REPORT
issued by an Accredited Testing Laboratory

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Date 2015-04-30 | Reference 4P03111 | 

1002
ISO/IEC 17025

Northern Solutions AS
Steinalderveien 2E
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Norway

# Type approval test of EMES60 System

(2 appendices)

## SP Technical Research Institute of Sweden
### Electronics

Performed by

David Busk

Examined by

Kennet Palm

| | | | |
|---|---|---|---|
| **Report no.:** | 4P03111 | **Report date:** | 2015-04-30 |
| **Test started:** | 2014-06-26 | **Test ended:** | 2015-02-20 |
| **Number of pages:** | 124 | **Contact person:** | Leonid Boldyrev |

| | | | |
|---|---|---|---|
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| | | |
|---|---|---|
| **Test specimens:** | Display unit echosounder Panel PC | Serial no.: EMES60D2014001 |
| | Universal Dual Marine Interface | Serial no.: EMES60IO2014001 |
| | EMES60 Sensor Dual Power Supply | Serial no.: EMES60PW2014001 |
| | EMES60 Dual Sensor | Serial no.: EMES60S2014001 |

**Test specifications:**

IEC 60945, Fourth edition, 2002 - Maritime navigation and radiocommunication equipment and systems - General requirements - Methods of testing and required test results.

The tests relevant for the test specimens are listed in *section 1.1.2*

**Documentation:**

This test report must always be reproduced in full; reproduction of an excerpt only is subject to written approval of the testing laboratory.

The complete test documentation is archived for 10 years at the testing laboratory.

**Test results:**

The test specimen complies with all relevant parts of the test specifications.

The test results relate only to the specimen tested.

| | | |
|---|---|---|
| **Test personnel:** | David Busk | Bo Schødt |
| | Stig Larsen | Bengt Andersson |

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## Appendices

# 1 SUMMARY

## 1.1 Test plan

### 1.1.1 Test plan - Overview

| Test name | Display Unit | Interface Unit | PS Unit | Sensor Unit |
|---|---|---|---|---|
| **Electromagnetic compatibility** | | | | |
| Radiated emission | X | X | X | NR |
| Conducted emission | NR | X | X | NR |
| Radiated radio frequency interference | X | X | X | NR |
| Conducted radio frequency interference | X | X | X | X |
| Burst / Fast transients | X | X | X | X |
| Surge / Slow transients | NR | X | X | NR |
| Electrostatic discharge | X | X | X | NR |
| Power supply failure | NR | X | X | NR |
| Extreme power supply | NR | X | X | NR |
| Power supply variations (transient) | NR | X | X | NR |
| Power supply excessive conditions | NR | X | X | NR |
| **Environmental** | | | | |
| Low temperature | X | X | X | NR |
| Dry heat, functional | X | X | X | NR |
| Dry heat, storage | NR | NR | NR | X |
| Damp heat, cyclic | X | X | X | NR |
| Insulation resistance | X | X | X | X |
| Vibration | X | X | X | X |
| Corrosion (Salt mist) | NR | NR | NR | NR |
| **Supplementary tests** | | | | |
| Visual inspection and performance test | X | X | X | X |
| Compass safe distance | X | X | X | NR |
| Protection against access to dangerous voltage | X | X | X | X |
| X-radiation | NR | NR | NR | NR |

NR The test is not relevant for the test specimen or has been waived by the manufacturer.
X The test is performed.

- The test specification and the functional test procedure by Northern Solutions A/S are enclosed in *appendix 1*.

### 1.1.2 Test plan – Display Unit

| Test specification | Name of the test | Test | Result |
|---|---|---|---|
| **Electromagnetic compatibility** | | | |
| IEC 60945, section 9.3 | Radiated emission | X | PASSED |
| IEC 60945, section 9.2 | Conducted emission | NR | - |
| IEC 60945, section 10.4 | Radiated radio frequency interference | X | PASSED |
| IEC 60945, section 10.3 | Conducted radio frequency interference | X | PASSED |
| IEC 60945, section 10.5 | Bursts / Fast transients | X | PASSED |
| IEC 60945, section 10.6 | Surge / Slow transients | NR | - |
| IEC 60945, section 10.9 | Electrostatic discharge | X | PASSED |
| IEC 60945, section 10.8 | Power supply failure | NR | - |
| IEC 60945, section 7.1 | Extreme power supply | NR | - |
| IEC 60945, section 10.7 | Power supply variations (transient) | NR | - |
| IEC 60945, section 7.2 | Power supply excessive conditions | NR | - |
| **Environmental** | | | |
| IEC 60945, section 8.4 | Low temperature | X | PASSED |
| IEC 60945, section 8.2 | Dry heat, functional | X | PASSED |
| IEC 60945, section 8.2 | Dry heat, storage | NR | - |
| IEC 60945, section 8.3 | Damp heat | X | PASSED |
| IEC 60945, section 8.7 | Vibration | X | PASSED |
| IEC 60945, section 8.12 | Corrosion (Salt Mist) | NR | - |
| **Supplementary tests** | | | |
| IEC 60945, section 8.1 | Visual inspection and performance test | X | PASSED |
| IEC 60945, section 11.2 | Compass safe distance | X | PASSED |
| IEC 60945, section 12.1 | Protection against access to dangerous voltage | X | PASSED |
| IEC 60945, section 12.4 | X-radiation | NR | - |

PASSED The test specimen complies with the essential requirements in the standard.
FAILED The test specimen does not comply with the essential requirements in the standard.
NR The test is not relevant for the test specimen or has been waived by the manufacturer.
X The test is performed.

- Measurement uncertainties are listed on the *last page.*

### 1.1.3 Test plan – Interface Unit

| Test specification | Name of the test | Test | Result |
|---|---|---|---|
| **Electromagnetic compatibility** | | | |
| IEC 60945, section 9.3 | Radiated emission | X | PASSED |
| IEC 60945, section 9.2 | Conducted emission | X | PASSED |
| IEC 60945, section 10.4 | Radiated radio frequency interference | X | PASSED |
| IEC 60945, section 10.3 | Conducted radio frequency interference | X | PASSED |
| IEC 60945, section 10.5 | Bursts / Fast transients | X | PASSED |
| IEC 60945, section 10.6 | Surge / Slow transients | X | PASSED |
| IEC 60945, section 10.9 | Electrostatic discharge | X | PASSED |
| IEC 60945, section 10.8 | Power supply failure | X | PASSED |
| IEC 60945, section 7.1 | Extreme power supply | X | PASSED |
| IEC 60945, section 10.7 | Power supply variations (transient) | X | PASSED |
| IEC 60945, section 7.2 | Power supply excessive conditions | X | PASSED |
| **Environmental** | | | |
| IEC 60945, section 8.4 | Low temperature | X | PASSED |
| IEC 60945, section 8.2 | Dry heat, functional | X | PASSED |
| IEC 60945, section 8.2 | Dry heat, storage | X | PASSED |
| IEC 60945, section 8.3 | Damp heat | X | PASSED |
| IEC 60945, section 8.7 | Vibration | X | PASSED |
| IEC 60945, section 8.12 | Corrosion (Salt Mist) | NR | - |
| **Supplementary tests** | | | |
| IEC 60945, section 8.1 | Visual inspection and performance test | X | PASSED |
| IEC 60945, section 11.2 | Compass safe distance | X | PASSED |
| IEC 60945, section 12.1 | Protection against access to dangerous voltage | X | PASSED |
| IEC 60945, section 12.4 | X-radiation | NR | - |

PASSED The test specimen complies with the essential requirements in the standard.
FAILED The test specimen does not comply with the essential requirements in the standard.
NR The test is not relevant for the test specimen or has been waived by the manufacturer.
X The test is performed.

- Measurement uncertainties are listed on the *last page.*

### 1.1.4 Test plan – Power Supply Unit

| Test specification | Name of the test | Test | Result |
|---|---|---|---|
| **Electromagnetic compatibility** | | | |
| IEC 60945, section 9.3 | Radiated emission | X | PASSED |
| IEC 60945, section 9.2 | Conducted emission | X | PASSED |
| IEC 60945, section 10.4 | Radiated radio frequency interference | X | PASSED |
| IEC 60945, section 10.3 | Conducted radio frequency interference | X | PASSED |
| IEC 60945, section 10.5 | Bursts / Fast transients | X | PASSED |
| IEC 60945, section 10.6 | Surge / Slow transients | X | PASSED |
| IEC 60945, section 10.9 | Electrostatic discharge | X | PASSED |
| IEC 60945, section 10.8 | Power supply failure | X | PASSED |
| IEC 60945, section 7.1 | Extreme power supply | X | PASSED |
| IEC 60945, section 10.7 | Power supply variations (transient) | X | PASSED |
| IEC 60945, section 7.2 | Power supply excessive conditions | X | PASSED |
| **Environmental** | | | |
| IEC 60945, section 8.4 | Low temperature | X | PASSED |
| IEC 60945, section 8.2 | Dry heat, functional | X | PASSED |
| IEC 60945, section 8.2 | Dry heat, storage | X | PASSED |
| IEC 60945, section 8.3 | Damp heat | X | PASSED |
| IEC 60945, section 8.7 | Vibration | X | PASSED |
| IEC 60945, section 8.12 | Corrosion (Salt Mist) | NR | - |
| **Supplementary tests** | | | |
| IEC 60945, section 8.1 | Visual inspection and performance test | X | PASSED |
| IEC 60945, section 11.2 | Compass safe distance | X | PASSED |
| IEC 60945, section 12.1 | Protection against access to dangerous voltage | X | PASSED |
| IEC 60945, section 12.4 | X-radiation | NR | - |

PASSED The test specimen complies with the essential requirements in the standard.
FAILED The test specimen does not comply with the essential requirements in the standard.
NR The test is not relevant for the test specimen or has been waived by the manufacturer.
X The test is performed.

- Measurement uncertainties are listed on the *last page.*

### 1.1.5 Test plan – Sensor Unit

| Test specification | Name of the test | Test | Result |
|---|---|---|---|
| **Electromagnetic compatibility** | | | |
| IEC 60945, section 9.3 | Radiated emission | NR | - |
| IEC 60945, section 9.2 | Conducted emission | NR | - |
| IEC 60945, section 10.4 | Radiated radio frequency interference | NR | - |
| IEC 60945, section 10.3 | Conducted radio frequency interference | X | PASSED |
| IEC 60945, section 10.5 | Bursts / Fast transients | X | PASSED |
| IEC 60945, section 10.6 | Surge / Slow transients | NR | - |
| IEC 60945, section 10.9 | Electrostatic discharge | NR | - |
| IEC 60945, section 10.8 | Power supply failure | NR | - |
| IEC 60945, section 7.1 | Extreme power supply | NR | - |
| IEC 60945, section 10.7 | Power supply variations (transient) | NR | - |
| IEC 60945, section 7.2 | Power supply excessive conditions | NR | - |
| **Environmental** | | | |
| IEC 60945, section 8.4 | Low temperature | NR | - |
| IEC 60945, section 8.2 | Dry heat, functional | NR | - |
| IEC 60945, section 8.2 | Dry heat, storage | X | PASSED |
| IEC 60945, section 8.3 | Damp heat | NR | - |
| IEC 60945, section 8.7 | Vibration | X | PASSED |
| IEC 60945, section 8.12 | Corrosion (Salt Mist) | NR | - |
| **Supplementary tests** | | | |
| IEC 60945, section 8.1 | Visual inspection and performance test | X | PASSED |
| IEC 60945, section 11.2 | Compass safe distance | NR | - |
| IEC 60945, section 12.1 | Protection against access to dangerous voltage | X | PASSED |
| IEC 60945, section 12.4 | X-radiation | NR | - |

PASSED The test specimen complies with the essential requirements in the standard.
FAILED The test specimen does not comply with the essential requirements in the standard.
NR The test is not relevant for the test specimen or has been waived by the manufacturer.
X The test is performed.

- Measurement uncertainties are listed on the *last page.*

## 1.2 Test specimens

### 1.2.1 Display Unit

| | |
|---|---|
| **Manufacturer** | Northern Solutions A/S |
| **Type** | Display unit echosounder Panel PC |
| **Serial no.** | EMES60D2014001 |
| **Details** | Display Left |
| **Supply voltage** | 24V supplied by the Universal Dual Marine Interface |
| **Operational mode** | Displays ‘echosounder’ and is connected to the ‘left side’ of the EMES system |

**I/O cables Display Unit**

| I/O Port Cable | Type | Length | Shielding |
|---|---|---|---|
| Display unit cable | 3 twisted individually screened pairs in common screen | 10 m | Shielded |

**Photo 1. Display Unit front.**

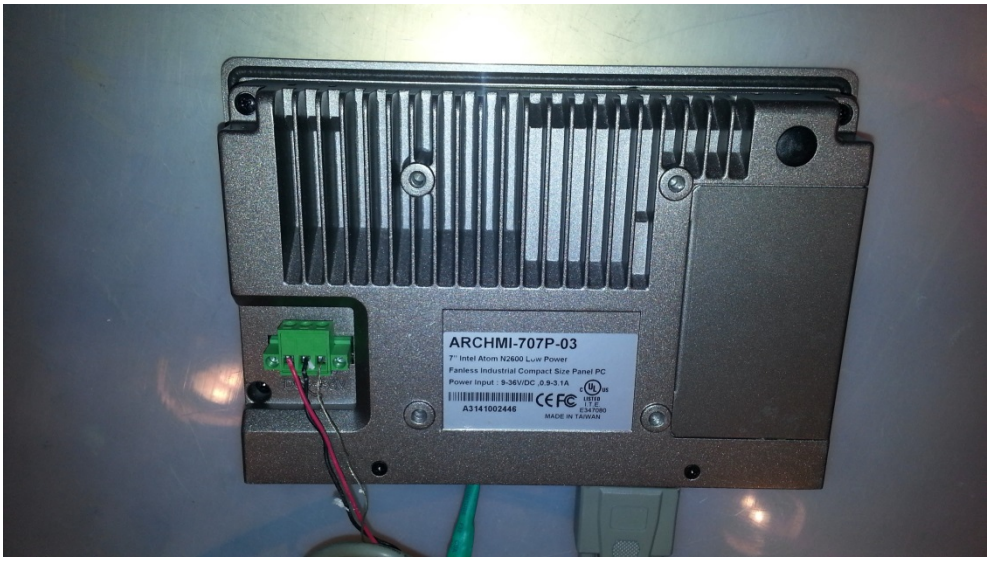



**Photo 2. Display Unit back.**

### 1.2.2 Interface Unit

| | |
|---|---|
| **Manufacturer** | Northern Solutions A/S |
| **Type** | Universal Dual Marine Interface |
| **Serial no.** | EMES60IO2014001 |
| **Details** | - |
| **Supply voltage** | Two 230/115 VAC inputs and two 24 VDC inputs |
| **Operational mode** | Normal |

**I/O cables test Interface Unit**

| I/O Port Cable | Type | Length | Shielding |
|---|---|---|---|
| Power AC Left | 3 wire | 3 m | Shielded |
| Power AC Right | 3 wire | 3 m | Shielded |
| Power DC Left | 2 wire | 3 m | Shielded |
| Power DC Right | 2 wire | 3 m | Shielded |
| Display unit cable | 3 twisted individually screened pairs in common screen | 10 m | Shielded |
| Interface cable | 4 twisted individually screened pairs in common screen | 10 m | Shielded |
| ANAOUT | 2 wire | 10 m | Shielded |
| OPT1OUT | 2 wire | 10 m | Shielded |
| DIG1IN | 2 wire | 10 m | Shielded |
| RELAYOUT | 3 wire | 10 m | Shielded |

Only Power AC Left and Power DC Left are tested as both side are identical.


**Photo 3. Interface Unit chassis.**


**Photo 4. Interface Unit interior.**

## Modifications to test specimen

Date: 2015-02-20:

To comply with the limits in the conducted emission test, the client inserted a Schaffner filter of type: FN409 at the DC input power port. The filter is deemed not to have any effect on previous performed tests other than improving results.

See *appendix 2* for a description of the modifications by the client.

### 1.2.3 Power Supply Unit

| | |
|---|---|
| **Manufacturer** | Northern Solutions A/S |
| **Type** | EMES60 Sensor Dual Power Supply |
| **Serial no.** | EMES60PW2014001 |
| **Details** | - |
| **Supply voltage** | Two 230/115 VAC inputs and two 24 VDC inputs |
| **Operational mode** | Normal |

**I/O cables to Power Supply Unit**

| I/O Port Cable | Type | Length | Shielding |
|---|---|---|---|
| Power AC Left | 3 wire | 3 m | Shielded |
| Power AC Right | 3 wire | 3 m | Shielded |
| Power DC Left | 2 wire | 3 m | Shielded |
| Power DC Right | 2 wire | 3 m | Shielded |
| EMES60 sensor cable | 6 twisted individually screened pairs in common screen | 10 m | Shielded |
| Interface cable | 4 twisted individually screened pairs in common screen | 10 m | Shielded |

Only Power AC Left and Power DC Left are tested as both side are identical.


**Photo 5. Power Supply Unit chassis.**

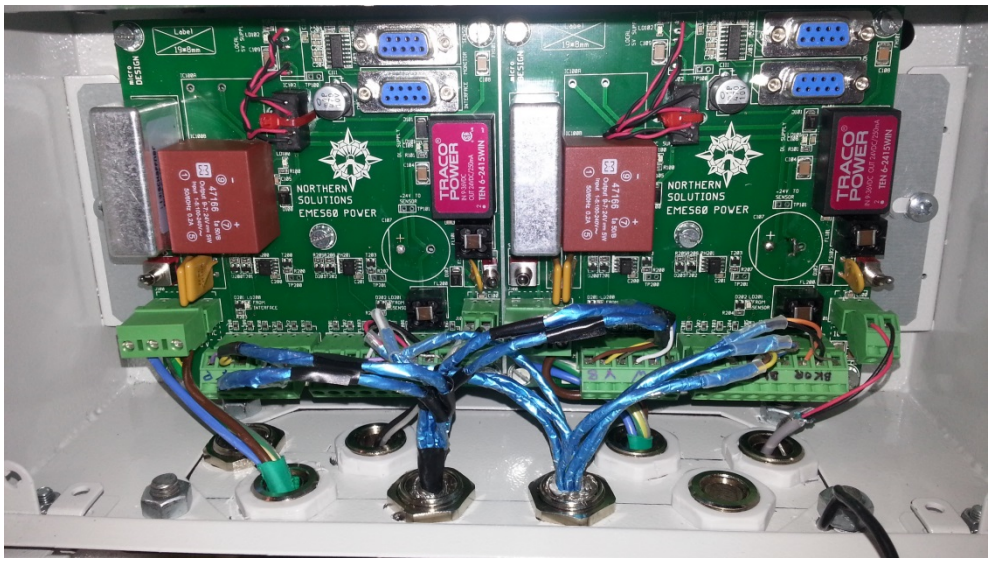



**Photo 6. Power supply Unit interior.**

### Modifications to test specimen

Date: 2014-11-25:

To comply with the limits in the radiated emission test, the client inserted a NEC/TOKIN filter of type: SH_102 at the DC input power port. The filter is used in all other performed tests except for conducted emission test where a Schaffner filter was used.

See *appendix 2* for a description of the modifications by the client.

Date: 2015-02-20:

To comply with the limits in the conducted emission test, the client exchanged the NEC/TOKIN SH_102 filter with a Schaffner filter of type: FN409 at the DC input power port. The filter is deemed not to have any effect on previous performed tests other than improving results.

See *appendix 2* for a description of the modifications by the client.

### 1.2.4 Sensor Unit

| | |
|---|---|
| **Manufacturer** | Northern Solutions A/S |
| **Type** | EMES60 Dual Sensor |
| **Serial no.** | EMES60S2014001 |
| **Details** | - |
| **Supply voltage** | 24 V supplied by the EMES60 Sensor Dual Power Supply |
| **Operational mode** | Normal |

**I/O cables Sensor Unit**

| I/O Port Cable | Type | Length | Shielding |
|---|---|---|---|
| EMES60 sensor cable | 6 twisted individually screened pairs in common screen | 10 m | Shielded |

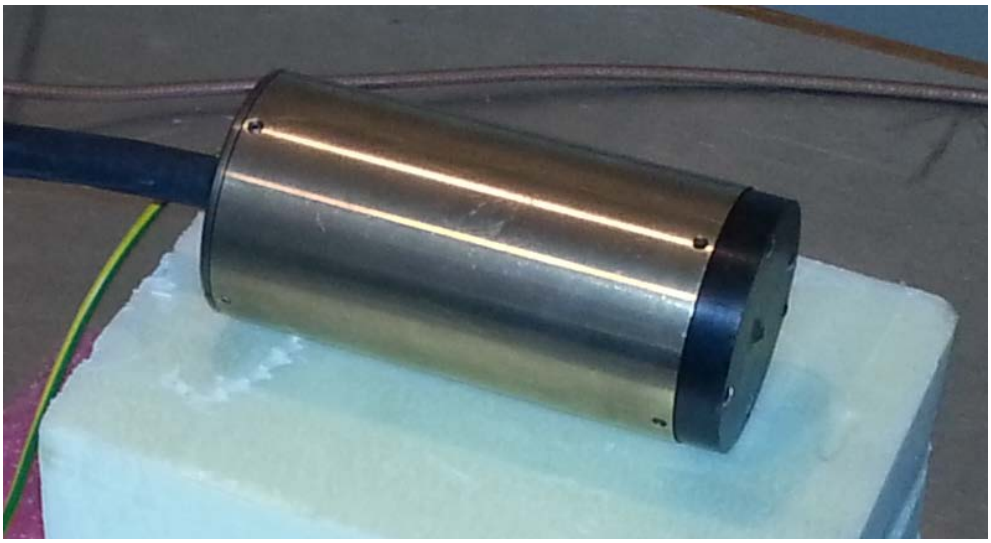


**Photo 7. Sensor Unit.**

## 1.3 Auxiliary equipment

### 1.3.1 Display Unit (Right)

| | |
|---|---|
| **Manufacturer** | Northern Solutions A/S |
| **Type** | Display unit speedlog Panel PC |
| **Serial no.** | EMES60D2014002 |
| **Details** | Display Right |
| **Supply voltage** | 24 V supplied by the Universal Dual Marine Interface |
| **Operational mode** | Displays a 'speedlog' and is connected to the 'right side' of the EMES system. Used to check the functionality of the speedlog in the Sensor Unit |

**I/O cables Display Unit (Right)**

| I/O Port Cable | Type | Length | Shielding |
|---|---|---|---|
| Display unit cable | 3 twisted individually screened pairs in common screen | 10 m | Shielded |

### 1.3.2 Voltmeter 1 / Amperemeter

| | |
|---|---|
| **Manufacturer** | Hewlett Packard |
| **Type** | 34401A |
| **SP ID Tag** | 14885 |
| **Details** | - |
| **Supply voltage** | 230 VAC |
| **Operational mode** | Used as voltmeter and amperemeter – connected to port: ANAOUT |

### 1.3.3 Voltmeter 2

| | |
|---|---|
| **Manufacturer** | Hewlett Packard |
| **Type** | 34401A |
| **SP ID Tag** | 14880 |
| **Details** | - |
| **Supply voltage** | 230 VAC |
| **Operational mode** | Used as voltmeter – connected to port: OPT1OUT |

### 1.3.4 Ohmmeter 1

| | |
|---|---|
| **Manufacturer** | Hewlett Packard |
| **Type** | 34401A |
| **SP ID Tag** | 15374 |
| **Details** | - |
| **Supply voltage** | 230 VAC |
| **Operational mode** | Used as ohmmeter – connected to port: RELAY1 (REL1NO) |

### 1.3.5 Ohmmeter 2

| | |
|---|---|
| **Manufacturer** | Hewlett Packard |
| **Type** | 34401A |
| **SP ID Tag** | 14118 |
| **Details** | - |
| **Supply voltage** | 230 VAC |
| **Operational mode** | Used as ohmmeter – connected to port: RELAY1 (REL1NC) |

### 1.3.6 Voltage Source

| | |
|---|---|
| **Manufacturer** | Hewlett Packard |
| **Type** | E3632A |
| **SP ID Tag** | 14622 |
| **Details** | - |
| **Supply voltage** | 230 VAC |
| **Operational mode** | Used as 24 VDC power supply |

## 1.4 Test set-up

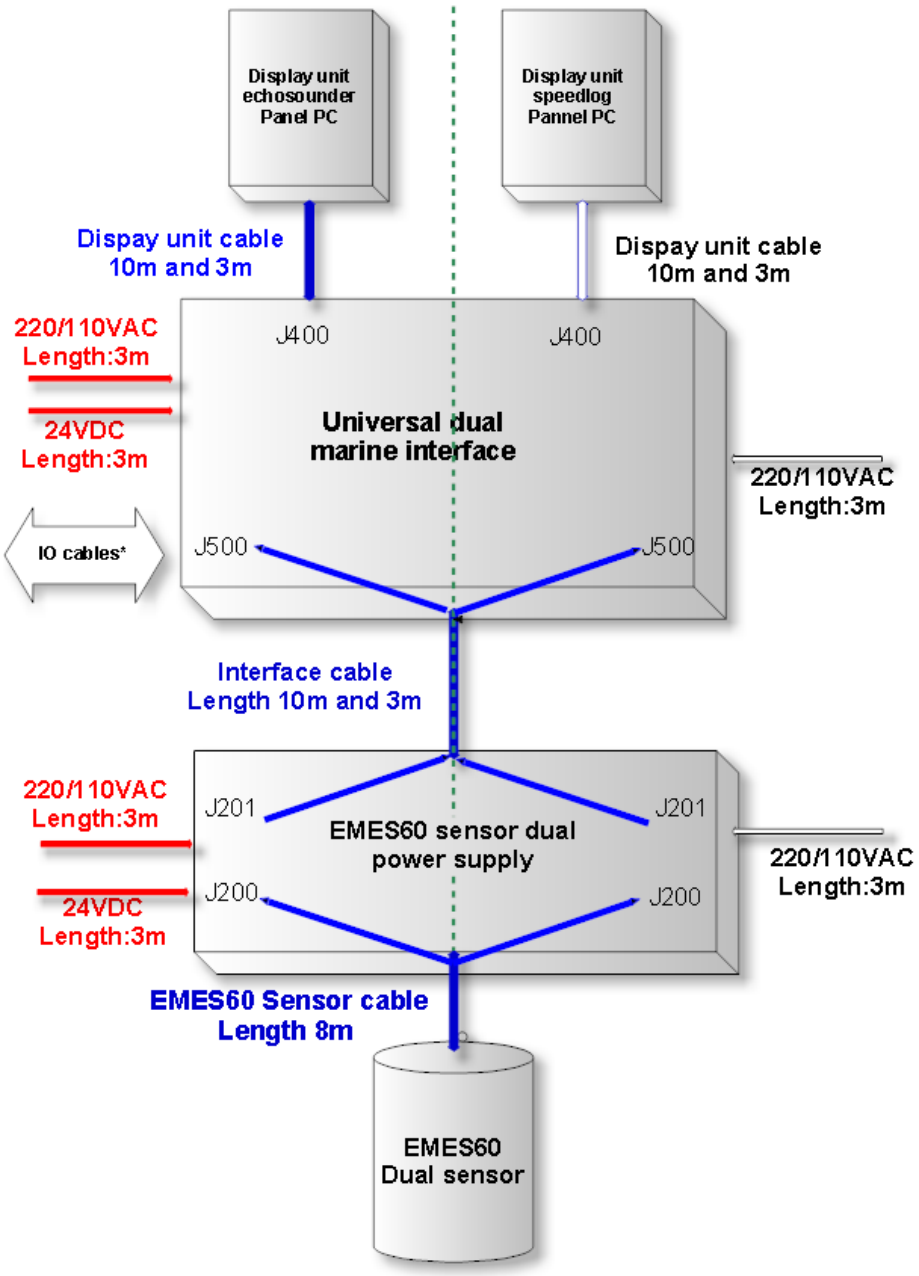



**Figure 1. Test setup by client.**

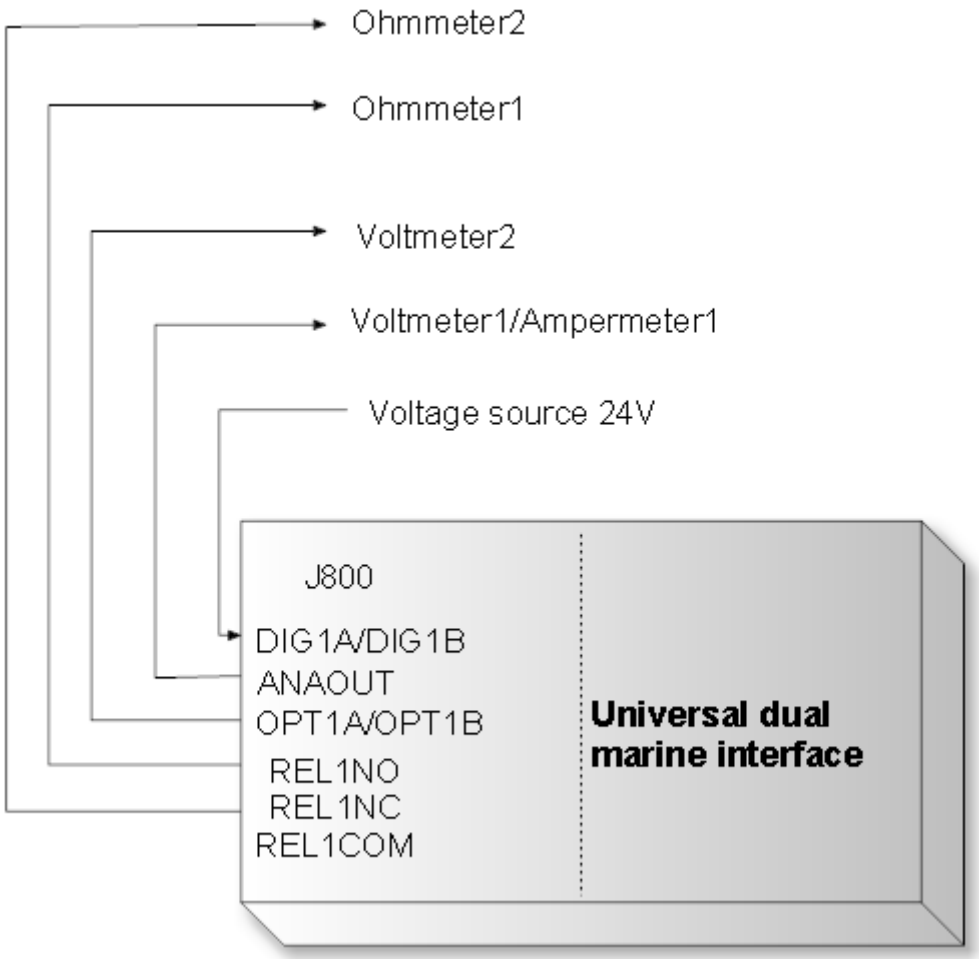



**Figure 2. IO cables to Interface Unit by client. REL1NO and REL1NC are part of a single cable connected to the RELAYOUT port. The ports are connected to the left side of the Interface Unit.**

### 1.4.1 Display Unit

Displays ‘echosounder’ and is connected to the ‘left side’ of the EMES system.

