VERIFICATION REPORT

The requirement on Grid Connection of Provincial Electricity Authority B.E. 2559 (2016)

Report No.	**: 162/65-002**
EUT No.	**: SC-64-0182**
Laboratory Name	: **Electrical and Electronic Products Testing Center**
Address	: 141 Thailand Science Park, Innovation Cluster 2 Tower D, Phahonyothin Rd., Khlong Nueng, Khlong Luang, Pathum Thani 12120, Thailand
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, IEC 62116:2008, Deviations for Thailand according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016)
Non-standard test method	: -
Test item description	: Grid-tied photovoltaic inverter
Trademark	: GOODWE YOUR SOLAR ENGINE
Model and/or type reference	: GW30K-MT
Date of receipt	: 11 October 2021
Date of report issue	: 12 October 2021

Prepare by

T. Eakkachai

Eakkachai Taesanoo
Engineer

Approved by

N. Ruengrit

Ruengrit Ninae
Operation Manager

Detail of reference test report	
Test Report No.....:	PVTH2103WDG0205-5
Total number of pages. .....:	62
Testing Laboratory.....:	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch** No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China
Testing location.....:	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch** No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China
Test specification .....:	IEC 61727:2004, IEC 62116:2008, Deviations for Thailand according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016)
Tested by.....:	Colin Chen
Reviewed by.....:	-
Approved by	Ken Chan
Date of report issue .....:	2021-09-26

Test item description .....:	Grid-Tied PV Inverter
Trademark .....:	GOODWE
Model and/or type reference .....:	GW30K-MT
Rating	
Input DC MPP voltage range [V]:	200-950
Input DC voltage Max [V].....:	1100
Input DC current [A].....:	30A / 30A / 30A
Output AC voltage [V] .....:	3/N/PE~400 or 3/PE~400, 50Hz
Output AC current [A].....:	48
Output power [kW].....:	30
Firmware Version	V1.11.11.12

Summary of verification report

Test result of report No. **PVTH2103WDG0205-5** was result of Photovoltaic Grid-Tied Inverter model **GW30K-MT**. It was verified by Electrical and Electronic Products Testing Center (PTEC) and **complied** according to Requirements on Grid Connection of Provincial Electricity Authority BE 2559 (2016) as following.

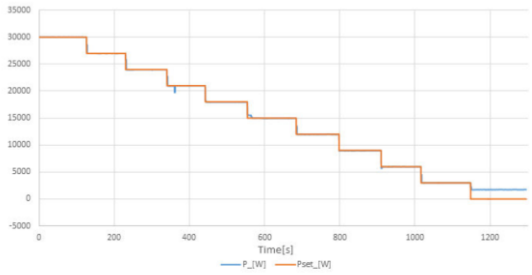
No.	Item	Reference Report No.	Standard Reference	Verdict
1	Active power control	PVTH2103WDG0205-5	PEA	Pass
2	Reactive power control	-	-	-
2.1	A Fixed Displacement Factor cos θ	PVTH2103WDG0205-5	PEA	Pass
2.2	A variable reactive power depending on the voltage Q(U)	-	-	-
3	Under/over frequency protection	PVTH2103WDG0205-5	IEC 61727	Pass
4	Voltage fluctuation	PVTH2103WDG0205-5	IEC 61000-3-11	Pass
5	Harmonics	PVTH2103WDG0205-5	IEEE 1547.1	Pass
6	DC injection	PVTH2103WDG0205-5	IEC 61727	Pass
7	Low voltage fault ride through	-	-	-
8	Under/over voltage protection	PVTH2103WDG0205-5	IEC 61727	Pass
9	Anti-islanding	PVTH2103WDG0205-5	IEC 62116	Pass
10	Response to utility recovery	PVTH2103WDG0205-5	IEC 61727	Pass

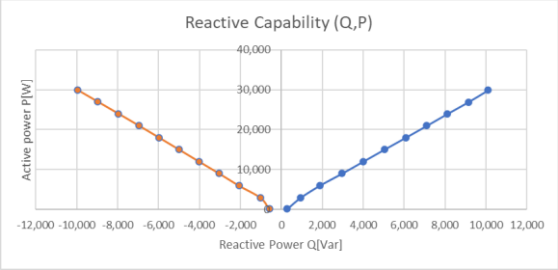
This report consists of the following document:

1. Verification Result (11 Page)
2. Attach Document Reference Report No. PVTH2103WDG0205-5 (62 Page)

Standard Reference.

- **IEEE 1547.1 2005** Interconnecting Distributed Resources with Electric Power Systems
- **IEC 62116:2008**: Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
- **IEC 61727** Photovoltaic (PV) systems - Characteristics of the utility interface
- **IEC 61000-3-11**: Electromagnetic compatibility (EMC) - Part 3-11: Limits - Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current > 75 A
- **PEA**: Thailand according to the grid-connected inverter regulations of the Provincial Electricity Authority (PEA):2016

VERIFICATION REPORT			
Clause	PEA Requirement	Result – Remark	Verdict
8.1.2	**Active Power Control** The power generating system of VSPP must be capable of reducing electric power from 100 %to zero by decreasing 10 % electric power per one minute .In this regard, if there is any abnormality occurred in the grid system or any incident considered by PEA as an impact affecting safety and stability of the grid system, PEA would inform and/or give an order to the VSPP to reduce electric power as appropriate.	**Active Power Control** **1) Requirement** The requirements on Grid Connection of Provincial Electricity Authority **2) Test result** See Test report no : PVTH2103WDG0205-5, Page 45 **3) Verification test result**  The PV inverter is capable of reducing electric power from 100 %to zero by decreasing 10 % electric power per one minute.	Pass
8.1.3	**Reactive Power Control** The power generating system of VSPP must be able to control power factor)PF (or reactive power to maintain voltage level at PCC aligned with PEA's standards .The power generating system of service applicants must have capacity as stated in Table 1.	**Reactive Power Control** **1) Requirement** The requirements on Grid Connection of Provincial Electricity Authority **2) Test result** See Test report no : PVTH2103WDG0205-5, - Page 40 Reactive power capability - Page 41-42 A Fixed Displacement Factor cos θ test result. - No A variable reactive power depending on the voltage Q(U) test result.	Pass

VERIFICATION REPORT			
Clause	PEA Requirement	Result – Remark	Verdict
		3) Verification test result 3.1 Reactive power capability  	Pass
		3.2 A Fixed Displacement Factor cos θ test PF. Set point / PF. Measurement* (Max / Min) 1.0: 0.999 / 0.999 0.95 lagging: 0.960 / 0.950 0.95 Leading: 0.949 / 0.941 *@Pout =10% to 100%	Pass
		3.3 A variable reactive power depending on the voltage Q (U) test -	-
8.2	**Under and Over Frequency Protection** The power generating system of VSPP must disconnect itself from the grid system within 0.1 seconds if the frequency at PCC is not in the range of 47 Hz-52 Hz.	**Under and Over Frequency Protection** 1) Reference Standard IEEE 1547,1-2005 2) Test result See Test report no: PVTH2103WDG0205-5 Page 30-31 3) Verification test result Frequency at PCC / Measured (Sec) / Limit (Sec) / Result f < 47: 0.0665 / <0.1 / Pass f > 52: 0.0660 / <0.1 / Pass	Pass

<table>
<tr><th colspan="4">VERIFICATION REPORT</th></tr>
<tr><th>Clause</th><th>PEA Requirement</th><th>Result – Remark</th><th>Verdict</th></tr>
<tr><td>8.3</td><td>Voltage Fluctuation
The power generating system of VSPP must not create voltage fluctuation exceeding the limit based on the PEA’s rules concerning the Regulations on Grid Connection B.E.2559.

Regulations on Grid Connection B.E.2559.
The operation of the inverter should not cause voltage flicker in excess of limits :
Short-term Severity Values (Pst) not exceed 1.0 Long-term Severity Values (Plt) not exceed 0.8</td><td>Voltage Fluctuation
1) Reference Standard
IEC 61000-3-11

2) Test result
See Test report no : PVTH2103WDG0205-5, Page 14

3) Verification test result
<table><tr><th>Test item</th><th>Limit</th><th>Result</th><th>Verdict</th></tr><tr><td>Pst</td><td>1.0</td><td>0.296</td><td>Pass</td></tr><tr><td>Plt</td><td>0.8</td><td>0.290</td><td>Pass</td></tr></table></td><td>Pass</td></tr>
</table>

VERIFICATION REPORT

Clause	PEA Requirement	Result – Remark	Verdict
8.4	**Harmonic** The power generating system of VSPP must not inject harmonic current to the grid system exceeding the limit based on the PEA's rules concerning the Regulations of Grid Connection B.E.2559. Regulations of Grid Connection B.E.2559. The Inverter output should have low current-distortion and low voltage distortion levels to ensure that no adverse effects are caused to other equipment connected to the utility system .Each individual harmonic shall be limited to the listed in Table 5.1 and Table 5-2 of attach 4.	**Harmonics** **1) Reference Standard** IEEE1547.1-2005 Total harmonic current distortion is less than 5 %at rated inverter output Individual harmonics don't exceed the given distortion limit **2) Test result** See Test report no : PVTH2103WDG0205-5, Page 16 - 20 **3) Verification test result**	Pass

ตารางที่ 5-1

ขีดจำกัดกระแสฮาร์มอนิกสำหรับผู้ใช้ไฟฟ้ารายใดๆที่จุดต่อร่วม *

ระดับแรงดันไฟฟ้าที่จุดต่อร่วม (kV)	อันดับฮาร์มอนิกและขีดจำกัดของกระแส (A rms)																	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0.400	48	34	22	56	11	40	9	8	7	19	6	16	5	5	5	6	4	6
11 and 12	13	8	6	10	4	8	3	3	3	7	2	6	2	2	2	2	1	1
22 , 24 and 33	11	7	5	9	4	6	3	2	2	6	2	5	2	1	1	2	1	1
69	8.8	5.9	4.3	7.3	3.3	4.9	2.3	1.6	1.6	4.9	1.6	4.3	1.6	1	1	1.6	1	1
115 and above	5	4	3	4	2	3	1	1	1	3	1	3	1	1	1	1	1	1

ตารางที่ 5-2

ขีดจำกัดความเพี้ยนฮาร์มอนิกของแรงดันสำหรับผู้ใช้ไฟฟ้ารายใดๆที่จุดต่อร่วม (รวมทั้งระดับความเพี้ยนที่มีอยู่เดิม)

ระดับแรงดันไฟฟ้าที่จุดต่อร่วม (kV)	ค่าความเพี้ยนฮาร์มอนิกรวมของแรงดัน (%)	ค่าความเพี้ยนฮาร์มอนิกของแรงดันแต่ละอันดับ (%)	
		อันดับคี่	อันดับคู่
0.400	5	4	2
11 , 12 , 22 and 24	4	3	1.75
33	3	2	1
69	2.45	1.63	0.82
115 and above	1.5	1	0.5

%Pout	THD (<5%)	THDi	Verdict
33%	0.446	THDi in each harmonic does not exceed in table 5-1	Pass
66%	0.531		Pass
100%	0.582		Pass

Item	Verdict
THDv in each harmonic does not exceed in table 5-2	Pass
Total harmonic voltage distortion less than 5 %	0.067

<table>
<tr><th colspan="4">VERIFICATION REPORT</th></tr>
<tr><th>Clause</th><th>PEA Requirement</th><th>Result – Remark</th><th>Verdict</th></tr>
<tr><td>8.5</td><td>DC Injection
The power generating system of VSPP must not supply direct current to the grid system exceeding the limit based on the PEA’s regulations concerning the Regulations on Grid Connection B.E.2559.

Regulations on Grid Connection B.E.2559.
The inverter shall not inject DC current greater than 0.5 % of the rated inverter output current, into the utility AC interface under any operating condition.</td><td>DC Injection
1) Referrence Standard
IEC 61727

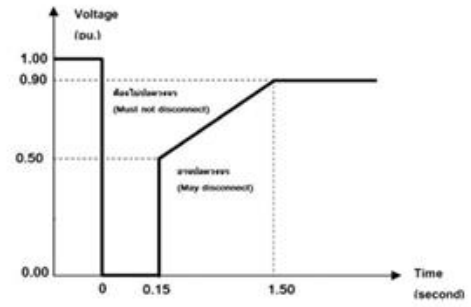
2) Test result
See Test report no: PVTH2103WDG0205-5, Page 15

3) Verification test result
<table>
<tr><th>Output Power</th><th>Limit</th><th>Max.DC</th><th>Verdict</th></tr>
<tr><td>33%</td><td>0.5%</td><td>0.127%</td><td>Pass</td></tr>
<tr><td>66%</td><td>0.5%</td><td>0.446%</td><td>Pass</td></tr>
<tr><td>100%</td><td>0.5%</td><td>0.483%</td><td>Pass</td></tr>
</table></td><td>Pass</td></tr>
</table>

VERIFICATION REPORT

Clause	PEA Requirement	Result – Remark	Verdict
12.1	**Low Voltage Fault Ride Through** The power system of VSPP must not disconnect itself from the grid system within the required period during temporary low voltage of the grid system .The voltage at PCC is determined as shown in Table Fault Ride Through Duration of Low Voltage Fault Ride Through	**Low Voltage Fault Ride Through** **1) Requirement** The requirements on Grid Connection of Provincial Electricity Authority **2) Test result** - **3) Verification test result**	-

Voltage at PCC	Duration Time (Second)
1) Low voltage 2) Moderate voltage or high voltage (electrical installation not exceeding 500 kilowatt).	Not required.
3) Moderate voltage or high voltage (electrical installation exceeding 500 kilowatt).	As shown in Picture 1.



Picture 1. Low Voltage Fault Ride Through

3.1) Output Power >0.9Pn

Test	V (V/Vn)	Duration (mS)	Limit (mS)	verdict
Three-phase faults	0.7-0.8 Vn		>993.75	
	0.3-0.5 Vn		>150	
	0-0.049Vn		>150	
Phase to Phase faults	0.7-0.8 Vn		>993.75	
	0.3-0.5 Vn		>150	
	0-0.049Vn		>150	
Phase to ground faults	0.7-0.8 Vn		>993.75	
	0.3-0.5 Vn		>150	
	0-0.049Vn		>150	

3.2) Output Power 0.3Pn

Test	V (V/Vn)	Duration (mS)	Limit (mS)	verdict
Three-phase faults	0.7-0.8 Vn		>993.75	
	0.3-0.5 Vn		>150	
	0-0.049Vn		>150	
Phase to Phase faults	0.7-0.8 Vn		>993.75	
	0.3-0.5 Vn		>150	
	0-0.049Vn		>150	
Phase to ground faults	0.7-0.8 Vn		>993.75	
	0.3-0.5 Vn		>150	
	0-0.049Vn		>150	

VERIFICATION REPORT

Clause	PEA Requirement	Result – Remark	Verdict
		3.3) Output Power 0.1Pn	-

Test	V (V/Vn)	Duration (mS)	Limit (mS)	verdict
Three-phase faults	0.7-0.8 Vn		>993.75	
	0.3-0.5 Vn		>150	
	0-0.049Vn		>150	
Phase to Phase faults	0.7-0.8 Vn		>993.75	
	0.3-0.5 Vn		>150	
	0-0.049Vn		>150	
Phase to ground faults	0.7-0.8 Vn		>993.75	
	0.3-0.5 Vn		>150	
	0-0.049Vn		>150	

12.2

Under and Over Voltage Protection

The power system of VSPP must disconnect itself from the grid system if voltage level of line to neutral in the utility system is out of ranges as stated in Table 3.

Table 3. The Disconnect Duration of Falling Voltage Out of Rated Voltage Ranges

Voltage at PCC	Disconnect Duration (Second)
V < 50%	0.3
50% ≤ V< 90%	2.0
90% ≤ V ≤ 110%	continual voltage
110% < V < 120%	1.0
V ≥ 120%	0.16

Under and Over Voltage Protection

1) Reference Standard

IEC 61727

2) Test result

See Test report no: PVTH2103WDG0205-5 Page 22-27

3) Verification test result

Voltage at PCC	Max Meas. (Sec)	Limit (Sec)	Result
V < 50%	0.284	<0.3	Pass
50% ≤ V< 90%	1.028	<2.0	Pass
90% ≤ V ≤ 110%	No trip	Cont.	Pass
110% < V < 120%	0.922	<1.0	Pass
V ≥ 120%	0.144	<0.16	Pass

Pass

<table>
<tr><th colspan="4">VERIFICATION REPORT</th></tr>
<tr><th>Clause</th><th>PEA Requirement</th><th>Result – Remark</th><th>Verdict</th></tr>
<tr><td>12.3</td><td>Anti-Islanding
In order to prevent anti-islanding while there is no electricity in grid system to be supplied to the power system of VSPP, the power generating system of VSPP must disconnect itself from the utility system within 1 seconds.</td><td>Anti-Islanding
1) Reference Standard
IEC 62116

2) Test result
See Test report no: PVTH2103WDG0205-5
Page 33-39

3) Verification test result
<table><tr><th>% Off $Pout_{rating}$</th><th>Maximum Runtime (Sec)</th><th>Limit (Sec)</th><th>Result</th></tr><tr><td>100</td><td>0.117</td><td>< 1.0</td><td>Pass</td></tr><tr><td>66</td><td>0.128</td><td>< 1.0</td><td>Pass</td></tr><tr><td>33</td><td>0.149</td><td>< 1.0</td><td>Pass</td></tr></table></td><td>Pass</td></tr>
<tr><td>12.4</td><td>Response to Utility Recovery
After the power generating system of VSPP disconnect itself from the grid system because of power outage or voltage/frequency is out of the ranges, when the grid system is back to normal, the power system of VSPP must delay the time to reconnect itself to the grid system at a minimum of 20 seconds to 5 minutes.</td><td>Response to Utility Recovery
1) Reference Standard
IEC 61727

2) Test result
See Test report no: PVTH2103WDG0205-5
Page 22-23, 28-30, 32

3) Verification test result
<table><tr><th>Limit Recovery time (Sec)</th><th>Max. Mesurement Recovery time (Sec)</th><th>Result</th></tr><tr><td>20 - 300</td><td>41.13</td><td>Pass</td></tr></table></td><td>Pass</td></tr>
</table>

---------- END OF REPORT ----------

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 ..... :	**PVTH2103WDG0205-5**
Date of issue ..... ::	2021-09-26
Testing laboratory name ..... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
Address ..... :	No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China
Accreditation ..... :	ilac-MRA ACCREDITED Certificate # 2951.01
Applicant's name..... :	**Jiangsu Goodwe Power Supply Technology Co.,Ltd.**
Address ..... :	No.90 ZiJin Rd., New District, Suzhou,215011,China
Test specification	
Standard..... :	IEC 61727:2004, IEC 62116:2008, Deviations for Thailand according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016)
Test Report Form No. ..... :	IEC61727/IEC62116_PEA 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 1's name ..... :	**Jiangsu Goodwe Power Supply Technology Co.,Ltd.**
Factory 1 address	No.90 ZiJin Rd., New District, Suzhou,215011,China
Factory 2's name ..... :	**GoodWe(GuangDe) Power Supply Technology Co.,Ltd.**
Factory 2 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 .. :	IP66 according to EN 60529

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 ..... :	2021-05-04
Date(s) of performance of test ..... :	2021-05-04 to 2021-08-24

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.

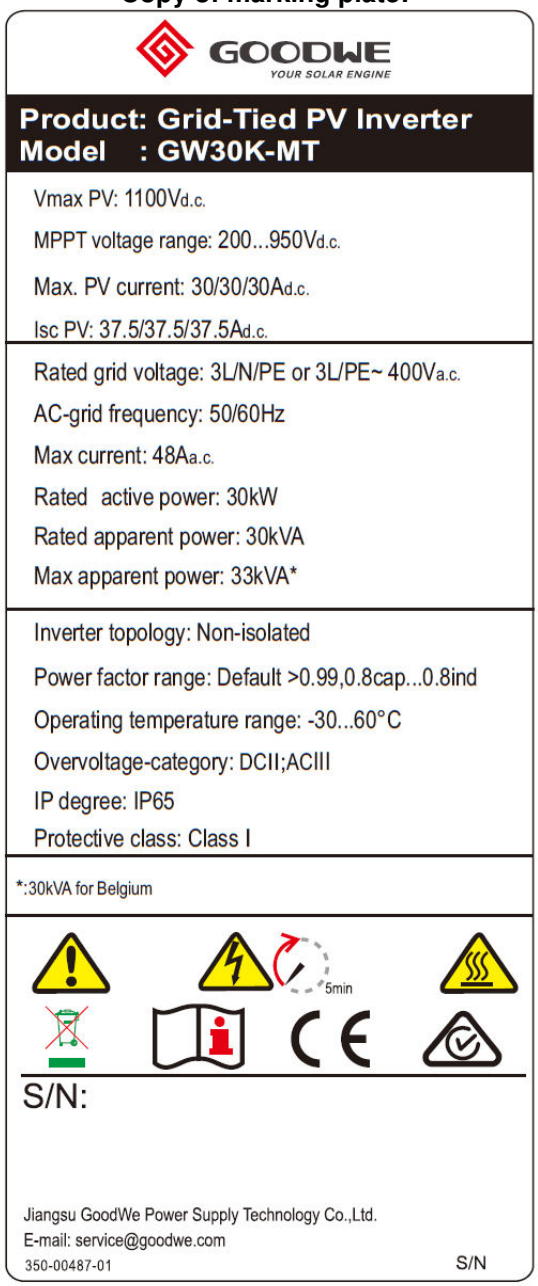
”(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

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

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.

