TEST REPORT

AS_NZS 4777.2

Grid connection of energy systems via inverters

Part 2: Inverter requirements

Report reference number .....:	**PVAU200224N005-3-R1**
Date of issue .....:	2021-03-23
Total number of pages .....:	29
Testing laboratory name.....:	**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
Applicant's name.....:	**Shenzhen SOFAR SOLAR Co., Ltd.**
Address .....:	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Test specification	
Standard.....:	Short duration under voltage response test (LVRT capability) - Inverter Conformance Test Procedure For South Australia
Test report form number.....:	LVRT For South Australia VER.0
Master TRF originator .....:	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Matster TRF .....:	Dated 2020-08-13
Test item description .....:	**Solar Grid-tied Inverter**
Trademark .....:	SOFAR SOLAR
Model / Type.....:	SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL, SOFAR 2700TL, SOFAR 3000TL

Ratings ..... :	**SOFAR 1100TL**	**SOFAR 1600TL**	**SOFAR 2200TL**	**SOFAR 2700TL**	**SOFAR 3000TL**
Input DC Voltage [V]:	90-400, max. 450		100-480, max. 500		
MPP input DC Voltage [V]:	110-380	165-380	170-450	210-450	230-450
Input DC current [A]:	Max. 10		Max. 13		
Output AC Voltage [V]:	230, 50Hz				
Output AC current [A]:	Max. 4,5	Max. 7,0	Max. 9,5	Max. 11,5	Max. 13,0
Output power [W]:	Max. 1000	Max. 1500	Max. 2000	Max. 2500	Max. 2800

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, function and signature) .....:	Lukes Lin 
Approved by (name, function and signature) .....:	James Huang 
Manufacturer's name .....:	**Shenzhen SOFAR SOLAR Co., Ltd.**
Factory 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**
2020-09-22	Lukes Lin	Initial report was written	0
2021-03-23	Lukes Lin	Update test result of clause 2.2 and 2.3	R1
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] ..... :	SOFAR 1100TL, SOFAR 1600TL: 11kg
	SOFAR 2200TL, SOFAR 2700TL, SOFAR 3000TL: 12kg

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 ..... :	2020-09-08
Date(s) of performance of test ..... :	2020-09-08 to 2020-09-15, 2021-03-22

General remarks:

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

The report shall state compliance of the tested objects with the requirements of Short Duration Undervoltage Disturbance Ride-Through – Inverter Conformance Test Procedure for South Australia.

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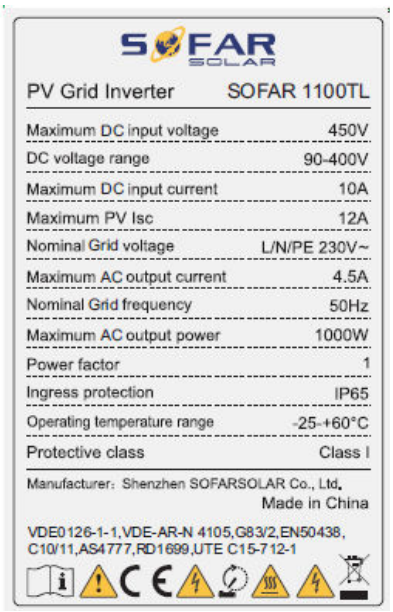
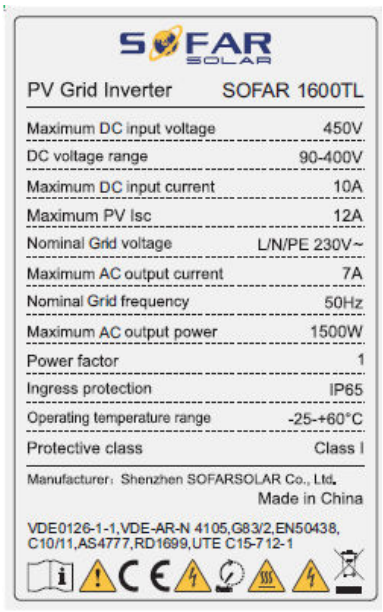
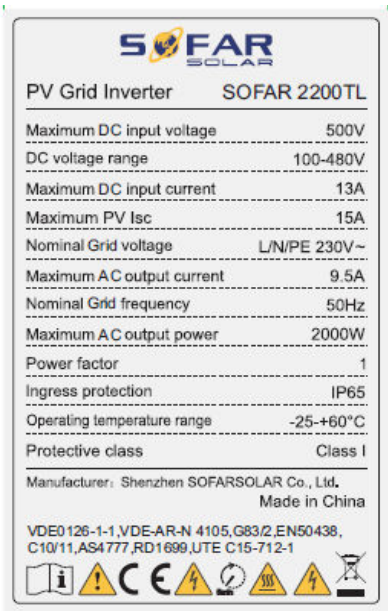
”(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

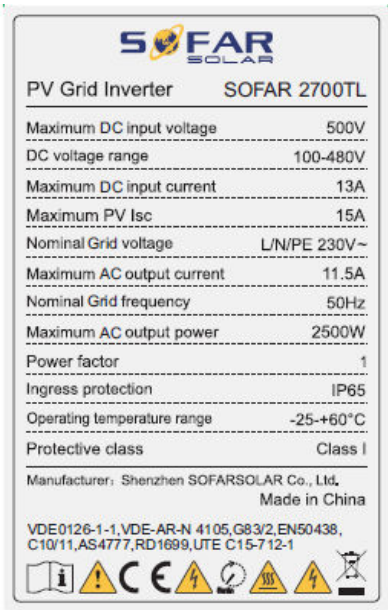
Throughout this report a comma is used as the decimal separator.

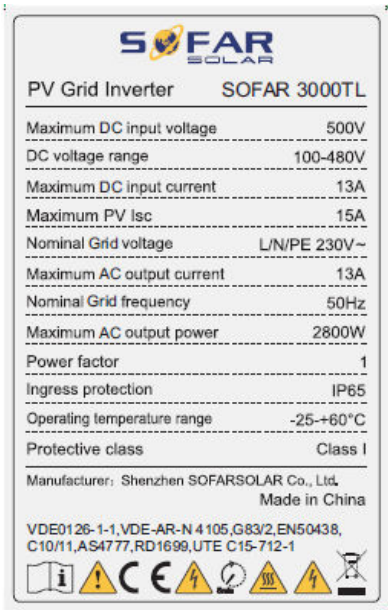
Copy of marking plate

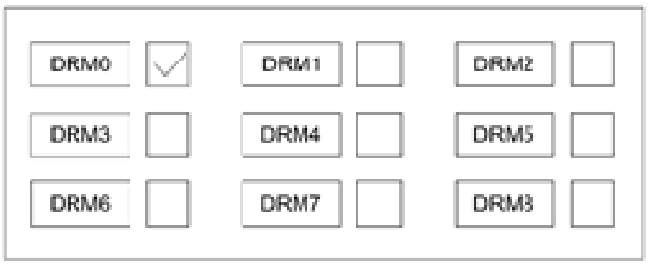












General product information:

The Solar converter converts DC voltage into AC voltage.

The DC input of Solar converter can be supplied from PV array.

The input and output are protected by Varistors to Earth. 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):

Description of the electrical circuit: (Figure 1):

The internal control is redundant built. It consists of Microcontroller Master DSP (UC34) and Slave DSP (UC35).

The Master DSP control the relays (RYP2-RYP5) 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 (UC35) is measures the grid voltage, AC current, grid frequency and residual current, also can switch off the relays (RYP2-RYP5) independently, and communicate with Master DSP (UC34) each other.

The current is measured by a current sensor. The AC current signal and the injected DC current signal are sent to the Master DSP(UC34). The Master DSP(UC34) 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.

