TESTING FOR THE VERIFICATION OF COMPLIANCE OF GRID CONNECTED POWER CONVERSION SYSTEM WITH:

FGW TG3: DETERMINATION OF THE ELECTRICAL CHARACTERISTICS OF POWER GENERATING UNITS AND SYSTEMS, STORAGE SYSTEMSAS WELL FOR THEIR COMPONENTS IN MV, HV AND EHV GRIDS.

(REV. 25 DATED ON 01/09/2018 + SUPPLEMENT 1 DATED ON 22/01/2019)

Procedure: PE.T-LE-62

Test Report Number ....: **2219 / 0373 / E1 (*)**

(*)This test report cancels and supersedes test report n. 2219/0373, see Test Report Historical revision table on page 2.

Type ....: 3 Phase Grid Connected PV Inverter

Tested Model ....: **SUN2000-100KTL-M1**

Variant Models ....: SUN2000-100KTL-INM0

APPLICANT

Name ....: **Huawei Technologies Co., Ltd.**

Address ....: Huawei Industrial Park, Bantian, Longgang District
Shenzhen, Guangdong, 518129 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)

Reviewed and Approved by ....: Jacobo Tévar
(Technical Reviewer)

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

Date of issue ....: 2020/10/09

Number of pages ....: 200

Attachments and pages ....: Attachment (2219/0373-Att 1 Rev 0) including 345 pages

Number of pages ....: 545

Important Note:

- This document is issued by the Company under its General Conditions of service accessible at http://www.sgs.com/terms_and_conditions.htm. Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

- This document cannot be reproduced except in full, without prior written approval of the Company. Any unauthorized alteration, forgery or falsification of the content or appearance of this document is unlawful and offenders may be prosecuted to the fullest extent of the law.

- Unless otherwise stated the results shown in this test report refer only to the sample(s) tested as received. **Information of derived or extension models of the range as provided by the applicant, (if any), is included in this report only for informative purposes.** The Company SGS shall not be liable for any incorrect results arising from unclear, erroneous, incomplete, misleading or false information provided by Client.

Test Report Historical Revision:

Test Report Version	Date	Resume
2219 / 0373	2020/03/20	First issuance
2219 / 0373 / E1	2020/10/09	Add a new alternative rating plate on page 7. Clauses 4.1.2.1, 4.3.2, 4.3.3 and 4.3.4 have been modified for the inclusion of tests results considering maximum apparent power as rated. This has been included by petition of the customer to show evidence of behavior of the EUT at 110%Pn. Clause 4.5.1 have been modified to add new test of 51Hz according to VDE-AR-N 4120 requirements. Clause 4.1.4 and 4.5.2 have been modified for the correction of the gradient of power recovery within 0.33-0.66%Pn/s according to VDE-AR-N 4110 and VDE-AR-N 4120 requirements.

INDEX

1 SCOPE

SGS Tecnos, S.A. (Electrical Testing Laboratory) has been contract by Huawei Technologies Co., Ltd., in order to perform the testing according to FGW-TG3: Technical Guidelines for Power Generating Units and Systems. TG3 (Revision 25 Dated 01/09/2018 + Supplement 1 Dated 22/01/2019): Determination of Electrical Characteristics of Power Generating Units and Systems, Storage Systems as well for their Components in MV, HV and EHV grids.

The following standards are covered with testing of FGW-TG3 (Revision 25 Dated 01/09/2018) (*):

- VDE-AR-N 4110: 2018-11. Technical requirements for the connection and operation of customer installations to the medium voltage network (TAR medium voltage).
- VDE-AR-N 4120: 2018-11. Technical requirements for the connection and operation of customer installations to the high voltage network (TAR high voltage).

(*) As stated in chapter 11.2.1 of both covered standards.

2 GENERAL INFORMATION

2.1 TESTING PERIOD AND CLIMATIC CONDITIONS

The necessary testing has been performed along between November 18th of 2019 and March 5th of 2020 and between September 21th and September 28th of 2020.

All the tests and checks have been performed at climatic conditions:

Temperature	25 ± 10 ºC
Relative Humidity	50 ± 20 %
Pressure	90 ± 10 kPa

SITE TEST

Name...: Shanghai Huawei Technologies Co., Ltd.

Address ....: 901 Tanglu Road, Pudong - 201206 Shanghai (China)

2.2 EQUIPMENT UNDER TESTING

Apparatus type .... : **Grid-Connected PV Inverter**

Installation .... : 3 Phase ~ / Fixed installation

Manufacturer .... : Huawei Technologies Co., Ltd

Trade mark.. : HUAWEI

Model / Type reference .... : SUN2000-100KTL-M1

Serial Number .... : 6T19A9066325

Software Version... : V500R001

Validation Model Checksum .... : 82CDCCA8DF02BB7E83EEEDF3ED06CE01

Rated Characteristics.................................. : Input: 1100 $V_{dc,max}$ (200-1000 $V_{dc,MPPT}$); 10*26 A_{dc} Max
Output: 3~ 380/400/480Vac; 50 Hz;
380V: 152.0A_{ac}, 168.8A_{ac} Max, 100kW (110kVA Max).
400V: 144.4A_{ac}, 160.4A_{ac} Max, 100kW (110kVA Max).
480V: 120.3A_{ac}, 133.7A_{ac} Max, 100kW (110kVA Max).

Date of manufacturing: 2019

Test item particulars

Input .... : DC

Output .... 3 Phase(N) ~

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

Degree of protection against moisture .... : IP 66

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

Cooling group.. : Combined air cooling (Fans and heatsink)

Modular .... : No

Internal Transformer .... : No

Rating Plate:

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. There are two kinds of rating plate of Model SUN2000-100KTL-M1. The only difference is including the optional AFCI function or not.

Equipment under testing:

- **SUN2000-100KTL-M1**

The variants models are:

- **SUN2000-100KTL-INM0**

Models	SUN2000-100KTL-M1	SUN2000-100KTL-INM0
DC		
Input MPPT voltage range	200-1000 V	
Max. input voltage, open circuit	1100 V	
Max. input operating current	(10x) 26 A	
AC		
Maximum output apparent power	110 kVA	
Maximum output real power	100 kW	
Nominal output voltage	380/400 V (3 Ph / N / PE) 480 V (3 Ph / PE)	400/415 V (3 Ph / N / PE) 480 (3 Ph / PE)
Nominal frequency	50 Hz	
Rated output current with PF=1	152.0 A (380 V) 144.4 A (400 V) 120.3 A (480 V)	144.4 A (400 V) 139.2 A (415 V) 120.3 A (480 V)
Maximum output current	168.8 A (380 V) 160.4 A (400 V) 133.7 A (480 V)	160.4 A (400 V) 154.6 A (415 V) 133.7 A (480 V)

The variants models have been included in this test report without tests because the following features do not change regarding to the tested model:

- Same connection system and hardware topology
- Same control algorithm.
- Output power within 2 and 1/√10 of the EUT rated power or Modular inverters.
- 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 is used as the decimal separator.

2.2.1 Reference Values

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

Reference Values	
Rated power, **Pn** in kW	100
Rated apparent power, **Sn** in kVA	100
Maximum power, **Pn** in kW	110
Maximum apparent power, **Sn** in kVA	110
Rated wind speed (only WT), **vn** in m/s	Not applicable
Rated current (determined), **In** in A	144.4 (400V) and 120.3 (480V)
Rated output voltage, (phase to phase) **Un** in Vac	400 / 480
Note: In this report p.u. values are calculated as follows: -For Active & Reactive Power p.u values are reference to **Pn** -For Currents p.u values, the reference is always **In** -For Voltages p.u values, the reference is always **Un**	

Note: Only point 4.1.1 Active power peaks and point 4.3 System Perturbations were performed under 400V and 480V output voltage, other tests were only performed under 400V output voltage as representative.

2.3 TEST EQUIPMENT LIST

Equipment used between November 18th of 2019 and March 5th of 2020:

Owner	EQUIPMENT	MARK/MODEL	S/N	CALIBRATION DATE
HUAWEI	Wave Recorder	YOKOGAWA / DL850E	91U116322	2019/08/15 to 2020/08/14
	AC Current Probe	HIOKI / CT6863	140201351	2019/02/23 to 2020/02/22
	AC Current Probe	HIOKI / CT6863	140201344	2019/02/23 to 2020/02/22
	AC Current Probe	HIOKI / CT6863	140201347	2019/02/23 to 2020/02/22
	AC Current Probe	HIOKI / CT6865	120118226	2019/06/06 to 2020/06/05
	AC Current Probe	HIOKI / CT6865	120118228	2019/06/06 to 2020/06/05
	AC Current Probe	HIOKI / CT6865	120118229	2019/06/06 to 2020/06/05
	Power Analyzer	YOKOGAWA / WT3000	91J902079	2019/02/18 to 2020/02/17
	Power Analyzer	HIOKI / PW6001-06	151209243	2019/12/11 to 2020/12/10
	Power Analyzer	DEWETRON / DEWE2-A7	B4190044-CHN	2019/09/30 to 2020/09/29
	Temperature & Humidity meter	Elitech / GSP-6	JL1806022	2019/05/14 to 2020/05/13
SGS	Multimeter	Fluke / 289C	SHES500602	2019/07/03 to 2020/07/02
	Matlab function	SGS / RMS+POWER	DIE.001461-1	2019/02/15 to --
	Matlab function	SGS / VoltageChangeMeasures	DIE 001461-2	2019/02/15 to --
	Matlab function	SGS / Sequences	DIE 001461-3	2019/03/07 to --
	Matlab function	SGS / Static+MobileWindow	DIE 001461-4	2019/06/10 to --
	Matlab function	SGS / Parameter	DIE 001461-5	2019/02/14 to --
	Matlab function	SGS / Rise&SettlingTime	DIE 001461-6	2019/05/09 to --

Equipment used between September 21th and September 28th of 2020:

Owner	EQUIPMENT	MARK/MODEL	S/N	CALIBRATION DATE
HUAWEI	AC Current Probe	HIOKI / CT6865	120118228	2020/07/21 to 2021/07/20
	AC Current Probe	HIOKI / CT9555	170333301	2019/12/30 to 2020/12/29
	AC Current Probe	HIOKI / CT9555	170239123	2019/12/27 to 2020/12/26
	AC Current Probe	HIOKI / CT9555	170234315	2019/12/27 to 2020/12/26
	Power Analyzer	YOKOGAWA / WT3000	91J902079	2020/07/10 to 2021/07/09
	Power Analyzer	DEWETRON / DEWE2-A7	B4190044-CHN	2019/09/30 to 2020/09/29
	Temperature & Humidity meter	Elitech / GSP-6	JL1806022	2020/07/23 to 2021/07/22
SGS	Multimeter	Fluke / 289C	SHES500602	2020/06/12 to 2021/06/11

Note:
1. All measurement equipment was used inside their corresponding calibration period. Copy of all calibration certificates are available at the laboratory for reference.
2. Since those Matlab function are mathematical functions there is no need to establish a final calibration date.

2.4 MEASUREMENT UNCERTAINTY AND DATA SAMPLING RATES

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	±1º
Temperature	±3º C
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.	

Applicable to measurement and testing equipment (without current and voltage transformers). The following measurements uncertainties have been taken into account for the performance of the testing process:

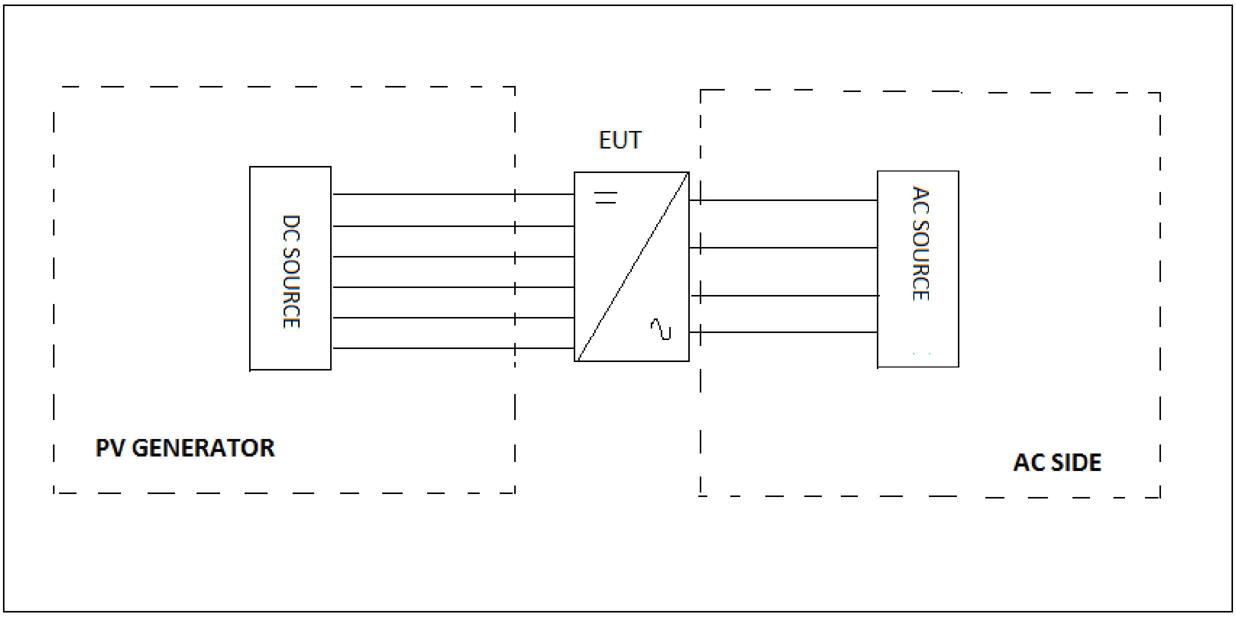
	Measurement uncertainty (K=2)
Voltage (Fundamental frequency)	≤ 0.5 % of Un
Current (Fundamental frequency)	≤ 0.5 % of In
Harmonic current up to 9 kHz	
≥ 0.1 % In	≤ 30 % relative to the measured value
< 0.1 % In	≤ 0.03 % of In
Setpoint signals	≤ 0.5 % of the reference variable (e.g 20 mA corresponding to Pn)
Flicker	≤ 5.8 % relative to Pst = 1
Grid protection	Specific voltage ≤ 0.5 % of Un
	Specific frequency ≤ 0.01 % of fn
Note: regarding flicker measurement uncertainty: IEC 61000-4-15 relates to a tolerance (accuracy) of <5%. Based on the assumption that the tolerance follows a rectangular distribution, the simple uncer-tainty is: (5%)/ √ 3= 2.89%. This results in an extended uncertainty at k=2 of 5.8%.	

Data sampling rates have been applied complying with the chapter 3.3 of the standard:

	Chapter of standard	Voltage, currents	Setpoint and actual value signals	External signals
Active power output	4.1	≥ 3 kHz	≥ 3 kHz	≥ 1 Hz
Reactive power provision	4.2	≥ 3 kHz	≥ 3 kHz	≥ 1 Hz
Switching operations, flicker	4.3.2, 4.3.3	≥ 3 kHz	- -	≥ 1 Hz
Harmonics	4.3.4	≥ 20 kHz	- -	≥ 1 Hz
PGU disconnection from the grid	0	≥ 10 kHz	- -	≥ 10 kHz
Verification of cut-in conditions	4.5	≥ 3 kHz	- -	≥ 1 Hz
Response during grid faults	4.6	≥ 10 kHz	- -	≥ 1 Hz

2.5 Test set up & Test Conditions

Below is the simplified construction of the test set up used in all test of this report.



Test Conditions		
Condition	**Value**	**Comments**
Point of measurement	EUT Output (Low Voltage)	Equipment enounced in section 2.3 of this report has been used in the point of measurement
Short circuit ratio at the measurement point (S_k /Sn)	20	--
If the PGU is connected directly to the medium-voltage grid and a step-up transformer is installed between the PGU and the grid (which is not part of the PGU), a standard transformer must be used, the rated apparent power of which corresponds at least to the rated apparent power of the PGU being evaluated.	All the tests have been performed measuring at the output of the PGU. No MV transformer used for the test measurments.	--
MV Tansformer: Short circuit Power	--	Not applicable measured in Low voltage side
MV Tansformer: Network impedance Phase Angle	--	Not applicable measured in Low voltage side
MV Tansformer: Service voltage Uc	--	Not applicable measured in Low voltage side
LV Isolation transformer: Nominal Power (kVA)	--	Not applicable measured in Low voltage side
LV Isolation transformer: Short circuit voltage U_k (%)	--	Not applicable measured in Low voltage side
LV Isolation transformer: Tap possition	--	Not applicable measured in Low voltage side
MV Side: Additional impedance	--	Not applicable measured in Low voltage side

Test Conditions		
Condition	**Value**	**Comments**
LV Side: Additional impedance	--	Not applicable measured in Low voltage side
The THDSU of the voltage which includes all integer harmonics up to the 50th order must be smaller than 5%. It is measured as the 10-minute mean at the PGU terminals while the PGU is not generating any power.	0.92% under 480Vac output 0.52% under 400Vac output	
The voltage, measured as a 10-minute mean at the PGU terminals, must lie within a range of ±10% of the rated voltage	Confirmed before tests.	
The voltage unbalance, measured as a 10-minute mean at the PGU terminals, must be less than 2%.	1.7% at 0%Pn 0.5% maximum at 10%Pn to 110%Pn (Refer point 4.3.4 for more details)	
The grid frequency, measured as a 0.2 second mean, must lie within a range of ±1% of the rated frequency around the rated frequency. The rate of change of the grid fre-quency, measured as a 0.2 second mean, must be smaller than 0.2% of the rated fre-quency per 0.2 seconds.	Confirmed before tests.	
Note 1: These test conditions have been used in all the test performed in Sections 4.1 to 4.7 of this report. Note 2: See also the test bench information table in this section		

Test bench used includes:

Test bench Equipment	Trademark / Model	Serial number / ID	Characteristics
DC Source	Keysight N8957APV	DE16391780	15 kW per unit, 1500 $V_{dc\text{-}max}$
		DE16391779	
		DE16391778	
		DE16321622	
		DE16321623	
		DE16341673	
		DE16341669	
		DE16341674	
AC Source	Ametek RS180-3PI	1751A02055	180kVA, 200-400A

Test bench requirements according to Annex D from the standard.

2.6 DEFINITIONS

EUT	Equipment Under Testing	W	Watt
A	Ampere	p.u.	Per unit
VAr	Volt-Ampere reactive	Pn	Nominal Active Power
Un	Nominal Voltage	P_{mom}	Instantaneous Active Power
In	Nominal Current	P_{ref}	P_{mom} in case of PV and Storage
MV	Medium Voltage	P_{10}	Active power as 10 s mean value
LV	Low Voltage	Qn	Nominal Reactive Power
LVRT	Low Voltage Ride Through	Sn	Nominal Apparent Power
V1+ / V_{AC+}	Voltage positive sequence	S_k	Symetrical Fault level
V1- / V_{AC-}	Voltage negative sequence	I_h	Harmonic Current
K_f (Ψ_k)	Flicker Form Factor	TDC	Total Demand Current Distortion
K_u (Ψ_k)	Voltage Variation Factor	TDD	Total Demand Distortion
P_{st}	Short-term flicker disturbance factor	$THDS_U$	Subgroup Total Harmonic Distortion
PGU	Power Genaration Unit	Ui	Current Imbalance
Hz	Hertz	Uv	Voltage Imbalance
V	Volt	I+	Current Positive Sequence
		I1-	Current Negative Sequence

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

VDE-AR-N 4120 SECTION	VDE-AR-N 4110 SECTION	FGW TG3 SECTION	CHAPTER OF THE STANDARD FGW-TG3	RESULT
--	**--**	**4.1**	**Active Power Output**	**P**
11.2.7	11.2.7	4.1.1	Active power peaks	P
10.2.4.1 10.2.4.2 11.2.7	10.2.4.1 10.2.4.2 11.2.7	4.1.2	Operating power limited by grid operator	P
10.2.4.3 11.2.8	10.2.4.3 11.2.8	4.1.3	Active power feed-in as a function of grid frequency	P
10.2.4. 11.2.11	10.2.4. 11.2.11	4.1.4	Active power gradient following disconnection from the grid	P
--	**--**	**4.2**	**Reactive Power Provision**	**P**
10.2.2.4 11.2.4	10.2.2.4 11.2.4	4.2.1	Reactive power response in the normal operating mode (Q=0 kVAr)	P
10.2.2.4 11.2.4	10.2.2.4 11.2.4	4.2.2	Measuring the maximum reactive power range (PQ Diagram)	P
10.2.2 11.2.4	10.2.2 11.2.4	4.2.3	Measuring separate operating points in the voltage-dependent PQ diagram	P
10.2.2.4 11.2.4	10.2.2.4 11.2.4	4.2.4	Reactive power following setpoints	P
10.2.2.4 11.2.4	10.2.2.4 11.2.4	4.2.5	Q (U) control	P
--	10.2.2.4 11.2.4	4.2.6	Q (P) Control	P
10.2.2.4 11.2.4	10.2.2.4 11.2.4	4.2.7	Reactive Power Q with voltage Limitation Function.	P
--	**--**	**4.3**	**System Perturbations**	**P**
--	--	4.3.1	General procedures	P
5.4.2 11.2.2.1	5.4.2 11.2.2.1	4.3.2	Switching operations	P
5.4.3 11.2.2.2	5.4.3 11.2.2.2	4.3.3	Flickers	P
5.4.4 11.2.2.3	5.4.4 11.2.2.3	4.3.4	Harmonics	P
5.4.6 11.2.2.5	5.4.6 11.2.2.5	4.3.5	Unbalances of the current	P
10.3.4.1 10.3.4.2 10.3.4.3 10.3.4.7 11.2.10	10.3.3.1 10.3.3.2 10.3.3.3 10.3.4.2.2 11.2.10	**4.4**	**PGU disconnection from the grid**	**P**
--	**--**	**4.5**	**Verification of connection conditions**	**P**
10.4.1 11.2.11	10.4.1 11.2.11	4.5.1	Connection without previous protection trigger	P
10.4.2 11.2.11	10.4.2 11.2.11	4.5.2	Connection after triggering of the uncoupling protection	P

VDE-AR-N 4120 SECTION	VDE-AR-N 4110 SECTION	FGW TG3 SECTION	CHAPTER OF THE STANDARD FGW-TG3	RESULT
10.2.3 **11.2.5**	**10.2.3** **11.2.5**	**4.6**	**Response during grid faults (FRT)**	**P(*)**
--	**10.2.1.2** **11.2.3**	**4.7**	**Verification of the working range with regard to voltage and frequency**	**P**

(*) Results are shown in Attachment I -2219 / 0373-Att1 Rev0 of this test report. The Attachment I -2219 / 0373-Att1 Rev0 has to be considered together with this report.

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

4 TEST RESULTS

4.1 ACTIVE POWER OUTPUT

4.1.1 Active power peaks

The aim of the test is to determine the maximum active power peaks from different averaging intervals.

The active power in the output will be measured in function of the DC input voltage applied. In this way, the DC input voltage is increased in steps, or continuously, from the minimum value of the MPPT range up until the EUT limits active power or the maximum value of the MPPT is reached. This method applies not only for PV, but also for Storage equipment.
The point of maximum active power is adopted at least twice.

The reactive power setpoint prior to the test was set to Q=0, and was maintained during the whole test.

The test has been performed following the testing method detailed in the point 4.1.1 of the reference standard, maximum values of injected active power by the EUT for averaging times of 0.2 s; 60 s and 600 s.

Used settings of the measurement device for this active power peaks testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/01/22	100 ms values	3 kHz

Test results under 400Vac output voltage are offered in the following table:

DC Voltage (V)	Active power peaks (kW)			Normalized active power peaks (p.u.)			No. of used 600 seconds records		
	$P_{0.2}$	P_{60}	P_{600}	$p_{0.2}$	P_{60}	P_{600}	$P_{0.2}$	P_{60}	P_{600}
537	110.2	110.3	110.3	1.102	1.103	1.103	10	10	10
566	110.4	110.4	110.3	1.104	1.104	1.103			
600	110.0	109.9	109.9	1.100	1.099	1.099			
630	109.9	109.8	109.8	1.099	1.098	1.098			
660	110.0	110.0	110.0	1.100	1.100	1.100			
690	110.0	110.0	110.0	1.100	1.100	1.100			
720	110.0	110.0	110.0	1.100	1.100	1.100			
748	110.0	110.0	110.0	1.100	1.100	1.100			
778	110.0	110.0	109.9	1.100	1.100	1.099			
800	110.0	109.9	109.8	1.100	1.099	1.098			

Note: Under 400Vac output voltage, the MPPT range of full power is from 540V to 800V (full MPPT range is from 200V to 1000V).

The Reactive Power prior to start the test was set to a setpoint of Q=0, this value was maintained during the whole test.

Reactive Power Measured (p.u.)	0.015

Test results under 480Vac output voltage are offered in the following table:

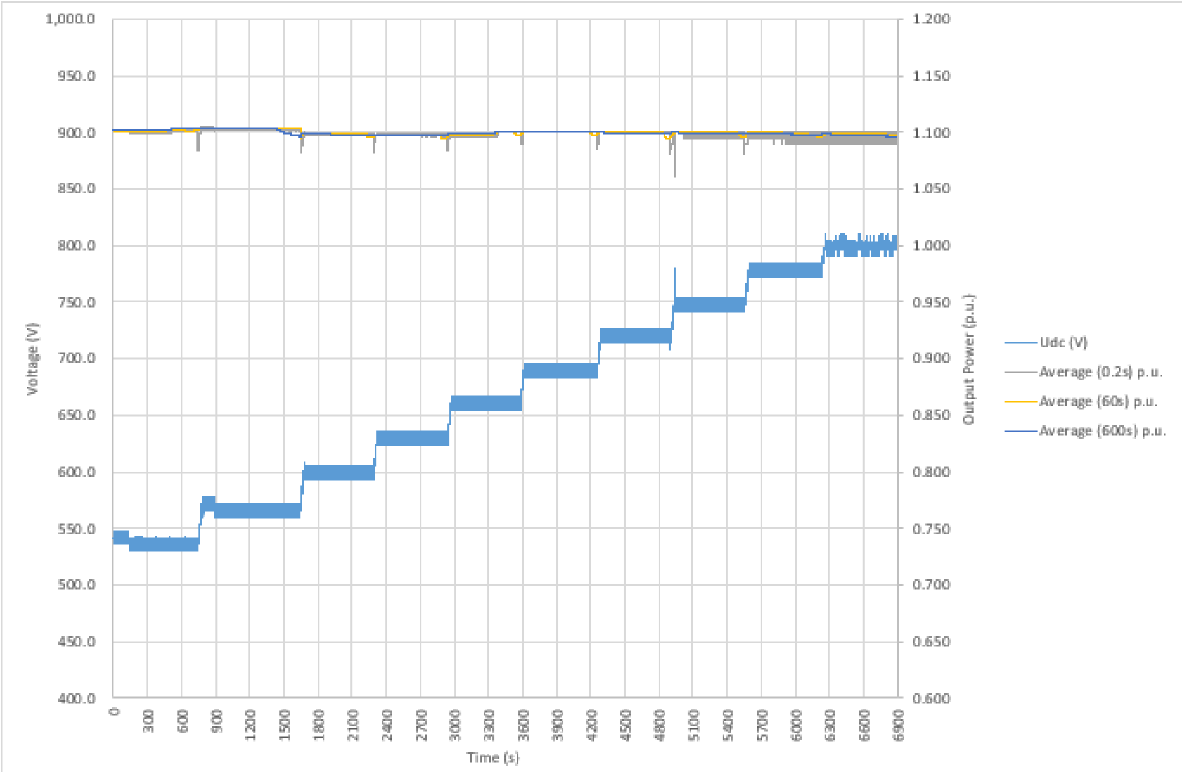
DC Voltage (V)	Active power peaks (kW)			Normalized active power peaks (p.u.)			No. of used 600 seconds records		
	$P_{0.2}$	P_{60}	P_{600}	$p_{0.2}$	P_{60}	P_{600}	$P_{0.2}$	P_{60}	P_{600}
625	110.4	110.1	110.1	1.104	1.101	1.101	10	10	10
646	110.2	110.1	110.2	1.102	1.101	1.102			
667	110.3	110.3	110.3	1.103	1.103	1.103			
691	110.4	110.8	110.8	1.104	1.108	1.108			
715	111.0	110.9	110.9	1.110	1.109	1.109			
739	110.9	110.8	110.8	1.109	1.108	1.108			
763	110.9	110.8	110.8	1.109	1.108	1.108			
783	110.9	110.7	110.7	1.109	1.107	1.107			
806	110.9	110.7	110.7	1.109	1.107	1.107			
830	110.8	110.7	110.7	1.108	1.107	1.107			
848	110.8	110.7	110.7	1.108	1.107	1.107			

Note: Under 480Vac output voltage, the MPPT range of full power is from 625V to 850V (full MPPT range is from 200V to 1000V).

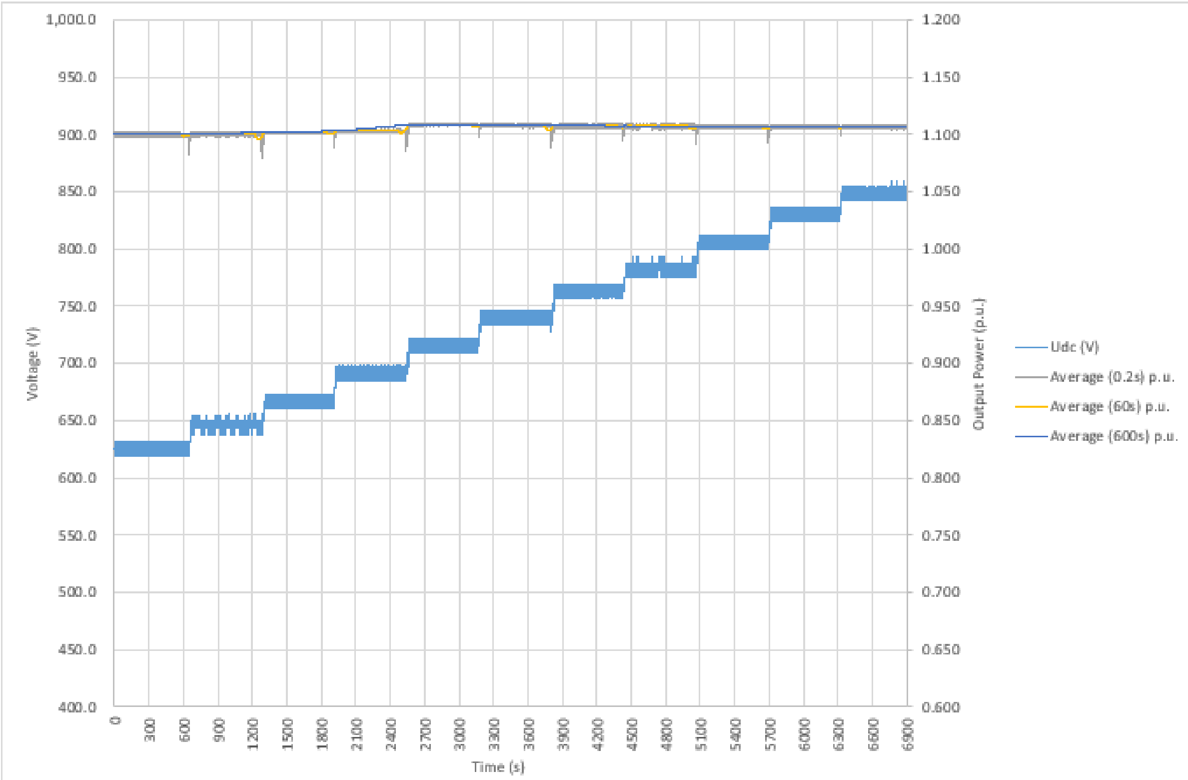
The Reactive Power prior to start the test was set to a setpoint of Q=0, this value was maintained during the whole test.

Reactive Power Measured (p.u.)	0.004

Active Power Peaks – 400Vac output



Active Power Peaks – 480Vac output



4.1.2 Operating power limited by grid operator

The aim of the test is to determine how fast (Settling time) and how precisely (setting accuracy) the PGU can follow an active power setpoint input, e.g. from a grid operator. Additionally, the capacity of following a setpoint with a specific gradient is to be tested.

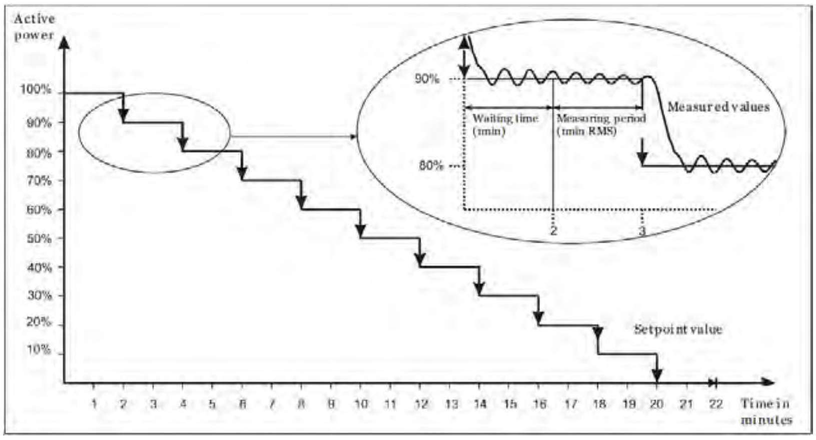
Interface information	
Interface used	RS485
Interface version used	SmartLogger V200R002
Other interfaces in the equipment	SUN 2000APP:3.2.00.002
Name or code of the parameter for active power setting	Active Power Control
If the EUT has several different interfaces for defining the setpoint, it has been tested the interface returning the most unfavourable results according to the manufacturer information.	

4.1.2.1 Active Power setting accuracy

This test has been performed according to the point 4.1.2.2 of the standard.

Test procedure applied consist on active output power reductions in steps of 10% Pn from 110% Pn to 0% Pn. During these reduction steps there was no disconnection of the generating unit.

Between each power step, the EUT has a maximum of 1 minute to adjust to the new setpoint. After this, measurements of the setpoint are taken as 1-minute mean values as stated in the image represented below.



The active power and the reactive power have been represented in the positive phase sequence system and as 200 ms means for every setpoint step.

Measurement equipment settings used for this tes are shown in the following table:

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/09/28	50 ms values	3 kHz

The table below shows measured values:

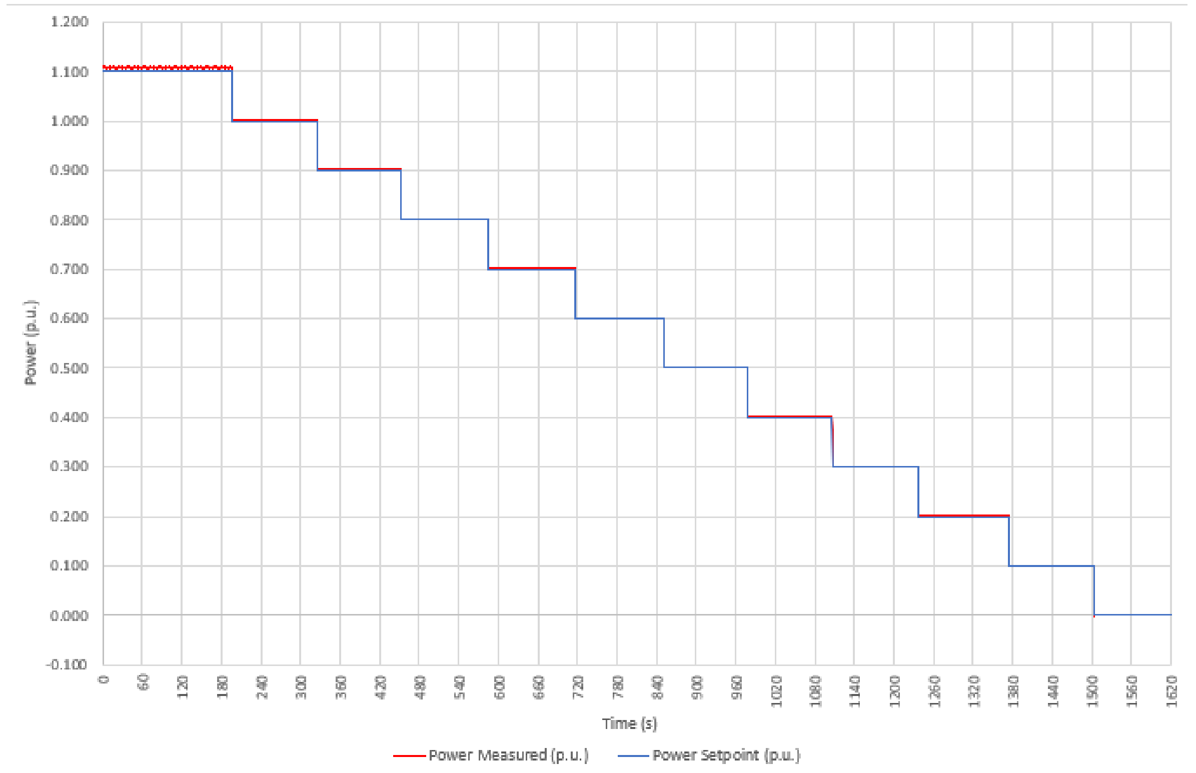
Active Power step ($\%P_n$)	Setpoint value		Actual value		Deviation	
	(kW)	(%Pn)	(kW)	($\%P_n$)	(kW)	($\%P_n$)
110.0	110.000	110.0	110.843	110.8	0.843	0.8
100.0	100.000	100.0	100.321	100.3	0.321	0.3
90.0	90.000	90.0	90.159	90.2	0.159	0.2
80.0	80.000	80.0	80.197	80.2	0.197	0.2
70.0	70.000	70.0	70.128	70.1	0.128	0.1
60.0	60.000	60.0	60.072	60.1	0.072	0.1
50.0	50.000	50.0	50.056	50.1	0.056	0.1
40.0	40.000	40.0	40.122	40.1	0.122	0.1
30.0	30.000	30.0	30.162	30.2	0.162	0.2
20.0	20.000	20.0	20.095	20.1	0.095	0.1
10.0	10.000	10.0	10.025	10.0	0.025	0.0
0.0	0.000	0.0	0.064	0.1	0.064	0.1

- Values above detailed are obtained as 1-minute mean after 1 minute since the setpoint was adjusted to the required active power step.

Maximum active power above the defined setpoint (1-minute mean)	0.8%Pn
Maximum active power below the defined setpoint (1-minute mean)	0.0%Pn

In the following graph, test results are represented after the test has been performed:

Output power reduction by steps (110 % to 0% Pn)



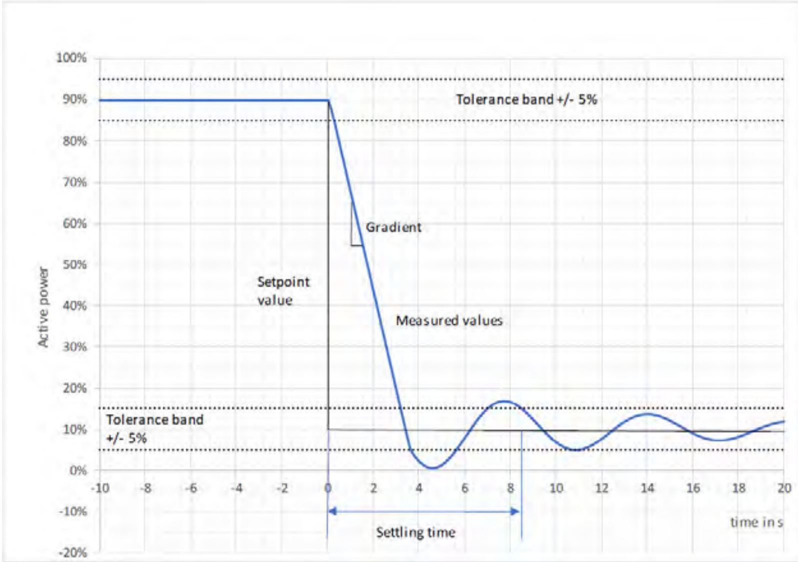
4.1.2.2 Active Power settling time and active power gradient.

This test has been performed according to the point 4.1.2.2 of the standard for settling time and active power gradient.

Two tests have been done in order to determine both the maximum and the minimum active power gradient. The evidence for the maximum active power gradient has to be provided by a step from 90% P_n to P_{min}, whereas, for the minimum active power gradient, this step has to be from 70% P_n to 50% P_n. Settling time and gradient measurements have been taken in the range of 65%P_n and 55%P_n.

Both tests have been repeated testing these steps in the opposite direction.

The settling times for the maximum active power gradients have been measured taking into account the tolerance band of ± 5% P_n as shown in the following image:



The active power and the reactive power have been represented in the positive phase sequence system and as 200 ms means for every setpoint step.

Used settings of the measurement device for Active Power settling time test.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/21	100 ms values	3 kHz

EUT Settings	
Maximum Active Power Gradient (%Pn/s)	0.66
Minimum Active Power Gradient (%Pn/s)	0.33
Operanting mode	Active power priority
Active control modes	Active power control LVRT mode

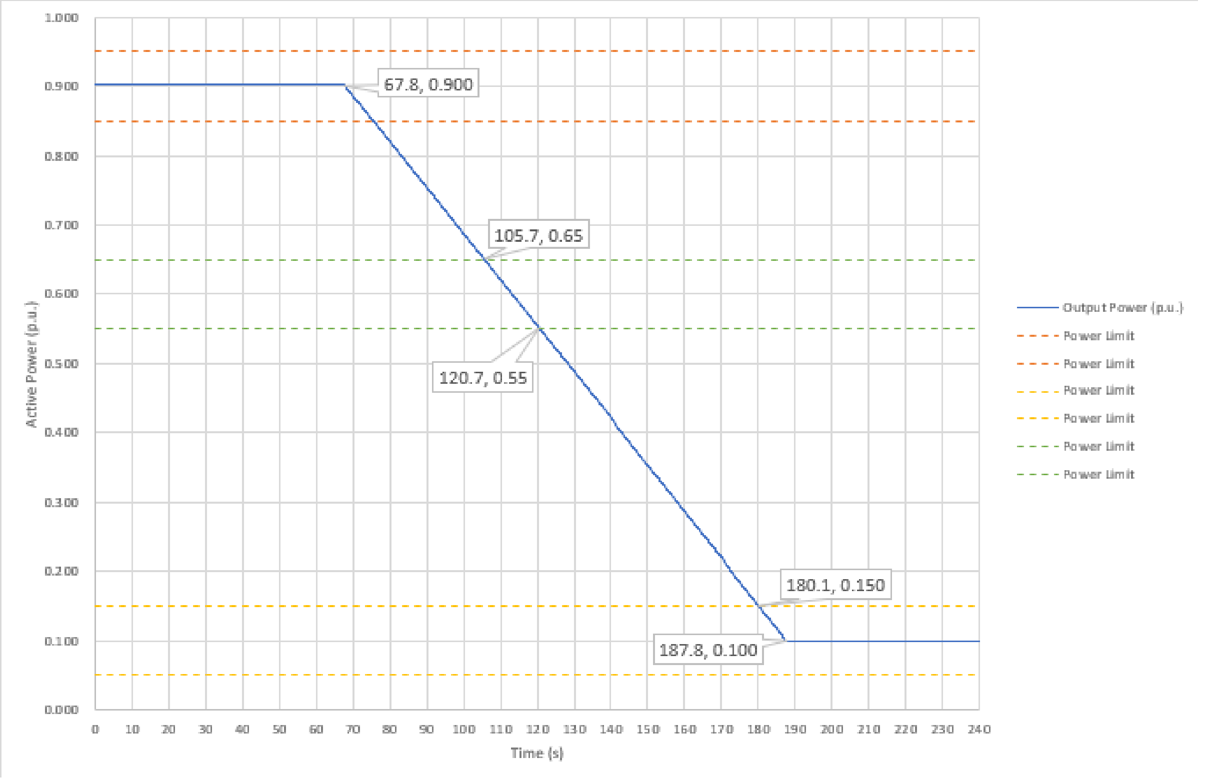
The table below shows measured values:

Test at maximum power gradient		
Active Power step (Setpoint)	**Settling time measured (s)**	**Gradient measured (%Pn/s)**
90.0% to 10.0% Pn	112.3	0.67
10.0% to 90.0% Pn	111.5	0.67
Note: 10% has been used as Pmin for testing purposes (Type 2 PGU). Pmin that can be configured is 0 %Pn. The Gradient were measured for the range 65% Pn and 55% Pn.		

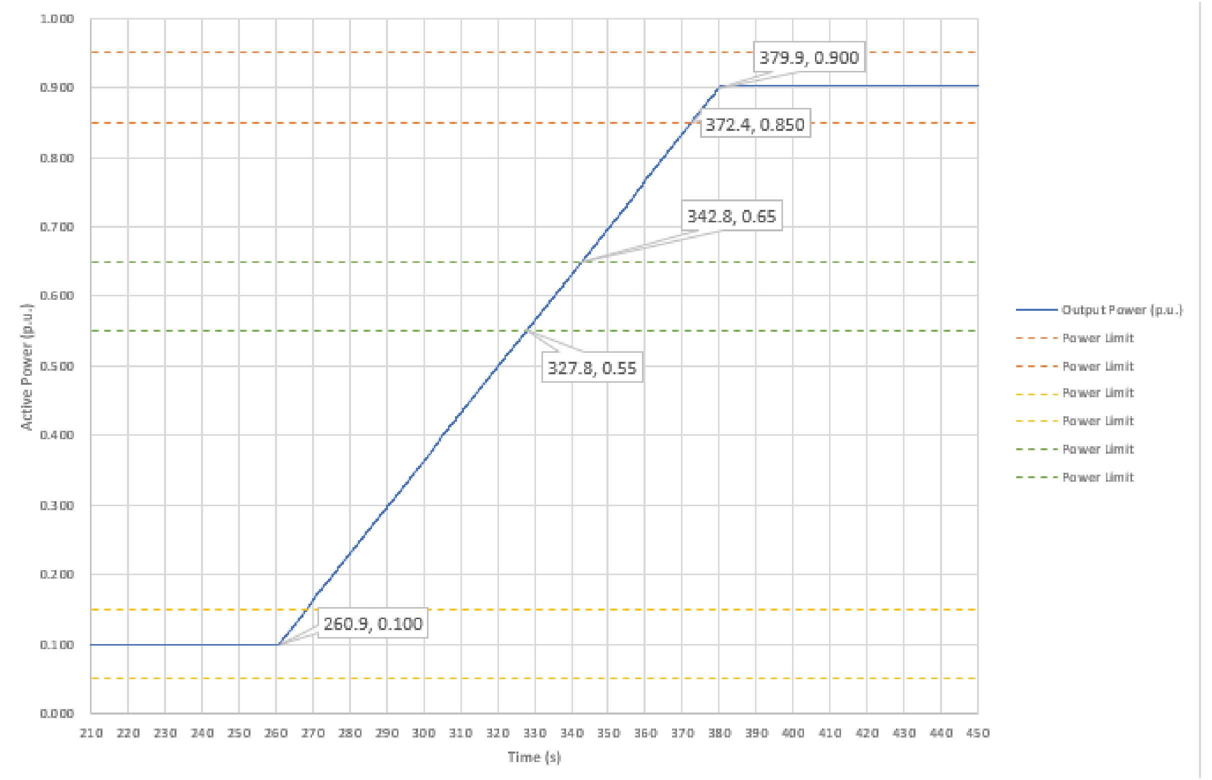
Test at minimum power gradient		
Active Power step (Setpoint)	**Settling time measured (s)**	**Gradient measured (%Pn/s)**
70.0% to 50.0% Pn	45.5	0.33
50.0% to 70.0% Pn	44.6	0.33
Note: 10% has been used as Pmin for testing purposes (Type 2 PGU). Pmin that can be configured is 0 %Pn. The Gradient were measured for the range 65% Pn and 55% Pn.		

The following charts shows the gradient and the settling time:

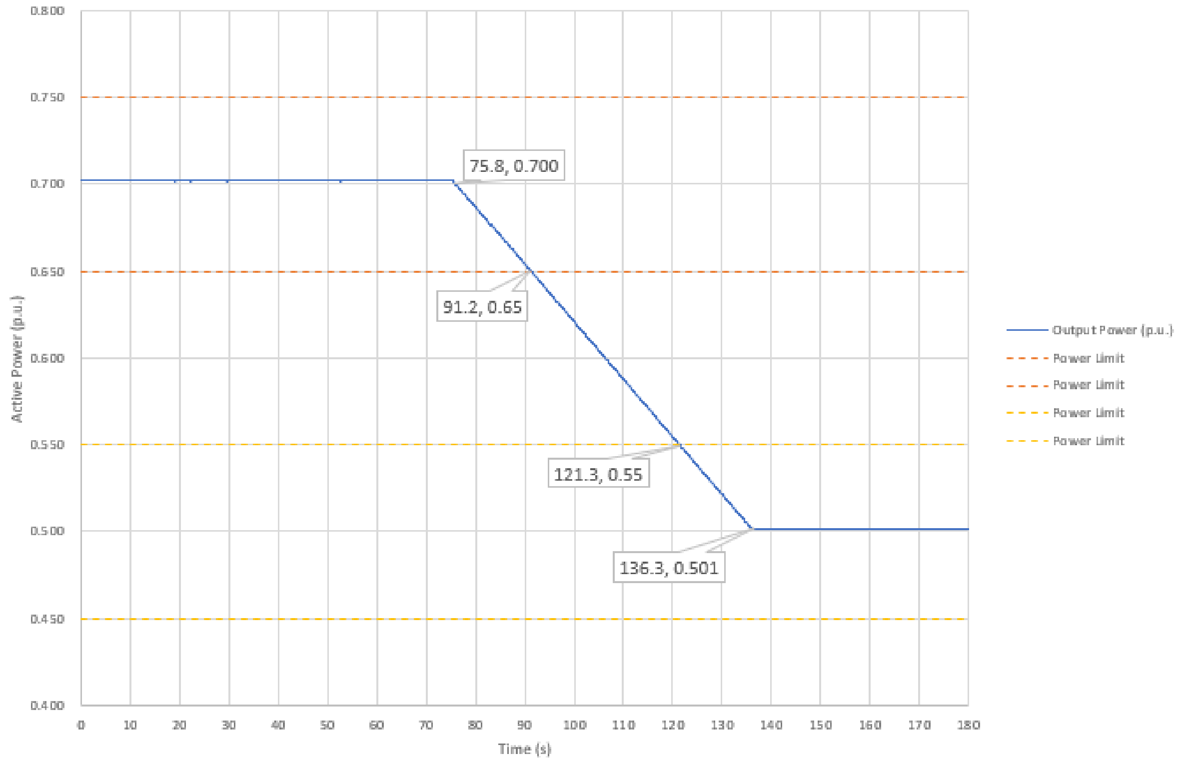
Output power reduction (90% to 10% of Pn) – 0.66%%Pn/s



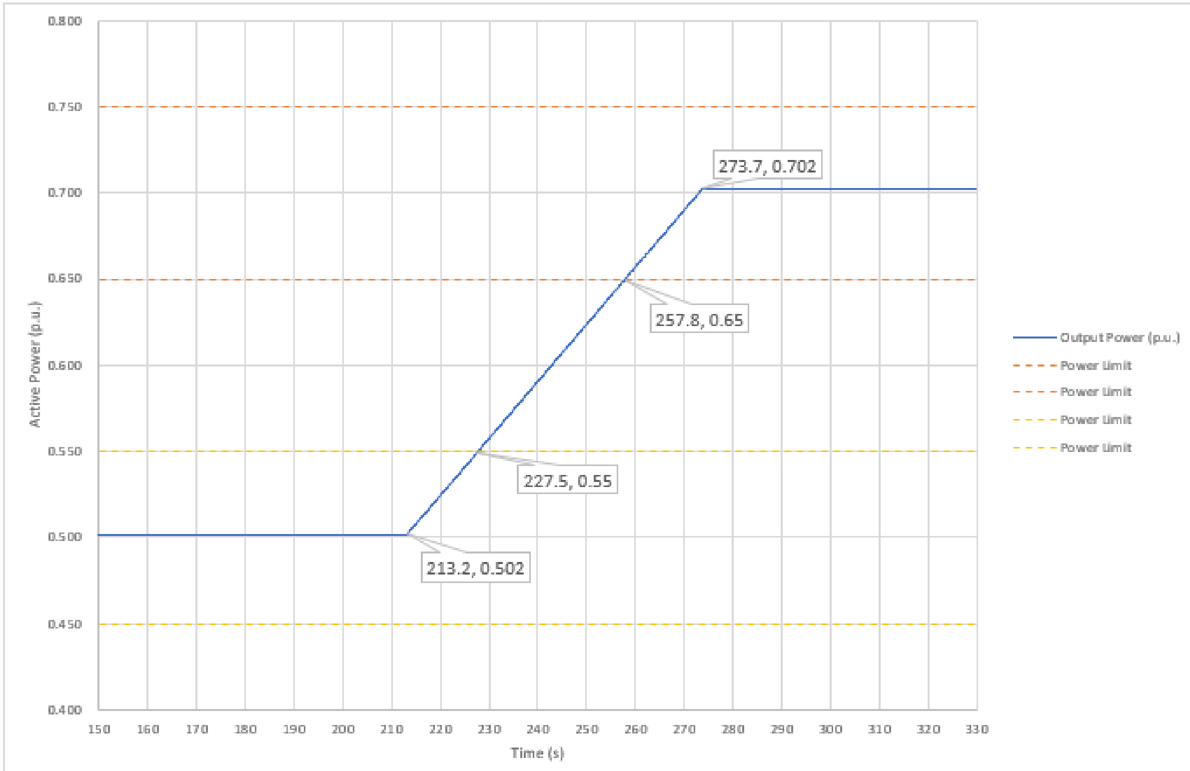
Output power increase (10% to 90% of Pn) – 0.66%%Pn/s



Output power reduction (70% to 50% of Pn) – 0.33%%Pn/s



Output power increase (50% to 70% of Pn) – 0.33%%Pn/s



4.1.3 Active Power feed-in as a function of grid frequency

The aim of the test is to demonstrate the response of the EUT due to a deviation in grid frequency from rated value in terms of speed (rise/settling time) and the active power gradient.

This test has been performed according to the point 4.1.3.1 of the standard, changing the parameters in the PGU control system. The following figure has been performed.

Two tests have been done for both over and underfrequency tests:

- Overfrequency test (LFSM-O): According to chapter 4.1.3.1.a).
- Underfrequency test (LFSM-U): According to chapter 4.1.3.1.b).

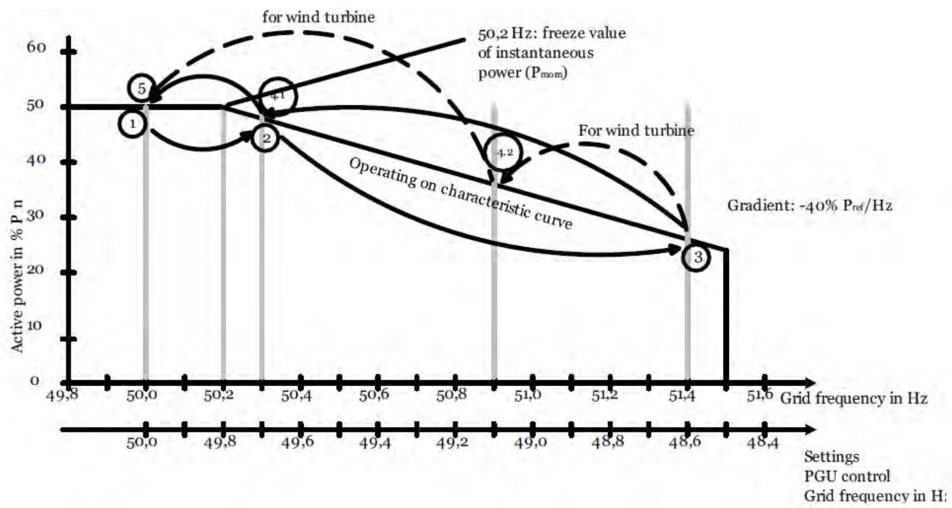
Testing Method Used (LFSM-O & LFSM-U)		Comments
Changing parameters in the PGU control system	☐	
Signal input to control system	☐	
Grid simulator	☒	Changed Grid simulator frequency and recorded the Unit output.
Alternative procedures	☐	

4.1.3.1 Overfrequency (LFSM-O)

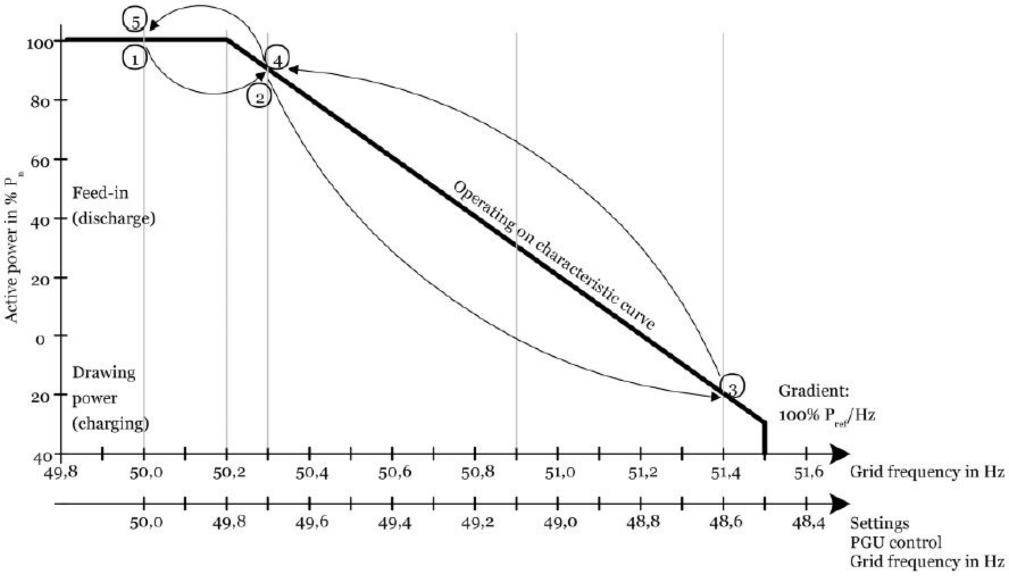
For this test. power reduction has been applied with a gradient of -40% P_{ref}/Hz in the range of 50.2 Hz to 51.5 Hz. Once the grid frequency falls below the 50.2 Hz threshold. the active power recuperation must be with a maximum gradient of 10%P_n/min.

For the test, at the beginning, active power was set over 100%Pn and, before the power reduction started, active power was reduced to a 50%Pn through a setpoint.

Frequency values must be inside next ranges (referred to the points on the figure):



Frequency values must be inside next ranges (referred to the points on the figure):



Frequency Step	Simulated grid frequencies	Note
1	50.00 Hz ± 0.05 Hz	--
2	50.30 Hz ± 0.05 Hz	--
3	51.40 Hz ± 0.05 Hz	Verification of adherence to characteristic
4	50.30 Hz ± 0.05 Hz	
5	50.00 Hz ± 0.05 Hz	Power increase to the maximum possible active power with a maximum gradient P(t) of 10%Pn/min

Starting at P_{ref}, it has been performed the frequency steps that can be seen on the table above, taking measures of the active power at every set point of frequency. Every point has a measured duration of 30 seconds at least.

Gradient has been calculated as follows:

$$\frac{\Delta P}{\Delta f} = \frac{P_{Step\ i+1} - P_{Step\ i}}{|f_{Step\ i+1} - f_{Step\ i}|}$$

$P_{Step\ i+1}$ 10-s-mean of the active power which is calculated at the end of frequency step i+1.
$P_{Step\ i}$ 10-s-mean of the active power which is calculated at the end of frequency step i.
$f_{Step\ i+1}$ 10-s-mean of the grid frequency, at which PStep i+1 is determined.
$f_{Step\ i}$ 10-s-mean of the grid frequency, at which PStep i is determined.

To determine the rise and settling times, a tolerance band of ± 5% of Pn is applied around the controlled active power end value.

Used settings of the measurement device for this power limitation for an increase in grid frequency testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/01/22	200 ms values	3 kHz

The tables below show measured values:

a) Accuracy results

LSFM-O					
Step	**Simulated grid frequency (Hz)**	**Measured grid frequency (Hz)**	**Normalized Active Power *Setpoint* (P/Pn)**	**Normalized Active Power *Measured* (P/Pn)**	**Active power gradient P(f) relative to the reference frequency**
1	50.00 ± 0.01	50.00	0.500	0.501	-------
Reference frequency and for Type 2 determination of P_{mom} (*)	Change from 50.00 to 50.30	50.20	-------	---------	-------
2	50.30 ± 0.05	50.30	0.480	0.480	-------
3	51.40 ± 0.05	51.40	0.260	0.260	40.0% P_{ref}/Hz
4	50.30 ± 0.05	50.30	0.480	0.480	40.0% P_{ref}/Hz
5	50.00 ± 0.05	50.00	1.000	1.007	-------
(*): As the EUT is Type 2, according to the standard **Pmom = Pref** is defined as the mean value of the active power immediately prior to frequency transition at 50.2 Hz. Here, the manufacturer specifies the averaging time 200 ms.					

ΔP/Δf	
Mean active power gradient while frequency limit is exceeded	40.0 % P_{ref}/Hz
Defined active power gradient ΔP/Δf	40.0 % P_{ref}/Hz

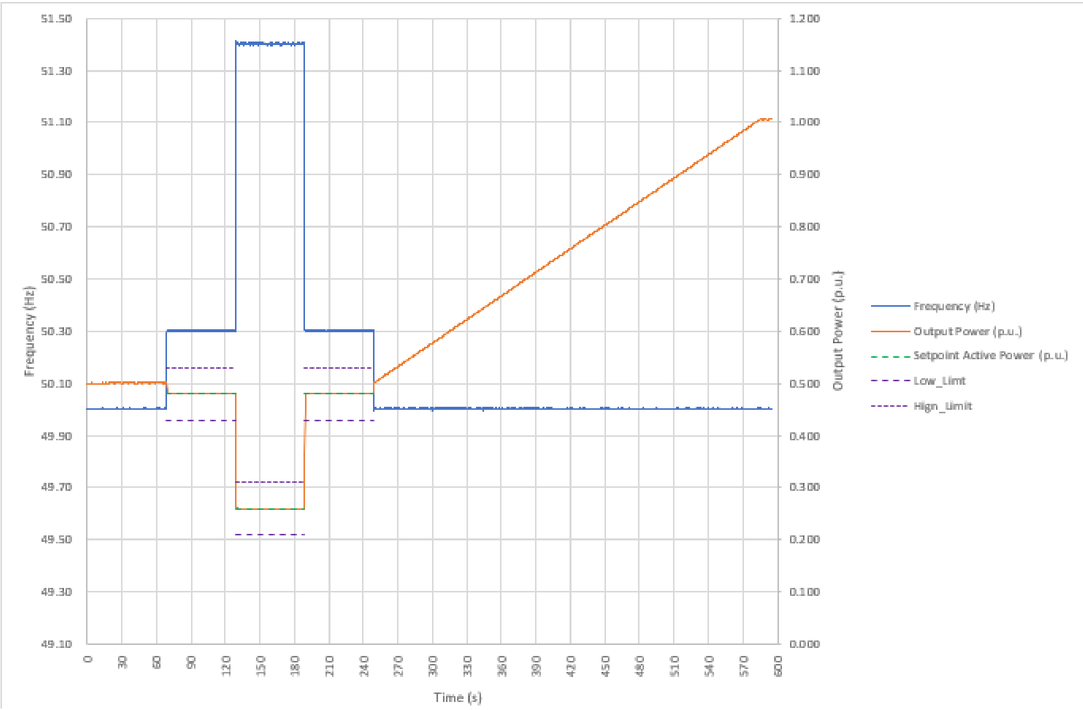
b) Settling time and Rise time results

Frequency step	Rise Time (s)	Settling time (s)
Step 2 → Step 3	0.6	0.6
Step 3 → Step 4	0.6	0.6

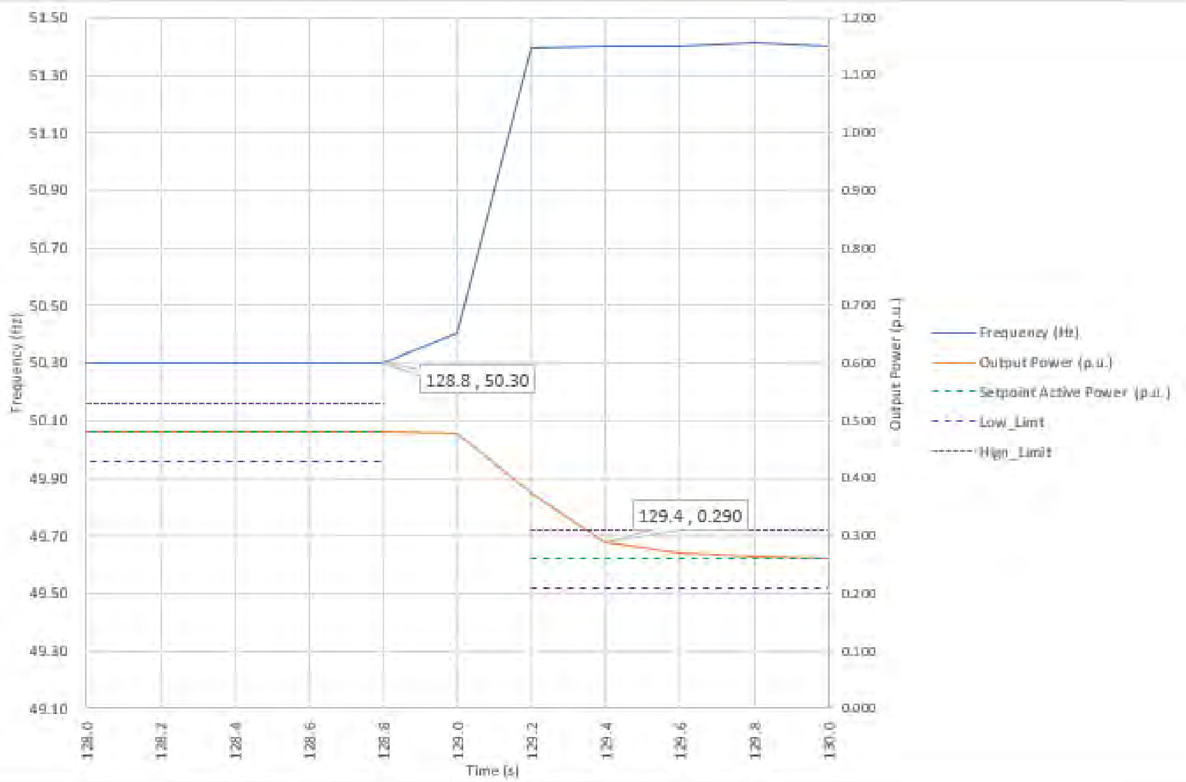
ΔP/Δt	
Maximum active power gradient	9.06 % Pn/min
Mean active power gradient	9.02 % Pn/min
Defined gradient ΔP/Δt	10 % Pn/min
The gradient of active power after removal of the active power limitation has been measured as follows: The active power has to be calculated as a 0.2 second mean. The mean 1-minute power is determined at intervals of 1 min. The first averaging interval starts 1 min prior to the removal of the active power limitation. The last averaging interval ends after reaching the stationary final value of active power. The gradient of the active power increase ΔP/Δt is determined from the difference between consecutive 1-minute mean values with reference to 1 min in each case for the time point at the boundary between two averaging intervals.	

In following graphs, test results are represented:

Output power reduction: Active power and Frequency over time

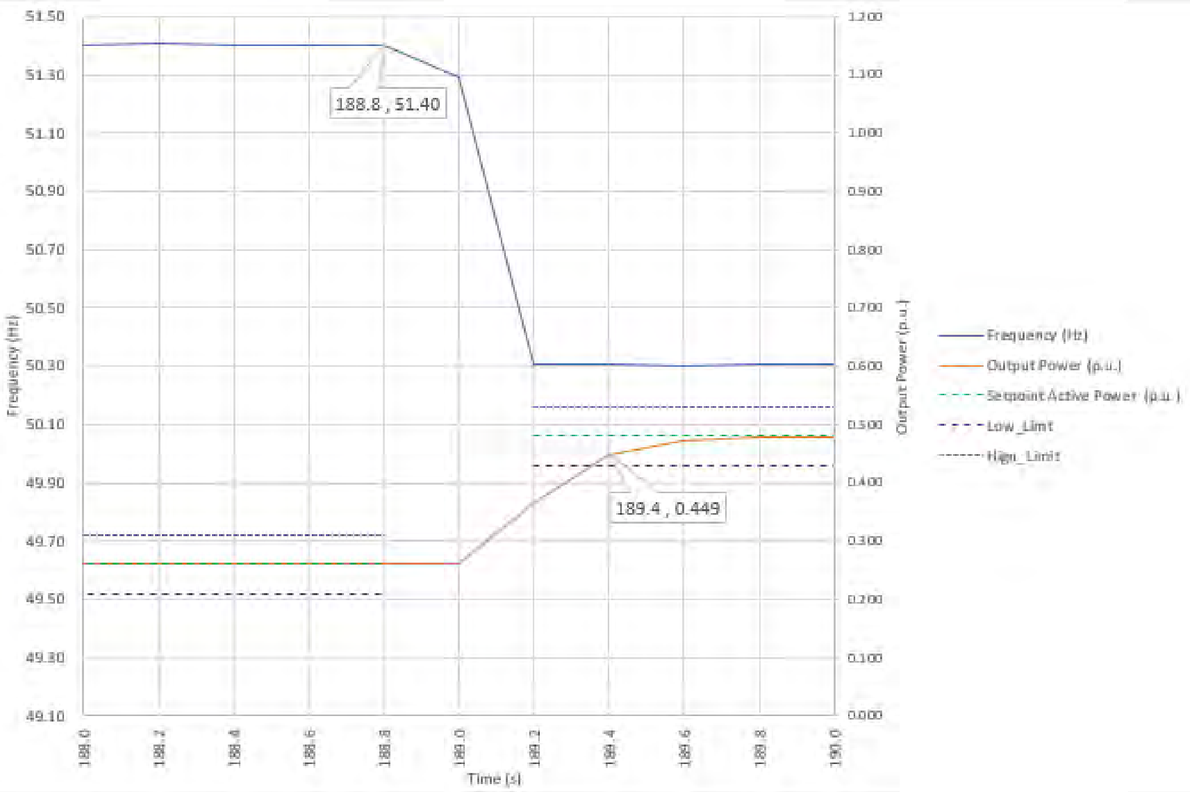


Power gradient (Step 2 to 3)



dP(f) desired: 40.0% P_{ref}/Hz	dP(f) measured: 40.0% P_{ref}/Hz

Power gradient (Step 3 to 4)



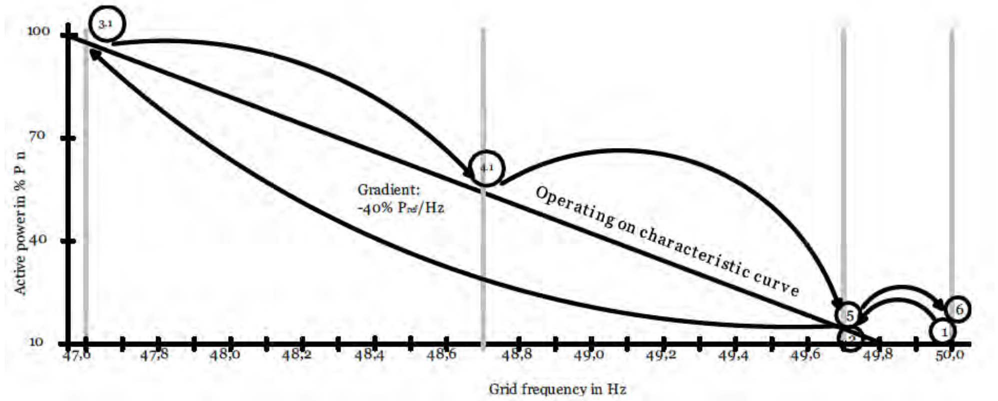
dP(f) desired: 40.0% P_{ref}/Hz	dP(f) measured: 40.0% P_{ref}/Hz

4.1.3.2 Underfrequency (LSFM-U)

For this test. power increase has been applied with a gradient of 40% P_{ref}/Hz in the range of 49.8Hz to 47.5 Hz. Once the grid frequency falls below the 49.8 Hz threshold. the active power recuperation must be with a maximum gradient of 10%P_n/min.

For the test. before the power reduction starts. active power has been reduced to a 10%Pn through a setpoint.

Frequency values must be inside next ranges (referred to the points on the figure):



Frequency Step	Simulated grid frequencies	Note
1	50.00 Hz ± 0.05 Hz	
2	49.70 Hz ± 0.05 Hz	
3	3.1: 47.60 Hz ± 0.05 Hz	
4	4.1: 48.70 Hz ± 0.05 Hz	
5	49.70 Hz ± 0.05 Hz	
6	50.00 Hz ± 0.05 Hz	Charge of active power with a maximum gradient of 10%Pn/min

60s after reaching point 5, the power reduction applied at the beginning of the test is disabled in order to verify the recuperation gradient limit of 10%Pn/min

Starting at P_{ref}, it has been performed the frequency steps that can be seen on the table above, taking measures of the active power at every set point of frequency. Every point has a measured duration of 30 seconds at least.

Gradient has been calculated as follows:

$$\frac{\Delta P}{\Delta f} = \frac{P_{Step\ i+1} - P_{Step\ i}}{|f_{Step\ i+1} - f_{Step\ i}|}$$

$P_{Step\ i+1}$ 10-s-mean of the active power which is calculated at the end of frequency step i+1.
$P_{Step\ i}$ 10-s-mean of the active power which is calculated at the end of frequency step i.
$f_{Step\ i+1}$ 10-s-mean of the grid frequency, at which PStep i+1 is determined.

$f_{Step\ i}$ 10-s-mean of the grid frequency, at which PStep i is determined.

To determine the rise and settling times, a tolerance band of ± 5% of Pn is applied around the controlled active power end value.

Used settings of the measurement device for this power limitation for an increase in grid frequency testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/01/17	100 ms values	3 kHz

The tables below show measured values:

a) Accuracy results

LSFM-U					
Step	**Simulated grid frequency (Hz)**	**Measured grid frequency (Hz)**	**Normalized Active Power *Setpoint* (P/Pn)**	**Normalized Active Power *Measured* (P/Pn)**	**Active power gradient P(f) relative to the reference frequency**
1	50.00 ± 0.05	50.00	0.500	0.501	-------
(*)	50.00 to 49.70	From 50.00 to 49.70	--	--	-------
2	49.70 ± 0.05	49.70	0.520	0.523	-------
3	47.60 ± 0.05	47.60	0.940	0.970	42.6 % P_{ref}/Hz
4	48.70 ± 0.05	48.70	0.720	0.727	44.0 % P_{ref}/Hz
5	49.70 ± 0.05	49.70	0.520	0.523	40.8 % P_{ref}/Hz
6	50.00 ± 0.05	50.00	1.000	1.007	-------
(*): As the EUT is Type 2, according to the standard **Pmom = Pref** is defined as the mean value of the active power immediately prior to frequency transition at 49.8 Hz. Here, the manufacturer specifies the averaging time 100ms.					

ΔP/Δf	
Mean active power gradient while frequency limit is exceeded	42.5 % P_{ref}/Hz
Defined active power gradient ΔP/Δf	40.0 % P_{ref}/Hz

b) Settling time and Rise time results

Frequency step	Rise Time (s)	Settling time (s)
Step 2 → Step 3	0.5	0.5
Step 3 → Step 4	0.5	0.5
Step 4 → Step 5	0.4	0.4

ΔP/Δt	
Maximum active power gradient	11.0 % Pn/min
Mean active power gradient	10.4 % Pn/min
Defined gradient ΔP/Δt	10.0 % Pn/min

The gradient of active power after removal of the active power limitation has been measured as follows:

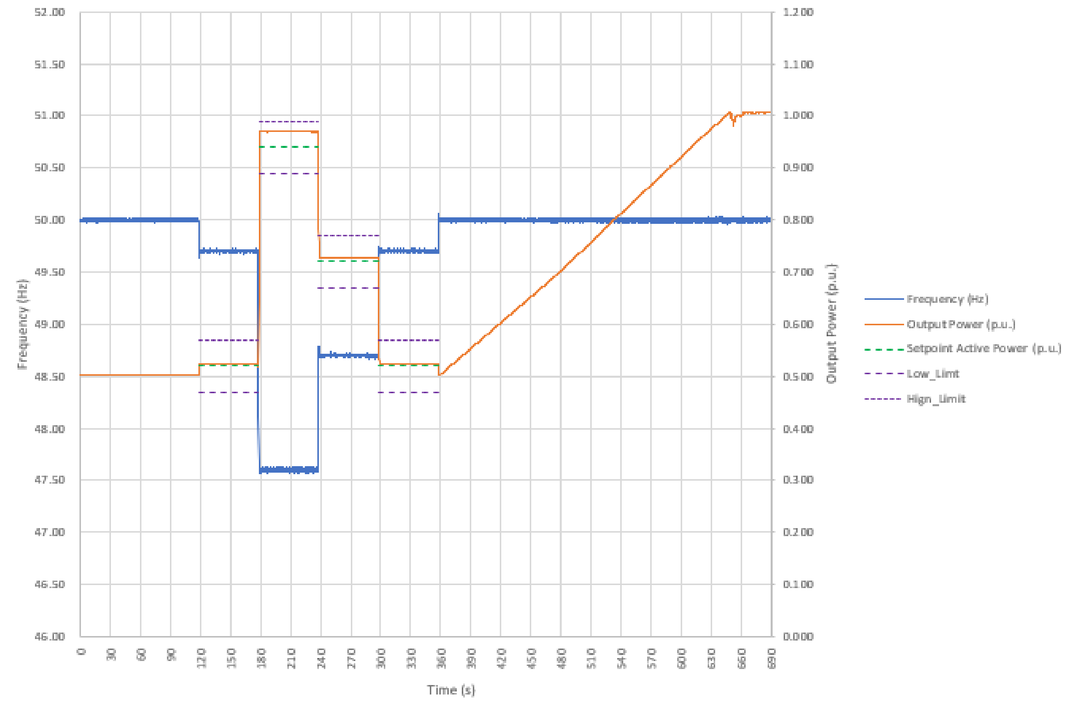
The active power has to be calculated as a 0.1 second mean.

The mean 1-minute power is determined at intervals of 1 min.
The first averaging interval starts 1 min prior to the removal of the active power limitation. The last averaging interval ends after reaching the stationary final value of active power.

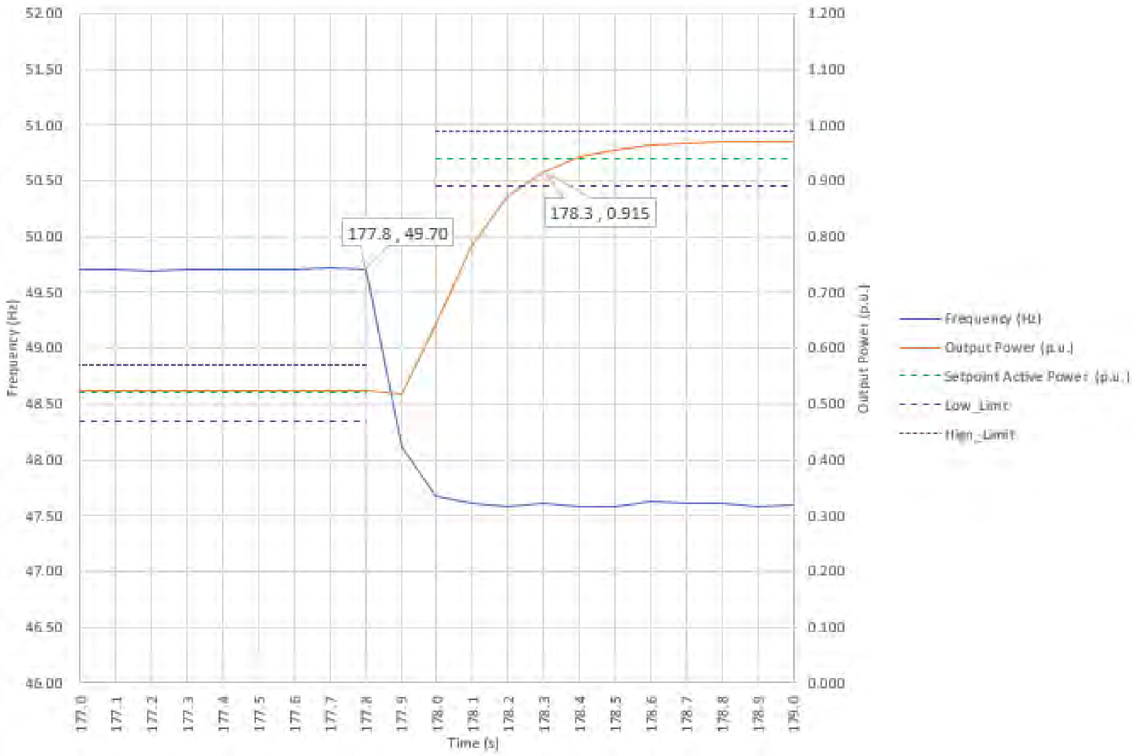
The gradient of the active power increase ΔP/Δt is determined from the difference between consecutive 1-minute mean values with reference to 1 min in each case for the time point at the boundary between two averaging intervals.

In following graphs, test results are represented after the test has been performed:

Output power increase: Active power and Frequency over time

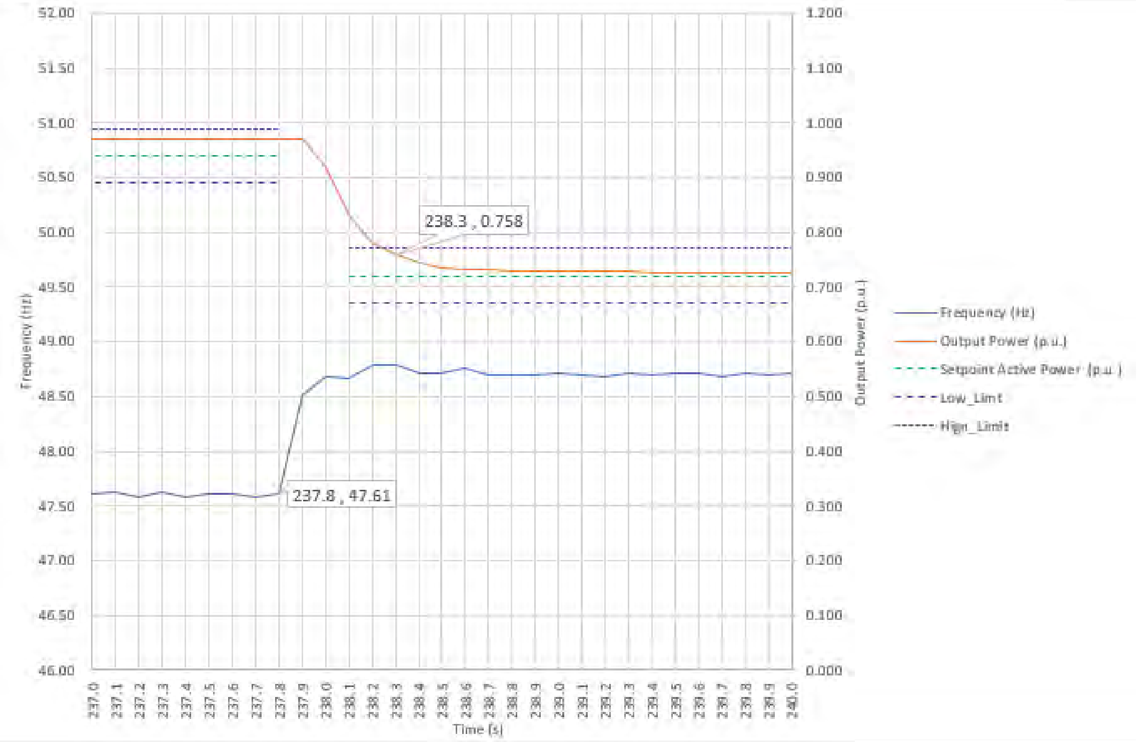


Power gradient (Step 2 to 3)



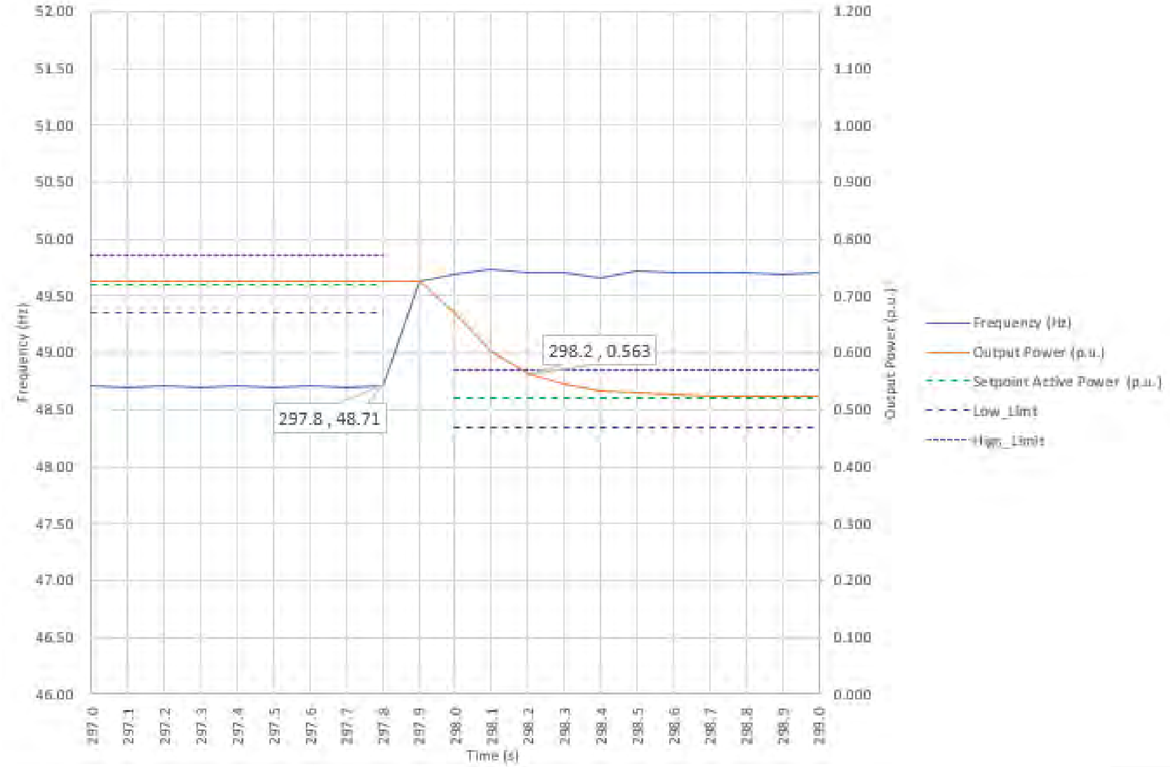
dP(f) desired: 40.0% P_{ref}/Hz	dP(f) measured: 42.6% P_{ref}/Hz

Power gradient (Step 3 to 4)



dP(f) desired: 40.0% P_{ref}/Hz	dP(f) measured: 41.3% P_{ref}/Hz

Power gradient (Step 4 to 5)

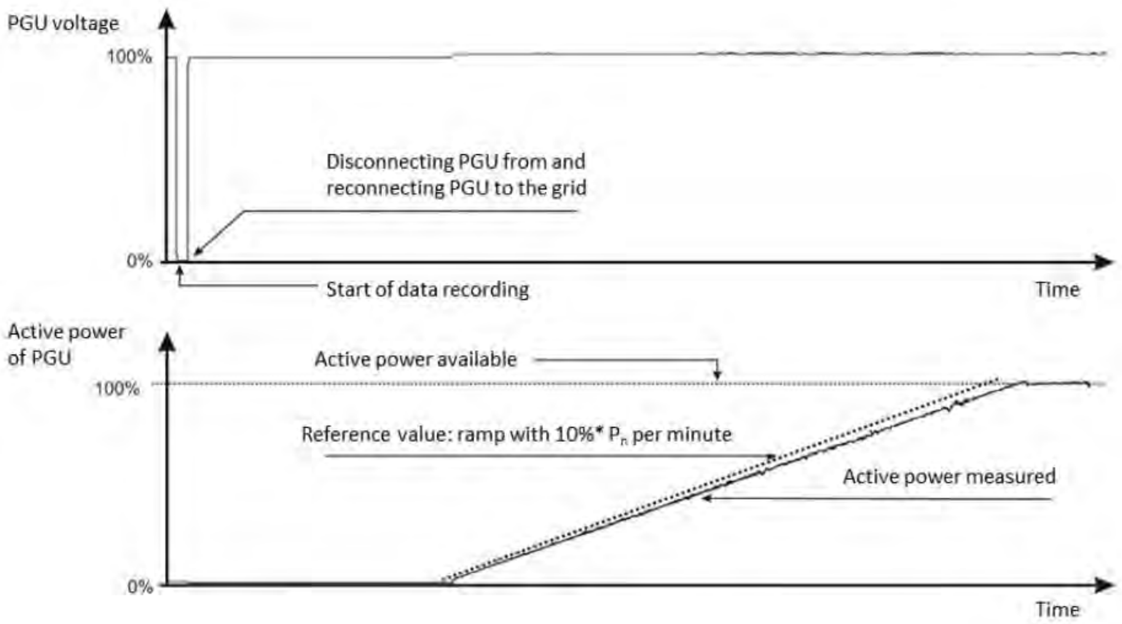


dP(f) desired: 40.0% P_{ref}/Hz	dP(f) measured: 41.3% P_{ref}/Hz

4.1.4 Active Power gradient following disconnection from the grid

The aim of this test is to measure the PGU's active power gradient when restarting following disconnection from the grid.

The test was performed according to the point 4.1.4 of the standard. By the following graph, it is represented the test to be done:



In the example tested, the inverter was adjusted to be disconnected from the grid when the output voltage exceeds below than 50% of the rated voltage in less than 1 seconds.

After this, the inverter was set to be reconnected when the voltage grid is recovered more than 95% of the rated voltage for more than 600 seconds.

Once reconnected, the inverter shall start to inject active power into the grid following a soft ramp. The power gradient has been checked to be adjustable and it must be set according to requirements from VDE-AR-N 4110:2018 and VDE-AR-N 4120:2018 requirements (0.33-0.66%Pn/s) before plant certification. For the tested case, the active power gradient was set to follow a ramp rate corresponding to 0.45%Pn/s.

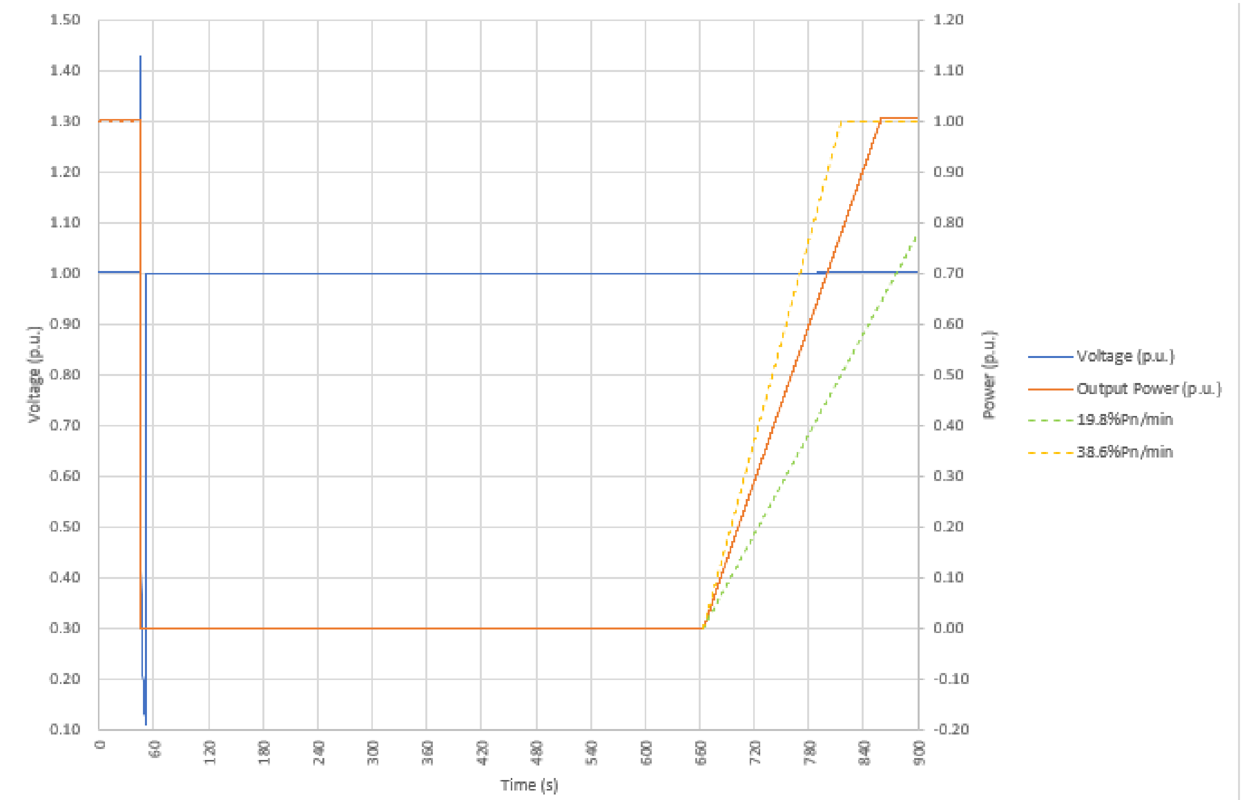
Active output power and output voltage have been represented as 0.2 seconds mean as shown in the graphs below.

Used settings of the measurement device for the active power gradient testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/09/23	200 ms values	3 kHz

By the following graph, test results are represented after the test has been performed:

Graphical representation of the test over time



As it can be seen in the graph above, the active power gradient has been done according with option 1 of FGW Rev.25 as seen in the picture below:

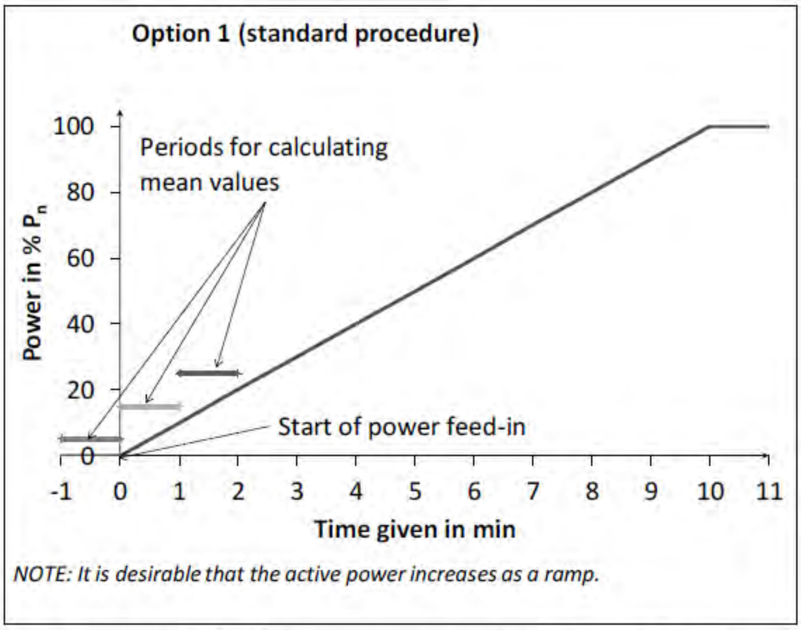


Fig. 4–9: Example with the first averaging interval 60 s before power increase

Gradients are calculated using averaging periods of 60 seconds starting at -90 seconds before the connection starts.

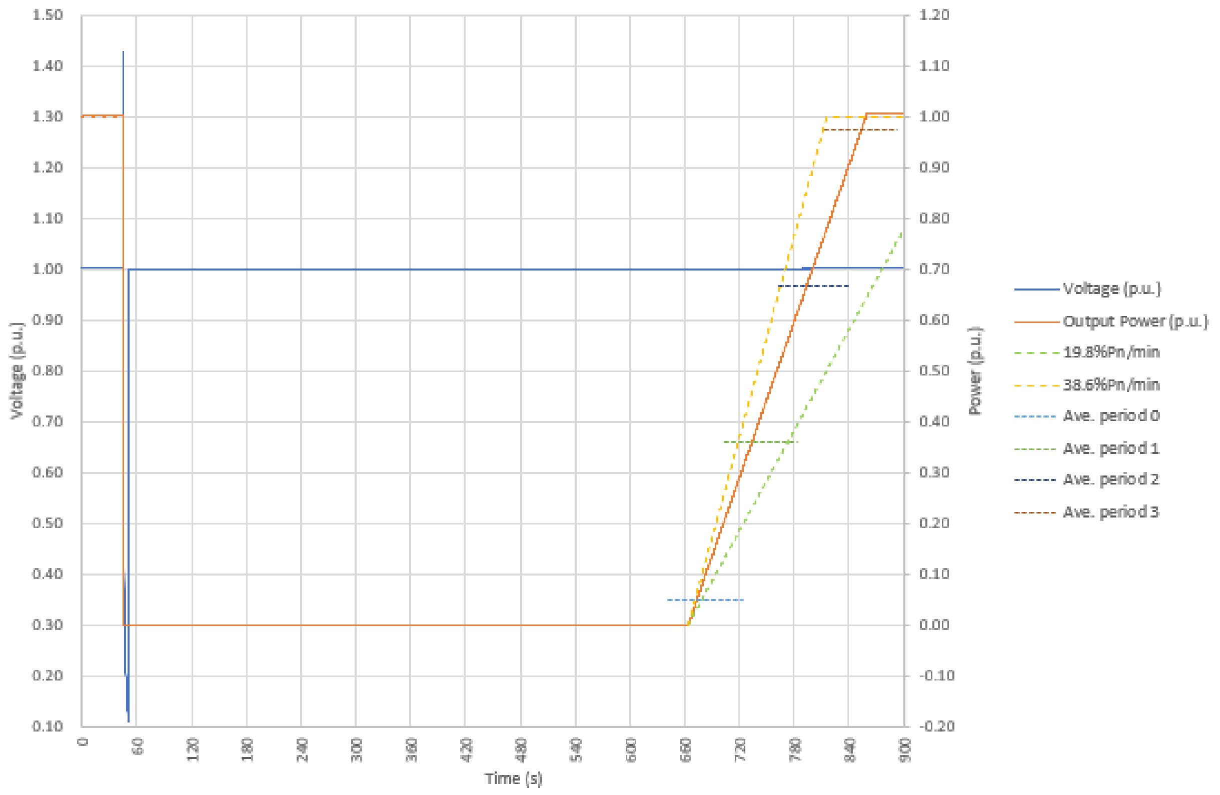
For each one of this averaging period, the active power gradient is calculated according to the following equation:

$$\frac{\Delta p}{1\ min} = \frac{P_{t=t1+1min} - P_{t=t1}}{1\ min}$$

Here t1 is the time commencing the generator active power feed in after reconnection until the end of power limitation.

For the example tested, they have been calculated up to 3 averaging periods as represented in the image below:

Active Power Gradient over time



In the following table, they are summarized all active power gradients calculated. They are as well calculated the maximum and the mean active power gradients take in to account all power gradients determined

Active power gradient determined for the averaging period 1	0.51% Pn/s
Active power gradient determined for the averaging period 2	0.51% Pn/s
Active power gradient determined for the averaging period 3	0.51% Pn/s
Maximum active power gradient	0.51% Pn/s
Mean active power gradient (averaging periods 1 to 3)	0.51% Pn/s
Defined gradient dP/dt	0.50% Pn/s

Note: The measured mean active power gradient is 0.51%Pn/s, so the active power gradient compliacce with the required power gradient range (0.33-0.66%Pn/s).

4.2 REACTIVE POWER PROVISION

4.2.1 Reactive Power response in the normal operating mode and Maximum Reactive Power

Aims of these tests are to determine the PGU's active and reactive power response in normal operating mode for a specified setpoint of Q=0 and the maximum capacitive (overexcited) and inductive (underexcited) reactive power provision of the EUT.

For all tests, the active power of the inverter must vary from 0% to 110%. This variation must be done each 10 %Pn increasing range. Each step was maintained for at least 1 minute, taken for the calculations 1 minute displacement factor cos φ, voltage and reactive power mean.

Five different tests have been performed:

- According to the point 4.2.1 of the standard, the first test has been performed with a specified setpoint Q=0 kVAr in normal operating mode.
- According to the point 4.2.2 of the standard, the second test has been performed in order to determine the maximum capacitive (overexcited) and inductive (underexcited) reactive power provision of the PGU (PQ diagram). In this test the apparent power, S, has been kept at 110%Sn.
- In addition to point 4.2.2, it has been done a rectangular curve to prove that the inverter is capable of providing a fixed amount of reactive power at any active power level.
  The reactive power value has been set at 66.0%Pn (inductive and capacitive).
- In addition to point 4.2.2, it has been done a triangular curve to prove that the inverter is capable of providing a fixed amount of reactive power in relation to its power factor.
  Power factor value has been set at 0.90 (inductive and capacitive)
- According to the point 4.2.3 of the standard, the fifth test has been performed in order to verify the maximum capacitive (overexcited) and inductive (underexcited) recative power provision of the PGU with under/over voltage situations (voltage-dependent PQ diagram)
  This capability has been verified at 85%Un, 90%Un as well as 110%Un and 120%Un.

The maximum steady-state error between the desired and actual value in the range P ≥ 0.10 p.u. will be ±2%. It will be allowed ±4% for equipments with capacity below 300 kVA.

Below a power of 0.10 p.u, an underexcited operation in the amount of up to 5% will be permitted. While for overexcited, the maximum deviation allowed will be a maximum of 2%.

The positive phase sequence values of the active and reactive power, as well as the displace-ment factor, have been determined from each measured record.

In following points are offered all test results after tests above detailed.

Interface information	
Interface used	RS485
Interface version used	SmartLogger V200R002
Other interfaces in the equipment	SUN 2000APP:3.2.00.002
Name or code of the parameter for active power setting	Active Power Control
Name or code of the parameter for reactive power setting	Reactive Power Control
If the EUT has several different interfaces for defining the setpoint, it has been tested the interface returning the most unfavourable results according to the manufacturer information.	

EUT Settings used for these tests are provided in the following table:

EUT Settings	
Operanting mode	Active power priority / Reactive power priority
Active control modes	Active power control LVRT mode Fixed Reactive power control Cos Phi

4.2.1.1 Reactive Power Fixed (Q=0)

Used settings of the measurement device for Normal operating mode (Q=0kVAr).

