TEST REPORT

UTE C15-712-1

Photovoltaic installations connected to the public distribution network

Report reference number ..... :	**PVFR200511N080-3**
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Testing laboratory name ..... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
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Accrediation ..... :	
Applicant's name ..... :	**Shenzhen SOFARSOLAR Co., Ltd.**
Address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Test specification	
Standard..... :	UTE C15-712-1:2010-07, UTE C 15-712-1Rec0:2010-09 , UTE C15-712-1Rec1:2012-02, UTE C15-712-1:2013-07 DIN V VDE V 0126-1-1/A1 VFR 2019 (Protections des Installations de Production raccordées au Réseau Public de Distribution, Enedis-NOI-RES_13E, Version 7, 14/12/2018) With deviations for French Islands according protection de Découplage pour le Raccordement d'une production décentralisée en HTA et en BT dans les zones non interconnectées, référentiel technique – SEI REF 04, V6 With deviations for French Islands according contrat de raccordement, d'accès et d'exploitation (CRAE) pour une installation de production photovoltaïque raccordée au réseau public d'électricité
Test Report Form No. ..... :	UTE-C15-712-1 VER.2
TRF Originator ..... :	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF ..... :	Dated 2020-03-11

Test item description ..... :	**Solar Grid-tied Inverter**
Trademark ..... :	
Model / Type ..... :	SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3, SOFAR 22KTLX-G3, SOFAR 24KTLX-G3

Ratings	**SOFAR 15KTLX-G3**	**SOFAR 17KTLX-G3**	**SOFAR 20KTLX-G3**
Input DC voltage [V]	Max. 1100Vd.c.		
MPPT DC voltage range [V]	140-1000Vd.c.		
Full load MPPT DC voltage range [V]	420-850 Vd.c.	450-850 Vd.c.	480-850 Vd.c.
Input DC current [A]	Max. 26.0A /26.0A		
Output AC voltage [V]	3/N/P, 380/400Va.c., 50/60Hz		
Output AC current [A]	3 x 23,9	3 x 27,1	3 x 31,9
Nominal Output power [kW]	15,0	17,0	20,0
Maximum Output power [kVA]	16,5	18,7	22,0

Ratings	**SOFAR 22KTLX-G3**	**SOFAR 24KTLX-G3**
Input DC voltage range [V]	Max. 1100Vd.c.	
MPPT DC voltage range [V]	140-1000Vd.c.	
Full load MPPT DC voltage range [V]	510-850 Vd.c.	540-850 Vd.c.
Input DC current [A]	Max. 26.0A /26.0A	
Output AC voltage [V]	3/N/P, 380/400Va.c., 50/60Hz	
Output AC current [A]	3 x 35,1	3 x 38,3
Nominal Output power [kW]	22,0	24,0
Maximum Output power [kVA]	24,2	26,4

Testing Location ..... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
Address ..... :	No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China
Tested by (name and signature) ..... :	Lukes Lin 
Approved by (name and signature) ..... :	James Huang 
Manufacturer's name ..... :	**Shenzhen SOFARSOLAR Co., Ltd.**
Manufacturer address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
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

Document History			
Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2021-02-19	Lukes Lin	Initial report was written	0
Supplementary information:			

Test items particulars	
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]..... :	Approx. 20,0 kg for SOFAR 15KTLX-G3; Approx. 22,0 kg for SOFAR 17KTLX-G3, SOFAR 20KTLX-G3; Approx. 23,0 kg for SOFAR 22KTLX-G3, SOFAR 24KTLX-G3;
Test case verdicts	
Test case does not apply to the test object..... :	N/A
Test item does meet the requirement..... :	P(ass)
Test item does not meet the requirement..... :	F(ail)
Testing	
Date of receipt of test item..... :	2020-05-11
Date(s) of performance of test..... :	2020-05-11 to 2021-02-02

General remarks:

The test result presented in this report relate only to the object(s) tested.
This report must not be reproduced in part or in full without the written approval of the issuing testing laboratory.

”(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

Throughout this report a comma is used as the decimal separator.

This Test Report consists of the following documents:

1. Test Results
2. Annex No. 1 – DIN V VDE V 0126-1-1:2006-02/A1:2012-02 Test Report
3. Annex No. 2 – Pictures of the unit
4. Annex No. 3 – Test equipment list

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 15KTLX-G3
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	140~1000V
Max. Input Current	26A/26A
Max. PV Isc	36A/36A
Nominal Grid Voltage	3/N/PE,380/400V
Max.Output Current	3x23.9A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	15000W
Max.Output Power	16500VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-30℃~+60℃
Protective Class	Class I

Made in China

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community,XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G99,IEC61727
IEC62116,UTE C15-712-1,AS4777

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 17KTLX-G3
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	140~1000V
Max. Input Current	26A/26A
Max. PV Isc	36A/36A
Nominal Grid Voltage	3/N/PE,380/400V
Max.Output Current	3x27.1A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	17000W
Max.Output Power	18700VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-30℃~+60℃
Protective Class	Class I

Made in China

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community,XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G99,IEC61727
IEC62116,UTE C15-712-1,AS4777

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 20KTLX-G3
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	140~1000V
Max. Input Current	26A/26A
Max. PV Isc	36A/36A
Nominal Grid Voltage	3/N/PE,380/400V
Max.Output Current	3x31.9A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	20000W
Max.Output Power	22000VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-30℃~+60℃
Protective Class	Class I

Made in China

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community,XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G99,IEC61727
IEC62116,UTE C15-712-1,AS4777

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 22KTLX-G3
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	140~1000V
Max. Input Current	26A/26A
Max. PV Isc	36A/36A
Nominal Grid Voltage	3/N/PE,380/400V
Max.Output Current	3x35.1A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	22000W
Max.Output Power	24200VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-30℃~+60℃
Protective Class	Class I

Made in China

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community,XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G99,IEC61727
IEC62116,UTE C15-712-1,AS4777

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 24KTLX-G3
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	140~1000V
Max. Input Current	26A/26A
Max. PV Isc	36A/36A
Nominal Grid Voltage	3/N/PE,380/400V
Max.Output Current	3x38.3A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	24000W
Max.Output Power	26400VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-30℃~+60℃
Protective Class	Class I

Made in China

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community,XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G99,IEC61727
IEC62116,UTE C15-712-1,AS4777

General product information:

The Solar Grid-tied Inverter converts DC voltage into AC voltage.
The DC input of Solar Grid-tied Inverter can be supplied from PV array.
The Solar Grid-tied Inverter is a three-phase type.
The unit is providing EMC filtering at the output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundant by the high power switching bridge and a two relays. This assures that the opening of the output circuit will also operate in case of one error.

Description of the electrical circuit: (Figure 1):

The internal control is redundant built. It consists of Microcontroller Main DSP (U30) and slave DSP (U23).

The Main DSP (U30) control the relays by switching signals; measures the PV voltage, PV current, 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 (U23) is measures the grid voltage, grid frequency and residual current, also can switch off the relays independently, and communicate with Main DSP (U30) 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(U30). The Main DSP(U30) 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 PV array and the mains. All the relays are tested before each start up

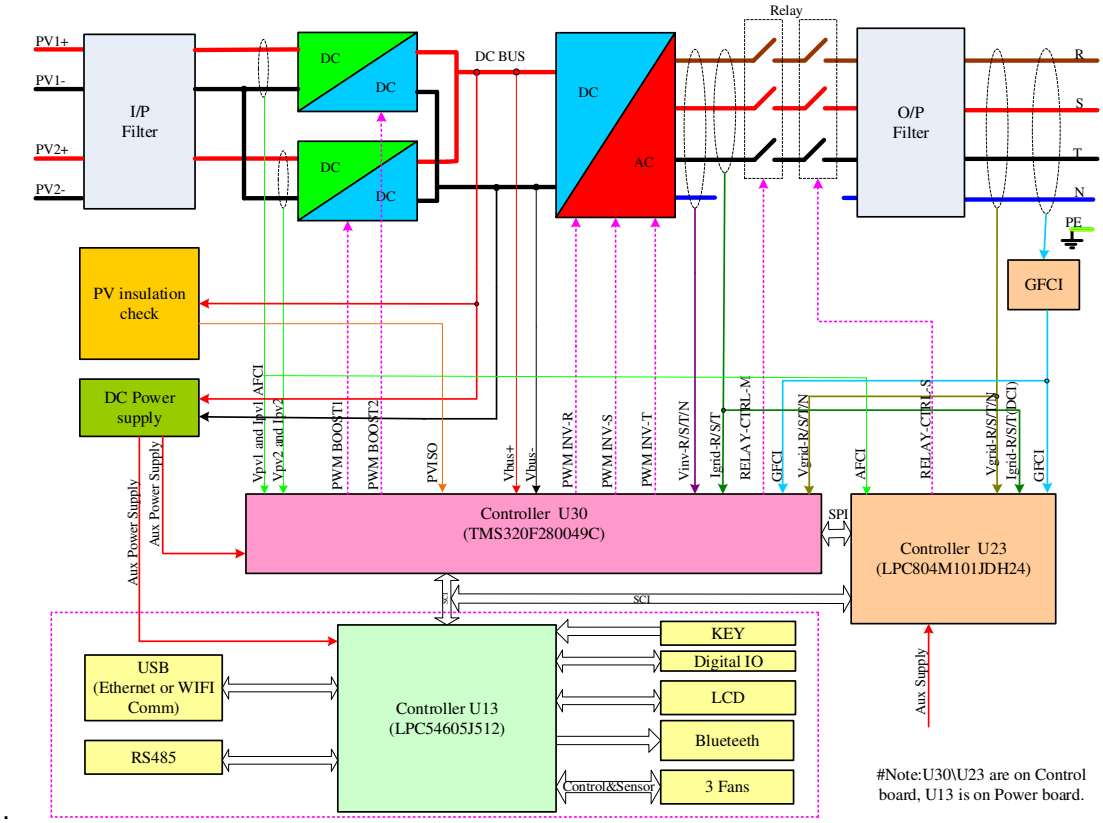

Figure 1 – Block diagram

The models SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3, SOFAR 22KTLX-G3 and SOFAR 24KTLX-G3 are use the identical hardware platform, control unit, control system and software except the output power derated by software and in following table descripts for different.

	SOFAR 15KTLX-G3	SOFAR 17KTLX-G3	SOFAR 20KTLX-G3	SOFAR 22KTLX-G3	SOFAR 24KTLX-G3
Thin-film capacitor of BUS	4pcs (110uF, 550V)	6pcs (110uF, 550V)			
INV IGBT (Q60, Q67, Q71 Q72, Q75, Q76)	6pcs 40A, 1200V	6pcs 75A, 1200V			
External Fan	1		2		

The product was tested on

Hardware version: V101

Software version: V010000

All tests were performed on SOFAR 15KTLX-G3 and SOFAR 24KTLX-G3 are valid for the SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3 since it's use the identical hardware and software construction except output power derated by software.

The following deviations for France according DIN V VDE V 0126-1-1/A1 VFR 2019 has been applied according Protections des Installations de Production raccordées au Réseau Public de Distribution, Enedis-NOI-RES_13E, Version 7, 14/12/2018.		
Parameter	**Max. clearance time**	**Trip setting**
Over voltage	200ms	264,5V
Under voltage	200ms	184,0V
Over frequency	200ms	51,50Hz
Under frequency	200ms	47,50Hz
Reconnection time	>=30s	>=30s

The following deviations for French Islands to UTE C15-712-1 and DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02 have been applied according to protection de Découplage pour le Raccordement d'une production décentralisée en HTA et en BT dans les zones non interconnectées, référentiel technique – SEI REF 04, V6:		
Parameter	**Max. clearance time**	**Trip setting**
Over voltage	200ms	255,3V
Under voltage	200ms	195,5V
Over frequency	200ms	52,0Hz
Under frequency	200ms	46,0Hz
Reconnection time	>=30s	>=30s

The following deviations for French Islands to UTE C15-712-1 and DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02 have been applied according to Contrat de raccordement, d'accès et d'exploitation (CRAE) pour une installation de production photovoltaïque raccordée au Réseau Public d'électricité:		
Parameter	**Max. clearance time**	**Trip setting**
Over voltage	200ms	264,5V
Under voltage	200ms	195,5V
Over frequency	200ms	62,5Hz
Under frequency	200ms	55,0Hz
Reconnection time	>=30s	>=30s

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**

1	**Introduction** The use of photovoltaic generators is growing for a variety of reasons, such as the generation of electricity in places that are difficult to access by public distribution networks or the development of renewable energy with production fed into the public network. The development of such generators requires the specification of implementation rules, which are the subject of this guide. The application of these rules does not remove the need to observe administrative regulations by which certain installations are bound.
2	**Applicability** This guide deals with low-voltage photovoltaic installations connected to the low-voltage or high-voltage public distribution network. The a.c. modules (PV module and associated inverter) are not included in this guide. The installation of these is subject to the regulations set down in NF C 15-100. The only issue covered in this guide is operation under voltage on the public distribution network.
3	**Normative references**
	NF EN 50380 (C 57-201)
	NF EN 50521 (CF57-339)
	NF EN 60269-1 (C 60-200-1)
	NF EN 60904-3 (C 57-323)
	NF EN 60947-1 (C 63-001)
	NF EN 60947-2 (C 63-120)
	NF EN 60947-3 (C 63-130)
	NF EN 61215 (C 57-105)
	NF EN 61439
	NF EN 61557-8 (C 42-198-8)
	NF EN 61643-11 (C 61-740)
	NF EN 61646 (C 57-109)
	NF EN 61730-1 (C 57-111-1)
	NF EN 61730-2 (C 57-111-2)
	NF EN 62262 (C 20-015)
	NF EN 62305-1 (C 17-100-1)
	NF EN 62305-2 (C 17-100-2)
	NF EN 62305-3 (C 17-100-3
	NF C 14-100
	NF C 15-100
	NF C 17-102
	UTE C 15-105

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**
	UTE C 15-400		
	UTE C 15-520		
	UTE C 32-502		
	UTE C 17-100-2		
	UTE C 61-740-51		
	UTE C 61-740-52		
	UTE C 17-108		
	DIN VDE 0126-1-1		
	DIN EN61000-6-3		
4	In addition to the definitions set out in NF C 15-100, the following definitions apply to this guide:	Noticed.	**P**
5	Description of PV installations		**P**
6.	**Earthing of the installation**		**P**
6.1	**Diagrams showing bonding of alternating current part with earth** The earthing system has been produced in accordance with the requirements of NF C 15-100.	Must be taken under consideration for the installation.	**N/A**
6.2	**Earthing of one polarity in the d.c. part** In a PV installation, the protection devices against indirect contact are independent of the principle of the earthing systems. The direct current part is created in accordance with the rules for class II or equivalent isolation.	Must be taken under consideration for the installation.	**N/A**
6.3	**Earthing of conductive masses and elements**		**P**
6.3.1	**Direct current part** To minimise the effects of induced overvoltages, the metal structures of the modules and the metal support structures (including the metal cable runs) must be connected to equipotential bonding, which in turn is connected to the earth.	Must be taken under consideration for the installation.	**N/A**
6.3.2	**Alternating current part** All chassis on the a.c. side must be connected to the earth via a protective conductor that meets the requirements of paragraph 411.3.1.2 and section 5-54 of NF C 15-100. If a transformer is installed outside the inverter (low voltage/low voltage or high voltage/low voltage transformer), equipotential bonding is required between these items of equipment.	Must be taken under consideration for the installation.	**N/A**
6.3.3	**Inverter** The inverter body must be connected to the equipotential bonding via a conductor with a minimum cross-section of 6mm² Cu or equivalent and to the protective conductor of the a.c. part.	A minimum cross-section of the protective earthing wire of 6mm² is required in the manual.	**P**
7.	**Protection against electric shock**		**P**

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**
7.1	**General points** The PV equipment of the direct current part must be treated as being under voltage, even if it is disconnected from the alternating current part.		**P**
7.2	Protective measure SELV or PELV by the DC part The requirements of SELV or PELV are described in Article 414 of the NF C 15-100 and are detailed below: - The ac part of the plant is separated by a safety transformer according to the NF EN 61558-2-6 or safety converter according to the NF EN 61046, in accordance with 414.3 of the NF C 15-100. The safety transformer or safety converter can be integrated in the inverter or close to it if the link between the two devices is done with the Class II equipment or equivalent insulation. - PELV, a polarity of the d.c. part is grounded. - SELV is prohibited if the party d.c. includes a set of functional ground polarity In cases where the protective measure by SELV or PELV is prohibited, the general protection measures apply (double or reinforced insulation).	SELV is classified for communication ports.	**P**
7.3	**Protection against direct contact**		**P**
7.3.1	**General** All connection points required for the realization of a PV string whose Uocmax voltage is above 60 V, should be insured by connectors including at it ends. These connectors must be conform to the EN 50521 standard.	Must be taken under consideration for the installation.	**P**
7.3.2	**Case of the installation in LV** Electrical equipment must be fitted with a form of protection either by insulation of the live parts or through a casing. The cabinets or boxes containing accessible live parts must be locked either with a key or with a tool, unless they are located in a place to which only authorised or qualified persons have access. If the boxes or cabinets are not located in a place to which only authorised or qualified persons have access, protection against direct access must be ensured when an access door is opened by installing equipment that, by the nature of its design or installation, has a minimum degree of protection of IP2X or IPXXB.	The unit is rated IP 65	**P**

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**
7.3.3	**If the installation is SELV (extra-low voltage) and PELV (protective extra-low voltage)** If the nominal voltage of the safety extra-low voltage circuit is less than or equal to 25 V rms a.c. or 60 V d.c. without ripple, protection against direct contact through insulation of the live parts or a casing is not necessary. If the nominal voltage of the protective extra-low voltage circuit is less than or equal to 12 V rms a.c. or 30 V d.c. without ripple, protection against direct contact through insulation of the live parts or a casing is not necessary.	Unit is rated for voltages above 120V	**N/A**
7.4	**Protection against indirect contact**		**P**
7.4.1	**General** The regulations for protection against indirect contact are set out in section 4-41 of NF C 15-100. The circuits covered by 411.3.3 of standard NF C 15-100 and, in particular, circuits in residential buildings must be protected with a differential device with a sensitivity of 30 mA or less. The aim of this section is to describe the different ways of protecting people against indirect contact in a photovoltaic installation according to the measures implemented on the d.c. side and the presence or otherwise of galvanic isolation via a transformer between the d.c. and a.c. parts.	Must be taken under consideration for the installation.	**N/A**
7.4.2	**Direct current part**		**N/A**
7.4.2.1	**General** For the direct current part (PV modules, junction boxes, chain cables, group cables, marshalling boxes or cabinets, etc.), protection against indirect contact must be ensured through at least one of the following measures: • Protection through safety extra-low voltage or protective extra-low voltage; • Protection through double or reinforced insulation. In the case of the installation of cabinets in a building or electrical service site where access is restricted to qualified personnel, this cabinet can be a class 1 cabinet.	Must be taken under consideration for the installation.	**N/A**
7.4.2.2	**Protection with double or reinforced insulation**		**N/A**

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Clause	**Requirement**	**Remark**	**Verdict**
7.4.3	**Alternating current part** Protection against indirect contact is ensured through double or reinforced insulation or by an automatic cut-out of the supply, according to one of the following measures: • In a TT system: cut-out on the first fault; • In a TN system: cut-out on the first fault; • In an IT system: cut-out on the second fault.	The unit is only intended for TT or TN systems. The unit is rated class 1. In combination with the required differential device in clause 7.3.1 no hazard can occur in single fault.	**P**
8	**Overcurrent protection**		**N/A**
8.1	**Direct current part**		**N/A**
8.1.1	**General points** See figure 7 of this standard	Must be taken under consideration for the installation.	**N/A**
8.1.2	**Protection of PV modules** In an installation with several PV module chains in parallel, the modules must be protected against the effect of reverse currents that may be generated in the chains in the event of a fault.	Must be taken under consideration for the installation.	**N/A**
8.1.3	**Protection of PV chain cables** The sizing of the PV chain cables takes into account the choice of protection device for the PV modules adopted in 8.1.2.	Must be taken under consideration for the installation.	**N/A**
8.1.4	**Protection of PV group cables** In an installation with several PV groups in parallel, the cables for the groups must be protected against the effect of reverse currents caused by a short circuit in a group.	Must be taken under consideration for the installation.	**N/A**
8.1.5	**Protection of main PV cable** The main cable of a PV generator must be dimensioned with a permissible current Iz greater than or equal to 1.25 IscSTC_gen.	Must be taken under consideration for the installation.	**N/A**
8.1.6	**Characteristics of overcurrent protection devices** The overcurrent protection devices must be either fuses compliant with standard NF EN 60269-1 or circuit-breakers compliant with standard NF EN 60947-2. These devices must be implemented for both polarities, regardless of the configuration of the installation.	Must be taken under consideration for the installation.	**N/A**
8.2	**Alternating current part**		**N/A**

