แบบตรวจสอบและรับรองรายงานผลการทดสอบ
อินเวอร์เตอร์ที่ใช้ในระบบผลิตไฟฟ้าประเภทเชื่อมต่อกับระบบโครงข่ายไฟฟ้าของการไฟฟ้านครหลวง

ส่วนที่ 1 การรับรองรายงานผลการทดสอบอินเวอร์เตอร์

1.1 รายละเอียดของอินเวอร์เตอร์	
ยี่ห้อ	GOODWE
รุ่น	GW30K-MT
Firmware Version	V1.11.11.12
พิกัดทางไฟฟ้า	30 kW, 3/N/PE 400V, 50Hz
1.2 รายละเอียดของรายงานผลการทดสอบ	
หมายเลขรายงานผลการทดสอบ	PVTH2103WDG0205-4
ออกเมื่อวันที่	2021-09-26
ชื่อสถาบันหรือหน่วยงานที่ออกรายงานผลการทดสอบอินเวอร์เตอร์	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
ที่อยู่สถาบันหรือหน่วยงานที่ออกรายงานผลการทดสอบอินเวอร์เตอร์	No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China
1.3 การรับรองรายงานผลการทดสอบ	
ข้าพเจ้าขอรับรองว่าข้อมูลที่กรอกในเอกสารฉบับนี้มีความถูกต้องเป็นจริงและได้ตรวจสอบพบว่าผลการทดสอบอินเวอร์เตอร์ตามรายงานในข้อ 1.2 เป็นไปตามข้อกำหนดสำหรับอินเวอร์เตอร์ที่ใช้ในระบบผลิตไฟฟ้าประเภทเชื่อมต่อกับระบบโครงข่ายไฟฟ้าของการไฟฟ้านครหลวงทุกประการ	
ชื่อหน่วยตรวจสอบและรับรองผลการทดสอบอินเวอร์เตอร์	ศูนย์ทดสอบผลิตภัณฑ์ไฟฟ้าและอิเล็กทรอนิกส์
ที่อยู่หน่วยตรวจสอบและรับรองผลการทดสอบอินเวอร์เตอร์	141 อาคารกลุ่มนวัตกรรม ตึก D อุทยานวิทยาศาสตร์ประเทศไทย ถนนพหลโยธิน ตำบลคลองหนึ่ง อำเภอคลองหลวง จังหวัดปทุมธานี 12120
วันที่ออกเอกสาร	12 ตุลาคม 2564

ตรวจสอบและรับรองข้อมูลโดย	อนุมัติโดย
ลงชื่อ .....เอกชัย.....	ลงชื่อ .....เรืองฤทธิ์ หนิแหนะ.....
(นายเอกชัย เต๊ะสนู)	(นายเรืองฤทธิ์ หนิแหนะ)
ตำแหน่ง..วิศวกร	ตำแหน่ง.ผู้จัดการฝ่ายปฏิบัติการ
	หมายเหตุ: ผู้อนุมัติต้องเป็นหัวหน้าสูงสุดของหน่วยตรวจสอบและรับรองผล การทดสอบ หรือผู้ที่ได้รับมอบหมายให้ปฏิบัติงานแทน

ส่วนที่ 2 รายละเอียดผลการทดสอบอินเวอร์เตอร์

2.1 การทดสอบกระแสฮาร์มอนิก (Harmonic Current)								
Order	33% of output current		66% of output current		100% of output current		Limit (% of output current)	Result confirmation
	measured in Amp*	% of output current*	measured in Amp*	% of output current*	measured in Amp*	% of output current*		
2nd	0.102	0.234	0.143	0.328	0.129	0.297	≤ 1%	☑Pass ☐Fail
3rd	0.061	0.141	0.098	0.225	0.105	0.242	≤ 4%	☑Pass ☐Fail
4th	0.036	0.083	0.063	0.146	0.076	0.174	≤ 1%	☑Pass ☐Fail
5th	0.095	0.219	0.067	0.153	0.103	0.238	≤ 4%	☑Pass ☐Fail
6th	0.032	0.074	0.046	0.106	0.062	0.142	≤ 1%	☑Pass ☐Fail
7th	0.062	0.143	0.085	0.195	0.091	0.210	≤ 4%	☑Pass☐Fail
8th	0.035	0.080	0.046	0.105	0.041	0.095	≤ 1%	☑Pass ☐Fail
9th	0.070	0.161	0.061	0.140	0.072	0.166	≤ 4%	☑Pass ☐Fail
10th	0.028	0.065	0.028	0.065	0.033	0.076	≤ 1%	☑Pass ☐Fail
11th	0.052	0.120	0.039	0.089	0.043	0.099	≤ 2%	☑Pass ☐Fail
12th	0.025	0.057	0.029	0.067	0.031	0.072	≤ 0.5%	☑Pass ☐Fail
13th	0.044	0.102	0.032	0.073	0.036	0.082	≤2%	☑Pass ☐Fail
14th	0.027	0.063	0.028	0.065	0.030	0.069	≤ 0.5%	☑Pass ☐Fail
15th	0.029	0.067	0.035	0.080	0.037	0.086	≤ 2%	☑Pass ☐Fail
16th	0.031	0.072	0.024	0.056	0.025	0.058	≤ 0.5%	☑Pass ☐Fail
17th	0.045	0.104	0.034	0.077	0.040	0.091	≤ 1.5%	☑Pass ☐Fail
18th	0.025	0.057	0.024	0.056	0.026	0.059	≤ 0.375%	☑Pass ☐Fail
19th	0.040	0.092	0.035	0.081	0.035	0.080	≤ 1.5%	☑Pass ☐Fail
20th	0.037	0.085	0.031	0.071	0.032	0.074	≤ 0.375%	☑Pass ☐Fail
21th	0.030	0.070	0.035	0.080	0.038	0.086	≤ 1.5%	☑Pass ☐Fail
22th	0.036	0.083	0.025	0.056	0.028	0.065	≤ 0.375%	☑Pass ☐Fail
23th	0.052	0.120	0.033	0.076	0.032	0.074	≤ 0.6%	☑Pass ☐Fail
24th	0.026	0.060	0.021	0.048	0.024	0.055	≤ 0.15%	☑Pass ☐Fail
25th	0.041	0.094	0.038	0.088	0.041	0.095	≤ 0.6%	☑Pass ☐Fail
26th	0.039	0.090	0.034	0.079	0.035	0.079	≤ 0.15%	☑Pass ☐Fail
27th	0.022	0.050	0.027	0.063	0.029	0.068	≤ 0.6%	☑Pass ☐Fail
28th	0.037	0.085	0.032	0.073	0.031	0.071	≤ 0.15%	☑Pass ☐Fail
29th	0.038	0.088	0.040	0.092	0.048	0.111	≤ 0.6%	☑Pass ☐Fail
30th	0.021	0.048	0.023	0.052	0.026	0.060	≤ 0.15%	☑Pass ☐Fail
31th	0.033	0.076	0.033	0.075	0.046	0.106	≤ 0.6%	☑Pass ☐Fail

Order	33% of output current		66% of output current		100% of output current		Limit (% of output current)	Result confirmation
	measured in Amp*	% of output current*	measured in Amp*	% of output current*	measured in Amp*	% of output current*		
32th	0.030	0.068	0.033	0.077	0.034	0.079	≤ 0.15%	☑Pass ☐Fail
33th	0.017	0.039	0.023	0.053	0.027	0.061	≤ 0.6%	☑Pass ☐Fail
34th	0.029	0.067	0.033	0.077	0.035	0.080	≤ 0.15%	☑Pass ☐Fail
35th	0.020	0.046	0.030	0.070	0.049	0.112	≤ 0.3%	☑Pass ☐Fail
36th	0.013	0.030	0.012	0.027	0.016	0.038	≤ 0.075%	☑Pass ☐Fail
37th	0.014	0.031	0.020	0.045	0.029	0.066	≤ 0.3%	☑Pass ☐Fail
38th	0.024	0.055	0.017	0.040	0.019	0.044	≤ 0.075%	☑Pass ☐Fail
39th	0.011	0.025	0.012	0.028	0.014	0.032	≤ 0.3%	☑Pass ☐Fail
40th	0.021	0.047	0.018	0.041	0.017	0.040	≤ 0.075%	☑Pass ☐Fail
TRDi	--	0.519	--	0.545	--	0.597	≤ 5%	☑Pass ☐Fail

อ้างอิงจากรายงานผลการทดสอบตามข้อ 4.6 หน้า : 16 - 21

หมายเหตุ* กรณีอินเวอร์เตอร์ชนิด3 เฟส ให้ระบุค่าสูงสุดที่ได้จากแต่ละเฟส

2.2 การทดสอบแรงดันกระเพื่อม (Voltage Fluctuation)

	Pst	Plt
Limit	≤ 1.0	≤ 0.65
Test results	0.295	0.289
Result confirmation	☑Pass ☐Fail	☑Pass ☐Fail

อ้างอิงจากรายงานผลการทดสอบตามข้อ 4.3 หน้า : 14

2.3 การทดสอบการจ่ายไฟฟ้ากระแสตรง (Direct Current)

Test level	33% of rated output current	66% of rated output current	100% of rated output current
Limit (% of rated output current)	≤ 0.5%	≤ 0.5%	≤ 0.5%
Test results* (% of rated output current)	0.147	0.198	0.253
Result confirmation	☑Pass ☐Fail	☑Pass ☐Fail	☑Pass ☐Fail

อ้างอิงจากรายงานผลการทดสอบตามข้อ 4.4 หน้า: 15

หมายเหตุ * กรณีอินเวอร์เตอร์ชนิด 3 เฟส ให้ระบุค่าสูงสุดที่ได้จากแต่ละเฟส

2.4 การทดสอบช่วงความถี่ทำงาน (Operating Frequency Range)

	Actual Trip Setting		Test Result	Limit	Result confirmation
	Frequency (Hz)	Trip Time (sec)	Trip Time* (sec)	Time Delay (sec)	
Under frequency	47	0.1	0.074	≤ 0.1	☑Pass ☐Fail
Over frequency	52	0.1	0.076	≤ 0.1	☑Pass ☐Fail

อ้างอิงจากรายงานผลการทดสอบตามข้อ 5.2.2 หน้า: 32-33

หมายเหตุ* ให้ระบุค่าสูงสุดที่ได้จากการทดสอบ

2.5 การทดสอบช่วงแรงดันการทำงาน (Operating Voltage Range)

☑ Grid-connected inverter which connected to the grid at low voltage (230/400V) (1)

	Actual Setting			Result	Limit	Result confirmation
	☑ V_{L-N}setting(2) (V)	☐ V_{L-L}setting(2) (V)	Time Delay (sec)	Time Delay(3) (sec)	Time Delay (sec)	
Undervoltage level 2(4)	☑ 114 or ☐.....	☐ 198 or ☐.....	0.1	0.093	≤ 0.1	☑ Pass ☐ Fail
Undervoltage level 1	199	345	2.0	1.940	≤ 2	☑ Pass ☐ Fail
Overvoltage level 1	241	417	2.0	1.937	≤ 2	☑ Pass ☐ Fail
Overvoltage level 2(4)	☑ 311 or ☐.....	☐ 539 or ☐.....	0.05	0.0495	≤ 0.05	☑ Pass ☐ Fail

☐ Grid-connected inverter which connected to the grid at voltage ≥ 12kV(1)

	Actual Setting		Result	Limit	Result confirmation
	V setting (%of rated output voltage)	Time Delay (sec)	Time Delay(3) (sec)	Time Delay (sec)	
Undervoltage level 2(4)	☐ 50% or ☐.....%			≤ 0.1	☐ Pass ☐ Fail
Undervoltage level 1	85%			≤ 2	☐ Pass ☐ Fail
Overvoltage level 1	110%			≤ 2	☐ Pass ☐ Fail
Overvoltage level 2(4)	☐ 135% or ☐.....%			≤ 0.05	☐ Pass ☐ Fail

อ้างอิงจากรายงานผลการทดสอบตามข้อ 5.2.1 หน้า: 23-28

Note(1) Select MEA's voltage level where grid-connected inverter connected to.
(2) Select between line-neutral or line-line voltage test based on the actual operation of inverter.
(3) Insert maximum value recorded during test.
(4) If inverter cannot be adjusted for overvoltage and/or undervoltage trip setting as per MEA's grid-connected Inverter regulation, it shall be adjusted the overvoltage or undervoltage trip setting to the maximum and/or minimum voltage that inverter can be set.

2.6 การทดสอบการป้องกันสภาวะไอส์แลนดิ่ง (Islanding Protection)

Item	Test Condition C			Test Condition B			Test Condition A		
	P_{AC} (% of nominal)	Q_{AC} (% of nominal)	Run on Time (sec) (Limit ≤ 2 sec)	P_{AC} (% of nominal)	Q_{AC} (% of nominal)	Run on Time (sec) (Limit ≤ 2 sec)	P_{AC} (% of nominal)	Q_{AC} (% of nominal)	Run on Time (sec) (Limit ≤ 2 sec)
1	0	0	0.132	0	0	0.110	0	0	**0.126**
2	0	-5	0.114	0	-5	0.097	-10	-10	--
3	0	-4	0.129	0	-4	0.098	-10	-5	--
4	0	-3	0.112	0	-3	0.112	-10	0	--
5	0	-2	0.150	0	-2	0.108	-10	+5	--
6	0	-1	**0.233**	0	-1	**0.116**	-10	+10	--
7	0	1	0.094	0	1	0.103	-5	-10	--
8	0	2	0.092	0	2	0.091	-5	-5	0.095
9	0	3	0.085	0	3	0.083	-5	0	0.102
10	0	4	0.082	0	4	0.084	-5	+5	0.085
11	0	5	0.069	0	5	0.082	-5	+10	--
12							0	-10	--
13							0	-5	0.093
14							0	+5	0.070
15							0	+10	--
16							+5	-10	--
17							+5	-5	0.121
18							+5	0	0.108
19							+5	+5	0.071
20							+5	+10	--
21							+10	-10	--
22							+10	-5	--
23							+10	0	--
24							+10	+5	--
25							+10	+10	--
Result confirmation	☑Pass ☐Fail			☑Pass ☐Fail			☑Pass ☐Fail		

อ้างอิงจากรายงานผลการทดสอบตามข้อ 6.1 หน้า : 35 – 41

2.7 การทดสอบการเชื่อมต่อหลังไฟฟ้ากลับคืน (Power Recovery Response)					
	Actual Setting (sec)	Test Result (sec) (Limit ≥120)	Compliance with clause 5.10.2(c) of IEEE std1547.1-2005(1)	Compliance with clause 5.10.2(g) of IEEE std1547.1-2005(2)	Result confirmation
Underfrequency	120	134.7	☐Yes ☐No	☑Yes ☐No	☑Pass ☐Fail
Over frequency	120	134.8	☐Yes ☐No	☑Yes ☐No	☑Pass ☐Fail
Undervoltage level 2	120	134.8	☐Yes ☐No	☑Yes ☐No	☑Pas s☐Fail
Undervoltage level 1	120	134.8	☐Yes ☐No	☑Yes ☐No	☑Pass ☐Fail
Overvoltage level 1	120	134.7	☐Yes ☐No	☑Yes ☐No	☑Pass ☐Fail
Overvoltage level 2	120	134.9	☐Yes ☐No	☑Yes ☐No	☑Pass ☐Fail
อ้างอิงจากรายงานผลการทดสอบตามข้อ 5.10 หน้า: 29-32, 34					

Note (1) Adjust the voltage so that it is beyond the reconnect voltage by twice the manufacturer's stated tolerance. The simulated area EPS voltage source shall maintain the abnormal voltage for two times the reconnect time delay. Verify that the EUT does not reenergize the simulated area EPS.

(2)To verify that the timer resets for additional voltage excursions within the reconnect time, retest with an abnormal voltage step-change event that is introduced during the reconnect countdown period. While the unit is counting down to reconnect, step the voltage to a value 5% outside of the manufacturer's specified normal operating voltage for the trip time setting plus twice the manufacturer's stated timer accuracy, and then return to the normal operating voltage. The unit shall restart its reconnect timer and not reconnect until the grid voltage has been within the specified range for the specified reconnect time.

2.8 การตรวจสอบสถาบันหรือหน่วยงานที่ออกรายงานผลการทดสอบอินเวอร์เตอร์	
รายละเอียด	Result confirmation
☐ อินเวอร์เตอร์ผ่านการทดสอบจากสถาบันหรือหน่วยงานทดสอบที่เป็นกลางภายในประเทศ.ซึ่งได้รับการรับรองห้องปฏิบัติการทดสอบตามมาตรฐานมอก. 17025 (สำหรับอินเวอร์เตอร์) จากสำนักงานคณะกรรมการแห่งชาติว่าด้วยการรับรองระบบงาน.หรือได้รับการตรวจสอบและยอมรับจากการไฟฟ้านครหลวง.	☑ Pass ☐Fail
☑ อินเวอร์เตอร์ผ่านการทดสอบจากสถาบันหรือหน่วยงานทดสอบที่เป็นกลางในต่างประเทศ.ซึ่งได้รับการรับรองห้องปฏิบัติการทดสอบตามมาตรฐาน ISO/IEC 17025 (สำหรับอินเวอร์เตอร์) จากหน่วยงานระดับชาติที่มีหน้าที่เทียบเคียงกันกับ.สำนักงานคณะกรรมการแห่งชาติว่าด้วยการรับรองระบบงาน.และอยู่ในทะเบียนขององค์กรความร่วมมือระหว่างประเทศว่าด้วยการรับรองห้องปฏิบัติการ (International Laboratory Accreditation Cooperation, ILAC)	

TEST REPORT

IEC 61727 / IEC 62116

Photovoltaic (PV) systems
Characteristics of the utility interface
Test procedure of islanding prevention measures for utility-interconnected photovoltaic inverters

Report reference number ..... :	**PVTH2103WDG0205-4**
Date of issue ..... ::	2021-09-26
Total number of pages ..... ::	56
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 A2LA ACCREDITED Certificate # 2951.01
Applicant's name..... :	**JIANGSU GOODWE POWER SUPPLY TECHNOLOGY CO.,LTD.**
Address ..... :	No.90 ZiJin Rd., New District, Suzhou,215011,China
Test specification	
Standard..... :	IEC 61727:2004, EN 61727:1995, DIN EN 61727:1996 IEC 62116:2008, EN 62116:2011, DIN EN 62116:2012 Deviations for Thailand according the grid-connected inverter regulations of the Metropolitan Electricity Authority (MEA 2015)
Test Report Form No. ..... :	IEC61727/IEC62116_MEA VER.2
TRF Originator ..... :	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF ..... :	Dated 2020-03-20
Test item description ..... :	**Grid-Tied PV Inverter**
Trademark ..... :	GOODWE your solar engine
Model / Type ..... :	GW30K-MT

Ratings .....:	GW30K-MT
MPP DC voltage range [V] .....:	200-950Vd.c.
Input DC voltage [V] .....:	Max 1100Vd.c.
Input DC current [A] .....:	30A / 30A / 30A
Output AC voltage [V] .....:	3/N/PE~400 or 3/PE~400, 50Hz
Output AC current [A].....:	Max. 48A
Nominal Output power [kW] .....:	30,0
Maximum Output power [kVA] .....:	33,0

