FORM A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

This form should be used by the **Manufacturer** to demonstrate and declare compliance with the requirements of EREC G99. The form can be used in a variety of ways as detailed below:

1. To obtain **Fully Type Tested** status

The **Manufacturer** can use this form to obtain **Fully Type Tested** status for a **Power Generating Module** by registering this completed form with the Energy Networks Association (ENA) Type Test Verification Report Register.

Note:
Within this Form A2-3 the term Power Park Module will be used but its meaning can be interpreted within Form A2-3 to mean Power Park Module, Generating Unit or Inverter as appropriate for the context. However, note that compliance must be demonstrated at the Power Park Module level.

If the Power Generating Module is Fully Type Tested and registered with the Energy Networks Association (ENA) Type Test Verification Report Register, the Installation Document (Form A3) should include the Manufacturer's reference number (the Product ID), and this form does not need to be submitted.

Where the Power Generating Module is not registered with the ENA Type Test Verification Report Register or is not Fully Type Tested this form (all or in parts as applicable) needs to be completed and provided to the DNO, to confirm that the Power Generating Module has been tested to satisfy all or part of the requirements of this EREC G99.

Manufacturer´s reference number		Fronius Primo 6.0-1	
PGM technology		IGBT power modules, transformerless	
Manufacturer name		Fronius International GmbH	
Adress		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			6.0kW

Manufacturer compliance declaration. - I certify that all products supplied by the company with the above **Type Tested Manufacturer's** 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 G99.

Signed		On behalf of	Fronius International GmbH

FRONIUS INTERNATIONAL GMBH
Günter Fronius-Str. 1, A-4600 Wels/Thalheim
Tel: +43 / (0) 72 42 / 241-0, Fax: 47 8 25

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: Five tests should be carried with the **Power Generating Module** operating at **Registered Capacity** and connected to a suitable test supply or grid simulation set. The power supplied by the primary source shall be kept stable within ± 5 % of the apparent power value set for the entire duration of each test sequence. Frequency, voltage and **Active Power** measurements at the output terminals of the **Power Generating Module** shall be recorded every second. The tests will verify that the **Power Generating Module** 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 **Power Park Module** the PV primary source may be replaced by a DC source. In case of a full converter **Power Park Module** (eg wind) the primary source and the prime mover **Inverter**/rectifier may be replaced by a DC source.
Test 1 Voltage = 85% of nominal (195.5 V) Frequency = 47.0 Hz Power factor = 1 Period of test 20 s
Test 2 Voltage = 85% of nominal (195.5 V). Frequency = 47.5 Hz Power factor = 1 Period of test 90 minutes
Test 3 Voltage = 110% of nominal (253 V). Frequency = 51.5 Hz Power factor = 1 Period of test 90 minutes
Test 4 Voltage = 110% of nominal (253 V). Frequency = 52.0 Hz Power factor = 1 Period of test 15 minutes
Test 5 RoCoF withstand Confirm that the Power Generating Module is capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hzs-1 as measured over a period of 500 ms. Note that this is not expected to be demonstrated on site.
Remark: During the tests 1, 2, 3, 4 and 5 the unit does not disconnect, tests have been passed.

2. Power Quality – Harmonics:

For **Power Generating Module**s of **Registered Capacity** of less than 75 A per phase (ie 50 kW) the test requirements are specified in Annex A.7.1.5. These tests should be carried out as specified in BS EN 61000-3-12 The results need to comply with the limits of Table 2 of BS EN 61000-3-12 for single phase equipment and Table 3 of BS EN 610000-3-12 for three phase equipment.

Power Generating Modules 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 **Power Generating Module** in order to accept the connection to a **Distribution Network.**

For **Power Generating Module**s of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation shall be designed in accordance with EREC G5.

Power Generating Module rating per phase (rpp)			6.0	kVA	Harmonic % = Measured Value (A) x 23/rating per phase (kVA)	
Harmonic	At 45-55% of **Registered Capacity**		100% of **Registered Capacity**		Limit in BS EN 61000-3-12 in Amps	
	Measured Value MV in Amps		Measured Value MV in Amps		1 Phase	3 phase
2	0.069	0.192	0.088	0.246	8%	8%
3	0.604	1.695	0.658	1.846	21.6%	Not stated
4	0.110	0.308	0.101	0.284	4%	4%
5	0.397	1.115	0.478	1.341	10.7%	10.7%
6	0.028	0.078	0.025	0.069	2.67%	2.67%
7	0.152	0.427	0.238	0.668	7.2%	7.2%
8	0.027	0.075	0.033	0.094	2%	2%
9	0.174	0.487	0.263	0.737	3.8%	Not stated
10	0.022	0.061	0.026	0.072	1.6%	1.6%
11	0.047	0.132	0.121	0.341	3.1%	3.1%
12	0.034	0.095	0.040	0.111	1.33%	1.33%
13	0.108	0.303	0.166	0.465	2%	2%
THD[12]	0.72	4.12	0.81	2.39	23%	13%
PWHD[13]	0.00	0.00	0.00	0.00	23%	22%

[12] THD = Total Harmonic Distortion
[13] PWHD = Partial Weighted Harmonic Distortion

3. Power Quality – Voltage fluctuations and Flicker:

For **Power Generating Modules** of **Registered Capacity** of less than 75 A per phase (ie 50 kW) these tests should be undertaken in accordance with Annex A.7.1.4.3. 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.

For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation shall be designed in accordance with EREC P28.

	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	0.40 %	1.79%		2.18%	2.16%		0.412	0.387
Normalised to standard impedance	0.40 %	1.79%		2.18%	2.16%		0.412	0.387
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	0.4	Ω	X	0.25	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 **Power Generating Modules**.

