TEST REPORT

IEC 61683

Photovoltaic systems – Power conditioners – Procedure for measuring efficiency

Report reference number ..... :	**PV200224N005-7**
Date of issue ..... ……..:	2020-09-14
Total number of pages ..... ……..:	41
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
Accreditation ..... :	ilac-MRA ACCREDITED Certificate # 2951.01
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..... :	IEC 61683:1999
Test Report Form No. ..... :	IEC61683 VER.1
TRF Originator ..... :	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF ..... :	Dated 2020-03-11
Test item description ..... :	**Solar Grid-tied Inverter**
Trademark..... :	SOFAR SOLAR
Model / Type ..... :	SOFAR 11000TL-LV, SOFAR 13500TL-LV, SOFAR 16500TL-LV, SOFAR 18000TL-LV

Ratings ..... :	**SOFAR 11000TL-LV**	**SOFAR 13500TL-LV**	**SOFAR 16500TL-LV**
Input DC voltage [V] ..... :	Max. 1100Vd.c.		
MPP DC voltage range [V] ..... :	230-960Vd.c.		
Input DC current [A] ..... :	24,0*2	28,0*2	30,0*2
Output AC voltage [V] ..... :	3/N/P, 127/220Va.c., 60Hz		
Output AC current [A] ..... :	32,0*3	40,0*3	48,0*3
Nominal Output power [kW] ..... :	11,0	13,5	16,5
Maximum Output power [kVA] ..... :	11,0	13,5	16,5
Ratings ..... :	**SOFAR 18000TL-LV**		
Input DC voltage range [V] ..... :	Max. 1100Vd.c.		
MPP DC voltage range [V] ..... :	230-960Vd.c.		
Input DC current [A] ..... :	30,0*2		
Output AC voltage [V] ..... :	3/N/P, 127/220Va.c., 60Hz		
Output AC current [A] ..... :	53,0*3		
Nominal Output power [kW] ..... :	18,0		
Maximum Output power [kVA] ..... :	18,0		

Testing Location ..... :	**Shenzhen Academy of Metrology & Quality Inspection**
Address ..... :	3/F Building 6, Houhai Xufa Industrial Park, Loucun, Xinhu street, Guangming District, Shenzhen, Guangdong, China
Tested by (name and signature) ..... :	Lukes Lin 
Approved by (name and signature) ..... :	James Huang 
Manufacturer's name ..... :	**Shenzhen SOFAR SOLAR Co., Ltd.**
Manufacturer address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Factory's name 1 ..... :	**Dongguan SOFAR SOLAR Co.,Ltd.**
Factory address	1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City, Guangdong, China.

Document History			
Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2020-09-14	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. 37

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 ..... :	2020-08-24
Date(s) of performance of test ..... :	2020-08-24 to 2020-09-10

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 point is used as the decimal separator.

This Test Report consists of the following documents:

1. Test Results
2. Annex No. 1 – Pictures of the unit
3. Annex No. 2 – Test equipment list

Copy of marking plate:

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 11000TL-LV
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	230~960V
Max. Input Current	24A/24A
Max. PV Isc	30A/30A
Nominal Grid Voltage	3/N/PE,127/220Vac
Max.Output Current	3x32A
Nominal Grid Frequency	60Hz
Nominal Output Power	11000W
Max.Output Power	11000VA
Power Factor	>0.99(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-25℃~+60℃
Protective Class	Class I

Made in China

Manufacturer : Shenzhen SOFAR SOLAR 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 13500TL-LV
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	230~960V
Max. Input Current	28A/28A
Max. PV Isc	35A/35A
Nominal Grid Voltage	3/N/PE,127/220Vac
Max.Output Current	3x40A
Nominal Grid Frequency	60Hz
Nominal Output Power	13500W
Max.Output Power	13500VA
Power Factor	>0.99(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-25℃~+60℃
Protective Class	Class I

Made in China

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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 16500TL-LV
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	230~960V
Max. Input Current	30A/30A
Max. PV Isc	37.5A/37.5A
Nominal Grid Voltage	3/N/PE,127/220Vac
Max.Output Current	3x48A
Nominal Grid Frequency	60Hz
Nominal Output Power	16500W
Max.Output Power	16500VA
Power Factor	>0.99(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-25℃~+60℃
Protective Class	Class I

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VDE0126-1-1,VDE-AR-N4105,G99,IEC61727, IEC62116,UTE C15-712-1,AS4777

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 18000TL-LV
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	230~960V
Max. Input Current	30A/30A
Max. PV Isc	37.5A/37.5A
Nominal Grid Voltage	3/N/PE,127/220Vac
Max.Output Current	3x53A
Nominal Grid Frequency	60Hz
Nominal Output Power	18000W
Max.Output Power	18000VA
Power Factor	>0.99(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-25℃~+60℃
Protective Class	Class I

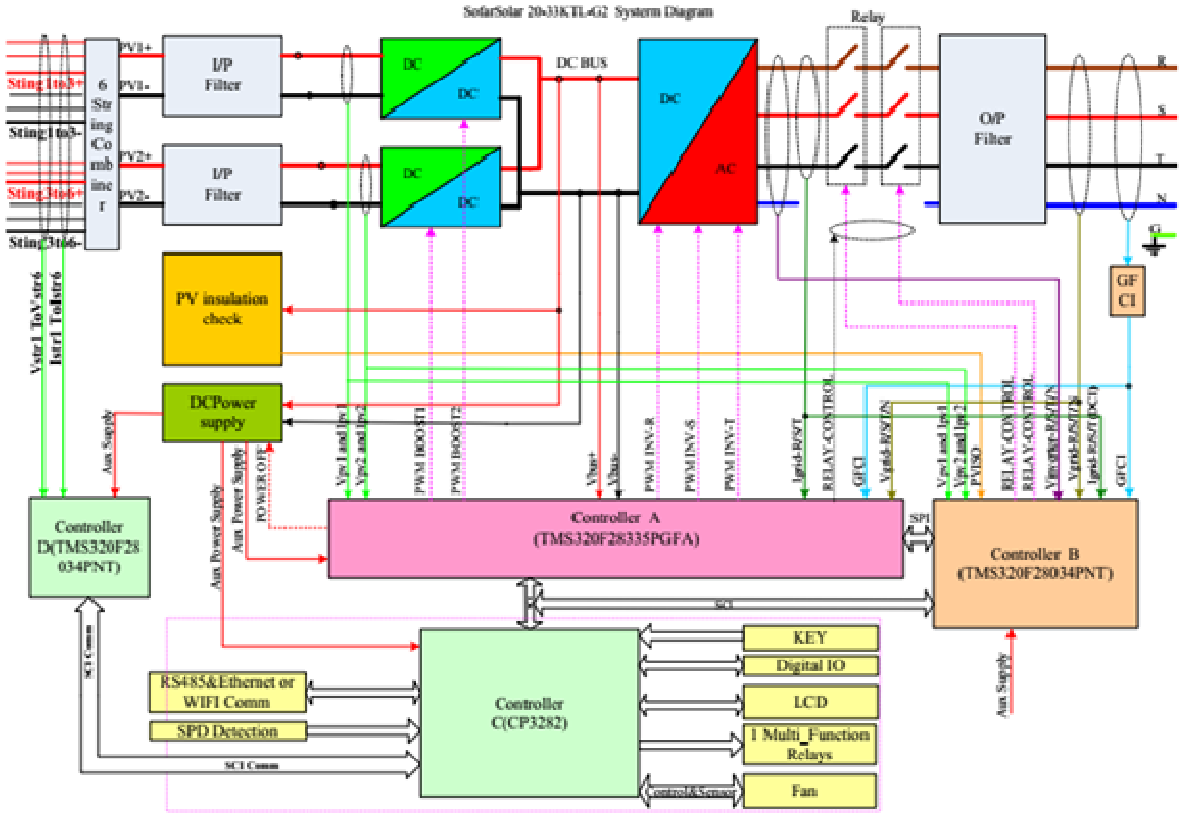
Made in China

Manufacturer : Shenzhen SOFAR SOLAR 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 converter converts DC voltage into AC voltage.
The DC input of Solar converter can be supplied from PV array.
The Solar converter 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 two relays in each phase. This assures that the opening of the output circuit will also operate in case of one error.

Description of the electrical circuit



Block diagram

The internal control is redundant built. It consists of Main DSP(UC20) and slave DSP(UC73).

The Main DSP(UC20) can control the relays, measures voltage, and frequency, AC current with injected DC, insulation resistance and residual current, In addition it tests the array insulation resistance and the RCMU circuit before each start up.

The slave DSP(UC73) is using for detect residual current, also can open the relays independently and communicate with Main DSP(UC20).

The unit provides two relays in each phase. 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 start up. Both controllers(Main DSP(UC20), Slave DSP(UC73) can open the relays.

Differences of the models

The models SOFAR 11000TL-LV, SOFAR 13500TL-LV, SOFAR 16500TL-LV and SOFAR 18000TL-LV are almost identical in hardware except the shown in the following table and the output power derated by software.

The product was tested on

Hardware version: V1.00

Software version: V3.00

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Clause	Requirement + Test	Result - Remark	Verdict

4	**Efficiency measurement conditions**	Considered.	**P**
	Efficiency shall be measured under the matrix of conditions as described in the following clauses and table 1. Specific conditions may be excluded by mutual agreement when those conditions are outside the manufacturer's allowable operating range. The resulting data shall be presented in tabular form and may also be presented graphically.	See below.	**P**
4.1	DC power source for testing		**P**
	For power conditioners operating with fixed input voltage, the d.c. power source is a storage battery or constant voltage power source to maintain the input voltage.		**N/A**
	For power conditioners that employ maximum power point tracking (MPPT) and shunt-type power conditioners, either a photovoltaic array or a photovoltaic array simulator is utilized.	Photovoltaic array simulator used.	**P**
4.2	Temperature		**P**
	All measurements are to be made at an ambient temperature of 25 °C ± 2 °C.	25°C	**P**
	Other ambient temperatures may be allowed by mutual agreement. However, the temperature used must be clearly stated in all documentation.		**N/A**
4.3	Output voltage and frequency		**P**
	The output voltage and frequency are maintained at the manufacturer's stated nominal values.	3/N/PE, 127/220Va.c., 60Hz	**P**
4.4	Input voltage		**P**
	Measurements performed in each of the following tests are repeated at three power conditioner input voltages: a) manufacturer's minimum rated input voltage; b) the inverter's nominal voltage or the average of its rated input range; c) 90 % of the inverter's maximum input voltage.	Input voltages: **a).** SOFAR 11000TL-LV: 480Vd.c.; SOFAR 13500TL-LV: 460Vd.c.; SOFAR 16500TL-LV: 520Vd.c.; SOFAR 18000TL-LV: 580Vd.c.; **b).** 620Vd.c.; **c).** 850Vd.c.* * The voltage value is defined by manufacturer because the value is the max value of full load MPP DC voltage range.	**P**

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Clause	Requirement + Test	Result - Remark	Verdict
	In the case where a power conditioner is to be connected with a battery at its input terminals, only the nominal or rated input voltage may be applied.		**N/A**
4.5	Ripple and distortion		**P**
	Record input voltage and current ripple for each measurement. Also record output voltage and current distortion (if a.c.) or ripple (if d.c.). Ensure that these measurements remain within the manufacturer's specified values.	The ripple of the input voltage had no influence on the measurements. (see appended table)	**P**
4.6	Resistive loads/utility grid		**P**
	At unity power factor, or at the intrinsic power factor of grid-connected inverters without power factor adjustment, measure the efficiency for power levels of 10 %, 25 %, 50 %, 75 %, 100 % and 120 % of the inverter's rating.	The efficiency measurement was performed at 10 %, 25 %, 50 %, 75 % and 100 %, because the unit does not provide 120% of the inverter's rating overload function.	**P**
	Stand-alone inverters are also measured at a power level of 5 % of rated. The power conditioner test is conducted with a specified resistive and reactive grid impedance.	Grid-connected inverters.	**N/A**
4.7	Reactive loads		**N/A**
	For stand-alone inverters, measure the efficiency with a load which provides a power factor equal to the manufacturer's specified minimum level (or 0,25, whichever is greater) and at power levels of 25 %, 50 % and 100 % of rated VA.	Grid-connected inverters.	**N/A**
	Repeat for power factors of 0,5 and 0,75 (do not go below the manufacturer's specified minimum PF) and power levels of 25 %, 50 %, and 100 % of rated VA.		**N/A**
4.8	Resistive plus non-linear loads		**N/A**
	For stand-alone inverters, measure the efficiency with a fixed non-linear load (total harmonic distortion (THD) = (80 ± 5) %) equal to (25 ± 5) % of the inverter's rated VA plus sufficient resistive load in parallel to achieve a total load of 25 %, 50 % and 100 % of rated VA.	Grid-connected inverters.	**N/A**
	Repeat the measurements with a fixed non-linear load equivalent to (50 ± 5) % of the inverter's rated VA plus sufficient resistive load in parallel to achieve a total load of 50% and 100% of rated VA.		**N/A**
	The type of non-linear load must be clearly stated in all documentation.		**N/A**
4.9	Complex loads		**N/A**

