Test Report

Requirements of general application resulting from Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (NC RfG)

For the unit(s)	Tiger-2KW4E1P, Tiger-1.8KW4E1P, Tiger-1.6KW4E1P
Test report no	230612025GZU-001
Date	2023-7-11

Test report number.....:	230612025GZU-001
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Test specification	
Standard .....:	PTPiREE 2021 PSE:18 December 2018 (NC RfG) COMMISSION REGULATION (EU) 2016/631 (NC RfG) Type approval for Type A PPMs
Test report form number.....:	NC RfG_V1.0
Test report form(s) originator.....:	Intertek
Master TRF.....:	Dated 2023-01-24
Test item description.....:	Microinverter
Trademark .....:	TENTEK — Catch Every Sunbeam —
Manufacturer.....:	Same as applicant
Model / Type reference.....:	Tiger-2KW4E1P, Tiger-1.8KW4E1P, Tiger-1.6KW4E1P
Technical data .....:	See section 3.1.1 on p.5
Testing location / address.....:	Intertek Testing Services Shenzhen Ltd. Guangzhou Branch Room 02, & 101/E201/E301/E401/E501/E601/E701/E801 of Room 01 1-8/F., No. 7-2. Caipin Road, Science City, GETDD, Guangzhou, Guangdong, China
Dates of testing.....:	2023-6-12 – 2023-7-10

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1 General information of test report

1.1 Revision history

Revision	Date	Editor	Modification / Change	Status
1	2023-7-11	Allen Feng	Initial report was written	active

2 General remarks for documentation

The test results presented in this report relate only to the object(**s**) tested.

Throughout this report a ☒ comma ',' / ☐ point '.' is used as decimal separator and a ☐ point '.' / ☐ comma ',' as thousands separator.

The following **suffixes/indices** are used for variables in tables and figures:

0,2	gliding average values over 200 milliseconds
10	gliding average values over 10 seconds
60	gliding average values over 60 seconds
600	gliding average values over 10 minutes
+	positive sequence system values
-	negative sequence system values
0	zero sequence system values
1	fundamental component (main frequency). In case of power values (P, Q, S) this is the sum of the 3 phase values
Lx	index of phase x
LxLy	phase-to-phase voltages of phase x and phase y
s	apparent
p	active
q	reactive

Abbreviations

AC	:	Alternating Current
DC	:	Direct Current
EUT	:	Equipment Under Test
MP	:	Measurement Point
MPP	:	Maximum Power Point
N_{10}	:	Maximum number of switching operations within a time period of 10 minutes
N_{120}	:	Maximum number of switching operations within a time period of 120 minutes
PGU	:	Power Generating Unit
PGS	:	Power Generating System
PCC	:	Point of Common Coupling (grid connection point)
THC	:	Total Harmonic Current Distortion
$THDS_U$	:	Total demand distortions of voltage harmonics

General remarks for testing

3.1 General product information

3.1.1 Technical data of the unit(s)

Model	Tiger-1.6KW4E1P	Tiger-1.8KW4E1P	Tiger-2KW4E1P
PV Input			
Max. input voltage	60V		
MPPT voltage range	25-50V		
Max. input current	60A		
Max. short circuit current	72A		
Output AC (Grid side)			
Rated output power	1.6kW	1.8kW	2.0kW
Max. apparent output power	1.6kVA	1.8kVA	2.0kVA
Rated grid voltage	L/N/PE, 230V		
Rated grid frequency	50Hz		
Max. output current	6.95A	7.83A	8.7A
Power factor	>0.99 default (0.8 leading...0.8 lagging)		
Ambient temperature range	-40...+65℃		
Degree of protection	IP67		
Software Version	TJ01V1.002		

Equipment mobility ..... : Permanent connection

Operating condition..... : Continuous

Class of equipment..... : Class I

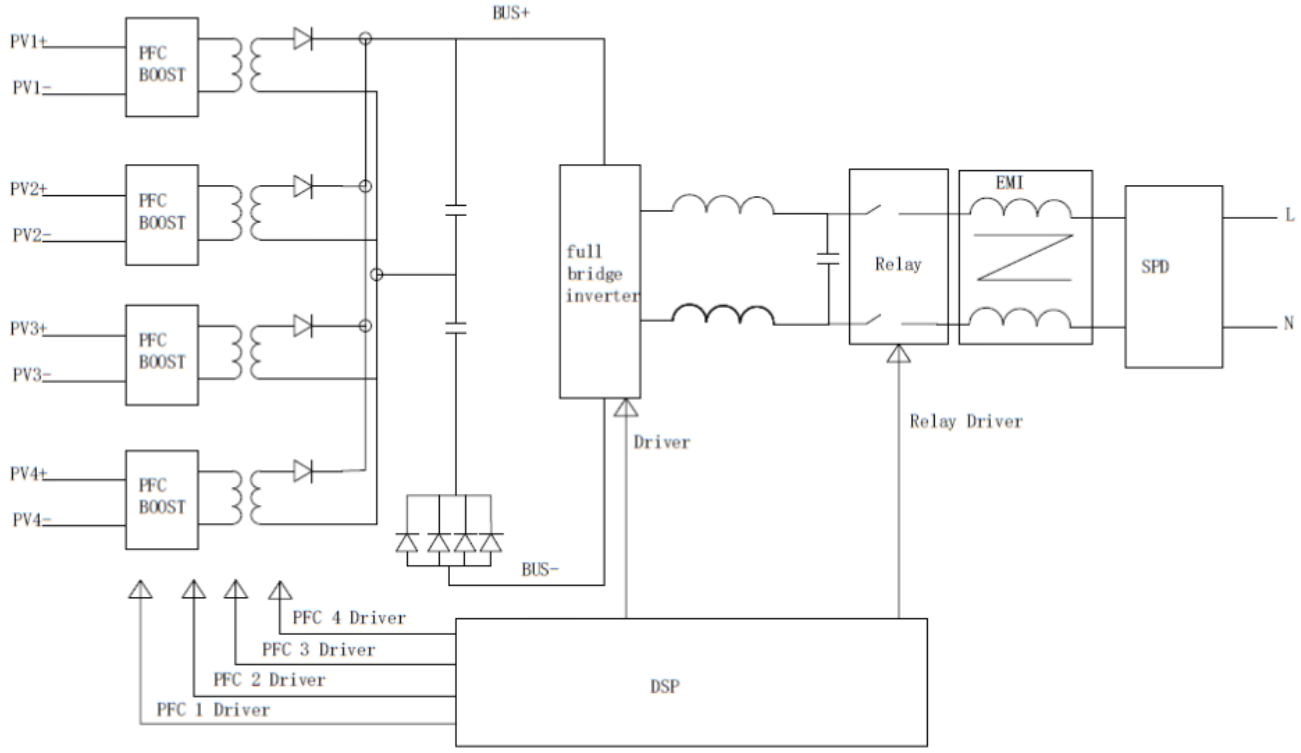
Protection against ingress of water ..... : IP67 according to EN 60529

The unit is a single-phase Solar Grid-tied inverter, it can convert the PV voltage to Grid voltage and feed into Grid network.

The unit does provide galvanic separation (high frequency isolated transformer) from PV side to Grid.

The Grid relays and high frequency isolated transformer are designed on insulation separation that make sure the Grid securely open even if the single fault applied.