### 1.4.2 Interface Unit

The Interface Unit consists of 2 totally identical and independent Interface PCBs.

The interface Unit has 24VDC and 115/230 VAC power inputs on each PCB. Because the two sides are identical, only the left side of the system is tested.

IO cables are connected to the left side.

During radiated emission tests and radiated radio frequency interference tests both sides are powered. The left side is powered with 230 VAC and the right side is powered with 24 VDC, to be able to test both voltages at the same time.

When performing the tests on the Sensor Unit, both sides are ON and supplied the power to both Display Units; both the echosounder signal and the speedlog signal were sent from the Sensor Unit to both Display Units.

### 1.4.3 Power Supply Unit

The Power Supply Unit consists of 2 totally identical and independent Interface PCBs.

The Power Supply Unit has 24VDC and 115/230 VAC power inputs on each PCB. Because the two sides are identical, only the left side of the system is tested.

During radiated emission tests and radiated radio frequency interference tests both sides are powered. The left side is powered with 230 VAC and the right side is powered with 24 VDC, to be able to test both voltages at the same time.

When testing on the Sensor Unit, both sides were powered to display both the echosound signal and the speedlog signal from the Sensor Unit to both Display Units.

### 1.4.4 Sensor Unit

The communication line is connecting the EMES60 Sensor Unit all the way to the Display unit Echosounder (left side) and Display unit Speedlog (right side).

## 1.5 Functional test procedure

Functional test procedure by Northern Solutions A/S:

### 1.5.1 Display Unit

The IEC61162 Communication line is connecting the EMES60 dual sensor all the way to the Display unit Echosounder and Display unit Speedlog.

The operator shall observe the indications of the display during the test. The simulated data, which is sent from the sensor, must be continuously indicated on the display unit. This would confirm normal operation of the communication lines.

Observe the screen picture. The echogram must continuously advance along the screen.

No abnormalities are observed on the screen. Try to change the screens by “swiping in horizontal direction”. The screens must change smoothly.

This would confirm normal operation of the touch screen.

### 1.5.2 Interface Unit

The IEC61162 Communication line is connecting the EMES60 dual sensor all the way to the Display unit Echosounder and Display unit Speedlog.

The operator shall observe the indications of the display during the test. The simulated data, which is sent from the sensor, must be continuously indicated on the display unit.

This would confirm normal operation of the communication lines.

Verification condition 1: Voltage source 24 V on

- Voltmeter 1: 5 V
- Voltmeter 2: 0 V
- Ohmmeter 1: 0 Ohm
- Ohmmeter 2: Infinity

Verification condition 2: Voltage source 24 V off

- Amperemeter 1: 16 mA
- Voltmeter 2: 15 V
- Ohmmeter 1: Infinity
- Ohmmeter 2: 0 Ohm

### 1.5.3 Power Supply Unit

The IEC61162 Communication line is connecting the EMES60 dual sensor all the way to the Display unit Echosounder and Display unit Speedlog.

The operator shall observe the indications of the display during the test. The simulated data, which is sent from the sensor, must be continuously indicated on the display unit.

No Display Unit restart sequences must be observed.

### 1.5.4 Sensor Unit

The simulated data is generated by the built-in simulator, which consists of the system transmitter and system receiver. In the simulation mode the transmitter is transmitting the recorded signals, which are received and processed by the receiver.

The IEC61162 Communication line is connecting the EMES60 dual sensor all the way to the Display unit Echosounder and Display unit Speedlog.

The operator shall observe the indications of the display during the test. The simulated data, which is sent from the sensor, must be continuously indicated on both display units.

## 1.6 Performance criterion

The following acceptance criteria for compliance by Northern Solutions A/S are in force:

*The operator shall observe the indications of the display during the test. The simulated data, which is sent from the sensor, must be continuously indicated on the display unit.*

The generic acceptance criteria for compliance from IEC 60945:2002 is in force during the EMC immunity testing:

| Performance criterion | Description |
|---|---|
| **A** | The EUT shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed, as defined in the relevant equipment standard and in the technical specification published by the manufacturer |
| **B** | The EUT shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed, as defined in the relevant equipment standard and in the technical specification published by the manufacturer. During the test, degradation or loss of function or performance which is self-recoverable is however, allowed, but no change of actual operating state or stored data is allowed. |
| **C** | Temporary degradation or loss of function or performance is allowed during the test, provided the function is self-recoverable, or can be restored at the end of the test by the operation of the controls, as defined in the relevant equipment standard and in the technical specification published by the manufacturer. |

# 2 ELECTROMAGNETIC COMPATIBILITY

## 2.1 Radiated emission

### 2.1.1 Radiated emission – Display Unit

| | |
|---|---|
| **Test specimen** | Display Unit |
| **Test specification** | IEC 60945:2002, section 9.3 |
| **Test method** | CISPR 16-2-3:2010 |
| **Frequency range** | 0.15-2000 MHz |
| **Limits** | IEC 60945:2002 |
| **Comments** | The test specimen was tested as standalone |
| **Temperature / Humidity** | 23°C / 45%RH |
| **Date of measurements** | 2014-06-26 |
| **Test personnel** | David Busk |

#### 2.1.1.1 Test setup

The EUT was placed 80 cm above ground on a non-conductive table.

Radiated emissions in the frequency range 150 kHz – 30 MHz were premeasured with turn table steps of 45° and an antenna height of 1.5 meter without absorbers on the floor. Final measurements were made at selected frequencies after maximizing the signal by turning turntable.

Radiated emissions in the frequency range 30 – 2000 MHz were premeasured with turn table steps of 45° and antenna height between 1 – 4 m in 1 m step. Both vertical and horizontal antenna polarization were measured with reflective floor. Final measurements were made at selected frequencies after maximizing the signal by turning turntable and changing the height of the antenna.

**Photo 8. 0.15 - 30 MHz Measurement.**

**Photo 9. 30 - 2000 MHz Measurement.**

### 2.1.1.2 Test results

The measured emissions were below the limits.

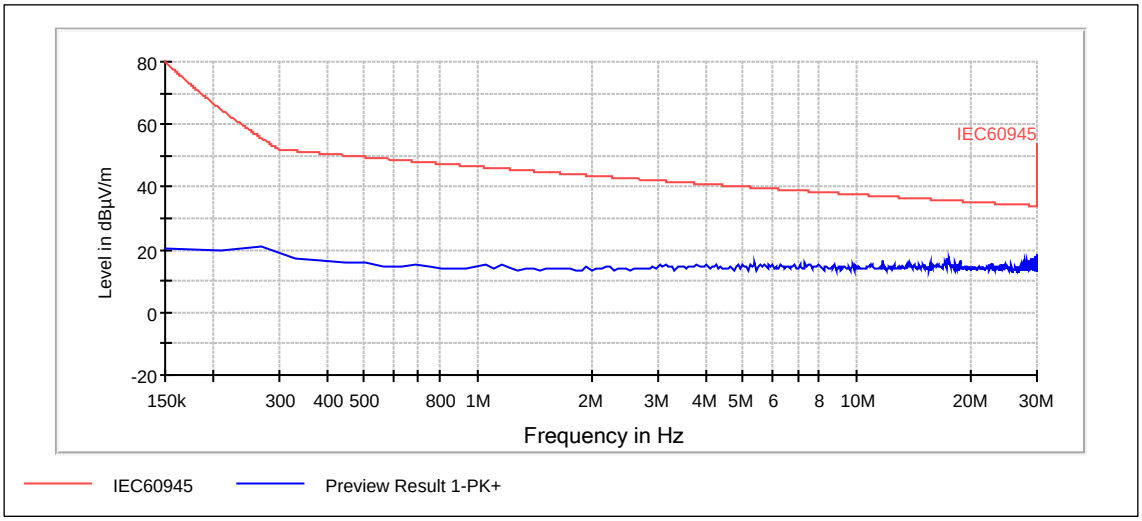



**Figure 3. Radiated Emission 150 kHz - 30 MHz. Antenna 0º.**

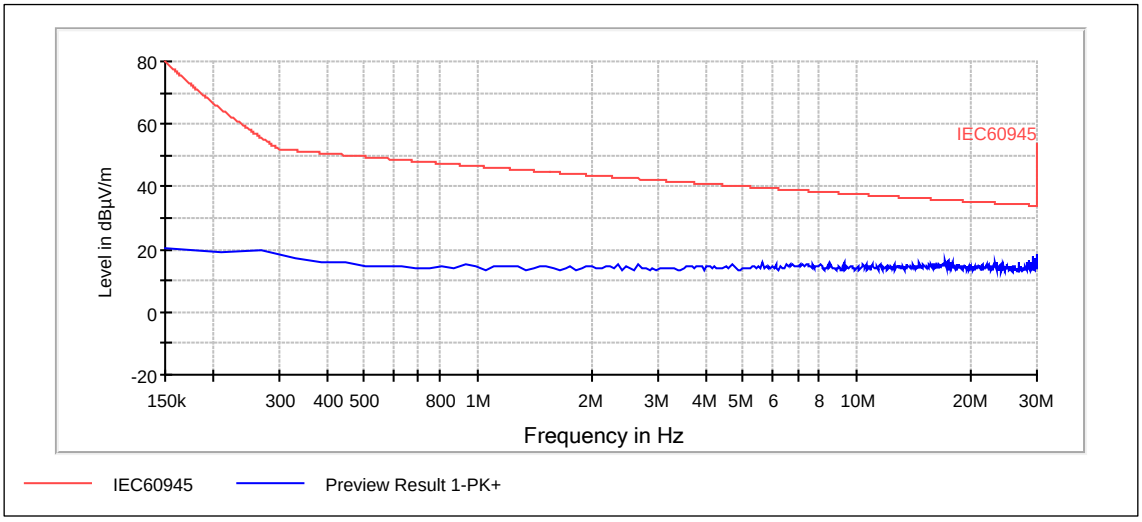



**Figure 4. Radiated Emission 150 kHz - 30 MHz. Antenna 90º.**

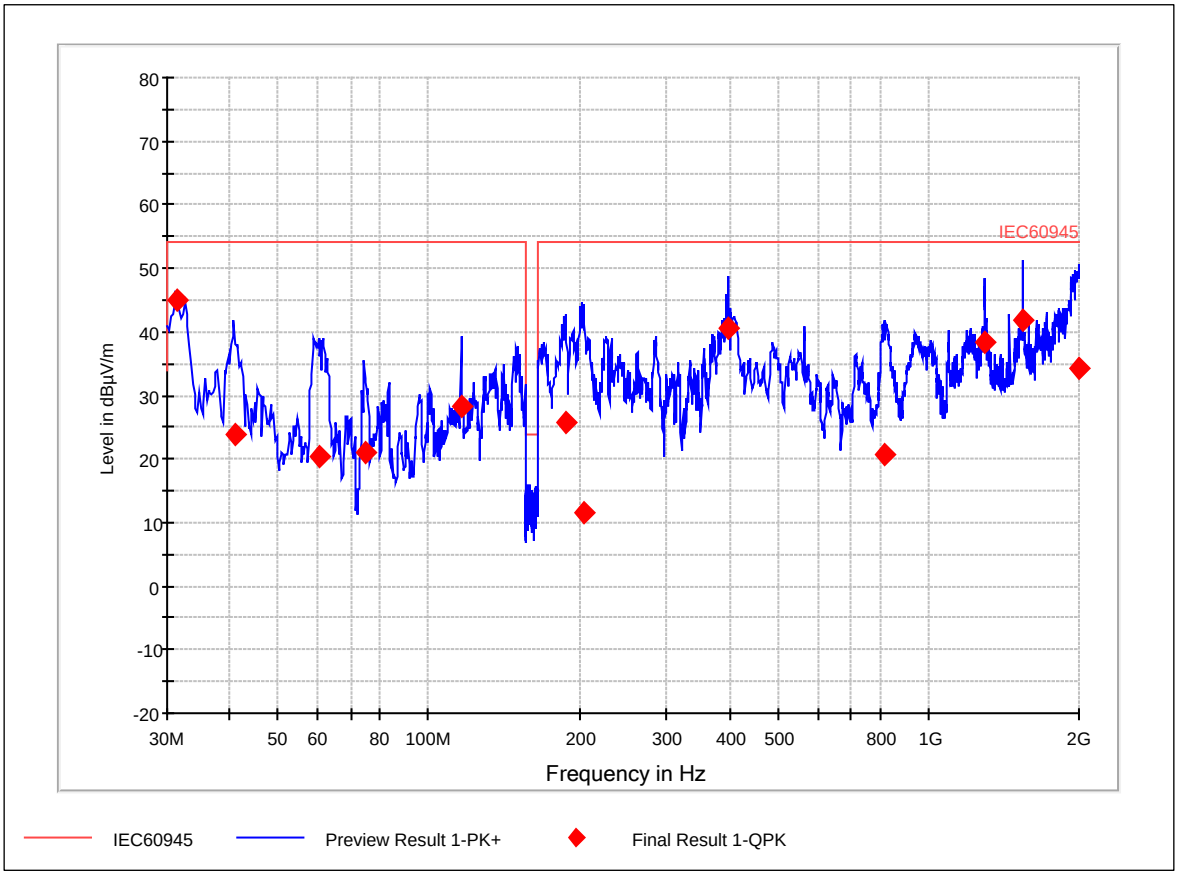



**Figure 5. Radiated Emission 30 - 2000 MHz.**

| Frequency [MHz] | QP [dBµV/m] | BW [kHz] | Height [cm] | Pol. | Azimuth [deg] | Margin [dB] | Limit [dBµV/m] | Result |
|---|---|---|---|---|---|---|---|---|
| 31.380000 | 44.9 | 120.0 | 101.0 | V | 170.0 | 9.1 | 54.0 | PASSED |
| 41.077715 | 23.8 | 120.0 | 150.0 | V | 106.0 | 30.2 | 54.0 | PASSED |
| 60.340601 | 20.2 | 120.0 | 150.0 | V | 105.0 | 33.8 | 54.0 | PASSED |
| 74.900882 | 21.0 | 120.0 | 150.0 | V | 74.0 | 33.0 | 54.0 | PASSED |
| 116.156713 | 28.2 | 120.0 | 101.0 | V | -22.0 | 25.8 | 54.0 | PASSED |
| 187.705211 | 25.8 | 120.0 | 250.0 | H | 92.0 | 28.2 | 54.0 | PASSED |
| 203.666293 | 11.5 | 120.0 | 300.0 | H | 267.0 | 42.5 | 54.0 | PASSED |
| 398.267174 | 40.5 | 120.0 | 101.0 | H | 268.0 | 13.5 | 54.0 | PASSED |
| 815.109659 | 20.6 | 120.0 | 150.0 | V | 80.0 | 33.4 | 54.0 | PASSED |
| 1294.30517 | 38.4 | 120.0 | 101.0 | H | 136.0 | 15.6 | 54.0 | PASSED |
| 1547.01418 | 41.9 | 120.0 | 138.0 | H | 202.0 | 12.1 | 54.0 | PASSED |
| 1998.33599 | 34.3 | 120.0 | 200.0 | V | 112.0 | 19.7 | 54.0 | PASSED |

**Table 1. Radiated Emission 30 - 2000 MHz results. Measurement time 15 s.**

### 2.1.2 Radiated emission – Interface Unit

| | |
|---|---|
| **Test specimen** | Interface Unit |
| **Test specification** | IEC 60945:2002, section 9.3 |
| **Test method** | CISPR 16-2-3:2010 |
| **Frequency range** | 0.15-2000 MHz |
| **Limits** | IEC 60945:2002 |
| **Comments** | None |
| **Temperature / Humidity** | 21°C / 43%RH |
| **Date of measurements** | 2014-11-20 |
| **Test personnel** | David Busk |

#### 2.1.2.1 Test setup

The EUT was placed 80 cm above ground on a non-conductive table. The auxiliary equipment was positioned outside the chamber.

A FTC 101 decoupling clamp from Luthi Elektronik was mounted to the interface cable closest to the auxiliary equipment to isolate the auxiliary equipment from the test.

Both sides of the test specimen were powered during the test. The left side was powered with 230 VAC and the right side was powered with 24 VDC.

Radiated emissions in the frequency range 150 kHz – 30 MHz were premeasured with turn table steps of 45° and an antenna height of 1.5 meter without absorbers on the floor. Final measurements were made at selected frequencies after maximizing the signal by turning turntable.

Radiated emissions in the frequency range 30 – 2000 MHz were premeasured with turn table steps of 45° and antenna height between 1 – 4 m in 1 m step. Both vertical and horizontal antenna polarization were measured with reflective floor. Final measurements were made at selected frequencies after maximizing the signal by turning turntable and changing the height of the antenna.

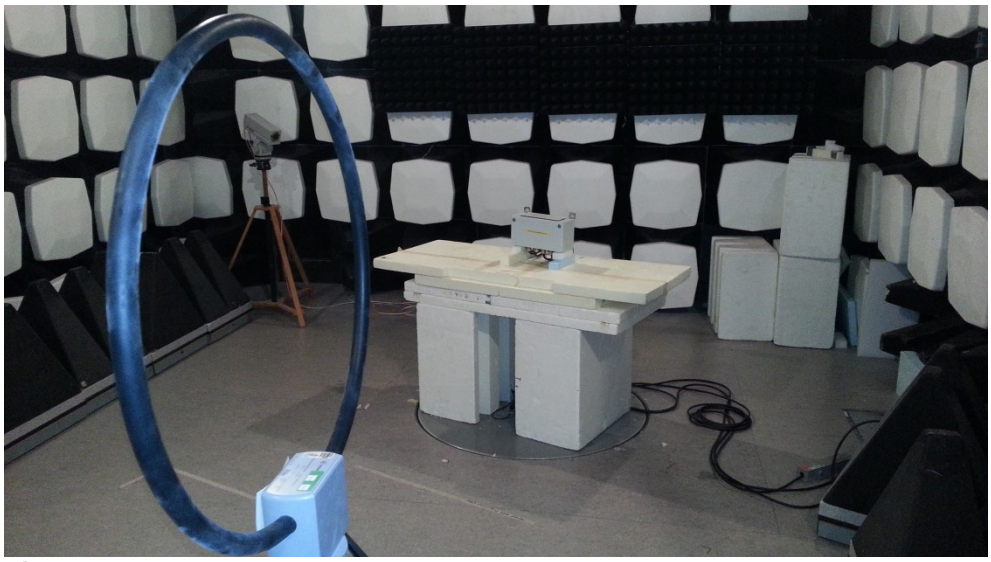


**Photo 10. 0.15 - 30 MHz Measurement.**

**Photo 11. 30 - 2000 MHz Measurement.**

### 2.1.2.2 Test results

The measured emissions were below the limits.

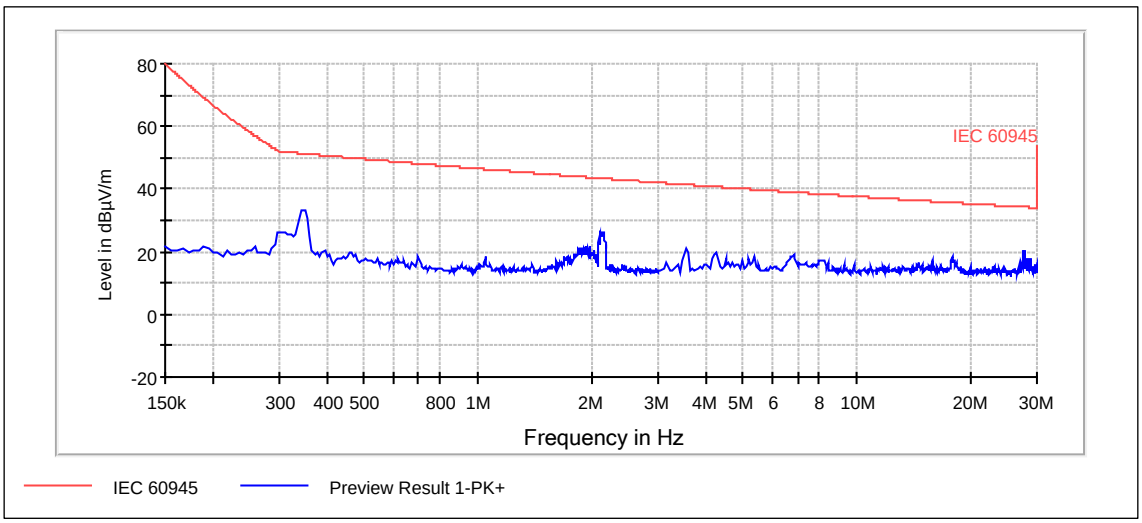



**Figure 6. Radiated Emission 150 kHz - 30 MHz. Antenna 0º.**

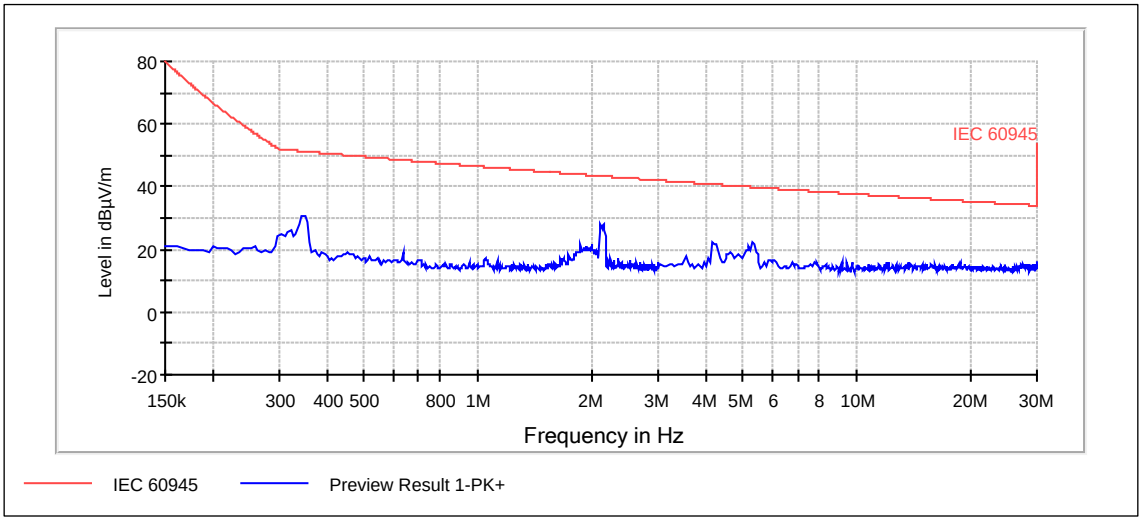



**Figure 7. Radiated Emission 150 kHz - 30 MHz. Antenna 90º.**

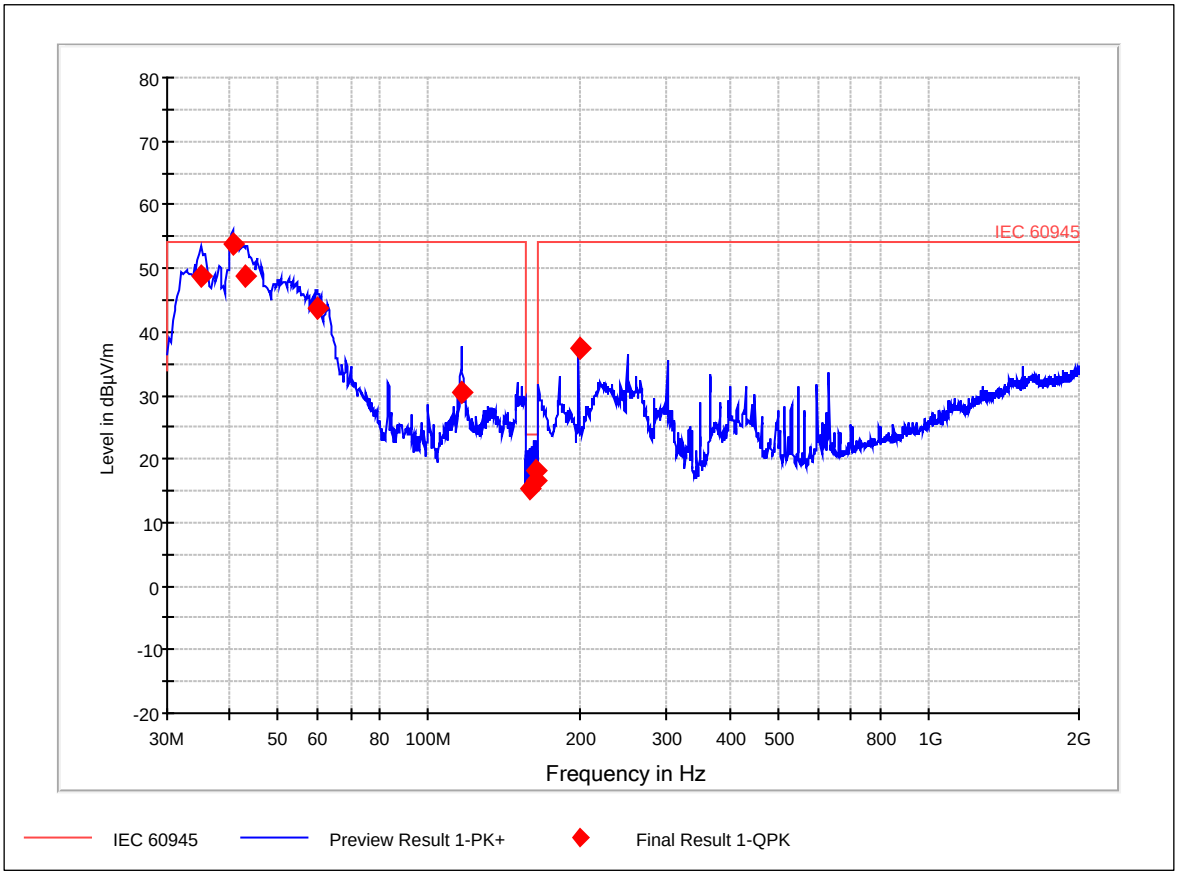



**Figure 8. Radiated Emission 30 - 2000 MHz.**

| Frequency [MHz] | QP [dBµV/m] | BW [kHz] | Height [cm] | Pol. | Azimuth [deg] | Margin [dB] | Limit [dBµV/m] | Result |
|---|---|---|---|---|---|---|---|---|
| 35.210100 | 48.7 | 120.0 | 100.0 | V | 247.0 | 5.3 | 54.0 | PASSED |
| 40.525210 | 53.7 | 120.0 | 100.0 | V | 247.0 | 0.3 | 54.0 | PASSED |
| 43.122766 | 48.9 | 120.0 | 100.0 | V | 323.0 | 5.1 | 54.0 | PASSED |
| 59.943086 | 43.8 | 120.0 | 183.0 | V | 118.0 | 10.2 | 54.0 | PASSED |
| 116.576713 | 30.4 | 120.0 | 100.0 | V | 9.0 | 23.6 | 54.0 | PASSED |
| 158.998627 | 15.4 | 9.0 | 100.0 | V | 1.0 | 8.6 | 24.0 | PASSED |
| 163.551543 | 16.6 | 9.0 | 100.0 | V | 281.0 | 7.4 | 24.0 | PASSED |
| 164.189259 | 18.3 | 9.0 | 100.0 | V | 248.0 | 5.7 | 24.0 | PASSED |
| 200.009699 | 37.4 | 120.0 | 172.0 | H | 76.0 | 16.6 | 54.0 | PASSED |

**Table 2. Radiated Emission 30 - 2000 MHz results. Measurement time 15 s.**

### 2.1.3 Radiated emission – Power Supply Unit

| | |
|---|---|
| **Test specimen** | Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 9.3 |
| **Test method** | CISPR 16-2-3:2010 |
| **Frequency range** | 0.15-2000 MHz |
| **Limits** | IEC 60945:2002 |
| **Comments** | None |
| **Temperature / Humidity** | 21°C / 45%RH |
| **Date of measurements** | 2014-11-18 |
| **Test personnel** | David Busk |

#### 2.1.3.1 Test setup

The EUT was placed 80 cm above ground on a non-conductive table. The auxiliary equipment was positioned in a well near .the wall of the chamber.