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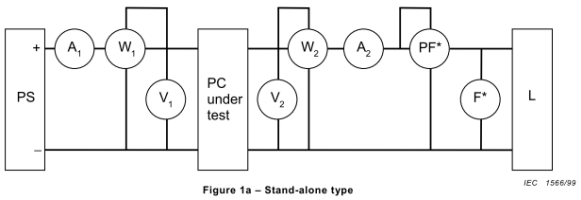
	When a non-linear plus a sufficient reactive load condition is specified for stand-alone inverters, measure the efficiency with a fixed non-linear load (THD = (80 ± 5) %) equal to (50 ± 5) % of the inverter's rated VA plus a sufficient reactive load (PF = 0,5) in parallel to achieve a total load of 50 % and 100 % of rated VA.	Grid-connected inverters.	**N/A**
	The type of complex load is clearly stated in all documentation.		**N/A**
5.	**Efficiency calculations**	See below.	**P**
5.1	Rated output efficiency		**P**
	Rated output efficiency shall be calculated from measured data as follows: $\eta_R = (P_o / P_i) \times 100$	Considered.	**P**
5.2	Partitial output efficiency		**N/A**
	Partial output efficiency shall be calculated from measured data as follows: $\eta_{par} = (P_{op} / P_{ip}) \times 100$	No derating during testing.	**N/A**
5.3	Energy efficiency		**P**
	Energy efficiency shall be calculated from measured data as follows: $\eta_E = (W_o / W_i) \times 100$	Considered.	**P**
5.4	Efficiency tolerances		**P**
	When an efficiency value has been guaranteed, the tolerance of this value shall be within: $-0,2(1-\eta)\eta$ (%)	Considered.	**P**
6.	**Efficiency test circuits**	See below.	**P**
6.1	Test circuits	Considered.	**P**
	Figure 1a is applied to standard-alone power conditioners	Figure 1b used.	**N/A**
	 Figure 1a – Stand-alone type		**N/A**
	Figure 1b is applied to utility-interactive power conditioners	Considered.	**P**

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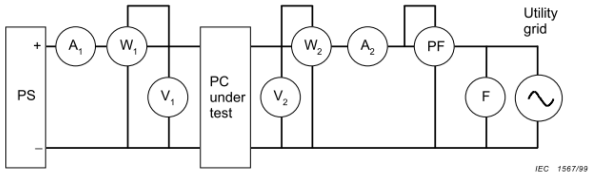
Clause	Requirement + Test	Result - Remark	Verdict
	 **Figure 1b – Utility-interactive type** PC power conditioner PS variable voltage-current d.c. power supply A_1 DC ammeter A_2 AC or d.c. ammeter W_1 DC wattmeter W_2 AC or d.c. wattmeter L load F frequency meter V_1 DC voltmeter V_2 AC or d.c. voltmeter PF power factor meter		**P**
6.2	Measurement procedure	Considered.	**P**
	a) Efficiency is calculated with equation (1) or (2) using measured P_i, P_o or P_{ip}, P_{op}. DC input power P_i, P_{ip} can be measured by wattmeter W_1, or determined by multiplying the d.c. voltmeter V_1 and d.c. ammeter A_1 readings. Output power P_o, P_{op} is measured with wattmeter W_2.	Considered.	**P**
	b) DC input voltage, which is measured by d.c. voltmeter V_1, shall be varied in the defined range where the output current, which is measured with a.c. ammeter A_2, is varied from low output to the rated output.	Considered.	**P**
	c) An average indicating instrument shall be used for the d.c. voltmeter and d.c. ammeter. A true r.m.s. type of indicating instrument shall be used for the a.c. voltmeter and a.c. ammeter. The d.c. wattmeter W_1 shall be a d.c. measuring type. The wattmeter W_2 shall be an a.c. or d.c. measuring type according to the output.	Considered.	**P**
	d) Power factor (PF in per cent) can be measured by a power factor meter PF, or calculated from the readings of V_2, A_2, W_2 and as follows: $PF = (W_2/(V_2 \times A_2)) \times 100$	Considered.	**P**
	e) Each meter may be an analogue type or a digital type. The measurement accuracy shall be better than ± 0,5 % of the full-scale value for each power measured. Digital power instruments for W1 and W2 are also recommended.	Digital measurement devices were used for testing. The accuracy of the measurement devices fulfills the requirements.	**P**
	f) An MPPT dynamically adjusts the input voltage so as to maximize the output power. In principle, the monitoring equipment shall sample all of the electrical parameters, such as input voltage and current, output power and current, within the update period of the MPPT. If the MPPT and input source (PV array or PV array simulator) interact in such a way that the input voltage varies by less than 5 %, then averaging of readings is acceptable. The averaging period shall be 30 s or longer.	The dynamic MPPT was deactivated, the 60s average was used anyway.	**P**

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Clause	Requirement + Test	Result - Remark	Verdict
7.	**Loss measurement**	See below.	**P**
7.1	No-load loss		**P**
	Stand-alone inverters: reading of d.c. input voltage, output voltage and frequency is given with meters V_1, V_2 and F respectively in figure 1a, and shall be adjusted to the rated values.	Grid-connected inverters.	**N/A**
	Utility-interactive inverters: reading of d.c. input voltmeter V_1, a.c. output voltmeter V_2 and frequency meter F in figure 1b shall be adjusted to meet the specified voltages and frequency.	See appended table.	**P**
7.2	Standby loss		**P**
	Stand-alone inverters: Consumption of utility power when the power conditioner is not operating but is under standby condition.	No such inverters.	**N/A**
	Utility-interactive inverters: consumption from the d.c. source when the power conditioner is not operating but is under standby condition.	See appended table.	**P**
Annex A	**Power conditioner description (informative)**	See below.	**P**
	A power conditioner is defined in IEC 61277	Figure A.2	**P**
Annex B	**Power efficiency and conversion factor (informative)**	See below.	**P**
	There are two types of efficiencies shown in IEC 60146-2; one is a power efficiency, the other is a conversion factor. Power efficiency is defined as the ratio of active output power and active input power. Conversion factor is the ratio between output and input fundamental power levels.	Power efficiency used.	**P**
Annex C	**Weighted-average energy efficiency (informative)**	See below.	**P**
	The energy of a power conditioner depends on both the irradiance profile and the load profile. The energy efficiency of a power conditioner shall be calculated by the ratio of the output to the input energy actually measured over a certain period	Considered.	**P**
C.1	η_{WT} of power conditioner for utility-interactive PV systems	Considered.	**P**
	Utility-interactive PV systems, which have no storage and for which reverse-power flow is accepted, are described. In this case, d.c. power generated by the PV array is supplied direct into the power conditioner (PC). Almost all of the input power to the PC is converted to a.c. power. A part of it is dissipated as the PC loss.	Considered.	**P**

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Clause	Requirement + Test	Result - Remark	Verdict
C.2	η_{WT} of power conditioner for stand-alone PV systems	Grid-connected inverters.	**N/A**
	In stand-alone PV systems with a storage subsystem, power generated from the PV array is stored and stabilized by the batteries. DC power is converted into regulated d.c. power or constant-voltage and constant-frequency a.c. power by a power conditioner (PC) and supplied to the load. In this case, some fraction of the generated power is dissipated as a loss in the batteries and power conditioner.		**N/A**
Annex D	**Derivation of efficiency tolerance in table 2 (informative)**	Considered.	**P**

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Clause	Requirement + Test	Result - Remark	Verdict

TABLE	**Efficiency recording and efficient calculation sheet**								
power conditioner type	**Grid-connected**								
Model:	**SOFAR 11000TL-LV**								
Parameters of power conditioner	Minimum rated input voltage: 480Vd.c. Nominal voltage: 620Vd.c. Maximum input voltage: 1100Vd.c. Rated output voltage: 127Va.c. Rated output frequency: 60Hz Max output apparent power:11,0kVA								
PV input voltage	**a) Manufacturer's minimum rated input voltage(480Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	480,09	479,95	479,69	479,45	479,16	480,09	/	/
Input voltage ripple (V)	/	0,02	0,02	0,02	0,02	0,03	0,02	/	/
Input current (A)	/	2,428	5,93	11,808	17,744	24,041	2,428	/	/
Input current ripple (A)	/	0,005	0,008	0,016	0,023	0,032	0,005	/	/
Input power (Pi) (kW)	/	1,165	2,846	5,664	8,506	11,519	1,165	/	/
Output power (Po) (kW)	/	1,095	2,733	5,471	8,221	11,119	1,095	/	/
Output efficiency	/	93,99%	96,03%	96,59%	96,65%	96,53%	93,99%	/	/
Input energy (Wi) (kWh)	/	0,019	0,047	0,094	0,142	0,192	0,019	/	/
Output energy (Wo) (kWh)	/	0,018	0,046	0,091	0,137	0,185	0,018	/	/
Energy efficiency	/	93,99%	96,03%	96,59%	96,65%	96,53%	93,99%	/	/
PV input voltage	**b) The inverter's nominal voltage(620Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	620,23	620,11	619,91	619,72	619,5	620,23	/	/
Input voltage ripple (V)	/	0,02	0,02	0,02	0,02	0,03	0,02	/	/
Input current (A)	/	1,905	4,625	9,151	13,74	18,694	1,905	/	/
Input current ripple (A)	/	0,004	0,007	0,013	0,018	0,026	0,004	/	/

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Clause	Requirement + Test	Result - Remark	Verdict

Input power (Pi) (W)	/	1,179	2,867	5,671	8,513	11,579	1,179	/	/
Output power (Po) (W)	/	1,098	2,741	5,457	8,197	11,137	1,098	/	/
Output efficiency	/	93,13%	95,61%	96,23%	96,29%	96,18%	93,13%	/	/
Input energy (Wi) (kWh)	/	0,020	0,048	0,095	0,142	0,193	0,020	/	/
Output energy (Wo) (kWh)	/	0,018	0,046	0,091	0,137	0,186	0,018	/	/
Energy efficiency	/	93,13%	95,61%	96,23%	96,29%	96,18%	93,13%	/	/
PV input voltage	**c) 90% of the inverter's maximum input voltage**(850Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	848,36	848,29	848,14	848,01	847,84	848,36	/	/
Input voltage ripple (V)	/	0,02	0,02	0,02	0,02	0,03	0,02	/	/
Input current (A)	/	1,418	3,422	6,771	10,154	13,768	1,418	/	/
Input current ripple (A)	/	0,004	0,005	0,011	0,017	0,019	0,004	/	/
Input power (Pi) (W)	/	1,202	2,902	5,741	8,608	11,67	1,202	/	/
Output power (Po) (W)	/	1,100	2,754	5,495	8,247	11,166	1,100	/	/
Output efficiency	/	91,51%	94,90%	95,72%	95,81%	95,68%	91,51%	/	/
Input energy (Wi) (kWh)	/	0,020	0,048	0,096	0,143	0,195	0,020	/	/
Output energy (Wo) (kWh)	/	0,018	0,046	0,092	0,137	0,186	0,018	/	/
Energy efficiency	/	91,51%	94,90%	95,72%	95,81%	95,68%	91,51%	/	/

Remark:

*If limited by design, inverter is not capable to operate with the 120% of rated output load, test under this condition is waived;

