TESTING FOR THE VERIFICATION OF COMPLIANCE OF POWER CONVERTER WITH:

G99 (MARCH 2020): REQUIREMENTS FOR THE CONNECTION OF GENERATION EQUIPMENT IN PARALLEL WITH PUBLIC DISTRIBUTION NETWORKS ON OR AFTER 27 APRIL 2019

Procedure: PE.T-LE-62

Test Report Number	:	**2220 / 0019 - F - A1**

This Test Report modifies and supersedes Test Report No. 2220 / 0019 – F.
See Test Report Historical Revision table on page 2.

Type	:	Inverter / charger with UPS functionality
Trademark	:	**Quattro**
Tested Model	:	**48/15000/200-100/100**
Variant Models	:	**48/8000/110-100/100** **48/10000/140-100/100**

APPLICANT

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Hired by	:	Victron Energy B. V.
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TESTING LABORATORY

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Test Report Historical Revision:

Test Report Version	Date	Resume
2220 / 0019 - F	17/05/2021	• First issuance
2220 / 0019 - F – A1	11/03/2022	• Addition of calculated flicker parameters for Z_{max} • Added evaluation of *Clause 15.2 – Wiring for Type Tested Power Generating Modules* • Editorial changes

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1 SCOPE

SGS Tecnos, S.A. (Electrical Testing Laboratory) has been contract by SGS Tecnos, S.A. (Certification body) in order to perform testing according to:

- **G99/1-6 (March 2020)**: Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019

Tests have been performed to show just compliance with requirements for inverter generation systems of type A.

2 GENERAL INFORMATION

2.1 TESTING PERIOD AND CLIMATIC CONDITIONS

The necessary testing has been performed along between July 27th, 2020 and May 11th, 2021.

All the tests and checks have been performed at 25 ± 5ºC, 96 kPa ± 10 kPa and 40% RH ± 10% RH.

SITE TEST

Name.....: Victron Energy, B. V.

Address.....: Koldingweg 9a, 9723HL – Groningen
The Netherlands

2.2 EQUIPMENT UNDER TESTING

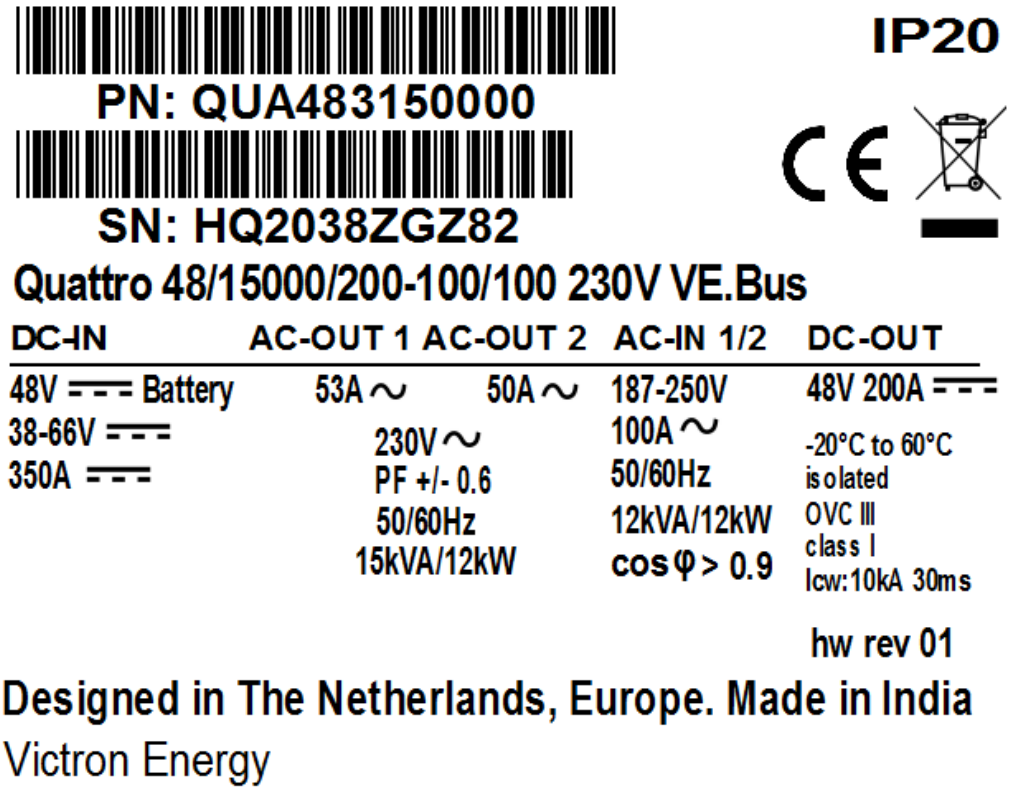
Apparatus type ..... :	Inverter / charger with UPS functionality
Installation ..... :	Fixed installation
Manufacturer ..... :	Victron Energy, B. V.
Trademark ..... :	Quattro
Model / Type reference ..... :	48/15000/200-100/100 (see pages 7 and 8 for further information)
Serial Number ..... :	HQ1930C9TQJ
Software Version ..... :	2656475.1
Rated Characteristics ..... :	See pages 7 and 8 for full ratings of equipment

Date of manufacturing: 2019

Test item particulars

Input ..... :	2x 1 phase, AC
Output ..... :	2x 1 phase, AC
Input/output ..... :	Battery, DC
Class of protection against electric shock... :	Class I
Degree of protection against moisture ..... :	IP 20
Type of connection to the main supply ..... :	Fixed connection
Cooling group ..... :	Fans
Modular ..... :	No
Internal Transformer ..... :	Yes

Rating Plate (representative):



Equipment under testing:

- 48/15000/200-100/100

The variants models are:

- 48/8000/110-100/100
- 48/10000/140-100/100

The variants models have been included in this test report without tests because the following features don´t change regarding to the tested model:

- Same connection system and hardware topology
- Same control algorithm.
- Output power within 1/√10 and 2 times of the rated output power of the EUT or Modular inverters.
- Same Firmware Version ([1])

([1]) Firmware versions for the covered models are:

- 2656475.1 (48/15000/200-100/100 model)
- 2653475.1 (48/10000/140-100/100 model)
- 2655475.1 (48/8000/110-100/100 model)

The different software versions for the covered models don't affect grid code requirements, the only change is to limit maximum AC power in the different models, as declared by the manufacturer.

Victron Quattro is a combined inverter / charger, with UPS functionality.

It has two one-phase AC input and two one-phase AC output ports, and an input / output port for the connection of batteries.

The following table including ratings of the tested and the variant models:

Quattro	12/5000/220-100/100 24/5000/120-100/100 48/5000/70-100/100	24/8000/200-100/100 48/8000/110-100/100	48/10000/140-100/100	48/15000/200-100/100
PowerControl / PowerAssist	Yes			
Integrated Transfer switch	Yes			
AC inputs (2x)	Input voltage range: 187-265 VAC Input frequency: 45 – 65 Hz Power factor: 1			
Maximum feed through current (A)	2x100	2x100	2x100	2x100
INVERTER				
Input voltage range (V DC)	9,5 – 17V 19 – 33V 38 – 66V			
Output (1)	Output voltage: 230 VAC ± 2% Frequency: 50 Hz ± 0,1%			
Cont. output power at 25°C (VA) (3)	5000	8000	10000	15000
Cont. output power at 25°C (W)	4000	6500	8000	12000
Cont. output power at 40°C (W)	3700	5500	6500	10000
Cont. output power at 65°C (W)	3000	3600	4500	7000
Peak power (W)	10000	16000	20000	25000
Maximum efficiency (%)	94 / 94 / 95	94 / 96	96	96
Zero load power (W)	30 / 30 / 35	45 / 50	55	80
Zero load power in AES mode (W)	20 / 25 / 30	30 / 30	35	50
Zero load power in Search mode (W)	10 / 10 / 15	10 / 20	20	30
CHARGER				
Charge voltage 'absorption' (V DC)	14,4 / 28,8 / 57,6	28,8 / 57,6	57,6	57,6
Charge voltage 'float' (V DC)	13,8 / 27,6 / 55,2	27,6 / 55,2	55,2	55,2
Storage mode (V DC)	13,2 / 26,4 / 52,8	26,4 / 52,8	52,8	52,8
Charge current house battery (A) (4)	220 / 120 / 70	200 / 110	140	200
Charge current starter battery (A)	4 (12V and 24V models only)			
Battery temperature sensor	Yes			
GENERAL				
Auxiliary output (A) (5)	50	50	50	50
Programmable relay (6)	3x	3x	3x	3x
Protection (2)	a-g			
VE.Bus communication port	For parallel and three phase operation, remote monitoring and system integration			
General purpose com. port	2x	2x	2x	2x
Remote on-off	Yes			
Common Characteristics	Operating temp.: -40 to +65°C Humidity (non-condensing): max. 95%			
ENCLOSURE				
Common Characteristics	Material & Colour: aluminium (blue RAL 5012) Protection category: IP 21			
Battery-connection	Four M8 bolts (2 plus and 2 minus connections)			
230 V AC-connection	Bolts M6	Bolts M6	Bolts M6	Bolts M6
Weight (kg)	34 / 30 / 30	45 / 41	45	72
Dimensions (hxwxd in mm)	470 x 350 x 280 444 x 328 x 240 444 x 328 x 240	470 x 350 x 280	470 x 350 x 280	572 x 488 x 344
STANDARDS				
Safety	EN-IEC 60335-1, EN-IEC 60335-2-29, EN-IEC 62109-1			
Emission, Immunity	EN 55014-1, EN 55014-2, EN-IEC 61000-3-2, EN-IEC 61000-3-3, EN-IEC 61000-6-3, EN-IEC 61000-6-2, EN-IEC 61000-6-1			
Vehicles, aftermarket	12V and 24V models: EN 50498			
Anti-islanding	See our website			
1) Can be adjusted to 60 HZ; 120 V 60 Hz on request 2) Protection key: a) output short circuit b) overload c) battery voltage too high d) battery voltage too low e) temperature too high f) 230 VAC on inverter output g) input voltage ripple too high	3) Non-linear load, crest factor 3:1 4) At 25°C ambient 5) Switches off when no external AC source available 6) Programmable relay that can a.o. be set for general alarm, DC under voltage or genset start/stop function AC rating: 230 V / 4 A DC rating: 4 A up to 35 VDC, 1 A up to 60 VDC			

Model / Rating	48/8000/110-100/100	48/10000/140-100/100	48/15000/200-100/100
AC IN 1/2	187-250V_{ac}; 100A; 50/60Hz, cos φ >0.9		
	6.4kVA/6.4kW	8kVA/8kW	12kVA/12kW
AC OUT 1/2	230V_{ac}; 50/60Hz; PF: ±0.6		
	30A, 8kVA/6.4kW	37A, 10kVA/8kW	53A (AC OUT 1) / 50A (AC OUT 2), 15kVA/12kW
DC IN	38-66V_{dc} (48V_{dc} battery)		
	110A	140A	200A
DC OUT	48V_{dc}		
	188A	235A	350A

The results obtained apply only to the particular sample tested that is the subject of the present test report. The most unfavorable result values of the verifications and tests performed are contained herein. Throughout this report a point ~~(comma)~~ is used as the decimal separator.

