Test Report issued under the responsibility of:

TEST REPORT
IEC 62116
Test procedure of islanding prevention measures for utility-interconnected photovoltaic inverters

Report Number. .....:	2219 / 0019 - 4
Date of issue .....:	23/05/2019
Total number of pages.....	12
Name of Testing Laboratory preparing the Report.....:	SGS Tecnos, S.A. (Electrical Testing Laboratory)
Applicant's name.....:	Shenzhen SOFAR SOLAR Co., Ltd.
Address .....:	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen City, Guangdong Province, P.R. China
Test specification:	
Standard .....:	IEC/EN 62116: 2014 (Second Edition)
Test procedure .....:	Characteristic Examination
Non-standard test method .....:	N/A
Test Report Form No. .....:	IEC62116B
Test Report Form(s) Originator ....:	TÜV SÜD Product Service GmbH
Master TRF.....:	Dated 2014-10

This report is not valid as a CB Test Report unless signed by an approved CB Testing Laboratory and appended to a CB Test Certificate issued by an NCB in accordance with IECEE 02.

General disclaimer:

The test results presented in this report relate only to the object tested.
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Test item description..:	Hybrid inverter
Trade Mark.....:	SOFAR SOLAR
Manufacturer .....:	Shenzhen SOFAR SOLAR Co., Ltd.
Model/Type reference.:	HYD 6000-ES
Ratings.....:	**DC input:** 90-580V Max.2x15A **AC output**: 230Vac, 50Hz, Imax 27.3A, 6000VA **Serial Number:** SM1ES060JCS423 **Firmware version:** V1.60

Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):			
☐	~~**CB Testing Laboratory:**~~		
~~**Testing location/ address.....:**~~			
☐	~~**Associated CB Testing Laboratory:**~~		
☒	**Testing procedure: TMP/CTF Stage 1:**	Shenzhen BALUN Technology Co.,Ltd.	
Testing location/ address.....:		Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province. P.R. China	
Tested by (name, function, signature).....:		Hugo Zhang (Project Engineer)	Hugo Zhang
		Roger Hu (Project Engineer)	Roger Hu
Approved by (name, function, signature....:		Jacobo Tevar (Technical Reviewer)	SGS Tecnos, S.A. Laboratorio de Ensayos E&E
☐	~~**Testing procedure: WMT/CTF Stage 2:**~~		
☐	~~**Testing procedure: SMT/CTF Stage 3 or 4:**~~		

List of Attachments (including a total number of pages in each attachment):

50 Hz		
Attachment #	Description	Pages
Attachment I	Pictures of the EUT and Electrical Schemes	16pages
Attachment II	Graphics of the Test Results	3 pages
Attachment III	Graphics of the Islanding Behavior Detection	19 pages
Attachment IV	Testing Information	4 pages

Summary of testing:

Tests performed (name of test and test clause):

All clauses except:

- Sub-clause d) of the Table 5 of the point 6.1. Voltage and frequency trips shall be adjusted according to National Standards and/or local codes.

From the result of inspection and tests performed on the submitted sample we conclude that it complies with the requirements of the Standard.

Testing location:

Shenzhen BALUN Technology Co.,Ltd.

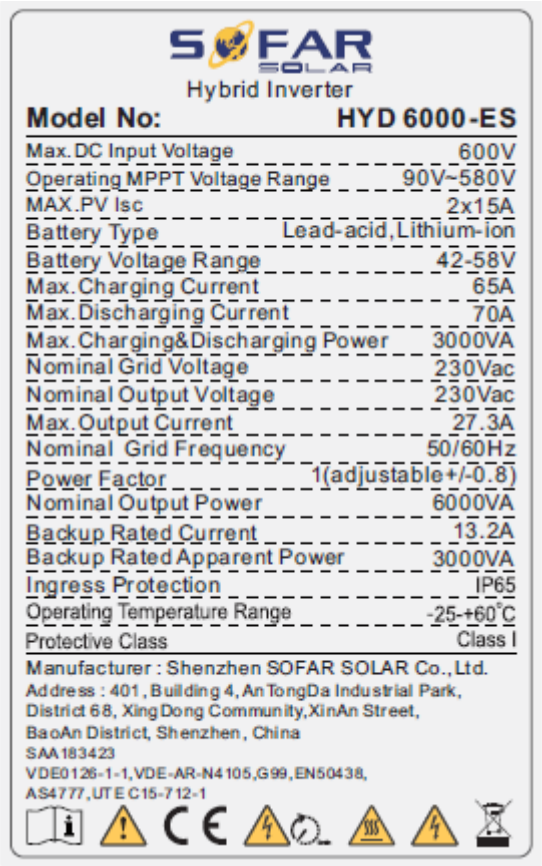
Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province. P.R. China