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**
8.2.1	**General points** In the case of an installation connected to the network via a branch line with limited power, the minimum cross-section of the conductors connected to the terminals downstream of the general isolating and protection device is 10 mm2 Cu.	Must be taken under consideration for the installation.	**N/A**
8.2.2	**Overload protection** Alternating current circuits are protected against surges in accordance with the requirements of article 433 of standard NF C 15-100.	Must be taken under consideration for the installation.	**N/A**
8.2.3	**Short-circuit protection** In the case of a short circuit in an inverter or its line, the inverter is regarded as the load and the public network as the source.	Must be taken under consideration for the installation.	**N/A**
9.	**Interface protection** This protection device is designed to disconnect generators in the event of: • a fault on the public distribution network; • a failure in the supply from the public distribution network; • fluctuations in the voltage or frequency greater than those specified by the distributor.	The unit provides a integral disconnection facility according to VDE 0126-1-1 an it is rated below 250kW	**P**
10	**Prevention of degradation of photovoltaic installations** In order to prevent the degradation of PV installations due to specific external influences and the presence of direct current, and despite the implementation of measures such as the installation of double insulation and monoconductor cables, additional measures must be implemented for the direct current part.	The inverter is applicable to be used for no galvanic insulation and PV array not earthed	**P**
11	**Voltage drop**		**N/A**
11.1	**General points** The objective of technical and commercial optimisations is to minimise voltage drops.	Must be taken under consideration for the installation.	**N/A**
11.2	**Direct current installation** The authorised maximum drop in voltage in the direct current part of the installation is between 3% and ImppSTC (STC: standard test conditions).	Must be taken under consideration for the installation.	**N/A**

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**
11.3	**Alternating current installation** For PV installations connected directly to the LV public distribution network, the maximum authorised drop in voltage between the a.c. terminals of the inverter and the point of delivery (NF C 14-100) is 3% at the nominal power of the inverter(s). It is recommended to limit this drop in voltage to 1% in order to be able to limit energy losses on the one hand and momentary disconnection of the inverter on the other, maintaining a margin between the average operating voltage of the inverter and the setting of its protection at maximum voltage.	Must be taken under consideration for the installation.	**N/A**
12.	**Isolation, control and disconnection**		**N/A**
12.1	**Isolation / Disconnection** To facilitate maintenance of the PV inverters, disconnection mechanisms must be installed close to the inverter, on both direct current and alternating current sides. NOTE For high power inverters whose maintainability can be ensured by replacement of internal components, the isolating device can be integrated in the same envelope. All disconnectors must be omnipolar. The disconnector installed on the direct current side does not have to be with simultaneous opening of each polarity.	Must be taken under consideration for the installation.	**N/A**
12.2	**Control** To allow maintenance work on junction boxes fitted with protection devices, a circuit-breaker must be installed inside or immediately downstream of these protection devices.	Must be taken under consideration for the installation.	**N/A**
12.3	**Emergency circuit-breakers**		**N/A**
12.3.1	**General points** In accordance with the regulations set down in articles 463 and 536.3 of standard NF C 15-100, emergency circuit-breakers must be fitted on both a.c. and d.c. sides in order to cut off the electricity supply in the event of an unexpected hazard. All emergency circuit-breakers must effect an omnipolar and simultaneous disconnection. These devices are either switches or breakers or contactors. The semiconductor devices do not comply with this requirement. The controls of emergency circuit-breakers on both d.c. and a.c. sides must be easily recognisable and quickly accessible. Emergency circuit-breakers must not be built into the inverter. NOTE For high-power inverters, the switchgear device can be integrated in the same envelope.	Must be taken under consideration for the installation.	**N/A**

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Clause	**Requirement**	**Remark**	**Verdict**
12.3.2	**Emergency cutoff of the DC part** A cut-off device must be provided upstream from the inverter and its control shall be located close to this one. The emergency disconnection can be ensured by manual control of the circuit-breaker or via a remote control action. It must be possible to cut each supply to the inverter. In the case of inverters with multiple inputs, it is permissible to ensure an emergency disconnection by means of separately controlled devices.	Must be taken under consideration for the installation.	**N/A**
12.3.3	**Alternating current part**		**N/A**
12.3.4	**Measures specific to residential buildings** In conformity with the regulations set down in article 771.463 of standard NF C 15-100, the emergency circuit-breakers must be tripped by a direct manual action. If the route between the inverter and the network passes through the residential part, the emergency circuit-breaker of the PV installation must be installed in the residential service duct of the building, if there is one, in accordance with articles 771.463 and 771.558 of standard NF C 15-100.	Must be taken under consideration for the installation.	**N/A**
12.4	**Cut-out for intervention by emergency services**	Must be taken under consideration for the installation.	**N/A**

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**
12.4.1	**General** If a cut-out is required to allow the intervention of the emergency services, this must be triggered by one of the following events: • Cut-out of all sources of electrical energy o PV generator o Public distribution network • Switching devices must meet the following principles o these devices are either switches or breakers or contactors; the semiconductor devices do not comply with this requirement; o each device must be omnipolar and simultaneous interruption; • the failure of the PV generator circuit is done as close to the photovoltaic modules and in any case upstream of accessible rooms and passages to the occupants; • orders for these switching devices for intervention of emergency services are grouped. In the case of facilities on an existing building, it is assumed to have non-grouped commands. The switching devices can be: • Mechanical direct action; • Remote-controlled (electric or pneumatic) The remote control may be provided by one of three principles: • Trigger voltage loss; • trigger current or powered engine emissions, through CR1 type cable, by AES (Safety Electric Power) implemented under subsection 562.8 of the NF C 15-100; • pneumatic actuator with a compressed gas energy source and copper pipes or steel tube (according to standard NF EN 12101). Signaling the action disconnection should be done by voltage measurements indications or voltage free loop devices by type O / F. In the case of using the DC voltage measurement, it should then be taken between the separating apparatus and the area to be secured. The cables used for signaling are CR1 type. This signal is provided by the extinction of a white LED that indicates the actual disconnection.	Must be taken under consideration for the installation.	**N/A**

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Clause	**Requirement**	**Remark**	**Verdict**
12.4.1	**Additional provisions** If it is required that the voltage of the PV generator is below 60 Vdc, the circuit upstream of the required disconnection is general in provisions of 12.4.1, this is achieved by: • an electromechanical load breaking or unloaded in series in each string by PV Uocmax section whose voltage is lower or equal to 60 V, or • electromechanical short-circuit or electronic systems by Uocmax section whose voltage is lower or equal to 60 V, or • electromechanical or electronic shorting by Modular Systems The operational safety of these principles requires: • a positive safety control; • in the case of an electromechanical load cut off, his order should be performed after the charge downstream switching device. The implementation of this equipment must be comply with the rules of double insulation (or reinforced insulation) imposed in this part of the system and for a voltage corresponding to the chain tension Uocmax.	Must be taken under consideration for the installation.	**N/A**
13	**Protection from surges emanating from the atmosphere or caused by operations**		**N/A**
13.1	**General points** The information contained in this chapter refers to overvoltage protection for photovoltaic installations connected to the network and complements standard NF C 15-100 and guide UTE C 61-740-52.	Must be taken under consideration for the installation.	**N/A**
13.1.1	**Types of protection**		**N/A**
13.1.1.1	**Protection through equipotential bonding** As described in section 6.3, an equipotential bonding conductor must connect all the metal structures of the modules and the metal structures of the supports of the PV installation (including the metal cable runs) whether or not lightning conductors are present. This conductor must be connected to the earth.	Must be taken under consideration for the installation.	**N/A**
13.1.1.2	**Protection by lightning arresters** The installation conditions are described in 13.2.	Must be taken under consideration for the installation.	**N/A**
13.2	**Installation conditions for lightning arresters**		**N/A**

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Clause	**Requirement**	**Remark**	**Verdict**
13.2.1	**Installation conditions for lightning arresterson a.c. side** Based on guide UTE C 61-740-52, protection by a lightning arrester is obligatory if there is a lightning conductor or if the lightning density (Ng) is greater than 2.5.	Must be taken under consideration for the installation.	**N/A**
13.2.2	**Installation conditions for lightning arresters on d.c. side**		**N/A**
13.2.2.1	**Installation without lightning conductor** The length L is the accumulated distance between the inverter(s) and the furthest points of the photovoltaic modules comprising the chain, as a sum of the lengths of the routes in accordance with the principles shown in Figure 7.	Must be taken under consideration for the installation.	**N/A**
13.2.2.2	**Installation with lightning conductor** The installation of type 2 lightning conductor(s) is obligatory on the d.c. side.	Must be taken under consideration for the installation.	**N/A**
13.3	**Overvoltage protection for installations without lightning conductor**	Must be taken under consideration for the installation.	**N/A**
13.3.1	**Choice and installation of lightning arresters on a.c. side** If a lightning arrester is prescribed for the a.c. part of a PV installation connected to the public low-voltage distribution network, it is always installed in the panel nearest to the installation origin of the installation. If this lightning arrester is located more than 10 metres away from the inverter, a second lightning arrester must be installed near the latter.	Must be taken under consideration for the installation.	**N/A**
13.3.2	**Choice and installation of lightning arresters on d.c. side** If a lightning arrester is prescribed for the d.c. part of a PV installation, it is always installed in the panel nearest to the inverter. If one of the chains is located more than 10 metres away from the inverter, the installation of a second lightning arrester near the chains is recommended.	Must be taken under consideration for the installation.	**N/A**
13.3.2.1	**Choice of I_n** The lightning arresters are type 2 with a minimum value for the nominal discharge current In of 5 kA. A higher nominal discharge current than the required value will prolong the service life of the lightning arrester.	Must be taken under consideration for the installation.	**N/A**
13.3.2.2	**Choice of I_{max}** This parameter is used to coordinate the energy of the lightning arresters: please refer to information from the manufacturer.	Must be taken under consideration for the installation.	**N/A**

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Clause	**Requirement**	**Remark**	**Verdict**
13.3.2.3	**Choice of I_{imp}** The impulse current I_{imp} for Type 1 arresters is chosen according to the UTE C 61-740-52 guide or by default with a minimum value of 12.5 kA.	Must be taken under consideration for the installation.	**N/A**
13.3.2.4	**Choice of U_p** The value of U_p must be less than 80% of the surge withstand voltage of the equipment to be protected.	Must be taken under consideration for the installation.	**N/A**
13.3.2.5	**Choice of U_{CPV}** The value of the maximum permissible voltage from the lightning arrester UCPV must be selected according to the maximum open-circuit voltage of the PV generator corresponding to the voltage UocSTC specified by the manufacturers of the PV modules. The voltage UCPV must be greater than or equal to the maximum voltage UocMAX of the photovoltaic generator. Whatever the protection methods of the lightning arrester, it must also withstand the maximum voltage UocMAX between these live terminals (+ and - terminals) and the earth.	Must be taken under consideration for the installation.	**N/A**
13.3.2.6	**Choice of I_{SCPV} and protection device associated with the lightning arrester** I_{SCPV} keeping abreast short of an arrester system The lightning arrester must be fitted with an external disconnection device, if specified by the manufacturer; this assembly must be sized to function regardless of the current produced by the PV modules. Note: The lightning arresters can come to the end of their service life for the following reasons: • Due to overheating caused by an excessive accumulation of lightning stresses that do not exceed the normal characteristics of the lightning arrester but lead to a gradual destruction of its internal components; • Short-circuiting caused by the normal characteristics of the lightning arrester being exceeded, leading to a drastic reduction in its impedance. The maximum value I_{scPV} of the current permitted by the lightning arrester and any disconnector it may have must be selected according to the current I_{sccpv} that may be delivered by the photovoltaic generator. The I_{SCPV} current must be greater than or equal to Is_{cmax} of the PV generator. Lightning arresters for which fulfilment of this parameter is not stated must not be used.	Must be taken under consideration for the installation.	**N/A**

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Clause	**Requirement**	**Remark**	**Verdict**
13.4	**Additional regulations for surge protection for installations with a lightning conductor** The regulations are set out in guide UTE C 61-740-52.	Must be taken under consideration for the installation.	**N/A**
14.	**Choice and installation of equipment**		**P**
14.1	**General points** The rated operating voltage of all the equipment of the d.c. part must be equal to or greater than the voltage UOCMAX. In the case of buildings with multiple occupation (for tertiary or residential use) with photovoltaic production in communal parts, the lines coming from the PV modules must be routed round the outside of private areas to the junction boxes for the chain/group located in the communal areas or in the buildings or the electrical service site dedicated to this purpose. The equipment installed outside must have a minimum degree of protection of IP44. The degree of protection against mechanical impacts must be at least IK07 in compliance with standard NF EN 62262 (C 20-015). It must be possible to carry out work on the removable equipment, devices and connections in the utmost safety. If a transformer is installed, the inverters and any general low-voltage panel must be installed close to the transformer in the same room or in adjoining rooms. The location of equipment (junction box(es), inverter(s), cabinets with protection devices and meter cabinets etc.) must comply with article 513.1 of standard NF C 15-100. Special regulations for residential buildings are given in article 771. The equipment, including the ducts etc., must be arranged so that they can be operated, inspected and serviced easily and their connections can be accessed.	The inverter is rated IP65 and IK07. For IK see test results below.	**P**
14.2	**Ducts etc.**		**N/A**
14.2.1	**Choice for the d.c. part** The ducts are sized in accordance with the regulations in standard NF C 15-100 on the basis of cables with reticulated polyethylene insulation.	Must be taken under consideration for the installation.	**N/A**
14.2.2	**Installation** The connections and the cables must be installed in a manner that will prevent any deterioration due to external influences. See the requirements set out in guide UTE C 15-520.	Must be taken under consideration for the installation.	**N/A**

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**
14.3	**PV modules** The PV modules must comply with the standards in series NF EN 61730.	Must be taken under consideration for the installation.	**N/A**
14.4	**Inverters** The inverters must be comply with IEC 62109-1 and EN 62109-2. The level of the current for the inverter must be based on ImppSTC. Direct current generated by invertes injected on the public distribution network must be less than 0.5% of its rated current.	Comply with IEC 62109-1 and IEC 62109-2. For DC injection, see table 6.4 below.	**P**
14.5	**Equipment** All equipment installed in the d.c. part must be adapted for operation in direct current and be selected and installed in accordance with the manufacturer's instructions. Equipment installed in the d.c. part must be of the industrial type, in other words compliant with the NF EN 60947 series of standards. • The characteristics of switches, switch-disconnectors and fuse-combination units must conform to the operating category DC21B. • The characteristics of disconnectors must conform to the operating category DC20. • The characteristics of contactors must conform to the operating category DC1.	The DC switch of the inverter is rated for operation category DC21B. Connectors in the DC lines are rated for operation category DC1.	**P**

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**
14.6	**Equipment assemblies** The direct current and alternating parts of the installation can be accommodated in the same panel if there is a physical separation of these two parts. For the d.c. part, it is imperative to protect all the connections or disconnection devices against accidental or unauthorised opening when live in accordance with 536.2.3 of standard NF C 15-100. To this end, a notice “Do not operate when live” must be placed inside the boxes or cabinets near these disconnection devices. Furthermore, in premises accessible to persons other than those with the requisite authorisation or qualification (BA4 or BA5): • The design or installation must be such that it is only possible to disassemble the connection devices with the aid of a tool; • Equipment that does not have an under load circuit-breaking feature must require the either the use of a key or tool or the direct operation of a device with an under load circuit-breaking feature.	The PV input connectors can not be removed with out a aid of a tool. In addition there is a marking adjent the connectors with states ”Do not operate when live”	**P**
14.7	**Connectors** In the d.c. part, the connectors used must comply with the standard NF EN 50521. To guarantee the quality of the connection and limit the risks of an electric arc that could spark a fire, each pair of male and female connectors to be assembled must be of the same type and the same brand.	The unit provide only one type and brand of connectors fro DC with male and female plugs, which are not interchangeable. The plugs are according to EN 50521	**P**
14.8	**Lightning arresters**	Must be taken under consideration for the installation.	**N/A**
14.8.1	**Choice of lightning arresters** The lightning arresters installed in the a.c. part of the PV installation must comply with standard NF EN 61643-11. The lightning arresters installed in the d.c. part of the PV installation must meet the requirements of guide UTE C 61-740-51.	The surge arrestors incoperated in the inverter are not according to EN 61643-11 or UTE C 61-740-51. Therefore an external lightning protection device must be installed.	**N/A**
14.8.2	**Installation of lightning arresters** Alternating current and direct current lightning arresters are installed in accordance with the regulations set out in guide UTE C 61-740-52.	Must be taken under consideration for the installation.	**N/A**
15	**Markings**		**P**

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**
15.1	**Identification of components** The main components comprising the photovoltaic installations must be identified and marked with clearly visible labels fixed permanently in accordance with the installation plans and diagrams:	The inverter provides permanent marking.	**P**
15.2	**Labelling** For safety reasons and to alert the different people carrying out work in and around the building (staff tasked with maintenance work, inspectors, public distribution network operators, emergency services, etc.), it is imperative that the presence of a photovoltaic installation on a building is indicated.		**P**
15.2.1	**Labelling on the a.c. part**	Must be taken under consideration for the installation.	**N/A**
15.2.2	**Labelling on the d.c. part** All the junction boxes (PV generator and PV groups) and d.c. ducts must carry a visible and permanent marking indicating that live parts within these boxes may remain under voltage even after the inverter has been disconnected on the direct current side.	Must be taken under consideration for the installation.	**N/A**
15.3.2	**Labelling on the inverter** All inverters must bear a marking indicating that before any work is carried out, the two sources of voltage must be isolated.	The unit is provided with the applicabe marking	**P**
16.	**Technical file** The technical file must include the following items drawn up in French: • A circuit diagram of the photovoltaic system; • The list of installed equipment mentioning the characteristics and references to the replacement parts (fuses, lightning arrester cartridges etc.); • An installation diagram for the various photovoltaic components and modules as well as the corresponding connections (ducts); • A description of the procedure for working on the photovoltaic system and safety instructions.	The required information are stated in the manual.	**P**
17.	**Maintenance of photovoltaic installations**		**N/A**

UTE C15-712-1			
Clause	**Requirement**	**Remark**	**Verdict**
17.1	**General points** The minimal technical maintenance work must be provided for during the life cycle of a photovoltaic installation to maintain or restore the installation to a state in which it can fulfil the function for which it was designed.	Must be taken under consideration for the installation.	**N/A**
17.2	**Levels and frequency of maintenance** A distinction is made between the following three levels of maintenance comprising: • Conditional maintenance based on monitoring of the key parameters of the installation; • Precautionary maintenance carried out according to the prognoses extrapolated from the analysis and evaluation of the key parameters concerning the degradation of the asset (e.g. corrosion); • Systematic maintenance carried out at predetermined intervals and without a prior check of the state of the product or its constituent components.	Must be taken under consideration for the installation.	**N/A**
17.3	**Technical areas covered during maintenance** A distinction is made between operations relating to the safety of persons and property, and actions relating to functional reliability.	Must be taken under consideration for the installation.	**N/A**
Annex A **Agreements between the administrator of the public distribution network and the user/produce**			
A1	**Provisions for limiting effects adversely affecting supply quality** The study of the connection by the administrator of the public distribution network requires the communication of the characteristic data for the project, the generators and the provisions for connection to the network. The administrator of the public distribution network may disclose data sheets summarising the minimum list of data required to study the request.	Must be taken under consideration for the installation.	**N/A**
A2	**Choice of tripping device and approval** The installation or modification of a tripping device must be subject to an agreement with the administrator of the public distribution network. This process must take account of the situation and the features at the point of delivery and must therefore, where necessary, be coordinated with the connection study for the site.	Must be taken under consideration for the installation.	**N/A**

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Clause	**Requirement**	**Remark**	**Verdict**
A3	**Start-up by the administrator of the public distribution network** For installations with a power of less than 250 kVA, this step is subject to prior submission of proof of conformity stamped by CONSUEL (Comité National pour la Sécurité des Usagers de l'Electricité, the National Committee for the Safety of Users of Electricity).	Must be taken under consideration for the installation.	**N/A**
	Annex B **Cables for photovoltaic installations - values for permissible currents** (informative)		
	Specific cables for photovoltaic installations have been refined in order to meet the needs of these installations. The tables below, taken from document UTE C 32-502, give the values for the permissible currents for cables compliant with this guide.	Must be taken under consideration for the installation.	**N/A**
	Annex C **Keraunic levels in France and in the overseas departments** (informative)		
	Note – To obtain the corresponding lightning density (Ng), simply divide Nk by 10.		**--**

