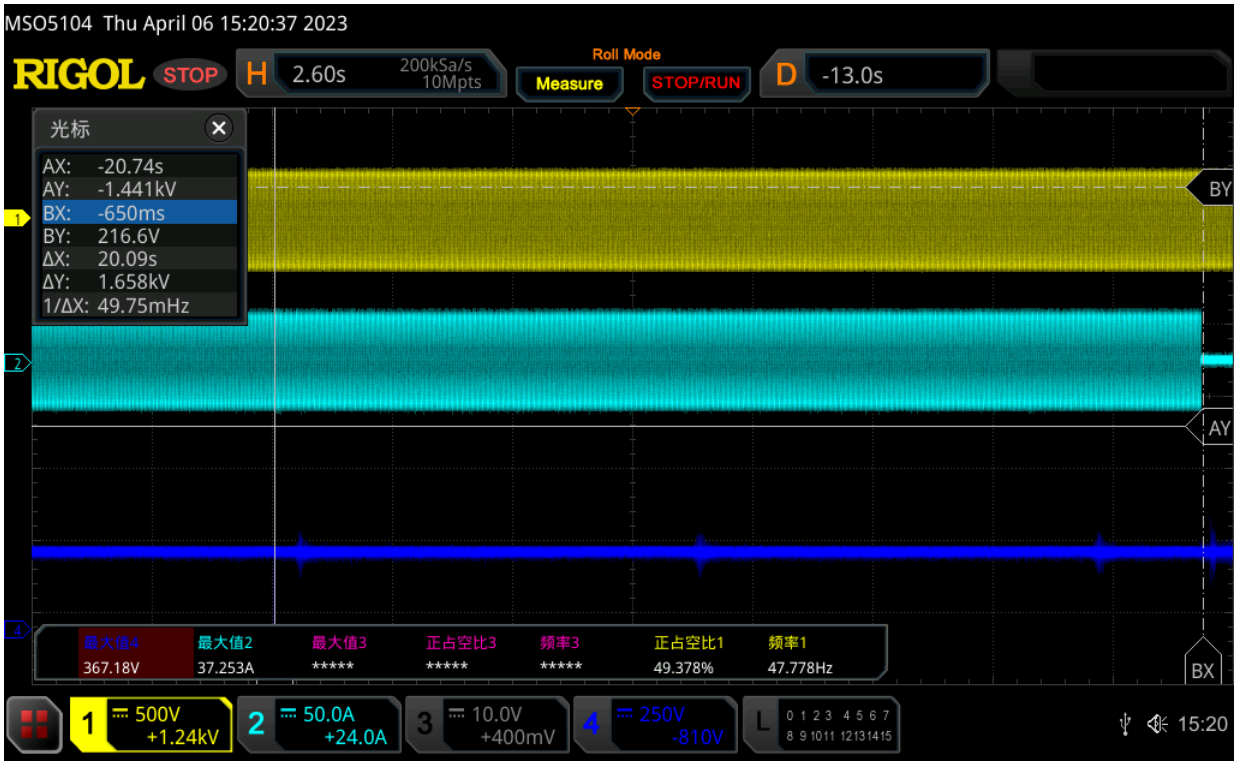
To establish the trip time, the test frequency should be applied starting from 0.3 Hz below or above the recorded trip frequency and should be changed to 0.3 Hz above or below the recorded trip frequency in a single step. For each trip setting five tests shall be carried out.

Function	Setting		Trip test (5 times)		"No trip tests"	
	Frequency	Time delay	Frequency (Hz)	Time delay (s)	Frequency /time	Confirm no trip
U/F stage 1	47.5 Hz	20 s	47.50	20.090	47.7 Hz / 30.00 s	Pass
			47.50	20.040		
			47.50	20.040		
			47.50	20.020		
			47.50	20.040		
U/F stage 2	47 Hz	0.5 s	47.00	0.535	47.2 Hz / 19.5 s	Pass
			47.00	0.550		
			47.00	0.540		
			47.00	0.550		
			47.00	0.525		
					46.8 Hz / 0.45 s	Pass
O/F stage 1	52 Hz	0.5 s	52.00	0.570	51.8 Hz / 120.00 s	Pass
			52.00	0.575		
			52.00	0.585		
			52.00	0.575		
			52.00	0.575		
					52.2 Hz / 0.45 s	Pass

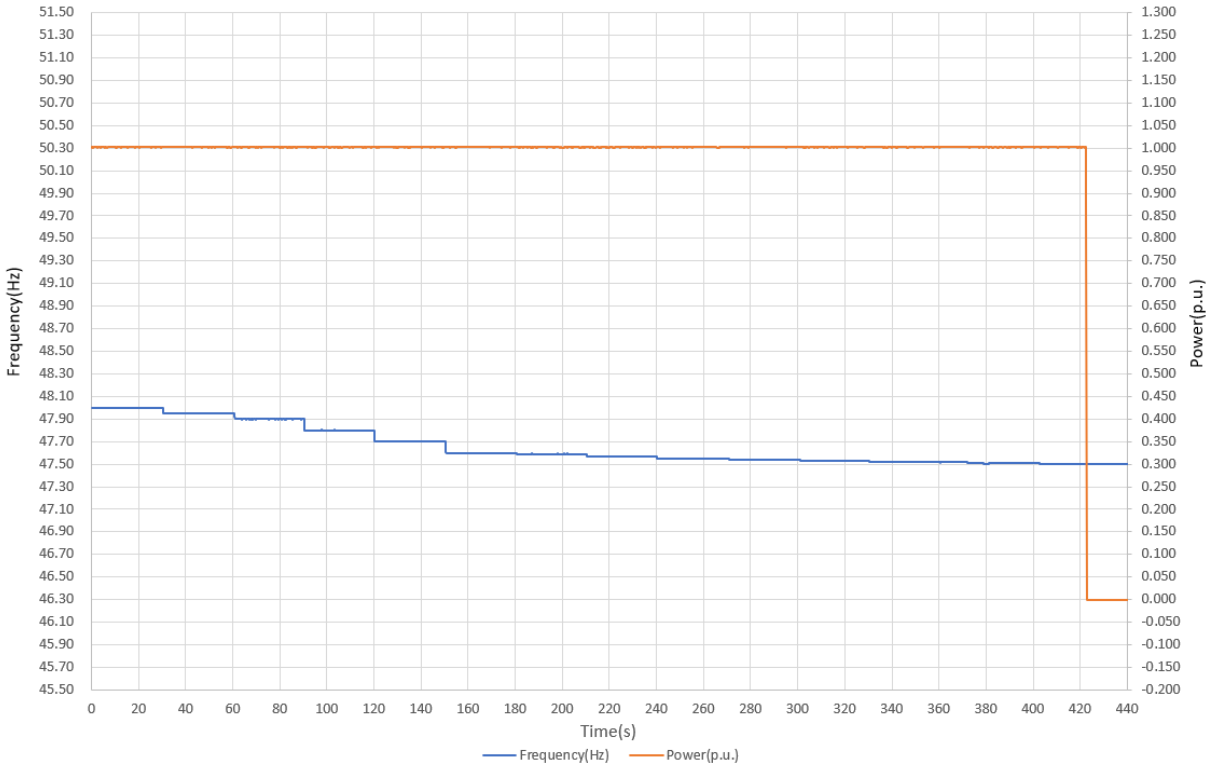
Test results are graphically shown below.

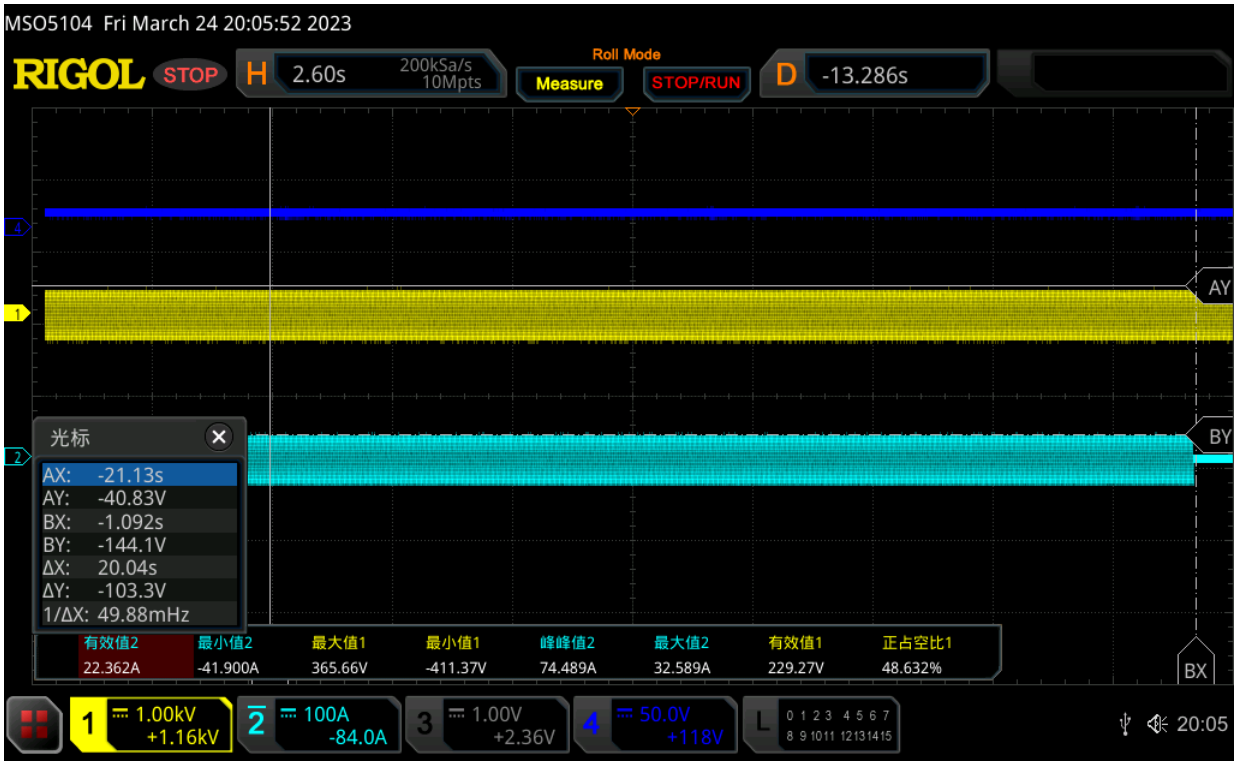
U/F stage 1-1



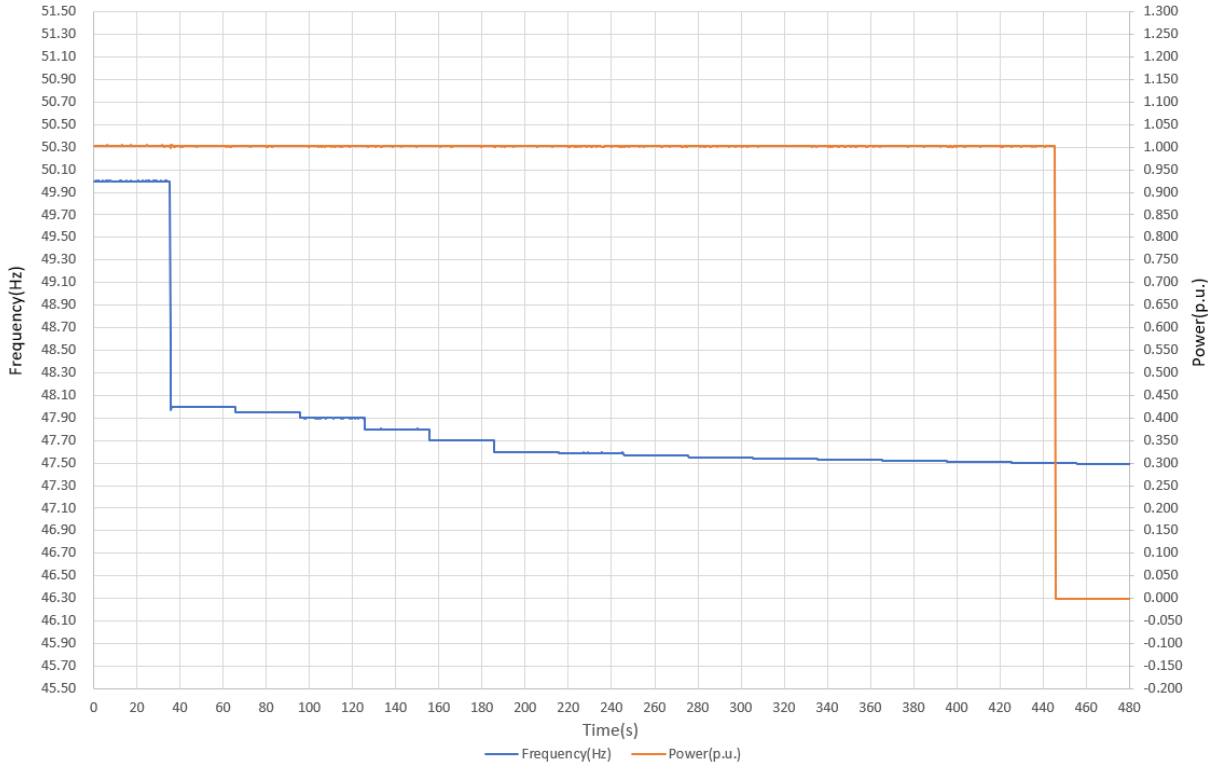


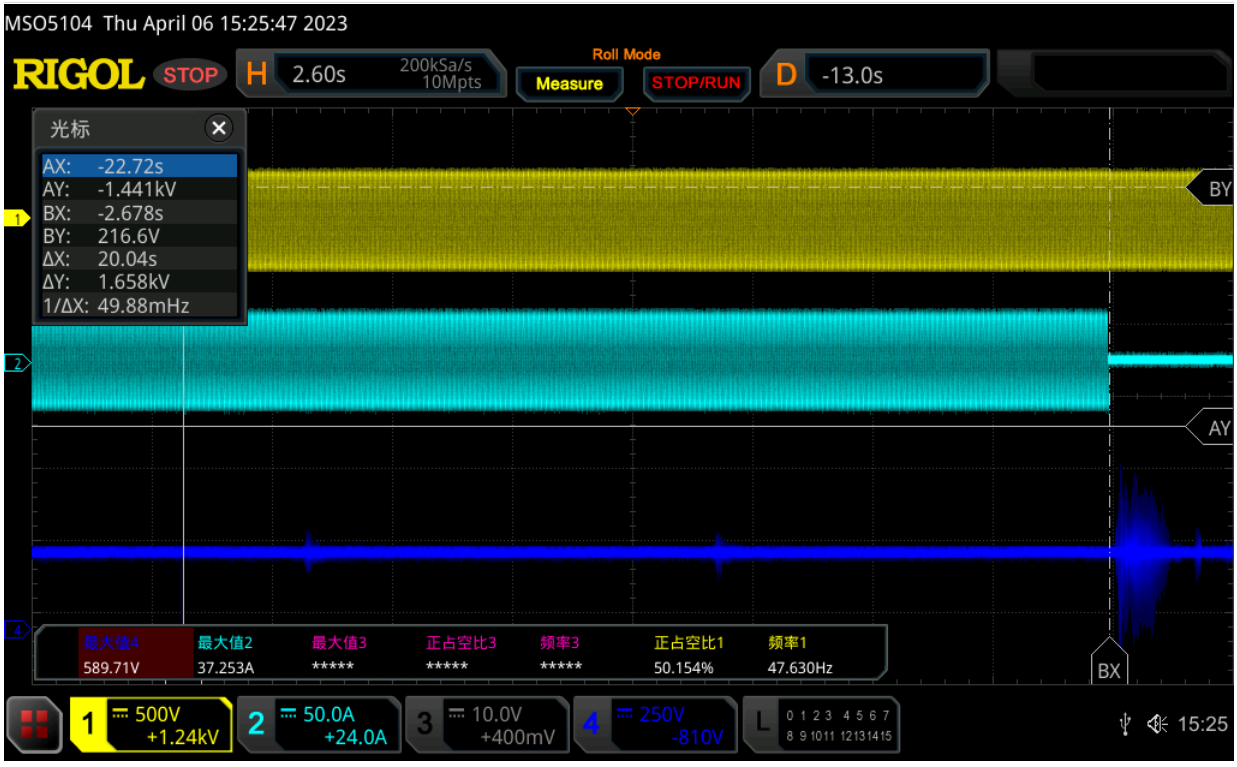
U/F stage 1-2


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

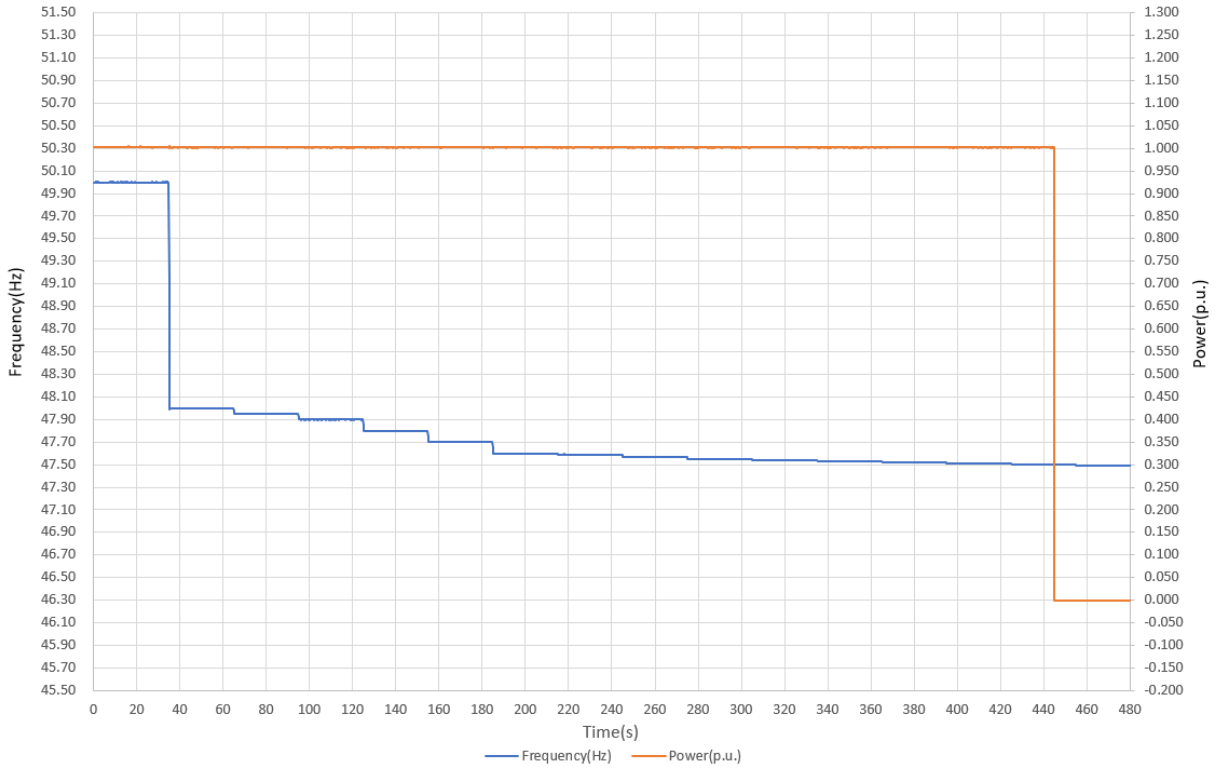

MSO5104 Fri March 24 20:05:52 2023
RIGOL
STOP
H 2.60s
200kSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -13.286s
AY
BY
BX
光标
AX: -21.13s
AY: -40.83V
BX: -1.092s
BY: -144.1V
ΔX: 20.04s
ΔY: -103.3V
1/ΔX: 49.88mHz
有效值2 22.362A
最小值2 -41.900A
最大值1 365.66V
最小值1 -411.37V
峰峰值2 74.489A
最大值2 32.589A
有效值1 229.27V
正占空比1 48.632%
1 1.00kV +1.16kV
2 100A -84.0A
3 1.00V +2.36V
4 50.0V +118V
20:05

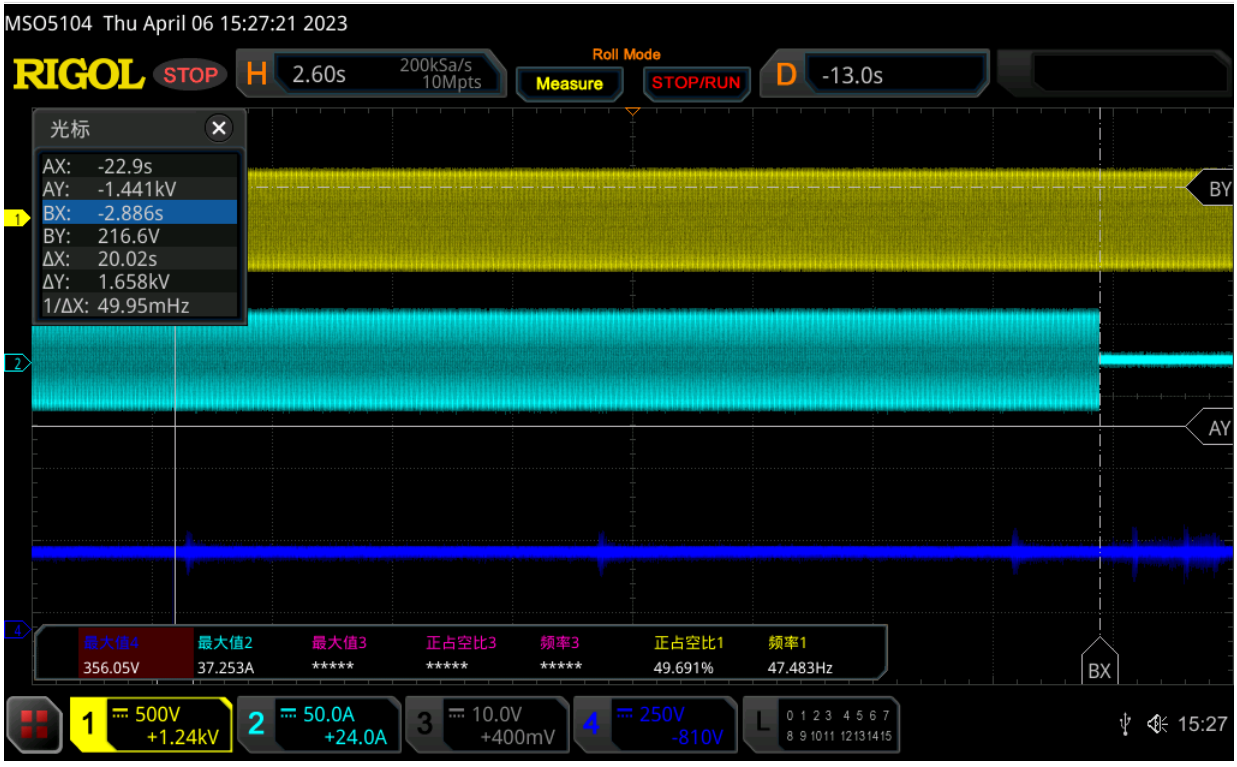
U/F stage 1-3


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

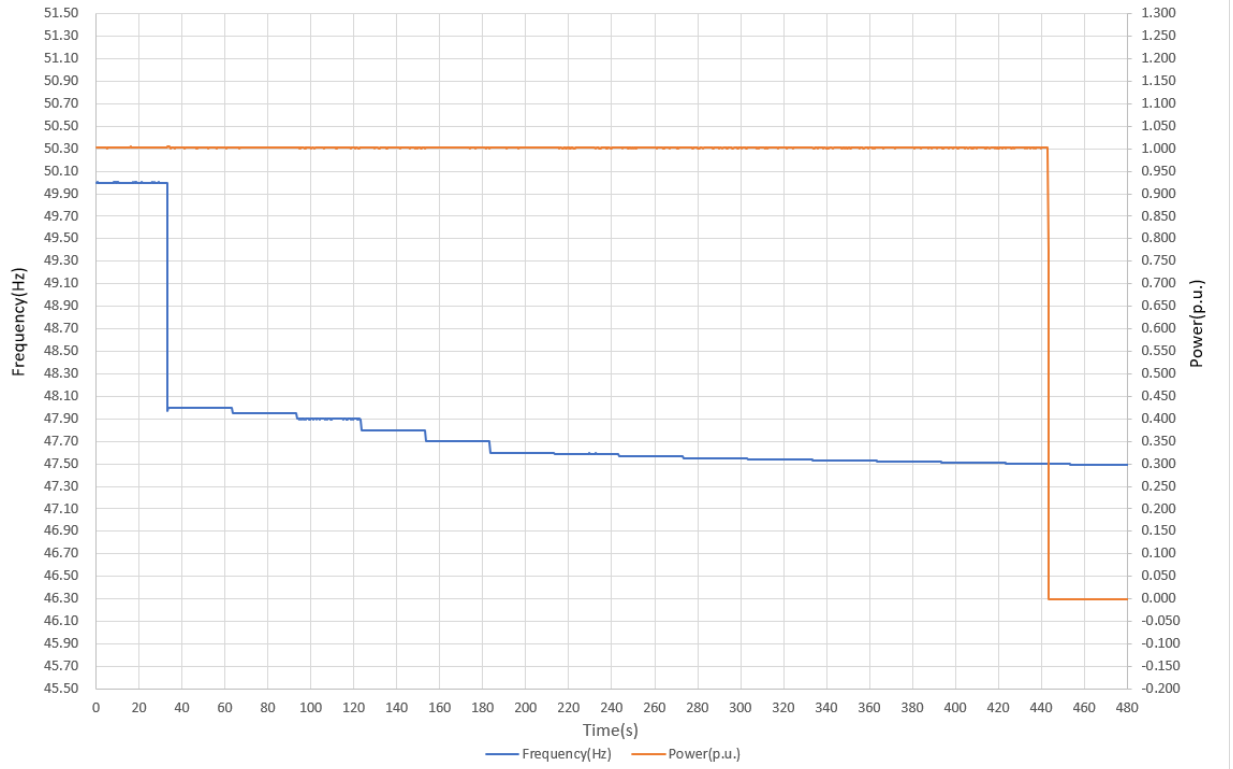

MSO5104 Thu April 06 15:25:47 2023
RIGOL
STOP
H 2.60s
200kSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -13.0s
光标
AX: -22.72s
AY: -1.441kV
BX: -2.678s
BY: 216.6V
ΔX: 20.04s
ΔY: 1.658kV
1/ΔX: 49.88mHz
BY
AY
BX
最大值4 589.71V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 50.154%
频率1 47.630Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:25

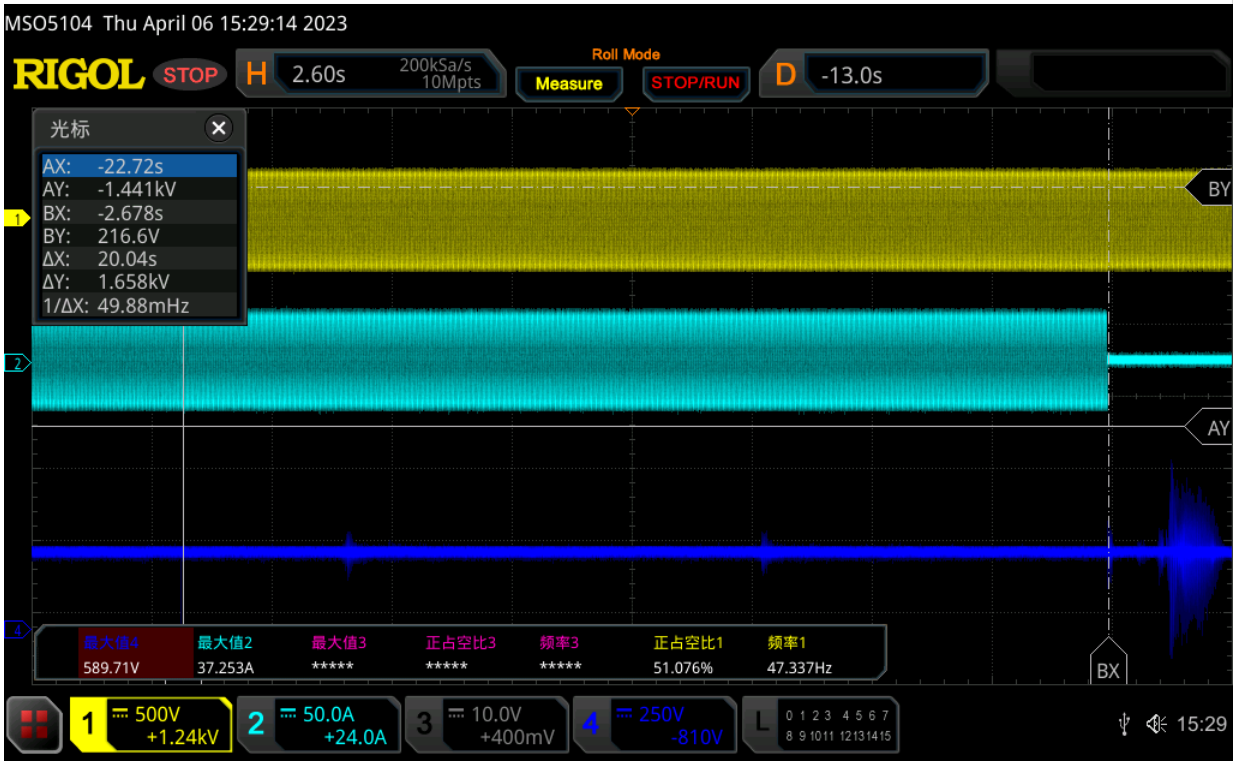
U/F stage 1-4


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

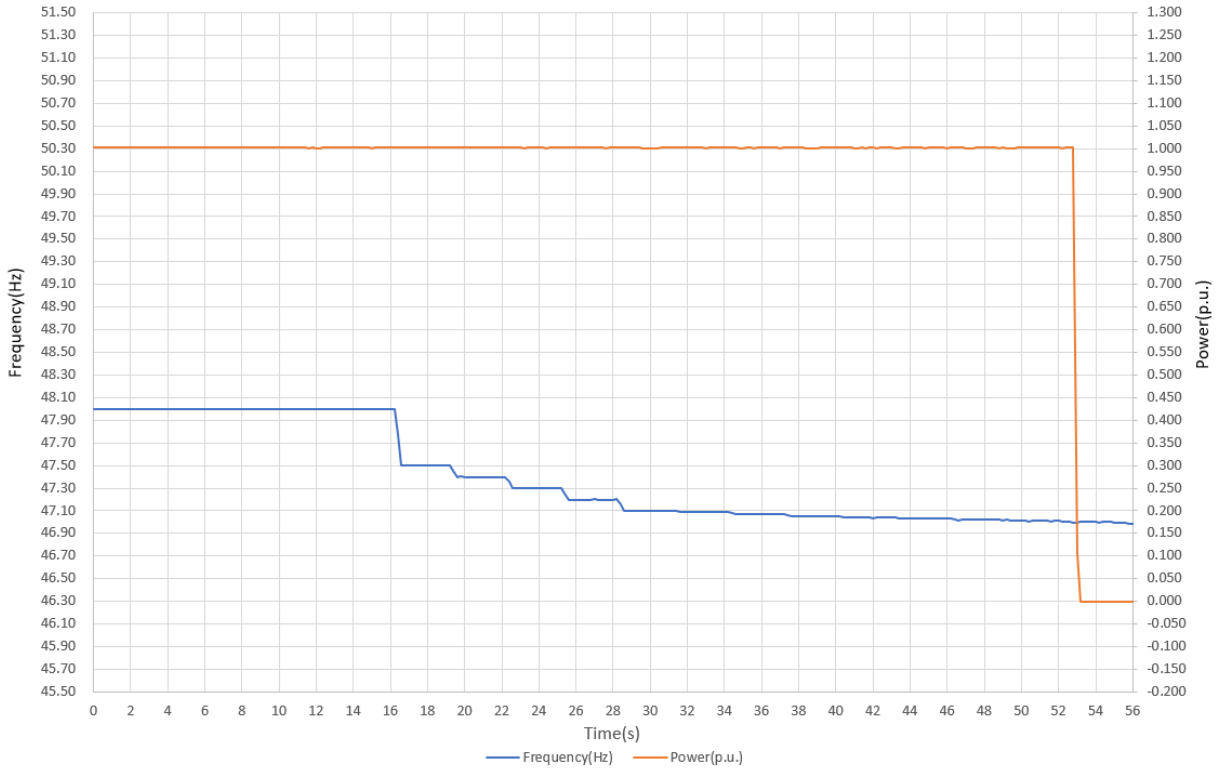

MSO5104 Thu April 06 15:27:21 2023
RIGOL
STOP
H 2.60s
200kSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -13.0s
光标
AX: -22.9s
AY: -1.441kV
BX: -2.886s
BY: 216.6V
ΔX: 20.02s
ΔY: 1.658kV
1/ΔX: 49.95mHz
BY
AY
BX
最大值4 356.05V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.691%
频率1 47.483Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:27

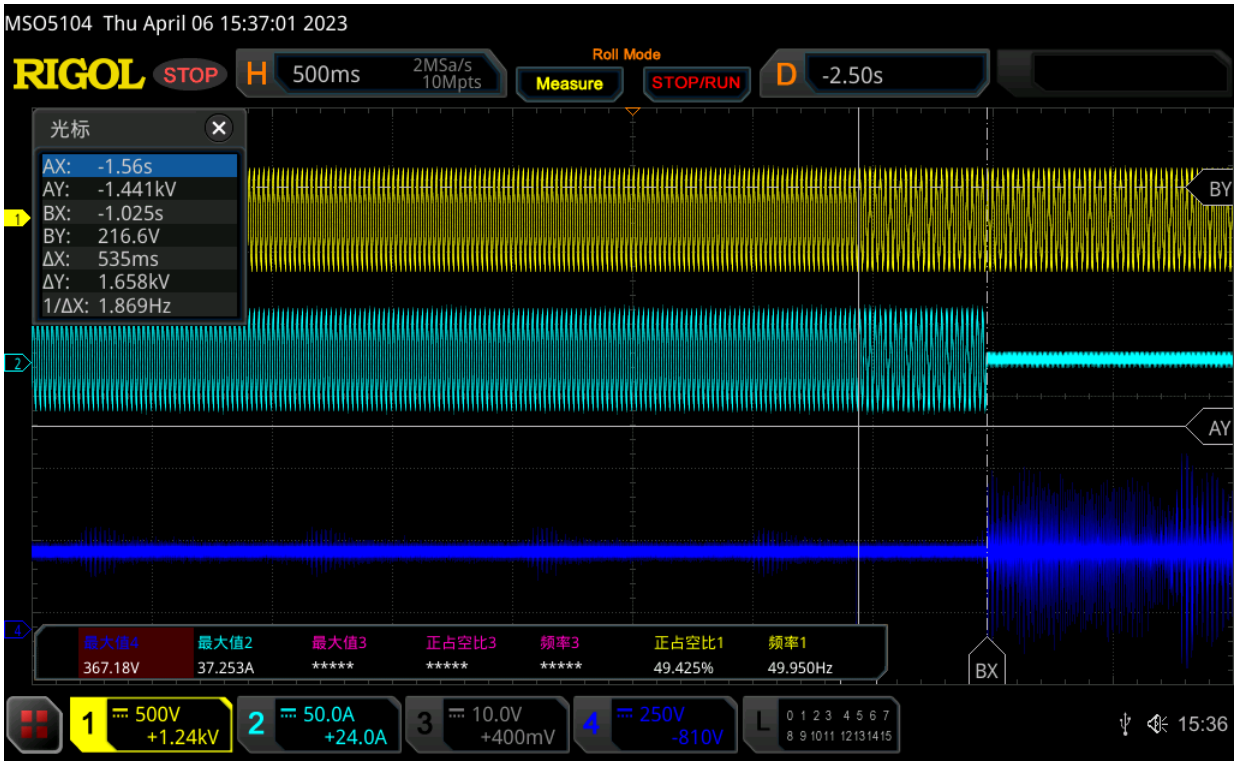
U/F stage 1-5


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

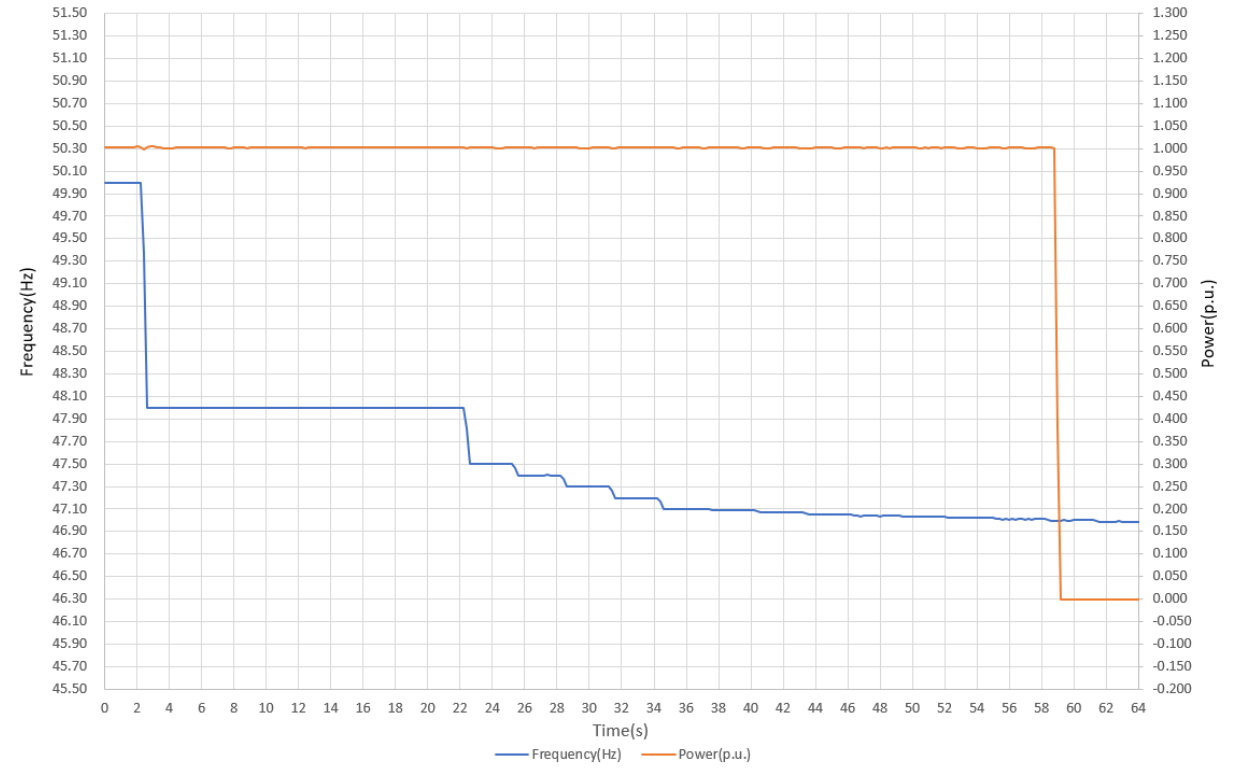

MSO5104 Thu April 06 15:29:14 2023
RIGOL
STOP
H 2.60s
200kSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -13.0s
光标
AX: -22.72s
AY: -1.441kV
BX: -2.678s
BY: 216.6V
ΔX: 20.04s
ΔY: 1.658kV
1/ΔX: 49.88mHz
BY
AY
BX
最大值4 589.71V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 51.076%
频率1 47.337Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:29

