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 ....:	PVTH200320N031
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Total number of pages ....:	63
Testing laboratory name ....:	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
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Accreditation ....:	ilac-MRA; A2LA ACCREDITED Certificate # 2951.01
Applicant's name...........................:	**Shenzhen SOFAR SOLAR Co., Ltd.**
Address ....:	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Test specification	
Standard..:	IEC 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 ....:	**Hybrid inverter**
Trademark.......................................:	SOFAR SOLAR
Model / Type ....:	HYD 10KTL-3PH

Ratings ....:	**HYD 10KTL-3PH**
Full power MPPT voltage range [V] . :	220-850V
MPP DC voltage range [V] ....:	180-960V
Input DC current [A] ....:	Max. 25.0 x 2
Isc PV [A]..:	Max. 30.0 x 2
Output AC voltage [V] ....:	3/N/PE, 380/400,50Hz
Max. Output AC current [A]..............:	16
Rated Output power [kVA] ....:	10000
Max Output power [kVA] ....:	11000
Battery input voltage [V]...................:	180-800
Battery current [A] ....:	Max. 25A*2

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) ....:	Lukes Zhang	[signature]
Approved by (name and signature) ....:	James Huang	[signature]
Manufacturer's name ....:	**Shenzhen SOFAR SOLAR Co., Ltd.**	
Manufacturer's address.................:	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China.	
Factory's name ....:	**Dongguan SOFAR SOLAR Co.,Ltd.**	
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Document History

Date	Internal reference	Modification / Change / Status	Revision
2020-07-07	Lukes Zhang	Initial report was written	0

Supplementary information:

Test items particulars

Equipment mobility ....:	Permanent connection
Operating condition ....:	Continuous
Class of equipment ....:	Class I
Protection against ingress of water ..:	IP65 according to EN 60529
Mass of equipment [kg] ....:	Approx. 37

Test case verdicts

Test case does not apply to the test object ....:	N/A
Test item does meet the requirement ....:	P(ass)
Test item does not meet the requirement ....:	F(ail)

Testing

Date of receipt of test item ....:	2020-03-20
Date(s) of performance of test ....:	2020-03-20 to 2020-07-07

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 –Test equipment list

Copy of marking plate:

General product information:

The Solar converter converts DC voltage into AC voltage.
The DC input of Solar converter can be supplied from PV array and Batteries.
The charging current to batteries from PV array or grid, battery management unit is integrated in External Energy storage.
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.

Three Phase Hybrid Inverter

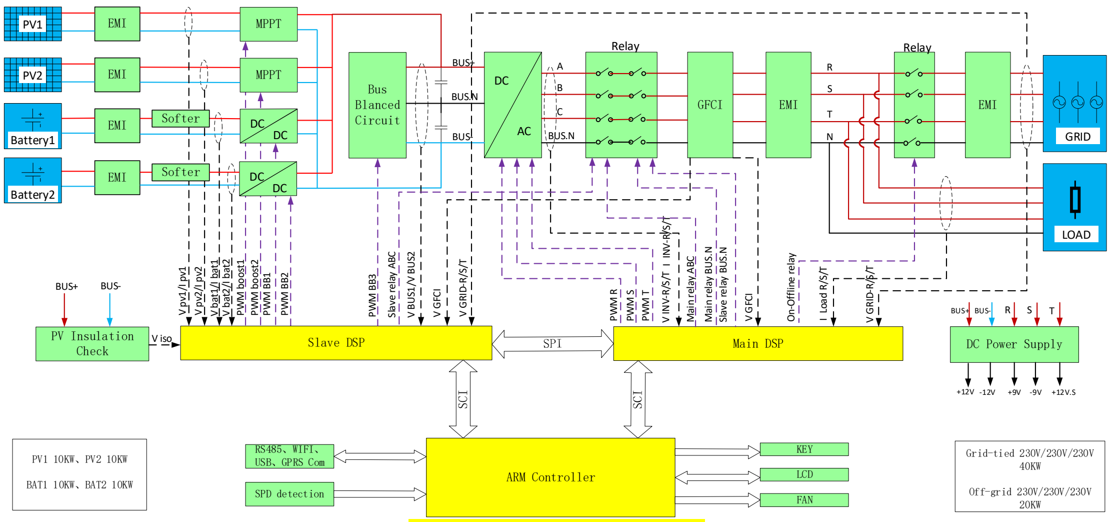


Figure 1-Block diagram

The internal control is redundant built. It consists of Main DSP (U37) and slave DSP (U39).

The Main MCU(U37) can control the relays, measures voltage, and frequency, AC current with injected DC, insulation resistance and residual current, In addition it tests the array insulation resistance and the RCMU circuit before each start up.

The slave MCU (U39) is using for controlling the relays, measuring the voltage , frequency, inject a dc AC current, the residual current, and communicating with the master MCU (U37). And if the communicating with the master DSP, the slave DSP will disconnect the relays.

The unit provides two relays in series on Line and Neutral 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 start up. Both controllers Main MCU(U39), Slave MCU (U37) can open the relays.

The product was tested on:

Hardware version: V1.0
Software version: V2.00 e superiore

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 1 % 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**

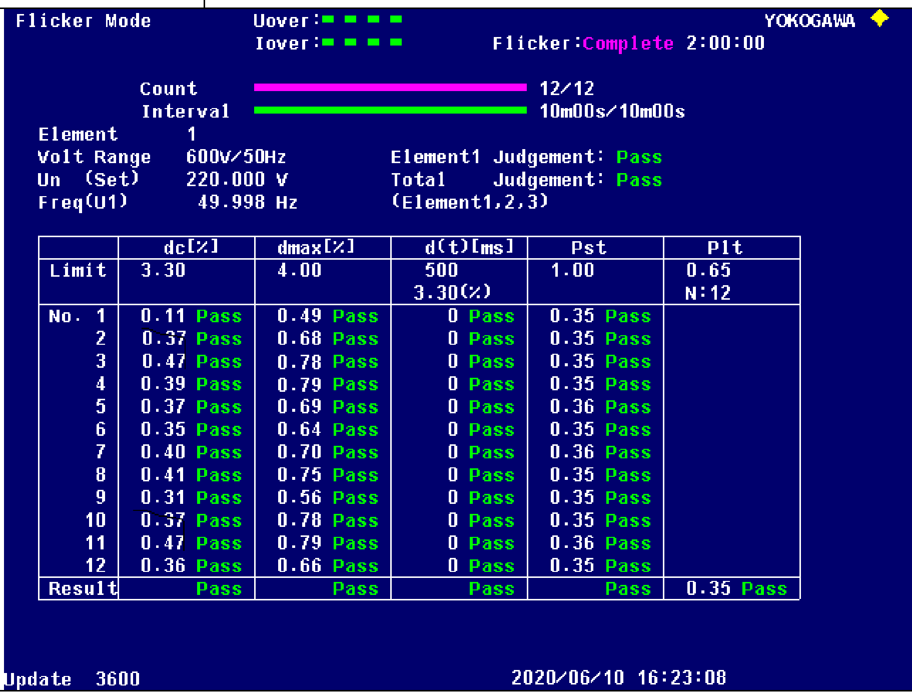
Test overview:		
IEC 61727:2004		
Clause	**Type Test**	**Result**
4	Type test:	
4.3	Voltage Fluctuations and Flicker	**P**
4.4	Monitoring of DC-Injection	**P**
4.5	Normal frequency operating range (see 5.2.2 below)	**P**
4.6	Harmonics and waveform distortion	**P**
4.7	Power factor	**P**
5.2.1	Voltage 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}=0,65	
Test value	*	*	*	*	
inverter >16A					
Limit	dc% = 3,3		P_{st}=1,0	P_{lt}=0,65	
Test value	See below				


Flicker Mode Uover:- - - - Iover:- - - - YOKOGAWA
Flicker:Complete 2:00:00
Count 12/12
Interval 10m00s/10m00s
Element 1
Volt Range 600V/50Hz Element1 Judgement: Pass
Un (Set) 220.000 V Total Judgement: Pass
Freq(U1) 49.998 Hz (Element1,2,3)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.11 Pass	0.49 Pass	0 Pass	0.35 Pass	
2	0.37 Pass	0.68 Pass	0 Pass	0.35 Pass	
3	0.47 Pass	0.78 Pass	0 Pass	0.35 Pass	
4	0.39 Pass	0.79 Pass	0 Pass	0.35 Pass	
5	0.37 Pass	0.69 Pass	0 Pass	0.36 Pass	
6	0.35 Pass	0.64 Pass	0 Pass	0.35 Pass	
7	0.40 Pass	0.70 Pass	0 Pass	0.36 Pass	
8	0.41 Pass	0.75 Pass	0 Pass	0.35 Pass	
9	0.31 Pass	0.56 Pass	0 Pass	0.35 Pass	
10	0.37 Pass	0.78 Pass	0 Pass	0.35 Pass	
11	0.47 Pass	0.79 Pass	0 Pass	0.36 Pass	
12	0.36 Pass	0.66 Pass	0 Pass	0.35 Pass	
Result	Pass	Pass	Pass	Pass	0.35 Pass

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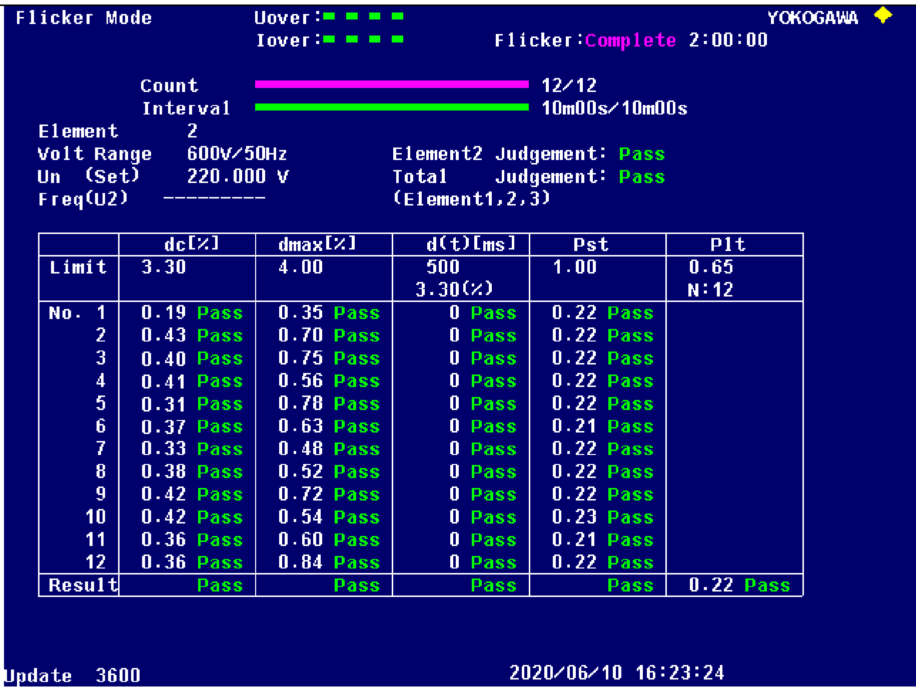

Flicker Mode Uover:- - - - YOKOGAWA
Iover:- - - - Flicker:Complete 2:00:00

Count 12/12
Interval 10m00s/10m00s
Element 2
Volt Range 600V/50Hz Element2 Judgement: Pass
Un (Set) 220.000 V Total Judgement: Pass
Freq(U2) --------- (Element1,2,3)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.19 Pass	0.35 Pass	0 Pass	0.22 Pass	
2	0.43 Pass	0.70 Pass	0 Pass	0.22 Pass	
3	0.40 Pass	0.75 Pass	0 Pass	0.22 Pass	
4	0.41 Pass	0.56 Pass	0 Pass	0.22 Pass	
5	0.31 Pass	0.78 Pass	0 Pass	0.22 Pass	
6	0.37 Pass	0.63 Pass	0 Pass	0.21 Pass	
7	0.33 Pass	0.48 Pass	0 Pass	0.22 Pass	
8	0.38 Pass	0.52 Pass	0 Pass	0.22 Pass	
9	0.42 Pass	0.72 Pass	0 Pass	0.22 Pass	
10	0.42 Pass	0.54 Pass	0 Pass	0.23 Pass	
11	0.36 Pass	0.60 Pass	0 Pass	0.21 Pass	
12	0.36 Pass	0.84 Pass	0 Pass	0.22 Pass	
Result	Pass	Pass	Pass	Pass	0.22 Pass

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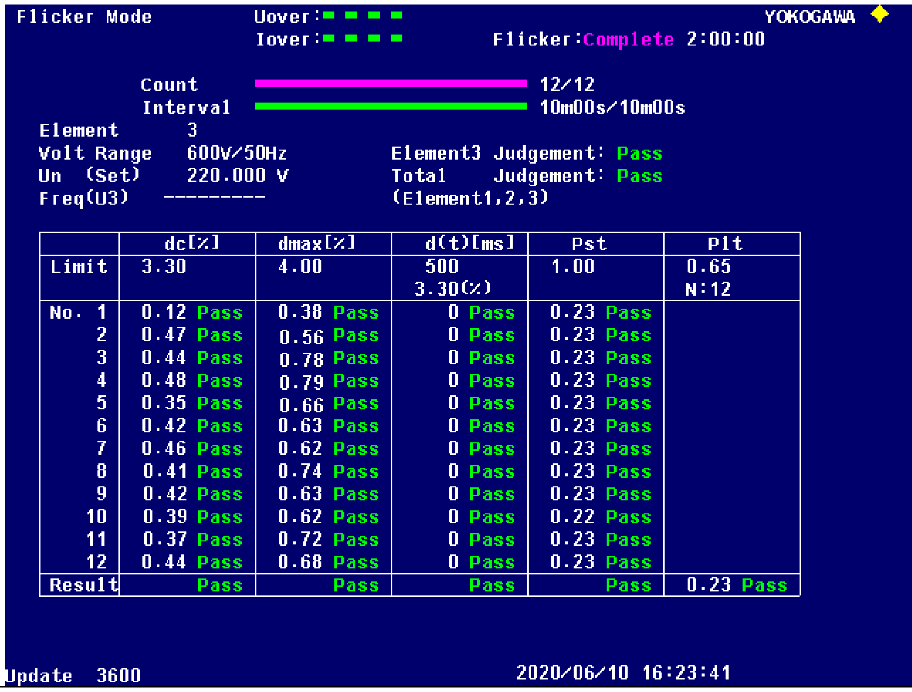

Flicker Mode Uover:- - - - YOKOGAWA
Iover:- - - - Flicker:Complete 2:00:00

Count 12/12
Interval 10m00s/10m00s
Element 3
Volt Range 600V/50Hz Element3 Judgement: Pass
Un (Set) 220.000 V Total Judgement: Pass
Freq(U3) --------- (Element1,2,3)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.12 Pass	0.38 Pass	0 Pass	0.23 Pass	
2	0.47 Pass	0.56 Pass	0 Pass	0.23 Pass	
3	0.44 Pass	0.78 Pass	0 Pass	0.23 Pass	
4	0.48 Pass	0.79 Pass	0 Pass	0.23 Pass	
5	0.35 Pass	0.66 Pass	0 Pass	0.23 Pass	
6	0.42 Pass	0.63 Pass	0 Pass	0.23 Pass	
7	0.46 Pass	0.62 Pass	0 Pass	0.23 Pass	
8	0.41 Pass	0.74 Pass	0 Pass	0.23 Pass	
9	0.42 Pass	0.63 Pass	0 Pass	0.23 Pass	
10	0.39 Pass	0.62 Pass	0 Pass	0.22 Pass	
11	0.37 Pass	0.72 Pass	0 Pass	0.23 Pass	
12	0.44 Pass	0.68 Pass	0 Pass	0.23 Pass	
Result	Pass	Pass	Pass	Pass	0.23 Pass

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

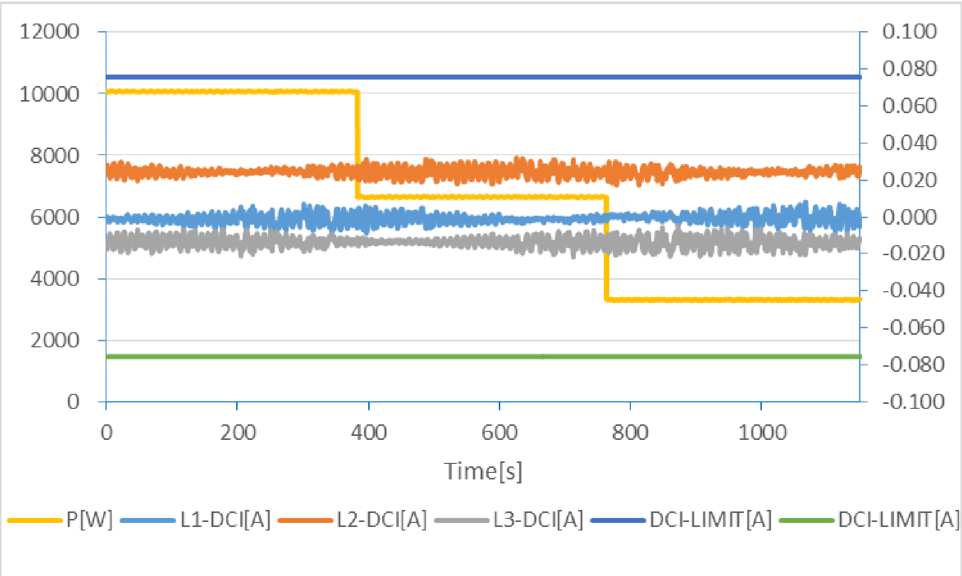
Mains Impedance according EN61000-3-3: **R_{max} = 0,24Ω; jX_{max}= 0,15Ω @50Hz (|Z_{max}| = 0,283 Ω)**
for single phase inverter use also **R_n = 0,16Ω; jX_n= 0,1Ω**

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 61000-3-3 for less 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} : 76mA**		
L1 Output power:	33%	66%	100%
Max. test value (mA):	8	8	9
Mean test value(mA) :	1	1	1
L2 Output power:	33%	66%	100%
Max. test value (mA):	30	32	30
Mean test value(mA) :	24	25	24
L3 Output power:	33%	66%	100%
Max. test value (mA):	5	7	21
Mean test value(mA) :	14	14	13

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)			1088		1095		1098	
VA (VA)			1091		1100		1097	
Vrms (V)			220,20		220,21		220,26	
Arms (A)			4,953		4,997		4,982	
PF			0,9976		0,9975		0,9983	
Frequency (Hz)			50,00					
THD50 (%)			1,007		0,887		0,895	
Harmonics	**Current Magnitude [A]**			**% of Rated Current**			**Phase**	**Harmonic Current Limits [%]**
1st	4,941	4,985	4,973	0,326	0,329	0,328	Three Phase	--
2nd	0,009	0,014	0,010	0,060	0,090	0,067	Three Phase	1
3rd	0,016	0,016	0,030	0,109	0,105	0,198	Three Phase	4
4th	0,005	0,005	0,004	0,035	0,033	0,028	Three Phase	1
5th	0,085	0,062	0,068	0,561	0,407	0,446	Three Phase	4
6th	0,004	0,008	0,009	0,029	0,050	0,062	Three Phase	1
7th	0,023	0,020	0,013	0,154	0,133	0,083	Three Phase	4
8th	0,009	0,007	0,009	0,060	0,044	0,057	Three Phase	1
9th	0,022	0,013	0,029	0,143	0,087	0,190	Three Phase	4
10th	0,007	0,005	0,007	0,049	0,033	0,043	Three Phase	1
11th	0,050	0,041	0,032	0,332	0,271	0,212	Three Phase	2
12th	0,003	0,008	0,007	0,022	0,052	0,047	Three Phase	0,5
13th	0,072	0,066	0,064	0,478	0,437	0,424	Three Phase	2
14th	0,007	0,004	0,006	0,049	0,028	0,039	Three Phase	0,5
15th	0,013	0,009	0,020	0,086	0,060	0,131	Three Phase	2
16th	0,005	0,004	0,006	0,032	0,023	0,037	Three Phase	0,5
17th	0,014	0,031	0,025	0,095	0,202	0,164	Three Phase	1,5
18th	0,003	0,005	0,003	0,021	0,032	0,019	Three Phase	0,375
19th	0,048	0,039	0,040	0,314	0,259	0,263	Three Phase	1,5
20th	0,004	0,002	0,004	0,029	0,015	0,027	Three Phase	0,375
21th	0,005	0,004	0,008	0,035	0,026	0,054	Three Phase	1,5
22th	0,004	0,002	0,005	0,023	0,016	0,030	Three Phase	0,375
23th	0,022	0,029	0,020	0,145	0,194	0,134	Three Phase	0,6
24th	0,003	0,002	0,002	0,020	0,016	0,013	Three Phase	0,15
25th	0,019	0,014	0,017	0,126	0,095	0,114	Three Phase	0,6
26th	0,003	0,002	0,002	0,019	0,016	0,015	Three Phase	0,15
27th	0,008	0,004	0,008	0,051	0,025	0,054	Three Phase	0,6
28th	0,003	0,003	0,004	0,021	0,018	0,026	Three Phase	0,15
29th	0,032	0,031	0,026	0,208	0,208	0,173	Three Phase	0,6
30th	0,002	0,002	0,003	0,015	0,016	0,017	Three Phase	0,15
31th	0,010	0,010	0,010	0,065	0,067	0,065	Three Phase	0,6
32th	0,003	0,003	0,002	0,017	0,017	0,016	Three Phase	0,15
33th	0,005	0,005	0,007	0,033	0,033	0,049	Three Phase	0,6
34th	0,004	0,002	0,004	0,026	0,010	0,027	Three Phase	0,15
35th	0,015	0,020	0,018	0,102	0,132	0,121	Three Phase	0,3