Test Results

14.1 IEC 60068-2-75 (Hammer test)										**P**
Use method	Swing hammer			Spring hammer			Vertical hammer			
	N/A			P			N/A			
	Severity									
Repeats	3 Hits unless otherwise specified									
Energy (J)	0,14	0,2	0,35	0,5	0,7	1	2	5	10	20
Mass (kg)	0,25						--	1,7	5	5
Radius (mm)	10						--	25	50	50
IK code	IK01	IK02	IK03	IK04	IK05	IK06	IK07	IK08	IK09	IK10
	N/A	N/A	N/A	N/A	N/A	N/A	P	N/A	N/A	N/A
Note:										

Annex 1

DIN V VDE V 0126-1-1/A1 VFR2019 Test Report

DIN V VDE V 0126-1-1/A1 VFR2019			
Clause/§	**Requirement**	**Remark**	**Verdict**
1	**Scope (Automatic disconnecting facility for photovoltaic installations)**		
2	**Normative references**		
	DIN EN 50160:2003-03		
	DIN EN 50178 (VDE 0160):1998-04		
	DIN EN 60664-1 (VDE 0110-1)		
	E DIN VDE 0664-100:2005-05		
	DIN EN 61000-6-2		
	DIN EN61000-6-3		
	DIN EN 61008-1 (VDE 0664-10):2000-09		
	DIN VDE 0105-100:2000-06		
4	**Requirements:** 1. Monitoring of voltage and frequency derivation 2. Monitoring of DC-Injection 3. Monitoring of accidental anti Islanding 4. Monitoring of intended anti Islanding 5. Residual Current Monitoring Unit –RCMU (only if no galvanic separation)		
4.1	Functional safety: Automatic disconnecting facility	Considered, see annex. The single fault safe system was reviewed. The theoretical investigation was verified by error simulation.	**P**
4.1.1	Single fault safety of the automatic disconnecting facility	Considered, see block diagram, functional explanation and table 6.1 below.	**P**
4.1.2	Disconnection device: At least two independent disconnection devices. At least one relay and one switch with overvoltage category 2. If without galvanic seperation then two relays are necessary	Disconnection takes place redundant through two relays and the IGBT-fullbridge in series. The relays and the IGBT-full bridge are able to switch the full current.	**P**
4.2	Monitoring of the voltage: Voltages <=80% and >=115% of V_{nom} cause a disconnection within 0,2s (reconnection after min. 5s if voltage fluctuation <=3s; min. 30s if voltage fluctuation >3s). Test voltage steps should not be below 77% and above 118% of V_{nom}. Continuous over voltage above 110% up to 115% (adjustable, default setting 110%) causes disconnection after max. 10min. Re-connection after min. 30s.	Tested with a variable AC-Power supply at the output. Inverter disconnects within the limits, see table 6.2 below.	**P**

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Clause/§	**Requirement**	**Remark**	**Verdict**
4.3	Monitoring of frequency: Frequencies <=47,5Hz and >=51,5Hz cause a disconnection within 0,2s (frequenz derivation 1Hz/s)	Tested with an AC-Source at the output. See table 6.3 below.	**P**
4.4	Monitoring of DC-Injection: DC error or DC-Currents >= 1A cause disconnection within 0,2s (positive and negative polarity)	See table 6.4 below.	**P**
4.5	Detection of anti islanding: anti islanding causes disconnection within 5s (for multiple installations 0,2s if triggered external). For the detection of anti-islanding is only one of the following methods necessary: -6.5.1 Measurement of impedance or -6.5.2 Resonant circuit test or -6.5.3 3-phase grid-voltage monitoring	See table 6.5.2 below.	**P**
4.6	Marking: In case of an automatic disconnecting facility there is a note at the type plate necessary	Marking provided on the type label.	**P**
4.7	**Special requirements:**		
4.7.1	Photovoltaics: If without galvanic separation then a RCMU is necessary. Insulation resistance > 1kOhm/V, at least 500kOhm. Slowly increasing DC-Leaking currents up to 300mA cause disconnection within 0,3s / Surge dc-leakage currents should lead to a disconnection of: -30mA within 0,3s -60mA within 0,15s -150mA within 0,04s Before every connection to the grid, the d.c. array ground insulation has to be checked. (see 6.6.2.2.4).	For Residual Current Monitoring see table 6.6 below.	**P**
5	**General requirements:** Electromagnetic compatibility (EMC)		
	Emitted interference *DIN EN 61000-6-3 (VDE 0839-6-3)*	Covered by EMC report Report No.: CE200511N080, issued by Bureau Veritas Shenzhen Co.,Ltd.Dongguan Branch	**P**
	Interference resistance *DIN EN 61000-6-2 (VDE 0839-6-2)*	Covered by EMC report Report No.: CE200511N080, issued by Bureau Veritas Shenzhen Co.,Ltd.Dongguan Branch	**P**
6	**Type test :**	See following test report	
7.	**Routine test*:***	Routine testing described above	**P**

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Clause/§	**Requirement**	**Remark**	**Verdict**
8	**Specification of installation:**		**P**
	Annex		
A.1	**Additional Methods of monitoring anti islanding:**	Additional Methods can be added	**N/A**
A.4	**Disconnection for a short period**	If frequency fluctuation of <=3s occur, the reconnection after min. 5s is permitted.	**P**

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Clause	**Test**	**Result**
6.1 (4.1)	Functional safety	**P**
6.2 (4.2)	Monitoring of voltage	**P**
6.3 (4.3)	Monitoring of frequency	**P**
6.4 (4.4)	Monitoring of DC-Injection	**P**
6.5 (4.5)	Detection of anti-islanding (only one method is necessary!)	
	6.5.1 Measurement of impedance	**N/A**
	6.5.2 Resonant circuit test	**P**
	6.5.3 3-phase grid-voltage monitoring	**P**
6.6 (4.7)	Residual Current Monitoring	**P**

Test Results

6.1 Functional safety - fault condition tests								P
component No.	fault	test condition		test time	fuse No.	fault condition		result
		AC	DC			AC	DC	
PV inverter current monitoring defect R3	Short	230V 35A	850V 29A	10min.	--	230V 0,1A	850V <1A	Inverter disconnected from grid immediately. Error message:" HwPVOCP". No damaged. No hazard.
PV current monitoring defect R852	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" HwPVOCP". No damaged.No hazard
PV inverter current monitoring defect U1 pin1-3	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" HwPVOCP". No damaged.No hazard.
Relay detect RL1	Short before start-up	230V <1A	850V <1A	10min.	--	230V <1A	850V <1A	Inverter did not start-up. Error message:" RelayTestFail". No damage.No hazard.
Relay detect RL2	Short before start-up	230V <1A	850V <1A	10min.	--	230V <1A	850V <1A	Inverter did not start-up. Error message:" RelayTestFail". No damage.No hazard.
Relay detect RL3	Short before start-up	230V <1A	850V <1A	10min.	--	230V <1A	850V <1A	Inverter did not start-up. Error message:" RelayTestFail". No damage.No hazard.
Relay detect RL4	Short before start-up	230V <1A	850V <1A	10min.	--	230V <1A	850V <1A	Inverter did not start-up. Error message:" RelayTestFail". No damage.No hazard.
Relay detect RL5	Short before start-up	230V <1A	850V <1A	10min.	--	230V <1A	850V <1A	Inverter did not start-up. Error message:" RelayTestFail". No damage.No hazard.
Relay detect RL6	Short before start-up	230V <1A	850V <1A	10min.	--	230V <1A	850V <1A	Inverter did not start-up. Error message:" RelayTestFail". No damage.No hazard.
AC Voltage monitoring defect R56	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.
AC Voltage monitoring defect R58	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
AC Voltage monitoring defect R95	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.

AC Voltage monitoring defect R96	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.
AC Voltage monitoring defect R97	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.
AC Voltage monitoring defect R101	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
AC Voltage monitoring defect R102	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
AC Voltage monitoring defect R103	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
ISO detect R168	short before start-up	230V 0,1A	850V 0,1A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO detect R169	short before start-up	230V 0,1A	850V 0,1A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO detect R22	Open before start-up	230V 0,1A	850V 0,1A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO detect R23	short before start-up	230V 0,1A	850V 0,1A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO detect R186	Open before start-up	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO detect R188	Short before start-up	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO detect R193	Open before start-up	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.

ISO detect R194	Short before start-up	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO detect R174	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO detect R175	Short before start-up	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO detect R212	Open before start-up	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO detect R207	Short before start-up	230V 35A	850V 29A	10min.	--	230V 35A	850V 29A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
GFCI monitoring defect R421	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" AFCIFault". No damaged.No hazard.
GFCI protect R426	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" AFCIFault". No damaged.No hazard.
GFCI protect C275	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" AFCIFault". No damaged.No hazard.
GFCI protect C270	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" AFCIFault". No damaged.No hazard.
GFCI protect R413	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" AFCIFault". No damaged.No hazard.
GFCI protect U5-D pin12-14	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" AFCIFault". No damaged.No hazard.
GFCI protect U5-C pin10-8	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" AFCIFault". No damaged.No hazard.
GFCI protect C252	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" AFCIFault". No damaged.No hazard.

GFCI protect R411	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" AFCIFault". No damaged.No hazard.
PV voltage monitor defect R515	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" InvOVP" No damaged.No hazard.
PV voltage monitor defect R517	Open	230V 17A	850V 15A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" InvUVP" No damaged.No hazard.
PV voltage monitor defect R522	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" InvOVP" No damaged.No hazard.
PV voltage monitor defect R524	Open	230V 17A	850V 15A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" InvUVP" No damaged.No hazard.
PV voltage monitor defect R529	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" InvOVP" No damaged.No hazard.
PV voltage monitor defect R531	Open	230V 17A	850V 15A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" InvUVP" No damaged.No hazard.
PV voltage monitor defect R538	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" InvOVP" No damaged.No hazard.
PV voltage monitor defect R540	Open	230V 17A	850V 15A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" InvUVP" No damaged.No hazard.
Bus voltage detect R547	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" VbusRmsUnbalance". No damaged.No hazard.
Bus voltage detect R549	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" VbusRmsUnbalance". No damaged.No hazard.
Bus voltage detect R552	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" VbusRmsUnbalance". No damaged.No hazard.

Bus voltage detect R554	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" VbusRmsUnbalance". No damaged.No hazard.
Bus voltage detect R557	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" VbusRmsUnbalance". No damaged.No hazard.
Bus voltage detect R559	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" VbusRmsUnbalance". No damaged.No hazard.
Bus voltage detect R562	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" VbusRmsUnbalance". No damaged.No hazard.
Bus voltage detect R564	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" VbusRmsUnbalance". No damaged.No hazard.
Grid voltage monitor defect R601	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.
Grid voltage monitor defect R602	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
Grid voltage monitor defect R589	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
Grid voltage monitor defect R590	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.
Grid voltage monitor defect R597	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
Grid voltage monitor defect R596	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.

Grid voltage monitor defect R569	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
Grid voltage monitor defect R836	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.
Grid voltage monitor defect R574	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
Grid voltage monitor defect R839	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.
Grid voltage monitor defect R578	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
Grid voltage monitor defect R841	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.
Grid voltage monitor defect R583	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridOVP". No damaged.No hazard.
Grid voltage monitor defect R587	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" GridUVP". No damaged.No hazard.
BUS voltage monitoring defect R613	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" BUS voltage is low". No damaged.No hazard.
BUS voltage monitoring defect R614	Short	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" Inverter bus hardware overvoltage". No damaged.No hazard.
ISO monitoring defect R189	Open before start-up	230V <1A	850V <1A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.

ISO monitoring defect R510	Short before start-up	230V <1A	850V <1A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO monitoring defect R799	Open before start-up	230V <1A	850V <1A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
ISO monitoring defect R801	Short before start-up	230V <1A	850V <1A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" IsoFault". No damaged.No hazard.
Communic ationdefect U13 pin82	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" BluetoothFault". No damaged.No hazard.
Communic ationdefect U13 pin95	Open	230V 35A	850V 29A	10min.	--	230V <1A	850V <1A	Inverter disconnected from grid immediately. Error message:" BluetoothFault". No damaged.No hazard.

Note:

The errors in the control circuit simulate that the safety is even under one error ensured.

s-c: short circuit; o-c: open circuit
* Before start-up.

The conditions and testing is performed according to VDE V 0124-100, 5.4.5.2

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.
The test results refer to the report PV200511N080-7 issued by Bureau Veritas Shenzhen Co.,Ltd.Dongguan Branch on 2020-12-18.

6.2 (4.2.3) Overvoltage protection according to DIN EN 50160:2000-03, 2.3			**P**
Setting values:		Setting U> [V]	253
		Setting $T_{disconnection}$ U> [s]	600
		Setting $T_{disconnection}$ [ms]	200
Test:			
		Disconnection time:	Limit:
a)	The voltage is set to 100% U_n and held for 600 s. Thereafter the voltage is set to 112% Un. Disconnection must take place within 600 s.		
	Phase 1	491 s	≤ 600 s
	Phase 2	486 s	
	Phase 3	486 s	
b)	The voltage is set to U_n for 600 s and then to 108% Un for 600 s. No disconnection should take place.		
	Phase 1	No Disconnection	Disconnection should not take place.
	Phase 2	No Disconnection	
	Phase 3	No Disconnection	
c)	The voltage is set to 106 % U_n and held for 600 s. Thereafter the voltage is set to 114 % U_n. Disconnection must take place within 300 s or about 50 % of the disconnection time measured in point a).*		
	Phase 1	302 s	The disconnection time should be about 50 % of the value measured in a), *
	Phase 2	294 s	
	Phase 3	290 s	

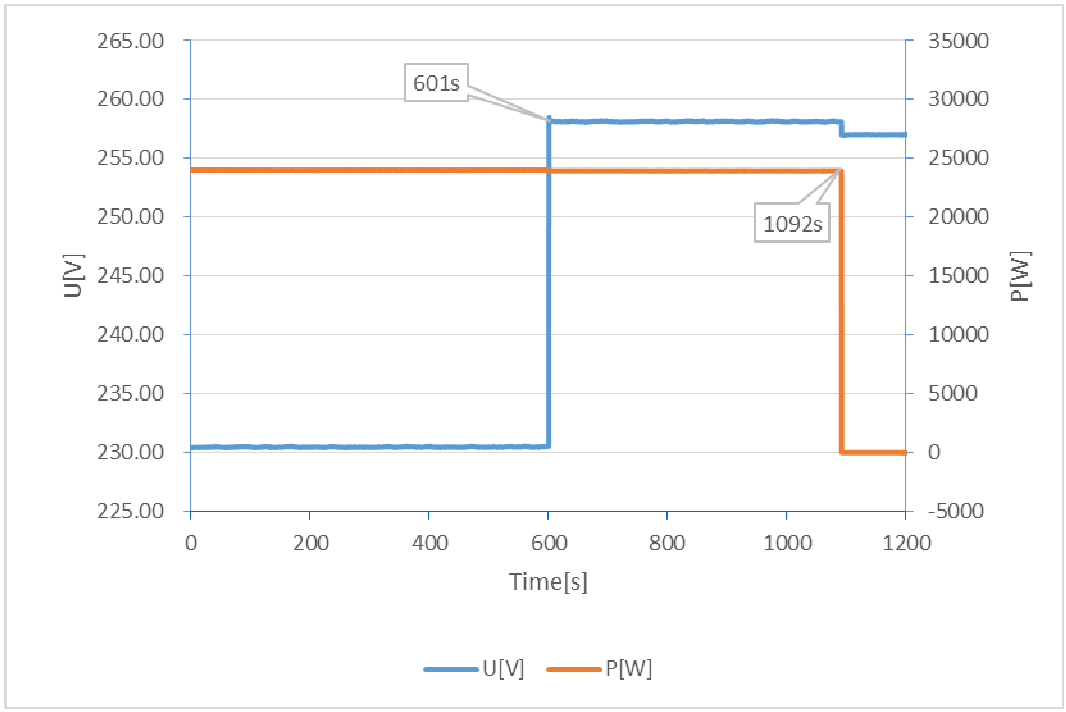
Note:

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.

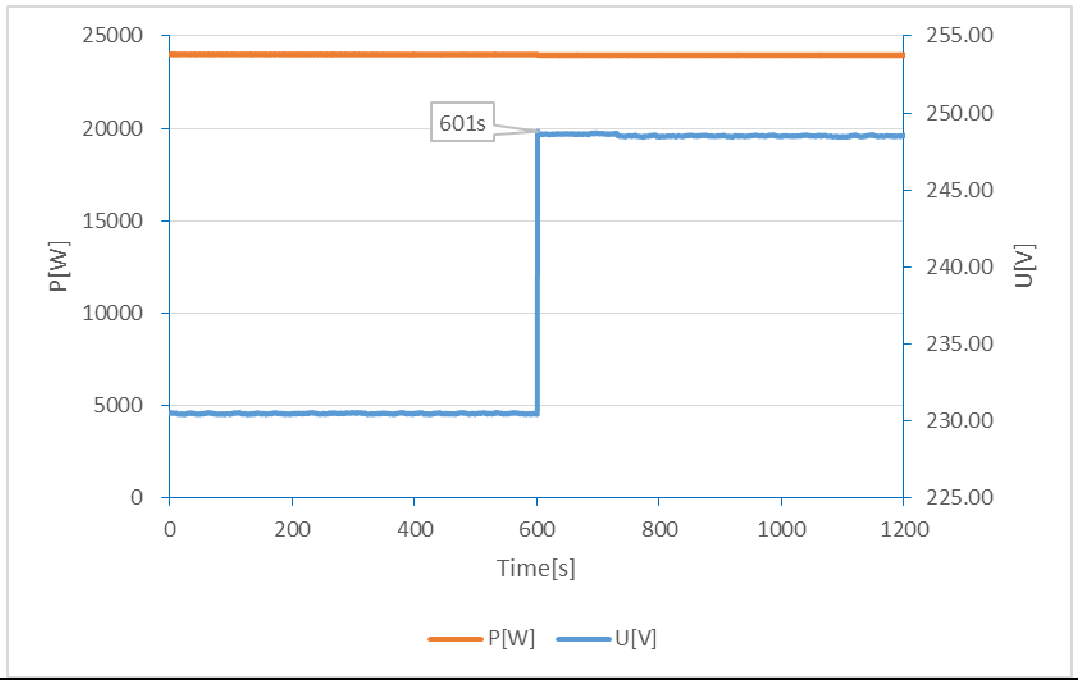
*If the setting value is set to 600 s, then the disconnection time can be in the range between 225 s and 375 s.

The test results refer to the report PV200511N080-7 issued by Bureau Veritas Shenzhen Co.,Ltd.Dongguan Branch on 2020-12-18.

