TEST ACCORDING TO
EN 50530:2010/A1:2013
OVERALL EFFICIENCY OF GRID CONNECTED PHOTOVOLTAIC INVERTERS

Test Report Number .... :	**GZES181100301001**
Tested Model .... :	**SOFAR 15000TL-Sx Series**
Variant Model .... :	**N/A**

APPLICANT

Name .... :	Shenzhen SOFAR SOLAR Co., Ltd.
Address .... :	5/F., Building 4, Antongda Industrial Park, No. 1 Liuxian Avenue, Xin'an Street, Bao'an District, Shenzhen City, Guangdong Province, P.R. China

TESTING LABORATORY

Name .... :	SGS-CSTC Standards Technical Services Co., Ltd. Guangzhou Branch
Address .... :	198 Kezhu Road, Science City, Economic & Technology Development Area, Guangzhou, Guangdong, China

Conducted (tested) by .... :	Michael Tong (Project Engineer)
Reviewed & Approved by .... :	Roger Hu (Technical Reviewer)
Date of issue .... :	**23/11/2018**
Number of pages .... :	**29**

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Test Report Historical Revision:

Test Report Version	Date	Resume
GZES1811003012PV	23/11/2018	First issuance

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1 SCOPE

SGS-CSTC Standards Technical Services Co., Ltd. Guangzhou Branch has been contract by Shenzhen SOFARSOLAR Co., Ltd, in order to perform the testing according to following standards:
:

- **EN 50530:2010/A1:2013**. Overall efficiency of grid connected photovoltaic inverters.

2 GENERAL INFORMATION

2.1 Testing Period and Climatic conditions

The necessary testing has been performed along 12 working days between the 08th of Nov and the 22st of November of 2018.

All the tests and checks have been performed in accordance with the reference Standard (the tests are done at 25 ± 5ºC, 96 kPa ± 10 kPa and 50% RH ± 10% RH).

SITE TEST

Name .... : Shenzhen BALUN Technology Co., Ltd

Address .... : Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China

2.2 Equipment under Testing

Test Item

Apparatus type/ Installation ....: Solar Grid-tied Inverter
Manufacturer/ Supplier/ Installer ....: Shenzhen SOFAR SOLAR Co., Ltd.
Trade mark ....: SOFAR SOLAR

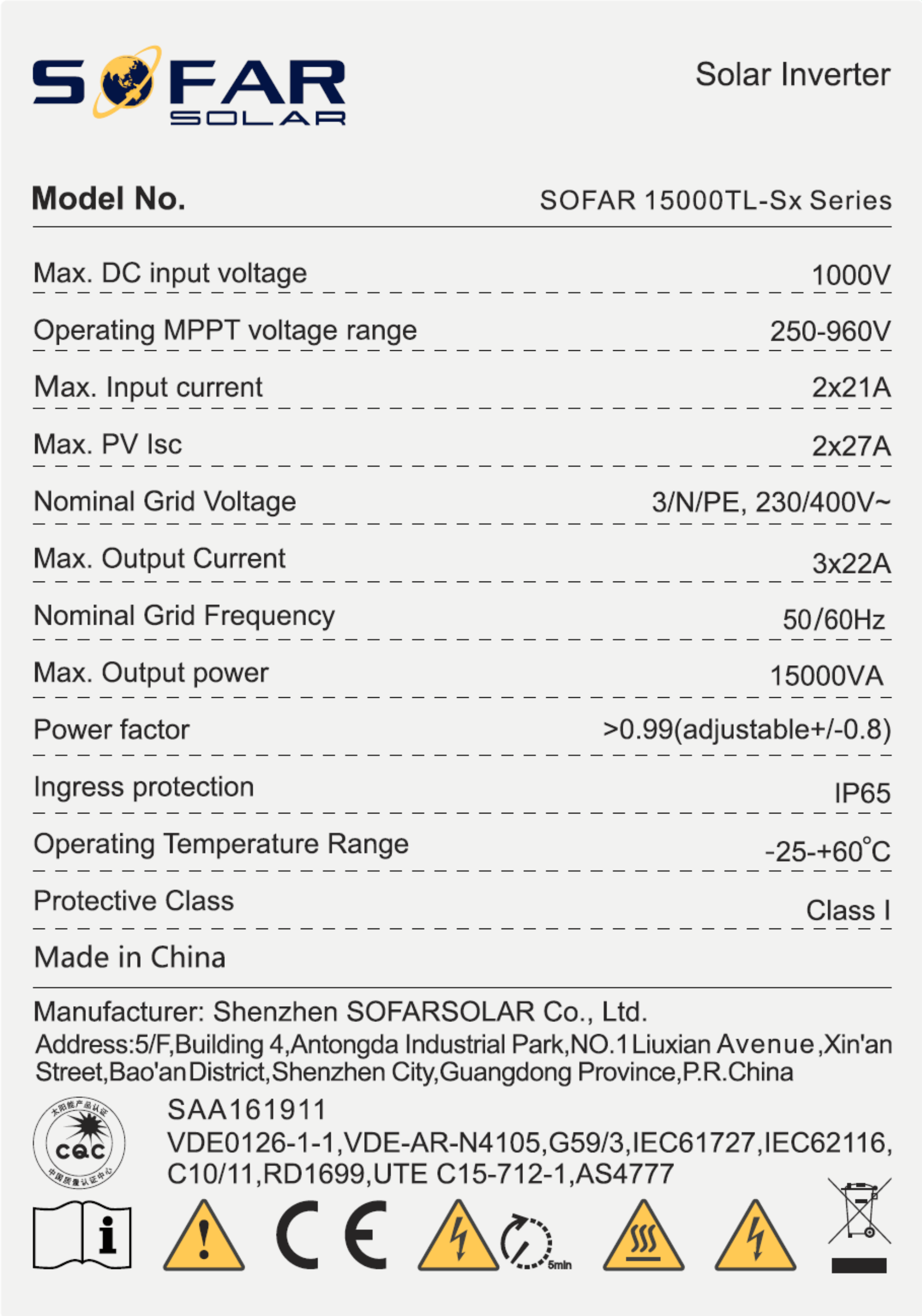
Type..: SOFAR
Model ....: SOFAR 15000TL-Sx Series

Serial Number...: SC3ES215H4E469
Software Version ....: V4.10
Rated Characteristics ....: DC input: 250-960V (1000V max.), Max. 21/21A
AC output: 3~ /N/PE 230/400Vac, 50Hz, 3*22A, 15000VA

Date of manufacturing: 2018

Test item particulars
Input.. DC
Output.. 3~/N/PE
Class of protection against electric shock .... Class I
Degree of protection against moisture .... IP 65
Type of connection to the main supply......................... Three phase – Fixed installation
Cooling group .... Fans
Modular .... No
Internal Transformer.. No

Rating Plate:



Model fully tested:

- **SOFAR 40000TL-Sx Series**

The results obtained apply only to the particular sample tested that is the subject of the present test report. The most unfavorable result values of the verifications and tests performed are contained herein.
Throughout this report a comma (point) is used as the decimal separator.

2.3 Test Equipment List

	No.	Equipment Name	MARK/Model No.	Equipment No.	Equipment calibration due date
BALUN	1	Heating Recoder	Agilent / 34970A	BZ-SFT-L130	2019/03/14
	2	Power analyzer	HIOKI / PW6001-16	BZ-EP-L005	2019/05/22
	3	Temperature & Humidity meter	BENETECH/GM1360	BL-SFT-L055	2019/03/13
SGS	4	True RMS Multimeter	Fluke / 289C	GZE012-53 (22930028)	2019/03/05

2.4 Measurement Uncertainty

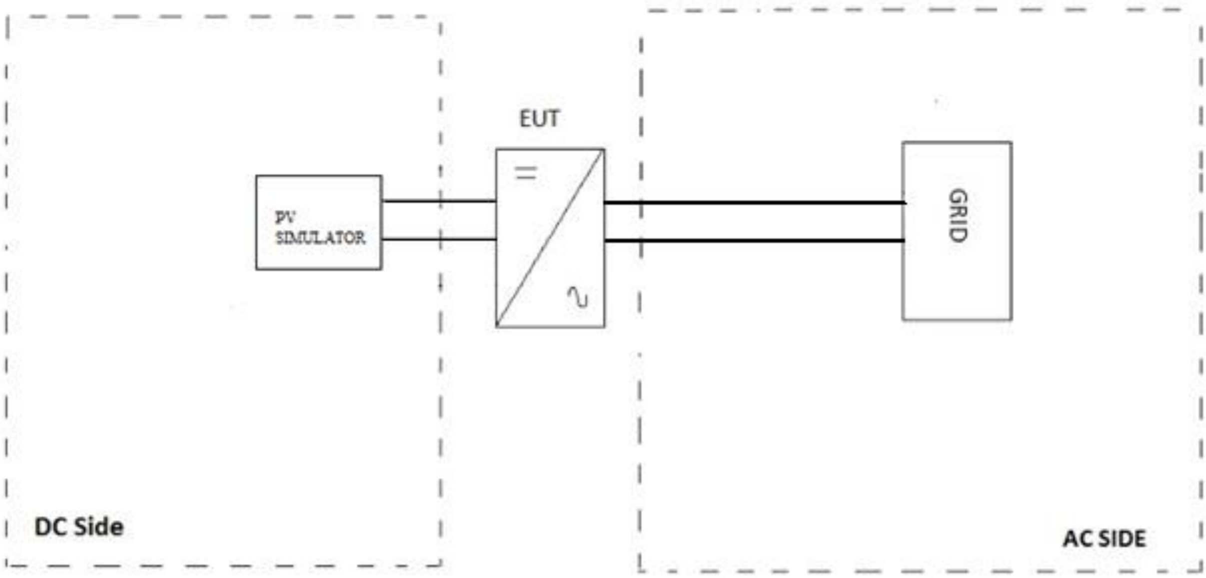
	Voltage measurement uncertainty	±1,5 %
	Current measurement uncertainty	±2,0 %
	Frequency measurement uncertainty	±0,2 %
	Time measurement uncertainty	±0,2 %
	Power measurement uncertainty	±2,5 %
	Phase Angle	±1º
	cosφ	±0,01
Note: The measurement uncertainties associated with other parameters measured during the tests are in the laboratory at disposal of the solicitant.		

