LYNS-TCi

TEST REPORT

Engineering Recommendation G99

Issue 1 – Amendment 9

Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019

Shenzhen SOFARSOLAR Co., Ltd.

For the unit(s) **HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH, HYD 10KTL-3PH-A, HYD 15KTL-3PH, HYD 20KTL-3PH**

Test report no. **220622BW001-EG-UK-001**

Date **2023-03-23**

ilac-MRA ACCREDITED Certificate # 5200.02

Guangdong HuaChuang Technology Service Co., Ltd.
Address: Room 815, No.122, Houjie Road (West), Houjie Town, Dongguan City, Guangdong, 523960 P.R.C
Tel: +86 769 85598986 | E-Mail: service-hc@huachuang-ts.com | Web: www.huachuang-ts.com

Test report number.....:	**220622BW001-EG-UK-001**
Date of issue.....:.....	2023-03-23
Total number of pages.....:.....	64
Testing laboratory .....:	**Guangdong HuaChuang Technology Service Co., Ltd.**
Address.....:	Room 815, No.122, Houjie Road (West), Houjie Town, Dongguan City, Guangdong, 523960 P.R. China
Testing location / address.....:	Same as above
Applicant's name .....:	**Shenzhen SOFARSOLAR Co., Ltd.**
Address.....:	11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district, Bao'an District, Shenzhen City, P.R. China
Test specification	
Standard .....:	Engineering Recommendation G99 Issue 1 – Amendment 9 3 October 2022 Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019
Test report form number.....:	EREC G99_v1.0
Test report form(s) originator.....:	Guangdong HuaChuang Technology Service Co., Ltd.
Master TRF.....:	Dated 2022-02-01
Test item description.....:	Device Category: **Inverter** Device Type: **Hybrid (PV with DC coupled Electricity Storage)**
Trademark .....:	SOFAR
Model / Type reference.....:	HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH, HYD 10KTL-3PH-A, HYD 15KTL-3PH, HYD 20KTL-3PH
Technical data .....:	See section 3.1 on p.8
Dates of testing.....:	2022-10-14 to 2023-03-10

Tested / Report prepared by

Allen

Allen Zhang (Test engineer)

GUANGDONG HUACHUANG TECHNOLOGY SERVICE CO.,LTD HUA CHUANG REPORT

Approved by

Lukes

Lukes Lin (Project manager)

Contents

1 General information of test report

1.1 Important Note

General disclaimer

The test results presented in this report relate only to the object tested.

This report is for the exclusive use of Huachuang's Client and is provided pursuant to the agreement between Huachuang and its Client. This report shall not be reproduced, except in full, without the written approval of Huachuang. Test reports without seal and signature are not valid.

Huachuang's responsibility and liability are limited to the terms and conditions of the agreement. Huachuang assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned using this report.

Information on derived or extended models of the range as provided by the applicant (if any) is included in this report for information purposes only. Huachuang shall not be liable for any incorrect results due to unclear, incorrect, incomplete, misleading or false information provided by client.

1.2 Revision history

Report version	Date	Editor	Modification / Change	Status
220622BW001-EG-UK-001	2023-03-23	Allen Zhang	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:

n	Nominal value
max	Maximum value
Lx	index of phase x
LxLy	phase-to-phase voltages of phase x and phase y

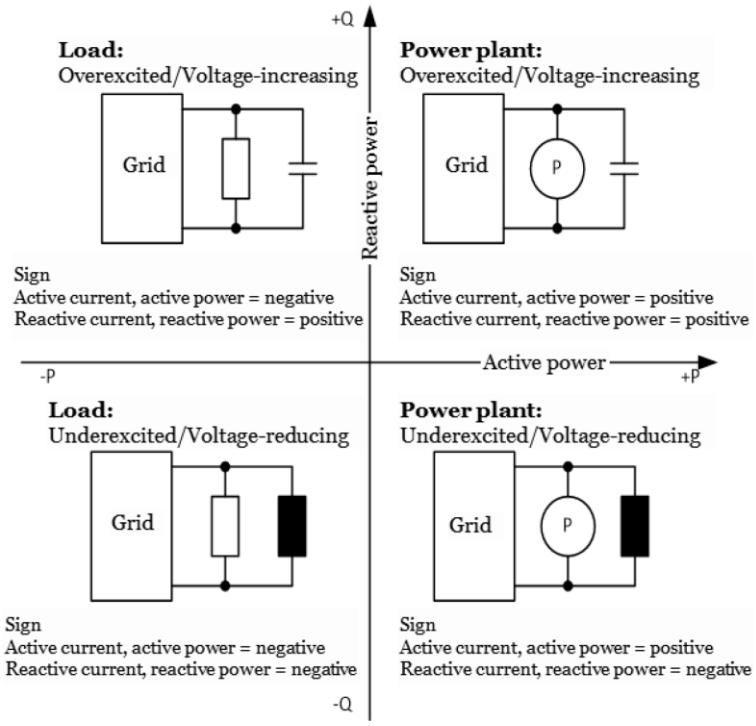
Abbreviations

AC	:	Alternating Current
DC	:	Direct Current
EUT	:	Equipment Under Test
LV	:	Low Voltage
MP	:	Measurement Point
MPP	:	Maximum Power Point
MV	:	Medium Voltage
PGF	:	Power Generating Facility
PGM	:	Power Generating Module
PGU	:	Power Generating Unit
P_{max}	:	Registered Capacity
PPM	:	Power Park Module
PWHD	:	Partial Weighted Harmonic Distortion
THD	:	Total Harmonic Distortion
PWHD	:	Partial Weighted Harmonic Distortion

Direction definition of P and Q

in this test report, the regarded system of the voltage and current vectors is the active sign convention system:

- If the inverter feeds to the grid the active power is measured with positive sign.
- If the inverter injects reactive power / current with leading power factor the reactive power / current is marked “leading” or “inductive” (under-excited) or has a negative sign.
- If the inverter injects reactive power / current with lagging power factor the reactive power / current is marked “lagging” or “capacitive” (over-excited) or has a positive sign.



3 General product information

Factory's name ..... : Dongguan SOFAR SOLAR Co., Ltd.

Factory address ..... : 1F-6F, Building E, No.1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City, Guangdong Province, P.R. China

3.1 Technical data of the unit(s)

Unit / Type ..... :	**HYD 5KTL-3PH**	**HYD 6KTL-3PH**	**HYD 8KTL-3PH**
Hardware version (tested) ..... :	V3.0		
Software version (tested) ..... :	V2.00		
DC input (PV)			
Max. DC input voltage [V]..... :	1000		
Operating MPPT voltage range [V] ..... :	180 ~ 960		
Input DC current [A]..... :	max. 12.5 / 12.5		
Battery connection			
Battery voltage range [V] ..... :	180 ~ 800		
Battery charging current [A]..... :	max. 25		
Battery discharging current [A] ..... :	max. 25		
AC connection			
Nominal output AC voltage [V] ..... :	230/400 (3~ + N + PE, 50/60Hz)		
Output AC current [A] ..... :	max. 8	max. 10	max. 13
Nominal active output power P_n [kW] .... :	5.0	6.0	8.0
Registered Capacity [1] P_{max} [kW] ..... :	5.0	6.0	8.0
Max. apparent power [kVA] ..... :	5.5	6.6	8.8

Unit / Type ..... :	**HYD 10KTL-3PH / HYD 10KTL-3PH-A**	**HYD 15KTL-3PH**	**HYD 20KTL-3PH**
Hardware version (tested) ..... :	V3.0		
Software version (tested) ..... :	V2.00		
DC input (PV)			
Max. DC input voltage [V]..... :	1000		
Operating MPPT voltage range [V] ..... :	180 ~ 960		
Input DC current [A]..... :	max. 25 / 25		
Battery connection			
Battery voltage range [V] ..... :	180 ~ 800		
Battery charging current [A]..... :	max. 25 / 25		

[1] In this report, the stated values of "registered capacity" related to single Generating Unit.

Battery discharging current [A] ..... :	max. 25 / 25		
AC connection			
Nominal output AC voltage [V] ..... :	230/400 (3~ + N + PE, 50/60Hz)		
Output AC current [A] ..... :	max. 16	max. 24	max. 32
Nominal active output power P_n [kW] .... :	10.0 / 10.0	15.0	20.0
Registered Capacity [2] P_{max} [kW]	10.0 / 10.0	15.0	20.0
Max. apparent power [kVA] ..... :	11.0 / 10.0	16.5	22.0

Note:

- The Power Park Modules (Generating Units):
  HYD 5KTL-3PH, *HYD 6KTL-3PH*, *HYD 8KTL-3PH*, *HYD 10KTL-3PH*, *HYD 15KTL-3PH* and *HYD 20KTL-3PH*
  are designed to be capable of operating within the range ±0.95 Power Factor at Registered Capacity.
  Max. operating range of Power Factor at Registered Capacity: 0.909 lagging to 0.909 leading.
- For Power Park Module (Generating Unit) *HYD 10KTL-3PH-A* to meet the requirement:
  "*When operating at **Registered Capacity** the **Power Generating Module** shall be capable of operating at a **Power Factor** within the range 0.95 lagging to 0.95 leading relative to the voltage waveform*"
  - a semi-permanent active power reduction to a value $P_{max} \leq 9.5$ kW
    can be applied by software (the parameter setting needs to follow the manufacturer's guidance).
  - or this need to be considered in the Power Generating Module design
  - or otherwise agreed with the DNO
- Setting range of the Power Factor:
  0.800 lagging to 0.800 leading

Equipment mobility ..... :	Permanent connection		
Operating condition..... :	Continuous		
Class of equipment..... :	Class I		
Protection against ingress of water ..... :	IP65 according to EN 60529		
Mass of equipment [kg] ..... :	HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH	:	approx. 33
	HYD 10KTL-3PH, HYD 10KTL-3PH-A, HYD 15KTL-3PH, HYD 20KTL-3PH	:	approx. 37
Type of internal transformer ..... :	No internal transformer (transformerless)		

[2] In this report, the stated values of "registered capacity" related to single Generating Unit.

Datasheet of the generating units:

Model	HYD 5KTL-3PH	HYD 6KTL-3PH	HYD 8KTL-3PH	HYD 10KTL-3PH	HYD 10KTL-3PH-A	HYD 15KTL-3PH	HYD 20KTL-3PH
DC input (PV)							
Recommended Max. PV input power	7500Wp (6000Wp/ 6000Wp)	9000Wp (6600Wp/ 6600Wp)	12000Wp (6600Wp/ 6600Wp)	15000Wp (7500Wp/ 7500Wp)	15000Wp (7500Wp/ 7500Wp)	22500Wp (11250Wp/ 11250Wp)	30000Wp (15000Wp/ 15000Wp)
Max. input voltage	1000V						
Start-up voltage	200V						
Rated input voltage	600V						
MPPT operating voltage range	180V~960V						
Number of MPPT	2						
Max. number of input strings per MPPT	1/1			2/2			
Max. input current per MPPT	12.5A/12.5A			25A/25A			
Max. short-circuit current per MPPT	15A/15A			30A/30A			
AC output (on grid)							
Rated output power	5000W	6000W	8000W	10000W	10000W	15000W	20000W
Rated output current	7.2A	8.7A	11.6A	14.5A	14.5A	21.7A	29.0A
Rated grid voltage	3/N/PE, 230/400Vac						
Rated grid frequency	50/60Hz						
Max. output apparent power	5500VA	6600VA	8800VA	11000VA	10000VA	16500VA	22000VA
Max. output current	8A	10A	13A	16A	16A	24A	32A
THDi	<3%						
Power factor	1 default (+/-0.8 adjustable)						
Battery Parameters							
Battery type	Lithium-ion & Lead-acid						
Battery voltage range	180V~800V						
Number of battery input channels	1	1	1	2	2	2	2

Model	HYD 5KTL-3PH	HYD 6KTL-3PH	HYD 8KTL-3PH	HYD 10KTL-3PH	HYD 10KTL-3PH-A	HYD 15KTL-3PH	HYD 20KTL-3PH
Max.charge/discharge power	5000W	6000W	8000W	10000W	10000W	15000W	20000W
Max.charge/discharge current	25A	25A	25A	50A (25A/25A)	50A (25A/25A)	50A (25A/25A)	50A (25A/25A)
BMS communication mode	CAN, RS485						
AC output (off grid)							
Rated output power	5000W	6000W	8000W	10000W	10000W	15000W	20000W
Rated output current	7.2A	8.7A	11.6A	14.5A	14.5A	21.7A	29.0A
Rated output voltage	3/N/PE, 230/400Vac						
Rated output frequency	50/60Hz						
Max. output apparent power	5500VA	6600VA	8800VA	11000VA	10000VA	16500VA	22000VA
Peak output apparent power, time	10000VA, 60s	12000VA, 60s	16000VA, 60s	20000VA, 60s	20000VA, 60s	22000VA, 60s	22000VA, 60s
Max. output current	8A	10A	13A	16A	16A	24A	32A
THDv(@ linear load)	<3%						
Switching time	<10ms						
Efficiency							
Max. MPPT efficiency	99.9%						
Max. efficiency	98%			98.2%			
European efficiency	97.5%			97.7%			
Max. efficiency of charging/discharging [1]	97.6%			97.8%			
Protection							
DC switch	Yes						
PV reverse connection protection	Yes						
Battery reverse connection protection	Yes						

Model	HYD 5KTL-3PH	HYD 6KTL-3PH	HYD 8KTL-3PH	HYD 10KTL-3PH	HYD 10KTL-3PH-A	HYD 15KTL-3PH	HYD 20KTL-3PH
Output short circuit protection	Yes						
Output overcurrent protection	Yes						
Output overvoltage protection	Yes						
Insulation impedance detection	Yes						
Residual current detection	Yes						
Anti-island protection	Yes						
Surge protection	PV:Type Ⅱ, AC:Type Ⅱ						
General Parameters							
Operating temperature range	-30℃~60℃						
Relative humidity range	5%~95%						
Max. operating altitude	<4000m						
Standby self-consumption [2]	<20W						
Topology	Transformerless						
Installation method	Wall Mounted						
Max. number of parallel units [3]	10 pcs						
Degree of protection	IP65						
Dimensions (W*H*D)	586.6*515*261.2mm						
Cooling mode	Natural			Forced airflow			
Weight	33kg			37kg			
Communication	RS485/CAN/WiFi, Optional:Ethernet/4G						
Display	LCD & Bluetooth+APP						

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

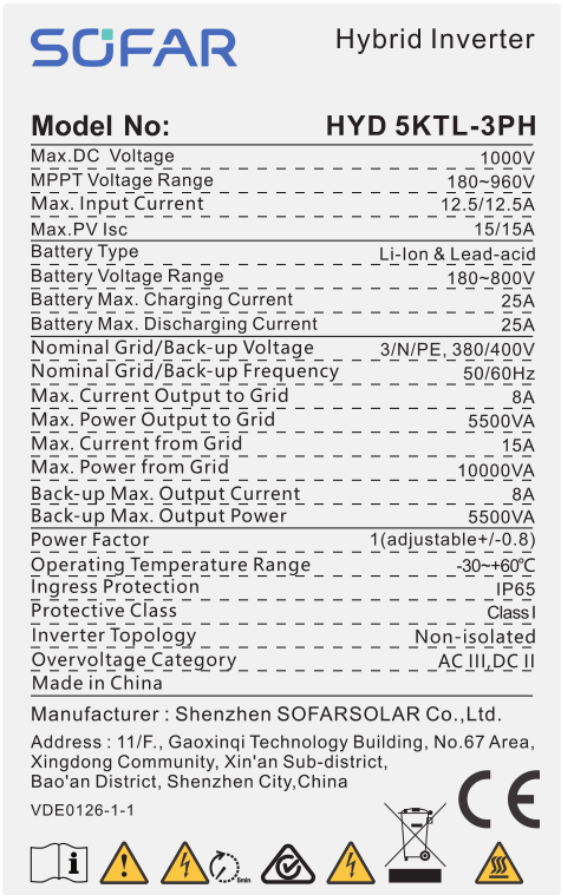
The units in the product series:

- sharing the same control electronics,
- with the same implemented control and firmware,
- with the same construction solutions including the power part,
- with the same number of phases,
- with the power electronics, filters and transducers designed for different sizes of voltage and current ratings.

The unit differences in the series are as follows:

Models	HYD 5KTL-3PH	HYD 6KTL-3PH	HYD 8KTL-3PH	HYD 10KTL-3PH HYD 10KTL-3PH-A	HYD 15KTL-3PH	HYD 20KTL-3PH
Battery DCDC induction	0.663 mH *1pcs			0.915 mH *2pcs		
Inverter induction	2mH		1.12mH		0.876mH	
INV switching circuits	discrete IGBT 40A/1200V*6pcs 40A/650V*6pcs		discrete IGBT 50A/1200V*6pcs 60A/650V*6pcs		IGBT module 50A/1200V*1pcs	
Bus capacitor	Electrolytic capacitor *8pcs thin-film capacitors * 2pcs				Electrolytic capacitor *12pcs thin-film capacitors * 4pcs	
DCDC switching circuits	SiC MOSFET 33A/1200V*4pcs*1			IGBT 40A/1200V*4pcs*2		
Boost induction	2mH			0.915mH		
Cooling system	Without external fans			With external fans		
Weight	33Kg			37Kg		

3.3 Copy of marking plate



SOFAR Hybrid Inverter

Model No:	HYD 5KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	12.5/12.5A
Max.PV Isc	15/15A
Battery Type	Li-Ion & Lead-acid
Battery Voltage Range	180~800V
Battery Max. Charging Current	25A
Battery Max. Discharging Current	25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	8A
Max. Power Output to Grid	5500VA
Max. Current from Grid	15A
Max. Power from Grid	10000VA
Back-up Max. Output Current	8A
Back-up Max. Output Power	5500VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	ClassI
Inverter Topology	Non-isolated
Overvoltage Category	AC III,DC II
Made in China	

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.

Address : 11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district, Bao'an District, Shenzhen City,China

VDE0126-1-1

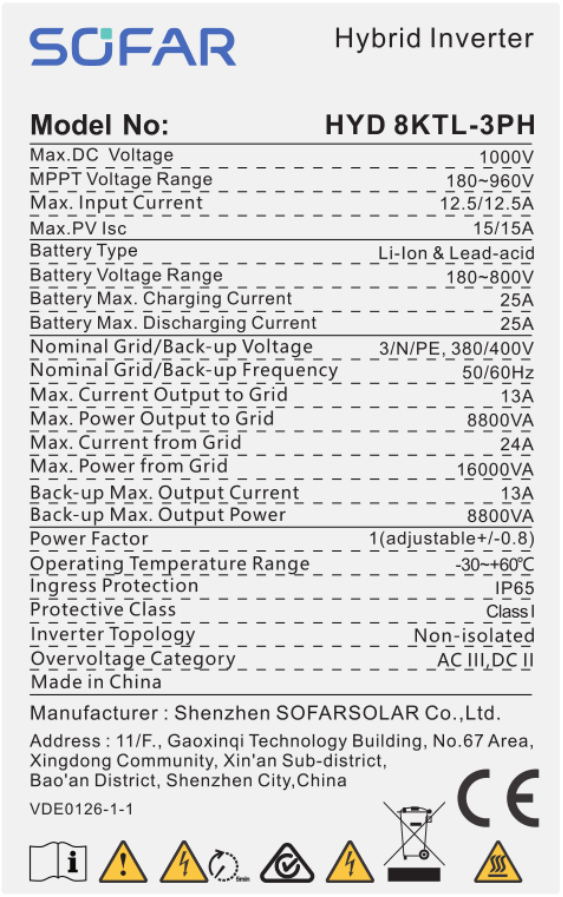
SOFAR Hybrid Inverter

Model No:	HYD 6KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	12.5/12.5A
Max.PV Isc	15/15A
Battery Type	Li-Ion & Lead-acid
Battery Voltage Range	180~800V
Battery Max. Charging Current	25A
Battery Max. Discharging Current	25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	10A
Max. Power Output to Grid	6600VA
Max. Current from Grid	17A
Max. Power from Grid	12000VA
Back-up Max. Output Current	10A
Back-up Max. Output Power	6600VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	ClassI
Inverter Topology	Non-isolated
Overvoltage Category	AC III,DC II
Made in China	

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.

Address : 11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district, Bao'an District, Shenzhen City,China

VDE0126-1-1



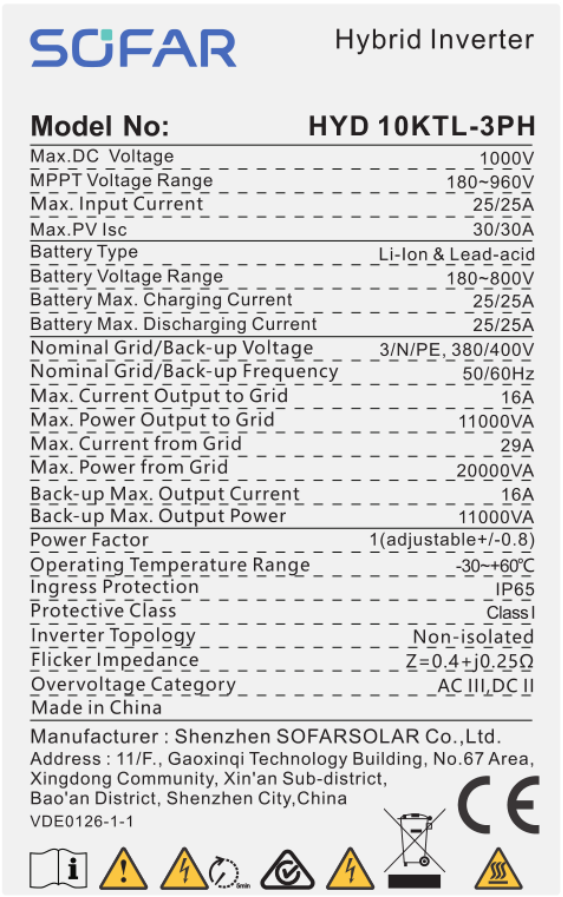
SOFAR Hybrid Inverter

Model No:	HYD 8KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	12.5/12.5A
Max.PV Isc	15/15A
Battery Type	Li-Ion & Lead-acid
Battery Voltage Range	180~800V
Battery Max. Charging Current	25A
Battery Max. Discharging Current	25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	13A
Max. Power Output to Grid	8800VA
Max. Current from Grid	24A
Max. Power from Grid	16000VA
Back-up Max. Output Current	13A
Back-up Max. Output Power	8800VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	ClassI
Inverter Topology	Non-isolated
Overvoltage Category	AC III,DC II
Made in China	

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.