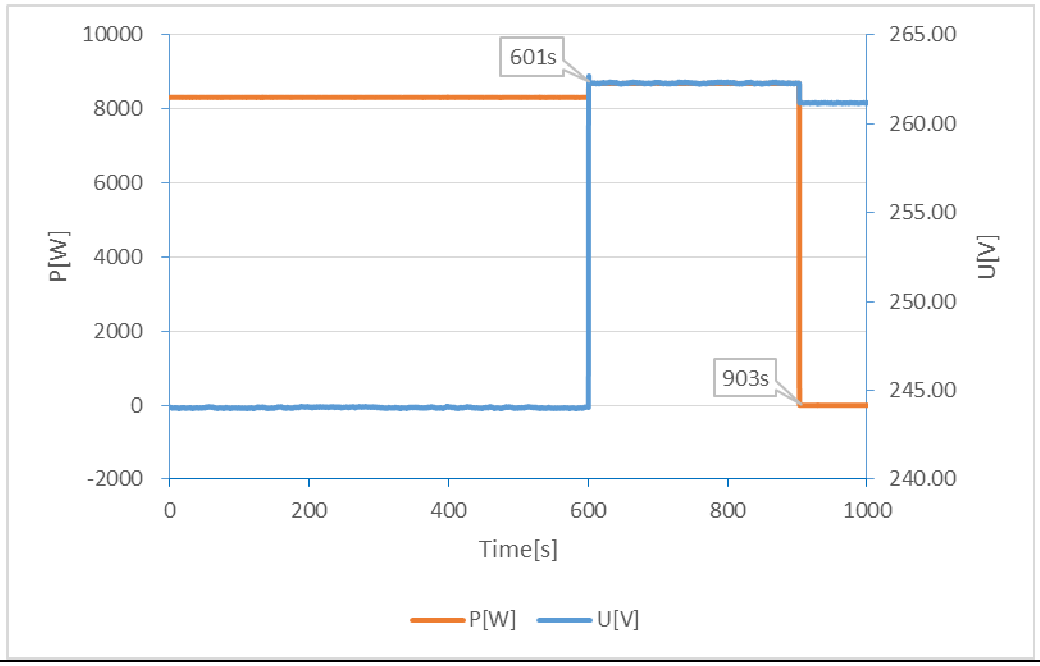
a) Voltage set to 112 % U_n:



b) Voltage set to 108% U_n:



c) Voltage set to 106 % U_n, thereafter 114% U_n:



6.3 (4.3) Frequency monitoring
DIN V VDE V 0126-1-1/A1 VFR2019

P

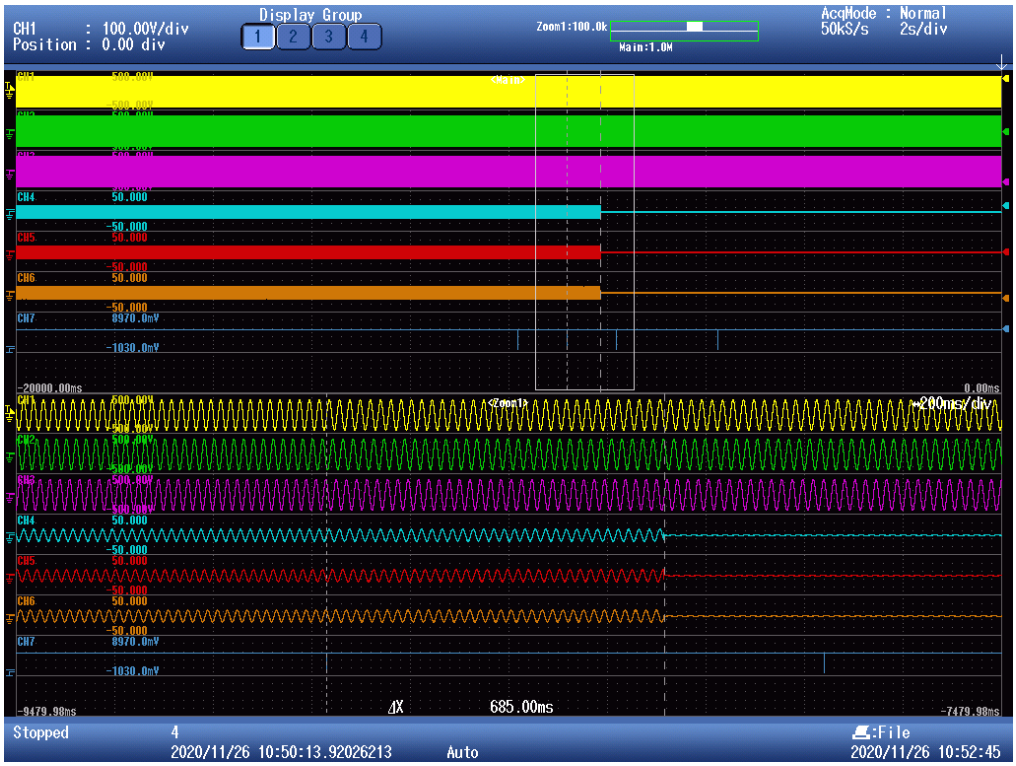
Test conditions:	Output power: 12000W							
	Under frequency				**Over frequency**			
Parameter	Frequency [Hz]	Time [ms]			Frequency [Hz]	Time [ms]		
Output Voltage		80%U_N	U_N	115%U_N		80%U_N	U_N	115%U_N
Limit	47,5Hz	<= 200ms			51,5Hz	<= 200ms		
Trip value		47,50	47,50	47,50		51,50	51,50	51,50
Disconnection time (ms)	48,00Hz to 47,00Hz	177,5	176,0	185,0	51,00Hz to 52,00Hz	169,0	165,5	165,0
		173,5	180,0	181,0		170,0	165,5	167,0
Reconnection time (fluctuation <=3s):	>= 5s	-			>= 5s	-		
Reconnection time (fluctuation >3s):	>= 60s	71,0			>= 60s	71,0		

Note:

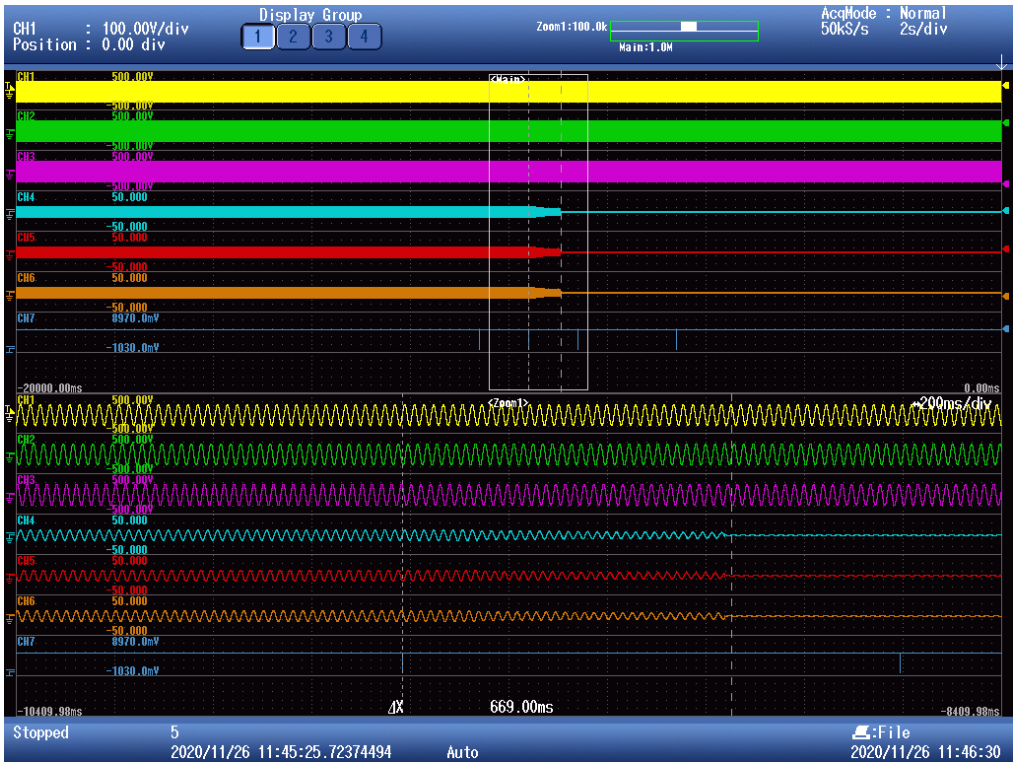
It was measured at a continuous change of frequency of 1Hz/s at lower, nominal and upper U_N and arbitary output power. The trip value was determined manually by reducing the frequency in 10mHz steps. When the trip value is known (e.g. 47,50Hz), the ac-source is programmed to run from e.g. 48,00Hz to 47,00Hz with 1Hz/s. The disconnection time is calculated by the measured time minus the 500ms from 48,00Hz to 47,50Hz.

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.

Under frequency:



Over frequency:



Island 50Hz

6.3 (4.3) Frequency monitoring according protection de Découplage pour le Raccordement d'une production décentralisée en HTA et en BT dans les zones non interconnectées, référentiel technique – SEI REF 04, V5	**P**

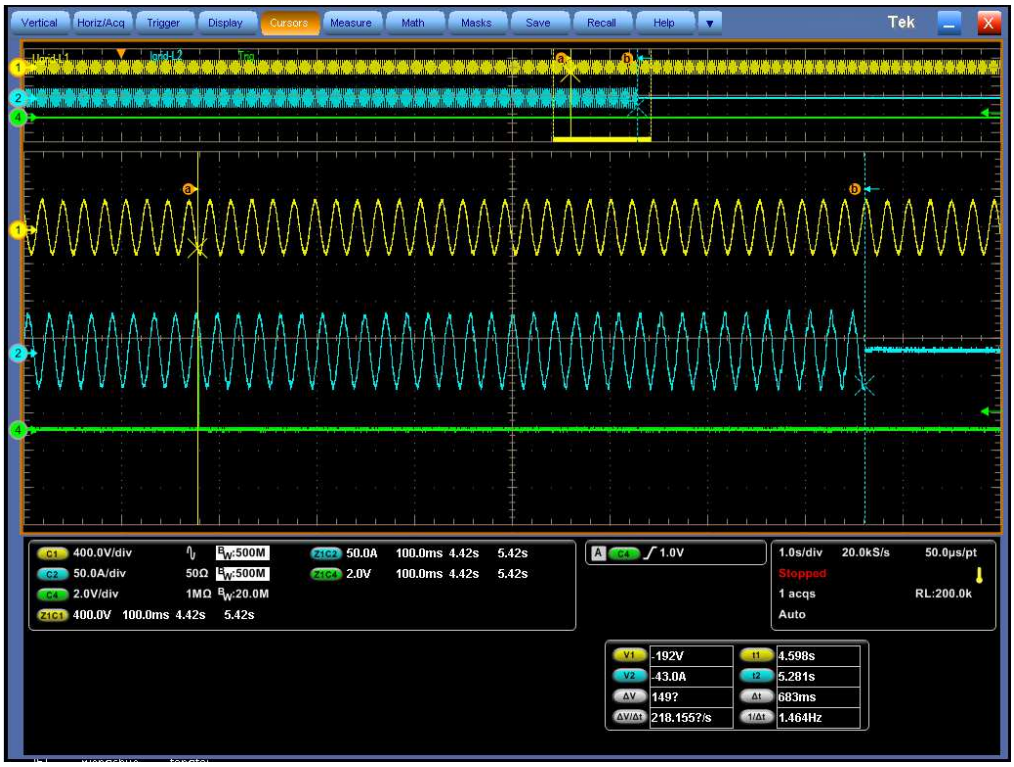
Test conditions:	Output power: 12000W							
	Under frequency				**Over frequency**			
Parameter	Frequency [Hz]	Time [ms]			Frequency [Hz]	Time [ms]		
Output Voltage		80%U_N	U_N	111%U_N		80%U_N	U_N	111%U_N
Limit	46,0Hz	200ms	200ms	200ms	52,0Hz	200ms	200ms	200ms
Trip value		45,99	45,99	45,99		52,00	52,00	52,00
Disconnection time (ms)	46,5 Hz to 45,5Hz	158,0	171,0	187,0	51,5 Hz to 52.5Hz	150,0	165,0	170,0
		177,0	167,0	185,0		153,0	166,0	170,0
Reconnection time (fluctuation <=3s):	>= 5s	-			>= 5s	-		
Reconnection time (fluctuation >3s):	>= 60s	70,0			>= 60s	70,0		

Note:

It was measured at a continuous change of frequency of 1Hz/s at lower, nominal and upper U_N and arbitary output power. The trip value was determined manually by reducing the frequency in 10mHz steps. When the trip value is known (e.g. 46,00Hz), the ac-source is programmed to run from e.g. 46,50Hz to 45,50Hz with 1Hz/s. The disconnection time is calculated by the measured time minus the 500ms from 46,50Hz to 45,50Hz.

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.

Under frequency:



Over frequency:

Island 60Hz

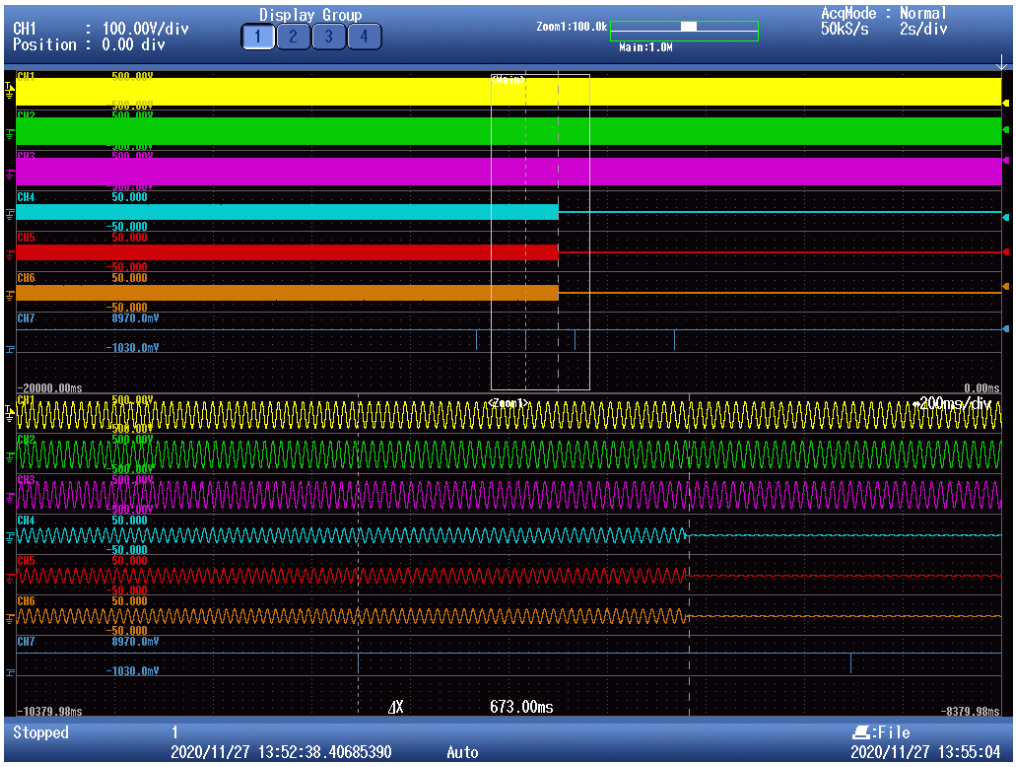
6.3 (4.3) Frequency monitoring according contrat de raccordement, d'accès et d'exploitation (CRAE) pour une installation de production photovoltaïque raccordée au réseau public d'électricité	**P**

Test conditions:	Output power: 12000W							
	Under frequency				**Over frequency**			
Parameter	Frequency [Hz]	Time [ms]			Frequency [Hz]	Time [ms]		
Output Voltage		85%U_N	U_N	115%U_N		85%U_N	U_N	115%U_N
Limit	55,0Hz	200ms	200ms	200ms	62,5Hz	200ms	200ms	200ms
Trip value		54,99	54,99	54,99		62,50	62,50	62,50
Disconnection time (ms)	55,5 Hz to 54,5Hz	157,0	173,0	161,0	62,0Hz to 63,0Hz	152,0	158,0	145,0
		158,0	166,0	162,0		154,0	144,0	145,0
Reconnection time (fluctuation <=3s):	>= 5s	-			>= 5s	-		
Reconnection time (fluctuation >3s):	>= 60s	69,8s			>= 60s	70,2s		

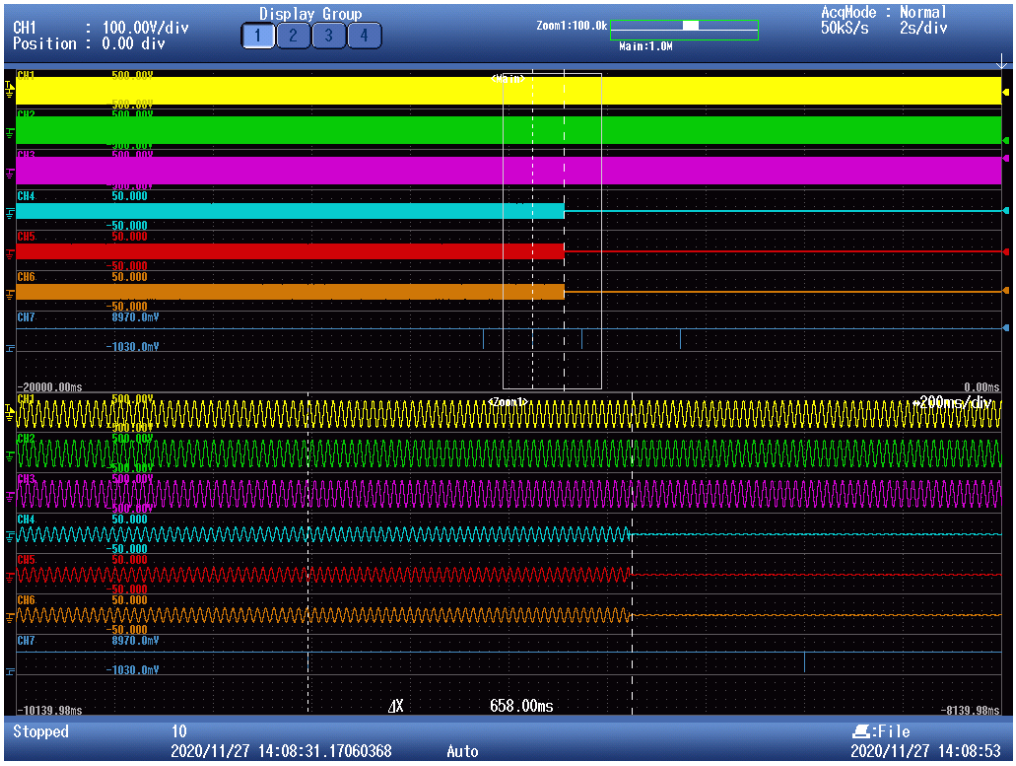
Note:
It was measured at a continuous change of frequency of 1Hz/s at lower, nominal and upper U_N and arbitary output power. The trip value was determined manually by reducing the frequency in 10mHz steps. When the trip value is known (e.g. 55,00Hz), the ac-source is programmed to run from e.g. 55,50Hz to 54,50Hz with 1Hz/s. The disconnection time is calculated by the measured time minus the 500ms from 55,50Hz to 54,50Hz.

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.

Under frequency:



Over frequency:



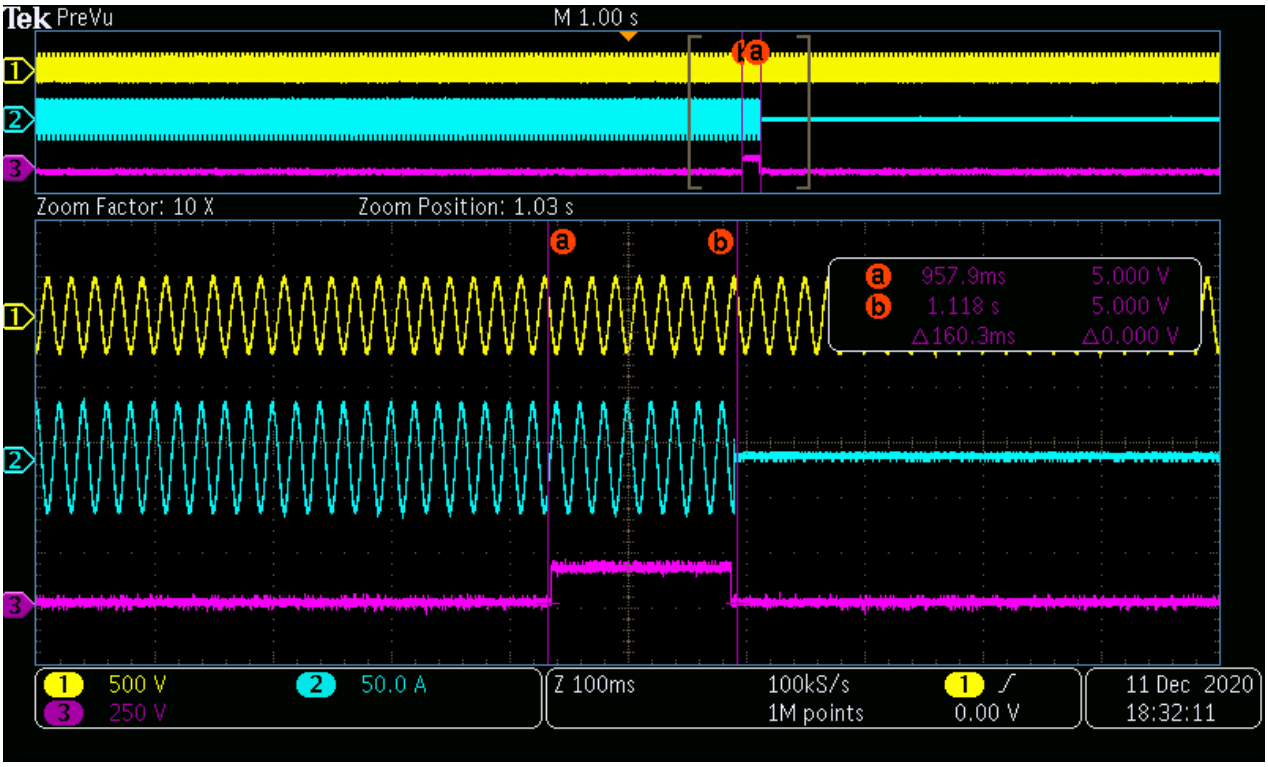
6.4 (4.4) Monitoring of DC-Injection				**P**
Test conditions:	U_N = 230Vac; Uinput = 620Vd.c. Rated Power: 24kW			
DC Injection [A]	**Limits**	**Trip Time [ms]**		
		L1 Phase	**L2 Phase**	**L3 Phase**
+1A	I_{DC}:>1A than disconnection within 0,2 sec	160	159	142
-1A	I_{DC}:>1A than disconnection within 0,2 sec	159	157	160

Note:
A dc-current of 1A is injected, disconnection time of max. 0,2s

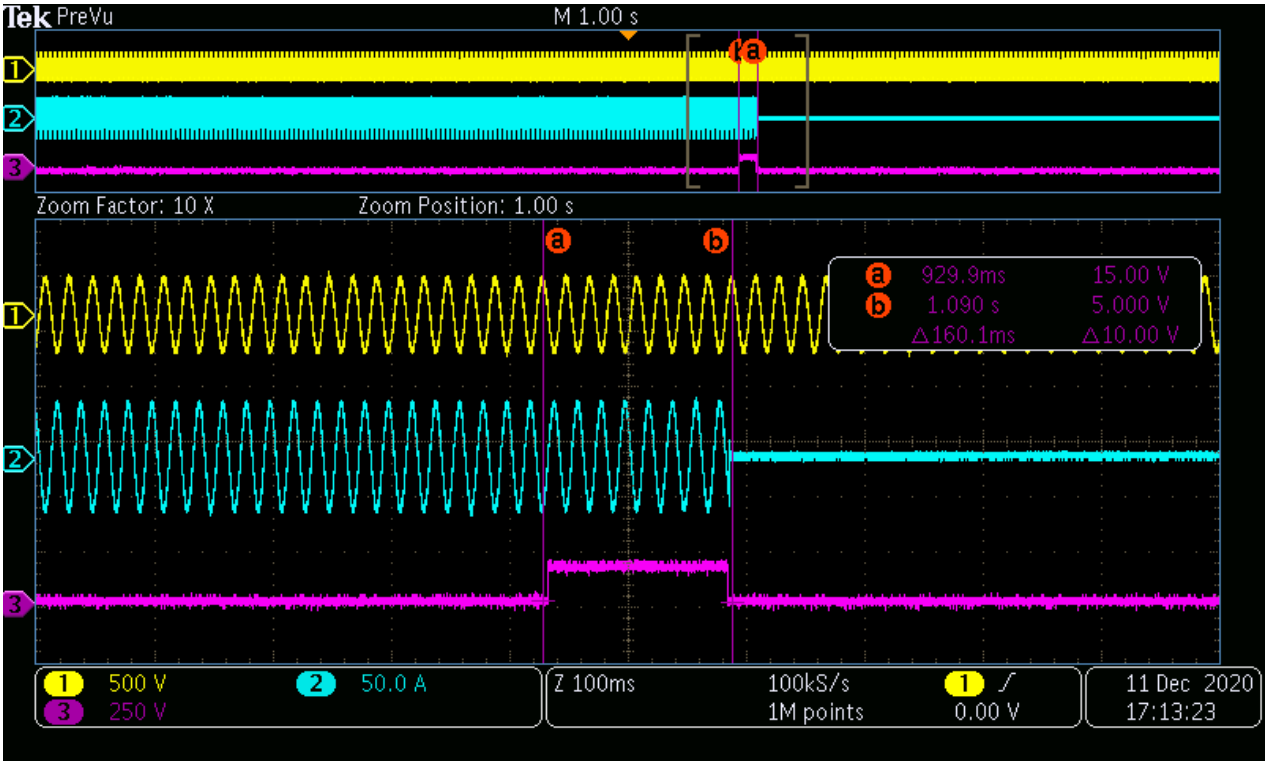
The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.

