

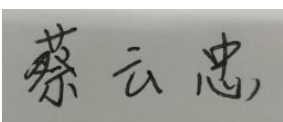
Form C: Type Test Verification Report

Type Approval and **Manufacturer** 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 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		Growatt SPH3600 2020	
Micro-generator technology		Growatt SPH3000 , Growatt SPH3600	
Manufacturer name		Growatt New Energy Technology Co., Ltd.	
Address		1st East & 3rd Floor of Building A,Building B, Jiayu Industrial Park, #28, GuangHui Road, LongTeng Community, Shiyuan Street, Baoan District, Shenzhen, P.R.China	
Tel	+86 755 2951 5888	Fax	+86 755 2747 2131
E-mail	Yunzhong.cai@growatt.com	Web site	www.ginverter.com
Registered Capacity , use separate sheet if more than one connection option.	Connection Option		
	3~3.6	kW single phase, single, split or three phase system	
	N/A	kW three phase	
	N/A	kW two phases in three phase system	
	N/A	kW two phases split phase system	
Manufacturer Type Test declaration. - I certify that all products supplied by the company with the above 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		On behalf of	Growatt New Energy Technology Co., Ltd.

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.

1. 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.

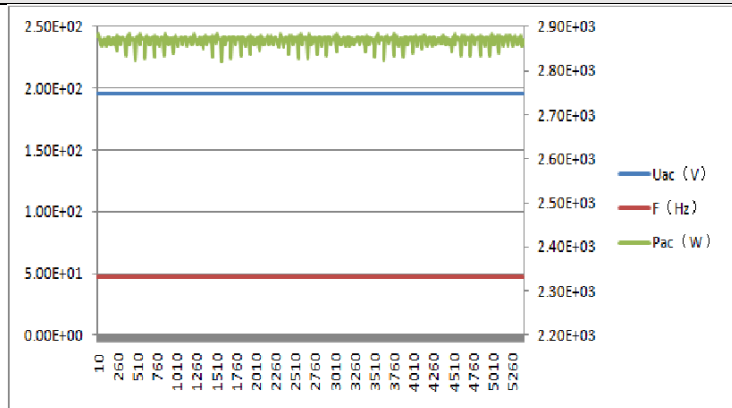
The **Interface Protection** shall be disabled during the tests.

In case of a PV **Micro-generator** the PV primary source may be replaced by a **DC** source.

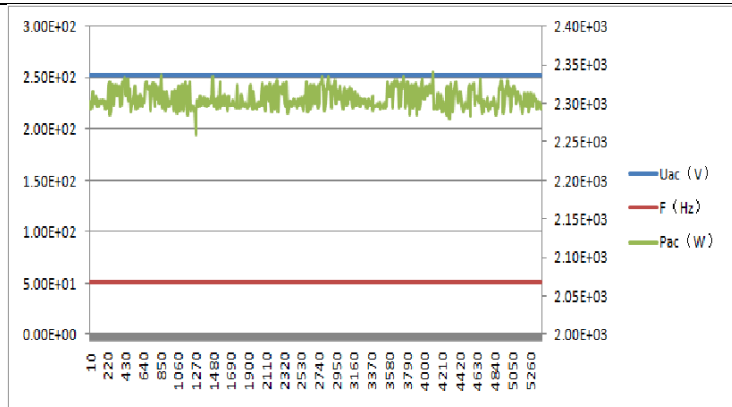
In case of a full converter **Micro-generator** (eg wind) the primary source and the prime mover **Inverter/rectifier** may be replaced by a **DC** source.

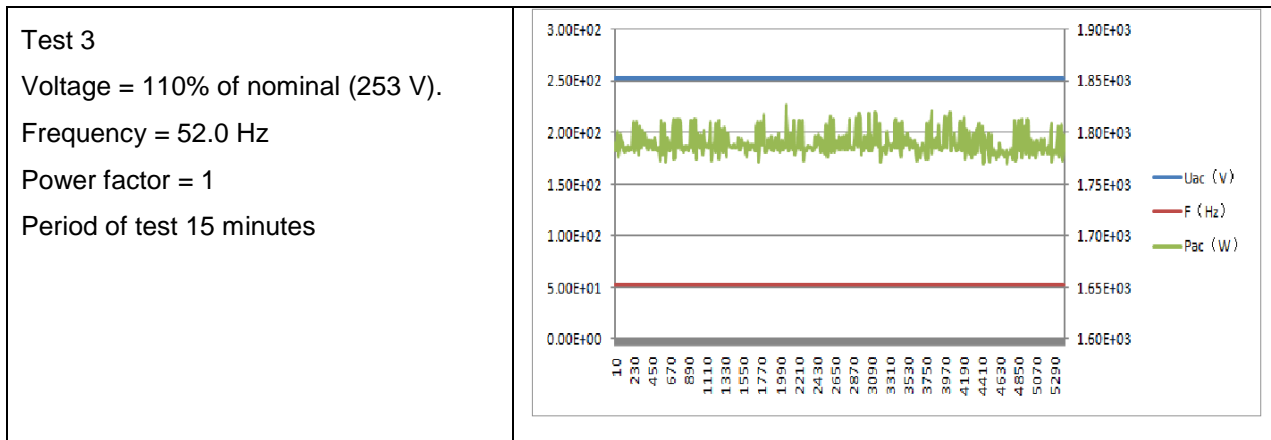
In case of a DFIG **Micro-generator** the mechanical drive system may be replaced by a test bench motor.