SITE FACTORY

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Address.....: Pandithanahalli Hirehalli Post
Tumkur, 572168 Karnataka, India

2.2.1 *Reference Values*

The values presented in the following table have been used for calculation of referenced values (p.u.; %) through the report if not otherwise indicated.

Reference Values	
Rated power, $\mathbf{P_n}$ in kW	12 kW (9.6 kW in charging batteries mode)
Rated apparent power, $\mathbf{S_n}$ in kVA	12 kVA (9.6 kVA in charging batteries mode)
Rated wind speed (only WT), $\mathbf{v_n}$ in m/s	Not applicable
Rated current (determined), $\mathbf{I_n}$ in A	53 A_{ac}
Rated output voltage, (phase to phase) $\mathbf{U_n}$ in V_{ac}	230 V_{ac}
Note: In this report p.u. values are calculated as follows: -For Active & Reactive Power p.u values are reference to $\mathbf{P_n}$ -For Currents p.u values, the reference is always $\mathbf{I_n}$ -For Voltages p.u values, the reference is always $\mathbf{U_n}$	

2.3 SGS TEST EQUIPMENT LIST

Equipment used from 27/07/2020 to 07/08/2020			
EQUIPMENT	**MARK/MODEL**	**SGS CODE (DIE)**	**CALIBRATION DATE**
Temp / HR data logger	TESTO / 622	DIE.840051	10/07/2020 to 10/10/2021
Multimeter	FLUKE / 289	DIE.560020	15/11/2019 to 15/11/2020
Voltage probe	SAPPHIRE / SI-9010	DIE.610300-03	13/12/2019 to 13/12/2020
		DIE.610300-07	13/12/2019 to 13/12/2020
Amperimetric clamp	HIOKI / 3285	DIE.510051	08/04/2020 to 08/04/2021
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 --
EQUIPMENT	**MARK/MODEL**	**Internal ID Code (VICTRON)**	**CALIBRATION DATE**
Oscilloscope	TEKTRONIX / MDO4034C	MDO4034C C002403	15/07/2020 to 15/07/2021
Current Clamp	PICO / TA167	P15430447975	17/07/2020 to 17/07/2021
Power Analyzer	ZES ZIMMER / LMG640	LMG640 01751907	21/07/2020 to 21/07/2021
Note: All equipment used inside their calibration dates.			

Equipment used from 10/08/2020 to 11/05/2021			
EQUIPMENT	**MARK/MODEL**	**SGS CODE (DIE)**	**CALIBRATION DATE**
Temp / HR data logger	TESTO / 622	DIE.840051	10/07/2020 to 10/10/2021
Multimeter	FLUKE / 289	DIE.560020	15/11/2019 to 15/11/2020 02/12/2020 to 02/12/2021
Amperimetric clamp	HIOKI / 3285	DIE.510052	20/02/2020 to 20/02/2021 13/04/2021 to 13/04/2022
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 --
EQUIPMENT	**MARK/MODEL**	**Internal ID Code (VICTRON)**	**CALIBRATION DATE**
Current Clamp	PICO / TA167	P15430447975	17/07/2020 to 17/07/2021
Voltage Probe	TESTEC / TT-SI9002	1906168	17/07/2020 to 17/07/2021
Measuring system	DEWESOFT / SIRIUSi-SYSTEM (4xHV; 4xLV)	DB19102621	07/08/2020 to 07/08/2021
Note: All equipment used inside their calibration dates.			

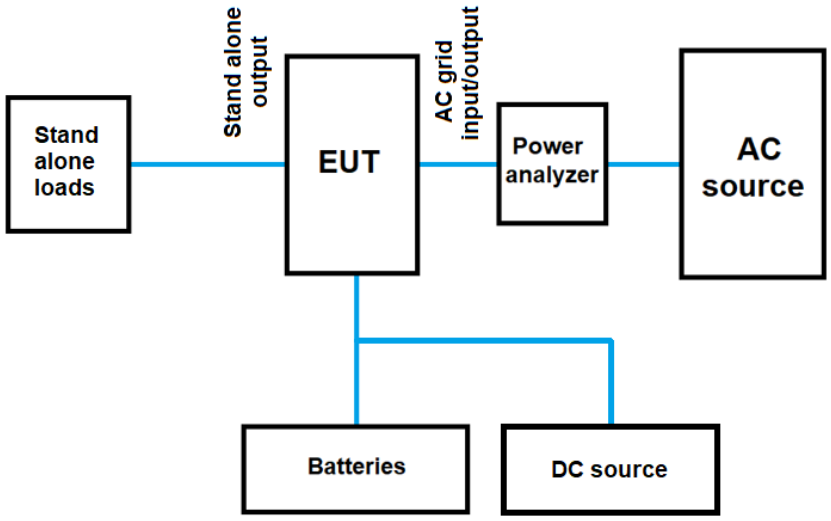
2.4 MEASUREMENT UNCERTAINTY AND DATA SAMPLING RATES

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	±3 °C
Note 1: 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. Note 2: Where the standard requires lower uncertainties that those in this table. Most restrictive uncertainty has been considered.	

2.5 TEST SET UP

Below is the simplified construction of the test set up.



Different equipment has been used to take measures as it shows in section 2.3 of this Test Report. Current and voltage clamps have been connected to the inverter input / output for all the tests.

All the tests described in the following pages have used this specified test setup.

The test bench used includes:

EQUIPMENT	MARK / MODEL	RATED CHARACTERISTICS	OWNER / ID.CODE
DC source	DELTAELEKTRONIKA / SM70-CP-450	V_{dc} 0 – 70 V $I_{dc\ max}$=450 A. 15 kW	VICTRON
Batteries	Victron Energy / LFP Smart 12.8/300 (4 in series)	12.8 V 300 Ah	VICTRON
AC Source	Regatron / TC.ACS.30.528.AWR.S.LC	230 V_{ac} / 50 Hz 3 phase 30 kW I_{nom} = 72 A per phase	VICTRON
AC Source Loads	Regatron / TC.ACS.30.528.AWR.S.LC	230 V_{ac} / 50 Hz 3 phase 30 kW I_{nom} = 72 A per phase	VICTRON

2.6 DEFINITIONS

EUT	Equipment Under Testing	Hz	Hertz
A	Ampere	V	Volt
VAr	Volt-Ampere reactive	W	Watt
U_n	Nominal Voltage	p.u.	Per unit
I_n	Nominal Current	P_n	Nominal Active Power
MV	Medium Voltage	P_M	Instantaneous Active Power
LV	Low Voltage	Q_n	Nominal Reactive Power
LVRT	Low Voltage Ride Through	S_n	Nominal Apparent Power
K_f (Ψ_k)	Flicker Form Factor	S_k	Symetrical Fault level
K_u (Ψ_k)	Voltage Variation Factor	I_h	Harmonic Current
P_{st}	Short-term flicker disturbance factor	TDC	Total Demand Current Distortion
		TDD	Total Demand Distortion
PGU	Power Generation Unit		

2.7 STANDARD CATEGORIES

The standard defines connection types, depending on capacity and voltage at connection point:

Type A capacity range	Type B capacity range	Type C capacity range	Type D capacity range
0.8 kW ≤ P < 1 MW	1 MW ≤ P < 10 MW	10 MW ≤ P < 50 MW	≥ 50 MW

Type A, B or C generation modules require a connexion point lower than 110 KV, whereas Type D generation modules require a connexion point higher than 110 KV. If voltage is lower than 110 KV and its maximum capacity its equal or higher than the one specified above, it will also be considered Type D.

As explained in the Scope of the Test Report, tests have been performed to show compliance with requirements for inverter generation systems of type A.

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

REPORT SECTION	G99 SECTION	CHAPTER OF THE STANDARD G99	RESULT
4.1		**Functional Testing of the Interface Protection**	**P**
4.1.1	A.7.1.2.2	Over / Undervoltage protection	P
4.1.2	A.7.1.2.3	Over / Underfrequency protection	P
4.1.3	A.7.1.2.4	Loss of Mains Protection	P
4.1.4	A.7.1.2.5	Reconnection	P
4.1.5	A.7.1.2.6	Frequency drift and step change stability test	P
4.2	**A.7.1.3**	**Limited Frequency Sensitive Mode – Over (LFSM-O)**	**N/A**
4.3	**A.7.1.4**	**Power Quality**	**P**
4.3.1	A.7.1.4.1	Harmonics	P
4.3.2	A.7.1.4.2	Power Factor	P
4.3.3	A.7.1.4.3	Voltage Flicker	P
4.3.4	A.7.1.4.4	DC Injection	N/A
4.4	**A.7.1.5**	**Short Circuit Current Contribution**	**P**
4.5	**A.7.1.6**	**Self-Monitoring – Solid State Disconnection**	**P**
4.6	**11.1.3**	**Active Power Cessation Following Instruction**	**P**
4.7	**11.2.1 / 11.2.3**	**Operation Range**	**P**
4.8	**15.2**	**Wiring for Type Tested Power Generating Modules**	**N/A**

Note: Decision rule of the declaration of conformity evaluated according to the ILAC G8: 09/2019 & IEC 115 Guidelines (Proc. 2 “Accuracy Method” based on OD-5014).

Decision rule used: Binary with simple acceptance. (Safety Zone with respect to the limit w=0).

Specific risk: Probability of False Acceptance or Rejection less than 50%, (PFA / PFR <50%). **For more information see ILAC Guide G8 / 09.**

4 TEST RESULTS

4.1 FUNCTIONAL TESTING OF THE INTERFACE PROTECTION

4.1.1 Under/Overvoltage protection

These tests have been done according to chapter A.7.1.2.2 applying testing procedure and testing points from Annex A2-3 and Table 10.1 of the Standard.

To evaluate this protection, three different tests have been performed:

- Trip voltage test, to assess that the protection function of the inverter works as the voltage levels stated by the standard.
- Trip time test, to assess that the disconnection of the inverter takes place into the time limits established by the standard.
- No trip test, to assess that the protection does not trip with a voltage value within the limits stated, or if the voltage is outside the limits for a time shorter than the delay time.

Five repetitions have been performed for the trip time and trip voltage tests of each voltage protective function to test the repetibility.

The applied tolerance for the voltage value tests has been ± 0.015 U p.u.

