

**13.1 GENERATING UNIT TYPE TEST SHEET**

**Type Tested Generating Unit (>16A per phase but ≤ 50 kW 3 phase)**


**TYPE TEST SHEET**

**This Type Test sheet shall be used to record the results of the type testing of Generating Unit** between 16A per phase and 17kW per phase maximum output at 230V (17kW limit single phase, 34kW limit split phase, 50kW limit 3 phase)

It includes the **Generating Units** supplier declaration of compliance with the requirements of Engineering Recommendation G59/3

|   |  |   |  |
|---|--|---|--|
| Type Tested reference number  |  | Fronius Symo 12.5-3-M                                 |  |
| <b>Generating Unit</b> technology   |  | IGBT power modules, transformerless                   |  |
| System Supplier name  |  | Fronius International GmbH                            |  |
| Address   |  | Guenther Fronius Str 1<br>4600 Wels-Thalheim, Austria |  |
| Tel   | +43-7242-241-0                                     | Fax   | +43-7242-241-224                                     |
| E:mail  | <a href="mailto:pv@fronius.com">pv@fronius.com</a> | Web site  | <a href="http://www.fronius.com">www.fronius.com</a> |
| Maximum export capacity, use separate sheet if more than one connection option. | --   | kW single phase, single, split or three phase system  |  |
|   | 12.5   | kW three phase  |  |
|   | --   | kW two phases in three phase system                   |  |
|   | --   | kW two phases split phase system                      |  |

System supplier declaration. - I certify on behalf of the company named above as a supplier of a **Generating Unit**, that all products supplied by the company with the above Type Test 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 G59/3.

|        |   |              |                            |
|--------|---|--------------|----------------------------|
| Signed |  | On behalf of | Fronius International GmbH |
|--------|---|--------------|----------------------------|

Note that testing can be done by the manufacturer of an individual component, by an external test house, or by the supplier of the complete system, or any combination of them as appropriate.

Where parts of the testing are carried out by persons or organisations other than the supplier then the supplier 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.





**Power Quality. Harmonics.** These tests should be carried out as specified in 61000-3-12 or 61000-3-2. Only one set of tests is required and the **Manufacturer** should decide which one to use and complete the relevant table. 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 maximum export capacity.

The test should be carried out on a single **Generating Unit**. The results need to comply with the limits of table 2 of BS EN 61000-3-12 for single phase equipment, to table 3 of BS EN 61000-3-12 for three phase equipment or to table 1 of BS EN 61000-3-2 if that standard is used.

Note that Generating Units meeting the requirements of BS EN 61000-3-2 will need no further assessment with regards to harmonics. Generating Units with emissions close to the limits laid down in BE EN 61000-3-12 may require the installation of a transformer between 2 and 4 times the rating of the **Generating Unit** in order to accept the connection to a **DNO**'s network.

Generating Unit tested to BS EN 61000-3-12

| Generating Unit rating per phase (rpp) |                           | 5,0    | kVA                       |        | Harmonic % = Measured Value (Amps) x 23/rating per phase (kVa) |            |
|--|---------------------------|--------|---------------------------|--------|--|------------|
| Harmonic                               | At 45-55% of rated output |        | 100% of rated output      |        | Limit BS EN 61000-3-12   |            |
|  | Measured Value MV in Amps | %      | Measured Value MV in Amps |        | 1 phase  | 3 phase    |
| 2                                      | 0,092                     | 0,051% | 0,090                     | 0,049% | 8%   | 8%         |
| 3                                      | 0,102                     | 0,056% | 0,099                     | 0,054% | 21.6%  | Not stated |
| 4                                      | 0,025                     | 0,014% | 0,028                     | 0,016% | 4%   | 4%         |
| 5                                      | 0,147                     | 0,081% | 0,177                     | 0,098% | 10.7%  | 10.7%      |
| 6                                      | 0,017                     | 0,010% | 0,016                     | 0,009% | 2.67%  | 2.67%      |
| 7                                      | 0,067                     | 0,037% | 0,063                     | 0,035% | 7.2%   | 7.2%       |
| 8                                      | 0,026                     | 0,014% | 0,023                     | 0,013% | 2%   | 2%         |
| 9                                      | 0,055                     | 0,030% | 0,067                     | 0,037% | 3.8%   | Not stated |
| 10                                     | 0,014                     | 0,008% | 0,014                     | 0,008% | 1.6%   | 1.6%       |
| 11                                     | 0,045                     | 0,025% | 0,049                     | 0,027% | 3.1%   | 3.1%       |
| 12                                     | 0,017                     | 0,010% | 0,019                     | 0,010% | 1.33%  | 1.33%      |
| 13                                     | 0,077                     | 0,043% | 0,104                     | 0,058% | 2%   | 2%         |
| THD                                    | 1,56%                     |        | 1,39%                     | THD    | 23%  | 13%        |
| PWHD                                   | 2,63%                     |        | 2,73%                     | PWHD   | 23%  | 22%        |