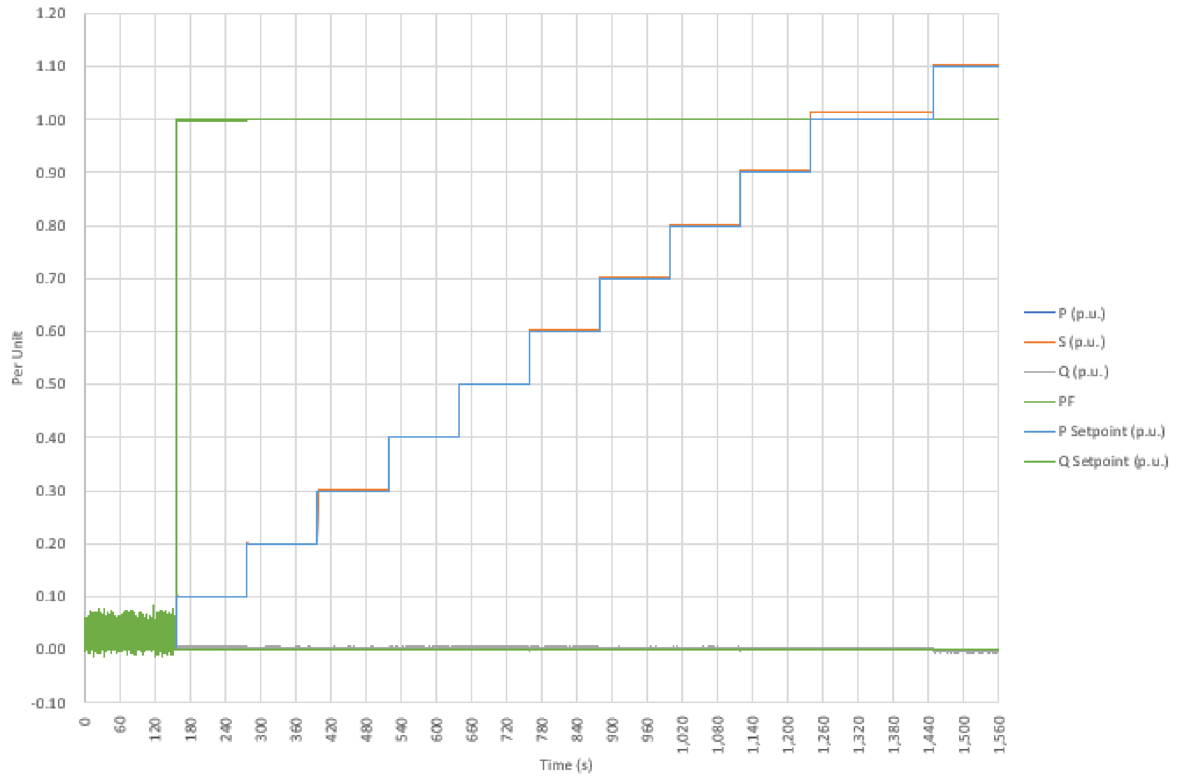
Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/18 and 2020/01/22	100 ms values	3 kHz

The table below shows measured values for each power step tested:

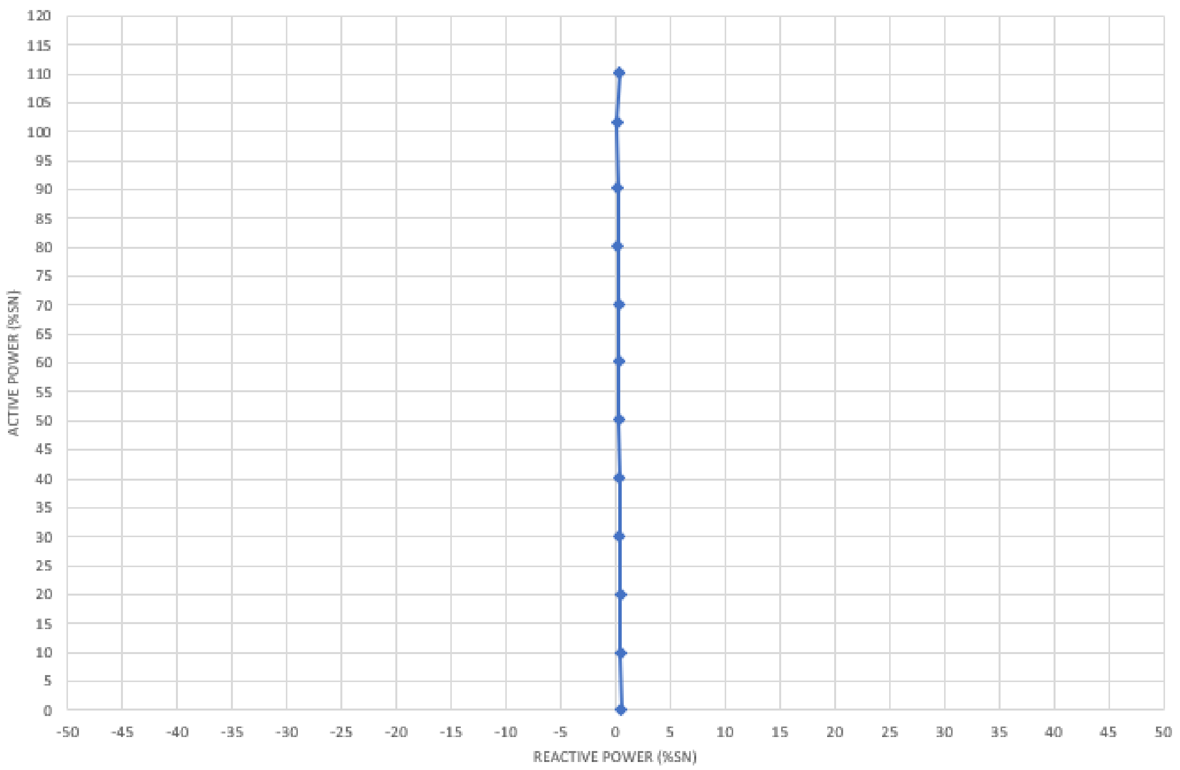
Reactive Power Fixed: Q = 0 kVAr						
P Desired (%Sn)	**P measured (kW)**	**Q measured (kVAr)**	**Q Deviation (kVAr)**	**Power Factor (cos φ)**	**V_{AC} + (V)**	**Number of records**
0%	0.023	0.548	0.548	0.030	398.9	1200
10%	9.968	0.469	0.469	0.999	399.0	1200
20%	20.026	0.447	0.447	1.000	399.1	1200
30%	30.075	0.419	0.419	1.000	399.1	1200
40%	40.136	0.386	0.386	1.000	399.2	1200
50%	50.180	0.344	0.344	1.000	399.2	1200
60%	60.202	0.310	0.310	1.000	399.3	1200
70%	70.254	0.277	0.277	1.000	399.4	1200
80%	80.329	0.245	0.245	1.000	399.4	1200
90%	90.423	0.209	0.209	1.000	399.5	1200
100%	101.519	0.175	0.175	1.000	399.6	1200
110%	110.314	0.367	0.367	1.000	399.5	1200

In following graphs, test results are represented after the test has been performed:

Q = 0 kVAr. Power Factor and Powers over time



Q = 0 kVAr. Active Power over Reactive Power



4.2.1.2 Semicircular Curve: Maximum Apparent Power

Used settings of the measurement device for this semicircular curve testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/20, 2019/11/23 and 2020/01/22	100 ms values	3 kHz

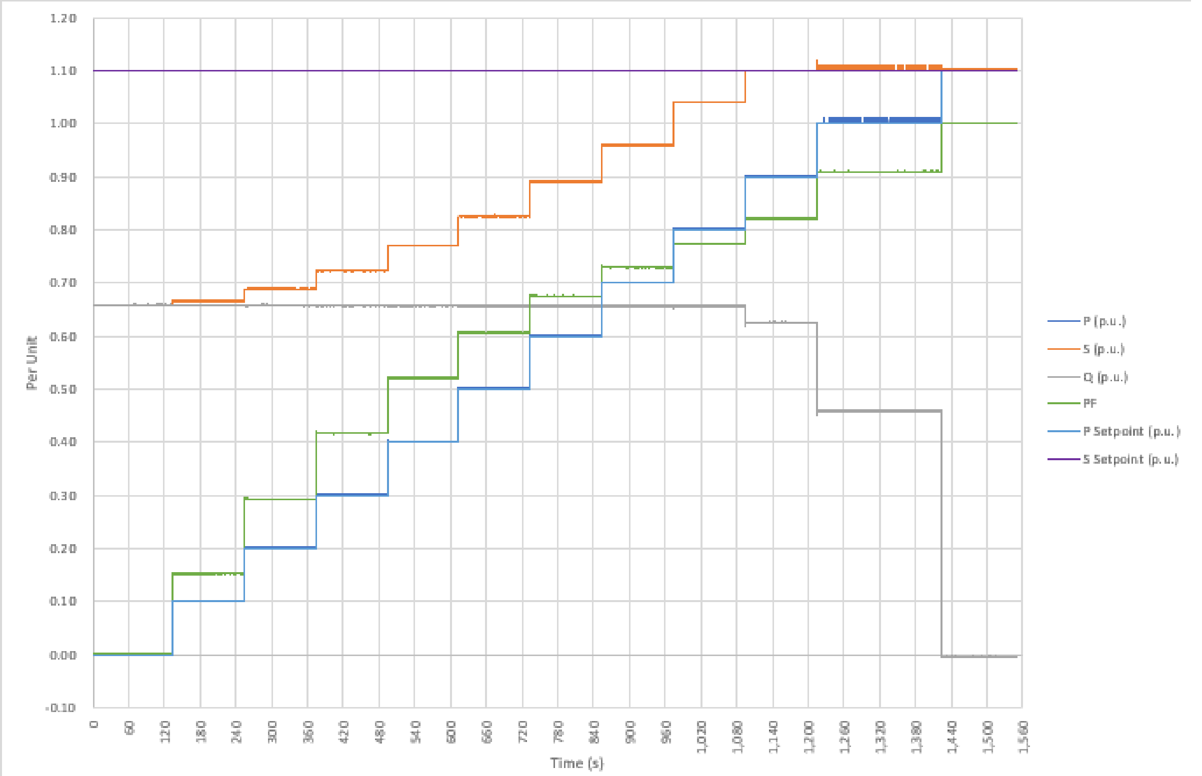
Tables below show measured values for each power step tested, at both the inductive and the capacitive sides:

Semicircular Curve (U = 100% Un) – Inductive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA)**	**S deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC} + (V)**	**Number of records**
0%	0.177	65.895	65.895	44.105	0.003	399.0	1200
10%	10.200	65.864	66.644	43.356	0.153	399.1	1200
20%	20.200	65.826	68.852	41.148	0.293	399.1	1200
30%	30.200	65.788	72.381	37.619	0.417	399.7	1200
40%	40.200	65.757	77.066	32.934	0.521	401.0	1200
50%	50.197	65.712	82.678	27.322	0.607	402.1	1200
60%	60.196	65.655	89.065	20.935	0.676	403.3	1200
70%	70.200	65.615	96.098	13.902	0.730	404.4	1200
80%	80.276	65.588	103.997	6.003	0.774	405.6	1200
90%	90.303	62.587	110.000	0.000	0.822	406.1	1200
100%	100.082	45.834	110.085	-0.085	0.910	403.4	1200
110%	110.314	0.367	110.314	-0.314	1.000	399.5	1200

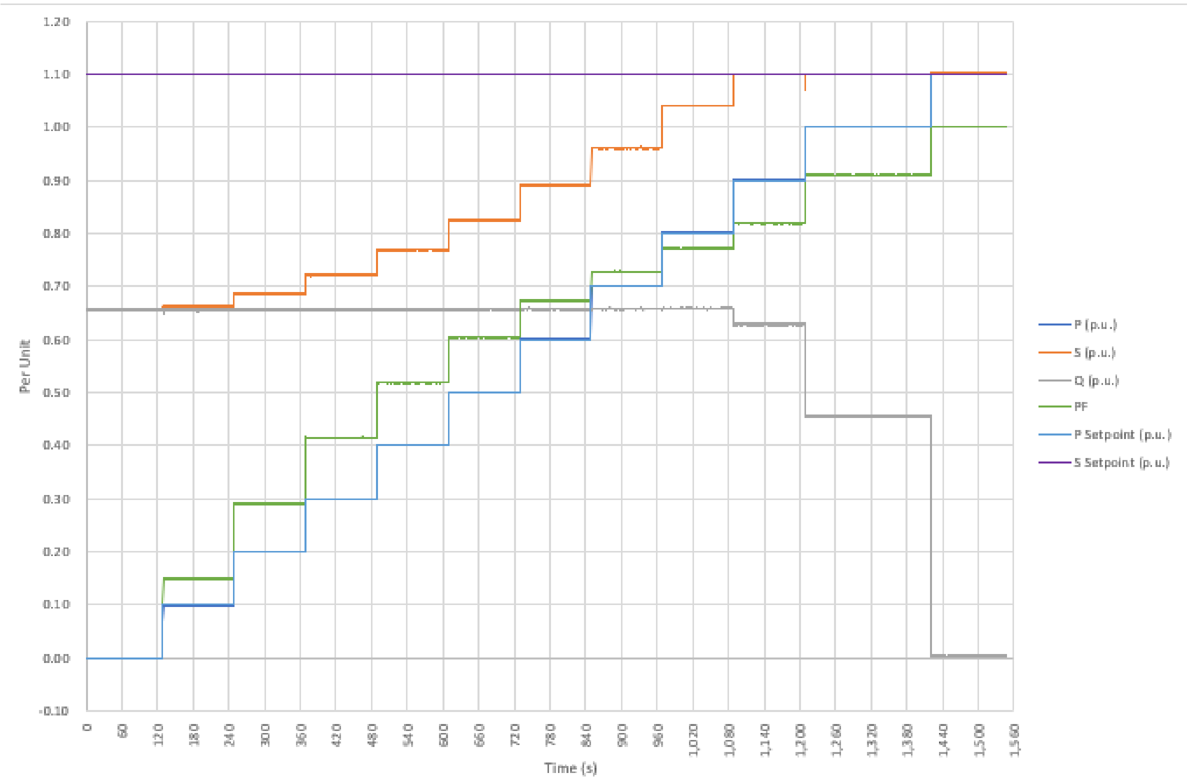
Semicircular Curve (U = 100% Un) – Capacitive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA)**	**S deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC} + (V)**	**Number of records**
0%	0.048	65.587	65.587	44.413	0.001	398.8	1200
10%	9.960	65.614	66.366	43.634	0.149	398.8	1200
20%	19.999	65.643	68.617	41.383	0.291	398.8	1200
30%	30.000	65.682	72.209	37.791	0.415	398.9	1200
40%	40.000	65.713	76.936	33.064	0.519	399.0	1200
50%	50.005	65.740	82.610	27.390	0.605	399.1	1200
60%	60.075	65.783	89.078	20.922	0.673	399.1	1200
70%	70.101	65.836	96.172	13.828	0.728	399.2	1200
80%	80.159	65.881	104.000	6.000	0.772	399.3	1200
90%	90.259	62.973	109.998	0.002	0.819	399.3	1200
100%	100.000	45.599	110.000	0.000	0.910	399.5	1200
110%	110.314	0.367	110.314	-0.314	1.000	399.5	1200

In following graphs, test results are represented after the test has been performed:

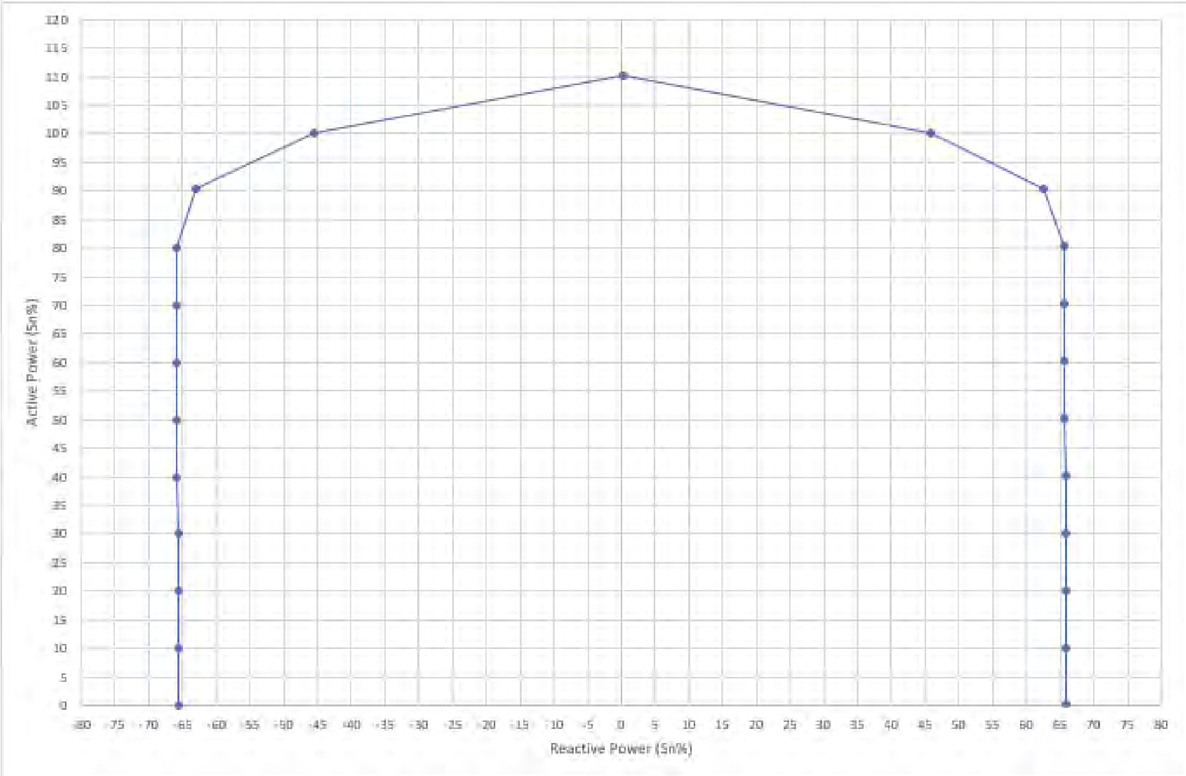
Semicircular Curve (100%Un), Inductive side: Power Factor and Powers over time



Semicircular Curve (100%Un), Capacitive side: Power Factor and Powers over time



Semicircular Curve (100%Un): Active Power over Reactive Power



4.2.1.3 Rectangular Curve: Fixed Reactive Power (Q = 66 % Sn)

Used settings of the measurement device for this rectangular curve (Q = 66% Pn) testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/19	100 ms values	3 kHz

Tables below show measured values for each power step tested, at both the inductive and the capacitive sides:

Rectangular Curve (Q=66.0 %S_n) – Inductive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA)**	**Q deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC} + (V)**	**Number of records**
0%	0.255	66.551	66.552	0.551	0.003	399.1	1200
10%	10.297	66.537	67.323	0.537	0.152	399.2	1200
20%	20.300	66.517	69.543	0.517	0.291	399.4	1200
30%	30.301	66.503	73.091	0.503	0.415	400.3	1200
40%	40.331	66.492	77.775	0.492	0.519	401.6	1200
50%	50.323	66.436	83.355	0.436	0.604	402.8	1200
60%	60.391	66.409	89.744	0.409	0.673	404.0	1200
70%	70.400	66.396	96.773	0.396	0.727	405.3	1200
80%	80.500	66.388	104.000	0.388	0.771	406.5	1200
90% (*)	88.301	66.234	110.025	0.234	0.800	406.8	1200
100% (*)	88.301	66.234	110.025	0.234	0.800	406.8	1200

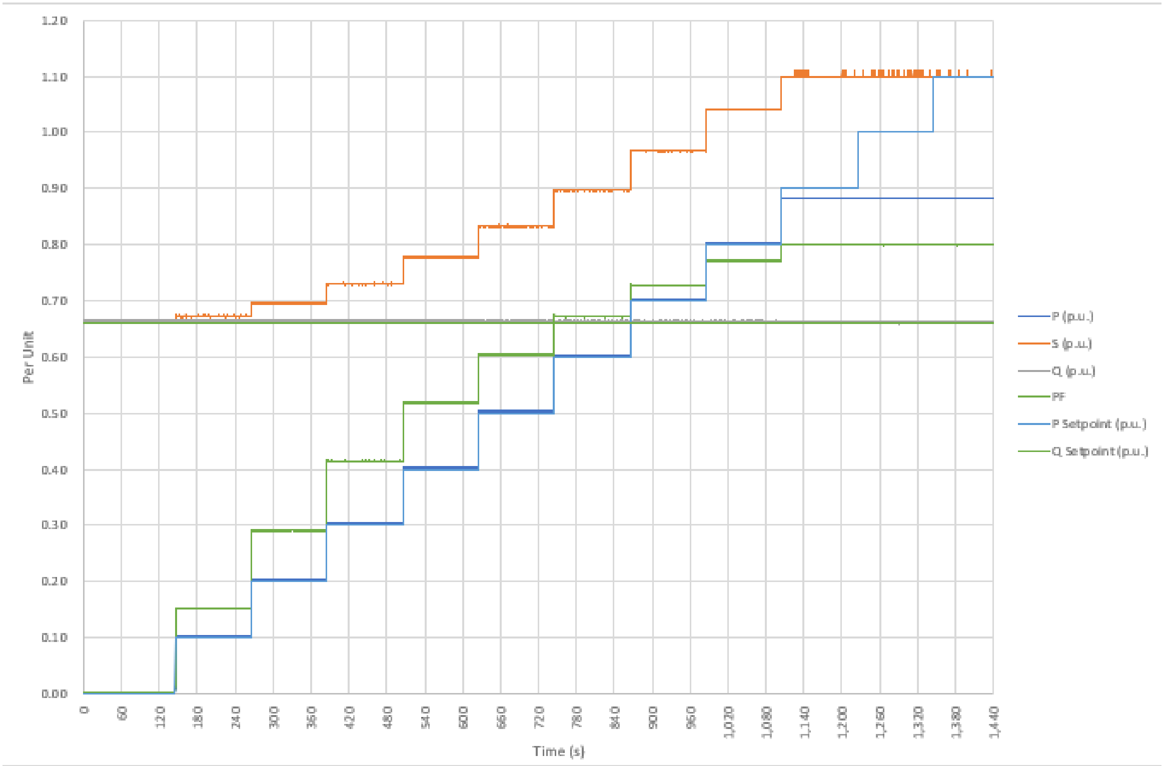
(*) The inverter does not reach the fixed active power value of 90%Pn and 100%Pn due to the current limitation function. And in this Fixed Reactive Power operating mode, the inverter is reactive priority.

Rectangular Curve (Q=66.0 %S_n) – Capacitive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA)**	**Q deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC} + (V)**	**Number of records**
0%	0.100	65.558	65.558	-0.442	0.003	398.7	1200
10%	9.929	65.607	66.352	-0.393	0.148	398.8	1200
20%	19.969	65.652	68.619	-0.348	0.290	398.8	1200
30%	29.993	65.689	72.207	-0.311	0.414	398.9	1200
40%	39.996	65.711	76.920	-0.289	0.519	399.0	1200
50%	50.003	65.755	82.611	-0.245	0.604	399.1	1200
60%	60.069	65.818	89.103	-0.182	0.673	399.2	1200
70%	70.109	65.878	96.213	-0.122	0.728	399.2	1200
80%	80.202	65.944	104.000	-0.056	0.772	399.3	1200
90%	88.089	65.788	110.000	-0.212	0.800	399.3	1200
100% (*)	88.089	65.788	110.000	-0.212	0.800	399.3	1200

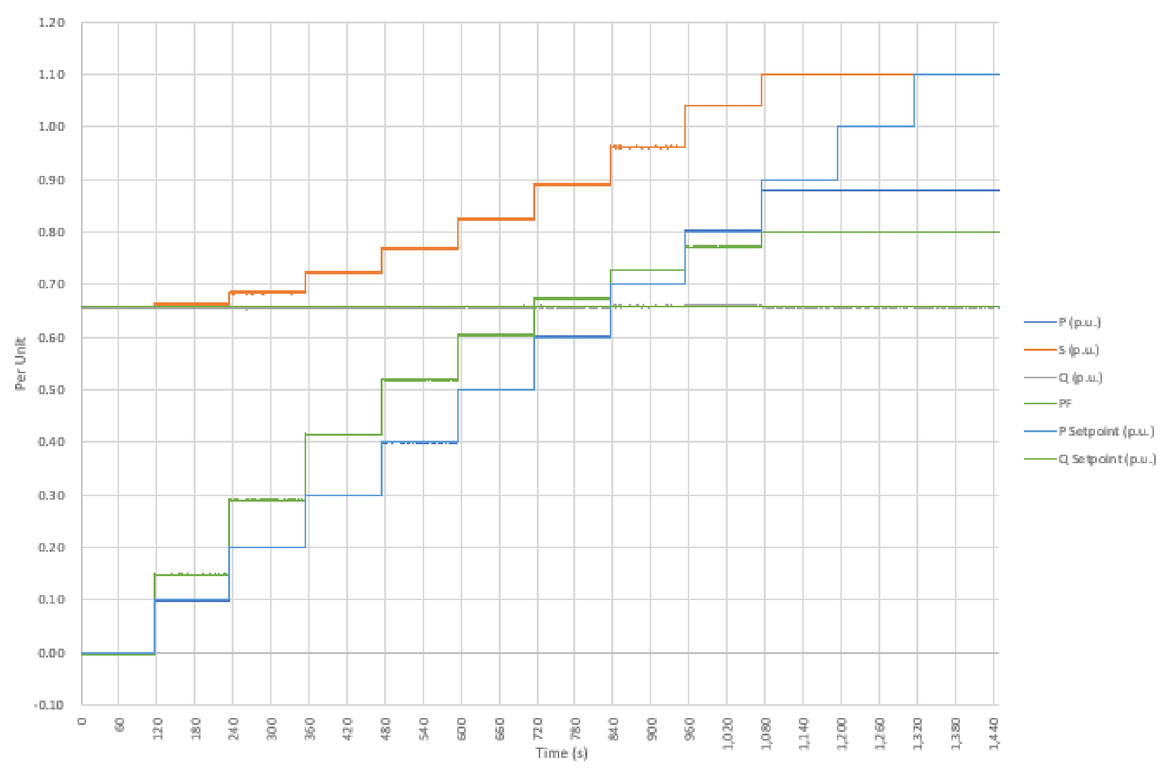
(*) The inverter does not reach the fixed active power value of 90%Pn and 100%Pn due to the current limitation function. And in this Fixed Reactive Power operating mode, the inverter is reactive priority.

In following graphs, test results are represented after the test has been performed:

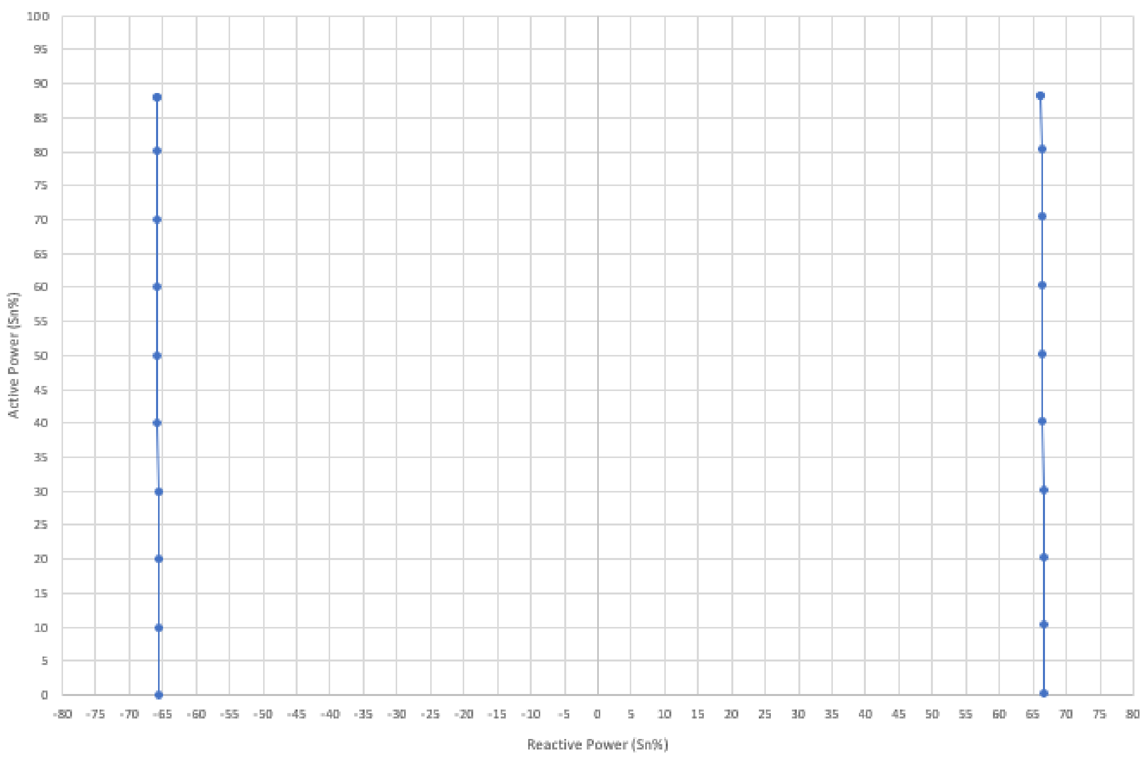
Rectangular Curve (Q=66%S_n), Inductive side: Power Factor and Powers over time



Rectangular Curve (Q=66%S_n), Capacitive side: Power Factor and Powers over time



Rectangular Curve: Active Power over Reactive Power



4.2.1.4 Triangular Curve: Fixed Power Factor (PF = 0.9)

Used settings of the measurement device for this triangular curve (PF=0.9) testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/30	100 ms values	3 kHz

Tables below show measured values for each power step tested, at both the inductive and the capacitive sides:

Triangular Curve (PF=0.90) – Inductive							
P Desired (%Pn)	P measured (kW)	Q measured (kVAr)	S measured (kVA)	PF deviation	Power Factor (cos φ)	V_{AC} + (V)	Number of records
0%	0.039	0.025	0.050	-0.217	0.683 (*)	398.7	1300
10%	9.997	4.698	11.046	0.005	0.905	398.7	1300
20%	20.057	9.526	22.205	0.003	0.903	398.8	1300
30%	30.125	14.357	33.371	0.003	0.903	398.7	1300
40%	40.138	19.169	44.481	0.003	0.903	398.6	1300
50%	50.188	23.980	55.623	0.002	0.902	398.7	1300
60%	60.249	28.810	66.783	0.002	0.902	398.7	1300
70%	70.313	33.632	77.943	0.002	0.902	398.8	1300
80%	80.348	38.442	89.071	0.002	0.902	398.9	1300
90%	90.413	43.271	100.234	0.002	0.902	399.0	1300
100%	99.438	47.614	110.250	0.002	0.902	399.1	1300

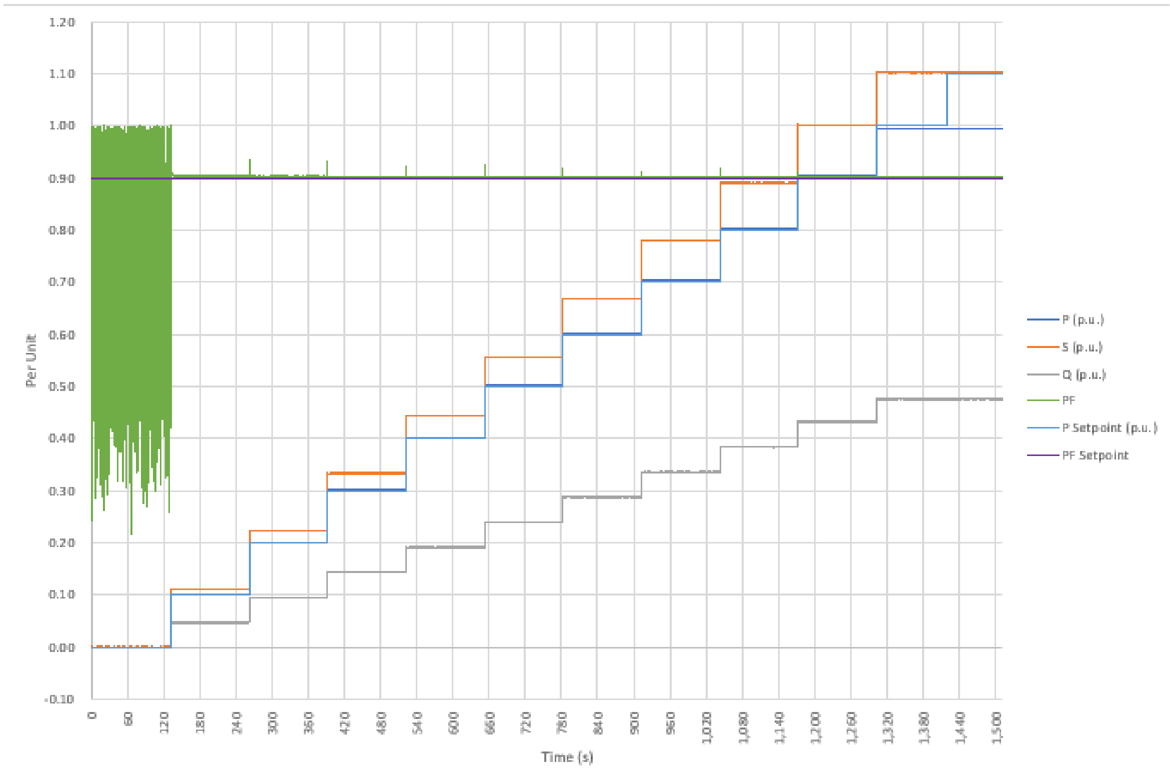
(*) The power factor can not keep stable due to the active power is almost 0.

Triangular Curve (PF=0.90) – Capacitive							
P Desired (%Pn)	P measured (kW)	Q measured (kVAr)	S measured (kVA)	PF deviation	Power Factor (cos φ)	V_{AC} + (V)	Number of records
0%	0.045	0.024	0.055	-0.145	0.755 (*)	398.8	1300
10%	9.979	4.916	11.124	-0.003	0.897	398.9	1300
20%	20.014	9.807	22.287	-0.002	0.898	398.9	1300
30%	30.048	14.702	33.452	-0.002	0.898	399.0	1300
40%	40.041	19.566	44.566	-0.002	0.898	399.0	1300
50%	50.070	24.449	55.720	-0.002	0.898	399.1	1300
60%	60.115	29.344	66.895	-0.002	0.898	399.1	1300
70%	70.146	34.235	78.055	-0.002	0.898	399.2	1300
80%	80.161	39.123	89.198	-0.002	0.898	399.2	1300
90%	90.210	44.022	100.378	-0.002	0.898	399.3	1300
100%	99.239	48.444	110.431	-0.002	0.898	399.3	1300

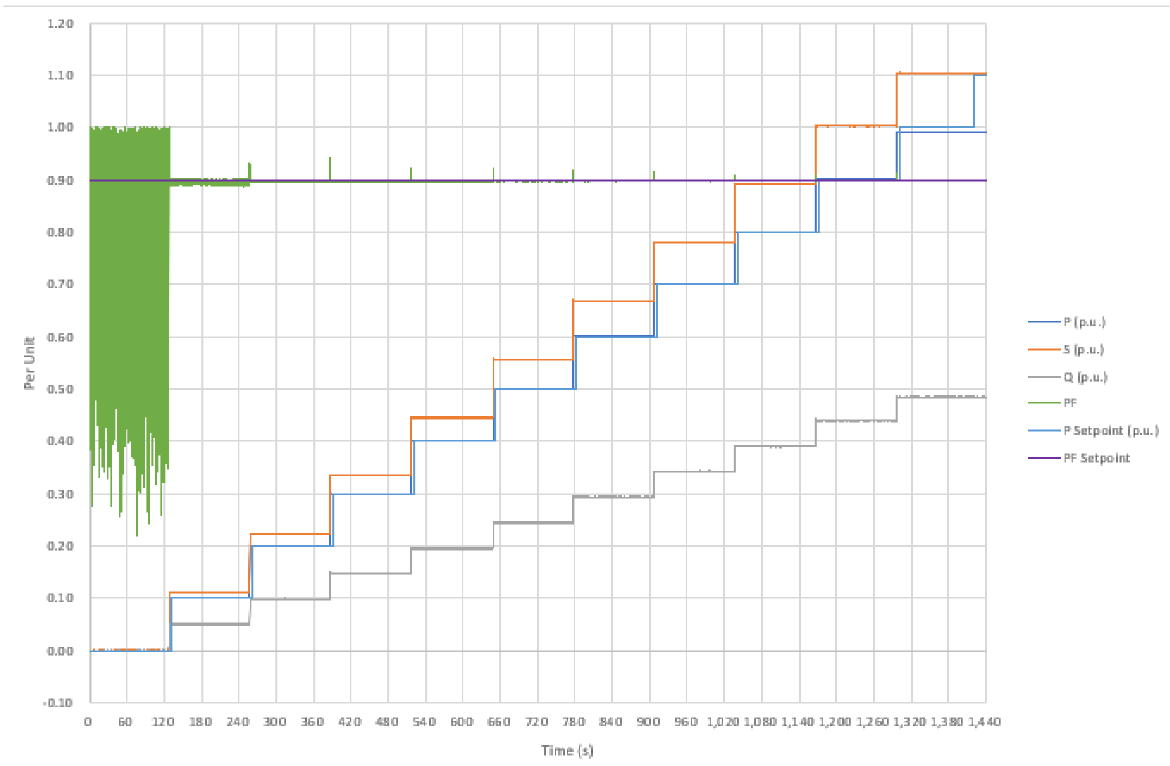
(*) The power factor can not keep stable due to the active power is almost 0.

In following graphs, test results are represented after the test has been performed:

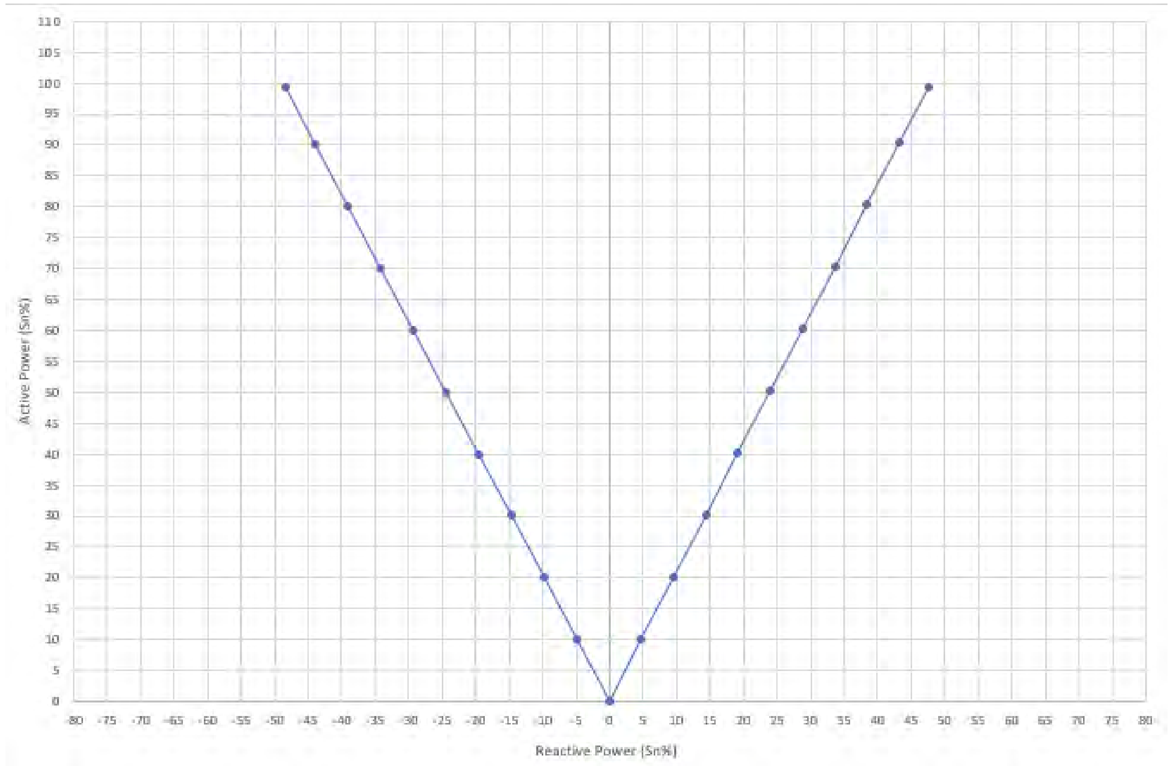
Triangular Curve (PF=0.9), Inductive side: Power Factor and Powers over time



Triangular Curve (PF=0.9), Capacitive side: Power Factor and Powers over time



Triangular Curve: Active Power over Reactive Power



4.2.1.5 Voltage-Dependent PQ diagram: Semicircular Curve

Testing Method Used for voltage variation		Comments
LVRT and/or HVRT container	☐	
PGU transformer tap-changer	☐	
Grid simulator	☒	Changed Grid simulator voltage and recorded the Unit output.
Autotransformer	☐	
Alternative test method	☐	

4.2.1.5.1 Test 1 (85 % Un)

Used settings of the measurement device for this voltage-dependant PQ diagram (85% Un) testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/09/21	200 ms values	3 kHz

Tables below show measured values for each power step tested, at both the inductive and the capacitive sides:

Semicircular Curve (U = 85% Un) – Inductive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA) (*)**	**S deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC+} (V)**	**Number of records**
0%	-0.881	68.130	68.135	26.365	-0.013	338.6	1200
11%	10.307	68.158	68.933	25.567	0.150	338.7	1200
22%	21.562	68.180	71.502	22.998	0.301	338.7	1200
33%	32.763	68.216	75.672	18.828	0.433	338.8	1200
44%	44.000	68.274	81.210	13.290	0.542	338.9	1200
50%	50.200	68.295	84.755	9.745	0.592	338.9	1200
66%	66.162	66.147	93.551	0.949	0.707	339.4	1200
77% (*)	77.866	54.909	95.272	-0.772	0.817	339.5	1200
88% (*)	89.000	33.637	95.180	-0.680	0.935	339.5	1200
94.5% (*)	95.100	-1.121	95.100	-0.600	1.000	339.4	1200

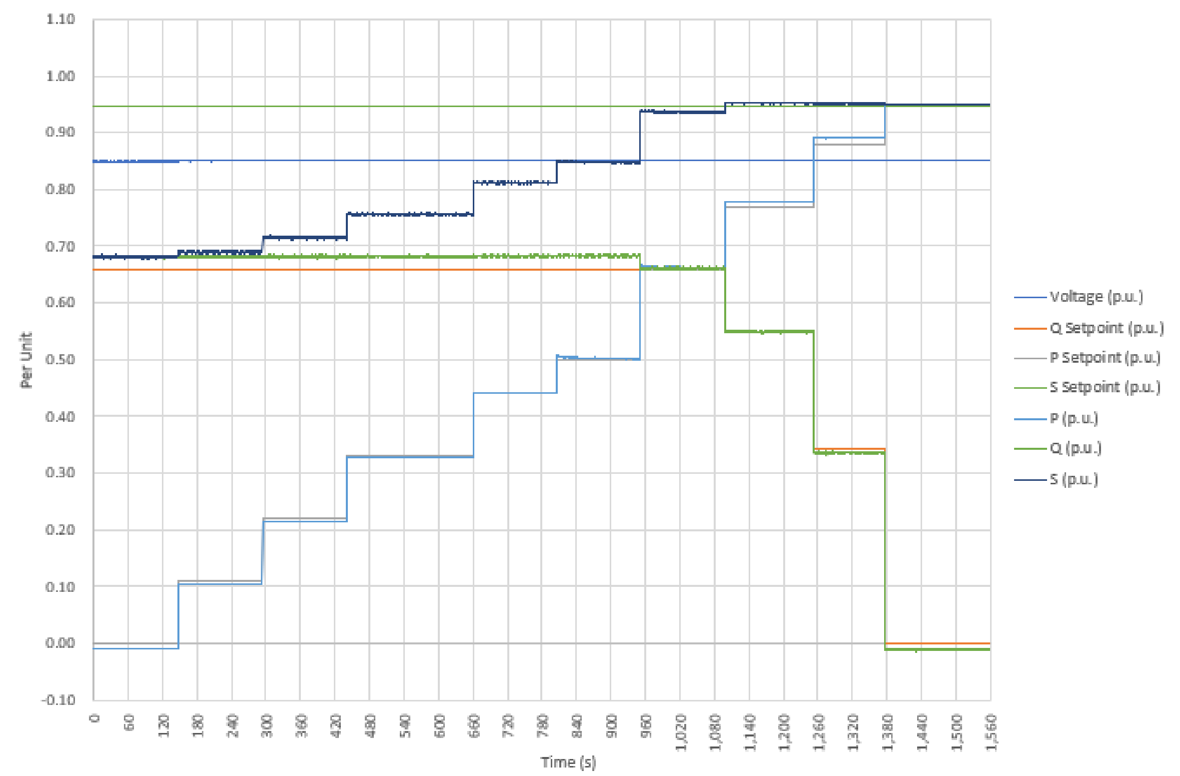
(*) Test performed in active power priority mode. Working at 85% Un the inverter does not reach the maximum 110% Sn due to the current limitation function. Maximum apparent power that can be reached corresponds to 94.5%Sn, approximately. Deviations are calculated in relation to this expected semicircular value.

Semicircular Curve (U = 85% Un) – Capacitive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA) (*)**	**S deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC+} (V)**	**Number of records**
0%	-0.871	-68.093	68.098	26.402	-0.013	338.6	1200
11%	10.340	-68.144	68.923	25.577	0.150	338.6	1200
22%	21.543	-68.179	71.501	22.999	0.301	338.7	1200
33%	32.739	-68.230	75.678	18.822	0.433	338.8	1200
44%	43.974	-68.295	81.227	13.273	0.541	338.9	1200
55%	55.263	-68.376	87.907	6.593	0.629	339.0	1200
66%	66.484	-67.297	94.605	-0.105	0.703	339.1	1200
77% (*)	77.696	-54.326	94.804	-0.304	0.819	339.2	1200
88% (*)	88.389	-34.824	94.990	-0.490	0.930	339.3	1200
94.5% (*)	95.100	-1.121	95.100	-0.600	1.000	339.4	1200

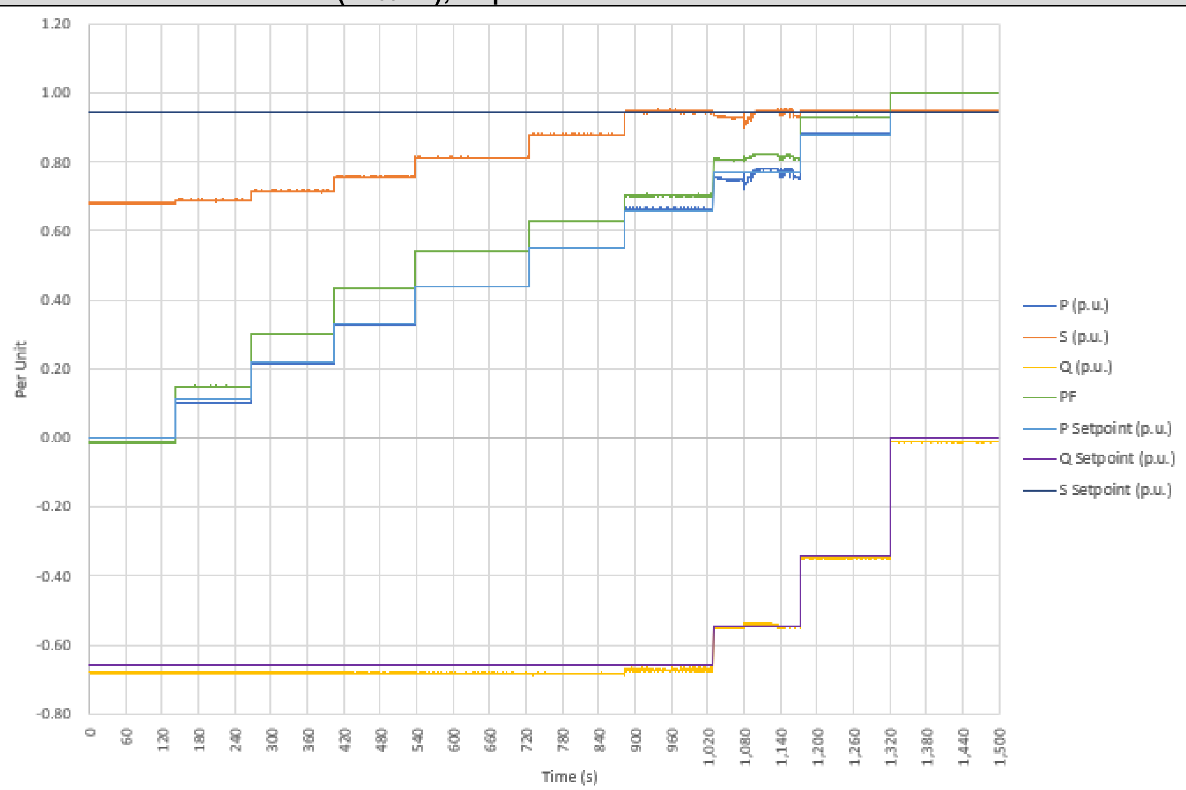
(*) Test performed in active power priority mode. Working at 85% Un the inverter does not reach the maximum 110% Sn due to the current limitation function. Maximum apparent power that can be reached corresponds to 94.5%Sn, approximately. Deviations are calculated in relation to this expected semicircular value.

In following graphs, test results are represented after the test has been performed:

Semicircular Curve (85%Un), Inductive side: Power Factor vs Powers over time



Semicircular Curve (85%Un), Capacitive side: Power Factor vs Powers over time



4.2.1.5.2 Test 2 (90 % Un)

Used settings of the measurement device for this voltage-dependant PQ diagram (90% Un) testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/27 to 2019/11/28	100 ms values	3 kHz

Tables below show measured values for each power step tested, at both the inductive and the capacitive sides:

Semicircular Curve (U = 90% Un) – Inductive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA) (*)**	**S deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC+} (V)**	**Number of records**
0%	0.071	65.819	65.819	34.181	0.001	359.0	1300
10%	10.200	65.798	66.588	33.412	0.154	359.1	1300
20%	20.200	65.790	68.829	31.171	0.294	359.1	1300
30%	30.200	65.750	72.359	27.641	0.418	359.2	1300
40%	40.200	65.730	77.051	22.949	0.522	359.3	1300
50%	50.200	65.710	82.691	17.309	0.607	359.3	1300
60%	60.200	65.697	89.096	10.904	0.676	359.4	1300
70%	70.131	65.686	96.100	3.900	0.730	359.5	1300
80%(*)	79.700	59.696	99.574	0.426	0.800	359.5	1300
90%(*)	90.027	43.653	100.000	0.000	0.900	359.6	1300
100%(*)	99.334	10.658	99.906	0.094	0.994	359.6	1300

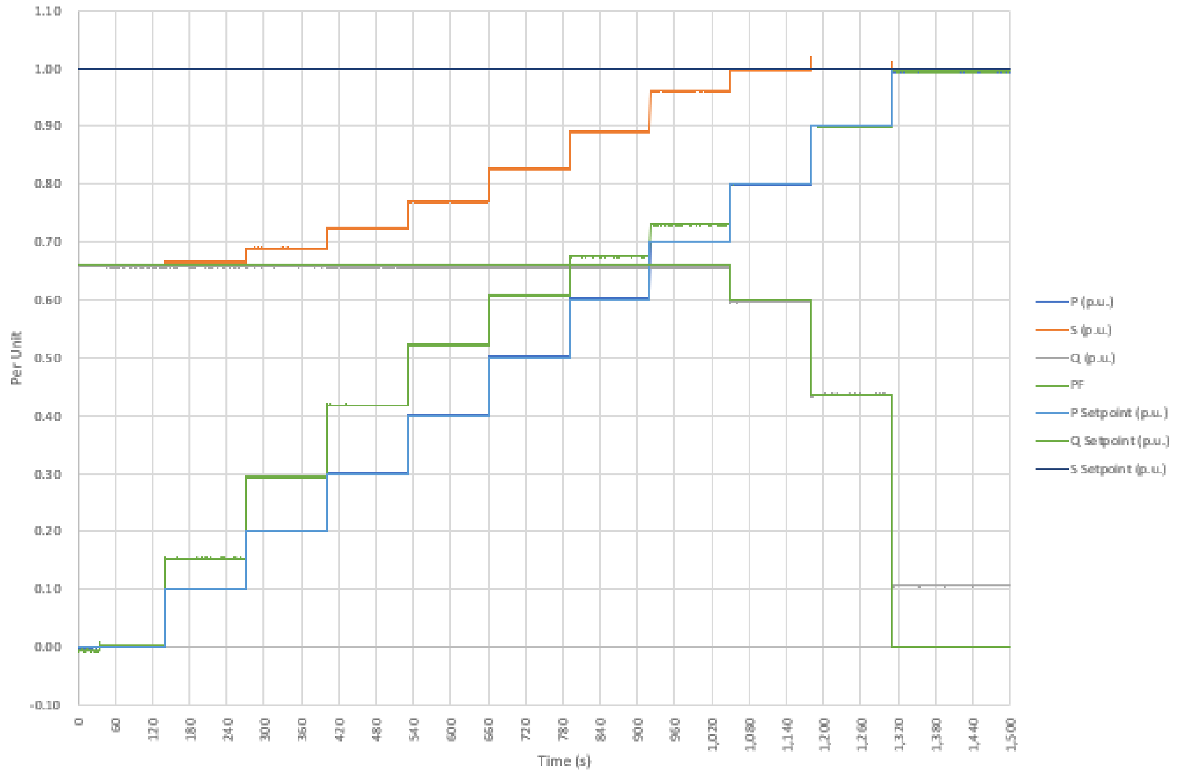
(*) Test performed in active power priority mode. Working at 90% Un the inverter does not reach the maximum 110% Sn due to the current limitation function. Maximum apparent power that can be reached corresponds to 100%Sn, approximately. Deviations are calculated in relation to this expected semicircular value.

Semicircular Curve (U = 90% Un) – Capacitive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA) (*)**	**S deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC+} (V)**	**Number of records**
0%	0.065	65.988	65.988	34.012	0.001	358.6	1300
10%	9.930	66.028	66.773	33.227	0.149	358.6	1300
20%	19.900	66.063	69.000	31.000	0.289	358.7	1300
30%	29.900	66.092	72.553	27.447	0.412	358.8	1300
40%	39.901	66.137	77.254	22.746	0.516	358.8	1300
50%	49.901	66.184	82.903	17.097	0.602	358.9	1300
60%	59.900	66.232	89.298	10.702	0.670	359.0	1300
70%	69.861	66.271	96.288	3.712	0.725	359.0	1300
80%(*)	79.320	60.372	99.686	0.314	0.795	359.1	1300
90%(*)	89.131	44.315	99.547	0.453	0.896	359.3	1300
100%(*)	99.122	11.324	99.776	0.224	0.994	359.5	1300

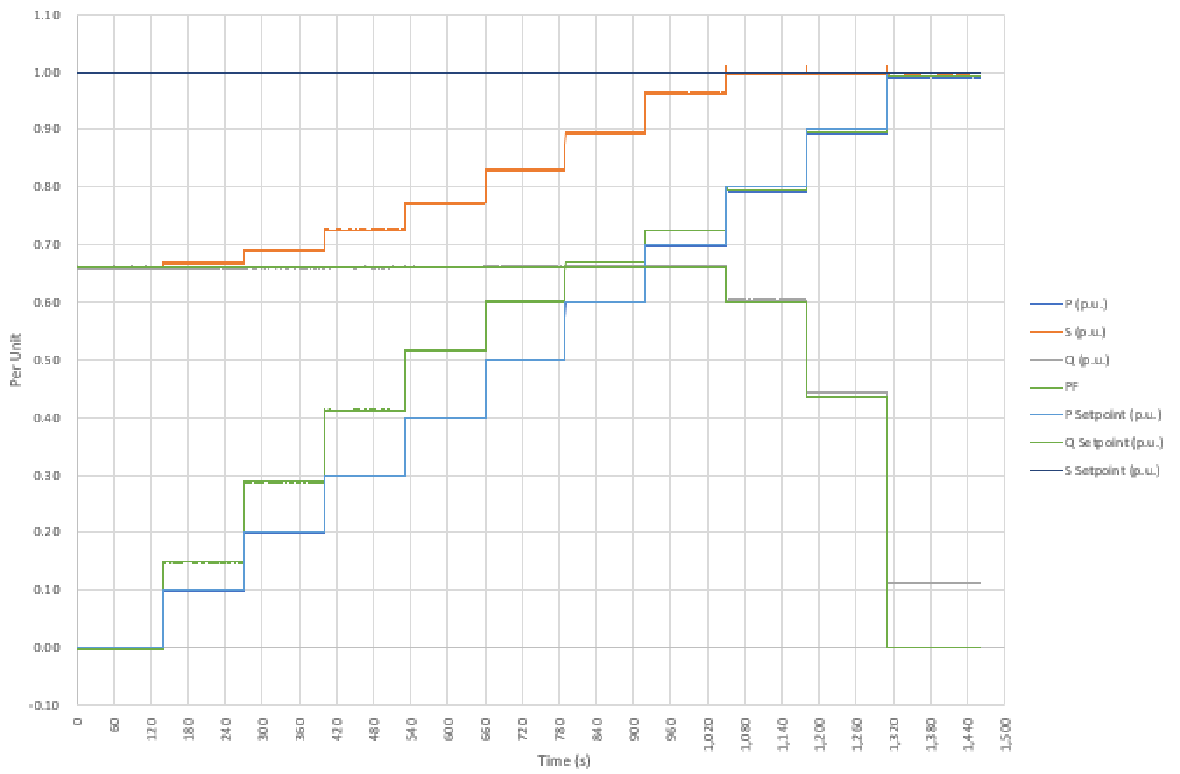
(*) Test performed in active power priority mode. Working at 90% Un the inverter does not reach the maximum 110% Sn due to the current limitation function. Maximum apparent power that can be reached corresponds to 100%Sn, approximately. Deviations are calculated in relation to this expected semicircular value.

In following graphs, test results are represented after the test has been performed:

Semicircular Curve (90%Un), Inductive side: Power Factor vs Powers over time



Semicircular Curve (90%Un), Capacitive side: Power Factor vs Powers over time



4.2.1.5.3 Test 3 (110 % Un)

Used settings of the measurement device for this voltage-dependant PQ diagram (110% Un) testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/25	100 ms values	3 kHz

Tables below show measured values for each power step tested, at both the inductive and the capacitive sides:

Semicircular Curve (U = 110% Un) – Inductive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA) (*)**	**S deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC+} (V)**	**Number of records**
0%	0.229	65.821	65.821	44.179	0.003	438.9	1200
10%	10.201	65.805	66.597	43.403	0.154	438.9	1200
20%	20.201	65.780	68.823	41.177	0.294	439.0	1200
30%	30.206	65.758	72.378	37.622	0.418	439.0	1200
40%	40.250	65.748	77.090	32.910	0.522	439.1	1200
50%	50.298	65.714	82.735	27.265	0.608	439.2	1200
60%	60.300	65.666	89.127	20.873	0.677	439.5	1200
70%	70.300	65.618	96.153	13.847	0.731	440.3	1200
80%	80.300	65.596	103.998	6.002	0.775	441.3	1200
90%(*)	90.400	62.659	110.000	0.000	0.822	439.1	1200
100%(*)	100.000	44.878	109.981	0.019	0.913	439.5	1200
110%(*)	109.823	0.141	109.823	0.177	1.000	439.6	1200

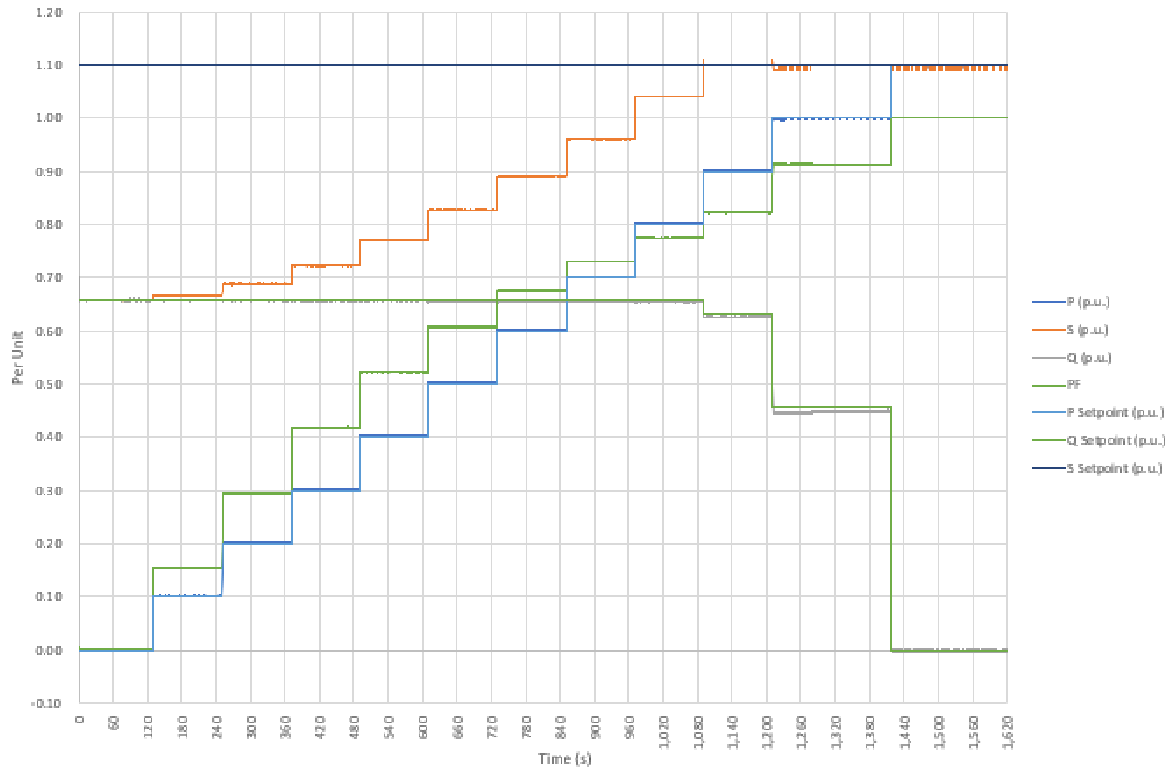
(*) Test performed in active power priority mode. Maximum apparent power that can be reached corresponds to 110%Sn, approximately. Deviations are calculated in relation to this expected semicircular value.

Semicircular Curve (U = 110% Un) – Capacitive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA) (*)**	**S deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC+} (V)**	**Number of records**
0%	0.131	66.208	66.208	43.792	0.003	438.6	1200
10%	9.890	66.232	66.967	43.033	0.147	438.7	1200
20%	19.908	66.268	69.193	40.807	0.286	438.7	1200
30%	29.925	66.313	72.752	37.248	0.410	438.8	1200
40%	39.935	66.355	77.445	32.555	0.514	438.9	1200
50%	49.954	66.388	83.083	26.917	0.600	438.9	1200
60%	59.954	66.390	89.454	20.546	0.669	439.0	1200
70%	69.967	66.417	96.470	13.530	0.725	439.0	1200
80%	80.003	66.454	104.003	5.997	0.769	439.1	1200
90%(*)	90.055	63.528	110.207	-0.207	0.817	439.1	1200
100%(*)	100.027	45.916	110.062	-0.062	0.909	439.3	1200
110%(*)	109.823	0.141	109.823	0.177	1.000	439.6	1200

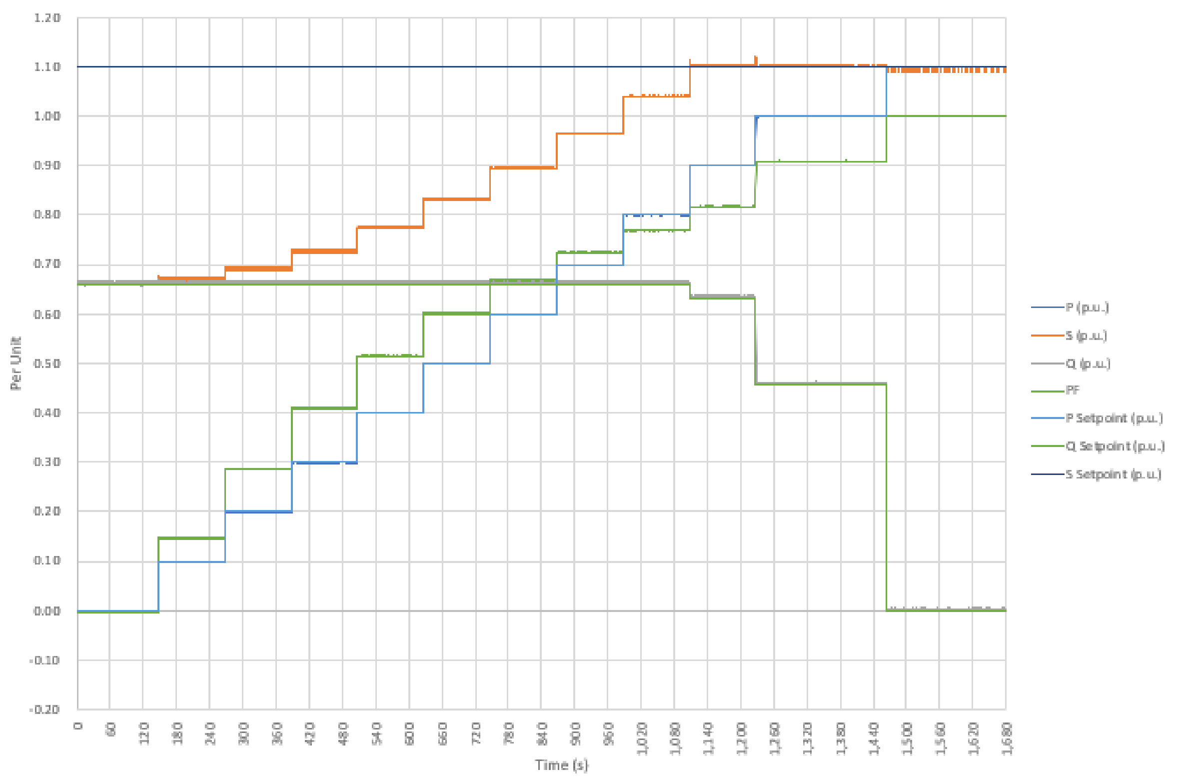
(*) Test performed in active power priority mode. Maximum apparent power that can be reached corresponds to 110%Sn, approximately. Deviations are calculated in relation to this expected semicircular value.

In following graphs, test results are represented after the test has been performed:

Semicircular Curve (110%Un), Inductive side: Power Factor and Powers over time



Semicircular Curve (110%Un), Capacitive side: Power Factor and Powers over time



4.2.1.5.4 Test 4 (120 % Un)

Used settings of the measurement device for this voltage-dependant PQ diagram (120% Un) testing.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/09/21 and 2020/09/27	100 ms values	3 kHz

Tables below show measured values for each power step tested, at both the inductive and the capacitive sides:

Semicircular Curve (U = 120% Un) – Inductive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA) (*)**	**S deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC+} (V)**	**Number of records**
0%	0.230	65.821	65.821	44.179	0.003	480.7	1200
10%	10.201	65.807	66.599	43.401	0.154	480.8	1200
20%	20.200	65.778	68.820	41.180	0.294	480.9	1200
30%	30.206	65.759	72.378	37.622	0.418	480.9	1200
40%	40.248	65.746	77.085	32.915	0.522	481.0	1200
50%	50.298	65.709	82.730	27.270	0.608	481.1	1200
60%	60.300	65.659	89.122	20.878	0.676	481.4	1200
70%	70.300	65.615	96.153	13.847	0.731	482.3	1200
80%	80.300	65.599	104.000	6.000	0.774	483.5	1200
90%(*)	90.400	62.663	110.000	0.000	0.822	481.0	1200
100%(*)	99.984	45.004	110.000	0.000	0.912	481.5	1200
110%(*)	110.399	-0.428	110.400	-0.400	1.000	479.1	1200

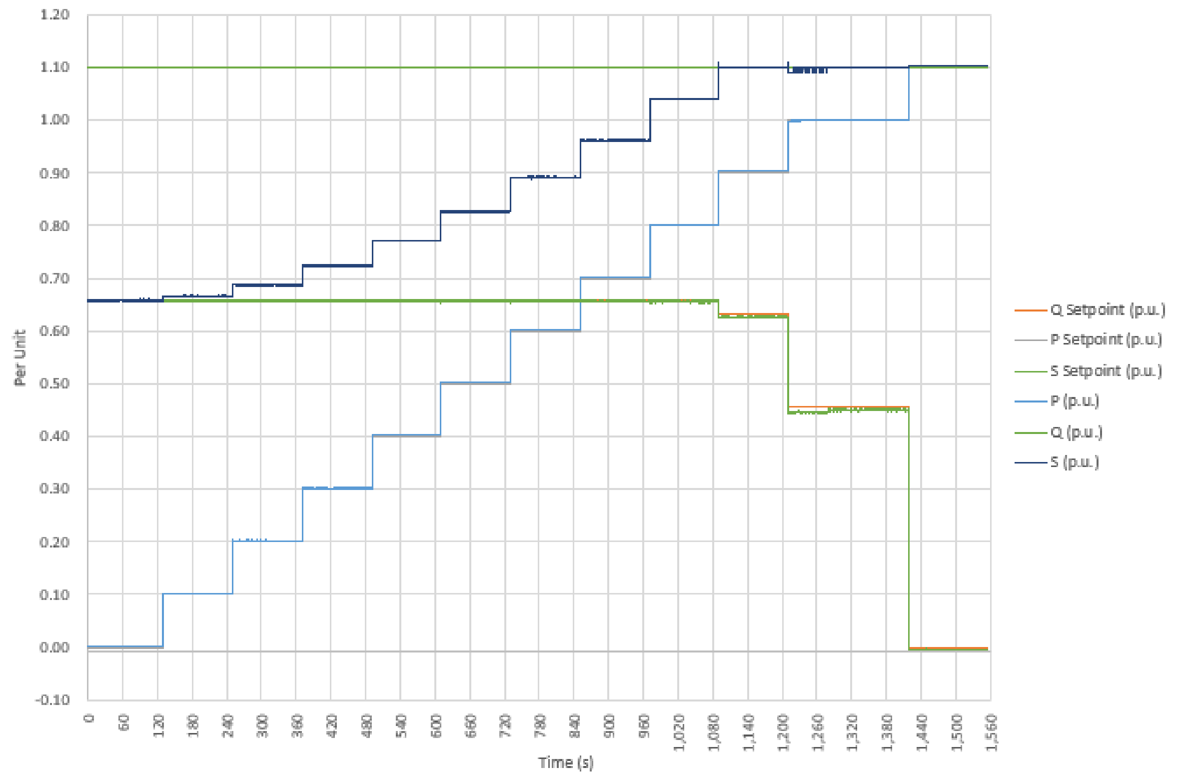
(*) Test performed in active power priority mode. Maximum apparent power that can be reached corresponds to 110%Sn, approximately. Deviations are calculated in relation to this expected semicircular value.

Semicircular Curve (U = 120% Un) – Capacitive							
P Desired (%Pn)	**P measured (kW)**	**Q measured (kVAr)**	**S measured (kVA) (*)**	**S deviation (kVA)**	**Power Factor (cos φ)**	**V_{AC+} (V)**	**Number of records**
0%	-0.126	-66.208	66.208	43.792	-0.002	478.5	1200
10%	9.892	-66.230	66.966	43.034	0.148	478.6	1200
20%	19.900	-66.273	69.199	40.801	0.288	478.6	1200
30%	29.903	-66.315	72.755	37.245	0.411	478.7	1200
40%	39.913	-66.356	77.447	32.553	0.516	478.8	1200
50%	49.954	-66.383	83.081	26.919	0.601	478.8	1200
60%	59.956	-66.390	89.455	20.545	0.670	478.9	1200
70%	69.984	-66.413	96.471	13.529	0.725	478.9	1200
80%	80.000	-66.457	104.000	6.000	0.769	479.0	1200
90%(*)	90.069	-63.529	110.000	0.000	0.817	479.1	1200
100%(*)	99.984	-45.922	110.000	0.000	0.909	479.2	1200
110%(*)	110.399	-0.428	110.400	-0.400	1.000	479.1	1200

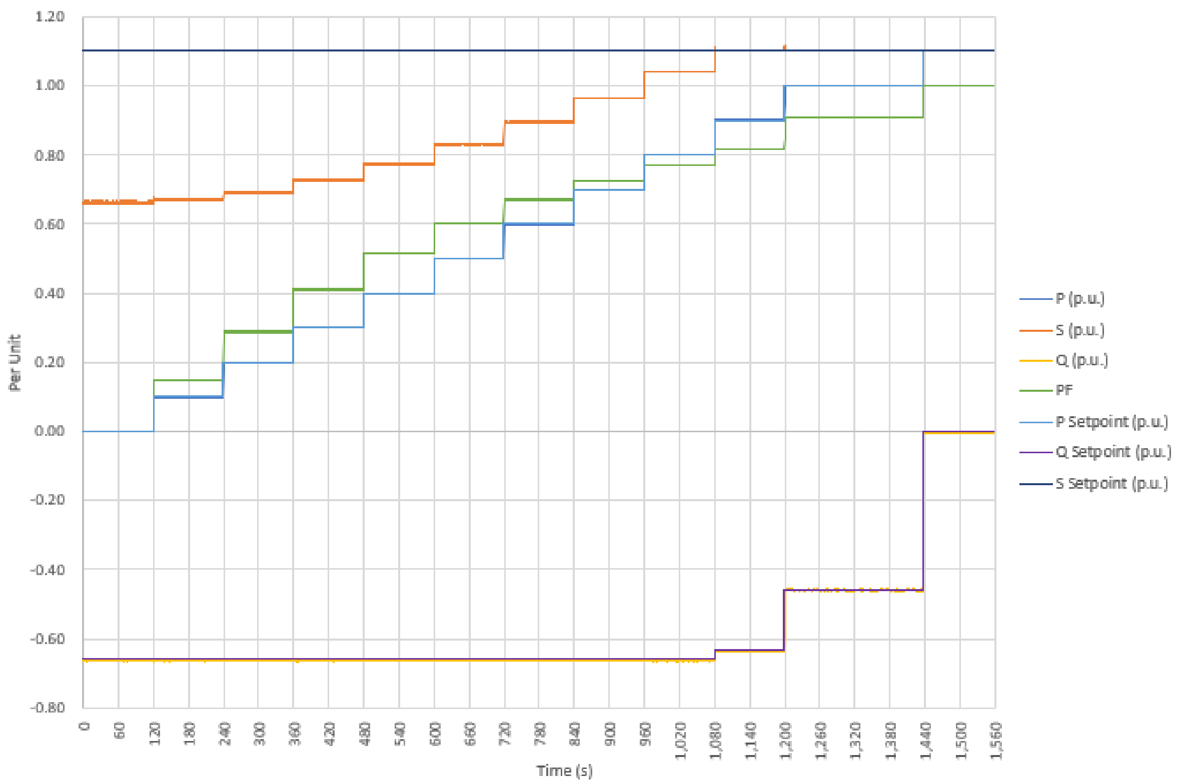
(*) Test performed in active power priority mode. Maximum apparent power that can be reached corresponds to 110%Sn, approximately. Deviations are calculated in relation to this expected semicircular value.

In following graphs, test results are represented after the test has been performed:

Semicircular Curve (110%Un), Inductive side: Power Factor and Powers over time



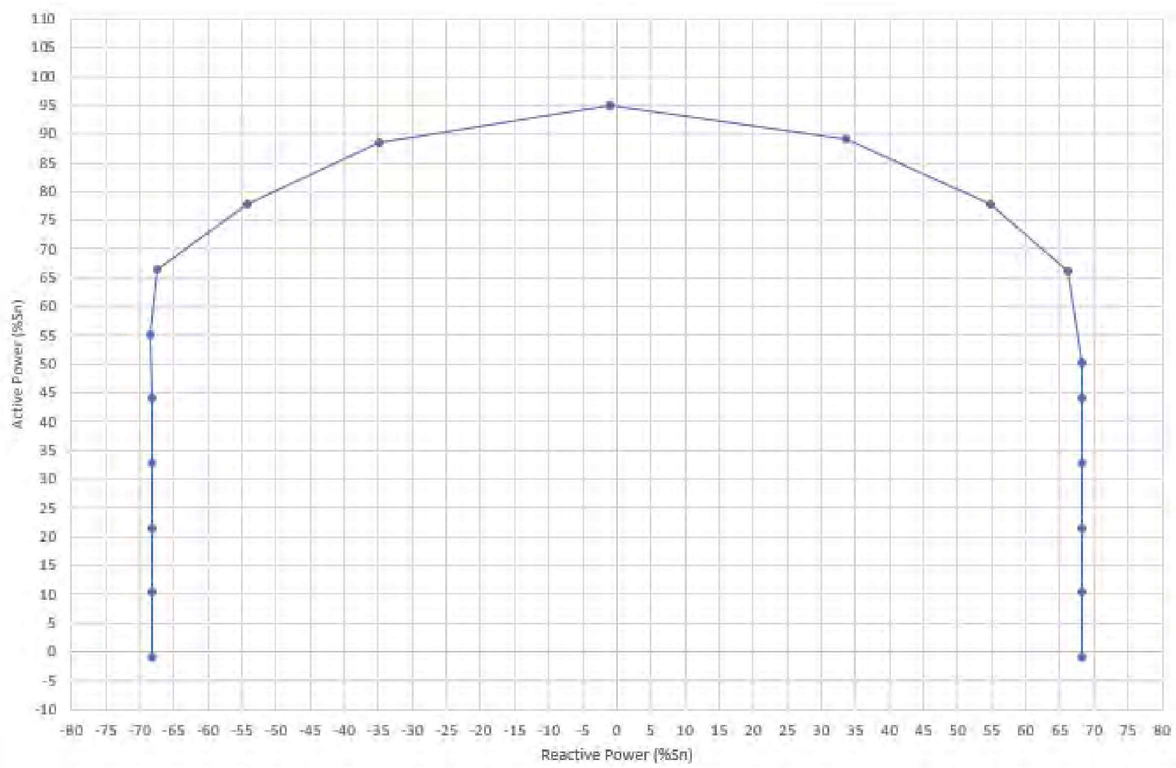
Semicircular Curve (110%Un), Capacitive side: Power Factor and Powers over time



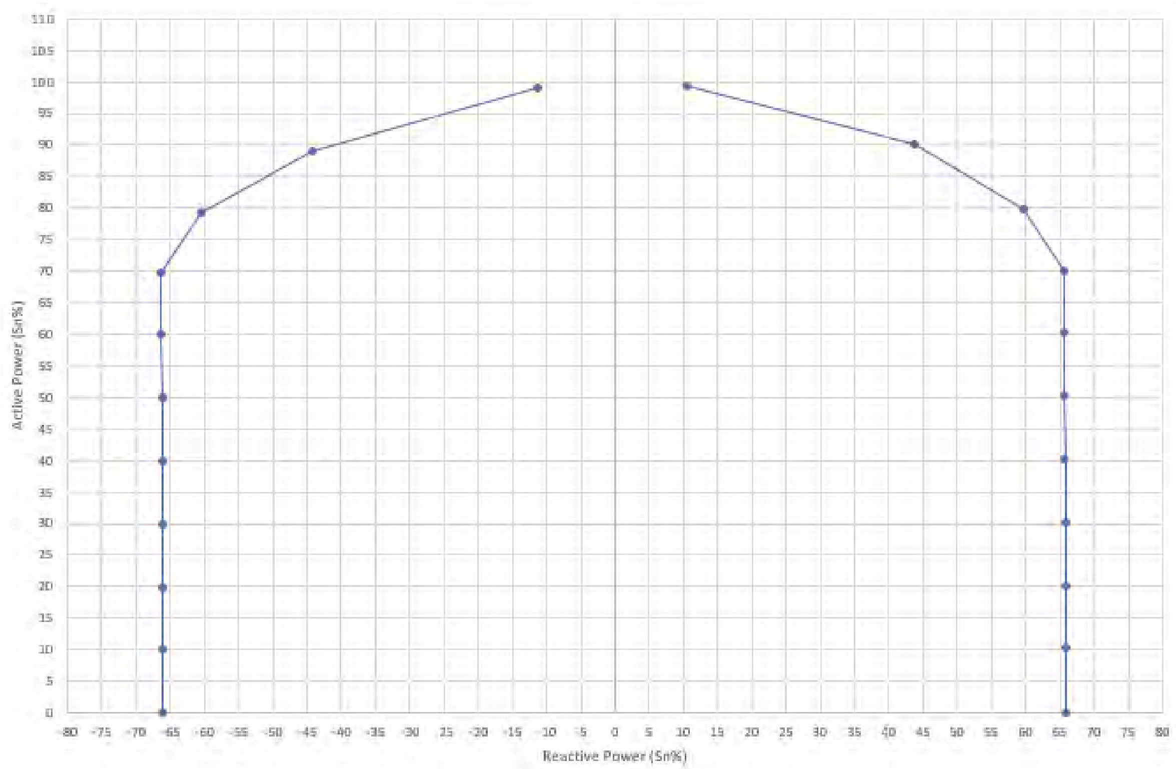
4.2.1.5.5 Voltage-Dependent PQ diagram: resume of results

In following graphs, semicircular curves are represented for tests above detailed.

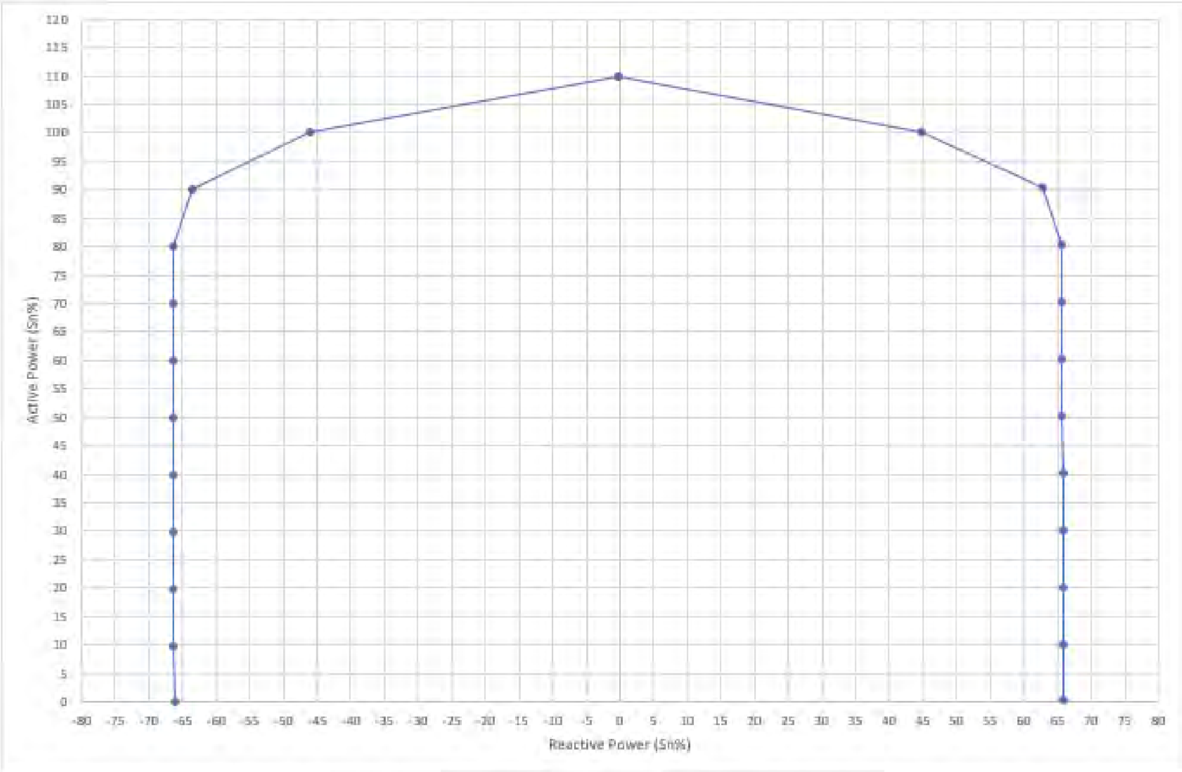
Semicircular Curve (85%Un): Active Power over Reactive Power



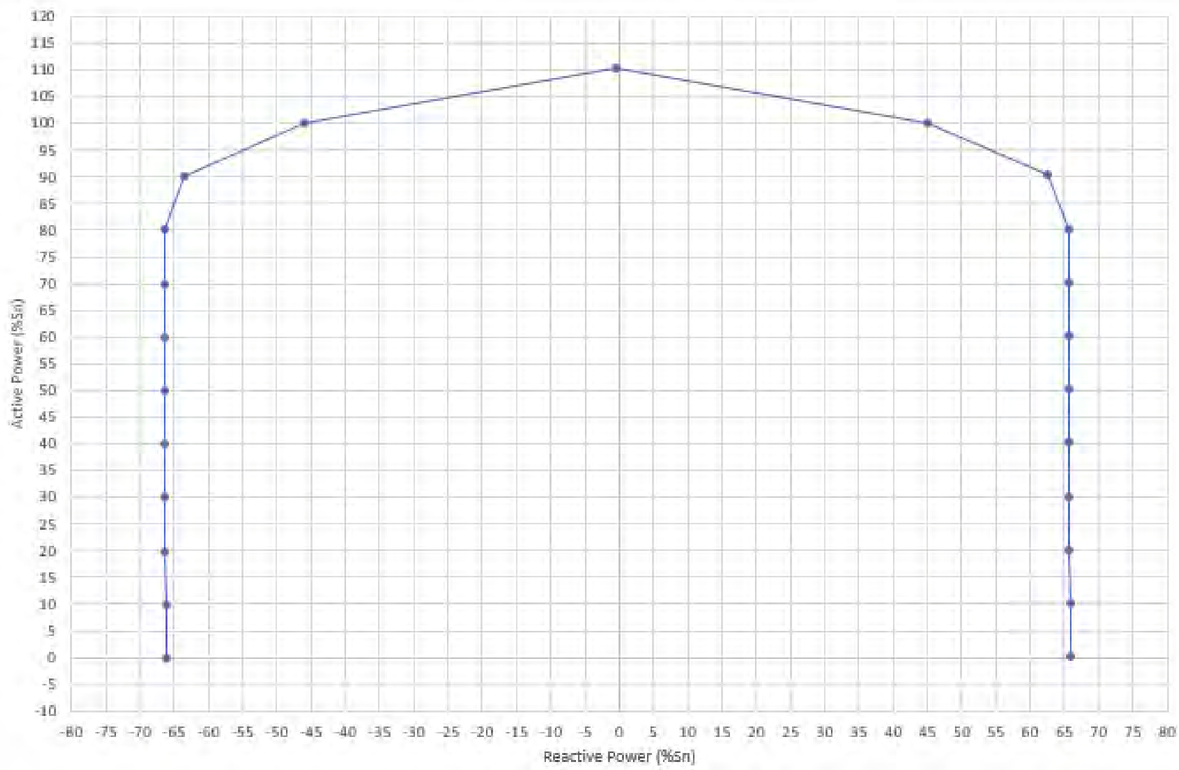
Semicircular Curve (90%Un): Active Power over Reactive Power



Semicircular Curve (110%Un): Active Power over Reactive Power



Semicircular Curve (120%Un): Active Power over Reactive Power



4.2.2 Reactive Power Following Setpoints

The aim of this test is to determine the PGU's reaction to the reactive power setpoint input in relation to the setting accuracy and the settling time.

The required testing has been performed according to the point 4.2.4 of the standard. It can be applied to both PV and storage systems

Different reactive power Q setpoint signals were applied to the inverter in order to verify the proper behavior working at different active power levels. In addition, it was verified the capability of the inverter to set different setting values for the time response.

For all test, the displacement factor, the active power and the reactive power measurements in the positive phase sequence system have been represented as 100 milisecond means for every setpoint step.

Interface information	
Interface used	RS485
Interface version used	SmartLogger V200R002
Other interfaces in the equipment	SUN 2000APP:3.2.00.002
Name or code of the parameter for Reactive power setpoint & settling time	Reactive Power Control of setting value Reactive power change gradient for configuration of settling time
If the EUT has several different interfaces for defining the setpoint, it has been tested the interface returning the most unfavourable results according to the manufacturer information.	

EUT Settings used for this test are provided in the following table:

EUT Settings	
Operanting mode	Reactive power priority
Active control modes	Active power control LVRT mode Fixed Reactive power control

Test results are offered in following points.

4.2.2.1 Determining the settling time

Different tests have been performed at two different reactive power levels:

- Test 1: P=50%Pn, Q=100%Pn (settling time shortest as possible); Configured time setting value: 1 s
- Test 2: P=50%Pn, Q=50%Pn (settling time shortest as possible); Configured time setting value: 1 s
- Test 3: P=50%Pn, Q=100%Pn (settling time longest as possible); Configured time setting value: 60 s

(Due to the maximum reactive power range lies within an active power level of 66 %Pn).

Time setting values that may be parametrized in the control as given by manufacturer's specifications: Range from 1 to 60 s

The following table shows de reactive power range:

Q range at 50% P_n	66 % Pn
Maximum Q range	66 % Pn
Note: Maximum power range can achieved with an Active power of 75 %Pn.	

- **Test 1: Active power at 50 %Pn**

Operating at this active power level, the inverter was subjected to following reactive power step changes providing its maximum Q level available corresponding to 66%Pn.

Step	Comments	
1	t_1 = 0 s	Recording is started
2	t_2 = 10 s	Setting the setpoint to the maximum possible reactive power in overexcited operation with the selected active power level $Q_{max,oe}$
3	$t_3 \geq t_2 + t_{settling}$ + 10 s	Setting the setpoint to the maximum possible reactive power in underexcited operation with the selected active power level $Q_{max,ue}$
4	$t_4 \geq t_3 + t_{settling}$ + 10 s	Setpoint set to cosφ = 1 (Q=0)
5	$t_5 \geq t_4 + t_{settling}$ + 10 s	Recording is stopped

The settling time for this test was set to be the shortest as possible (but no longer than 6s) corresponding to 1 seconds, approximately.

- **Test 2: Active power at 50 %Pn**

Operating at this active power level, the inverter was subjected to following reactive power step changes providing its 50% maximum Q level available corresponding to 33%Pn.

Step	Comments	
1	$t_1 = 0$ s	Recording is started
2	$t_2 = 10$ s	Setting the setpoint to the maximum possible reactive power in overexcited operation with the selected active power level 50%$Q_{max,oe}$
3	$t_3 \geq t_2 + t_{settling} + 10$ s	Setting the setpoint to the maximum possible reactive power in underexcited operation with the selected active power level 50%$Q_{max,ue}$
4	$t_4 \geq t_3 + t_{settling} + 10$ s	Setpoint set to cosφ = 1 (Q=0)
5	$t_5 \geq t_4 + t_{settling} + 10$ s	Recording is stopped

The settling time for this test was set to be the shortest as possible (but no longer than 6s) corresponding to 1 seconds, approximately.

- **Test 3: Active power at 50 %Pn**

The same testing procedure as detailed in test 1 was repeated but adjusted the settling time for to be the longest as possible (but no longer than 60 seconds) corresponding to 60 seconds, approximately.

Used settings of the measurement device for the testing of reactive power following setpoins (Settling time). According to the standard, measurements must be taken every 20 ms.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/01/19 to 2020/01/21	100 ms values	3 kHz

Test results are offered in following points:

The settling time for all steps is determined and given while taking the ±5%Pn tolerance band into consideration.

4.2.2.1.1 Test 1

The following table show test results of the settling time determined after each step.

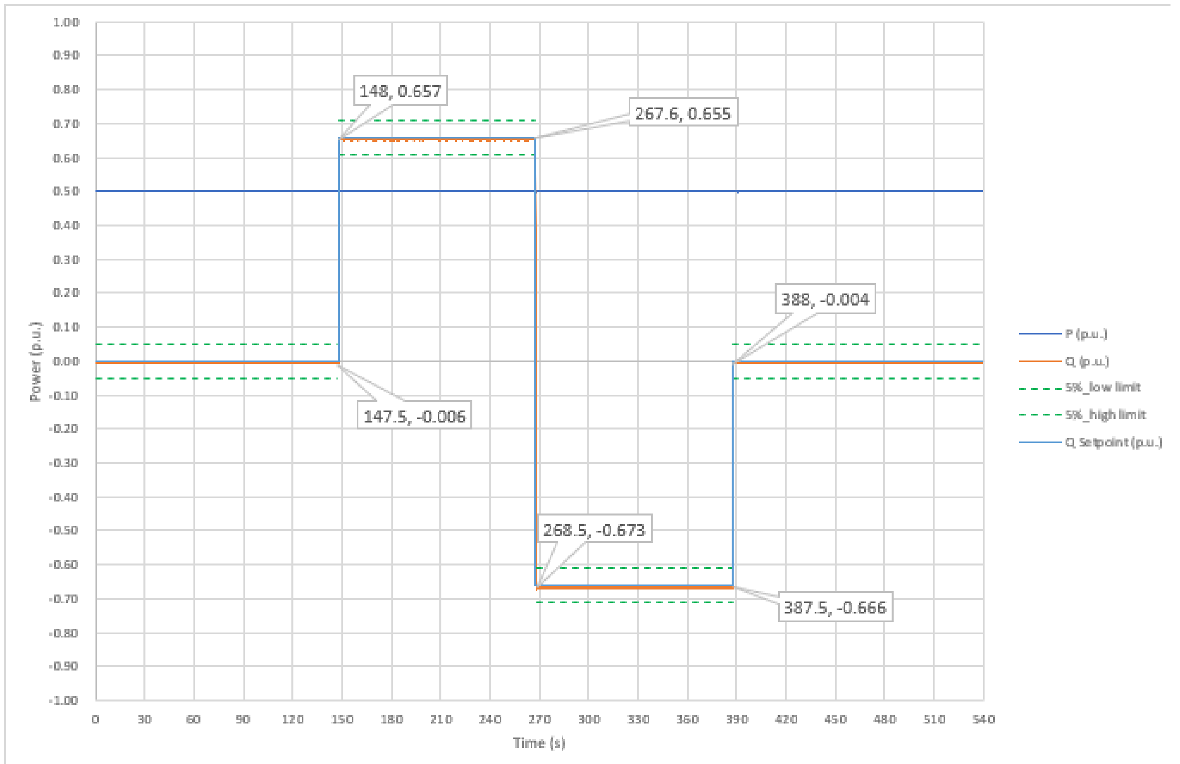
Settling time (shortest possible)						
Power		Reactive Power Steps		Point in time of setpoint Change (s)	Point in time of settling (s)	Time Difference / Settling time(*) (s)
Desired (% Pn)	Measured (% Pn)	Step	Description			
50%	50.0%	1	0% Q_{max}	--	--	--
		2	0% Q_{max} → +100% Q_{max}	147.5	148.0	0.5
		3	+100% Q_{max} → -100% Q_{max}	267.6	268.5	0.9
		4	-100% Q_{max} → 0% Q_{max}	387.5	388.0	0.5
		5	0% Q_{max}	--	--	--

Longest measured setting time (s)(*)	0.9

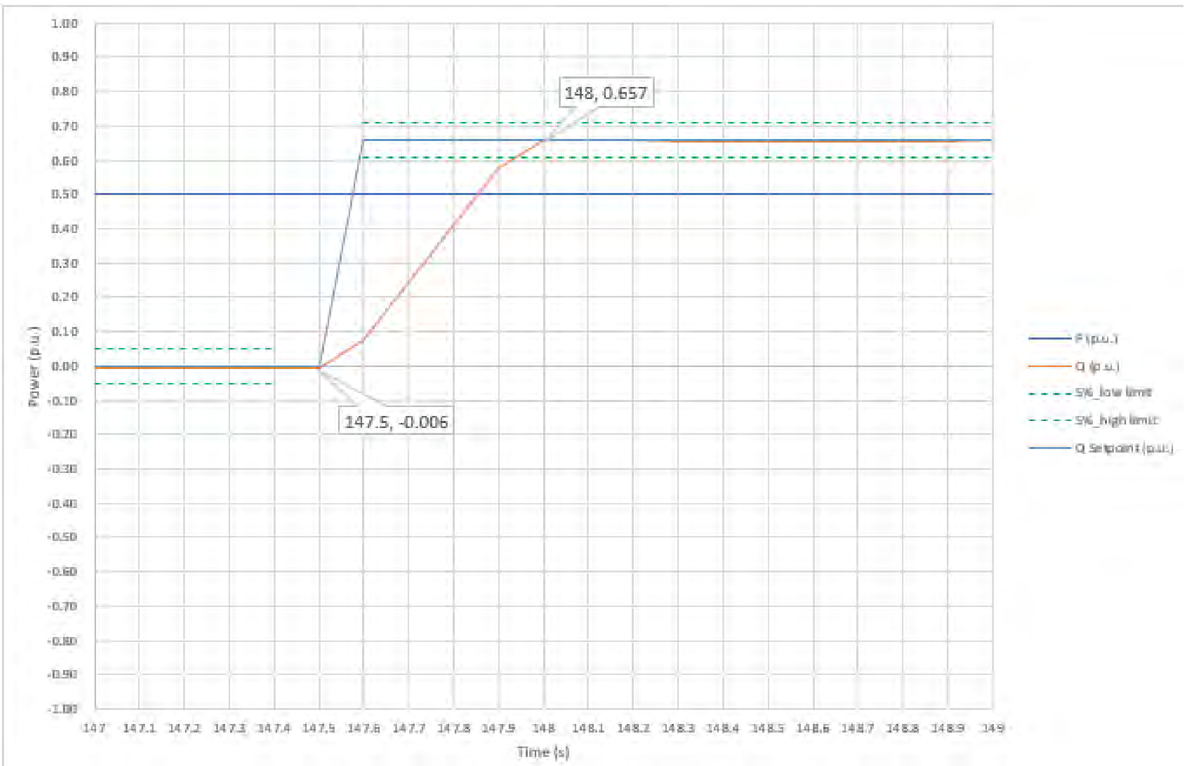
(*)Note: It is less than 200ms form the unit received the signal to the output power begin to change.

In following graphs, test results are represented after the test has been performed:

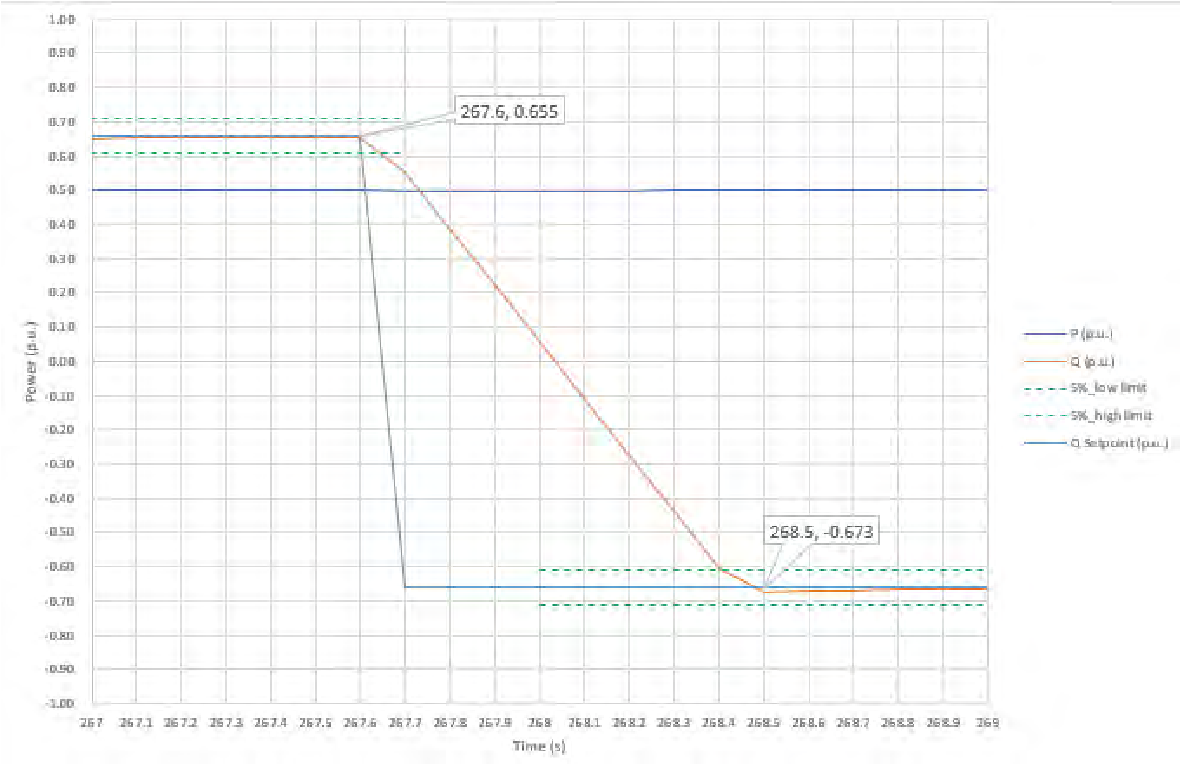
Test over Time



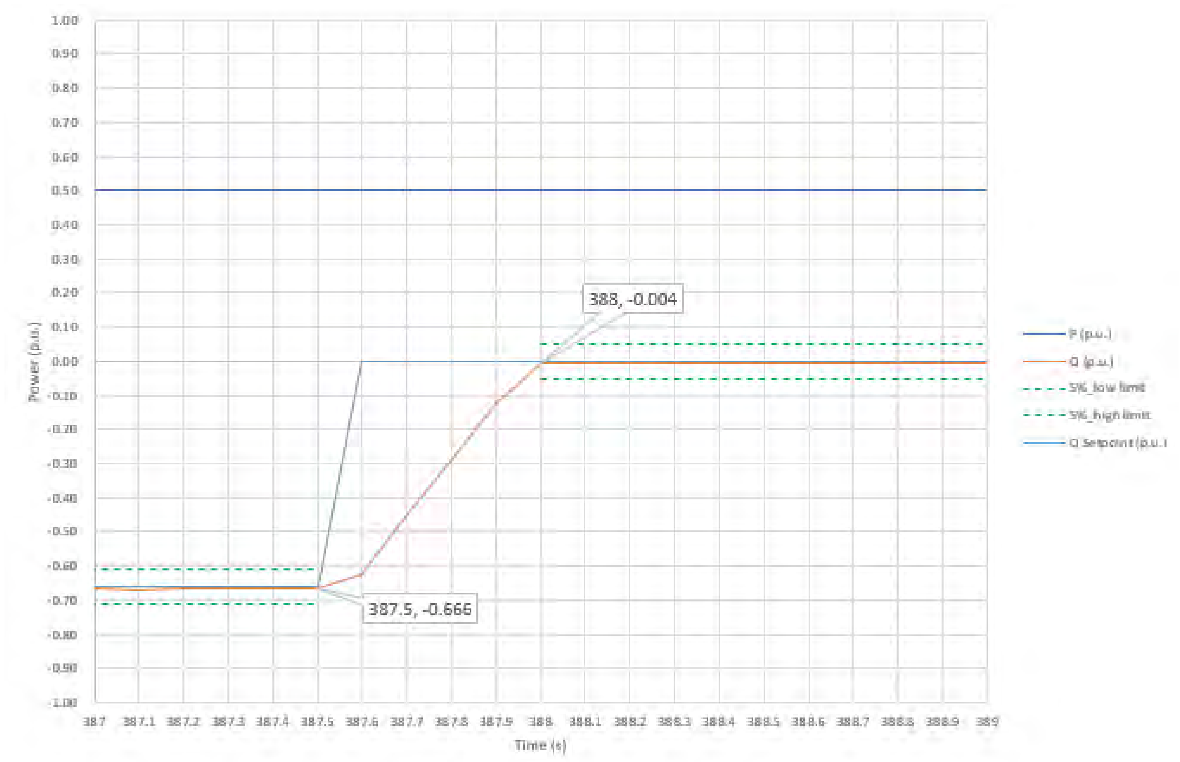
Test 1: zoom time of the step 2



Test 1: zoom time of the step 3



Test 1: zoom time of the step 4



4.2.2.1.2 Test 2

The following table show test results of the settling time determined after each step.

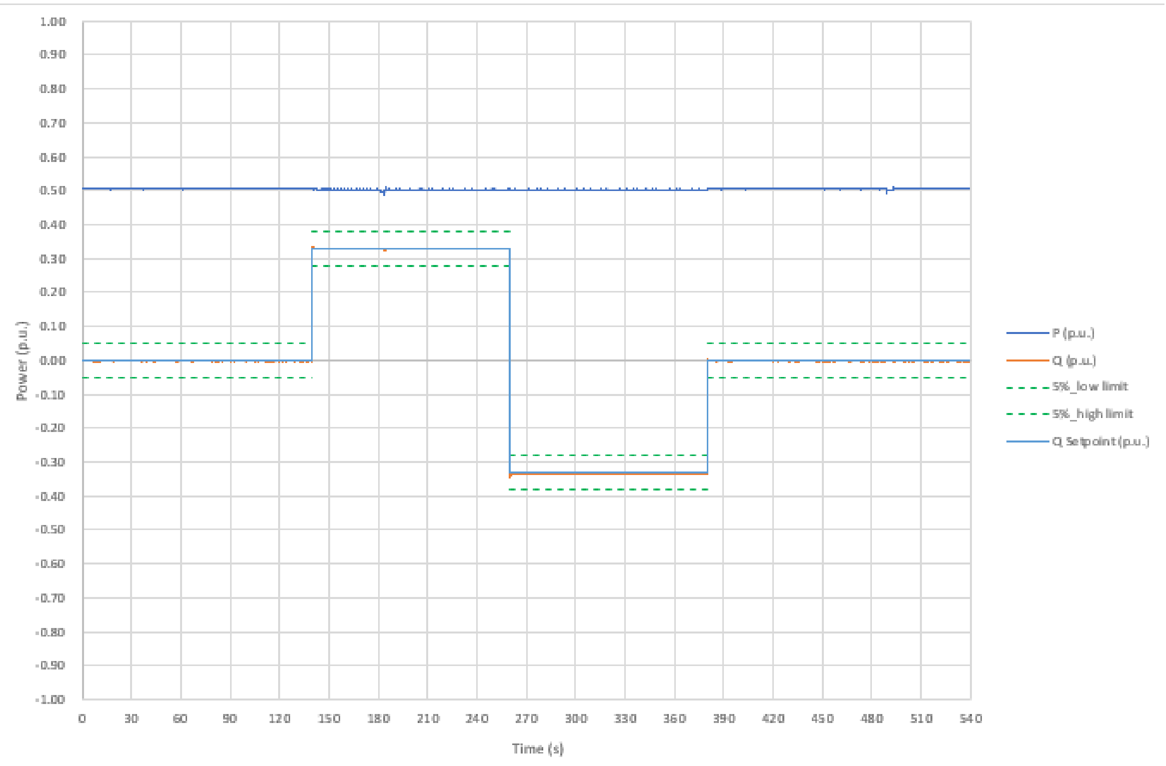
Settling time (shortest possible)						
Power		Reactive Power Steps		Point in time of setpoint Change (s)	Point in time of settling (s)	Time Difference (s)(*)
Desired (% Pn)	Measured (% Pn)	Step	Description			
50.0%	50.0%	1	0% Q_{max}	--	--	--
		2	0% Q_{max} → +50.0% Q_{max}	139.9	140.1	0.2
		3	+50.0% Q_{max} → -50.0% Q_{max}	259.8	260.1	0.3
		4	-50.0% Q_{max} → 0% Q_{max}	379.9	380.0	0.1
		5	0% Q_{max}	--	--	--

Longest measured setting time (s)(*)	0.3

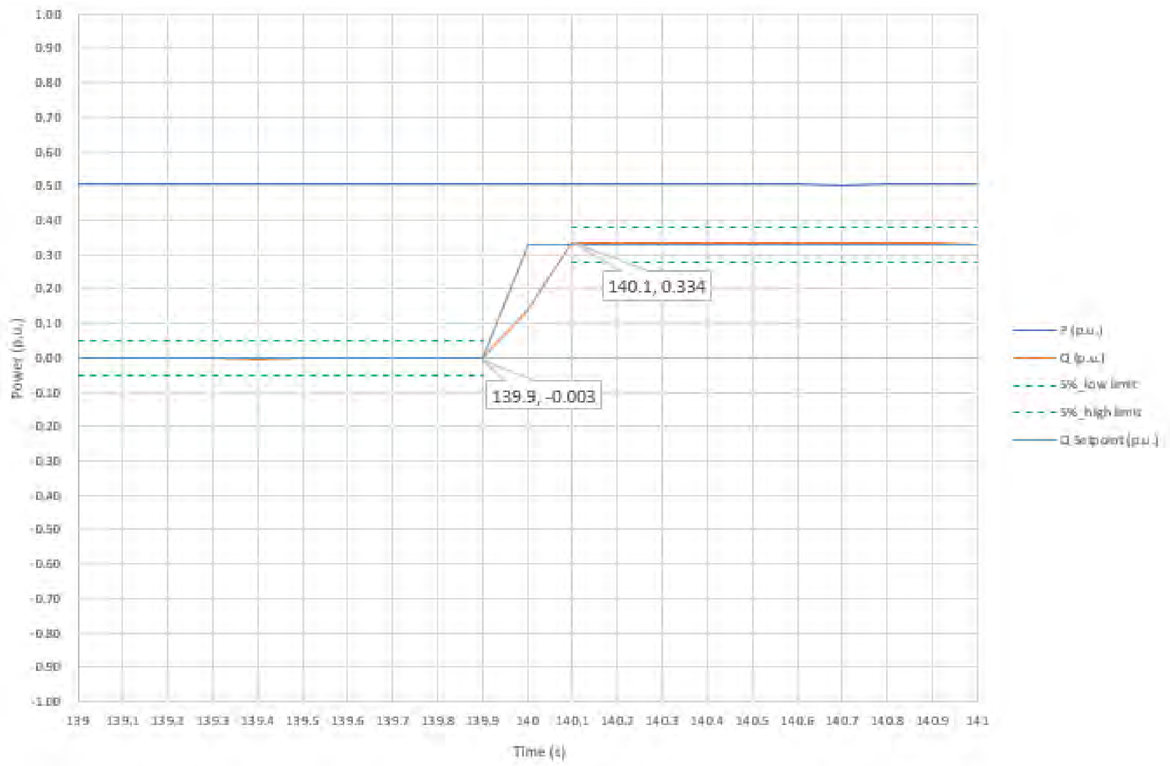
(*)Note: It is less than 200ms form the unit received the signal to the output power begin to change.

In following graphs, test results are represented after the test has been performed:

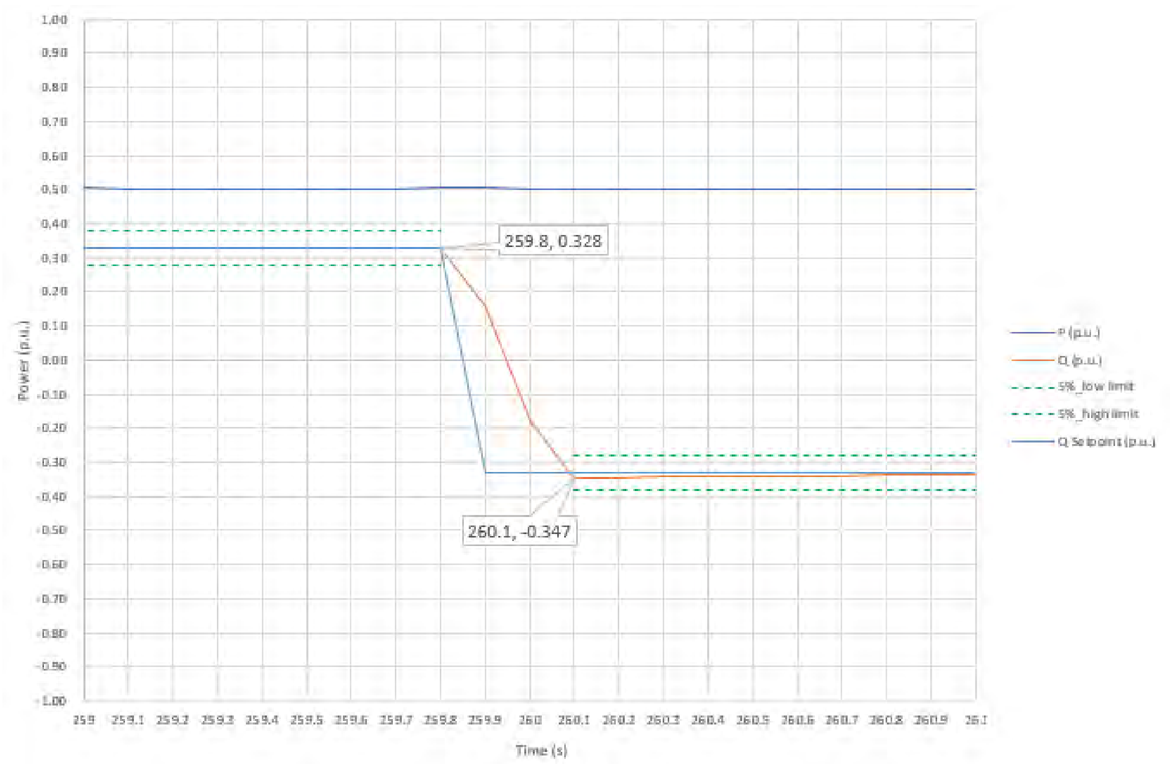
Test over Time



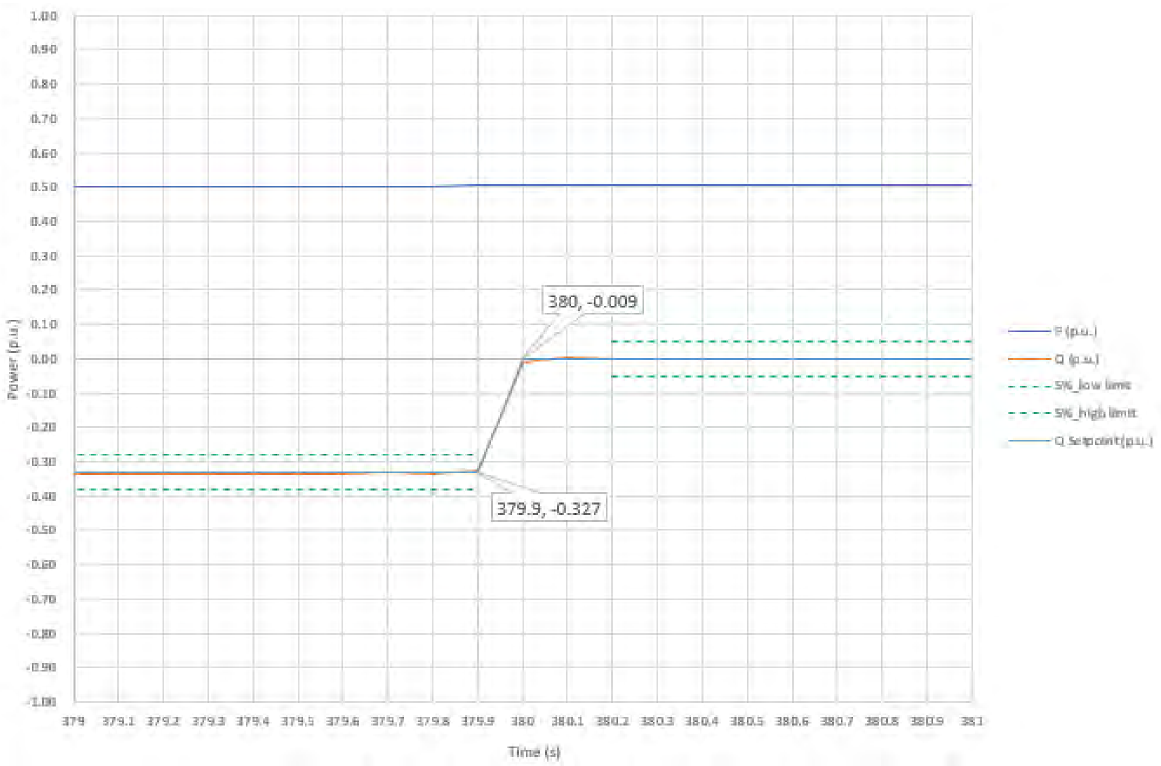
Test 2: zoom time of the step 2



Test 2: zoom time of the step 3



Test 2: zoom time of the step 4



4.2.2.1.3 Test 3

The following table show test results of the settling time determined after each step.