Testing Location ..... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
Address ..... :	No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China
Tested by (name and signature) ..... :	Colin Chen 
Approved by (name and signature) ..... :	Ken Chan 
Manufacturer's name ..... :	**JIANGSU GOODWE POWER SUPPLY TECHNOLOGY CO.,LTD.**
Manufacturer address ..... :	No.90 ZiJin Rd., New District, Suzhou,215011,China
Factory's name 1 ..... :	**JIANGSU GOODWE POWER SUPPLY TECHNOLOGY CO.,LTD.**
Factory address ..... :	No.90 ZiJin Rd., New District, Suzhou,215011,China
Factory's name 2 ..... :	**GoodWe(GuangDe) Power Supply Technology Co.,Ltd.**
Factory address: :	NO.208, TongRui East Road,Guangde, Anhui, ,China

Document History			
Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2021-09-26	Colin Chen	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. 55,0kg

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 ..... :	2021-07-28
Date(s) of performance of test ..... :	2021-07-28 to 2021-08-25

General remarks:

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

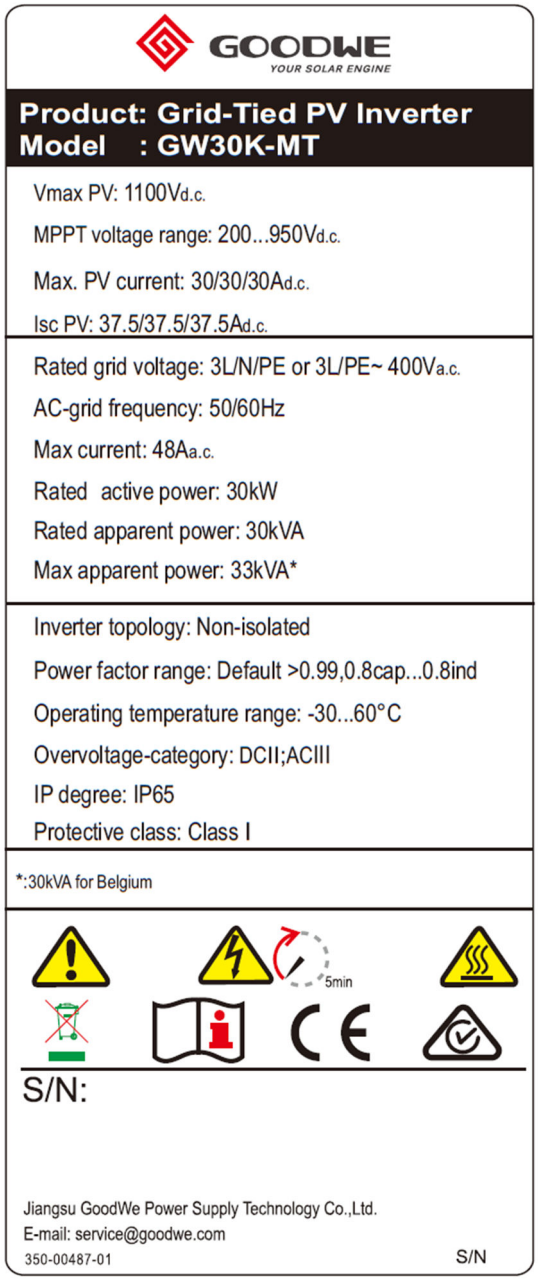
”(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

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

This Test Report consists of the following documents:

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

Copy of marking plate:



General product information:

input of Solar converter can be supplied from PV array.
The Solar converter converts DC voltage into AC voltage.
The DC
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.

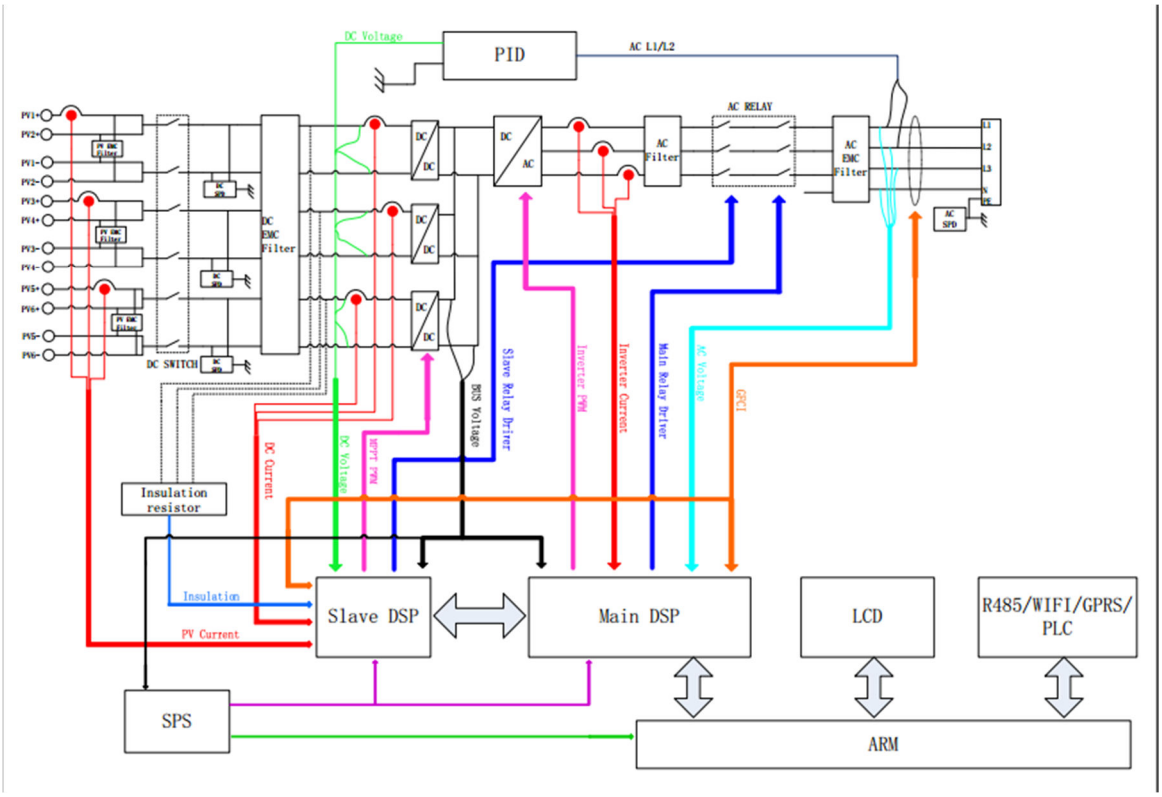


Figure 1 – Block diagram

Description of the electrical circuit: (Figure 1):
The internal control is redundant built. It consists of Microcontroller DSP (U401) and MCU (U503).

The DSP (U401) control the relays by switching signals; measures the PV voltage, PV current, Bus voltage, grid voltage, frequency, AC current with injected DC and the array insulation resistance to ground. In addition it tests the current sensors and the RCMU circuit before each start up.

The MCU (U503) is measures the grid voltage, grid frequency, DCI and residual current, also can switch off the relays independently, and communicate with the DSP (U401) each other.

The current is measured by a current sensor. The AC current signal and the injected DC current signal are sent to the DSP (U401). The DSP (U401) 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.

The product was tested on:

Hardware: 290-10280
Software: V1.11.11.12

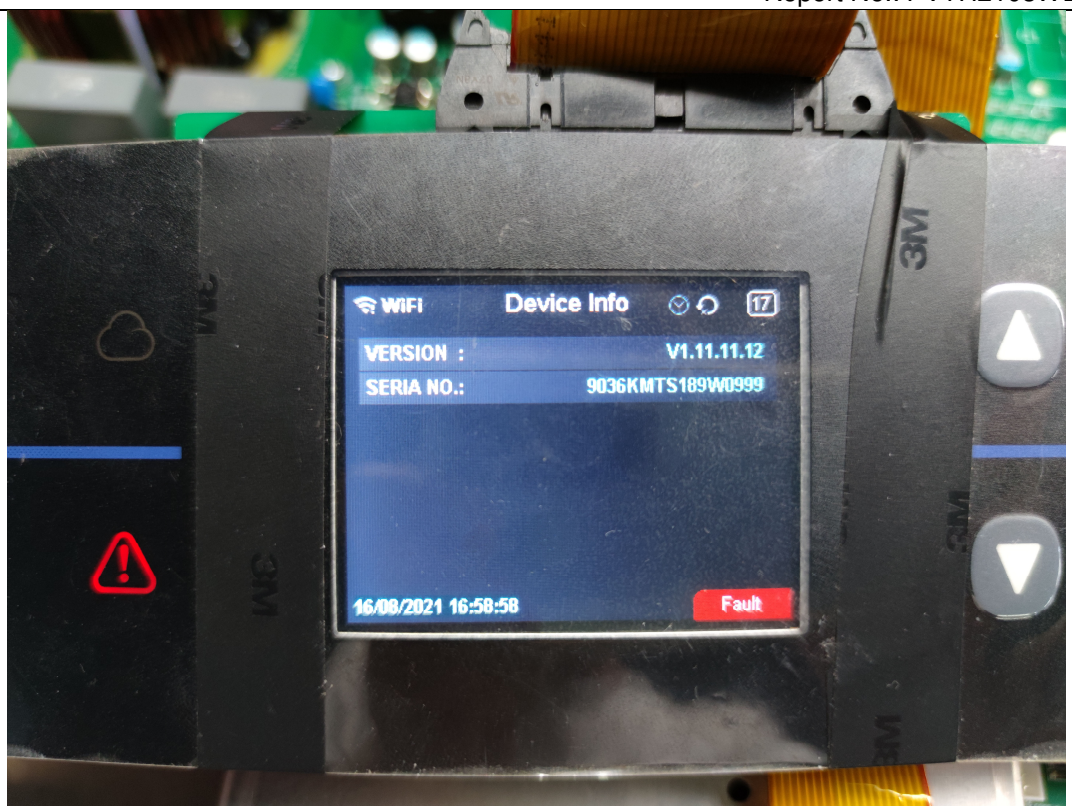


Figure 2 – Photo of software version

Interface protection settings with deviations according the grid-connected inverter regulations of the Metropolitan Electricity Authority (MEA:2015) **For gird-connected inverter which connected to the grid at low voltage(230/400)** **(Thailand MEA)**		
Parameter	**Max. clearance time***	**Trip setting(Line to Neutral)**
Over voltage (level 2)	0,05s	311V
Over voltage (level 1)	2,0s	241V
Under voltage (level 1)	2,0s	199V
Under voltage (level 2)	0,1s	114V
Over frequency	0,1s	52,0Hz
Under frequency	0,1s	47,0Hz
Reconnection time	at least 120s	
Permanent DC-injection	0,5% of rated inverter output current	
Loss of main IEC 62116:2008	Inverter shall detect and disconnect within 2,0s	
* Trip time refers to the time between the abnormal condition occurring and the inverter ceasing to energize the utility line. The PV system control circuits shall actually remain connected to the utility to allow sensing of utility electrical conditions for use by the “reconnect” feature.		

Interface protection settings with deviations according the grid-connected inverter regulations of the Metropolitan Electricity Authority (MEA:2015) **For gird-connected inverter which connected to the grid at voltage ≥ 12kV** **(Thailand MEA)**		
Parameter	**Max. clearance time***	**Trip setting(Line to Neutral)**
Over voltage (level 2)	0,05s	≥135%Un (310,5V)
Over voltage (level 1)	2,0s	>110%Un(254V)
Under voltage (level 1)	2,0s	<85%Un(195V)
Under voltage (level 2)	0,1s	<50%Un(114V)
Over frequency	0,1s	52,0Hz
Under frequency	0,1s	47,0Hz
Reconnection time	at least 120s	
Permanent DC-injection	0,5% of rated inverter output current	
Loss of main IEC 62116:2008	Inverter shall detect and disconnect within 2,0s	
* Trip time refers to the time between the abnormal condition occurring and the inverter ceasing to energize the utility line. The PV system control circuits shall actually remain connected to the utility to allow sensing of utility electrical conditions for use by the “reconnect” feature.		

IEC61727:2004			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4: Utility compatibility			
4	**General** The quality of power provided by the PV system for the on-site AC loads and for power delivered to the utility is governed by practices and standards on voltage, flicker, frequency, harmonics and power factor. Deviation from these standards represents out-of-bounds conditions and may require the PV system to sense the deviation and properly disconnect from the utility system. All power quality parameters (voltage, flicker, frequency, harmonics, and power factor) must be measured at the utility interface/ point of common coupling unless otherwise specified.	Noticed.	**P**
4.1	**Voltage, current and frequency** The PV system AC voltage, current and frequency shall be compatible with the utility system.	Derived from tests	**P**
4.2	**Normal voltage operating range** Utility-interconnected PV systems do not normally regulate voltage; they inject current into the utility. Therefore, the voltage operating range for PV inverters is selected as a protection function that responds to abnormal utility conditions, not as a voltage regulation function.	Derived from tests	**P**
4.3	**Flicker** The operation of the PV system should not cause voltage flicker in excess of limits stated in the relevant sections of IEC 61000-3-3 for systems less than 16 A or IEC 61000-3-5 for systems with current of 16 A and above.	See table 4.3	**P**
4.4	**DC injection** The PV system shall not inject DC current greater than 1 % of the rated inverter output current, into the utility AC interface under any operating condition.	The following deviations were used: Metropolitan Electricity Authority (MEA 2015) See table 4.4	**P**
4.5	**Normal frequency operating range** The PV system shall operate in synchronism with the utility system, and within the frequency trip limits defined in 5.2.2.	The following deviations were used: Metropolitan Electricity Authority (MEA 2015) See table 4.5 and 5.2.2	**P**

IEC61727:2004			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4: Utility compatibility			
4.6	**Harmonics and waveform distortion** Low levels of current and voltage harmonics are desirable; the higher harmonic levels increase the potential for adverse effects on connected equipment. Acceptable levels of harmonic voltage and current depend upon distribution system characteristics, type of service, connected loads/apparatus, and established utility practice. The PV system output should have low current-distortion levels to ensure that no adverse effects are caused to other equipment connected to the utility system. Total harmonic current distortion shall be less than 5 % at rated inverter output. Each individual harmonic shall be limited to the percentages listed in Table 1. Even harmonics in these ranges shall be less than 25 % of the lower odd harmonic limits listed. (see Clause 4.6 Table 1 – Current distortion limits)	The following deviations were used: Metropolitan Electricity Authority (MEA 2015) See tables 4.6 (1) and 4.6 (2)	**P**
4.7	**Power factor** The PV system shall have a lagging power factor greater than 0,9 when the output is greater than 50 % of the rated inverter output power.	See table 4.7	**P**

IEC61727:2004			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 5: Personnel safety and equipment protection			
5	**General** This Clause provides information and considerations for the safe and proper operation of the utility-connected PV systems.	Noticed	**P**
5.1	**Loss of utility voltage** To prevent islanding, a utility connected PV system shall cease to energize the utility system from a de-energized distribution line irrespective of connected loads or other generators within specified time limits. A utility distribution line can become de-energized for several reasons. For example, a substation breaker opening due to fault conditions or the distribution line switched out during maintenance. If inverters (single or multiple) have DC SELV input and have accumulated power below 1 kW then no mechanical disconnect (relay) is required.	The following deviations were used: Metropolitan Electricity Authority (MEA 2015) See table 5.3	**P**
5.2	**Over/under voltage and frequency** Abnormal conditions can arise on the utility system that requires a response from the connected photovoltaic system. This response is to ensure the safety of utility maintenance personnel and the general public, as well as to avoid damage to connected equipment, including the photovoltaic system. The abnormal utility conditions of concern are voltage and frequency excursions above or below the values stated in this Clause, and the complete disconnection of the utility, presenting the potential for a distributed resource island.	The following deviations were used: Metropolitan Electricity Authority (MEA 2015) See table 5.2.1 and 5.2.2	**P**
5.2.1	**Over/under voltage** When the interface voltage deviates outside the conditions specified in Table 2, the photovoltaic system shall cease to energize the utility distribution system. This applies to any phase of a multiphase system. All discussions regarding system voltage refer to the local nominal voltage. The system shall sense abnormal voltage and respond. The following conditions should be met, with voltages in RMS and measured at the point of utility connection. (see clause 5.2.1 Table 2 – Response to abnormal voltages) The purpose of the allowed time delay is to ride through short-term disturbances to avoid excessive nuisance tripping. The unit does not have to cease to energize if the voltage returns to the normal utility continuous operation condition within the specified trip time.	The following deviations were used: Metropolitan Electricity Authority (MEA 2015) See table 5.2.1	**P**
5.2.2	**Over/under frequency** When the utility frequency deviates outside the specified conditions the photovoltaic system shall cease to energize the utility line. The unit does not have to cease to energize if the frequency returns to the normal utility continuous operation condition within the specified trip time. When the utility frequency is outside the range of ±1 Hz, the system shall cease to energize the utility line within 0,2 s. The purpose of the allowed range and time delay is to allow continued operation for short-term disturbances and to avoid excessive nuisance tripping in weak-utility system conditions.	The following deviations were used: Metropolitan Electricity Authority (MEA 2015) See table 5.2.2	**P**

IEC61727:2004			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 5: Personnel safety and equipment protection			
5.3	**Islanding protection** The PV system must cease to energize the utility line within 2 s of loss of utility.	The following deviations were used: Metropolitan Electricity Authority (MEA 2015) See table 5.3(1) and 5.3(2)	**P**
5.4	**Response to utility recovery** Following an out-of-range utility condition that has caused the photovoltaic system to cease energizing, the photovoltaic system shall not energize the utility line for 20 s to 5 min after the utility service voltage and frequency have recovered to within the specified ranges**.**	See table 5.2.1 and 5.2.2	**P**
5.5	**Earthing** The utility interface equipment shall be earthed/grounded in accordance with IEC 60364-7-712.	Stated in the manual.	**P**
5.6	**Short circuit protection** The photovoltaic system shall have short-circuit protection in accordance with IEC 60364-7-712.	Stated in the manual.	**P**
5.7	**Isolation and switching** A method of isolation and switching shall be provided in accordance with IEC 60364-7-712.	Stated in the manual.	**P**

Test overview:

IEC 61727:2004		
Clause	**Test**	**Result**
4	Type test:	
4.3	Voltage Fluctuations and Flicker	**P**
4.4	Monitoring of DC-Injection	**P**
4.5	Normal frequency operating range (see 5.2.2 below)	**P**
4.6	Harmonics and waveform distortion	**P**
4.7	Power factor	**P**
5.2.1	Voltage monitoring	**P**
5.2.2	Frequency monitoring	**P**

IEC 62116:2008		
Clause	**Test**	**Result**
	Type test:	
6.1	Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%)	**P**
6.1	Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %)	**P**
6.1	Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %)	**P**

Test Results

4.3 Voltage fluctuation and flicker **3.1.2, 4.3.2 Voltage fluctuation and flicker (MEA:2015)**					**P**
Test conditions:	Maximum permissible voltage fluctuation (expressed as a percentage of nominal voltage at 100 % power) and flicker as per EN 61000-3-11				
	Starting		**Stopping**	**Running**	
Limit	3,3%		3,3%	P_{st}=1,0	P_{lt}=0,65
Test value	*		*	*	*
inverter < 16A					
Limit		dc% = 3,3	P_{st}=1,0		P_{lt}=0,65
Test value	**L1**	--	0,153		0,148
	L2	--	0,295		0,289
	L3	--	0,136		0,130

Note:
*The stationary deviance of dc% is more relevant than the dynamic deviance of d_{max} at starting and stopping.