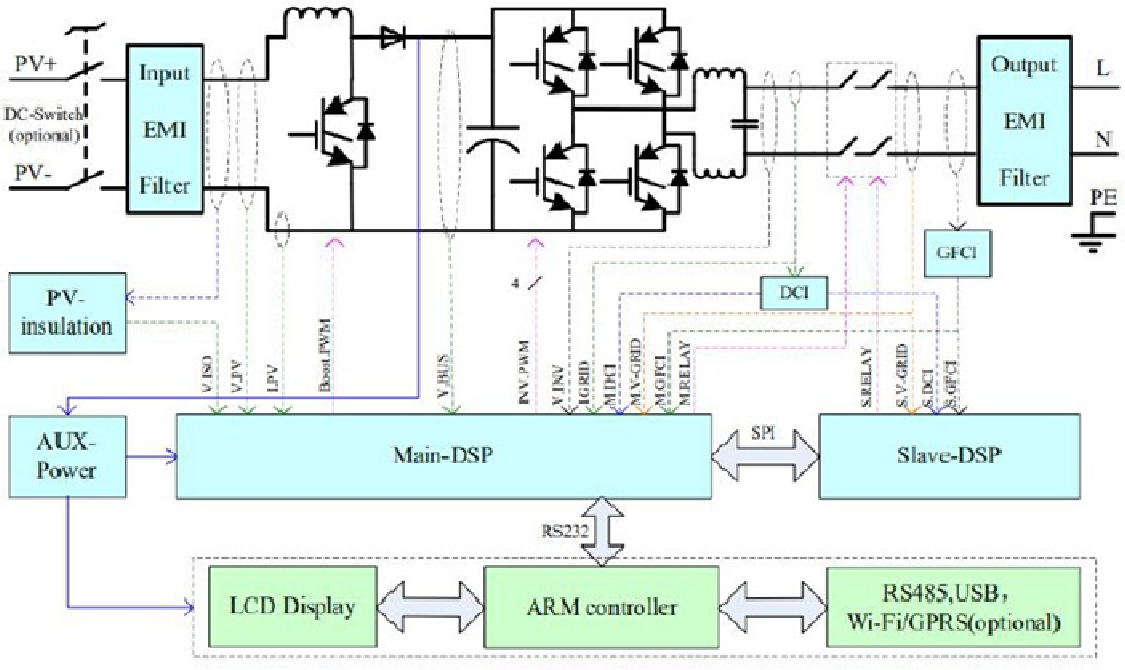


Figure 1 – Block diagram

Differences of the models in the series:

The models SOFAR 1100TL, SOFAR 1600TL, SOFAR 2200TL, SOFAR 2700TL and SOFAR 3000TL are same as in hardware except the components are in the difference table. Identical in software the output power just adjusted by software.

Difference table					
	SOFAR 1100TL	SOFAR 1600TL	SOFAR 2500TL	SOFAR 2700TL	SOFAR 3000TL
Boost inductor	2,6mH	2,6mH	1,9mH	1,9mH	1,9mH
Resistor (RP105, RP108 /RP189,RP109)	220ohm / 10Kohm	220ohm / 10Kohm	200ohm / 7,5Kohm	200ohm / 7,5Kohm	200ohm / 7,5Kohm
BUS capacitor (ECP1, ECP3, ECP4)	2 pcs	2 pcs	3 pcs	3 pcs	3 pcs
Inverter inductor	3,4mH	2,3mH	2,1mH	1,5mH	1,3mH
Resistor (RP118, RP119, RC18 /RP120, RP121,RC22)	499 Ω, 200 Ω, 200 Ω	1 KΩ, 200 Ω, 100 Ω	1 KΩ, 330 Ω, 330 Ω	2 KΩ, 100 Ω, 100 Ω	2 KΩ, 100 Ω, 100 Ω
DC switch and Wi-Fi module are optional.					

The product was tested on:

Hardware version: V1.00

Software version: V4.30

Test Results

1	General test and reporting requirments	
Clause	**Requirement – Test**	**Verdict**
1.1	General	**P**
1.2	Test condition	**P**
1.3	Inverter setup	**P**
1.4	Grid source	**P**
2	**Test procedure**	
2.1	General	**P**
2.2	Undervoltage (V<) disconnection test in response to event duration exceeding trip delay time	**P**
2.3	Undervoltage (V<) withstand test in response to event duration of less than trip delay time	**P**

2.2 Under voltage (V<) trip setting of disconnection test in response to event duration exceeding trip delay time	**P**

L1 phase

	Output Current level: 50+/-5% of rated current						
Test	**Voltage (V)**			**Time to disconnect (s) (Trip delay 1s)**			**Time to reconnection (s)**
Limit	**--**			**<=2s**			**>=60s**
Grid source voltage 230V down to 177,5 V (2,.5 V below 180 V)	177,5			2,0			--
Measured value	177,4	177,6	177,6	1,920	1,920	1,930	--
Return the voltage (177.5 V) to the grid test voltage (230V)	230			--			--
Measured value				--			

L2 phase

	Output Current level: 50+/-5% of rated current						
Test	**Voltage (V)**			**Time to disconnect (s) (Trip delay 1s)**			**Time to reconnection (s)**
Limit	--			<=2s			>=60s
Grid source voltage 230V down to 177,5 V (2,.5 V below 180 V)	177,5			2,0			--
Measured value	N/A	N/A	N/A	N/A	N/A	N/A	--
Return the voltage (177.5 V) to the grid test voltage (230V)	230			--			--
Measured value	N/A			--			N/A

L3 phase

	Output Current level: 50+/-5% of rated current						
Test	**Voltage (V)**			**Time to disconnect (s) (Trip delay 1s)**			**Time to reconnection (s)**
Limit	--			<=2s			>=60s
Grid source voltage 230V down to 177,5 V (2,.5 V below 180 V)	177,5			2,0			--
Measured value	N/A	N/A	N/A	N/A	N/A	N/A	--
Return the voltage (177.5 V) to the grid test voltage (230V)	230			--			--
Measured value	N/A			--			N/A

2.2 Under voltage (V<) trip setting of disconnection test in response to event duration exceeding trip delay time	**P**

All phases

	Output Current level: 50+/-5% of rated current		
Test	**Voltage (V)**	**Time to disconnect (s) (Trip delay 1s)**	**Time to reconnection (s)**
Limit	--	<=2s	>=60s
Grid source voltage 230V down to 177,5 V (2,.5 V below 180 V)	177,5	2,0	--
Measured value			--
Return the voltage (177.5 V) to the grid test voltage (230V)	230	--	--
Measured value		--	

Test procedure:
The disconnection time for the protective function undervoltage (180 V) for a voltage step shall be confirmed. The procedure shall be as follows:
(a) Set the grid source equal to the grid test voltage. The energy source shall be varied until the a.c. output of the device under test equals 50 ± 5 % of its rated current output.
NOTE: For three-phase inverters or inverter combinations, the required inverter output is based on the per phase inverter current rating.
(b) The grid source voltage shall be stepped to 177.5 V (2.5 V below 180 V) with the step change completed within 2 ms and occurring at the zero crossing of the grid source voltage. The time interval between the start of the voltage step and the device under test disconnecting from the grid source shall be recorded.
(c) Adjust the grid source to return the voltage to the grid test voltage. The reconnection time (the time taken for the device under test to reconnect to the grid source) shall be recorded.

Note:

The Voltage required to trip is the setting 177.5V (180V minus 2.5V). The time delay can be measured at a larger deviation than the minimum required to operate the protection. It has to be in the range of *+/- 2,3V* of the grid test voltage.