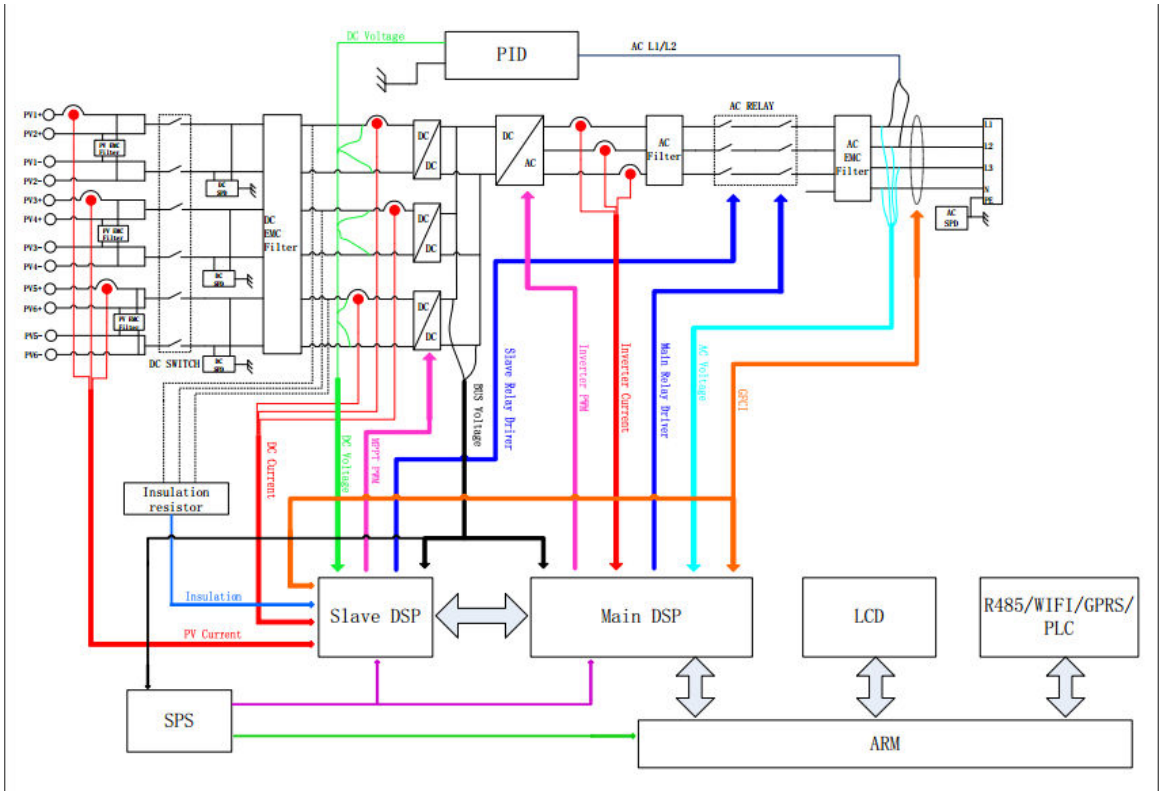


Figure 1 – Block diagram

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

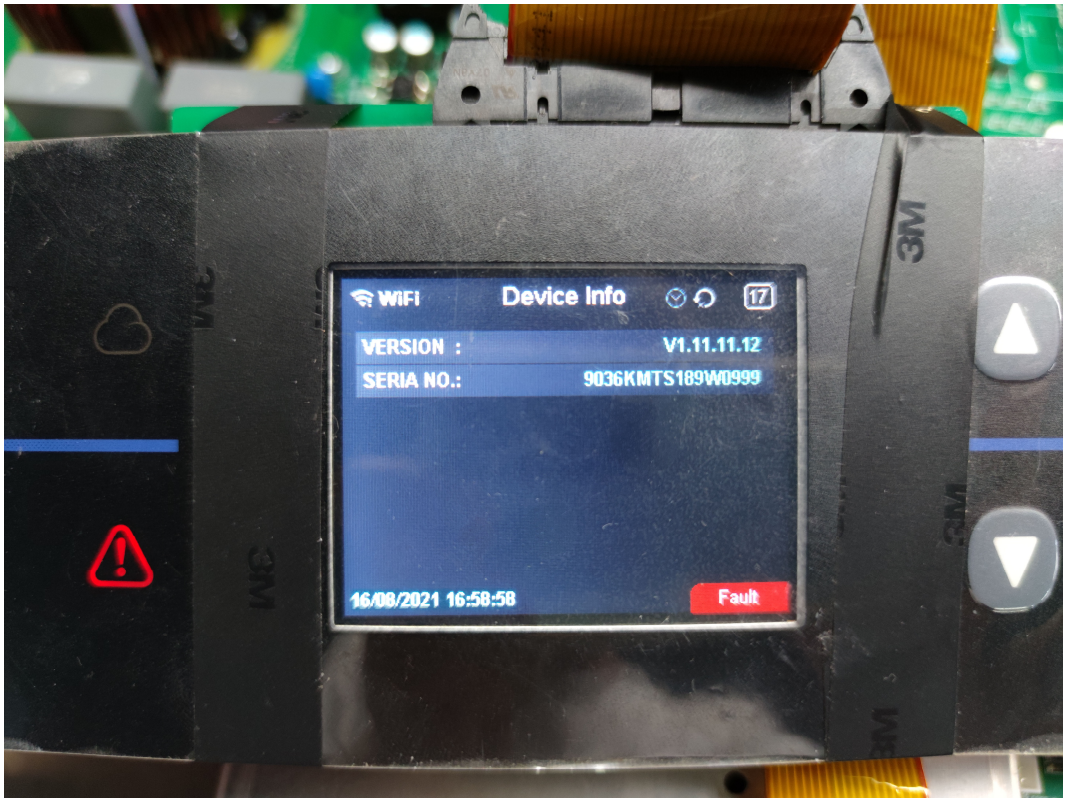


Figure 2 – Photo of software version

Interface protection settings with deviations according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016) **(Thailand PEA)**		
Parameter	**Max. clearance time***	**Trip setting**
Over voltage (level 2)	0,16s	220V +20% (264V)
Over voltage (level 1)	1,0s	220V +10% (242V)
Under voltage (level 1)	2,0s	220V -10% (198V)
Under voltage (level 2)	0,3s	220V -50% (110V)
Over frequency	0,1s	50Hz +4% (52,0Hz)
Under frequency	0,1s	50Hz -6% (47,0Hz)
Reconnection time	20s - 5min	
Permanent DC-injection	0,5% of rated inverter output current	
Loss of main IEC 62116:2008	Inverter shall detect and disconnect within 1s	
* 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 0.5% of the rated inverter output current, into the utility AC interface under any operating condition.	The following deviations were used: Provincial Electricity Authority (PEA:2016) 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: Provincial Electricity Authority (PEA:2016) See table 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: Provincial Electricity Authority (PEA:2016) 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 3.4	**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: Provincial Electricity Authority (PEA:2016)	**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: Provincial Electricity Authority (PEA:2016) 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: Provincial Electricity Authority (PEA:2016) See table 5.2.1	**P**

IEC61727:2004			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 5: Personnel safety and equipment protection			
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: Provincial Electricity Authority (PEA:2016) See table 5.2.2	**P**
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: Provincial Electricity Authority (PEA:2016) See table 6.1	**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	**Type Test**	**Result**
4	Type test:	
4.3	Voltage Fluctuations and Flicker (see Annex 1 EMC Report)	**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	**Type Test**	**Result**
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**

Deviations for Thailand according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016)		
Clause	**Type Test**	**Result**
3.4	Reactive power control	
3.4.1, 8.1.2	A fixed displacement factor cosφ	**P**
3.4.2, 8.1.2	A variable reactive power depending on the voltage Q(U)	**N/A**
3.5, 12.1	Active power control	**P**
3.6, 12.2	Low voltage fault ride through capability	**N/A**

Test Results

4.3 Voltage fluctuation and flicker **3.2, 8.3 Voltage Fluctuation Regulation (PEA 2016)**				**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}=0,8
Test value	*	*	*	*
inverter >16A				
Limit	dc% = 3,3	P_{st}=1,0	P_{lt}=0,8	
Test value	*	L1: 0,154	L1: 0,148	
	*	L2: 0,296	L2: 0,290	
	*	L3: 0,137	L3: 0,131	

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

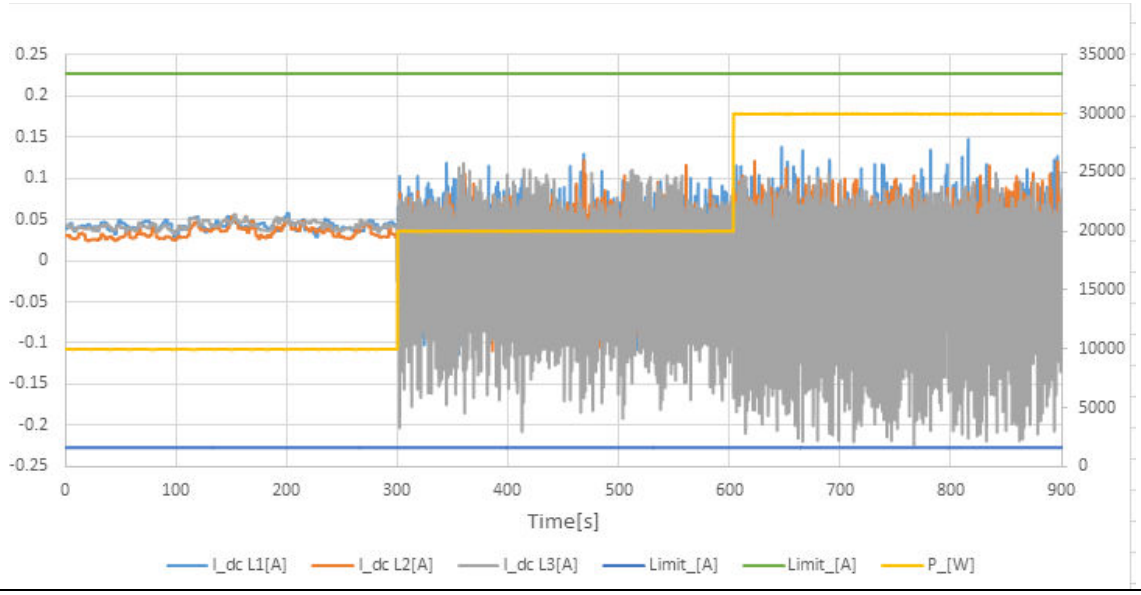
Mains Impedance according EN61000-3-11: **R_{max} = 0,24Ω; jX_{max}= 0,15Ω @50Hz ($|Z_{max}|$ = 0,283 Ω)**
for single phase inverter use also **R_n = 0,1Ω; jX_n= 0,1Ω**

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 **3.3, 8.5 Direct Current Dispatch to the Power Network System (PEA:2016)**			**P**
PEA Limit:	**0,5% of I_{nom} : 227mA**		
Output power:	33%	66%	100%
Max. test value (mA): L1 phase	57,5	129,3	147,5
Mean test value(mA) : L1 phase	42,0	34,2	37,3
Max. test value (mA): L2 phase	53,9	123,5	133,6
Mean test value (mA): L2 phase	34,0	43,9	49,9
Max. test value (mA): L3 phase	56,0	202,3	219,4
Mean test value (mA): L3 phase	42,5	49,7	59,0

Diagram of permanent DC-injection



Note:

4.6 Harmonic Current Limit Test the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016)	P

33% Output Power			
Watts (W)	3299,082	3330,088	3338,846
VA (VA)	3302,329	3338,564	3342,640
Vrms (V)	220,295	220,496	220,102
Arms (A)	15,002	15,002	15,139
PF	1,00		
Frequency (Hz)	50,00		
THD50 (%)	0,382	0,382	0,446

Harmonics	Current Magnitude [A]			% of Rated Current			Phase	Harmonic Current Limits [%]
1st	15,002	15,002	15,139	32,972	32,972	33,272	Three Phase	--
2nd	0,058	0,058	0,109	0,127	0,127	0,240	Three Phase	1
3rd	0,037	0,037	0,050	0,082	0,082	0,110	Three Phase	4
4th	0,020	0,020	0,030	0,045	0,045	0,066	Three Phase	1
5th	0,045	0,045	0,083	0,099	0,099	0,181	Three Phase	4
6th	0,033	0,033	0,015	0,071	0,071	0,033	Three Phase	1
7th	0,058	0,058	0,016	0,127	0,127	0,035	Three Phase	4
8th	0,014	0,014	0,026	0,032	0,032	0,057	Three Phase	1
9th	0,055	0,055	0,014	0,122	0,122	0,031	Three Phase	4
10th	0,018	0,018	0,021	0,040	0,040	0,046	Three Phase	1
11th	0,014	0,014	0,048	0,032	0,032	0,105	Three Phase	2
12th	0,019	0,019	0,011	0,041	0,041	0,023	Three Phase	0,5
13th	0,028	0,028	0,016	0,061	0,061	0,036	Three Phase	2
14th	0,019	0,019	0,012	0,041	0,041	0,026	Three Phase	0,5
15th	0,019	0,019	0,013	0,041	0,041	0,029	Three Phase	2
16th	0,018	0,018	0,027	0,039	0,039	0,060	Three Phase	0,5
17th	0,014	0,014	0,034	0,031	0,031	0,075	Three Phase	1,5
18th	0,020	0,020	0,010	0,044	0,044	0,021	Three Phase	0,375
19th	0,016	0,016	0,026	0,036	0,036	0,058	Three Phase	1,5
20th	0,033	0,033	0,016	0,072	0,072	0,036	Three Phase	0,375
21th	0,020	0,020	0,012	0,044	0,044	0,027	Three Phase	1,5
22th	0,025	0,025	0,031	0,056	0,056	0,068	Three Phase	0,375
23th	0,026	0,026	0,031	0,057	0,057	0,068	Three Phase	0,6
24th	0,019	0,019	0,010	0,042	0,042	0,022	Three Phase	0,15
25th	0,021	0,021	0,037	0,045	0,045	0,082	Three Phase	0,6
26th	0,035	0,035	0,023	0,076	0,076	0,050	Three Phase	0,15
27th	0,014	0,014	0,009	0,031	0,031	0,019	Three Phase	0,6
28th	0,032	0,032	0,033	0,071	0,071	0,072	Three Phase	0,15
29th	0,023	0,023	0,020	0,050	0,050	0,045	Three Phase	0,6
30th	0,015	0,015	0,012	0,034	0,034	0,026	Three Phase	0,15
31th	0,019	0,019	0,030	0,041	0,041	0,066	Three Phase	0,6
32th	0,029	0,029	0,025	0,063	0,063	0,056	Three Phase	0,15
33th	0,013	0,013	0,008	0,028	0,028	0,016	Three Phase	0,6
34th	0,026	0,026	0,022	0,057	0,057	0,048	Three Phase	0,15
35th	0,017	0,017	0,014	0,037	0,037	0,030	Three Phase	0,3

36th	0,010	0,010	0,010	0,022	0,022	0,021	Three Phase	0,075
37th	0,011	0,011	0,015	0,023	0,023	0,034	Three Phase	0,3
38th	0,016	0,016	0,022	0,035	0,035	0,047	Three Phase	0,075
39th	0,007	0,007	0,007	0,016	0,016	0,015	Three Phase	0,3
40th	0,020	0,020	0,016	0,043	0,043	0,035	Three Phase	0,075
41th	0,009	0,009	0,010	0,020	0,020	0,023	Three Phase	N/A
42th	0,007	0,007	0,008	0,016	0,016	0,018	Three Phase	N/A
43th	0,017	0,017	0,016	0,038	0,038	0,035	Three Phase	N/A
44th	0,011	0,011	0,017	0,024	0,024	0,038	Three Phase	N/A
45th	0,007	0,007	0,008	0,016	0,016	0,018	Three Phase	N/A
46th	0,014	0,014	0,015	0,032	0,032	0,034	Three Phase	N/A
47th	0,021	0,021	0,020	0,046	0,046	0,045	Three Phase	N/A
48th	0,007	0,007	0,008	0,016	0,016	0,018	Three Phase	N/A
49th	0,020	0,020	0,020	0,045	0,045	0,043	Three Phase	N/A
50th	0,011	0,011	0,012	0,025	0,025	0,027	Three Phase	N/A

66% Output Power								
Watts (W)				6642,913		6679,319		6689,267
VA (VA)				6644,417		6681,851		6690,009
Vrms (V)				220,711		220,686		220,550
Arms (A)				30,105		30,278		30,333
PF				1,00				
Frequency (Hz)				50,00				
THD50 (%)				0,442		0,513		0,531
Harmonics	**Current Magnitude [A]**			**% of Rated Current**			**Phase**	**Harmonic Current Limits [%]**
1st	30,103	30,276	30,332	66,162	66,540	66,663	Three Phase	--
2nd	0,052	0,111	0,080	0,114	0,243	0,176	Three Phase	1
3rd	0,058	0,088	0,105	0,127	0,194	0,231	Three Phase	4
4th	0,034	0,044	0,062	0,076	0,096	0,137	Three Phase	1
5th	0,048	0,073	0,047	0,105	0,161	0,103	Three Phase	4
6th	0,034	0,032	0,041	0,075	0,070	0,089	Three Phase	1
7th	0,075	0,038	0,066	0,164	0,083	0,145	Three Phase	4
8th	0,023	0,035	0,044	0,051	0,077	0,098	Three Phase	1
9th	0,057	0,025	0,062	0,125	0,054	0,136	Three Phase	4
10th	0,023	0,026	0,029	0,051	0,057	0,063	Three Phase	1
11th	0,030	0,036	0,031	0,066	0,079	0,068	Three Phase	2
12th	0,022	0,026	0,028	0,048	0,058	0,062	Three Phase	0,5
13th	0,029	0,030	0,029	0,065	0,065	0,064	Three Phase	2
14th	0,021	0,026	0,029	0,047	0,058	0,064	Three Phase	0,5
15th	0,029	0,025	0,034	0,063	0,054	0,075	Three Phase	2
16th	0,020	0,024	0,024	0,044	0,054	0,052	Three Phase	0,5
17th	0,036	0,031	0,021	0,079	0,068	0,047	Three Phase	1,5
18th	0,022	0,023	0,025	0,049	0,050	0,056	Three Phase	0,375
19th	0,030	0,026	0,024	0,066	0,057	0,053	Three Phase	1,5
20th	0,022	0,024	0,032	0,049	0,052	0,070	Three Phase	0,375
21th	0,028	0,023	0,034	0,063	0,051	0,076	Three Phase	1,5
22th	0,018	0,027	0,027	0,039	0,058	0,058	Three Phase	0,375

