# Teseq - Schaffner
# Profline 2145-EOS

## Harmonics - Flicker Test System
## Calibration & Verification Report

for

# XXXXXXXX

**Xxxxxxxxxxxx**
**44227 Dortmund - Germany**

**Xxxxxxxx P.O.156688**

July 19-25, 2018
Mathieu van den Bergh

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## Summary of calibration activities, conclusions & recommendations, July 19-25 - 2018

### 1: Calibration and software update activities

The system for XXX was sent to San Diego for upgrade and calibration- the Profline 2145 system was inspected, and the calibration was verified.

The systems upgrade added a NSG2200-3 Dip switch for IEC61000-4-11 testing, power source upgrade (with new firmware) and regeneration option.

The initial data, which included verification of the power source output voltage levels was found to be well within permitted tolerances. Subsequently, a series of tests were run to verify that the system complies very well with the tolerances as required per the applicable IEC61000-3-2, IEC61000-3-3, IEC 61000-3-11, and 61000-3-12 standards, and the IEC 61000-4-7 and IEC61000-4-15 measurement standards. It was noticed, while running flicker tests the system was out of tolerance and needed to be adjusted. Once adjusted and verified all tests and tolerances were within the permitted values. Furthermore, the power source voltage linearity and frequency accuracy was verified, and found to be excellent, and well within the required tolerances per IEC 61000-4-14, and IEC 61000-4-28. Detailed data for the tests is provided in this report. In addition, performance per IEC61000-11 and IEC61000-4-13, IEC 61000-4-14 and IEC 61000-4-28 was verified. Note that the IEC 61000-4-11 tests also apply to IEC 61000-4-34.

Versions of WIN2100V4 (4.14) and WIN2106V2 (2.14) software was installed, and in part used to run the foregoing tests. The existing WIN2100V3 and WIN2106 software versions were left intact, as they are needed to replay existing tests data files. The newer software versions have slightly different data formats, and thus cannot replay older test data files.

### 2: Calibration equipment and ISO-17025 traceable calibration data

The list of primary test equipment, along with ISO-17025 traceable calibration certificate numbers is provided on page 3 of this report. Copies of calibration certificates can be provided upon request.

### 3: Conclusions and recommendations

Given the overall system performance, all measured parameters are well within permitted tolerances, and new calibration stickers were attached to the system. The calibration interval is at the discretion of the system user.

CNS Inc. will maintain copies of the updated calibration files, which are located in the root directory of the PC. It is recommended that the system user also make copies of the calibration files.

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Mathieu van den Bergh - CNS Inc.
August 4, 2018

## System inspection & calibration activities, July 21-25, 2018

### System inspection, software update and detailed tests

Upon arrival at Ametek San Diego, the 45 kVA - 3 phase Profline 2145 compliance test system was inspected for functionality and overall operability after upgrade. All measurements were well within their respective tolerances after flicker measurements were adjusted.

Version WIN2100V4.14 and WIN2106V2.14 software were installed. The existing versions were left intact, as they are needed to re-play existing data files. The latest version of WIN2100V4 updated the test reports to reference the latest editions of IEC 61000-3-2 (Ed. 4 – 2014) and IEC 61000-3-3 (Ed. 3 – 2013).

Overall voltage and current measurement accuracy was verified at multiple levels. Next, a series of harmonics and Flicker tests were run, including various test classes per IEC 61000-3-2, and a test per IEC 61000-3-12 Table-2. Flicker tests were run using the 18 Amp "Z-ref" impedance, as well as the 75 Amp "Z-test" impedance. While running these tests it was noticed that the impedance was just out of tolerance for both impedance units (partially due to the added wiring in the system from upgrade.). Once adjusted multiple tests were ran and was then found to be well within the permitted tolerances. Frequency accuracy in accordance with IEC61000-4-28 and voltage fluctuations in accordance with IEC 61000-4-14 were also verified. The latest version of the MXGUI software to control the 45 kVA power source was installed on the user's PC.

The system consists of the following building blocks;
Dell Precision PC with Intel i3 dual core processor, with Windows-7 Professional.
NSG-1007-45, 45 kVA power source s/n 1143A04873 Firmware version 5.40.
CCN-1000-3, 3 phase Signal conditioner unit, s/n 1143A04873
INA 2175 / OMNI-3-75i, 3 phase Reference Impedance with IEC61000-3-11 Z-test values, s/n 1143A04873
OMNI-3-18, 3 phase reference impedance per IEC-TR-60725 for IEC61000-3-3 testing s/n X71117
NSG2200-3 dip switch s/n EKA45995
NI-M series A/D card s/n1599673 (installed in PC)

**Temperature during calibration: 22 ºC ± 2 °C**
**Humidity during calibration: 55 % RH ± 5 %**

### Calibration equipment used:

| Model # | Serial # | Equipment type | ISO Trace # | Cal due date |
|---|---|---|---|---|
| 7003-257 | 0724 | Current shunt 36A | BL7118 | 2/07/2019 |
| 10 mV/A | NA | Current shunt 100A | CV4560 | 2/07/2019 |
| Fluke 8846A | 1998007 | 6.5 Digit Multimeter | CT5792 | 6/13/2020 |
| Agilent 34410A | MY45002306 | 6.5 Digit Multimeter, | BL2709 | 2/16/2019 |
| TDS2004B | C011624 | Digital storage scope | CN7004 | 2/15/2019 |
| DS6062V | 1301058 | Digital storage scope | AX6160 | 2/16/2019 |
| 570A | 103381623 | Handheld DVM | CN7003 | 2/15/2019 |
| HFCIII | 1406 | Calibrator | NA- verified with above equipment | |

**Profline 2145 System Calibration Test Data-voltage and current accuracy**

Note: The voltage reference readings were made at the output terminals, on the front of the system. Thus, there is a small voltage drop compared to the measurement point of the CCN1000-3. The impedances were set to bypass mode for the voltage and current measurements listed below. The system performance is excellent as evidenced by the test data, with only minor deviations compared to the permitted tolerances per standards.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **NRW EMC** | | | **Teseq Profline 2145** | | | | | |
| **Calibration Win2100V4 (<16 Amp) and WIN2106V2 > 16 Amp** | | | | | | | | |
| July 19-25 2018 | | | | | | | | |
| | | | | | | | | |
| **Phase-A data** | | **Profl** | | | | | **Profl** | |
| **Reference** | **Profl** | **error %** | **Reference** | | | **Profl** | **error %** | |
| **DVM-1** | **Voltage** | **voltage** | **DVM-2** | **Current** | | **Current** | **Current** | |
| | | | 100 mV/amp | | | | | |
| 229.952 | 230.06 | 0.047 | 0.1000 | 1.000 | | 1.001 | 1 mA | |
| 229.939 | 230.05 | 0.048 | 0.2000 | 2.000 | | 1.998 | -0.100 | |
| 229.622 | 229.97 | 0.152 | 0.5000 | 5.000 | | 5.003 | 0.060 | |
| 229.303 | 229.87 | 0.247 | 1.0000 | 10.000 | | 10.001 | 0.010 | |
| 228.800 | 229.75 | 0.415 | 1.6000 | 16.000 | | 16.000 | 0.000 | |
| 227.700 | 229.37 | 0.733 | 3.0000 | 30.000 | | 29.924 | -0.253 | |
| 226.973 | 229.18 | 0.972 | 4.0000 | 40.000 | | 39.900 | -0.250 | |
| 226.122 | 228.90 | 1.229 | 5.0000 | 50.000 | | 49.684 | -0.632 | |
| | | | | | | | | |
| **Phase-B data** | | | | | | | | |
| **Reference** | **Profl** | **error %** | **Reference** | | | **Profl** | **error %** | |
| **DVM-1** | **Voltage** | **voltage** | **DVM-2** | **Current** | | **Current** | **Current** | |
| | | | 100 mV/amp | | | | | |
| 229.941 | 230.09 | 0.065 | 0.1000 | 1.000 | | 1.000 | 0.000 | |
| 229.939 | 230.09 | 0.066 | 0.2000 | 2.000 | | 1.997 | -0.150 | |
| 229.726 | 230.04 | 0.137 | 0.5000 | 5.000 | | 4.997 | -0.060 | |
| 229.269 | 229.91 | 0.280 | 1.0000 | 10.000 | | 9.997 | -0.030 | |
| 228.780 | 229.79 | 0.441 | 1.6000 | 16.000 | | 15.995 | -0.031 | |
| 227.697 | 229.47 | 0.779 | 3.0000 | 30.000 | | 29.904 | -0.320 | |
| 226.947 | 229.22 | 1.002 | 4.0000 | 40.000 | | 39.853 | -0.367 | |
| 226.220 | 228.99 | 1.224 | 5.0000 | 50.000 | | 49.817 | -0.366 | |
| | | | | | | | | |
| **Phase-C data** | | | | | | | | |
| **Reference** | **Profl** | **error %** | **Reference** | | | **Profl** | **error %** | |
| **DVM-1** | **Voltage** | **voltage** | **DVM-2** | **Current** | | **Current** | **Current** | |
| | | | 100 mV/amp | | | | | |
| 229.961 | 230.09 | 0.056 | 0.1000 | 1.000 | | 1.000 | 0.000 | |
| 229.861 | 230.06 | 0.087 | 0.2000 | 2.000 | | 2.001 | 0.050 | |
| 229.660 | 229.99 | 0.144 | 0.5000 | 5.000 | | 5.000 | 0.000 | |
| 229.288 | 229.90 | 0.267 | 1.0000 | 10.000 | | 10.002 | 0.020 | |
| 228.804 | 229.76 | 0.418 | 1.6000 | 16.000 | | 16.001 | 0.006 | |
| 228.482 | 229.39 | 0.397 | 3.0000 | 30.000 | | 29.908 | -0.307 | |
| 226.924 | 229.15 | 0.981 | 4.0000 | 40.000 | | 39.897 | -0.257 | |
| 226.231 | 228.91 | 1.184 | 5.0000 | 50.000 | | 49.846 | -0.308 | |
| | | | | | | | | |
| **Measurement uncertainty:** | | | | **Voltage** | **+/- 0.1 %** | | | |
| (evaluation method per ISO-17025 - K=2) | | | | **Current** | **+/- 0.15 %** | | | |
| | | | | | | | | |
| **Permitted errors in standards:** | | | Harmonics IEC61000-3-2 | | | | **+/- 5% or +/- 5 mA** | |
| | | | Voltage IEC61000-4-7 | | | | **+/- 5%** | |
| | | | Flicker IEC61000-3-3 "Pst" | | | | **+/- 8 %** | |
| | | | Flicker IEC61000-3-3 "dc" | | | | **+/- 8 %** | |

Table-1 Overall voltage & Current data as found and as left

| Flicker test results per IEC61000-3-3 | | | | |
|---|---|---|---|---|
| | | | | |
| **Phase** | **Modulation** | **Target** | **Actual** | **error** |
| | **Freq.** | **Pst** | **Pst** | **%** |
| | | | | |
| A | 0.058 Hz | 1.186 | 1.183 | -0.25 |
| B | 0.325 Hz | 0.813 | 0.801 | -1.48 |
| C | 0.917 Hz | 1.006 | 0.99 | -1.59 |
| A | 13.5 Hz | 1.209 | 1.216 | 0.58 |
| **Flicker test results per IEC 61000-3-11** | | | | |
| A | 0.058 Hz | 0.747 | 0.756 | 1.20 |
| B | 0.325 Hz | 0.511 | 0.522 | 2.15 |
| C | 0.917 Hz | 0.663 | 0.655 | -1.21 |
| A | 13.5 Hz | 0.819 | 0.813 | -0.73 |
| | | | | |
| | | | | |
| **Permitted errors in standards:** | | | | |
| | | | | |
| Flicker IEC61000-3-3 and 61000-3-11 | | | | **+/- 8 %** |
| | | | | |
| | | | | |
| | | | | |
| **Voltage Fluctuations test IEC 61000-4-14** | | | | |
| Nominal voltage; 230.0 V-rms | | | | |
| **Programmed voltage** | | | **Actual** | **Deviation** |
| + 8 % | 248.4 | | 248.35 | -0.02% |
| - 8 % | 211.6 | | 211.58 | -0.01% |
| + 12 % | 257.6 | | 257.61 | 0.00% |
| - 12 % | 202.4 | | 202.33 | -0.03% |
| | | | | |
| **Frequency accuracy and variations IEC 61000-4-28** | | | | |
| **Programmed** | | **Actual** | | **Deviation** |
| 50.00 | | 50.0001 | | 0% |
| 60.00 | | 60.0000 | | 0% |
| 47.00 | | 46.9999 | | 0% |
| 53.00 | | 53.0000 | | 0% |
| 63.00 | | 63.0001 | | 0% |

Table-2 Flicker tests after adjustments were made and voltage fluctuation and frequency accuracy data

Voltage level, frequency accuracy and modulation and voltage variation are also included in the above Table-2 to provide testing per IEC61000-4-14 and -28. Data per IEC61000-4-11 and IEC 61000-4-13 can be found on pages 16 -20..