36th	0,003	0,002	0,003	0,020	0,011	0,018	Three Phase	0,075
37th	0,007	0,004	0,007	0,048	0,027	0,043	Three Phase	0,3
38th	0,003	0,003	0,002	0,022	0,017	0,012	Three Phase	0,075
39th	0,007	0,007	0,010	0,045	0,044	0,064	Three Phase	0,3
40th	0,003	0,002	0,002	0,017	0,011	0,015	Three Phase	0,075
41th	0,011	0,009	0,009	0,071	0,063	0,059	Three Phase	N/A
42th	0,003	0,002	0,002	0,017	0,014	0,011	Three Phase	N/A
43th	0,012	0,016	0,017	0,079	0,108	0,109	Three Phase	N/A
44th	0,004	0,003	0,003	0,027	0,018	0,020	Three Phase	N/A
45th	0,007	0,006	0,005	0,043	0,038	0,036	Three Phase	N/A
46th	0,009	0,010	0,008	0,061	0,063	0,054	Three Phase	N/A
47th	0,028	0,029	0,026	0,182	0,192	0,168	Three Phase	N/A
48th	0,011	0,010	0,008	0,070	0,066	0,056	Three Phase	N/A
49th	0,012	0,013	0,015	0,079	0,086	0,101	Three Phase	N/A
50th	0,004	0,002	0,004	0,026	0,016	0,026	Three Phase	N/A

66% Output Power								
Watts (W)				2200		2207		2204
VA (VA)				2201		2208		2205
Vrms (V)				220,41		220,37		220,45
Arms (A)				9,987		10,020		10,004
PF				0,9994		0,9994		0,9997
Frequency (Hz)				50				
THD50 (%)				0,863		0,802		0,802
Harmonics	**Current Magnitude [A]**			**% of Rated Current**			**Phase**	**Harmonic Current Limits [%]**
1st	9,982	10,015	10,000	0,659	0,661	0,660	Three Phase	--
2nd	0,012	0,010	0,008	0,078	0,064	0,051	Three Phase	1
3rd	0,012	0,013	0,022	0,076	0,084	0,146	Three Phase	4
4th	0,005	0,006	0,003	0,035	0,041	0,023	Three Phase	1
5th	0,063	0,054	0,058	0,416	0,355	0,382	Three Phase	4
6th	0,005	0,004	0,006	0,032	0,026	0,041	Three Phase	1
7th	0,015	0,017	0,014	0,099	0,112	0,090	Three Phase	4
8th	0,006	0,004	0,006	0,040	0,026	0,040	Three Phase	1
9th	0,012	0,008	0,015	0,080	0,055	0,102	Three Phase	4
10th	0,006	0,004	0,004	0,039	0,029	0,029	Three Phase	1
11th	0,039	0,030	0,033	0,258	0,198	0,220	Three Phase	2
12th	0,003	0,003	0,004	0,018	0,023	0,029	Three Phase	0,5
13th	0,046	0,042	0,041	0,301	0,275	0,273	Three Phase	2
14th	0,006	0,003	0,005	0,042	0,019	0,034	Three Phase	0,5
15th	0,008	0,006	0,012	0,050	0,040	0,078	Three Phase	2
16th	0,004	0,003	0,003	0,029	0,021	0,017	Three Phase	0,5
17th	0,025	0,024	0,018	0,165	0,157	0,118	Three Phase	1,5
18th	0,002	0,002	0,003	0,012	0,015	0,018	Three Phase	0,375
19th	0,044	0,040	0,039	0,290	0,267	0,254	Three Phase	1,5
20th	0,005	0,002	0,004	0,030	0,013	0,023	Three Phase	0,375
21th	0,004	0,004	0,007	0,024	0,024	0,043	Three Phase	1,5
22th	0,003	0,002	0,002	0,022	0,016	0,015	Three Phase	0,375

23th	0,044	0,044	0,040	0,289	0,292	0,261	Three Phase	0,6
24th	0,002	0,001	0,002	0,010	0,009	0,011	Three Phase	0,15
25th	0,014	0,011	0,012	0,090	0,071	0,079	Three Phase	0,6
26th	0,003	0,002	0,002	0,018	0,012	0,015	Three Phase	0,15
27th	0,005	0,003	0,005	0,031	0,019	0,030	Three Phase	0,6
28th	0,003	0,002	0,002	0,017	0,013	0,011	Three Phase	0,15
29th	0,035	0,035	0,032	0,232	0,229	0,211	Three Phase	0,6
30th	0,002	0,002	0,002	0,012	0,011	0,012	Three Phase	0,15
31th	0,028	0,026	0,027	0,182	0,169	0,178	Three Phase	0,6
32th	0,002	0,002	0,002	0,010	0,011	0,012	Three Phase	0,15
33th	0,007	0,005	0,007	0,049	0,034	0,045	Three Phase	0,6
34th	0,002	0,001	0,002	0,016	0,010	0,013	Three Phase	0,15
35th	0,016	0,021	0,019	0,105	0,137	0,123	Three Phase	0,3
36th	0,002	0,002	0,002	0,013	0,010	0,013	Three Phase	0,075
37th	0,011	0,011	0,010	0,073	0,070	0,064	Three Phase	0,3
38th	0,002	0,002	0,002	0,011	0,011	0,011	Three Phase	0,075
39th	0,009	0,011	0,008	0,059	0,072	0,051	Three Phase	0,3
40th	0,002	0,002	0,002	0,014	0,011	0,011	Three Phase	0,075
41th	0,010	0,012	0,011	0,069	0,080	0,070	Three Phase	N/A
42th	0,002	0,002	0,002	0,014	0,010	0,012	Three Phase	N/A
43th	0,015	0,019	0,018	0,100	0,124	0,117	Three Phase	N/A
44th	0,002	0,002	0,002	0,011	0,011	0,011	Three Phase	N/A
45th	0,005	0,004	0,005	0,032	0,029	0,034	Three Phase	N/A
46th	0,010	0,009	0,008	0,063	0,061	0,052	Three Phase	N/A
47th	0,026	0,028	0,026	0,173	0,184	0,168	Three Phase	N/A
48th	0,010	0,009	0,009	0,068	0,061	0,056	Three Phase	N/A
49th	0,009	0,010	0,011	0,062	0,065	0,071	Three Phase	N/A
50th	0,002	0,002	0,002	0,012	0,010	0,012	Three Phase	N/A

100% Output Power								
Watts (kW)				3336		3325		3327
VA (kVA)				3338		3326		3328
Vrms (V)				220,76		220,76		220,68
Arms (A)				15,121		15,070		15,081
PF				0,9997		0,9996		0,9997
Frequency (Hz)				50,00				
THD50 (%)				1,514		1,514		1,459
Harmonics	**Current Magnitude [A]**			**% of Rated Current**			**Phase**	**Harmonic Current Limits [%]**
1st	15,144	15,178	15,162	0,999	1,002	1,001	Three Phase	--
2nd	0,011	0,008	0,006	0,070	0,055	0,042	Three Phase	1
3rd	0,010	0,013	0,020	0,063	0,088	0,132	Three Phase	4
4th	0,006	0,007	0,003	0,037	0,044	0,023	Three Phase	1
5th	0,059	0,051	0,054	0,393	0,336	0,356	Three Phase	4
6th	0,004	0,004	0,005	0,029	0,024	0,035	Three Phase	1
7th	0,012	0,014	0,014	0,078	0,094	0,090	Three Phase	4
8th	0,005	0,004	0,005	0,036	0,026	0,034	Three Phase	1

9th	0,013	0,009	0,013	0,083	0,056	0,085	Three Phase	4
10th	0,005	0,004	0,004	0,036	0,028	0,027	Three Phase	1
11th	0,041	0,032	0,036	0,269	0,213	0,239	Three Phase	2
12th	0,003	0,004	0,004	0,017	0,026	0,028	Three Phase	0,5
13th	0,036	0,035	0,034	0,237	0,233	0,225	Three Phase	2
14th	0,005	0,003	0,004	0,033	0,019	0,024	Three Phase	0,5
15th	0,009	0,007	0,012	0,058	0,048	0,077	Three Phase	2
16th	0,004	0,003	0,003	0,027	0,019	0,019	Three Phase	0,5
17th	0,012	0,008	0,008	0,077	0,054	0,054	Three Phase	1,5
18th	0,002	0,003	0,003	0,012	0,022	0,021	Three Phase	0,375
19th	0,028	0,027	0,025	0,182	0,179	0,165	Three Phase	1,5
20th	0,004	0,002	0,002	0,025	0,016	0,016	Three Phase	0,375
21th	0,004	0,004	0,008	0,030	0,025	0,055	Three Phase	1,5
22th	0,003	0,002	0,002	0,019	0,016	0,015	Three Phase	0,375
23th	0,024	0,024	0,022	0,161	0,156	0,146	Three Phase	0,6
24th	0,002	0,002	0,002	0,010	0,012	0,012	Three Phase	0,15
25th	0,013	0,012	0,013	0,085	0,079	0,083	Three Phase	0,6
26th	0,002	0,002	0,002	0,015	0,012	0,013	Three Phase	0,15
27th	0,007	0,002	0,006	0,048	0,016	0,039	Three Phase	0,6
28th	0,002	0,002	0,002	0,010	0,013	0,010	Three Phase	0,15
29th	0,022	0,021	0,021	0,142	0,139	0,141	Three Phase	0,6
30th	0,002	0,001	0,001	0,011	0,010	0,010	Three Phase	0,15
31th	0,036	0,035	0,034	0,239	0,232	0,223	Three Phase	0,6
32th	0,001	0,001	0,002	0,009	0,009	0,011	Three Phase	0,15
33th	0,009	0,004	0,008	0,058	0,024	0,054	Three Phase	0,6
34th	0,002	0,001	0,001	0,010	0,009	0,009	Three Phase	0,15
35th	0,009	0,007	0,009	0,062	0,045	0,059	Three Phase	0,3
36th	0,002	0,002	0,002	0,012	0,011	0,011	Three Phase	0,075
37th	0,017	0,016	0,013	0,112	0,108	0,089	Three Phase	0,3
38th	0,002	0,002	0,002	0,013	0,010	0,012	Three Phase	0,075
39th	0,007	0,010	0,005	0,045	0,066	0,031	Three Phase	0,3
40th	0,002	0,002	0,002	0,012	0,013	0,012	Three Phase	0,075
41th	0,011	0,010	0,012	0,073	0,068	0,080	Three Phase	N/A
42th	0,002	0,002	0,002	0,013	0,011	0,011	Three Phase	N/A
43th	0,021	0,025	0,021	0,139	0,165	0,135	Three Phase	N/A
44th	0,002	0,002	0,002	0,012	0,012	0,011	Three Phase	N/A
45th	0,005	0,004	0,004	0,032	0,028	0,026	Three Phase	N/A
46th	0,009	0,009	0,008	0,059	0,057	0,051	Three Phase	N/A
47th	0,028	0,027	0,026	0,182	0,180	0,169	Three Phase	N/A
48th	0,010	0,009	0,008	0,063	0,061	0,054	Three Phase	N/A
49th	0,009	0,009	0,007	0,062	0,062	0,046	Three Phase	N/A
50th	0,002	0,002	0,002	0,013	0,012	0,011	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)				220,005	220,922	220,822		
Frequency (Hz)				50,00				
THD50 (%)				1,199	1,333	1,327		
Harmonics	**Voltage Magnitude [V]**			**% of Rated Voltage**			**Phase**	**Limits [%]**
2nd	0,113	0,134	0,227	0,051	0,061	0,103	Three Phase	0,2
3rd	2,424	2,696	2,660	1,102	1,226	1,209	Three Phase	4
4th	0,124	0,148	0,101	0,056	0,067	0,046	Three Phase	0,2
5th	0,599	0,701	0,739	0,272	0,318	0,336	Three Phase	4
6th	0,081	0,093	0,083	0,037	0,042	0,038	Three Phase	0,2
7th	0,501	0,573	0,594	0,228	0,260	0,270	Three Phase	4
8th	0,075	0,078	0,074	0,034	0,036	0,034	Three Phase	0,2
9th	0,274	0,329	0,371	0,124	0,149	0,168	Three Phase	2
10th	0,070	0,054	0,058	0,032	0,024	0,027	Three Phase	0,2
11th	0,210	0,204	0,191	0,095	0,093	0,087	Three Phase	0,1
12th	0,060	0,064	0,055	0,027	0,029	0,025	Three Phase	0,1
13th	0,208	0,197	0,198	0,094	0,090	0,090	Three Phase	0,1
14th	0,056	0,058	0,053	0,025	0,026	0,024	Three Phase	0,1
15th	0,089	0,109	0,131	0,041	0,050	0,059	Three Phase	0,1
16th	0,066	0,070	0,058	0,030	0,032	0,026	Three Phase	0,1
17th	0,111	0,146	0,150	0,051	0,066	0,068	Three Phase	0,1
18th	0,050	0,054	0,046	0,023	0,024	0,021	Three Phase	0,1
19th	0,123	0,135	0,150	0,056	0,061	0,068	Three Phase	0,1
20th	0,039	0,041	0,040	0,018	0,019	0,018	Three Phase	0,1
21th	0,055	0,044	0,060	0,025	0,020	0,027	Three Phase	0,1
22th	0,039	0,041	0,039	0,018	0,019	0,018	Three Phase	0,1
23th	0,089	0,105	0,101	0,040	0,048	0,046	Three Phase	0,1
24th	0,036	0,044	0,036	0,016	0,020	0,016	Three Phase	0,1
25th	0,084	0,082	0,083	0,038	0,037	0,038	Three Phase	0,1
26th	0,036	0,040	0,039	0,016	0,018	0,018	Three Phase	0,1
27th	0,050	0,053	0,041	0,023	0,024	0,019	Three Phase	0,1
28th	0,040	0,041	0,036	0,018	0,019	0,016	Three Phase	0,1
29th	0,102	0,099	0,099	0,046	0,045	0,045	Three Phase	0,1
30th	0,041	0,040	0,044	0,019	0,018	0,020	Three Phase	0,1
31th	0,154	0,177	0,155	0,070	0,080	0,070	Three Phase	0,1
32th	0,045	0,047	0,043	0,021	0,021	0,020	Three Phase	0,1
33th	0,075	0,051	0,049	0,034	0,023	0,022	Three Phase	0,1
34th	0,060	0,058	0,048	0,027	0,027	0,022	Three Phase	0,1
35th	0,160	0,177	0,168	0,073	0,080	0,077	Three Phase	0,1
36th	0,065	0,071	0,076	0,030	0,032	0,034	Three Phase	0,1
37th	0,193	0,181	0,177	0,088	0,082	0,080	Three Phase	0,1
38th	0,170	0,165	0,160	0,077	0,075	0,073	Three Phase	0,1
39th	0,175	0,081	0,124	0,080	0,037	0,056	Three Phase	0,1
40th	0,121	0,133	0,105	0,055	0,061	0,048	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%**
220	0,9926	0,9995	0,9999	0,9999	0,9999

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)

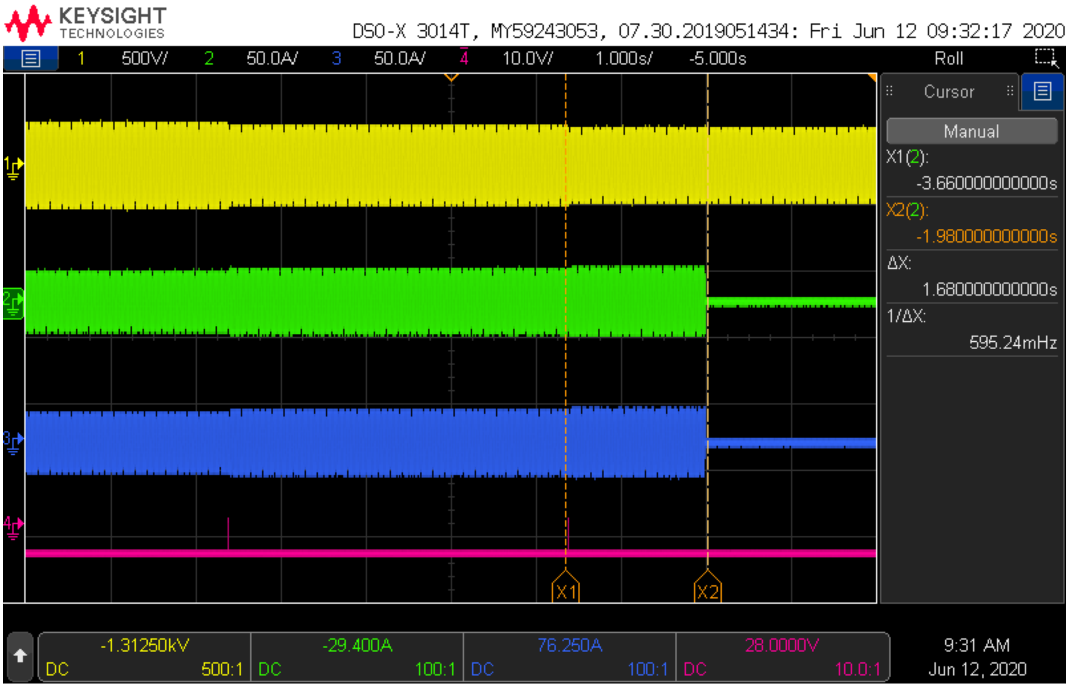
Test conditions:	Output power: 10KW Frequency: 50Hz									
	Under Voltage					**Over Voltage**				
		Voltage [V]					Voltage [V]			
Set value		**198V**					**242V**			
Measured trip value		All	L1	L2	L3		All	L1	L2	L3
		197,8	197,8	197,7	197,9		242,3	243,0	242,5	243,2
		197,8	197,7	197,9	197,7		242,3	243,6	242,6	242,7
		197,8	197,9	197,8	197,8		242,3	243,1	242,3	242,1
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
		1,68	1,62	1,64	1,62		0,64	0,63	0,64	0,62
		1,66	1,64	1,64	1,62		0,64	0,62	0,64	0,62
		1,66	1,64	1,64	1,64		0,64	0,64	0,63	0,63
Reconnection time	20s - 5min	62s				20s - 5min	63s			

Second Level (Phase to Neutral)										
Test conditions:	Output power:10KW 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
		109,0	109,7	109,3	109,7		264,2	265,2	265,0	265,0
		109,5	109,4	109,5	109,7		264,1	265,3	265,1	265,3
		109,8	109,4	109,7	109,6		264,1	265,2	264,9	265,0
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
		188	206	192	194		80	78	80	82
		190	204	192	190		82	78	76	80
		192	198	210	210		80	78	72	80
Reconnection time	20s - 5min	60s				20s - 5min	62s			

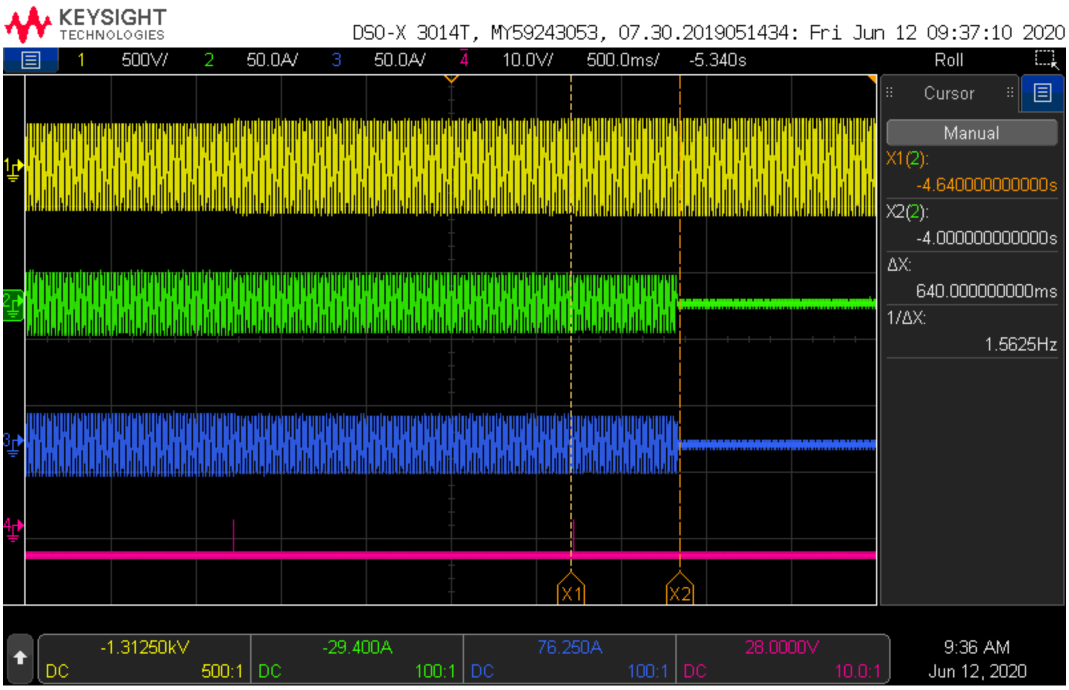
Note:
Note:
The tests are according PEA 8/9/2556. The voltage settings of the EUT are set for the tests as stated to 198V, 110V for undervoltage and 242V, 264V for overvoltage.