A EM 101 electromagnetic injection clamp from Luthi Elektronik was mounted to the interface cable and sensor cable closest to the auxiliary equipment to isolate the auxiliary equipment from the test.

A FTC 101decoupling clamp from Luthi Elektronik was mounted to the interface cable and sensor cable on the floor below the test specimen.

Both sides of the test specimen were powered during the test. The left side was powered with 230 VAC and the right side was powered with 24 VDC.

Radiated emissions in the frequency range 150 kHz – 30 MHz were premeasured with turn table steps of 45° and an antenna height of 1.5 meter without absorbers on the floor. Final measurements were made at selected frequencies after maximizing the signal by turning turntable.

Radiated emissions in the frequency range 30 – 2000 MHz were premeasured with turn table steps of 45° and antenna height between 1 – 4 m in 1 m step. Both vertical and horizontal antenna polarization were measured with reflective floor. Final measurements were made at selected frequencies after maximizing the signal by turning turntable and changing the height of the antenna.

To comply with the limits, the client inserted a NEC/TOKIN filter of type: SH_102 at the DC input power port. The filter is used in all other performed tests except for conducted emission test where a Schaffner filter was used. See section 1.2.3.

**Photo 12. 0.15 - 30 MHz Measurement.**

**Photo 13. 30 - 2000 MHz Measurement.**

### 2.1.3.2 Test results

The measured emissions were below the limits.

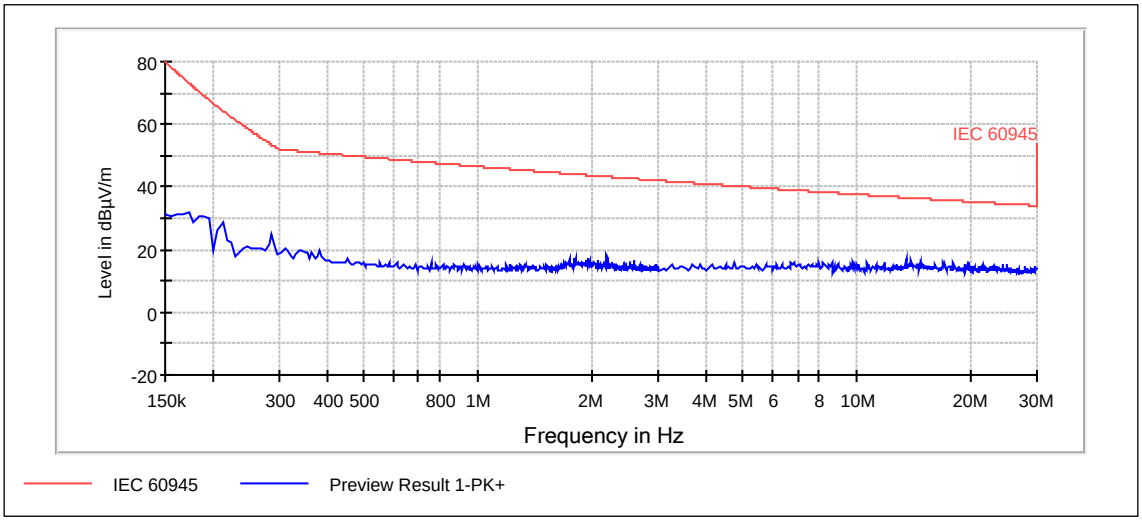



**Figure 9. Radiated Emission 150 kHz - 30 MHz. Antenna 0º.**

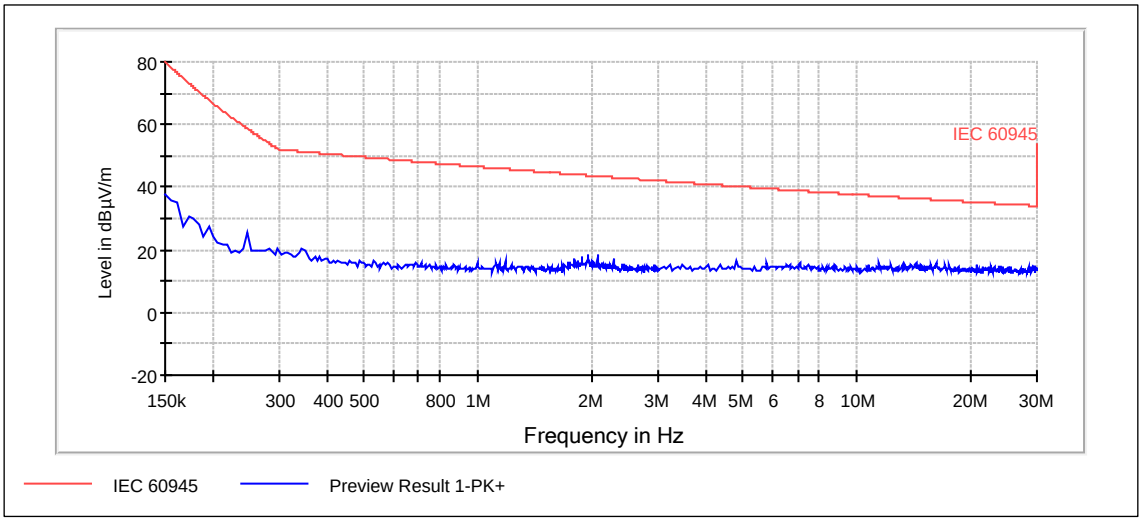



**Figure 10. Radiated Emission 150 kHz - 30 MHz. Antenna 90º.**

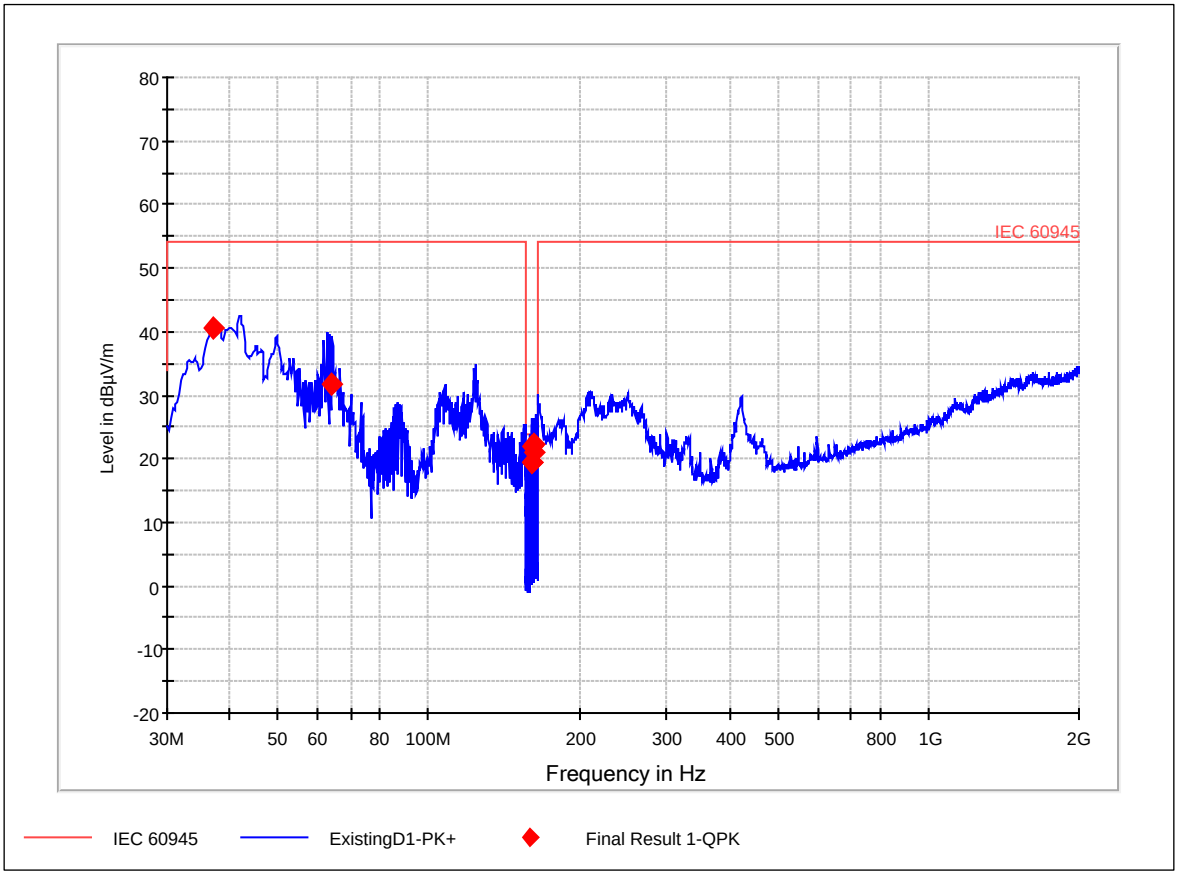



**Figure 11. Radiated Emission 30 - 2000 MHz.**

| Frequency [MHz] | QP [dBµV/m] | BW [kHz] | Height [cm] | Pol. | Azimuth [deg] | Margin [dB] | Limit [dBµV/m] | Result |
|---|---|---|---|---|---|---|---|---|
| 37.170140 | 40.4 | 120.0 | 100.0 | V | 192.0 | 13.6 | 54.0 | PASSED |
| 64.113146 | 31.6 | 120.0 | 158.0 | V | 55.0 | 22.4 | 54.0 | PASSED |
| 160.527425 | 19.5 | 9.0 | 244.0 | H | 73.0 | 4.5 | 24.0 | PASSED |
| 160.533687 | 21.8 | 9.0 | 258.0 | H | 67.0 | 2.2 | 24.0 | PASSED |
| 161.167986 | 19.4 | 9.0 | 255.0 | H | 76.0 | 4.6 | 24.0 | PASSED |
| 161.844259 | 21.1 | 9.0 | 171.0 | H | 73.0 | 2.9 | 24.0 | PASSED |
| 163.139820 | 22.2 | 9.0 | 156.0 | H | 76.0 | 1.8 | 24.0 | PASSED |

**Table 3. Radiated Emission 30 - 2000 MHz results. Measurement time 15 s.**

### 2.1.4 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Antenna, Ultra Broadband, 30MHz-3GHz | Rohde&Schwarz | HL562 | 19830 |
| Antenna Magnetic Loop 9 kHz - 30 MHz | Rohde&Schwarz | HFH2-Z2 | 19966 |
| Analyzer 20Hz-26.5GHz | Rohde&Schwarz | ESI | 20763 |

**Table 4. Equipment for Radiated Emission.**

## 2.2 Conducted emission

### 2.2.1 Conducted emission – Interface Unit

| | |
|---|---|
| **Test specimen** | Interface Unit |
| **Test specification** | IEC 60945:2002, section 9.2 |
| **Test method** | CISPR 16-2-1:2014 |
| **Frequency range** | 0.01 - 30 MHz |
| **Limits** | IEC 60945:2002 |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 41%RH |
| **Date of measurements** | 2015-02-20 |
| **Test personnel** | David Busk |

#### 2.2.1.1 Test setup

The test was made at nominal supply voltages of 115 VAC, 230 VAC and 24 VDC.

The test specimen was mounted on, and bonded, to an earth plan.

Cables and auxiliary equipment were elevated 10 mm above the conductive table.

The power supply cable to the test specimen was a 0.8 m shielded power supply cable connected directly to the artificial mains network.

Auxiliary equipment was powered through a separate artificial mains network.

To comply with the limits, the client inserted a Shaffner filter of type: FN409 at the DC input power port. The filter is deemed not to have any effect on previous performed tests other than improving results. See section 1.2.2.

**Photo 14. Conducted emission test setup. AC voltage.**

**Photo 15. Conducted emission test setup. DC voltage.**

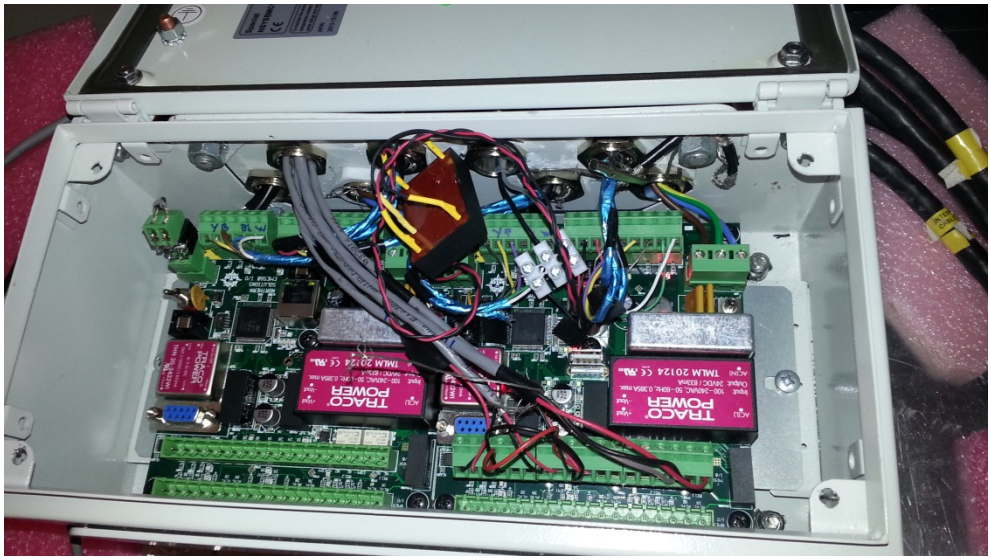



**Photo 16. Shaffner filter used for DC test.**

### 2.2.1.2 Test results

The measured emissions were below the limits.

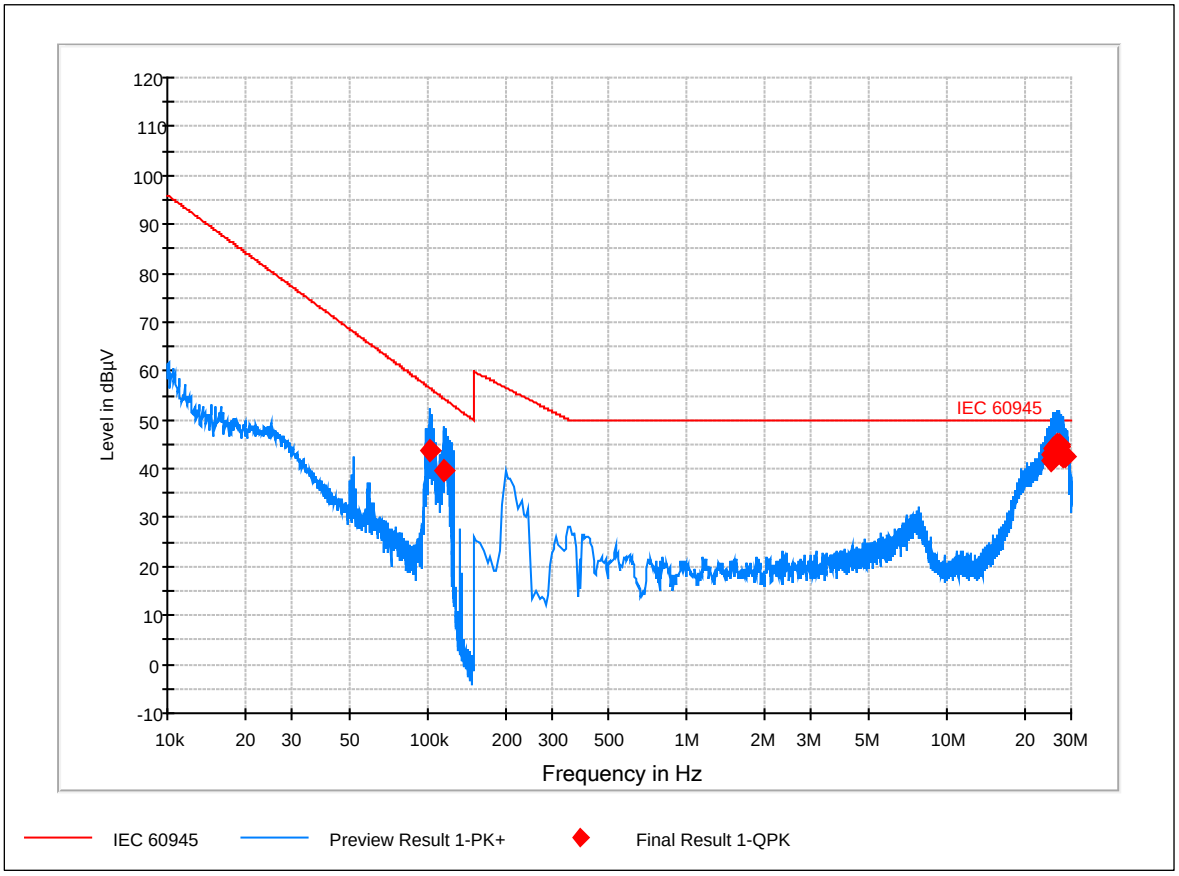



**Figure 12. Conducted emission test. Supply voltage: 115 VAC.**

| Frequency [MHz] | QuasiPeak [dBµV] | BW [kHz] | Line | Margin [dB] | Limit [dBµV] | Result |
|---|---|---|---|---|---|---|
| 0.101540 | 43.7 | 0.200 | N | 13.0 | 56.6 | PASSED |
| 0.116720 | 39.8 | 0.200 | L1 | 14.5 | 54.3 | PASSED |
| 24.919500 | 41.7 | 9.000 | L1 | 8.3 | 50.0 | PASSED |
| 25.094700 | 42.7 | 9.000 | N | 7.3 | 50.0 | PASSED |
| 25.670100 | 44.2 | 9.000 | N | 5.8 | 50.0 | PASSED |
| 25.852600 | 44.5 | 9.000 | N | 5.5 | 50.0 | PASSED |
| 26.175900 | 43.9 | 9.000 | L1 | 6.1 | 50.0 | PASSED |
| 26.449000 | 44.9 | 9.000 | N | 5.1 | 50.0 | PASSED |
| 26.731400 | 44.8 | 9.000 | N | 5.2 | 50.0 | PASSED |
| 26.807400 | 44.7 | 9.000 | N | 5.3 | 50.0 | PASSED |
| 26.972000 | 43.6 | 9.000 | L1 | 6.4 | 50.0 | PASSED |
| 27.139900 | 44.4 | 9.000 | N | 5.6 | 50.0 | PASSED |
| 27.344400 | 43.1 | 9.000 | L1 | 6.9 | 50.0 | PASSED |
| 27.781000 | 42.4 | 9.000 | L1 | 7.6 | 50.0 | PASSED |
| 28.119300 | 43.1 | 9.000 | N | 6.9 | 50.0 | PASSED |
| 28.532000 | 42.4 | 9.000 | N | 7.6 | 50.0 | PASSED |

**Table 5. Conducted emission results. Measurement time 15 s. Supply voltage: 115 VAC.**

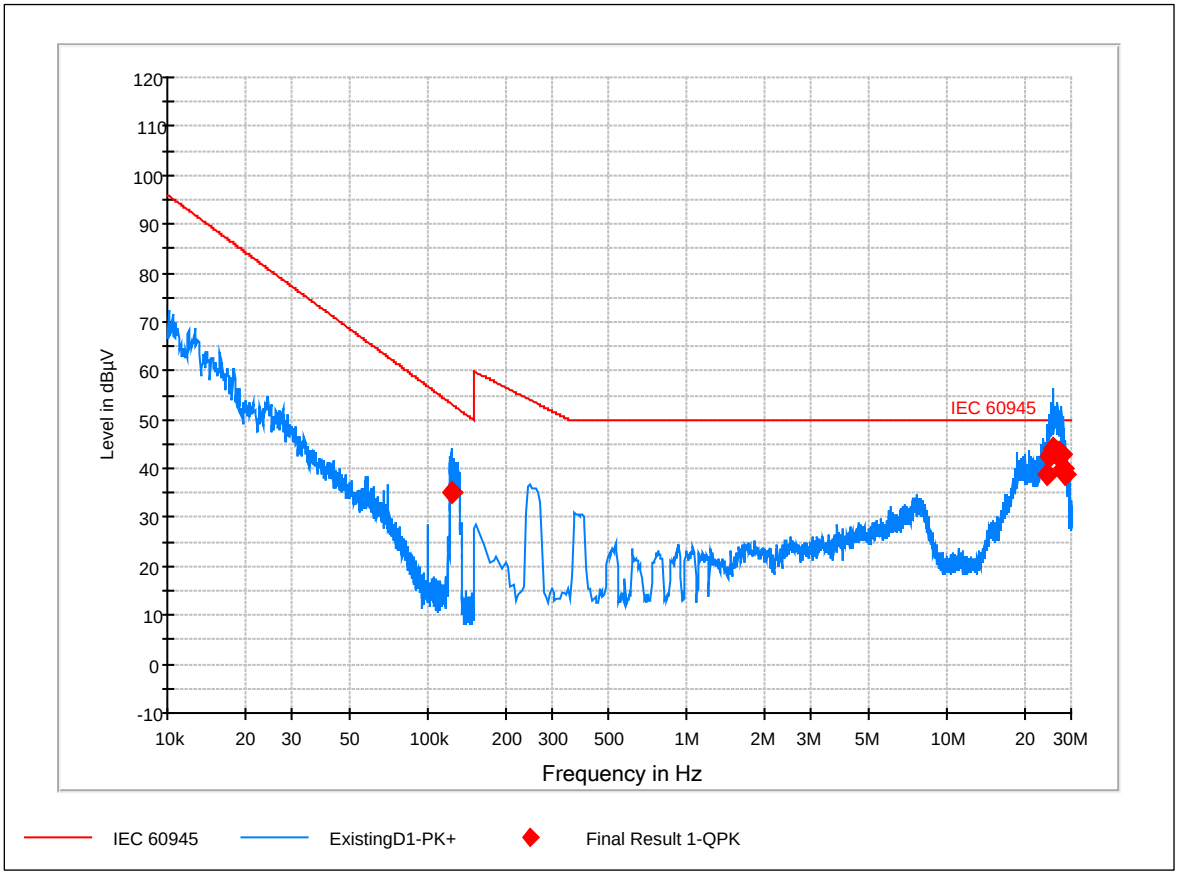



**Figure 13. Conducted emission test. Supply voltage: 230 VAC.**

| Frequency [MHz] | QuasiPeak [dBµV] | BW [kHz] | Line | Margin [dB] | Limit [dBµV] | Result |
|---|---|---|---|---|---|---|
| 0.123780 | 35.3 | 0.200 | L1 | 18.0 | 53.3 | PASSED |
| 24.101600 | 38.8 | 9.000 | L1 | 11.2 | 50.0 | PASSED |
| 24.574100 | 42.3 | 9.000 | N | 7.7 | 50.0 | PASSED |
| 25.017500 | 43.1 | 9.000 | N | 6.9 | 50.0 | PASSED |
| 25.518700 | 43.9 | 9.000 | N | 6.1 | 50.0 | PASSED |
| 25.729900 | 44.2 | 9.000 | N | 5.8 | 50.0 | PASSED |
| 26.061700 | 43.3 | 9.000 | L1 | 6.7 | 50.0 | PASSED |
| 26.347400 | 43.5 | 9.000 | N | 6.5 | 50.0 | PASSED |
| 26.517400 | 43.1 | 9.000 | N | 6.9 | 50.0 | PASSED |
| 26.660600 | 42.8 | 9.000 | N | 7.2 | 50.0 | PASSED |
| 26.991900 | 43.3 | 9.000 | N | 6.8 | 50.0 | PASSED |
| 27.264900 | 43.0 | 9.000 | N | 7.0 | 50.0 | PASSED |
| 27.378600 | 42.9 | 9.000 | N | 7.1 | 50.0 | PASSED |
| 27.942300 | 39.9 | 9.000 | N | 10.1 | 50.0 | PASSED |
| 28.382900 | 38.6 | 9.000 | N | 11.4 | 50.0 | PASSED |

**Table 6. Conducted emission results. Measurement time 15 s. Supply voltage: 230 VAC.**

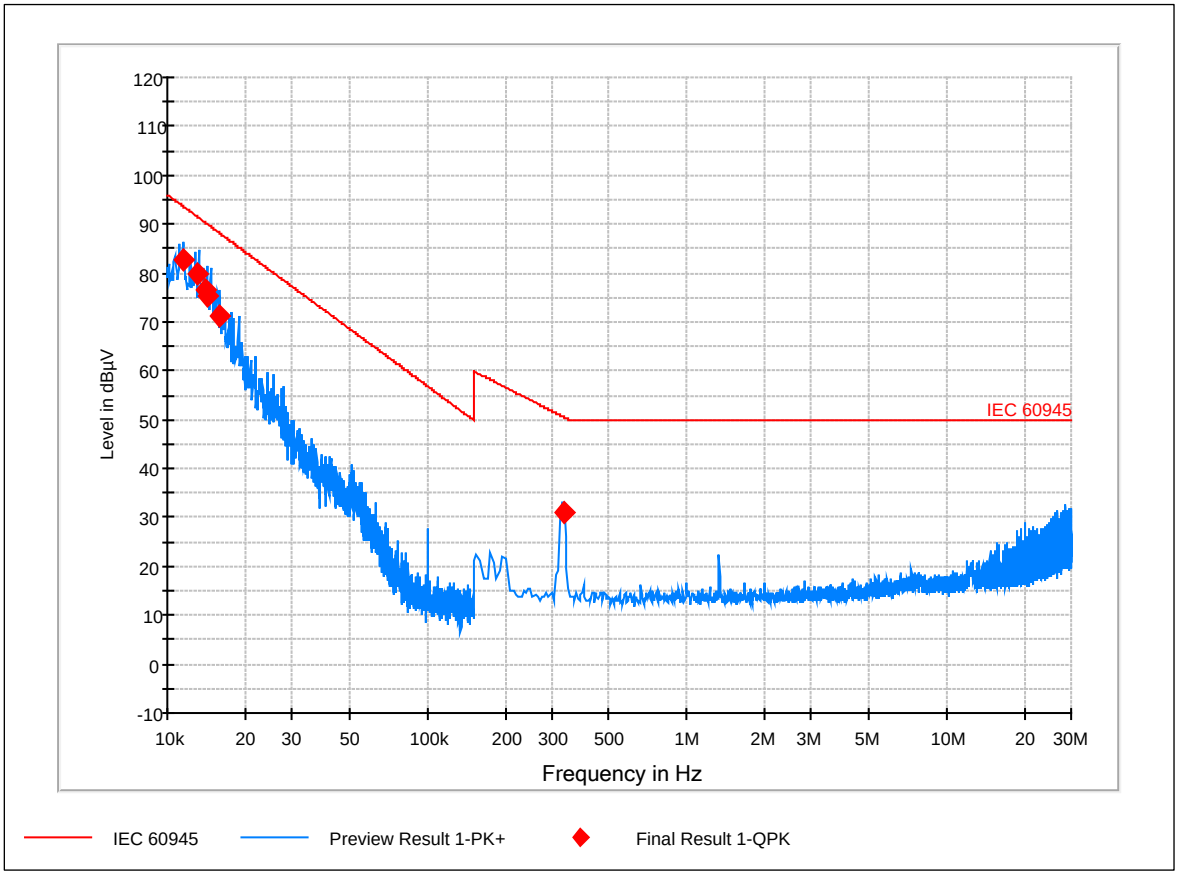



**Figure 14. Conducted emission test. Supply voltage: 24 VDC.**

| Frequency [MHz] | QuasiPeak [dBµV] | BW [kHz] | Line | Margin [dB] | Limit [dBµV] | Result |
|---|---|---|---|---|---|---|
| 0.011580 | 82.8 | 0.200 | N | 10.7 | 93.5 | PASSED |
| 0.013030 | 80.0 | 0.200 | L1 | 11.6 | 91.5 | PASSED |
| 0.013910 | 76.4 | 0.200 | L1 | 14.0 | 90.4 | PASSED |
| 0.014270 | 75.2 | 0.200 | N | 14.8 | 90.0 | PASSED |
| 0.015910 | 71.3 | 0.200 | N | 16.8 | 88.1 | PASSED |
| 0.335000 | 30.8 | 9.000 | N | 19.7 | 50.5 | PASSED |

**Table 7. Conducted emission results. Measurement time 15 s. Supply voltage: 24 VDC.**

### 2.2.2 Conducted emission – Power Supply Unit

| | |
|---|---|
| **Test specimen** | Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 9.2 |
| **Test method** | CISPR 16-2-1:2014 |
| **Frequency range** | 0.01 - 30 MHz |
| **Limits** | IEC 60945:2002 |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 47%RH, 23°C / 41%RH |
| **Date of measurements** | 2015-01-22, 2015-02-20 |
| **Test personnel** | David Busk |

#### 2.2.2.1 Test setup

The test was made at nominal supply voltages of 115 VAC, 230 VAC and 24 VDC.

