Section 13.1 G59/3 Generating Unit Type Test Sheet

Type Tested Generating Unit (>16A per phase but ≤ 50 kW 3 phase or 17 kW 1 phase)

G59/3 TYPE TEST VERIFICATION REPORT

This Type Test sheet shall be used to record the results of the type testing of Generating Unit between 16A per phase and 17kW per phase maximum output at 230V (17kW limit single phase, 34kW limit split phase, 50kW limit 3 phase) It includes the **Generating Unit**s supplier declaration of compliance with the requirements of Engineering Recommendation G59/3			
Type Tested reference number		Grid-tied PV inverter	
Generating Unit technology		SOFAR 10000TL; SOFAR 15000TL; SOFAR 17000TL; SOFAR 20000TL.	
System supplier name		Shenzhen SOFARSOLAR Co., Ltd.	
Address		3A-1, Huake Building, East Technology Park, Qiaoxiang Road, Nanshan District, Shenzhen, China.	
Tel	+86-755-26969476	Fax	+86-755-26969476-666
E:mail	info@sofarsolar.com	Web site	www.sofarsolar.com

Maximum export capacity, use separate sheet if more than one connection option.	10	kW three phase
	15	kW three phase
	17	kW three phase
	20	kW three phase

System supplier declaration. - I certify on behalf of the company named above as a supplier of a **Generating Unit**, that all products supplied by the company with the above Type Test reference number will be manufactured and tested to ensure that they perform as stated in this document, prior to shipment to site and that no site modifications are required to ensure that the product meets all the requirements of G59/3.

Signed		On behalf of	Shenzhen SOFARSOLAR Co., Ltd.

Shenzhen SOFARSOLAR CO., LTD. 深圳市首航新能源有限公司

Note that testing can be done by the manufacturer of an individual component, by an external test house, or by the supplier of the complete system, or any combination of them as appropriate.

Where parts of the testing are carried out by persons or organisations other than the supplier then the supplier shall keep copies of all test records and results supplied to them to verify that the testing has been carried out by people with sufficient technical competency to carry out the tests.

Power Quality. Harmonics. These tests should be carried out as specified in 61000-3-12 or 61000-3-2. Only one set of tests is required and the **Manufacturer** should decide which one to use and complete the relevant table. The chosen test should be undertaken with a fixed source of energy at two power levels a) between 45 and 55% and b) at 100% of maximum export capacity.

The test should be carried out on a single **Generating Unit.** The results need to comply with the limits of table 2 of BS EN 61000-3-12 for single phase equipment, to table 3 of BS EN 61000-3-12 for three phase equipment or to table 1 of BS EN 61000-3-2 if that standard is used.

Note that Generating Units meeting the requirements of BS EN 61000-3-2 will need no further assesment with regards to harmonics. Generating Units with emissions close to the limits laid down in BS EN 61000-3-12 may require the installation of a transformer between 2 and 4 times the rating of the **Generating Unit** in order to accept the connection to a **DNO**'s network.

Generating Unit tested to BS EN 61000-3-12						
Model: SOFAR 20000TL						
Generating Unit rating per phase (rpp)		6.67	kVA	Harmonic % =Measured Value (Amps) x 23/rating per phase (kVA)		
Harmonic	At 45-55% of rated output		100% of rated output		Limit in BS EN 61000-3-12	
Average harmonic current results – Phase L1						
	Measured Value MV in Amps	%	Measured Value MV in Amps	%	1 phase	3 phase
2	0.0114	0.0789	0.0385	0.1324	8%	8%
3	0.0769	0.5307	0.0725	0.2496	21.6%	Not stated
4	0.0133	0.0920	0.0162	0.0558	4%	4%
5	0.2062	1.4242	0.2089	0.7191	10.7%	10.7%
6	0.0064	0.0444	0.0113	0.0389	2.67%	2.67%
7	0.1339	0.9245	0.1118	0.3850	7.2%	7.2%
8	0.0055	0.0383	0.0350	0.1204	2%	2%
9	0.0213	0.1473	0.0428	0.1474	3.8%	Not stated
10	0.0058	0.0398	0.0398	0.1371	1.6%	1.6%
11	0.0405	0.2800	0.0509	0.1752	3.1%	3.1%
12	0.0048	0.0330	0.0131	0.0451	1.33%	1.33%