## Voltage & Current Calibration files

The calibration file is named “CTSMXH calibration.dat” for Win2106, and “CTS Calibration.dat” for the WIN2100V3 and WIN2100V4 software (for IEC61000-3-2 and 61000-3-3 testing). Back-up copies are maintained by CNS Inc. but the user should also make copies. If the Profline program needs to be re-installed, or the PC hard drive is upgraded, the calibration file will be required. The file contents are shown below, and can be used to recreate the file if so required.

The “calibration.log” file (see next page) shows the various parameters that were used, and recorded, during the calibration process. The values of the calibration factors show that the hardware is close to the ideal accuracies. For voltage and the current high range the software correction factors are very close to 1.000, while the factors for the middle and high current ranges are close to the ideal 1.333. Hence, this permits the conclusion that the hardware is highly accurate, and requires only minor corrections via the software calibration factors.

***Contents of the “CTSMXH calibration.dat” file;***

CTSMXH calibration.dat - Notepad

File Edit Format View Help

```
"1599673","12/03/2014","10:31:54 AM"
 100 , 40 , 8 , 2 , 100 , 40 , 8 , 2 , 100 , 40 , 8 , 2 , 1 , 1 , 1 , 1
 39 , 26 , 41 , 41 , 44 , 47 , 42 , 42 , 42 , 27 , 42 , 42 , 0 , 0 , 0 , 0
 1.609614E-04 , 1.612156E-04 , 2.172534E-04 , 2.169686E-04 , 1.608649E-04 ,
1.609389E-04 , 2.184537E-04 , 2.180579E-04 , 1.609614E-04 , 1.607957E-04 ,
2.173838E-04 , 2.17181E-04 , 1.525879E-04 , 1.525879E-04 , 1.525879E-04 ,
1.525879E-04
 32000 , 25000 , 25000 , 19999671
 1 , 250 , 796 , 400 , 370 , 90 , 159 , 400 , 796 , 150 , 477 , 210 , 230 , 100
, 318 , 190 , 140
 0
1143A04873
NSG1007-45
Mathieu CNS Inc
```

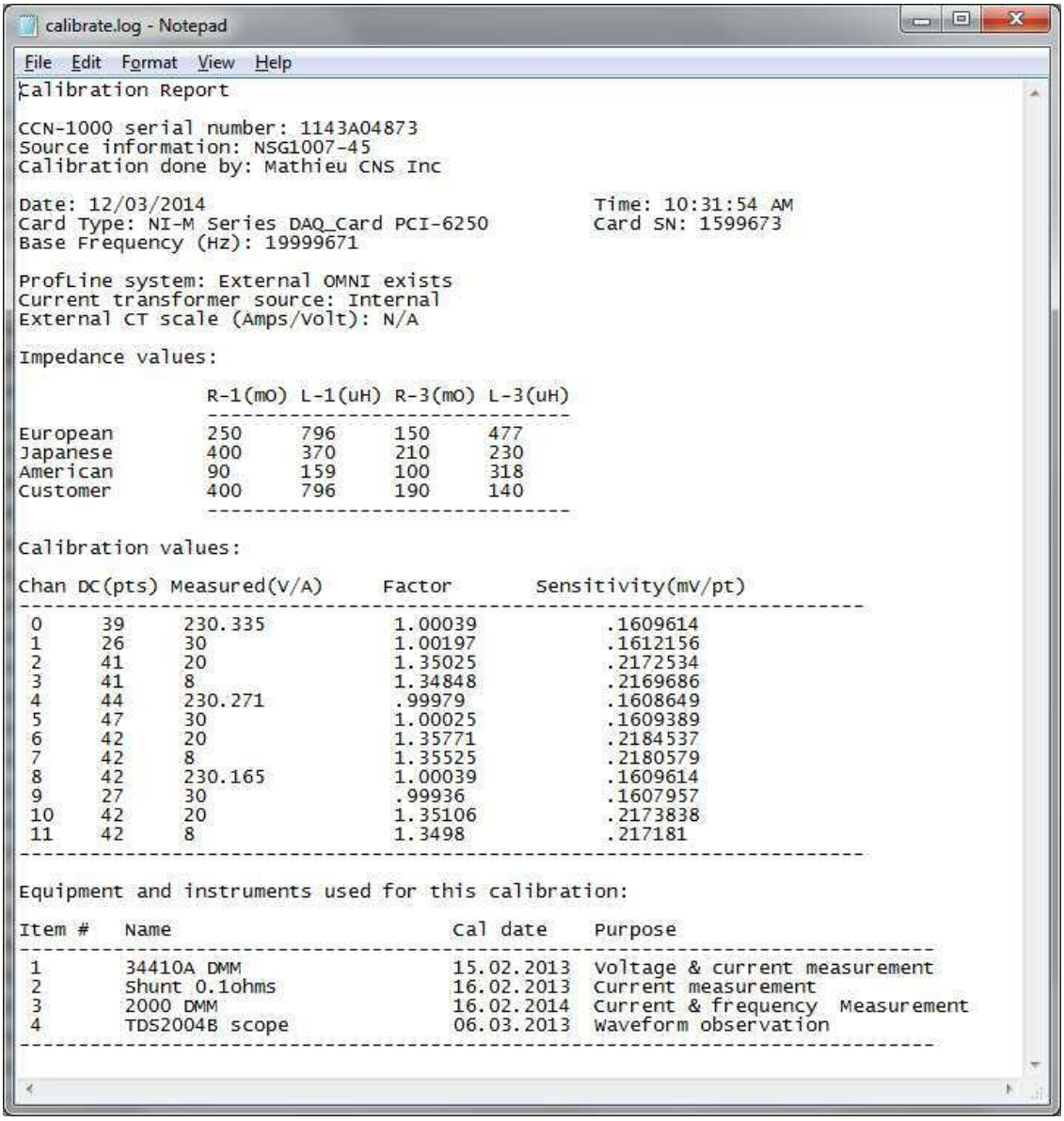
***Contents of the “CTS calibration.dat” file;***

CTS calibration.dat - Notepad

File Edit Format View Help

```
"1599673","12/3/2014","10:10:05 AM"
 100 , 40 , 8 , 2 , 100 , 40 , 8 , 2 , 100 , 40 , 8 , 2 , 1 , 1 , 1 , 1
 39 , 36 , 41 , 40 , 45 , 39 , 41 , 41 , 41 , 27 , 42 , 41 , 0 , 0 , 0 , 0
 1.608826E-04 , 1.614602E-04 , 2.172518E-04 , 2.16745E-04 , 1.608311E-04 ,
1.613395E-04 , 2.184618E-04 , 2.178713E-04 , 1.609534E-04 , 1.60897E-04 ,
2.172148E-04 , 2.171376E-04 , 1.525879E-04 , 1.525879E-04 , 1.525879E-04 ,
1.525879E-04
 32000 , 25000 , 25000 , 19999725
 0 , 400 , 796 , 400 , 370 , 400 , 796 , 400 , 796 , 240 , 477 , 190 , 230 , 240
, 477 , 240 , 477
 0
sn 1143A04873
NSG1007-45
Mathieu- CNS Inc File updated Dec.3, 2014
```

## Calibrate.log file



calibrate.log - Notepad

File Edit Format View Help

```
Calibration Report

CCN-1000 serial number: 1143A04873
Source information: NSG1007-45
Calibration done by: Mathieu CNS Inc

Date: 12/03/2014                                Time: 10:31:54 AM
Card Type: NI-M Series DAQ Card PCI-6250        Card SN: 1599673
Base Frequency (Hz): 19999671

ProfLine system: External OMNI exists
Current transformer source: Internal
External CT scale (Amps/Volt): N/A

Impedance values:

               R-1(mO) L-1(uH) R-3(mO) L-3(uH)
               -------------------------------
European       250     796     150     477
Japanese       400     370     210     230
American       90      159     100     318
Customer       400     796     190     140
               -------------------------------

Calibration values:

Chan DC(pts) Measured(V/A)     Factor       Sensitivity(mV/pt)
-------------------------------------------------------------------------
 0     39     230.335           1.00039          .1609614
 1     26     30                1.00197          .1612156
 2     41     20                1.35025          .2172534
 3     41     8                 1.34848          .2169686
 4     44     230.271           .99979           .1608649
 5     47     30                1.00025          .1609389
 6     42     20                1.35771          .2184537
 7     42     8                 1.35525          .2180579
 8     42     230.165           1.00039          .1609614
 9     27     30                .99936           .1607957
 10    42     20                1.35106          .2173838
 11    42     8                 1.3498           .217181
-------------------------------------------------------------------------

Equipment and instruments used for this calibration:

Item #   Name                        Cal date    Purpose
-----------------------------------------------------------------------------
 1       34410A DMM                  15.02.2013  Voltage & current measurement
 2       Shunt 0.1ohms               16.02.2013  Current measurement
 3       2000 DMM                    16.02.2014  Current & frequency  Measurement
 4       TDS2004B scope              06.03.2013  Waveform observation
-----------------------------------------------------------------------------
```

## Detailed harmonics & Flicker test data

The following pages illustrate details of the tests that were run to verify the accuracy and proper operation of the system. The tests included various harmonics patterns per Class-A, B, C and D of IEC61000-3-2, as well as Flicker tests per IEC 61000-3-3. Various screenshots were also done for IEC Standards 61000-4-11 and 61000-4-13. The detailed pages are produced by replaying the data files that were recorded during the actual system tests. The ideal values, along with the applied tolerance levels for this test are overlaid onto the CTS report page.

Page 9 shows a Class-A Pass test with page 10 a screenshot of the test.

Page 11 follows the same concept for the Class-A Fail test. As follows from pages 9 to 13 all harmonics are within a few mA of their ideal values. Permitted tolerance per IEC61000-3-2 is (1 % of the fundamental current + 10 mA), but the target accuracy used for the tests is (0.3 % + 5 mA). This approximately 3:1 safety ratio results for this test (2.3 A-rms fundamental) in a permitted tolerance of (7 mA + 5 mA) = 12 mA. The largest error is well within this tight tolerance, and thus an even smaller fraction of the actual tolerances permitted per IEC61000-3-2. Hence, the system performance is excellent.

Pages 12 and 13 are data for a Class C test set to just pass the limits and a Class D test set to fail the limits.

