

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

Test Report Number: **GZES181100301101**
Tested Model: **SOFAR 30000TL-G2**
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
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Conducted (tested) by: Michael Tong
(Project Engineer)



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(Technical Reviewer)

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Test Report Historical Revision:

Test Report Version	Date	Resume
GZES1811003011PV	06/12/2018	First issuance

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EN 50530:2010/A1:2013**1 SCOPE**

SGS-CSTC Standards Technical Services Co., Ltd. Guangzhou Branch has been contract by Shenzhen SOFAR SOLAR 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 9 working days between the 26th of November and the 06th of December of 2018.

All the tests and checks have been performed in accordance with the reference Standard (the tests are done at $25 \pm 5^{\circ}\text{C}$, $96 \text{ kPa} \pm 10 \text{ kPa}$ and $50\% \text{ RH} \pm 10\% \text{ RH}$).

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 :



Type : SOFAR
 Model : SOFAR 30000TL-G2
 Serial Number : ZL1CS025J44007
 Software Version : V1.40
 Rated Characteristics : DC input: 230-960V (1000V max.), Max. 30/30A
 AC output: 3~ /N/PE 230/400Vac, 50Hz, 3*48A, 30000VA

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

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Rating Plate:



Solar Grid-tied Inverter

Model No.	SOFAR 30000TL-G2
Max.DC input Voltage	1100V
Operating MPPT voltage range	230V ~ 960V
Max. Input current	30A/30A
Max. PV Isc	37.5A/37.5A
Nominal Grid Voltage	3/N/PE, 400Vac
Max. Output Current	3x48A
Nominal Grid Frequency	50Hz/60Hz
Nominal Output power	30000W
Max. Output power	33000VA
Power factor	>0.99(adjustable+/-0.8)
Ingress protection	IP65
Operating Temperature Range	-25~+60°C
Protective Class	Class I

Manufacturer: Shenzhen SOFARSOLAR 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



SAA XXXXXX
 VDE0126-1-1, VDE-AR-N4105, G59/3, IEC61727,
 IEC62116, C10/11, RD1699, UTE C15-712-1, AS4777



Model fully tested:

- **SOFAR 30000TL-G2**

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/GM136 0	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	±1°
	cosφ	±0,01

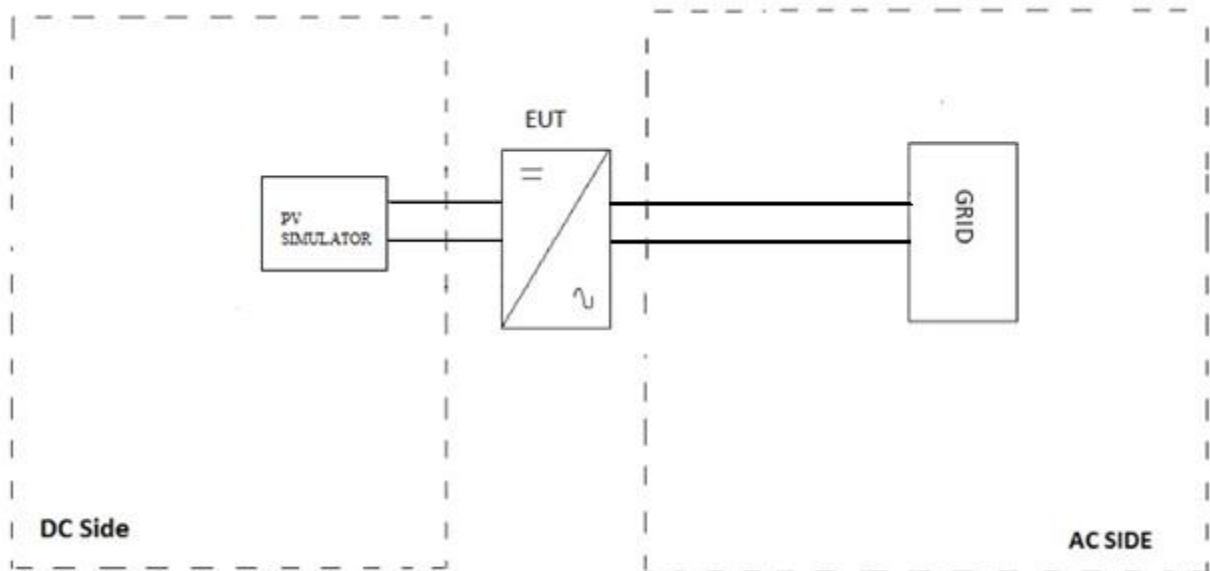
Note: The measurement uncertainties associated with other parameters measured during the tests are in the laboratory at disposal of the solicitant.

2.5 Definitions

EUT	Equipment Under Testing	Q _n	Nominal Reactive Power
I _{DC,I}	Sampled value of the inverter's input current	S _n	Nominal Apparent Power (Inverter)
I _n	Nominal Current (Inverter)	T _M	Overall measuring period
p.u	Per unit	U _{DC,I}	Sampled value of the inverter's input voltage
P _{DC}	Measured input power of the device under test	U _n	Nominal Voltage
P _{MPP,PVS}	MPP power provided by the PV simulator	ΔT	Period between two subsequent sample values
P _n	Nominal Active Power (Inverter)	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.

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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 simulated 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 560 Vdc	c-Si	92.38	99.09	99.38	99.33	99.42	99.48	99.48	99.53
U nom 620 Vdc		93.63	95.48	96.48	97.09	98.05	98.95	99.31	99.75
U max 800 Vdc		98.98	99.26	99.47	99.65	99.68	99.86	99.87	99.90
U min 560 Vdc	TF	98.15	99.18	99.59	99.56	99.74	99.87	99.96	99.87
U nom 620 Vdc		92.34	93.28	93.46	94.37	95.67	97.29	98.53	99.51
U max 700 Vdc		98.03	99.06	99.56	99.22	99.71	99.81	99.88	99.91

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.

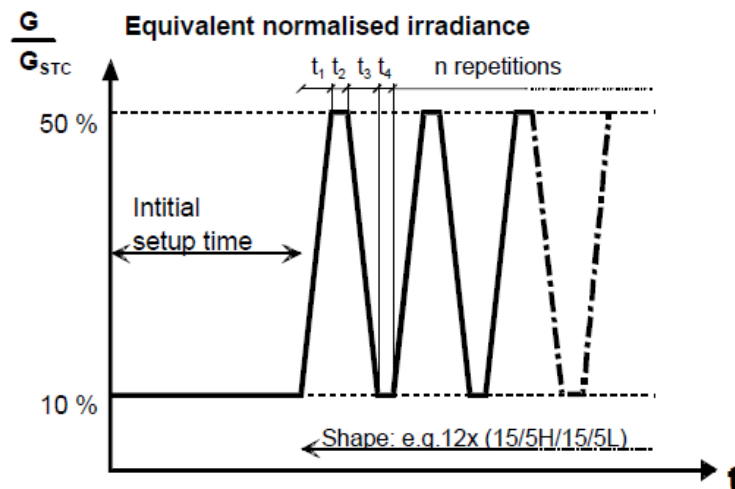


Figure B.1 – Test sequence for fluctuations between small and medium irradiation intensities

From-to W/m ²	Delta W/m ²					Waiting time setting s	
100-500	400					300	
# Number	Slope W/m ² /s	Ramp UP s	Dwell time s	Ramp DN s	Dwell time s	Duration s	Efficiency (%)
2	0.5	800	10	800	10	3540	97.66
2	1	400	10	400	10	1940	97.66
3	2	200	10	200	10	1560	97.29
4	3	133	10	133	10	1447	95.41
6	5	80	10	80	10	1300	94.46
8	7	57	10	57	10	1374	93.84
10	10	40	10	40	10	1700	93.05
10	14	29	10	29	10	1071	91.58
10	20	20	10	20	10	900	91.62
10	30	13	10	13	10	767	90.46
10	50	8	10	8	10	660	91.19

4.2.2 Test sequence with ramps 30 % - 100 % PDCn

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

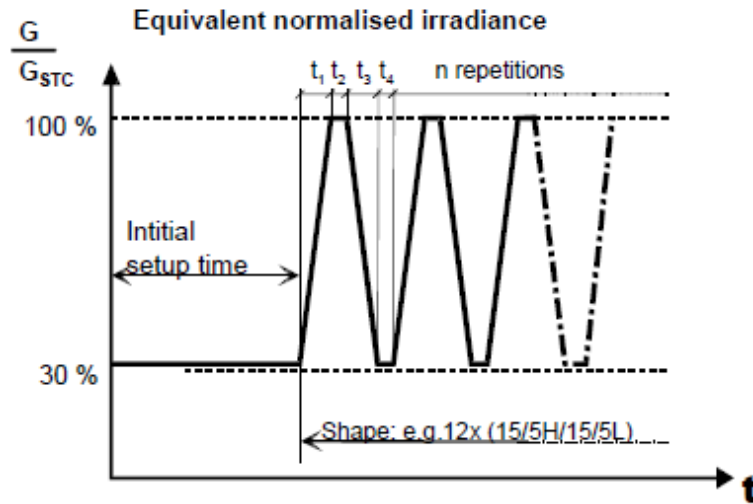


Figure B.2 – Test sequence for fluctuations between medium and high irradiation intensities

From-to W/m ²	Delta W/m ²					Waiting time setting s	
300-1000	700					300	
# Number	Slope W/m ² /s	Ramp UP s	Dwell time s	Ramp DN s	Dwell time s	Duration s	Efficiency (%)
10	10	70	10	70	10	1900	99.50
10	14	50	10	50	10	1500	99.50
10	20	35	10	35	10	1200	99.50
10	30	23	10	23	10	967	99.50
10	50	14	10	14	10	780	99.50
10	100	7	10	7	10	640	98.42

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.