Mains Impedance according EN61000-3-11: **R_{max} = 0,24Ω; jX_{max}= 0,15Ω @50Hz (|Z_{max}| = 0,283 Ω)**
for single phase inverter use also **R_n = 0,1Ω; jX_n= 0,1Ω**

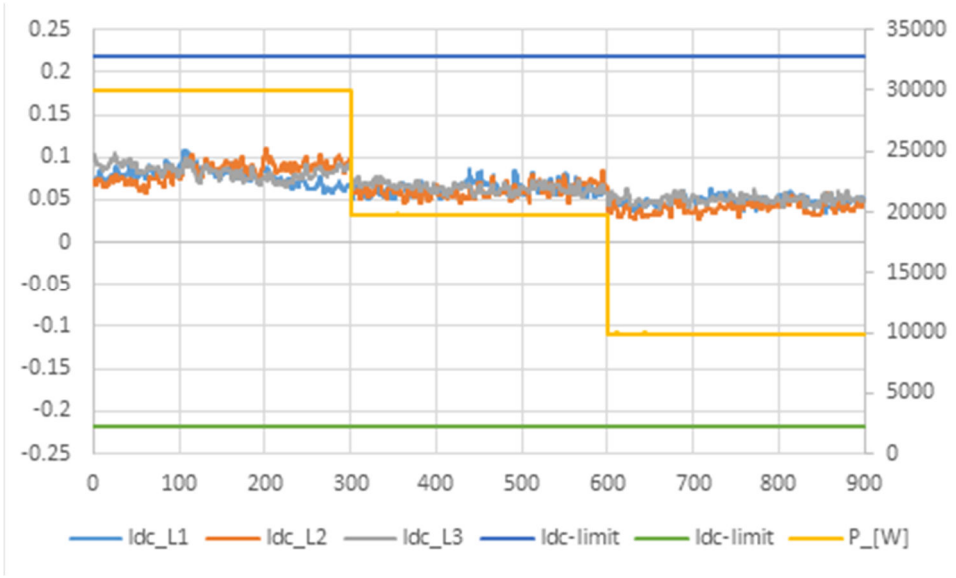
Calculation of the maximum permissible grid impedance at the point of common coupling based on d_c:
$Z_{max} = Z_{ref} * 3,3\% / d_c(P_n)$

The tests should be based on the limits of the EN 61000-3-11 for more than 16A.

4.4 Monitoring of Permanent DC-Injection 3.1.3, 4.3.3 Direct Current Injection (MEA 2015)	**P**

MEA Limit:	**0,5% of I_{nom} : = 217,4 mA**		
Output power:	33%	66%	100%
Max. test value (mA): L1 phase	61,9	86,2	108,8
Average test value (mA): L1 phase	48,2	63,7	78,8
Max. test value (mA): L2 phase	58,2	83,5	110,0
Average test value (mA): L1 phase	40,5	61,3	83,7
Max. test value (mA): L3 phase	63,9	76,9	104,2
Average test value (mA): L3 phase	50,6	64,5	83,3

Diagram



Note:

4.6 Harmonic Current Limit Test 3.1.1, 4.3.1 Harmonic Current Limit Test (MEA 2015)	P

33% Output Power			
Watts (kW)	3,279	3,312	3,321
VA (kVA)	3,285	3,321	3,324
Vrms (V)	230,2	230,5	230,1
Arms (A)	14,271	14,408	14,446
PF	0,998	0,998	0,999
Frequency (Hz)	50,00		
THD40 (%)	0,422	0,480	0,519

Harmonics	Current Magnitude [A]			% of Rated Current			Phase	Harmonic Current Limits [%]
1st	14,268	14,397	14,433	32,816	33,114	33,195	Three Phase	--
2nd	0,057	0,102	0,088	0,131	0,234	0,202	Three Phase	1
3rd	0,040	0,053	0,061	0,092	0,122	0,141	Three Phase	4
4th	0,020	0,033	0,036	0,046	0,076	0,083	Three Phase	1
5th	0,063	0,095	0,043	0,146	0,219	0,099	Three Phase	4
6th	0,027	0,016	0,032	0,063	0,036	0,074	Three Phase	1
7th	0,058	0,016	0,062	0,134	0,037	0,143	Three Phase	4
8th	0,014	0,028	0,035	0,033	0,063	0,080	Three Phase	1
9th	0,059	0,015	0,070	0,137	0,035	0,161	Three Phase	4
10th	0,017	0,023	0,028	0,039	0,052	0,065	Three Phase	1
11th	0,016	0,052	0,043	0,037	0,120	0,100	Three Phase	2
12th	0,023	0,011	0,025	0,053	0,025	0,057	Three Phase	0,5
13th	0,028	0,019	0,044	0,065	0,044	0,102	Three Phase	2
14th	0,021	0,012	0,027	0,048	0,028	0,063	Three Phase	0,5
15th	0,021	0,013	0,029	0,049	0,030	0,067	Three Phase	2
16th	0,021	0,031	0,018	0,048	0,072	0,040	Three Phase	0,5
17th	0,017	0,038	0,045	0,039	0,088	0,104	Three Phase	1,5
18th	0,022	0,010	0,025	0,051	0,024	0,057	Three Phase	0,375
19th	0,016	0,033	0,040	0,037	0,076	0,092	Three Phase	1,5
20th	0,037	0,019	0,030	0,085	0,043	0,068	Three Phase	0,375
21th	0,023	0,012	0,030	0,053	0,028	0,070	Three Phase	1,5
22th	0,032	0,036	0,016	0,075	0,083	0,038	Three Phase	0,375
23th	0,031	0,031	0,052	0,071	0,071	0,120	Three Phase	0,6
24th	0,022	0,010	0,026	0,051	0,024	0,060	Three Phase	0,15
25th	0,021	0,041	0,040	0,048	0,094	0,092	Three Phase	0,6
26th	0,039	0,029	0,025	0,090	0,066	0,058	Three Phase	0,15
27th	0,016	0,009	0,022	0,038	0,021	0,050	Three Phase	0,6
28th	0,037	0,036	0,018	0,085	0,083	0,041	Three Phase	0,15
29th	0,026	0,019	0,038	0,060	0,044	0,088	Three Phase	0,6
30th	0,016	0,012	0,021	0,036	0,028	0,048	Three Phase	0,15
31th	0,017	0,033	0,028	0,040	0,076	0,063	Three Phase	0,6
32th	0,029	0,030	0,019	0,068	0,068	0,045	Three Phase	0,15
33th	0,013	0,008	0,017	0,031	0,017	0,039	Three Phase	0,6
34th	0,029	0,022	0,018	0,067	0,052	0,041	Three Phase	0,15
35th	0,016	0,010	0,020	0,036	0,022	0,046	Three Phase	0,3
36th	0,009	0,010	0,013	0,021	0,023	0,030	Three Phase	0,075
37th	0,007	0,012	0,014	0,017	0,029	0,031	Three Phase	0,3
38th	0,016	0,024	0,021	0,038	0,055	0,048	Three Phase	0,075
39th	0,008	0,007	0,011	0,019	0,016	0,025	Three Phase	0,3
40th	0,021	0,017	0,020	0,047	0,039	0,046	Three Phase	0,075
41th	0,009	0,011	0,011	0,021	0,026	0,025	Three Phase	N/A

4.6 Harmonic Current Limit Test **3.1.1, 4.3.1 Harmonic Current Limit Test (MEA 2015)**								**P**
42th	0,007	0,009	0,010	0,016	0,020	0,022	Three Phase	N/A
43th	0,019	0,017	0,019	0,044	0,040	0,044	Three Phase	N/A
44th	0,013	0,017	0,022	0,029	0,039	0,051	Three Phase	N/A
45th	0,009	0,008	0,011	0,020	0,019	0,025	Three Phase	N/A
46th	0,016	0,018	0,020	0,036	0,041	0,045	Three Phase	N/A
47th	0,026	0,024	0,025	0,060	0,055	0,057	Three Phase	N/A
48th	0,008	0,009	0,010	0,019	0,021	0,024	Three Phase	N/A
49th	0,025	0,023	0,025	0,057	0,054	0,058	Three Phase	N/A
50th	0,014	0,013	0,021	0,031	0,029	0,048	Three Phase	N/A

4.6 Harmonic Current Limit Test 3.1.1, 4.3.1 Harmonic Current Limit Test (MEA 2015)	P

66% Output Power			
Watts (kW)	6.647	6.686	6.700
VA (kVA)	6.649	6.689	6.700
Vrms (V)	230.66	230.59	230.53
Arms (A)	28.826	29.007	29.066
PF	1.000	1.000	1.000
Frequency (Hz)	50,00		
THD40 (%)	0,241	0,483	0,545

Harmonics	Current Magnitude [A]			% of Rated Current			Phase	Harmonic Current Limits [%]
1st	28,826	29,008	29,065	66,299	66,719	66,850	Three Phase	--
2nd	0,083	0,143	0,092	0,191	0,328	0,212	Three Phase	1
3rd	0,056	0,086	0,098	0,128	0,197	0,225	Three Phase	4
4th	0,042	0,037	0,063	0,096	0,084	0,146	Three Phase	1
5th	0,035	0,067	0,046	0,080	0,153	0,105	Three Phase	4
6th	0,038	0,026	0,046	0,087	0,060	0,106	Three Phase	1
7th	0,085	0,039	0,067	0,195	0,091	0,154	Three Phase	4
8th	0,023	0,038	0,046	0,053	0,088	0,105	Three Phase	1
9th	0,056	0,024	0,061	0,130	0,054	0,140	Three Phase	4
10th	0,022	0,025	0,028	0,051	0,057	0,065	Three Phase	1
11th	0,033	0,039	0,031	0,077	0,089	0,072	Three Phase	2
12th	0,023	0,024	0,029	0,052	0,055	0,067	Three Phase	0,5
13th	0,028	0,029	0,032	0,064	0,066	0,073	Three Phase	2
14th	0,022	0,023	0,028	0,050	0,054	0,065	Three Phase	0,5
15th	0,027	0,022	0,035	0,062	0,051	0,080	Three Phase	2
16th	0,020	0,022	0,024	0,047	0,050	0,056	Three Phase	0,5
17th	0,034	0,028	0,021	0,077	0,065	0,048	Three Phase	1,5
18th	0,022	0,019	0,024	0,051	0,045	0,056	Three Phase	0,375
19th	0,035	0,024	0,025	0,081	0,055	0,057	Three Phase	1,5
20th	0,023	0,021	0,031	0,054	0,048	0,071	Three Phase	0,375
21th	0,027	0,022	0,035	0,063	0,051	0,080	Three Phase	1,5
22th	0,018	0,025	0,024	0,040	0,056	0,056	Three Phase	0,375
23th	0,024	0,033	0,021	0,055	0,076	0,047	Three Phase	0,6
24th	0,018	0,018	0,021	0,042	0,042	0,048	Three Phase	0,15
25th	0,038	0,023	0,025	0,088	0,053	0,058	Three Phase	0,6
26th	0,025	0,023	0,034	0,058	0,053	0,079	Three Phase	0,15
27th	0,018	0,021	0,027	0,042	0,047	0,063	Three Phase	0,6
28th	0,023	0,032	0,030	0,053	0,073	0,069	Three Phase	0,15
29th	0,030	0,040	0,030	0,069	0,092	0,069	Three Phase	0,6
30th	0,020	0,020	0,023	0,045	0,045	0,052	Three Phase	0,15
31th	0,033	0,025	0,030	0,075	0,057	0,068	Three Phase	0,6
32th	0,031	0,022	0,033	0,071	0,051	0,077	Three Phase	0,15
33th	0,019	0,019	0,023	0,044	0,043	0,053	Three Phase	0,6
34th	0,026	0,033	0,029	0,060	0,077	0,067	Three Phase	0,15
35th	0,022	0,030	0,025	0,050	0,070	0,059	Three Phase	0,3
36th	0,011	0,008	0,012	0,026	0,019	0,027	Three Phase	0,075
37th	0,020	0,015	0,018	0,045	0,035	0,042	Three Phase	0,3
38th	0,017	0,012	0,016	0,040	0,027	0,037	Three Phase	0,075
39th	0,012	0,010	0,012	0,028	0,024	0,028	Three Phase	0,3
40th	0,014	0,018	0,014	0,032	0,041	0,032	Three Phase	0,075
41th	0,011	0,018	0,018	0,026	0,043	0,041	Three Phase	N/A

4.6 Harmonic Current Limit Test 3.1.1, 4.3.1 Harmonic Current Limit Test (MEA 2015)								P
42th	0,009	0,009	0,010	0,021	0,020	0,023	Three Phase	N/A
43th	0,010	0,008	0,010	0,023	0,018	0,023	Three Phase	N/A
44th	0,014	0,010	0,012	0,031	0,023	0,027	Three Phase	N/A
45th	0,008	0,007	0,009	0,018	0,017	0,020	Three Phase	N/A
46th	0,014	0,016	0,013	0,032	0,037	0,029	Three Phase	N/A
47th	0,008	0,009	0,008	0,019	0,020	0,018	Three Phase	N/A
48th	0,008	0,008	0,007	0,019	0,018	0,017	Three Phase	N/A
49th	0,025	0,022	0,020	0,057	0,050	0,045	Three Phase	N/A
50th	0,012	0,013	0,012	0,027	0,030	0,027	Three Phase	N/A

4.6 Harmonic Current Limit Test 3.1.1, 4.3.1 Harmonic Current Limit Test (MEA 2015)	P

100% Output Power			
Watts (kW)	9,964	10,010	10,025
VA (kVA)	9,966	10,013	10,026
Vrms (V)	231,00	230,93	230,78
Arms (A)	43,143	43,358	43,442
PF	1,000	1,000	1,000
Frequency (Hz)	50,00		
THD40 (%)	0,268	0,523	0,597

Harmonics	Current Magnitude [A]			% of Rated Current			Phase	Harmonic Current Limits [%]
1st	43,144	43,356	43,442	99,232	99,719	99,916	Three Phase	--
2nd	0,065	0,129	0,081	0,149	0,297	0,187	Three Phase	1
3rd	0,064	0,090	0,105	0,147	0,206	0,242	Three Phase	4
4th	0,056	0,038	0,076	0,129	0,088	0,174	Three Phase	1
5th	0,033	0,103	0,075	0,076	0,238	0,173	Three Phase	4
6th	0,046	0,034	0,062	0,105	0,077	0,142	Three Phase	1
7th	0,091	0,035	0,078	0,210	0,080	0,180	Three Phase	4
8th	0,023	0,034	0,041	0,053	0,079	0,095	Three Phase	1
9th	0,062	0,026	0,072	0,143	0,060	0,166	Three Phase	4
10th	0,024	0,029	0,033	0,055	0,067	0,076	Three Phase	1
11th	0,029	0,043	0,039	0,068	0,099	0,089	Three Phase	2
12th	0,022	0,026	0,031	0,051	0,060	0,072	Three Phase	0,5
13th	0,027	0,034	0,036	0,062	0,079	0,082	Three Phase	2
14th	0,021	0,028	0,030	0,049	0,065	0,069	Three Phase	0,5
15th	0,029	0,024	0,037	0,066	0,054	0,086	Three Phase	2
16th	0,020	0,023	0,025	0,047	0,054	0,058	Three Phase	0,5
17th	0,040	0,031	0,023	0,091	0,072	0,053	Three Phase	1,5
18th	0,023	0,022	0,026	0,052	0,050	0,059	Three Phase	0,375
19th	0,035	0,031	0,024	0,080	0,072	0,055	Three Phase	1,5
20th	0,022	0,024	0,032	0,051	0,055	0,074	Three Phase	0,375
21th	0,029	0,026	0,038	0,067	0,059	0,086	Three Phase	1,5
22th	0,019	0,025	0,028	0,044	0,058	0,065	Three Phase	0,375
23th	0,032	0,030	0,023	0,074	0,068	0,053	Three Phase	0,6
24th	0,018	0,021	0,024	0,042	0,048	0,055	Three Phase	0,15
25th	0,041	0,034	0,022	0,095	0,079	0,050	Three Phase	0,6
26th	0,023	0,025	0,035	0,052	0,059	0,079	Three Phase	0,15
27th	0,019	0,023	0,029	0,045	0,052	0,068	Three Phase	0,6
28th	0,023	0,026	0,031	0,053	0,059	0,071	Three Phase	0,15
29th	0,044	0,048	0,033	0,101	0,111	0,075	Three Phase	0,6
30th	0,021	0,024	0,026	0,049	0,056	0,060	Three Phase	0,15
31th	0,046	0,042	0,033	0,106	0,097	0,075	Three Phase	0,6
32th	0,028	0,027	0,034	0,064	0,062	0,079	Three Phase	0,15
33th	0,025	0,026	0,027	0,057	0,059	0,061	Three Phase	0,6
34th	0,029	0,033	0,035	0,066	0,076	0,080	Three Phase	0,15
35th	0,045	0,049	0,036	0,103	0,112	0,082	Three Phase	0,3
36th	0,016	0,015	0,013	0,038	0,035	0,029	Three Phase	0,075
37th	0,029	0,027	0,024	0,066	0,062	0,054	Three Phase	0,3

4.6 Harmonic Current Limit Test **3.1.1, 4.3.1 Harmonic Current Limit Test (MEA 2015)**								**P**
38th	0,017	0,015	0,019	0,039	0,035	0,044	Three Phase	0,075
39th	0,013	0,013	0,014	0,030	0,029	0,032	Three Phase	0,3
40th	0,015	0,016	0,017	0,034	0,037	0,040	Three Phase	0,075
41th	0,019	0,028	0,024	0,044	0,065	0,055	Three Phase	N/A
42th	0,011	0,011	0,012	0,025	0,026	0,028	Three Phase	N/A
43th	0,028	0,026	0,025	0,065	0,060	0,058	Three Phase	N/A
44th	0,013	0,011	0,013	0,030	0,026	0,031	Three Phase	N/A
45th	0,009	0,010	0,010	0,022	0,023	0,022	Three Phase	N/A
46th	0,012	0,015	0,014	0,028	0,034	0,031	Three Phase	N/A
47th	0,019	0,026	0,021	0,043	0,059	0,048	Three Phase	N/A
48th	0,009	0,010	0,009	0,021	0,024	0,022	Three Phase	N/A
49th	0,040	0,038	0,040	0,093	0,088	0,092	Three Phase	N/A
50th	0,016	0,012	0,013	0,037	0,028	0,029	Three Phase	N/A

Note:
The harmonics are tested and evaluated according the IEEE1547.1-2005 clause 5.11.1 according the grid-connected inverter regulations of the Metropolitan Electricity Authority (MEA).

4.7 Power factor					P
Test conditions:					
Output power / **Test AC voltage [V]**	**~10% 2,961kW**	**~25% 7,515kW**	**~50% 15,021kW**	**~75% 22,472kW**	**~100% 29,944kW**
230	0,991	0,998	0,998	0,999	0,999

Note:
The PV system shall have a lagging power factor greater than 0,95 when the output is greater than 50% of the rated inverter output power.

The letter “i” is short for “inductive” and indicates inductive power factor. In case of capacitive power factor the letter “c” is used instead.