23th	0,025	0,034	0,019	0,055	0,074	0,042	Three Phase	0,6
24th	0,019	0,021	0,022	0,041	0,045	0,049	Three Phase	0,15
25th	0,037	0,025	0,024	0,082	0,054	0,053	Three Phase	0,6
26th	0,024	0,026	0,035	0,054	0,057	0,077	Three Phase	0,15
27th	0,018	0,023	0,026	0,039	0,050	0,058	Three Phase	0,6
28th	0,022	0,032	0,031	0,049	0,071	0,068	Three Phase	0,15
29th	0,031	0,041	0,028	0,067	0,090	0,062	Three Phase	0,6
30th	0,019	0,022	0,023	0,042	0,048	0,052	Three Phase	0,15
31th	0,032	0,025	0,027	0,071	0,055	0,059	Three Phase	0,6
32th	0,030	0,024	0,034	0,066	0,053	0,075	Three Phase	0,15
33th	0,020	0,022	0,023	0,043	0,049	0,051	Three Phase	0,6
34th	0,026	0,034	0,031	0,057	0,076	0,068	Three Phase	0,15
35th	0,025	0,032	0,024	0,056	0,071	0,052	Three Phase	0,3
36th	0,014	0,012	0,011	0,030	0,027	0,024	Three Phase	0,075
37th	0,020	0,016	0,018	0,043	0,036	0,040	Three Phase	0,3
38th	0,017	0,014	0,017	0,037	0,032	0,037	Three Phase	0,075
39th	0,011	0,011	0,012	0,024	0,024	0,026	Three Phase	0,3
40th	0,014	0,017	0,015	0,030	0,037	0,034	Three Phase	N/A
41th	0,011	0,018	0,016	0,025	0,041	0,035	Three Phase	N/A
42th	0,009	0,009	0,009	0,019	0,020	0,020	Three Phase	N/A
43th	0,011	0,009	0,010	0,025	0,021	0,022	Three Phase	N/A
44th	0,014	0,011	0,012	0,030	0,024	0,027	Three Phase	N/A
45th	0,008	0,008	0,008	0,017	0,017	0,018	Three Phase	N/A
46th	0,014	0,016	0,014	0,031	0,036	0,031	Three Phase	N/A
47th	0,007	0,010	0,008	0,016	0,021	0,017	Three Phase	N/A
48th	0,007	0,008	0,007	0,016	0,017	0,016	Three Phase	N/A
49th	0,028	0,026	0,023	0,062	0,056	0,051	Three Phase	N/A
50th	0,013	0,014	0,012	0,028	0,030	0,027	Three Phase	N/A

100% Output Power								
Watts (W)				9954,417		9994,894		10013,001
VA (VA)				9956,053		9997,829		10013,952
Vrms (V)				221,054		220,969		220,838
Arms (A)				45,039		45,245		45,345
PF				1,00				
Frequency (Hz)				50,00				
THD50 (%)				0,514		0,562		0,582
Harmonics	**Current Magnitude [A]**			**% of Rated Current**			**Phase**	**Harmonic Current Limits [%]**
1st	45,036	45,241	45,341	98,980	99,431	99,651	Three Phase	--
2nd	0,055	0,103	0,083	0,121	0,227	0,182	Three Phase	1
3rd	0,064	0,066	0,083	0,141	0,144	0,182	Three Phase	4
4th	0,058	0,040	0,080	0,127	0,089	0,176	Three Phase	1
5th	0,044	0,109	0,074	0,097	0,240	0,164	Three Phase	4
6th	0,045	0,038	0,052	0,098	0,083	0,115	Three Phase	1
7th	0,080	0,034	0,069	0,177	0,075	0,151	Three Phase	4
8th	0,022	0,031	0,034	0,049	0,068	0,075	Three Phase	1
9th	0,061	0,026	0,072	0,134	0,056	0,158	Three Phase	4

10th	0,026	0,027	0,030	0,056	0,060	0,065	Three Phase	1
11th	0,026	0,045	0,048	0,058	0,100	0,105	Three Phase	2
12th	0,024	0,027	0,031	0,052	0,059	0,068	Three Phase	0,5
13th	0,030	0,032	0,031	0,067	0,071	0,068	Three Phase	2
14th	0,022	0,029	0,029	0,049	0,063	0,063	Three Phase	0,5
15th	0,029	0,027	0,040	0,064	0,059	0,088	Three Phase	2
16th	0,021	0,025	0,026	0,046	0,055	0,056	Three Phase	0,5
17th	0,041	0,031	0,025	0,091	0,068	0,054	Three Phase	1,5
18th	0,023	0,024	0,027	0,050	0,053	0,059	Three Phase	0,375
19th	0,034	0,033	0,024	0,074	0,072	0,053	Three Phase	1,5
20th	0,022	0,026	0,032	0,049	0,058	0,070	Three Phase	0,375
21th	0,029	0,028	0,038	0,063	0,061	0,083	Three Phase	1,5
22th	0,020	0,025	0,027	0,045	0,055	0,060	Three Phase	0,375
23th	0,033	0,030	0,024	0,073	0,065	0,054	Three Phase	0,6
24th	0,019	0,023	0,025	0,042	0,050	0,055	Three Phase	0,15
25th	0,043	0,036	0,022	0,094	0,079	0,048	Three Phase	0,6
26th	0,022	0,027	0,033	0,048	0,060	0,073	Three Phase	0,15
27th	0,020	0,025	0,030	0,045	0,055	0,067	Three Phase	0,6
28th	0,023	0,027	0,030	0,051	0,059	0,066	Three Phase	0,15
29th	0,043	0,048	0,033	0,095	0,105	0,073	Three Phase	0,6
30th	0,022	0,027	0,028	0,048	0,058	0,061	Three Phase	0,15
31th	0,049	0,045	0,034	0,107	0,100	0,074	Three Phase	0,6
32th	0,028	0,028	0,033	0,061	0,062	0,073	Three Phase	0,15
33th	0,027	0,028	0,028	0,059	0,061	0,062	Three Phase	0,6
34th	0,031	0,034	0,035	0,068	0,074	0,078	Three Phase	0,15
35th	0,048	0,051	0,037	0,105	0,112	0,081	Three Phase	0,3
36th	0,017	0,016	0,013	0,038	0,036	0,029	Three Phase	0,075
37th	0,029	0,027	0,023	0,063	0,060	0,051	Three Phase	0,3
38th	0,017	0,017	0,019	0,037	0,036	0,041	Three Phase	0,075
39th	0,014	0,015	0,015	0,031	0,032	0,033	Three Phase	0,3
40th	0,015	0,017	0,018	0,033	0,036	0,039	Three Phase	0,075
41th	0,019	0,028	0,024	0,043	0,062	0,052	Three Phase	N/A
42th	0,010	0,012	0,012	0,023	0,027	0,027	Three Phase	N/A
43th	0,031	0,029	0,027	0,068	0,063	0,060	Three Phase	N/A
44th	0,013	0,012	0,013	0,029	0,027	0,030	Three Phase	N/A
45th	0,009	0,011	0,010	0,020	0,023	0,022	Three Phase	N/A
46th	0,012	0,014	0,014	0,027	0,032	0,031	Three Phase	N/A
47th	0,021	0,029	0,022	0,046	0,063	0,049	Three Phase	N/A
48th	0,009	0,011	0,010	0,020	0,023	0,022	Three Phase	N/A
49th	0,034	0,031	0,033	0,075	0,069	0,072	Three Phase	N/A
50th	0,016	0,012	0,013	0,036	0,026	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 Provincial Electricity Authority (PEA:2016).								

4.6 Harmonic Voltage Limit Test the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016)								P
Vrms (V)				221,1/221,0/220,8				
Frequency (Hz)				50,00				
THD40 (%)				0,061/0,067/0,063				
Harmonics	**Voltage Magnitude [V]**			**% of Rated Voltage**			**Phase**	**Limits [%]**
2nd	0,010	0.014	0.011	0.004	0.006	0.005	Three Phase	0,2
3rd	0,020	0.039	0.014	0.009	0.017	0.006	Three Phase	4
4th	0,009	0.028	0.013	0.004	0.012	0.005	Three Phase	0,2
5th	0,104	0.109	0.116	0.045	0.048	0.050	Three Phase	4
6th	0,009	0.011	0.010	0.004	0.005	0.004	Three Phase	0,2
7th	0,038	0.033	0.029	0.016	0.014	0.013	Three Phase	4
8th	0,014	0.017	0.012	0.006	0.008	0.005	Three Phase	0,2
9th	0,033	0.032	0.033	0.014	0.014	0.014	Three Phase	2
10th	0,017	0.018	0.012	0.007	0.008	0.005	Three Phase	0,2
11th	0,019	0.025	0.027	0.008	0.011	0.012	Three Phase	0,1
12th	0,012	0.011	0.009	0.005	0.005	0.004	Three Phase	0,1
13th	0,016	0.014	0.009	0.007	0.006	0.004	Three Phase	0,1
14th	0,010	0.013	0.009	0.004	0.006	0.004	Three Phase	0,1
15th	0,010	0.014	0.008	0.004	0.006	0.004	Three Phase	0,1
16th	0,011	0.014	0.011	0.005	0.006	0.005	Three Phase	0,1
17th	0,015	0.016	0.013	0.006	0.007	0.006	Three Phase	0,1
18th	0,010	0.010	0.010	0.004	0.004	0.004	Three Phase	0,1
19th	0,013	0.011	0.009	0.005	0.005	0.004	Three Phase	0,1
20th	0,010	0.012	0.009	0.004	0.005	0.004	Three Phase	0,1
21th	0,012	0.015	0.009	0.005	0.007	0.004	Three Phase	0,1
22th	0,009	0.012	0.010	0.004	0.005	0.004	Three Phase	0,1
23th	0,012	0.014	0.009	0.005	0.006	0.004	Three Phase	0,1
24th	0,009	0.010	0.010	0.004	0.004	0.004	Three Phase	0,1
25th	0,012	0.011	0.009	0.005	0.005	0.004	Three Phase	0,1
26th	0,009	0.010	0.009	0.004	0.004	0.004	Three Phase	0,1
27th	0,010	0.014	0.009	0.004	0.006	0.004	Three Phase	0,1
28th	0,010	0.010	0.011	0.004	0.004	0.005	Three Phase	0,1
29th	0,011	0.013	0.010	0.005	0.006	0.004	Three Phase	0,1
30th	0,009	0.010	0.010	0.004	0.004	0.004	Three Phase	0,1
31th	0,011	0.011	0.010	0.005	0.005	0.004	Three Phase	0,1
32th	0,010	0.010	0.010	0.004	0.004	0.004	Three Phase	0,1
33th	0,010	0.012	0.010	0.004	0.005	0.004	Three Phase	0,1
34th	0,011	0.011	0.012	0.005	0.005	0.005	Three Phase	0,1
35th	0,013	0.014	0.011	0.005	0.006	0.005	Three Phase	0,1
36th	0,011	0.011	0.010	0.005	0.005	0.004	Three Phase	0,1
37th	0,012	0.012	0.011	0.005	0.005	0.005	Three Phase	0,1
38th	0,010	0.011	0.010	0.004	0.005	0.004	Three Phase	0,1
39th	0,011	0.012	0.009	0.005	0.005	0.004	Three Phase	0,1
40th	0,011	0.011	0.011	0.005	0.005	0.005	Three Phase	0,1
Note: The harmonics are tested and evaluated according the IEEE1547.1-2005 clause 5.11.1 according the grid-connected inverter regulations of the Provincial Electricity Authority (PEA:2016).								

4.7 Power factor(PEA) **3.1, 8.4 Harmonic Regulation (PEA: 2016)**					**P**
Test conditions:					
Output power [kW] / **Test AC voltage [V]**	**~10%**	**~25%**	**~50%**	**~75%**	**~100%**
--	--	--	--	--	--

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.

Test result refer to table 3.4.1, 8.1.2 1.

5.2.1 Voltage monitoring **3.7, 12.3 Under and Over Voltage Protection (PEA:2016)** **3.10, 12.5 Response to utility recovery (PEA:2016)**	**P**

First Level (Phase to Neutral)

Test conditions:	Output power:20 KW Frequency: 50Hz									
	Under Voltage					**Over Voltage**				
		Voltage [V]					Voltage [V]			
Set value		**198V**					**242V**			
Measured trip value		All	L1	L2	L3		All	L1	L2	L3
		197,1	197,0	196,8	197,5		241,7	241,7	241,6	241,9
		197,1	197,0	196,8	197,5		241,8	241,7	241,6	242,0
		197,1	197,0	196,8	197,5		241,8	241,7	241,6	242,0
Parameter		Time [s]					Time [s]			
Limit		**<= 2,0s**					**<= 1,0s**			
Disconnetion time	220V to 203V (4s min) to 193V	All	L1	L2	L3	220V to 237V (2s min) to 247V	All	L1	L2	L3
		1,011	1,013	1,021	1,025		0,915	0,916	0,922	0,912
		1,018	1,009	1,013	1,011		0,902	0,905	0,907	0,911
		1,012	1,028	1,005	1,027		0,911	0,915	0,919	0,914
Reconnection time	20s - 5min	41,13 s				20s - 5min	41,13 s			

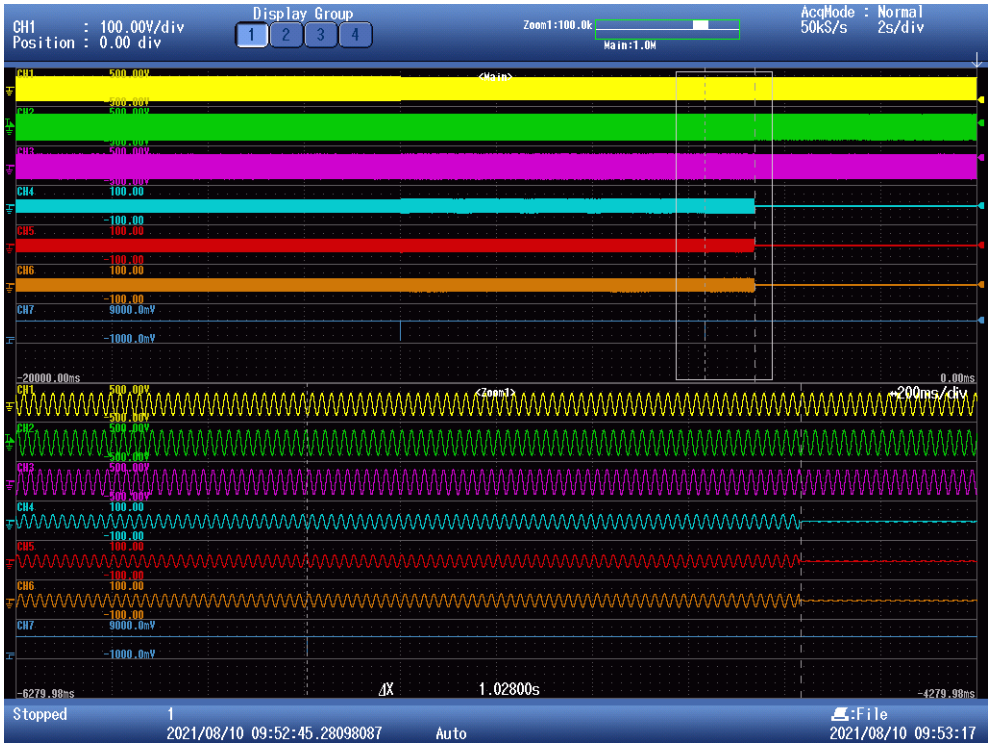
Second Level (Phase to Neutral)										
Test conditions:	Output power: 20KW Frequency: 50Hz									
	Under Voltage					**Over Voltage**				
Parameter		Voltage [V]					Voltage [V]			
Set value		**110V**					**264V**			
Measured trip value		All	L1	L2	L3		All	L1	L2	L3
		109,5	109,2	109,4	109,8		263,8	263,7	263,4	264,2
		109,5	109,3	109,4	109,8		263,8	263,8	263,4	264,2
		109,5	109,3	109,4	109,8		263,8	263,8	263,4	264,2
Parameter		Time [ms]					Time [ms]			
Limit		**<= 300ms**					**<= 160ms**			
Disconnection time	220V to 203V (0,6s min) to 105V	All	L1	L2	L3	220V to 237V (0,32s min) to 269V	All	L1	L2	L3
		257,0	268,0	262,0	255,0		120,8	142,5	125,5	133,8
		251,0	262,0	260,0	256,0		133,3	128,0	144,5	125,8
		250,0	256,0	284,0	258,0		134,0	133,0	132,8	140,8
Reconnection time	20s - 5min	41,1s				20s - 5min	41,1s			

Note:

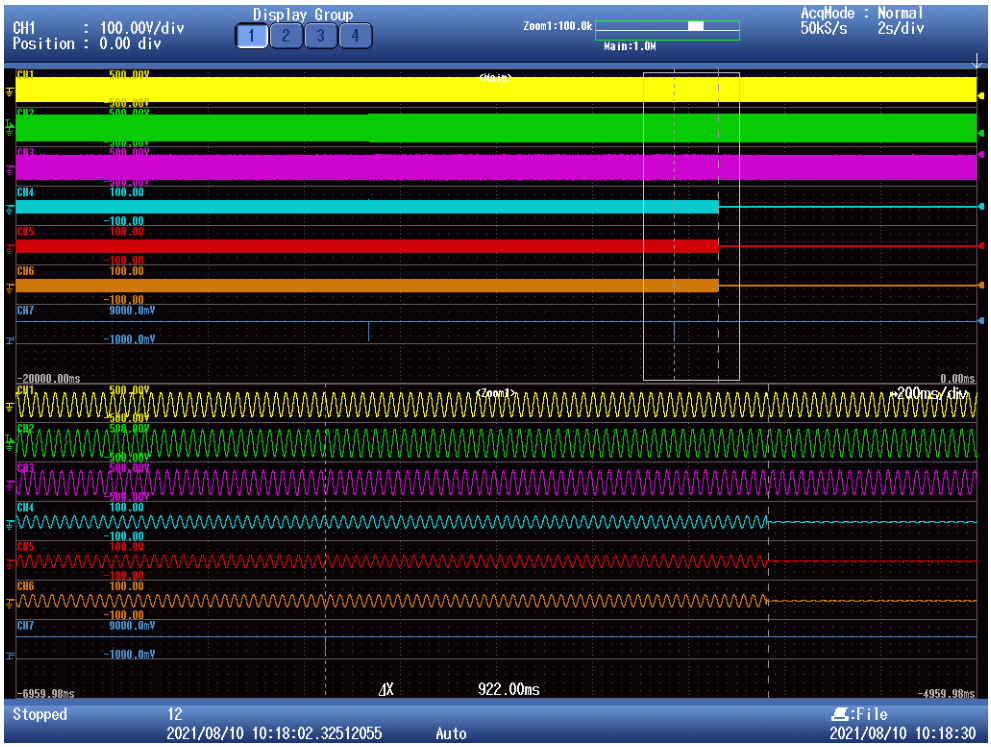
The tests are according PEA:2016, The voltage settings of the EUT are set for the tests as stated to 198V, 110V for undervoltage and 242V, 264V for overvoltage,

Response to utility recovery is according to the appropriate IEEE or IEC standard test methods,

Under Voltage First Level single phase

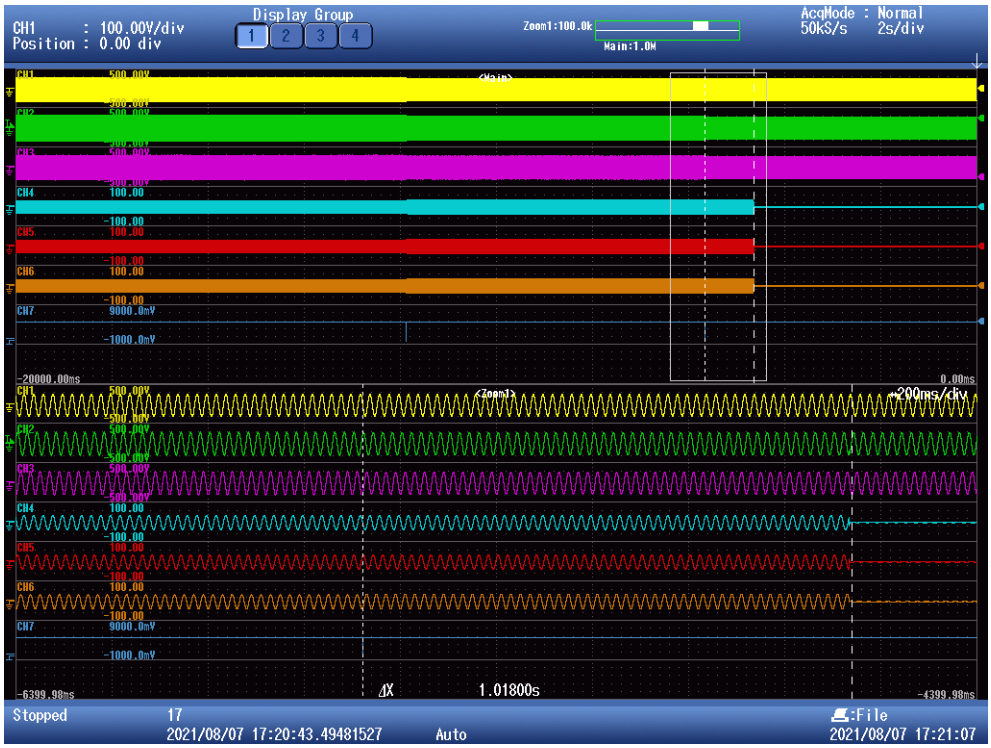


Over voltage First Level single phase

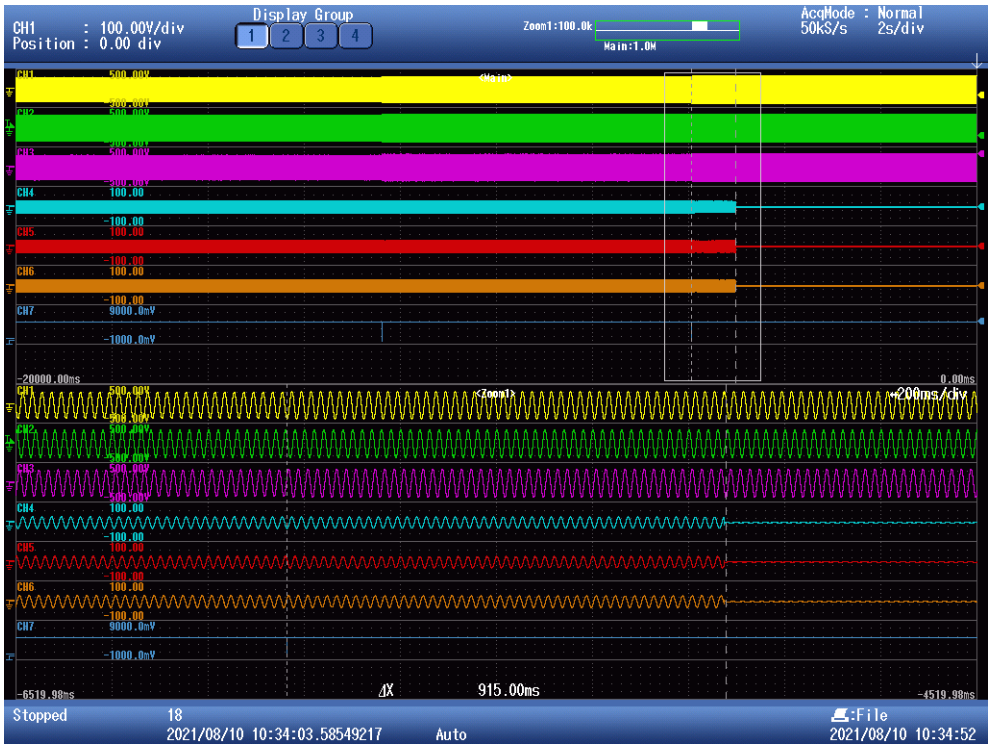


Note: CH1,CH2,CH3:grid voltage(1000V/div); CH4,CH5,CH6: current of EUT(20A/div); CH7 trip signal (100mV/div)