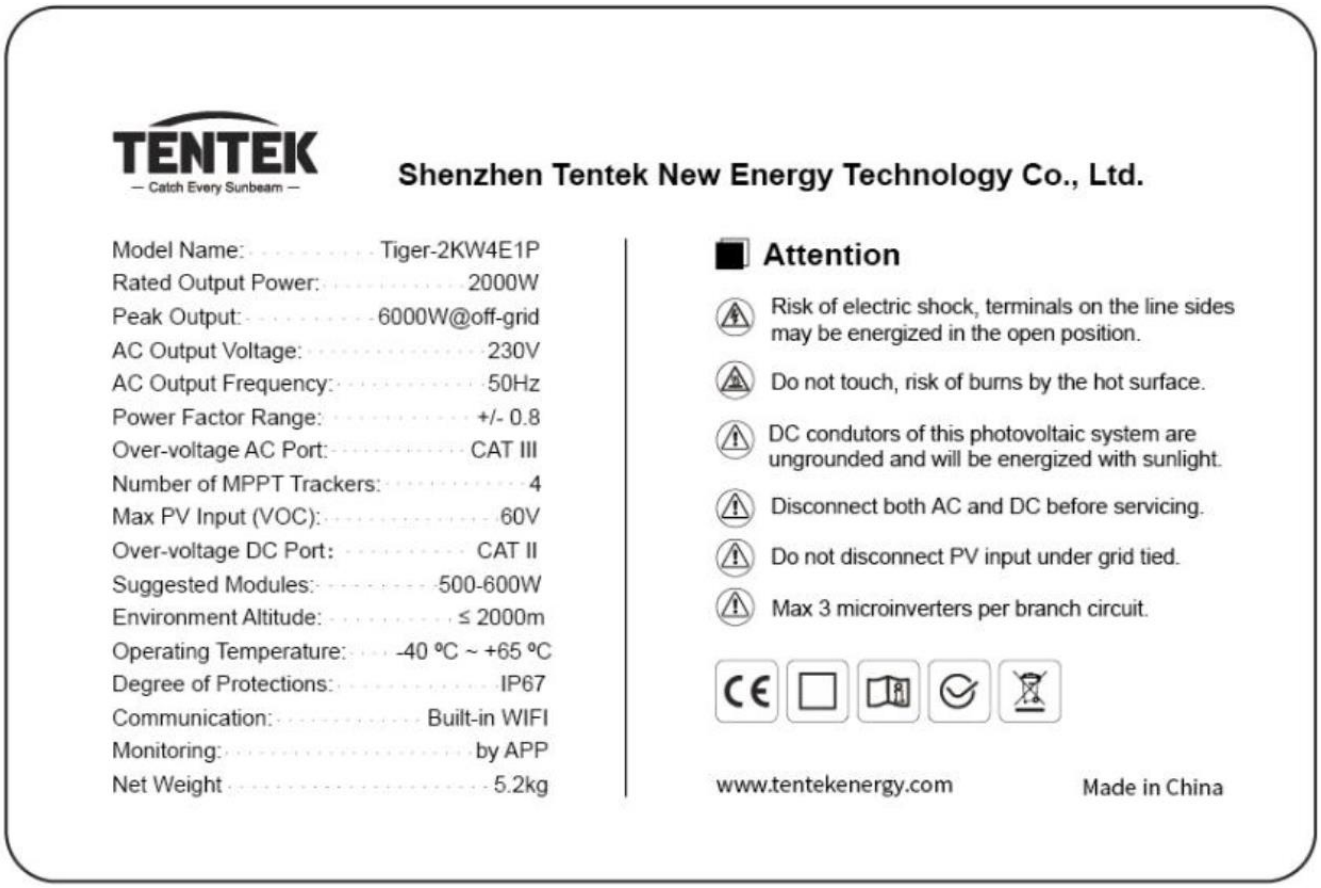
The topology diagram as following:



3.1.2 Description of the differences of the models within the product series

All models are identical with mechanical and electrical construction except the power is derated by software.

3.1.3 Copy of marking 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. Other labels are identical to above, except the model's name and ratings.

3.2 Scope of measurements

3.2.1 General

The assessment covers requirements applicable to Types A-B Power Park Modules (PPMs) for which Equipment Certificates are requested in the Polish certification guideline, as further detailed in Section 3.2.2 The assessment covers both exhaustive requirements, fully defined by the NC RfG , and non-exhaustive requirements, for which complementary requirement details have been collected from the national specification for Poland in PSE 2018-12 .
The scope of assessment covers the following:

• The completeness of documents and measurements

• The plausibility of the documents received

• The compliance of the test conditions of the documents with those listed in standard

• The assessment of the measurement results concerning the requirements of the documents listed in standard

3.2.2 Paragraphs of NC RfG within scope

Table 3-1 Scope of assessment and results

Capability	NC RfG /D/	PSE 2018-12 /C/	Type A	Assessment result(**)
Frequency range	13.1(a)	13.1(a)(i)	x	Compliant
Rate of Change of Frequency (RoCoF) withstand capability, df/dt	13.1(b)	13.1(b)	x	Compliant
Remote cessation of active power	13.6	13.6	x	Compliant
Limited Frequency Sensitive Mode – over frequency (LFSM-O)	13.2 (*)	13.2(a), (b), (f)	x	Compliant

Please note also the corresponding conditions for compliance.

3.3 Reference values

Representative sample for testing

Reference values for the p,u, or percentage calculations:

	Tiger-2KW4E1P
Rated active power, P_n [kW]	2,0
Max, apparent and active output power, S_{max} / P_{max} [kVA]	2,0
Rated voltage (phase-to-phase), U_n [V]	1/N/PE, 230V
Rated current, I_n [A]	8,7
Maximum current, I_{max} [A]	8,7

3.4 Measurement setup

Tests documented in this test report were performed using the following test configuration:

☐ Measurements in the field on real grid

☐ Test bench tests on real grid

☒ Test bench tests on an AC grid simulator

The PGU is connected on the DC-side to a PV-simulator and on the AC-side to an AC-grid simulator, The AC-grid simulator is operated with nominal conditions of U_n = 230 (phase-to-neutral) and f_n = 50 Hz unless stated otherwise by the applied test requirement,

Available primary power is modified by adapting the short circuit current (I_{sc}) value of the I-V curve, Following example shows a PV-curve (I_{sc} = 61,31 A, U_{oc} = 719,3 V) simulated according to EN50530:

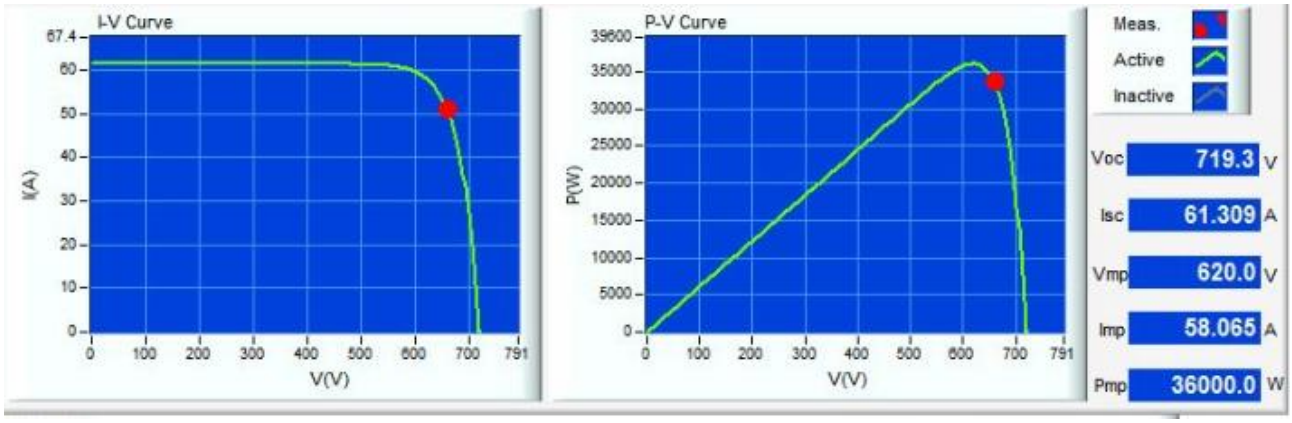


Figure 1 – DC characteristics for testing

The measurement setup is shown in Figure 2, The specific test and measurement devices are stated in section 3.5,

