TESTING FOR THE VERIFICATION OF COMPLIANCE OF PV INVERTER WITH :

TECHNICAL REGULATION 3.2.1 FOR PV POWER PLANTS UP TO AND INCLUDING 11 KW AND TECHNICAL REGULATION 3.2.2 FOR PV POWER PLANTS ABOVE 11 KW.

Protocol. PE.T-LE-62

Test Report Number	:	**2219 / 0019 - 2**
Trademark	:	SOFAR SOLAR
Tested Model	:	**HYD 6000-ES**
Variants Models	:	**HYD 3000-ES** **HYD 3600-ES** **HYD 4000-ES** **HYD 5000-ES**

APPLICANT

Name	:	**Shenzhen SOFAR SOLAR Co., Ltd**
Address	:	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen City, Guangdong Province, P.R. China

TESTING LABORATORY

Name	:	SGS Tecnos, S.A. (Electrical Testing Laboratory)
Address	:	C/ Trespaderne, 29 - Edificio Barajas 1 28042 Madrid (Spain)
Conducted (tested) by	:	Michael Tong (Project Engineer) Roger Hu (Project Engineer)
Reviewed & Approved by	:	Jacobo Tevar (Technical Reviewer)
Date of issue	:	**20/03/2019**
Number of pages	:	**90**

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

Important Note:

Test Report Historical Revision:

Test Report Version	Date	Resume
2219 / 0019 - 2	20/03/2019	First issuance

INDEX

1 SCOPE

SGS Tecnos, S.A. (Electrical Testing Laboratory) has been contracted by **Shenzhen SOFAR SOLAR Co., Ltd** to perform the testing according the following standard: "**Technical regulation 3.2.1 for PV power plants up to and including 11 kW", b**y ENERGINET (rev. 2. Dated on 30th June 2016).and "**Technical regulation 3.2.2 for PV power plants above 11 kW**", by ENERGINET (rev. 4. Dated on 14th July 2016).

Note: The tests offered at this test report evaluate the EUT compliance with the requirements of **categories A1, A2 and B** defined as below:

Plant categories in relation to the total rated power at the Point of Connection:

A1. Plants up to and including 11 kW
A2. Plants above 11 kW up to and including 50 kW
B. Plants above 50 kW up to and including 1.5 MW
C. Plants above 1.5 MW up to and including 25 MW
D. Plants above 25 MW or connected to over 100 kV.

2 GENERAL INFORMATION

2.1 Testing Period and Climatic conditions

The necessary testing has been performed along 11 working days between the 27th of October of 2018 and the 19th of March of 2019.

All the tests and checks have been performed in accordance with the reference Standard (the tests are done at ≈ 25 ºC).

SITE TEST

Name ..... :	Shenzhen SOFAR SOLAR Co., Ltd
Address..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen City, Guangdong Province, P.R. China

2.2 Equipment under Testing

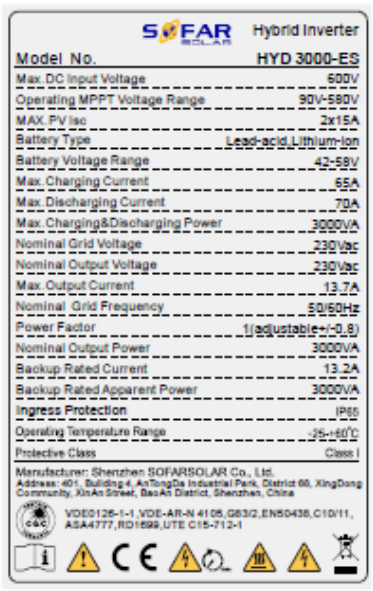
Apparatus type/ Installation .....:	Hybrid Inverter
Manufacturer/ Supplier/ Installer .....:	Shenzhen SOFAR SOLAR Co., Ltd.
Trade mark .....:	
Type.....:	HYD-ES
Model/ Type.....:	HYD 6000-ES
Serial Number.....:	ZM1ES060J8A025
Software Version .....:	V1.30
Rated Characteristics .....:	DC input: 90-580V for MPPT Max. 12 A x 2 and 42-58V for battery, Max. 70 A AC output: 230Vac, 50/60Hz, 26.1A for rated and 27.3A for maximum, 6000VA

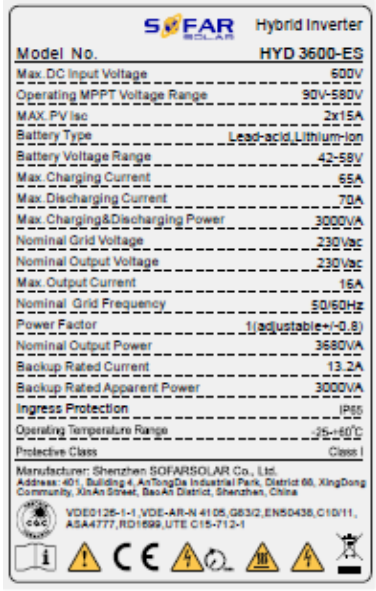
Date of manufacturing: 2018

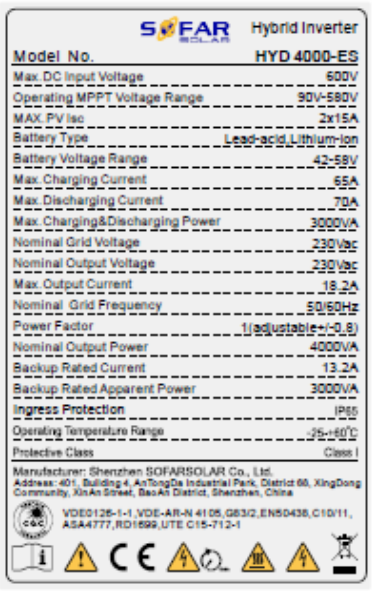
Test item particulars

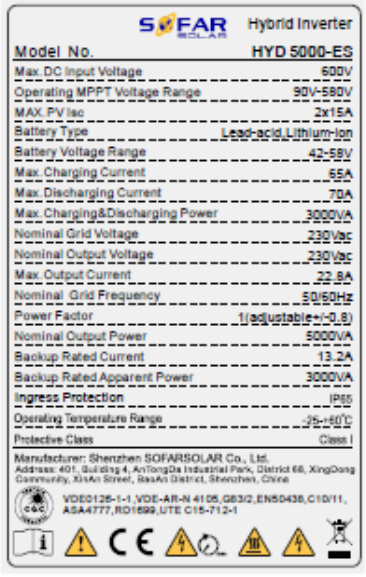
Input.....:	PV and Batteries
Output	AC
Class of protection against electric shock .....:	Class I
Degree of protection against moisture .....:	IP 65
Type of connection to the main supply.....:	Single phase – Fixed installation
Cooling group	Natural Convection
Modular.....	No
Internal Transformer	No

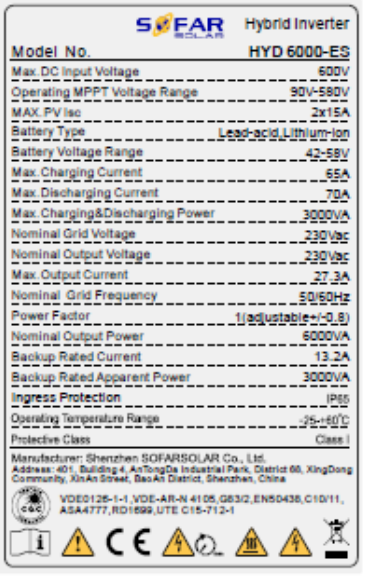
Copy of marking plate (representative):











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:

- **HYD 6000-ES**

The variants models are:

- **HYD 3000-ES**
- **HYD 3600-ES**
- **HYD 4000-ES**
- **HYD 5000-ES**

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 2.5 and 2/3 of the rated power output of the EUT.
- Same Firmware Version

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 Test Equipment List

From	No.	Equipment Name	MARK/Model No.	Equipment No.	Equipment calibration due date
Sofarsolar	1	Digital oscilloscope	Agilent / DSO5014A	MY50070266	2020-02-12
	2	Current clamp	FLUKE / i1000s	29503223	2020-02-12
	3	Current clamp	FLUKE / i1000s	30413441	2020-02-12
	4	Current clamp	FLUKE / i1000s	30413448	2020-02-12
	5	Differential probe	Sanhua / SI-9110	111541	2020-02-12
	6	Differential probe	Sanhua / SI-9110	152627	2020-02-12
	7	Differential probe	Sanhua / SI-9110	111134	2020-02-12
	8	Power analyzer	ZLG / PA3000	PA3005-P0005-1246	2020-02-12
	9	Temperature & Humidity meter	Anymetre/ TH101B	201030245220	2020-02-12
	10	Power analyzer	Yokogawa / WT3000	91N610888	2020-02-12
	11	Digital oscilloscope	KEYSIGHT / DSOX3024T	MY57251898	2020-02-12
SGS	12	True RMS Multimeter	Fluke / 289C	GZE012-53	2019-03-05

2.4 Measurement Uncertainly

	Voltage measurement uncertainty	±1.5 %
	Current measurement uncertainty	±2.0 %
	Frequency measurement uncertainty	±0.2 %
	Time measurement uncertainty	±0.2 %
	Power measurement uncertainty	±2.5 %
	Phase Angle	±1º
	cosφ	±0.01

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 solicitant.

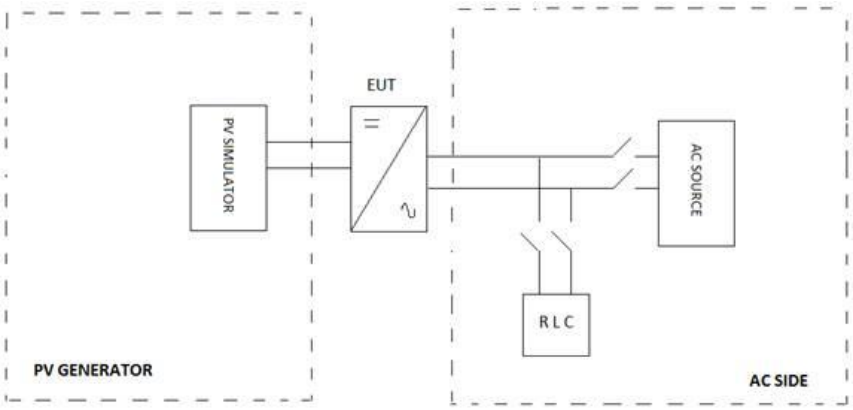
Note2: Where the standard requires lower uncertainties that those in this table. Most restrictive uncertainty has been considered.

2.5 Definitions

ESE	Auxiliary inverter	Pn	Nominal Power
EUT	Equipment under testing	Q_f	Quality factor
In	Nominal Current	UF	Under frequency
OF	Over frequency	Un	Nominal Voltage
OV	Over voltage	UV	Under voltage
PF	Power Factor		

2.6 Test set up

Below is the simplified construction of the test set up.



Current and voltage clamps have been connected to the inverter output for all the tests.

All the tests and checks have been performed in accordance with the reference Standard as specified previously.

The test bench used includes:

EQUIPMENT	MARK / MODEL	RATED CHARACTERISTICS	OWNER / ID.CODE
AC source	Chroma / 61860	100KVA 10-300Vrms 45-65Hz	--
DC source	Chroma / 62150H-1000S	0 – 1000Vdc (0.01V step) 0 – 40A (0.01A step)	--

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

Standard Section	STANDARD REQUIREMENTS	
	Technical regulation 3.2.1 for PV power plants up to and including 11 kW	
	Technical requirements	
3.2	Normal operating conditions	P
3.3	Abnormal operating conditions	P
4	Power quality	
4.1	Voltage changes	P
4.2	DC content	P
4.3	Asymmetry	NA
4.4	Flicker	P
4.5	Harmonic distortions	P
4.6	Interharmonic distortions	NA
4.7	Distortions in the 2-9 kHz frequency range	NA
5	Control and regulation	
5.2	Active power control functions	
5.2.1	Frequency response	P
5.2.2	Constraint functions	
5.2.2.1	Absolute power constraint	P
5.2.2.2	Ramp rate constraint	P
5.3	Reactive power and voltage control functions	
5.3.1	Q control	P
5.3.2	Power factor control	P
5.3.3	Automatic power factor control	P
6.1	Reconnection	P
6.2	Voltage and frequency trips	P

Standard Section	STANDARD REQUIREMENTS	
	Technical regulation 3.2.2 for PV power plants above 11 kW	
	Technical requirements	
3.2	Normal operating conditions	
3.2.1	Normal production requirements	P
3.3	Abnormal operating conditions	
3.3.1	Voltage dip tolerance	NA
3.3.2	Recurring faults in the public electricity supply grid	NA
4	Power quality	
4.2	DC content	P
4.3	Asymmetry	NA
4.4	Flicker	P
4.5	Harmonic distortions	P
4.6	Interharmonic distortions	P
4.7	Distortions in the 2-9 kHz frequency range	P
5	Control and regulation	
5.2	Active power control functions	
5.2.1	Frequency response	P
5.2.2	Frequency control	NA
5.2.3	Constraint functions	
5.2.3.1	Absolute power constraint	P
5.2.3.2	Delta power constraint (spinning reserve)	NA
5.2.3.3	Ramp rate constraint	P
5.3	Reactive power and voltage control functions	
5.3.1	Q control	P
5.3.2	Power factor control	P
5.3.3	Voltage control	NA
5.3.4	Automatic power factor control	P
5.4	System protection	NA
6.1	Reconnection	P
6.3.2	Voltage and frequency trips	P

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

4 TEST RESULTS

The tests offered at this test report evaluate the EUT compliance with the requirements for Standard "Technical regulation 3.2.1 for PV power plants up to and including 11 kW" as category A1 and "Technical Regulation 3.2.2 for PV power plants above 11 kW" as category A2 and B.

4.1 NORMAL OPERATING CONDITIONS

4.1.1 Normal Operating Requirements

Normal operating requirements are different when unit is connected as plant category A1 or plant category A2, B.

For connected as plant category A1, the normal operating voltage is Uc+10% and Uc-15%, and the frequency range is 49.00 to 51.00 Hz. Tests have been tested according to chapter 3.2 of TR3.2.1, and the requirements should be referred to the chapter 3.2.1 of the standard.

For connected as plant category A2 or B, the normal operating voltage is Uc±10%, and the frequency range is 47.00 to 52.00 Hz. Tests have been tested according to chapter 3.2 of TR3.2.2, and the requirements should be referred to the chapter 3.2.1 of the standard.

The settings of normal voltage and frequency is adjustable.

Test results are offered at the tables below.

For category A1:

Test 1		Under Voltage + Under Frequency		
Voltage	Frequency	Active Power measured (*)	Minimum Operation Time	Time measured
85.0%Un	49.0 Hz	99.51%Pn	Continuous operation	> 30 minutes
Disconnection		☒ NO ☐ YES		

Test 2		Over Voltage + Over Frequency		
Voltage	Frequency	Active Power measured	Minimum Operation Time	Time measured
110.0%Un	51.0 Hz	99.84%Pn	Continuous operation	> 30 minutes
Disconnection		☒ NO ☐ YES		

Test 3		Normal Voltage + Under Frequency		
Voltage	Frequency	Active Power measured	Minimum Operation Time	Time measured
100.0%Un	47.5 Hz	85.52%Pn	Continuous operation	> 30 minutes
Disconnection		☒ NO ☐ YES		

Test 4		Normal Voltage + Over Frequency		
Voltage	Frequency	Active Power measured (*)	Minimum Operation Time	Time measured
100.0%Un	51.5 Hz	100.17%Pn	Continuous operation	> 30 minutes
Disconnection		☒ NO ☐ YES		

Test 5		Normal Voltage + Under Frequency		
Voltage	Frequency	Active Power measured	Minimum Operation Time	Time measured
100.0%Un	47.1 Hz	98.82%Pn	Continuous operation	> 10 s
Disconnection		☒ NO ☐ YES		

Test 6		Normal Voltage + Over Frequency		
Voltage	Frequency	Active Power measured	Minimum Operation Time	Time measured
100.0%Un	51.9 Hz	98.82%Pn	Continuous operation	> 10 s
Disconnection		☒ NO ☐ YES		

For category A2 and B:

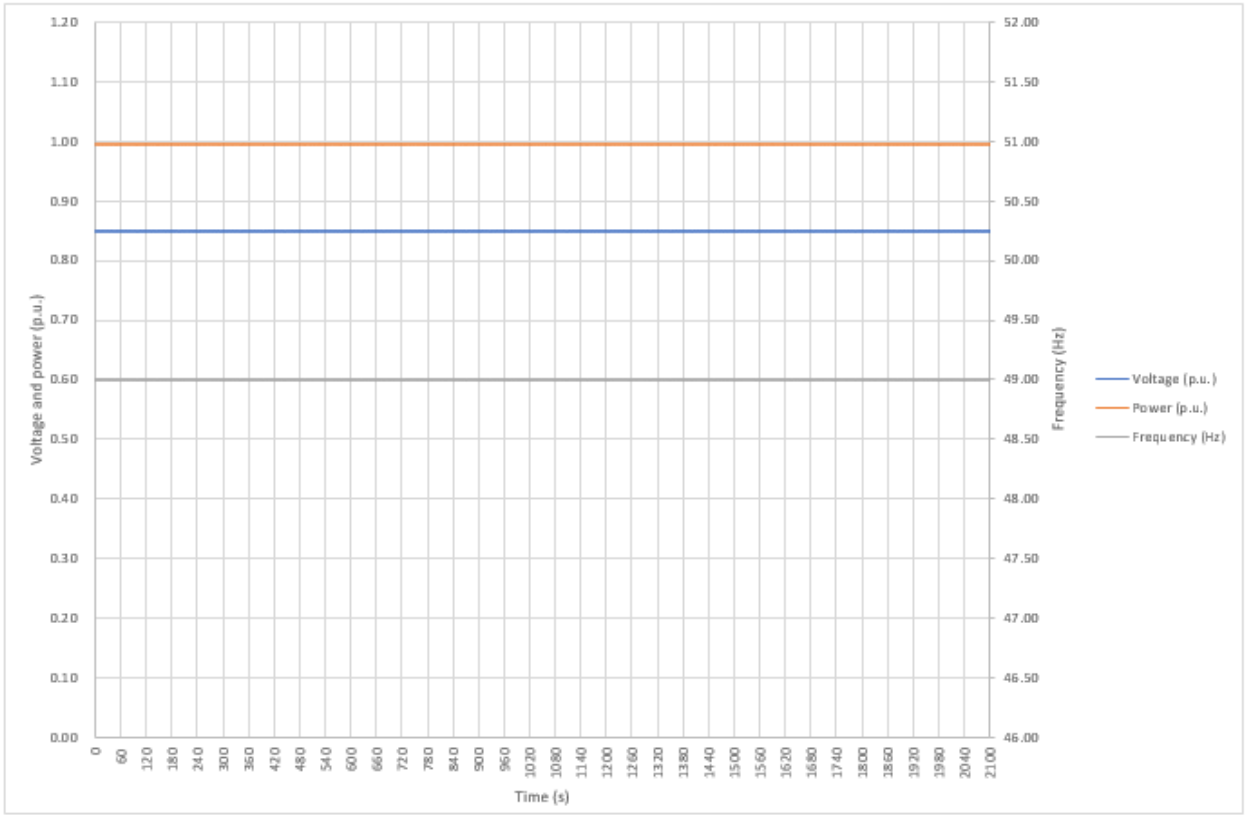
Test 7		Under Voltage + Under Frequency		
Voltage	Frequency	Active Power measured (*)	Minimum Operation Time	Time measured
90.0%Un	47.0 Hz	91.30%Pn	Continuous operation	> 4 minutes
Disconnection		☒ NO ☐ YES		

Test 8		Over Voltage + Over Frequency		
Voltage	Frequency	Active Power measured	Minimum Operation Time	Time measured
110.0%Un	52.0 Hz	100.30%Pn	Continuous operation	> 4 minutes
Disconnection		☒ NO ☐ YES		

(*) The full value of active power has not been reached due to limitations in the maximum current of the inverter.

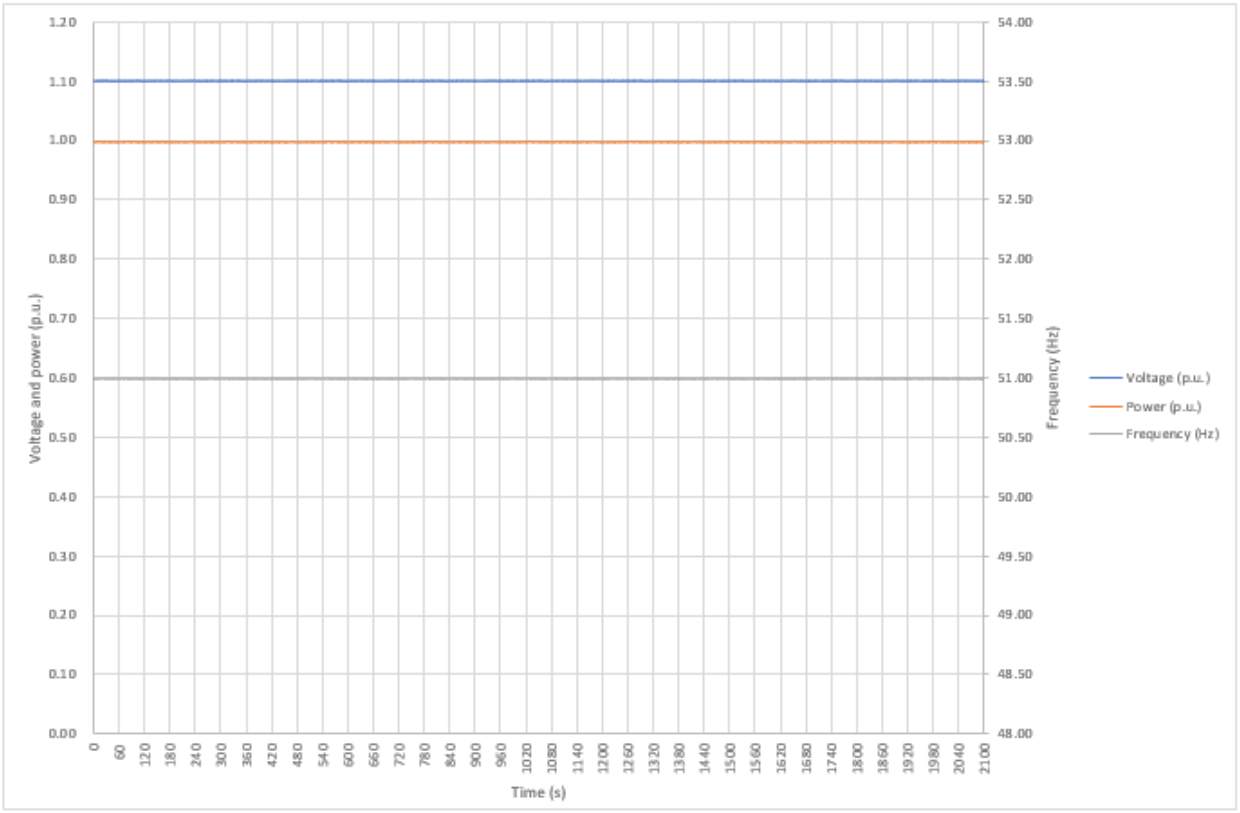
Test results are represented in graphics on the following pages.

Test 1 (V = 85.0%Un and F = 49.0 Hz)



	Time measured: 2100 s
Voltage average measured: 85.1 %Un	Frequency measured: 49.0 Hz

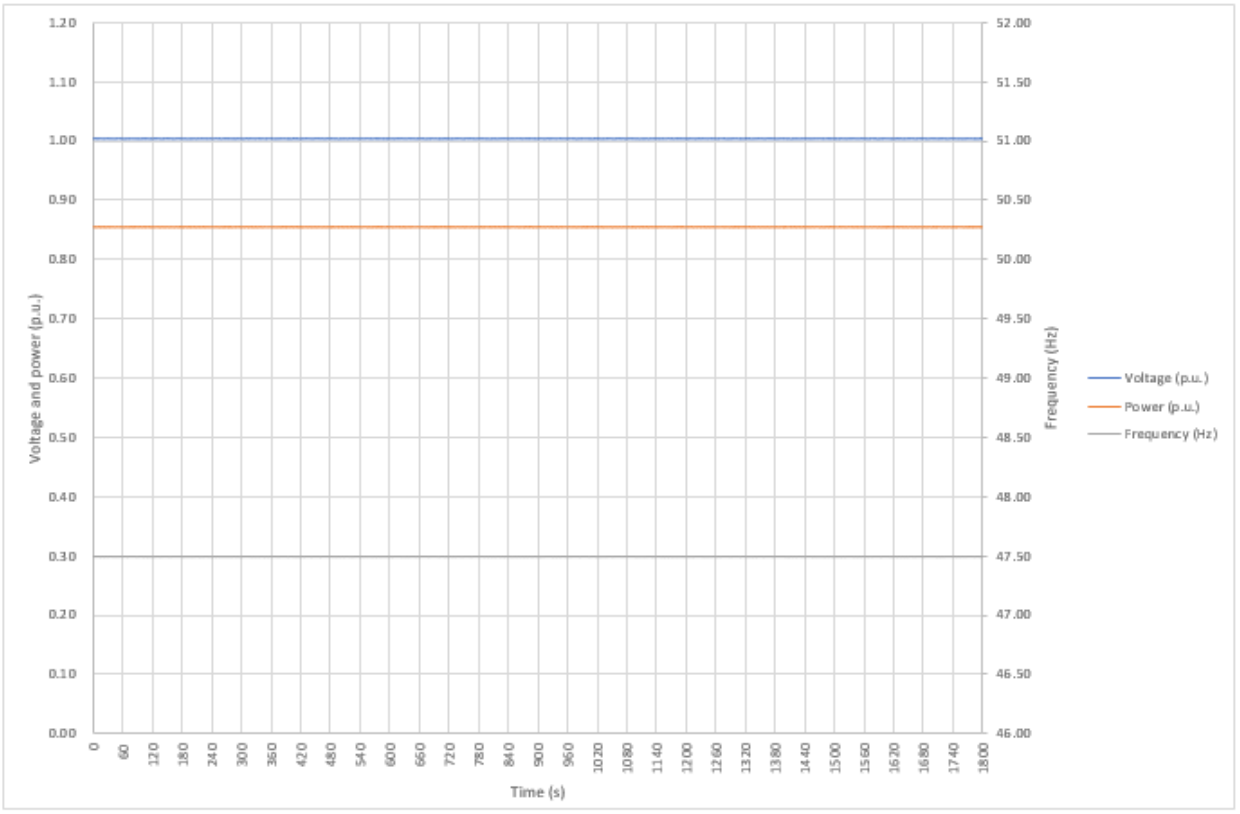
Test 2 (V = 110.0%Un and F = 51.0 Hz)



Time measured: 2100 s

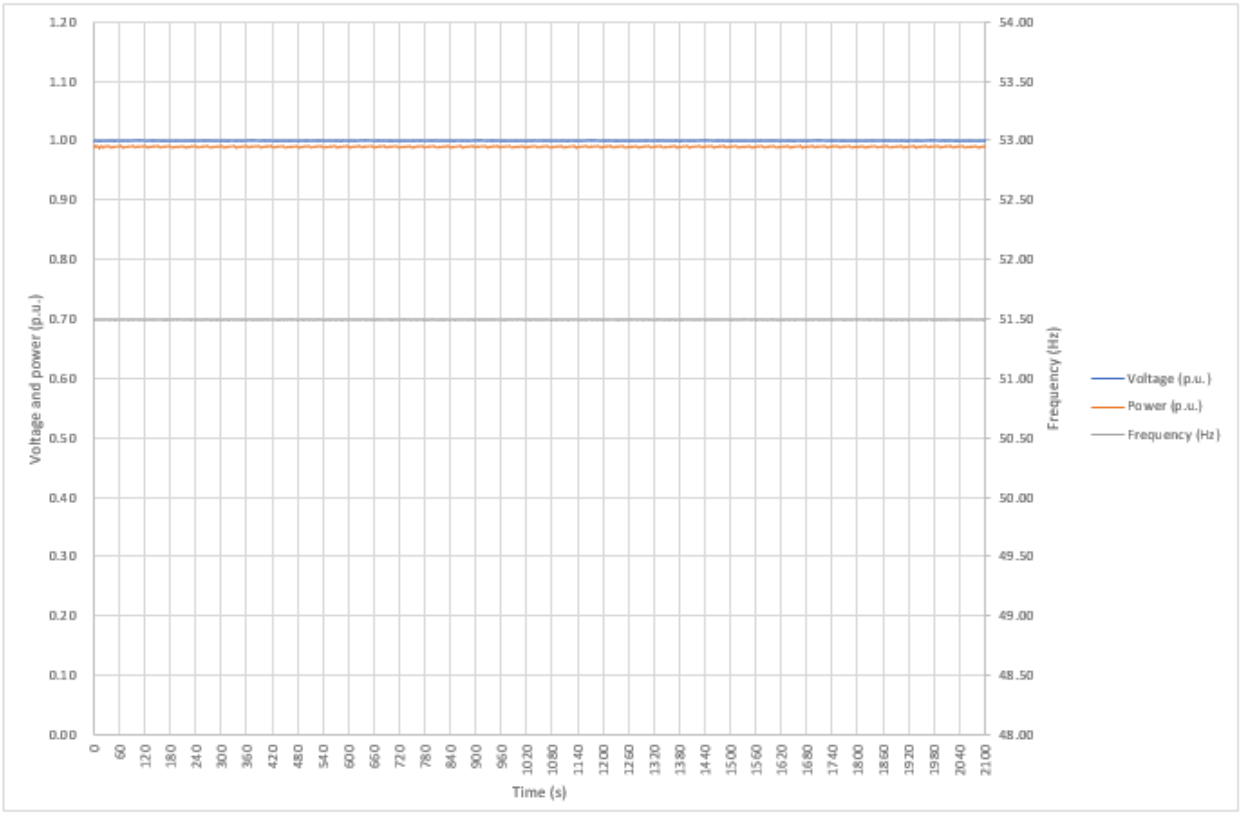
Voltage average measured: 110.1 %Un | Frequency measured: 51.0 Hz

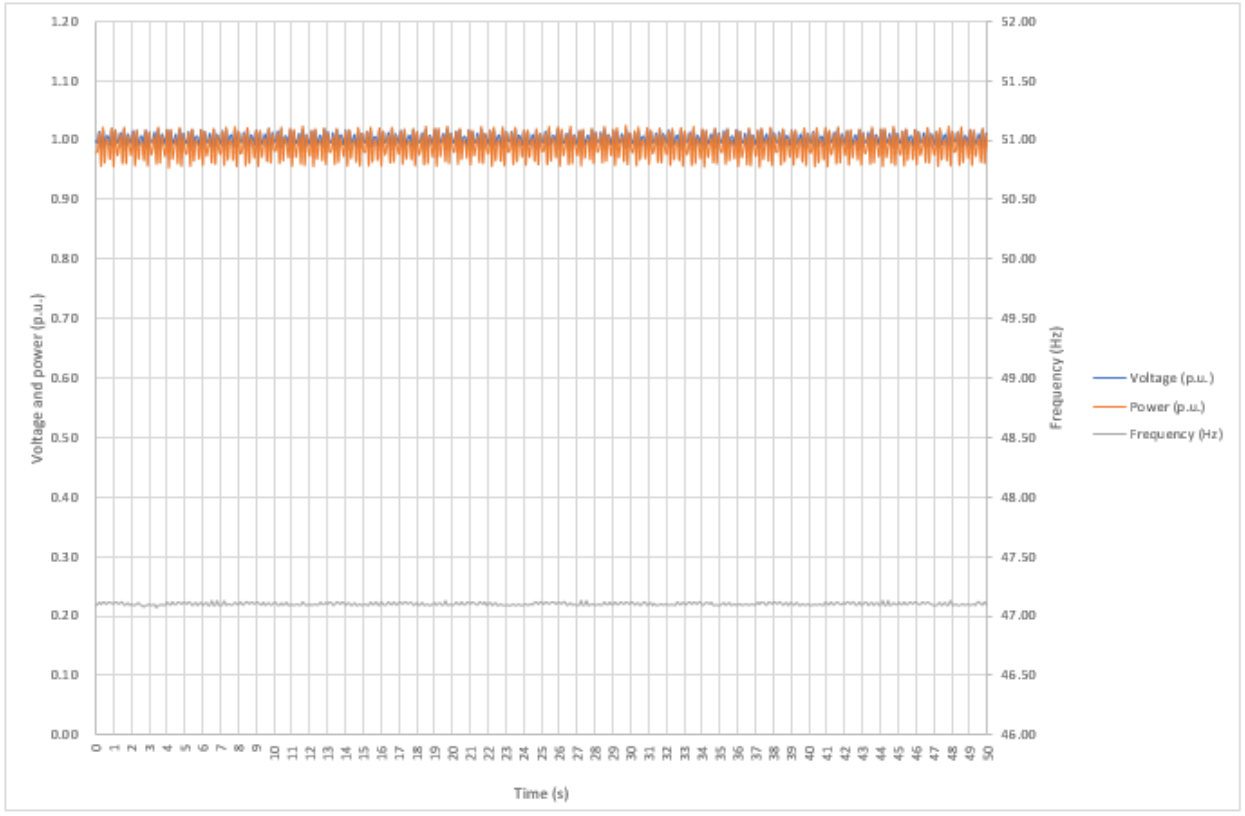
Test 3 (V = 100.0%Un and F = 47.5.0 Hz)



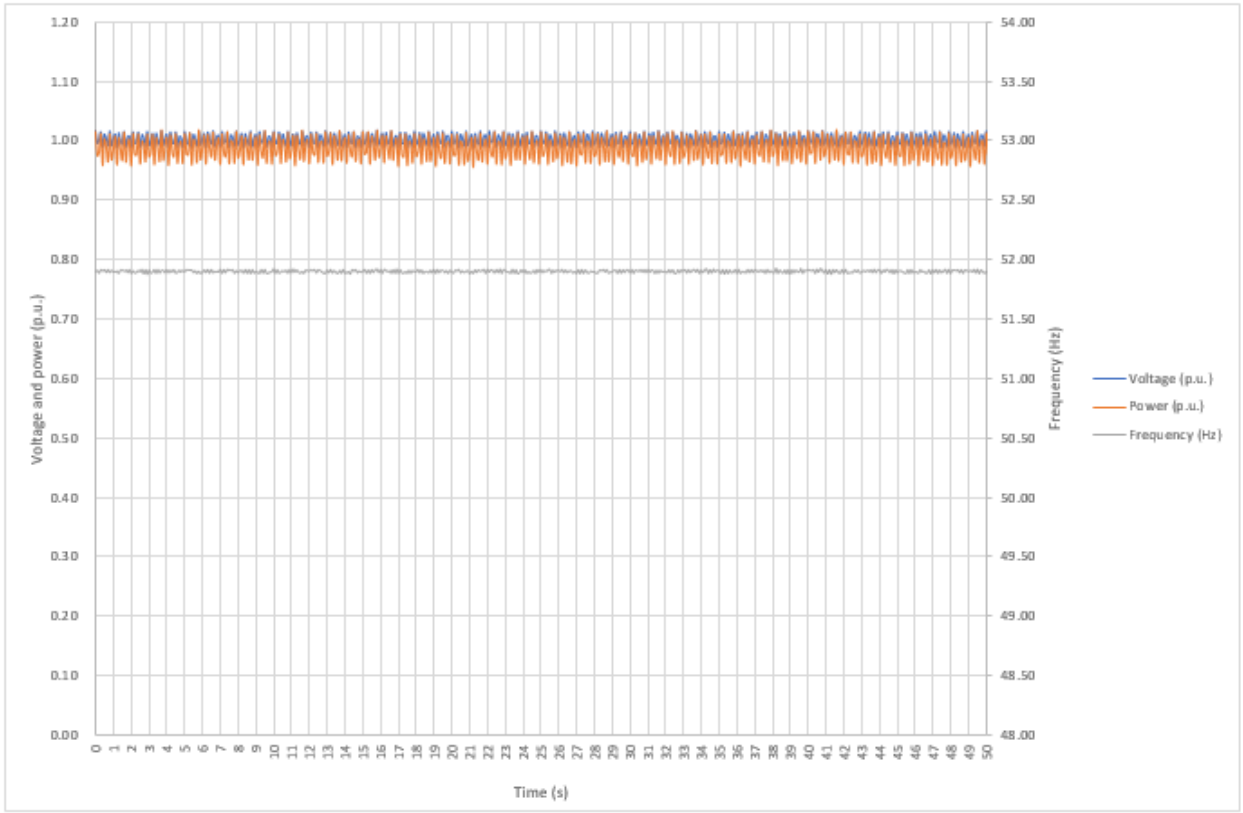
Time measured: 1800 s

Voltage average measured: 100.2 %Un | Frequency measured: 47.5 Hz

Test 4 (V = 100.0%Un and F = 51.5 Hz)	
	
	Time measured: 2100 s
Voltage average measured: 100.2 %Un	Frequency measured: 51.5 Hz

Test 5 (V = 100.0%Un and F = 47.1 Hz)	
	
	Time measured: 50 s
Voltage average measured: 100.15 %Un	Frequency measured: 47.1 Hz

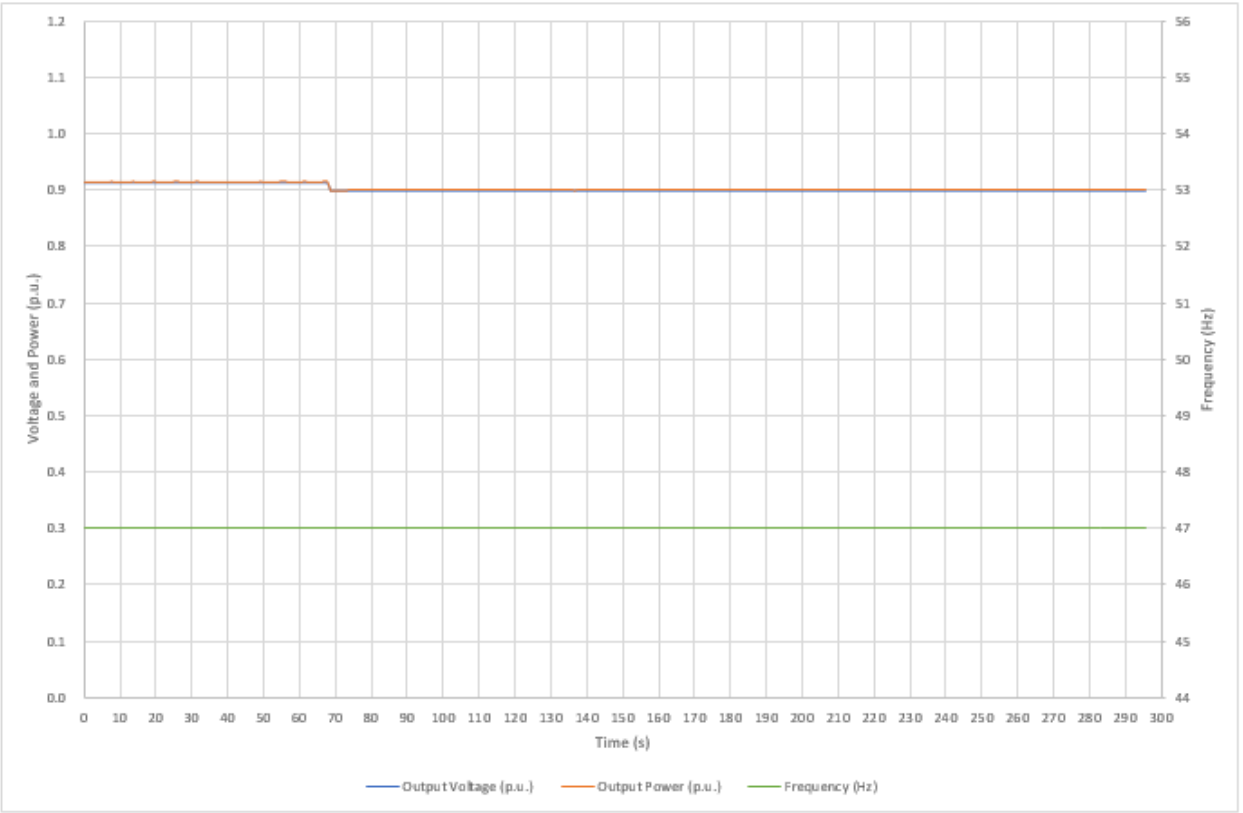
Test 6 (V = 100.0%Un and F = 51.9 Hz)