U/F stage 2-1


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

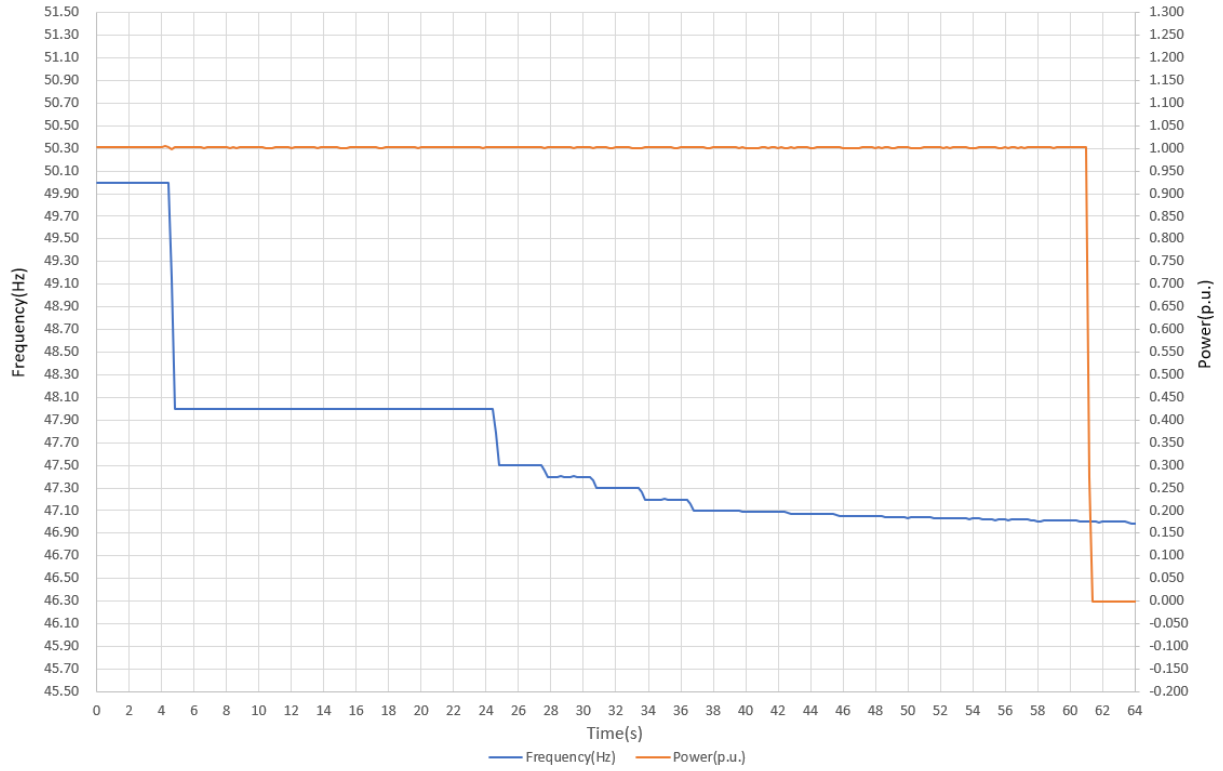

MSO5104 Thu April 06 15:37:01 2023
RIGOL
STOP
H 500ms
2MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -1.56s
AY: -1.441kV
BX: -1.025s
BY: 216.6V
ΔX: 535ms
ΔY: 1.658kV
1/ΔX: 1.869Hz
BY
AY
BX
最大值4 367.18V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.425%
频率1 49.950Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:36

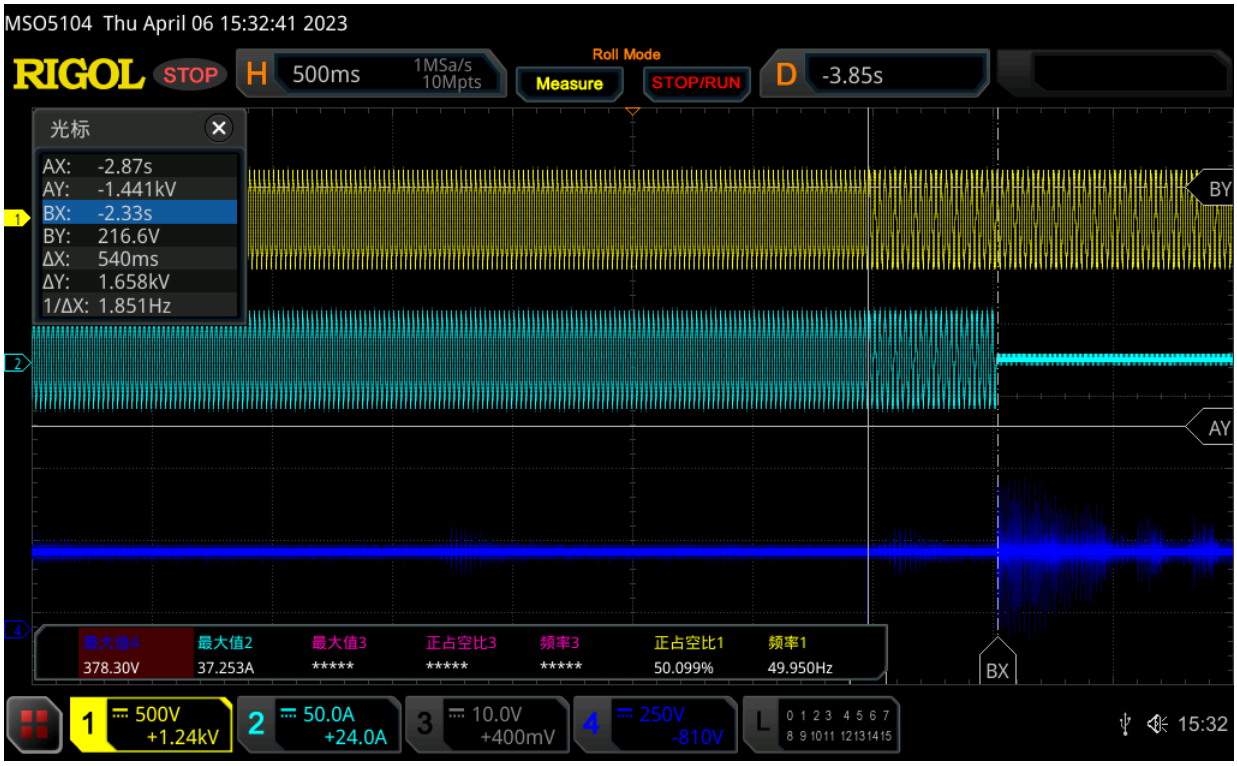
U/F stage 2-2


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

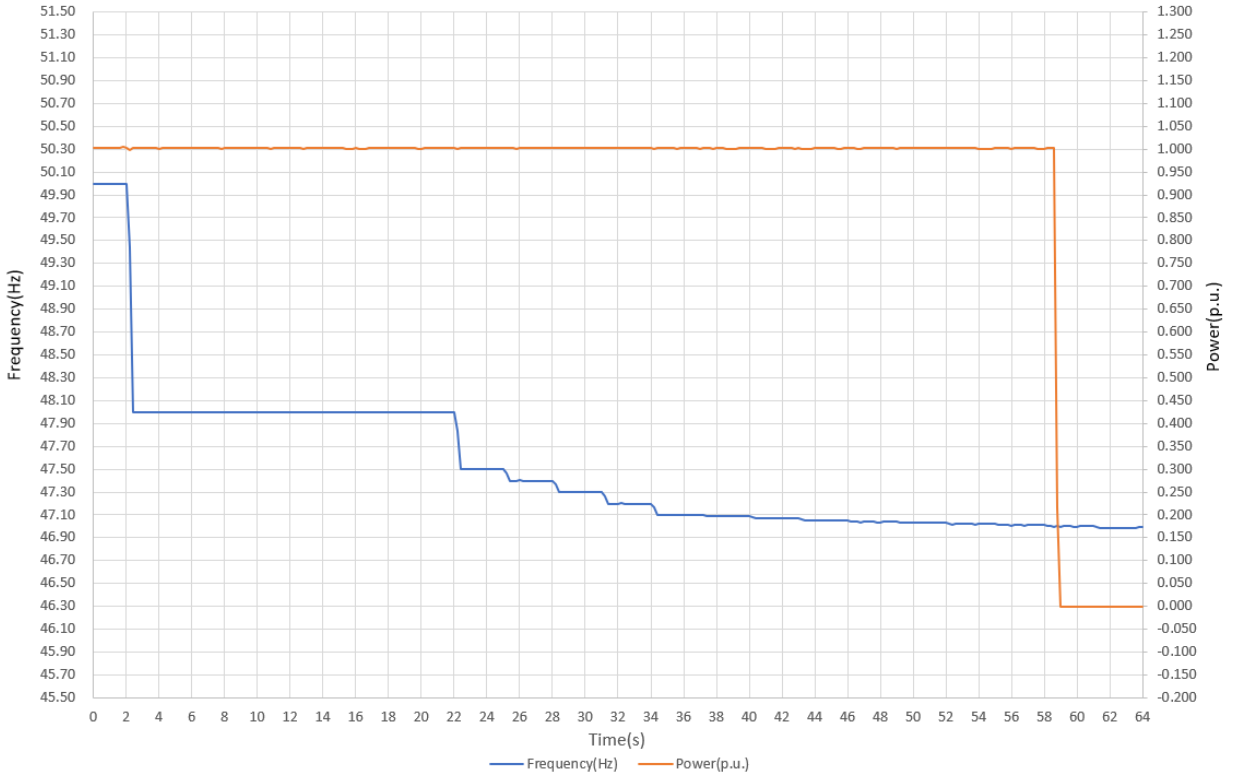

MSO5104 Thu April 06 15:38:31 2023
RIGOL
STOP
H 500ms 2MSa/s 10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -1.45s
AY: -1.441kV
BX: -900ms
BY: 216.6V
ΔX: 550ms
ΔY: 1.658kV
1/ΔX: 1.818Hz
BY
AY
BX
最大值4 300.42V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.825%
频率1 49.975Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:38

U/F stage 2-3


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

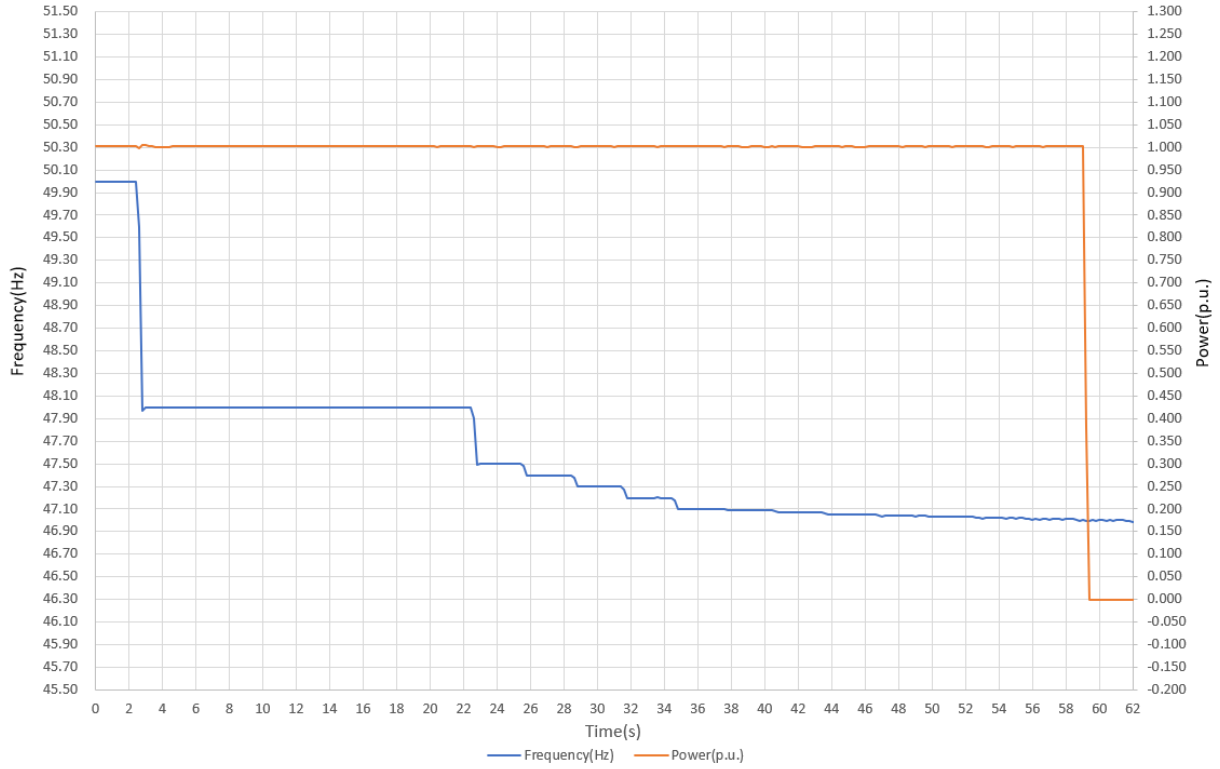

MSO5104 Thu April 06 15:32:41 2023
RIGOL
STOP
H 500ms
1MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -3.85s
光标
AX: -2.87s
AY: -1.441kV
BX: -2.33s
BY: 216.6V
ΔX: 540ms
ΔY: 1.658kV
1/ΔX: 1.851Hz
BY
AY
BX
最大值4 378.30V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 50.099%
频率1 49.950Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:32

U/F stage 2-4


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

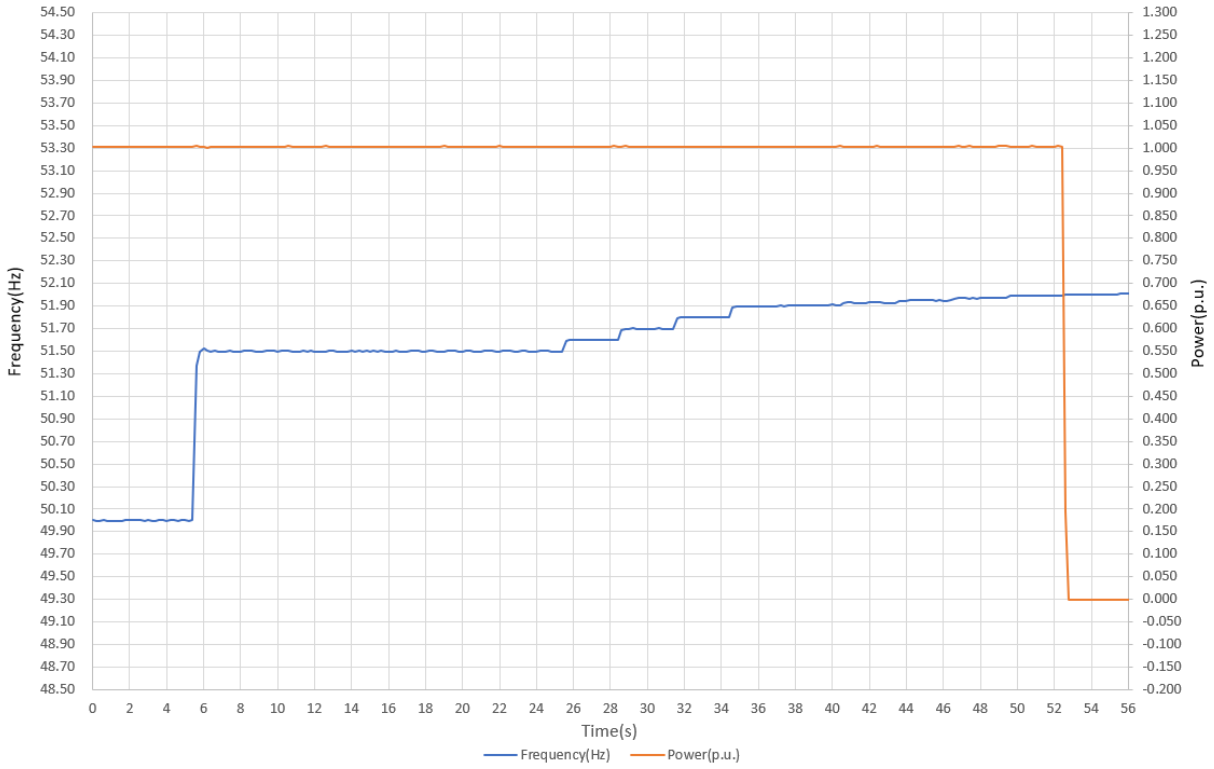

MSO5104 Thu April 06 15:34:11 2023
RIGOL
STOP
H 500ms 2MSa/s 10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -2.59s
AY: -1.441kV
BX: -2.04s
BY: 216.6V
ΔX: 550ms
ΔY: 1.658kV
1/ΔX: 1.818Hz
BY
AY
最大值4 600.84V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.504%
频率1 47.169Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:34

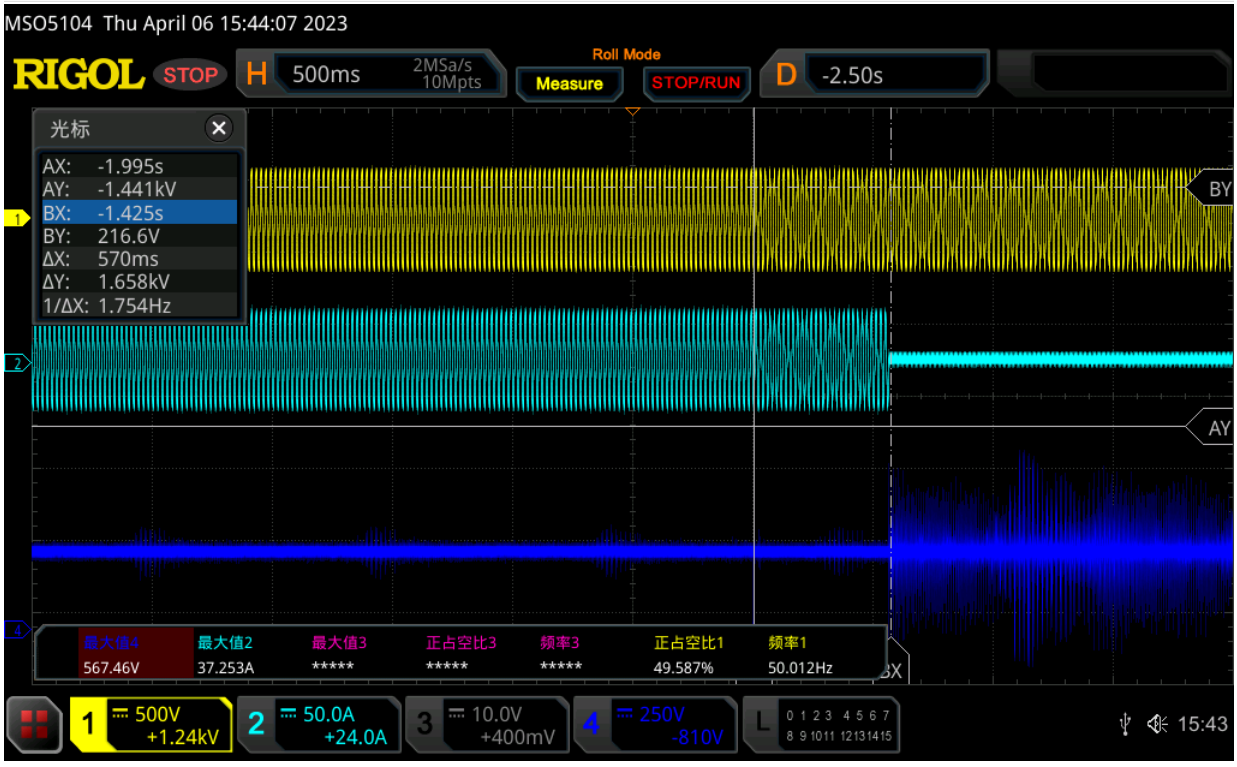
U/F stage 2-5


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

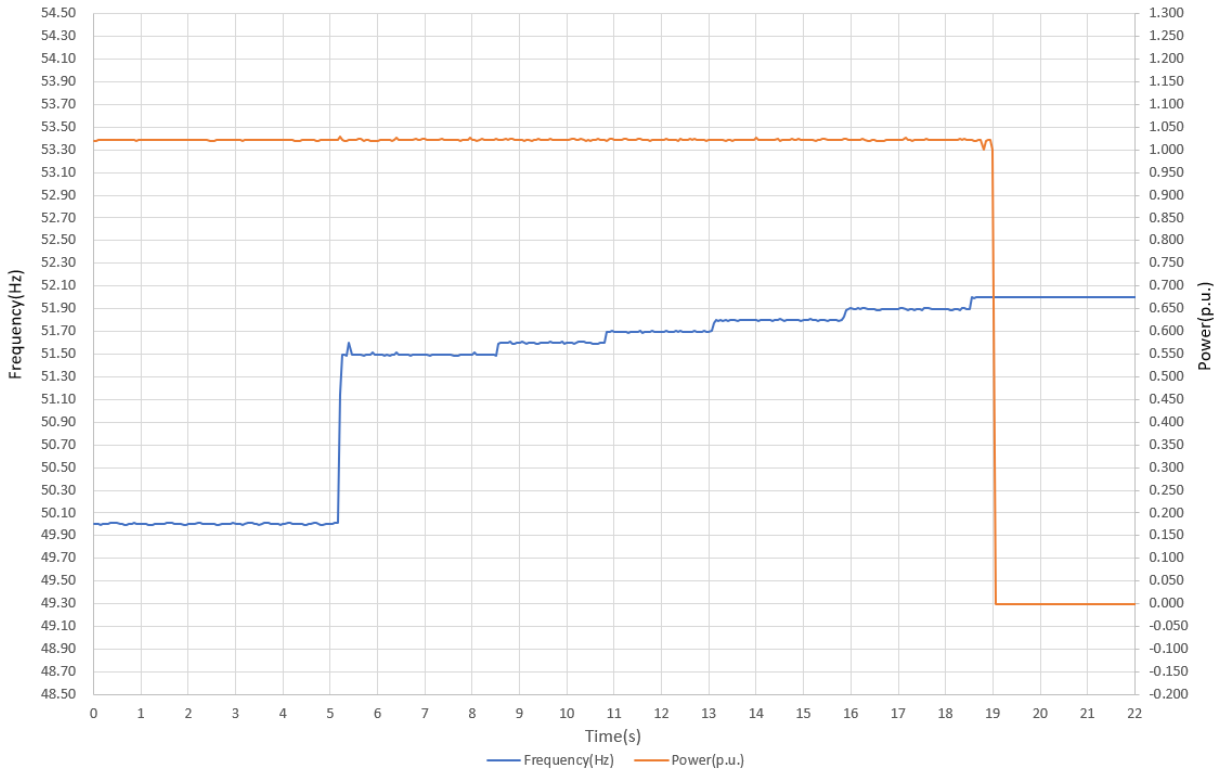

MSO5104 Thu April 06 15:35:39 2023
RIGOL
STOP
H 500ms 2MSa/s 10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -3.105s
AY: -1.441kV
BX: -2.58s
BY: 216.6V
ΔX: 525ms
ΔY: 1.658kV
1/ΔX: 1.904Hz
BY
AY
最大值4 378.30V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 51.409%
频率1 46.992Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:35

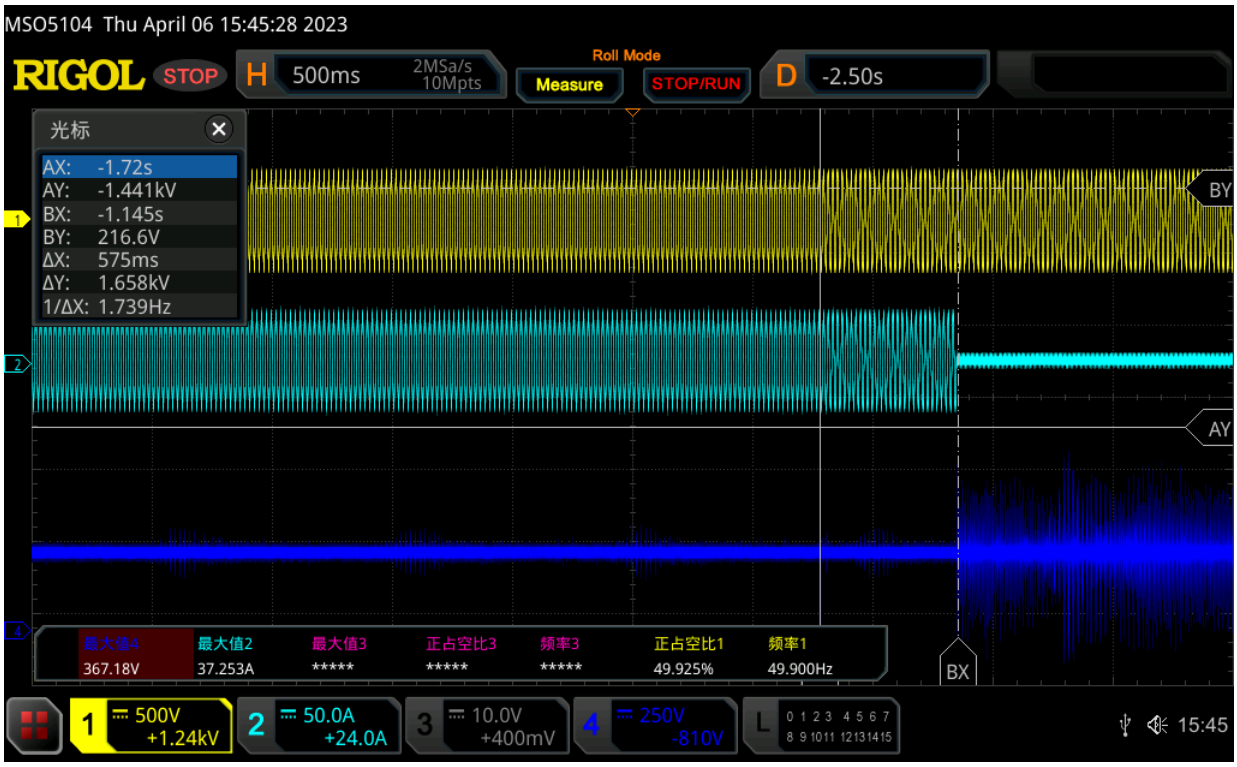
O/F stage 1-1


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

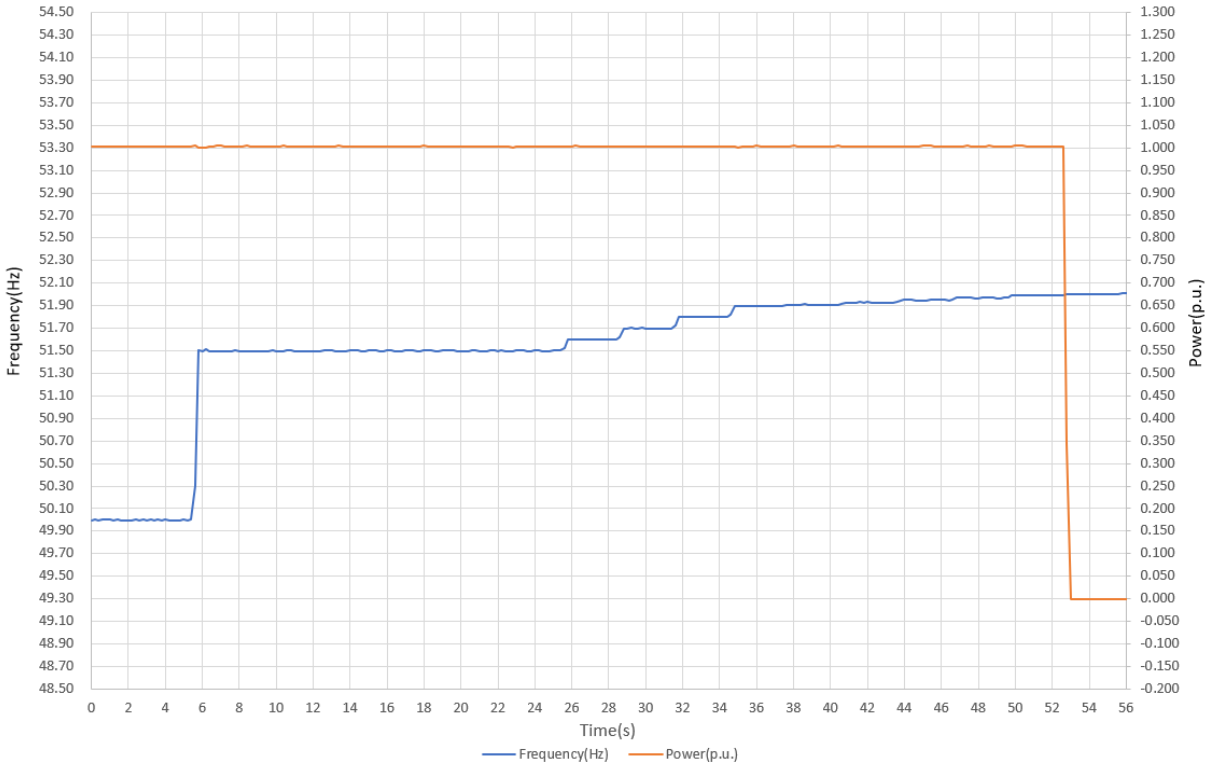

MSO5104 Thu April 06 15:44:07 2023
RIGOL
STOP
H 500ms
2MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -1.995s
AY: -1.441kV
BX: -1.425s
BY: 216.6V
ΔX: 570ms
ΔY: 1.658kV
1/ΔX: 1.754Hz
BY
AY
最大值4 567.46V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.587%
频率1 50.012Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:43

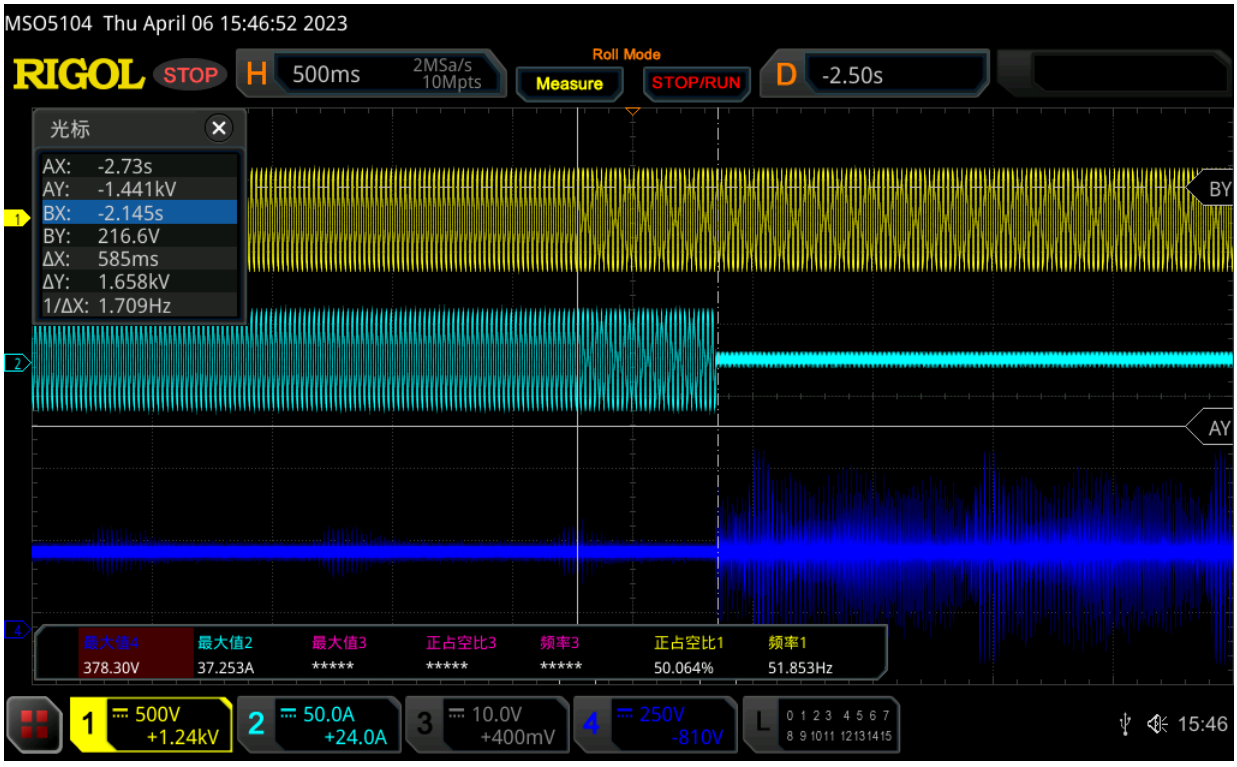
O/F stage 1-2


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

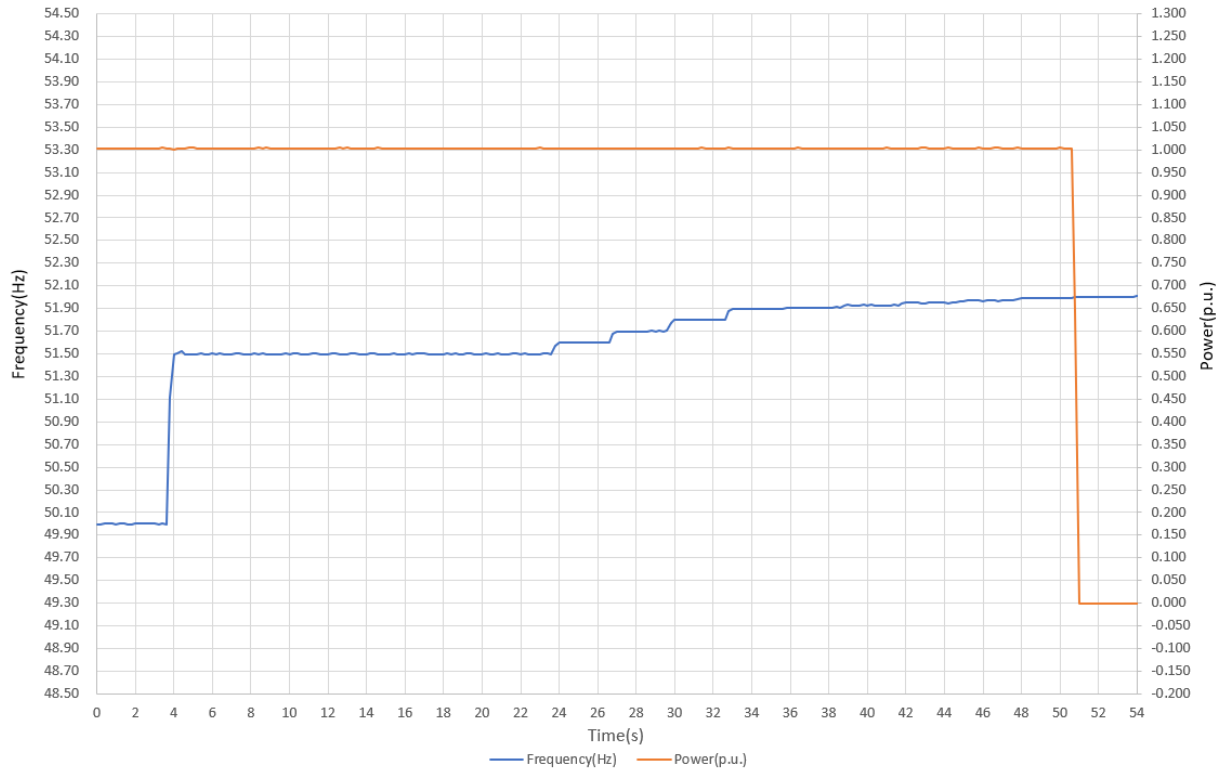

MSO5104 Thu April 06 15:45:28 2023
RIGOL
STOP
H 500ms 2MSa/s 10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -1.72s
AY: -1.441kV
BX: -1.145s
BY: 216.6V
ΔX: 575ms
ΔY: 1.658kV
1/ΔX: 1.739Hz
BY
AY
BX
最大值4 367.18V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.925%
频率1 49.900Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:45

O/F stage 1-3


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

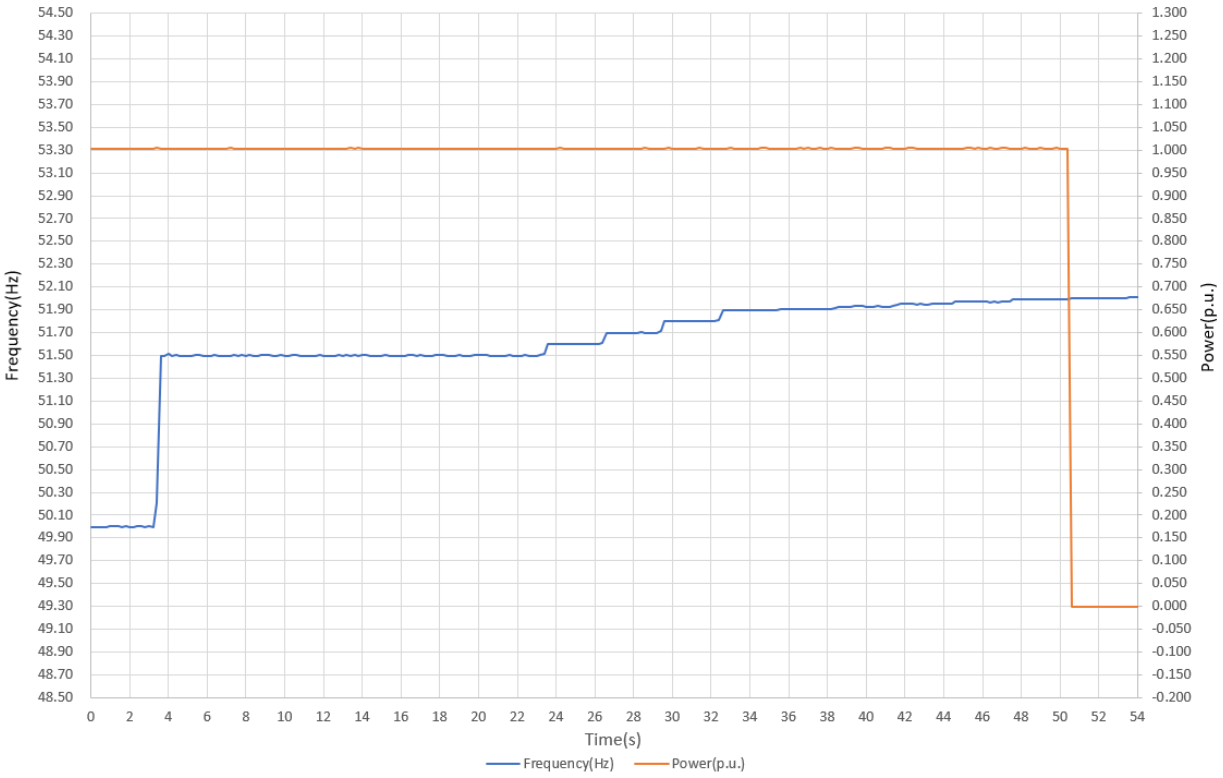

MSO5104 Thu April 06 15:46:52 2023
RIGOL
STOP
H 500ms
2MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -2.73s
AY: -1.441kV
BX: -2.145s
BY: 216.6V
ΔX: 585ms
ΔY: 1.658kV
1/ΔX: 1.709Hz
BY
AY
最大值4 378.30V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 50.064%
频率1 51.853Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:46

