G98: Type Test Verification Report

All Micro-generators connected to the **DNO Distribution Network** shall be **Fully Type Tested**. This form is the **Manufacturer**'s declaration of compliance with the requirements of G98.

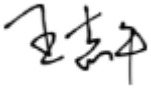
This form should be used when making a Type Test submission to the Energy Networks Association (ENA).

If the **Micro-generator** is **Fully Type Tested** and already registered with the ENA **Type Test Verification Report** Register, the **Installation Document** should include the **Manufacturer**'s Reference Number (the Product ID), and this form does not need to be submitted.

Where the **Micro-generator** is **Fully Type Tested** and not registered with the ENA **Type Test Verification Report** Register this form needs to be completed and provided to the **DNO**, to confirm that the **Micro-generator** has been tested to satisfy the requirements of this EREC G98.

Manufacturer's reference number		201908001	
Micro-generator technology		Energy Storage Device	
Manufacturer name		Alpha ESS Co., Ltd.	
Address	Jiu Hua Road 888, Nantong High-Tech Industrial Development Zone, Nantong City, 226300		
Tel	+86 0512 6828 0679	Fax	+86 0512 6828 0679
E-mail	Jester.li@alpha-ess.com	Web site	http://www.alpha-ess.com
Type	Three phase hybrid inverter	Registered Capacity	10kW

Manufacturer Type Test declaration. - I certify that all products supplied by the company with the above **Fully Type Tested** 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 EREC G98.

Signed	 Li zhijie	On behalf of	 Wang zhiping

Test start date	15 Aug, 2019	Test end date	28 Aug, 2019
Test location	Jiu Hua Road 888, Nantong High-Tech Industrial Development Zone, Nantong, 226300		

Note that testing can be done by the **Manufacturer** of an individual component or by an external test house.

Where parts of the testing are carried out by persons or organisations other than the **Manufacturer** then that person or organisation 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.

Operating Range: This test should be carried out as specified in EN 50438 D.3.1. **Active Power** shall be recorded every second. The tests will verify that the **Micro-generator** can operate within the required ranges for the specified period of time. The **Interface Protection** shall be disabled during the tests. In case of a PV **Micro-generator** the PV primary source may be replaced by a **DC** source. In case of a full converter **Micro-generator** (eg wind) the primary source and the prime mover **Inverter**/rectifier may be replaced by a **DC** source. In case of a DFIG **Micro-generator** the mechanical drive system may be replaced by a test bench motor.

Test 1 Voltage = 85% of nominal (195.5 V) Frequency = 47.5 Hz Power factor = 1 Period of test 90 minutes	Result Pass
Test 2 Voltage = 110% of nominal (253 V). Frequency = 51.5 Hz Power factor = 1 Period of test 90 minutes	Result Pass
Test 3 Voltage = 110% of nominal (253 V). Frequency = 52.0 Hz Power factor = 1 Period of test 15 minutes	Result Pass

Power Quality – Harmonics: These tests should be carried out as specified in BS EN 61000-3-2. 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 **Registered Capacity**. The test requirements are specified in Annex A1 A.1.3.1 (**Inverter** connected) or Annex A2 A.2.3.1 (Synchronous).

Micro-generator tested to BS EN 61000-3-2						
Micro-generator rating per phase (rpp)			10	kW	NV=MV*3.68/rpp	
Harmonic	At 45-55% of **Registered Capacity**		100% of **Registered Capacity**			
	Measured Value MV in Amps	Normalised Value (NV) in Amps	Measured Value MV in Amps	Normalised Value (NV) in Amps	Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
L1						