2.5 Definitions

EUT	Equipment Under Testing
$I_{DC,I}$	Sampled value of the inverter's input current
I_n	Nominal Current (Inverter)
p.u	Per unit
P_{DC}	Measured input power of the device under test
$P_{MPP,PVS}$	MPP power provided by the PV simulator
P_n	Nominal Active Power (Inverter)
Qn	Nominal Reactive Power
S_n	Nominal Apparent Power (Inverter)
T_M	Overall measuring period
$U_{DC,I}$	Sampled value of the inverter's input voltage
U_n	Nominal Voltage
ΔT	Period between two subsequent sample values
η	Efficiency

2.6 TEST SET UP OF THE DIFFERENT STANDARDS.

Below is the simplified construction of the test set up.



Different equipment has been used to take measures as it shows in chapter 2.3. Current and voltage clamps have been connected to the inverter output for all the tests.

All the tests described in the following pages have used this specified test setup.

The test bench used includes:

EQUIPMENT	MARK / MODEL	RATED CHARACTERISTICS	OWNER / ID.CODE
AC source	Kewell / KACM-75-33	Voltage: 0-600 V 75kVA	Balun/BZ-EP-L001
PV source(*)	Kewell / IVS-60KW	Voltage: 0 - 1000 V 60kW	Balun/BZ-EP-L002
Programmable ac load	QUNLING / ACLT-3820	Voltage: 0-600 V 60kVA	Balun/BZ-EP-L003

(*) Validation by SGS. The report of verification is in the laboratory at disposal of the requestor.

3 RESUME OF TEST RESULTS

INTERPRETATION KEYS

Test object does meet the requirement .... **P** Pass

Test object does not meet the requirement .... **F** Fails

Test case does not apply to the test object .... **N/A** Not applicable

To make a reference to a table or an annex................. See additional sheet

To indicate that the test has not been realized............ **N/R** Not realized

STANDARD SECTION	STANDARD REQUIREMENTS EN 50530:2010/A1:2013	
4.3	**Static MPPT efficiency**	**P**
4.3.1	Test conditions for the Static MPPT efficiency	P
4.3.2	Measurement procedure	P
4.3.3	Evaluation – Calculation of static MPPT efficiency	P
4.5	**Static power conversion efficiency**	**P**
4.5.1	Test conditions for the static power conversion efficiency	P
4.5.2	Measurement procedure	P
4.5.3	Evaluation – Calculation of the static conversion efficiency	P
5	**Calculation of the overall efficiency**	**P**

4 TEST RESULTS

4.1 STATIC MPPT EFFICIENCY TEST

Static MPPT efficiency test has been performed according to point 4.3 of the standard.

The MPPT efficiency describes the accuracy of an inverter to set the maximum power point on the characteristic curve of a PV generator. It is determined from the sampled instantaneous values of voltage and current at the input.

$$\eta_{MPPTstat} = \frac{1}{P_{MPP,PVS} \cdot T_M} \sum_i U_{DC,i} \cdot I_{DC,i} \cdot \Delta T$$

See point 2.5 (Definitions) of this report

The following table shows the results of this test:

MPP voltage of the simu-lated *I/V*-characteristic	Simulated I/V characteristic	MPP power of the simulated *I/V* characteristic normal-ised to rated DC power, $P_{MPP,PVS}/P_{DC,}$(%)							
		0.05	0.10	0.20	0.25	0.30	0.50	0.75	1.00
U min 370 Vdc	c-Si	96.77	98.93	99.23	99.49	99.59	99.75	99.83	99.87
U nom 620 Vdc	c-Si	97.60	98.45	98.60	99.26	99.56	99.77	99.36	99.75
U max 800 Vdc	c-Si	99.40	99.65	99.79	99.87	99.87	99.87	99.98	99.94
U min 370 Vdc	TF	96.83	98.76	99.42	99.59	99.58	99.74	99.84	99.79
U nom 620 Vdc	TF	96.86	97.56	99.16	99.34	99.58	99.87	99.87	99.78
U max 700 Vdc	TF	99.49	99.67	99.85	99.89	99.91	99.91	99.97	99.92

4.2 DYNAMIC MPPT EFFICIENCY TEST

Test for the dynamic MPPT efficiency are to be performed with the following sequences. The percentage specification of the radiation intensity is related to standard test conditions (STC). 100 % corresponds to 1 000 W/m² at 25 °C.

4.2.1 *Test sequence with ramps 10 % - 50 % PDCn*

The test has been performed according to point Annex B.2 of the standard.

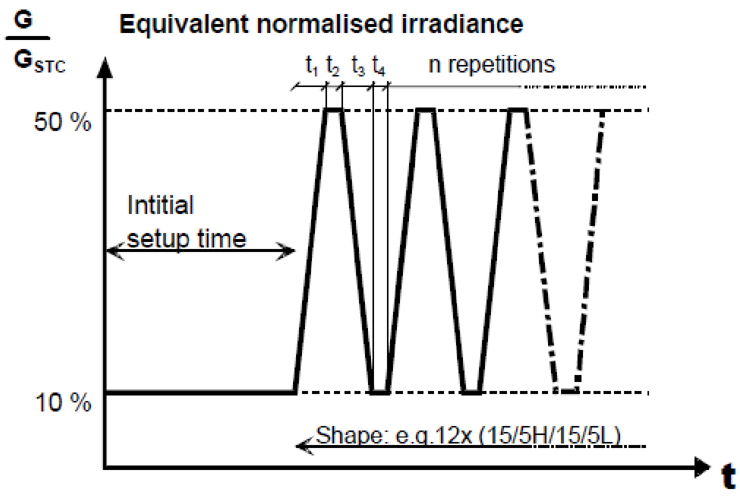


Figure B.1 – Test sequence for fluctuations between small and medium irradiation intensities

From-to W/m²	Delta W/m²					Waiting time setting s	
100-500	400					300	
# Number	**Slope** W/m²/s	**Ramp UP** s	**Dwell time** s	**Ramp DN** s	**Dwell time** s	**Duration** s	**efficiency**
2	0.5	800	10	800	10	3540	0.9934
2	1	400	10	400	10	1940	0.9950
3	2	200	10	200	10	1560	0.9950
4	3	133	10	133	10	1447	0.9931
6	5	80	10	80	10	1300	0.9375
8	7	57	10	57	10	1374	0.9491
10	10	40	10	40	10	1700	0.9373
10	14	29	10	29	10	1071	0.9295
10	20	20	10	20	10	900	0.8974
10	30	13	10	13	10	767	0.9087
10	50	8	10	8	10	660	0.9156

4.2.2 Test sequence with ramps 30 % - 100 % P_{DCn}

The test has been performed according to point Annex B.3 of the standard.

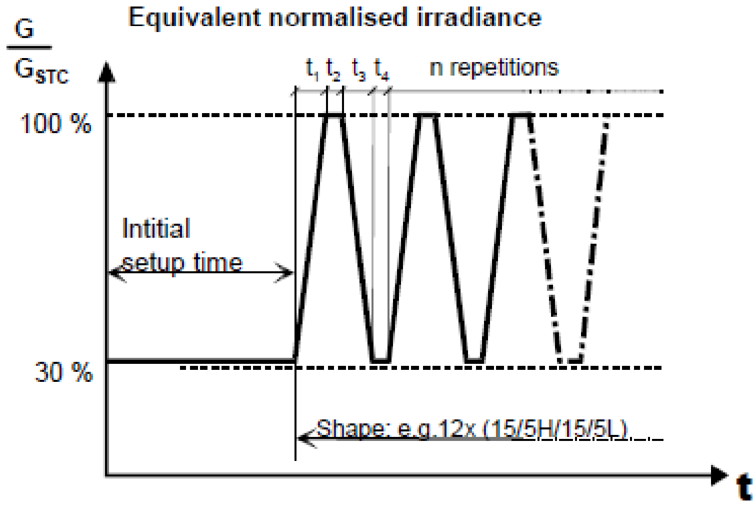


Figure B.2 – Test sequence for fluctuations between medium and high irradiation intensities

From-to W/m²	Delta W/m²					Waiting time setting s	
300-1000	700					300	
# Number	**Slope** W/m²/s	**Ramp UP** s	**Dwell time** s	**Ramp DN** s	**Dwell time** s	**Duration** s	**efficiency**
10	10	70	10	70	10	1900	0.9950
10	14	50	10	50	10	1500	0.9950
10	20	35	10	35	10	1200	0.9950
10	30	23	10	23	10	967	0.9950
10	50	14	10	14	10	780	0.9950
10	100	7	10	7	10	640	0.9950

4.2.3 Start-up and shut-down test with slow ramps

The test has been performed according to point Annex B.4 of the standard.