Diagram of under-voltage protection:

2.3 Undervoltage (V<) withstand test in response to event duration of less than trip delay time	P

Test procedure

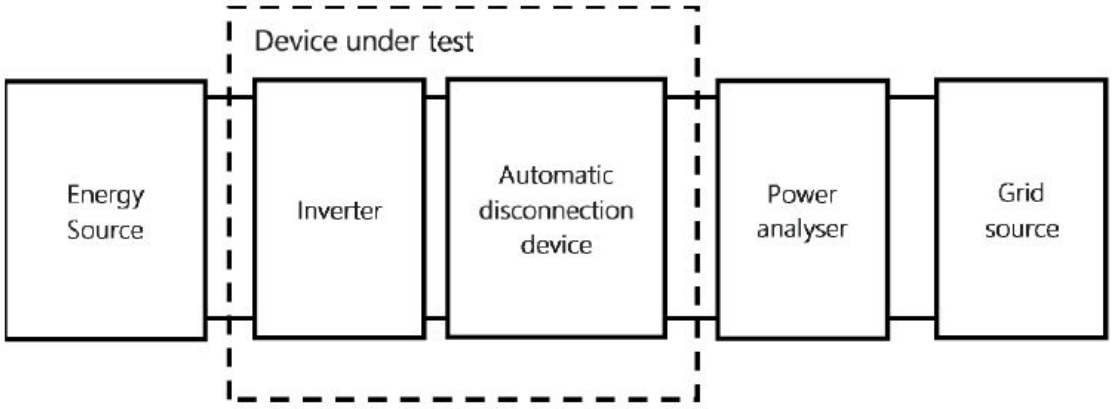


Figure 1 – Test circuit of voltage limits

The trip delay requirement for the protective function undervoltage 1 (V <) of 180 V for a voltage step shall be confirmed. The procedure shall be as follows:

(d) Set the grid source equal to the grid test voltage. Vary the energy source until the a.c. output of the device under test equals 50 ± 5 % of its rated current output.
NOTE: For three-phase inverters or inverter combinations, the required inverter output is based on the per phase inverter current rating.

(e) Record the stabilised active power output.

(f) Step the grid source voltage down to 50 V with the step change completed within 2 ms and occurring at the zero crossing of the grid source voltage, remain at 50 V for 220 ms. Increase the grid source voltage to the grid test voltage with the step change completed within 2 ms and occurring at the zero crossing of the grid source voltage. Record the time interval between each voltage step passing through 180 V (i.e. the duration for which voltage lies below 180 V).

NOTE: For three phase systems, the test shall be conducted at the zero-crossing for each phase individually, and additionally for all three phases stepped together at the zero-crossing for one of the phases.

(g) After 1 second, record the active power output, and confirm it is equal to that recorded at Step (e) ± 4 %.
NOTE: There is no defined behaviour of the inverter during the simulated fault. Monitor and recording at this stage is to better understand the anticipated inverter response.

List of tests	Residual amplitude of phase-to-neutral voltage V	Tolerance	Duration [ms]	Form (*)
Type for single phase inverter				
test 1 one-phase symmetrical fault	50V	± 0,01Un	220	
Type for three phase inverter				
test 1 a) one-phase: L1 symmetrical fault	50V	± 0,01Un	220	
test 1 b) one-phase: L1 symmetrical fault	50V	± 0,01Un	220	

test 1 c) one-phase: L1 symmetrical fault	50V	± 0,01Un	220	
test 2 a) one-phase: L2 symmetrical fault	50V	± 0,01Un	220	
test 2 b) one-phase: L2 symmetrical fault	50V	± 0,01Un	220	
test 2 c) one-phase: L2 symmetrical fault	50V	± 0,01Un	220	
test 3 a) one-phase: L3 symmetrical fault	50V	± 0,01Un	220	
test 3 b) one-phase: L3 symmetrical fault	50V	± 0,01Un	220	
test 3 c) one-phase: L3 symmetrical fault	50V	± 0,01Un	220	
test 4 a) all-phase: L1, L2, L3 symmetrical fault	50V	± 0,01Un	220	
test 4 b) all-phase: L1, L2, L3 symmetrical fault	50V	± 0,01Un	220	
test 4 c) all-phase: L1, L2, L3 symmetrical fault	50V	± 0,01Un	220	

Criteria for acceptance

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a. The device under test shall remain connected for the duration of test step (f).

b. At Step (g) the device under test shall have recovered its active power output to that recorded at Step (e) ± 4 % within 1 second.

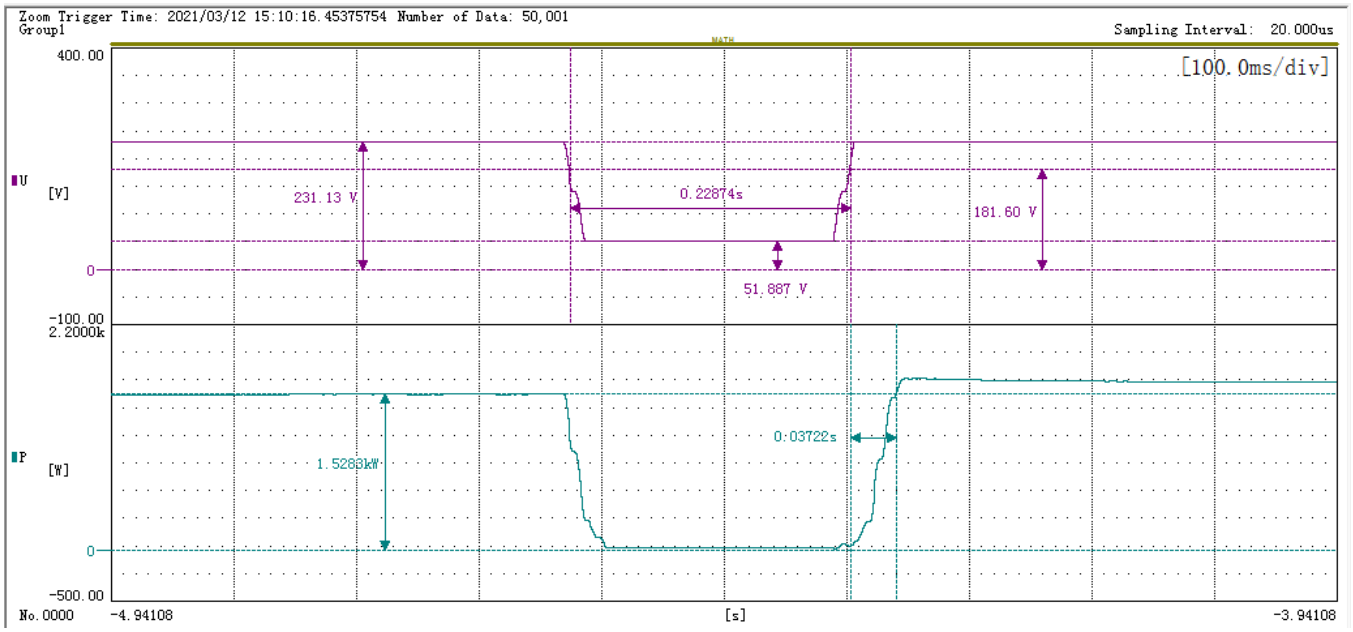
Graph of LVRT testing

List of tests	Output Current level: 50+/-5% of rated current			
	Residual amplitude of phase-to-phase voltage (V)	**Duration limit of Voltage dips [ms]**	**Measured duration [ms]**	**Measured power recover time (s)**
L1 phase				
Test 1 a) – one-phase symmetrical fault	50	220	229	37
Test 1 b) – one-phase symmetrical fault	50	220	229	32
Test 1 c) one-phase symmetrical fault	50	220	230	31
Test voltage	Voltage 230V +/- 1%			
Before test - Active power output (kW)	1,528	1,509	1,557	
After test - Active power output(kW) after 1s	1,563	1,551	1,568	
Limit(%)	+/- 4 %	+/- 4 %	+/- 4 %	
L2 phase				
Test 2 a) – one-phase symmetrical fault	50	220	N/A	N/A
Test 2 b) – one-phase symmetrical fault	50	220	N/A	N/A
Test 2 c) one-phase symmetrical fault	50	220	N/A	N/A
Test voltage	Voltage 230V +/- 1%			
Before test - Active power output (W)	N/A	N/A	N/A	
After test - Active power output(W) after 1s	N/A	N/A	N/A	
Limit(%)	+/- 4 %	+/- 4 %	+/- 4 %	
L3 phase				
Test 3 a) – one-phase symmetrical fault	50	220	N/A	N/A
Test 3 b) – one-phase symmetrical fault	50	220	N/A	N/A
Test 3 c) one-phase symmetrical fault	50	220	N/A	N/A
Test voltage	Voltage 230V +/- 1%			
Before test - Active power output (W)	N/A	N/A	N/A	