The following procedures have been used for the different tests:

- For testing the accuracy of trigger value threshold: Starting from a voltage level 1.5% U_n below or above the trip value of the protection function to be tested, the voltage is increased or decreased in steps of 0.5% U_n for at least 1.5 times of the trip time delay stated in the protection function to be tested, and the voltage at which the EUT trips is to be recorded

- For testing the accuracy of the trip time: Starting from a voltage value 4 V below or above the previously recorded trigger value, the voltage shall be increased in a single step to a value 4V above or below that recorded value. The time taken from the start of the step until the EUT trips is recorded as the trip time.

- For the no-trip test, two procedures have been used:
  - Set the voltage to a value just above or below the measured trip value, but within the valid operating range, for a duration longer than the trip time configured
  - Set the voltage to a value just below or above the measured trip value, but outside the valid operating range, for a duration shorter than the trip time configured, then return to the valid operating range

The following tables show the test results for the trip voltage, the trip time and the no-trip tests:

Trip voltage test						
Stage/Prot Function	**Test**	**Voltage at the start (p.u.)**	**Trip Voltage Desired (p.u.)**	**Trip voltage measured (p.u.)**	**Disconnection**	**Deviation measured (p.u.)**
U/V	1	0.820	0.800	0.804	☐ NO ☒ YES	+0.004
	2	0.820		0.804	☐ NO ☒ YES	+0.004
	3	0.820		0.804	☐ NO ☒ YES	+0.004
	4	0.820		0.804	☐ NO ☒ YES	+0.004
	5	0.820		0.804	☐ NO ☒ YES	+0.004
O/V st. 1	1	1.120	1.140	1.143	☐ NO ☒ YES	+0.003
	2	1.120		1.143	☐ NO ☒ YES	+0.003
	3	1.120		1.143	☐ NO ☒ YES	+0.003
	4	1.120		1.143	☐ NO ☒ YES	+0.003
	5	1.120		1.143	☐ NO ☒ YES	+0.003
O/V st. 2	1	1.170	1.190	1.198	☐ NO ☒ YES	+0.008
	2	1.170		1.198	☐ NO ☒ YES	+0.008
	3	1.170		1.197	☐ NO ☒ YES	+0.007
	4	1.170		1.197	☐ NO ☒ YES	+0.007
	5	1.170		1.197	☐ NO ☒ YES	+0.007

Trip time test				
Stage/Prot. Function	**Test**	**Delay Time limit (s)**	**Trip time measured (s)**	**Disconnection**
U/V	1	2.500	2.543	☐ NO ☒ YES
	2		2.542	☐ NO ☒ YES
	3		2.523	☐ NO ☒ YES
	4		2.542	☐ NO ☒ YES
	5		2.542	☐ NO ☒ YES
O/V st. 1	1	1.000	1.087	☐ NO ☒ YES
	2		1.088	☐ NO ☒ YES
	3		1.068	☐ NO ☒ YES
	4		1.063	☐ NO ☒ YES
	5		1.066	☐ NO ☒ YES
O/V st. 2	1	0.500	0.541	☐ NO ☒ YES
	2		0.542	☐ NO ☒ YES
	3		0.543	☐ NO ☒ YES
	4		0.540	☐ NO ☒ YES
	5		0.540	☐ NO ☒ YES

No-trip test										
Stage / Prot Function	Step 1			Step 2			Step 3			Disconn. Step1, Step 2 or Step 3
	U (p.u.)	Time req. (s)	Time meas. (s)	U (p.u.)	Time req. (s)	Time meas. (s)	U (p.u.)	Time req. (s)	Time meas. (s)	
U/V	0.817	5.00	5.01	0.780	2.48	2.48	0.817	5.00	5.00	☒ NO ☐ YES
O/V st. 1	1.135	5.00	5.00	1.170	0.98	0.98	1.135	2.00	3.65	☒ NO ☐ YES
O/V st. 2	1.135	5.00	5.00	1.210	0.48	0.48	1.135	1.00	4.14	☒ NO ☐ YES

4.1.2 Under/Overfrequency protection

These tests have been done according to chapter A.7.1.2.3 applying testing procedure and testing points from Annex A2-3 and Table 10.1 of the Standard.

To evaluate this protection, three different tests have been performed:

- Trip voltage test, to assess that the protection function of the inverter works at the frequency levels stated by the standard.
- Trip time test, to assess that the disconnection of the inverter takes place into the time limits established by the standard.
- No trip test, to assess that the protection does not trip with a frequency value within the limits stated, or if the frequency is outside the limits for a time shorter than the delay time.

Three repetitions have been performed for the trip time and trip frequency tests of each frequency protective function to test the repetibility.

The applied tolerance for the frequency value tests has been ± 0.10 Hz.

The following procedures have been used for the different tests:

- For testing the accuracy of trigger value threshold: The frequency shall be increased or decreased with a slow ramp rate of less than 0.10 Hz/s, or, if it is not possible, in steps of 0.05 Hz for a duration that is longer than the trip time delay stated in the protection function to be tested, and the frequency at which the EUT trips is to be recorded

- Starting from a frequency value 0.30 Hz below or above the previously recorded trigger value, the frequency shall be increased in a single step to a value 0.30 Hz above or below that recorded value. The time taken from the start of the step until the EUT trips is recorded as the trip time.

- For the no-trip test, two procedures have been used:
  - Set the frequency to a value just above or below the measured trip value, but within the valid operating range, for a duration longer than the trip time configured
  - Set the frequency to a value just below or above the measured trip value, but outside the valid operating range, for a duration shorter than the trip time configured, then return to the valid operating range

The following tables show the test results for the trip frequency, the trip time and the no-trip tests:

Trip frequency test						
Stage/Prot Function	**Test**	**Frequency at the start (Hz)**	**Trip Frequency Desired (Hz)**	**Trip frequency measured (Hz)**	**Disconnection**	**Deviation measured (Hz)**
U/F st. 1	1	47.80	47.50	47.45	☐ NO ☒ YES	-0.05
	2	47.80		47.45	☐ NO ☒ YES	-0.05
	3	47.80		47.45	☐ NO ☒ YES	-0.05
U/F st. 2	1	47.30	47.00	46.95	☐ NO ☒ YES	-0.05
	2	47.30		46.95	☐ NO ☒ YES	-0.05
	3	47.30		46.95	☐ NO ☒ YES	-0.05
O/F	1	51.70	52.00	52.05	☐ NO ☒ YES	+0.05
	2	51.70		52.05	☐ NO ☒ YES	+0.05
	3	51.70		52.05	☐ NO ☒ YES	+0.05

Trip time test				
Stage/Prot. Function	**Test**	**Delay Time limit (s)**	**Trip time measured (s)**	**Disconnection**
U/F st. 1	1	20.00	20.07	☐ NO ☒ YES
	2		20.05	☐ NO ☒ YES
	3		20.06	☐ NO ☒ YES
U/F st. 2	1	0.50	0.57	☐ NO ☒ YES
	2		0.58	☐ NO ☒ YES
	3		0.56	☐ NO ☒ YES
O/F	1	0.50	0.59	☐ NO ☒ YES
	2		0.59	☐ NO ☒ YES
	3		0.59	☐ NO ☒ YES

No-trip test										
Stage / Prot Function	**Step 1**			**Step 2**			**Step 3**			**Disconn. Step1, Step 2 or Step 3**
	f (Hz)	**Time req. (s)**	**Time meas. (s)**	**f (Hz)**	**Time req. (s)**	**Time meas. (s)**	**f (Hz)**	**Time req. (s)**	**Time meas. (s)**	
U/F st. 1	47.70	30.00	32.77	47.20	19.80	19.80	47.70	30.00	31.78	☒ NO ☐ YES
U/F st. 2	47.70	30.00	33.30	46.80	0.48	0.48	47.70	30.00	33.13	☒ NO ☐ YES
O/F	51.80	120.00	122.00	52.20	0.48	0.48	51.80	120.00	122.00	☒ NO ☐ YES

4.1.3 Loss of Mains

Tests regarding loss of mains have been done according to chapter A.7.1.2.4 and Annex A2-3.

The tests have been performed according to BS EN 62116 standard. Results presented in the following table are a subset of the complete results and have been evaluated considering a trip time limit of 1 second.

Loss of Mains Test						
Test power and imbalance	Test 22	Test 12	Test 5	Test 31	Test 21	Test 10
	33%	66%	100%	33%	66%	100%
	-5% Q	-5% Q	-5% P	+5% Q	+5% Q	+5% P
Trip Time (ms)	192	165	233	164	253	220

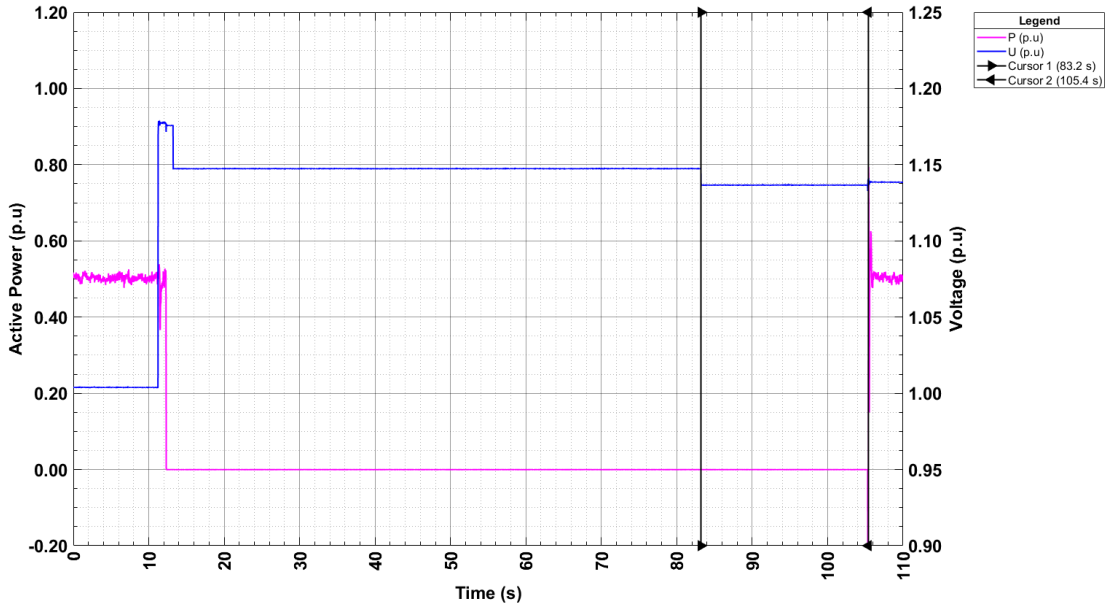
For additional and detailed information about the complete tests and the results, refer to Test Report No. 2220 / 0019 – A.