**Power Quality. Voltage fluctuations and Flicker.** The tests should be carried out on a single Generating Unit. Results should be normalized 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.

|  | Starting   |                |                  | Stopping         |                |                  | Running         |                         |
|--|--|----------------|------------------|------------------|----------------|------------------|-----------------|-------------------------|
|  | d <sub>max</sub>   | d <sub>c</sub> | d <sub>(t)</sub> | d <sub>max</sub> | d <sub>c</sub> | d <sub>(t)</sub> | P <sub>st</sub> | P <sub>lf</sub> 2 hours |
| Measured Values at test impedance  | -  | -              | -                | -                | -              | -                | -               | -                       |
| Normalised to standard impedance   | 0%   | -              | 0%               | 1.66%            | 0.45%          | 0                | 0.231           | 0.264                   |
| Normalised to required maximum impedance   | -  | -              | -                | -                | -              | -                | -               | -                       |
| Limits set under BS EN 61000-3-2   | 4%   | 3.3%           | 3.3%             | 4%               | 3.3%           | 3.3%             | 1.0             | 0.65                    |
|  |  |                |                  |                  |                |                  |                 |                         |
| Test Impedance   | R  |                |                  | Ω                |                | XI               |                 | Ω                       |
| Standard Impedance   | R  |                | 0,4              | Ω                |                | XI               | 0,25            | Ω                       |
| Maximum Impedance  | R  |                |                  | Ω                |                | XI               |                 | Ω                       |
| <p>*Applies to three phase and split single phases <b>Generating Units</b></p> <p>^ Applies to single phase <b>Generating Units</b> and <b>Generating Units</b> 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 value 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>Singe phase units reference source resistance is 0.4Ω</p> <p>Two phase units in a three phase system reference source resistance is 0.4Ω</p> <p>Two phase units in a split phase system reference source resistance is 0.24Ω</p> <p>Three phase units reference source resistance is 0.24Ω</p> <p>Where the power factor of the output is under 0.98 then the XI 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 comply with 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   |  |                |                  | Test end         |                |                  |                 |                         |
| Test location  | Fronius R&D Laboratories, Fronius International GmbH, Guenter Fronius Str 1, A-4600 Wels-Thalheim, Austria |                |                  |                  |                |                  |                 |                         |

**Power quality. DC injection.** The tests should be carried out on a single **Generating Unit**. Tests are to be carried out at three power defined levels  $\pm 5\%$ . At 230V a 2kW single phase inverter has a current output of 8.7A so DC limit is 21.75mA, a 10kW three phase inverter has a current output of 43.5A at 230V so DC limit is 108.75mA.

|                          |        |        |        |  |
|--------------------------|--------|--------|--------|--|
| Test power level         | 10%    | 55%    | 100%   |  |
| Recorded value           | 12.7mA | 13.9mA | 14.6mA |  |
| as % of rated AC current | 0.07%  | 0.08%  | 0.08%  |  |
| Limit                    | 0.25%  | 0.25%  | 0.25%  |  |

**Power quality. Power factor.** The tests should be carried out on a single **Generating Unit**. Tests are to be carried out at three voltage levels and at full output. Voltage can be maintained within + or - 1.5% of the stated level during the test.

|                |        |       |       |   |
|----------------|--------|-------|-------|---|
|                | 216.2V | 230V  | 253V  | Measured at three voltage levels and at full output. Voltage to be maintained within + or - 1.5% of the stated level during the test. |
| Measured value | 0.997  | 0.998 | 0.997 |   |
| Limit          | >0.95  | >0.95 | >0.95 |   |

