Form C: 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	RI-Energyflow MINI 2.7-3.68kW-G98
Micro-generator technology	Grid-tied photovoltaic inverter
Manufacturer name	Rayleigh Instruments LTD
Address	1-5 Raytel House, Cutlers road, South Woodham Ferrers, Chelmsford Essex. England

Tel	01245428500	Fax	01245 428509
E-mail	Sales@rayleigh.com	Web site	www.Rayleigh.com

Registered Capacity, use separate sheet if more than one connection option.	Connection Option	
	3.68	kW single phase,
	3.3	kW Single phase
	2.7	kW Single phase
		kW Single phase

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	Ryan Welshman	On behalf of	Rayleigh Instruments 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.

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.

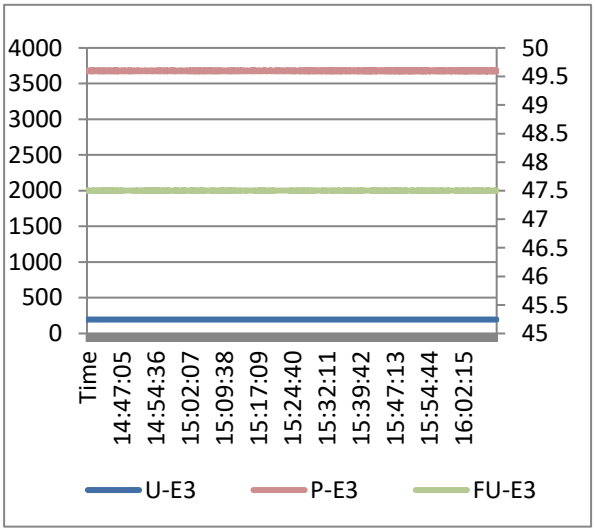
Test 1

Voltage = 85% of nominal (195.5 V)

Frequency = 47.5 Hz

Power factor = 1

Period of test 90 minutes



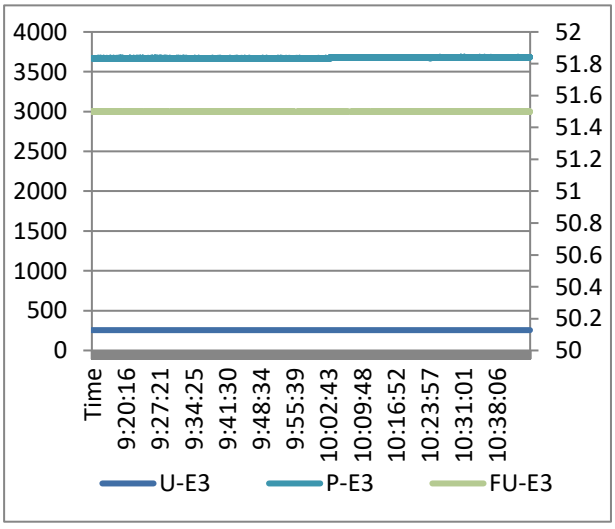
Test 2

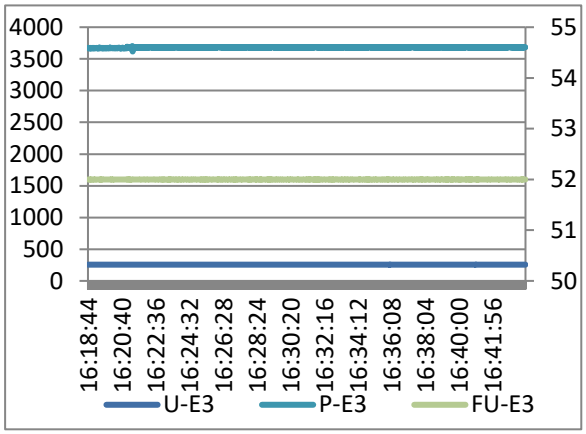
Voltage = 110% of nominal (253 V).