O/F stage 1-4


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

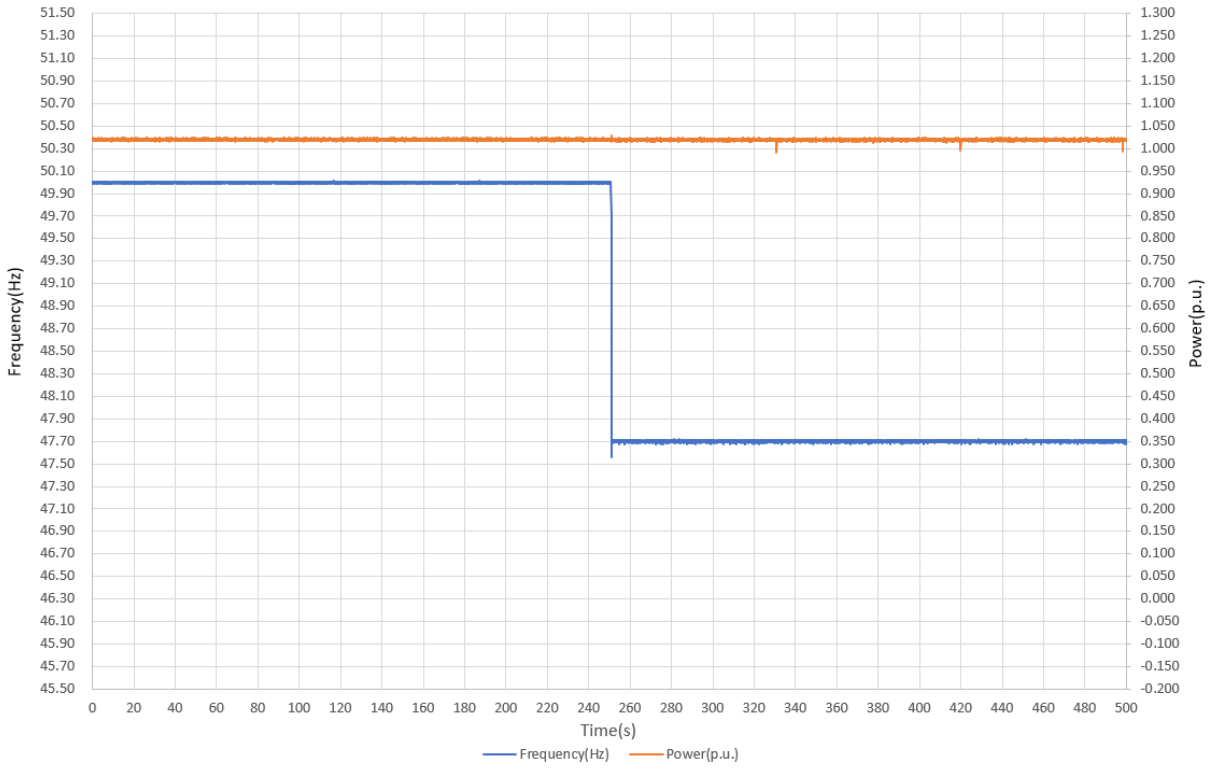

MSO5104 Thu April 06 15:48:26 2023
RIGOL
STOP
H 500ms
2MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -1.345s
AY: -1.441kV
BX: -770ms
BY: 216.6V
ΔX: 575ms
ΔY: 1.658kV
1/ΔX: 1.739Hz
BY
AY
AX
BX
最大值4 356.05V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.148%
频率1 50.100Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:48

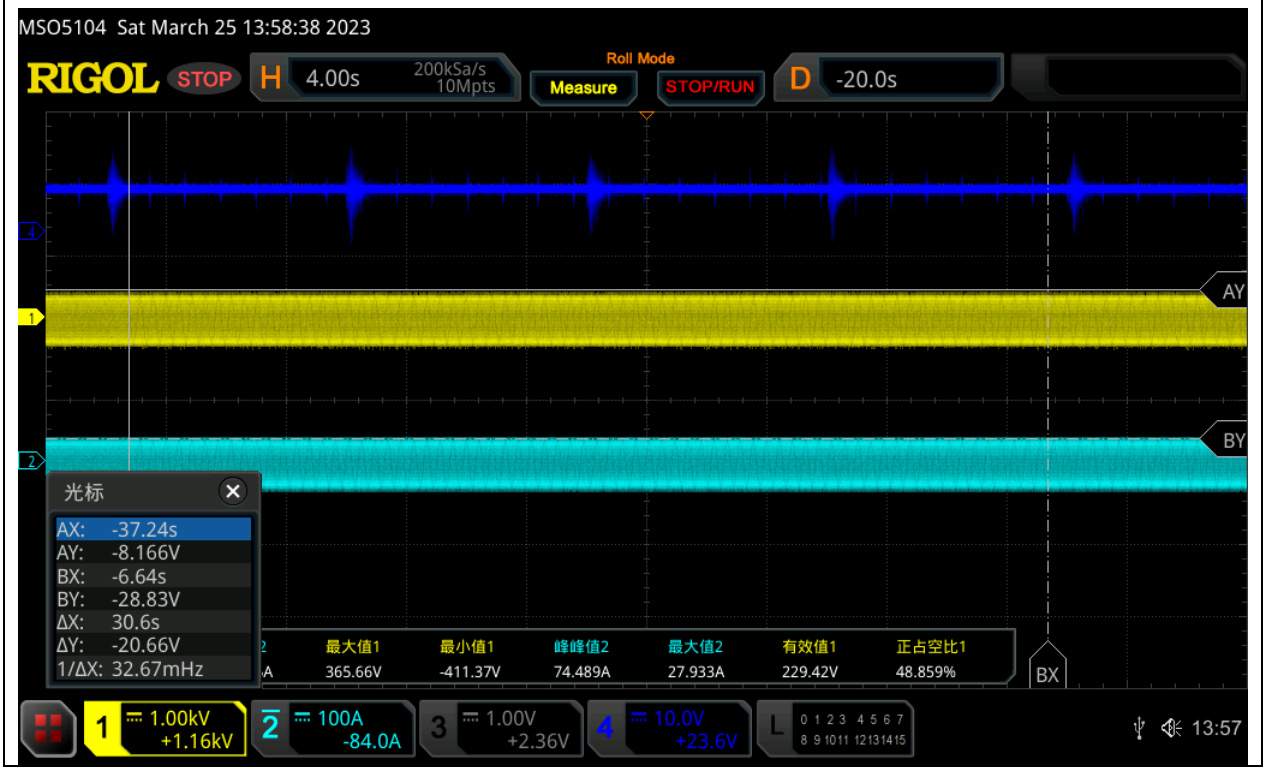
O/F stage 1-5


Frequency(Hz)
Power(p.u.)
Time(s)
Frequency(Hz)
Power(p.u.)

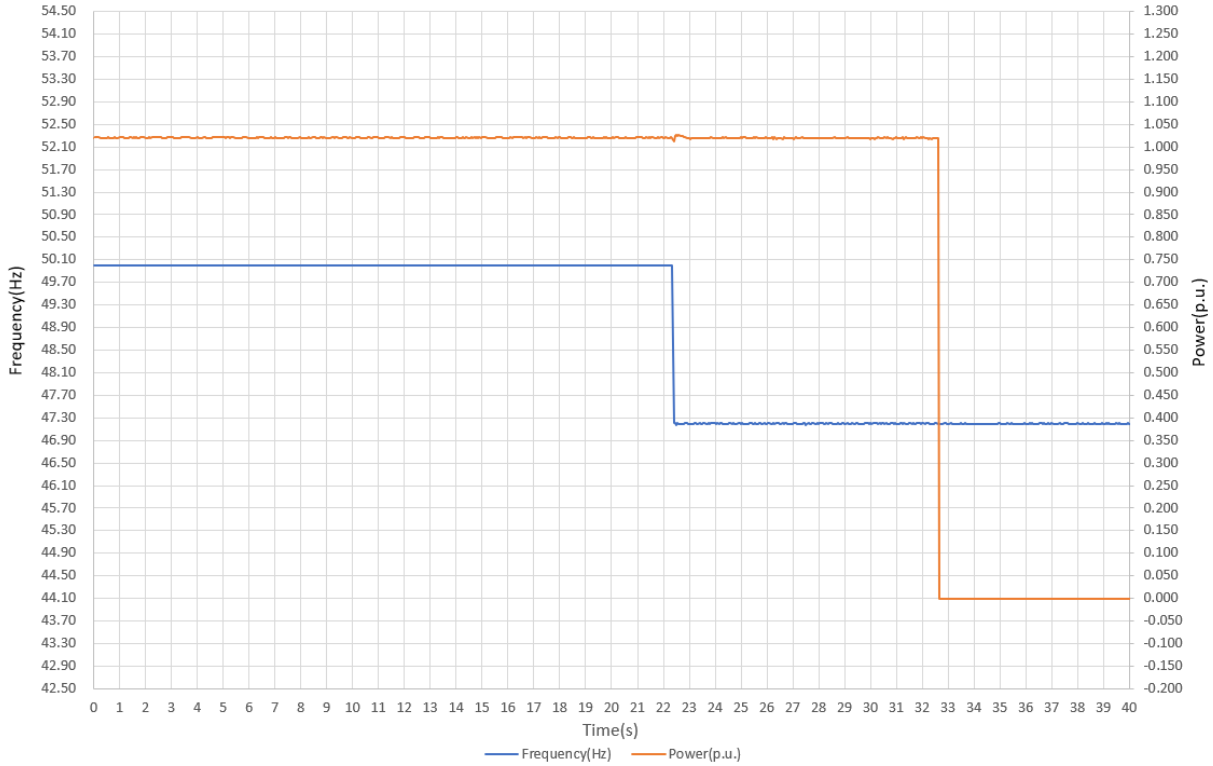

MSO5104 Thu April 06 15:42:25 2023
RIGOL
STOP
H 500ms
2MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -1.815s
AY: -1.441kV
BX: -1.24s
BY: 216.6V
ΔX: 575ms
ΔY: 1.658kV
1/ΔX: 1.739Hz
BY
AY
BX
最大值4 367.18V
最大值2 37.253A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.875%
频率1 49.950Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
15:42

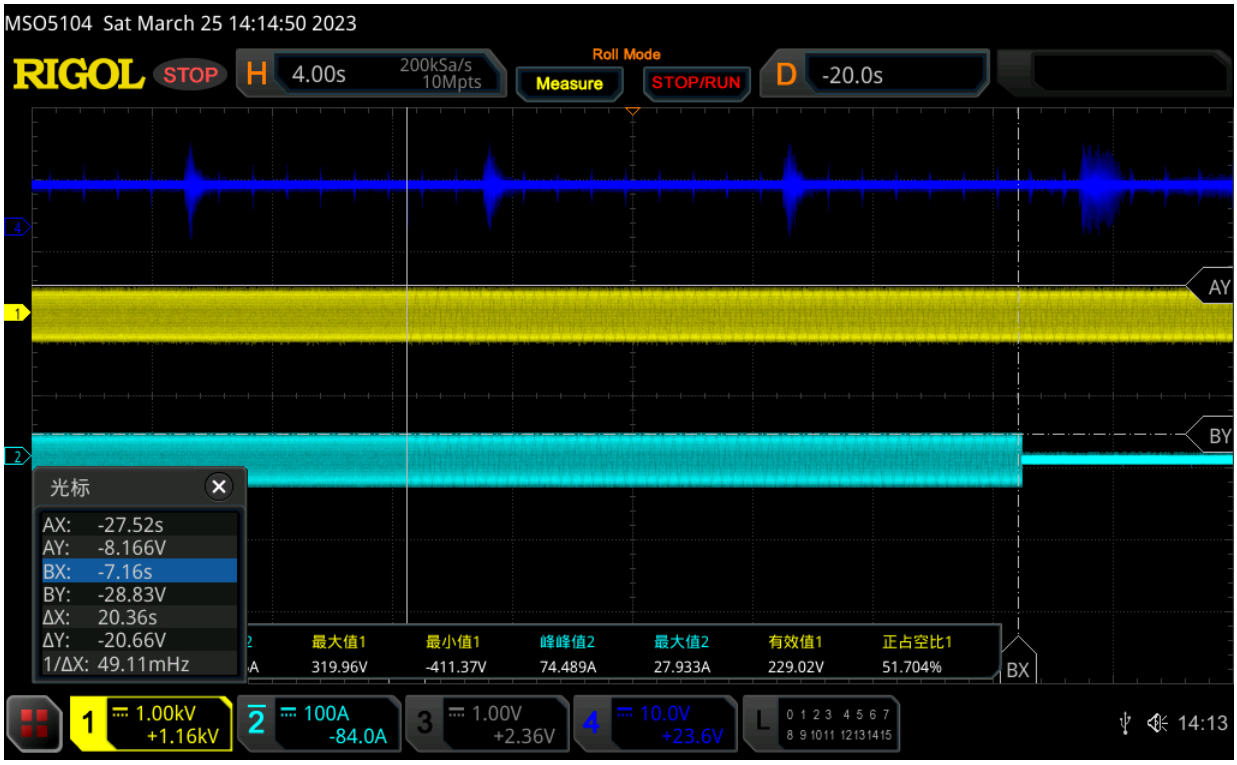
No trip tests - 47.7Hz



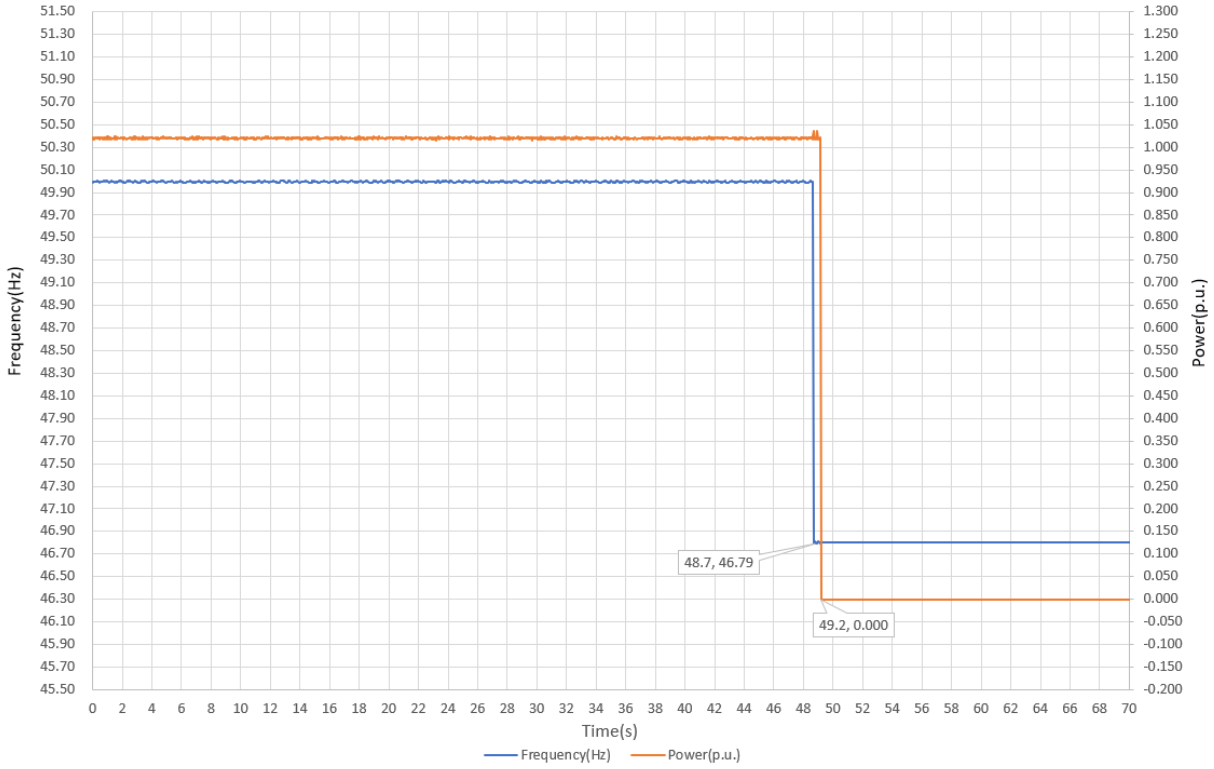


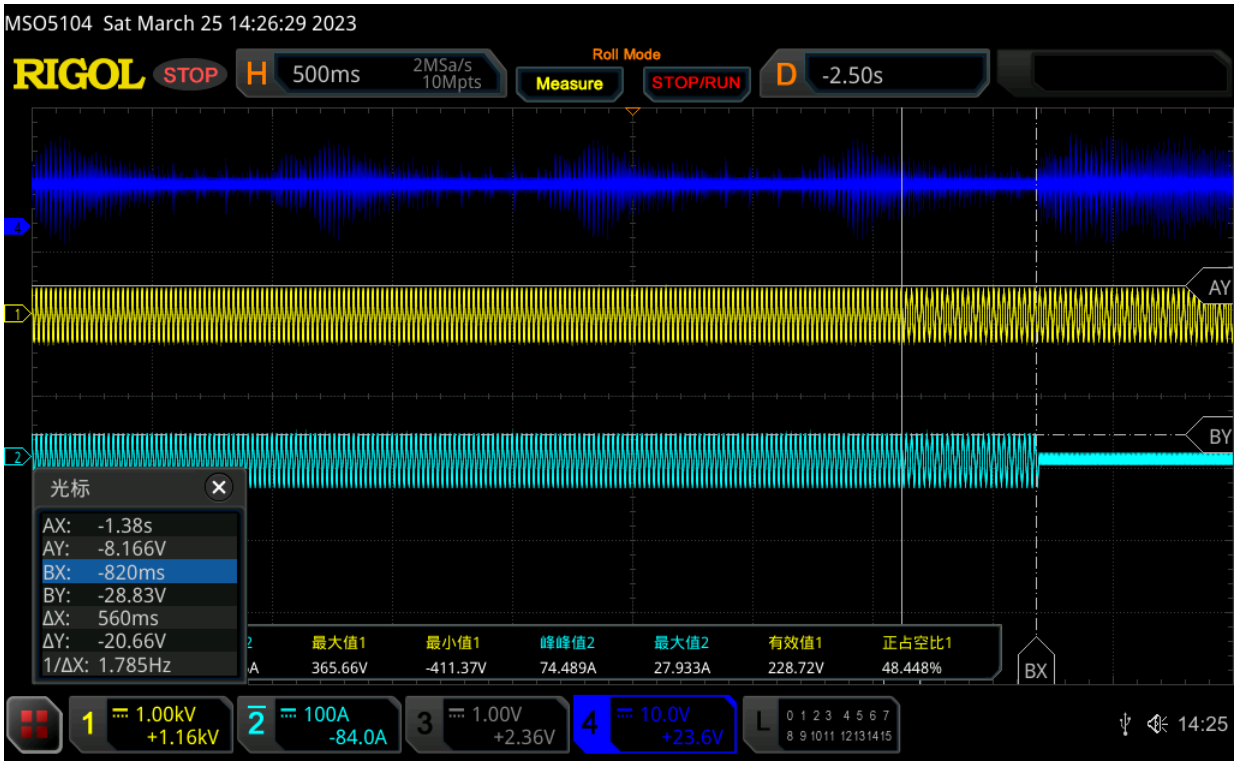
No trip tests – 47.2Hz



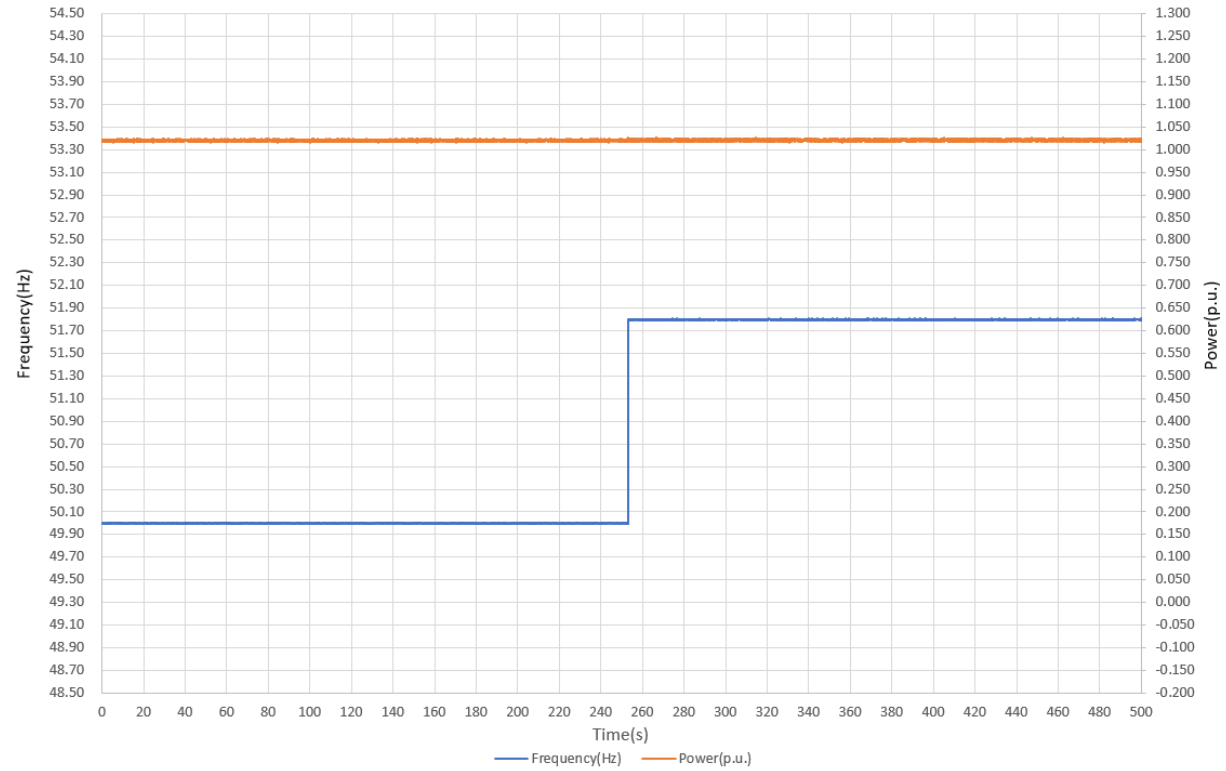


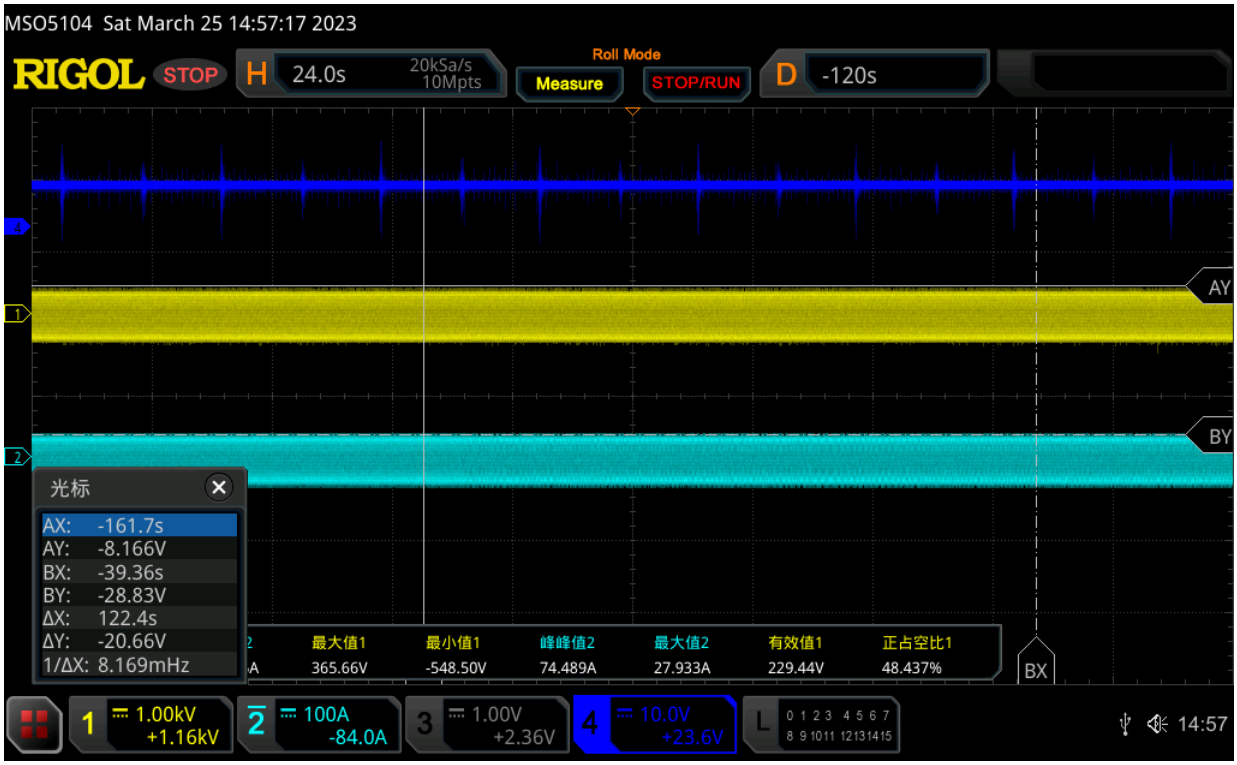
No trip tests – 46.8Hz



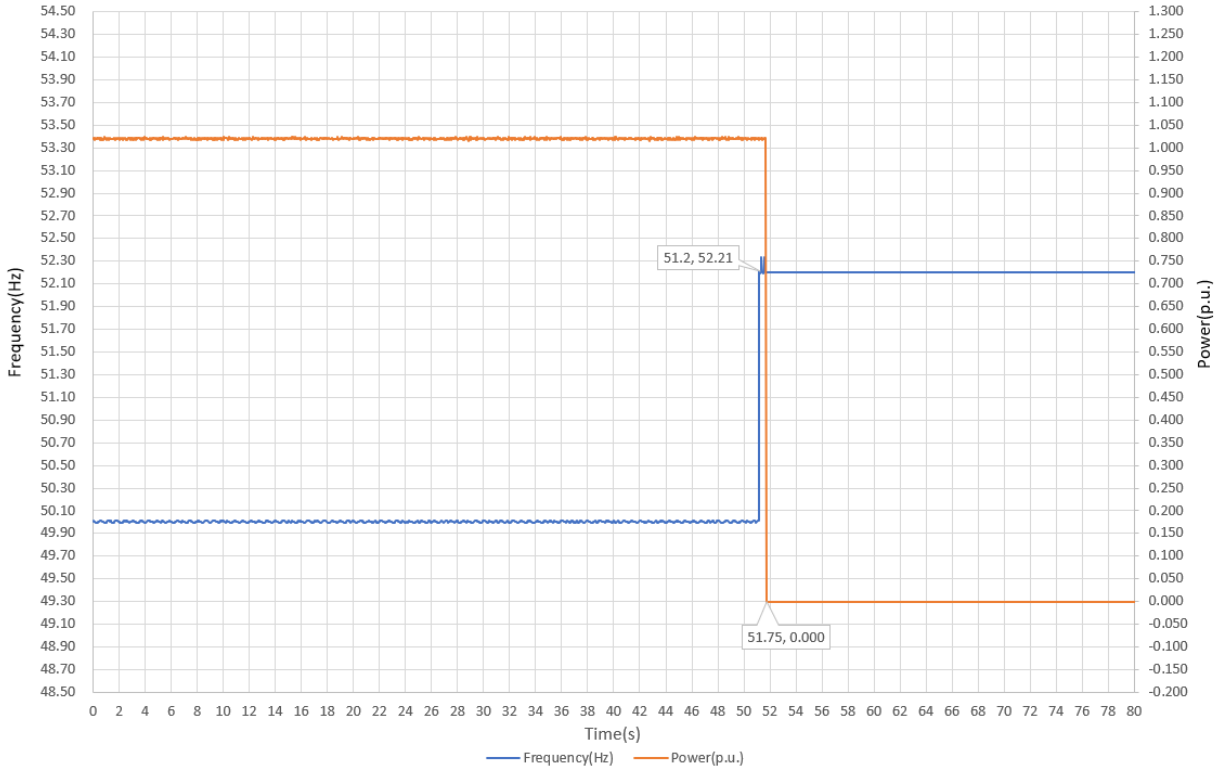


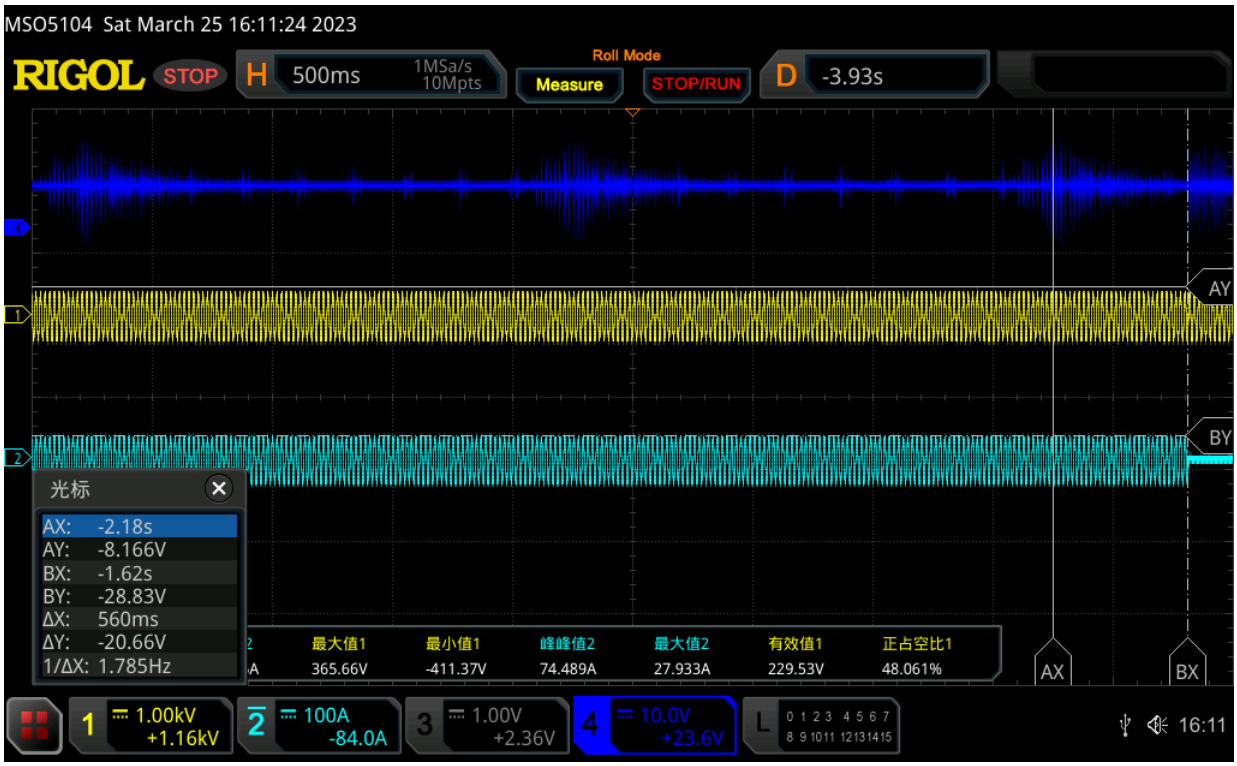
No trip tests - 51.8Hz





No trip tests – 52.2Hz





4.3.2 Voltage tests

These tests should be carried out in accordance with Annex A.7.1.2.2.

To establish the certified trip voltage, the test voltage should be applied in steps of ± 0.5% of setting for a duration that is longer than the trip time delay.

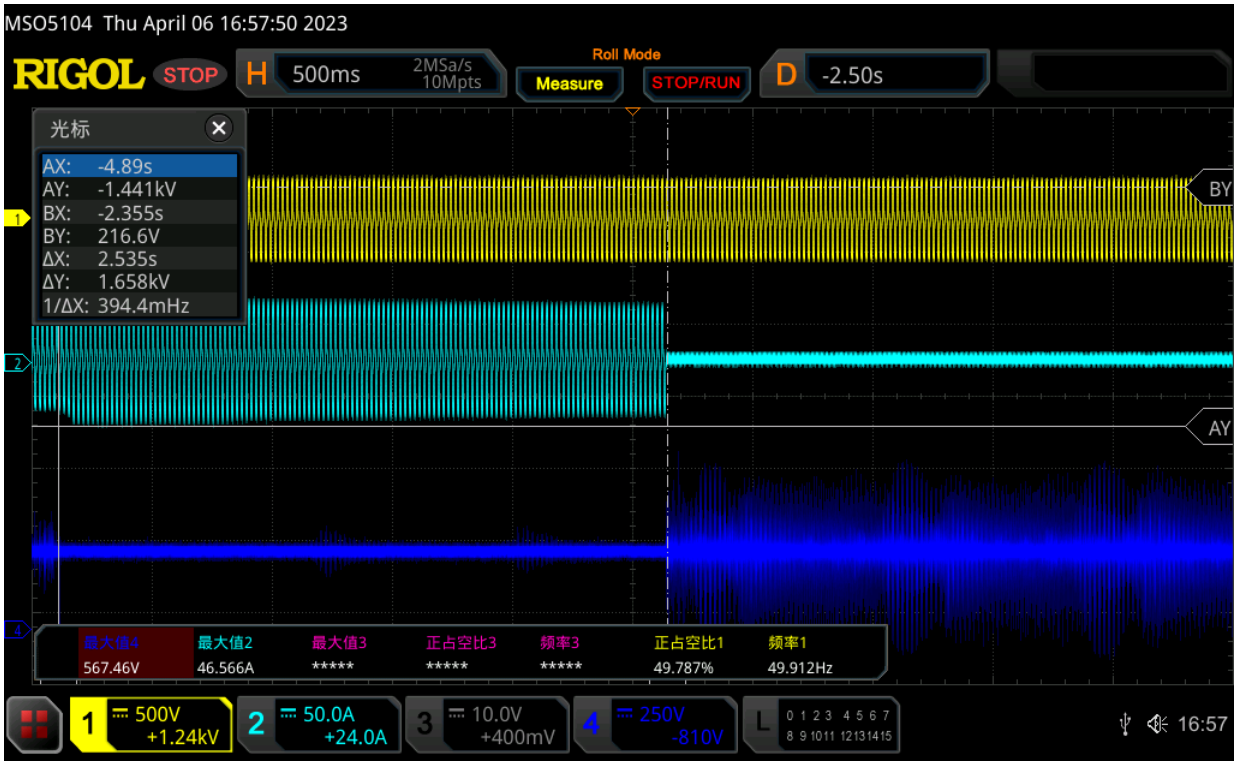
To establish the certified trip time, the test voltage should be applied starting from ± 1.8% below the certified trip voltage in a step of at least ± 0.5% of setting for a duration that is longer than the trip time delay. For each trip setting five tests shall be carried out.

Following tables show the test results:

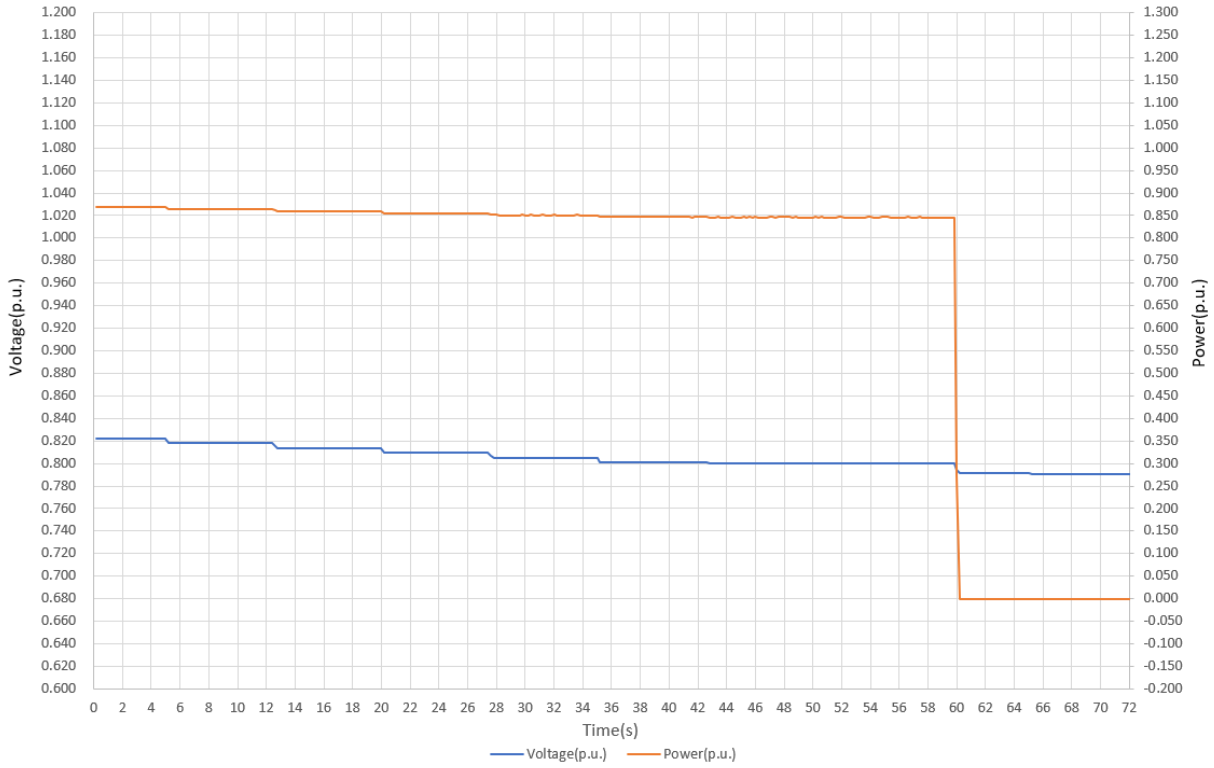
Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage (V)	Time delay (s)	Voltage /time	Confirm no trip
U/V	184 V	2.5 s	183.18	2.535	188.0 V / 5.00 s	Pass
			183.45	2.520		
			183.74	2.525		
			183.22	2.530		
			183.89	2.535		
					180.0 V / 2.45s	Pass
O/V stage 1	262.2 V	1.0 s	261.81	1.055	258.2 V / 5.00 s	Pass
			261.31	1.060		
			261.59	1.055		
			261.92	1.050		
			261.51	1.055		
O/V stage 2	273.7 V	0.5 s	273.21	0.550	269.7 V / 0.95 s	Pass
			273.32	0.556		
			273.13	0.552		
			273.00	0.548		
			273.23	0.554		
					277.7 V / 0.45 s	Pass
Note for Voltage tests the Voltage required to trip is the setting ±3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±4 V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

Test results are graphically shown in following pages.