^ Applies to single phase **Power Generating Module** and **Power Generating Modules** 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	2019-04-01	Test end	2019-04-12	
Test location	Fronius R&D Laboratories, Fronius International GmbH, Guenter Fronius Str 1, A-4600 Wels-Thalheim, Austria			

4. Power quality – DC injection: The tests should be carried out on a single **Generating Unit**. Tests are to be carried out at three defined power levels ±5%. At 230 V a 50 kW three phase **Inverter** has a current output of 217 A so DC limit is 543 mA. These tests should be undertaken in accordance with Annex A.7.1.4.4.

Test power level	10%	55%	100%
Recorded value in Amps	4.3mA	12.0mA	15.7mA
as % of rated AC current	0.016%	0.045%	0.060%
Limit	0.25%	0.25%	0.25%

5. Power Factor: The tests should be carried out on a single **Power Generating Module**. Tests are to be carried out at three voltage levels and at **Registered Capacity**. Voltage to be maintained within ±1.5% of the stated level during the test. These tests should be undertaken in accordance with Annex A.7.1.4.2.

Voltage	0.94 pu (216.2 V)	1 pu (230 V)	1.1 pu (253 V)
Measured value	1.000	1.000	1.000
Power Factor Limit	>0.95	>0.95	>0.95

6. Protection – Frequency tests: These tests should be carried out in accordance with Annex A.7.1.2.3.

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	47.495Hz	20.059s	47.7Hz 30s	No trip occurred
U/F stage 2	47Hz	0.5s	46.990Hz	0.558s	47.2Hz 19.5s	No trip occurred
					46.8Hz 0.45s	No trip occurred
O/F stage 1	52Hz	0.5s	52.006Hz	0.558s	51.8Hz 120.0s	No trip occurred
					52.2Hz 0.45s	No trip occurred

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.

7. Protection – Voltage tests: These tests should be carried out in accordance with Annex A.7.1.2.2.

Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V	0.8 pu (184V)	2.5s	183.07V	2.543s	188V 5.0s	No trip occurred
					180V 2.45s	No trip occurred
O/V stage 1	1.14 (262.2V)	1.0s	262.95V	1.041s	258.2V 5.0s	No trip occurred
O/V stage 2	1.19 (273.7V)	0.5s	273.97V	0.538s	269.7V 0.95s	No trip occurred
					277.7V 0.45s	No trip occurred

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: These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4.

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	166.49ms	169.19ms	301.8ms	179.59ms	153.99ms	444.4ms

Loss of Mains Protection, Vector Shift Stability test. This test should be carried out in accordance with Annex A.7.1.2.6.

	Start Frequency	Change	Confirm no trip
Positive Vector	49.0Hz	+50 degrees	No trip occurred
Negative Vector	50.0Hz	-50 degrees	No trip occurred

Loss of Mains Protection, RoCoF Stability test: This test should be carried out in accordance with Annex A.7.1.2.6.

Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0 Hz to 51.0Hz	+0.95 Hzs^{-1}	2.1 s	No trip occurred
51.0 Hz to 49.0Hz	-0.95 Hzs^{-1}	2.1 s	No trip occurred

9. Limited Frequency Sensitive Mode – Over frequency test: The test should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10%. This test should be carried out in accordance with Annex A.7.1.3.				
Active Power response to rising frequency/time plots are attached if Y/N Frequency injection tests are undertaken in accordance with Annex A.7.2.4.				
Alternatively, simulation results should be noted below:				
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	6010W	50,00Hz	6.2kW	20%/Hz
Step b) 50.45 Hz ±0.05 Hz	6000W	50,45Hz		
Step c) 50.70 Hz ±0.10 Hz	5760W	50,70Hz		
Step d) 51.15 Hz ±0.05 Hz	5200W	51,15Hz		
Step e) 50.70 Hz ±0.10 Hz	5760W	50,70Hz		
Step f) 50.45 Hz ±0.05 Hz	6000W	50,45Hz		
Step g) 50.00 Hz ±0.01 Hz	6010W	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	3020W	50,00Hz	3.1kW	20%/Hz
Step b) 50.45 Hz ±0.05 Hz	3000W	50,45Hz		
Step c) 50.70 Hz ±0.10 Hz	2850	50,70Hz		
Step d) 51.15 Hz ±0.05 Hz	2575W	51,15Hz		
Step e) 50.70 Hz ±0.10 Hz	2850W	50,70Hz		
Step f) 50.45 Hz ±0.05 Hz	3000W	50,45Hz		
Step g) 50.00 Hz ±0.01 Hz	3020	50,00Hz		
Steps as defined in EN 50438				

10. Protection - 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 10.1.						
Time delay setting	Measured delay		Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 10.1.			
20.0s	75.2s		At 1.16 pu (266.2V)	At 0.78 pu (180.0V)	At 47.4Hz	At 52.1Hz
Confirmation that the **Power Generation Module** does not re-connect.			No re-connect occurred	No re-connect occurred	No re-connect occurred	No re-connect occurred

11. Fault level contribution: These tests shall be carried out in accordance with EREC G99 Annex A.7.1.5.		
For **inverter** output		
Time after fault	Volts	Amps
20 ms	8.52	53.3
100 ms	7.77	36.3
250 ms	7.63	25.6
500 ms	7.61	19.5
Time to trip	0.195	In seconds

12. Self-Monitoring solid state switching: No specified test requirements. Refer to Annex A.7.1.7.	
It has been verified that in the event of the solid state switching device failing to disconnect the **Power Park Module**, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 s.	NA

13. Wiring functional tests: If required by para 15.2.1.	
Confirm that the relevant test schedule is attached (tests to be undertaken at time of commissioning)	NA

14. Logic interface (input port).	
Confirm that an input port is provided and can be used to shut down the module.	YES

Additional comments