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

Under Voltage First Level

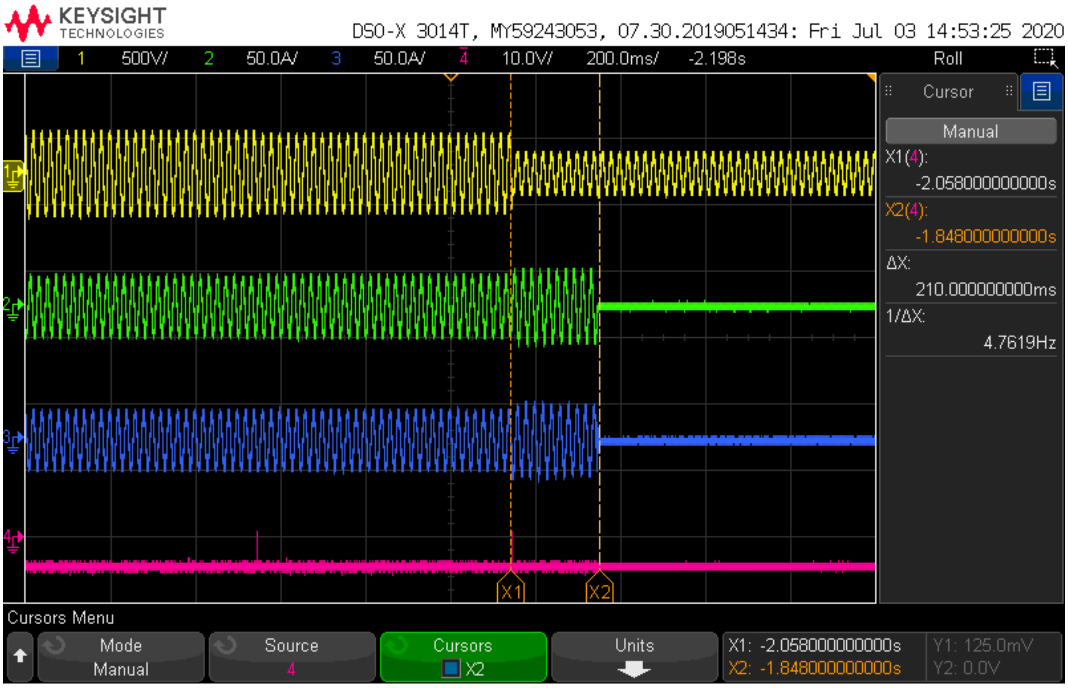


Over voltage First Level

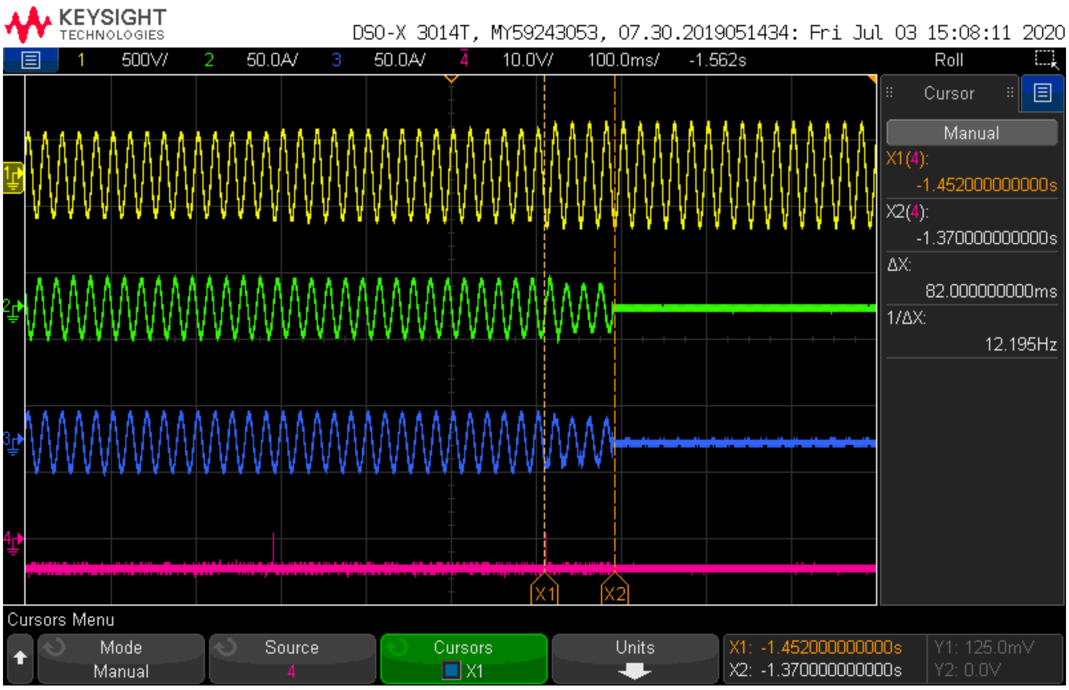


Note: CH1: grid voltage(300V/div); CH2: Current of EUT(15A/div); CH3: Current of EUT(15A/div)

Under Voltage Second Level

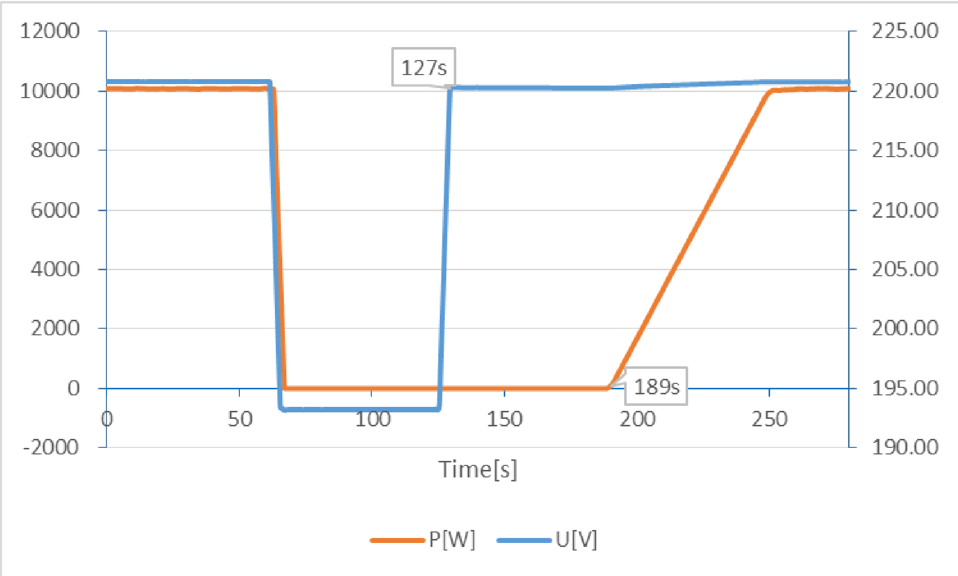


Over voltage Second Level

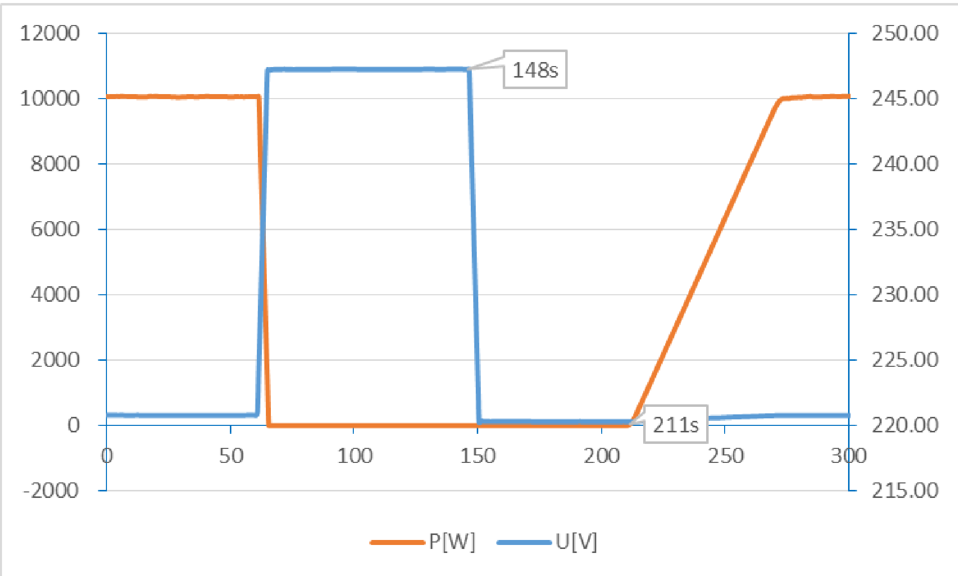


Note: CH1: grid voltage(300V/div); CH2: Current of EUT(15A/div); CH3: Current of EUT(15A/div)

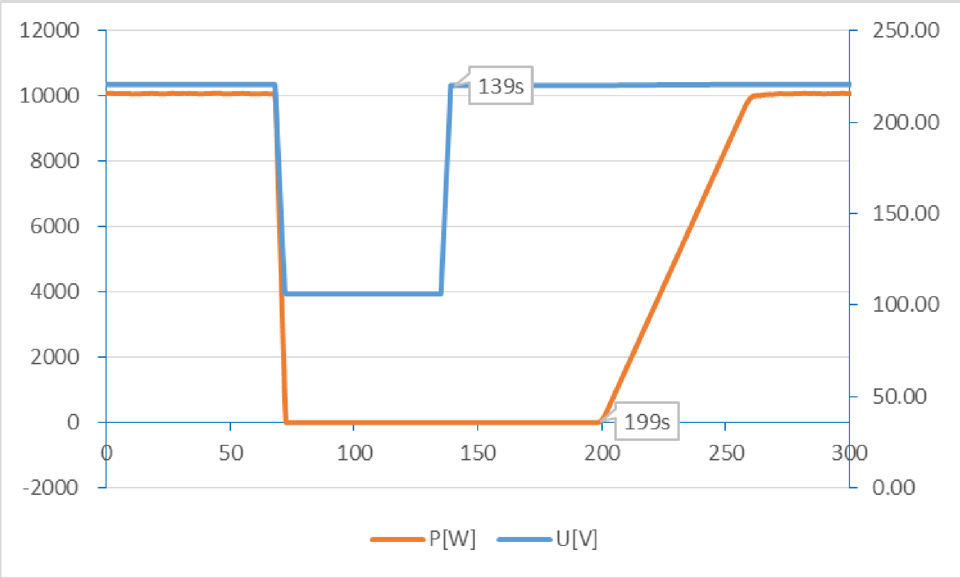
Reconnection after Under Voltage First Level



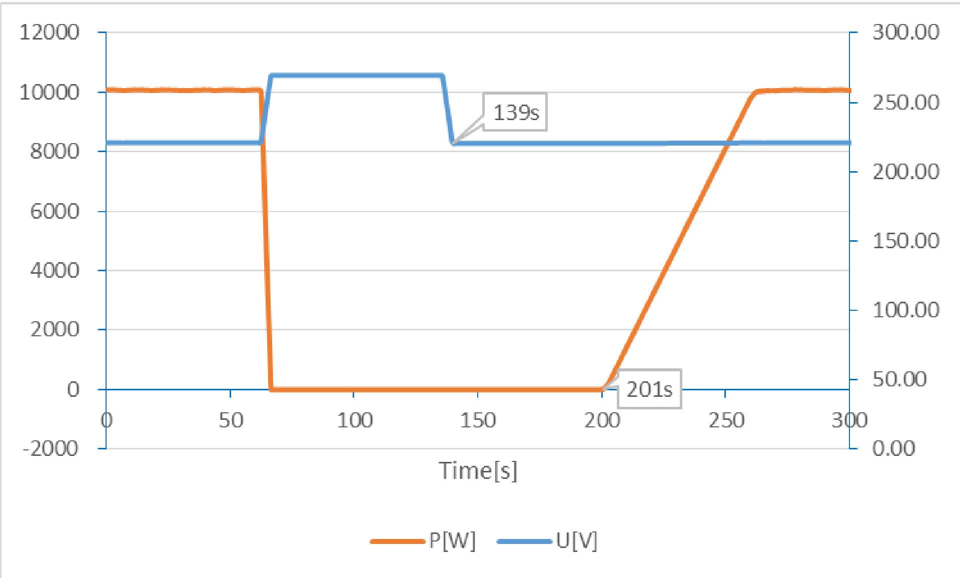
Reconnection after Over Voltage First Level



Reconnection after Under Voltage Second Level



Reconnection after Over Voltage Second Level

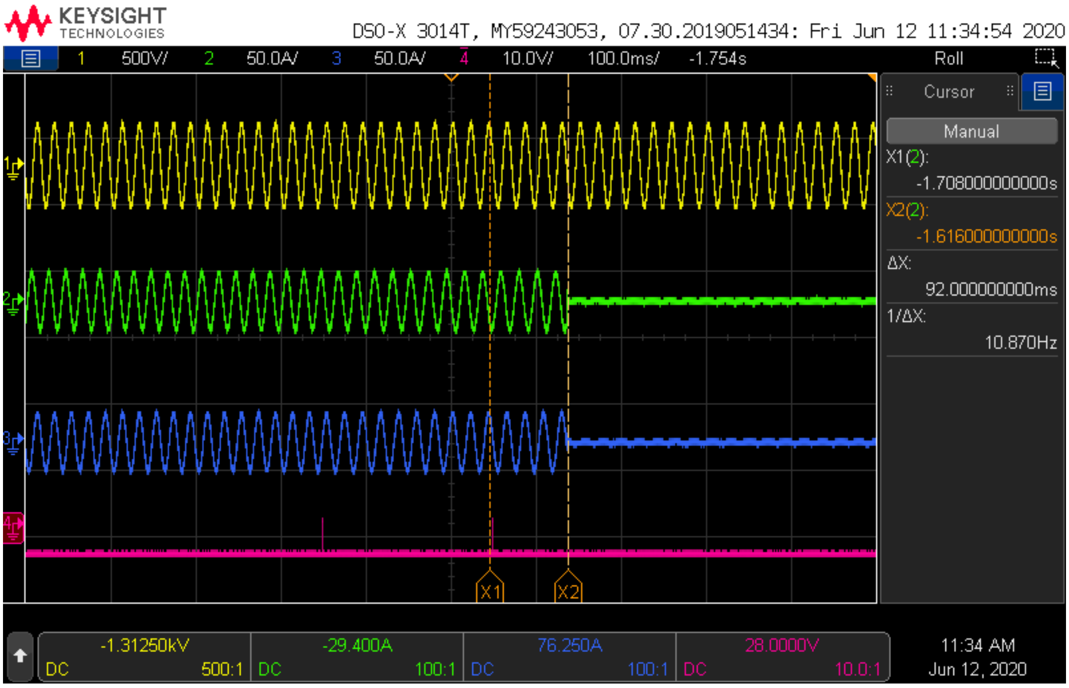


5.2.2 Frequency monitoring				**P**
IEC 61727 **8.2 Under and Over Frequency Protection (PEA:2016)** **3.10, 12.5 Response to utility recovery (PEA:2016)**				
Test conditions:	Any output power level			
	Under frequency		**Over frequency**	
Parameter		Frequency [Hz]		Frequency [Hz]
Output Voltage		U_N		U_N
Set value		**47,00Hz**		**52,00Hz**
Measured trip value(V)		46,98		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	92	50,0 Hz to 51,80 Hz (0,2s min) to 52,5Hz	92
Reconnection time (Sec)	20s – 5min	63s	20s-5min	63s

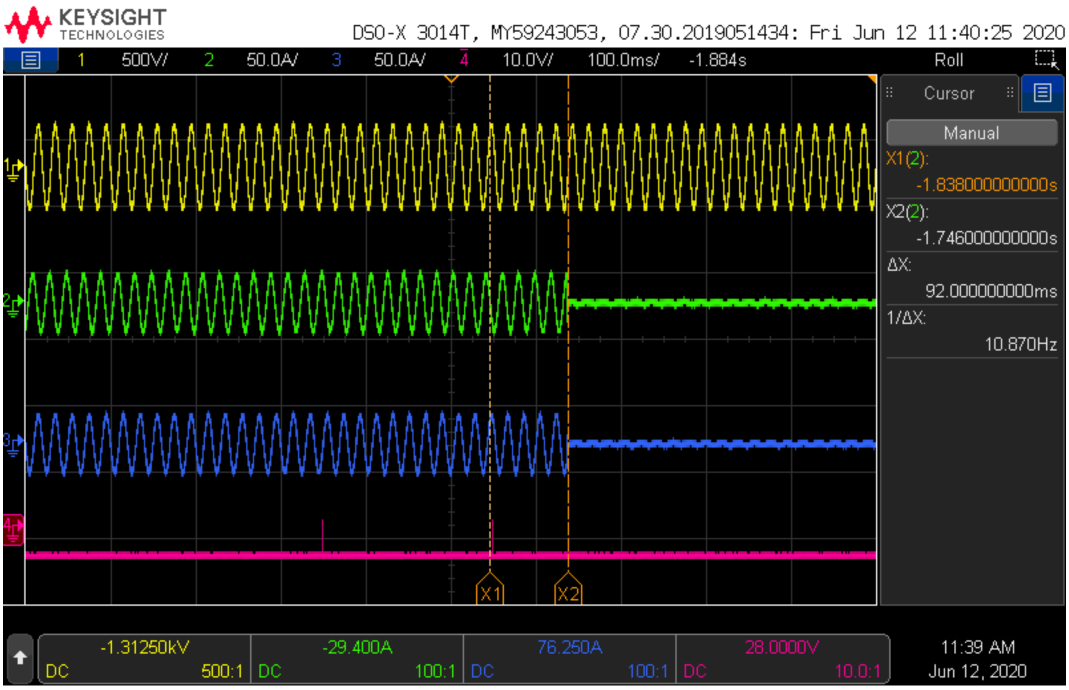
Note:
The frequency which inverter stops feeding power to electrical system in each test must be in the range of the frequency trip setting +/- 0,1Hz and the time it takes to cut off the power must be within 0.1 second.