13	0.0365	0.2519	0.0791	0.2724	2%	2%
THD	1.8483%		1.0425%		23%	13%
PWHD	1.1940%		1.9637%		23%	22%
Average harmonic current results – Phase L2						
	Measured Value MV in Amps	%	Measured Value MV in Amps	%	1 phase	3 phase
2	0.0173	0.1199	0.0388	0.1337	8%	8%
3	0.0124	0.0859	0.0205	0.0706	21.6%	Not stated
4	0.0123	0.0853	0.0116	0.0400	4%	4%
5	0.2286	1.5828	0.2176	0.7510	10.7%	10.7%
6	0.0055	0.0384	0.0231	0.0798	2.67%	2.67%
7	0.1359	0.9410	0.1331	0.4591	7.2%	7.2%
8	0.0053	0.0366	0.0104	0.0359	2%	2%
9	0.0079	0.0545	0.0420	0.1450	3.8%	Not stated
10	0.0045	0.0312	0.0121	0.0418	1.6%	1.6%
11	0.0467	0.3231	0.0689	0.2378	3.1%	3.1%
12	0.0034	0.0237	0.0183	0.0633	1.33%	1.33%
13	0.0313	0.2168	0.0639	0.2204	2%	2%
THD	1.9050%		1.0408%		23%	13%
PWHD	1.1078%		1.8097%		23%	22%
Average harmonic current results – Phase L3						
	Measured Value MV in Amps	%	Measured Value MV in Amps	%	1 phase	3 phase
2	0.0168	0.1160	0.0463	0.1596	8%	8%
3	0.0700	0.4843	0.0829	0.2858	21.6%	Not stated
4	0.0159	0.1100	0.0163	0.0563	4%	4%
5	0.2382	1.6491	0.2499	0.8619	10.7%	10.7%
6	0.0090	0.0625	0.0164	0.0567	2.67%	2.67%
7	0.1488	1.0300	0.1274	0.4395	7.2%	7.2%

8	0.0075	0.0518	0.0368	0.1268	2%	2%
9	0.0166	0.1146	0.0097	0.0335	3.8%	Not stated
10	0.0074	0.0509	0.0389	0.1341	1.6%	1.6%
11	0.0460	0.3187	0.0519	0.1789	3.1%	3.1%
12	0.0053	0.0368	0.0085	0.0292	1.33%	1.33%
13	0.0345	0.2389	0.0722	0.2491	2%	2%
THD	2.0744%		1.1632%		23%	13%
PWHD	1.3424%		1.9865%		23%	22%

Generating Unit tested to BS EN 61000-3-2						
Model: SOFAR 10000TL						
Generator Unit rating per phase (rpp)			3.33	kW		
Harmonic	At 45-55% of rated output		100% of rated output			
Average harmonic current results – Phase L1						
	Measured Value MV in Amps	Normalised value(NV)	Measured Value MV in Amps	Normalised value(NV)	Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2	0.0088	0.0098	0.0385	0.0425	1.080	
3	0.0671	0.0741	0.0725	0.0800	2.300	
4	0.0118	0.0130	0.0162	0.0179	0.430	
5	0.1274	0.1406	0.2089	0.2306	1.140	
6	0.0072	0.0080	0.0113	0.0125	0.300	
7	0.0376	0.0415	0.1118	0.1235	0.770	
8	0.0098	0.0108	0.0350	0.0386	0.230	
9	0.0209	0.0231	0.0428	0.0473	0.400	
10	0.0076	0.0084	0.0398	0.0440	0.184	
11	0.0438	0.0484	0.0509	0.0562	0.330	
12	0.0037	0.0041	0.0131	0.0145	0.153	
13	0.0393	0.0434	0.0791	0.0874	0.210	

