TEST REPORT

IEC 62116

Test procedure of islanding prevention measures for utility-interconnected photovoltaic inverters

Report reference number ..... :	**PV200917N006-7**
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Address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Test specification	
Standard..... :	IEC 62116:2014
Test Report Form No. ..... :	IEC/EN 62116 VER.2
TRF Originator ..... :	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF ..... :	Dated 2020-03-11
Test item description ..... :	**Hybrid Inverter**
Trademark..... :	SOFAR SOLAR
Model / Type ..... :	HYD 6000-EP, HYD 5500-EP, HYD 5000-EP, HYD 4600-EP, HYD 4000-EP, HYD 3680-EP, HYD 3000-EP

Ratings .....:	**HYD 3000-EP**	**HYD 3680-EP**	**HYD 4000-EP**
Full load MPP DC voltage range [V].:	160-520V	180-520V	200-520V
Input DC voltage range[V].....:	90-600V		
Input DC current [A].....:	Max. 13A/13A		
Output AC voltage [V].....:	L/N/PE, 220 / 230Vac, 50/60Hz		
Output AC current [A].....:	15,0	16,0	20,0
Output power [W].....:	3000	3680	4000
Max. output power [VA].....:	3300	3680	4400
Output DC voltage range [V].....: [Battery charge]……:	42-58V		
Input/Output DC current [A].....: [Battery charge/discharge] ……:	Max. 75A	Max. 80A	Max. 85A
Charge and discharge power[W].....:	Max. 3750	Max. 4000	Max. 4250
Output AC voltage [V].....:	L/N/PE, 220 / 230Vac, 50/60Hz		
Max. Input/Output AC current [A].....: [Battery charge/discharge mode] …:	13,6	16,0	18,2
Max. Input/Output AC power [VA]....: [Battery charge/discharge mode] …:	3000	3680	4000
Ratings .....:	**HYD 4600-EP**	**HYD 5000-EP**	**HYD 5500-EP**
Full load MPP DC voltage range [V].:	230-520V	250-520V	250-520V
Input DC voltage range[V].....:	90-600V		
Input DC current [A].....:	Max. 13A/13A		
Output AC voltage [V].....:	L/N/PE, 220 / 230Vac, 50/60Hz		
Output AC current [A].....:	20,9	21,7	25,0
Output power [W].....:	4600	5000	5000
Max. output power [VA].....:	4600	5000	5500
Output DC voltage range [V].....: [Battery charge]……:	42-58V		
Input/Output DC current [A].....: [Battery charge/discharge] ……:	Max. 100A		
Charge and discharge power[W].....:	Max. 5000		
Output AC voltage [V].....:	L/N/PE, 220 / 230Vac, 50/60Hz		
Max. Input/Output AC current [A].....: [Battery charge/discharge mode] …:	20,9	22,7	22,7
Max. Input/Output AC power [VA]....: [Battery charge/discharge mode] …:	4600	5000	5000

Ratings .....:	**HYD 6000-EP**
Full load MPP DC voltage range [V].:	300-520V
Input DC voltage range[V].....:	90-600V
Input DC current [A].....:	Max. 13A/13A
Output AC voltage [V].....:	L/N/PE, 220 / 230Vac, 50/60Hz
Output AC current [A].....:	27,3
Output power [W].....:	6000
Max. output power [VA].....:	6000
Output DC voltage range [V].....: [Battery charge]……:	42-58V
Input/Output DC current [A].....: [Battery charge/discharge] ……:	Max. 100A
Charge and discharge power[W].....:	Max. 5000
Output AC voltage [V].....:	L/N/PE, 220 / 230Vac, 50/60Hz
Max. Input/Output AC current [A].....: [Battery charge/discharge mode] …:	22,7
Max. Input/Output AC power [VA]....: [Battery charge/discharge mode] …:	5000

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 Lin 
Approved by (name and signature) ..... :	James Huang 
Manufacturer's name ..... :	**Shenzhen SOFARSOLAR Co., Ltd.**
Manufacturer address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Factory's name 1 ..... :	**Dongguan SOFAR SOLAR Co.,Ltd**
Factory address 1	1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City

Document History			
Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2021-01-28	Lukes Lin	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. 21,5 kg

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 ..... :	2020-09-17
Date(s) of performance of test ..... :	2020-09-17 to 2020-12-28

General remarks:

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

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

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

This Test Report consists of the following documents:

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

Copy of marking plates:

SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 3000-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	75A
Max.Discharging Current	75A
Max.Charging&Discharging Power	3750W
Nominal Grid Voltage	220/230Vac
Nominal Output Voltage	230Vac
Max.Output Current	15.0A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	3000W
Backup Rated Current	13.6A
Backup Rated Apparent Power	3000VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

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G98,AS4777,UTE C15-712-1

SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 3680-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	80A
Max.Discharging Current	80A
Max.Charging&Discharging Power	4000W
Nominal Grid Voltage	220/230Vac
Nominal Output Voltage	230Vac
Max.Output Current	16.0A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	3680W
Backup Rated Current	16.0A
Backup Rated Apparent Power	3680VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

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SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 4000-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	85A
Max.Discharging Current	85A
Max.Charging&Discharging Power	4250W
Nominal Grid Voltage	220/230Vac
Nominal Output Voltage	230Vac
Max.Output Current	20.0A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	4000W
Backup Rated Current	18.2A
Backup Rated Apparent Power	4000VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

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SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 4600-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	100A
Max.Discharging Current	100A
Max.Charging&Discharging Power	5000W
Nominal Grid Voltage	220/230Vac
Nominal Output Voltage	230Vac
Max.Output Current	20.9A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	4600W
Backup Rated Current	20.9A
Backup Rated Apparent Power	4600VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

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Copy of marking plates:

SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 5000-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	100A
Max.Discharging Current	100A
Max.Charging&Discharging Power	5000W
Nominal Grid Voltage	220/230Vac
Nominal Output Voltage	230Vac
Max.Output Current	21.7A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	5000W
Backup Rated Current	22.7A
Backup Rated Apparent Power	5000VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

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SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 5500-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	100A
Max.Discharging Current	100A
Max.Charging&Discharging Power	5000W
Nominal Grid Voltage	220/230Vac
Nominal Output Voltage	230Vac
Max.Output Current	25.0A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	5000W
Backup Rated Current	22.7A
Backup Rated Apparent Power	5000VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

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SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 6000-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	100A
Max.Discharging Current	100A
Max.Charging&Discharging Power	5000W
Nominal Grid Voltage	220/230Vac
Nominal Output Voltage	230Vac
Max.Output Current	27.3A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	6000W
Backup Rated Current	22.7A
Backup Rated Apparent Power	5000VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

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General product information:

The Hybrid Inverter converts DC voltage into AC voltage.

The Hybrid Inverter is a single phase type inverter and it can be used in parallel.

The DC input of Hybrid Inverter can be supplied from PV array and batteries.

The charging current to batteries from PV array and power grid, battery management unit is integrated in External Energy storage.

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.

Description of the electrical circuit:

The internal control is redundant built. It consists of Master DSP (U4) and Slave DSP (U43).

The Master DSP (U4) control the relays by switching signals; measures the Battery voltage, Battery currenet, 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 Slave DSP (U43) is measures the grid voltage, grid frequency, DCI and residual current, also can switch off the relays independently, and communicate with the Master DSP (U4) each other.

The current is measured by a current sensor. The AC current signal and the injected DC current signal are sent to the Master DSP (U4). The Master DSP (U4) 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.

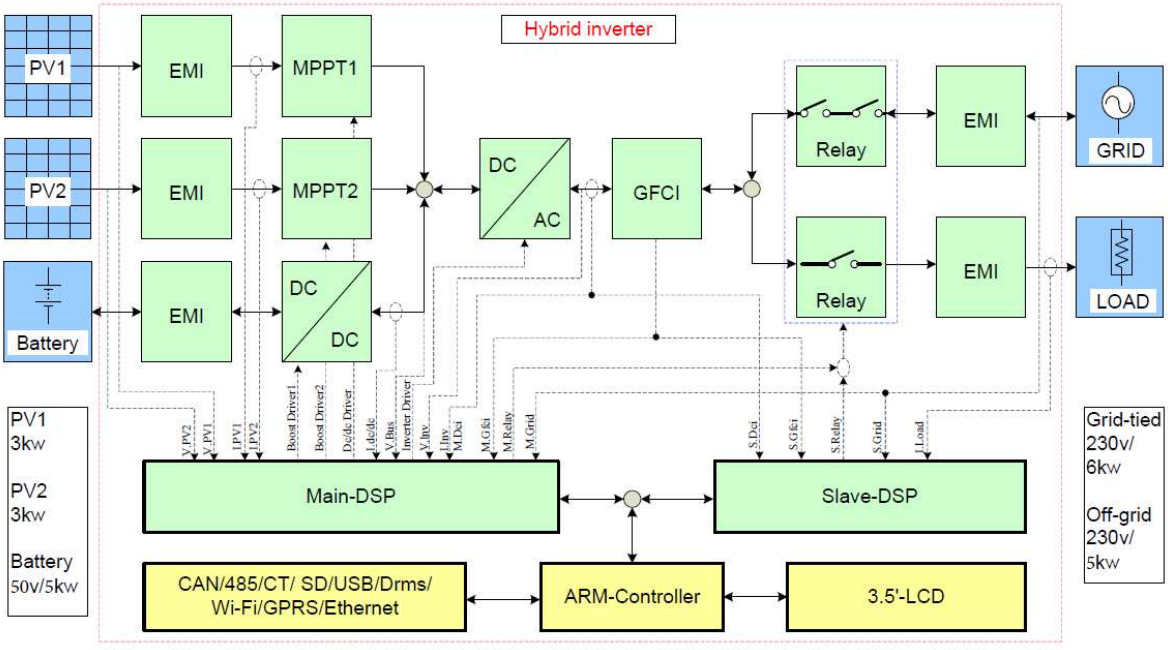

Figure 1 – Block diagram

Model difference:

The models HYD 6000-EP, HYD 5500-EP, HYD 5000-EP, HYD 4600-EP, HYD 4000-EP, HYD 3680-EP and HYD 3000-EP are use the identical hardware platform, control unit, control system and software except the output power derated by software and in following table descripts for different.