Under Voltage First Level all phases

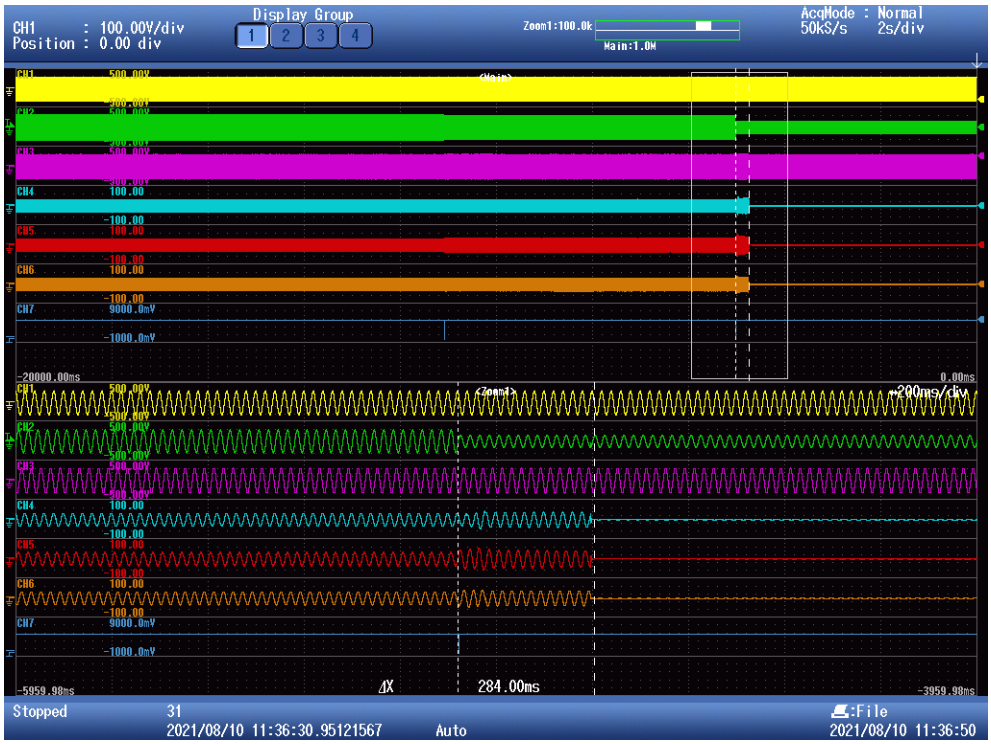


Over voltage First Level all phases



Note: CH1,CH2,CH3:grid voltage(1000V/div); CH4,CH5,CH6: current of EUT(20A/div); CH7 trip signal (100mV/div)

Under Voltage Second Level single phase

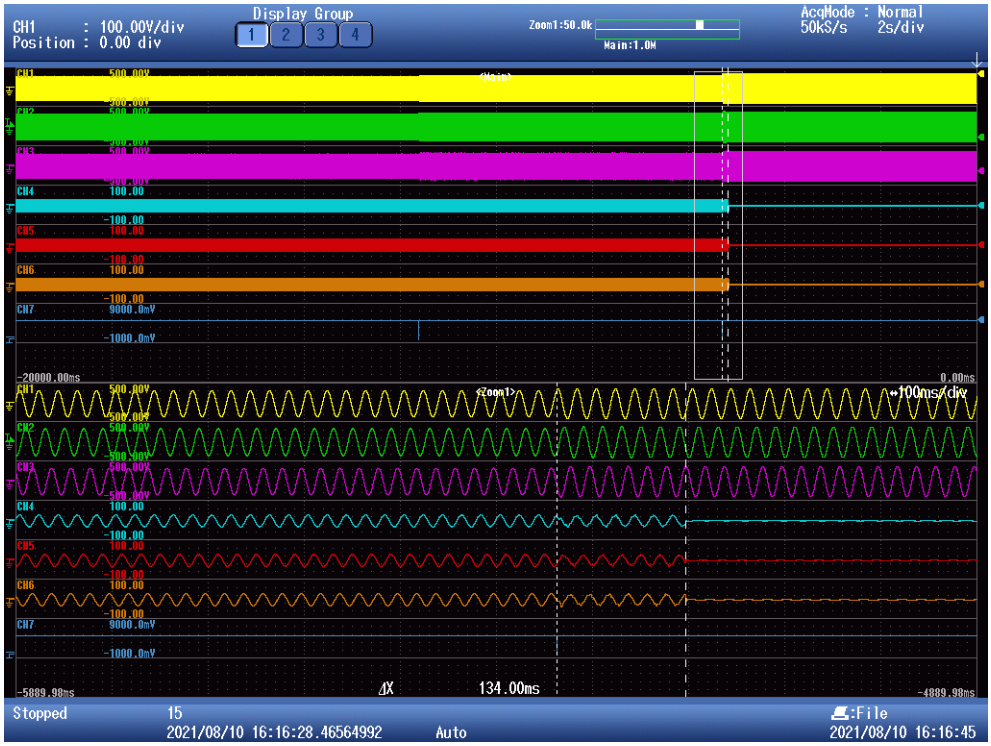


Over voltage Second Level single phase

Note: CH1,CH2,CH3:grid voltage(1000V/div); CH4,CH5,CH6: current of EUT(20A/div); CH7 trip signal (100mV/div)

Under Voltage Second Level all phase

Over voltage Second Level all phase



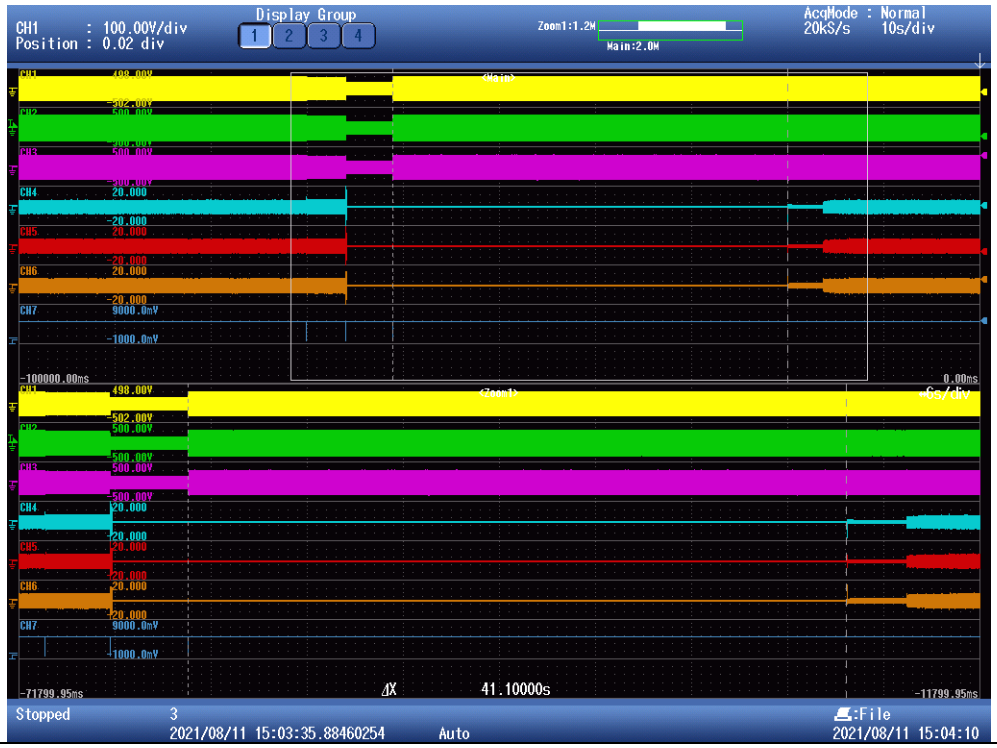
Note: CH1,CH2,CH3:grid voltage(1000V/div); CH4,CH5,CH6: current of EUT(20A/div); CH7 trip signal (100mV/div)

Reconnection after Under Voltage First Level

Reconnection after Over Voltage First Level

Note: CH1,CH2,CH3:grid voltage(1000V/div); CH4,CH5,CH6: current of EUT(20A/div); CH7 trip signal (100mV/div)

Reconnection after Under Voltage Second Level



Reconnection after Over Voltage Second Level

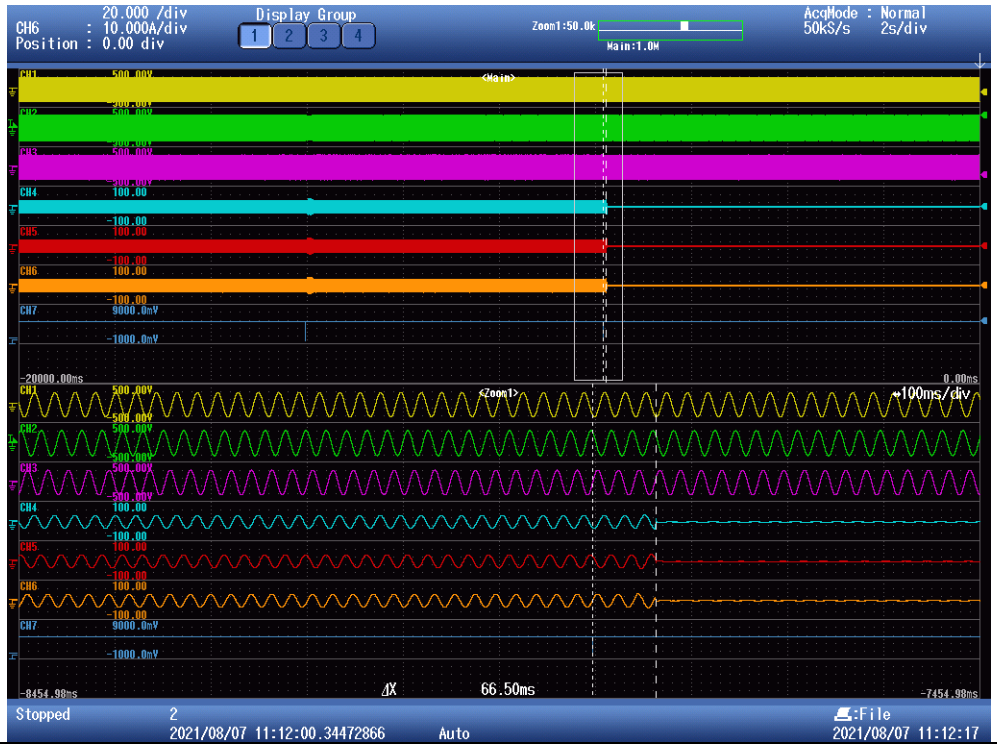
Note: CH1,CH2,CH3:grid voltage(1000V/div); CH4,CH5,CH6: current of EUT(20A/div); CH7 trip signal (100mV/div)

5,2,2 Frequency monitoring					**P**
IEC 61727 **8,2 Under and Over Frequency Protection (PEA:2016)** **3,10, 12,5 Response to utility recovery (PEA:2016)**					
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)		47,00		52,01	
		47,00		52,01	
		47,00		52,01	
		Time [ms]		Time [ms]	
Limit		**<= 100ms**		**<= 100ms**	
Disconnection time(ms)	50,0Hz to 47,2 Hz (0,2s min) to 46,5 Hz	58,5	50,0 Hz to 51,80 Hz (0,2s min) to 52,5Hz	62,5	
		63,5		57,5	
		66,5		66,0	
Reconnection time (Sec)	20s – 5min	41,10 s	20s-5min	41,07 s	

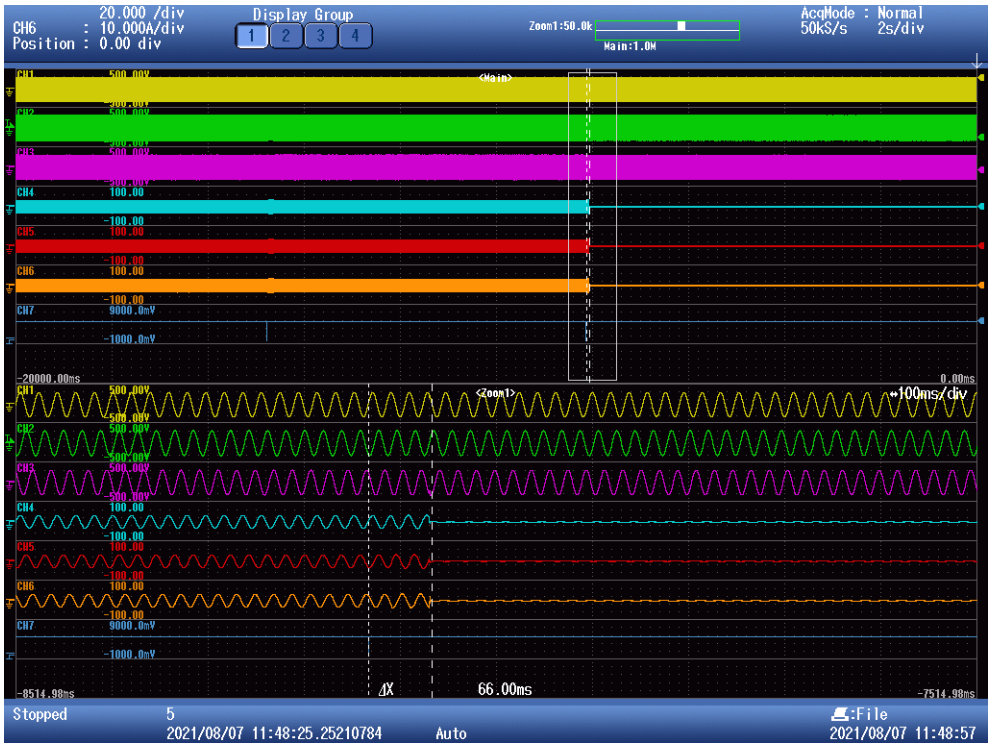
Note:
The frequency which inverter stops feeding power to electrical system in each test must be in the range of the frequency trip setting +/- 0,1Hz and the time it takes to cut off the power must be within 0,1 second,

The tests are performed according the IEEE 1547,1-2005, annex A,
Response to utility recovery is according to the appropriate IEEE or IEC standard test methods,

Under Frequency:



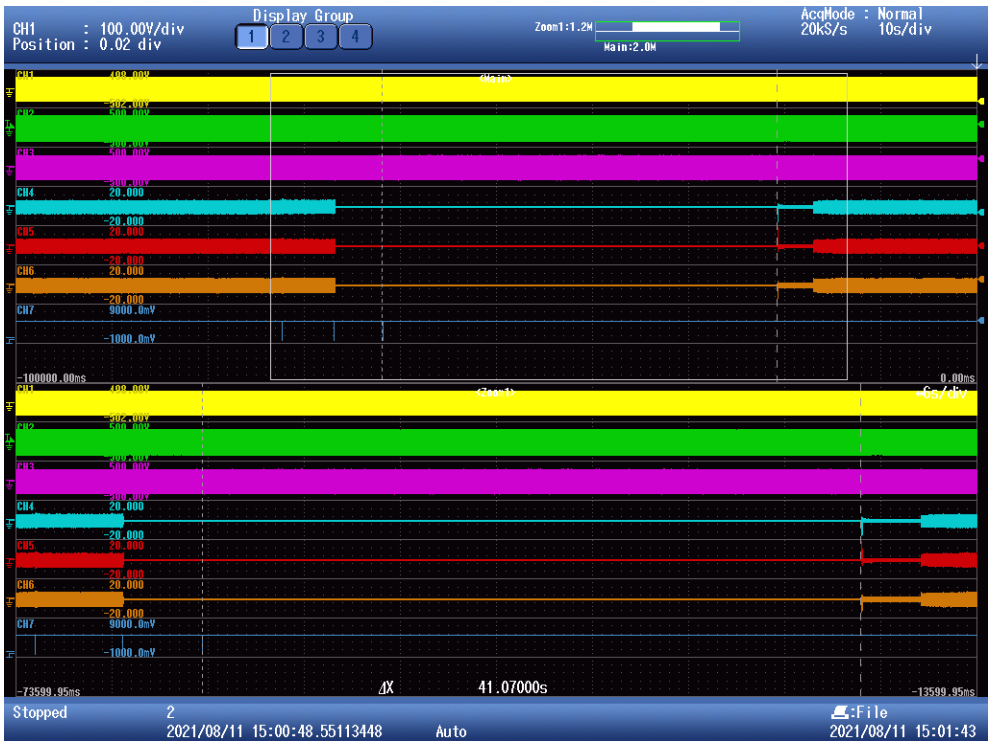
Over Frequency:



Note: CH1,CH2,CH3:grid voltage(1000V/div); CH4,CH5,CH6: current of EUT(20A/div); CH7 trip signal (100mV/div)

Reconnection after Under Frequency:

Reconnection after Over Frequency:



Note: CH1,CH2,CH3:grid voltage(1000V/div); CH4,CH5,CH6: current of EUT(20A/div); CH7 trip signal (100mV/div)

6,1 Islanding protection
3,9, 12,4 Anti-Islanding (PEA:2016)

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

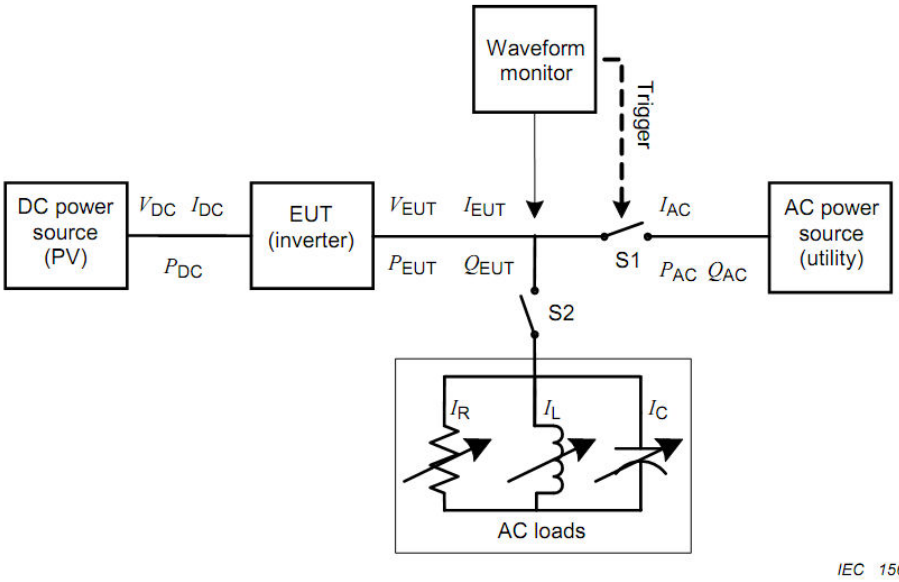


Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

6,1 Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%) **3,9, 12,4 Anti-Islanding (PEA:2016)**	**P**