Time measured: 50 s

Voltage average measured: 100.16 %Un | Frequency measured: 51.9 Hz

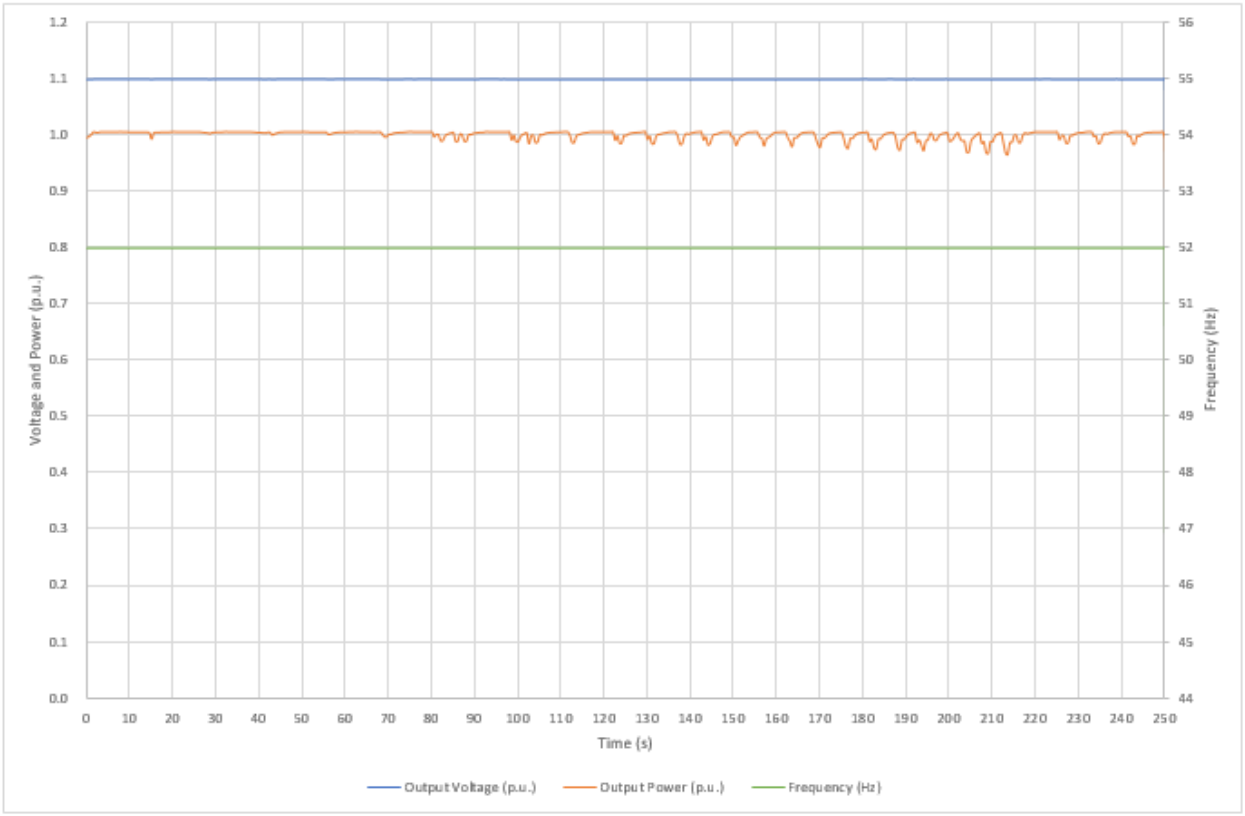
Test 7 (V = 90.0%Un and F = 47.0 Hz)



Time measured: 295 s

Voltage average measured: 90.3 %Un | Frequency measured: 47.0 Hz

Test 8 (V = 110.0%Un and F = 52.0 Hz)



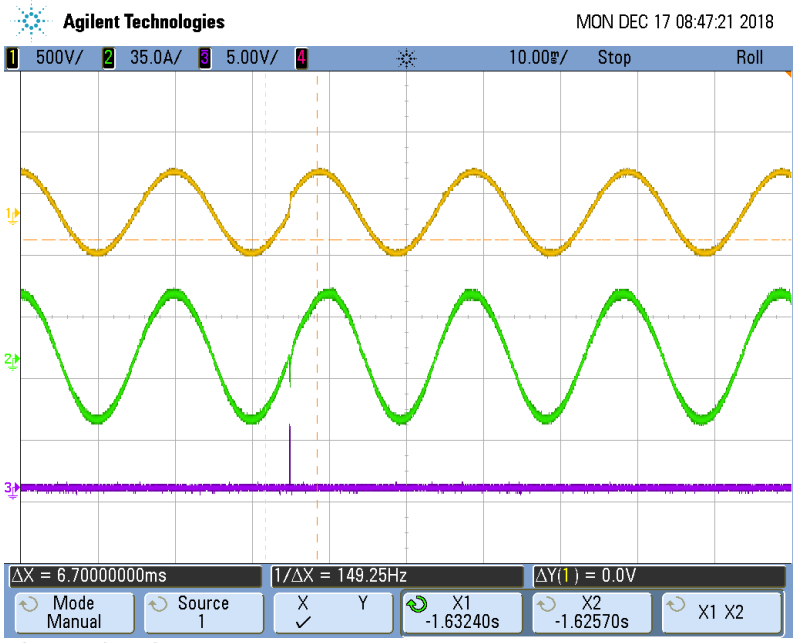
	Time measured: 250 s
Voltage average measured: 109.8 %Un	Frequency measured: 52.0 Hz

4.2 ABNORMAL OPERATING CONDITIONS

According to chapter 3.3 of standard TR3.2.1, a plant in plant category A1 must be designed to withstand transitory (80-100 ms) phase jumps of up to 20° in the Point of Connection (POC) without disrupting.

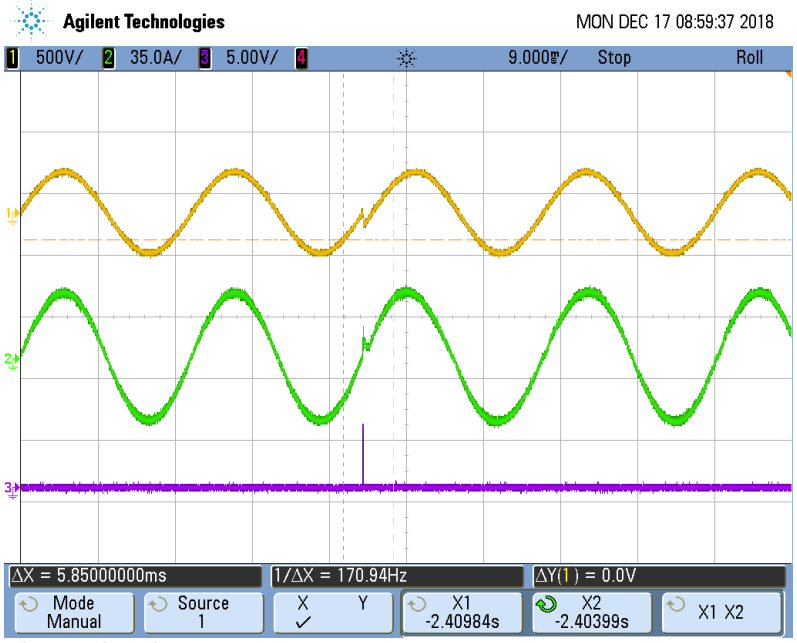
Test results are represented in graphics below.

20° phase jump ahead



Note: Purple line is trigger signal.

20° phase jump ahead



Note: Purple line is trigger signal.

Note: It is not applicable when the inverter is installed as plant category A2 and B according to standard TR3.2.2.

4.2.1 Voltage Dip Tolerance

According to chapter 3.3.1 of standard TR3.2.2, in the Point of Connection, a PV power plant must be designed to withstand voltage dips down to 10% of the voltage in the Point of Connection over a period of minimum 250 ms (line-to-line voltages for the 50 Hz component), as shown in Figure below, without disconnecting.

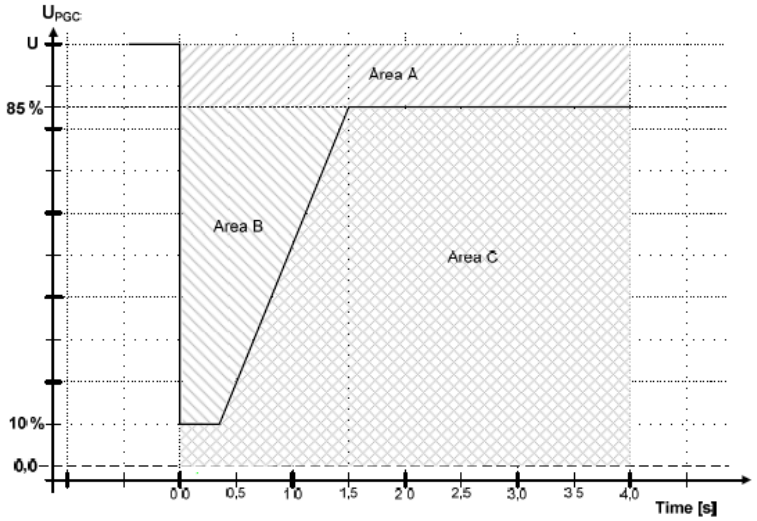


Figure 5 Voltage dip tolerance requirements for category C and D PV power plants.

It is not applicable due to the inverter is applying to plant category A1, A2 and B defined in this standard, according to manufacturer Statements.

4.2.2 Recurring Faults In The Public Electricity Supply Grid

According to chapter 3.3.2 of standard TR3.2.2, the PV power plant and any compensation equipment must stay connected during and after faults have occurred in the public electricity supply grid as specified in Table below. These requirements apply to the Point of Connection, but the fault sequence is at a random point in the public electricity supply grid.

Type	**Duration of fault**
Three-phase short circuit	Short circuit for 150 ms
Phase-to-phase-to-earth short circuit/phase-to-phase short circuit	Short circuit for 150 ms followed by a new short circuit 0.5 to 3 seconds later, also with a duration of 150 ms
Phase-to-earth short circuit	Phase-to-earth fault for 150 ms followed by a new phase-to-earth fault 0.5 to 3 seconds later, also with a duration of 150 ms

Table 2 Types and duration of faults in the public electricity supply grid.

It is not applicable due to the inverter is applying to plant category A1, A2 and B defined in this standard, according to manufacturer Statements.

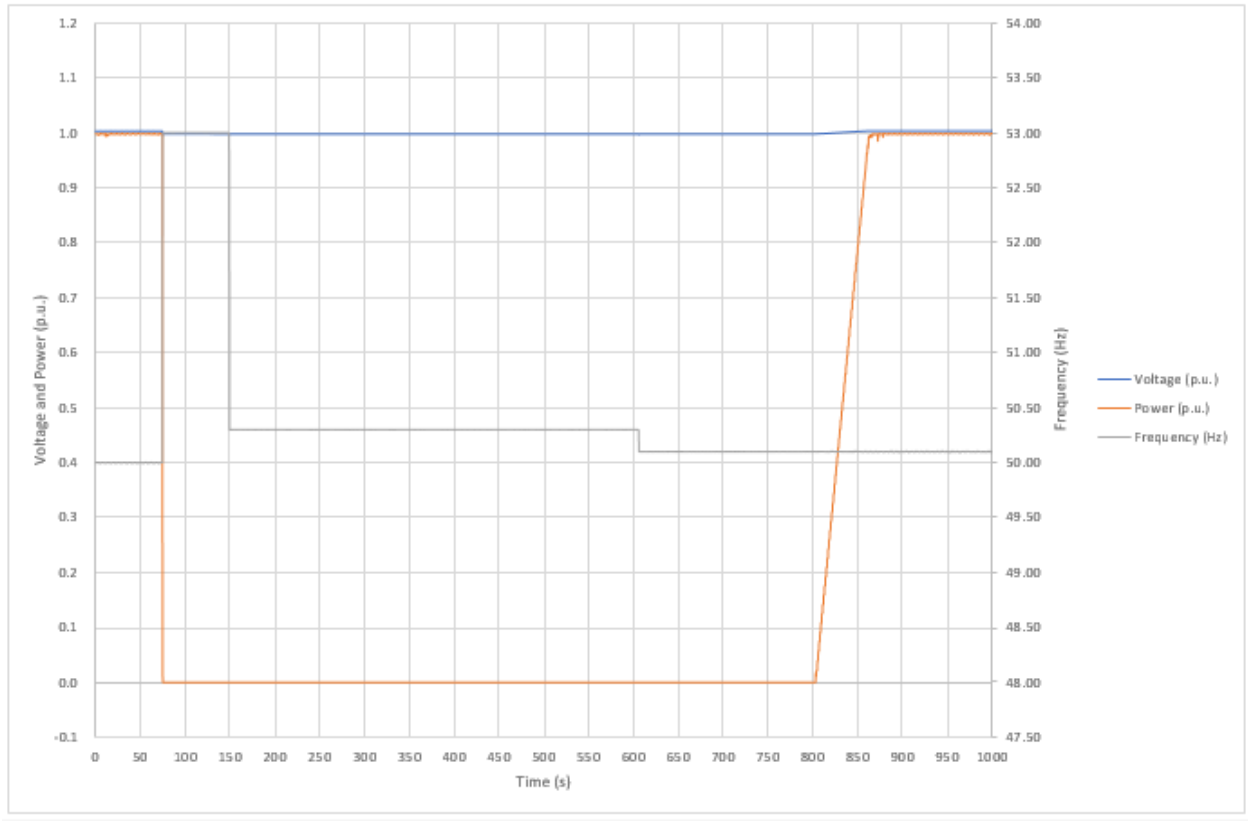
4.3 POWER QUALITY

4.3.1 Voltage Changes

According to chapter 4.1 of standard TR3.2.1, The inrush current must not lead to a voltage change of more than 4% in the Point of Connection.

Voltage is stable when the unit start up and on operation. Test results is represented in graphics below.

Voltage Change



4.3.2 DC Content

According to chapter 4.2 of standard TR3.2.1 and TR3.2.2, the DC content of the supplied AC current in the plant's Point of Connection (POC) may not exceed 0.5% of the nominal current.

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

- CEI 0-21: Test Report no. 18TH0539-CEI 0-21_0 on 2018/11/26 which was issued by Bureau Veritas Consumer Products Services Germany GmbH, accredited by DAkkS.

4.3.3 Asymmetry

According to chapter 4.3 of standard TR3.2.1 and TR3.2.2, the asymmetry between the phases at normal operation or in the event of faults in the electricity-generating unit may not exceed 16A.

It is not applicable due to the unit is single phase.

4.3.4 Flicker

Test is to verify that the flicker emission from continuous operation of the PV power plant is below the limit value in the Point of Connection according to chapter 4.4 of standard TR3.2.1 and TR3.2.2.

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

Starting operation and Stopping operation				
P_{bin}(%)	Limit	33 %	66 %	100 %
PST	≤ 1	0.08	0.09	0.10
PLT	≤ 0.65	0.04	0.05	0.06
dc	≤ 3.30%	0.23%	0.46%	0.59%
dmax	4%	0.29%	0.62%	0.75%

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 33% Pn

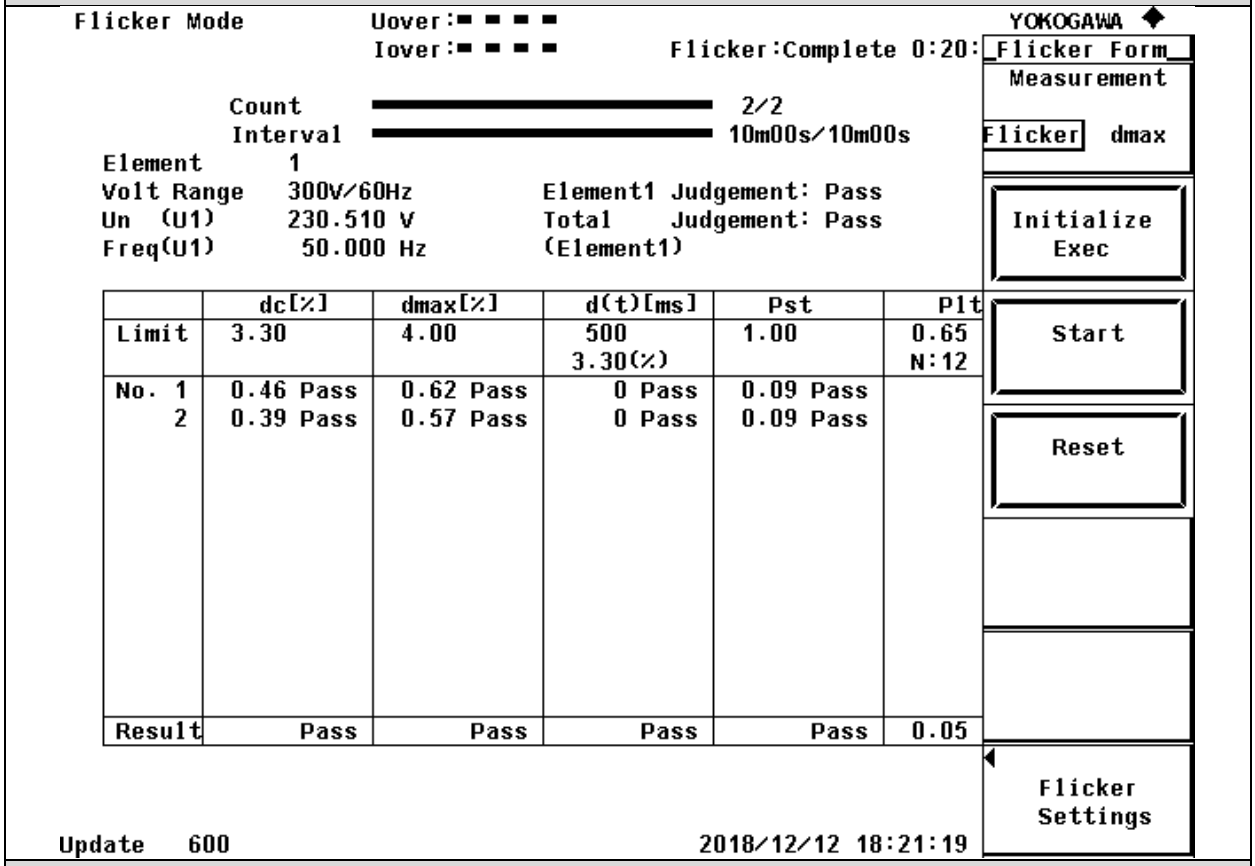
Flicker Mode Uover:■ ■ ■ ■ YOKOGAWA
Iover:■ ■ ■ ■ Flicker:Complete 0:20:00

Count 2/2
Interval 10m00s/10m00s
Element 1
Volt Range 300V/60Hz Element1 Judgement: Pass
Un (U1) 230.072 V Total Judgement: Pass
Freq(U1) 49.999 Hz (Element1)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.23 Pass	0.29 Pass	0 Pass	0.08 Pass	
2	0.16 Pass	0.25 Pass	0 Pass	0.08 Pass	
Result	Pass	Pass	Pass	Pass	0.04 Pass

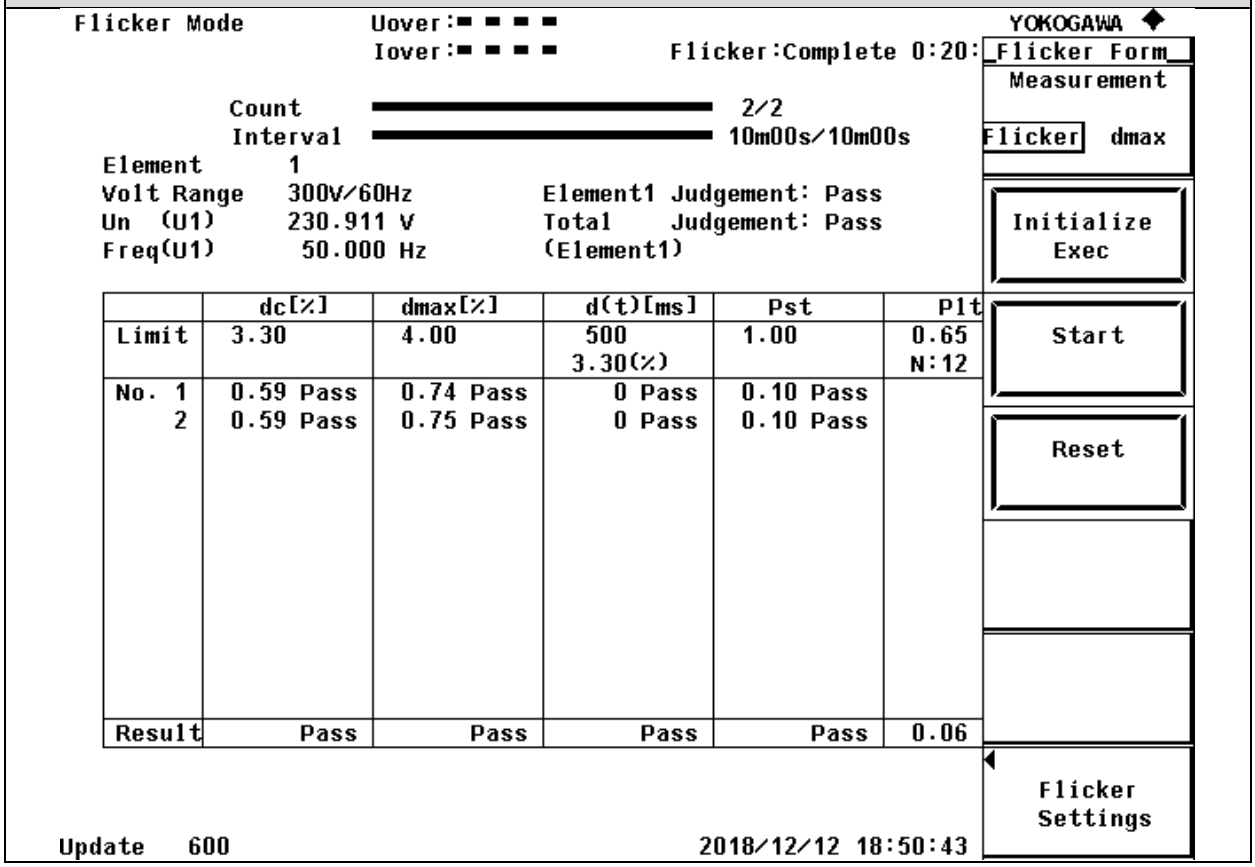
Update 600 2018/12/12 17:34:14

Starting operation and Stopping operation 66% Pn



	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.46 Pass	0.62 Pass	0 Pass	0.09 Pass	
2	0.39 Pass	0.57 Pass	0 Pass	0.09 Pass	
Result	Pass	Pass	Pass	Pass	0.05

Starting operation and Stopping operation 100% Pn



	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.59 Pass	0.74 Pass	0 Pass	0.10 Pass	
2	0.59 Pass	0.75 Pass	0 Pass	0.10 Pass	
Result	Pass	Pass	Pass	Pass	0.06

Running operation				
P_{bin}(%)	Limit	33 %	66 %	100 %
PST	≤ 1	0.07	0.10	0.09
PLT	≤ 0.65	0.07	0.09	0.09
dc	≤ 3.30%	0.21%	0.39%	0.14%
dmax	4%	0.28%	0.49%	0.28%

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 of 10 minutes each one.

Running operation 33% Pn

Flicker Mode　Uover:■ ■ ■ ■　YOKOGAWA ◆
Iover:■ ■ ■ ■　Flicker:Complete 2:00:00

Count　12/12
Interval　10m00s/10m00s
Element　1
Volt Range　300V/60Hz　Element1 Judgement: Pass
Un (U1)　230.226 V　Total Judgement: Pass
Freq(U1)　50.000 Hz　(Element1)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.16 Pass	0.26 Pass	0 Pass	0.07 Pass	
2	0.16 Pass	0.21 Pass	0 Pass	0.07 Pass	
3	0.17 Pass	0.22 Pass	0 Pass	0.07 Pass	
4	0.19 Pass	0.27 Pass	0 Pass	0.07 Pass	
5	0.21 Pass	0.28 Pass	0 Pass	0.07 Pass	
6	0.16 Pass	0.25 Pass	0 Pass	0.07 Pass	
7	0.14 Pass	0.23 Pass	0 Pass	0.07 Pass	
8	0.14 Pass	0.22 Pass	0 Pass	0.07 Pass	
9	0.14 Pass	0.23 Pass	0 Pass	0.07 Pass	
10	0.13 Pass	0.22 Pass	0 Pass	0.07 Pass	
11	0.15 Pass	0.23 Pass	0 Pass	0.07 Pass	
12	0.15 Pass	0.23 Pass	0 Pass	0.07 Pass	
Result	Pass	Pass	Pass	Pass	0.07 Pass

Update 3600　2018/12/13 18:43:45

Running operation 66% Pn

Flicker Mode   Uover:■ ■ ■ ■   I2 : 30A   YOKOGAWA ◆
Iover:■ ■ ■ ■   Flicker:Complete 2:00:

Count 12/12
Interval 10m00s/10m00s

Element 1
Volt Range 300V/60Hz   Element1 Judgement: Pass
Un (U1) 230.591 V   Total Judgement: Pass
Freq(U1) 49.999 Hz   (Element1)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.39 Pass	0.49 Pass	0 Pass	0.10 Pass	
2	0.08 Pass	0.11 Pass	0 Pass	0.07 Pass	
3	0.35 Pass	0.43 Pass	0 Pass	0.08 Pass	
4	0.35 Pass	0.44 Pass	0 Pass	0.09 Pass	
5	0.35 Pass	0.48 Pass	0 Pass	0.08 Pass	
6	0.33 Pass	0.45 Pass	0 Pass	0.08 Pass	
7	0.35 Pass	0.45 Pass	0 Pass	0.08 Pass	
8	0.35 Pass	0.47 Pass	0 Pass	0.08 Pass	
9	0.35 Pass	0.47 Pass	0 Pass	0.08 Pass	
10	0.35 Pass	0.42 Pass	0 Pass	0.08 Pass	
11	0.34 Pass	0.42 Pass	0 Pass	0.09 Pass	
12	0.33 Pass	0.43 Pass	0 Pass	0.09 Pass	
Result	Pass	Pass	Pass	Pass	0.09

Flicker Form
Measurement
Flicker dmax
Initialize Exec
Start
Reset
Flicker Settings

Update 3600   2018/12/14 10:39:51

Running operation 100% Pn

Flicker Mode   Uover:■ ■ ■ ■   I1 : 30A   YOKOGAWA ◆
Iover:■ ■ ■ ■   Flicker:Complete 2:00:00

Count 12/12
Interval 10m00s/10m00s

Element 1
Volt Range 300V/50Hz   Element1 Judgement: Pass
Un (U1) 231.021 V   Total Judgement: Pass
Freq(U1) 50.001 Hz   (Element1)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.14 Pass	0.28 Pass	0 Pass	0.09 Pass	
2	0.12 Pass	0.27 Pass	0 Pass	0.09 Pass	
3	0.12 Pass	0.28 Pass	0 Pass	0.09 Pass	
4	0.14 Pass	0.26 Pass	0 Pass	0.09 Pass	
5	0.11 Pass	0.26 Pass	0 Pass	0.09 Pass	
6	0.14 Pass	0.28 Pass	0 Pass	0.09 Pass	
7	0.13 Pass	0.26 Pass	0 Pass	0.09 Pass	
8	0.11 Pass	0.25 Pass	0 Pass	0.09 Pass	
9	0.14 Pass	0.26 Pass	0 Pass	0.09 Pass	
10	0.14 Pass	0.25 Pass	0 Pass	0.09 Pass	
11	0.11 Pass	0.25 Pass	0 Pass	0.09 Pass	
12	0.11 Pass	0.27 Pass	0 Pass	0.09 Pass	
Result	Pass	Pass	Pass	Pass	0.09 Pass

Update 3600   2018/12/18 08:05:14

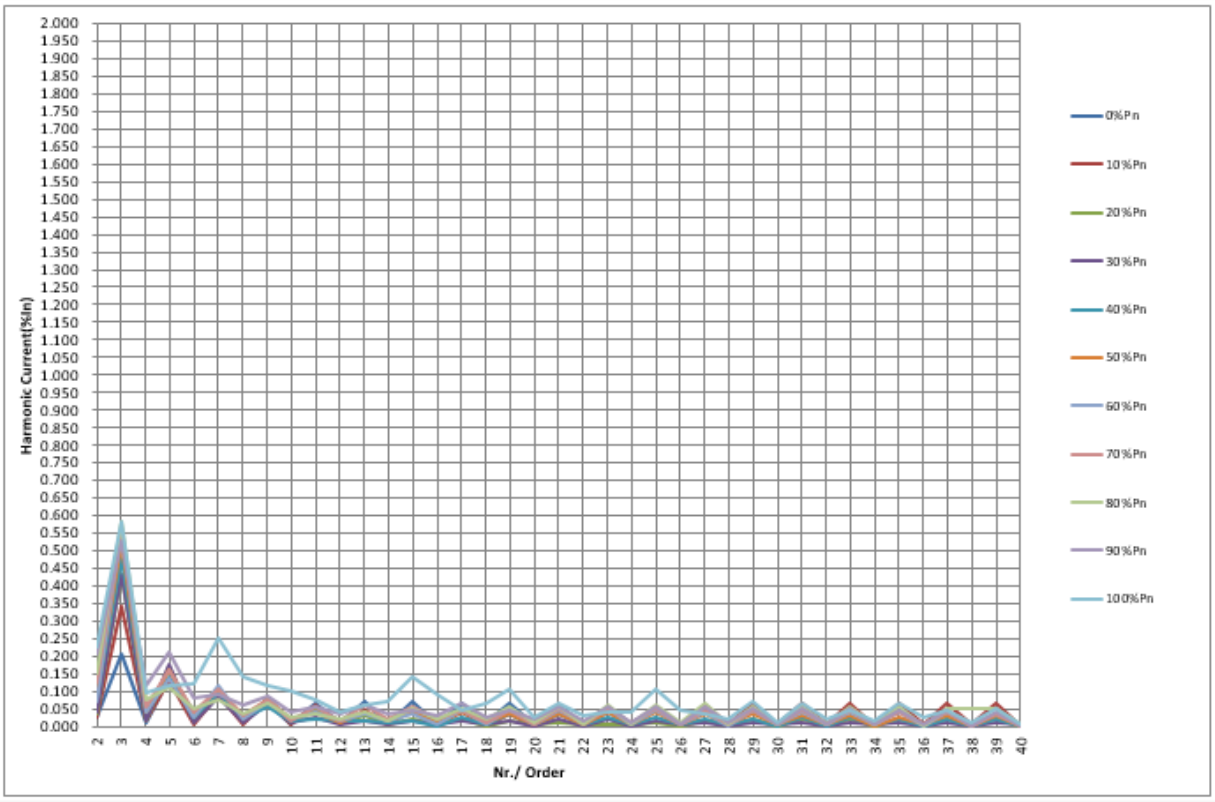
4.3.5 Harmonic Distortions

Test is according to chapter 4.5 of standard TR3.2.1 and TR3.2.2.

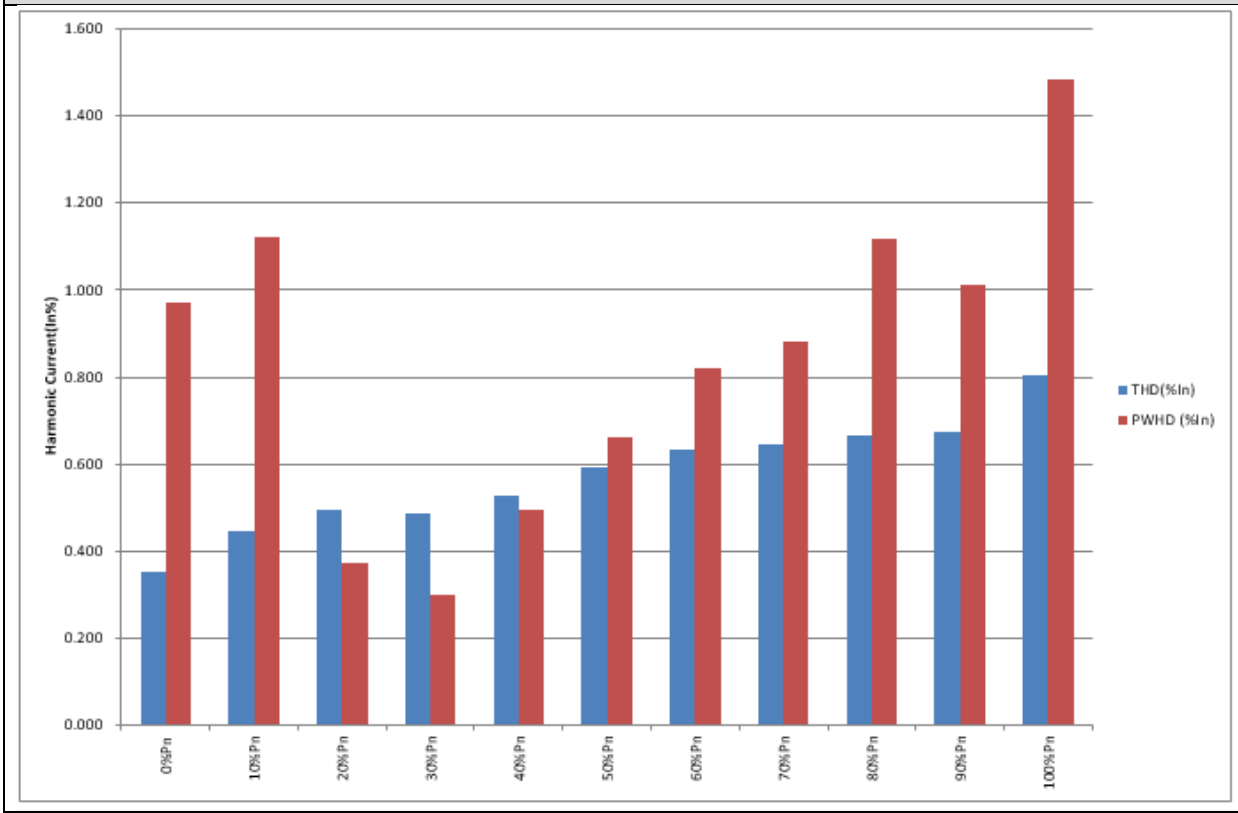
The values measured for current harmonics is respectively offered in the following points.