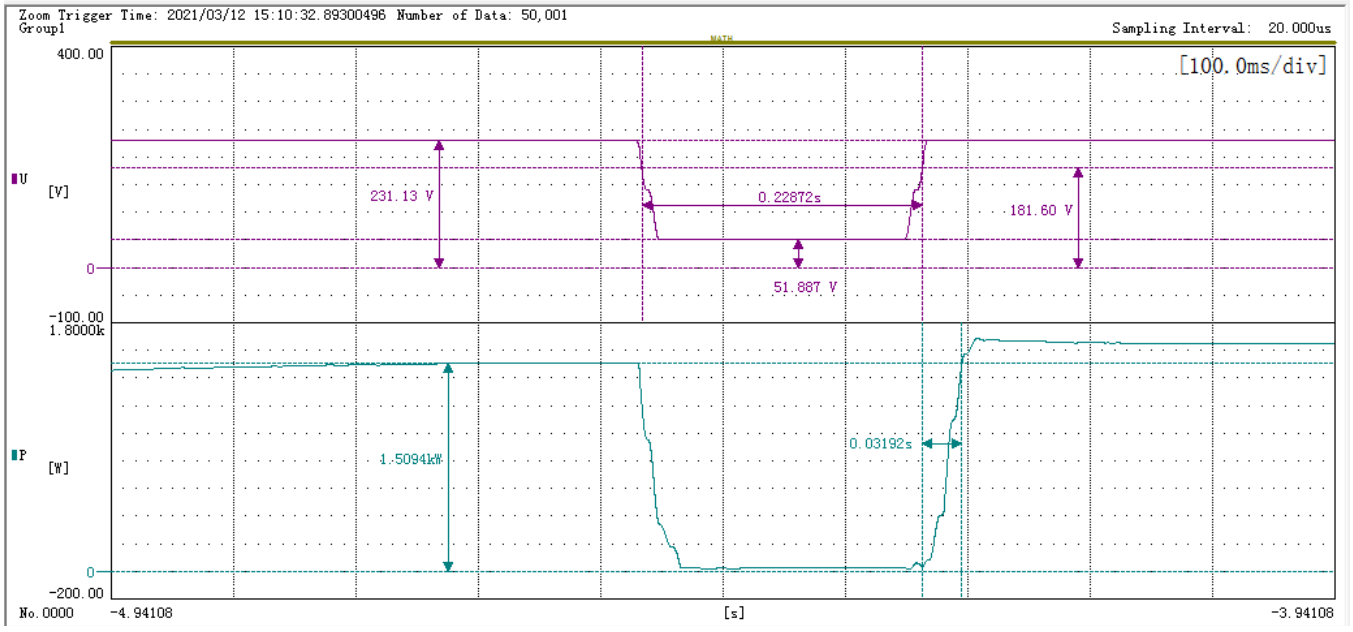
Graph of LVRT testing

After test - Active power output(W) after 1s	N/A	N/A		N/A
Limit(%)	+/- 4 %	+/- 4 %		+/- 4 %
All (L1,L2,L3) phase				
Test 4 a) – All-phase symmetrical fault (P = 0,5)	50	220	N/A	N/A
Test 4 a) – All-phase symmetrical fault	50	220	N/A	N/A
Test 4 a) – All-phase symmetrical fault	50	220	N/A	N/A
Test voltage	Voltage 230V +/- 1%			
Before test - Active power output (W)	N/A	N/A	N/A	
After test - Active power output(W) after 1s	N/A	N/A	N/A	
Limit(%)	+/- 4 %	+/- 4 %	+/- 4 %	
Test conditions: Voltage simulator fall and rise time: < 2ms The test conditions are performed as 50% ± 5% of In conditions. The inverter feeds maximal active and reactive power during the complete test.				
Note:				