5.2.1 Voltage monitoring **3.2.1, 4.3.4 Operating Voltaga Range (MEA 2015)** **(For gird-connected inverter which connected to the grid at low voltage(230/400))**	**P**

First Level

Test conditions:	Output power: 15kW Frequency: 50Hz									
	Under Voltage					**Over Voltage**				
		Voltage [V]					Voltage [V]			
Set value		**199V**					**241V**			
Measured trip value		All	L1	L2	L3		All	L1	L2	L3
		198,5	198,7	198,7	198,1		240,8	241,1	241,1	240,1
		198,5	198,7	198,7	198,1		240,8	241,2	241,0	240,1
		198,5	198,7	198,7	198,1		240,8	241,2	241,0	240,1
		198,5	198,7	198,7	198,1		240,7	241,1	241,0	240,1
		198,5	198,7	198,7	198,1		240,8	241,2	241,1	240,1
Parameter		Time [ms]					Time [ms]			
Limit		**<= 2,0s**					**<= 2,0s**			
Disconnetion time	230V to 204V (4s min) to 198V	All	L1	L2	L3	230V to 236V (4s min) to 242V	All	L1	L2	L3
		1,922	1,922	1,920	1,912		1,925	1,927	1,932	1,910
		1,907	1,917	1,937	1,900		1,912	1,927	1,922	1,920
		1,910	1,940	1,917	1,935		1,925	1,922	1,905	1,922
		1,922	1,940	1,907	1,915		1,920	1,937	1,927	1,925
		1,907	1,915	1,910	1,907		1,922	1,930	1,925	1,910

Second Level										
Test conditions:	Output power: 15,0kW Frequency: 50Hz									
	Under Voltage					**Over Voltage**				
Parameter		Voltage [V]					Voltage [V]			
Set value		**114V**					**311V**			
Measured trip value		All	L1	L2	L3		All	L1	L2	L3
		113,4	113,6	113,4	113,2		311,3	311,1	311,6	311,8
		113,4	113,6	113,4	113,2		311,4	311,0	311,7	311,9
		113,4	113,6	113,4	113,2		311,3	310,9	311,6	311,8
		113,4	113,6	113,4	113,2		311,4	311,0	311,7	311,9
		113,4	113,6	113,4	113,2		311,4	311,1	311,7	311,9
Parameter		Time [ms]					Time [ms]			
Limit		**<= 100ms**					**<= 50ms**			
Disconnection time	230V to 204V (0,2s min) to 113V	All	L1	L2	L3	230V to 236V (0,1s min) to 312V	All	L1	L2	L3
		93,0	80,5	85,5	81,5		23,2	40,6	16,9	48,4
		75,0	82,5	86,0	76,5		32,3	40,6	15,4	49,5
		89,0	88,0	76,0	81,0		38,6	32,4	37,4	12,2
		86,0	79,0	91,5	68,0		26,1	39,2	34,1	31,2
		79,0	88,0	91,5	77,5		23,4	40,9	48,9	30,8

Note:
The tests according to the grid-connected inverter regulation Metropolitan Electricity Authority 2015.
The voltage settings of the EUT are set for the tests as stated to 199V, 114V for undervoltage and 241V, 311V for overvoltage.
Set all other parameter to the normal operating conditions for inverter.
Suddenly increase testing voltage to overvoltage trip setting -1V/+1 V and maintain this value until the inverter stop energize.
For 3 phase inverter, the test must perform on each phase and all 3 phases together. During the test in each phase, the voltage in other phase shall be at normal operating condition.

Under Voltage First Level for single phase

Over voltage First Level for single phase

Note: CH1, CH2, CH3: grid voltage(100V/div); CH4, CH5, CH6: Current of EUT(20A/div); CH7: trip signal

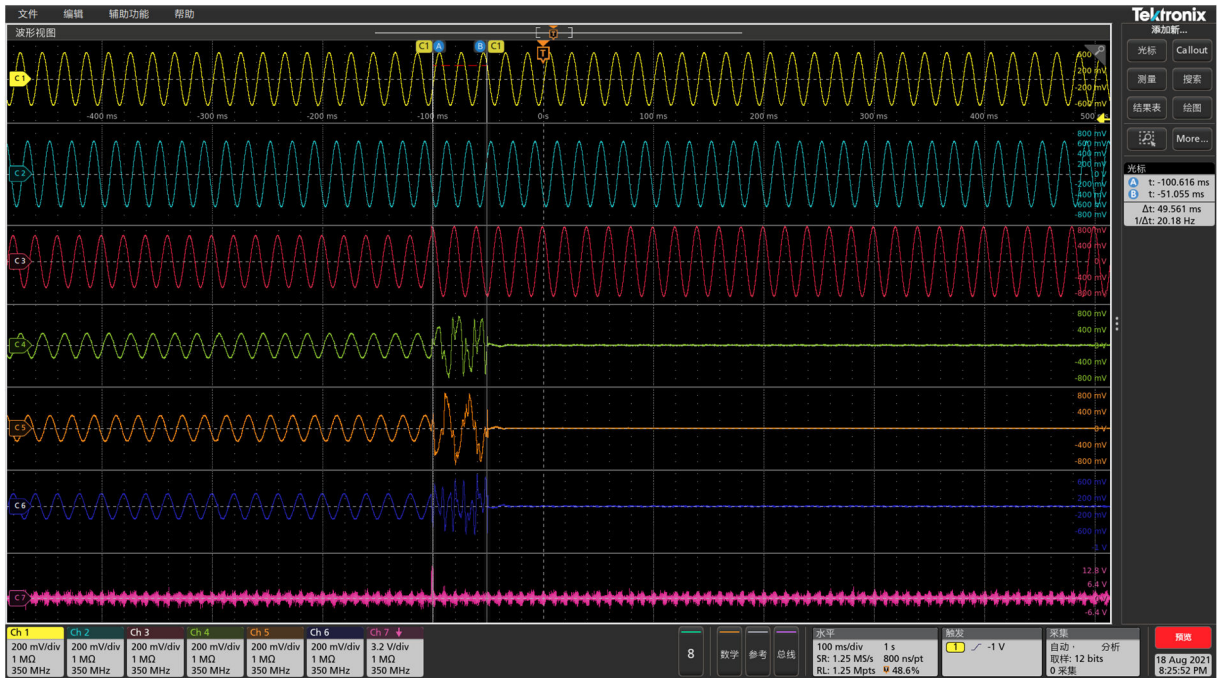
Under Voltage First Level for all phase

Over voltage First Level for all phase

Note: CH1, CH2, CH3: grid voltage(100V/div); CH4, CH5, CH6: Current of EUT(20A/div); CH7: trip signal

Under Voltage Second Level for single phase

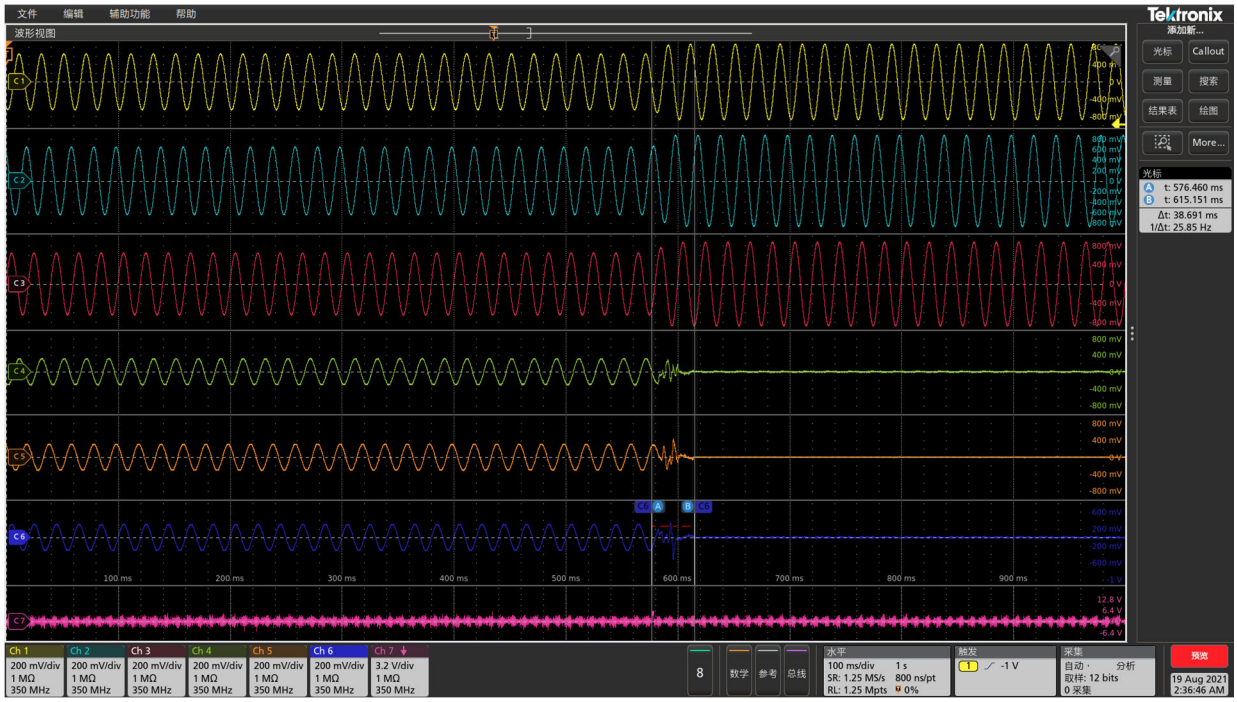
Over voltage Second Level for single phase



Note: CH1, CH2, CH3: grid voltage(100V/div); CH4, CH5, CH6: Current of EUT(20A/div); CH7: trip signal

Under Voltage Second Level for all phase

Over voltage Second Level for all phase



Note: CH1, CH2, CH3: grid voltage(100V/div); CH4, CH5, CH6: Current of EUT(20A/div); CH7: trip signal

5.2.1 Voltage monitoring **3.2.4, 4.3.7 Response to Utility Recovery (MEA 2015)**					**P**
First Level					
Test conditions:	Output power: 15,0kW Frequency: 50Hz				
Reconnection time(Sec)	at least 120s	134,8 s	at least 120s	134,7 s	
Second Level					
Test conditions:	Output power: 15,0kW Frequency: 50Hz				
Reconnection time(Sec)	at least 120s	134,8 s	at least 120s	134,9 s	

Note:

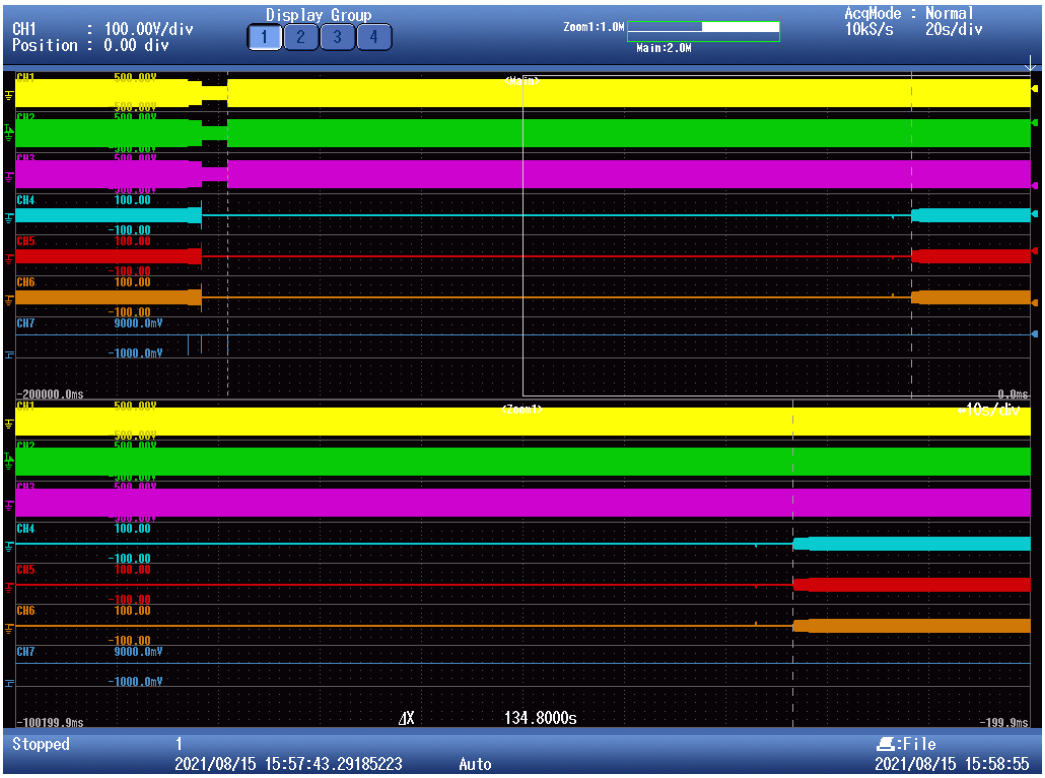
Response to Utility Recovery Test:
The test methods shall be in accordance with IEEE 1547.1-2005 clause 5.10 and evaluation criteria refer to clause 3.2.4 in this regulation.

Reconnection after Under Voltage First Level

Reconnection after Over voltage First Level

Note: CH1, CH2, CH3: grid voltage(100V/div); CH4, CH5, CH6: Current of EUT(20A/div); CH7: trip signal

Reconnection after Under Voltage Second Level



Reconnection after Over voltage Second Level

Note: CH1, CH2, CH3: grid voltage(100V/div); CH4, CH5, CH6: Current of EUT(20A/div); CH7: trip signal

5.2.2 Frequency monitoring **3.2.2, 4.3.5 Operating Voltaga Range (MEA 2015)** **3.2.4, 4.3.7 Response to Utility Recovery**	**P**

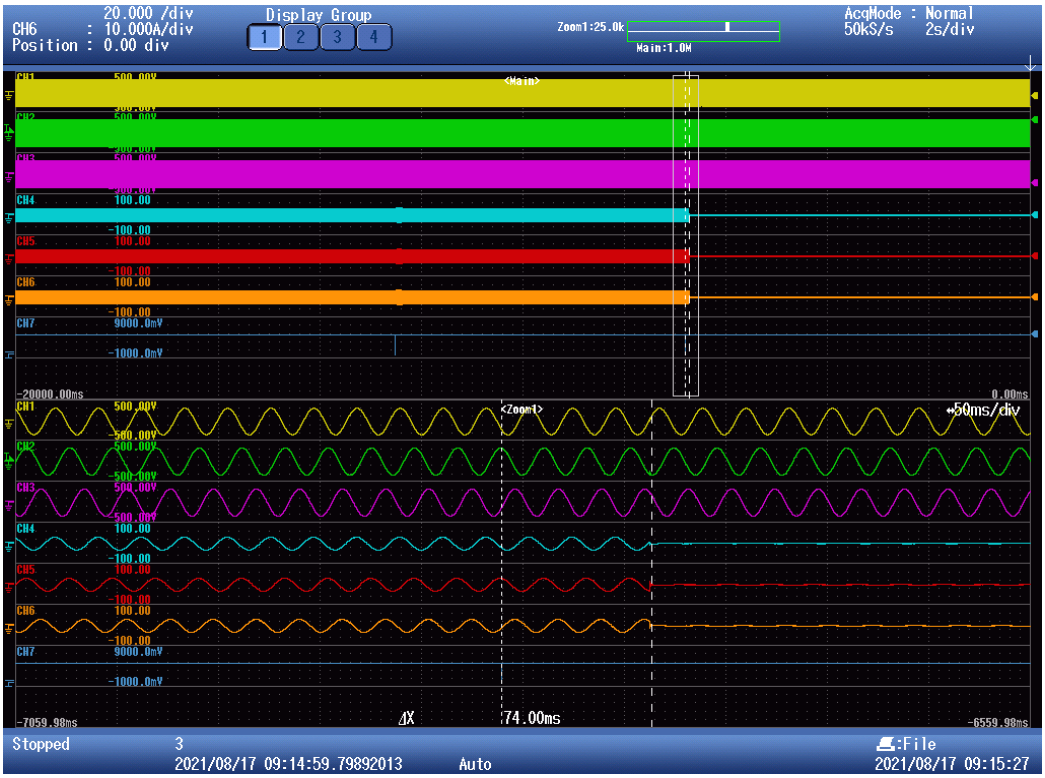
Test conditions:	Any output power level			
	Under frequency		**Over frequency**	
Parameter		Frequency [Hz]		Frequency [Hz]
Output Voltage		U_N		U_N
Set value		**47,00Hz**		**52,00Hz**
Measured trip value(Hz)		47,01		52,00
		47,01		52,00
		47,01		52,01
		47,01		52,00
		47,01		52,00
		Time [ms]		Time [ms]
Limit		**<= 100ms**		**<= 100ms**
Disconnection time(ms)	47,10 Hz to 46,90 Hz	55,0	51,90 Hz to 52,10 Hz	76,0
		71,5		58,0
		65,0		62,0
		56,2		68,3
		74,0		52,0
Reconnection time (Sec)	at least 120s	134,7 s	at least 120s	134,8 s

Note:
Set all other parameter to the normal operating conditions for inverter.
Suddenly increase testing frequency to overfrequency trip setting +/-0.1 Hz and maintain this value until the inverter stop energize. And the time it takes to cut off the power must be within 0.1 second.

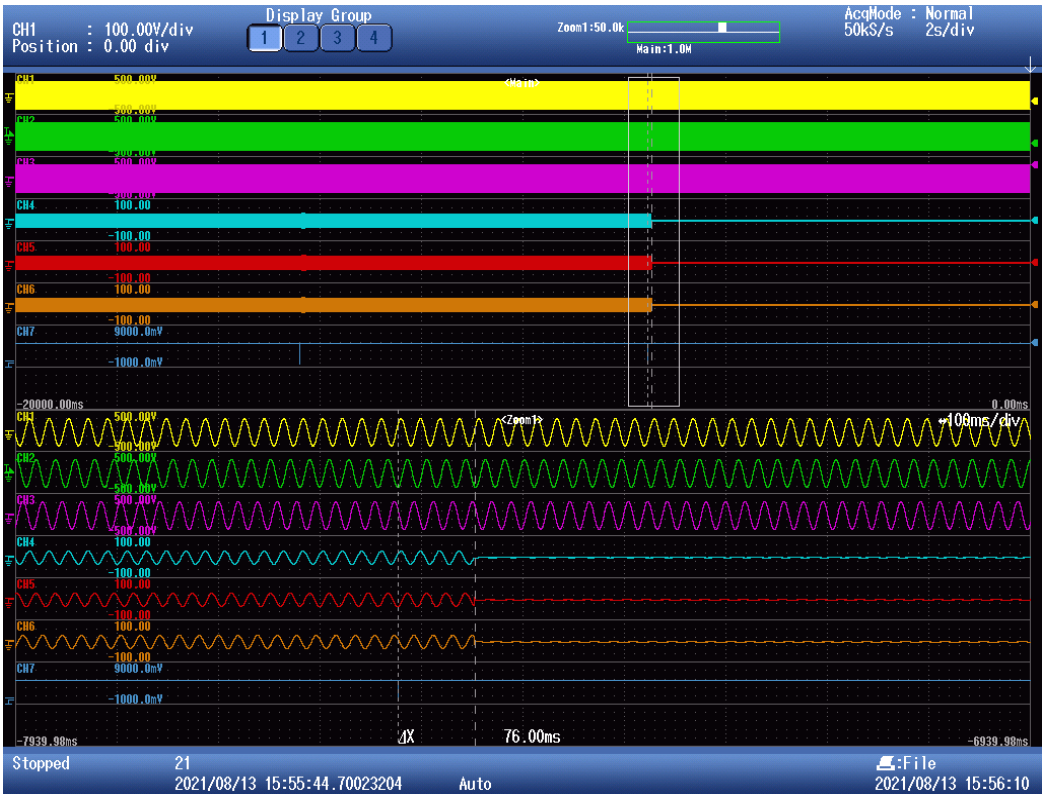
The tests according to the grid-connected inverter regulation Metropolitan Electricity Authority 2015. The frequency settings are set for the test as stated to 47,0Hz and 52,0Hz.