P (%P_n)	0	10	20	30	40	50	60	70	80	90	100	Category A2 Limit	Category B Limit
Nr./ Order	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)
2	0.026	0.024	0.038	0.042	0.081	0.093	0.073	0.127	0.154	0.205	0.229	-	-
3	0.209	0.342	0.434	0.430	0.475	0.522	0.568	0.559	0.581	0.529	0.581	-	-
4	0.011	0.015	0.017	0.015	0.041	0.044	0.042	0.057	0.075	0.118	0.099	-	-
5	0.139	0.132	0.171	0.178	0.143	0.161	0.138	0.162	0.112	0.210	0.117	10.7	3.6
6	0.010	0.007	0.016	0.013	0.028	0.038	0.026	0.043	0.049	0.081	0.123	-	-
7	0.089	0.093	0.111	0.089	0.097	0.109	0.116	0.108	0.074	0.094	0.252	7.2	2.5
8	0.010	0.006	0.014	0.011	0.025	0.030	0.023	0.033	0.034	0.059	0.142	-	-
9	0.067	0.080	0.076	0.066	0.055	0.078	0.070	0.075	0.067	0.087	0.118	-	-
10	0.008	0.007	0.012	0.010	0.018	0.020	0.022	0.017	0.024	0.043	0.103	-	-
11	0.066	0.061	0.049	0.025	0.020	0.043	0.043	0.056	0.037	0.055	0.077	3.1	1.0
12	0.010	0.007	0.014	0.008	0.014	0.011	0.015	0.018	0.020	0.034	0.039	-	-
13	0.072	0.048	0.032	0.016	0.015	0.041	0.034	0.061	0.043	0.063	0.060	2	0.7
14	0.007	0.005	0.007	0.007	0.011	0.015	0.017	0.022	0.018	0.036	0.071	-	-
15	0.069	0.046	0.019	0.014	0.018	0.042	0.037	0.055	0.052	0.048	0.144	-	-
16	0.007	0.008	0.010	0.008	0.003	0.012	0.008	0.020	0.023	0.029	0.091	-	-
17	0.066	0.044	0.023	0.019	0.028	0.040	0.047	0.049	0.050	0.067	0.048	-	-
18	0.010	0.004	0.003	0.007	0.006	0.012	0.007	0.013	0.022	0.026	0.066	-	-
19	0.065	0.039	0.018	0.018	0.036	0.038	0.051	0.048	0.054	0.048	0.107	-	-
20	0.007	0.004	0.005	0.004	0.006	0.005	0.007	0.005	0.013	0.020	0.025	-	-
21	0.060	0.037	0.013	0.021	0.034	0.034	0.048	0.051	0.057	0.059	0.068	-	-
22	0.008	0.007	0.004	0.004	0.006	0.007	0.010	0.007	0.008	0.014	0.033	-	-
23	0.059	0.040	0.009	0.020	0.028	0.040	0.050	0.050	0.061	0.057	0.040	-	-
24	0.008	0.005	0.004	0.002	0.008	0.006	0.009	0.011	0.006	0.014	0.042	-	-
25	0.056	0.051	0.011	0.019	0.027	0.040	0.047	0.050	0.063	0.058	0.105	-	-
26	0.006	0.005	0.003	0.004	0.006	0.005	0.005	0.008	0.009	0.006	0.047	-	-
27	0.052	0.062	0.015	0.014	0.024	0.037	0.042	0.048	0.065	0.057	0.036	-	-
28	0.008	0.005	0.003	0.003	0.005	0.004	0.004	0.008	0.008	0.014	0.019	-	-
29	0.048	0.068	0.022	0.013	0.024	0.035	0.046	0.046	0.058	0.052	0.072	-	-
30	0.007	0.005	0.003	0.004	0.003	0.006	0.005	0.005	0.007	0.005	0.011	-	-
31	0.048	0.068	0.023	0.012	0.027	0.034	0.044	0.045	0.056	0.052	0.064	-	-
32	0.005	0.005	0.004	0.003	0.003	0.004	0.004	0.007	0.007	0.008	0.019	-	-
33	0.046	0.067	0.022	0.012	0.024	0.032	0.041	0.045	0.058	0.053	0.048	-	-
34	0.006	0.004	0.004	0.004	0.005	0.003	0.005	0.008	0.007	0.005	0.017	-	-
35	0.044	0.065	0.022	0.012	0.023	0.028	0.042	0.043	0.055	0.047	0.068	-	-
36	0.005	0.005	0.004	0.004	0.002	0.004	0.004	0.005	0.004	0.006	0.025	-	-
37	0.040	0.068	0.023	0.014	0.024	0.030	0.039	0.043	0.051	0.046	0.047	-	-
38	0.003	0.004	0.004	0.003	0.003	0.003	0.005	0.003	0.051	0.004	0.009	-	-
39	0.037	0.068	0.021	0.013	0.022	0.032	0.035	0.037	0.051	0.044	0.052	-	-
40	0.004	0.003	0.004	0.005	0.003	0.003	0.005	0.002	0.005	0.004	0.005	-	-
THD (%)	0.353	0.446	0.497	0.486	0.528	0.592	0.631	0.645	0.665	0.676	0.804	13	4.5
PWHD (%)	0.969	1.123	0.375	0.298	0.493	0.661	0.822	0.880	1.118	1.012	1.483	22	7.9

Current Harmonics



THD and PWHD



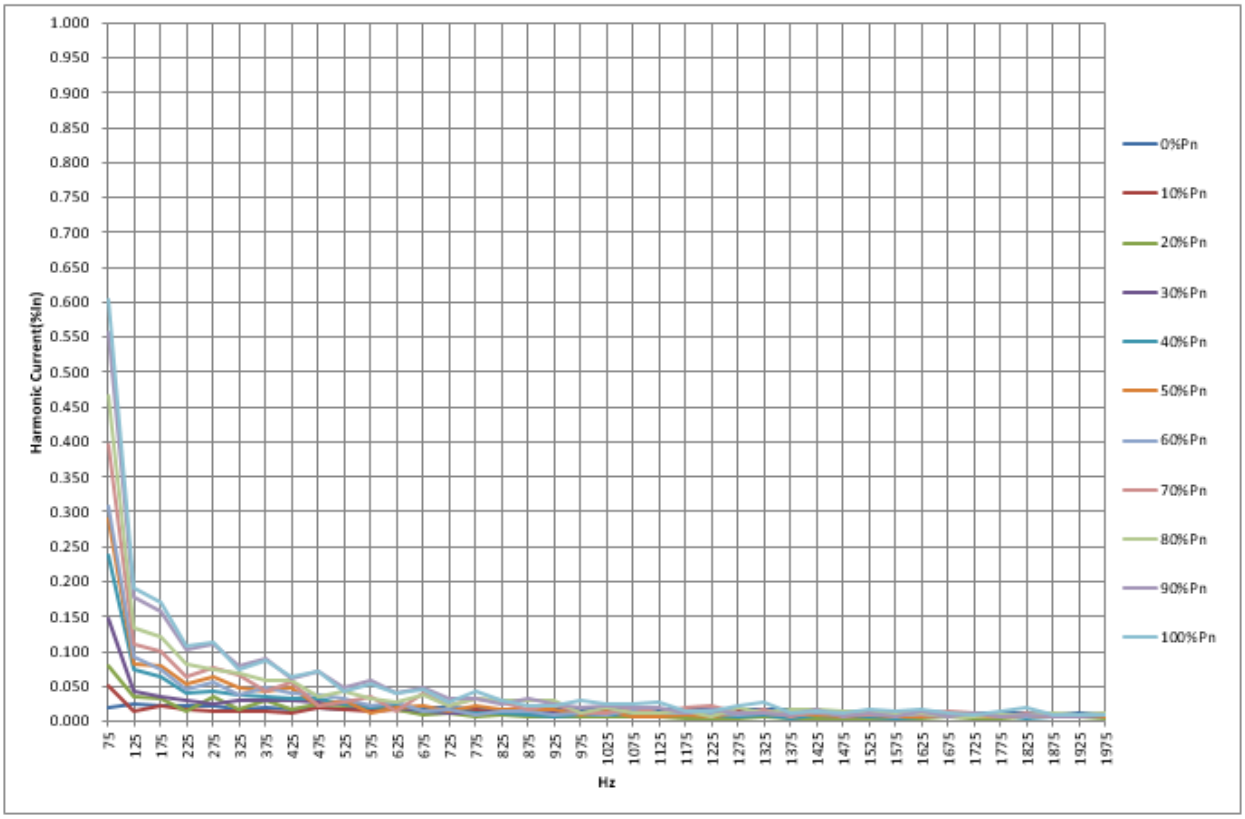
4.3.6 Interharmonic Distortions

Test is according to chapter 4.6 of standard TR3.2.2.

The results of inter-harmonics measurements are represented in the tables and graphics below.

P (%P_n)	0	10	20	30	40	50	60	70	80	90	100	Limit
f [Hz]	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)
75	0.019	0.050	0.078	0.147	0.238	0.289	0.309	0.396	0.182	0.340	0.202	0.4
125	0.025	0.013	0.034	0.043	0.074	0.081	0.091	0.109	0.054	0.070	0.069	0.6
175	0.022	0.021	0.032	0.036	0.065	0.078	0.074	0.099	0.044	0.066	0.057	0.429
225	0.021	0.016	0.014	0.030	0.041	0.052	0.045	0.065	0.030	0.056	0.036	0.333
275	0.021	0.013	0.036	0.026	0.043	0.064	0.057	0.075	0.040	0.043	0.046	0.273
325	0.017	0.014	0.017	0.029	0.038	0.049	0.037	0.066	0.038	0.034	0.041	0.231
375	0.020	0.015	0.030	0.030	0.036	0.043	0.048	0.042	0.032	0.033	0.043	0.200
425	0.018	0.011	0.018	0.031	0.032	0.048	0.039	0.055	0.043	0.051	0.045	0.176
475	0.020	0.020	0.026	0.027	0.031	0.022	0.037	0.021	0.025	0.034	0.068	0.158
525	0.018	0.018	0.021	0.025	0.024	0.029	0.033	0.028	0.029	0.038	0.040	0.143
575	0.019	0.015	0.021	0.022	0.020	0.013	0.022	0.034	0.033	0.041	0.068	0.130
625	0.020	0.018	0.016	0.018	0.024	0.019	0.028	0.015	0.024	0.029	0.034	0.120
675	0.020	0.012	0.010	0.015	0.013	0.021	0.014	0.039	0.036	0.051	0.038	0.111
725	0.018	0.012	0.013	0.012	0.016	0.013	0.016	0.023	0.023	0.037	0.028	0.103
775	0.017	0.016	0.008	0.012	0.011	0.022	0.009	0.032	0.033	0.032	0.028	0.100
825	0.017	0.010	0.010	0.013	0.012	0.016	0.015	0.028	0.027	0.035	0.040	0.100
875	0.016	0.013	0.007	0.011	0.010	0.016	0.015	0.018	0.030	0.021	0.029	0.100
925	0.018	0.011	0.005	0.013	0.007	0.016	0.010	0.025	0.039	0.040	0.037	0.100
975	0.018	0.013	0.007	0.011	0.009	0.009	0.013	0.011	0.031	0.025	0.020	0.100
1025	0.017	0.011	0.007	0.013	0.010	0.014	0.010	0.011	0.028	0.040	0.044	0.100
1075	0.019	0.011	0.006	0.013	0.010	0.007	0.016	0.020	0.032	0.031	0.026	0.100
1125	0.017	0.012	0.007	0.012	0.011	0.006	0.012	0.011	0.023	0.019	0.036	0.100
1175	0.017	0.011	0.005	0.012	0.009	0.008	0.011	0.021	0.018	0.023	0.029	0.100
1225	0.017	0.013	0.004	0.010	0.010	0.007	0.013	0.021	0.026	0.025	0.030	0.100
1275	0.017	0.013	0.003	0.010	0.007	0.013	0.008	0.013	0.033	0.039	0.023	0.100
1325	0.016	0.009	0.006	0.010	0.010	0.011	0.012	0.016	0.030	0.046	0.053	0.100
1375	0.016	0.012	0.005	0.010	0.005	0.008	0.009	0.006	0.032	0.026	0.019	0.100
1425	0.015	0.011	0.004	0.008	0.010	0.010	0.011	0.014	0.023	0.041	0.039	0.100
1475	0.015	0.012	0.004	0.011	0.005	0.007	0.008	0.008	0.034	0.023	0.033	0.100
1525	0.014	0.010	0.004	0.008	0.007	0.010	0.010	0.008	0.022	0.025	0.024	0.100
1575	0.013	0.009	0.004	0.007	0.005	0.006	0.009	0.013	0.024	0.016	0.033	0.100
1625	0.014	0.009	0.004	0.008	0.008	0.006	0.008	0.009	0.035	0.026	0.028	0.100
1675	0.013	0.010	0.006	0.007	0.005	0.007	0.007	0.015	0.026	0.018	0.027	0.100
1725	0.011	0.008	0.005	0.008	0.007	0.005	0.010	0.013	0.017	0.023	0.026	0.100
1775	0.011	0.010	0.005	0.007	0.008	0.007	0.010	0.008	0.028	0.026	0.028	0.100
1825	0.012	0.008	0.005	0.007	0.005	0.008	0.007	0.011	0.023	0.025	0.032	0.100
1875	0.010	0.010	0.006	0.005	0.007	0.008	0.010	0.007	0.023	0.017	0.035	0.100
1925	0.012	0.008	0.007	0.008	0.007	0.009	0.010	0.007	0.020	0.032	0.031	0.100
1975	0.010	0.010	0.005	0.007	0.005	0.006	0.008	0.011	0.031	0.029	0.025	0.100

Inter-Harmonics Current



Note: There are no interharmonic distortion emission requirements for plant category A1.

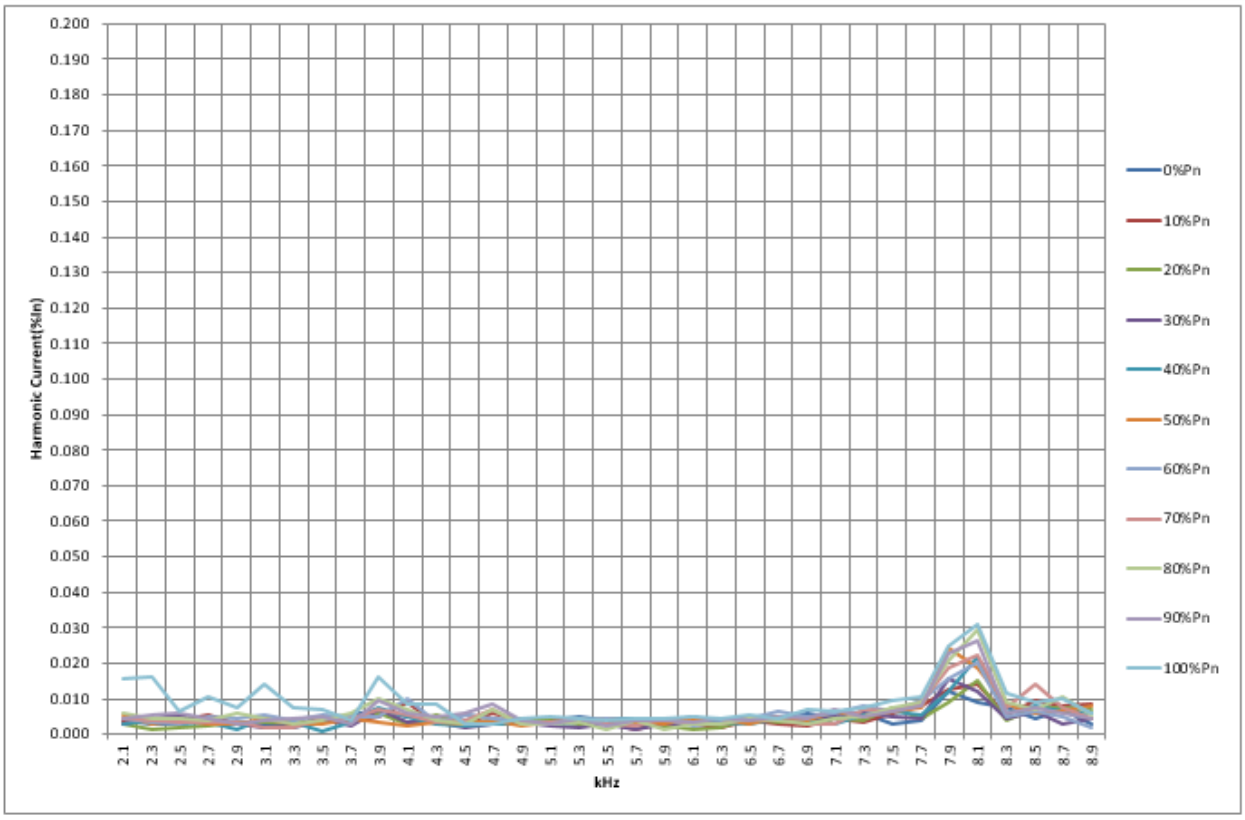
4.3.7 Distortions In The 2-9 kHz Frequency Range

Test is according to chapter 4.7 of standard TR3.2.2.

The results of higher frequency components measurements are represented in the tables and graphics below.

P (%P_n)	0	10	20	30	40	50	60	70	80	90	100	Limit
f (kHz)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)
2.1	0.004	0.004	0.003	0.003	0.003	0.005	0.004	0.004	0.006	0.005	0.015	0.2
2.3	0.003	0.004	0.002	0.004	0.004	0.003	0.003	0.004	0.004	0.005	0.016	0.2
2.5	0.003	0.004	0.002	0.005	0.003	0.004	0.003	0.003	0.004	0.006	0.007	0.2
2.7	0.005	0.005	0.002	0.003	0.003	0.003	0.005	0.003	0.004	0.005	0.011	0.2
2.9	0.003	0.003	0.003	0.003	0.002	0.003	0.004	0.003	0.006	0.003	0.007	0.2
3.1	0.003	0.004	0.003	0.002	0.004	0.005	0.005	0.002	0.005	0.004	0.014	0.2
3.3	0.002	0.003	0.003	0.002	0.003	0.003	0.004	0.002	0.003	0.005	0.008	0.2
3.5	0.004	0.003	0.004	0.005	0.001	0.003	0.005	0.005	0.004	0.005	0.007	0.2
3.7	0.005	0.003	0.004	0.002	0.003	0.004	0.005	0.005	0.006	0.003	0.004	0.2
3.9	0.007	0.005	0.006	0.007	0.007	0.003	0.005	0.007	0.010	0.010	0.016	0.2
4.1	0.005	0.009	0.003	0.003	0.005	0.002	0.010	0.005	0.007	0.006	0.008	0.2
4.3	0.003	0.003	0.005	0.003	0.003	0.003	0.003	0.003	0.004	0.005	0.008	0.2
4.5	0.005	0.003	0.003	0.002	0.002	0.003	0.005	0.004	0.003	0.006	0.003	0.2
4.7	0.005	0.006	0.004	0.003	0.003	0.004	0.004	0.007	0.007	0.008	0.003	0.2
4.9	0.003	0.004	0.005	0.003	0.003	0.002	0.004	0.003	0.003	0.004	0.004	0.2
5.1	0.004	0.004	0.004	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.005	0.2
5.3	0.005	0.003	0.003	0.002	0.003	0.003	0.004	0.004	0.003	0.005	0.005	0.2
5.5	0.004	0.003	0.003	0.003	0.004	0.004	0.004	0.003	0.002	0.002	0.004	0.2
5.7	0.004	0.002	0.003	0.002	0.005	0.003	0.004	0.002	0.004	0.004	0.005	0.2
5.9	0.003	0.003	0.002	0.003	0.004	0.003	0.004	0.004	0.002	0.004	0.005	0.2
6.1	0.005	0.003	0.002	0.003	0.004	0.004	0.002	0.003	0.003	0.003	0.005	0.2
6.3	0.003	0.002	0.002	0.004	0.003	0.004	0.003	0.003	0.003	0.004	0.004	0.2
6.5	0.004	0.004	0.004	0.005	0.003	0.003	0.004	0.005	0.004	0.004	0.005	0.2
6.7	0.004	0.003	0.003	0.005	0.004	0.005	0.007	0.004	0.004	0.005	0.004	0.2
6.9	0.006	0.002	0.003	0.004	0.004	0.004	0.005	0.003	0.003	0.005	0.007	0.2
7.1	0.005	0.004	0.005	0.005	0.003	0.007	0.006	0.003	0.004	0.007	0.007	0.2
7.3	0.006	0.003	0.004	0.006	0.005	0.005	0.008	0.007	0.005	0.005	0.007	0.2
7.5	0.003	0.006	0.007	0.005	0.007	0.007	0.007	0.007	0.007	0.007	0.010	0.2
7.7	0.004	0.008	0.004	0.005	0.005	0.007	0.010	0.009	0.009	0.008	0.011	0.2
7.9	0.012	0.013	0.009	0.016	0.012	0.024	0.016	0.019	0.021	0.023	0.025	0.2
8.1	0.009	0.014	0.015	0.012	0.022	0.018	0.020	0.022	0.029	0.026	0.031	0.2
8.3	0.007	0.005	0.004	0.005	0.006	0.008	0.005	0.008	0.009	0.006	0.012	0.2
8.5	0.005	0.010	0.008	0.007	0.008	0.006	0.007	0.014	0.007	0.007	0.009	0.2
8.7	0.007	0.008	0.007	0.003	0.007	0.007	0.005	0.007	0.011	0.006	0.010	0.2
8.9	0.003	0.008	0.007	0.005	0.006	0.008	0.002	0.005	0.005	0.004	0.006	0.2

Current high frequency harmonics



Note: There are no high-frequency distortion emission requirements for plant category A1.

4.4 CONTROL AND REGULATION

4.4.1 Active Power Control Functions

A PV power plant must be equipped with active power control functions capable of controlling the active power supplied by a PV power plant in the Point of Connection using activation orders with set points. It must be possible to indicate set points for active power with a 1 kW resolution or better.

4.4.1.1 Frequency Response

The test is to verify the automatic response for active power reduction due to over frequency variations according to chapter 5.2.1 of standard TR3.2.1 and TR3.2.2.

In the event of frequency deviations in the public electricity supply grid, the PV power plant must contribute to grid stability by automatically reducing active power at grid frequencies above f_R. This is referred to as frequency response.

It must be possible to set the frequency response function for the frequency points shown in Figure 8.

It must be possible to set the frequency f_R to any value in the 50.00-52.00 Hz range with an accuracy of 10 mHz or higher. The standard f_R value is 50.20 Hz. The f_R setting value is determined by the transmission system operator.

It must be possible to set the droop for the downward regulation to any value in the range 2-12% of Pn and this must be effected with an accuracy of ±10% of Pn. The standard value for droop is 4% of Pn. In this context, droop is the change in active power as a function of the grid frequency. Droop is stated as a percentage of the plant's nominal output.

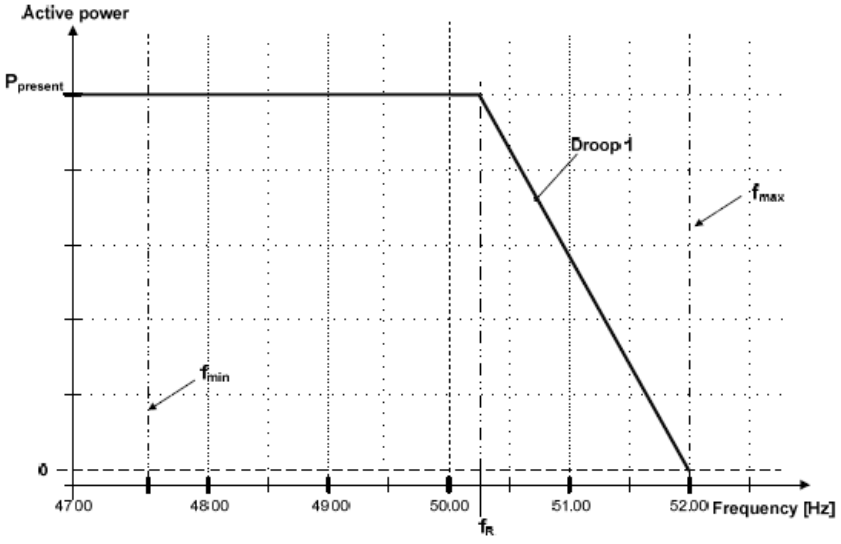
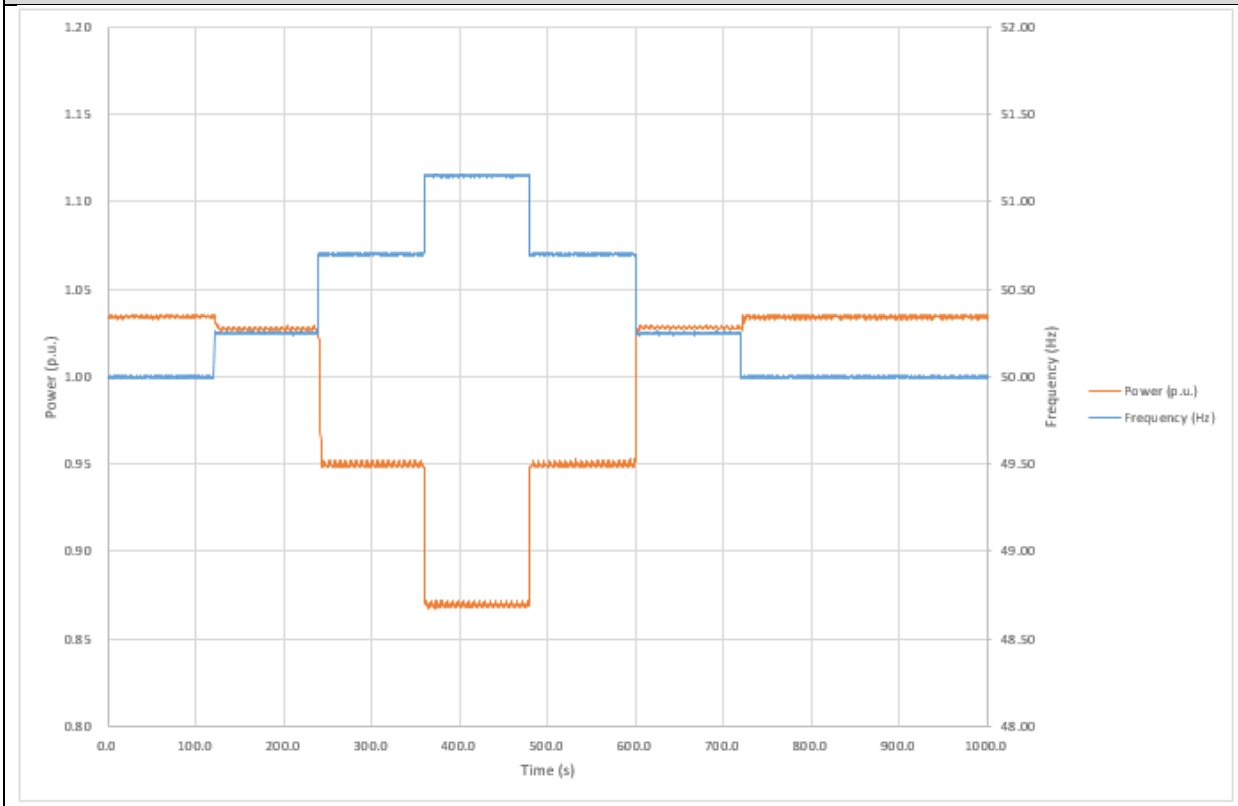


Figure 8 Frequency response for a PV power plant.

The following measuring points a) to g) have be tested:

Threshold frequency 50.20 Hz in combination with a droop of 12 % at 100% Pn							
Step	**Frequency measured**	**Power measured (p.u)**	**Power desired (p.u)**	**Deviation (%)**	**Variation expected**	**Variation measured**	**Delay time measured (<2s)**
a)	50.00	1.034	1.000	3.4	No power variation	3.4% Pn	--
b)	50.25	1.027	0.992	3.5	-0.8% Pn	2.7% Pn	0.5s
c)	50.70	0.950	0.917	3.6	-8.3% Pn	-5.0% Pn	0.5s
d)	51.15	0.869	0.842	3.2	-15.8% Pn	-13.1% Pn	0.5s
e)	50.70	0.949	0.917	3.5	-8.3% Pn	-5.1% Pn	0.5s
f)	50.25	1.028	0.992	3.6	-0.8% Pn	2.8% Pn	0.5s
g)	50.00	1.034	1.000	3.4	No power variation	3.4% Pn	0.5s

Over-frequency curve (droop of 12 % at 100% Pn)

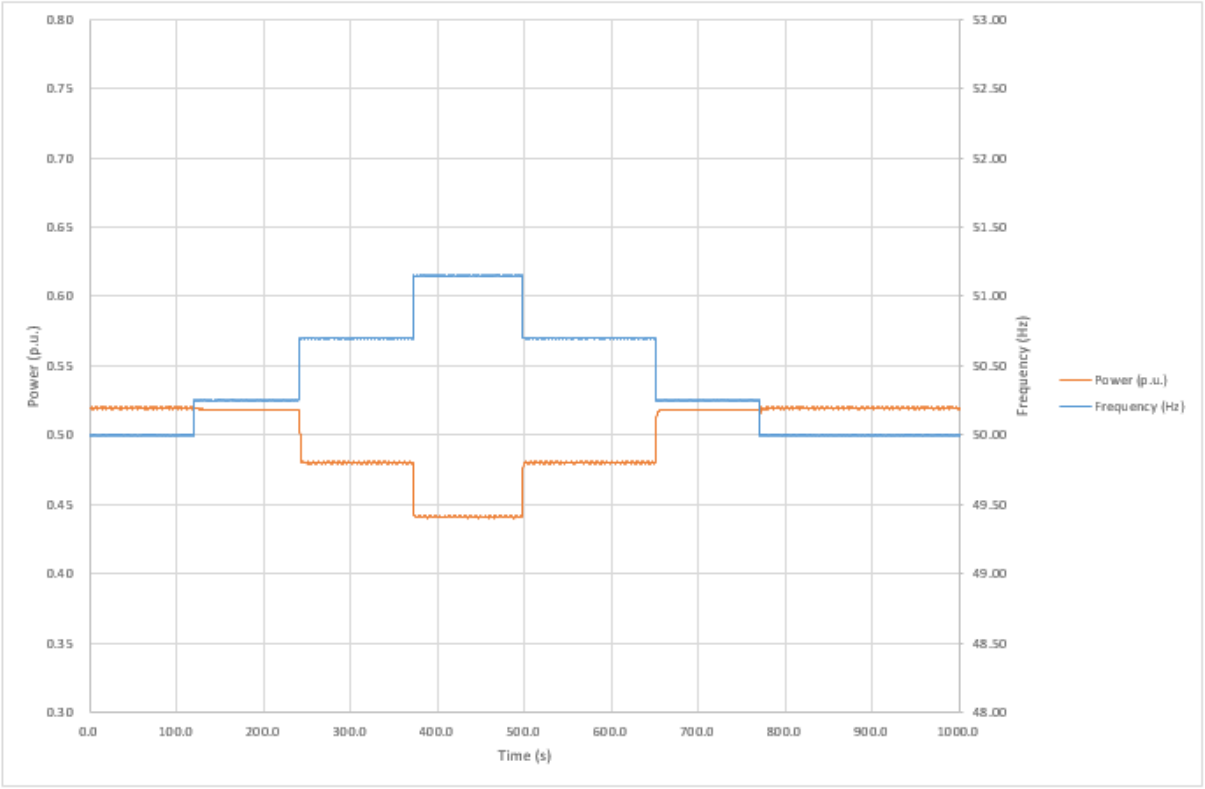


Remark:

Test for frequency threshold 50.2Hz with droop 12%, intentional delay is setting to 0s.

Threshold frequency 50.20 Hz in combination with a droop of 12 % at 50% Pn							
Step	**Frequency measured**	**Power measured (p.u)**	**Power desired (p.u)**	**Deviation (%)**	**Variation expected**	**Variation measured**	**Delay time measured (<2s)**
a)	50.00	0.520	0.500	4.0%	No power variation	4.0% Pn	--
b)	50.25	0.518	0.496	4.4%	-0.8% Pn	3.6% Pn	0.1s
c)	50.70	0.480	0.458	4.8%	-8.3% Pn	-4.0% Pn	0.5s
d)	51.15	0.442	0.421	5.0%	-15.8% Pn	-11.6% Pn	0.5s
e)	50.70	0.480	0.458	4.8%	-8.3% Pn	-4.0% Pn	0.5s
f)	50.25	0.518	0.496	4.4%	-0.8% Pn	3.6% Pn	0.5s
g)	50.00	0.520	0.500	4.0%	No power variation	4.0% Pn	0.1s

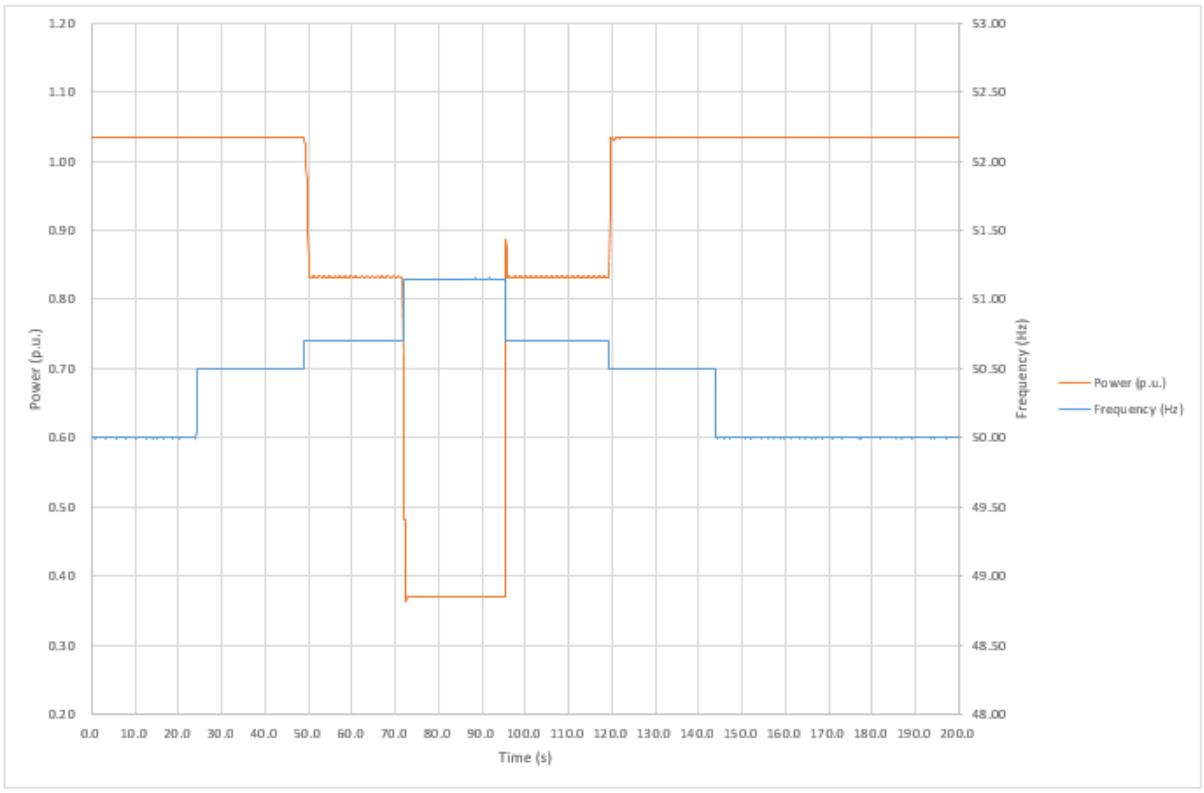
Over-frequency curve (droop of 12 % at 50% Pn)



Remark:
Test for frequency threshold 50.2Hz with droop 12%, intentional delay is setting to 0s.

Threshold frequency 50.50 Hz in combination with a droop of 2 % at 100% Pn							
Step	**Frequency measured**	**Power measured (p.u)**	**Power desired (p.u)**	**Deviation (%)**	**Variation expected**	**Variation measured**	**Delay time measured (<2s)**
a)	50.00	1.035	1.000	3.5	No power variation	3.5% Pn	--
b)	50.50	1.035	1.000	3.5	No power variation	3.5% Pn	0.1s
c)	50.70	0.832	0.800	4.0	-20.0% Pn	-16.8% Pn	0.5s
d)	51.15	0.370	0.350	5.7	-65.0% Pn	-63.0% Pn	0.1s
e)	50.70	0.833	0.800	4.1	-20.0% Pn	-16.7% Pn	0.1s
f)	50.50	1.035	1.000	3.5	No power variation	3.5% Pn	0.4s
g)	50.00	1.035	1.000	3.5	No power variation	3.5% Pn	0.1s

Over-frequency curve (droop of 2 % at 100% Pn)

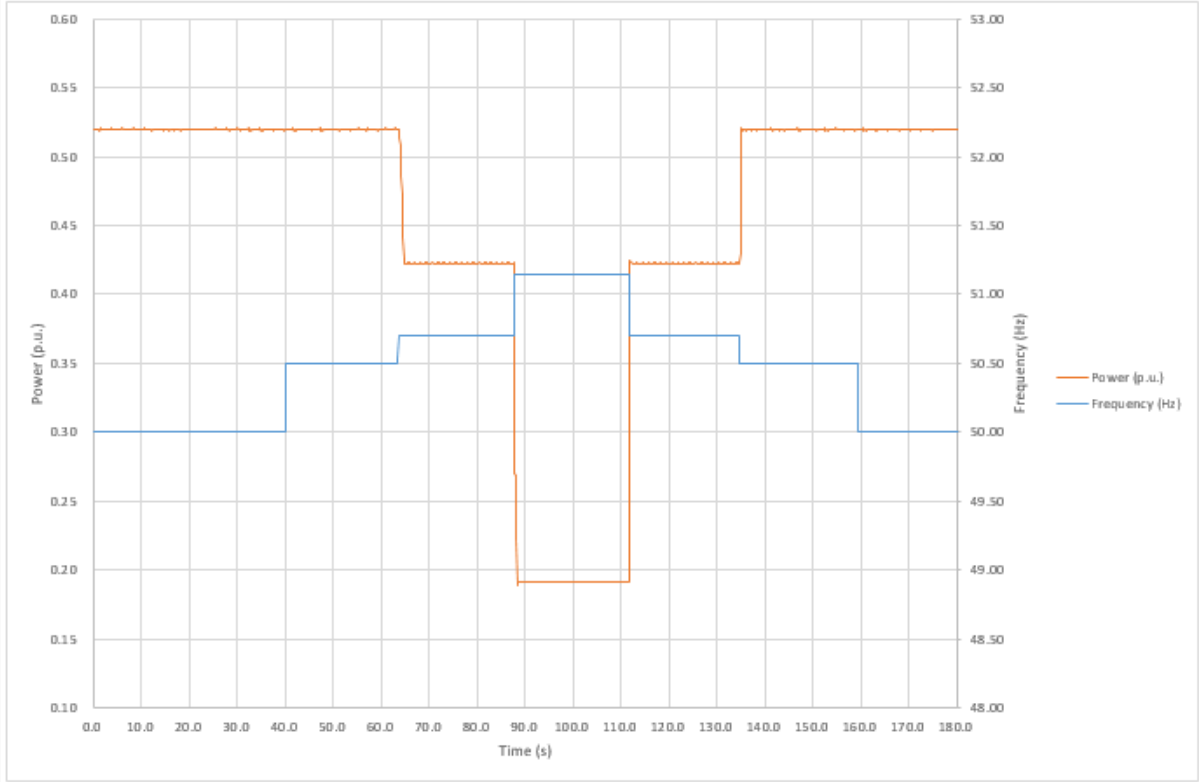


Remark:

Test for frequency threshold 50.5Hz with droop 2%, intentional delay is setting to 0s.

Threshold frequency 50.5 Hz in combination with a droop of 2 % at 50% Pn							
Step	**Frequency measured**	**Power measured (p.u)**	**Power desired (p.u)**	**Deviation (%)**	**Variation expected**	**Variation measured**	**Delay time measured (<2s)**
a)	50.00	0.520	0.500	4.0	No power variation	4.0% Pn	--
b)	50.50	0.520	0.500	4.0	No power variation	4.0% Pn	0.1s
c)	50.70	0.422	0.400	5.5	-20.0% Pn	-15.6% Pn	0.4s
d)	51.15	0.191	0.175	9.14	-65.0% Pn	-61.8% Pn	0.5s
e)	50.70	0.422	0.400	5.5	-20.0% Pn	-15.6% Pn	0.4s
f)	50.50	0.520	0.500	4.0	No power variation	4.0% Pn	0.5s
g)	50.00	0.520	0.500	4.0	No power variation	4.0% Pn	0.1s

Over-frequency curve (droop of 2 % at 50% Pn)



Remark:

Test for frequency threshold 50.5Hz with droop 2%, intentional delay is setting to 0s.

4.4.1.2 Frequency Control

The test is to verify the frequency control function according to chapter 5.2.2 of standard TR3.2.2.

It is not applicable due to the inverter is apply to plant category A1, A2 and B defined in this standard, according to manufacturer Statements.

4.4.1.3 Constraint Functions

A PV power plant must be equipped with constraint functions, i.e. supplementary active power control functions.

The constraint functions are used to avoid instability or overloading of the public electricity supply grid in connection with switching in the public electricity supply grid, in fault situations or the like.

4.4.1.3.1 Absolute Power Constraint

An absolute power constraint is used to limit active power from a PV power plant to a set point-defined maximum power limit in the Point of Connection.