	HYD 6000-EP	HYD 5500-EP	HYD 5000-EP	HYD 4600-EP	HYD 4000-EP	HYD 3680-EP	HYD 3000-EP
Resistor ↓ R332, R334, R336	(0Ω, NC, 0Ω)				(NC, 0Ω, NC)		
BUS capacitors	8 pcs				6 pcs		
Inductor	0,75mH				1.035mH		
Sampling resistor of output current (R123,R132)	(1,5kΩ, 1,5kΩ)				(499Ω, 499Ω)		

The product was tested on:

Hardware version: V001
Software version: V02000

All tests were performed on HYD 6000-EP and HYD 3000-EP are valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP, HYD 4000-EP and HYD 3680-EP since it's use the identical hardware and software construction except output power derated by software.

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Clause	Requirement + Test	Result - Remark	Verdict

4	**Testing circuit**		**P**
	The testing circuit shown in Figure 1 is employed.	Considered.	P
	Similar circuits are used for three-phase output.		P
	Parameters to be measured are shown in Table 1 and Figure 1. Parameters to be recorded in the test report are discussed in Clause 7.	Considered.	P
5	**Testing equipment**		P
5.1	**Measuring instruments**		P
	The waveform measurement/capture device is able to record the waveform from the beginning of the islanding test until the EUT ceases to energize the island.		P
	For multi-phase EUT, all phases are monitored.	Three phases ara monitored.	P
	A waveform monitor designed to detect and calculate the run-on time may be used.	Oscilloscope is used.	P
	For multi-phase EUT, the test and measurement equipment is recorded each phase current and each phase-to-neutral or phase-to-phase voltage, as appropriate, to determine fundamental frequency active and reactive power flow over the duration of the test.	Considered.	P
	A sampling rate of 10 kHz or higher is recommended. The minimum measurement accuracy is 1 % or less of rated EUT nominal output voltage and 1 % or less of rated EUT output current	Considered.	P
	Current, active power, and reactive power measurements through switch S1 used to determine the circuit balance conditions report the fundamental (50 Hz or 60 Hz) component.	Considered.	P
5.2	**DC power source**		P
5.2.1	**General**		**P**
	A PV array or PV array simulator (preferred) may be used. If the EUT can operate in utility-interconnected mode from a storage battery, a DC power source may be used in lieu of a battery as long as the DC power source is not the limiting device as far as the maximum EUT input current is concerned.	PV array simulator is used.	P
	The DC power source provides voltage and current necessary to meet the testing requirements described in Clause 6.	Considered.	P
5.2.2	**PV array simulator**		**P**
	The tests are conducted at the input voltage defined in Table 2 below, and the current is limited to 1,5 times the rated photovoltaic input current, except when specified otherwise by the test requirements.	Considered.	P
	A PV array simulator is recommended, however, any type of power source may be used if it does not influence the test results.	PV array simulator is used.	P

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Clause	Requirement + Test	Result - Remark	Verdict

5.2.3	**Current and voltage limited DC power supply with series resistance**	PV array simulator is used.	**N/A**
	A DC power source used as the EUT input source is capable of EUT maximum input power (so as to achieve EUT maximum output power) at minimum and maximum EUT input operating voltage.		N/A
	The power source provides adjustable current and voltage limit, set to provide the desired short circuit current and open circuit voltage when combined with the series and shunt resistance described below.		N/A
	A series resistance (and, optionally, a shunt resistance) is selected to provide a fill factor within the range: Output power: Sufficient to provide maximum EUT output power and other levels specified by test conditions of table 5. Response speed: The response time of a simulator to a step in output voltage, due to a 5% load change, results in a settling of the output current to within 10% of its final value in less than 1ms. Stability: Excluding the variations caused by the EUT MPPT, simulator output power remains stable within 2 % of specified power level over the duration of the test: from the point where load balance is achieved until the island condition is cleared or the allowable run-on time is exceeded. Power factor: 0.25 to 0.8		N/A
5.2.4	**PV array**	PV array simulator is used.	**N/A**
	A PV array used as the EUT input source is capable of EUT maximum input power at minimum and maximum EUT input operating voltage.		N/A
	Testing is limited to times when the irradiance varies by no more than 2 % over the duration of the test as measured by a silicon-type pyranometer or reference device. It may be necessary to adjust the array configuration to achieve the input voltage and power levels prescribed in 6.1.		N/A
5.3	**AC power source**		**P**
	The utility grid or other AC power source may be used as long as it meets the conditions specified in Table 4. **Table 4 – AC power source requirements** Items / Conditions Voltage / Nominal ±2,0 % Voltage THD / < 2,5 % Frequency / Nominal ±0,1 Hz Phase angle distance [1] / 120 ° ± 1,5 ° [1] Three-phase case only	Considered.	P
5.4	**AC loads**		**P**

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Clause	Requirement + Test	Result - Remark	Verdict
	On the AC side of the EUT, variable resistance, capacitance, and inductance are connected in parallel as loads between the EUT and the AC power source. Other sources of load, such as electronic loads, may be used if it can be shown that the source does not cause results that are different than would be obtained with passive resistors, inductors, and capacitors.	Considered.	P
	All AC loads are rated for and adjustable to all test conditions. The equations for Qf are based upon an ideal parallel RLC circuit. For this reason, non-inductive resistors, low loss (high Qf) inductors, and capacitors with low effective series resistance and effective series inductance are utilized in the test circuit. Iron core inductors, if used, are not exceed a current THD of 2 % when operated at nominal voltage. Load components are conservatively rated for the voltage and power levels expected. Resistor power ratings are chosen so as to minimize thermally-induced drift in esistance values during the course of the test.	Considered.	P
	Active and reactive power is calculated (using the measurements provided in Table 1) in each of the R, L and C legs of the load so that these parasitic parameters (and parasitics introduced by variacs or autotransformers) are properly accounted for when calculating Qf.	Considered.	P
6	**Test for single or multi-phase inverter**		**P**
6.1	**Test procedure**	(see appended table)	**P**
	The test uses an RLC load, resonant at the EUT nominal frequency (50 Hz or 60 Hz) and matched to the EUT output power.		P
	For multi-phase EUT, the load is balanced across all phases and the switch S1 as in Figure 1 opens all phases	The switch could open all phases.	P
	This test is performed with the EUT conditions as in Table 5, where power and voltage values are given as a percent of EUT full output rating.		P
	a)..Determine EUT test output power		P
	b) .Adjusting the DC input source		P
	c) .Turn off the EUT and open S1		P
	d) .Adjust the RLC circuit to have Qf = 1.0 ±0.05		P
	e)..Connect the RLC load configured in step d) to the EUT by closing S2		P
	f)...Open the utility-disconnect switch S1 to initiate the test, Run-on time is recorded.		P
	g)..For test condition A, adjust the real load and only one of the reactive load components to each of the load imbalance conditions shown in the shaded portion of table 6. If any of the recorded run-on times are longer than the one recorded for the rated balance condition, then the non-shaded parameter combinations also require testing.		P

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Clause	Requirement + Test	Result - Remark	Verdict
	h) For test condition B and C, adjust the only one reactive load components by approximately 1,0% per test, within a total range of 95% to 105% of the operating point. If run-on times are still increasing at the 95% or 105% points, additional 1% increments have to be taken until run-on times begin decreasing.		P
6.2	**Pass/fail criteria**		**P**
	An EUT is considered to comply with the requirements for islanding protection when each case of recorded run-on time is less than 2 s or meets the requirements of local codes.		P
7	**Documentation**		**P**
	At a minimum, the following information is recorded and maintained in the test report.		P
	a) Specifications of EUT. Table 8 provides an example of the type of information that is provided.		P
	b) Measurement results. Table 9 provides an example of the type of information that is provided. Actual measured values is to be recorded.		P
	c) Block diagram of test circuit.		P
	d) Specifications of the test and measurement equipment. Table 10 provides an example of the type of information that is provided.		P
	e) Any test configuration or procedure details such as methods of achieving specified load and EUT output conditions.		P
	f) Any additional information required by the testing laboratory's accreditation.		P
	g) Specify the evaluation criterion from clause 6.2 that was utilized to determine if the product passed or failed the test.		P
Annex A	Islanding as it applies to PV systems(Informative)		--
A.1	General		--
A.2	Impact of distortion on islanding		--
Annex B	Test for independent islanding detection device (relay)(Informative)		--
B.1	Introduction		--
B.2	Testing circuit		--
B.3	Testing equipment		--
B.4	Testing procedure		--
B.5	Documentation		--

IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

Test overview:

IEC 62116:2014		
Clause	**Test**	**Result**
	Type test:	
6.1	Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%)	**P**
6.1	Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %)	**P**
6.1	Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %)	**P**

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Clause	Requirement + Test	Result - Remark	Verdict