4.1.4 Reconnection

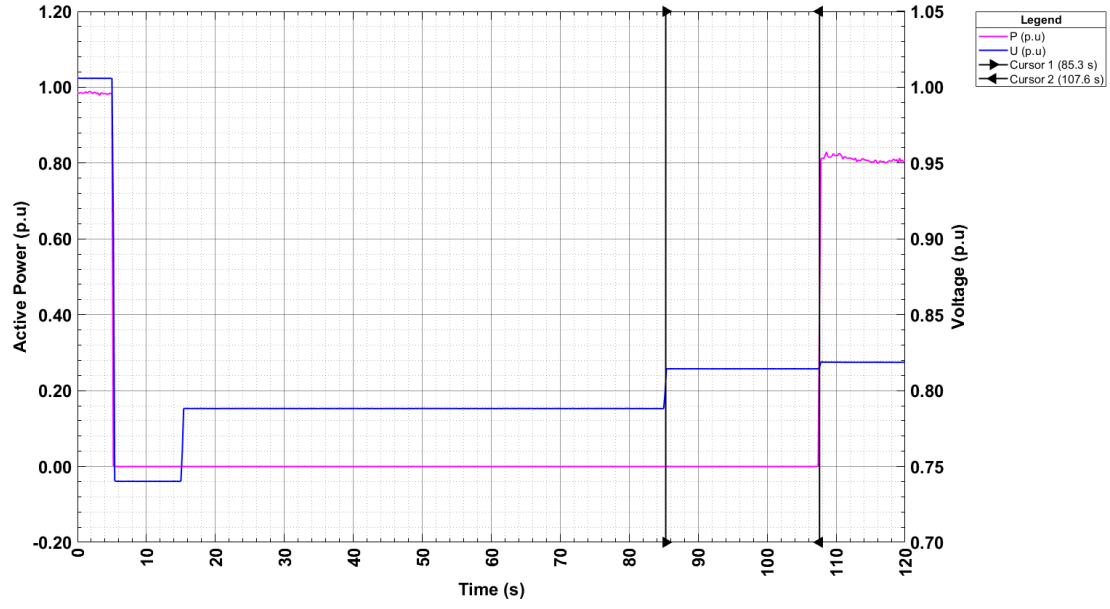
This test has been done according to chapter A.7.1.2.5 using tests values presented in Annex A2-3 of the standard. The aim is to confirm that once the AC supply voltage and frequency have returned within the Stage 1 protection settings (see sections *"4.1.1 - Under/Overvoltage protection and 4.1.2 - Under/Overfrequency protection"* of this Test Report) following an automatic protection trip operation there is a minimum time delay of 20s before the output is restored.

Prot. Function	Step 1			Step 2		
	Measured value	Time measured (s)	Reconnect	Measured Value	Reconnect time (s)	Reconnect
U/V stg. 1 0.800 p.u.	0.790 U p.u.	70	☒ NO ☐ YES	0.814 U p.u.	22	☐ NO ☒ YES
O/V stg. 1 1.140 p.u.	1.150 U p.u.	70	☒ NO ☐ YES	1.136 U p.u.	22	☐ NO ☒ YES
U/F stg. 1 47.50 Hz	47.40 Hz	74	☒ NO ☐ YES	47.60 Hz	22	☐ NO ☒ YES
O/F stg. 1 52.00 Hz	52.10 Hz	80	☐ NO ☒ YES	51.90 Hz	23	☐ NO ☒ YES

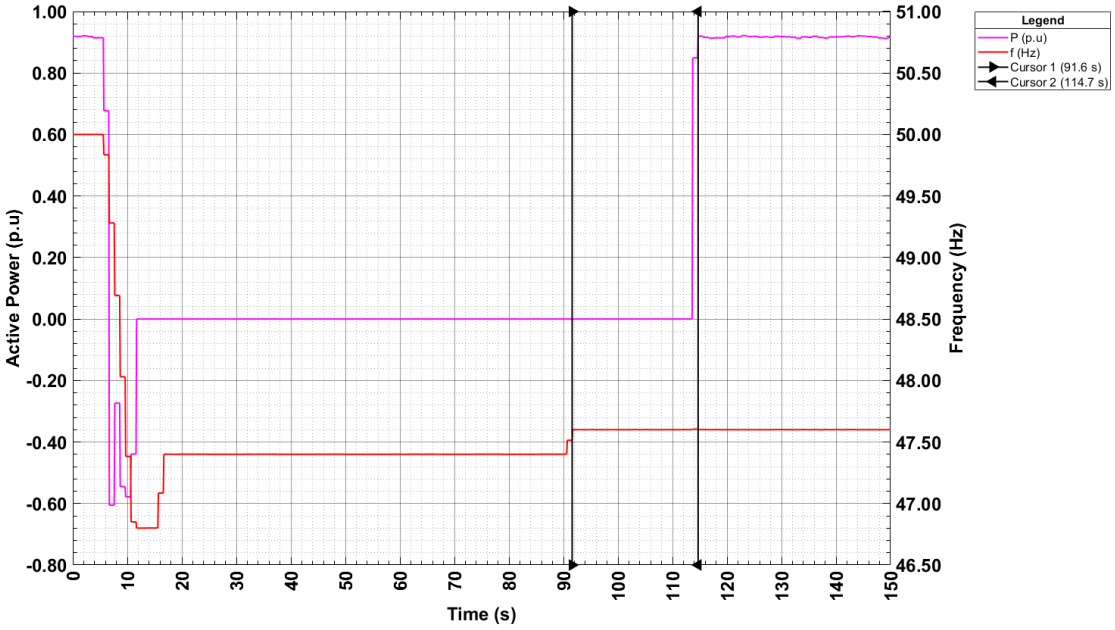
Overvoltage reconnection



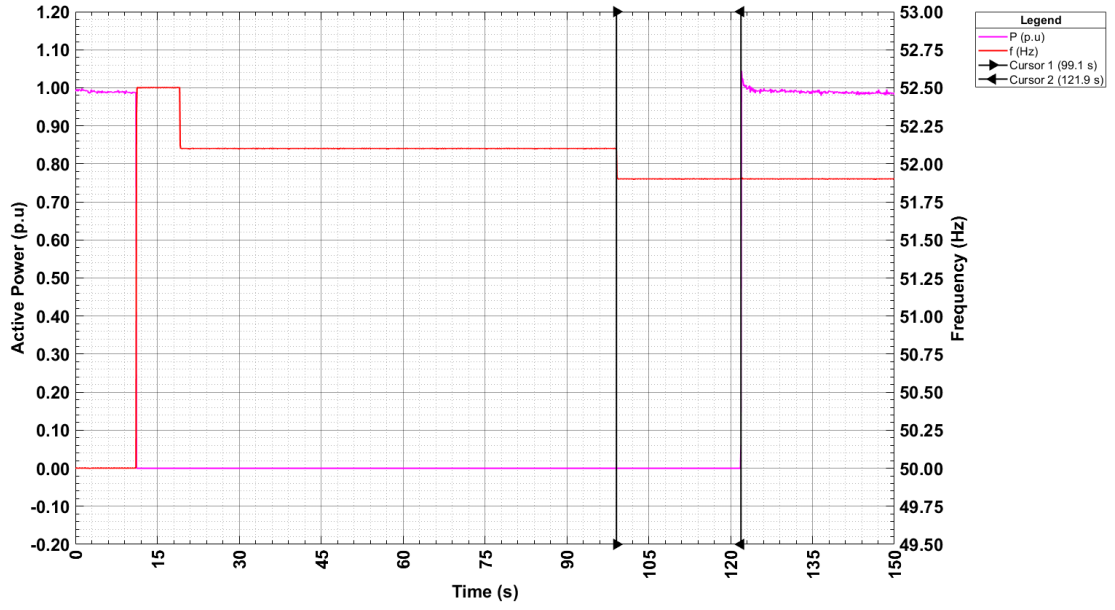
Undervoltage reconnection



Underfrequency reconnection



Overfrequency reconnection



4.1.5 Frequency drift and step change stability test

These tests have been performed according requirements from chapter A.7.1.2.6 and taking the test levels from Annex A2-3 of the standard.

4.1.5.1 Vector shift stability test

The aim of this test is to verify that the EUT is capable of operating without disconnection after a single cycle of frequency is reduced or extended, with subsequent cycles returning to the normal frequency.

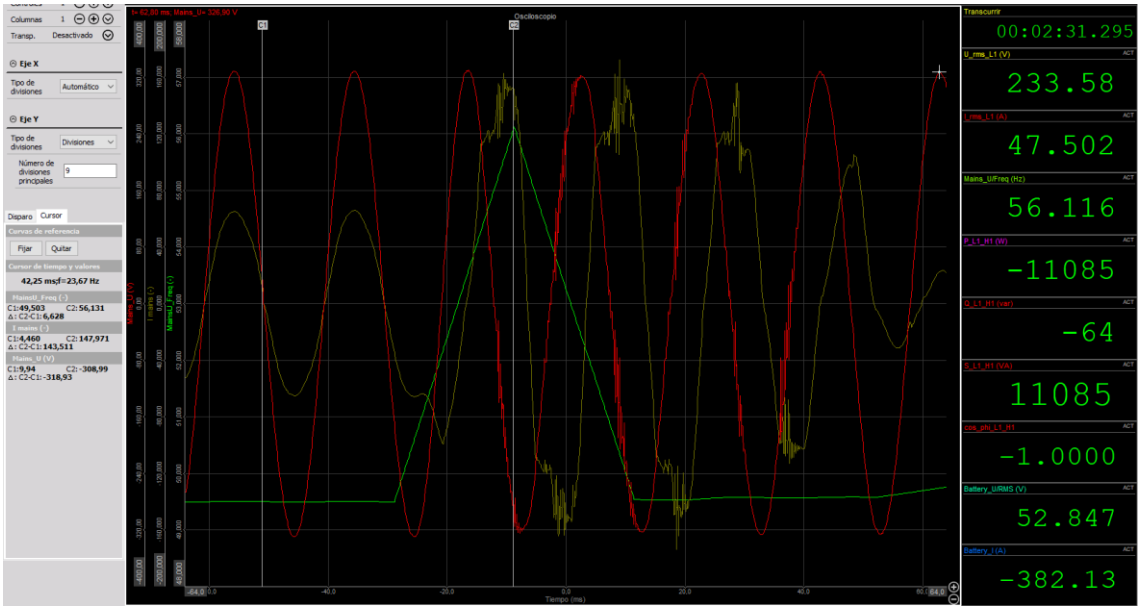
This test has been performed programming a 50º vector shift in a voltage cycle to verify that the EUT does not disconnect.

The end frequency has been maintained for at least 10 s after the frequency jump is made.