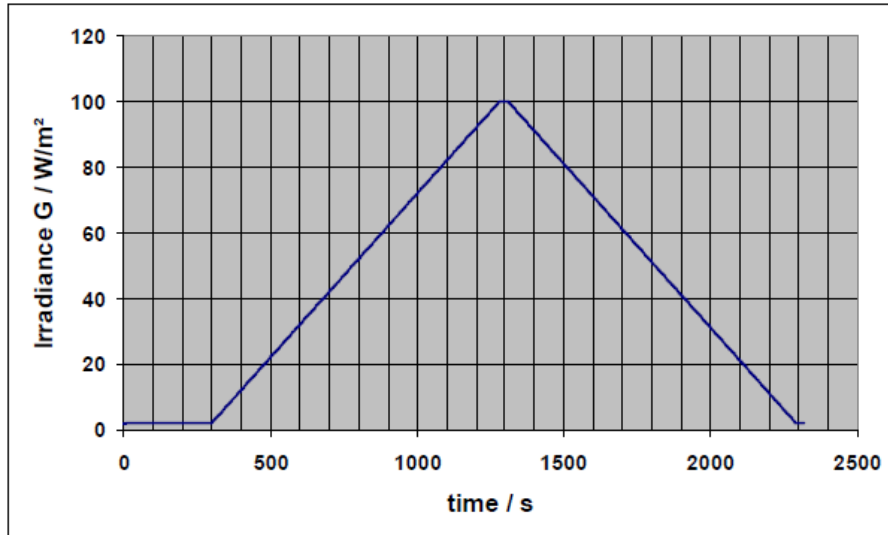


Figure B.3 – Test sequence for the start-up and shut-down test of grid connected inverters

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	91.76

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 simu- lated 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 560 Vdc	c-Si	94.89	97.14	97.32	97.44	97.51	97.51	97.29	97.10
U nom 620 Vdc		94.73	96.62	97.35	97.56	97.56	97.60	97.42	97.26
U max 800 Vdc		95.14	97.01	97.78	97.91	97.94	98.00	97.90	97.71
U min 560 Vdc	TF	94.50	96.65	97.35	97.44	97.49	97.51	97.31	97.12
U nom 620 Vdc		92.43	95.94	97.11	97.31	97.40	97.50	97.40	97.24
U max 700 Vdc		95.51	97.47	98.09	98.18	98.22	97.52	98.02	97.83

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:

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

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 570 Vdc	c-Si	87.66	96.26	96.72	96.79	96.94	97.00	96.78	96.64
U nom 700 Vdc		88.70	92.25	93.92	94.72	95.66	96.58	96.75	97.02
U max 800 Vdc		94.17	96.29	97.26	97.57	97.63	97.86	97.77	97.61
U min 570 Vdc	TF	92.75	95.86	96.95	97.01	97.24	97.38	97.27	96.99
U nom 650 Vdc		85.35	89.49	90.76	91.83	93.18	94.86	95.97	96.76
U max 700 Vdc		93.63	96.55	97.66	97.41	97.94	97.33	97.90	97.74

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_j} 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

$$\eta_{MPPTstat, EUR(c-si)} = 96.60\%$$

$$\eta_{MPPTstat, EUR(TF)} = 96.10\%$$

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:

$$\eta_{MPPTstat,CEC} = a_{CEC_1} \cdot \eta_{MPP_1} + a_{CEC_2} \cdot \eta_{MPP_2} + a_{CEC_3} \cdot \eta_{MPP_3} + a_{CEC_4} \cdot \eta_{MPP_4} + a_{CEC_5} \cdot \eta_{MPP_5} + a_{CEC_6} \cdot \eta_{MPP_6} \quad (D.2)$$

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)

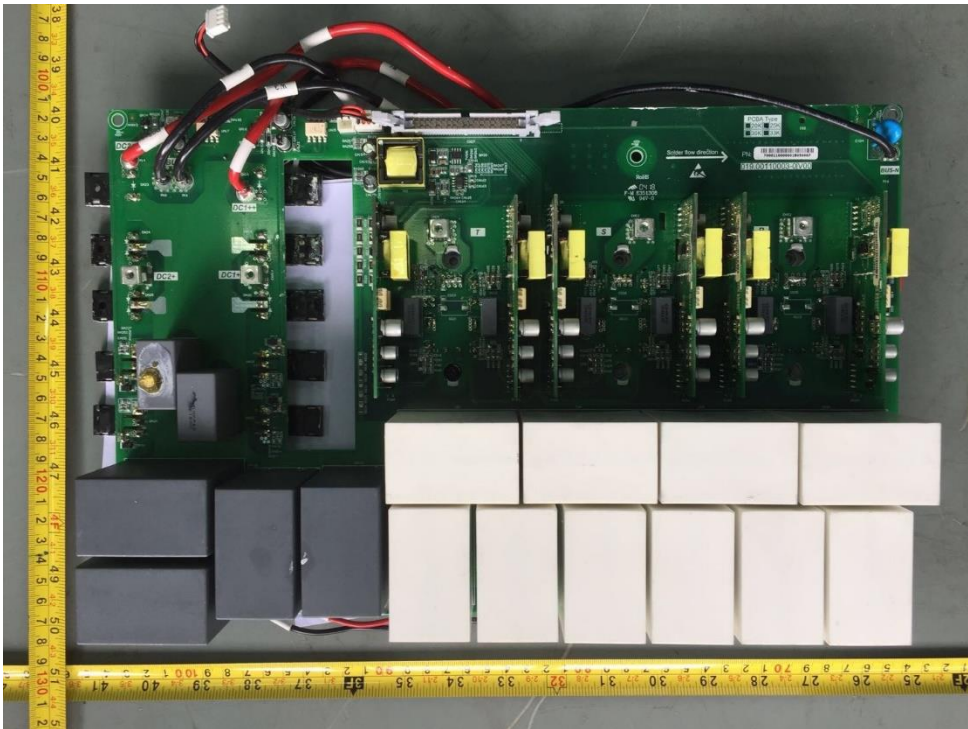
Weighting Factor	a_{CEC_1}	a_{CEC_2}	a_{CEC_3}	a_{CEC_4}	a_{CEC_5}	a_{CEC_6}
	0.04	0.05	0.12	0.21	0.53	0.05
Partial MPP power $P_{MPP,PVS}/P_{DC,r}$	MPP_1	MPP_2	MPP_3	MPP_4	MPP_5	MPP_6
	0.1	0.2	0.3	0.5	0.75	1