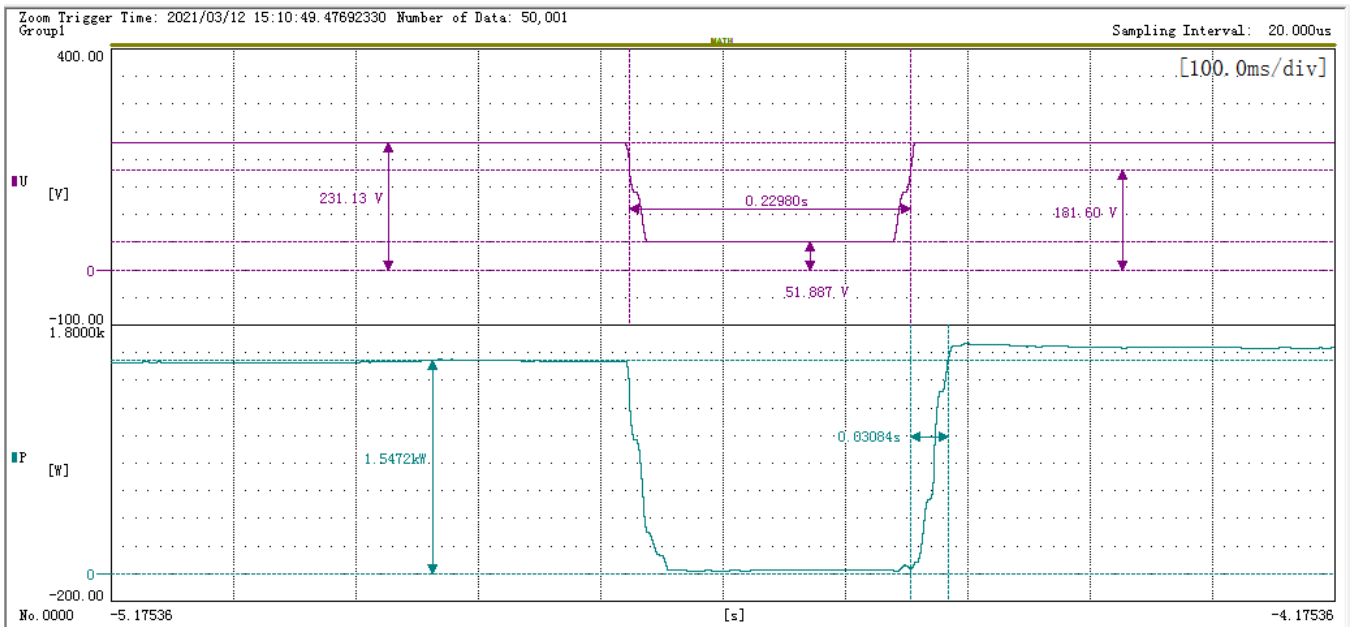
Test 1 a) – one-phase symmetrical fault



Test 1 b) – one-phase symmetrical fault



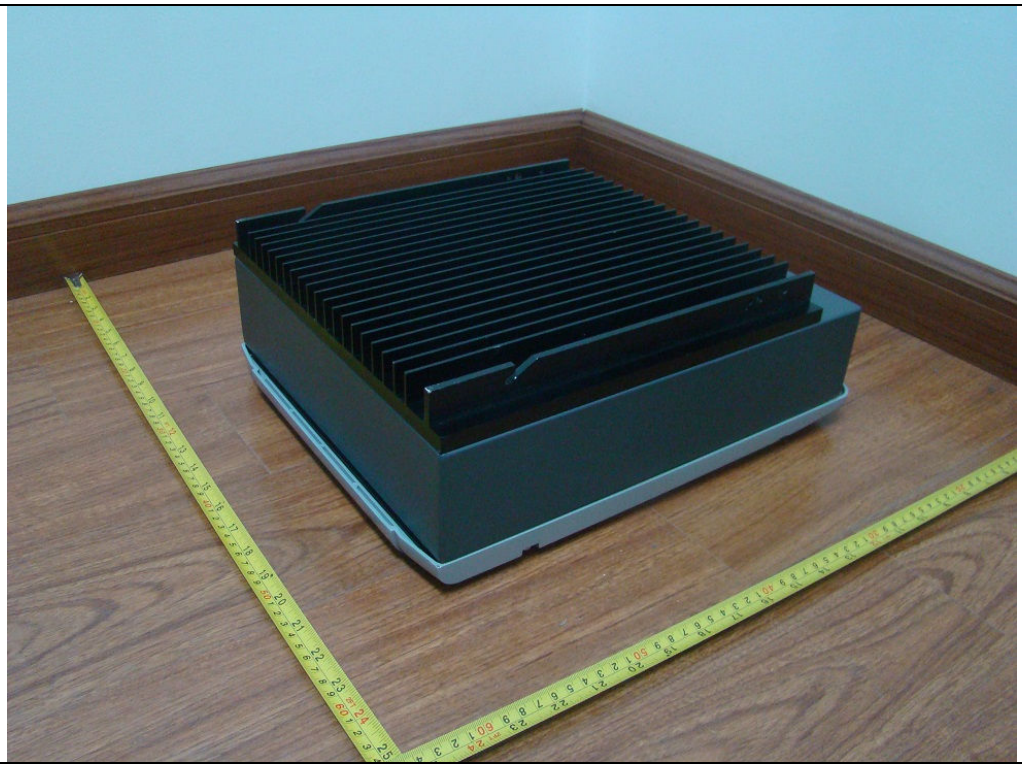
Test 1 c) – one-phase symmetrical fault



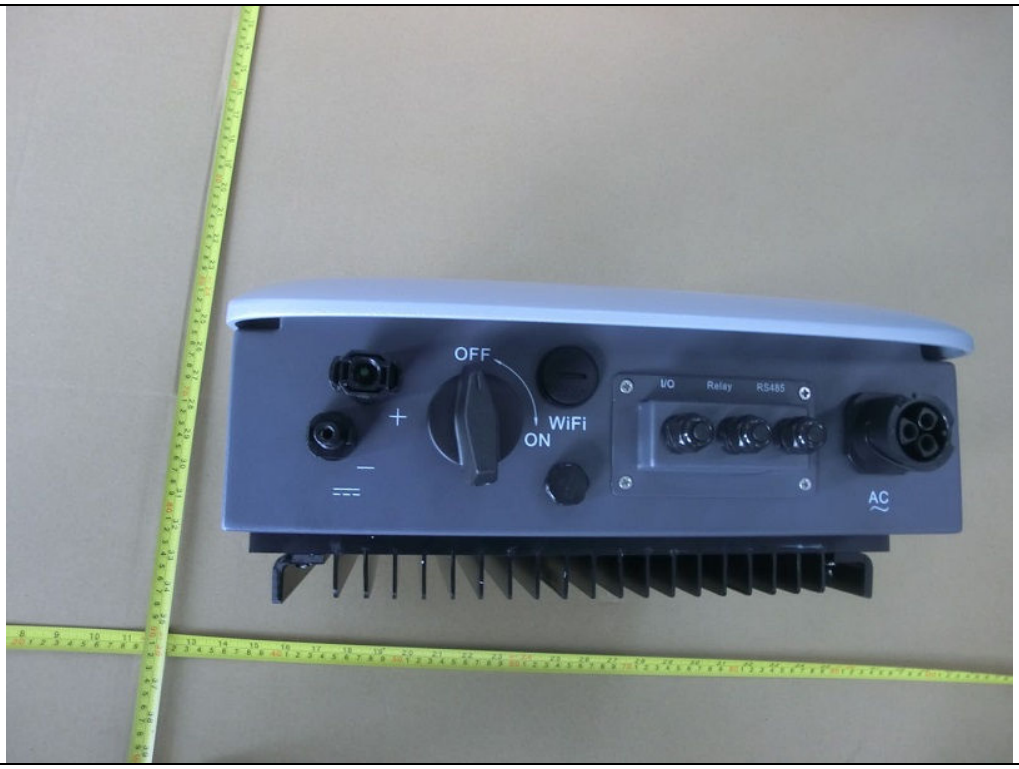
Annex No. 1
Pictures of the unit

Enclosure front view

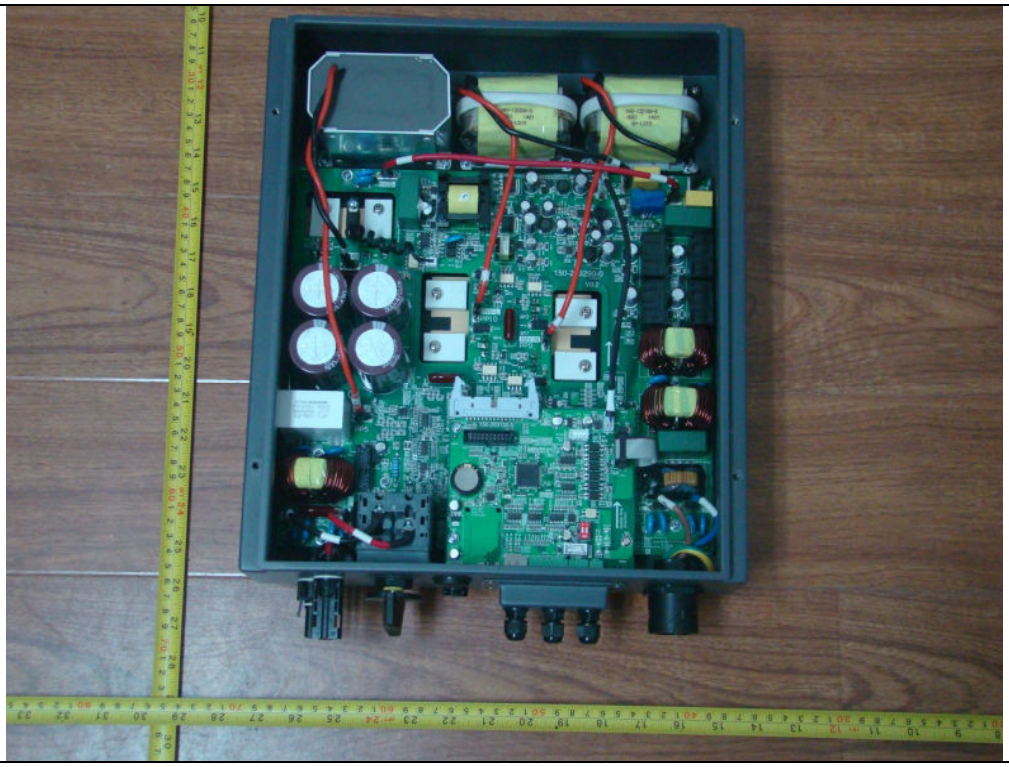
Enclosure rear view



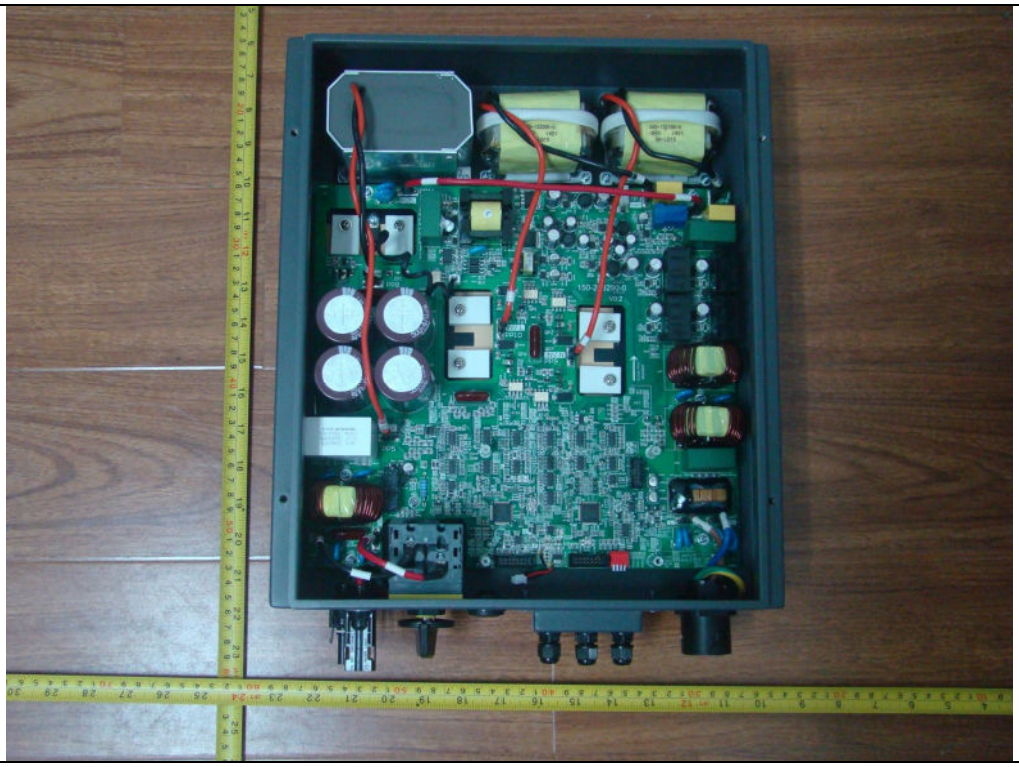