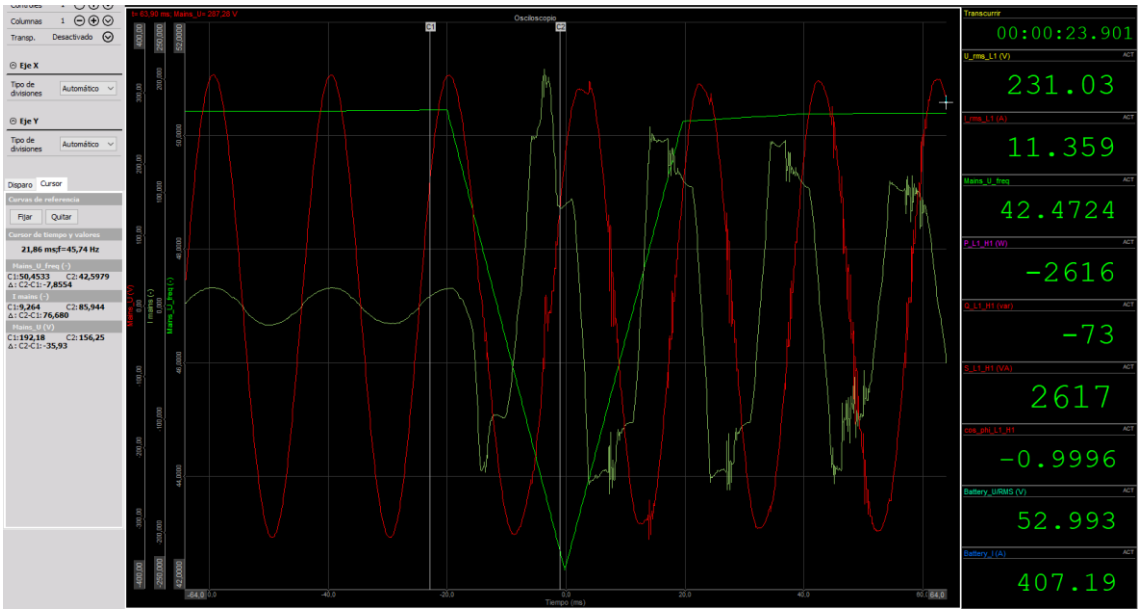
Test results are presented in the following table and graphs:

	Start frequency	Jump Performed (º)	Disconnection
Positive Vector Shift	49.50 Hz	+50	☒ NO ☐ YES
Negative Vector Shift	50.50 Hz	-50	☒ NO ☐ YES

+50° phase jump



-50° phase jump



4.1.5.2 Frequency drift test

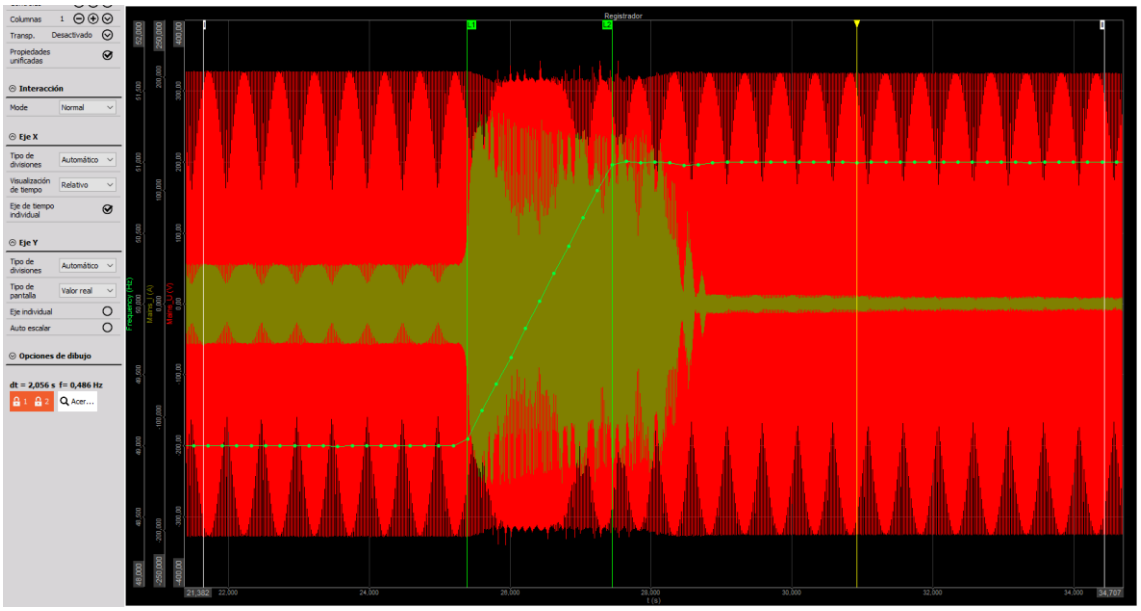
The aim of this test is to verify if the EUT is capable of operating without disconnection when submitted to frequency ramps.

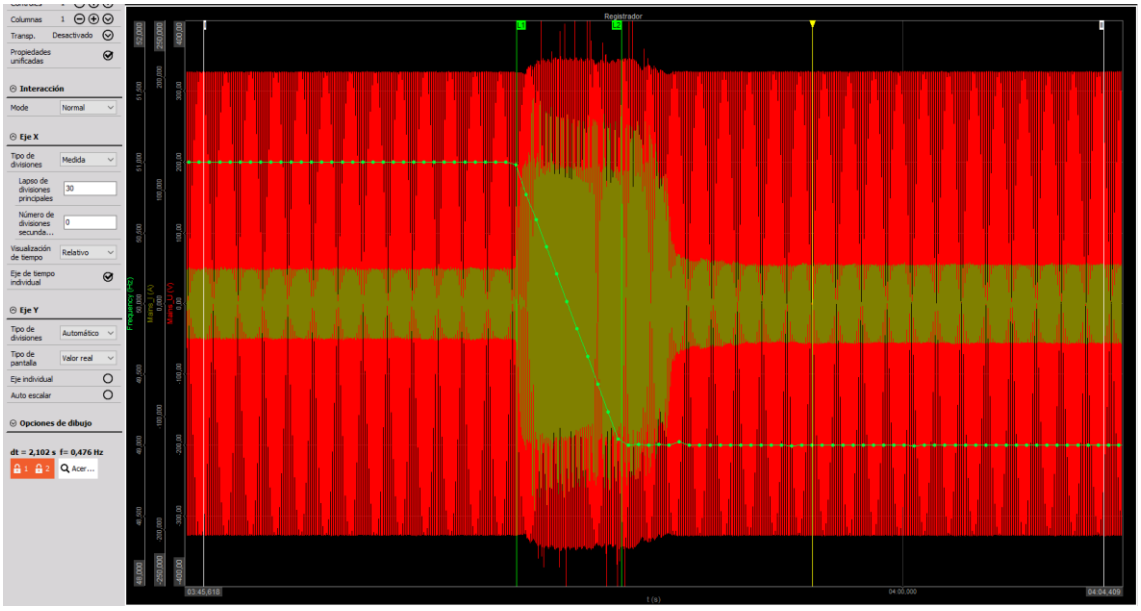
The test has been done applying jumps up to 1 Hz/s measured over a window of 500 ms as stated in the standard. The test has been done at 50% P_n.

The end frequency has been maintained for at least 10 s after the frequency jump is made.

Results are presented in the following table and graphs:

	Ramp range desired	Change desired (Hz/s)	Final Value (Hz)	Ramp (Hz/s)	Disconnection
Positive frequency drift	49.00 to 51.00 Hz	+0.95 Hz/s	51.00	+0.97	☒ NO ☐ YES
Negative frequency drift	51.00 to 49.00 Hz	-0.95 Hz/s	49.00	-0.95	☒ NO ☐ YES

Positive frequency drift

Time of change measured: 2056 ms

Negative frequency drift

Time of change measured: 2102 ms

4.2 LIMITED FREQUENCY SENSITIVE MODE – OVER (LFSM-O)

The requisites for this test are stated in chapter A.7.1.3, and the testing points are shown in Annex A2-3 of the Standard.

According to chapter A.4.2, this test is not applicable to Electricity Storage devices, so it was not evaluated for the EUT.

4.3 POWER QUALITY

Measurement of energy quality have been measured according to chapter 9.4 of the standard, using requirements from Annex A.7.1.4 of the standard and testing values from Annex A2-3.

4.3.1 Current Harmonics

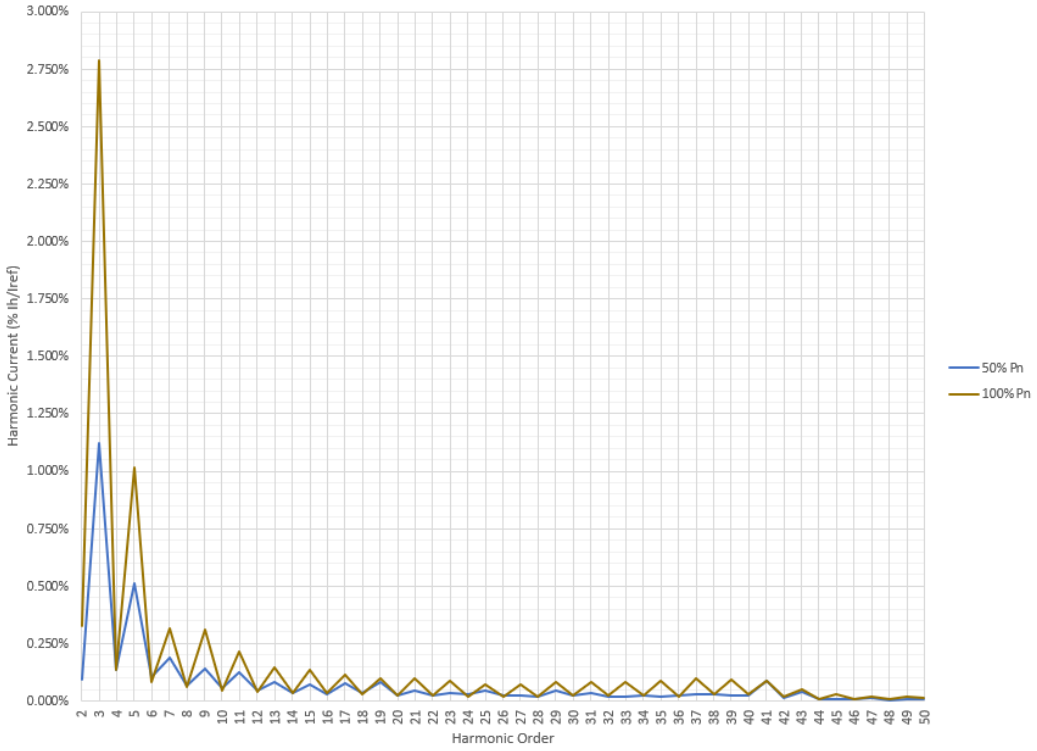
Measurements have been taken according to BS EN 61000-3-12 standard. For this test, harmonics have been measured twice, one at 100%Pn and another at 45% - 55% P_n.