Frequency = 51.5 Hz

Power factor = 1

Period of test 90 minutes



Test 3 Voltage = 110% of nominal (253 V). Frequency = 52.0 Hz Power factor = 1 Period of test 15 minutes	

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)			3.68	kW		
Harmonic	At 45-55% of **Registered Capacity**		100% of **Registered Capacity**			
	Measured Value MV in Amps		Measured Value MV in Amps		Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2	0.0345		0.0849		1.080	
3	0.2647		0.4317		2.300	
4	0.0105		0.0182		0.430	
5	0.0752		0.0982		1.140	
6	0.0035		0.0033		0.300	
7	0.0359		0.0589		0.770	
8	0.0029		0.0044		0.230	
9	0.035		0.0334		0.400	
10	0.0031		0.0038		0.184	
11	0.0107		0.0336		0.330	
12	0.0023		0.0033		0.153	
13	0.0209		0.0157		0.210	
14	0.0027		0.0029		0.131	
15	0.0056		0.0233		0.150	
16	0.0015		0.002		0.115	
17	0.015		0.006		0.132	
18	0.002		0.0024		0.102	
19	0.0043		0.0188		0.118	
20	0.0015		0.0022		0.092	

21	0.0116		0.0025		0.107	0.160
22	0.0012		0.0015		0.084	
23	0.0038		0.0144		0.098	0.147
24	0.0015		0.0017		0.077	
25	0.0098		0.0039		0.090	0.135
26	0.0012		0.0017		0.071	
27	0.0033		0.011		0.083	0.124
28	0.0008		0.0015		0.066	
29	0.0086		0.0046		0.078	0.117
30	0.0018		0.002		0.061	
31	0.0024		0.0077		0.073	0.109
32	0.0005		0.0013		0.058	
33	0.0076		0.0055		0.068	0.102
34	0.0008		0.001		0.054	
35	0.0028		0.0056		0.064	0.096
36	0.001		0.0014		0.051	
37	0.0066		0.0062		0.061	0.091
38	0.0007		0.0006		0.048	
39	0.0034		0.0035		0.058	0.087
40	0.0006		0.0012		0.046	
Micro-generator rating per phase (rpp)			3.3	kW		
Harmonic	At 45-55% of **Registered Capacity**		100% of **Registered Capacity**			
	Measured Value MV in Amps		Measured Value MV in Amps		Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2	0.0476		0.0405		1.080	
3	0.0388		0.0487		2.300	
4	0.0416		0.0509		0.430	

5	0.0578		0.0603		1.140	
6	0.1076		0.0907		0.300	
7	0.0486		0.0590		0.770	
8	0.0082		0.0156		0.230	
9	0.0365		0.0468		0.400	
10	0.0361		0.0281		0.184	
11	0.0305		0.0380		0.330	
12	0.0158		0.0096		0.153	
13	0.0249		0.0347		0.210	
14	0.0122		0.0158		0.131	
15	0.0182		0.0282		0.150	
16	0.0164		0.0142		0.115	
17	0.0174		0.0251		0.132	
18	0.0101		0.0117		0.102	
19	0.0157		0.0249		0.118	
20	0.0167		0.0127		0.092	
21	0.0126		0.0227		0.107	0.160
22	0.0094		0.0111		0.084	
23	0.0116		0.0198		0.098	0.147
24	0.0141		0.0161		0.077	
25	0.0109		0.0141		0.090	0.135
26	0.0122		0.0133		0.071	
27	0.0102		0.0196		0.083	0.124
28	0.0103		0.0160		0.066	
29	0.0098		0.0172		0.078	0.117
30	0.0093		0.0135		0.061	
31	0.0093		0.0127		0.073	0.109
32	0.0095		0.0134		0.058	

33	0.0091		0.0141		0.068	0.102
34	0.0081		0.0130		0.054	
35	0.0082		0.0137		0.064	0.096
36	0.0088		0.0125		0.051	
37	0.0078		0.0130		0.061	0.091
38	0.0077		0.0111		0.048	
39	0.0071		0.0107		0.058	0.087
40	0.0068		0.0103		0.046	
Micro-generator rating per phase (rpp)			2.7	kW		
Harmonic	At 45-55% of **Registered Capacity**		100% of **Registered Capacity**			
	Measured Value MV in Amps		Measured Value MV in Amps		Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2	0.0528		0.0499		1.080	
3	0.0371		0.0453		2.300	
4	0.0346		0.0437		0.430	
5	0.0572		0.0635		1.140	
6	0.1080		0.1000		0.300	
7	0.0458		0.0579		0.770	
8	0.0109		0.0086		0.230	
9	0.0326		0.0423		0.400	
10	0.0333		0.0300		0.184	
11	0.0275		0.0386		0.330	
12	0.0152		0.0122		0.153	
13	0.0225		0.0299		0.210	
14	0.0122		0.0149		0.131	
15	0.0151		0.0257		0.150	
16	0.0174		0.0142		0.115	