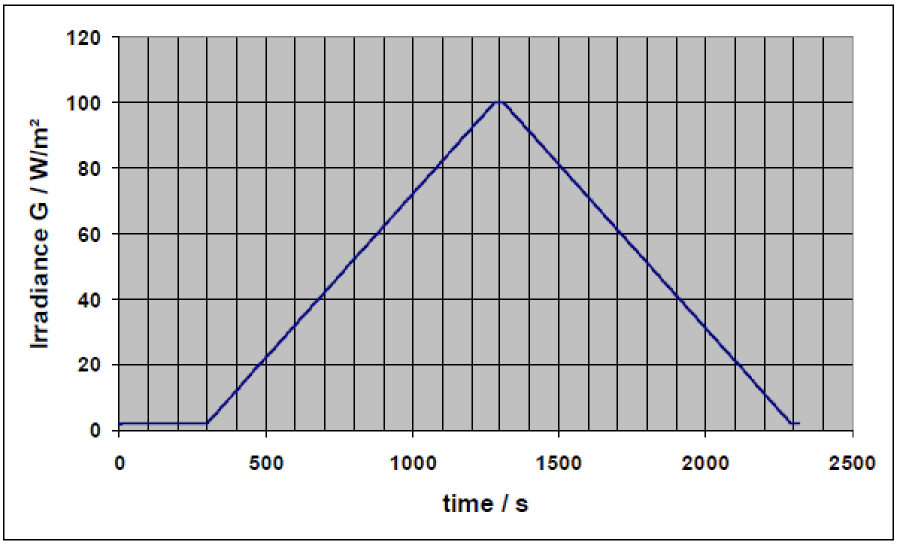


Figure B.3 – Test sequence for the start-up and shut-down test of grid connected inverters

From-to W/m²	Delta W/m²		**Dwell time setting** s			Waiting time setting s	
10-100	90		30			300	
# Number	**Slope** W/m²/s	**Ramp UP** s	**Dwell time** s	**Ramp DN** s	**Dwell time** s	**Duration** s	**efficiency**
1	0.1	980	30	980	30	2320	0.8661

4.3 STATIC POWER CONVERSION EFFICIENCY

Static power conversion efficiency test has been performed according to point 4.5 of the standard.

Rated output efficiency shall be calculated from measured data as follows:

$$\eta_R = (P_o / P_i) \times 100$$

where
η_R is the rated output efficiency (%);
P_o is the rated output power from power conditioner (kW);
P_i is the input power to power conditioner at rated output (kW).

The following table shows the results of this test:

MPP voltage of the simulated *I/V*-characteristic	Simulated I/V characteristic	Power conversion efficiency(%)							
		0.05	0.10	0.20	0.25	0.30	0.50	0.75	1.00
U min 370 Vdc	c-Si	90.83	94.06	96.02	96.36	96.56	96.69	96.52	97.14
U nom 620 Vdc		94.27	95.38	96.98	97.58	97.51	98.00	97.58	97.28
U max 800 Vdc		91.85	95.48	97.19	97.56	97.75	98.01	98.02	97.88
U min 370 Vdc	TF	90.77	94.11	95.91	96.28	96.60	96.81	96.58	97.12
U nom 620 Vdc		92.76	95.56	95.31	96.94	97.63	97.56	97.65	97.63
U max 700 Vdc		93.28	96.36	97.65	97.91	98.08	98.25	98.22	98.07

4.4 OVERALL EFFICIENCY

Overall efficiency test has been performed according to point 5 of the standard.

The overall efficiency has been calculated according the following equation:

$$\eta_t = \eta_{conv} \cdot \eta_{MPPTstat} = \frac{P_{AC}}{P_{MPP,PVS}}$$

The following table shows the results of this test:

MPP voltage of the simulated *I/V*-characteristic	Simulated I/V characteristic	Overall efficiency (%)							
		0.05	0.10	0.20	0.25	0.30	0.50	0.75	1.00
U min 370 Vdc	c-Si	87.90	93.05	95.28	95.87	96.16	96.45	96.36	97.01
U nom 620 Vdc		92.01	93.90	95.62	96.86	97.08	97.77	96.96	97.04
U max 800 Vdc		91.30	95.15	96.99	97.43	97.62	97.88	98.00	97.82
U min 370 Vdc	TF	87.89	92.94	95.35	95.89	96.19	96.56	96.43	96.92
U nom 620 Vdc		89.85	93.23	94.51	96.30	97.22	97.43	97.52	97.42
U max 700 Vdc		92.80	96.04	97.50	97.80	97.99	98.16	98.19	97.99

4.5 EUROPEAN EFFICIENCY

European efficiency test has been performed according to point annex D.1 of the standard.

For the calculation of a weighted European MPPT and conversion efficiency the following formula and factors are to be applied:

$$\eta_{MPPTstat,EUR} = a_{EU\_1} \cdot \eta_{MPP\_1} + a_{EU\_2} \cdot \eta_{MPP\_2} + a_{EU\_3} \cdot \eta_{MPP\_3} + a_{EU\_4} \cdot \eta_{MPP\_4} + a_{EU\_5} \cdot \eta_{MPP\_5} + a_{EU\_6} \cdot \eta_{MPP\_6} \quad (D.1)$$

a_{EU_i} weighting factor

η_{MPP_i} static MPPT efficiency at partial MPP power MPP_i

Table D.1 – Weighting factors and partial MPP power levels for the calculation of the European efficiency

Weighting Factor	a_{EU_1}	a_{EU_2}	a_{EU_3}	a_{EU_4}	a_{EU_5}	a_{EU_6}
	0.03	0.06	0.13	0.1	0.48	0.2
Partial MPP power $P_{MPP,PVS}/P_{DC,r}$	MPP_1	MPP_2	MPP_3	MPP_4	MPP_5	MPP_6
	0.05	0.1	0.2	0.3	0.5	1

$$\eta_{MPPTstat,EUR(c\text{-}si)} = 96.72\%$$

$$\eta_{MPPTstat,EUR(TF)} = 96.75\%$$

4.6 CEC EFFICIENCY

European efficiency test has been performed according to point annex D.2 of the standard.

For the calculation of a weighted CEC MPPT and conversion efficiency the following formula and factors are to be applied:

$$\eta_{MPPTstat,CEC} = a_{CEC\_1} \cdot \eta_{MPP\_1} + a_{CEC\_2} \cdot \eta_{MPP\_2} + a_{CEC\_3} \cdot \eta_{MPP\_3} + a_{CEC\_4} \cdot \eta_{MPP\_4} + a_{CEC\_5} \cdot \eta_{MPP\_5} + a_{CEC\_6} \cdot \eta_{MPP\_6} \quad \text{(D.2)}$$

a_{CEC_i} weighting factor

η_{MPP_i} static MPPT efficiency at partial MPP power MPP_i

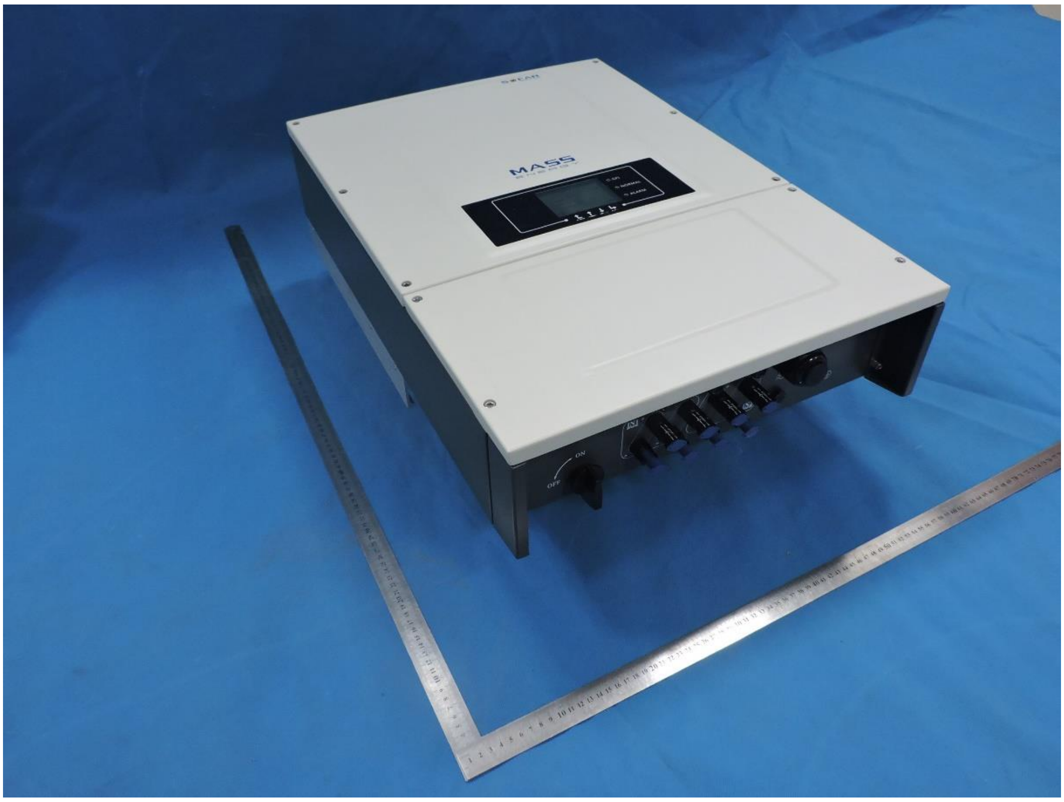
Table D.2 – Weighting factors and partial MPP power levels for the calculation of the CEC efficiency (California Energy Commission)

