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	Fronius Symo GEN24
Micro-generator technology	transformerless
Manufacturer name	Fronius International GmbH
Address	*Guenter Fronius Str 1* *4600 Wels-Thalheim, Austria*

Tel	*+43-7242-241-0*	Fax	*+43-7242-241-224*
E:mail	*pv@fronius.com*	Web site	www.fronius.com

Registered Capacity, use separate sheet if more than one connection option.	Connection Option
--	kW single phase, single, split or three phase system
10	kW three phase
--	kW two phases in three phase system
--	kW two phases split phase system

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		On behalf of	Fronius International GmbH

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** (e.g. 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
Remark: During the tests 1, 2 and 3 the unit does not disconnect, tests have been passed.

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 Phase 1						
Micro-generator rating per phase (rpp)			3,454	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	0.002		0.004		1.080	
3	0.001		0.003		2.300	
4	0.001		0.001		0.430	
5	0.001		0.001		1.140	
6	0.000		0.001		0.300	
7	0.003		0.004		0.770	
8	0.001		0.000		0.230	
9	0.001		0.001		0.400	
10	0.000		0.001		0.184	
11	0.015		0.013		0.330	
12	0.000		0.000		0.153	
13	0.014		0.012		0.210	
14	0.000		0.001		0.131	
15	0.000		0.000		0.150	
16	0.000		0.000		0.115	
17	0.012		0.011		0.132	
18	0.000		0.000		0.102	
19	0.013		0.012		0.118	

20	0.000		0.000		0.092	
21	0.000		0.000		0.107	0.160

22	0.000		0.000		0.084	
23	0.011		0.011		0.098	0.147
24	0.000		0.001		0.077	
25	0.010		0.011		0.090	0.135
26	0.000		0.000		0.071	
27	0.000		0.000		0.083	0.124
28	0.000		0.000		0.066	
29	0.009		0.010		0.078	0.117
30	0.000		0.000		0.061	
31	0.008		0.011		0.073	0.109
32	0.001		0.000		0.058	
33	0.000		0.001		0.068	0.102
34	0.000		0.000		0.054	
35	0.007		0.013		0.064	0.096
36	0.000		0.000		0.051	
37	0.007		0.011		0.061	0.091
38	0.000		0.000		0.048	
39	0.000		0.001		0.058	0.087
40	0.000		0.000		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 – 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 Phase 2						
Micro-generator rating per phase (rpp)			3,408	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	0.001		0.002		1.080	
3	0.004		0.001		2.300	
4	0.001		0.001		0.430	
5	0.000		0.002		1.140	
6	0.000		0.001		0.300	
7	0.002		0.003		0.770	
8	0.001		0.000		0.230	
9	0.000		0.001		0.400	
10	0.000		0.000		0.184	
11	0.015		0.013		0.330	
12	0.000		0.000		0.153	
13	0.015		0.012		0.210	
14	0.000		0.000		0.131	
15	0.000		0.000		0.150	
16	0.000		0.000		0.115	
17	0.013		0.012		0.132	
18	0.000		0.000		0.102	
19	0.013		0.012		0.118	
20	0.000		0.000		0.092	

21	0.000		0.000		0.107	0.160

22	0.000		0.000		0.084	
23	0.011		0.011		0.098	0.147
24	0.000		0.000		0.077	
25	0.010		0.012		0.090	0.135
26	0.000		0.000		0.071	
27	0.001		0.000		0.083	0.124
28	0.000		0.000		0.066	
29	0.009		0.011		0.078	0.117
30	0.000		0.000		0.061	
31	0.008		0.011		0.073	0.109
32	0.000		0.000		0.058	
33	0.001		0.001		0.068	0.102
34	0.000		0.000		0.054	
35	0.007		0.012		0.064	0.096
36	0.000		0.000		0.051	
37	0.007		0.012		0.061	0.091
38	0.001		0.000		0.048	
39	0.000		0.000		0.058	0.087
40	0.000		0.000		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 – 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 Phase 3

Micro-generator rating per phase (rpp)			3,410	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	0.000		0.002		1.080	
3	0.001		0.002		2.300	
4	0.001		0.003		0.430	
5	0.001		0.001		1.140	
6	0.000		0.001		0.300	
7	0.002		0.003		0.770	
8	0.001		0.000		0.230	
9	0.001		0.001		0.400	
10	0.000		0.001		0.184	
11	0.015		0.013		0.330	
12	0.000		0.000		0.153	
13	0.014		0.012		0.210	
14	0.000		0.001		0.131	
15	0.000		0.001		0.150	
16	0.000		0.000		0.115	
17	0.013		0.012		0.132	
18	0.000		0.000		0.102	
19	0.013		0.011		0.118	

