

G98/1-2 Type Test Verification Report

| | | | |
|---|--|---|---------------------------|
| Inverter Model | | ATG-3K-T, ATG-4K-T | |
| Manufacturer Reference number | | | |
| Micro-generator technology | | Hybrid inverter | |
| Manufacturer name | | Aton Green Storage SpA | |
| Registered office address | | Via Nuova Circonvallazione, 57/B - 47923 Rimini (RN), Italy | |
| Operational headquarters address | | Via Guido Rossa, 5 – 41057 Spilamberto (MO), Italy | |
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| E:mail | a.ferrero@atonstorage.com | E:mail | a.ferrero@atonstorage.com |
| Maximum rated capacity | Connection Option | | |
| | 3 | kW single phase | |
| | 3.68 | | |
| <p>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.</p> | | | |
| Signed | Mr. Ettore Uguzzoni  | On behalf of | Aton Green Storage SpA |
| <p>The tests were carried out by personnel with sufficient technical competence at:</p> <ul style="list-style-type: none"> - the internal laboratories of the Company that produces the Equipment Under Test on behalf of the Manufacturer and with the Manufacturer's brand: Jiangsu GoodWe Power Supply Technology Co., Ltd. - No. 90 Zijin Road, Suzhou New District, Jiangsu, PRC; - or at external laboratories identified by Jiangsu GoodWe Power Supply Technology Co., Ltd. <p>All organizations involved in the tests keep copies of all records of the tests and results.</p> | | | |

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 | Result Pass |
| Test 2 Voltage = 110% of nominal (253 V). Frequency = 51.5 Hz Power factor = 1 Period of test 90 minutes | Result Pass |
| Test 3 Voltage = 110% of nominal (253 V). Frequency = 52.0 Hz Power factor = 1 Period of test 15 minutes | Result Pass |

| | | | | | | |
|--|----------------------------------|-------------------------------|-----------------------------|-------------------------------|---------------------------------|---|
| 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). | | | | | | Pass |
| Micro-generator tested to BS EN 61000-3-2 | | | | | | |
| Micro-generator rating per phase (rpp) | | | 3.6kW | | $NV = MV * 3.68 / rpp$ | |
| | At 45-55% of Registered Capacity | | 100% of Registered Capacity | | | |
| Harmonic | Measured Value (MV) in Amps | Normalized Value (NV) in Amps | Measured Value (MV) in Amps | Normalized Value (NV) in Amps | Limit in BS EN61000-3-2 in Amps | Higher limit for odd harmonics 21 and above |
| 2nd | 0.129 | 0.131 | 0.256 | 0.262 | 1.080 | |
| 3rd | 0.108 | 0.110 | 0.107 | 0.110 | 2.300 | |
| 4th | 0.013 | 0.014 | 0.020 | 0.020 | 0.430 | |
| 5th | 0.070 | 0.071 | 0.077 | 0.079 | 1.140 | |
| 6th | 0.011 | 0.012 | 0.019 | 0.020 | 0.300 | |
| 7th | 0.066 | 0.067 | 0.063 | 0.064 | 0.770 | |
| 8th | 0.007 | 0.008 | 0.008 | 0.008 | 0.230 | |
| 9th | 0.049 | 0.050 | 0.053 | 0.055 | 0.400 | |
| 10th | 0.007 | 0.007 | 0.005 | 0.006 | 0.184 | |