Address : 11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district, Bao'an District, Shenzhen City,China

VDE0126-1-1



SOFAR Hybrid Inverter

Model No:	HYD 10KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	25/25A
Max.PV Isc	30/30A
Battery Type	Li-Ion & Lead-acid
Battery Voltage Range	180~800V
Battery Max. Charging Current	25/25A
Battery Max. Discharging Current	25/25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	16A
Max. Power Output to Grid	11000VA
Max. Current from Grid	29A
Max. Power from Grid	20000VA
Back-up Max. Output Current	16A
Back-up Max. Output Power	11000VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	ClassI
Inverter Topology	Non-isolated
Flicker Impedance	Z=0.4+j0.25Ω
Overvoltage Category	AC III,DC II
Made in China	

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.

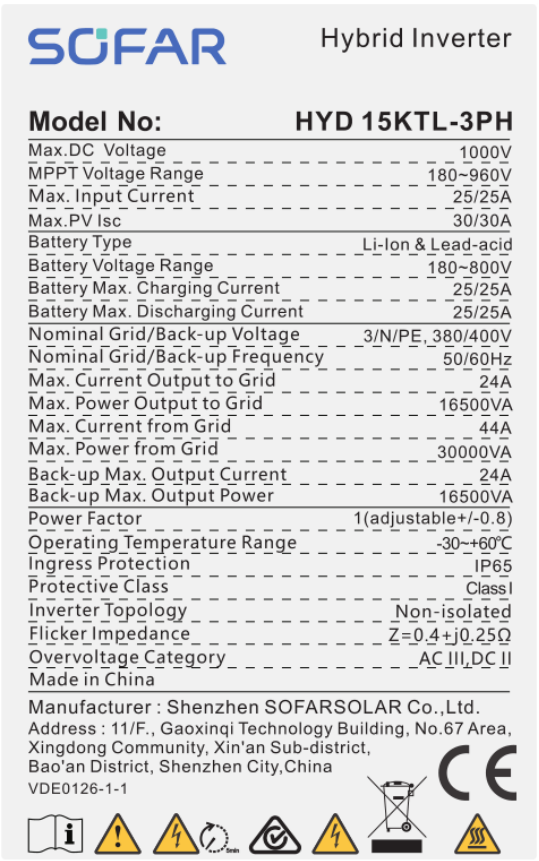
Address : 11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district, Bao'an District, Shenzhen City,China

VDE0126-1-1

SOFAR Hybrid Inverter

Model No:	HYD 10KTL-3PH-A
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	25/25A
Max.PV Isc	30/30A
Battery Type	Li-Ion & Lead-acid
Battery Voltage Range	180~800V
Battery Max. Charging Current	25/25A
Battery Max. Discharging Current	25/25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	16A
Max. Power Output to Grid	10000VA
Max. Current from Grid	29A
Max. Power from Grid	20000VA
Back-up Max. Output Current	16A
Back-up Max. Output Power	10000VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	ClassI
Inverter Topology	Non-isolated
Overvoltage Category	AC III,DC II
Made in China	

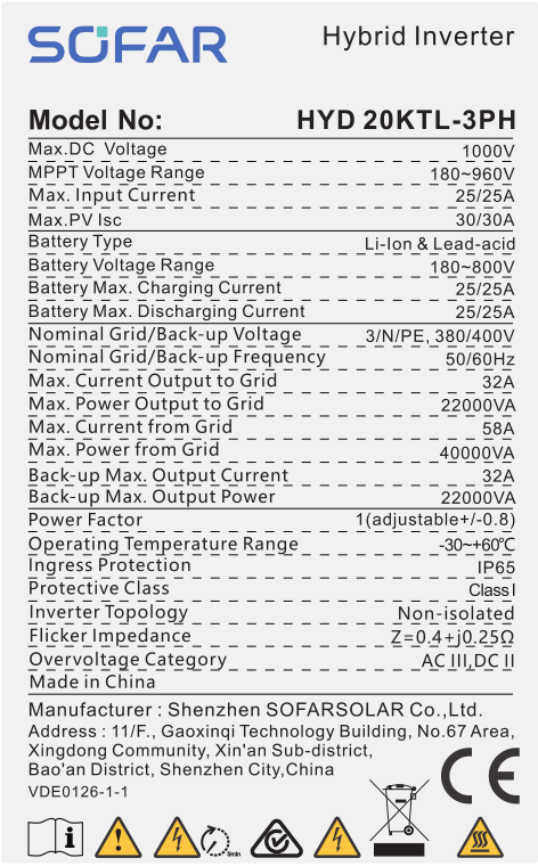
Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district, Bao'an District, Shenzhen City,China
VDE0126-1-1



SOFAR Hybrid Inverter

Model No:	HYD 15KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	25/25A
Max.PV Isc	30/30A
Battery Type	Li-Ion & Lead-acid
Battery Voltage Range	180~800V
Battery Max. Charging Current	25/25A
Battery Max. Discharging Current	25/25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	24A
Max. Power Output to Grid	16500VA
Max. Current from Grid	44A
Max. Power from Grid	30000VA
Back-up Max. Output Current	24A
Back-up Max. Output Power	16500VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	ClassI
Inverter Topology	Non-isolated
Flicker Impedance	Z=0.4+j0.25Ω
Overvoltage Category	AC III,DC II
Made in China	

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district, Bao'an District, Shenzhen City,China
VDE0126-1-1



SOFAR Hybrid Inverter

Model No:	HYD 20KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	25/25A
Max.PV Isc	30/30A
Battery Type	Li-Ion & Lead-acid
Battery Voltage Range	180~800V
Battery Max. Charging Current	25/25A
Battery Max. Discharging Current	25/25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	32A
Max. Power Output to Grid	22000VA
Max. Current from Grid	58A
Max. Power from Grid	40000VA
Back-up Max. Output Current	32A
Back-up Max. Output Power	22000VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	ClassI
Inverter Topology	Non-isolated
Flicker Impedance	Z=0.4+j0.25Ω
Overvoltage Category	AC III,DC II
Made in China	

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district, Bao'an District, Shenzhen City,China
VDE0126-1-1

Note:

The marking plates shown above may be only a draft. The use of certification marks on products must be approved by the respective NCBs to which these marks belong.

The marking plate is attached to the side surface or the back of the enclosure and is visible after installation.

3.4 Description of the power circuit

The input and output are protected by varistors to Earth. The unit is providing EMI filtering at the PV input and output toward mains. The unit does not provide galvanic separation from input to output (transformerless).

The output is switched off redundantly by the high-power switching bridge and two relays. This assures that the opening of the output circuit will also operate in case of a single error.

The internal control is redundant built. It consists of Microcontroller Main DSP (U37) and slave DSP (U39).

The Main DSP (U37) control the relays by switching signals; measures the Bus voltage, grid voltage, frequency, AC current with injected DC and the array insulation resistance to ground. In addition, it tests the current sensors and the RCMU circuit before each start up.

The slave DSP (U39) is measuring the grid voltage, grid frequency and residual current, also can switch off the relays independently, and communicate with Main DSP (U37) each other.

The current is measured by a current sensor. The AC current signal and the injected DC current signal are sent to the Main DSP(U37). The Main DSP(U37) tests and calibrates before each start up all current sensors.

The unit provides two relays in series in all output conductors. When single fault applied to one relay, alarm an error code in display panel, another redundant relay provides basic insulation maintained between the battery and the mains. All the relays are tested before each start up.

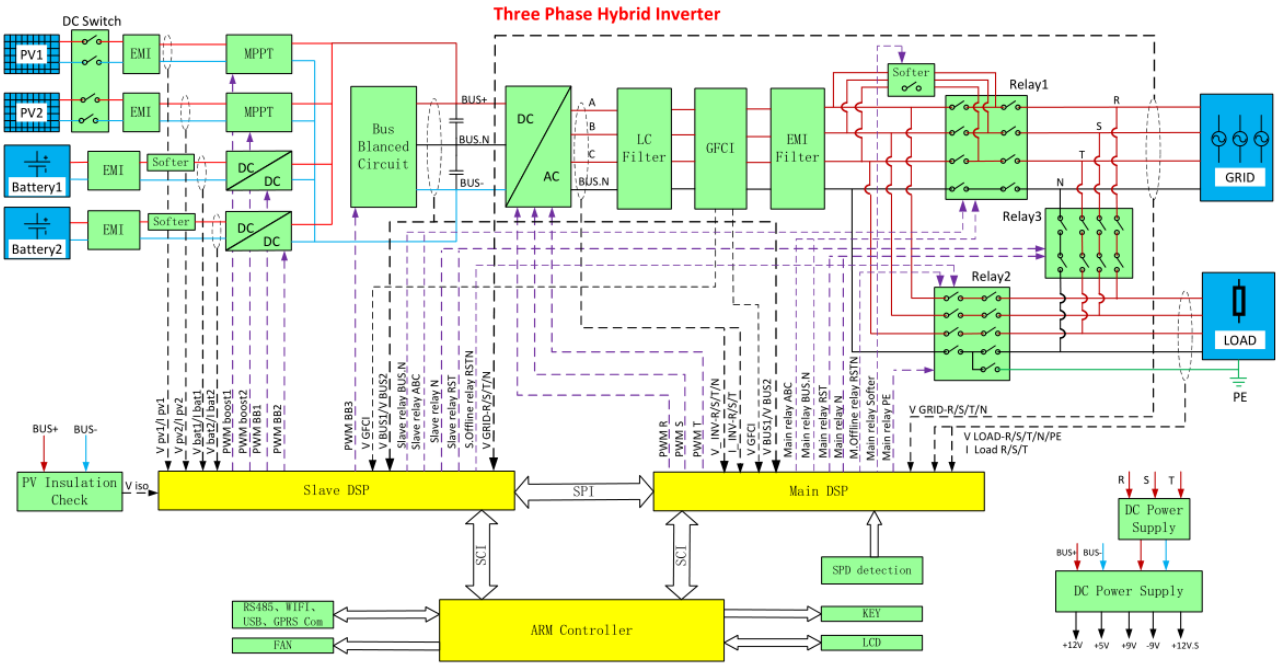


Figure 1 – Block diagram of the power circuit

4 General remarks for testing

4.1 PGM categories

According to definition of the standard the PGUs considered in this test report are Type A generating units:

Type A	Type B	Type C	Type D
Voltage level at connection point <110kV			Voltage level at connection point ≥110kV
0.8 kW ≤ P_{max} < 1 MW	1 MW ≤ P_{max} < 10 MW	10 MW ≤ P_{max} < 50 MW	P_{max} ≥ 50 MW
☒	☐	☐	☐

4.2 Energy Conversion Technology

Domestic CHP (1)	Photovoltaic (2) *	Fuel Cells (3)	Hydro (4)	Wind (5)	Electricity Storage devices (6) *
☐	☒	☐	☐	☐	☒

Type testing was carried out according to EREC G99, Annex A.7.
The following Additional Technology Requirements according to (depending on the selection in the table above):
(1) A.7.3.1.
(2) A.7.3.2.
(3) A.7.3.3.
(4) A.7.3.4.
(5) A.7.3.5.
(6) A.7.3.6.
have been taken into account.
Measurement results documented according to EREC G99, Form A2-3.

Note:

* Connection scenario:

☐ Photovoltaic Power Park Module connected to the DNO's Distribution Network via an Inverter

☒ Hybrid converter:

Photovoltaic Power Park Module with DC coupled storage unit connected to the DNO's Distribution Network via an Inverter (corresponding case EREC G99, Figure 6.6).

In this case the Registered Capacity is based on the Inverter rating. The storage unit has no compliance effect, compliance based on the inverter.

The Electricity Storage exceptions according to EREC G99, section A.4.2 do not apply to the Inverter.

4.3 Exceptions

According to EREC G99, Annex A.4:

☐ **Emerging Technology**

the following sections of EREC G99 do not apply:

- 11.2.1 (frequency withstand capability)
- 11.2.2 (rate of change of frequency)
- 11.2.3 (constant Active Power output)
- 11.2.4 (Limited Frequency Sensitive Mode – Overfrequency)
- 10.6.7 (Interface Protection settings).

☐ **Electricity Storage devices commissioned before 01 September 2022**

the following sections of EREC G99 do not apply:

- Type A - less than 1 MW
  - 11.2.3 (constant Active Power output)
  - 11.2.4 (Limited Frequency Sensitive Mode – Over frequency)
- Type B - 1 MW or greater but less than 10 MW
  - 12.2.3 (constant Active Power output)
  - 12.2.4 (Limited Frequency Sensitive Mode – Over frequency)
  - 12.3.1 – 12.3.1.7 inclusive, 12.3.4 and 12.6 (Fault Ride Through, Fast Fault Current injection)
- Type C and Type D - 10 MW or greater and / or with a Connection Point at greater than 110 kV
  - 13.2.3 (constant Active Power output)
  - 13.2.4 (Limited Frequency Sensitive Mode – Over frequency)
  - 13.2.5 (Limited Frequency Sensitive Mode – Under frequency)
  - 13.2.6 (Frequency Sensitive Mode)
  - 13.3 – 13.3.1.11 inclusive, 13.3.4 and 13.6 (Fault Ride Through, Fast Fault Current injection)

☐ **Infrequent Short-Term Parallel Operation**

the following sections of EREC G99 do not apply:

- Type A - less than 1 MW
  - All of Section 11
- Type B - 1 MW or greater but less than 10 MW
  - All of Section 12
- Type C and Type D - 10 MW or greater and / or with a Connection Point at greater than 110 kV
  - All of Section 13

☒ **Other**

No exceptions.

4.4 Scope of measurements

Date of receipt of test items ..... : 2022-10-14

Date(s) of performance of tests ..... : 2022-10-14 to 2023-03-10

During the test period stated above following environmental data were recorded:

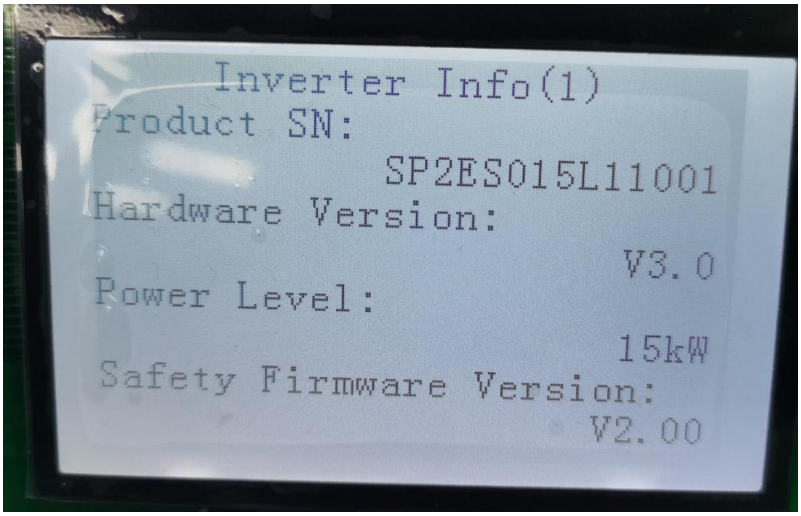
- Temperature: 20.5 ~ 25.1°C
- Rel. humidity: 39.3 ~ 58.1%RH
- Air pressure: 991.1 ~ 1001.3 hPa

Test items	Testing requirements (Section EREC G99)	Section in this test report	Tests completed
1. Operating Range	10.3.4, 11.2.1	6.1	☒
2. Harmonics	A.7.1.4.1	6.2	☒
3. Voltage Fluctuation and Flicker	A.7.1.4.3	6.3	☒
4. DC injection	A.7.1.4.4	6.4	☒
5. Power Factor (PF)	A.7.1.4.2	6.5	☒
6. Frequency protection trip and ride through tests	A.7.1.2.1, A.7.1.2.3	6.6.1	☒
7. Voltage protection trip and ride through tests	A.7.1.2.1, A.7.1.2.2	6.6.2	☒
8. Protection – Loss of Mains Test, Vector Shift and RoCoF Stability Test	A.7.1.2.4, A.7.1.2.6	6.6.3, 6.6.4 and 6.6.5	☒
9. LFSM-O Test	A.7.1.3	6.7	☒
10. Protection – Reconnection Timer	A.7.1.2.5	6.8	☒
11. Fault Level Contribution	A.7.1.5	6.9	☒
12. Self-monitoring Solid State Switch	A.7.1.6	6.10	☐
13. Wiring functional tests if required by para 15.2.1 (attach relevant schedule of tests)	15.2.1	6.11	☐
14. Logic Interface (input port)	11.1.3	6.12	☒
15. Cyber security	9.1.7	6.13	☐ [3]
Output power with falling frequency	11.2.3	Test not performed and not documented in this report.	☐

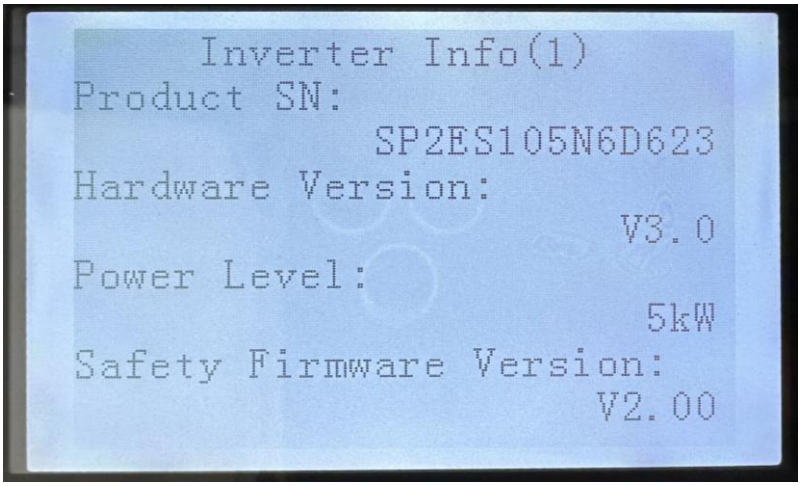
[3] Manufacturer's declaration provided, for details see section 6.13.

Note:

- The (full) tests were performed on EUT *HYD 15KTL-3PH*.
  Spot testing was conducted on *HYD 5KTL-3PH*: 6.4 Power Quality – DC injection.
- The products wer tested on:
  - *HYD 15KTL-3PH* (full testing)
    - Serial No.: SP2ES015L11001
    - Hardware Version: V3.0
    - Firmware Version: V2.00



  - *HYD 5KTL-3PH* (spot testing)
    - Serial No.: SP2ES105N6D623
    - Hardware Version: V3.0
    - Firmware Version: V2.00



- Measurement done at output terminals of the EUT, see Figure 3, Figure 4 and Figure 5.
- According to EREC G99, section 15.6.1 the following applies:
  since the rated power of *HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH, HYD 10KTL-3PH-A* and *HYD 20KTL-3PH* is between $1/\sqrt{10}\cdot P_{n,\ HYD\ 15KTL\text{-}3PH}$ and $2\cdot P_{n,\ HYD\ 15KTL\text{-}3PH}$, a family approach to type testing is acceptable.
- A transfer of measurement results from the *HYD 15KTL-3PH* to other units in the product series according to EREC G99, section 15.6.2 is allowed (for details see section *5 Assessment overview*).
- Technical justification for transferability of measurement results:
  see section 3.2 on p.13.

4.5 Reference values

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

	HYD 5KTL-3PH	HYD 6KTL-3PH	HYD 8KTL-3PH
Registered Capacity [4] P_{max} [kW]	5.0	6.0	8.0
Rated voltage (phase-to-neutral), U_n [V]	230		
Rated current, I_n [5] [A]	7.2	8.7	11.6
	HYD 10KTL-3PH / HYD 10KTL-3PH-A	**HYD 15KTL-3PH**	**HYD 20KTL-3PH**
Registered Capacity [4] P_{max} [kW]	10.0 / 10.0 *	15.0	20.0
Rated voltage (phase-to-neutral), U_n [V]	230		
Rated current, I_n [5] [A]	14.5 / 14.5 *	21.7	29.0

Note:
* see also "*Note*" on p.9.