U/V -1

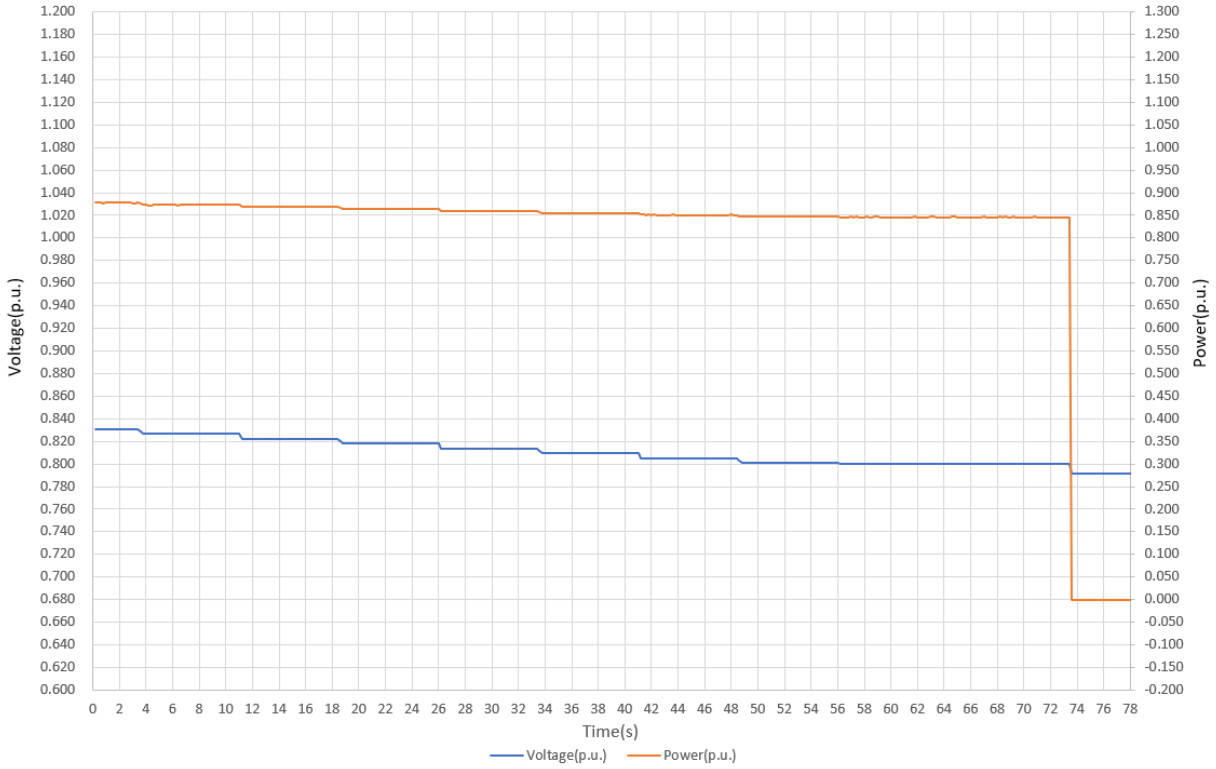


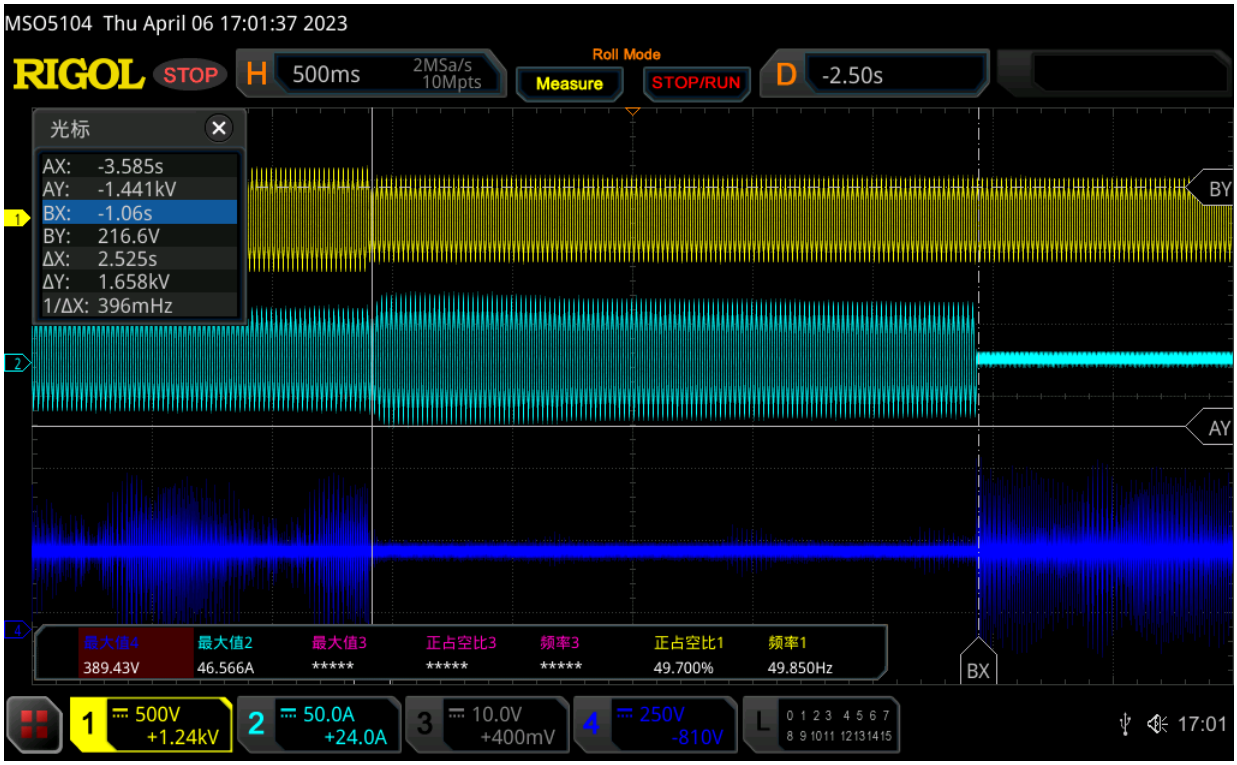
U/V -2


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

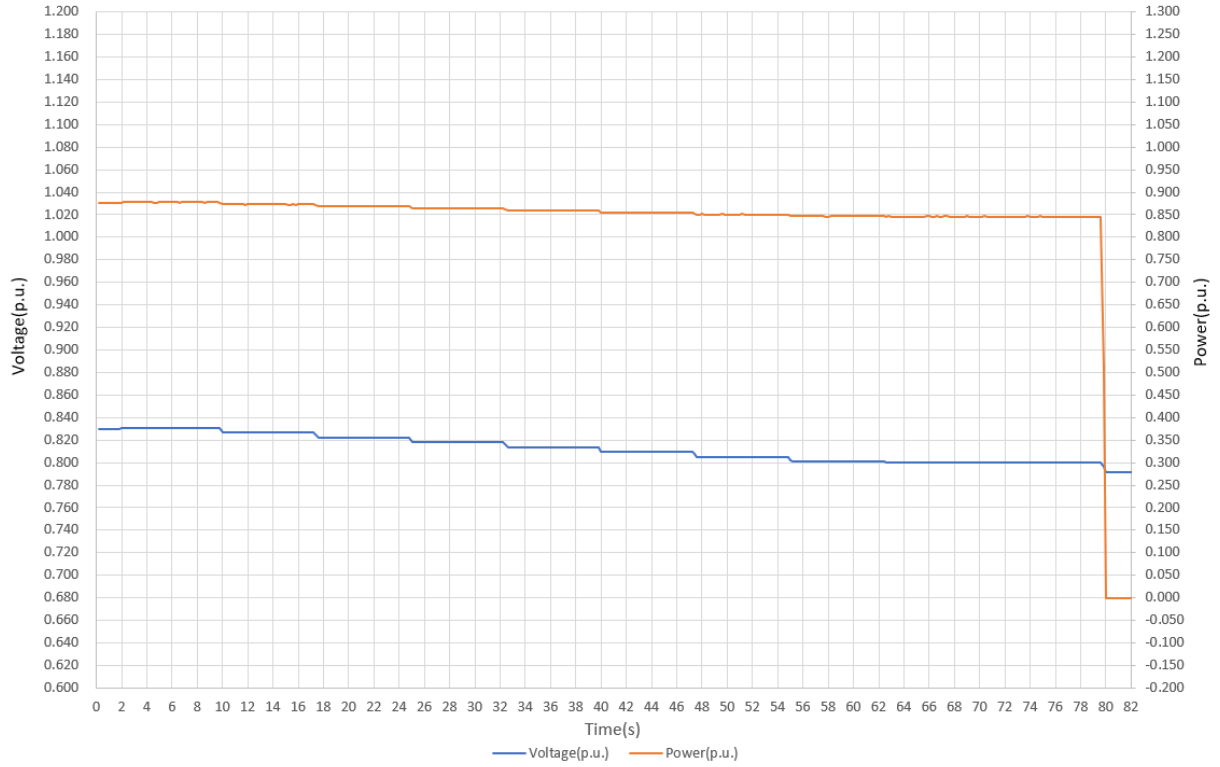

MSO5104 Thu April 06 17:00:09 2023
RIGOL
STOP
H 500ms 2MSa/s 10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -3.2s
AY: -1.441kV
BX: -680ms
BY: 216.6V
ΔX: 2.52s
ΔY: 1.658kV
1/ΔX: 396.8mHz
BY
AY
BX
最大值4 567.46V
最大值2 46.566A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.737%
频率1 50.087Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
16:59

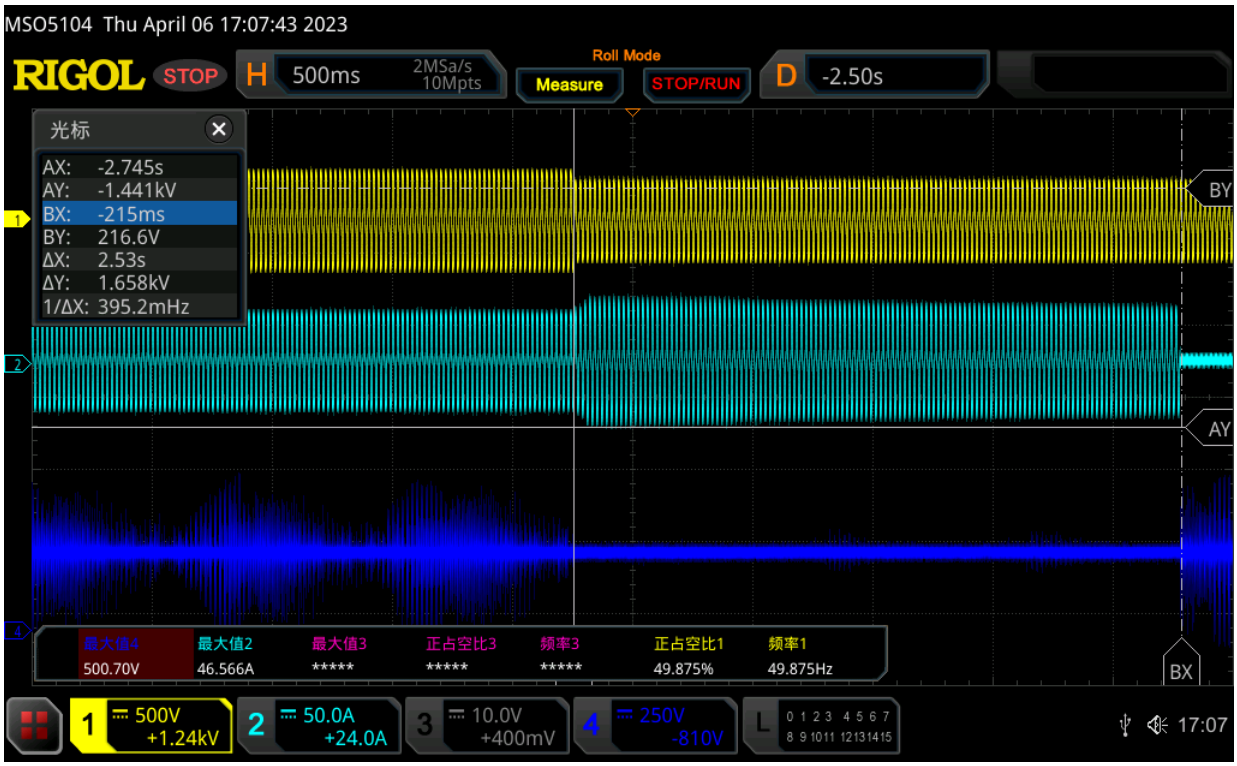
U/V -3


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

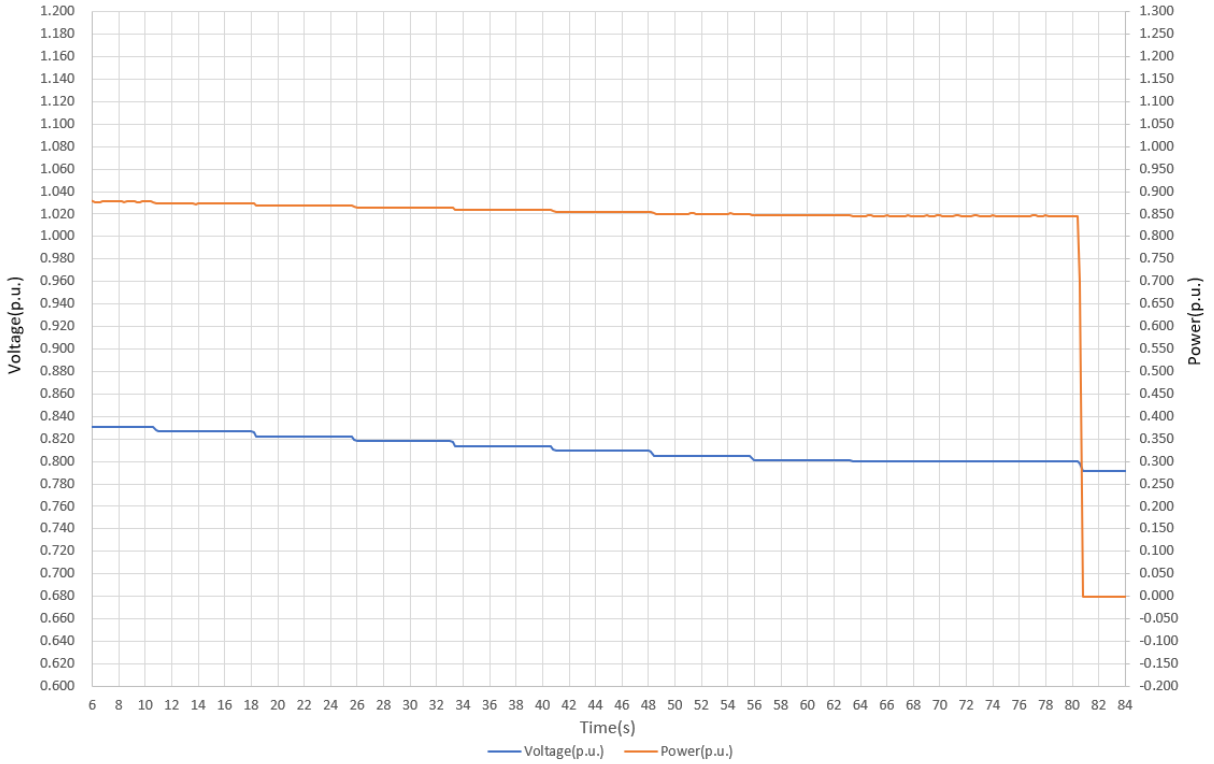

MSO5104 Thu April 06 17:01:37 2023
RIGOL
STOP
H 500ms 2MSa/s 10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -3.585s
AY: -1.441kV
BX: -1.06s
BY: 216.6V
ΔX: 2.525s
ΔY: 1.658kV
1/ΔX: 396mHz
BY
AY
BX
最大值4 389.43V
最大值2 46.566A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.700%
频率1 49.850Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
17:01

U/V -4


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

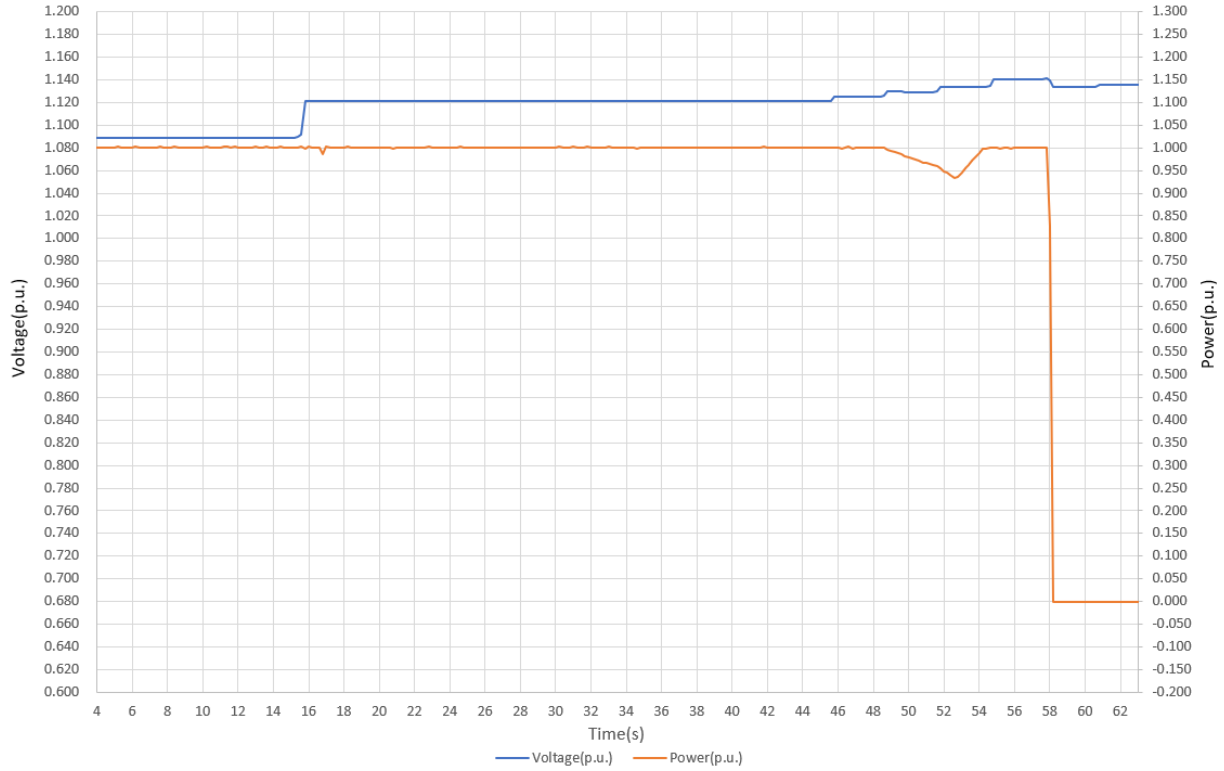

MSO5104 Thu April 06 17:07:43 2023
RIGOL
STOP
H 500ms 2MSa/s 10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -2.745s
AY: -1.441kV
BX: -215ms
BY: 216.6V
ΔX: 2.53s
ΔY: 1.658kV
1/ΔX: 395.2mHz
BY
AY
BX
最大值4 500.70V
最大值2 46.566A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.875%
频率1 49.875Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
17:07

U/V -5


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

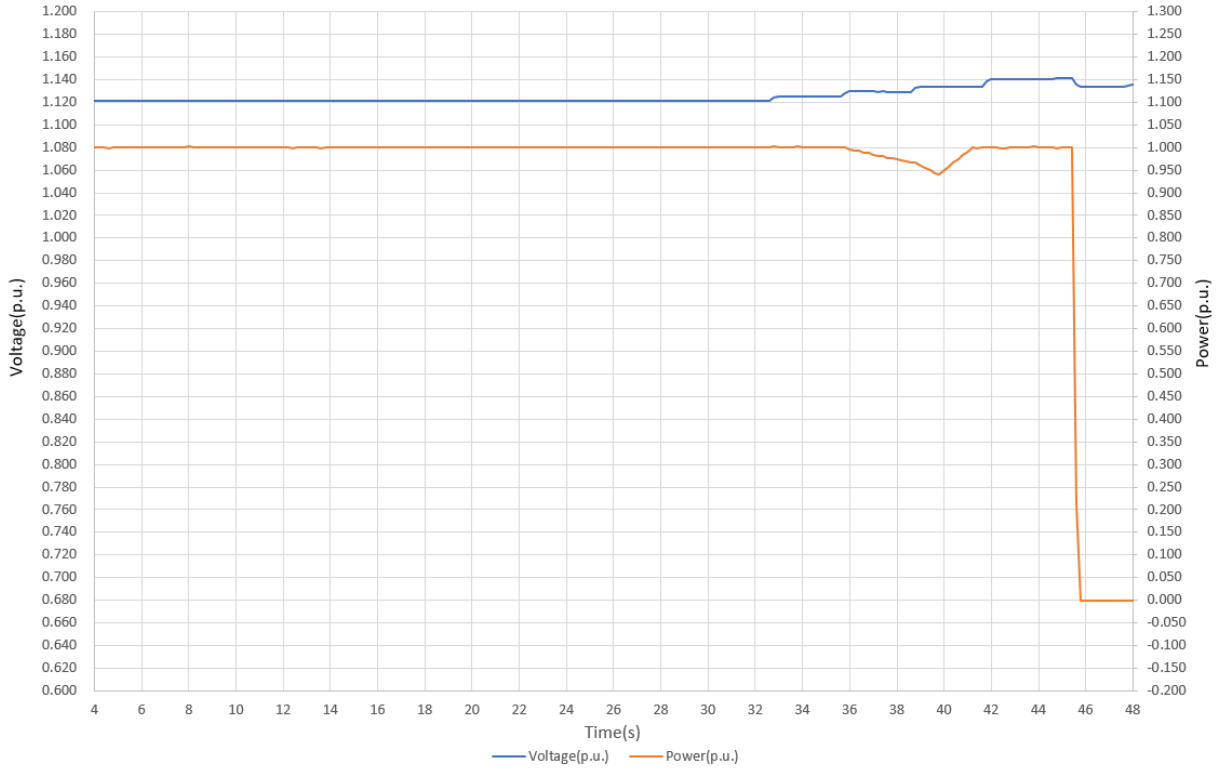

MSO5104 Thu April 06 17:14:53 2023
RIGOL
STOP
H 500ms 2MSa/s 10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -3.22s
AY: -1.441kV
BX: -685ms
BY: 216.6V
ΔX: 2.535s
ΔY: 1.658kV
1/ΔX: 394.4mHz
BY
AY
BX
最大值4 378.30V
最大值2 44.238A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 49.674%
频率1 50.100Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
17:14

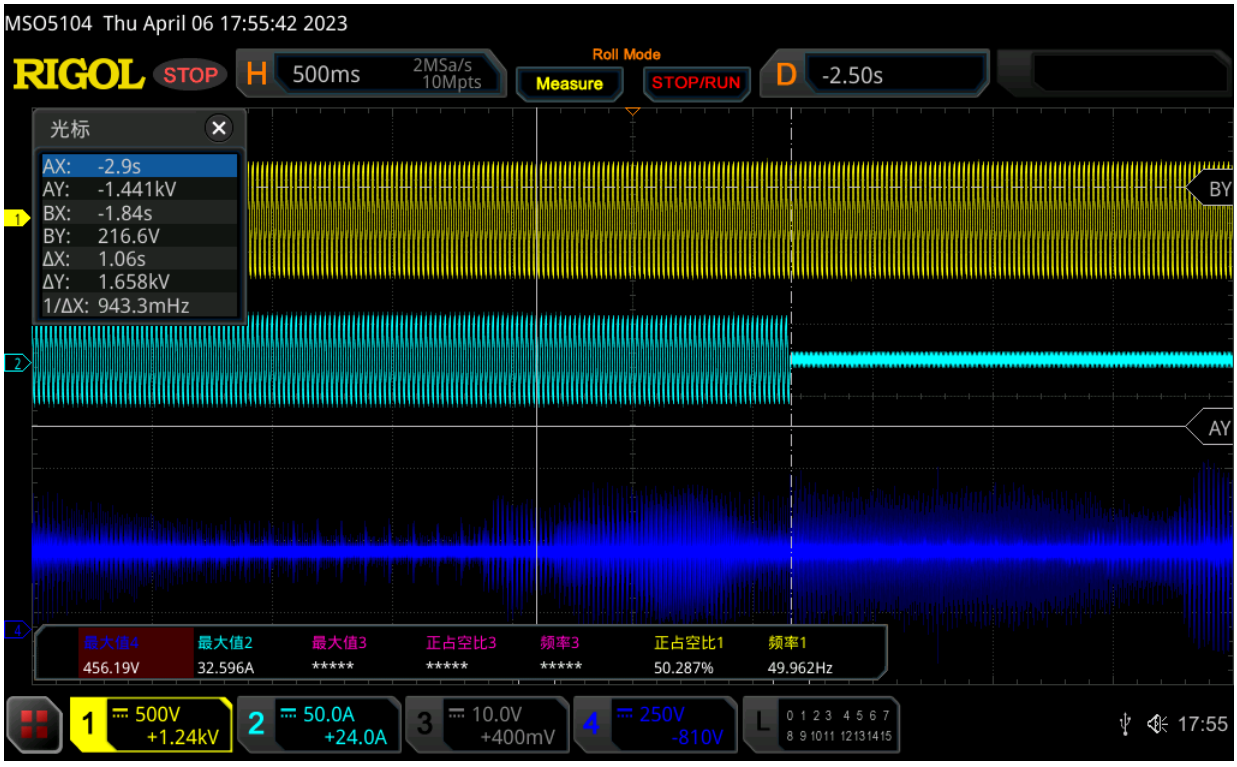
O/V stage 1-1


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

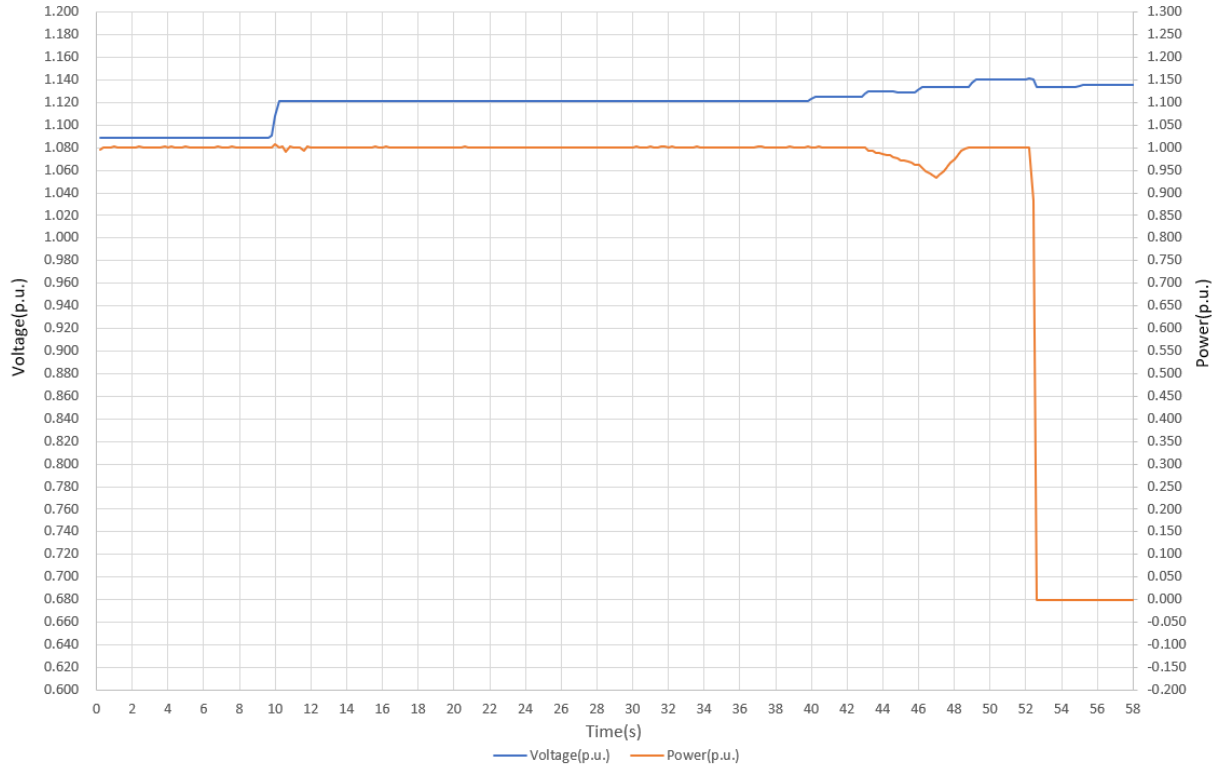

MSO5104 Thu April 06 17:53:48 2023
RIGOL
STOP
H 500ms
2MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -2.695s
AY: -1.441kV
BX: -1.64s
BY: 216.6V
ΔX: 1.055s
ΔY: 1.658kV
1/ΔX: 947.8mHz
BY
AY
最大值4 356.05V
最大值2 32.596A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 50.012%
频率1 49.763Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
17:53

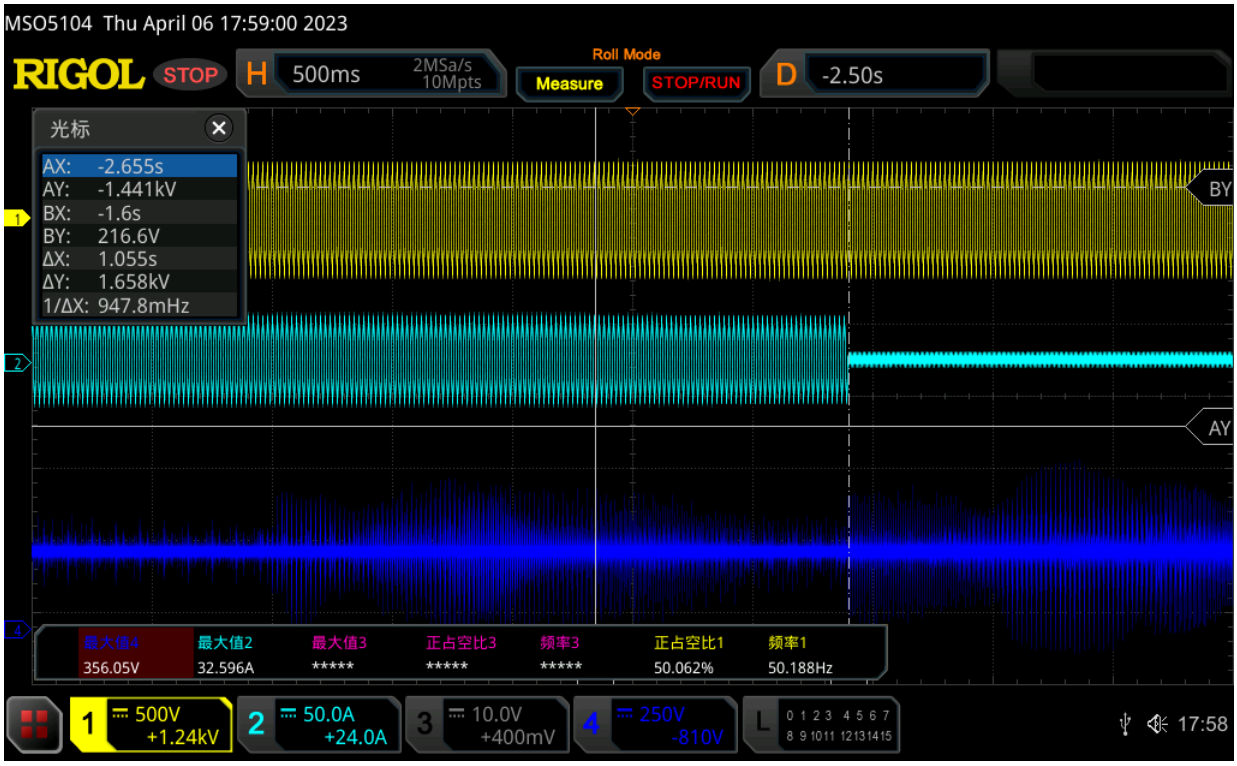
O/V stage 1-2


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

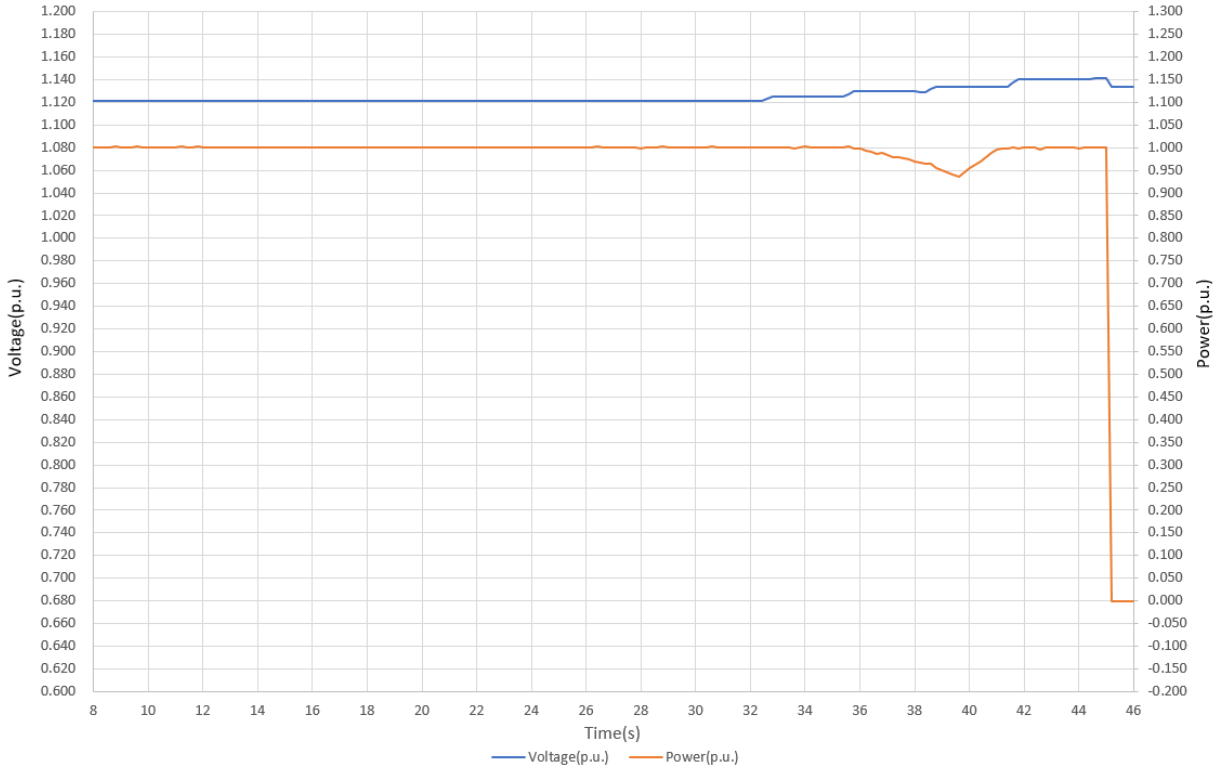

MSO5104 Thu April 06 17:55:42 2023
RIGOL
STOP
H 500ms 2MSa/s 10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -2.9s
AY: -1.441kV
BX: -1.84s
BY: 216.6V
ΔX: 1.06s
ΔY: 1.658kV
1/ΔX: 943.3mHz
BY
AY
最大值4 456.19V
最大值2 32.596A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 50.287%
频率1 49.962Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
17:55

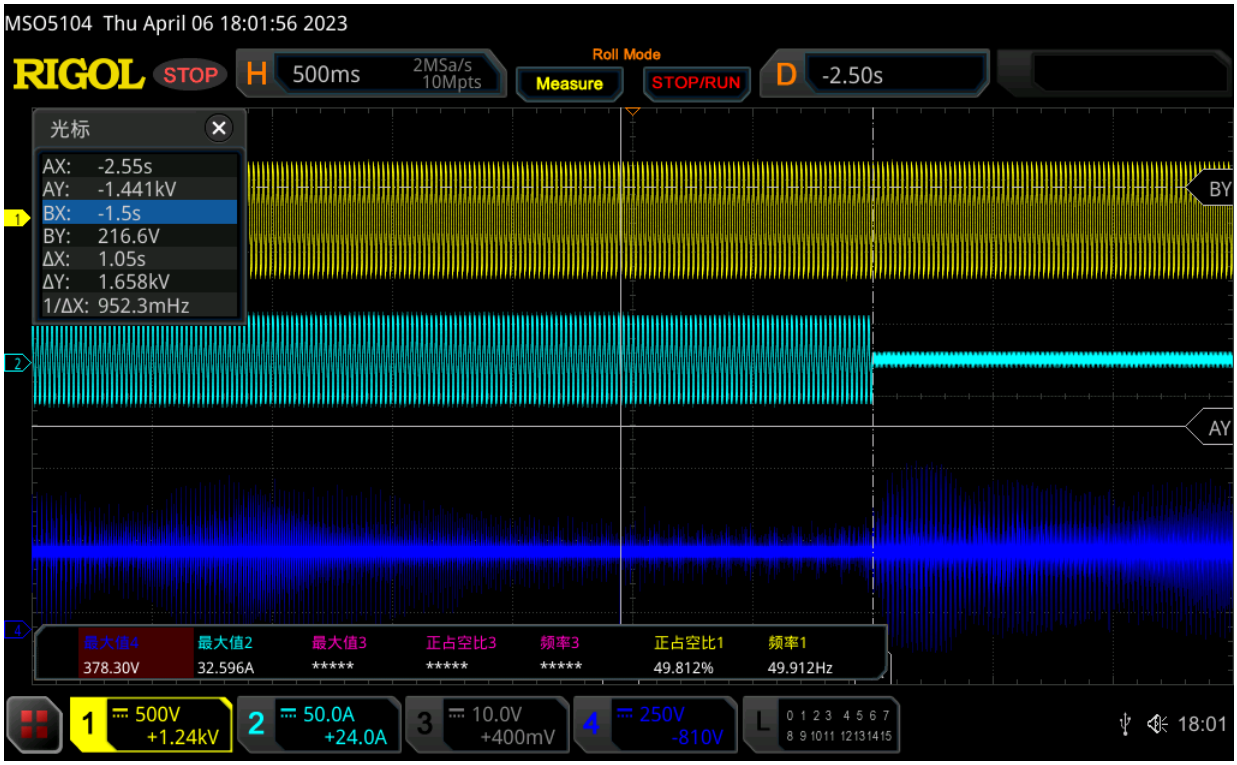
O/V stage 1-3


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

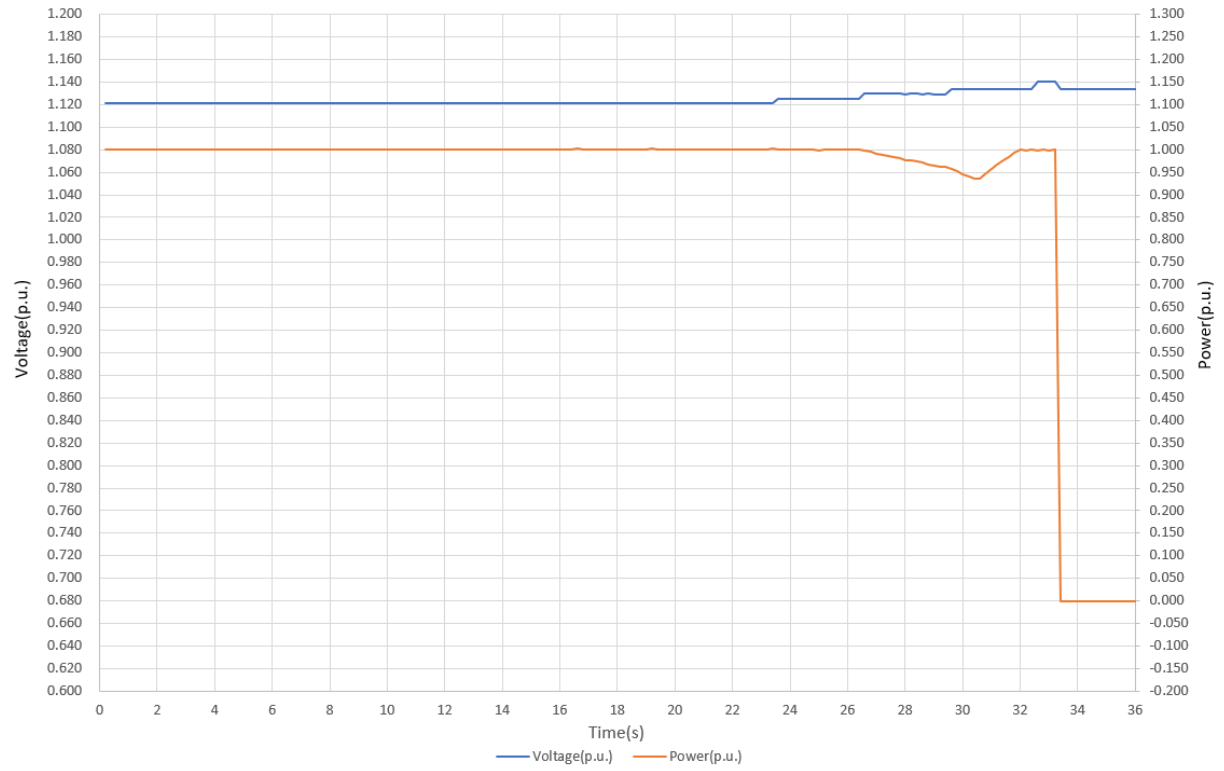

MSO5104 Thu April 06 17:59:00 2023
RIGOL
STOP
H 500ms
2MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -2.655s
AY: -1.441kV
BX: -1.6s
BY: 216.6V
ΔX: 1.055s
ΔY: 1.658kV
1/ΔX: 947.8mHz
BY
AY
最大值4 356.05V
最大值2 32.596A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 50.062%
频率1 50.188Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
17:58