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: grid voltage(300V/div); CH2: Current of EUT(15A/div); CH3: Current of EUT(15A/div) CH4: trip signal

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

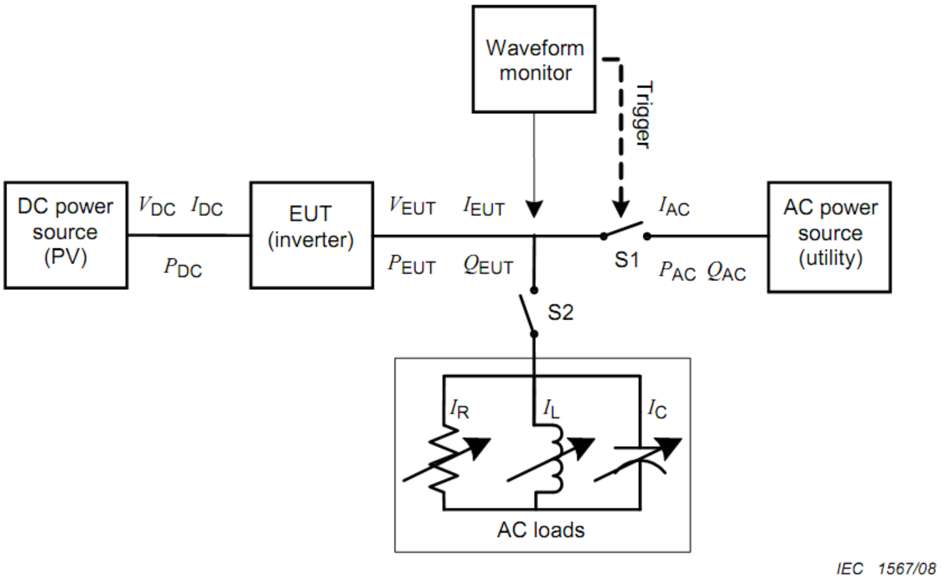


Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

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} (W per phase)	Actual Q_f	V_{DC} (V)	Remarks4)
1	100	100	0	0	524	3333	1,001	745	Test A at BL
4	100	100	-5	-5	380	3333	1,027	745	Test A at IB
5	100	100	-5	0	436	3333	1,054	745	Test A at IB
6	100	100	-5	+5	490	3333	1,080	745	Test A at IB
7	100	100	0	-5	482	3333	0,976	745	Test A at IB
8	100	100	0	+5	416	3333	1,026	745	Test A at IB
9	100	100	+5	-5	408	3333	0,929	745	Test A at IB
10	100	100	+5	0	484	3333	0,953	745	Test A at IB
11	100	100	+5	+5	402	3333	0,977	745	Test A at IB

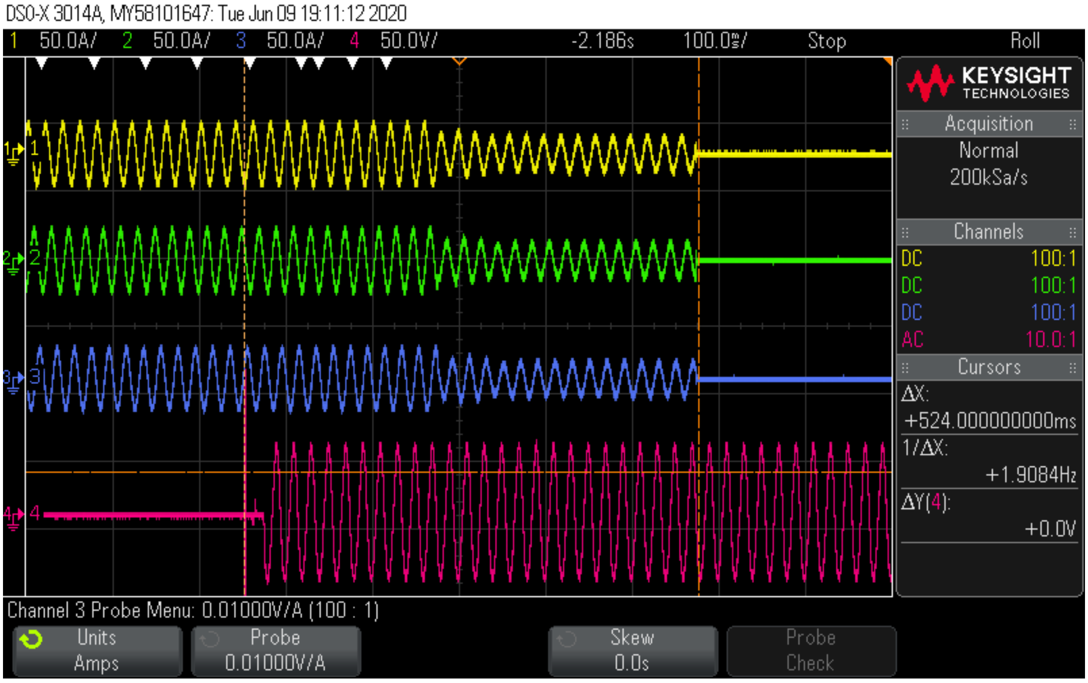
Parameter at 0% per phase	L= 50,45mH	R= 15,87Ω	C= 200,67µF
IAC fundamental current(A)	102 mA		

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



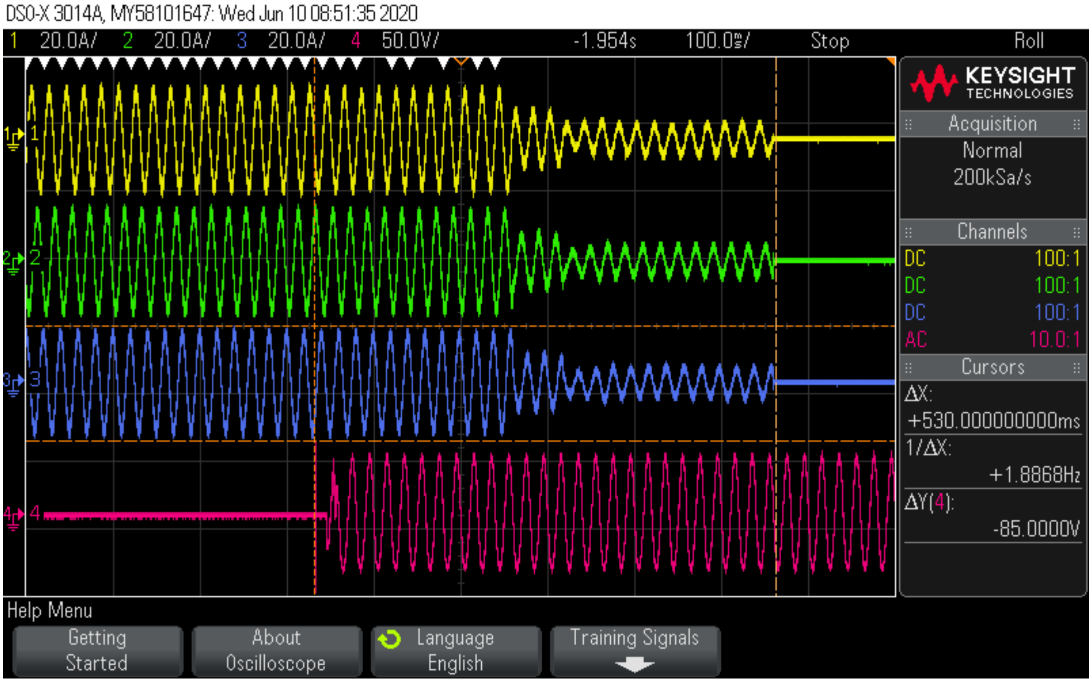
Attention:
For Thailand only picture with all three current phases L1, L2 and L3 are accepted.
All relays are direct coupled and open directly by receiving the islanding signal from the controller.

Note:
CH1,CH2,CH3: Current of EUT(20A/div); CH4: trip signal

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} (W per phase)	Actual Qf	V_{DC} (V)	Remarks4)
1	66	66	0	-5	420	2200	0,976	525	Test B at IB
2	66	66	0	-4	482	2200	0,981	525	Test B at IB
3	66	66	0	-3	490	2200	0,986	525	Test B at IB
4	66	66	0	-2	474	2200	0,991	525	Test B at IB
5	66	66	0	-1	446	2200	0,996	525	Test B at IB
6	66	66	0	0	530	2200	1,001	525	Test B at BL
7	66	66	0	1	432	2200	1,006	525	Test B at IB
8	66	66	0	2	394	2200	1,011	525	Test B at IB
9	66	66	0	3	380	2200	1,016	525	Test B at IB
10	66	66	0	4	412	2200	1,021	525	Test B at IB
11	66	66	0	5	330	2200	1,026	525	Test B at IB
Parameter at 0% per phase	L= 76,19mH		R= 23,97Ω			C= 132,98µF			
IAC fundamental current(A)	98 mA								

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



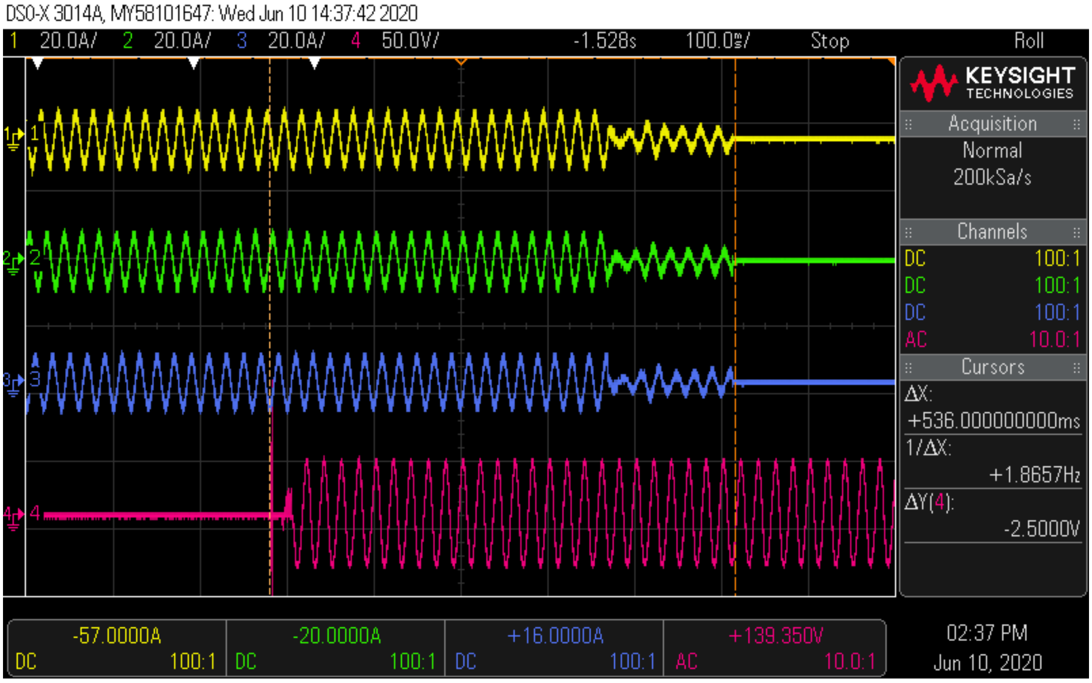
Attention:
For Thailand only picture with all three current phases L1, L2 and L3 are accepted
All relays are direct coupled and open directly by receiving the islanding signal from the controller.

Note:
CH1,CH2,CH3: Current of EUT(20A/div); CH4: trip signal

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} (W per phase)	Actual Q_f	V_{DC} (V)	Remarks4)
1	33	33	0	-5	432	1100	0,975	305	Test C at IB
2	33	33	0	-4	468	1100	0,980	305	Test C at IB
3	33	33	0	-3	484	1100	0,985	305	Test C at IB
4	33	33	0	-2	430	1100	0,990	305	Test C at IB
5	33	33	0	-1	430	1100	0,995	305	Test C at IB
6	33	33	0	0	536	1100	1,000	305	Test C at BL
7	33	33	0	1	414	1100	1,005	305	Test C at IB
8	33	33	0	2	458	1100	1,010	305	Test C at IB
9	33	33	0	3	394	1100	1,015	305	Test C at IB
10	33	33	0	4	520	1100	1,020	305	Test C at IB
11	33	33	0	5	424	1100	1,025	305	Test C at IB
Parameter at 0% per phase			L= 152,39mH		R= 47,87Ω		C= 66,49μF		
IAC fundamental current(A)			102 mA						

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:
CH1,CH2,CH3: Current of EUT(20A/div); CH4: trip signal

PEA:2016 additional test	P
3.4 Reactive power control(PEA:2016)	**P**

Test conditions:	Output: 220 Vac,50Hz					
P (setting)	P(kW)ind	P(kW)cap	Q(kVar)ind, max	Q(kVar)cap, max	PFind, max	PFcap, max
0%	0,454	0,455	0,237	0,172	0,8380	0,9332
10%	0,968	0,970	0,428	0,444	0,8869	0,9091
20%	1,987	1,985	-0,992	0,963	0,8945	0,8997
30%	3,002	3,003	-1,459	1,423	0,8994	0,9037
40%	4,020	4,018	-1,929	1,940	0,9016	0,9005
50%	5,030	5,030	-2,395	2,456	0,9029	0,8986
60%	6,038	6,039	-2,860	2,970	0,9037	0,8974
70%	7,043	7,046	-3,324	3,483	0,9043	0,8965
80%	8,050	8,052	-3,788	3,996	0,9048	0,8958
90%	9,054	9,055	-4,253	4,508	0,9051	0,8952
100%	10,047	10,032	-4,713	5,004	0,9053	0,8949
Note:						

PEA:2016 additional test				P
3.4.1, 8.1.2 1) A fixed displacement factor cosφ				P
Test conditions:	Output: 220 Vac, 50Hz			
P (setting)	PF (setting)	P(kW)	Q(kVar)	PF
0%	0,90 lagging	0,454	0,237	0,8380
10%	0,90 lagging	0,968	0,428	0,8869
20%	0,90 lagging	1,987	-0,992	0,8945
30%	0,90 lagging	3,002	-1,459	0,8994
40%	0,90 lagging	4,020	-1,929	0,9016
50%	0,90 lagging	5,030	-2,395	0,9029
60%	0,90 lagging	6,038	-2,860	0,9037
70%	0,90 lagging	7,043	-3,324	0,9043
80%	0,90 lagging	8,050	-3,788	0,9048
90%	0,90 lagging	9,054	-4,253	0,9051
100%	0,90 lagging	10,047	-4,713	0,9053
P (setting)	PF (setting)	P(kW)	Q(kVar)	PF
0%	0,90 leading	0,455	0,172	0,9332
10%	0,90 leading	0,970	0,444	0,9091
20%	0,90 leading	1,985	0,963	0,8997
30%	0,90 leading	3,003	1,423	0,9037
40%	0,90 leading	4,018	1,940	0,9005
50%	0,90 leading	5,030	2,456	0,8986
60%	0,90 leading	6,039	2,970	0,8974
70%	0,90 leading	7,046	3,483	0,8965
80%	0,90 leading	8,052	3,996	0,8958
90%	0,90 leading	9,055	4,508	0,8952
100%	0,90 leading	10,032	5,004	0,8949
P (setting)	PF (setting)	P(kW)	Q(kVar)	PF
0%	1,00	0,449	0,124	0,9547
10%	1,00	0,972	0,108	0,9935
20%	1,00	1,992	0,090	0,9989
30%	1,00	3,010	0,070	0,9997

40%	1,00	4,026	0,066	0,9999
50%	1,00	5,039	0,069	0,9999
60%	1,00	6,053	0,078	0,9999
70%	1,00	7,064	0,086	0,9999
80%	1,00	8,073	0,099	0,9999
90%	1,00	9,081	0,114	0,9999
100%	1,00	10,078	0,131	0,9999
Note:				

PEA:2016 additional test	P
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)	**P**

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.

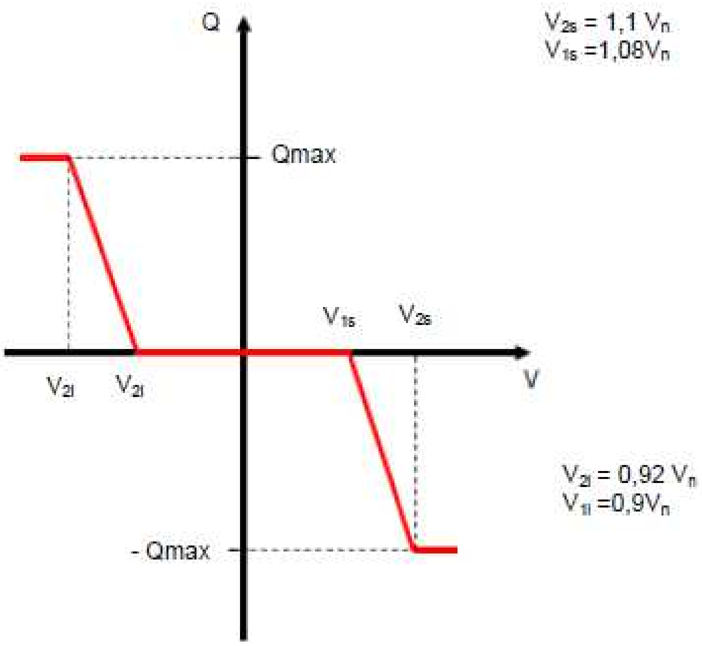
Activation must be at the Distributor's request, when the Operating Regulations are issued. The Distributor shall also specify the values of the parameters that uniquely characterise the curve, i.e.: V1i, V2i, V1s and V1s as well as the lock-in value of active power (default value P = 0,2 P_n).

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

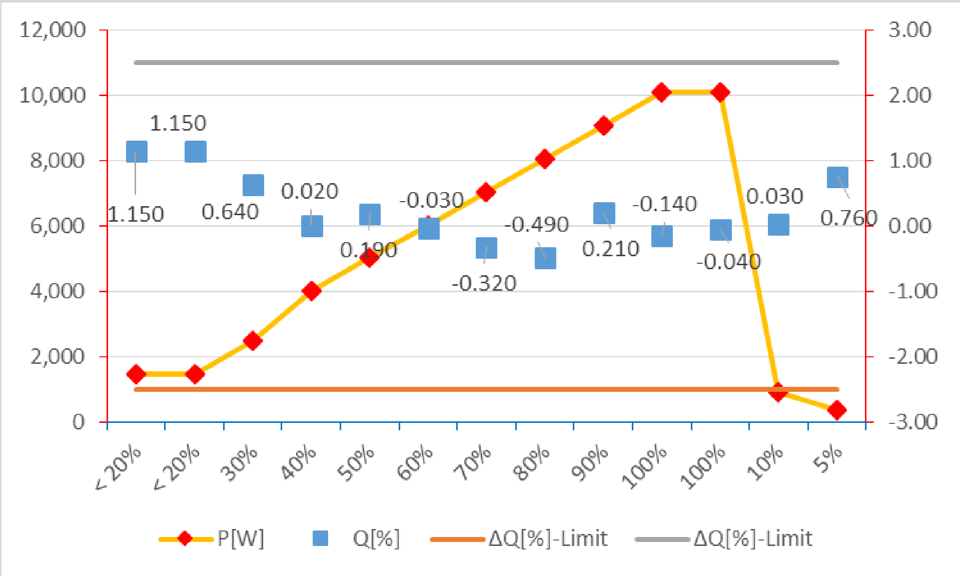
and the active power lock-in value (default value P = 0,2 P_n).