4.6 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} = 26.372 A, U_{oc} = 696.71 V) simulated according to EN50530:

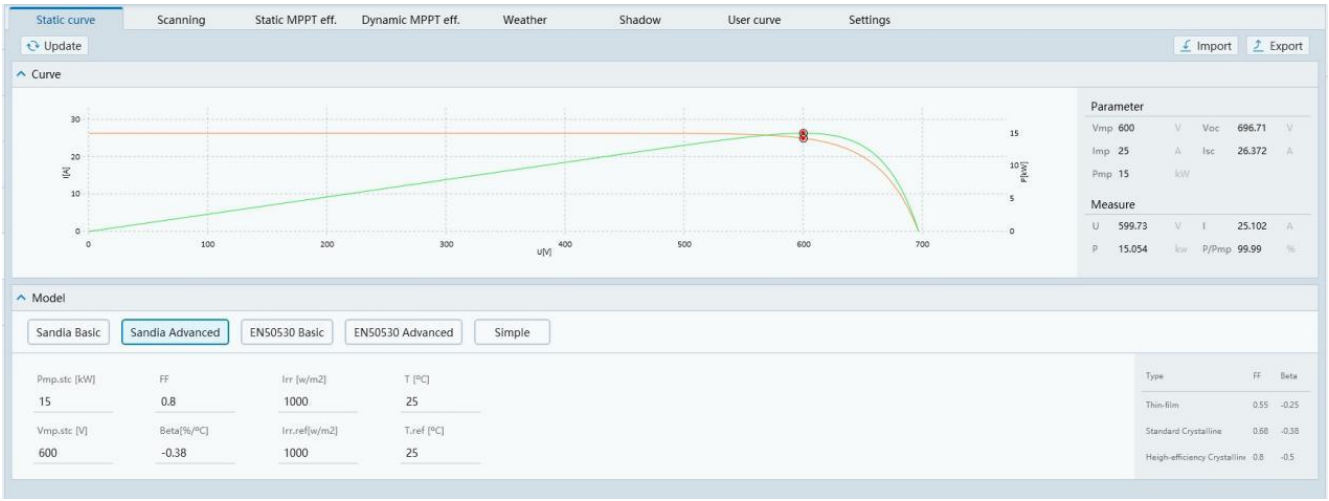


Figure 2 – DC characteristics for testing

[4] In this report, the stated values of "registered capacity" related to single Generating Unit.

[5] The rated current stated in this report is calculated based on the "registered capacity" and the rated voltage.

The measurement setups are shown in Figure 3 Figure 4 and Figure 5. The specific test and measurement devices are stated in section 4.7.

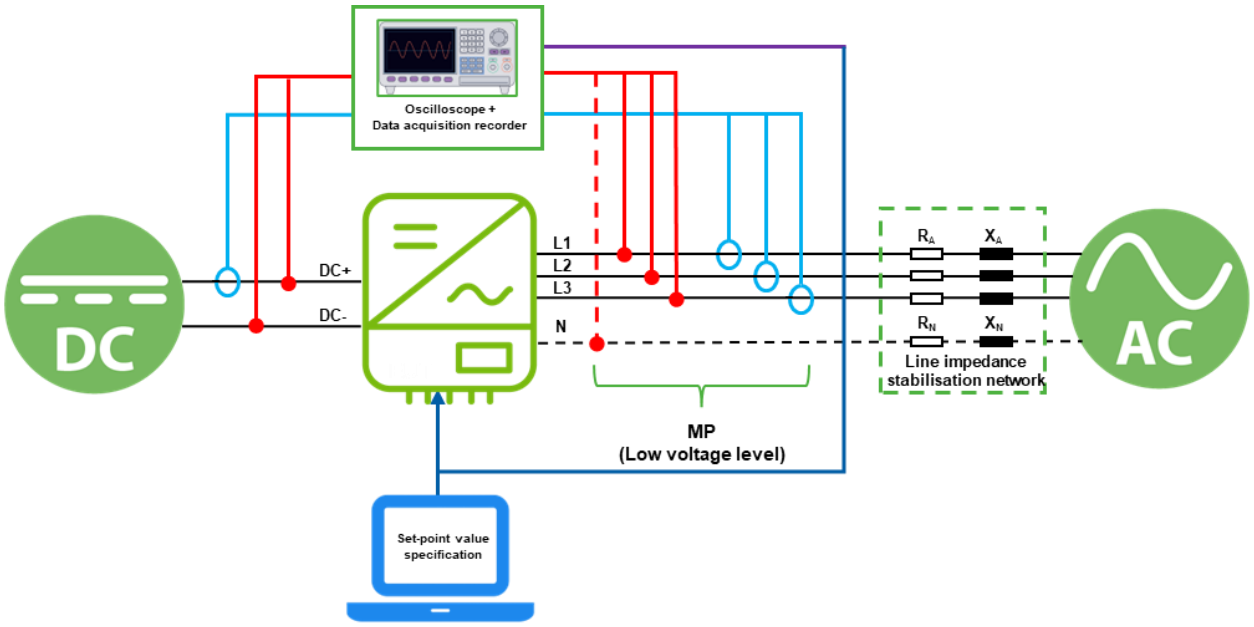


Figure 3 – Measurement setup used for tests except Loss of Mains and Short Circuit test

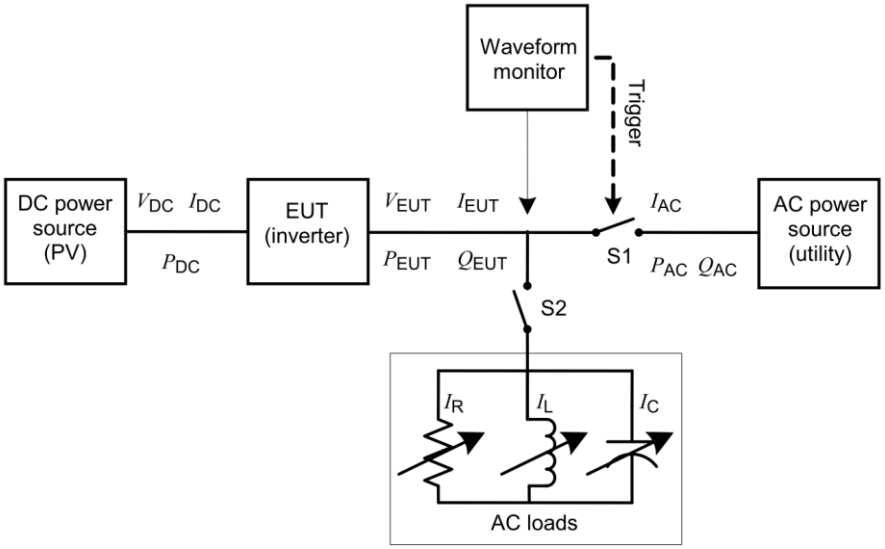


Figure 4 – Test circuit for Loss of Mains according to *IEC 62116:2014*

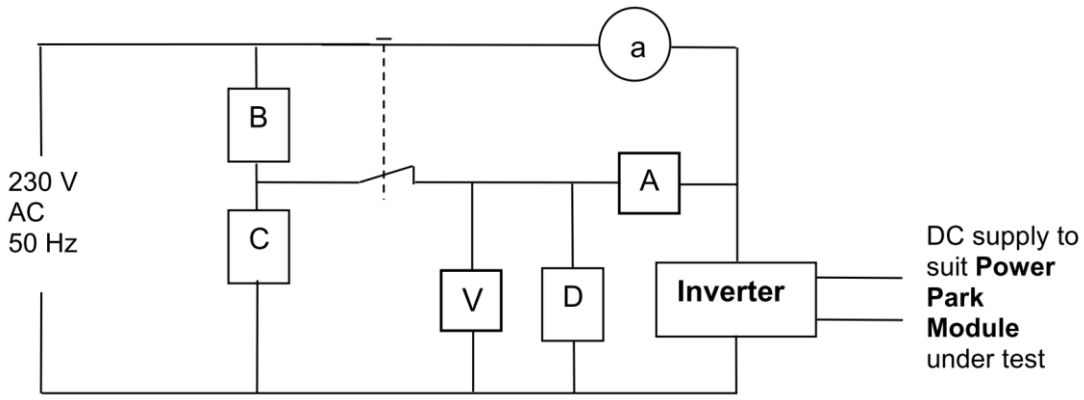


Figure 5 – Short circuit test circuit according to *EREC G99, Figure A.7.5*

4.7 Measurement equipment

Equipment	Internal No.	Manufacturer	Type	Serial No.	Next Calibration
DC power supply [6]	--	ACTIONPOWER	PRD2006	B1022E0193	--
AC Simulator [6]	HC-ENG-012	Chroma	61830	618303800281	--
Oscilloscope	--	Agilent	DSO-X3014A	MY50510707	2023-12-01
Power analyser	HC-ENG-003	DEWESOFT	SIRIUSi-HS-4xHV-4xLV	DB20123915	2023-09-05
Current sensor	HC-ENG-019	LEM	IT 400-S	82021060080	2023-09-05
	HC-ENG-020	LEM	IT 400-S	82021060081	2023-09-05
	HC-ENG-021	LEM	IT 400-S	82021060082	2023-09-05
	HC-ENG-022	LEM	IT 400-S	82021060084	2023-09-05
Digital hygrometer	HC-ENG-002	Jiangsu Jingchuang Electric Co., Ltd.	GSP-8A	CMA215000031	2023-08-31

Note:

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

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

5 Assessment overview

Possible test case verdicts:

Test item does meet the requirement.....: P (Pass)

Test item does not meet the requirement....: F (Fail)

Test case does not apply to the test object...: N/A

Test case is not rated .....: N/R

Reference to declaration documents.....: R/D

Items	Technical requirements (Section EREC G99)	Remark / Transfer of measurement results *	Verdict
1. Operating Range	10.3.4, 11.2.1	See section 6.1 / The verified operating range of the HYD 15KTL-3PH can be applied to other units in the product series directly.	P
2. Harmonics	9.4.3	See section 6.2 / The percentage harmonics results of the HYD 15KTL-3PH can be applied to other units in the product series scaled by the factor $P_{n,\ HYD\ 15KTL-3PH}$ / $P_{n,\ unit\text{-}not\text{-}tested}$. The transferred results are below the required limit values according to BS EN 61000-3-12.	P
3. Voltage Fluctuation and Flicker	9.4.2	See section 6.3 / The Flicker results of the HYD 15KTL-3PH can be applied to other units in the product series scaled by the factor $P_{n,\ HYD\ 15KTL-3PH}$ / $P_{n,\ unit\text{-}not\text{-}tested}$. The transferred results (values at test and standard impedance) are below the required limit values according to BS EN 61000-3-11.	P
4. DC injection	9.4.6	See section 6.4 / The percentage DC injection of the HYD 15KTL-3PH can be considered as worst case results and applied to the HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH,HYD 10KTL-3PH-A directly. The percentage DC injection of the HYD 15KTL-3PH can be applied to the HYD 20KTL-3PH scaled by the factor $P_{n,\ HYD\ 15KTL-3PH}$ / $P_{n,\ unit\text{-}not\text{-}tested}$. The transferred results are below the required limit of 0.25%.	P
5. Power Factor (PF)	11.1.5	See section 6.5 / The Power Factor results of the HYD 15KTL-3PH can be applied to other units in the product series directly.	P

Items	Technical requirements (Section EREC G99)	Remark / Transfer of measurement results *	Verdict
6. Frequency protection trip and ride through tests	10.3, 10.6	See section 6.6.1 / The measurement results of the HYD 15KTL-3PH can be applied to other units in the product series directly.	P
7. Voltage protection trip and ride through tests	10.3, 10.6	See section 6.6.2 / The measurement results of the HYD 15KTL-3PH can be applied to other units in the product series directly.	P
8. Protection – Loss of Mains Test, Vector Shift and RoCoF Stability Test	10.3, 10.4, 10.6	See section 6.6.3, 6.6.4 and 6.6.5 / The measurement results of the HYD 15KTL-3PH can be applied to other units in the product series directly.	P
9. LFSM-O Test	11.2.4	See section 6.7 / The determined droops of the HYD 15KTL-3PH can be applied to other units in the product series directly.	P
10. Protection – Reconnection Timer	A.7.1.2.5	See section 6.8 / The measurement results of the HYD 15KTL-3PH can be applied to other units in the product series directly.	P
11. Fault Level Contribution	9.7, A.7.1.5	See section 6.9 / The measurement results of the HYD 15KTL-3PH can be applied to other units in the product series directly.	P
12. Self-monitoring Solid State Switch	9.7.9	See section 6.10 / ---	N/A
13. Wiring functional tests if required by para 15.2.1 (attach relevant schedule of tests)	15.2.1	See section 6.11 / ---	N/A
14. Logic Interface (input port)	11.1.3	See section 6.12 / The measurement results of the HYD 15KTL-3PH can be applied to other units in the product series directly. The high-level description of logic interface applies to the whole product series.	P
15. Cyber security	9.1.7	See section 6.13 / Manufacturer's declaration provided. See *Annex 2 - Manufacturer's declaration regarding Cyber Security*.	R/D
Output power with falling frequency	A.7.1.7, 11.2.3.3	Test not required for Power Generating Modules using inverter	N/A

Note:

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

* According to EREC G99, section 15.6.2 the following applies:

All absolute values (e.g. operating range tests) shall be transferred directly in the compliance forms of an assumed compliant Generating Unit of the same family. ***All relative results related to design Active Power or current (e.g. power quality fluctuation and flicker) from the tested Generating Unit shall be transferred to the compliance form of a Generating Unit in the same family according to the ratio of the respective nameplate rating (W) of the tested Generating Unit and the assumed compliant Generating Unit****. For the avoidance of doubt, the Manufacturer shall register each Generating Unit in the family on the Energy Networks Association Type Test register.*

In general, the ***relative results*** of EUT *HYD 15KTL-3PH* can be applied to other units in the product series scaled by the factor $P_{n,\ HYD\ 15KTL\text{-}3PH}$ / $P_{n,\ unit\text{-}not\text{-}tested}$. Exceptions are detailed in the table above.

6 Measurement results

A2-3 Compliance Verification Report –Tests for Type A Inverter Connected Power Generating Modules – test record

6.1 Operating Range

Tests should be carried with the Power Generating Module operating at Registered Capacity and connected to a suitable test supply or grid simulation set. The power supplied by the primary source shall be kept stable within ± 5 % of the apparent power value set for the entire duration of each test sequence.

Frequency, voltage and Active Power measurements at the output terminals of the Power Generating Module shall be recorded every second. The tests will verify that the Power Generating Module can operate within the required ranges for the specified period of time.

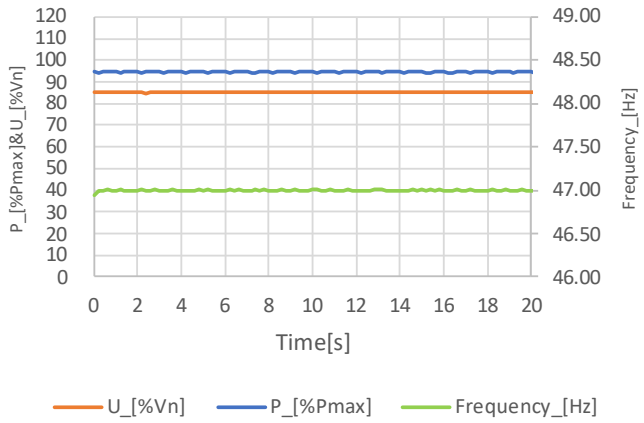
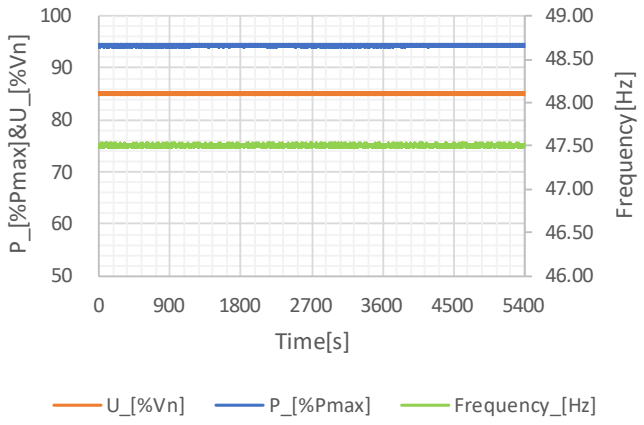
The Interface Protection shall be disabled during the tests.

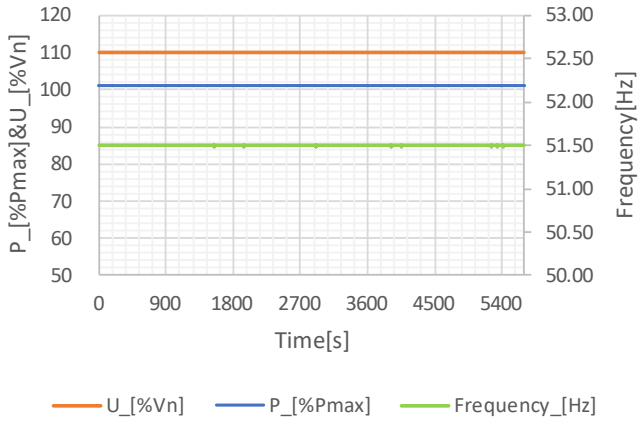
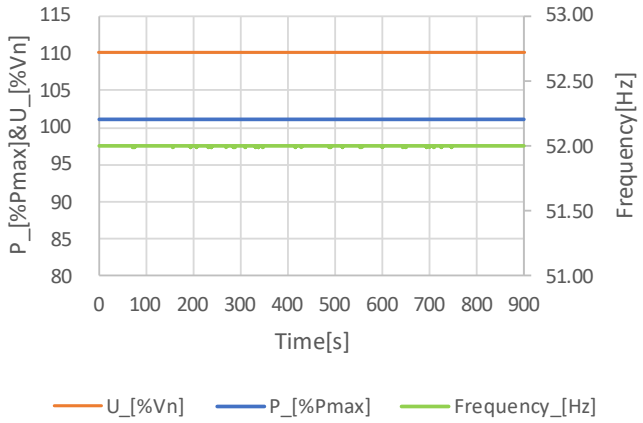
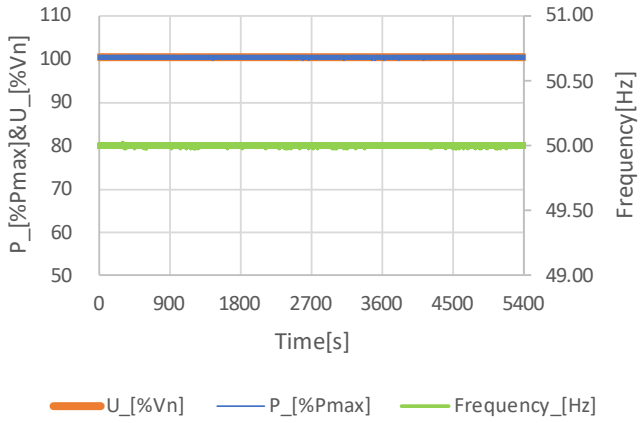
In case of a PV Power Park Module the PV primary source may be replaced by a DC source.

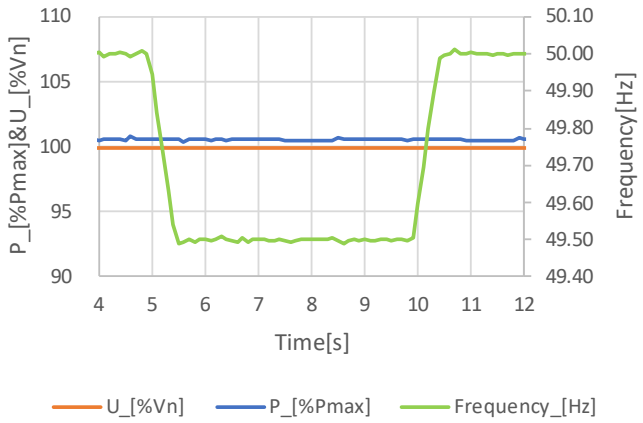
In case of a full converter Power Park Module (eg wind) the primary source and the prime mover Inverter/rectifier may be replaced by a DC source.

Pass or failure of the test should be indicated in the fields below (right hand side), for example with the statement "Pass", "No disconnection occurs", etc. Graphical evidence is preferred.

Note that the value of voltage stated in brackets assumes a LV connection. This should be adjusted for HV as required.

Test 1 Voltage = 85% of nominal (195.5 V), Frequency = 47 Hz, **Power Factor** = 1, Period of test 20 s	Pass, no disconnection occurs. 
Test 2 Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz, **Power Factor** = 1, Period of test 90 minutes	Pass, no disconnection occurs. 

Test 3 Voltage = 110% of nominal (253 V)., Frequency = 51.5 Hz, **Power Factor** = 1, Period of test 90 minutes	Pass, no disconnection occurs. 
Test 4 Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz, **Power Factor** = 1, Period of test 15 minutes	Pass, no disconnection occurs. 
Test 5 Voltage = 100% of nominal (230 V), Frequency = 50.0 Hz, **Power Factor** = 1, Period of test = 90 minutes	Pass, no disconnection occurs. 
Test 6 RoCoF withstand Confirm that the Power Generating Module is capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hzs-1 as measured over a period of 500 ms. Note that this is not expected to be demonstrated on site.	Pass, no disconnection occurs.



6.2 Power Quality – Harmonics

For **Power Generating Module**s of **Registered Capacity** of less than 75 A per phase (ie 50 kW) the test requirements are specified in Annex A.7.1.5. These tests should be carried out as specified in BS EN 61000-3-12, and measurements for the 2nd – 13th harmonics should be provided. The results need to comply with the limits of Table 2 of BS EN 61000-3-12 for single phase equipment and Table 3 of BS EN 610000-3-12 for three phase equipment. For three phase **Power Generating Module**s, measurements for all phases should be provided.