(All clauses)

Summary of compliance with National Differences:

No National Differences are addressed to this test report

Copy of marking plate(representative):



Note:

1. The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.
2. Label is attached on the side surface of enclosure and visible after installation
3. Labels of other models are as the same with HYD 6000-ES's except the parameters of rating.

Test item particulars..... :	Hybrid Inverter
Classification of installation and use..... :	Fixed (permanent connection)
Supply Connection ..... :	DC; PV
..... :	AC; Grid connection
Possible test case verdicts:	
- test case does not apply to the test object.....:	N/A
- test object does meet the requirement.....:	P (Pass)
- test object does not meet the requirement.....:	F (Fail)
Testing.....:	CTF Stage 1 procedure
Date of receipt of test item .....:	N/A
Date (s) of performance of tests .....:	From 26/04/2019

General remarks:

"(See Enclosure #)" refers to additional information appended to the report.
"(See appended table)" refers to a table appended to the report.

Throughout this report a ☐ comma / ☒ point is used as the decimal separator.

Manufacturer's Declaration per sub-clause 4.2.5 of IECEE 02:

The application for obtaining a CB Test Certificate includes more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided ..... :	☐ **Yes** ☒ **Not applicable**

When differences exist; they shall be identified in the General product information section.

Name and address of factory (ies) ..... :	Dongguan SOFAR SOLAR Co.,Ltd. 1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City, Guangdong Province,P.R. China.

General product information:

Product covered by this report is hybrid inverter for indoor or outdoor installation. The connection to the DC input and AC output are through connectors.

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 PV 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 can operate in case of one error.

Equipment Under Testing:

– HYD 6000-ES

Variant models:

– HYD 5000-ES
– HYD 4000-ES
– HYD 3600-ES
– HYD 3000-ES

Model Number	HYD 6000-ES	HYD 5000-ES	HYD4000-ES	HYD 3600-ES	HYD 3000-ES
Max. input voltage	600Vd.c.				
Max. input current	2 x 15.0 A_{dc}	2 x 15.0A_{dc}	2 x 15.0 A_{dc}	2 x 15.0 A_{dc}	2 x 15.0 A_{dc}
MPPT voltage range	90-580Vd.c.				
Rated grid voltage	230Va.c.				
Rated grid frequency	50Hz				
Rated output power	6kW	5kW	4kW	3.68kW	3kW
Max output current	27.3A_{ac}	22.8A_{ac}	18.2A_{ac}	16A_{ac}	13.7A_{ac}
Power factor	0.8 leading to 0.8 lagging				
Ambient temperature	-25℃~60℃				
Ingress protection	IP65				
Protective class	Class I				

The variants models have been included in this test report without tests because the following features don´t change regarding to the tested model:

- Same connection system and hardware topology
- Same control algorithm.
- Output power within 2.5 and 2/3 of the rated power output of the EUT.
- Same Firmware Version

IEC 62116			
Clause	Requirement + Test	Result - Remark	Verdict
4	**Testing circuit**		
	The testing circuit shown in Figure 1 is employed.		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.		P
5	**Testing equipment**		
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.	Oscilloscope and Power analyzer equipped with memory function Waveform caught from the switch open and the EUT cease to energize	P
	For multi-phase EUT, all phases are monitored.		P
	A waveform monitor designed to detect and calculate the run-on time may be used.	See Annex IV for testing equipment information	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.		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	Less than 1% of the rated EUT output current	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.		P
5.2	**DC power source**		
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.	Chroma PV simulator used	P
	The DC power source provides voltage and current necessary to meet the testing requirements described in Clause 6.		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.		P
	A PV array simulator is recommended, however, any type of power source may be used if it does not influence the test results.		P
5.2.3	**Current and voltage limited DC power supply with series resistance**		N/A