Test conditions	Frequency: 50+/-0,1Hz U_N=220+/-3Vac Distortion factor of chokes < 2% Quality = 1
Disconnection limit	1s

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)	Remarks[4]
1	100	100	0	0	117,0	10,040	1,00	812	Test A at BL
2	100	100	-5	-5	111,0	10,040	1,03	812	Test A at BL
3	100	100	-5	0	103,0	10,040	1,05	812	Test A at BL
4	100	100	-5	+5	90,0	10,040	1,05	812	Test A at BL
5	100	100	0	-5	116,0	10,040	0,97	812	Test A at BL
6	100	100	0	+5	80,0	10,040	1,02	812	Test A at BL
7	100	100	+5	-5	115,0	10,040	0,95	812	Test A at BL
8	100	100	+5	0	100,0	10,040	0,95	812	Test A at BL
9	100	100	+5	+5	76,0	10,040	0,97	812	Test A at BL

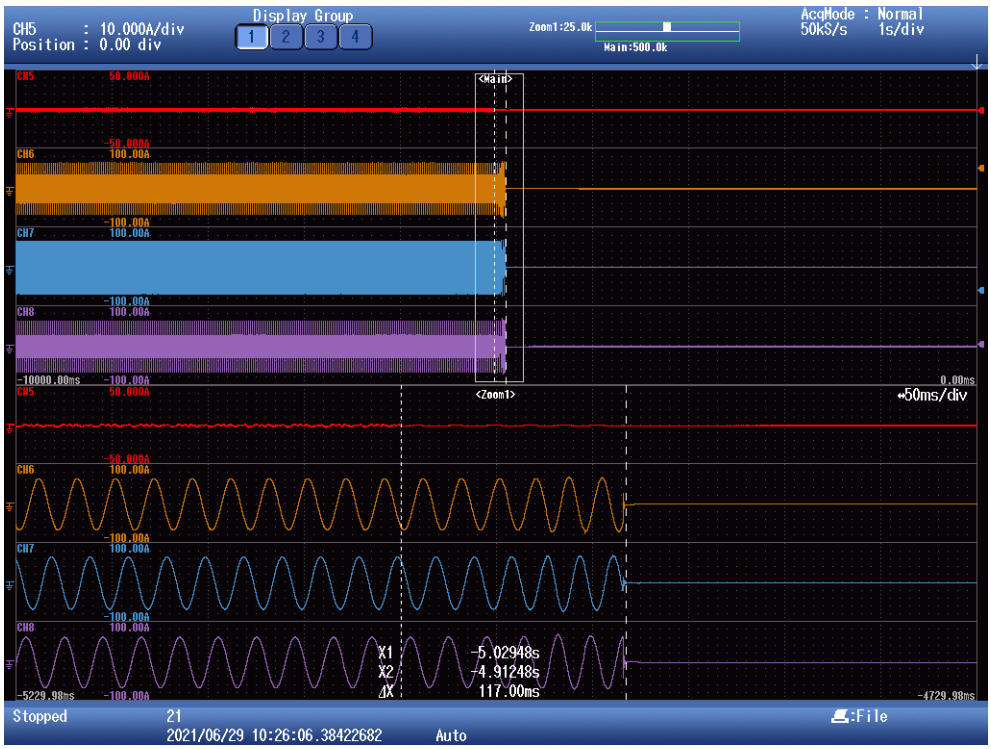
Parameter at 0% per phase	L= 15,41 mH	R= 4,84 Ω	C= 657,67 µF
IAC fundamental current(A)	L1: 0,84A	L2: 0,83A	L3: 0,95A

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} 0% and Q_{AC} 0% reactive load No, 1



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: Trigger signal(10A/div)

6,1 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %) **3,9, 12,4 Anti-Islanding (PEA:2016)**	**P**

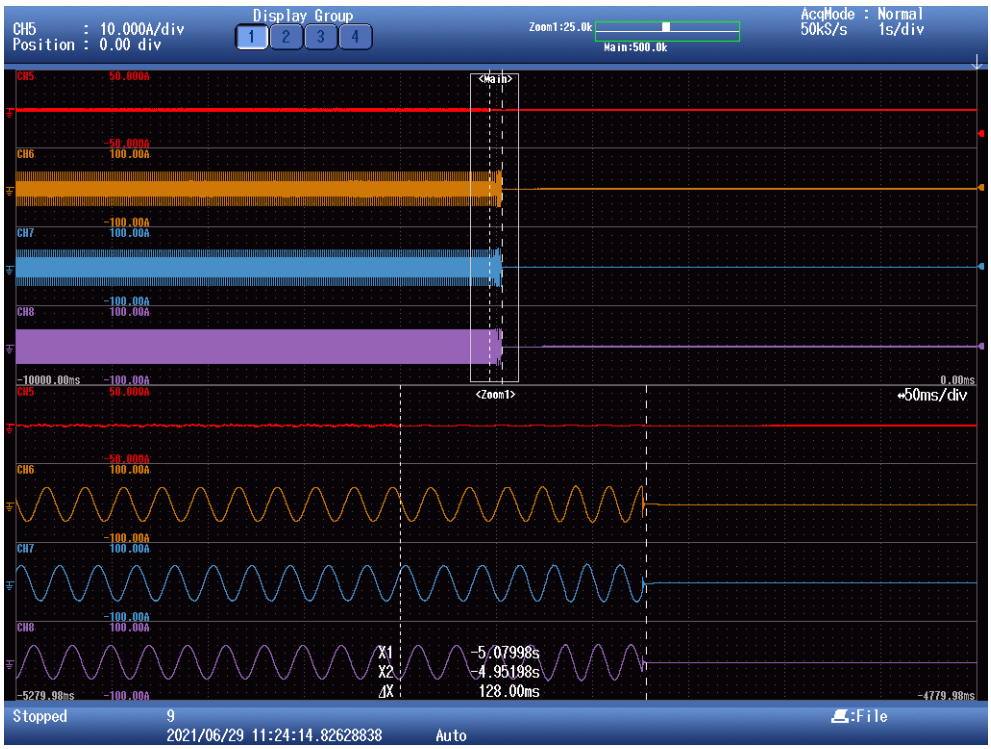
Test conditions	Frequency: 50+/-0,1Hz U_N=220+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	1s

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 Qf	V_{DC} (V)	Remarks4)
1	66	66	0	-5	96,0	6,660	0,97	540	Test B at IB
2	66	66	0	-4	113,0	6,660	0,97	540	Test B at IB
3	66	66	0	-3	116,0	6,660	0,98	540	Test B at IB
4	66	66	0	-2	126,0	6,660	0,98	540	Test B at IB
5	66	66	0	-1	112,0	6,660	0,98	540	Test B at IB
6	66	66	0	0	128,0	6,660	0,99	540	Test B at BL
7	66	66	0	1	94,0	6,660	0,99	540	Test B at IB
8	66	66	0	2	87,0	6,660	1,00	540	Test B at IB
9	66	66	0	3	90,0	6,660	1,01	540	Test B at IB
10	66	66	0	4	88,0	6,660	1,01	540	Test B at IB
11	66	66	0	5	72,0	6,660	1,02	540	Test B at IB

Parameter at 0% per phase	L=25,51 mH	R= 7,67 Ω	C=434,06 µF
IAC fundamental current(A)	L1: 0,71A	L2: 0,69A	L3:0,71A

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, 50 % 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: Trigger signal(10A/div)

6,1 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %) **3,9, 12,4 Anti-Islanding (PEA:2016)**	**P**

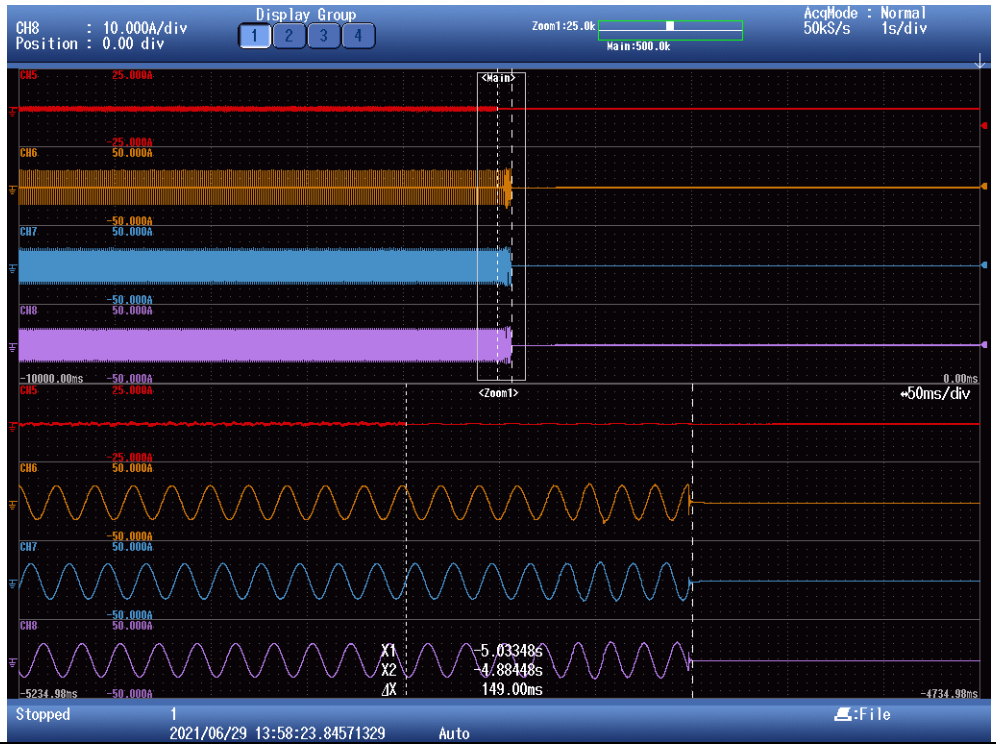
Test conditions	Frequency: 50+/-0,1Hz U_N=220+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	1s

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	33	33	0	-5	106,0	3,330	0,95	268	Test C at IB
2	33	33	0	-4	123,0	3,330	0,95	268	Test C at IB
3	33	33	0	-3	114,0	3,330	0,95	268	Test C at IB
4	33	33	0	-2	113,0	3,330	0,96	268	Test C at IB
5	33	33	0	-1	112,0	3,330	0,96	268	Test C at IB
6	33	33	0	0	149,0	3,330	0,97	268	Test C at BL
7	33	33	0	1	99,0	3,330	0,97	268	Test C at IB
8	33	33	0	2	102,0	3,330	0,98	268	Test C at IB
9	33	33	0	3	90,0	3,330	0,98	268	Test C at IB
10	33	33	0	4	81,0	3,330	0,99	268	Test C at IB
11	33	33	0	5	69,0	3,330	0,99	268	Test C at IB

Parameter at 0% per phase	L= 50,57 mH	R= 15,89 Ω	C= 200,37 µF
IAC fundamental current(A)	L1: 0,52A	L2: 0,56A	L3: 0,59A

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, 10 % 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: Trigger signal(10A/div)

PEA:2016 additional test	**P**
3,4 Reactive power control(PEA:2016)	**P**

Test conditions:	Input: 600 Vdc Output: 220 Vac

P (setting)	P(kW)ind	P(kW)cap	Q(kVar)ind, max	Q(kVar)cap, max	PFind, max	PFcap, max
0%	1,42	1,44	-0,585	0,284	0,955	0,964
10%	2,956	2,963	-1,016	0,945	0,96	0,941
20%	5,987	5,993	-2,067	1,879	0,953	0,949
30%	9,005	9,012	-3,029	2,966	0,953	0,946
40%	12,006	12,017	-4,015	4,000	0,952	0,946
50%	15,003	15,011	-4,993	5,034	0,952	0,945
60%	17,988	18,001	-5,966	6,076	0,952	0,945
70%	20,97	20,982	-6,946	7,109	0,951	0,945
80%	23,995	23,888	-7,959	8,095	0,951	0,945
90%	26,979	26,882	-8,965	9,136	0,951	0,945
100%	29,942	29,848	-9,964	10,099	0,95	0,946

Note:

PEA:2016 additional test	**P**
3,4,1, 8,1,2 1) A fixed displacement factor cosφ	**P**

Test conditions:	Input: 600Vdc Output: 220Vac

P (setting)	PF (setting)	P(kW)	Q(kVar)	PF
0%	0,95 lagging	1,420	-0,585	0,955
10%	0,95 lagging	2,956	-1,016	0,960
20%	0,95 lagging	5,987	-2,067	0,953
30%	0,95 lagging	9,005	-3,029	0,953
40%	0,95 lagging	12,006	-4,015	0,952
50%	0,95 lagging	15,003	-4,993	0,952
60%	0,95 lagging	17,988	-5,966	0,952
70%	0,95 lagging	20,970	-6,946	0,951
80%	0,95 lagging	23,995	-7,959	0,951
90%	0,95 lagging	26,979	-8,965	0,951
100%	0,95 lagging	29,942	-9,964	0,950

P (setting)	PF (setting)	P(kW)	Q(kVar)	PF
0%	0,95 leading	1,440	0,284	0,964
10%	0,95 leading	2,963	0,945	0,941
20%	0,95 leading	5,993	1,879	0,949
30%	0,95 leading	9,012	2,966	0,946
40%	0,95 leading	12,017	4,000	0,946
50%	0,95 leading	15,011	5,034	0,945
60%	0,95 leading	18,001	6,076	0,945
70%	0,95 leading	20,982	7,109	0,945
80%	0,95 leading	23,888	8,095	0,945
90%	0,95 leading	26,882	9,136	0,945
100%	0,95 leading	29,848	10,099	0,946

P (setting)	PF (setting)	P(kW)	Q(kVar)	PF
0%	1,00	1,431	-0,224	0,998
10%	1,00	2,972	-0,285	0,999
20%	1,00	6,007	-0,413	0,999
30%	1,00	9,047	-0,528	0,999

40%	1,00	12,065	-0,663	0,999
50%	1,00	15,024	-0,782	0,999
60%	1,00	18,055	-0,931	0,999
70%	1,00	21,062	-1,061	0,999
80%	1,00	23,990	-1,212	0,999
90%	1,00	27,024	-1,362	0,999
100%	1,00	30,006	-1,515	0,999
Note:				

PEA:2016 additional test	N/A
3,4,2, 8,1,2 2) A variable reactive power depending on the voltage Q(U) (PEA:2016) (Power generation system is greater than 500kW)	**N/A**

The purpose of the test is to ensure that the converter complies with the methods for automatically supplying reactive power according to the standard characteristic curve Q(U) indicated in 1,5,

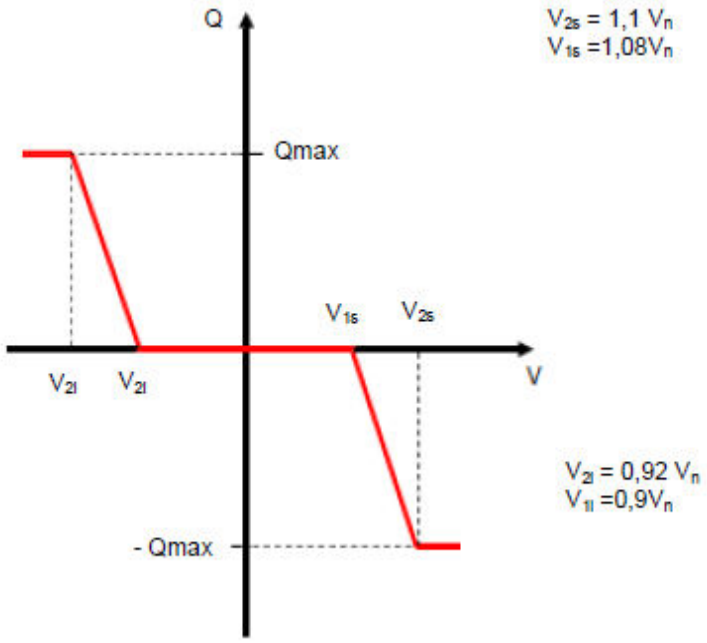
Activation must be at the Distributor's request, when the Operating Regulations are issued, The Distributor shall also specify the values of the parameters that uniquely characterise the curve, i,e,: V1i, V2i, V1s and V1s as well as the lock-in value of active power (default value P = 0,2 P_n),

The parameters V1i, V2i, V1s and V1s should be set in the range between 0,9 and 1,1 with 0,01 V_n steps, In order to facilitate execution of the type tests, the characterising parameters are conventionally set as follows:

V1s =1,08 V_n; V2s = 1,1 V_n

V1i =0,92 V_n; V2i = 0,9 V_n

and the active power lock-in value (default value P = 0,2 P_n),



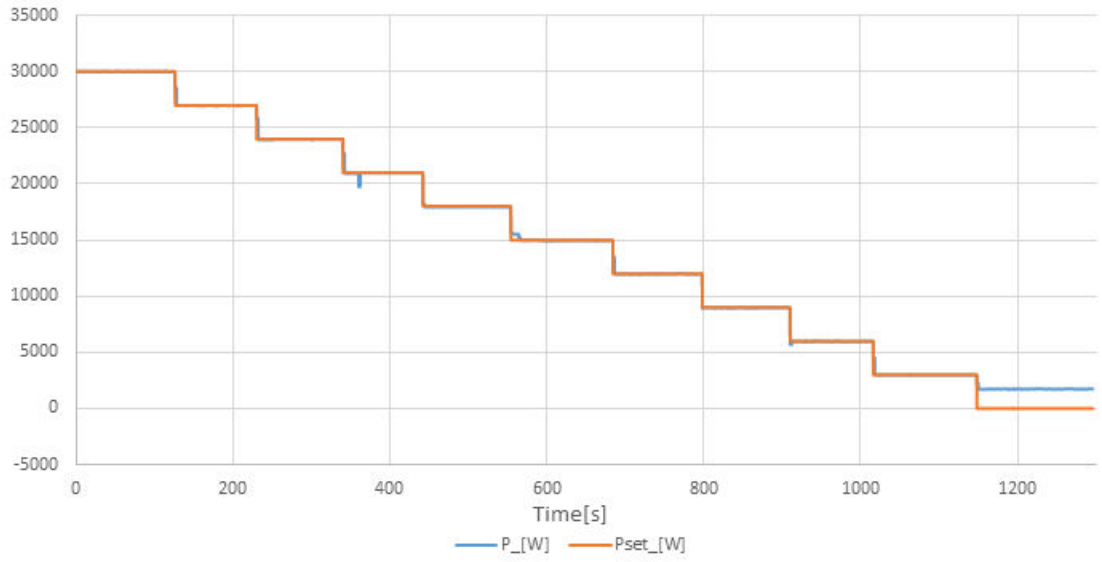
Qmin reactive power in accordance to standard characteristic curve Q=f(V)						
P/Pn	Vac [V] Set point	P[kW] measured	Vac [V] measured	Q [kVar] measured	Q [kVar] expected	ΔQ [kVar]
< 20%	1,07Vn	--	--	--	--	--
< 20%	1,09Vn	--	--	--	--	--
< 20%-30%	1,09Vn	--	--	--	--	--
40%	1,09Vn	--	--	--	--	--
50%	1,09Vn	--	--	--	--	--
60%	1,09Vn	--	--	--	--	--
70%	1,09Vn	--	--	--	--	--
80%	1,09Vn	--	--	--	--	--
90%	1,09Vn	--	--	--	--	--
100%	1,09Vn	--	--	--	--	--
100%	1,1 Vn	--	--	--	--	--
100%-10%	1,1 Vn	--	--	--	--	--
10%→ ≤5%	1,1 Vn	--	--	--	--	--
Qmax reactive power in accordance to standard characteristic curve Q=f(V)						
P/Pn	Vac [V] Set point	P[kW] measured	Vac [V] measured	Q [kVar] measured	Q [kVar] expected	ΔQ [kVar]
< 20%	0,93Vn	--	--	--	--	--
< 20%	0,91Vn	--	--	--	--	--
< 20%-30%	0,91Vn	--	--	--	--	--
40%	0,91Vn	--	--	--	--	--
50%	0,91Vn	--	--	--	--	--
60%	0,91Vn	--	--	--	--	--
70%	0,91Vn	--	--	--	--	--
80%	0,91Vn	--	--	--	--	--
90%	0,91Vn	--	--	--	--	--
100%	0,91Vn	--	--	--	--	--
100%	0,91Vn	--	--	--	--	--
100%-10%	0,90Vn	--	--	--	--	--
10%→ ≤5%	0,90Vn	--	--	--	--	--