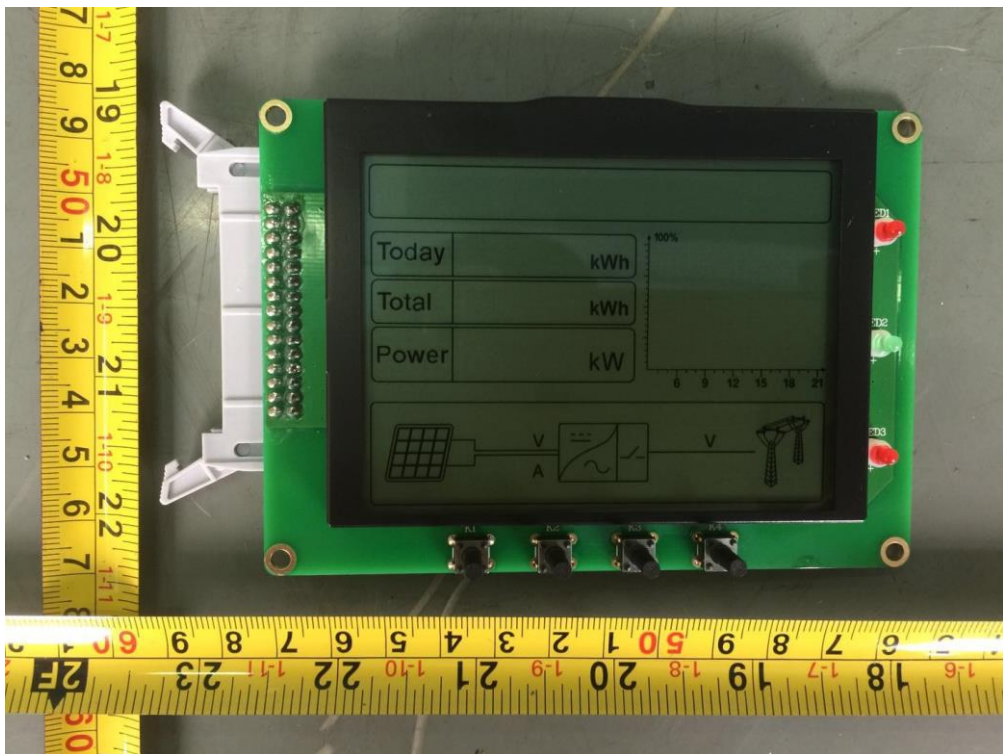
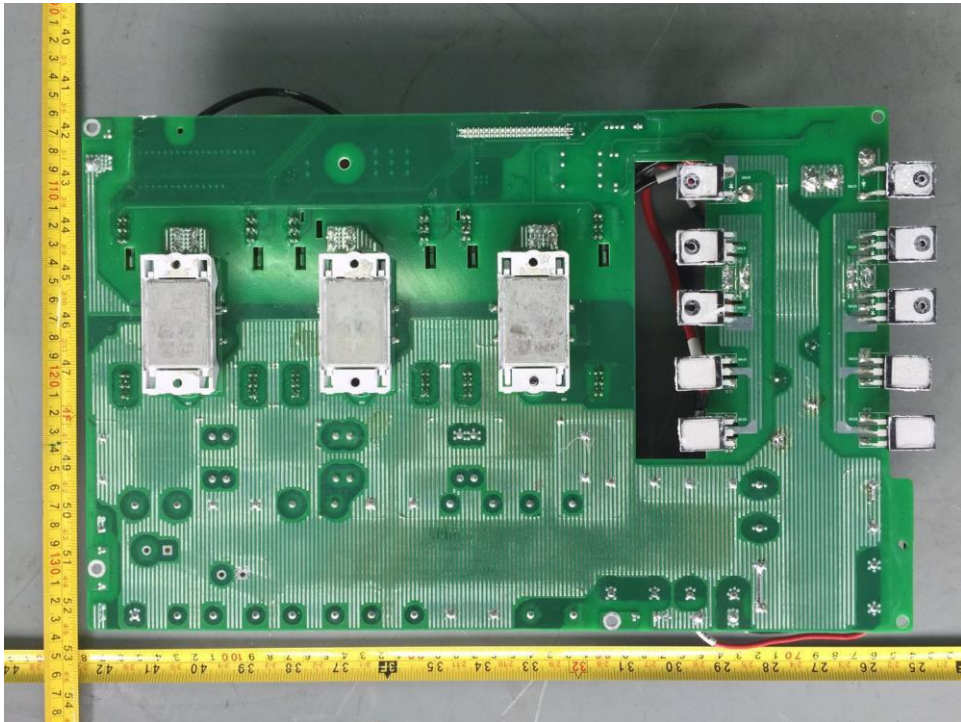
$$\eta_{MPPTstat,CEC(c-si)} = 96.92\%$$

$$\eta_{MPPTstat,CEC(TF)} = 96.61\%$$

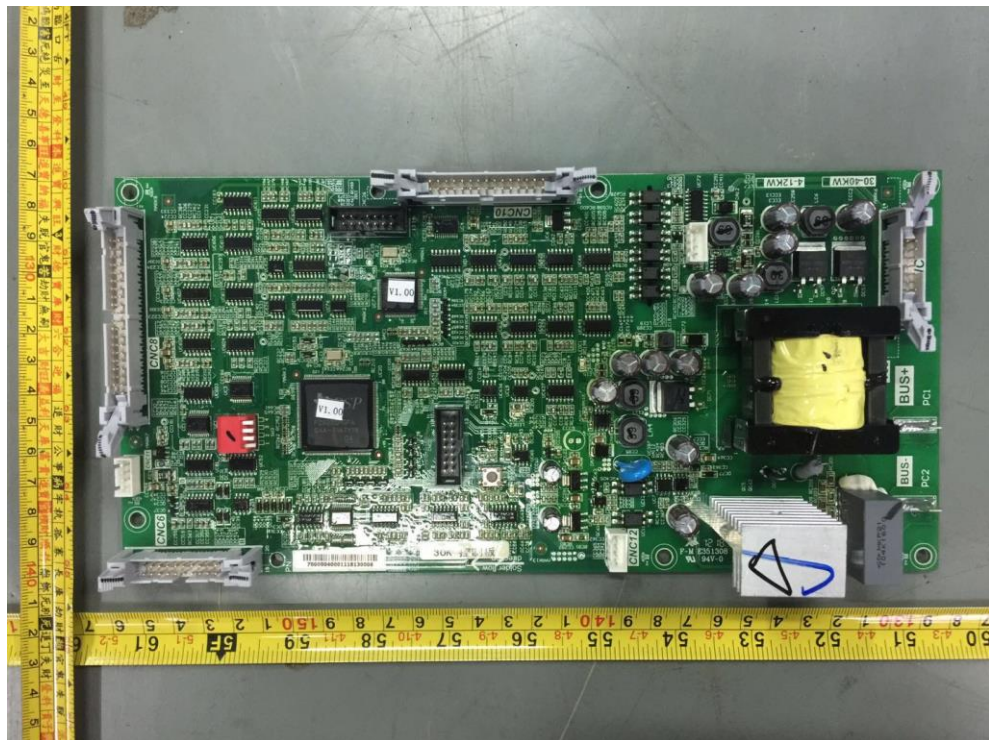
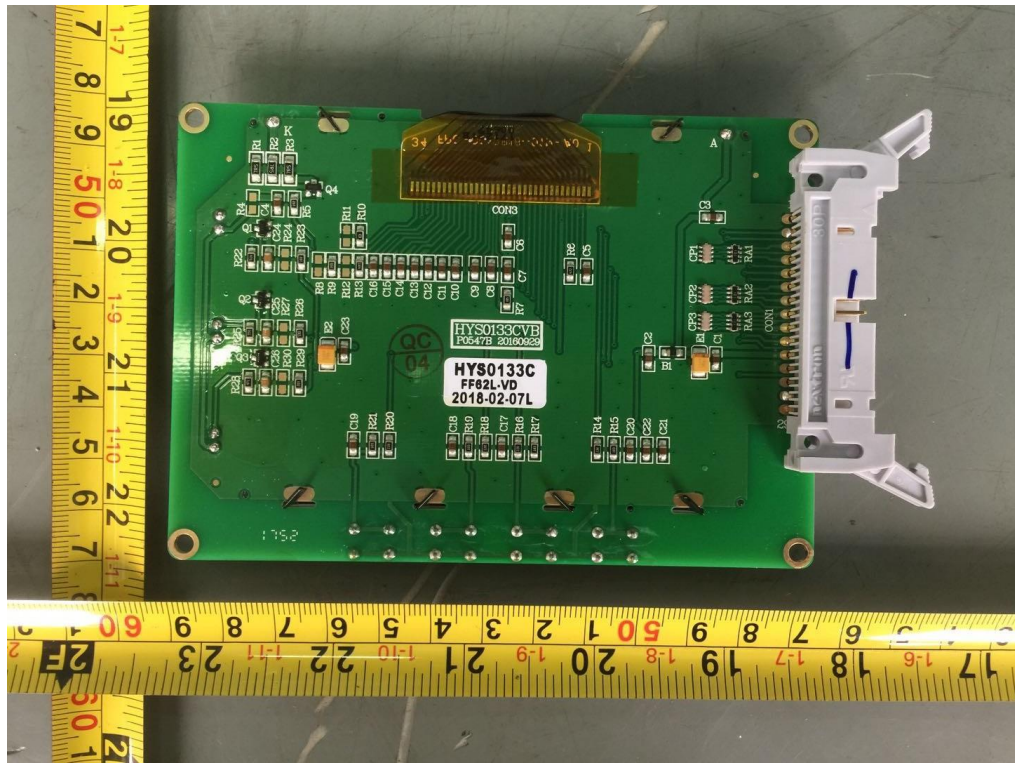
5 PICTURES