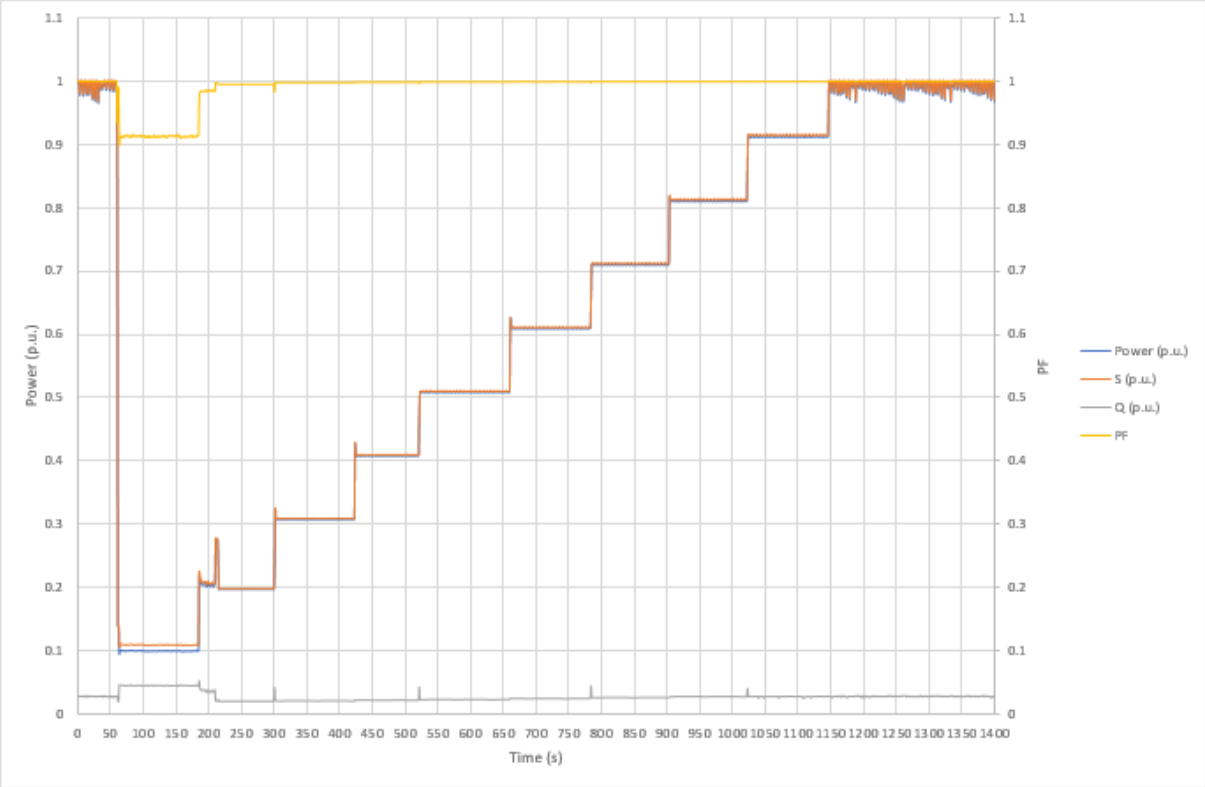
The test has been performed according to chapter 5.2.2.1 of standard TR3.2.1 and chapter 5.2.3.1 of standard TR3.2.2.

Test results are offered at the table below.

Active Power Setpoint (%Pn)	Power measured (%Pn)	Active Power Deviation from setpoint (%)	Time Response (s)
10%	9.9%	-0.1%	1.0
20%	19.7%	-0.3%	1.0
30%	30.8%	0.8%	1.0
40%	40.8%	0.8%	1.0
50%	50.9%	0.9%	1.0
60%	60.9%	0.9%	1.0
70%	71.0%	1.0%	1.0
80%	81.1%	1.1%	1.0
90%	91.1%	1.1%	1.0
100%	99.2%	-0.8%	1.0

Test results are graphically represented below.

Absolute Power Constraint



4.4.1.3.2 Delta Power Constraint (Spinning Reserve)

A delta power constraint is used to limit the active power from a PV power plant to a desired constant value in proportion to the possible active power.

The test should be performed according to chapter 5.2.3.2 of standard TR3.2.2.

It is not applicable due to the inverter is apply to plant category A1, A2 and B defined in this standard, according to manufacturer Statements.

4.4.1.3.3 Ramp Rate Constraint

Ramp rate constraint is used to limit the maximum speed by which the active power can be changed in the event of changes in power or in the set points for a PV power plant.

The test has been performed according to chapter 5.2.2.2 of standard TR3.2.1 and chapter 5.2.3.3 of standard TR3.2.2. The maximum standard value for the ramp rate constraint cannot be greater than 100kW/s.

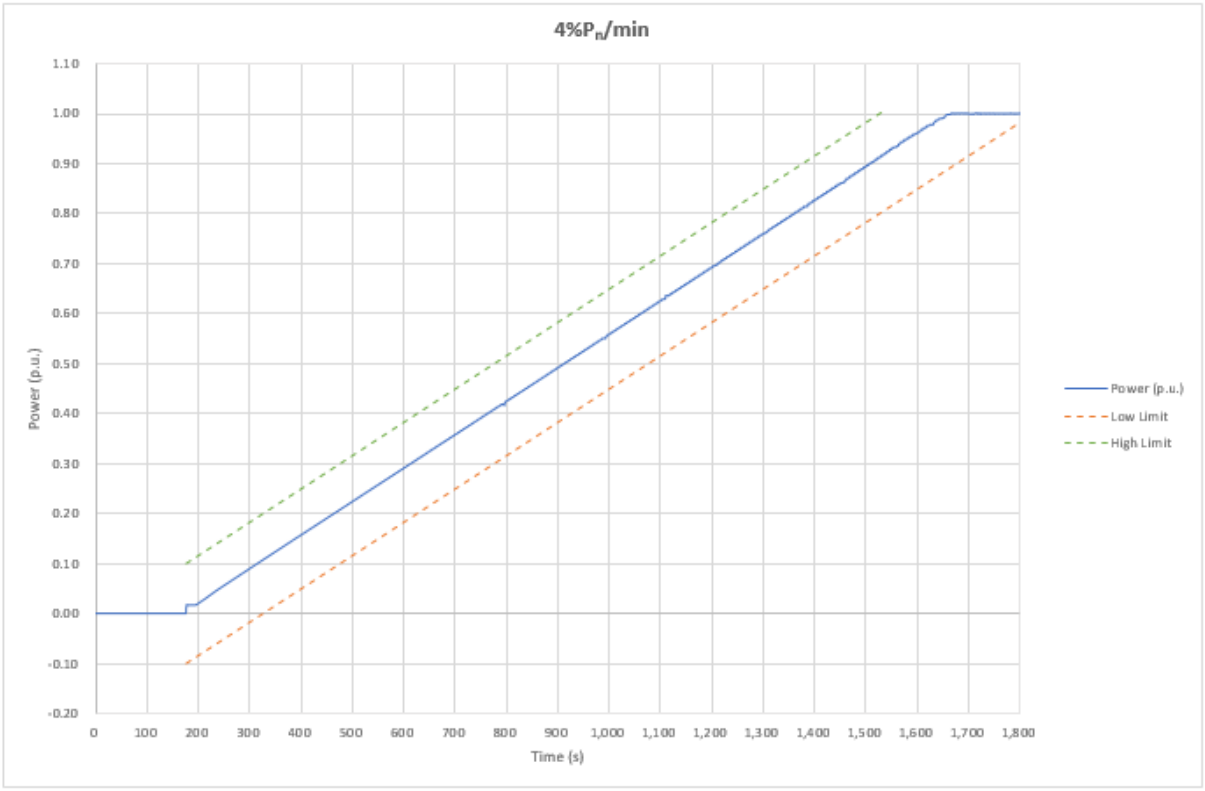
Test results are offered in the table and pictures below:

Increase of Active Power			
Gradient (ΔP) desired (%P_n/min)	**Nominal Ramp Time (s)**	**Gradient measured (%P_n/min)**	**Measured Ramp time (s)**
≈ 4.0%	1500.0	4.1%	1481.0
≈ 100.0%	60.0	100.0%	60.0

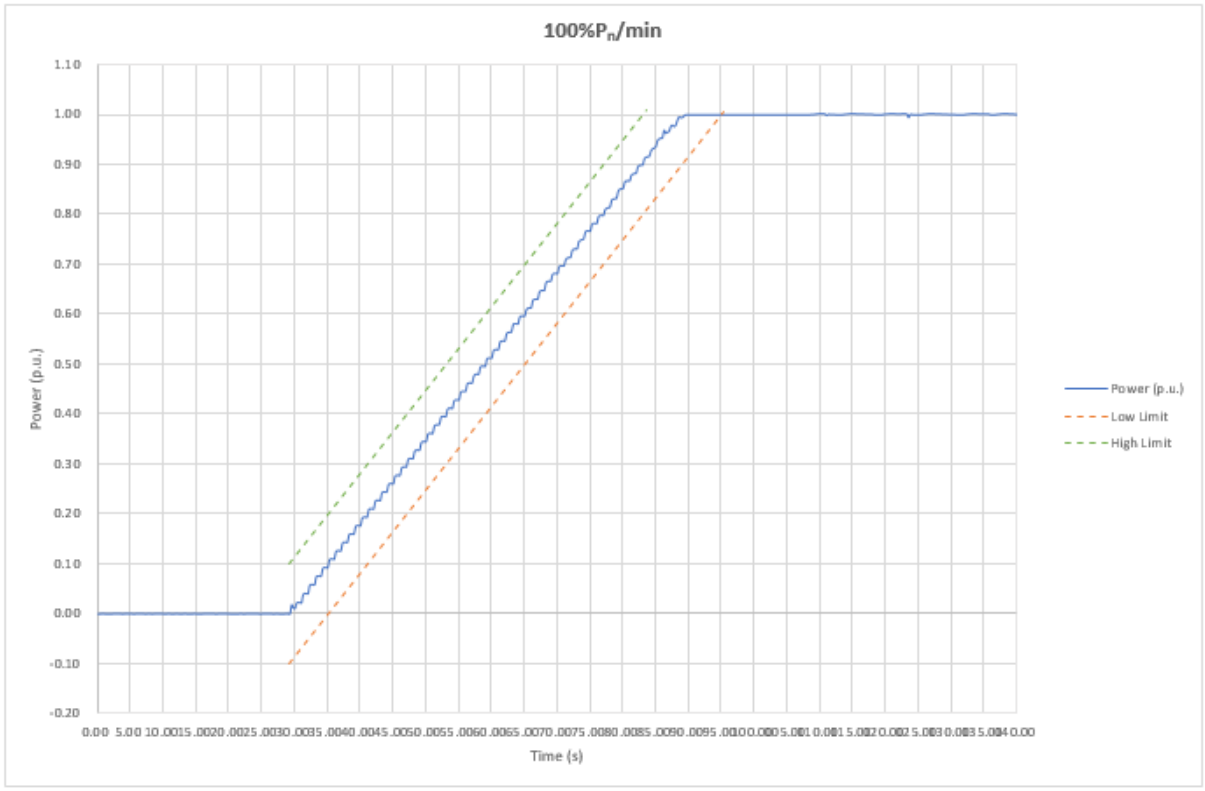
Decrease of Active Power			
Gradient (ΔP) desired (%P_n/min)	**Nominal Ramp Time (s)**	**Gradient measured (%P_n/min)**	**Measured Ramp time (s)**
≈ 4.0%	1500.0	4.1%	1471.0
≈ 100.0%	60.0	100.0%	60.0

Note:
1. The Gradient is adjustable from 1% P_n/min to 100% P_n/min.
2. It has been verified that the inverter complies with a maximum nonlinearity less than ±10%.

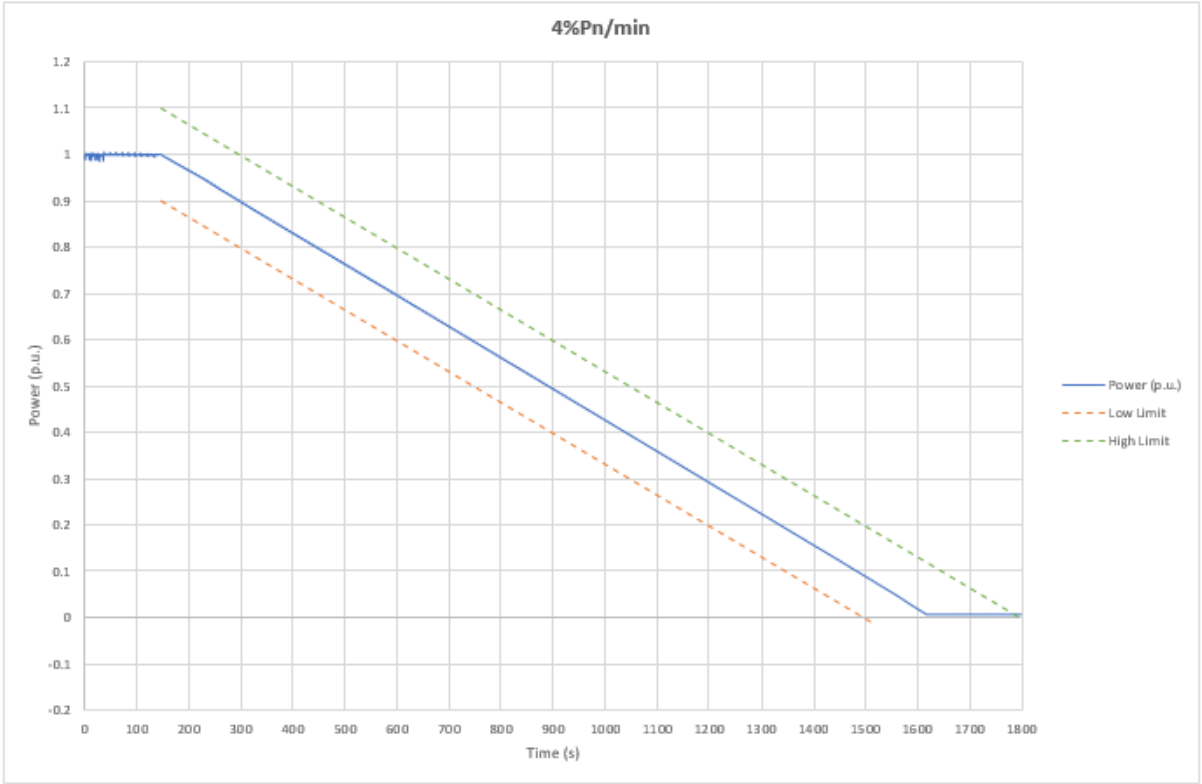
Increase of Active Power with 4%Pn/min



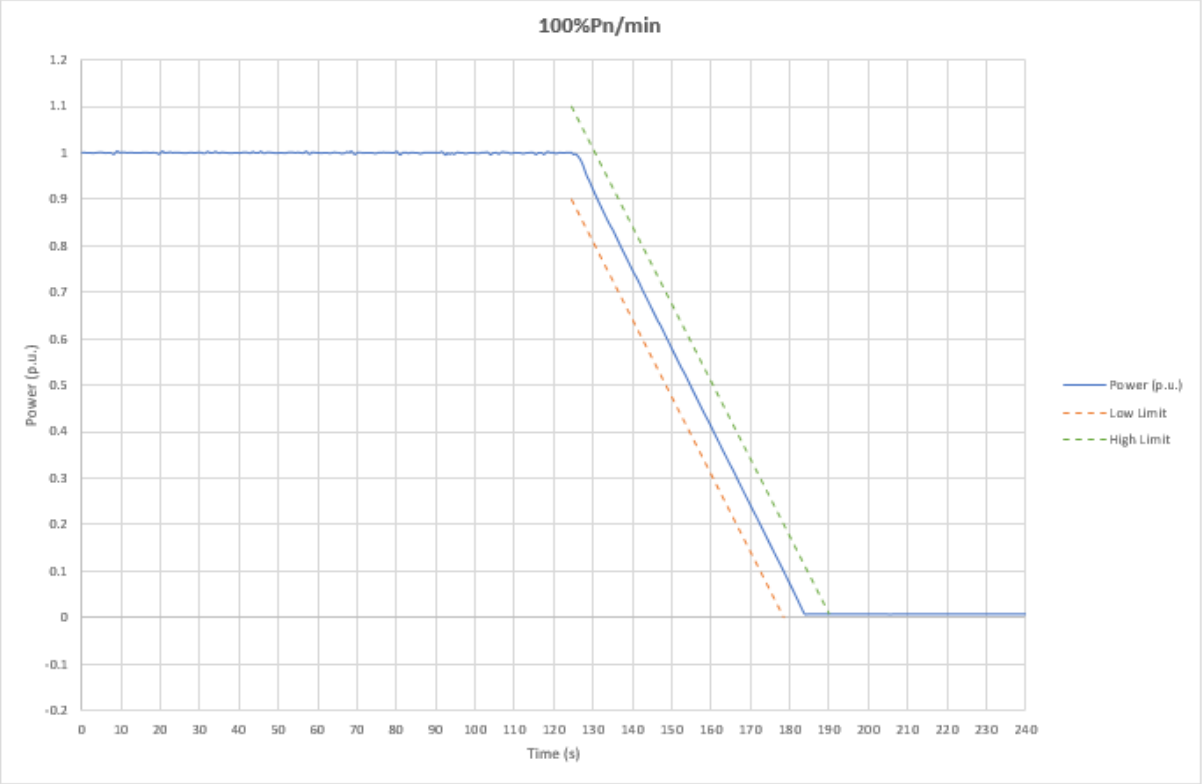
Increase of Active Power with 100%Pn/min



Decrease of Active Power with 4%Pn/min



Decrease of Active Power with 100%Pn/min



4.4.2 Reactive power and voltage control functions

A PV power plant must be equipped with reactive power and voltage control functions capable of controlling the reactive power supplied by a PV power plant in the Point of Connection, and with a control function capable of controlling the voltage in the voltage reference point via activation orders containing set points for the specified parameters.

4.4.2.1 Q Control

This test verifies the capability of the inverter to provide a fixed value of reactive power according to chapter 5.3.1 of standard TR3.2.1 and TR3.2.2. The accuracy of the control performed and of the set point may not deviate by more than ±2% of the set point value or by ±0.5% of the rated power, depending on which yields the highest tolerance.

At high active power levels the reactive power provided by the inverter is automatically limited by the inverter in order to protect against over current.

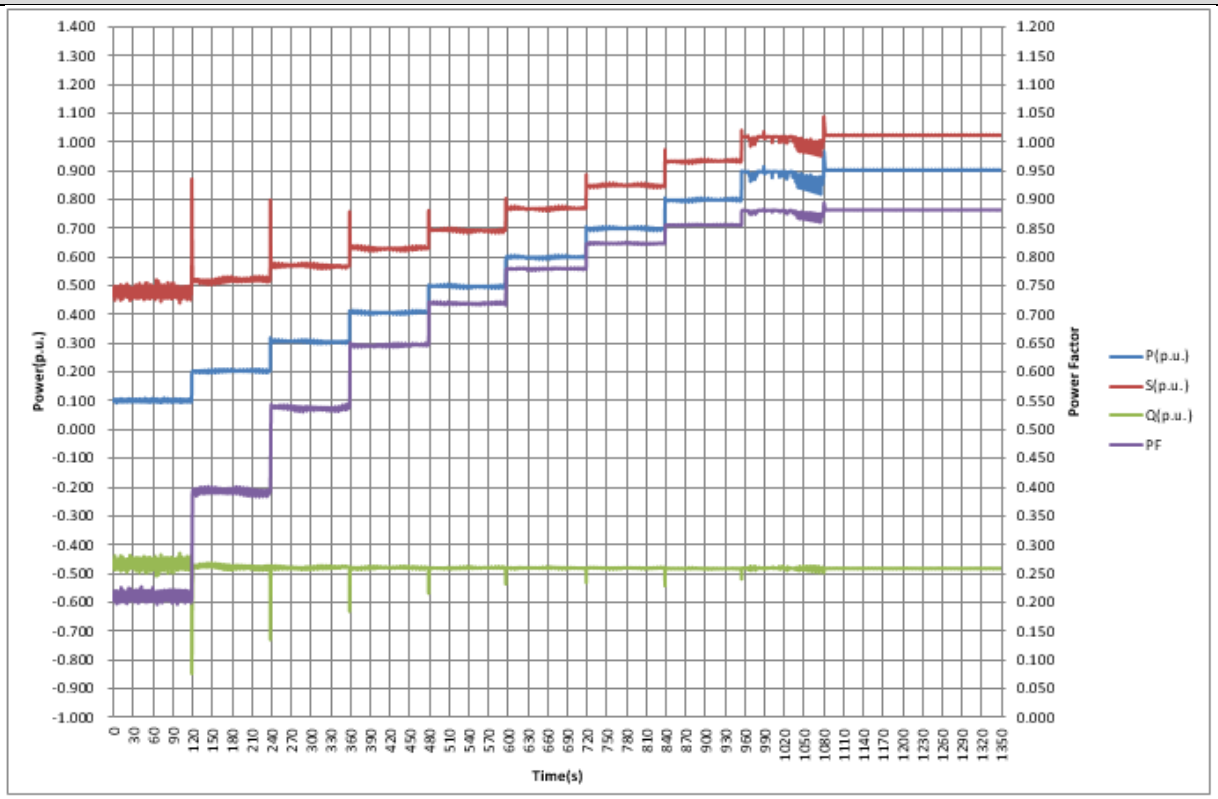
The following table shows the test results:

Rectangular Curve (Q=48.43%Sn / Capacitive)							
P Desired (%Sn)	**Power DC (W)**	**P measured (%Sn)**	**Q desired (%Sn)**	**Q measured (%Sn)**	**Q Deviation (%Sn)**	**Power Factor (cos φ)**	**Measured Accuracy**
10%	693	10.5	-48.43	-47.8	0.6	0.198	-1.24%
20%	1312	20.5	-48.43	-47.7	0.7	0.383	-1.45%
30%	1933	30.6	-48.43	-47.8	0.6	0.531	-1.24%
40%	2557	40.7	-48.43	-48.0	0.5	0.646	-1.03%
50%	3113	49.8	-48.43	-48.2	0.2	0.719	-0.41%
60%	3736	59.9	-48.43	-48.1	0.3	0.779	-0.62%
70%	4355	69.9	-48.43	-48.0	0.4	0.823	-0.83%
80%	4972	79.8	-48.43	-48.3	0.1	0.856	-0.21%
90%	5551	89.1	-48.43	-48.1	0.3	0.878	-0.62%
100%	5619	90.1	-48.43	-48.2	0.2	0.882	-0.41%

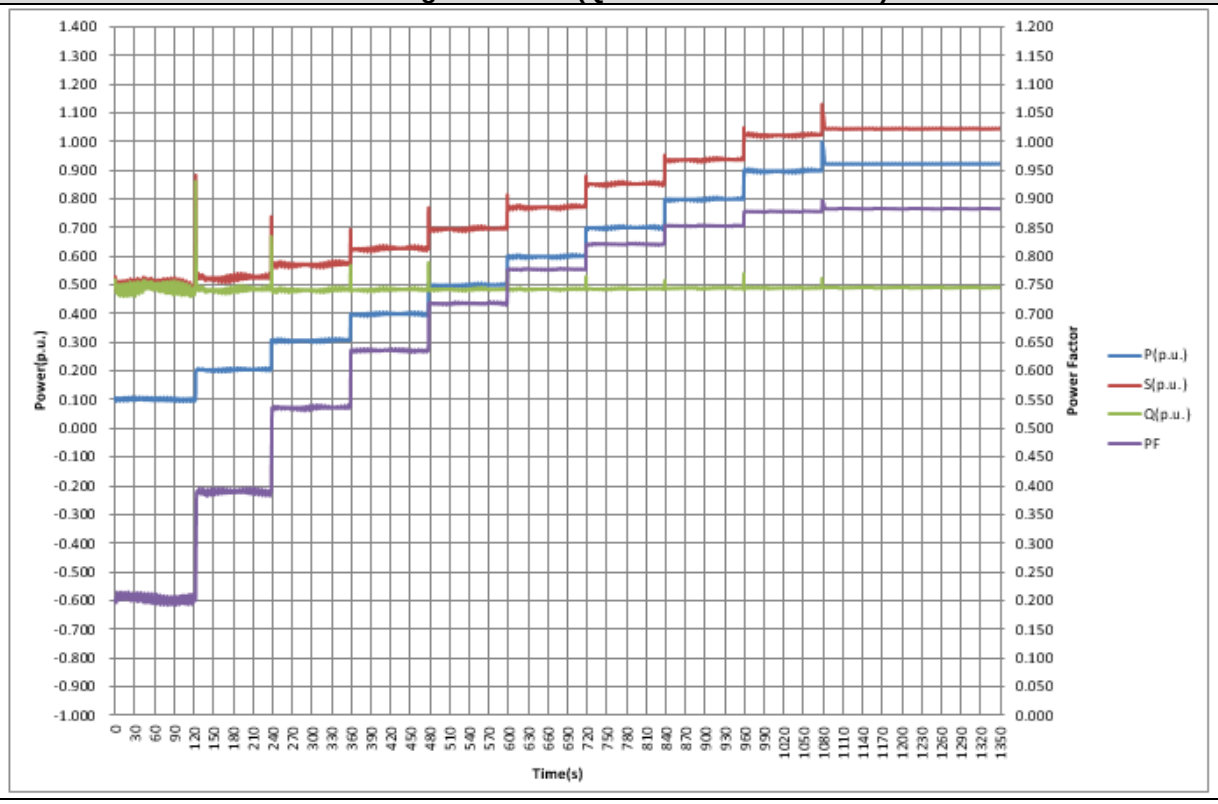
Rectangular Curve (Q=48.43%Sn / Inductive)							
P Desired (%Sn)	**Power DC (W)**	**P measured (%Sn)**	**Q desired (%Sn)**	**Q measured (%Sn)**	**Q Deviation (%Sn)**	**Power Factor (cos φ)**	**Measured Accuracy**
10%	686	10.0	48.43	48.3	-0.2	0.203	-0.41%
20%	1307	20.3	48.43	48.3	-0.1	0.388	-0.21%
30%	1935	30.7	48.43	48.3	-0.1	0.536	-0.21%
40%	2495	39.8	48.43	48.3	-0.1	0.636	-0.21%
50%	3112	49.9	48.43	48.5	0.1	0.717	0.21%
60%	3735	60.0	48.43	48.4	0.0	0.778	0.00%
70%	4354	69.9	48.43	48.5	0.1	0.822	0.21%
80%	4971	79.9	48.43	48.9	0.4	0.853	0.83%
90%	5586	89.7	48.43	48.8	0.4	0.878	0.83%
100%	5752	92.3	48.43	49.1	0.7	0.883	1.45%

Test results are represented at diagrams below.

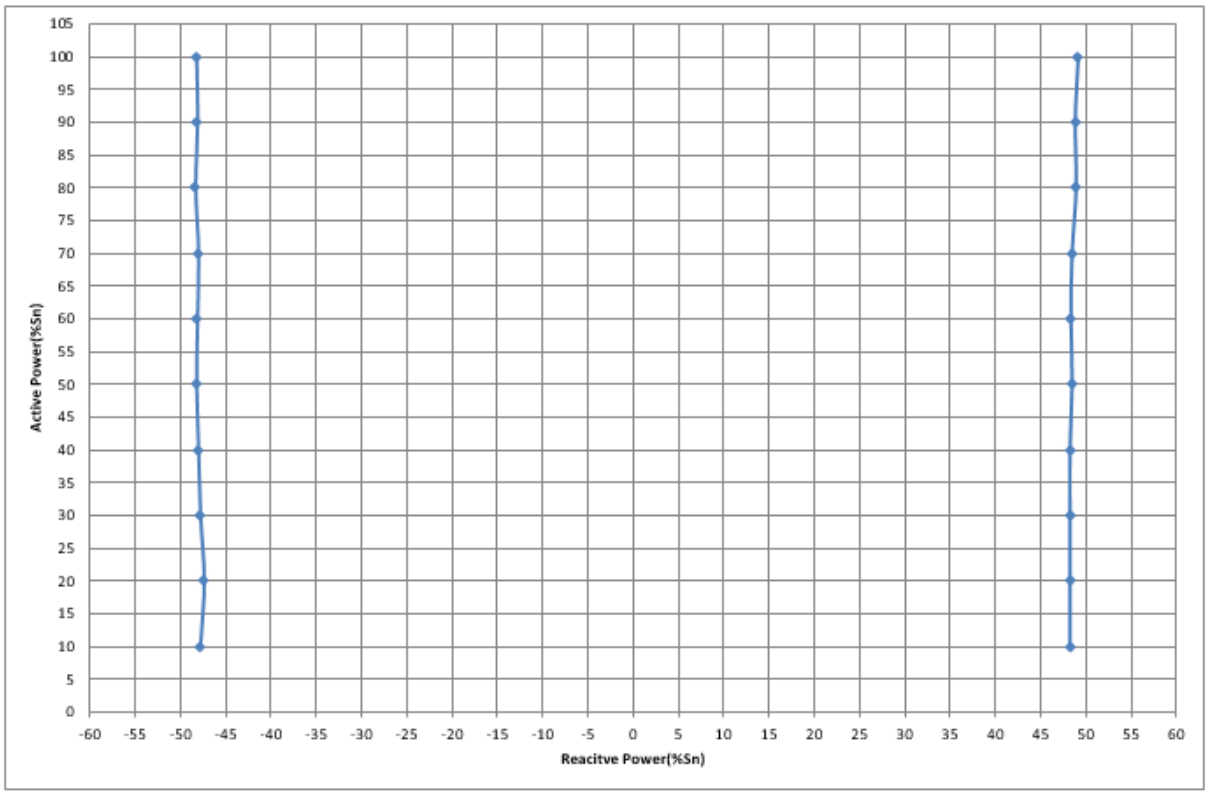
Rectangular Curve (Q=48.43%Sn / Capacitive)



Rectangular Curve (Q=48.43%S_n / Inductive)



Rectangular Curve (Capacitive vs Inductive)



4.4.2.2 Power Factor Control

The power factor control function controls reactive power proportionately to the active power in the Point of Connection. Tests have been done according to chapter 5.3.2 of standard TR3.2.1 and TR3.2.2.

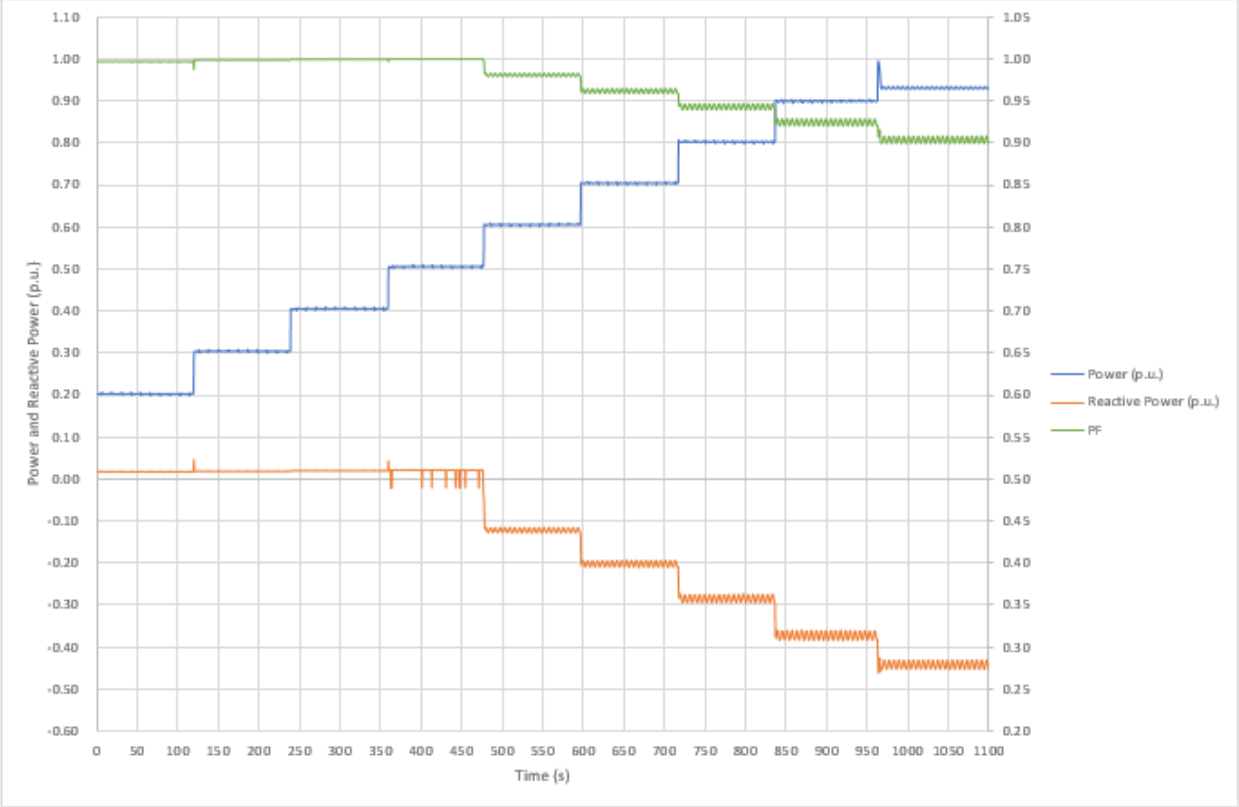
The test have been performed to check the possibility of establishing a power factor limit on current injection, first at 0.9 and second at 0.8. The following table shows the test results:

PF limit = 0.90					
P/Pn (%)	**Power (p.u.)**	**Q (p.u.)**	**Measured cos φ**	**Desired cos φ**	**Δ cos φ**
20%	0.201	0.017	0.996	1.000	0.004
30%	0.301	0.019	0.998	1.000	0.002
40%	0.401	0.021	0.999	1.000	0.001
50%	0.505	0.022	0.999	1.000	0.001
60%	0.605	-0.126	0.979	0.980	0.001
70%	0.702	-0.195	0.964	0.960	-0.004
80%	0.802	-0.284	0.943	0.940	-0.003
90%	0.900	-0.367	0.926	0.920	-0.006
100%(*)	0.932	-0.440	0.904	0.900	-0.004

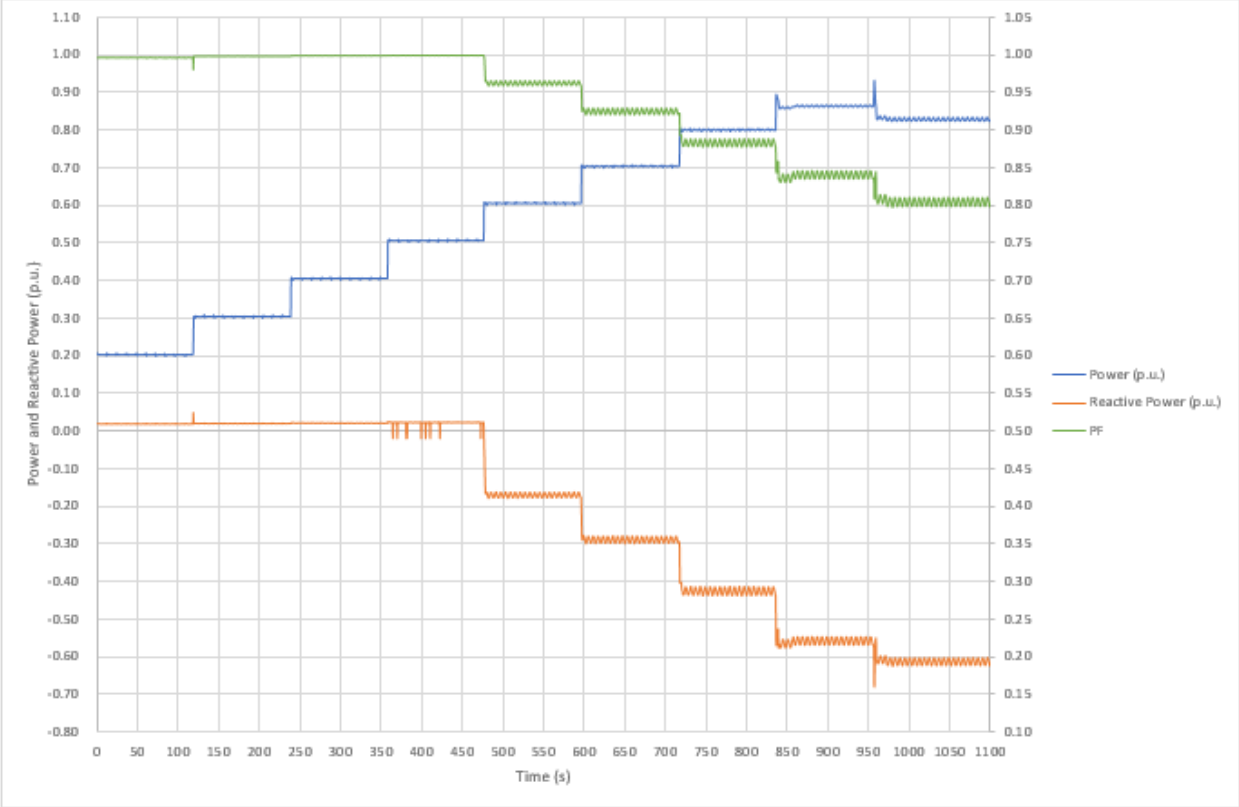
PF limit = 0.80					
P/Pn (%)	**Power (p.u.)**	**Q (p.u.)**	**Measured cos φ**	**Desired cos φ**	**Δ cos φ**
20%	0.201	0.017	0.996	1.000	0.004
30%	0.303	0.018	0.998	1.000	0.002
40%	0.404	0.020	0.999	1.000	0.001
50%	0.501	0.022	0.999	1.000	0.001
60%	0.603	-0.167	0.964	0.960	-0.004
70%	0.701	-0.290	0.924	0.920	-0.004
80%	0.800	-0.416	0.887	0.880	-0.007
90%	0.861	-0.552	0.842	0.840	-0.002
100%(*)	0.830	-0.613	0.804	0.800	-0.004

Note:
1. Test with cosφ fixed between 20% -50% Pn and decreasing the value of cosφ between 50%-100% Pn.
2. Because of limited by apparent power, the active does not reach to 100% when cos φ = 0.9.