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

The rating of the **Power Generating Module** (per phase) should be provided below, and the Total Harmonic Distortion (THD) and Partial Weighted Harmonic Distortion (PWHD) should be provided at the bottom of this section.

Power Generating Module tested to BS EN 61000-3-12

Power Generating Module rating per phase (rpp)	5.000	kVA	Harmonic % = Measured Value (A) x 23/rating per phase (kVA)
Single or three phase measurements (for single phase measurements, only complete L1 columns below).	three phases		

Harmonic	At 45-55% of **Registered Capacity**						Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps			Measured Value (MV) in %[7]				
Order	L_1	L_2	L_3	L_1	L_2	L_3	1-phase	3-phases
2	0.0055	0.0023	0.0068	0.025	0.010	0.031	8%	8%
3	0.0269	0.0203	0.0277	0.124	0.093	0.127	21.6%	Not stated
4	0.0039	0.0031	0.0045	0.018	0.014	0.021	4%	4%
5	0.0535	0.0428	0.0527	0.246	0.197	0.242	10.7%	10.7%
6	0.0042	0.0037	0.0037	0.019	0.017	0.017	2.67%	2.67%
7	0.0201	0.0164	0.0099	0.093	0.075	0.046	7.2%	7.2%
8	0.0047	0.0038	0.0042	0.022	0.018	0.019	2%	2%
9	0.0162	0.0046	0.0166	0.075	0.021	0.076	3.8%	Not stated
10	0.0061	0.0047	0.0056	0.028	0.021	0.026	1.6%	1.6%
11	0.0436	0.0321	0.0397	0.200	0.148	0.183	3.1%	3.1%
12	0.0048	0.0033	0.0038	0.022	0.015	0.017	1.33%	1.33%

[7] The percentage values of harmonic currents (for both partial load and full load tests) were calculated using the formula:
Harmonic % = Measured Value (A) x 23/rating per phase (kVA)
according to Form A2-3, which corresponding to a reference current equal to rated current of the inverter.

Order	L_1	L_2	L_3	L_1	L_2	L_3	1-phase	3-phases
13	0.0220	0.0104	0.0192	0.101	0.048	0.088	2%	2%
14	0.0094	0.0071	0.0054	0.043	0.033	0.025	---	---
15	0.0190	0.0044	0.0161	0.087	0.020	0.074	---	---
16	0.0121	0.0102	0.0111	0.056	0.047	0.051	---	---
17	0.0337	0.0253	0.0301	0.155	0.116	0.139	---	---
18	0.0060	0.0029	0.0042	0.028	0.014	0.019	---	---
19	0.0325	0.0247	0.0327	0.150	0.114	0.150	---	---
20	0.0127	0.0109	0.0078	0.058	0.050	0.036	---	---
21	0.0164	0.0053	0.0112	0.075	0.024	0.051	---	---
22	0.0183	0.0171	0.0173	0.084	0.079	0.080	---	---
23	0.0237	0.0186	0.0164	0.109	0.086	0.075	---	---
24	0.0067	0.0036	0.0047	0.031	0.016	0.022	---	---
25	0.0369	0.0328	0.0348	0.170	0.151	0.160	---	---
26	0.0152	0.0145	0.0108	0.070	0.067	0.050	---	---
27	0.0114	0.0043	0.0074	0.052	0.020	0.034	---	---
28	0.0207	0.0194	0.0183	0.095	0.089	0.084	---	---
29	0.0283	0.0289	0.0228	0.130	0.133	0.105	---	---
30	0.0056	0.0032	0.0041	0.026	0.015	0.019	---	---
31	0.0305	0.0255	0.0275	0.140	0.117	0.126	---	---
32	0.0166	0.0171	0.0160	0.076	0.079	0.074	---	---
33	0.0060	0.0034	0.0039	0.028	0.016	0.018	---	---
34	0.0144	0.0124	0.0151	0.066	0.057	0.070	---	---
35	0.0199	0.0156	0.0169	0.092	0.072	0.078	---	---
36	0.0050	0.0021	0.0028	0.023	0.010	0.013	---	---
37	0.0291	0.0301	0.0310	0.134	0.139	0.143	---	---
38	0.0038	0.0035	0.0018	0.017	0.016	0.008	---	---
39	0.0047	0.0028	0.0033	0.021	0.013	0.015	---	---
40	0.0162	0.0159	0.0163	0.075	0.073	0.075	---	---
THD [8]	---	---	---	0.599	0.483	0.549	23%	13%
PWHD [9]	---	---	---	2.359	2.053	2.138	23%	22%

[8] THD = Total Harmonic Distortion, order 2 - 40 according to BS EN 61000- 3-12 considered. The stated values in the results table are in %.

[9] PWHD = Partial Weighted Harmonic Distortion, order 14 - 40 according to BS EN 61000- 3-12 considered. The stated values in the results table are in %.

Harmonic	At 100% of **Registered Capacity**						Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps			Measured Value (MV) in % [7]				
Order	L_1	L_2	L_3	L_1	L_2	L_3	1-phase	3-phases
2	0.0071	0.0043	0.0073	0.033	0.020	0.034	8%	8%
3	0.0259	0.0213	0.0270	0.119	0.098	0.124	21.6%	Not stated
4	0.0031	0.0025	0.0039	0.014	0.012	0.018	4%	4%
5	0.0494	0.0388	0.0476	0.227	0.179	0.219	10.7%	10.7%
6	0.0037	0.0033	0.0033	0.017	0.015	0.015	2.67%	2.67%
7	0.0164	0.0160	0.0089	0.075	0.074	0.041	7.2%	7.2%
8	0.0046	0.0039	0.0049	0.021	0.018	0.023	2%	2%
9	0.0167	0.0041	0.0127	0.077	0.019	0.059	3.8%	Not stated
10	0.0042	0.0039	0.0052	0.019	0.018	0.024	1.6%	1.6%
11	0.0347	0.0241	0.0308	0.160	0.111	0.142	3.1%	3.1%
12	0.0043	0.0034	0.0037	0.020	0.016	0.017	1.33%	1.33%
13	0.0202	0.0117	0.0190	0.093	0.054	0.087	2%	2%
14	0.0047	0.0030	0.0042	0.022	0.014	0.019	---	---
15	0.0189	0.0042	0.0143	0.087	0.020	0.066	---	---
16	0.0047	0.0041	0.0063	0.022	0.019	0.029	---	---
17	0.0255	0.0148	0.0227	0.117	0.068	0.105	---	---
18	0.0044	0.0026	0.0030	0.020	0.012	0.014	---	---
19	0.0347	0.0295	0.0371	0.159	0.136	0.171	---	---
20	0.0052	0.0032	0.0036	0.024	0.015	0.017	---	---
21	0.0170	0.0058	0.0116	0.078	0.026	0.054	---	---
22	0.0081	0.0075	0.0092	0.037	0.034	0.042	---	---
23	0.0186	0.0120	0.0133	0.085	0.055	0.061	---	---
24	0.0044	0.0025	0.0026	0.020	0.012	0.012	---	---
25	0.0418	0.0378	0.0415	0.192	0.174	0.191	---	---
26	0.0048	0.0042	0.0028	0.022	0.019	0.013	---	---
27	0.0139	0.0044	0.0082	0.064	0.020	0.038	---	---
28	0.0117	0.0107	0.0122	0.054	0.049	0.056	---	---
29	0.0215	0.0179	0.0149	0.099	0.082	0.069	---	---
30	0.0044	0.0023	0.0024	0.020	0.011	0.011	---	---
31	0.0389	0.0347	0.0372	0.179	0.160	0.171	---	---
32	0.0073	0.0078	0.0050	0.033	0.036	0.023	---	---
33	0.0078	0.0040	0.0050	0.036	0.018	0.023	---	---
34	0.0103	0.0086	0.0094	0.048	0.040	0.043	---	---
35	0.0265	0.0265	0.0236	0.122	0.122	0.109	---	---
36	0.0026	0.0020	0.0023	0.012	0.009	0.011	---	---
37	0.0267	0.0234	0.0257	0.123	0.108	0.118	---	---
38	0.0073	0.0069	0.0065	0.034	0.032	0.030	---	---
39	0.0061	0.0026	0.0039	0.028	0.012	0.018	---	---
40	0.0100	0.0092	0.0105	0.046	0.042	0.048	---	---
THD [8]	---	---	---	0.551	0.438	0.511	23%	13%
PWHD [9]	---	---	---	2.240	1.890	2.069	23%	22%

6.3 Power Quality – Voltage fluctuations and Flicker

For **Power Generating Module**s of **Registered Capacity** of less than 75 A per phase (ie 50 kW) these tests should be undertaken in accordance with Annex A.7.1.4.3. Results should be normalised to a standard source impedance, or if this results in figures above the limits set in BS EN 61000-3-11 to a suitable Maximum Impedance.

For **Power Generating Module**s of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation shall be designed in accordance with EREC P28.

The standard test impedance is 0.4 Ω for a single-phase **Power Generating Module** (and for a two-phase unit in a three-phase system) and 0.24 Ω for a three phase **Power Generating Module** (and for a two-phase unit in a split phase system). Please ensure that both test and standard impedance are completed on this form. If the test impedance (or the measured impedance) is different to the standard impedance, it must be normalised to the standard impedance as follows (where the **Power Factor** of the generation output is 0.98 or above):

d_{max} normalised value = (Standard impedance / Measured impedance) x Measured value.

Where the **Power Factor** of the output is under 0.98 then the X to R ratio of the test impedance should be close to that of the standard impedance.

The stopping test should be a trip from full load operation.

The duration of these tests needs to comply with the particular requirements set out in the testing notes for the technology under test.

The test date and location must be declared.

Test start date	2022-11-14	Test end date	2022-11-14
Test location	Guangdong HuaChuang Technology Service Co., Ltd. (see *Testing location* on p.2)		

		Starting			Stopping			Running	
	Phase no.	d_{max} [%]	d_c [%]	d(t) [ms]	d_{max} [%]	d_c [%]	d(t) [ms]	P_{st}	P_{lt} 2 hours
Measured Values at test impedance	L1	0.142	0.118	0.000	0.376	0.286	0.000	0.036	0.033
	L2	0.150	0.084	0.000	0.337	0.267	0.000	0.040	0.033
	L3	0.199	0.151	0.000	0.323	0.269	0.000	0.031	0.030
	Overall worst case	0.199	0.151	0.000	0.376	0.286	0.000	0.040	0.033
Normalised to standard impedance	L1	0.142	0.118	0.000	0.376	0.286	0.000	0.036	0.033
	L2	0.150	0.084	0.000	0.337	0.267	0.000	0.040	0.033
	L3	0.199	0.151	0.000	0.323	0.269	0.000	0.031	0.030
	Overall worst case	0.199	0.151	0.000	0.376	0.286	0.000	0.040	0.033
Normalised to required maximum impedance	L1	1.511	1.255	0.000	4.000	3.043	0.000	0.383	0.351
	L2	1.596	0.894	0.000	3.585	2.840	0.000	0.426	0.351
	L3	2.117	1.606	0.000	3.436	2.862	0.000	0.330	0.319
	Overall worst case	2.117	1.606	0.000	4.000	3.043	0.000	0.426	0.351
Limits set under BS EN 61000-3-11		4	3.3	500 (3.3%)	4	3.3	500 (3.3%)	1.0	0.65

Test Impedance	R:	0.24 Ω	X:	0.15 Ω
Standard Impedance	R:	☒ 0.24 * ☐ 0.4 ^ Ω	X:	☒ 0.15 * ☐ 0.25 ^ Ω
Maximum Impedance	R:	2.553 Ω	X:	1.596 Ω

* ☒ three-phase **Power Generating Module**s ☐ split single phase **Power Generating Module**s

^ ☐ single phase **Power Generating Module** ☐ **Power Generating Module**s using two phases on a three-phase system

6.4 Power Quality – DC injection

The tests should be carried out on a single **Generating Unit**. Tests are to be carried out at three defined power levels ±5%. At 230 V a 50 kW three phase **Inverter** has a current output of 217 A so DC limit is 543 mA. These tests should be undertaken in accordance with Annex A.7.1.4.4.

The % DC injection ("as % of rated AC current" below) is calculated as follows:

% DC injection = Recorded DC value in Amps / Base current

where the base current is the **Registered Capacity** (W) / V_{phase} *. The % DC injection should not be greater than 0.25%.

HYD 5KTL-3PH			
Test power level	10%	55%	100%
Recorded DC value in Amps	0.031	0.028	0030
as % of rated AC current	0.143	0.131	0.138
Limit [%]	0.25	0.25	0.25
HYD 15KTL-3PH			
Test power level	10%	55%	100%
Recorded DC value in Amps	0.130	0.125	0.116
as % of rated AC current	0.199	0.192	0.178
Limit [%]	0.25	0.25	0.25

Note:

* Calculation is the same for 1 phase and 3 phase devices:

- Base current = Registered Capacity (W) / 230 (V)

- % DC injection = Recorded DC value (A) / Base current (A) *100

6.5 Power Factor

The tests should be carried out on a single **Power Generating Module**. Tests are to be carried out at three voltage levels and at **Registered Capacity** and the measured **Power Factor** must be greater than 0.95 to pass. Voltage to be maintained within ±1.5% of the stated level during the test. These tests should be undertaken in accordance with Annex A.7.1.4.2. Note that the value of voltage stated in brackets assumes a **LV** connection. This should be adjusted for **HV** as required.			
Voltage	0.94 pu (216.2 V)	1 pu (230 V)	1.1 pu (253 V)
Measured value	0.999	0.999	0.998
Power Factor Limit	>0.95	>0.95	>0.95

Note:

See also "*Note"* on Power Factor on p.9.

6.6 Protection

The Interface Protection setting information can be displayed in one or more of the following ways:

☒ A display on a screen which can be read

☐ A display on an electronic device which can communicate with the Power Generating Module and confirm that it is the correct device by means of a Identification number / name permanently fixed to the device and visible on the electronic device screen at the same time as the settings

☐ Display of all settings including nominal voltage and current outputs, alongside the identification number / name of the device, permanently fixed to the Power Generating Module

☐ Other (please specify)

Note:

The protection device considered in this report is the integrated protection relay / generating unit switch in the Power Generating Modules.

Manufacturer Data:

The integrated Interface Protection in the Power Generating Modules considered in this report is capable of measuring voltage to an accuracy of ±1.5% of the nominal value and of measuring frequency to ± 0.2% of the nominal value across its operating range of voltage, frequency and temperature (-30°C ~ +60°C).

(See also subsections 6.6.1 ~ 6.6.5 below)

6.6.1 Protection – Frequency tests

These tests should be carried out in accordance with the Annex A.7.1.2.3. For trip tests, frequency and time delay should be stated. For “no trip tests”, “no trip” can be stated.

Function	Setting		Trip test		“No trip tests”	
	Frequency	Time delay	Frequency	Time delay	Frequency / time	Confirm no trip
U/F stage 1	47.5 Hz	20 s	47.50 Hz	20.060 s	47.7 Hz 30 s	No trip occurred
U/F stage 2	47 Hz	0.5 s	47.00 Hz	0.546 s	47.2 Hz 19.5 s	No trip occurred
					46.8 Hz 0.45 s	No trip occurred
O/F	52 Hz	0.5 s	51.99 Hz	0.536 s	51.8 Hz 120.0 s	No trip occurred
					52.2 Hz 0.45 s	No trip occurred

Note:

for frequency trip tests the frequency required to trip is the setting ± 0.1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0.2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

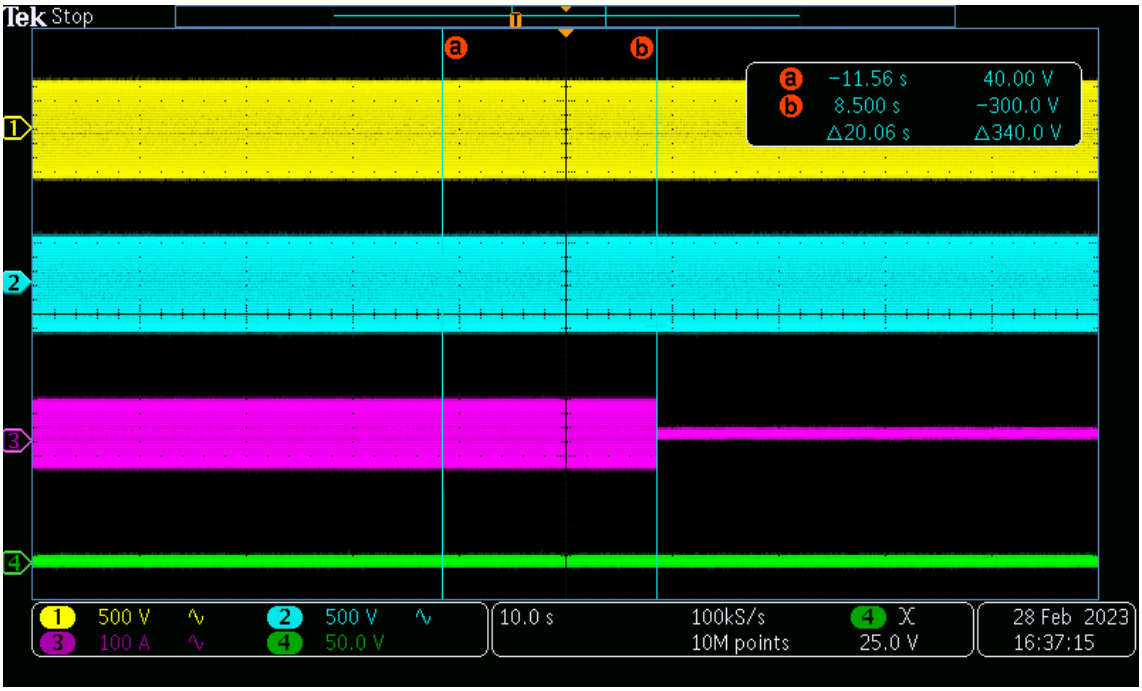


Figure 6 – Test U/F stage 1 (Trip test)

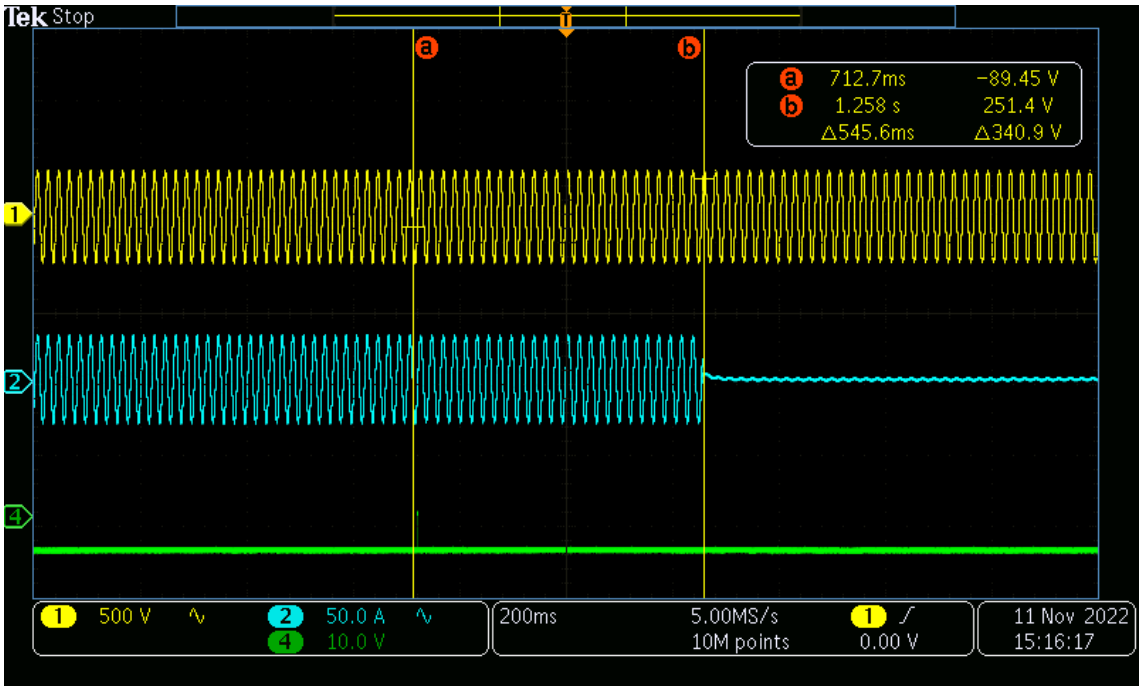


Figure 7 – Test U/F stage 2 (Trip test)

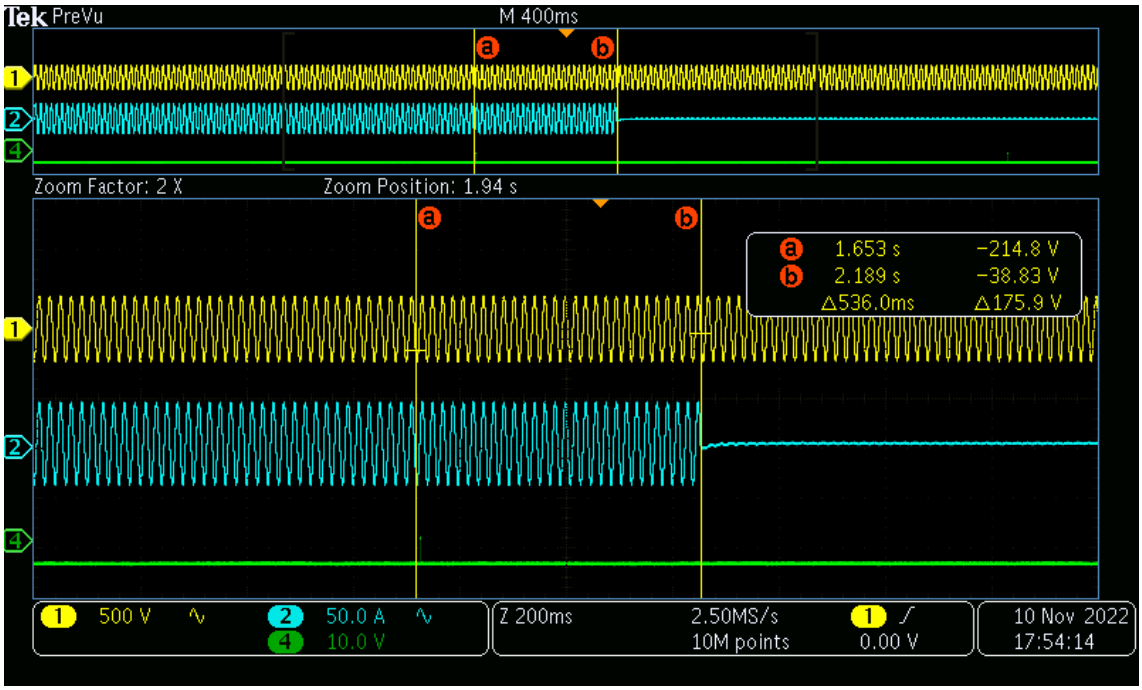


Figure 8 – Test OF (Trip test)

6.6.2 Protection – Voltage tests

These tests should be carried out in accordance with Annex A.7.1.2.2. For trip tests, voltage and time delay should be stated. For “no trip tests”, “no trip” can be stated.