The test results refer to the report 20TH0192-CEI0-21_0 issued by Bureau Veritas Shenzhen Co.,Ltd.Dongguan Branch on 2020-12-14.

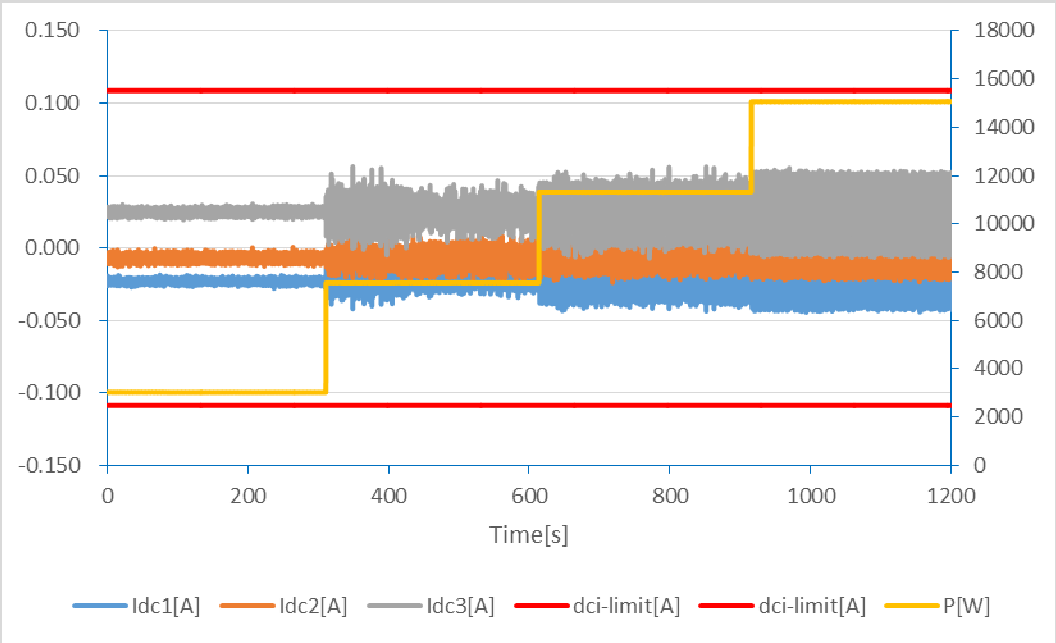
Positive DC-Injection:



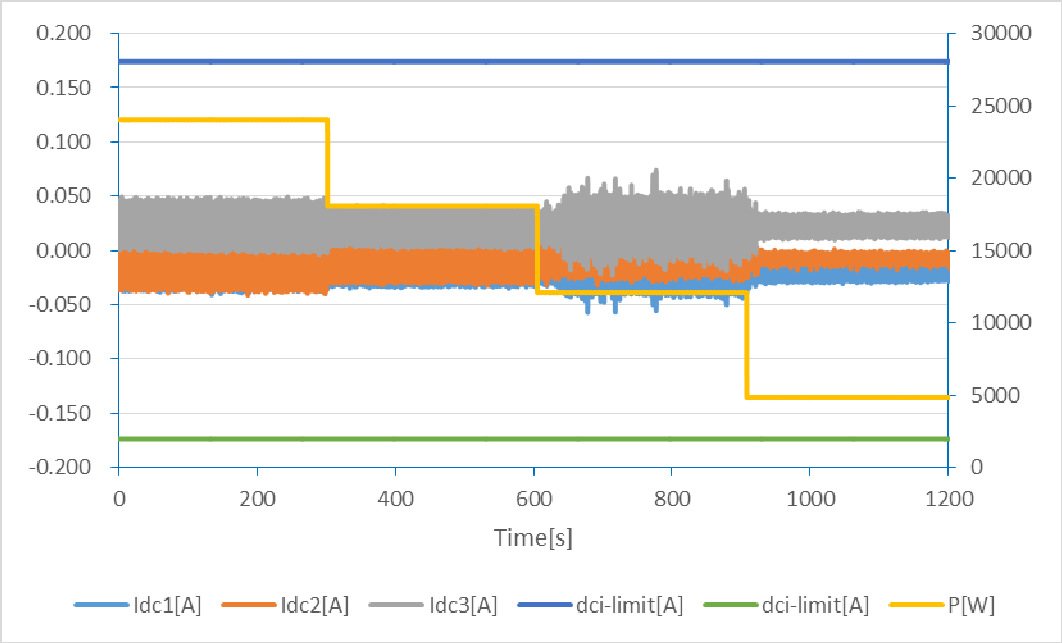
Negative DC-Injection



DC-Injection				**P**
SOFAR 15KTLX-G3				
Protection limit	Tested at four power levels limit 0,5% of IAC;nom			
Output power	~20%	~50%	75%	~100%
L1 Abs. Max. test value [A]	0,028	0,042	0,044	0,044
L1 Abs. Ave. test value [A]	0,023	0,023	0,023	0,023
L2 Abs. Max. test value [A]	0,013	0,024	0,024	0,023
L2 Abs. Ave. test value [A]	0,007	0,008	0,008	0,010
L3 Abs. Max. test value [A]	0,031	0,056	0,056	0,055
L3 Abs. Ave. test value [A]	0,025	0,024	0,024	0,025



SOFAR 24KTLX-G3				
Protection limit	Tested at four power levels limit 0,5% of IAC;nom			
Output power	~20%	~50%	75%	~100%
L1 Abs. Max. test value [A]	0,039	0,057	0,035	0,041
L1 Abs. Ave. test value [A]	0,022	0,022	0,023	0,024
L2 Abs. Max. test value [A]	0,025	0,032	0,032	0,041
L2 Abs. Ave. test value [A]	0,007	0,010	0,013	0,017
L3 Abs. Max. test value [A]	0,046	0,074	0,041	0,049
L3 Abs. Ave. test value [A]	0,023	0,023	0,021	0,023



Note:

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.

The test results refer to the report PV200511N080-7 issued by Bureau Veritas Shenzhen Co.,Ltd.Dongguan Branch on 2020-12-18.

6.5 (4.5) Detection of Anti-Islanding	**P**
6.5.2 Resonant circuit test	**P**

Test conditions:	Frequency: 50+/-0,2Hz U_N=230+/-3Vac RLC consumes inverter real power within +/-3% Distortion factor of chokes <3% Quality Q>2		
L1 phase			
Disconnection limit:	5000 ms		
Output power: / Osc. Parameter	25%	50%	100%
- 5%	121,5	117,3	102,0
- 4%	127,7	122,0	103,0
- 3%	115,5	133,7	102,0
- 2%	123,0	123,7	113,0
- 1%	136,7	145,7	118,0
0 %	291,0	456,0	125,0
+1 %	120,3	143,5	115,5
+2 %	125,0	139,3	118,5
+3 %	123,7	133,8	126,5
+4 %	127,7	129,5	125,0
+5 %	116,0	125,0	119,0
Parameter at 0%	L= 39,25 mH R= 26,68 Ω C= 256,93 µF	L= 20,84 mH R= 13,25 Ω C= 486,79 µF	L= 10,04 mH R= 6,65 Ω C= 1016,31 µF
L2 phase			
Output power: / Osc. parameter	25%	50%	100%
- 5%	114,3	100,0	103,5
- 4%	130,0	111,0	126,5
- 3%	127,5	110,5	122,5
- 2%	122,2	116,5	112,5
- 1%	131,0	106,0	122,5
0%	128,5	102,5	118,5
+1%	136,5	119,0	112,5
+2%	120,2	121,0	125,5
+3%	131,7	118,0	106,0
+4%	123,5	119,0	115,0
+5%	133,7	106,5	104,5
Parameter at 0%	L= 40,00 mH R= 26,83 Ω	L= 21,00 mH R= 13,20 Ω	L= 10,05 mH R= 6,66 Ω

	C= 253,32 µF	C= 483,78 µF	C= 1013,9 µF
L3 phase			
Output power: / Osc. parameter	25%	50%	100%
- 5%	121,0	100,0	100,5
- 4%	123,5	111,0	114,0
- 3%	120,5	110,5	110,0
- 2%	119,5	116,5	105,5
- 1%	119,0	106,0	114,5
0%	125,0	102,5	129,0
+1%	114,0	119,0	114,5
+2%	113,0	121,0	122,5
+3%	119,0	118,0	122,5
+4%	124,5	119,0	121,0
+5%	119,5	106,5	120,0
Parameter at 0%	L= 41,99 mH R= 26,34Ω C= 241,29 µF	L= 21,00 mH R= 13,20Ω C= 483,78 µF	L= 9,94 mH R= 6,64 Ω C= 1021,72 µF

Note:
The capacitors and the Chokes of the resonant circuit were adjusted in order to reach a quality of >2. $P_{QC}+P_{QL}=-P_{Q,WR}$. The resitors of the resonant circuit consumed the real power of the inverter (P_{WR}) within +/- 3%.

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.

Oscillating circuit test: 25% output power

Oscillating circuit test: 50% output power

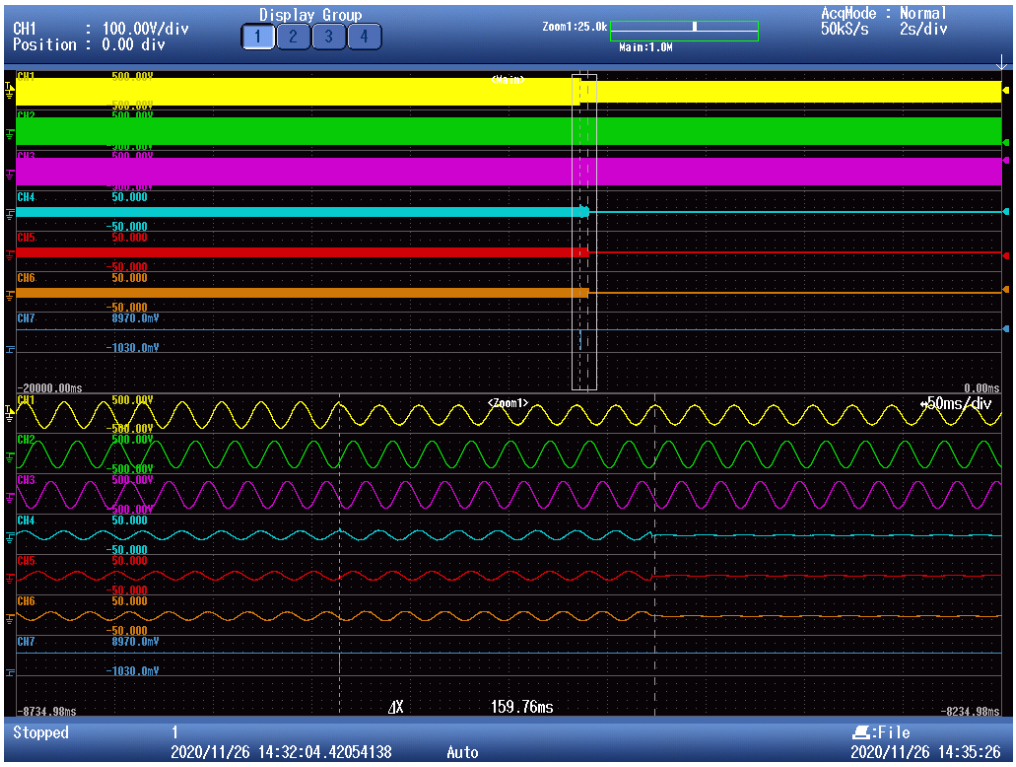
Oscillating circuit test: 100% output power

6.5.3 3-phase grid-voltage monitoring							**P**
Test Condition:			Frequency: 50+/-0,2Hz U_N=230Vac				
Phase	**Limit:**	**Voltage step: (to min. 177,1 or max. 270,9)**	**Trip value [V]:**	**Reconnection time if <=3s [s]:**	**Reconnection time if >3s [s]:**	**Disconnection time [ms]:**	**Limit [ms]:**
L1	80% of Un	190V->180V	182,0	N/A	70,6	160	**200**
		230V->180V				146	
	115% of Un	260V->270V	264,6	N/A	70,5	164	**200**
		230V->270V				158	
L2	80% of Un	190V->180V	181,5	N/A	70,3	160	**200**
		230V->180V				158	
	115% of Un	260V->270V	264,3	N/A	70,6	168	**200**
		230V->270V				152	
L3	80% of Un	190V->180V	181,8	N/A	70,7	152	**200**
		230V->180V				145	
	115% of Un	260V->270V	264,3	N/A	70,2	156	**200**
		230V->270V				154	

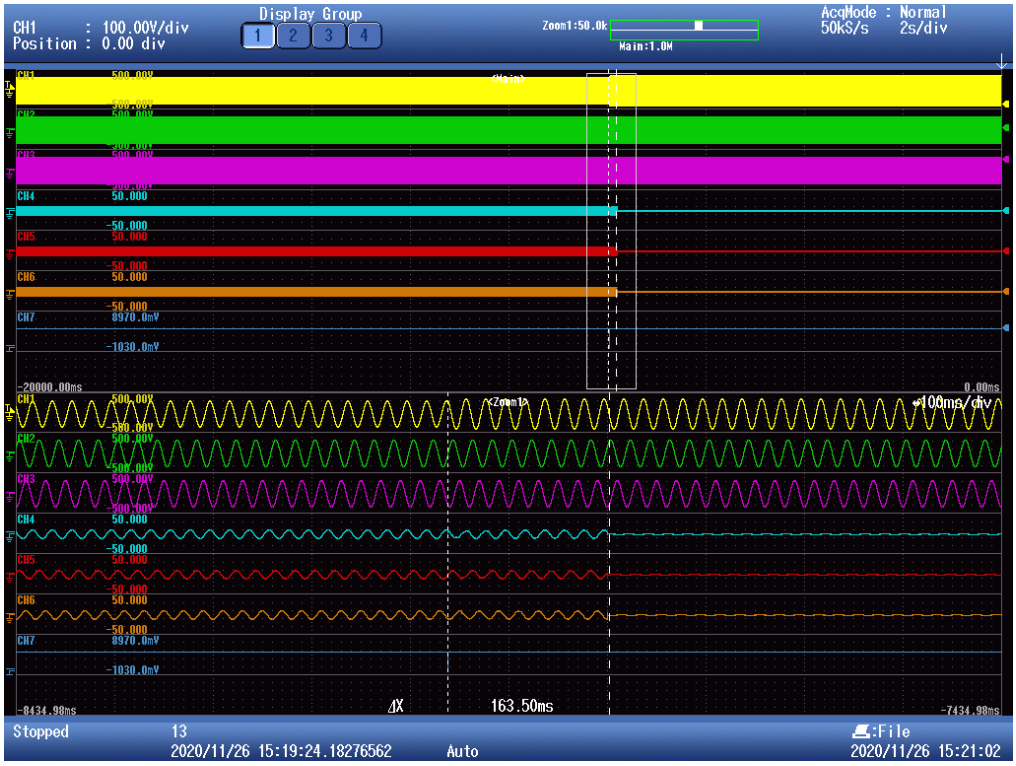
Note:
Lower and upper threshold voltage shall not fall or rise below or above 3% of the threshold voltage itself (min. 177,1V; max. 270,9V). The measurement shall take place at nominal frequency and any power.

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.