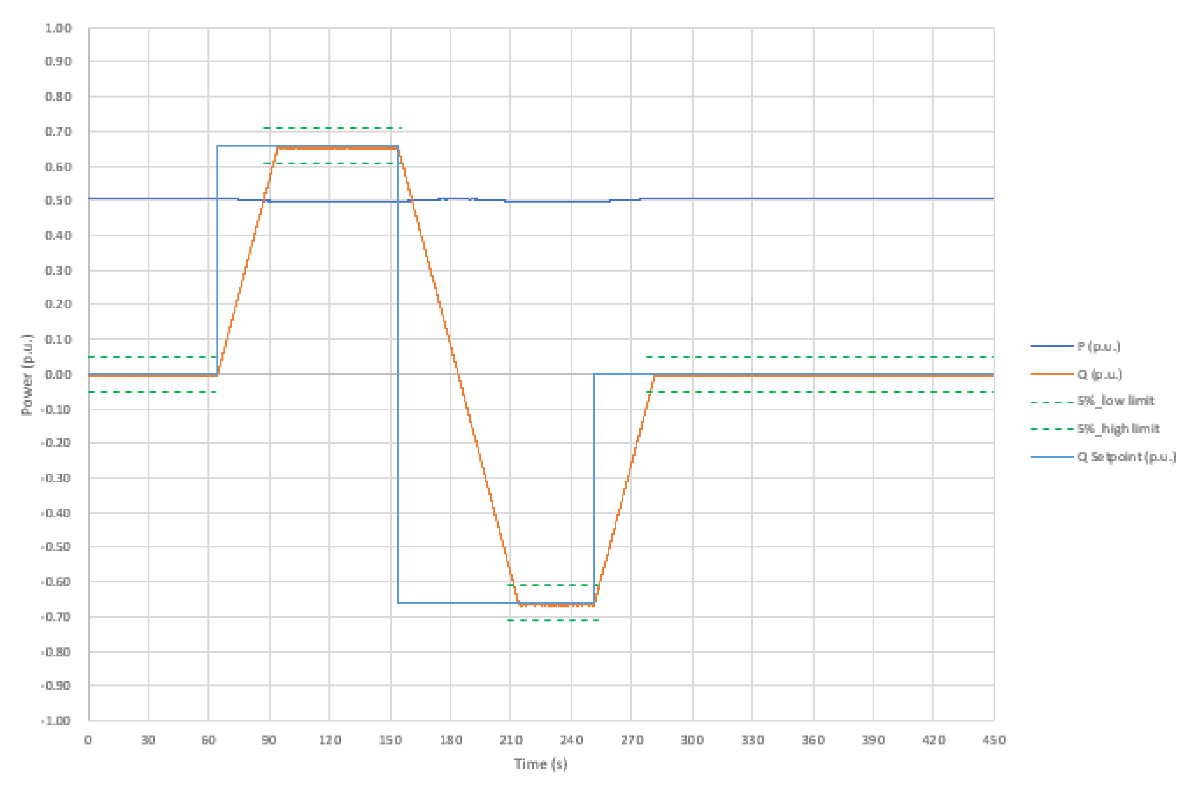
Settling time (longest possible but lower than 60 seconds)						
Power		Reactive Power Steps		Point in time of setpoint Change (s)	Point in time of settling (s)	Time Difference (s)(*)
Desired (% Pn)	Measured (% Pn)	Step	Description			
50.0%	50.0%	1	0% Q_{max}	--	--	--
		2	0% Q_{max} → +100.0% Q_{max}	62.4	92.3	29.9
		3	+100.0% Q_{max} → -100.0% Q_{max}	154.1	211.6	57.5
		4	-100.0% Q_{max} → 0% Q_{max}	251.6	279.5	27.9
		5	0% Q_{max}	--	--	--

Longest measured setting time (s)(*)	57.5

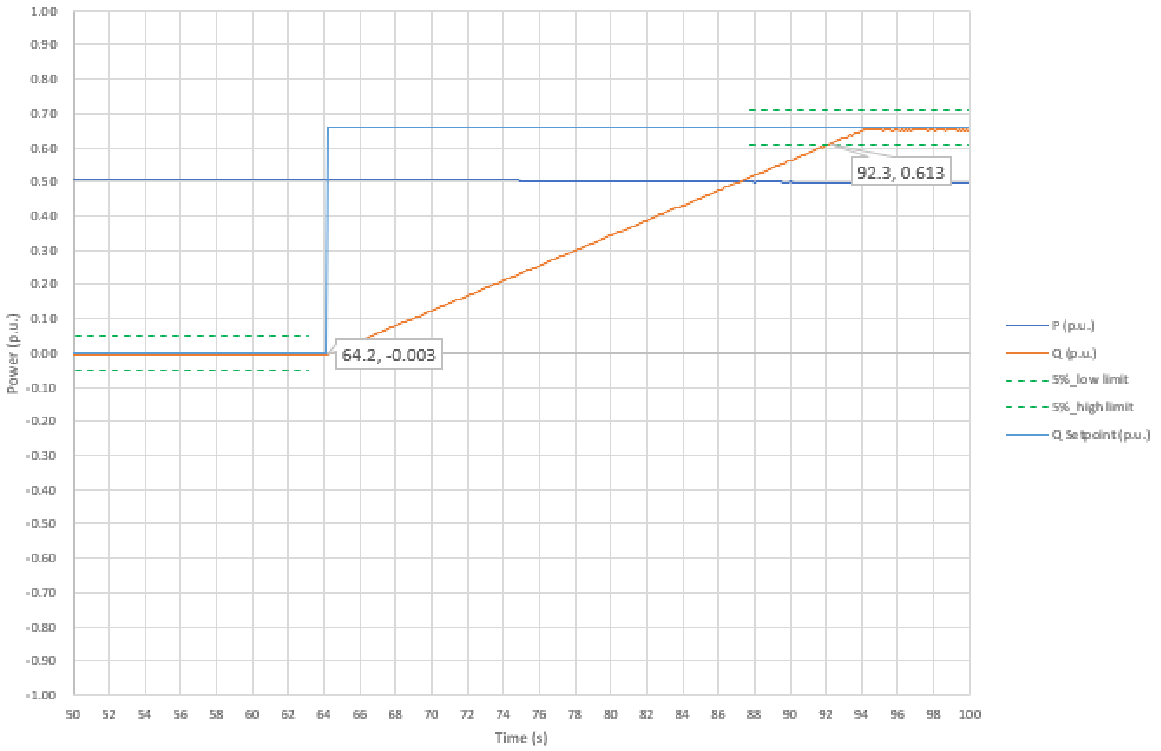
(*)Note: It is less than 200ms form the unit received the signal to the output power begin to change.

In following graphs, test results are represented after the test has been performed:

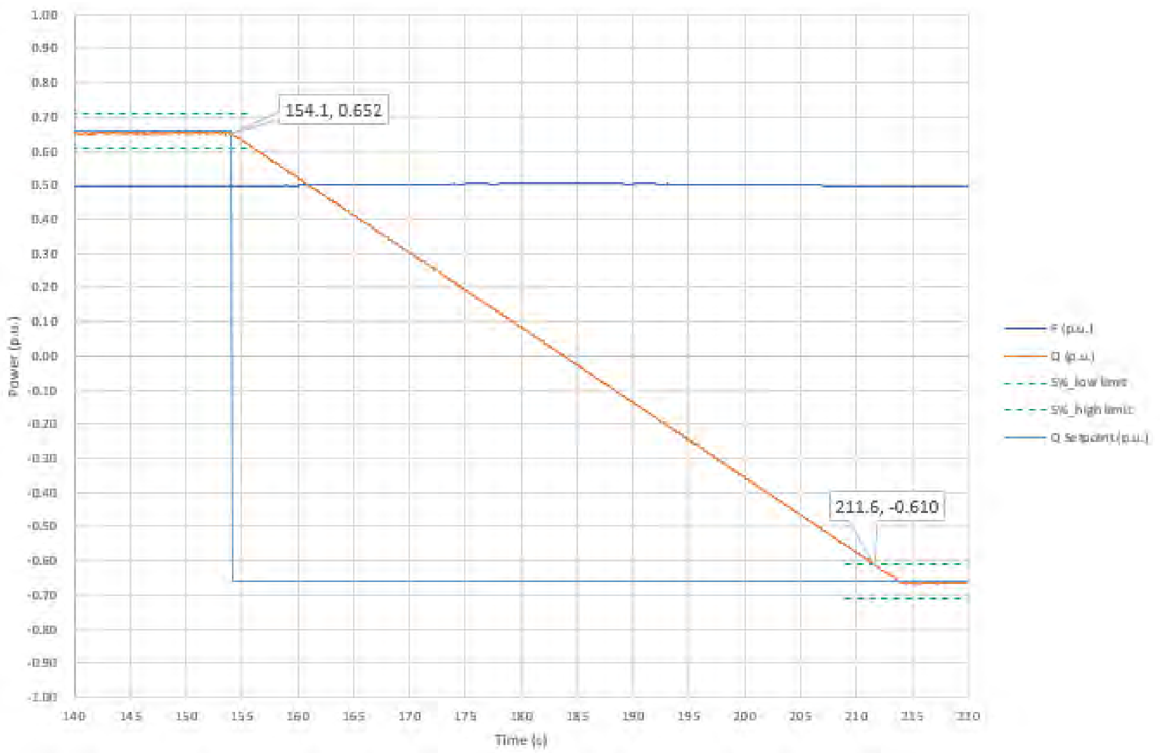
Test over Time



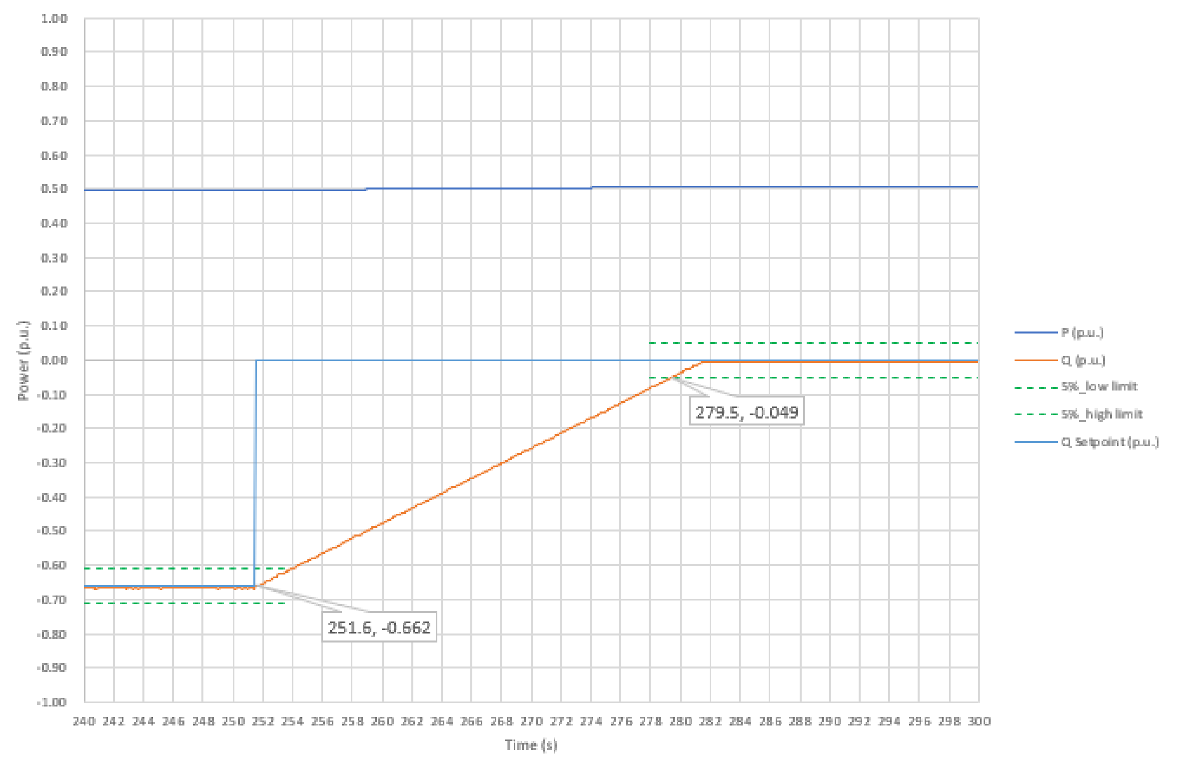
Test 3: zoom time of the step 2



Test 3: zoom time of the step 3



Test 3: zoom time of the step 4



4.2.2.2 Determining the setting accuracy

It has been been done the following steps measuring the time from leaving the initial Q set point until reaching the final.

Step	Comments	
1	t_1 = 0 s	Recording is started
2	t_2 = 10 s	Setpoint set to 50.0% $Q_{max.\ oe}$
3	$t_3 = t_2$ + 120 s	Setpoint set to 50.0% $Q_{max.ue}$
4	$t_4 = t_3$ + 120 s	Setpoint set to cosφ = 1 (Q=0)
5	$t_5 = t_4$ + 120 s	Recording is stopped

Used settings of the measurement device for the testing of reactive power following setpoins (Accuracy).

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/01/20	100 ms values	3 kHz

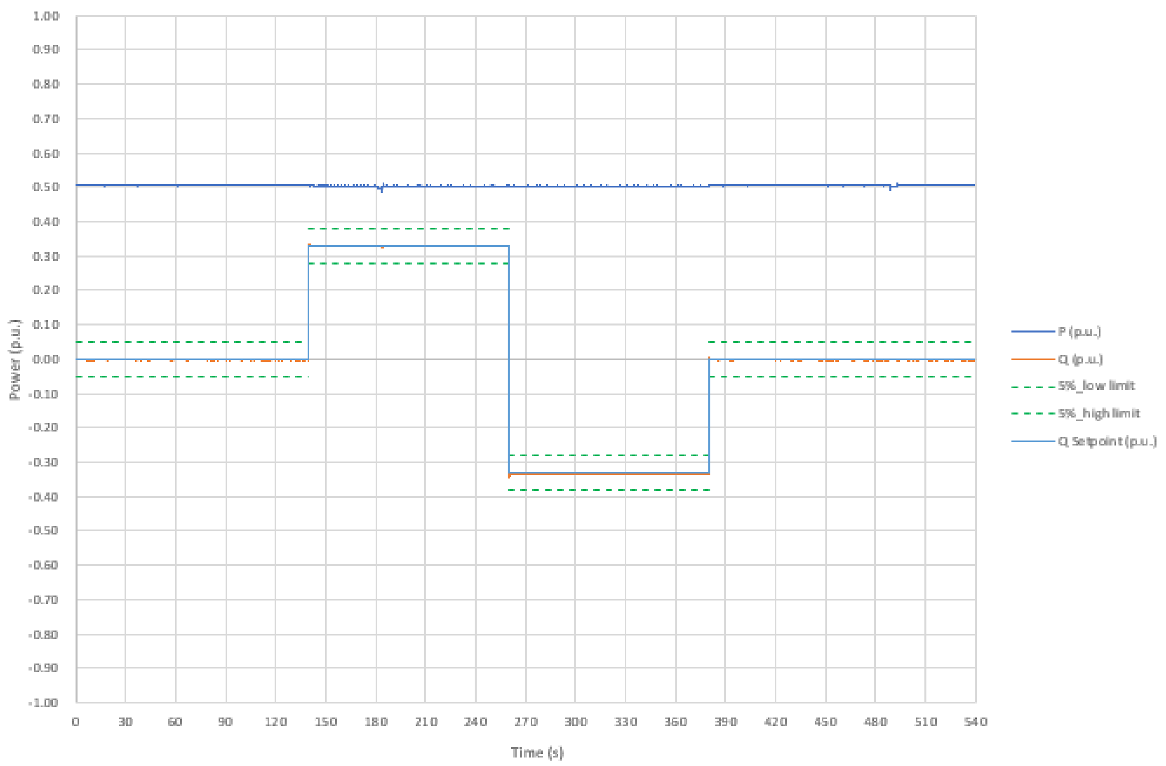
The following table shows the results of reactive power, active power, displacement factor and output voltage measured for the test performed under partial load (50%Pn). Setpoints of reactive power fixed, as 1 minute mean values, have a maximum tolerance allowed up to ± 5% Pn.
All values are in the positive sequence system.

Accuracy test					
Reactive Power steps	**Setpoint value (kVAr)**	**Actual value (kVAr)**	**cos φ**	**Grid voltage (V)**	**Measured Active Power (kW)**
50% Q_{max} Overexcited	33.000	32.798	0.838	230.4	50.400
50% Q_{max} Underexcited	33.000	33.301	0.834	230.3	50.384
Q_0	0	0.243	1.000	230.4	50.682

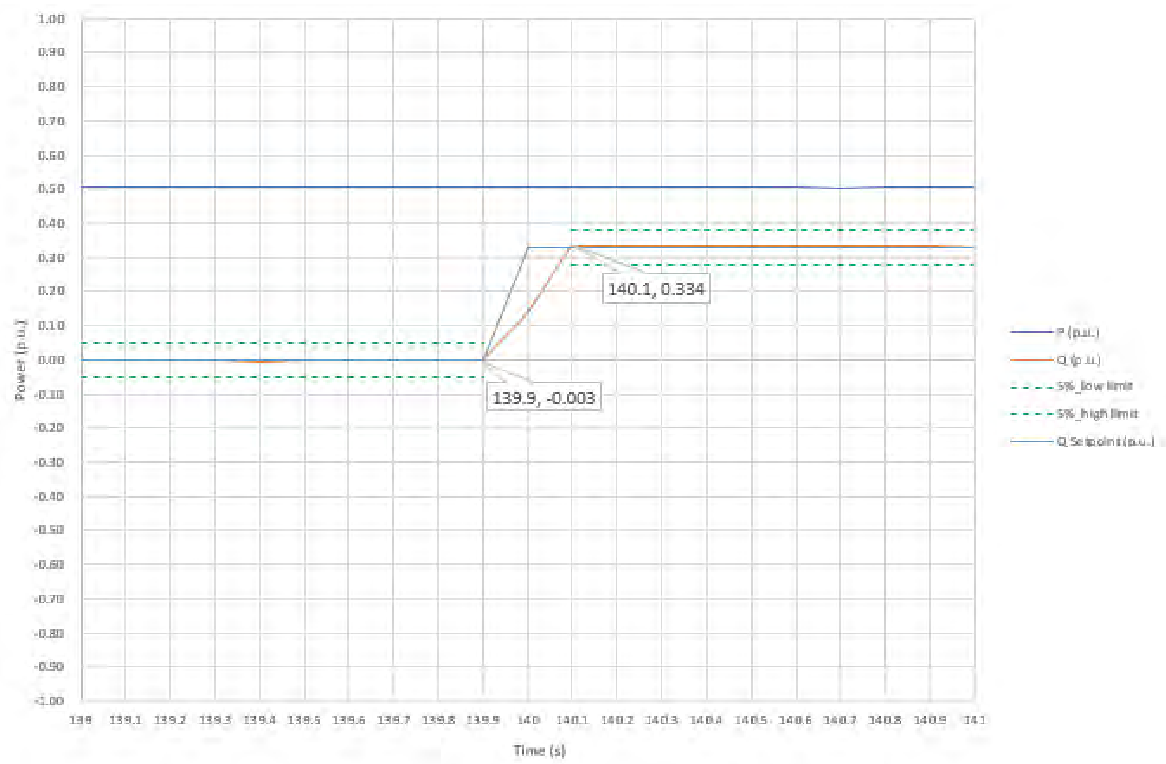
Maximum deviation from the setpoint (kVAr)	0.301
Q range at 50%P_n active power	66%Pn
Maximum Q range	66%Pn

In following graphs, test results are represented after the test has been performed:

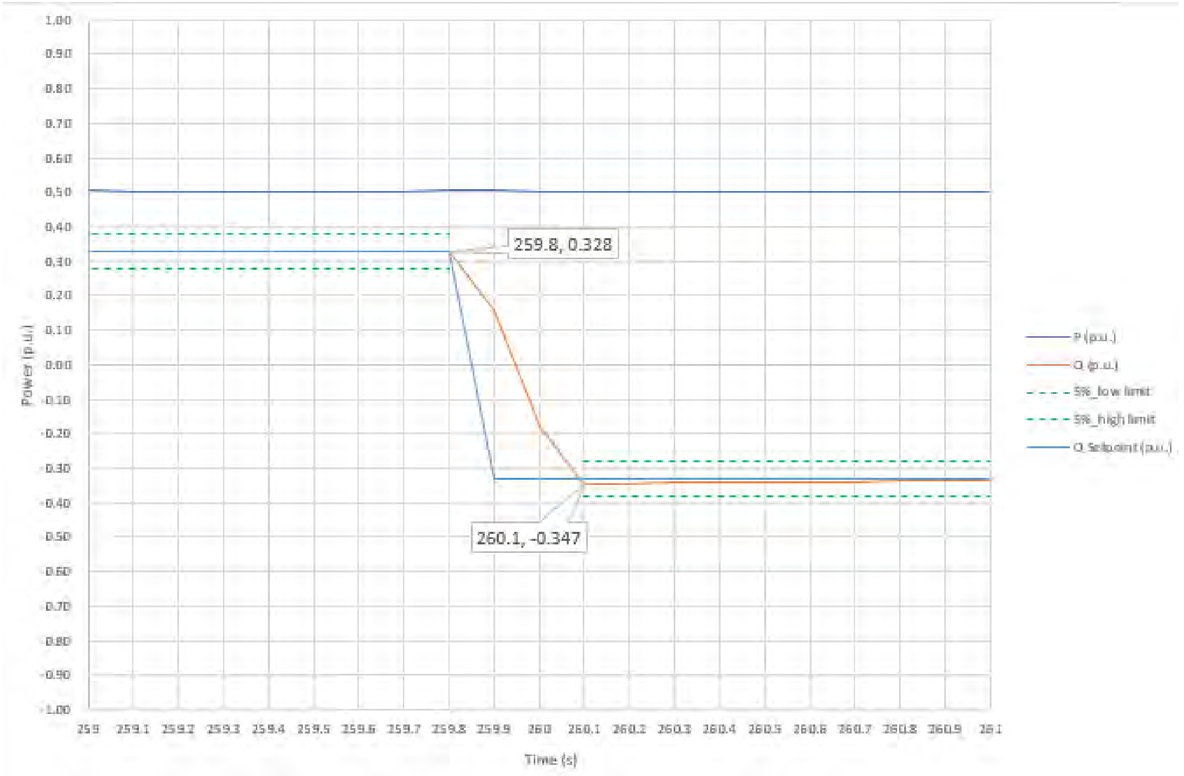
Test over Time



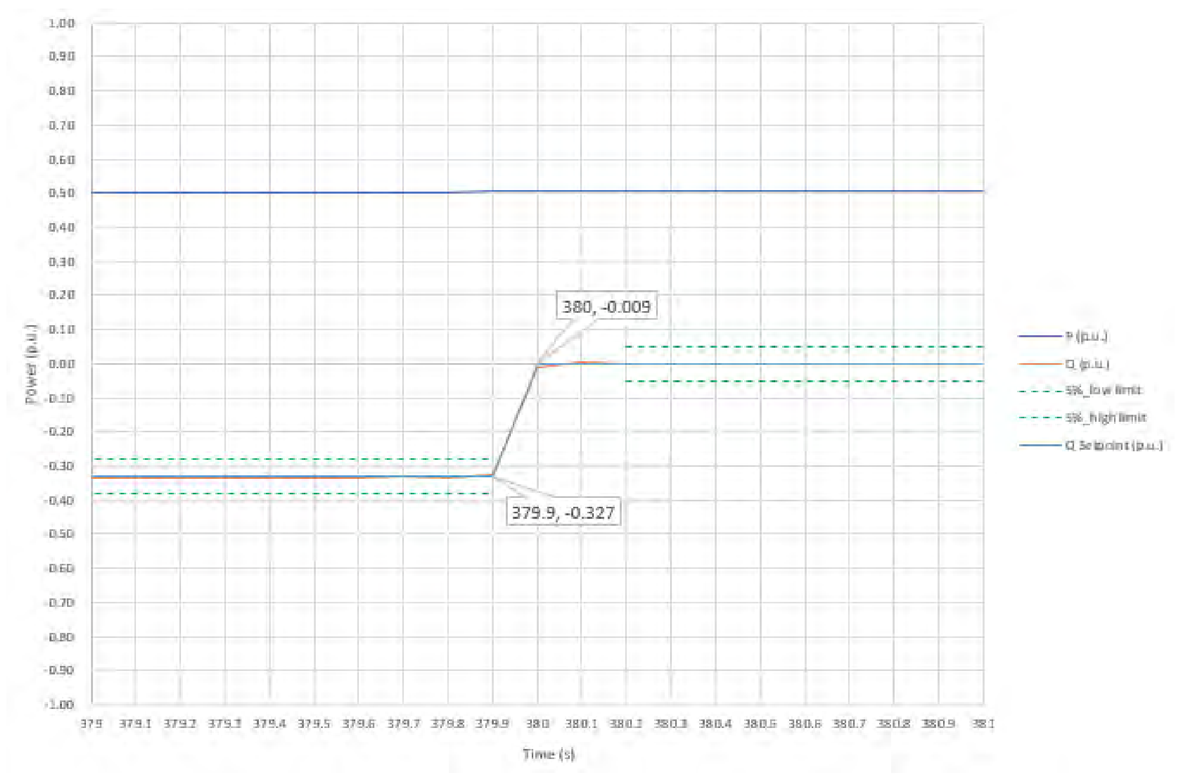
Zoom time of the step 1: 0% to +50% Q_{max}



Zoom time of the step 2: +50% to -50% Q_{max}



Zoom time of the step 3: -50% to 0% Q_{max}

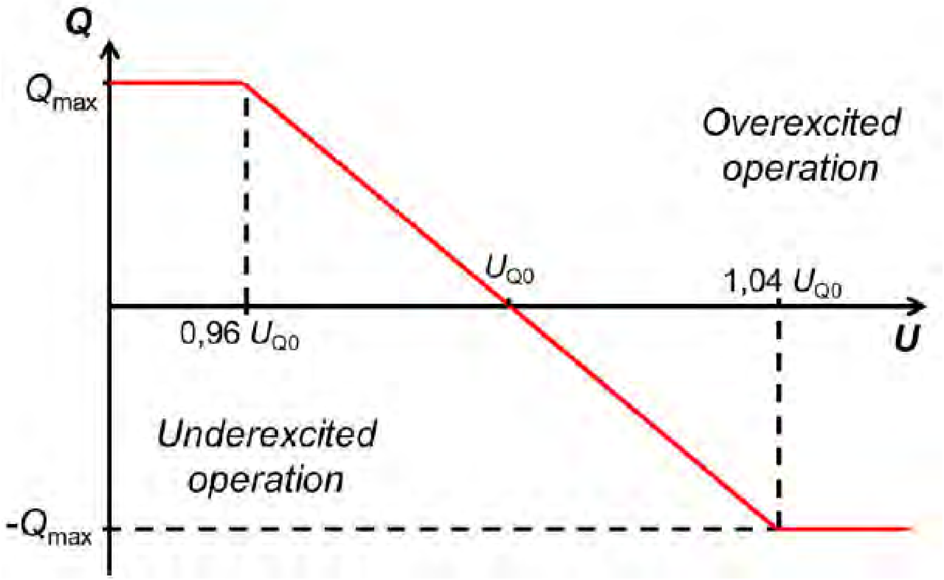


4.2.3 Q (U) Control (Voltage regulation)

The aim of this test is to examine the voltage regulation method by means of reactive power or displacement factor control as a function of the voltage.

These tests have been performed according to the point 4.2.5 of the standard. It can be applied to both PV and storage systems.

The Q(U) characteristic curve was set to follow a response as represented in the following image:



Being defined this Q(U) curve as follows:

Output Voltage, U	0.96 Un	Un	1.04 Un
Reactive Power, Q	+ 66.0 % Sn (leading)	0.0 % Sn	- 66.0 % Sn (lagging)

Different tests have been done to determinate both the setting accuracy and the setting time. In both cases, the setting time was adjusted to be the shortest as possible.

For all test, the active power, reactive power and voltage have been measured in the positive phase sequence system and have been represented as 100 milisecond means for every setpoint step.

Interface information	
Interface used	RS485
Interface version used	SmartLogger V200R002
Other interfaces in the equipment	SUN 2000APP:3.2.00.002
Name or code of the parameter for Q (U) & settling time	Reactive Power Control – Q-U characteristic curve of QU value and setting time setting
If the EUT has several different interfaces for defining the setpoint, it has been tested the interface returning the most unfavourable results according to the manufacturer information.	

EUT Settings used for this test are provided in the following table:

EUT Settings	
Operanting mode	Reactive power priority
Active control modes	Active power control LVRT mode Reactive power VS Voltage

Test results are offered in following points.

4.2.3.1 Determining the accuracy

This test verifies the capability of the inverter to modify the injection of reactive power under voltage variations inside the normal operation range.

Used settings of the measurement device for the testing of Q (U) control:

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/03/05	100 ms values	3 kHz

Steps have been commanded as follow that can be seen on the following table:

Step	Step time	Voltage desired (p.u)	Reactive Power expected (%Pn)
1	t1 = 0 s	1.00	0
2	t2 = t1 + 120 s	0.97	49.5
3	t3 = t2 + 120 s	1.03	49.5
4	t4 = t3 + 120 s	1.00	0
5	t5 = t4 + 120 s	1.00	0

Each voltage step was maintained for at least 60 seconds and the complete test was performed maintaining an active power level corresponding to 55%Pn, as the standard requires a power level superior to 50%Pn.

The maximum tolerance allowed for reactive power measurements is ± 5 % Pn and they have been verified for the last 1 minute mean average at the end of the step.

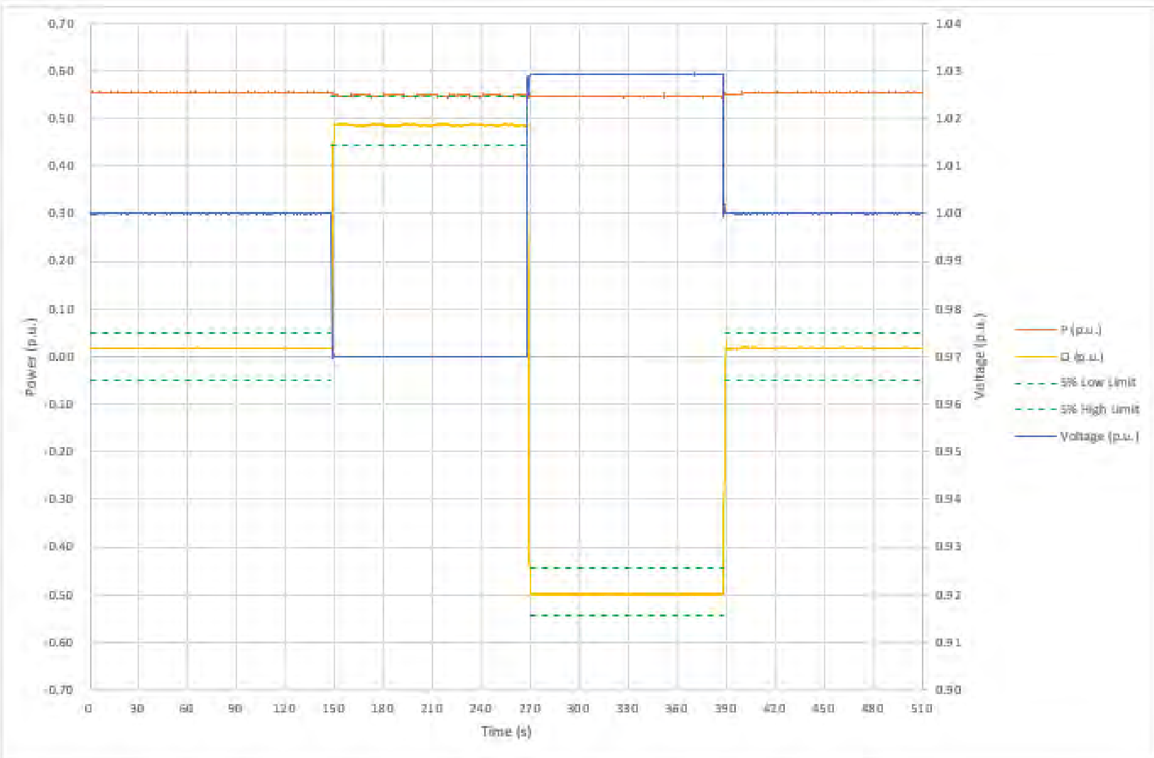
The following table shows the test results for the last 60 seconds average of each step:

Step	Measured Vac +		Measured P		Measured Q		Q deviation (kVAr)	Measured Power Factor
	(p.u)	(V)	(%Sn)	(kW)	(%Sn)	(kVAr)		
1	1.000	230.0	55.4	55.437	1.8	1.759	1.759	1.000
2	0.970	223.1	54.7	54.788	48.6	48.580	-0.920	0.750
3	1.029	236.7	54.6	54.629	49.9	49.881	0.381	0.738
4	1.000	230.0	55.4	55.436	1.8	1.789	1.789	1.000
5	1.000	230.0	55.4	55.437	1.8	1.789	1.789	1.000

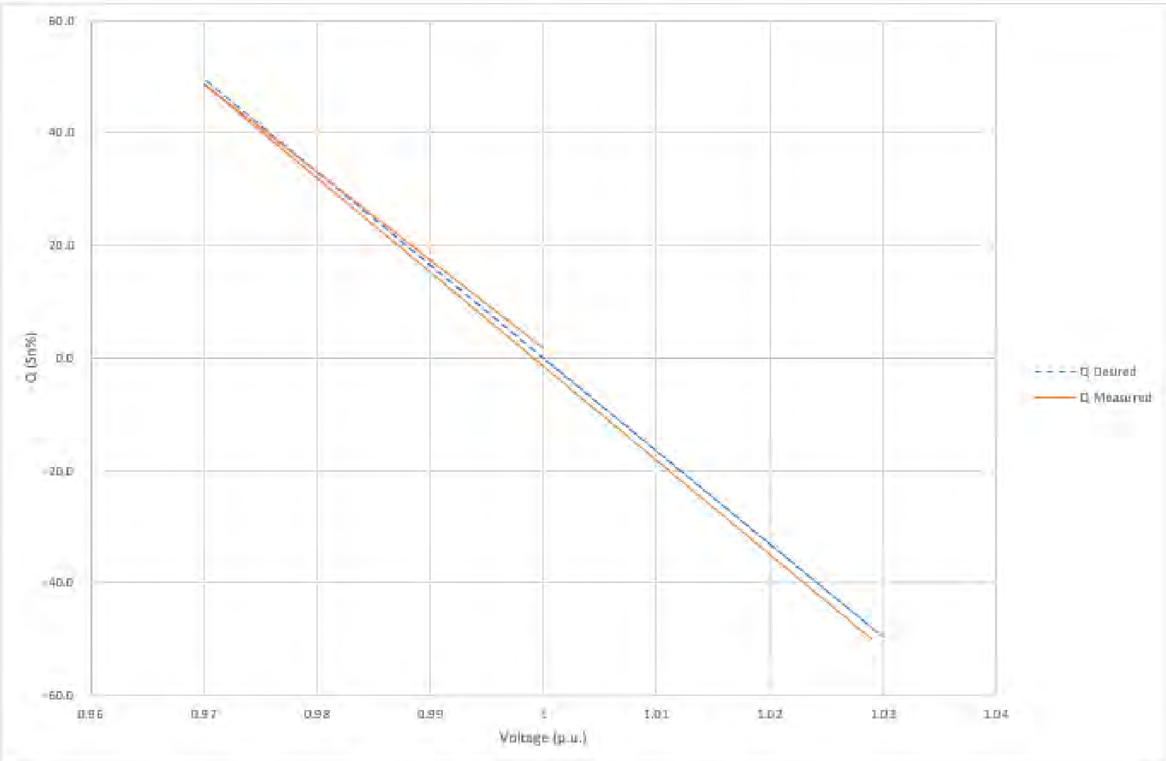
Maximum deviation from the setpoint (kVAr)	1.789

In following graphs, test results are represented after test has been performed:

Test over Time



Reactive Power over Voltage



4.2.3.2 Determining the settling time

This test determines the time response of the inverter to modify the injection of reactive power under voltage variations inside the normal operation range.

Used settings of the measurement device for the testing of Q (U) control:

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000 and PW6001-06	2019/11/24 and 2020/03/05	100 ms values	3 kHz

Operating at an active power level corresponding to 55%Pn, the inverter was subjected to following voltage step changes:

Step	Comment	
1	t_1=0s	Recording is started
2	t_2=120s	Step change to 0.97 Un
3	t_3= t_2 + 120s	Step change to 1.03 Un
4	t_4= t_3 + 120s	Step change to Un
5	t_5= t_4 + 120s	Recording is stopped

The settling time for all steps is determined and given while taking the ±5%Pn tolerance band into consideration.

Two tests have been carried out, one with the case of settling time set as the shortest as possible and another with the settling time set as the longest as possible.

- Test 1: Settling time shortest as possible: Configured time setting value: 1 s
- Test 2: Settling time longest as possible: Configured time setting value: 60 s

Time setting values that may be parametrized in the control as given by manufacturer's specifications: Range from 1 to 60 s

4.2.3.2.1 Test 1

The following table shows test results:

The actual value is predefined by the network operator, then a value of 1 s applies. Due to the installations may have adjustable settling time between 1 s and 5 s (step response time)

Settling time (shortest possible)						
Power		Step	Comments	Point in time of setpoint change (s)	Point in time of settling inside the tolerance band (s)	Time different (s)
Desired (% Pn)	Measured (% Pn)					
≥ 50%	55.1%	1	$U_0 = U_n$	--	--	--
		2	$U_n \rightarrow 0.97\ U_n$	147.9	149.1	1.2
		3	$0.97\ U_n \rightarrow 1.03\ U_n$	267.9	269.3	1.4
		4	$1.03\ U_n \rightarrow U_n$	387.9	389.2	1.3
		5	Recording is Stopped	--	--	--

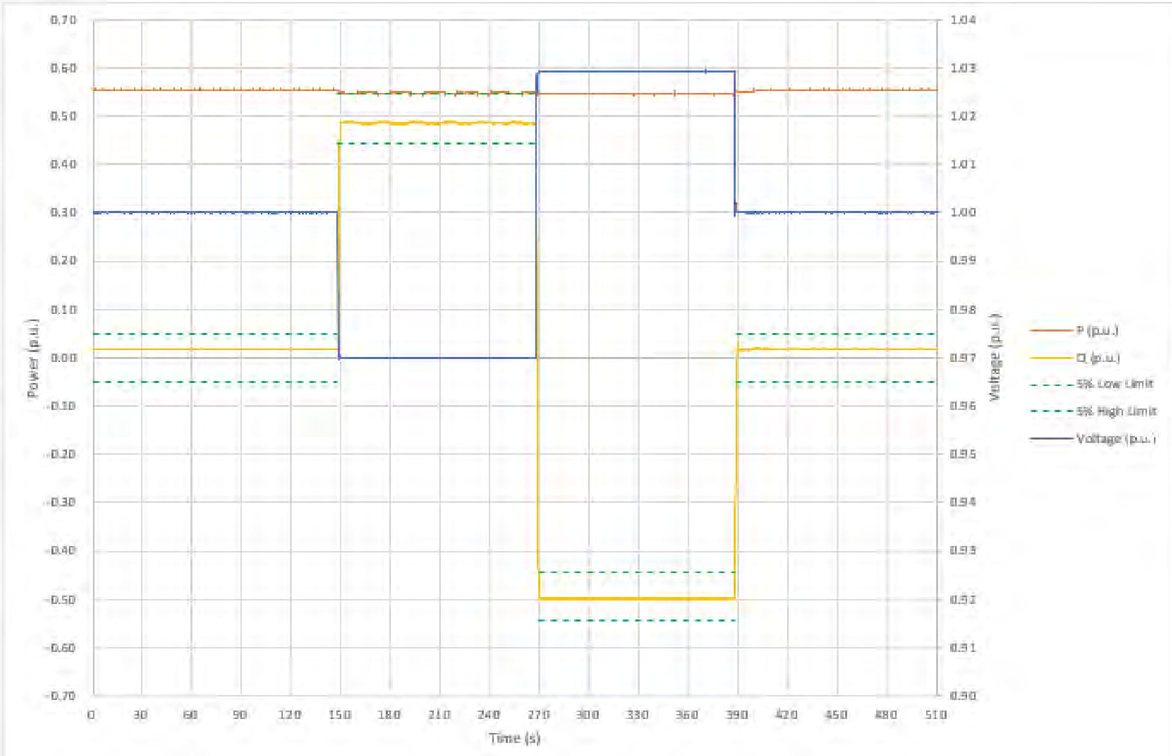
Longest Measured settling time (s)	1.4

The following table shows the reactive power variation to time (ΔQ/Δt) during the settling time:

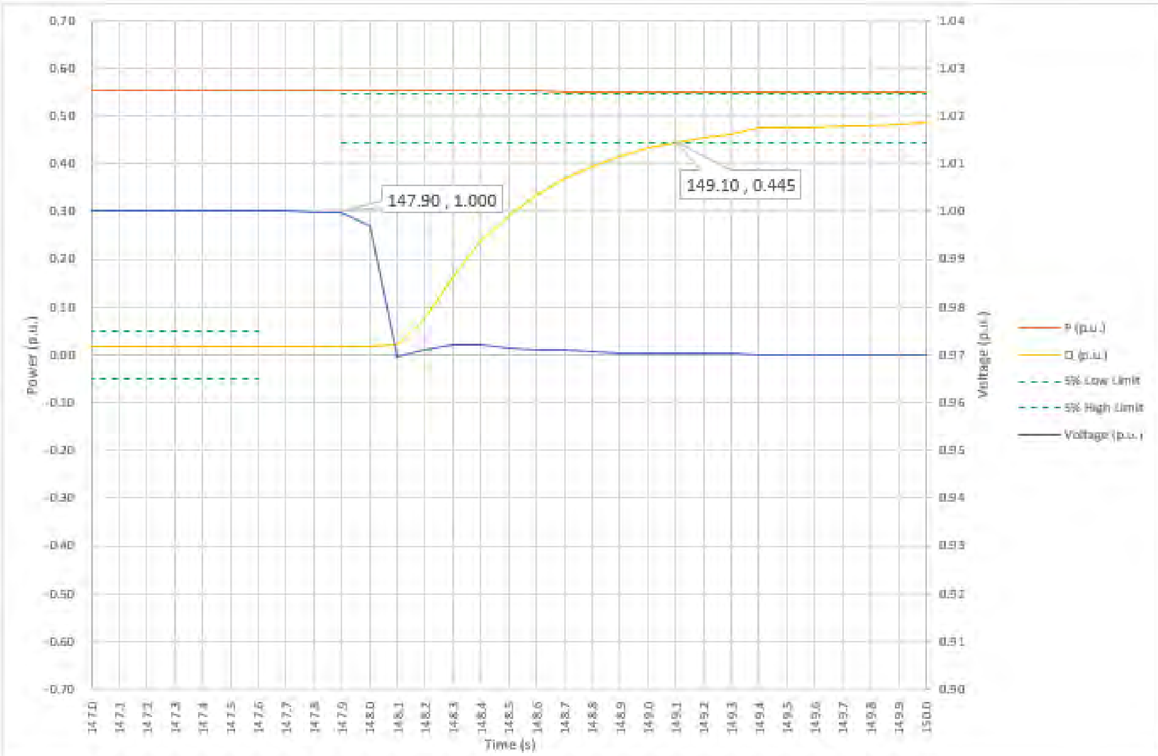
Step	Q at the start (kVAr)	Q at the end (kVAr)	Time Response (s)	ΔQ/Δt (kVAr/s)
2	1.7	44.5	1.2	35.7
3	48.4	-44.5	1.4	66.4
4	-49.8	-5.0	1.3	34.5

In following graphs, they are represented test results after the test performed:

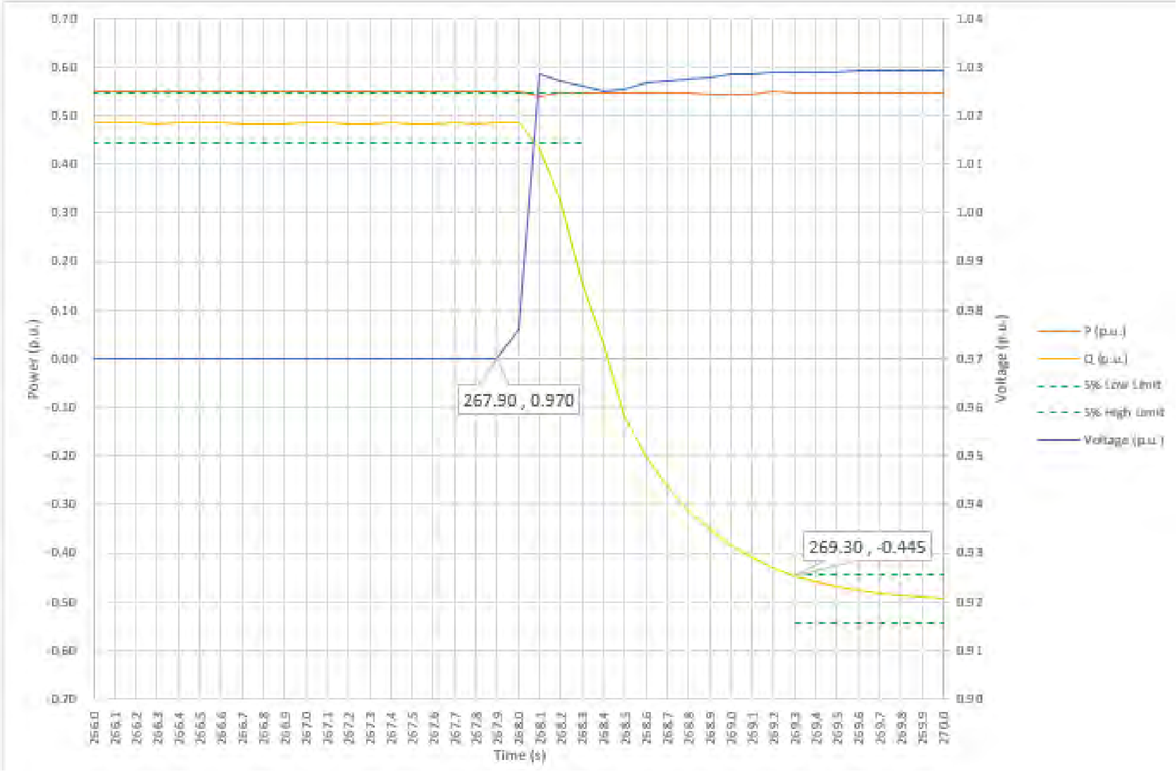
Test over Time



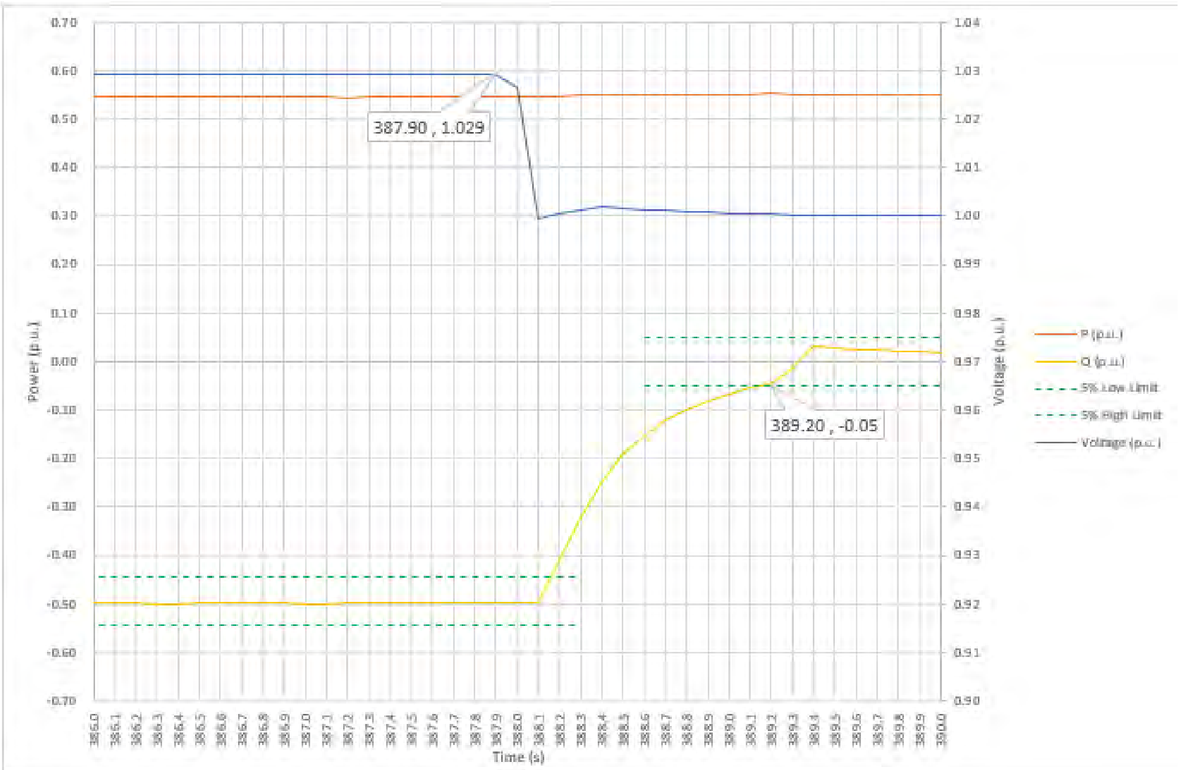
Zoom time of the step 2: Un to 0.97 Un



Zoom time of the step 3: 0.97 Un to 1.03 Un



Zoom time of the step 4: 1.03 Un to Un



4.2.3.2.2 Test 2

The following table shows test results:

The actual value is predefined by the network operator, then a value of 60 s applies. Due to the installations may have adjustable settling time between 6 s and 60 s (step response time)

Settling time (longest possible)						
Power		**Step**	**Comments**	**Point in time of setpoint change (s)**	**Point in time of settling inside the tolerance band (s)**	**Time different (s)**
Desired (% Pn)	**Measured (% Pn)**					
≥ 50%		**1**	$U_0 = U_n$	--	--	--
		2	$U_n \rightarrow 0.97\ U_n$	126.6	187.6	61.0
		3	$0.97\ U_n \rightarrow 1.03\ U_n$	246.7	299.9	53.2
		4	$1.03\ U_n \rightarrow U_n$	366.7	411.8	45.1
		5	Recording is Stopped	--	--	--

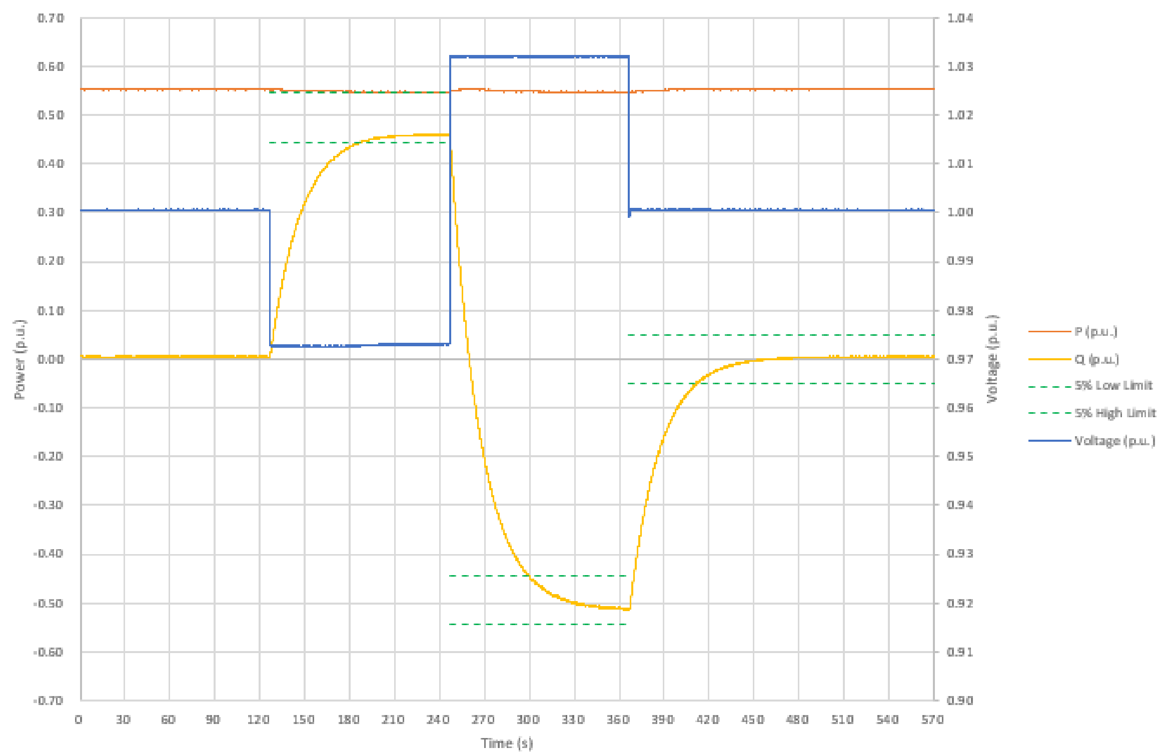
Longest Measured settling time (s)	61.0

The following table shows the reactive power variation to time (ΔQ/Δt) during the settling time:

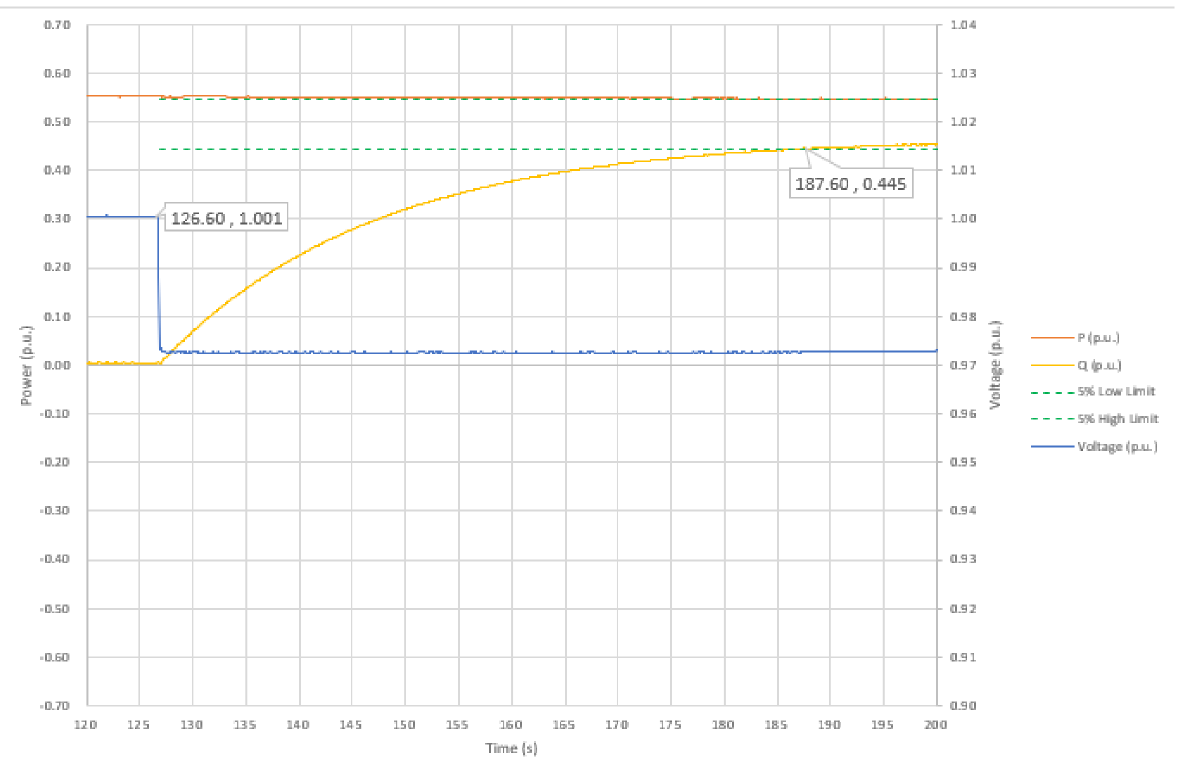
Step	**Q at the start (kVAr)**	**Q at the end (kVAr)**	**Time Response (s)**	**ΔQ/Δt (kVAr/s)**
2	0.5	44.5	60.8	0.7
3	46.7	-44.5	53.0	1.7
4	-51.2	-4.9	44.9	1.0

following graphs, they are represented test results after the test performed:

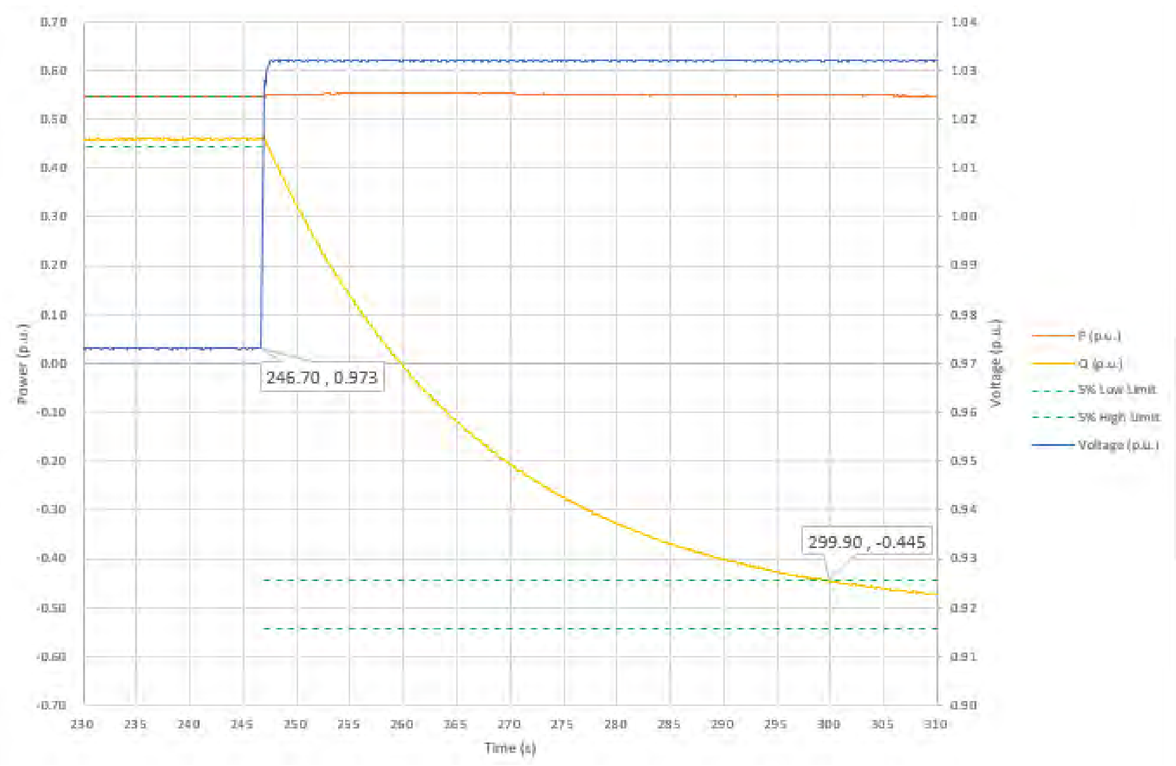
Test over Time



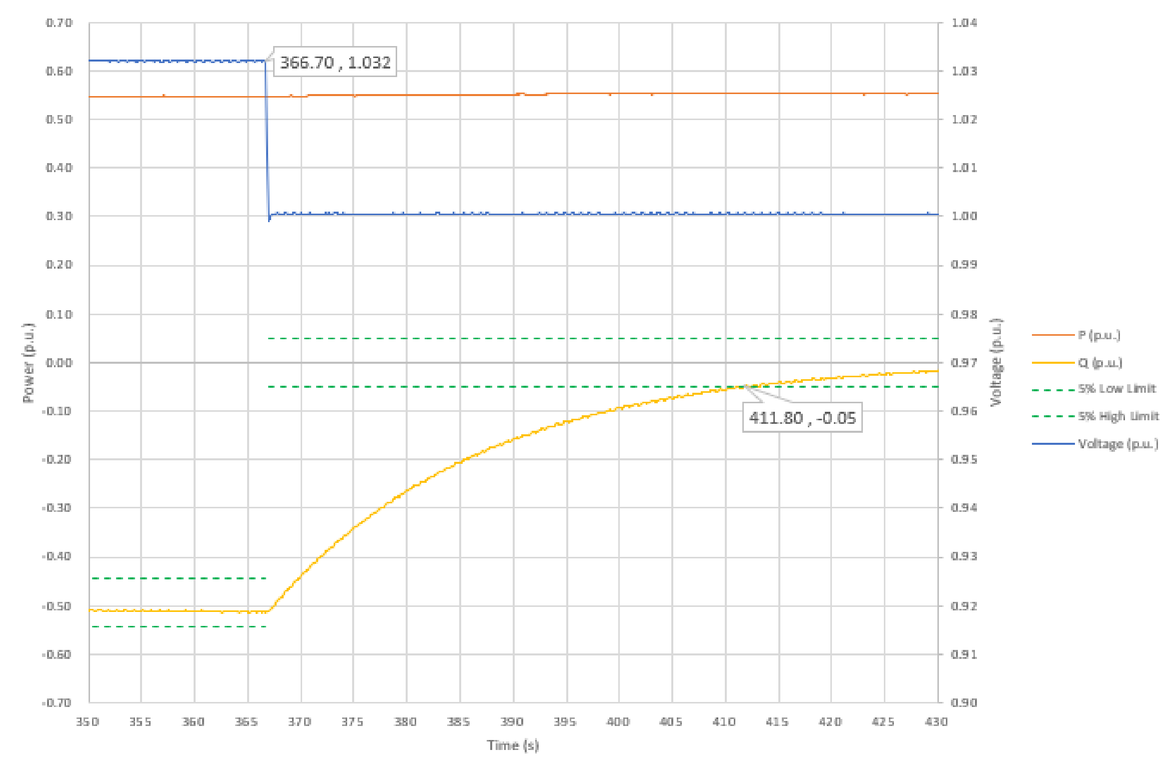
Zoom time of the step 2: Un to 0.97 Un



Zoom time of the step 3: 0.97 Un to 1.03 Un



Zoom time of the step 4: 1.03 Un to Un

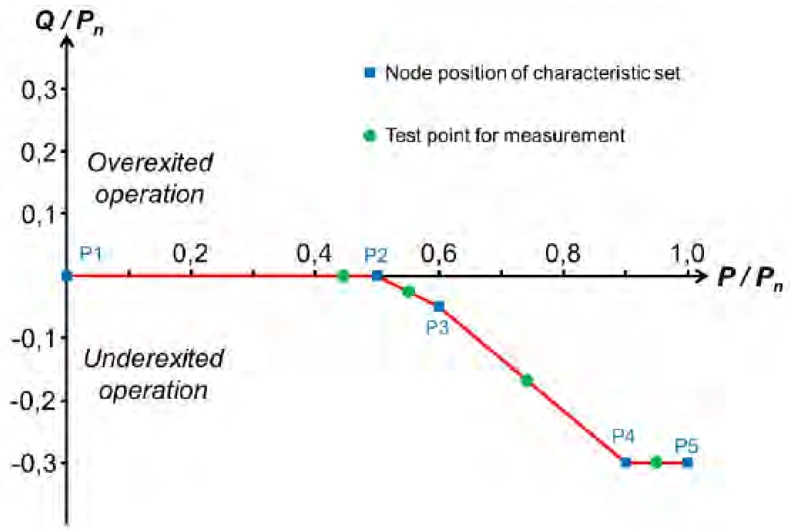


4.2.4 Q(P) control (OPTIONAL)

The aim of this test is to examine the reactive power control method as a function of the active power.

These tests have been performed according to the point 4.2.6 of the standard. Although this test is optional, it has been tested nevertheless.

The Q(P) characteristic curve was set to follow a response as represented in the following image:



Being defined this Q(P) curve as follows:

Node Position	P_{mom} / P_n	Q / P_n
P1	0	0
P2	0.5	0
P3	0.6	-0.05
P4	0.9	-0.33
P5	1.0	-0.33

The response time was adjusted to be the shortest as possible.

Test results are offered in following points.

Interface information	
Interface used	RS485
Interface version used	SmartLogger V200R002
Other interfaces in the equipment	SUN 2000APP:3.2.00.002
Name or code of the parameter for Q (P) & settling time	Reactive Power Control – Q-P characteristic curve
If the EUT has several different interfaces for defining the setpoint, it has been tested the interface returning the most unfavourable results according to the manufacturer information.	

EUT Settings used for this test are provided in the following table:

EUT Settings	
Operanting mode	Reactive power priority
Active control modes	Active power control LVRT mode Reactive power VS Active power

- Test 1: Settling time shortest as possible: Configured time setting value: 6 s

Time setting values that may be parametrized in the control as given by manufacturer's specifications: Range from 0 to 60 s

4.2.4.1 Determining the setting accuracy

This test verifies the capability of the inverter to modify the reactive power under changes in the active power commanded by setpoint.

Used settings of the measurement device for the testing of Q(P) control:

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/25	100 ms values	3 kHz

They have been commanded steps that can be seen on the following table:

Step	Active power desired (%Sn)	Reactive Power expected (%Sn)
1	10.0	0.0
2	45.0	0.0
3	55.0	2.5
4	75.0	19.0
5	95.0	33.0

The inverter shall calculate automatically the reactive power setpoint from the measured active power.

Each active power step was maintained for at least 120 seconds, being calculated voltage, powers and power factor signals for the last 60 seconds mean average at the end of the step.
The response time was adjusted to be the shortest as possible (but no longer than 6s).
The actual value is predefined by the network operator, then a value of 5 s applies. Due to the installations may have adjustable settling time between 1 s and 5 s (step response time)

According to testing method of the standard, the 1-minute mean value at the end of the step is measured. Dropping below or exceeding the active power node points in the stationary condition of a step has to be avoided.

The following table shows the test results for the last 60 second average of each step:

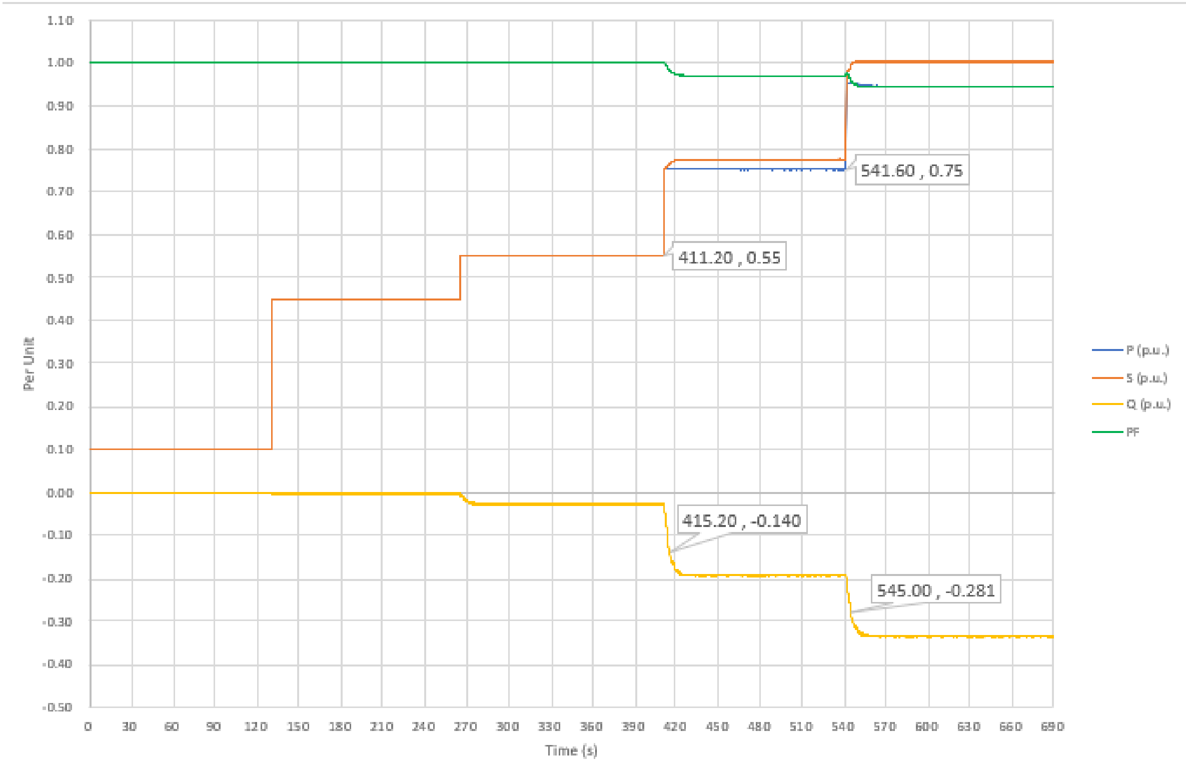
Step	P Setpoint		Measured P		Q Setpoint		Measured Q		Q deviation (kVAr)
	(%Pn)	(kW)	(%Pn)	(kW)	(%Pn)	(kVAr)	(%Pn)	(kVAr)	
1	10	10	9.9	9.9	0.0	0.0	-0.1	-0.1	0.1
2	45	45	45.1	45.1	0.0	0.0	-0.2	-0.2	0.2
3	55	55	55.1	55.1	-2.5	-2.5	-2.8	-2.8	0.3
4	75	75	75.2	75.2	-19.0	-19.0	-19.3	-19.3	0.3
5	95	95	94.7	94.7	-33.0	-33.0	-33.4	-33.4	0.4

Maximum deviation from the Q calculated setpoint (kVAr)	0.4
Settling time (s)	4.0

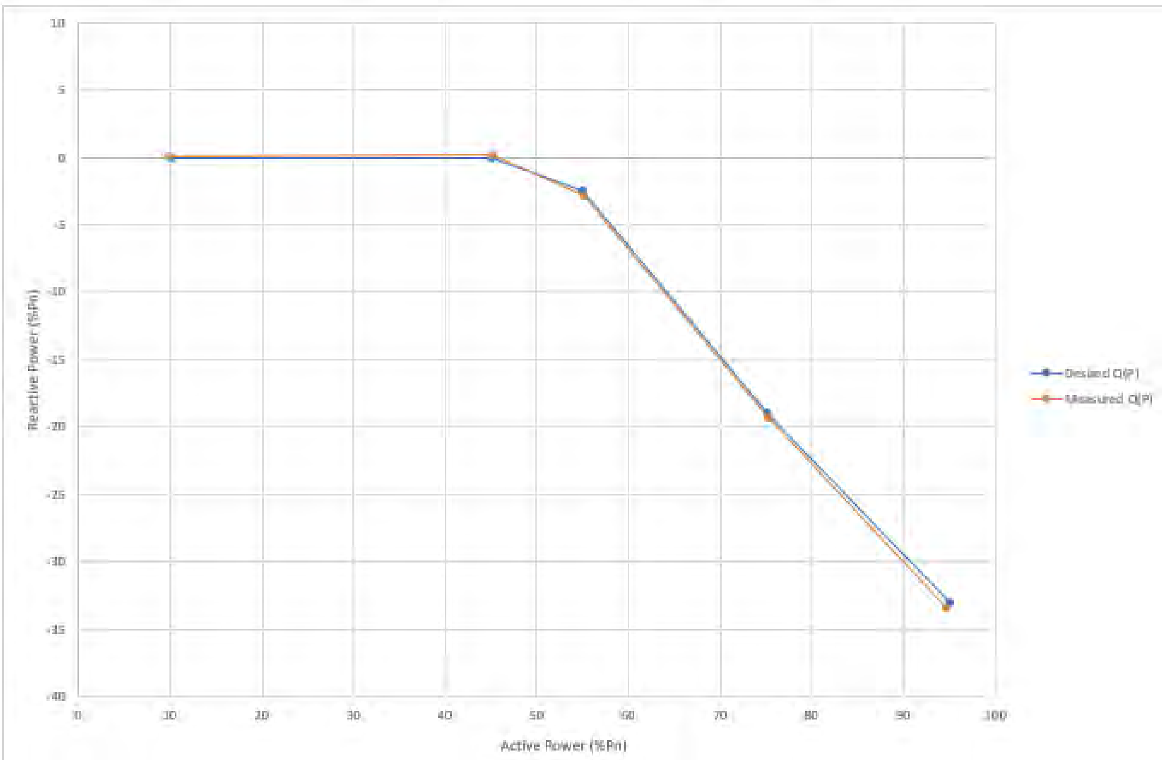
The maximum tolerance allowed for each value is 2% of the rated value per each value.

In following graphs, test results are represented using 100 ms mean values of active power, reactive power and calculated reactive power set-point input after the test has been performed:

Test over Time



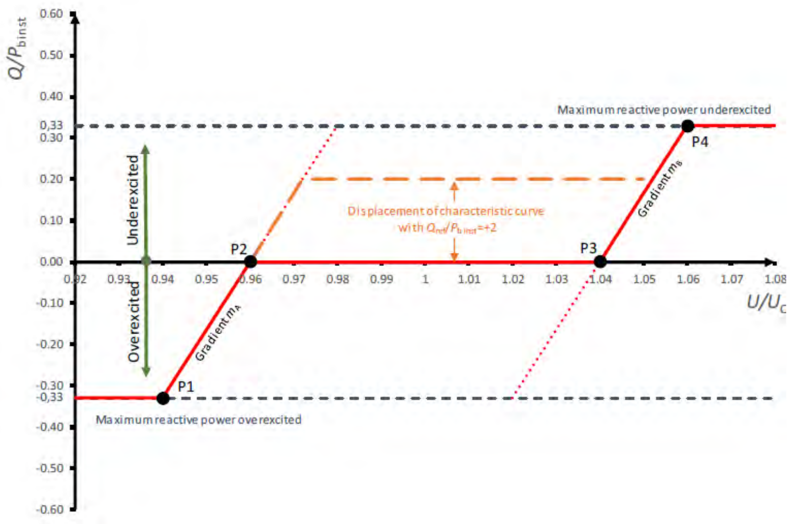
Reactive Power over Active Power



4.2.5 Reactive Power Q with voltage limitation function (OPTIONAL)

These tests have been performed according with chapter 4.2.7, 6.1.3.2 and 6.1.4.2 of the standard.

The aim of these tests is to show compliance with the characteristic curve from both VDE AR-N 4110:2018 and VDE AR-N 4120:2018 presented below:



The active power at the beginning of this test should be ≥40% of the total rated active power of the operating PGU. Each step has been measured at least 2 min. The 1-minute mean value at the end of each step have been measured.

Different tests have been done to determinate both the setting accuracy and the setting time. In both cases, the setting time was adjusted to be the shortest as possible.

Interface information	
Interface used	RS485
Interface version used	SmartLogger V200R002
Other interfaces in the equipment	SUN 2000APP:3.2.00.002
Name or code of the parameter for Q (U) & settling time	Reactive Power Control – Q-U characteristic curve of QU value and setting time setting
If the EUT has several different interfaces for defining the setpoint, it has been tested the interface returning the most unfavourable results according to the manufacturer information.	

EUT Settings used for this test are provided in the following table:

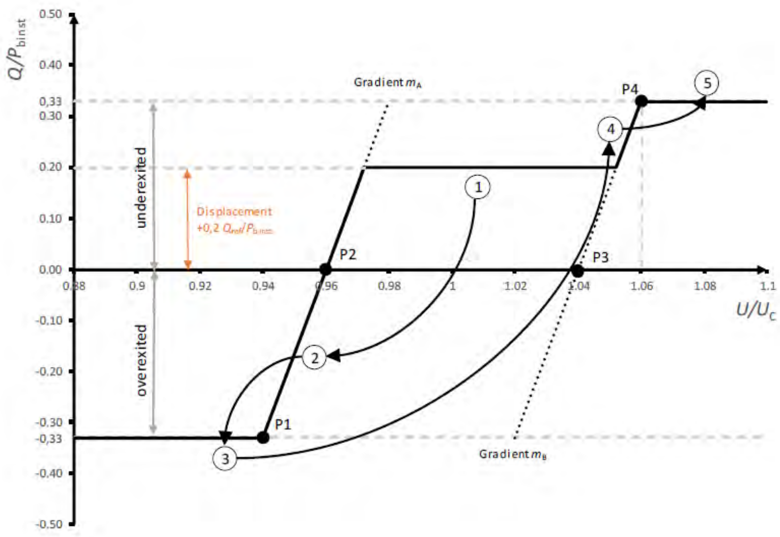
EUT Settings	
Operanting mode	Reactive power priority
Active control modes	Active power control LVRT mode Reactive power VS Voltage

4.2.5.1 Determining the setting accuracy

For this test, the following reactive power steps are applied:

- ±0.05 Q / P_{binst}
- ±0.2 Q / P_{binst} (ind.)
- ±0.2 Q / P_{binst} (cap.)

For each of the previous reactive power steps, a voltage variation has to be implemented in the ranges divided by points P1 to P4 and expressed by markers 1 to 5 of the following picture from the standard:



According to the graph above, the following voltage points shall be measured:

1. Rated voltage
2. Voltage between P1 and P2
3. Voltage below P1
4. Voltage between P3 and P4
5. Voltage above P4

Being defined this Q(U) curve as follows:

Output Voltage, U	0.940 Un	0.972Un	1.052 Un	1.060Un
Reactive Power, Q	+ 33.0 % Sn (leading)	- 20.0 % Sn (lagging)	- 20.0 % Sn (lagging)	- 33.0 % Sn (lagging)

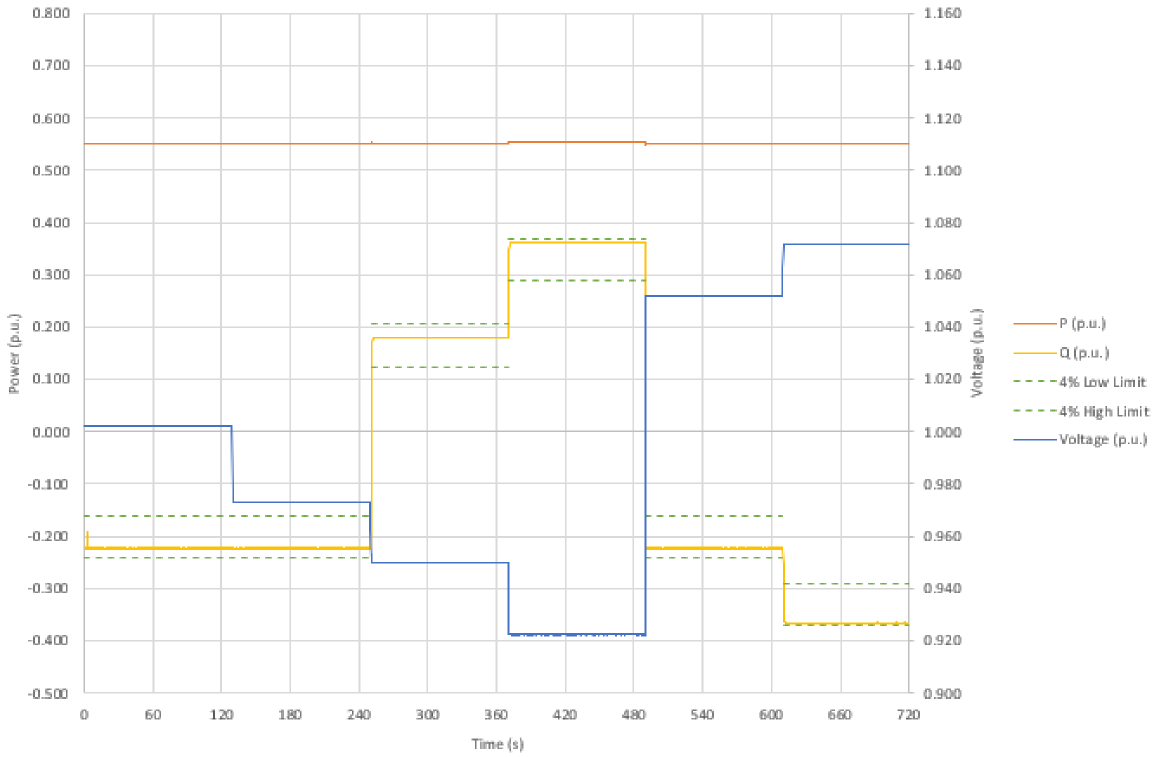
Used settings of the measurement device for the test:

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/09/28	200 ms values	3 kHz

Test results are offered in tables and graphs presented below:

Setting accuracy									
Step	U Setpoint		U Measured		Q Setpoint		Measured Q		Q deviation
	(%Un)	(V)	(%Un)	(V)	(%Sn)	(kVAr)	(%Sn)	(kVAr)	(kVAr)
1	100.0	230.0	100.2	230.5	-20.0	-20.0	-22.3	-22.275	-2.275
2	97.2	223.6	97.3	223.8	-20.0	-20.0	-22.3	-22.278	-2.278
3	95.0	218.5	95.0	218.5	16.5	16.5	18.0	17.978	1.478
4	92.0	211.6	92.2	212.1	33.0	33.0	36.2	36.173	3.173
5	105.2	242.0	105.2	242.0	-20.0	-20.0	-22.3	-22.290	-2.290
6	107.0	246.1	107.2	246.5	-33.0	-33.0	-36.6	-36.626	-3.626

Test over Time



4.2.5.2 Determining the settling time

For this test, the following reactive power and voltage steps are applied:

Q Points	Voltage points:
1. 0.20 Q/Pn (cap.)	1. Reccording is starterd at Un
2. 0.20 Q/Pn (cap.)	2. Step change to 0.972 Un
3. 0.33 Q/Pn (ind.)	3. Step change to 0.92 Un
4. 0.20 Q/Pn (cap.)	4. Step change to 1.052 Un
5. 0.33 Q/Pn (cap.)	5. Step change to 1.07 Un
6. 0.20 Q/Pn (cap.)	6. Step change to Un
7. 0.33 Q/Pn (ind.)	7. Step change to 0.92 Un
8. 0.20 Q/Pn (cap.)	8. Step change to Un
9. 0.33 Q/Pn (cap.)	9. Step change to 1.07 Un
10. 0.20 Q/Pn (cap.)	10. Step change to Un
	11. Reccording is stopped

Test has been repeated two times in order to verify both the minimum and the maximum time which are 1s and 60s.

For determination of the settling time, a tolerance band of ±4% P_{binst} is applied to the reactive power in each step.

The parameters of the tests have been measured with the minimum and maximum settling time:

- Test 1: Settling time shortest as possible: Configured time setting value: 1 s
- Test 2: Settling time longest as possible: Configured time setting value: 60 s

Time setting values that may be parametrized in the control as given by manufacturer's specifications: Range from 1 to 60 s

Used settings of the measurement device for the test:

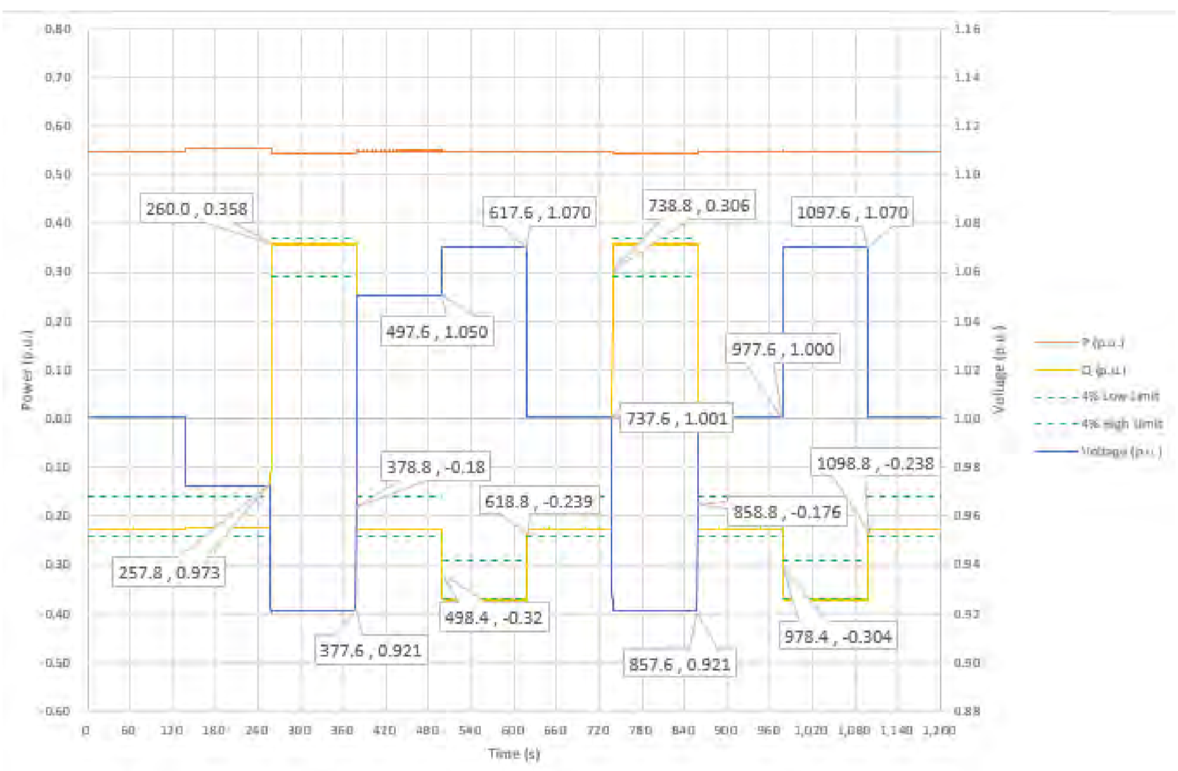
Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/02/07	200 ms values	3 kHz

Test results are offered in tables and graphs presented below:

4.2.5.2.1 Test 1

Settling time (Shortests possible)						
Step	Qsetpoint		Measured Q		Set time	Measured settling time
	(%Sn)	(kVAr)	(%Sn)	(kVAr)	(s)	(s)
1	-20.0	-20.0	-22.7	-22.7	--	--
2	-20.0	-20.0	-22.3	-22.3	--	--
3	33.0	33.0	35.7	35.7	1.0	2.2
4	-20.0	-20.0	-22.7	-22.7	1.0	1.2
5	-33.0	-33.0	-37.0	-37.0	1.0	0.8
6	-20.0	-20.0	-22.7	-22.7	1.0	1.2
7	33.0	33.0	35.7	35.7	1.0	1.2
8	-20.0	-20.0	-22.7	-22.7	1.0	1.2
9	-33.0	-33.0	-37.0	-37.0	1.0	0.8
10	-20.0	-20.0	-22.7	-22.7	1.0	1.2

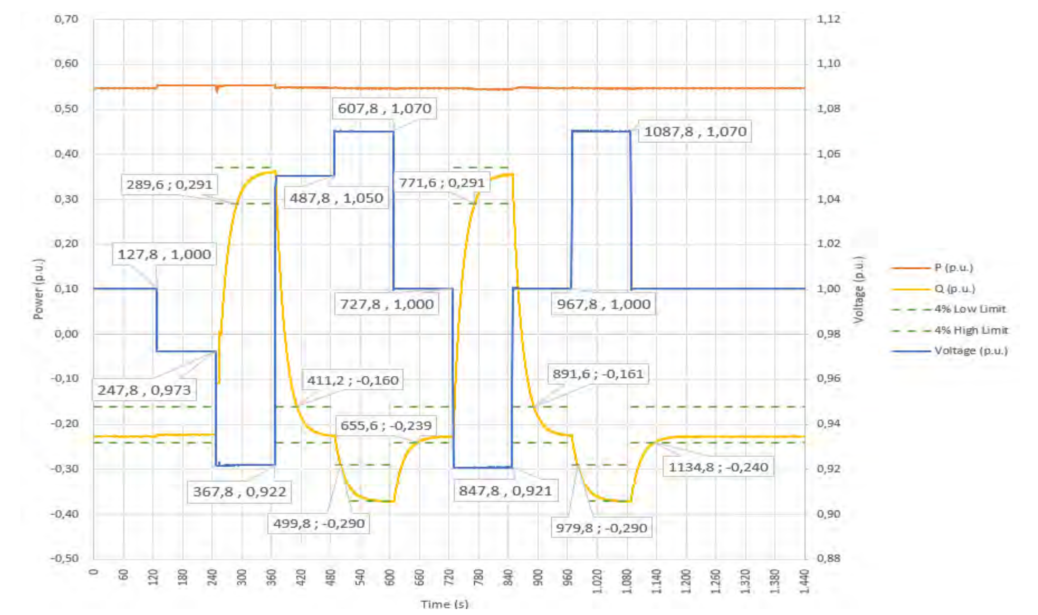
Test over Time



4.2.5.2.2 Test 2

Settling time (Longest possible)						
Step	**Qsetpoint**		**Measured Q**		**Set time**	**Measured settling time**
	(%Sn)	**(kVAr)**	**(%Sn)**	**(kVAr)**	**(s)**	**(s)**
1	-20.0	-20.0	-22.7	-22.7	60.0	--
2	-20.0	-20.0	-22.3	-22.3	60.0	--
3	33.0	33.0	35.3	35.3	60.0	41.8
4	-20.0	-20.0	-21.8	-21.8	60.0	43.4
5	-33.0	-33.0	-36.9	-36.9	60.0	12.0
6	-20.0	-20.0	-22.9	-22.9	60.0	47.8
7	33.0	33.0	34.8	34.8	60.0	43.8
8	-20.0	-20.0	-21.7	-21.7	60.0	43.8
9	-33.0	-33.0	-36.9	-36.9	60.0	12.0
9	-20.0	-20.0	-22.7	-22.7	60.0	47.0

Test over Time



4.3 SYSTEM PERTURBATIONS.

The tests were tested under Sk/Sn=20. Tests bave been performed under different AC output voltage (400Vac and 480Vac).

4.3.1 Switching operations

The aim of this test is to determine the grid-dependent voltage variation factors K_u (Ψ_k) and flicker form factors K_f (Ψ_k) in order to estimate systems perturbations at the point of common coupling.

This test has been performed according to the 4.3.2. of the standard.

These measures have been done following the reference IEC 61400-21

The following definitions apply to the test:

• Maximum number of switching operations within a time period of 10 min. N_{10}

• Maximum number of switching operations within a time period of 120 min. N_{120}

The following switching operations should be investigated at each impedance angle (30º, 50º, 70º, 85º):

- Test 1: Switching at Pavailable <10 % Pn. N_{10} = 20, N_{120} = 240. T_p =30 s.
- Test 2: Switching at Pavailable = Pn. N_{10} = 20, N_{120} = 240. T_p =30 s
- Test 3: Service shutdown at rated power (no emergency stop).

<u>Note:</u> T_p ≡ Time per switching operation $T_p = t_3 - t_0$. T_p includes the following times:

1. Start of measurement.
2. Beginning of recording analysis range ($t=t_0$)
3. Beginning of switching operation ($t=t_1$)
4. Switching operation's transient phenomena have dissipated, PGU feeds in active power in line with the active power setpoint ($t=t_2$)
5. End of recording analysis range ($t=t_3$)
6. End of measurement.

The following parameters are to be reported:

Flicker factor $k_f(\Psi_k)$:

$$k_f(\Psi_k) = \frac{1}{130} \times \frac{S_{k,fic}}{S_n} \times P_{st,fic} \times T_p^{0,31}$$

Voltage variation factor $k_u(\Psi_k)$:

$$k_u(\Psi_k) = \sqrt{3} \times \frac{U_{fic,max} - U_{fic,min}}{U_n} \times \frac{S_{k,fic}}{S_n}$$

General specifications:

- PGU operation mode   Q setpoint = 0
- $S_{k,fic}/S_n$ 20
- Voltage range   400 V and 480V
- Grid frequency range   50 Hz

Used settings of the measurement device for switching operations measurement

Measurement device	Date of measurement	Recording	Sampling frequency
DEWETRON	2019/12/05 to 2019/12/06	100 ms	20 kHz

The switching operations tests results are offered below with more detail.

4.3.1.1 Test 1: Switch-on at P<10%Pn

Test conditions:

- T_p = 60 s. 400V Vac Output Voltage.

Results obtained from the test are offered at the table below.

Flicker factor and voltage change factor are determined for each record of measured voltage and measured current per phase according to the table below:

Case of switching operation	Switch-on at $P_{available}$ < 10% P_n			
Max, number of switching operations, N_{10}	20			
Max, number of switching operations, N_{120}	240			
Grid impedance angle	30º	50º	70º	85º
Flicker step factor, k_f (Ψ_k)	0.006	0.006	0.006	0.006
Voltage change factor, k_u (Ψ_k)	0.026	0.026	0.026	0.026

Test conditions:

- T_p = 60 s. 480V Vac Output Voltage.

Results obtained from the test are offered at the table below.

Flicker factor and voltage change factor are determined for each record of measured voltage and measured current per phase according to the table below:

Case of switching operation	Switch-on at $P_{available}$ < 10% P_n			
Max, number of switching operations, N_{10}	20			
Max, number of switching operations, N_{120}	240			
Grid impedance angle	30º	50º	70º	85º
Flicker step factor, k_f (Ψ_k)	0.006	0.006	0.006	0.006
Voltage change factor, k_u (Ψ_k)	0.007	0.007	0.007	0.007

4.3.1.2 Test 2: Switch-on at P=100%Pn

Test conditions:

- T_p = 60 s. 400V Vac Output Voltage.

Results obtained from the test are offered at the table below.

Flicker factor and voltage change factor are determined for each record of measured voltage and measured current per phase according to the table below:

Case of switching operation	Switch-on at $P_{available}$ P=100%Pn			
Max, number of switching operations, N_{10}	20			
Max, number of switching operations, N_{120}	240			
Grid impedance angle	30º	50º	70º	85º
Flicker step factor, k_f (Ψ_k)	0.006	0.006	0.006	0.006
Voltage change factor, k_u (Ψ_k)	0.015	0.015	0.015	0.015

Test conditions:

- T_p = 60 s. 480V Vac Output Voltage.

Results obtained from the test are offered at the table below.

Flicker factor and voltage change factor are determined for each record of measured voltage and measured current per phase according to the table below:

Case of switching operation	Switch-on at $P_{available}$ P=100%Pn			
Max, number of switching operations, N_{10}	20			
Max, number of switching operations, N_{120}	240			
Grid impedance angle	30º	50º	70º	85º
Flicker step factor, k_f (Ψ_k)	0.006	0.006	0.006	0.006
Voltage change factor, k_u (Ψ_k)	0.056	0.056	0.056	0.056

4.3.1.3 Test 3: Service shutdown P=100%Pn

Test conditions:

- T_p = 30 s. 400V Vac Output Voltage.

Case of switching operation	Service shutdown P=100%Pn			
Max, number of switching operations, N_{10}	10			
Max, number of switching operations, N_{120}	120			
Grid impedance angle	30º	50º	70º	85º
Flicker step factor, k_f (Ψ_k)	0.010	0.013	0.016	0.016
Voltage change factor, ku (Ψk)	0.195	0.195	0.195	0.195

Test conditions:

- T_p = 30 s. 480V Vac Output Voltage.

Case of switching operation	Service shutdown P=100%Pn			
Max, number of switching operations, N_{10}	10			
Max, number of switching operations, N_{120}	120			
Grid impedance angle	30º	50º	70º	85º
Flicker step factor, k_f (Ψ_k)	0.010	0.014	0.016	0.017
Voltage change factor, ku (Ψk)	0.117	0.117	0.117	0.117

4.3.2 Flickers

The aim of this test is to determine the flicker coefficient c as a function of the grid impedance phase angle.

Test performed according point 4.3.3 of the standard. It applies to both PV and storage systems.

According to standard, it has been measured at least 12 P_{st} in total between 0%-90% of P_n, at least one P_{st} per 10% of P_n and at least 3 P_{st} in total between 90% and 100% P_n per each phase and per each operation point. The power bins tested can be found on the table of results offered at this chapter of the test report.

The value of $S_{k,fic}/S_n$ used for the analysis has been 20.

The flicker coefficient c (Ψ_k) is determinate per each flicker emission value $P_{st,fic}$:

$$\mathrm{c}\ (\Psi\mathrm{k}) = \mathrm{Pst}(\Psi\mathrm{k})\ x\ \frac{Sk}{Sn}$$

NOTE: According to Standard, the requirements for Flicker test are applicable at plant level, the results shown in this chapter are performed at inverter level. The results shown are informative.

Used settings of the measurement device for flicker measurement.

Measurement device	Date of measurement	Recording	Sampling frequency
DEWETRON	2019/12/05 and 2020/09/21	--	20 kHz

The conditions during testing are specified below:

- PGU operation mode — Q setpoint = 0
- Voltage range — 400 V and 480V
- Grid frequency range — 50 Hz
- Voltage unbalance — Same conditions as point 4.3.4 of this test report (*) (Umbalance chapter)

(*) As the test procedure for both tests is similar, representing the inverter working in continuous operation in a wide range of power bins, it is considered that the voltage unbalance conditions will be similar at both tests.

The system flicker coefficient is the maximum value of all measurements, tests bave been performed under different AC output voltage (400Vac and 480Vac), the following table shows the results obtained.

Under 400V Output voltage:

Network impedance phase angle, Ψk	30º	50º	70º	85º
Average active power, P (%Pn)	Flicker coefficient, C (Ψk, P_{bin})			
0	0.247	0.247	0.248	0.248
10	0.253	0.262	0.269	0.271
20	0.269	0.296	0.318	0.326
30	0.293	0.342	0.381	0.395
40	0.320	0.397	0.455	0.475
50	0.353	0.460	0.538	0.563
60	0.388	0.524	0.619	0.651
70	0.429	0.594	0.708	0.744
80	0.471	0.665	0.797	0.838
90	0.515	0.739	0.888	0.935
100	0.560	0.814	0.982	1.034
110	0.703	0.924	1.131	1.155

Under 480V Output voltage:

Network impedance phase angle, Ψk	30º	50º	70º	85º
Average active power, P (%Pn)	Flicker coefficient, C (Ψk, P_{bin})			
0	0.248	0.249	0.250	0.250
10	0.254	0.263	0.270	0.273
20	0.269	0.294	0.315	0.322
30	0.291	0.341	0.380	0.394
40	0.321	0.400	0.458	0.478
50	0.354	0.463	0.540	0.566
60	0.391	0.527	0.622	0.653
70	0.433	0.598	0.711	0.748
80	0.474	0.669	0.799	0.841
90	0.520	0.743	0.892	0.938
100	0.565	0.818	0.984	1.036
110	0.709	0.920	1.141	1.165

4.3.3 Harmonic

The aim of this test is to determine relevant values for PGU continuous operation.

Test performed according to point 4.3.4 of the standard. It can be applied at both PV and storage systems.

The reactive power setpoint is 0 VAr, the harmonics have been measured 10 minutes average values of line current, at least three records consisting of 3-phase measurements.

They have been verified limits at different power levels, from 0%Pn to 110% Pn, in 10%Pn steps.

The arithmetic average is formed over the 10 minutes record for each harmonic, interharmonic and higher frequency component of the current.

The total distortion of the current harmonics (TDC) has been calculated according to standard:

$$\mathrm{TDC} = \frac{\sqrt{\sum_{h=2}^{50} I_h^2}}{I_n} \cdot 100$$

See point 2.6 (Definitions) of this report.
The total distortion of the voltage harmonics (TDD) has been determined using the same procedure.

NOTE: According to Standard, the requirements for Harmonics test are applicable at plant level, the results shown in this chapter are performed at inverter level. The results shown are informative.

Used settings of the measurement device for harmonic measurement.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/26, 2020/01/21 and 2020/09/21	100 ms values	3 kHz

Tests bave been performed under different AC output voltage (400Vac and 480Vac),

• PGU operation mode; Q (VAr)	Q setpoint = 0 VAr
• Voltage range (V)	400 V
• Voltage unbalance	Same conditions as point 4.3.4 of this test report (*) (Umbalace Chapter)
• Measured period (min)	10 min each active power level

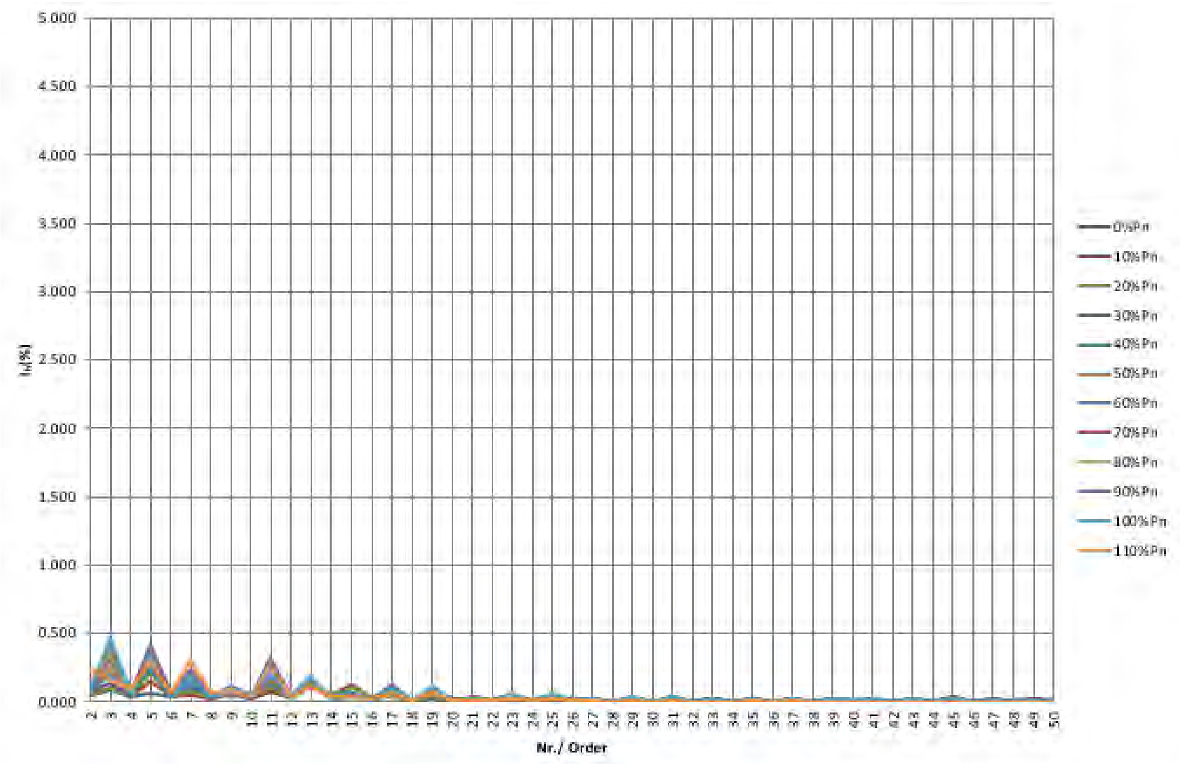
(*) As the test procedure for both tests is similar, representing the inverter working in continuous operation in a wide range of power bins, it is considered that the voltage unbalance conditions will be similar at both tests.