17	0.0148		0.0261		0.132	
18	0.0092		0.0095		0.102	
19	0.0134		0.0219		0.118	
20	0.0157		0.0145		0.092	
21	0.0107		0.0176		0.107	0.160
22	0.0090		0.0115		0.084	
23	0.0098		0.0184		0.098	0.147
24	0.0124		0.0179		0.077	
25	0.0097		0.0150		0.090	0.135
26	0.0104		0.0108		0.071	
27	0.0091		0.0146		0.083	0.124
28	0.0098		0.0145		0.066	
29	0.0093		0.0139		0.078	0.117
30	0.0093		0.0119		0.061	
31	0.0090		0.0119		0.073	0.109
32	0.0087		0.0108		0.058	
33	0.0087		0.0125		0.068	0.102
34	0.0079		0.0113		0.054	
35	0.0078		0.0115		0.064	0.096
36	0.0077		0.0109		0.051	
37	0.0074		0.0109		0.061	0.091
38	0.0069		0.0102		0.048	
39	0.0064		0.0094		0.058	0.087
40	0.0062		0.0089		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).

	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	0.44 %	0.12 %	0%	0.53 %	0.11 %	0%	0.19	0.16
Normalised to standard impedance	0.44 %	0.12 %	0%	0.53 %	0.11 %	0%	0.19	0.16
Normalised to required maximum impedance	0.44 %	0.12 %	0%	0.53 %	0.11 %	0%	0.19	0.16
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	0.4	Ω	X	0.25	Ω
Standard Impedance	R	0.24 * 0.4 ^	Ω	X	0.15 * 0.25 ^	Ω
Maximum Impedance	R	0.4	Ω	X	0.25	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	08 June.,2020		Test end date	8 June.,2020
Test location	Suzhou National Hi-Tech District, Suzhou, China.			
Power quality – DC injection: This test should be carried out in accordance with EN 50438 Annex D.3.10				
3.68kW				
Test power level	20%	50%	75%	100%
Recorded value in Amps	0.018	0.002	0.022	0.025
as % of rated AC current	0.12%	0.01%	0.14%	0.16%
Limit	0.25%	0.25%	0.25%	0.25%
3.3kW				
Test power level	20%	50%	75%	100%
Recorded value in Amps	0.014	0.015	0.025	0.031
as % of rated AC current	0.10%	0.10%	0.17%	0.22%
Limit	0.25%	0.25%	0.25%	0.25%
2.7kW				
Test power level	20%	50%	75%	100%
Recorded value in Amps	0.022	0.010	0.023	0.021
as % of rated AC current	0.18%	0.08%	0.19%	0.18%
Limit	0.25%	0.25%	0.25%	0.25%
Power Quality – Power factor: 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.				
3.68kW				

Output power	216.2 V	230 V	253.20 V
20% of **Registered Capacity**	0,9693	0,9628	0,9515
50% of **Registered Capacity**	0,9938	0,9929	0,9916
75% of **Registered Capacity**	0,9968	0,9966	0,9961
100% of **Registered Capacity**	0,9978	0,9975	0,9975
Limit	>0.95	>0.95	>0.95
3.3kW			
	216.2 V	230 V	253 V
20% of **Registered Capacity**	0.997	0.997	0.997
50% of **Registered Capacity**	0.999	0.999	0.999
75% of **Registered Capacity**	0.999	0.999	0.999
100% of **Registered Capacity**	0.999	0.999	0.999
Limit	>0.95	>0.95	>0.95
2.7kW			
	216.2 V	230 V	253 V
20% of **Registered Capacity**	0.999	0.999	0.995
50% of **Registered Capacity**	0.999	0.999	0.998
75% of **Registered Capacity**	0.999	0.999	0.999
100% of **Registered Capacity**	0.999	0.999	0.999
Limit	>0.95	>0.95	>0.95

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 1	47.5 Hz	20 s	47.45Hz	19.99s	47.7 Hz 30 s	no trip
U/F stage 2	47 Hz	0.5 s	46.95Hz	0.51s	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	52.05Hz	0.48s	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 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)

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	182V	2.48s	188 V 5.0 s	no trip
					180 V 2.45 s	no trip
O/V stage 1	262.2 V	1.0 s	265V	0.99S	258.2 V 5.0 s	no trip
O/V stage 2	273.7 V	0.5 s	275V	0.51S	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.