The test specimen was mounted on, and bonded, to an earth plan.

Cables and auxiliary equipment were elevated 10 mm above the conductive table.

The power supply cable to the test specimen was a 0.8 m shielded power supply cable connected directly to the artificial mains network.

Auxiliary equipment was powered through a separate artificial mains network.

To comply with the limits, the client exchanged the NEC/TOKIN SH_102 filter with a Shaffner filter of type: FN409 at the DC input power port. The filter is deemed not to have any effect on previous performed tests other than improving results. See section 1.2.3.

**Photo 17. Conducted emission test setup. AC voltage.**

**Photo 18. Conducted emission test setup. DC voltage.**

**Photo 19. Shaffner filter used for DC test.**

### 2.2.2.2 Test results

The measured emissions were below the limits.

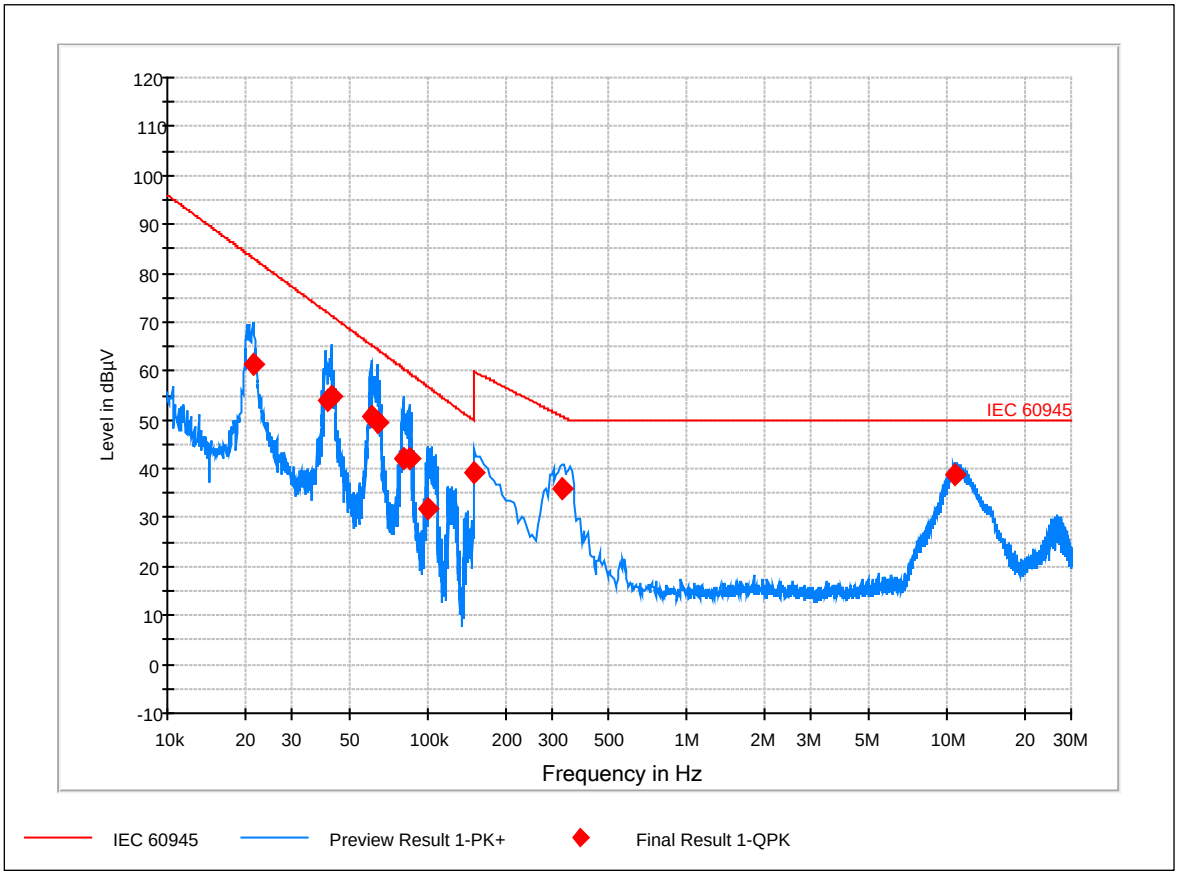



**Figure 15. Conducted emission test. Supply voltage: 115 VAC.**

| Frequency [MHz] | QuasiPeak [dBµV] | BW [kHz] | Line | Margin [dB] | Limit [dBµV] | Result |
|---|---|---|---|---|---|---|
| 0.021500 | 61.3 | 0.200 | N | 21.7 | 83.0 | PASSED |
| 0.041140 | 53.8 | 0.200 | N | 18.2 | 72.0 | PASSED |
| 0.043010 | 54.7 | 0.200 | L1 | 16.5 | 71.2 | PASSED |
| 0.061010 | 50.5 | 0.200 | L1 | 14.7 | 65.3 | PASSED |
| 0.064250 | 49.3 | 0.200 | N | 15.1 | 64.4 | PASSED |
| 0.081030 | 42.2 | 0.200 | L1 | 18.3 | 60.5 | PASSED |
| 0.086370 | 42.2 | 0.200 | N | 17.2 | 59.4 | PASSED |
| 0.100870 | 31.8 | 0.200 | L1 | 24.9 | 56.7 | PASSED |
| 0.150000 | 39.2 | 0.200 | L1 | 20.8 | 60.0 | PASSED |
| 0.329800 | 35.8 | 9.000 | L1 | 14.9 | 50.7 | PASSED |
| 10.770100 | 39.0 | 9.000 | L1 | 11.0 | 50.0 | PASSED |

**Table 8. Conducted emission results. Measurement time 15 s. Supply voltage: 115 VAC.**

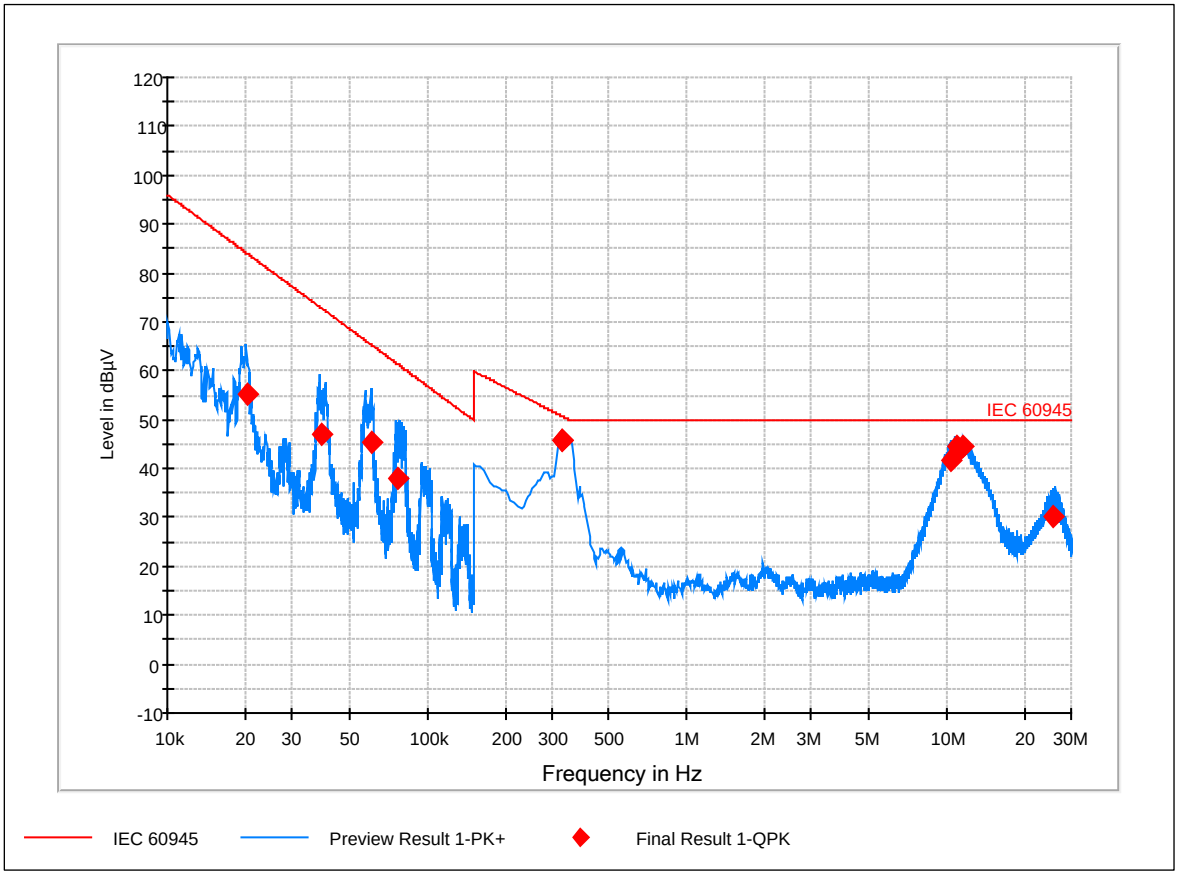



**Figure 16. Conducted emission test. Supply voltage: 230 VAC.**

| Frequency [MHz] | QuasiPeak [dBµV] | BW [kHz] | Line | Margin [dB] | Limit [dBµV] | Result |
|---|---|---|---|---|---|---|
| 0.020330 | 55.4 | 0.200 | L1 | 28.6 | 83.9 | PASSED |
| 0.038920 | 47.2 | 0.200 | N | 25.7 | 72.9 | PASSED |
| 0.061250 | 45.2 | 0.200 | N | 20.0 | 65.2 | PASSED |
| 0.076650 | 38.2 | 0.200 | N | 23.2 | 61.4 | PASSED |
| 0.329900 | 45.9 | 9.000 | N | 4.8 | 50.7 | PASSED |
| 0.331300 | 45.8 | 9.000 | N | 4.8 | 50.6 | PASSED |
| 10.416000 | 41.7 | 9.000 | L1 | 8.3 | 50.0 | PASSED |
| 10.842500 | 44.4 | 9.000 | L1 | 5.6 | 50.0 | PASSED |
| 11.171200 | 43.9 | 9.000 | N | 6.1 | 50.0 | PASSED |
| 11.595200 | 44.4 | 9.000 | L1 | 5.6 | 50.0 | PASSED |
| 25.728200 | 30.3 | 9.000 | N | 19.7 | 50.0 | PASSED |

**Table 9. Conducted emission results. Measurement time 15 s. Supply voltage: 230 VAC.**

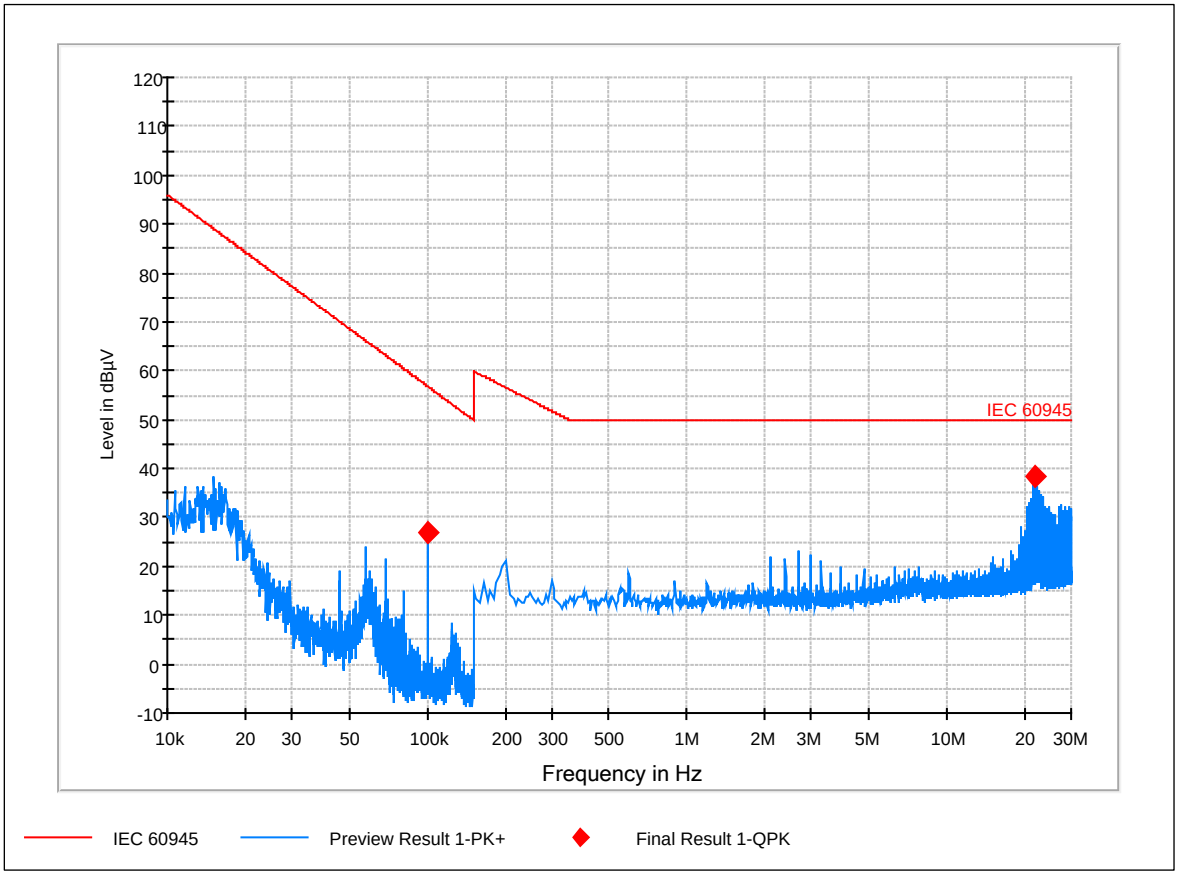



**Figure 17. Conducted emission test. Supply voltage: 24 VDC.**

| Frequency [MHz] | QuasiPeak [dBµV] | BW [kHz] | Line | Margin [dB] | Limit [dBµV] | Result |
|---|---|---|---|---|---|---|
| 0.100040 | 27.0 | 0.200 | L1 | 29.9 | 56.9 | PASSED |
| 21.811200 | 38.2 | 9.000 | L1 | 11.8 | 50.0 | PASSED |

**Table 10. Conducted emission results. Measurement time 15 s. Supply voltage: 24 VDC.**

### 2.2.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Pulse Limiter 9KHz-30MHz | Rohde&Schwarz | ESH3-Z2 | 13513 |
| V-network Two Line | Rohde&Schwarz | ESH3-Z5 | 13935 |
| Receiver EMI Test 9KHz-2750MHz | Rohde&Schwarz | ESCS30 | 14993 |
| V-network Two Line | Rohde&Schwarz | ESH3-Z5 | 20682 |

**Table 11. Test equipment for conducted emission.**

## 2.3 Radiated radio frequency interference

### 2.3.1 Radiated RF interference - Display Unit and Interface Unit

| | |
|---|---|
| **Test specimen** | Display Unit and Interface Unit |
| **Test specification** | IEC 60945:2002, section 10.4 |
| **Test method** | IEC 61000-4-3:2006+A1+A2 |
| **Performance criterion** | A |
| **Frequency range** | 80-2000 MHz |
| **Field strength** | 10 V/m |
| **Modulation** | 80% AM, 400 Hz sine wave |
| **Step size / dwell time** | 1% / 3 s (80 – 1000 MHz), 1% / 9 s (1 – 2 GHz) |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 39%RH |
| **Date of measurements** | 2014-11-12 |
| **Test personnel** | David Busk |

#### 2.3.1.1 Test setup

The tests were performed in a semi anechoic chamber with absorbers on floor. The test specimens were placed on a non-conductive foam table. The auxiliary equipment was placed on the floor under the table. The multimeters were positioned outside the chamber.

Both sides of the Interface Unit were powered during the test. The left side was powered with 230 VAC and the right side was powered with 24 VDC.

The distance between the antenna and test specimen was 2.5 m. The antenna height was 1.55 m in the frequency range 80 MHz to 1000 MHz. In the frequency range 1 GHz to 2 GHz the antenna height was 1.35 m.

Functional tests were performed before, during and after testing.

**Photo 20. Radio frequency electromagnetic interference. 80 MHz – 1000 MHz.**

**Photo 21. Radio frequency electromagnetic interference. 1 GHz – 2 GHz.**

### 2.3.1.2 Test results

No change in actual operating state or stored data was observed. The test specimen continued to operate as intended before, during and after the test.

| Frequency [MHz] | Specimen side facing antenna | Horizontal | | Vertical | |
|---|---|---|---|---|---|
| | | V/m | Result | V/m | Result |
| 80-1000 | 0° (Left) | 10 | PASSED | 10 | PASSED |
| 80-1000 | 90° (Back) | 10 | PASSED | 10 | PASSED |
| 80-1000 | 180° (Right) | 10 | PASSED | 10 | PASSED |
| 80-1000 | 270° (Front) | 10 | PASSED | 10 | PASSED |
| 1000-2000 | 0° (Left) | 10 | PASSED | 10 | PASSED |
| 1000-2000 | 90° (Back) | 10 | PASSED | 10 | PASSED |
| 1000-2000 | 180° (Right) | 10 | PASSED | 10 | PASSED |
| 1000-2000 | 270° (Front) | 10 | PASSED | 10 | PASSED |

**Table 12. Results for radio frequency electromagnetic interference 80 MHz – 2000 MHz.**

### 2.3.2 Radiated RF interference - Power Supply Unit

| | |
|---|---|
| **Test specimen** | Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 10.4 |
| **Test method** | IEC 61000-4-3:2006+A1+A2 |
| **Performance criterion** | A |
| **Frequency range** | 80-2000 MHz |
| **Field strength** | 10 V/m |
| **Modulation** | 80% AM, 400 Hz sine wave |
| **Step size / dwell time** | 1% / 3 s (80 – 1000 MHz), 1% / 9 s (1 – 2 GHz) |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 35%RH |
| **Date of measurements** | 2014-11-17 |
| **Test personnel** | David Busk |

#### 2.3.2.1 Test setup

The tests were performed in a semi anechoic chamber with absorbers on floor. The test specimen was placed on a non-conductive foam table. The auxiliary equipment was placed on the floor under the table. The multimeters were positioned outside the chamber.

Both sides of the Power Supply Unit were powered during the test. The left side was powered with 230 VAC and the right side was powered with 24 VDC.

The distance between the antenna and test specimen was 2.5 m. The antenna height was 1.55 m in the frequency range 80 MHz to 1000 MHz. In the frequency range 1 GHz to 2 GHz the antenna height was 1.35 m.

Functional tests were performed before, during and after testing.

**Photo 22. Radio frequency electromagnetic field 80 MHz – 1000 MHz.**

**Photo 23. Radio frequency electromagnetic interference. 1 GHz – 2 GHz.**

### 2.3.2.2 Test results

No change in actual operating state or stored data was observed. The test specimen continued to operate as intended before, during and after the test.

| Frequency [MHz] | Specimen side facing antenna | Horizontal | | Vertical | |
|---|---|---|---|---|---|
| | | V/m | Result | V/m | Result |
| 80-1000 | 0° (Left) | 10 | PASSED | 10 | PASSED |
| 80-1000 | 90° (Back) | 10 | PASSED | 10 | PASSED |
| 80-1000 | 180° (Right) | 10 | PASSED | 10 | PASSED |
| 80-1000 | 270° (Front) | 10 | PASSED | 10 | PASSED |
| 1000-2000 | 0° (Left) | 10 | PASSED | 10 | PASSED |
| 1000-2000 | 90° (Back) | 10 | PASSED | 10 | PASSED |
| 1000-2000 | 180° (Right) | 10 | PASSED | 10 | PASSED |
| 1000-2000 | 270° (Front) | 10 | PASSED | 10 | PASSED |

**Table 13. Results for radio frequency electromagnetic interference. 80 MHz – 2000 MHz.**

### 2.3.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Amplifier 25-1000MHz 100W | Amplifier Research | 100W1000M1A | 13787 |
| Amplifier 800MHz-4,2GHz 25W | Amplifier Research | 25S1G4 | 13788 |
| Antenna, MicroWave Horn, 1-4,2GHz | Amplifier Research | AT4002 | 13792 |
| Directional Coupler 1-4,2GHz 40dB 600W | Amplifier Research | DC7140 | 13809 |
| Directional Coupler 80-1000MHz 60dB 600W | Amplifier Research | DC6180 | 13810 |
| Power Meter Digital | Rohde&Schwarz | NRVD | 13830 |
| Power Probe 1nW-20mW 10MHz-18GHz | Rohde&Schwarz | NRV-Z1 | 13831 |
| Power Probe 1nW-20mW 10MHz-18GHz | Rohde&Schwarz | NRV-Z1 | 13832 |
| Signal generator 5kHz - 6GHz | Rohde&Schwarz | SME06 | 14152 |
| Antenna Log Periodic 80-1300 MHz | Rohde&Schwarz | HL023A1 | 16217 |
| Amplifier 10kHz 250MHz 500W | Amplifier Research | 500A250B | 50020 |

**Table 14. Test equipment for radiated radio frequency interference.**

## 2.4 Conducted radio frequency interference

### 2.4.1 Conducted RF interference - Display Unit

| | |
|---|---|
| **Test specimen** | Display Unit |
| **Test specification** | IEC 60945:2002, section 10.3 |
| **Test method** | IEC 61000-4-6:2013 |
| **Performance criterion** | A |
| **Frequency range** | 150 kHz – 80 MHz |
| **Amplitude** | 3 $V_{rms}$ and 10 $V_{rms}$ at spot frequencies ($U_0$) |
| **Spot frequencies** | 2, 3, 4, 6.2, 8.2, 12.6, 16.5, 18.8, 22 and 25 MHz |
| **Modulation** | 80% AM, 400 Hz sine wave |
| **Sweep rate** | 3 seconds per 1% step size |
| **Comments** | None |
| **Temperature / Humidity** | 24°C / 36%RH |
| **Date of measurements** | 2014-12-03 |
| **Test personnel** | David Busk, Bo Schødt |

### 2.4.2 Test setup

The test specimen was grounded through a CDN-M1. The CDN-M1 was terminated in 50 Ω during all tests.

Cables not connected to a CDN were exposed through an injection clamp. The injected current was monitored by a current probe. If the current exceeded $I_{max} = U_0 / 150\ \Omega$ the amplitude was reduced until the measured current was equal to the $I_{max}$ value.

The auxiliary equipment was grounded through a CDN-M1 terminated in 50 Ω.

All cables not under test were decoupled.

Functional tests were performed before, during and after testing.

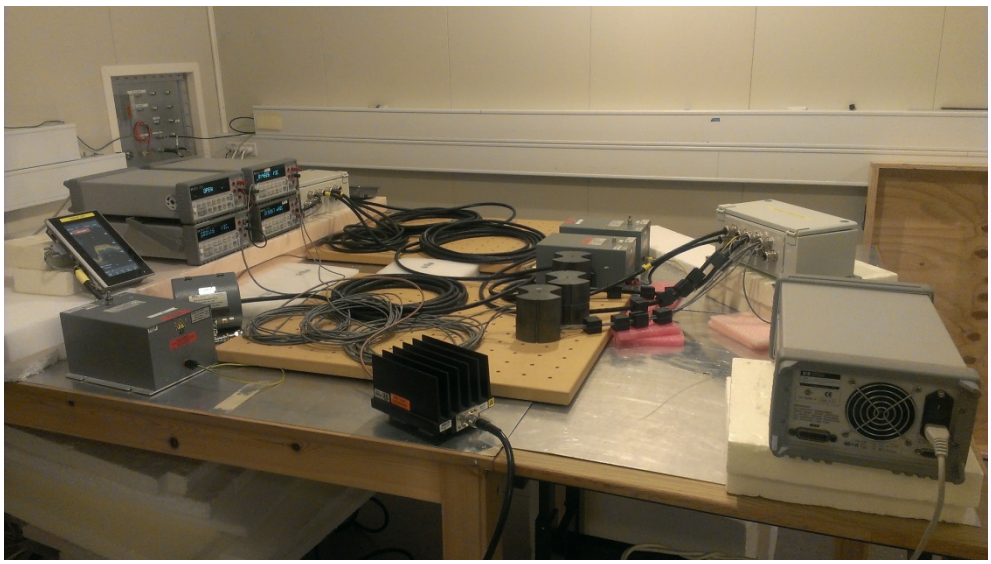


**Photo 24. Conducted radio frequency interference test setup. Clamp injection on signal cable.**

### 2.4.3 Test results

No change in actual operating state or stored data was observed. The test specimen continued to operate as intended during and after the test.

The injection current did not exceed the $I_{max}$ value so the voltage was not reduced.

| Port | Injection method | Results |
|---|---|---|
| Display unit cable | Clamp and sensor | PASSED |

**Table 15. Results for conducted radio frequency interference.**

### 2.4.4 Conducted RF interference - Interface Unit

| | |
|---|---|
| **Test specimen** | Interface Unit |
| **Test specification** | IEC 60945:2002, section 10.3 |
| **Test method** | IEC 61000-4-6:2013 |
| **Performance criterion** | A |
| **Frequency range** | 150 kHz – 80 MHz |
| **Amplitude** | 3 $V_{rms}$ and 10 $V_{rms}$ at spot frequencies ($U_0$) |
| **Spot frequencies** | 2, 3, 4, 6.2, 8.2, 12.6, 16.5, 18.8, 22 and 25 MHz |
| **Modulation** | 80% AM, 400 Hz sine wave |
| **Sweep rate** | 3 seconds per 1% step size |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 37%RH, 23°C / 39%RH |
| **Date of measurements** | 2014-11-27 - 2014-12-03 |
| **Test personnel** | David Busk, Bo Schødt |

### 2.4.5 Test setup

The test specimen was powered through a CDN-M3.

The test specimen was grounded through a CDN-M1. The CDN-M1 was terminated in 50 Ω during all tests.

Cables not connected to a CDN were exposed through an injection clamp. The injected current was monitored by a current probe. If the current exceeded $I_{max} = U_0 / 150\ \Omega$ the amplitude was reduced until the measured current was equal to the $I_{max}$ value.

When testing on a signal port the auxiliary equipment was grounded through a CDN-M1 terminated in 50 Ω.

All cables not under test were decoupled.

Functional tests were performed before, during and after testing.

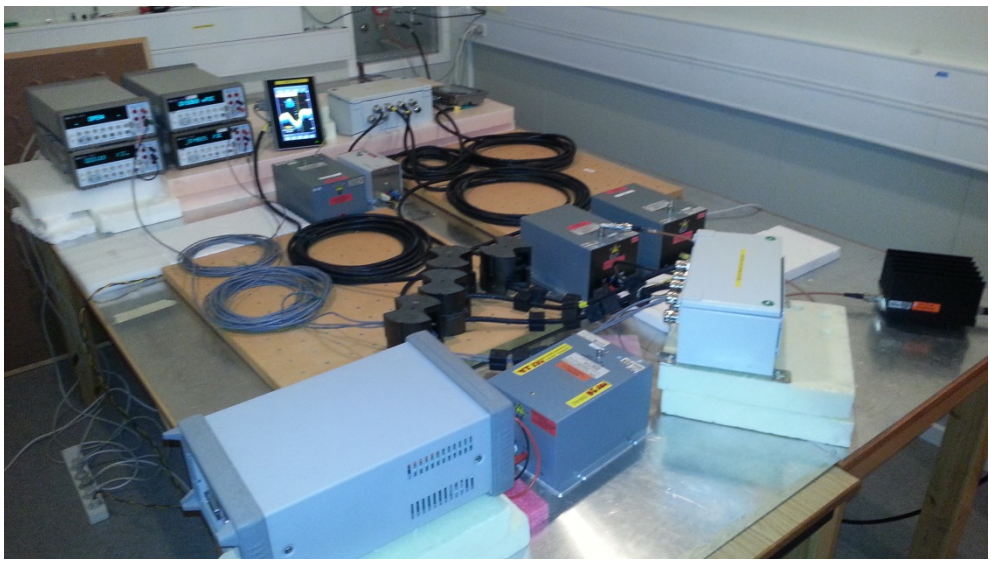


**Photo 25. Conducted radio frequency interference test setup. AC power.**

**Photo 26. Conducted radio frequency interference test setup. DC power.**

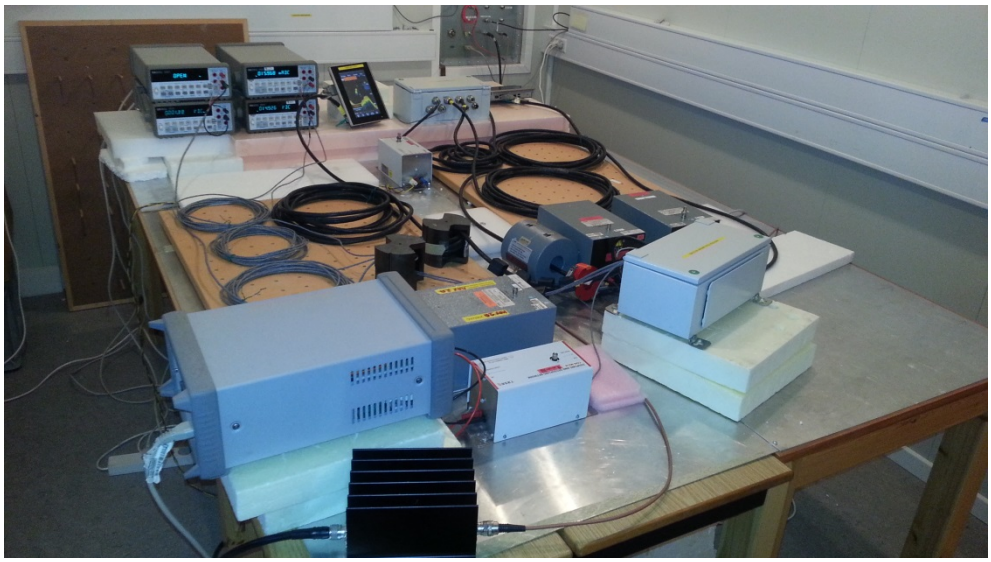


**Photo 27. Conducted radio frequency interference test setup. Clamp injection on signal cables.**

### 2.4.6 Test results

No change in actual operating state or stored data was observed. The test specimen continued to operate as intended during and after the test.