** The EUT can't start up at 990Vdc.

IEC 61683			
Clause	Requirement + Test	Result - Remark	Verdict

TABLE	**Efficiency recording and efficient calculation sheet**								
power conditioner type	**Grid-connected**								
Model:	**SOFAR 13500TL-LV**								
Parameters of power conditioner	Minimum rated input voltage: 460Vd.c. Nominal voltage: 620Vd.c. Maximum input voltage: 1100Vd.c. Rated output voltage: 127Va.c. Rated output frequency: 60Hz Max output apparent power:13,5kVA								
PV input voltage	**a) Manufacturer's minimum rated input voltage(460Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	460,06	459,86	459,56	459,22	458,87	/	/	/
Input voltage ripple (V)	/	0,02	0,02	0,02	0,02	0,03	/	/	/
Input current (A)	/	2,936	7,81	15,189	23,074	30,833	/	/	/
Input current ripple (A)	/	0,006	0,012	0,02	0,032	0,045	/	/	/
Input power (Pi) (kW)	/	1,350	3,591	6,98	10,595	14,147	/	/	/
Output power (Po) (kW)	/	1,276	3,461	6,749	10,238	13,643	/	/	/
Output efficiency (%)	/	94,52%	96,38%	96,69%	96,63%	96,44%	/	/	/
Input energy (Wi) (kWh)	/	0,023	0,060	0,116	0,177	0,236	/	/	/
Output energy (Wo) (kWh)	/	0,021	0,058	0,112	0,171	0,227	/	/	/
Energy efficiency	/	94,52%	96,38%	96,69%	96,63%	96,44%	/	/	/
PV input voltage	**b) The inverter's nominal voltage(620Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	620,2	620,07	619,83	619,57	619,31	/	/	/
Input voltage ripple (V)	/	0,02	0,02	0,03	0,02	0,02	/	/	/
Input current (A)	/	2,212	5,527	11,319	17,082	22,692	/	/	/
Input current ripple (A)	/	0,005	0,007	0,017	0,025	0,033	/	/	/

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Clause	Requirement + Test	Result - Remark	Verdict

Input power (Pi) (W)	/	1,369	3,426	7,014	10,581	14,051	/	/	/
Output power (Po) (W)	/	1,283	3,282	6,753	10,177	13,492	/	/	/
Output efficiency	/	93,72%	95,80%	96,28%	96,18%	96,02%	/	/	/
Input energy (Wi) (kWh)	/	0,023	0,057	0,117	0,176	0,234	/	/	/
Output energy (Wo) (kWh)	/	0,021	0,055	0,113	0,170	0,225	/	/	/
Energy efficiency	/	93,72%	95,80%	96,28%	96,18%	96,02%	/	/	/
PV input voltage	**c) 90% of the inverter's maximum input voltage**(850Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	848,36	848,26	848,09	847,9	847,71	/	/	/
Input voltage ripple (V)	/	0,03	0,02	0,02	0,02	0,02	/	/	/
Input current (A)	/	1,635	4,1	8,315	12,4	16,794	/	/	/
Input current ripple (A)	/	0,004	0,006	0,012	0,017	0,025	/	/	/
Input power (Pi) (W)	/	1,386	3,476	7,05	10,51	14,233	/	/	/
Output power (Po) (W)	/	1,289	3,307	6,751	10,058	13,593	/	/	/
Output efficiency	/	93,00%	95,14%	95,76%	95,70%	95,50%	/	/	/
Input energy (Wi) (kWh)	/	0,023	0,058	0,118	0,175	0,237	/	/	/
Output energy (Wo) (kWh)	/	0,021	0,055	0,113	0,168	0,227	/	/	/
Energy efficiency	/	93,00%	95,14%	95,76%	95,70%	95,50%	/	/	/

Remark:

*If limited by design, inverter is not capable to operate with the 120% of rated output load, test under this condition is waived;

** The EUT can't start up at 990Vdc.

IEC 61683			
Clause	Requirement + Test	Result - Remark	Verdict

TABLE	**Efficiency recording and efficient calculation sheet**								
power conditioner type	**Grid-connected**								
Model:	**SOFAR 16500TL-LV**								
Parameters of power conditioner	Minimum rated input voltage: 520Vd.c. Nominal voltage: 620Vd.c. Maximum input voltage: 1100Vd.c. Rated output voltage: 230Va.c. Rated output frequency: 50Hz Max output apparent power:16,5kVA								
PV input voltage	**a) Manufacturer's minimum rated input voltage(520Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	520,09	519,88	519,53	519,15	518,78	/	/	/
Input voltage ripple (V)	/	0,02	0,02	0,02	0,02	0,02	/	/	/
Input current (A)	/	3,309	8,372	16,341	24,816	33,317	/	/	/
Input current ripple (A)	/	0,005	0,013	0,023	0,036	0,045	/	/	/
Input power (Pi) (kW)	/	1,720	4,352	8,488	12,882	17,282	/	/	/
Output power (Po) (kW)	/	1,642	4,193	8,195	12,416	16,611	/	/	/
Output efficiency (%)	/	95,47%	96,35%	96,55%	96,38%	96,12%	/	/	/
Input energy (Wi) (kWh)	/	0,029	0,073	0,141	0,215	0,288	/	/	/
Output energy (Wo) (kWh)	/	0,027	0,070	0,137	0,207	0,277	/	/	/
Energy efficiency	/	95,47%	96,35%	96,55%	96,38%	96,12%	/	/	/
PV input voltage	**b) The inverter's nominal voltage(620Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	620,23	620,06	619,76	619,44	619,12	/	/	/
Input voltage ripple (V)	/	0,02	0,02	0,02	0,02	0,02	/	/	/
Input current (A)	/	2,811	7,029	13,754	20,78	28,014	/	/	/
Input current ripple (A)	/	0,005	0,01	0,023	0,029	0,038	/	/	/

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Clause	Requirement + Test	Result - Remark	Verdict

Input power (Pi) (kW)	/	1,743	4,357	8,523	12,87	17,341	/	/	/
Output power (Po) (kW)	/	1,647	4,184	8,203	12,359	16,61	/	/	/
Output efficiency (%)	/	94,49%	96,03%	96,25%	96,03%	95,78%	/	/	/
Input energy (Wi) (kWh)	/	0,029	0,073	0,142	0,215	0,289	/	/	/
Output energy (Wo) (kWh)	/	0,027	0,070	0,137	0,206	0,277	/	/	/
Energy efficiency	/	94,49%	96,03%	96,25%	96,03%	95,78%	/	/	/
PV input voltage	**c) 90% of the inverter's maximum input voltage**(850Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	848,36	848,24	848,02	847,79	847,56	/	/	/
Input voltage ripple (V)	/	0,02	0,02	0,02	0,02	0,02	/	/	/
Input current (A)	/	2,091	5,205	10,109	15,375	20,437	/	/	/
Input current ripple (A)	/	0,006	0,008	0,019	0,025	0,034	/	/	/
Input power (Pi) (kW)	/	1,771	4,414	8,569	13,032	17,317	/	/	/
Output power (Po) (kW)	/	1,658	4,216	8,207	12,456	16,494	/	/	/
Output efficiency (%)	/	93,62%	95,51%	95,78%	95,58%	95,25%	/	/	/
Input energy (Wi) (kWh)	/	0,030	0,074	0,143	0,217	0,289	/	/	/
Output energy (Wo) (kWh)	/	0,028	0,070	0,137	0,208	0,275	/	/	/
Energy efficiency	/	93,62%	95,51%	95,78%	95,58%	95,25%	/	/	/

Remark:

*If limited by design, inverter is not capable to operate with the 120% of rated output load, test under this condition is waived;

** The EUT can't start up at 990Vdc.

IEC 61683			
Clause	Requirement + Test	Result - Remark	Verdict

TABLE	**Efficiency recording and efficient calculation sheet**								
power conditioner type	**Grid-connected**								
Model:	**SOFAR 18000TL-LV**								
Parameters of power conditioner	Minimum rated input voltage: 580Vd.c. Nominal voltage: 720Vd.c. Maximum input voltage: 1100Vd.c. Rated output voltage: 400Va.c. Rated output frequency: 50Hz Rated output power: 42,0kW Max output apparent power: 47kVA								
PV input voltage	**a) Manufacturer's minimum rated input voltage(580Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	580,12	579,90	579,54	579,17	578,80	/	/	/
Input voltage ripple (V)	/	0,03	0,02	0,02	0,03	0,02	/	/	/
Input current (A)	/	3,317	8,171	15,996	24,217	32,435	/	/	/
Input current ripple (A)	/	0,005	0,012	0,021	0,035	0,059	/	/	/
Input power (Pi) (kW)	/	1,923	4,737	9,269	14,023	18,77	/	/	/
Output power (Po) (kW)	/	1,828	4,561	8,935	13,485	17,99	/	/	/
Output efficiency (%)	/	95,06%	96,28%	96,40%	96,16%	95,84%	/	/	/
Input energy (Wi) (kWh)	/	0,032	0,079	0,154	0,234	0,313	/	/	/
Output energy (Wo) (kWh)	/	0,030	0,076	0,149	0,225	0,300	/	/	/
Energy efficiency	/	95,06%	96,28%	96,40%	96,16%	95,84%	/	/	/
PV input voltage	**b) The inverter's nominal voltage (620Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (V)	/	620,22	620,02	619,69	619,36	619,00	/	/	/
Input voltage ripple (V)	/	0,02	0,02	0,02	0,03	0,02	/	/	/
Input current (A)	/	3,113	7,656	15,286	22,689	30,424	/	/	/

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Clause	Requirement + Test	Result - Remark	Verdict

Input current ripple (A)	/	0,005	0,011	0,02	0,035	0,068	/	/	/
Input power (Pi) (kW)	/	1,93	4,746	9,47	14,05	18,829	/	/	/
Output power (Po) (kW)	/	1,83	4,563	9,117	13,496	18,023	/	/	/
Output efficiency (%)	/	94,82%	96,14%	96,27%	96,06%	95,72%	/	/	/
Input energy (Wi) (kWh)	/	0,032	0,079	0,158	0,234	0,314	/	/	/
Output energy (Wo) (kWh)	/	0,031	0,076	0,152	0,225	0,300	/	/	/
Energy efficiency	/	94,82%	96,14%	96,27%	96,06%	95,72%	/	/	/
PV input voltage	**c) 90% of the inverter's maximum input voltage**(850Vd.c.)**								
Temperature (°C)	25,0								
Operating period for energy measurement (min)	1,0								
Percentage of rated output VA	/	10%	25%	50%	75%	100%	120%*	/	/
Input voltage (Vd.c.)	/	848,35	848,21	847,96	847,72	847,47	/	/	/
Input voltage ripple (Vd.c.)	/	0,02	0,03	0,02	0,02	0,02	/	/	/
Input current (Ad.c.)	/	2,306	5,636	11,271	16,746	22,492	/	/	/
Input current ripple (Ad.c.)	/	0,005	0,01	0,017	0,025	0,053	/	/	/
Input power (Pi) (kW)	/	1,954	4,779	9,555	14,192	19,054	/	/	/
Output power (Po) (kW)	/	1,833	4,563	9,141	13,543	18,128	/	/	/
Output efficiency (%)	/	93,81%	95,48%	95,67%	95,43%	95,14%	/	/	/
Input energy (Wi) (kWh)	/	0,033	0,080	0,159	0,237	0,318	/	/	/
Output energy (Wo) (kWh)	/	0,031	0,076	0,152	0,226	0,302	/	/	/
Energy efficiency	/	93,81%	95,48%	95,67%	95,43%	95,14%	/	/	/

Remark:

*If limited by design, inverter is not capable to operate with the 120% of rated output load, test under this condition is waived;

** The EUT can't start up at 990Vdc.

IEC 61683			
Clause	Requirement + Test	Result - Remark	Verdict

TABLE	No load loss: SOFAR 11000TL-LV
power conditioner type	Utility-interactive
Measure input voltage (V)	620,32
Measured input power(W)	32,329
Remark: No load loss is measured when the power conditioner works at rated input voltage and it's load is disconnected.	

TABLE	No load loss: SOFAR 13500TL-LV
power conditioner type	Utility-interactive
Measure input voltage (V)	620,29
Measured input power(W)	32,588
Remark: No load loss is measured when the power conditioner works at rated input voltage and it's load is disconnected.	

TABLE	No load loss: SOFAR 16500TL-LV
power conditioner type	Utility-interactive
Measure input voltage (V)	33,129
Measured input power(W)	620,34
Remark: No load loss is measured when the power conditioner works at rated input voltage and it's load is disconnected.	

TABLE	No load loss: SOFAR 18000TL-LV
power conditioner type	Utility-interactive
Measure input voltage (V)	620,29
Measured input power(W)	33,23
Remark: No load loss is measured when the power conditioner works at rated input voltage and it's load is disconnected.	