Power bin (%Pn)	Number of records
0 %	6000
10 %	6000
20 %	6000
30 %	6000
40 %	6000
50 %	6000
60 %	6000
70 %	6000
80 %	6000
90 %	6000
100 %	6000
110 %	6000

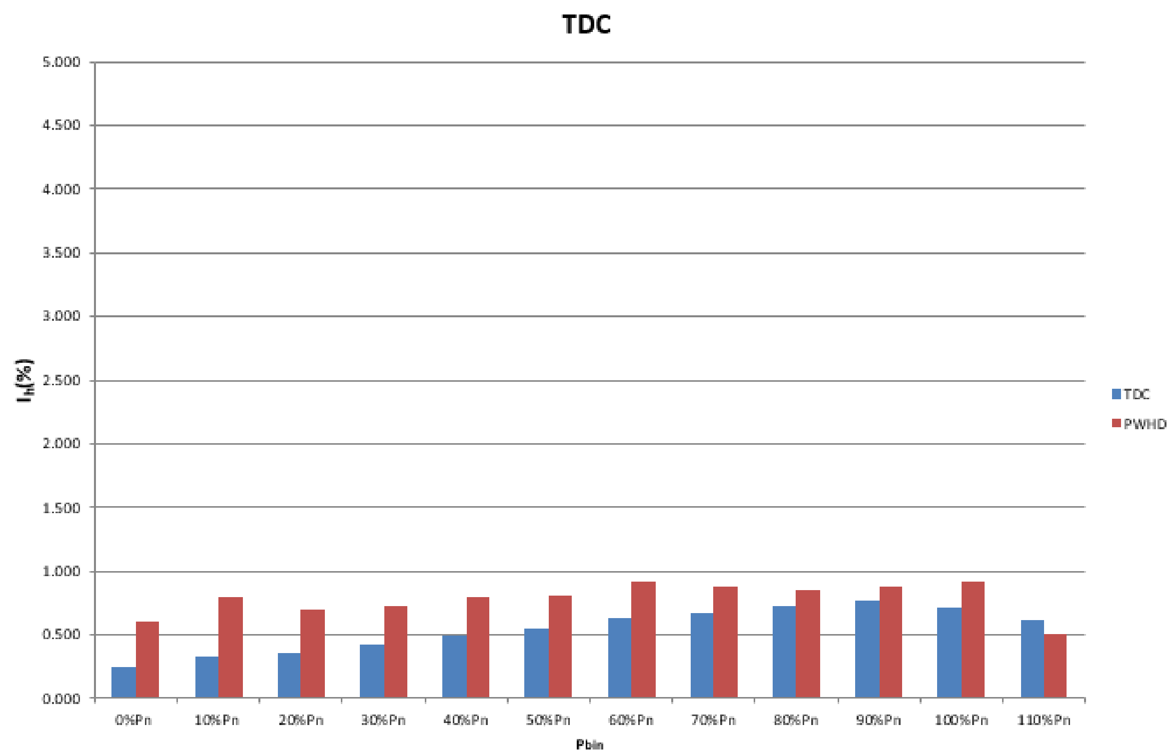
4.3.3.1 Current harmonics

P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
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(%)	
2	0.044	0.047	0.060	0.074	0.080	0.090	0.092	0.108	0.130	0.140	0.101	0.245	0.245
3	0.085	0.096	0.100	0.141	0.200	0.242	0.306	0.320	0.354	0.411	0.464	0.150	0.464
4	0.040	0.039	0.042	0.041	0.048	0.051	0.060	0.054	0.050	0.059	0.060	0.100	0.100
5	0.063	0.151	0.217	0.262	0.238	0.336	0.367	0.400	0.397	0.414	0.325	0.288	0.414
6	0.032	0.036	0.033	0.034	0.040	0.042	0.049	0.048	0.048	0.058	0.040	0.062	0.062
7	0.108	0.053	0.074	0.155	0.230	0.200	0.216	0.223	0.239	0.222	0.161	0.307	0.307
8	0.025	0.026	0.032	0.035	0.035	0.036	0.035	0.038	0.039	0.042	0.038	0.065	0.065
9	0.043	0.061	0.064	0.073	0.079	0.076	0.117	0.079	0.068	0.078	0.082	0.083	0.117
10	0.022	0.029	0.033	0.036	0.043	0.040	0.043	0.036	0.033	0.040	0.045	0.041	0.045
11	0.077	0.078	0.103	0.130	0.140	0.165	0.183	0.260	0.312	0.319	0.241	0.267	0.319
12	0.025	0.036	0.040	0.039	0.046	0.033	0.042	0.033	0.028	0.034	0.030	0.039	0.046
13	0.111	0.144	0.121	0.111	0.135	0.130	0.137	0.125	0.134	0.167	0.183	0.116	0.183
14	0.022	0.044	0.049	0.039	0.032	0.026	0.041	0.027	0.018	0.024	0.021	0.037	0.049
15	0.046	0.130	0.101	0.058	0.054	0.040	0.062	0.048	0.042	0.043	0.035	0.033	0.130
16	0.013	0.025	0.031	0.030	0.020	0.016	0.021	0.015	0.013	0.016	0.014	0.023	0.031
17	0.053	0.047	0.031	0.067	0.081	0.097	0.108	0.114	0.118	0.123	0.097	0.064	0.123
18	0.008	0.012	0.012	0.012	0.013	0.010	0.013	0.010	0.008	0.010	0.010	0.014	0.014
19	0.021	0.038	0.041	0.075	0.083	0.076	0.090	0.083	0.073	0.086	0.114	0.074	0.114
20	0.016	0.009	0.010	0.013	0.020	0.021	0.022	0.023	0.024	0.021	0.016	0.012	0.024
21	0.020	0.032	0.025	0.022	0.024	0.021	0.024	0.019	0.019	0.015	0.024	0.009	0.032
22	0.005	0.007	0.008	0.008	0.007	0.006	0.007	0.006	0.006	0.006	0.006	0.008	0.008
23	0.026	0.024	0.017	0.030	0.039	0.050	0.052	0.055	0.056	0.050	0.049	0.018	0.056
24	0.004	0.006	0.005	0.005	0.006	0.004	0.005	0.004	0.004	0.004	0.005	0.005	0.006
25	0.017	0.033	0.031	0.044	0.049	0.046	0.055	0.052	0.049	0.052	0.056	0.022	0.056
26	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.004	0.004	0.004	0.006	0.004	0.006
27	0.015	0.020	0.017	0.018	0.018	0.018	0.021	0.017	0.016	0.014	0.025	0.005	0.025
28	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.004	0.004	0.004
29	0.027	0.016	0.015	0.016	0.023	0.031	0.034	0.031	0.032	0.029	0.034	0.007	0.034
30	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.003	0.002	0.003
31	0.024	0.019	0.023	0.025	0.030	0.032	0.036	0.035	0.033	0.034	0.035	0.008	0.036
32	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003
33	0.020	0.019	0.019	0.019	0.020	0.018	0.018	0.017	0.017	0.016	0.025	0.003	0.025
34	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.002	0.002	0.003
35	0.020	0.014	0.012	0.011	0.016	0.021	0.023	0.022	0.022	0.022	0.026	0.005	0.026
36	0.002	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.003
37	0.022	0.020	0.019	0.018	0.022	0.023	0.026	0.024	0.024	0.023	0.025	0.004	0.026
38	0.002	0.003	0.002	0.003	0.003	0.002	0.003	0.002	0.002	0.002	0.003	0.001	0.003
39	0.019	0.023	0.024	0.023	0.022	0.021	0.019	0.019	0.019	0.018	0.025	0.002	0.025
40	0.005	0.002	0.003	0.003	0.005	0.004	0.003	0.002	0.003	0.005	0.005	0.001	0.005
41	0.016	0.016	0.014	0.012	0.014	0.017	0.018	0.018	0.018	0.019	0.019	0.003	0.019
42	0.003	0.003	0.003	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.003	0.001	0.003
43	0.022	0.020	0.017	0.015	0.018	0.019	0.021	0.020	0.019	0.019	0.019	0.003	0.022
44	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.003	0.001	0.003
45	0.033	0.032	0.034	0.031	0.028	0.026	0.023	0.022	0.022	0.019	0.024	0.001	0.034
46	0.003	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.004
47	0.015	0.023	0.019	0.014	0.015	0.015	0.017	0.017	0.017	0.019	0.016	0.002	0.023
48	0.004	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.003	0.001	0.004
49	0.024	0.025	0.017	0.015	0.017	0.018	0.019	0.018	0.016	0.018	0.014	0.002	0.025
50	0.004	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.003	0.001	0.004
TDC (%)	0.250	0.323	0.354	0.428	0.487	0.554	0.632	0.677	0.720	0.770	0.709	0.621	0.770

Current Harmonics



Total Distortion Current Harmonic

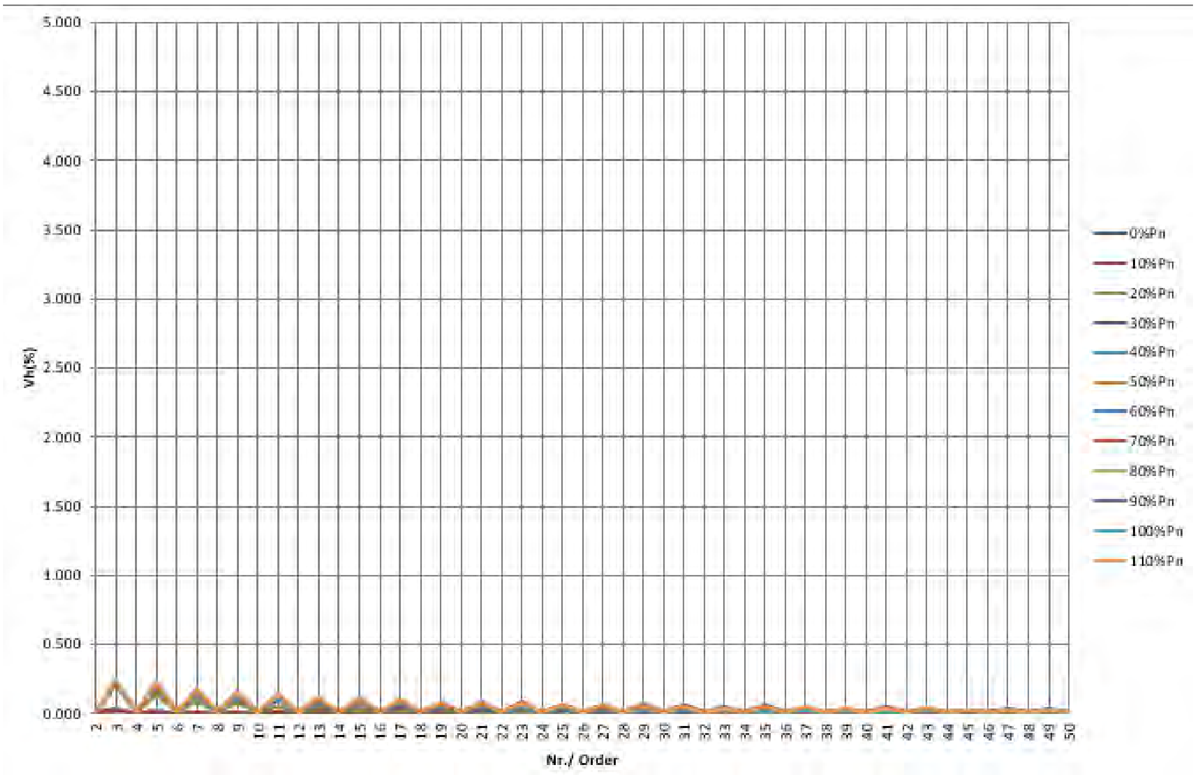


4.3.3.2 Voltage harmonics

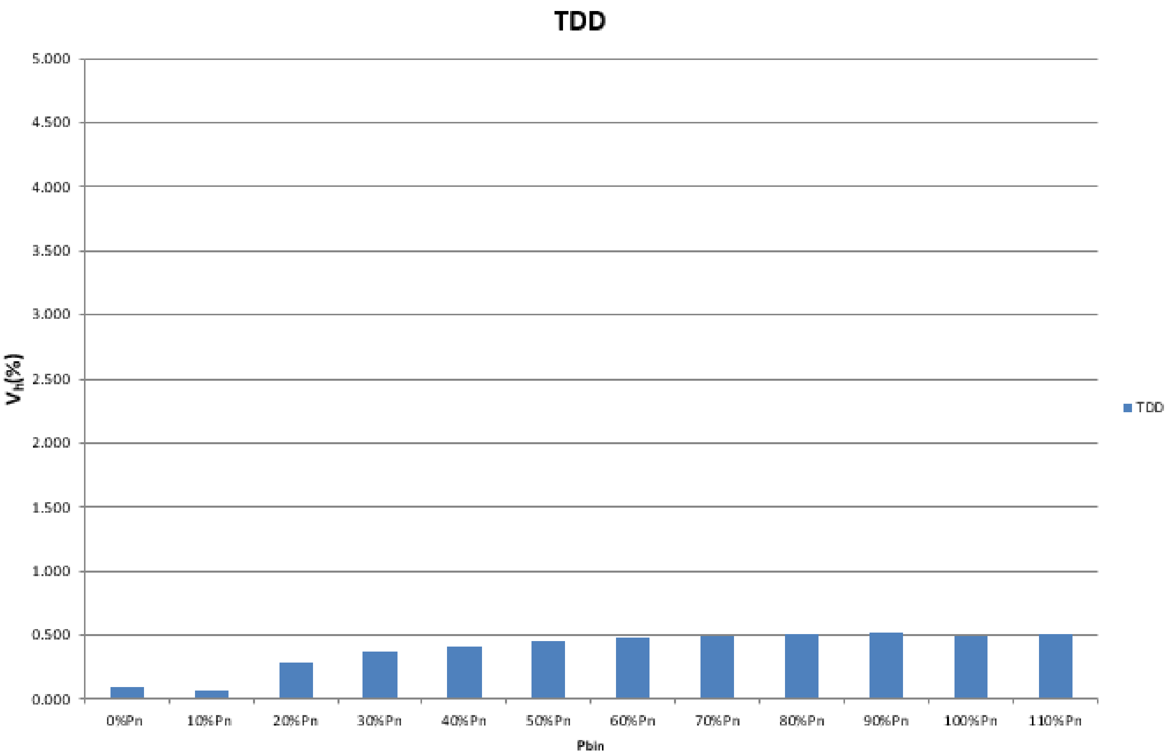
Measurements of voltage harmonics at continuous operation are done according to IEC 61000-4-7:2002

P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
Nr./ Order	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	
2	0.007	0.008	0.012	0.010	0.008	0.008	0.007	0.007	0.007	0.007	0.008	0.007	0.012
3	0.037	0.027	0.198	0.217	0.224	0.227	0.230	0.233	0.236	0.238	0.242	0.238	0.242
4	0.004	0.006	0.013	0.011	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.007	0.013
5	0.018	0.016	0.141	0.177	0.193	0.196	0.202	0.207	0.212	0.223	0.227	0.221	0.227
6	0.004	0.004	0.013	0.011	0.009	0.009	0.008	0.007	0.006	0.005	0.006	0.006	0.013
7	0.015	0.010	0.089	0.122	0.141	0.156	0.168	0.172	0.177	0.178	0.181	0.179	0.181
8	0.004	0.004	0.012	0.011	0.009	0.008	0.007	0.006	0.006	0.005	0.006	0.006	0.012
9	0.008	0.007	0.069	0.109	0.128	0.140	0.148	0.152	0.155	0.157	0.157	0.156	0.157
10	0.003	0.003	0.010	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.006	0.010
11	0.005	0.008	0.053	0.094	0.114	0.127	0.133	0.135	0.136	0.137	0.128	0.134	0.137
12	0.003	0.003	0.008	0.009	0.008	0.008	0.007	0.007	0.007	0.006	0.007	0.007	0.009
13	0.021	0.006	0.030	0.063	0.083	0.094	0.100	0.102	0.107	0.107	0.105	0.106	0.107
14	0.003	0.004	0.007	0.009	0.009	0.008	0.007	0.007	0.007	0.006	0.007	0.007	0.009
15	0.005	0.006	0.027	0.059	0.080	0.093	0.102	0.109	0.113	0.116	0.112	0.114	0.116
16	0.003	0.003	0.006	0.008	0.009	0.008	0.008	0.007	0.007	0.007	0.007	0.007	0.009
17	0.016	0.011	0.025	0.054	0.075	0.089	0.097	0.102	0.101	0.097	0.083	0.094	0.102
18	0.003	0.003	0.005	0.007	0.008	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.008
19	0.013	0.006	0.017	0.036	0.052	0.065	0.072	0.076	0.078	0.076	0.067	0.074	0.078
20	0.005	0.005	0.005	0.007	0.008	0.009	0.008	0.008	0.008	0.008	0.008	0.008	0.009
21	0.005	0.005	0.013	0.027	0.043	0.056	0.067	0.073	0.079	0.082	0.076	0.079	0.082
22	0.003	0.004	0.004	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
23	0.013	0.008	0.015	0.030	0.047	0.064	0.076	0.081	0.081	0.074	0.051	0.069	0.081
24	0.003	0.004	0.004	0.006	0.008	0.008	0.007	0.007	0.007	0.008	0.008	0.008	0.008
25	0.017	0.007	0.013	0.025	0.038	0.053	0.063	0.067	0.067	0.063	0.044	0.058	0.067
26	0.004	0.004	0.005	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
27	0.007	0.006	0.010	0.012	0.021	0.033	0.044	0.052	0.058	0.062	0.056	0.059	0.062
28	0.003	0.004	0.005	0.005	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
29	0.018	0.008	0.009	0.014	0.025	0.042	0.057	0.068	0.071	0.063	0.031	0.055	0.071
30	0.003	0.004	0.004	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007
31	0.028	0.009	0.013	0.013	0.021	0.035	0.048	0.057	0.061	0.059	0.032	0.050	0.061
32	0.004	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007
33	0.009	0.007	0.016	0.011	0.010	0.017	0.026	0.034	0.041	0.045	0.041	0.042	0.045
34	0.004	0.004	0.005	0.004	0.005	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007
35	0.035	0.022	0.029	0.024	0.016	0.019	0.032	0.046	0.059	0.060	0.016	0.045	0.060
36	0.003	0.003	0.004	0.004	0.006	0.007	0.007	0.008	0.009	0.008	0.008	0.008	0.009
37	0.008	0.013	0.028	0.022	0.014	0.017	0.029	0.041	0.050	0.055	0.030	0.045	0.055
38	0.003	0.004	0.005	0.004	0.005	0.006	0.006	0.007	0.007	0.007	0.008	0.007	0.008
39	0.014	0.012	0.023	0.020	0.015	0.013	0.016	0.023	0.029	0.033	0.030	0.030	0.033
40	0.004	0.005	0.005	0.005	0.006	0.006	0.007	0.008	0.009	0.010	0.011	0.010	0.011
41	0.011	0.016	0.036	0.035	0.029	0.023	0.020	0.026	0.040	0.052	0.017	0.036	0.052
42	0.003	0.004	0.004	0.004	0.004	0.005	0.006	0.006	0.007	0.007	0.008	0.007	0.008
43	0.017	0.011	0.030	0.032	0.028	0.021	0.017	0.021	0.031	0.040	0.026	0.033	0.040
44	0.004	0.004	0.004	0.004	0.005	0.006	0.006	0.007	0.008	0.009	0.009	0.009	0.009
45	0.008	0.011	0.021	0.021	0.018	0.014	0.013	0.016	0.020	0.025	0.023	0.023	0.025
46	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.006	0.007	0.007	0.007	0.007	0.007
47	0.023	0.008	0.017	0.025	0.028	0.027	0.025	0.023	0.025	0.036	0.018	0.026	0.036
48	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.007	0.006	0.007
49	0.015	0.010	0.012	0.022	0.026	0.026	0.023	0.020	0.021	0.031	0.026	0.026	0.031
50	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.006
TDD (%)	0.088	0.060	0.291	0.368	0.413	0.445	0.473	0.492	0.508	0.517	0.492	0.504	0.517

Voltage Harmonics



Total Voltage Distortion



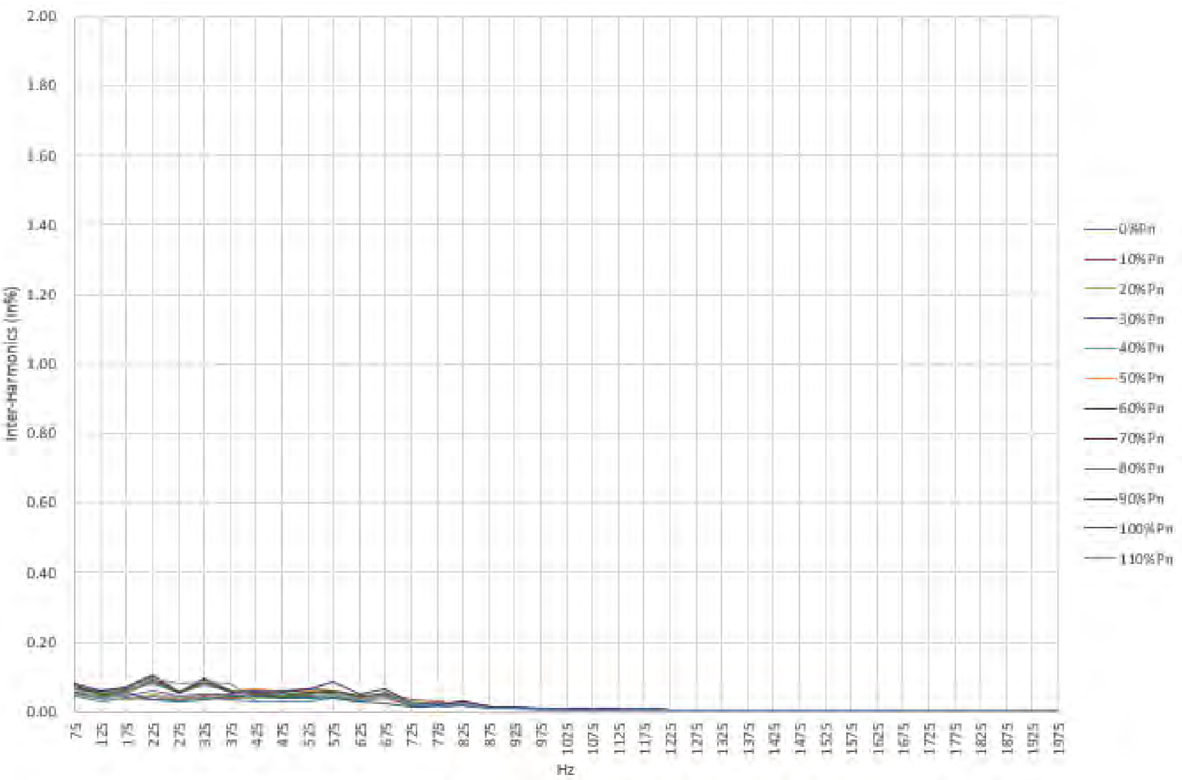
4.3.3.3 Interharmonics at continuous operation

Test performed according to point 4.3.4 of the standard.

Measurements of interharmonics at continuous operation are done according to IEC 61000-4-7:2002.

P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
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(%)	
75	0.044	0.052	0.048	0.054	0.071	0.073	0.081	0.074	0.063	0.066	0.056	0.064	0.081
125	0.029	0.037	0.042	0.046	0.053	0.052	0.058	0.052	0.049	0.058	0.038	0.036	0.058
175	0.042	0.032	0.034	0.045	0.061	0.047	0.070	0.056	0.060	0.066	0.054	0.054	0.070
225	0.036	0.046	0.051	0.058	0.080	0.095	0.108	0.091	0.085	0.100	0.036	0.097	0.108
275	0.033	0.035	0.038	0.044	0.056	0.057	0.057	0.055	0.055	0.055	0.030	0.082	0.082
325	0.037	0.046	0.049	0.052	0.074	0.082	0.097	0.085	0.081	0.093	0.033	0.087	0.097
375	0.036	0.041	0.043	0.050	0.060	0.058	0.058	0.058	0.061	0.053	0.042	0.080	0.080
425	0.028	0.039	0.041	0.045	0.049	0.063	0.054	0.052	0.052	0.058	0.044	0.029	0.063
475	0.028	0.042	0.042	0.045	0.049	0.058	0.060	0.045	0.045	0.056	0.042	0.030	0.060
525	0.028	0.039	0.041	0.042	0.056	0.061	0.064	0.056	0.052	0.067	0.040	0.032	0.067
575	0.038	0.043	0.044	0.047	0.061	0.061	0.061	0.057	0.059	0.084	0.038	0.050	0.084
625	0.030	0.037	0.034	0.032	0.046	0.039	0.046	0.043	0.040	0.048	0.030	0.036	0.048
675	0.039	0.053	0.042	0.044	0.049	0.042	0.048	0.047	0.049	0.065	0.025	0.046	0.065
725	0.018	0.033	0.031	0.026	0.023	0.021	0.023	0.021	0.021	0.024	0.015	0.022	0.033
775	0.013	0.031	0.026	0.022	0.019	0.017	0.019	0.016	0.017	0.018	0.012	0.014	0.031
825	0.020	0.018	0.019	0.019	0.021	0.029	0.027	0.028	0.026	0.028	0.020	0.023	0.029
875	0.011	0.015	0.014	0.014	0.015	0.014	0.014	0.013	0.013	0.016	0.009	0.009	0.016
925	0.009	0.011	0.011	0.011	0.012	0.011	0.012	0.011	0.010	0.011	0.008	0.007	0.012
975	0.009	0.011	0.010	0.010	0.011	0.010	0.011	0.010	0.010	0.011	0.007	0.005	0.011
1025	0.006	0.009	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.006	0.004	0.009
1075	0.006	0.008	0.007	0.007	0.008	0.007	0.007	0.007	0.007	0.007	0.006	0.004	0.008
1125	0.006	0.007	0.007	0.007	0.007	0.006	0.007	0.006	0.006	0.007	0.005	0.003	0.007
1175	0.009	0.006	0.006	0.007	0.011	0.011	0.010	0.010	0.009	0.009	0.009	0.004	0.011
1225	0.005	0.005	0.005	0.006	0.006	0.005	0.006	0.005	0.005	0.005	0.005	0.003	0.006
1275	0.005	0.006	0.005	0.005	0.006	0.005	0.005	0.005	0.005	0.005	0.004	0.002	0.006
1325	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.005	0.004	0.002	0.005
1375	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.002	0.005
1425	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.002	0.004
1475	0.004	0.004	0.003	0.004	0.004	0.004	0.004	0.004	0.003	0.004	0.003	0.002	0.004
1525	0.003	0.004	0.003	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.002	0.004
1575	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.004
1625	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.002	0.004
1675	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003
1725	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003
1775	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003
1825	0.004	0.003	0.003	0.003	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.002	0.005
1875	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003
1925	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.001	0.003
1975	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.001	0.003

Inter-Harmonics Current



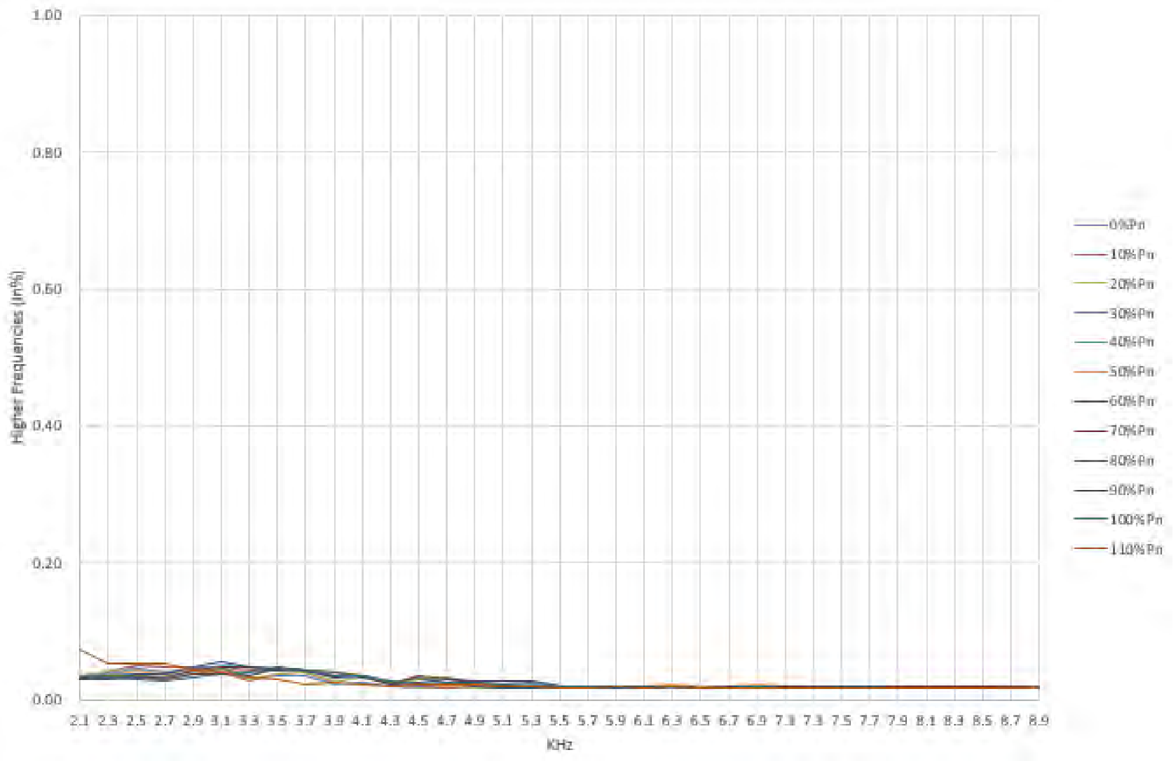
4.3.3.4 Higher frequency components

Test performed according to point 4.3.4 of the standard.

Measurements of Higher frequency are done according to IEC 61000-4-7:2002.

P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
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	0.036	0.032	0.029	0.030	0.030	0.031	0.033	0.031	0.030	0.031	0.032	0.072	0.072
2.3	0.041	0.041	0.042	0.039	0.035	0.034	0.035	0.034	0.034	0.031	0.033	0.053	0.053
2.5	0.051	0.050	0.045	0.045	0.047	0.043	0.039	0.036	0.035	0.033	0.031	0.054	0.054
2.7	0.049	0.047	0.040	0.041	0.036	0.036	0.038	0.033	0.030	0.030	0.028	0.052	0.052
2.9	0.049	0.048	0.043	0.046	0.041	0.047	0.049	0.042	0.038	0.038	0.033	0.042	0.049
3.1	0.048	0.041	0.045	0.047	0.049	0.041	0.055	0.048	0.045	0.038	0.038	0.041	0.055
3.3	0.030	0.027	0.030	0.043	0.049	0.046	0.049	0.048	0.036	0.035	0.041	0.033	0.049
3.5	0.034	0.039	0.038	0.044	0.045	0.042	0.042	0.046	0.045	0.047	0.045	0.029	0.047
3.7	0.035	0.039	0.041	0.043	0.042	0.042	0.043	0.042	0.043	0.042	0.042	0.023	0.043
3.9	0.022	0.026	0.028	0.034	0.033	0.040	0.041	0.036	0.039	0.033	0.035	0.025	0.041
4.1	0.026	0.036	0.034	0.034	0.034	0.036	0.032	0.036	0.036	0.036	0.034	0.021	0.036
4.3	0.019	0.021	0.021	0.022	0.024	0.027	0.025	0.023	0.026	0.022	0.026	0.021	0.027
4.5	0.018	0.018	0.018	0.021	0.021	0.022	0.034	0.035	0.029	0.026	0.021	0.023	0.035
4.7	0.018	0.018	0.019	0.020	0.021	0.021	0.024	0.030	0.032	0.029	0.025	0.024	0.032
4.9	0.017	0.018	0.018	0.020	0.021	0.019	0.019	0.025	0.025	0.028	0.024	0.021	0.028
5.1	0.017	0.017	0.018	0.020	0.021	0.019	0.019	0.019	0.022	0.027	0.022	0.020	0.027
5.3	0.017	0.017	0.018	0.019	0.022	0.019	0.018	0.019	0.020	0.026	0.026	0.019	0.026
5.5	0.017	0.017	0.018	0.018	0.020	0.019	0.018	0.018	0.019	0.020	0.021	0.018	0.021
5.7	0.017	0.017	0.018	0.018	0.019	0.019	0.018	0.018	0.018	0.019	0.020	0.018	0.020
5.9	0.017	0.017	0.018	0.018	0.019	0.020	0.018	0.018	0.018	0.018	0.019	0.019	0.020
6.1	0.017	0.017	0.018	0.018	0.019	0.020	0.018	0.018	0.018	0.018	0.019	0.019	0.020
6.3	0.018	0.019	0.019	0.019	0.020	0.021	0.020	0.019	0.020	0.020	0.020	0.019	0.021
6.5	0.017	0.017	0.018	0.018	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.018	0.019
6.7	0.017	0.017	0.017	0.017	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.018	0.019
6.9	0.017	0.017	0.018	0.018	0.019	0.021	0.020	0.019	0.018	0.019	0.019	0.018	0.021
7.1	0.018	0.018	0.018	0.018	0.019	0.019	0.021	0.019	0.018	0.018	0.018	0.018	0.021
7.3	0.018	0.018	0.018	0.019	0.019	0.020	0.020	0.019	0.018	0.019	0.019	0.018	0.020
7.5	0.017	0.017	0.017	0.018	0.018	0.019	0.019	0.018	0.018	0.018	0.018	0.018	0.019
7.7	0.017	0.017	0.017	0.018	0.018	0.019	0.019	0.018	0.018	0.018	0.018	0.018	0.019
7.9	0.017	0.017	0.017	0.018	0.018	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.019
8.1	0.017	0.017	0.017	0.018	0.018	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.019
8.3	0.017	0.017	0.017	0.018	0.018	0.019	0.018	0.019	0.018	0.018	0.018	0.018	0.019
8.5	0.017	0.017	0.017	0.017	0.018	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.019
8.7	0.017	0.017	0.018	0.018	0.018	0.019	0.018	0.019	0.018	0.018	0.018	0.018	0.019
8.9	0.017	0.017	0.017	0.017	0.018	0.018	0.019	0.018	0.017	0.018	0.018	0.018	0.019

Current high frequency harmonics



Used settings of the measurement device for harmonic measurement.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/26 and 2020/09/22	100 ms values	3 kHz

- PGU operation mode; Q (VAr) — Q setpoint = 0 VAr
- Voltage range (V) — 480 V
- Voltage unbalance — Same conditions as point 4.3.4 of this test report (*) (Umbalace Chapter)
- Measured period (min) — 10 min each active power level

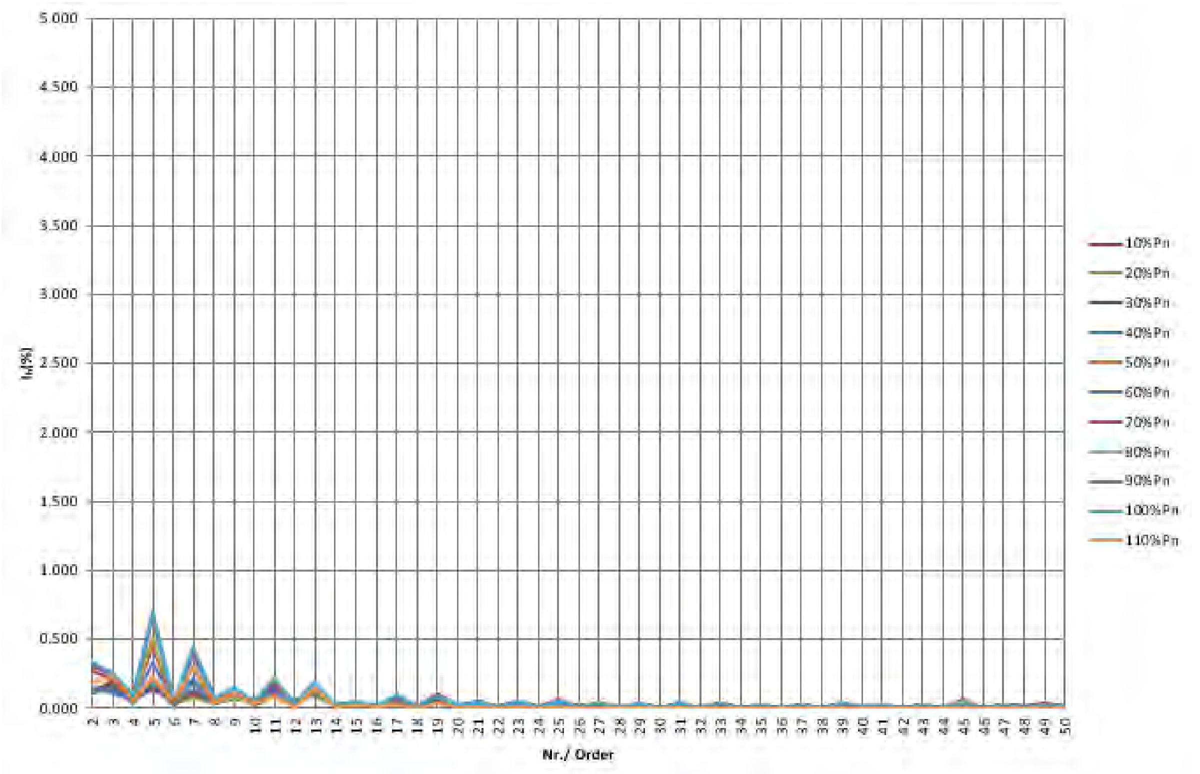
(*) As the test procedure for both tests is similar, representing the inverter working in continuous operation in a wide range of power bins, it is considered that the voltage unbalance conditions will be similar at both tests.

Power bin (%Pn)	Number of records
0 %	6000
10 %	6000
20 %	6000
30 %	6000
40 %	6000
50 %	6000
60 %	6000
70 %	6000
80 %	6000
90 %	6000
100 %	6000
110 %	6000

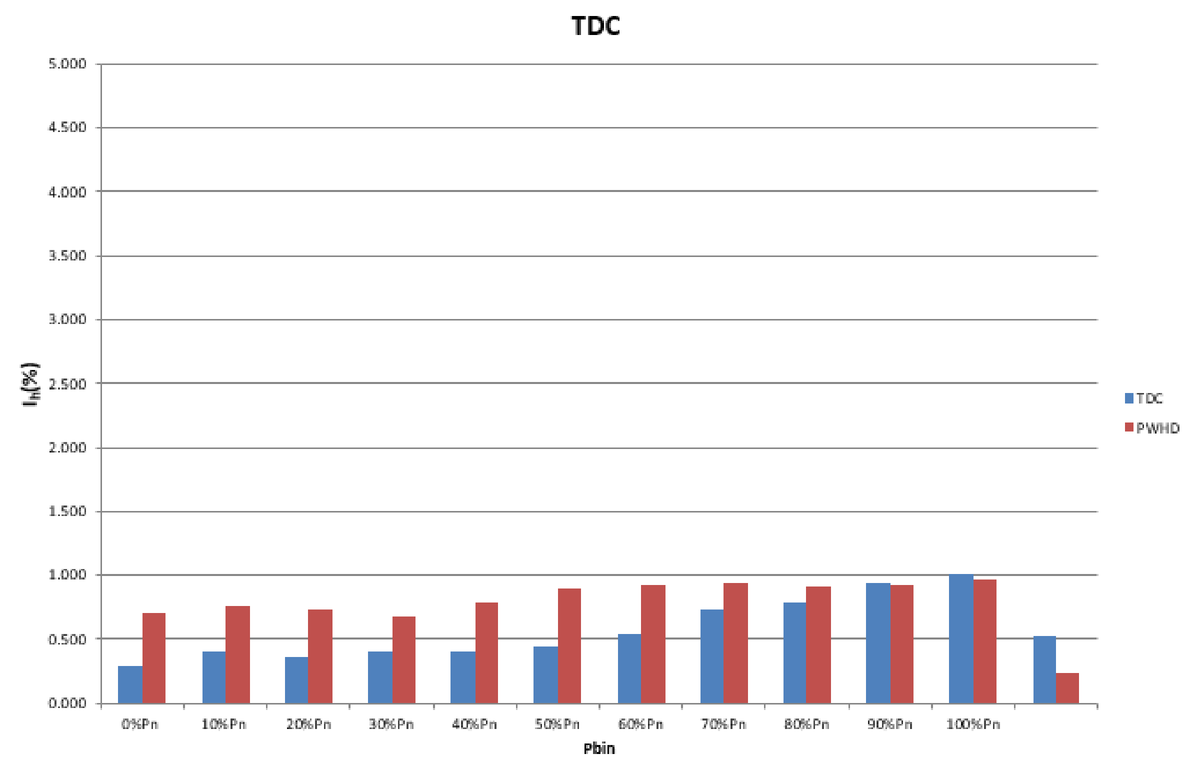
4.3.3.5 Current harmonics

P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
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(%)	
2	0.077	0.108	0.121	0.141	0.118	0.136	0.154	0.259	0.299	0.308	0.331	0.193	0.331
3	0.125	0.208	0.171	0.163	0.132	0.115	0.108	0.218	0.252	0.238	0.258	0.232	0.258
4	0.032	0.046	0.051	0.058	0.038	0.053	0.067	0.071	0.077	0.086	0.097	0.056	0.097
5	0.148	0.161	0.173	0.143	0.187	0.223	0.332	0.448	0.504	0.661	0.695	0.220	0.695
6	0.021	0.029	0.039	0.051	0.031	0.040	0.048	0.039	0.036	0.042	0.048	0.056	0.056
7	0.074	0.094	0.079	0.129	0.171	0.204	0.220	0.305	0.309	0.395	0.445	0.292	0.445
8	0.023	0.036	0.042	0.054	0.032	0.031	0.038	0.060	0.066	0.068	0.075	0.034	0.075
9	0.052	0.095	0.057	0.077	0.087	0.091	0.109	0.098	0.078	0.115	0.144	0.114	0.144
10	0.025	0.035	0.056	0.058	0.023	0.027	0.034	0.050	0.036	0.038	0.046	0.033	0.058
11	0.059	0.166	0.082	0.151	0.086	0.104	0.120	0.193	0.211	0.211	0.209	0.084	0.211
12	0.022	0.026	0.060	0.054	0.029	0.023	0.025	0.021	0.021	0.021	0.024	0.015	0.060
13	0.088	0.128	0.084	0.124	0.134	0.146	0.163	0.159	0.174	0.177	0.184	0.134	0.184
14	0.014	0.017	0.025	0.029	0.015	0.014	0.015	0.022	0.018	0.021	0.023	0.015	0.029
15	0.034	0.041	0.034	0.036	0.041	0.052	0.050	0.037	0.030	0.037	0.045	0.029	0.052
16	0.011	0.010	0.014	0.020	0.010	0.012	0.014	0.011	0.010	0.012	0.013	0.008	0.020
17	0.070	0.044	0.059	0.039	0.053	0.067	0.074	0.085	0.077	0.080	0.096	0.022	0.096
18	0.008	0.010	0.012	0.013	0.008	0.008	0.007	0.008	0.008	0.008	0.010	0.004	0.013
19	0.024	0.046	0.056	0.050	0.081	0.099	0.106	0.099	0.092	0.090	0.089	0.032	0.106
20	0.006	0.007	0.010	0.009	0.009	0.011	0.017	0.019	0.021	0.019	0.018	0.005	0.021
21	0.019	0.027	0.026	0.022	0.043	0.046	0.044	0.035	0.031	0.035	0.039	0.010	0.046
22	0.004	0.005	0.007	0.007	0.005	0.006	0.006	0.006	0.005	0.005	0.007	0.003	0.007
23	0.029	0.025	0.020	0.018	0.025	0.033	0.041	0.048	0.048	0.051	0.051	0.010	0.051
24	0.003	0.004	0.006	0.005	0.003	0.003	0.004	0.005	0.004	0.004	0.005	0.002	0.006
25	0.023	0.020	0.022	0.034	0.039	0.050	0.052	0.056	0.047	0.050	0.053	0.011	0.056
26	0.004	0.004	0.005	0.004	0.005	0.006	0.006	0.006	0.005	0.005	0.006	0.002	0.006
27	0.018	0.025	0.027	0.022	0.034	0.036	0.035	0.036	0.033	0.034	0.036	0.003	0.036
28	0.003	0.003	0.003	0.004	0.003	0.004	0.005	0.004	0.003	0.004	0.004	0.002	0.005
29	0.026	0.022	0.016	0.016	0.017	0.023	0.028	0.033	0.034	0.034	0.035	0.005	0.035
30	0.003	0.003	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.001	0.004
31	0.022	0.027	0.023	0.023	0.024	0.031	0.032	0.036	0.035	0.036	0.037	0.005	0.037
32	0.003	0.003	0.003	0.004	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.001	0.004
33	0.021	0.026	0.026	0.027	0.034	0.034	0.033	0.035	0.034	0.035	0.035	0.002	0.035
34	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.001	0.004
35	0.020	0.017	0.014	0.013	0.013	0.017	0.020	0.023	0.024	0.026	0.026	0.003	0.026
36	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.001	0.004
37	0.022	0.018	0.021	0.018	0.016	0.022	0.022	0.026	0.025	0.027	0.028	0.003	0.028
38	0.002	0.003	0.004	0.004	0.003	0.003	0.003	0.004	0.003	0.003	0.004	0.001	0.004
39	0.029	0.034	0.034	0.033	0.039	0.039	0.036	0.037	0.038	0.038	0.037	0.002	0.039
40	0.003	0.003	0.003	0.003	0.002	0.003	0.005	0.003	0.003	0.003	0.004	0.001	0.005
41	0.015	0.021	0.015	0.016	0.013	0.017	0.019	0.017	0.021	0.021	0.022	0.002	0.022
42	0.003	0.004	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.001	0.004
43	0.023	0.021	0.018	0.017	0.014	0.018	0.018	0.021	0.022	0.023	0.023	0.002	0.023
44	0.002	0.004	0.003	0.004	0.003	0.003	0.003	0.004	0.003	0.004	0.004	0.001	0.004
45	0.047	0.055	0.051	0.050	0.047	0.045	0.040	0.042	0.043	0.042	0.041	0.002	0.055
46	0.003	0.004	0.003	0.004	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.001	0.004
47	0.022	0.024	0.026	0.024	0.016	0.019	0.021	0.016	0.018	0.018	0.018	0.002	0.026
48	0.006	0.007	0.005	0.004	0.004	0.004	0.004	0.003	0.004	0.003	0.004	0.001	0.007
49	0.034	0.042	0.027	0.017	0.017	0.020	0.019	0.020	0.022	0.023	0.022	0.002	0.042
50	0.007	0.006	0.006	0.006	0.005	0.004	0.004	0.005	0.004	0.005	0.005	0.001	0.007
TDC (%)	0.288	0.409	0.359	0.399	0.396	0.450	0.541	0.728	0.793	0.940	1.007	0.524	1.007

Current Harmonics



Total Distortion Current Harmonic

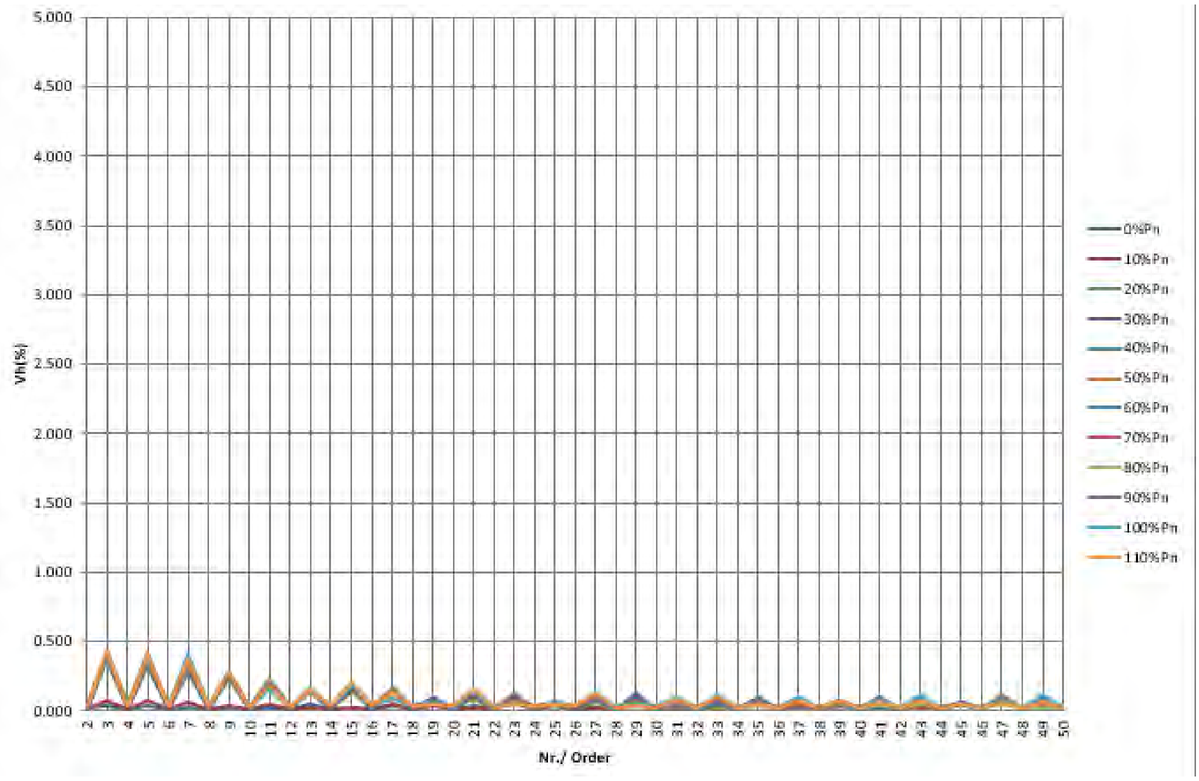


4.3.3.6 Voltage harmonics

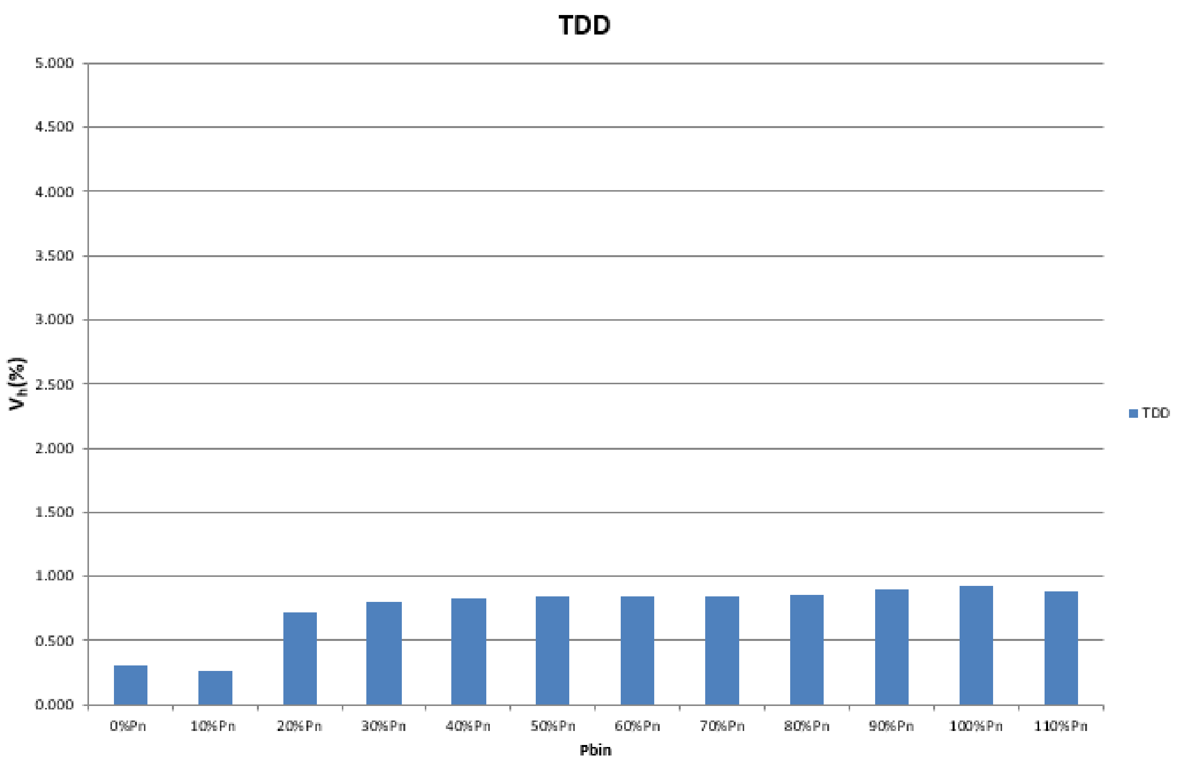
Measurements of voltage harmonics at continuous operation are done according to IEC 61000-4-7:2002

P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
Nr./ Order	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	U_h(%)	
2	0.020	0.013	0.013	0.013	0.016	0.022	0.026	0.031	0.037	0.041	0.042	0.040	0.042
3	0.035	0.077	0.364	0.377	0.387	0.396	0.404	0.410	0.418	0.425	0.434	0.425	0.434
4	0.016	0.013	0.018	0.010	0.012	0.020	0.024	0.029	0.034	0.039	0.052	0.042	0.052
5	0.037	0.074	0.313	0.342	0.359	0.365	0.366	0.379	0.395	0.417	0.405	0.406	0.417
6	0.013	0.015	0.022	0.012	0.012	0.021	0.026	0.029	0.033	0.036	0.039	0.036	0.039
7	0.020	0.061	0.272	0.293	0.306	0.324	0.339	0.328	0.333	0.347	0.407	0.363	0.407
8	0.009	0.013	0.022	0.012	0.014	0.019	0.023	0.026	0.030	0.032	0.037	0.033	0.037
9	0.021	0.042	0.231	0.256	0.266	0.273	0.276	0.278	0.280	0.282	0.282	0.281	0.282
10	0.008	0.012	0.023	0.013	0.014	0.019	0.021	0.022	0.024	0.026	0.026	0.025	0.026
11	0.026	0.045	0.217	0.227	0.232	0.231	0.227	0.218	0.211	0.200	0.157	0.189	0.232
12	0.008	0.011	0.025	0.016	0.015	0.021	0.021	0.023	0.027	0.027	0.029	0.028	0.029
13	0.046	0.026	0.143	0.152	0.150	0.151	0.144	0.143	0.140	0.149	0.162	0.150	0.162
14	0.010	0.009	0.022	0.013	0.014	0.021	0.025	0.028	0.033	0.036	0.036	0.035	0.036
15	0.028	0.027	0.139	0.168	0.181	0.189	0.194	0.198	0.200	0.203	0.203	0.202	0.203
16	0.009	0.009	0.022	0.014	0.015	0.024	0.028	0.030	0.033	0.035	0.042	0.037	0.042
17	0.031	0.047	0.128	0.155	0.158	0.157	0.154	0.151	0.140	0.124	0.093	0.119	0.158
18	0.011	0.010	0.023	0.016	0.015	0.023	0.027	0.029	0.032	0.032	0.032	0.032	0.032
19	0.105	0.034	0.058	0.079	0.073	0.061	0.049	0.047	0.047	0.051	0.061	0.053	0.105
20	0.013	0.011	0.018	0.014	0.015	0.024	0.029	0.033	0.036	0.040	0.041	0.039	0.041
21	0.031	0.027	0.091	0.115	0.126	0.135	0.144	0.148	0.150	0.151	0.149	0.150	0.151
22	0.010	0.010	0.016	0.013	0.015	0.020	0.022	0.023	0.025	0.026	0.035	0.029	0.035
23	0.097	0.062	0.099	0.119	0.117	0.110	0.100	0.088	0.066	0.053	0.045	0.055	0.119
24	0.010	0.010	0.016	0.013	0.015	0.022	0.028	0.027	0.033	0.034	0.037	0.035	0.037
25	0.073	0.035	0.031	0.044	0.040	0.033	0.031	0.032	0.039	0.048	0.059	0.049	0.073
26	0.010	0.009	0.013	0.011	0.013	0.021	0.025	0.028	0.033	0.036	0.036	0.035	0.036
27	0.021	0.028	0.067	0.086	0.094	0.102	0.110	0.118	0.121	0.124	0.121	0.122	0.124
28	0.010	0.009	0.012	0.010	0.012	0.017	0.020	0.021	0.023	0.024	0.030	0.026	0.030
29	0.123	0.066	0.088	0.099	0.088	0.076	0.064	0.046	0.031	0.033	0.043	0.036	0.123
30	0.010	0.009	0.013	0.010	0.012	0.017	0.020	0.022	0.026	0.028	0.031	0.028	0.031
31	0.025	0.027	0.020	0.033	0.033	0.029	0.034	0.045	0.066	0.080	0.102	0.083	0.102
32	0.009	0.009	0.012	0.010	0.012	0.017	0.020	0.023	0.026	0.027	0.026	0.026	0.027
33	0.063	0.038	0.028	0.050	0.061	0.068	0.075	0.085	0.096	0.105	0.108	0.103	0.108
34	0.010	0.010	0.011	0.010	0.011	0.015	0.017	0.019	0.021	0.019	0.022	0.021	0.022
35	0.082	0.060	0.079	0.097	0.090	0.079	0.065	0.042	0.034	0.057	0.052	0.048	0.097
36	0.009	0.009	0.010	0.009	0.011	0.016	0.022	0.022	0.026	0.027	0.029	0.027	0.029
37	0.060	0.042	0.024	0.043	0.048	0.037	0.029	0.037	0.058	0.078	0.105	0.080	0.105
38	0.009	0.008	0.010	0.009	0.010	0.015	0.018	0.020	0.023	0.023	0.022	0.023	0.023
39	0.080	0.067	0.030	0.042	0.053	0.055	0.055	0.059	0.065	0.074	0.076	0.072	0.080
40	0.010	0.010	0.010	0.010	0.010	0.018	0.022	0.021	0.021	0.022	0.027	0.023	0.027
41	0.019	0.070	0.070	0.101	0.102	0.090	0.074	0.050	0.042	0.068	0.070	0.060	0.102
42	0.008	0.008	0.010	0.008	0.009	0.013	0.015	0.017	0.021	0.023	0.025	0.023	0.025
43	0.088	0.051	0.038	0.053	0.065	0.054	0.035	0.027	0.043	0.075	0.108	0.075	0.108
44	0.009	0.008	0.010	0.008	0.009	0.014	0.017	0.020	0.023	0.023	0.021	0.022	0.023
45	0.055	0.065	0.046	0.049	0.054	0.054	0.052	0.050	0.051	0.056	0.050	0.052	0.065
46	0.008	0.008	0.009	0.008	0.009	0.012	0.015	0.018	0.021	0.020	0.019	0.020	0.021
47	0.088	0.091	0.065	0.100	0.116	0.108	0.088	0.065	0.052	0.073	0.079	0.068	0.116
48	0.009	0.008	0.009	0.008	0.009	0.012	0.014	0.016	0.020	0.022	0.022	0.021	0.022
49	0.065	0.066	0.062	0.064	0.085	0.080	0.057	0.033	0.025	0.063	0.112	0.067	0.112
50	0.009	0.008	0.009	0.008	0.009	0.013	0.016	0.018	0.023	0.022	0.019	0.021	0.023
TDD (%)	0.312	0.271	0.727	0.799	0.831	0.845	0.849	0.847	0.861	0.893	0.923	0.890	0.923

Voltage Harmonics



Total Voltage Distortion



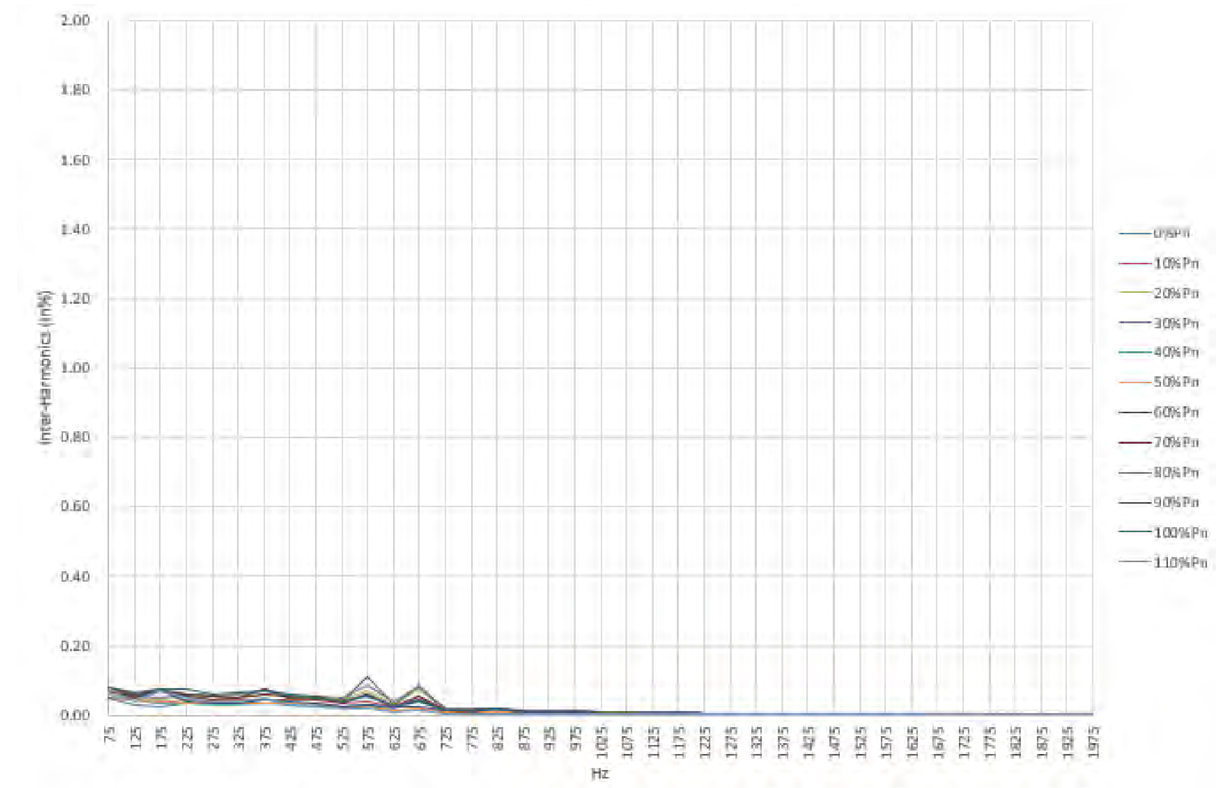
4.3.3.7 Interharmonics at continuous operation

Test performed according to point 4.3.4 of the standard.

Measurements of interharmonics at continuous operation are done according to IEC 61000-4-7:2002.

P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
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(%)	
75	0.048	0.049	0.060	0.068	0.059	0.069	0.072	0.073	0.078	0.079	0.082	0.075	0.082
125	0.031	0.043	0.050	0.054	0.042	0.045	0.048	0.057	0.057	0.060	0.065	0.041	0.065
175	0.026	0.035	0.043	0.048	0.036	0.042	0.075	0.069	0.074	0.071	0.075	0.068	0.075
225	0.034	0.044	0.054	0.061	0.034	0.036	0.039	0.056	0.058	0.061	0.078	0.048	0.078
275	0.033	0.038	0.045	0.053	0.031	0.033	0.036	0.045	0.054	0.056	0.062	0.039	0.062
325	0.032	0.042	0.051	0.059	0.031	0.033	0.035	0.049	0.049	0.051	0.065	0.039	0.065
375	0.037	0.047	0.061	0.069	0.034	0.036	0.046	0.059	0.076	0.075	0.070	0.050	0.076
425	0.029	0.044	0.055	0.062	0.034	0.037	0.038	0.057	0.050	0.051	0.060	0.028	0.062
475	0.027	0.043	0.049	0.056	0.030	0.034	0.035	0.043	0.055	0.054	0.048	0.024	0.056
525	0.024	0.035	0.042	0.050	0.023	0.025	0.026	0.040	0.039	0.033	0.042	0.019	0.050
575	0.030	0.041	0.068	0.088	0.024	0.026	0.030	0.062	0.110	0.059	0.055	0.020	0.110
625	0.019	0.025	0.030	0.037	0.014	0.016	0.022	0.027	0.029	0.026	0.026	0.012	0.037
675	0.043	0.053	0.076	0.082	0.015	0.020	0.024	0.054	0.087	0.046	0.041	0.012	0.087
725	0.012	0.016	0.017	0.021	0.011	0.011	0.013	0.014	0.016	0.014	0.014	0.006	0.021
775	0.011	0.015	0.015	0.018	0.008	0.009	0.011	0.013	0.015	0.013	0.013	0.005	0.018
825	0.011	0.012	0.013	0.018	0.007	0.008	0.017	0.019	0.020	0.020	0.017	0.006	0.020
875	0.010	0.015	0.015	0.015	0.007	0.008	0.008	0.009	0.010	0.009	0.009	0.004	0.015
925	0.008	0.010	0.010	0.012	0.006	0.006	0.007	0.008	0.009	0.008	0.008	0.003	0.012
975	0.008	0.012	0.012	0.012	0.005	0.006	0.007	0.008	0.010	0.008	0.008	0.003	0.012
1025	0.006	0.007	0.007	0.008	0.005	0.005	0.006	0.006	0.007	0.006	0.006	0.003	0.008
1075	0.005	0.006	0.007	0.007	0.005	0.005	0.006	0.006	0.007	0.006	0.006	0.003	0.007
1125	0.005	0.006	0.006	0.007	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.003	0.007
1175	0.005	0.006	0.006	0.007	0.004	0.005	0.007	0.008	0.009	0.009	0.009	0.003	0.009
1225	0.004	0.005	0.005	0.005	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.002	0.005
1275	0.004	0.005	0.005	0.006	0.003	0.004	0.004	0.005	0.006	0.005	0.005	0.002	0.006
1325	0.003	0.004	0.005	0.005	0.003	0.004	0.004	0.004	0.005	0.004	0.004	0.002	0.005
1375	0.003	0.004	0.004	0.004	0.003	0.003	0.005	0.005	0.006	0.005	0.005	0.002	0.006
1425	0.003	0.004	0.004	0.004	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.002	0.004
1475	0.003	0.004	0.004	0.005	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.002	0.005
1525	0.003	0.003	0.004	0.004	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.002	0.004
1575	0.003	0.004	0.004	0.004	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.002	0.004
1625	0.003	0.003	0.004	0.004	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.002	0.004
1675	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.004	0.004	0.003	0.003	0.002	0.004
1725	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.004	0.004	0.003	0.003	0.002	0.004
1775	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.004
1825	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.002	0.004
1875	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003
1925	0.002	0.003	0.004	0.004	0.002	0.003	0.003	0.003	0.004	0.003	0.003	0.002	0.004
1975	0.003	0.003	0.004	0.004	0.003	0.003	0.003	0.004	0.004	0.003	0.003	0.002	0.004

Inter-Harmonics Current



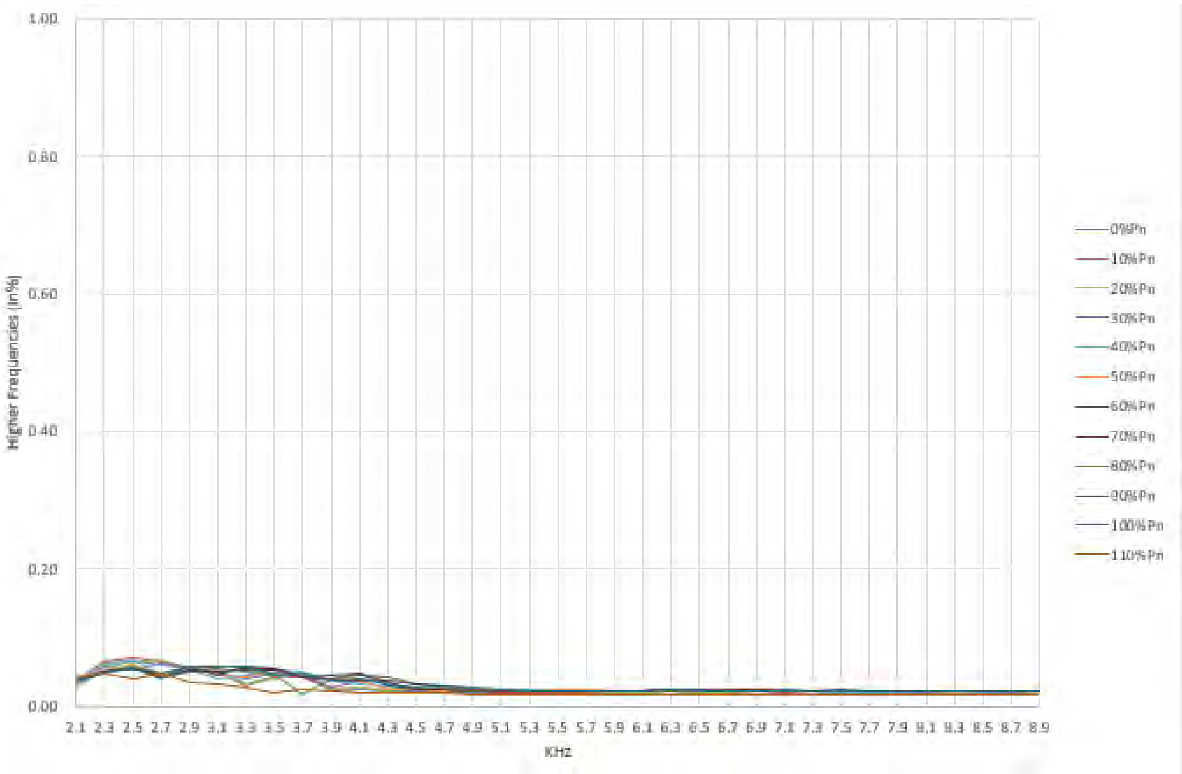
4.3.3.8 Higher frequency components

Test performed according to point 4.3.4 of the standard.

Measurements of Higher frequency are done according to IEC 61000-4-7:2002.

P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
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	0.039	0.036	0.039	0.034	0.028	0.033	0.035	0.036	0.037	0.037	0.037	0.044	0.044
2.3	0.062	0.065	0.061	0.059	0.053	0.053	0.051	0.051	0.051	0.050	0.047	0.048	0.065
2.5	0.065	0.070	0.064	0.054	0.067	0.061	0.056	0.055	0.058	0.055	0.055	0.041	0.070
2.7	0.061	0.066	0.068	0.062	0.046	0.044	0.048	0.043	0.042	0.042	0.041	0.047	0.068
2.9	0.057	0.056	0.053	0.054	0.054	0.057	0.058	0.050	0.059	0.053	0.059	0.035	0.059
3.1	0.051	0.052	0.052	0.048	0.040	0.046	0.045	0.049	0.056	0.050	0.058	0.032	0.058
3.3	0.033	0.031	0.033	0.040	0.046	0.044	0.057	0.057	0.051	0.054	0.058	0.028	0.058
3.5	0.042	0.042	0.040	0.049	0.053	0.053	0.056	0.055	0.048	0.054	0.045	0.021	0.056
3.7	0.047	0.042	0.048	0.045	0.051	0.044	0.042	0.042	0.017	0.044	0.047	0.025	0.051
3.9	0.023	0.025	0.024	0.029	0.037	0.041	0.045	0.041	0.039	0.039	0.036	0.022	0.045
4.1	0.024	0.027	0.029	0.038	0.034	0.037	0.048	0.047	0.044	0.039	0.039	0.021	0.048
4.3	0.021	0.022	0.024	0.025	0.030	0.025	0.031	0.036	0.044	0.038	0.032	0.020	0.044
4.5	0.021	0.021	0.022	0.023	0.025	0.025	0.024	0.026	0.031	0.032	0.028	0.020	0.032
4.7	0.021	0.021	0.023	0.022	0.025	0.023	0.025	0.025	0.026	0.031	0.030	0.020	0.031
4.9	0.021	0.021	0.021	0.022	0.025	0.026	0.023	0.023	0.023	0.025	0.028	0.018	0.028
5.1	0.021	0.021	0.022	0.021	0.024	0.026	0.023	0.022	0.022	0.022	0.025	0.018	0.026
5.3	0.021	0.021	0.022	0.021	0.024	0.024	0.022	0.022	0.022	0.023	0.023	0.018	0.024
5.5	0.021	0.021	0.021	0.021	0.024	0.025	0.022	0.022	0.022	0.022	0.022	0.018	0.025
5.7	0.021	0.021	0.021	0.021	0.024	0.025	0.023	0.022	0.021	0.021	0.022	0.018	0.025
5.9	0.021	0.021	0.021	0.021	0.022	0.023	0.024	0.022	0.022	0.022	0.022	0.018	0.024
6.1	0.021	0.021	0.021	0.021	0.022	0.024	0.023	0.022	0.022	0.021	0.021	0.018	0.024
6.3	0.023	0.023	0.023	0.024	0.024	0.025	0.024	0.024	0.024	0.024	0.024	0.018	0.025
6.5	0.021	0.021	0.021	0.021	0.022	0.023	0.024	0.023	0.022	0.022	0.021	0.018	0.024
6.7	0.021	0.021	0.021	0.021	0.021	0.024	0.023	0.024	0.021	0.021	0.021	0.018	0.024
6.9	0.022	0.022	0.022	0.022	0.021	0.024	0.024	0.024	0.022	0.022	0.022	0.018	0.024
7.1	0.021	0.021	0.021	0.021	0.022	0.024	0.025	0.023	0.022	0.022	0.022	0.018	0.025
7.3	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.024	0.023	0.023	0.022	0.018	0.024
7.5	0.021	0.021	0.021	0.021	0.021	0.022	0.024	0.023	0.023	0.022	0.021	0.018	0.024
7.7	0.021	0.021	0.021	0.021	0.021	0.021	0.023	0.023	0.024	0.022	0.021	0.018	0.024
7.9	0.021	0.021	0.021	0.021	0.021	0.022	0.023	0.022	0.023	0.022	0.021	0.018	0.023
8.1	0.021	0.021	0.021	0.021	0.021	0.021	0.023	0.023	0.022	0.022	0.021	0.017	0.023
8.3	0.021	0.020	0.021	0.021	0.021	0.021	0.023	0.023	0.022	0.023	0.021	0.018	0.023
8.5	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.023	0.023	0.021	0.018	0.023
8.7	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.023	0.023	0.022	0.022	0.018	0.023
8.9	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.021	0.022	0.022	0.022	0.018	0.022

Current high frequency harmonics



4.3.4 Unbalances

The aim of this test is to determinate the unbalance in the PGU's fed-in current.

This test was performed according to point 4.3.5 of the standard.

They have been determined the unbalance between positive and negative sequences for currents (U_i) using following equation:

$$U_i = (I_{1-} / I_{1+}) \cdot 100\ \%$$

They have been measured currents and voltages at each power level, taking into account the positive and negative phase sequence system components, as well as the active power positive sequence.

All measurements have been recorded, at least 2 minutes per power level.

Additional information about the testing is provided below:

Measurement device	Date of measurement	Recording	Sampling frequency
DL850E	2019/11/26	100 ms values	10 kHz

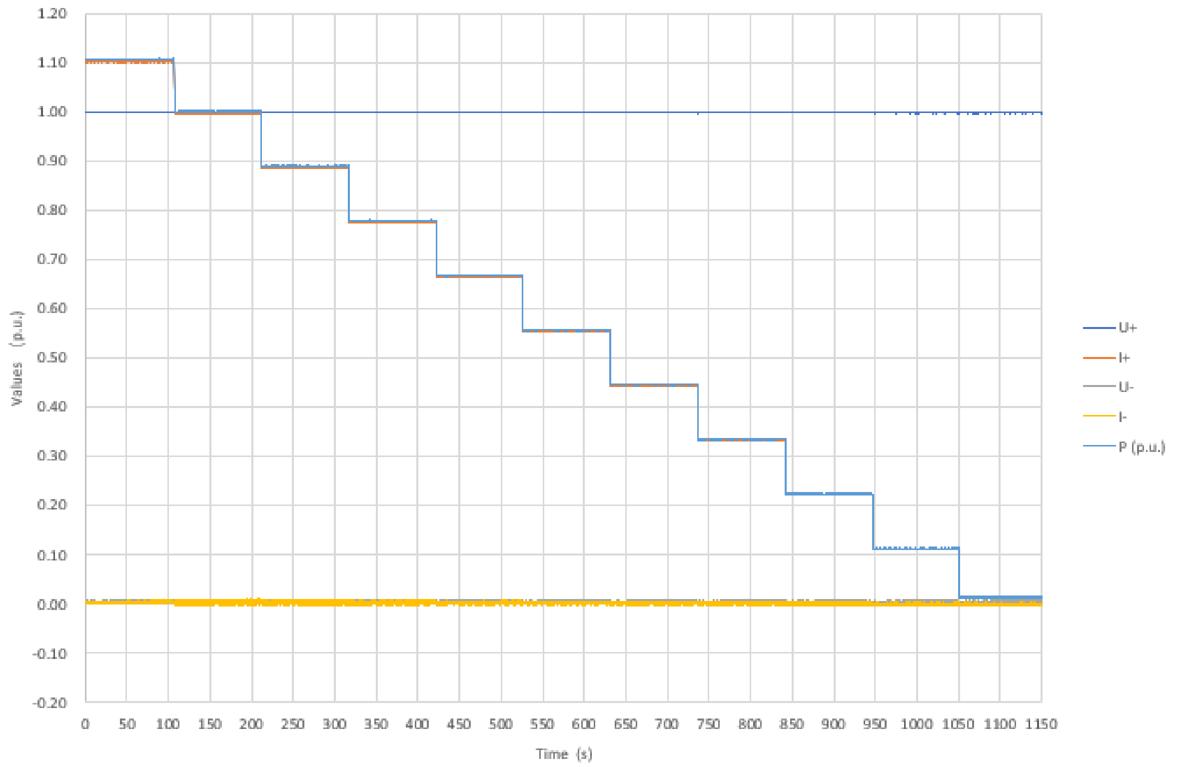
Test results represented in the table below are calculated as 1-minute mean values and they represent the maximum unbalance. Voltage calculations are represented as line values.

P_n (%Sn)	V_{1+} (p.u.)	V_{1-} (p.u.)	I_{1+} (p.u.)	I_{1-} (p.u.)	U_i (%)	Number of records
0	0.999	0.006	0.014	0.000	1.686	1200
11	0.999	0.006	0.112	0.001	0.470	1200
22	0.999	0.006	0.223	0.001	0.502	1200
33	0.999	0.006	0.334	0.001	0.423	1200
44	0.999	0.006	0.444	0.002	0.393	1200
55	0.999	0.006	0.554	0.002	0.396	1200
66	0.999	0.006	0.665	0.003	0.391	1200
77	0.999	0.006	0.775	0.003	0.389	1200
88	1.000	0.006	0.886	0.003	0.377	1200
99	1.000	0.006	0.997	0.004	0.363	1200
110	1.000	0.006	1.102	0.004	0.353	1200

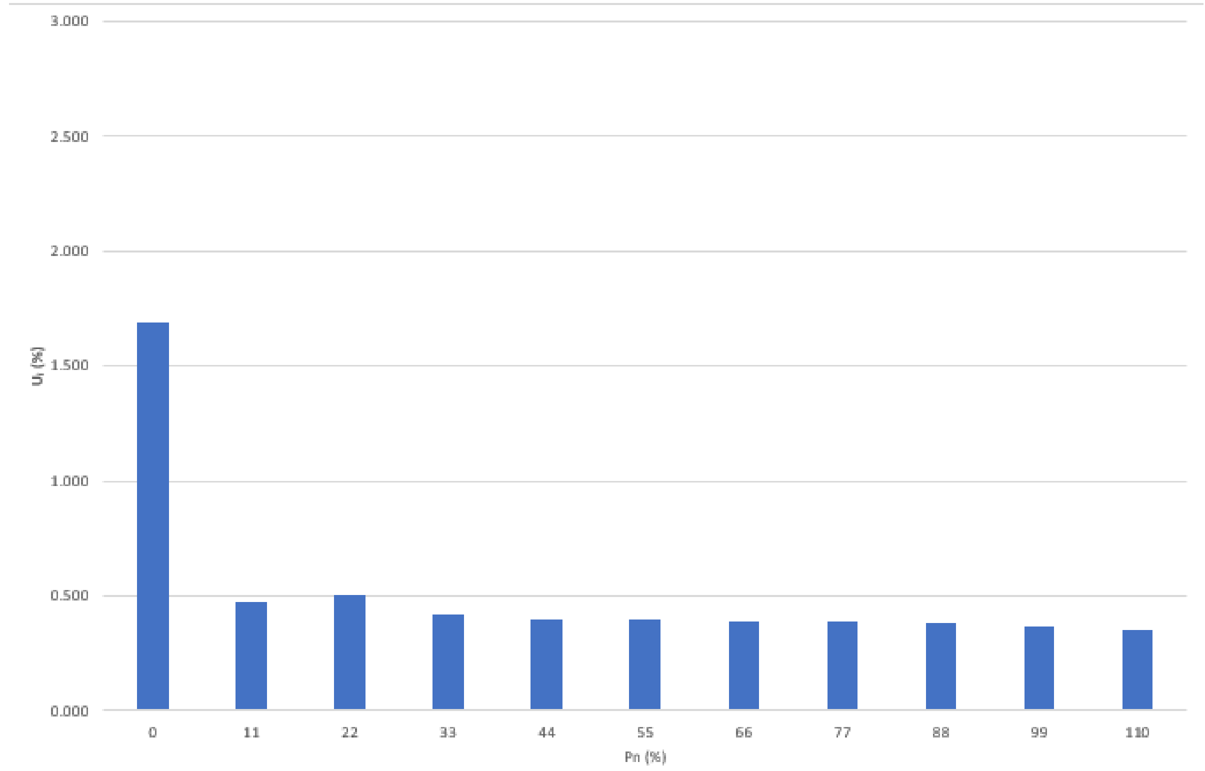
According to VDE-AR-N 4110: 2018-11 and VDE-AR-N 4120: 2018-11, from the 10%Pn, the generating unit shall not exceed a maximum limit defined at 1.5%, for VDE-AR-N 4110: 2018-11 and a maximum limit defined at 2.5%, for VDE-AR-N 4120: 2018-11.

In following graphs, test results are represented after the test has been performed:

Test over Time



U_i – P Diagram



4.4 Disconnecting the PGU from the grid

These tests have been performed according to point 4.4 of the standard.

The aim of this test is to determine the functional capability of the grid protection and the operating range of the PGU-protection for type testing purposes.

Two different levels of voltage and frequency have been set (In overvoltage, undervoltage, overfrequency and underfrequency) in order to see that this value is configurable, and all the values are in compliance with the trip limits, according to the mínimum and máximum possible trigger values and times.

Measurement for determination of under and overvoltage as well as under- and over-frequency characteristics (release values, release times and disengaging ratio) of EUT's grid protection unit are carried out as described subsequent. The settings of internal variable for the grid protection unit are given by the manufacturer.

The under and overvoltage conditions have been applied to each phase alone and to all the phases at the same time in order to see that the place of the fault is not a condition for the inverter to trip.

This test has been done performing two different tests:

- Trip voltage or frequency test, to asses that the protection function of the inverter works as the voltage and frequency levels stated by the standard.
- Trip time test, to asses that the disconnection of the inverter takes place into the time limits established by the standard.

In accordance with the table 4-49 of the standard, recommended grid protection parameters for compliance with standards VDE AR-N 4110:2018 and VDE AR-N 4120:2018 are presented below:

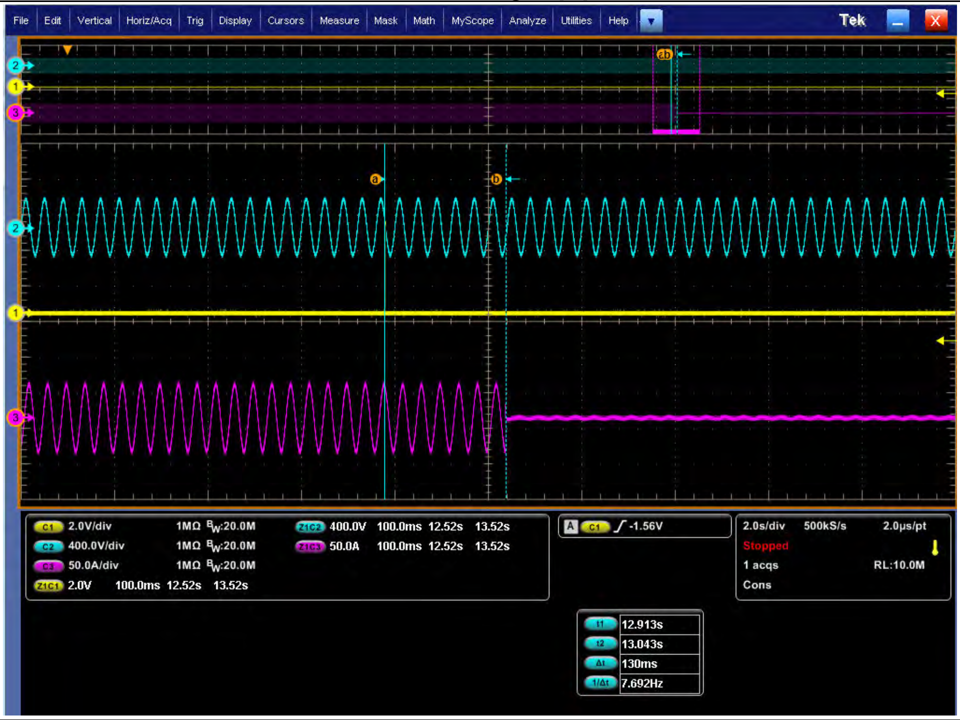
Function	Test case	Trigger threshold	Trigger time
Overvoltage U>	U1	Min. threshold	Max. time
		100% Un	180.00 s
	U2	Max. threshold	Min. time
		130% Un	0.00 s (*)
Overvoltage U>>	U3	Min. threshold	Max. time
		100% Un	0.10 s
	U4	Max. threshold	Min. time
		135% Un	0.00 s (*)
Under-voltage U<	U5	Min. threshold	Min. time
		10% Un	0.00 s (*)
	U6	Max. threshold	Max. time
		100% Un	2.40 s
Under-voltage U<<	U7	Min. threshold	Min. time
		10% Un	0.00 s (*)
	U8	Max. threshold	Max. time
		100%Un	0.80 s

Function	Test case	Trigger threshold	Trigger time
Overfrequency F>	F1	Min. threshold	Max. time
		50 Hz	5.00 s
	F2	Max. threshold	Min. time
		55 Hz	0.00 s (*)
Overfrequency F>>	F3	Min. threshold	Max. time
		50 Hz	0.10 s
	F4	Max. threshold	Min. time
		55 Hz	0.00 s (*)
Underfrequency F<	F5	Min. threshold	Min. time
		45 Hz	0.00 s (*)
	F6	Max. threshold	Max. time
		50 Hz	0.10 s

(*) As it is not possible to set a minimum delay of 0s, the smallest value of 50ms was tested.

Following indications shall be taken into account to for test results offered.

Information relating trip pictures

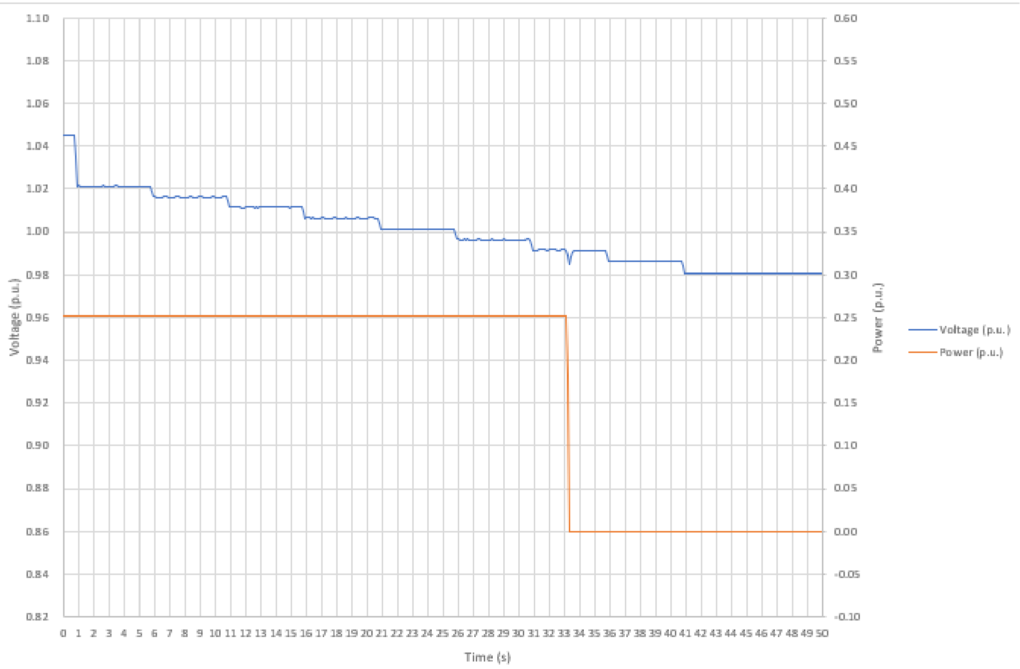


Variable name	Colour	Definition
1		Trigger Signal
2		AC Voltage
3		Output Current

For testing the accuracy of trigger value, the procedure followed has been the following:

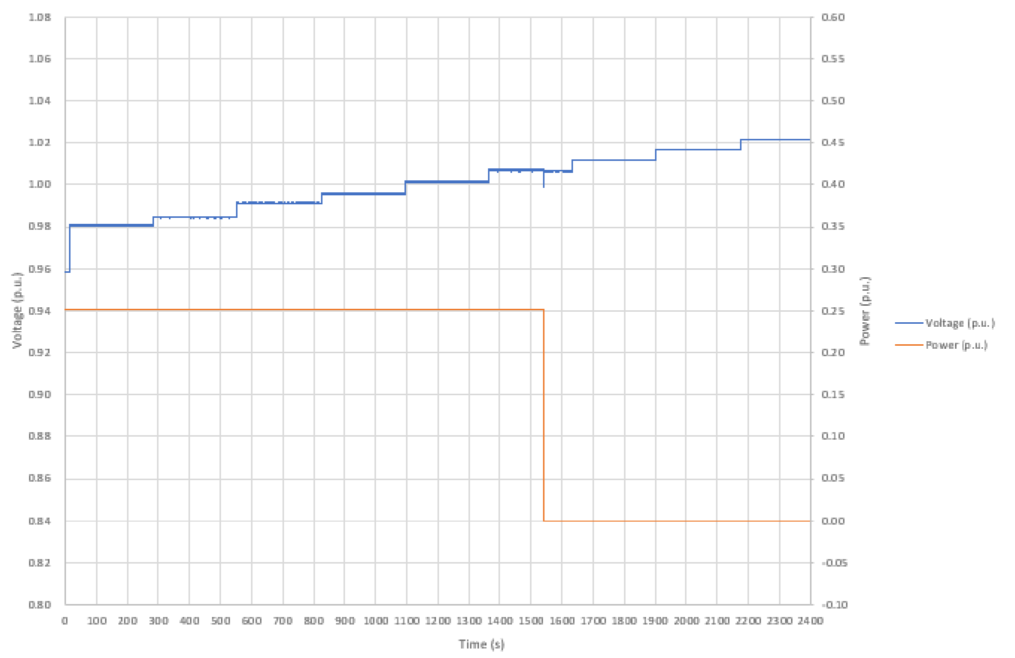
- For undervoltage protection: Starting from a voltage level 2% Un above the trip value of the protection function to be tested, the voltage is decreased 0.5% Un in steps of at least 150% of the trip time delay stated in the protection function to be tested, with a minimum step time of 0.1 seconds.

Example of undervoltage decreasing steps applied



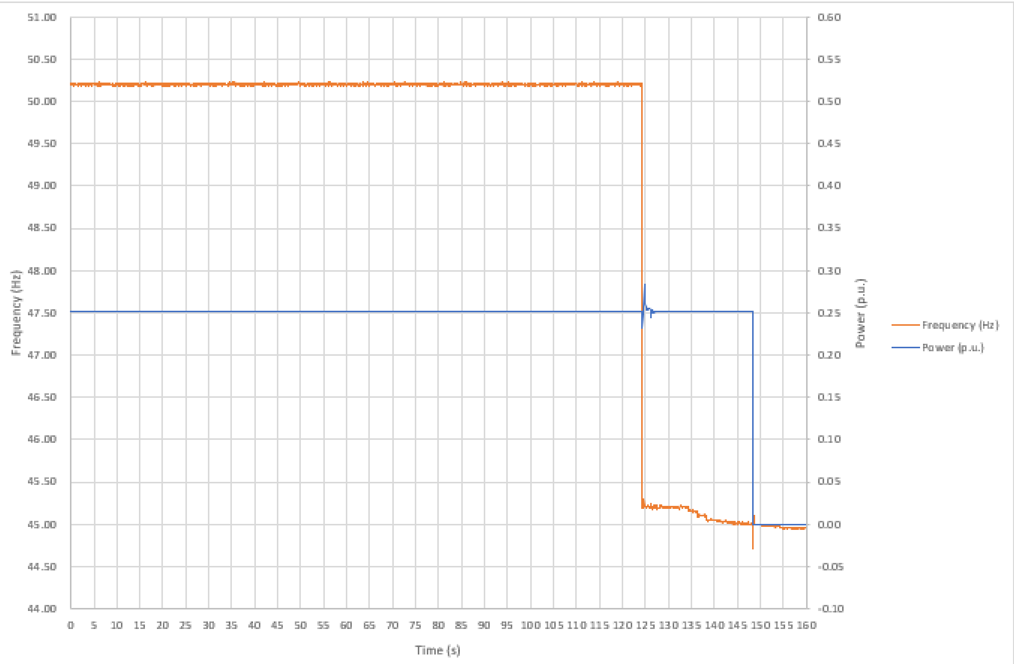
- For overvoltage protection: Starting from a voltage level 2% Un below the trip value of the protection function to be tested, the voltage is increased 0.5% Un in steps of at least 150% of the trip time delay stated in the protection function to be tested, with a minimum step time of 0.1 seconds.

Example of overvoltage increasing steps applied



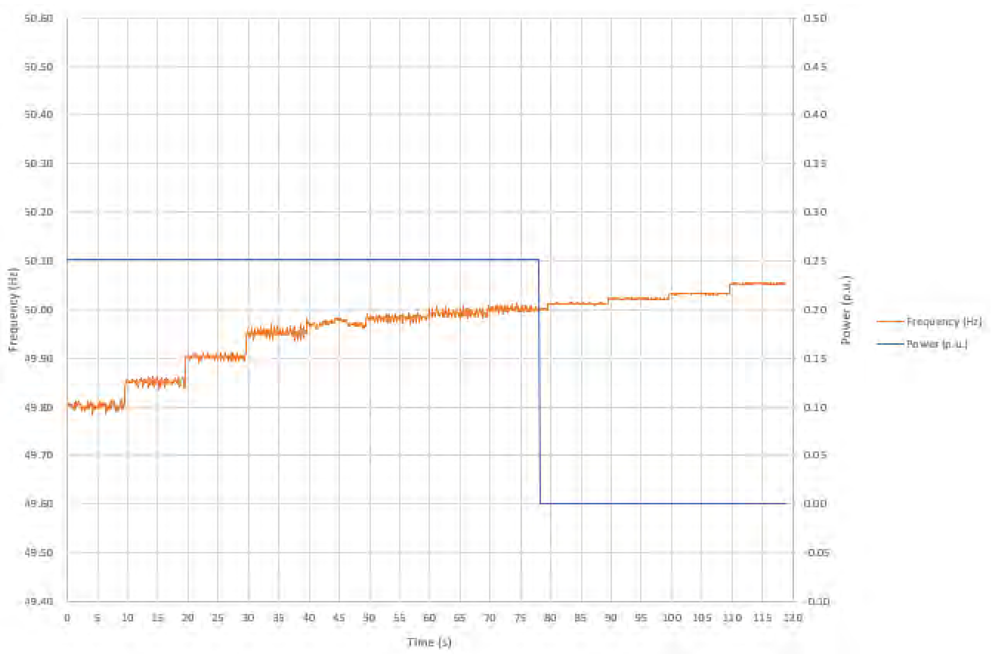
- For underfrequency protection: Starting from a frequency level 0.2 Hz above the trip value of the protection function to be tested, the frequency is decreased 0.05Hz in steps of at least 150% of the trip time delay stated in the protection function to be tested, with a minimum step time of 0.1 seconds.

Example of underfrequency decreasing steps applied



- For overfrequency protection: Starting from a frequency level 0.2 Hz below the trip value of the protection function to be tested, the frequency is increased 0.05 Hz in steps of at least 150% of the trip time delay stated in the protection function to be tested, with a minimum step time of 0.1 seconds.

Example of overfrequency increasing steps applied



Maximum deviation allowed in accuracy of trigger value threshold is 1% Un for abnormal voltage protection and 0.01 Hz for abnormal frequency protection.

4.4.1 Circuit breaker operating time

According to the relay specification, the operation time of circuit breaker is always the same < 30 ms, and the release time is always the same < 10 ms.

4.4.2 Over & undervoltage protection

Used settings of the measurement device for Over and undervoltage protection measurement.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/19 to 2019/11/23	100 ms values	10 kHz
DL850E		--	--

For Over and Undervoltage protection test, the measurements have been carried out individually for all 3 phases and 3 phase test per each protection.

The following tables show the test results for trip value test and trip time test:

Overvoltage (U>)					
Settings	**Setting values**	**Trigger values/times (*)**			
		3-phase	**Phase A**	**Phase B**	**Phase C**
Min. threshold (Test case U1)	1.000 Un	1.000 Un	1.001 Un	1.007 Un	1.001 Un
Max. time (Test case U1)	180.00 s	180.00 s	180.24 s	180.20 s	180.30 s
Max. threshold (Test case U2)	1.250 Un	1.250 Un	1.246 Un	1.252 Un	1.248 Un
Min. time (Test case U2)	0.050 s	0.050 s	0.074 s	0.080 s	0.078 s
Overvoltage (U>>)					
Settings	**Setting values**	**Trigger values/times (*)**			
		3-phase	**Phase A**	**Phase B**	**Phase C**
Min. threshold (Test case U3)	1.000 Un	1.000 Un	1.001 Un	1.007 Un	1.001 Un
Max. time (Test case U3)	0.100 s	0.100 s	0.119 s	0.119 s	0.130 s
Max. threshold (Test case U4)	1.300 Un	1.300 Un	1.296 Un	1.303 Un	1.299 Un
Min. time (Test case U4)	0.050 s	0.050 s	0.080 s	0.086 s	0.073 s

(*) Important note: The time accuracy is +50ms due to relay delay. The setting time for the trigger has been established equal to the setting value. Therefore, some of the measured times are over the setting value but within the given tolerance.

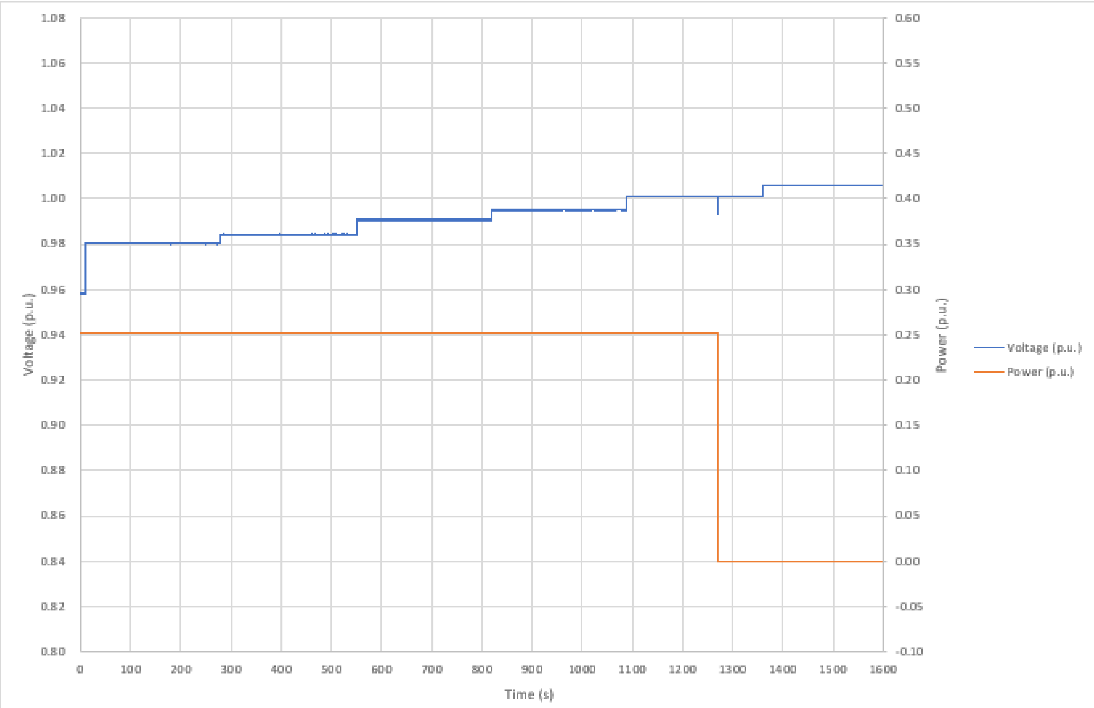
Undervoltage (U<)					
Settings	**Setting values**	**Trigger values/times (*)**			
		3-phase	**Phase A**	**Phase B**	**Phase C**
Min. threshold (Test case U5)	0.150 Un	0.150 Un	0.150 Un	0.150Un	0.145 Un
Min. time (Test case U5)	0.050 s	0.050 s	0.083 s	0.090 s	0.093 s
Max. threshold (Test case U6)	1.000 Un	1.000 Un	1.001 Un	0.997 Un	0.992 Un
Max. time (Test case U6)	2.400 s	2.400 s	2.430 s	2.443 s	2.444 s
Undervoltage (U<<)					
Settings	**Setting values**	**Trigger values/times (*)**			
		3-phase	**Phase A**	**Phase B**	**Phase C**
Min. threshold (Test case U7)	0.150 Un	0.150 Un	0.144 Un	0.143 Un	0.143 Un
Min. time (Test case U7)	0.050 s	0.080 s	0.082 s	0.083 s	0.077 s
Max. threshold (Test case U8)	1.000 Un	1.001 Un	0.997 Un	0.991 Un	0.996 Un
Max. time (Test case U8)	0.800 s	0.822 s	0.836 s	0.824 s	0.834 s

(*) Important note: The time accuracy is +50ms due to relay delay. The setting time for the trigger has been established equal to the setting value. Therefore, some of the measured times are over the setting value but within the given tolerance.