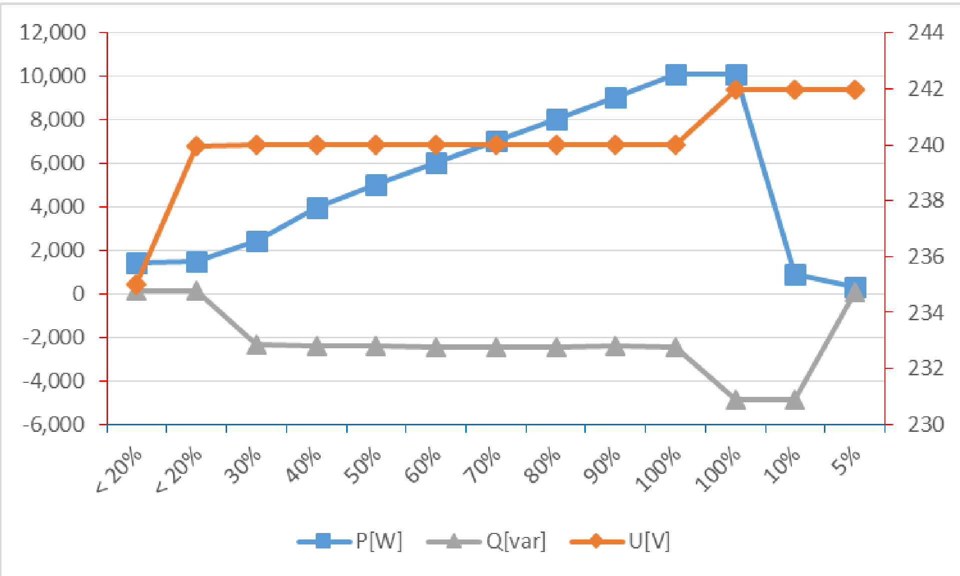
Qmin reactive power in accordance to standard characteristic curve Q=f(V)								
P(setting)	Vac [V] Set point	P[KW] measured	Vac [V]measured			Q [kVar] measured	Q [kVar] expected	ΔQ [kVar]
			L1	L2	L3			
< 20%	1,07Vn	1,470	235,00	235,00	235,00	0,115	≈0(<±2,5%Pn)	0,115
< 20%	1,09Vn	1,473	239,98	239,98	239,98	0,115	≈0(<±2,5%Pn)	0,115
< 20%-30%	1,09Vn	2,469	240,00	240,00	240,00	-2,358	-2,422	0,064
40%	1,09Vn	3,999	240,00	240,00	240,00	-2,420	-2,422	0,002
50%	1,09Vn	5,024	240,00	240,00	240,00	-2,403	-2,422	0,019
60%	1,09Vn	6,030	240,00	240,00	240,00	-2,425	-2,422	-0,003
70%	1,09Vn	7,042	240,00	240,00	240,00	-2,454	-2,422	-0,032
80%	1,09Vn	8,051	240,00	240,00	240,00	-2,471	-2,422	-0,049
90%	1,09Vn	9,075	240,00	240,00	240,00	-2,401	-2,422	0,021
100%	1,09Vn	10,100	240,00	240,00	240,00	-2,436	-2,422	-0,014
100%	1,10Vn	10,100	242,00	242,00	242,00	-4,847	-4,843	-0,004
100%-10%	1,10Vn	0,894	242,00	242,00	242,00	-4,840	-4,843	0,003
10%→ ≤5%	1,10Vn	0,347	242,00	242,00	242,00	0,076	≈0(<±2,5%Pn)	0,076
Qmax reactive power in accordance to standard characteristic curve Q=f(V)								
P(setting)	Vac [V] Set point	P[KW] measured	Vac [V]measured			Q [kVar] measured	Q [kVar] expected	ΔQ [kVar]
			L1	L2	L3			
< 20%	0,93Vn	1,464	204,62	204,63	204,62	0,085	≈0(<±2,5%Pn)	0,085
< 20%	0,91Vn	1,465	200,22	200,23	200,23	0,080	≈0(<±2,5%Pn)	0,080
< 20%-30%	0,91Vn	2,478	200,29	200,29	200,31	2,464	2,422	0,042
40%	0,91Vn	4,002	200,38	200,39	200,35	2,438	2,422	0,016
50%	0,91Vn	5,012	200,00	200,00	200,00	2,426	2,422	0,004
60%	0,91Vn	6,021	200,41	200,38	200,36	2,475	2,422	0,053
70%	0,91Vn	7,016	200,00	200,00	200,00	2,443	2,422	0,021
80%	0,91Vn	8,031	200,51	200,48	200,49	2,409	2,422	-0,013
90%	0,91Vn	9,034	200,57	200,55	200,53	2,371	2,422	-0,051
100%	0,91Vn	10,033	200,48	200,47	200,48	2,471	2,422	0,049
100%	0,90Vn	10,010	198,32	198,30	198,30	4,804	4,843	-0,039
100%-10%	0,90Vn	0,906	198,00	197,98	198,00	4,844	4,843	0,001
10%→ ≤5%	0,90Vn	0,349	197,94	197,96	197,96	0,086	≈0(<±2,5%Pn)	0,086

Note:
The lock-in value is adjustable between V_n and $1.1V_n$ and the lock-out value between V_n and $0.9V_n$ in $0,01V_n$ steps.

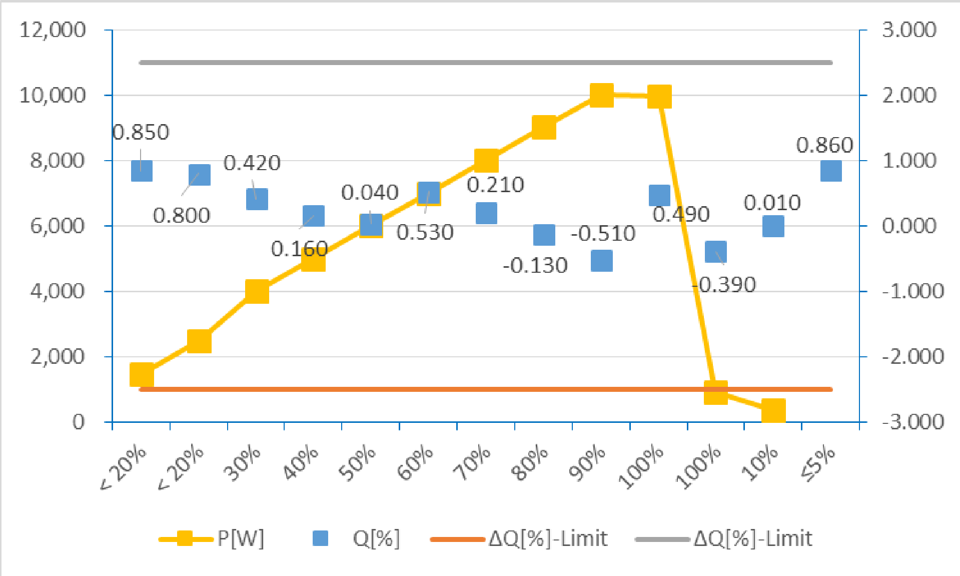
Graph: Lock-in at 1,08Vn



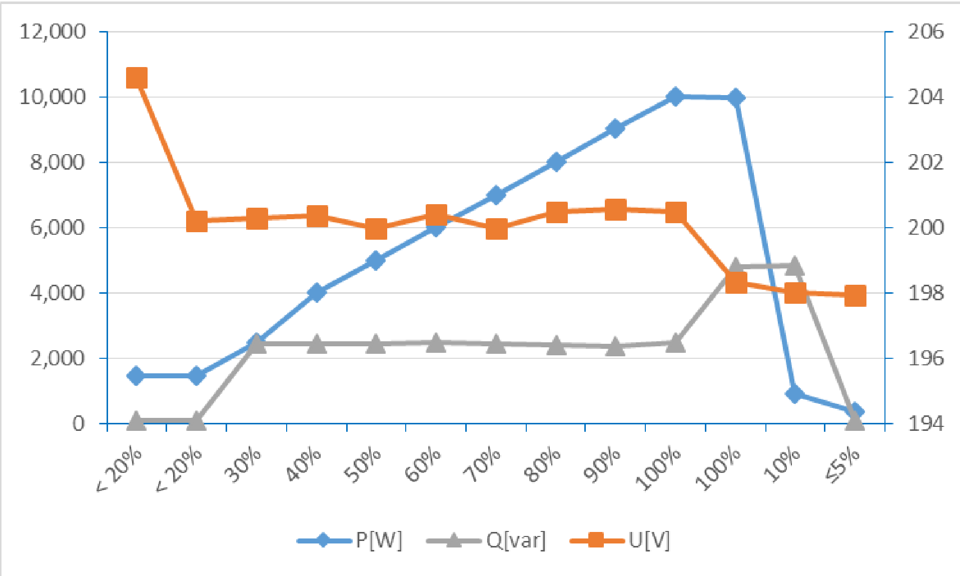
Graph: Lock-in at 1,08Vn



Graph: Lock-in at 0,92Vn

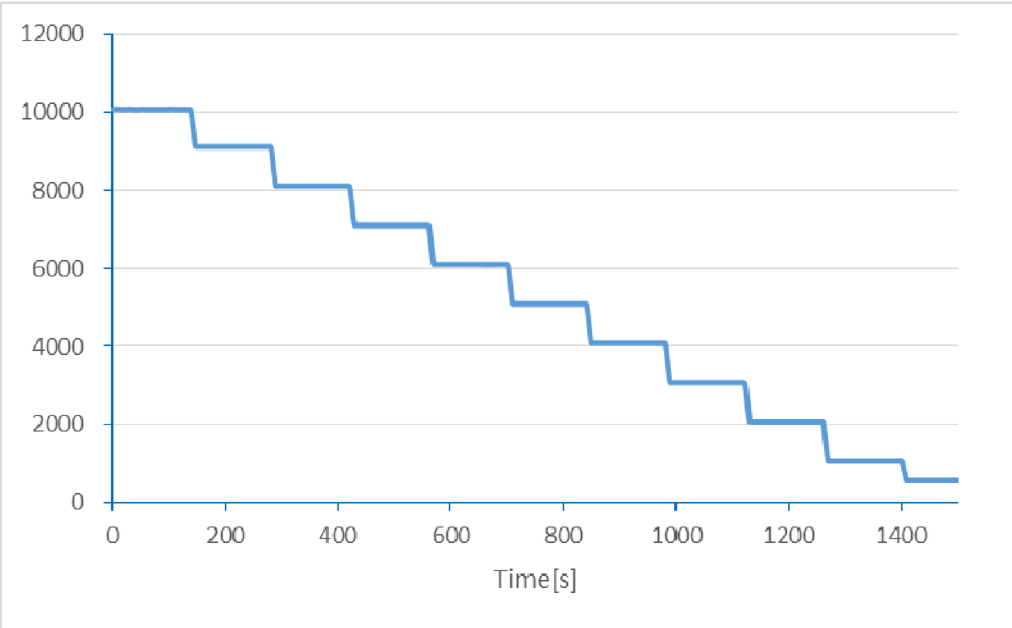


Graph: Lock-in at 0,92Vn



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%	10,00	10,08	
90%	9,00	9,12	7
80%	8,00	8,12	7
70%	7,00	7,11	8
60%	6,00	6,10	7
50%	5,00	5,09	8
40%	4,00	4,08	7
30%	3,00	3,08	7
20%	2,00	2,07	8
10%	1,00	1,06	7
0%	0,00	0,56	6

Graph of the setting accuracy



Note:

PEA:2016 additional test		P
3.6, 12.2	Low voltage fault Ride through capability (PEA:2016) (Power generation system is greater than 500kW)	P

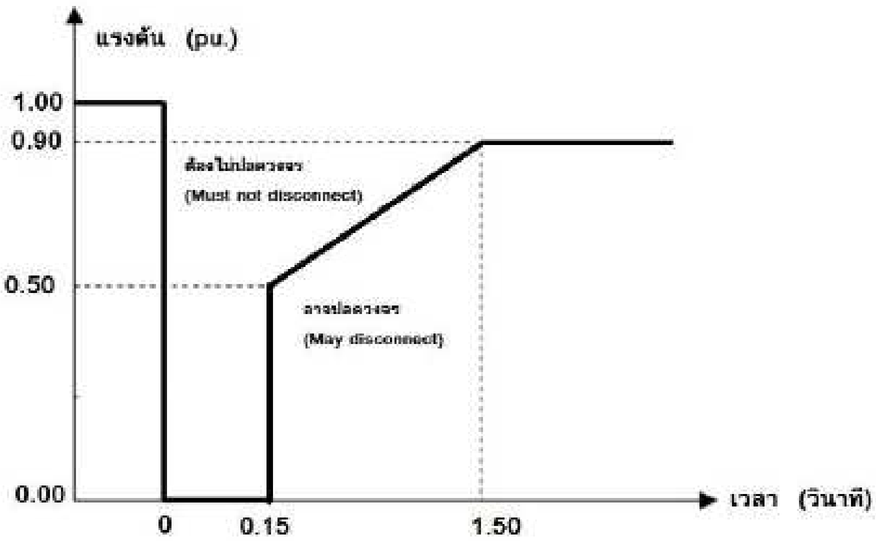
Test List	V(V/V_n)	Duration time (Sec)
Test P>0,9P_n*		
Three-phase faults	0,7-0,8V_n (166,4V)	1,019
	0,3-0,5V_n (100,4V)	0,161
	0-0,05V_n (10,5V)	0,161
Phase to phase faults	0,7-0,8V_n (165,0V)	1,014
	0,3-0,5V_n (97,9V)	0,160
	0-0,05V_n (9,8V)	0,161
Single phase to ground faults	0,7-0,8V_n (165,0V)	1,017
	0,3-0,5V_n (100,4V)	0,160
	0-0,05V_n (9,8V)	0,161
Test P=0,3P_n		
Three-phase faults	0,7-0,8V_n (165,0V)	1,016
	0,3-0,5V_n(97,9V)	0,161
	0-0,049V_n(10,6V)	0,161
Phase to phase faults	0,7-0,8V_n(165,0V)	1,014
	0,3-0,5V_n(97,9V)	0,161
	0-0,049V_n(9,8V)	0,161
Single phase to ground faults	0,7-0,8V_n(166,4V)	1,017
	0,3-0,5V_n(97,9V)	0,161
	0-0,049V_n(9,8V)	0,160
Test P=0,1 Pn		
Three-phase faults	0,7-0,8V_n(166,1V)	1,013
	0,3-0,5V_n(100,4V)	0,161
	0-0,049V_n(10,5V)	0,161
Phase to phase faults	0,7-0,8V_n(164,0V)	1,019
	0,3-0,5V_n(100,4V)	0,161
	0-0,049V_n(9,8V)	0,161

Single phase to ground faults	0,7-0,8V_n(166,4V)	1,016
	0,3-0,5V_n(100,4V)	0,161
	0-0,049V_n(9,8V)	0,161

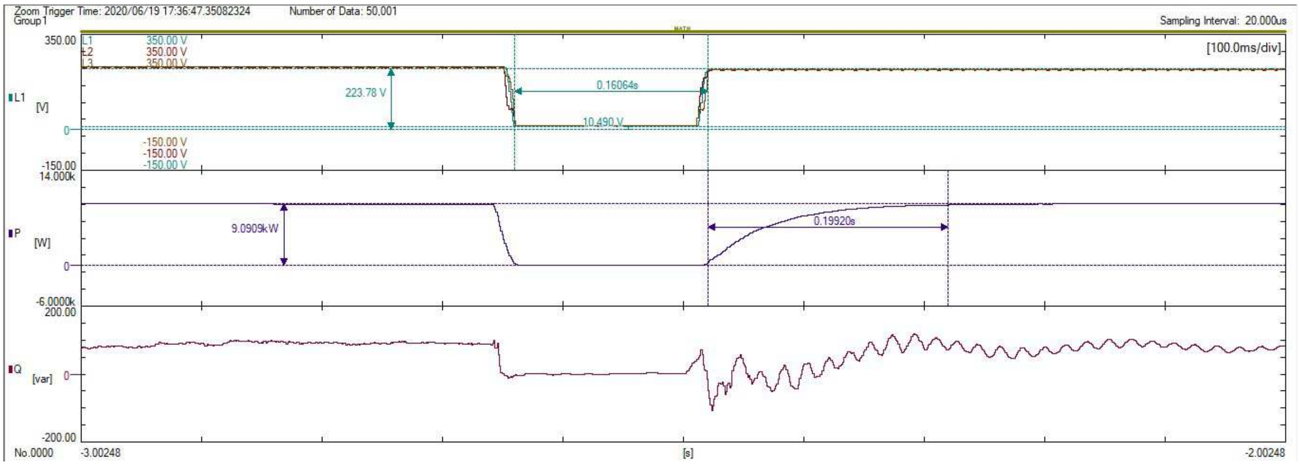
Note:

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

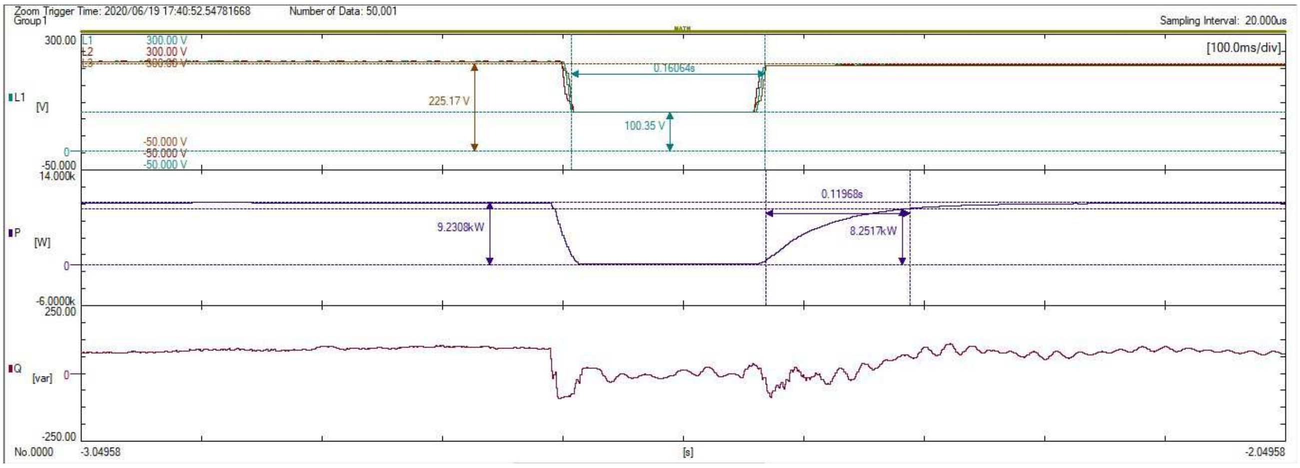
a) install and connect the PGS and recommendation of the technical requirements of the equipment manufacturer .
b) Check all parameters of power supply in normal conditions, the operation of power system equipment .
c) testing by simulation the voltage . (I try to short-circuit in the power network) 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.



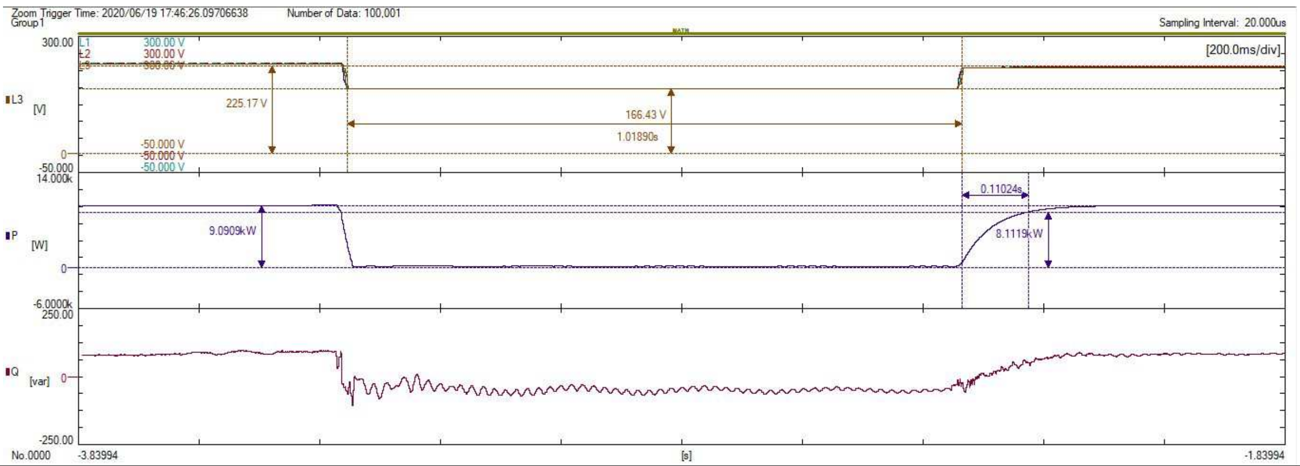
Three-phase faults graph at 100%P_n: 0,7-0,8U_n



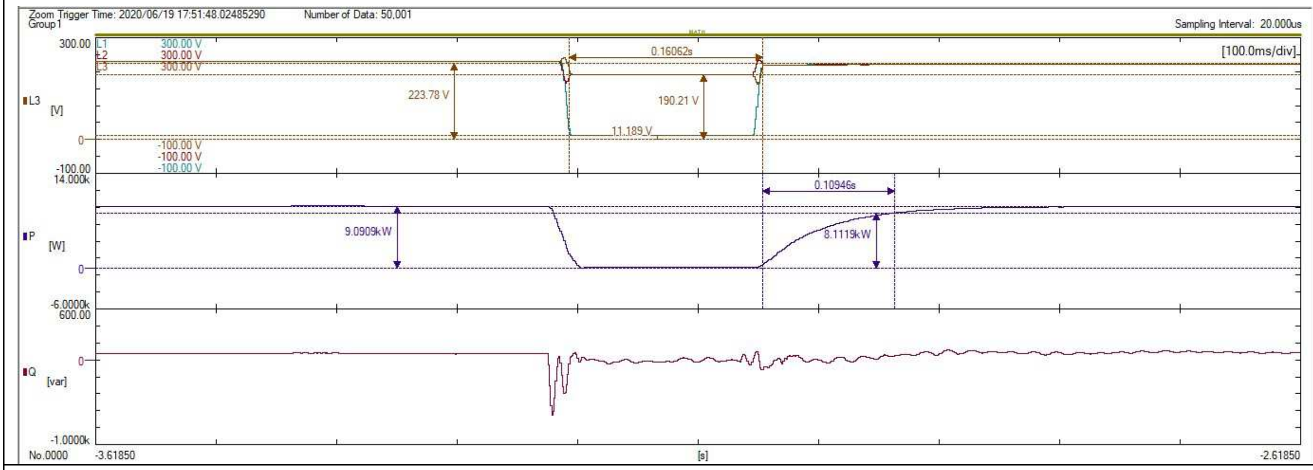
Three-phase faults graph at 100%P_n: 0,3-0,5U_n