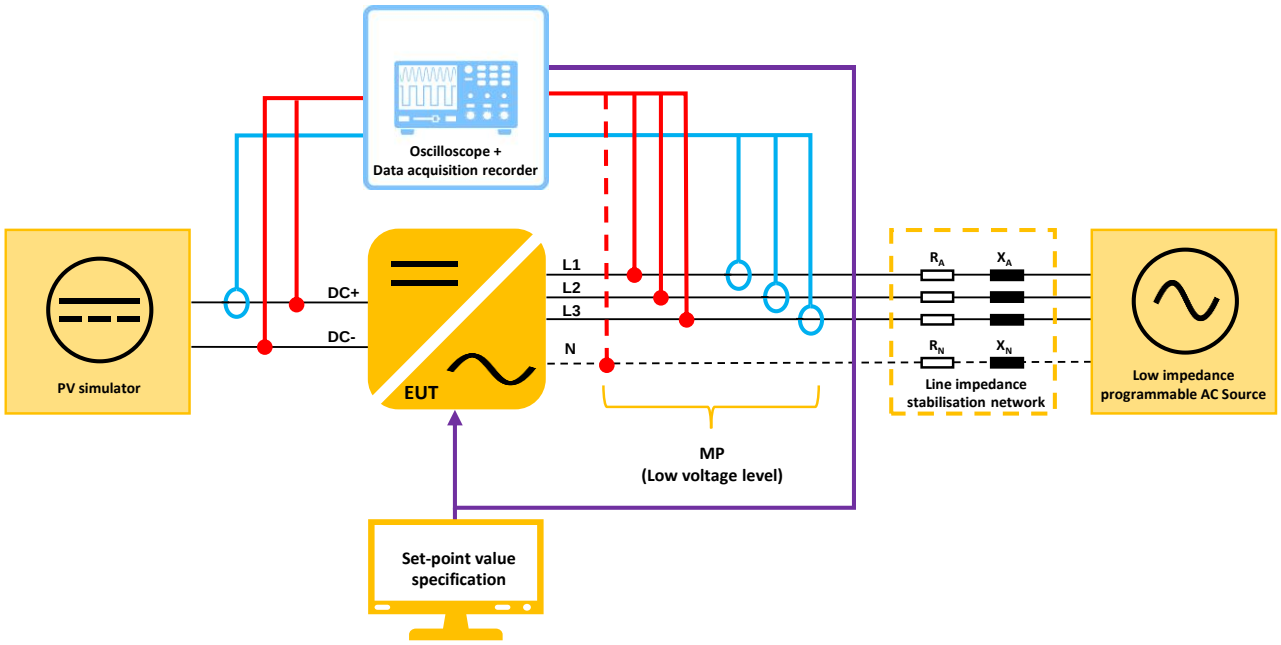


Figure 2 – Measurement setup scheme （The test setup will set to single phase as the test unit is a single phase inverter）

3.5 Measurement equipment

Equipment	Internal No,	Manufacturer	Type	Serial No,	Last Calibration
DC power supply [1]	SA200-18	REGATRON	TC,P,32,1000, 400,PV,HMI	1244CC683	--
AC Simulator [1]	SA200-52	Chroma	61860	618603800386	--
Oscilloscope	SA050-33	YOKOGAWA	DL850E	91S416984	2024-01-04
Power analyser	SA200-16	YOKOGAWA	WT3000	91LB24254	2023-08-16
Current sensor	SA200-16-01	YOKOGAWA	751552	141215	2023-10-24
	SA200-16-02	YOKOGAWA	751552	141221	2023-10-24
	SA200-16-03	YOKOGAWA	751552	141224	2023-10-24
	SA200-16-04	CT1000	CT1000	9112570083	2023-10-24

Note:

All measurement equipment was used within the calibration period, copy of calibration certificates are available at the laboratory for reference,

3.6 Sampling rates

Following sampling rates were used for the measurement:

	Chapter according to	Voltages, currents	Setpoint and actual value signals
Power-frequency regulation mode limited to overfrequency (MRPFL-O)	5,1	10 kHz	10 kHz

[1] The AC simulator and DC sources are not need to be calibrated, since the AC voltage and current is measured and determined using the calibrated oscilloscope and power analyser.

3.7 Measurement uncertainties

Measurement category	Measurement uncertainty (k=2)
AC Current (50 Hz signal)	±0,104%
AC Voltage (50 Hz signal)	±0,097%
AC Powers	±0,38%
DC Current	±0,41%
DC Voltage	±0,50%
DC Power	±0,33%
Frequency	±0,01%

Note:

The data and results within this document are accurate, For the uncertainty calculation a confidence level of 95% is assessed,

All stated uncertainties are worst case values due to the definition of uncertainty calculation, The shown uncertainties are equal or lower than the shown values depending on the equipment used for measurements which is stated in this report,

The variability of the components and processes used for manufacturing of devices similar to the tested one can contribute to additional deviation, It is the responsibility of the manufacturer to assure compliance for these devices,

Conformity statements are decided in accordance with IEC GUIDE 115:2021 Procedure 2 (accuracy method), unless otherwise normatively specified or contractually agreed,

3.8 Test conditions

Condition / Requirement	Determined value / Description	Remarks
Point of measurement	☐ medium-voltage side ☒ low-voltage side	Measurement at output terminals of the PGU, see Figure 2,
Data medium-voltage system (if applicable)	N/A	Measurement on LV side
• Short Circuit Power	N/A	---
• Network impedance phase angle	N/A	---
• Agreed service voltage UC	N/A	---
Transformer data (if existing):	N/A	Measurement on LV side, no transformer existing
• Nominal power of transformer	N/A	---
• rel, short-circuit voltage of transformer uk	N/A	---
• Tap position of transformer	N/A	---
Grid frequency:		
• within $f_n \pm 1\% f_n$	Requirement met	Stable AC source used
• $df/dt < 0{,}2\% f_n$ / (0,2 s)	Requirement met	Stable AC source used
Voltage at PGU terminals within $U_n \pm 10\% U_n$	Requirement met	Checked before testing
The voltage unbalance < 2%	Requirement met: 0,04%	Determined according to IEC 61000-4-30, measured as a 10-minute mean at the PGU terminals,
Environmental conditions must correspond to the manufacturer's requirements of the measuring instruments	Requirement met	During the test period following environmental data were recorded: • Temperature: 20,3 ~ 25,2°C • Rel, humidity: 36,5 ~ 57,3%RH • Air pressure: 985,2 ~ 1003,6 hPa