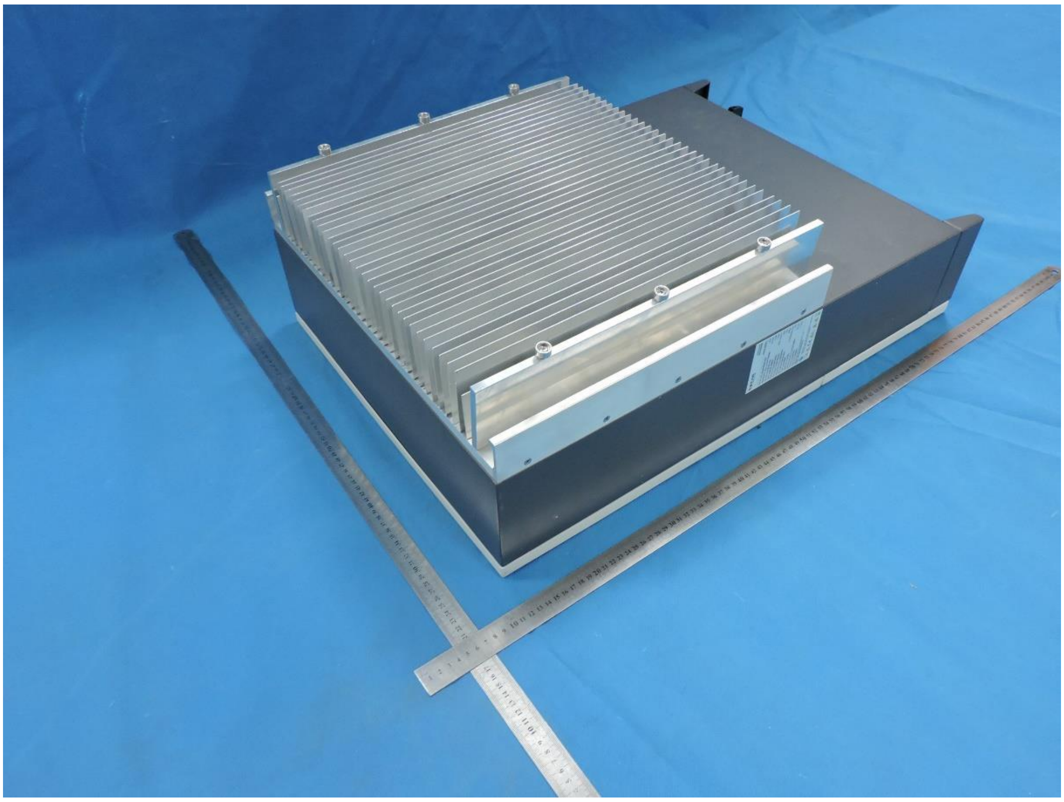
Weighting Factor	a_{CEC_1}	a_{CEC_2}	a_{CEC_3}	a_{CEC_4}	a_{CEC_5}	a_{CEC_6}
	0.04	0.05	0.12	0.21	0.53	0.05
Partial MPP power $P_{MPP,PVS}/P_{DC,r}$	MPP_1	MPP_2	MPP_3	MPP_4	MPP_5	MPP_6
	0.1	0.2	0.3	0.5	0.75	1

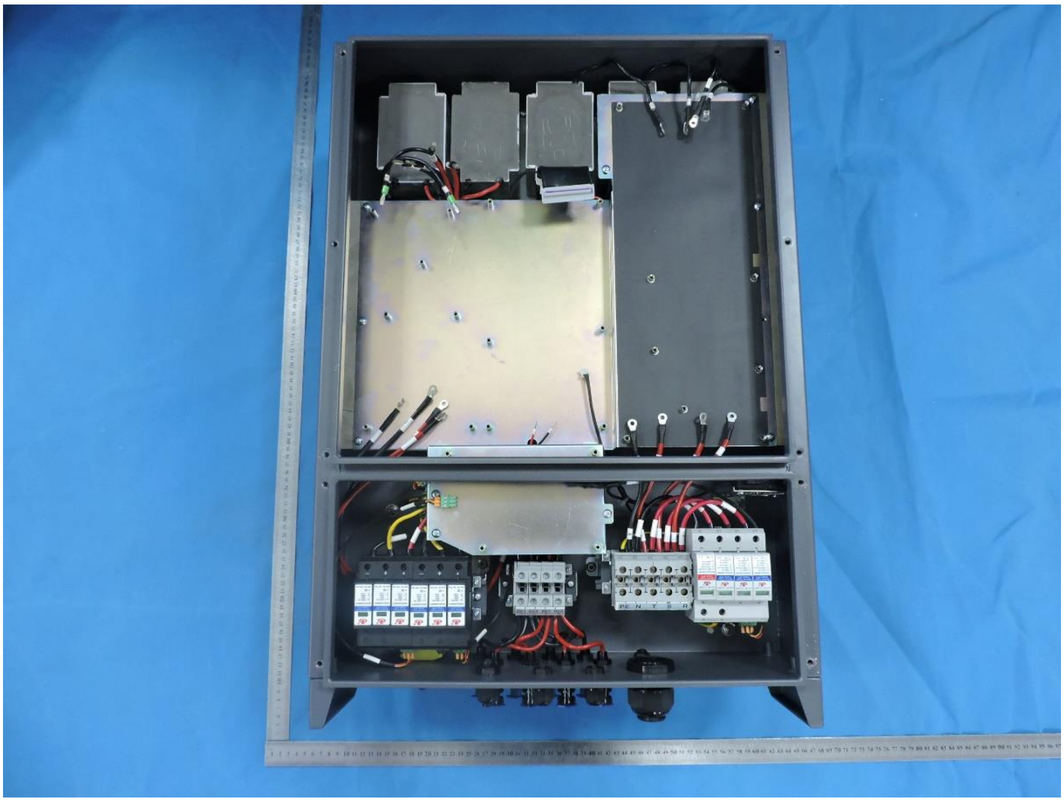
$$\eta_{MPPTstat,CEC(c\text{-}si)} = 96.97\%$$