For calculations, the fundamental value of the 100% P_n measurement has been considered as the reference value.

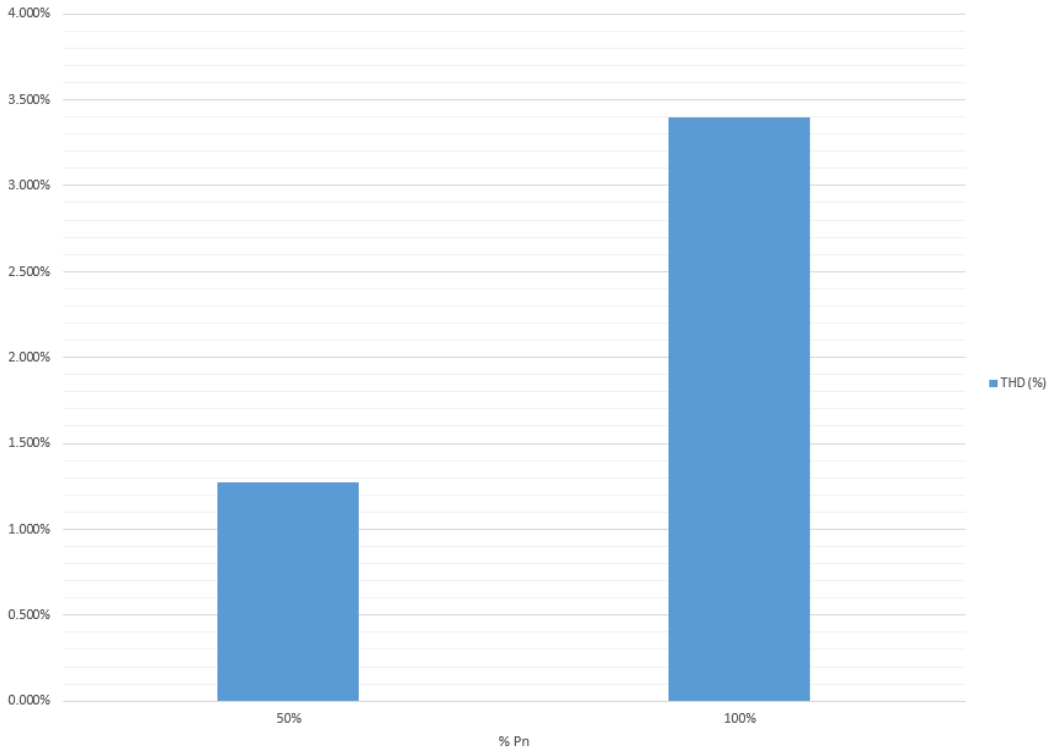
Results are presented in the table and graphs below:

P_n (%)	50%		100%		LIMIT (%)
Nr./Order	I_h (A)	I_h (%)	I_h (A)	I_h (%)	
2	0.050	0.095	0.170	0.326	8.000
3	0.589	1.121	1.456	2.787	21.600
4	0.070	0.134	0.070	0.134	4.000
5	0.269	0.511	0.532	1.019	10.700
6	0.056	0.106	0.043	0.083	2.700
7	0.100	0.191	0.166	0.319	7.200
8	0.035	0.067	0.031	0.059	2.000
9	0.074	0.140	0.162	0.310	3.800
10	0.029	0.055	0.025	0.048	1.600
11	0.065	0.123	0.114	0.218	3.100
12	0.024	0.047	0.022	0.042	1.300
13	0.043	0.082	0.077	0.148	2.000
14	0.018	0.035	0.018	0.034	--
15	0.038	0.073	0.071	0.136	--
16	0.015	0.029	0.019	0.035	--
17	0.041	0.079	0.060	0.115	--
18	0.018	0.033	0.015	0.029	--
19	0.043	0.081	0.051	0.098	--
20	0.012	0.023	0.013	0.025	--
21	0.024	0.045	0.051	0.097	--
22	0.013	0.025	0.012	0.023	--
23	0.017	0.032	0.045	0.086	--
24	0.014	0.027	0.009	0.018	--
25	0.024	0.046	0.037	0.071	--
26	0.012	0.022	0.009	0.018	--
27	0.012	0.023	0.038	0.073	--
28	0.011	0.021	0.011	0.021	--
29	0.025	0.047	0.043	0.082	--
30	0.012	0.022	0.013	0.025	--
31	0.019	0.037	0.043	0.083	--
32	0.011	0.021	0.013	0.025	--
33	0.009	0.017	0.042	0.081	--
34	0.012	0.022	0.012	0.022	--
35	0.011	0.020	0.045	0.085	--
36	0.013	0.025	0.008	0.016	--
37	0.016	0.031	0.051	0.097	--
38	0.014	0.027	0.014	0.027	--
39	0.012	0.024	0.049	0.093	--
40	0.012	0.022	0.014	0.027	--
THD (%)	2.548		3.395		23.000
PWHD (%)	1.860		1.767		23.000

Current Harmonics



Total Harmonic Current Distortion



4.3.2 Power factor

This test has been done according section A.7.1.2 of the standard, using the reference points and requirements from Annex A2-3 and chapter 11.1.5 of the standard. The aim of the test is to verify the capacity of the EUT of operating at rated power with a power factor within 0.950 lagging and 0.950 leading.

For the test, the power factor has been measured at rated power and at three different voltage levels. For compliance, voltage has to be within ±1.5% of its setpoint.

Test results are presented in the tables below:

Voltage measured (p.u.)	Power factor setpoint	Active power measured (p.u)	Active power expected (p.u)	Reactive power measured (p.u)	Reactive power expected (p.u)	Power factor measured	Power factor deviation
0.943	1.000	0.864 (1)	1.000	-0.002	0.000	1.000	0.000
1.006	1.000	0.980	1.000	0.006	0.000	0.998	-0.002
1.103	1.000	0.993	1.000	-0.003	0.000	1.000	0.000

(1) The inverter does not reach the expected power values due to the current limitation.

Additionally, to check the compliance with requirements from chapter 11.1.5, the EUT was set to operate with two power factors within 0.950 lagging and 0.950 leading, at the voltage levels required by the previous test.

Cos phi setpoint: 0.960 (inductive).							
Voltage measured (p.u.)	Power factor setpoint	Active power measured (p.u)	Active power expected (p.u)	Reactive power measured (p.u)	Reactive power expected (p.u)	Power factor measured	Power factor deviation
0.940	0.960	0.821 (1)	0.960	0.241	0.280	0.960	0.000
1.000	0.960	0.874	0.960	0.257	0.280	0.959	-0.001
1.100	0.960	0.962	0.960	0.284	0.280	0.959	-0.001

(1) The inverter does not reach the expected power values due to the current limitation.

Cos phi setpoint: 0.960 (capacitive)							
Voltage measured (p.u.)	Power factor setpoint	Active power measured (p.u)	Active power expected (p.u)	Reactive power measured (p.u)	Reactive power expected (p.u)	Power factor measured	Power factor deviation
0.940	0.960	0.851 (1)	0.960	-0.241	-0.280	0.959	-0.001
1.000	0.960	0.869	0.960	-0.257	-0.280	0.959	-0.001
1.100	0.960	0.956	0.960	-0.281	-0.280	0.960	0.000

(1) The inverter does not reach the expected power values due to the current limitation.

4.3.3 Flicker

Flicker and voltage fluctuations have been measured according to chapter A.7.1.4.3 and Annex A2-3 of the standard.

This test has been performed with three modes of operation: Starting, normal operation and stopping.

Results are presented in the following tables, using the most unfavorable values registered:

Starting test (Ramp change from 0.0% P_n to 100.0% P_n)			
Parameters	**d_c (%)**	**d_{max} (%)**	**d (t)**
Limits	**3.3 %**	**4 %**	**500ms**
100% P_n	4.70%	5.22%	697ms

Running test					
Parameters	**d_c (%)**	**d_{max} (%)**	**d (t)**	**P_{st}**	**P_{lt}**
Limits	**3.3 %**	**4 %**	**500ms**	**1.0**	**0.65**
33% P_n	0.00%	0.00%	0ms	0.079	0.071
66% P_n	0.05%	0.11%	0ms	0.092	0.086
100% P_n	0.57%	1.17%	0ms	0.525	0.458

Stopping test (Ramp change from 100.0% P_n to 0.0% P_n)			
Parameters	**d_c (%)**	**d_{max} (%)**	**d (t)**
Limits	**3.3 %**	**4 %**	**500ms**
100% P_n	8.50%	8.58%	959ms

Parameters dc, dmax and d(t) in the Starting and the Stopping tests are above the limits of the reference Standard BS EN 61000-3-11, so a new maximum system impedance shall be calculated according to the standard:

	Z_{ref}	**Z_{test}**	**Z_{sys1}**	**Z_{sys2}**	**Z_{sys3}**	**Z_{sys4}**
R (Ω)	0.40	0.40	0.33	0.16	1.05	0.68
Xj (Ω)	0.25	0.25	0.20	0.10	0.66	0.42

Evaluating the calculation results, the maximum permissible system impedance for the equipment is Z_{sys} = 0.16 + j0.10 Ω.

The recalculated parameters normalized for required maximum Z_{sys} = 0.16 + j0.10 Ω are the following for 100% P_n:

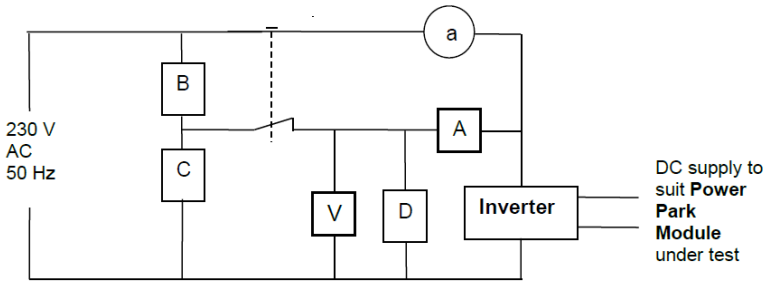
	Starting test			**Stopping test**			**Running test**	
Parameters	**d_c (%)**	**d_{max} (%)**	**d (t)**	**dc (%)**	**dmax (%)**	**d (t)**	**P_{st}**	**P_{lt}**
Limits	**3.3 %**	**4 %**	**500ms**	**3.3 %**	**4 %**	**500ms**	**1.0**	**0.65**
100% P_n	1.8 %	2.0 %	271 ms	3.3 %	3.3 %	372 ms	0.204	0.178

4.3.4 DC Injection

Clauses A.7.1.4.4 and Annex A2-3 of the standard are not applicable to the EUT, as it has an internal isolation transformer.

4.4 SHORT-CIRCUIT CURRENT CONTRIBUTION

This test has been done according to chapter A.7.1.5, and test results are presented as requested in Annex A2-3 of the standard.