Test 1
 Voltage = 85% of nominal (195.5 V)
 Frequency = 47.5 Hz
 Power factor = 1
 Period of test 90 minutes



Test 2
 Voltage = 110% of nominal (253 V).
 Frequency = 51.5 Hz
 Power factor = 1
 Period of test 90 minutes





2.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)			3.6	kW			
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	
2	0.039	0.50	0.033	0.42	1.080		
3	0.046	0.59	0.110	1.41	2.300		
4	0.120	1.53	0.091	1.16	0.430		
5	0.062	0.79	0.162	2.07	1.140		
6	0.032	0.41	0.047	0.60	0.300		
7	0.084	1.07	0.163	2.08	0.770		
8	0.021	0.27	0.025	0.32	0.230		
9	0.025	0.32	0.043	0.55	0.400		
10	0.038	0.49	0.033	0.42	0.184		
11	0.019	0.24	0.043	0.55	0.330		

12	0.012	0.15	0.014	0.18	0.153	
13	0.027	0.35	0.048	0.61	0.210	
14	0.012	0.15	0.013	0.17	0.131	
15	0.019	0.24	0.026	0.33	0.150	
16	0.009	0.12	0.017	0.22	0.115	
17	0.015	0.19	0.029	0.37	0.132	
18	0.012	0.15	0.010	0.13	0.102	
19	0.010	0.13	0.007	0.09	0.118	
20	0.009	0.12	0.008	0.10	0.092	
21	0.006	0.08	0.007	0.09	0.107	0.160
22	0.008	0.10	0.008	0.10	0.084	
23	0.007	0.09	0.009	0.12	0.098	0.147
24	0.005	0.06	0.010	0.13	0.077	
25	0.006	0.08	0.011	0.14	0.090	0.135
26	0.004	0.05	0.010	0.13	0.071	
27	0.005	0.06	0.006	0.08	0.083	0.124
28	0.005	0.06	0.009	0.12	0.066	
29	0.004	0.05	0.004	0.05	0.078	0.117
30	0.007	0.09	0.004	0.05	0.061	
31	0.003	0.04	0.009	0.12	0.073	0.109
32	0.004	0.05	0.005	0.06	0.058	
33	0.008	0.10	0.012	0.15	0.068	0.102
34	0.003	0.04	0.006	0.08	0.054	
35	0.005	0.06	0.003	0.04	0.064	0.096
36	0.003	0.04	0.003	0.04	0.051	
37	0.003	0.04	0.004	0.05	0.061	0.091
38	0.003	0.04	0.003	0.04	0.048	

39	0.003	0.04	0.002	0.03	0.058	0.087
40	0.003	0.04	0.002	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.

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3.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).

	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	0.96	0.15	0	1.07	0.16	0	0.19	0.2
Normalised to standard impedance	0.96	0.15	0	1.07	0.16	0	0.19	0.2
Normalised to required maximum impedance	-	-	-	-	-	-	-	-
Limits set under BS EN 61000-	4%	3.3%	3.3%	4%	3.3%	3.3%	1.0	0.65

3-11						
Test Impedance	R	0.4	Ω	X	0.25	Ω
Standard Impedance	R	0.4	Ω	X	0.25	Ω
Maximum Impedance	R	-	Ω	X	-	Ω
<p>Applies to three phase and split single phase Micro-generators.</p> <p>^ Applies to single phase Micro-generators and Micro-generators using two phases on a three phase system.</p> <p>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.</p> <p>Normalised value = Measured value*reference source resistance/measured source resistance at test point.</p> <p>Single phase units reference source resistance is 0.4 Ω</p> <p>Two phase units in a three phase system reference source resistance is 0.4 Ω.</p> <p>Two phase units in a split phase system reference source resistance is 0.24 Ω.</p> <p>Three phase units reference source resistance is 0.24 Ω.</p> <p>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.</p> <p>The stopping test should be a trip from full load operation.</p> <p>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.</p>						
Test start date	18. June.2020		Test end date	21. June.2020		
Test location	Growatt R&D Test Lab					
4.Power quality – DC injection: This test should be carried out in accordance with EN 50438 Annex D.3.10						
Test power level (3.6K)	20%	50%	75%	100%		
Recorded value in Amps	0.026	0.020	0.024	0.025		

as % of rated AC current	0.16%	0.14%	0.16%	0.16%		
Limit	0.25%	0.25%	0.25%	0.25%		
Test power level (3K)	20%	50%	75%	100%		
Recorded value in Amps	0.024	0.025	0.023	0.024		
as % of rated AC current	0.18%	0.18%	0.17%	0.18%		
Limit	0.25%	0.25%	0.25%	0.25%		
5.Power Quality – Power factor: This test shall be carried out in accordance with EN 50548 Annex D.3.4.1 but with nominal voltage -6% and +10%. Voltage to be maintained within $\pm 1.5\%$ of the stated level during the test.						
	216.2 V	230 V	253 V			
20% of Registered Capacity	0.996	0.997	0.996			
50% of Registered Capacity	0.999	0.999	0.998			
75% of Registered Capacity	0.998	0.999	0.998			
100% of Registered Capacity	0.998	0.999	0.998			
Limit	>0.95	>0.95	>0.95			
6.Protection – Frequency tests: 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	47.5 Hz	20 s	47.49Hz	20.08s	47.7 Hz	No trip