Page 15 shows a screenshot of a flicker test of a modulation of 13.5Hz.

Pages 16 to 20 are various screenshots of tests for IEC61000-4-11 and IEC61000-4-13

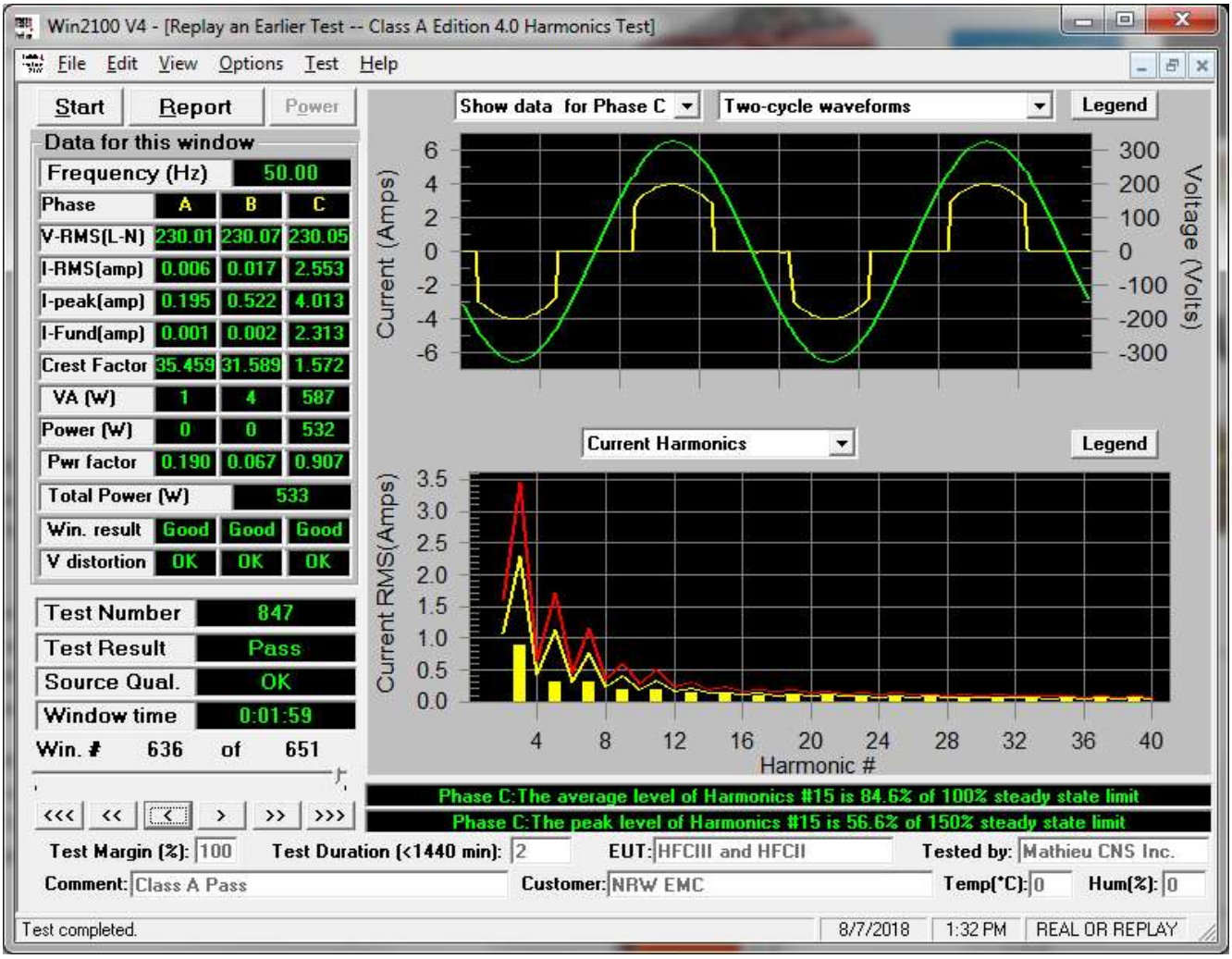
Page 21 illustrates the regeneration function using three of Ametek's solar inverters.

Page 22 shows photos of the system as found and with new calibration stickers applied.

## Detailed data for a Class-A PASS test

| Current Test Result Summary (Phase C-Replay) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EUT: HFCIII and HFCII | | | | | | Tested by: Mathieu CNS Inc. | | | | | | | | |
| Test category: Class-A per Ed. 4.0 (2014) (European limits) | | | | | | Test Margin: 100 | | | | | | | | |
| Test date: 7/19/2018 End time: 12:02:02 AM | | | | | | Start time: 11:59:39 PM | | | | | | | | |
| Test duration (min): 2 | | | | | | Data file name: H-000847.cts_data | | | | | | | | |
| Comment: Class A Pass | | | | | | | | | | | | | | |
| Customer: NRW EMC | | | | | | | | | | | | | | |
| Test Result: Pass Source qualification: Normal | | | | | | | | | | | | | | |
| THC(A): 1.069 I-THD(%): 46.1 POHC(A): 0.198 POHC Limit(A): 0.251 | | | | | | | | | | | | | | |
| Highest parameter values during test: | | | | | | | | | | | | | | |
| V_RMS (V | 230.07 | Frequency(Hz): | 50.00 | | | | | | THC-I | POHC | | | | |
| I_Peak (A | 4.022 | I_RMS (Ar | 2.557 | | | | | | 1.071 | 0.201 | | | | |
| I_Fund (A | 2.317 | Crest Fac | 1.574 | | | | | | | | | | | |
| Power (W | 533.3 | Power Fa | 0.907 | | | | | | | | | | | |
| | | | | | | | | | Ideal | Min | Max | Limits | Pass/Fail | Percent |
| Harm# | Harms(av | 100%Limit | %of Limit | Harms(ma | 150%Limit | %of Limit | Status | | 2.3148 | Tolerance | | | | of Limit |
| 2 | 0.001 | 1.08 | N/A | 0.001 | 1.62 | N/A | Pass | | 0.002 | 0.000 | 0.015 | 1.080 | PASS | 0 |
| 3 | 0.9 | 2.3 | 39.1 | 0.901 | 3.45 | 26.1 | Pass | | 0.899 | 0.854 | 0.942 | 2.300 | PASS | 39.1 |
| 4 | 0.001 | 0.43 | N/A | 0.001 | 0.645 | N/A | Pass | | 0.000 | 0.000 | 0.013 | 0.430 | PASS | 0 |
| 5 | 0.299 | 1.14 | 26.2 | 0.3 | 1.71 | 17.5 | Pass | | 0.301 | 0.286 | 0.315 | 1.140 | PASS | 26.4 |
| 6 | 0.001 | 0.3 | N/A | 0.001 | 0.45 | N/A | Pass | | 0.002 | 0.000 | 0.015 | 0.300 | PASS | 0 |
| 7 | 0.298 | 0.77 | 38.7 | 0.299 | 1.155 | 25.9 | Pass | | 0.299 | 0.284 | 0.314 | 0.770 | PASS | 38.9 |
| 8 | 0.001 | 0.23 | N/A | 0.001 | 0.345 | N/A | Pass | | 0.000 | 0.000 | 0.013 | 0.230 | PASS | 0 |
| 9 | 0.179 | 0.4 | 44.9 | 0.18 | 0.6 | 30.1 | Pass | | 0.181 | 0.168 | 0.193 | 0.400 | PASS | 45.2 |
| 10 | 0.001 | 0.184 | N/A | 0.001 | 0.276 | N/A | Pass | | 0.002 | 0.000 | 0.015 | 0.184 | PASS | 0 |
| 11 | 0.178 | 0.33 | 54 | 0.179 | 0.495 | 36.1 | Pass | | 0.179 | 0.167 | 0.192 | 0.330 | PASS | 54.3 |
| 12 | 0.001 | 0.153 | N/A | 0.001 | 0.23 | N/A | Pass | | 0.000 | 0.000 | 0.013 | 0.153 | PASS | 0 |
| 13 | 0.128 | 0.21 | 61.1 | 0.129 | 0.315 | 41.1 | Pass | | 0.129 | 0.117 | 0.142 | 0.210 | PASS | 61.6 |
| 14 | 0.001 | 0.131 | N/A | 0.001 | 0.197 | N/A | Pass | | 0.002 | 0.000 | 0.015 | 0.131 | PASS | 0 |
| 15 | 0.127 | 0.15 | 84.6 | 0.127 | 0.225 | 56.6 | Pass | | 0.128 | 0.115 | 0.141 | 0.150 | PASS | 85.3 |
| 16 | 0.001 | 0.115 | N/A | 0.001 | 0.173 | N/A | Pass | | 0.000 | 0.000 | 0.013 | 0.115 | PASS | 0 |
| 17 | 0.1 | 0.132 | 75.6 | 0.101 | 0.198 | 50.9 | Pass | | 0.101 | 0.088 | 0.113 | 0.132 | PASS | 76.1 |
| 18 | 0.001 | 0.102 | N/A | 0.001 | 0.153 | N/A | Pass | | 0.002 | 0.000 | 0.015 | 0.102 | PASS | 0 |
| 19 | 0.098 | 0.118 | 83 | 0.099 | 0.178 | 55.6 | Pass | | 0.099 | 0.087 | 0.112 | 0.118 | PASS | 83.9 |
| 20 | 0 | 0.092 | N/A | 0.001 | 0.138 | N/A | Pass | | 0.000 | 0.000 | 0.013 | 0.092 | PASS | 0 |
| 21 | 0.082 | 0.107 | 76.4 | 0.083 | 0.161 | 51.6 | Pass | | 0.083 | 0.070 | 0.095 | 0.107 | PASS | 77.0 |
| 22 | 0.001 | 0.084 | N/A | 0.001 | 0.125 | N/A | Pass | | 0.002 | 0.000 | 0.015 | 0.084 | PASS | 0 |
| 23 | 0.08 | 0.098 | 81.9 | 0.08 | 0.147 | 54.8 | Pass | | 0.081 | 0.068 | 0.094 | 0.098 | PASS | 82.9 |
| 24 | 0 | 0.077 | N/A | 0.001 | 0.115 | N/A | Pass | | 0.000 | 0.000 | 0.013 | 0.077 | PASS | 0 |
| 25 | 0.069 | 0.09 | 77 | 0.07 | 0.135 | 52 | Pass | | 0.070 | 0.057 | 0.083 | 0.090 | PASS | 77.7 |
| 26 | 0.001 | 0.071 | N/A | 0.001 | 0.107 | N/A | Pass | | 0.002 | 0.000 | 0.015 | 0.071 | PASS | 0 |
| 27 | 0.068 | 0.083 | 81.1 | 0.068 | 0.125 | 54.3 | Pass | | 0.069 | 0.056 | 0.081 | 0.083 | PASS | 82.3 |
| 28 | 0 | 0.066 | N/A | 0.001 | 0.099 | N/A | Pass | | 0.000 | 0.000 | 0.013 | 0.066 | PASS | 0 |
| 29 | 0.06 | 0.078 | 77.6 | 0.061 | 0.116 | 52.5 | Pass | | 0.061 | 0.048 | 0.073 | 0.078 | PASS | 78.2 |
| 30 | 0.001 | 0.061 | N/A | 0.001 | 0.092 | N/A | Pass | | 0.002 | 0.000 | 0.015 | 0.061 | PASS | 0 |
| 31 | 0.058 | 0.073 | 80.4 | 0.059 | 0.109 | 53.8 | Pass | | 0.059 | 0.047 | 0.072 | 0.073 | PASS | 81.7 |
| 32 | 0 | 0.058 | N/A | 0.001 | 0.086 | N/A | Pass | | 0.000 | 0.000 | 0.013 | 0.058 | PASS | 0 |
| 33 | 0.053 | 0.068 | 78 | 0.054 | 0.102 | 52.9 | Pass | | 0.054 | 0.041 | 0.066 | 0.068 | PASS | 78.7 |
| 34 | 0.001 | 0.054 | N/A | 0.001 | 0.081 | N/A | Pass | | 0.002 | 0.000 | 0.015 | 0.054 | PASS | 0 |
| 35 | 0.051 | 0.064 | 79.8 | 0.052 | 0.096 | 53.5 | Pass | | 0.052 | 0.040 | 0.065 | 0.064 | PASS | 81.3 |
| 36 | 0 | 0.051 | N/A | 0.001 | 0.077 | N/A | Pass | | 0.000 | 0.000 | 0.013 | 0.051 | PASS | 0 |
| 37 | 0.048 | 0.061 | 78.3 | 0.049 | 0.091 | 53.3 | Pass | | 0.048 | 0.035 | 0.061 | 0.061 | PASS | 79.0 |
| 38 | 0.001 | 0.048 | N/A | 0.001 | 0.073 | N/A | Pass | | 0.002 | 0.000 | 0.015 | 0.048 | PASS | 0 |
| 39 | 0.046 | 0.058 | 79.2 | 0.046 | 0.087 | 53.2 | Pass | | 0.047 | 0.034 | 0.059 | 0.058 | PASS | 80.9 |
| 40 | 0.001 | 0.046 | N/A | 0.001 | 0.069 | N/A | Pass | | 0.000 | 0.000 | 0.013 | 0.046 | PASS | 0 |