IEC 61683			
Clause	Requirement + Test	Result - Remark	Verdict

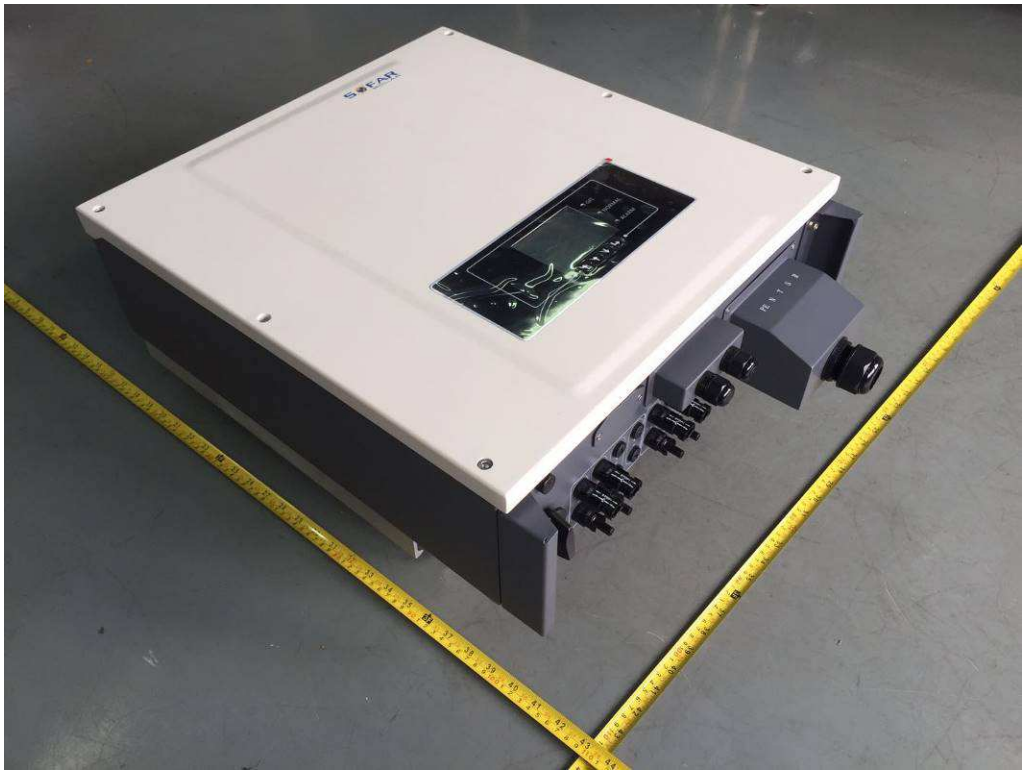
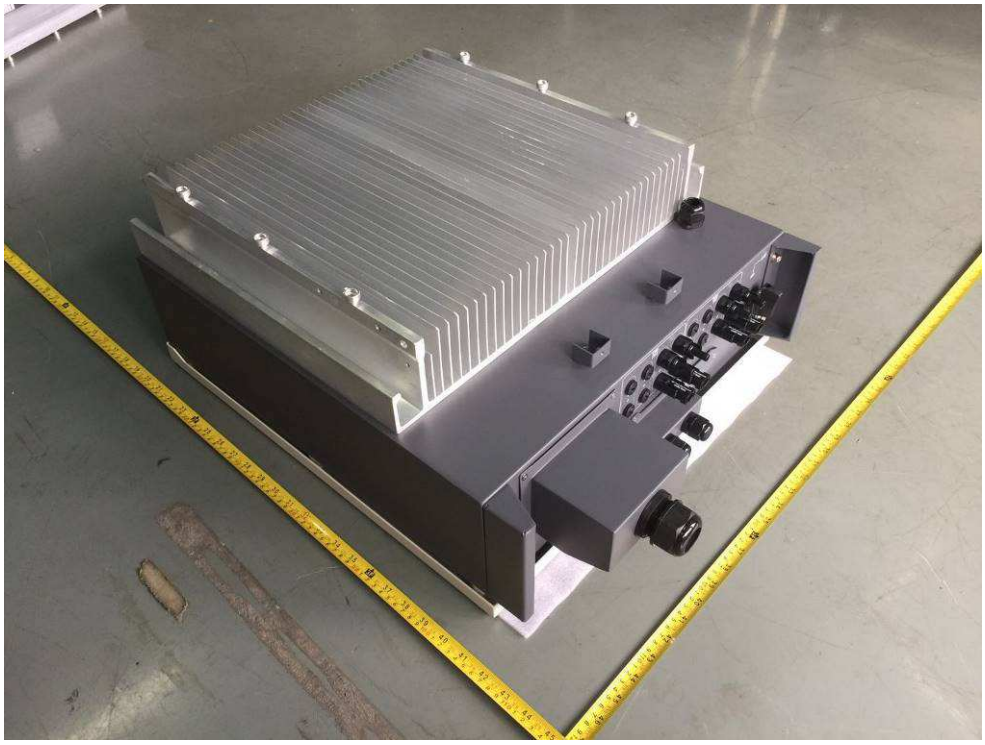
TABLE	Standby loss: SOFAR 11000TL-LV
power conditioner type	Utility-interactive
Measure output voltage (V)	127,03
Measured output power(W)	0,140
Remark: Standby loss is measured when the power conditioner works at rated input voltage and in standby mode.	

TABLE	Standby loss: SOFAR 13500TL-LV
power conditioner type	Utility-interactive
Measure output voltage (V)	127,23
Measured output power(W)	0,140
Remark: Standby loss is measured when the power conditioner works at rated input voltage and in standby mode.	

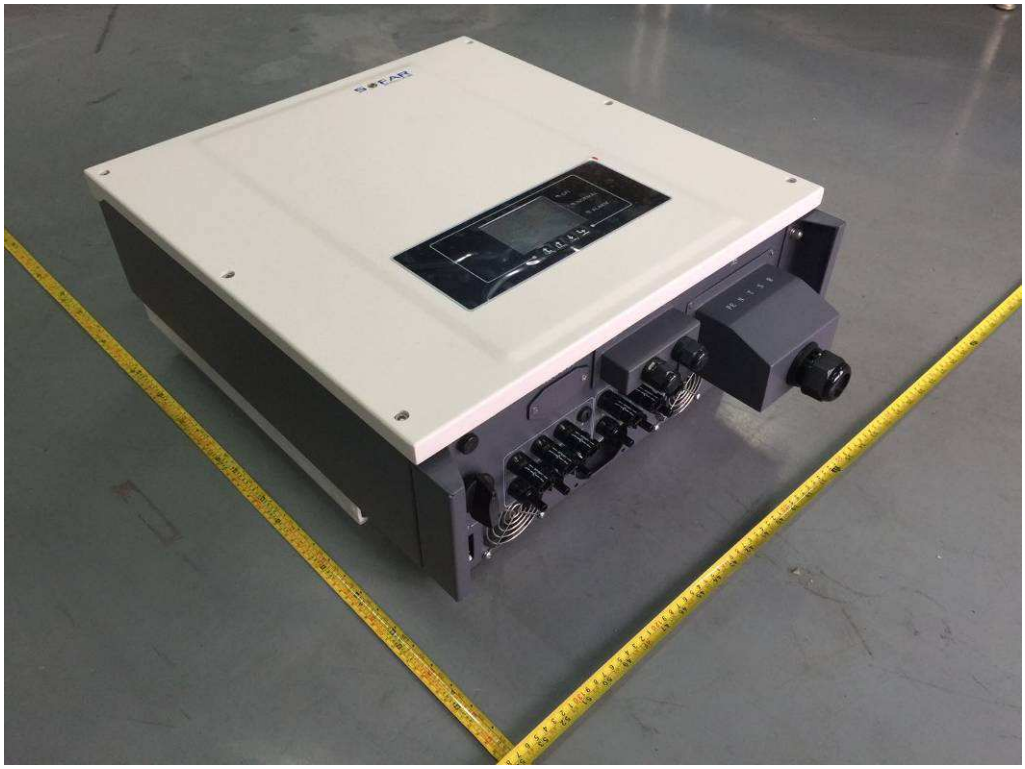
TABLE	Standby loss: SOFAR 16500TL-LV
power conditioner type	Utility-interactive
Measure output voltage (V)	127,01
Measured output power(W)	0,136
Remark: Standby loss is measured when the power conditioner works at rated input voltage and in standby mode.	

TABLE	Standby loss: SOFAR 18000TL-LV
power conditioner type	Utility-interactive
Measure output voltage (V)	127,04
Measured output power(W)	0,138
Remark: Standby loss is measured when the power conditioner works at rated input voltage and in standby mode.	

Annex 1
Pictures of the unit

Enclosure front view: SOFAR 11000TL-LV

Enclosure rear view: SOFAR 11000TL-LV


Enclosure front view: SOFAR 13500TL-LV

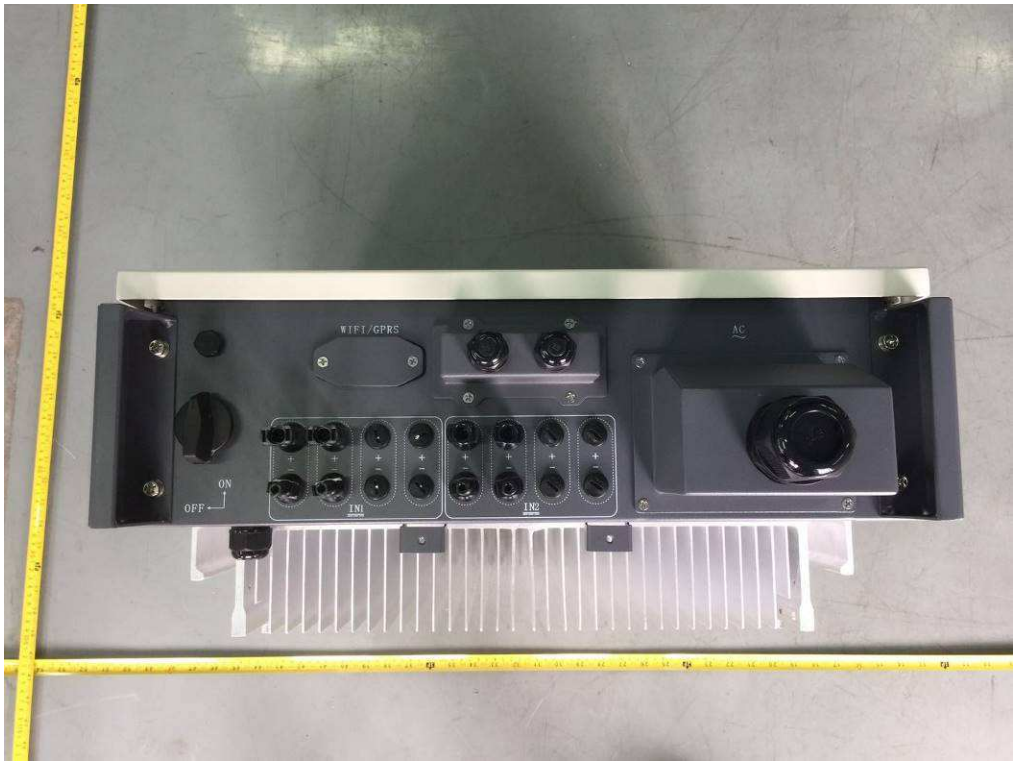


Enclosure rear view: SOFAR 13500TL-LV

Enclosure front view: SOFAR 16500TL-LV、SOFAR 18000TL-LV

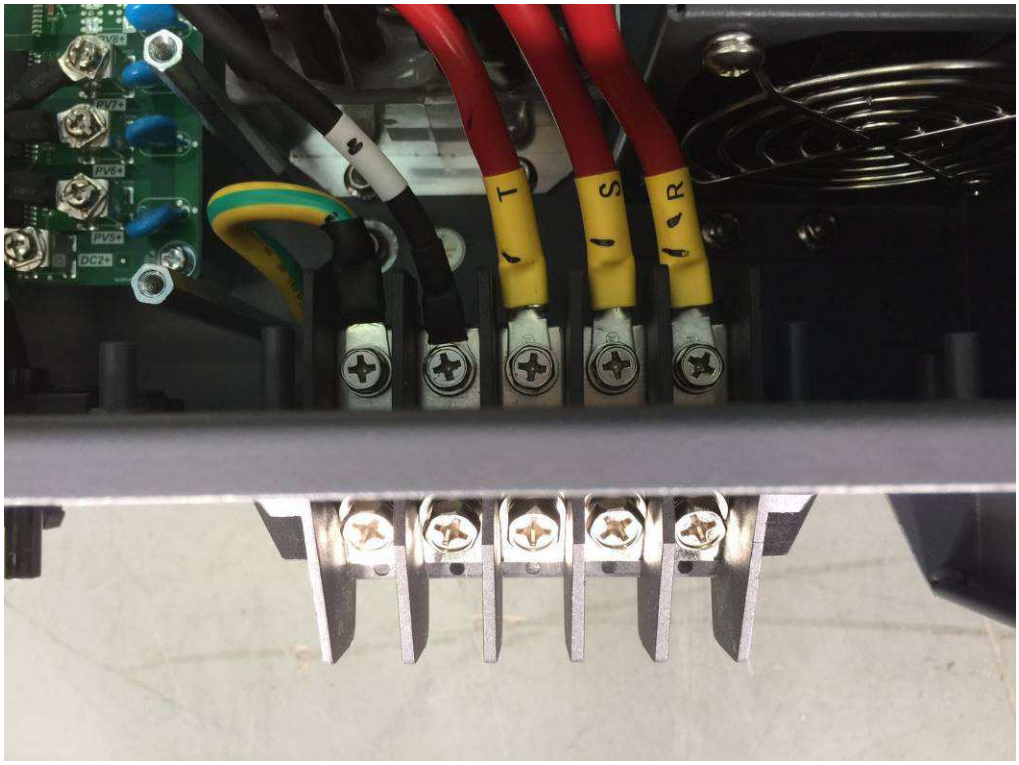
Enclosure rear view: SOFAR 16500TL-LV、SOFAR 18000TL-LV