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%
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	N/A	N/A	N/A	N/A	N/A	N/A
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	N/A	N/A	N/A	N/A	N/A	N/A
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	N/A	N/A	N/A	N/A	N/A	N/A
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	N/A	N/A	N/A	N/A	N/A	N/A
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.			N/A			ms

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	208ms	180ms	186ms	206ms	195ms	190ms

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

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

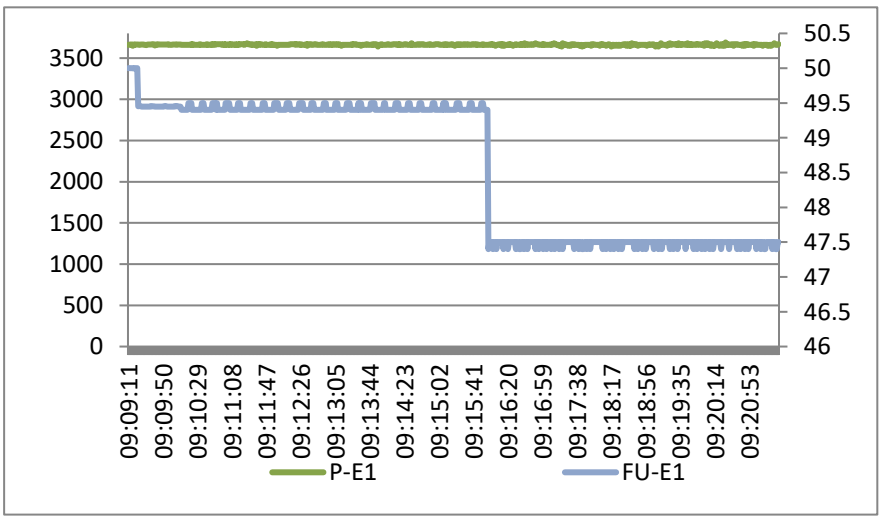
Limited Frequency Sensitive Mode – Overfrequency test: This test should be carried out in accordance with EN 50438 Annex D.3.3 Power response to over- frequency. The test should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10%.				
Test sequence at **Registered Capacity** >80%	Measured **Active Power** Output	Frequency	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	3671.7W	50Hz	380V/3800W	99.8%
Step b) 50.45 Hz ±0.05 Hz	3632.5W	50.45Hz		98.7%
Step c) 50.70 Hz ±0.10 Hz	3447.5W	50.7Hz		93.7%
Step d) 51.15 Hz ±0.05 Hz	3118.4W	51.15Hz		84.7%
Step e) 50.70 Hz ±0.10 Hz	3453.2W	50.7Hz		93.8%
Step f) 50.45 Hz ±0.05 Hz	3635.7W	50.45Hz		98.8%
Step g) 50.00 Hz ±0.01 Hz	3669.8W	50Hz		99.7%
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	1876.7W	50Hz	380V/3800W	51.0%
Step b) 50.45 Hz ±0.05 Hz	1858.5W	50.45Hz		50.5%
Step c) 50.70 Hz ±0.10 Hz	1747.8W	50.7Hz		47.5%
Step d) 51.15 Hz ±0.05 Hz	1485.5W	51.15Hz		40.4%
Step e) 50.70 Hz ±0.10 Hz	1746.3W	50.7Hz		47.5%
Step f) 50.45 Hz ±0.05 Hz	1857.9W	50.45Hz		50.5%
Step g) 50.00 Hz ±0.01 Hz	1877.9	50Hz		51.0%
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	3680W	50Hz	3800W
Test b) Point between 49.5 Hz and 49.6 Hz	3680W	49.5Hz	3800W
Test c) Point between 47.5 Hz and 47.6 Hz	3680W	47.5Hz	3800W

NOTE: The operating point in Test (b) and (c) shall be maintained for at least 5 minutes



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.			
30S	60S		At 266.2 V	At 180.0 V	At 47.4 Hz	At 52.1 Hz
Confirmation that the **Micro-generator** does not re-connect.			Not re-connect	not re-connect	not re-connect	not re-connect

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	N/A	20 ms	25V	11.5A
Initial Value of aperiodic current	A	N/A	100 ms	12V	0.13A
Initial symmetrical short-circuit current*	I_k	N/A	250 ms	12V	0.13A
Decaying (aperiodic) component of short circuit current*	i_{DC}	N/A	500 ms	12V	0.13A
Reactance/Resistance Ratio of source*	X/R	N/A	Time to trip	0.696s	In seconds

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.

* Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot

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.	N/A
Additional comments	