**Certificate G59/3**
Engineering Recommendation

The results of the G59/3 test are summarized in this certificate. Delta Energy Systems (Germany) GmbH declares that devices shipped to the UK comply with the requirements defined in engineering recommendation G59/3 :2013.

Hereby tests Delta Energy Systems internal test results for Solivia three phase and Grid Tied Inverters.

| | Max. apparent power (VA) | Rated AC power (VA) |
|---|---|---|
| SOLIVIA 15 EU G4 TL EOE48010362 | 15750 | 15000 |
| SOLIVIA 20 EU G4 TL EOE48010364 | 21000 | 20000 |
| SOLIVIA 30 EU T4 TL EOE48030458 | 30000* | 30000 |

Note that all tests were carried out on the largest inverter of the family under tests. The results for the other inverters of the family are equivalent.
These settings are available when inverter runs at least with following FW components, or upper:

RED >= 1.50 / DSP >= 2.16 / COMM >= 2.20

Delta Energy Systems (Germany) GmbH can only certify performances related to inverters (not for requirements related to the solar plant system).

Teningen, December 2nd, 2014

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**max possible power can be set to 31.5KVA by setting tunings*

## 1.1. Harmonics

| Harmonics as per BS EN 61000-3-12 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Order | Freq. (Hz) | P/Pn(%) | | | | | |
| | | 50% | | 100% | | Limit I/In (%) / Results | |
| | | Measured (A) / (%) | | Measured (A) / (%) | | | |
| 2 | 100 | 0,06 | 0,14% | 0,048 | 0,11% | 8,0% | Ok |
| 3 | 150 | 0,011 | 0,03% | 0,037 | 0,09% | N/A | - |
| 4 | 200 | 0,043 | 0,10% | 0,039 | 0,09% | 4,0% | Ok |
| 5 | 250 | 0,184 | 0,43% | 0,106 | 0,25% | 10,7% | Ok |
| 6 | 300 | 0,06 | 0,14% | 0,055 | 0,13% | 2,7% | Ok |
| 7 | 350 | 0,146 | 0,34% | 0,084 | 0,20% | 7,2% | Ok |
| 8 | 400 | 0,042 | 0,10% | 0,035 | 0,08% | 2,0% | Ok |
| 9 | 450 | 0,017 | 0,04% | 0,016 | 0,04% | N/A | - |
| 10 | 500 | 0,012 | 0,03% | 0,018 | 0,04% | 1,6% | Ok |
| 11 | 550 | 0,04 | 0,09% | 0,105 | 0,24% | 3,1% | Ok |
| 12 | 600 | 0,007 | 0,02% | 0,011 | 0,03% | 1,3% | Ok |
| 13 | 650 | 0,215 | 0,50% | 0,124 | 0,29% | 2,0% | Ok |
| 14 | 700 | 0,01 | 0,02% | 0,009 | 0,02% | - | - |
| 15 | 750 | 0,011 | 0,03% | 0,02 | 0,05% | - | - |
| 16 | 800 | 0,021 | 0,05% | 0,017 | 0,04% | - | - |
| 17 | 850 | 0,1 | 0,23% | 0,057 | 0,13% | - | - |
| 18 | 900 | 0,02 | 0,05% | 0,018 | 0,04% | - | - |
| 19 | 950 | 0,118 | 0,27% | 0,136 | 0,32% | - | - |
| 20 | 1000 | 0,021 | 0,05% | 0,015 | 0,03% | - | - |
| 21 | 1050 | 0,006 | 0,01% | 0,013 | 0,03% | - | - |
| 22 | 1100 | 0,007 | 0,02% | 0,011 | 0,03% | - | - |
| 23 | 1150 | 0,075 | 0,17% | 0,07 | 0,16% | - | - |
| 24 | 1200 | 0,002 | 0,00% | 0,006 | 0,01% | - | - |
| 25 | 1250 | 0,031 | 0,07% | 0,044 | 0,10% | - | - |
| 26 | 1300 | 0,003 | 0,01% | 0,004 | 0,01% | - | - |
| 27 | 1350 | 0,006 | 0,01% | 0,01 | 0,02% | - | - |
| 28 | 1400 | 0,005 | 0,01% | 0,005 | 0,01% | - | - |
| 29 | 1450 | 0,047 | 0,11% | 0,042 | 0,10% | - | - |
| 30 | 1500 | 0,004 | 0,01% | 0,006 | 0,01% | - | - |
| 31 | 1550 | 0,023 | 0,05% | 0,036 | 0,08% | - | - |
| 32 | 1600 | 0,006 | 0,01% | 0,005 | 0,01% | - | - |
| 33 | 1650 | 0,001 | 0,00% | 0,006 | 0,01% | - | - |
| 34 | 1700 | 0,004 | 0,01% | 0,007 | 0,02% | - | - |
| 35 | 1750 | 0,024 | 0,06% | 0,028 | 0,07% | - | - |
| 36 | 1800 | 0,001 | 0,00% | 0,003 | 0,01% | - | - |
| 37 | 1850 | 0,021 | 0,05% | 0,028 | 0,07% | - | - |
| 38 | 1900 | 0,001 | 0,00% | 0,005 | 0,01% | - | - |
| 39 | 1950 | 0,001 | 0,00% | 0,009 | 0,02% | - | - |
| 40 | 2000 | 0,003 | 0,01% | 0,005 | 0,01% | - | - |
| THD | - | 1.77% | - | 0,71% | - | - | - |
| PWHD | - | 3.94% | - | 2.07% | - | - | - |