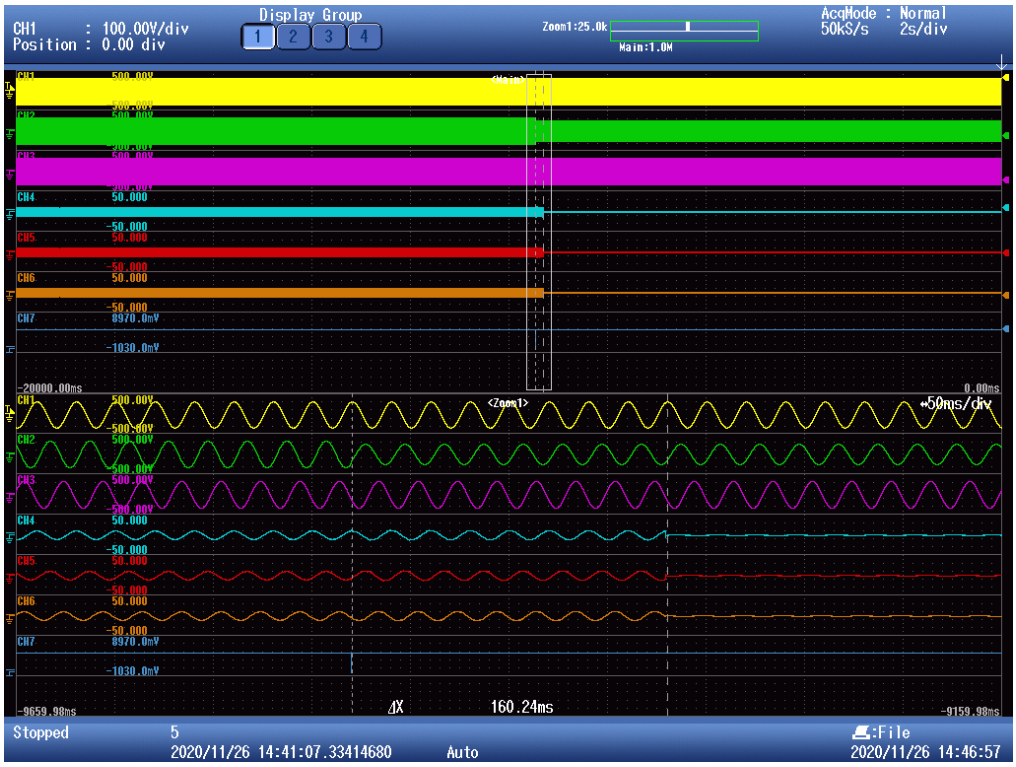
Under voltage: L1 phase



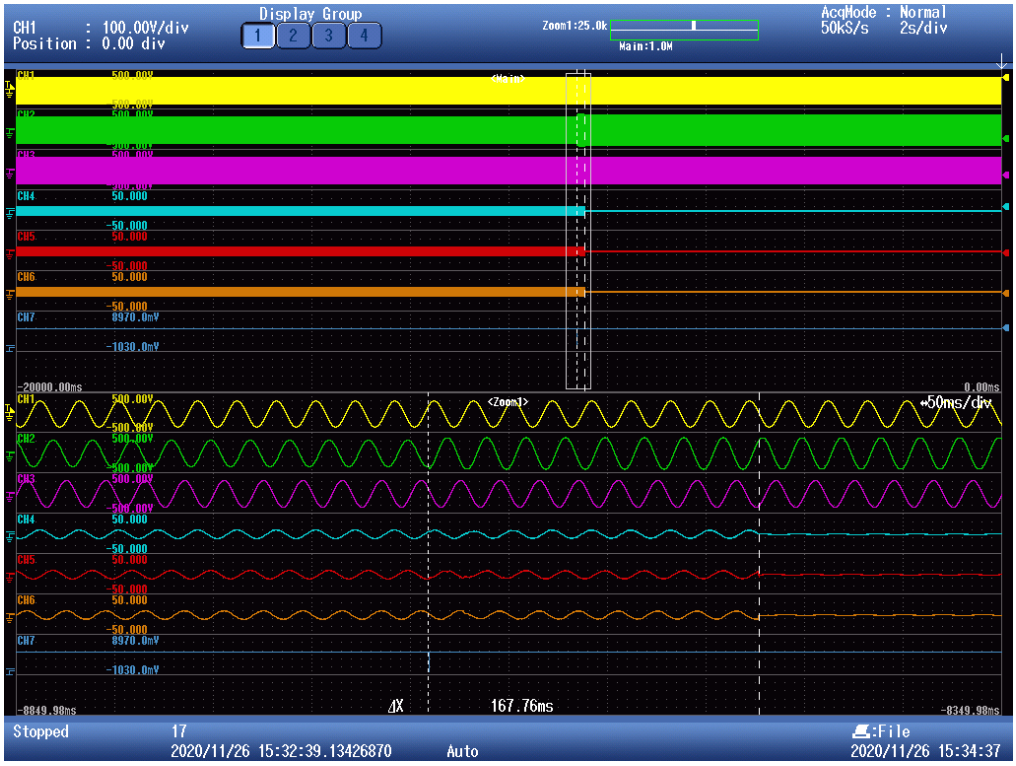
Over voltage: L1 phase



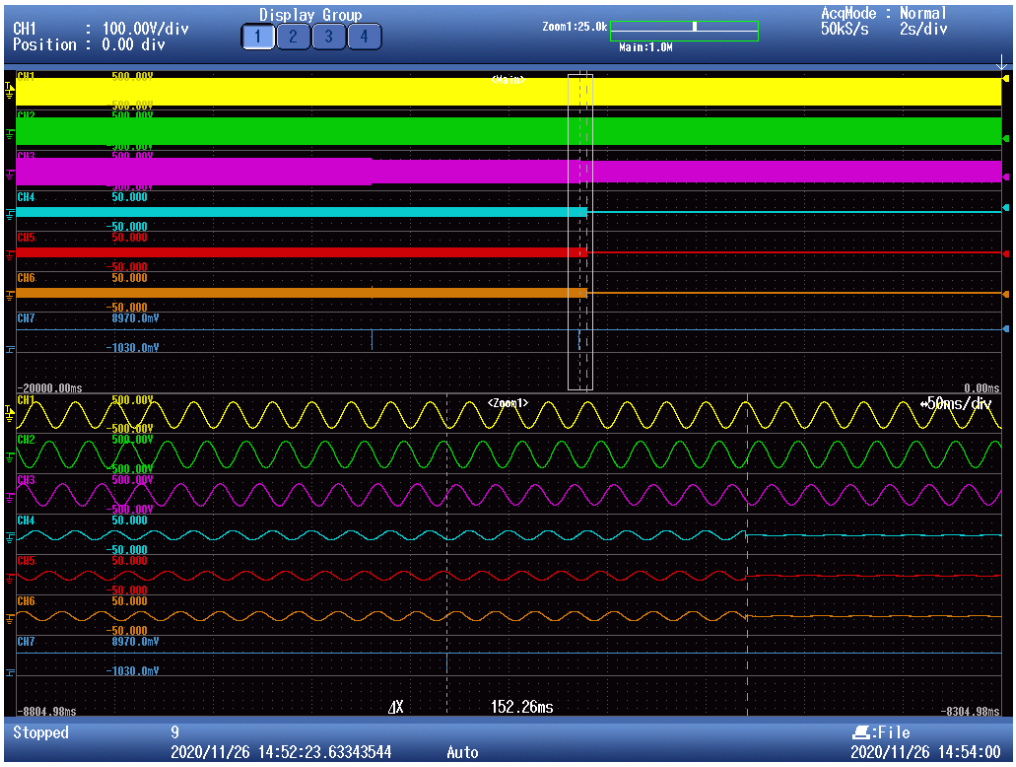
Under voltage: L2 phase



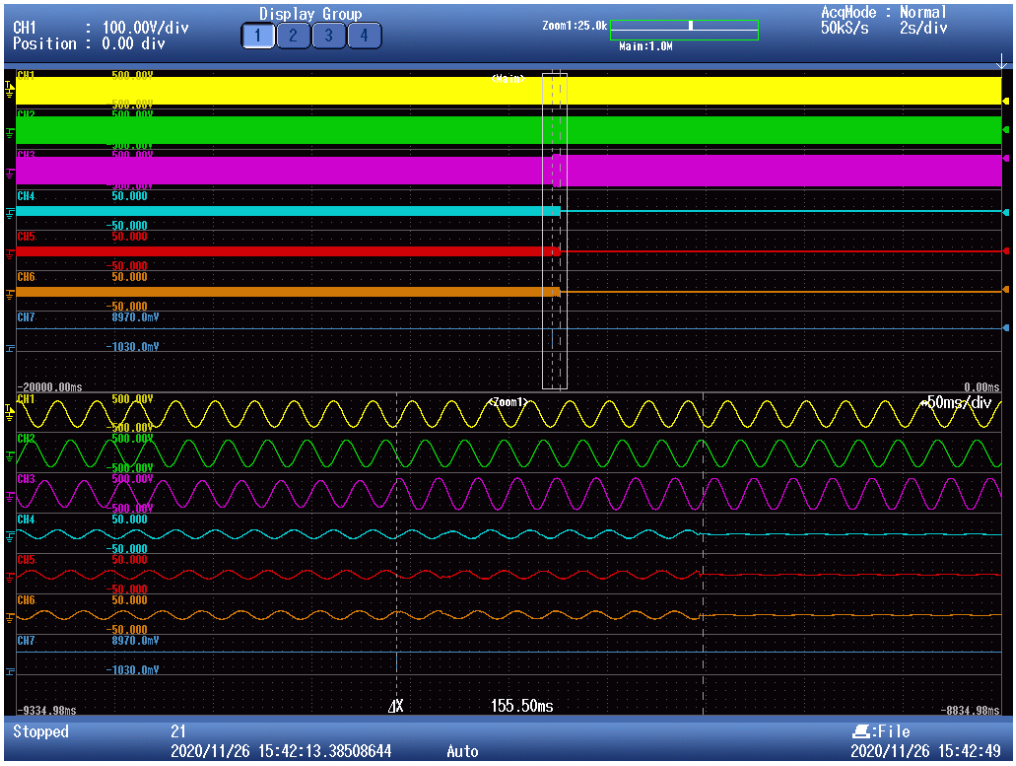
Over voltage: L2 phase



Under voltage: L3 phase



Over voltage: L3 phase



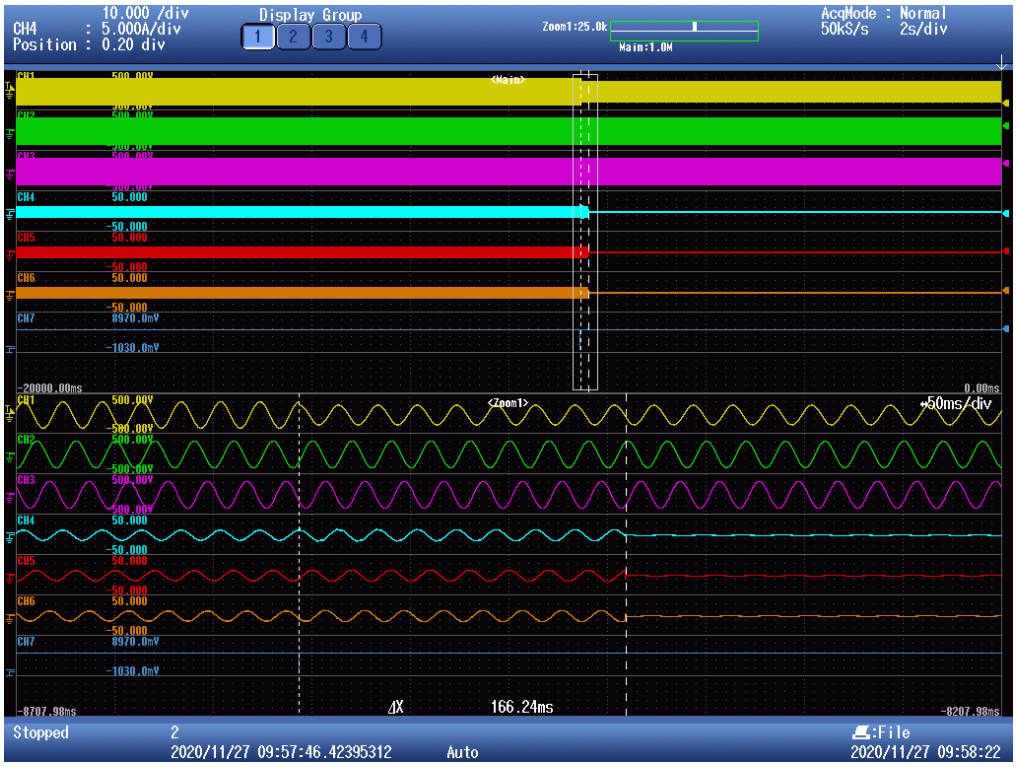
Island 50Hz

6.5.3.3 Voltage monitoring according protection de Découplage pour le Raccordement d'une production décentralisée en HTA et en BT dans les zones non interconnectées, référentiel technique – SEI REF 04, V5							**P**
Test Condition:			Frequency: 50+/-0,2Hz U_N=230Vac				
Phase	**Limit:**	**Voltage step: (to min. 177,1 or max. 270,9)**	**Trip value [V]:**	**Reconnection time if <=3s [s]:**	**Reconnection time if >3s [s]:**	**Disconnection time [ms]:**	**Limit [ms]:**
L1	85% of Un	199V->189V	182,0	N/A	70,3	154	**200**
		230V->189V				166	
	110% of Un	250V->260V	254,9	N/A	70,1	163	**200**
		230V->260V				163	
L2	85% of Un	199V->189V	181,4	N/A	70,1	153	**200**
		230V->189V				154	
	110% of Un	250V->260V	254,7	N/A	70,0	153	**200**
		230V->260V				162	
L3	85% of Un	199V->189V	181,7	N/A	70,1	167	**200**
		230V->189V				163	
	110% of Un	250V->260V	254,7	N/A	69,9	164	**200**
		230V->260V				150	

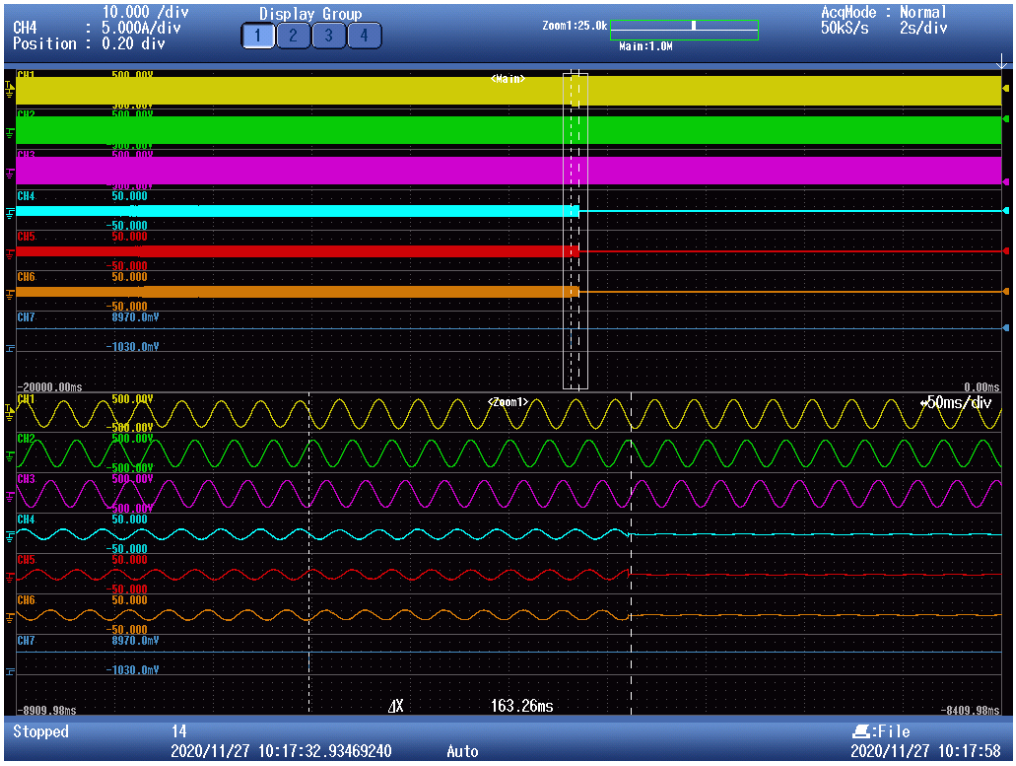
Note:
Lower and upper threshold voltage shall not fall or rise below or above 3% of the threshold voltage itself (min. 177,1V; max. 270,9V). The measurement shall take place at nominal frequency and any power.

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.