Test data and ideal values for test no. 847 (Class-A Pass) showing only milli-Amperes difference between ideal and actual values. The leftmost 8 columns show the measurement data, and the rightmost 6 columns show the "ideal" data and permitted tolerances for this test. The measured harmonics are within 5 mA of their ideal values, and the deviations are only a fraction of the permitted tolerances used by CNS, and thus are less than 1/3rd of the permitted tolerances specified in IEC 61000-3-2. See next page for a screen shot of actual test.




The above figure shows a test pattern with the non-linear load set to 45 – 135 degrees, and configured to pass the Class-A test The harmonics and the comparison vs. the ideal values is shown on the previous page (9), and illustrates that the system operates within a fraction of the harmonics tolerances mentioned earlier in this report.

Similar tests results were obtained for Class-B, C and Class-D test patterns. The observed deviations were in the ± 3 to 4 mA range, where acceptable tolerances per IEC 61000-3-2 are in the order of ± 25 – 30 mA.

## Detailed data for a Class-A FAIL test

| Current Test Result Summary (Phase A-Replay) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EUT: HFCIII and HFCII | | | | | | Tested by: Mathieu CNS Inc. | | | | | | | | |
| Test category: Class-A per Ed. 4.0 (2014) (European limits) | | | | | | Test Margin: 100 | | | | | | | | |
| Test date: 7/20/2018 | End time: 12:05:29 AM | | | | | Start time: 12:03:07 AM | | | | | | | | |
| Test duration (min): 2 | | | | | | Data file name: H-000848.cts_data | | | | | | | | |
| Comment: Class A Fail Phase A | | | | | | | | | | | | | | |
| Customer: NRW EMC | | | | | | | | | | | | | | |
| Test Result: Fail | Source qualification: Normal | | | | | | | | | | | | | |
| THC(A): 1.337 | I-THD(%): 46.2 | POHC(A): 0.248 | POHC Limit(A): 0.251 | | | | | | | | | | | |
| Highest parameter values during test: | | | | | | | | | THC-I | POHC | | | | |
| V_RMS (Volts | 229.94 | Frequency(Hz): | 50.00 | | | | | | 1.340 | 0.251 | | | | |
| I_Peak (Amps | 5.023 | I_RMS (Ar | 3.197 | | | | | | | | | | | |
| I_Fund (Amps | 2.896 | Crest Fac | 1.572 | | | | | | | | | | | |
| Power (Watts | 666.4 | Power Fa | 0.907 | | | | | | | | | | | |
| | | | | | | | | | Ideal | Min | Max | Limits | Pass/Fail | Percent |
| Harm# | Harms(av | 100%Limit | %of Limit | Harms(max) | 150%Limit | %of Limit | Status | | 2.895 | Tolerance | | | | of Limit |
| 2 | 0.002 | 1.08 | N/A | 0.002 | 1.62 | N/A | Pass | | 0.002 | 0.000 | 0.017 | 1.080 | PASS | 0 |
| 3 | 1.125 | 2.3 | 48.9 | 1.126 | 3.45 | 32.6 | Pass | | 1.125 | 1.069 | 1.178 | 2.300 | PASS | 48.9 |
| 4 | 0.001 | 0.43 | N/A | 0.001 | 0.645 | N/A | Pass | | 0.000 | 0.000 | 0.015 | 0.430 | PASS | 0 |
| 5 | 0.373 | 1.14 | 32.8 | 0.374 | 1.71 | 21.9 | Pass | | 0.376 | 0.357 | 0.394 | 1.140 | PASS | 33.0 |
| 6 | 0.001 | 0.3 | N/A | 0.001 | 0.45 | N/A | Pass | | 0.002 | 0.000 | 0.017 | 0.300 | PASS | 0 |
| 7 | 0.373 | 0.77 | 48.5 | 0.374 | 1.155 | 32.4 | Pass | | 0.374 | 0.356 | 0.392 | 0.770 | PASS | 48.6 |
| 8 | 0.001 | 0.23 | N/A | 0.001 | 0.345 | N/A | Pass | | 0.000 | 0.000 | 0.015 | 0.230 | PASS | 0 |
| 9 | 0.224 | 0.4 | 56.1 | 0.225 | 0.6 | 37.4 | Pass | | 0.226 | 0.211 | 0.241 | 0.400 | PASS | 56.5 |
| 10 | 0.001 | 0.184 | N/A | 0.001 | 0.276 | N/A | Pass | | 0.002 | 0.000 | 0.017 | 0.184 | PASS | 0 |
| 11 | 0.223 | 0.33 | 67.6 | 0.224 | 0.495 | 45.2 | Pass | | 0.224 | 0.210 | 0.239 | 0.330 | PASS | 68.0 |
| 12 | 0.001 | 0.153 | N/A | 0.001 | 0.23 | N/A | Pass | | 0.000 | 0.000 | 0.015 | 0.153 | PASS | 0 |
| 13 | 0.16 | 0.21 | 76.4 | 0.161 | 0.315 | 51 | Pass | | 0.162 | 0.147 | 0.176 | 0.210 | PASS | 77.0 |
| 14 | 0.001 | 0.131 | N/A | 0.001 | 0.197 | N/A | Pass | | 0.002 | 0.000 | 0.017 | 0.131 | PASS | 0 |
| 15 | 0.159 | 0.15 | 105.9 | 0.159 | 0.225 | 70.8 | Fail | | 0.160 | 0.145 | 0.175 | 0.150 | Fail | 106.6 |
| 16 | 0.001 | 0.115 | N/A | 0.001 | 0.173 | N/A | Pass | | 0.000 | 0.000 | 0.015 | 0.115 | PASS | 0 |
| 17 | 0.125 | 0.132 | 94.6 | 0.125 | 0.198 | 63.3 | Pass | | 0.126 | 0.111 | 0.141 | 0.132 | PASS | 95.2 |
| 18 | 0.001 | 0.102 | N/A | 0.001 | 0.153 | N/A | Pass | | 0.002 | 0.000 | 0.017 | 0.102 | PASS | 0 |
| 19 | 0.123 | 0.118 | 103.9 | 0.124 | 0.178 | 69.5 | Fail | | 0.124 | 0.110 | 0.139 | 0.118 | Fail | 104.9 |
| 20 | 0.001 | 0.092 | N/A | 0.001 | 0.138 | N/A | Pass | | 0.000 | 0.000 | 0.015 | 0.092 | PASS | 0 |
| 21 | 0.102 | 0.107 | 95.6 | 0.103 | 0.161 | 64.2 | Pass | | 0.103 | 0.089 | 0.118 | 0.107 | PASS | 96.3 |
| 22 | 0.001 | 0.084 | N/A | 0.001 | 0.125 | N/A | Pass | | 0.002 | 0.000 | 0.017 | 0.084 | PASS | 0 |
| 23 | 0.1 | 0.098 | 102.5 | 0.101 | 0.147 | 68.7 | High | | 0.101 | 0.087 | 0.116 | 0.098 | Fail | 103.7 |
| 24 | 0.001 | 0.077 | N/A | 0.001 | 0.115 | N/A | Pass | | 0.000 | 0.000 | 0.015 | 0.077 | PASS | 0 |
| 25 | 0.087 | 0.09 | 96.5 | 0.087 | 0.135 | 64.5 | Pass | | 0.087 | 0.073 | 0.102 | 0.090 | PASS | 97.2 |
| 26 | 0.001 | 0.071 | N/A | 0.001 | 0.107 | N/A | Pass | | 0.002 | 0.000 | 0.017 | 0.071 | PASS | 0 |
| 27 | 0.085 | 0.083 | 101.5 | 0.085 | 0.125 | 68 | High | | 0.086 | 0.071 | 0.100 | 0.083 | Fail | 102.9 |
| 28 | 0.001 | 0.066 | N/A | 0.001 | 0.099 | N/A | Pass | | 0.000 | 0.000 | 0.015 | 0.066 | PASS | 0 |
| 29 | 0.075 | 0.078 | 97.2 | 0.076 | 0.116 | 65.1 | Pass | | 0.076 | 0.061 | 0.091 | 0.078 | PASS | 97.8 |
| 30 | 0.001 | 0.061 | N/A | 0.001 | 0.092 | N/A | Pass | | 0.002 | 0.000 | 0.017 | 0.061 | PASS | 0 |
| 31 | 0.073 | 0.073 | 100.6 | 0.074 | 0.109 | 67.5 | High | | 0.074 | 0.060 | 0.089 | 0.073 | Fail | 102.2 |
| 32 | 0.001 | 0.058 | N/A | 0.001 | 0.086 | N/A | Pass | | 0.000 | 0.000 | 0.015 | 0.058 | PASS | 0 |
| 33 | 0.067 | 0.068 | 97.8 | 0.067 | 0.102 | 65.5 | Pass | | 0.067 | 0.052 | 0.082 | 0.068 | PASS | 98.4 |
| 34 | 0.001 | 0.054 | N/A | 0.001 | 0.081 | N/A | Pass | | 0.002 | 0.000 | 0.017 | 0.054 | PASS | 0 |
| 35 | 0.064 | 0.064 | 100 | 0.065 | 0.096 | 67.1 | High | | 0.065 | 0.051 | 0.080 | 0.064 | Fail | 101.7 |
| 36 | 0.001 | 0.051 | N/A | 0.001 | 0.077 | N/A | Pass | | 0.000 | 0.000 | 0.015 | 0.051 | PASS | 0 |
| 37 | 0.06 | 0.061 | 98.3 | 0.06 | 0.091 | 65.8 | Pass | | 0.060 | 0.046 | 0.075 | 0.061 | PASS | 98.9 |
| 38 | 0.001 | 0.048 | N/A | 0.001 | 0.073 | N/A | Pass | | 0.002 | 0.000 | 0.017 | 0.048 | PASS | 0 |
| 39 | 0.057 | 0.058 | 99.3 | 0.058 | 0.087 | 66.8 | Pass | | 0.058 | 0.044 | 0.073 | 0.058 | Fail | 101.2 |
| 40 | 0.001 | 0.046 | N/A | 0.001 | 0.069 | N/A | Pass | | 0.000 | 0.000 | 0.015 | 0.046 | PASS | 0 |

As the above data shows, the Class-A FAIL test yields the expected result, and the harmonics are very close to the ideal values.