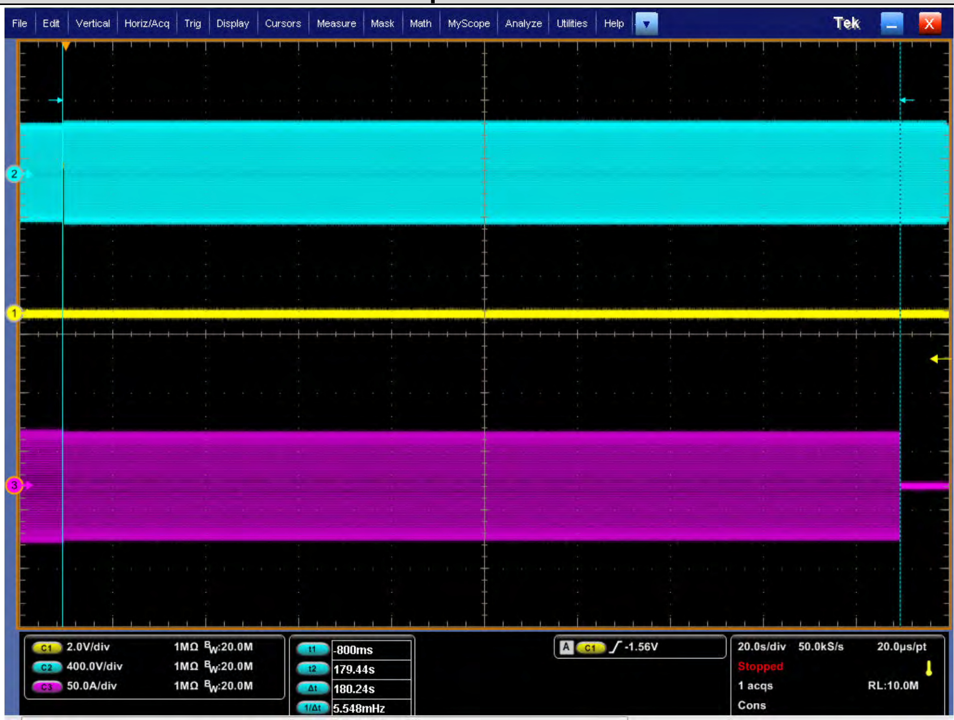
The following pictures show the result obtained:

Over voltage (Test case U1) 3 – Phases

Trip value test

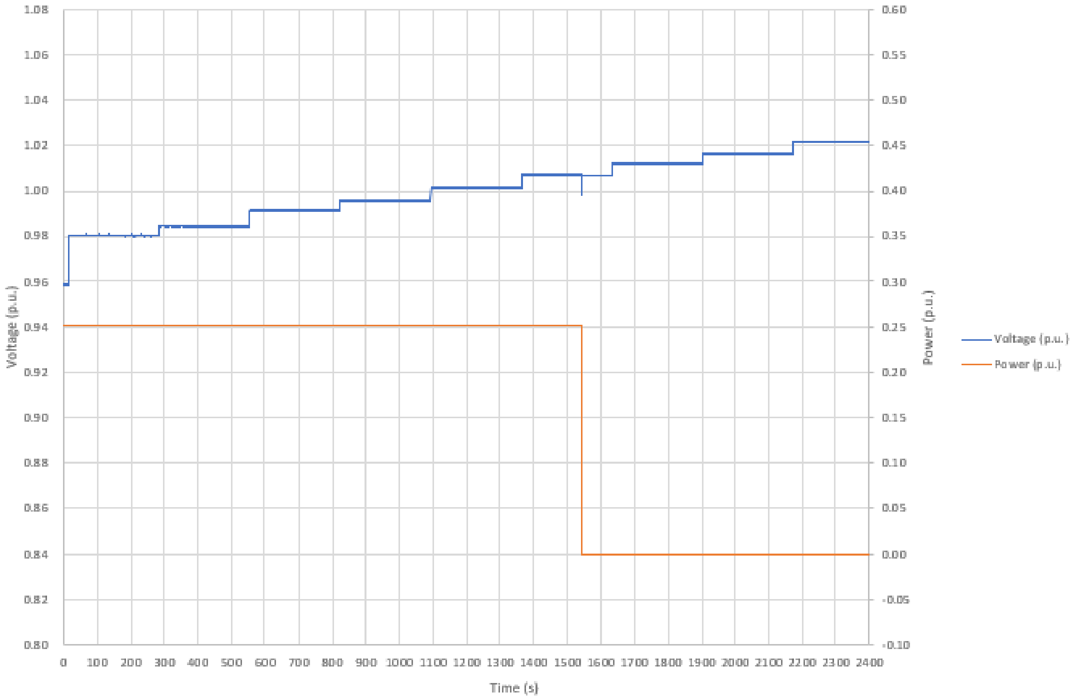


Trip time test

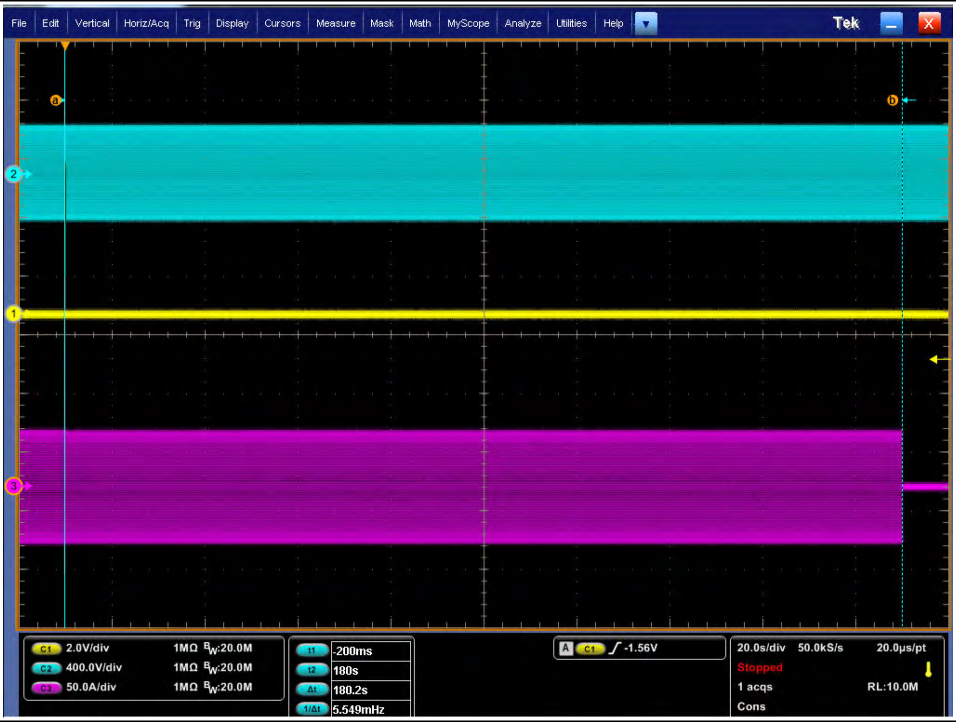


Trip time measured: 180.24 s

Over voltage (Test case U1) Phase A
Trip value test



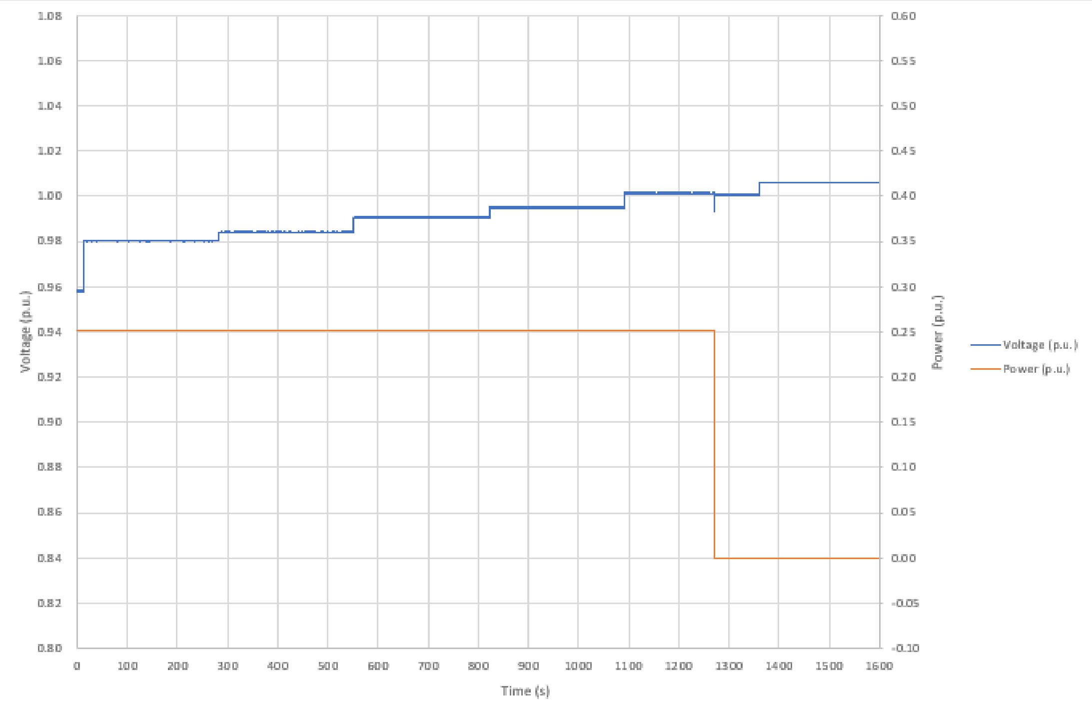
Trip time test



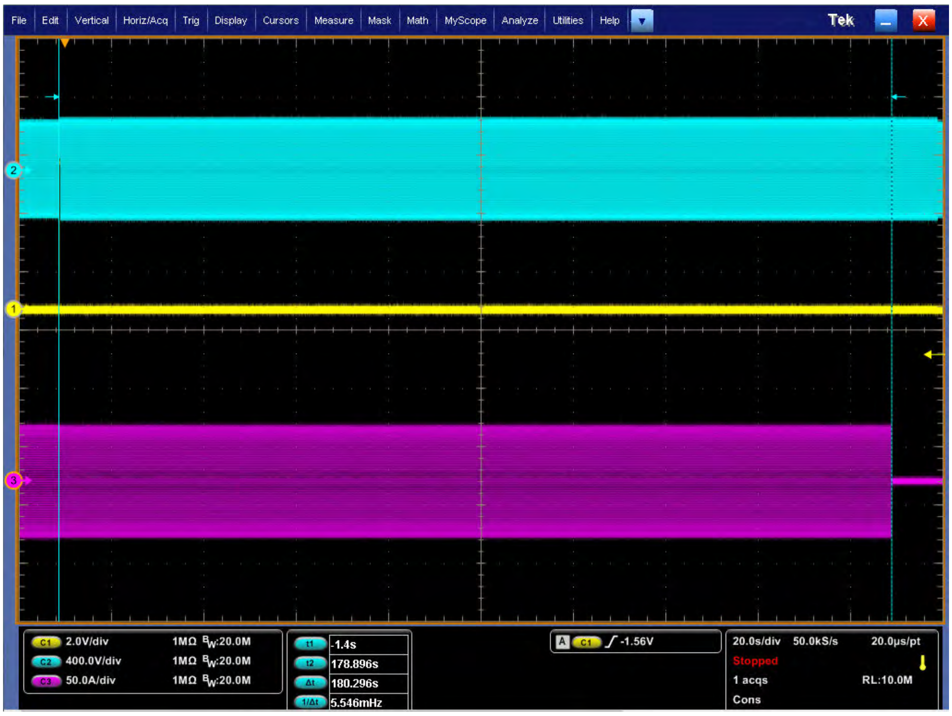
Trip time measured: 180.20 s

Over voltage (Test case U1) Phase B

Trip value test



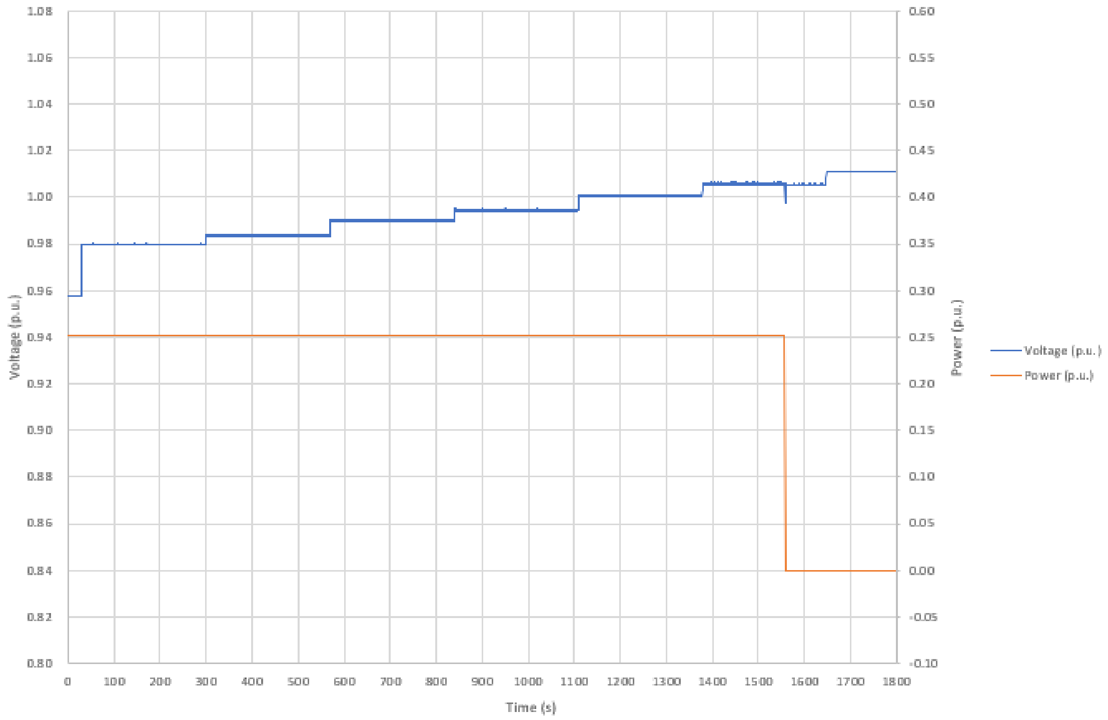
Trip time test



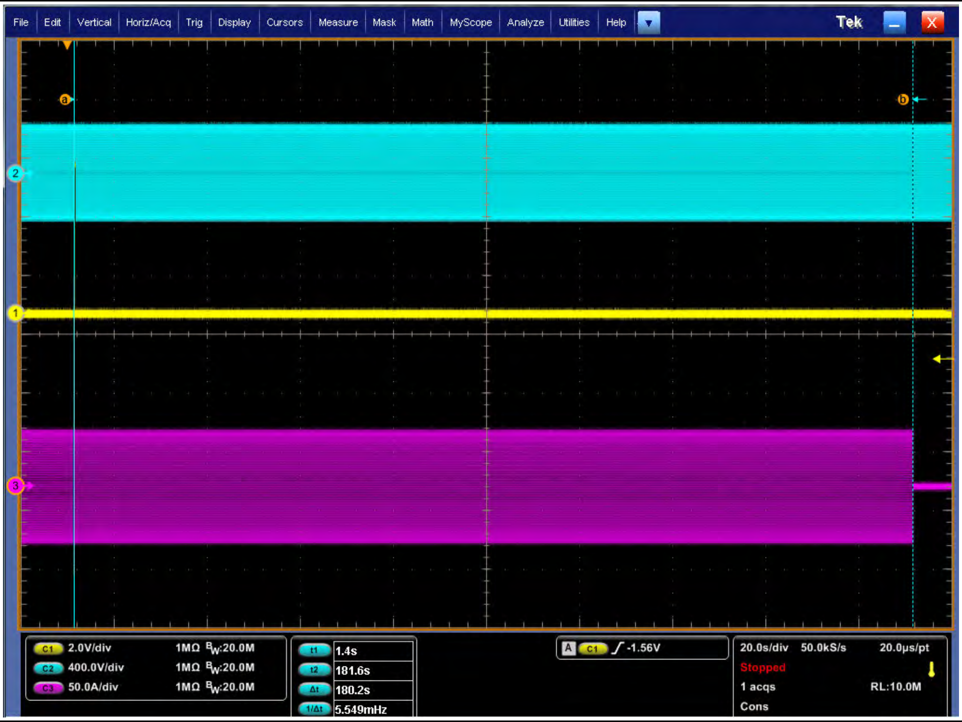
Trip time measured: 180.30 s

Over voltage (Test case U1) Phase C

Trip value test



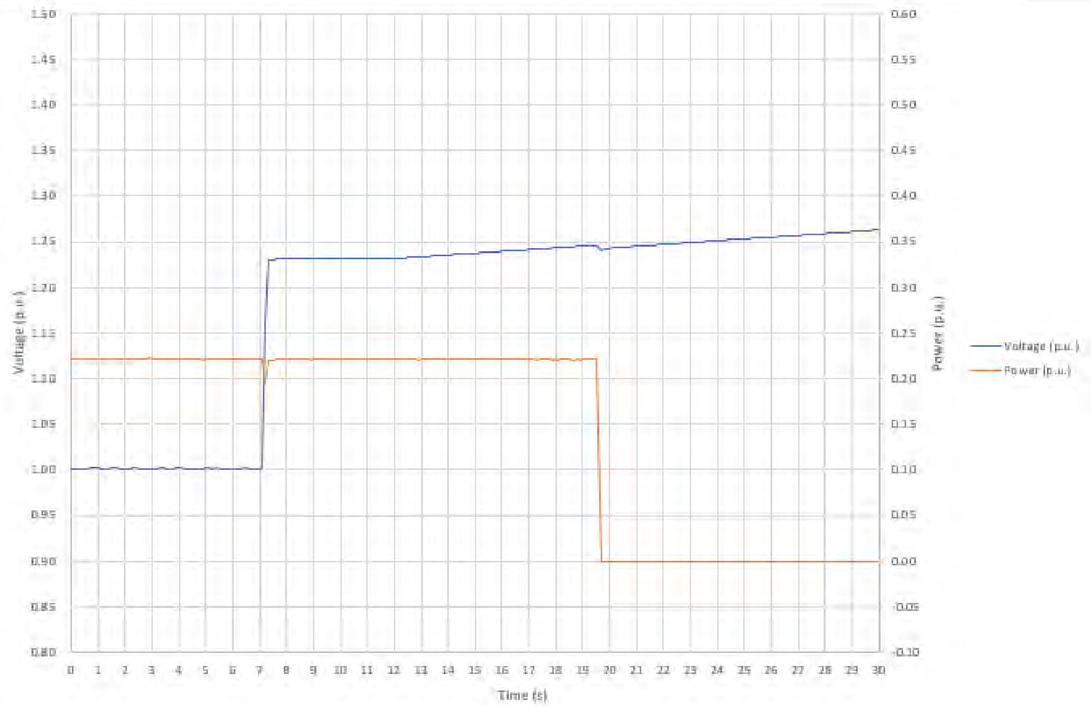
Trip time test



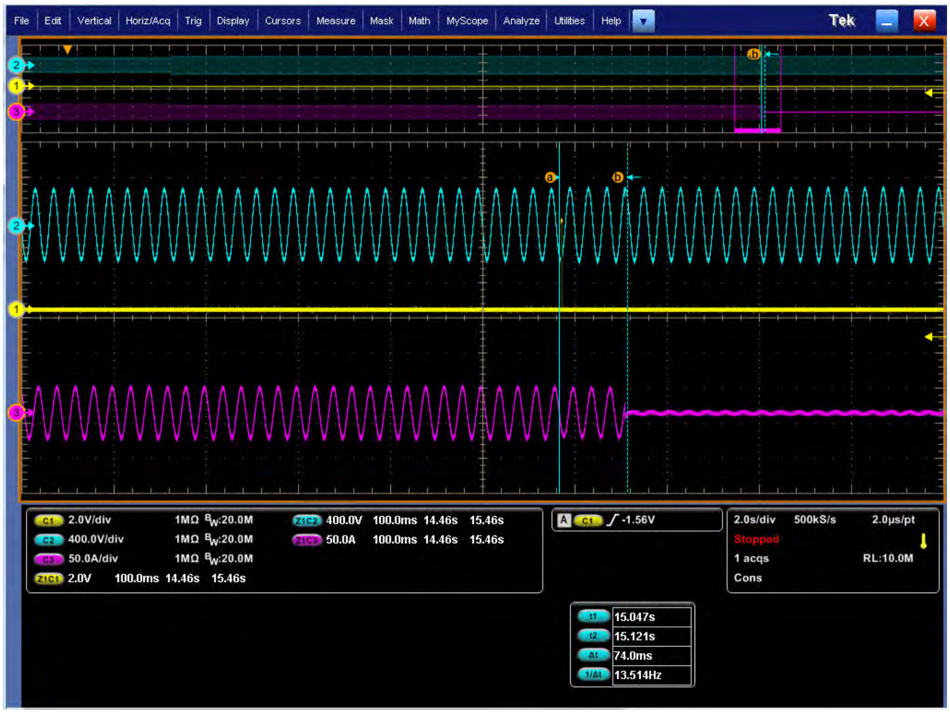
Trip time measured: 180.20 s

Over voltage (Test case U2) 3 – Phases

Trip value test



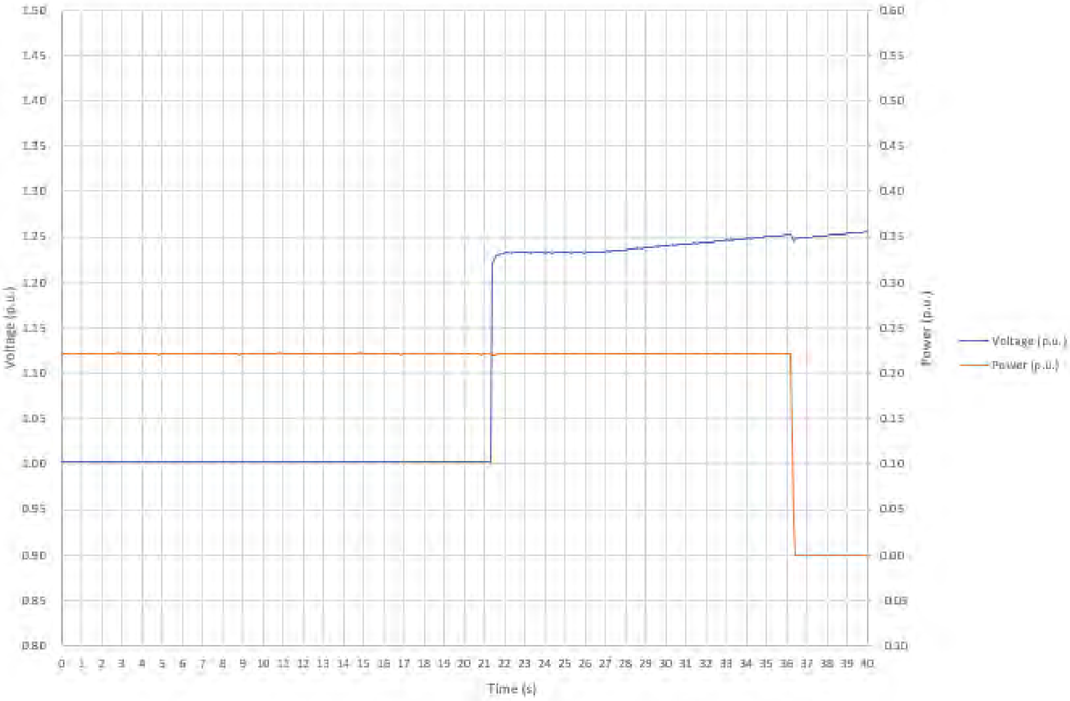
Trip time test



Trip time measured: 74 ms

Over voltage (Test case U2) Phase A

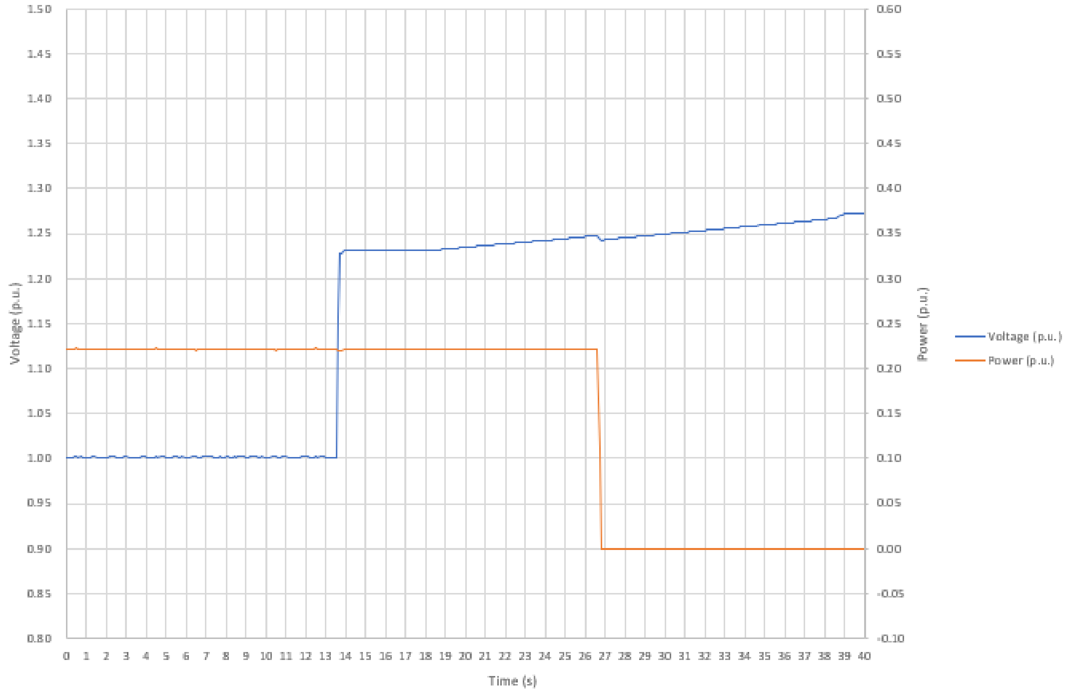
Trip value test



Trip time test

Trip time measured: 80 ms

Over voltage (Test case U2) Phase B
Trip value test

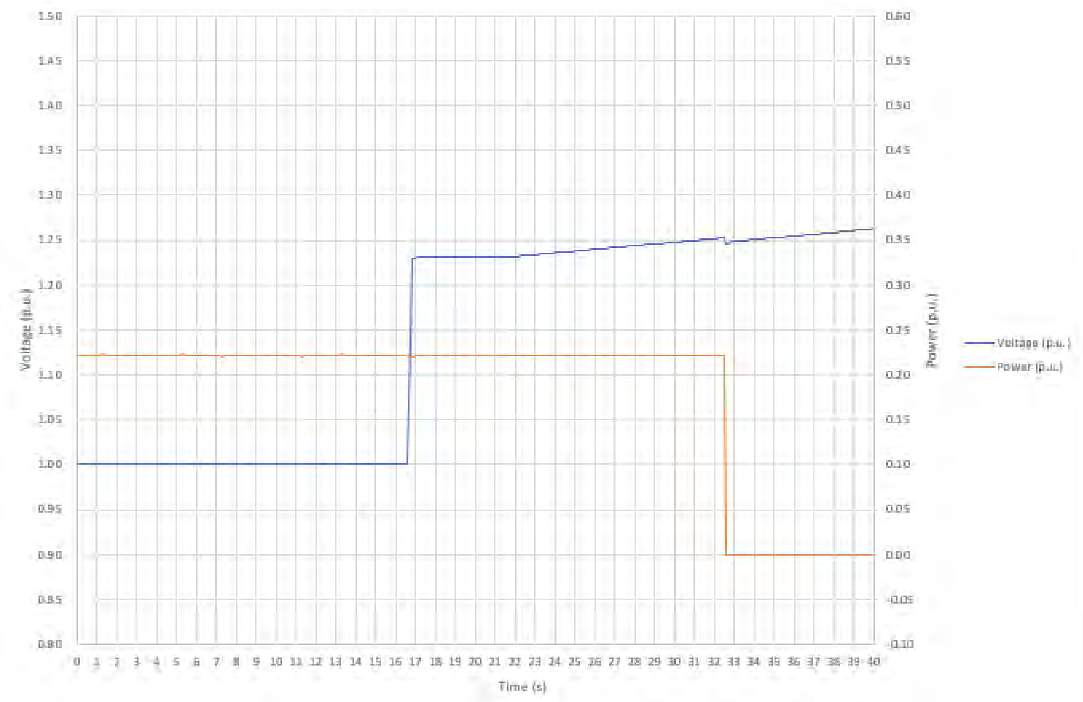


Trip time test

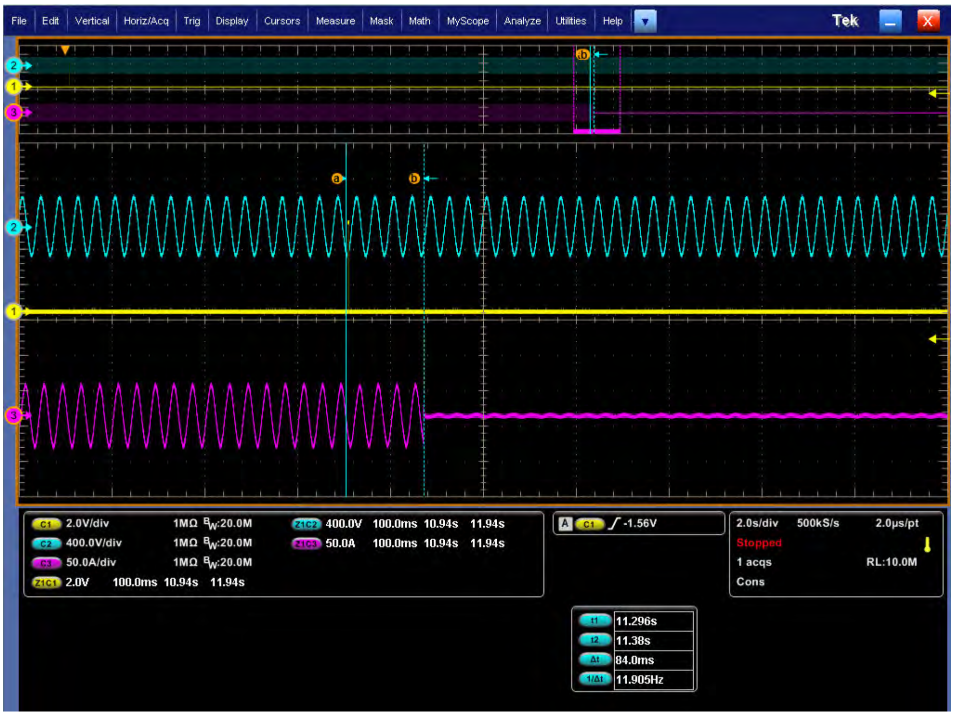
Trip time measured: 78 ms

Over voltage (Test case U2) Phase C

Trip value test



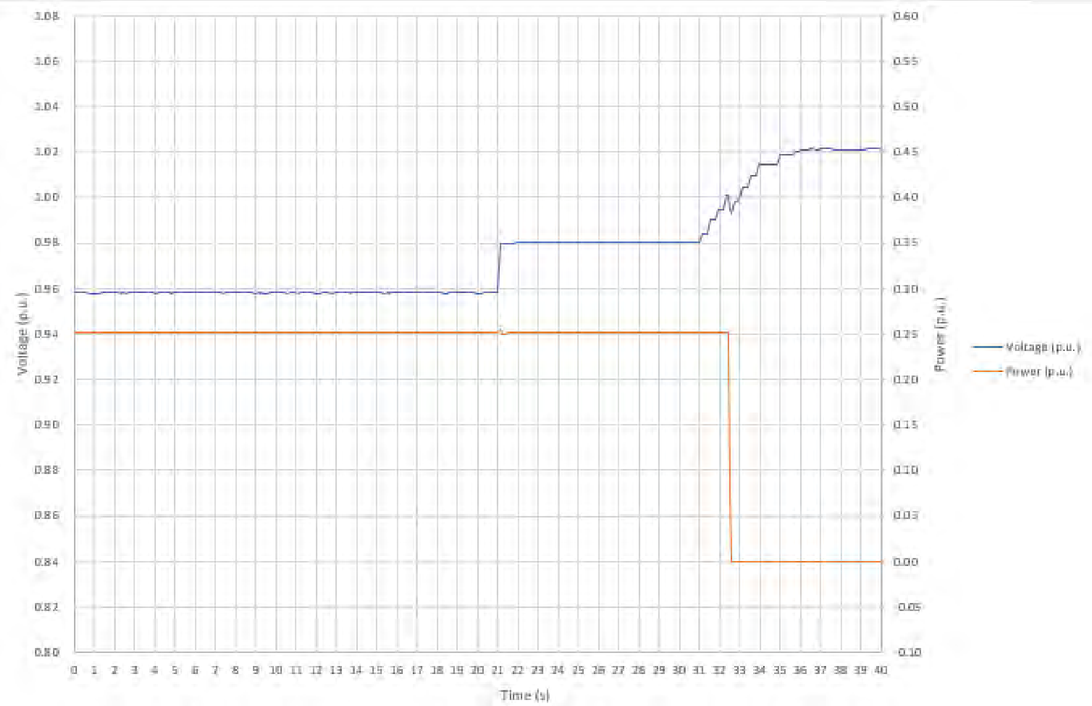
Trip time test



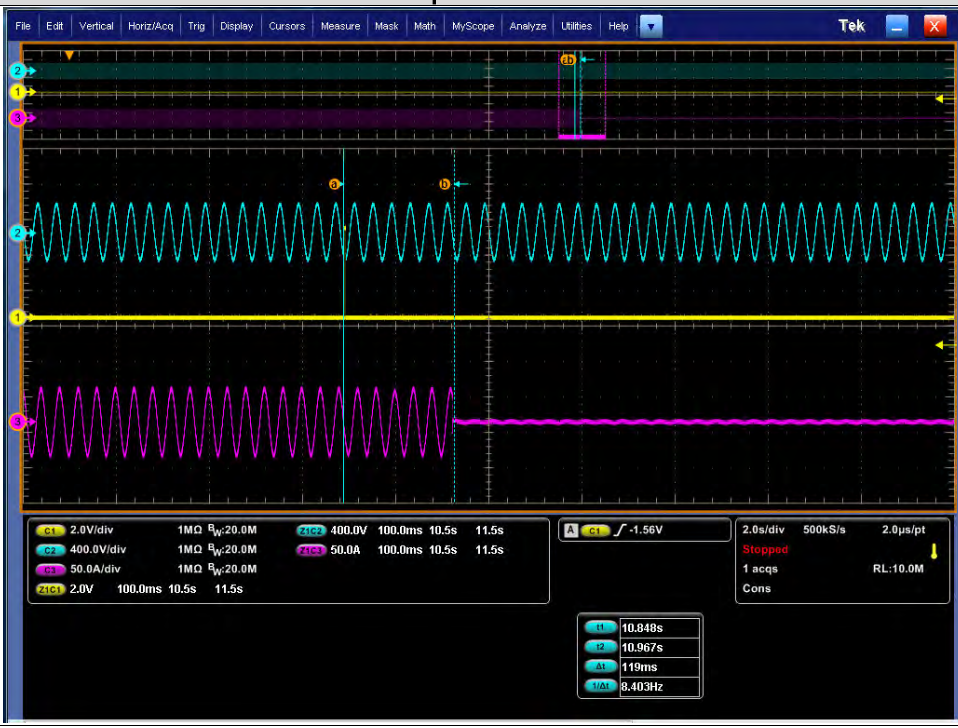
Trip time measured: 84 ms

Over voltage (Test case U3) 3 – Phases

Trip value test



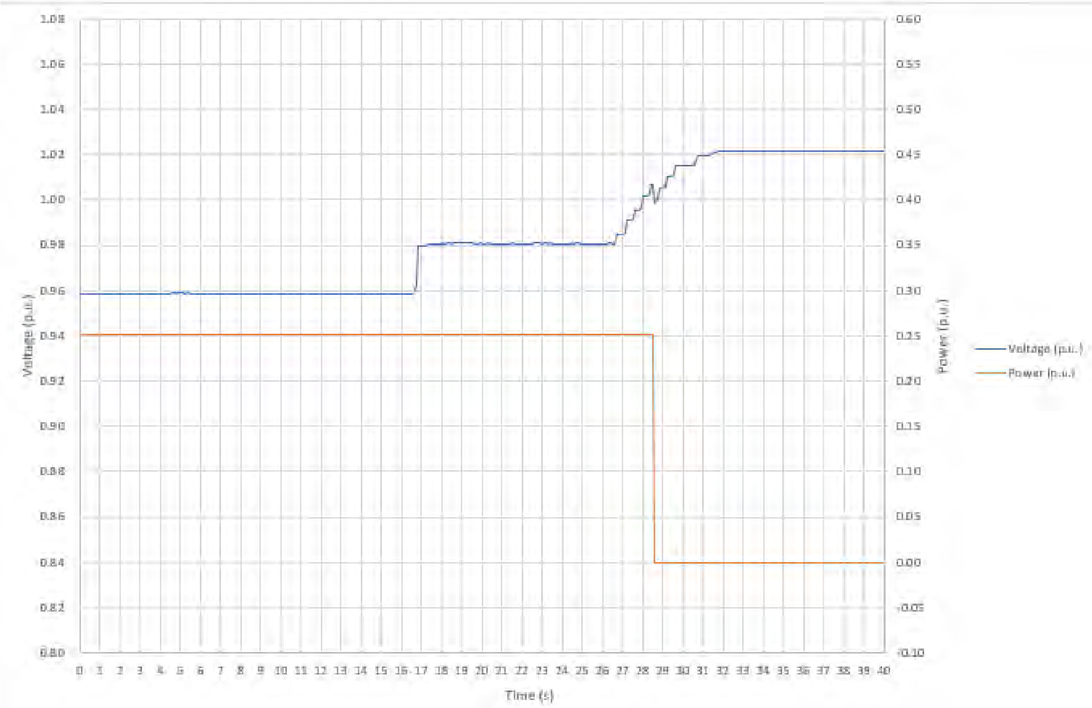
Trip time test



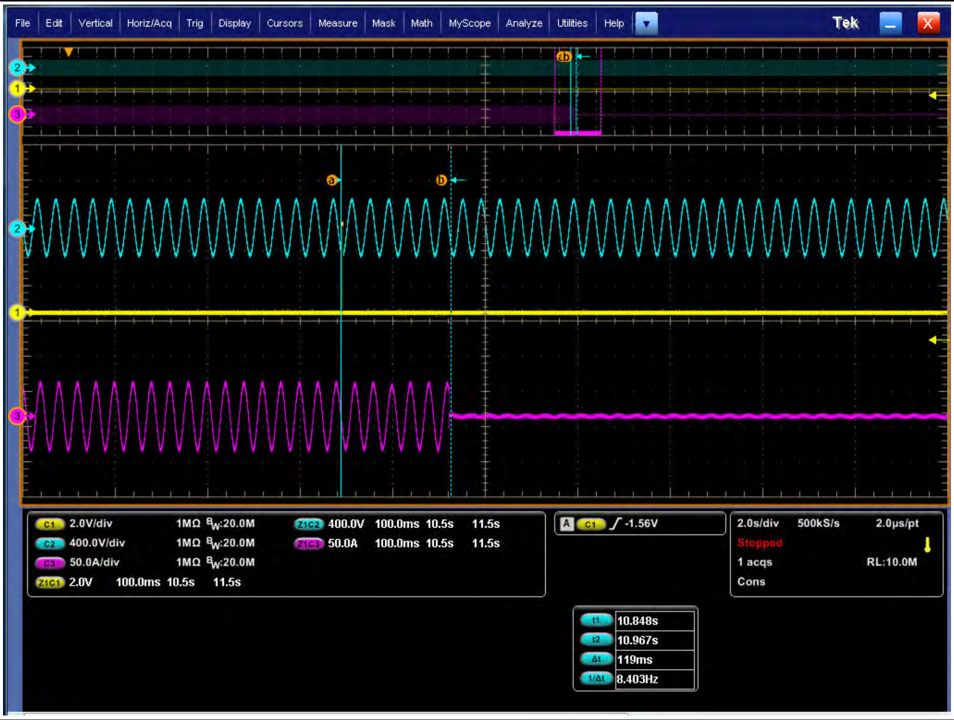
Trip time measured: 119 ms

Over voltage (Test case U3) Phase A

Trip value test

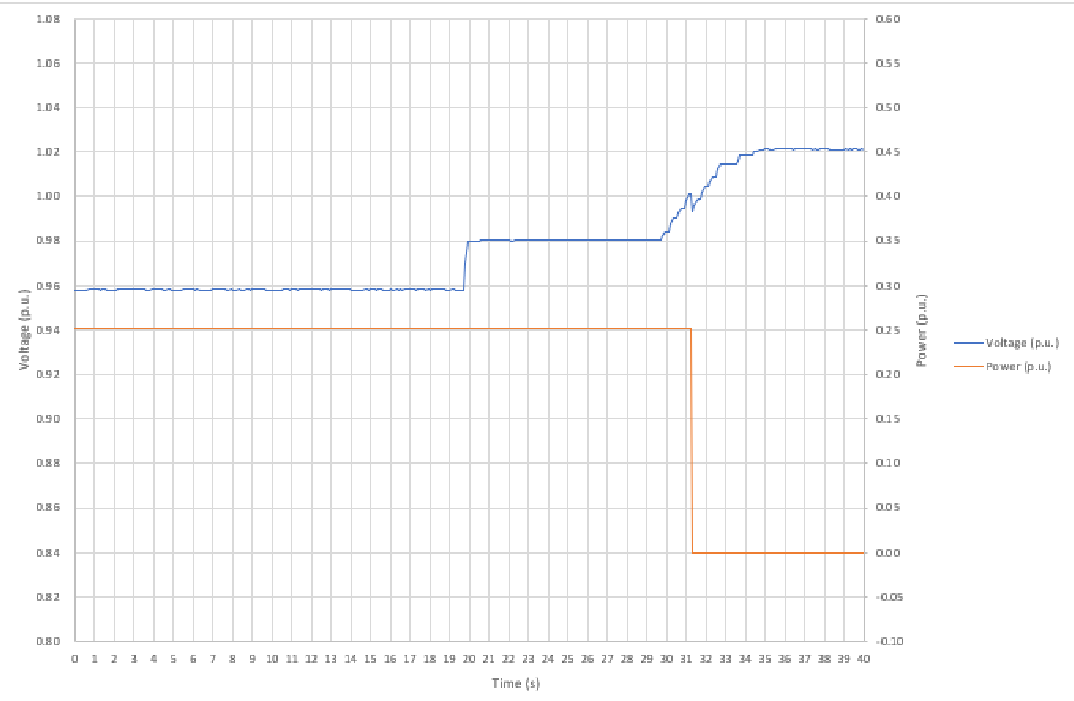


Trip time test

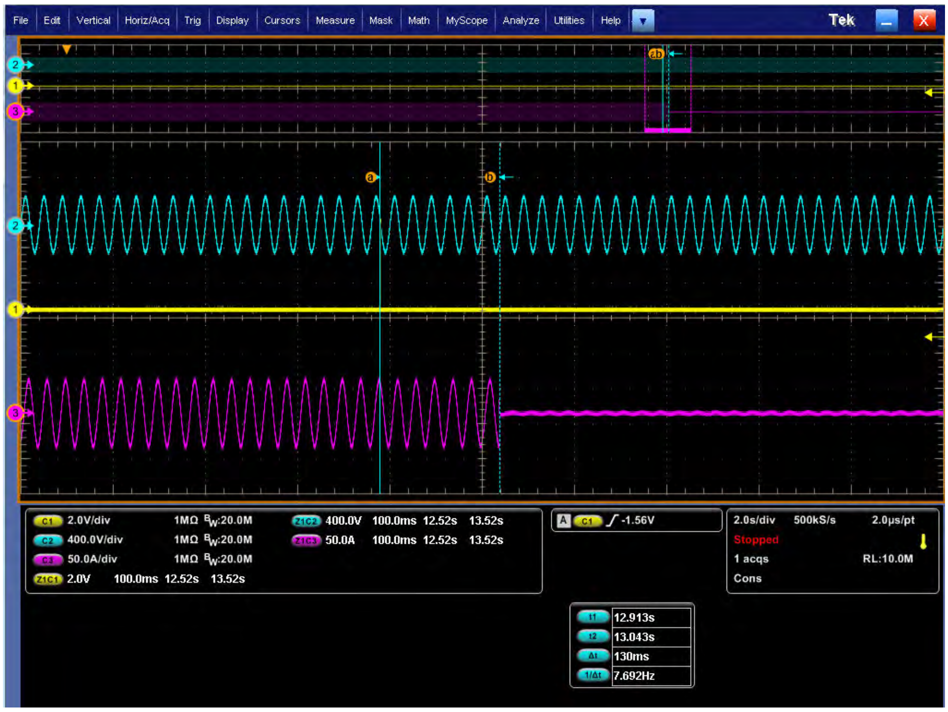


Trip time measured: 119 ms

Over voltage (Test case U3) Phase B
Trip value test



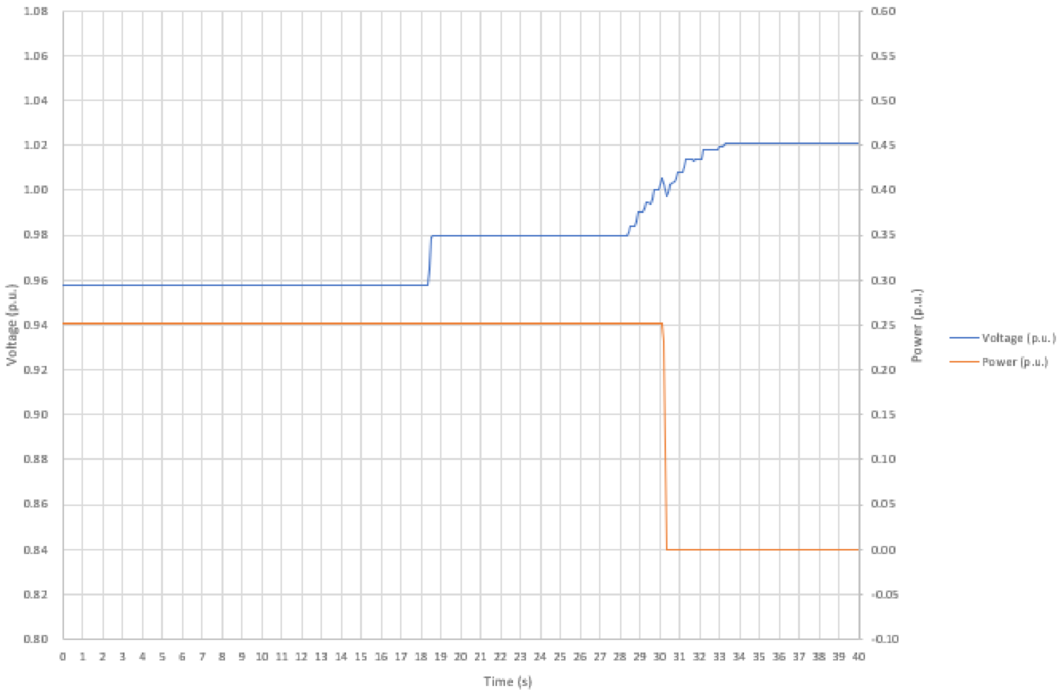
Trip time test



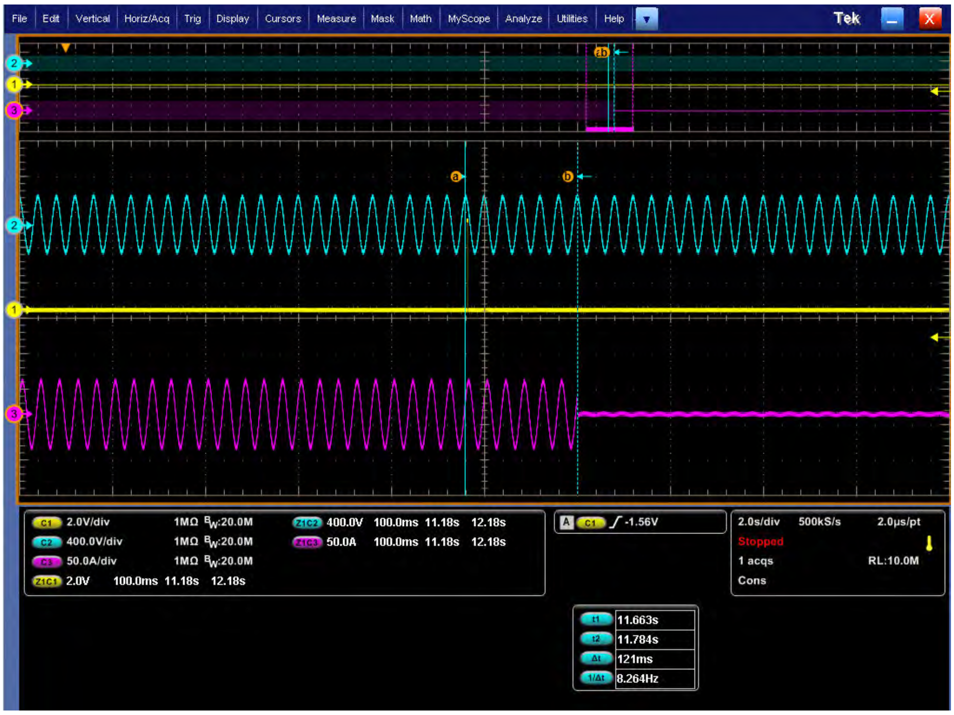
Trip time measured: 130 ms

Over voltage (Test case U3) Phase C

Trip value test



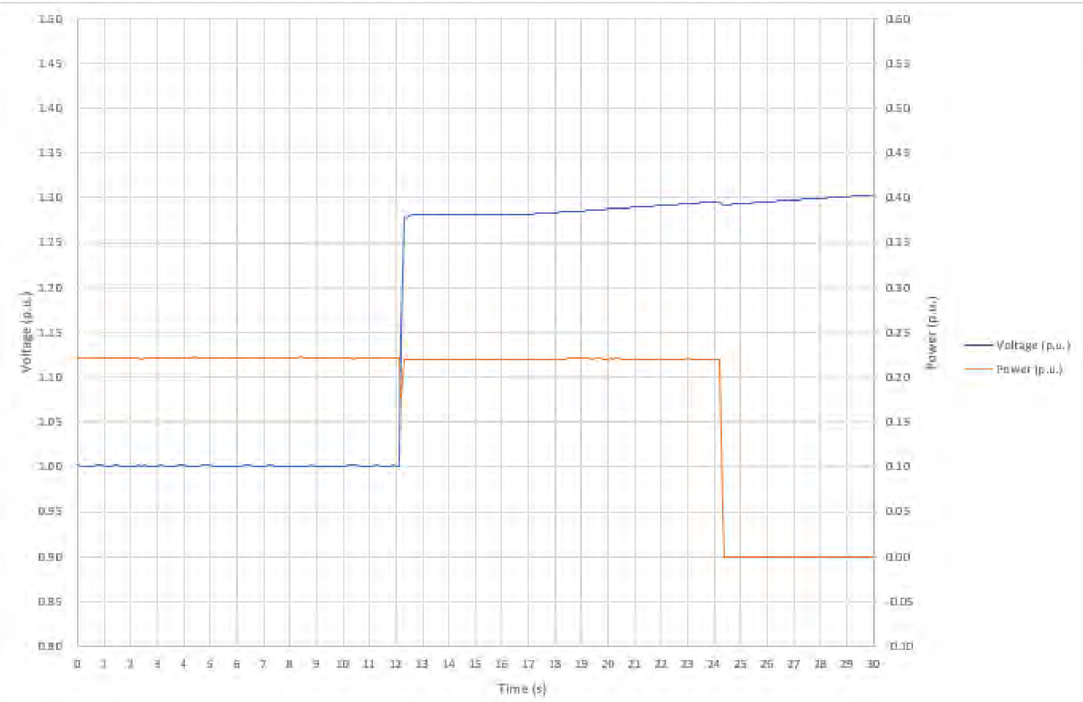
Trip time test



Trip time measured: 121 ms

Over voltage (Test case U4) 3 – Phases

Trip value test

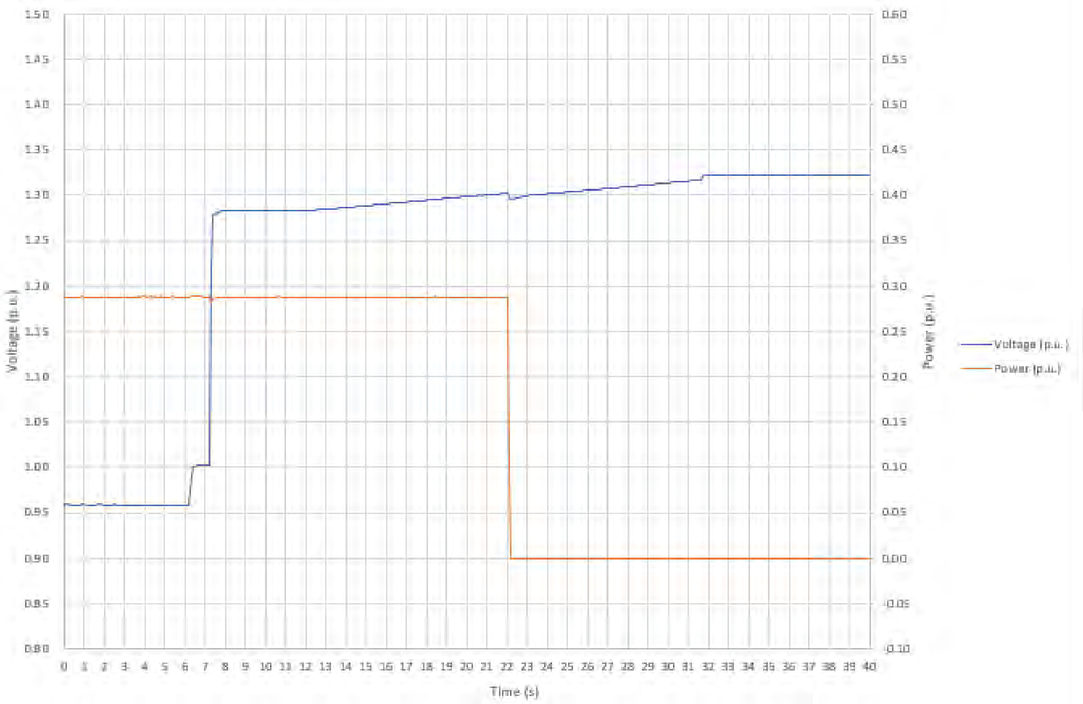


Trip time test

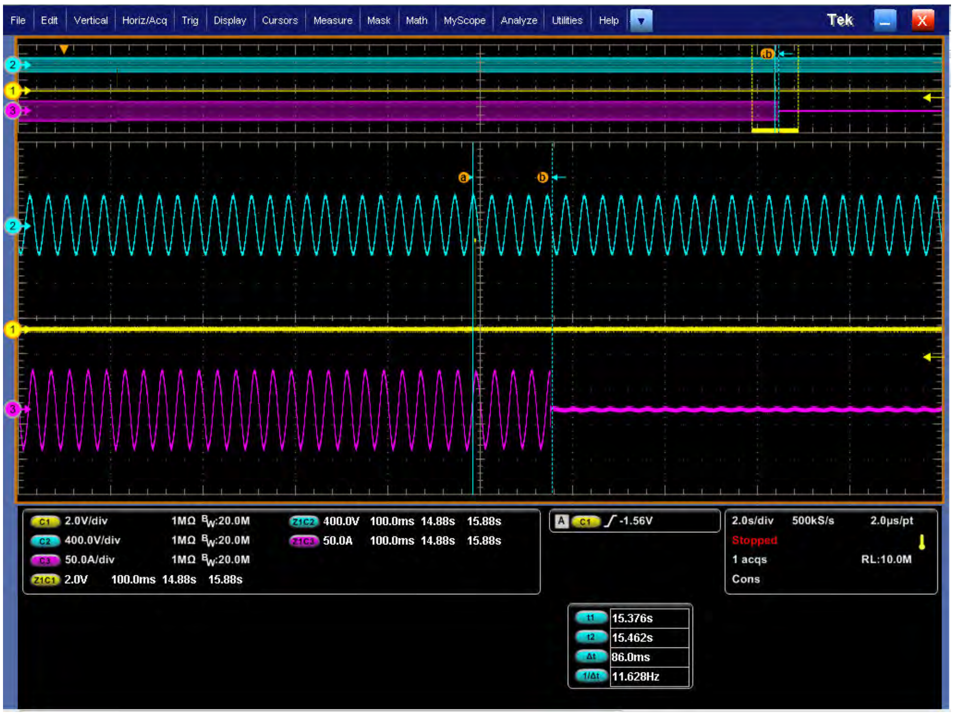
Trip time measured: 80 ms

Over voltage (Test case U4) Phase A

Trip value test

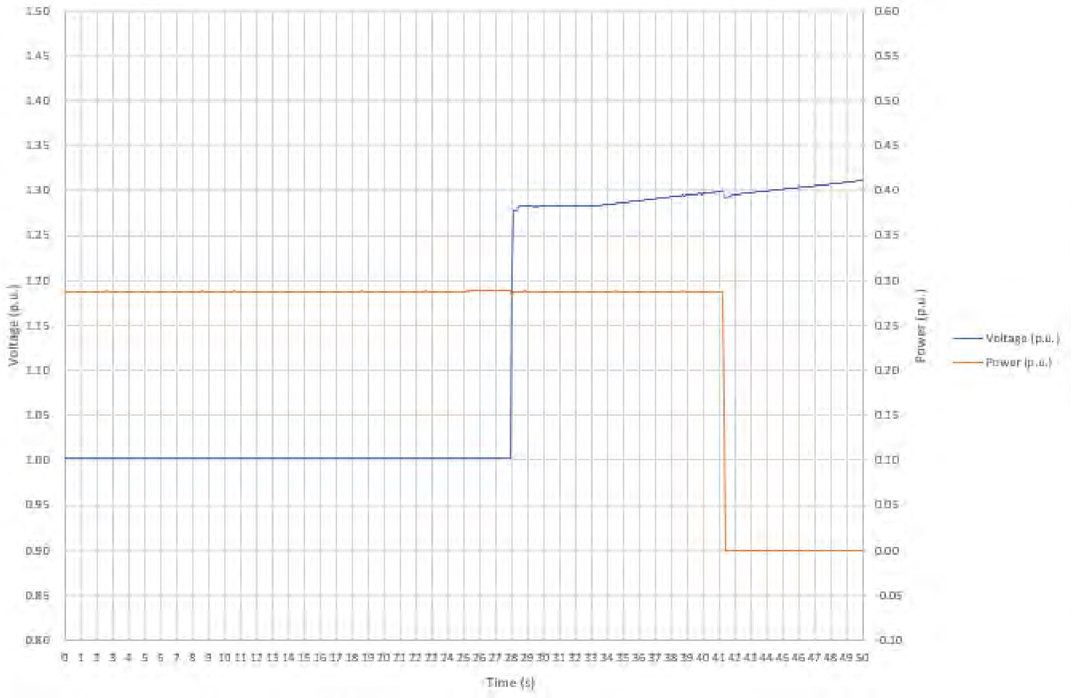


Trip time test

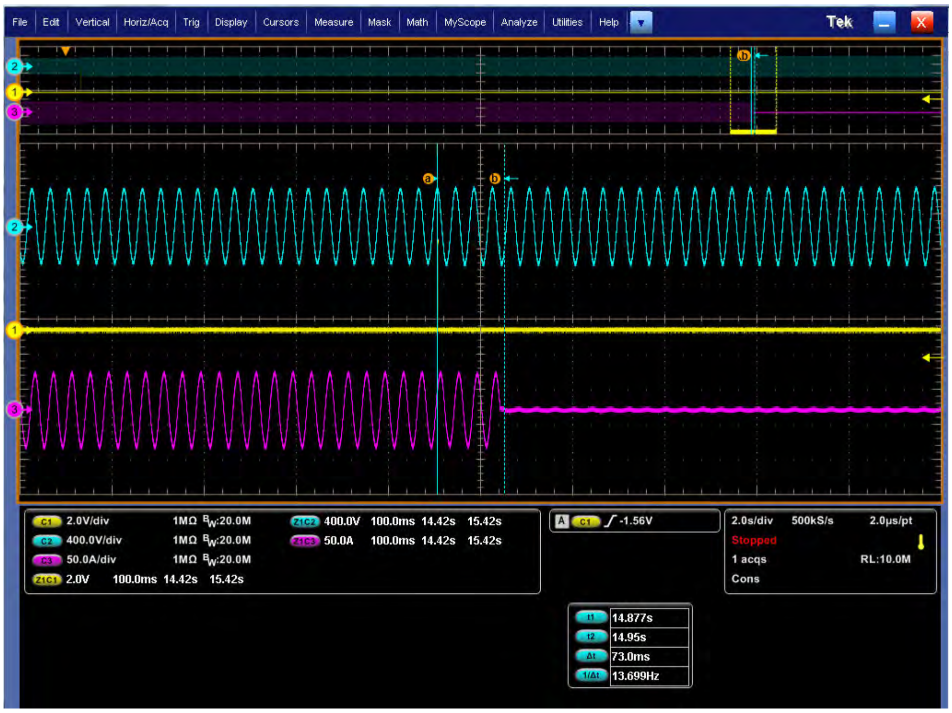


Trip time measured: 86 ms

Over voltage (Test case U4) Phase B
Trip value test



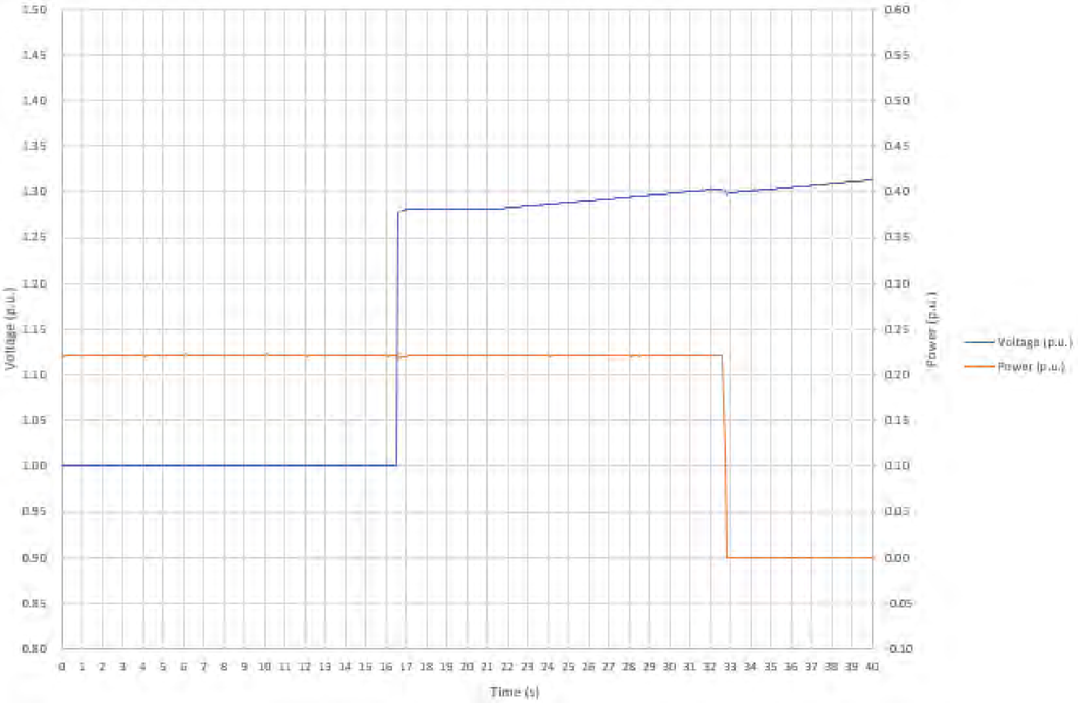
Trip time test



Trip time measured: 73 ms

Over voltage (Test case U4) Phase C

Trip value test

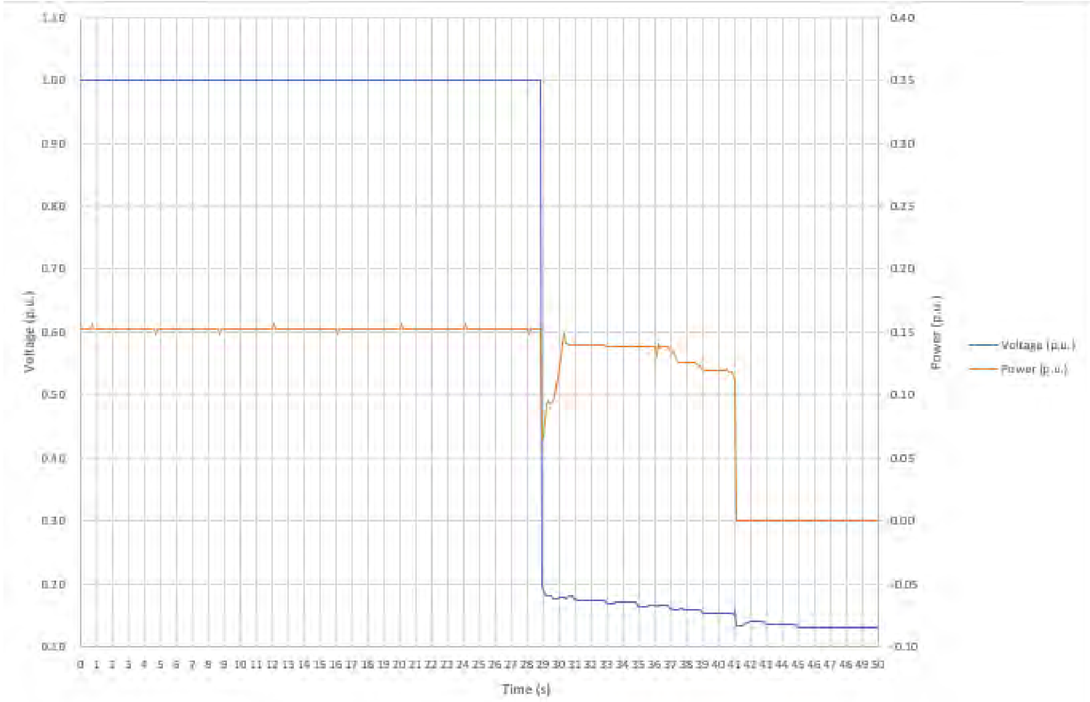


Trip time test

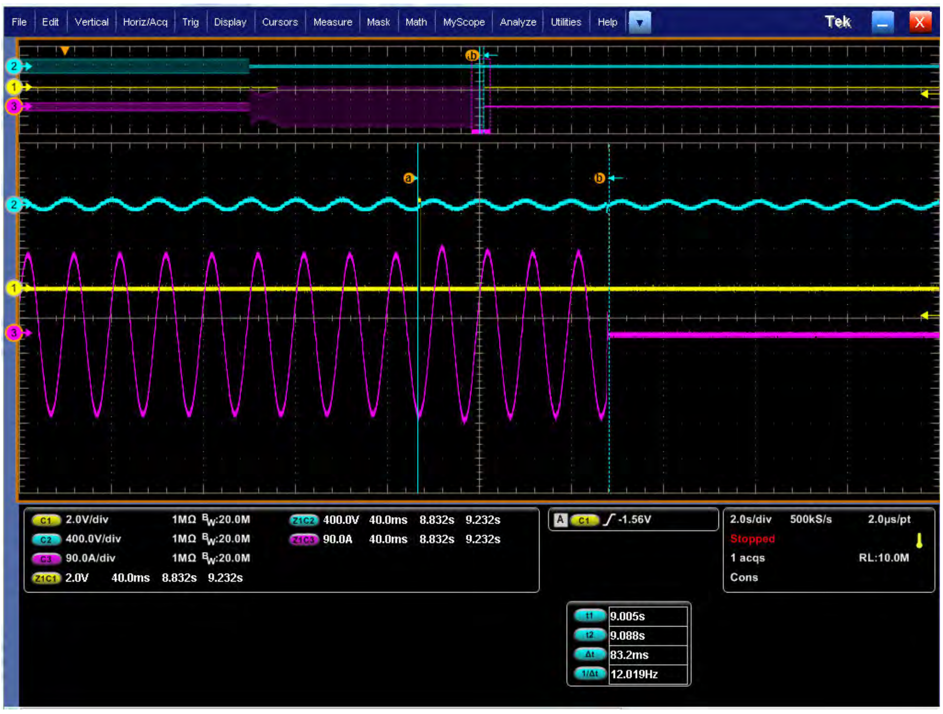
Trip time measured: 75 ms

Under voltage (Test case U5) 3 – Phases

Trip value test



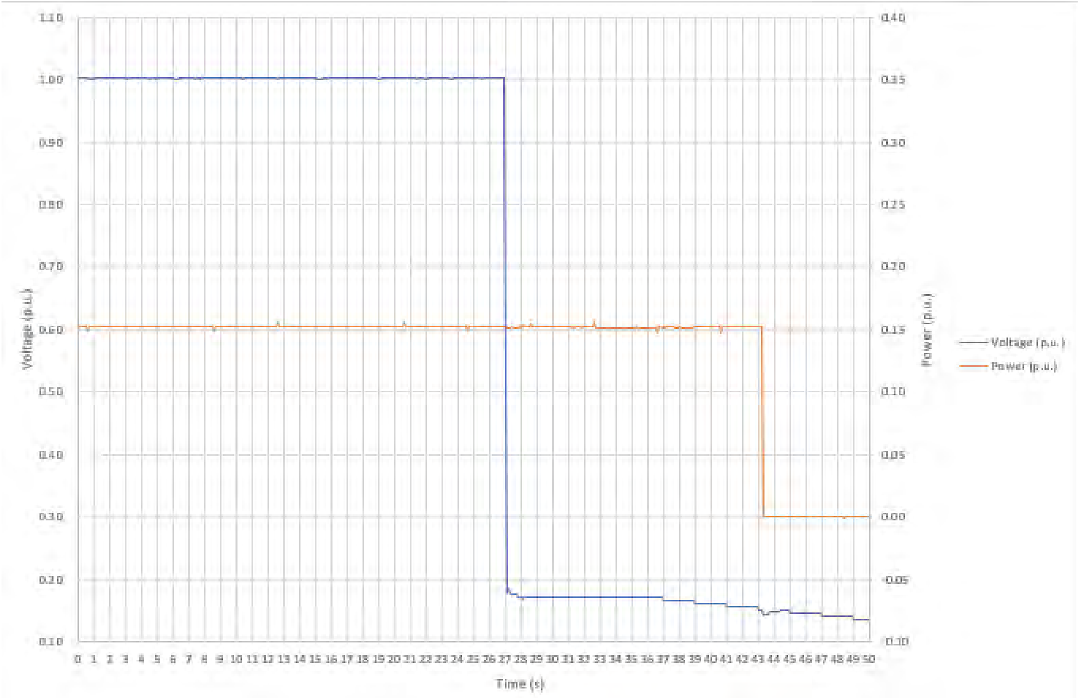
Trip time test



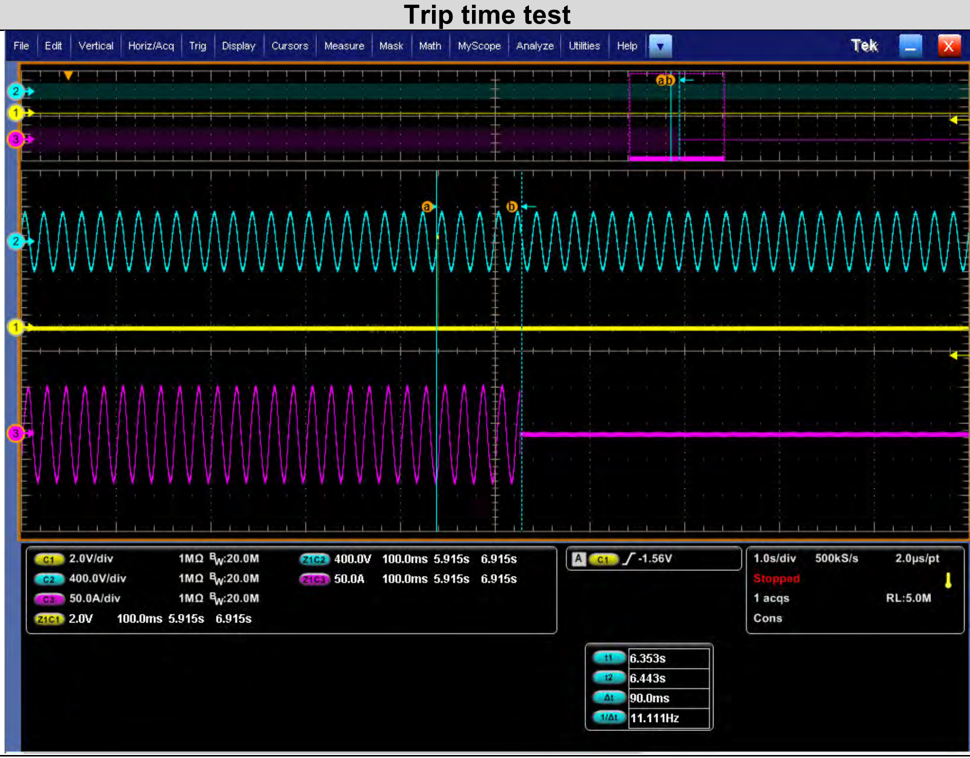
Trip time measured: 83 ms

Under voltage (Test case U5) Phase A

Trip value test



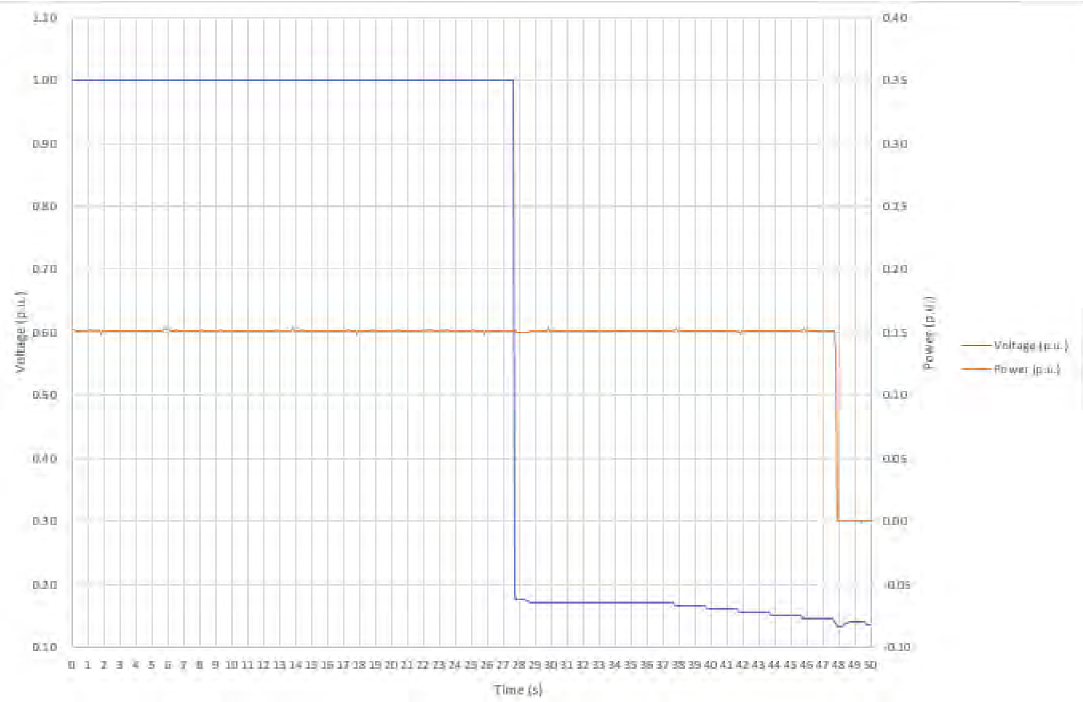
Trip time test



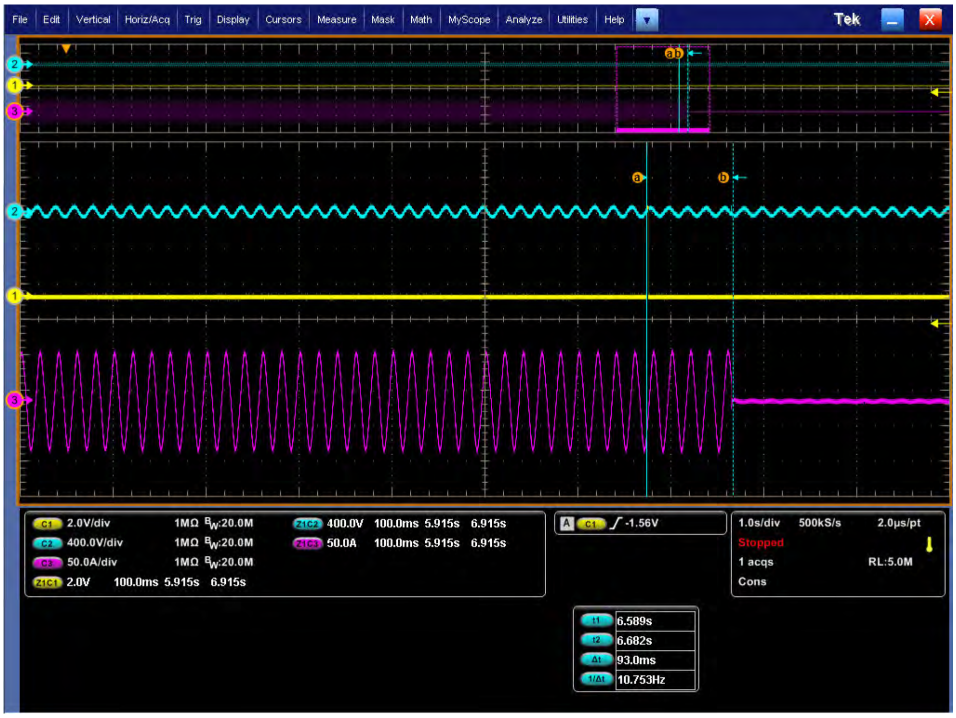
Trip time measured: 90 ms

Under voltage (Test case U5) Phase B

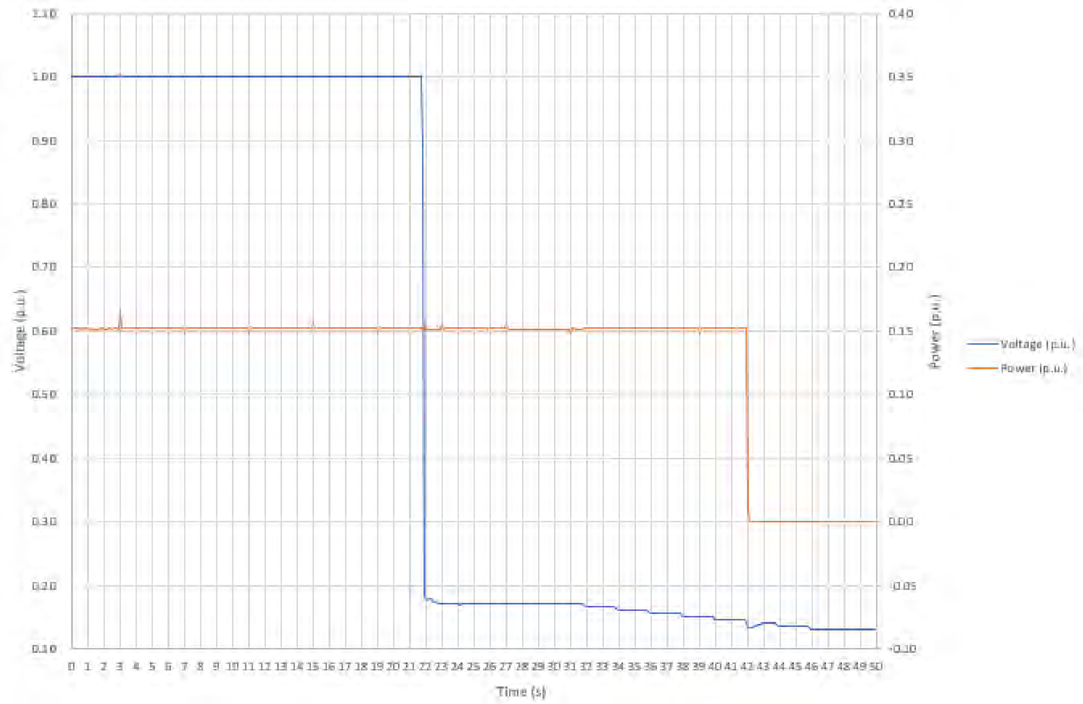
Trip value test



Trip time test



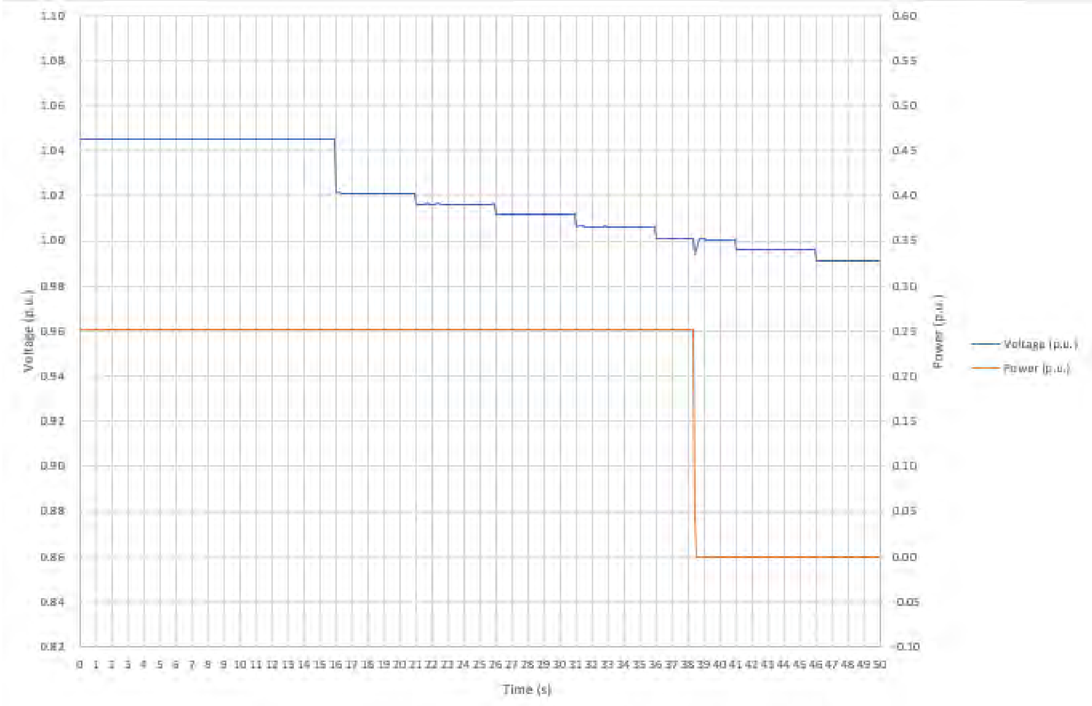
Trip time measured: 93 ms

Under voltage (Test case U5) Phase C
Trip value test

Trip time test

Trip time measured: 88 ms

Under voltage (Test case U6) 3 – Phases

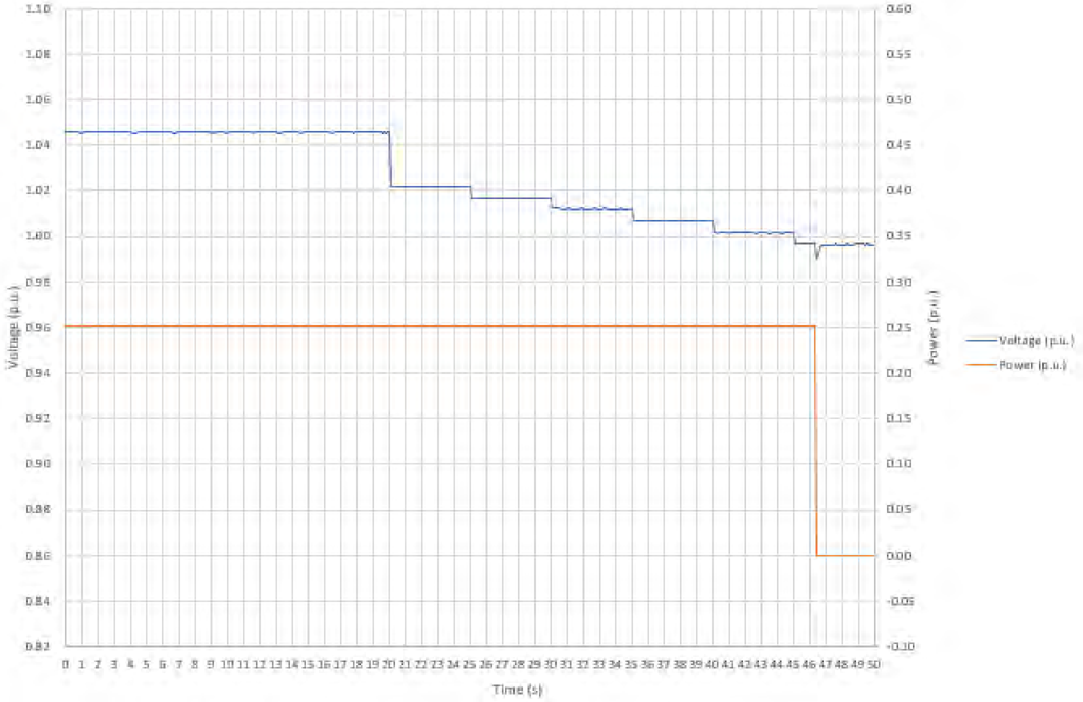
Trip value test



Trip time test

Trip time measured: 2.430 s

Under voltage (Test case U6) Phase A
Trip value test

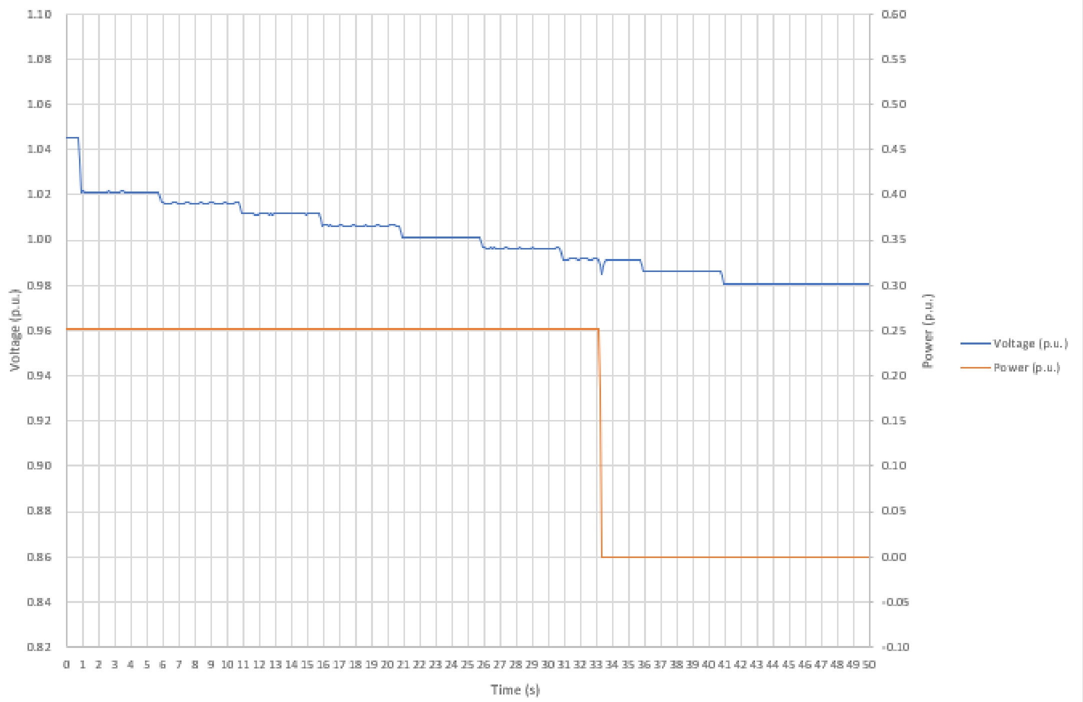


Trip time test

Trip time measured: 2.442 s

Under voltage (Test case U6) Phase B

Trip value test

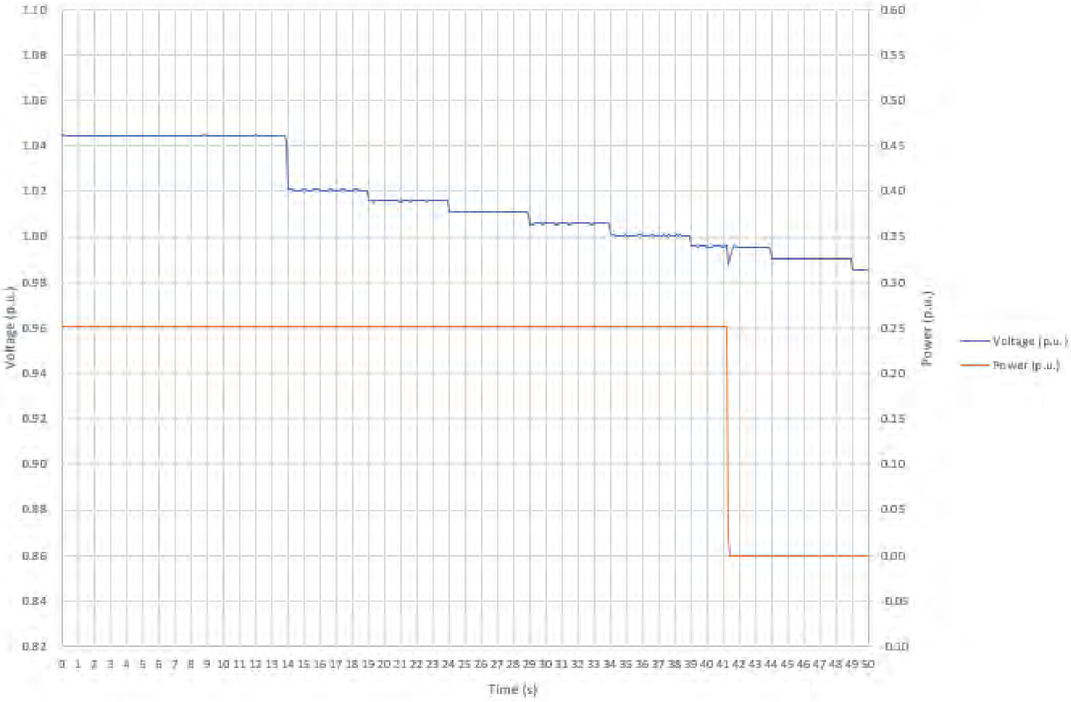


Trip time test

Trip time measured: 2.444 s

Under voltage (Test case U6) Phase C

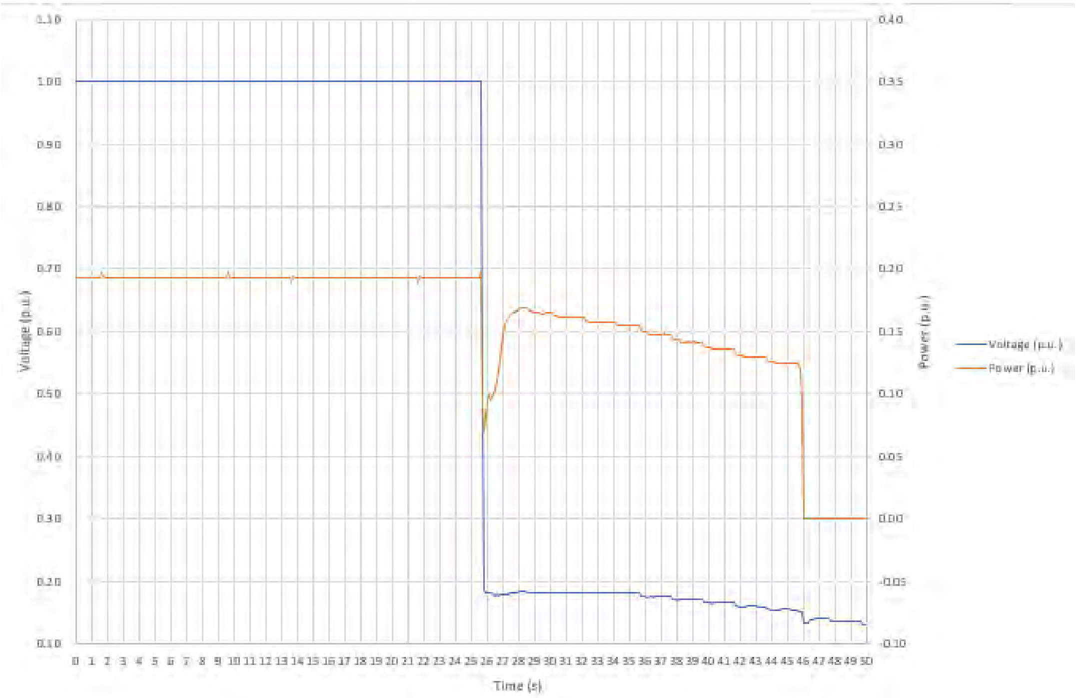
Trip value test



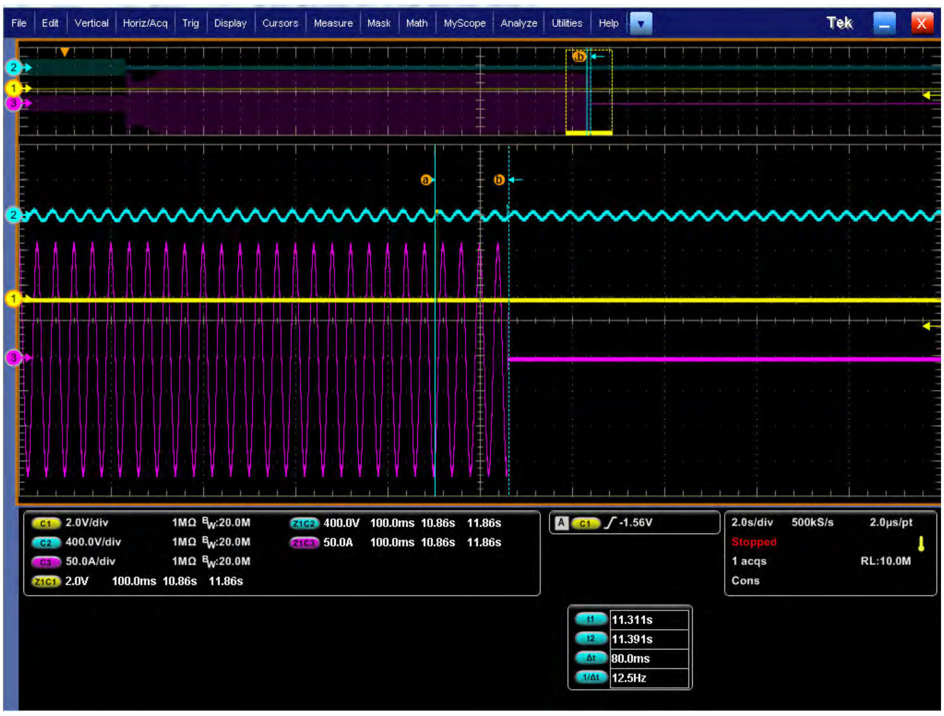
Trip time test

Trip time measured: 2.424 s

Under voltage (Test case U7) 3 – Phases
Trip value test

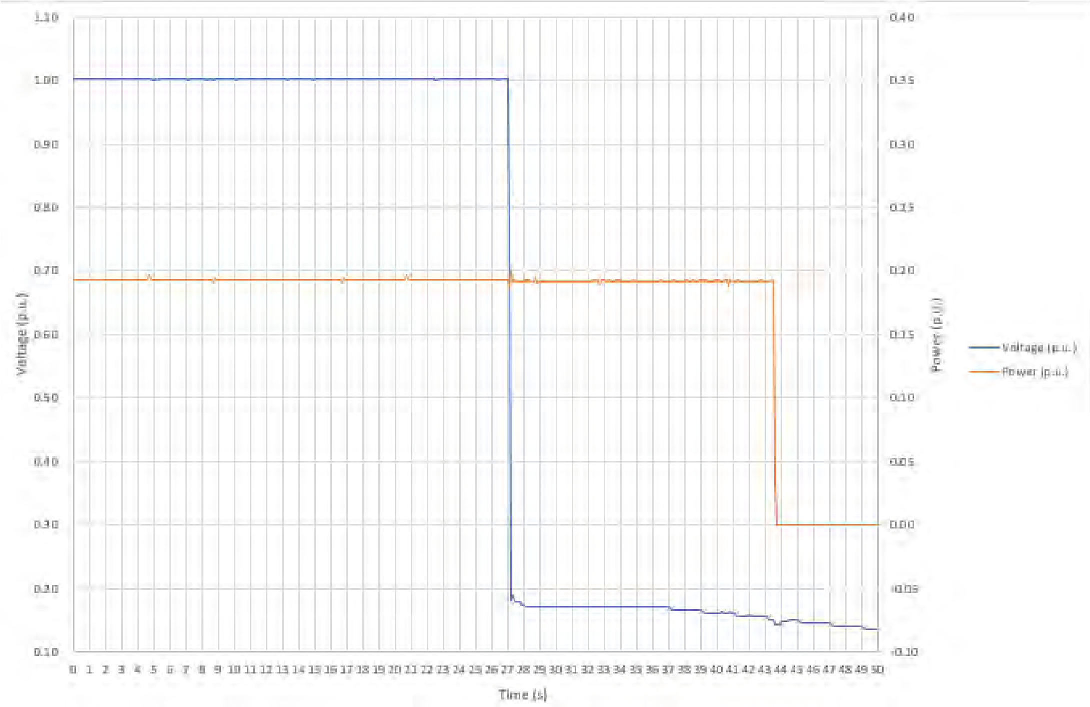


Trip time test

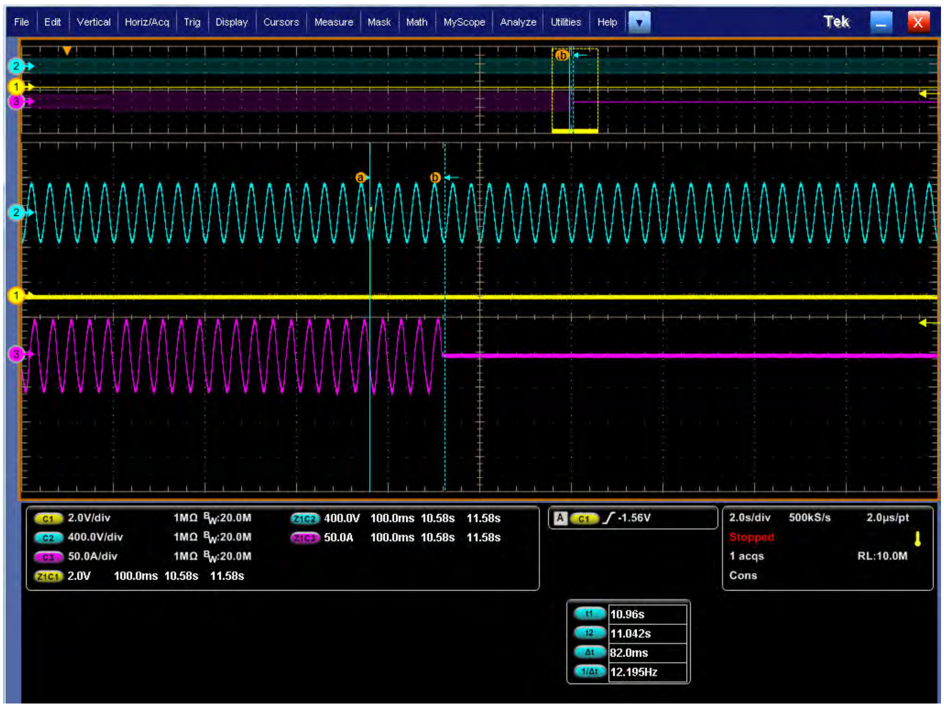


Trip time measured: 80 ms

Under voltage (Test case U7) Phase A
Trip value test



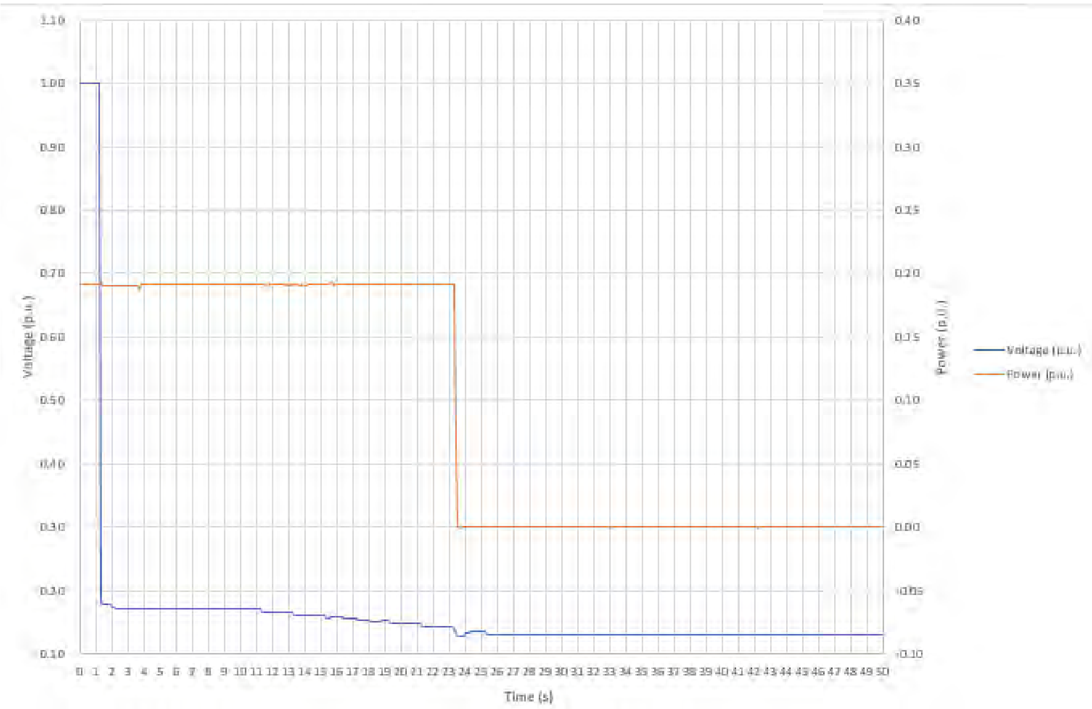
Trip time test



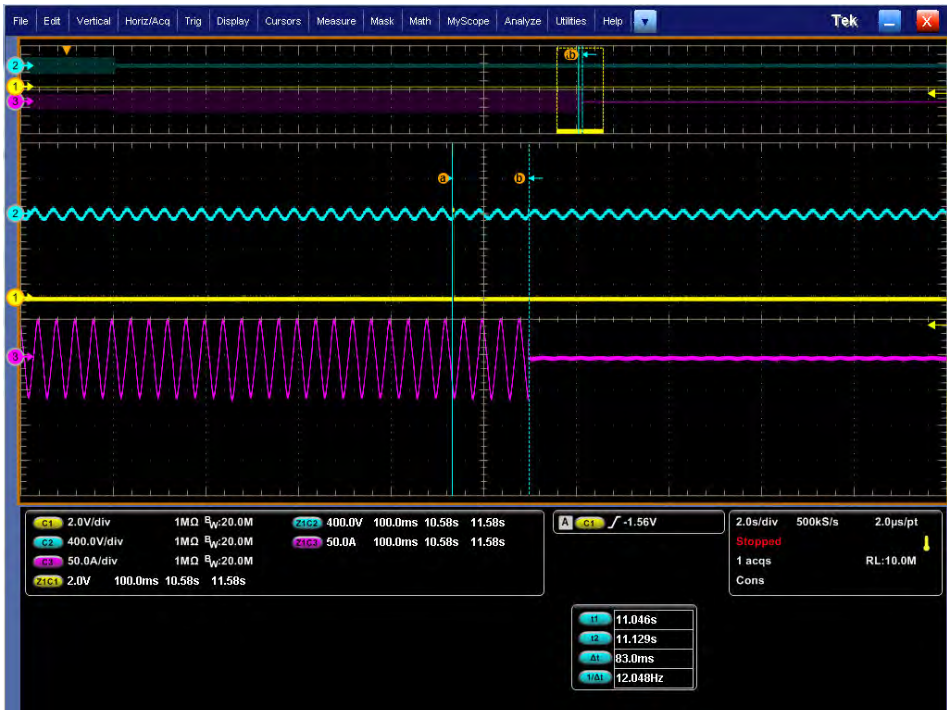
Trip time measured: 82 ms

Under voltage (Test case U7) Phase B

Trip value test



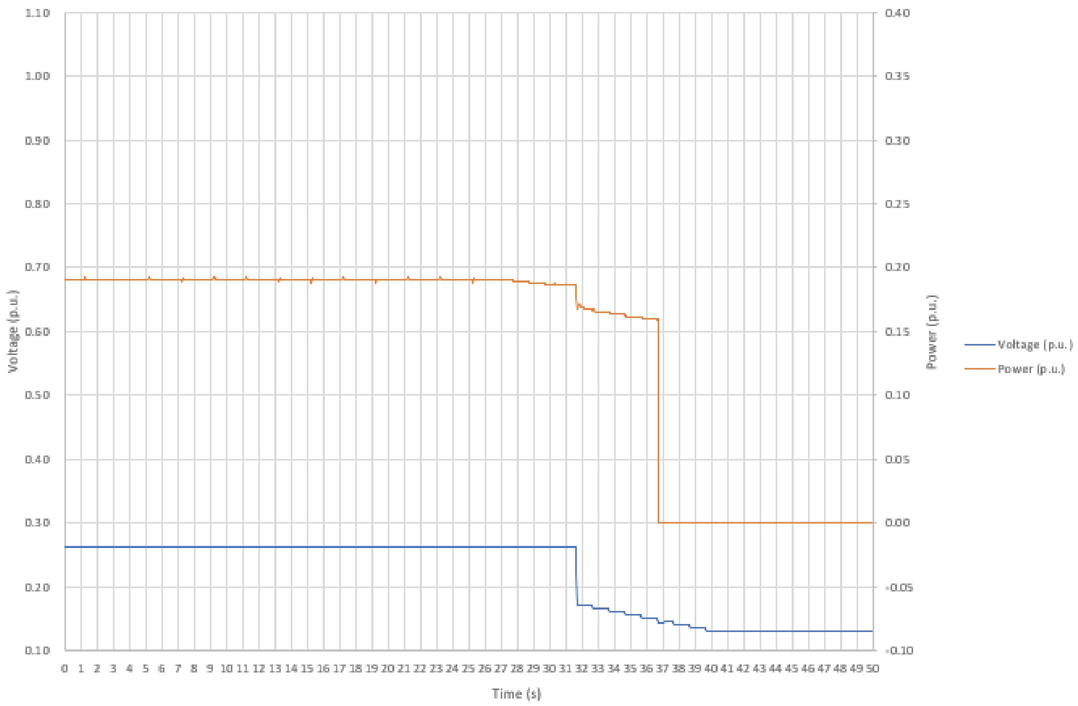
Trip time test



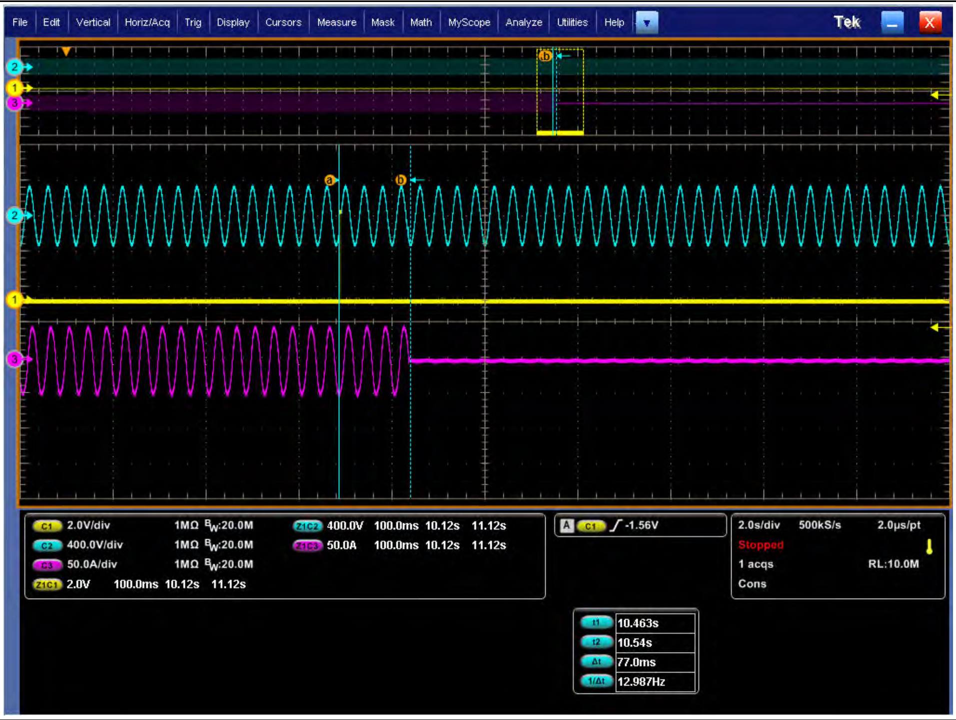
Trip time measured: 83 ms

Under voltage (Test case U7) Phase C

Trip value test

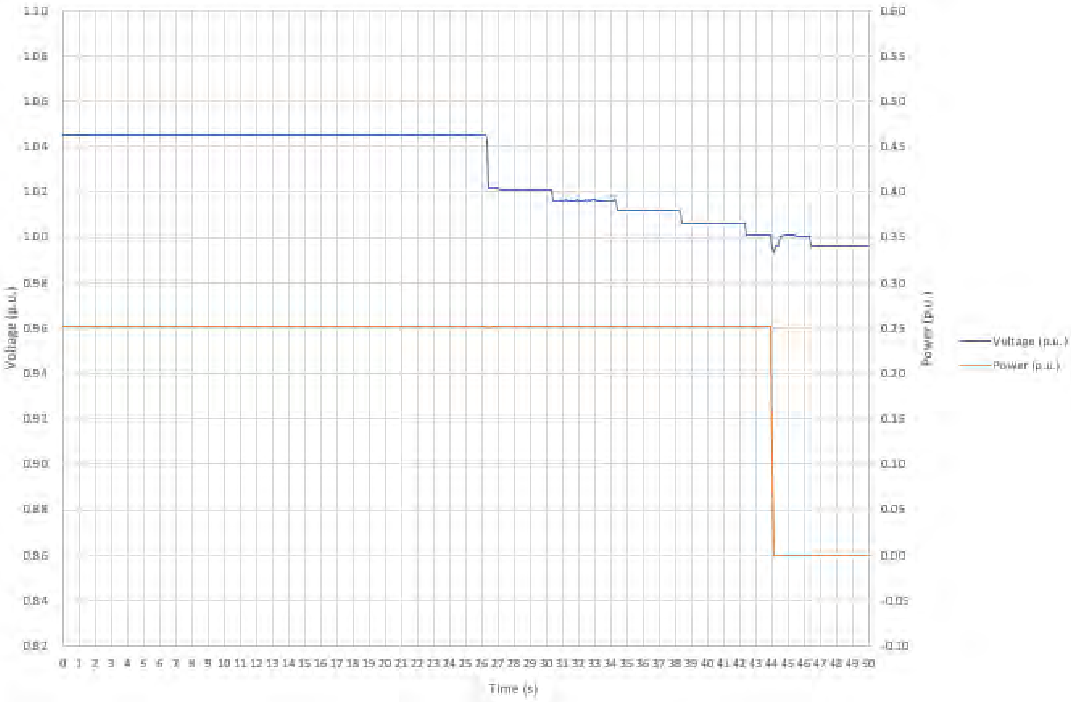


Trip time test



Trip time measured: 77 ms

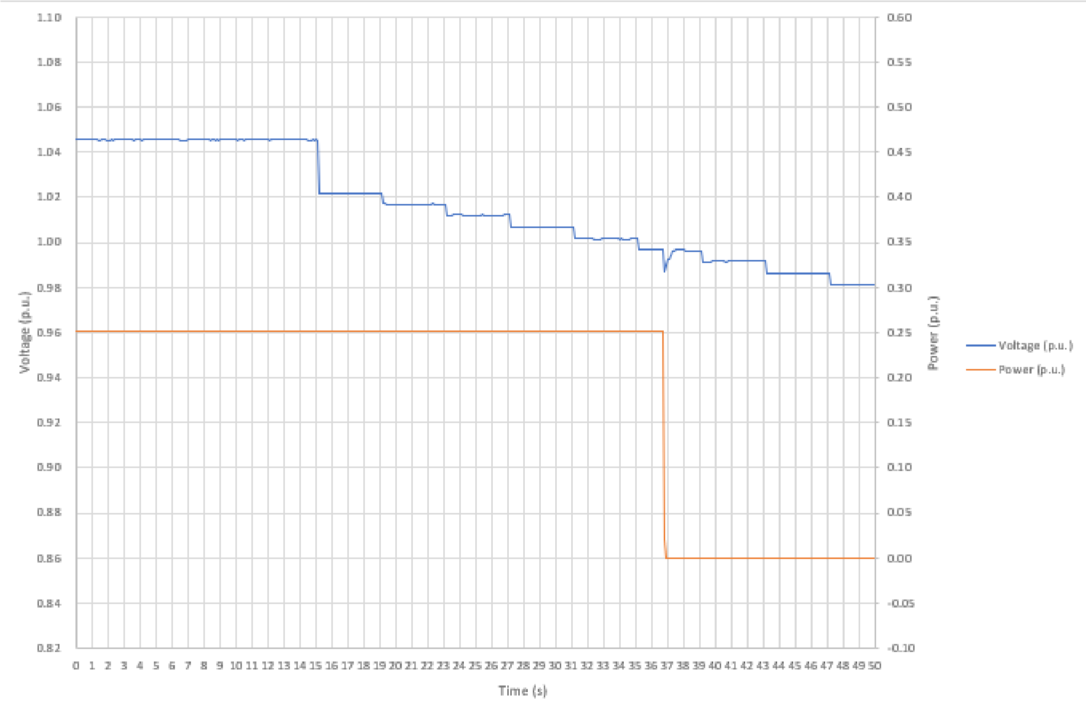
Under voltage (Test case U8) 3 – Phases
Trip value test



Trip time test

Trip time measured: 822 ms

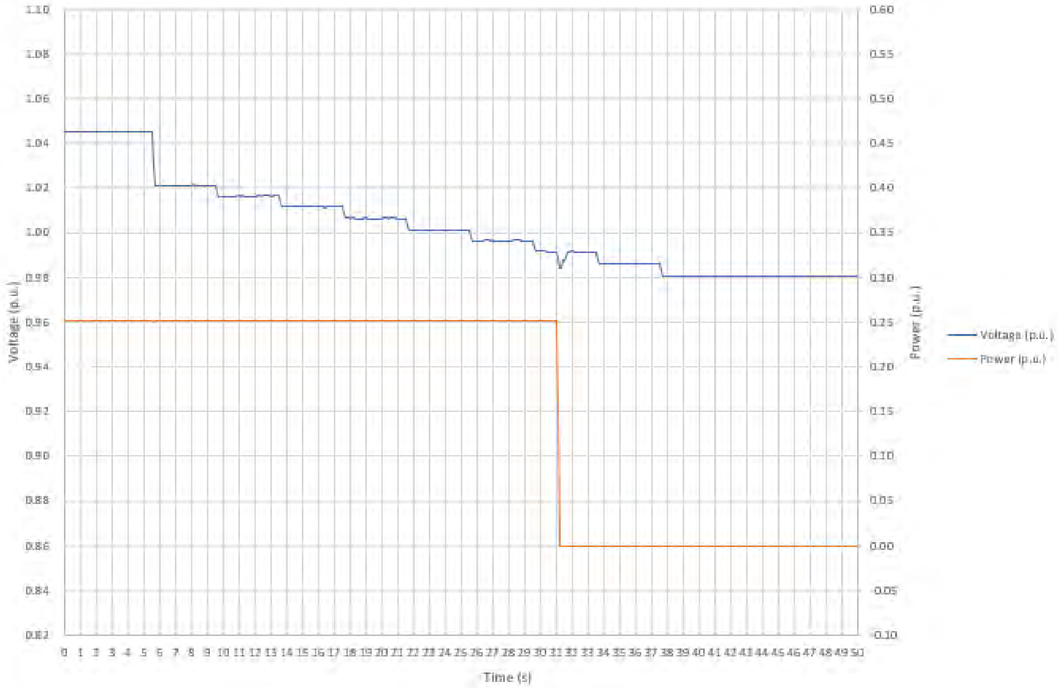
Under voltage (Test case U8) Phase A
Trip value test



Trip time test

Trip time measured: 836 ms

Under voltage (Test case U8) Phase B
Trip value test

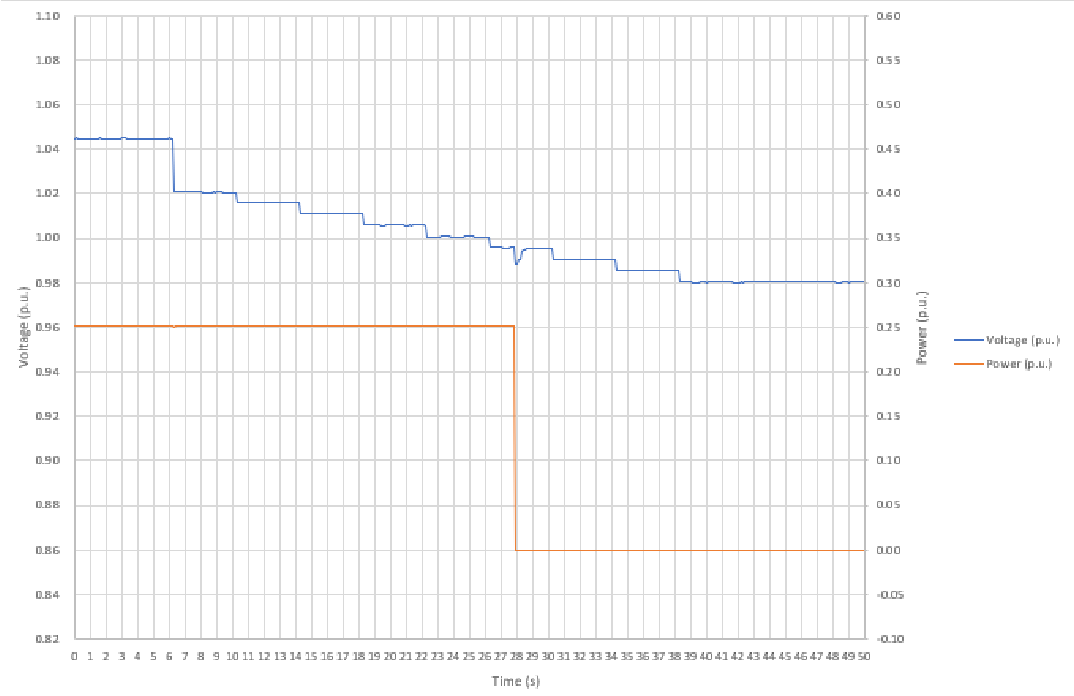


Trip time test

Trip time measured: 824 ms

Under voltage (Test case U8) Phase C

Trip value test



Trip time test

Trip time measured: 834 ms

4.4.3 Over & underfrequency protection

Used settings of the measurement device for Over and undervoltage protection measurement.

Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/20 to 2019/11/23	100 ms values	10 kHz
DL850E		--	--

For over and underfrequency protection test, the measurements have been carried out at the same time for all 3 phases.