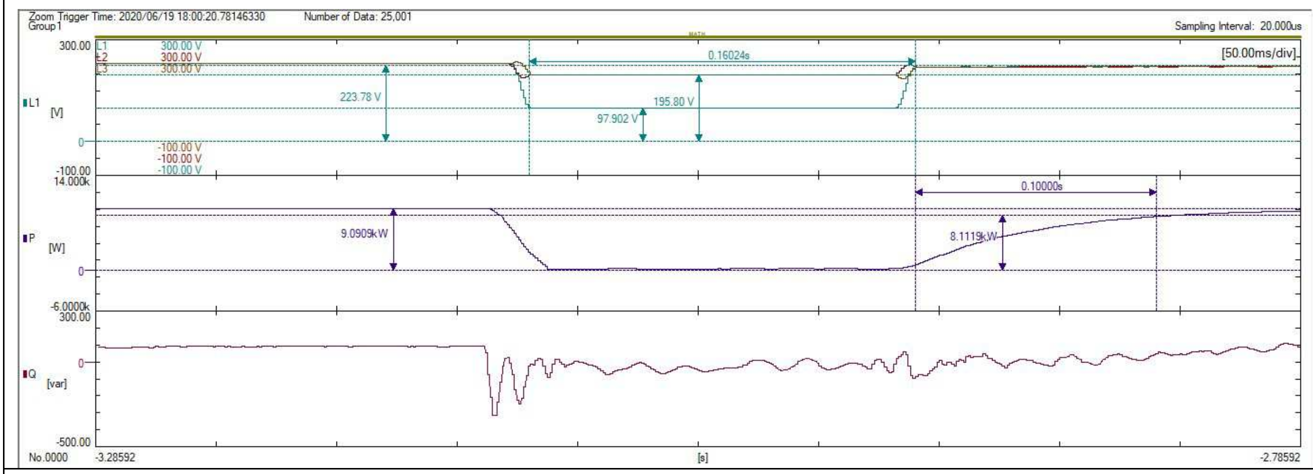
Three-phase faults graph at 100%P_n: 0,00Un-0,049U_n



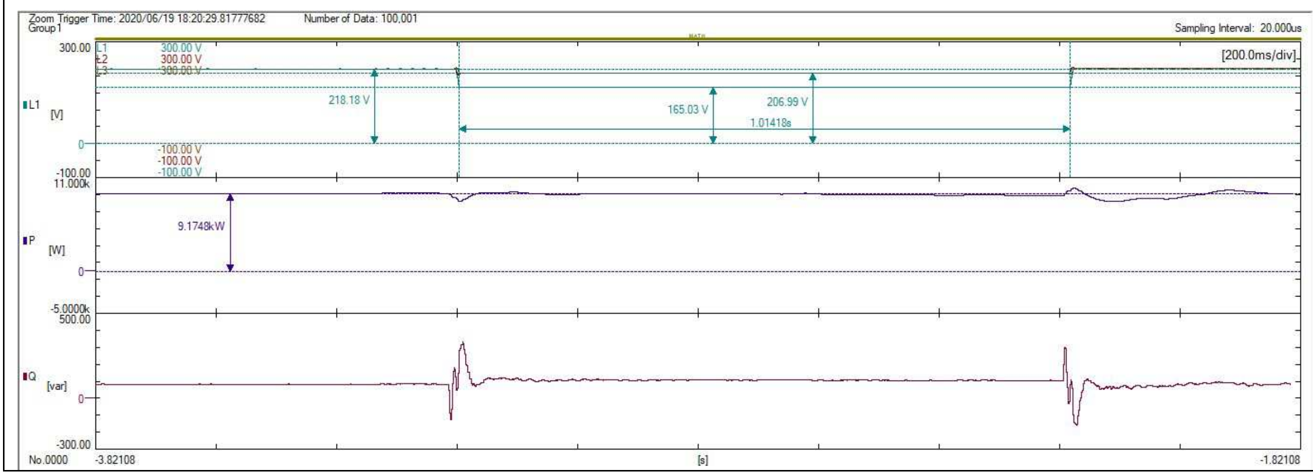
L1 phase-L2 phase faults 0,7-0,8Vn-Voltage graph at 100%P_n



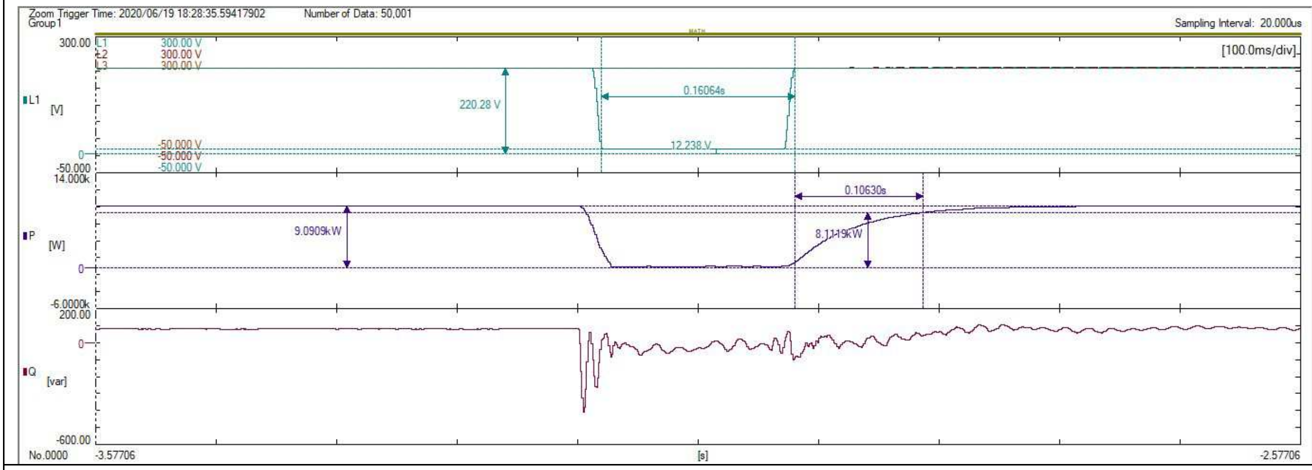
L1 phase-L2 phase faults 0,3-0,5Vn-Voltage graph at 100%P_n



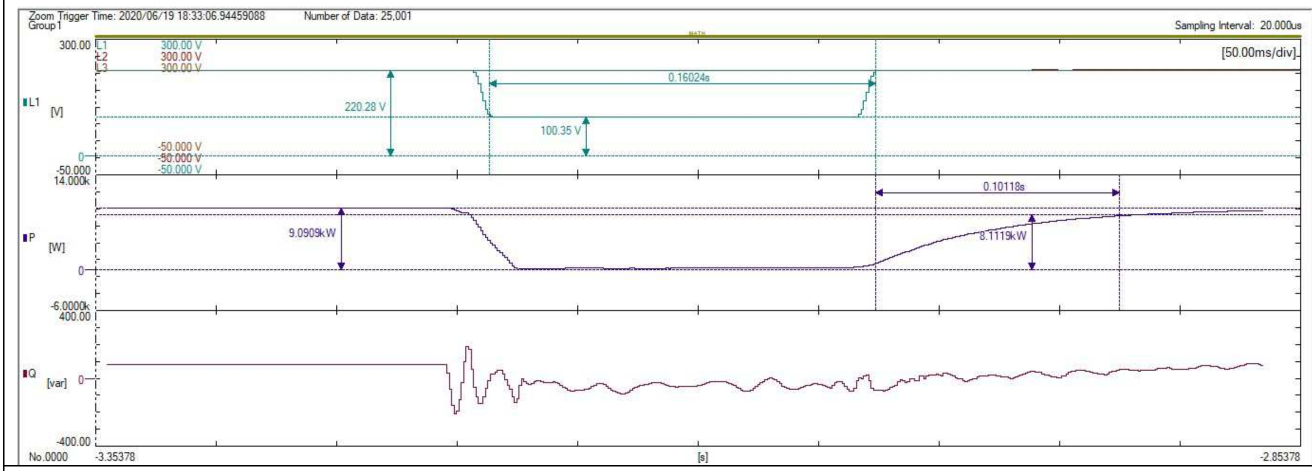
L1 phase-L2 phase faults 0-0,049Vn-Voltage graph at 100%P_n



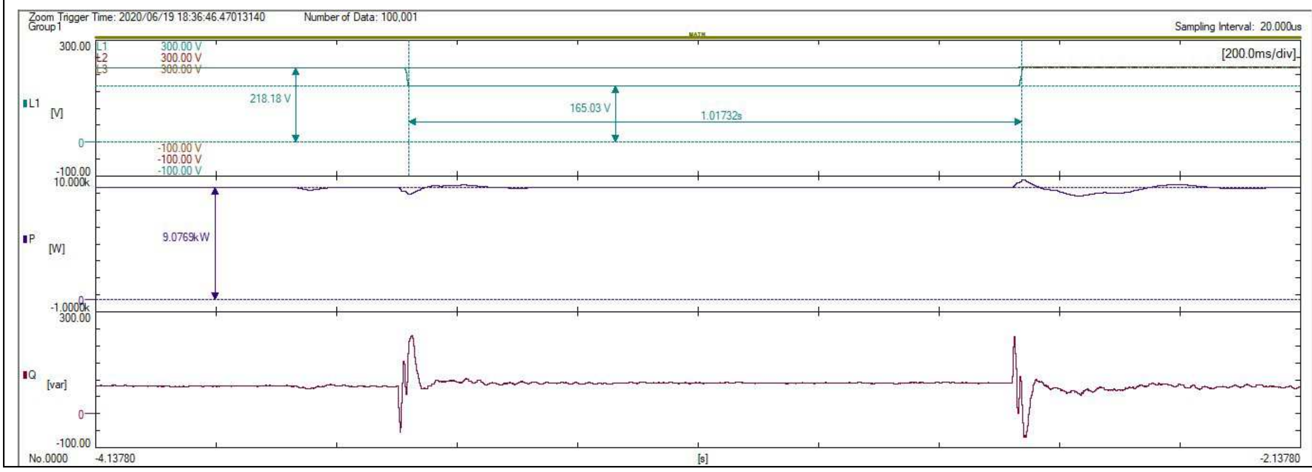
L1 phase-ground faults 0,7-0,8Vn-Voltage graph at 100%P_n



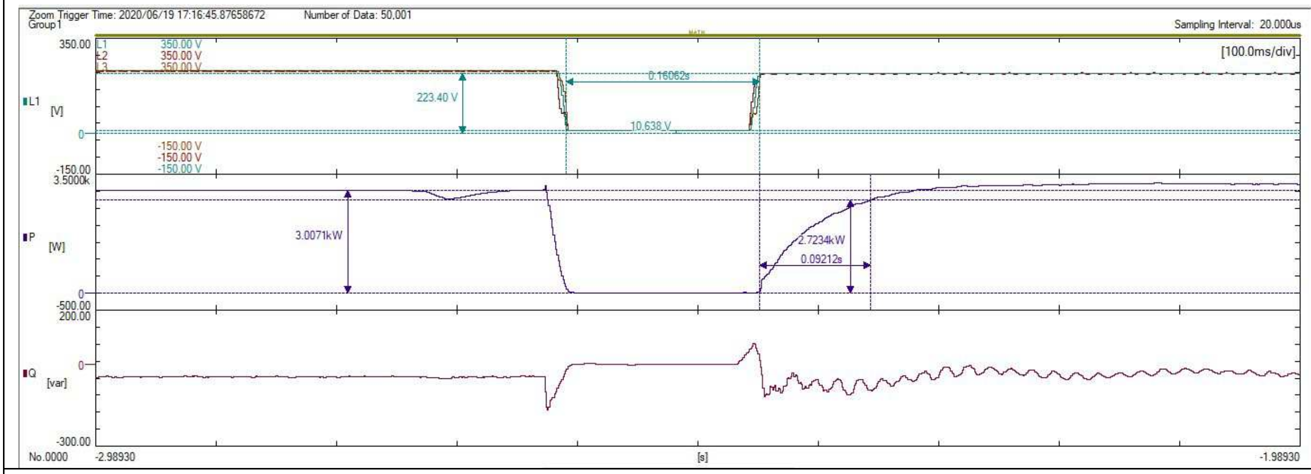
L1 phase-ground faults 0,3-0,5Vn-Voltage graph at 100%P_n



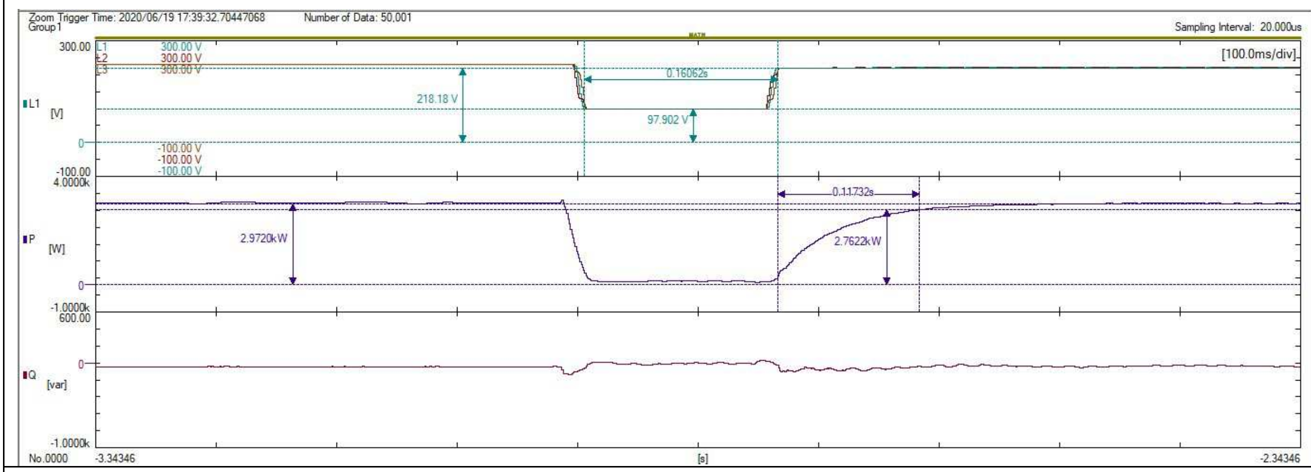
L1 phase-ground faults 0-0,049Vn-Voltage graph at 100%P_n



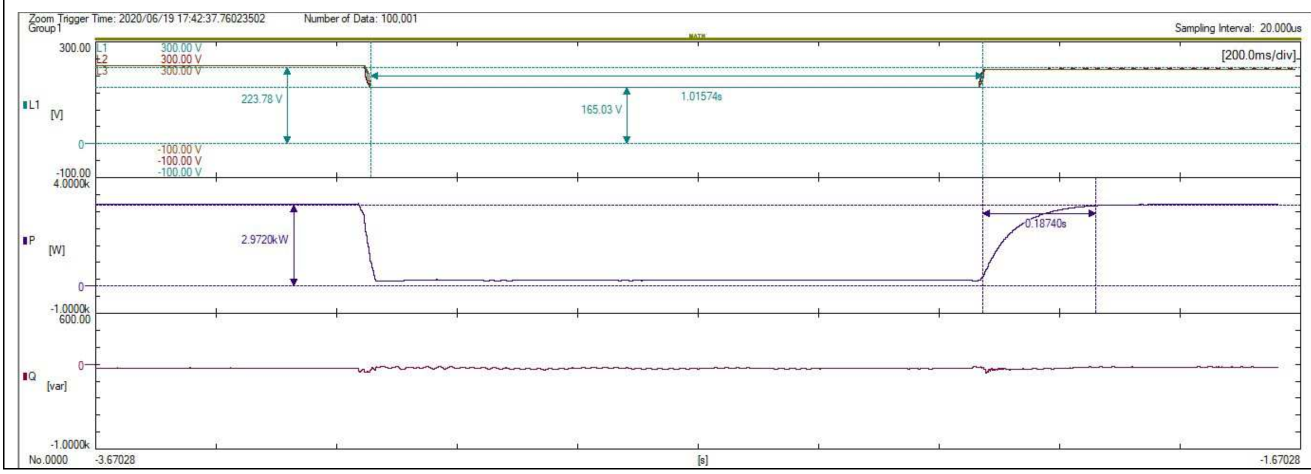
Three-phase faults graph at 30%P_n: 0.7-0.8U_n



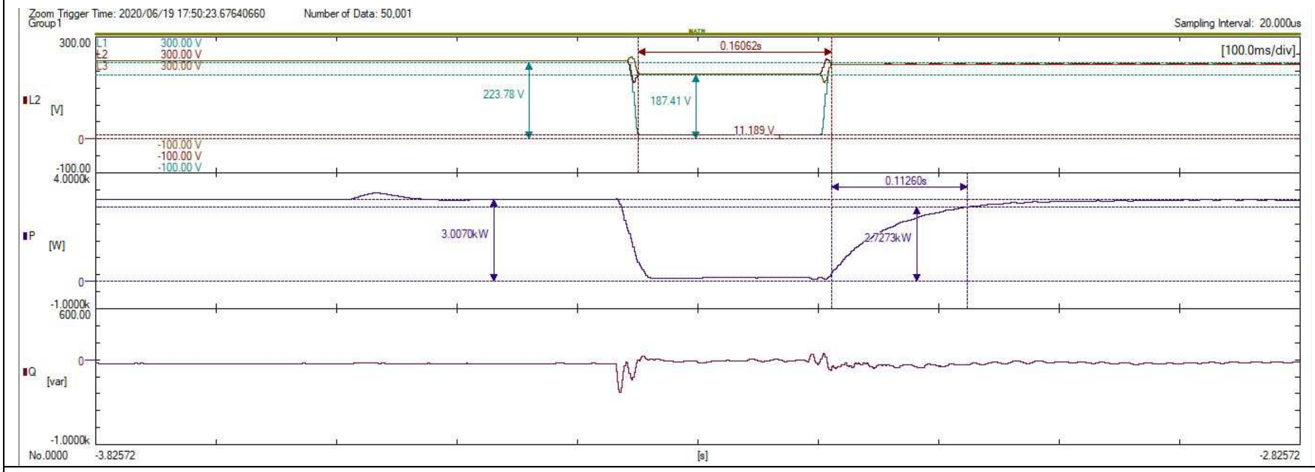
Three-phase faults graph at 30%P_n: 0.3-0.5U_n



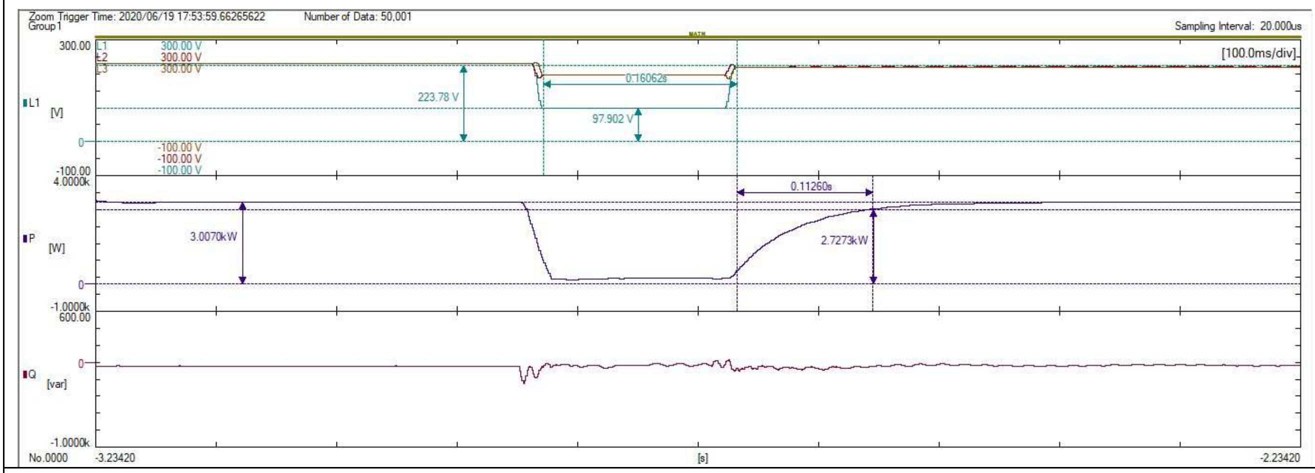
Three-phase faults graph at 30%P_n: 0-0.049U_n