## Detailed data for Class-C Pass Test

| Current Test Result Summary (Phase A-Replay) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EUT: HFCIII and HFCII | | | | | | Tested by: Mathieu CNS Inc. | | | | | | | | |
| Test category: Class-C per Ed. 4.0 (2014) (European limits) | | | | | | Test Margin: 100 | | | | | | | | |
| Test date: 7/20/2018 | End time: 12:09:19 AM | | | | | Start time: 12:06:57 AM | | | | | | | | |
| Test duration (min): 2 | | | | | | Data file name: H-000849.cts_data | | | | | | | | |
| Comment: Class C Pass Phase A | | | | | | | | | | | | | | |
| Customer: NRW EMC | | | | | | | | | | | | | | |
| Test Result: Pass (POHC fail) | | Source qualification: Normal | | | | | | | | | | | | |
| THC(A): 0.113 | I-THD(%): 16.4 | POHC(A): 0.027 | | POHC Limit(A): 0.065 | | | | | | | | | | |
| Highest parameter values during test: | | | | | | | | | | | | | | |
| V_RMS (V | 230 | Frequency(Hz): | 50.00 | | | | | THC-I | POHC | PF | I-fund | | | |
| I_Peak (A | 1.023 | I_RMS (Ar | 0.7 | | | | | 0.113 | 0.027 | 0.982 | 0.689 | | | |
| I_Fund (A | 0.69 | Crest Fac | 1.464 | | | | | | | | | | | |
| Power (W | 158.1 | Power Fa | 0.983 | | | | | | | | | | | |
| | | | | | | | | Ideal | Min | Max | Limits | Pass/Fail | Percent | |
| Harm# | Harms(av | 100%Limit | %of Limit | Harms(ma | 150%Limit | %of Limit | Status | 0.689 | Tolerance | | | | of Limit | |
| 2 | 0 | 0.014 | N/A | 0 | 0.021 | N/A | Pass | 0.000 | 0.000 | 0.007 | 0.014 | PASS | 0 | |
| 3 | 0.064 | 0.204 | 31.3 | 0.064 | 0.305 | 20.9 | Pass | 0.063 | 0.056 | 0.070 | 0.203 | PASS | 30.9 | |
| 4 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 5 | 0.057 | 0.069 | 83.1 | 0.057 | 0.103 | 55.4 | Pass | 0.057 | 0.050 | 0.064 | 0.069 | PASS | 83.0 | |
| 6 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 7 | 0.047 | 0.048 | 97.3 | 0.047 | 0.072 | 65 | Pass | 0.047 | 0.040 | 0.054 | 0.048 | PASS | 98.1 | |
| 8 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 9 | 0.034 | 0.034 | 97.3 | 0.034 | 0.052 | 64.9 | Pass | 0.034 | 0.027 | 0.041 | 0.034 | PASS | 98.7 | |
| 10 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 11 | 0.02 | 0.021 | 98 | 0.02 | 0.031 | 65.4 | Pass | 0.021 | 0.013 | 0.028 | 0.021 | PASS | 99.3 | |
| 12 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 13 | 0.014 | 0.021 | 66.3 | 0.014 | 0.031 | 44.3 | Pass | 0.014 | 0.007 | 0.021 | 0.021 | PASS | 66.2 | |
| 14 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 15 | 0.016 | 0.021 | 76.4 | 0.016 | 0.031 | 51.3 | Pass | 0.016 | 0.009 | 0.023 | 0.021 | PASS | 76.8 | |
| 16 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 17 | 0.017 | 0.021 | 83.5 | 0.017 | 0.031 | 55.8 | Pass | 0.017 | 0.010 | 0.025 | 0.021 | PASS | 84.7 | |
| 18 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 19 | 0.015 | 0.021 | 71.4 | 0.015 | 0.031 | 47.7 | Pass | 0.015 | 0.008 | 0.022 | 0.021 | PASS | 72.5 | |
| 20 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 21 | 0.01 | 0.021 | 48.9 | 0.01 | 0.031 | 32.9 | Pass | 0.010 | 0.003 | 0.017 | 0.021 | PASS | 49.3 | |
| 22 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 23 | 0.008 | 0.021 | 39.3 | 0.008 | 0.031 | 26.3 | Pass | 0.008 | 0.001 | 0.015 | 0.021 | PASS | 39.2 | |
| 24 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 25 | 0.01 | 0.021 | 48.5 | 0.01 | 0.031 | 32.4 | Pass | 0.010 | 0.003 | 0.017 | 0.021 | PASS | 48.9 | |
| 26 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 27 | 0.011 | 0.021 | 52.4 | 0.011 | 0.031 | 35 | Pass | 0.011 | 0.004 | 0.018 | 0.021 | PASS | 53.3 | |
| 28 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 29 | 0.009 | 0.021 | 43.8 | 0.009 | 0.031 | 29.3 | Pass | 0.009 | 0.002 | 0.016 | 0.021 | PASS | 44.5 | |
| 30 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 31 | 0.006 | 0.021 | 30.6 | 0.006 | 0.031 | 20.5 | Pass | 0.006 | -0.001 | 0.013 | 0.021 | PASS | 30.6 | |
| 32 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 33 | 0.006 | 0.021 | 29.5 | 0.006 | 0.031 | 19.9 | Pass | 0.006 | -0.001 | 0.013 | 0.021 | PASS | 29.6 | |
| 34 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 35 | 0.008 | 0.021 | 37 | 0.008 | 0.031 | 24.8 | Pass | 0.008 | 0.001 | 0.015 | 0.021 | PASS | 37.6 | |
| 36 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 37 | 0.008 | 0.021 | 37.8 | 0.008 | 0.031 | 25.4 | Pass | 0.008 | 0.001 | 0.015 | 0.021 | PASS | 38.5 | |
| 38 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |
| 39 | 0.006 | 0.021 | 29.9 | 0.006 | 0.031 | 20 | Pass | 0.006 | -0.001 | 0.013 | 0.021 | PASS | 30.2 | |
| 40 | 0 | 0 | N/A | 0 | 0 | N/A | Pass | 0.000 | 0.000 | 0.007 | n/l | PASS | 0 | |

For the above test data, the HFC-III harmonics & Flicker calibrator was set to produce current harmonics that are just below the limits. The system properly evaluates this test, with harmonic levels deviating no more than 2 mA from the ideal values.

## Detailed data for Class-D FAIL test

| Current Test Result Summary (Phase B-Replay) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EUT: HFCIII and HFCII | | | | | | Tested by: Mathieu CNS Inc. | | | | | | | | |
| Test category: Class-D per Ed. 4.0 (2014) (European limits) | | | | | | Test Margin: 100 | | | | | | | | |
| Test date: 7/20/2018 | End time: 12:13:25 AM | | | | | Start time: 12:11:03 AM | | | | | | | | |
| Test duration (min): 2 | | | | | | Data file name: H-000850.cts_data | | | | | | | | |
| Comment: Class D Fail Phase B | | | | | | | | | | | | | | |
| Customer: NRW EMC | | | | | | | | | | | | | | |
| Test Result: Fail | Source qualification: Normal | | | | | | | | | | | | | |
| THC(A): 0.332 | I-THD(%): 77.6 | POHC(A): 0.063 | POHC Limit(A): 0.041 | | | | | | | | | | | |
| Highest parameter values during test: | | | | | | | | | THC-I | POHC | Pwr | I-THD | | |
| V_RMS (V | 230.09 | Frequency(Hz): | 50.00 | | | | | | 0.331 | 0.063 | 95.75 | 77.5% | | |
| I_Peak (A | 1.486 | I_RMS (Ar | 0.544 | | | | | | | | | | | |
| I_Fund (A | 0.428 | Crest Fac | 2.732 | | | | | | | | | | | |
| Power (W | 96.1 | Power Fa | 0.769 | | | | | | | | | | | |
| | | | | | | | | | Ideal | Min | Max | Limits | Pass/Fail | Percent |
| Harm# | Harms(av | 100%Limit | %of Limit | Harms(ma | 150%Limit | %of Limit | Status | | 0.427 | Tolerance | | | | of Limit |
| 2 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 3 | 0.286 | 0.327 | 87.5 | 0.286 | 0.49 | 58.4 | Pass | | 0.285 | 0.271 | 0.299 | 0.326 | PASS | 87.6 |
| 4 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 5 | 0.092 | 0.183 | 50.3 | 0.092 | 0.274 | 33.6 | Pass | | 0.091 | 0.085 | 0.098 | 0.182 | PASS | 50.3 |
| 6 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 7 | 0.055 | 0.096 | 57.1 | 0.055 | 0.144 | 38.2 | Pass | | 0.055 | 0.049 | 0.062 | 0.096 | PASS | 57.6 |
| 8 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 9 | 0.085 | 0.048 | 176.7 | 0.085 | 0.072 | 117.9 | Fail | | 0.085 | 0.078 | 0.092 | 0.048 | Fail | 177.4 |
| 10 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 11 | 0.033 | 0.034 | 97.8 | 0.033 | 0.05 | 65.5 | Pass | | 0.033 | 0.026 | 0.039 | 0.034 | PASS | 97.5 |
| 12 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 13 | 0.034 | 0.029 | 117.2 | 0.034 | 0.043 | 79.4 | Fail | | 0.034 | 0.027 | 0.041 | 0.028 | Fail | 120.2 |
| 14 | 0 | 0 | N/A | 0.003 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 15 | 0.05 | 0.025 | 200.6 | 0.051 | 0.037 | 135 | Fail | | 0.050 | 0.044 | 0.057 | 0.025 | Fail | 204.2 |
| 16 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 17 | 0.018 | 0.022 | 82.2 | 0.02 | 0.033 | 59.7 | Pass | | 0.018 | 0.011 | 0.025 | 0.022 | PASS | 82.8 |
| 18 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 19 | 0.025 | 0.02 | 129.8 | 0.027 | 0.029 | 92.4 | Fail | | 0.026 | 0.019 | 0.032 | 0.019 | Fail | 131.8 |
| 20 | 0 | 0 | N/A | 0.003 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 21 | 0.035 | 0.018 | 200.8 | 0.036 | 0.026 | 137.2 | Fail | | 0.035 | 0.029 | 0.042 | 0.018 | Fail | 201.6 |
| 22 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 23 | 0.011 | 0.016 | 71.5 | 0.012 | 0.024 | 49.1 | Pass | | 0.011 | 0.005 | 0.018 | 0.016 | PASS | 70.4 |
| 24 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 25 | 0.021 | 0.015 | 139.7 | 0.021 | 0.022 | 93.7 | High | | 0.021 | 0.014 | 0.028 | 0.015 | Fail | 142.0 |
| 26 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 27 | 0.027 | 0.014 | 196.8 | 0.027 | 0.021 | 131.7 | Fail | | 0.027 | 0.020 | 0.034 | 0.014 | Fail | 198.5 |
| 28 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 29 | 0.008 | 0.013 | 60.1 | 0.008 | 0.019 | 40.7 | Pass | | 0.007 | 0.001 | 0.014 | 0.013 | PASS | 59.0 |
| 30 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 31 | 0.018 | 0.012 | 148.9 | 0.018 | 0.018 | 100 | High | | 0.018 | 0.011 | 0.025 | 0.012 | Fail | 151.3 |
| 32 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 33 | 0.022 | 0.011 | 194.9 | 0.022 | 0.017 | 130.6 | Fail | | 0.022 | 0.015 | 0.028 | 0.011 | Fail | 194.8 |
| 34 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 35 | 0.005 | 0.011 | 49.9 | 0.005 | 0.016 | 34 | Pass | | 0.005 | -0.002 | 0.012 | 0.011 | PASS | 48.6 |
| 36 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 37 | 0.016 | 0.01 | 156.6 | 0.016 | 0.015 | 105.3 | Fail | | 0.016 | 0.009 | 0.023 | 0.010 | Fail | 159.8 |
| 38 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |
| 39 | 0.018 | 0.01 | 188.9 | 0.018 | 0.014 | 127.4 | Fail | | 0.018 | 0.011 | 0.025 | 0.009 | Fail | 190.4 |
| 40 | 0 | 0 | N/A | 0.001 | 0 | N/A | Pass | | 0.000 | 0.000 | 0.007 | N/A | PASS | 0 |

For the above test data, the HFC-III harmonics & Flicker calibrator was set to produce current harmonics that are well above the Class-D limits. The system properly evaluates this test, with harmonic levels deviating no more than 2 mA from the ideal values.