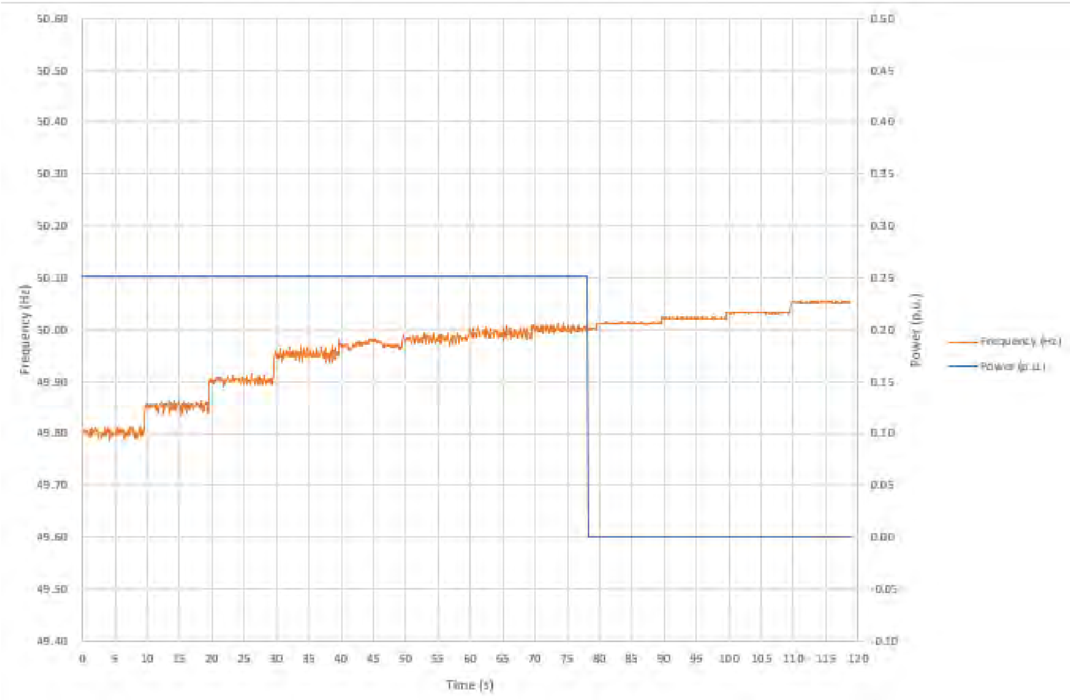
The following tables show the test results for trip value test and trip time test:

Overfrequency (F>)		
Settings	**Min. threshold, Max. time (Test case F1)**	**Max. threshold, Min. time (Test case F2)**
Setting value	50.00 Hz	55.00 Hz
Trigger value	50.00 Hz	55.00 Hz
Time setting value	5.000 s	0.050 s
Trigger time	5.040 s	0.074 s

Overfrequency (F>>)		
Settings	**Min. threshold, Max. time (Test case F3)**	**Max. threshold, Min. time (Test case F4)**
Setting value	50.00 Hz	55.00 Hz
Trigger value	50.00 Hz	55.01 Hz
Time setting value	0.100 s	0.050 s
Trigger time	0.128 s	0.066 s

Underfrequency (F<)		
Settings	**Min. threshold, Min. time (Test case F5)**	**Max. threshold, Max. time (Test case F6)**
Setting value	45.00 Hz	50.00 Hz
Trigger value	45.00 Hz	49.99 Hz
Time setting value	0.050 s	0.100 s
Trigger time	0.083 s	0.127 s

Overfrequency (Test case F1)
Trip value test

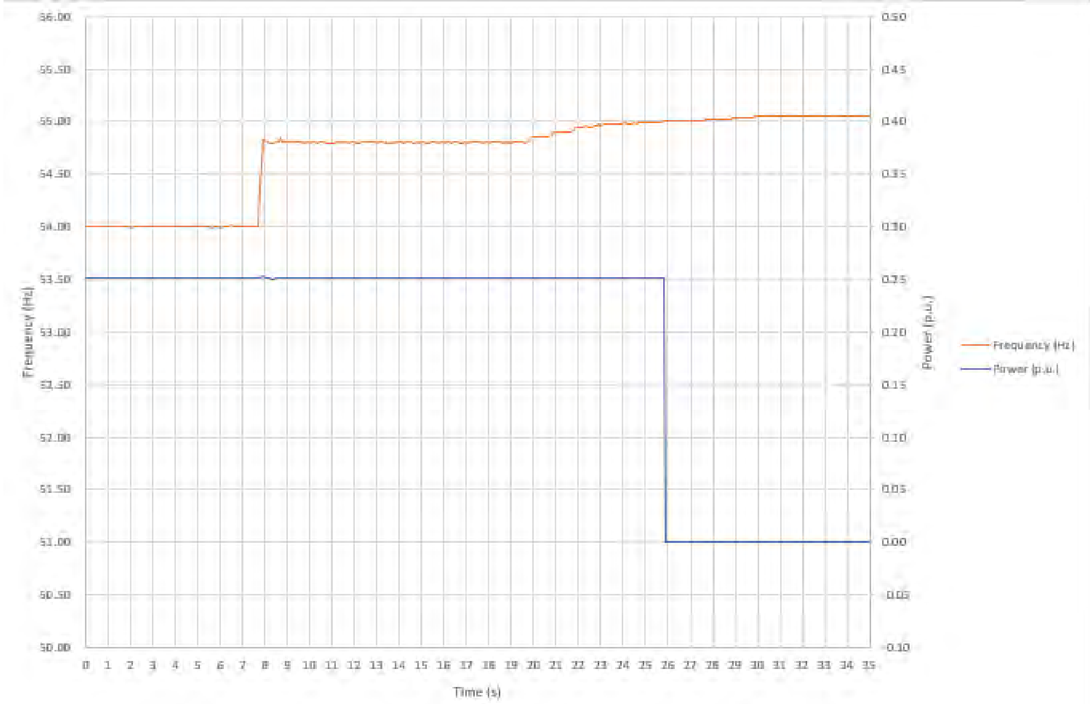


Trip time test

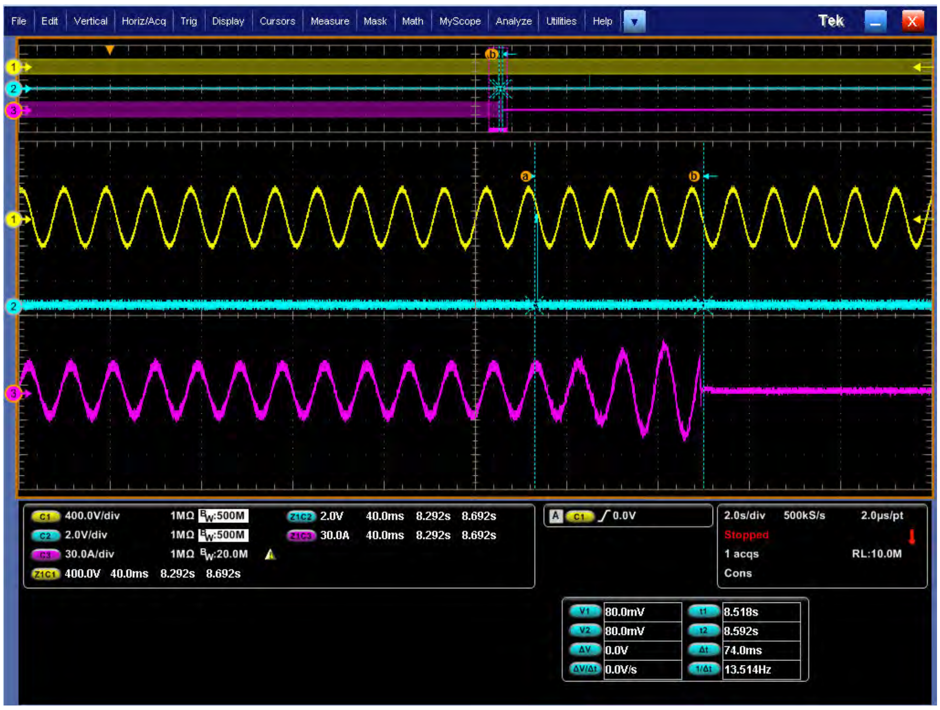
Trip time measured: 5.040 s

Overfrequency (Test case F2)

Trip value test



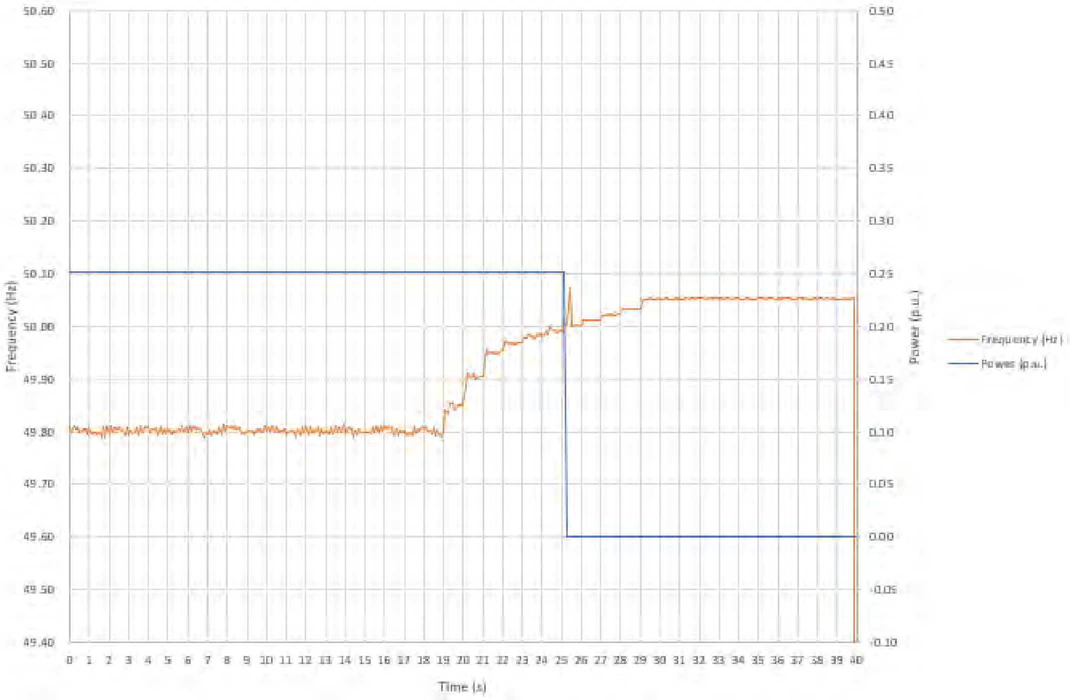
Trip time test



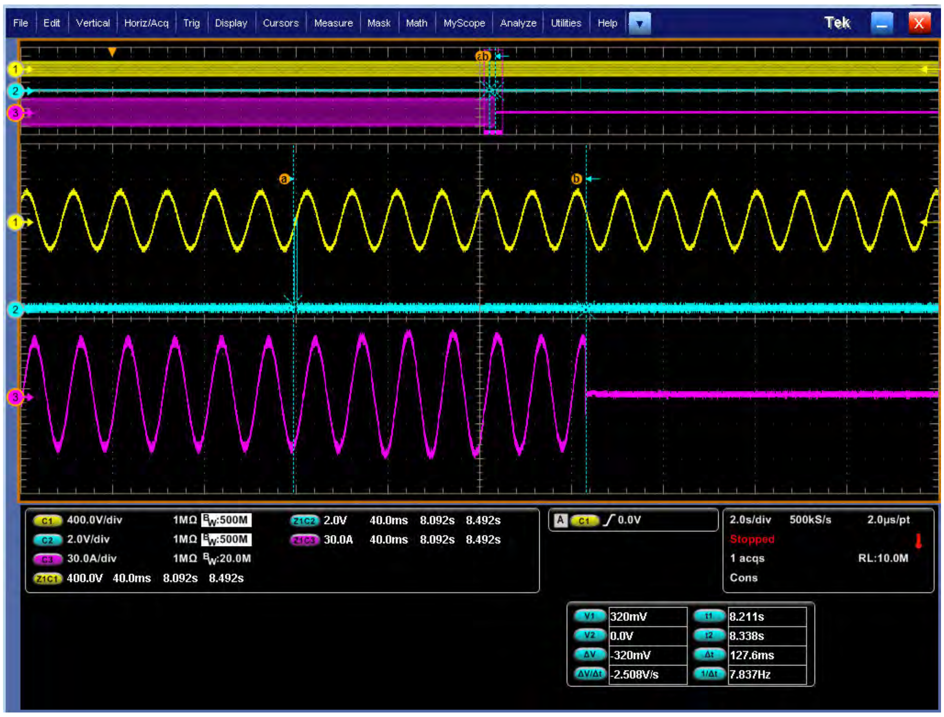
Trip time measured: 74 ms

Overfrequency (Test case F3)

Trip value test

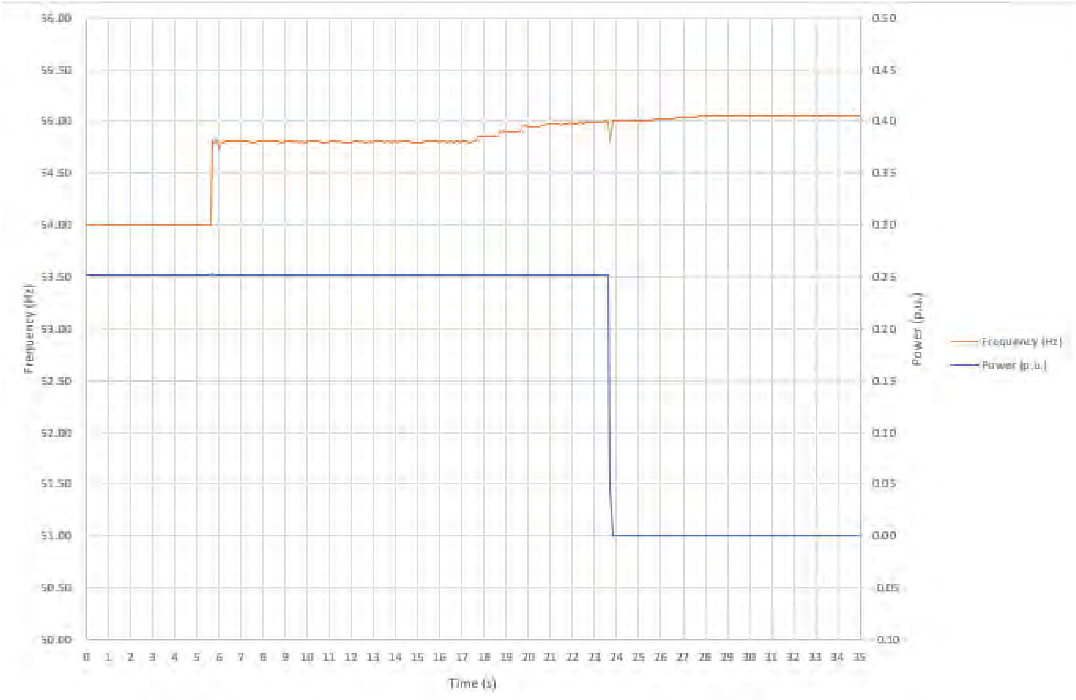


Trip time test

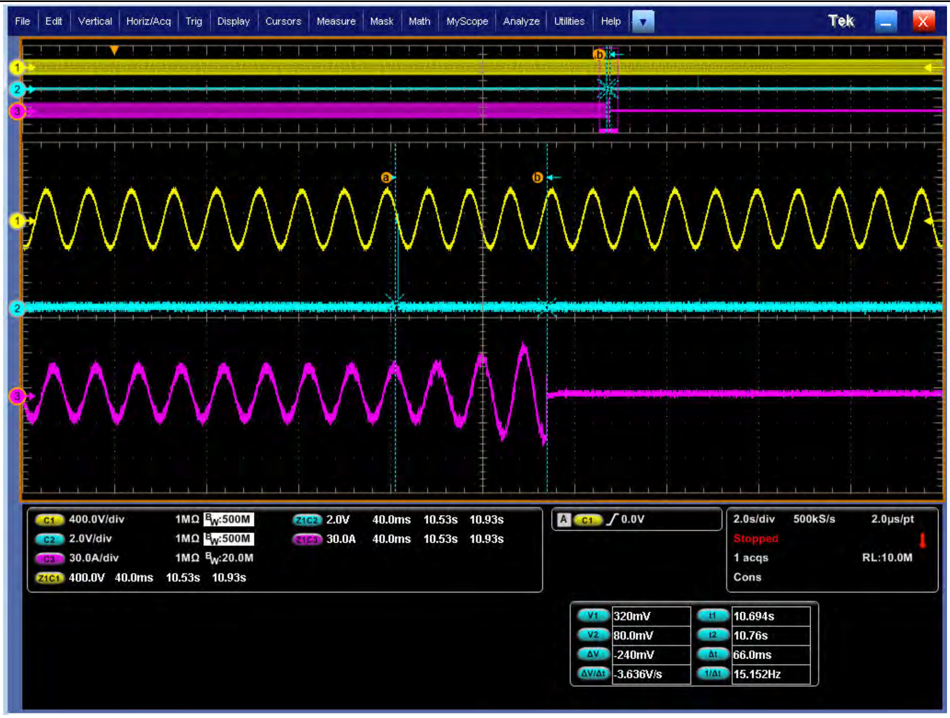


Trip time measured: 128 ms

Overfrequency (Test case F4)
Trip value test



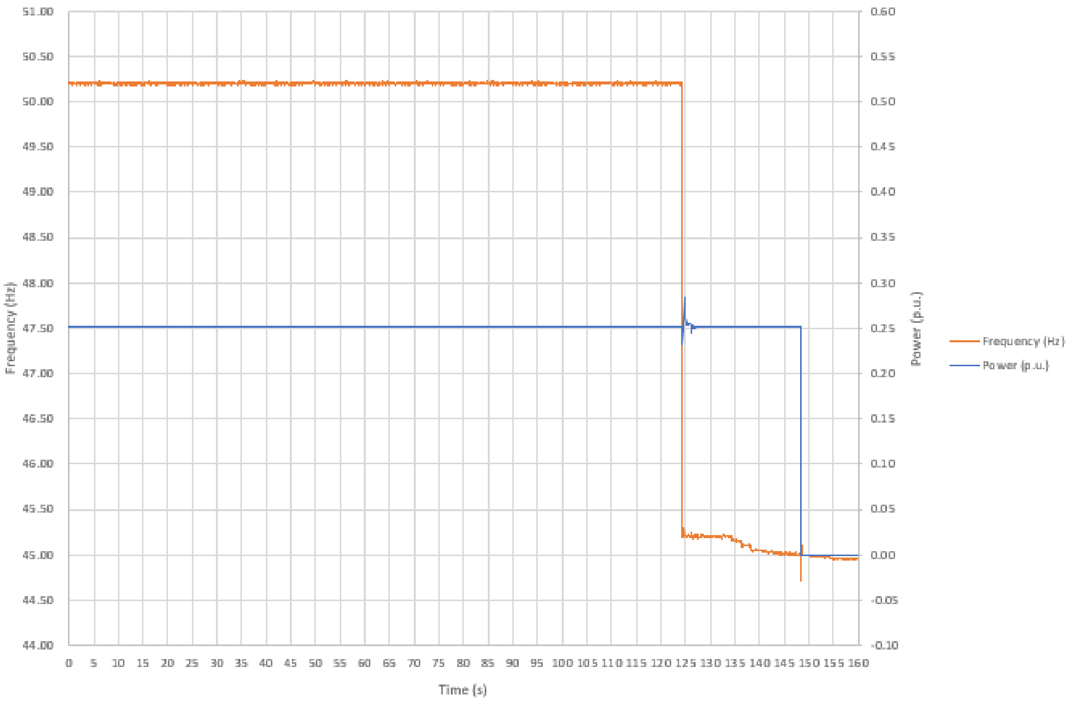
Trip time test



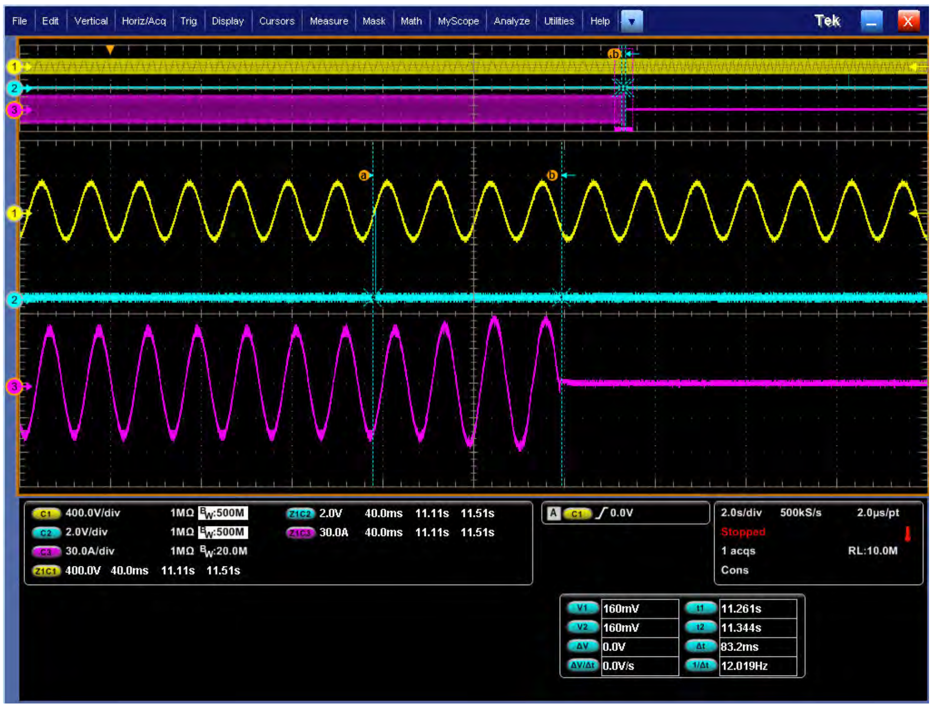
Trip time measured: 66 ms

Overfrequency (Test case F5)

Trip value test



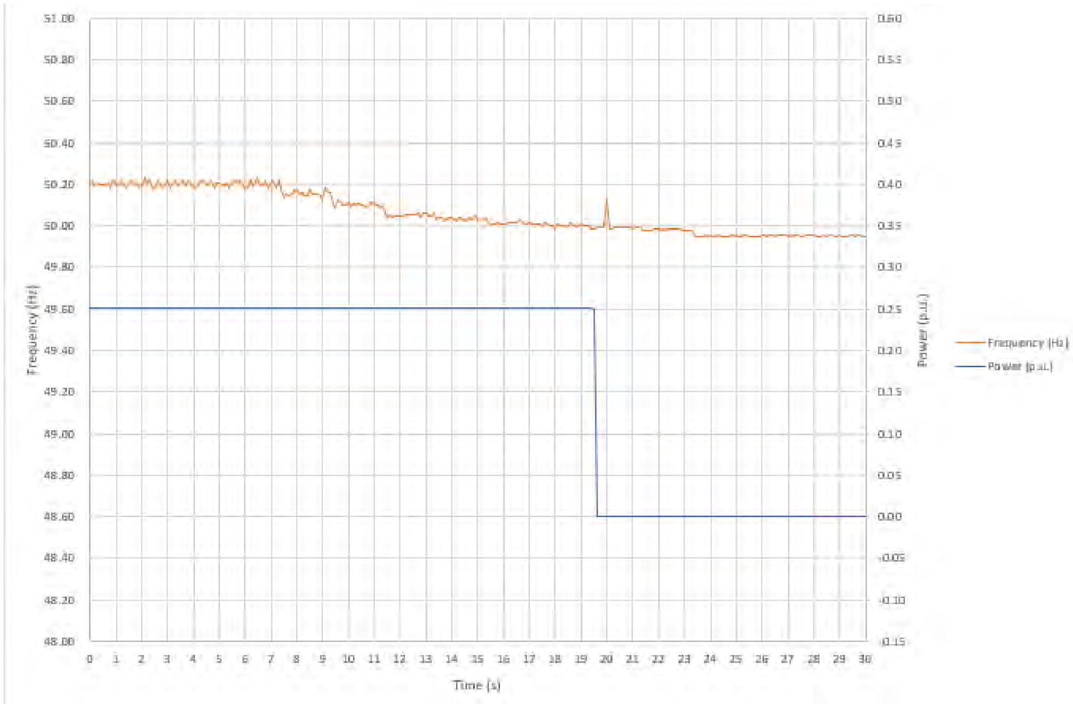
Trip time test



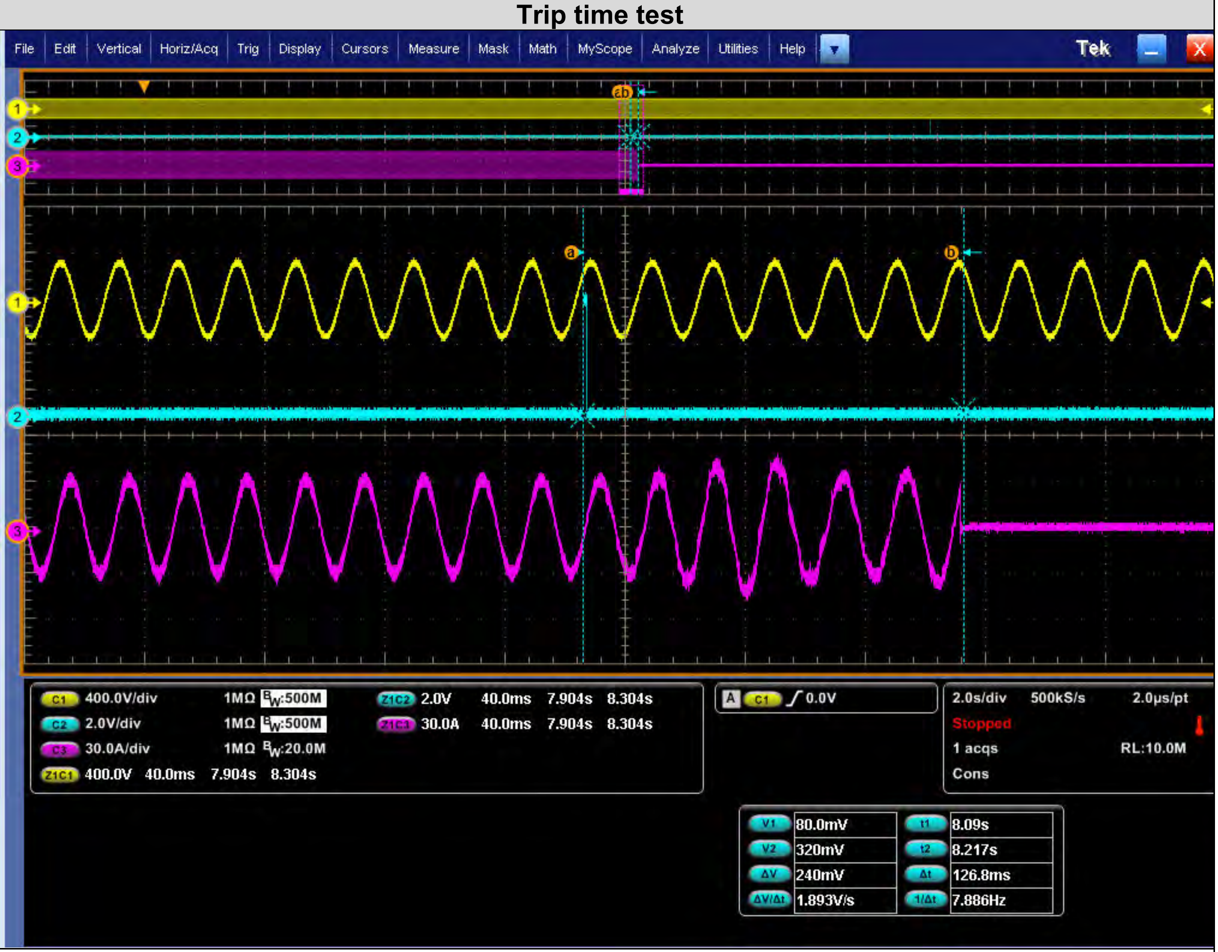
Trip time measured: 83 ms

Overfrequency (Test case F6)

Trip value test



Trip time test



Trip time measured: 127 ms

4.4.4 Resetting Ratio

These tests have been done in order to see that if the time of the abnormal voltage conditions is lower in comparison with the setting time the inverter do not trip. These tests are only carried out on three phases. Trigger time has been set at 1.4 seconds and trigger values for over-voltage and under-voltaege at 110%Un and 80%Un/45% respectively. Test procedure is detailed below in the following table and graphs from the standard:

TEST PROCEDURE	
Resetting ratio Over-voltage protection	Starting from a voltage of 0.98*trigger value (Step 1), the voltage steps to 1.02*trigger value for 500 ms (Step 2). The voltage then steps back to a value of 0.98*trigger value for 5s (Step 3). After another 5s the voltage steps to 1.02*trigger value and remains there until it triggers (Step 4).
Resetting ratio Under-voltage protection	Starting from a voltage of 1.02*trigger value (Step 1), the voltage steps to 0.98*trigger value for 500 ms (Step 2). The voltage then steps back to a value of 1.02*trigger value for 5s (Step 3). After another 5s the voltage steps to 0.98*trigger value and remains there until it triggers (Step 4).

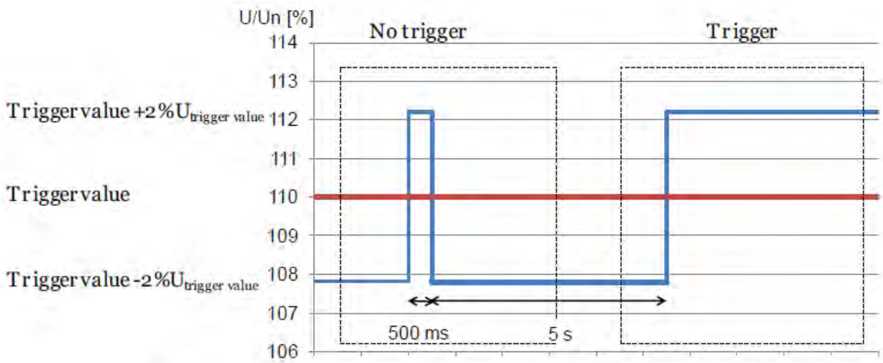


Fig. 4–23: Resetting ratio test for overvoltage protection

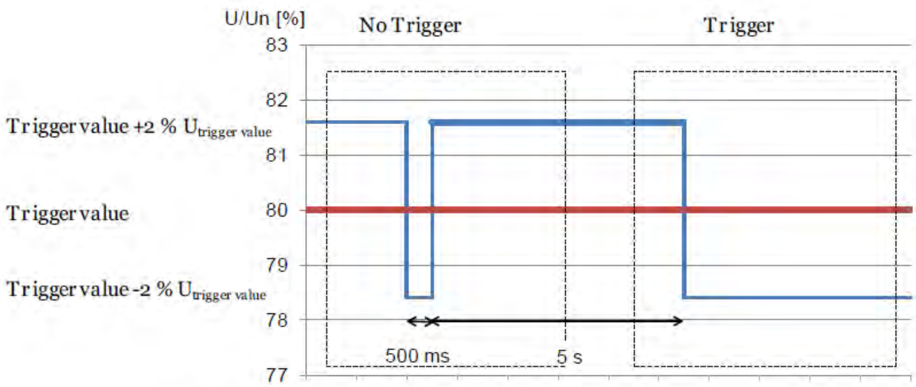
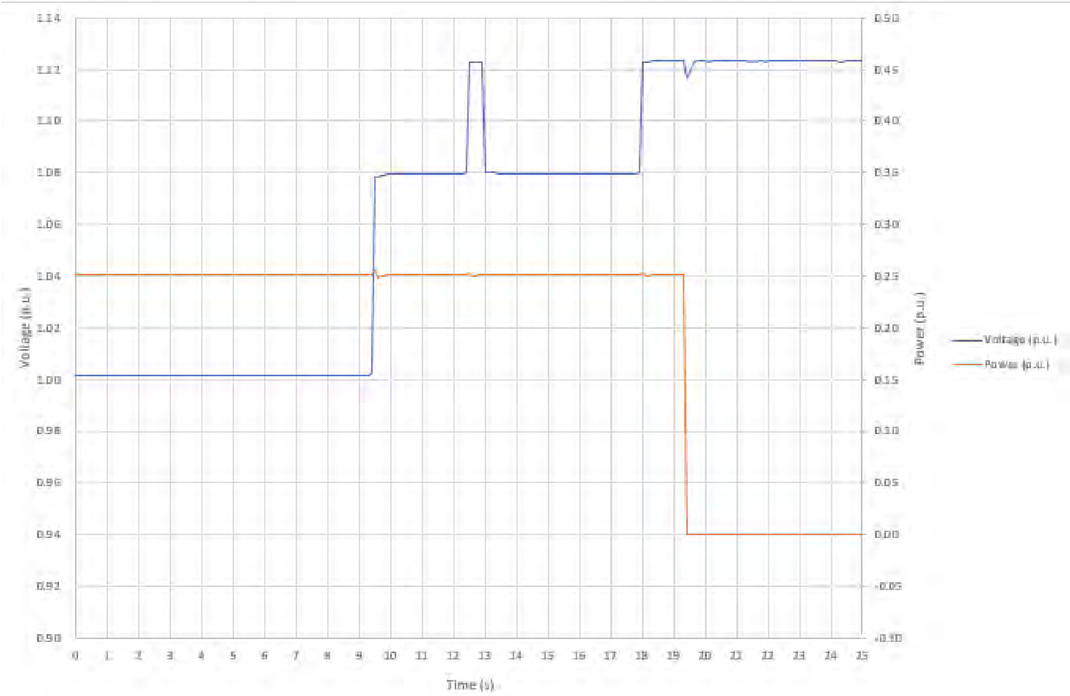


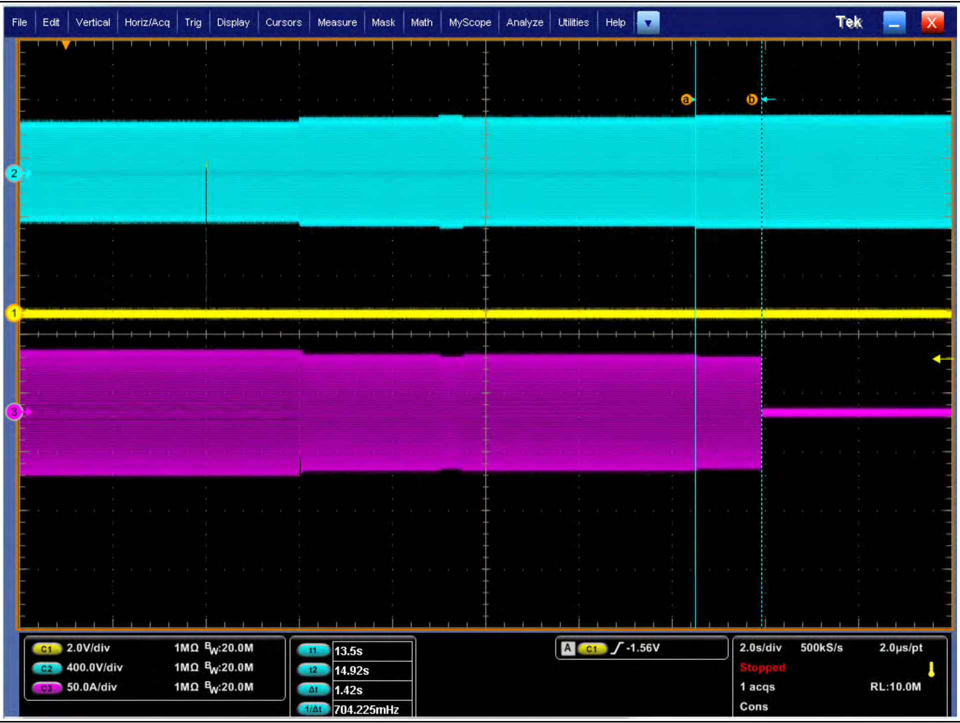
Fig. 4–24: Resetting ratio test for undervoltage protection

The following table shows the result of resetting ratio results:

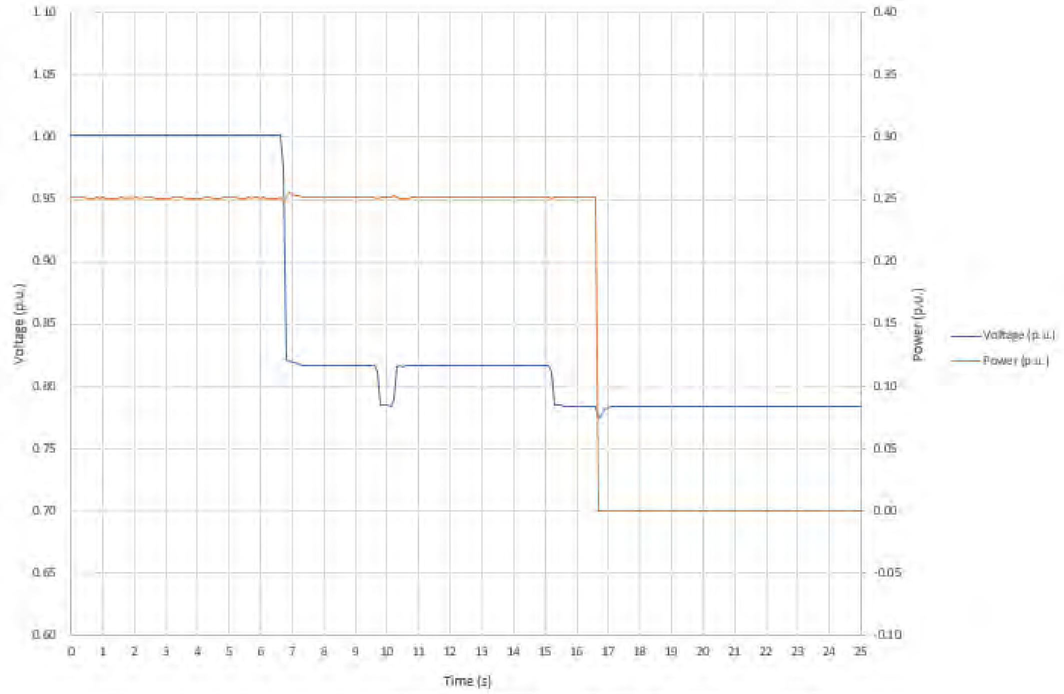
Resetting ratios				
Type test	Trigger values setting	Step no trigger time	Desconnection from the grid (YES/NO)	Trip time measured
Overvoltage Protection 1	1.10 Un	500 ms	No	1.420s
Undervoltage Protection 1	0.80 Un	500 ms	No	1.430s
Undervoltage Protection 2	0.45Un	500 ms	No	1.426s

Overvoltage Protection 1

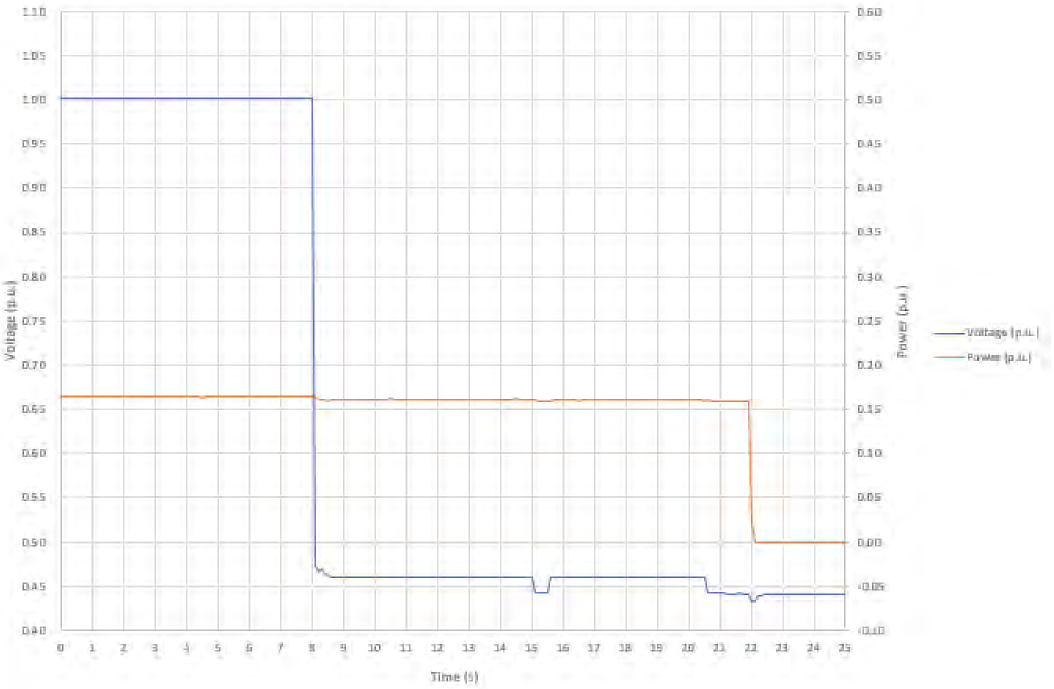




Undervoltage Protection 1



Undervoltage Protection 2



4.5 VERIFICATION OF CONNECTION CONDITIONS

4.5.1 Connection without previous protection trigger (OPTIONAL)

The aim of this test is to demonstrate that a connection and reconnection of the EUT at the voltage and frequency ranges included below. This test is optional but has been tested yet.
This test has been done according to chapter 4.5.1 of the standard.

Ranges for compliance with VDE AR-N 4110: 2018 are:

Type	Inferior Threshold	Superior Threshold
Voltage	90%Un ± 2%Un	110%Un ± 2%Un
Frequency	47.5 Hz ± 0.1 Hz	50.2 Hz ± 0.1 Hz

Ranges for compliance with VDE AR-N 4120:2018 are:

Type	Inferior Threshold	Superior Threshold
Voltage	90%Un ± 2%Un	110%Un ± 2%Un
Frequency	47.5 Hz ± 0.1 Hz	51.0 Hz ± 0.1 Hz

Used settings of the measurement device for connection conditions are:

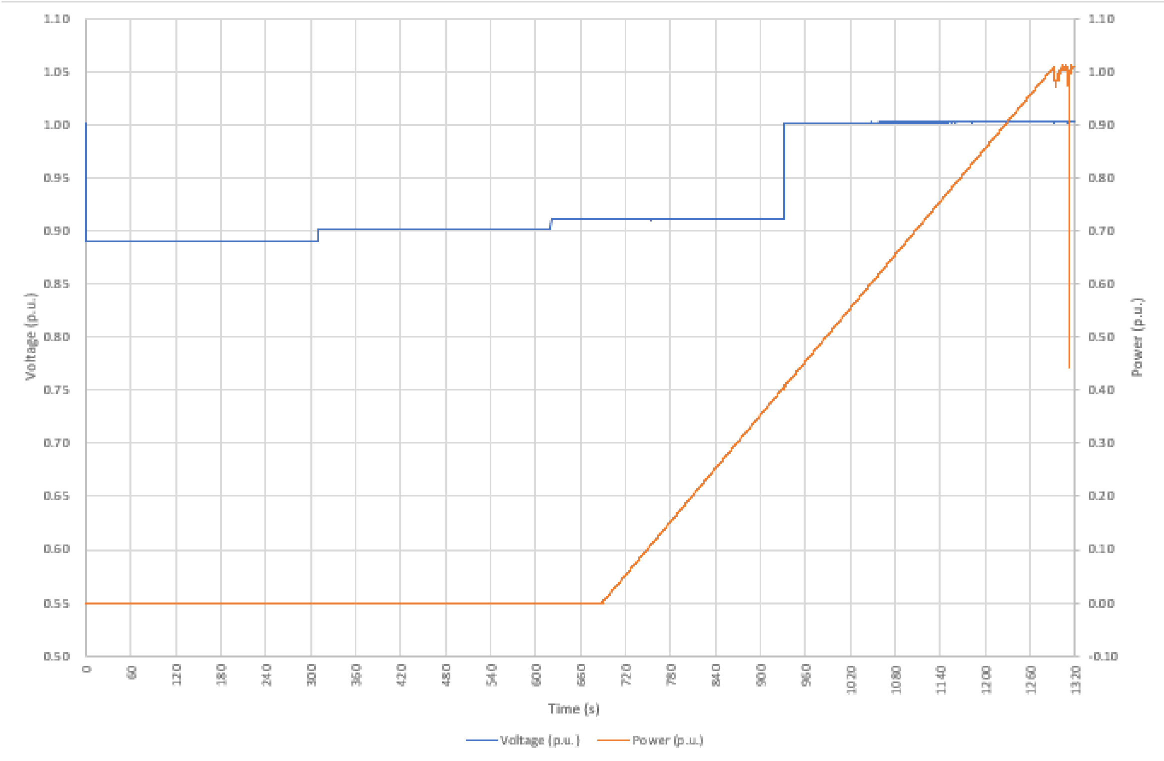
Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/21 to 2019/11/22 and 2020/09/21	100 ms values or 200 ms values	3 kHz

Tests consists in steps as included in table below. Each step has been maintained for 5 min and, once the EUT connects, the test is stopped. The following table shows the test results:

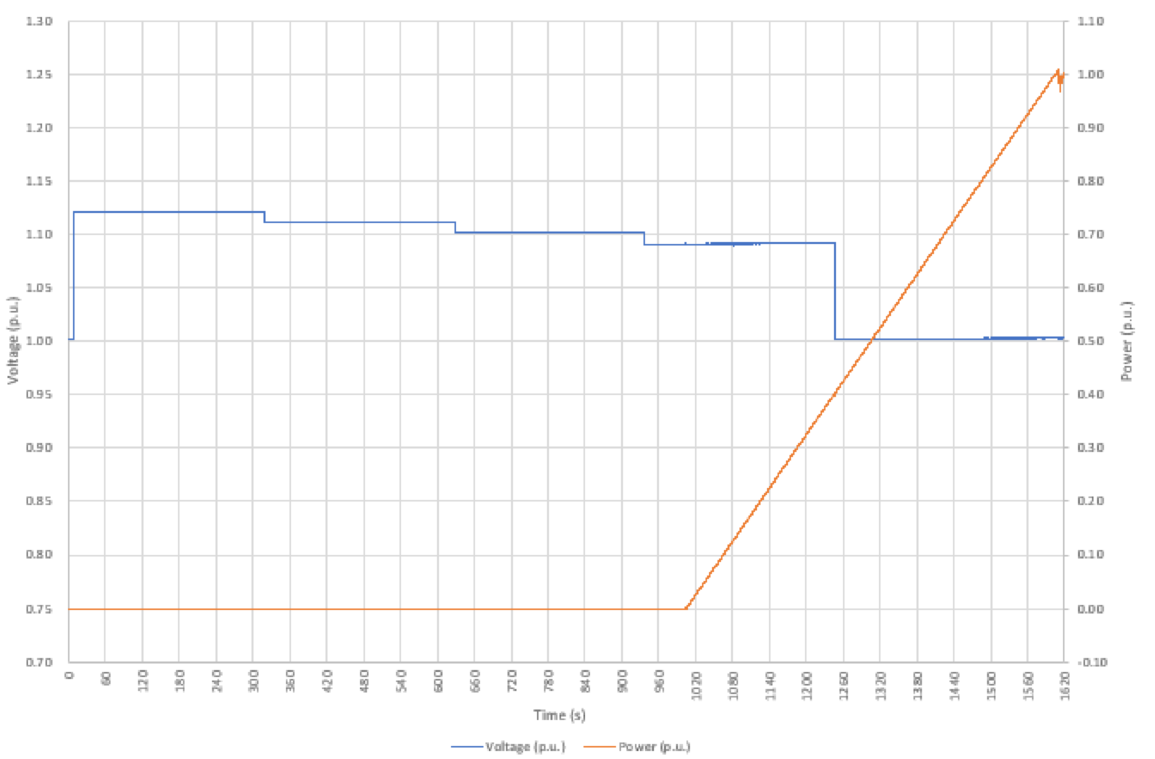
Undervoltage test		Overvoltage test		Underfrequency test		Overfrequency test 1	
Step (% of U_n)	Connection (Yes/No)	Step (% of Un)	Connection (Yes/No)	Step (Hz)	Connection (Yes/No)	Step (Hz)	Connection (Yes/No)
89	☒ NO ☐ YES	112	☒ NO ☐ YES	47.3	☒ NO ☐ YES	50.4	☒ NO ☐ YES
90	☒ NO ☐ YES	111	☒ NO ☐ YES	47.4	☒ NO ☐ YES	50.3	☒ NO ☐ YES
91	☐ NO ☒ YES	110	☒ NO ☐ YES	47.5	☒ NO ☐ YES	50.2	☒ NO ☐ YES
		109	☐ NO ☒ YES	47.6	☐ NO ☒ YES	50.1	☐ NO ☒ YES
		108	☐ NO ☐ YES	47.7	☐ NO ☐ YES	50.0	☐ NO ☐ YES

Overfrequency test 2	
Step (Hz)	Connection (Yes/No)
51.2	☒ NO ☐ YES
51.1	☒ NO ☐ YES
51.0	☒ NO ☐ YES
50.9	☐ NO ☒ YES

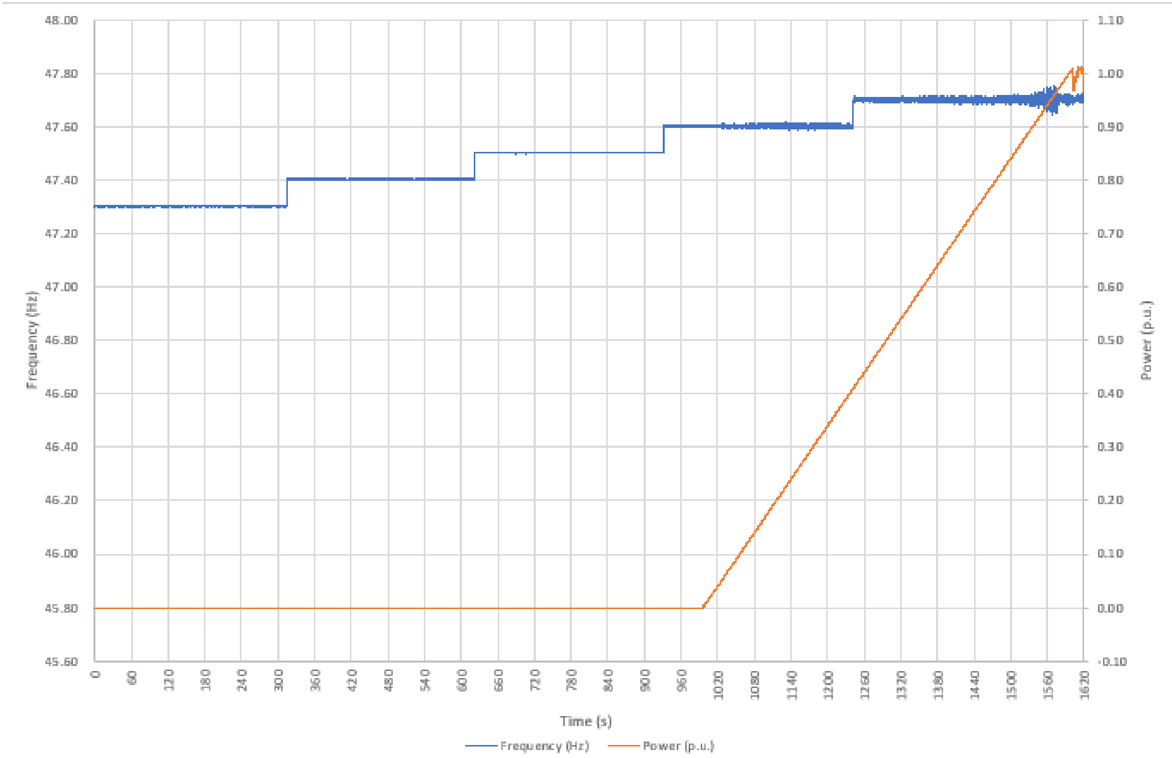
(U > 90% Un)



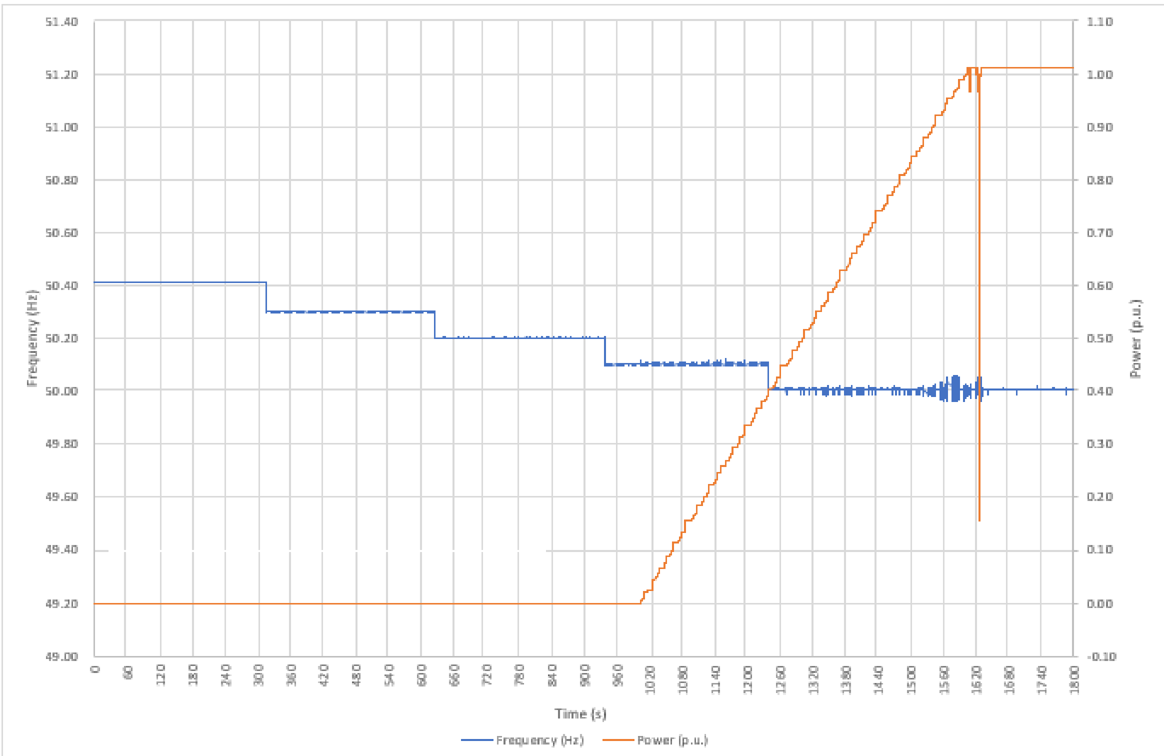
(U < 110% Un)



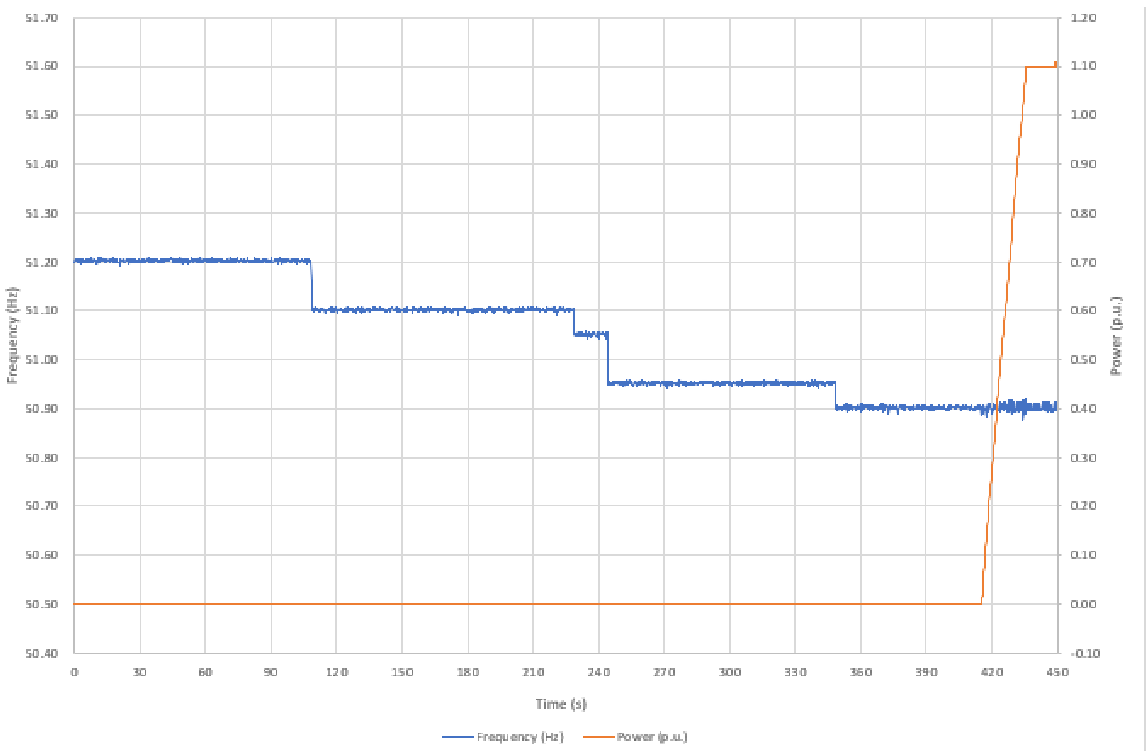
(f > 47.5 Hz)



(f < 50.2 Hz)



(f < 51.0 Hz)



Frequency (Hz)
Power (p.u.)
Time (s)
51.70
51.60
51.50
51.40
51.30
51.20
51.10
51.00
50.90
50.80
50.70
50.60
50.50
50.40
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
0
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
Frequency (Hz)
Power (p.u.)

4.5.2 Connection after triggering of the uncoupling protection

This test has been performed according to point 4.5.2 of the standard.

This test allows to realize that the inverter does not connect to the grid when is out of normal operation range conditions; on the test performing time spend on each set point is greater than set reconnection time in order to see that the inverter does not connect to the grid before the normal operation conditions are reached.

Ranges for compliance with both VDE AR-N 4110:2018 and VDE AR-N 4120:2018 are:

Type	Inferior Threshold	Superior Threshold
Voltage	95%Un	--
Frequency	49.9 Hz	50.1 Hz

Used settings of the measurement device for connection conditions measurement:

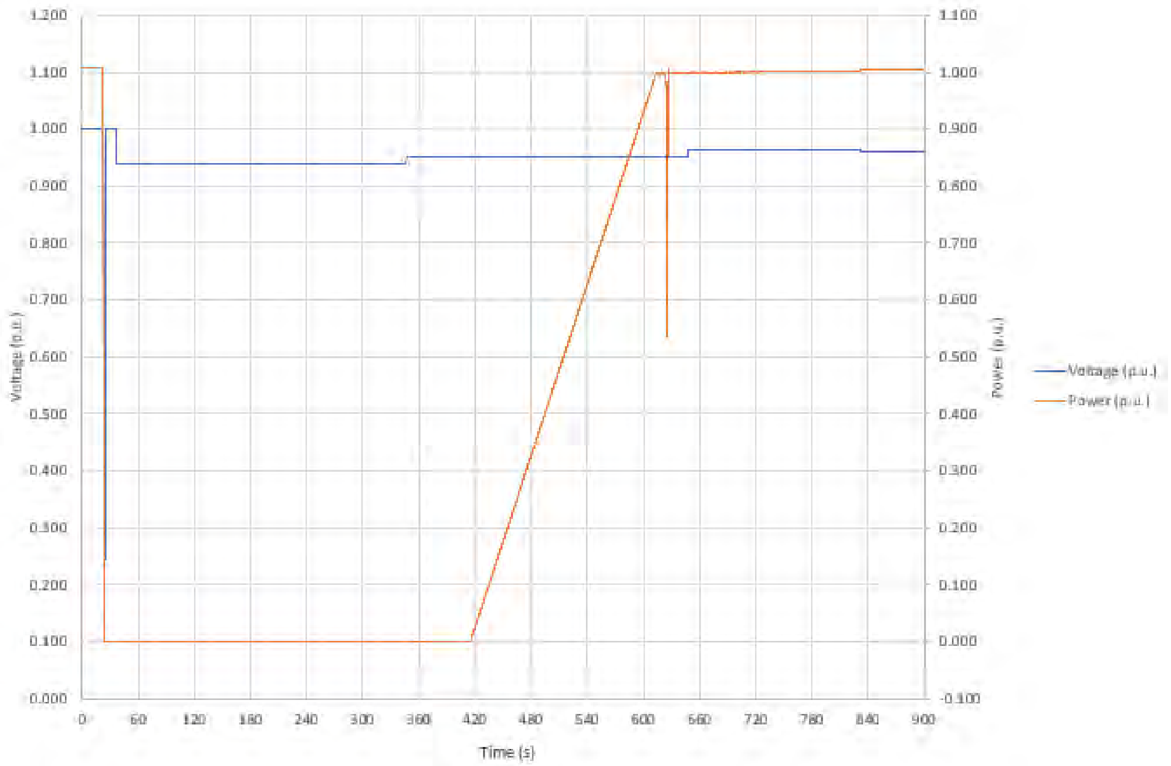
Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2020/09/22 and 2020/09/24	200 ms values	3 kHz

Tests consists in steps as included in table below. Each step has been maintained for 5 min and, once the EUT connects, the test can be stopped.

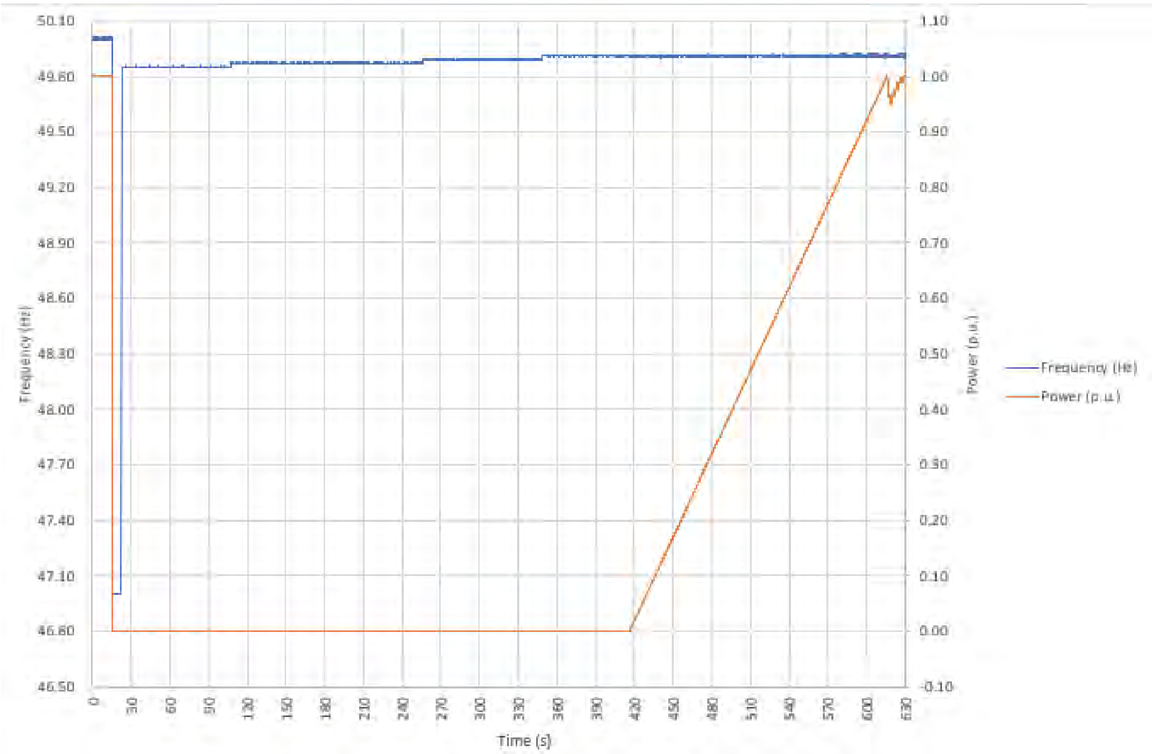
The following table shows the test results:

Undervoltage test		Underfrequency test		Overfrequecy test	
Step (% of U_n)	**Connection (Yes/No)**	**Step (Hz)**	**Connection (Yes/No)**	**Step (Hz)**	**Connection (Yes/No)**
94	☒ NO ☐ YES	49.85	☒ NO ☐ YES	50.14	☒ NO ☐ YES
95	☐ NO ☒ YES	49.87	☒ NO ☐ YES	50.12	☒ NO ☐ YES
96	☐ NO ☐ YES	49.89	☒ NO ☐ YES	50.10	☐ NO ☒ YES
--	--	49.91	☐ NO ☒ YES	50.08	☐ NO ☐ YES
--	--	--	--	50.06	☐ NO ☐ YES

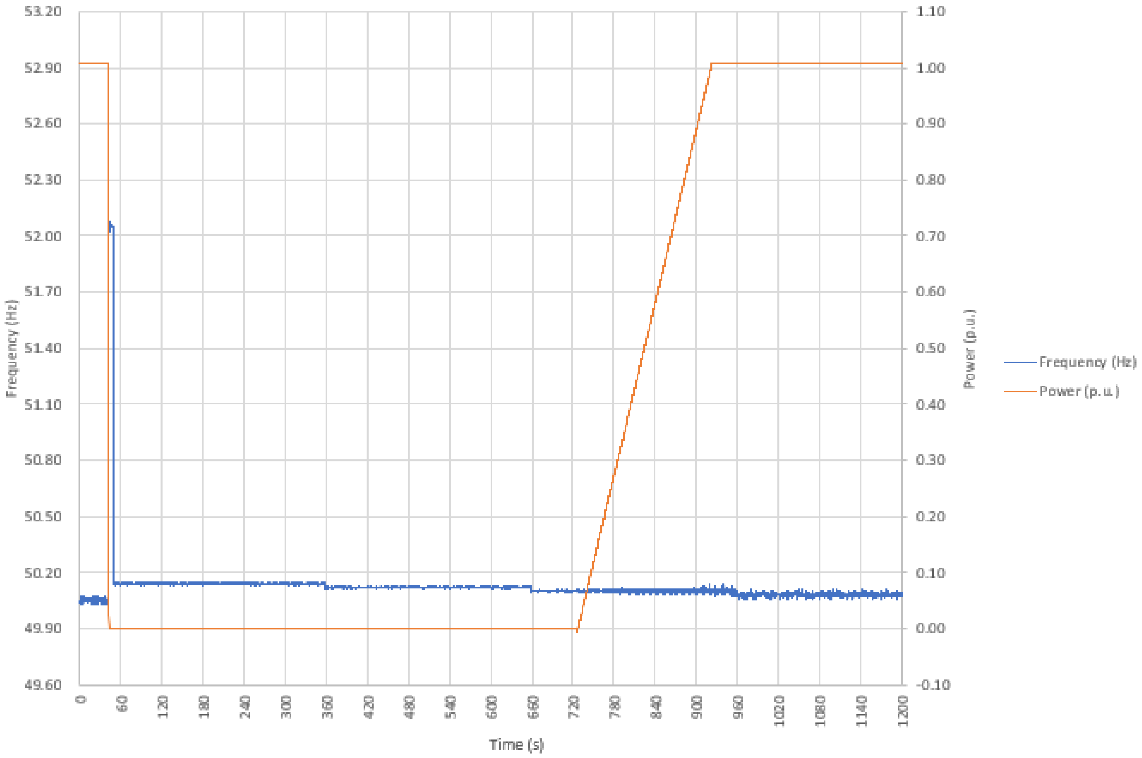
(U > 95% Un)



(f > 49.9 Hz)



(f < 50.1 Hz)


53.20
52.90
52.60
52.30
52.00
51.70
51.40
51.10
50.80
50.50
50.20
49.90
49.60
Frequency (Hz)
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
Power (p.u.)
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960
1020
1080
1140
1200
Time (s)
Frequency (Hz)
Power (p.u.)

4.6 RESPONSE DURING GRID FAULTS

The aim of this test is to determinate whether the EUT is able to detect a voltage dip and to ride through this undamaged. It can be applied to both PV and storage equipment.

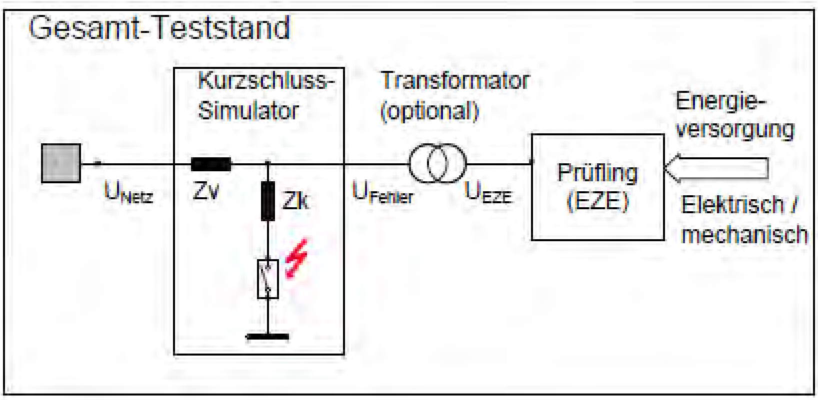
These tests have been done according to point 4.6 of the standard.

The voltage dead band declared by the manufacturer is Un ± 10% Un for all the tests.

The inverter is configurated to limit the current when it reaches 100% In.

The test has been carried out using a short circuit simulator which automatically adjusts the value of the series impedances and shotcircuit impedances in order to obtain the type of fault configurated for each test.

At the electric scheme below it can be seen the connection configuration for the short circuit simulator:



In the page below it is provided a table with the test conditions based on tables 4-68 and 4-69 of the FGW-TG3 standard.

Remaining phase-to-phase voltage [p.u.]	Fault type	Fault duration compliant with (*):		Load	Reactive power Q/Pn	K	Test no.
		AR-N-4110 [ms]	AR-N-4120 AR-N-4130 [ms]				
≤ 0.05	Three phase	Not required	≥ 150 (for U=0) ≥ 318 (for U=0.05)	Full load	0% ± 10 %.	K = 2	0.1
				Partial load			0.2
	Two phase		≥ 220 (for U=0) ≥ 406 (for U=0.05)	Full load			0.3
				Partial load			0.4
0.20 – 0.30	Three phase	≥ 354 (for U=0.2) ≥ 760 (for U=0.3)	≥ 821 (for U=0.2) ≥ 1156 (for U=0.3)	Full load	0% ± 10 %.	K = 2	25.1
				Partial load			25.2
		Optional: Test sequence for multiple faults: Duration: 140 - 160 Pause: 300 - 2000 Duration: 550 - 600 Pause: 20 s - 30 s Duration: 950 - 1050 Pause: 20 s - 30s Duration: 140 - 160 Pause: 300 - 2000 Duration: 950 – 1050		P>0.7Pn			25.3
	Two phase	≥ 452 (for U=0.2) ≥ 915 (for U=0.3)	≥ 962 (for U=0.2) ≥ 1332 (for U=0.3)	Full load			25.4
				Partial load			25.5
0.45 - 0.60	Three phase	≥ 1371(for U=0.45) ≥ 1982 (for U=0.6)	≥ 1659 (for U=0.45) ≥ 2162 (for U=0.6)	Full load	0% ± 10 %.	K = 2	50.1
				Partial load			50.2
	Two phase	≥ 1610 (for U=0.45) ≥ 2305 (for U=0.6)	≥ 1888 (for U=0.45) ≥ 2444 (for U=0.6)	Full load			50.3
				Partial load			50.4
	Three phase	≥ 1371 (for U=0.45) ≥ 1982 (for U=0.6)	-	Full load	0% ± 10 %.	K = 2	50.5
	Two phase	≥ 1610 (for U=0.45) ≥ 2305 (for U=0.6)	-	Full load	0% ± 10 %.	K = 2	50.6
0.70 – 0.80	Three phase	≥ 2389 (for U=0.7) ≥ 2796 (for U=0.8)	≥ 2498 (for U=0.7) ≥ 2833 (for U=0.8)	Full load	0% ± 10 %.	K = 2	75.1
				Partial load	0% ± 10 %.		75.2
					Max.underexcited		75.3
					Max.overexcited		75.4
				(P>0.1Pn)	0% ± 10 %.	K = 4	75.5
	Two phase	≥ 2764 (for U=0.7) ≥ 3000 (for U=0.8)	≥ 2815 (for U=0.7) ≥ 3000 (for U=0.8)	Full load	0% ± 10 %.	K = 2	75.6
				Partial load			75.7
				(P>0.1Pn)		K = 4	75.8
0.75 – 0.85	Three phase	≥ 2593 (for U=0.75) ≥ 3000 (for U=0.85)	-	Full load	0% ± 10 %.	K = 2	80.1
		≥ 3000			≤ 0.1	K = 0	80.2
0.85 – 0.90	Three phase	≥ 60000 s		(P>0.1Pn)	0% ± 10 %.	K = 2	85.1

Remaining phase-to-phase voltage [p.u.]	Fault type	Fault duration compliant with:			Load	Reactive power Q/Pn	K	Test no.
		AR-N-4110 [ms]	AR-N-4120 [ms]	AR-N-4130 [ms]				
Increase by ≥ 0.1 to a value > 1.10	Three phase	≥ 5000			Full load	0% ± 10 %	K = 2	115.1
					Partial Load			115.2
Rise by ≥ 0.1 to a value ≥ 1.10 as largest external vonductor voltage	Two phase	≥ 5000			Full load	0% ± 10 %	K = 2	110.1
					Partial Load			110.2
> 1.10	Three phase	≥ 60000			(P>0.1Pn)	0% ± 10 %	K = 2	110.3
From around 1.05 to ≥ 1.10	Two phase	-	-	≥ 5000	(P>0.1Pn)	0% ± 10 %	K = 4	110.4
From around 1.05 to ≥ 1.10	Three phase	-	-	≥ 5000	(P>0.1Pn)	0% ± 10 %	K = 4	115.1

(*) Only AR-N-4110 and AR-N-4120 have been evaluated in this report.

Apart from test attached in the table above, idle tests have been performed to chech that the equipment is capable of producing te relevant voltage drop or increase with tolerances following the next images:

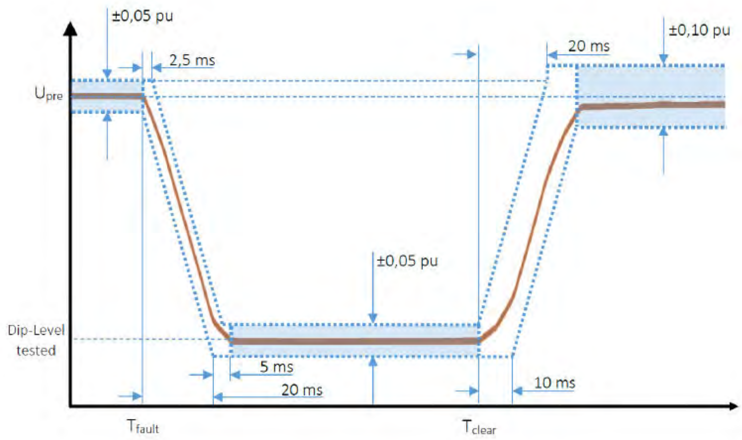


Fig. 4–26: Tolerances for voltage drop tests [2]

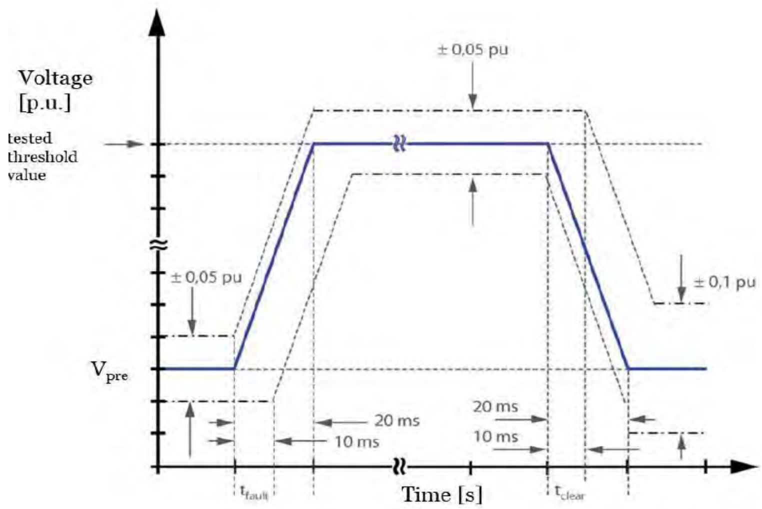


Fig. 4–27: Tolerances for overvoltage tests [2]

For all tests, as stated in the standard, two repetitions have been done and measurements have been taken for 10s before and after the fault. For asymmetric thwo-phase faults, different conductor voltages have been used in different tests as required by FGW TG3 Rev. 25.

Tests 50.5, 50.6 and 80.1 are done to comply with chapter 10.2.3.3.3 of VDE AR-N 4110:2018, where it is required that active and reactive current components shall be 0 A, with a maximum feed-in of apparent current ob 10%In.

The capability of a Type-2 power generating unit to ride through several consecutive voltage dips is deemed to be proven, when the power generating unit is able to dissipate, during these network faults, at least the energy PEmax for a duration of 2 seconds without taking into account the energy fed into the network. This has been verified by testing optional test 25.3, where multiple faults are tested in sequence.

As required by the standard, power generating systems must be capable of feeding a reactive current of 100% of the design current in each conductor. Regarding this, it has to be cheched that the following requirement is fulfilled:

$$|I_{B1}| + |I_{B2}| \geq I_r$$

I_{B1} – Positive sequence reactive current

I_{B1} – Negative sequence reactive current

I_r – Rated current of the PGU

For compliance with VDE AR-N 4110:2018 and VDE AR-N 4120:2018, it has been checked that limits for rise time and settling time for both positive and negative sequence of the reactive current comply with:

$T_{Rise\ Time} \leq 30$ ms
$T_{Settling\ Time} \leq 60$ ms

Tolerance bands for reactive current is included in the graph below:

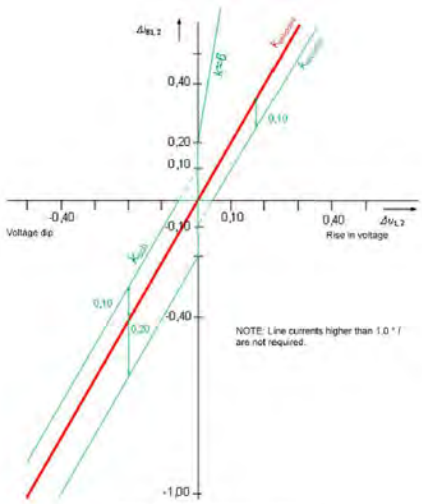


Figure C.1 – Tolerance range for ΔI_B

For drops in voltage below 15%Un, rise time and settling time of reactive current is not required, and reactive current value measurement are substituted with apparent current value of positive sequence measurements.

Result tables and graphs have been included in **Attachment 1** -2219 / 0373-Att1 Rev0 of this report.

4.7 VERIFICATION OF THE WORKING RANGE WITH REGARD TO VOLTAGE AND FREQUENCY

This test has been done according to chapter 4.7 of the standard in order to verify operation times of the EUT across the complete voltage and frequency range.

The test consists on verification of operation time at different measurement points. The test starts at rated values and then it goes through the measurements points with a gradient of maximum 5% Un / min or 0.5% fn / min. In case both frequency and voltage have to change to a different setpoint, voltage changes first and then frequency, as stated in the standard. During the test, power feed-in of the EUT is set over 80%Pn.

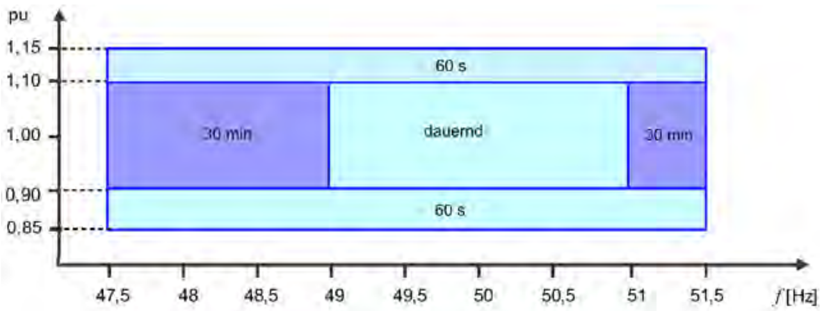
Measurement points included in the standard are:

- Measurement point 1: U=1.15 p.u., f=47.5 Hz recording period at least 60 s from reaching the measurement points.
- Measurement point 2: U=0.85 p.u., f=51.5 Hz recording period at least 60 s from reaching the measurement points.
- Measurement point 3: U=1.10 p.u., f=51.0 Hz recording period at least 60 min from reaching the measurement points.
- Measurement point 4: U=0.90 p.u., f=49.0 Hz recording period at least 60 min from reaching the measurement points.
- Measurement point 5: U=0.90 p.u., f=47.5 Hz recording period at least 30 min from reaching the measurement points.
- Measurement point 6: U=1.09 p.u., f=51.5 Hz recording period at least 30 min from reaching the measurement points.

For each measurement point the 200 ms average values of the phase conductor voltages, the frequency as well as the active power habe been presented graphically.

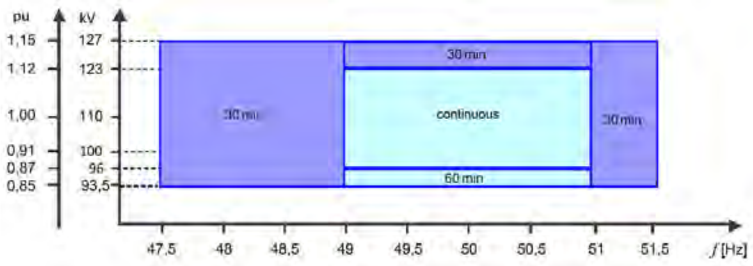
(For VDE 4110)

These measurement points are used to verify chapters 10.2.1.2 and 11.2.3.1 of VDE AR-N 4110:2018 as, they require compliance with the following figure:



(For VDE 4120)

Additional measurement points have been included to cover chapters 10.2.1.2 and 11.2.3.1 of VDE AR-N 4120:2018, which require compliance with the following figure:



Measurement device	Date of measurement	Recording	Sampling frequency
WT3000	2019/11/21 to 2019/11/23 and 2020/01/21	100 ms values or 200 ms values	3 kHz

The following tables show the results of the tests performed:

Measurement Point 1		**Over Voltage + Under Frequency**			
Voltage	**Frequency**	**Active Power Desired (p.u)**	**Active Power measured**	**Minimum Operation Time**	**Time measured**
90%Un	**47.0Hz**	> 80.0%Pn	100.8%	60 seconds	180s
Disconnection		☐ NO ☐ YES			

Measurement Point 2		**Under Voltage + Over Frequency**			
Voltage	**Frequency**	**Active Power Desired (p.u)**	**Active Power measured**	**Minimum Operation Time**	**Time measured**
85%Un	**51.5Hz**	> 80.0%Pn	94.5% (*)	60 seconds	180s
Disconnection		☐ NO ☐ YES			

Measurement Point 3		**Over Voltage + Over Frequency**			
Voltage	**Frequency**	**Active Power Desired (p.u)**	**Active Power measured**	**Minimum Operation Time**	**Time measured**
110%Un	**51.0Hz**	> 80.0%Pn	100.0%	60 minutes	61 minutes
Disconnection		☐ NO ☐ YES			

Measurement Point 4		**Under Voltage + Under Frequency**			
Voltage	**Frequency**	**Active Power Desired (p.u)**	**Active Power measured**	**Minimum Operation Time**	**Time measured**
90%Un	**49.0Hz**	> 80.0%Pn	100.0% Pn	60 minutes	61 minutes
Disconnection		☐ NO ☐ YES			

Measurement Point 5		**Under Voltage + Under Frequency**			
Voltage	**Frequency**	**Active Power Desired (p.u)**	**Active Power measured**	**Minimum Operation Time**	**Time measured**
90%Un	**47.5Hz**	> 80.0%Pn	100.0% Pn	30 minutes	31 minutes
Disconnection		☐ NO ☐ YES			

Measurement Point 6		**Over Voltage + Over Frequency**			
Voltage	**Frequency**	**Active Power Desired (p.u)**	**Active Power measured**	**Minimum Operation Time**	**Time measured**
109%Un	**51.5Hz**	> 80.0%Pn	100.0% Pn	30 minutes	31 minutes
Disconnection		☐ NO ☐ YES			

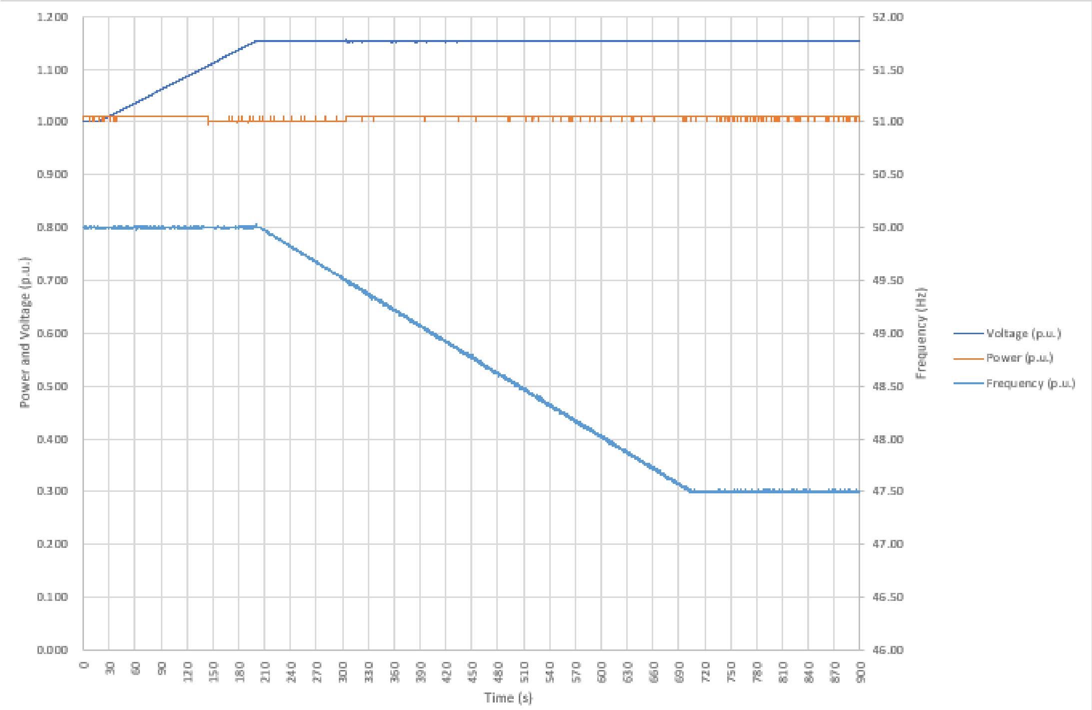
(*) Unit doesn’t reach 100% power due to the current limitation.

The following table shows the gradients obtained between measurement points:

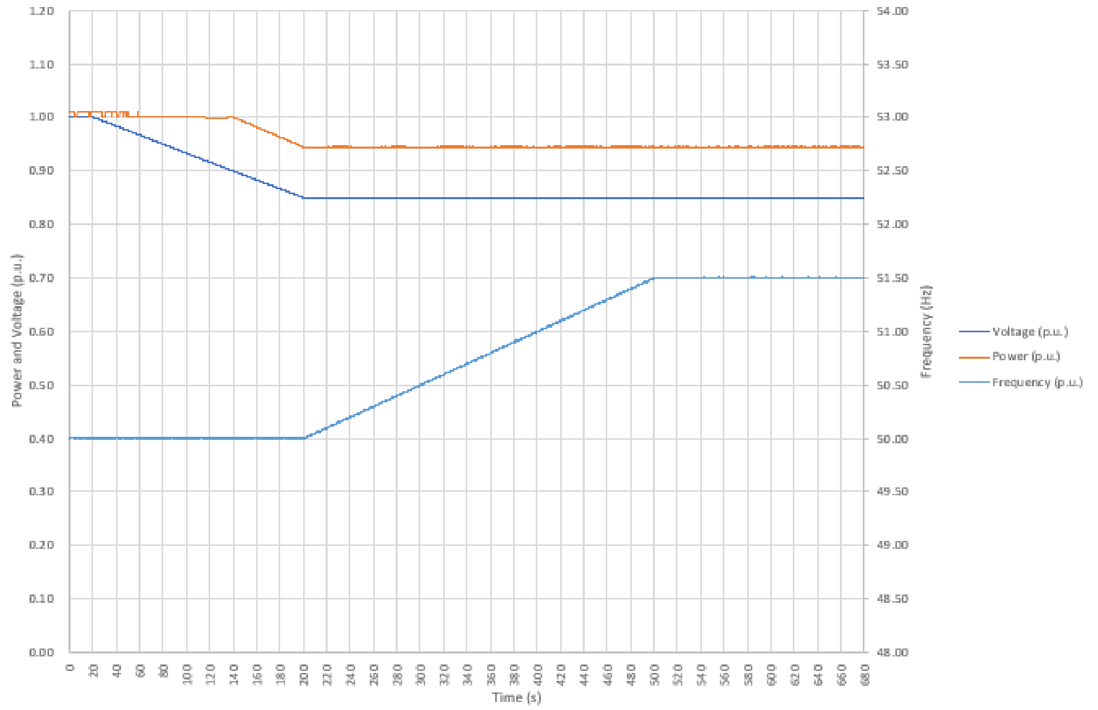
Measurement Points	Voltage Gradient Required (%U_n/min)	Voltage Gradient Measured (%U_n/min)	Frequency Gradient Required (%f_n/min)	Frequency Gradient Measured (%f_n/min)
Point 1	< 5	5.0	< 0.5	0.5
Point 2	< 5	5.0	< 0.5	0.5
Point 3	< 5	5.0	< 0.5	0.5
Point 4	< 5	3.9	< 0.5	0.4
Point 5	< 5	4.0	< 0.5	0.4
Point 6	< 5	4.0	< 0.5	0.4

Verification of the Working Range

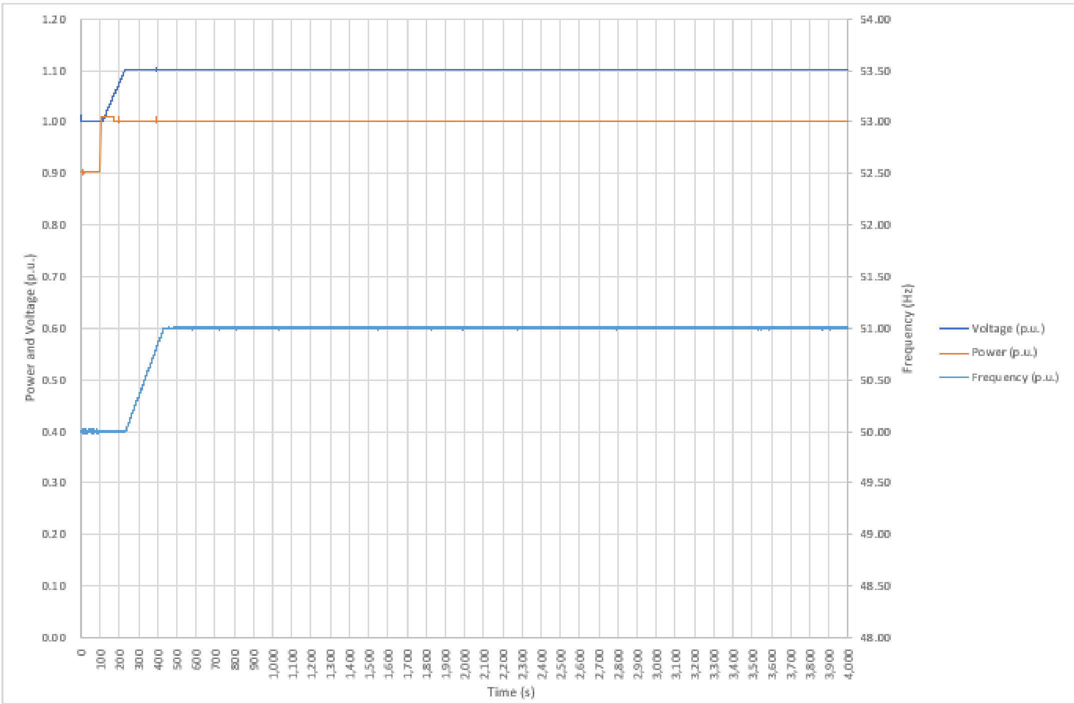
Points 1



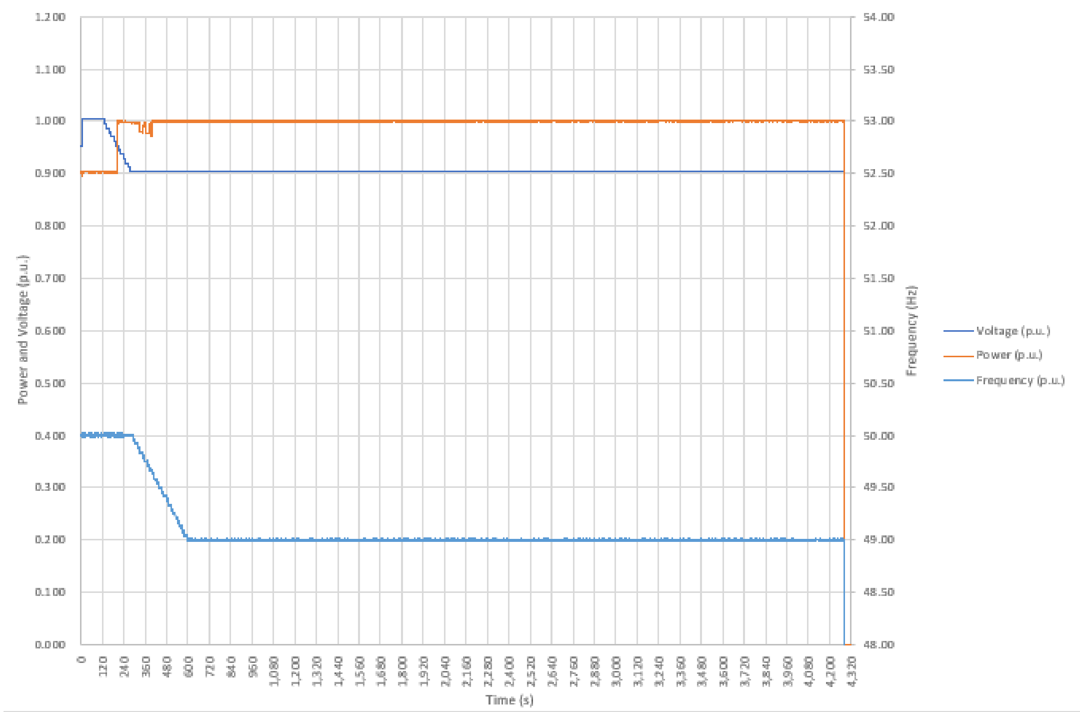
Points 2



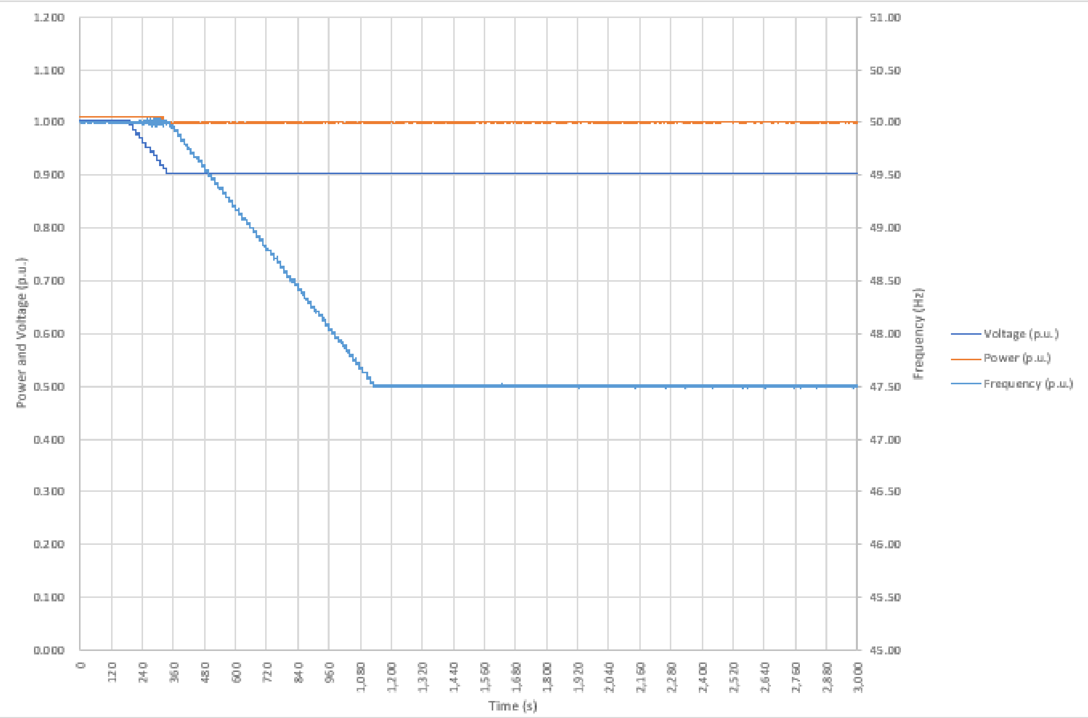
Points 3



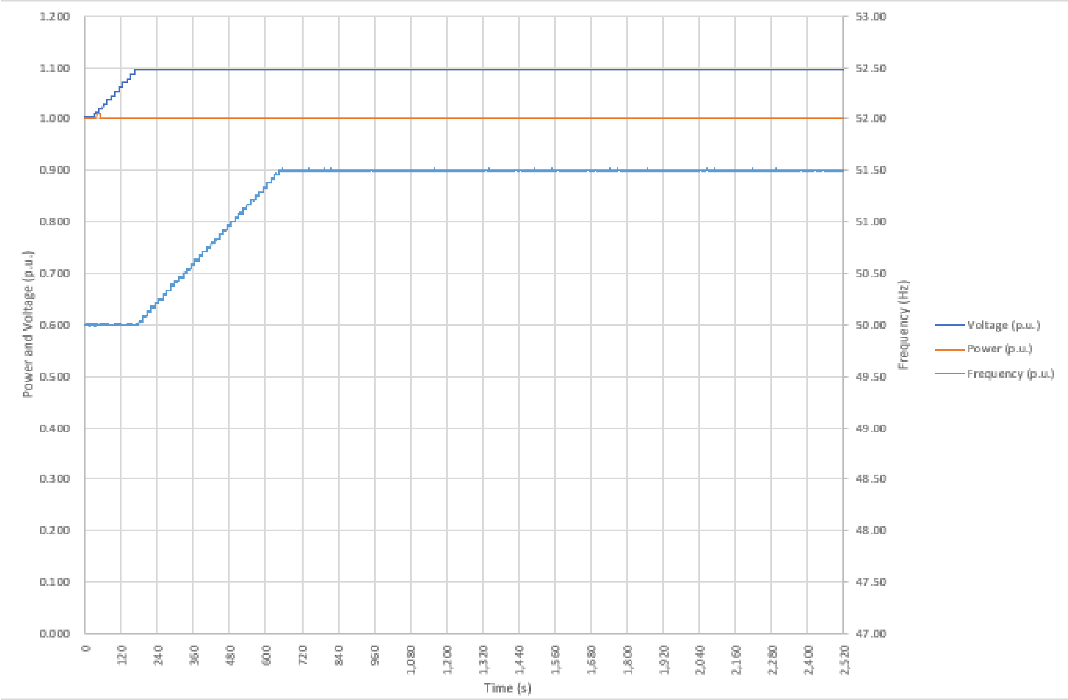
Points 4



Points 5



Points 6



1.200
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Power and Voltage (p.u.)
53.00
52.50
52.00
51.50
51.00
50.50
50.00
49.50
49.00
48.50
48.00
47.50
47.00
Frequency (Hz)
0
120
240
360
480
600
720
840
960
1,080
1,200
1,320
1,440
1,560
1,680
1,800
1,920
2,040
2,160
2,280
2,400
2,520
Time (s)
Voltage (p.u.)
Power (p.u.)
Frequency (p.u.)

5 PICTURES

Overview

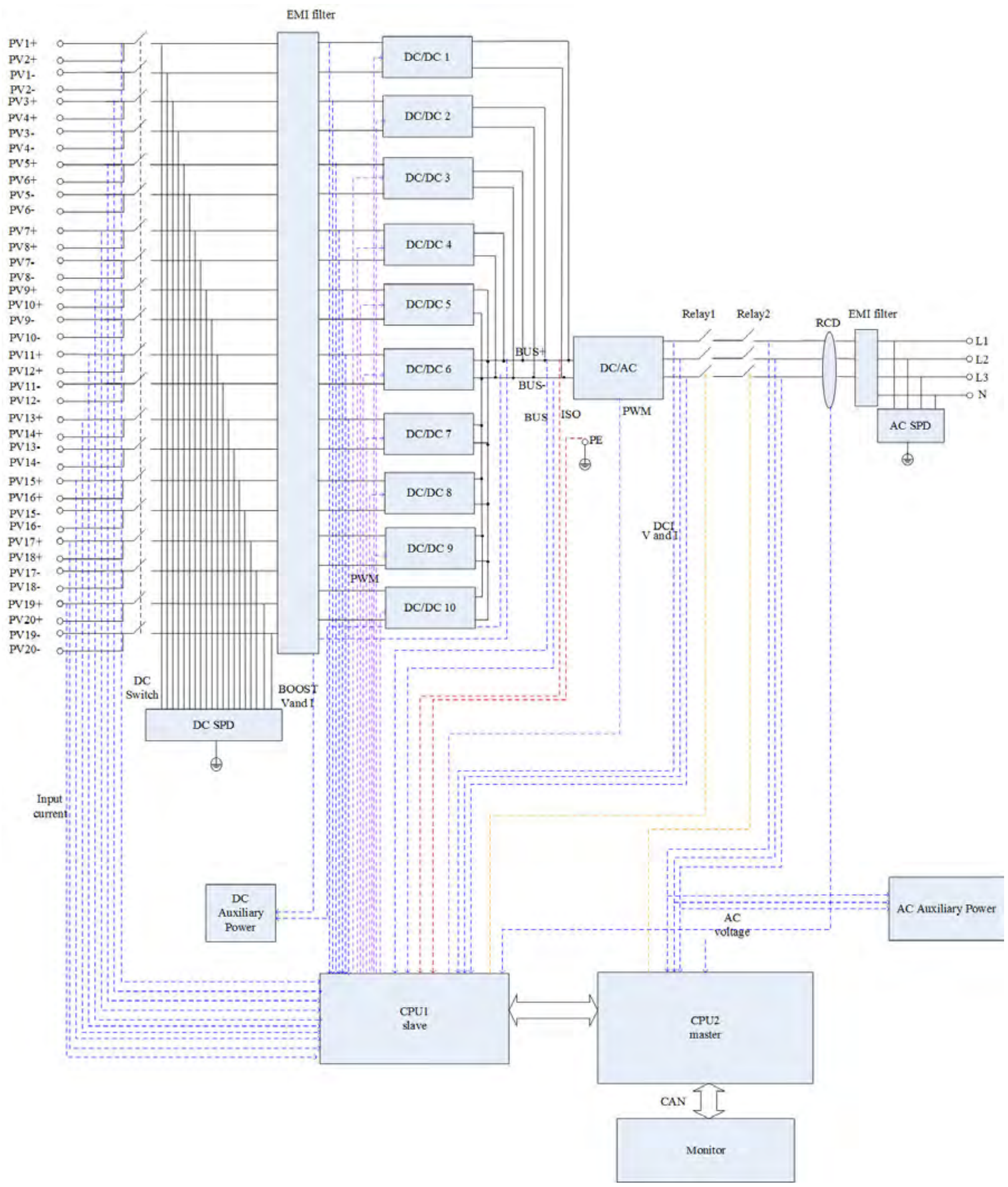
Front View

Connection Side


Serial Number and Software Version

No.	Signal Name	Value
1	Model	SUN2000-100KTL-M1
2	SN	6T19A9066325
3	PN	01074695-001
4	Software version	V500R001

6 ELECTRICAL SCHEMES

Equipment under testing


ANNEX TO THE CERTIFICATE

2619/0373-E1-CER

Important Note :

- This document is issued by the Company under its General Conditions of service accessible at http://www.sgs.com/terms_and_conditions.htm. Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.
- Any unauthorized alteration, forgery or falsification of the content or appearance of this document is unlawful, and offenders may be prosecuted to the fullest extent of the law.
- Unless otherwise stated the results shown in this document refer only to the sample(s) tested as received. The Company SGS shall not be liable for any incorrect results arising from unclear, erroneous, incomplete, misleading or false information provided by Client. This document cannot be reproduced except in full, without prior approval of the Company.

Document Historical Revision:

Document Version	Date	Resume
Revision 0	27/03/2020	First issuance
Revision 1	09/10/2020	Modified to add detail of new evaluations of compliance according to updated reports for FGW TG3 and FGW TG4. Further editorial changes are added after new manufacturer declaration is updated in 08/10/2020.

This document is created based on requirments of FGW Technical Guidelines for Power Generating Units, Systems and Storage Systems as well as for their Components.
Part 8 (TG8). Certification of the Electrical Characteristics of Power Generating Units, Systems and Storage Systems as well as their Components on the Grid.
Revision 09. Dated 01/02/2019.

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

INDEX

1 OVERVIEW OF THE FGW TR8 EVALUATION REPORT

This point of this annex of the certificate no. 2619 / 0373 – E1 – CER contains the information of all items and documentation used for the evaluation of compliance of the certified product according to standards VDE-AR-N 4110: 2018-11, VDE-AR-N 4120:2018-11, FGW-Richlinie TR 3 Rev. 25 (including supplement 1, dated on 22/01/2019) and FGW-Richlinie TR 4 Rev. 9.

The information contained in this point is extracted from the SGS Evaluation Report Number: 2619 / 0373, rev1. With date on 09-10-2020 according of FGW TR8 rev. 9.

The evaluation performed by SGS comprises the checking in compliance with following requirements:

Evaluation:	Remarks	Result		
Keys: P……………………………………..Pass. NC…………………………………….Not Comply NA…………………………………….Not Applicable				
Checking of the PGU tested	**See point 1.1 of this document**	☒ P	☐ NC	☐ NA
Checking of the variant models to be included in the certification process	**See point 1.1 of this document**	☒ P	☐ NC	☐ N/A
Review Test Report according FGW TG3 per VDE-AR-N 4110: 2018 certification	**See point 1.3 of this document**	☒ P	☐ NC	☐ NA
Review Test Report according FGW TG3 per VDE-AR-N 4120: 2018 certification	**See point 1.3 of this document**	☒ P	☐ NC	☐ NA
Review Test Report according FGW TG4.	**See point 1.4 of this document**	☒ P	☐ NC	☐ NA
Quality system certificate according ISO 9001	**See point 1.5 of this document**	☒ P	☐ NC	☐ NA
Compromise letter of maintain ISO 9001 certified during the validity period of VDE certificate.	**See point 1.6 of this document**	☒ P	☐ NC	☐ NA
Compromise letter of product to certify is the same that the product tested, and transferability acceptance of non-tested PGU.	**See point 1.7 of this document**	☒ P	☐ NC	☐ NA

1.1 Information about the tested model.

Information appearing in the application form (CPR1FRM5):

- **Date of the application form:** 17/03/2020
- **Applicant:** Huawei Technologies Co., Ltd.
- **License holder:** Huawei Technologies Co., Ltd.
- **Factories:**
  1. **Huawei Machine Co., Ltd**
     Address: NO.2 New City avenue Song Shan Hu Science & Technology Industry Park, Dongguan, Guangdong, 523808, China.
  2. **Shenzhen Fugui Precision Industry CO., Ltd.**
     Address: NWE product Division Building B4, D10, Foxconn Science and Technology Industrial Park, East Side of Min Qing Road. Longhua District Shenzhen. Guangdong, 518109, China.
- **Product:**
  - Type: PV inverter
  - Trademark: Huawei
  - Base model: SUN2000-100KTL-M1
  - Input ratings: 1100 Vdc,max (200-1000 Vdc,MPPT); 10*26 Adc Max
  - Output ratings: 3~ 380/400/480Vac; 50 Hz;
    380V: 168,8Aac Max, 100kW (110kVA Max),
    400V: 160,4Aac Max, 100kW (110kVA Max),
    480V: 133,7Aac Max, 100kW (110kVA Max),
  - Software Version: V500R001
  - Variant models: SUN2000-100KTL-INM0

Information appearing in the test report according to FGW TG3:

- **Manufacturer:** Huawei Technologies Co., Ltd
- **Product:**
  - Type: PV inverter
  - Trademark: Huawei
  - Base model: SUN2000-100KTL-M1
  - Input ratings: 1100 Vdc,max (200-1000 Vdc,MPPT); 10*26 Adc Max
  - Output ratings: 3~ 380/400/480Vac; 50 Hz;
    380V: 152,0Aac, 168,8Aac Max, 100kW (110kVA Max),
    400V: 144,4Aac, 160,4Aac Max, 100kW (110kVA Max),
    480V: 120,3Aac, 133,7Aac Max, 100kW (110kVA Max),
  - Software Version: V500R001
  - Variant models: SUN2000-100KTL-INM0

Revision 1 dated 09th October 2020.

The manufacturer provides a new application form dated on 29/09/2020 requesting to modify the certificate in order to add into its scope the rating of the maximum apparent power of the previously certified PV inverter.
New tests have been repeated in the certified unit to verify these maximum power capabilities. Some other tests concerned with the TG3 test report have also been repeated to verify capabilities declared by the manufacturer.

The manufacturer assures in the application form that the unit has not been varied in hardware, nor firmware since tests performed for the original certification, so not repeated tests are still valid.

Concerned with the FGW TG4 report, new simulations have been added to verify the dynamic of P and Q adjustments by setpoint after requested by the manufacturer.

In addition, the manufacturer has asked to update the annex of the certification after some comments received from plant certifiers requesting of further in the documentation annexed to the certificate. For this reason, a new manufacturer declaration related with the certified product has been provided.

Information appearing in the application form (CPR1FRM5):

- **Date of the application form:** 29/09/2020
- **Applicant:** Huawei Technologies Co., Ltd.
- **License holder:** Huawei Technologies Co., Ltd.
- **Factories:**
  1. **Huawei Machine Co., Ltd**
     Address: NO.2 New City avenue Song Shan Hu Science & Technology Industry Park, Dongguan, Guangdong, 523808, China.
  2. **Shenzhen Fugui Precision Industry CO., Ltd.**
     Address: NWE product Division Building B4, D10, Foxconn Science and Technology Industrial Park, East Side of Min Qing Road. Longhua District Shenzhen. Guangdong, 518109, China.
- **Product:**
  - Type: PV inverter
  - Trademark: Huawei
  - Base model: SUN2000-100KTL-M1
  - Input ratings: 1100 Vdc,max (200-1000 Vdc,MPPT); 10*26 Adc Max
  - Output ratings: 3~ 380/400/480Vac; 50 Hz;
    380V: 168,8Aac Max, 100kW (110kVA Max),
    400V: 160,4Aac Max, 100kW (110kVA Max),
    480V: 133,7Aac Max, 100kW (110kVA Max),
  - Software Version: V500R001
  - Variant models: SUN2000-100KTL-INM0

Information appearing in the test report according to FGW TG3:
- **Manufacturer:** Huawei Technologies Co., Ltd
- **Product:**
  - Type: PV inverter
  - Trademark: Huawei
  - Base model: SUN2000-100KTL-M1
  - Input ratings: 1100 Vdc,max (200-1000 Vdc,MPPT); 10*26 Adc Max
  - Output ratings: 3~ 380/400/480Vac; 50 Hz;
    380V: 152,0Aac, 168,8Aac Max, 100kW (110kVA Max),
    400V: 144,4Aac, 160,4Aac Max, 100kW (110kVA Max),
    480V: 120,3Aac, 133,7Aac Max, 100kW (110kVA Max),
  - Software Version: V500R001
  - Variant models: SUN2000-100KTL-INM0

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

1.2 Information about variant models to be included into the scope of the certification process.

Taking as reference the article 2.12.2 of the standard FGW TG8, revision 9, test results can be transferred from test reports to non-tested units taking into account following items:

a) The design and the control engineering critical to the electrical characteristics including the software used are equivalent in both PGUs from a technical perspective.
b) The test results for the smallest and the largest power version are available or alternatively the rated power of the power generation unit to be certified is between 1/√10 times and twice (for Type 2 systems) of the rated power of the power generation unit to be measured.

- **Information of the base model:**
  - Brand name base model: SUN2000-100KTL-M1
  - Rated output power base model: 100 kW
  - Firmware version base model: V500R001

After the characteristic given for the tested unit (s), test results can be transferred to other non-tested units of complying with the previously mentioned clause a), having output active power comprised between:

- Lower limit: 31,63 kW (1/√10 x Base model's Rated output power), and
- Upper limit: 200 kW (2 x Base model's Rated output power)

- **Information of the variant models:**
  - Brand name base model: SUN2000-100KTL-INM0
  - Rated output power base model [kW]: 100 kW
  - Firmware version base model: V500R001
  - Note: the variant model just has different voltages. So, the output current is different. But the design and the control engineering critical to the electrical characteristics including the software used are equivalent in both PGUs from a technical perspective.

Full characteristics of models to add in the certification are:

Models	**SUN2000-100KTL-M1**	**SUN2000-100KTL-INM0**
DC		
Input MPPT voltage range	200-1000 V	
Max. input voltage, open circuit	1100 V	
Max. input operating current	(10x) 26 A	
AC		
Maximum output apparent power	110 kVA	
Maximum output real power	100 kW	
Nominal output voltage	380/400 V (3 Ph / N / PE) 480 V (3 Ph / PE)	400/415 V (3 Ph / N / PE) 480 (3 Ph / PE)
Nominal frequency	50 Hz	
Rated output current with PF=1	152.0 A (380 V) 144.4 A (400 V) 120.3 A (480 V)	144.4 A (400 V) 139.2 A (415 V) 120.3 A (480 V)
Maximum output current	168.8 A (380 V) 160.4 A (400 V) 133.7 A (480 V)	160.4 A (400 V) 154.6 A (415 V) 133.7 A (480 V)

1.3 Summary of the evaluation of the test results

The following documentation is used for the evaluation:

Information of the test report:

- Test report number: 2219 / 0373 – E1
- Issuance date: 09/10/2020.
- Testing laboratory: SGS Tecnos, S.A. (Electrical Testing Laboratory).
- Accreditation number of the laboratory: Nº 5/LE011.

Information of the manufacturer declaration:

- Document reference name: Manufacturer's declaration for compliance to technical requirements of the VDE-AR-N 4110:2018-11 / VDE-AR-N 4120:2018-11 for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0.
- Issuance date: 08/10/2020.
- Issued by: HUAWEI TECHNOLOGIES CO.,LTD.

<table>
<tr><th>FGW TG8</th><th colspan="4">Title</th><th>Result</th></tr>
<tr><td>A.1.2.1
A.2.2.1</td><td colspan="4">Physical part</td><td>--</td></tr>
<tr><td rowspan="2">A.1.2.1.1
A.2.2.1.1</td><td colspan="4">Dimensioning of the equipment at the substation</td><td>--</td></tr>
<tr><td colspan="4">Not applicable to PGU</td><td>NA</td></tr>
<tr><td>A.1.2.2
A.2.2.2</td><td colspan="4">Operating range</td><td>P</td></tr>
<tr><td>A.1.2.2.1
A.2.2.2.1</td><td colspan="4">Quasi-steady-state operation</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.2.1.1
A.2.2.2.1.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.2.1.2</td><td>11.2.3.1
11.2.4
11.2.5.5</td><td>TG3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.2.1.2</td><td>11.2.3.1
11.2.4
11.2.5.4</td><td>TG3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td colspan="4">
<u>Evaluated documentation:</u>

- **Manufacturer declaration:**
“Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 8th, 2020.
Compliance is evidenced by the information declared by the manufacturer in the point 2 of this manufacturer declaration. Among others, main points detailed by the manufacturer are:
“The entire power generating unit, respectively, including all its associated parts, has been designed for the frequency and voltage ranges of quasi-steady-state operation defined in VDE-AR-N 4120:2018-11 Figure 4.”