### 1.2. Power Quality

| Voltage fluctuations and flicker as per BS EN 61000-3-11 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Starting | | | Stopping | | | Running | |
| | dmax | Dc | d(t) in ms | dmax | dc | d(t) in ms | Pst | Plt (2h) |
| Limits under BS EN 61000 3-11 | 4% | 3.3% | 3.3% / 500ms | 4% | 3.3% | 3.3% / 500ms | 1.0 | 0.65 |
| Measured | 0.244% | 0.031% | 0 | 0.258% | 0.031% | 0 | 0.198 | 0.126 |
| Verification | Ok | Ok | Ok | Ok | Ok | Ok | Ok | Ok |
| Test Impedance | 0.133+0.0833j | | | 0.133+0.0833j | | | | |

| Dc Injection | | | |
|---|---|---|---|
| | P/Pn (%) | | |
| | 10 % | 55 % | 100% |
| Limit | 0.25%In | 0.25%In | 0.25%In |
| measured | 11.6mA | -52mA | -67mA |
| %Inom | 0.026% | 0.119% | 0.154% |
| Verification | Ok | Ok | Ok |

| Power factor | | | |
|---|---|---|---|
| | Voltage (V) | | |
| | 216.4V | 230V | 253V |
| Limit | 0.95 | 0.95 | 0.95 |
| measured | 0.996 | 0.996 | 0.996 |
| Verification | Ok | Ok | Ok |

### 1.3. Protection – Grid monitoring and reconnection time

| **Trip Tests** | G59/3 | | Settings | | Measures Values | | Verification |
|---|---|---|---|---|---|---|---|
| Function | Magnitude | Time | Magnitude | Time | Magnitude | Time | |
| UnderVoltage stage1 | 200.1V | 2.5s | 200.1V | 2.5s | 200.1 | 2.5s | Ok |
| UnderVoltage stage2 | 184V | 0.5s | 184V | 0.5s | 183.9 | 0.5s | Ok |
| OverVoltage stage1 | 262.2V | 1s | 262.2V | 1s | 262.8V | 1.0s | Ok |
| OverVoltage stage2 | 273.7V | 0.5s | 273.7V | 0.5s | 274.2V | 0.5s | Ok |
| UnderFrequency stage1 | 47.5Hz | 20s | 47.5Hz | 20s | 47.5Hz | 20s | Ok |
| UnderFrequency stage2 | 47Hz | 0.5s | 47Hz | 0.5s | 47Hz | 0.5s | Ok |
| OverFrequency stage1 | 51.5Hz | 90s | 51.5Hz | 90s | 51.5Hz | 91s | Ok |
| OverFrequency stage2 | 52Hz | 0.5s | 52Hz | 0.5s | 52Hz | 0.5s | Ok |