Response to Utility Recovery Test:
The test methods shall be in accordance with IEEE 1547.1-2005 clause 5.10 and evaluation criteria refer to clause 3.2.4 in this regulation.

Under Frequency:



Over Frequency:



Note: CH1, CH2, CH3: grid voltage(100V/div); CH4, CH5, CH6: Current of EUT(20A/div); CH7: trip signal

Reconnection after Under Frequency:

Reconnection after Over Frequency:

Note: CH1, CH2, CH3: grid voltage(100V/div); CH4, CH5, CH6: Current of EUT(20A/div); CH7: trip signal

6.1 Islanding protection
3.2.3, 4.3.6 Islanding Protection (MEA:2015)

Test circuit and parameters

Parameter	Symbol	Units
EUT DC Input		
DC voltage	V_{DC}	V
DC Current	I_{DC}	A
DC Power	P_{DC}	W
EUT AC ouput		
AC voltage	V_{EUT}	V
AC current	I_{EUT}	A
Real power	P_{EUT}	W
Reactive power	Q_{EUT}	VAr
Test Load		
Resistive load current	I_R	A
Inductive load current	I_L	A
Capacitive load current	I_C	A
AC (utility) power source		
Utility real power	P_{AC}	W
Utility reactive power	Q_{AC}	VAr
Utility current	I_{AC}	A

Block diagram test circuit IEC 62116:2008

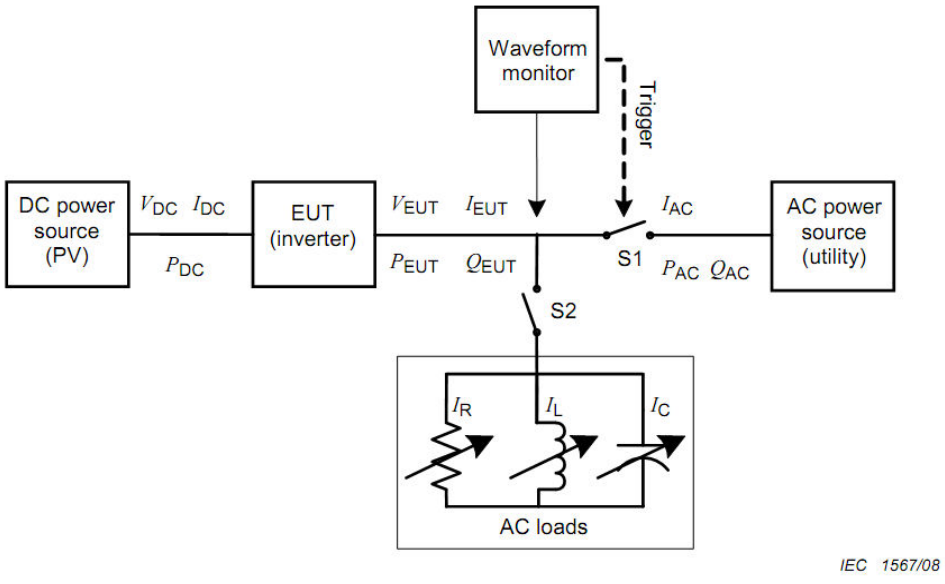


Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

6.1 Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%) 3.2.3, 4.3.6 Islanding Protection (MEA:2015)	**P**

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality = 1
Disconnection limit	2,0s for MEA

No	P_{EUT} 1) (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{AC} 2) (% of nominal)	Q_{AC} 3) (% of nominal)	Run on Time (ms)	P_{EUT} (KW per phase)	Actual Q_f	V_{DC} (V)	Remarks4)
1	100	100	0	0	126	10,040	0,970	812	Test A at BL
2	100	100	-5	-5	95	10,040	0, 995	812	Test A at IB
3	100	100	-5	0	102	10,040	1,021	812	Test A at IB
4	100	100	-5	+5	85	10,040	1,046	812	Test A at IB
5	100	100	0	-5	93	10,040	0,945	812	Test A at IB
6	100	100	0	+5	70	10,040	0,994	812	Test A at IB
7	100	100	+5	-5	121	10,040	0,900	812	Test A at IB
8	100	100	+5	0	108	10,040	0,924	812	Test A at IB
9	100	100	+5	+5	71	10,040	0,947	812	Test A at IB

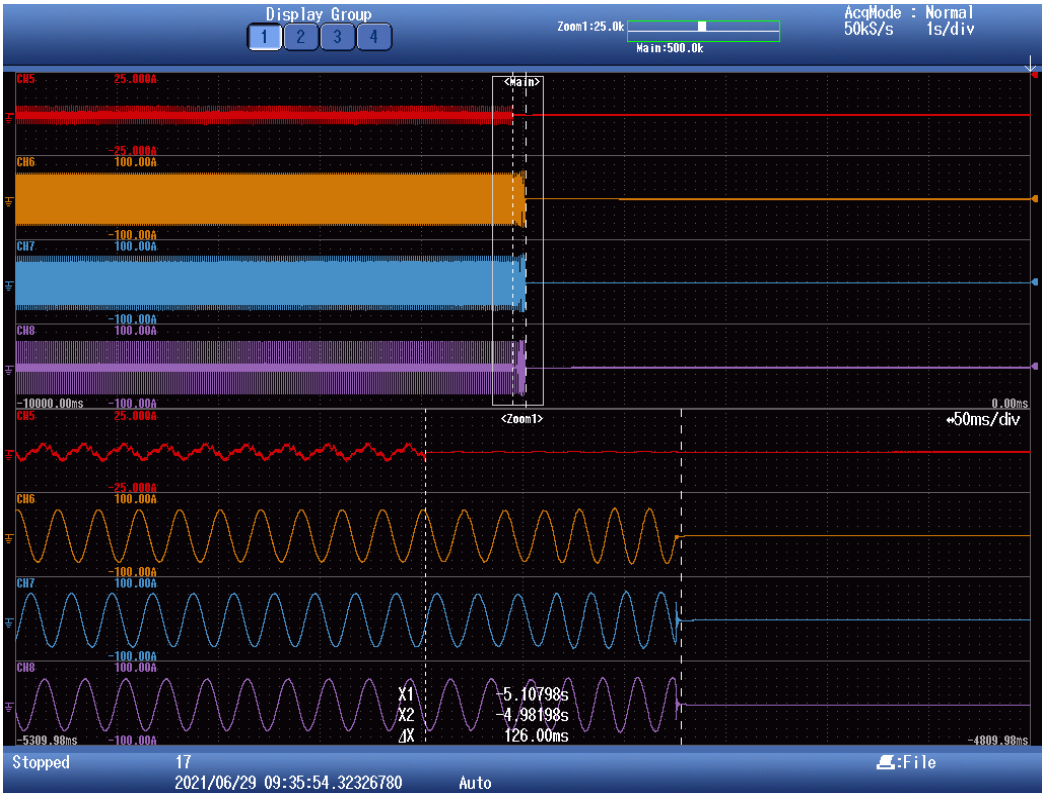
Parameter at 0% per phase	L= 17,72 mH	R= 5,27 Ω	C= 600,52 µF
I_{AC} fundamental current at balance condition	L1: 136mA	L2: 88mA	L3: 58mA

Note:
RLC is adjusted to min. +/-1% of the inverter rated output power
1) P_{EUT}: EUT output power
2) P_{AC}: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
3) Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
4) BL: Balance condition, IB: Imbalance condition.

Condition A:
EUT output power PEUT = Maximum 5)
EUT input voltage 6) = >90% of rated input voltage range

5) Maximum EUT output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.
6) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % of range =X + 0,9 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

Disconnection at P_{AC} +10% and Q_{AC} 0% reactive load No.23



Attention:
For Thailand only picture with all three current phases L1, L2 and L3 are accepted
All relays are direct coupled and open directly by receiving the islanding signal from the controller.

Note:
CH6, CH7, CH8: L1, L2, L3 current of EUT(20A/div)., CH5: trip signal

6.1 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %) **3.2.3, 4.3.6 Islanding Protection (MEA:2015)**	**P**

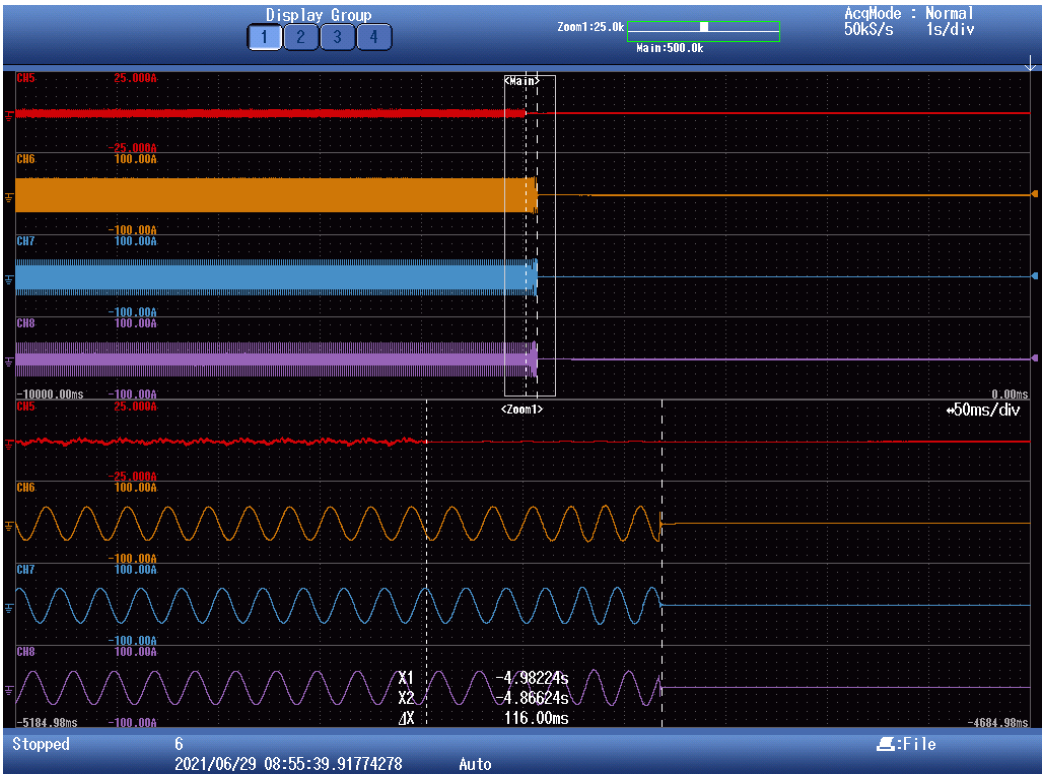
Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	2,0 s for MEA

No	P_{EUT} [1] (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{AC} [2] (% of nominal)	Q_{AC} [3] (% of nominal)	Run on Time (ms)	P_{EUT} (W per phase)	Actual Qf	V_{DC} (V)	Remarks[4]
1	66	66	0	-5	97	6,660	0,951	540	Test B at IB
2	66	66	0	-4	98	6,660	0,956	540	Test B at IB
3	66	66	0	-3	112	6,660	0,961	540	Test B at IB
4	66	66	0	-2	108	6,660	0,966	540	Test B at IB
5	66	66	0	-1	116	6,660	0,971	540	Test B at IB
6	66	66	0	0	110	6,660	0,976	540	Test B at BL
7	66	66	0	1	103	6,660	0,981	540	Test B at IB
8	66	66	0	2	91	6,660	0,986	540	Test B at IB
9	66	66	0	3	83	6,660	0,990	540	Test B at IB
10	66	66	0	4	84	6,660	0,995	540	Test B at IB
11	66	66	0	5	82	6,660	1,000	540	Test B at IB

Parameter at 0% per phase	L= 26,57mH	R= 7,94Ω	C= 401,15µF
I_{AC} fundamental current at balance condition	L1: 177mA	L2: 43mA	L3: 119mA

Note:
RLC is adjusted to min. +/-1% of the inverter rated output power
[1] P_{EUT}: EUT output power
[2] P_{AC}: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
[3] Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
[4] BL: Balance condition, IB: Imbalance condition.
Condition B:
EUT output power PEUT = 50 % – 66 % of maximum
EUT input voltage [5] = 50 % of rated input voltage range, ±10 %
[5] Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % of range =X + 0,5 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load No. 6



Attention:
For Thailand only picture with all three current phases L1, L2 and L3 are accepted
All relays are direct coupled and open directly by receiving the islanding signal from the controller.

Note:
CH6, CH7, CH8: L1, L2, L3 current of EUT(20A/div)., CH5: trip signal

6.1 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %) **3.2.3, 4.3.6 Islanding Protection (MEA:2015)**	**P**

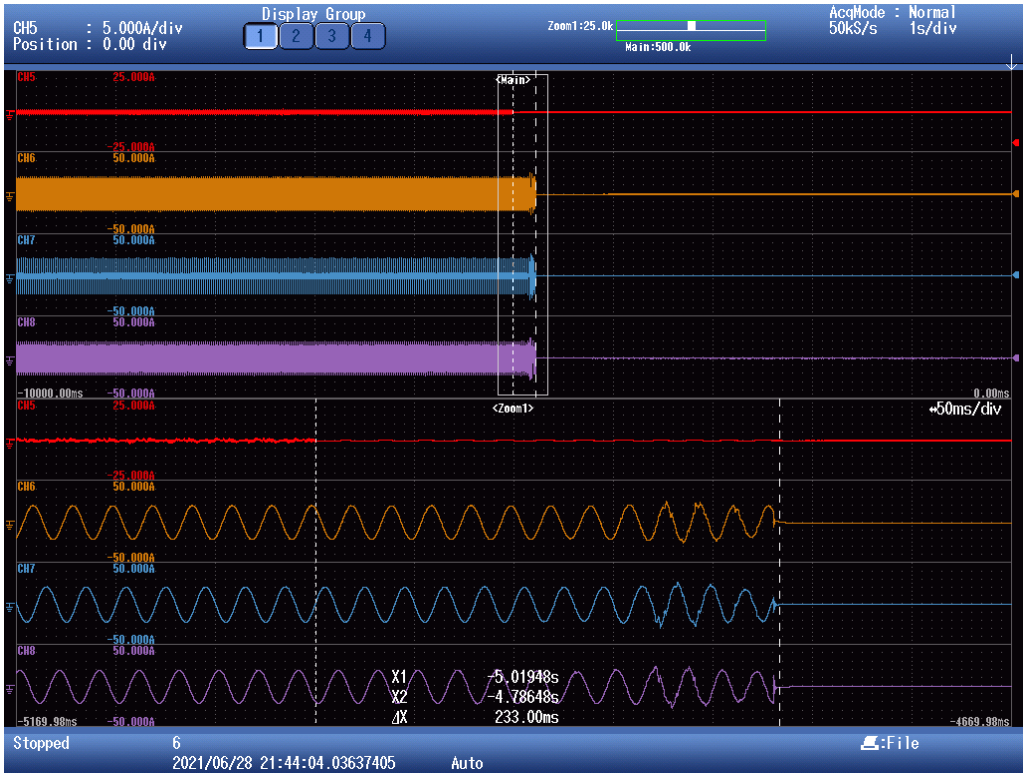
Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	2,0 s for MEA

No	P_{EUT} 1) (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{AC} 2) (% of nominal)	Q_{AC} 3) (% of nominal)	Run on Time (ms)	P_{EUT} (KW per phase)	Actual Q_f	V_{DC}	Remarks4)
1	33	33	0	-5	114	3,330	0,968	268	Test C at IB
2	33	33	0	-4	129	3,330	0,973	268	Test C at IB
3	33	33	0	-3	112	3,330	0,978	268	Test C at IB
4	33	33	0	-2	150	3,330	0,983	268	Test C at IB
5	33	33	0	-1	233	3,330	0,988	268	Test C at IB
6	33	33	0	0	132	3,330	0,993	268	Test C at BL
7	33	33	0	1	94	3,330	0,998	268	Test C at IB
8	33	33	0	2	92	3,330	1,003	268	Test C at IB
9	33	33	0	3	85	3,330	1,008	268	Test C at IB
10	33	33	0	4	82	3,330	1,013	268	Test C at IB
11	33	33	0	5	69	3,330	1,018	268	Test C at IB

Parameter at 0% per phase	L= 52,51mH	R= 15,89Ω	C= 205,19µF
I_{AC} fundamental current at balance condition	L1: 43mA	L2: 39mA	L3: 26mA

Note:
RLC is adjusted to min. +/-1% of the inverter rated output power
1) P_{EUT}: EUT output power
2) P_{AC}: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
3) Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
4) BL: Balance condition, IB: Imbalance condition.
Condition C:
EUT output power PEUT = 25 % – 33 % 5) of maximum
EUT input voltage 6) = <10 % of rated input voltage range
5) Or minimum allowable EUT output level if greater than 33 %.
6) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % of range =X + 0,1 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load No. 6



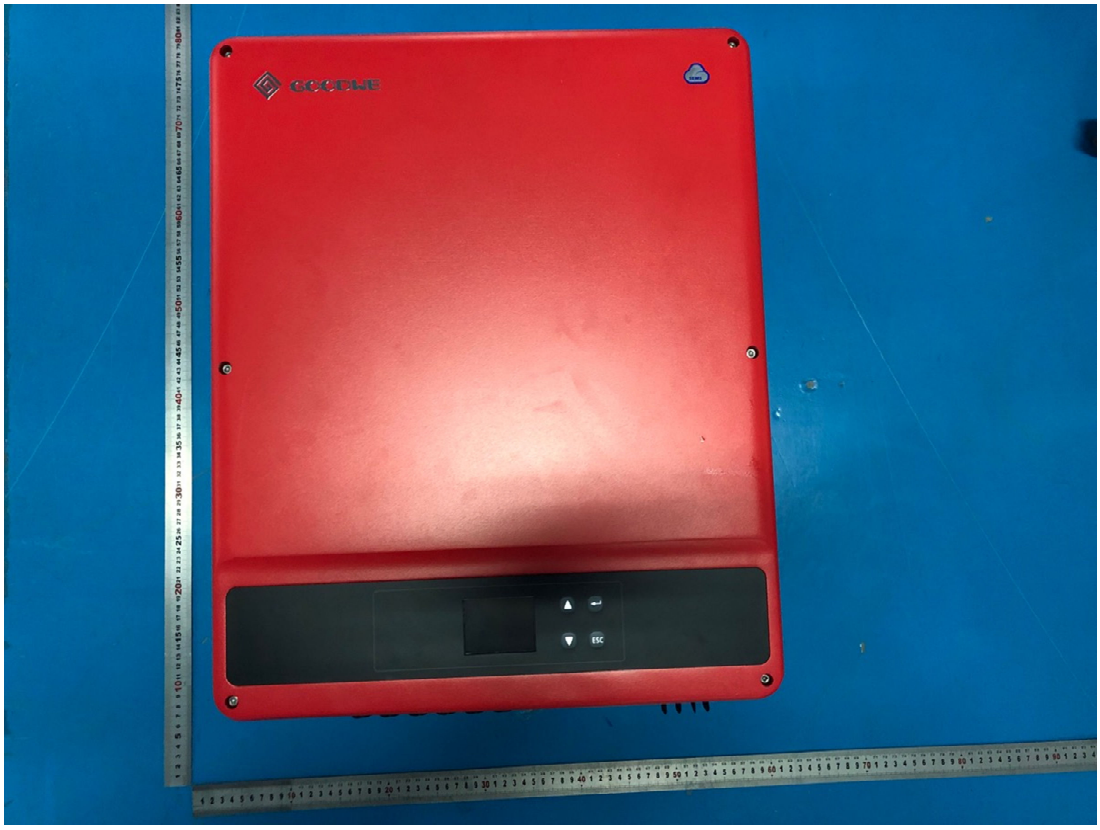
Attention:
For Thailand only picture with all three current phases L1, L2 and L3 are accepted
All relays are direct coupled and open directly by receiving the islanding signal from the controller.