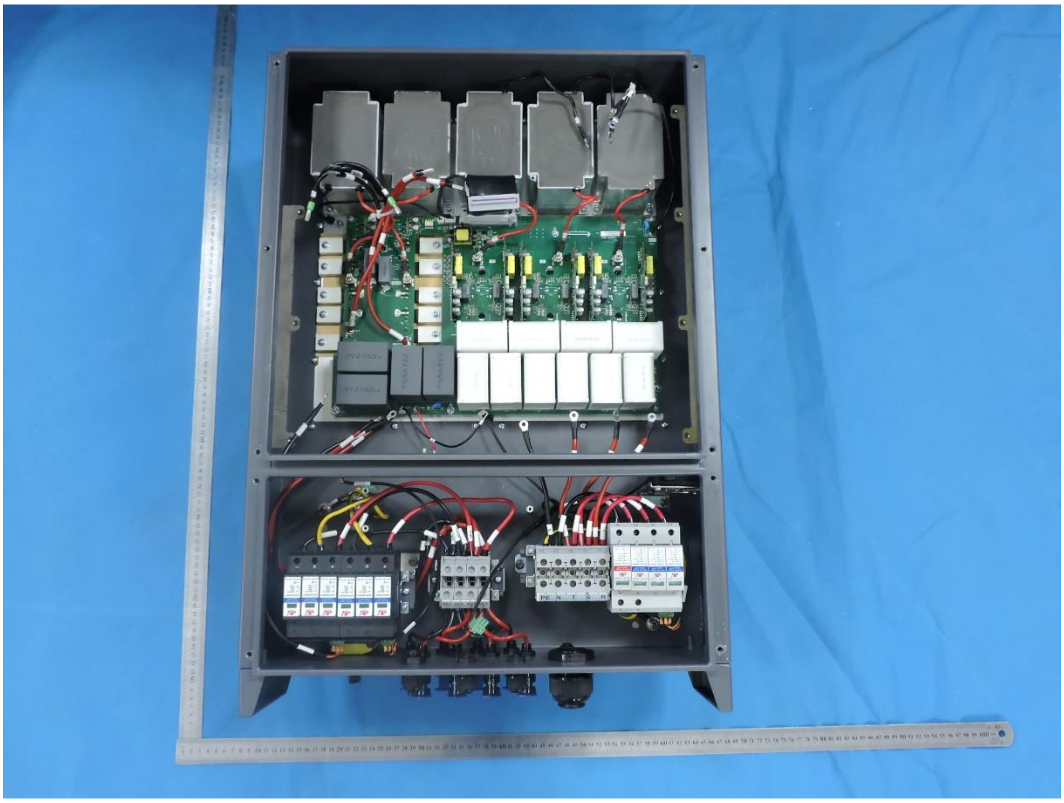
$$\eta_{MPPTstat,CEC(TF)} = 97.14\%$$

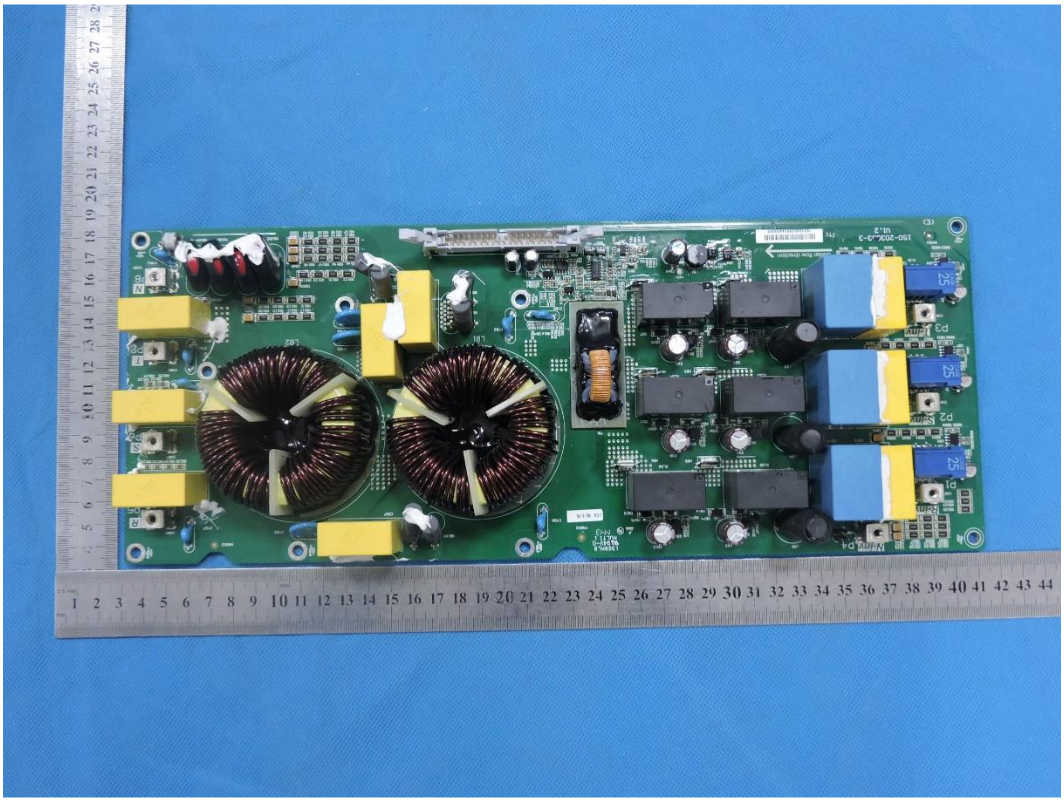
5 PICTURES

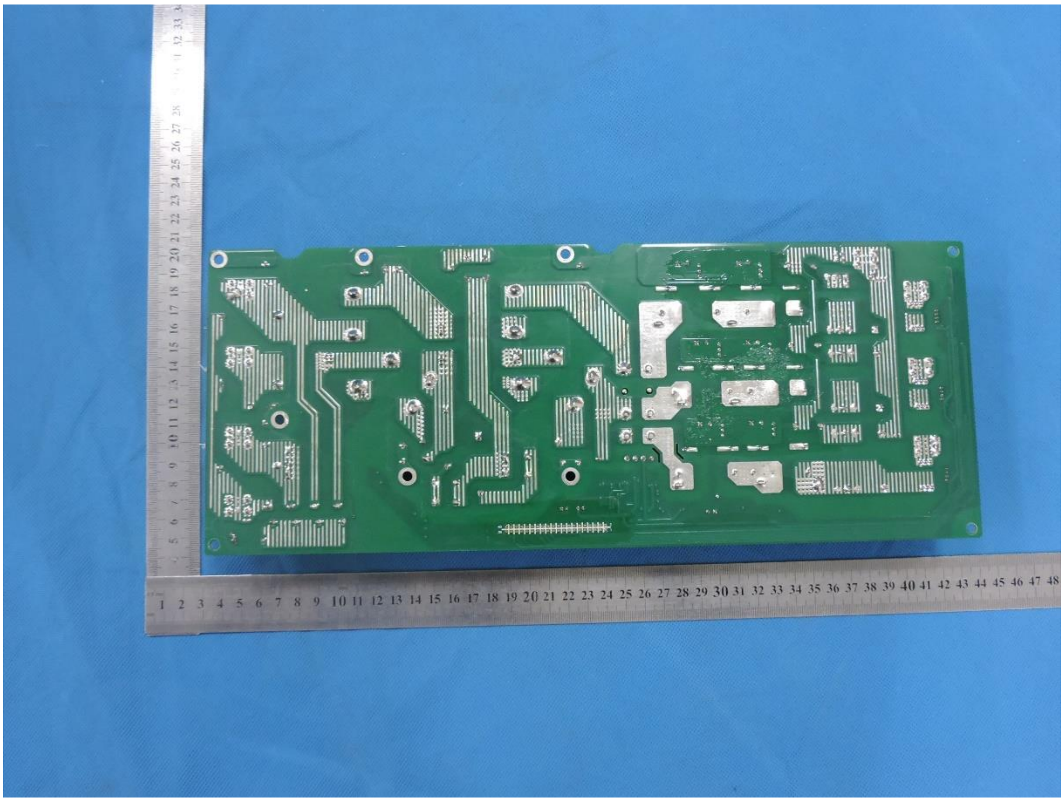


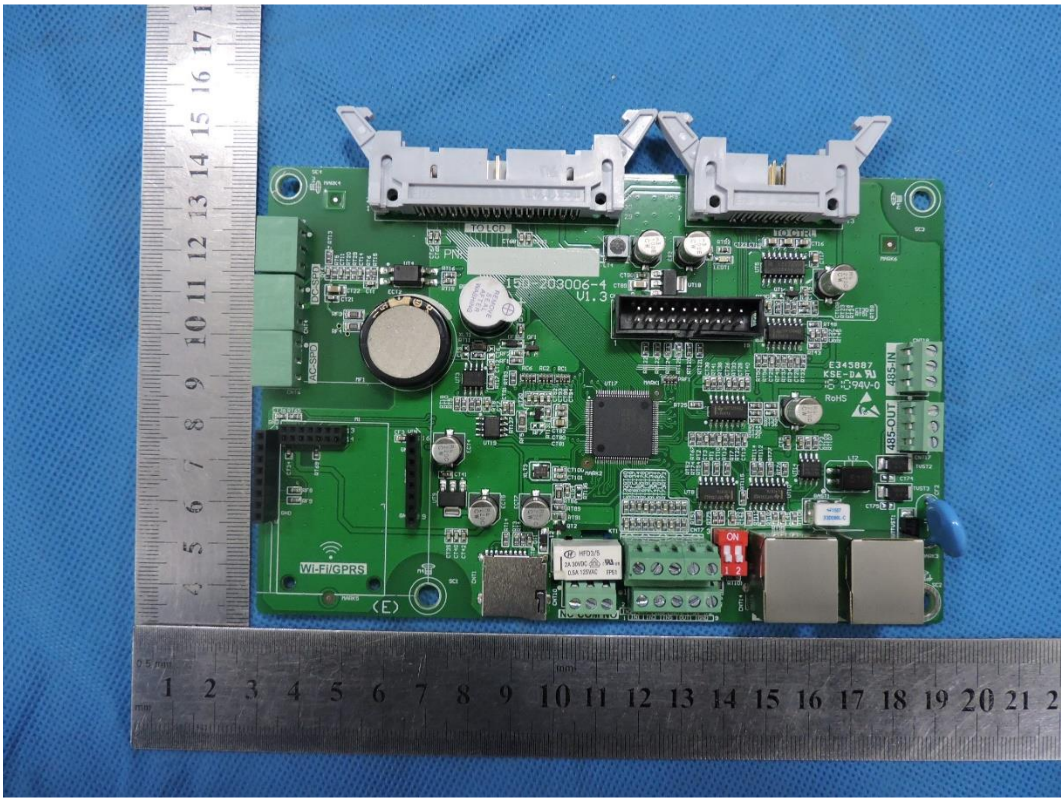


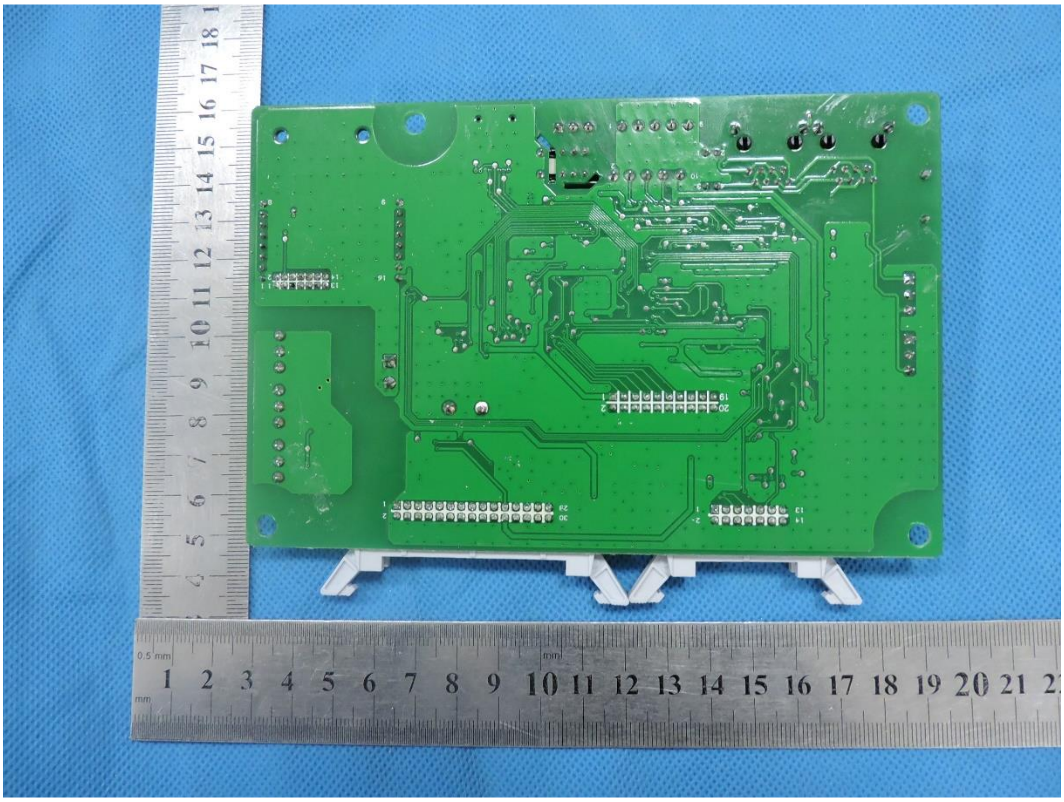