14	0.0038	0.0041	0.0056	0.0062	0.131	
15	0.0157	0.0174	0.0133	0.0147	0.150	
16	0.0036	0.0040	0.0174	0.0192	0.115	
17	0.0453	0.0501	0.0435	0.0480	0.132	
18	0.0032	0.0035	0.0093	0.0103	0.102	
19	0.0422	0.0466	0.0749	0.0826	0.118	
20	0.0037	0.0041	0.0208	0.0229	0.092	
21	0.0044	0.0048	0.0149	0.0164	0.107	0.160
22	0.0049	0.0054	0.0128	0.0141	0.084	
23	0.0235	0.0259	0.0417	0.0460	0.098	0.147
24	0.0040	0.0045	0.0042	0.0046	0.077	
25	0.0184	0.0204	0.0390	0.0431	0.090	0.135
26	0.0100	0.0110	0.0080	0.0089	0.071	
27	0.0095	0.0105	0.0070	0.0077	0.083	0.124
28	0.0024	0.0027	0.0098	0.0108	0.066	
29	0.0115	0.0127	0.0320	0.0353	0.078	0.117
30	0.0024	0.0027	0.0042	0.0046	0.061	
31	0.0166	0.0183	0.0198	0.0219	0.073	0.109
32	0.0026	0.0028	0.0076	0.0084	0.058	
33	0.0057	0.0063	0.0057	0.0063	0.068	0.102
34	0.0018	0.0020	0.0066	0.0073	0.054	
35	0.0147	0.0162	0.0219	0.0242	0.064	0.096
36	0.0022	0.0025	0.0030	0.0033	0.051	
37	0.0129	0.0143	0.0154	0.0170	0.061	0.091
38	0.0024	0.0027	0.0037	0.0041	0.048	
39	0.0049	0.0054	0.0046	0.0051	0.058	0.087
40	0.0023	0.0025	0.0075	0.0083	0.046	
Average harmonic current results – Phase L2						
	Measured Value MV in	Normalised	Measured Value MV	Normalised	Limit in BS EN	Higher limit for odd

	Amps	value(NV)	in Amps	value(NV)	61000-3-2 in Amps	harmonics 21 and above
2	0.0135	0.0149	0.0388	0.0428	1.080	
3	0.0103	0.0114	0.0205	0.0226	2.300	
4	0.0130	0.0143	0.0116	0.0128	0.430	
5	0.1489	0.1644	0.2176	0.2403	1.140	
6	0.0057	0.0063	0.0231	0.0255	0.300	
7	0.0227	0.0250	0.1331	0.1469	0.770	
8	0.0075	0.0082	0.0104	0.0115	0.230	
9	0.0096	0.0106	0.0420	0.0464	0.400	
10	0.0063	0.0069	0.0121	0.0134	0.184	
11	0.0379	0.0418	0.0689	0.0761	0.330	
12	0.0042	0.0047	0.0183	0.0202	0.153	
13	0.0489	0.0540	0.0639	0.0705	0.210	
14	0.0036	0.0040	0.0045	0.0050	0.131	
15	0.0057	0.0063	0.0105	0.0115	0.150	
16	0.0035	0.0038	0.0089	0.0098	0.115	
17	0.0451	0.0498	0.0513	0.0566	0.132	
18	0.0034	0.0038	0.0165	0.0182	0.102	
19	0.0427	0.0471	0.0542	0.0598	0.118	
20	0.0033	0.0036	0.0091	0.0100	0.092	
21	0.0049	0.0054	0.0140	0.0155	0.107	0.160
22	0.0046	0.0051	0.0047	0.0052	0.084	
23	0.0239	0.0264	0.0420	0.0463	0.098	0.147
24	0.0031	0.0034	0.0037	0.0040	0.077	
25	0.0140	0.0154	0.0339	0.0375	0.090	0.135
26	0.0053	0.0059	0.0066	0.0073	0.071	
27	0.0066	0.0073	0.0093	0.0103	0.083	0.124
28	0.0027	0.0030	0.0043	0.0047	0.066	