4 Measurement result

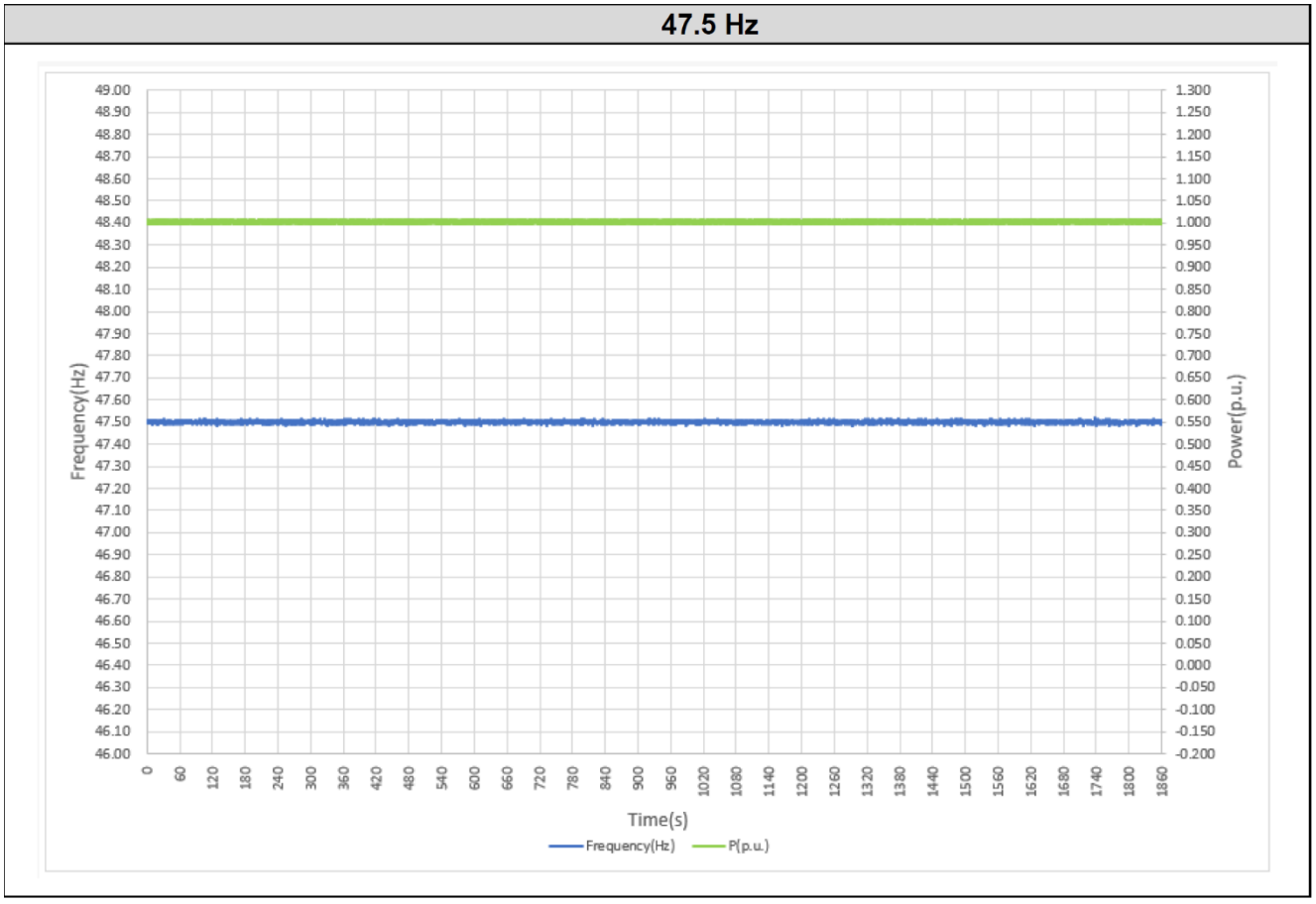
4,1 Frequency Range

The frequency range requirements, as specified for Continental Europe in Article 13 item 1 (a)(i) in NC RfG and the national specification for Poland PSE 2018-12, are summarized in Table 4-1.

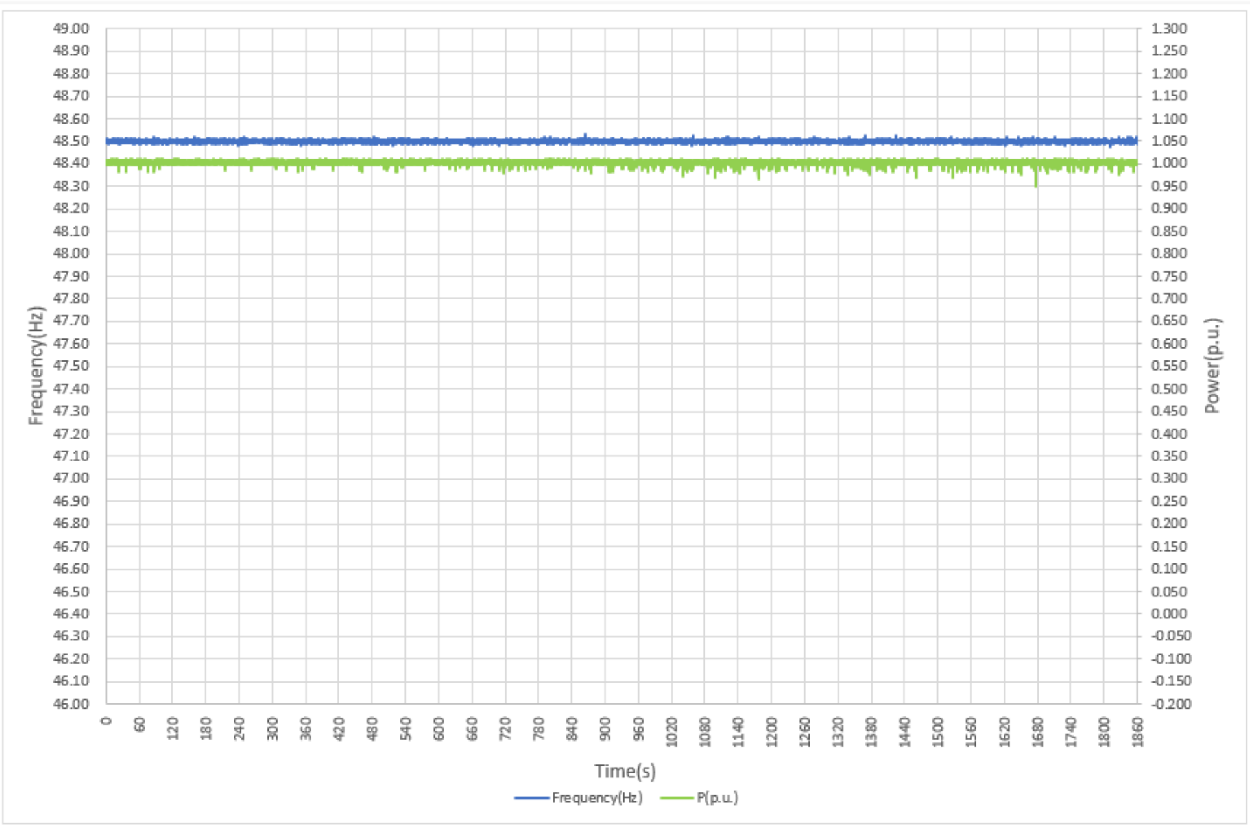
Table 4-1 Frequency range: requirement

Frequency range	Required time for operation
47,5 Hz-48,5 Hz	30 min
48,5 Hz-49,0 Hz	30 min
49,0 Hz-51,0 Hz	Unlimited
51,0 Hz-51,5 Hz	30 min