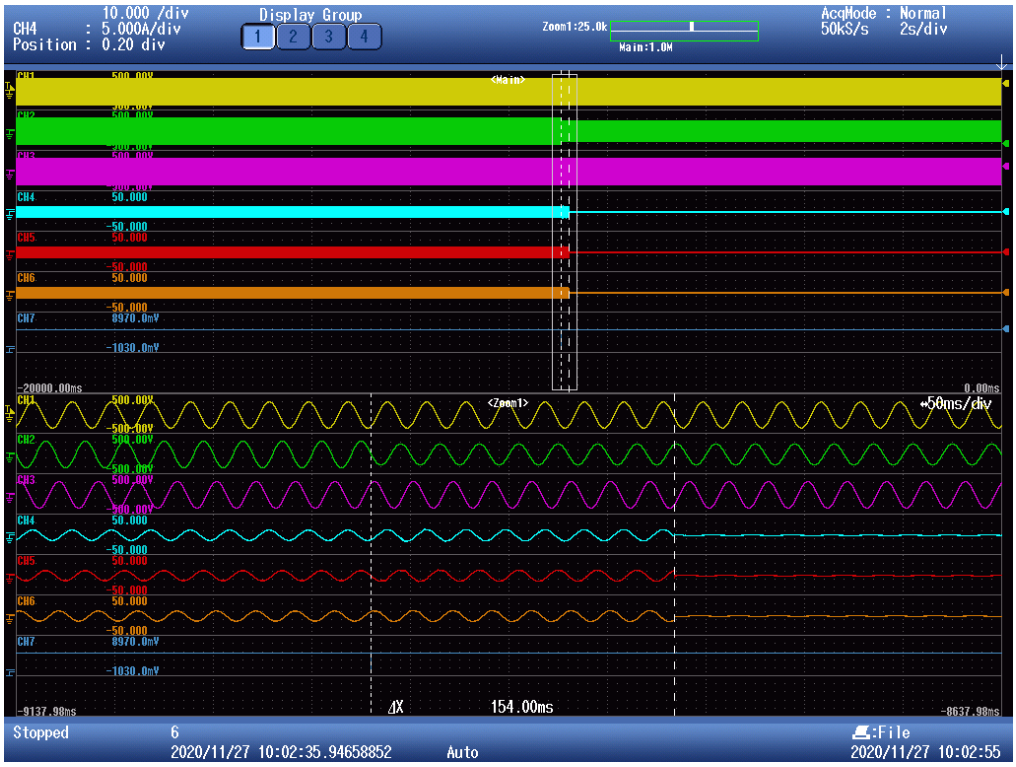
Under voltage: L1 phase



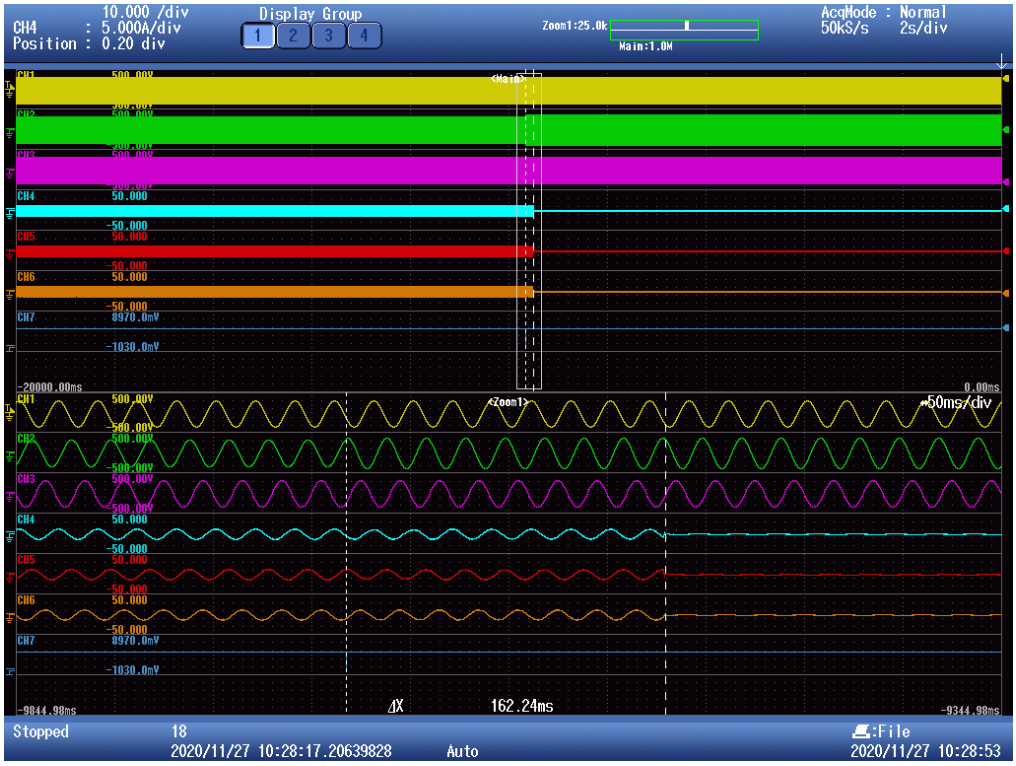
Over voltage: L1 phase



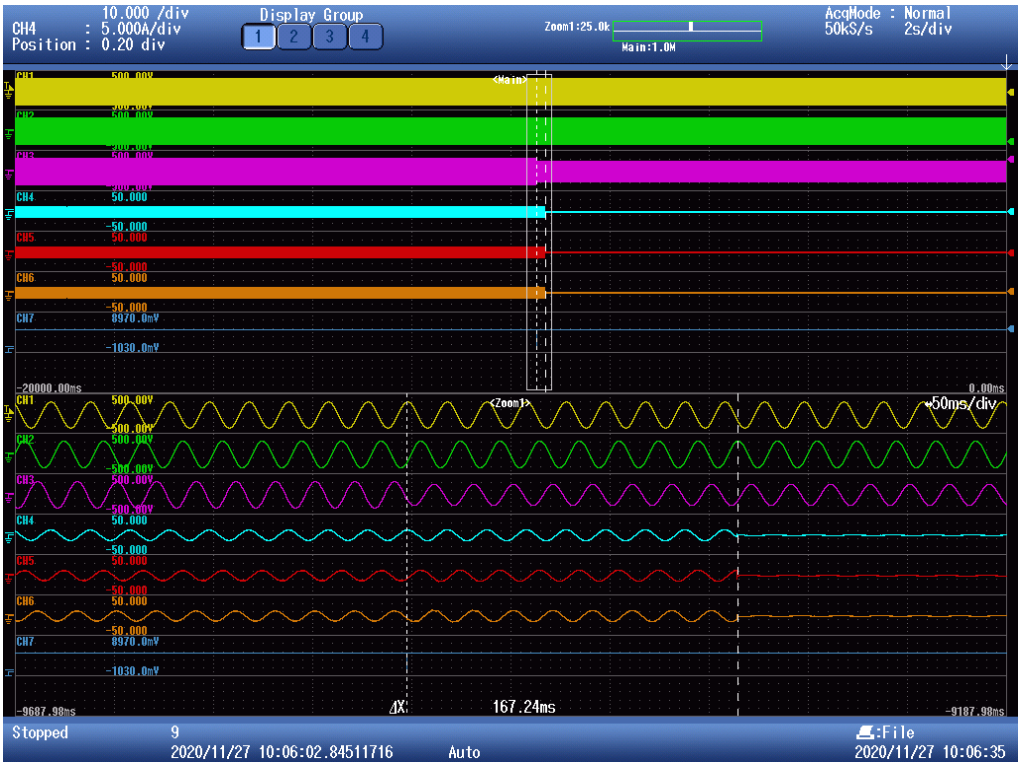
Under voltage: L2 phase



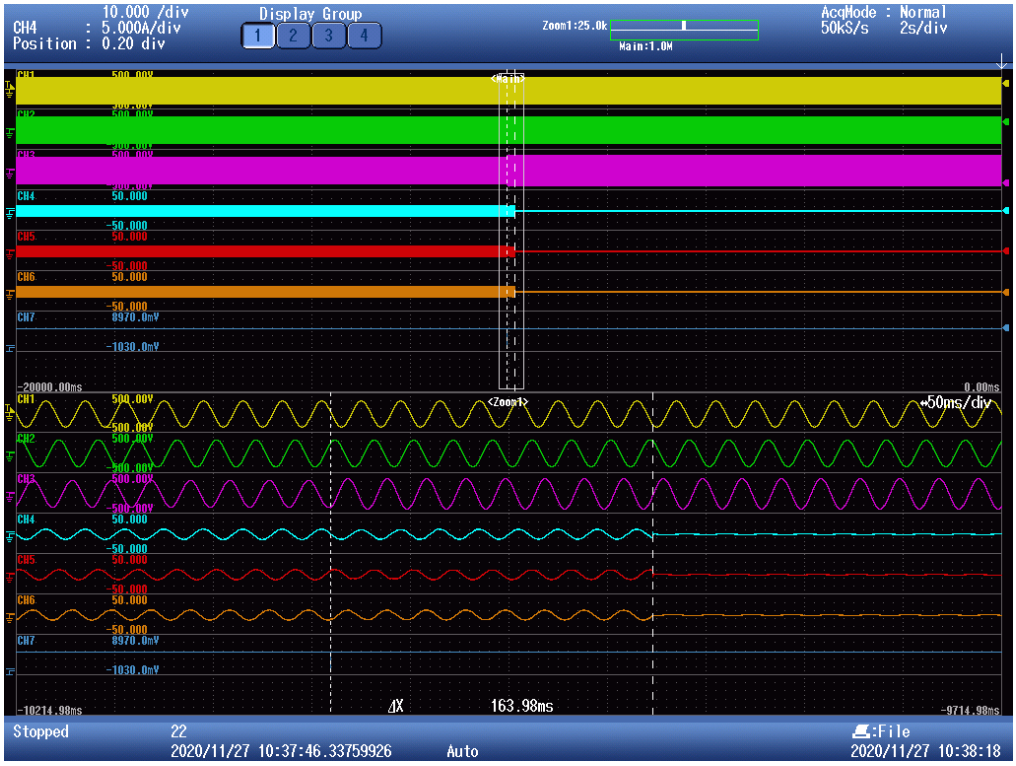
Over voltage: L2 phase



Under voltage: L3 phase



Over voltage: L3 phase



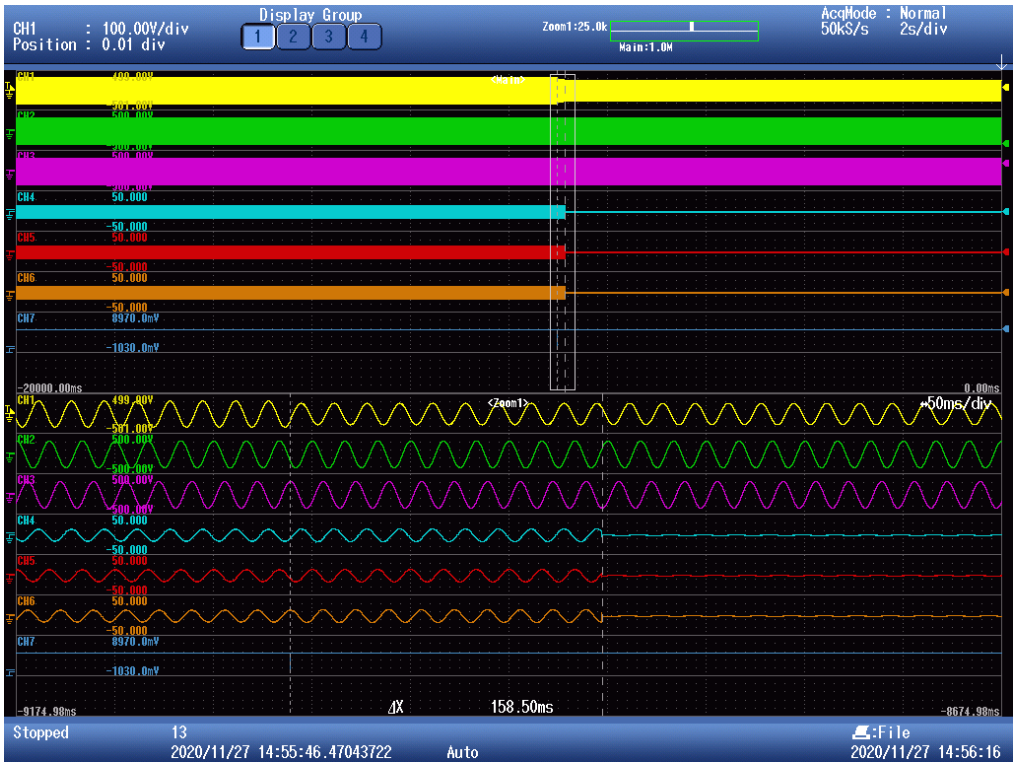
Island 60Hz

6.5.3.3 Voltage monitoring according contrat de raccordement, d'accès et d'exploitation (CRAE) pour une installation de production photovoltaïque raccordée au réseau public d'électricité							P
Test Condition:			Frequency: 50+/-0,2Hz U_N=230Vac				
Phase	**Limit:**	**Voltage step: (to min. 177,1 or max. 270,9)**	**Trip value [V]:**	**Reconnection time if <=3s [s]:**	**Reconnection time if >3s [s]:**	**Disconnection time [ms]:**	**Limit [ms]:**
L1	85% of Un	199V->189V	193,8	N/A	70,3	159	**200**
		230V->189V				156	
	115% of Un	260V->270V	264,6	N/A	70,1	150	**200**
		230V->270V				162	
L2	85% of Un	199V->189V	193,3	N/A	70,1	154	**200**
		230V->189V				167	
	115% of Un	260V->270V	264,1	N/A	70,0	153	**200**
		230V->270V				164	
L3	85% of Un	199V->189V	193,5	N/A	70,1	146	**200**
		230V->189V				144	
	115% of Un	260V->270V	264,1	N/A	69,9	142	**200**
		230V->270V				146	

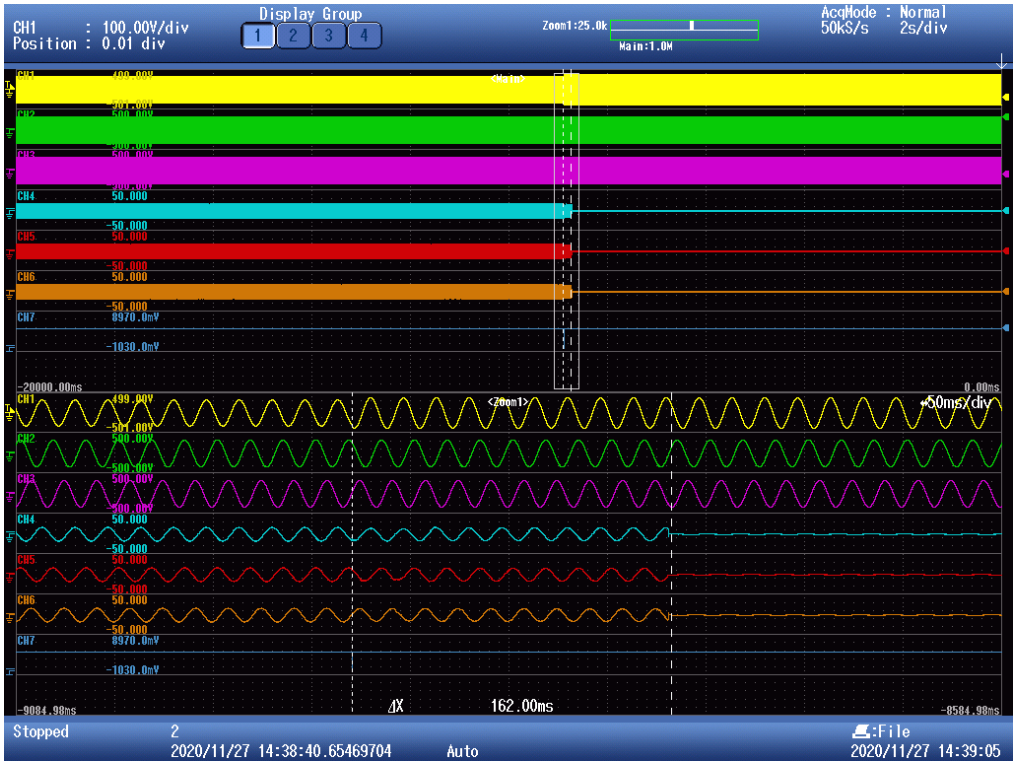
Note:
Lower and upper threshold voltage shall not fall or rise below or above 3% of the threshold voltage itself (min. 177,1V; max. 270,9V). The measurement shall take place at nominal frequency and any power.

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.

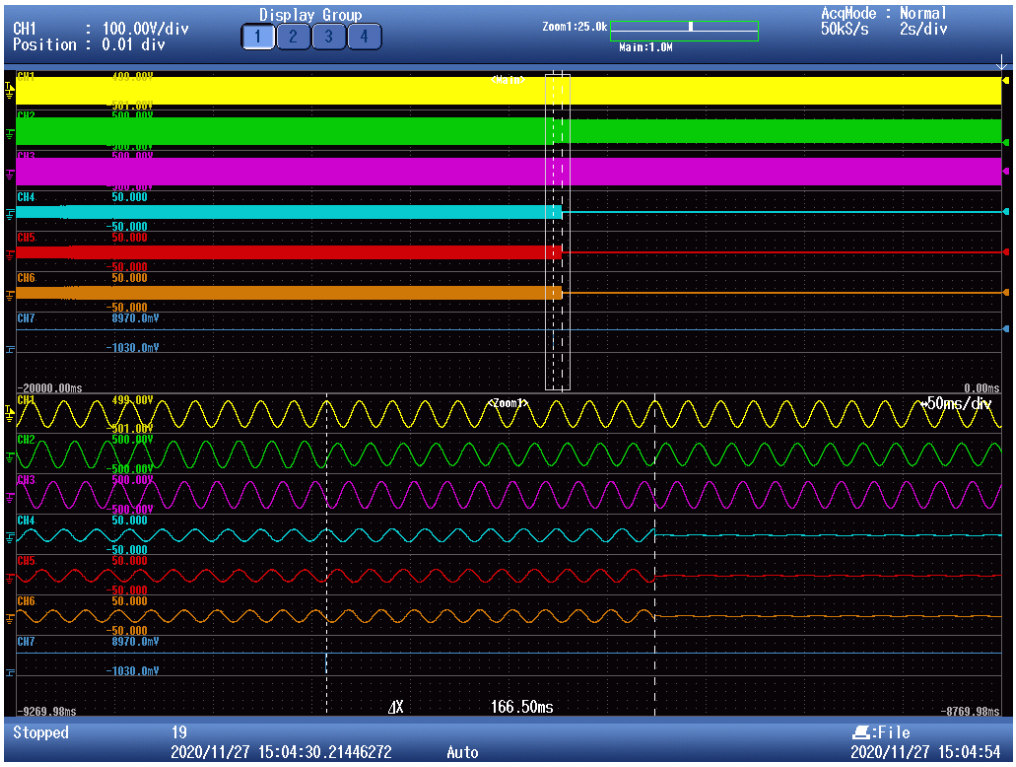
Under voltage: L1 phase



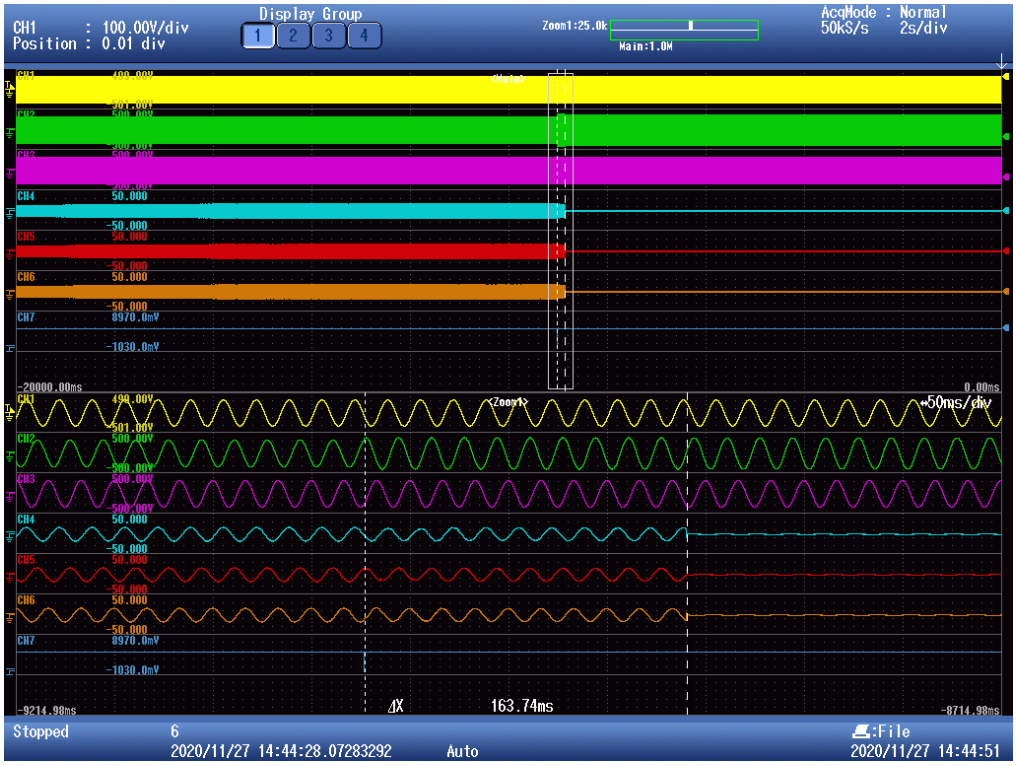
Over voltage: L1 phase



Under voltage: L2 phase

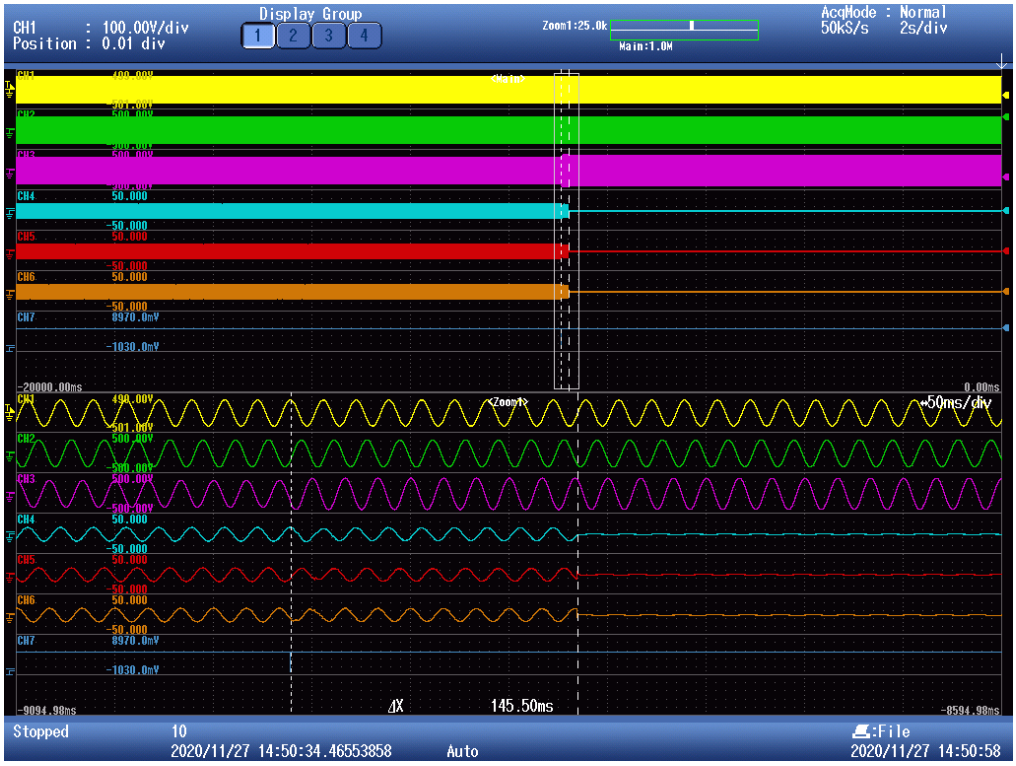


Over voltage: L2 phase



Under voltage: L3 phase

Over voltage: L3 phase



6.6 (4.7) Residual current monitoring		**P**
Test conditions:	Output power: 24kW V_{DC}: 1100V Frequency: 50Hz Current measuring devices: min. class 0,5	
6.6.2.2.2 Test for correct disconnection in case of a continuously rising residual current		**P**

+ PV to N:	
	Fault Current [mA]
Limit [mA]	U_N
<=300	257
<=300	262
<=300	252
<=300	254
<=300	252
- PV to N:	
	Fault Current (mA)
Limit (mA)	U_N
<=300	255
<=300	254
<=300	254
<=300	254
<=300	254

Note:
Comparing test circuit at 6.6.2.1, pic. 4. Fault current will rise up to 300mA within 30s. 5 values will be measured and listed.
The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.
The test results refer to the report LD200511N080 issued by Bureau Veritas Shenzhen Co.,Ltd.Dongguan Branch on 2020-12-17.

6.6.2.2.2 Test for correct disconnection in case of an abrupt appearing residual current >300mA	**P**

+ PV to N:	
Fault Current > 300mA	
Limit [ms]	U_N
300	268
300	266
300	272
300	264
300	272
- PV to N:	
Fault Current > 300mA	
Limit [ms]	U_N
300	276
300	266
300	274
300	272
300	266

Note:
To test the trip time, the test resistance is then adjusted to set the residual current to a value approximately 10 mA below the actual trip level. A second external resistance, adjusted to cause approximately 20 mA of residual current to flow, is connected through a switch from ground to the same PV input terminal as the first resistance. The switch is closed, increasing the residual current to a level above the trip level determined above. The time shall be measured from the moment the second resistance is connected until the moment the inverter disconnects from the mains, as determined by observing the inverter output current and measuring the time until the current drops to zero.

The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.
The test results refer to the report LD200511N080 issued by Bureau Veritas Shenzhen Co.,Ltd.Dongguan Branch on 2020-12-17.

6.6.2.2.3 Test for correct disconnection in case of a suddenly occuring residual current		P
+PV to N		
Limit (mA)	U_N Disconnection time (ms)	Limit (ms)
30	220	300
30	215	300
30	223	300
30	232	300
30	234	300
60	136	150
60	128	150
60	129	150
60	111	150
60	113	150
150	36	40
150	36	40
150	29	40
150	33	40
150	34	40
-PV to N		
Limit (mA)	U_N Disconnection time (ms)	Limit (ms)
30	241	300
30	237	300
30	236	300
30	231	300
30	239	300
60	132	150
60	133	150
60	120	150
60	126	150
60	117	150
150	30	40
150	32	40
150	34	40
150	35	40
150	32	40

Note:
The capacitive current is risen until disconnection.
Test condition: I_c + 30/60/150mA <= I_{cmax}. R_1 is set that 30/60/150mA Flow and switch S is closed.