Enclosure bottom view



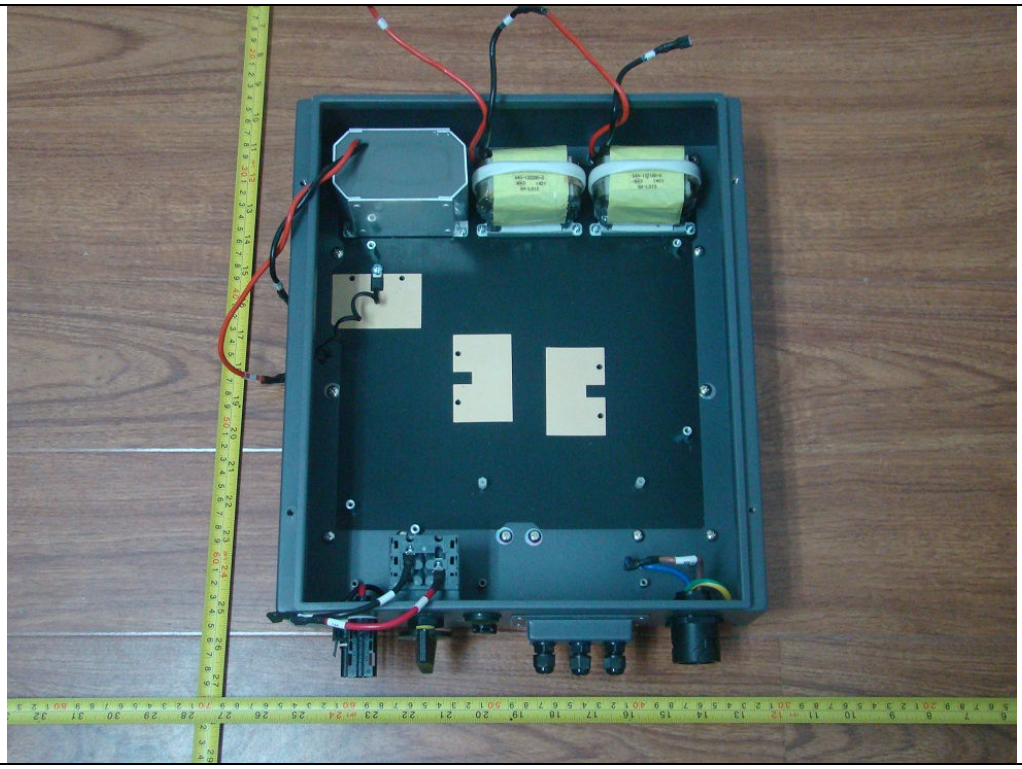
Internal view-1



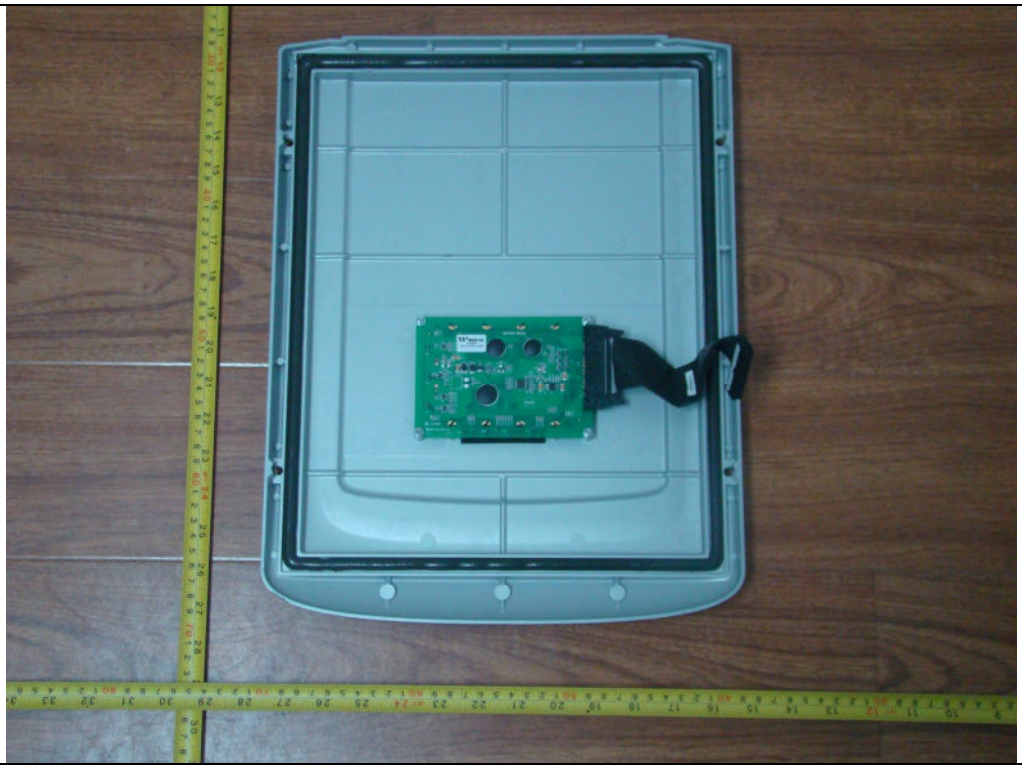
Internal view-2



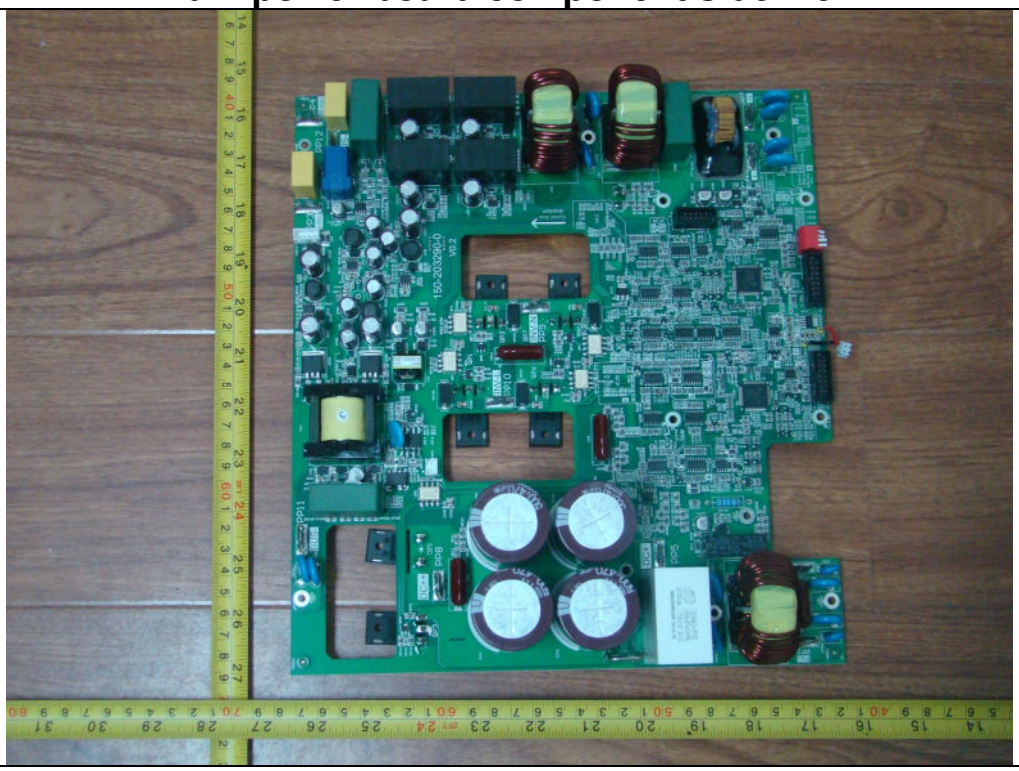
Internal view-3



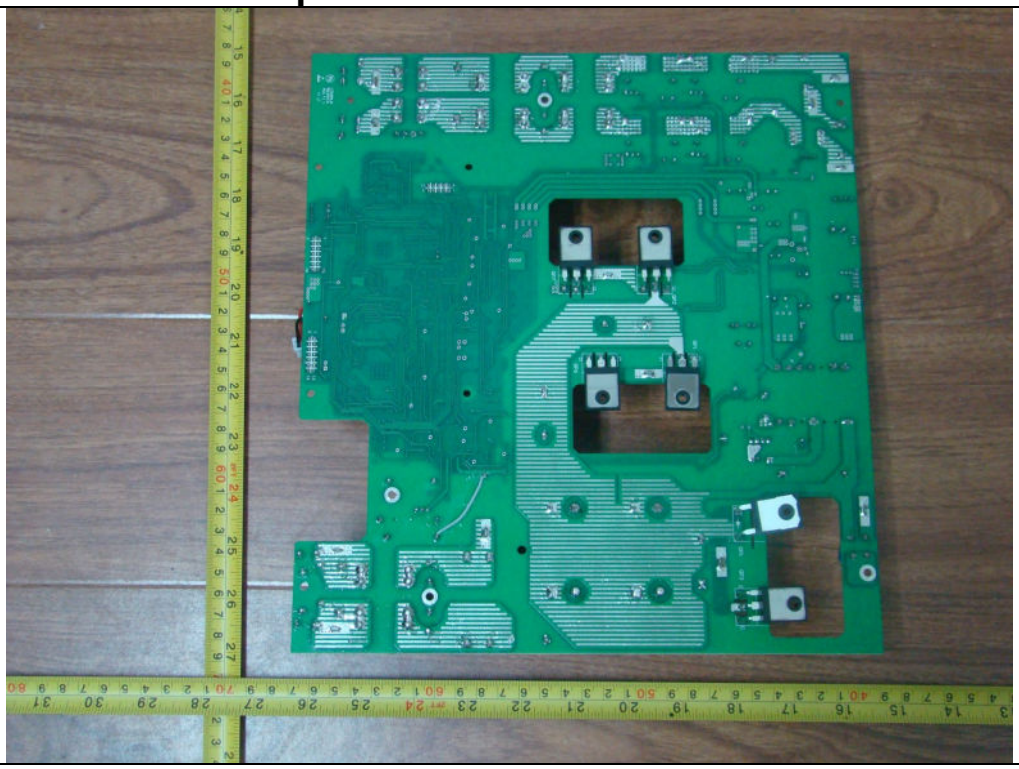
Internal view-4



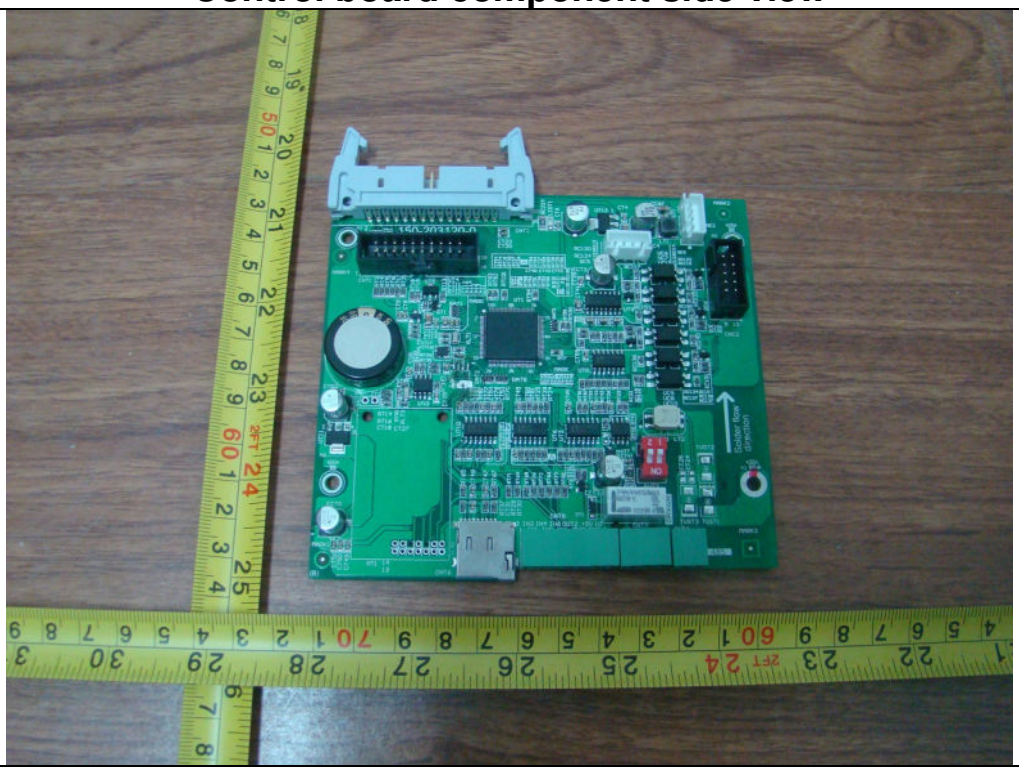
Main power board component side view



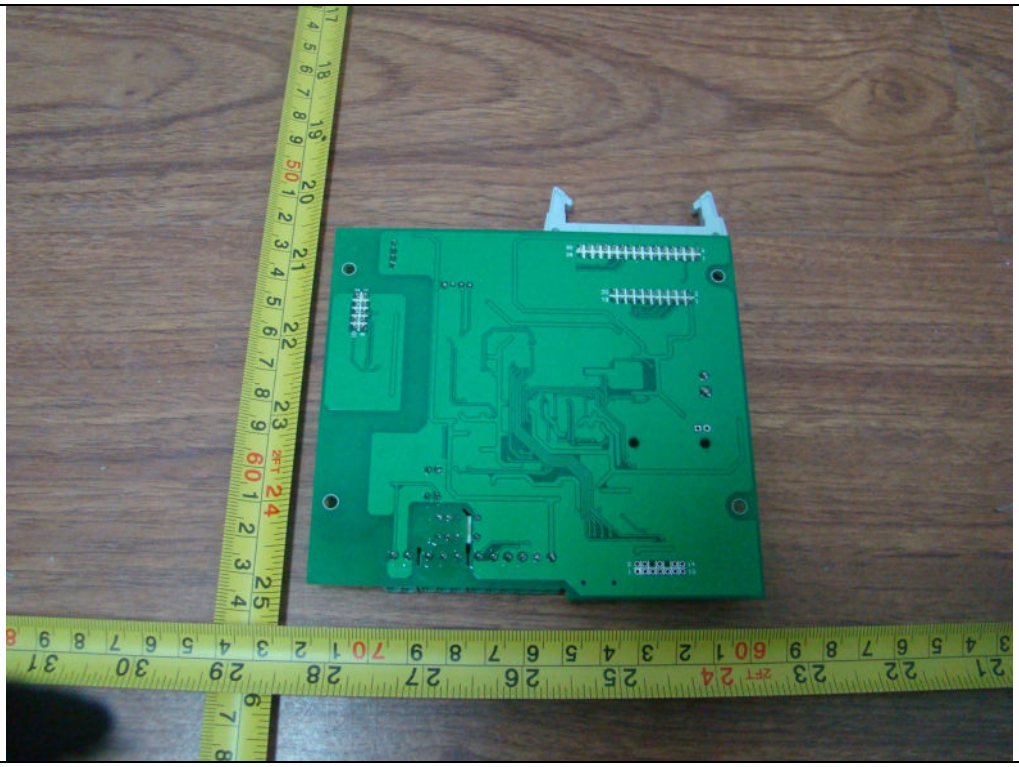