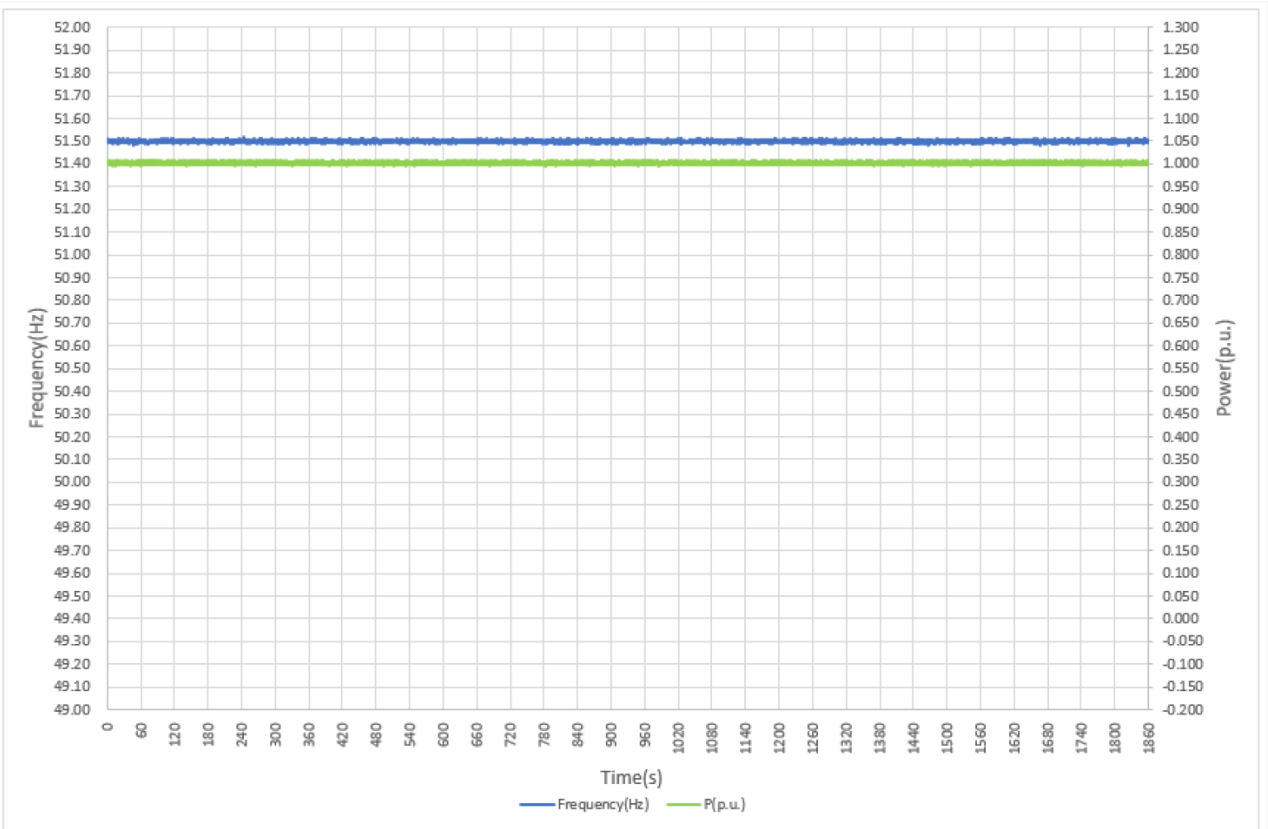
Test result:



48.5 Hz



51.5 Hz



The inverter did not disconnect during this time.

4,2 Rate of Change of Frequency (ROCOF) withstand capability

Regarding RoCoF withstand capability, as specified in Article 13 item 1(b) of NC RfG , together with the national specification for Poland in PSE 2018-12 , the Power Generating Unit (PGU) must have the capability of remaining connected to the network and operate at the rate of change of frequency up to:

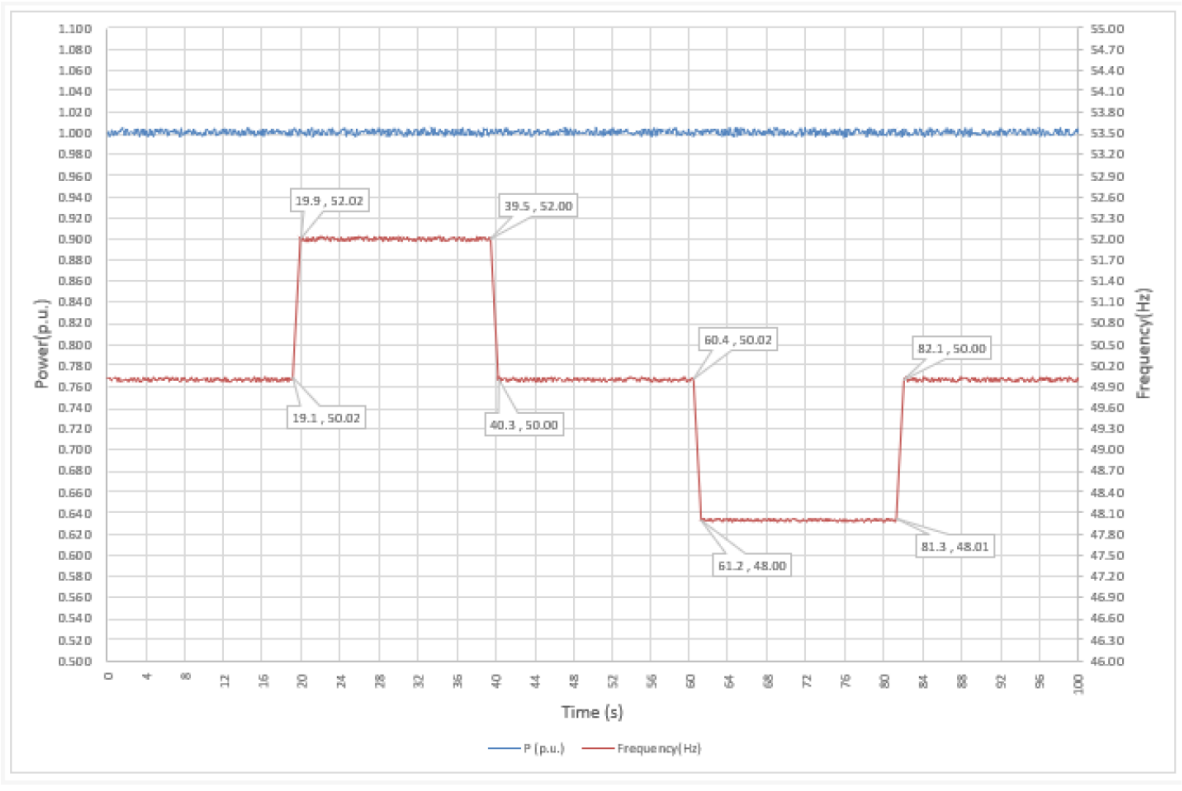
$$\left|\frac{df_{max}}{dt}\right| = 2.0 \left|\frac{Hz}{s}\right|$$

where this value would be measured as an average value within a shiftable measurement window with a length of 500 ms.

The requirement $\left|\frac{df_{max}}{dt}\right| = 2.0 \left|\frac{Hz}{s}\right|$ constitutes a minimum requirement. If the applied technology allows connection to the network and operation at a higher rate of change of frequency, limiting the operation of the PGU to the value defined above or lower is not allowed, unless it results from the arranged rate-of-change-of-frequency-type loss of mains protection.