PF = 0.90


Power and Reactive Power (p.u.)
Time (s)
Power (p.u.)
Reactive Power (p.u.)
PF

PF = 0.80


Power and Reactive Power (p.u.)
Time (s)
Power (p.u.)
Reactive Power (p.u.)
PF

4.4.2.3 Voltage Control

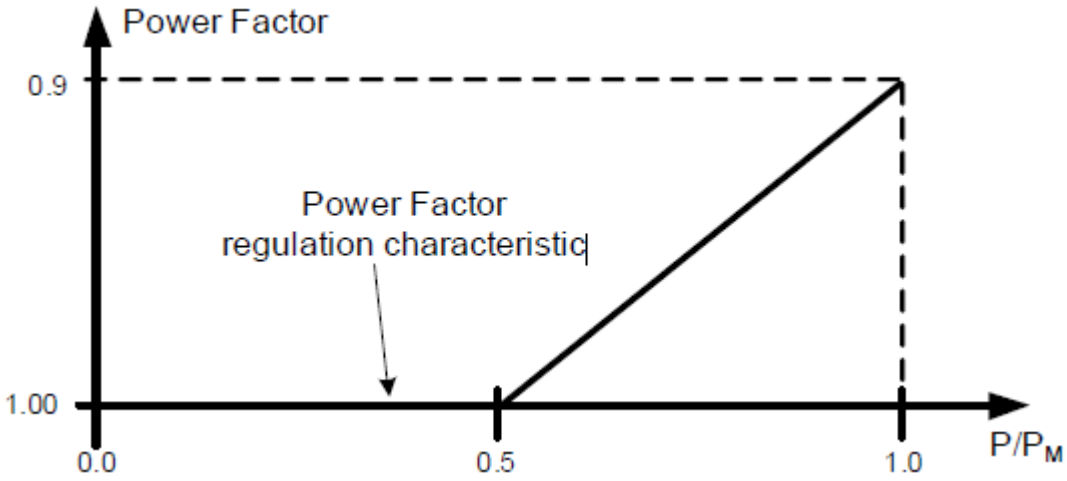
According to chapter 5.3.3 of standard TR3.2.2, the voltage control function stabilises the voltage in the voltage reference point. Voltage control must have a setting range within minimum to maximum voltage, with an accuracy of 0.5% or better of the nominal voltage.

It is not applicable due to the inverter is apply to plant category A1, A2 and B defined in this standard, according to manufacturer Statements.

4.4.2.4 Automatic Power Factor Control

According to chapter 5.3.3 of standard TR3.2.1 and chapter 5.3.4 of standard TR3.2.2, the automatic Power Factor control function automatically activates/deactivates the Power Factor control at defined voltage levels in the voltage reference point.

The principle of the automatic Power Factor control is illustrated in Figure below:



The default setting for the automatic control (PF) is given by the following three support points with linear interpolation between them:

1: P/P_M = 0.0, PF = 1.00
2: P/P_M = 0.5, PF = 1.00
3: P/P_M = 1.0, PF = 0.90

Note: P_M indicates the active power which can be generated under the given circumstances.

The activation level for the function is normally 105% of the nominal voltage, and the deactivation level is normally 100% of the nominal voltage. The activation/deactivation level must be adjustable via set points.

The test has been done with the following threshold values settled at the inverter.

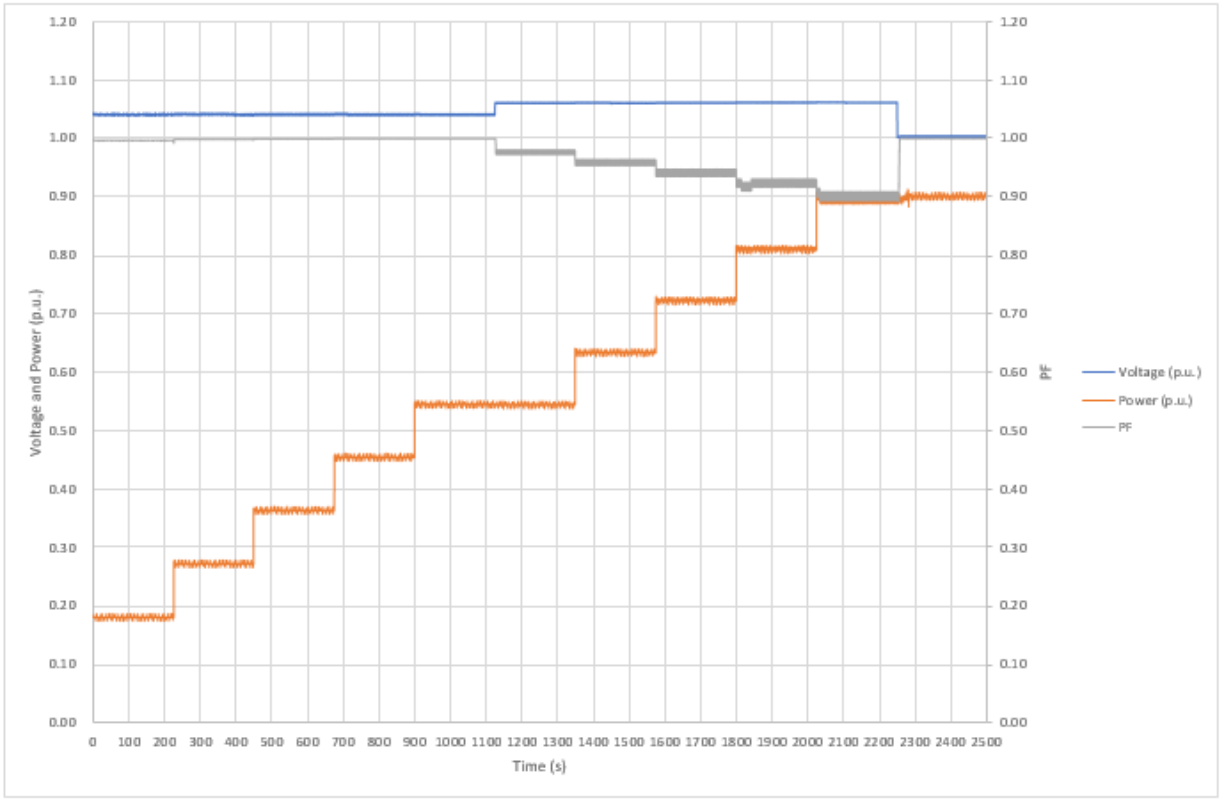
Curve Parameters		
Point	**Active Power**	**cos φ**
A	20%*P_n	1.000
B	50%* P_n	1.000
C	100%* P_n	0.900
V lock-in		**V lock-out**
105%Un		100%Un

Test results are offered at the table below.

Test results							
P Desired (%Sn)	P measured (p.u.)	Q measured (p.u.)	Voltage Desired (p.u.)	Voltage Measured (p.u.)	Power Factor desired (cos φ)	Power Factor measured (cos φ)	Power Factor Deviation (cos φ)
0.20	0.181	0.015	<1.05	1.040	1.000	0.997	-0.003
0.30	0.272	0.016	<1.05	1.040	1.000	0.998	-0.002
0.40	0.364	0.017	<1.05	1.040	1.000	0.999	-0.001
0.50	0.454	-0.018	<1.05	1.041	1.000	0.999	-0.001
0.60	0.545	-0.020	<1.05	1.041	1.000	0.999	-0.001
0.60	0.544	-0.119	>1.05	1.061	0.980	0.977	-0.003
0.70	0.635	-0.185	>1.05	1.060	0.960	0.960	0.000
0.80	0.723	-0.274	>1.05	1.061	0.940	0.935	-0.005
0.90	0.812	-0.356	>1.05	1.061	0.920	0.916	-0.004
1.00	0.890	-0.425	>1.05	1.062	0.900	0.902	-0.008
1.00	0.901	-0.027	<=1.00	1.000	1.000	1.000	0.000
Supplementary information: This test has the maximum settling time observed. This is from step *60%P & <105%Un* to *60%P & >105%Un*. Time observed 3 s							

Test results are graphically represented at the diagrams below:

Power Factor vs Power



4.4.3 System Protection

According to chapter 5.4 of standard TR3.2.2, a PV power plant must be equipped with system protection – a control function which must be capable of very quickly regulating the active power supplied by a PV power plant to one or more predefined set points based on a downward regulation order. The set points are determined by the electricity supply undertaking upon commissioning.

The PV power plant must have at least five different configurable regulation step options.
The following regulation steps are recommended as default values:

1. Up to 70% of rated power
2. Up to 50% of rated power
3. Up to 40% of rated power
4. Up to 10% of rated power
5. Up to 0% of rated power, ie the plant is shut down, but not disconnected from the grid.

It is not applicable due to the inverter is apply to plant category A1, A2 and B defined in this standard, according to manufacturer Statements.

4.5 RECONNECTION

Reconnection requirements are different when unit is connected as plant category A1 or plant category A2, B. The settings of reconnect voltage and frequency is adjustable.

For connected as plant category A1, the normal operating voltage is Uc+10% and Uc-15%, and the frequency range is 49.00 to 51.00 Hz. Automatic connection of a plant can at the earliest take place three minutes after the voltage has come within the normal operating voltage range, and the frequency is within the 47.00 to 50.20 Hz range. The maximum permitted upward regulation of the active power is at a droop of 10% Pn/min.

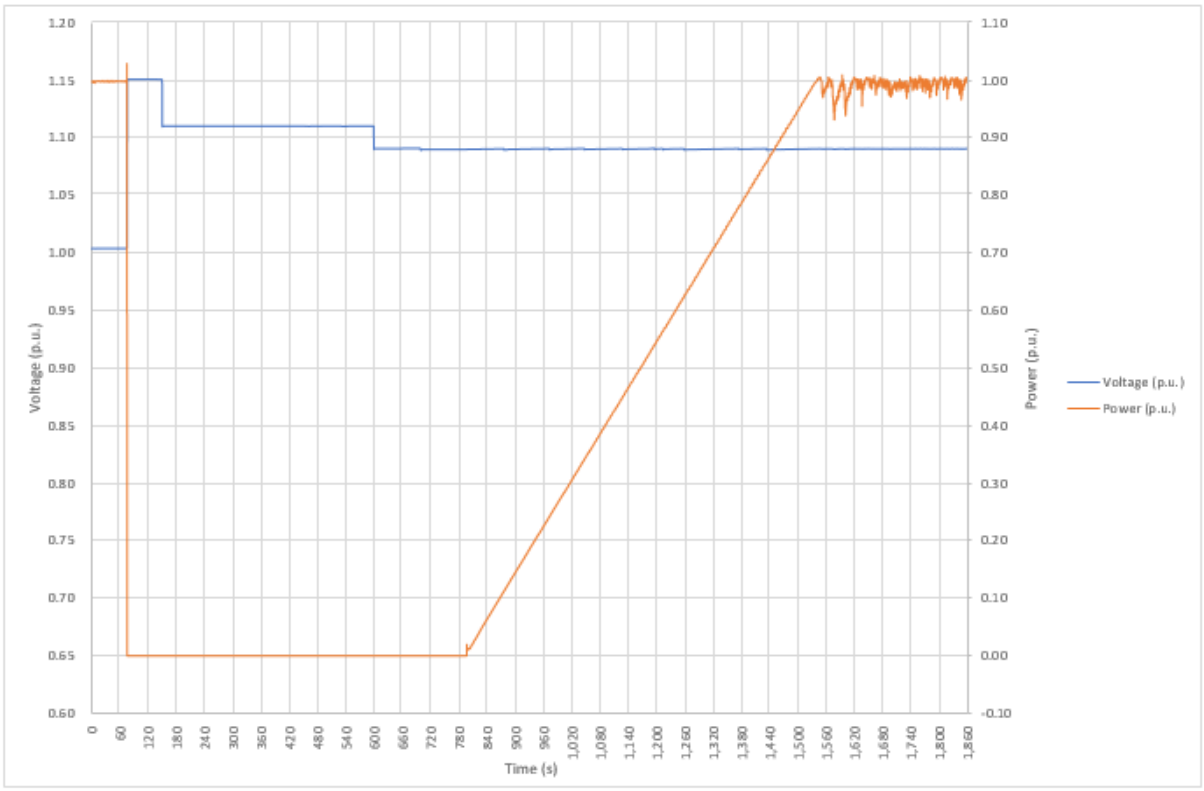
For connected as plant category A2 or B, the normal operating voltage is Uc±10%, and the frequency range is 47.00 to 52.00 Hz. Automatic connection of a PV power plant can take place no earlier than three minutes after the voltage and frequency have come within the normal production range.

Test results are graphically represented at the diagrams below:

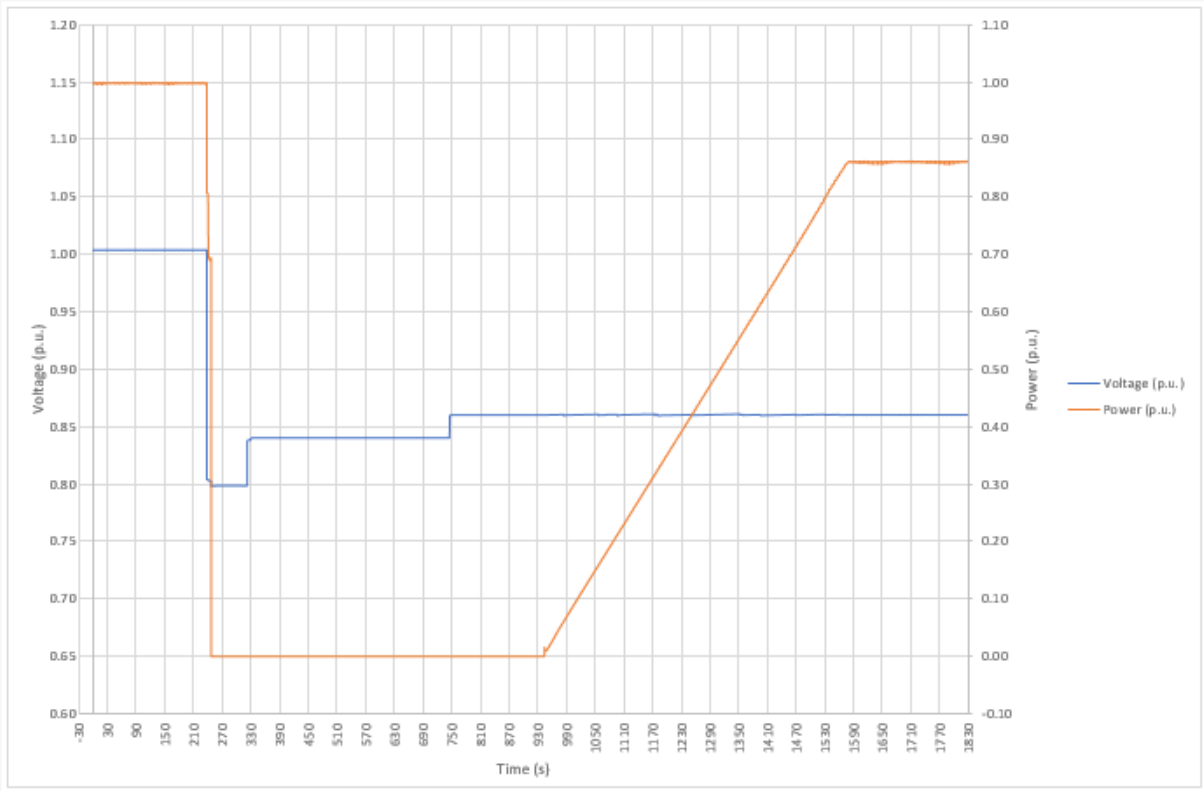
For plant category A1:

Type	Required Delay time	Time measured (s)	Upward regulation of the active power
OV: 110%Un	>3 min	197.8	7.5% Pn/min
UV: 85%Un	>3 min	198.3	8.2% Pn/min
OF: 50.2 Hz	>3 min	197.8	8.1% Pn/min
UF: 47.0 Hz	>3 min	274.0	7.8% Pn/min

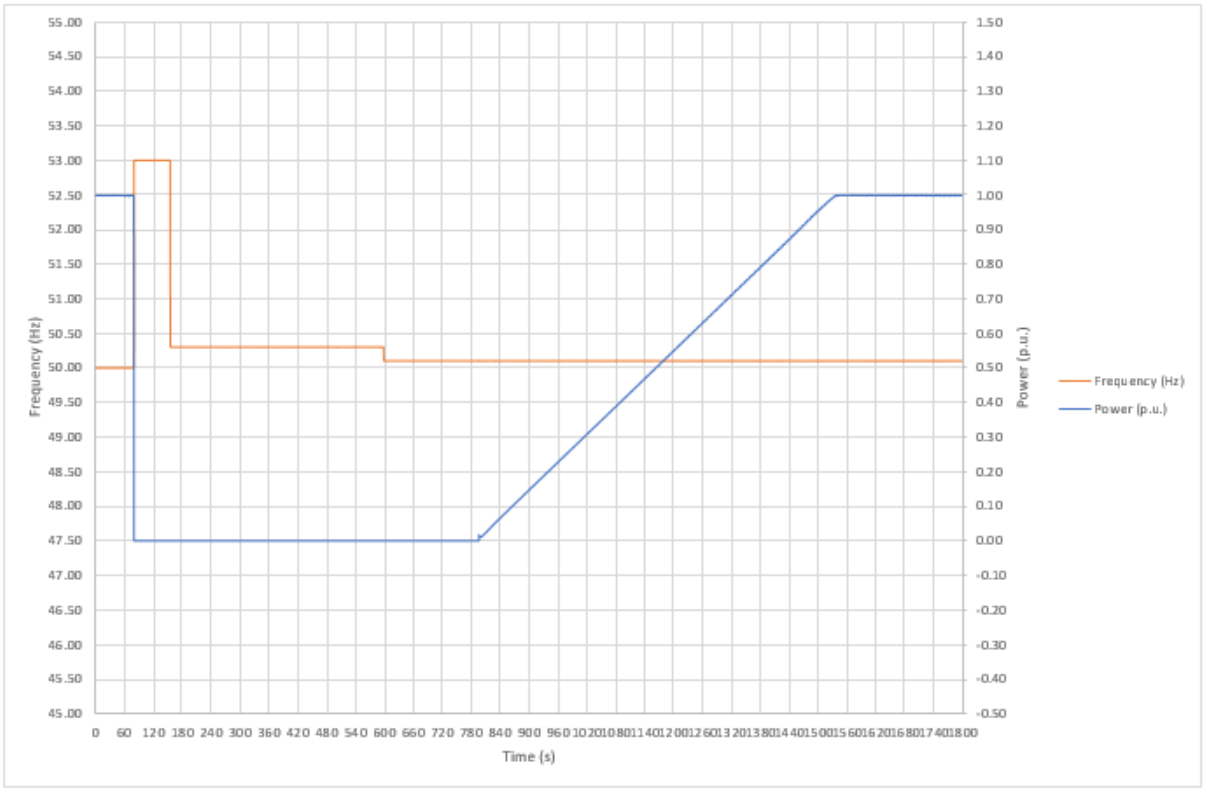
OV: 110%Un



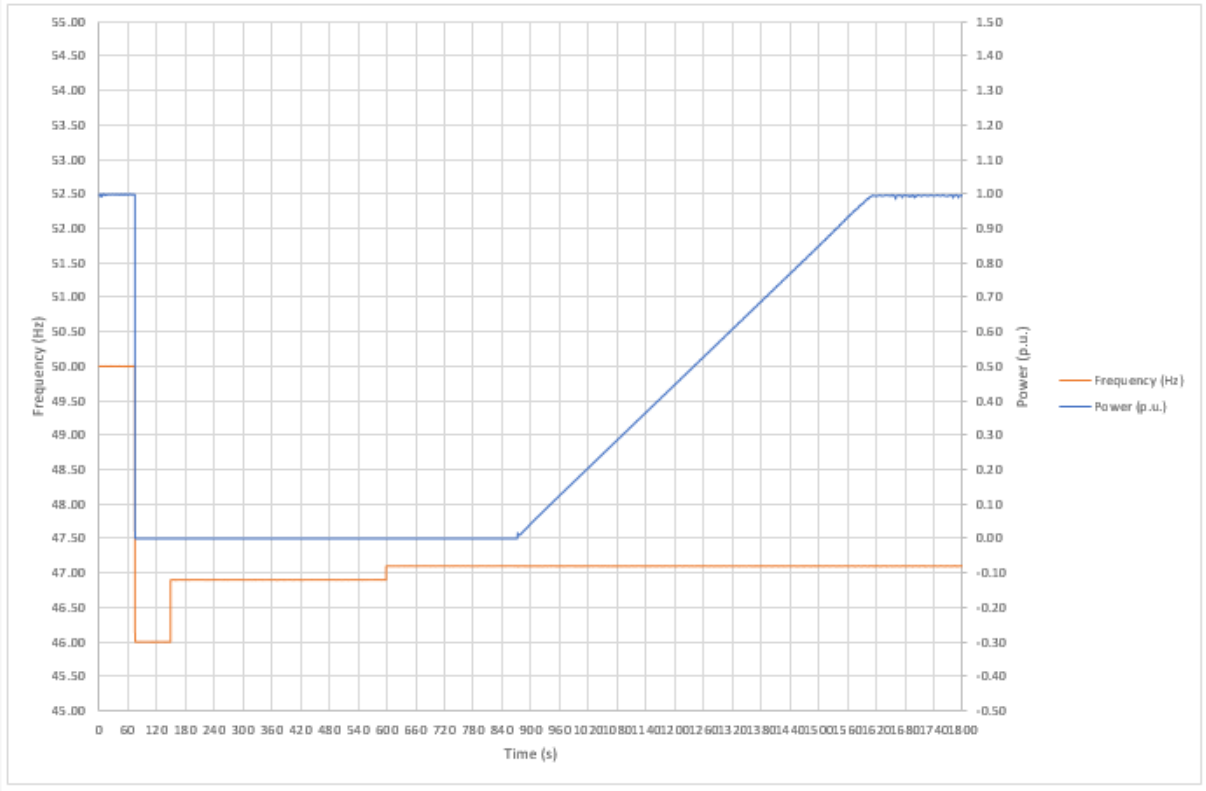
UV: 90%Un



OF: 52.0 Hz



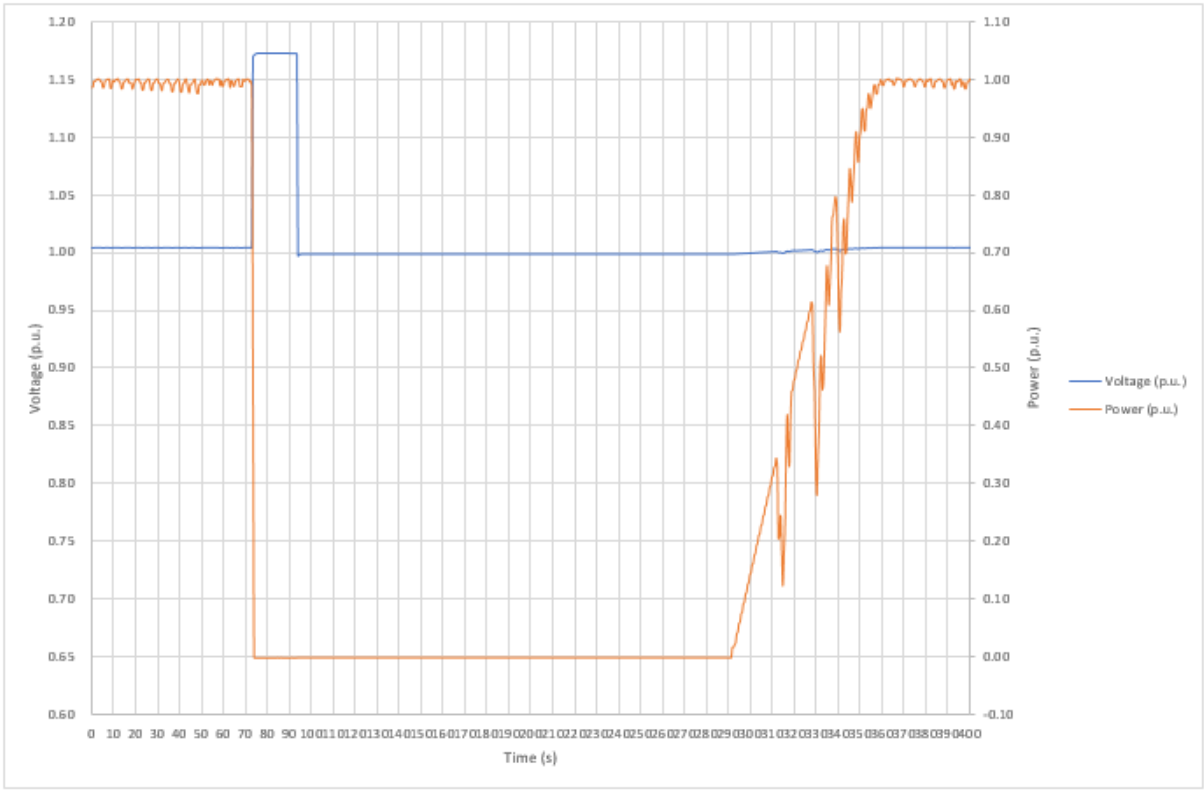
UF: 47.0 Hz



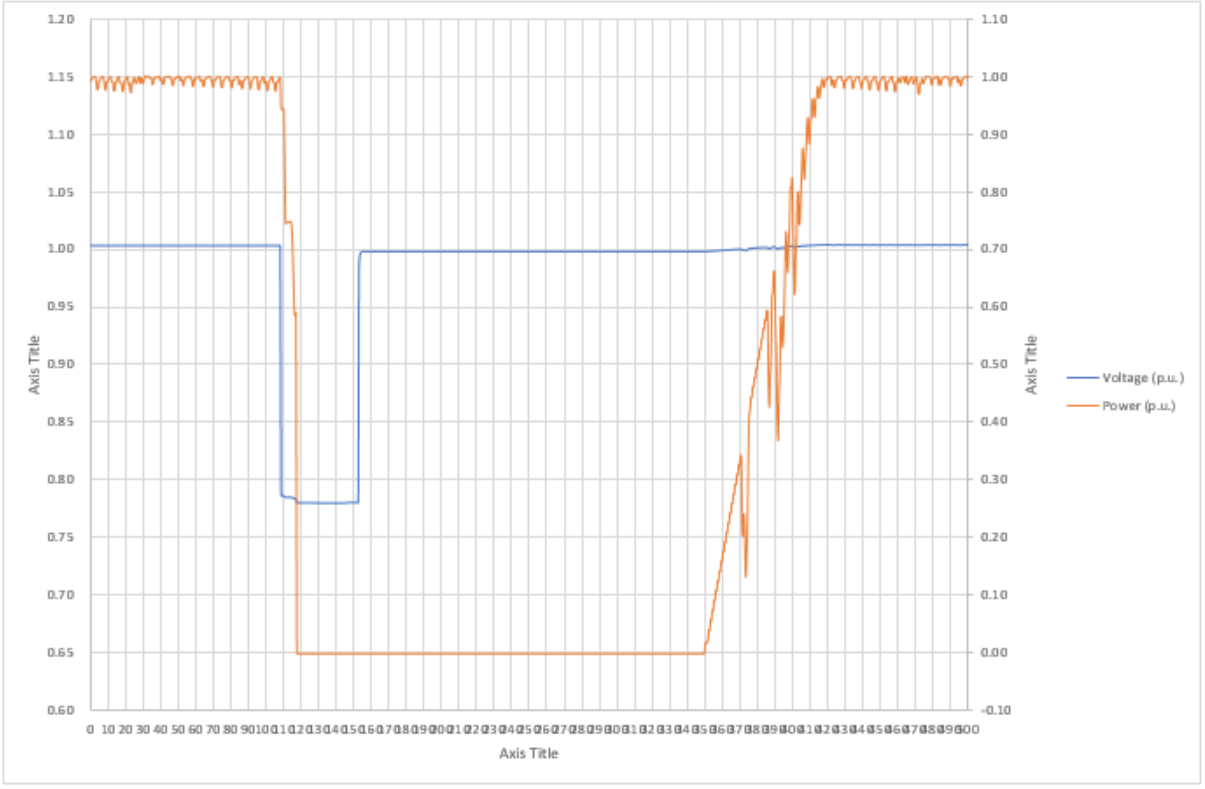
For plant category A2 or B:

Type	Required Delay time	Time measured (s)
OV: 110%Un	>3 min	197.5
UV: 90%Un	>3 min	198.0
OF: 52.0 Hz	>3 min	198.0
UF: 47.0 Hz	>3 min	198.0

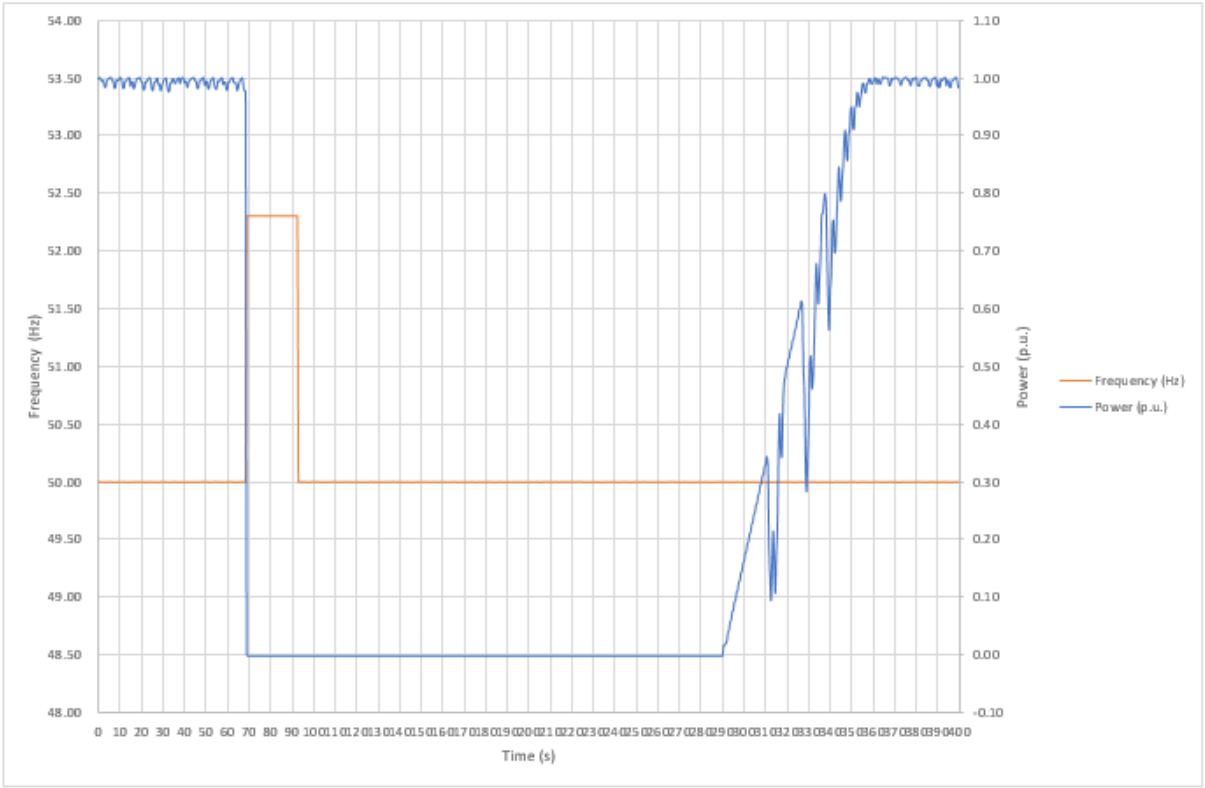
OV: 110%Un



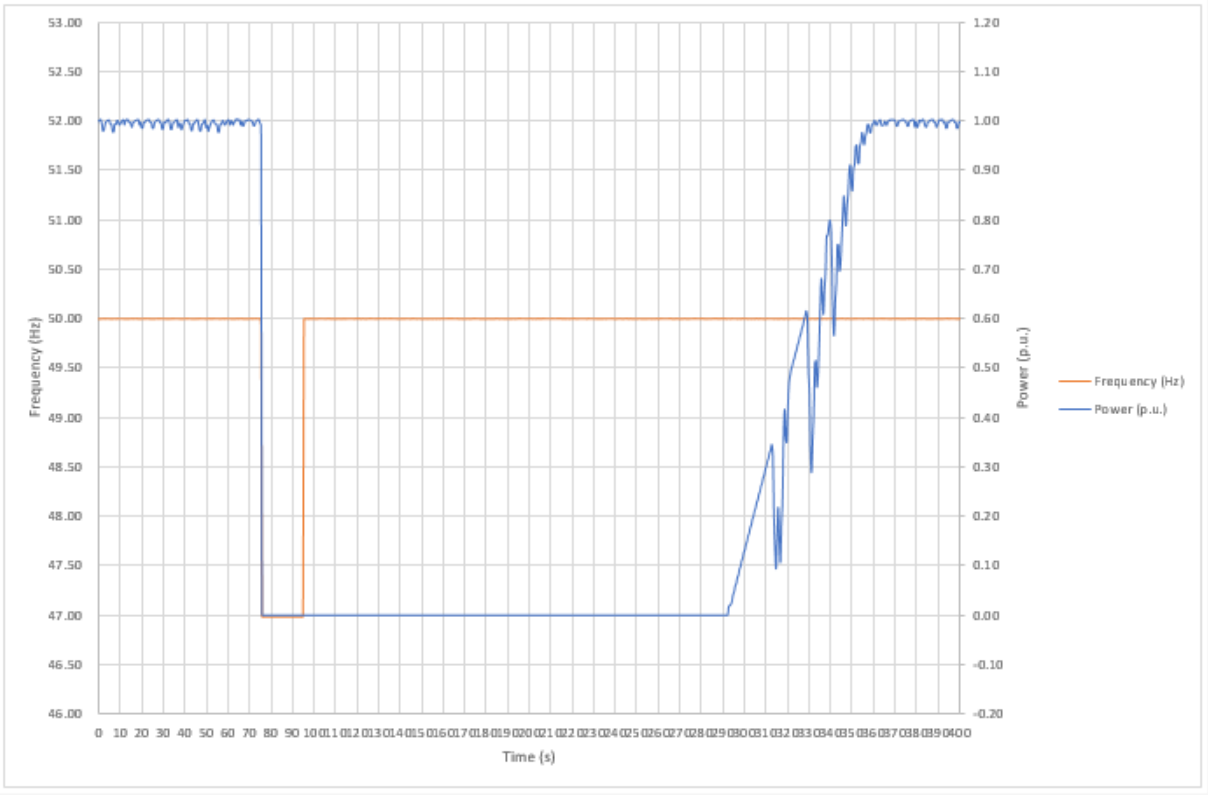
UV: 90%Un



OF: 52.0 Hz



UF: 47.0 Hz



4.6 VOLTAGE AND FREQUENCY TRIPS

Voltage and frequency trips requirements are different when unit is connected as plant category A1 or plant category A2, B. The settings of reconnect voltage and frequency is adjustable.

For connected as plant category A1, according to chapter 6.2 of standard TR3.2.1, protective functions with associated operating settings and trip time must match the values in the table below.

Protective function	Symbol	Setting		Functional area		Standard setting**
Overvoltage (step 2)	$U_{>>}$	1.15 · U_n	V	200	ms	200 ms
Overvoltage (step 1)	$U_{>}$	1.10 · U_n	V	60	s	60 s
Undervoltage (step 1)	$U_{<}$	0.85 · U_n	V	10...60	s	50 s
Undervoltage (step 2)***)	$U_{<<}$	0.80 · U_n	V	100	ms	100 ms
Overfrequency	$f_{>}$	52	Hz	200	ms	200 ms
Underfrequency	$f_{<}$	47	Hz	200	ms	200 ms
Change of frequency***)	*df/dt*	±2.5	Hz/s	50 - 100	ms	80 ms

***) One of the specified functions must be implemented.
**) This value is used unless agreed otherwise with the *electricity supply undertaking*.

For connected as plant category A2, according to chapter 6.3.2 of standard TR3.2.2, protective functions with associated operating settings and trip time must match the values in the table below.

Protective function	Symbol	Setting		Trip time		Standard value
Overvoltage (step 2)	$U_{>>}$	1.15 · U_n	V	200	ms	200 ms
Overvoltage (step 1)	$U_{>}$	1.10 · U_n	V	60	s	60 s
Undervoltage (step 1)	$U_{<}$	0.85 · U_n	V	10...60	s	50 s
Undervoltage (step 2) ***)	U<<	0.80 · U_n	V	100...200	ms	100 ms
Overfrequency	$f_{>}$	52.0	Hz	200	ms	200 ms
Underfrequency	$f_{<}$	47.0	Hz	200	ms	200 ms
Change of frequency ***)	*df/dt*	±2.5	Hz/s	50...100	ms	80 ms

***) One of the specified functions must be implemented.

For connected as plant category B, according to chapter 6.3.2 of standard TR3.2.2, protective functions with associated operating settings and trip time must match the values in the table below.

Protective function	Symbol	Setting		Trip time		Standard value
Overvoltage (step 2)	$U_{>>}$	1.15 · U_n	V	200	ms	200 ms
Overvoltage (step 1)	$U_{>}$	1.10 · U_n	V	60	s	60 s
Undervoltage (step 1)	$U_{<}$	0.90 · U_n	V	10...60	s	10 s
Overfrequency	$f_{>}$	52	Hz	200	ms	200 ms
Underfrequency	$f_{<}$	47	Hz	200	ms	200 ms
Change of frequency	*df/dt*	±2.5	Hz/s	50...100	ms	80 ms

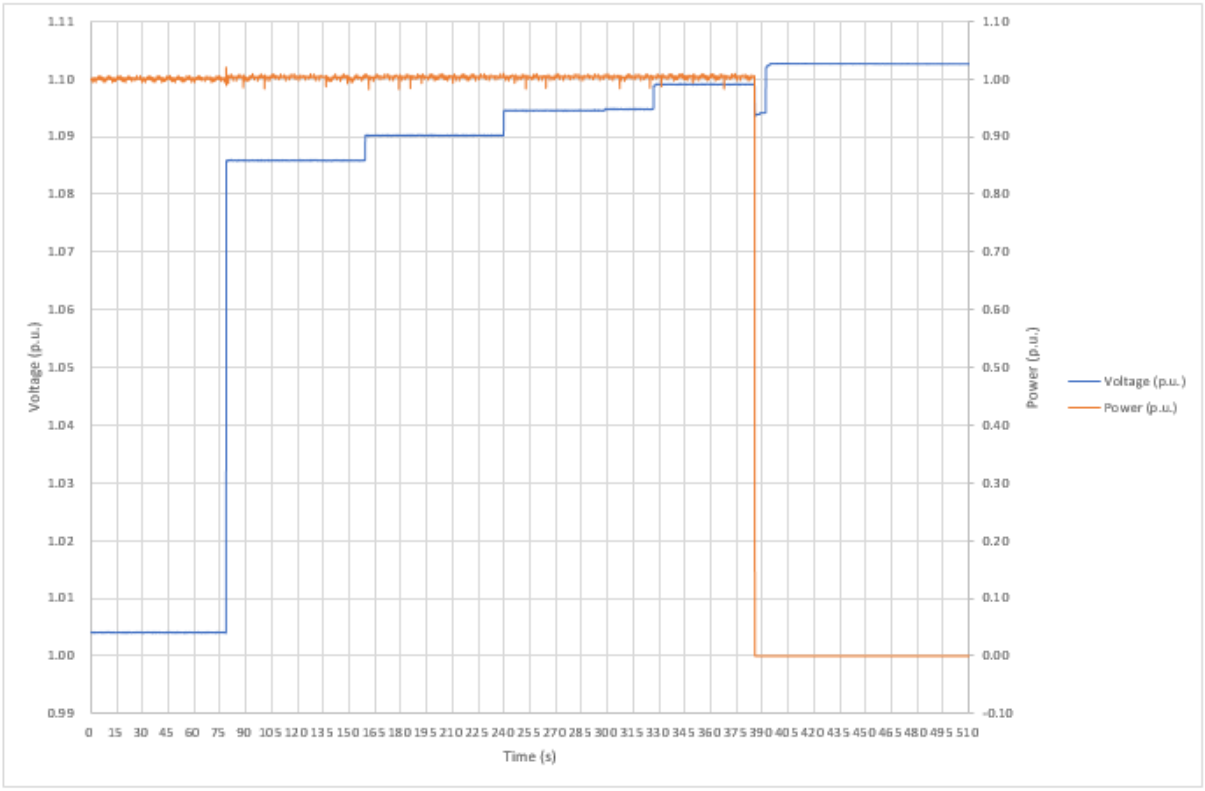
The settings of voltage and frequency trips is adjustable.