1					30 s	
U/F stage 2	47 Hz	0.5 s	47Hz	0.527s	47.2 Hz 19.5 s	No trip
					46.8 Hz 0.45 s	No trip
O/F stage 1	52 Hz	0.5 s	52.01Hz	0.528s	51.8 Hz 120.0 s	No trip
					52.2 Hz 0.45 s	No trip

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 protection 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.

7. 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)

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	183.5V	2.571s	188 V 5.0 s	No trip
					180 V 2.45 s	No trip
O/V stage 1	262.2 V	1.0 s	263V	1.056s	258.2 V 5.0 s	No trip
O/V stage 2	273.7 V	0.5 s	274V	0.517s	269.7 V 0.95 s	No trip
					277.7 V 0.45 s	No trip

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.

8. 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.

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%
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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. Limit is 0.5 s	0.052	0.067s	0.053s	0.058	0.06	0.06s
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.						
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 fuse removed	-	-	-	-	-	-
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. Ph2 fuse removed	-	-	-	-	-	-
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. Ph3 fuse removed	-	-	-	-	-	-
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.					0.3ms	
For Inverters tested to BS EN 62116 the following sub set of tests should be recorded in the following table.						
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 0.5 s	0.048s	0.41s	0.53s	0.6s	0.5s	0.6s
9.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).						
	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			
10.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			
11.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%.						
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	3601.11W	50.002Hz	3688.6W	-		
Step b) 50.45 Hz ±0.05 Hz	3563.2W	50.451Hz		-		
Step c) 50.70 Hz ±0.10 Hz	3384.88W	50.702Hz		-		
Step d) 51.15 Hz ±0.05 Hz	3059.85W	51.152Hz		-		
Step e) 50.70 Hz ±0.10 Hz	3380.81W	50.701Hz		-		
Step f) 50.45 Hz ±0.05 Hz	3562.2W	50.451Hz		-		
Step g) 50.00 Hz ±0.01 Hz	3602.15W	50.001Hz				
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	1801.12W	50.001Hz	1853.74W	-		
Step b) 50.45 Hz ±0.05 Hz	1784.12W	50.451Hz		-		
Step c) 50.70 Hz ±0.10 Hz	1693.58W	50.701Hz		-		

Step d) 51.15 Hz ±0.05 Hz	1534.29W	51.152Hz		-	
Step e) 50.70 Hz ±0.10 Hz	1692.17W	50.7Hz		-	
Step f) 50.45 Hz ±0.05 Hz	1782.83W	50.45Hz		-	
Step g) 50.00 Hz ±0.01 Hz	1802.11W	50.001Hz			
Steps as defined in EN 50438					
12.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	3581.23W	50Hz	3702.17W		
Test b) Point between 49.5 Hz and 49.6 Hz	3580.24W	49.501Hz	3687.32W		
Test c) Point between 47.5 Hz and 47.6 Hz	3569.79W	47.501Hz	3697.19W		
NOTE: The operating point in Test (b) and (c) shall be maintained for at least 5 minutes					
13.Re-connection timer.					
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	Measured delay	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 2.			
20	21	At 266.2 V	At 180.0 V	At 47.4 Hz	
Confirmation that the Micro-generator does not re-connect.		Yes	Yes	Yes	
14.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).					
For machines with electro-magnetic output			For Inverter output		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p	-	20 ms	81.2V	28A
Initial Value of aperiodic current	A	-	100 ms	77.3V	22.5A
Initial symmetrical short-circuit	I_k	-	250 ms	76.9V	16.5A

current*					
Decaying (aperiodic) component of short circuit current*	i_{DC}	-	500 ms	73.5V	8.9A
Reactance/Resistance Ratio of source*	X/R		Time to trip	0.15s	In seconds
<p>For rotating machines and linear piston machines the test should produce a 0 s – 2 s plot of the short circuit current as seen at the Micro-generator terminals.</p> <p>* Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot</p>					
15.Logic Interface.					Yes
<p>This equipment is equipped with RJ45 terminal for logic interface that being received the signal from the DNO, the connection should be installed per installation manual, and the signal should be a simple binary output that captured by RJ45 terminal(PIN 5 and 1 for detecting the signal). Once the signal actived, the inverter will reduce its active power to zero within 5s.</p>					
16.Self-Monitoring solid state switching: No specified test requirements. Refer to EREC G98 Annex A1 A.1.3.6 (Inverter connected).					Yes/or NA
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.					NA
Additional comments					