Enclosure terminal view: SOFAR 11000TL-LV

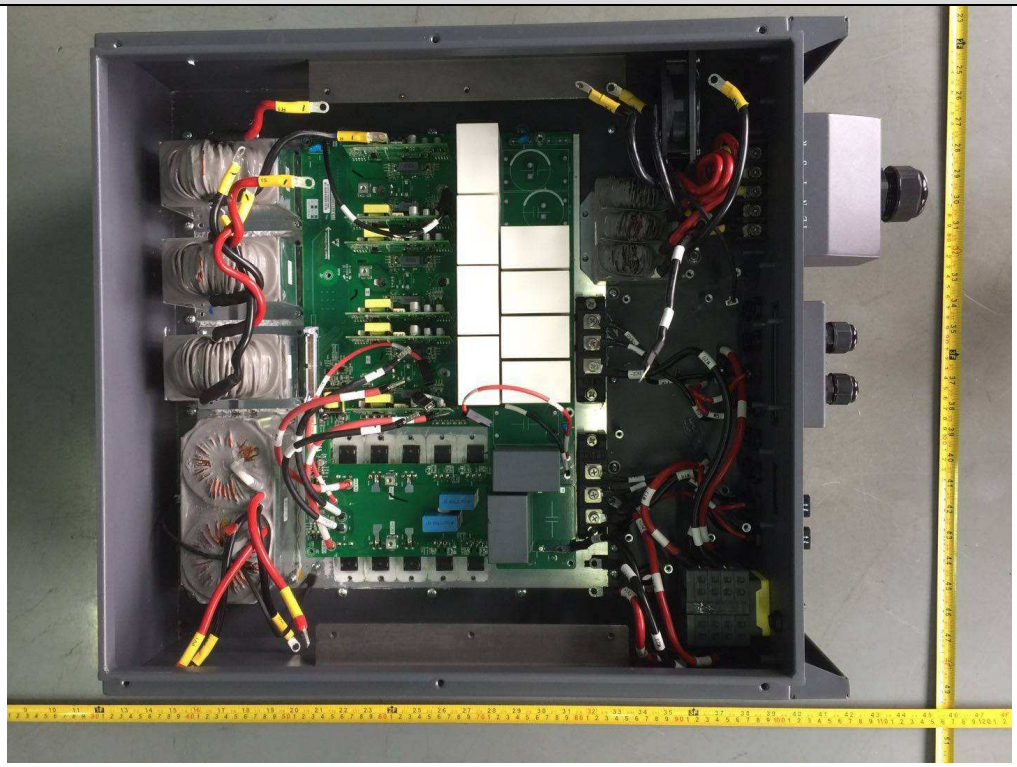


Enclosure terminal view: SOFAR 13500TL-LV

Enclosure terminal view: SOFAR 16500TL-LV、SOFAR 18000TL-LV

AC output terminal


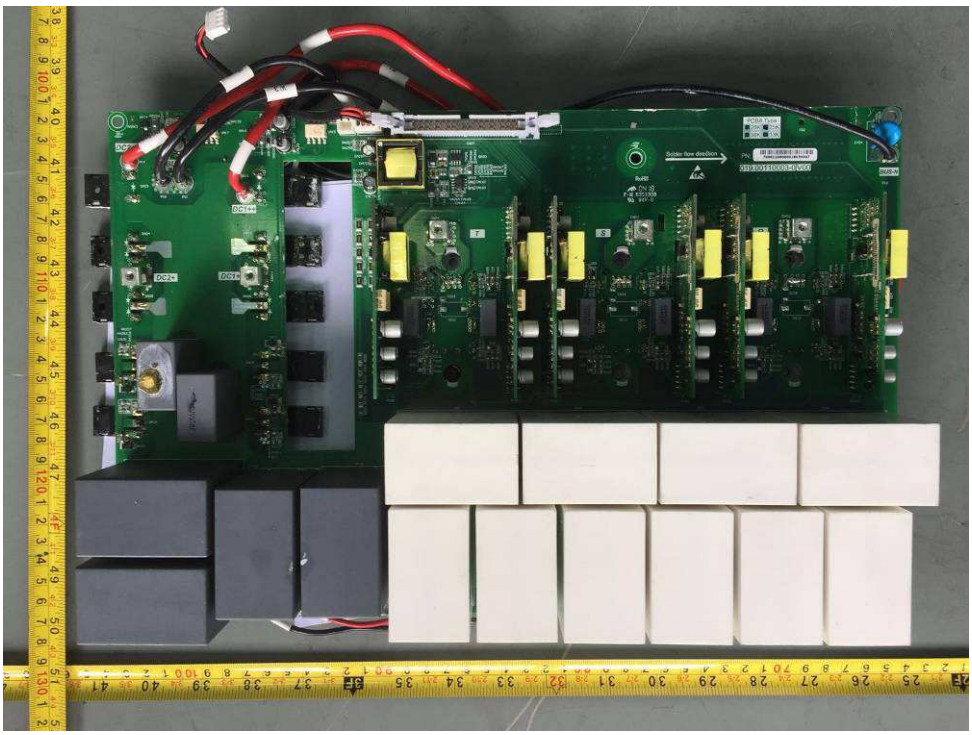
Internal view: SOFAR 11000TL-LV

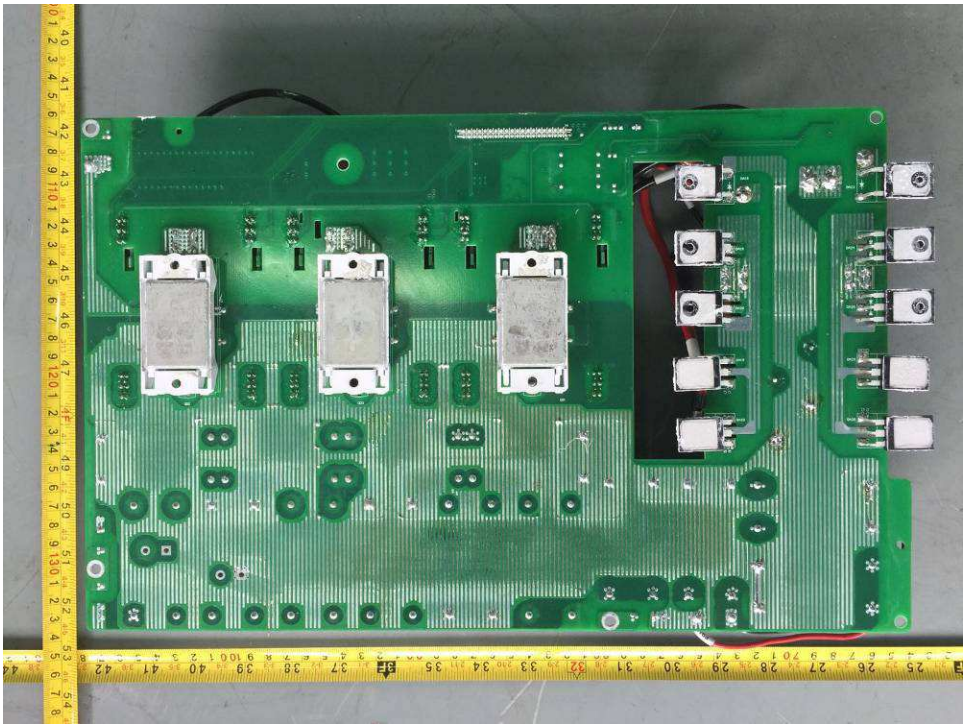
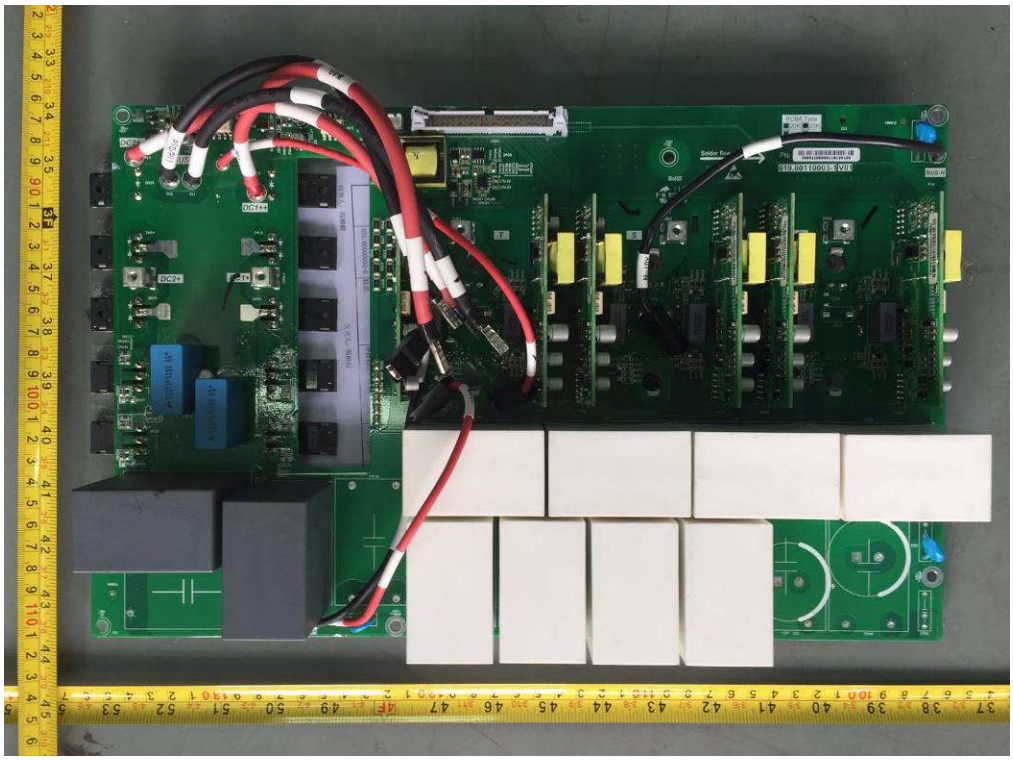