Test results are offered at the tables below.

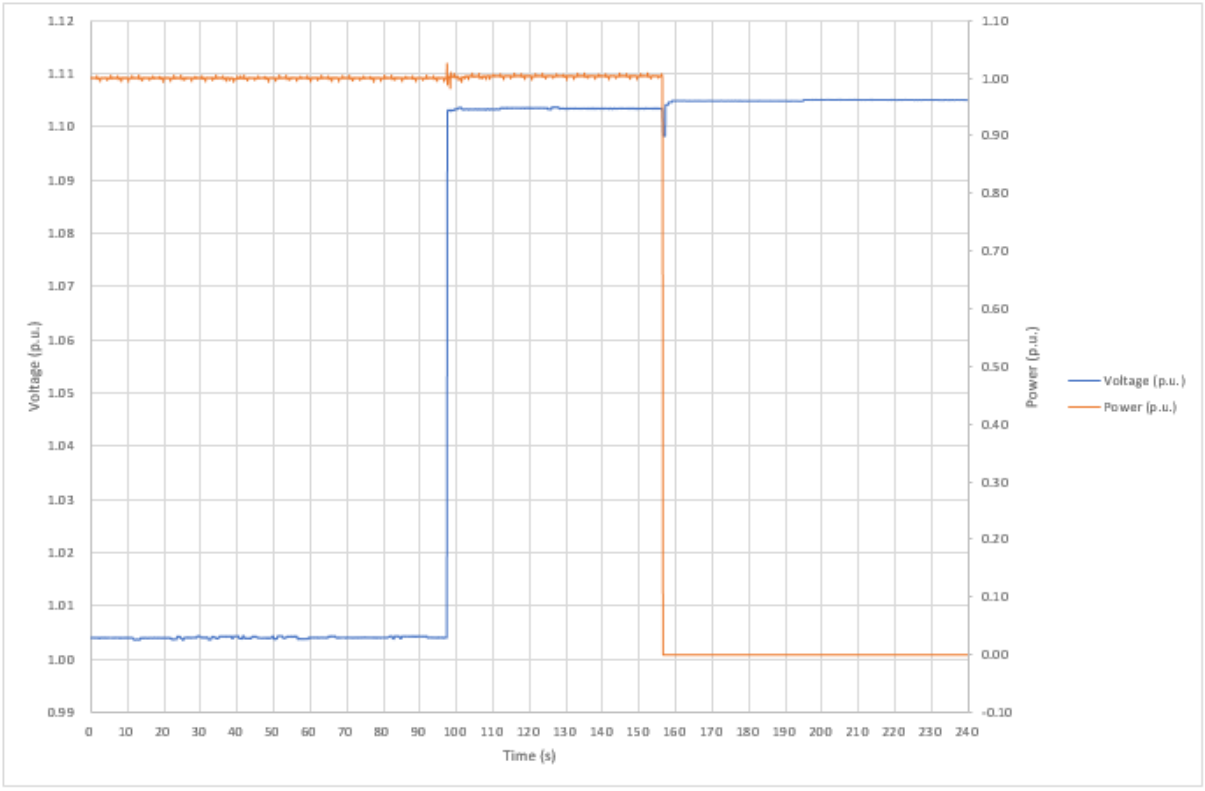
4.6.1 Voltage Trip

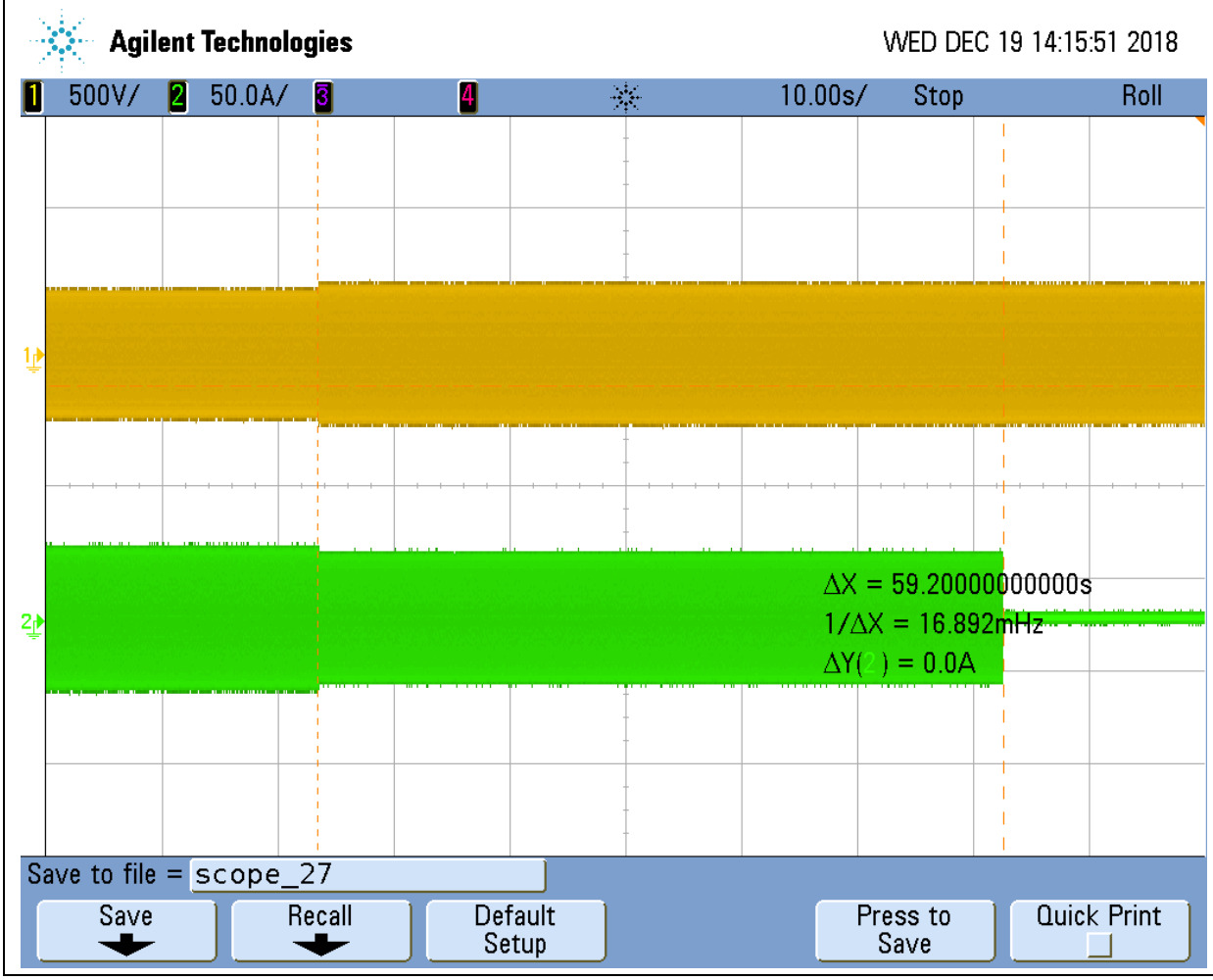
Voltage	Disconnection time limits (s)	Disconnection time measured (s)
Un+10%Un	60	59.200
Un+15%Un	0.2	0.150
Un-10%Un	10 to 60	57.400
Un-15%Un	10 to 60	52.300
Un-20%Un	0.1 to 0.2	0.107