2	0.0433	0.17%	0.1333	0.53%	1.080	
3	0.0254	0.10%	0.0344	0.14%	2.300	
4	0.0174	0.07%	0.0735	0.29%	0.430	
5	0.0891	0.35%	0.0987	0.39%	1.140	
6	0.0047	0.02%	0.0071	0.03%	0.300	
7	0.091	0.36%	0.0835	0.33%	0.770	
8	0.0107	0.04%	0.0295	0.12%	0.230	
9	0.0047	0.02%	0.0034	0.01%	0.400	
10	0.0063	0.03%	0.0103	0.04%	0.184	
11	0.0691	0.28%	0.0719	0.29%	0.330	
12	0.0039	0.02%	0.0042	0.02%	0.153	
13	0.0703	0.28%	0.0684	0.27%	0.210	
14	0.0042	0.02%	0.0076	0.03%	0.131	
15	0.0043	0.02%	0.0036	0.01%	0.150	
16	0.0044	0.02%	0.0065	0.03%	0.115	
17	0.0333	0.13%	0.00418	0.02%	0.132	
18	0.0026	0.01%	0.0029	0.01%	0.102	
19	0.0407	0.16%	0.0606	0.24%	0.118	
20	0.0031	0.01%	0.0051	0.02%	0.092	
21	0.0027	0.01%	0.0031	0.01%	0.107	0.160
22	0.0044	0.02%	0.0039	0.02%	0.084	
23	0.0234	0.09%	0.0385	0.15%	0.098	0.147
24	0.0047	0.02%	0.0043	0.02%	0.077	
25	0.0152	0.06%	0.0312	0.12%	0.090	0.135
26	0.004	0.02%	0.0044	0.02%	0.071	
27	0.0019	0.01%	0.0026	0.01%	0.083	0.124
28	0.0046	0.02%	0.0059	0.02%	0.066	
29	0.0104	0.04%	0.0147	0.06%	0.078	0.117

30	0.0033	0.01%	0.0028	0.01%	0.061	
31	0.0227	0.09%	0.0317	0.13%	0.073	0.109
32	0.0042	0.02%	0.0051	0.02%	0.058	
33	0.0019	0.01%	0.0024	0.01%	0.068	0.102
34	0.0046	0.02%	0.0074	0.03%	0.054	
35	0.0223	0.09%	0.0215	0.09%	0.064	0.096
36	0.004	0.02%	0.0028	0.01%	0.051	
37	0.0331	0.13%	0.0038	0.02%	0.061	0.091
38	0.0047	0.02%	0.007	0.03%	0.048	
39	0.0033	0.01%	0.0027	0.01%	0.058	0.087
40	0.0029	0.01%	0.0105	0.04%	0.046	
L2						
2	0.0266	0.11%	0.1322	0.53%	1.080	
3	0.0374	0.15%	0.0548	0.22%	2.300	
4	0.0133	0.05%	0.0589	0.23%	0.430	
5	0.0909	0.36%	0.1004	0.40%	1.140	
6	0.0131	0.05%	0.0185	0.07%	0.300	
7	0.0836	0.33%	0.0801	0.32%	0.770	
8	0.02	0.08%	0.0372	0.15%	0.230	
9	0.012	0.05%	0.0114	0.05%	0.400	
10	0.0126	0.05%	0.0171	0.07%	0.184	
11	0.0701	0.28%	0.0714	0.28%	0.330	
12	0.0096	0.04%	0.01	0.04%	0.153	
13	0.0652	0.26%	0.0649	0.26%	0.210	
14	0.0078	0.03%	0.0085	0.03%	0.131	
15	0.0105	0.04%	0.0085	0.03%	0.150	
16	0.0056	0.02%	0.0065	0.03%	0.115	
17	0.0399	0.16%	0.0476	0.19%	0.132	

18	0.0037	0.01%	0.0041	0.02%	0.102	
19	0.0381	0.15%	0.0557	0.22%	0.118	
20	0.0031	0.01%	0.0043	0.02%	0.092	
21	0.0036	0.01%	0.0055	0.02%	0.107	0.160
22	0.0043	0.02%	0.0052	0.02%	0.084	
23	0.0242	0.10%	0.0384	0.15%	0.098	0.147
24	0.0069	0.03%	0.0087	0.03%	0.077	
25	0.0171	0.07%	0.0264	0.11%	0.090	0.135
26	0.0053	0.02%	0.006	0.02%	0.071	
27	0.0034	0.01%	0.0071	0.03%	0.083	0.124
28	0.006	0.02%	0.0055	0.02%	0.066	
29	0.0107	0.04%	0.0179	0.07%	0.078	0.117
30	0.0033	0.01%	0.0042	0.02%	0.061	
31	0.0224	0.09%	0.0284	0.11%	0.073	0.109
32	0.006	0.02%	0.0052	0.02%	0.058	
33	0.0036	0.01%	0.0036	0.01%	0.068	0.102
34	0.0065	0.03%	0.0045	0.02%	0.054	
35	0.0208	0.08%	0.0224	0.09%	0.064	0.096
36	0.0037	0.01%	0.006	0.02%	0.051	
37	0.0333	0.13%	0.0028	0.01%	0.061	0.091
38	0.004	0.02%	0.0053	0.02%	0.048	
39	0.0028	0.01%	0.0059	0.02%	0.058	0.087
40	0.0029	0.01%	0.0076	0.03%	0.046	
L3						
2	0.0268	0.11%	0.1322	0.53%	1.080	
3	0.0377	0.15%	0.0551	0.22%	2.300	
4	0.0133	0.05%	0.0593	0.24%	0.430	
5	0.0913	0.36%	0.1013	0.40%	1.140	