## Current Test Result Summary (Phase A-Replay)

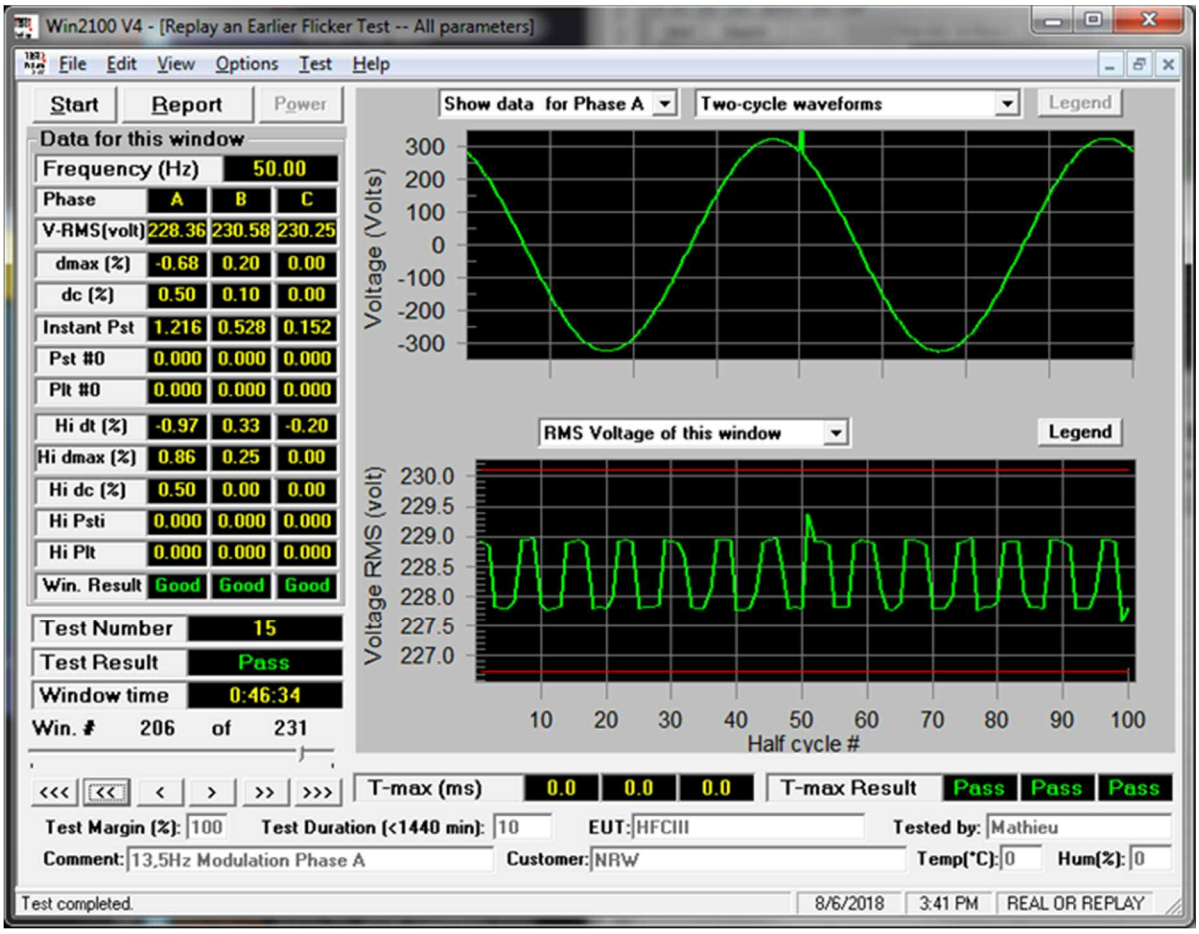
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EUT: HFCIII & HFCII | | | | Tested by: Mathieu CNS Inc. | | | |
| Test category: Table:2, Rsce=33, Inter-Harm, | | | | Test Margin: 100 | | | |
| Test date:7/20/2018 | End time: 12:47:05 PM | | | Start time: 12:45:00 PM | | | |
| Test duration (min): 2 | | | | Data file name: CTSMXH_H-000029.cts_data | | | |
| Comment: Table 2 test Phase A | | | | | | | |
| Customer: NRW-EMC | | | | | | | |
| | | | | | | | |
| Test Resu Measured | Source: Normal | | | | | | |
| THC/Iref (%): 8.1 | Limit (%): 23.0 | PWHC/Iref (%): 0.0 | | PWHC Limit(%): 23.0 | | | |
| | | | | | | | |
| Highest parameter values during test: | | | | | | | |
| V_RMS (V 228.59 | Frequency (Hz): 50.00 | | | | | | |
| I_Peak (A 28.685 | I_RMS (Ar 19.529 | | | | | | |
| I_Fund (AI9.437(avg | Crest Fact 1.471 | | | | | | |
| Power (W 4450 | Power Fa 0.997 | | | | | | |
| | | | | | | | |

| Harm# | Harms(av | 100%Limit | %of Limit | Harms(ma | 150%Limit | %of Limit | Status | |
|---|---|---|---|---|---|---|---|---|
| | 2 | 0.016 | 1.561 | 1.1 | 0.018 | 2.341 | 0.8 | Pass |
| | 3 | 1.379 | 4.214 | 32.7 | 1.38 | 6.32 | 21.8 | Pass |
| | 4 | 0.012 | 0.78 | 1.5 | 0.012 | 1.17 | 1.1 | Pass |
| | 5 | 0.462 | 2.087 | 22.1 | 0.462 | 3.131 | 14.8 | Pass |
| | 6 | 0.008 | 0.52 | 1.6 | 0.009 | 0.78 | 1.2 | Pass |
| | 7 | 0.449 | 1.405 | 32 | 0.45 | 2.107 | 21.3 | Pass |
| | 8 | 0.009 | 0.39 | 2.4 | 0.01 | 0.585 | 1.7 | Pass |
| | 9 | 0.266 | 0.741 | 35.9 | 0.266 | 1.112 | 23.9 | Pass |
| | 10 | 0.008 | 0.312 | 2.6 | 0.008 | 0.468 | 1.8 | Pass |
| | 11 | 0.276 | 0.605 | 45.7 | 0.277 | 0.907 | 30.5 | Pass |
| | 12 | 0.009 | 0.26 | 3.3 | 0.009 | 0.39 | 2.4 | Pass |
| | 13 | 0.196 | 0.39 | 50.3 | 0.197 | 0.585 | 33.7 | Pass |
| | 14 | 0.008 | N/A | N/A | 0.008 | N/A | N/A | N/A |
| | 15 | 0.188 | N/A | N/A | 0.189 | N/A | N/A | N/A |
| | 16 | 0.008 | N/A | N/A | 0.009 | N/A | N/A | N/A |
| | 17 | 0.144 | N/A | N/A | 0.144 | N/A | N/A | N/A |
| | 18 | 0.007 | N/A | N/A | 0.008 | N/A | N/A | N/A |
| | 19 | 0.153 | N/A | N/A | 0.154 | N/A | N/A | N/A |
| | 20 | 0.008 | N/A | N/A | 0.008 | N/A | N/A | N/A |
| | 21 | 0.124 | N/A | N/A | 0.125 | N/A | N/A | N/A |
| | 22 | 0.007 | N/A | N/A | 0.008 | N/A | N/A | N/A |
| | 23 | 0.118 | N/A | N/A | 0.118 | N/A | N/A | N/A |
| | 24 | 0.007 | N/A | N/A | 0.008 | N/A | N/A | N/A |
| | 25 | 0.097 | N/A | N/A | 0.098 | N/A | N/A | N/A |
| | 26 | 0.007 | N/A | N/A | 0.007 | N/A | N/A | N/A |
| | 27 | 0.106 | N/A | N/A | 0.107 | N/A | N/A | N/A |
| | 28 | 0.007 | N/A | N/A | 0.008 | N/A | N/A | N/A |
| | 29 | 0.091 | N/A | N/A | 0.092 | N/A | N/A | N/A |
| | 30 | 0.007 | N/A | N/A | 0.008 | N/A | N/A | N/A |
| | 31 | 0.086 | N/A | N/A | 0.087 | N/A | N/A | N/A |
| | 32 | 0.007 | N/A | N/A | 0.008 | N/A | N/A | N/A |
| | 33 | 0.074 | N/A | N/A | 0.075 | N/A | N/A | N/A |
| | 34 | 0.008 | N/A | N/A | 0.008 | N/A | N/A | N/A |
| | 35 | 0.082 | N/A | N/A | 0.082 | N/A | N/A | N/A |
| | 36 | 0.008 | N/A | N/A | 0.008 | N/A | N/A | N/A |
| | 37 | 0.071 | N/A | N/A | 0.072 | N/A | N/A | N/A |
| | 38 | 0.009 | N/A | N/A | 0.01 | N/A | N/A | N/A |
| | 39 | 0.068 | N/A | N/A | 0.068 | N/A | N/A | N/A |
| | 40 | 0.006 | N/A | N/A | 0.006 | N/A | N/A | N/A |

*Note: Measured I-ref was applied for this test. The peak Irms was applied to the 150% limits.*

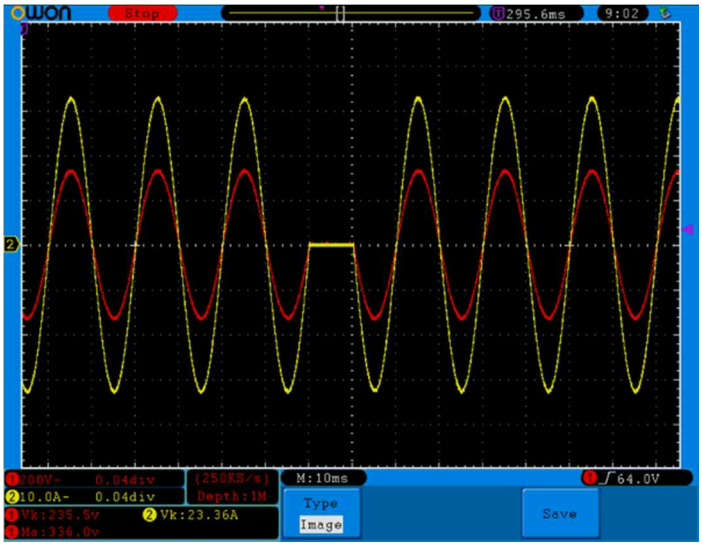
## Flicker screen shot

The screen shot below shows one of the Flicker test patterns, with the modulation set to 13.5 Hz, and the modulation percentage set to 0.5 % which ideally would result in a Pst level of 1.209. The measured Pst for Phase A is 1.212 i.e. the deviation is 0.6 %, which is less than 1/4$^{th}$ of the permitted tolerance of ± 8 %.