Test result:

Rate of change of frequency (ROCOF) immunity



The inverter could withstand ROCOF capability and did not disconnect during ROCOF.

4,3 Cessation of Active Power

General requirements relating to Cessation of Active Power are defined by Article 13 item 6 of NC RfG . Further specification for Poland is added by Article 13 item 6 of PSE 2018-12 . The unit shall be equipped with a logic interface (input port) in order to cease active power output within five seconds following an instruction being received at the input port.

It is required that PGU has the capability of remote control of the facility by a relevant SO. The reduction requirement remains active also where the primary source of energy is insufficient to achieve the set limit value. In order to allow remote operation of generated active power by means of additional devices, telecommunication standards determined and published by a relevant SO must be met.

As no specific communication standards have been stated in the assessment criteria used for this certification, listed in section 13(6) of the PSE 2018-12 , the compliance to any telecommunication standards must be further assessed at project level.

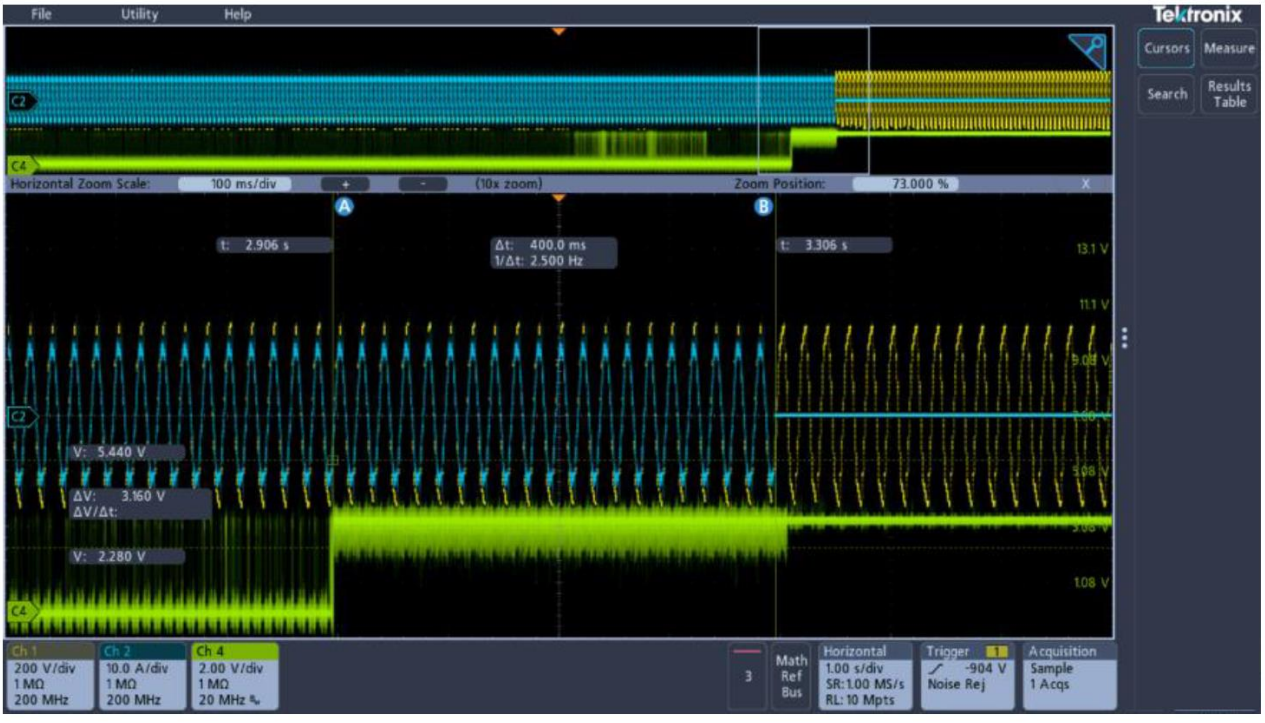
The tests were performed using a DC Power supply as a simulation of the PV module and a grid simulator as a simulation of the power grid and the transmission network.

The inverter was operated remotely to validate its capability to cease active power within 5 seconds. To achieve remote control, a RS485 (Modbus) input of the inverter was used. The signal for cessation of active power was then given via PC using Shinebus software. The time period was measured following the cessation command being received till the active power was reduced to zero.

Test result:

Test waveform:

Ceasing active power



Tested ceasing active power time: 0.4 s

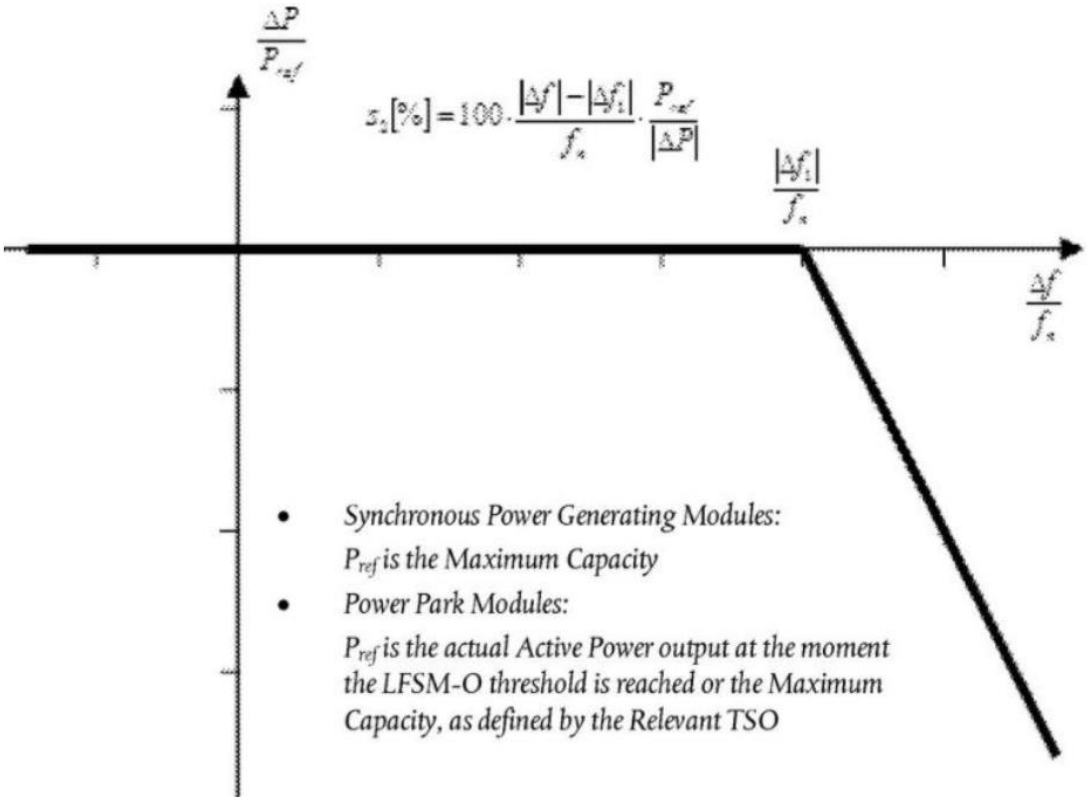
Ch2: Output current ; Ch4: Output voltage ;

The waveform above shown that the inverter is capable of reducing the active power within 0,4 s after reception of remote shutdown signal to cease active power.