Voltage measured: Un+10%Un

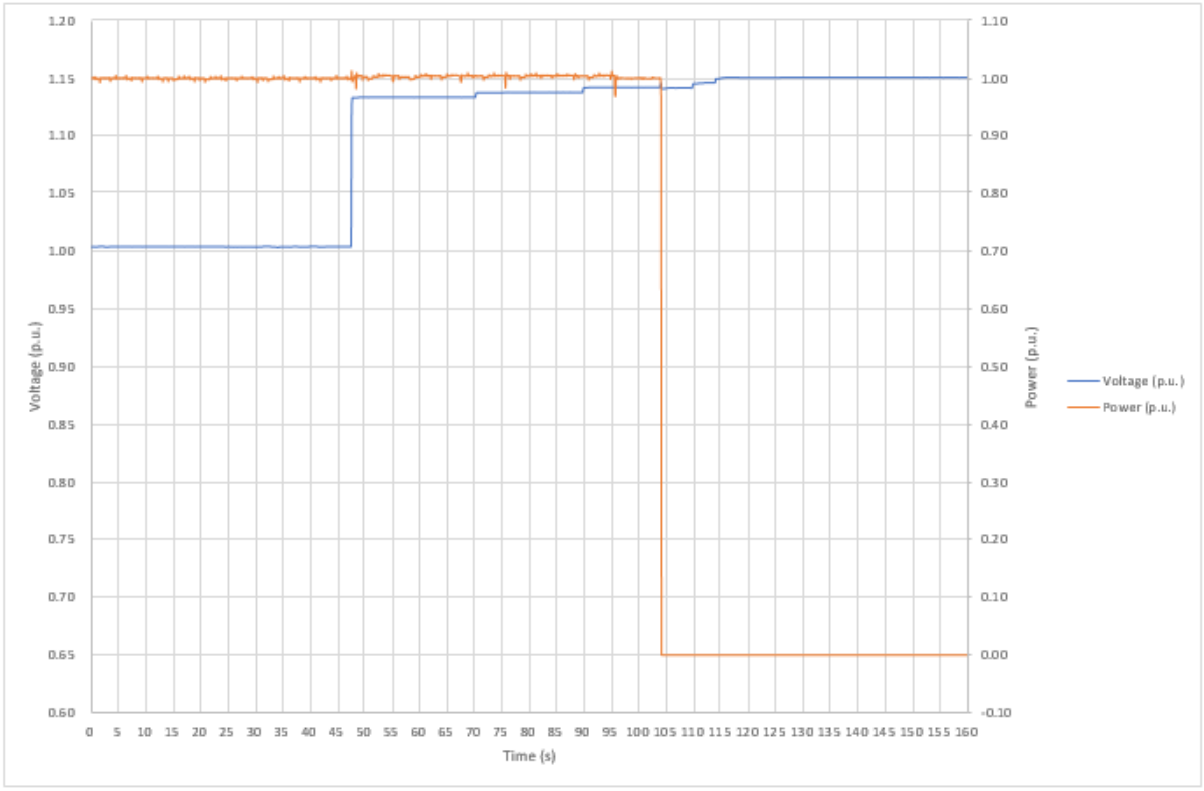


Voltage Trip Time: Un+10%Un

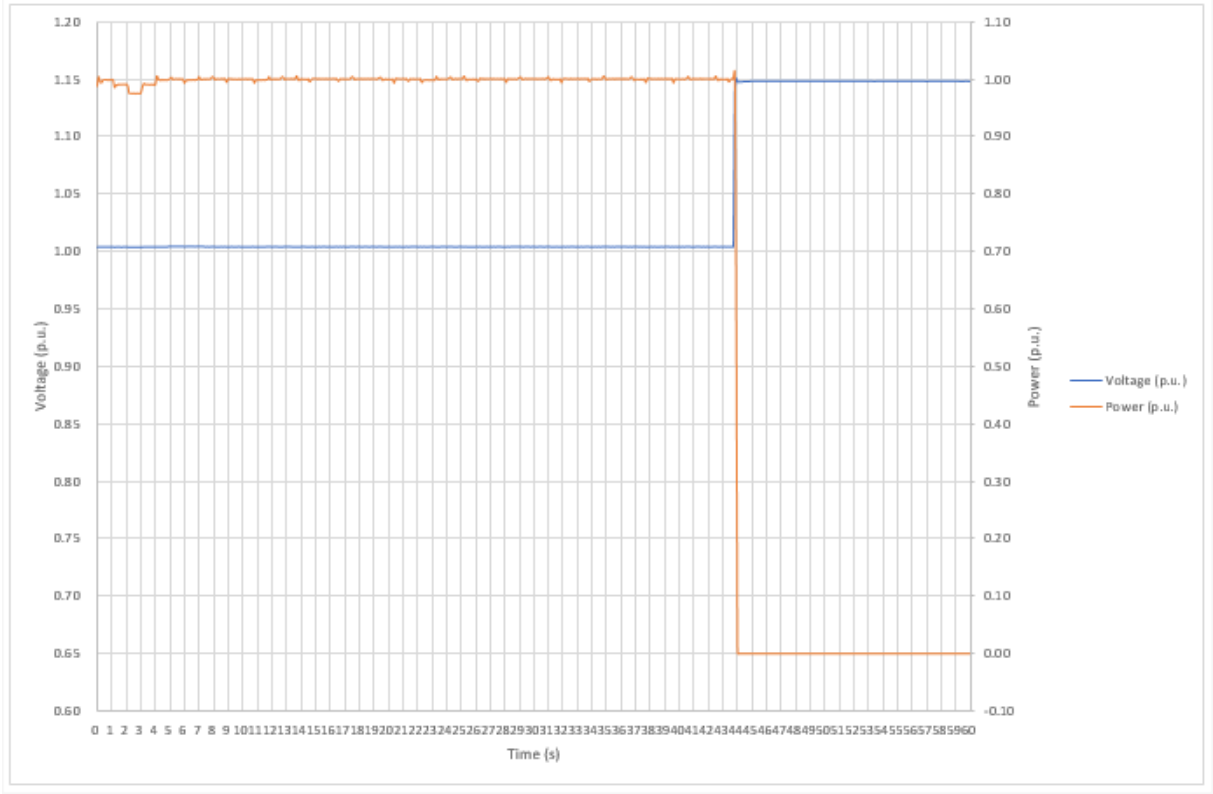


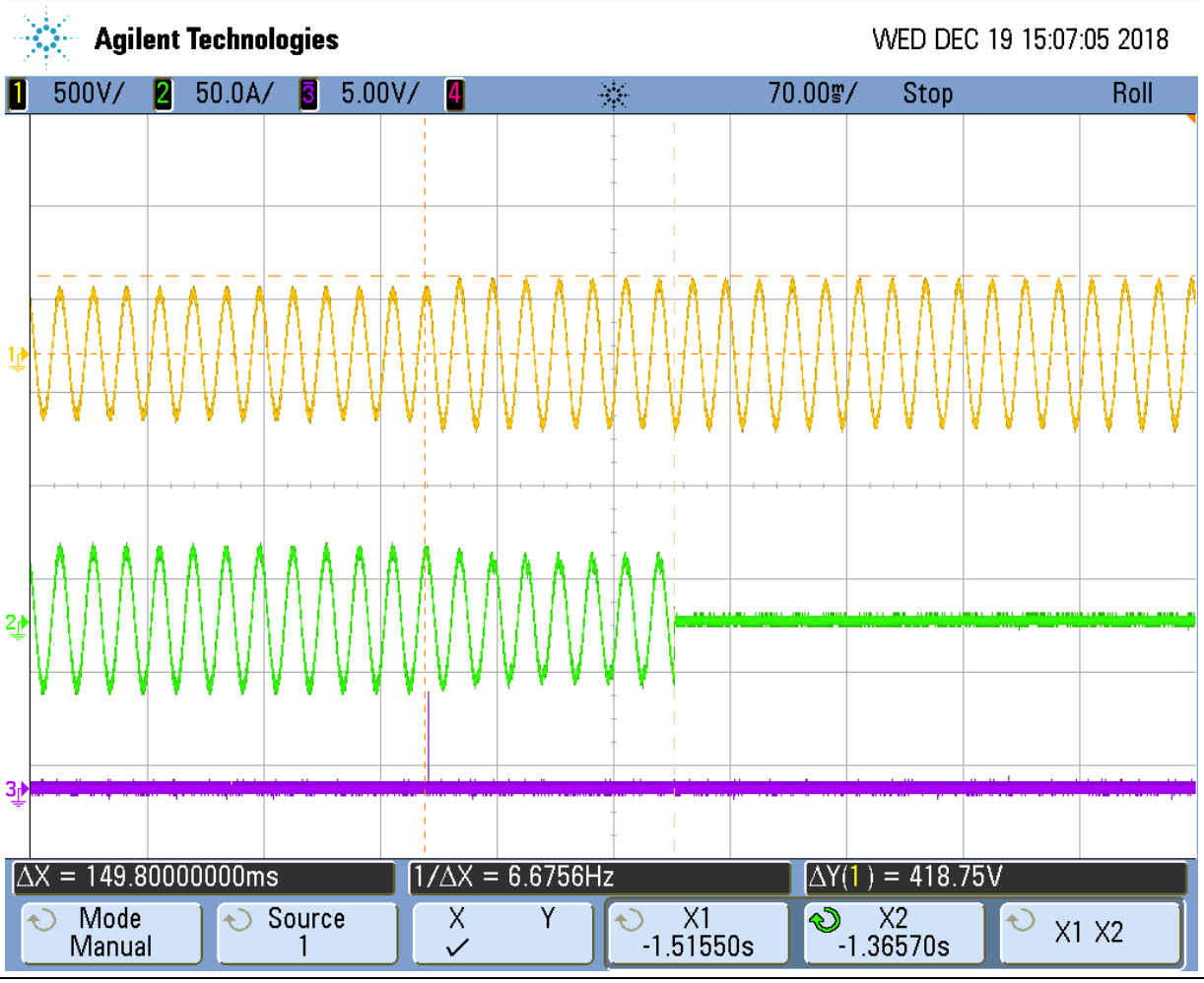


Voltage measured: Un+15%Un

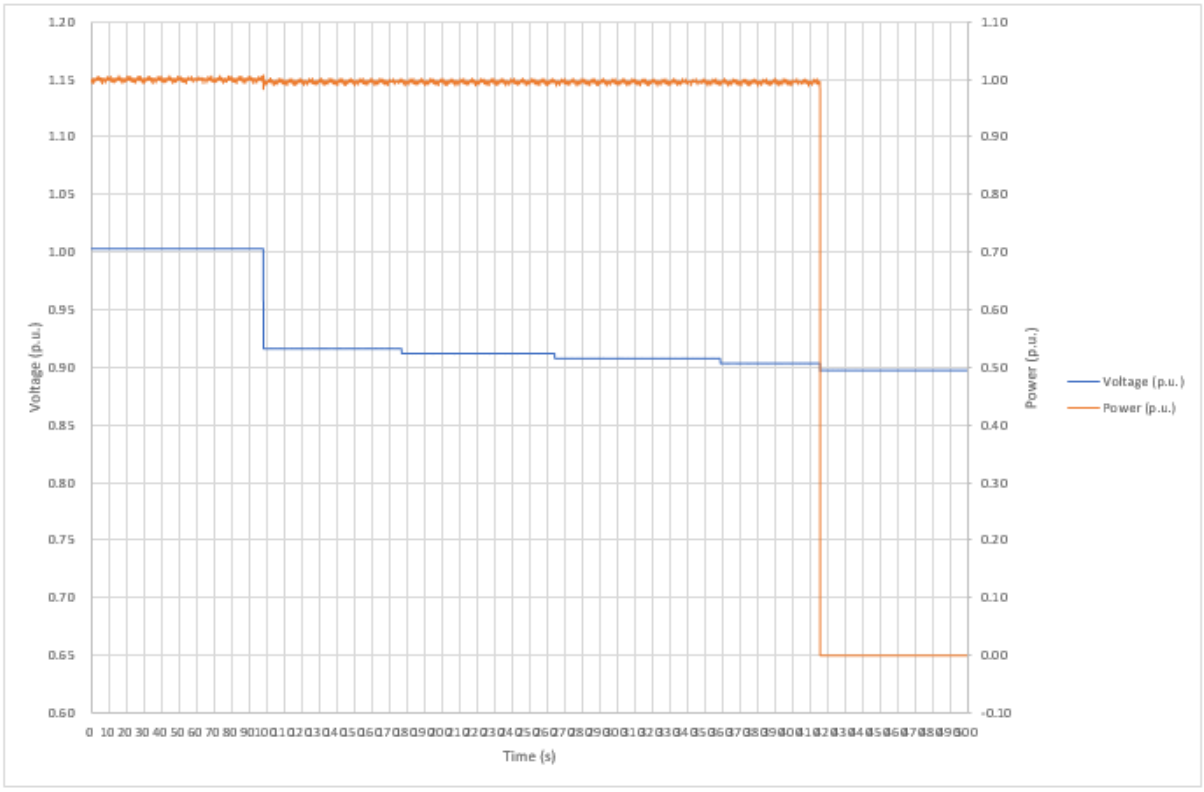


Voltage Trip Time: Un+15%Un

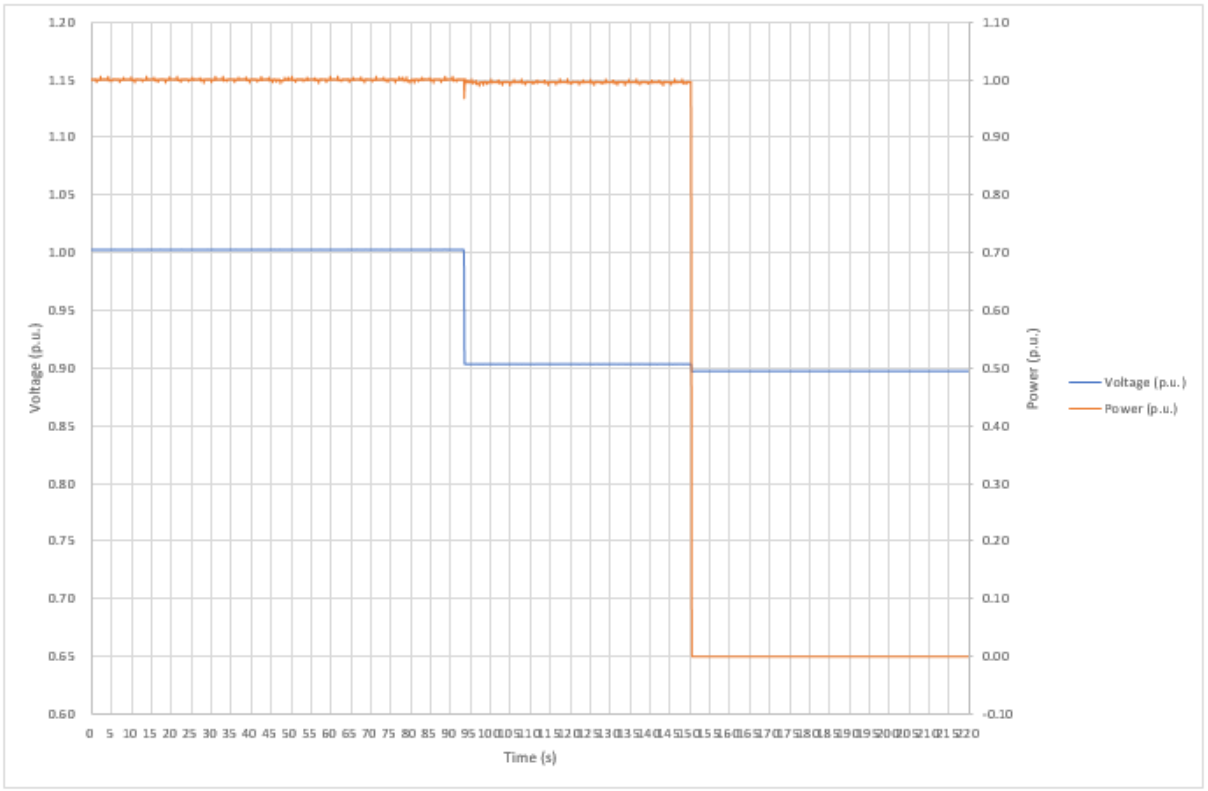


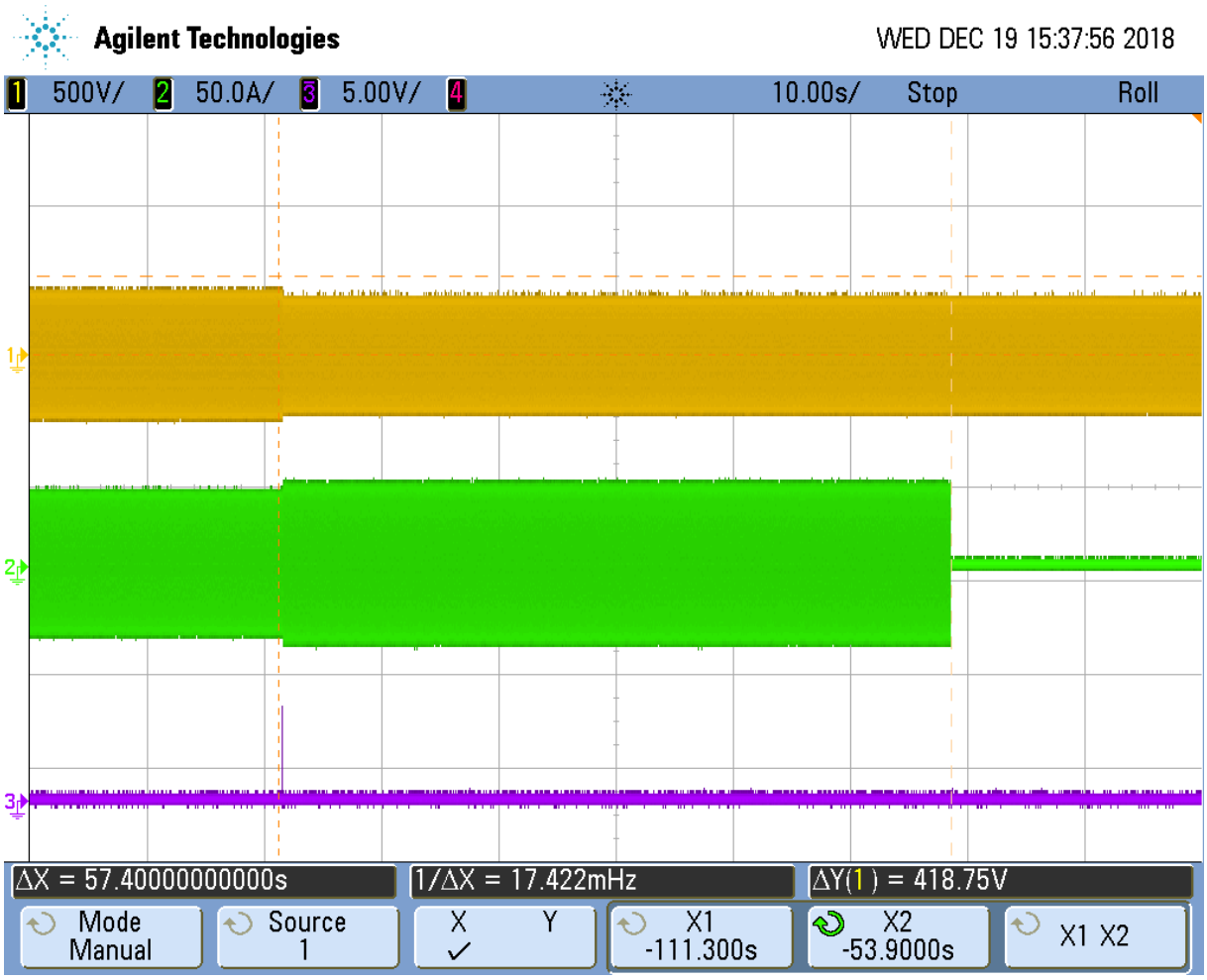


Voltage measured: Un-10%Un

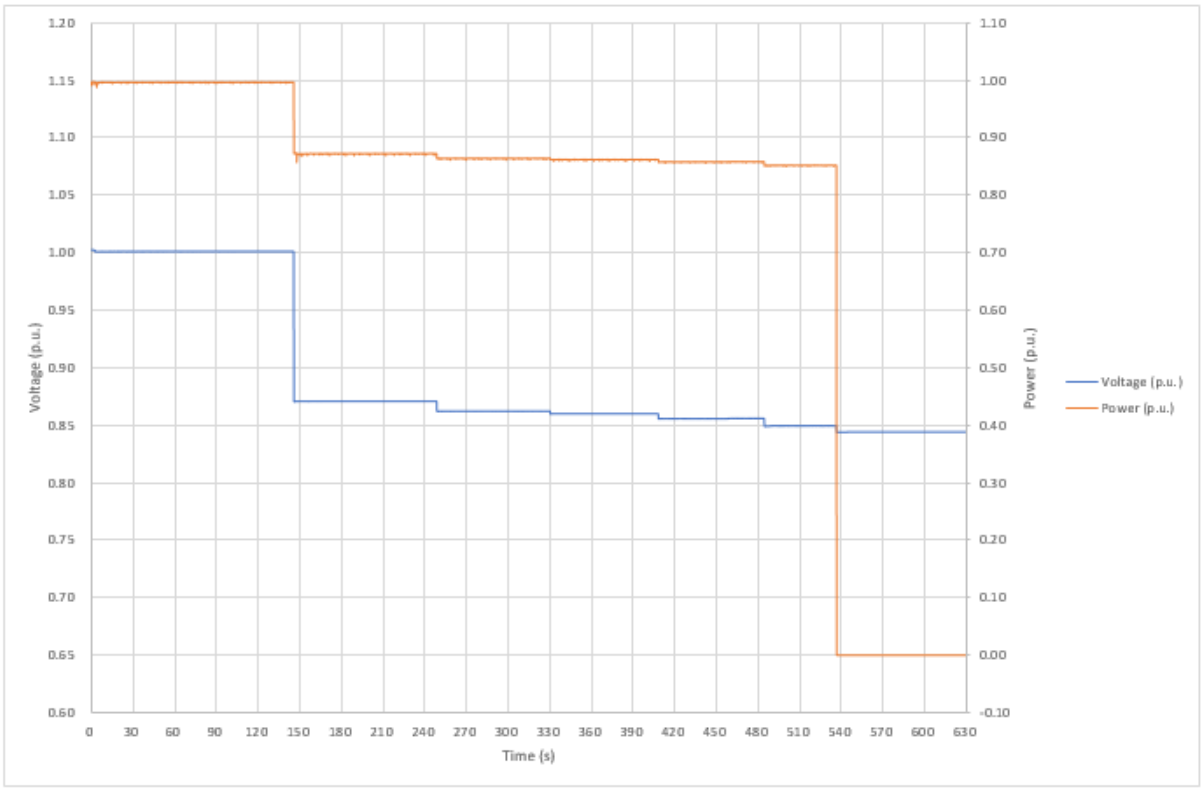


Voltage Trip Time: Un-10%Un

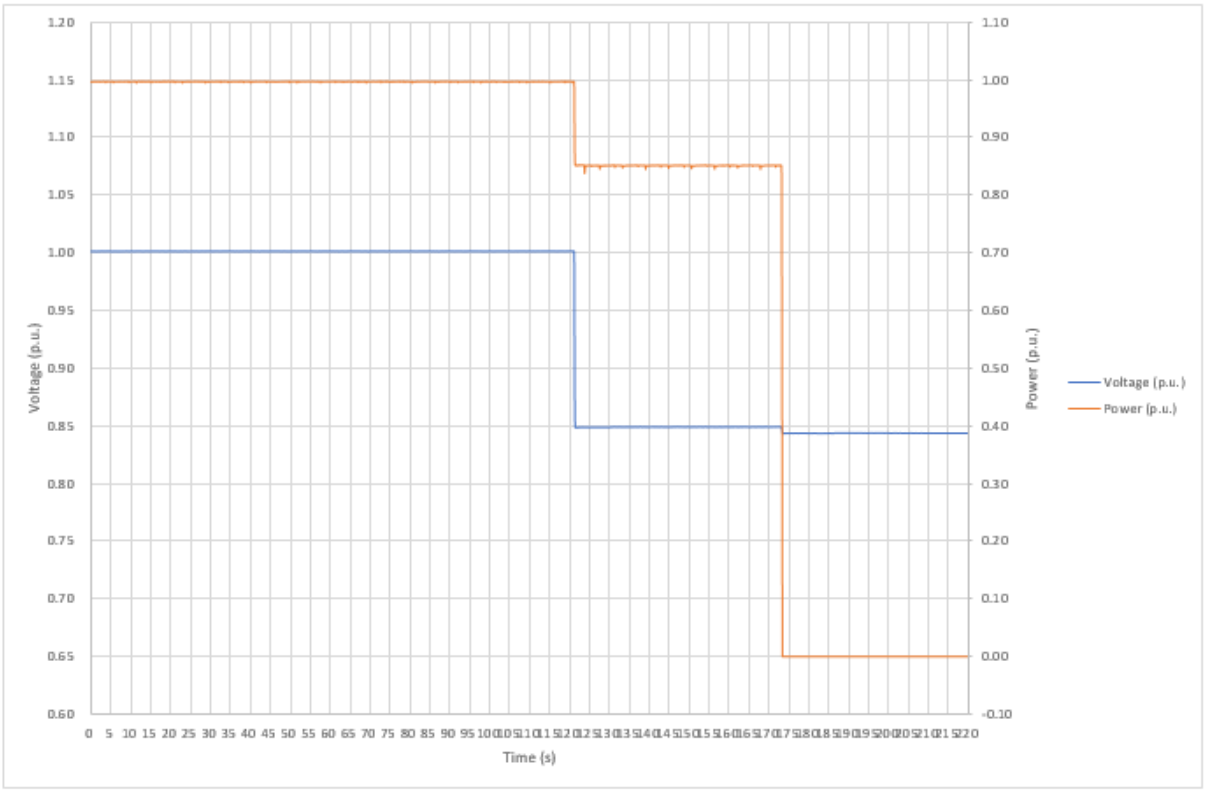


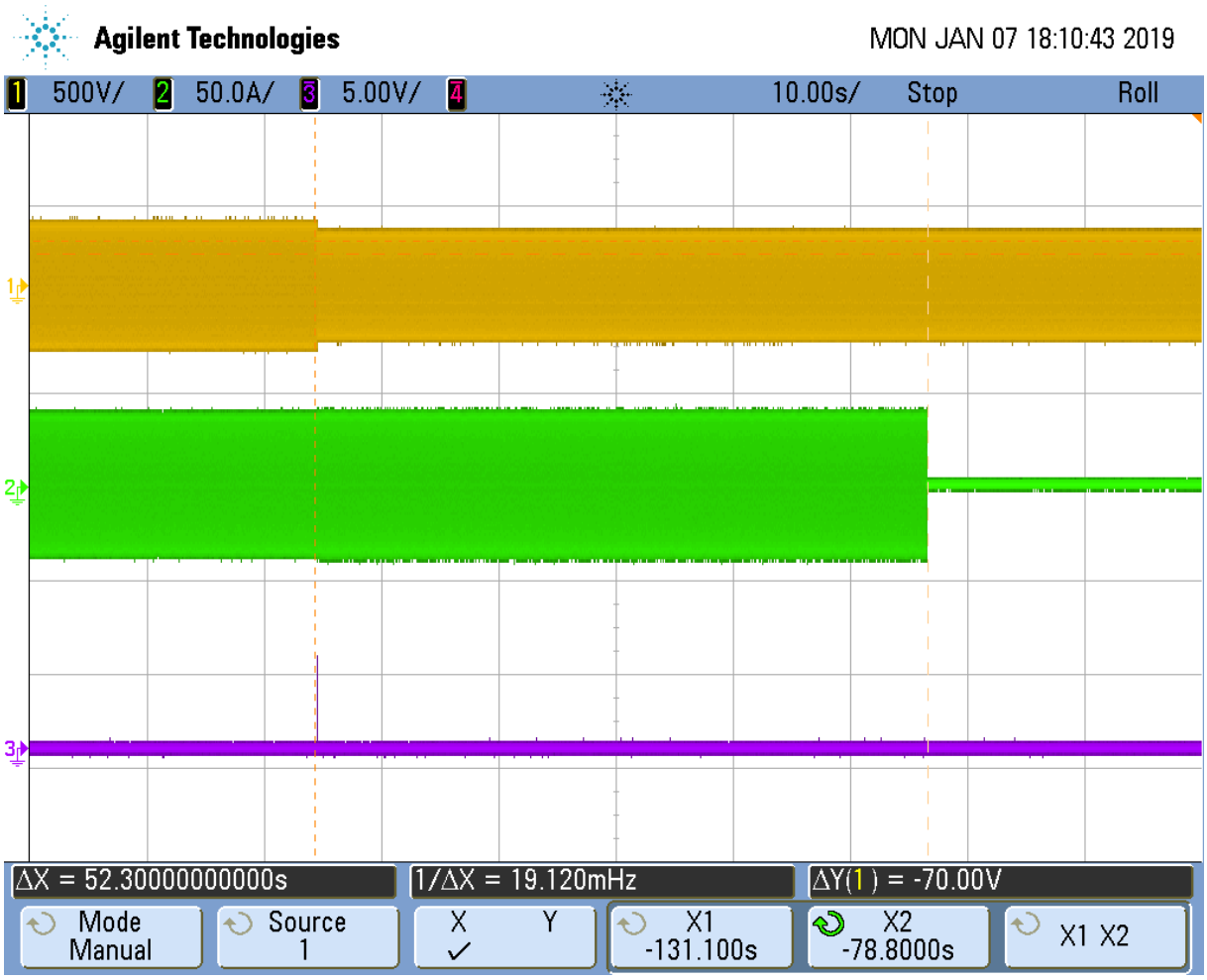


Voltage measured: Un-15%Un

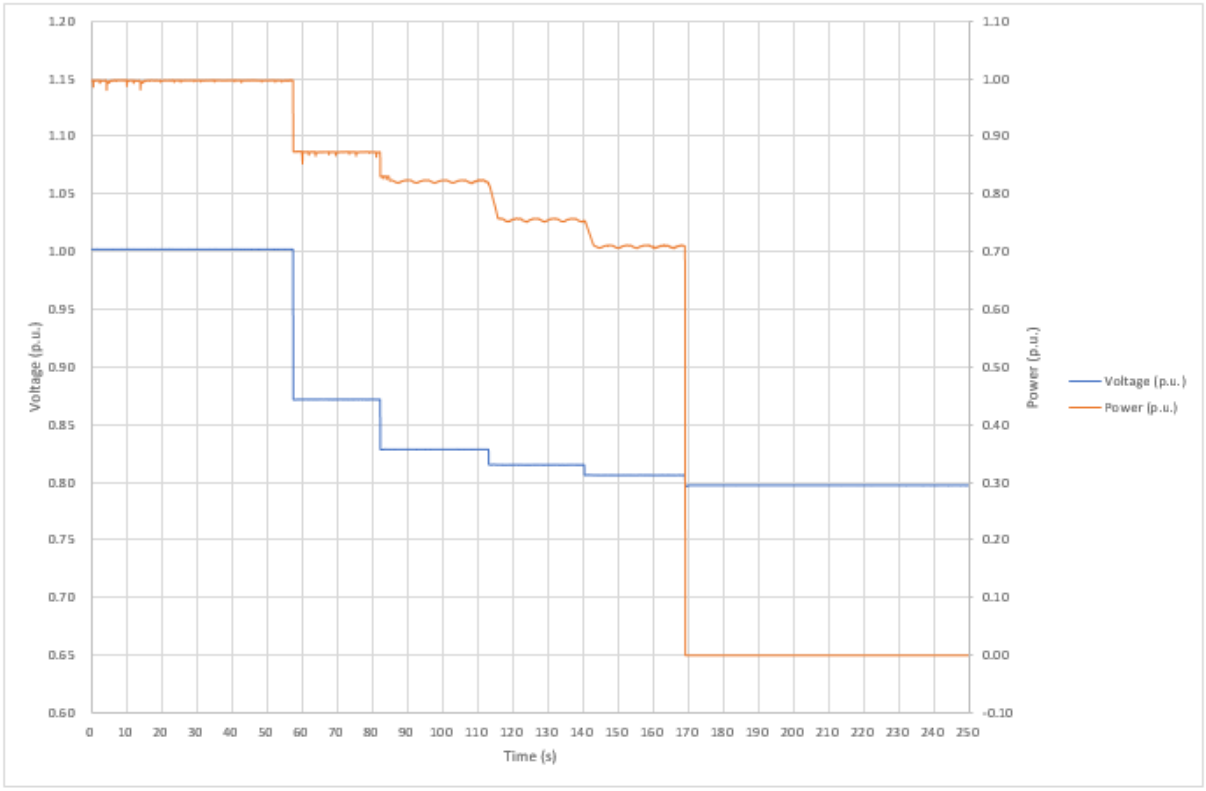


Voltage Trip Time: Un-15%Un

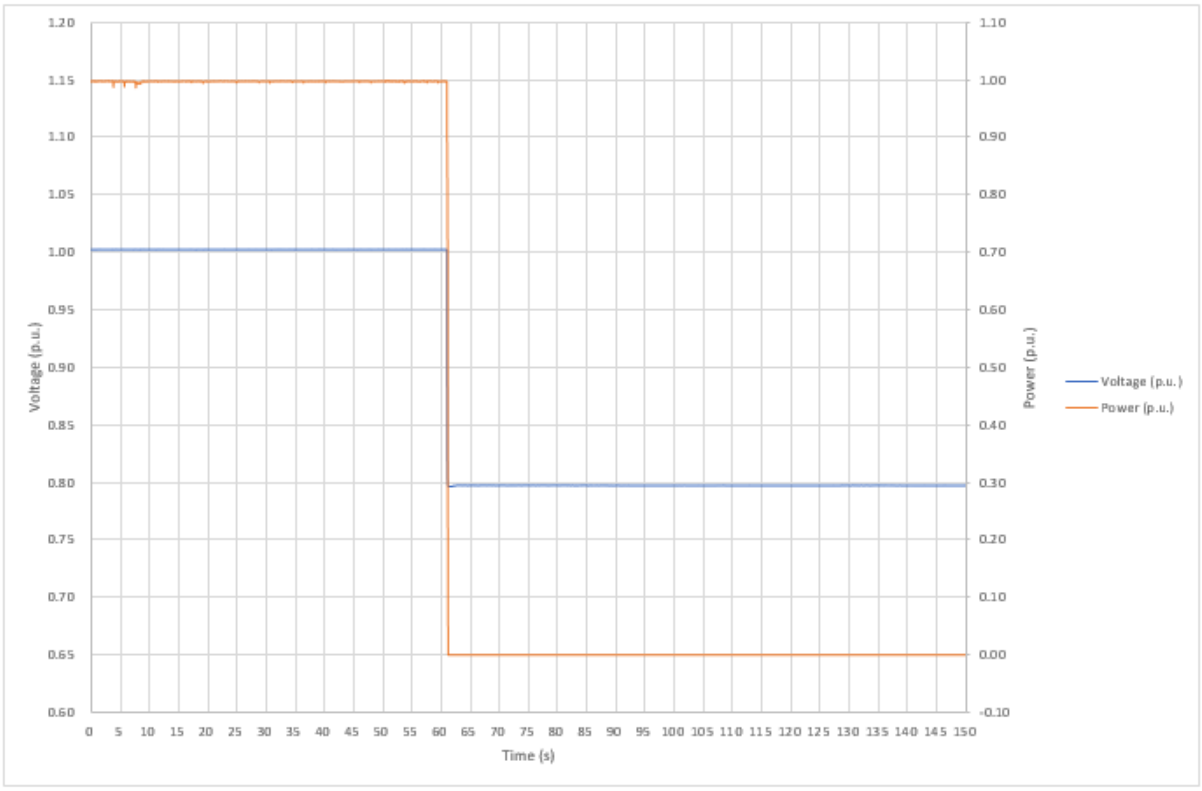


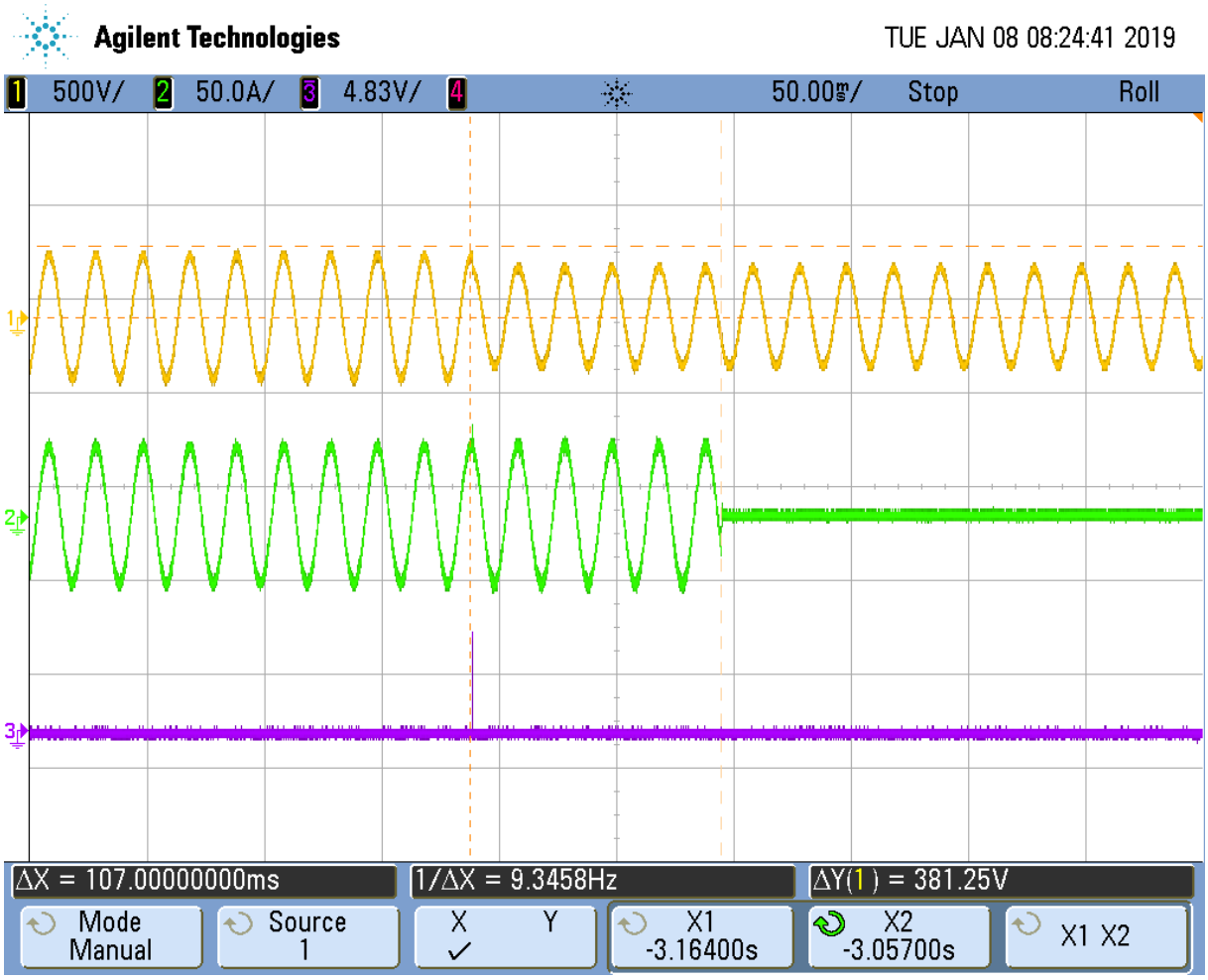


Voltage measured: Un-20%Un



Voltage Trip Time: Un-20%Un

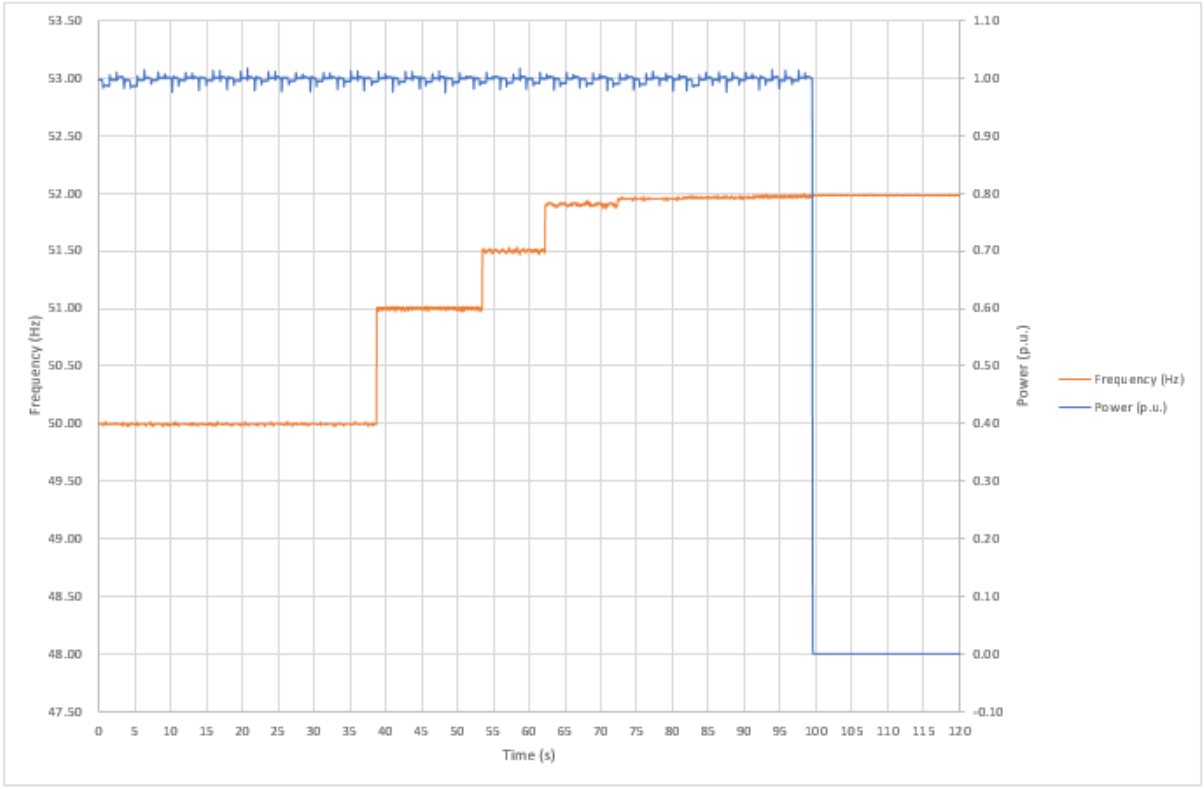




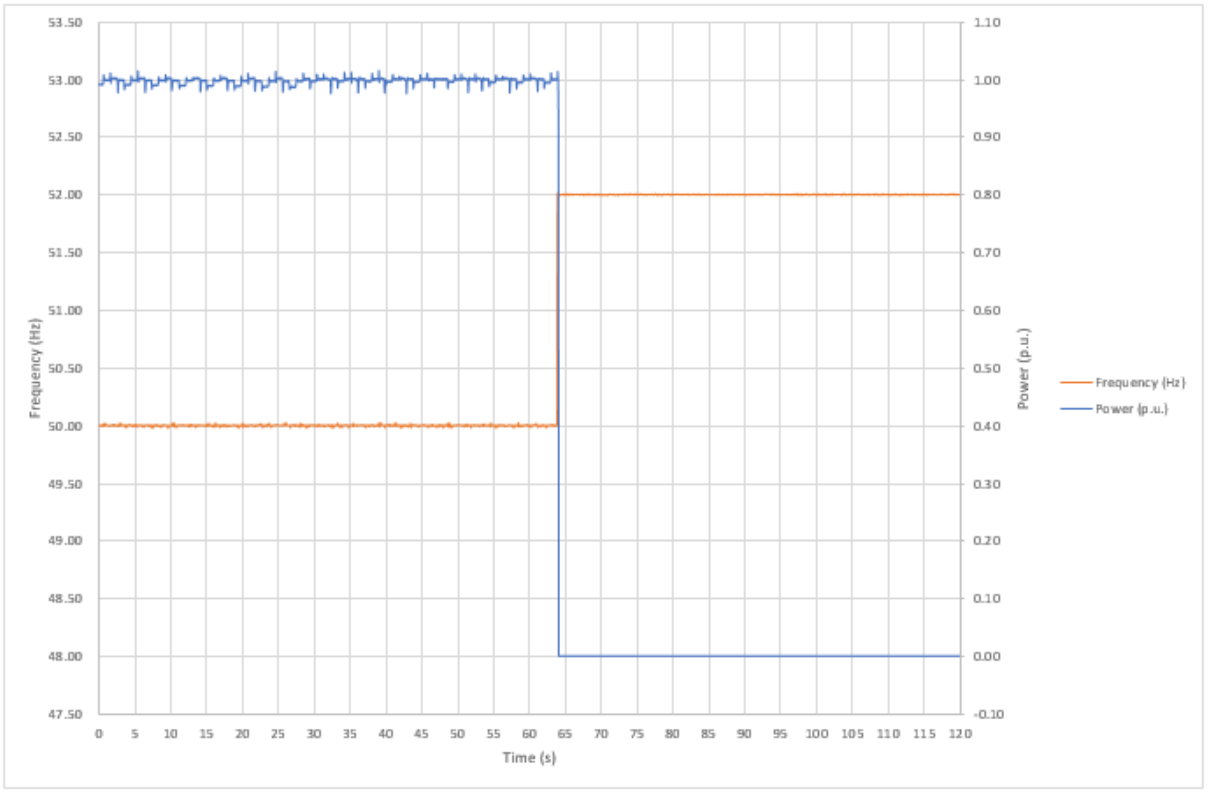
4.6.2 Frequency disconnection

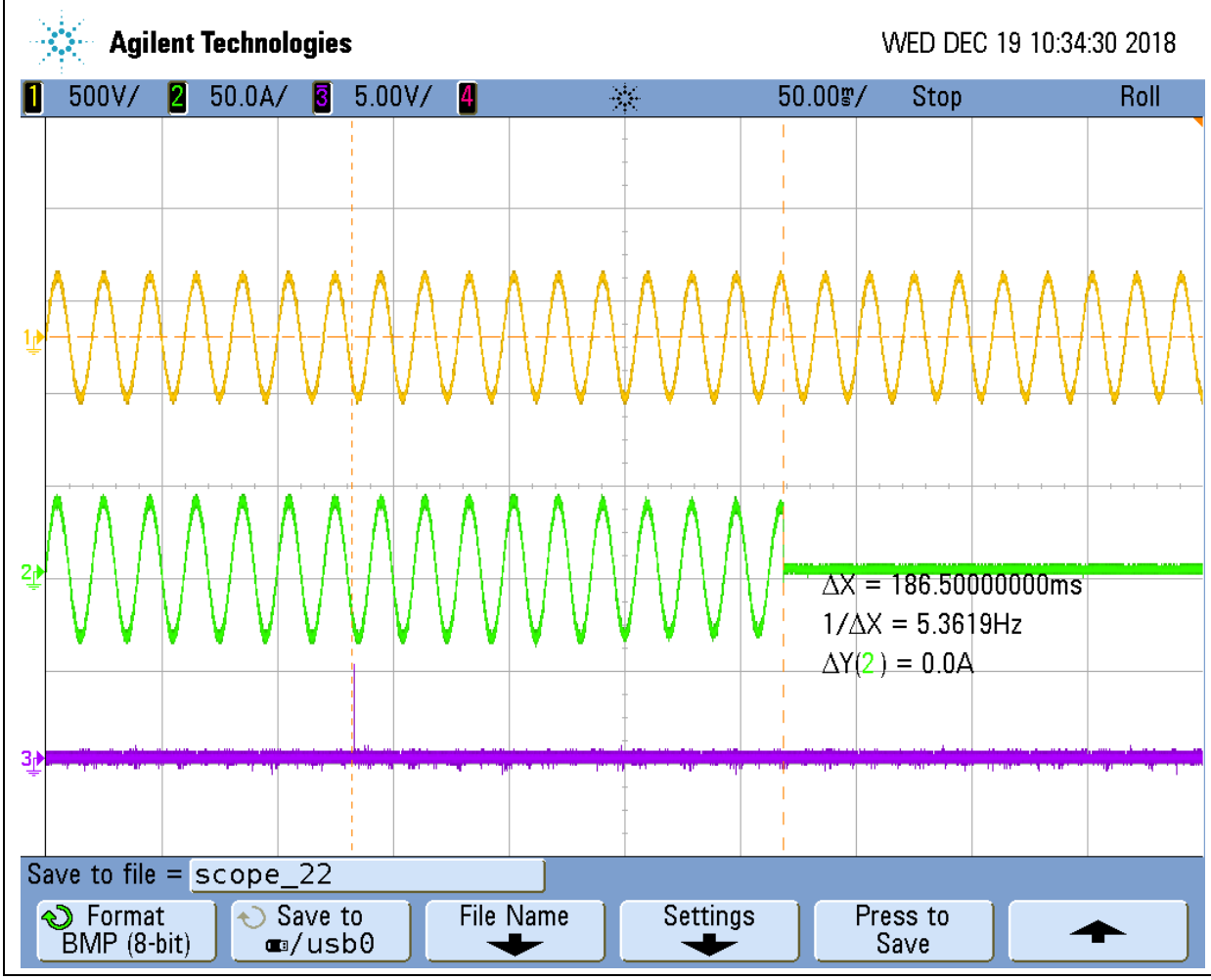
Frequency (Hz)	Disconnection time limits (ms)	Disconnection time measured (ms)
52	200	187
47	200	147

Frequency measured: 52 Hz
Trip value

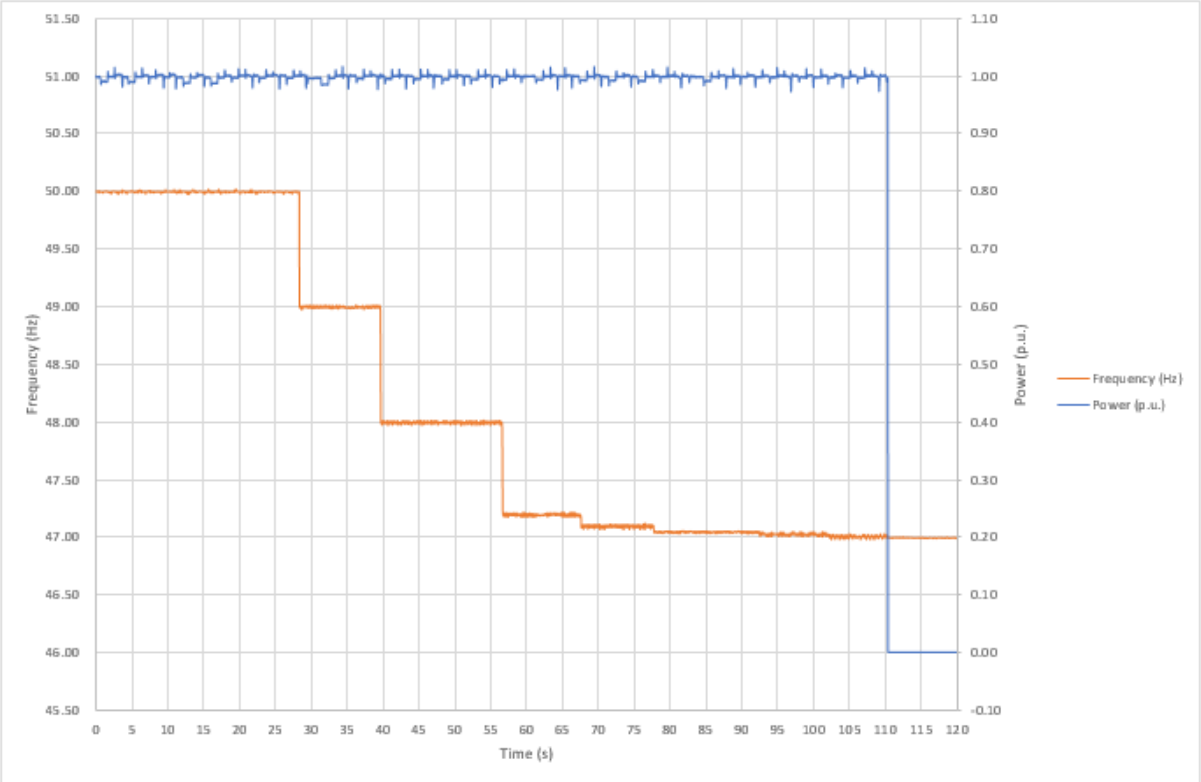


Disconnection time

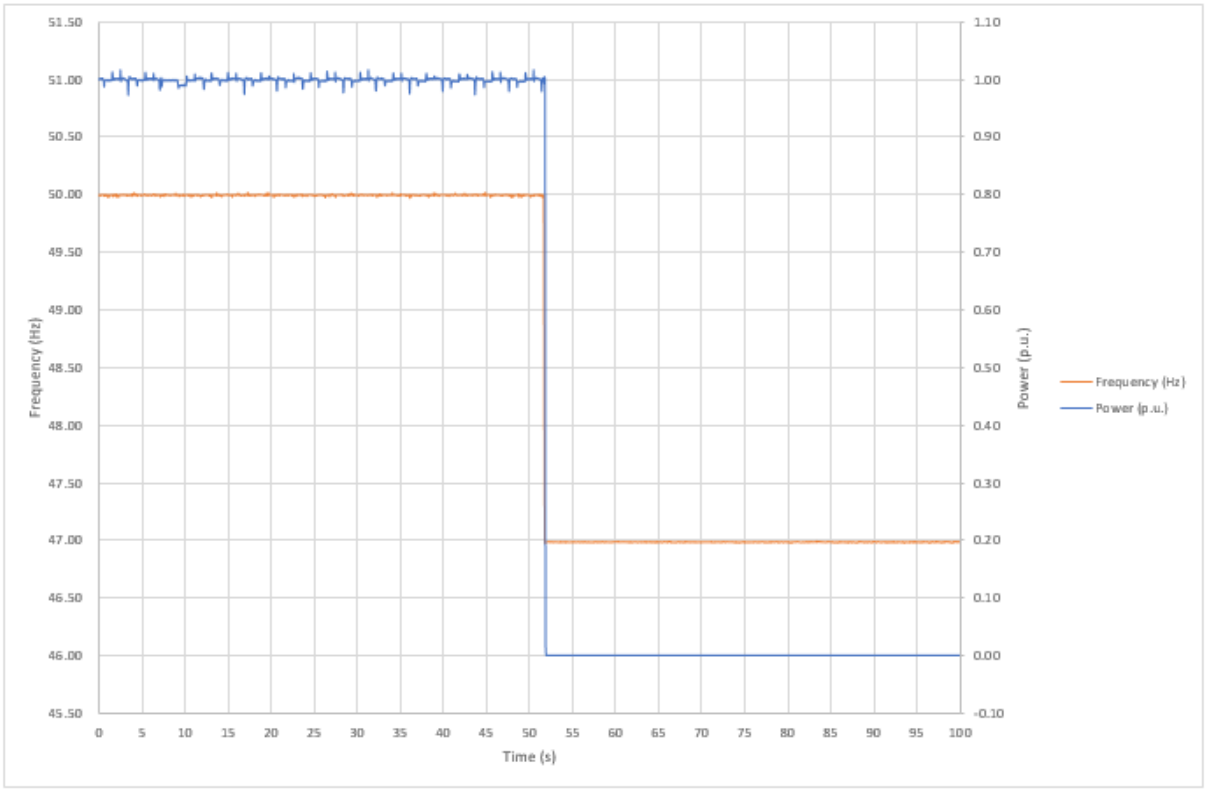


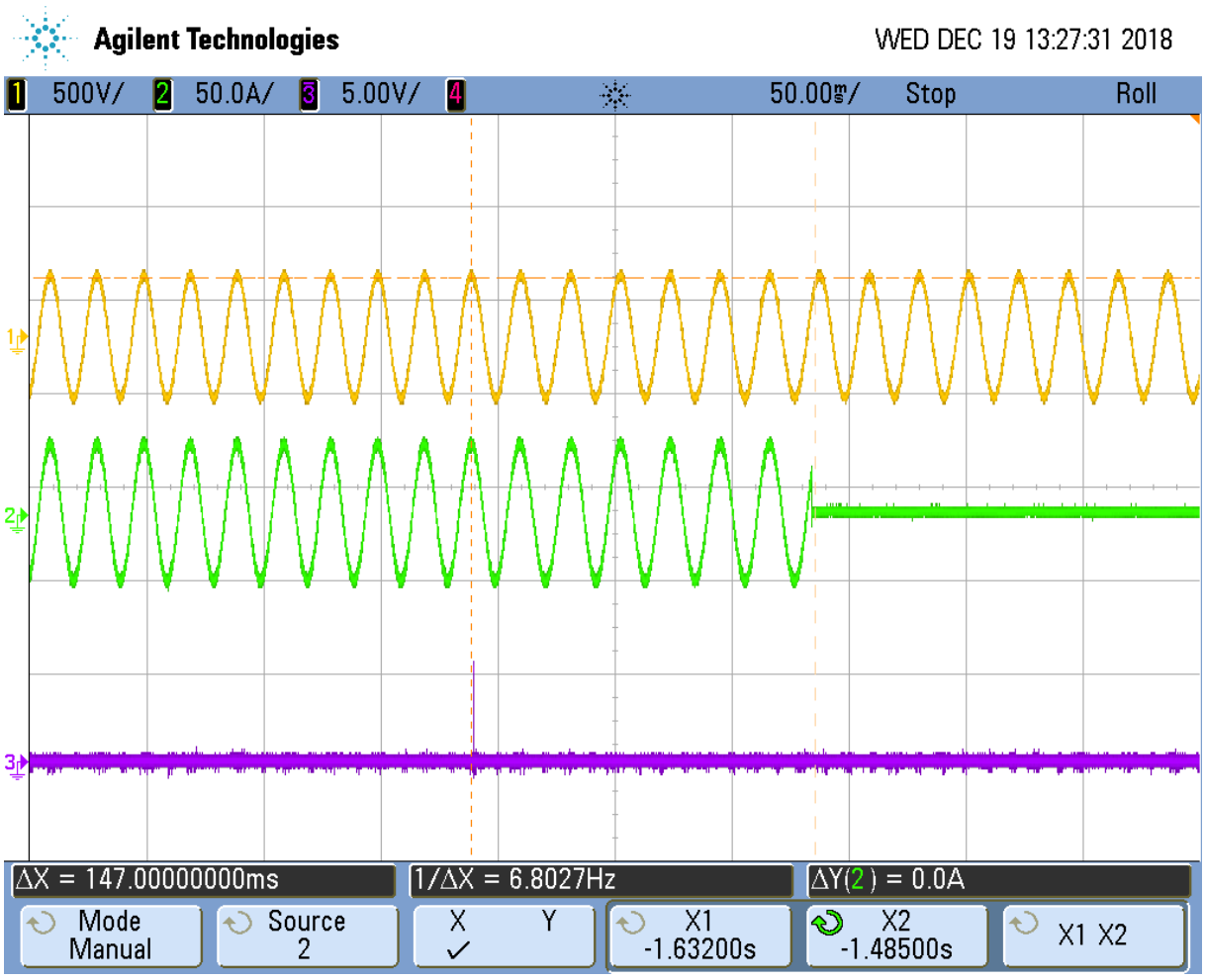


Frequency measured: 47 Hz
Trip value



Disconnection time





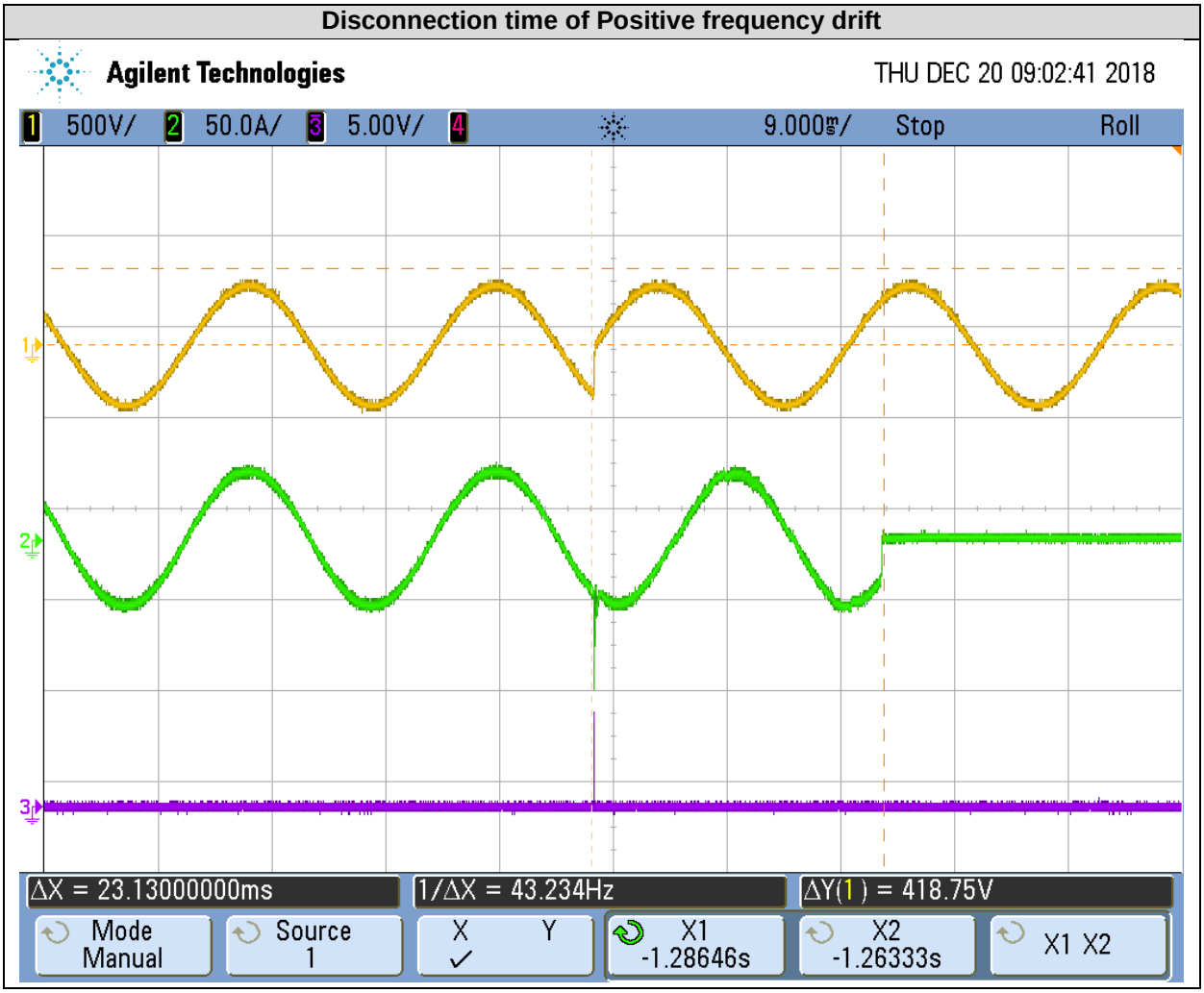
4.6.3 Change Of Frequency

Test results are offered at the table below.

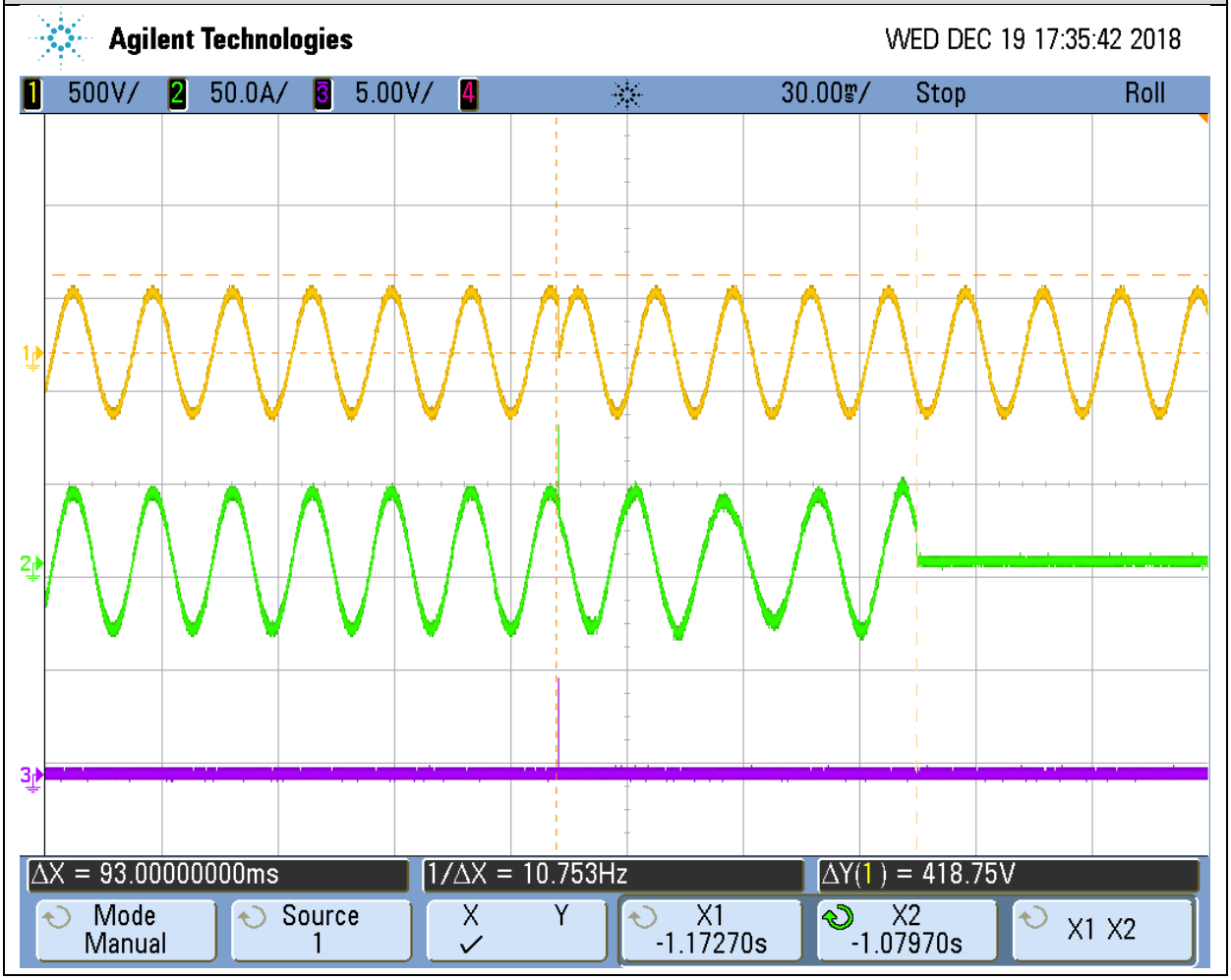
Type of drift	Start Frequency (Hz)	Final Value (Hz)	Ramp measured (Hz/s)	**Disconnection time limits (ms)**	**Disconnection time measured (ms)**
Positive frequency drift	50.0	51.3	2.6	50 to 100	23
Negative frequency drift	50.0	48.7	2.6	50 to 100	93

Test results are represented at the images below.