The injection current did not exceed the $I_{max}$ value so the voltage was not reduced.

| Port | Injection method | Results |
|---|---|---|
| Power AC Left | CDN-M3 | PASSED |
| Power DC Left | CDN-M3 | PASSED |
| Display unit cable | Clamp and sensor | PASSED |
| Interface cable | Clamp and sensor | PASSED |
| ANAOUT | Clamp and sensor | PASSED |
| OPT1OUT | Clamp and sensor | PASSED |
| DIG1IN | CDN-M2 | PASSED |
| RELAYOUT | Clamp and sensor | PASSED |

**Table 16. Results for conducted radio frequency interference.**

### 2.4.7 Conducted RF interference - Power Supply Unit

| | |
|---|---|
| **Test specimen** | Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 10.3 |
| **Test method** | IEC 61000-4-6:2013 |
| **Performance criterion** | A |
| **Frequency range** | 150 kHz – 80 MHz |
| **Amplitude** | 3 $V_{rms}$ and 10 $V_{rms}$ at spot frequencies ($U_0$) |
| **Spot frequencies** | 2, 3, 4, 6.2, 8.2, 12.6, 16.5, 18.8, 22 and 25 MHz |
| **Modulation** | 80% AM, 400 Hz sine wave |
| **Sweep rate** | 3 seconds per 1% step size |
| **Comments** | None |
| **Temperature / Humidity** | 24°C / 37%RH, 23°C / 39%RH |
| **Date of measurements** | 2014-11-26, 2014-11-27 |
| **Test personnel** | David Busk |

### 2.4.8 Test setup

The test specimen was powered through a CDN-M3.

The test specimen was grounded through a CDN-M1. The CDN-M1 was terminated in 50 Ω during all tests.

Cables not connected to a CDN were exposed through an injection clamp. The injected current was monitored by a current probe. If the current exceeded $I_{max} = U_0 / 150\ \Omega$ the amplitude was reduced until the measured current was equal to the $I_{max}$ value.

When testing on a signal port the auxiliary equipment was grounded through a CDN-M1 terminated in 50 Ω.

All cables not under test were decoupled.

Functional tests were performed before, during and after testing.

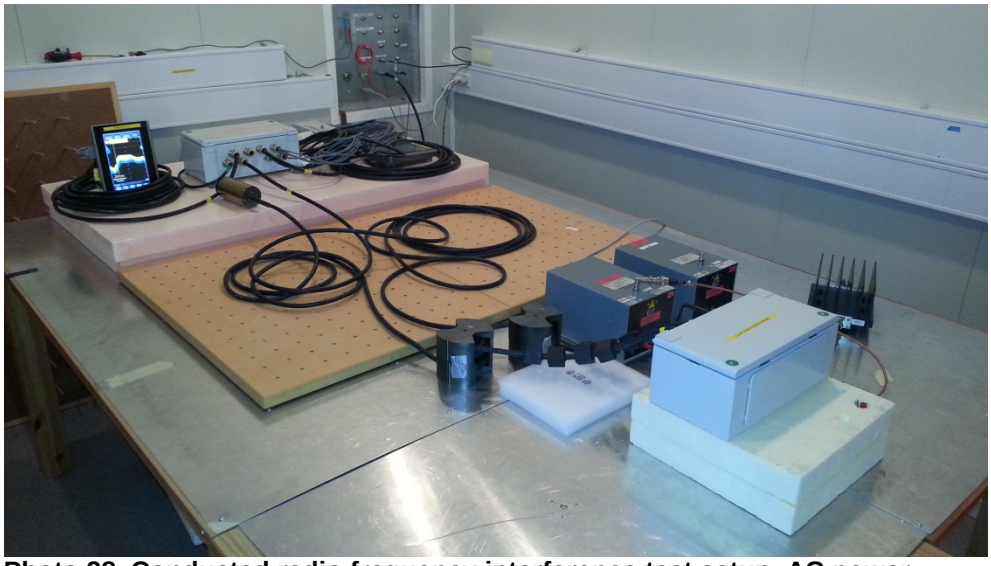


**Photo 28. Conducted radio frequency interference test setup. AC power.**

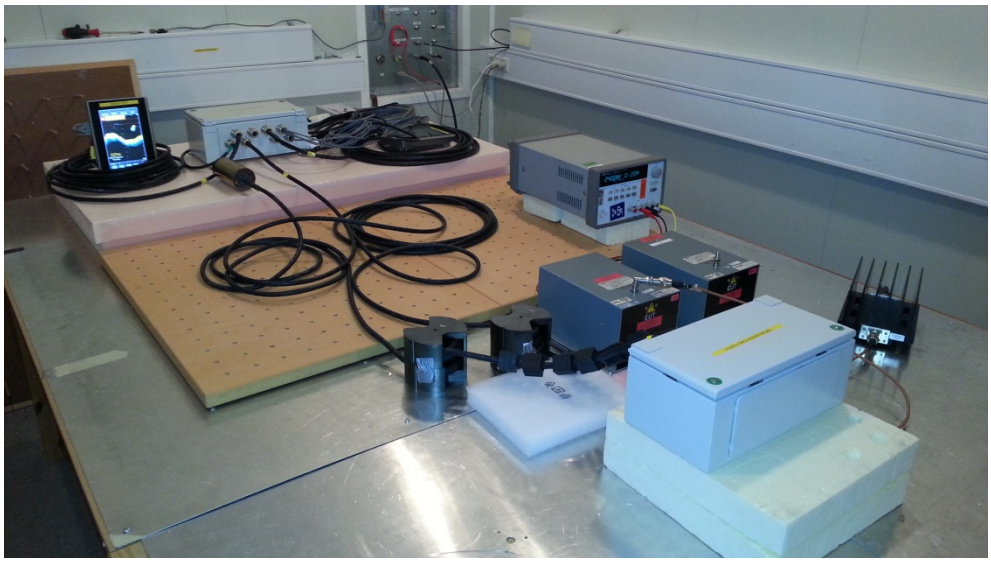


**Photo 29. Conducted radio frequency interference test setup. DC power.**

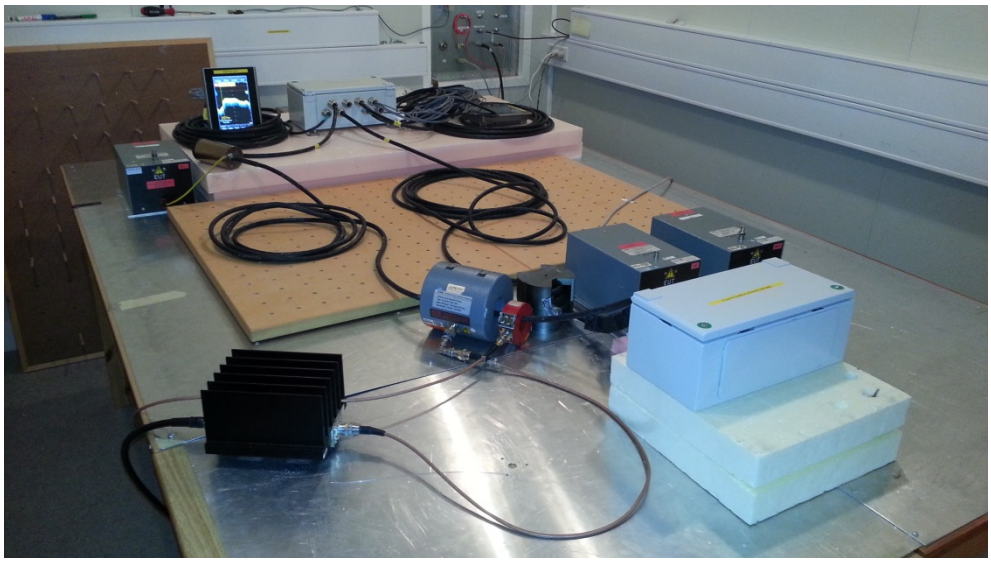


**Photo 30. Conducted radio frequency interference test setup. Clamp injection on signal cables.**

### 2.4.9 Test results

No change in actual operating state or stored data was observed. The test specimen continued to operate as intended during and after the test.

The injection current did not exceed the $I_{max}$ value so the voltage was not reduced.

| Port | Injection method | Results |
|---|---|---|
| Power AC Left | CDN-M3 | PASSED |
| Power DC Left | CDN-M3 | PASSED |
| EMES60 sensor cable | Clamp and sensor | PASSED |
| Interface cable | Clamp and sensor | PASSED |

**Table 17. Results for conducted radio frequency interference.**

### 2.4.10 Conducted RF interference - Sensor Unit

| | |
|---|---|
| **Test specimen** | Sensor Unit |
| **Test specification** | IEC 60945:2002, section 10.3 |
| **Test method** | IEC 61000-4-6:2013 |
| **Performance criterion** | A |
| **Frequency range** | 150 kHz – 80 MHz |
| **Amplitude** | 3 $V_{rms}$ and 10 $V_{rms}$ at spot frequencies ($U_0$) |
| **Spot frequencies** | 2, 3, 4, 6.2, 8.2, 12.6, 16.5, 18.8, 22 and 25 MHz |
| **Modulation** | 80% AM, 400 Hz sine wave |
| **Sweep rate** | 3 seconds per 1% step size |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 38%RH |
| **Date of measurements** | 2015-01-21 |
| **Test personnel** | David Busk, Bo Schødt |

### 2.4.11 Test setup

The test specimen was grounded through a CDN-M1. The CDN-M1 was terminated in 50 Ω during all tests.

Cables not connected to a CDN were exposed through an injection clamp. The injected current was monitored by a current probe. If the current exceeded $I_{max} = U_0 / 150\ \Omega$ the amplitude was reduced until the measured current was equal to the $I_{max}$ value.

The auxiliary equipment was grounded through a CDN-M1 terminated in 50 Ω.

All cables not under test were decoupled.

Functional tests were performed before, during and after testing.

**Photo 31. Conducted radio frequency interference test setup. Clamp injection on signal cable.**

### 2.4.12 Test results

No change in actual operating state or stored data was observed. The test specimen continued to operate as intended during and after the test.

The injection current did not exceed the $I_{max}$ value so the voltage was not reduced.

| Port | Injection method | Results |
|---|---|---|
| EMES60 sensor cable | Clamp and sensor | PASSED |

**Table 18. Results for conducted radio frequency interference.**

### 2.4.13 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Clamp HF Current | | | 13138 |
| Amplifier 10KHz-220MHz | Amplifier Research | 75A220 | 13367 |
| Decoupling Clamp | Luthi Elektronik | FTC101 | 13417 |
| Power Meter Digital | Rohde&Schwarz | NRVD | 13857 |
| Power Sensor 1uW-100mW DC-18GHz | Rohde&Schwarz | NRV-Z51 | 13858 |
| Directional Coupler Dual 0,1-1000MHz 40dB | Amlifier Research | DC3002 | 13859 |
| CDN Signal Line | Fischer Custom Comm. | FCC-801-M3-16A | 14428 |
| CDN Power Line | Fischer Custom Comm. | FCC-801-M1-10A | 18401 |
| CDN Signal Line | Fischer Custom Comm. | FCC-801-AF2 | 14427 |
| CDN Power Line | TESEQ | CDN M216 | 50051 |
| CDN Power Line | TESEQ | CDN M316 | 50052 |
| Signal Generator | Rohde&Schwarz | SME03 | 15328 |
| Bulk Injection Probe | FCC | F-120-9A | 16298 |
| Powersensor 100pW-20mW 100kHz-6GHz | Rohde&Schwarz | NRV-Z4 | 17472 |
| Attenuator 300W 6dB | Bird | 300WA-FFN06 | 20109 |

**Table 19. Test equipment for conducted radio frequency.**

## 2.5 Burst / Fast transients

### 2.5.1 Burst / Fast transients – Display Unit

| | |
|---|---|
| **Test specimen** | Display Unit |
| **Test specification** | IEC 60945:2002, section 10.5 |
| **Test method** | IEC 61000-4-4:2012 |
| **Performance criterion** | B |
| **Amplitude** | ±1 kV common mode on signal ports |
| **Pulse rise time / duration** | 5 ns / 50 ns |
| **Repetition rate** | 5 kHz |
| **Application** | 15 ms burst every 300 ms |
| **Duration** | 5 minutes for each polarity |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 38%RH |
| **Date of measurements** | 2014-12-05 |
| **Test personnel** | David Busk |

#### 2.5.1.1 Test setup

The power cable between the power supply and the test generator was 0.5 m.

The test specimen, the auxiliary equipment and the cables were raised 10 cm above the ground reference plane on foam.

Functional tests were performed before and after testing.

**Photo 32. Burst / Fast transients test setup.**

#### 2.5.1.2 Test results

No change in actual operating state or stored data was observed. The test specimen operated as intended before and after the test.

| Port | Level | Injection method | Result |
|---|---|---|---|
| Display cable | ±1 kV | Capacitive clamp | PASSED |

**Table 20. Results for fast transients tests.**

### 2.5.2 Burst / Fast transients – Interface Unit

| | |
|---|---|
| **Test specimen** | Interface Unit |
| **Test specification** | IEC 60945:2002, section 10.5 |
| **Test method** | IEC 61000-4-4:2012 |
| **Performance criterion** | B |
| **Amplitude** | ±1 kV common mode on signal ports |
| **Pulse rise time / duration** | 5 ns / 50 ns |
| **Repetition rate** | Signal ports: 5 kHz, AC ports: 5 kHz and 100 kHz |
| **Application** | 15 ms burst every 300 ms |
| **Duration** | 5 minutes for each polarity |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 38%RH |
| **Date of measurements** | 2014-12-05 |
| **Test personnel** | David Busk |

#### 2.5.2.1 Test setup

The power cable between the power supply and the test generator was 0.5 m.
The test specimen, the auxiliary equipment and the cables were raised 10 cm above the ground reference plane on foam.

Functional tests were performed before and after testing.

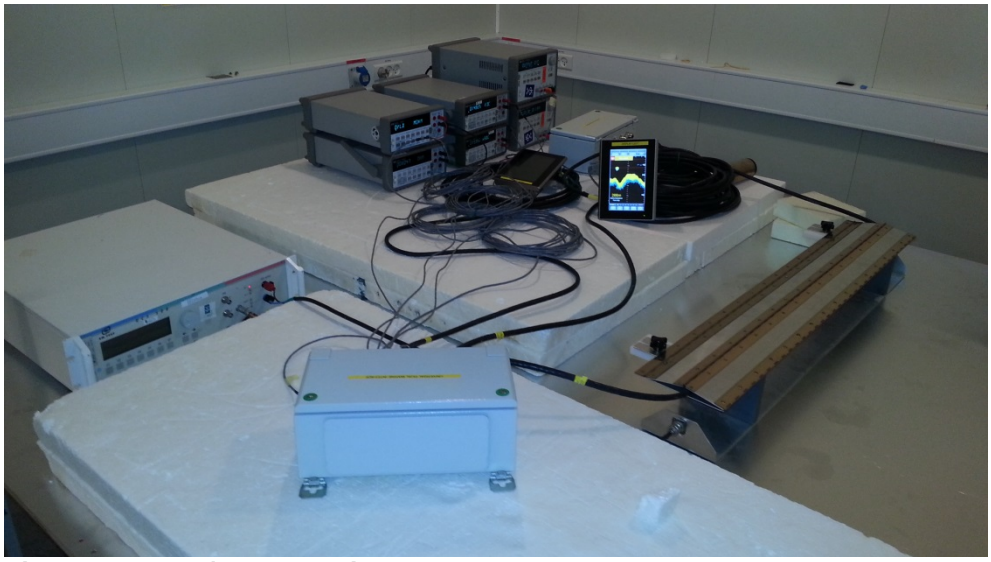


**Photo 33. Burst / Fast transients test setup.**

### 2.5.2.2 Test results

No change in actual operating state or stored data was observed. The test specimen operated as intended before and after the test.

| Port | Level | Injection method | Result |
|---|---|---|---|
| Power AC Left | ±2 kV | CDN | PASSED |
| Display unit cable | ±1 kV | Capacitive clamp | PASSED |
| Interface cable | ±1 kV | Capacitive clamp | PASSED |
| ANAOUT | ±1 kV | Capacitive clamp | PASSED |
| OPT1OUT | ±1 kV | Capacitive clamp | PASSED |
| DIG1IN | ±1 kV | Capacitive clamp | PASSED |
| RELAYOUT | ±1 kV | Capacitive clamp | PASSED |

**Table 21. Results for fast transients tests.**

### 2.5.3 Burst / Fast transients – Power Supply Unit

| | |
|---|---|
| **Test specimen** | Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 10.5 |
| **Test method** | IEC 61000-4-4:2012 |
| **Performance criterion** | B |
| **Amplitude** | ±1 kV common mode on signal ports |
| **Pulse rise time / duration** | 5 ns / 50 ns |
| **Repetition rate** | Signal ports: 5 kHz, AC ports: 5 kHz and 100 kHz |
| **Application** | 15 ms burst every 300 ms |
| **Duration** | 5 minutes for each polarity |
| **Comments** | None |
| **Temperature / Humidity** | 24°C / 38%RH |
| **Date of measurements** | 2014-12-05 |
| **Test personnel** | David Busk |

#### 2.5.3.1 Test setup

The power cable between the power supply and the test generator was 0.5 m.
The test specimen, the auxiliary equipment and the cables were raised 10 cm above the ground reference plane on foam.

Functional tests were performed before and after testing.

**Photo 34. Burst / Fast transients test setup.**

### 2.5.3.2 Test results

No change in actual operating state or stored data was observed. The test specimen operated as intended before and after the test.

| Port | Level | Injection method | Result |
|---|---|---|---|
| Power AC Left | ±2 kV | CDN | PASSED |
| Interface cable | ±1 kV | Capacitive clamp | PASSED |
| EMES60 sensor cable | ±1 kV | Capacitive clamp | PASSED |

**Table 22. Results for fast transients tests.**

### 2.5.4 Burst / Fast transients – Sensor Unit

| | |
|---|---|
| **Test specimen** | Sensor Unit |
| **Test specification** | IEC 60945:2002, section 10.5 |
| **Test method** | IEC 61000-4-4:2012 |
| **Performance criterion** | B |
| **Amplitude** | ±1 kV common mode on signal ports |
| **Pulse rise time / duration** | 5 ns / 50 ns |
| **Repetition rate** | 5 kHz |
| **Application** | 15 ms burst every 300 ms |
| **Duration** | 5 minutes for each polarity |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 46%RH |
| **Date of measurements** | 2015-01-21 |
| **Test personnel** | David Busk |

#### 2.5.4.1 Test setup

The power cable between the power supply and the test generator was 0.5 m.
The test specimen, the auxiliary equipment and the cables were raised 10 cm above the ground reference plane on foam.

Functional tests were performed before and after testing.

**Photo 35. Burst / Fast transients test setup.**

#### 2.5.4.2 Test results

No change in actual operating state or stored data was observed. The test specimen operated as intended before and after the test.

| Port | Level | Injection method | Result |
|---|---|---|---|
| EMES60 sensor cable | ±1 kV | Capacitive clamp | PASSED |

**Table 23. Results for fast transients test.**

### 2.5.5 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Ultra Compact Simulator | EM Test | UCS500 | 13504 |
| Capacitive Coupling Clamp | Nokia | - | 15310 |

**Table 24. Test equipment for burst / fast transients.**

## 2.6 Surge / Slow transients

### 2.6.1 Surge / Slow transients – Interface Unit

| | |
|---|---|
| **Test specimen** | Interface Unit |
| **Test specification** | IEC 60945:2002, section 10.6 |
| **Test method** | IEC 61000-4-5:2005 |
| **Performance criterion** | B |
| **Amplitude** | ±1 kV Line / Earth<br>±0.5 kV Line / Line. |
| **Pulse rise time / duration** | 1.2 µs / 50 µs |
| **Repetition rate** | 1 pulse pr. minute |
| **Duration** | 5 minutes for each polarity |
| **Source impedance** | 2 Ω Line-Line / 12 Ω Line-Earth |
| **Comments** | None |
| **Temperature / Humidity** | 22°C / 36%RH |
| **Date of measurements** | 2014-12-04 |
| **Test personnel** | David Busk |

#### 2.6.1.1 Test setup

The test was done on AC Power Left.
The length of the power cable to the test generator was 0.5 m.
The test specimen and auxiliary equipment were raised on 10 cm foam.

Functional tests were performed before and after testing.

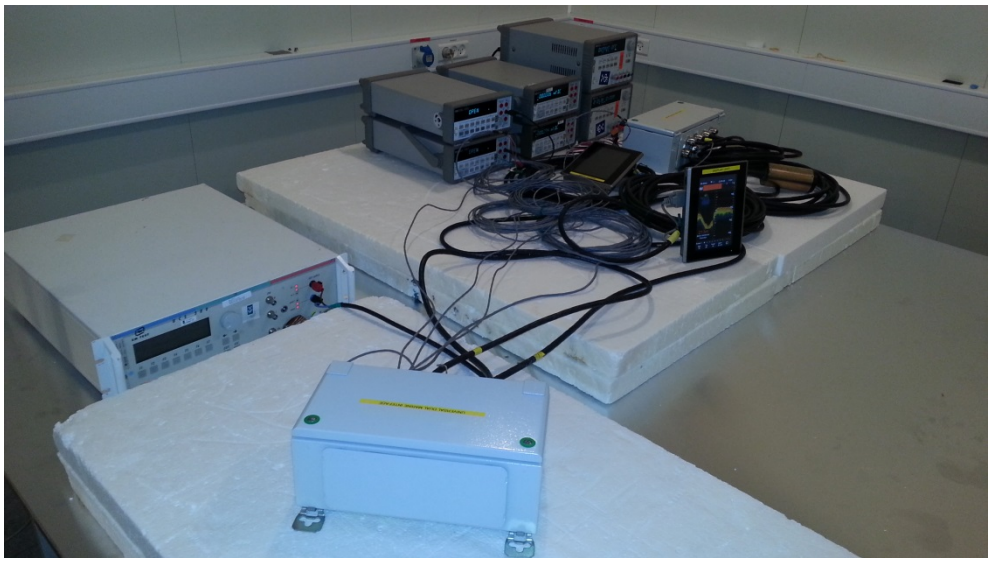


**Table 25. Test setup for surge tests.**

#### 2.6.1.2 Test results

No change in actual operating state or stored data was observed. The test specimen operated as intended before and after the test.

| Port | Injection level | Results |
|---|---|---|
| **Line / Neutral** | 500 V | PASSED |
| **Line / Earth** | 500 V | PASSED |
| **Line / Earth** | 1 kV | PASSED |
| **Neutral / Earth** | 500 V | PASSED |
| **Neutral / Earth** | 1 kV | PASSED |

**Table 26. Results for surge on AC power line.**

### 2.6.2 Surge / Slow transients – Power Supply Unit

| | |
|---|---|
| **Test specimen** | Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 10.6 |
| **Test method** | IEC 61000-4-5:2005 |
| **Performance criterion** | B |
| **Amplitude** | ±1 kV Line / Earth<br>±0.5 kV Line / Line. |
| **Pulse rise time / duration** | 1.2 µs / 50 µs |
| **Repetition rate** | 1 pulse pr. minute |
| **Duration** | 5 minutes for each polarity |
| **Source impedance** | 2 Ω Line-Line / 12 Ω Line-Earth |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 37%RH |
| **Date of measurements** | 2014-12-05 |
| **Test personnel** | David Busk |

#### 2.6.2.1 Test setup

The test was done on AC Power Left.
The length of the power cable to the test generator was 0.5 m.
The test specimen and auxiliary equipment were raised on 10 cm foam.

Functional tests were performed before and after testing.

**Table 27. Test setup for surge tests.**

#### 2.6.2.2 Test results

No change in actual operating state or stored data was observed. The test specimen operated as intended before and after the test.

| Port | Injection level | Results |
|---|---|---|
| **Line / Neutral** | 500 V | PASSED |
| **Line / Earth** | 500 V | PASSED |
| **Line / Earth** | 1 kV | PASSED |
| **Neutral / Earth** | 500 V | PASSED |
| **Neutral / Earth** | 1 kV | PASSED |

**Table 28. Results for surge on AC power line.**

### 2.6.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Ultra Compact Simulator | EM Test | UCS500 | 13504 |

**Table 29. Test equipment for surge / slow transients.**

## 2.7 Electrostatic discharge

### 2.7.1 Electrostatic discharge – Display Unit

| | |
|---|---|
| **Test specimen** | Display Unit |
| **Test specification** | IEC 60945:2002, section 10.9 |
| **Test method** | IEC 61000-4-2:2008 |
| **Performance criterion** | B |
| **Discharges** | Cont. discharge: ±6kV<br>Air discharge: ±2kV, ±4kV, ±8kV |
| **Comments** | None |
| **Temperature / Humidity** | 22°C / 48%RH |
| **Atmospheric pressure** | 1001 mbar |
| **Date of measurements** | 2015-01-28 |
| **Test personnel** | David Busk |

#### 2.7.1.1 Test setup

Indirect discharges were performed on the vertical and horizontal coupling planes.
All non-conductive parts were investigated with an air discharge tip at the specified levels.

Functional tests were performed before and after testing.

**Photo 36. ESD test setup.**

### 2.7.1.2 Test results

No change in actual operating state or stored data was observed. The test specimen operated as intended before and after the test.

Air discharges were not possible at the specified test levels.

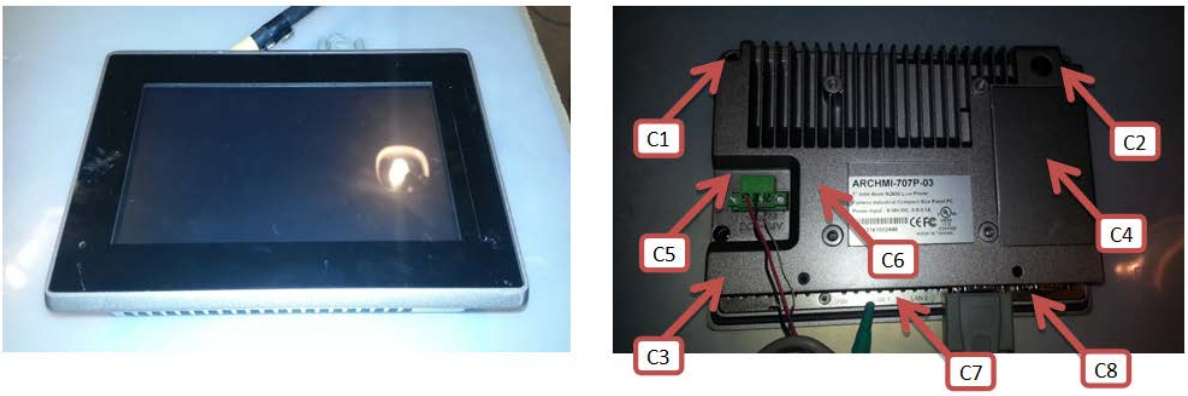



**Photo 37. Discharge points for ESD tests. Red arrows show contact discharge points. Air discharges were not applicable.**

| Direct contact discharge | | Indirect contact discharge | | Air discharge | |
|---|---|---|---|---|---|
| **Voltage** | **Result** | **Voltage** | **Result** | **Voltage** | **Result** |
| ±6 kV | PASSED | ±6 kV | PASSED | ±2 kV | PASSED |
| | | | | ±4 kV | PASSED |
| | | | | ±8 kV | PASSED |

**Table 30. Results for electrostatic discharge test.**

### 2.7.2 Electrostatic discharge – Interface Unit

| | |
|---|---|
| **Test specimen** | Interface Unit |
| **Test specification** | IEC 60945:2002, section 10.9 |
| **Test method** | IEC 61000-4-2:2008 |
| **Performance criterion** | B |
| **Discharges** | Cont. discharge: ±6kV<br>Air discharge: ±2kV, ±4kV, ±8kV |
| **Comments** | None |
| **Temperature / Humidity** | 22°C / 48%RH |
| **Atmospheric pressure** | 1001 mbar |
| **Date of measurements** | 2015-01-28 |
| **Test personnel** | David Busk |

#### 2.7.2.1 Test setup

Indirect discharges were performed on the vertical and horizontal coupling planes.
All non-conductive parts were investigated with an air discharge tip at the specified levels.

Functional tests were performed before and after testing.