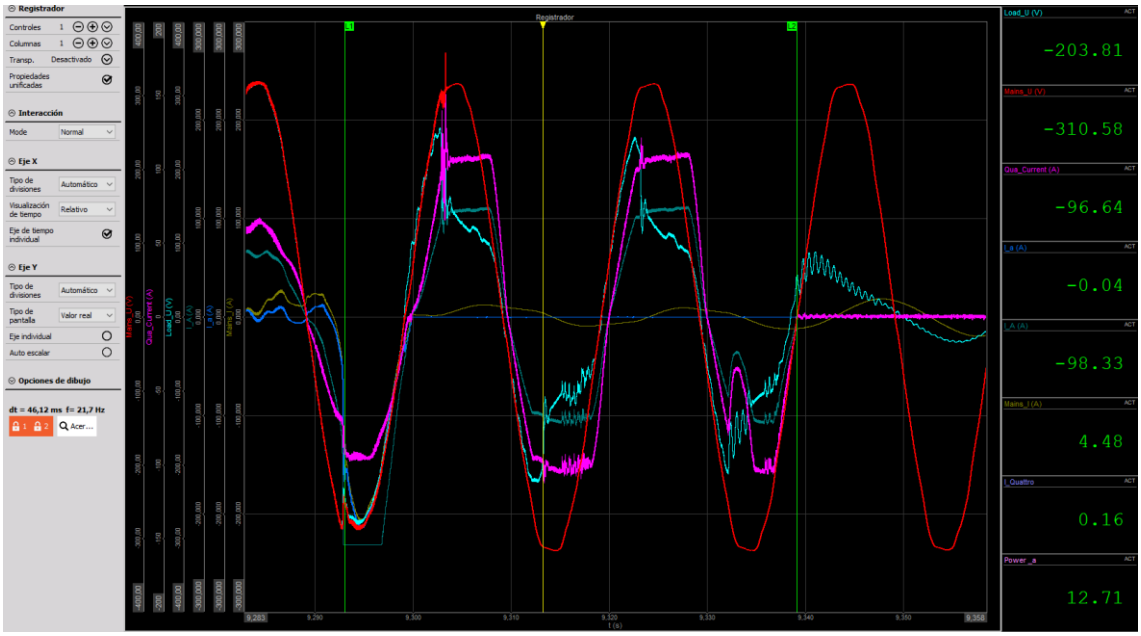


With the unit delivering rated output to resonant load “D”, current through ammeter “a” is measured to be zero. After that, the changeover switch is activated, and the unit is connected to the reduced voltage caused by loads “B” and “C”. After the changeover switch is activated, the unit is expected to disconnect in less than 1 second. Voltage and current values through time are measured from voltmeter and ammeter “V” and “A” in the diagram above.

Time after fault	Voltage (V)	Current (A)
20 ms	176.2	132.4
100 ms	105.5	74.3
250 ms	71.0	47.0
500 ms	55.6	33.2
Time to trip	46 ms	

The voltage and current values for the different times after the fault have been calculated as the RMS for that time period.

Short-circuit contribution



4.5 SELF-MONITORING – SOLID STATE DISCONNECTION

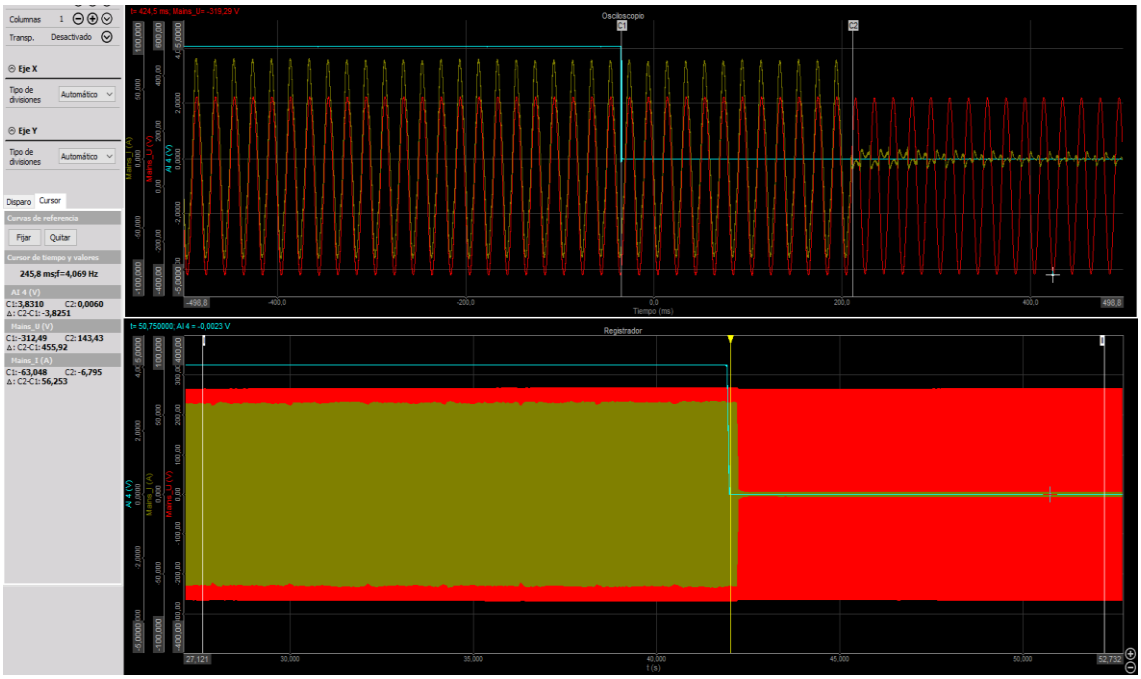
Requirements for solid state switching devices for disconnection from the grid are covered in Annex A.7.1.6 of the standard.

Since the EUT does not have them, this test is not applicable.

4.6 ACTIVE POWER CESSATION FOLLOWING INSTRUCTION

This test has been done according to chapter 11.1.3 of the standard. The aim is to verify the capacity of the EUT of ceasing active power following an instruction at the input port.

The equipment shall be capable of stopping the active power output within 5 s after the instruction of ceasing in the logic interface (input port “AUX 1”).

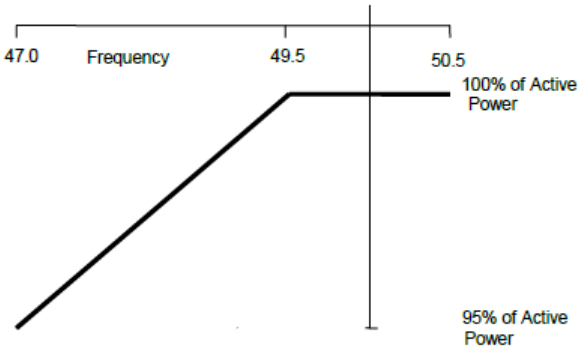
Disconnection time

Tested ceasing active power time: 246 ms

4.7 OPERATION RANGE

This test has been done according to chapters 11.2.1 and 11.2.3 of the standard, using testing points of Annex A2-3. The aim of the test is to verify if the EUT is capable of operating at different frequency ranges without disconnection and power reduction for the amount of time specified in the table below:

Test Nº	Frequency range	Voltage level	Operating period
Test 1	47.00 Hz to 47.50 Hz	0.850 p.u.	≥ 20 s
Test 2	47.50 Hz to 49.00 Hz	0.850 p.u.	≥ 90 min
--	49.00 Hz to 51.00 Hz	1.000 p.u.	Unlimited
Test 3	51.00 Hz to 51.50 Hz	1.100 p.u.	≥ 90 min
Test 4	51.50 Hz to 52.00 Hz	1.100 p.u.	≥ 15 min

In the range from 47-50.5 Hz, according to chapter 11.2.3, the EUT shall be capable of keeping its active power output level constant and not lower than the following characteristic:



According chapter A.4.2 of the standard, the requirement for continuous active power output is not applicable for storage equipment, so it was not tested.

Tested levels have been taken from Annex A2-3 of the standard.

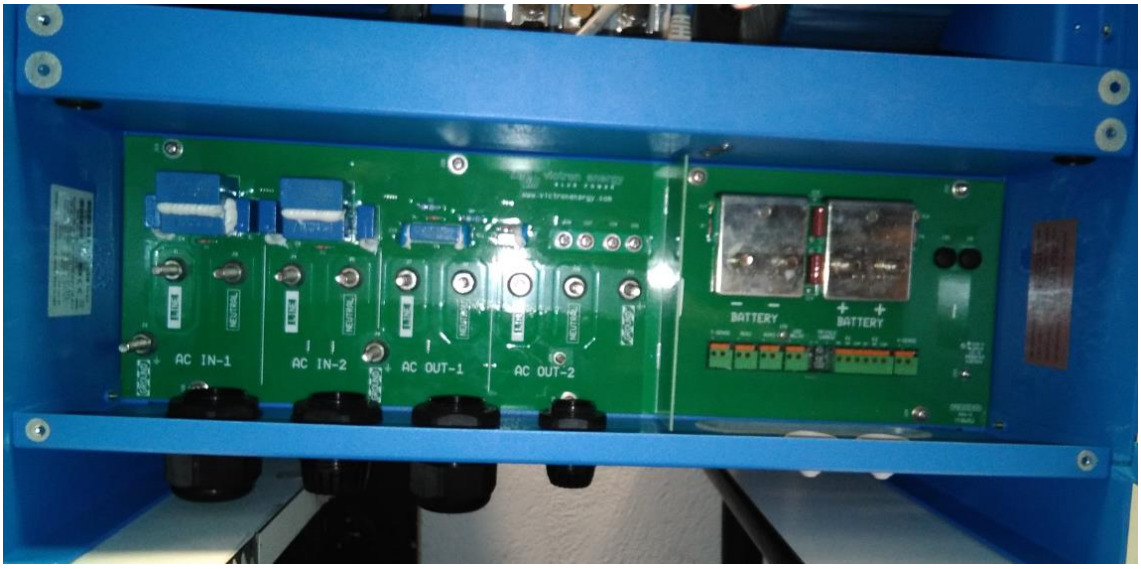
Test Nº	Voltage setpoint (p.u)	Frequency setpoint (Hz)	Voltage measured (p.u)	Frequency measured (Hz)	Active Power measured (p.u)	Time measured	Disconnection
Test 1	0.850	47.00 Hz	0.851	47.00	0.844	20.7 s	☐ YES ☒ NO
Test 2	0.850	47.50 Hz	0.853	47.51	0.841	91 min	☐ YES ☒ NO
Test 3	1.100	51.50 Hz	1.100	51.49	0.989	91 min	☐ YES ☒ NO
Test 4	1.100	52.00 Hz	1.101	51.99	1.000	16 min	☐ YES ☒ NO