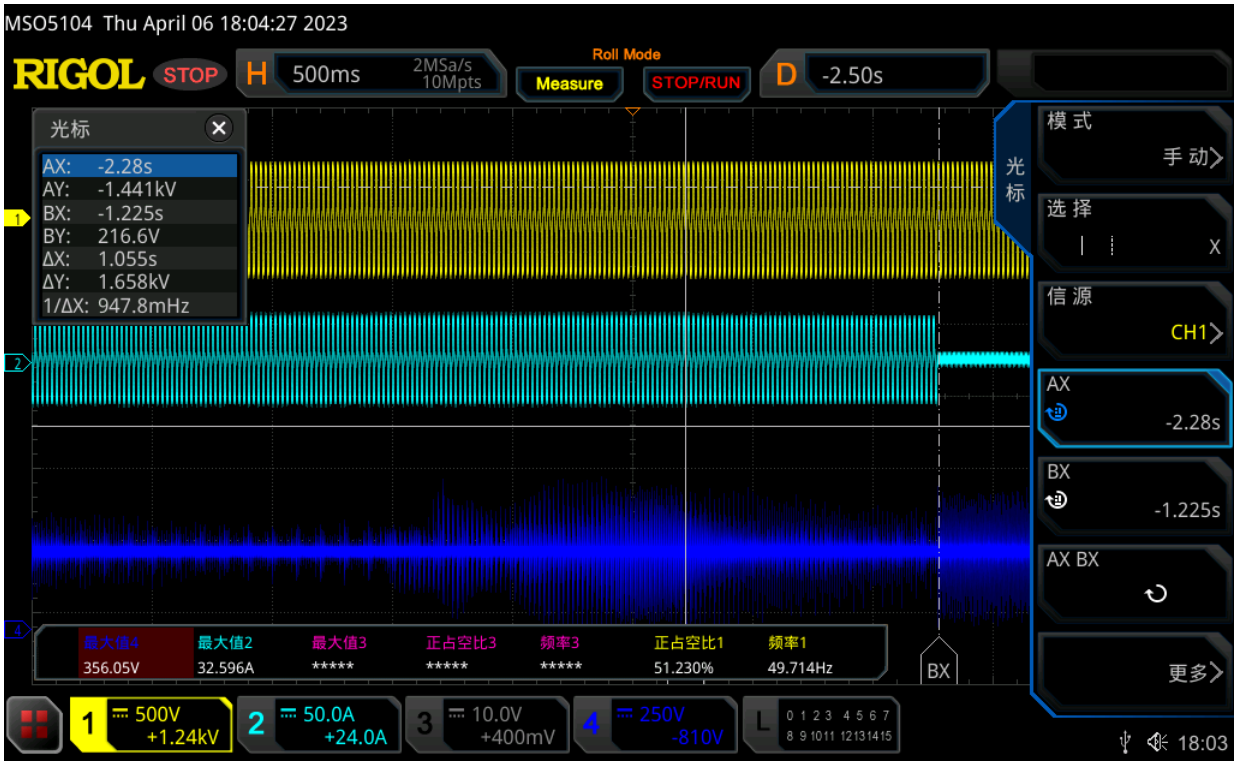
O/V stage 1-4


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

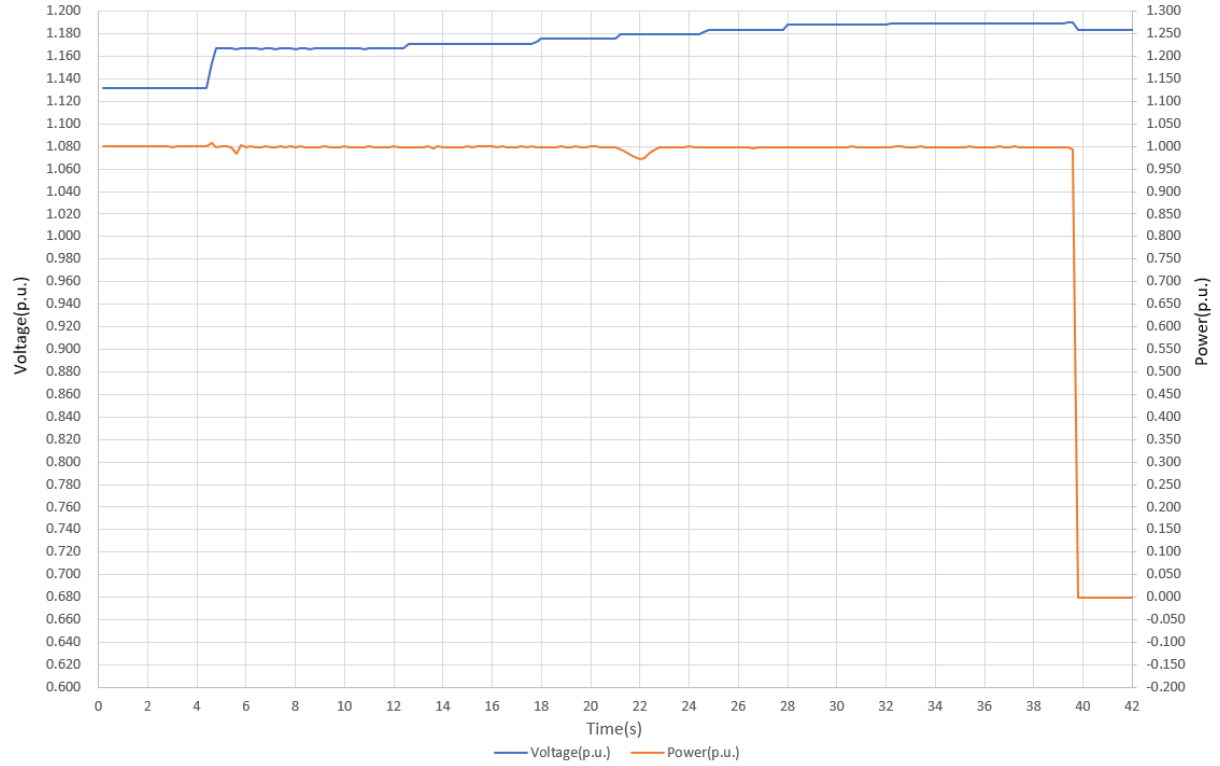

MSO5104 Thu April 06 18:01:56 2023
RIGOL
STOP
H 500ms
2MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -2.55s
AY: -1.441kV
BX: -1.5s
BY: 216.6V
ΔX: 1.05s
ΔY: 1.658kV
1/ΔX: 952.3mHz
BY
AY
最大值4 最大值2 最大值3 正占空比3 频率3 正占空比1 频率1
378.30V 32.596A ***** ***** ***** 49.812% 49.912Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
18:01

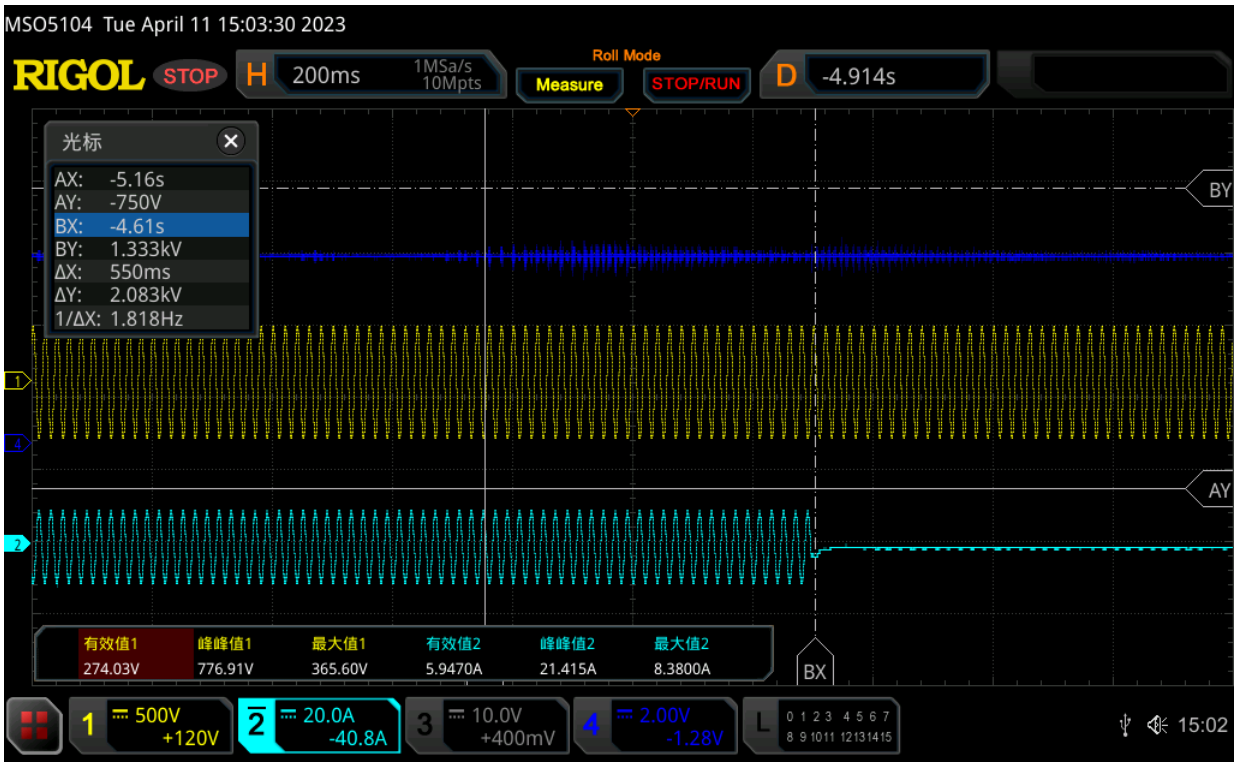
O/V stage 1-5


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

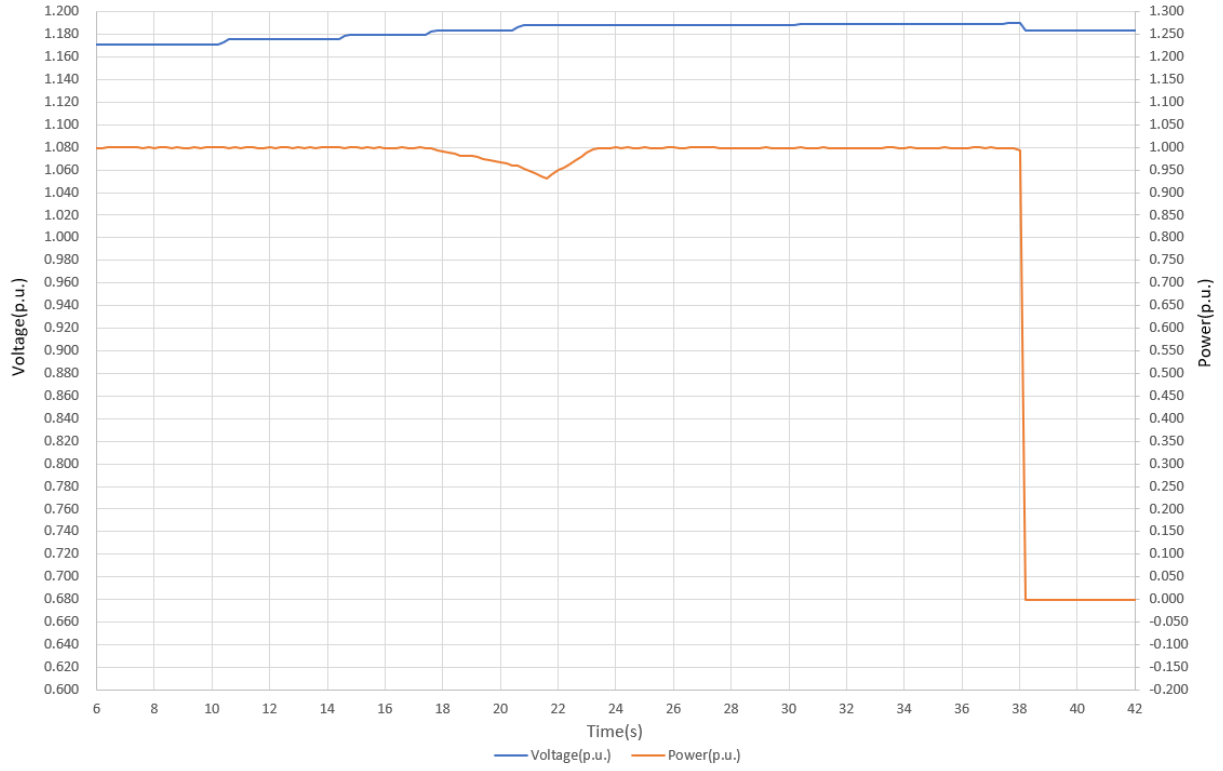

MSO5104 Thu April 06 18:04:27 2023
RIGOL
STOP
H 500ms 2MSa/s 10Mpts
Roll Mode
Measure
STOP/RUN
D -2.50s
光标
AX: -2.28s
AY: -1.441kV
BX: -1.225s
BY: 216.6V
ΔX: 1.055s
ΔY: 1.658kV
1/ΔX: 947.8mHz
模式
手动
选择
信源
CH1
AX
-2.28s
BX
-1.225s
AX BX
更多
最大值4 356.05V
最大值2 32.596A
最大值3 *****
正占空比3 *****
频率3 *****
正占空比1 51.230%
频率1 49.714Hz
1 500V +1.24kV
2 50.0A +24.0A
3 10.0V +400mV
4 250V -810V
18:03

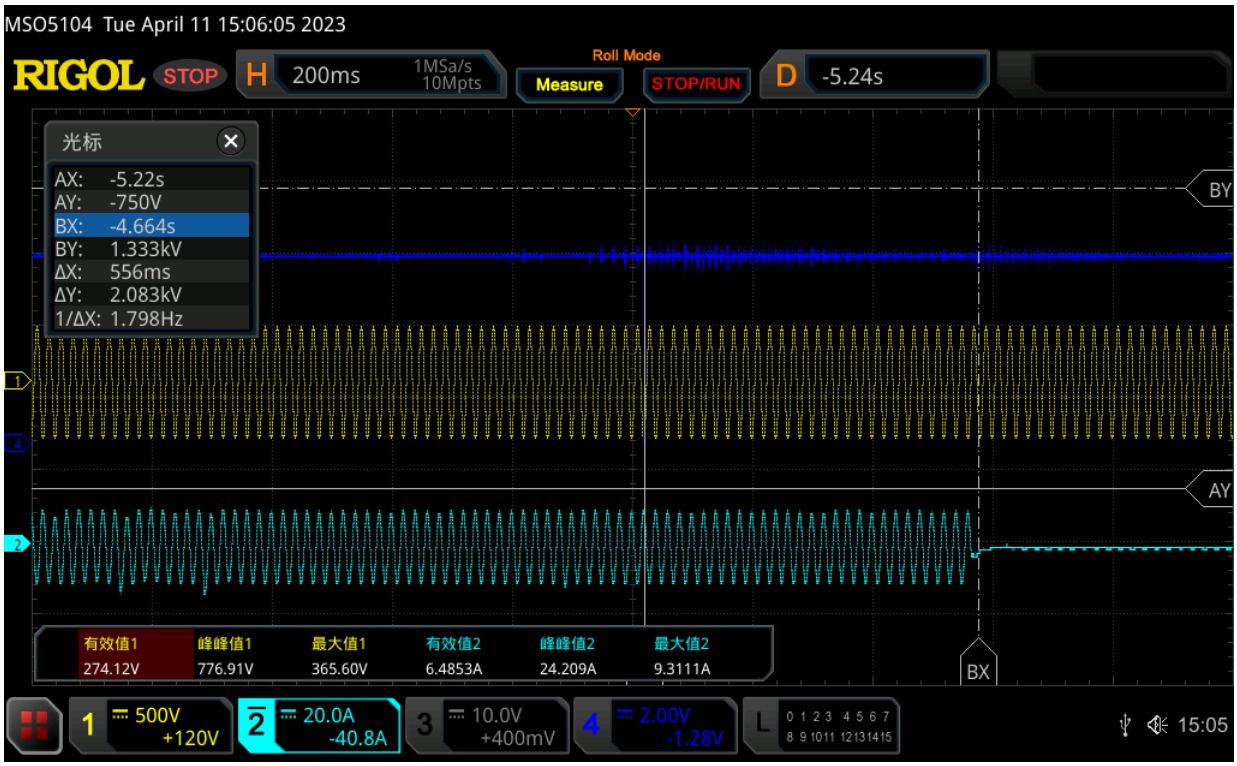
O/V stage 2-1


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

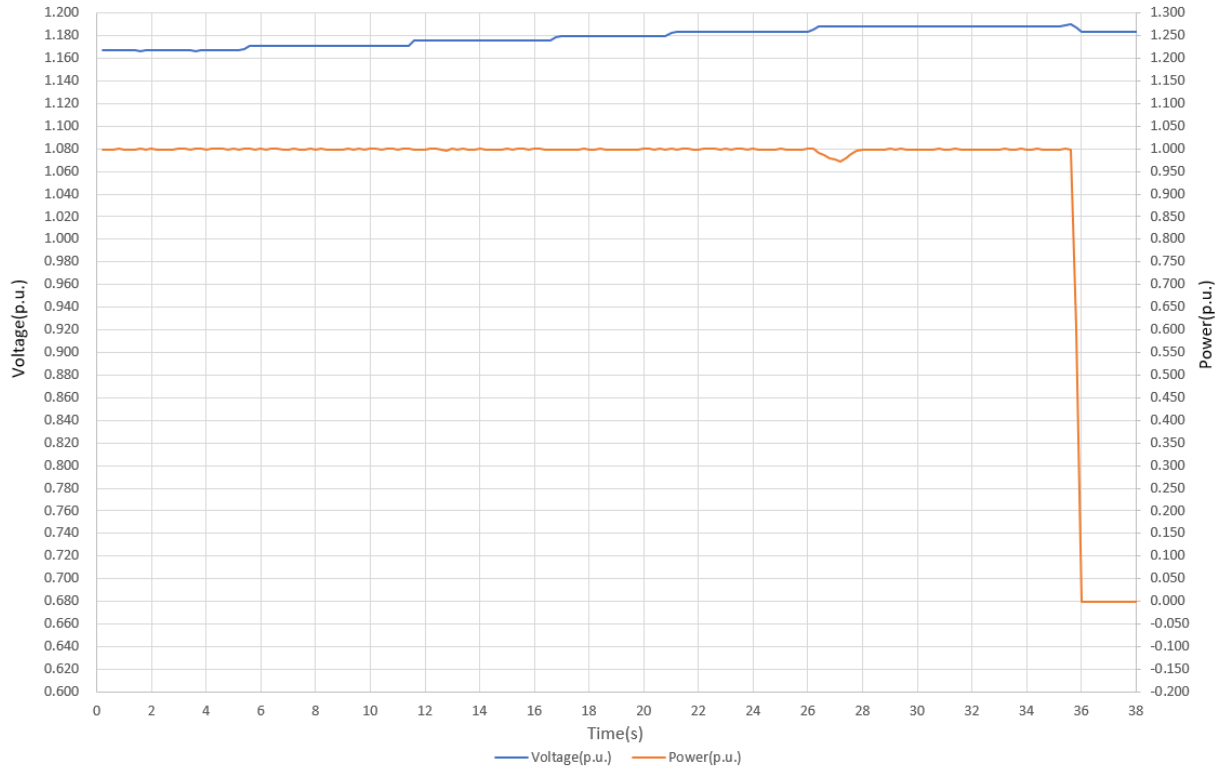

MSO5104 Tue April 11 15:03:30 2023
RIGOL
STOP
H 200ms
1MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -4.914s
光标
AX: -5.16s
AY: -750V
BX: -4.61s
BY: 1.333kV
ΔX: 550ms
ΔY: 2.083kV
1/ΔX: 1.818Hz
BY
AY
BX
有效值1 峰峰值1 最大值1 有效值2 峰峰值2 最大值2
274.03V 776.91V 365.60V 5.9470A 21.415A 8.3800A
1 500V +120V
2 20.0A -40.8A
3 10.0V +400mV
4 2.00V -1.28V
15:02

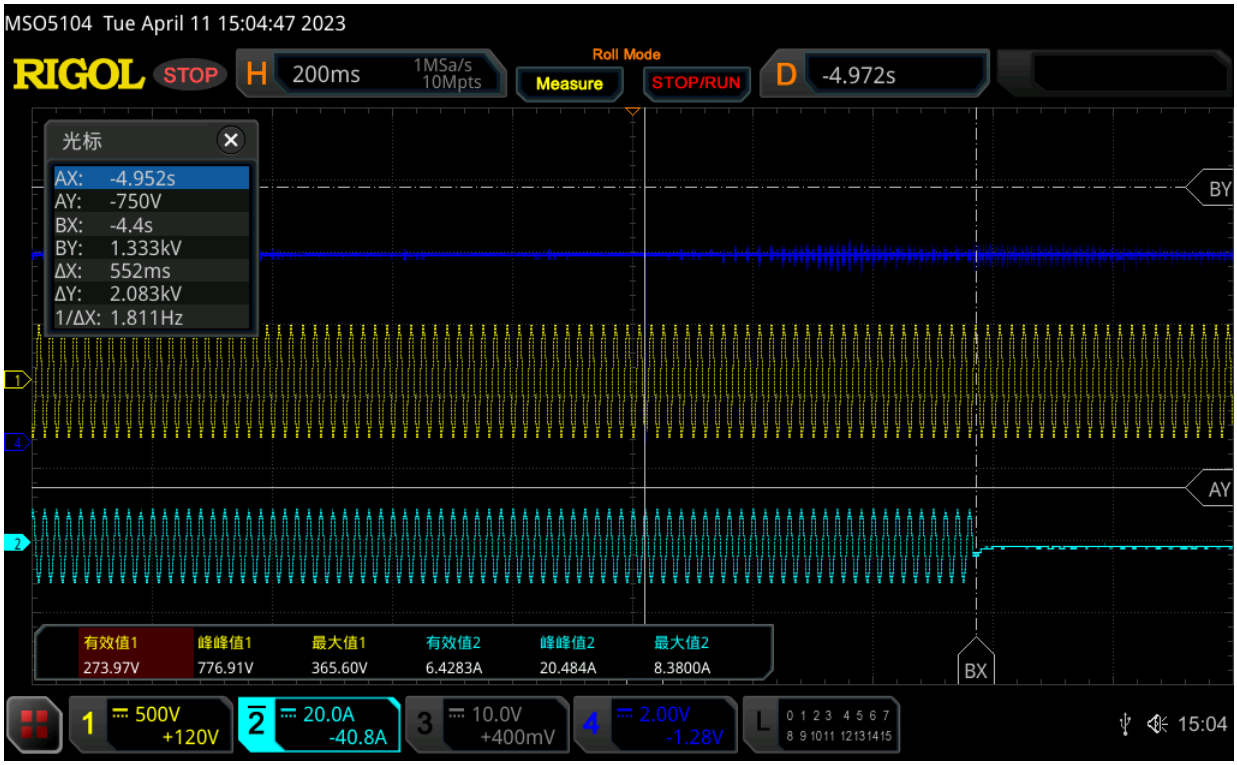
O/V stage 2-2


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

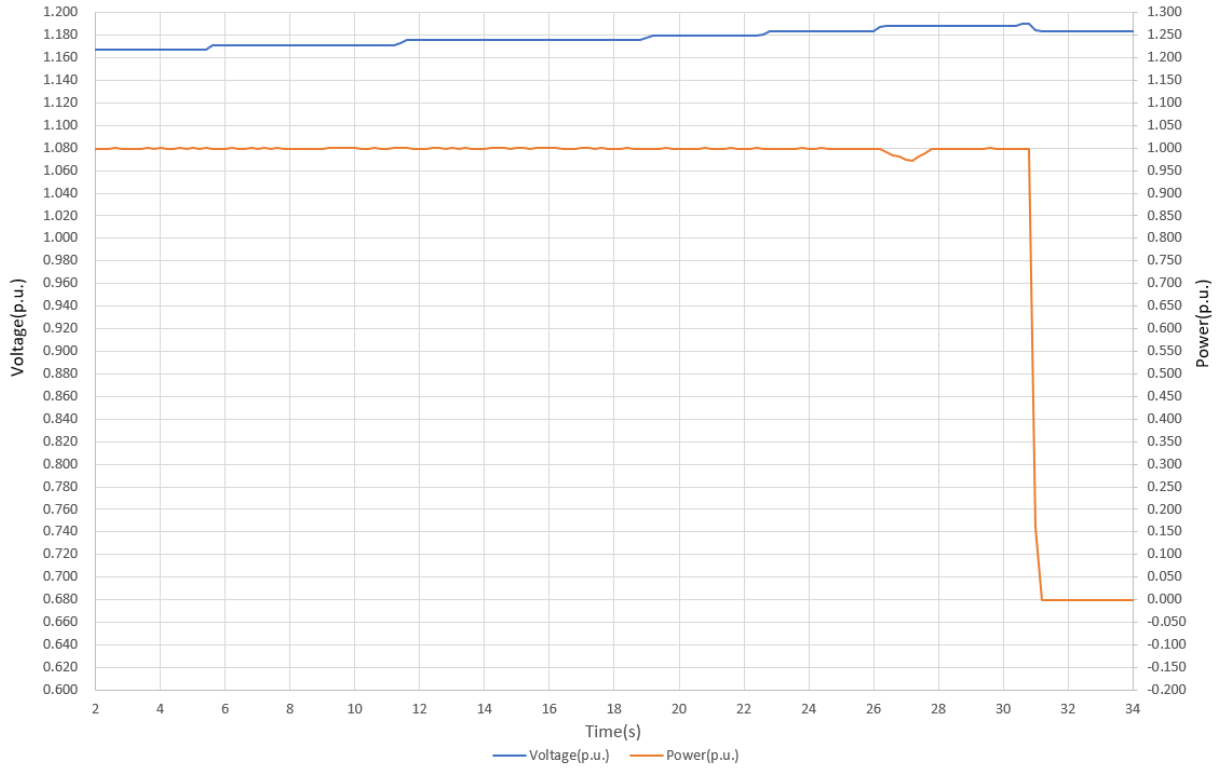

MSO5104 Tue April 11 15:06:05 2023
RIGOL
STOP
H 200ms
1MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -5.24s
光标
AX: -5.22s
AY: -750V
BX: -4.664s
BY: 1.333kV
ΔX: 556ms
ΔY: 2.083kV
1/ΔX: 1.798Hz
BY
AY
BX
有效值1 峰峰值1 最大值1 有效值2 峰峰值2 最大值2
274.12V 776.91V 365.60V 6.4853A 24.209A 9.3111A
1 500V +120V
2 20.0A -40.8A
3 10.0V +400mV
4 2.00V -1.28V
15:05

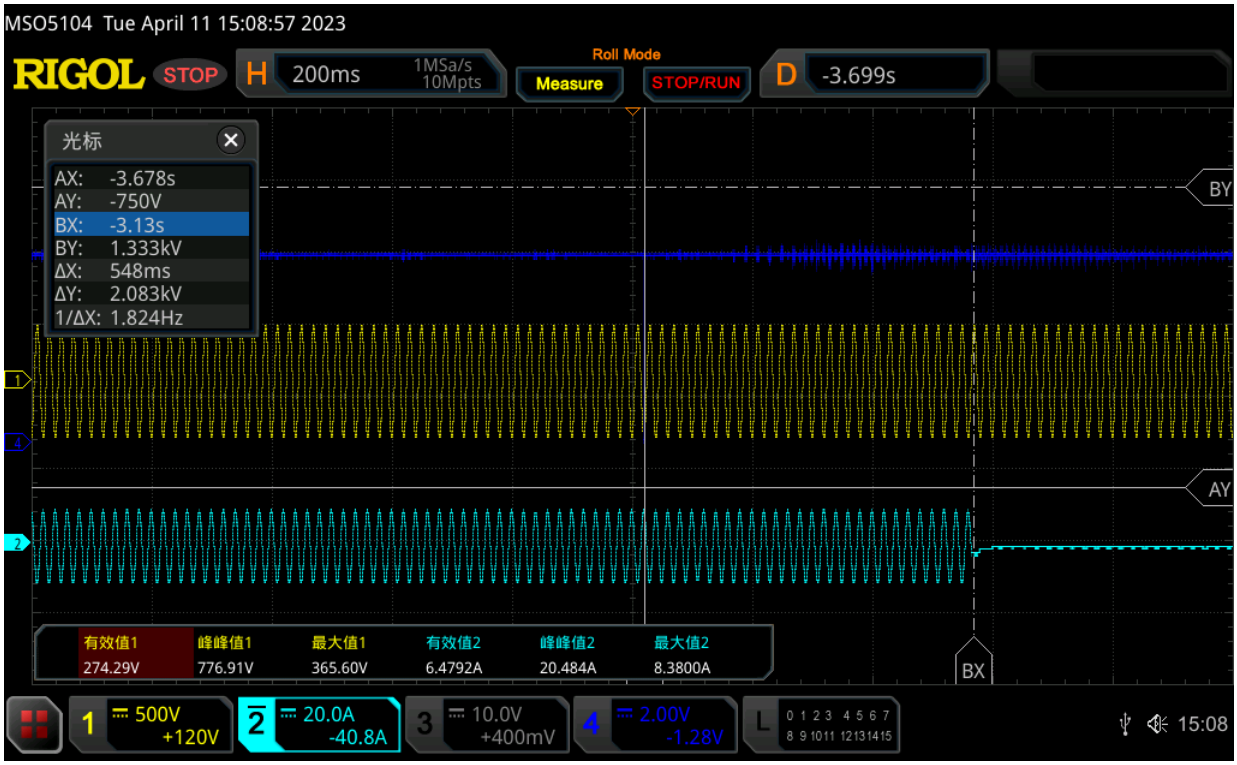
O/V stage 2-3


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

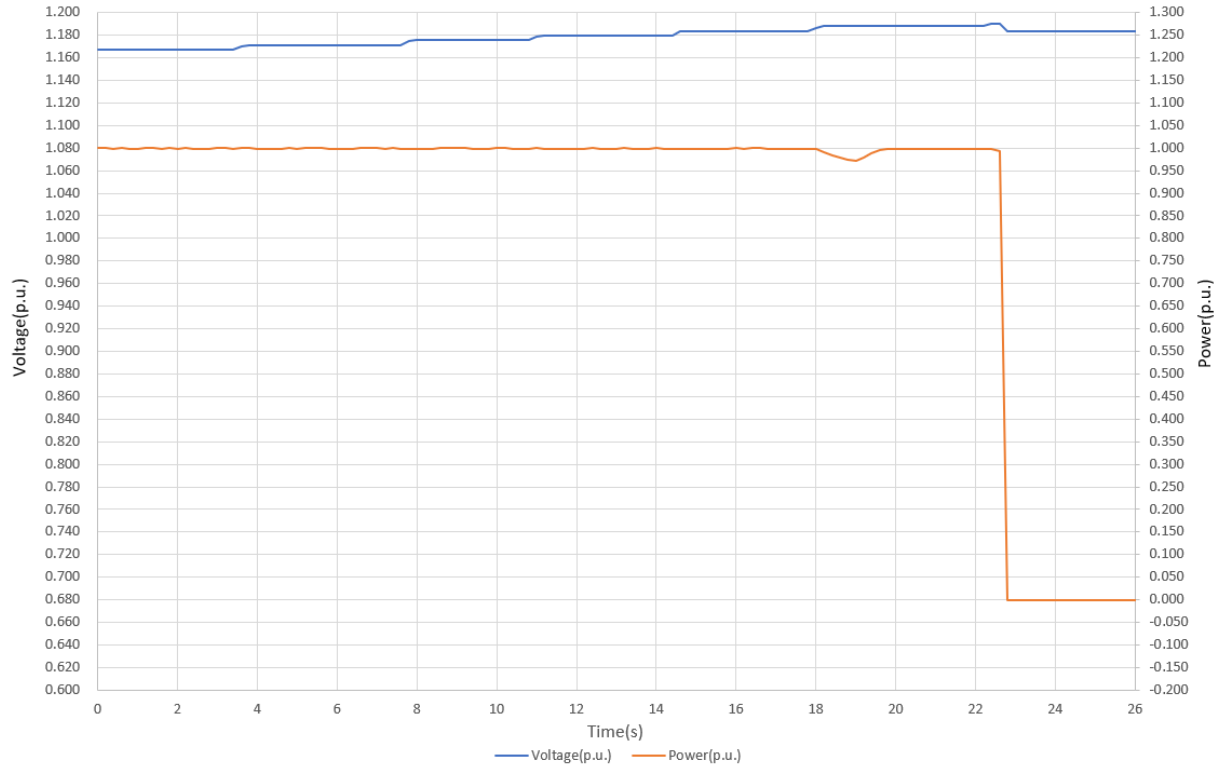

MSO5104 Tue April 11 15:04:47 2023
RIGOL
STOP
H 200ms
1MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -4.972s
光标
AX: -4.952s
AY: -750V
BX: -4.4s
BY: 1.333kV
ΔX: 552ms
ΔY: 2.083kV
1/ΔX: 1.811Hz
BY
AY
BX
有效值1 峰峰值1 最大值1 有效值2 峰峰值2 最大值2
273.97V 776.91V 365.60V 6.4283A 20.484A 8.3800A
1 500V +120V
2 20.0A -40.8A
3 10.0V +400mV
4 2.00V -1.28V
15:04

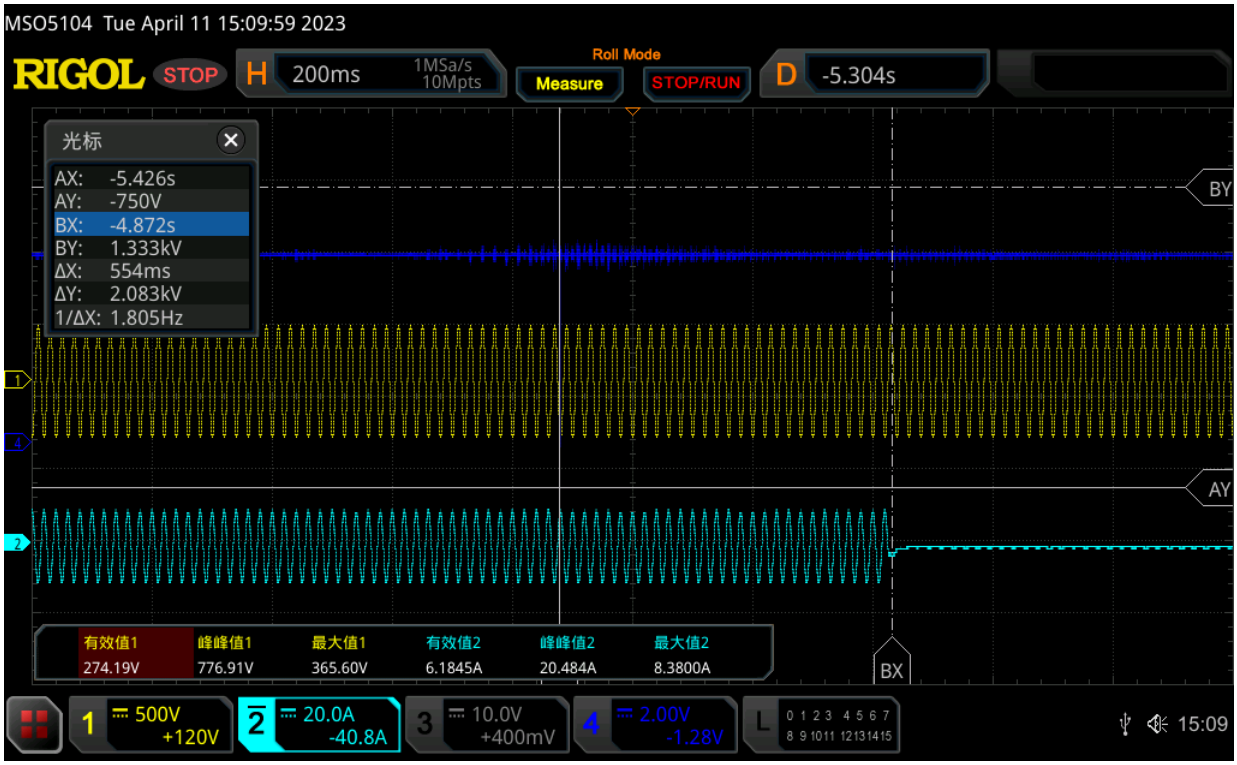
O/V stage 2-4


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

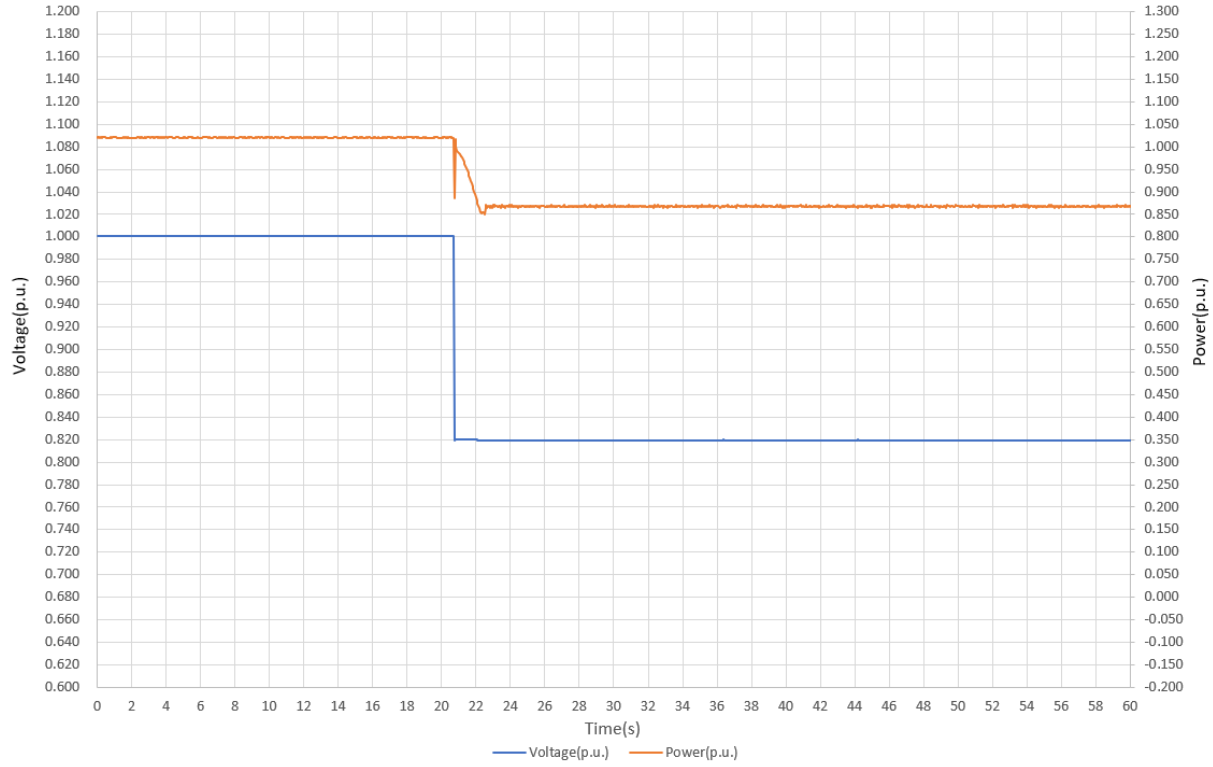

MSO5104 Tue April 11 15:08:57 2023
RIGOL
STOP
H 200ms
1MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -3.699s
光标
AX: -3.678s
AY: -750V
BX: -3.13s
BY: 1.333kV
ΔX: 548ms
ΔY: 2.083kV
1/ΔX: 1.824Hz
BY
AY
BX
有效值1 峰峰值1 最大值1 有效值2 峰峰值2 最大值2
274.29V 776.91V 365.60V 6.4792A 20.484A 8.3800A
1 500V +120V
2 20.0A -40.8A
3 10.0V +400mV
4 2.00V -1.28V
15:08

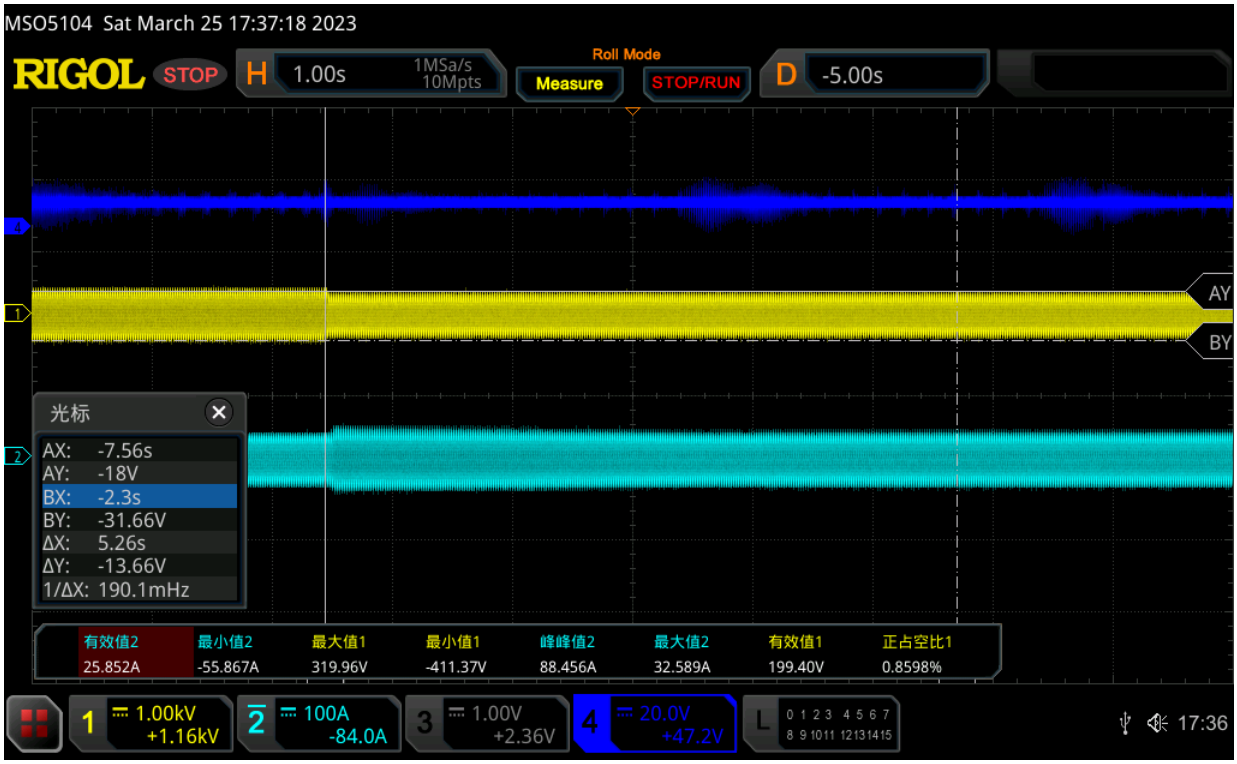
O/V stage 2-5


Voltage(p.u.)
Power(p.u.)
Time(s)
Voltage(p.u.)
Power(p.u.)