29	0.0169	0.0186	0.0333	0.0368	0.078	0.117
30	0.0021	0.0024	0.0092	0.0101	0.061	
31	0.0183	0.0202	0.0235	0.0259	0.073	0.109
32	0.0023	0.0026	0.0049	0.0055	0.058	
33	0.0041	0.0045	0.0074	0.0082	0.068	0.102
34	0.0022	0.0024	0.0031	0.0034	0.054	
35	0.0155	0.0172	0.0226	0.0249	0.064	0.096
36	0.0016	0.0018	0.0027	0.0030	0.051	
37	0.0131	0.0145	0.0177	0.0196	0.061	0.091
38	0.0021	0.0023	0.0027	0.0030	0.048	
39	0.0031	0.0034	0.0057	0.0063	0.058	0.087
40	0.0027	0.0029	0.0038	0.0042	0.046	
Average harmonic current results – Phase L3						
	Measured Value MV in Amps	Normalised value(NV)	Measured Value MV in Amps	Normalised value(NV)	Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2	0.0142	0.0156	0.0463	0.0511	1.080	
3	0.0654	0.0722	0.0829	0.0915	2.300	
4	0.0144	0.0159	0.0163	0.0180	0.430	
5	0.1387	0.1532	0.2499	0.2759	1.140	
6	0.0085	0.0094	0.0164	0.0181	0.300	
7	0.0341	0.0377	0.1274	0.1407	0.770	
8	0.0128	0.0141	0.0368	0.0406	0.230	
9	0.0195	0.0215	0.0097	0.0107	0.400	
10	0.0120	0.0132	0.0389	0.0429	0.184	
11	0.0538	0.0594	0.0519	0.0573	0.330	
12	0.0051	0.0056	0.0085	0.0094	0.153	
13	0.0490	0.0541	0.0722	0.0797	0.210	
14	0.0046	0.0050	0.0055	0.0060	0.131	

15	0.0156	0.0173	0.0108	0.0119	0.150	
16	0.0045	0.0050	0.0217	0.0240	0.115	
17	0.0534	0.0590	0.0372	0.0410	0.132	
18	0.0039	0.0043	0.0092	0.0102	0.102	
19	0.0419	0.0463	0.0698	0.0771	0.118	
20	0.0051	0.0057	0.0215	0.0237	0.092	
21	0.0055	0.0061	0.0090	0.0099	0.107	0.160
22	0.0046	0.0050	0.0120	0.0132	0.084	
23	0.0216	0.0239	0.0428	0.0472	0.098	0.147
24	0.0034	0.0037	0.0037	0.0041	0.077	
25	0.0172	0.0190	0.0419	0.0463	0.090	0.135
26	0.0070	0.0077	0.0115	0.0127	0.071	
27	0.0067	0.0073	0.0076	0.0083	0.083	0.124
28	0.0027	0.0030	0.0112	0.0123	0.066	
29	0.0147	0.0162	0.0362	0.0399	0.078	0.117
30	0.0024	0.0026	0.0066	0.0073	0.061	
31	0.0176	0.0195	0.0263	0.0290	0.073	0.109
32	0.0023	0.0025	0.0072	0.0080	0.058	
33	0.0053	0.0058	0.0073	0.0081	0.068	0.102
34	0.0021	0.0024	0.0053	0.0059	0.054	
35	0.0168	0.0186	0.0200	0.0221	0.064	0.096
36	0.0020	0.0022	0.0043	0.0047	0.051	
37	0.0115	0.0127	0.0166	0.0184	0.061	0.091
38	0.0031	0.0034	0.0049	0.0054	0.048	
39	0.0039	0.0043	0.0063	0.0069	0.058	0.087
40	0.0026	0.0029	0.0086	0.0095	0.046	

Note the higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below.

The tests had been performed on the SOFAR 10000TL and SOFAR 20000TL are valid for the SOFAR 15000TL and SOFAR 17000TL, since it is same as in hardware and just power

derated by software.