Note that the value of voltage stated below assumes a **LV** connection This should be adjusted for **HV** taking account of the VT ratio as required.

Function		Setting		Trip test		“No trip tests”	
		Voltage	Time delay	Voltage	Time delay	Voltage / time	Confirm no trip
U/V	L1-N	0.8 pu (184 V)	2.5 s	183.52 V	2.534 s	188 V 5.0 s	No trip occurred
	L2-N			182.17 V	2.514 s		No trip occurred
	L3-N			183.14 V	2.525 s		No trip occurred
						180 V 2.45 s	No trip occurred
O/V stage 1	L1-N	1.14 pu (262.2 V)	1.0 s	262.32 V	1.030 s	258.2 V 5.0 s	No trip occurred
	L2-N			262.43 V	1.026 s		No trip occurred
	L3-N			262.29 V	1.026 s		No trip occurred
O/V stage 2	L1-N	1.19 pu (273.7 V)	0.5 s	273.56 V	0.527 s	269.7 V 0.95 s	No trip occurred
	L2-N			273.51 V	0.519 s		No trip occurred
	L3-N			273.64 V	0.515 s		No trip occurred
						277.7 V 0.45 s	No trip occurred

Note:

for voltage tests the Voltage required to trip is the setting ±3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±4 V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

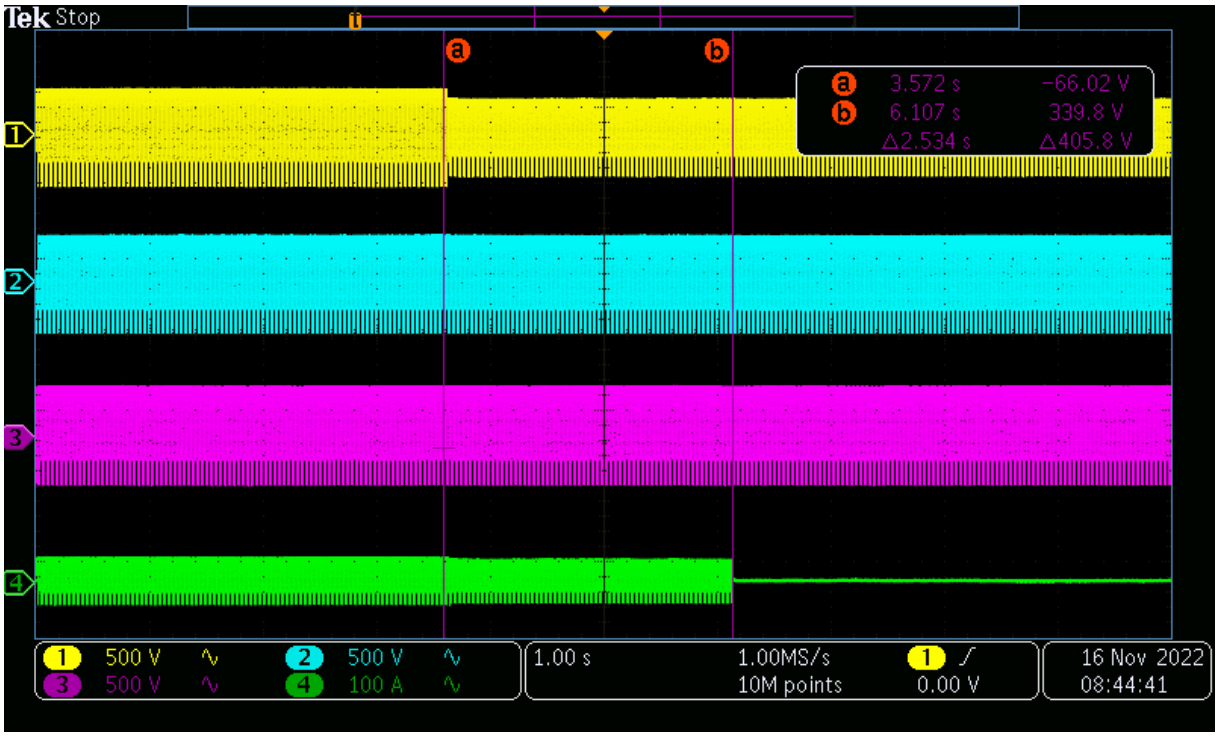


Figure 9 – Test U/V (Trip test, L1-N)

Figure 10 – Test U/V (Trip test, L2-N)

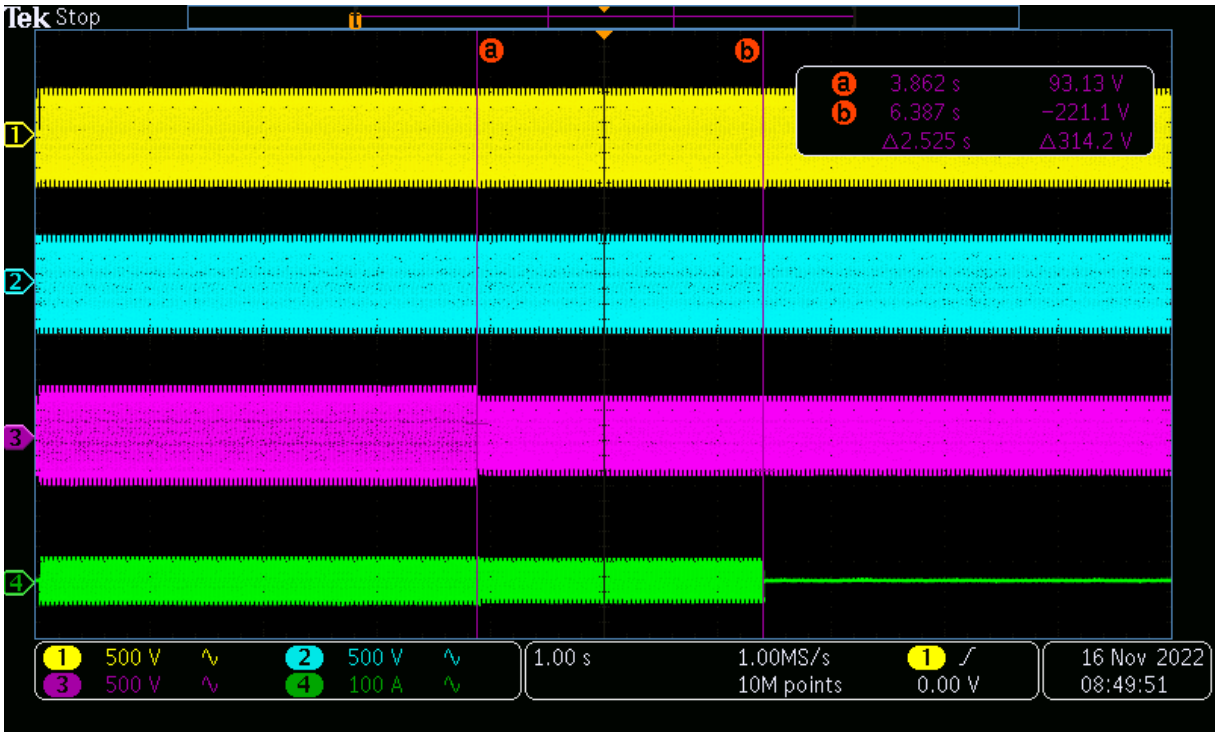


Figure 11 – Test U/V (Trip test, L3-N)

Figure 12 – Test O/V stage 1 (Trip test, L1-N)

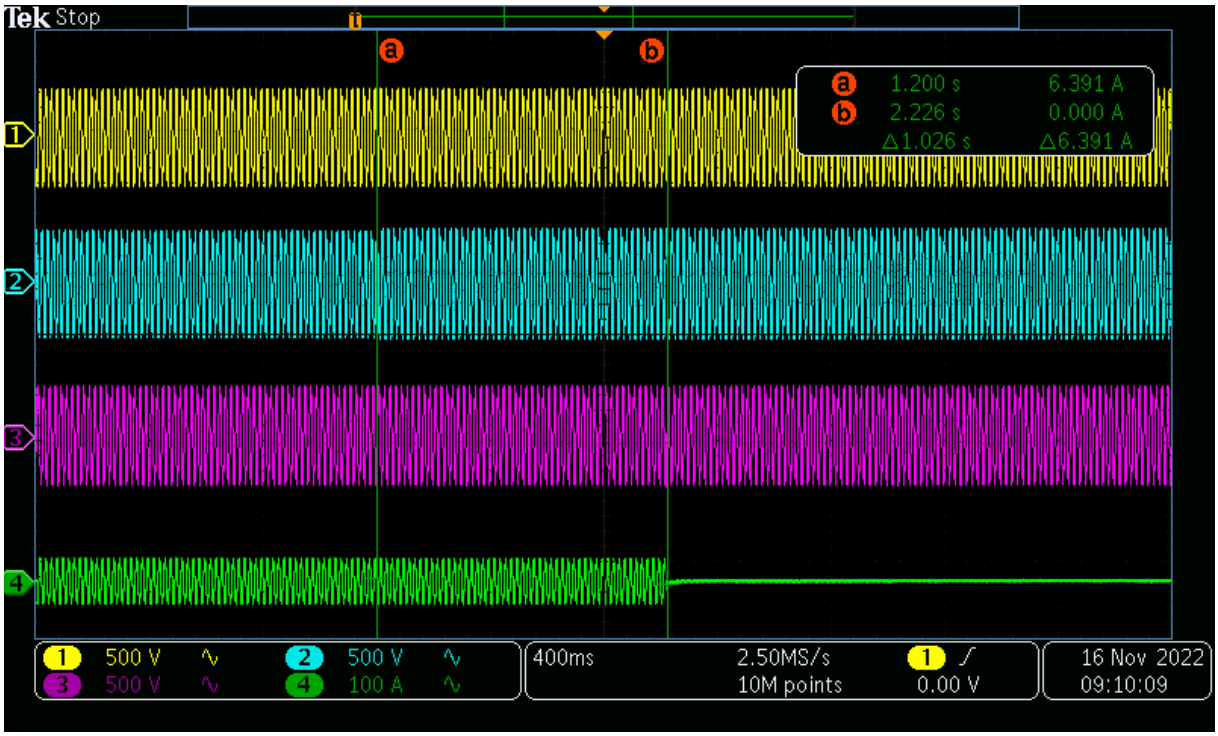


Figure 13 – Test O/V stage 1 (Trip test, L2-N)

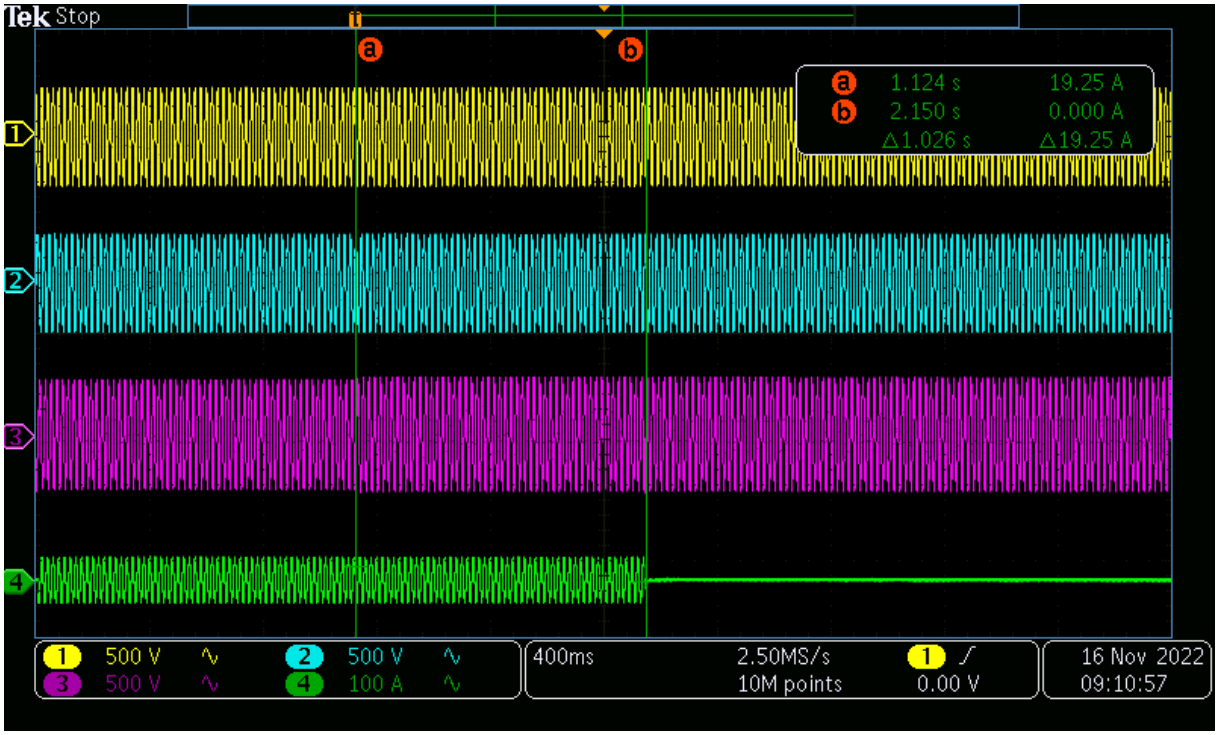


Figure 14 – Test O/V stage 1 (Trip test, L3-N)

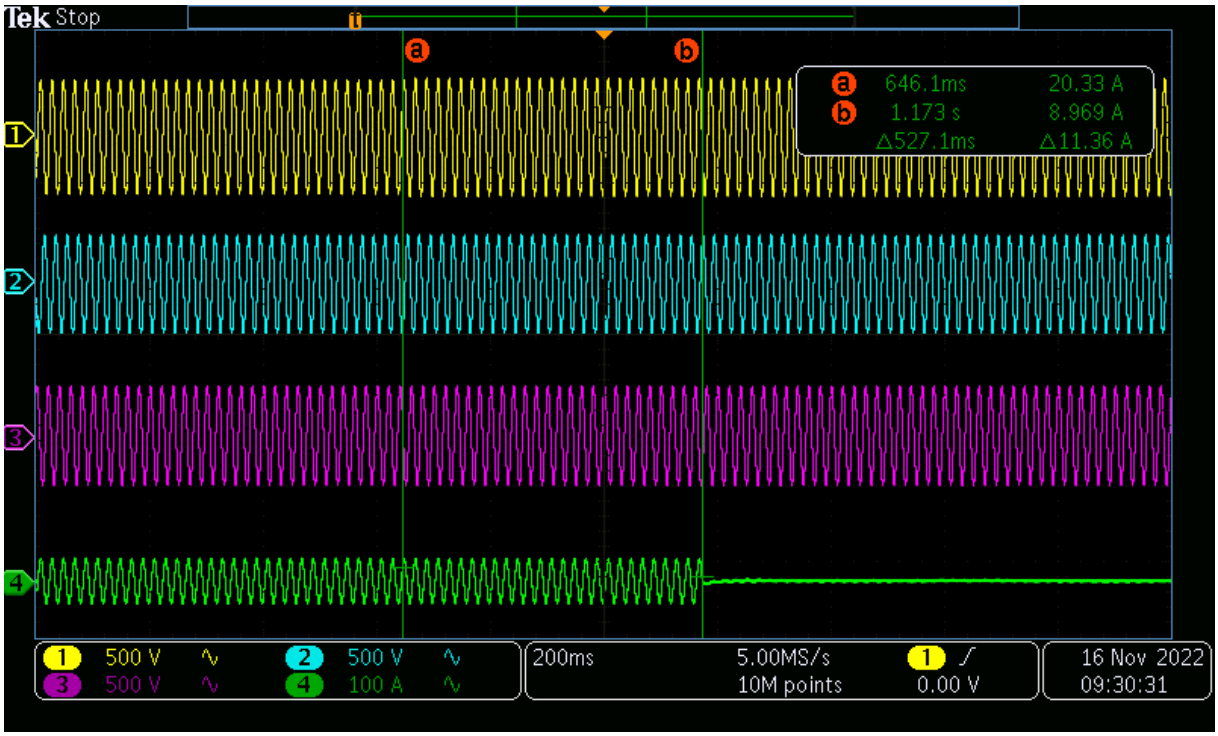


Figure 15 – Test O/V stage 2 (Trip test, L1-N)

Figure 16 – Test O/V stage 2 (Trip test, L2-N)

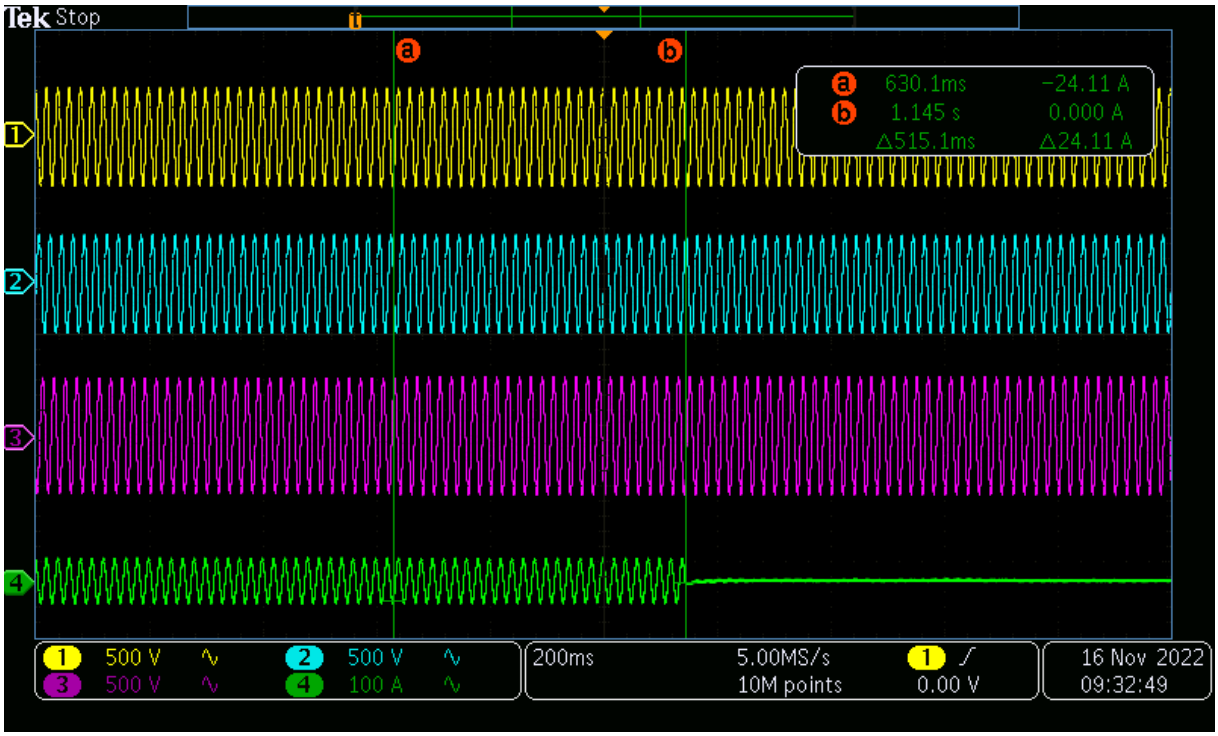


Figure 17 – Test O/V stage 2 (Trip test, L3-N)

6.6.3 Protection – Loss of Mains test

These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4.						
The following sub set of tests should be recorded in the following table.						
Test Power and imbalance	33% -5%Q (Test 22)	66% -5%Q (Test 12)	100% -5%P (Test 5)	33% +5%Q (Test 31)	66% +5%Q (Test 21)	100% +5%P (Test 10)
Trip time [s]	0.317	0.263	0.219	0.199	0.327	0.315
Trip time limit [s]	0.5 [10]					
Note: For full testing according to BS EN 62116 see *Annex 1 - Loss of Mains test according to BS EN 62116*.						