Note:
The lock-in value is adjustable between Vn and 1,1Vn and the lock-out value between Vn and 0,9Vn in 0,01V steps,
Power generation system is less than 500kW

PEA:2016 additional test	P
3,5, 12,1 Active power control (PEA:2016)	**P**

Setpoint in power bin [%]	$P_{setpoint}$ [kW]	P_{60} [kW]	Decrease time (s)
100%	30,0	29,997	
90%	27,0	26,973	2s
80%	24,0	23,948	2s
70%	21,0	20,943	2s
60%	18,0	17,950	2s
50%	15,0	14,971	5s
40%	12,0	11,963	2s
30%	9,0	8,967	0,2s
20%	6,0	5,975	2s
10%	3,0	2,997	2s
0%	0,0	1,736	2s

Graph of the setting accuracy



Note:

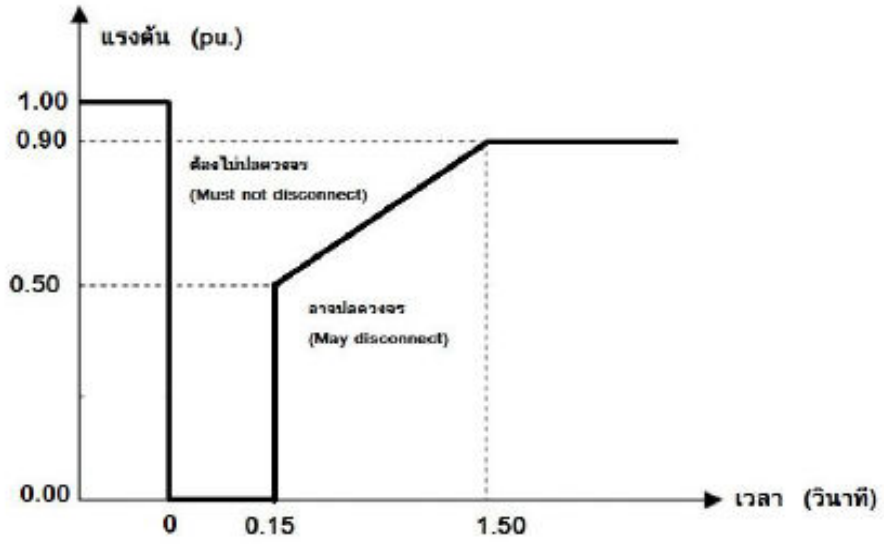
PEA:2016 additional test	**N/A**
3,6, 12,2 Low voltage fault Ride through capability (PEA:2016) (Power generation system is greater than 500kW)	**N/A**

Test List	V(V/V_n)	Duration time (Sec)
Test P>0,9P_n*		
Three-phase faults	--	--
	--	--
	--	--
Phase to phase faults	--	--
	--	--
	--	--
Single phase to ground faults	--	--
	--	--
	--	--
Test P=0,3P_n		
Three-phase faults	--	--
	--	--
	--	--
Phase to phase faults	--	--
	--	--
	--	--
Single phase to ground faults	--	--
	--	--
	--	--
Test P=0,1 Pn		
Three-phase faults	--	--
	--	--
	--	--
Phase to phase faults	--	--
	--	--
	--	--

Single phase to ground faults	--	--
	--	--
	--	--

Note:
The PGS must not disconnected from gird while the PCC voltage dip period less than below curve limit,

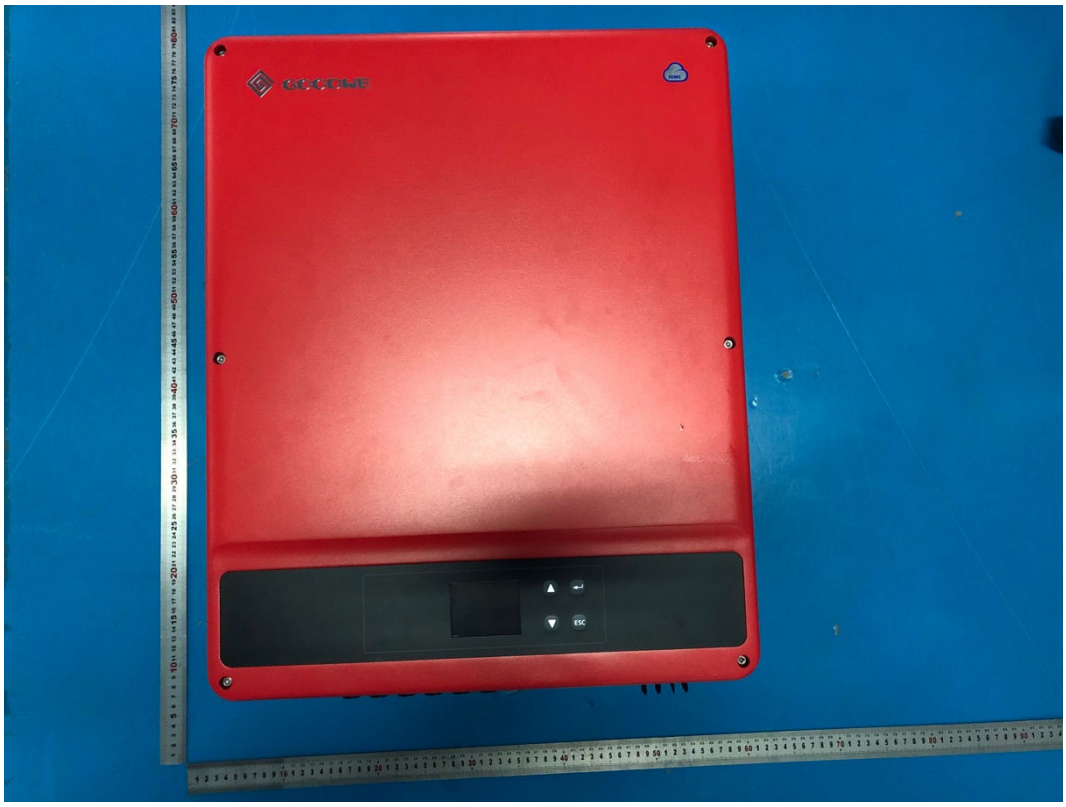
a) install and connect the PGS and recommendation of the technical requirements of the equipment manufacturer ,
b) Check all parameters of power supply in normal conditions, the operation of power system equipment ,
c) testing by simulation the voltage , (I try to short-circuit in the power network) in the electricity network to balance the pressure between 70-80%V_n , 30-50%V_n, and less than 5 percent of the normal operating pressure ,
d) Record the maximum time power system can still connect to the electricity network as shown on above table,
Power generation system is less than 500kW