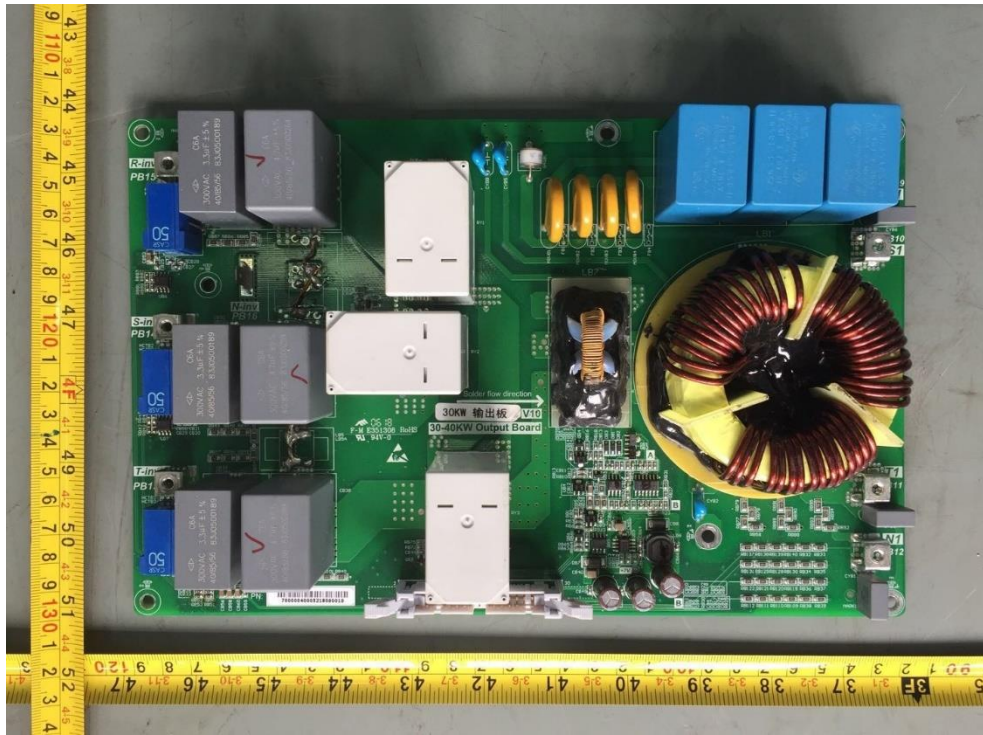
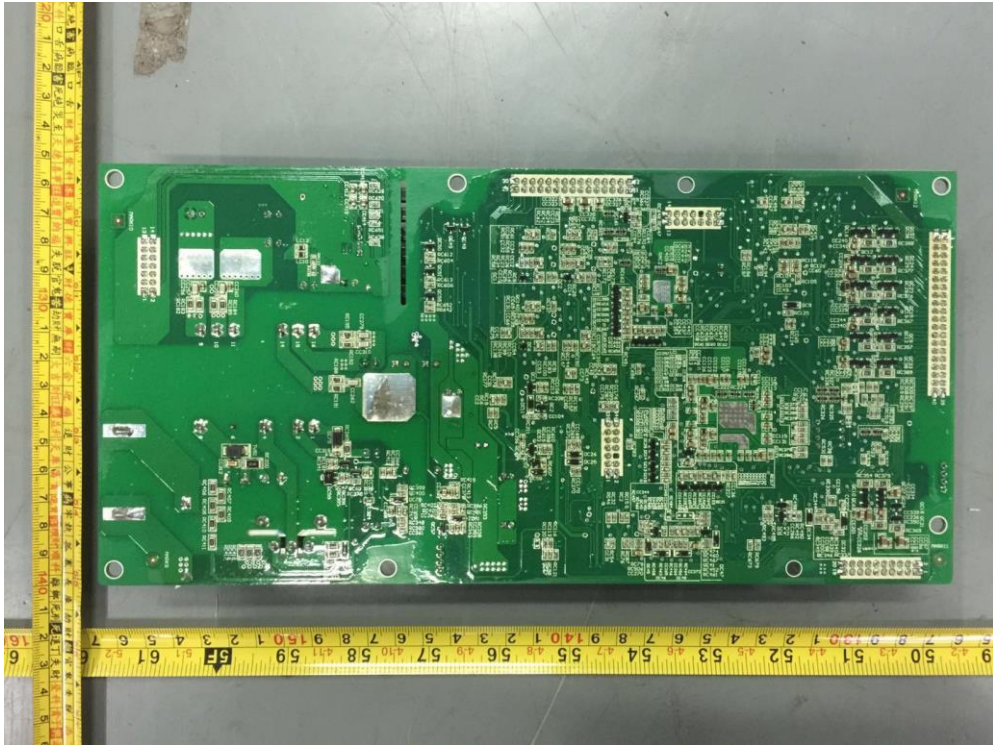