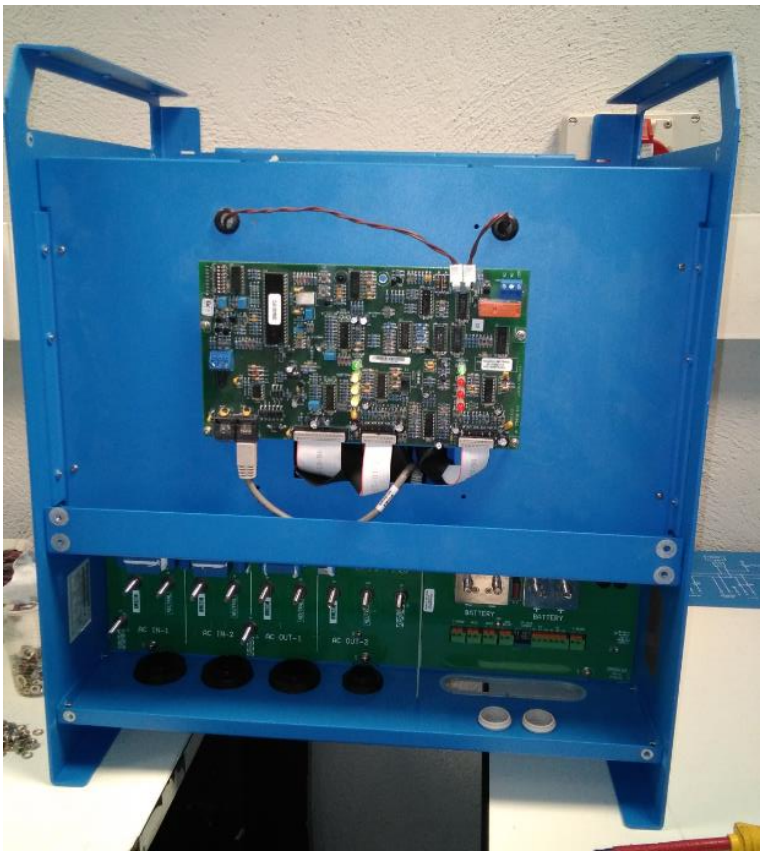
4.8 WIRING FOR TYPE TESTED POWER GENERATING MODULES

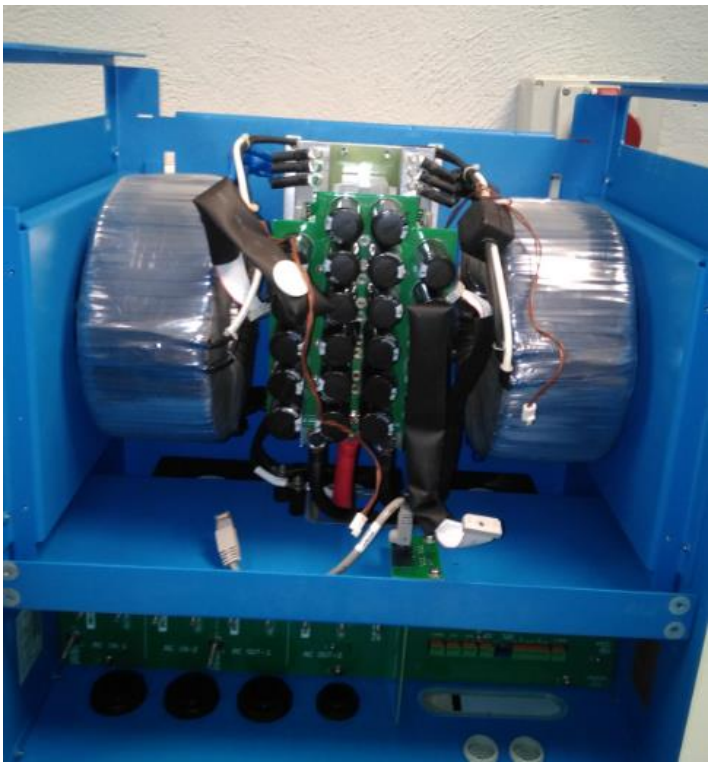
Requirements for on-site wiring made with non specifically designed plugs are covered in Clause 15.2 and section 13 of Annex A2-3.

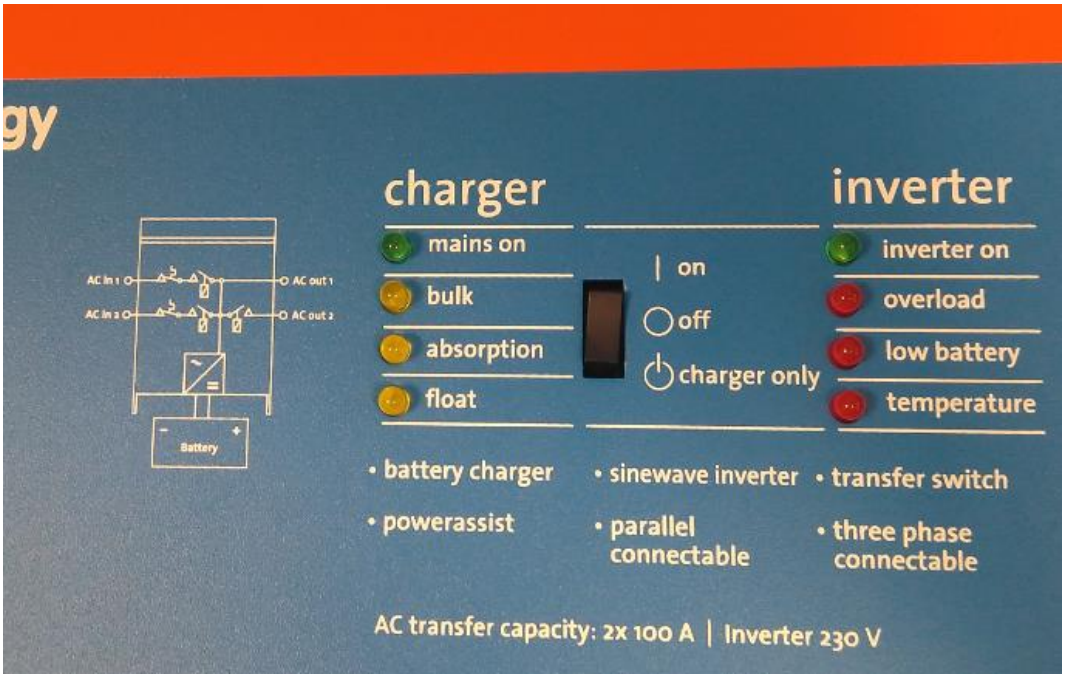
Since these requirements have to be evaluated at the site of the final installation, they are consided as not applicable to the EUT.

5 PICTURES

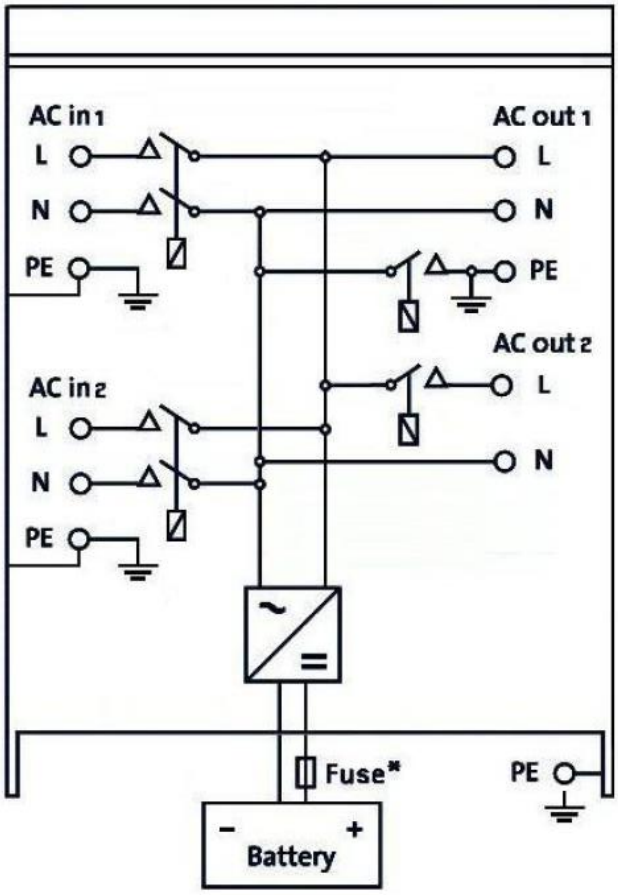

AC IN-1
AC IN-2
AC OUT-1
AC OUT-2
BATTERY
BATTERY






gy
charger
mains on
bulk
absorption
float
on
off
charger only
inverter
inverter on
overload
low battery
temperature
AC in 1
AC in 2
AC out 1
AC out 2
Battery
• battery charger
• powerassist
• sinewave inverter
• parallel connectable
• transfer switch
• three phase connectable
AC transfer capacity: 2x 100 A | Inverter 230 V

6 ELECTRICAL SCHEMES

Equipment under testing


7 CE DECLARATION

DECLARATION OF CONFORMITY

CE

COMPANY : Victron Energy B.V.

ADDRESS : De Paal 35
1351 JG Almere
The Netherlands

Declares that the following products:

PRODUCT TYPE : SINEWAVE INVERTER / BATTERY CHARGER

BRAND : Victron Energy

MODELS :

Quattro 12/3000/120-50/50	Quattro 24/3000/70-50/50	Quattro 48/3000/35-50/50
Quattro 12/5000/200-100/100	Quattro 24/5000/120-100/100	Quattro 48/5000/70-100/100
	Quattro 24/8000/200-100/100	Quattro 48/8000/110-100/100
		Quattro 48/10000/140-100/100
		Quattro 48/15000/200-100/100

Are in conformity with the requirements of the following Directives of the European Union:

EMC Directive 2014/30/EU with the following harmonized standards:
EN-IEC 61000-3-11: 2017
EN-IEC 61000-3-12: 2011
EN-IEC 61000-6-1:2007
EN-IEC 61000-6-2:2005
EN-IEC 61000-6-3:2007/A1:2011/C11:2012
EN 55014-1:2017
EN 55014-2:2015
EN-IEC 62040-2:2018
ISO 7637-2:2016

Low Voltage Directive 2014/35/EU with the following harmonized standards:
EN-IEC 60335-1:2012/A13:2017
EN-IEC 62109-1:2010
EN-IEC 62109-2:2011
EN-IEC 62040-1:2009/C1:2009/A1:2013

Restriction of the use of certain hazardous substances RoHS (2011/65/EU and 2015/863/EU) with the following harmonized standards:
EN-IEC 63000:2018

CE MARK DATE: November, 2011

Signed : Reinout Vader

Authority : Managing Director
Date : 18 July 2019