Annex 1

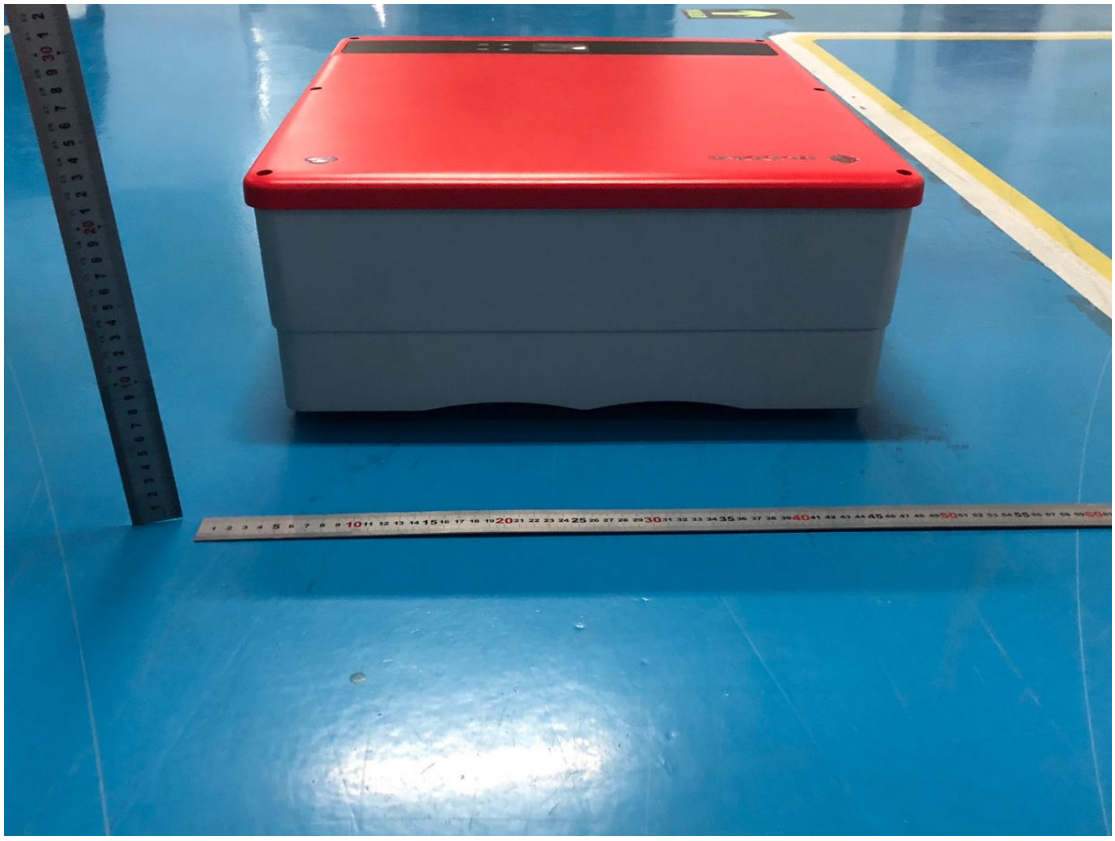
Pictures of the unit

Enclosure front view

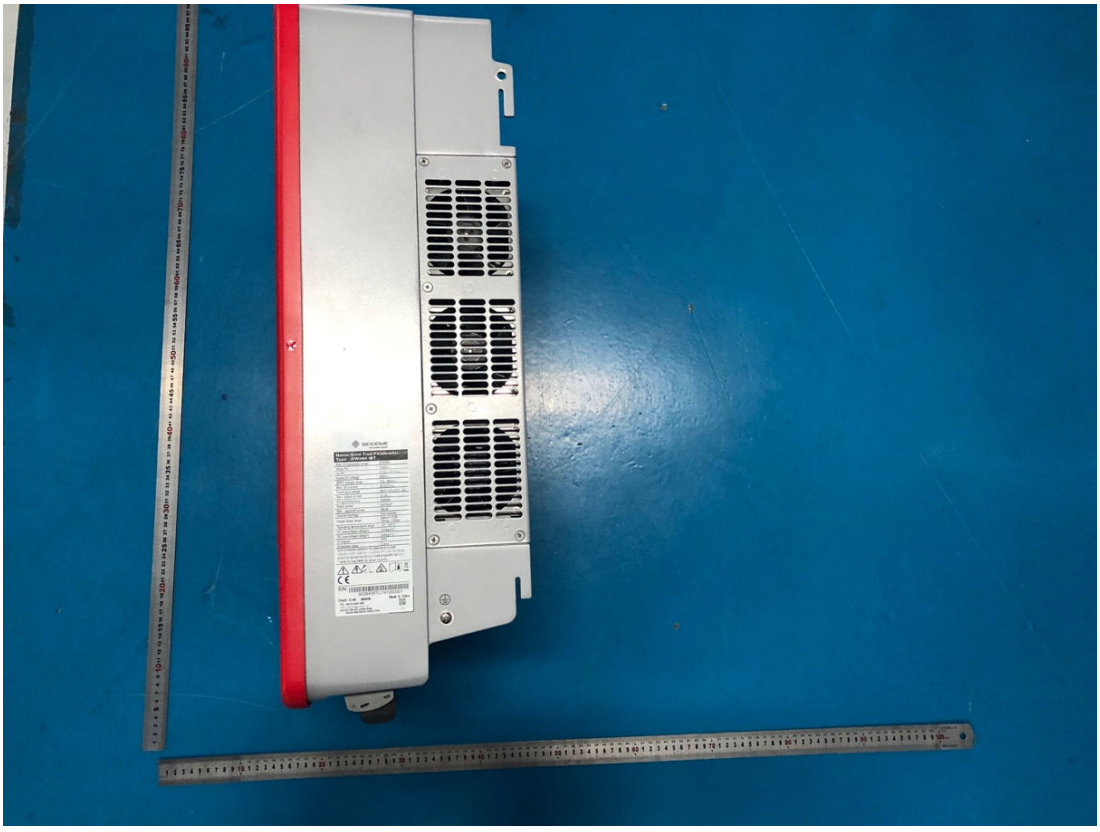


Enclosure top view

Enclosure side view



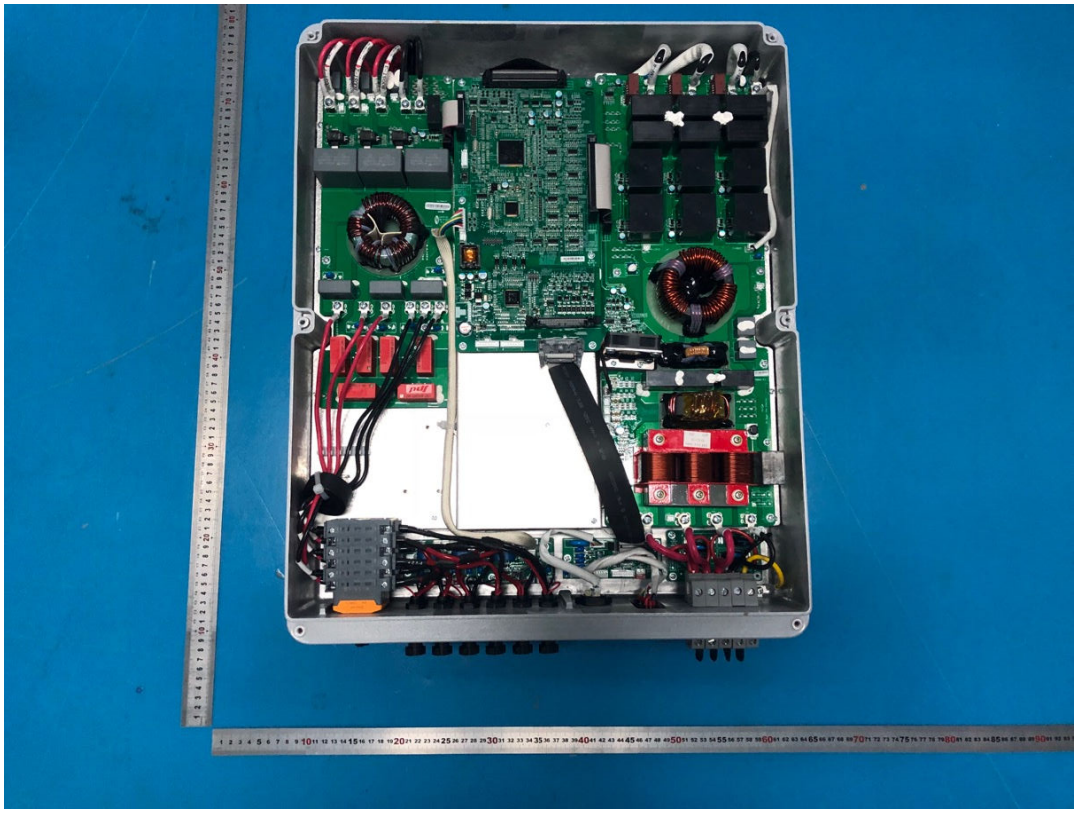
Enclosure side view



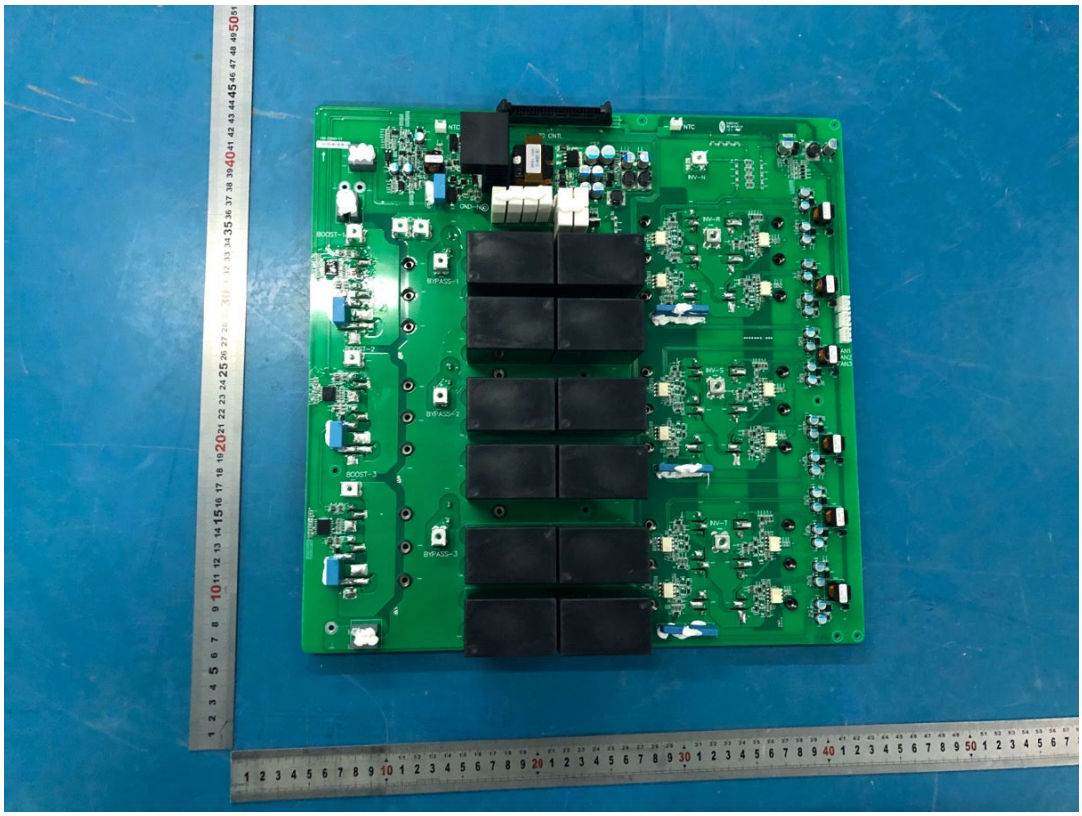
Enclosure bottom view

Enclosure side view

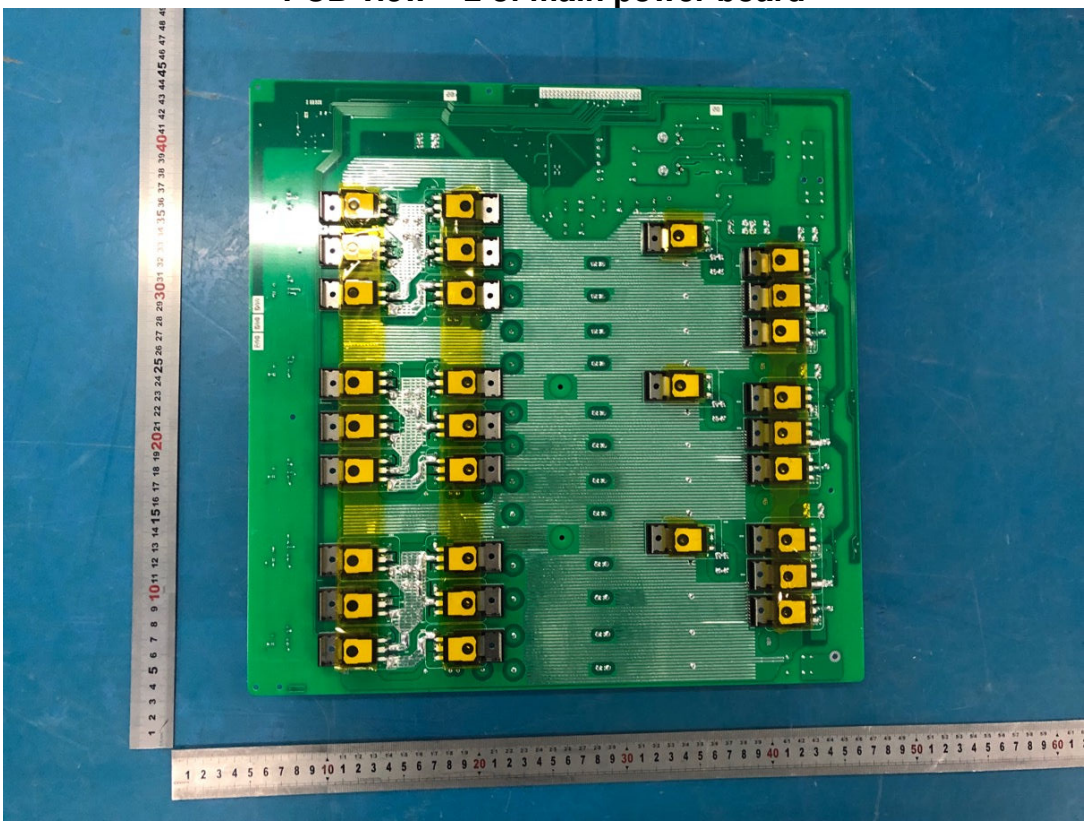
Inside view



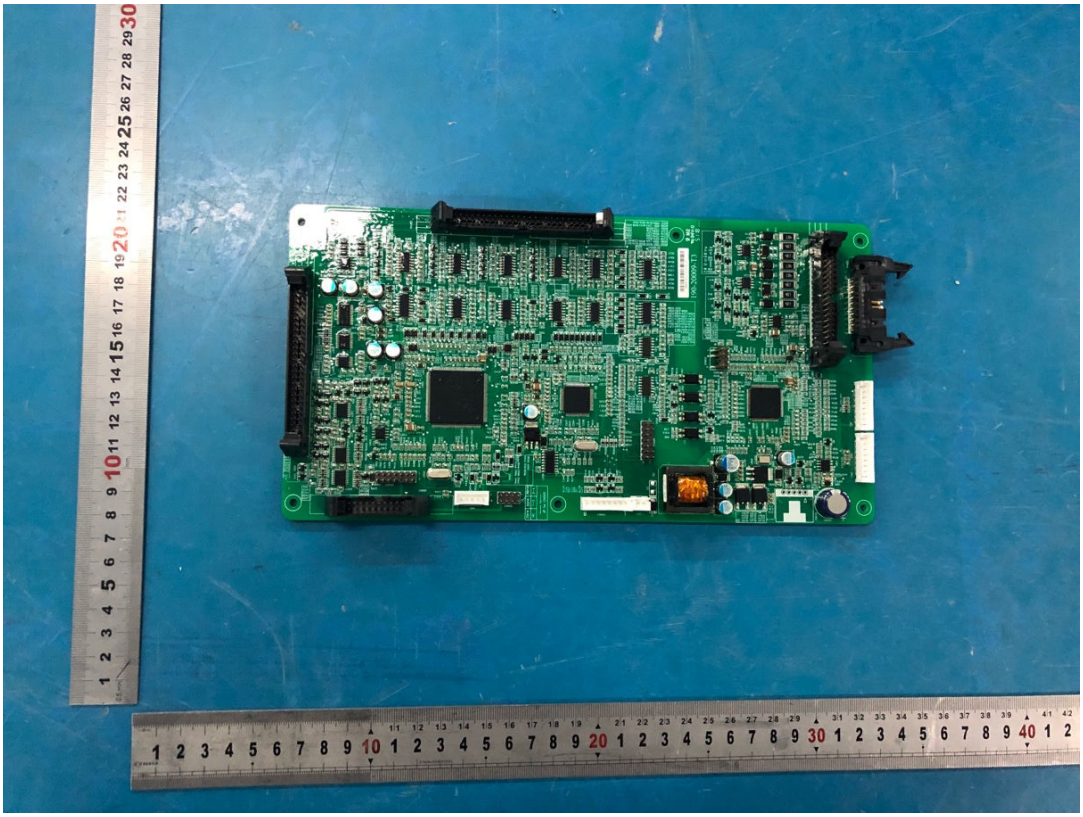
PCB view – 1 of main power board



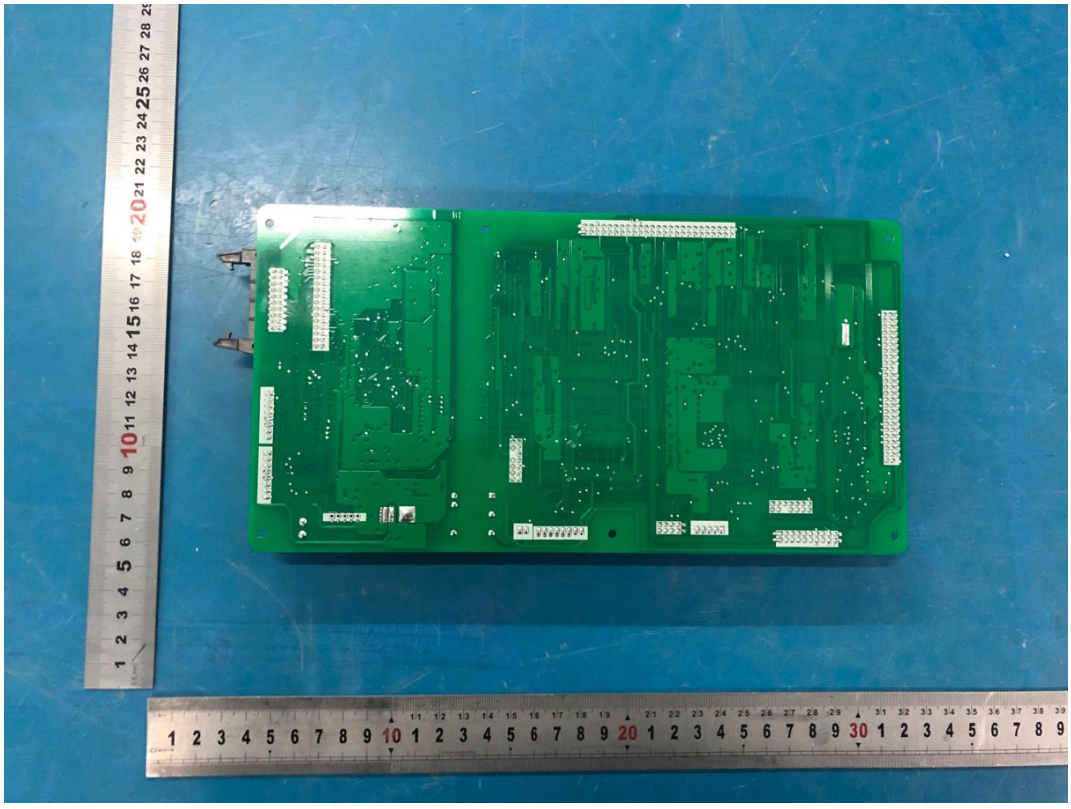
PCB view – 2 of main power board



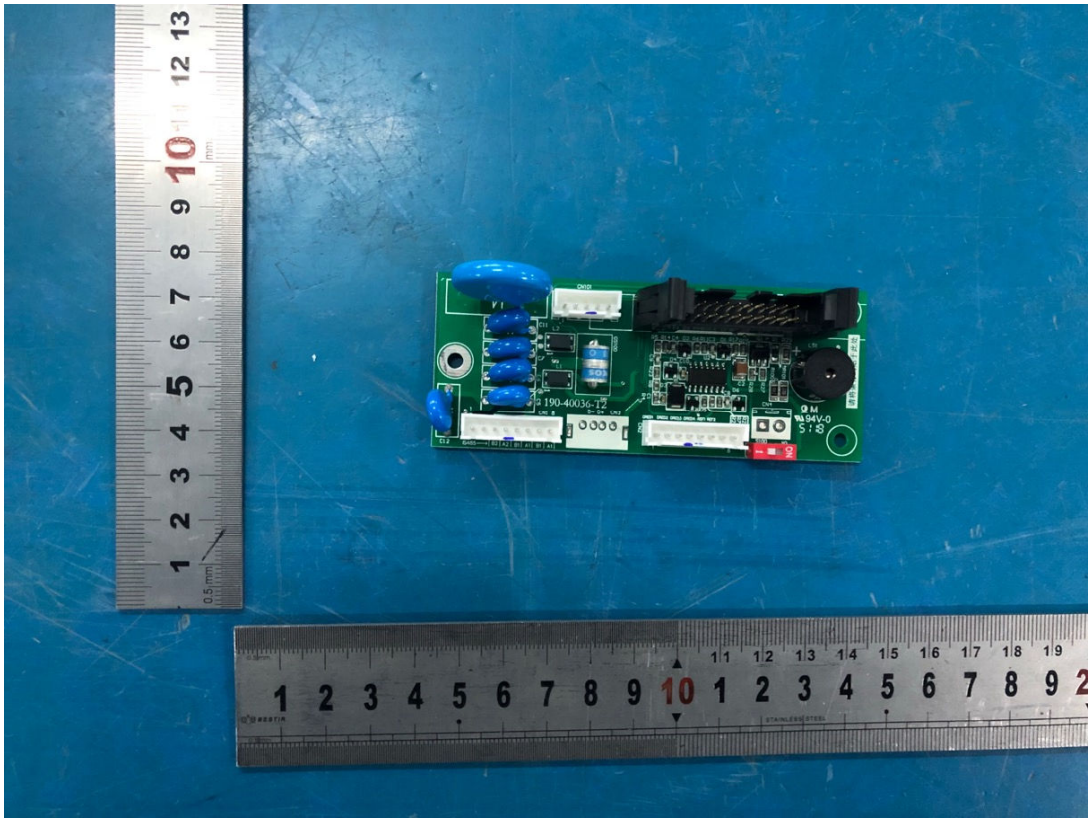
PCB view – 1 of control board



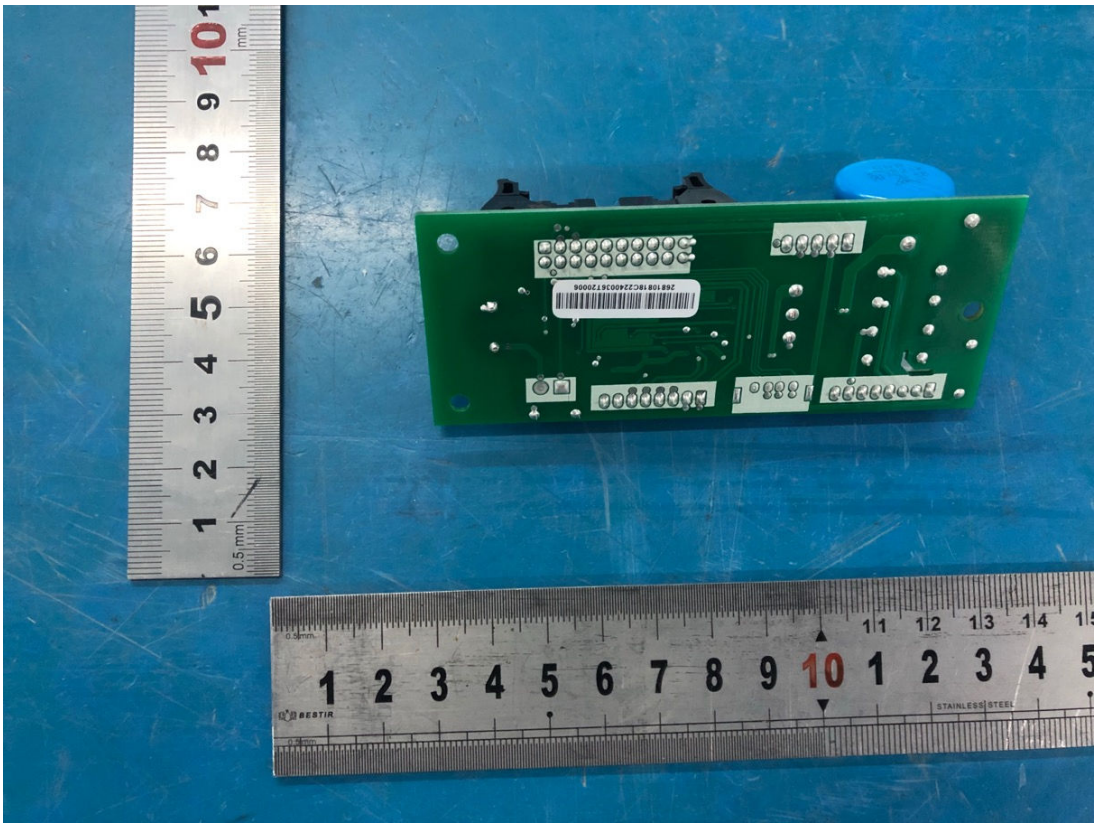
PCB view – 2 of control board



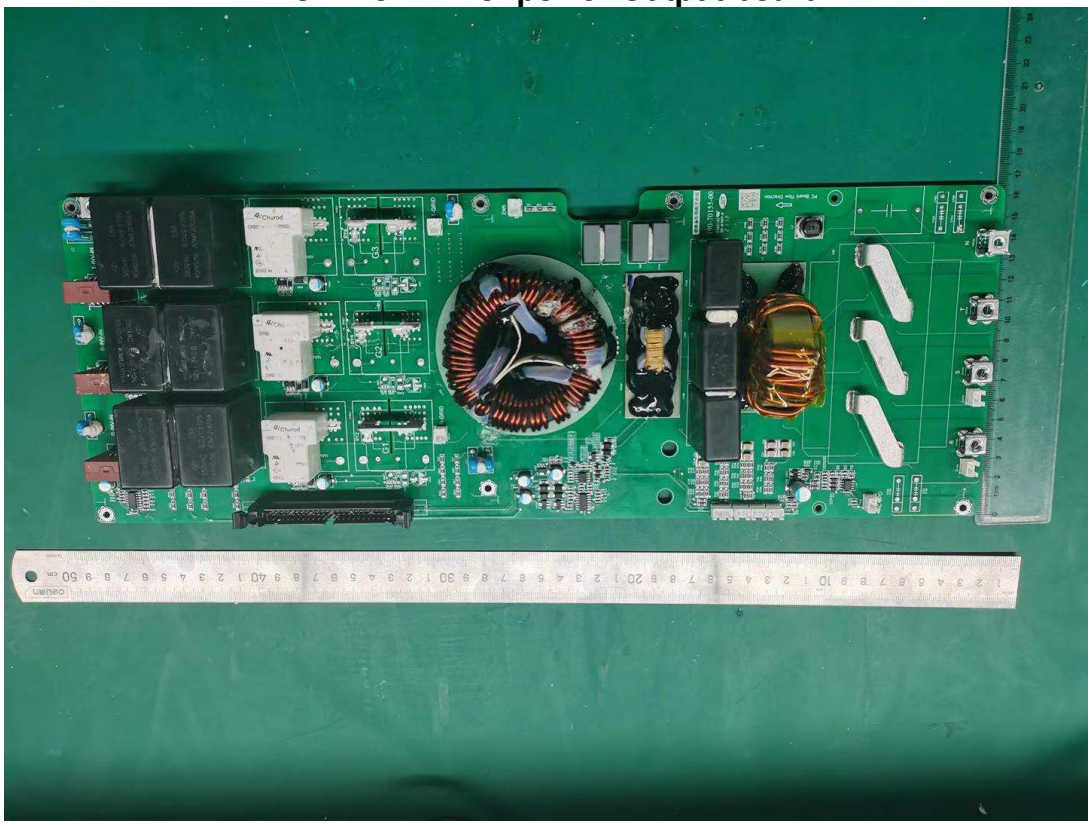
PCB view – 1 of Communication board



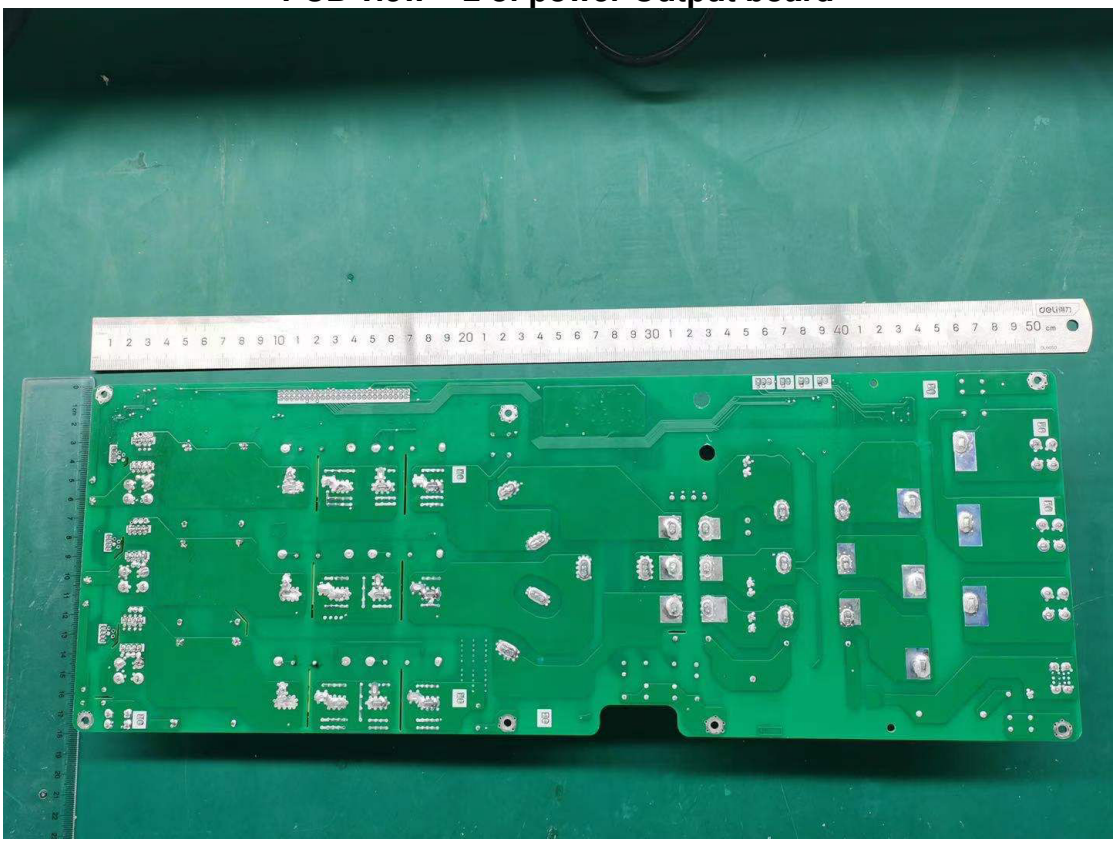
PCB view – 2 of Communication board