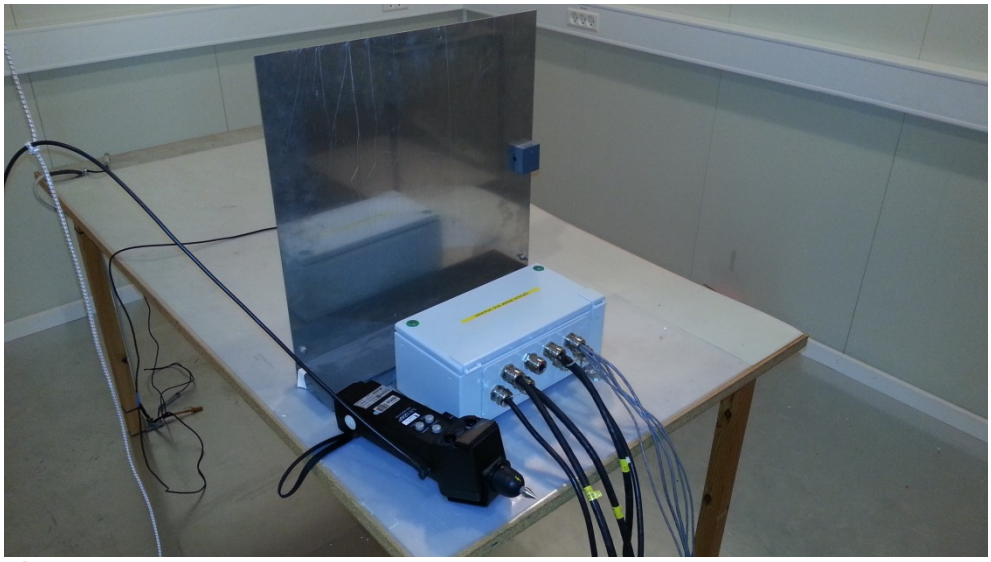


**Photo 38. ESD test setup.**

### 2.7.2.2 Test results

No change in actual operating state or stored data was observed. The test specimen operated as intended before and after the test.

Air discharges were not possible at the specified test levels.

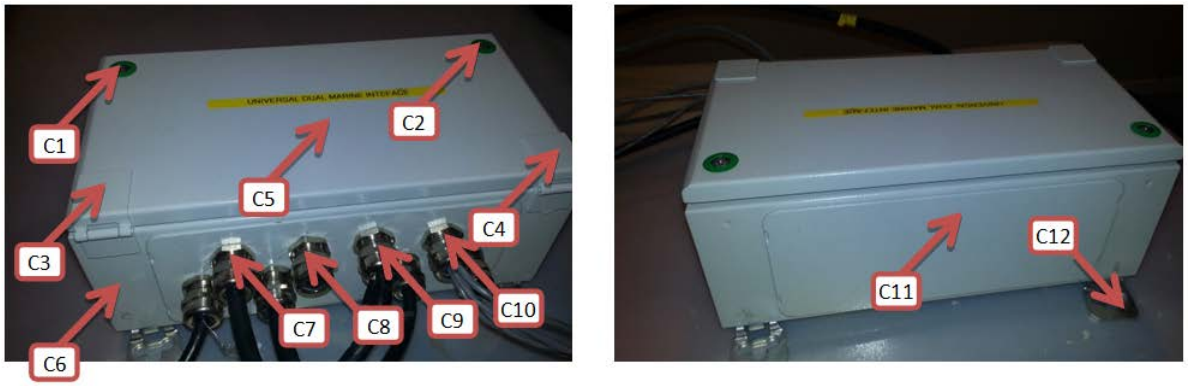



**Photo 39. Discharge points for ESD tests. Red arrows show contact discharge points. Air discharges were not applicable.**

| Direct contact discharge | | Indirect contact discharge | | Air discharge | |
|---|---|---|---|---|---|
| **Voltage** | **Result** | **Voltage** | **Result** | **Voltage** | **Result** |
| ±6 kV | PASSED | ±6 kV | PASSED | ±2 kV | PASSED |
| | | | | ±4 kV | PASSED |
| | | | | ±8 kV | PASSED |

**Table 31. Results for electrostatic discharge test.**

### 2.7.3 Electrostatic discharge – Power Supply Unit

| | |
|---|---|
| **Test specimen** | Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 10.9 |
| **Test method** | IEC 61000-4-2:2008 |
| **Performance criterion** | B |
| **Discharges** | Cont. discharge: ±6kV<br>Air discharge: ±2kV, ±4kV, ±8kV |
| **Comments** | None |
| **Temperature / Humidity** | 22°C / 48%RH |
| **Atmospheric pressure** | 1001 mbar |
| **Date of measurements** | 2015-01-28 |
| **Test personnel** | David Busk |

#### 2.7.3.1 Test setup

Indirect discharges were performed on the vertical and horizontal coupling planes.
All non-conductive parts were investigated with an air discharge tip at the specified levels.

Functional tests were performed before and after testing.

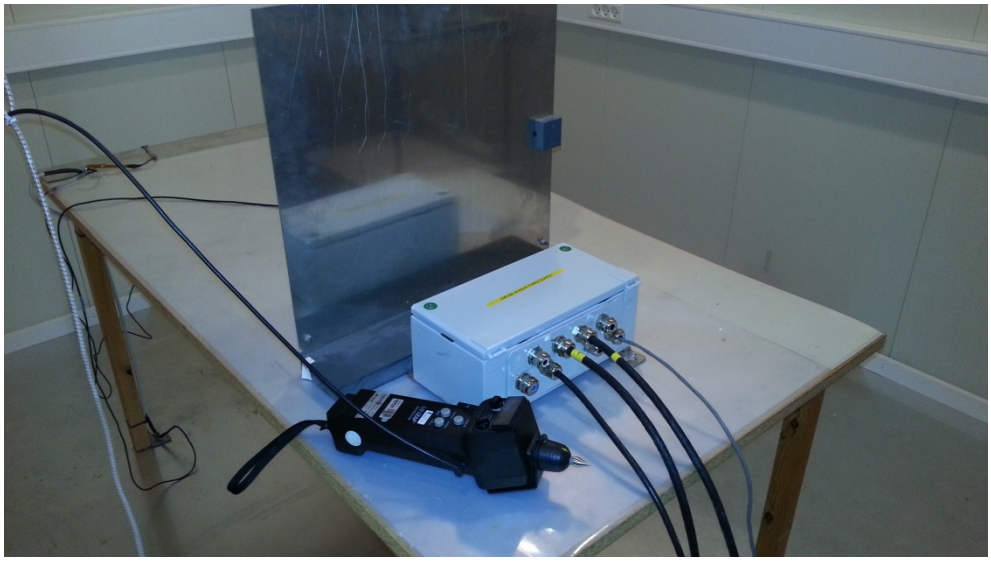


**Photo 40. ESD test setup.**

### 2.7.3.2 Test results

No change in actual operating state or stored data was observed. The test specimen operated as intended before and after the test.

Air discharges were not possible at the specified test levels.

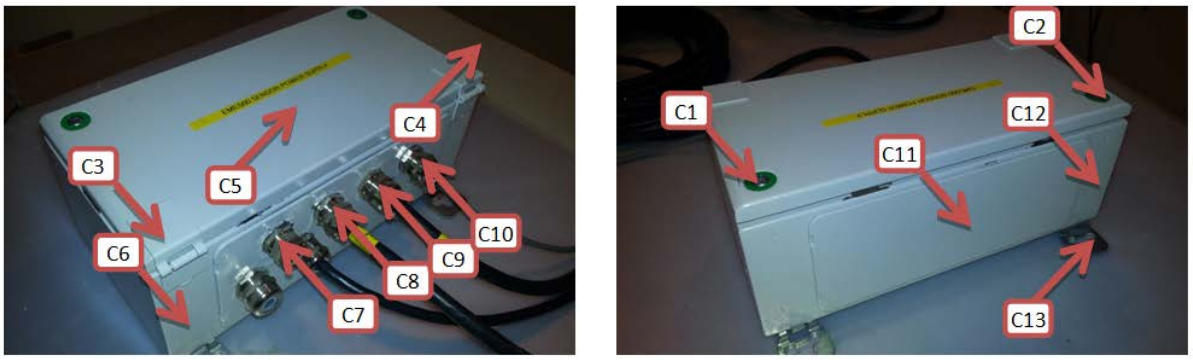



**Photo 41. Discharge points for ESD tests. Red arrows show contact discharge points. Air discharges were not applicable.**

| Direct contact discharge | | Indirect contact discharge | | Air discharge | |
|---|---|---|---|---|---|
| Voltage | Result | Voltage | Result | Voltage | Result |
| ±6 kV | PASSED | ±6 kV | PASSED | ±2 kV | PASSED |
| | | | | ±4 kV | PASSED |
| | | | | ±8 kV | PASSED |

**Table 32. Results for electrostatic discharge test.**

### 2.7.4 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| ESD Simulator MiniZap | Thermo KeyTek | MZ-15/EC | 18357 |

**Table 33. Test equipment for electrostatic discharge test.**

## 2.8 Power supply failure

| | |
|---|---|
| **Test specimen** | Interface Unit and Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 10.8 |
| **Test method** | None |
| **Performance criterion** | C |
| **Specifications** | 3 interrupts during 5 minutes. Switching off time 30 seconds |
| **Comments** | None |
| **Temperature / Humidity** | 23°C / 37%RH |
| **Date of measurements** | 2015-09-24 |
| **Test personnel** | David Busk |

### 2.8.1 Test setup

The test was made at nominal supply voltages of 115 VAC, 230 VAC and 24 VDC.

3 interruptions were made within 5 minutes with 30 seconds pause between switching off and switching back on.

Functional tests were performed before and after testing.

**Photo 42. Test setup for power supply failure. DC power.**

**Photo 43. Test setup for power supply failure. AC power.**

### 2.8.2 Test results

No change in actual operating state or stored data was observed. The test specimen operated as intended before and after the test.

| Voltage | Frequency | Result |
|---|---|---|
| 115 VAC | 60 Hz | PASSED |
| 230 VAC | 50 Hz | PASSED |
| 24 VDC | None | PASSED |

**Table 34. Power supply failure results.**

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Programmable AC Source | Chroma | 61502 | 19062 |
| Multimeter | Hewlett Packard | 34401A | 14880 |
| DC Power supply | Hewlett Packard | E3632A | 14519 |
| DC Power supply | Hewlett Packard | E3632A | 14622 |

**Table 35. Test equipment for Power supply failure test.**

## 2.9 Extreme power supply

| | |
|---|---|
| **Test specimen** | Interface Unit and Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 7.1 |
| **Test method** | None |
| **Performance criterion** | A |
| **Environment** | Normal temperature |
| **Duration** | 15 minutes |
| **Comments** | Extreme power supply test was also done after return to normal environmental conditions in Dry Heat and Low temperature tests. (see respective paragraphs for results). |
| **Temperature / Humidity** | 23°C / 37%RH |
| **Date of measurements** | 2014-12-11 |
| **Test personnel** | David Busk |

### 2.9.1 Test setup

The test was made at nominal supply voltages of 115 VAC, 230 VAC and 24 VDC.
AC power supply variations were applied using a programmable power supply.
DC power supply variations were applied using DC power supplies.
A multimeter was used to ensure correct voltage and frequency levels.

Functional tests were performed during and after testing.

**Photo 44. Test setup for extreme power supply. DC power.**

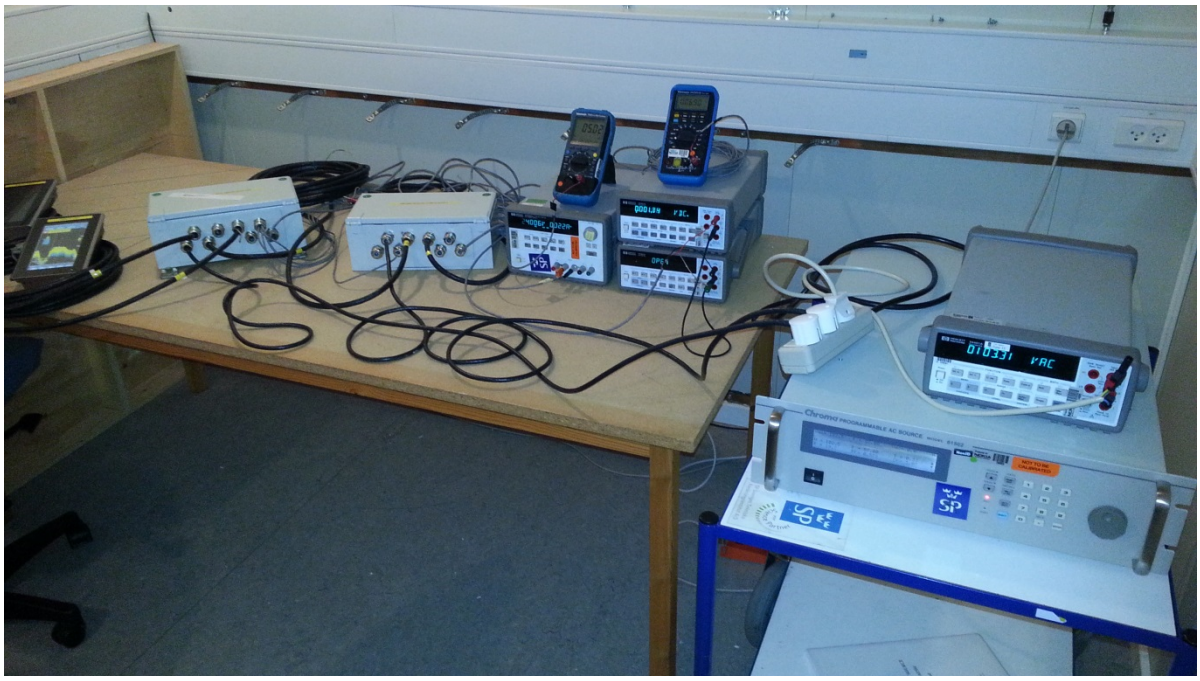


**Photo 45. Test setup for extreme power supply. AC power.**

### 2.9.2 Test results

No change in actual operating state or stored data was observed. The test specimen continued to operate as intended before, during and after the test.

| Extreme power supply | Performance | | |
|---|---|---|---|
| | Voltage | Frequency | Result |
| **230 VAC + 10%, 50 Hz + 5%** | 253 VAC | 52.5 Hz | PASSED |
| **230 VAC + 10%, 50 Hz - 5%** | 253 VAC | 47.5 Hz | PASSED |
| **115 VAC - 10%, 60 Hz - 5%** | 103,5 VAC | 57 Hz | PASSED |
| **115 VAC - 10%, 60 Hz + 5%** | 103,5 VAC | 63 Hz | PASSED |
| **24 VDC + 30%** | 31.2 VDC | None | PASSED |
| **24 VDC – 10%** | 21.6 VDC | None | PASSED |

**Table 36. Extreme power supply test results.**

### 2.9.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Programmable AC Source | Chroma | 61502 | 19062 |
| Multimeter | Hewlett Packard | 34401A | 14880 |
| DC Power supply | Hewlett Packard | E3632A | 14519 |
| DC Power supply | Hewlett Packard | E3632A | 14622 |

**Table 37. Test equipment for Extreme power supply test.**

## 2.10 Power supply variations (transient)

| | |
|---|---|
| **Test specimen** | Interface Unit and Power Supply Unit |
| **Test method** | IEC 60945:2002, section 10.7 |
| **Performance criterion** | A |
| **Specifications** | Duration of min. and max voltages: 1.5 s<br>Duration of min. and max frequency: 5.0 s |
| **Comments** | None |
| **Temp / Humidity** | 23°C / 37%RH |
| **Date of measurements** | 2014-12-11 |
| **Test personnel** | David Busk |

### 2.10.1 Test setup

The test was made at nominal supply voltages of both 115 VAC and 230 VAC.
Power supply variations were applied using a programmable power supply.
A multimeter was used to ensure correct voltage and frequency levels.
An oscilloscope was used to confirm that the shape of the waveform was properly generated.

Functional tests were performed before, during and after testing.

**Figure 18. Power supply variations (transient) test setup.**

### 2.10.2 Test results

No change in actual operating state or stored data was observed. The test specimen was operational and functional before, during and after the test.

| Voltage deviation transient | Performance | | |
|---|---|---|---|
| | Voltage | Frequency | Result |
| **230 VAC + 20%, 50 Hz + 10%** | 276 VAC | 55 Hz | PASSED |
| **230 VAC - 20%, 50 Hz - 10%** | 184 VAC | 45 Hz | PASSED |
| **115 VAC + 20%, 60 Hz + 10%** | 138 VAC | 66 Hz | PASSED |
| **115 VAC - 20%, 60 Hz - 10%** | 92 VAC | 54 Hz | PASSED |

**Table 38. Power supply variations (transient) results.**

### 2.10.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Programmable AC Source | Chroma | 61502 | 19062 |
| Multimeter | Hewlett Packard | 34401A | 14880 |
| Oscilioscope | Textronic | TDS 3014 | 16756 |

**Table 39. Test equipment for power supply variations (transient) test.**

## 2.11 Power supply excessive conditions

| | |
|---|---|
| **Test specimen** | Interface Unit and Power Supply Unit |
| **Test method** | IEC 60945:2002, section 7.2 |
| **Performance criterion** | Excessive voltage: A<br>Reverse polarity: C |
| **Specifications** | Excessive voltage: Duration of each exposure was 15 min.<br>Reverse polarity: Duration of each exposure was 5 min. |
| **Comments** | None |
| **Temp / Humidity** | 23°C / 37%RH |
| **Date of measurements** | 2014-12-11 |
| **Test personnel** | David Busk |

### 2.11.1 Test setup

The test was made at nominal supply voltages of 115 VAC, 230 VAC and 24 VDC.

AC excessive test voltages were applied using a programmable power supply.

DC excessive test voltages were applied using DC power supplies.

A multimeter was used to ensure correct voltage levels.

The excessive current tests are automatically performed together with the excessive low voltage operation.

The reverse polarity test was made by exchanging phase and neutral, or line and neutral, at the power supply.

Functional tests were performed during and after testing.

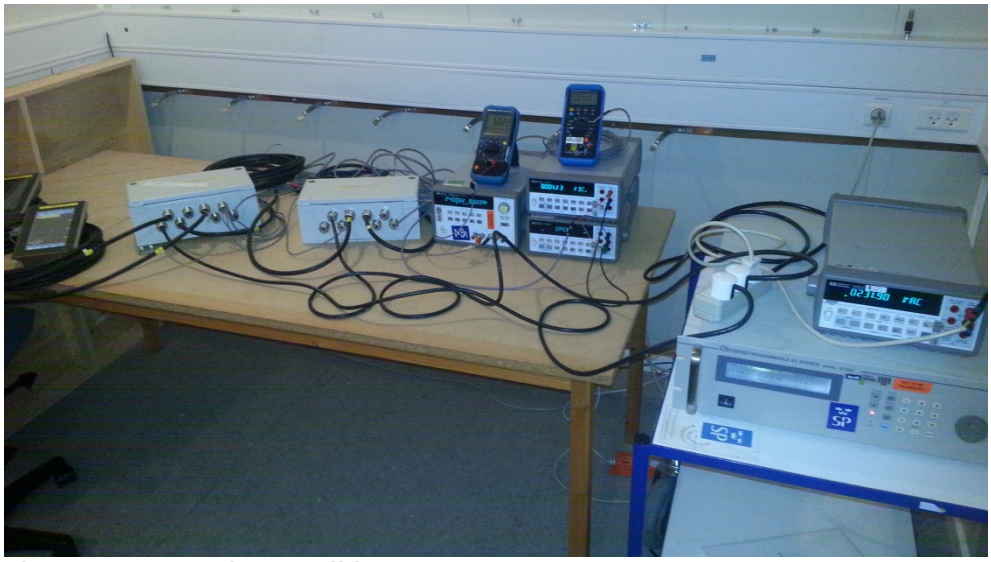


**Figure 19. Excessive conditions test setup. AC power.**

**Figure 20. Excessive conditions test setup. DC power.**

### 2.11.2 Test results

No change in actual operating state or stored data was observed. The test specimen continued to operate as intended during and after the test.

| Excessive voltage | Performance | | |
|---|---|---|---|
| | Voltage | Frequency | Result |
| **230 VAC + 20%** | 276 VAC | 50 Hz | PASSED |
| **115 VAC - 20%** | 92 VAC | 60 Hz | PASSED |
| **24 VDC + 50%** | 36 VDC | None | PASSED |
| **24 VDC - 40%** | 14.4 VDC | None | PASSED |

**Table 40. Excessive voltage test results.**

| Reverse polarity | Performance | | |
|---|---|---|---|
| | Line | Neutral | Result |
| **230 VAC** | Neutral | Phase | PASSED |
| **115 VAC** | Neutral | Phase | PASSED |
| **24 VDC** | Neutral | Line | PASSED |

**Table 41. Reverse polarity test results.**

### 2.11.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Programmable AC Source | Chroma | 61502 | 19062 |
| Multimeter | Hewlett Packard | 34401A | 14880 |
| DC Power supply | Hewlett Packard | E3632A | 14519 |
| DC Power supply | Hewlett Packard | E3632A | 14622 |

**Table 42. Test equipment for power supply excessive conditions test.**

# 3 ENVIRONMENTAL

## 3.1 Dry Heat, Functional

| | |
|---|---|
| **Test specimen** | Display Unit, Interface Unit, Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 8.2 (protected equipment) |
| **Test method** | IEC 60068-2-2: 2007-07 test Bb |
| **Temperature** | 55°C |
| **Duration** | 16 hours |
| **Comments** | None |
| **Date of test** | 2014-12-18 – 2014-12-19 |
| **Test personnel** | Stig Larsen |

### 3.1.1 Test setup

Test specimen and auxiliary equipment was turned on during the test.

Functional tests were performed before the climatic exposure, during the last two hours of the exposure, and after recovery.

Functional tests during the last two hours of the exposure included tests at extreme power supply conditions, with 15 minutes at each extreme. For AC supply +/- 10% voltage and +/- 5% for frequency was tested. For DC supply +30% -10% voltage was tested.

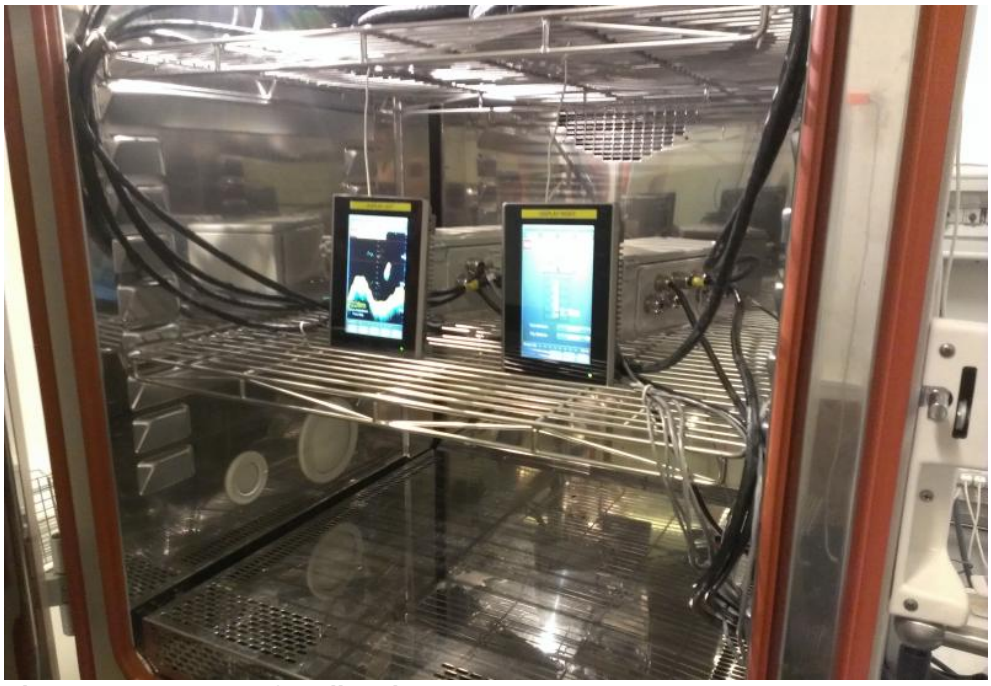


**Photo 46. Test setup for climatic tests.**

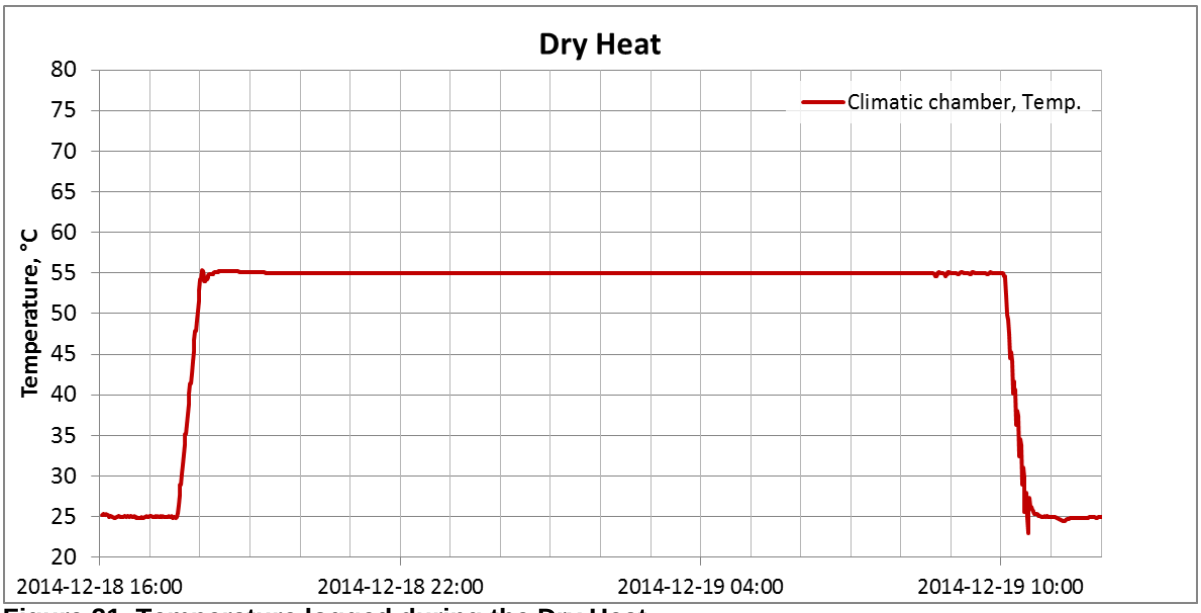



**Figure 21. Temperature logged during the Dry Heat.**

### 3.1.2 Test results

| Functional test | Result |
|---|---|
| Before exposure | PASSED |
| Last two hours of exposure | PASSED |
| After recovery | PASSED |

**Table 43. Results for Dry Heat, Functional, test functional test**

| Extreme power supply conditions | | Result |
|---|---|---|
| Voltage | Frequency | |
| 103.5 VAC (115 VAC - 10%) | 47.5 Hz (50 Hz - 5%) | PASSED |
| 103.5 VAC (115 VAC - 10%) | 63 Hz (60 Hz + 5%) | PASSED |
| 253 VAC (230 VAC + 10%) | 63 Hz (60 Hz + 5%) | PASSED |
| 253 VAC (230 VAC + 10%) | 47.5 Hz (50 Hz - 5%) | PASSED |
| 21.6 VDC (24 VDC – 10%) | - | PASSED |
| 31.2 VDC (24 VDC + 30%) | - | PASSED |

**Table 44: Results for Dry Heat, Functional, test extreme power supply test.**

### 3.1.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Temperature and Climatic Test Chamber H3 | Vötsch | VC 7060 | 17624 |
| Multimeter | Hewlett Packard | 34401A | 14885 |
| Programmable AC Source | Chroma | 61502 | 19062 |
| Powersupply DC 0-15V 7A , 0-30V 4A | HP | E3632A | 14306 |
| Powersupply DC 0-15V 7A , 0-30V 4A | HP | E3632A | 15761 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13184 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13191 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13202 |
| Multimeter (functional check) | Tektronix | TX3 | 15655 |

**Table 45: Test equipment for Dry Heat, Functional, test.**

## 3.2 Dry Heat, Storage

| | |
|---|---|
| **Test specimen** | Sensor Unit |
| **Test specification** | IEC 60945:2002, section 8.2 (submerged equipment) |
| **Test method** | IEC 60068-2-2: 2007-07 test Bb |
| **Temperature** | 70°C |
| **Duration** | 16 hours |
| **Comments** | Only Sensor Unit is included in Dry Heat, Storage |
| **Date of test** | 2014-12-14 – 2014-12-15 |
| **Test personnel** | Stig Larsen |

### 3.2.1 Test setup

Test specimen and auxiliary equipment was turned off throughout the climatic exposure. Functional tests were performed before the climatic exposure and after recovery.