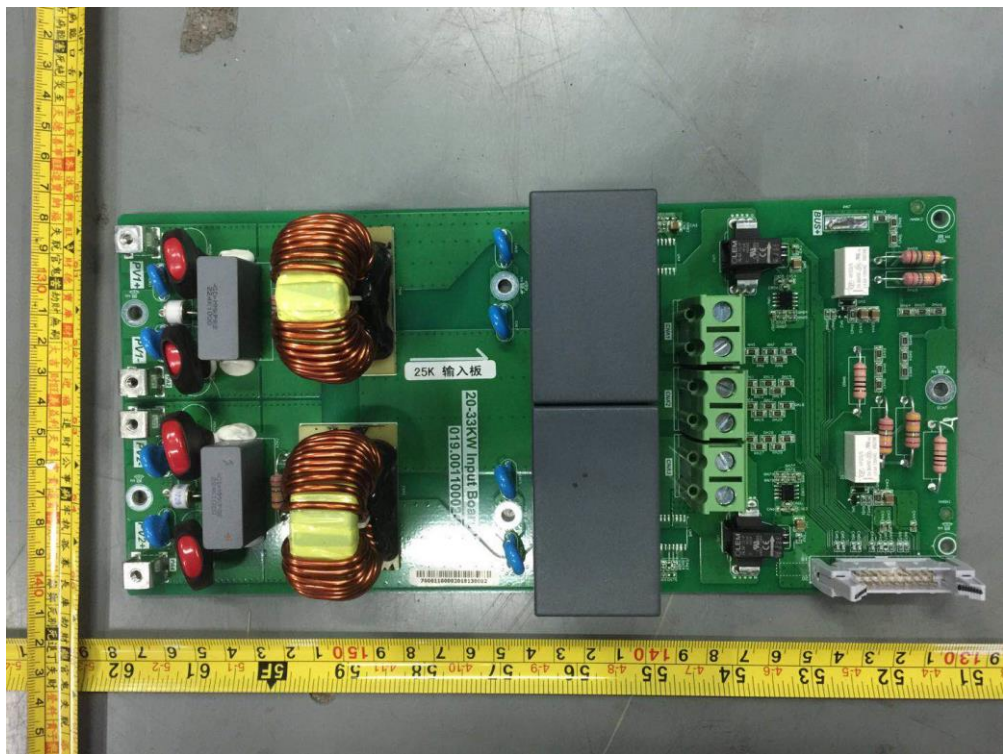
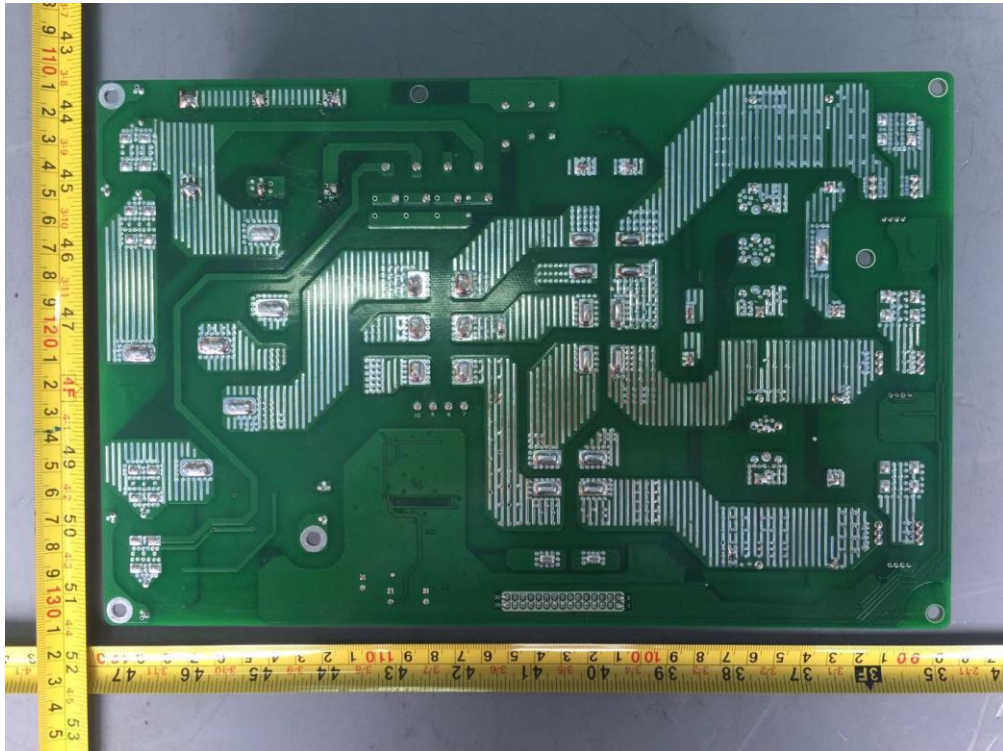
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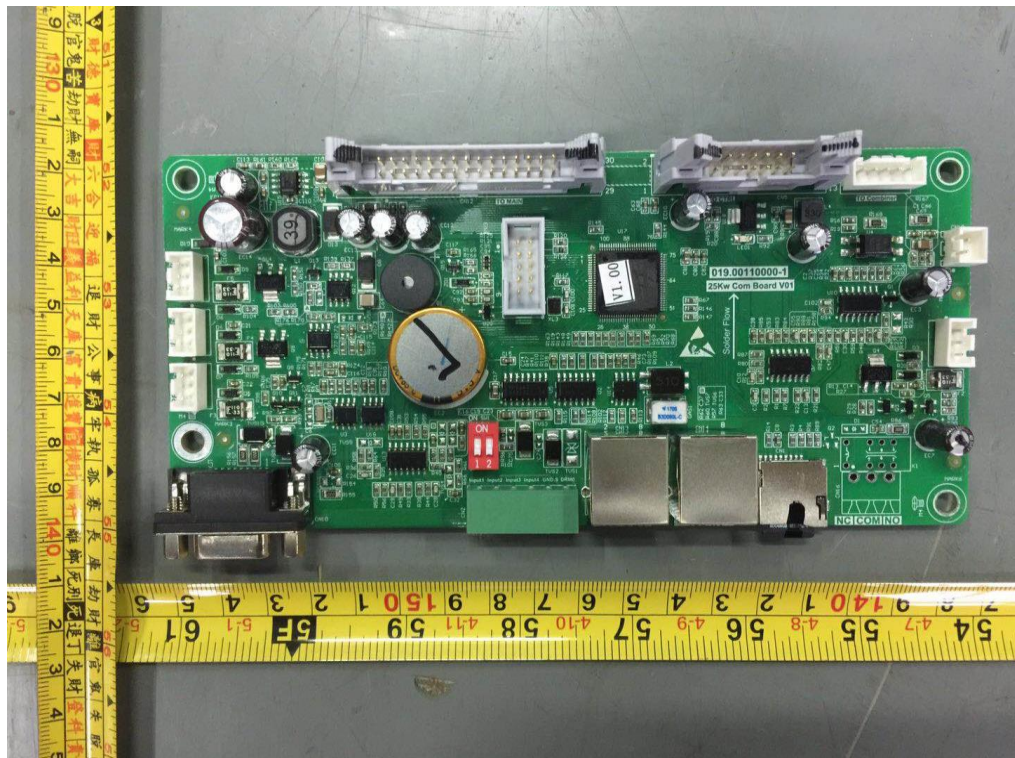
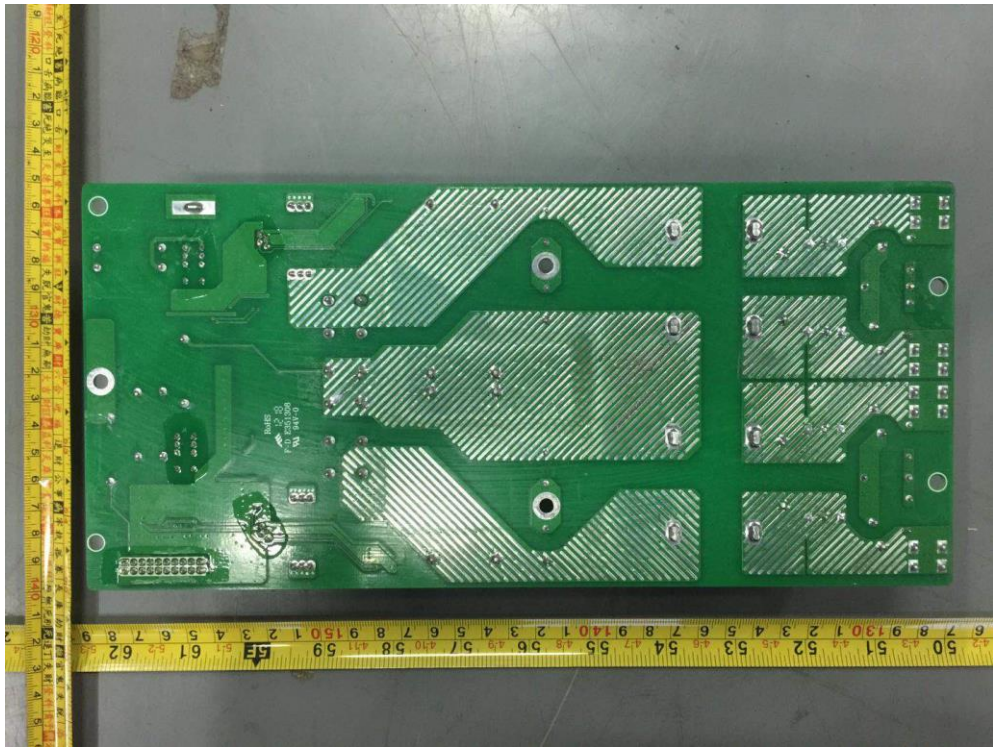