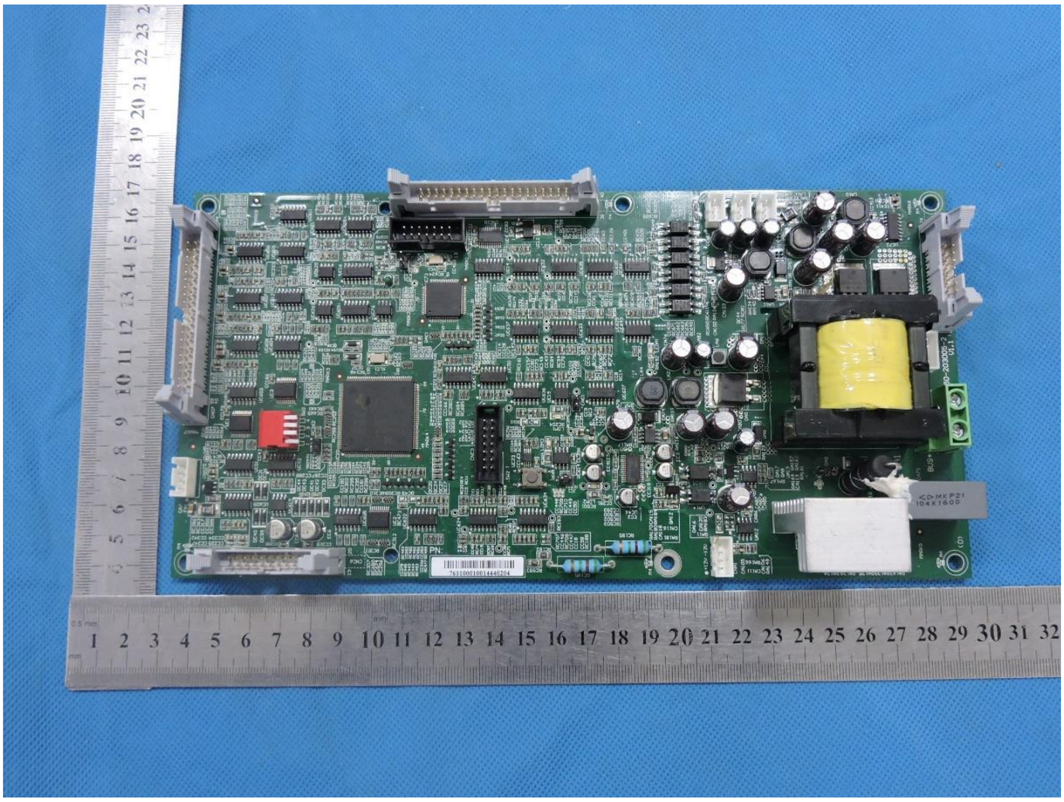


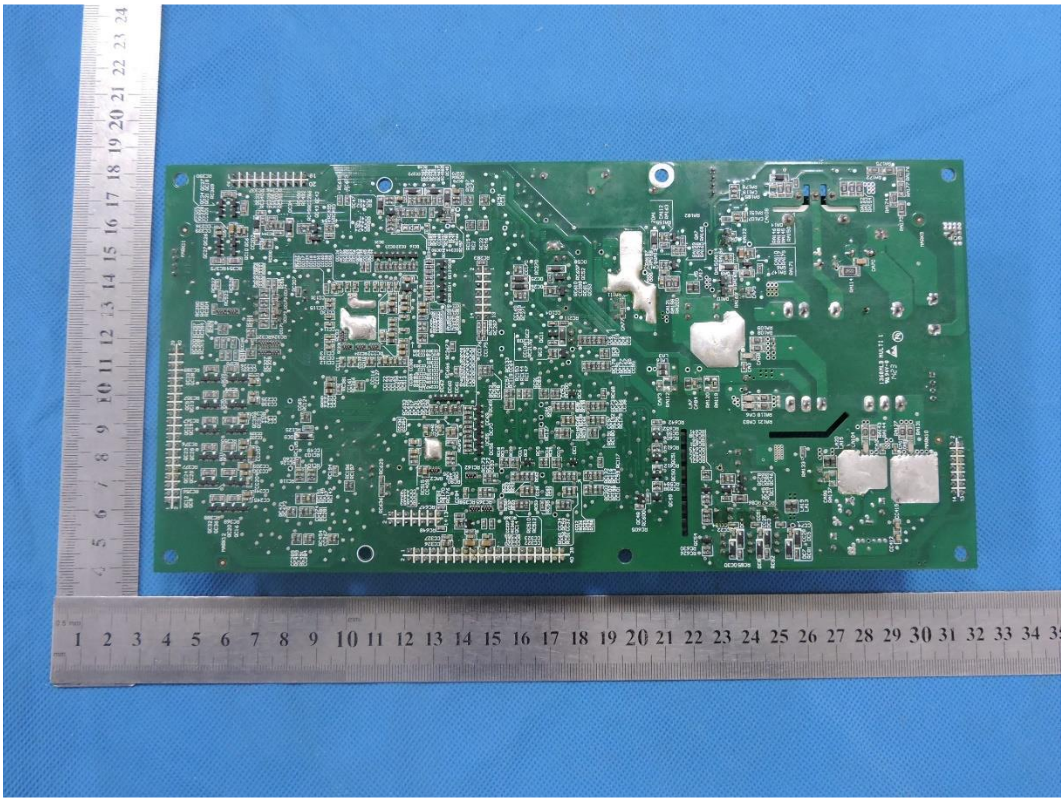


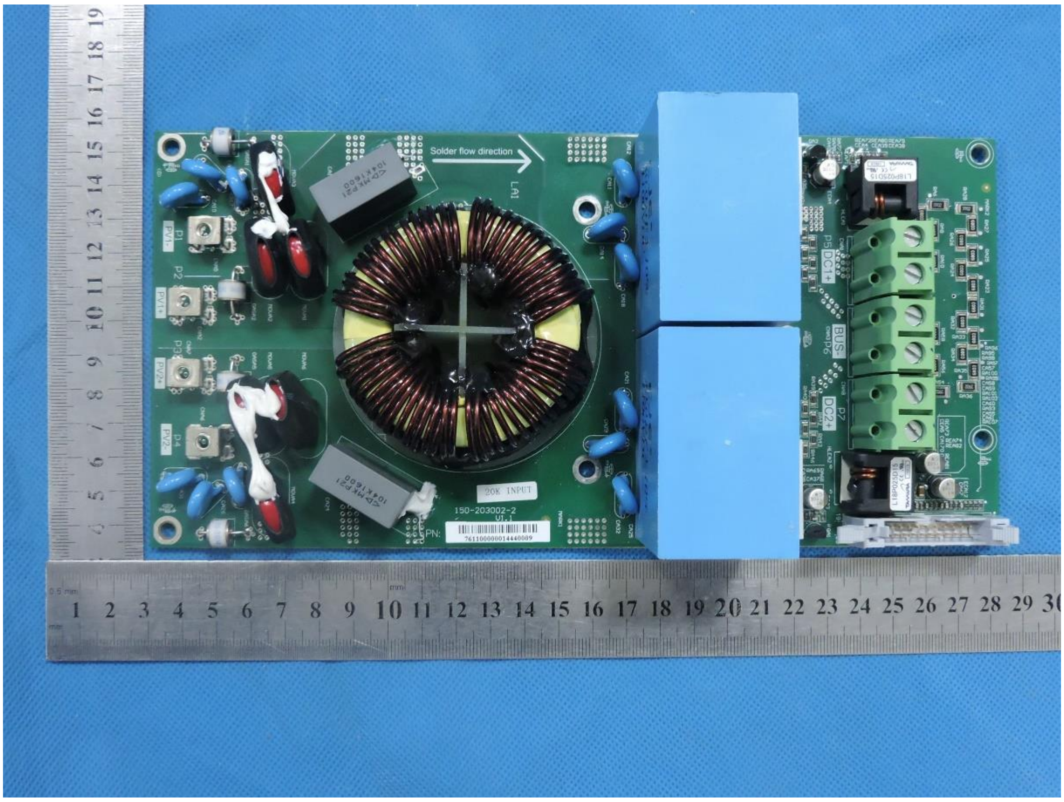


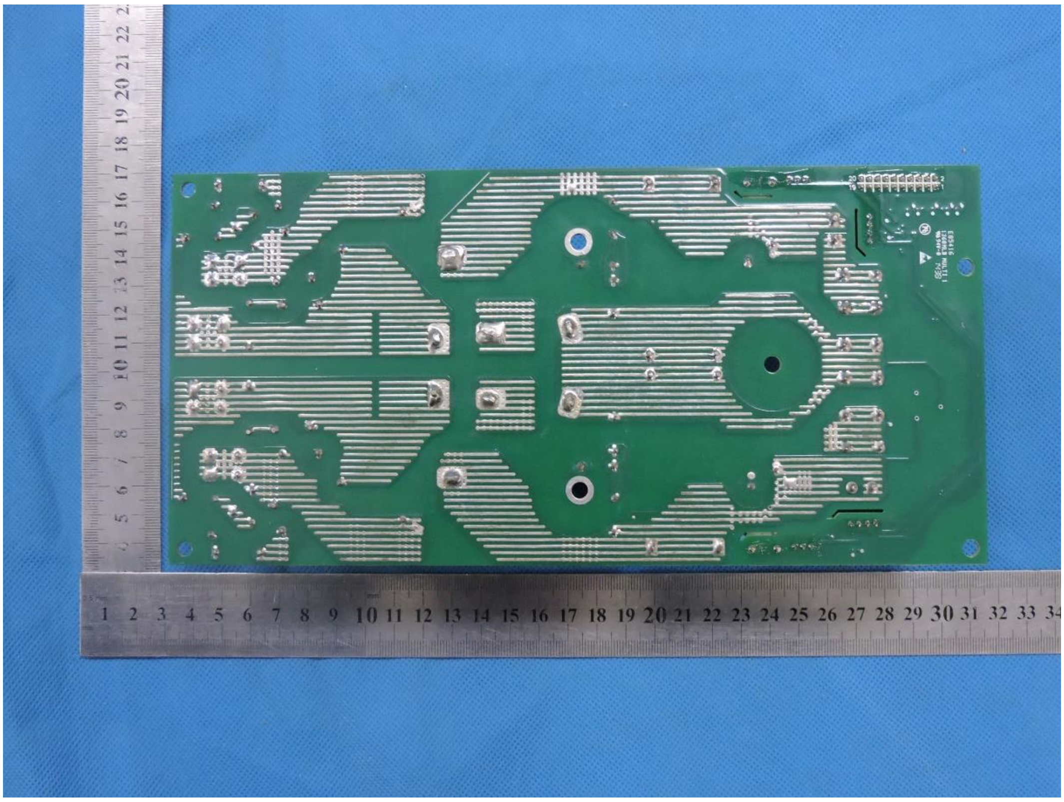


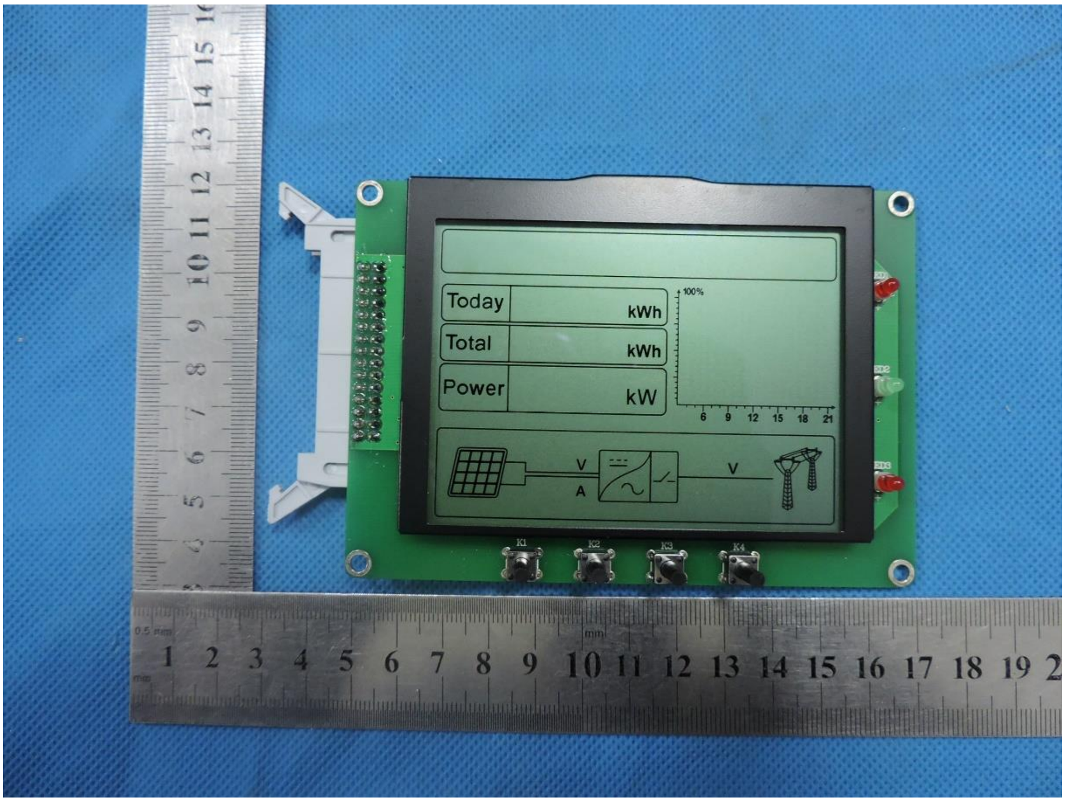