**Photo 47. Test setup for Dry Heat, Storage, for Sensor Unit.**

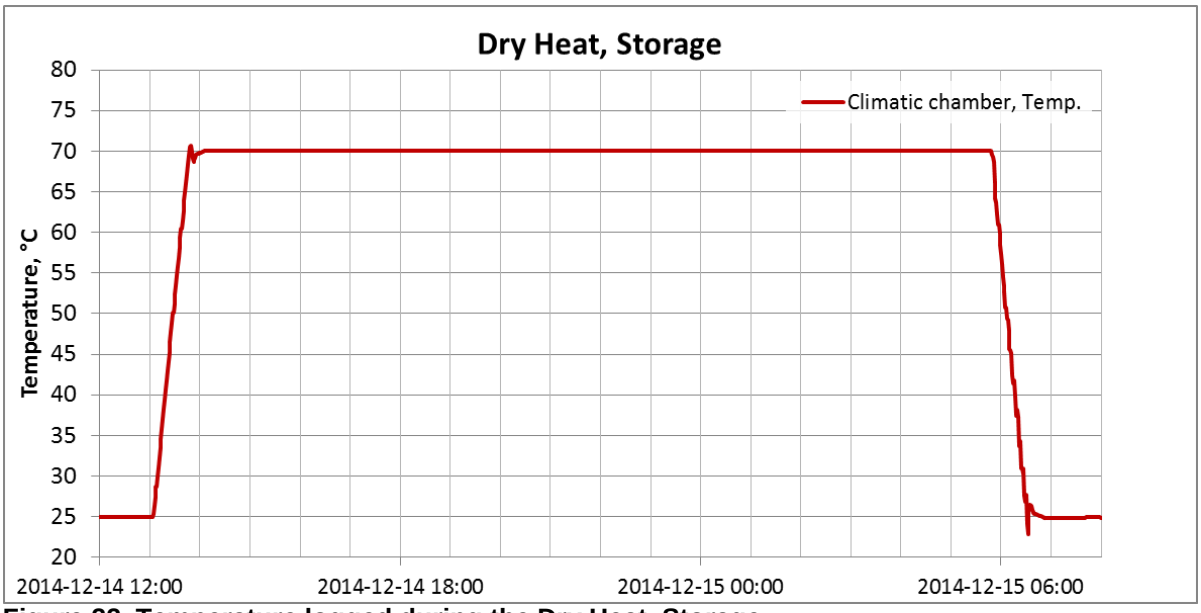



**Figure 22. Temperature logged during the Dry Heat, Storage.**

### 3.2.2 Test results

| Functional test | Result |
|---|---|
| Before exposure | PASSED |
| After exposure | PASSED |

**Table 46. Results for Dry Heat, Storage, functional test**

### 3.2.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Temperature and Climatic Test Chamber H3 | Vötsch | VC 7060 | 17624 |
| Powersupply DC 0-15V 7A , 0-30V 4A | HP | E3632A | 14306 |
| Powersupply DC 0-15V 7A , 0-30V 4A | HP | E3632A | 15761 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13184 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13191 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13202 |
| Multimeter (functional check) | Tektronix | TX3 | 15655 |

**Table 47: Test equipment for Dry Heat, Storage, test.**

## 3.3 Low temperature

| | |
|---|---|
| **Test specimen** | Display Unit, Interface Unit, Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 8.4 (protected equipment) |
| **Test method** | IEC 60068-2-1: 2007-03 test Ab |
| **Temperature** | -15°C |
| **Duration** | 16 hours |
| **Comments** | None |
| **Date of measurements** | 2014-12-16 – 2014-12-17 |
| **Test personnel** | Stig Larsen |

### 3.3.1 Test setup

Test specimen and auxiliary equipment was turned off from the functional test before exposure until the last 2 hours at -15°C.

Functional tests were performed before the climatic exposure, during the last two hours of the exposure, and after recovery.

Functional tests during the last two hours of the exposure included tests at extreme power supply conditions, with 15 minutes at each extreme. For AC supply +/- 10% voltage and +/- 5% for frequency was tested. For DC supply +30% -10% voltage was tested.

Setup in chamber was the same as for Dry Heat test (see paragraph 3.1.1).

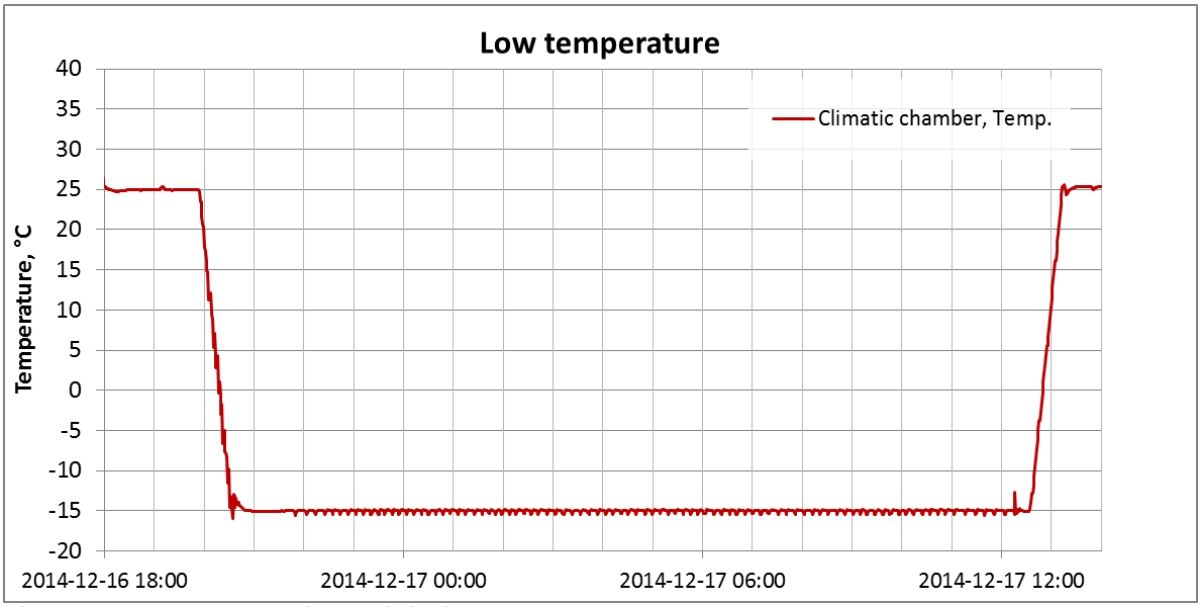



**Figure 23. Temperature logged during Low temperature test.**

### 3.3.2 Test results

| Functional test | Result |
|---|---|
| Before exposure | PASSED |
| Last two hours of exposure | PASSED |
| After exposure | PASSED |

**Table 48. Results for Low temperature test functional test.**

| Extreme power supply conditions | | Result |
|---|---|---|
| Voltage | Frequency | |
| 103.5 VAC (115 VAC - 10%) | 47.5 Hz (50 Hz - 5%) | PASSED |
| 103.5 VAC (115 VAC - 10%) | 63 Hz (60 Hz + 5%) | PASSED |
| 253 VAC (230 VAC + 10%) | 63 Hz (60 Hz + 5%) | PASSED |
| 253 VAC (230 VAC + 10%) | 47.5 Hz (50 Hz - 5%) | PASSED |
| 21.6 VDC (24 VDC – 10%) | - | PASSED |
| 31.2 VDC (24 VDC + 30%) | - | PASSED |

**Table 49: Results for Low Temperature, extreme power supply test.**

### 3.3.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Temperature and Climatic Test Chamber H3 | Vötsch | VC 7060 | 17624 |
| Multimeter | Hewlett Packard | 34401A | 14885 |
| Programmable AC Source | Chroma | 61502 | 19062 |
| Powersupply DC 0-15V 7A , 0-30V 4A | HP | E3632A | 14306 |
| Powersupply DC 0-15V 7A , 0-30V 4A | HP | E3632A | 15761 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13184 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13191 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13202 |
| Multimeter (functional check) | Tektronix | TX3 | 15655 |

**Table 50: Test equipment for Low Temperature test.**

## 3.4 Damp Heat

| | |
|---|---|
| **Test specimen** | Display Unit, Interface Unit, Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 8.3 (protected equipment) |
| **Test method** | IEC 60068-2-78:2012 |
| **Temperature** | +40°C |
| **Humidity** | 93% RH |
| **Duration** | 16 hours |
| **Comments** | None |
| **Date of test** | 2014-12-17 – 2014-12-18 |
| **Test personnel** | Stig Larsen |

### 3.4.1 Test setup

Test specimens and auxiliary equipment was turned on during the test.
Functional tests were performed before the climatic exposure, during the last two hours of the exposure, and after recovery.

Setup in chamber was the same as for Dry Heat test (see paragraph 3.1.1).

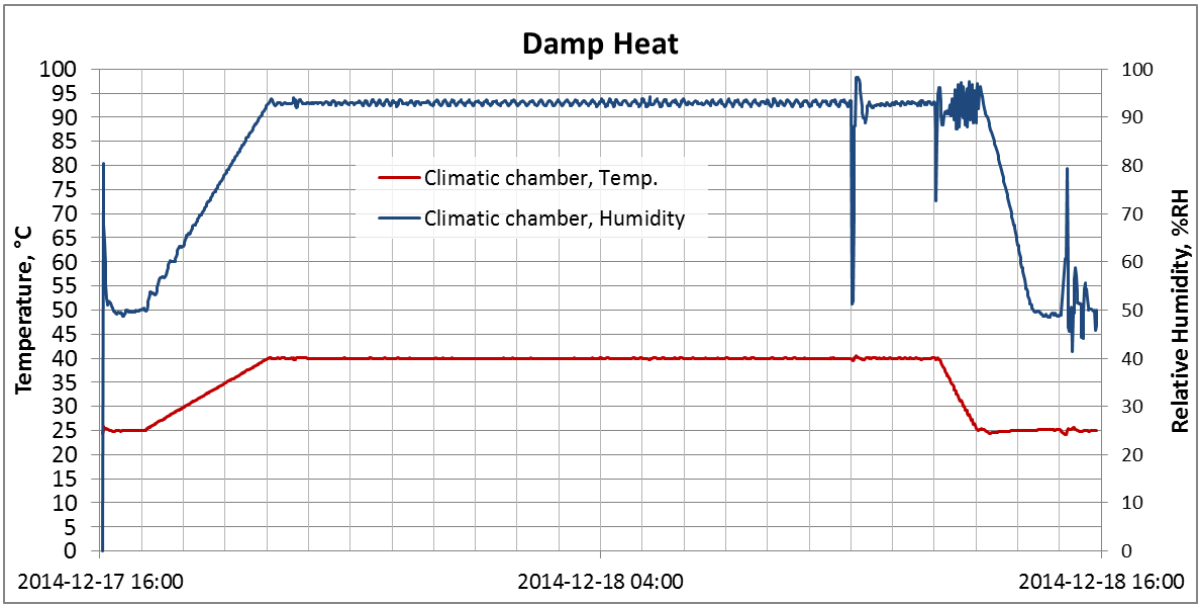



**Figure 24. Temperature and humidity logged during the Damp Heat test.**

### 3.4.2 Test results

| Functional test | Result |
|---|---|
| Before exposure | PASSED |
| Last two hours of exposure | PASSED |
| After recovery | PASSED |

**Table 51. Results for Damp Heat test.**

### 3.4.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Temperature and Climatic Test Chamber H3 | Vötsch | VC 7060 | 17624 |
| Powersupply DC 0-15V 7A , 0-30V 4A | HP | E3632A | 14306 |
| Powersupply DC 0-15V 7A , 0-30V 4A | HP | E3632A | 15761 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13184 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13191 |
| Multimeter (functional check) | Hewlett Packard | 34401A | 13202 |
| Multimeter (functional check) | Tektronix | TX3 | 15655 |

**Table 52: Test equipment for Damp Heat.**

## 3.5 Vibration

### 3.5.1 Vibration - Display Unit

| | |
|---|---|
| **Test specimen** | Display Unit |
| **Test specification** | IEC 60945:2002 Section 8.7 |
| **Test method** | IEC 60068-2-6:2007 test Fc |
| **Severity** | 2 Hz to 13.2 Hz – amplitude ±1 mm<br>13.2 Hz to 100 Hz – amplitude ±0.7 g |
| **Duration, sweep** | 0.5 octave per minute |
| **Duration, endurance** | 120 minutes |
| **Comments** | Test sequence: X, Y, Z |
| **Date of test** | 2015-01-15, 2015-01-19 |
| **Test personnel** | Stig Larsen |

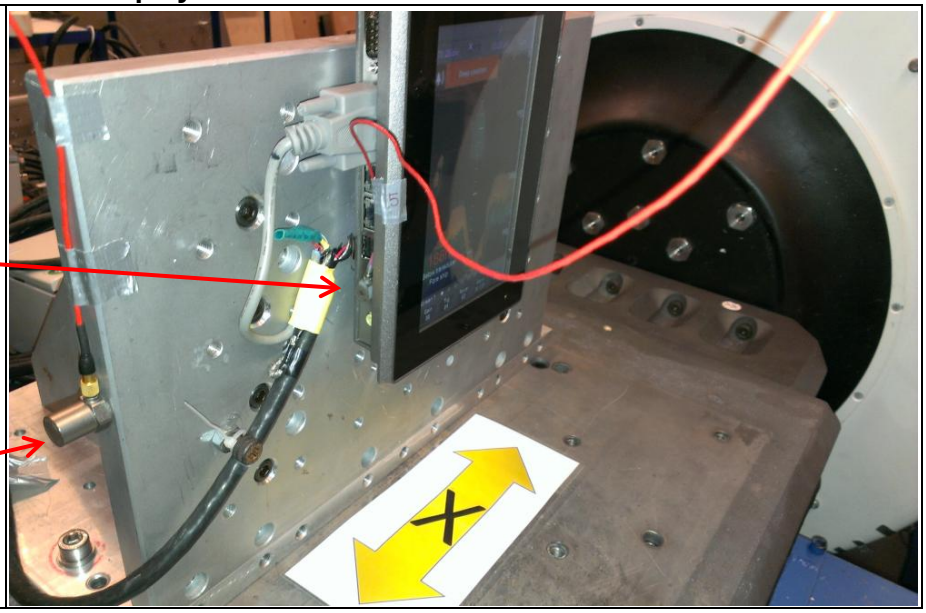
Sections below show, for each axis, the test setup and result of the resonance search. The graphs from resonance search contain the vibration profile, acceleration measured by control accelerometer, and the amplification factor for vibration measured on test specimen.

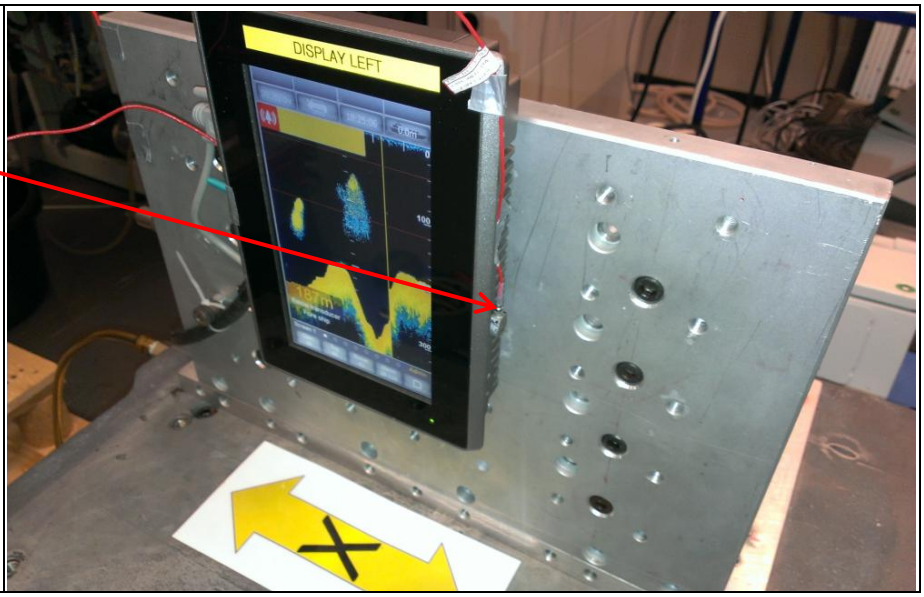
The test specimen was mounted on angle fixture using 4 screws attaching to the threaded holes on the back panel of the test specimen (VESA standard 75 x 75 mm hole pattern). Test specimen was mounted with display in portrait mode, in order to match the orientation of the content of the display.

Summary of vibration test results are found in section 3.5.5.

#### 3.5.1.1 X-axis vibration – Display Unit

Photo 48. Setup



| | |
|---|---|
| Photo 49. Setup<br><br>Accelerometer on specimen side (channel 4) |  |

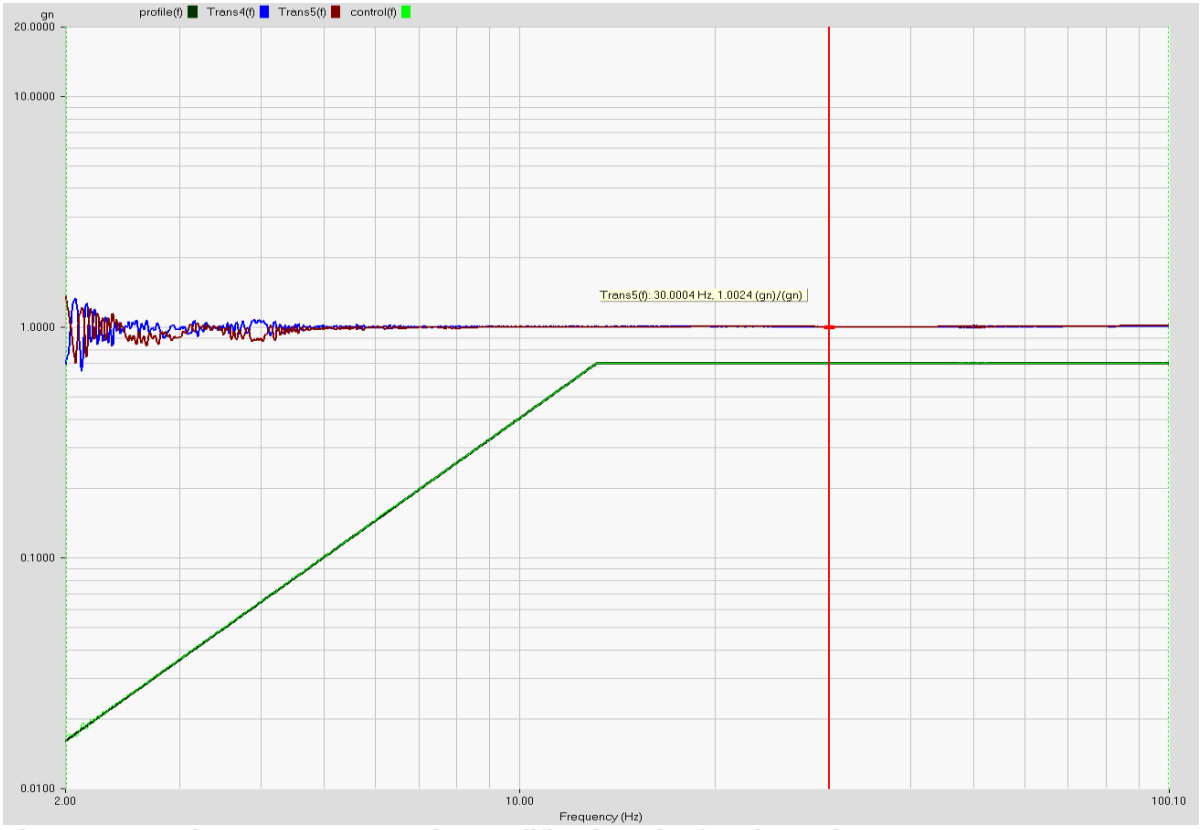
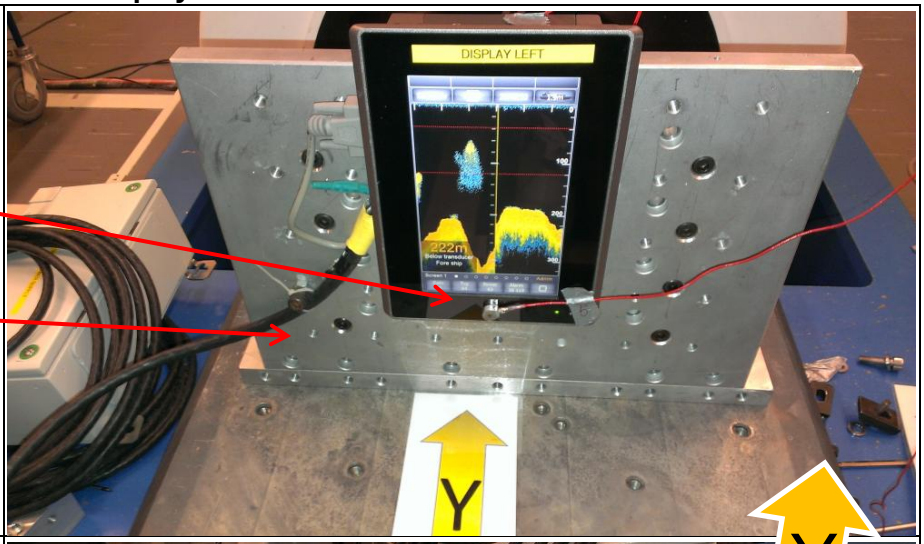
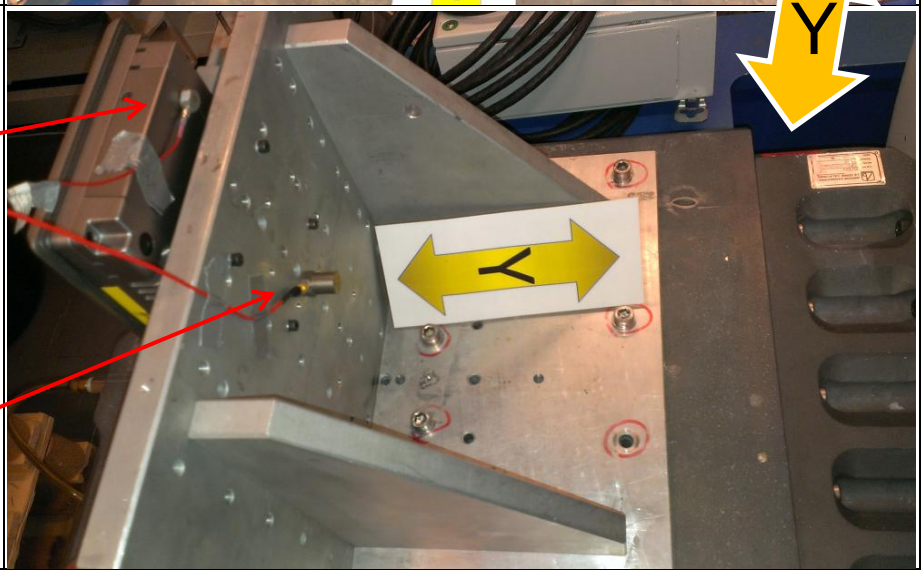



**Figure 25. X-axis resonance search. Amplification plot for channel 4 + 5.**

### 3.5.1.2 Y-axis vibration – Display Unit

| | |
|---|---|
| Photo 50. Setup<br><br>Accelerometer on specimen front (channel 5) |  |
| Photo 51. Setup<br><br>Accelerometer on specimen back (channel 4)<br><br>Control accelerometer on fixture (channel 1) |  |

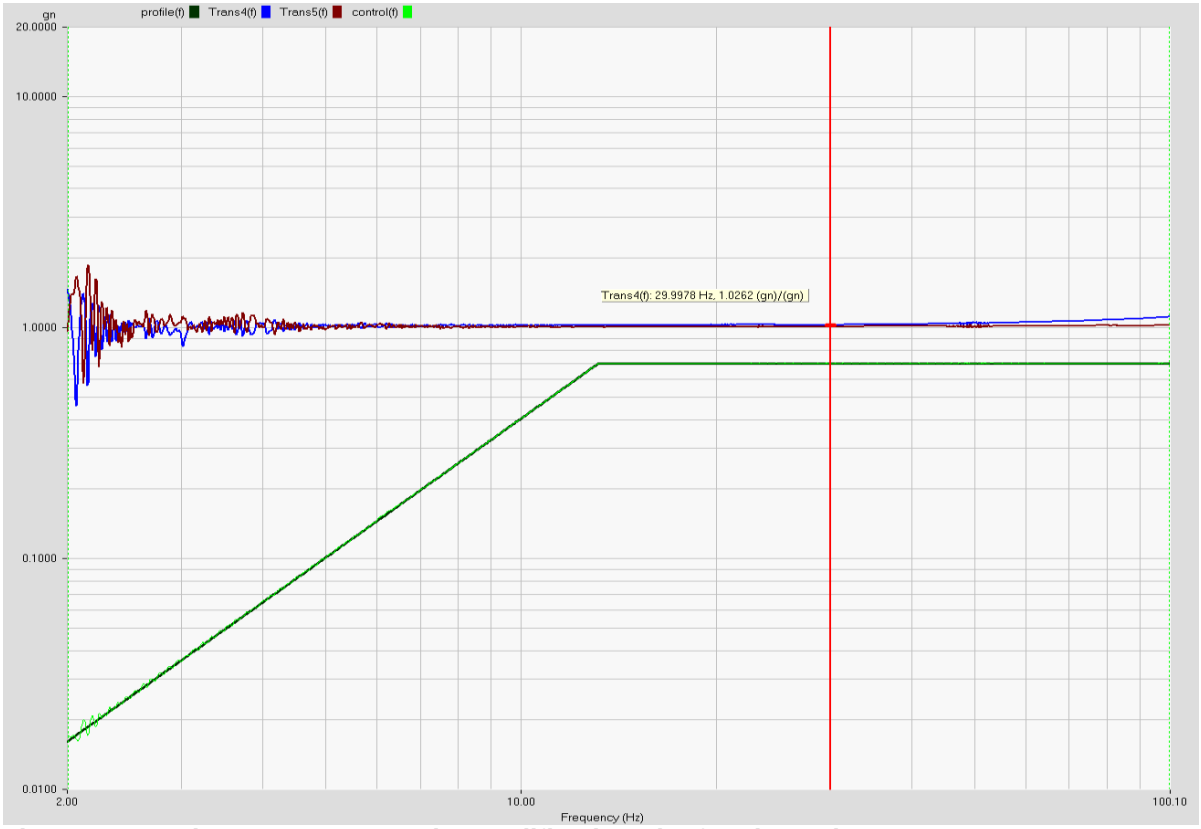


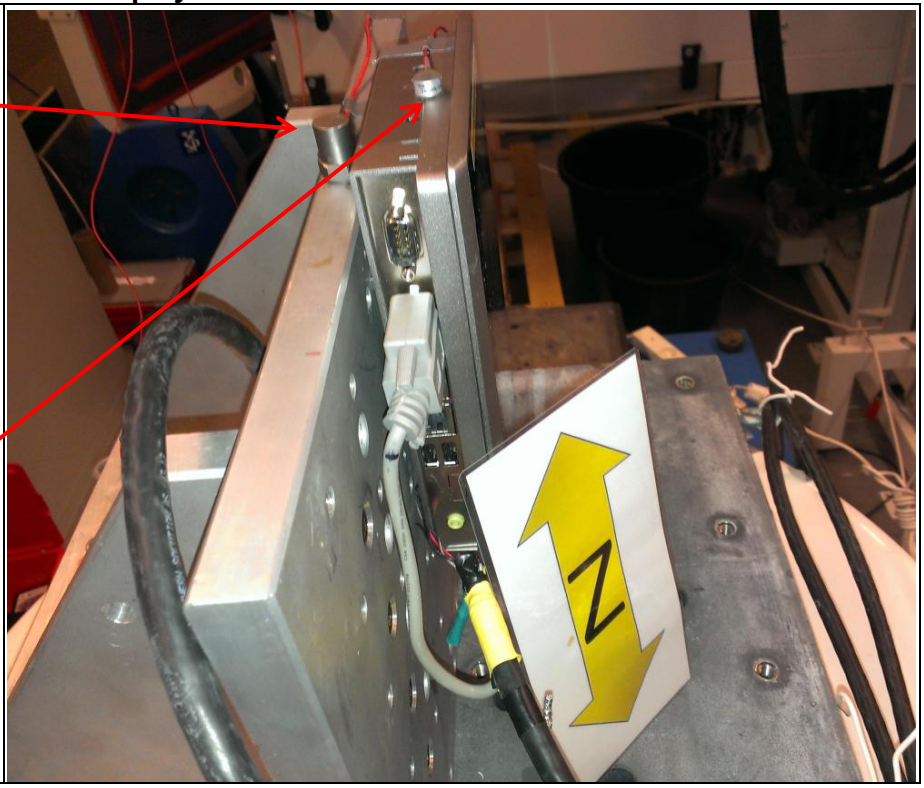

**Figure 26. Y-axis resonance search. Amplification plot for channel 4 + 5.**

### 3.5.1.3 Z-axis vibration – Display Unit

Photo 52. Setup

Control accelerometer on fixture (channel 1)

Accelerometer on specimen top (channel 4)



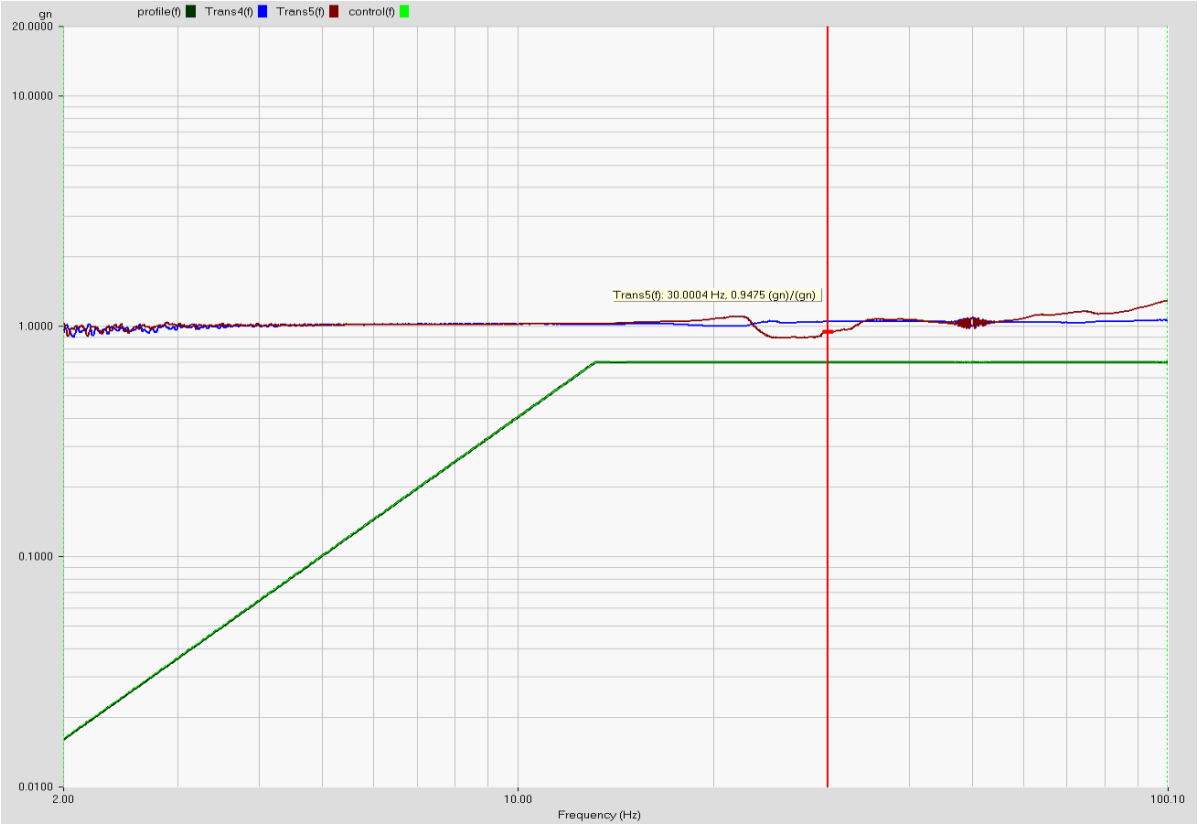



**Figure 27. Z-axis resonance search. Amplification plot for channel 4 (blue) on Display Unit.**

### 3.5.2 Vibration - Interface Unit

| | |
|---|---|
| **Test specimen** | Interface Unit |
| **Test specification** | IEC 60945:2002 Section 8.7 |
| **Test method** | IEC 60068-2-6:2007 test Fc |
| **Severity** | 2 Hz to 13.2 Hz – amplitude ±1 mm<br>13.2 Hz to 100 Hz – amplitude ±0.7 g |
| **Duration, sweep** | 0.5 octave per minute |
| **Duration, endurance** | 120 minutes |
| **Comments** | Test sequence: Y, X, Z |
| **Date of test** | 2015-01-15; 2015-01-16 |
| **Test personnel** | Stig Larsen |

Sections below show, for each axis, the test setup and result of the resonance search. The graphs from resonance search contain the vibration profile, acceleration measured by control accelerometer, and the amplification factor for vibration measured on test specimen.