Disconnection time of Positive frequency drift

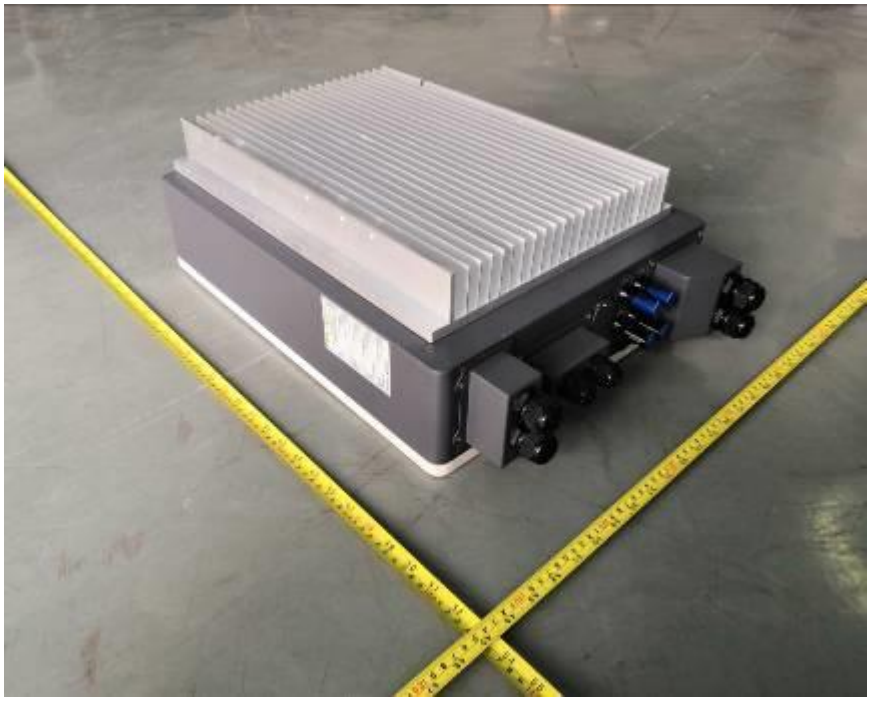


Disconnection time of Negative frequency drift

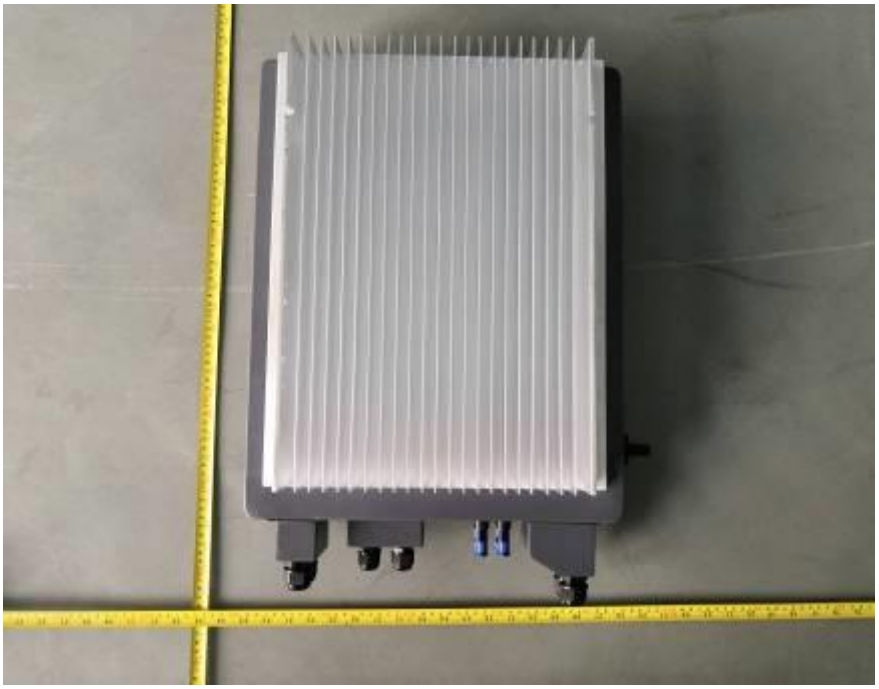


5 PICTURES

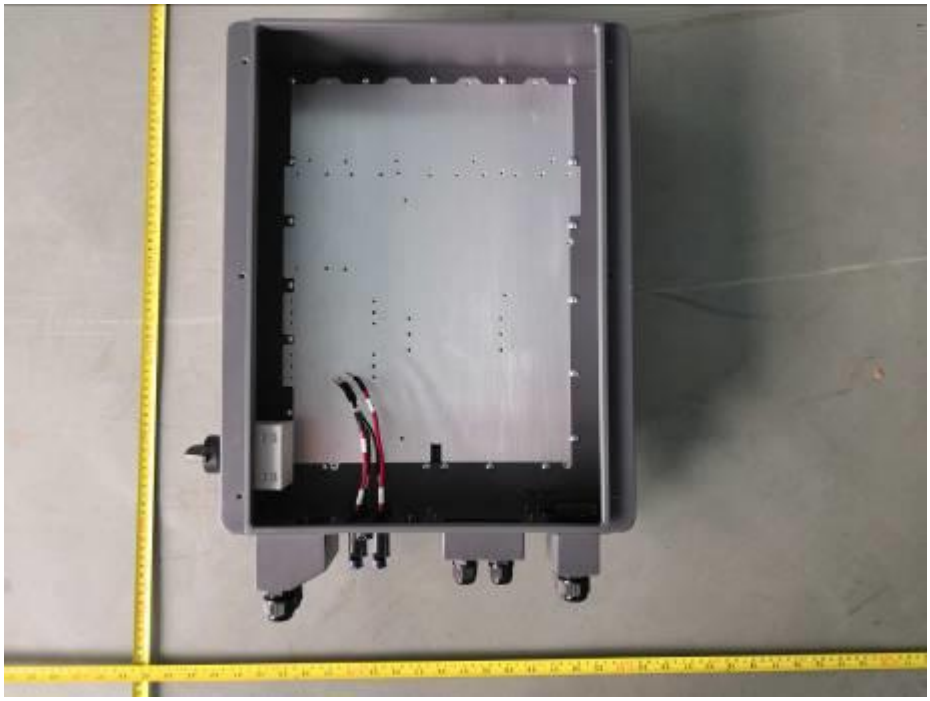
General view

General view


Front view

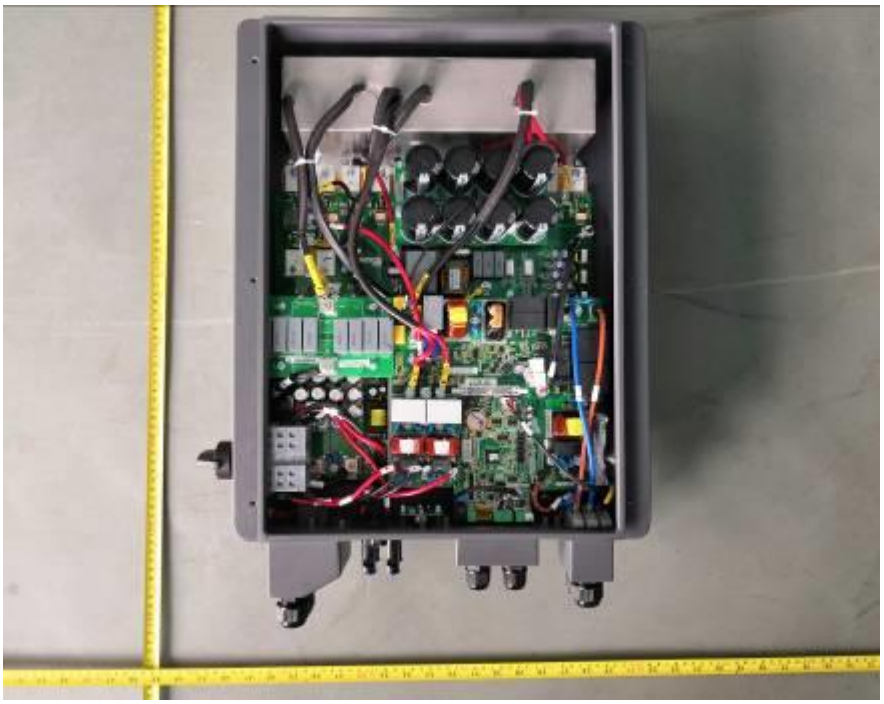
Back view


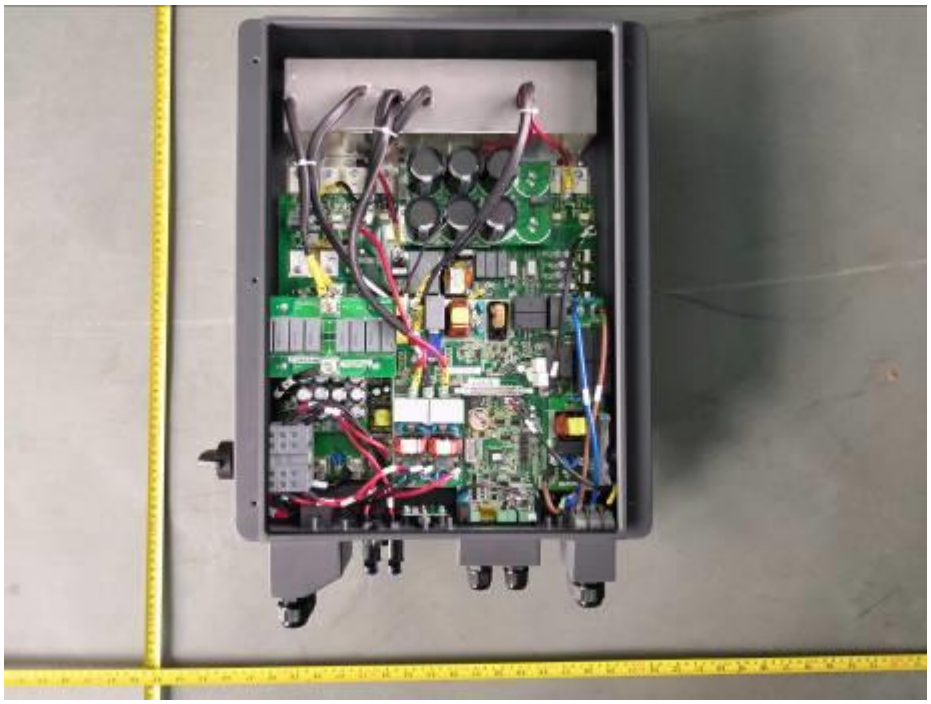
Side View

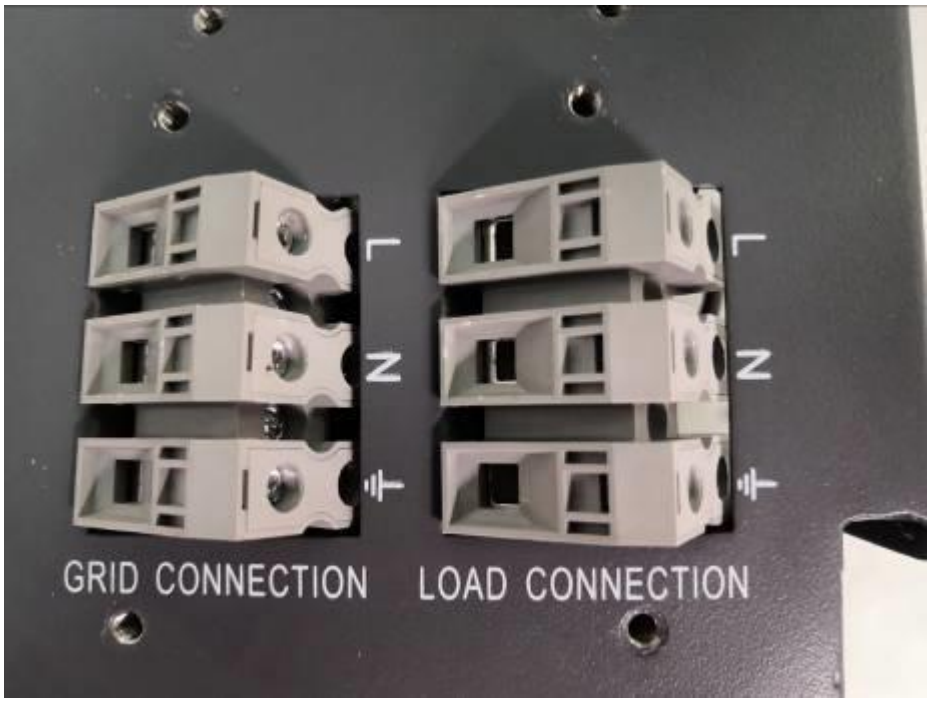
Internal view of enclosure


Top View

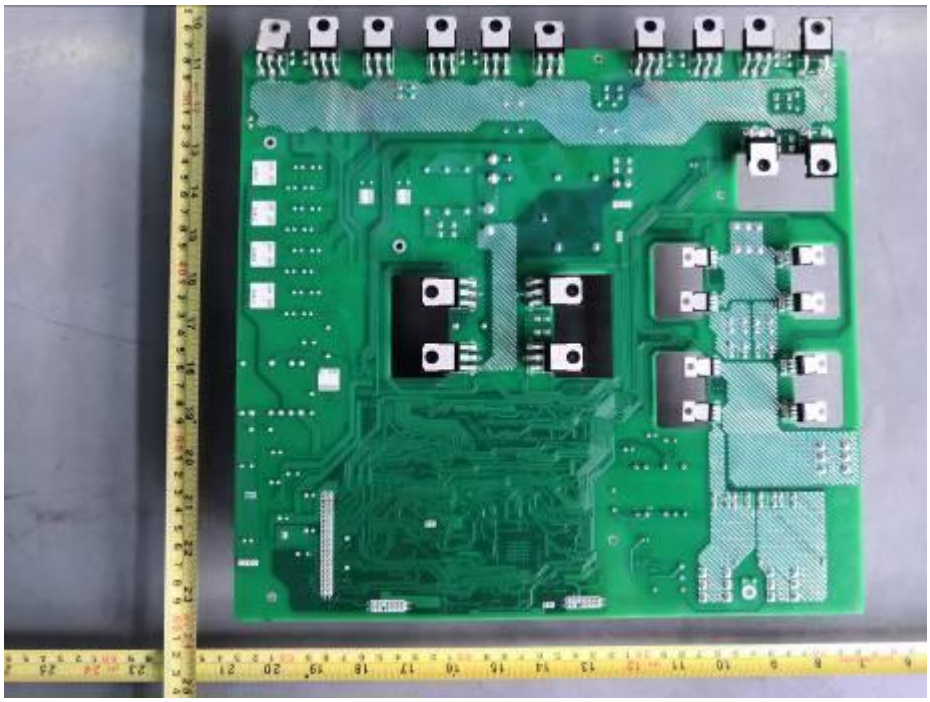
Internal View of Model HYD 5000-ES, HYD 6000-ES

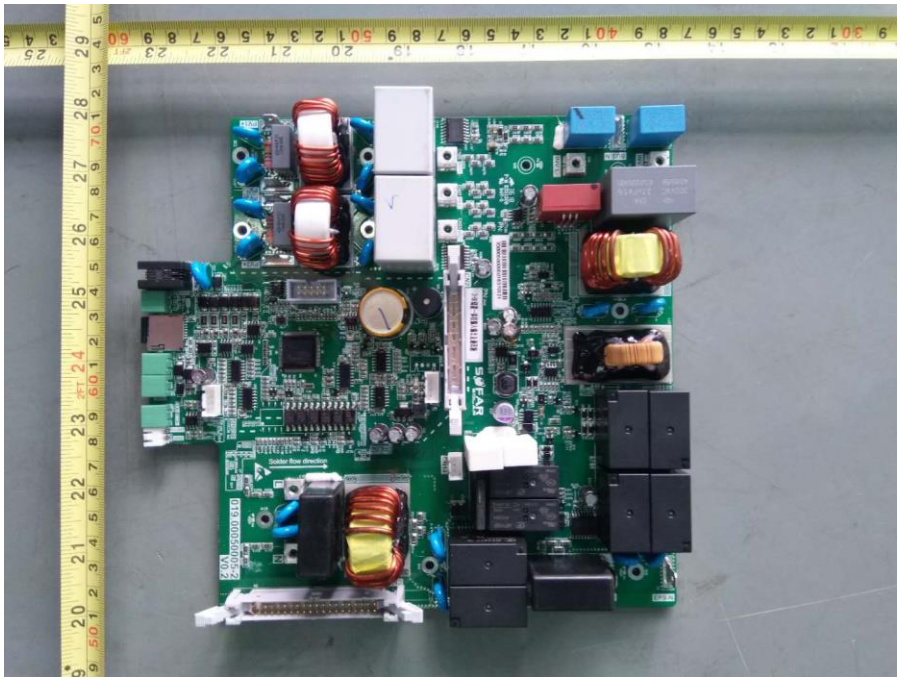
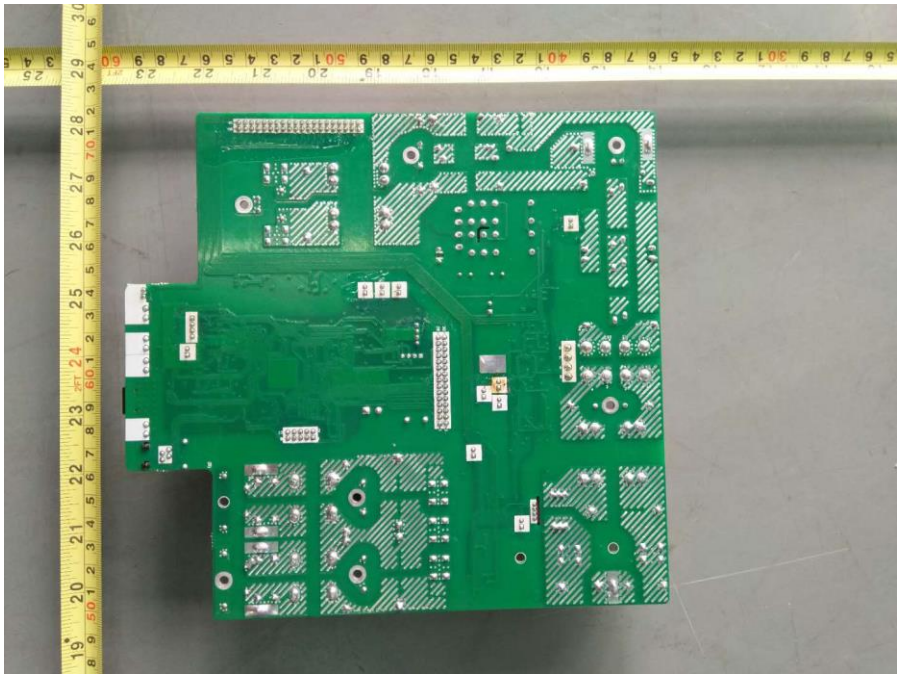


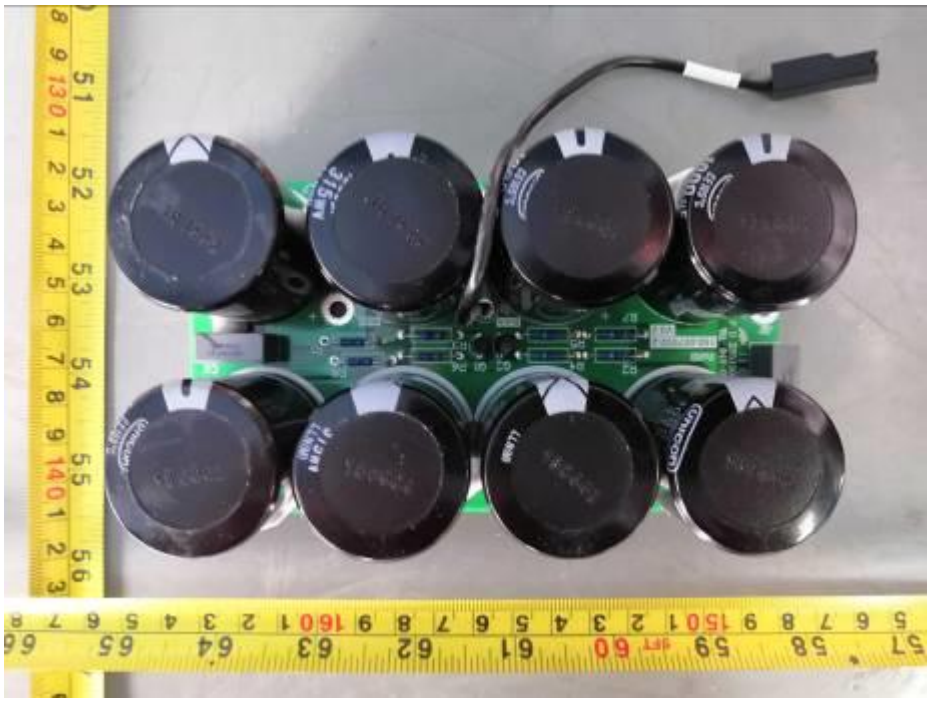
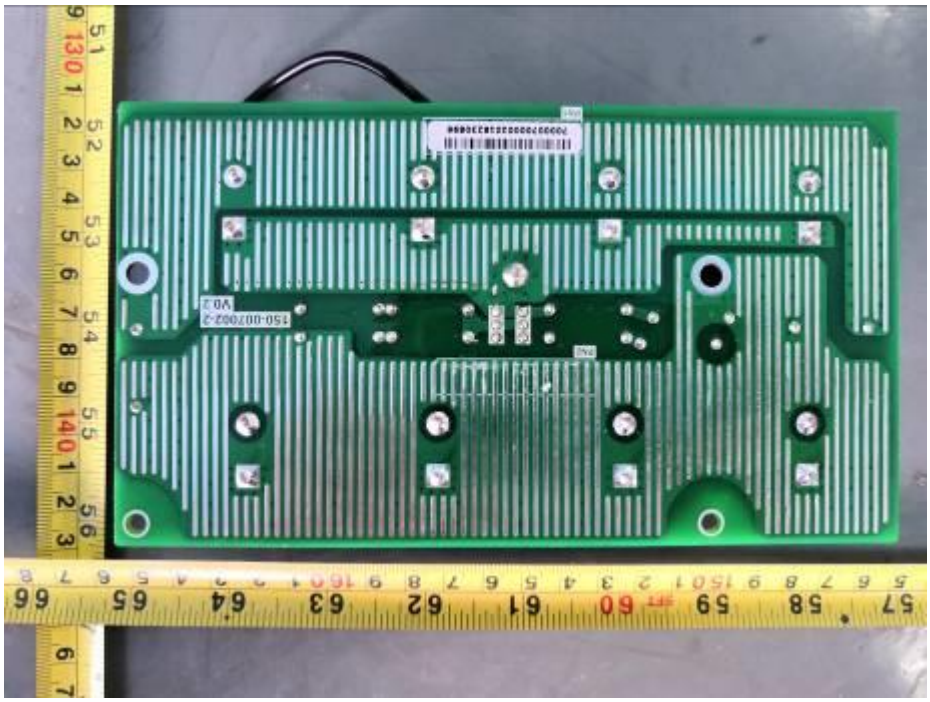
Internal View of Model HYD 3000-ES, HYD 3600-ES, HYD 4000-ES

Grounding

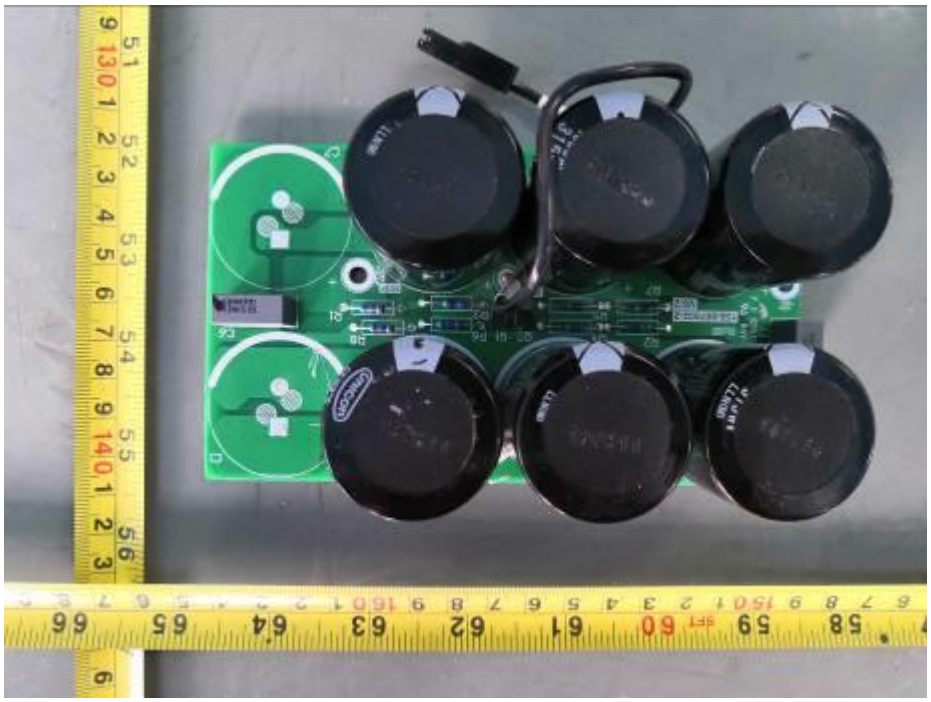
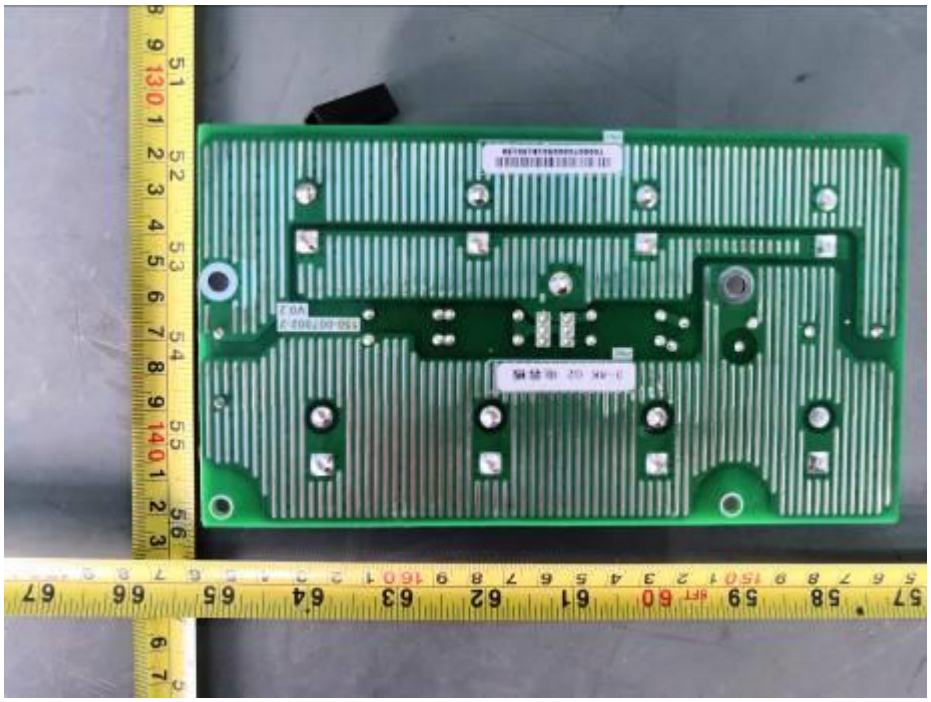

AC Ternimals

DC Ternimals


Front View of Power board

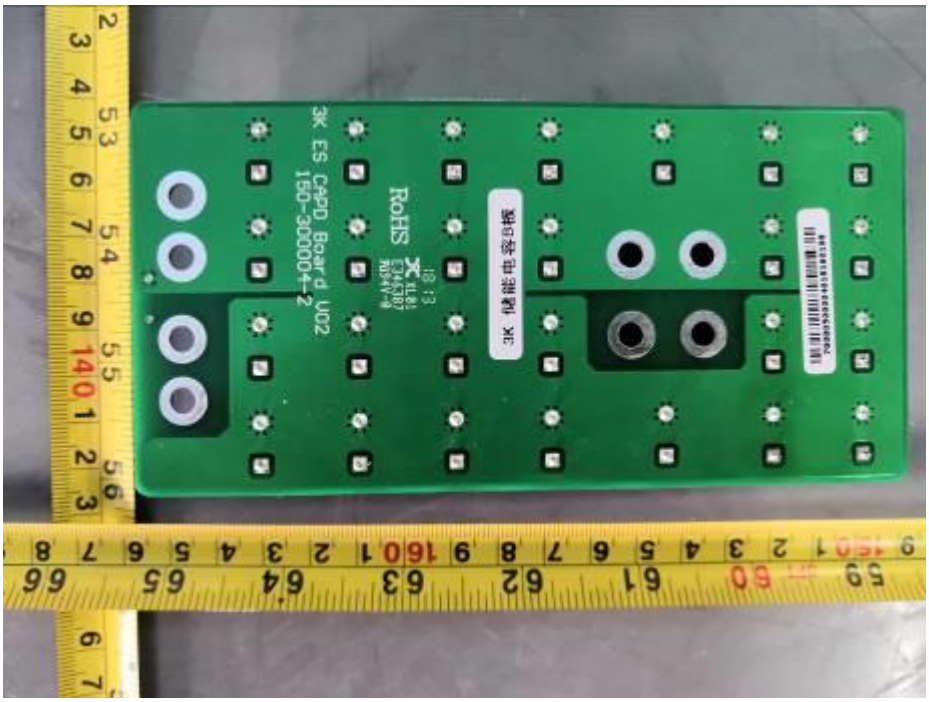
Back View of Power board


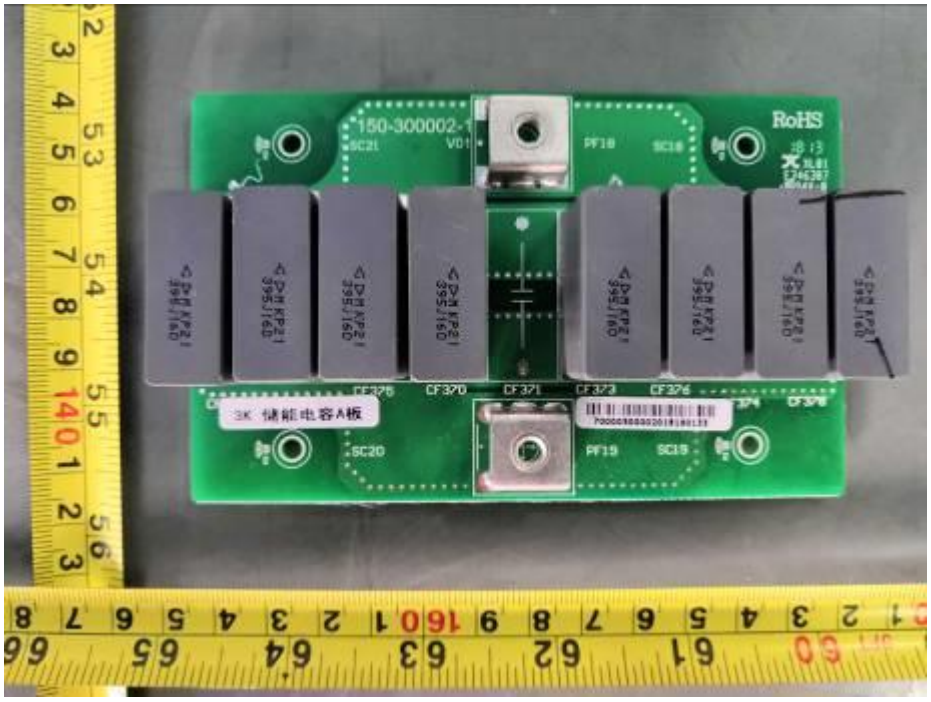
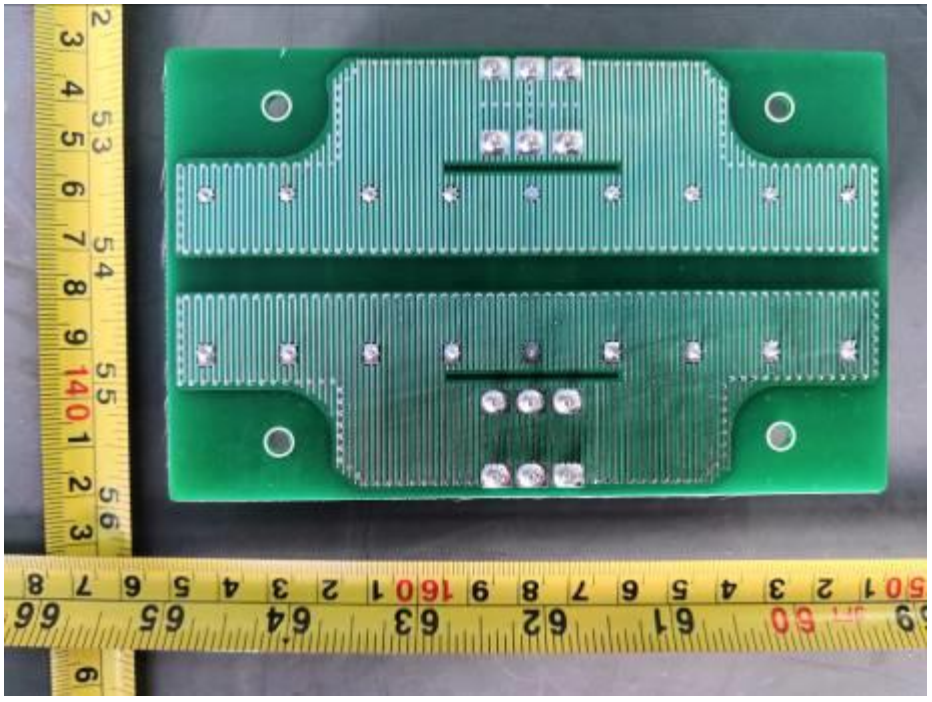
Front View of Input,output and communication board

Back View of Input,output and communication board


Front View of HYD 5000-ES, HYD 6000-ES Cap. board

Back View of HYD 5000-ES, HYD 6000-ES Cap. board


Front View of HYD 3000-ES, HYD 3600-ES, HYD 4000-ES Cap. board

Back View of HYD 3000-ES, HYD 3600-ES, HYD 4000-ES Cap. board


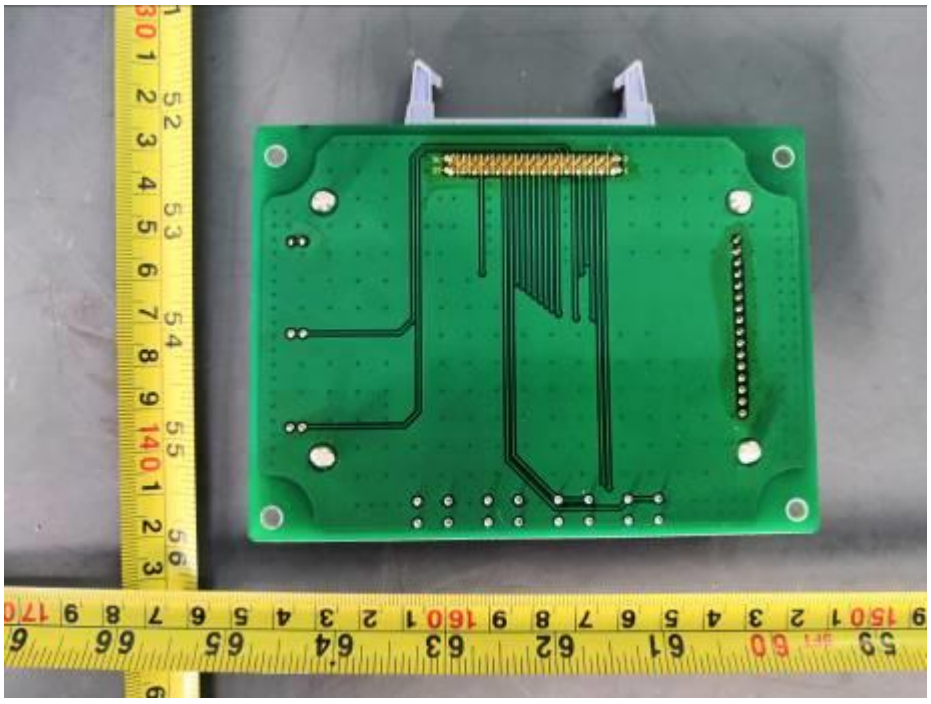
Front View of Cap board B

Back View of Cap board B


Front View of Cap board A

Back View of Cap board A


Front view of LED board

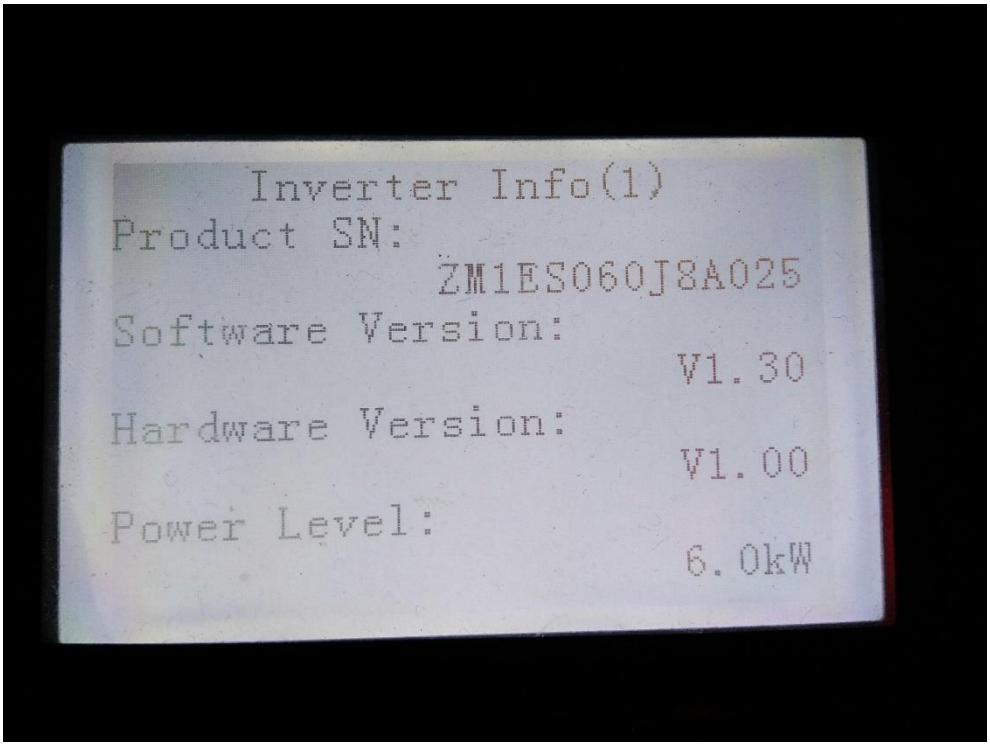
Back view of LED board



Front view of RS 232 board

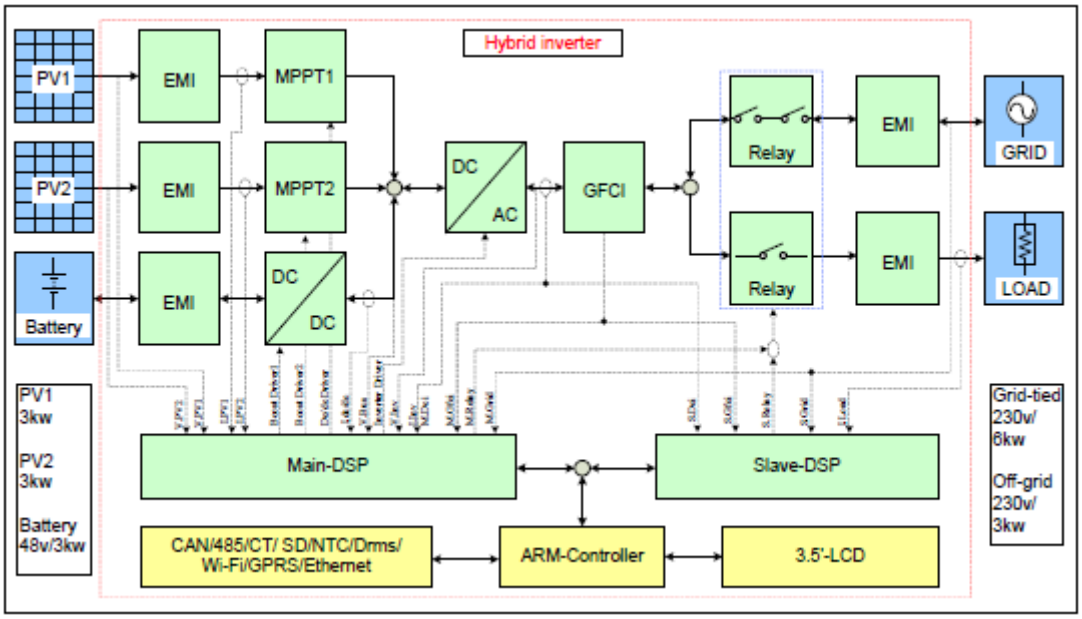
Back view of RS 232 board


Serial Number: ZM1ES060J8A025 and Software Version



6 ELECTRICAL SCHEME

Equipment under testing



----------END OF REPORT----------