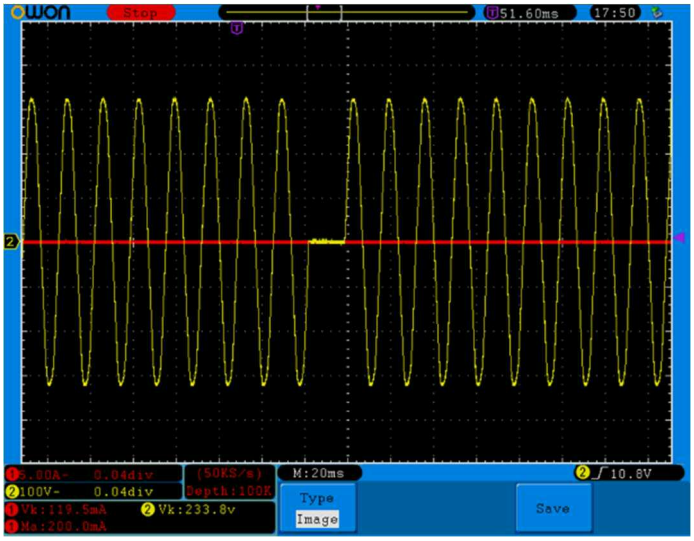


## Test patterns per IEC 61000-4-11

This page shows oscilloscope shots that were recorded during the tests per IEC 61000-4-11, with typical patterns for Class-2, per Table-1 of the standard, for a nominal voltage of 230 V rms, 50 Hz.

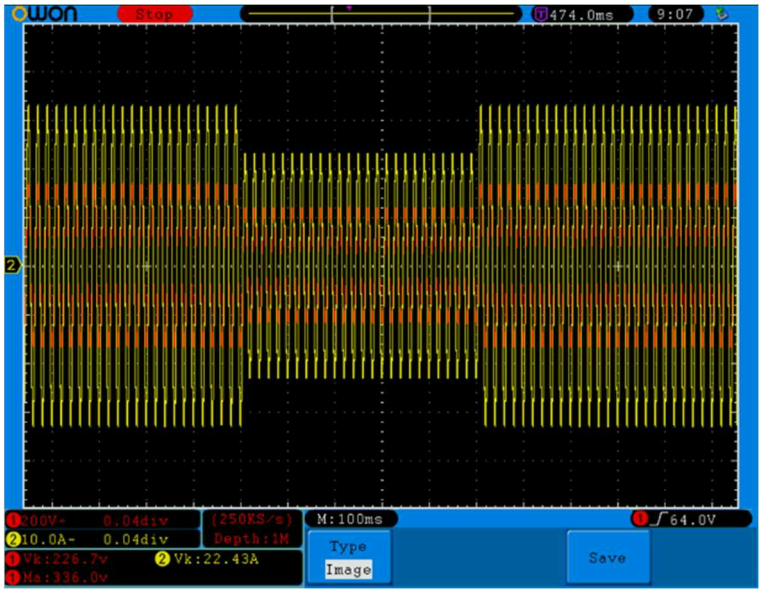



**Half cycle dropout to '0" volt**



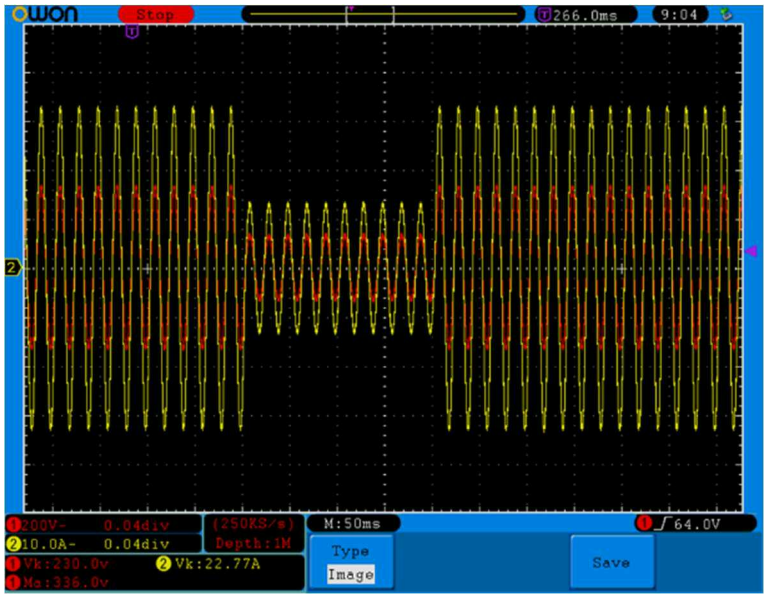

**1 cycle dropout to "0" volt**

| IEC 6100-4-11 data | |
|---|---|
| | |
| 50 Hz 0.5 cycle | Actual |
| target value 10 ms | 10.0 ms |
| | |
| 60 Hz 1 cycle | Actual |
| target value 16.67 ms | 16.7 ms |
| | |
| | Actual |
| 60 Hz 25 cycles @ 70 % | 70.5 % |
| Target values | 25.0 cycles |
| | |
| | Actual |
| 60 Hz 10 cycles @ 40 % | 40.2 % |
| Target values | 25.0 cycles |
| | |
| | Actual |
| 60 Hz rise/fall times | 2.5 µS |
| Target values1-5 µS | |
| | |
| | Actual |
| 60 Hz 1 cycle @ 90ndeg. | 90 deg |



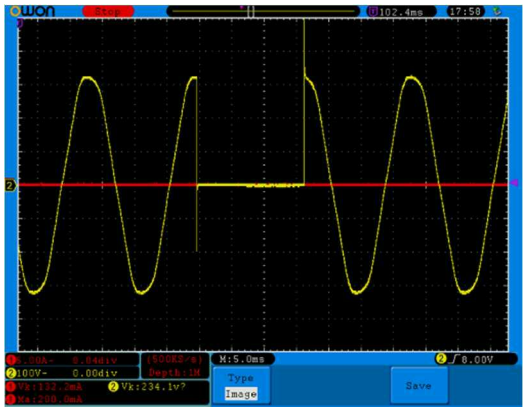

**70 % remaining voltage for 25 cycles per Class-2 Table1 of**

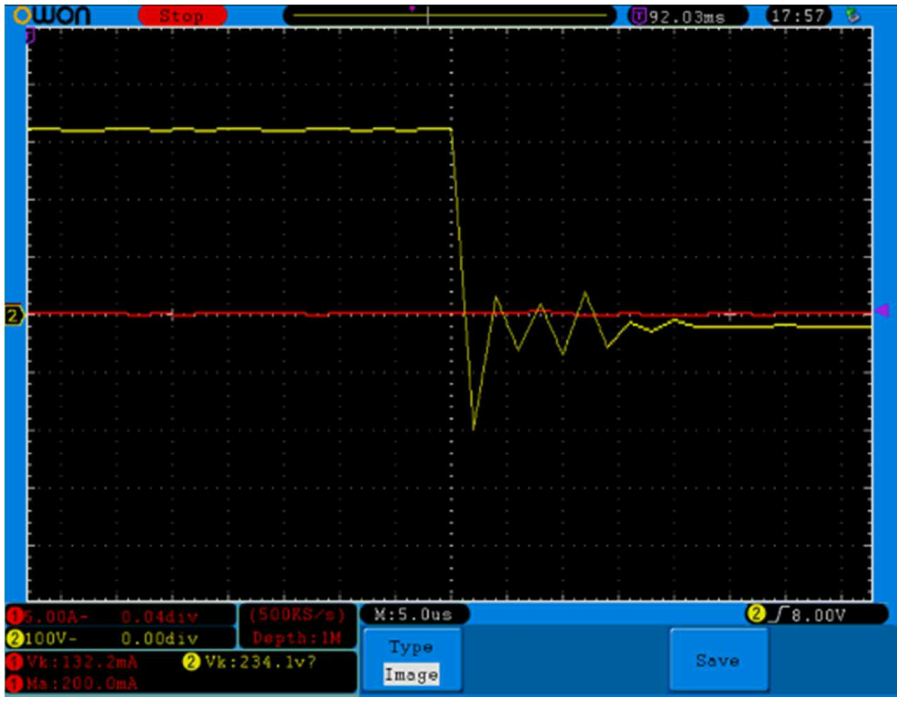
**IEC61000-4-11**

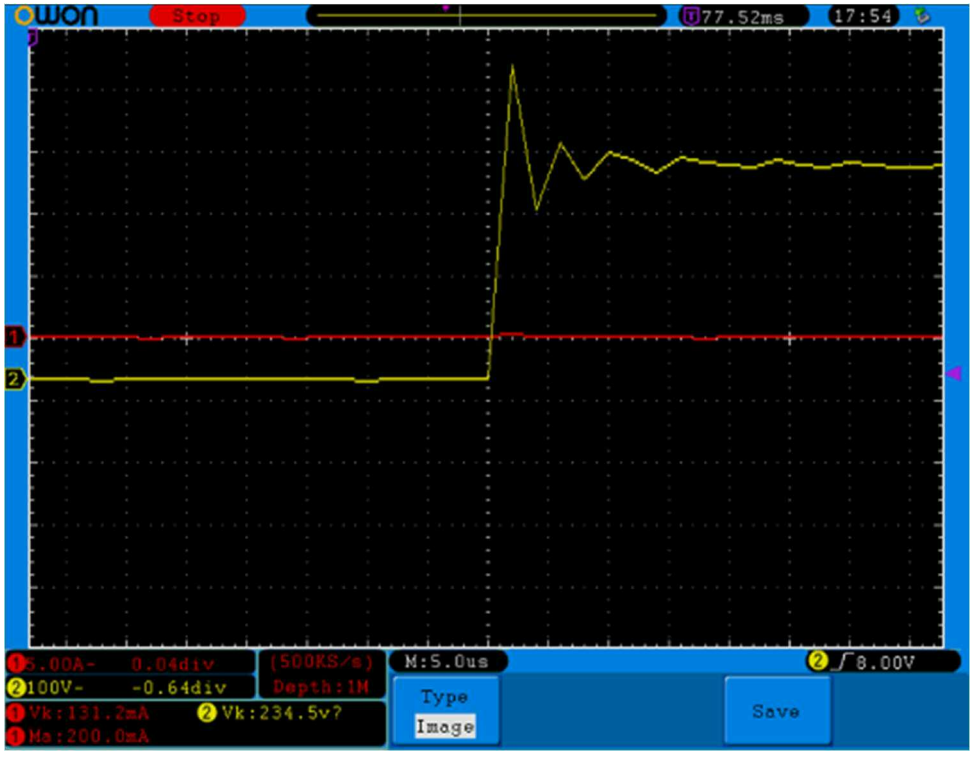



**40 % remaining voltage for 10 cycles**

**Below are screenshots of a 1 cycle drop out at 90 degrees with a rise and fall time within 1-5 microseconds. These tests were done using the NSG2200-3 switch, at 60 Hz.**

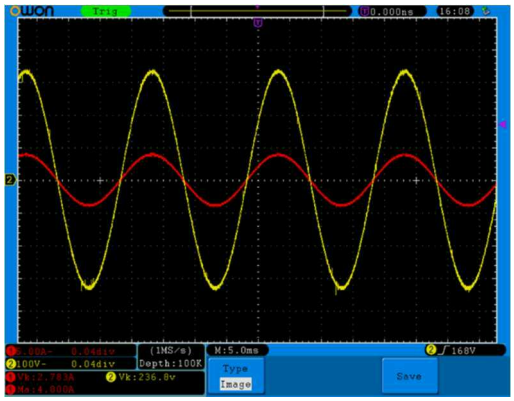




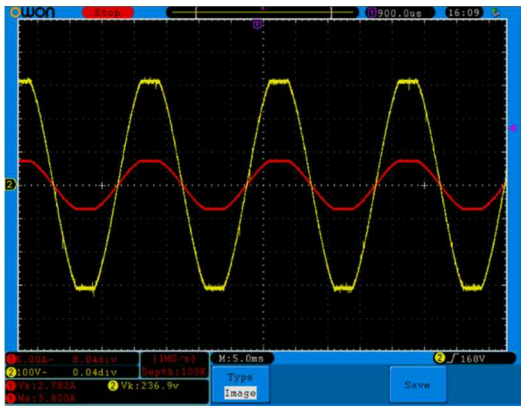
## Test patterns per IEC 61000-4-13

This page and the next show a series of oscilloscope shots with test patterns per IEC 61000-4-13, including tests per the so-called Meister curve.