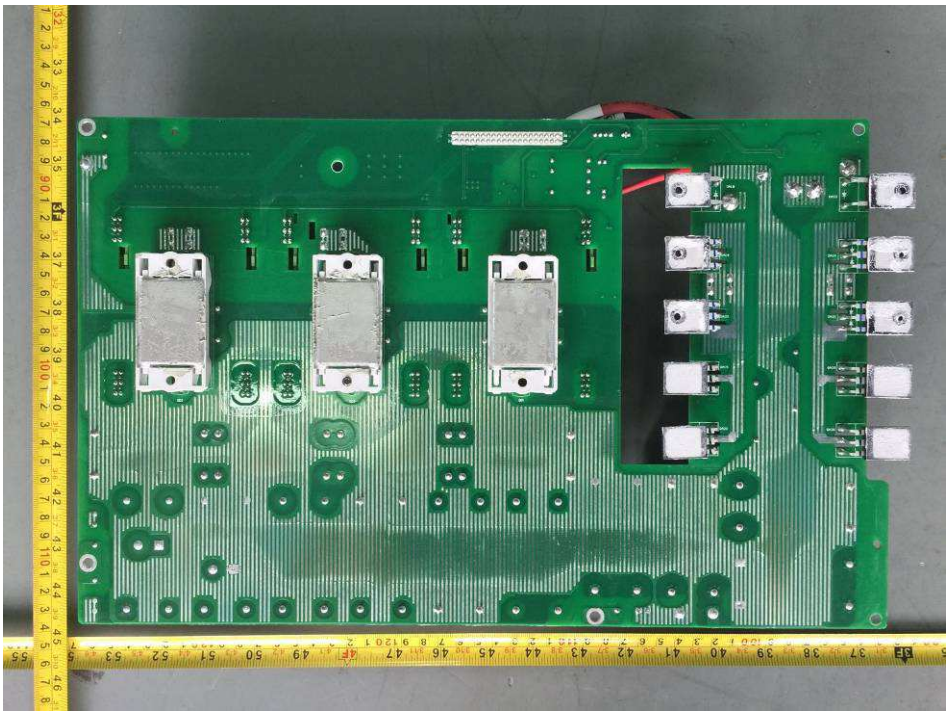
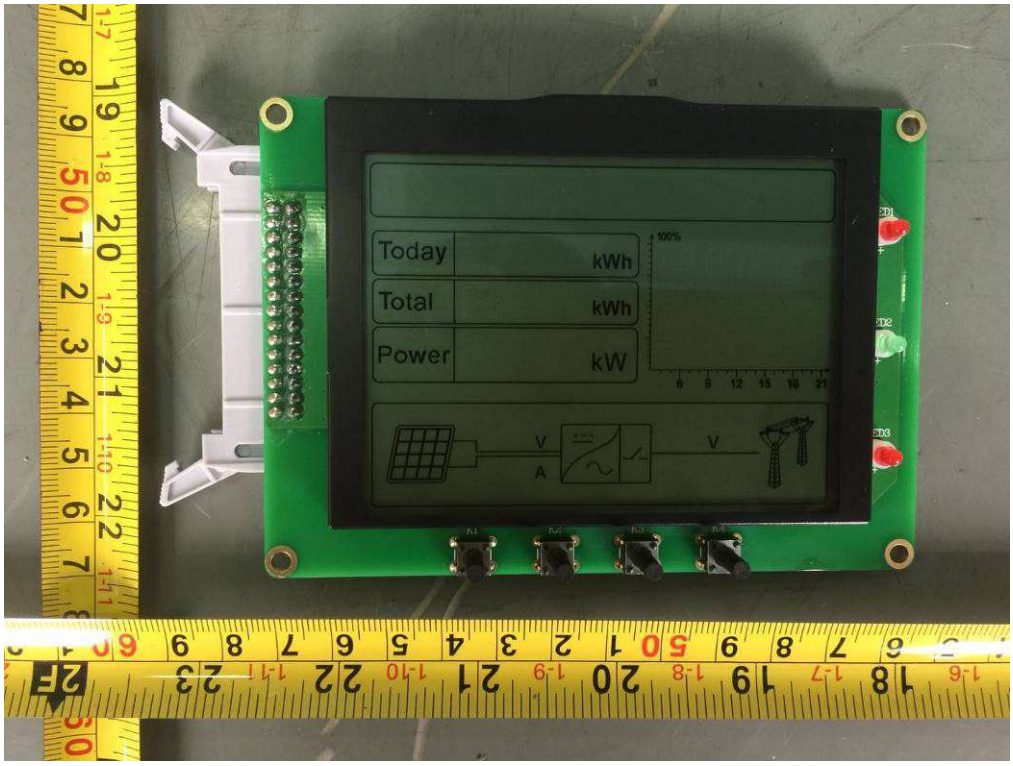
Internal view: SOFAR 13500TL-LV

Internal view: SOFAR 16500TL-LV、SOFAR 18000TL-LV

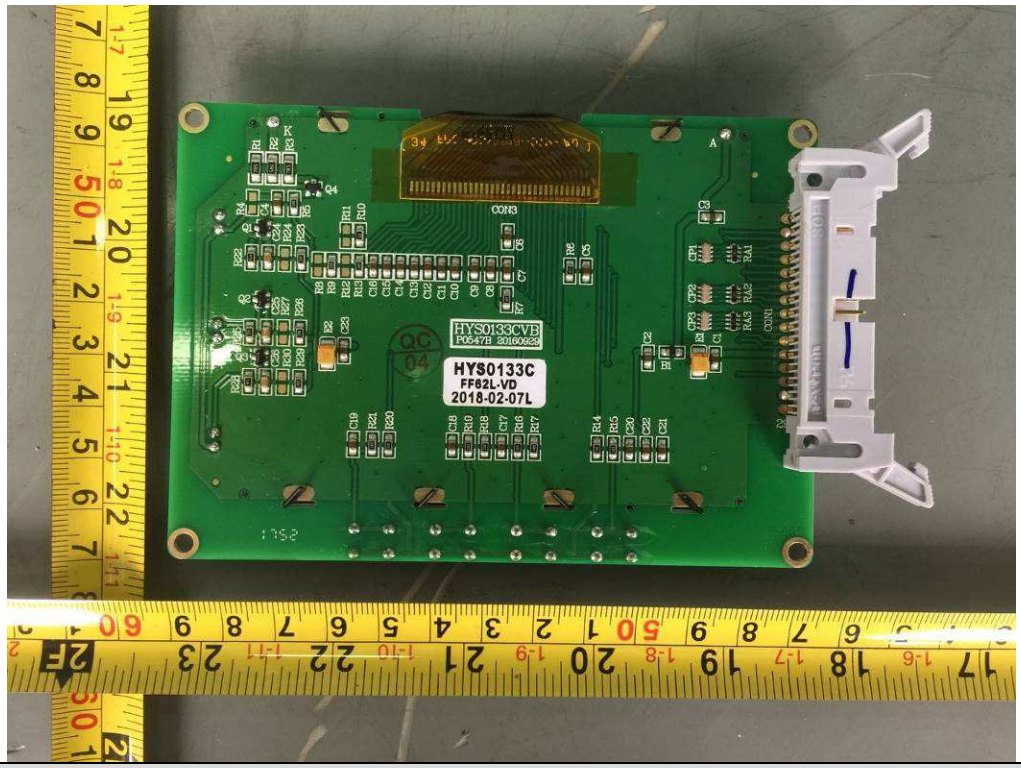
Main board-component side view: SOFAR 16500TL-LV、SOFAR 18000TL-LV



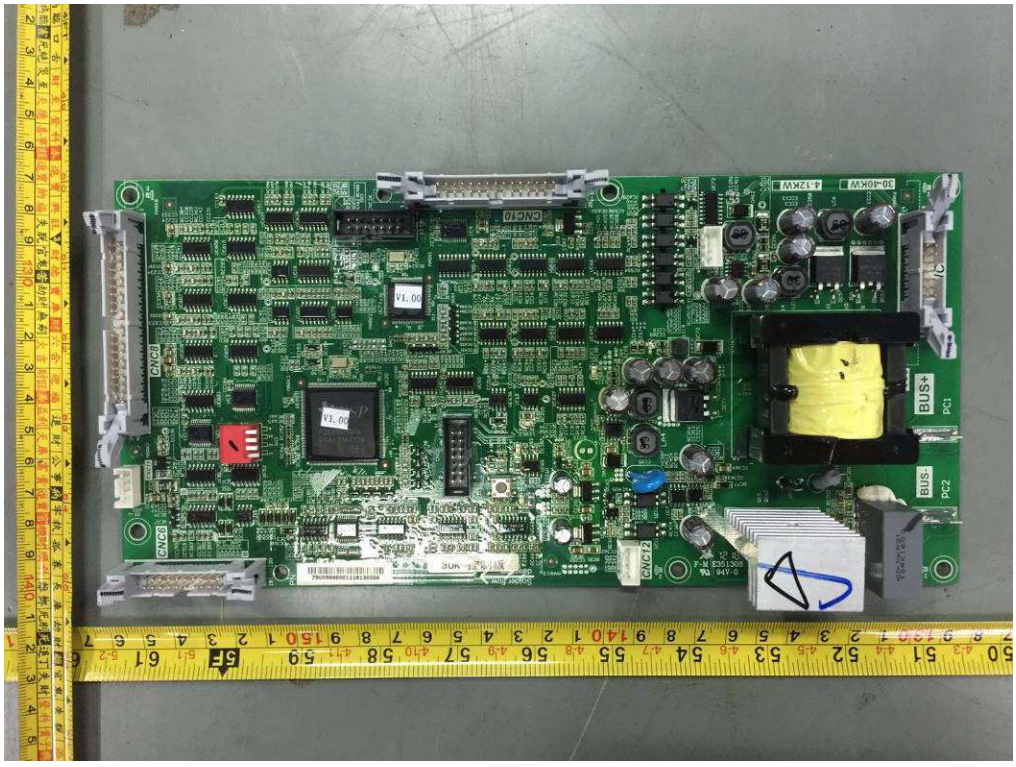
Main board- solder side view: SOFAR 16500TL-LV、SOFAR 18000TL-LV

Main board-component side view: SOFAR 11000TL-LV、SOFAR 13500TL-LV


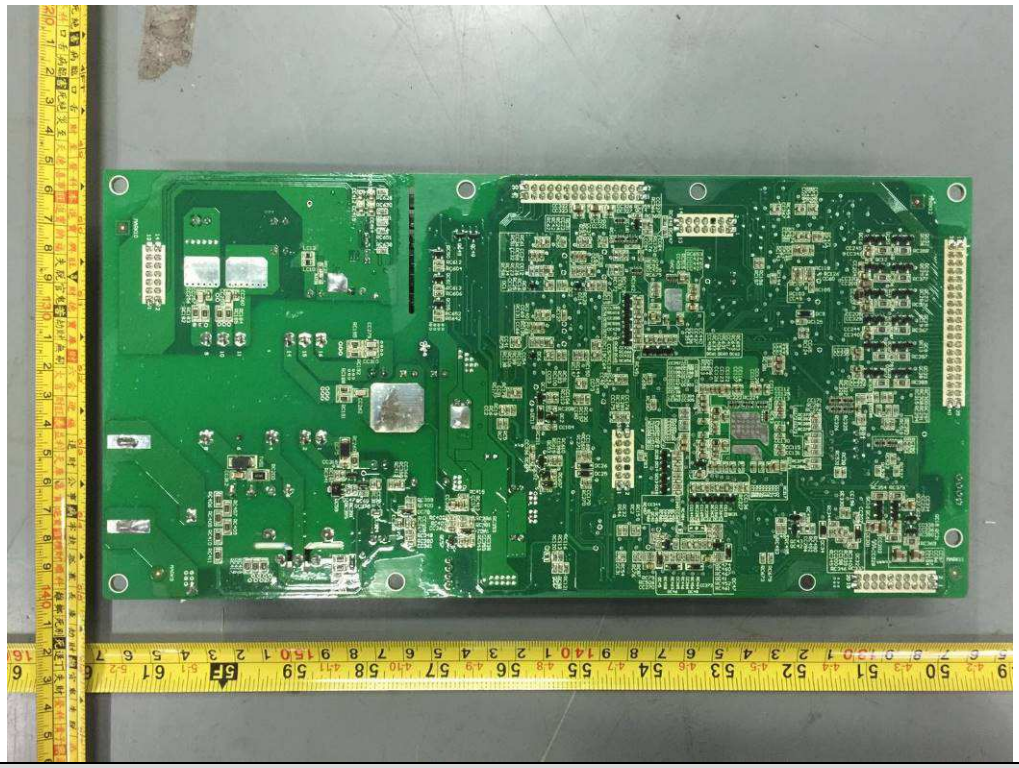
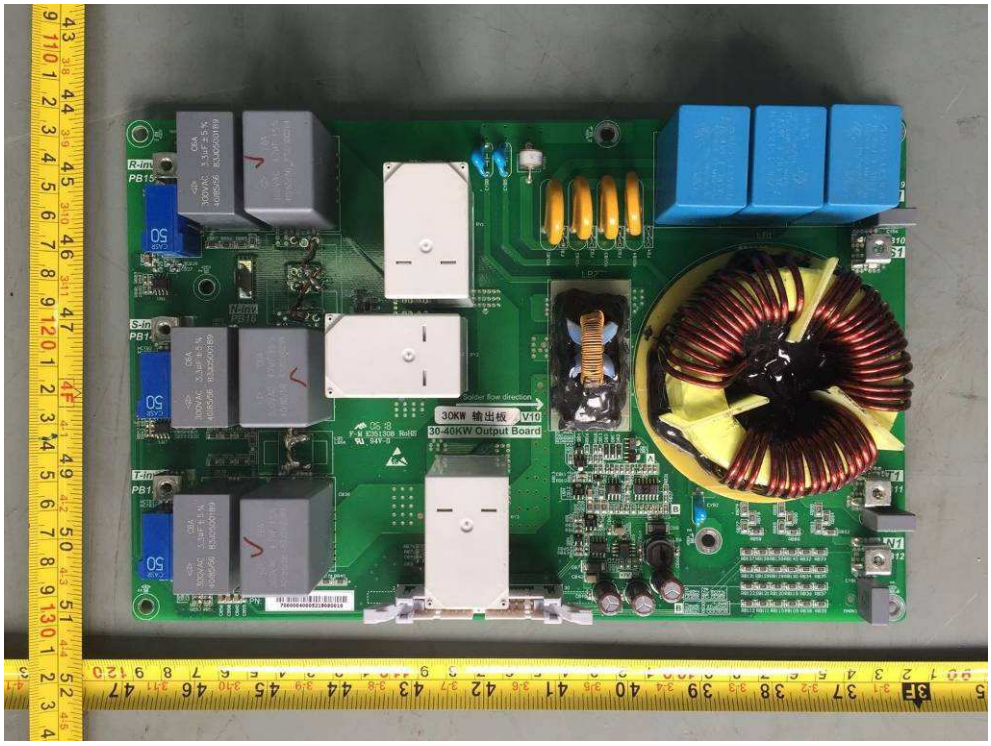
Main board- solder side view: SOFAR 11000TL-LV、SOFAR 13500TL-LV