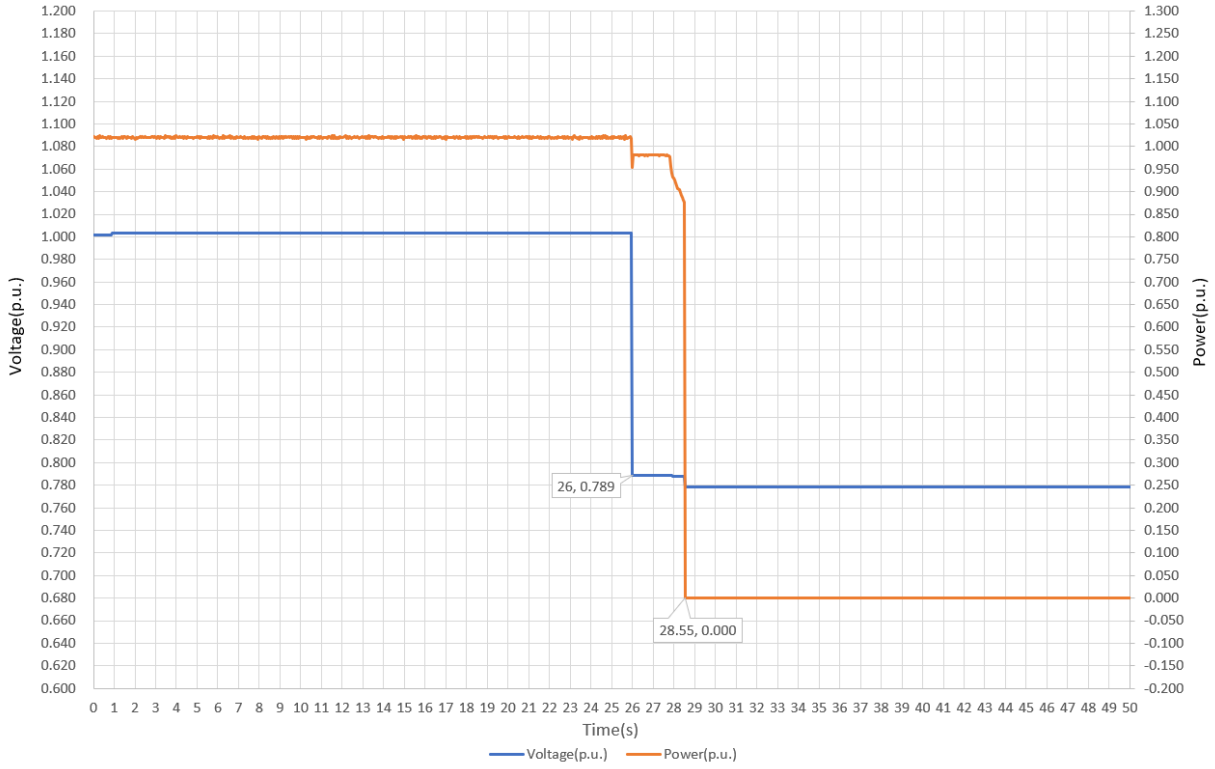

MSO5104 Tue April 11 15:09:59 2023
RIGOL
STOP
H 200ms
1MSa/s
10Mpts
Roll Mode
Measure
STOP/RUN
D -5.304s
光标
AX: -5.426s
AY: -750V
BX: -4.872s
BY: 1.333kV
ΔX: 554ms
ΔY: 2.083kV
1/ΔX: 1.805Hz
BY
AY
BX
有效值1 峰峰值1 最大值1 有效值2 峰峰值2 最大值2
274.19V 776.91V 365.60V 6.1845A 20.484A 8.3800A
1 500V +120V
2 20.0A -40.8A
3 10.0V +400mV
4 2.00V -1.28V
15:09

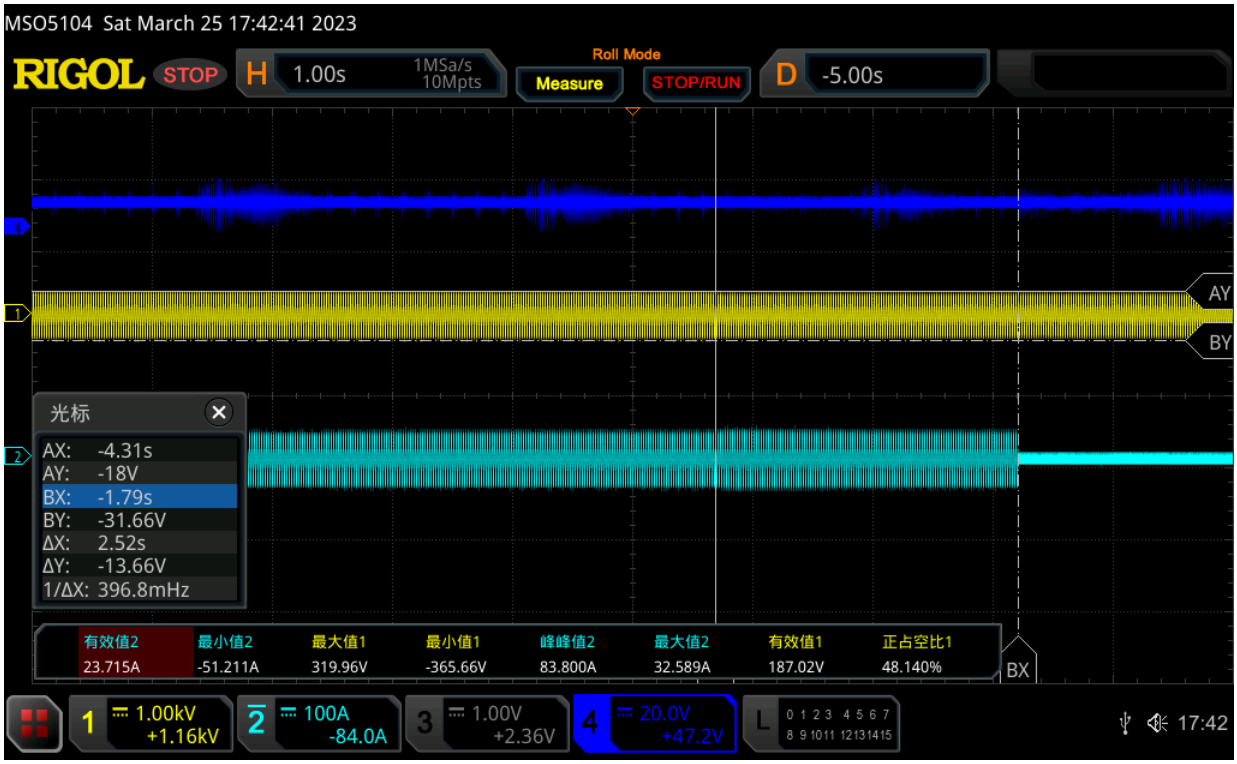
No trip tests – 188V



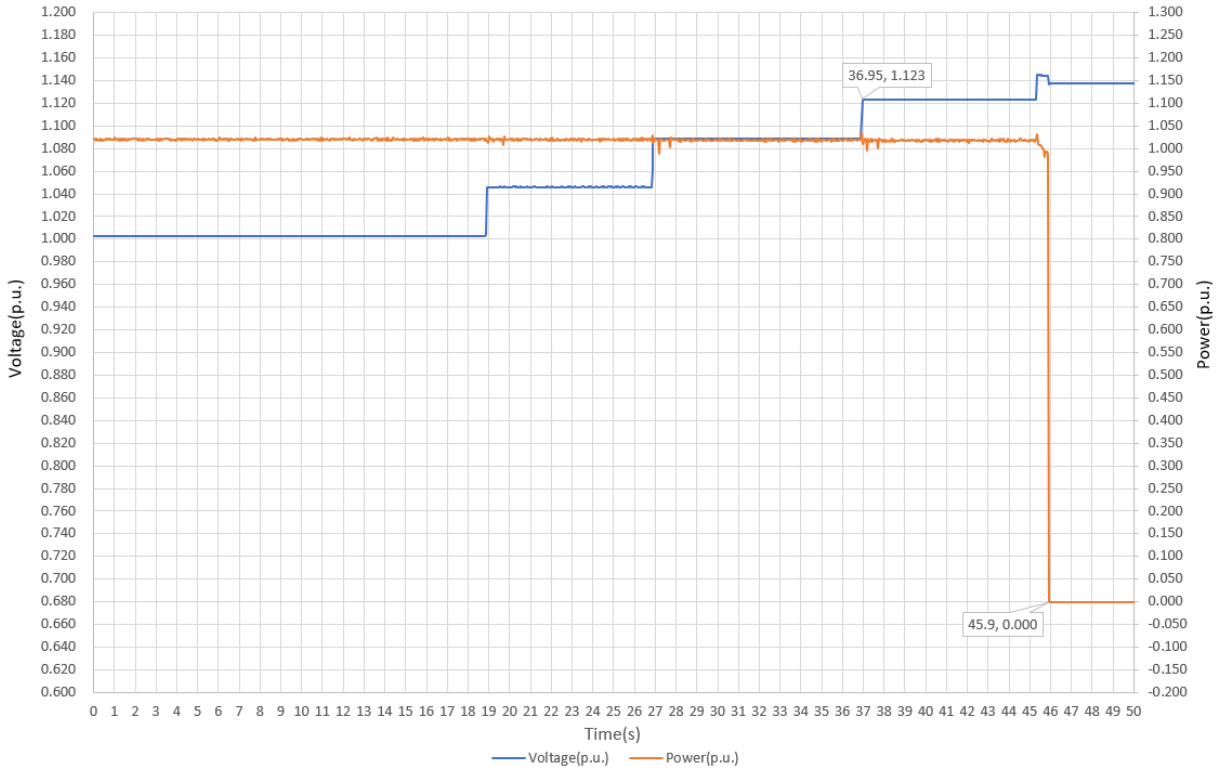


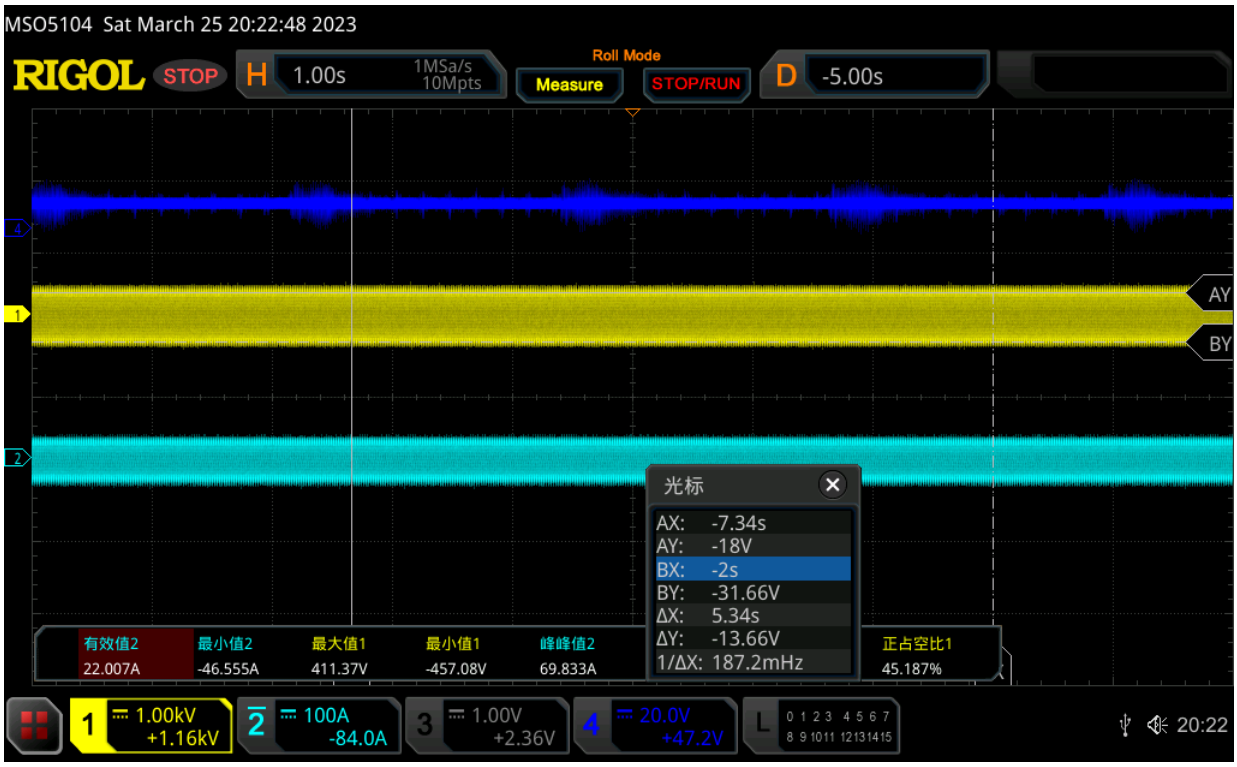
No trip tests – 180V



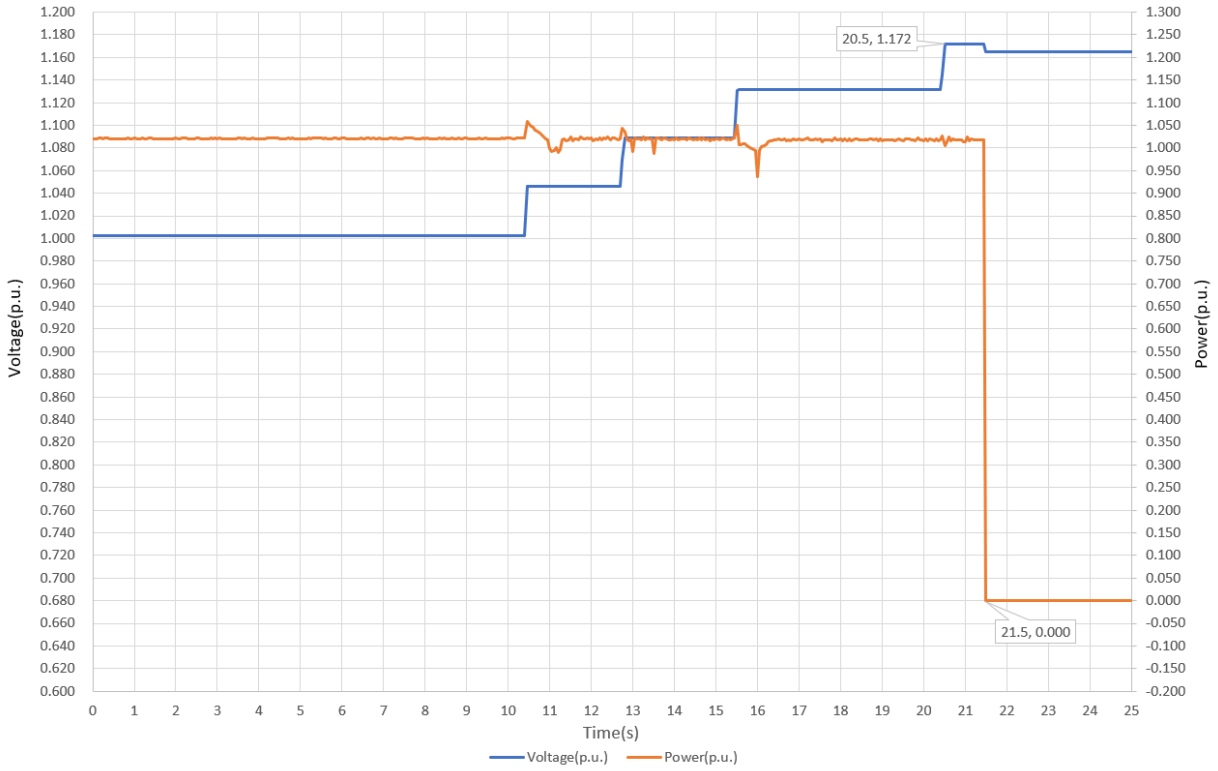


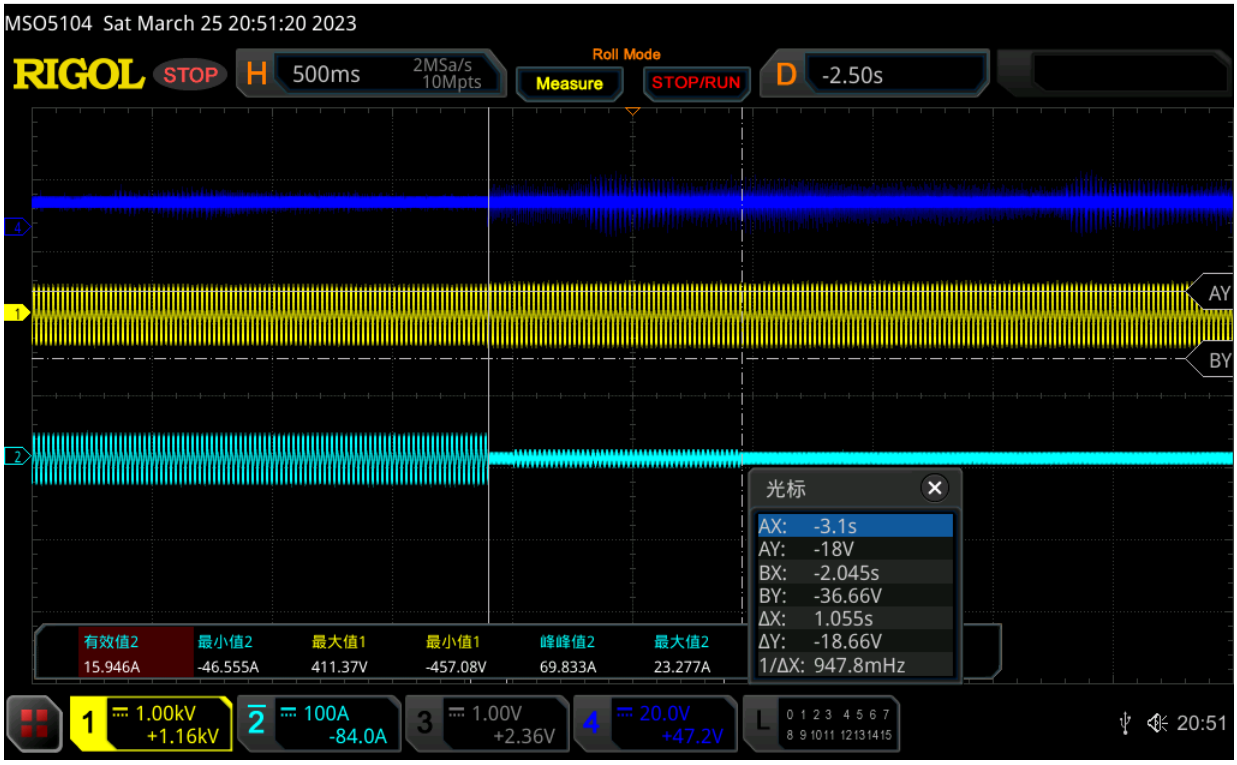
No trip tests – 258.2V



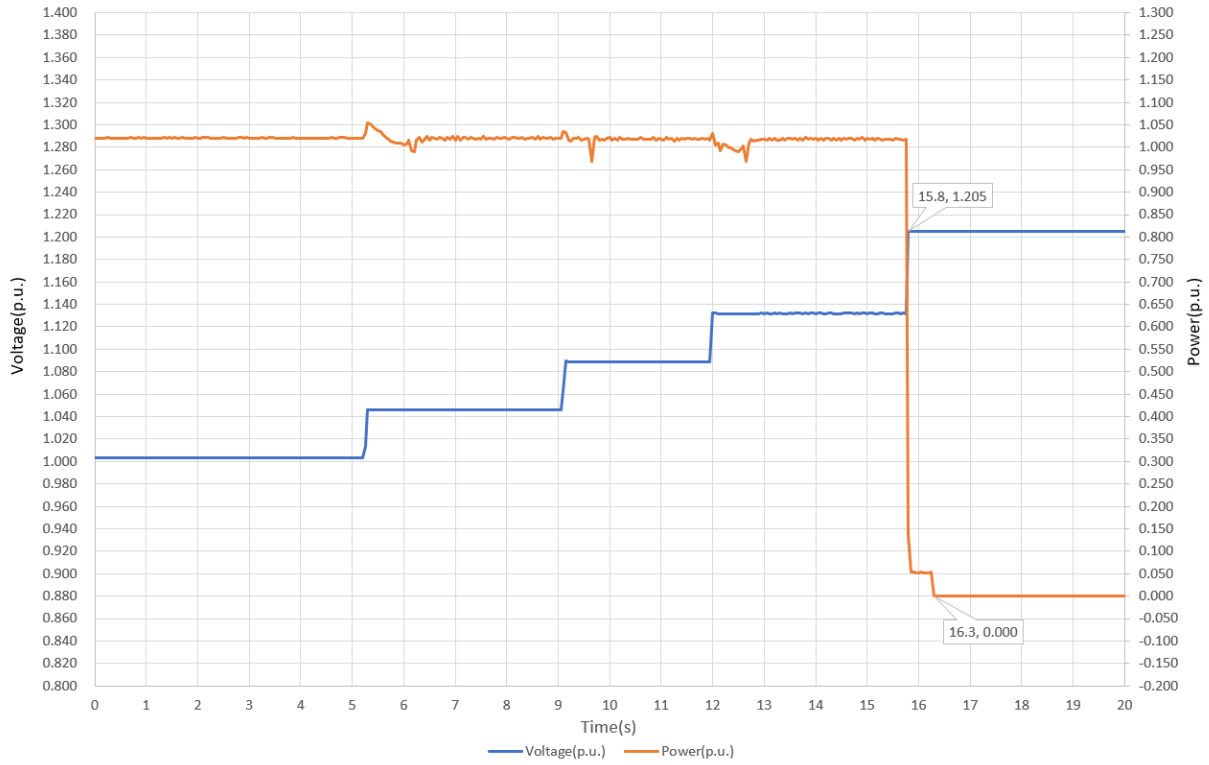


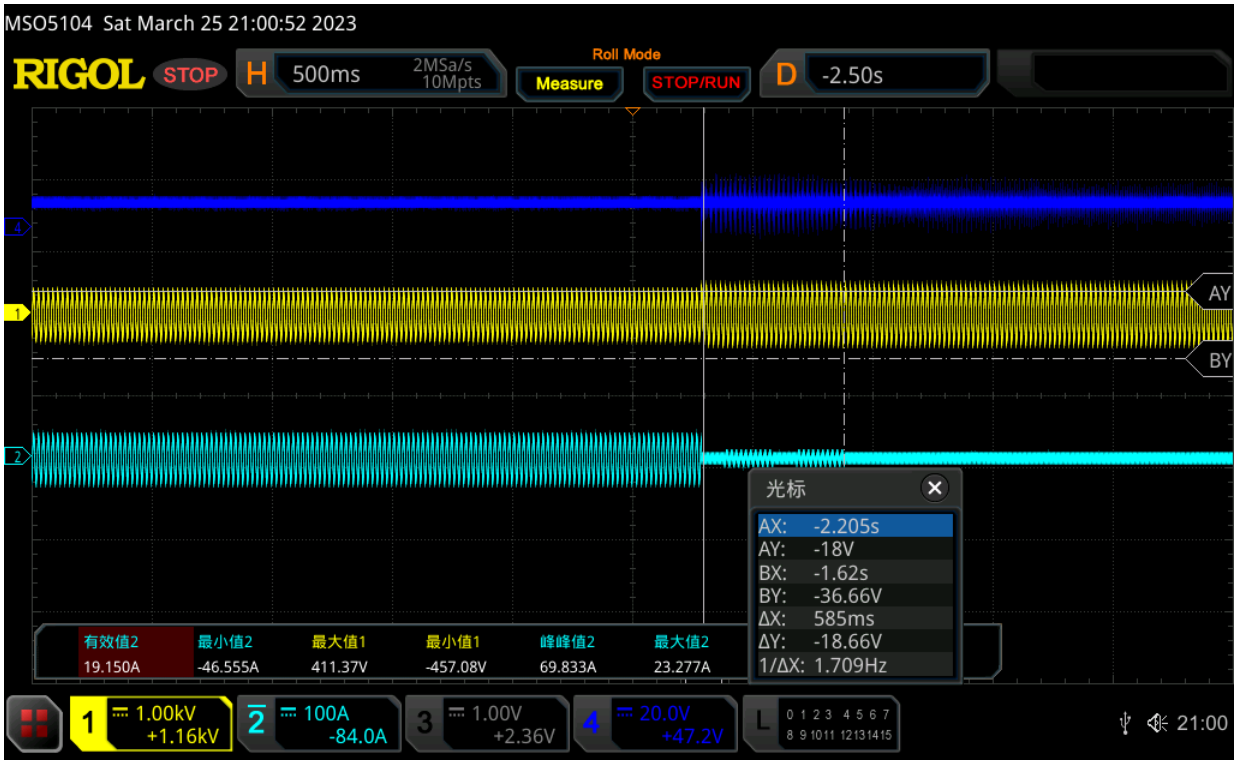
No trip tests – 269.7V





No trip tests – 277.7V





4.3.3 Loss of Mains test

These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4.

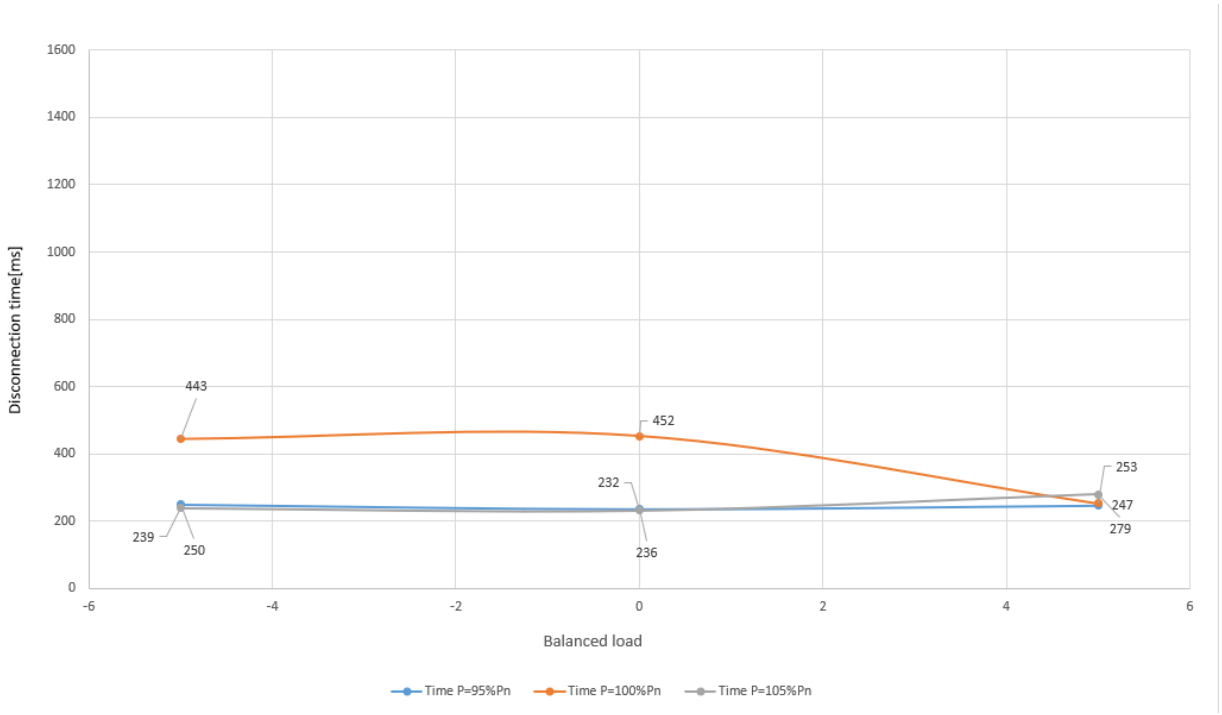
The maximum trip time is 0.5 s.

Note for technologies which have a substantial shut down time this can be added to the 0.5 s in establishing that the trip occurred in less than 0.5 s. Maximum shut down time could therefore be up to 1.0 s for these technologies.

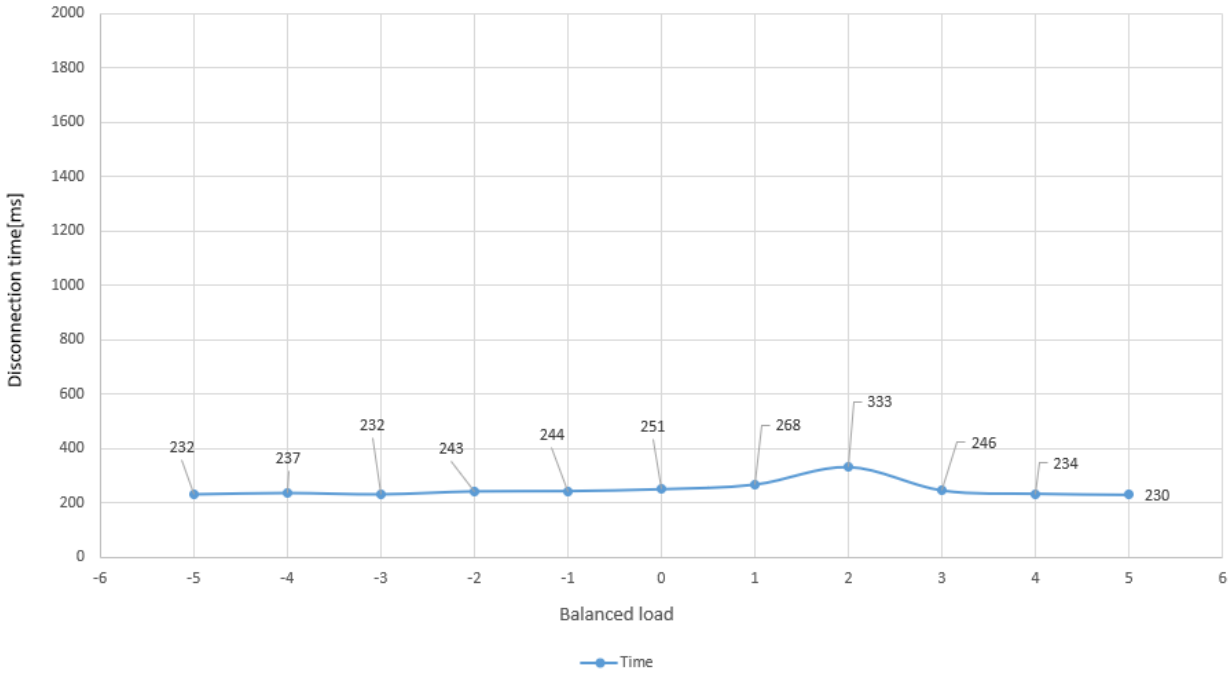
Following tables show the test results:

	Table: tested condition and trip time					P
No.	P_{EUT} (% of EUT rating)	Reactive load (% of normial)	P_{AC}	Q_{AC}	Trip time (s)	Which load is selected to be adjusted (R or L)
Test condition A						
1	100	100	0	0	0.452	--
2	100	100	-5	-5	0.250	R/L
3	100	100	-5	0	0.236	R
4	100	100	-5	+5	0.247	R/L
5	100	100	0	-5	0.443	L
6	100	100	0	+5	0.253	L
7	100	100	+5	-5	0.239	R/L
8	100	100	+5	0	0.232	R
9	100	100	+5	+5	0.279	R/L
10	100	100	-10	+10	--	R/L
11	100	100	-5	+10	--	R/L
12	100	100	0	+10	--	L
13	100	100	+10	+10	--	R/L
14	100	100	+10	+5	--	R/L
15	100	100	+10	0	--	R
16	100	100	+10	-5	--	R/L
17	100	100	+10	-10	--	R/L
18	100	100	+5	-10	--	R/L
19	100	100	+5	+10	--	R/L
20	100	100	0	-10	--	L
21	100	100	-5	-10	--	R/L
22	100	100	-10	-10	--	R/L
23	100	100	-10	-5	--	R/L
24	100	100	-10	0	--	R
25	100	100	-10	+5	--	R/L
Test condition B						
1	66	66	0	0	0.251	--
2	66	66	0	-5	0.232	L
3	66	66	0	-4	0.237	L
4	66	66	0	-3	0.232	L
5	66	66	0	-2	0.243	L
6	66	66	0	-1	0.244	L
7	66	66	0	1	0.268	L
8	66	66	0	2	0.333	L
9	66	66	0	3	0.246	L
10	66	66	0	4	0.234	L
11	66	66	0	5	0.230	L
Test condition C						
1	33	33	0	0	0.249	--
2	33	33	0	-5	0.241	L
3	33	33	0	-4	0.243	L
4	33	33	0	-3	0.245	L
5	33	33	0	-2	0.238	L
6	33	33	0	-1	0.232	L
7	33	33	0	1	0.240	L
8	33	33	0	2	0.232	L
9	33	33	0	3	0.228	L
10	33	33	0	4	0.230	L
11	33	33	0	5	0.228	L

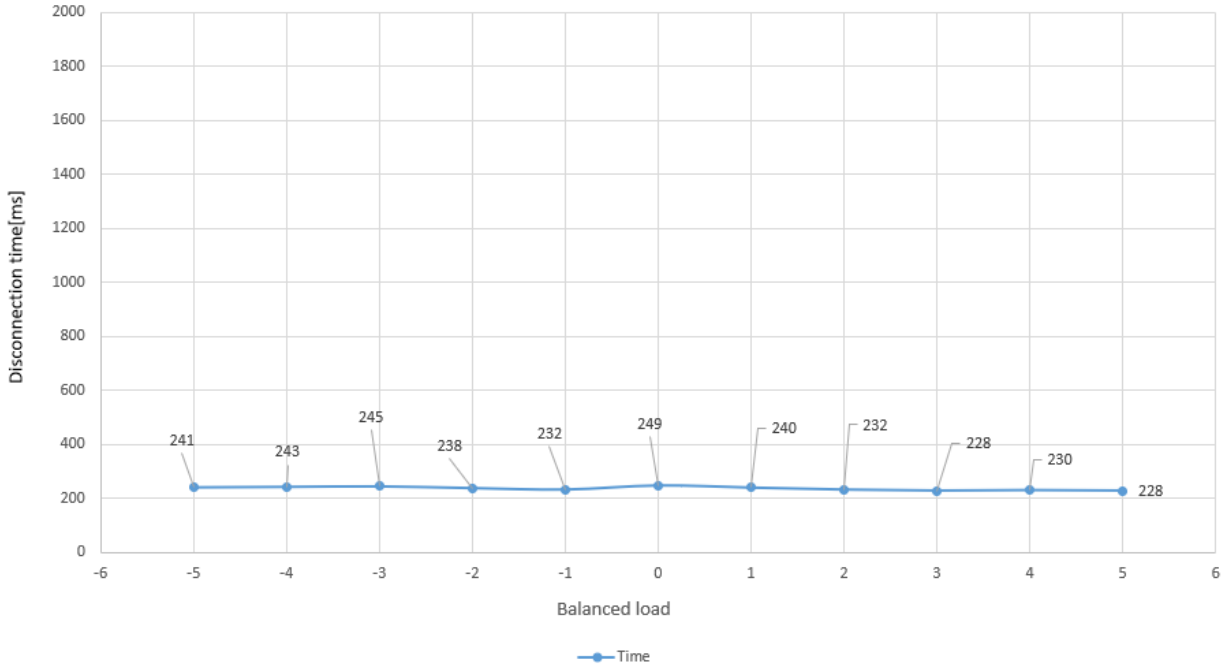
Test Condition A



Test Condition B



Test Condition C



4.3.4 Loss of Mains Protection, Vector Shift Stability test and *RoCoF Stability test*

This test should be carried out in accordance with Annex A.7.1.2.6.

Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the Micro-generator should not trip during the test.

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

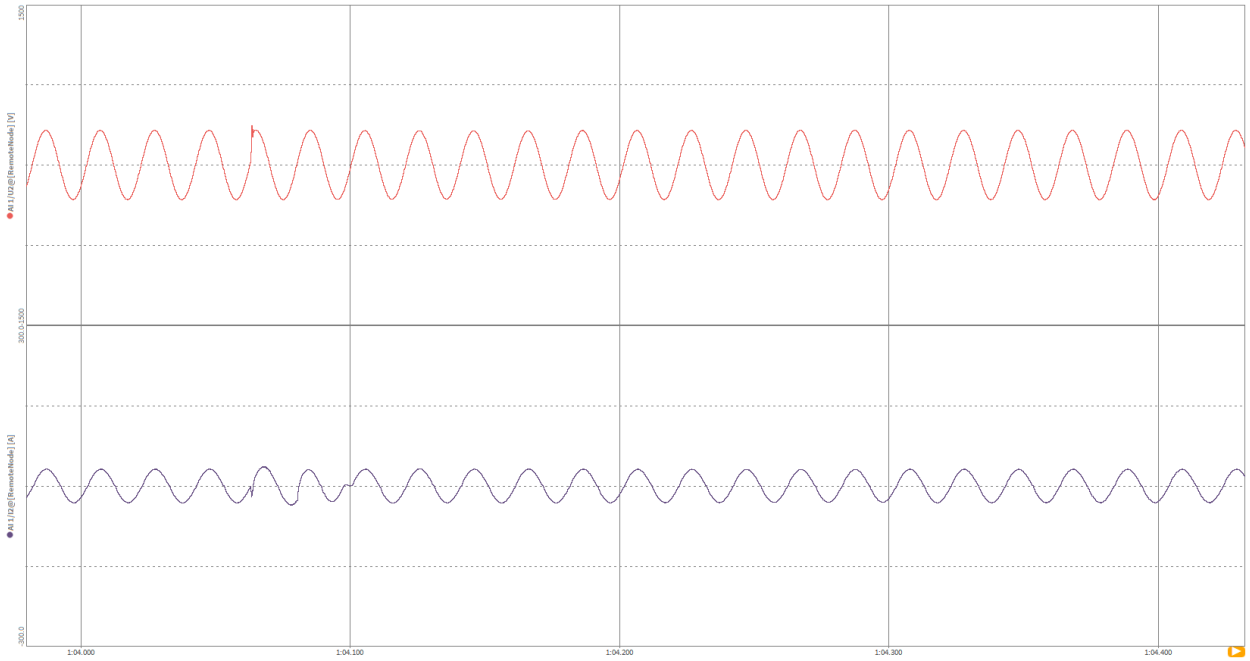
For frequency drift tests the Power Generating Module should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0.95 Hz/s to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10s. The Power Generating Module should not trip during this test.

Test results are graphically shown in following pages.

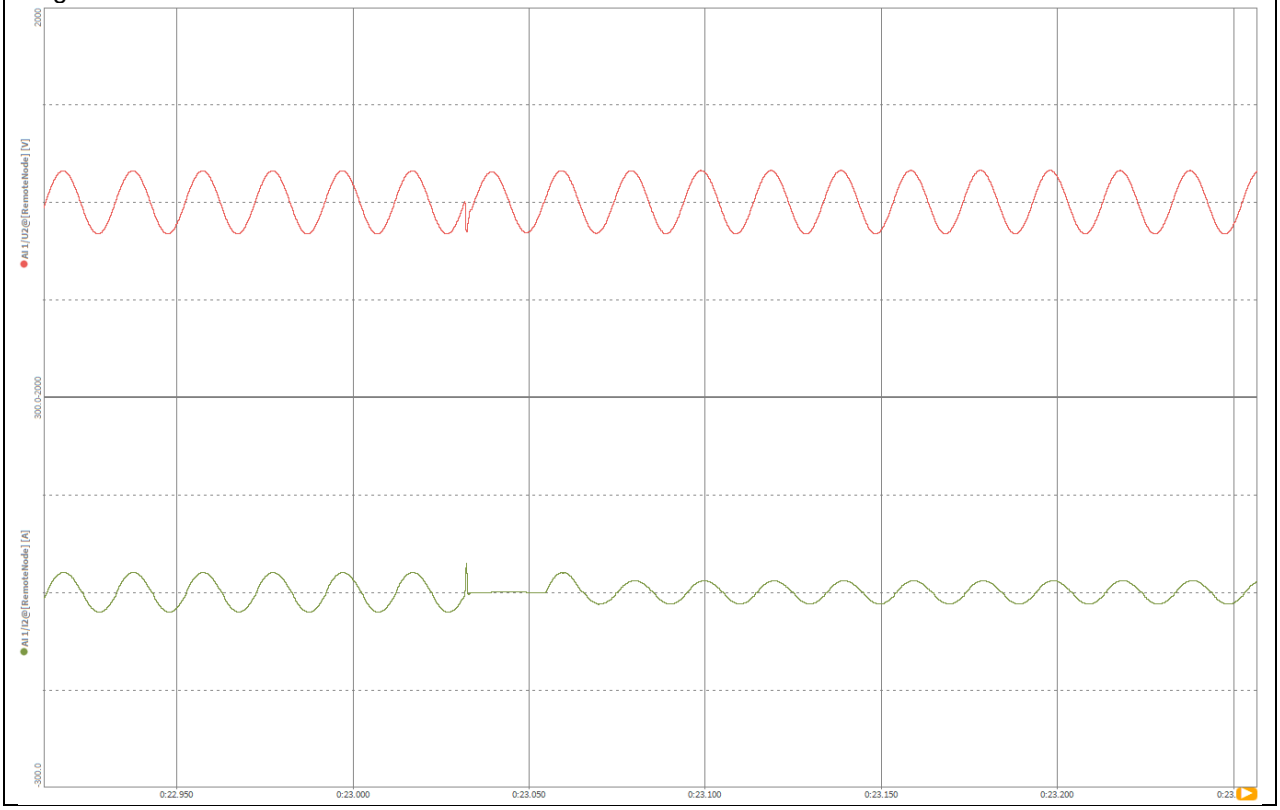
Protection –Loss of Mains Protection, Vector Shift Stability test: This test should be carried out in accordance with Annex A.7.1.2.6.

	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.5 Hz	+50 degrees	No Trip
Negative Vector Shift	50.5 Hz	- 50 degrees	No Trip

Positive Vector Shift



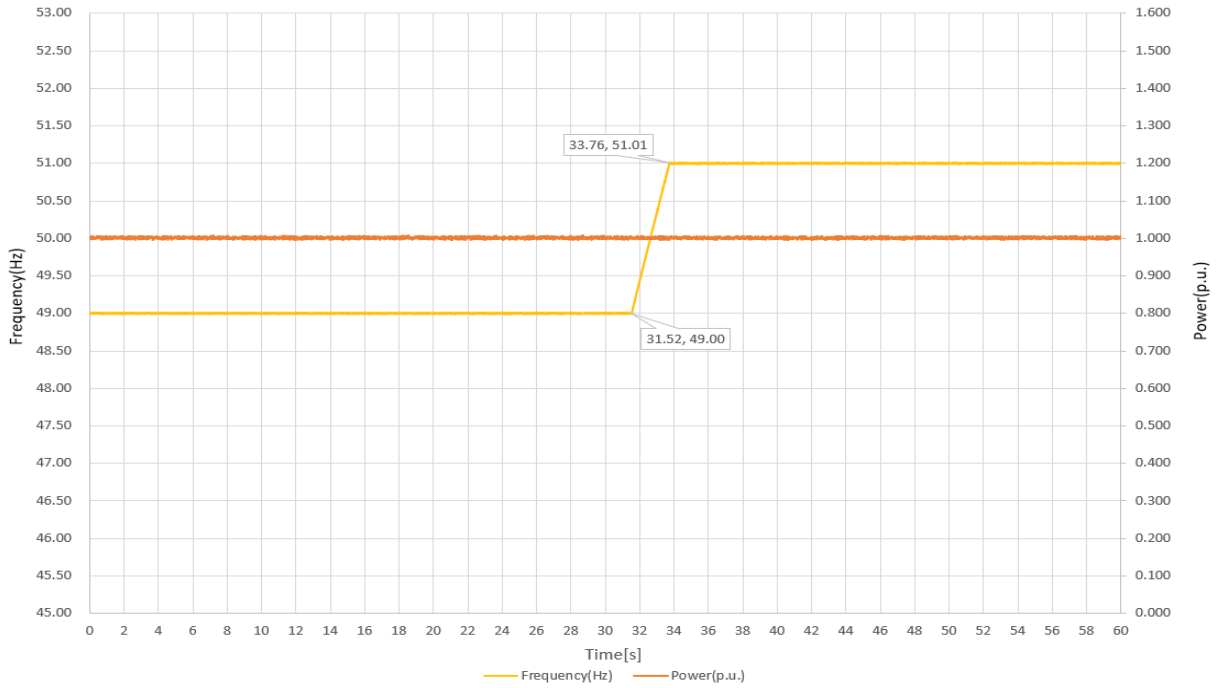
Negative Vector Shift



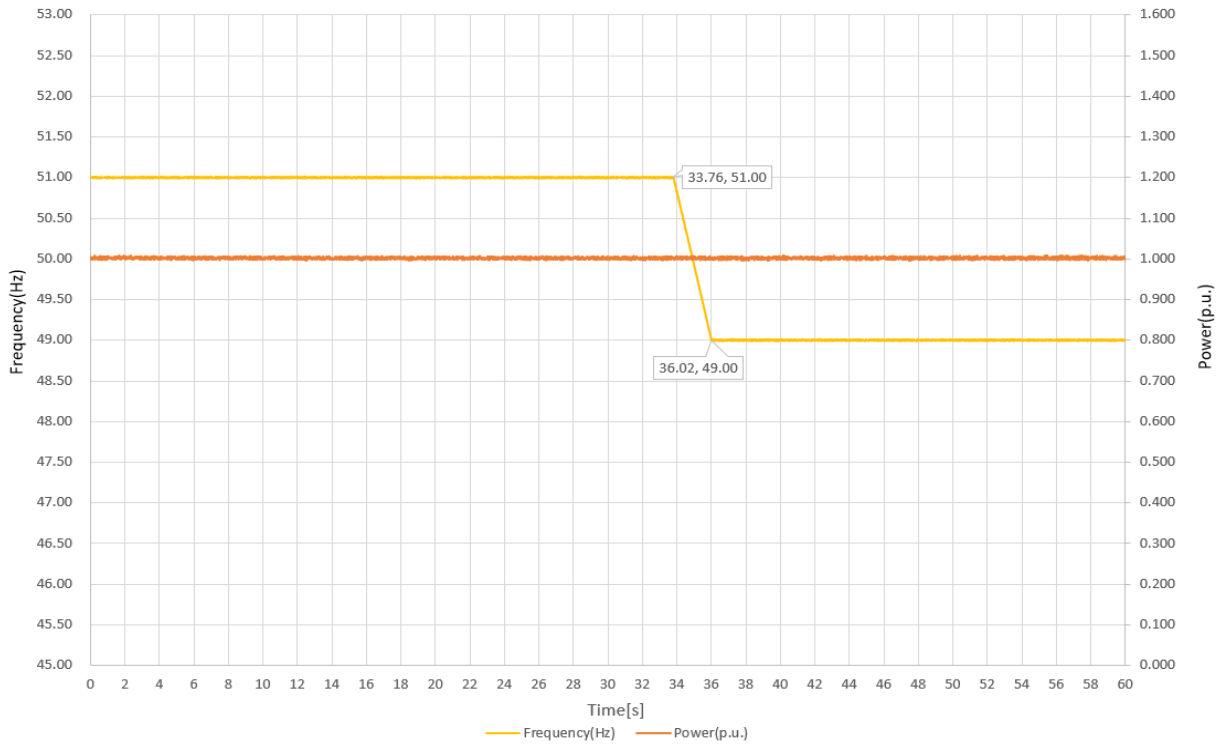
Protection –Loss of Mains Protection, RoCoF Stability test: This test should be carried out in accordance with Annex A.7.1.2.6.

Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0 Hz to 51.0 Hz	+0.95 Hzs^{-1}	2.24 s	No Trip
51.0 Hz to 49.0 Hz	-0.95 Hzs^{-1}	2.26 s	No Trip

+0.95 Hz/s:



-0.95 Hz/s:



4.4 Limited Frequency Sensitive Mode - Overfrequency test

This test should be carried out in accordance with Annex A.7.1.3.

The test should be carried out above 80% Registered Capacity and repeated at 40-60% Registered Capacity using the specific threshold frequency of 50.4 Hz and Droop of 10%.

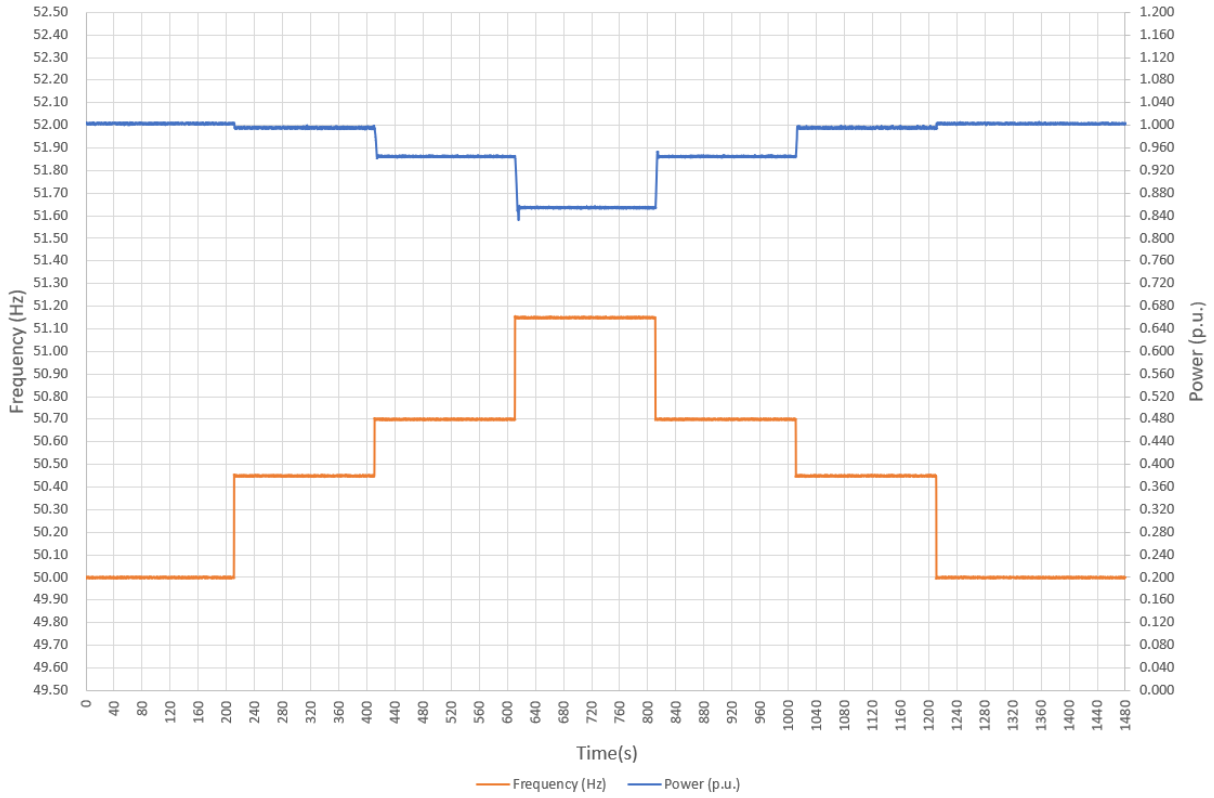
The Power Park Module should be tested at the following frequencies:
Step a) 50.00 Hz ±0.01 Hz
Step b) 50.45 Hz ±0.05 Hz
Step c) 50.70 Hz ±0.10 Hz
Step d) 51.15 Hz ±0.05 Hz
Step e) 50.70 Hz ±0.10 Hz
Step f) 50.45 Hz ±0.05 Hz
Step g) 50.00 Hz ±0.01 Hz

The frequency at each step should be maintained for at least one minute and the Active Power reduction in the form of a gradient determined and assessed for compliance with paragraph 11.2.3.

Test sequence at Registered Capacity 40% - 60%	Measured Active Power Output (W)	Frequency (Hz)	Primary Power Source	Active Power Gradient
Step a) 50.00 Hz ±0.01 Hz	5015.39	50.00	DC Souce	N/A
Step b) 50.45 Hz ±0.05 Hz	4977.62	50.45		13.2
Step c) 50.70 Hz ±0.10 Hz	4724.63	50.70		10.3
Step d) 51.15 Hz ±0.05 Hz	4270.93	51.15		10.1
Step e) 50.70 Hz ±0.10 Hz	4724.73	50.70		10.3
Step f) 50.45 Hz ±0.05 Hz	4978.67	50.45		13.6
Step g) 50.00 Hz ±0.01 Hz	5015.27	50.00		N/A

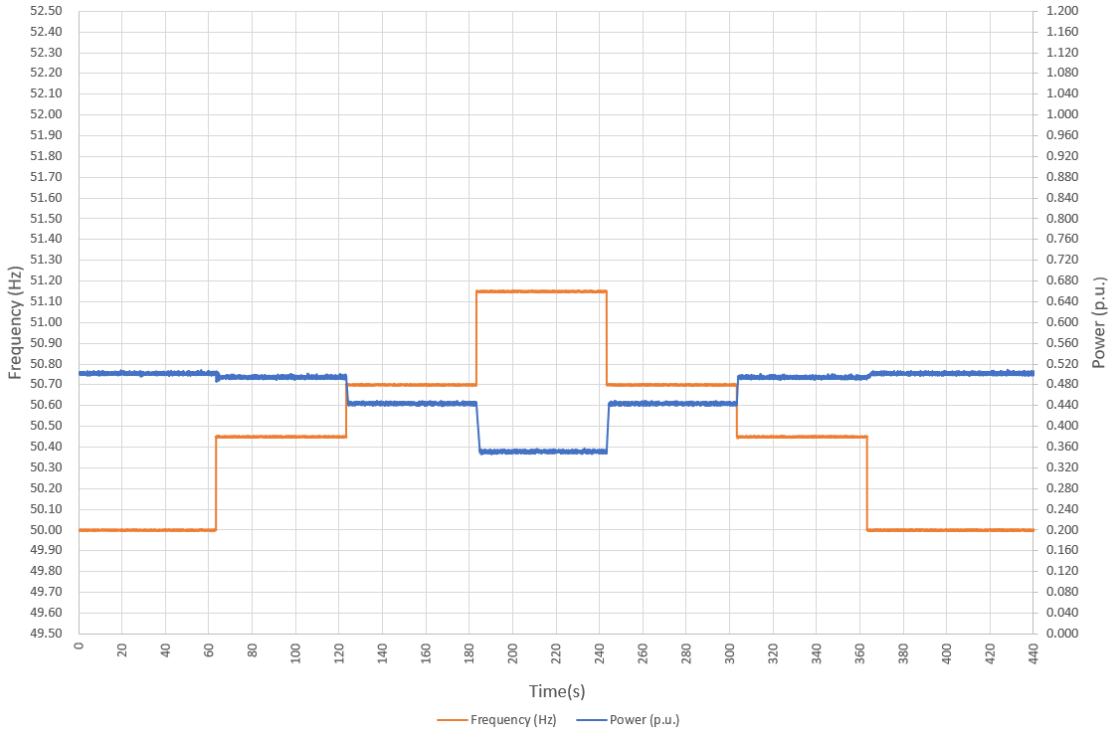
Test sequence at Registered Capacity 40% - 60%	Measured Active Power Output (W)	Frequency (Hz)	Primary Power Source	Active Power Gradient
Step a) 50.00 Hz ±0.01 Hz	2509.04	50.00	DC Souce	N/A
Step b) 50.45 Hz ±0.05 Hz	2474.33	50.43		14.4
Step c) 50.70 Hz ±0.10 Hz	2231.14	50.69		10.8
Step d) 51.15 Hz ±0.05 Hz	1780.84	51.13		10.3
Step e) 50.70 Hz ±0.10 Hz	2194.78	50.72		9.5
Step f) 50.45 Hz ±0.05 Hz	2459.57	50.46		10.1
Step g) 50.00 Hz ±0.01 Hz	2508.90	50.00		N/A

Over-frequency curve (droop of 10 % at 100% Pn)



Remark:Test for frequency threshold 50.4Hz with droop 10%, intentional delay is setting to 0s.

Over-frequency curve (droop of 10 % at 50% Pn)



Remark:Test for frequency threshold 50.4Hz with droop 10%, intentional delay is setting to 0s.

4.5 Re-connection timer

Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 10.1.

The evaluation of this point has been made according to Annex A.7.2.2.5.

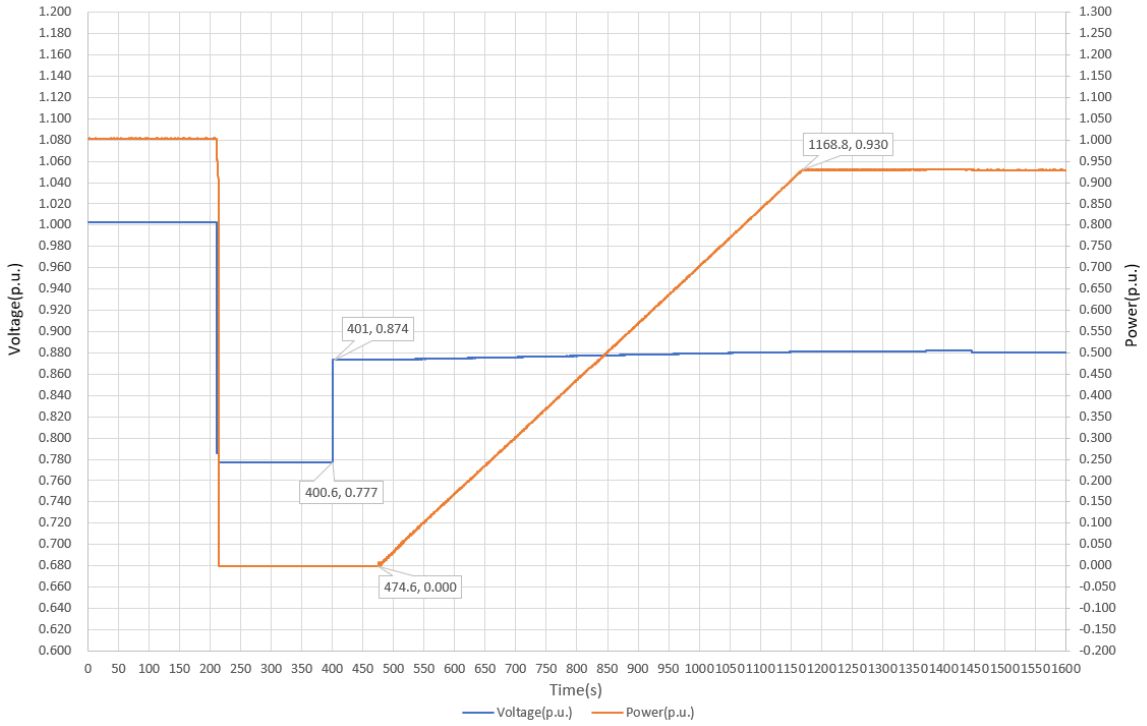
4.5.1 Voltage Reconnection Conditions

The following table detail tests performed

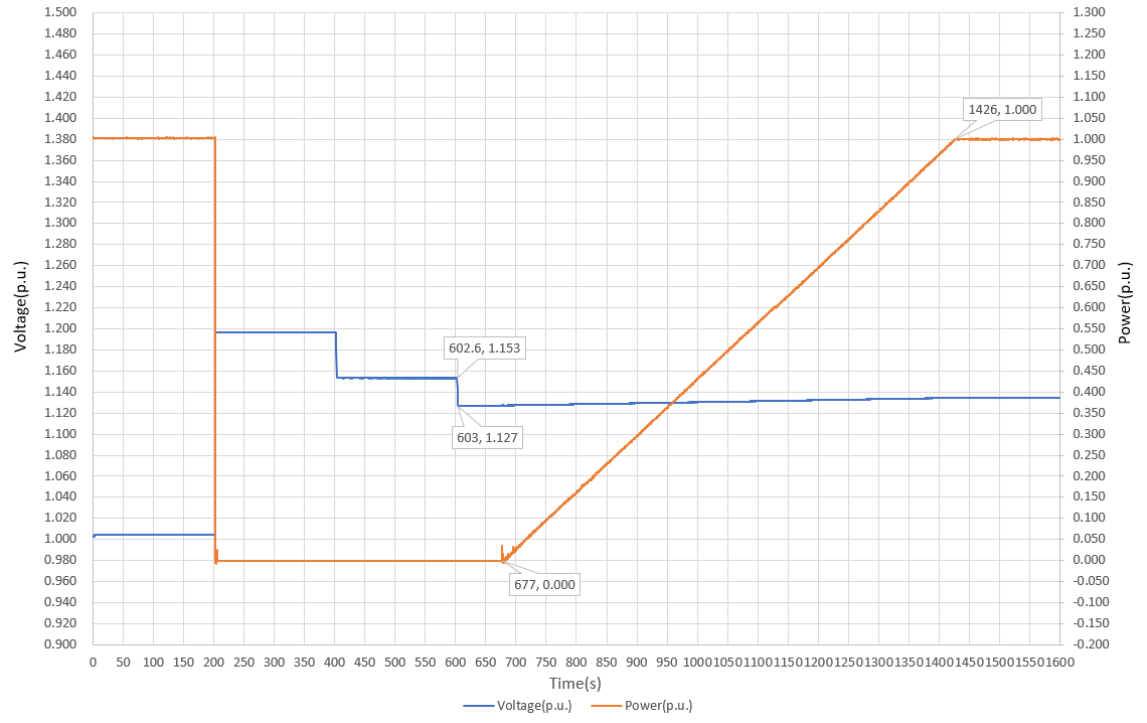
Test at	Time delay setting(s)	Measured delay(s)	Checks on no reconnection when voltage is brought to just outside stage 1 limits of table 1.	
UV	60	73.6	At 0.78 pu (180.0 V)	At 1.16 pu (266.2 V)
OV	60	74.0		
Confirmation that the Micro-generator does not re-connect.			Not reconnection	Not reconnection

Test results are graphically shown below.

Under voltage reconnection



Over voltage reconnection



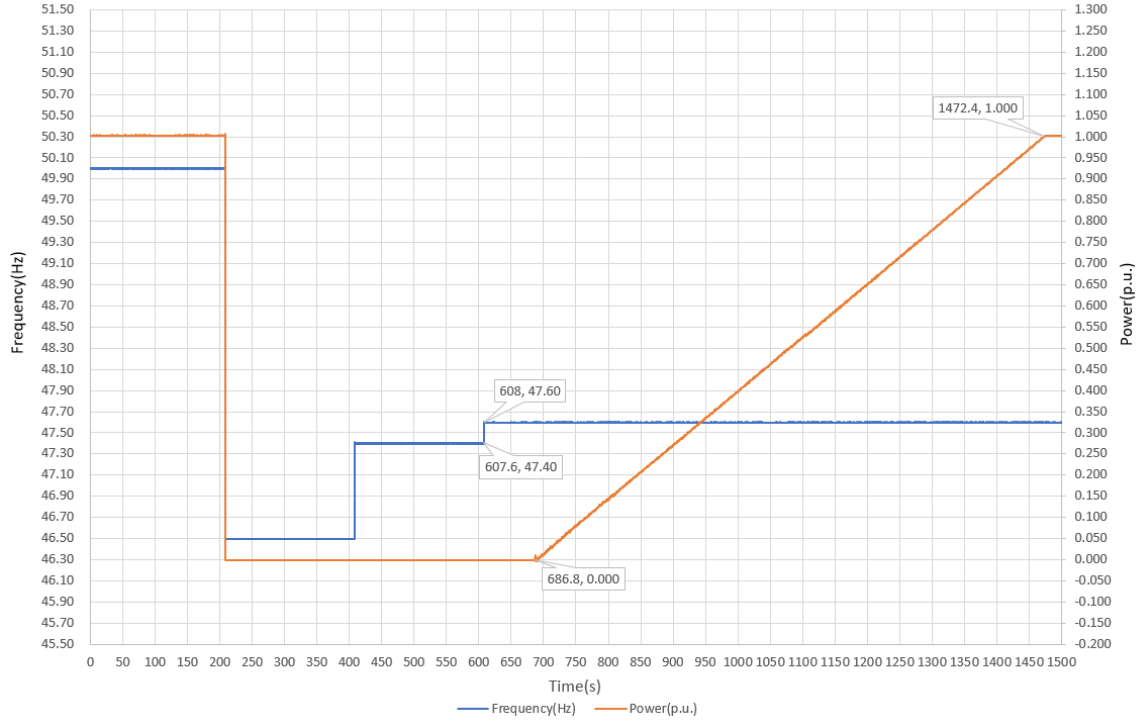
4.5.2 Frequency Reconnection Conditions

The following table detail tests performed

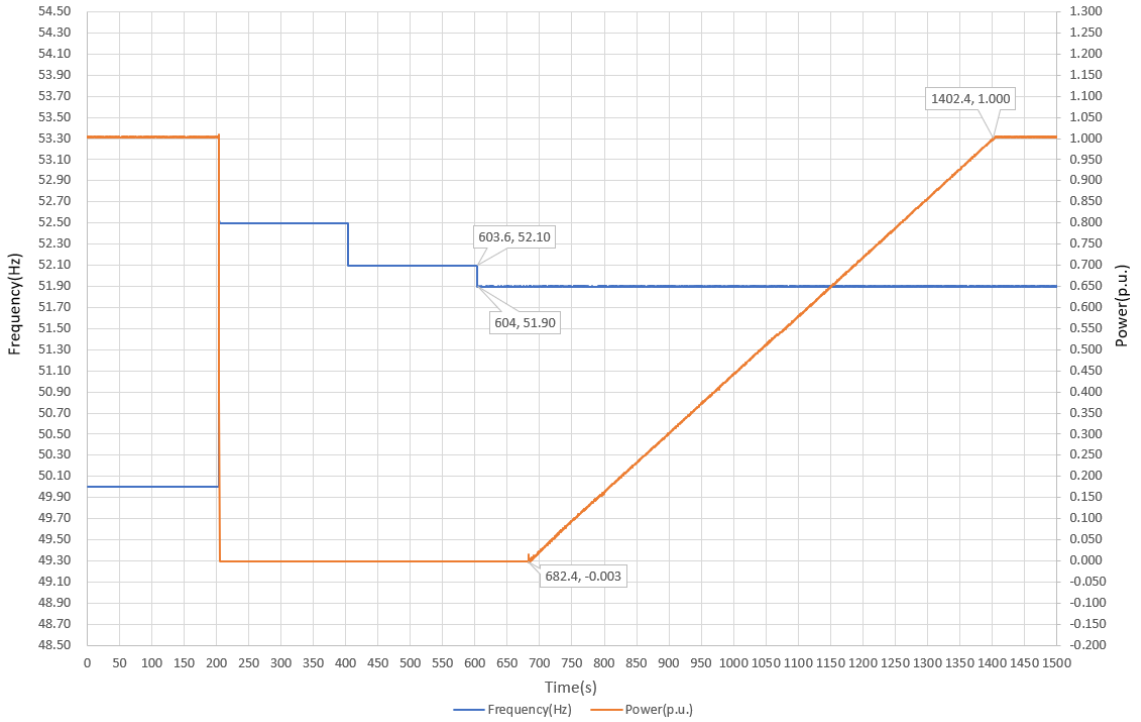
Test at	Time delay setting(s)	Measured delay(s)	Checks on no reconnection when frequency is brought to just outside stage 1 limits of table 1.	
UF	60	78.8	At 47.4Hz	At 52.1Hz
OF	20	78.4		
Confirmation that the Micro-generator does not re-connect.			Not reconnection	Not reconnection

Test results are graphically shown below.

Under frequency reconnection



Over frequency reconnection



4.6 Fault level contribution

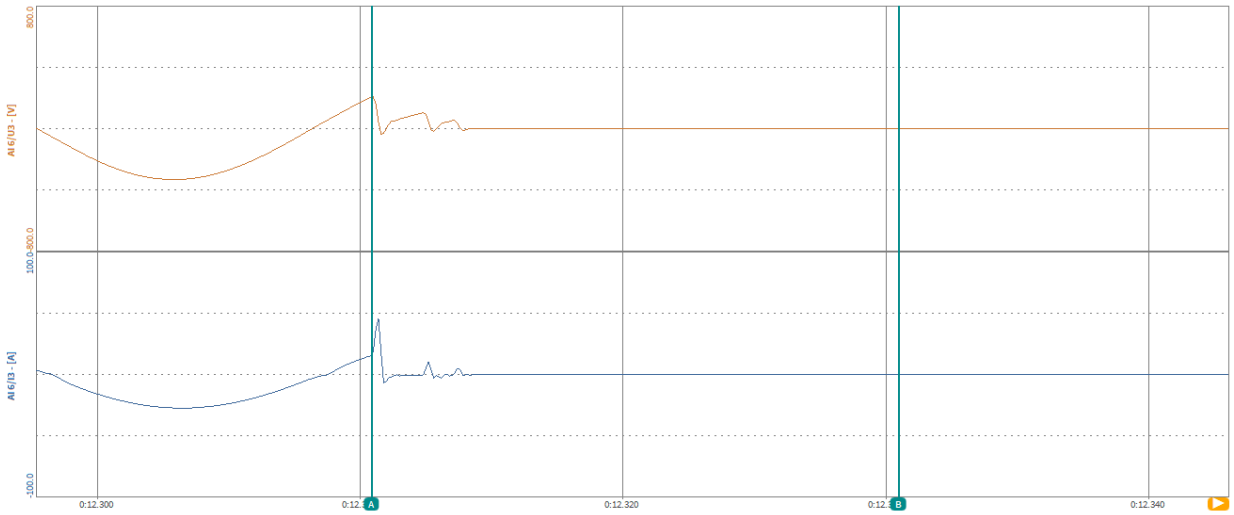
These tests shall be carried out in accordance with EREC G99 Annex A.7.1.5.

They have been performed different short circuit tests that are detailed in the table and pictures below.