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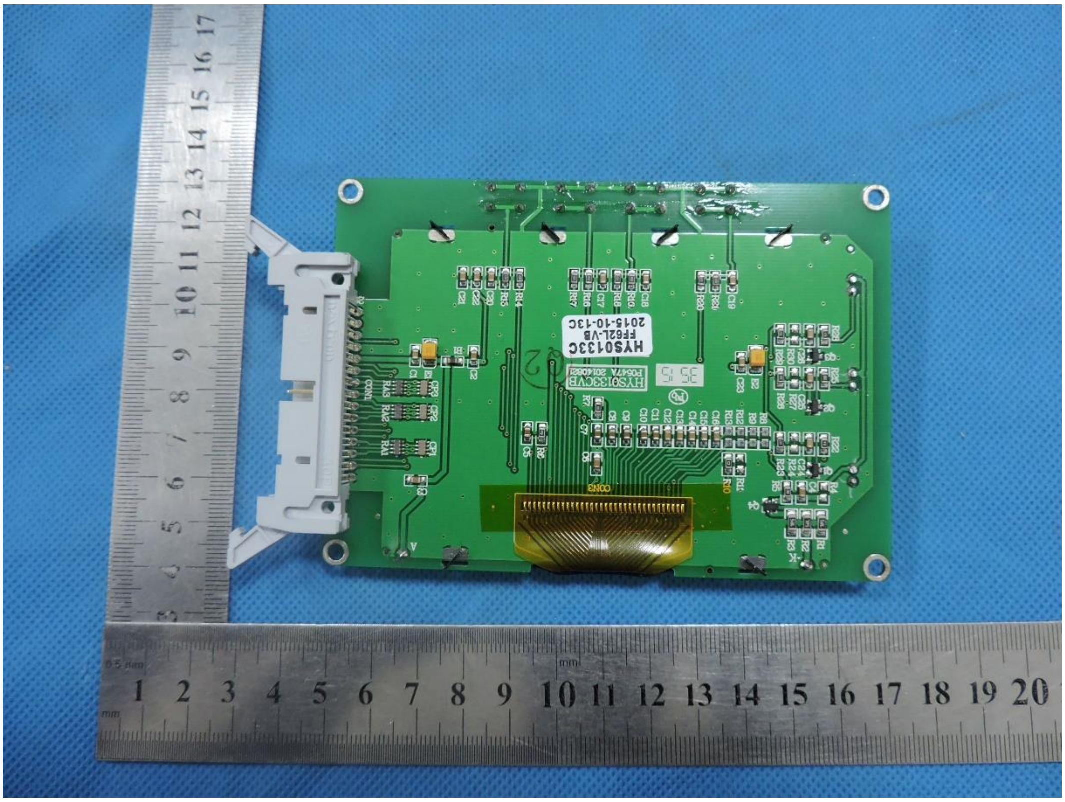
kWh
Total
kWh
Power
kW
100%
V
A
V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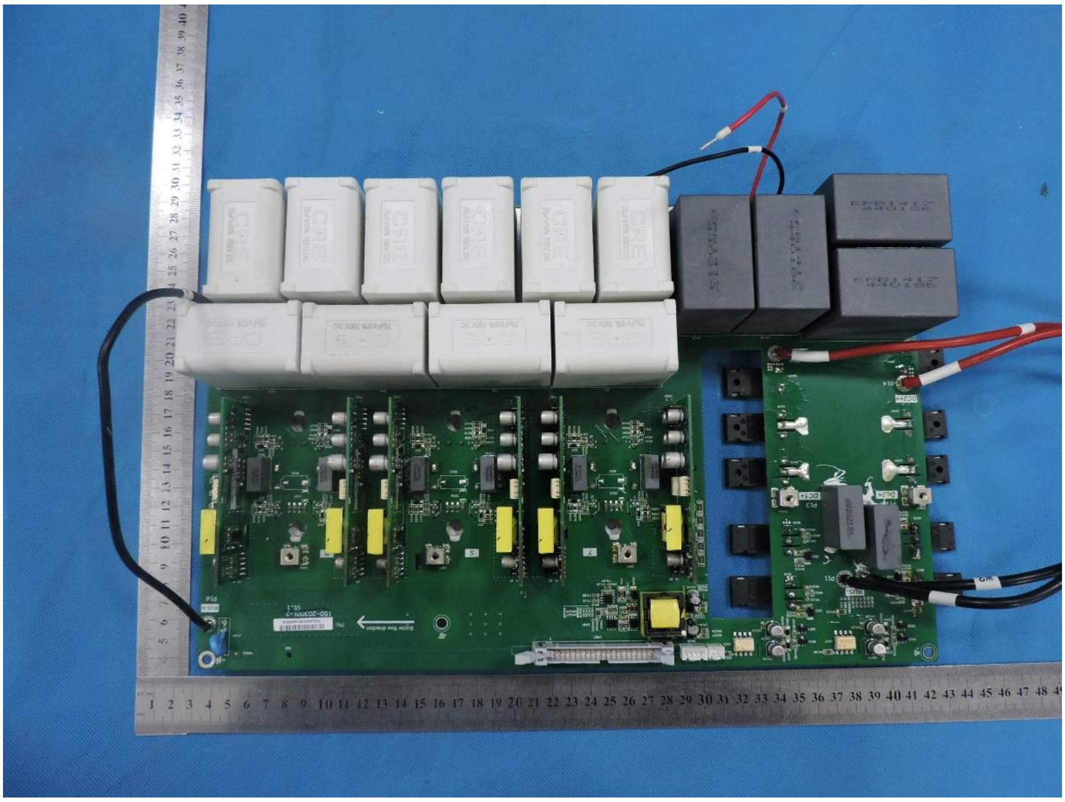
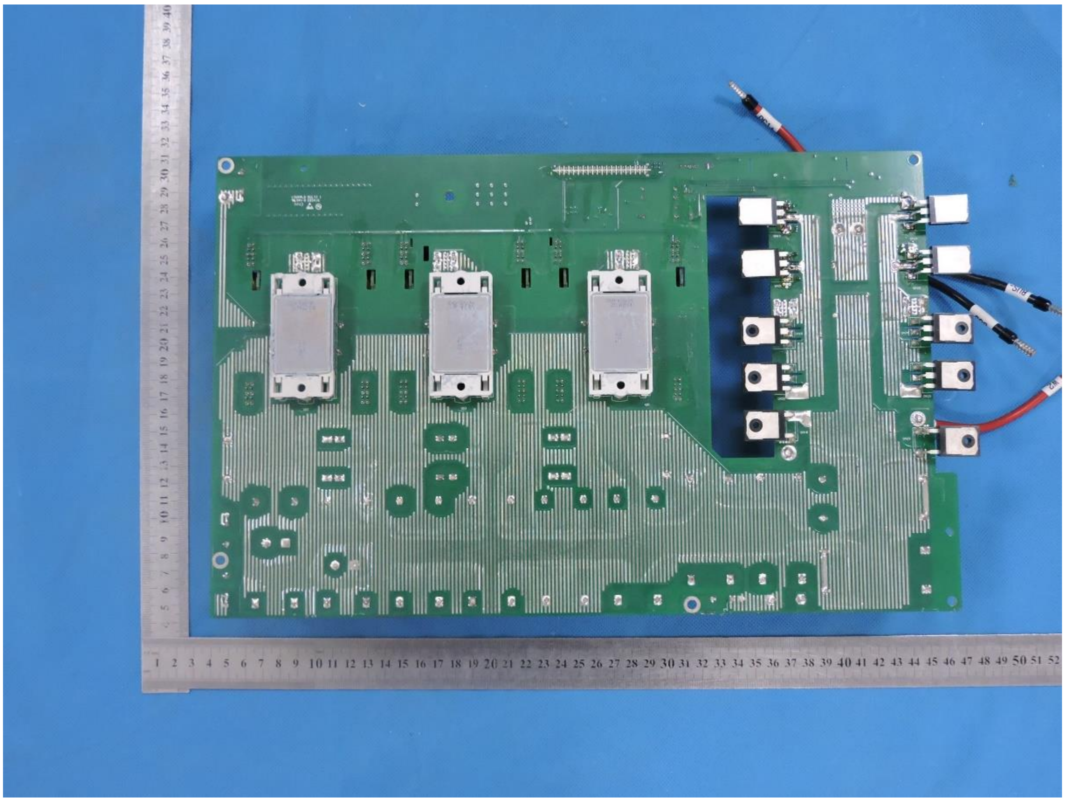
2015-10-13C