Display board-component side view


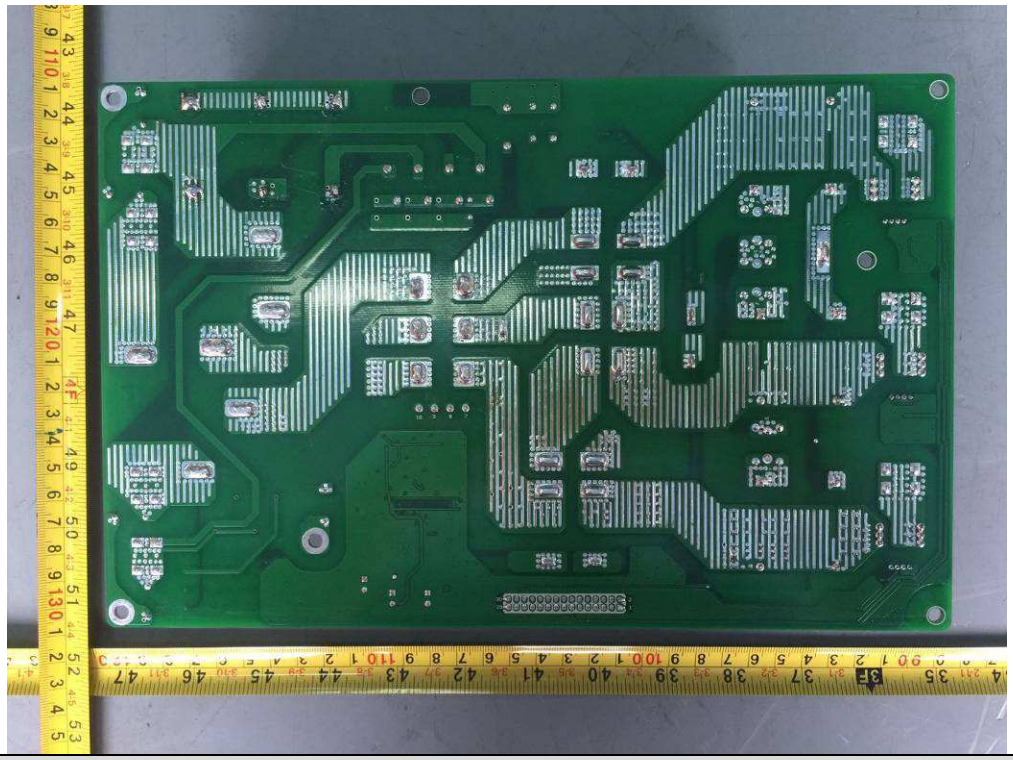
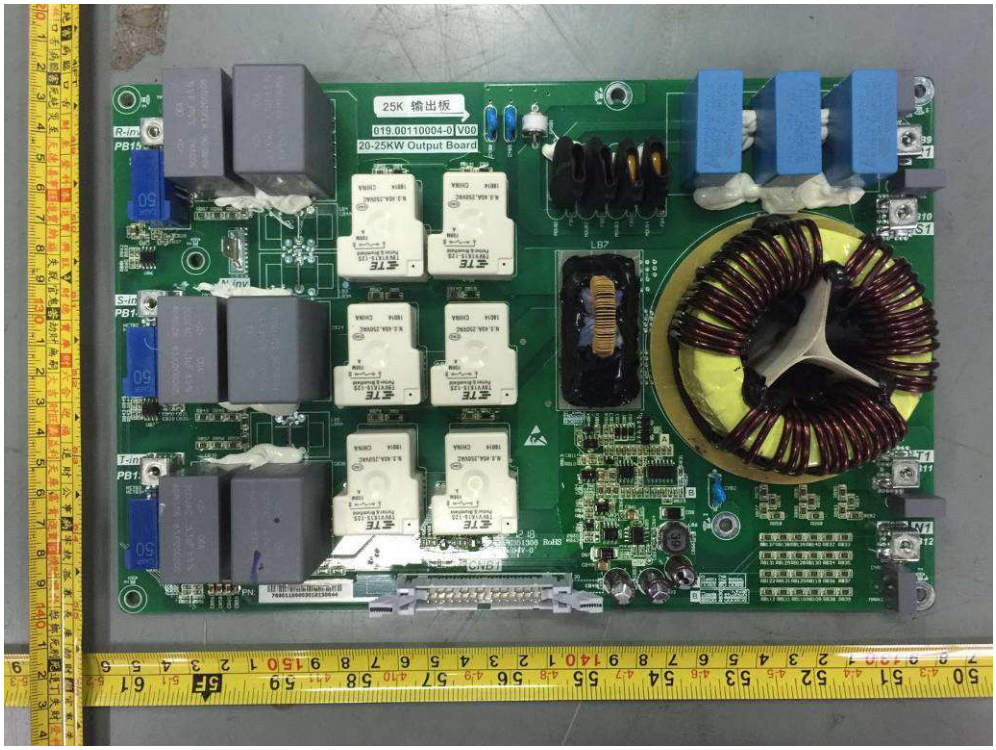
Display board-solder side view

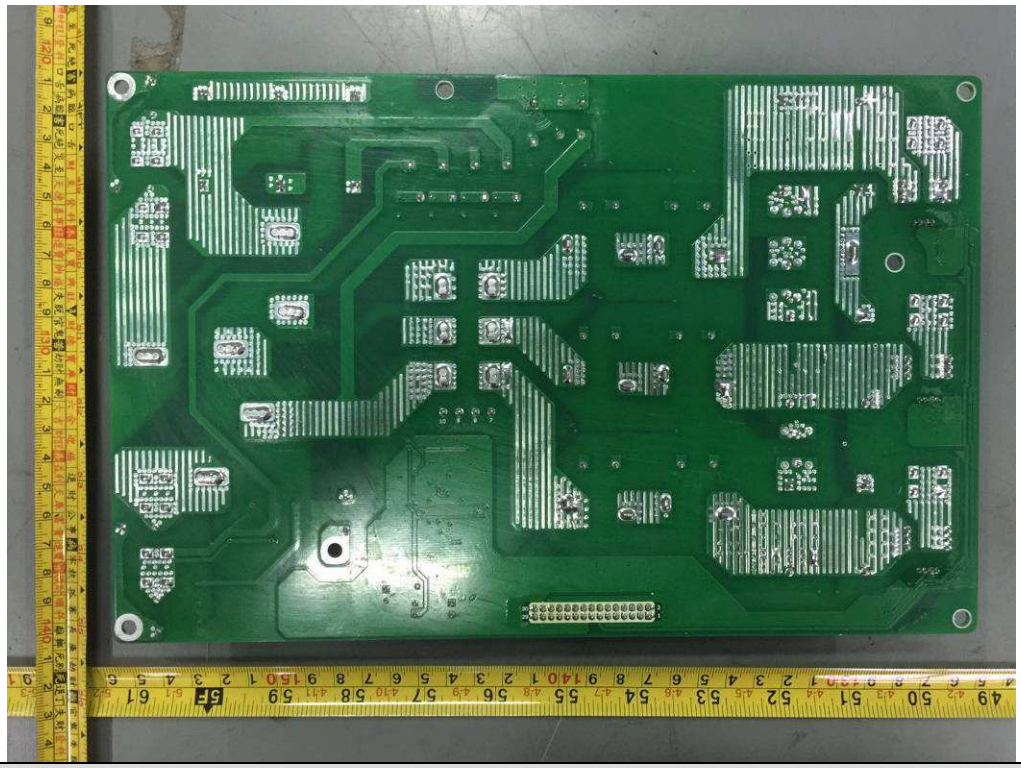
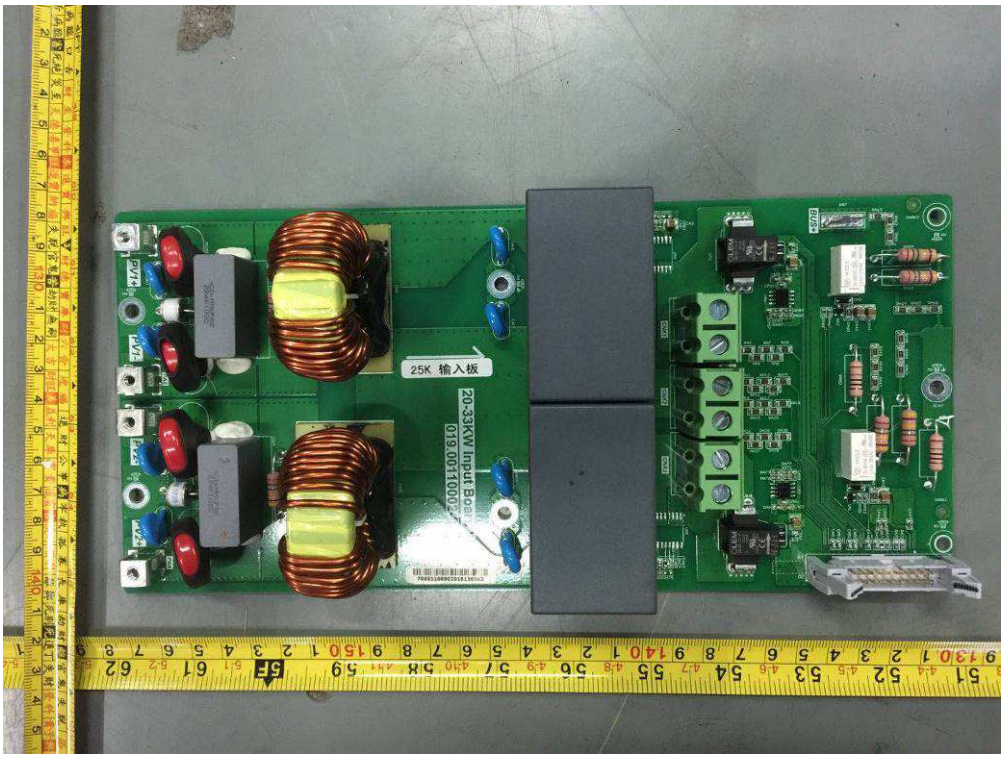