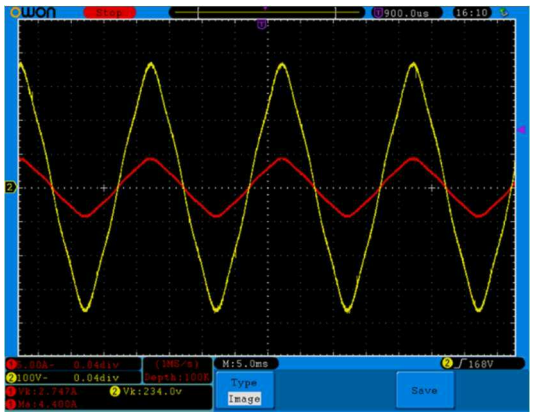


The test starts with a sine wave at nominal 230 V rms.

| IEC61004-13 data | |
|---|---|
| | |
| Flat top - Class 2 | Actual |
| Target value 230 V rms | 230.4 V rms |
| | |
| Overswing Class 2 | Actual |
| Taget value 230 Vrms | 230.2 V rms |
| | |
| Modulation < 100 Hz | Actual |
| Target value 3 % | 3.16% |
| | |
| Modulation 100-500 Hz | Actual |
| Taget value 9 % | 8.70% |
| | |
| Modulation @ 2000 Hz | Actual |
| Target valuua 2.25 % | 2.30% |
| | |

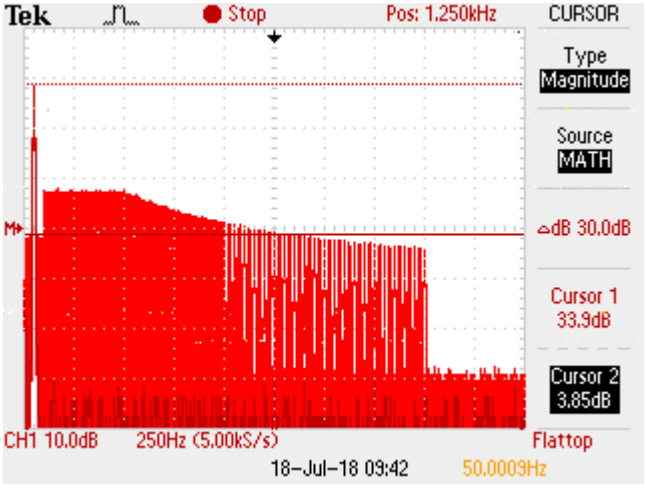


The flat top waveform per Class-2



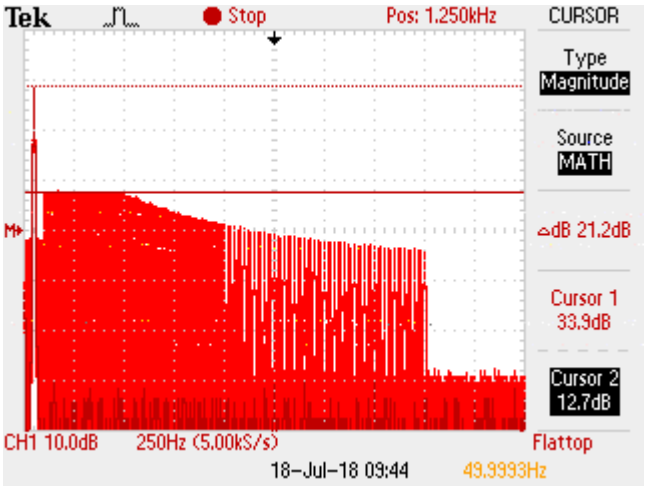
The “over-swing” waveform per Class-2.

**Test patterns per IEC 61000-4-13 cont.**

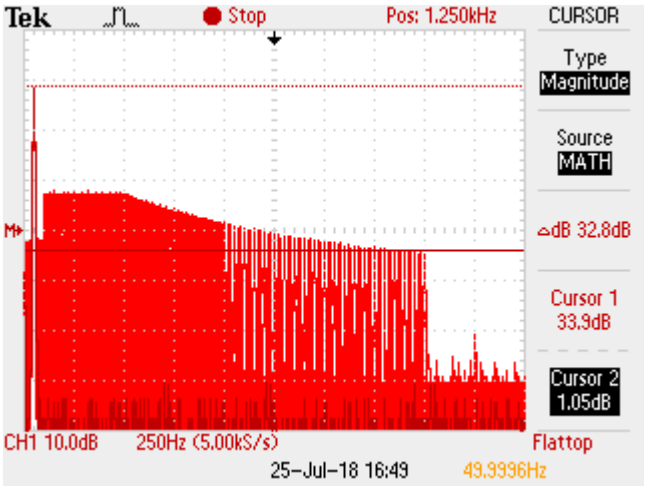



Meister curve @ 3% modulation below 100 Hz

Per Table 11 of IEEC 61000-4-13



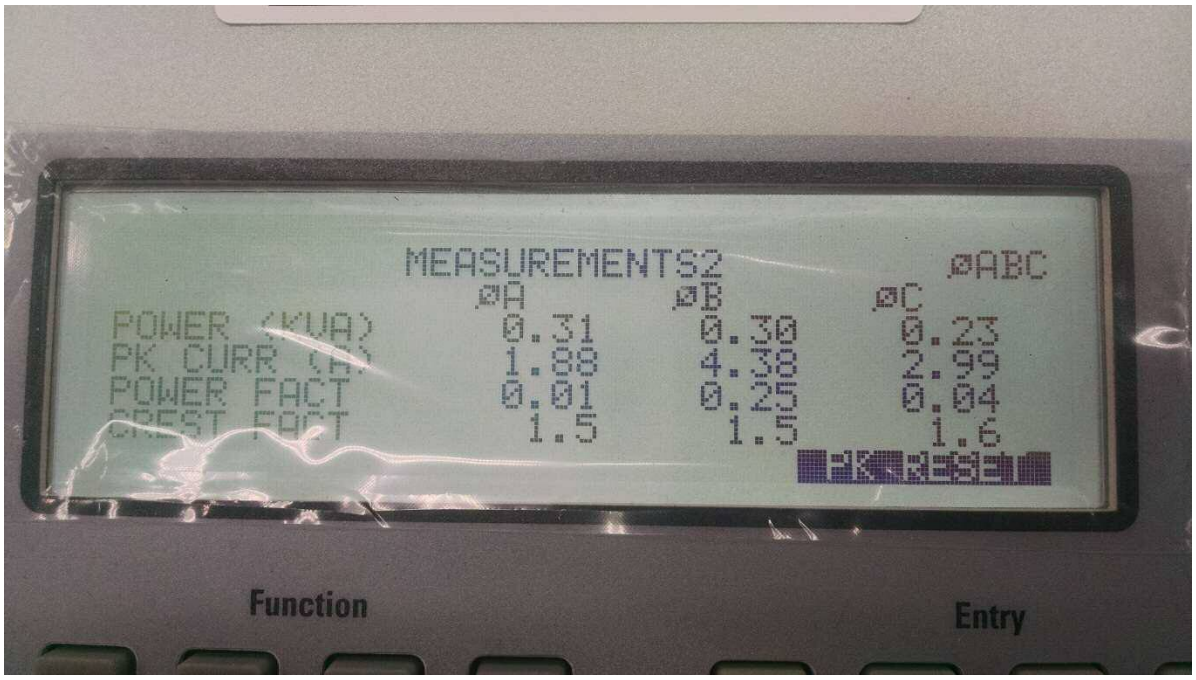

Meister curve @ 9% from 100 -500 Hz

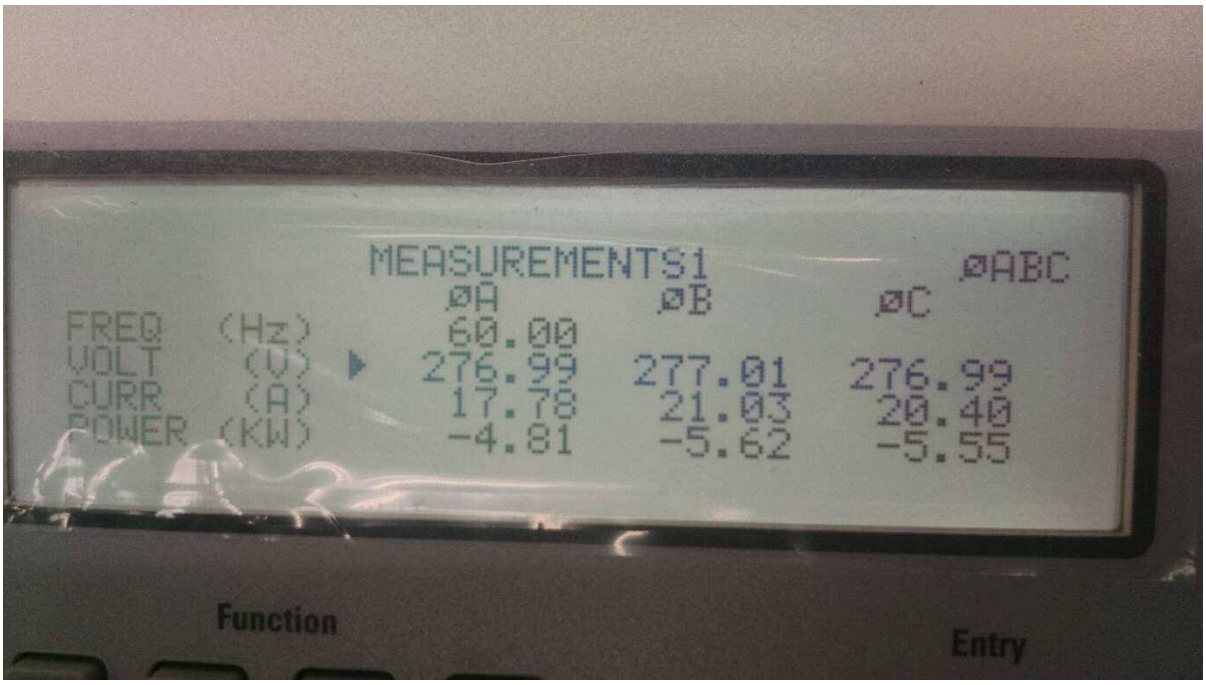



**Meister curve @ 2.3 % at 2000 Hz**

## Regeneration verification

For this test3 Solar inverters were connected, one to each Phase. The top photo shows the initial stage with virtually no load. The second picture shows the “negative’ power, i.e. the power generated by the inverters that is fed back into the power source.





**Photos showing the overall system during calibration, and a detail shot of the new calibration sticker on the power source.**

**End of Calibration & Verification Report**

**Xxxxxxxx – Dortmund, July 2018**