4,4 Limited Frequency Sensitive Mode – Overfrequency (LFSM-O)

The requirements for LFSM-O capabilities power-generating modules are defined by Article 13 item 2 of NC RfG . Further national specification is added by corresponding article in PSE 2018-12 .
The PGU shall be capable of providing active power frequency response according to the Figure 5-3 with selectable frequency threshold in the range: 50.2 Hz-50.5 Hz, with default value of, 50.2 Hz and a selectable droop settings in the range: 2-12 %, with default value of 5 %. A response time for activation longer than 2 second must be motivated technically, and the unit must be able to operate stably in LFSM-O mode when active power decreases down to its minimum regulating level. As further specified for Poland, the maximum capacity power (rather than the actual power before LFSM-O activation) shall be used as reference value PREF to calculate the droop. Furthermore, it must be possible for the System Operator (SO) to intervene and block the LFSM-O mode.

There is a specific request in Article 13 item 2(g) of NC RfG that when LFSM-O is active, the "LFSM-O setpoint will prevail over any other active power setpoints". This is not further addressed in PSE 2018-12 , but the authors PTPiREE has stated that implementations where the active power setpoint can be further decreased, but never increased, is to be accepted .



The tests were carried out for 3 different parameter sets to confirm ability for parameter changes and proper behaviour with those settings.

Setting for LFSM-O tests

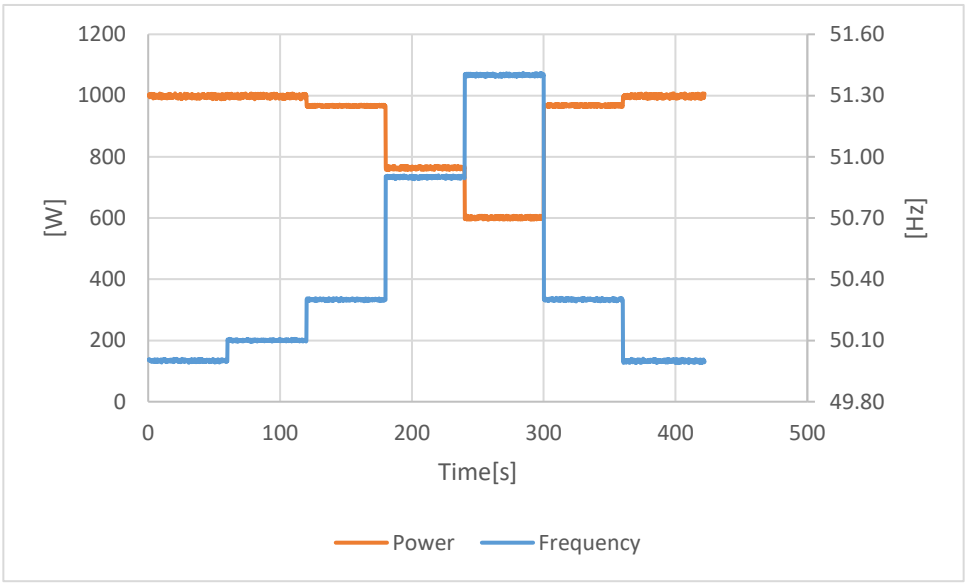
	Setting 1	Setting 2	Setting 3
Activation threshold	50.2 Hz	50.2 Hz	50.5 Hz
Droop	5 %	12 %	2%

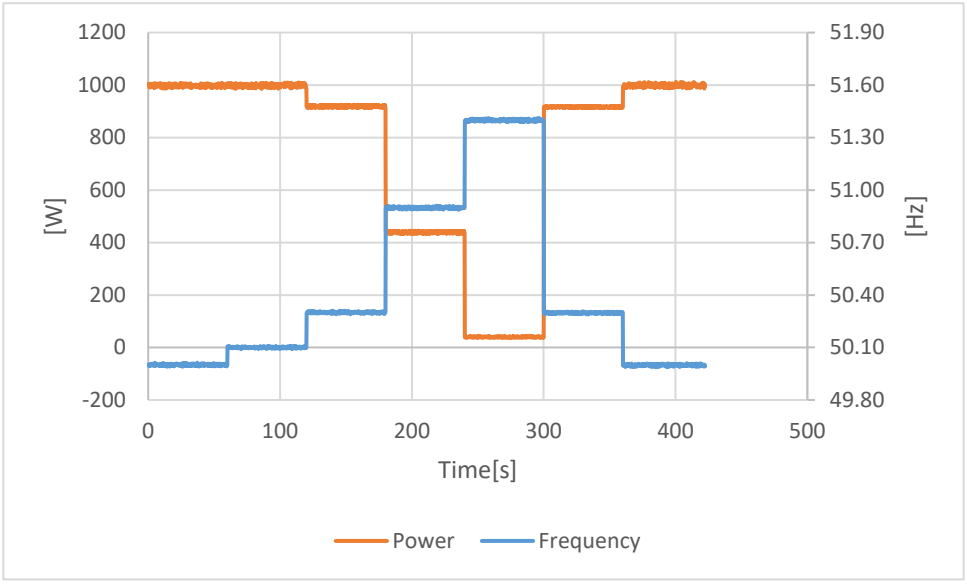
The frequency steps performed were as follows

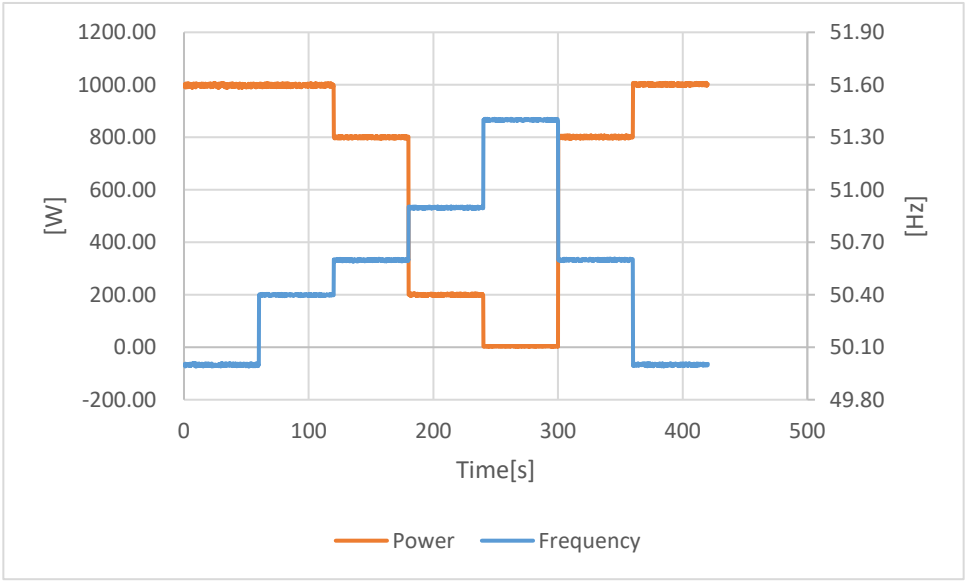
Frequency step	Simulated grid frequency setting 1 and setting 2	Simulated grid frequency setting 3
1	50.0 Hz ± 0.05 Hz	50.0 Hz ± 0.05 Hz
2	50.1 Hz ± 0.05 Hz	50.4 Hz ± 0.05 Hz
3	50.3 Hz ± 0.05 Hz	50.6 Hz ± 0.05 Hz
4	50.9 Hz ± 0.05 Hz	50.9 Hz ± 0.05 Hz
5	51.4 Hz ± 0.05 Hz	51.4 Hz ± 0.05 Hz
6	50.3 Hz ± 0.05 Hz	50.6 Hz ± 0.05 Hz
7	50.0 Hz ± 0.05 Hz	50.0 Hz ± 0.05 Hz