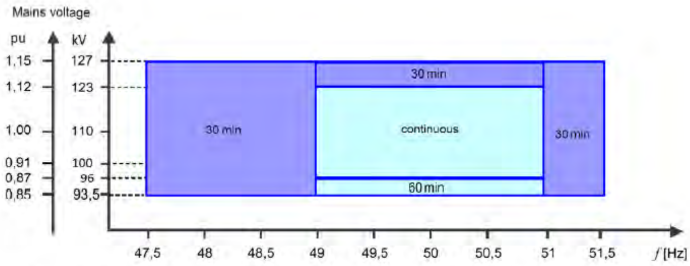
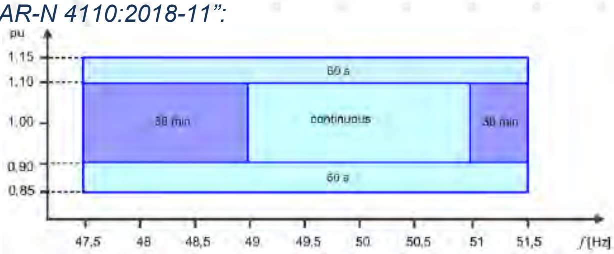


Figure 4 – Minimum requirements for the quasi-static operation of power generating plants

“ For VDE-AR-N 4110:2018-11”:



*“At 0% power setpoint the PGU stays connected without power feeding.
The PGU can be disconnected from grid using the Start/Stop control (gOD51_CrlCmd_0).”*

In addition, the annex 4 of this manufacturer declaration contains details of the capability of the PGU as a voltage-time characteristic curve.

- **Test Report:**
Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020.
Compliance is evidenced by test results provided in points 4.2.1.5 and 4.7 of this test report.
</td></tr>
</table>

FGW TG8	Title				Result
A.1.2.2 **A.2.2.2**	**Operating range**				**P**
A.1.2.2.2 **A.2.2.2.2**	**Polar wheel and/or grid oscillation**				--
A.1.2.2.2.1 **A.2.2.2.2.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**NA**
	10.2.1.3	11.2.3.2 11.2.3.3	--	☐ Manufacturer's declaration	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	10.2.1.3	11.2.3.2 11.2.3.3	--	☐ Manufacturer's declaration	
	Remarks: For Type 2 PGU no proof of polar wheel oscillations is required.				

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

FGW TG8	Title				Result
A.1.2.3 **A.2.2.3**	**System perturbations**				**P**
A.1.2.3.1 **A.2.2.3.1**	**Rapid voltage variations**				--
A.1.2.3.1.1 **A.2.2.3.1.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**P**
	5.4.2	11.2.2.1	TG3	☒ Test report	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	5.4.2	11.2.2.1	TG3	☒ Test report	
	Evaluated documentation: - **Test Report:** Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020. Compliance is evidenced by test results provided in the point 4.3.1 of this test report.				
A.1.2.3.2 **A.2.2.3.2.**	**Flicker**				--
A.1.2.3.2.1 **A.2.2.3.2.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**P**
	5.4.3	11.2.2.2	TG3	☒ Test report	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	5.4.3	11.2.2.2	TG3	☒ Test report	
	Evaluated documentation: - **Test Report:** Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020. Compliance is evidenced by test results provided in the point 4.3.2 of this test report.				
A.1.2.3.3 **A.2.2.3.3**	**Harmonics and Interharmonics**				--
A.1.2.3.3.1 **A.2.2.3.3.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**P**
	5.4.4	11.2.2.3	TG3	☒ Test report	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	5.4.4	11.2.2.3	TG3	☒ Test report	
	Evaluated documentation: - **Test Report:** Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020. Compliance is evidenced by test results provided in the points 4.3.3.1 to 4.3.3.4 of this test report.				
A.1.2.3.4 **A.2.2.3.4**	**Commutation notches**				--
A.1.2.3.4.1 **A.2.2.3.4.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**NA**
	5.4.5	11.2.2.4	TG3	☐ Test report	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	5.4.5	11.2.2.4	TG3	☐ Test report	
	Remarks: Evidence only for converters with thyristors which use short-circuit current coming from the grid for commutation of the thyristors. The certified PV inverter doesn't have thyristors which use short-circuit current coming from the grid for commutation of the thyristors.				

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

<table>
<tr><th>FGW TG8</th><th colspan="4">Title</th><th>Result</th></tr>
<tr><td>A.1.2.3
A.2.2.3</td><td colspan="4">System perturbations</td><td>P</td></tr>
<tr><td>A.1.2.3.5
A.2.2.3.5</td><td colspan="4">Asymmetries</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.3.5.1
A.2.2.3.5.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>5.4.6</td><td>11.2.2.5</td><td>TG3</td><td>☒ Test report</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>5.4.6</td><td>11.2.2.5</td><td>TG3</td><td>☒ Test report</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Test Report:
Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020.
Compliance is evidenced by test results provided in the point 4.3.4 of this test report.</td></tr>
<tr><td rowspan="2">A.1.2.3.6
A.2.2.3.6</td><td colspan="4">Audio frequency ripple control</td><td>--</td></tr>
<tr><td colspan="4">Not applicable to PGU</td><td>NA</td></tr>
<tr><td rowspan="2">A.1.2.3.7
A.2.2.3.7</td><td colspan="4">Carrier frequency use of the customer grid</td><td>--</td></tr>
<tr><td colspan="4">Not applicable to PGU</td><td>NA</td></tr>
<tr><td>A.1.2.4
A.2.2.4</td><td colspan="4">Reactive power</td><td>P</td></tr>
<tr><td>A.1.2.4.1
A.2.2.4.1</td><td colspan="4">Reactive power provision</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.4.1.1
A.2.2.4.1.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.2.2.1 to 10.2.2.3</td><td>11.2.4</td><td>TG3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.2.2.1 to 10.2.2.3</td><td>11.2.4</td><td>TG3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Manufacturer declaration:
“Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 8th, 2020.
Compliance is evidenced by the information declared by the manufacturer in point 3 of this manufacturer declaration. Among others, main points detailed by the manufacturer are:
“The power provision is limited by the maximum apparent current and maximum apparent / active power provides 10,0%Pn overload capacity.”
“The reactive power is prioritised versus the active power.”
“A maximum reactive power provision of 60%Smax (using Q set-point) or cosφ = 0,8 (using cosφ set-point) is possible.”
“At overvoltage the apparent / active power threshold limit the injected power. At undervoltage the apparent current limitation will also contribute.”
“The continuous provision is possible within the voltage corridor 80%Un through 120%Un and the frequency range between 47,5 and 52,0 Hz.”
“A permanent active power reduction can be applied by setting parameters Plimilt and Pmaxref (the following applies: Plimilt ≤ Pmaxref ≤ Pmax. Default: Plimilt = Pmaxref = Pmax.)”
“The value of Plimilt will then be the new active power limitation which will not be exceeded during operation of the PGU, while Pmaxref will be the new reference for the P set-point control. Any signal for a setpoint of 100%Pmaxref, by the ripple control receiver or other P-parameter setpoint, causes the PGU to inject the new lower Pmax-value (active power higher than new lower Pmax-value will never be injected). The reference power for percentage or p.u. in this limited mode is the new lower Pmaxref-value.”
- Test Report:
Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020.
Compliance is evidenced by test results provided in points 4.2.1.1, 4.2.1.5, 4.2.2 and 4.2.4 of this test report.</td></tr>
</table>

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

FGW TG8	Title				Result
A.1.2.4 **A.2.2.4**	**Reactive power**				**P**
A.1.2.4.2 **A.2.2.4.2**	**Procedure for reactive power provision**				--
A.1.2.4.2.1 **A.2.2.4.2.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**P**
	10.2.2.4	--	TG3	☒ Manufacturer's declaration ☒ Test report	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	10.2.2.4	--	TG3	☒ Manufacturer's declaration ☒ Test report	

Evaluated documentation:

- **Manufacturer declaration:**
  "Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0". Dated on October 8th, 2020.
  Compliance is evidenced by the information declared by the manufacturer in point 3 of this manufacturer declaration. Among others, main points detailed by the manufacturer are:

  "The following reactive power control functions are implemented on the PGU level:
  a) Settable Q-parameter (range: +/- 60%Pmax)
  b) Settable cosφ-set-parameter (range: +/- 0,8)
  c) Configurable Q(U)-characteristic line (No. of supporting points: 10)
  d) Configurable Q(P)-characteristic line (No. of supporting points: 10)

  Under the country code setting VDE-AR-N 4110, for a Q step response the following control functions implemented on the PGU level:
  1) cosφ setpoint
  2) Q(P)
  3) Q(U)
  These funtions show a PT1 behavour;

  Under the country code setting VDE-AR-N 4120, for a Q step response the following control functions implemented on the PGU level:
  1) Q(P)
  2) Q(U)
  These funtions show a PT1 behavour;

  The required response time and settling time of the reactive power control can be provided by corresponding setting of the time constant parameter (for details see the points 4.2 and 4.4 of this document).

  "In the event the communication with the PGS controller is disturbed, the PGU will remain in operation with the last setpoint value."

- **Test Report:**
  Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020.

FGW TG8	Title				Result
A.1.2.5 **A.2.2.5**	**Active power**				**P**
A.1.2.5.1 **A.2.2.5.1**	**General information and grid safety management**				**--**
A.1.2.5.1.1 **A.2.2.5.1.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**P**
	10.2.4.1 and 10.2.4.2	11.2.7	TG3	☒ Manufacturer's declaration ☒ Test report	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	10.2.4.1 and 10.2.4.2	11.2.7	TG3	☒ Manufacturer's declaration ☒ Test report	
	Evaluated documentation: - **Manufacturer declaration:** "Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0". Dated on October 8th, 2020. Compliance is evidenced by the information declared by the manufacturer in point 4 of this manufacturer declaration. Among others, main points detailed by the manufacturer are: *"The active gradient method is implemented on the PGU level. (for details see the points 4.2 and 4.4 of this document).".* *"The active power output of the PGU is dependent on the ambient temperature."* - **Test Report:** Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020. Compliance is evidenced by test results provided in points 4.1.1 and 4.1.2.1 of this test report.				

<table>
<tr><th>FGW TG8</th><th colspan="4">Title</th><th>Result</th></tr>
<tr><td>A.1.2.5
A.2.2.5</td><td colspan="4">Active power</td><td>P</td></tr>
<tr><td>A.1.2.5.2
A.2.2.5.2</td><td colspan="4">Active power output as a function of grid frequency</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.5.2.1
A.2.2.5.2.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.2.4.3</td><td>11.2.8</td><td>TG3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.2.4.3</td><td>11.2.8</td><td>TG3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Manufacturer declaration:
“Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 8th, 2020.
Compliance is evidenced by the information declared by the manufacturer in point 5 of this manufacturer declaration. Among others, main points detailed by the manufacturer are:
“The min. active power in case of overfrequency derating can be limited using parameter Cutoff power of overfrequency derating. The PGU can be operated by a active power setpoint of 0.”
“The initial time delay of the frequency-dependent active power variation is defined as 0 ms.”
“The PGU can remain in operation in case that the grid frequency increases above fStop> but not triggered by the grid protection or self-protection, in this case the active power will be kept at the power level defined by parameter Cutoff power of overfrequency derating.”
“In the range between 50 Hz and the curve in Figure 17 (Figure 14 in VDE-AR-N 4120:2018-11), PGUs do not reduce their active power”.
“The PGU can remain in operation at the grid frequency above 51,5 Hz if not interfered by the grid protection setting.”
- Test Report:
Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020.
Compliance is evidenced by test results provided in points 4.1.2 and 4.1.3 of this test report.</td></tr>
</table>

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

<table>
<tr><th>FGW TG8</th><th colspan="4">Title</th><th>Result</th></tr>
<tr><td>A.1.2.6
A.2.2.6</td><td colspan="4">Connection</td><td>--</td></tr>
<tr><td>A.1.2.6.1</td><td colspan="4">Black start capability</td><td>--</td></tr>
<tr><td>A.2.2.6.1</td><td colspan="4">Not applicable to PGU</td><td>NA</td></tr>
<tr><td>A.1.2.6.2
A.2.2.6.2</td><td colspan="4">Switching-in conditions</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.6.2.1
A.2.2.6.2.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.4</td><td>11.2.11</td><td>TG 3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.4</td><td>11.2.11</td><td>TG 3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Manufacturer declaration:
“Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 8th, 2020.
Compliance is evidenced by the information declared by the manufacturer in point 6 of this manufacturer declaration. Among others, main points detailed by the manufacturer are:
“The procedure of the connection is implemented in the PGU level”. (for details see the point 4.2 of this document).”.
“Following describes the reconnection concept implemented on the PGU level:
After tripping by protection equipment the integrated protection relay will keep monitoring the grid voltage and frequency. If the reconnection conditions are met the timer (corresponding to the set reconnection delay) will start to count. During the reconnection process if a new grid fault is detected, the timer will be reset. After the timer running out the integrated disconnection devices will be closed and the active power will ramp up according to the defined gradient.
The reconnection can be switched between manual reconnection mode and automatic reconnection mode using the parameter Auto start upon grid recovery.”

- Test Report:
Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020.
Compliance is evidenced by test results provided in points 4.1.4, 4.5.1 and 4.5.2 of this test report.</td></tr>
</table>

FGW TG8	Title				Result
A.1.2.7 **A.2.2.7**	**FRT**				**P**
A.1.2.7.1 **A.2.2.7.1**	**Loss of static stability**				**--**
A.1.2.7.1.1 **A.2.2.7.1.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**NA**
	10.2.1.3 10.5.2	11.2.12	--	--	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	10.2.1.3 10.5.2	11.2.12	--	--	
	<u>Remarks:</u> No evidence necessary.				
A.1.2.7.2 **A.2.2.7.2**	**Island and partial grid operation capability**				**--**
A.1.2.7.2.1 **A.2.2.7.2.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**NA**
	10.2.1.4	--	--	☒ Manufacturer's declaration	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	10.2.1.4	--	--	☒ Manufacturer's declaration	
	<u>Remarks:</u> No requirements for island operation have been defined. Partial grid operation capability does not constitute a minimum requirement. The distribution grid operator may however require partial grid operation capability and the controller stability in individual cases. Only in this case do the following requirements apply. Here only optional characteristics of the PGU are shown, however not a declaration of conformity. <u>Evaluated documentation:</u> - **Manufacturer declaration:** "Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0". Dated on October 8th, 2020. Compliance is evidenced by the information declared by the manufacturer in point 7 of this manufacturer declaration. Among others, main points detailed by the manufacturer are: *"The PGU does not provide islanding operation and partial grid operation capability."*				

<table>
<tr><th>FGW TG8</th><th colspan="4">Title</th><th>Result</th></tr>
<tr><td>A.1.2.7
A.2.2.7</td><td colspan="4">FRT</td><td>P</td></tr>
<tr><td>A.1.2.7.3
A.2.2.7.3</td><td colspan="4">Dynamic grid support</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.7.3.1
A.2.2.7.3.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.2.1.2
10.2.3</td><td>11.2.5</td><td>TG 3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.2.1.2
10.2.3</td><td>11.2.5</td><td>TG 3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Manufacturer declaration:
“Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 8th, 2020.
Compliance is evidenced by the information declared by the manufacturer in point 8 of this manufacturer declaration. Among others, main points detailed by the manufacturer are:
“The Type-2 power generating unit is able to ride through several consecutive voltage dips. After 30 min, the power generating unit is able again to ride through a further multiple fault.”

- Test Report:
Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020.
Compliance is evidenced by test results provided in points 4.6 and 4.7 of this test report. The point 4.6 of the test report refers to the attachment I of the report: 2219 / 0373 ATTACHMENT I which includes calculations of short-circuit AC currents.</td></tr>
<tr><td>A.1.2.7.4
A.2.2.7.4</td><td colspan="4">Contribution to short-circuit current</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.7.4.1
A.2.2.7.4.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.2.5.2</td><td>11.2.9</td><td>TG 3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.2.5.2</td><td>11.2.9</td><td>TG 3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Manufacturer declaration:
“Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 8th, 2020.
Compliance is evidenced by the information declared by the manufacturer in point 8 of this manufacturer declaration. Among others, main points detailed by the manufacturer are:
“IskPF = 160,4 A
I(1)sk2PF = 160,4 A
I(1)sk1PF = 160,4 A.”

- Test Report:
Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020.
Compliance is evidenced by test results provided in the point 4.6 of this test report. The point 4.6 of the test report refers to the attachment I of the report: 2219 / 0373 ATTACHMENT I which includes calculations of short-circuit AC currents.</td></tr>
</table>

FGW TG8	Title				Result
A.1.2.8 **A.2.2.8**	**Protection**				**P**
A.1.2.8.1	**Reserve protection concept**				**--**
A.2.2.8.1	Not applicable to PGU				**NA**
A.1.2.8.2 **A.2.2.8.2**	**Readability of protection settings**				**--**
A.1.2.8.2.1 **A.2.2.8.2.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**NA**
	6.3.3	11.2.10	--	☒ Manufacturer's declaration ☐ Or component certificate	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	6.3.3	11.2.10 11.4.17	--	☒ Manufacturer's declaration ☐ Or component certificate	
	<u>Evaluated documentation:</u> - **Manufacturer declaration:** "Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0". Dated on October 8th, 2020. Compliance is evidenced by the information declared by the manufacturer in point 10 of this manufacturer declaration. Among others, main points detailed by the manufacturer are: *"The integrated grid monitoring/protection parameters can be checked per remote via WebUI or via SUN2000 app using a mobile phone."*				
A.1.2.8.3 **A.2.2.8.3**	**Test terminal**				**--**
A.1.2.8.3.1 **A.2.2.8.3.1**	**VDE 4110 Requirement Cl.**	**VDE 4110 Verification Cl.**	**Associated documents**	**Requirement needed**	**NA**
	6.3.4.5	11.2.10	--	☒ Manufacturer's declaration	
	VDE 4120 Requirement Cl.	**VDE 4120 Verification Cl.**	**Associated documents**	**Requirement needed**	
	6.3.3.5	11.2.10	--	☒ Manufacturer's declaration	
	<u>Evaluated documentation:</u> - **Manufacturer declaration:** "Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0". Dated on October 8th, 2020. Compliance is evidenced by the information declared by the manufacturer in point 3.6.2 of this manufacturer declaration. Among others, main points detailed by the manufacturer are: *"The PGU does not provide test terminals for on-site testing. For necessary on-site testing, an external monitoring relay with corresponding test terminals must be installed and the PGU's monitoring parameters must be set accordingly."*				

<table>
<tr><th>FGW TG8</th><th colspan="4">Title</th><th>Result</th></tr>
<tr><td>A.1.2.8
A.2.2.8</td><td colspan="4">Protection</td><td>P</td></tr>
<tr><td>A.1.2.8.4
A.2.2.8.4</td><td colspan="4">Operating range</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.8.4.1
A.2.2.8.4.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.3.4.2.2</td><td>11.2.10</td><td>TG 3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.3.4.7</td><td>11.2.10</td><td>TG 3</td><td>☒ Manufacturer’s declaration
☒ Test report</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Manufacturer declaration:
“Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 8th, 2020.
Compliance is evidenced by the information declared by the manufacturer in point 10 of this manufacturer declaration.

There is no additional protection equipment present in the product to certify.

- Test Report:
Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020.
Compliance is evidenced by test results provided in the point 4.4 of this test report.</td></tr>
<tr><td rowspan="2">A.1.2.8.5
A.2.2.8.5</td><td colspan="4">Voltage protection device and Q(U) protection</td><td>--</td></tr>
<tr><td colspan="4">Not applicable to PGU</td><td>NA</td></tr>
<tr><td>A.1.2.8.6
A.2.2.8.6</td><td colspan="4">Accuracy</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.8.6.1
A.2.2.8.6.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.3.3.2</td><td>11.2.10</td><td>TG 3</td><td>☒ Test report</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.2.4.3
10.3.4.2</td><td>11.2.10</td><td>TG 3</td><td>☒ Test report</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Test Report:
Test report no. 2219 / 0373 – E1. Dated on October 09th, 2020.
Compliance is evidenced by test results provided in the point 4.4 of this test report.</td></tr>
<tr><td>A.1.2.8.7
A.2.2.8.7</td><td colspan="4">Independence of the protection functions</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.8.7.1
A.2.2.8.7.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.3.3.1</td><td>11.2.10</td><td>--</td><td>☒ Manufacturer’s declaration</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.3.3.1</td><td>11.2.10</td><td>--</td><td>☒ Manufacturer’s declaration</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Manufacturer declaration:
“Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 8th, 2020.
Compliance is evidenced by the information declared by the manufacturer in point 10 of this manufacturer declaration. Among others, main points detailed by the manufacturer are:
“The integrated protection functions are implemented independent from other parameters and control functions.”</td></tr>
<tr><td rowspan="2">A.1.2.8.8
A.2.2.8.8</td><td colspan="4">Protection monitoring</td><td>--</td></tr>
<tr><td colspan="4">Not applicable to PGU</td><td>NA</td></tr>
</table>

<table>
<tr><th>FGW TG8</th><th colspan="4">Title</th><th>Result</th></tr>
<tr><td>A.1.2.8
A.2.2.8</td><td colspan="4">Protection</td><td>P</td></tr>
<tr><td>A.1.2.8.9
A.2.2.8.9</td><td colspan="4">Own and auxiliary power supply</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.8.9.1
A.2.2.8.9.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.3.3.6</td><td>11.2.10</td><td>TG 3</td><td>☒ Manufacturer’s declaration
☐ Component certificate</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.3.1</td><td>11.2.10</td><td>TG 3</td><td>☒ Manufacturer’s declaration
☐ Component certificate</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Manufacturer declaration:
“Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 8th, 2020.
Compliance is evidenced by the information declared by the manufacturer in point 10 of this manufacturer declaration. Among others, main points detailed by the manufacturer are:
“The grid monitoring functions can be maintained for at least 5 s during grid voltage loss.”
“Functionality of the protection functions within the operating ranges shown in Figure 4 are provided”.
“The loss of power supply for the grid monitoring results in a non-delayed triggered disconnection.”
“Operability of the protection functions are provided before the power generating units start feeding in power.”
“The voltage transformers are installed at the power generating units on the network side of the of the power generating unit’s circuit-breaker”</td></tr>
<tr><td>A.1.2.8.9.4</td><td colspan="4">Fault logger</td><td>--</td></tr>
<tr><td>A.2.2.8.9.10</td><td colspan="4">Not applicable to PGU</td><td>NA</td></tr>
<tr><td>A.1.2.8.10
A.2.2.8.11</td><td colspan="4">Coupling switch</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.8.9.1
A.2.2.8.9.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.3
10.4.5</td><td>--</td><td>--</td><td>☒ Manufacturer’s declaration</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.3
10.4.5</td><td>--</td><td>--</td><td>☒ Manufacturer’s declaration</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Manufacturer declaration:
“Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 8th, 2020.
Compliance is evidenced by the information declared by the manufacturer in point 10 of this manufacturer declaration. Among others, main points detailed by the manufacturer are:
“The coupling switch ensures three-pole galvanic separation.”
“The coupling switch is designed as specified by the manufacturer. The switching capacity of the coupling switch is stated.”
“The coupling switch is able to be triggered without delay taking into account the protection equipment required according to 10.3.”
“The sum of time elements of the protection and switching equipment does not exceed 100 ms.”</td></tr>
</table>

CAPABILITY OF PRIMARY CONTROL ENERGY SUPPLY.
As stated in the Manufacturer Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0”. Dated on October 08th, 2020.
“The PGU does not provide primary control energy supply”.

1.3 Summary of the evaluation of the validation results

The following documentation is used for the evaluation:

Information of the test report:

- Test report number: 2219/0373-E1-TG4
- Issuance date: 10/09/2020
- Issued by: SGS Tecnos, S.A. (Electrical Testing Laboratory)
- Simulation model name: Huawei_ Huawei_VDE4120&4110_SUN2000-100KTL-M1_400V_Enc_V1.7.pfd
- Version of the simulation model: V1.7
- MD5 Checksum: 82CDCCA8DF02BB7E83EEEDF3ED06CE01
- Simulation platform: DigSilent PowerFactory
- Simulation platform version: V 20.0.3_A.2. The validation report doesn't cover upper version of Digsilent above V20.0.3_A.2.

Information of the user manual documentation of the dynamic simulation model:

- Document reference name: User Manual of DIgSILENT Model for Huawei Inverter SUN2000-100KTL-M1 & INM0.
- Version: V1.6
- Issuance date: 17/03/2020
- Issued by: Huawei Technologies Co., Ltd.

<table>
<tr><th>FGW TG8</th><th colspan="4">Title</th><th>Result</th></tr>
<tr><td>A.1.2.9
A.2.2.9</td><td colspan="4">Simulation models</td><td>P</td></tr>
<tr><td>A.1.2.9.1
A.2.2.9.1</td><td colspan="4">Requirements for simulation models</td><td>--</td></tr>
<tr><td rowspan="5">A.1.2.9.1.1
A.2.2.9.1.1</td><td>VDE 4110 Requirement Cl.</td><td>VDE 4110 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td><td rowspan="5">P</td></tr>
<tr><td>10.6</td><td>11.2.6</td><td>TG4</td><td>☒ Validated model
☒ Validation report
☒ Model documentation</td></tr>
<tr><td>VDE 4120 Requirement Cl.</td><td>VDE 4120 Verification Cl.</td><td>Associated documents</td><td>Requirement needed</td></tr>
<tr><td>10.6</td><td>11.2.6</td><td>TG4</td><td>☒ Validated model
☒ Validation report
☒ Model documentation</td></tr>
<tr><td colspan="4"><u>Evaluated documentation:</u>
- Model Documentation:
"User Manual of DIgSILENT Model for Huawei Inverter SUN2000-100KTL-M1 & INM0". Rev 1.6 dated on March 17th, 2020.
- Validation Report:
Test report no. 2219 / 0373 – E1– TG4. Dated on October 09th, 2020.</td></tr>
</table>

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

1.4 Evaluation of the ISO 9001 Quality Management System Certificate of manufacturers

Huawei have 2 factory location where it is produced the certified PV Inverter:

Factory 1:

Name: **Huawei Machine Co., Ltd**
Address: Address: NO.2 New City avenue Song Shan Hu Science & Technology Industry Park, Dongguan, Guangdong, 523808, China.
Evidence: Certificate 01 100 1933213 Issued by TÜV Rheinland (Dakks accredited). Valid until 11th November 2020.

Certificate

Standard	**ISO 9001:2015**
Certificate Registr. No.	**01 100 1933213**

Certificate Holder:

HUAWEI TECHNOLOGIES CO., LTD.
Unified Social Credit Code: 914403001922038216
Registration Address: Huawei Headquarters, Bantian, Longgang District, Shenzhen, Guangdong Province 518129, P. R. China
Operation Address: Refer to the "Operation Address List"

including locations and information according to annex

Scope:

Design, Manufacture, Procurement, Supply Chain Management, Sales, and Services (include Installation, Network Engineering Services, Network Field Maintenance, Repair, Customer Support and Training Services) of Fixed Access Products, Radio Access Products, Core Network Products, Transport Network Products, Data Communication Products, Synchronization Network Products, Antenna System and Radio Frequency Products, Copper and Optical Distribution Network Products(ODN and Distribution Product), Business Support System Products, Network Management System and Tool Products, Data Service Products, Enterprise Service Products, Security Products, Enterprise UC&C Products, Infrastructure Network and Security Products, Cloud Computing and Data Center Products, Storage Products, Server Products, Digital Entertainment Products, Telecommunication Terminal Products(include Mobile Phone), Portable Computer and Accessories, Energy Products (include Communication Power System, BMP&CP, Hybrid Power, UPS, Inverter, Data Center Infrastructure(include Precision Air Conditioning), Network Management and Monitoring Products) by Huawei Technologies.
Design, Manufacture, Procurement, Supply Chain Management, Sales and Services (include Installation, Network Engineering Services,Network Field Maintenance and Customer Support Services) of Business Support System Products, Network Management System and Tool Products, Data Service Products, Enterprise Service Products, Cloud Computing and Data Center Products, Server Products and Security Products by Huawei Software.
Design, Manufacture, Procurement, Supply Chain Management, Sales and Services (include Repair and Customer Support Service) of Digital Entertainment Products, Telecommunication Terminal Products (include Mobile Phone), Portable Computer and Accessories by Huawei Device.
Note1: ODN and Distribution Product: ODF (Optical Distribution Frame), FDT (Fiber Distribution Terminal), SPL (Splitter), FAT (Fiber Access Terminal), SSC (Splitting and Splicing Closure), Indoor Cable, Iodf (Intelligent Optical Distribution Frame), Ifdt (Intelligent Fiber Distribution Terminal), Ifat (Intelligent Fiber Access Terminal), Intelligent Patch Cord, Ispl (Intelligent Electric ID).
Note2: The Disign and Service of Cloud Computing Products include Provision of Planning and Design Service, Reserch and Development Services, Operation and Maintenance Service, Service Operation and Customer Support Service For Huawei Cloud Service, Including Computing, Storage, Network, Database, Security, Domain & Website, Application, Management & Deployment, Devcloud, Migration, Cloud Communications, Iot, Dedicated Cloud, Enterprise Network, Enterprise Intelgigence. the Service of Data Center Products include the Provision of Operation and Maintenance Services For Huawei Ciud Data Centers.
Note3: Supply Chain Management include Storage, Logistic and Delivery Management.

Proof has been furnished by means of an audit that the requirements of ISO 9001:2015 are met.

Validity:

the certificate is valid from 2020-04-09 until 2020-11-11.
It remains valid subject to satisfactory surveillance audits.
First certification 2005

This certificate information can be searched on CNCA official website http://www.cnca.gov.cn

2020-04-09

TÜV Rheinland Cert GmbH
Am Grauen Stein · 51105 Köln

www.tuv.com

DAkkS Deutsche Akkreditierungsstelle D-ZM-16031-01-00

TÜVRheinland®
Precisely Right.

Registered Scope Categories

Standard **ISO 9001:2015**

Certificate Registr. No. **01 100 1933213**

Registered Scope/ Activities	**Huawei Technologies related products**	**Huawei Software related products**	**Huawei Device related products**
Design	A	I	P
Manufacture	B	J	Q
Procurement	C	K	R
Supply chain management	D	L	S
Sales	E	M	T
Services (include installation, network engineering services, network field maintenance)	F	N	/
Services (include training services)	G	/	/
Services (include repair and customer support services)	H	O	U
Operation and maintenance services for Huawei Cloud Data Centers	/	V	/

Note1: Huawei Technologies related products include fixed access products, radio access products, core network products, transport network products, data communication products, synchronization network products, antenna system and radio frequency products, copper and optical distribution network products (ODN and Distribution product), business support system products, network management system and tool products, data service products, enterprise

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

Operation Address List

Standard **ISO 9001:2015**

Certificate Registr. No. **01 100 1933213**

Company Name	Operation Address	Activity Code
Huawei Technologies Co., Ltd. Huawei Device (Shenzhen) Co., Ltd. Huawei Software Technologies Co., Ltd.	Huawei Headquarters, Bantian, Longgang District, Shenzhen, Guangdong Province 518129, P. R. China	**A-B, E-J, M-U**
Huawei Technologies Co., Ltd. Huawei Device (Shenzhen) Co., Ltd.	Building 2 and Block A&B of Building 1, Phase1 Tian An Cloud Park, No. 2018 Xuegang Road, Bantian, Longgang District, Shenzhen, Guangdong Province 518129, P. R. China	**AE, PRSTU**
Huawei Device (Shenzhen) Co., Ltd. Huawei Machine Co., Ltd.	Nanggang Campus 3, Tangtou Industrial Park, Shiyan, Bao'an District, Shenzhen, Guangdong Province 518108, P. R. China	**S**
Huawei Device Co., Ltd. Huawei Machine Co., Ltd. Huawei Technologies Co., Ltd. Huawei Software Technologies Co., Ltd.	No.2 New City Avenue, Song Shan Hu Science & Technologies Industrial Park, Dongguan, Guangdong Province 523808, P. R. China	**BCDH, JKLO,QU**
Huawei Technologies Co., Ltd. Beijing R&D Center. Beijing Huawei Digital Technologies Co., Ltd.	Huawei Building, No. 3 Xinxi Road, Shang Di, Haidian District, Beijing 100095, P. R. China	**A**

www.tuv.com

DAkkS Deutsche Akkreditierungsstelle D-ZM-16031-01-00

TÜVRheinland® Precisely Right.

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

Factory 2:

Name: **Shenzhen Fugui Precision Industry CO., Ltd.**
Address: NWE product Division Building B4, D10, Foxconn Science and Technology Industrial Park, East Side of Min Qing Road. Longhua District Shenzhen. Guangdong, 518109, China.
Evidence: Certificate FM 57135. Issued by BSI (ANAB accredited). Valid until 27th June 2022.

bsi.

By Royal Charter

Certificate of Registration

质量管理体系 – ISO 9001:2015

兹证明：

深圳富桂精密工業有限公司NWE产品事业处
91440300MA5EHGH388
中国
广东省
深圳市
龙华区
龙华街道民清路东侧
富士康科技工业园B4栋、D10栋
邮编：518109

Shenzhen Fugui Precision Industry Co., Ltd.
NWE Product Division
Building B4, D10, Foxconn Science and Technology Industrial Park, East Side of Min Qing Road
Longhua Subdistrict, Longhua District
Shenzhen
Guangdong
518109
China

持有证书： **FM 57135**

并运行符合 ISO 9001:2015 要求的质量管理体系，认证范围如下：

通讯及网络周边金属与塑料产品的制造(成型、压铸、冲压、组装与涂装制程)。太阳能光伏逆变器的装配及测试。通讯及网络产品组件的装配及测试。
The manufacture of sheet metal and plastic enclosure for networks and communication products (molding, die casting, stamping, assembly and painting process). The assembly and test of solar inverter. The assembly and test of the units of communication and networks products.

BSI代表：

Chris Cheung，亚太地区 合规风险主管

首次发证日期： 2000-12-18
最新发证日期： 2019-04-09

生效日期： 2019-06-28
有效期至： 2022-06-27

Page: 1 of 3

ANAB ACCREDITED ISO/IEC 17021 MANAGEMENT SYSTEMS CERTIFICATION BODY

...making excellence a habit.™

此证书以电子版本方式发放，所有权属BSI并受合同条款的约束。
可以 在线 查询电子证书的有效性
打印的证书可以通过网站 http://www.bsi-global.com/ClientDirectory或者致电 +86 10 8507 3000 查询。本证书信息亦可在国家认证认可监督管理委员会官方网站(www.cnca.gov.cn) 上查询。
关于证书范围及 ISO 9001:2015 要求的适用性的进一步说明请咨询BSI。
获证组织必须定期接受监督审核并经审核合格此证书方继续有效。
此证书只在提供完整正本时才有效。

信息查询及联系方式：BSI, Kitemark Court, Davy Avenue, Knowlhill, Milton Keynes MK5 8PP. 电话：+44 345 080 9000
BSI保证英国有限公司，注册地英国，注册号码7805321，地址：389 Chiswick High Road, London W4 4AL, UK
英标管理体系认证（北京）有限公司 北京市建国门外大街甲24号东海中心2008室 邮编：100004 电话：+86 10 85073000
BSI集团公司成员。

持有证书： **FM 57135**

地点	认证活动
深圳富桂精密工業有限公司NWE产品事业处 91440300MA5EHGH388 中国 广东省 深圳市 龙华区 龙华街道民清路东侧 富士康科技工业园B4栋、D10栋 邮编：518109 Shenzhen Fugui Precision Industry Co., Ltd. NWE Product Division Building B4, D10, Foxconn Science and Technology Industrial Park, East Side of Min Qing Road Longhua Subdistrict, Longhua District Shenzhen Guangdong 518109 China	通讯及网络周边金属与塑料产品的制造（成型、冲压、组装与涂装制程）。 The manufacture of sheet metal and plastic enclosure for networks and communication products (molding, stamping, assembly and painting process).
国基电子（上海）有限公司 CNSBG事业群NWE产品事业处 中国 上海市 松江出口加工区 南乐路1925号 邮编：201600 Ambit Microsystems (Shanghai) Ltd. CNSBG NWE Product Division No.1925 Nanle Road Songjiang Export Process District Shanghai 201600 China	通讯及网络周边金属与塑料产品的制造（成型、压铸、冲压、组装与涂装制程）。 The manufacture of sheet metal and plastic enclosure for networks and communication products (molding, die casting, stamping, assembly and painting process).

首次发证日期： 2000-12-18　　生效日期： 2019-06-28
最新发证日期： 2019-04-09　　有效期至： 2022-06-27

Page: 2 of 3

信息查询及联系方式：BSI, Kitemark Court, Davy Avenue, Knowlhill, Milton Keynes MK5 8PP. 电话：+44 345 080 9000
BSI保证英国有限公司，注册地英国，注册号码7805321，地址：389 Chiswick High Road, London W4 4AL, UK
英标管理体系认证（北京）有限公司 北京市建国门外大街甲24号东海中心2008室 邮编：100004 电话：+86 10 85073000
BSI集团公司成员。

持有证书: **FM 57135**

地点	认证活动
富弘精密组件（北江）有限公司 庭暂工业区 越安县 北江省 邮编：236100 越南 Fuhong Precision Component (Bac Giang) Limited Dinh Tram Industrial Park Viet Yen District Bac Giang Province 236100 Vietnam	塑料产品的制造。 The manufacture of plastic injection products.
东莞市富翼精密工业有限公司 中国 广东省 东莞市 大朗镇松木山村 松水路6号玮丰工业城12栋1-4楼 邮编：523770 Dongguan Fuyi Precision Industry Co., Ltd. Floor 1st-4th, Building 12 Weifeng Industrial City, No.6, Songshui Road Songmu Village, Dalang Town Dongguan Guangdong 523770 China	太阳能光伏逆变器的装配及测试。通讯及网络产品组件的装配及测试。 The assembly and test of solar inverter. The assembly and test of the units of communication and networks products.

首次发证日期： 2000-12-18
最新发证日期： 2019-04-09
生效日期： 2019-06-28
有效期至： 2022-06-27

Page: 3 of 3

1.5 Compromise letter to maintain ISO 9001 during the validity period of certificate

Compromise letter

We Huawei Technologies Co., Ltd.

Declare the maintenance of the quality system certified by a certification accredited company, according to the requirements of ISO 9001:2015, during the validity period of the certificate, at least 5 years.

We are also committed to require our assemblers to comply with the same standards of quality during that period.

Brand:

Models:

- SUN2000-100KTL-M1
- SUN2000-100KTL-INM0

Date: 18 March 2020

Name: ZhangYuanjun 00277797

Signature: ZhangYuanjun 00277797

1.6 Compromise letter of the certified product.

Product declaration

We Huawei Technologies Co., Ltd.

Declare that the product,

- SUN2000-100KTL-M1

tested by the SGS Tecnos E&E Laboratory Testing, according to the standards,

- VDE-AR-N 4110: 2018-11…
- VDE-AR-N 4120: 2018-11
- FGW TR3 according to test report 2219/0373
- FGW TR4 according to validation report 2219/0373 –TG4
- FGW TR8

are the same to the model to certify according to above-mentioned standards.
The variant models,

- SUN2000-100KTL-M1
- SUN2000-100KTL-INM0

can be added under scoped of the certification having the same hardware topology and firmware of the tested model.

Date: 18 March 2020

Name: ZhangYaunjun 00277797

Signature: Zhang Yuanjun 00277797

Note: the declaration is updated again after tests repeated for the issuance of the Revision 1 of the certificate.

Product declaration

We Huawei Technologies Co., Ltd

Declare that the product,

- SUN2000-100KTL-M1

tested by the SGS Tecnos E&E Laboratory Testing, according to the standards,

- VDE-AR-N 4110: 2018-11...
- VDE-AR-N 4120: 2018-11
- FGW TR3 according to test report 2219/0373-E1
- FGW TR4 according to validation report 2219/0373-E1-TG4
- FGW TR8

are the same to the model to certify according to above-mentioned standards.

The variant models,

- SUN2000-100KTL-M1
- SUN2000-100KTL-INM0

can be added under scoped of the certification having the same hardware topology and firmware of the tested model

Date: 29 September 2020

Name: ZhangYaunjun 00277797

Signature: Zhang Yaunjun 00277797

2 FGW TR3 TEST REPORT

Test Report Number: 2219 / 0373 -E1 with date 2020-10-09 according of FGW TR3 rev. 25

2.1 Nenndaten / Rated data:

Nennscheinleistung Sn	100 kVA	**Nennstrom In**	144,4 A (400 V) and 120,3 A (480 V)
Nennfrequenz f_n rated frequency f_n	50 Hz	**Nennspannung Un rated Voltage Un**	400 V and 480 V

Note 1: Only points Active power peaks and System Perturbations were checked under 400V and 480V output voltage. Other tests were only performed under 400V output voltage as representative.

Note 2: The maximum apparent power of the certified unit is 110 kVA.

2.2 Power quality

2.2.1 Wirkleistungsspitzen / Power Peaks

Test results under 400Vac output voltage are offered in the following table:

DC Voltage (V)	Wirkleistungsspitzen in kW / Power peaks in kW		Wirkleistungsspitzen in p.u. / Power peaks in p.u.		Anzahl 10-Minuten Datensätze in / Number of 10-minute data set
537	$p_{600} = P_{600}/P_n$	110,3	$p_{60} = P_{60}/P_n$	1,103	10
566	$p_{600} = P_{600}/P_n$	110,3	$p_{60} = P_{60}/P_n$	1,104	10
600	$p_{600} = P_{600}/P_n$	109,9	$p_{60} = P_{60}/P_n$	1,099	10
630	$p_{600} = P_{600}/P_n$	109,8	$p_{60} = P_{60}/P_n$	1,098	10
660	$p_{600} = P_{600}/P_n$	110,0	$p_{60} = P_{60}/P_n$	1,100	10
690	$p_{600} = P_{600}/P_n$	110,0	$p_{60} = P_{60}/P_n$	1,100	10
720	$p_{600} = P_{600}/P_n$	110,0	$p_{60} = P_{60}/P_n$	1,100	10
748	$p_{600} = P_{600}/P_n$	110,0	$p_{60} = P_{60}/P_n$	1,100	10
778	$p_{600} = P_{600}/P_n$	109,9	$p_{60} = P_{60}/P_n$	1,100	10
800	$p_{600} = P_{600}/P_n$	109,8	$p_{60} = P_{60}/P_n$	1,099	10

Note: Under 400Vac output voltage, the MPPT range of full power is from 540V to 800V. (full MPPT range is from 200V to 1000V).

Test results under 480Vac output voltage are offered in the following table:

DC Voltage (V)	Wirkleistungsspitzen in kW / Power peaks in kW		Wirkleistungsspitzen in p.u. / Power peaks in p.u.		Anzahl 10-Minuten Datensätze in / Number of 10-minute data set
625	$p_{600} = P_{600}/P_n$	110,1	$p_{60} = P_{60}/P_n$	1,101	10
646	$p_{600} = P_{600}/P_n$	110,2	$p_{60} = P_{60}/P_n$	1,101	10
667	$p_{600} = P_{600}/P_n$	110,3	$p_{60} = P_{60}/P_n$	1,103	10
691	$p_{600} = P_{600}/P_n$	110,8	$p_{60} = P_{60}/P_n$	1,108	10
715	$p_{600} = P_{600}/P_n$	110,9	$p_{60} = P_{60}/P_n$	1,109	10
739	$p_{600} = P_{600}/P_n$	110,8	$p_{60} = P_{60}/P_n$	1,108	10
763	$p_{600} = P_{600}/P_n$	110,8	$p_{60} = P_{60}/P_n$	1,108	10
783	$p_{600} = P_{600}/P_n$	110,7	$p_{60} = P_{60}/P_n$	1,107	10
806	$p_{600} = P_{600}/P_n$	110,7	$p_{60} = P_{60}/P_n$	1,107	10
830	$p_{600} = P_{600}/P_n$	110,7	$p_{60} = P_{60}/P_n$	1,107	10
848	$p_{600} = P_{600}/P_n$	110,7	$p_{60} = P_{60}/P_n$	1,107	10

Note: Under 480Vac output voltage, the MPPT range of full power is from 625V to 850V. (full MPPT range is from 200V to 1000V).

2.2.2 Schalthandlungen / Switching Operation

Test results under 400Vac output voltage are offered in the following tables:

Schalthandlungen / Case of switching operation	Einschalten bei $P_{verfügbar}$ <10 % P_n (Einschaltwindgeschw.) / Start-up at $P_{available}$ < 10% P_n (cut-in wind speed)			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	20			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	240			
Netzimpedanzwinkel / Grid impedance angle	30º	50º	70º	85º
Flickerformfaktor / Flicker step factor, k_f (Ψ_k)	0,006	0,006	0,006	0,006
Spannungsänderungsfaktor / Voltage change factor, k_U (Ψ_k)	0,026	0,026	0,026	0,026

Schalthandlungen / Case of switching operation	Einschalten bei $P_{verfügbar}$ - P_n (Nennwindgeschwindigkeit) Start-up at $P_{available}$ P_n (rated wind speed)			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	20			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	240			
Netzimpedanzwinkel / Grid impedance angle	30º	50º	70º	85º
Flickerformfaktor / Flicker step factor, k_f (Ψ_k)	0,006	0,006	0,006	0,006
Spannungsänderungsfaktor / Voltage change factor, k_U (Ψ_k)	0,015	0,015	0,015	0,015

Schalthandlungen / Case of switching operation	Seviceabschaltung bei Nennleistung / Cut off at rated power			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	10			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	120			
Netzimpedanzwinkel / Grid impedance angle	30º	50º	70º	85º
Flickerformfaktor / Flicker step factor, k_f (Ψ_k)	0,010	0,013	0,016	0,016
Spannungsänderungsfaktor / Voltage change factor, k_U (Ψ_k)	0,195	0,195	0,195	0,195

Test results under 480Vac output voltage are offered in the following tables:

Schalthandlungen / Case of switching operation	Einschalten bei $P_{verfügbar}$ <10 % P_n (Einschaltwindgeschw.) / Start-up at $P_{available}$ < 10% P_n (cut-in wind speed)			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	20			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	240			
Netzimpedanzwinkel / Grid impedance angle	30º	50º	70º	85º
Flickerformfaktor / Flicker step factor, k_f (Ψ_k)	0,006	0,006	0,006	0,006
Spannungsänderungsfaktor / Voltage change factor, k_U (Ψ_k)	0,007	0,007	0,007	0,007

Schalthandlungen / Case of switching operation	Einschalten bei $P_{verfügbar}$ - P_n (Nennwindgeschwindigkeit) Start-up at $P_{available}$ P_n (rated wind speed)			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	20			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	240			
Netzimpedanzwinkel / Grid impedance angle	30º	50º	70º	85º
Flickerformfaktor / Flicker step factor, k_f (Ψ_k)	0,006	0,006	0,006	0,006
Spannungsänderungsfaktor / Voltage change factor, k_U (Ψ_k)	0,056	0,056	0,056	0,056

Schalthandlungen / Case of switching operation	Seviceabschaltung bei Nennleistung / Cut off at rated power			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	10			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	120			
Netzimpedanzwinkel / Grid impedance angle	30º	50º	70º	85º
Flickerformfaktor / Flicker step factor, k_f (Ψ_k)	0,010	0,014	0,016	0,017
Spannungsänderungsfaktor / Voltage change factor, k_U (Ψ_k)	0,117	0,117	0,117	0,117

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

2.2.3 Unsymmetrie / Unbalances

Test results under 400Vac output voltage are offered in the following tables:

P_n (%Sn)	V_{1+} (p.u.)	V_{1-} (p.u.)	I_{1+} (p.u.)	I_{1-} (p.u.)	U_i (%)
0	0,999	0,006	0,014	0,000	1,686
11	0,999	0,006	0,112	0,001	0,470
22	0,999	0,006	0,223	0,001	0,502
33	0,999	0,006	0,334	0,001	0,423
44	0,999	0,006	0,444	0,002	0,393
55	0,999	0,006	0,554	0,002	0,396
66	0,999	0,006	0,665	0,003	0,391
77	0,999	0,006	0,775	0,003	0,389
88	1,000	0,006	0,886	0,003	0,377
99	1,000	0,006	0,997	0,004	0,363
110	1,000	0,006	1,102	0,004	0,353

According to VDE-AR-N 4110: 2018-11 and VDE-AR-N 4120: 2018-11, from the 10%Pn, the generating unit shall not exceed a maximum limit defined at 1,5%, for VDE-AR-N 4110: 2018-11 and a maximum limit defined at 2,5%, for VDE-AR-N 4120: 2018-11.

2.2.4 Flicker

Test results under 400Vac output voltage are offered in the following tables:

Netzimpedanzwinkel / Network impedance phase angle, Ψk	30º	50º	70º	85º
P (%Pn)	Flickerkoeffizient / Flicker coefficient, C (Ψk, Pa)			
0	0,247	0,247	0,248	0,248
10	0,253	0,262	0,269	0,271
20	0,269	0,296	0,318	0,326
30	0,293	0,342	0,381	0,395
40	0,320	0,397	0,455	0,475
50	0,353	0,460	0,538	0,563
60	0,388	0,524	0,619	0,651
70	0,429	0,594	0,708	0,744
80	0,471	0,665	0,797	0,838
90	0,515	0,739	0,888	0,935
100	0,560	0,814	0,982	1,034
110	0,703	0,924	1,131	1,155
Max	**0,703**	**0,924**	**1,131**	**1,155**

Test results under 480Vac output voltage are offered in the following tables:

Netzimpedanzwinkel / Network impedance phase angle, Ψk	30º	50º	70º	85º
P (%Pn)	Flickerkoeffizient / Flicker coefficient, C (Ψk, Pa)			
0	0,248	0,249	0,250	0,250
10	0,254	0,263	0,270	0,273
20	0,269	0,294	0,315	0,322
30	0,291	0,341	0,380	0,394
40	0,321	0,400	0,458	0,478
50	0,354	0,463	0,540	0,566
60	0,391	0,527	0,622	0,653
70	0,433	0,598	0,711	0,748
80	0,474	0,669	0,799	0,841
90	0,520	0,743	0,892	0,938
100	0,565	0,818	0,984	1,036
110	0,709	0,920	1,141	1,165
Max	**0,709**	**0,920**	**1,141**	**1,165**

2.2.5 Oberschwingungsmessungen / Harmonics

Test results under 400Vac output voltage													
P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
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(%)	
2	0,044	0,047	0,060	0,074	0,080	0,090	0,092	0,108	0,130	0,140	0,101	0,245	0,245
3	0,085	0,096	0,100	0,141	0,200	0,242	0,306	0,320	0,354	0,411	0,464	0,150	0,464
4	0,040	0,039	0,042	0,041	0,048	0,051	0,060	0,054	0,050	0,059	0,060	0,100	0,100
5	0,063	0,151	0,217	0,262	0,238	0,336	0,367	0,400	0,397	0,414	0,325	0,288	0,414
6	0,032	0,036	0,033	0,034	0,040	0,042	0,049	0,048	0,048	0,058	0,040	0,062	0,062
7	0,108	0,053	0,074	0,155	0,230	0,200	0,216	0,223	0,239	0,222	0,161	0,307	0,307
8	0,025	0,026	0,032	0,035	0,035	0,036	0,035	0,038	0,039	0,042	0,038	0,065	0,065
9	0,043	0,061	0,064	0,073	0,079	0,076	0,117	0,079	0,068	0,078	0,082	0,083	0,117
10	0,022	0,029	0,033	0,036	0,043	0,040	0,043	0,036	0,033	0,040	0,045	0,041	0,045
11	0,077	0,078	0,103	0,130	0,140	0,165	0,183	0,260	0,312	0,319	0,241	0,267	0,319
12	0,025	0,036	0,040	0,039	0,046	0,033	0,042	0,033	0,028	0,034	0,030	0,039	0,046
13	0,111	0,144	0,121	0,111	0,135	0,130	0,137	0,125	0,134	0,167	0,183	0,116	0,183
14	0,022	0,044	0,049	0,039	0,032	0,026	0,041	0,027	0,018	0,024	0,021	0,037	0,049
15	0,046	0,130	0,101	0,058	0,054	0,040	0,062	0,048	0,042	0,043	0,035	0,033	0,130
16	0,013	0,025	0,031	0,030	0,020	0,016	0,021	0,015	0,013	0,016	0,014	0,023	0,031
17	0,053	0,047	0,031	0,067	0,081	0,097	0,108	0,114	0,118	0,123	0,097	0,064	0,123
18	0,008	0,012	0,012	0,012	0,013	0,010	0,013	0,010	0,008	0,010	0,010	0,014	0,014
19	0,021	0,038	0,041	0,075	0,083	0,076	0,090	0,083	0,073	0,086	0,114	0,074	0,114
20	0,016	0,009	0,010	0,013	0,020	0,021	0,022	0,023	0,024	0,021	0,016	0,012	0,024
21	0,020	0,032	0,025	0,022	0,024	0,021	0,024	0,019	0,019	0,015	0,024	0,009	0,032
22	0,005	0,007	0,008	0,008	0,007	0,006	0,007	0,006	0,006	0,006	0,006	0,008	0,008
23	0,026	0,024	0,017	0,030	0,039	0,050	0,052	0,055	0,056	0,050	0,049	0,018	0,056
24	0,004	0,006	0,005	0,005	0,006	0,004	0,005	0,004	0,004	0,004	0,005	0,005	0,006
25	0,017	0,033	0,031	0,044	0,049	0,046	0,055	0,052	0,049	0,052	0,056	0,022	0,056
26	0,003	0,004	0,004	0,004	0,005	0,005	0,005	0,004	0,004	0,004	0,006	0,004	0,006
27	0,015	0,020	0,017	0,018	0,018	0,018	0,021	0,017	0,016	0,014	0,025	0,005	0,025
28	0,003	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,003	0,003	0,004	0,004	0,004
29	0,027	0,016	0,015	0,016	0,023	0,031	0,034	0,031	0,032	0,029	0,034	0,007	0,034
30	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,002	0,003	0,003	0,002	0,003
31	0,024	0,019	0,023	0,025	0,030	0,032	0,036	0,035	0,033	0,034	0,035	0,008	0,036
32	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,002	0,003
33	0,020	0,019	0,019	0,019	0,020	0,018	0,018	0,017	0,017	0,016	0,025	0,003	0,025
34	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,002	0,003	0,002	0,002	0,003
35	0,020	0,014	0,012	0,011	0,016	0,021	0,023	0,022	0,022	0,022	0,026	0,005	0,026
36	0,002	0,003	0,003	0,003	0,003	0,002	0,002	0,002	0,002	0,002	0,003	0,002	0,003
37	0,022	0,020	0,019	0,018	0,022	0,023	0,026	0,024	0,024	0,023	0,025	0,004	0,026
38	0,002	0,003	0,002	0,003	0,003	0,002	0,003	0,002	0,002	0,002	0,003	0,001	0,003
39	0,019	0,023	0,024	0,023	0,022	0,021	0,019	0,019	0,019	0,018	0,025	0,002	0,025
40	0,005	0,002	0,003	0,003	0,005	0,004	0,003	0,002	0,003	0,005	0,005	0,001	0,005
41	0,016	0,016	0,014	0,012	0,014	0,017	0,018	0,018	0,018	0,019	0,019	0,003	0,019
42	0,003	0,003	0,003	0,002	0,003	0,002	0,002	0,002	0,002	0,002	0,003	0,001	0,003
43	0,022	0,020	0,017	0,015	0,018	0,019	0,021	0,020	0,019	0,019	0,019	0,003	0,022
44	0,003	0,003	0,003	0,003	0,003	0,002	0,002	0,002	0,002	0,002	0,003	0,001	0,003
45	0,033	0,032	0,034	0,031	0,028	0,026	0,023	0,022	0,022	0,019	0,024	0,001	0,034
46	0,003	0,004	0,003	0,003	0,003	0,002	0,002	0,002	0,002	0,002	0,002	0,001	0,004
47	0,015	0,023	0,019	0,014	0,015	0,015	0,017	0,017	0,017	0,019	0,016	0,002	0,023
48	0,004	0,004	0,004	0,003	0,003	0,002	0,002	0,002	0,002	0,002	0,003	0,001	0,004
49	0,024	0,025	0,017	0,015	0,017	0,018	0,019	0,018	0,016	0,018	0,014	0,002	0,025
50	0,004	0,004	0,004	0,003	0,003	0,002	0,002	0,002	0,002	0,002	0,003	0,001	0,004
TDC (%)	0,250	0,323	0,354	0,428	0,487	0,554	0,632	0,677	0,720	0,770	0,709	0,621	0,770

Test results under 480Vac output voltage													
P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
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(%)	
2	0,077	0,108	0,121	0,141	0,118	0,136	0,154	0,259	0,299	0,308	0,331	0,193	0,331
3	0,125	0,208	0,171	0,163	0,132	0,115	0,108	0,218	0,252	0,238	0,258	0,232	0,258
4	0,032	0,046	0,051	0,058	0,038	0,053	0,067	0,071	0,077	0,086	0,097	0,056	0,097
5	0,148	0,161	0,173	0,143	0,187	0,223	0,332	0,448	0,504	0,661	0,695	0,220	0,695
6	0,021	0,029	0,039	0,051	0,031	0,040	0,048	0,039	0,036	0,042	0,048	0,056	0,056
7	0,074	0,094	0,079	0,129	0,171	0,204	0,220	0,305	0,309	0,395	0,445	0,292	0,445
8	0,023	0,036	0,042	0,054	0,032	0,031	0,038	0,060	0,066	0,068	0,075	0,034	0,075
9	0,052	0,095	0,057	0,077	0,087	0,091	0,109	0,098	0,078	0,115	0,144	0,114	0,144
10	0,025	0,035	0,056	0,058	0,023	0,027	0,034	0,050	0,036	0,038	0,046	0,033	0,058
11	0,059	0,166	0,082	0,151	0,086	0,104	0,120	0,193	0,211	0,211	0,209	0,084	0,211
12	0,022	0,026	0,060	0,054	0,029	0,023	0,025	0,021	0,021	0,021	0,024	0,015	0,060
13	0,088	0,128	0,084	0,124	0,134	0,146	0,163	0,159	0,174	0,177	0,184	0,134	0,184
14	0,014	0,017	0,025	0,029	0,015	0,014	0,015	0,022	0,018	0,021	0,023	0,015	0,029
15	0,034	0,041	0,034	0,036	0,041	0,052	0,050	0,037	0,030	0,037	0,045	0,029	0,052
16	0,011	0,010	0,014	0,020	0,010	0,012	0,014	0,011	0,010	0,012	0,013	0,008	0,020
17	0,070	0,044	0,059	0,039	0,053	0,067	0,074	0,085	0,077	0,080	0,096	0,022	0,096
18	0,008	0,010	0,012	0,013	0,008	0,008	0,007	0,008	0,008	0,008	0,010	0,004	0,013
19	0,024	0,046	0,056	0,050	0,081	0,099	0,106	0,099	0,092	0,090	0,089	0,032	0,106
20	0,006	0,007	0,010	0,009	0,009	0,011	0,017	0,019	0,021	0,019	0,018	0,005	0,021
21	0,019	0,027	0,026	0,022	0,043	0,046	0,044	0,035	0,031	0,035	0,039	0,010	0,046
22	0,004	0,005	0,007	0,007	0,005	0,006	0,006	0,006	0,005	0,005	0,007	0,003	0,007
23	0,029	0,025	0,020	0,018	0,025	0,033	0,041	0,048	0,048	0,051	0,051	0,010	0,051
24	0,003	0,004	0,006	0,005	0,003	0,003	0,004	0,005	0,004	0,004	0,005	0,002	0,006
25	0,023	0,020	0,022	0,034	0,039	0,050	0,052	0,056	0,047	0,050	0,053	0,011	0,056
26	0,004	0,004	0,005	0,004	0,005	0,006	0,006	0,006	0,005	0,005	0,006	0,002	0,006
27	0,018	0,025	0,027	0,022	0,034	0,036	0,035	0,036	0,033	0,034	0,036	0,003	0,036
28	0,003	0,003	0,003	0,004	0,003	0,004	0,005	0,004	0,003	0,004	0,004	0,002	0,005
29	0,026	0,022	0,016	0,016	0,017	0,023	0,028	0,033	0,034	0,034	0,035	0,005	0,035
30	0,003	0,003	0,004	0,004	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,001	0,004
31	0,022	0,027	0,023	0,023	0,024	0,031	0,032	0,036	0,035	0,036	0,037	0,005	0,037
32	0,003	0,003	0,003	0,004	0,003	0,004	0,004	0,004	0,004	0,004	0,004	0,001	0,004
33	0,021	0,026	0,026	0,027	0,034	0,034	0,033	0,035	0,034	0,035	0,035	0,002	0,035
34	0,002	0,003	0,003	0,003	0,003	0,003	0,004	0,003	0,003	0,003	0,003	0,001	0,004
35	0,020	0,017	0,014	0,013	0,013	0,017	0,020	0,023	0,024	0,026	0,026	0,003	0,026
36	0,003	0,003	0,004	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,001	0,004
37	0,022	0,018	0,021	0,018	0,016	0,022	0,022	0,026	0,025	0,027	0,028	0,003	0,028
38	0,002	0,003	0,004	0,004	0,003	0,003	0,003	0,004	0,003	0,003	0,004	0,001	0,004
39	0,029	0,034	0,034	0,033	0,039	0,039	0,036	0,037	0,038	0,038	0,037	0,002	0,039
40	0,003	0,003	0,003	0,003	0,002	0,003	0,005	0,003	0,003	0,003	0,004	0,001	0,005
41	0,015	0,021	0,015	0,016	0,013	0,017	0,019	0,017	0,021	0,021	0,022	0,002	0,022
42	0,003	0,004	0,003	0,003	0,003	0,003	0,004	0,003	0,003	0,003	0,003	0,001	0,004
43	0,023	0,021	0,018	0,017	0,014	0,018	0,018	0,021	0,022	0,023	0,023	0,002	0,023
44	0,002	0,004	0,003	0,004	0,003	0,003	0,003	0,004	0,003	0,004	0,004	0,001	0,004
45	0,047	0,055	0,051	0,050	0,047	0,045	0,040	0,042	0,043	0,042	0,041	0,002	0,055
46	0,003	0,004	0,003	0,004	0,003	0,003	0,004	0,003	0,003	0,003	0,003	0,001	0,004
47	0,022	0,024	0,026	0,024	0,016	0,019	0,021	0,016	0,018	0,018	0,018	0,002	0,026
48	0,006	0,007	0,005	0,004	0,004	0,004	0,004	0,003	0,004	0,003	0,004	0,001	0,007
49	0,034	0,042	0,027	0,017	0,017	0,020	0,019	0,020	0,022	0,023	0,022	0,002	0,042
50	0,007	0,006	0,006	0,006	0,005	0,004	0,004	0,005	0,004	0,005	0,005	0,001	0,007
TDC (%)	0,288	0,409	0,359	0,399	0,396	0,450	0,541	0,728	0,793	0,940	1,007	0,524	1,007

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

2.2.6 Zwischenharmonische / Interharmonics

Test results under 400Vac output voltage													
P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
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(%)	
75	0,044	0,052	0,048	0,054	0,071	0,073	0,081	0,074	0,063	0,066	0,056	0,064	0,081
125	0,029	0,037	0,042	0,046	0,053	0,052	0,058	0,052	0,049	0,058	0,038	0,036	0,058
175	0,042	0,032	0,034	0,045	0,061	0,047	0,070	0,056	0,060	0,066	0,054	0,054	0,070
225	0,036	0,046	0,051	0,058	0,080	0,095	0,108	0,091	0,085	0,100	0,036	0,097	0,108
275	0,033	0,035	0,038	0,044	0,056	0,057	0,057	0,055	0,055	0,055	0,030	0,082	0,082
325	0,037	0,046	0,049	0,052	0,074	0,082	0,097	0,085	0,081	0,093	0,033	0,087	0,097
375	0,036	0,041	0,043	0,050	0,060	0,058	0,058	0,058	0,061	0,053	0,042	0,080	0,080
425	0,028	0,039	0,041	0,045	0,049	0,063	0,054	0,052	0,052	0,058	0,044	0,029	0,063
475	0,028	0,042	0,042	0,045	0,049	0,058	0,060	0,045	0,045	0,056	0,042	0,030	0,060
525	0,028	0,039	0,041	0,042	0,056	0,061	0,064	0,056	0,052	0,067	0,040	0,032	0,067
575	0,038	0,043	0,044	0,047	0,061	0,061	0,061	0,057	0,059	0,084	0,038	0,050	0,084
625	0,030	0,037	0,034	0,032	0,046	0,039	0,046	0,043	0,040	0,048	0,030	0,036	0,048
675	0,039	0,053	0,042	0,044	0,049	0,042	0,048	0,047	0,049	0,065	0,025	0,046	0,065
725	0,018	0,033	0,031	0,026	0,023	0,021	0,023	0,021	0,021	0,024	0,015	0,022	0,033
775	0,013	0,031	0,026	0,022	0,019	0,017	0,019	0,016	0,017	0,018	0,012	0,014	0,031
825	0,020	0,018	0,019	0,019	0,021	0,029	0,027	0,028	0,026	0,028	0,020	0,023	0,029
875	0,011	0,015	0,014	0,014	0,015	0,014	0,014	0,013	0,013	0,016	0,009	0,009	0,016
925	0,009	0,011	0,011	0,011	0,012	0,011	0,012	0,011	0,010	0,011	0,008	0,007	0,012
975	0,009	0,011	0,010	0,010	0,011	0,010	0,011	0,010	0,010	0,011	0,007	0,005	0,011
1025	0,006	0,009	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,006	0,004	0,009
1075	0,006	0,008	0,007	0,007	0,008	0,007	0,007	0,007	0,007	0,007	0,006	0,004	0,008
1125	0,006	0,007	0,007	0,007	0,007	0,006	0,007	0,006	0,006	0,007	0,005	0,003	0,007
1175	0,009	0,006	0,006	0,007	0,011	0,011	0,010	0,010	0,009	0,009	0,009	0,004	0,011
1225	0,005	0,005	0,005	0,006	0,006	0,005	0,006	0,005	0,005	0,005	0,005	0,003	0,006
1275	0,005	0,006	0,005	0,005	0,006	0,005	0,005	0,005	0,005	0,005	0,004	0,002	0,006
1325	0,004	0,005	0,005	0,005	0,005	0,005	0,005	0,004	0,004	0,005	0,004	0,002	0,005
1375	0,004	0,004	0,004	0,004	0,005	0,005	0,005	0,005	0,005	0,005	0,005	0,002	0,005
1425	0,003	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,002	0,004
1475	0,004	0,004	0,003	0,004	0,004	0,004	0,004	0,004	0,003	0,004	0,003	0,002	0,004
1525	0,003	0,004	0,003	0,004	0,004	0,004	0,004	0,004	0,003	0,003	0,003	0,002	0,004
1575	0,003	0,003	0,003	0,004	0,004	0,004	0,004	0,003	0,003	0,003	0,003	0,002	0,004
1625	0,003	0,003	0,003	0,003	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,002	0,004
1675	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,002	0,003
1725	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,002	0,003
1775	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,002	0,003
1825	0,004	0,003	0,003	0,003	0,005	0,004	0,004	0,004	0,004	0,004	0,004	0,002	0,005
1875	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,002	0,003
1925	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,001	0,003
1975	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,001	0,003

Test results under 480Vac output voltage													
P_n (%)	0	10	20	30	40	50	60	70	80	90	100	110	Max (%)
Nr./ Order	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	I_h(%)	Ih(%)	
75	0,048	0,049	0,060	0,068	0,059	0,069	0,072	0,073	0,078	0,079	0,082	0,075	0,082
125	0,031	0,043	0,050	0,054	0,042	0,045	0,048	0,057	0,057	0,060	0,065	0,041	0,065
175	0,026	0,035	0,043	0,048	0,036	0,042	0,075	0,069	0,074	0,071	0,075	0,068	0,075
225	0,034	0,044	0,054	0,061	0,034	0,036	0,039	0,056	0,058	0,061	0,078	0,048	0,078
275	0,033	0,038	0,045	0,053	0,031	0,033	0,036	0,045	0,054	0,056	0,062	0,039	0,062
325	0,032	0,042	0,051	0,059	0,031	0,033	0,035	0,049	0,049	0,051	0,065	0,039	0,065
375	0,037	0,047	0,061	0,069	0,034	0,036	0,046	0,059	0,076	0,075	0,070	0,050	0,076
425	0,029	0,044	0,055	0,062	0,034	0,037	0,038	0,057	0,050	0,051	0,060	0,028	0,062
475	0,027	0,043	0,049	0,056	0,030	0,034	0,035	0,043	0,055	0,054	0,048	0,024	0,056
525	0,024	0,035	0,042	0,050	0,023	0,025	0,026	0,040	0,039	0,033	0,042	0,019	0,050
575	0,030	0,041	0,068	0,088	0,024	0,026	0,030	0,062	0,110	0,059	0,055	0,020	0,110
625	0,019	0,025	0,030	0,037	0,014	0,016	0,022	0,027	0,029	0,026	0,026	0,012	0,037
675	0,043	0,053	0,076	0,082	0,015	0,020	0,024	0,054	0,087	0,046	0,041	0,012	0,087
725	0,012	0,016	0,017	0,021	0,011	0,011	0,013	0,014	0,016	0,014	0,014	0,006	0,021
775	0,011	0,015	0,015	0,018	0,008	0,009	0,011	0,013	0,015	0,013	0,013	0,005	0,018
825	0,011	0,012	0,013	0,018	0,007	0,008	0,017	0,019	0,020	0,020	0,017	0,006	0,020
875	0,010	0,015	0,015	0,015	0,007	0,008	0,008	0,009	0,010	0,009	0,009	0,004	0,015
925	0,008	0,010	0,010	0,012	0,006	0,006	0,007	0,008	0,009	0,008	0,008	0,003	0,012
975	0,008	0,012	0,012	0,012	0,005	0,006	0,007	0,008	0,010	0,008	0,008	0,003	0,012
1025	0,006	0,007	0,007	0,008	0,005	0,005	0,006	0,006	0,007	0,006	0,006	0,003	0,008
1075	0,005	0,006	0,007	0,007	0,005	0,005	0,006	0,006	0,007	0,006	0,006	0,003	0,007
1125	0,005	0,006	0,006	0,007	0,004	0,005	0,005	0,006	0,006	0,006	0,006	0,003	0,007
1175	0,005	0,006	0,006	0,007	0,004	0,005	0,007	0,008	0,009	0,009	0,009	0,003	0,009
1225	0,004	0,005	0,005	0,005	0,004	0,004	0,004	0,005	0,005	0,005	0,005	0,002	0,005
1275	0,004	0,005	0,005	0,006	0,003	0,004	0,004	0,005	0,006	0,005	0,005	0,002	0,006
1325	0,003	0,004	0,005	0,005	0,003	0,004	0,004	0,004	0,005	0,004	0,004	0,002	0,005
1375	0,003	0,004	0,004	0,004	0,003	0,003	0,005	0,005	0,006	0,005	0,005	0,002	0,006
1425	0,003	0,004	0,004	0,004	0,003	0,003	0,004	0,004	0,004	0,004	0,004	0,002	0,004
1475	0,003	0,004	0,004	0,005	0,003	0,003	0,004	0,004	0,004	0,004	0,004	0,002	0,005
1525	0,003	0,003	0,004	0,004	0,003	0,003	0,003	0,004	0,004	0,004	0,004	0,002	0,004
1575	0,003	0,004	0,004	0,004	0,003	0,003	0,003	0,004	0,004	0,004	0,004	0,002	0,004
1625	0,003	0,003	0,004	0,004	0,003	0,003	0,004	0,004	0,004	0,004	0,004	0,002	0,004
1675	0,003	0,003	0,003	0,004	0,003	0,003	0,003	0,004	0,004	0,003	0,003	0,002	0,004
1725	0,003	0,003	0,003	0,004	0,003	0,003	0,003	0,004	0,004	0,003	0,003	0,002	0,004
1775	0,003	0,003	0,003	0,004	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,002	0,004
1825	0,003	0,003	0,003	0,003	0,003	0,003	0,004	0,004	0,004	0,004	0,004	0,002	0,004
1875	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,002	0,003
1925	0,002	0,003	0,004	0,004	0,002	0,003	0,003	0,003	0,004	0,003	0,003	0,002	0,004
1975	0,003	0,003	0,004	0,004	0,003	0,003	0,003	0,004	0,004	0,003	0,003	0,002	0,004

2.2.7 Höhere Frequenzen / Higher Frequencies components

Test results under 400Vac output voltage													
P_n (%)	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**Max**
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	0,036	0,032	0,029	0,030	0,030	0,031	0,033	0,031	0,030	0,031	0,032	0,072	0,072
2,3	0,041	0,041	0,042	0,039	0,035	0,034	0,035	0,034	0,034	0,031	0,033	0,053	0,053
2,5	0,051	0,050	0,045	0,045	0,047	0,043	0,039	0,036	0,035	0,033	0,031	0,054	0,054
2,7	0,049	0,047	0,040	0,041	0,036	0,036	0,038	0,033	0,030	0,030	0,028	0,052	0,052
2,9	0,049	0,048	0,043	0,046	0,041	0,047	0,049	0,042	0,038	0,038	0,033	0,042	0,049
3,1	0,048	0,041	0,045	0,047	0,049	0,041	0,055	0,048	0,045	0,038	0,038	0,041	0,055
3,3	0,030	0,027	0,030	0,043	0,049	0,046	0,049	0,048	0,036	0,035	0,041	0,033	0,049
3,5	0,034	0,039	0,038	0,044	0,045	0,042	0,042	0,046	0,045	0,047	0,045	0,029	0,047
3,7	0,035	0,039	0,041	0,043	0,042	0,042	0,043	0,042	0,043	0,042	0,042	0,023	0,043
3,9	0,022	0,026	0,028	0,034	0,033	0,040	0,041	0,036	0,039	0,033	0,035	0,025	0,041
4,1	0,026	0,036	0,034	0,034	0,034	0,036	0,032	0,036	0,036	0,036	0,034	0,021	0,036
4,3	0,019	0,021	0,021	0,022	0,024	0,027	0,025	0,023	0,026	0,022	0,026	0,021	0,027
4,5	0,018	0,018	0,018	0,021	0,021	0,022	0,034	0,035	0,029	0,026	0,021	0,023	0,035
4,7	0,018	0,018	0,019	0,020	0,021	0,021	0,024	0,030	0,032	0,029	0,025	0,024	0,032
4,9	0,017	0,018	0,018	0,020	0,021	0,019	0,019	0,025	0,025	0,028	0,024	0,021	0,028
5,1	0,017	0,017	0,018	0,020	0,021	0,019	0,019	0,019	0,022	0,027	0,022	0,020	0,027
5,3	0,017	0,017	0,018	0,019	0,022	0,019	0,018	0,019	0,020	0,026	0,026	0,019	0,026
5,5	0,017	0,017	0,018	0,018	0,020	0,019	0,018	0,018	0,019	0,020	0,021	0,018	0,021
5,7	0,017	0,017	0,018	0,018	0,019	0,019	0,018	0,018	0,018	0,019	0,020	0,018	0,020
5,9	0,017	0,017	0,018	0,018	0,019	0,020	0,018	0,018	0,018	0,018	0,019	0,019	0,020
6,1	0,017	0,017	0,018	0,018	0,019	0,020	0,018	0,018	0,018	0,018	0,019	0,019	0,020
6,3	0,018	0,019	0,019	0,019	0,020	0,021	0,020	0,019	0,020	0,020	0,020	0,019	0,021
6,5	0,017	0,017	0,018	0,018	0,019	0,019	0,019	0,018	0,018	0,018	0,018	0,018	0,019
6,7	0,017	0,017	0,017	0,017	0,019	0,019	0,019	0,018	0,018	0,018	0,018	0,018	0,019
6,9	0,017	0,017	0,018	0,018	0,019	0,021	0,020	0,019	0,018	0,019	0,019	0,018	0,021
7,1	0,018	0,018	0,018	0,018	0,019	0,019	0,021	0,019	0,018	0,018	0,018	0,018	0,021
7,3	0,018	0,018	0,018	0,019	0,019	0,020	0,020	0,019	0,018	0,019	0,019	0,018	0,020
7,5	0,017	0,017	0,017	0,018	0,018	0,019	0,019	0,018	0,018	0,018	0,018	0,018	0,019
7,7	0,017	0,017	0,017	0,018	0,018	0,019	0,019	0,018	0,018	0,018	0,018	0,018	0,019
7,9	0,017	0,017	0,017	0,018	0,018	0,019	0,019	0,019	0,018	0,018	0,018	0,018	0,019
8,1	0,017	0,017	0,017	0,018	0,018	0,019	0,019	0,019	0,018	0,018	0,018	0,018	0,019
8,3	0,017	0,017	0,017	0,018	0,018	0,019	0,018	0,019	0,018	0,018	0,018	0,018	0,019
8,5	0,017	0,017	0,017	0,017	0,018	0,019	0,019	0,019	0,018	0,018	0,018	0,018	0,019
8,7	0,017	0,017	0,018	0,018	0,018	0,019	0,018	0,019	0,018	0,018	0,018	0,018	0,019
8,9	0,017	0,017	0,017	0,017	0,018	0,018	0,019	0,018	0,017	0,018	0,018	0,018	0,019

Test results under 480Vac output voltage													
P_n (%)	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**Max**
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	0,039	0,036	0,039	0,034	0,028	0,033	0,035	0,036	0,037	0,037	0,037	0,044	0,044
2,3	0,062	0,065	0,061	0,059	0,053	0,053	0,051	0,051	0,051	0,050	0,047	0,048	0,065
2,5	0,065	0,070	0,064	0,054	0,067	0,061	0,056	0,055	0,058	0,055	0,055	0,041	0,070
2,7	0,061	0,066	0,068	0,062	0,046	0,044	0,048	0,043	0,042	0,042	0,041	0,047	0,068
2,9	0,057	0,056	0,053	0,054	0,054	0,057	0,058	0,050	0,059	0,053	0,059	0,035	0,059
3,1	0,051	0,052	0,052	0,048	0,040	0,046	0,045	0,049	0,056	0,050	0,058	0,032	0,058
3,3	0,033	0,031	0,033	0,040	0,046	0,044	0,057	0,057	0,051	0,054	0,058	0,028	0,058
3,5	0,042	0,042	0,040	0,049	0,053	0,053	0,056	0,055	0,048	0,054	0,045	0,021	0,056
3,7	0,047	0,042	0,048	0,045	0,051	0,044	0,042	0,042	0,017	0,044	0,047	0,025	0,051
3,9	0,023	0,025	0,024	0,029	0,037	0,041	0,045	0,041	0,039	0,039	0,036	0,022	0,045
4,1	0,024	0,027	0,029	0,038	0,034	0,037	0,048	0,047	0,044	0,039	0,039	0,021	0,048
4,3	0,021	0,022	0,024	0,025	0,030	0,025	0,031	0,036	0,044	0,038	0,032	0,020	0,044
4,5	0,021	0,021	0,022	0,023	0,025	0,025	0,024	0,026	0,031	0,032	0,028	0,020	0,032
4,7	0,021	0,021	0,023	0,022	0,025	0,023	0,025	0,025	0,026	0,031	0,030	0,020	0,031
4,9	0,021	0,021	0,021	0,022	0,025	0,026	0,023	0,023	0,023	0,025	0,028	0,018	0,028
5,1	0,021	0,021	0,022	0,021	0,024	0,026	0,023	0,022	0,022	0,022	0,025	0,018	0,026
5,3	0,021	0,021	0,022	0,021	0,024	0,024	0,022	0,022	0,022	0,023	0,023	0,018	0,024
5,5	0,021	0,021	0,021	0,021	0,024	0,025	0,022	0,022	0,022	0,022	0,022	0,018	0,025
5,7	0,021	0,021	0,021	0,021	0,024	0,025	0,023	0,022	0,021	0,021	0,022	0,018	0,025
5,9	0,021	0,021	0,021	0,021	0,022	0,023	0,024	0,022	0,022	0,022	0,022	0,018	0,024
6,1	0,021	0,021	0,021	0,021	0,022	0,024	0,023	0,022	0,022	0,021	0,021	0,018	0,024
6,3	0,023	0,023	0,023	0,024	0,024	0,025	0,024	0,024	0,024	0,024	0,024	0,018	0,025
6,5	0,021	0,021	0,021	0,021	0,022	0,023	0,024	0,023	0,022	0,022	0,021	0,018	0,024
6,7	0,021	0,021	0,021	0,021	0,021	0,024	0,023	0,024	0,021	0,021	0,021	0,018	0,024
6,9	0,022	0,022	0,022	0,022	0,021	0,024	0,024	0,024	0,022	0,022	0,022	0,018	0,024
7,1	0,021	0,021	0,021	0,021	0,022	0,024	0,025	0,023	0,022	0,022	0,022	0,018	0,025
7,3	0,022	0,022	0,022	0,022	0,022	0,023	0,023	0,024	0,023	0,023	0,022	0,018	0,024
7,5	0,021	0,021	0,021	0,021	0,021	0,022	0,024	0,023	0,023	0,022	0,021	0,018	0,024
7,7	0,021	0,021	0,021	0,021	0,021	0,021	0,023	0,023	0,024	0,022	0,021	0,018	0,024
7,9	0,021	0,021	0,021	0,021	0,021	0,022	0,023	0,022	0,023	0,022	0,021	0,018	0,023
8,1	0,021	0,021	0,021	0,021	0,021	0,021	0,023	0,023	0,022	0,022	0,021	0,017	0,023
8,3	0,021	0,020	0,021	0,021	0,021	0,021	0,023	0,023	0,022	0,023	0,021	0,018	0,023
8,5	0,021	0,021	0,021	0,021	0,021	0,021	0,022	0,022	0,023	0,023	0,021	0,018	0,023
8,7	0,021	0,021	0,021	0,021	0,021	0,021	0,022	0,023	0,023	0,022	0,022	0,018	0,023
8,9	0,021	0,021	0,021	0,021	0,021	0,021	0,022	0,021	0,022	0,022	0,022	0,018	0,022

2.3 Grid Control Capability

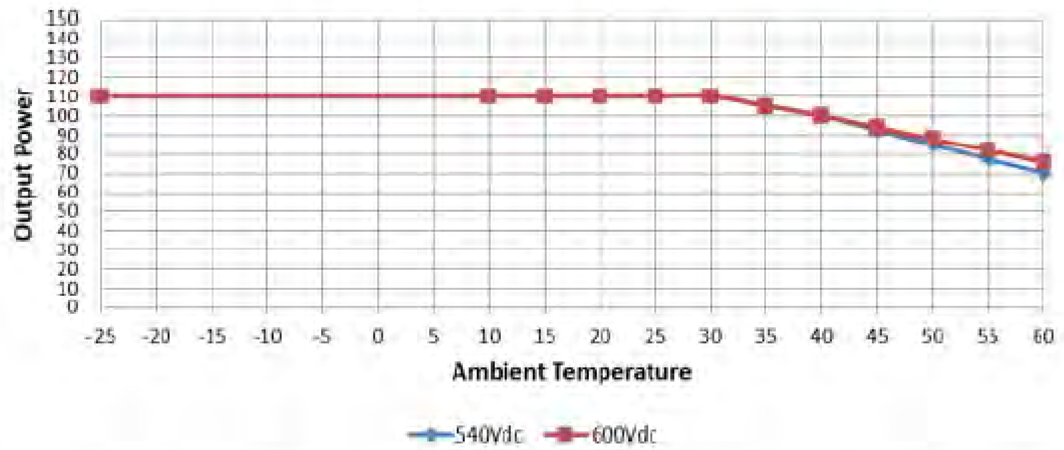
2.3.1 Wirkleistungs einspeisung in Abhängigkeit der Netfrequenz / Active power vs frequency

Überfrequenz / overfrequency	Mittlerer Gradient der Wirkleistung sum Zeitpunkt der Frequenzüberhöhung / Mean power gradient at overfrequency	mittl. Gradient / mean gradient 40,0 % P_M/Hz	
	Max. Einschwingzeit / Max. Settling time	0,6 s	
	Gradient der Wirkleistung nach Rückkehr aus Überfrequenz / Power gradient after recovery of over frequency	mittl. Gradient / mean gradient 9,02 %Pn/Hz max. Gradient / max. gradient 9,06 %Pn/Hz	
Unterfrequenz / underfrequency	Mittlerer Gradient der Wirkleistung sum Zeitpunkt der Frequenzunterschreitung / Mean power gradient at underfrequency	mittl. Gradient / mean gradient 42,5 % P_M/Hz	
	Max. Einschwingzeit / Max. Settling time	0,5 s	
	Gradient der Wirkleistung nach Rückkehr aus Unterfrequenz / Power gradient after recovery of under frequency	mittl. Gradient / mean gradient 10,4 %Pn/Hz max. Gradient / max. gradient 11,4 %Pn/Hz	
Die EZE kann mit reduzierter Leistung betrieben werden. / The unit is able to run at reduced power		☒ Ja / Yes	☐ Nein / No
Maximale Sollwertabweichung der Wirkleistung Max. deviation of power setting		Überschreitung / Exceeding 0,4 kW	Unterschreitung / Undercut 0,0 kW
Trennung vom Nets bei Wirkleistungssollwertvorgabe von: Disconnection from the grid at external active power setpoints at:		-- % Pn No disconnection is recorded. Operation at 0%Pn is evidenced.	
Einschwingzeit der Leistung für einen Sollwertsprung mit minimalem Gradienten / Response time of the power output after a change in setpoint with minimal gradient		P0 -> Pmin	Zeit / time : 45,5 s Gradient: 0,33 % Pn / s
		Pmin -> P0	Zeit / time : 44,6 s Gradient: 0,33 % Pn / s
Einschwingzeit der Leistung für einen Sollwertsprung mit maximalem Gradienten / Response time of the power output after a change in setpoint with maximum gradient		P0 -> Pmin	Zeit / time : 112,3 s Gradient: 0,67 % Pn / s
		Pmin -> P0	Zeit / time : 111,5 s Gradient: 0,67 % Pn / s

As stated in the Manufacturer Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0". Dated on October 08th, 2020.

"Active power output is dependent on the ambient temperature according to the following curves."

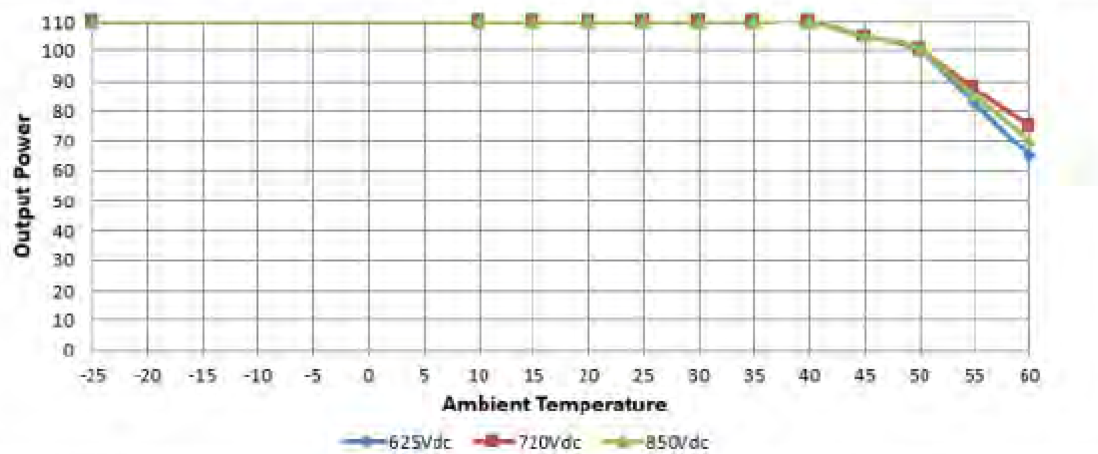
SUN2000-100KTL-M1/INM0 Temperature derating curve



MPPT Input	-25°C	30°C	35°C	40°C	45°C	50°C	55°C	60°C
540 Vdc	110kVA	110kVA	105kVA	100kVA	92.5kVA	85kVA	77.5kVA	70kVA
600 Vdc	110kVA	110kVA	105kVA	100kVA	94kVA	88kVA	82kVA	76kVA

Grid Voltage：400Vac, PF=1

SUN2000-100KTL-M1/INM0 Temperature derating curve

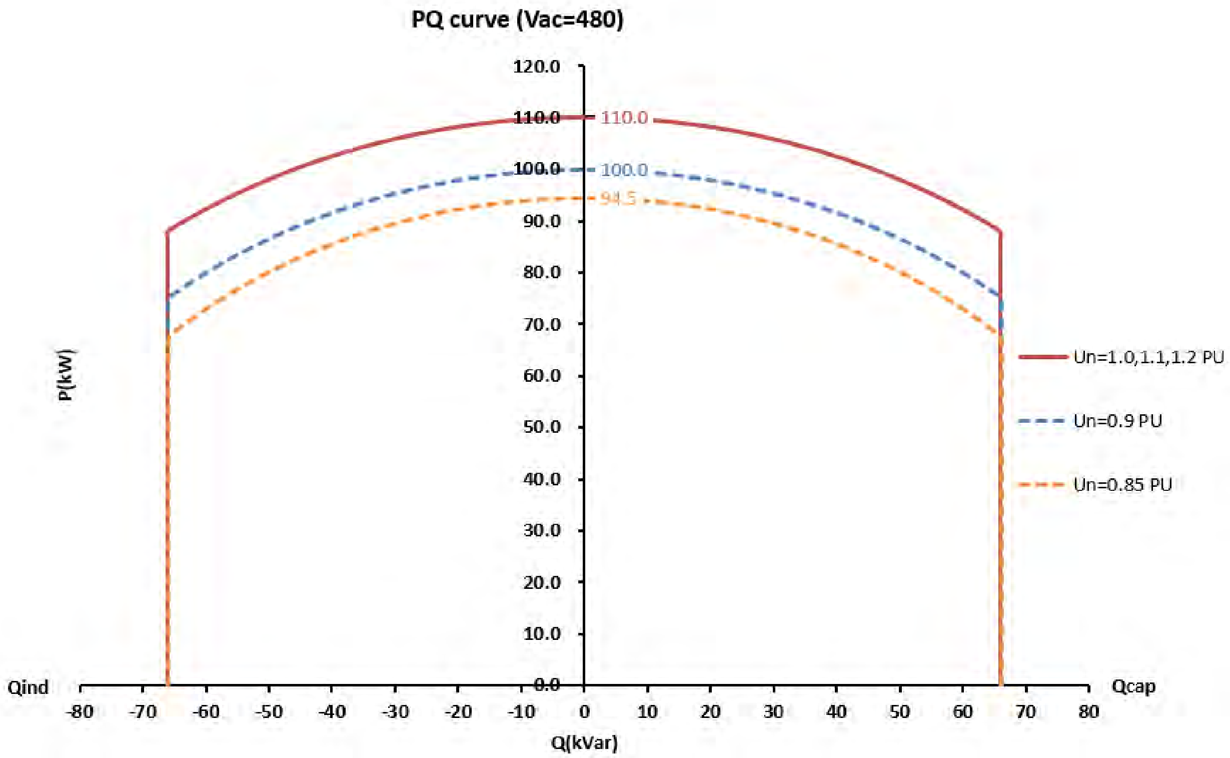


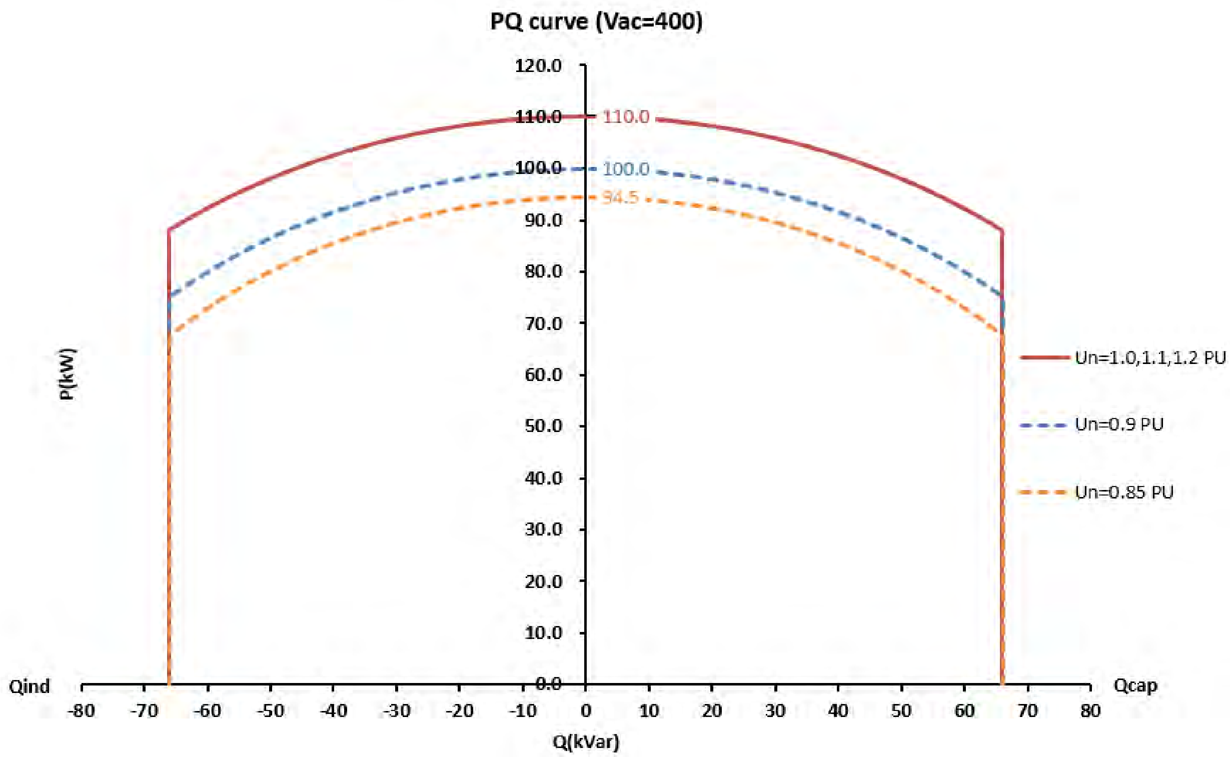
MPPT Input	-25°C	35°C	35°C	40°C	45°C	50°C	55°C	60°C
625 Vdc	110kVA	110kVA	110kVA	110kVA	105kVA	100kVA	82.5kVA	65kVA
720 Vdc	110kVA	110kVA	110kVA	110kVA	105kVA	100kVA	87.5kVA	75kVA
850 Vdc	110kVA	110kVA	110kVA	110kVA	105kVA	100kVA	85kVA	70kVA

Grid Voltage：480Vac, PF=1

2.3.2 Procedure for reactive power provision

The certified PV inverter fulfils the following P-Q diagram at different voltage levels, as stated in the Manufacturer Declaration for SUN2000-100KTL-M1 / SUN2000-100KTL-INM0. Dated on March 20th, 2020:





2.3.3 Blindleistungbereitstellung / Provision of reactive power

	P/Pn	Qind	Q0	Qkap	P/Pn	Qind	Q0	Qkap
Blindleistungsregelung im Normalbetrieb und maximaler Blindleistungstellbreich / Control of reactive power in normal operation and maximum reactive power range	0%	66,551	0,548	65,558	60%	66,409	0,310	65,818
	10%	66,537	0,469	65,607	70%	66,396	0,277	65,878
	20%	66,517	0,447	65,652	80%	66,388	0,245	65,944
	30%	66,503	0,419	65,689	90%	66,234	0,209	65,788
	40%	66,492	0,386	65,711	100%	-- (*)	0,175	-- (*)
	50%	66,436	0,344	65,755	110%	-- (*)	0,367	-- (*)
	Q in kVAr							

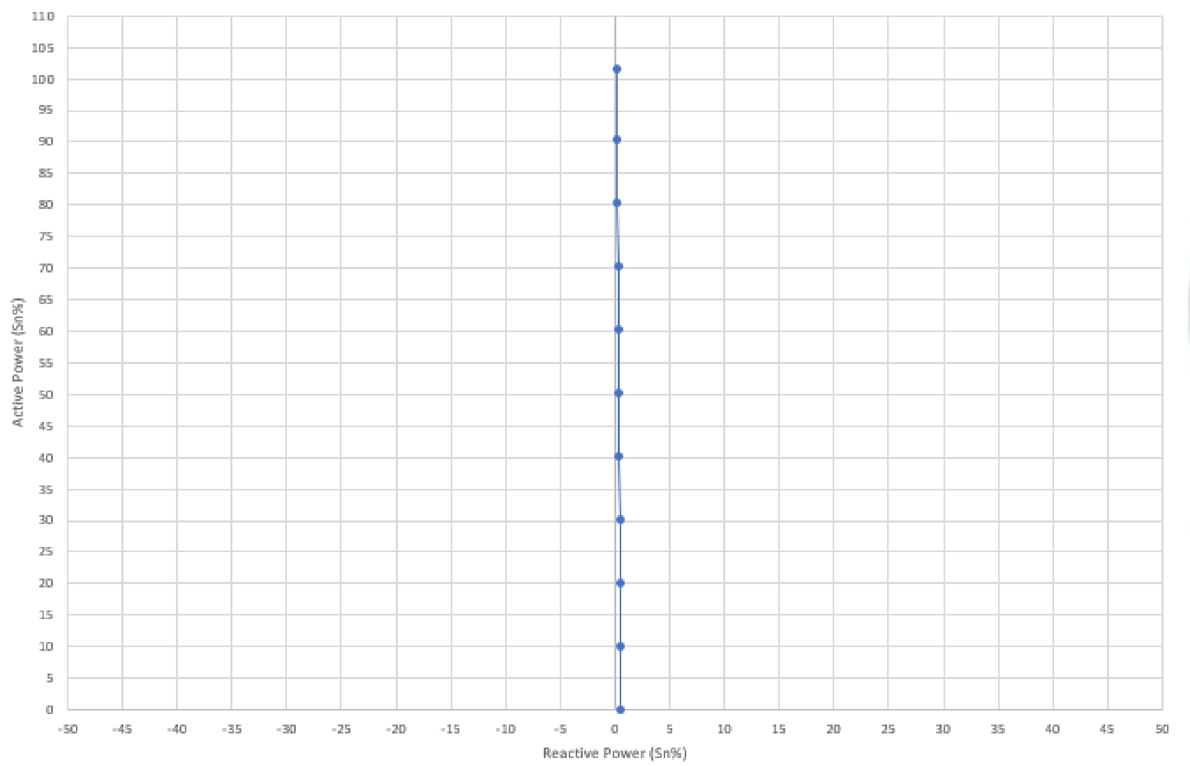
	AP / WP	U/Un in %	P/Pn in %	Q in kVAr
Arbitspunkte des spannungsanhängigen P-Q Diagramms / Working points of the voltage dependent P-Q diagram	1 ind	89,88	70,13	65,69
	2 ind	110,77	90,40	62,66
	1 kap / cap	89,75	69,86	66,27
	2 kap / cap	110,77	90,06	63,53

Blindleistungsregelung durch Sollwertvorgabe / Control of reactive power through set point signal	☐Verschiebungsfaktor / power factor	☒Blindleistung / reactive power
	Pbin bei / at Qmax	50 %Pn
Längste Einsschwingzeit / Longest response time	Parameter	Einsschwingzeit / settling time
	T < 6 s	0,9 s
	Standardzeit / standard time	--
	T < 60 s	57,5 s
Einstellgenauigkeit des Verschiebungsfaktors bzw. Blindleistung / Positioning accuracy of power factor or reactive power	Sollwert / setpoint	Istwert / measured value
	33,000 kVAr	32,978 kVAr
	0 kVA	0,243 kVAr
	-33,000 kVA	-33,301 kVAr
Anmerkung / remark	Soweit Q(U) und Q(P)- Regelung wurde, sind diese im Prüfbericht hinterlegt / See Q(U) and Q(P) in test report	

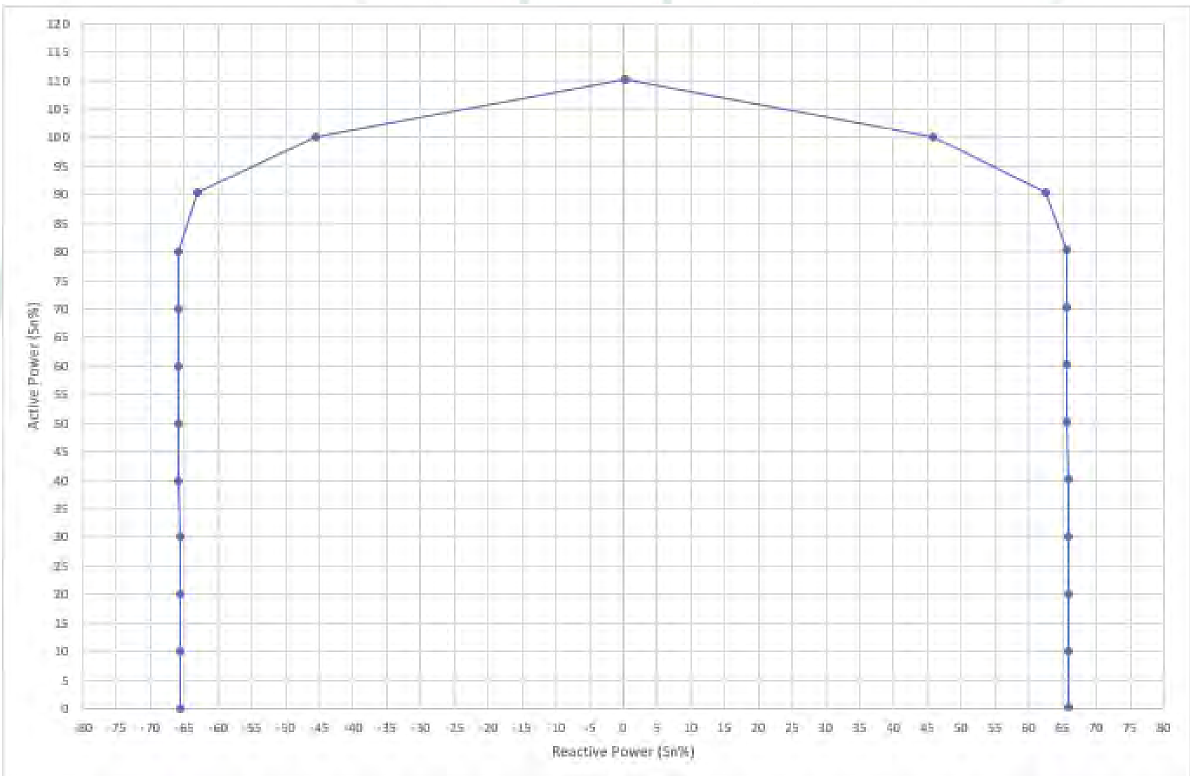
(*) The inverter works in reactive power priority in this mode. The inverter does not reach the fixed active power value of 90%Pn and 100%Pn due to the current limitation function.

In following charts, they are offered main results after performed tests included in the FGW TG3 test report.