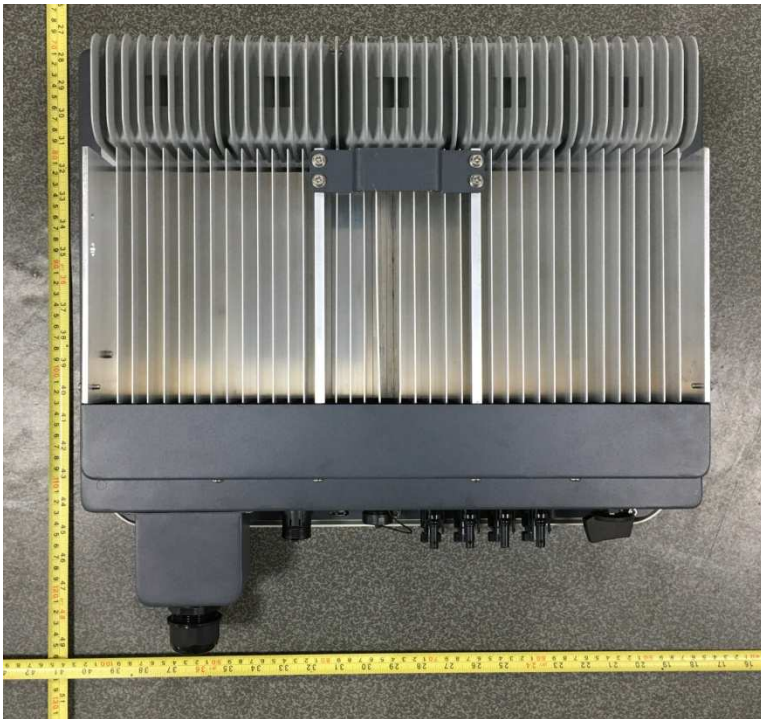
The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.
The test results refer to the report LD200511N080 issued by Bureau Veritas Shenzhen Co.,Ltd.Dongguan Branch on 2020-12-17.

6.6.2.2.4 Isolation measurement before feeding in			**P**
Condition	DC Voltage [V]	Required Insulation resistance (kOhm)	Result
DC+			
V+, the higher array voltage	1000	500 kΩ	Error message:" Error:"ID56"(The insulation resistance is too low)" PV inverter does not start-up.
Vcritical, the voltage level analyzed to be difficult to detect	400		
Varbitrary, any voltage within the range V- V+	720		
V-, the lower array voltage	140		
DC-			
V+, the higher array voltage	1000	500 kΩ	Error message:" Error:"ID56"(The insulation resistance is too low)" PV inverter does not start-up.
Vcritical, the voltage level analyzed to be difficult to detect	400		
Varbitrary, any voltage within the range V- V+	720		
V-, the lower array voltage	140		
Note: The array insulation resistance to ground shall be not less than 1 kΩ/V with respect to the maximum dc input voltage as specified by the manufacturer, with a minimum of 500 kΩ The tests had been performed on the SOFAR 24KTLX-G3 is valid for the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3, since it is identical in hardware and software construction except output power derated by software.			

Annex 2

Pictures of the unit

Front view

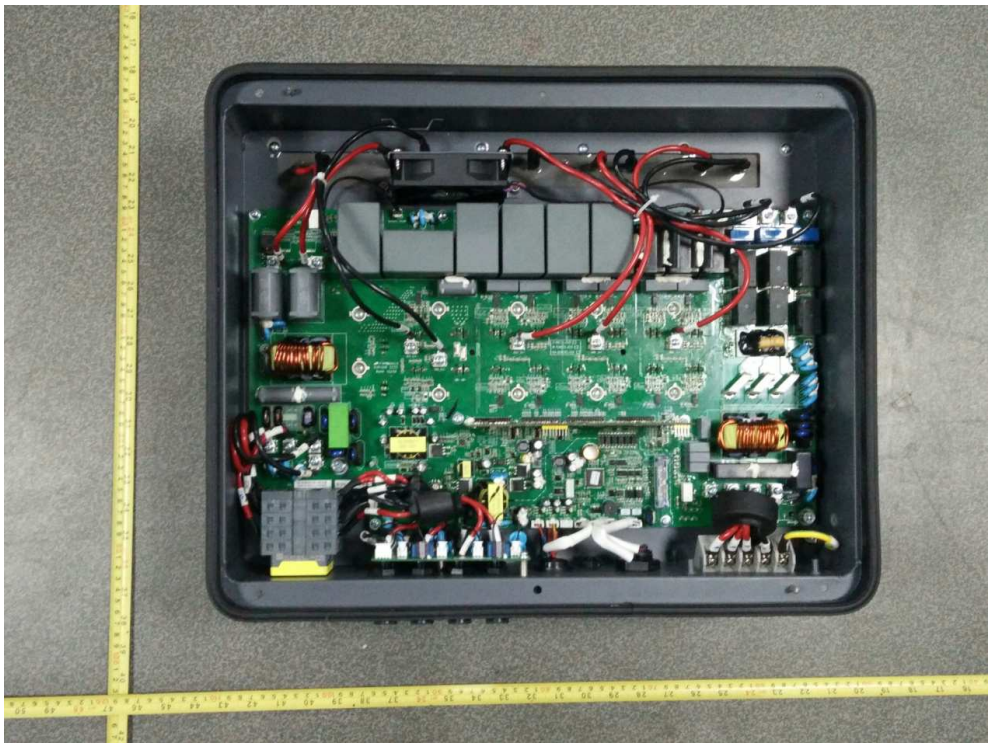

Rear view


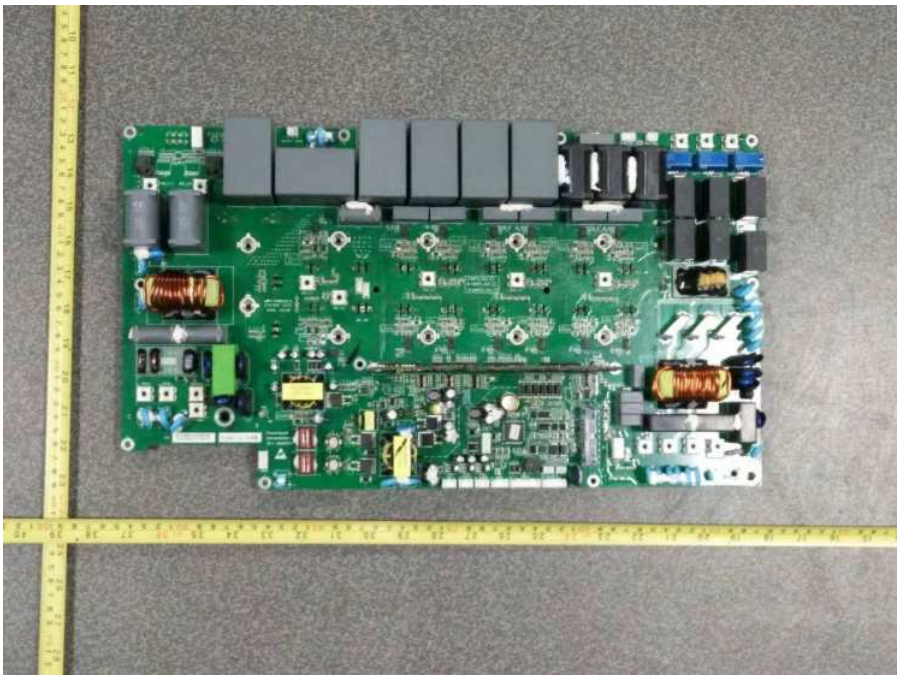
Bottom view (SOFAR 15KTLX-G3, SOFAR 17KTLX-G3)

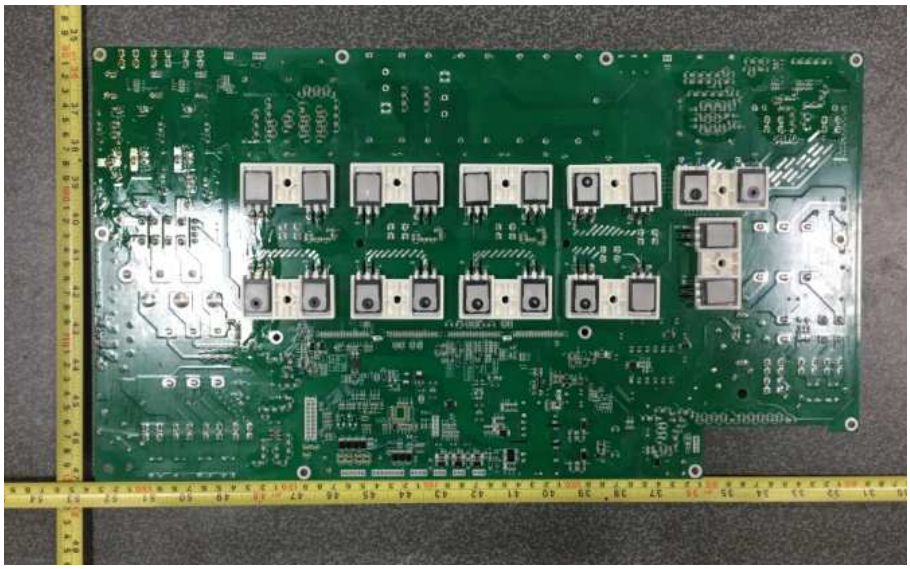
Bottom view (SOFAR 20KTLX-G3, SOFAR 22KTLX-G3, SOFAR 24KTLX-G3)

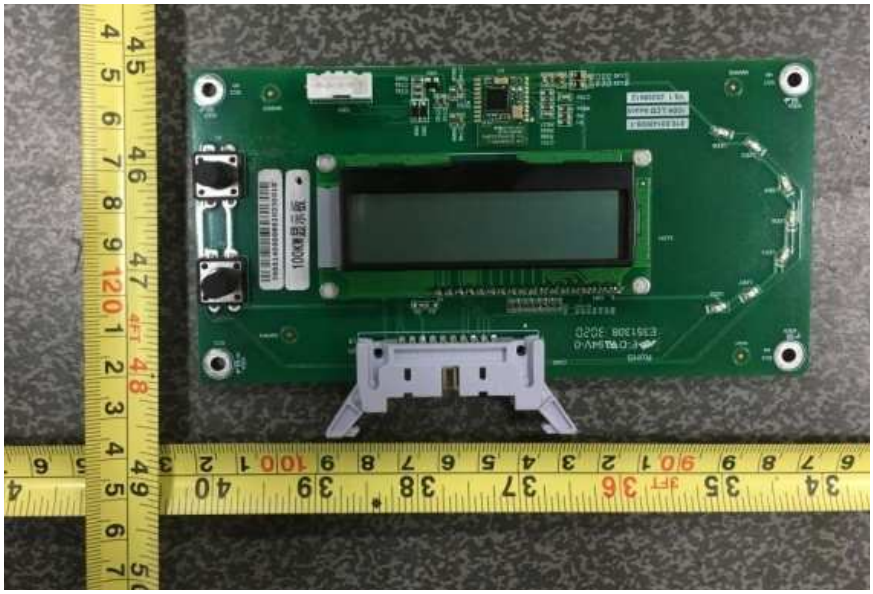
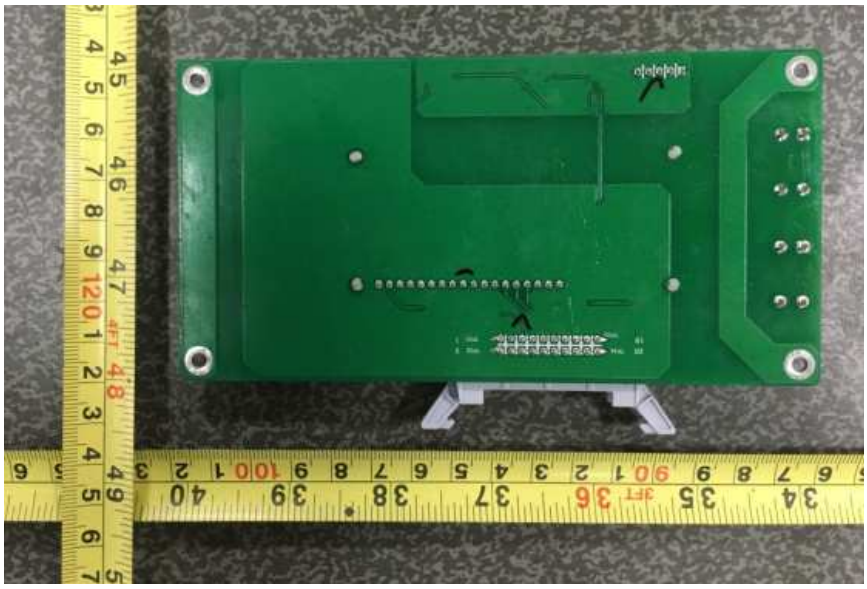
Right view

Internal view

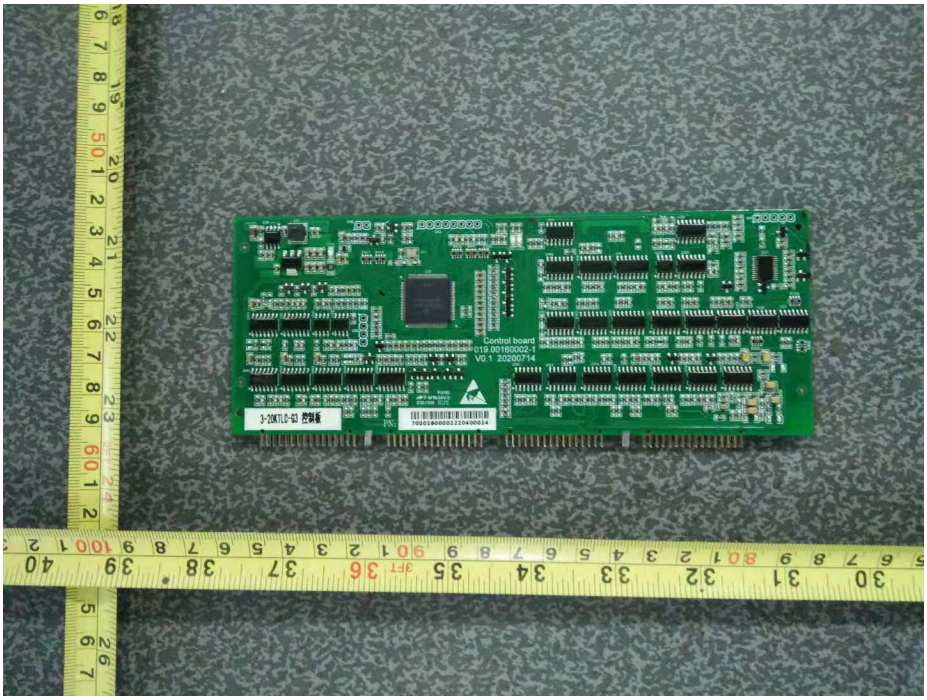


Power board component side view


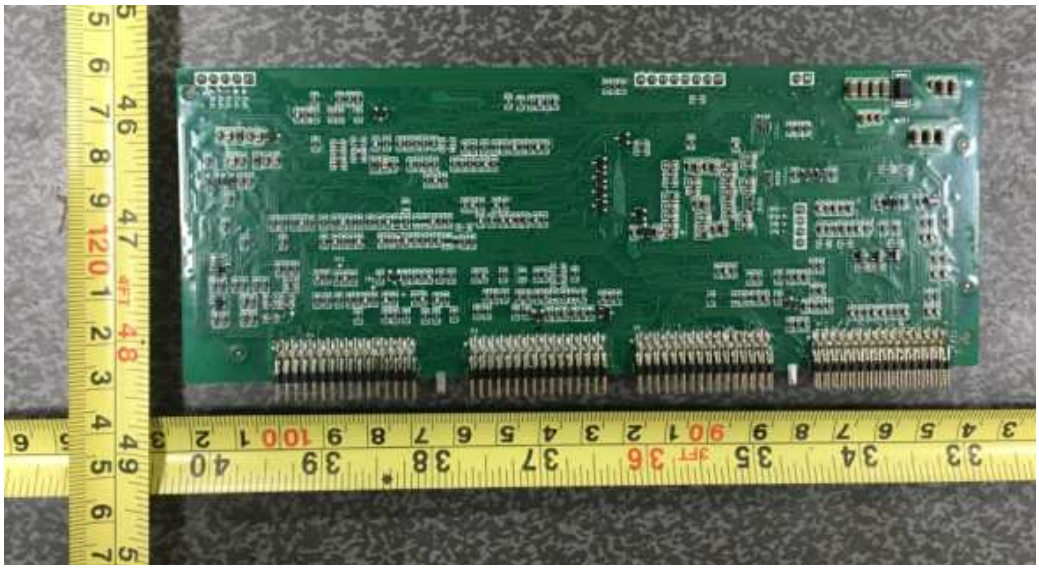
Power board solder side view


LCD board component side view

LCD board solder side view


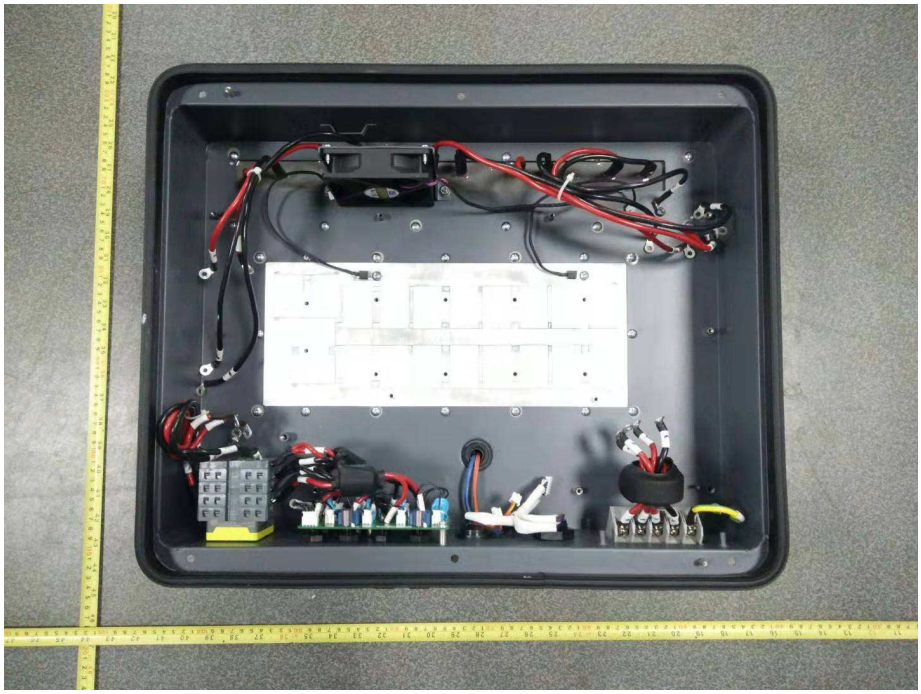
Control board component side view



Control power board solder side view



Internal view



Earthing terminal

Annex 3

Test equipment list

Test location: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Dates of performance test: 2020-05-11 to 2021-02-02

Equipment	Internal No.	Manufacturer	Type	Serial No.	Next Calibration date
Power Analyser	A4080002DG	YOKOGAWA	WT3000	91M210852	Jun. 16, 2021
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyser
	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040015DG	Chroma	62150H-1000S	62150EF00488	
	A7040016DG	Chroma	62150H-1000S	62150EF00490	
	A7040017DG	Chroma	620028	620028EF00120	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 24, 2020
Oscilloscope probe	A4089008DG	Tektronix	TPP1000	C008230	Aug. 10, 2021
	A4089010DG	Tektronix	TPP1000	C008228	Aug. 10, 2021
	A4089011DG	Tektronix	TPP1000	C008229	Aug. 10, 2021
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Sep. 02, 2021
	A1060008DG	YOKOGAWA	CT200	1130700017	Sep. 02, 2021
	A1060012DG	YOKOGAWA	CT200	1130700018	Sep. 02, 2021
Power Analyser	//	ZLG	PA5000H	C820290908200 2110001	Mar. 02, 2021
Oscilloscope	//	Agilent	DS05014A	MY50070266	Jan. 05, 2022
Oscilloscope current probe	//	FLUKE	i1000S	29503223	Jan. 05, 2022
	//	FLUKE	iL000S	30413448	Jan. 05, 2022
	//	CYBERTEK	CP1000A	C181000929	Jan. 05, 2022
	//	CYBERTEK	CP1000A	C181000922	Jan. 05, 2022
	//	CYBERTEK	CP1000A	C191000141	Jan. 05, 2022
Oscilloscope voltage probe	//	SANHUA	SI-9110	152655	Jan. 05, 2022
	//	SANHUA	SI-9110	111134	Jan. 05, 2022
	//	SANHUA	SI-9110	111539	Jan. 05, 2022
	//	SIGLENT	DPB5150A	D15A150052	Jan. 05, 2022
	//	SIGLENT	DPB5150A	D15A200317	Jan. 05, 2022
	//	SIGLENT	DPB5150A	D15A200314	Jan. 05, 2022
	//	SIGLENT	DPB5150A	D15A150047	Jan. 05, 2022