| **No Trip test** | G59/3 | | Verification |
|---|---|---|---|
| | Magnitude | Time | |
| UnderVoltage 1 | 204.1V | 3.5s | Ok |
| UnderVoltage 2 | 188V | 2.48s | Ok |
| UnderVoltage 3 | 180V | 0.48s | Ok |
| OverVoltage 1 | 258.2V | 2s | Ok |
| OverVoltage 2 | 269.7V | 0.98s | Ok |
| OverVoltage 3 | 277.7V | 0.48s | Ok |

| **No Trip test** | G59/3 | | Verification |
|---|---|---|---|
| | Magnitude | Time | |
| UnderFreq 1 | 47.7Hz | 25s | Ok |
| UnderFreq 2 | 47.2Hz | 19.98s | Ok |
| UnderFreq 3 | 46.8Hz | 0.48s | Ok |
| OverFreq 1 | 51.3Hz | 95s | Ok |
| OverFreq 2 | 51.8Hz | 89.98s | Ok |
| OverFreq 3 | 52.2Hz | 0.48s | Ok |

| Reconnection time (Voltage) | | | |
|---|---|---|---|
| Limit | Settings | Measured | Verification |
| 20s | 20s | 29.36s | Ok |

| No reconnection | | | |
|---|---|---|---|
| 266.2V | 196.1V | 47.4Hz | 51.6Hz |
| Ok | Ok | Ok | Ok |

| Reconnection time (Frequency) | | | |
|---|---|---|---|
| Limit | Settings | Measured | Verification |
| 20s | 20s | 29.59s | Ok |

### 1.4. Protection – Loss of main

| Test Power | 25% | 50% | 100% | 25% | 50% | 100% |
|---|---|---|---|---|---|---|
| Balancing load on island | 95% of generating unit output | | | 105% of generating unit output | | |
| Trip time limit :0.5s | 174ms | 100.6ms | 195ms | 151.4ms | 99.6ms | 177.6ms |
| | | | | | | |
| Phase1 removed | Phase2 removed | | | Phase3 removed | | |
| Trip confirmed | Trip confirmed | | | Trip confirmed | | |

| Protection Frequency change, stability test | Start Frequency | Change | End Frequency | Confirm no trip |
|---|---|---|---|---|
| Positive Vector Shift | 49.5Hz | +9 degrees | na | No Trip |
| Negative Vector Shift | 50.5Hz | -9 degrees | na | No Trip |
| Positive Frequency Shift | 49.5Hz | +0.19Hz/sec | 51.5Hz | No Trip |
| Negative Frequency Shift | 50.5Hz | -0.19Hz/sec | 47.5Hz | No Trip |

| Fault Level contribution | Volts | Amps r.m.s |
|---|---|---|
| Tine after Fault | | |
| 20ms | 27,04V | 28,05 |
| 100ms | 27,06V | N/A |
| 250ms | 27,06V | N/A |
| 500ms | 27,06V | N/A |
| Time to trip (s) | 0.074 | |

| Self-Monitoring – Solid state switching | |
|---|---|
| It has been verified that in the event of the solid state switching device failing to disconnect the generating unit, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5seconds. | |
| Note: Units do not provide solid state switching relays. In case the semiconductor bridge is switched off, then the voltage on the output drops to 0. In this case the relays on the output will also open | |