6.1 Islanding protection

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

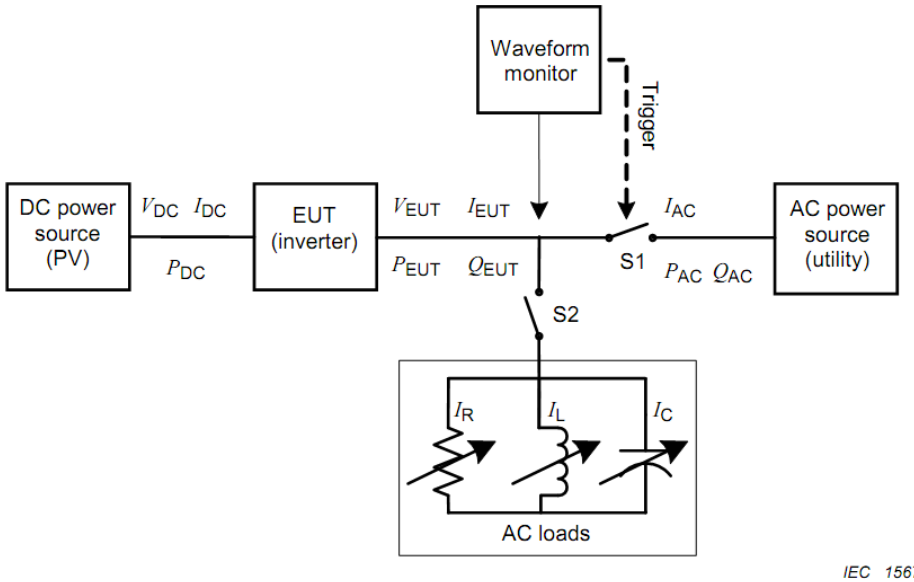


Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

6.1 Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT output = 100%)	**P**

HYD 6000-EP at 230Va.c. / 50Hz

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

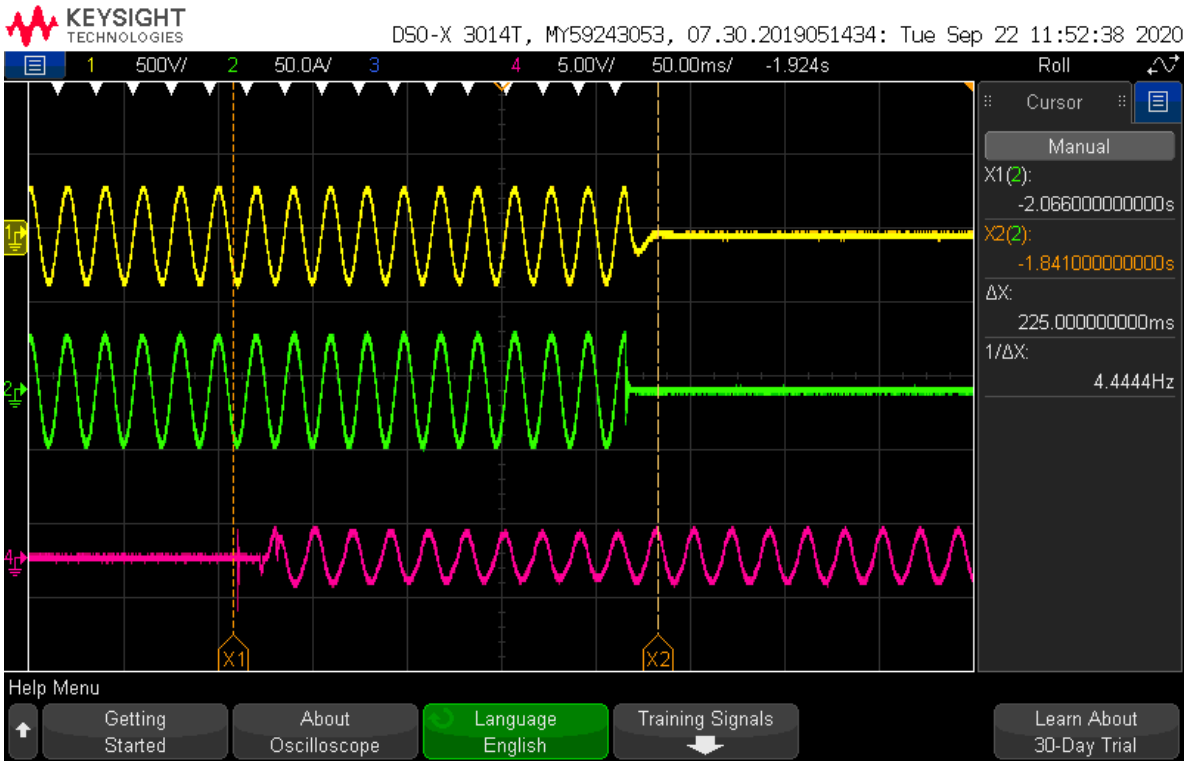
No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) 1]	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [kW per phase]	V_{DC} [V]	Q_f [1]	Run on Time [ms]	Remarks 5)
1	100	100	0	0	0,188	6,003	427	1,000	**225**	BL
2	100	100	-5	-5	1,459	6,003	427	1,026	208	IB
3	100	100	-5	0	1,493	6,003	427	1,053	216	IB
4	100	100	-5	+5	1,458	6,003	427	1,079	206	IB
5	100	100	0	-5	0,220	6,003	427	0,975	207	IB
6	100	100	0	+5	0,221	6,003	427	1,025	210	IB
7	100	100	+5	-5	1,524	6,003	427	0,928	148	IB
8	100	100	+5	0	1,493	6,003	427	0,953	207	IB
9	100	100	+5	+5	1,524	6,003	427	0,976	200	IB

Parameter at 0% per phase	L= 28,05 mH	R= 8,81 Ω	C= 361,21 µF

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) Fundamental of I_{AC} when RLC is adjusted
5) BL: Balance condition, IB: Imbalance condition.
Condition A:
EUT output power PEUT = Maximum 6)
EUT input voltage 6) = >75% of rated input voltage range
6) Maximum EUT output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.
7) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % of range =X + 0,75 × (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.
The tests had been performed on the HYD 6000-EP and is valid for the HYD 3000-EP, HYD 3680-EP, HYD 4000-EP, HYD 4600-EP, HYD 5000-EP and HYD 5500-EP, since it is identical in hardware and software construction except output power derated by software.

IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 100% nominal power



IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

6.1 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %)	**P**

HYD 6000-EP at 230Va.c. / 50Hz

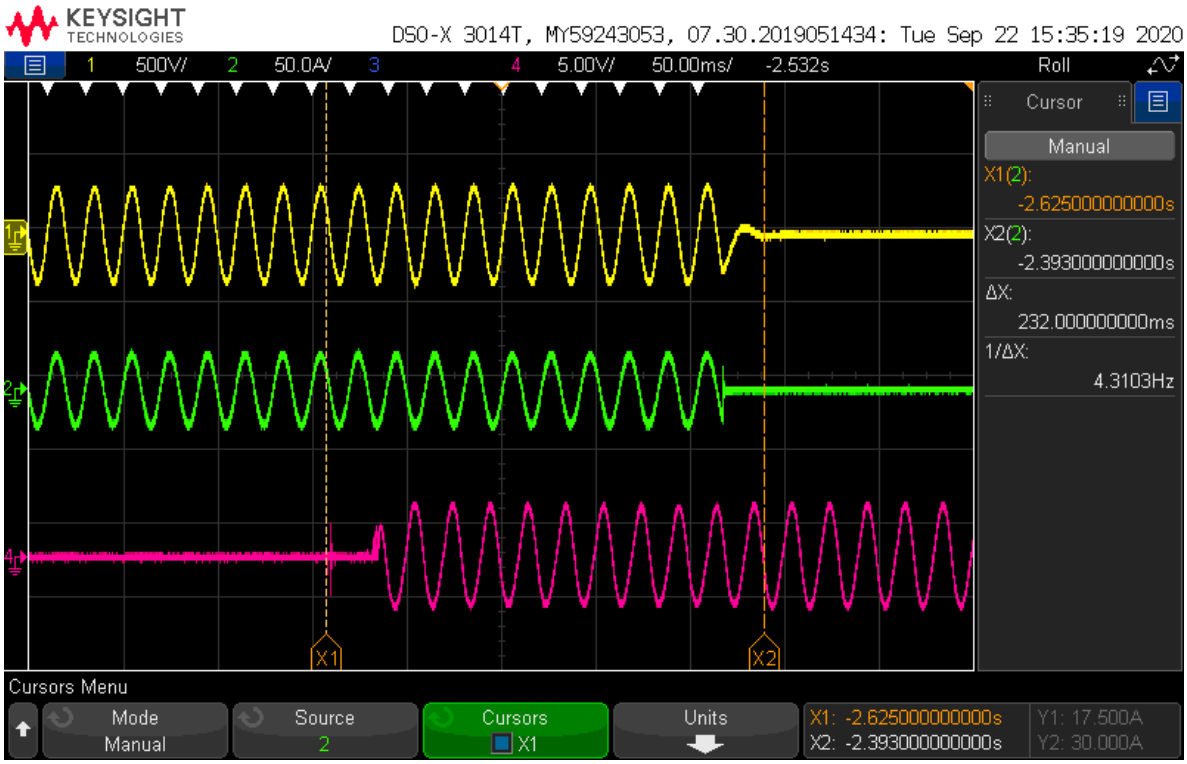
Test conditions			Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1							
Disconnection limit			2s							
No	P_{EUT} [1] [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) 1]	P_{AC} [2] [% of nominal]	Q_{AC} [3] [% of nominal]	I_{AC} [4] [A]	P_{EUT} [kW per phase]	V_{DC} [V]	Q_f [1]	Run on Time [ms]	Remarks [5]
12	66	66	0	-5	0,228	4,000	277	0,975	149	IB
13	66	66	0	-4	0,220	4,000	277	0,980	222	IB
14	66	66	0	-3	0,214	4,000	277	0,985	200	IB
15	66	66	0	-2	0,209	4,000	277	0,990	199	IB
16	66	66	0	-1	0,207	4,000	277	0,995	201	IB
2	66	66	0	0	0,206	4,000	277	1,000	**232**	BL
17	66	66	0	1	0,207	4,000	277	1,005	217	IB
18	66	66	0	2	0,209	4,000	277	1,010	203	IB
19	66	66	0	3	0,214	4,000	277	1,015	213	IB
20	66	66	0	4	0,220	4,000	277	1,020	215	IB
21	66	66	0	5	0,228	4,000	277	1,025	154	IB

Parameter at 0% per phase	L= 42,10 mH	R= 13,23 Ω	C= 240,69 µF

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] Fundamental of I_{AC} when RLC is adjusted
[5] BL: Balance condition, IB: Imbalance condition.
Condition B:
EUT output power P_{EUT} = 50 % – 66 % of maximum
EUT input voltage [6] = 50 % of rated input voltage range, ±10 %
[6] 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.
The tests had been performed on the HYD 6000-EP and is valid for the HYD 3000-EP, HYD 3680-EP, HYD 4000-EP, HYD 4600-EP, HYD 5000-EP and HYD 5500-EP, since it is identical in hardware and software construction except output power derated by software.

IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 66% nominal power



IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

6.1 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %) — **P**

HYD 6000-EP at 230Va.c. / 50Hz

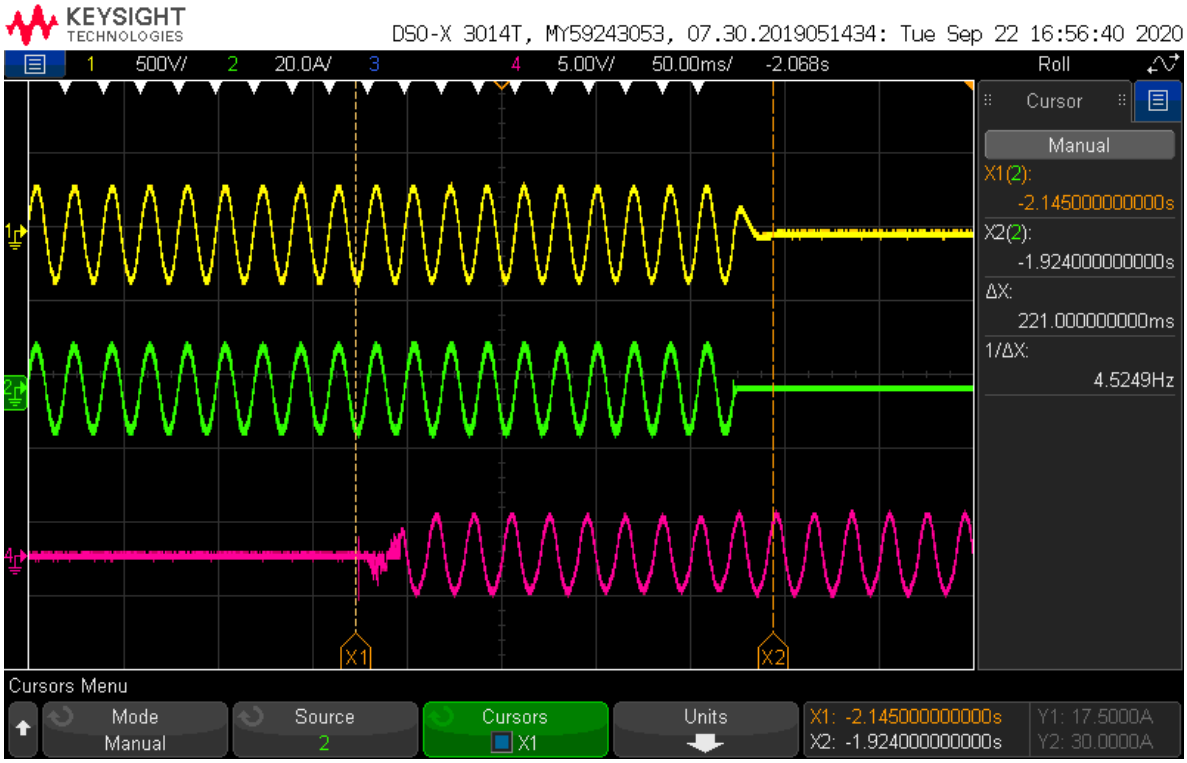
Test conditions			Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1							
Disconnection limit			2s							
No	P_{EUT} [1] [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) 1]	P_{AC} [2] [% of nominal]	Q_{AC} [3] [% of nominal]	I_{AC} [4] [A]	P_{EUT} [kW per phase]	V_{DC} [V]	Q_f [1]	Run on Time [ms]	Remarks [5]
22	33	33	0	-5	0,182	1,993	127	0,973	114	IB
23	33	33	0	-4	0,178	1,993	127	0,978	195	IB
24	33	33	0	-3	0,175	1,993	127	0,983	130	IB
25	33	33	0	-2	0,173	1,993	127	0,988	216	IB
26	33	33	0	-1	0,171	1,993	127	0,993	209	IB
3	33	33	0	0	0,171	1,993	127	0,998	**221**	BL
27	33	33	0	1	0,171	1,993	127	1,003	214	IB
28	33	33	0	2	0,173	1,993	127	1,008	211	IB
29	33	33	0	3	0,175	1,993	127	1,013	138	IB
30	33	33	0	4	0,178	1,993	127	1,018	208	IB
31	33	33	0	5	0,182	1,993	127	1,023	129	IB

Parameter at 0% per phase	L= 84,66 mH	R= 26,54 Ω	C= 119,68 µF

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] Fundamental of I_{AC} when RLC is adjusted
[5] BL: Balance condition, IB: Imbalance condition.
Condition B:
EUT output power PEUT = 25 % – 33 % [6] of maximum
EUT input voltage [7] = <20 % of rated input voltage range
[6] Or minimum allowable EUT output level if greater than 33 %.
[7] Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 10 % of range =X + 0,2 × (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.
The tests had been performed on the HYD 6000-EP and is valid for the HYD 3000-EP, HYD 3680-EP, HYD 4000-EP, HYD 4600-EP, HYD 5000-EP and HYD 5500-EP, since it is identical in hardware and software construction except output power derated by software.

IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 33% nominal power



IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

6.1 Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT output = 100%)	**P**

HYD 6000-EP at 230Va.c. / 60Hz

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

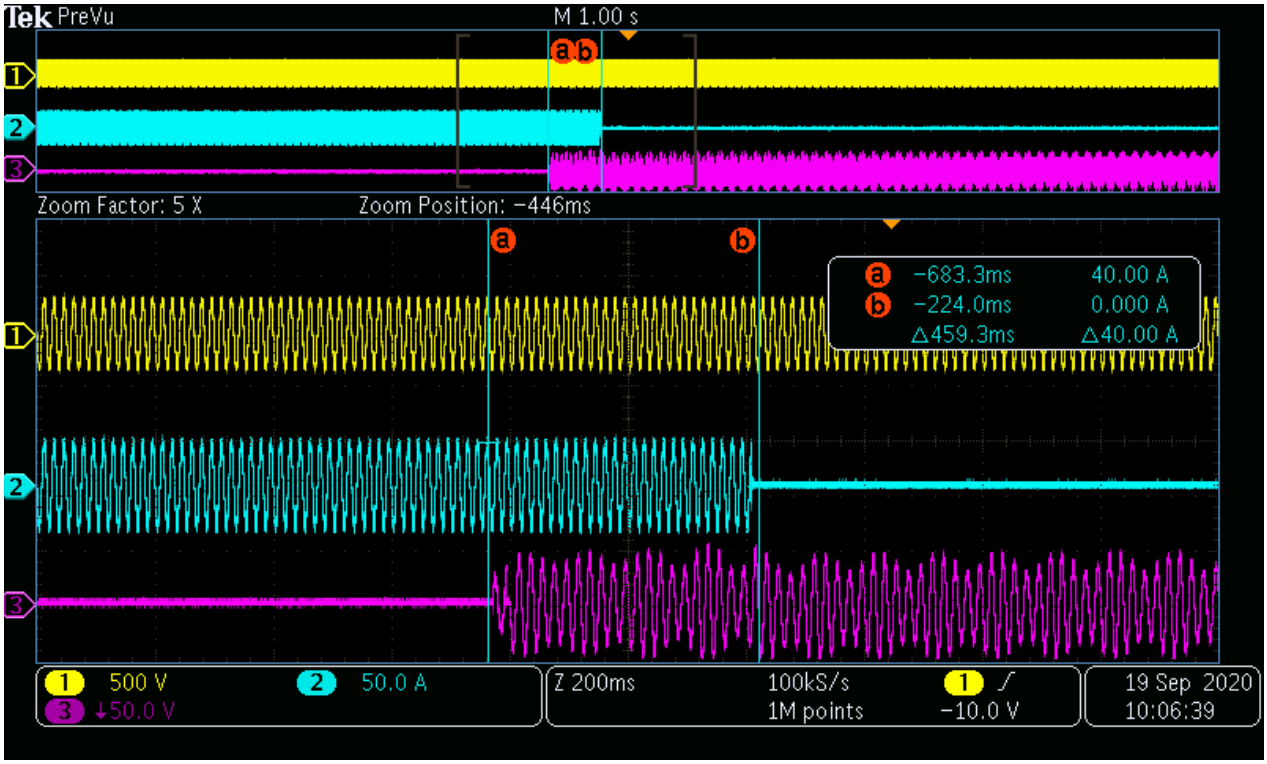
No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) 1]	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [kW per phase]	V_{DC} [V]	Q_f [1]	Run on Time [ms]	Remarks 5)
1	100	100	0	0	0,025	6,000	427	1,000	**459**	BL
2	100	100	-5	-5	1,292	6,000	427	1,026	343	IB
3	100	100	-5	0	1,325	6,000	427	1,053	395	IB
4	100	100	-5	+5	1,290	6,000	427	1,079	345	IB
5	100	100	0	-5	0,061	6,000	427	0,975	393	IB
6	100	100	0	+5	0,063	6,000	427	1,025	409	IB
7	100	100	+5	-5	1,364	6,000	427	0,928	361	IB
8	100	100	+5	0	1,334	6,000	427	0,953	387	IB
9	100	100	+5	+5	1,366	6,000	427	0,976	399	IB