Short circuit current		
L-N		
Time after fault	**Volts(V)**	**Amps(A)**
20ms	0.428	0.007
100ms	0.291	0.011
250ms	0.168	0.006
500ms	0.104	0.005
Time to trip	0.004	In seconds

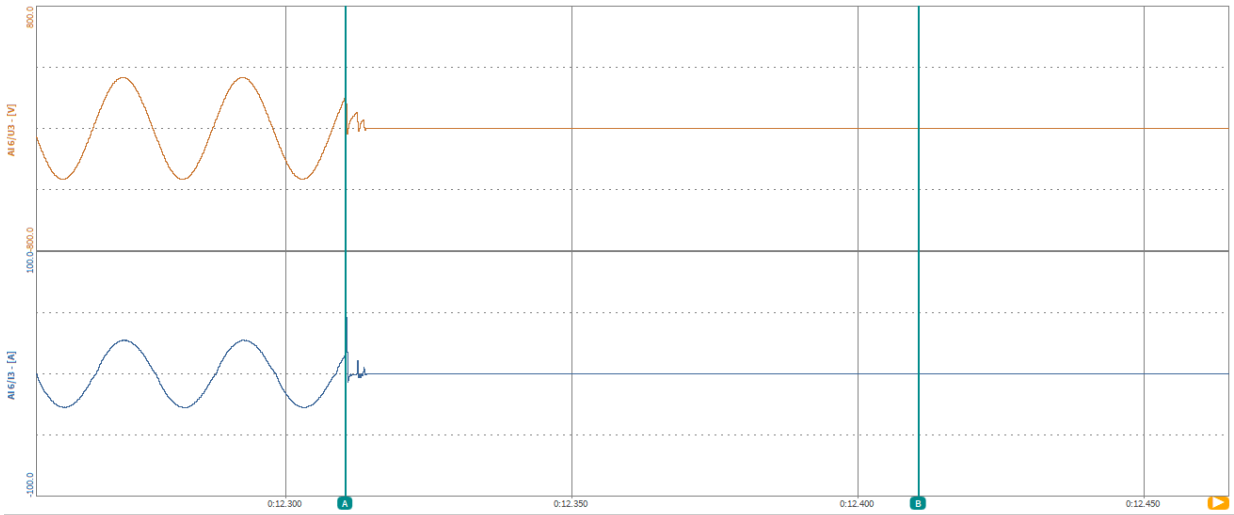
L-N

Time after 20ms fault



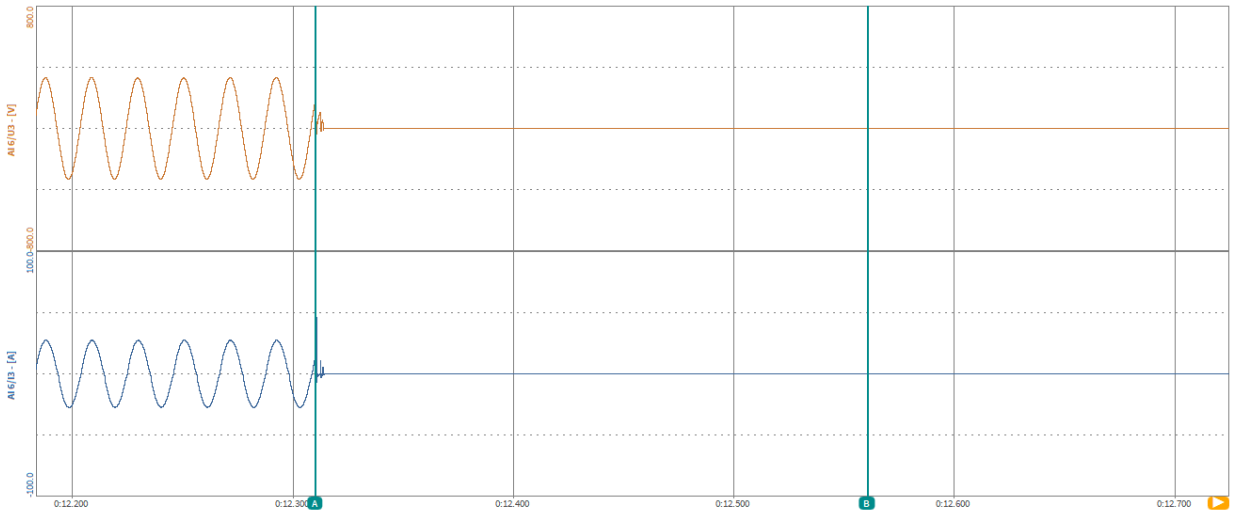
	A	B	间隔
时间 [s]	0:12.31046254	0:12.33049554	0.02003300
AI 6/U3 [V]	204.4616	0.428200	-204.0334
AI 6/I3 [A]	15.24985	-7.391e-3	-15.25724

Time after 100ms fault



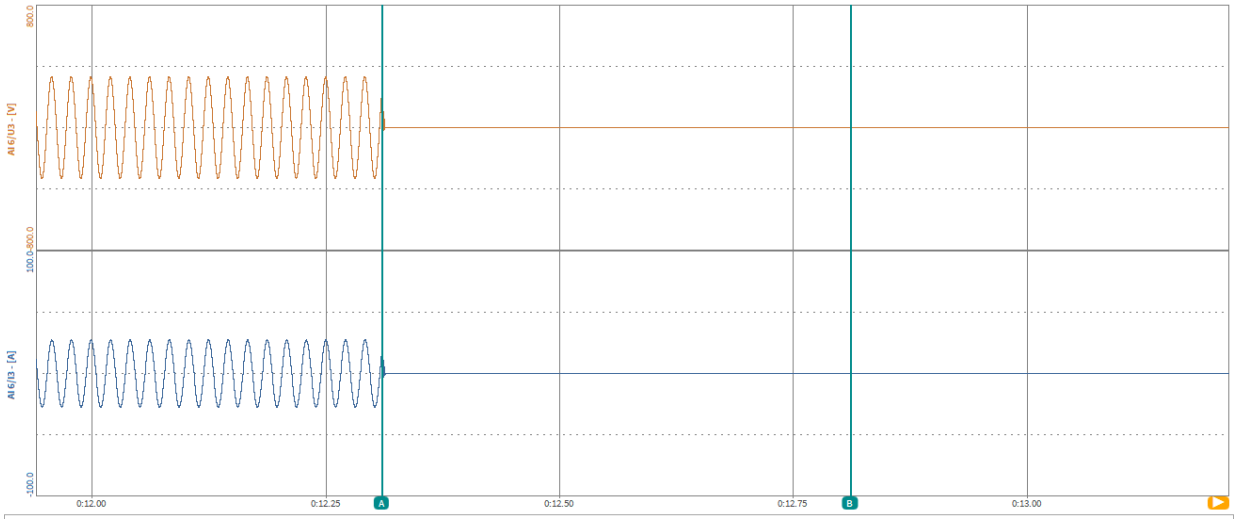
	A	B	间隔
时间 [s]	0:12.31046254	0:12.41059355	0.10013101
AI 6/U3 [V]	204.4616	0.290871	-204.1707
AI 6/I3 [A]	15.24985	-0.010610	-15.26046

Time after 250ms fault



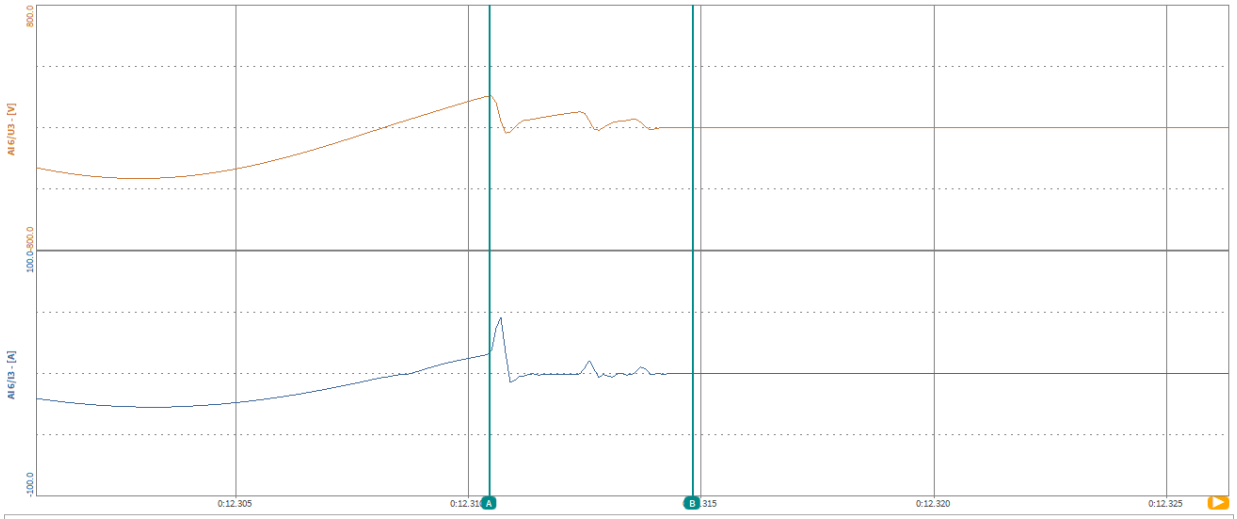
	A	B	间隔
时间 [s]	0:12.31046254	0:12.56064416	0.25018162
AI 6/U3 [V]	204.4616	0.168085	-204.2935
AI 6/I3 [A]	15.24985	-5.722e-3	-15.25557

Time after 500ms fault



	A	B	间隔
时间 [s]	0:12.31046254	0:12.81131503	0.50085249
AI 6/U3 [V]	204.4616	0.104189	-204.3574
AI 6/I3 [A]	15.24985	-5.484e-3	-15.25533

Time to trip



	A	B	间隔
时间 [s]	0:12.31046254	0:12.31482678	0.00436424
AI 6/U3 [V]	204.4616	0.059366	-204.4022
AI 6/I3 [A]	15.24985	0.024080	-15.22577

4.7 SELF-MONITORING SOLID STATE SWITCHING

It has been verified that in the event of the solid state switching device failing to disconnect the Power Park Module, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 s.

The evaluation of this point has been made according to Annex A.7.1.7.

This test does not apply because in the inverter there are not solid-state switching devices.

4.8 WIRING FUNCTIONAL TESTS:

Where Type Tested components are wired together on site, ie not using specifically designed plugs and sockets for the purpose, it will be necessary to prove that all wiring has been correctly terminated by proving the functions which rely on the wiring. The Generator will submit to the DNO for agreement a schedule of the wiring connections to be made, the functions that they enable, and the tests to prove them. Satisfactory completion of the agreed tests will enable the Power Generating Modules to attain or retain Type Tested status.

This test does not apply because connectors were designed error-proof connectors.

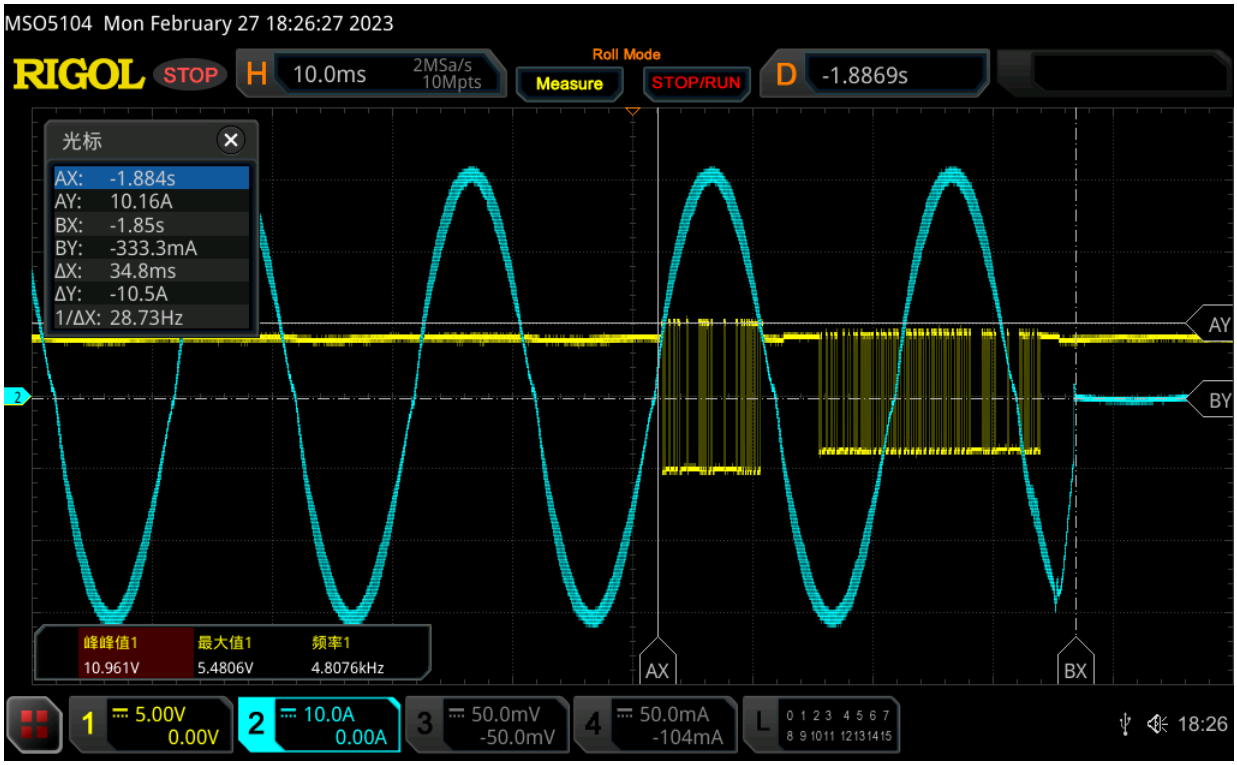
4.9 LOGIC INTERFACE (INPUT PORT).

Confirm that an input port is provided and can be used to shut down the module.

The evaluation of this point has been made according to Clause 11.1.3 of the standard.

Power Generating Modules connected to the DNO's Distribution Network shall be equipped with a logic interface (input port) in order to cease Active Power output within 5 s following an instruction being received at the input port.

Test results are graphically shown as below.



Ch2: Output Current

Ch1: Signal of logic interface.

4.10 CYBER SECURITY

Confirm that the **Power Generating Module** has been designed to comply with cyber security requirements, as detailed in 9.1.7.

The Manufacturer of the Micro-generator has provided a statement describing how the Micro-generator has been designed to comply with cyber security requirements in 9.1.7.

Additional comments.

The DNO logic interface will take the form of a simple binary output that can be operated by the switch. When the switch is turned off the Power Generating Module can operate normally. When the switch is turned on the Power Generating Module will reduce its Active Power to zero within 5 s. The signal from the Power Generating Module that is being switched is DC (maximum value 3.3Vdc)

5 PICTURES

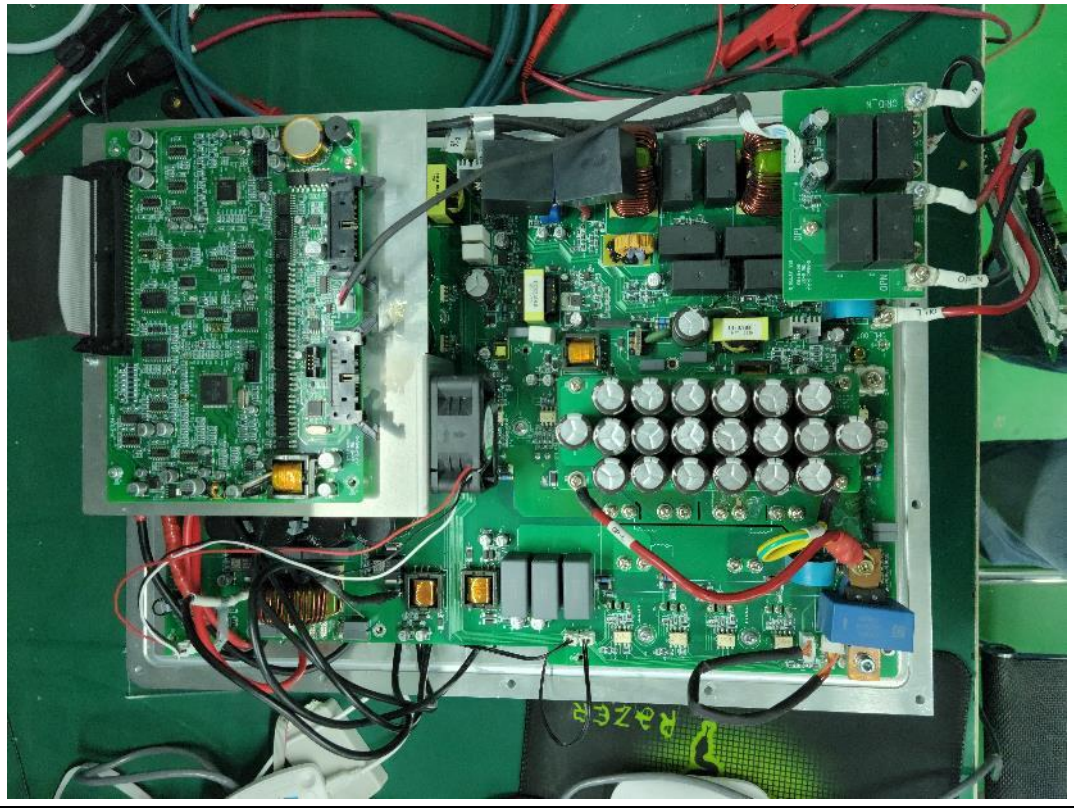
Front view

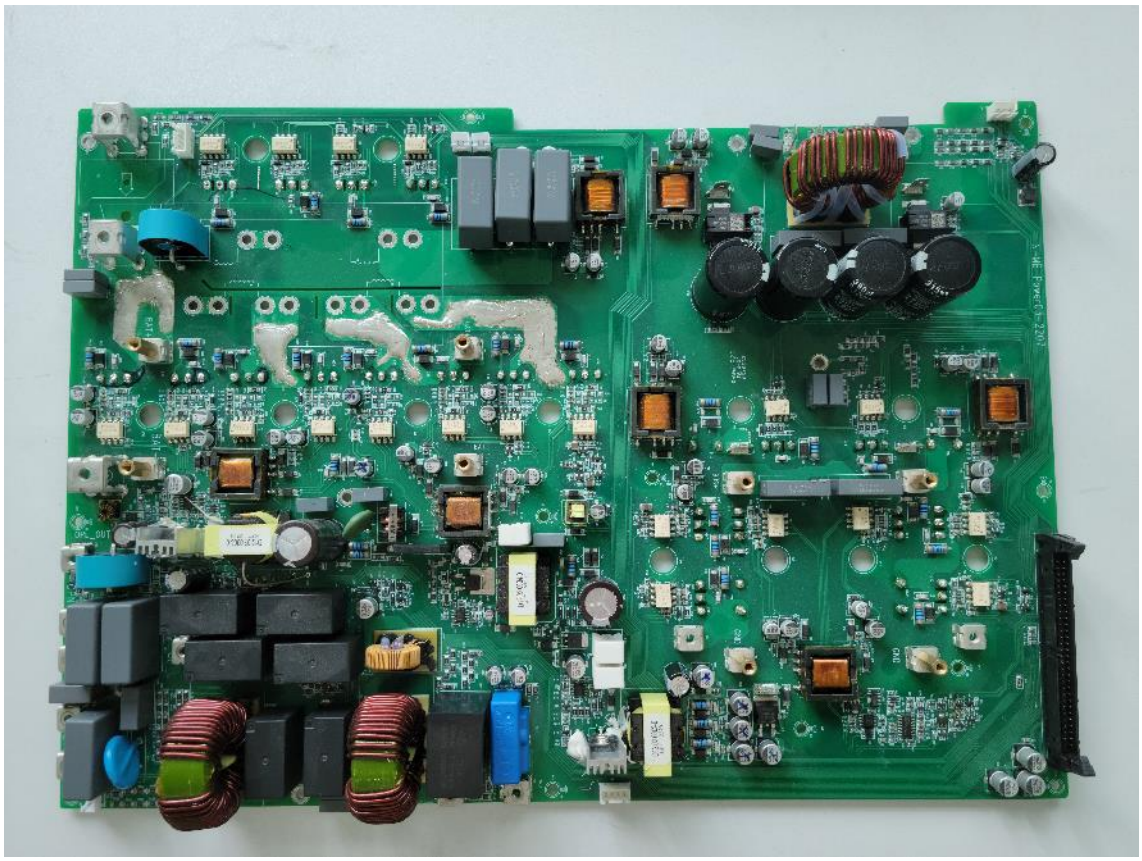
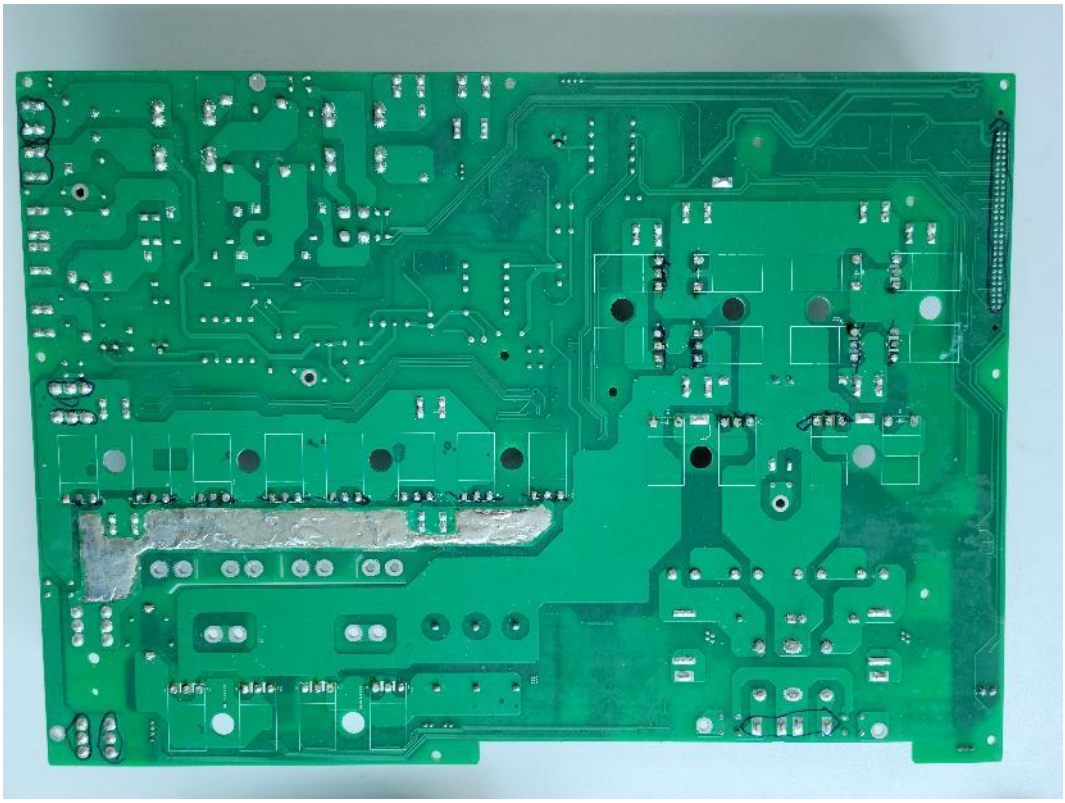
Back Side


Connection interface

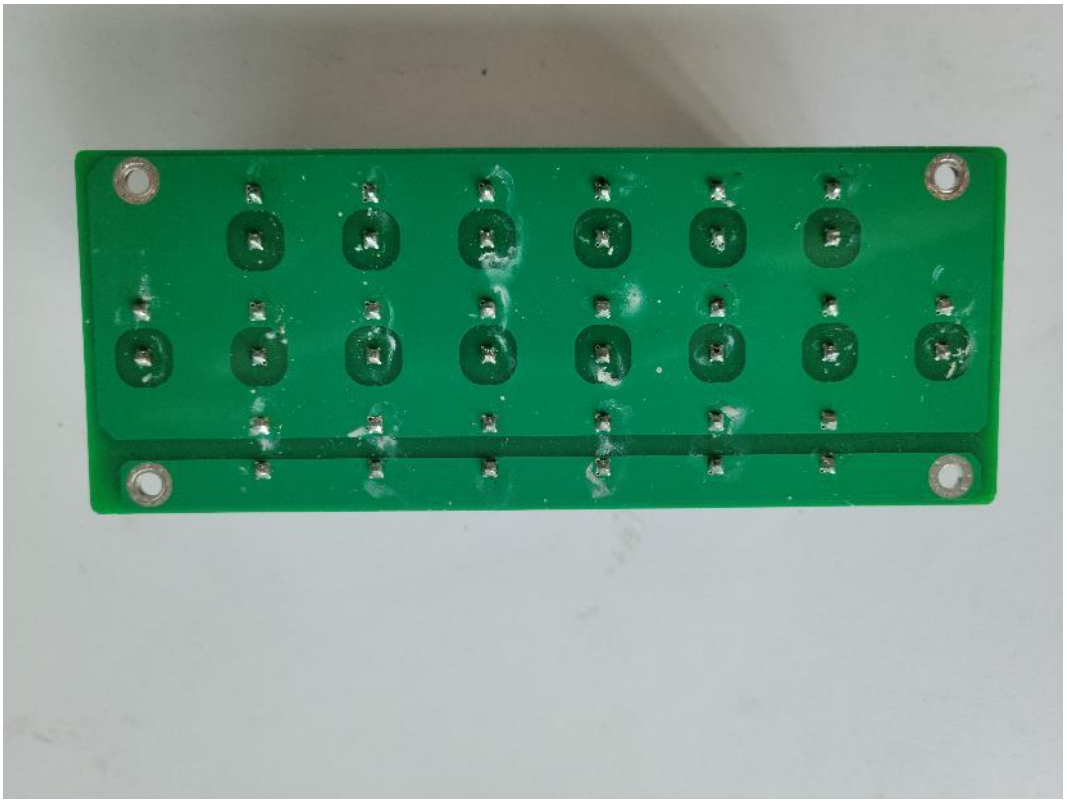
Top Side


External grounding

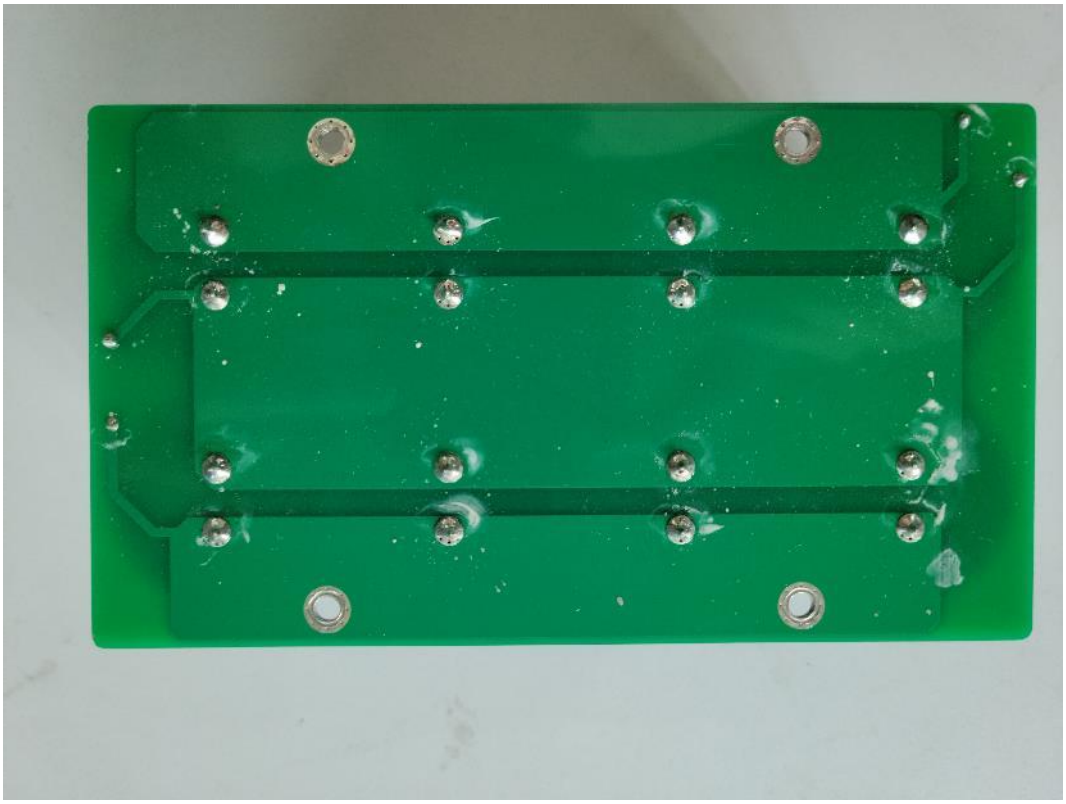
General Internal view of inverter


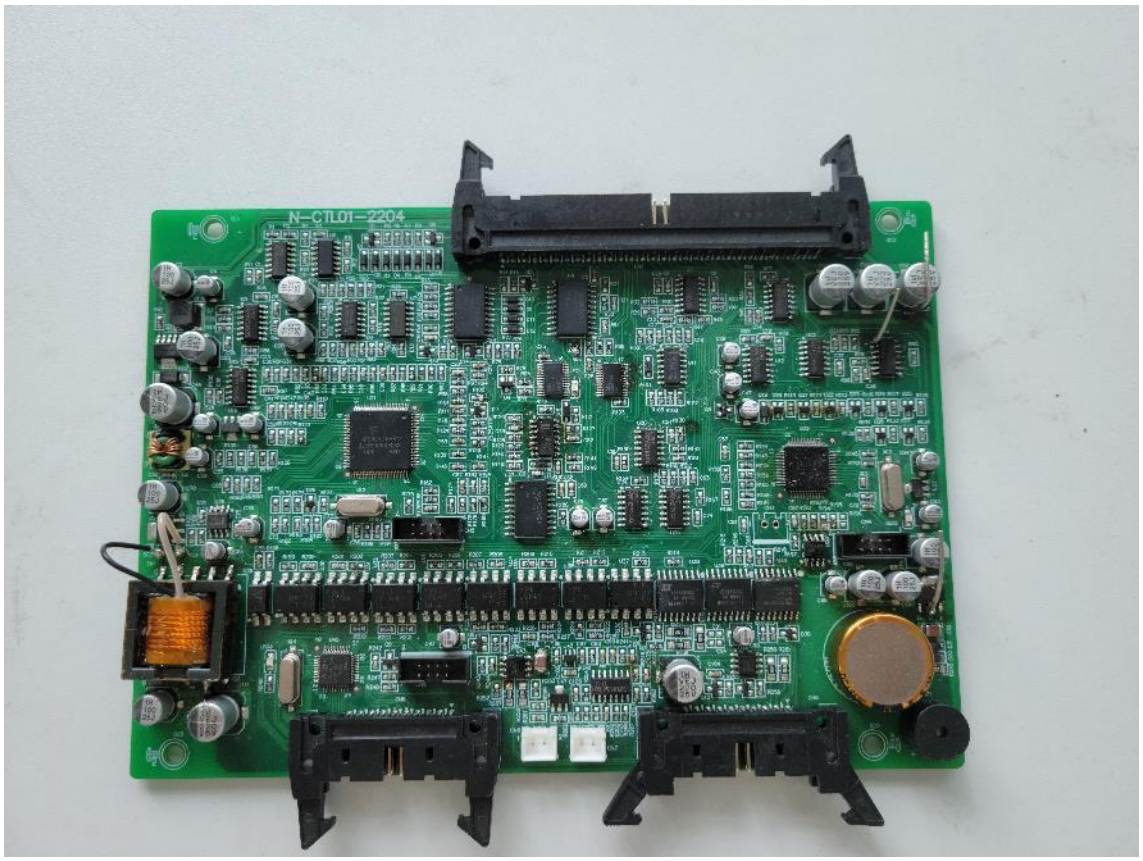
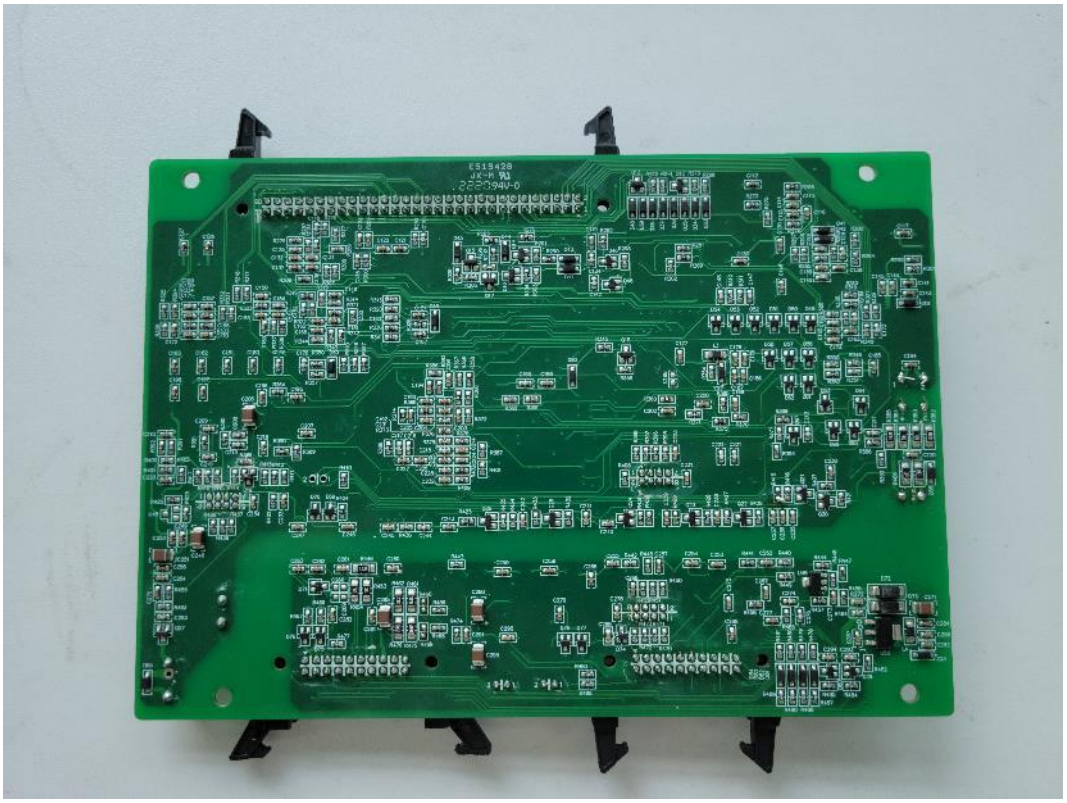
Front of main power board

Back of main power board


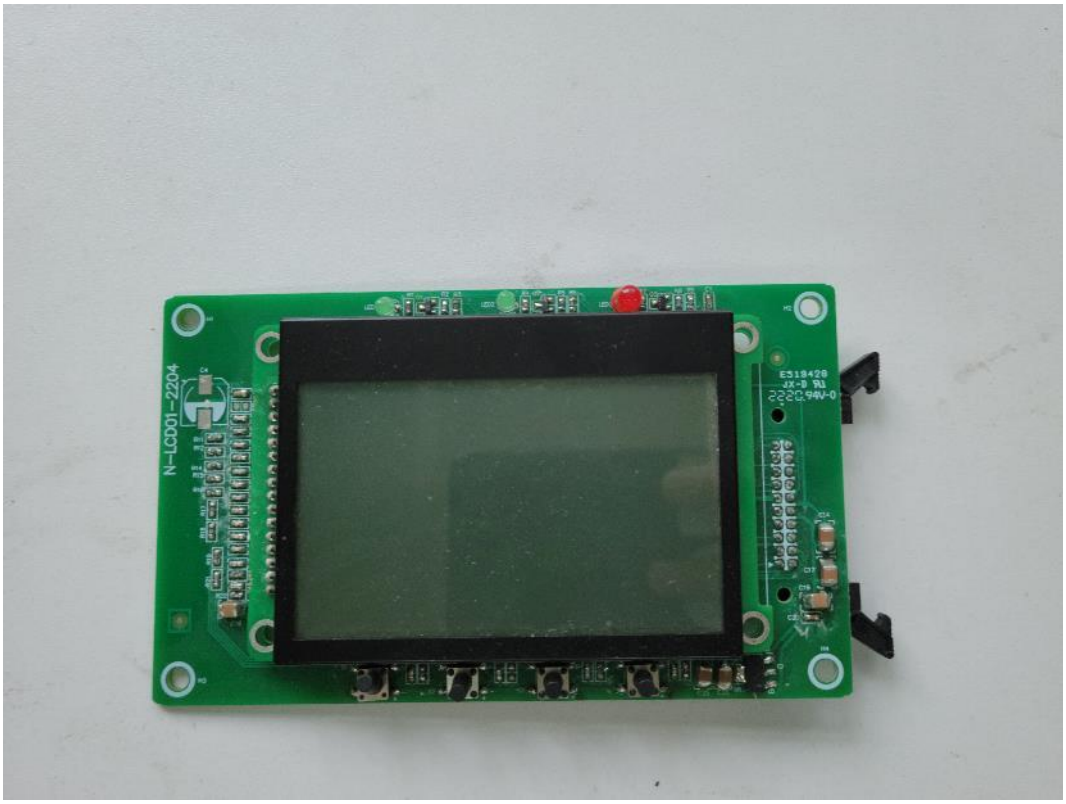
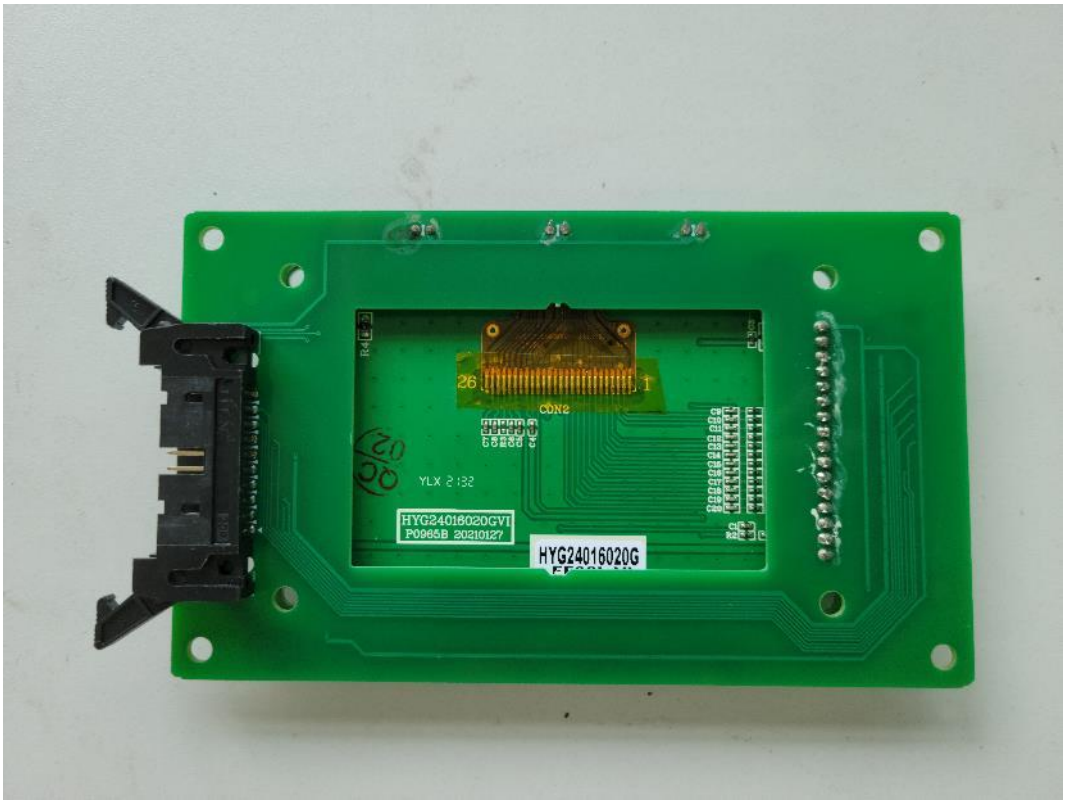
Front of Bus capacitance board

Back of Bus capacitance board


Front of capacitance board

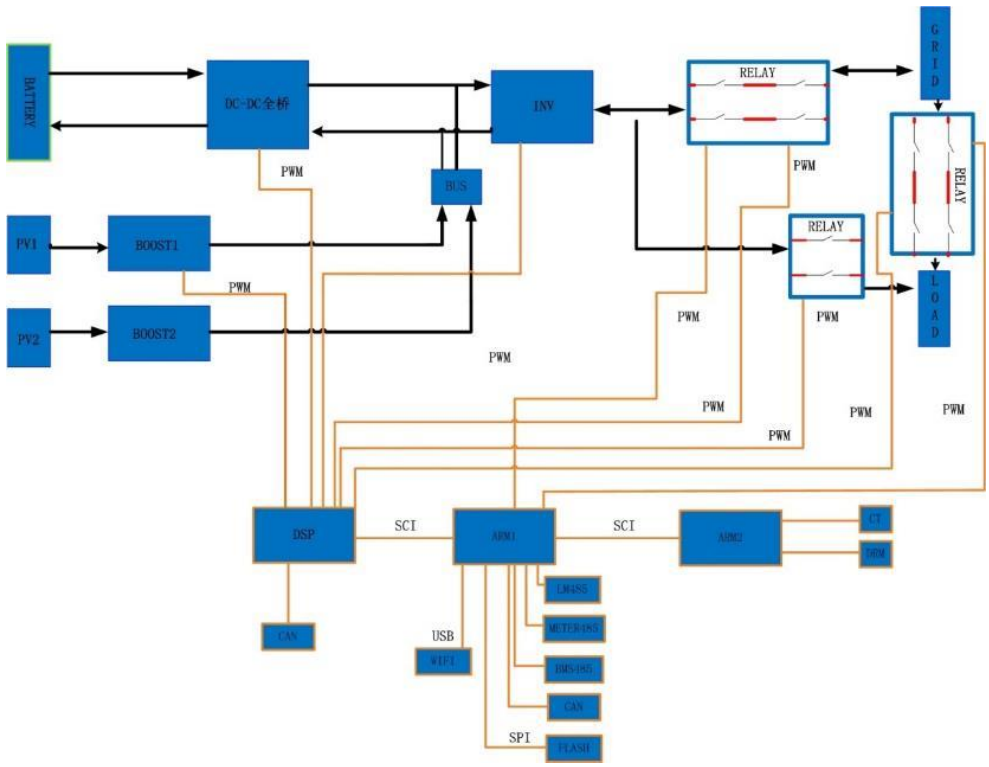
Back of capacitance board


Front of control board

Back of control board


Front of display board

Back of control board


Serial Number


6 ELECTRICAL SCHEME

Electrical Scheme of EUT


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