Power Quality. Voltage fluctuations and Flicker. The tests should be carried out on a single **Generating Unit.** Results should be normalised to a standard source impedance or if this results in figures above the limits set in BS EN 61000-3-11 to a suitable Maximum Impedance.

		Starting			Stopping			Running	
		d max	d c	d(t)	d max	d c	d(t)	P st	P lt 2 hours
Measured Values at test impedance	L1	0.95%	0.75%	0	0.95%	0.75%	0	0.192	0.132
	L2	1.01%	0.75%	0	1.01%	0.75%	0	0.193	0.134
	L3	0.91%	0.72%	0	0.91%	0.72%	0	0.188	0.130
Normalised to standard impedance	L1	0.95%	0.75%	0	0.95%	0.75%	0	0.192	0.132
	L2	1.01%	0.75%	0	1.01%	0.75%	0	0.193	0.134
	L3	0.91%	0.72%	0	0.91%	0.72%	0	0.188	0.130
Normalised to required maximum impedance	L1	--	--	--	--	--	--	--	--
	L2	--	--	--	--	--	--	--	--
	L3	--	--	--	--	--	--	--	--
Limits set under BS EN 61000-3-11		4%	3.3%	3.3%	4%	3.3%	3.3%	1.0	0.65

Test Impedance	R		Ω	Xl		Ω
Standard Impedance	R	0.24 * 0.4 ^	Ω	Xl	0.15 * 0.25 ^	Ω
Maximum Impedance	R		Ω	Xl		Ω

* Applies to three phase and split single phase **Generating Unit**s

^ Applies to single phase **Generating Unit**s and **Generating Unit**s using two phases on a three phase system

For voltage change and flicker measurements the following formula is to be used to convert the measured values to the normalised values where the power factor of the generation output is 0.98 or above.

Normalised value = Measured value*reference source resistance/measured source resistance at test point

Single phase units reference source resistance is 0.4 Ω

Two phase units in a three phase system reference source resistance is 0.4 Ω

Two phase units in a split phase system reference source resistance is 0.24 Ω

Three phase units reference source resistance is 0.24 Ω

Where the power factor of the output is under 0.98 then the XI to R ratio of the test impedance should be close to that of the Standard Impedance.

The stopping test should be a trip from full load operation.

The duration of these tests need to comply with the particular requirements set out in the testing notes for the technology under test. Dates and location of the test need to be noted below

Power quality. DC injection. The tests should be carried out on a single **Generating Unit** Tests are to be carried out three power defined levels ±5%. At 230V a 2kW single phase inverter has a current output of 8.7A so DC limit is 21.75mA, a 10kW three phase inverter has a current output of 43.5A at 230V so DC limit is 108.75mA

Test power level		10%	55%	100%
Recorded value in Amps	L1	0.0132	0.0093	0.0093
	L2	0.0035	0.0096	0.0106
	L3	0.0076	0.0168	0.0179
as % of rated AC current	L1	0.046	0.032	0.032
	L2	0.012	0.033	0.037
	L3	0.026	0.058	0.062
Limit		0.25%	0.25%	0.25%

Power Quality. Power factor. The tests should be carried out on a single Generating Unit. Testa are to be carried out at three voltage levels and at full output. Voltage to be maintained within + or – 1.5% of the stated level during the test.

	216.2V	230V	253V	Measured at three voltage levels and at full output. Voltage to be maintained within + or – 1.5% of the stated level during the test.
Measured value	0.9998	0.9998	0.9999	
Limit	>0.95	>0.95	>0.95	

Protection. Frequency tests						
Function	Setting		Trip test		“No-trip tests”	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
O/F stage 1	51.5Hz	90s	51.49Hz	90.054s	51.3Hz 95s	No trip
O/F stage 2	52Hz	0.5s	51.99Hz	0.56s	51.8Hz 89.98s	No trip
					52.2Hz 0.48s	No trip
U/F stage 1	47.5Hz	20s	47.5Hz	20.10s	47.7Hz 25s	No trip
U/F stage 2	47Hz	0.5s	47.0Hz	0.52s	47.2Hz 19.98s	No trip
					46.8 Hz 0.48s	No trip
Note. For frequency Trip tests the Frequency required to trip is the setting ± 0.1Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No-trip tests” need to be carried out at the setting ± 0.2Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