Control board- component side view

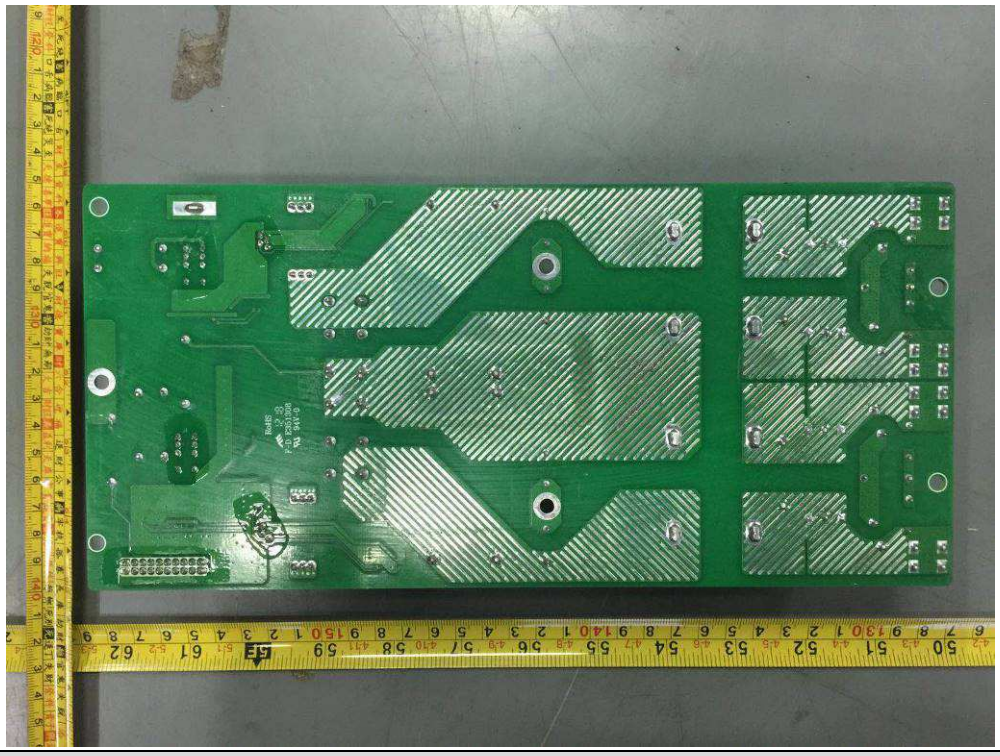


Control board- solder side view

AC output board- component side view: SOFAR 16500TL-LV，SOFAR 18000TL-LV


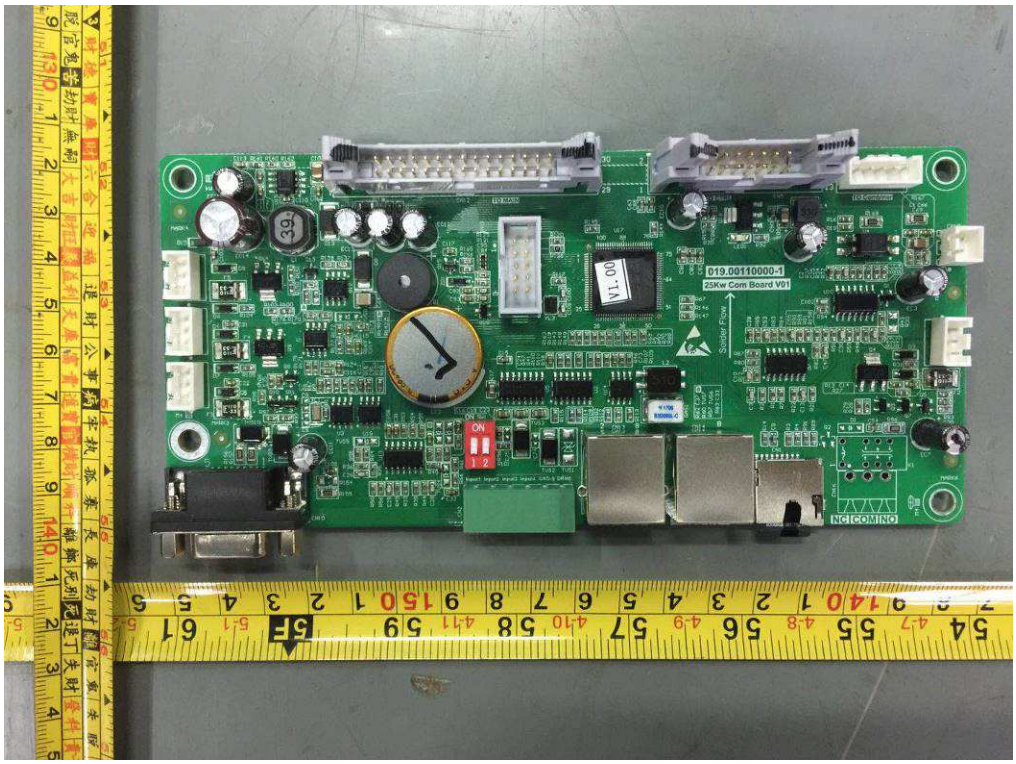
AC output board-solder side view: SOFAR 16500TL-LV，SOFAR 18000TL-LV

AC output board- component side view: SOFAR 11000TL-LV，SOFAR 13500TL-LV


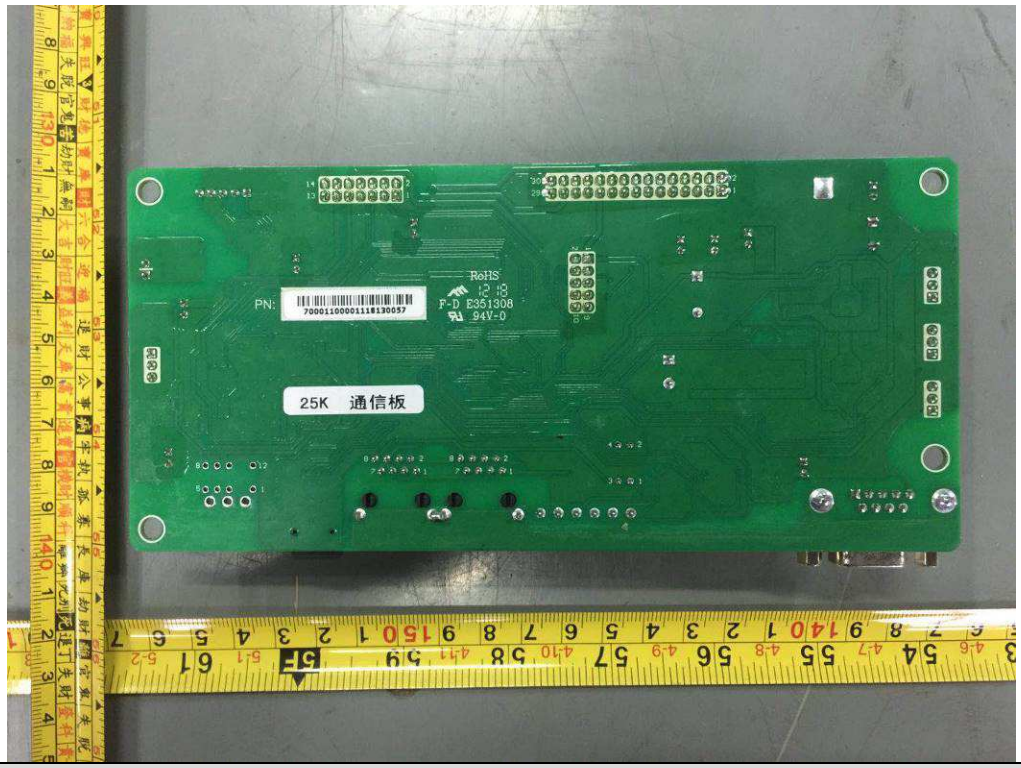
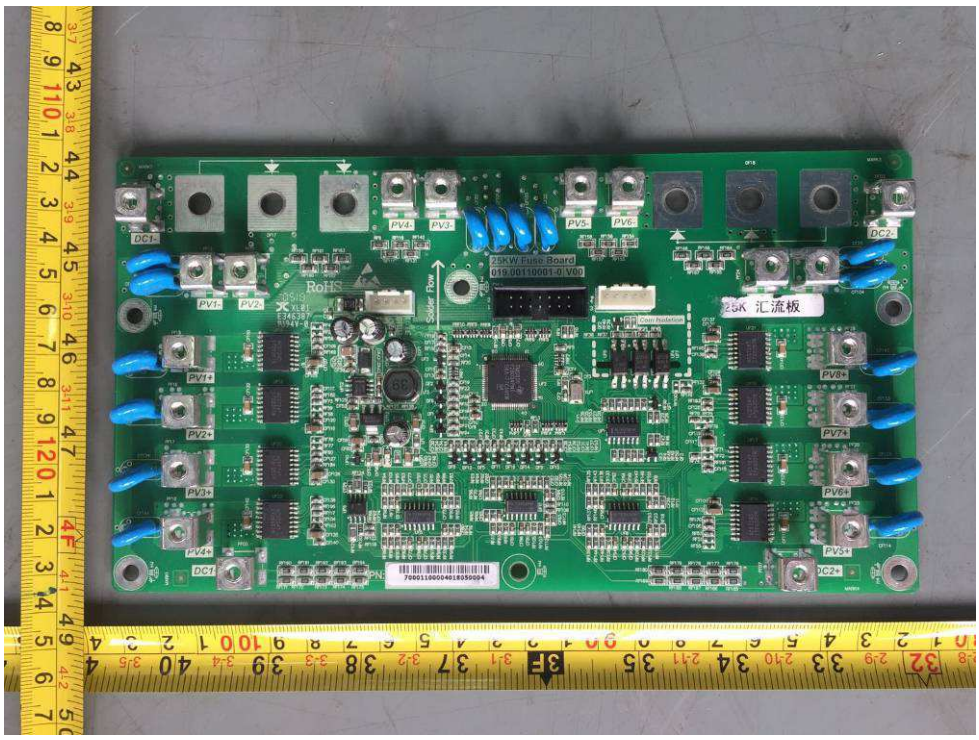
AC output board-solder side view: SOFAR 11000TL-LV，SOFAR 13500TL-LV

Output board-component side view


Output board-solder side view

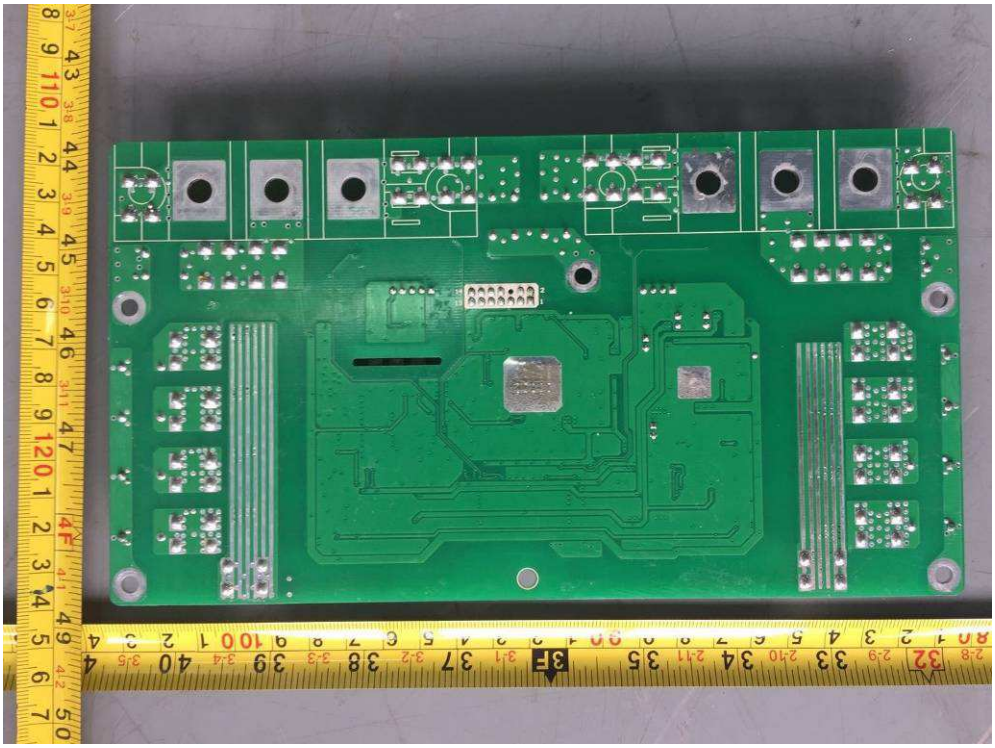


Communication board-component side view



Communication board-solder side view

Junction board-component side view: **SOFAR 13500TL-LV 、SOFAR 16500TL-LV、SOFAR 18000TL-LV**


Junction board -solder side view:
SOFAR 13500TL-LV 、SOFAR 16500TL-LV、SOFAR 18000TL-LV



Annex 2

Test equipment list

Date(s) of performance test: 2020-06-09 to 2020-09-10

Equipment	Internal No.	Manufacturer	Type	Serial No.	Calibration is valid to
DC power supply	SB14324	Chroma	62150H-1000S	6215EF01653	Monitored by Power Analyzer
	SB14324	Chroma	62150H-1000S	6215EF01653	
	SB14324	Chroma	62150H-1000S	6215EF01653	
	SB14324	Chroma	62150H-1000S	6215EF01653	
	SB14324	Chroma	62150H-1000S	6215EF01653	
	SB14324	Chroma	62150H-1000S	6215EF01653	
	SB14324	Chroma	62150H-1000S	6215EF01653	
	SB14324	Chroma	62150H-1000S	6215EF01653	
RLC Load	SB9605	Qunling	ACLT-3830H	--	
AC Simulator	SB14325	Chroma	61860	618603800236	
Power analyzer	SB11178	YOKOGAWA	WT3000	91P215776	2021-03-18
	//	DEWETRON	DEWE2-PA7	C7190048-CHN	2021-03-03
Current sensor	SB14641	YOKOGAWA	CT200	8173420022	2020-12-03
	SB14642	YOKOGAWA	CT200	8173420030	2020-12-03
	SB14643	YOKOGAWA	CT200	8173420024	2020-12-03
Oscilloscope probel	SB9149	TEKTRONIX	P5100A	--	2021-03-12
	SB9155	TEKTRONIX	P5100A	--	2020-12-26
	SB9159	TEKTRONIX	P5100A	--	2020-12-26