Main power board solder side view



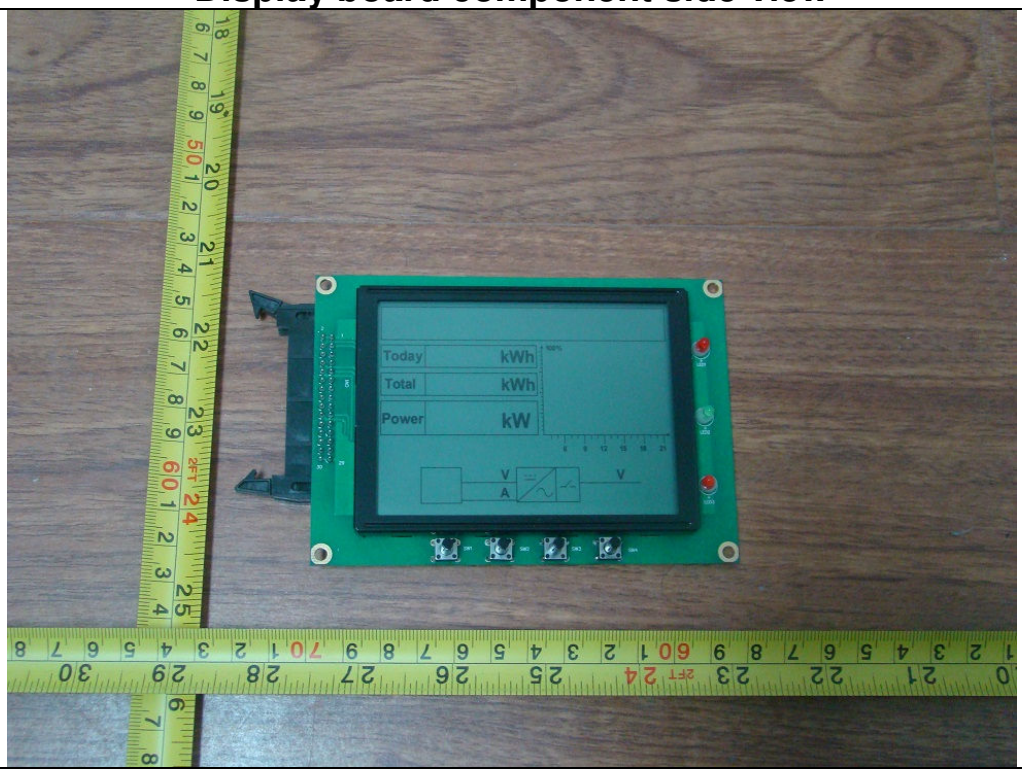
Control board component side view



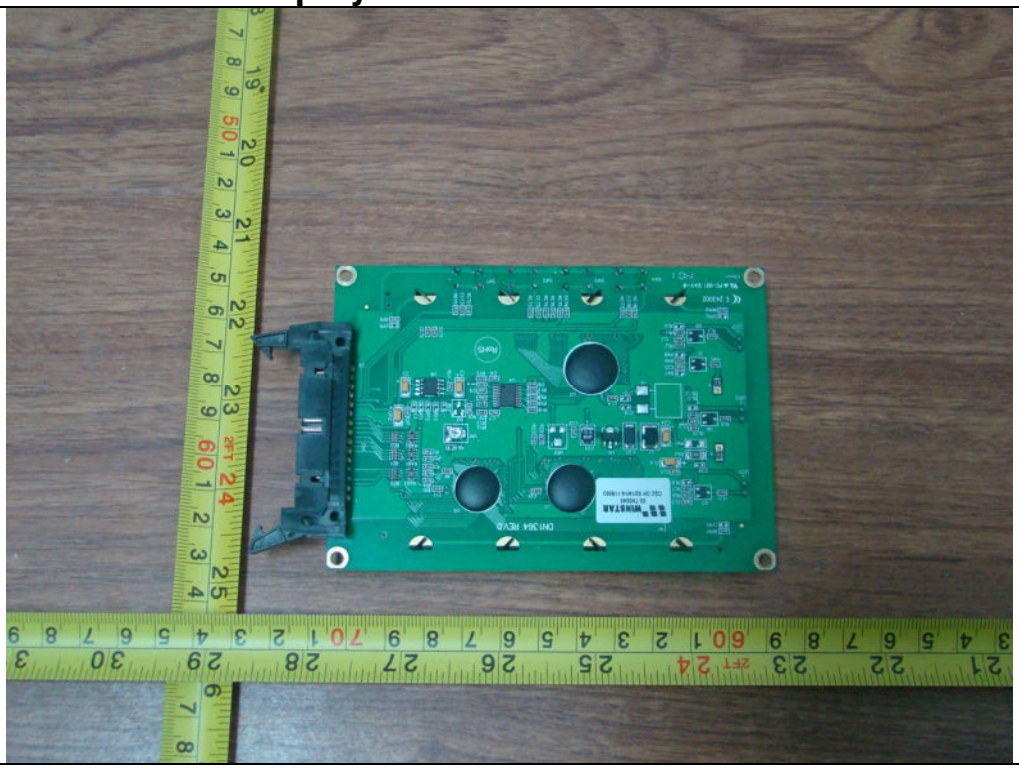
Control board solder side view



Display board component side view



Display board solder side view



Annex No. 2
Test Equipment list

Date(s) of performance test: 2020-09-08 to 2020-09-15

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	MY50070288	Jan. 13, 2021
Oscilloscope current probe	//	CYBERTEK	CP1000A	C181000922	Jan. 13, 2021
	//	CYBERTEK	CP1000A	C181000925	Jan. 13, 2021
	//	CYBERTEK	CP1000A	C181000929	Jan. 13, 2021
	//	CYBERTEK	CP1000A	C181000931	Jan. 13, 2021
Oscilloscope probe	//	SANHUA	SI-9110	152627	Jan. 13, 2021
	//	SIALENT	DS5034X	SDS5XEAC3R0 011	Jan. 13, 2021
	//	AGILENT	N2863B	YF0139	Jan. 13, 2021

End of Test Report