Protection. Voltage tests						
Function	Setting		Trip test		“No trip-tests” All phases at same voltage	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
O/V stage 1	262.2V	1.0s	261.5	1.015	258.2V 2.0 sec	No trip
O/V stage 2	273.7V	0.5s	274.0	0.528	269.7V 0.98s	No trip
					277.7V 0.48s	No trip

U/V stage 1	200.1V	2.5s	199.9	2.510	204.1V 3.5s	No trip
U/V stage 2	184V	0.5s	183.5	0.522	188V 2.48s	No trip
					180v 0.48 sec	No trip
Note. For voltage tests the voltage required to trip is the setting plus or minus 3.45V. The time delay can be measured at a larger deviation than the minimum required to operate the projection. The No-trip tests need to be carried out at the setting ±4V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

Protection. Loss of Mains test						
BS EN 62116						
SOFAR 20000TL						
Test Power and imbalance	33% -5% Q Test 22	66% -5% Q Test 12	100% -5% P Test 5	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
Trip time. Limit is 0.5s	108ms	190ms	137ms	104ms	273ms	154ms
SOFAR 10000TL						
Test Power and imbalance	33% -5% Q Test 22	66% -5% Q Test 12	100% -5% P Test 5	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
Trip time. Limit is 0.5s	156ms	220ms	158ms	226ms	191ms	179ms

Protection. Frequency change, Stability test				
	Start Frequency	Change	End Frequency	Confirm no trip
Positive Vector Shift	49.5Hz	+9 degrees	--	No trip
Negative Vector Shift	50.5Hz	- 9 degrees	--	No trip

Positive Frequency drift	49.5Hz	+0.19Hzs^{-1}	51.5Hz	No trip
Negative Frequency drift	50.5Hz	-0.19Hzs^{-1}	47.5Hz	No trip

Protection. Re-connection timer. The tests should prove that the reconnection sequence starts in no less than 20s for restoration of voltage and frequency to within the stage 1 settings of table 10.5.7.1					
Test should prove that the reconnection sequence starts in no less than 20s for restoration of voltage and frequency to within the stage 1 settings of table 10.5.7.1					
Time delay setting (s)	Measured delay (s)	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 10.5.7.1.			
20	34	At 266.2V	At 196.1V	At 47.4Hz	At 51.6Hz
Confirmation that the **Generating Unit** does not re-connect		not re-connect	not re-connect	not re-connect	not re-connect

Fault level contribution.					
For machines with electro-magnetic output			For Inverter output		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p	--	20ms	31.5V	L1:42.5A peak L2: 43.5A peak L3: 42.0A peak
Initial Value of aperiodic current	A	--	100ms	30.9V	L1: 43.0A peak L2: 43.0A peak L3: 42.5A peak
Initial symmetrical short-circuit current*	I_k	--	250ms	23.0V	L1: 43.5A peak L2: 42.5A peak L3: 43.0A peak

Decaying (aperiodic) component of short circuit current*	i_{DC}	--	500ms	23.0V	L1: 0 L2: 0 L3: 0
Reactance/Resistance Ratio of source*	$^{X}/_{R}$	--	Time to trip	0.28s	In seconds
For rotating machines and linear piston machines the test should produce a 0s – 2s plot of the short circuit current as seen at the **Generating Unit** terminals. * Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot					

Self Monitoring solid state switching	Yes/NA
It has been verified that in the event of the solid state switching device failing to disconnect the **Generating Unit**, the voltage on the output side of the switching device is reduced to a value below 50 Volts within 0.5 seconds	N/A

Additional comments
SOFAR 10000TL, SOFAR 15000TL, SOFAR 17000TL is similar to SOFAR 20000TL in circuit and construction except for output rating of current and power. The test result can refer to SOFAR 20000TL