Parameter at 0% per phase	L= 28,06 mH	R= 8,82 Ω	C= 361,09 µF

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) Fundamental of I_{AC} when RLC is adjusted
5) BL: Balance condition, IB: Imbalance condition.
Condition A:
EUT output power PEUT = Maximum 6)
EUT input voltage 6) = >75% of rated input voltage range
6) Maximum EUT output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.
7) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % of range =X + 0,75 × (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.
The tests had been performed on the HYD 6000-EP and is valid for the HYD 3000-EP, HYD 3680-EP, HYD 4000-EP, HYD 4600-EP, HYD 5000-EP and HYD 5500-EP, since it is identical in hardware and software construction except output power derated by software.

IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 100% nominal power



IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

6.1 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %)	**P**

HYD 6000-EP at 230Va.c. / 60Hz

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

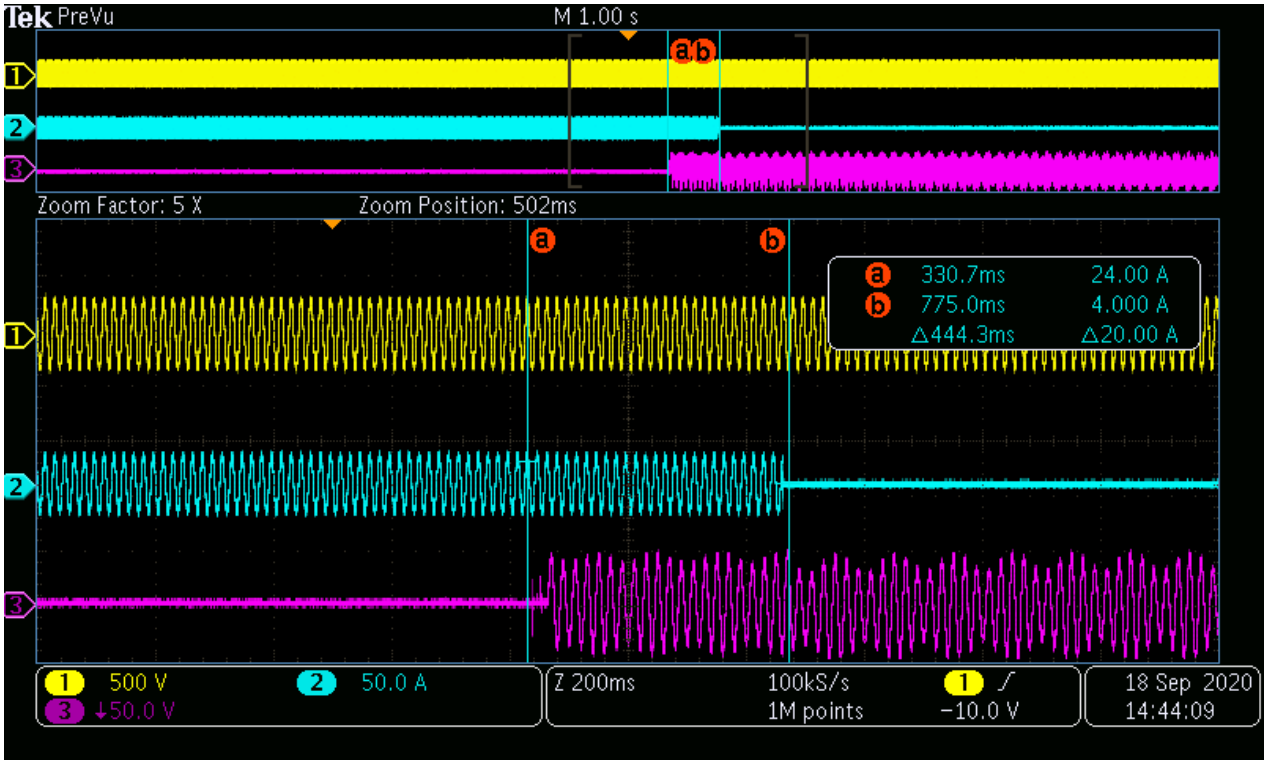
No	P_{EUT} [1] [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) 1]	P_{AC} [2] [% of nominal]	Q_{AC} [3] [% of nominal]	I_{AC} [4] [A]	P_{EUT} [kW per phase]	V_{DC} [V]	Q_f [1]	Run on Time [ms]	Remarks [5]
12	66	66	0	-5	0,087	3,961	277	0,974	358	IB
13	66	66	0	-4	0,079	3,961	277	0,979	378	IB
14	66	66	0	-3	0,073	3,961	277	0,984	372	IB
15	66	66	0	-2	0,069	3,961	277	0,989	382	IB
16	66	66	0	-1	0,067	3,961	277	0,994	340	IB
2	66	66	0	0	0,066	3,961	277	0,999	**444**	BL
17	66	66	0	1	0,067	3,961	277	1,004	344	IB
18	66	66	0	2	0,070	3,961	277	1,009	376	IB
19	66	66	0	3	0,074	3,961	277	1,014	364	IB
20	66	66	0	4	0,080	3,961	277	1,019	376	IB
21	66	66	0	5	0,088	3,961	277	1,024	312	IB

Parameter at 0% per phase	L= 42,55 mH	R= 13,35 Ω	C= 238,10 µF

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] Fundamental of I_{AC} when RLC is adjusted
[5] BL: Balance condition, IB: Imbalance condition.
Condition B:
EUT output power P_{EUT} = 50 % – 66 % of maximum
EUT input voltage [6] = 50 % of rated input voltage range, ±10 %
[6] 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.
The tests had been performed on the HYD 6000-EP and is valid for the HYD 3000-EP, HYD 3680-EP, HYD 4000-EP, HYD 4600-EP, HYD 5000-EP and HYD 5500-EP, since it is identical in hardware and software construction except output power derated by software.

IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 66% nominal power



IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

6.1 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %) — **P**

HYD 6000-EP at 230Va.c. / 60Hz

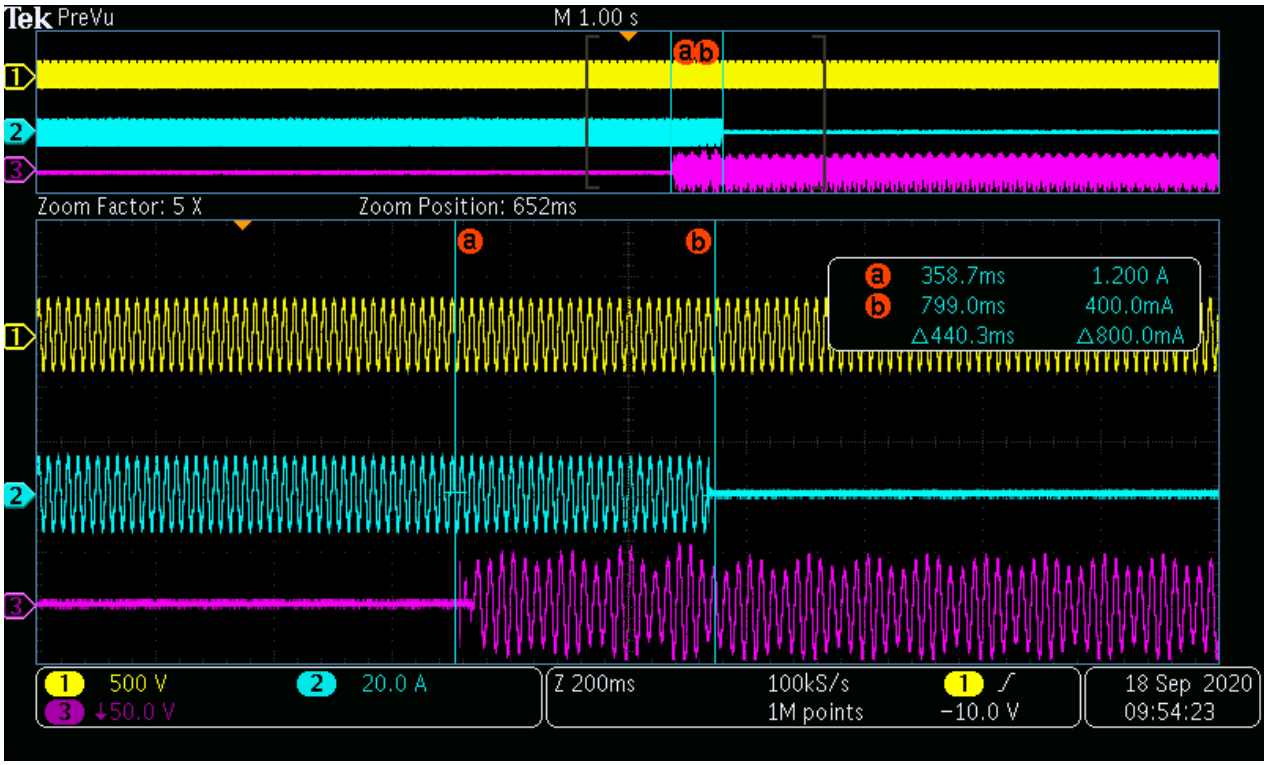
Test conditions			Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1							
Disconnection limit			2s							
No	P_{EUT} [1] [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) 1]	P_{AC} [2] [% of nominal]	Q_{AC} [3] [% of nominal]	I_{AC} [4] [A]	P_{EUT} [kW per phase]	V_{DC} [V]	Q_f [1]	Run on Time [ms]	Remarks [5]
22	33	33	0	-5	0,082	1,979	127	0,975	374	IB
23	33	33	0	-4	0,078	1,979	127	0,980	382	IB
24	33	33	0	-3	0,075	1,979	127	0,985	356	IB
25	33	33	0	-2	0,073	1,979	127	0,990	368	IB
26	33	33	0	-1	0,071	1,979	127	0,995	398	IB
3	33	33	0	0	0,071	1,979	127	1,001	**440**	BL
27	33	33	0	1	0,071	1,979	127	1,005	390	IB
28	33	33	0	2	0,073	1,979	127	1,010	382	IB
29	33	33	0	3	0,075	1,979	127	1,015	332	IB
30	33	33	0	4	0,078	1,979	127	1,020	398	IB
31	33	33	0	5	0,082	1,979	127	1,025	366	IB