6	0.0133	0.05%	0.0188	0.07%	0.300	
7	0.0846	0.34%	0.0807	0.32%	0.770	
8	0.02	0.08%	0.0374	0.15%	0.230	
9	0.0121	0.05%	0.0117	0.05%	0.400	
10	0.0127	0.05%	0.0174	0.07%	0.184	
11	0.0708	0.28%	0.0719	0.29%	0.330	
12	0.0096	0.04%	0.01	0.04%	0.153	
13	0.0658	0.26%	0.0652	0.26%	0.210	
14	0.0078	0.03%	0.0085	0.03%	0.131	
15	0.0105	0.04%	0.0085	0.03%	0.150	
16	0.0056	0.02%	0.0065	0.03%	0.115	
17	0.0401	0.16%	0.0476	0.19%	0.132	
18	0.0037	0.01%	0.0041	0.02%	0.102	
19	0.0384	0.15%	0.0561	0.22%	0.118	
20	0.0031	0.01%	0.0043	0.02%	0.092	
21	0.0036	0.01%	0.0055	0.02%	0.107	0.160
22	0.0043	0.02%	0.0052	0.02%	0.084	
23	0.0246	0.10%	0.0387	0.15%	0.098	0.147
24	0.0069	0.03%	0.0087	0.03%	0.077	
25	0.017	0.07%	0.0259	0.10%	0.090	0.135
26	0.0053	0.02%	0.006	0.02%	0.071	
27	0.0034	0.01%	0.0071	0.03%	0.083	0.124
28	0.006	0.02%	0.0055	0.02%	0.066	
29	0.0107	0.04%	0.0179	0.07%	0.078	0.117
30	0.0033	0.01%	0.0042	0.02%	0.061	
31	0.0227	0.09%	0.0288	0.11%	0.073	0.109
32	0.006	0.02%	0.0052	0.02%	0.058	
33	0.0036	0.01%	0.0036	0.01%	0.068	0.102

34	0.0065	0.03%	0.0045	0.02%	0.054	
35	0.0203	0.08%	0.0221	0.09%	0.064	0.096
36	0.0037	0.01%	0.006	0.02%	0.051	
37	0.0333	0.13%	0.0028	0.01%	0.061	0.091
38	0.004	0.02%	0.0053	0.02%	0.048	
39	0.0028	0.01%	0.0059	0.02%	0.058	0.087
40	0.0029	0.01%	0.0076	0.03%	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.

Power Quality – Voltage fluctuations and Flicker: These tests should be undertaken in accordance with EREC G98 Annex A1 A.1.3.3 (**Inverter** connected) or Annex A2 A.2.3.3 (Synchronous).	**Pass**

	Starting			Stopping			Running	
	d max	**d c**	**d(t)**	**d max**	**d c**	**d(t)**	**P_{st}**	**P_{lt} 2 hours**
L1								
Measured Values at test impedance	0.38	0.17	0	0.36	0.16	0	0.21	0.21
Normalised to standard impedance	0.4203	0.1875	0	0.3956	0.1757	0	0.2315	0.2315
Limits set under BS EN 61000-3-11	4%	3.3%	3.3%	4%	3.3%	3.3%	1.0	0.65
L2								
Measured Values at test impedance	0.52	0.10	0	0.65	0.09	0	0.2	0.2
Normalised to standard impedance	0.5746	0.1105	0	0.7183	0.0994	0	0.2210	0.2210
Limits set under BS EN 61000-3-11	4%	3.3%	3.3%	4%	3.3%	3.3%	1.0	0.65
L3								

Measured Values at test impedance	0.49	0.15	0	0.34	0.07	0	0.13	0.13
Normalised to standard impedance	0.5308	0.1651	0	0.3754	0.0659	0	0.1420	0.1420
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	0.23	Ω	Xl	0.14	Ω
Standard Impedance	R	0.24	Ω	Xl	0.15	Ω
Max. Impedance	R	N/A	Ω	Xl	N/A	Ω

*Applies to three phase and split single phase **Micro-generators**.

^ Applies to single phase **Micro-generators** and **Micro-generators** 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 X 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 conform to 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.