Note:
CH6, CH7, CH8: L1, L2, L3 current of EUT(20A/div)., CH5: trip signal

Annex 1

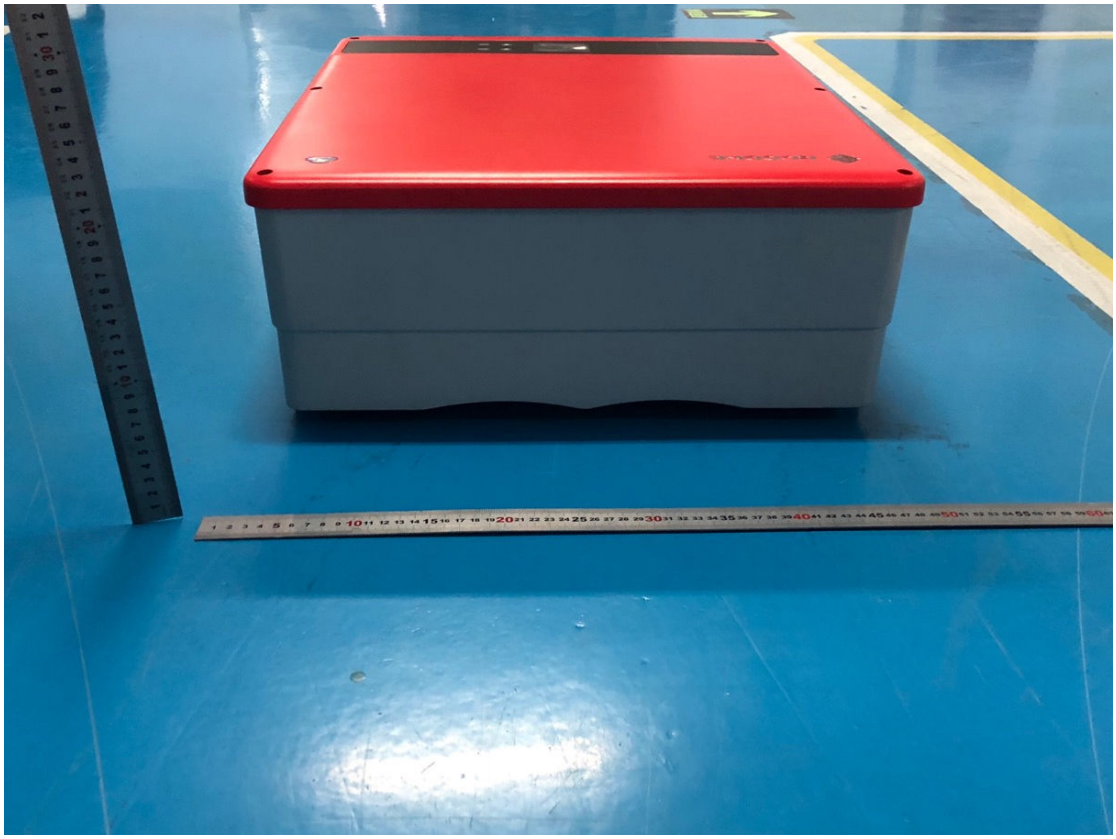
Pictures of the unit

Enclosure front view

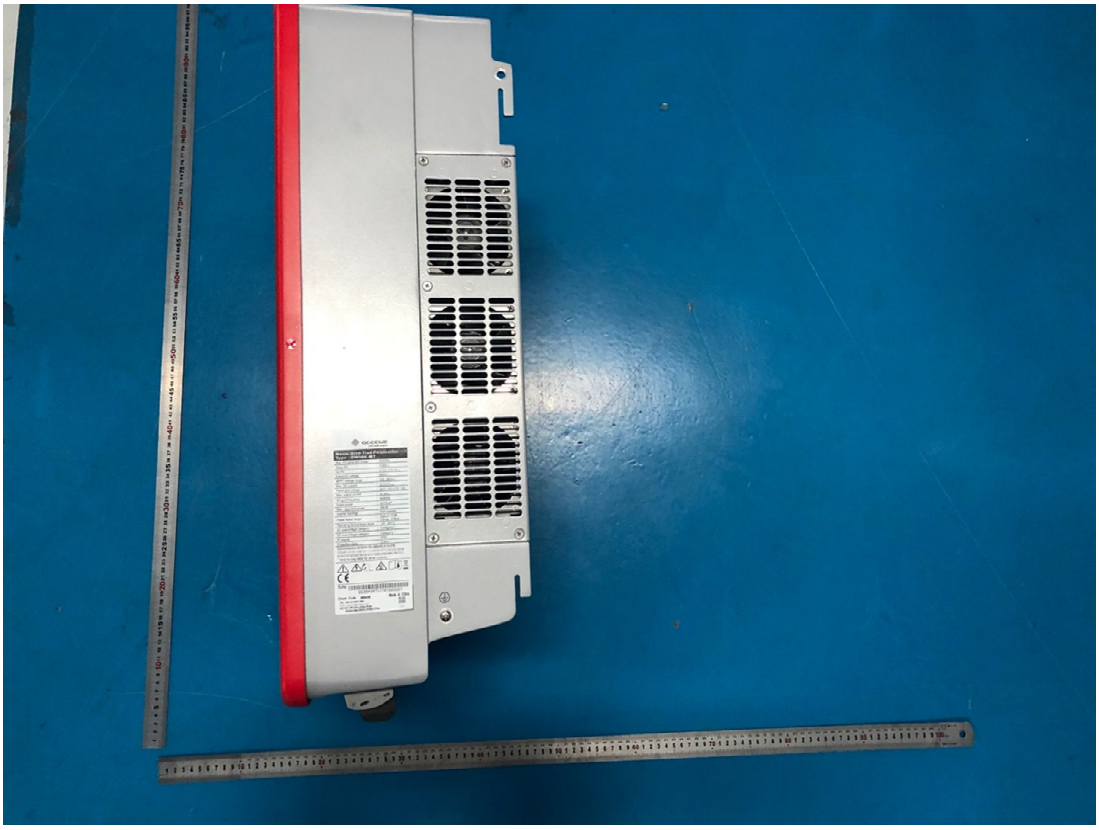


Enclosure top view

Enclosure side view



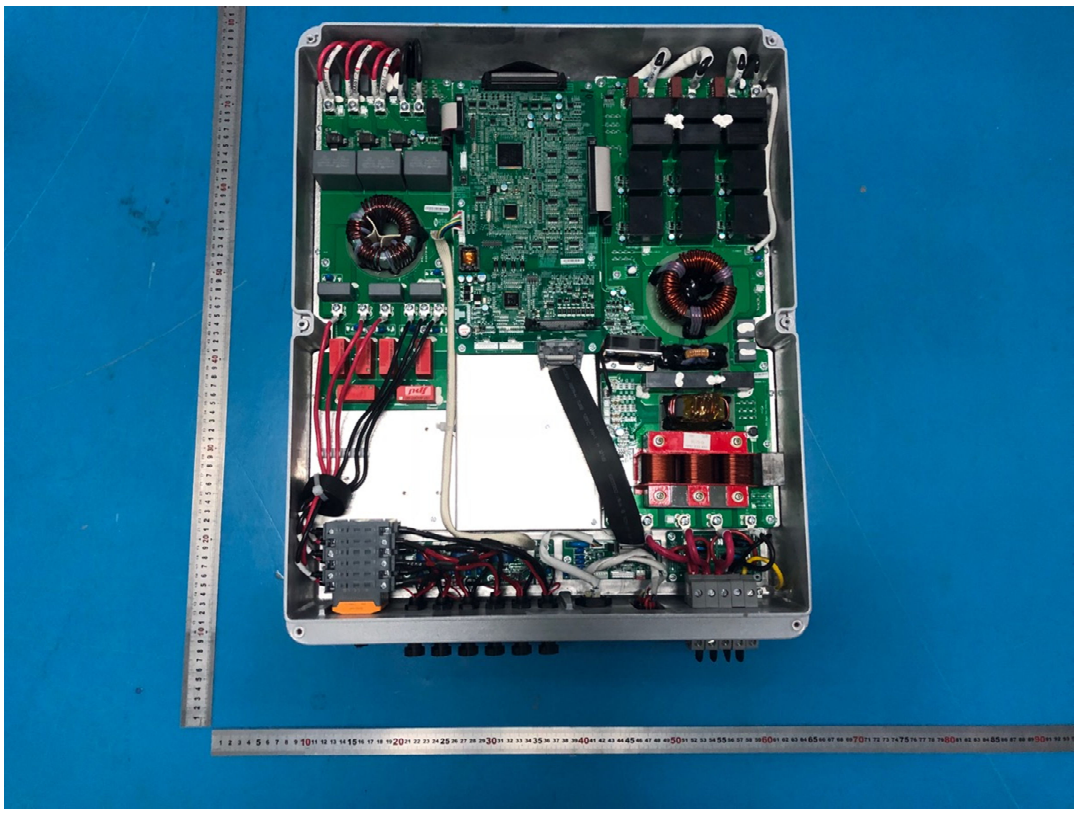
Enclosure side view



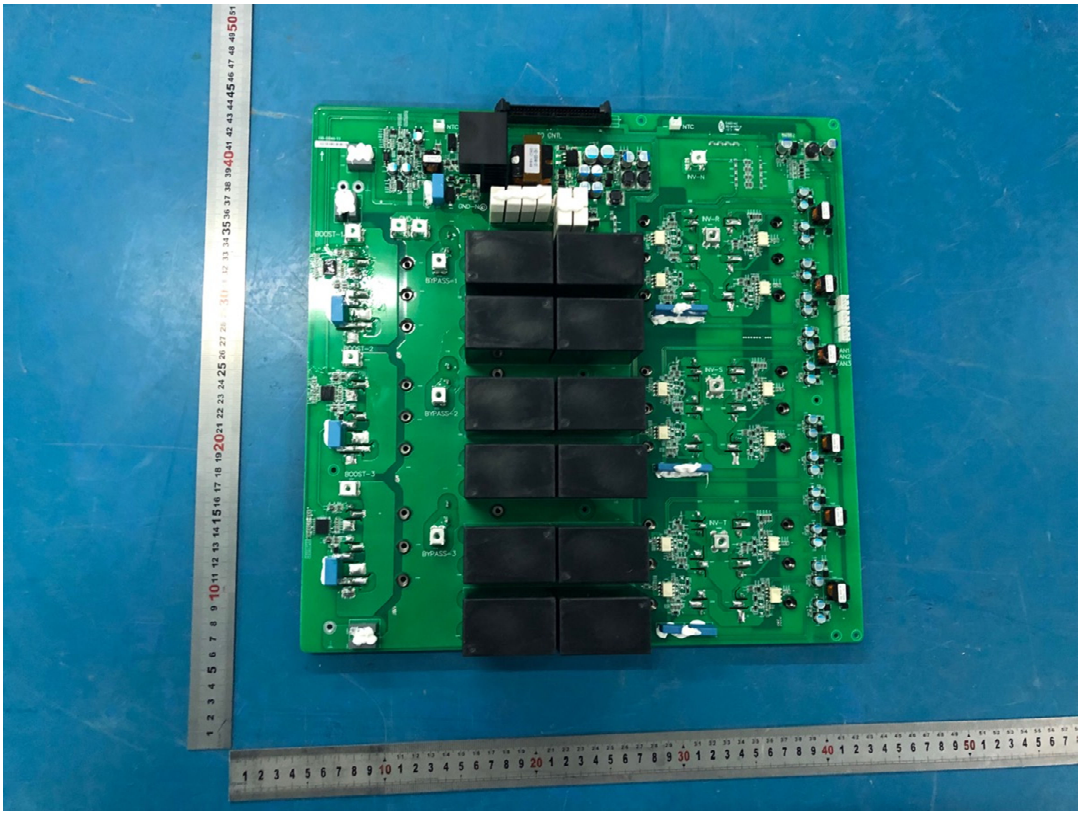
Enclosure bottom view

Enclosure side view

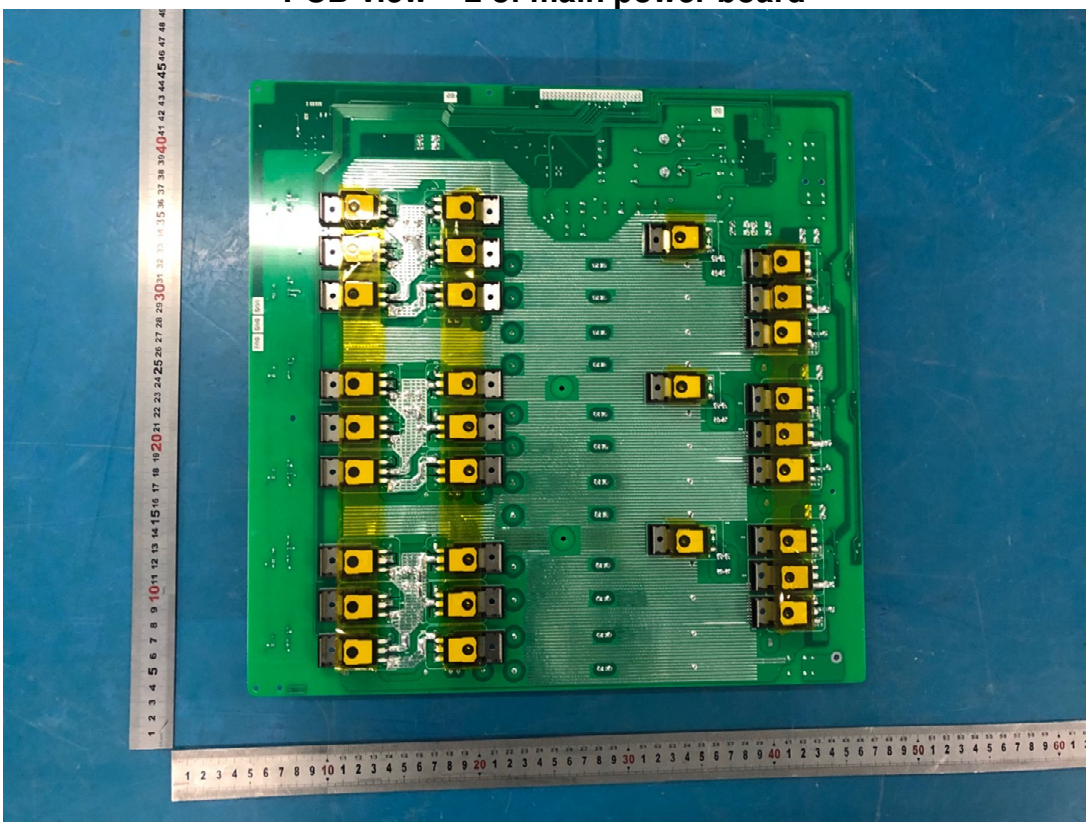
Inside view



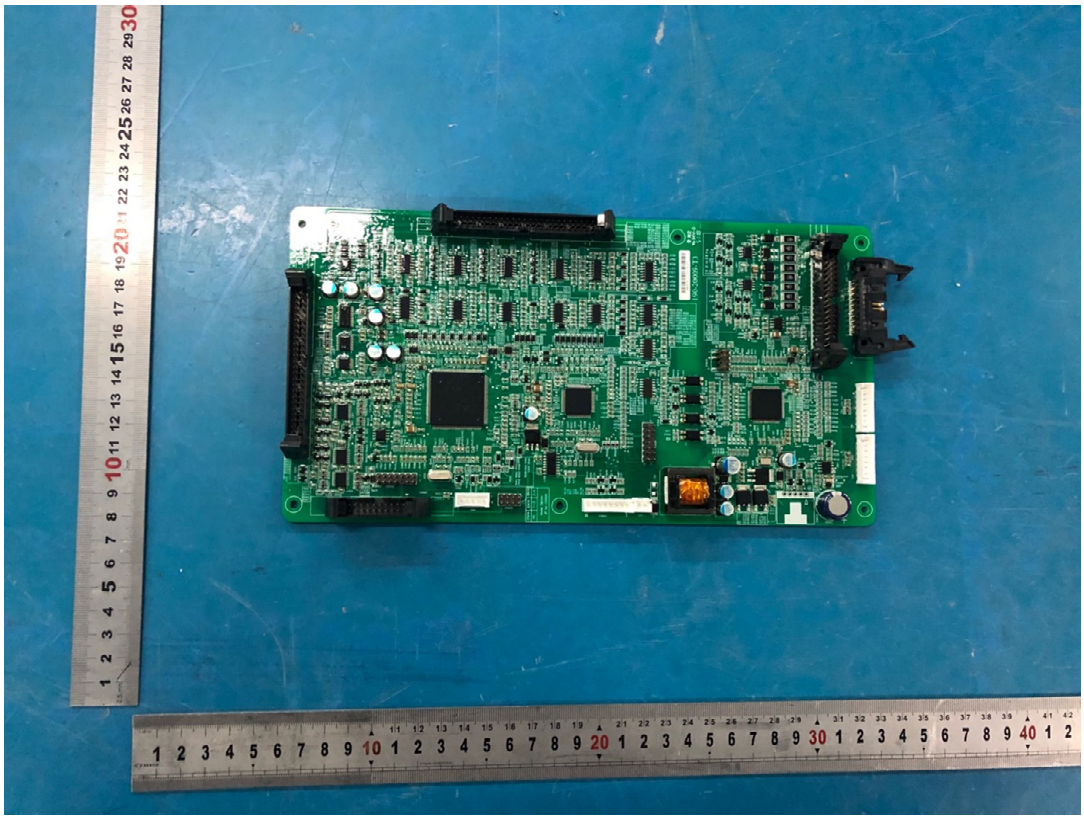
PCB view – 1 of main power board



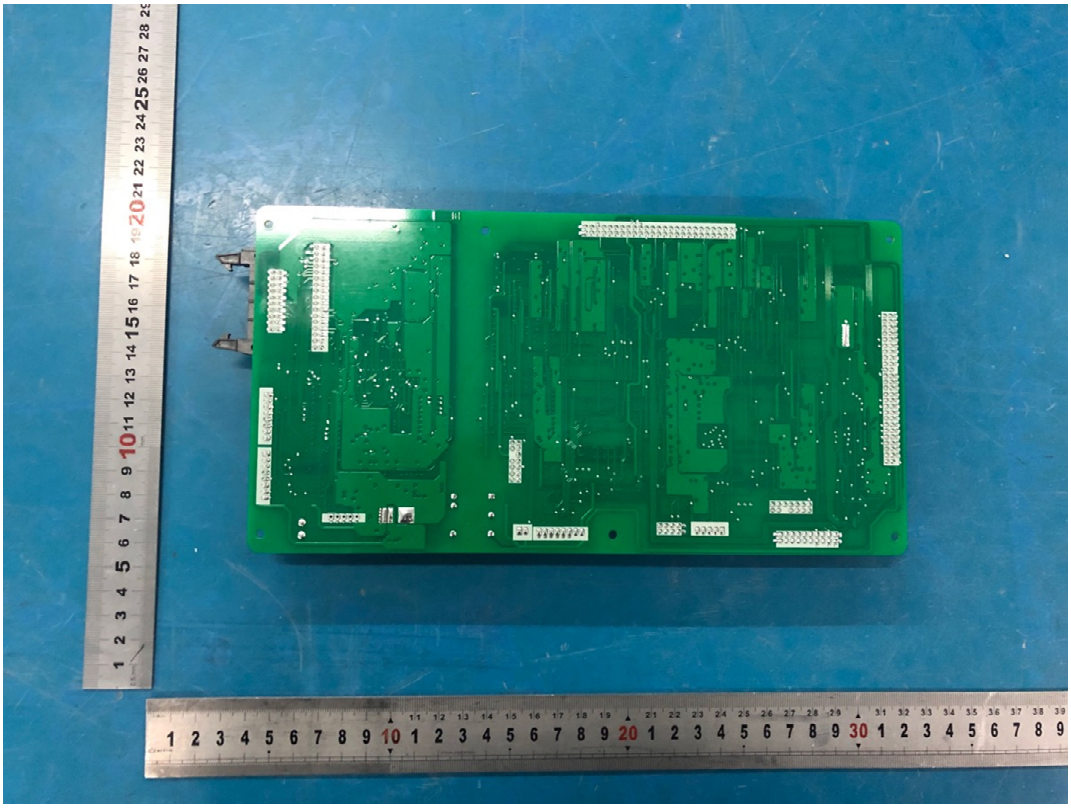
PCB view – 2 of main power board



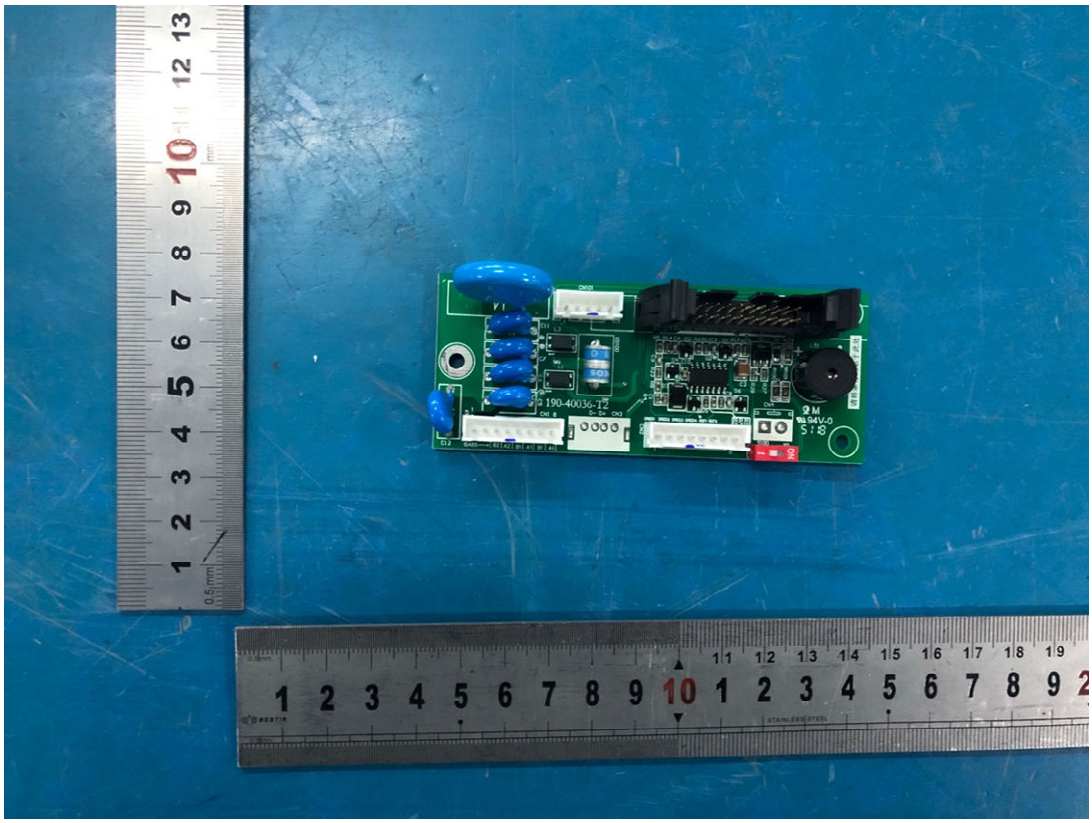
PCB view – 1 of control board



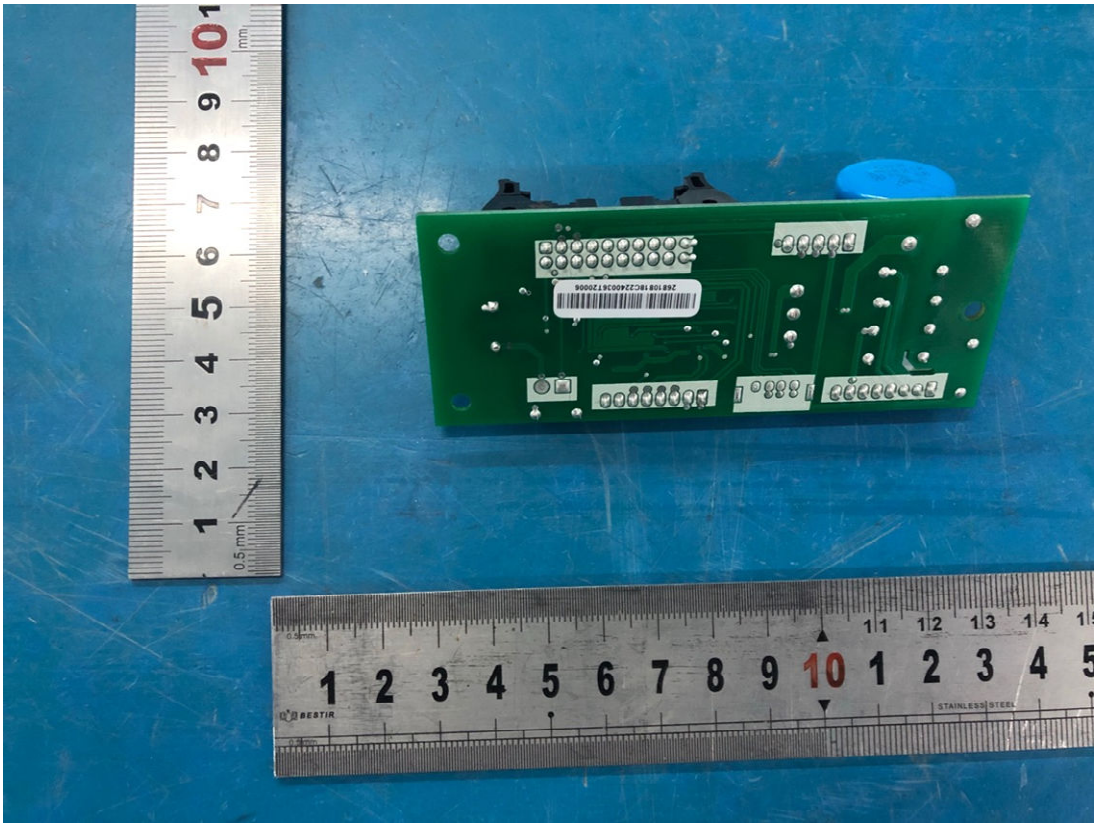
PCB view – 2 of control board



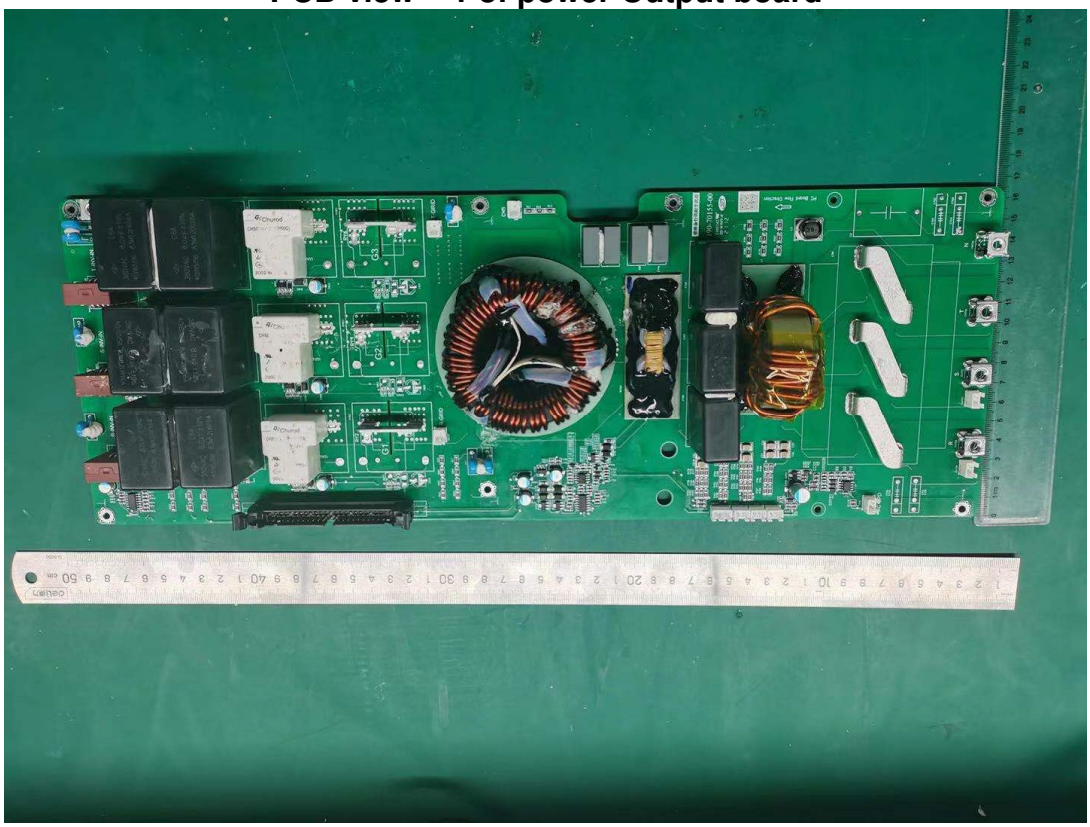
PCB view – 1 of Communication board



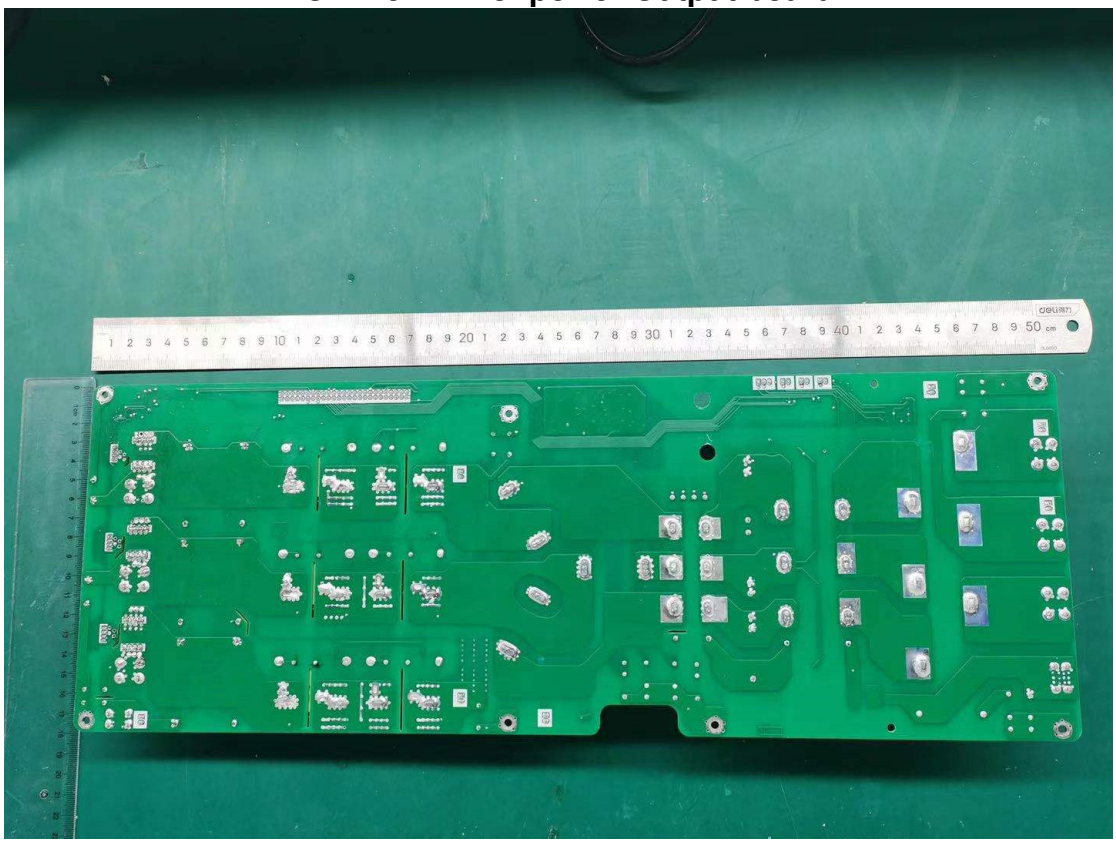