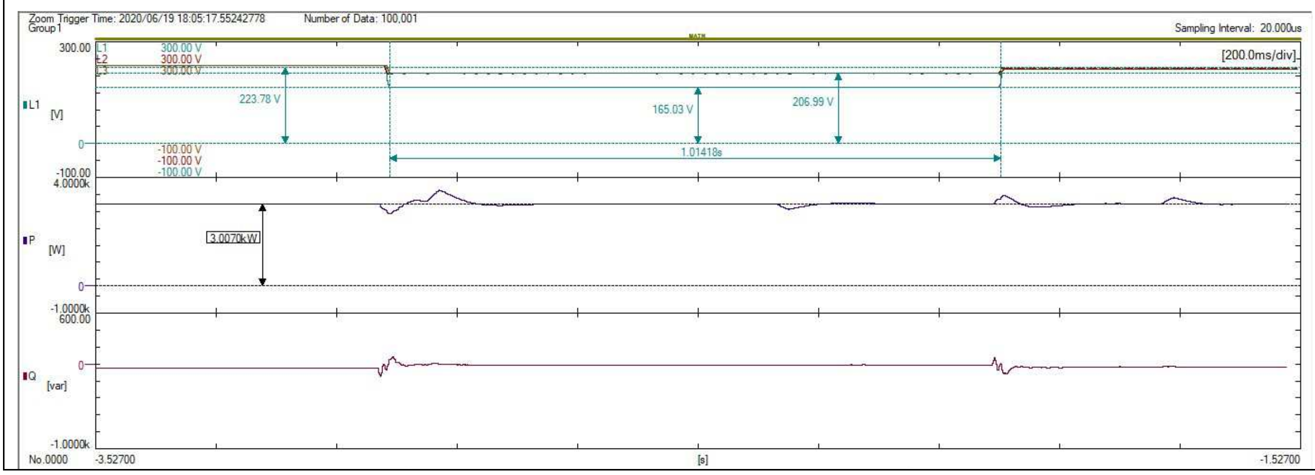
L1 phase-L2 phase faults graph at 30%P_n: 0.7-0.8U_n



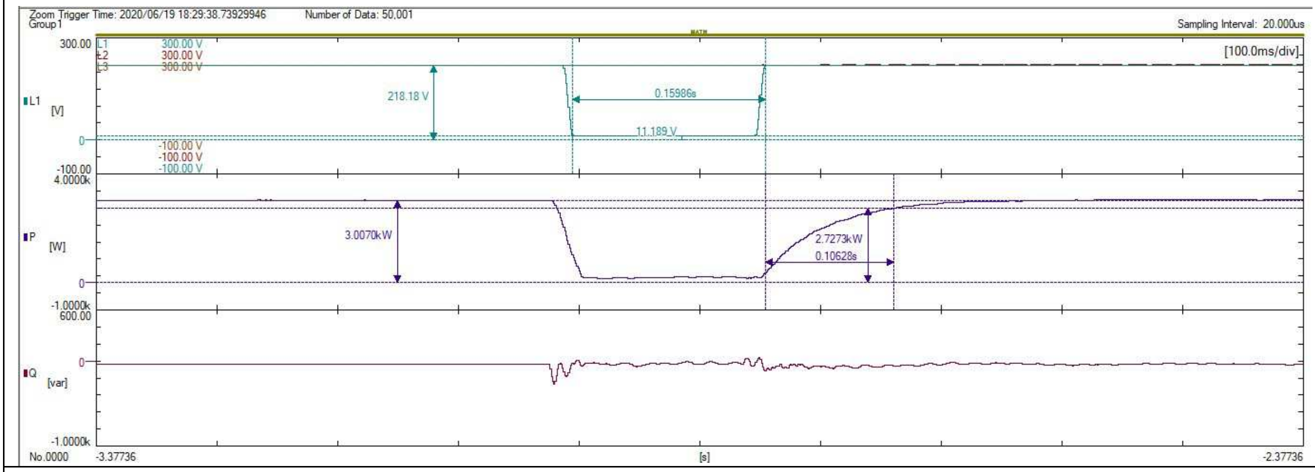
L1 phase-L2 phase faults graph at 30%P_n: 0.3-0.5U_n



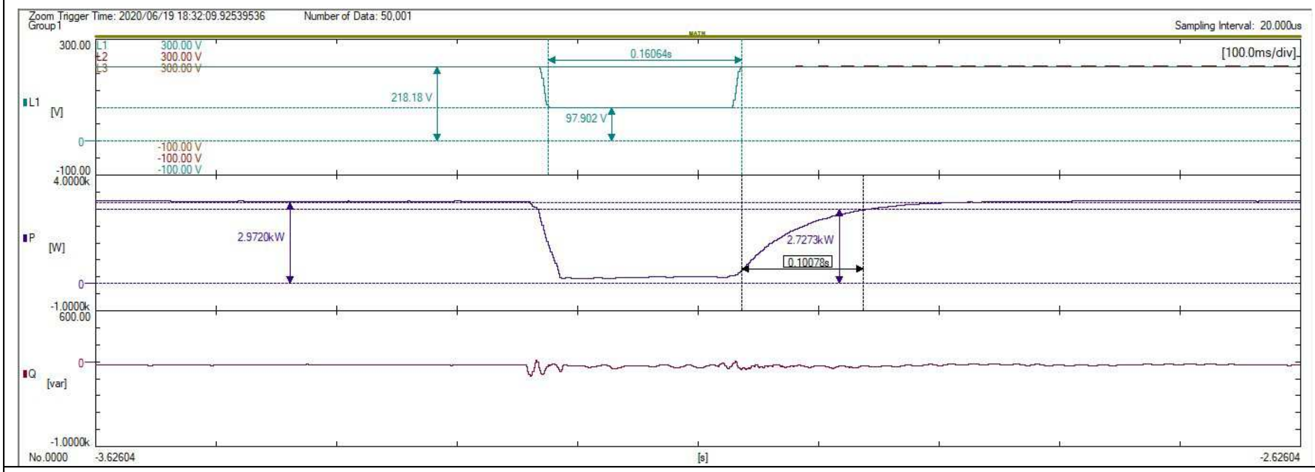
L1 phase-L2 phase faults graph at 30%P_n: 0-0.049U_n



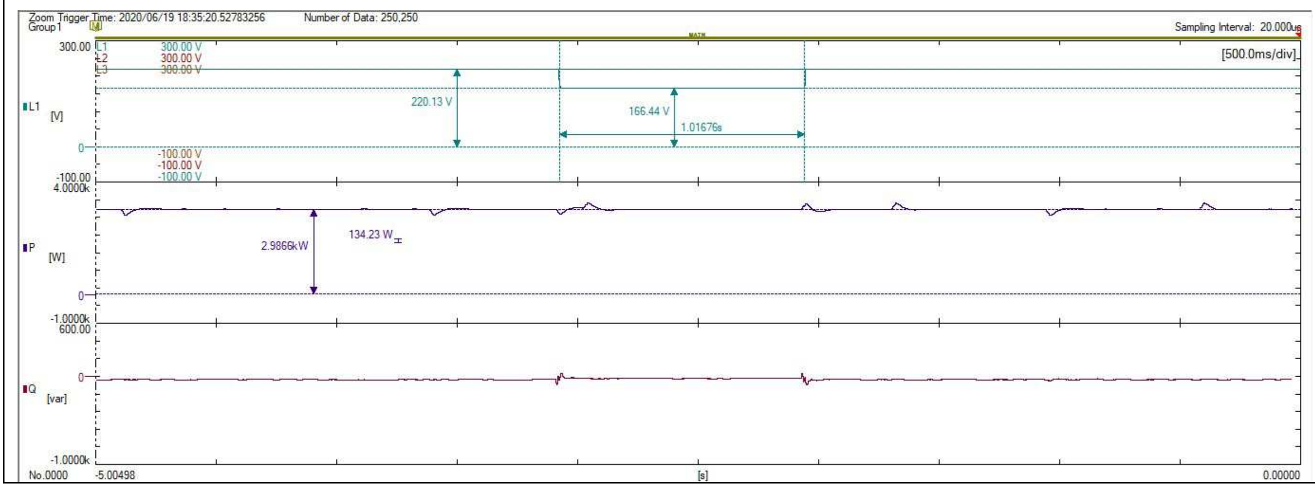
L1 phase-ground faults graph at 30%P_n: 0.7-0.8U_n



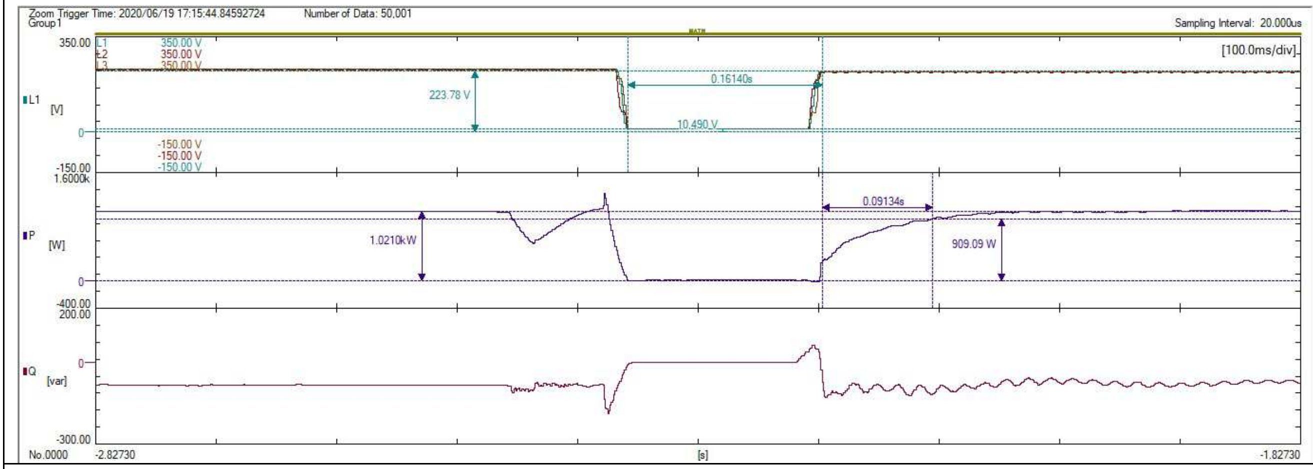
L1 phase-ground faults graph at 30%P_n: 0.3-0.5U_n



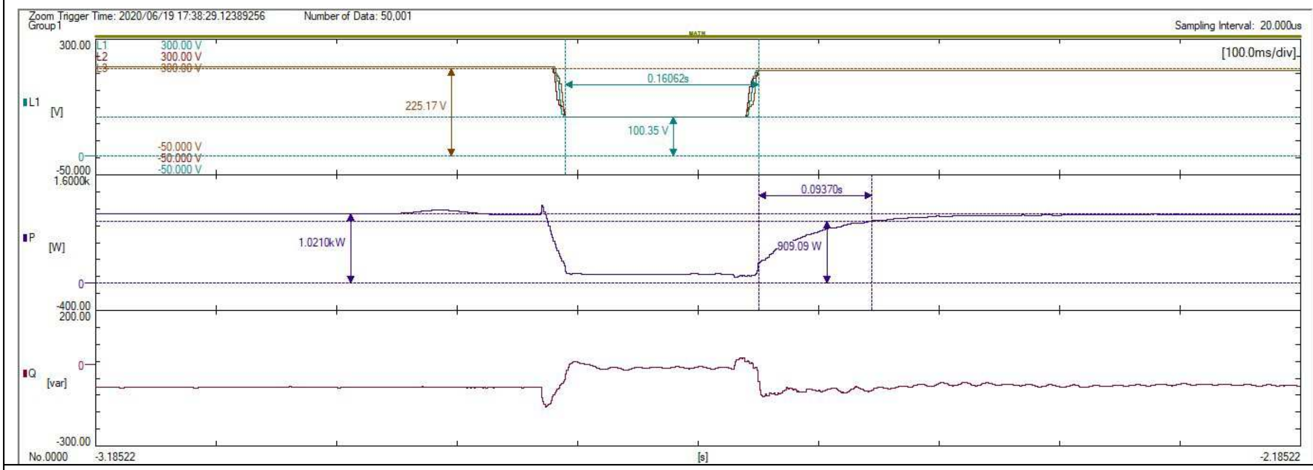
L1 phase-ground graph at 30%P_n: 0-0.049U_n



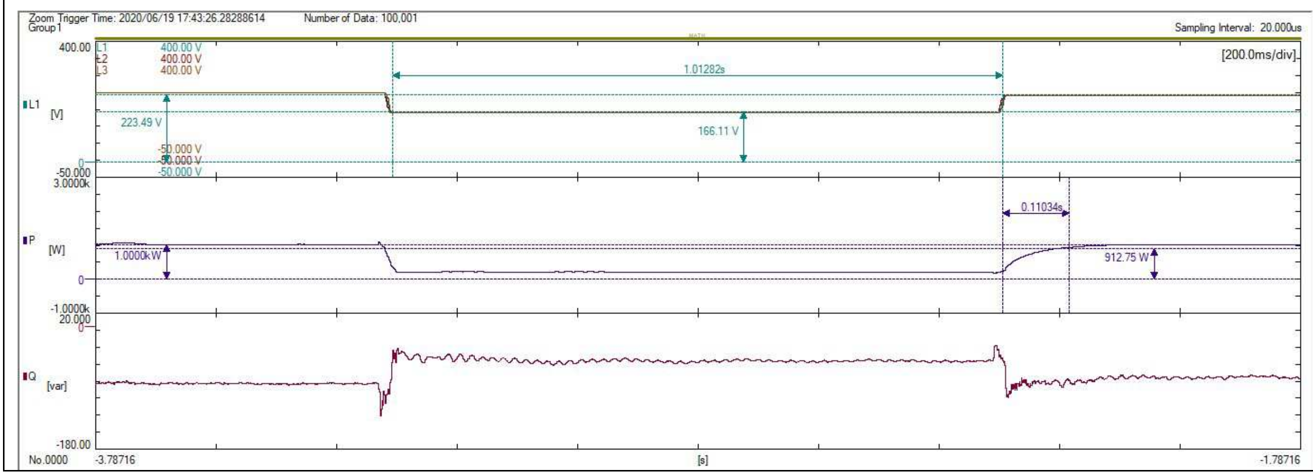
Three-phase faults graph at 10%P_n: 0.7-0.8U_n



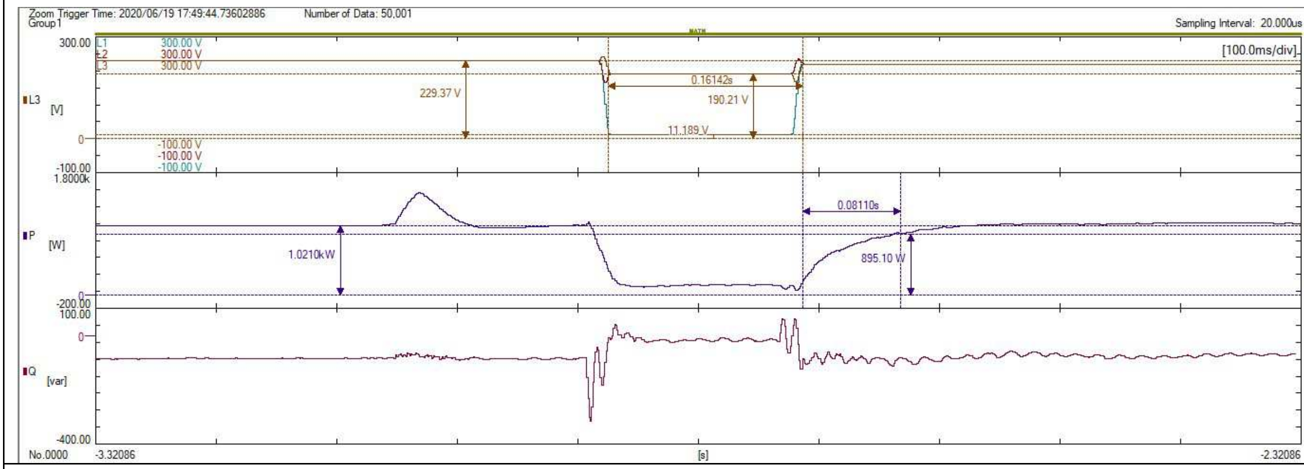
Three-phase faults graph at 10%P_n: 0.3-0.5U_n



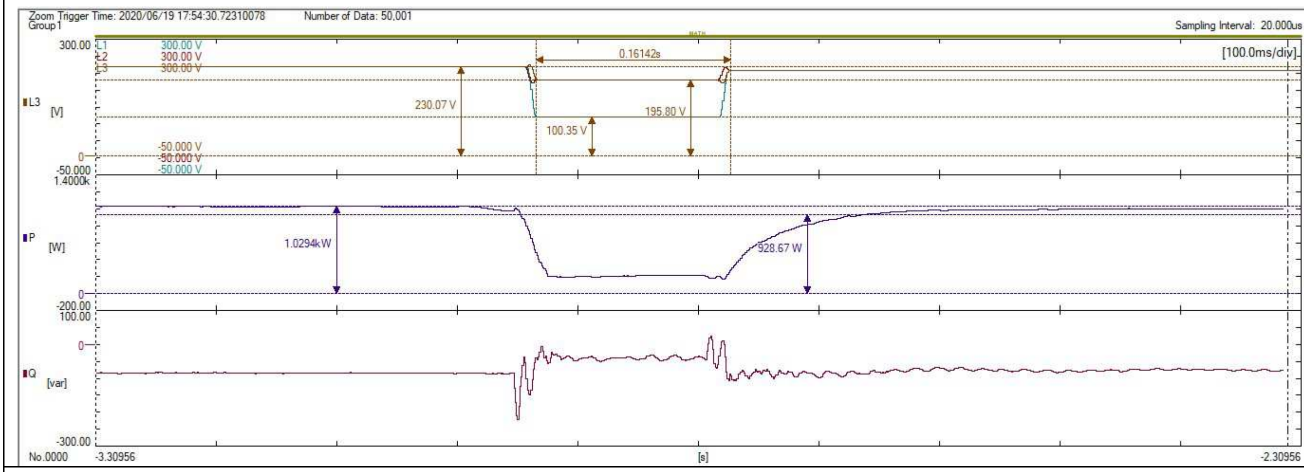
Three-phase faults graph at 10%P_n: 0-0.049U_n



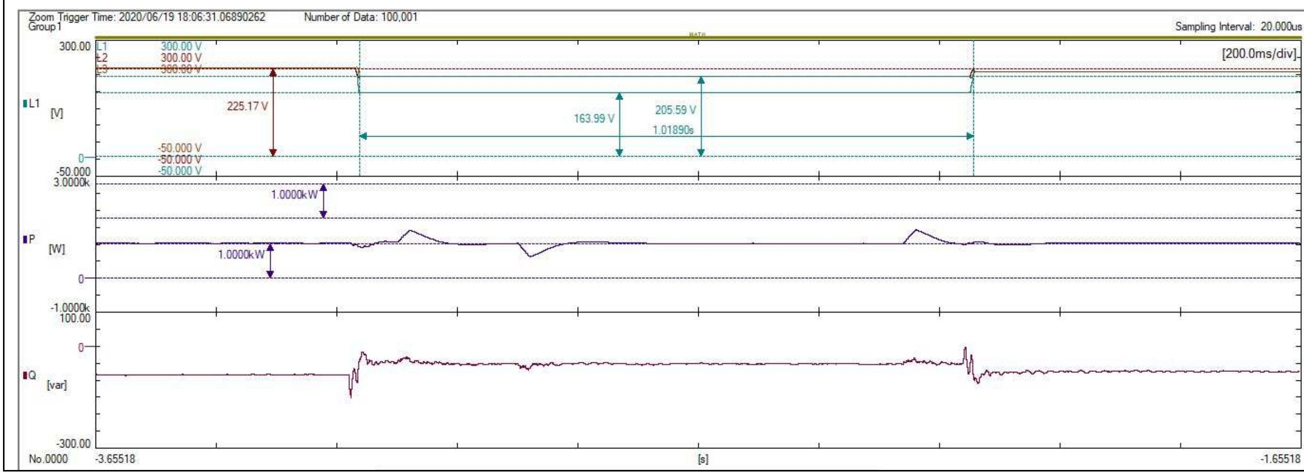
L1 phase-L2 phase graph at 10%P_n: 0.7-0.8U_n