6.6.4 Loss of Mains Protection, Vector Shift Stability test

This test should be carried out in accordance with Annex A.7.1.2.6. Confirmation is required that the **Power Generating Module** does not trip under positive / negative vector shift.			
The following sub set of tests should be recorded in the following table.			
	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.5 Hz	+50 degrees	No trip occurred
Negative Vector Shift	50.5 Hz	- 50 degrees	No trip occurred

[10] If the device requires additional shut down time (beyond 0.5 s but less than 1 s) then this should be stated on this form.

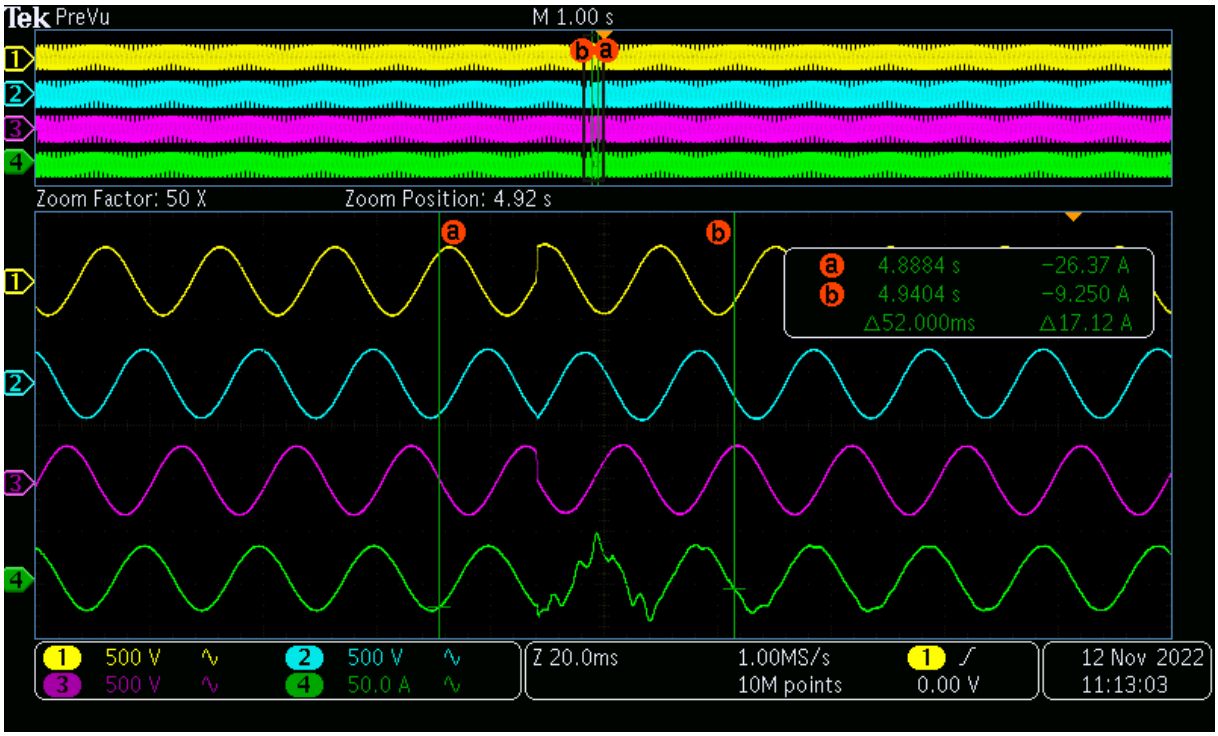


Figure 18 – Positive Step Change (+50 degrees)

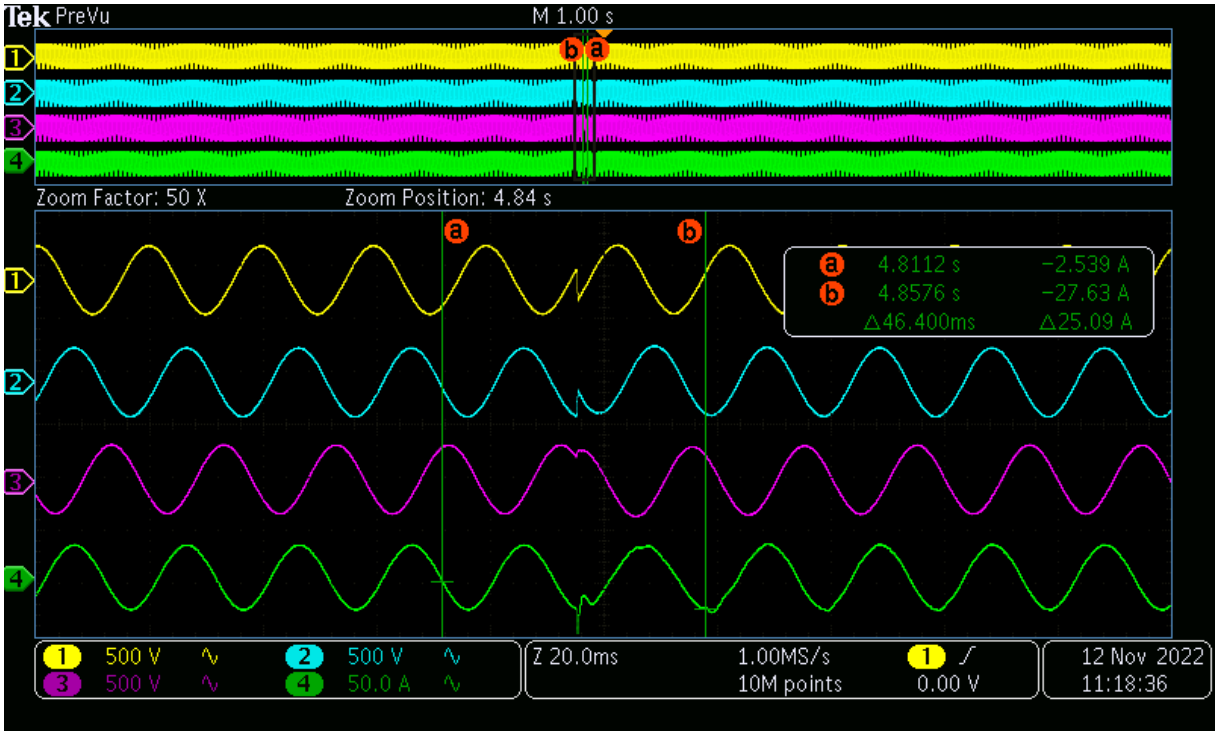


Figure 19 – Negative Step Change (-50 degrees)

6.6.5 Loss of Mains Protection, RoCoF Stability test

This test should be carried out in accordance with Annex A.7.1.2.6. Confirmation is required that the **Power Generating Module** does not trip for the duration of the ramp up and ramp down test.			
The following sub set of tests should be recorded in the following table.			
Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0 Hz to 51.0 Hz	+0.95 Hz/s	2.1 s	No trip occurred
51.0 Hz to 49.0 Hz	-0.95 Hz/s	2.1 s	No trip occurred
Note: During the test, the LFSM-O function was deactivated.			

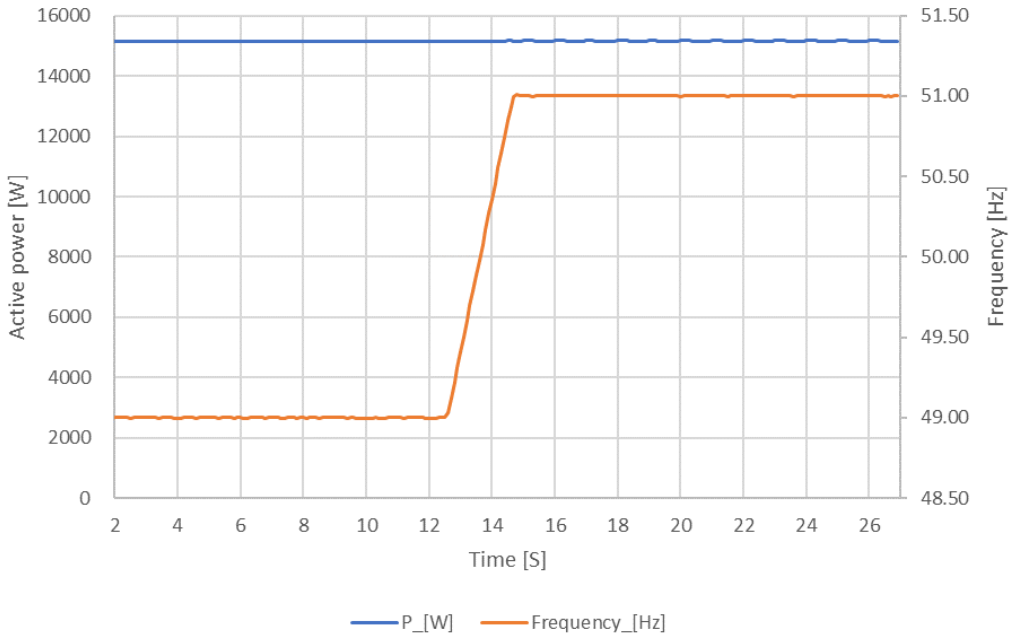


Figure 20 – Positive Frequency Drift (+0.95 Hz/s)

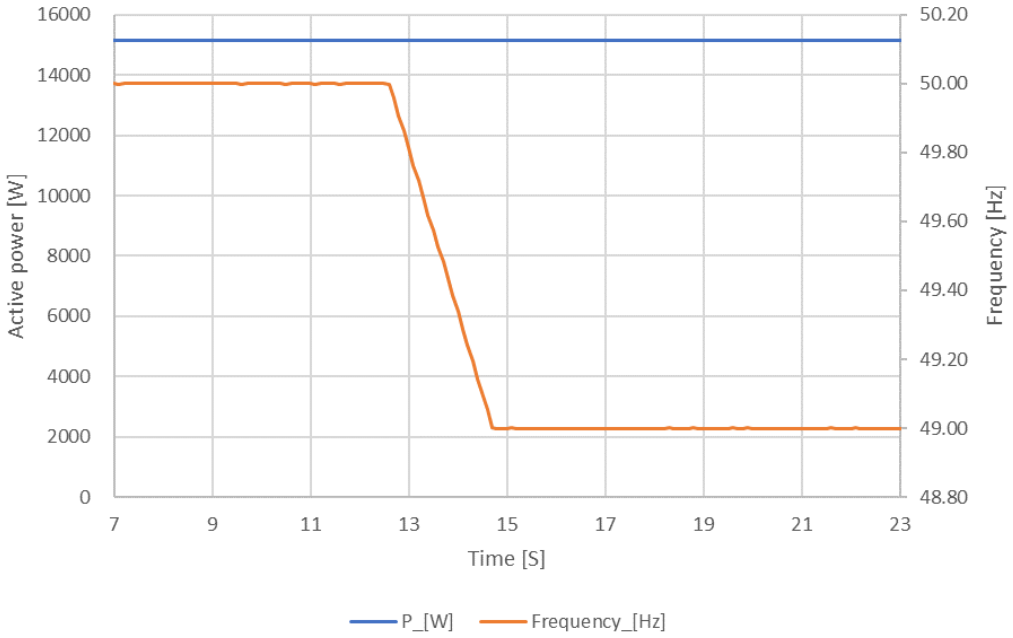


Figure 21 – Negative Frequency Drift (-0.95 Hz/s)

6.7 Limited Frequency Sensitive Mode – Overfrequency test

The test should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10%. This test should be carried out in accordance with Annex A.7.1.3, which also contains the measurement tolerances.				
Active Power response to rising frequency/time plots are attached if frequency injection tests are undertaken in accordance with Annex A.7.2.4.				**N** *
Alternatively, test results should be noted below:				
Test sequence at **Registered Capacity** >80%	Measured **Active Power** Output [W]	Frequency [Hz]	Primary Power Source [W]	**Active Power** Gradient Droop
Step a) 50.00Hz ± 0.01Hz	15004	50.00	15500	---
Step b) 50.45Hz ± 0.05Hz	14838	50.45		9.04% 1)
Step c) 50.70Hz ± 0.10Hz	14055	50.70		9.58% 2)
Step d) 51.15Hz ± 0.05Hz	12636	51.15		9.51% 3)
Step e) 50.70Hz ± 0.10Hz	14055	50.70		9.51% 4)
Step f) 50.45Hz ± 0.05Hz	14838	50.45		9.58% 5)
Step g) 50.00Hz ± 0.01Hz	15005	50.00		---
	1st Droop (calculated using frequency and power between steps d) & b))			9.54%
	2nd Droop (calculated using frequency and power between steps f) & d))			9.54%
Test sequence at **Registered Capacity** 40% - 60%	Measured **Active Power** Output [W]	Frequency [Hz]	Primary Power Source [W]	**Active Power** Gradient Droop
Step a) 50.00Hz ± 0.01Hz	7501	50.00	7800	---
Step b) 50.45Hz ± 0.05Hz	7361	50.45		10.71% 1)
Step c) 50.70Hz ± 0.10Hz	6576	50.70		9.55% 2)
Step d) 51.15Hz ± 0.05Hz	5159	51.15		9.53% 3)
Step e) 50.70Hz ± 0.10Hz	6576	50.70		9.53% 4)
Step f) 50.45Hz ± 0.05Hz	7361	50.45		9.55% 5)
Step g) 50.00Hz ± 0.01Hz	7501	50.00		---
	1st Droop (calculated using frequency and power between steps d) & b))			9.54%
	2nd Droop (calculated using frequency and power between steps f) & d))			9.54%

Note:

* Test according to Annex A.7.1.3. Frequency/time plots attached (see Figure 22 & Figure 23)

1) Droop calculated using frequency and power between steps b) & threshold frequency of 50.4 Hz

2) Droop calculated using frequency and power between steps c) & b)

3) Droop calculated using frequency and power between steps d) & c)

4) Droop calculated using frequency and power between steps e) & d)

5) Droop calculated using frequency and power between steps f) & e)

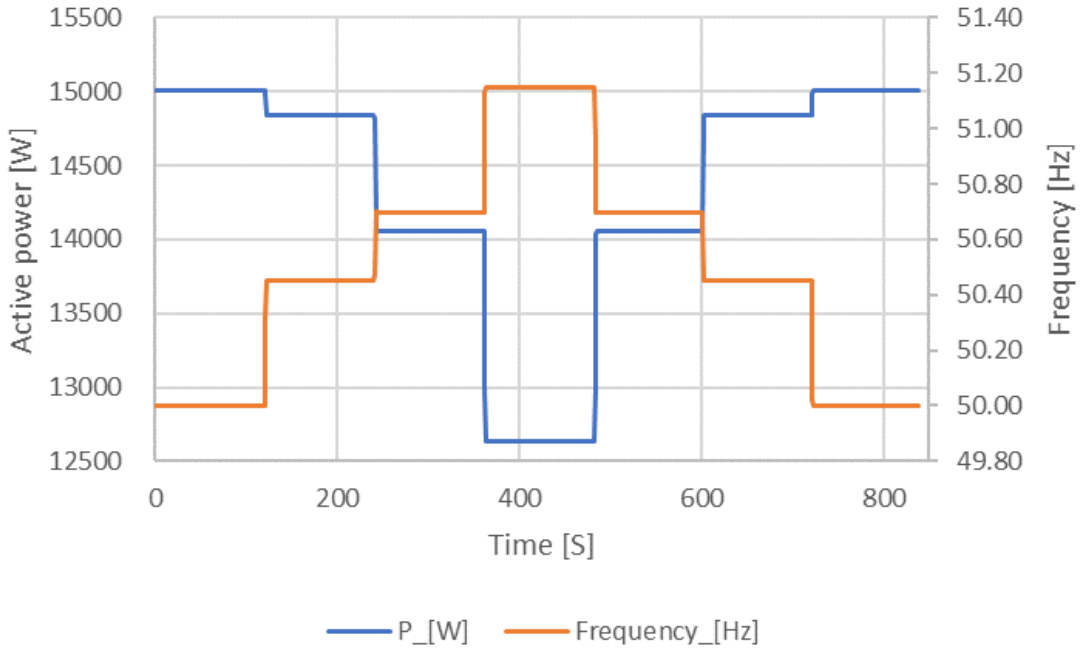


Figure 22 – Test sequence at Registered Capacity >80%

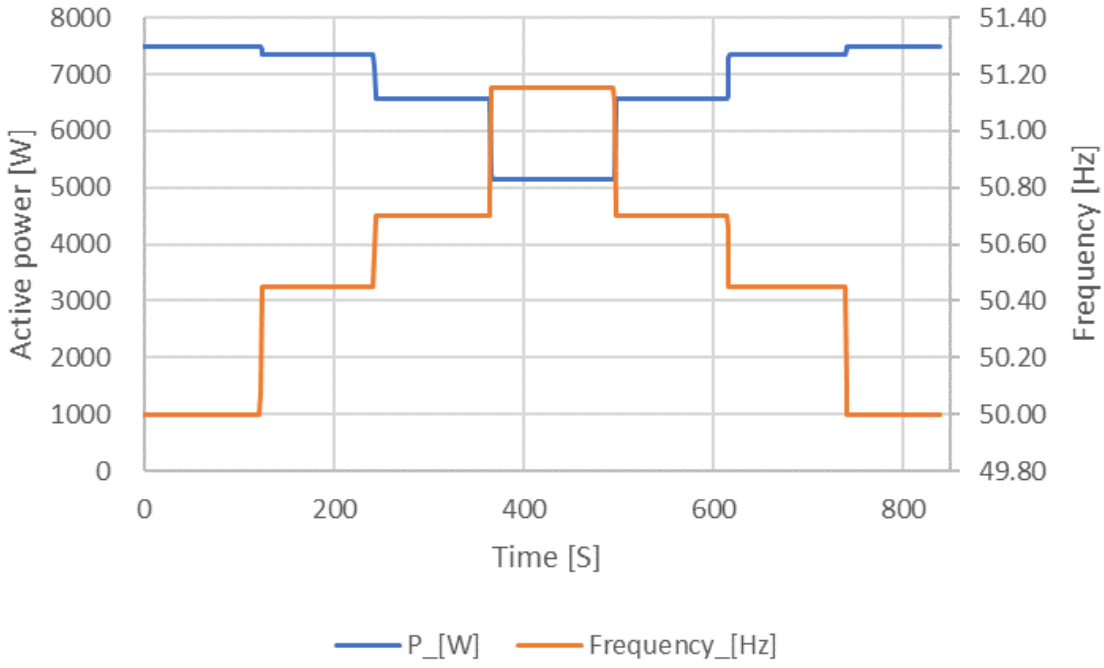


Figure 23 – Test sequence at Registered Capacity 40% - 60%

6.8 Protection – Re-connection timer

Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 10.1. Both the time delay setting and the measured delay should be provided in this form; both should be greater than 20 s to pass. Confirmation should be provided that the **Power Generating Module** does not reconnect at the voltage and frequency settings below; a statement of "no reconnection" can be made.					
Time delay setting	Measured delay	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of Table 10.1.			
60 s	79 s	At 1.16 pu (266.2 V **LV** connection)	At 0.78 pu (180.0 V **LV** connection)	At 47.4 Hz	At 52.1 Hz
Confirmation that the **Power Generating Module** does not re-connect.		No reconnection occurred	No reconnection occurred	No reconnection occurred	No reconnection occurred

6.9 Fault level contribution

These tests shall be carried out in accordance with EREC G99 Annex A.7.1.5. Please complete each entry, even if the contribution to the fault level is zero.		
For **Inverter** output		
Time after fault	Volts	Amps
20ms	L1: 12.0 L2: 11.0 L3: 6.0	L1: 28.7 L2: 29.6 L3: 23.5
100ms	L1: 6.0 L2: 6.0 L3: 6.0	L1: 1.3 L2: 1.2 L3: 1.5
250ms	L1: 5.0 L2: 5.0 L3: 6.0	L1: 1.0 L2: 1.3 L3: 1.5
500ms	L1: 7.0 L2: 5.0 L3: 7.0	L1: 0.9 L2: 1.5 L3: 1.2
Time to trip	0,054	In seconds

6.10 Self-Monitoring solid state switching

No specified test requirements. Refer to Annex A.7.1.6.	
It has been verified that in the event of the solid-state switching device failing to disconnect the **Power Park Module**, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 s.	NA
Note: The PGU used electromechanical relay to disconnect from the grid. No solid-state switching device available.	

6.11 Wiring functional tests

If required by para 15.2.1.	
Confirm that the relevant test schedule is attached (tests to be undertaken at time of commissioning)	NA
Note: Tests carried out in laboratory, specifically designed plugs and sockets used.	

6.12 Logic interface (input port)

Confirm that an input port is provided and can be used to shut down the module	Yes
Provide high level description of logic interface, e.g. details in 11.1.3.1 such as AC or DC signal (the additional comments box below can be used)	Yes
Note: For details see “Additional comments.” Below.	