20	0.000		0.000		0.092	
21	0.000		0.001		0.107	0.160

22	0.000		0.000		0.084	
23	0.011		0.011		0.098	0.147
24	0.000		0.000		0.077	
25	0.010		0.011		0.090	0.135
26	0.000		0.000		0.071	
27	0.000		0.001		0.083	0.124
28	0.001		0.000		0.066	
29	0.010		0.011		0.078	0.117
30	0.000		0.000		0.061	
31	0.008		0.011		0.073	0.109
32	0.000		0.000		0.058	
33	0.001		0.001		0.068	0.102
34	0.000		0.000		0.054	
35	0.007		0.013		0.064	0.096
36	0.001		0.001		0.051	
37	0.006		0.011		0.061	0.091
38	0.000		0.000		0.048	
39	0.000		0.001		0.058	0.087
40	0.000		0.000		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	0	-	1.6	1.56	-	0.034	0.114
Normalised to standard impedance	0	0	-	1.6	1.56	-	0.034	0.114
Normalised to required maximum impedance	-	-	-	-	-	-	-	-
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	0.24	Ω	X	0.15	Ω
Standard Impedance	R	0.24 * 0.4^	Ω	X	0.15 * 0.25^	Ω
Maximum Impedance	R	-	Ω	X	-	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	08:08	Test end	10:08	21.12.2020
Test location	Fronius R&D Laboratories, Fronius International GmbH, Guenter Fronius Str 1, A-4600 Wels-Thalheim, Austria			

Power quality – DC injection: This test should be carried out in accordance with EN 50438 Annex D.3.10				
Test power level	20%	50%	75%	100%
Recorded value in Amps	0.0064	0.0024	0.0039	0.0048
as % of rated AC current	0.03625	0.03625	0.03625	0.03625
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.			
	216.2 V	230 V	253 V
20% of **Registered Capacity**	1.00	1.00	1.00
50% of **Registered Capacity**	1.00	1.00	1.00
75% of **Registered Capacity**	1.00	1.00	1.00
100% of **Registered Capacity**	1.00	1.00	1.00
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	47.5Hz	20s	47.50Hz	20.047s	47.7 Hz 30 s	**Confirmed**
U/F stage 2	47Hz	0.5s	47.00Hz	0.546	47.2 Hz 19.5 s	**Confirmed**
					46.8 Hz 0.45 s	**Confirmed**
O/F stage 1	52Hz	0.5s	52.009Hz	0.546s	51.8 Hz 120.0 s	**Confirmed**
					52.2 Hz 0.45 s	**Confirmed**
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	184V	2.5s	184.02V	2.523	188 V 5.0 s	**Confirmed**
					180 V 2.45 s	**Confirmed**
O/V stage 1	262.2V	1.0s	261.99V	1.028s	258.2 V 5.0 s	**Confirmed**
O/V stage 2	273.7V	0.5s	273.38V	0.531s	269.7 V 0.95 s	**Confirmed**
					277.7 V 0.45 s	**Confirmed**
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 seconds						
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.						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 0.5s	186.4 ms	163.6 ms	404.7 ms	208.4 ms	169.9 ms	418.7 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).			
	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.0Hz	+50 degrees	**Confirmed**
Negative Vector Shift	50.0Hz	-50 degrees	**Confirmed**

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 51.0Hz	+0.95 Hzs^{-1}	2.1 s	**Confirmed**
51.0 Hz to 49.0Hz	-0.95 Hzs^{-1}	2.1 s	**Confirmed**

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	10100W	50.00Hz	10.3kW	20%/Hz
Step b) 50.45 Hz ±0.05 Hz	9900W	50.45Hz		
Step c) 50.70 Hz ±0.10 Hz	9480W	50.70Hz		
Step d) 51.15 Hz ±0.05 Hz	8570W	51.15Hz		
Step e) 50.70 Hz ±0.10 Hz	9480W	50.70Hz		
Step f) 50.45 Hz ±0.05 Hz	9900W	50.45Hz		
Step g) 50.00 Hz ±0.01 Hz	10100W	50.00Hz		
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	5020W	50.00Hz	5.1kW	20%/Hz
Step b) 50.45 Hz ±0.05 Hz	4970W	50.45Hz		
Step c) 50.70 Hz ±0.10 Hz	4715W	50.70Hz		
Step d) 51.15 Hz ±0.05 Hz	4260W	51.15Hz		
Step e) 50.70 Hz ±0.10 Hz	4715W	50.70Hz		
Step f) 50.45 Hz ±0.05 Hz	4970W	50.45Hz		
Step g) 50.00 Hz ±0.01 Hz	5020W	50.00Hz		
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	10000W	50Hz	10.3kW
Test b) Point between 49.5 Hz and 49.6 Hz	10000W	49.55Hz	10.3kW
Test c) Point between 47.5 Hz and 47.6 Hz	10000W	47.55Hz	10.3kW
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.			
20.0s	**71.92s**		At 266.2V	At 180.0V	At 47.4Hz	At 52.1Hz
Confirmation that the **Micro-generator** does not re-connect.			**Confirmed**	**Confirmed**	**Confirmed**	**Confirmed**

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	--	20ms	4.24	49.4
Initial Value of aperiodic current	A	--	100ms	3.6	22.4
Initial symmetrical short-circuit current*	I_k	--	250ms	3.43	14.3
Decaying (aperiodic) component of short circuit current*	i_{DC}	--	500ms	3.4	10.3
Reactance/Resistance Ratio of source*	X/R	--	Time to trip	0.110	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).	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.	

Additional comments