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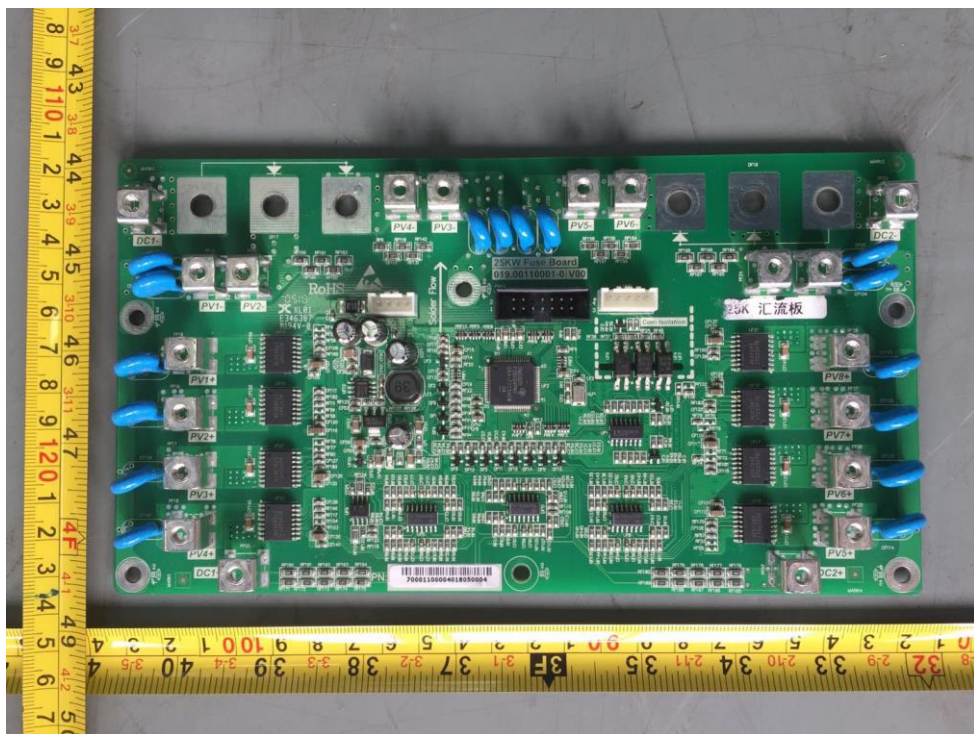
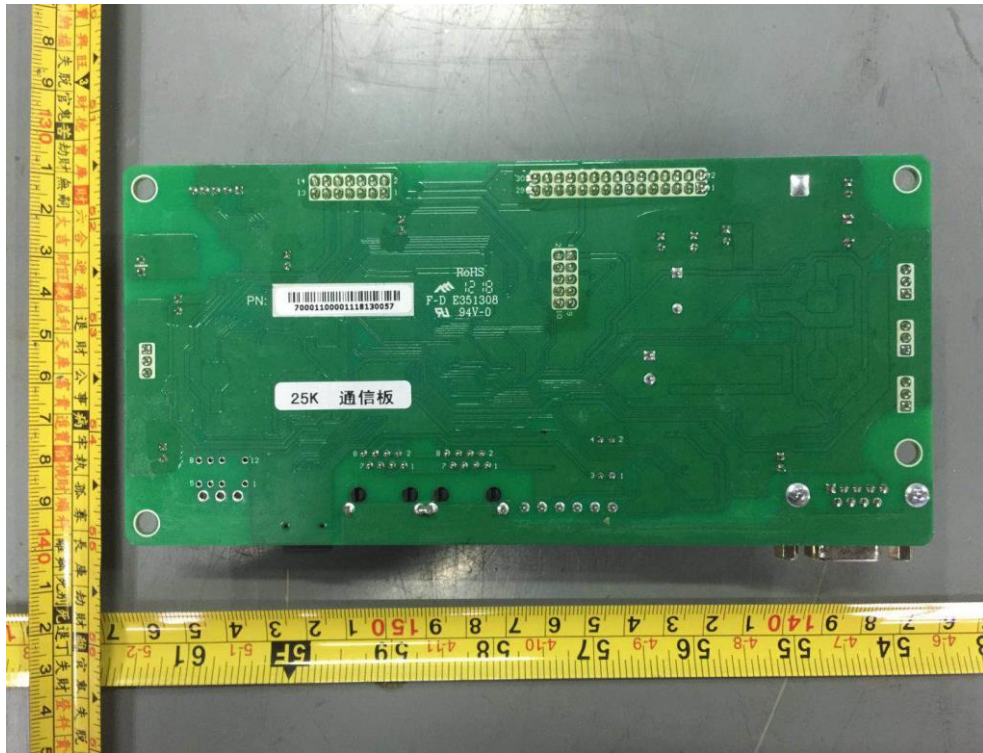
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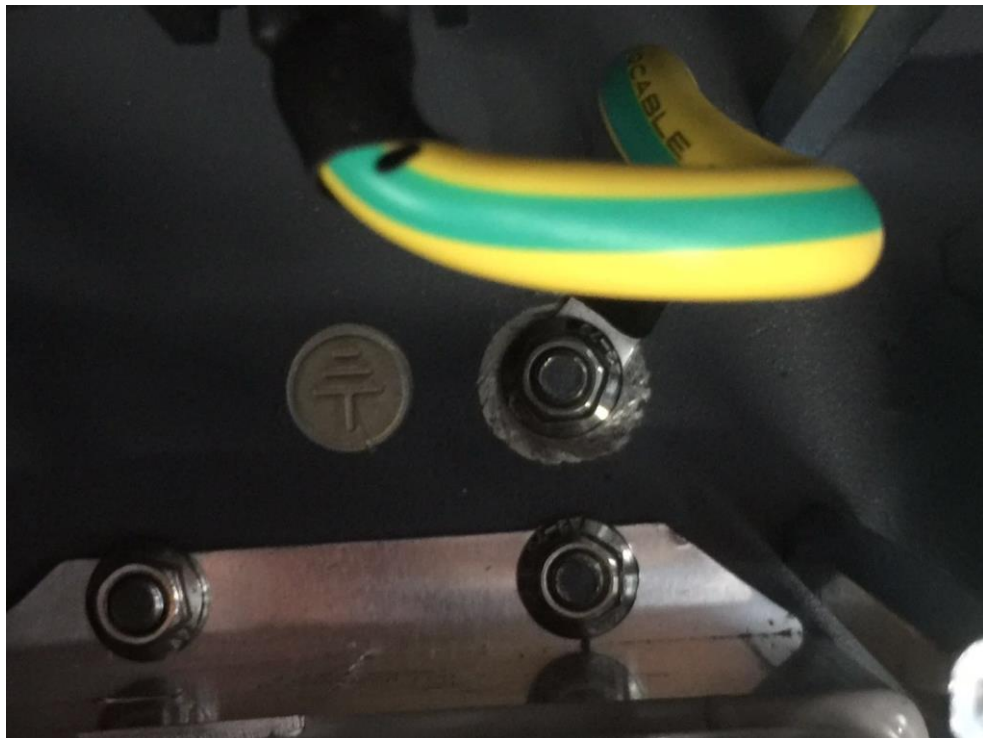
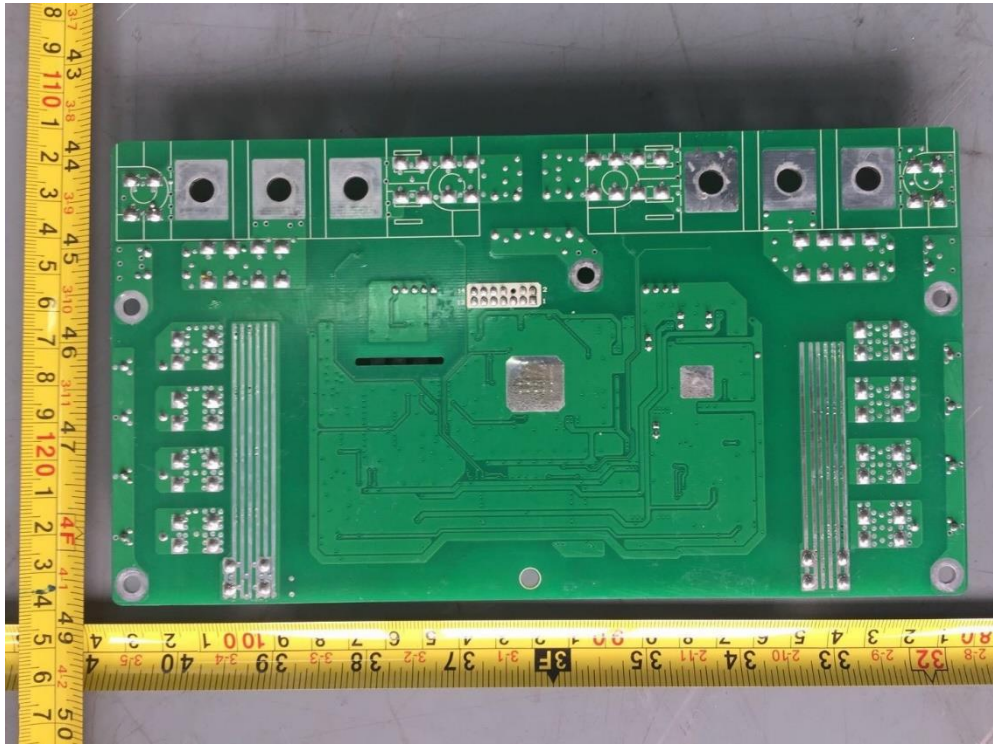