Parameter at 0% per phase	L= 85,00 mH	R= 26,73 Ω	C= 119,20 µF

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] Fundamental of I_{AC} when RLC is adjusted
[5] BL: Balance condition, IB: Imbalance condition.
Condition B:
EUT output power PEUT = 25 % – 33 % [6] of maximum
EUT input voltage [7] = <20 % of rated input voltage range
[6] Or minimum allowable EUT output level if greater than 33 %.
[7] Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 10 % of range =X + 0,2 × (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.
The tests had been performed on the HYD 6000-EP and is valid for the HYD 3000-EP, HYD 3680-EP, HYD 4000-EP, HYD 4600-EP, HYD 5000-EP and HYD 5500-EP, since it is identical in hardware and software construction except output power derated by software.

IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict

Disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 33% nominal power



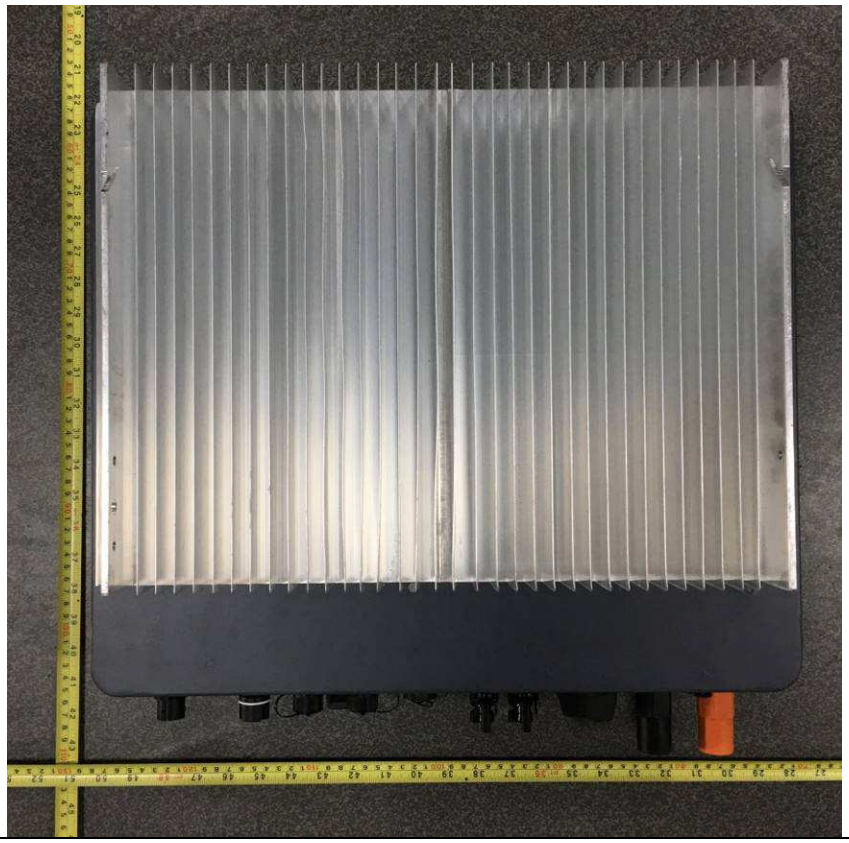
Annex 1

Pictures of the unit

EUT Photo

General view – 1 of Front

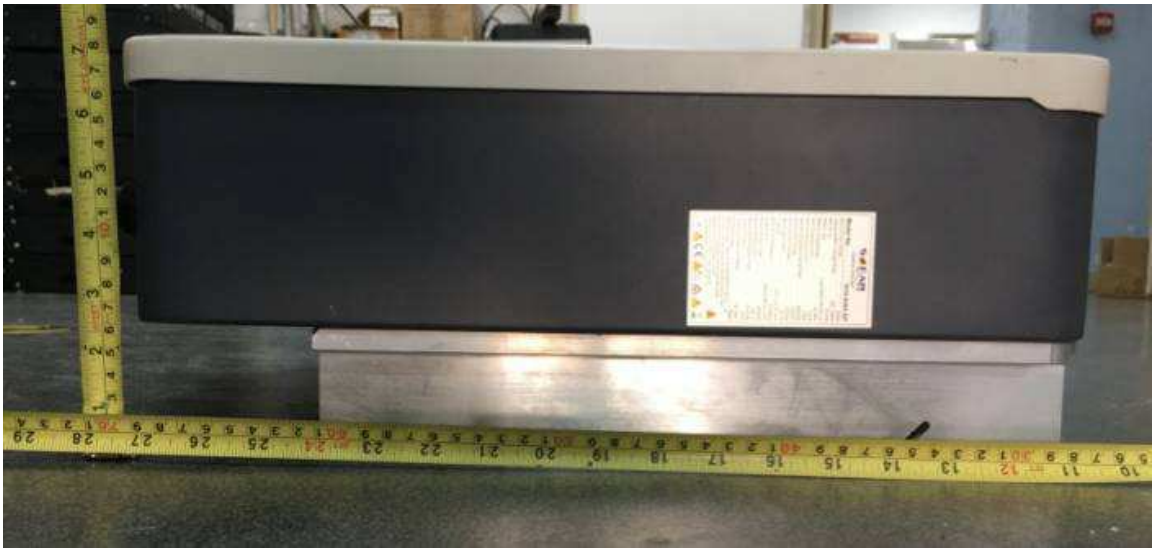
General view – 1 of Rear

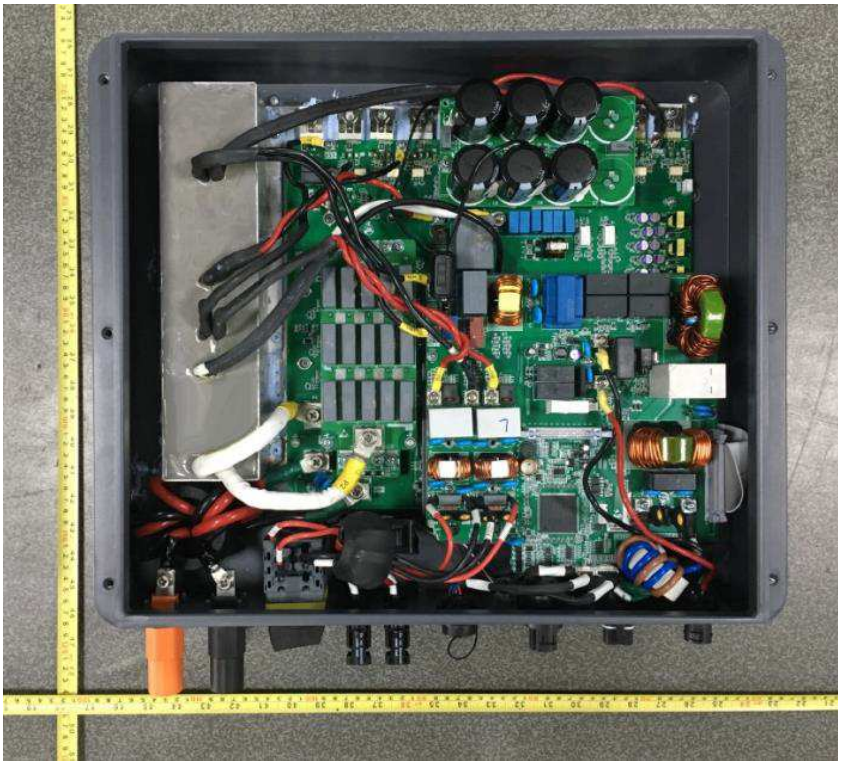


EUT Photo

General view – 1 of Bottom

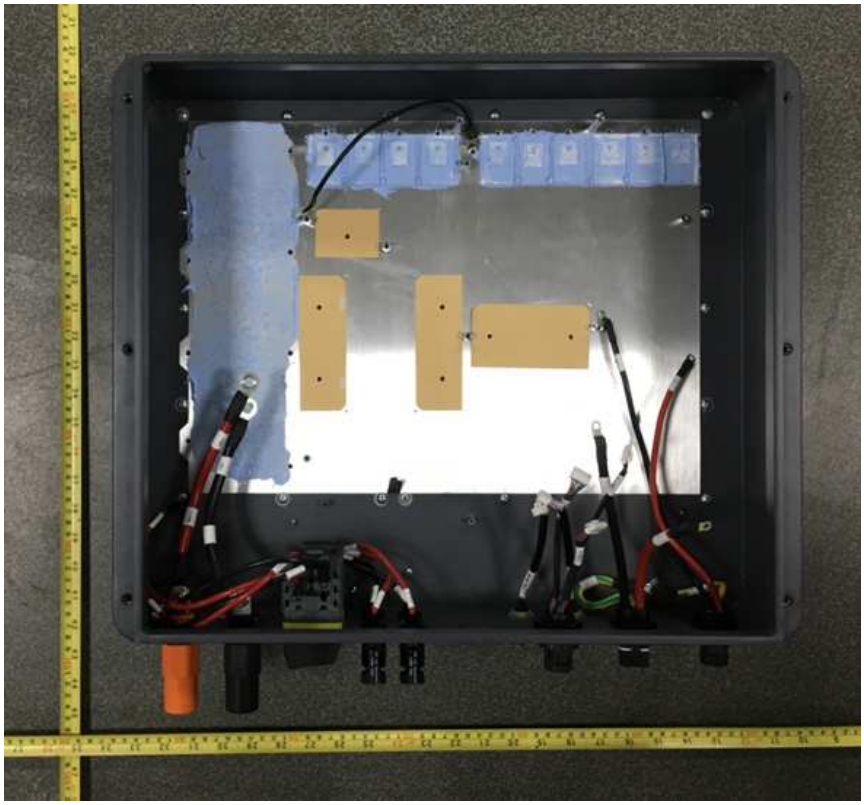
General view – 1 of Side



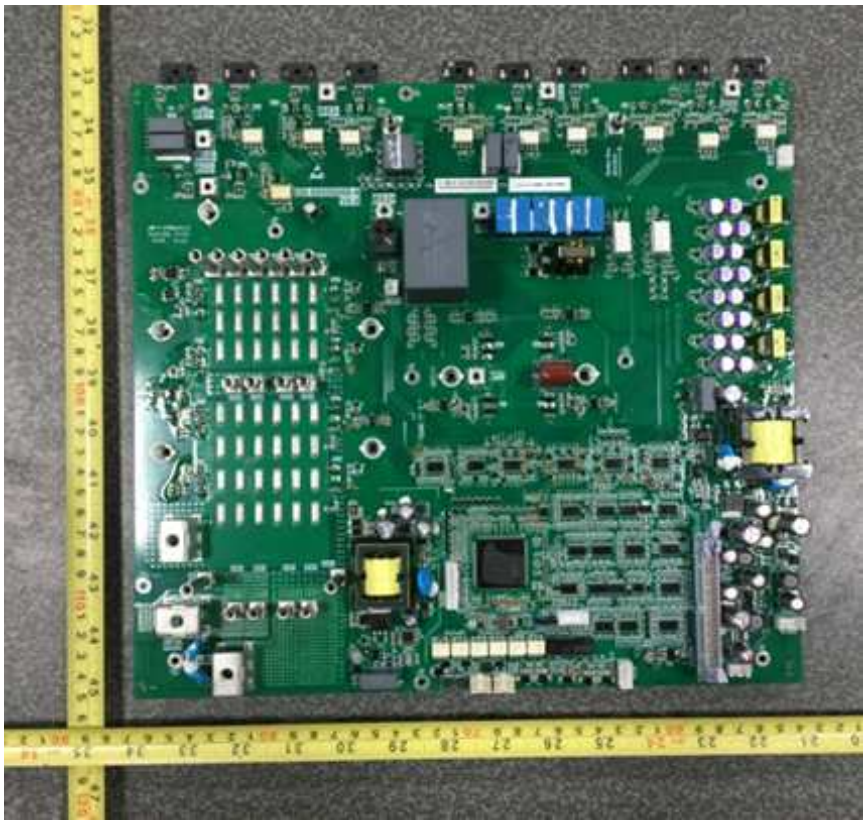
EUT Photo
Internal view – 1 **(**HYD 4600-EP, HYD 5000-EP, HYD 5500-EP,HYD 6000-EP) 
Internal view – 2 (HYD 3000-EP, HYD 3680-EP, HYD 4000-EP)