WiFi
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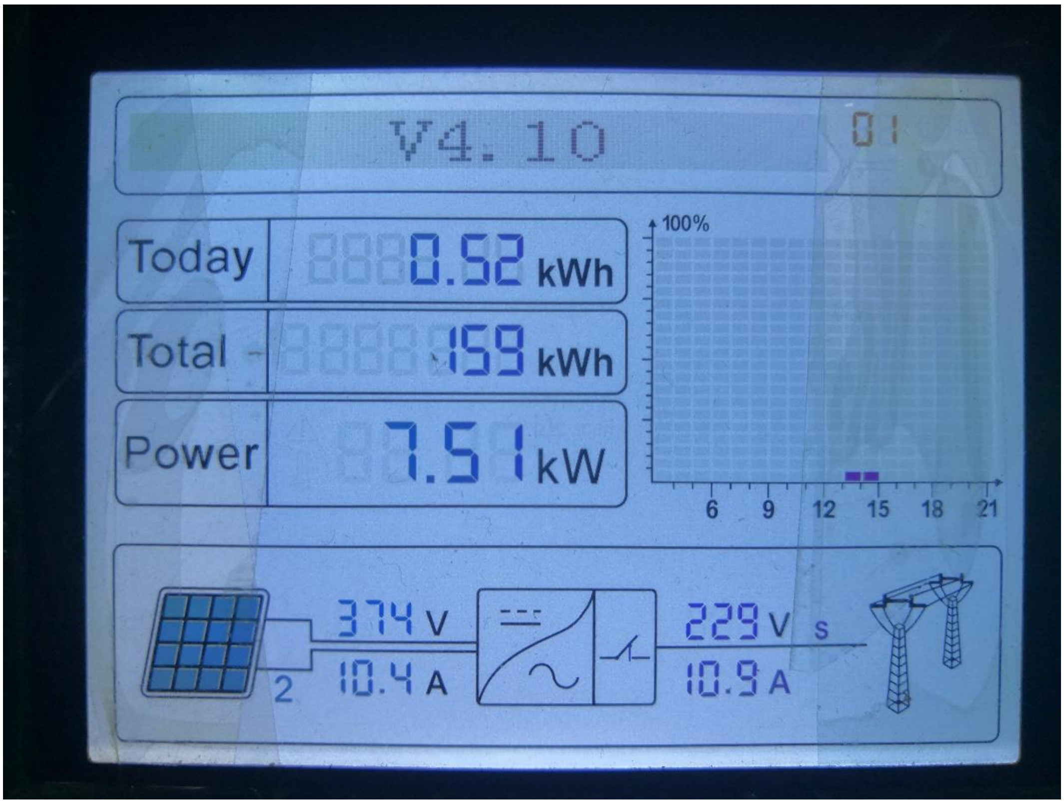
RS 485OUT
ON
OFF
IN1
IN2
AC


V4.10
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9
12
15
18
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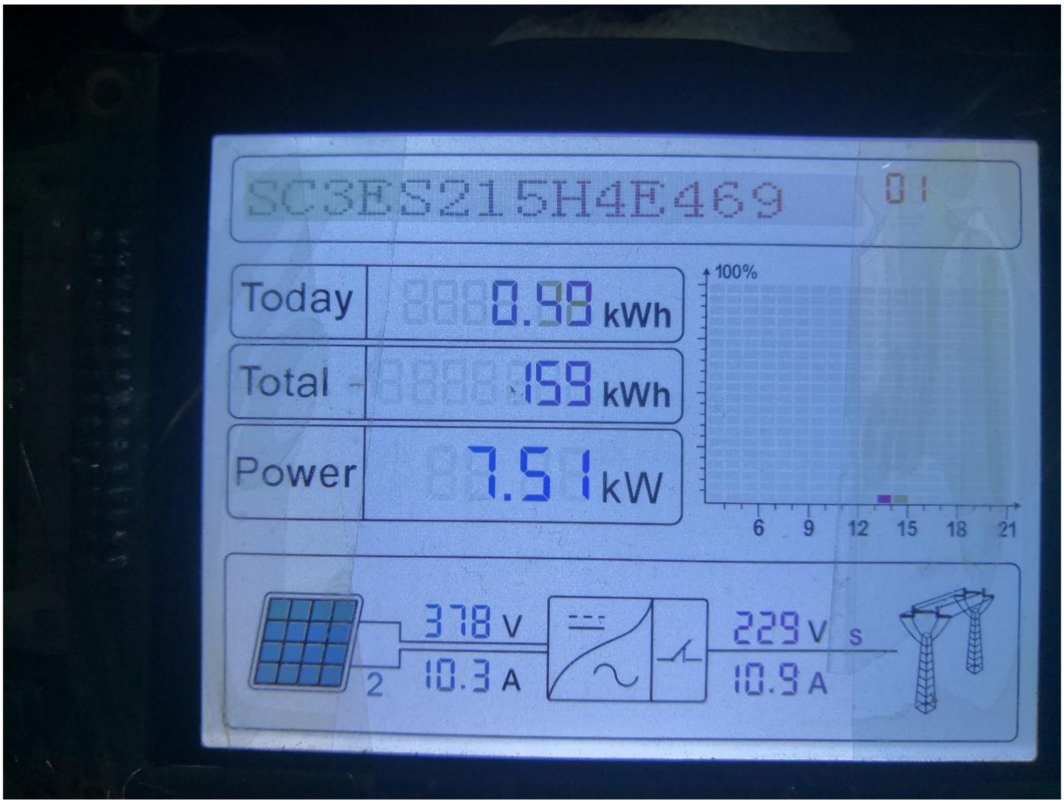
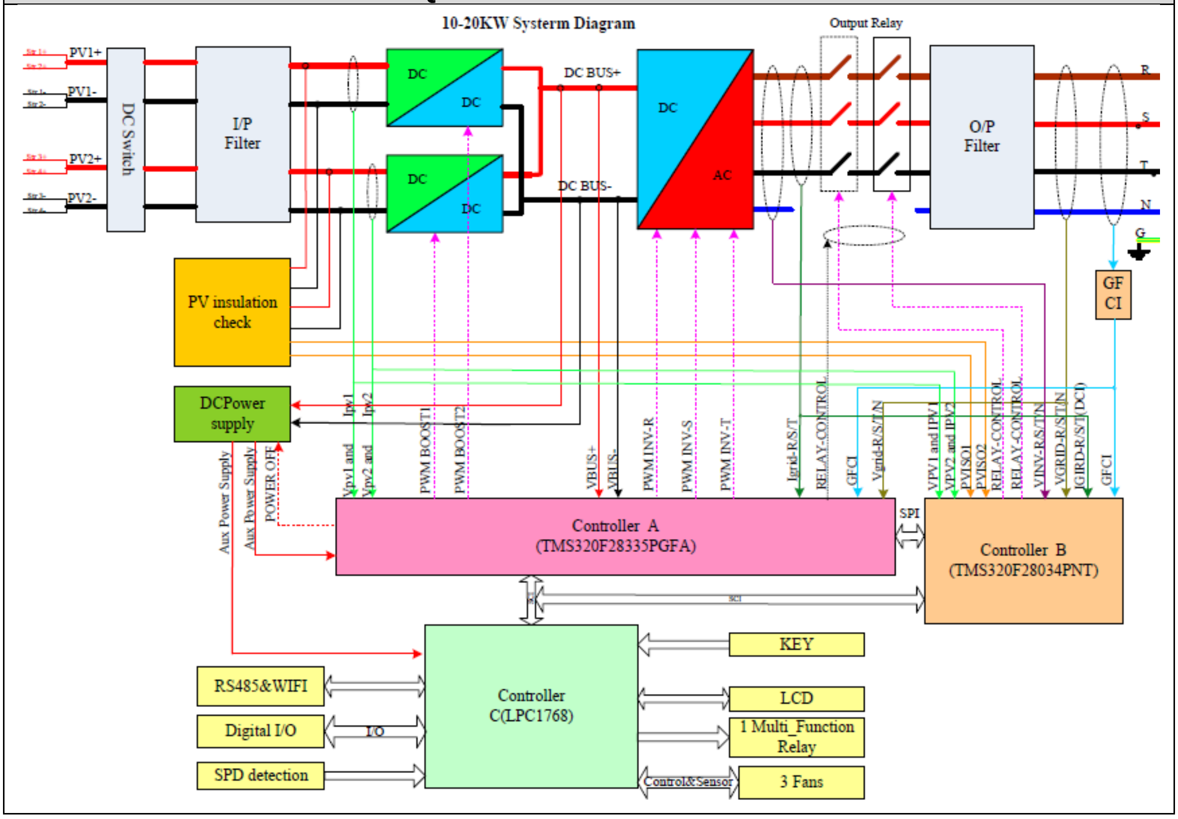
2
229 V
10.9 A


SC3ES215H4E469
01
Today
0.98 kWh
Total
159 kWh
Power
7.51 kW
100%
6
9
12
15
18
21
378 V
10.3 A
2
229 V
10.9 A

6 ELECTRICAL SCHEMES

EQUIPMENT UNDER TESTING



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