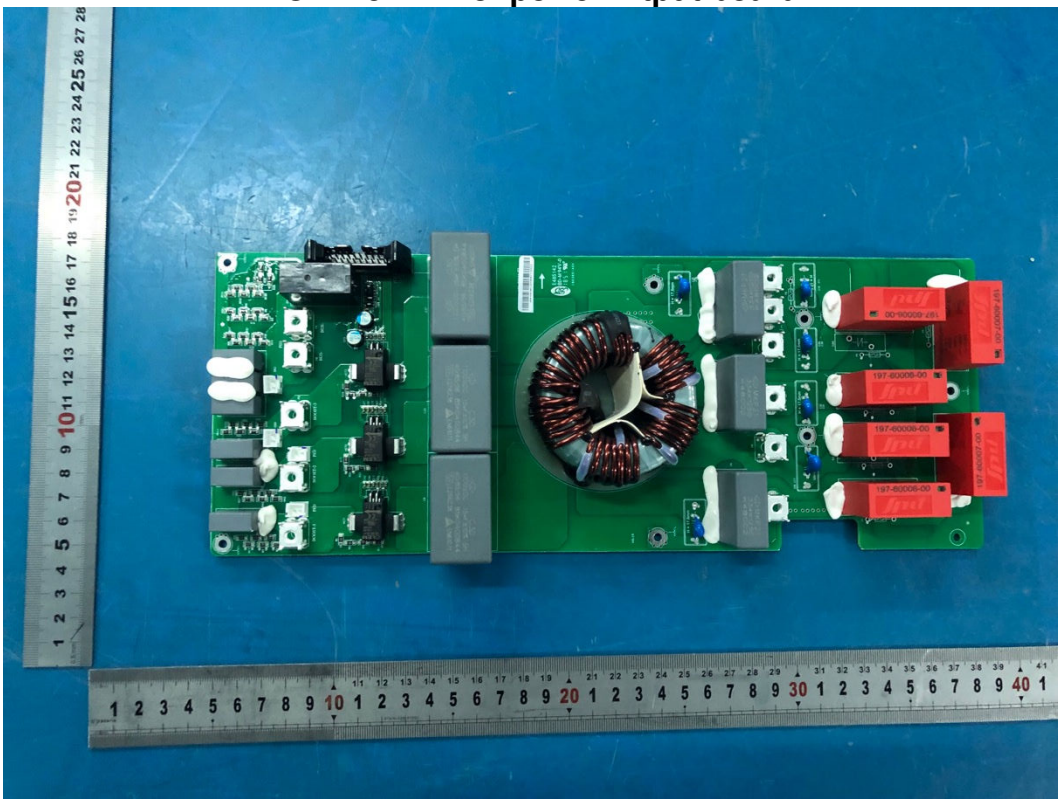
PCB view – 1 of power Output board



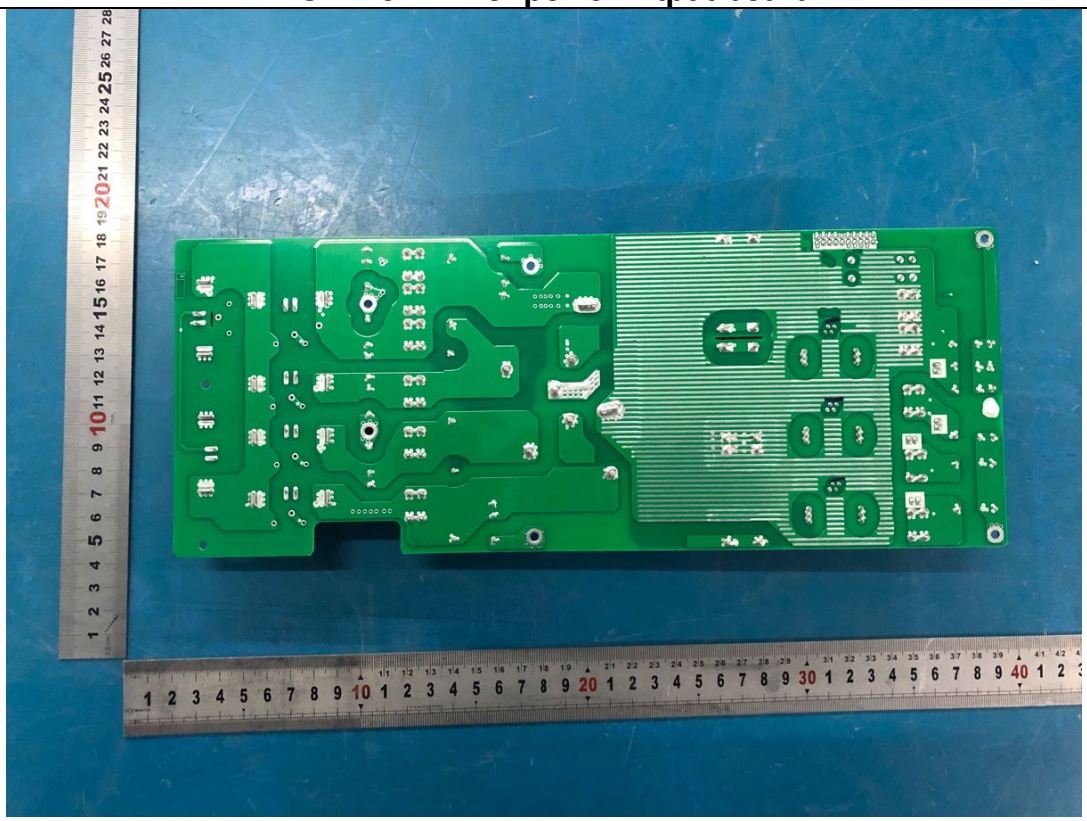
PCB view – 2 of power Output board



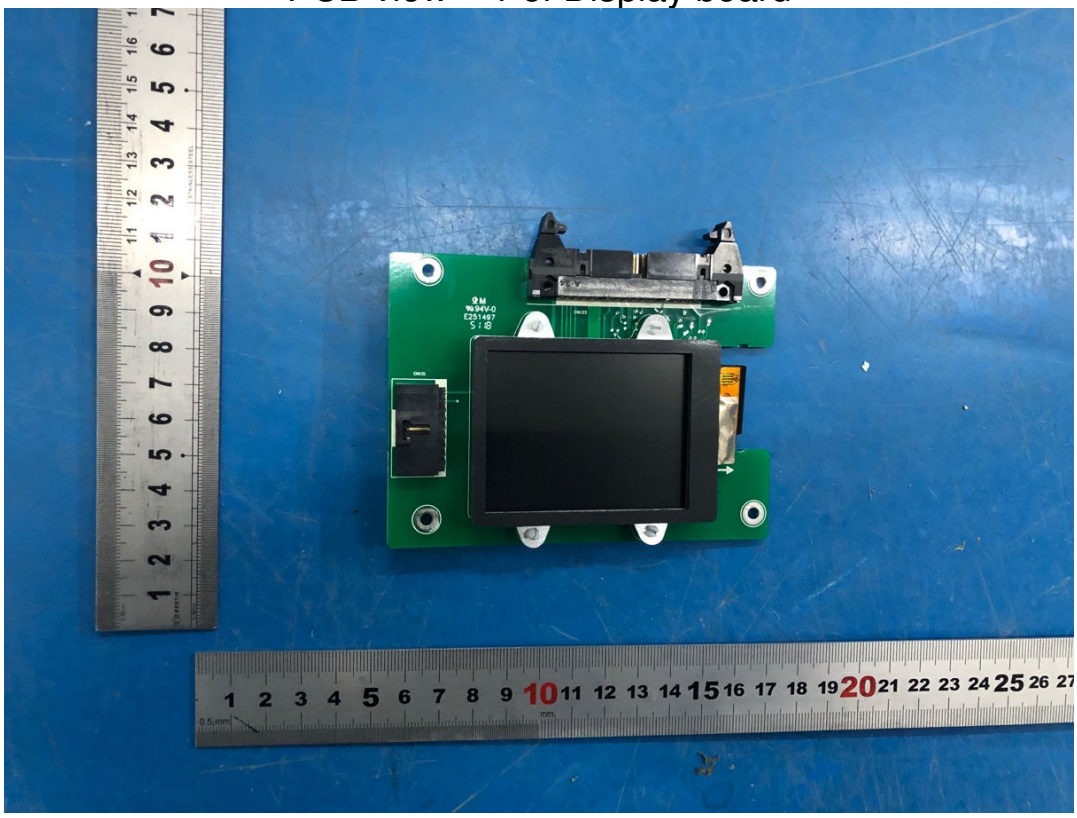
PCB view – 1 of power Intput board



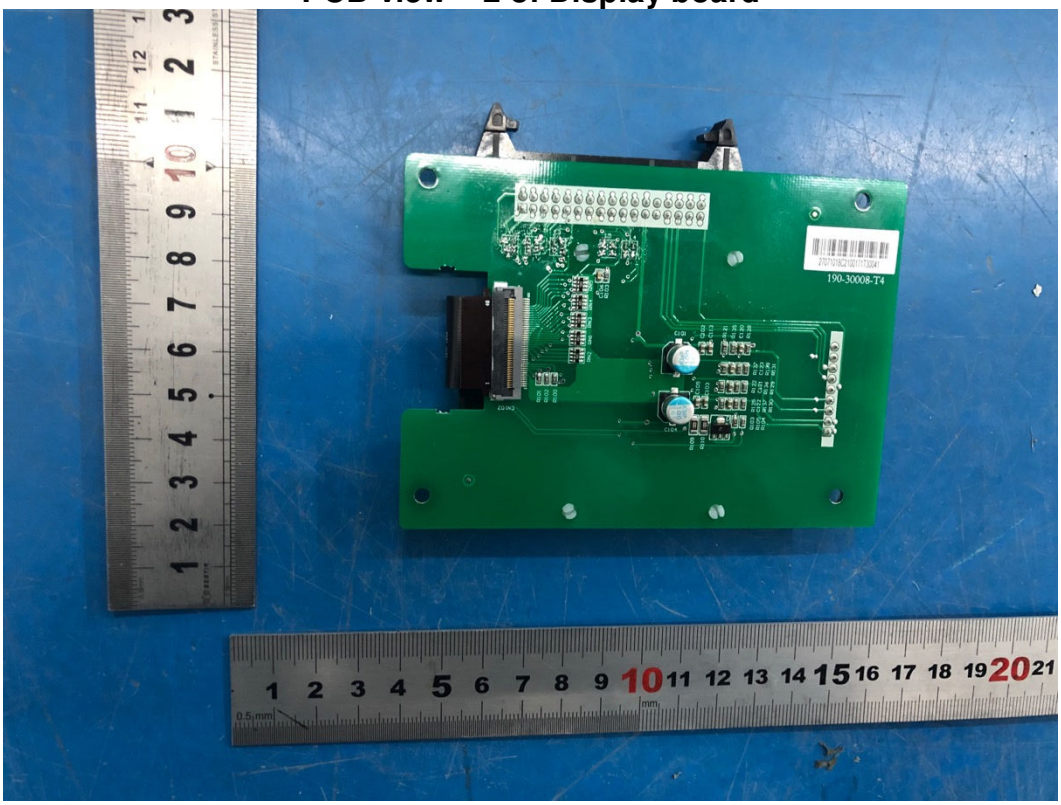
PCB view – 2 of power Intput board



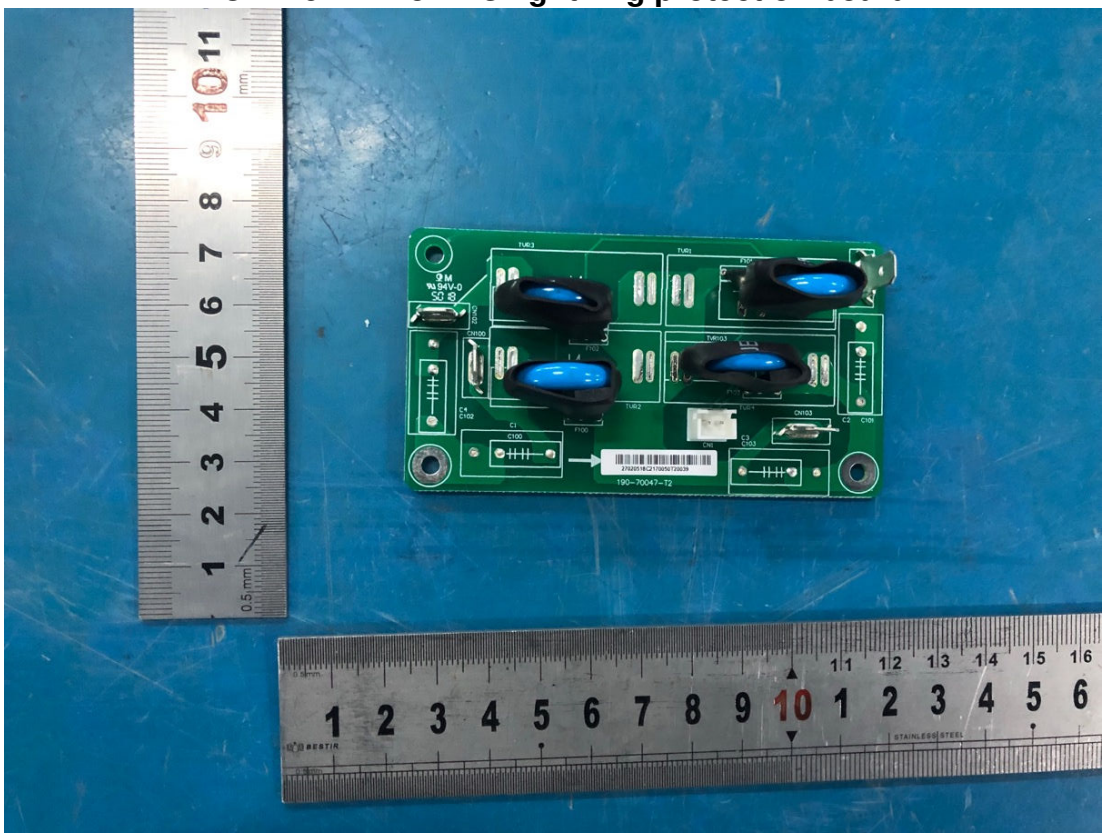
PCB view – 1 of Display board



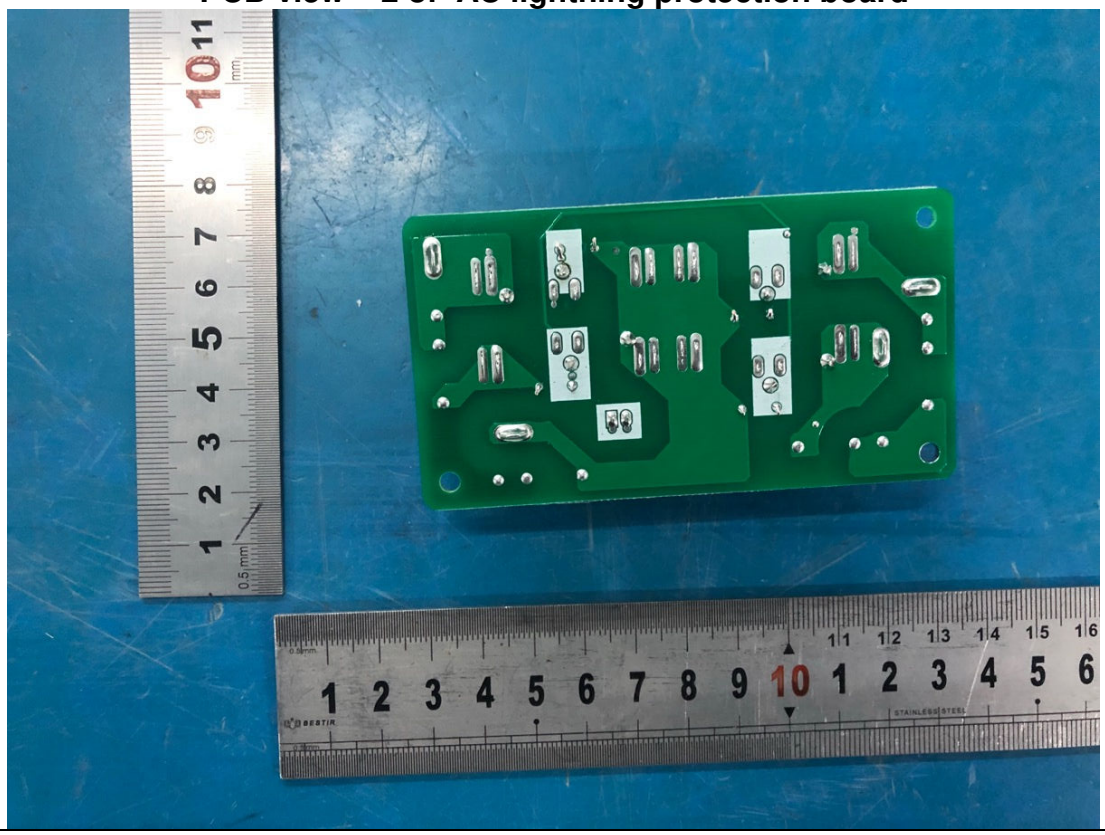
PCB view – 2 of Display board



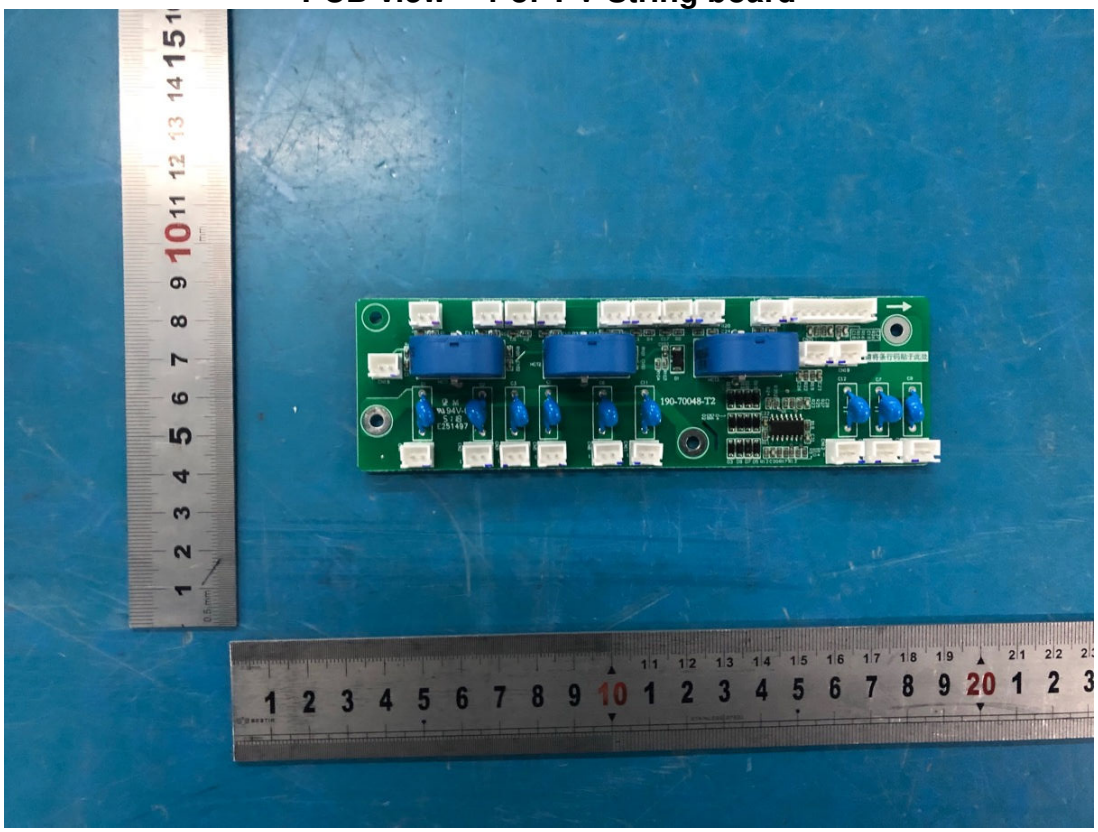
PCB view – 1 of AC lightning protection board



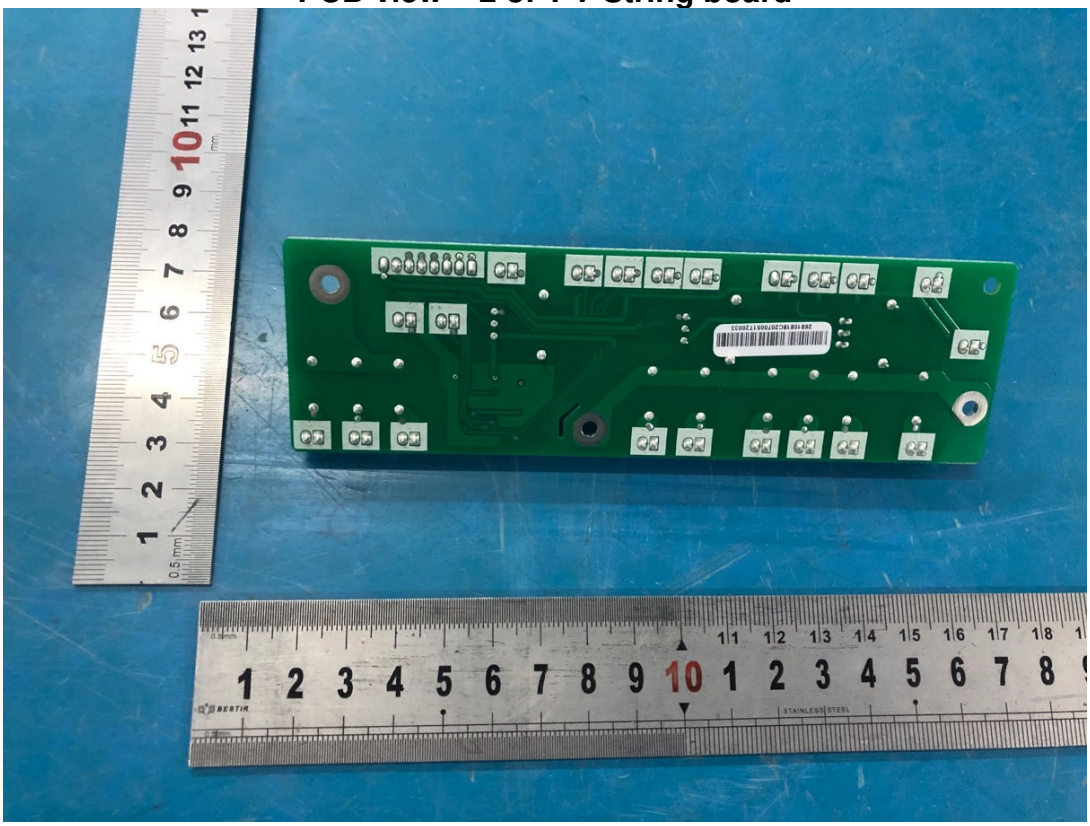
PCB view – 2 of AC lightning protection board



PCB view – 1 of PV String board



PCB view – 2 of PV String board



Annex 2

Test equipment list

Dates of performance test: 2021-05-04 to 2021-08-24

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