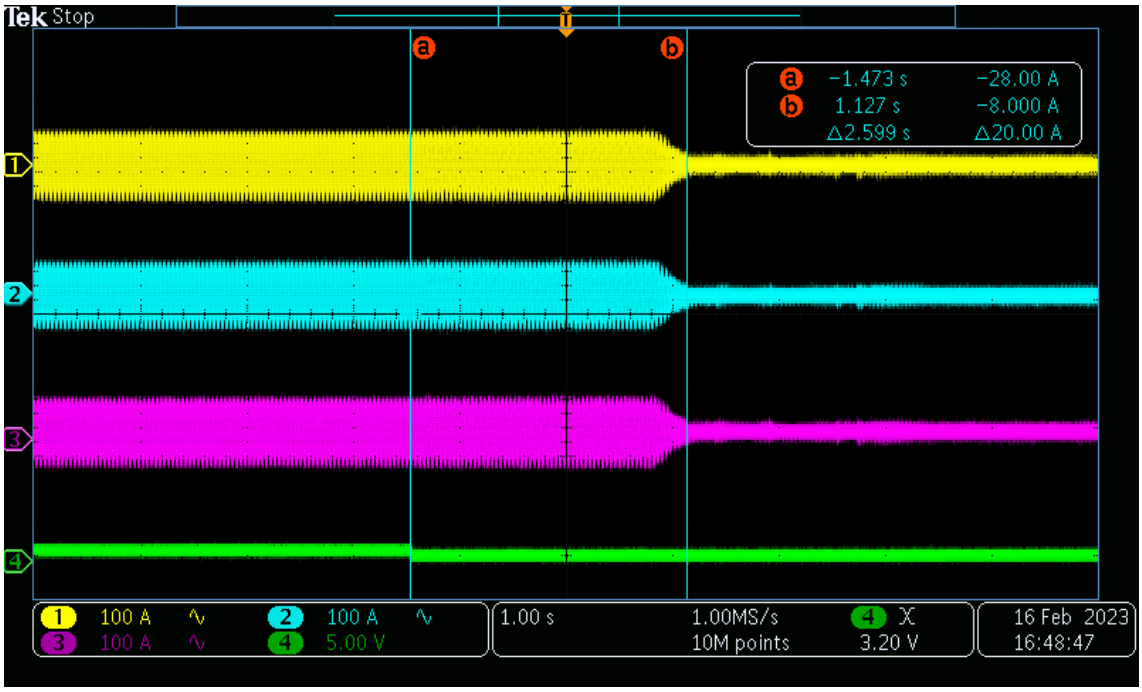
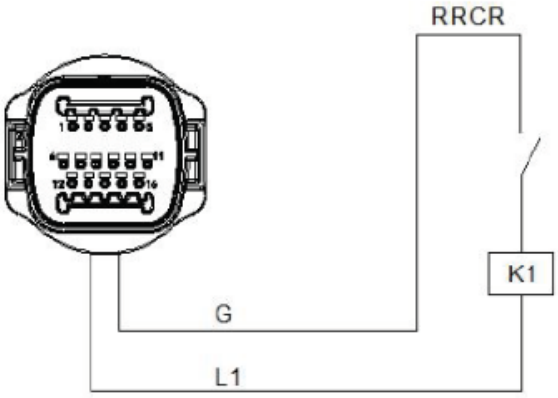


Figure 24 – Test ceasing active power output using logic interface

6.13 Cyber security

Confirm that the **Power Generating Module** has been designed to comply with cyber security requirements, as detailed in 9.1.7.	Yes. Manufacturer's declaration provided. See *Annex 2 - Manufacturer's declaration regarding Cyber Security*.

Additional comments.
High level description of logic interface: The PGU equipped with a logic interface for ceasing active power output within 5 s following an instruction being received. The following is a possible configuration (if another configuration is required, this can be agreed with the manufacturer):



where RRCR = Radio Ripple Control Receiver.

The signal from the Power Generating Module that is being switched can be either AC (maximum value 240 V) or DC (maximum value 110 V)

Function description of the terminal:

Pin NO.	Pin name	Description	Connected to (RRCR)
1	L1	Relay contact 1 input	K1 - Relay 1 output
2	NC	Not Connected	Not Connected
3	NC	Not Connected	Not Connected
4	NC	Not Connected	Not Connected
5	G	GND	K1 - Relay 1 output
6	NC	Not Connected	Not Connected
7	NC	Not Connected	Not Connected
8	NC	Not Connected	Not Connected

Relay status: close is 1, open is 0

L1	Active Power	Power drop rate	Cos(φ)
1	0%	＜5 seconds	1
0	100%	/	1

Annex 1 - Loss of Mains test according to BS EN 62116

No.	P_{EUT} [a] (% of EUT rating)	Reactive load (% of Q_L in 6.1d)1))	P_{AC} [b] (% of nominal)	Q_{AC} [c] (% of nominal)	Run on time (ms)	P_{EUT} (W)	Actual Q_f	V_{DC}	Remarks [d]
1	100	100	0	0	351	15012	1.000	873.2	Test A at BL
2	66	66	0	0	357	9901	1.000	623.9	Test B at BL
3	33	33	0	0	389	4950	1.000	358.3	Test C at BL
4	100	100	-5	-5	283	14253	1.080	876.4	Test A at IB
5	100	100	-5	0	219	14263	1.053	873.4	Test A at IB
6	100	100	-5	+5	275	14293	1.024	871.1	Test A at IB
7	100	100	0	-5	195	15022	1.024	873.6	Test A at IB
8	100	100	0	+5	231	15010	0.975	875.0	Test A at IB
9	100	100	+5	-5	227	15765	0.976	872.5	Test A at IB
10	100	100	+5	0	315	15765	0.953	873.7	Test A at IB
11	100	100	+5	+5	311	15752	0.929	871.8	Test A at IB
12	66	66	0	-5	263	9906	1.025	625.3	Test B at IB
13	66	66	0	-4	355	9895	1.021	626.3	Test B at IB
14	66	66	0	-3	355	9928	1.012	622.8	Test B at IB
15	66	66	0	-2	339	9931	1.008	622.5	Test B at IB
16	66	66	0	-1	303	9921	1.003	623.6	Test B at IB
17	66	66	0	1	287	9903	0.995	624.6	Test B at IB
18	66	66	0	2	211	9898	0.991	623.4	Test B at IB
19	66	66	0	3	301	9985	0.991	621.0	Test B at IB
20	66	66	0	4	345	9913	0.979	623.0	Test B at IB
21	66	66	0	5	327	9918	0.974	616.0	Test B at IB
22	33	33	0	-5	317	4951	1.024	360.9	Test B at IB
23	33	33	0	-4	385	4955	1.018	360.7	Test B at IB
24	33	33	0	-3	375	4963	1.013	360.7	Test B at IB
25	33	33	0	-2	251	4961	1.008	359.4	Test B at IB
26	33	33	0	-1	291	4955	1.003	358.2	Test B at IB
27	33	33	0	1	213	4948	0.996	359.6	Test B at IB
28	33	33	0	2	193	4961	0.988	357.3	Test B at IB
29	33	33	0	3	245	4953	0.984	361.8	Test B at IB
30	33	33	0	4	371	4945	0.980	359.3	Test B at IB
31	33	33	0	5	199	4943	0.976	359.6	Test B at IB

[a] P_{EUT}: EUT output power.

[b] P_{AC}: Active power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

[c] Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

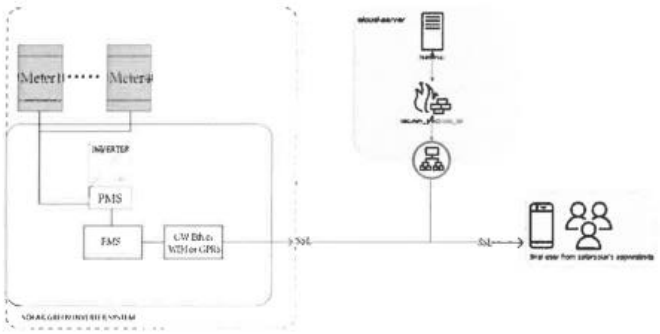
[d] BL: balance condition, IB: imbalance condition.

Annex 2 - Manufacturer's declaration regarding Cyber Security

SOFAR SOLAR

Shenzhen SOFARSOLAR Co., Ltd.
11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district, Bao'an District, Shenzhen City, China

1) The Sofar Solar Inverter include a system of internal and external logic communications as summarized in the following scheme:



where the main components involved and their main functions are explained in the following table:

acronym/ name	*meaning*	*function*	*location*
PMS	Power Management System	monitoring and management of power fluxes through the inverter, execution of EMS's commands or local logic functions depending on grid parameters values. Note: The PMS performs operational safety functions aimed at prevent physical damage/harm, typically by interrupting currents and/or opening contacts on some inverter ports when voltage, current or temperature limits are violated; no safety operation performed by PMS can be compromised/skypped by commands/signals originating outside the inverter.	inverter
EMS	Energy Management System	monitoring of all field's measures, calculus of power and currents for every component of the system, reception of external commands, transmission of commands to PMS. Note: No operational safety function aimed at preventing physical damage/harm is performed by the EMS; no operation performed by EMS can force the operational safety functions performed by PMS and electrical protections.	monitor board

GW	Gate-Way	transmission of data to cloud server, reception of commands/settings from external stakeholder.	Collector
Meter	External Power Meter(s) (one to four)	*included in the supply*: meter at the PCC, and possible meter at AC port of third party generator/inverter, for power measures	PCC; third party inverter

2）All communications between internal components of the Sofar solar Inverter, and between EMS and supplied External Power Meter(s), take place via appropriate serial lines (RS485, SCI) and are not directly connected to any device or system outside the Sofar solar Inverter.

3）The only communication port between the device and the outside is constituted by the Gate-Way layer of a logic board on the machine, the communication between Sofar solar Inverter and the outside world can take place via RS485 line, WiFi to the customer's request.

4）The direct recipients/senders of communications with the Sofar solar Inverter is the in-cloud server of Sofar Green Inverter - the communication is made secure by the use of TSL(Transport Layer Security) technology on collector, and by the use of SSL(Secure Sockets Layer) technology on Final User's device side and Installer/Sofar service web-tools side.

5）All communications between the in-cloud server and the subjects/parties are cyber-protected by SSL technology.

6）The cyber-security assessment of the Sofar Green Inverter was performed according to the ETSI EN 303 645 standard, and it is reported according to the Table B.1 form of the same standard:

EN 303 645 v2.1.1 (2020-06) Table B.1: Implementation of provisions for consumer IoT security			
Clause number and title			
Reference	Status	Support	Detail
5.1 No universal default passwords			
Provision 5.1-1	M C (1)	N/A	Device do not permit final user's login.
Provision 5.1-2	M C (2)	N/A	
Provision 5.1-3	M	N/A	
Provision 5.1-4	M C (8)	N/A	
Provision 5.1-5	M C (5)	N/A	
5.2 Implement a means to manage reports of vulnerabilities			
Provision 5.2-1	M	Y	
Provision 5.2-2	R	Y	
Provision 5.2-3	R	Y	
5.3 Keep software updated			
Provision 5.3-1	R	Y	
Provision 5.3-2	M C (5)	Y	
Provision 5.3-3	M C (12)	Y	

Provision 5.3-4	R C (12)	Y	
Provision 5.3-5	R C (12)	N	The manufacturer manages the updates of the systems by means of remote automatisms, selectively by type of machine or by activating special functions at the request of the user
Provision 5.3-6	R C (9, 12)	N	
Provision 5.3-7	M C (12)	Y	
Provision 5.3-8	M C (12)	Y	
Provision 5.3-9	R C (12)	N	See note at 5.3-5
Provision 5.3-10	M (11, 12)	Y	
Provision 5.3-11	R C (12)	Y	
Provision 5.3-12	R C (12)	N	The device failed to notify the user
Provision 5.3-13	M	Y	
Provision 5.3-14	R C (3, 4)	Y	
Provision 5.3-15	R C (3, 4)	N	
Provision 5.3-16	M	Y	
5.4 Securely store sensitive security parameters			
Provision 5.4-1	M	Y	
Provision 5.4-2	M C (10)	Y	
Provision 5.4-3	M	N/A	Hard-coded identity not used in source code
Provision 5.4-4	M	N	No unique key parameters are provided for the device
5.5 Communicate securely			
Provision 5.5-1	M	Y	
Provision 5.5-2	R	N	
Provision 5.5-3	R	N	
Provision 5.5-4	R	Y	
Provision 5.5-5	M	Y	
Provision 5.5-6	R	Y	
Provision 5.5-7	M	Y	
Provision 5.5-8	M	Y	
5.6 Minimize exposed attack surfaces			
Provision 5.6-1	M	Y	

SOFAR SOLAR

Provision 5.6-2	M	Y	
Provision 5.6-3	R	Y	
Provision 5.6-4	M C (13)	N/A	No debug interface accessible
Provision 5.6-5	R	Y	
Provision 5.6-6	R	Y	
Provision 5.6-7	R	Y	
Provision 5.6-8	R	N	The device don't have the access control mechanism
Provision 5.6-9	R	Y	
5.7 Ensure software integrity			
Provision 5.7-1	R	N	The device don't have the hardware root of trust
Provision 5.7-2	R	N	The device don't have the ability to be in administration mode
5.8 Ensure that personal data is secure			
Provision 5.8-1	R	N/A	No personal data transit through the device
Provision 5.8-2	M	Y	
Provision 5.8-3	M	Y	
5.9 Make systems resilient to outages			
Provision 5.9-1	R	Y	
Provision 5.9-2	R	Y	
Provision 5.9-3	R	Y	
5.10 Examine system telemetry data			
Provision 5.10-1	R C (6)	Y	
5.11 Make it easy for users to delete user data			
Provision 5.11-1	M	N/A	No user/personal data are stored in the device
Provision 5.11-2	R	N/A	
Provision 5.11-3	R	N/A	
Provision 5.11-4	R	N/A	
5.12 Make installation and maintenance of devices easy			
Provision 5.12-1	R	Y	
Provision 5.12-2	R	Y	
Provision 5.12-3	R	Y	
5.13 Validate input data			
Provision 5.13-1	M	Y	
6 Data protection provisions for consumer IoT			
Provision 6.1	M	N/A	No user/personal data are stored in the device
Provision 6.2	M C (7)	N/A	
Provision 6.3	M	N/A	
Provision 6.4	R C (6)	N/A	
Provision 6.5	M C (6)	N/A	

Conditions:

SOFAR SOLAR

1) passwords are used; 2) pre-installed passwords are used; 3) software components are not updateable; 4) the device is constrained; 5) the device is not constrained; 6) telemetry data being collected; 7) personal data is processed on the basis of consumers' consent; 8) the device allowing user authentication; 9) the device supports automatic updates and/or update notifications; 10) a hard-coded unique per device identity is used for security purposes; 11) updates are delivered over a network interface; 12) an update mechanism is implemented; 13) a debug interface is physically accessible.

Status' Column:	
M	Mandatory provision
R	Recommended provision
M C	Mandatory and conditional provision
R C	Recommended and conditional provision

Support' Column:	
Y	Implemented
N	Not implemented
N/A	Not applicable

Date:2022-08-08

Name: Feng Feng

Title: Product manager

Manufacture Seal

Annex 3 - CE declaration

SOFAR

Shenzhen SOFARSOLAR Co., Ltd.

Add: 11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district,Bao'an District,Shenzhen City,China

Tel: 15915311181

Email: wanghui@sofarsolar.com

EU Declaration of Conformity

Product: Hybrid Inverter

Product modelis as follows:

- HYD 5KTL-3PH
- HYD 6KTL-3PH
- HYD 8KTL-3PH
- HYD 10KTL-3PH
- HYD 10KTL-3PH-A
- HYD 15KTL-3PH
- HYD 20KTL-3PH

Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.

Address: 11/F., Gaoxinqi Technology Building, No.67 Area, Xingdong Community, Xin'an Sub-district,Bao'an District,Shenzhen City,China

This declaration of conformity is issued under the sole responsibility of the manufacturer. In addition, the product is within the manufacturer's warranty period.

CE

The object of the declaration described above is in conformity with the relevant Union harmonisation legislation: The Low Voltage Directive (LVD)

2014/35/EU and the Electromagnetic Compatibility (EMC) Directive 2014/30/EU.

References to the relevant harmonized standards used or references to the other technical

SOFAR

specifications in relation to which conformity is declared

LVD:	
IEC/EN 62109-1:2010	•
IEC/EN 62109-2:2011	•
EMC:	
EN IEC 61000-6-3:2021	•
EN IEC 61000-6-1:2019	•

Date: 2023-02-01

Name: 王辉 (Wang Hui)

Charge: General Standards

And Certification Manager

Signature:

Manufacture Seal

Annex 4 - Proof of conformity of the integrated protection relay

Note:
The full version of the attached document is available at the laboratory for reference.

Zertifikat *Certificate*

TÜVRheinland®

Zertifikat Nr. *Certificate No.*
R 50475730

Blatt *Sheet*
0001

Ihr Zeichen *Client Reference*	Unser Zeichen *Our Reference*	Ausstellungsdatum	*Date of Issue*
H.S.J	01-SDW-50399690 001	04.08.2020	*(day/mo/yr)*

Genehmigungsinhaber *License Holder*
Xiamen Hongfa Electroacoustic
Co., Ltd.
No. 91-101, Sunban South Rd.
Jimei North Ind. District
Xiamen
361021 Fujian
P.R. China

Fertigungsstätte *Manufacturing Plant*
Refer to latest revision
of the annex list of factories

Prüfzeichen *Test Mark*

TÜVRheinland® CERTIFIED
Type Approved
Safety
Regular Production
Surveillance
www.tuv.com
ID 1111227159

Geprüft nach *Tested acc. to*
EN 61810-1:2015
IEC 61810-1:2015

Zertifiziertes Produkt (Geräteidentifikation) *Certified Product (Product Identification)*

Lizenzentgelte - Einheit *License Fee - Unit*

Relay (Electromechanical Elementary Relays)

Type Designation	: HF161F-40 xHsTFf	5
	x,s,f = See appendix 1 (HF)	3
Rated Coil Voltage	: DC 5V; 12V; 24V or 48V	
Rated Coil Power	: 0,9W	
Ambient Temperature	: -40°C to +85°C	
Rated Contact Voltage	: 1)2)277VAC; 3)24VDC	
Rated Contact Current	: 1)Making 20A (100ms)	
	Loading 40A(800ms)	
	Breaking 20A (100ms)	
	2)40A	
	3)30A*	
Electrical Endurance	: 1)100 000	
	2)3)10 000	
Mechanical Endurance	: 2 000 000	
Type of Interruption	: Micro-Disconnection	
Insulation System between Coil and Contact	: Reinforced Insulation	

Remark:
1) The above overload and endurance test marked * are in accordance with clause G2.1 and G2.2 of IEC 62368-1:2018.
2) Endurance test is tested with opened vent hole.

ANLAGE (Appendix): 1

8

Dem Zertifikat liegt unsere Prüf- und Zertifizierungsordnung zugrunde und es bestätigt die Konformität des Produktes mit den oben genannten Standards und Prüfgrundlagen. Zusätzliche Anforderungen in Ländern, in denen das Produkt in Verkehr gebracht werden soll, müssen zusätzlich betrachtet werden. Die Herstellung des zertifizierten Produktes wird überwacht.
This certificate is based on our Testing and Certification Regulation and states the conformity of the product with the standards and testing requirements as indicated above. Any additional requirements in countries where the product is going to be marketed have to be considered additionally. The manufacturing of the certified product is subject to surveillance.

Zertifizierungsstelle

TÜV Rheinland LGA Products GmbH, Tillystraße 2, 90431 Nürnberg
Tel.: +49 221 806-1371 e-mail: cert-validity@de.tuv.com
Fax: +49 221 806-3935 http://www.tuv.com/safety

Kenny Shi

10/020 d 04.08 TÜV, TUEV and TUV are registered trademarks. Utilisation and application requires prior approval.

Zertifikat *Certificate*

TÜVRheinland®

Zertifikat Nr. *Certificate No.* R 50475730

Blatt *Sheet* 0002

Ihr Zeichen *Client Reference*	Unser Zeichen *Our Reference*	Ausstellungsdatum *Date of Issue* (day/mo/yr)
H.S.J	01-SDW-50399690 001	04.08.2020

Genehmigungsinhaber *License Holder*

Xiamen Hongfa Electroacoustic
Co., Ltd.
No. 91-101, Sunban South Rd.
Jimei North Ind. District
Xiamen
361021 Fujian
P.R. China

Fertigungsstätte *Manufacturing Plant*

Refer to latest revision
of the annex list of factories

Prüfzeichen *Test Mark*

TÜVRheinland CERTIFIED
Type Approved
Safety
Regular Production
Surveillance
www.tuv.com
ID 1111227159

Geprüft nach *Tested acc. to*

EN 61810-1:2015
IEC 61810-1:2015

Zertifiziertes Produkt (Geräteidentifikation) *Certified Product (Product Identification)*

Lizenzentgelte - Einheit *License Fee - Unit*

Relay (Electromechanical Elementary Relays)

as page 0001
Addition

Type Designation	: HF161F-40W xHTFf x,f = See appendix 1 (HF)	2
Rated Coil Voltage	: DC 6V; 9V; 12V or 24V	
Rated Coil Power	: 3,8W	
Ambient Temperature	: -40°C to +105°C	
Rated Contact Voltage	: 277VAC	
Rated Contact Current	: 1)Making 20A (100ms) Loading 40A(800ms) Breaking 20A (100ms) 2)40A 3)43A* 4)Making 10A (100ms) Loading 43A(800ms) Breaking 10A (100ms)	

Continued on page 0003

2

ANLAGE (Appendix): 1,1

Dem Zertifikat liegt unsere Prüf- und Zertifizierungsordnung zugrunde und es bestätigt die Konformität des Produktes mit den oben genannten Standards und Prüfgrundlagen. Zusätzliche Anforderungen in Ländern, in denen das Produkt in Verkehr gebracht werden soll, müssen zusätzlich betrachtet werden. Die Herstellung des zertifizierten Produktes wird überwacht.
This certificate is based on our Testing and Certification Regulation and states the conformity of the product with the standards and testing requirements as indicated above. Any additional requirements in countries where the product is going to be marketed have to be considered additionally. The manufacturing of the certified product is subject to surveillance.