**Protection. Frequency tests**

| Function    | Setting   |            | Trip test |         | "No trip tests"  |                  |
|-------------|-----------|------------|-----------|---------|------------------|------------------|
|             | Frequency | Time delay | Frequency |         | Frequency        | Time delay       |
| U/F stage 1 | 47.5Hz    | 20s        | 47.446Hz  | 20.030s | 47.7Hz<br>25s    | No trip occurred |
| U/F stage 2 | 47Hz      | 0.5s       | 46.972Hz  | 0.538s  | 47.2Hz<br>19.98s | No trip occurred |
|             |           |            |           |         | 46.8Hz<br>0.48s  | No trip occurred |
| O/F stage 1 | 51.5Hz    | 90s        | 51.590 Hz | 90.018s | 51.3Hz<br>95s    | No trip occurred |
| O/F stage 2 | 52Hz      | 0.5s       | 52.069Hz  | 0.548s  | 51.8Hz<br>89.98s | No trip occurred |
|             |           |            |           |         | 52.2Hz<br>0.48s  | No trip occurred |

Note. For Frequency tests the Frequency required to trip is the setting  $\pm 1\text{Hz}$ . 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  $\pm 0.2\text{Hz}$  and for the relevant times as shown in the table above to ensure that the protection will not trip in error.



| Protection. Voltage tests |         |            |           |        |                 |                  |
|---------------------------|---------|------------|-----------|--------|-----------------|------------------|
| Function                  | Setting |            | Trip test |        | "No trip tests" |                  |
|                           | Voltage | Time delay | Voltage   |        | Voltage         | Time delay       |
| U/V stage 1               | 200.1V  | 2.5s       | 197.38V   | 2.573s | 204.1V<br>3.5s  | No trip occurred |
| U/V stage 2               | 184V    | 0.5s       | 181.71V   | 0.543s | 188V<br>2.48s   | No trip occurred |
|                           |         |            |           |        | 180V<br>0.48s   | No trip occurred |
| O/V stage 1               | 262.2V  | 1.0s       | 263.34V   | 1.048s | 258.2V<br>2.0s  | No trip occurred |
| O/V stage 2               | 273.7V  | 0.5s       | 275.02V   | 0.541s | 269.7V<br>0.98s | No trip occurred |
|                           |         |            |           |        | 277.7V<br>0.48s | No trip occurred |

Note. For Voltage tests the voltage required to trip is the setting plus or minus 3.45V. 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  $\pm 4V$  and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

|  |                                      |                                      |                                      |                                       |                                       |                                       |
|--|--------------------------------------|--------------------------------------|--------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| <p><b>a) Protection. Loss of Mains test and single phase test.</b> The tests are to be carried out at three output power levels plus or minus 5%, an alternative for inverter connected Generating Units can be used instead.</p>  |                                      |                                      |                                      |                                       |                                       |                                       |
| <p>To be carried out at three output power levels plus or minus 5%, an alternative for inverter connected Generating Units can be used instead.</p>  |                                      |                                      |                                      |                                       |                                       |                                       |
| Test Power   | 10%                                  | 55%                                  | 100%                                 | 10%                                   | 55%                                   | 100%                                  |
| Balancing load on islanded network   | 95% of <b>Generating Unit</b> output | 95% of <b>Generating Unit</b> output | 95% of <b>Generating Unit</b> output | 105% of <b>Generating Unit</b> output | 105% of <b>Generating Unit</b> output | 105% of <b>Generating Unit</b> output |
| Trip time. Limit is 0.5s   | 0.246s                               | 0.246s                               | 0.053s                               | 0.500s                                | 0.500s                                | 0.460s                                |
| <p>Note. For technologies which have a substantial shut down time this can be added to the 0.5s in establishing that the trip occurred in less than 0.5s maximum. Shut down time could therefore be up to 1.0s for these technologies.</p>   |                                      |                                      |                                      |                                       |                                       |                                       |
| Indicate additional shut down time included in above results   |                                      |                                      |                                      |                                       | --                                    |                                       |
| <p>Note as an alternative, inverters can be tested to BS EN 62116. The following sub set of tests should be recorded in the following table.</p>   |                                      |                                      |                                      |                                       |                                       |                                       |
| Test Power and imbalance   | 33%<br>-5% Q<br>Test 22              | 66%<br>-5% Q<br>Test 12              | 100%<br>-5% P<br>Test 5              | 33%<br>+5% Q<br>Test 31               | 66%<br>+5% Q<br>Test 21               | 100%<br>+5% P<br>Test 10              |
| Trip Time. Limit is 0.5s   | --                                   | --                                   | --                                   | --                                    | --                                    | --                                    |
| <p>Single phase test for multi phase <b>Generating Units</b>. Confirm that when generating in parallel with a network operating at around 50Hz with no network disturbance, that the removal of a single phase connection to the <b>Generating Unit</b>, with the remaining phases connected causes a disconnection of the generating unit within a maximum of 1s.</p> |                                      |                                      |                                      |                                       |                                       |                                       |
|  | Ph1 removed                          | Confirm Trip                         | Ph2 removed                          | Confirm Trip                          | Ph3 removed                           | Confirm Trip                          |