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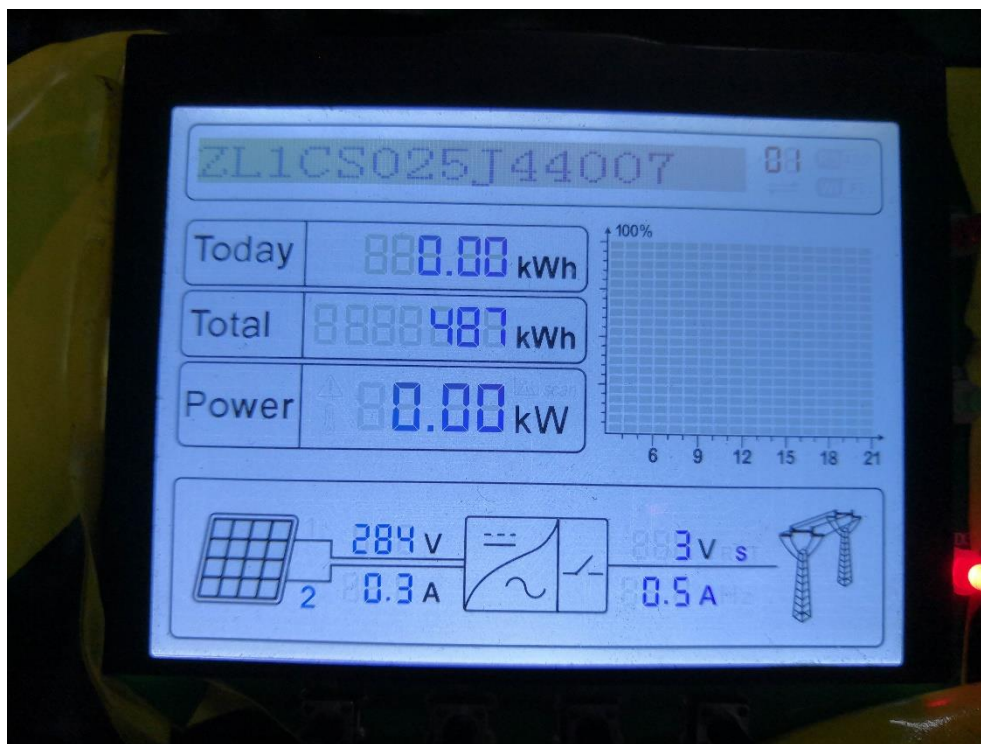
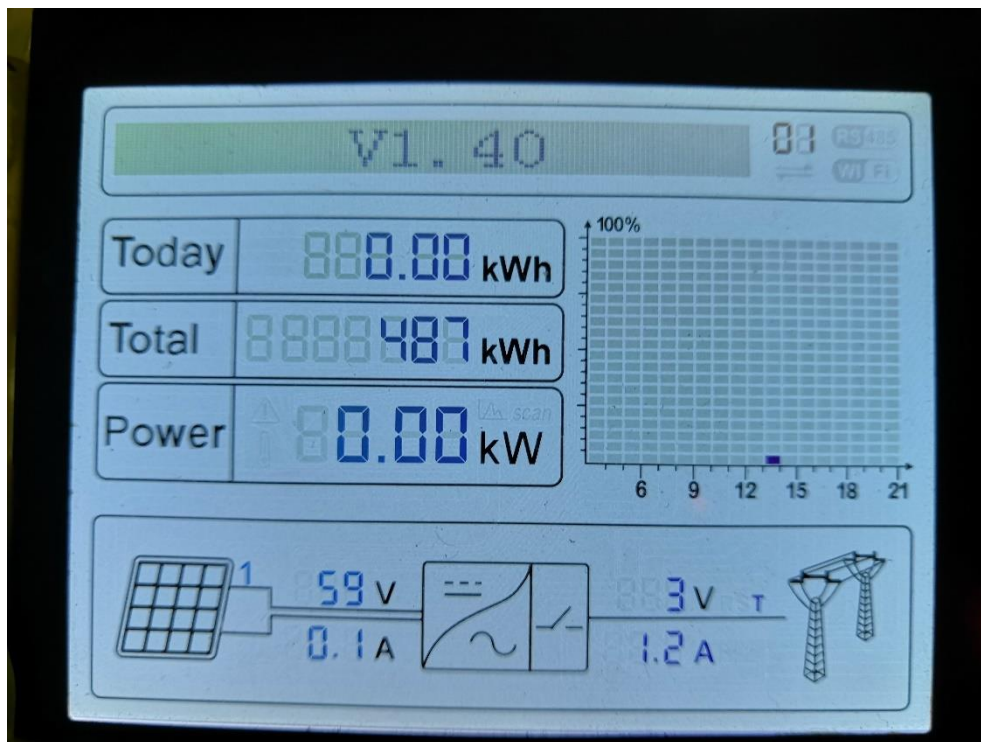