| | | | | | | |
|------|-------|-------|-------|-------|-------|-------|
| 11th | 0.046 | 0.047 | 0.042 | 0.043 | 0.330 | |
| 12th | 0.004 | 0.005 | 0.011 | 0.011 | 0.153 | |
| 13th | 0.036 | 0.037 | 0.035 | 0.035 | 0.210 | |
| 14th | 0.007 | 0.008 | 0.010 | 0.011 | 0.131 | |
| 15th | 0.038 | 0.039 | 0.030 | 0.031 | 0.150 | |
| 16th | 0.003 | 0.003 | 0.004 | 0.004 | 0.115 | |
| 17th | 0.030 | 0.031 | 0.023 | 0.023 | 0.132 | |
| 18th | 0.003 | 0.003 | 0.006 | 0.006 | 0.102 | |
| 19th | 0.026 | 0.027 | 0.018 | 0.018 | 0.118 | |
| 20th | 0.006 | 0.006 | 0.008 | 0.008 | 0.092 | |
| 21th | 0.022 | 0.023 | 0.015 | 0.015 | 0.107 | 0.160 |
| 22th | 0.006 | 0.006 | 0.003 | 0.003 | 0.084 | |
| 23th | 0.020 | 0.020 | 0.013 | 0.014 | 0.098 | 0.147 |
| 24th | 0.007 | 0.008 | 0.005 | 0.006 | 0.077 | |
| 25th | 0.018 | 0.019 | 0.013 | 0.013 | 0.090 | 0.135 |
| 26th | 0.006 | 0.006 | 0.002 | 0.002 | 0.071 | |
| 27th | 0.015 | 0.016 | 0.012 | 0.012 | 0.083 | 0.124 |
| 28th | 0.006 | 0.006 | 0.003 | 0.003 | 0.066 | |
| 29th | 0.013 | 0.014 | 0.009 | 0.009 | 0.078 | 0.117 |
| 30th | 0.006 | 0.006 | 0.002 | 0.002 | 0.061 | |
| 31th | 0.011 | 0.011 | 0.009 | 0.009 | 0.073 | 0.109 |
| 32th | 0.006 | 0.006 | 0.003 | 0.003 | 0.058 | |
| 33th | 0.010 | 0.010 | 0.008 | 0.008 | 0.068 | 0.102 |
| 34th | 0.006 | 0.007 | 0.003 | 0.003 | 0.054 | |
| 35th | 0.008 | 0.008 | 0.007 | 0.007 | 0.064 | 0.096 |
| 36th | 0.006 | 0.007 | 0.004 | 0.004 | 0.051 | |
| 37th | 0.006 | 0.006 | 0.007 | 0.007 | 0.061 | 0.091 |
| 38th | 0.006 | 0.006 | 0.004 | 0.004 | 0.048 | |
| 39th | 0.005 | 0.005 | 0.006 | 0.006 | 0.058 | 0.087 |
| 40th | 0.005 | 0.005 | 0.004 | 0.004 | 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). | | | | | | | | Pass | |
|--|------------------|----------------|------------------|------------------|----------------|------------------|----------------|-------------|--|
| | Starting | | | Stopping | | | Running | | |
| | d _{max} | d _c | d _(t) | d _{max} | d _c | d _(t) | Pst | Plt 2 hours | |
| Measured Values at test impedance | 0.44 | 0.04 | 0 | 0.48 | 0.05 | 0 | 0.19 | 0.17 | |
| Normalised to standard impedance | 0.352 | 0.032 | 0 | 0.384 | 0.04 | 0 | 0.152 | 0.136 | |
| Limits set under BS EN 61000-3-2 | 4% | 3.3% | 3.3% | 4% | 3.3% | 3.3% | 1.0 | 0.65 | |

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 normalized values where the power factor of the generation output is 0.98 or above.

Normalized value = Measured value × reference source resistance/measured source resistance at test point × 3.68/rating per phase.

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.

| Power quality. DC injection | | | | Pass |
|--|---------|--------|--------|-------------|
| This test should be carried out in accordance with EN 50438 Annex D.3.10 | | | | |
| Test level power | 20% | 50% | 75% | 100% |
| Recorded value in Amps | 2.5mA | 1.6mA | 4mA | 4.4mA |
| As % of rated AC current | 0.0125% | 0.008% | 0.020% | 0.022% |
| Limit | 0.25% | 0.25% | 0.25% | 0.25% |

| Power Quality. Power factor | | | Pass |
|--|---------|--------|-------------|
| 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 | 0.9644 | 0.9580 | 0.9785 |
| 50% of Registered Capacity | 0.9964 | 0.9956 | 0.9937 |
| 75% of Registered Capacity | 0.9987 | 0.9986 | 0.9980 |
| 100% of Registered Capacity | 0.9990 | 0.9991 | 0.9990 |
| Limit | >0.95 | >0.95 | >0.95 |

| Protection. Frequency test | | | | | | Pass |
|---|-----------|------------|-----------|------------|------------------|-----------------|
| 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 test | |
| | Frequency | Time delay | Frequency | Time delay | Frequency / time | Confirm no trip |
| U/F stage 1 | 47.5 Hz | 20 s | 47.49 Hz | 20.23s | 47.7Hz / 30s | no trip |
| U/F stage 2 | 47 Hz | 0.5 s | 47.00 Hz | 0.65s | 47.2Hz / 19.5s | no trip |
| | | | | | 46.8Hz / 0.45s | no trip |
| O/F stage 1 | 52 Hz | 0.5 s | 52.01 Hz | 0.64s | 51.8Hz / 120s | no trip |
| | | | | | 52.2Hz / 0.45s | no trip |
| 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 test | | | | | | Pass |
|---|---------|------------|-----------|------------|----------------|-----------------|
| The requirement is specified in section 5.3.1, test procedure in Annex A or B 1.3.2 | | | | | | |
| Function | Setting | | Trip test | | No trip test | |
| | Voltage | Time delay | Voltage | Time delay | Voltage / time | Confirm no trip |
| U/V stage 1 | 184 V | 2.5 s | 185.3V | 2.63s | 188V / 5s | no trip |
| | | | | | 180V / 2.45s | no trip |
| O/V stage 1 | 262.2 V | 1.0 s | 261.9V | 1.11s | 258.2V 5.0s | no trip |
| O/V stage 2 | 273.7 V | 0.5 s | 273.2V | 0.642s | 269.7V 0.95s | no trip |
| | | | | | 277.7V 0.45s | 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.