Test result:

Test 1	50% Pn, f1 =50.2Hz; droop=12%; no delay				
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)
50Hz ± 0.05Hz	50.00	997,37	1000	--	--
50.10Hz ± 0.05Hz	50.10	997,80	1000	--	--
50.30Hz ± 0.05Hz	50.30	966,38	966,66	-0,28	± 100
50.9Hz ± 0.05Hz	50.90	763,70	766,62	-2,92	± 100
51.4Hz ± 0.05Hz	51.40	601,14	599,92	1,22	± 100
50.3Hz ± 0.05Hz	50.30	967,35	966,66	0,69	± 100
50Hz ± 0.05Hz	50.00	997,89	1000	--	--
Test 2	50% Pn, f1 =50.2Hz; droop=5%; no delay				
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)
50Hz ± 0.05Hz	50.00	997,77	1000	--	--
50.10Hz ± 0.05Hz	50.10	997,95	1000	--	--
50.30Hz ± 0.05Hz	50.30	918,97	920	-1,03	± 100
50.9Hz ± 0.05Hz	50.90	438,85	440	-1,15	± 100
51.4Hz ± 0.05Hz	51.40	39,99	40	-0,01	± 100
50.3Hz ± 0.05Hz	50.30	916,45	920	-3,55	± 100
50Hz ± 0.05Hz	50.00	998,69	1000	--	--
Test 3	50% Pn, f1 =50.5Hz; droop=2%; no delay				
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)
50Hz ± 0.05Hz	50.00	997,76	1000	--	--
50.4Hz ± 0.05Hz	50.40	998,26	1000	--	--
50.60Hz ± 0.05Hz	50.60	799,85	800	-0.15	± 100
50.9Hz ± 0.05Hz	50.90	199,91	200	-0.09	± 100
51.40Hz ± 0.05Hz	51.40	3,65	0	3.65	± 100
50.60Hz ± 0.05Hz	50.60	800,84	800	0.84	± 100
50Hz ± 0.05Hz	50.00	1001,55	1000	--	--

Test 1_Graph


Test 2_Graph


Test 3_Graph


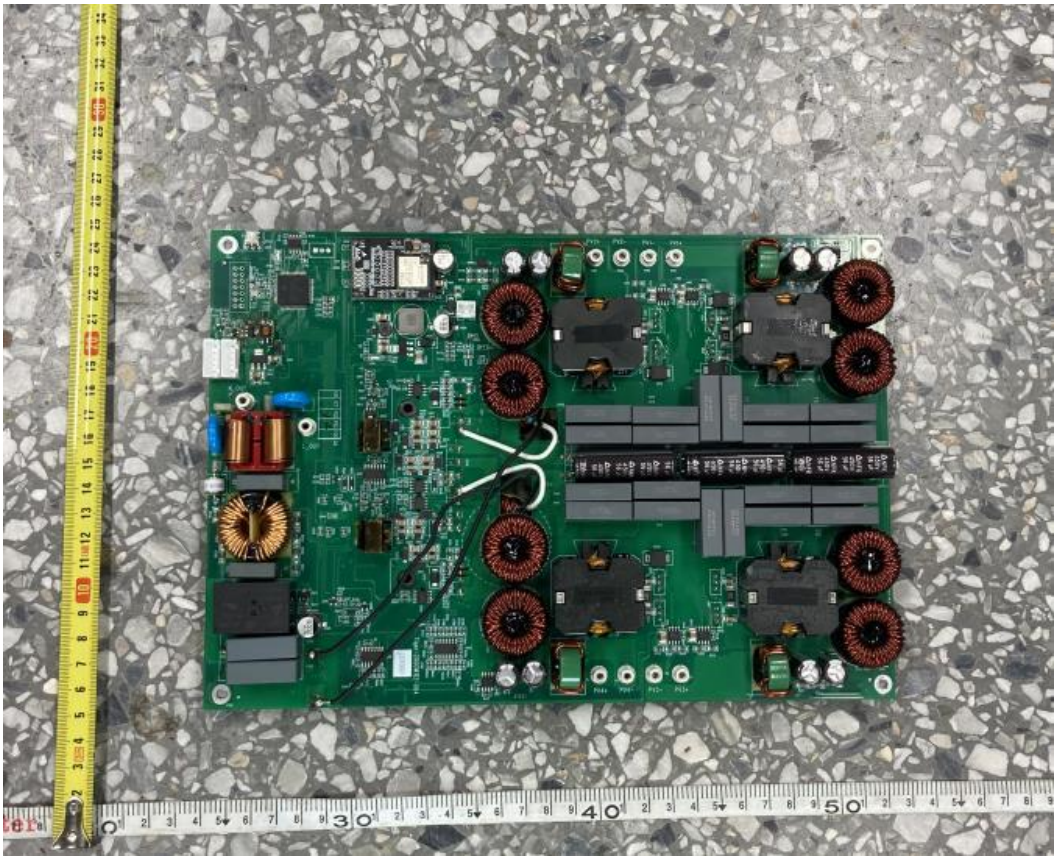
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
-200.00
[W]
51.90
51.60
51.30
51.00
50.70
50.40
50.10
49.80
[Hz]
0
100
200
300
400
500
Time[s]
Power
Frequency

Annex 1- Photo of the unit

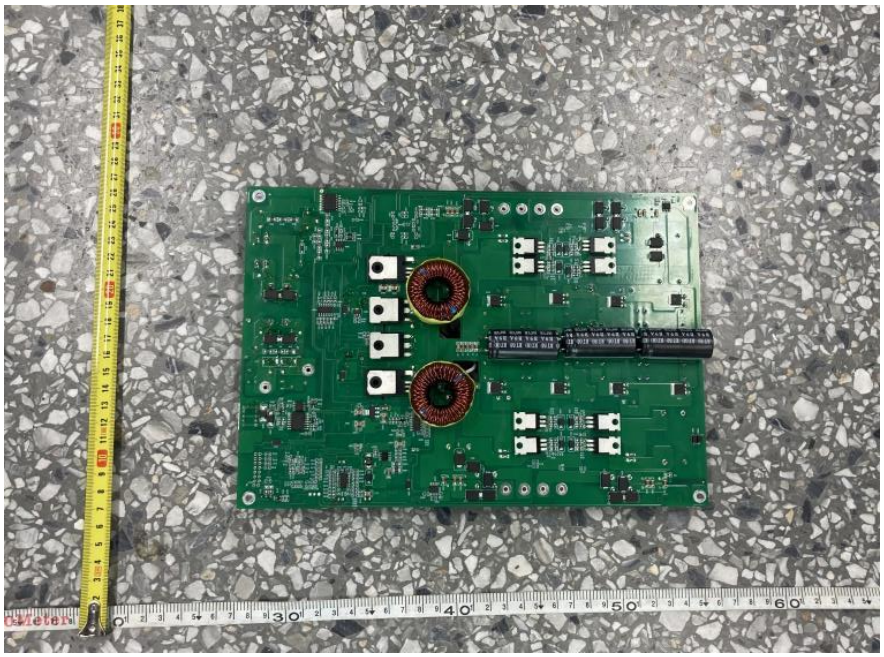
Front view

Rear view

Internal view



PCBA view



PCBA back view

End of Test Report