Test start date	20190805	Test end date	20190812
Test location	Jiu Hua Road 888, Nantong High-Tech Industrial Development Zone, Nantong City, 226300		

Power quality – DC injection: This test should be carried out in accordance with EN 50438 Annex D.3.10				**Pass**
Test power level	20%	50%	75%	100%
L1				
Recorded value in Amps	0.0059A	0.015A	0.017A	0.013A
as % of rated AC current	0.04%	0.10%	0.11%	0.08%

L2				
Recorded value in Amps	0.0091A	0.018A	0.023A	0.029A
as % of rated AC current	0.06%	0.13%	0.15%	0.19%
L3				
Recorded value in Amps	0.0097A	0.028A	0.023A	0.029A
as % of rated AC current	0.07%	0.19%	0.16%	0.20%
Limit	0.25%	0.25%	0.25%	0.25%

Power Quality – Power factor			**Pass**
This test shall be carried out in accordance with EN 50538 Annex D.3.4.1 but with nominal voltage -6% and +10%. Voltage to be maintained within ±1.5% of the stated level during the test.			
	216.2 V	230 V	253 V
20% of **Registered Capacity**	0.9651	0.9555	0.9537
50% of **Registered Capacity**	0.9955	0.9951	0.9917
75% of **Registered Capacity**	0.9987	0.9976	0.9971
100% of **Registered Capacity**	0.9994	0.9987	0.9984
Limit	>0.95	>0.95	>0.95

Protection – Frequency tests:						**Pass**
These tests should be carried out in accordance with EN 50438 Annex D.2.4 and the notes in EREC G98 Annex A1 A.1.2.3 (**Inverter** connected) or Annex A2 A.2.2.3 (Synchronous)						
Function	Setting		Trip test		"No trip tests"	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5 Hz	20 s	47.5 Hz	20.014s	47.7 Hz/30 s	No
U/F stage 2	47 Hz	0.5 s	47 Hz	0.527s	47.2 Hz/19.5 s	No
					46.8 Hz /0.45 s	No
O/F stage 1	52 Hz	0.5 s	52..01 Hz	0.527s	51.8 Hz /120.0 s	No
					52.2 Hz/0.45 s	No

Note. For frequency trip tests the frequency required to trip is the setting ± 0.1 Hz. 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 ± 0.2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

Protection – Voltage tests: These tests should be carried out in accordance with EN 50438 Annex D.2.3 and the notes in EREC G98 Annex A1 A.1.2.2 (**Inverter** connected) or Annex A2 A.2.2.2 (Synchronous)						**Pass**
Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V	184 V	2.5 s	184.1V	2.48s	188 V/5.0 s	No
					180 V/2.45 s	No
O/V stage 1	262.2 V	1.0 s	261.9V	1.020s	258.2 V/5.0 s	No
O/V stage 2	273.7 V	0.5 s	273.4V	0.525s	269.7 V/0.95 s	No
					277.7 V/0.45 s	No
Note for Voltage tests the Voltage required to trip is the setting ±3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±4 V 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:

For PV **Inverters** shall be tested in accordance with BS EN 62116. Other **Inverters** should be tested in accordance with EN 50438 Annex D.2.5 at 10%, 55% and 100% of rated power.

For Inverters tested to BS EN 62116 the following sub set of tests should be recorded in the following table.

Test Power	33%	66%	100%	33%	66%	100%
Balancing load on islanded network	- 5% Q Test 22	- 5% Q Test 12	- 5% P Test 5	+5% Q Test 31	+5% Q Test 21	+5% P Test 10
Trip time. Limit is 0.5 s	NA	NA	NA	NA	NA	NA

For other **Inverters** should be tested in accordance with EN 50438 Annex D.2.5 at 10%, 55% and 100% of rated power.

The following sub set of tests should be recorded in the following table.

For Multi-phase **Micro-generators** confirm that the device shuts down correctly after the removal of a single fuse as well as operation of all phases.

To be carried out at three output power levels with a tolerance of plus or minus 5% in Test Power levels.

Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of **Registered Capacity**	95% of **Registered Capacity**	95% of **Registered Capacity**	105% of **Registered Capacity**	105% of **Registered Capacity**	105% of **Registered Capacity**
Trip time. Ph1	234ms	299ms	221ms	225ms	278ms	196ms
Trip time. Ph2	241ms	327ms	255ms	209ms	209ms	209ms
Trip time. Ph3	222ms	384ms	278ms	215ms	274ms	318ms
Note for technologies which have a substantial shut down time this can be added to the 0.5 s in establishing that the trip occurred in less than 0.5 s. Maximum shut down time could therefore be up to 1.0 s for these technologies.						
Indicate additional shut down time included in above results.						400 ms