PCB view – 2 of Communication board



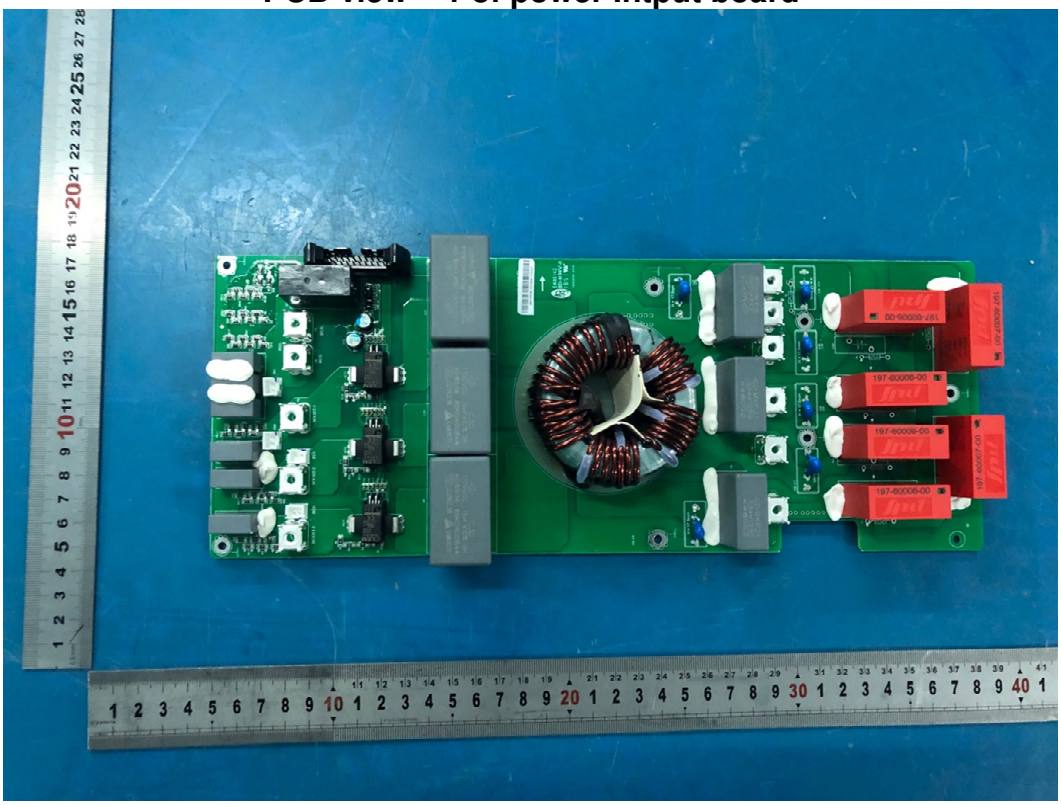
PCB view – 1 of power Output board



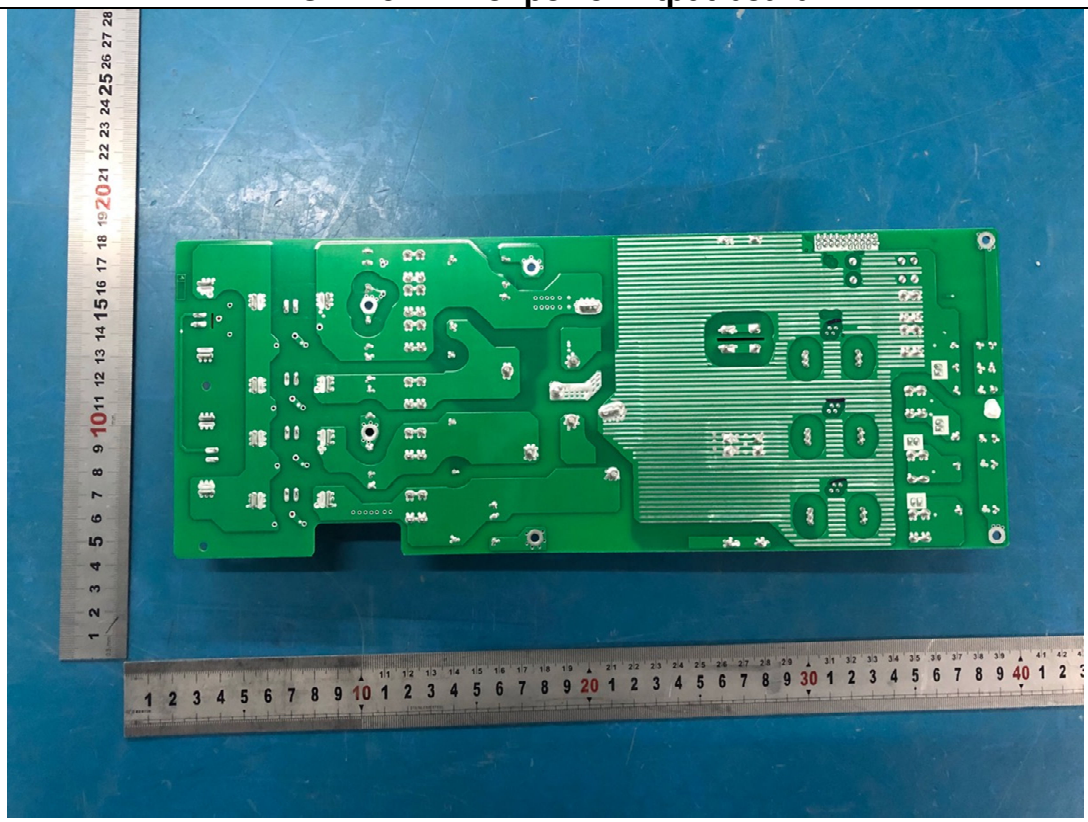
PCB view – 2 of power Output board



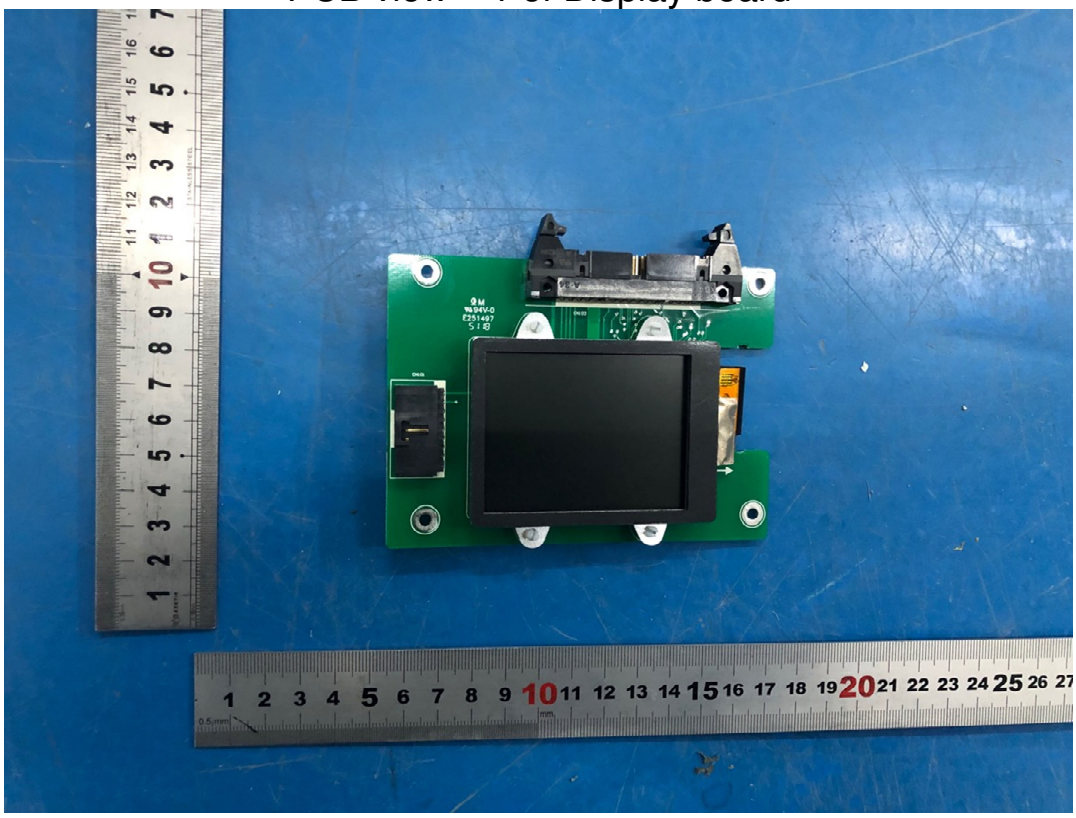
PCB view – 1 of power Intput board



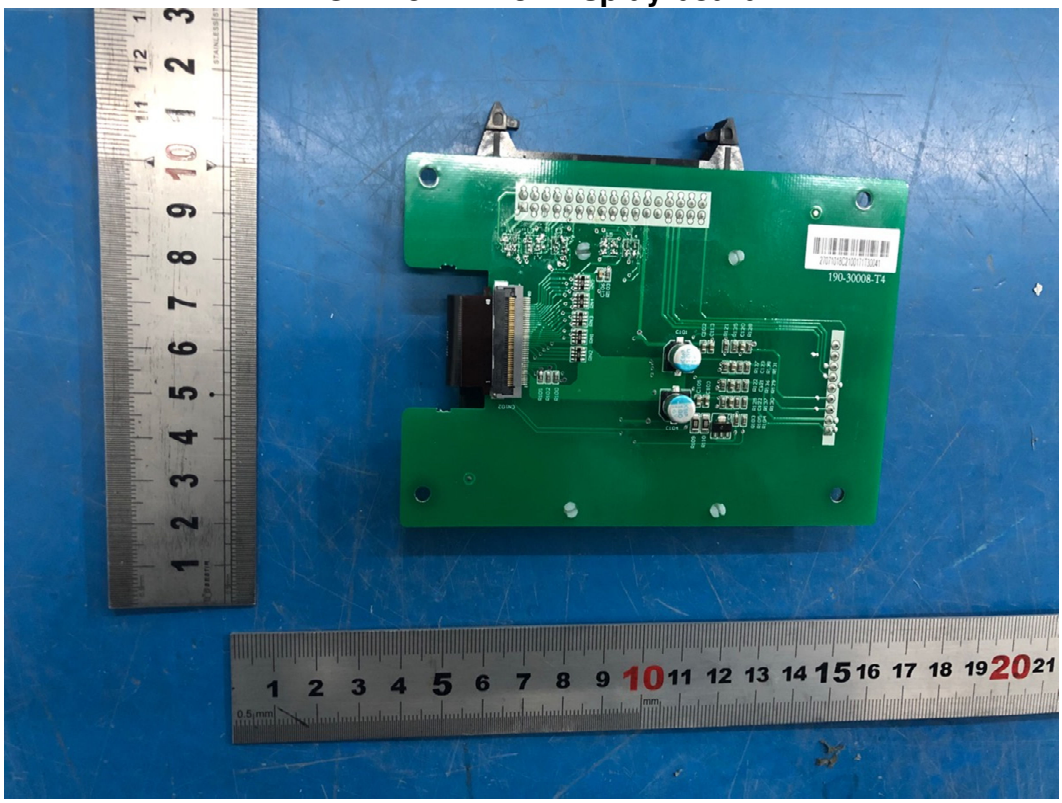
PCB view – 2 of power Intput board



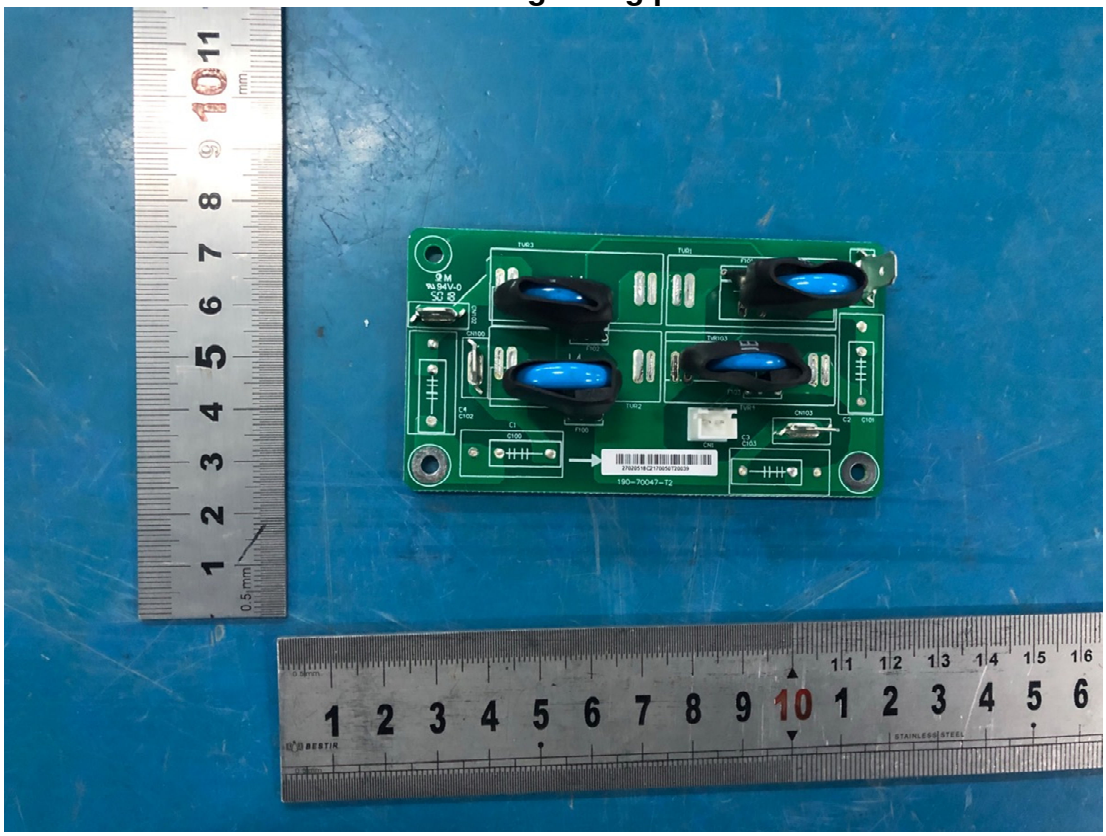
PCB view – 1 of Display board



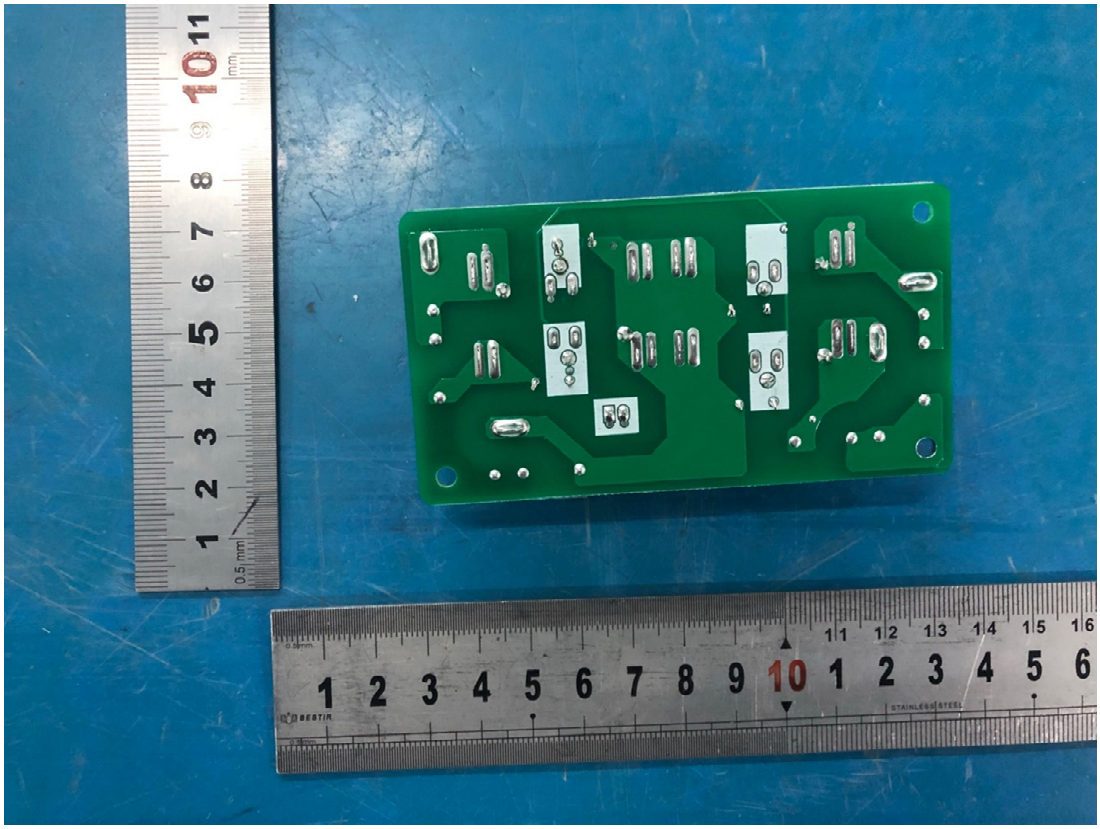
PCB view – 2 of Display board



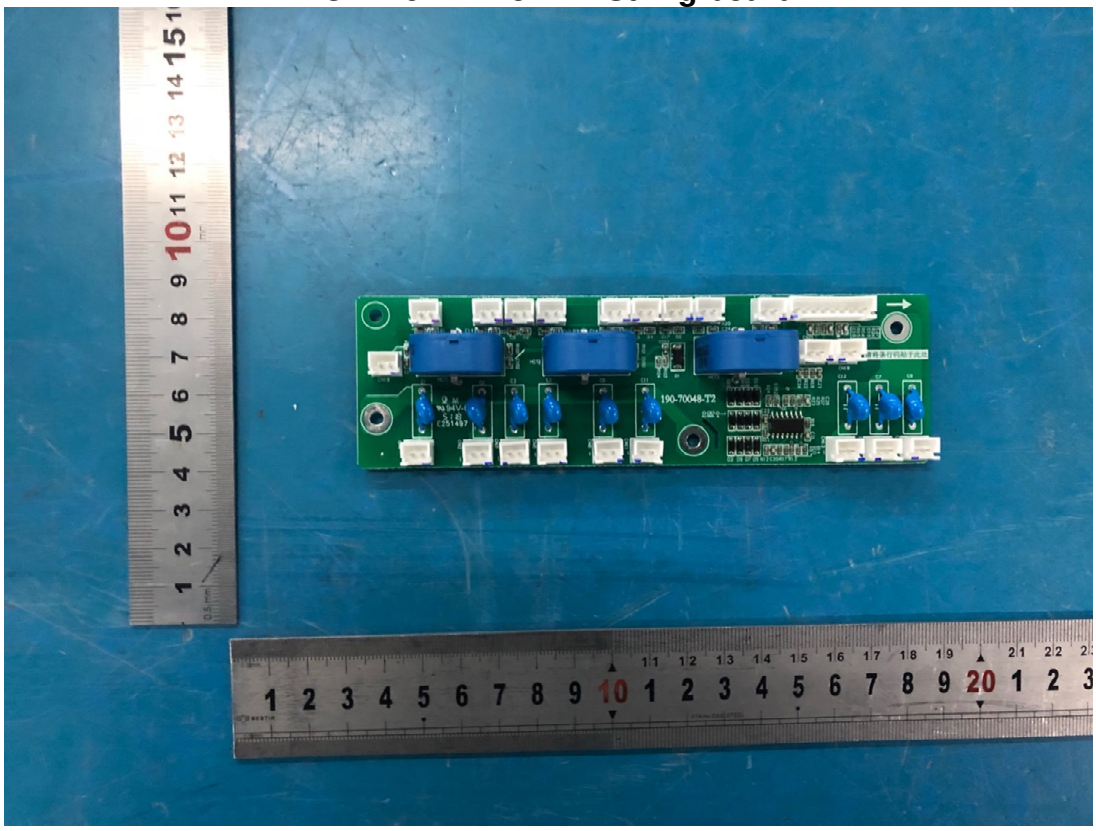
PCB view – 1 of AC lightning protection board



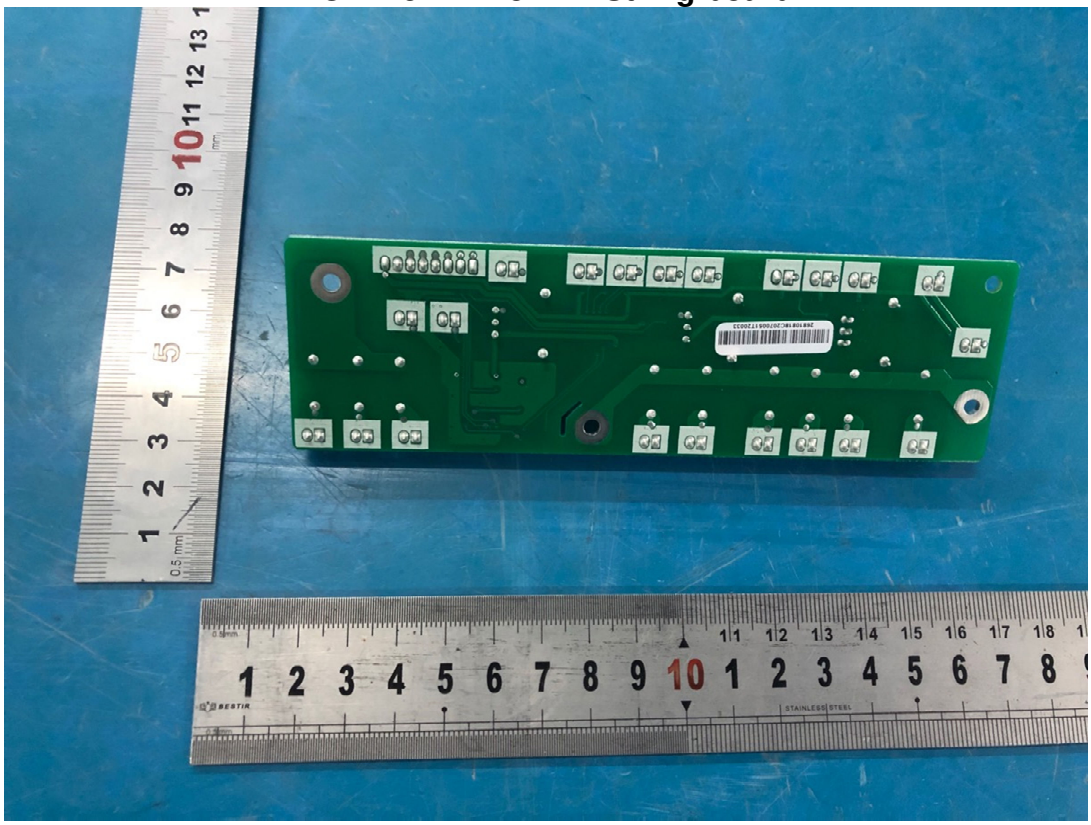
PCB view – 2 of AC lightning protection board



PCB view – 1 of PV String board



PCB view – 2 of PV String board



Annex 2

Test equipment list

Testing Location: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch

Dates of performance test: 2021-07-28 to 2021-08-25

Equipment	Internal No.	Manufacturer	Type	Serial No.	Last Calibration
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	Jul. 19, 2021
Power Analyzer	A4080004DG	DEWESoft	--	DB19104221	Jul. 18, 2021
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
AC Source	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040016DG	Chroma	62150H-1000S	62150EF00490	
DC Simulation Power Supply	A7040017DG	Chroma	620028	620028EF00120	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 24, 2020
Oscilloscope probel	A1490008DG	YOKOGAWA	701901	//	Aug. 12, 2021
Oscilloscope probel	A1490009DG	YOKOGAWA	701901	//	Aug. 12, 2021
Oscilloscope probel	A1490010DG	YOKOGAWA	701901	//	Aug. 12, 2021
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Aug. 09, 2021
Current transducer	A1060008DG	YOKOGAWA	CT200	1130700017	Aug. 09, 2021
Current transducer	A1060009DG	YOKOGAWA	CT200	1130700019	Aug. 09, 2021