Zertifizierungsstelle

Kenny Shi

TÜV Rheinland LGA Products GmbH, Tillystraße 2, 90431 Nürnberg
Tel.: +49 221 806-1371 e-mail: cert-validity@de.tuv.com
Fax: +49 221 806-3935 http://www.tuv.com/safety

Zertifikat *Certificate*

TÜVRheinland®

Zertifikat Nr. *Certificate No.* R 50475730

Blatt *Sheet* 0003

Ihr Zeichen *Client Reference*	Unser Zeichen *Our Reference*	Ausstellungsdatum	*Date of Issue*
H.S.J	01-SDW-50399690 001	04.08.2020	*(day/mo/yr)*

Genehmigungsinhaber *License Holder*
Xiamen Hongfa Electroacoustic
Co., Ltd.
No. 91-101, Sunban South Rd.
Jimei North Ind. District
Xiamen
361021 Fujian
P.R. China

Fertigungsstätte *Manufacturing Plant*
Refer to latest revision
of the annex list of factories

Prüfzeichen *Test Mark*

TÜVRheinland CERTIFIED
Type Approved
Safety
Regular Production
Surveillance
www.tuv.com
ID 1111227159

Geprüft nach *Tested acc. to*
EN 61810-1:2015
IEC 61810-1:2015

Zertifiziertes Produkt (Geräteidentifikation) *Certified Product (Product Identification)*

Lizenzentgelte - Einheit *License Fee - Unit*

Relay (Electromechanical Elementary Relays)

Continuation from page 0002

Electrical Endurance	:	1)50 000(105°C)
		2)10 000(105°C)
		3)10 000(85°C)
		4)30 000(85°C)
Mechanical Endurance	:	500 000
Type of Interruption	:	Full-Disconnection

Remark:
The above overload and endurance test marked * are in accordance with clause G2.1 and G2.2 of IEC 62368-1:2018.

ANLAGE (Appendix): 1,1

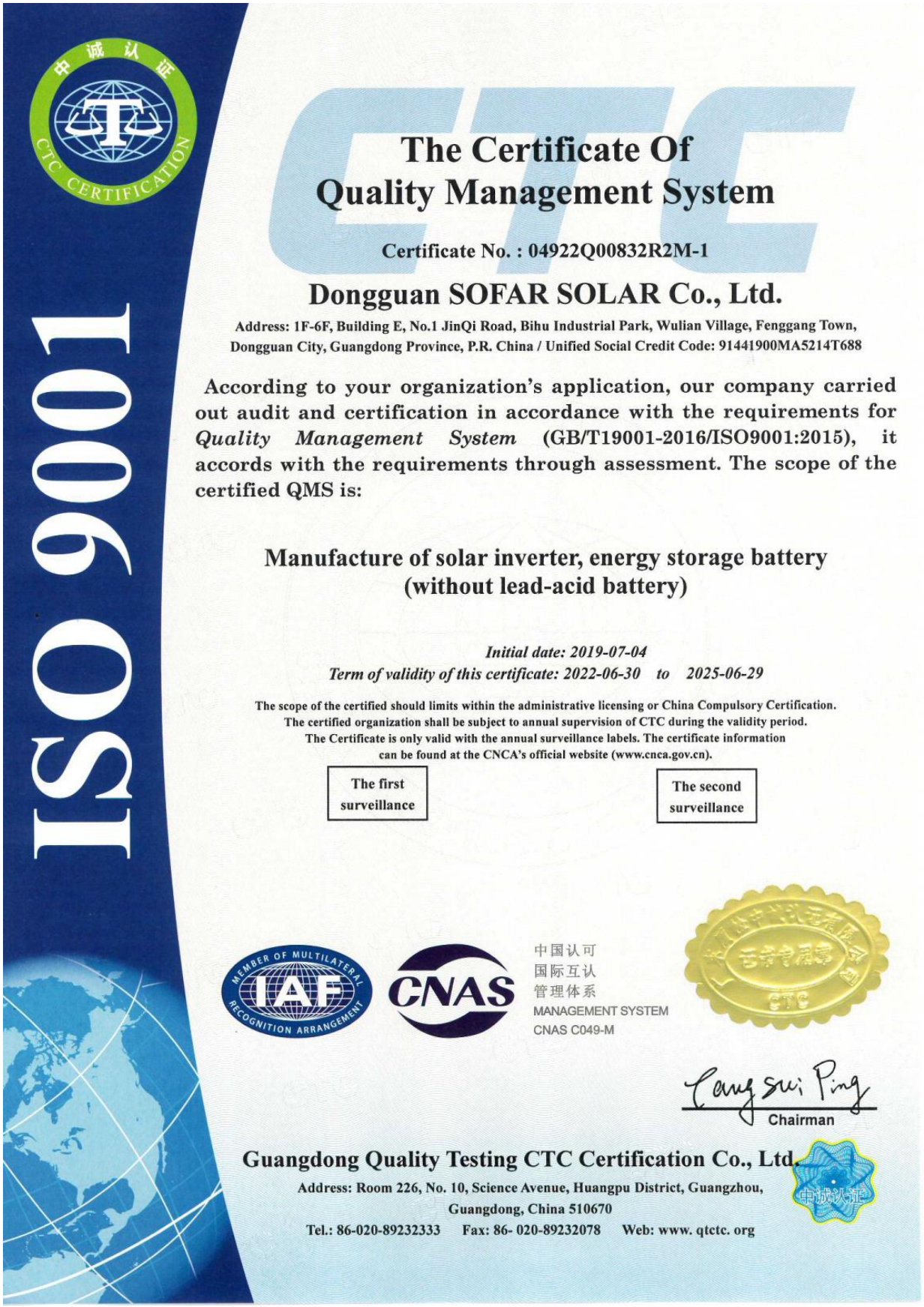
Dem Zertifikat liegt unsere Prüf- und Zertifizierungsordnung zugrunde und es bestätigt die Konformität des Produktes mit den oben genannten Standards und Prüfgrundlagen. Zusätzliche Anforderungen in Ländern, in denen das Produkt in Verkehr gebracht werden soll, müssen zusätzlich betrachtet werden. Die Herstellung des zertifizierten Produktes wird überwacht.
This certificate is based on our Testing and Certification Regulation and states the conformity of the product with the standards and testing requirements as indicated above. Any additional requirements in countries where the product is going to be marketed have to be considered additionally. The manufacturing of the certified product is subject to surveillance.

Zertifizierungsstelle

Kenny Shi

TÜV Rheinland LGA Products GmbH, Tillystraße 2, 90431 Nürnberg
Tel.: +49 221 806-1371 e-mail: cert-validity@de.tuv.com
Fax: +49 221 806-3935 http://www.tuv.com/safety

Annex 5 - ISO 9001 certificate



ISO 9001

The Certificate Of Quality Management System

Certificate No. : 04922Q00832R2M-1

Dongguan SOFAR SOLAR Co., Ltd.

Address: 1F-6F, Building E, No.1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City, Guangdong Province, P.R. China / Unified Social Credit Code: 91441900MA5214T688

According to your organization's application, our company carried out audit and certification in accordance with the requirements for *Quality Management System* (GB/T19001-2016/ISO9001:2015), it accords with the requirements through assessment. The scope of the certified QMS is:

Manufacture of solar inverter, energy storage battery (without lead-acid battery)

Initial date: 2019-07-04

Term of validity of this certificate: 2022-06-30 to 2025-06-29

The scope of the certified should limits within the administrative licensing or China Compulsory Certification.
The certified organization shall be subject to annual supervision of CTC during the validity period.
The Certificate is only valid with the annual surveillance labels. The certificate information can be found at the CNCA's official website (www.cnca.gov.cn).

The first surveillance	The second surveillance

中国认可
国际互认
管理体系
MANAGEMENT SYSTEM
CNAS C049-M

Chairman

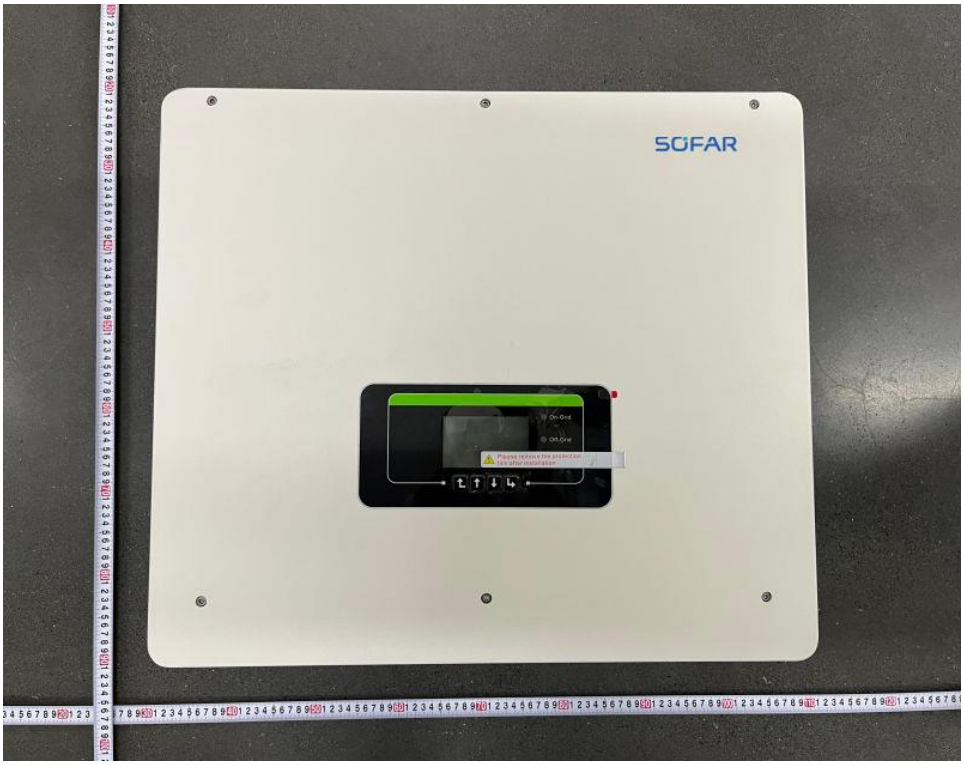
Guangdong Quality Testing CTC Certification Co., Ltd.

Address: Room 226, No. 10, Science Avenue, Huangpu District, Guangzhou, Guangdong, China 510670

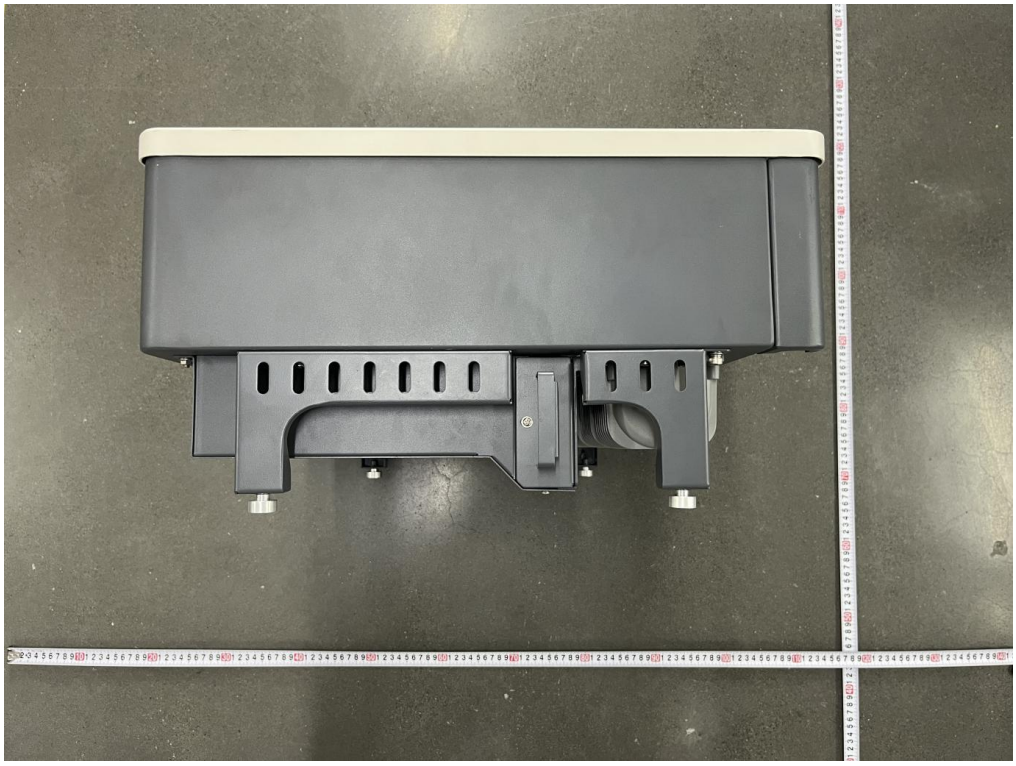
Tel.: 86-020-89232333 Fax: 86- 020-89232078 Web: www. qtctc. org

Annex 6 - Photo of the unit

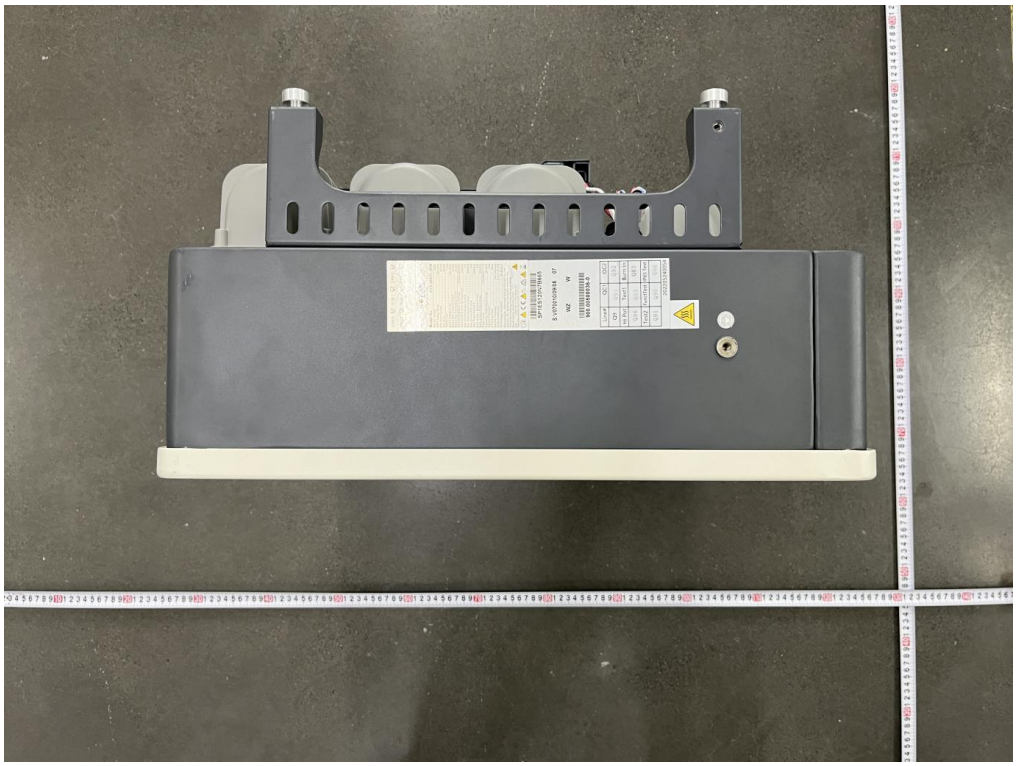
Enclosure front view



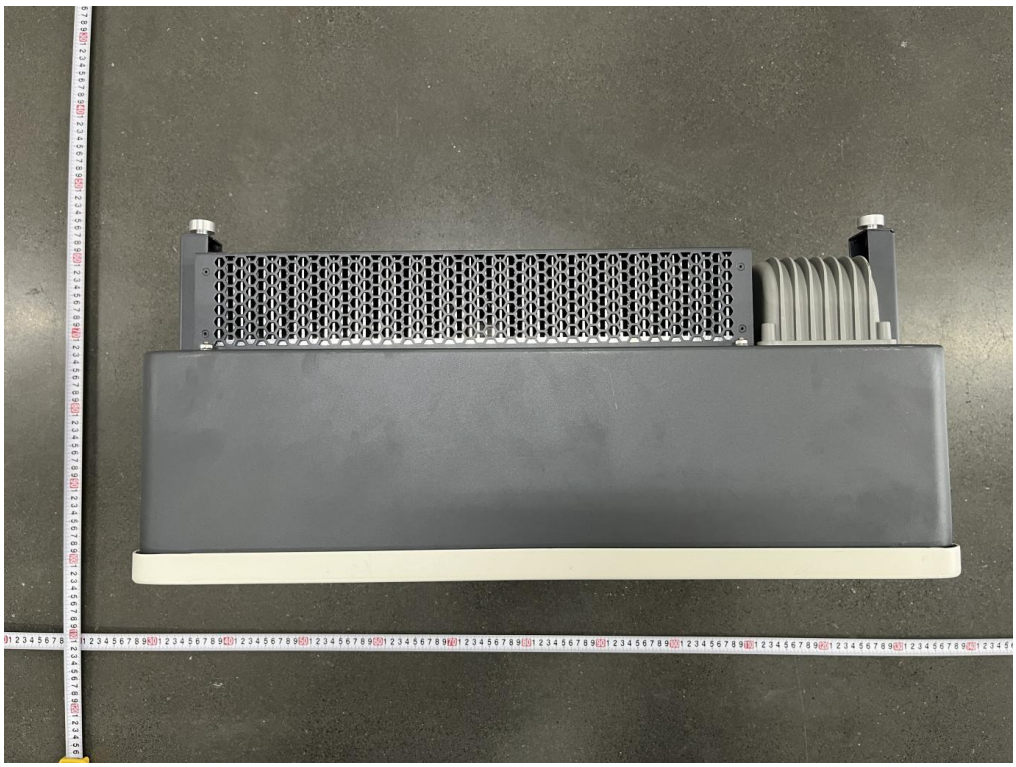
Enclosure side view-1



Enclosure side view-2

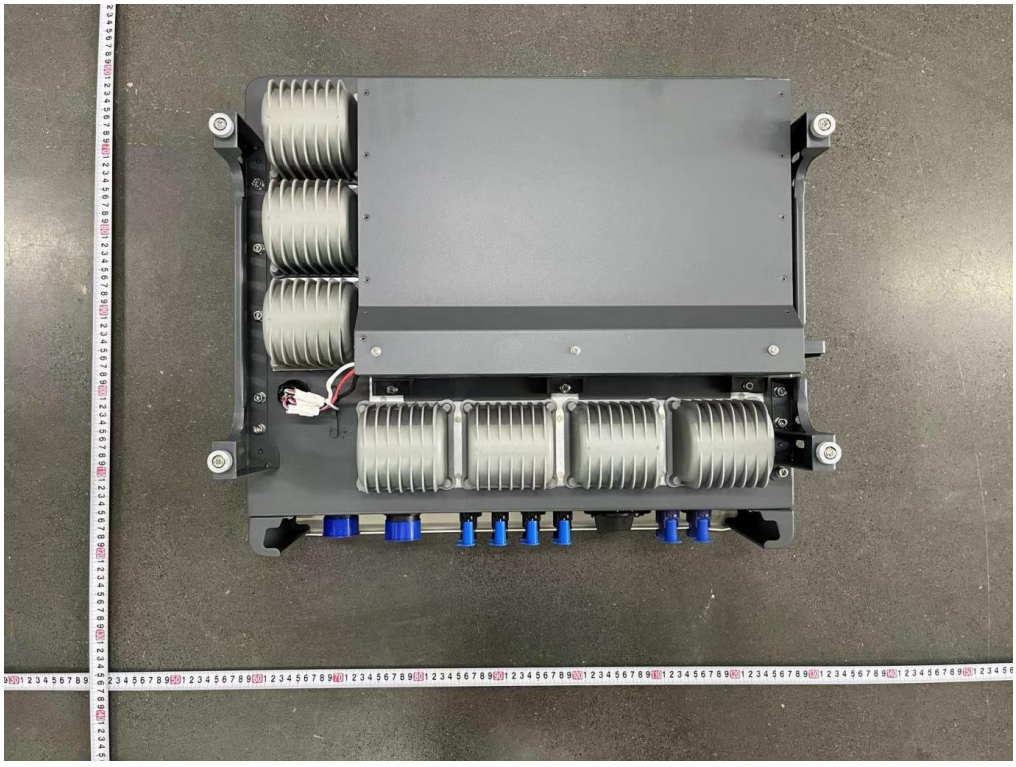


Enclosure top view



Enclosure bottom view

Enclosure rear view



»»»» **End of Test Report** ««««