For **Inverters** tested to BS EN 62116 the following sub set of tests should be recorded in the following table.

| Test Power | 33% | 66% | 100% | 33% | 66% | 100% |
|------------------------------------|------------------|------------------|-----------------|------------------|------------------|------------------|
| Balancing load on islanded network | -5% Q Test 22 | -5% Q Test 12 | -5% P Test 5 | +5% Q Test 31 | +5% Q Test 21 | +5% P Test 10 |
| Trip time. Limit is 0.5s | 0.0868s | 0.0998s | 0.145s | 0.110s | 0.1304s | 0.1512s |

For other Inverters should be tested in accordance with EN 50438 Annex D.2.5 at 10%, 55% and 100% of rated power. the following sub set of tests should be recorded in the following table

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.

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. Ph1 | NA | NA | NA | NA | NA | NA |
| Trip time. Ph2 | NA | NA | NA | NA | NA | NA |
| Trip time. Ph3 | NA | NA | NA | NA | NA | NA |

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

| | | | |
|---|-----------------|--------------|-----------------|
| 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). | | | Pass |
| | Start Frequency | Change | Confirm no trip |
| Positive Vector Shift | 49Hz | +50 degrees | no trip |
| Negative Vector Shift | 50.5Hz | - 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). | | | Pass |
| Ramp range | Test frequency ramp: | Test Duration | Confirm no trip |
| 49.0 Hz to 51.0 Hz | +0.95Hz/sec | 2.1 s | no trip |
| 51.0 Hz to 49.0 Hz | -0.95Hz/sec | 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%. | | | | Pass |
|--|------------------------------|-----------|----------------------|-----------------------|
| 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 | 50 | 3837 | |
| Step b) 50.45 Hz ±0.05 Hz | 3641 | 50.45 | 3805 | 16.67% |
| Step c) 50.70 Hz ±0.10 Hz | 3467 | 50.7 | 3622 | 18.89% |
| Step d) 51.15 Hz ±0.05 Hz | 3134 | 51.15 | 3272 | 19.89% |
| Step e) 50.70 Hz ±0.10 Hz | 3467 | 50.7 | 3621 | 18.89% |
| Step f) 50.45 Hz ±0.05 Hz | 3639 | 50.45 | 3804 | 17.78% |
| Step g) 50.00 Hz ±0.01 Hz | 3654 | 50 | 3820 | |
| 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 | 1844 | 50 | 1938 | |
| Step b) 50.45 Hz ±0.05 Hz | 1808 | 50.45 | 1903 | 20.00% |
| Step c) 50.70 Hz ±0.10 Hz | 1644 | 50.7 | 1730 | 18.52% |
| Step d) 51.15 Hz ±0.05 Hz | 1309 | 51.15 | 1394 | 19.81% |
| Step e) 50.70 Hz ±0.10 Hz | 1641 | 50.7 | 1727 | 18.80% |
| Step f) 50.45 Hz ±0.05 Hz | 1806 | 50.45 | 1903 | 21.11% |
| Step g) 50.00 Hz ±0.01 Hz | 1847 | 50 | 1941 | |

| 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. | | | | Pass |
|---|-------------------------------------|-----------|----------------------|-------------|
| Test sequence | Measured Active Power Output | Frequency | Primary power source | |
| Test a) 50 Hz ± 0.01 Hz | 3615 | 50 | 4003 | |
| Test b) Point between 49.5 Hz and 49.6 Hz | 3604 | 49.55 | 4019 | |
| Test c) Point between 47.5 Hz and 47.6 Hz | 3617 | 47.55 | 4021 | |
| NOTE: The operating point in Test (b) and (c) shall be maintained for at least 5 minutes | | | | |

| Protection. Re-connection time | | | | Pass |
|---|-----------------|-----------------|-----------------|-----------------|
| 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 | 30s | | | |
| Measured delay time(s) | At 258.2V | At 204.1V | At 47.6Hz | At 51.9Hz |
| | 47s | 47.4s | 47.4s | 46.4s |
| Confirmation that the SSEG does not re-connect | At 266.2V | At 196.1V | At 47.4Hz | At 52.1Hz |
| | no reconnection | no reconnection | no reconnection | no reconnection |

| | | |
|---|--------|-------------|
| 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). | | Pass |
| For a Inverter SSEG | | |
| Time after fault | Volts | Amps |
| 20ms | 3.464 | 8.1878 |
| 100ms | 6.544 | -10.8917 |
| 250ms | 2.849 | -5.2014 |
| 500ms | -2.695 | -0.8449 |
| Time to trip | 59.2ms | In seconds |
| 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 |

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| Additional comments |
| ATG-3K-T is similar to ATG-4K-T in circuit and construction except for rating. The test result can refer to ATG-4K-T |