EUT Photo

Internal view - 3

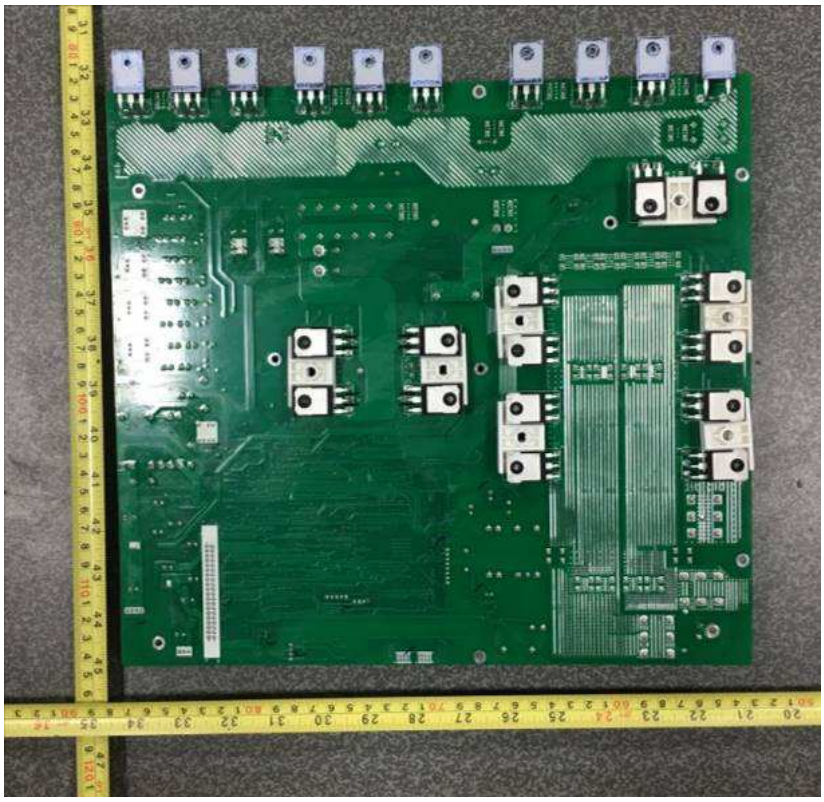


General view – 1 of Power board

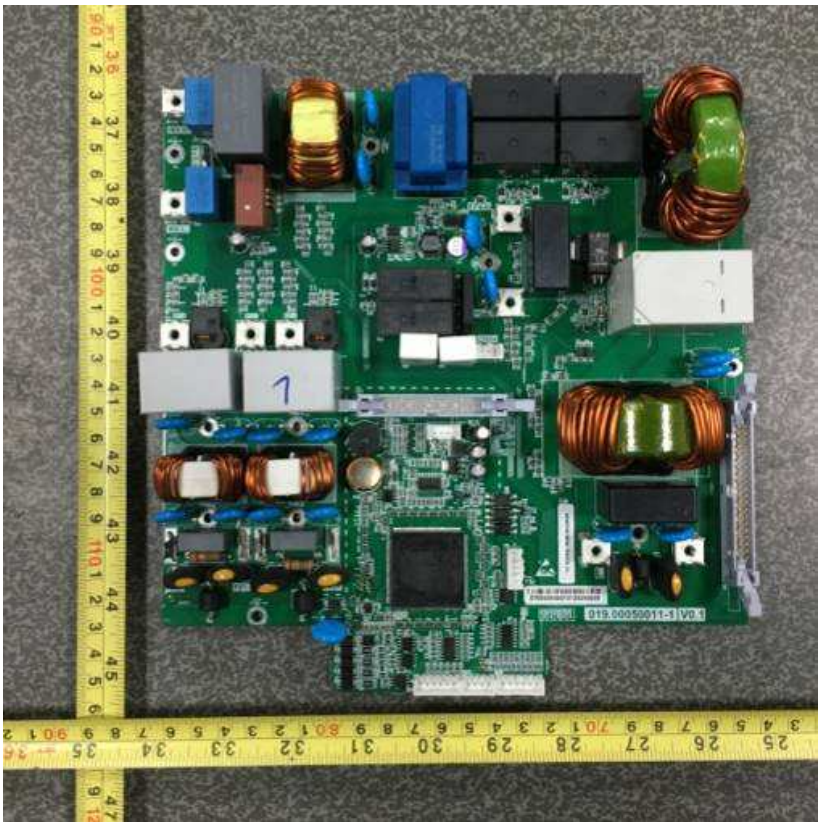


EUT Photo

General view – 2 of Power board

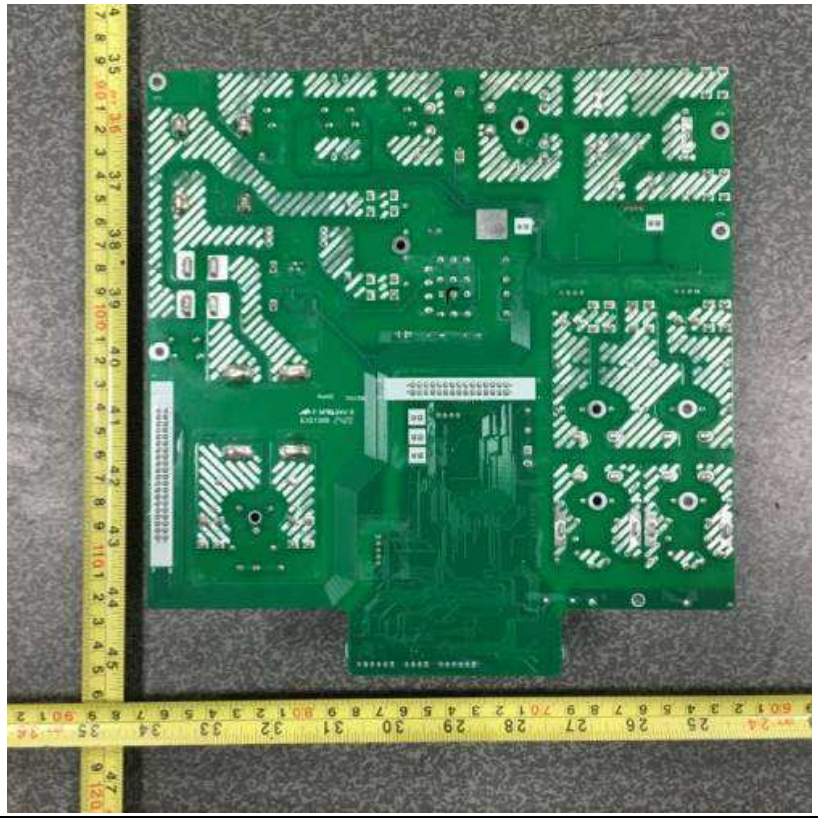


General view – 1 of Output board

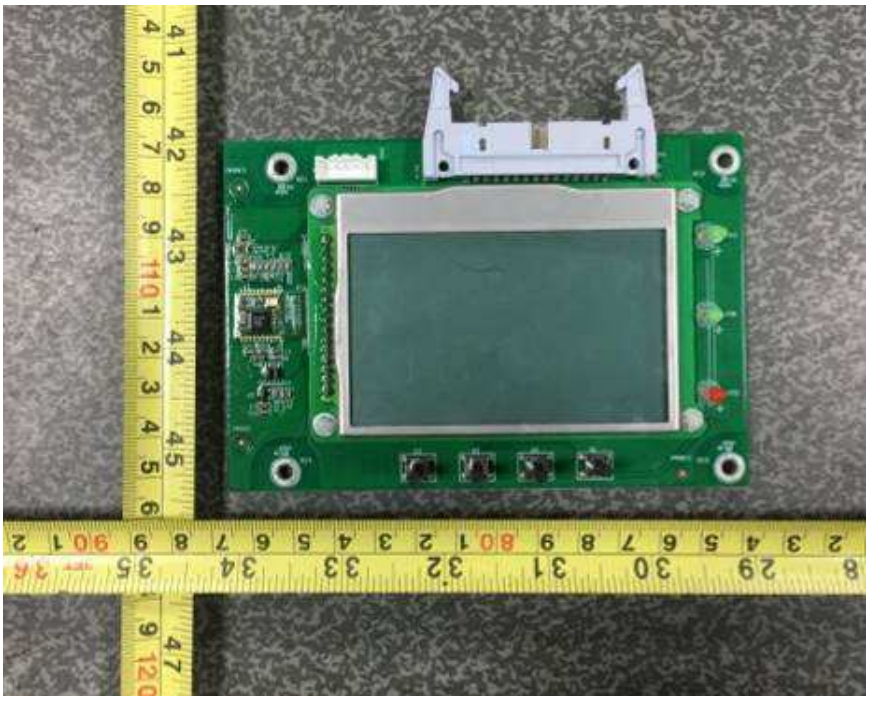


EUT Photo

General view – 2 of Output board

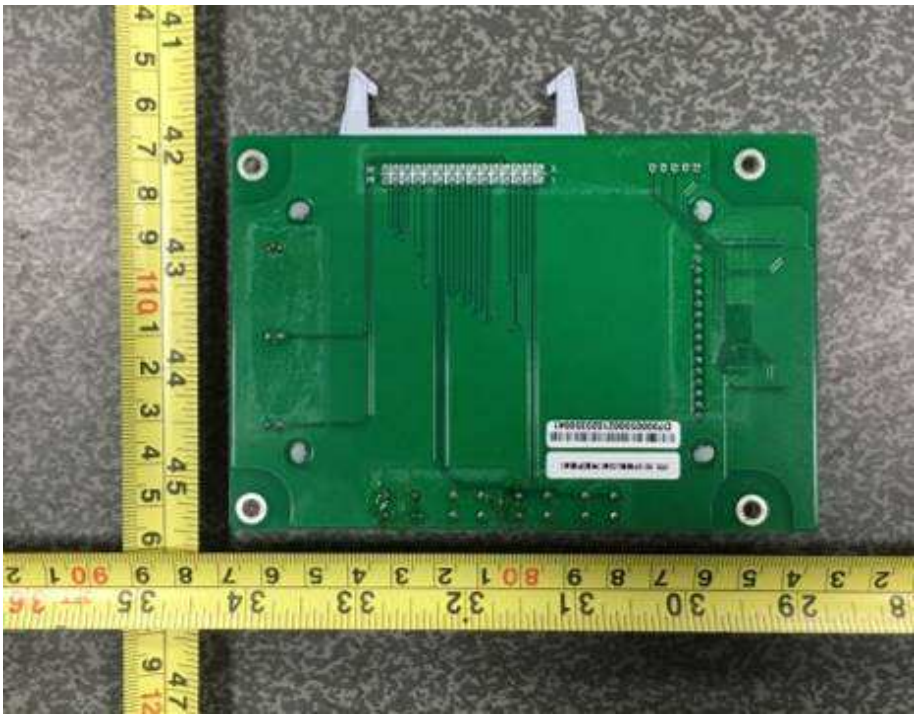


General view – 1 of LCD panel



EUT Photo

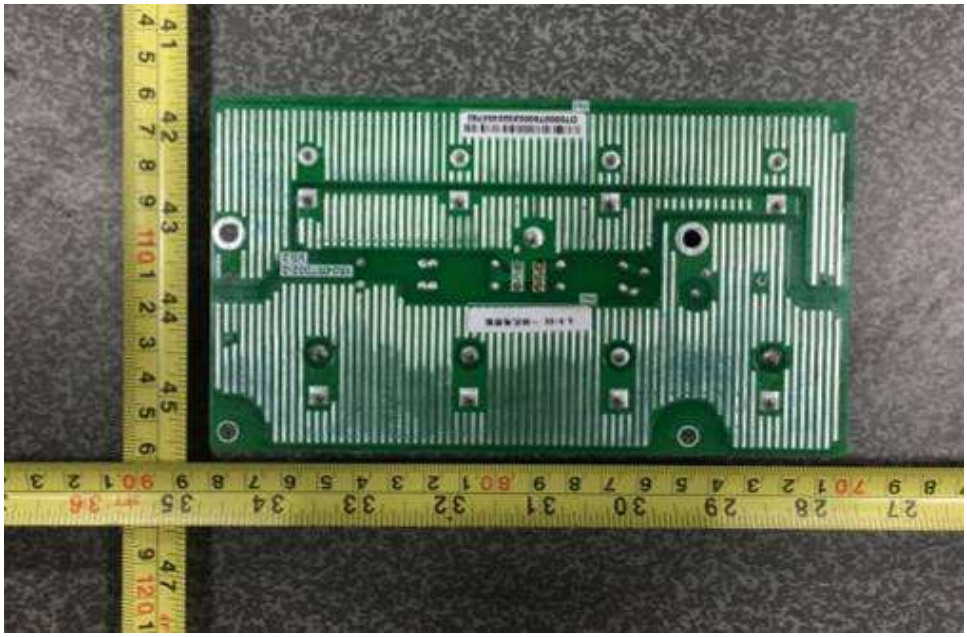
General view – 2 of LCD panel



General view - 1 of BUS board

EUT Photo

General view - 2 of BUS board



General view of Grouding point

Annex 2

Test equipment list

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

Date(s) of performance test: 2020-09-17 to 2020-12-28

Equipment	Internal No.	Manufacturer	Type	Serial No.	Next Calibration date
Power Analyser	A4080002DG	YOKOGAWA	WT3000	91M210852	Jun. 16, 2021
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyser
	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040015DG	Chroma	62150H-1000S	62150EF00488	