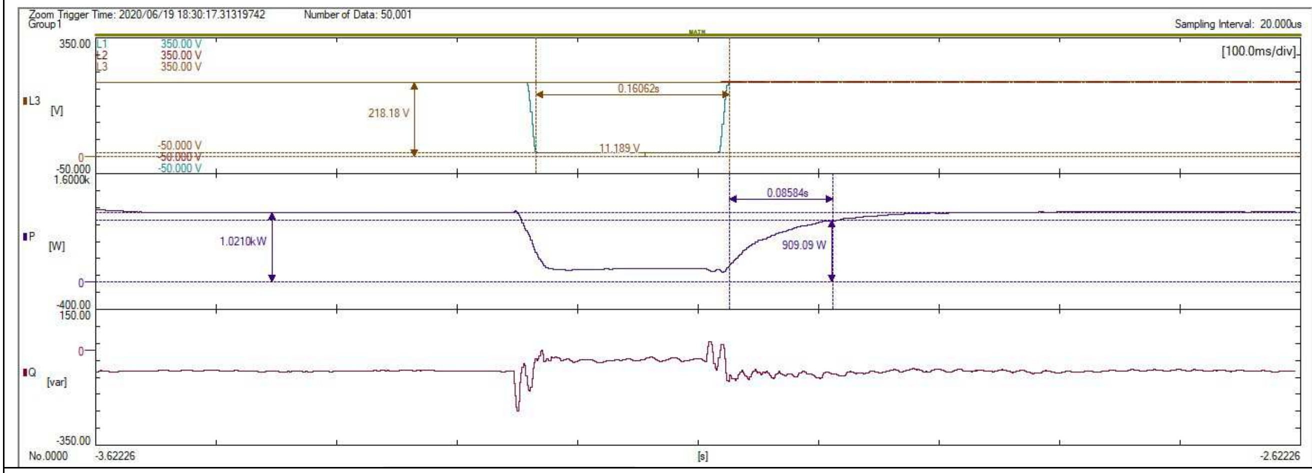
L1 phase-L2 phase faults graph at 10%P_n: 0.3-0.5U_n



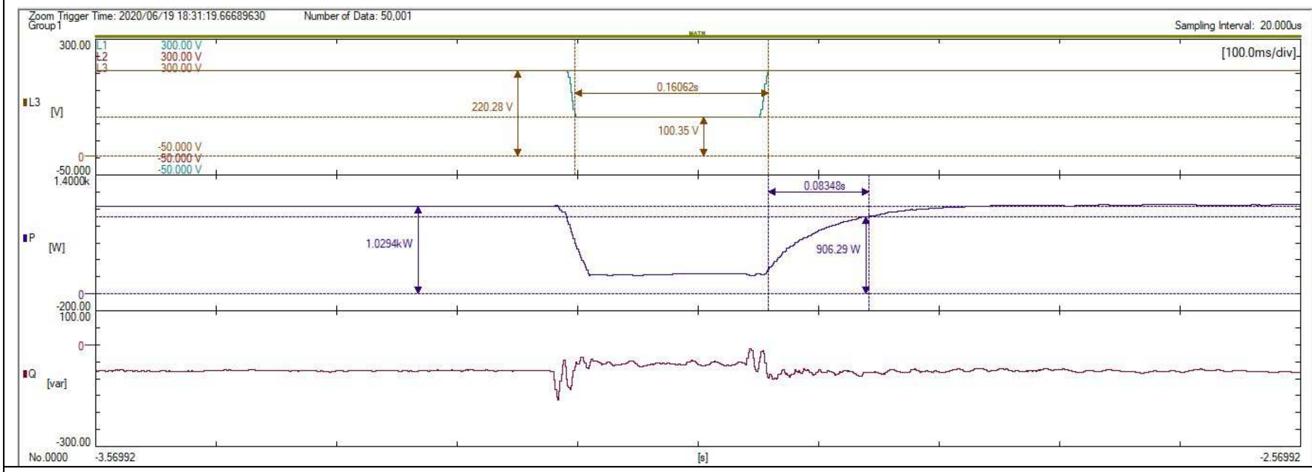
L1 phase-L2 phase faults graph at 10%P_n: 0-0.049U_n



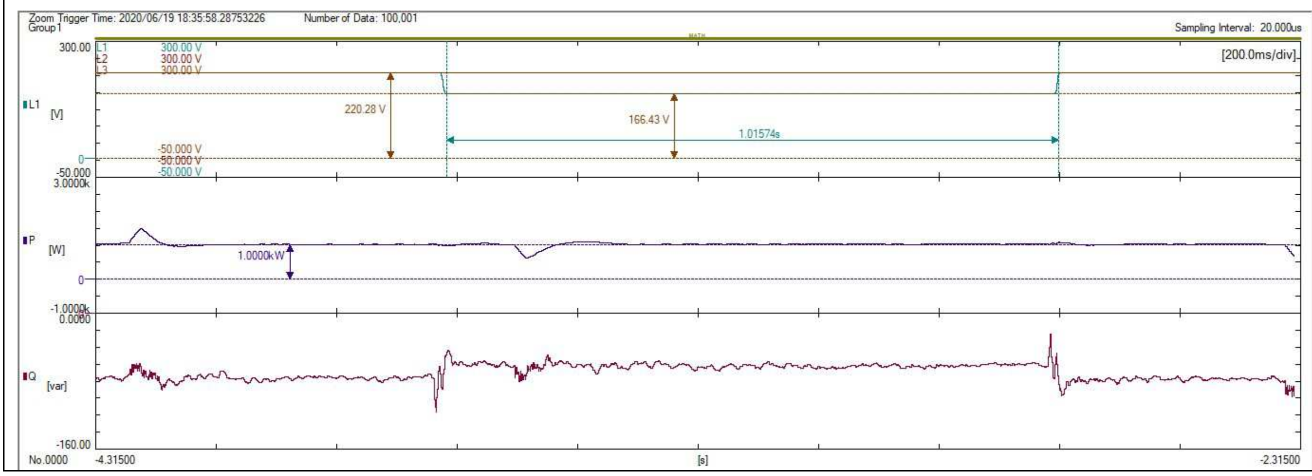
L1 phase-ground faults graph at 10%P_n: 0.7-0.8U_n



L1 phase-ground faults graph at 10%P_n: 0.3-0.5U_n



L1 phase-ground faults graph at 10%P_n: 0-0.049U_n



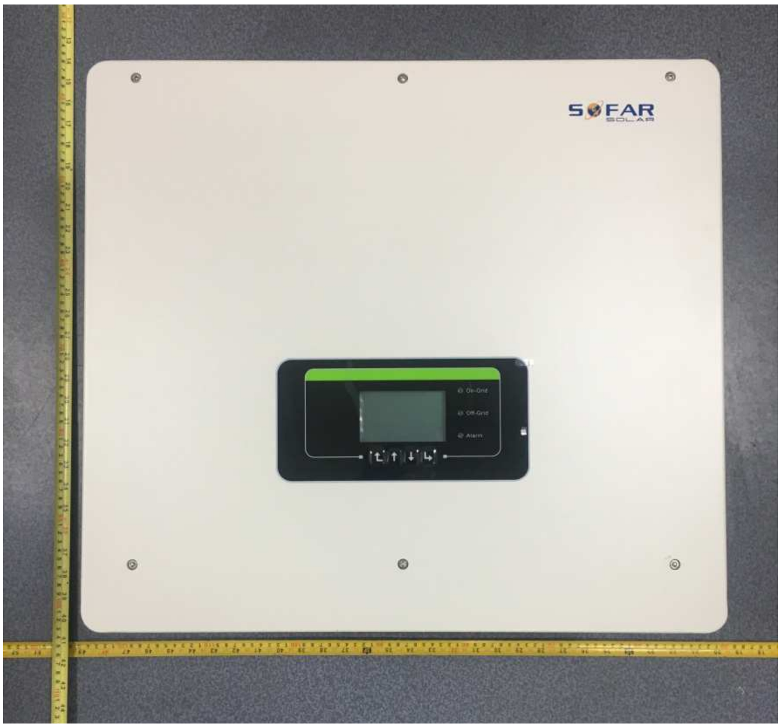
Annex No. 1

Test equipment list

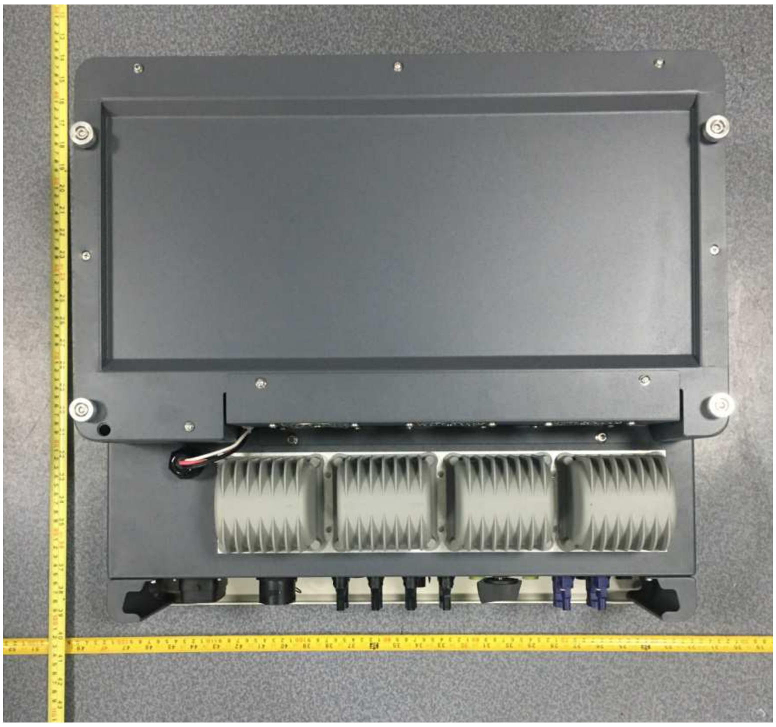
Date(s) of performance of test: 2020-03-20 to 2020-07-07

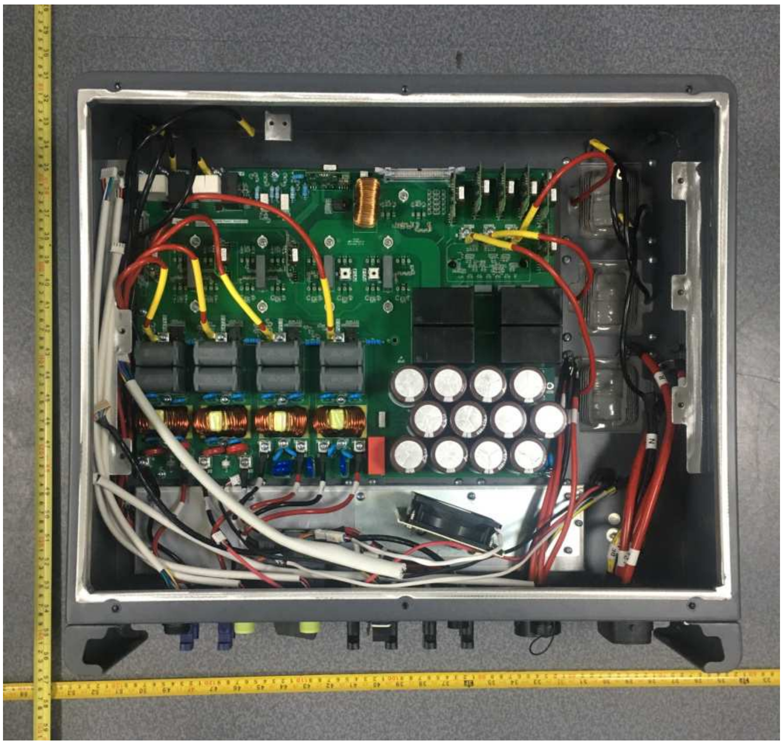
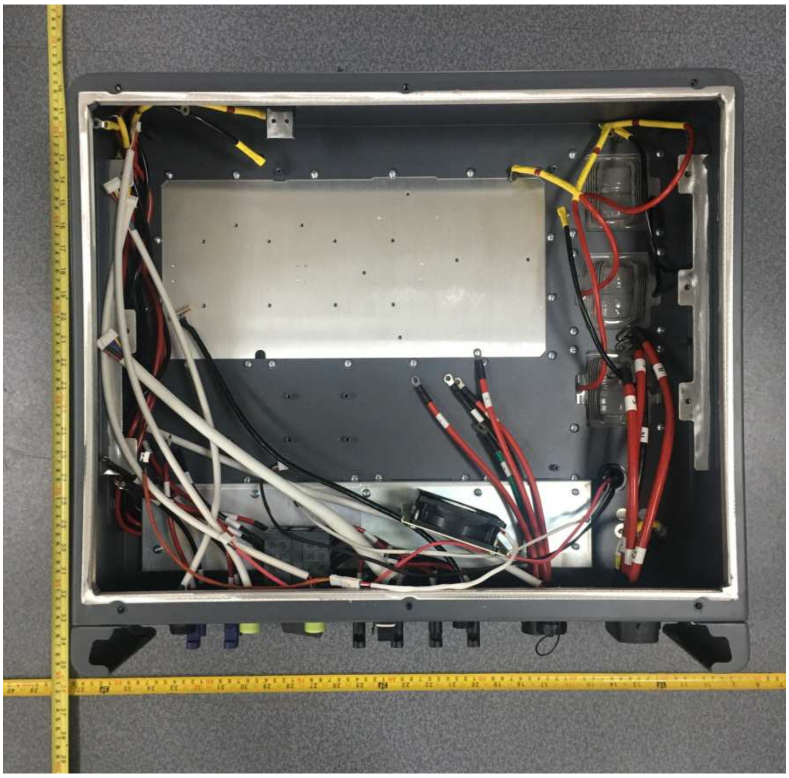
Equipment	Internal No.	Manufacturer	Type	Serial No.	Last Calibration
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	2019-09-12
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
AC Source	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040015DG	Chroma	62150H-1000S	62150EF00488	
	A7040016DG	Chroma	62150H-1000S	62150EF00490	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	MY57231269	KEYSIGHT	DSOX3014T	HK200110222	2020-01-14
Four Channel Digital Phosphor Oscilloscope	A4089003DG	Tektronix	DPO4104B	C010624	2019-09-24
Oscilloscope probel	A1490008DG	YOKOGAWA	701901	//	2019-09-20
	A1490009DG	YOKOGAWA	701901	//	2019-09-20
	A1490010DG	YOKOGAWA	701901	//	2019-09-20
Current transducer	A1060008DG	YOKOGAWA	CT200	1130700017	2019-09-12
	A1060009DG	YOKOGAWA	CT200	1130700019	2019-09-12
	A1060010DG	YOKOGAWA	CT200	1130700016	2019-09-12

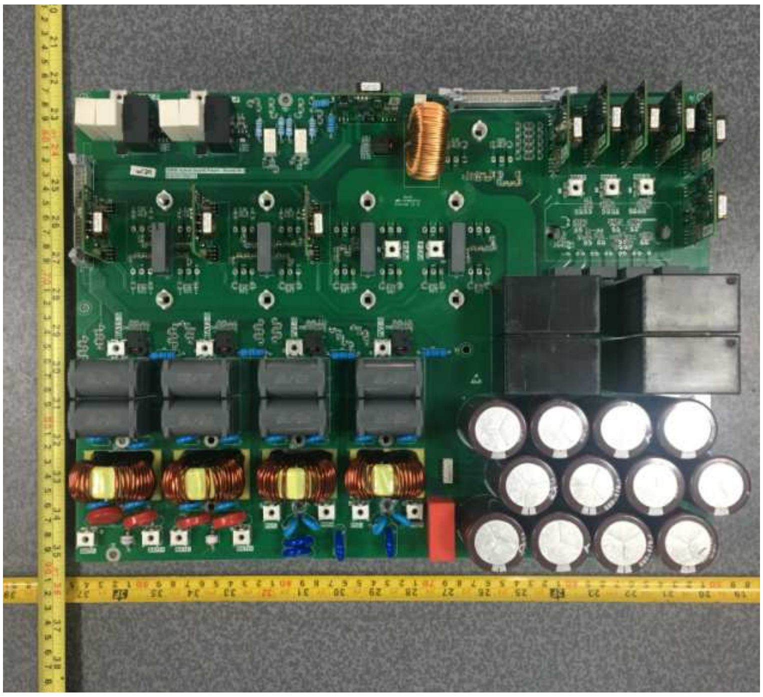
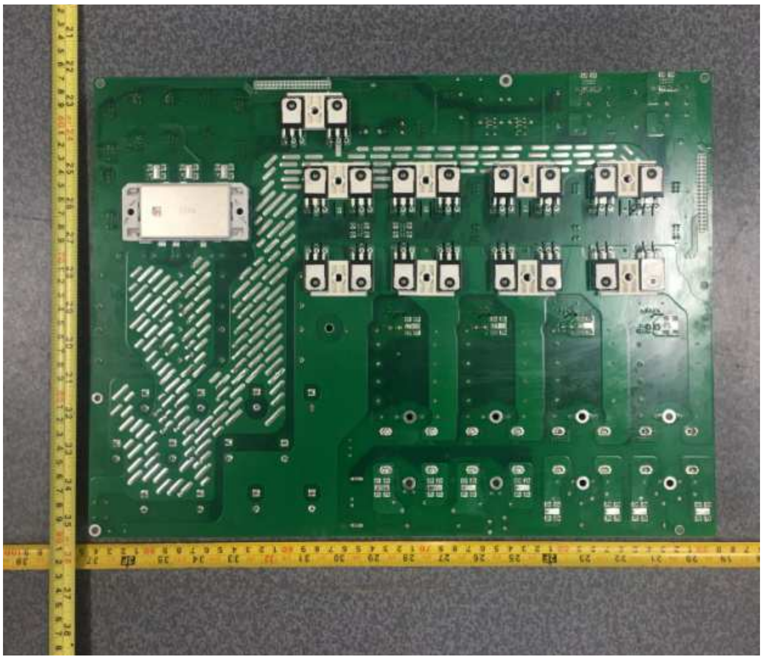
Annex No. 2
Pictures of the unit

Enclosure front view

Enclosure side view


Enclosure bottom view

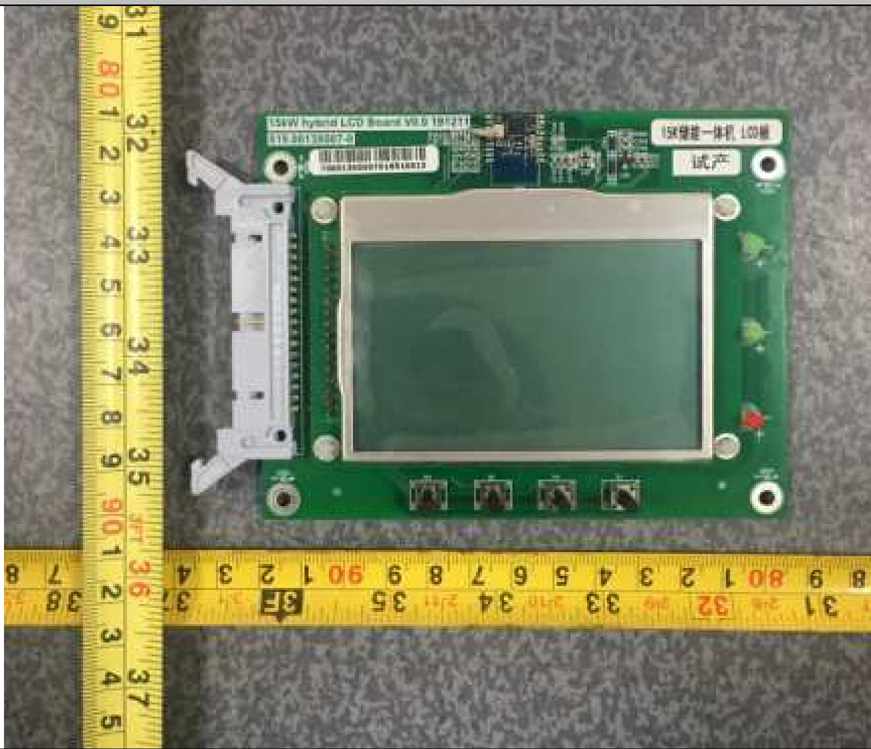

Enclosure rear view


Internal view

Internal view


Power board-component side view

Power board-component side view


Control board solder side view

Control board solder side view


LCD display board solder side view

LCD display board solder side view