Protection – Frequency change, Vector Shift Stability test: This test should be carried out in accordance with EREC G98 Annex A1 A.1.2.6 (**Inverter** connected) or Annex A2 A.2.2.6 (Synchronous).			**Pass**
	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.0 Hz	+50 degrees	No trip
Negative Vector Shift	50.0 Hz	- 50 degrees	No trip
Protection – Frequency change, RoCoF Stability test: The requirement is specified in section 11.3, test procedure in Annex A.1.2.6 (**Inverter** connected) or Annex A2 A.2.2.6 (Synchronous).			
Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0 Hz to 51.0 Hz	+0.95 Hzs^{-1}	2.1 s	No trip
51.0 Hz to 49.0 Hz	-0.95 Hzs^{-1}	2.1 s	No trip

Limited Frequency Sensitive Mode – Overfrequency test: This test should be carried out in accordance with EN 50438 Annex D.3.3 Power response to over- frequency. The test should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10%.				**Pass**
Test sequence at **Registered Capacity** >80%	Measured **Active Power** Output	Frequency	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	10071.52	50	10409.01	-
Step b) 50.45 Hz ±0.05 Hz	10000.59	50.45	10342.83	14.19%
Step c) 50.70 Hz ±0.10 Hz	9496.44	50.7	9812.56	19.17%
Step d) 51.15 Hz ±0.05 Hz	8564.74	51.15	8839.85	20.09%

Step e) 50.70 Hz ±0.10 Hz	9492.5	50.7	9809.93	19.30%
Step f) 50.45 Hz ±0.05 Hz	10001.4	50.45	10347.78	14.02%
Step g) 50.00 Hz ±0.01 Hz	10065.99	50	10410.47	
Test sequence at **Registered Capacity** 40% - 60%	Measured **Active Power** Output	Frequency	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	5058.15	50	5215.54	-
Step b) 50.45 Hz ±0.05 Hz	5021.78	50.45	5169.82	7.27%
Step c) 50.70 Hz ±0.10 Hz	4484.91	50.7	4627.96	19.11%
Step d) 51.15 Hz ±0.05 Hz	3550.88	51.15	3668.35	20.10%
Step e) 50.70 Hz ±0.10 Hz	4484.37	50.7	4627.65	19.13%
Step f) 50.45 Hz ±0.05 Hz	5003.21	50.45	5163.68	10.99%
Step g) 50.00 Hz ±0.01 Hz	5058.79	50	5217.64	
Steps as defined in EN 50438				

Power output with falling frequency test: This test should be carried out in accordance with EN 50438 Annex D.3.2 active power feed-in at under-frequency.			
Test sequence	Measured **Active Power** Output	Frequency	Primary power source
Test a) 50 Hz ± 0.01 Hz	10247	50Hz	10550
Test b) Point between 49.5 Hz and 49.6 Hz	10248	49.55Hz	10553
Test c) Point between 47.5 Hz and 47.6 Hz	10245	47.55Hz	10552
NOTE: The operating point in Test (b) and (c) shall be maintained for at least 5 minutes			

Re-connection timer.				**Pass**
Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 2.				
Time delay setting	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 2.			
Measured delay time(s)	At 258.2V	At 204.1V	At 47.6Hz	At 51.9Hz
	91.05s	91.17s	91.09s	91.11s

Confirmation that the **Micro-generator** does not re-connect.	At 266.2 V	At 180.0 V	At 47.4 Hz	At 52.1 Hz
	No	No	No	No

Fault level contribution: These tests shall be carried out in accordance with EREC G98 Annex A1 A.1.3.5 (**Inverter** connected) and Annex A2 A.2.3.4 (Synchronous).		**Pass**
For **Inverter** output		
L-L		
Time after fault	Volts	Amps
20 ms	10.79V	0A
100 ms	- 13.31V	0A
250 ms	- 13.31V	- 334.7mA
500 ms	- 13.31V	- 669.5mA
Time to trip	9.375ms	
L-N		
20 ms	- 214.15V	- 15.06A
100 ms	- 331.30V	- 26.78A
250 ms	- 20.01V	0A
500 ms	- 13.31V	0A
Time to trip	122.4ms	
Logic Interface.		Yes
Self-Monitoring solid state switching: No specified test requirements. Refer to EREC G98 Annex A1 A.1.3.6 (**Inverter** connected).		N/A
It has been verified that in the event of the solid state switching device failing to disconnect the **Micro-generator**, the voltage on the output side of the switching device is reduced to a value below 50 V within 0.5 s.		
Additional comments		