| b) Protection. Frequency change, Stability test |                 |                         |               |                  |
|---|-----------------|-------------------------|---------------|------------------|
|   | Start Frequency | Change                  | End Frequency | Confirm no trip  |
| Positive Vector Shift                           | 49.5Hz          | +9 degrees              |               | No trip occurred |
| Negative Vector Shift                           | 50.5Hz          | -9 degrees              |               | No trip occurred |
| Positive Frequency drift                        | 49.5Hz          | +0.19Hz/s <sup>-1</sup> | 51.5Hz        | No trip occurred |
| Negative Frequency drift                        | 50.5Hz          | -0.19Hz/s <sup>-1</sup> | 47.5Hz        | No trip occurred |

| c) Protection. Re-connection timer. The tests should prove that the reconnection sequence starts in no less than 20s for restoration of voltage and frequency to within the stage 1 settings of table 10.5.7.1 |                    |  |  |                        |                        |                        |
|--|--------------------|--|--|------------------------|------------------------|------------------------|
| Test should prove that the reconnection sequence starts in no less than 20s for restoration of voltage and frequency to within the stage 1 settings of table 10.5.7.1.   |                    |  |  |                        |                        |                        |
| Time delay setting (s)   | Measured delay (s) |  | Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 10.5.7.1. |                        |                        |                        |
| 20s  | 25s                |  | At 266.2V  | At 196.1V              | At 47.4Hz              | At 51.6Hz              |
| Confirmation that the <b>Generating Unit</b> does not re-connect.  |                    |  | No re-connect occurred   | No re-connect occurred | No re-connect occurred | No re-connect occurred |

| d) Fault level contribution.  |          |       |                     |        |                 |
|---|----------|-------|---------------------|--------|-----------------|
| For machines with electro-magnetic output   |          |       | For Inverter output |        |                 |
| Parameter   | Symbol   | Value | Time after fault    | Volts  | Amps            |
| Peak Short Circuit current  | $i_p$    | --    | 20ms                | 12.7V  | 32.2A           |
| Initial Value of aperiodic current  | $A$      | --    | 100ms               | 9.38V  | 25.4A           |
| Initial symmetrical short-circuit current*  | $I_k$    | --    | 250ms               | 8.80V  | 16.5A           |
| Decaying (aperiodic) component of short circuit current*  | $i_{DC}$ | --    | 500ms               | 8.55V  | 12.1A           |
| Reactance/Resistance Ratio of source*   | $X/R$    | --    | Time to trip        | 66.1ms | In milliseconds |
| For rotating machines and linear piston machines the test should produce a 0s – 2s plot of the sort circuit current as seen at the Generating Unit terminals. |          |       |                     |        |                 |
| *Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot                     |          |       |                     |        |                 |



| e) Self-Monitoring solid state switching  | Yes/or NA  |
|---|--|
| It has been verified that in the event of the solid state switching device failing to disconnect the <b>Generating Unit</b> , the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 seconds. | NA<br>(because electro-mechanical relays are used) |

| Additional comments |
|---------------------|
|                     |