	A7040016DG	Chroma	62150H-1000S	62150EF00490	
	A7040017DG	Chroma	620028	620028EF00120	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 23, 2021
Oscilloscope probe	A4089008DG	Tektronix	TPP1000	C008230	Aug. 10, 2021
	A4089010DG	Tektronix	TPP1000	C008228	Aug. 10, 2021
	A4089011DG	Tektronix	TPP1000	C008229	Aug. 10, 2021
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Sep. 02, 2021
	A1060008DG	YOKOGAWA	CT200	1130700017	Sep. 02, 2021
	A1060012DG	YOKOGAWA	CT200	1130700018	Sep. 02, 2021
Power Analyser	//	ZLG	PA5000H	C820290908200 2110001	Mar. 02, 2021
Oscilloscope	//	Agilent	DS05014A	MY50070288	Jan. 13, 2021
Oscilloscope current probe	//	CYBERTEK	CP1000A	C181000922	Jan. 13, 2021
	//	CYBERTEK	CP1000A	C181000925	Jan. 13, 2021
	//	CYBERTEK	CP1000A	C181000929	Jan. 13, 2021
	//	CYBERTEK	CP1000A	C181000931	Jan. 13, 2021
Oscilloscope probe	//	SANHUA	SI-9110	152627	Jan. 13, 2021
	//	SIALENT	DS5034X	SDS5XEAC3R0 011	Jan. 13, 2021
	//	AGILENT	N2863B	YF0139	Jan. 13, 2021