IEC 62116			
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	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**		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**		
	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: Voltage — Conditions: Nominal ±2,0 % Items: Voltage THD — Conditions: < 2,5 % Items: Frequency — Conditions: Nominal ±0,1 Hz Items: Phase angle distance [1] — Conditions: 120 ° ± 1,5 ° [1] Three-phase case only	AC power source used meets the conditions specified	P
5.4	**AC loads**		

IEC 62116			
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.	Passive loads (variable resistance, capacitance and inductance) have been connected.	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.		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.		P
6	**Test for single or multi-phase inverter**		
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		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

IEC 62116			
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	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**		
	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.	Run-on time is less than 2s in any case	P
7	**Documentation**		
	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

6.1	Table: tested condition and run-on time								P
No.	P_{EUT} (% of EUT rating)	Reactive load (% of normal)	P_{AC}	Q_{AC}	Run-on time(ms)	P_{EUT} (W)	Actual Q_f	V_{DC} (d.c.V)	Which load is selected to be adjusted (R or L)
Test condition A									
1	100	100	0	0	496	5948	0.99	500.2	--
2	100	100	-5	-5	189	5952	1.02	501.8	R/L
3	100	100	-5	0	456	5949	1.04	505.2	R
4	100	100	-5	+5	350	5949	1.07	503.6	R/L
5	100	100	0	-5	219	5948	0.97	503.2	L
6	100	100	0	+5	401	5948	1.02	501.4	L
7	100	100	+5	-5	274	5951	0.93	507.6	R/L
8	100	100	+5	0	367	5954	0.95	510.2	R
9	100	100	+5	+5	256	5946	0.95	509.4	R/L
10	100	100	-10	+10	--	--	--	--	R/L
11	100	100	-5	+10	--	--	--	--	R/L
12	100	100	0	+10	--	--	--	--	L
13	100	100	+10	+10	--	--	--	--	R/L
14	100	100	+10	+5	--	--	--	--	R/L
15	100	100	+10	0	--	--	--	--	R
16	100	100	+10	-5	--	--	--	--	R/L
17	100	100	+10	-10	--	--	--	--	R/L
18	100	100	+5	-10	--	--	--	--	R/L
19	100	100	+5	10	--	--	--	--	R/L
20	100	100	0	-10	--	--	--	--	L
21	100	100	-5	-10	--	--	--	--	R/L
22	100	100	-10	-10	--	--	--	--	R/L
23	100	100	-10	-5	--	--	--	--	R/L
24	100	100	-10	0	--	--	--	--	R/L
25	100	100	-10	+5	--	--	--	--	R/L
Test condition B									
10	66	66	0	0	429	3944	1.02	346.4	--
11	66	66	0	-5	343	3953	0.99	343.8	L
12	66	66	0	-4	490	3956	1.00	344.6	L
13	66	66	0	-3	440	3956	1.00	345.8	L
14	66	66	0	-2	304	3953	1.01	346.1	L
15	66	66	0	-1	304	3958	1.02	345.1	L
16	66	66	0	1	372	3964	1.02	344.7	L
17	66	66	0	2	369	3965	1.03	345.6	L
18	66	66	0	3	352	3963	1.04	346.2	L

IEC 62116			
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19	66	66	0	4	216	3958	1.04	343.8	L
20	66	66	0	5	156	3963	1.04	345.4	L
21	66	66	0	6	--	--	--	--	L
Test condition C									
22	33	33	0	0	352	1984	0.96	158.8	--
23	33	33	0	-6	208	1985	0.94	160.7	L
24	33	33	0	-5	244	1985	0.95	162.6	L
25	33	33	0	-4	232	1986	0.95	162.8	L
26	33	33	0	-3	555	1983	0.95	162.8	L
27	33	33	0	-2	410	1978	0.96	162.8	L
28	33	33	0	-1	419	1976	0.96	163.1	L
29	33	33	0	1	401	1970	0.98	163.3	L
30	33	33	0	2	462	1978	0.99	163.3	L
31	33	33	0	3	349	1975	1.00	163.3	L
32	33	33	0	4	368	1971	1.00	163.3	L

Remark:
For test condition A:
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.
For test condition B and C:
If run-on times are still increasing at the 95 % or 105 % points, additional 1 % increments are taken until run-on times begin decreasing.

--- End of test report---