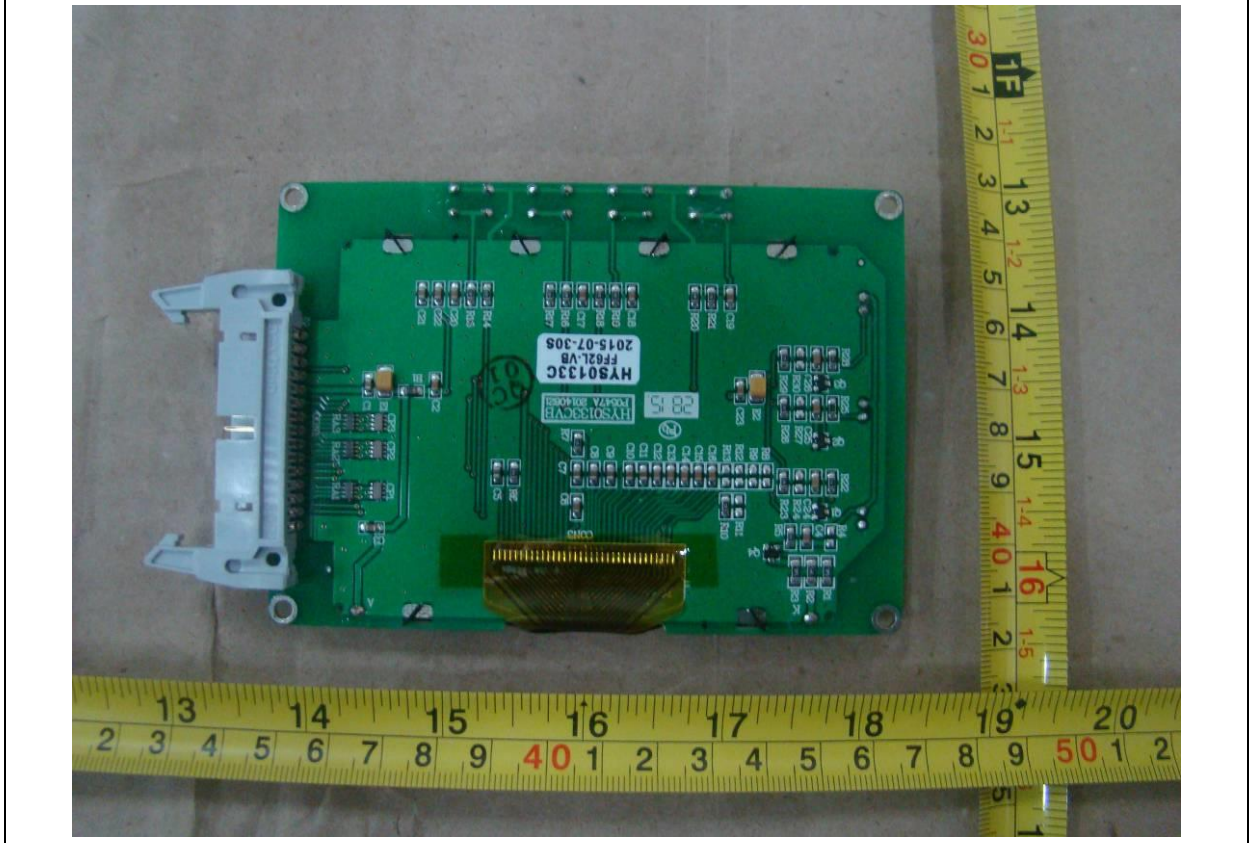
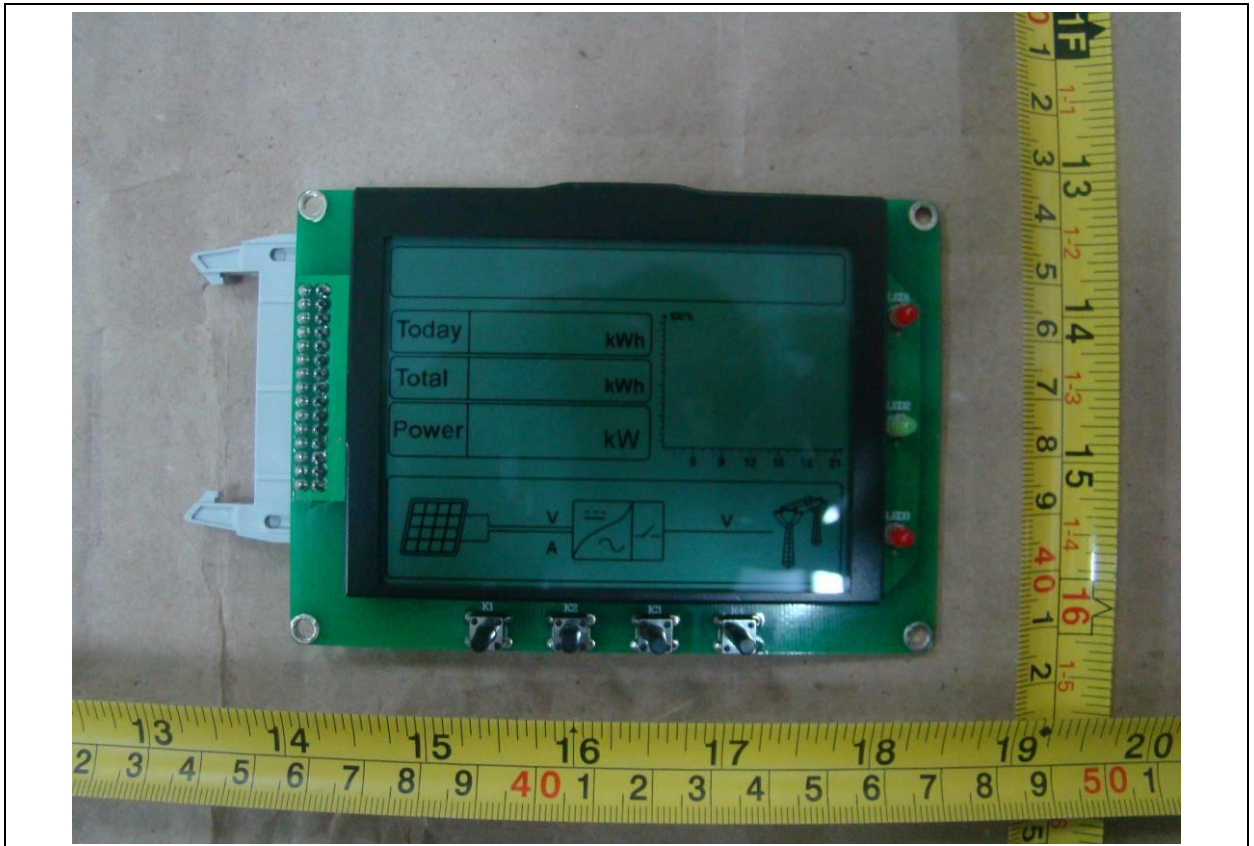
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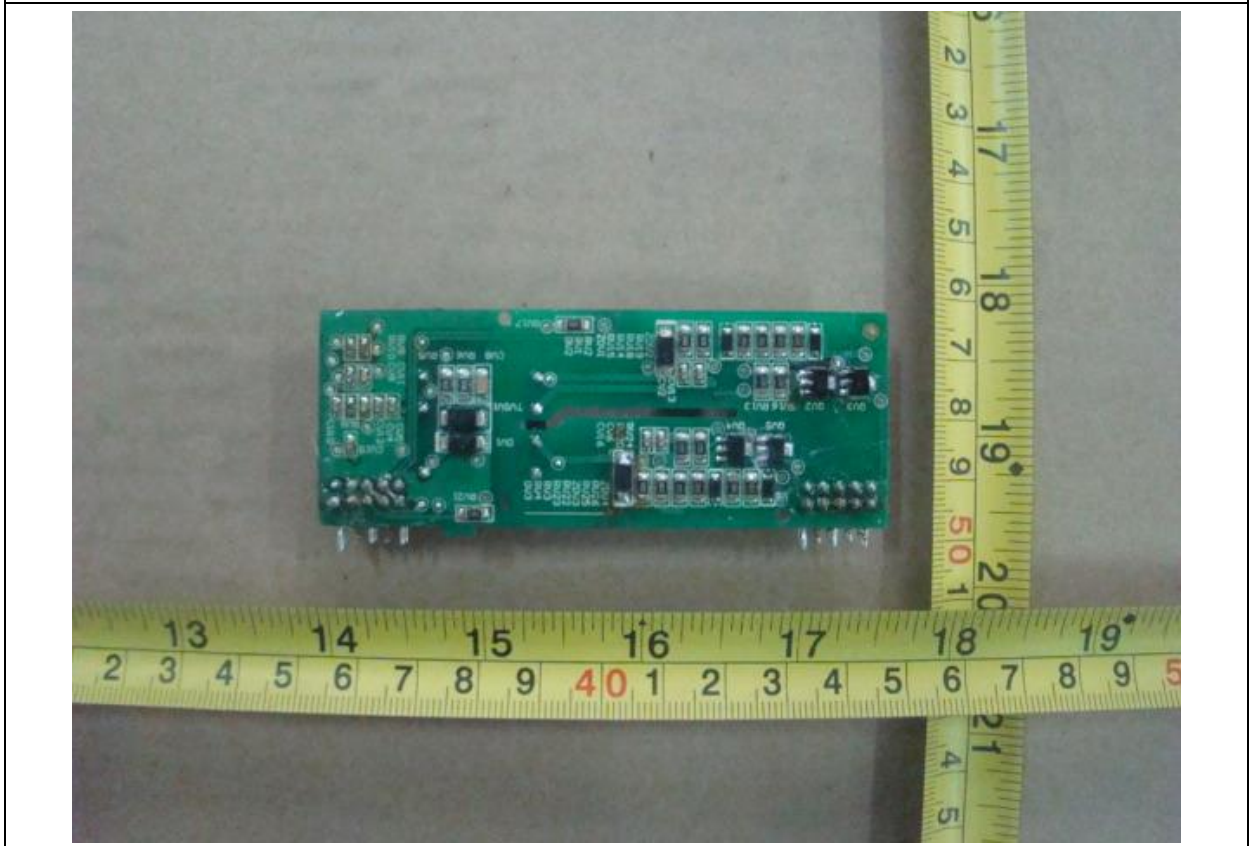
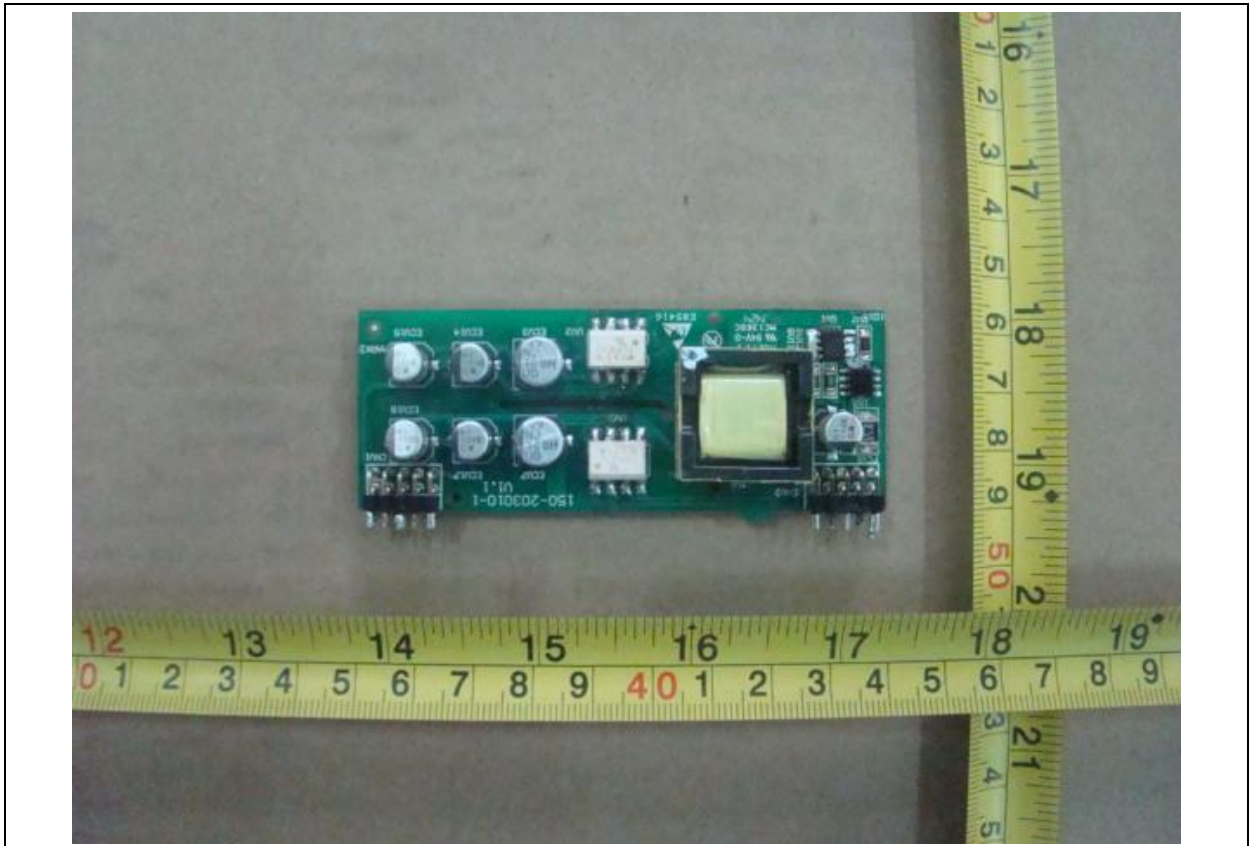
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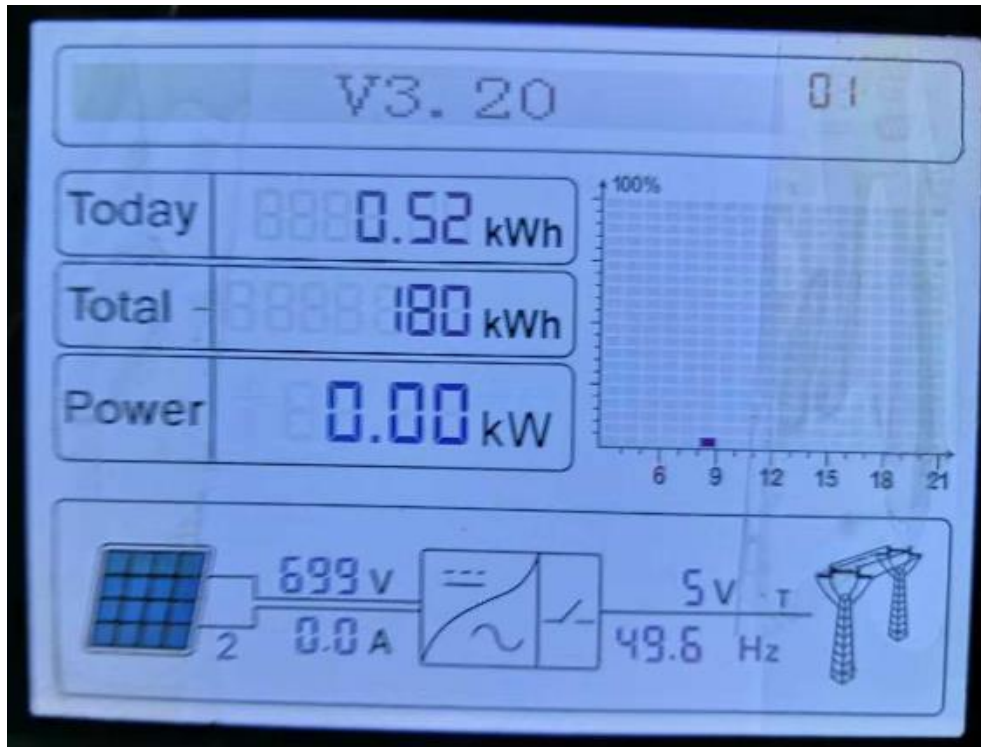


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6 ELECTRICAL SCHEMES