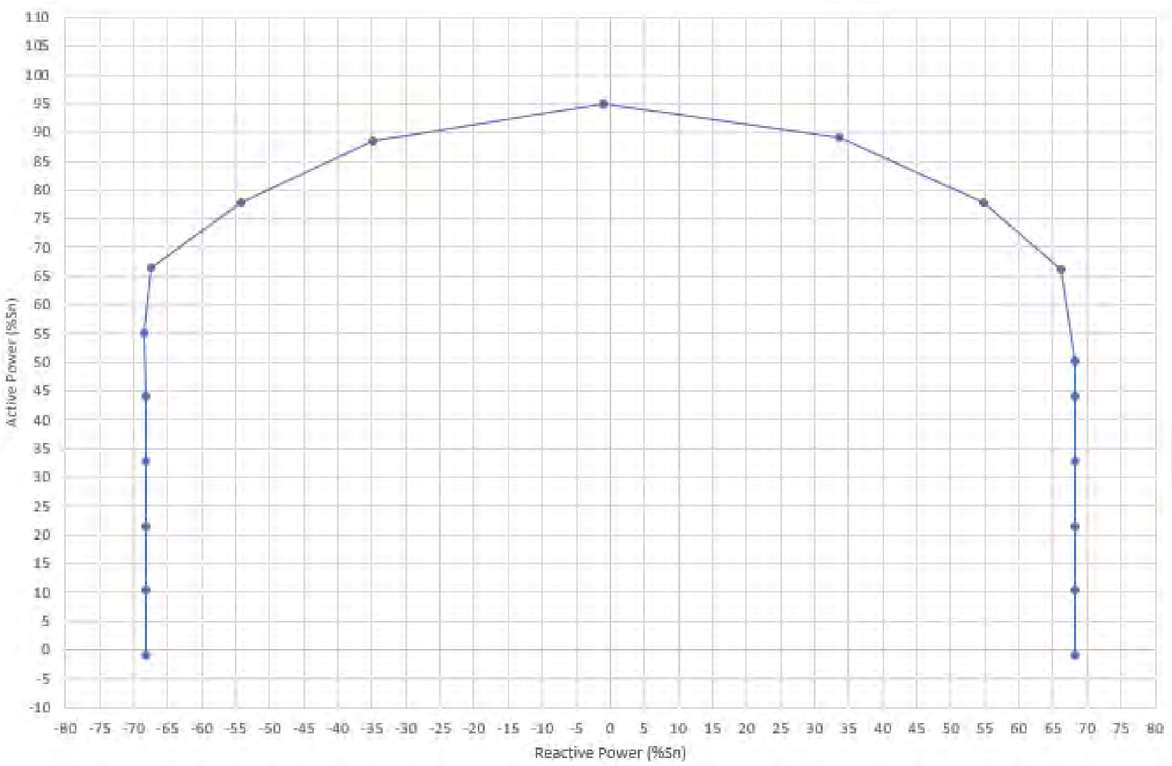
Q = 0 kVAr: Active Power over Reactive Power



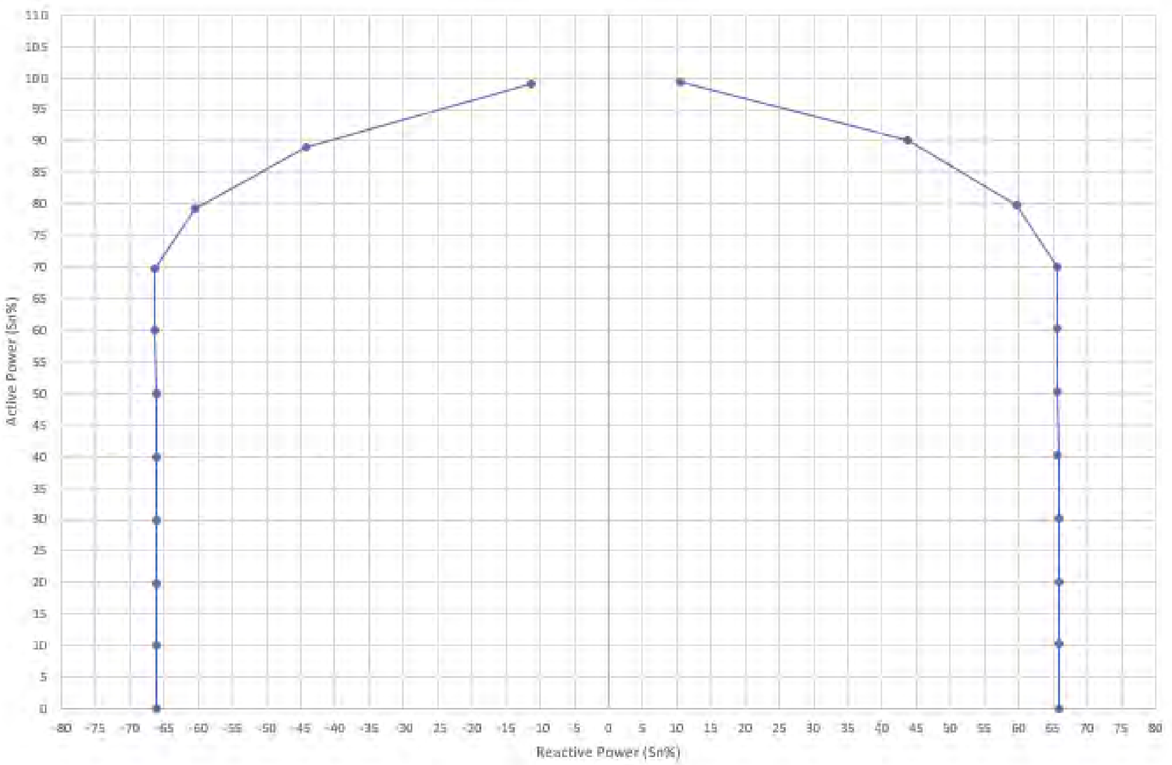
Q capabilities at Rated Voltage: Active Power over Reactive Power



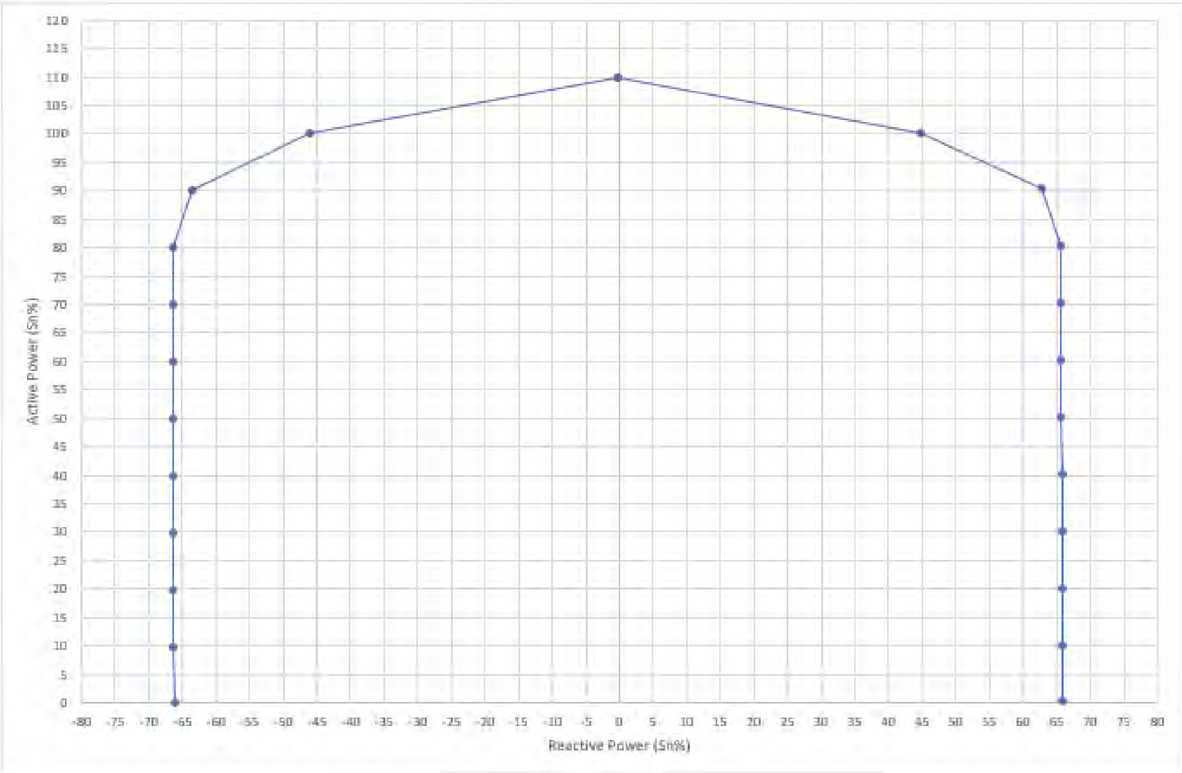
Q capabilities at Rated Voltage at U=85%Un: Active Power over Reactive Power



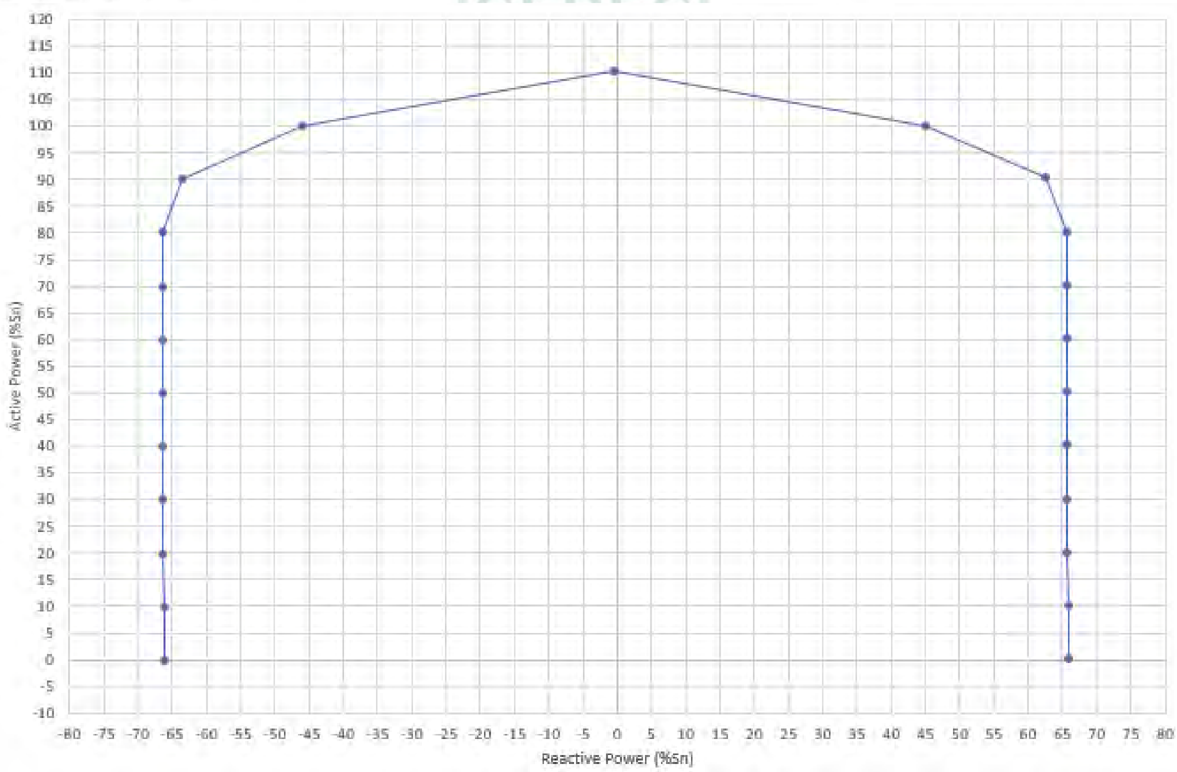
Q capabilities at Rated Voltage at U=90%Un: Active Power over Reactive Power



Q capabilities at Rated Voltage at U=110%Un: Active Power over Reactive Power



Q capabilities at Rated Voltage at U=120%Un: Active Power over Reactive Power



SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

2.4 Protection system

2.4.1 Trennung der EZE vom Netz / Cut-off from grid

☒ Die Überprüfung der Gesamtwirkungskette führte zu einer erfolgreichen Abschaltung.
The test of the whole trip circuit led to a successful shut down

	Einstellwert Setting In pu oder/or [Hz]		Auslösewert / Release value In pu oder/or [Hz]		Abschaltzeit / Disconnection time [ms]		Rückfallverhältnis Disengaging ratio
	Schwelle / value	Zelt / Time (ms)	Min.	Max.	Min.	Max.	
Spannungssteigerungsschutz/ Overvoltage protection: U>	1,000	180000	1,000	1,007	180000	180300	☒≥0.98 ☐<0.98
	1,250	50	1,246	1,250	50	80	
Spannungssteigerungsschutz/ Overvoltage protection: U>>	1,000	100	1,000	1,007	100	130	---
	1,300	50	1,296	1,303	50	86	
Spannungsrückgangsschutz/ Undervoltage protection: U<	0,100	50	0,145	0,150	50	83	☒≤1.02 ☐>1.02
	1,000	2400	0,992	1,001	2400	2444	
Spannungsrückgangsschutz/ Undervoltage protection: U<<	0,100	50	0,143	0,150	77	83	☒≤1.02 ☐>1.02
	1,000	800	0,991	1,001	822	836	
Frequenzsteigerungsschutz/ Overfrequency protection: F>	50,00	5000	50,00		5040		---
	55,00	50	55,00		74		
Frequenzsteigerungsschutz/ Overfrequency protection: F>>	50,00	100	50,00		128		---
	55,00	50	55,01		66		
Frequenzrückgangsschutz/ Underfrequency protection: F<	45,00	50	45,00		83		---
	50,00	100	49,99		126		
Eigenzeit der Abschalteinheit / Operating time of a circuit breaker:	☐ **aus Messung** by measurement				☒ **aus Prüfzertifikat** by test certificate		
	According to the relay specification, the operation time of circuit breaker is always the same < 30 ms, and the release time is always the same < 10 ms. See next page.						

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

产品规格书 Specification

厦门宏发电声股份有限公司

Xiamen Hongfa Electroacoustic Co.,Ltd.

电话 Tel：（86）- 592-6106888
传真 Fax：（86）- 592-6106878
网址：Web site:www.hongfa.com

产品规格书

Specification

文件编号 File No.：4523882GG3001

顾客 Customer: 华为技术

顾客产品名称 Your Product Name:

顾客零件号 Your Part No.: 11010360

宏发产品名称 Our Product Name: 继电器 RELAY

宏发产品型号 Our Product model: HF167F-200/12-HSF

发布日期 Publish Date: 2019.5.27

生产工厂 Production Plant:

版本 Version: a 更改单号 Number of Modification:

宏发审批签字 Signature by Hongfa			顾客确认 Custom Approval
拟制 Make	审核 Check	批准 Approved	负责人 By:
傅飞飞	朱艺青	刘金枪	日期 Date:

特别说明：
1. 此规格书请顾客在2周内确认，如未在规定时间内答复，则视为同意。
2. 自提供规格书之日起2年内，顾客没有下单订货，本规格书失效。

Especially claim:
1. This specification is expected to be checked within 2 weeks. Without feedback after 2 weeks, Hongfa will take it as granted that customer approves of this specification.
2. This specification will be invalid if no order within 2 years.

- 1 - 保存期限：长期 保存部门：技术系统

产品规格书 Relay Specification

顾客 Customer: 华为技术

1 品种 Type Model

1.1 种类 Kinds: 电磁继电器 Electromagnetic Relay

1.2 型号 Type: HF167F-200/12-H3F

1.3 外形尺寸 Outline: 65 mm×45.9 mm×53 mm

1.4 触点形式 Contact Arrangement: 一组常开 1 Form A

1.5 触点材料 Contact Material: AgNi

2 安全认证 Safety Approval

认证机构 Certification Agency	认证号 File No.
TÜV	R 50374273
UL/CUL	E133481

上述认证号代表该产品取得相关认证，但具体认证内容请以我公司提交的认证证书为准。The above certificate No. is just a license No. Please refer to the certificates we supplied for detail information.

3 线圈额定参数 Coil Rating

at 23 ℃

额定电压 Rated Voltage Vd.c.	动作电压 Operate Voltage Vd.c.	保持电压 Holding Voltage Vd.c.	释放电压 Release Voltage Vd.c.	允许最大线圈电压 Max. Allowable Coil Voltage Vd.c.	线圈电阻 Coil Resistance Ω	线圈功耗 Coil Power W 大约 Approx.
12	≤8.4	4.8～12（at 23 ℃） 6～7.2（at 85 ℃）	≥1.2	14.4	48×(1±10%)	3

备注 Note:

（1）线圈保持电压为线圈施加额定电压 100 ms 以后施加的线圈电压； The coil holding voltage is the voltage applied to coil 100 ms after the rated voltage.

（2）继电器线圈不允许长时间施加超过保持电压的上限值，防止继电器过热烧毁。To avoid overheating and burning, the coil can not be consistently applied to with voltage larger than maximum holding voltage.

4 触点参数 Contact Specification

4.1 触点额定负载 Contact Rating: 50 A, 300 Va.c.

产品规格书 Specification

4.2 最大切换电流 Max. Switching Current: 200 A

4.3 最大切换电压 Max. Switching Voltage: 800 Va.c.

4.4 最小适用负载 Min. Applicable Load: 24 V, 1 A

4.5 触点间隙 Contact gap: ≥1 mm

4.6 最大切换功率 Max. Switching power: 160000 VA

5 性能 Performance

5.1 初始接触电阻 Initial Contact Resistance:

出厂检验控制值 Delivery Inspection: ≤1 mΩ (at 6 Vd.c. 20A) (四端法 Four Probe Method).

华为入库检验: ≤3 mΩ (在 20 A 6Vd.c 下测试, 触点加载60 s, 如果不合格则重新测试, 以触点加载300 s后接触电阻进行判定)。

Incoming inspection of HUAWEI: ≤3mΩ (At 20 A 6Vd.c., after 60s current-carrying.If it is not satisfied, measure again after 300s and make a pass or fail judgment).

5.2 动作时间 Operate Time: ≤ 30 ms.

5.3 释放时间 Release Time: ≤ 10 ms.

5.4 耐久性 Endurance

5.4.1 电耐久性 Electrical Endurance

结构型式 Version	触点材料 Contact Material	触点负载 Contact Rating	环境温度 Ambient Temperature	通断比 ON: OFF	电耐久性 Electrical Endurance
H 型 type H	AgNi	阻性负载 Resistive Load 接通 50A 断开 200A, 800Va.c. Making 50A Breaking 200A 800Va.c.	85℃	1s:9s	100 次(ops)
H 型 type H	AgNi	阻性负载 Resistive Load 50A, 800Va.c.	85℃	1s:9s	1×10^{4} 次(ops)

5.4.2 机械耐久性 Mechanical Endurance

结构型式 Version	触点负载 Contact Rating	环境温度 Ambient Temperature	通断比 ON: OFF	机械耐久性 Mechanical Endurance
H 型 type H	无负载 No load	常温 Room Temperature	0.17 s: 0.17 s	1×10^{6} 次 (ops)

5.5 介质耐压 Dielectric Strength (漏电流 Leak Current: 1 mA)

5.5.1 断开触点电路的各引出端之间 Between terminals of each opened contact circuit: 2000 Va.c. (50/60 Hz 1 min).

5.5.2 所有线圈引出端与所有触点电路引出端之间 Between all coil terminals and all contact circuit terminals: 5000 Va.c. (50/60 Hz 1 min).

- 4 -

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

2.4.2 Zuschaltbedingungen / Cut-in conditions

- For VDE-AR-N 4110: 2018-11

	Bereich / range In pu order/ or [Hz]	Zuschaltung erfolgte im angegebenen Bereich / cut in occurred within the given range	
Zpannung / Voltage:	0,90 – 1,10	☐ nein / no	☒ ja / yes
Frequenz / Frequency:	47,5 – 50,2	☐ nein / no	☒ ja / yes

- For VDE-AR-N 4120: 2018-11

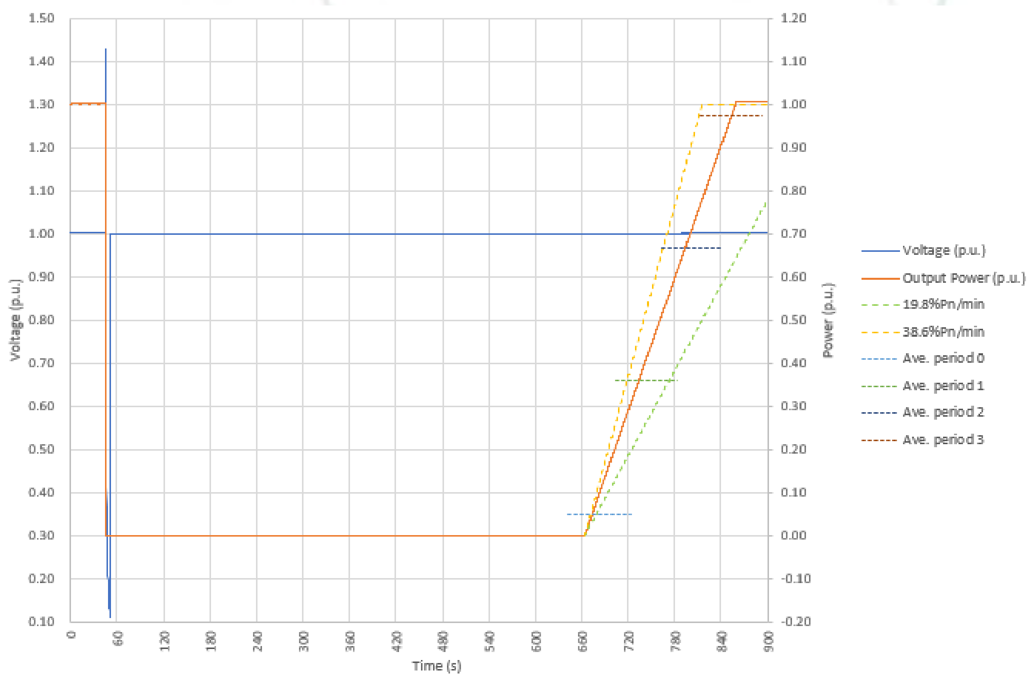
	Bereich / range In pu order/ or [Hz]	Zuschaltung erfolgte im angegebenen Bereich / cut in occurred within the given range	
Zpannung / Voltage:	0,90 – 1,10	☐ nein / no	☒ ja / yes
Frequenz / Frequency:	47,5 – 51,0	☐ nein / no	☒ ja / yes

2.4.3 Zuschaltbedingungen nach Auslösung des Entkupplungsschutzes / Cut-in conditions after tripping of protection

	Bereich / range In pu order/ or [Hz]	Zuschaltung erfolgte im angegebenen Bereich cut in occurred within the given range	
Unterspannung / Undervoltage:	> 0,95	☐ nein / no	☒ ja / yes
Unterfrequenz / Underfrequency:	≥ 49,9	☐ nein / no	☒ ja / yes
Überfrequenz / Overfrequency:	≤ 50,1	☐ nein / no	☒ ja / yes

As evidenced in the FGW TG3 test report, the certified unit follows a ramp gradient inside of the range 33%Pn/s – 66%Pn/s after the reconnection occurs.

Graphical representation of the test over time



SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

2.5 Response during grid faults

The compliance with these requirements including all calculations defined in the FGW TR3 standard is stated in the attachement to the test report:

- **2219 / 0373-Att1 : FGW-TG3: Grid Fault Tests Results**

3 FGW TR4 VALIDATION REPORT

Number: 2219 / 0373 – E1 – TG4 with date 2020-10-09 according FGW TR4 rev. 9.

Software Characteristics

- Software type: Simulator for Grid Connected Power Conversion System
- Simulation platform: DigSilent PowerFactory
- Used version of the simulation platform: 20.0.3_A.2 (*)
- Simulation Software File identification: Huawei_VDE4120&4110_SUN2000-100KTL-M1_400V_Enc_V1.7.pfd
- Dynamic Simulation Model version: V1.7
- MD5 Checksum: 82CDCCA8DF02BB7E83EEEDF3ED06CE01

(*) Simulation results offered in the validation report were obtained with the Powerfactory Digsilent Version 20.0.3_A.2. The validation report doesn't cover upper version of Digsilent above V20.0.3_A.2.

The model is in accordance with the requirements of the clause 5 of FGW TR4 rev.9. The validation of the dynamic simulation model has been performed in order to be compliant with evaluations required in the point 2.3.3 of the standard FGW TR8, rev9.

Requirements of the clause 11.2.6.3 of standards VDE-AR-N 4110: 2018 and VDE-AR-N 4120: 2018 have been considered for the evaluation process.

Deviations evaluated for MXE, ME and MAE calculations are in accordance with the chapter 5.3 of FGW TR4 rev.9.

The validation plan is according with the chapter 5.1 of FGW TR4 rev.9. where following tests have been used for validation:

- Validation requirements for voltage ride through:
  This involves the validation of symmetrical and asymmetrical test cases defined in the table 4-69 of the chapter 4.6.3 of FGW TR3 rev.25 for Type 2 PGUs.

- Validation of P and Q setpoint control functions
  This involves the validation of the dynamic response of the simulation model in front of P and Q changes commanded by set point. Test requirements offered in the chapter 4.2.4 of FGW TR3 rev.25 are considered.

- Validation requirements for reactive power control processes:
  This involves the validation of accuracy requirements defined in chapters 4.2.5 (Q vs U) and 4.2.6 (Q vs P) of FGW TR3 rev.25.

- Verification of requirements for protective settings:
  This involves the verification of the parameters for protection devices and settings declared by default for the certified product.

The validation overview for VRT cases is compliant with the Annex A.1.1, included in the report and compared with the validation overview in accordance with the table A-1. See FRT validation results in the point 2.1 of this document.

The additional plausibility tests have been performed in accordance with the chapter 5.5 of FGW TR4 rev.9.

See further information of the dynamic simulation model and the software used in the point 4 of this annex.

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

3.1 Validation results

3.1.1 Validation overview

The following table shows the FRT validation results in terms of deviations as defined by the standard for the positive and negative sequences of currents and powers in symmetrical and asymmetrical fault conditions at nominal and partial power.

All deviations are in accordance to the regular maximum tolerances given by the standard.

Test designation compliant with TR3, Chapter 4.6 Response during grid faults. Table 4-67			Three phase voltage drops in Positive phase sequence system											
			P			Q			Ia			Iq		
			MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE
Ures ≤ 0,05	In accordance with IEC	Pre	0,0054	0,0041	0,0041	0,0037	0,0023	0,0023	0,0176	-0,0129	0,0129	0,0037	0,0023	0,0023
0.1		Fault	0,0271	-0,0916	0,0234	0,0061	0,0097	0,0046	0,3251	-0,2693	0,2819	0,0807	0,1459	0,0700
3ph/100%/2		Post	0,0101	0,0065	0,0068	0,0050	0,0024	0,0045	0,0136	-0,0115	0,0151	0,0050	0,0011	0,0057
Ures ≤ 0,05	In accordance with IEC	Pre	0,0106	-0,0101	0,0101	0,0020	-0,0003	0,0008	0,0113	-0,0109	0,0109	0,0020	-0,0003	0,0008
0.2		Fault	0,0281	-0,0349	0,0250	0,0125	0,0152	0,0115	0,3456	-0,2384	0,3111	0,0855	0,1402	0,0758
3ph/20%/2		Post	0,0118	-0,0102	0,0107	0,0015	-0,0014	0,0020	0,0126	-0,0119	0,0124	0,0015	-0,0014	0,0024
0,20≤Ures≤0,30	In accordance with IEC	Pre	0,0039	-0,0022	0,0023	0,0043	0,0033	0,0033	0,0034	-0,0008	0,0009	0,0043	0,0033	0,0033
25.1		Fault	0,0088	-0,0268	0,0066	0,0108	0,0017	0,0057	0,0292	-0,0357	0,0216	0,0222	0,0096	0,0189
3ph/100%/2		Post	0,0083	-0,0035	0,0048	0,0062	0,0021	0,0060	0,0093	-0,0035	0,0047	0,0062	0,0007	0,0071
0,20≤Ures≤0,30	In accordance with IEC	Pre	0,0024	-0,0019	0,0019	0,0021	-0,0003	0,0007	0,0030	-0,0025	0,0025	0,0021	-0,0003	0,0007
25.2		Fault	0,0087	-0,0088	0,0072	0,0584	-0,0026	0,0067	0,0288	-0,0194	0,0231	0,0224	-0,0004	0,0189
3ph/20%/2		Post	0,0042	-0,0017	0,0024	0,0012	-0,0013	0,0016	0,0048	-0,0030	0,0037	0,0012	-0,0016	0,0018
0,45≤Ures≤0,60	In accordance with IEC	Pre	0,0034	-0,0024	0,0024	0,0043	0,0030	0,0030	0,0016	-0,0011	0,0011	0,0043	0,0030	0,0030
50.1		Fault	0,0519	0,0377	0,0462	0,0664	-0,0245	0,0295	0,1237	0,0710	0,0787	0,0805	-0,0533	0,0640
3ph/100%/2		Post	0,0039	0,0030	0,0076	0,0048	0,0027	0,0046	0,0047	0,0027	0,0055	0,0047	0,0024	0,0048
0,45≤Ures≤0,60	In accordance with IEC	Pre	0,0022	-0,0018	0,0018	0,0022	-0,0003	0,0008	0,0028	-0,0024	0,0024	0,0022	-0,0003	0,0008
50.2		Fault	0,0212	0,0170	0,0178	0,0248	-0,0156	0,0227	0,0365	0,0280	0,0265	0,0618	-0,0414	0,0561
3ph/20%/2		Post	0,0064	-0,0016	0,0021	0,0033	-0,0023	0,0024	0,0057	-0,0031	0,0032	0,0033	-0,0032	0,0033
0,45≤Ures≤0,60	In accordance with IEC	Pre	0,0059	-0,0040	0,0040	0,0027	0,0008	0,0009	0,0040	-0,0024	0,0025	0,0027	0,0008	0,0009
50.5		Fault	0,0013	-0,0139	0,0011	0,0033	-0,0031	0,0032	0,0017	-0,0140	0,0012	0,0067	-0,0061	0,0065
3ph/20%/2L		Post	0,0136	0,0020	0,0070	0,0062	0,0020	0,0023	0,0207	0,0042	0,0065	0,0061	0,0020	0,0023
0,70≤Ures≤0,80	In accordance with IEC	Pre	0,0037	-0,0028	0,0028	0,0046	0,0029	0,0029	0,0021	-0,0015	0,0015	0,0046	0,0029	0,0029
75.1		Fault	0,0447	-0,0231	0,0201	0,0327	0,0169	0,0134	0,0414	-0,0272	0,0263	0,0491	0,0220	0,0172
3ph/100%/2		Post	0,0054	-0,0008	0,0031	0,0057	0,0026	0,0046	0,0064	-0,0016	0,0022	0,0057	0,0023	0,0049
0,70≤Ures≤0,80	In accordance with IEC	Pre	0,0024	-0,0019	0,0019	0,0020	-0,0003	0,0009	0,0029	-0,0025	0,0025	0,0020	-0,0003	0,0009
75.2		Fault	0,0100	0,0048	0,0050	0,0344	0,0092	0,0048	0,0145	0,0072	0,0065	0,0601	0,0124	0,0064
3ph/20%/2		Post	0,0081	-0,0014	0,0018	0,0013	-0,0013	0,0017	0,0073	-0,0028	0,0030	0,0013	-0,0015	0,0019
0,70≤Ures≤0,80	In accordance with IEC	Pre	0,0024	-0,0019	0,0019	0,0033	-0,0021	0,0021	0,0055	-0,0050	0,0050	0,0043	-0,0031	0,0031
75.3		Fault	0,0071	0,0060	0,0062	0,0484	0,0270	0,0236	0,0150	0,0086	0,0081	0,0786	0,0360	0,0308
3ph/20%/2		Post	0,0032	-0,0014	0,0017	0,0031	-0,0024	0,0025	0,0058	-0,0052	0,0053	0,0043	-0,0038	0,0040
0,70≤Ures≤0,80	In accordance with IEC	Pre	0,0031	-0,0015	0,0016	0,0027	-0,0008	0,0011	0,0051	0,0006	0,0006	0,0035	-0,0015	0,0016
75.4		Fault	0,0048	0,0036	0,0038	0,0214	-0,0112	0,0192	0,0138	0,0057	0,0050	0,0369	-0,0147	0,0286
3ph/20%/2		Post	0,0080	-0,0010	0,0014	0,0026	-0,0019	0,0020	0,0100	0,0001	0,0017	0,0030	-0,0025	0,0025
0,70≤Ures≤0,80	In accordance with IEC	Pre	0,0066	-0,0021	0,0021	0,0018	-0,0006	0,0006	0,0071	-0,0026	0,0026	0,0018	-0,0006	0,0006
75.5		Fault	0,0292	0,0148	0,0151	0,0818	0,0299	0,0239	0,0463	0,0199	0,0195	0,1293	0,0397	0,0309
3ph/≥10%/4		Post	0,0033	-0,0010	0,0013	0,0024	-0,0009	0,0018	0,0026	-0,0023	0,0024	0,0024	-0,0011	0,0020

Test designation compliant with TG3, Chapter 4.6 Response during grid faults. Table 4-67			Three phase voltage drops in Positive phase sequence system											
			P			Q			Ia			Iq		
			MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE
0,75≤Ures≤0,85	In accordance with IEC	Pre	0,0092	-0,0078	0,0078	0,0046	0,0028	0,0028	0,0076	-0,0062	0,0062	0,0046	0,0028	0,0028
80.1		Fault	0,0444	-0,0225	0,0202	0,0446	0,0229	0,0198	0,0369	-0,0249	0,0243	0,0602	0,0286	0,0246
3ph/100%/2L		Post	0,0056	0,0002	0,0025	0,0040	0,0020	0,0042	0,0061	-0,0008	0,0022	0,0040	0,0017	0,0044
0,85≤Ures≤0,90	In accordance with IEC	Pre	0,0048	-0,0004	0,0005	0,0036	0,0023	0,0023	0,0031	0,0009	0,0010	0,0036	0,0023	0,0023
85.1		Fault QS1	0,0328	--	0,0114	0,0379	--	0,0127	0,0235	--	0,0153	0,0475	--	0,0142
3ph/100%/2		Fault	--	-0,0071	--	--	0,0023	--	--	-0,0080	--	--	0,0026	--
		Fault QS2	0,0933	--	0,0067	0,0149	--	0,0012	0,0080	--	0,0017	0,0156	--	0,0014
		Post	0,0044	0,0006	0,0009	0,0056	0,0033	0,0035	0,0000	0,0015	0,0000	0,0055	0,0033	0,0035
Ures≥1,15	In accordance with IEC	Pre	0,0016	-0,0007	0,0007	0,0045	0,0031	0,0031	0,0010	0,0004	0,0004	0,0045	0,0031	0,0031
115.1		Fault	0,0038	0,0012	0,0012	0,0550	-0,0020	0,0080	0,0163	0,0008	0,0039	0,0435	-0,0019	0,0061
3ph/100%/2		Post	0,0049	-0,0008	0,0011	0,0050	0,0046	0,0046	0,0057	0,0025	0,0026	0,0050	0,0045	0,0045
Ures≥1,15	In accordance with IEC	Pre	0,0029	-0,0025	0,0025	0,0021	-0,0006	0,0007	0,0035	-0,0031	0,0031	0,0021	-0,0006	0,0007
115.2		Fault	0,0038	0,0029	0,0028	0,0444	0,0033	0,0112	0,0035	0,0024	0,0026	0,0345	0,0028	0,0091
3ph/20%/2		Post	0,0042	-0,0014	0,0014	0,0035	0,0005	0,0021	0,0048	-0,0016	0,0019	0,0035	0,0004	0,0019
Ures≥1,10	In accordance with IEC	Pre	0,0018	-0,0014	0,0014	0,0026	-0,0009	0,0011	0,0025	-0,0020	0,0020	0,0026	-0,0009	0,0011
110.3		Fault	0,0031	0,0008	0,0008	0,0271	0,0069	0,0073	0,0029	0,0008	0,0003	0,0247	0,0061	0,0065
3ph/≥10%/2		Post	0,0025	-0,0013	0,0013	0,0021	0,0006	0,0019	0,0000	-0,0017	0,0000	0,0021	0,0005	0,0018

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

Test designation compliant with TR3, Chapter 4.6 Response during grid faults. Table 4-67			Two phase voltage drops in Positive phase sequence system											
			P			Q			Ia			Iq		
			MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE
Ures ≤ 0,05	In accordance with IEC	Pre	0,0043	0,0034	0,0034	0,0040	0,0025	0,0025	0,0052	0,0046	0,0046	0,0040	0,0025	0,0025
0.3		Fault	0,0021	-0,0571	0,0011	0,0204	-0,0022	0,0187	0,0039	-0,0542	0,0020	0,0364	-0,0018	0,0347
2ph/100%/2		Post	0,0074	0,0006	0,0062	0,0056	0,0014	0,0054	0,0082	0,0021	0,0073	0,0056	0,0008	0,0059
Ures ≤ 0,05	In accordance with IEC	Pre	0,0112	-0,0102	0,0102	0,0017	-0,0006	0,0007	0,0112	-0,0102	0,0102	0,0017	-0,0006	0,0007
0.4		Fault	0,0021	-0,0107	0,0011	0,0136	0,0038	0,0127	0,0038	-0,0078	0,0019	0,0240	0,0099	0,0225
2ph/20%/2		Post	0,0109	-0,0097	0,0107	0,0030	-0,0020	0,0027	0,0109	-0,0098	0,0106	0,0030	-0,0026	0,0031
0,20≤Ures≤0,30	In accordance with IEC	Pre	0,0027	-0,0017	0,0017	0,0035	0,0024	0,0024	0,0011	-0,0006	0,0006	0,0035	0,0024	0,0024
25.4		Fault	0,0031	-0,0192	0,0021	0,0119	-0,0018	0,0084	0,0042	-0,0197	0,0031	0,0212	-0,0024	0,0122
2ph/100%/2		Post	0,0040	-0,0035	0,0042	0,0032	0,0008	0,0041	0,0032	-0,0022	0,0031	0,0032	0,0004	0,0045
0,20≤Ures≤0,30	In accordance with IEC	Pre	0,0027	-0,0017	0,0017	0,0035	0,0024	0,0024	0,0011	-0,0006	0,0006	0,0035	0,0024	0,0024
25.5		Fault	0,0031	-0,0192	0,0021	0,0119	-0,0018	0,0084	0,0042	-0,0197	0,0031	0,0212	-0,0024	0,0122
2ph/20%/2		Post	0,0040	-0,0035	0,0042	0,0032	0,0008	0,0041	0,0032	-0,0022	0,0031	0,0032	0,0004	0,0045
0,45≤Ures≤0,60	In accordance with IEC	Pre	0,0019	-0,0010	0,0010	0,0038	0,0025	0,0025	0,0010	0,0004	0,0004	0,0038	0,0025	0,0025
50.3		Fault	0,0609	-0,0371	0,0290	0,0254	-0,0189	0,0226	0,0776	-0,0456	0,0378	0,0333	-0,0244	0,0294
2ph/100%/2		Post	0,0075	-0,0058	0,0063	0,0042	0,0015	0,0049	0,0083	-0,0053	0,0058	0,0042	0,0012	0,0052
0,45≤Ures≤0,60	In accordance with IEC	Pre	0,0027	-0,0022	0,0022	0,0017	-0,0007	0,0008	0,0026	-0,0022	0,0022	0,0017	-0,0007	0,0008
50.4		Fault	0,0116	0,0090	0,0092	0,0228	-0,0153	0,0197	0,0188	0,0124	0,0119	0,0305	-0,0197	0,0267
2ph/20%/2		Post	0,0073	-0,0019	0,0023	0,0021	-0,0022	0,0022	0,0073	-0,0026	0,0028	0,0021	-0,0024	0,0024
0,45≤Ures≤0,60	In accordance with IEC	Pre	0,0129	-0,0028	0,0028	0,0019	0,0007	0,0007	0,0113	-0,0015	0,0019	0,0019	0,0007	0,0007
50.6		Fault	0,0021	-0,0090	0,0009	0,0082	-0,0070	0,0072	0,0027	-0,0087	0,0012	0,0109	-0,0094	0,0096
2ph/100%/2L		Post	0,0177	0,0143	0,0143	0,0046	0,0001	0,0020	0,0190	0,0153	0,0153	0,0046	0,0001	0,0021
0,75≤Ures≤0,85	In accordance with IEC	Pre	0,0041	-0,0008	0,0009	0,0038	0,0025	0,0025	0,0047	0,0004	0,0005	0,0038	0,0025	0,0025
75.6		Fault	0,0477	-0,0278	0,0252	0,0229	0,0095	0,0076	0,0473	-0,0307	0,0288	0,0277	0,0108	0,0085
3ph/100%/2		Post	0,0076	0,0003	0,0012	0,0038	0,0017	0,0035	0,0059	0,0003	0,0016	0,0038	0,0016	0,0036
0,75≤Ures≤0,85	In accordance with IEC	Pre	0,0025	-0,0021	0,0021	0,0020	-0,0006	0,0009	0,0025	-0,0021	0,0021	0,0020	-0,0006	0,0009
75.7		Fault	0,0113	-0,0001	0,0008	0,0210	0,0020	0,0042	0,0129	0,0002	0,0008	0,0272	0,0023	0,0055
2ph/20%/2		Post	0,0104	-0,0016	0,0018	0,0017	-0,0015	0,0016	0,0104	-0,0020	0,0021	0,0017	-0,0016	0,0017
0,75≤Ures≤0,85	In accordance with IEC	Pre	0,0028	-0,0023	0,0023	0,0017	-0,0004	0,0005	0,0027	-0,0023	0,0023	0,0017	-0,0004	0,0005
75.8		Fault	0,0199	0,0080	0,0083	0,0644	0,0149	0,0100	0,0224	0,0094	0,0094	0,0793	0,0171	0,0113
2ph/≥10%/4		Post	0,0066	-0,0019	0,0023	0,0030	-0,0017	0,0024	0,0066	-0,0024	0,0027	0,0030	-0,0019	0,0025
0,85≤Ures≤0,90	In accordance with IEC	Pre	0,0016	0,0006	0,0006	0,0039	0,0023	0,0023	0,0022	0,0016	0,0016	0,0039	0,0023	0,0023
80.2		Fault	0,0123	-0,0080	0,0076	0,0021	-0,0014	0,0014	0,0082	-0,0071	0,0074	0,0023	-0,0016	0,0015
2ph/100%/0L		Post	0,0117	0,0024	0,0024	0,0044	0,0030	0,0030	0,0123	0,0026	0,0029	0,0044	0,0030	0,0030
Ures≥1,10	In accordance with IEC	Pre	0,0288	-0,0031	0,0032	0,0032	0,0000	0,0005	0,0696	-0,0025	0,0025	0,0030	0,0000	0,0005
110.1		Fault	0,0664	-0,0092	0,0087	0,0472	-0,0107	0,0096	0,0269	-0,0080	0,0071	0,0377	-0,0102	0,0091
2ph/100%/2		Post	0,0044	-0,0025	0,0026	0,0019	0,0008	0,0010	0,0038	-0,0001	0,0022	0,0019	0,0008	0,0010
Ures≥1,10	In accordance with IEC	Pre	0,0032	-0,0029	0,0029	0,0018	0,0008	0,0008	0,0032	-0,0029	0,0029	0,0018	0,0008	0,0008
110.2		Fault	0,0044	-0,0018	0,0019	0,0284	-0,0074	0,0068	0,0043	-0,0021	0,0021	0,0253	-0,0066	0,0061
2ph/20%/2		Post	0,0019	-0,0014	0,0014	0,0024	0,0005	0,0017	0,0019	-0,0012	0,0014	0,0024	0,0005	0,0017

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

Test designation compliant with TR3, Chapter 4.6 Response during grid faults. Table 4-67			Two phase voltage drops in Negative phase sequence system											
			P			Q			Ia			Iq		
			MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE
Ures ≤ 0,05	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0028	-0,0018	0,0018	0,0014	-0,0001	0,0005
0.3		Fault	0,0099	-0,0082	0,0087	0,0201	-0,0347	0,0191	0,0221	-0,0185	0,0196	0,0202	-0,0529	0,0190
2ph/100%/2		Post	0,0000	-0,0001	0,0001	0,0000	0,0005	0,0005	0,0033	-0,0020	0,0028	0,0021	0,0015	0,0029
Ures ≤ 0,05	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0019	-0,0004	0,0004	0,0020	-0,0002	0,0002
0.4		Fault	0,0150	-0,0122	0,0142	0,0048	-0,0213	0,0039	0,0321	-0,0260	0,0305	0,0081	-0,0443	0,0071
2ph/20%/2		Post	0,0000	-0,0001	0,0001	0,0000	0,0005	0,0005	0,0009	-0,0005	0,0013	0,0006	0,0018	0,0023
0,20≤Ures≤0,30	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0030	-0,0018	0,0018	0,0016	-0,0006	0,0008
25.4		Fault	0,0106	-0,0076	0,0084	0,0117	-0,0096	0,0056	0,0313	-0,0225	0,0252	0,0077	-0,0076	0,0056
2ph/100%/2		Post	0,0000	0,0000	0,0001	0,0000	0,0004	0,0004	0,0031	-0,0018	0,0024	0,0029	0,0016	0,0031
0,20≤Ures≤0,30	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0008	-0,0003	0,0003	0,0007	-0,0001	0,0002
25.5		Fault	0,0114	-0,0105	0,0108	0,0018	-0,0040	0,0004	0,0334	-0,0307	0,0318	0,0152	-0,0005	0,0108
2ph/20%/2		Post	0,0000	-0,0001	0,0001	0,0000	0,0005	0,0005	0,0009	-0,0007	0,0011	0,0007	0,0021	0,0025
0,45≤Ures≤0,60	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0030	-0,0019	0,0019	0,0018	-0,0006	0,0007
50.3		Fault	0,0081	-0,0063	0,0067	0,0177	-0,0129	0,0116	0,0363	-0,0287	0,0302	0,0432	-0,0322	0,0268
2ph/100%/2		Post	0,0000	0,0000	0,0000	0,0000	0,0002	0,0003	0,0053	-0,0022	0,0023	0,0025	0,0014	0,0026
0,45≤Ures≤0,60	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0007	-0,0003	0,0003	0,0007	-0,0001	0,0002
50.4		Fault	0,0020	0,0012	0,0012	0,0105	-0,0084	0,0073	0,0091	0,0057	0,0053	0,0208	-0,0151	0,0102
2ph/20%/2		Post	0,0000	0,0000	0,0000	0,0000	0,0002	0,0002	0,0036	-0,0004	0,0006	0,0045	0,0018	0,0020
0,45≤Ures≤0,60	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0036	-0,0011	0,0013	0,0032	-0,0005	0,0009
50.6		Fault	0,0005	0,0004	0,0002	0,0012	-0,0009	0,0009	0,0021	0,0018	0,0009	0,0048	-0,0038	0,0036
2ph/100%/2L		Post	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0046	-0,0013	0,0021	0,0035	-0,0006	0,0013
0,75≤Ures≤0,85	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0041	-0,0020	0,0020	0,0023	-0,0006	0,0009
75.6		Fault	0,0011	-0,0008	0,0008	0,0058	-0,0034	0,0031	0,0099	-0,0068	0,0070	0,0275	-0,0166	0,0146
3ph/100%/2		Post	0,0000	0,0000	0,0000	0,0000	0,0001	0,0001	0,0064	-0,0022	0,0022	0,0025	0,0010	0,0019
0,75≤Ures≤0,85	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0009	-0,0003	0,0003	0,0008	0,0002	0,0002
75.7		Fault	0,0038	0,0019	0,0018	0,0055	-0,0032	0,0030	0,0343	0,0166	0,0161	0,0199	-0,0117	0,0097
2ph/20%/2		Post	0,0000	0,0000	0,0000	0,0000	0,0001	0,0001	0,0046	-0,0003	0,0006	0,0035	0,0012	0,0014
0,75≤Ures≤0,85	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0008	-0,0003	0,0003	0,0006	-0,0001	0,0002
75.8		Fault	0,0056	0,0023	0,0022	0,0153	-0,0100	0,0094	0,0553	0,0221	0,0218	0,0686	-0,0440	0,0397
2ph/≥10%/4		Post	0,0000	0,0000	0,0000	0,0000	0,0001	0,0001	0,0041	-0,0002	0,0007	0,0037	0,0020	0,0022
0,85≤Ures≤0,90	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0027	-0,0017	0,0017	0,0016	0,0000	0,0005
80.2		Fault	0,0002	-0,0001	0,0001	0,0002	-0,0001	0,0001	0,0019	-0,0009	0,0010	0,0019	-0,0010	0,0010
2ph/100%/0L		Post	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0037	-0,0017	0,0018	0,0024	-0,0004	0,0008
Ures≥1,10	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0015	-0,0006	0,0006	0,0010	-0,0003	0,0003
110.1		Fault	0,0014	-0,0011	0,0012	0,0020	-0,0004	0,0003	0,0216	-0,0174	0,0177	0,0140	0,0002	0,0028
2ph/100%/2		Post	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0029	-0,0010	0,0010	0,0016	0,0004	0,0011
Ures≥1,10	In accordance with IEC	Pre	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0006	-0,0003	0,0003	0,0004	-0,0001	0,0001
110.2		Fault	0,0013	0,0010	0,0011	0,0026	-0,0010	0,0010	0,0203	0,0160	0,0162	0,0146	-0,0028	0,0023
2ph/20%/2		Post	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0007	-0,0001	0,0005	0,0004	0,0000	0,0003

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

3.2 Validation conclusion

Once evaluated the entire tests required to carry out the comparison between simulation and real tests, it is demonstrated that the behaviours of the electronic equipment and its dynamic simulation model **FULLY COMPLIES (*)** with validation requirements according to the specifications of the standard:

- FGW Technical Guidelines for Power Generating Units. Part 4 - Revision 9, dated on 01/02/2019 (FGW TG4 Rev.9): Demands on Modelling and Validating Simulation Models of the Electrical Characteristics of Power Generating Units and Systems, Storage Systems as well as their Components.

Using as reference following standards:

- VDE-AR-N 4110: 2018-11. Technical requirements for the connection and operation of customer installations to the medium voltage network (TAR medium voltage).
- VDE-AR-N 4120: 2018-11. Technical requirements for the connection and operation of customer installations to the high voltage network (TAR high voltage).

(*) Simulation results offered in this validation report were obtained with the Powerfactory Digsilent 2019 Version 20.0.3_A.2. This validation report doesn't cover upper version of Digsilent above V20.0.3_A.2.

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

4 TECHNICAL DATA

4.1 Technical data

Models	**SUN2000-100KTL-M1**	**SUN2000-100KTL-INM0**
DC		
Input MPPT voltage range	200-1000 V	
Max. input voltage, open circuit	1100 V	
Max. input operating current	(10x) 26 A	
AC		
Maximum output apparent power	110 kVA	
Maximum output real power	100 kW	
Nominal output voltage	380/400 V (3 Ph / N / PE) 480 V (3 Ph / PE)	400/415 V (3 Ph / N / PE) 480 (3 Ph / PE)
Nominal frequency	50 Hz	
Rated output current with PF=1	152,0 A (380 V) 144,4 A (400 V) 120,3 A (480 V)	144,4 A (400 V) 139,2 A (415 V) 120,3 A (480 V)
Maximum output current	168,8 A (380 V) 160,4 A (400 V) 133,7 A (480 V)	160,4 A (400 V) 154,6 A (415 V) 133,7 A (480 V)

4.2 Relevant parameters for the electrical behaviour

The following are important parameters of the generation unit. The specified "Default Values" do not automatically meet the requirements set out in VDE-AR-N 4110: 2018 and VDE-AR-N 4120: 2018.

The settings may be specific for each project and needed to be checked.

Parameter description	Unit	Default Value	Min.	Max.	Step- wide	Note
General parameter settings (rated values or reference values)						
Pn	kW	100	parameter not adjustable		--	Rated active power
Smax	kVA	110	parameter not adjustable			Max apparent power
Un	V	400/480	parameter not adjustable			Rated voltage
In	A	144,4@400V 120,3@480V	parameter not adjustable			Rated current
Fn	Hz	50	parameter not adjustable			Rated frequency
Active power peaks						
Pmax	kW	110	parameter not adjustable		--	Maximum active power limit
Maximum active power	kW	Pmax	Pmax		--	Plimit
Active power baseline	kW	Pmax	Pmax		--	Pmaxref
Operating power limited by grid operator						
Shutdown at 0% power limit	--	Disabled	Enabled / Disabled			Shutdown at 0% power limit function enable
Active power change gradient	%Pmaxref/s	125,00	0,10	1000,00	0,001	Active power change gradient
Fixed active power derated	kW	Plimilt	0,0	Plimilt	0,1	Fixed active power derated
Active power percentage derating	%Pmaxref	100,0	0,0	100,0	1	Active power percentage derating
Reactive power change gradient (*)	%(0,6Smax)/s	125,0	0,10	1000,00	0,1	Reactive power change gradient
Reactive power adjustment time (*)	s	10	1	1000	1	Reactive power adjustment time

Note (*): The fixed reactive power does not respond to the first-order filter and responds according to the reactive power gradient.

Parameter description	Unit	Default Value	Min.	Max.	Step- wide	Note
Active power feed-in as a function of grid frequency						
Over frequency derating	--	Enabled	Enabled / Disabled		--	The required gradient (or droop) of the frequency dependent active power derating can be defined using the Parameters Trigger frequency of over frequency derating, Cuttoff frequency of over frequency derating and Cutoff power of over frequency derating.
Trigger frequency	Hz	50,20	45,00	55,00	0,01	Start frequency P(f) (Start of frequency regulation - power reduction)
Quit frequency of over frequency derating	Hz	50,15	45,00	55,00	0,01	Quit frequency P(f) (End of frequency regulation - power reduction)
Cuttoff frequency of over frequency derating	Hz	51,50	45,00	55,00	0,01	End frequency P(f) (End of frequency regulation - power reduction)
Cutoff power of over frequency derating	%PM	48	0	100	1	End power P(f) (End of power of frequency regulation - power reduction)
Power recovery gradient of overfrequency derating	%Prated/min	10	1	6000	1	Power recovery gradient when quit overfrequency derating
Underfrequency rise power	--	Disabled	Enabled / Disabled		--	Underfrequency derating function enable
Trigger frequency of underfrequency rise power	Hz	49,80	40,00	60,00	0,01	Start frequency P(f) (Start of frequency regulation - power rise)
Quit frequency of underfrequency rise power	Hz	49,90	40,0	60,0	0,01	Quit frequency P(f) (End of frequency regulation - power rise)
Cuttoff frequency of underfrequency rise power	Hz	47,50	40,0	60,0	0,01	End frequency P(f) (End of frequency regulation - power rise)
Cutoff power of underfrequency rise power	%Pmax	92	0	100	1	End power P(f) (End of power of frequency regulation - power rise)
Power recovery gradient of underfrequency rise power	%Prated/ min	10	1	6000	1	Power recovery gradient when quit underfrequency rise power

Parameter description	Unit	Default Value	Min.	Max.	Step- wide	Note
Reactive power provision						
Reactive power regulation mode	--	Disabled	Active power percentage derating/ Fixed active power derated	--		
Power factor fix control						
PF	--	1,000	-1,000 ~ -0,800	+1,000 ~ +0,800	0,001	Cos phi specifications
Reactive power fix control						
Reactive power limit	p.u.	0,0	-0,6·Smax	0,6·Smax	0,1	Q specifications
Q-U characteristic curve						
Q(U) Curve	--	--	--	--	--	The Q-U characteristic curve is free programmable with up to 10 supporting points.
Trigger power ratio	%Pmax	20	10	100	1	Q(U) function trigger power ratio of Pmax
Characteristic curve points	---	3 (1) 4 (2)	2	10	1	Number of Q-U characteristic curve
U/Un(A)	%Un	96,0 (1) 94,0 (2)	80,0	136,0	0,1	Q(U) characteristic node 1 U
Q/S(A)	/Smax	0,330 (1) 0,330 (2)	-0,600	0,600	0,001	Q(U) characteristic node 1 Q
U/Un(B)	%Un	100,0 (1) 96,0 (2)	80,0	136,0	0,1	Q(U) characteristic node 2 U
Q/S(B)	/Smax	0,000 (1) 0,000 (2)	-0,600	0,600	0,001	Q(U) characteristic node 2 U
U/Un(C)	%Un	104,0 (1) 104,0 (2)	80,0	136,0	0,1	Q(U) characteristic node 3 U
Q/S(C)	/Smax	0,330 (1) 0,000 (2)	-0,600	0,600	0,001	Q(U) characteristic node 3 Q
U/Un(D)	%Un	106,0 (2)	80,0	136,0	0,1	Q(U) characteristic node 4 U
Q/S(D)	/Smax	0,330 (2)	-0,600	0,600	0,001	Q(U) characteristic node 4 Q

(1) For VDE-AR-N 4110: 2018-11
(2) For VDE-AR-N 4120: 2018-11

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

Parameter description	Unit	Default Value	Min.	Max.	Step- wide	Note
Q-P characteristic curve						
Q(P) curve						The Q-P characteristic curve is free programmable with up to 10 supporting points.
Characteristic curve points	--	5	2	10	1	
P/Pmax(A)	%Pmax	10,0	0,0	100,0	0.1	Q(P) characteristic node 1 P
Q/Qmax(A)	/Smax	0,000	-0,600	0,600	0.001	Q(P) characteristic node 1 Q
P/Pmax(B)	%Pmax	50,0	0,0	100,0	0.1	Q(P) characteristic node 2 P
Q/Qmax(B)	/Smax	0,000	-0,600	0,600	0.001	Q(P) characteristic node 2 Q
P/Pmax(C)	%Pmax	60,0	0,0	100,0	0.1	Q(P) characteristic node 3 P
Q/Qmax(C)	/Smax	-0,050	-0,600	0,600	0.001	Q(P) characteristic node 3Q
P/Pmax(D)	%Pmax	90,0	0,0	100,0	0.1	Q(P) characteristic node 4 P
Q/Qmax(D)	/Smax	-0,330	-0,600	0,600	0.001	Q(P) characteristic node 4 Q
P/Pmax(E)	%Pmax	100,0	0,0	100,0	0.1	Q(P) characteristic node 5 P
Q/Qmax(E)	/Smax	-0,330	-0,600	0,600	0.001	Q(P) characteristic node 5 Q

Parameter description	Unit	Default Value	Min.	Max.	Step- wide	Note
PGU disconnection from the grid						
10-minute OV protection	p.u	1,20Un	1,00Un	1,25Un	0,1V	10-minute voltage average value protection point
10-minute OV protection time	ms	200	50	7200000	1	10-minute voltage average value protection time
Level-1 OV protection	p.u	1,12Un	1,00Un	1,36Un	0,1V	Level 1 over voltage protection point
Level-1 OV protection time	ms	180000 (1) 1800000 (2)	50	7200000	1	Level 1 over voltage protection time
Level-2 OV protection	p.u	1,25Un	1,00Un	1,36Un	0,1V	Level 2 over voltage protection point
Level-2 OV protection time	ms	66000	50	7200000	1	Level 2 over voltage protection time
Level-1 UV protection	p.u	0,87Un	0,15Un	1,00Un	0,1V	Level 1 under voltage protection point
Level-1 UV protection time	ms	66000 (1) 3600000 (2)	50	7200000	1	Level 1 under voltage protection time
Level-2 UV protection	p.u	0,80Un	0,15Un	1,00Un	0,1V	Level 2 under voltage protection point
Level-2 UV protection time	ms	6000	50	7200000	1	Level 2 under voltage protection time
Level-1 OF protection	Hz	51,00	50,00	57,50	0,01	Level 1 over frequency protection point
Level-1 OF protection time	ms	1800000	50	7200000	1	Level 1 over frequency protection time
Level-2 OF protection	Hz	51,50	50,00	57,50	0,01	Level 2 over frequency protection point
Level-2 OF protection time	ms	100	50	7200000	1	Level 2 over frequency protection time
Level-1 UF protection	Hz	42,50	42,50	50,00	0,01	Level 1 under frequency protection point
Level-1 UF protection time	ms	1800000	50	7200000	1	Level 1 under frequency protection time
Level-2 UF protection	Hz	42,50	42,50	50,00	0,01	Level 2 under frequency protection point
Level-2 UF protection time	ms	100	50	7200000	1	Level 2 under frequency protection time
Evaluation of conductor-conductor or conductor-earth voltage	--	--	--			conductor-conductor or conductor-earth voltage
Logical AND or OR link	--	--	--			OR

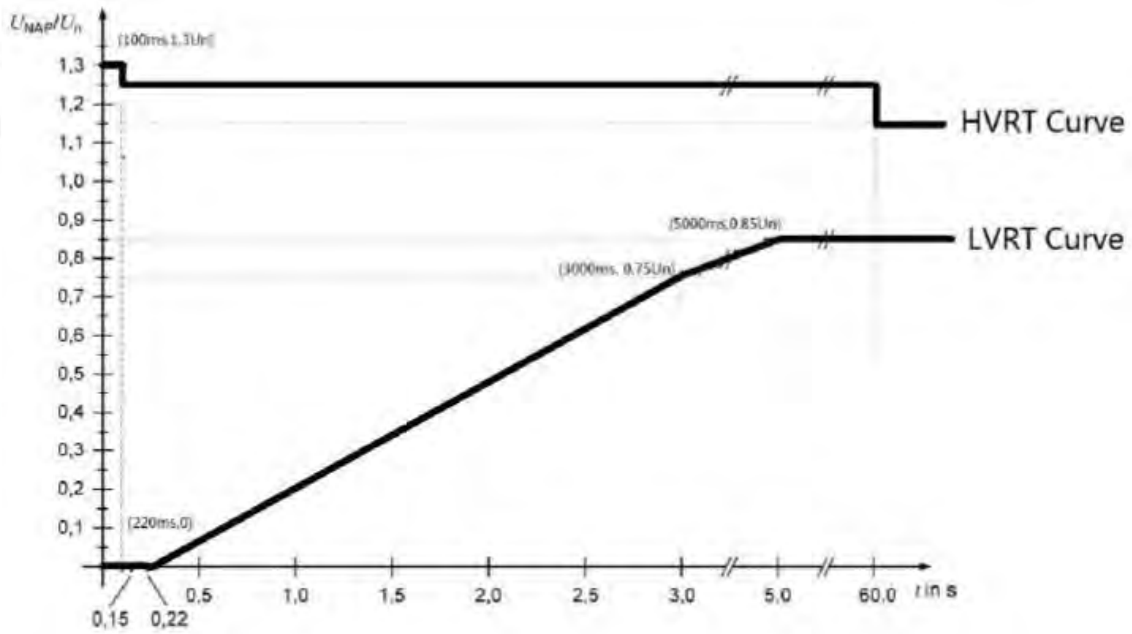
(1) For VDE-AR-N 4110: 2018-11
(2) For VDE-AR-N 4120: 2018-11

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

Parameter description	Unit	Default Value	Min.	Max.	Step- wide	Note
Self-protection						
Line voltage peak value protection point	p.u.		1,32 Un x Line voltage peak value (parameter not adjustable)			Line voltage peak value protection point, overvoltage limit of 1.3p.u is exceeded for 150ms
Limits for re-energizing (reconnection after fault event)						
Grid connection duration after power grid recovery	s	600	0	7200	1	
Fault Recovery Active Soft Start	s	600	1	1800	1	The soft start time the active power from 0 to power rated after fault
Connection conditions						
Auto start upon grid recovery	--	Enabled	Enabled / Disabled		--	Enable Auto start upon grid after grid fault
Grid reconnection voltage upper limit	p.u	1,10	1,00	1,36	0,1V	Limit value connection U>
Grid reconnection voltage lower limit	p.u	0,95	0,45	0,95	0,1V	Limit value connection U<
Grid reconnection frequency upper limit	Hz	50,10	50,00	56,00	0,01	Limit value connection f>
Grid reconnection frequency lower limit	Hz	49,90	42,50	50,00	0,01	Limit value connection f<

Parameter description	Unit	Default Value	Min.	Max.	Step- wide	Note
Response during grid faults						
LVRT	--	Enable	Enabled / Disabled		--	LVRT enabled
LVRT triggering threshold	% Un	90	50	92	1	LVRT triggering threshold
LVRT reactive power compensation factor	--	2,0	0,0	10,0		k factor
HVRT	--	Enable	Enabled / Disabled		--	HVRT enabled
HVRT triggering threshold	% Un	110	105	136	1	HVRT triggering threshold
HVRT reactive power compensation factor	--	2,0	0,0	6,0		k factor
Grid voltage protection shield during HVRT/LVRT	--	Enabled	Enabled / Disabled			Grid voltage protection shield during HVRT/LVRT
Zero current due to power grid fault	--	Disabled	Enabled / Disabled			Zero current due to power grid fault

Fault Ride-Through (FRT) limit curve:



SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

4.3 Description for reading out parameters

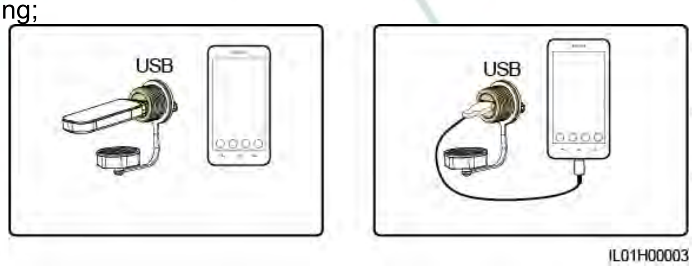
The parameters can be read out using the following software.

Name:	SmartLogger WebUI and SUN2000 APP
Version:	SmartLogger:V200R002 SUN2000 APP:3.2.00.002

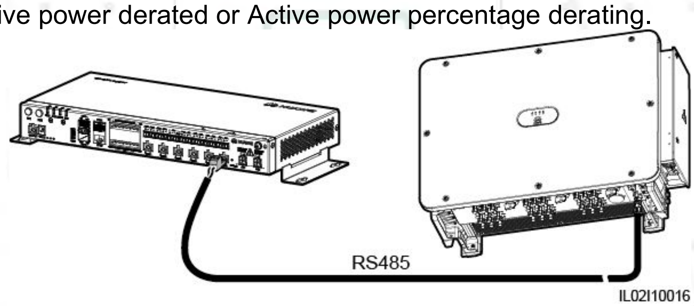
4.4 Interfaces

Interfaces for the active power reduction by defined setpoint

Following interfaces for control of the active power provision are provided on the PGU level:
connect a mobile phone that runs the SUN2000 app to the inverter using a Bluetooth module, a WLAN module, or a USB data cable for active power setting using parameter Fixed active power derated or Active power percentage derating;

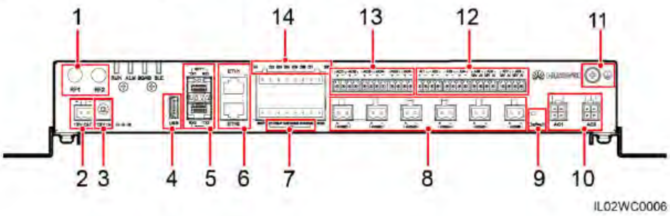


connect the inverter to SmartLogger via MBUS or RS485 for active power setting using the WebUI using the parameter Fixed active power derated or Active power percentage derating.



connect the inverter to SmartLogger via MBUS or RS485, the digital interfaces DI1, DI2, DI3, DI4 of the SmartLogger can be connected to the dry contacts for active power setting.

Figure 2-4 SmartLogger2000-10/10-B/11-B bottom

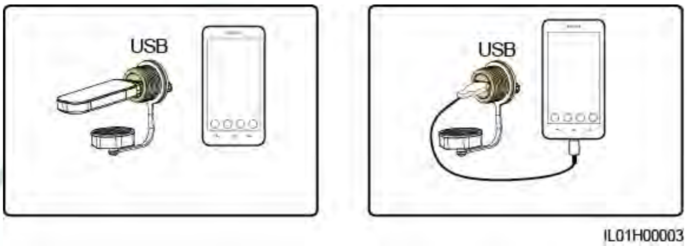
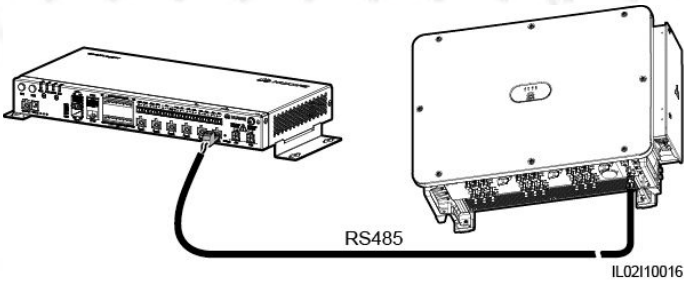


14	DI1–DI8	Digital parameter input	Connects to a dry contact input. GND1 and GND2 are grounding ports for DI signals.

There are no differences regarding the setpoint accuracy and settling / response times between the interfaces / software tools.

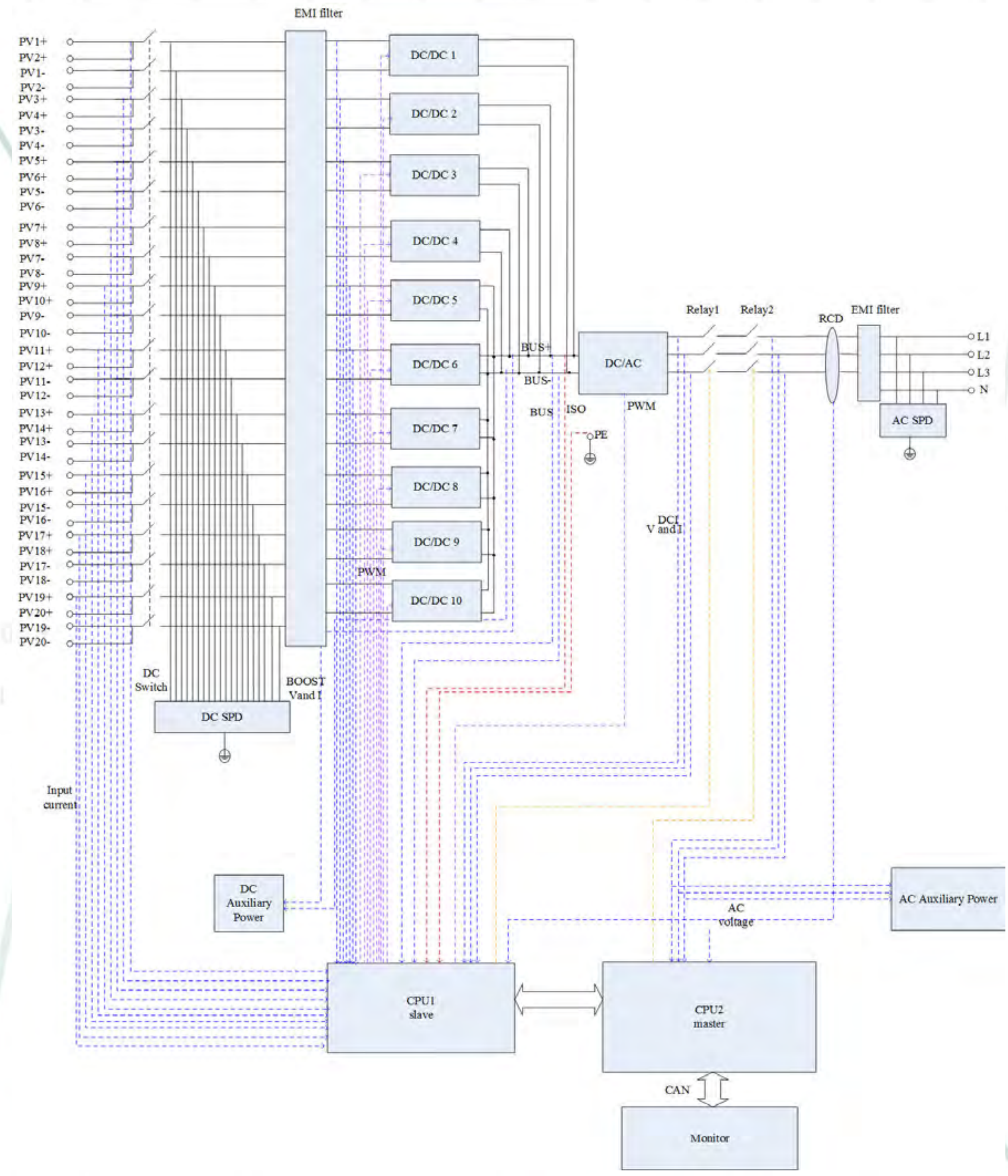
Hereby, the pick-up of a new active power setpoint is guaranteed within 2 s.

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

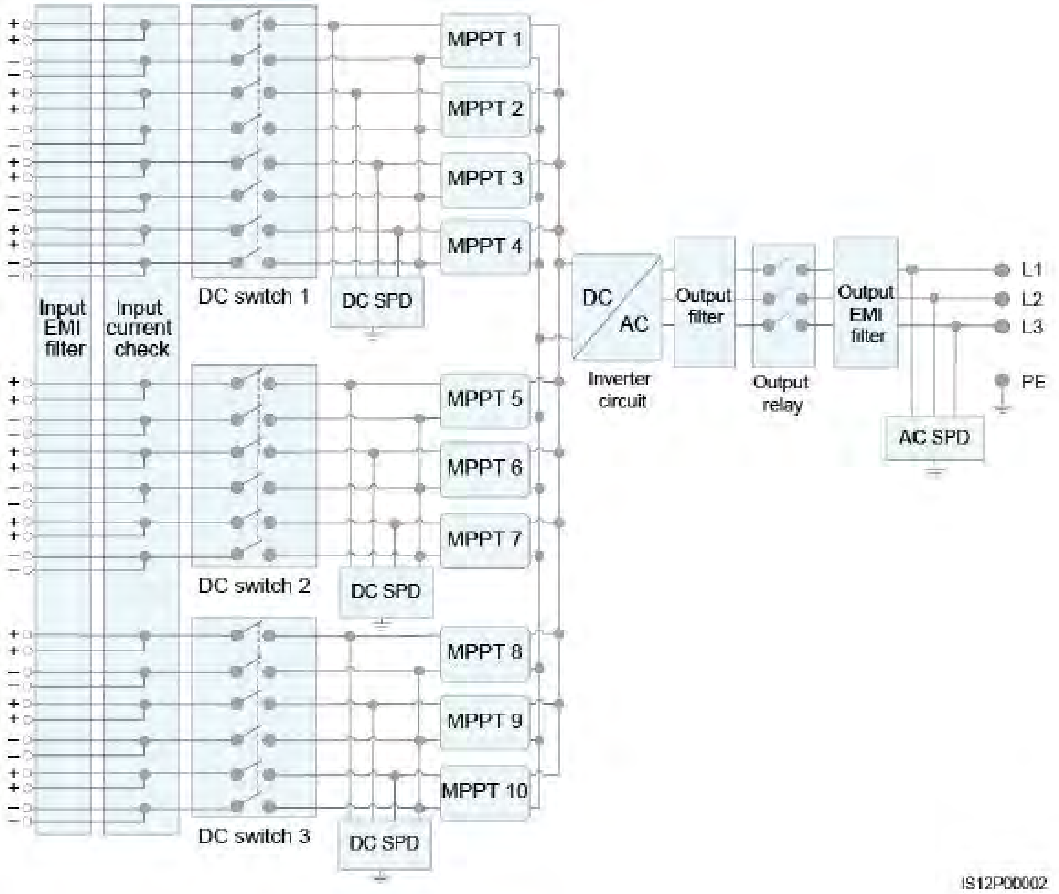
Interfaces for the provision of reactive power
Following interfaces for control of the reactive power provision are provided on the PGU level: connect a mobile phone that runs the SUN2000 app to the inverter using a Bluetooth module, a WLAN module, or a USB data cable for: - Power factor fix control - Reactive power fix control - Q-P characteristic curve - Q-U characteristic curve setting;  connect the inverter to SmartLogger via MBUS or RS485, the following reactive power control functions: - Power factor fix control - Reactive power fix control - Q-P characteristic curve - Q-U characteristic curve can be set using the WebUI.  There are no differences regarding the setpoint accuracy and settling / response times between the interfaces / software tools. Hereby, the pick-up of a new reactive power setpoint is guaranteed within 2 s.

4.5 Electric schemea

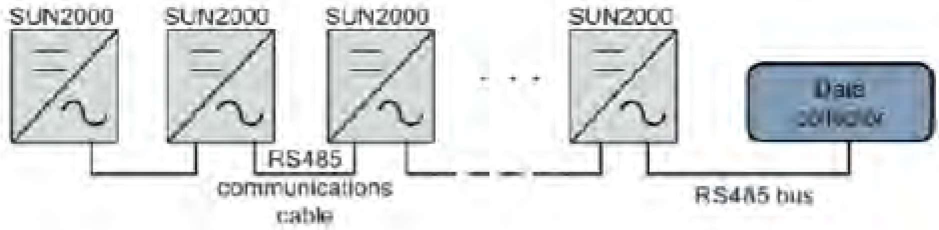
Equipment under testing



SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

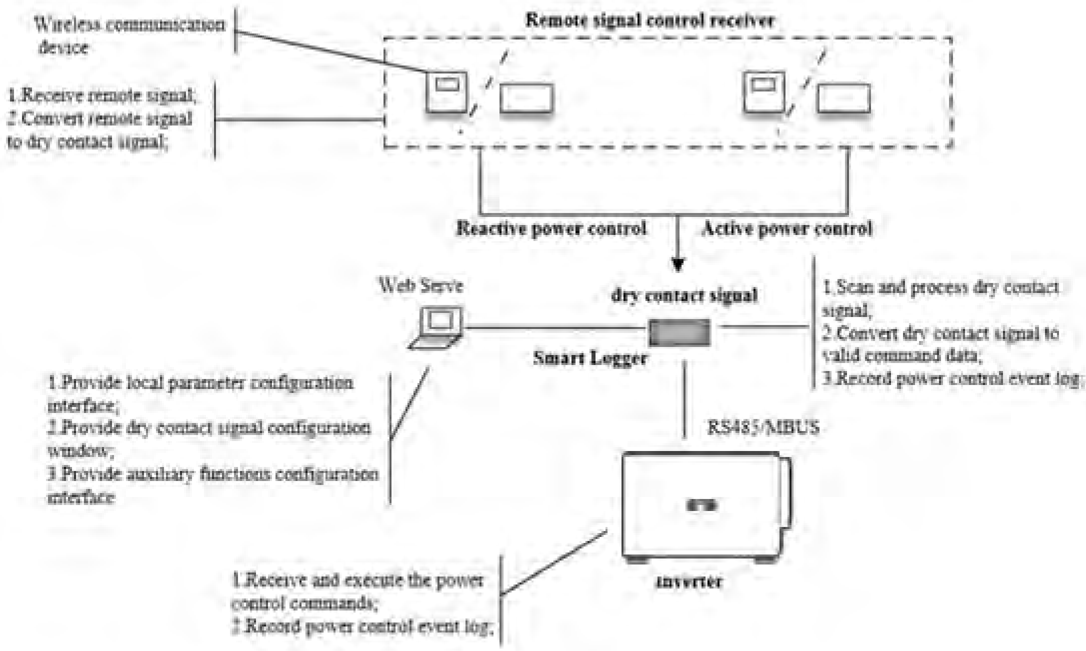
Description of the remote control in a typical installation


The SUN2000 receives inputs from eight PV strings. Then the inputs are grouped into four MPPT routes inside the SUN2000 to track the maximum power point of the PV strings. The DC power is then converted into three-phase AC power through an inverter circuit. Surge protection is supported on both the DC and AC sides.

Description of the remote control in a typical installation


In the RS485 communication mode a SUN2000 system (including up to 30 units recommended by manufacturer each RS485 port) can be connected to the SmartLogger (data collector) via RS485 bus.

A SmartLogger (data collector) can be connected to a SUN2000 system (including up to 30 units recommended by manufacturer each RS485 port) connected in series via RS485 communication cable (using MODBUS-RTU communication protocol). The length of the communication cable should be limited to max. 1000 m (for RS485 bus using 9600 baud rate). SmartLogger can control active / reactive power control via dry contact. The Ethernet-interface and corresponding WebUI “Data Collector Web” are available for setting / controlling active / reactive power and parameter configuration.

Description of the connection to the remote control receiver


A generating station can receive the signal from the State Load Dispatch Centre or Regional Load Dispatch Centre for regulation of the active and reactive power output using the Smart Logger (data acquisition device).
The remote control receiver can be connected to the Smart Logger using dry contact for active / reactive power control, which is connected to the inverters via RS485/MBUS.control via dry contact. The Ethernet-interface and corresponding WebUI “Data Collector Web” are available for setting / controlling active / reactive power and parameter configuration.

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

4.6 Manufacturer's certificates for certified PGUs according to FGW TG3

Manufacturer_Certificate_FGW-TR3PV-SUN2000-100KTL-INM0

Herstellerbescheinigung zu spezifischen Daten eines Photovoltaik-Wechselrichters vom Typ SUN2000-100KTL-INM0

Manufacturer's certificate on specific data of a Photovoltaic Converter of the type SUN2000-100KTL- INM0

Datum / Date: 08/10/2020 — **Seite/Page 1/1**

1	**Allgemeines und Ausgangsgrößen**			**General and Output values**
1	Hersteller	Huawei Technologies CO., LTD.		manufacturer
2	Typenbezeichnung	SUN2000-100KTL- INM0		type name
3	Einspeisung (einphasig/dreiphasig)	three-phase		no. of phases (single-phase/three-phase)
4	Nennscheinleistung	100	kVA	rated apparent power
5	Nennwirkleistung	100	kW	rated active power
6	AC-Nennspannung	400, 3W+(N)+PE	V	rated AC-voltage
7	AC-Nennfrequenz	50	Hz	rated frequency
8	Beitrag zum Stoßkurzschlussstrom	0.160	kA	contribution to short circuit current
2	**DC Eingangsgrößen**			**DC Input**
1	Min. MPP-Spannung	200	V	min. MPP voltage
2	Max. MPP-Spannung	1000	V	max. MPP voltage
3	Max. PV-Eingangsspannung	1100	V	max. DC input voltage
4	Max. PV-Eingangsstrom	26*10	A	max. DC input current
5	Max. Modulleistung	112.2	kW_p	max. peak power
3	**Wechselrichter-Leistungsteil**			**Converter-Power section**
1	Hersteller	Huawei Technologies CO., LTD.		manufacturer
2	Typenbezeichnung	SUN2000-100KTL-INM0		type name
3	Nennscheinleistung	100	kVA	rated apparent power
4	Art (HF/NF-Trafo, trafolos)	without		generic type (HV/LV of Trans., without)
5	Taktfrequenz	18	kHz	pulse rate of inverter
6	Art der Leistungsregelung (MPP-Tracking)	MPP-Tracking		generic type of power control (MPP-Tracking)
7	Software-Version	V500R001		software version
4	**Sonstige elektrische Komponenten**			**Other electric installations**
1	Art der Netzkopplung	Grid connection		generic type of interconnection
2	- Hersteller	Huawei Technologies CO., LTD.		- manufacturer
3	- Typenbezeichnung	SUN2000-100KTL-INM0		- type
4	Netzschutz integriert (ja/nein)	YES		integrated grid protection (yes/no)
5	Netzschutzhersteller	Huawei Technologies CO., LTD.		grid protection manufacturer
6	- Typenbezeichnung	SUN2000-100KTL-INM0		- type
7	- Einstellbereiche	YES		- adjustment ranges
8	Spannungssteigerungsschutz	1.2Un（Un：rated AC-voltage）	V	overvoltage protection
9	Spannungsrückgangschutz	0.8Un（Un：rated AC-voltage）	V	undervoltage protection
10	Frequenzsteigerungsschutz	52.0	Hz	overfrequency protection
11	Frequenzrückgangschutz	47.5	Hz	underfrequency protection
12	Typenbezeichnung der Abschalteinheit	HF167F-200/12-H3F		circuit breaker type
13	Oberschwingungsfilter (ja/nein)	YES		harmonic filter (yes / no)
5	**Typenprüfung**			**Type test**
1	Prüfbehörde	SGS		testing authority
2	Aktenzeichen	FGW TR3 REV.25		reference
3	Seriennummer des Wechselrichters	6T19A9066339		serial number of converter

Zhang Yuanjun 00277797

Stempel, Unterschrift
stamp, signature

Anschrift des Herstellers
Address of manufacturer

Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C

Der Hersteller des PV-Wechselrichters bestätigt, dass der PV-Wechselrichter, dessen elektrischen Eigenschaften in den Prüfberichten abgebildet sind, hinsichtlich seiner technischen Daten mit den o.g. Positionen identisch ist.

The manufacturer of the PV-Converter confirms that the PV-Converter whose power quality is measured and depicted in the test reports, is identical with the above entries with regard to its technical data

Manufacturer_Certificate_FGW-TR3PV-SUN2000-100KTL-INM0

Herstellerbescheinigung zu spezifischen Daten eines Photovoltaik-Wechselrichters vom Typ SUN2000-100KTL-INM0

Manufacturer's certificate on specific data of a Photovoltaic Converter of the type SUN2000-100KTL-INM0

Datum / Date: 08/10/2020 — **Seite/Page 1/1**

1	**Allgemeines und Ausgangsgrößen**			**General and Output values**
1	Hersteller	Huawei Technologies CO., LTD.		manufacturer
2	Typenbezeichnung	SUN2000-100KTL-INM0		type name
3	Einspeisung (einphasig/dreiphasig)	three-phase		no. of phases (single-phase/three-phase)
4	Nennscheinleistung	100	kVA	rated apparent power
5	Nennwirkleistung	100	kW	rated active power
6	AC-Nennspannung	480, 3W+PE	V	rated AC-voltage
7	AC-Nennfrequenz	50	Hz	rated frequency
8	Beitrag zum Stoßkurzschlussstrom	0.134	kA	contribution to short circuit current
2	**DC Eingangsgrößen**			**DC Input**
1	Min. MPP-Spannung	200	V	min. MPP voltage
2	Max. MPP-Spannung	1000	V	max. MPP voltage
3	Max. PV-Eingangsspannung	1100	V	max. DC input voltage
4	Max. PV-Eingangsstrom	26*10	A	max. DC input current
5	Max. Modulleistung	112.2	kW_p	max. peak power
3	**Wechselrichter-Leistungsteil**			**Converter-Power section**
1	Hersteller	Huawei Technologies CO., LTD.		manufacturer
2	Typenbezeichnung	SUN2000-100KTL-INM0		type name
3	Nennscheinleistung	100	kVA	rated apparent power
4	Art (HF/NF-Trafo, trafolos)	without		generic type (HV/LV of Trans., without)
5	Taktfrequenz	18	kHz	pulse rate of inverter
6	Art der Leistungsregelung (MPP-Tracking)	MPP-Tracking		generic type of power control (MPP-Tracking)
7	Software-Version	V500R001		software version
4	**Sonstige elektrische Komponenten**			**Other electric installations**
1	Art der Netzkopplung	Grid connection		generic type of interconnection
2	- Hersteller	Huawei Technologies CO., LTD.		- manufacturer
3	- Typenbezeichnung	SUN2000-100KTL-INM0		- type
4	Netzschutz integriert (ja/nein)	YES		integrated grid protection (yes/no)
5	Netzschutzhersteller	Huawei Technologies CO., LTD.		grid protection manufacturer
6	- Typenbezeichnung	SUN2000-100KTL-INM0		- type
7	- Einstellbereiche	YES		- adjustment ranges
8	Spannungssteigerungsschutz	1.2Un（Un：rated AC-voltage）	V	overvoltage protection
9	Spannungsrückgangschutz	0.8Un（Un：rated AC-voltage）	V	undervoltage protection
10	Frequenzsteigerungsschutz	52.0	Hz	overfrequency protection
11	Frequenzrückgangschutz	47.5	Hz	underfrequency protection
12	Typenbezeichnung der Abschalteinheit	HF167F-200/12-H3F		circuit breaker type
13	Oberschwingungsfilter (ja/nein)	YES		harmonic filter (yes / no)
5	**Typenprüfung**			**Type test**
1	Prüfbehörde	SGS		testing authority
2	Aktenzeichen	FGW TR3 REV.25		reference
3	Seriennummer des Wechselrichters	6T19A9066339		serial number of converter

Zhang Yuanjun 00277797

Stempel, Unterschrift
stamp, signature

Anschrift des Herstellers
Address of manufacturer
Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C

Der Hersteller des PV-Wechselrichters bestätigt, dass der PV-Wechselrichter, dessen elektrischen Eigenschaften in den Prüfberichten abgebildet sind, hinsichtlich seiner technischen Daten mit den o.g. Positionen identisch ist.

The manufacturer of the PV-Converter confirms that the PV-Converter whose power quality is measured and depicted in the test reports, is identical with the above entries with regard to its technical data

Manufacturer_Certificate_FGW-TR3PV-SUN2000-100KTL-M1

Herstellerbescheinigung zu spezifischen Daten eines Photovoltaik-Wechselrichters vom Typ SUN2000-100KTL-M1

Manufacturer's certificate on specific data of a Photovoltaic Converter of the type SUN2000-100KTL-M1

Datum / Date: 08/10/2020 | **Seite/Page 1/1**

1	**Allgemeines und Ausgangsgrößen**			**General and Output values**
1	Hersteller	Huawei Technologies CO., LTD.		manufacturer
2	Typenbezeichnung	SUN2000-100KTL-M1		type name
3	Einspeisung (einphasig/dreiphasig)	three-phase		no. of phases (single-phase/three-phase)
4	Nennscheinleistung	100	kVA	rated apparent power
5	Nennwirkleistung	100	kW	rated active power
6	AC-Nennspannung	480, 3W+PE	V	rated AC-voltage
7	AC-Nennfrequenz	50	Hz	rated frequency
8	Beitrag zum Stoßkurzschlussstrom	0.134	kA	contribution to short circuit current
2	**DC Eingangsgrößen**			**DC Input**
1	Min. MPP-Spannung	200	V	min. MPP voltage
2	Max. MPP-Spannung	1000	V	max. MPP voltage
3	Max. PV-Eingangsspannung	1100	V	max. DC input voltage
4	Max. PV-Eingangsstrom	26*10	A	max. DC input current
5	Max. Modulleistung	112.2	kW_p	max. peak power
3	**Wechselrichter-Leistungsteil**			**Converter-Power section**
1	Hersteller	Huawei Technologies CO., LTD.		manufacturer
2	Typenbezeichnung	SUN2000-100KTL-M1		type name
3	Nennscheinleistung	100	kVA	rated apparent power
4	Art (HF/NF-Trafo, trafolos)	without		generic type (HV/LV of Trans., without)
5	Taktfrequenz	18	kHz	pulse rate of inverter
6	Art der Leistungsregelung (MPP-Tracking)	MPP-Tracking		generic type of power control (MPP-Tracking)
7	Software-Version	V500R001		software version
4	**Sonstige elektrische Komponenten**			**Other electric installations**
1	Art der Netzkopplung	Grid connection		generic type of interconnection
2	- Hersteller	Huawei Technologies CO., LTD.		- manufacturer
3	- Typenbezeichnung	SUN2000-100KTL-M1		- type
4	Netzschutz integriert (ja/nein)	YES		integrated grid protection (yes/no)
5	Netzschutzhersteller	Huawei Technologies CO., LTD.		grid protection manufacturer
6	- Typenbezeichnung	SUN2000-100KTL-M1		- type
7	- Einstellbereiche	YES		- adjustment ranges
8	Spannungssteigerungsschutz	1.2Un（Un：rated AC-voltage）	V	overvoltage protection
9	Spannungsrückgangschutz	0.8Un（Un：rated AC-voltage）	V	undervoltage protection
10	Frequenzsteigerungsschutz	52.0	Hz	overfrequency protection
11	Frequenzrückgangschutz	47.5	Hz	underfrequency protection
12	Typenbezeichnung der Abschalteinheit	HF167F-200/12-H3F		circuit breaker type
13	Oberschwingungsfilter (ja/nein)	YES		harmonic filter (yes / no)
5	**Typenprüfung**			**Type test**
1	Prüfbehörde	SGS		testing authority
2	Aktenzeichen	FGW TR3 REV.25		reference
3	Seriennummer des Wechselrichters	6T19A9066325		serial number of converter

Zhang Yuanjun 00277797

Anschrift des Herstellers | Stempel, Unterschrift
Address of manufacturer | stamp, signature

Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C

Der Hersteller des PV-Wechselrichters bestätigt, dass der PV-Wechselrichter, dessen elektrischen Eigenschaften in den Prüfberichten abgebildet sind, hinsichtlich seiner technischen Daten mit den o.g. Positionen identisch ist.

The manufacturer of the PV-Converter confirms that the PV-Converter whose power quality is measured and depicted in the test reports, is identical with the above entries with regard to its technical data

Manufacturer_Certificate_FGW-TR3PV-SUN2000-100KTL-M1

Herstellerbescheinigung zu spezifischen Daten eines Photovoltaik-Wechselrichters vom Typ SUN2000-100KTL-M1

Manufacturer's certificate on specific data of a Photovoltaic Converter of the type SUN2000-100KTL-M1

Datum / Date: 08/10/2020 — **Seite/Page 1/1**

1	**Allgemeines und Ausgangsgrößen**			**General and Output values**	
1	Hersteller	Huawei Technologies CO., LTD.		manufacturer	
2	Typenbezeichnung	SUN2000-100KTL-M1		type name	
3	Einspeisung (einphasig/dreiphasig)	three-phase		no. of phases (single-phase/three-phase)	
4	Nennscheinleistung	100	kVA	rated apparent power	
5	Nennwirkleistung	100	kW	rated active power	
6	AC-Nennspannung	400, 3W+(N)+PE	V	rated AC-voltage	
7	AC-Nennfrequenz	50	Hz	rated frequency	
8	Beitrag zum Stoßkurzschlussstrom	0.160	kA	contribution to short circuit current	
2	**DC Eingangsgrößen**			**DC Input**	
1	Min. MPP-Spannung	200	V	min. MPP voltage	
2	Max. MPP-Spannung	1000	V	max. MPP voltage	
3	Max. PV-Eingangsspannung	1100	V	max. DC input voltage	
4	Max. PV-Eingangsstrom	26*10	A	max. DC input current	
5	Max. Modulleistung	112.2	kW_p	max. peak power	
3	**Wechselrichter-Leistungsteil**			**Converter-Power section**	
1	Hersteller	Huawei Technologies CO., LTD.		manufacturer	
2	Typenbezeichnung	SUN2000-100KTL-M1		type name	
3	Nennscheinleistung	100	kVA	rated apparent power	
4	Art (HF/NF-Trafo, trafolos)	without		generic type (HV/LV of Trans., without)	
5	Taktfrequenz	16	kHz	pulse rate of inverter	
6	Art der Leistungsregelung (MPP-Tracking)	MPP-Tracking		generic type of power control (MPP-Tracking)	
7	Software-Version	V500R001		software version	
4	**Sonstige elektrische Komponenten**			**Other electric installations**	
1	Art der Netzkopplung	Grid connection		generic type of interconnection	
2	- Hersteller	Huawei Technologies CO., LTD.		- manufacturer	
3	- Typenbezeichnung	SUN2000-100KTL-M1		- type	
4	Netzschutz integriert (ja/nein)	YES		integrated grid protection (yes/no)	
5	Netzschutzhersteller	Huawei Technologies CO., LTD.		grid protection manufacturer	
6	- Typenbezeichnung	SUN2000-100KTL-M1		- type	
7	- Einstellbereiche	YES		- adjustment ranges	
8	Spannungssteigerungsschutz	1.2Un（Un：rated AC-voltage）	V	overvoltage protection	
9	Spannungsrückgangschutz	0.8Un（Un：rated AC-voltage）	V	undervoltage protection	
10	Frequenzsteigerungsschutz	52.0	Hz	overfrequency protection	
11	Frequenzrückgangschutz	47.5	Hz	underfrequency protection	
12	Typenbezeichnung der Abschalteinheit	HF167F-200/12-H3F		circuit breaker type	
13	Oberschwingungsfilter (ja/nein)	YES		harmonic filter (yes / no)	
5	**Typenprüfung**			**Type test**	
1	Prüfbehörde	SGS		testing authority	
2	Aktenzeichen	FGW TR3 REV.25		reference	
3	Seriennummer des Wechselrichters	6T19A9066325		serial number of converter	

Zhang Yuanjun 00277797

Stempel, Unterschrift
stamp, signature

Anschrift des Herstellers
Address of manufacturer
Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C

Der Hersteller des PV-Wechselrichters bestätigt, dass der PV-Wechselrichter, dessen elektrischen Eigenschaften in den Prüfberichten abgebildet sind, hinsichtlich seiner technischen Daten mit den o.g. Positionen identisch ist.

The manufacturer of the PV-Converter confirms that the PV-Converter whose power quality is measured and depicted in the test reports, is identical with the above entries with regard to its technical data

5 DYNAMIC SIMULATION MODEL INFORMATION

5.1 Software Characteristics for the validated Dynamic Simulation Model

- Software type: Simulator for Grid Connected Power Conversion System
- Simulation platform: DigSilent PowerFactory
- Used version of the simulation platform: 20.0.3_A.2 (*)
- Simulation Software File identification: Huawei_VDE4120&4110_SUN2000-100KTL-M1_400V_Enc_V1.7.pfd
- Dynamic Simulation Model version: V1.7
- MD5 Checksum: 82CDCCA8DF02BB7E83EEEDF3ED06CE01

(*) Simulation results offered in the validation report were obtained with the Powerfactory Digsilent Version 20.0.3_A.2. The validation report doesn't cover upper version of Digsilent above V20.0.3_A.2.

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

5.2 Dynamic simulation model information for other output voltages

The manufacturer declares they can be used other three different dynamic simulation models for different output voltages of PV inverters listed under the scope of this report. The manufacturer states that the variant models described below have identical control systems in relation with the validated model covered by the validation report. Based on the described differences, their results are to be expected equivalent to the ones obtained in the validated model. These are:

Model to get SUN2000-100KTL-M1 380V

- Simulation Software File identification: Huawei_VDE4120&4110_SUN2000-100KTL-M1_380V_Enc_V1.0.pfd
- Dynamic Simulation Model version: V1.0
- MD5 Checksum:1FCF12F2B59C6433E950B239BF4FC24E

Changes declared by the manufacturer in relation with the validated model covered by this report are:

1. Change the parameter Imax to 1,1105 in the DSL mode “ Idq _Control”.
2. Change the parameter Unom to 380 in the DSL mode “ Idq _Control”.
3. Change the parameter Unom to 380 in the DSL mode “Protection”.

Model to get SUN2000-100KTL-M1 480V

- Simulation Software File identification: Huawei_VDE4120&4110_SUN2000-100KTL-M1_480V_Enc_V1.0.pfd
- Dynamic Simulation Model version: V1.0
- MD5 Checksum: 42D77D064B879C04FAECA91D9E9861EE

Changes declared by the manufacturer in relation with the validated model covered by this report are:

1. Change the parameter Imax to 1,1114 in the DSL mode “ Idq _Control”.
2. Change the parameter Unom to 480 in the DSL mode “ Idq _Control”.
3. Change the parameter Unom to 480 in the DSL mode “Protection”.

Model to get Huawei SUN2000-100KTL-INM0 415V

- Simulation Software File identification: Huawei_VDE4120&4110_SUN2000-100KTL-INM0_Enc_V1.0.pfd
- Dynamic Simulation Model version: V1.0
- MD5 Checksum: F078DF6E927B426CD09C4722D2EAAC04

Changes declared by the manufacturer in relation with the validated model covered by this report are:

1. Change the parameter Imax to 1,1106 in the DSL mode “ Idq _Control”.
2. Change the parameter Unom to 415 in the DSL mode “ Idq _Control”.
3. Change the parameter Unom to 415 in the DSL mode “Protection”.

Note 1: see the document “User Manual of DIgSILENT Model for Huawei Inverter SUN2000-100KTL-M1 & INM0” (version 1.6, issued on 17th March 2020), for further information.

Note 2: results offered in the validation report are just valid for the dynamic simulation model detailed in the clause 4.1 of this annex.

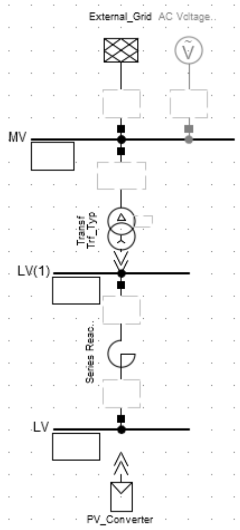
5.3 Software Information and Comments

As evidenced in the manufacturer's documentation and this validation report, the dynamic model could be completely able to represent the dynamic behaviours at the PV inverter terminal, and also be suitable for power grid studies. The dynamic model covered by this validation report is valid for fundamental frequency positive and negative sequence response. The dynamic model is developed with the following specifications in mind:

- The model is to be used primarily for power system stability studies and thus should represent all positive and negative sequence dynamics affected and relevant during:
  - Balanced and unbalanced short-circuits on the transmission grid (including voltage recovery)
  - Grid frequency disturbances
  - Reference value changes
- The model is for fundamental frequency positive and negative sequence response.
- The model is valid for typical power system frequency deviations.
- The model is able to handle numerically the simulation of phase jumps.
- The model is valid for steady state voltage deviations within the range from 0,9 p.u. to 1,1 p.u.
- The model could work with integration time step range from 0,001s to 0,01s.
- The model could be initialized to a steady state from load flow solutions at full or partial nominal power.
- Over/under frequency and over/under voltage protections are modelled in the control model in order to allow a realistic representation of PV inverter disconnection following grid disturbances. This may be separate modules that connect to the main PV inverter model.
- The model includes the reactive power capability of the PV inverter.

5.4 Description of the model

The model has the following design:



The grid information of SUN2000-100KTL Digsilent project is as follows:

	SCR implemented in the simulated grid
Validation requirements for Voltage Ride Through (LVRT cases 0.1 and 0.2)	20
Validation requirements for Voltage Ride Through (LVRT cases 0.3 and 0.4)	200
Validation requirements for Voltage Ride Through (LVRT and HVRT)	50
Validation requirements for Reactive Power Control processes (QvsU and QvsP)	50
Validation requirements for Active Power and Reactive Power Control by Setpoint	50
Verification of requirements for Protective Settings (Under/Over voltage cases)	50
Verification of requirements for Protective Settings (Under/Over frequency cases)	50
Plausibility checks with Kmin and K factor for P.2 and P.3 cases	50
Plausibility checks with Kmax cases	50
U-P-Q	50

For further information, see the “User Manual of DIgSILENT Model for Huawei Inverter SUN2000-100KTL-M1 & INM0” (version 1.6, issued on 17th March 2020).

The SCR is calculated by:

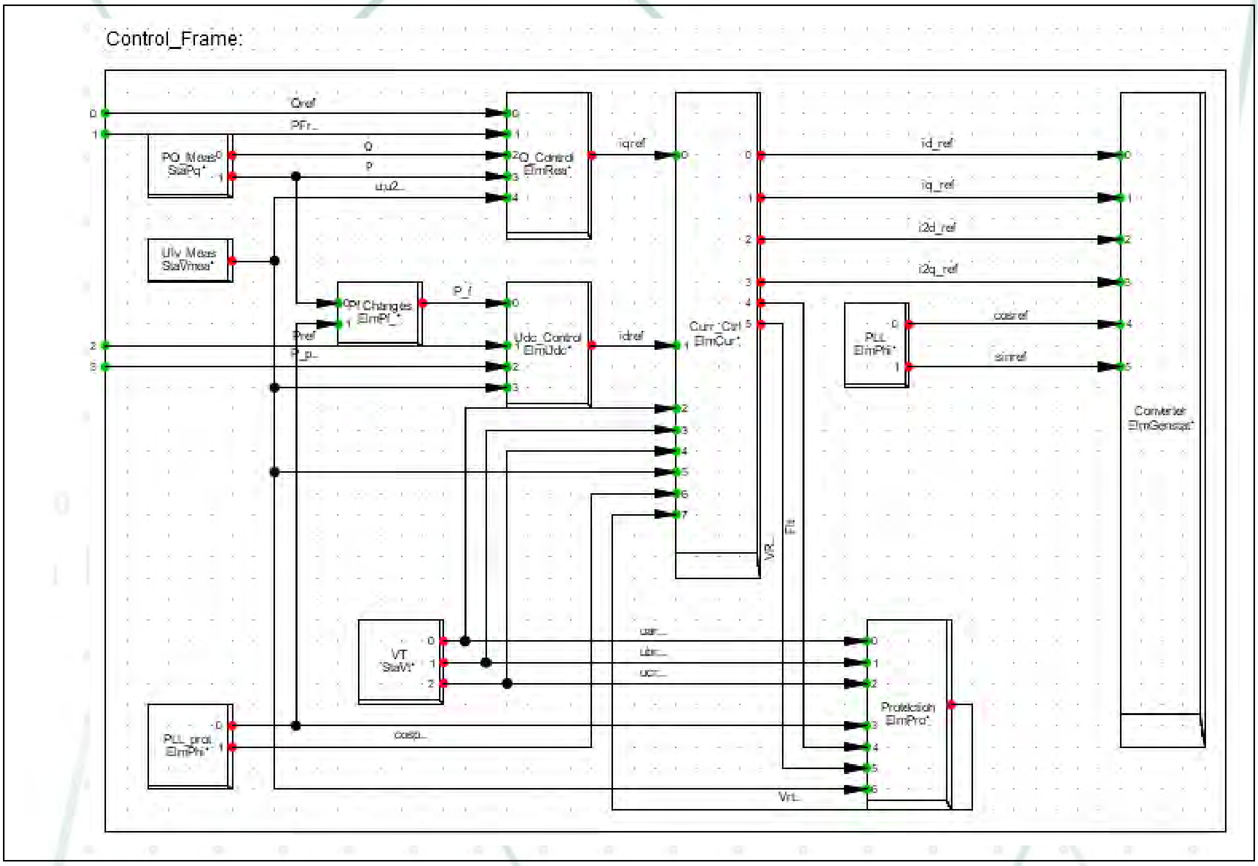
$$SCR = MSk/Pn$$

Where, MSk is the short-circuit capacity of interconnected of point, Pn is the rated capacity of inverter.

And the impedance Zk of grid is calculated by:

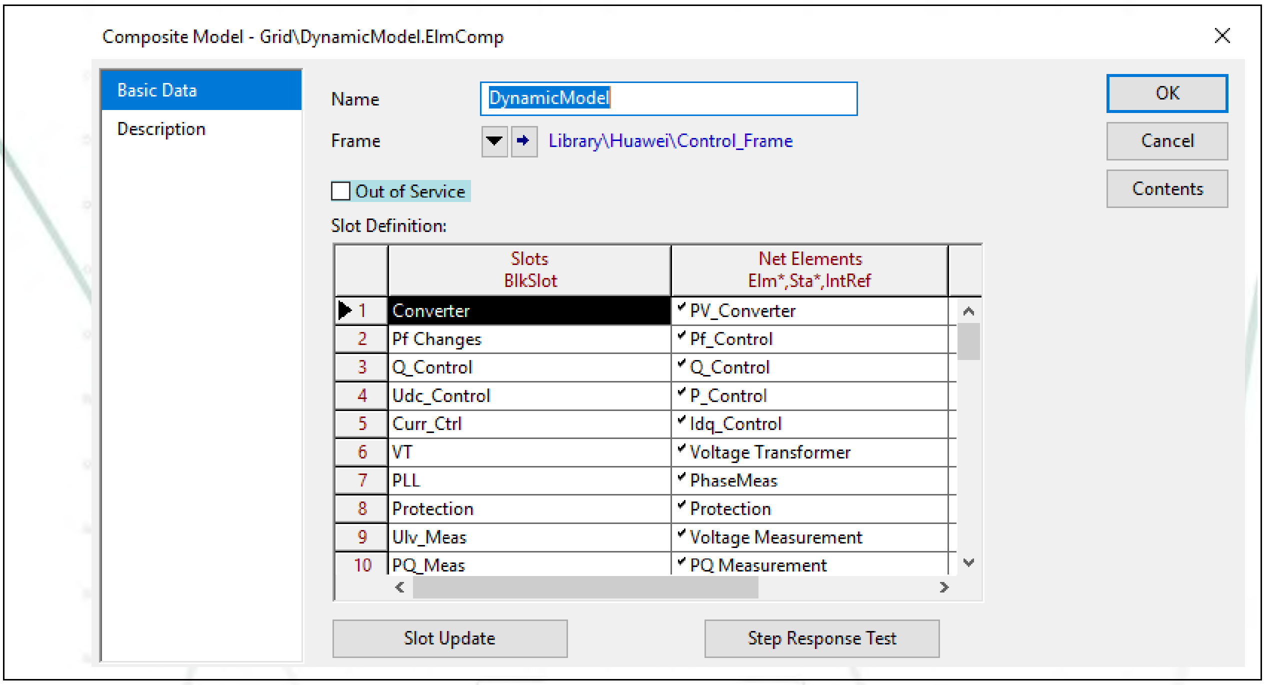
$$Zk=SCR*Pn/(1.732*Ug2)$$

Where, Ug is the rated voltage of inverter. The resistance is 10% of reactance for impedance



SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

Below is showed the composite model linked with the PV-frame



This controller block allows the user to configurate main adjustable parameters of the simulated conversion system for LVRT/HVRT tests.

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36

The following picture shows parameters adjusted by default for the simulations offered in this report.

	Parameter
Smax Apparent power limit [p.u.]	1,1
imax Current limit [p.u.]	1,1108
Unom Nominal line voltage [V]	400,
Tmu Voltage filter time constant [s]	0,001
Tq Pre-fault reactive current time constant [s]	1,
Tcc Equiv. converter reaction time [s]	0,001
Iq_pre Consider pre-fault reactive current [1/0]	1,
Ramp_I Post-fault current ramp rate [p.u.]	2,5
imax1 Current limit, symm. faults [p.u.]	1,
imax2 positive, Current limit, unsymm. faults [p.u.]	1,
Id_lim Id limit , fault [p.u.]	0,1
imax2_neg negative current limit, unsymm. faults [p.u.]	1,
Ut_OV Reactive support, HVRT threshold [p.u.]	0,1
Ut_UV Reactive support, LVRT threshold [p.u.]	0,1
K_Hvrt HVRT Slope diq/du characteristic [ ]	2,
K_Lvrt LVRT Slope diq/du characteristic [ ]	2,
Ut_AV Reactive support, Voltage change threshold [p.u.]	0,05
Udz VRT fault clear voltage thres [p.u.]	0,02
LVRT_EN LVRT 1 enable/ 0 disable [1/0]	1,
HVRT_EN HVRT 1 enable/ 0 disable [1/0]	1,
ZeroCurrMode limit power mode [1/0]	0,
Tu Pre-fault voltage time constant [s]	1,

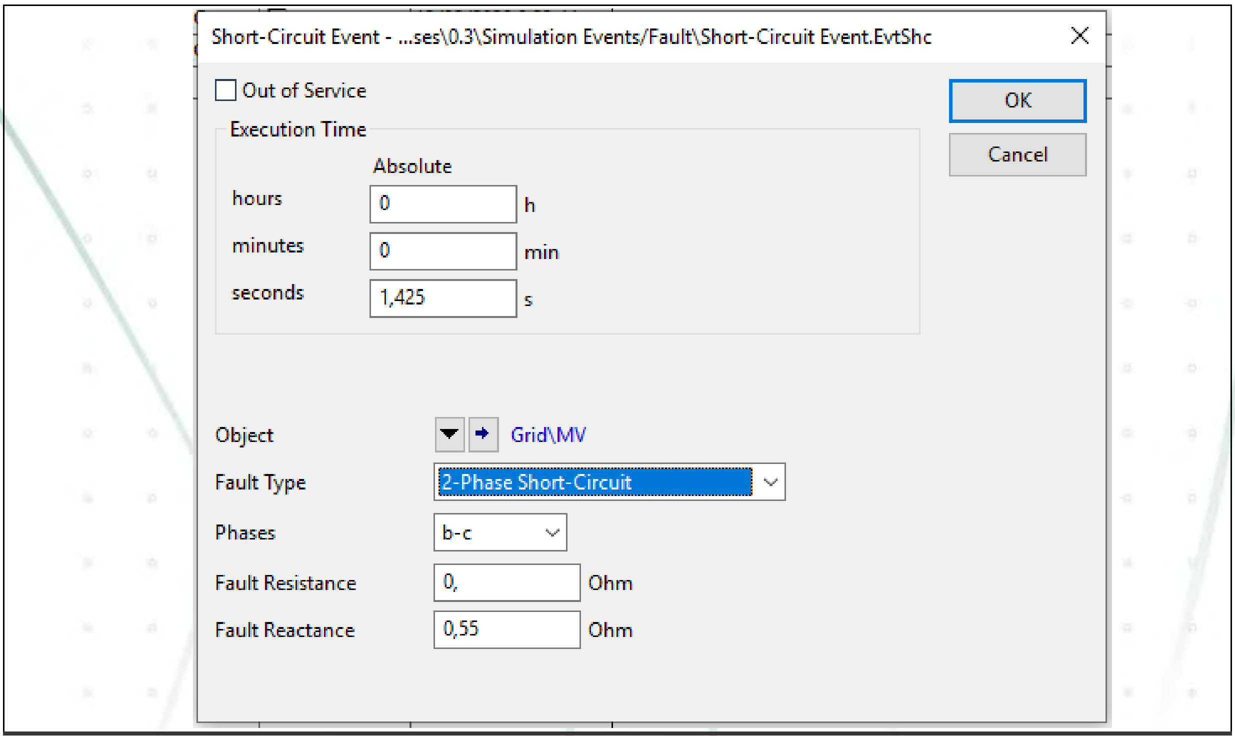
Just following parameters have been varied depending the case to evaluate:

- K_Lvrt LVRT Slope dip/ du characteristic [ ]. This flag set the K factor for LVRT.
- K_Lvrt HVRT Slope dip/ du characteristic [ ]. This flag set the K factor for HVRT.
- ZeroCurrMode limit power mode [1/0], This flag enables, with 1, or disables, with 0, the Limited Dynamic Grid Support Mode.

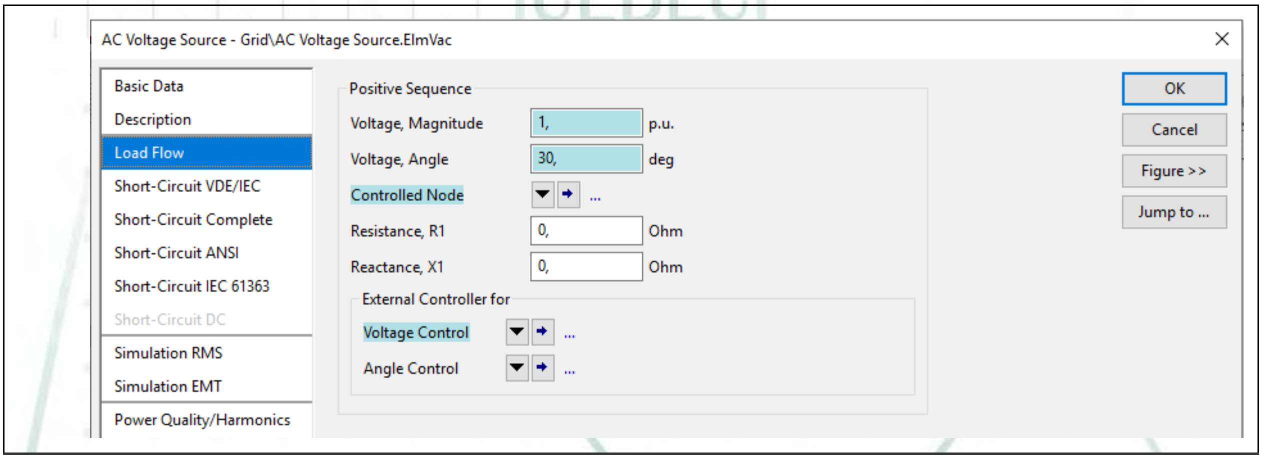
These are configurated as short-circuit events indicating phases affected by the dip event as corresponds.

Name	Object	Out of Se...	Execution Time	Absolute h	Absolute min	Absolute s	Ev...	Fault Type	Phases	Phase	Phases	Fault Resistance Ohm	Fault Reactance Ohm	Fault Inductanc mH
Short-Circuit Event	MV	☐	/01/1970 1:00:00	0	0	1,297		0	a-b	a	a,b	0,	0,35	0,
Short-Circuit Event(1)	MV	☐	/01/1970 1:00:00	0	0	1,644		4	a-b	a	a,b	0,	0,18	0,

The type of fault and short-circuit configurations are set in the Short Circuit Event configuration:



The slack node can also be configured for plausibility tests.



SGS Belgium NV – Division SGS CEBEC
Riverside Business Park
Bld. Internationalelaan, 55 Build. K
BE-1070 Brussels
Tel. +32 2 556 00 20
Fax +32 2 556 00 36