The test specimen was mounted on angle fixture through the 4 brackets supplied for the enclosure.

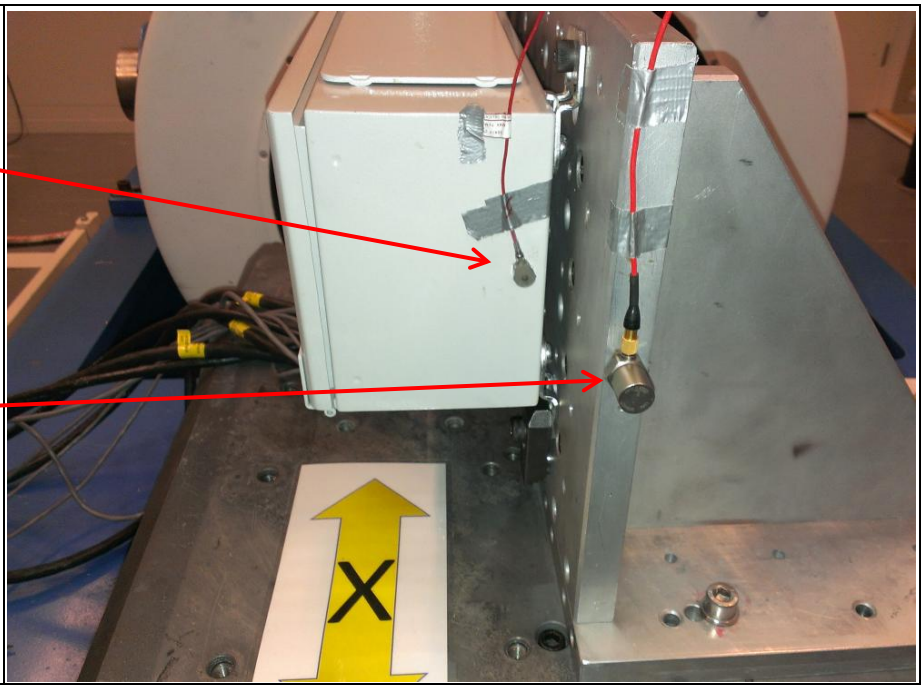
Summary of vibration test results are found in section 3.5.5.

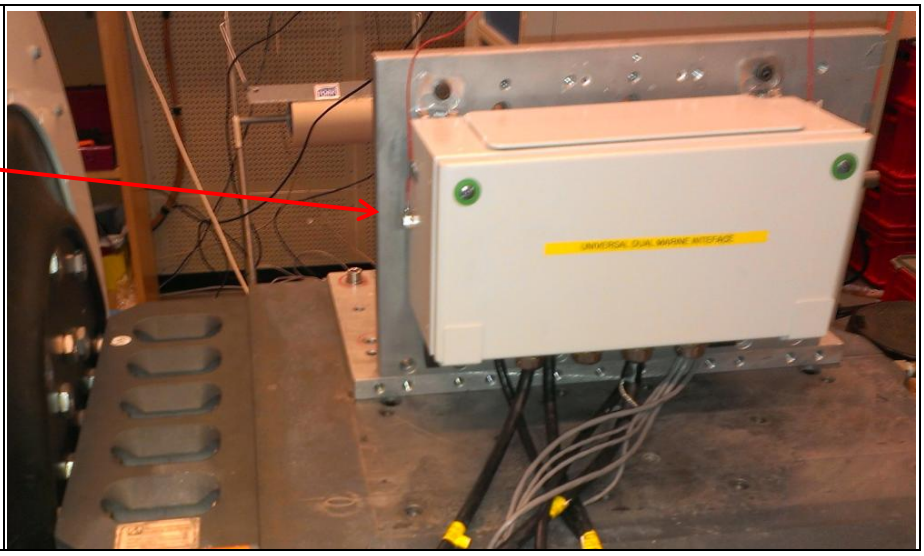
#### 3.5.2.1 X-axis vibration – Interface Unit

Photo 53. Setup

Accelerometer on right side (channel 4)

Control accelerometer on fixture (channel 1)



| | |
|---|---|
| Photo 54. Setup<br><br>Accelerometer on left side (channel 5) |  |

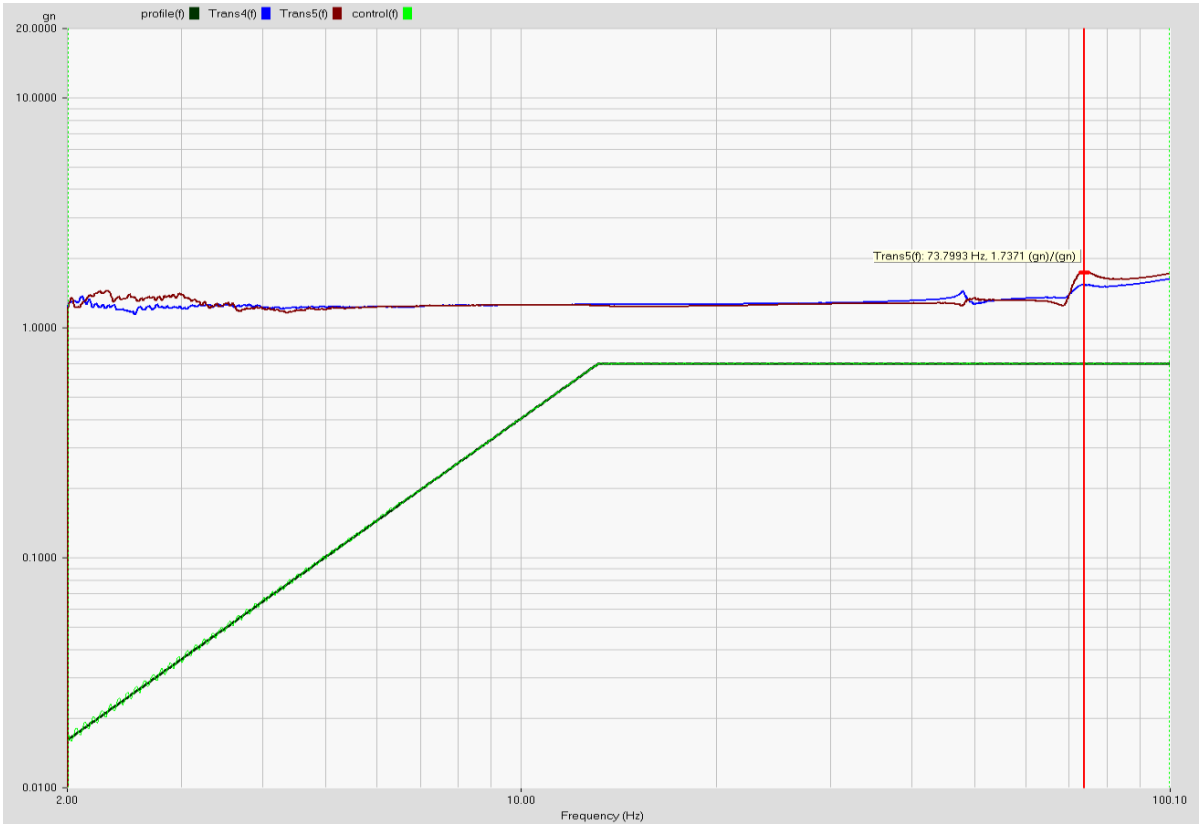



**Figure 28. X-axis resonance search. Amplification plot for channel 4.**

### 3.5.2.2 Y-axis vibration – Interface Unit

Photo 55. Setup

Control accelerometer on fixture (channel 1)

Accelerometer on back at right side (channel 4)

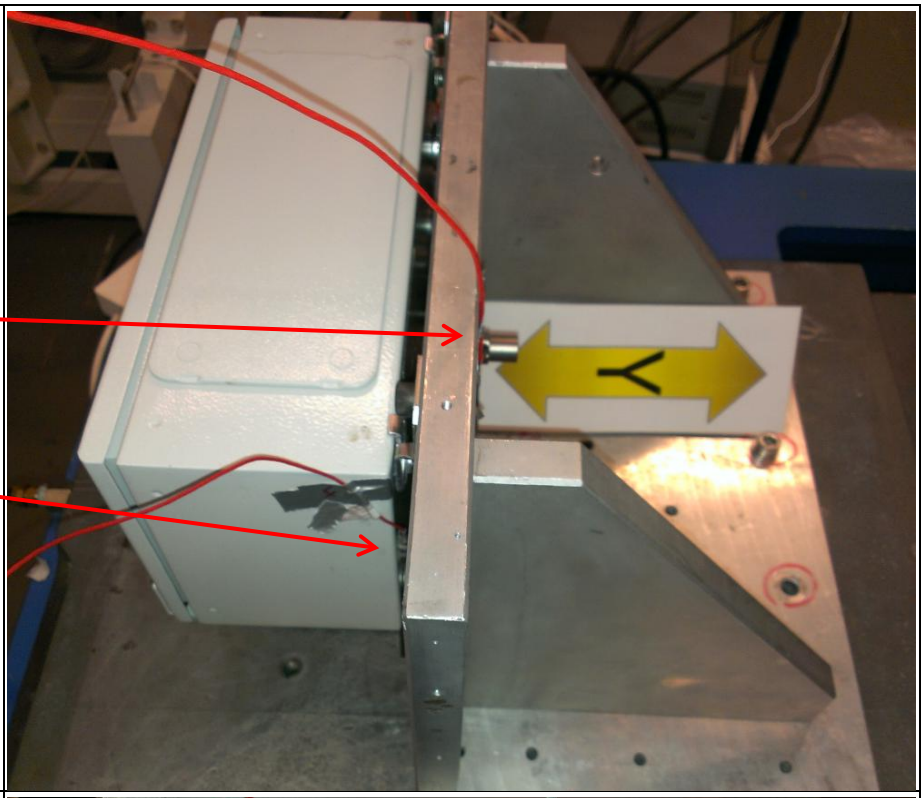



Photo 56. Setup

Accelerometer on back at left side (channel 5)

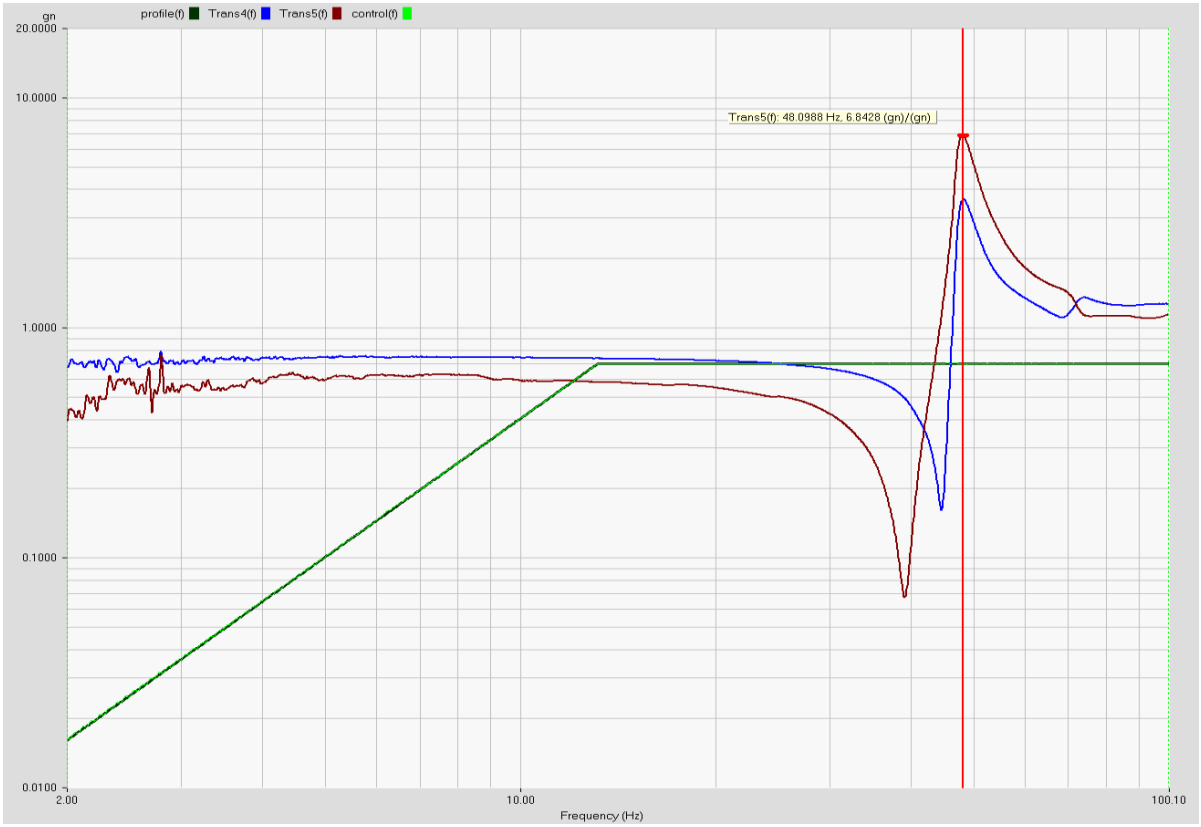


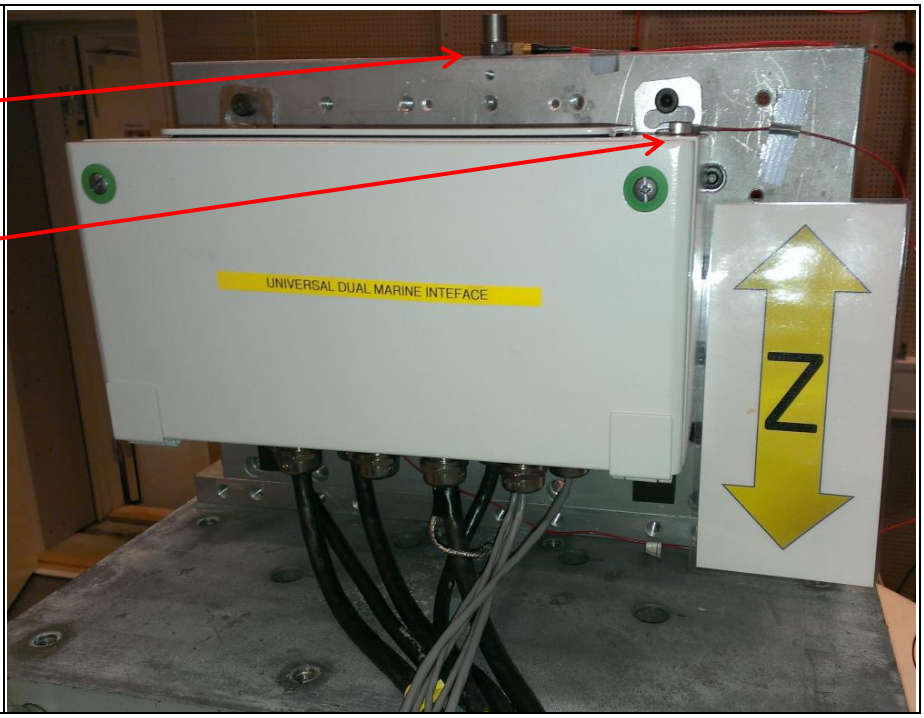

**Figure 29. Y-axis resonance search. Amplification plot for channel 4.**

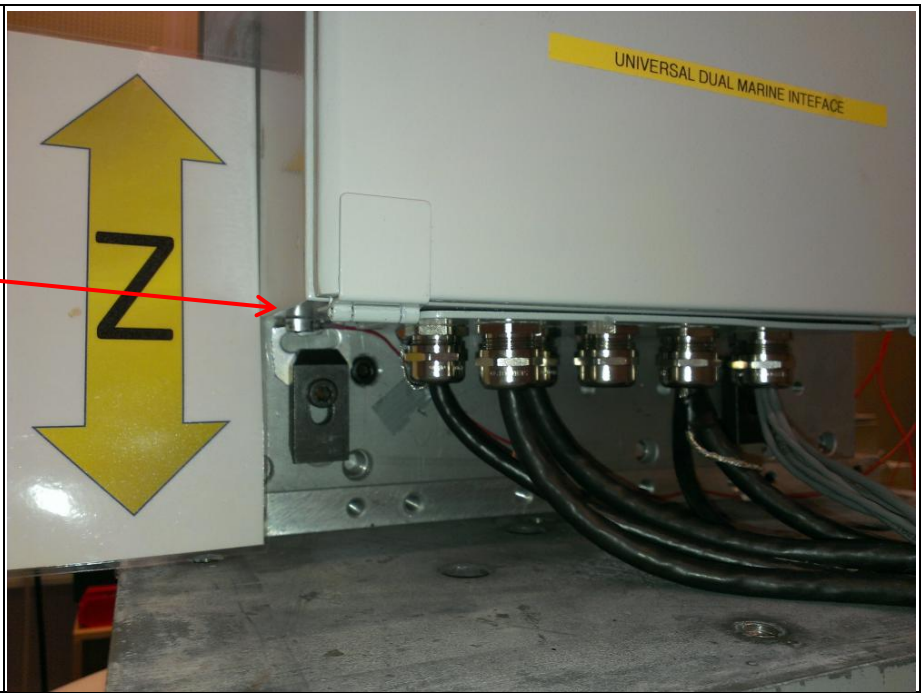
### 3.5.2.3 Z-axis vibration – Interface Unit

Photo 57. Setup

Control accelerometer on fixture (channel 1)

Accelerometer on top at right side (channel 5)



| | |
|---|---|
| Photo 58. Setup<br><br>Accelerometer on bottom at left side (channel 4) |  |

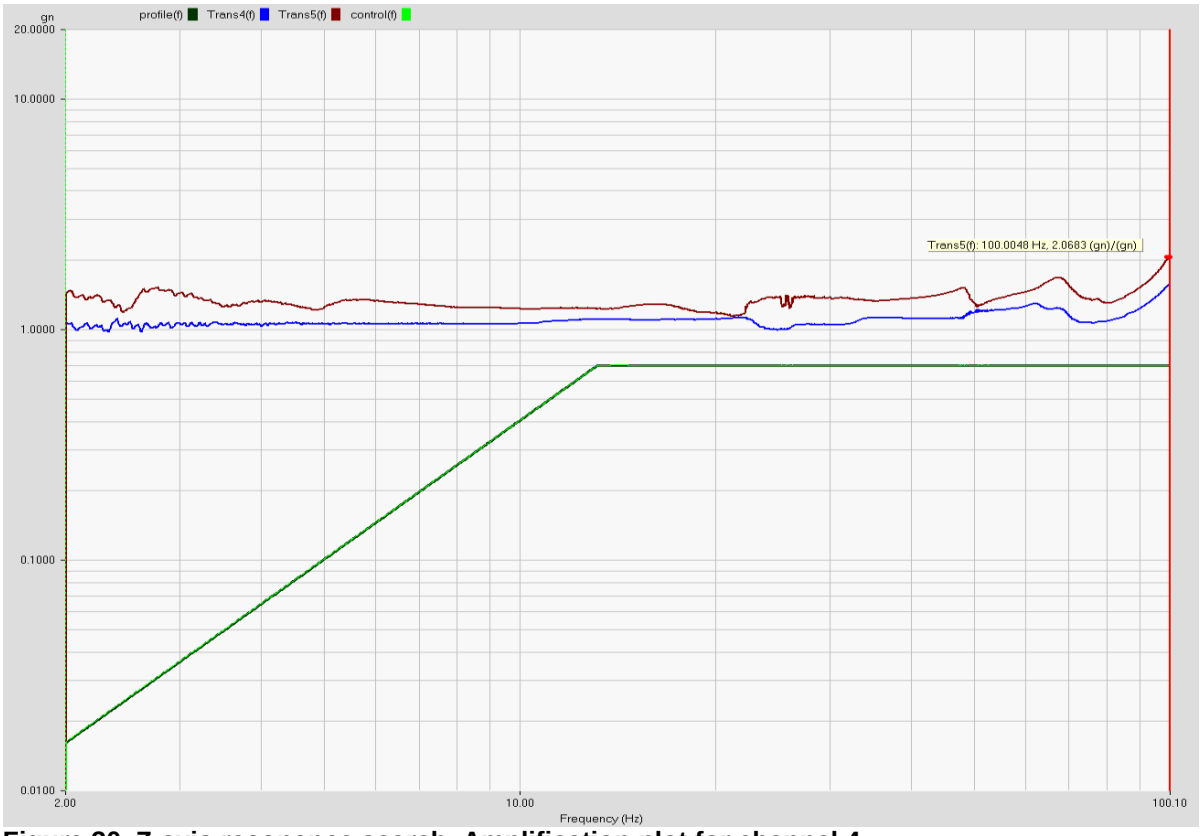



**Figure 30. Z-axis resonance search. Amplification plot for channel 4.**

### 3.5.3 Vibration - Power Supply Unit

| | |
|---|---|
| **Test specimen** | Display Unit, Interface Unit, Power Supply Unit, Sensor unit |
| **Test specification** | IEC 60945:2002 Section 8.7 |
| **Test method** | IEC 60068-2-6:2007 test Fc |
| **Severity** | 2 Hz to 13.2 Hz – amplitude ±1 mm<br>13.2 Hz to 100 Hz – amplitude ±0.7 g |
| **Duration, sweep** | 0.5 octave per minute |
| **Duration, endurance** | 120 minutes |
| **Comments** | Test sequence: Y, X, Z |
| **Date of test** | 2015-01-14; 2015-01-15; 2015-01-19 |
| **Test personnel** | Stig Larsen |

Sections below show, for each axis, the test setup and result of the resonance search. The graphs from resonance search contain the vibration profile, acceleration measured by control accelerometer, and the amplification factor for vibration measured on test specimen.

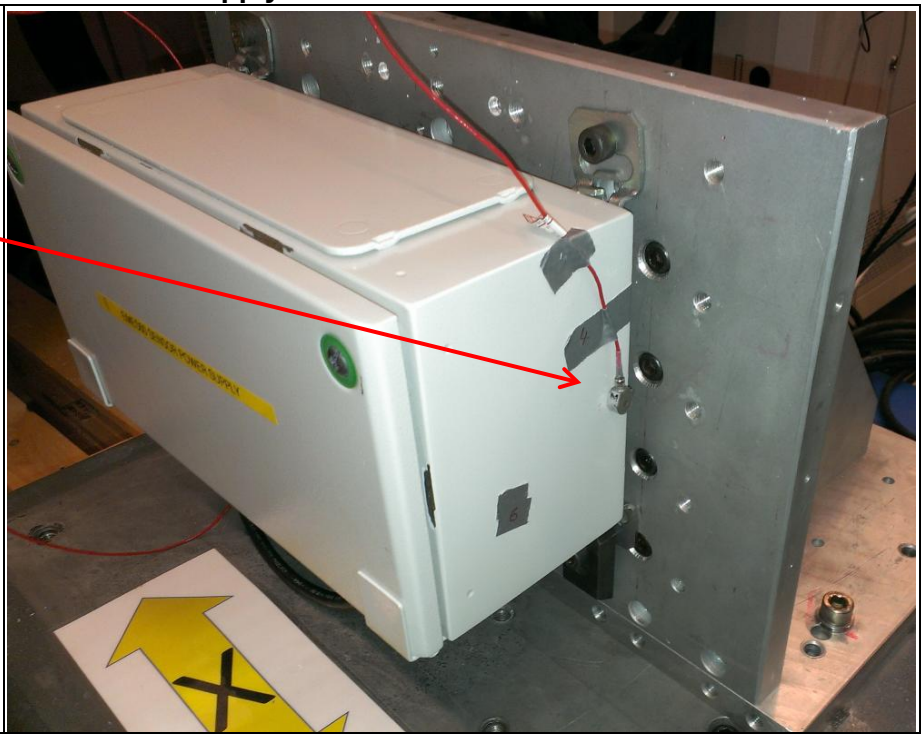
The test specimen was mounted on angle fixture through the 4 brackets supplied for the enclosure.

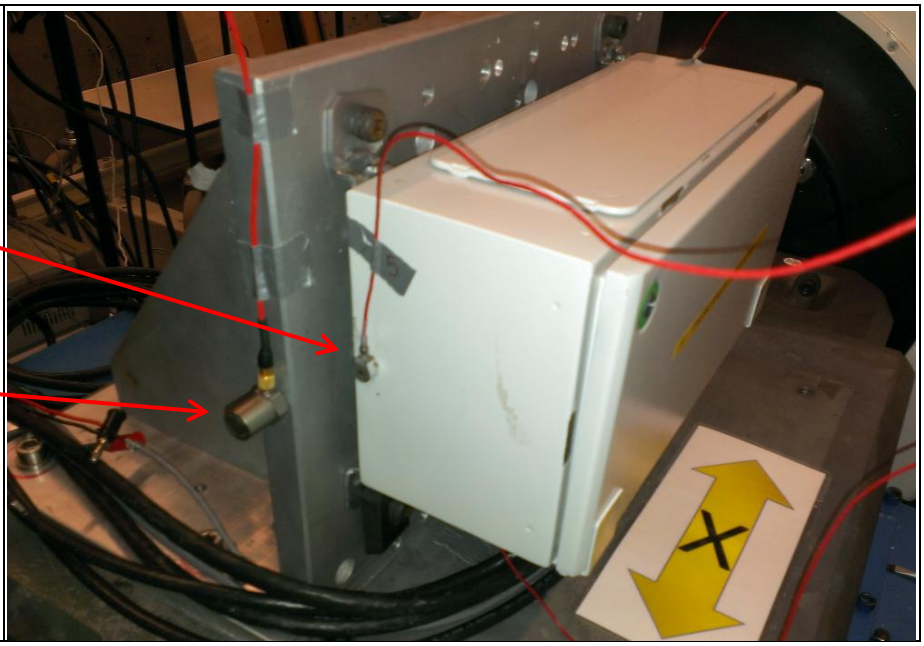
Summary of vibration test results are found in section 3.5.5.

#### 3.5.3.1 X-axis vibration – Power Supply Unit

Photo 59. Setup

Accelerometer on right side (channel 4)



| Photo 60. Setup |  |
|---|---|



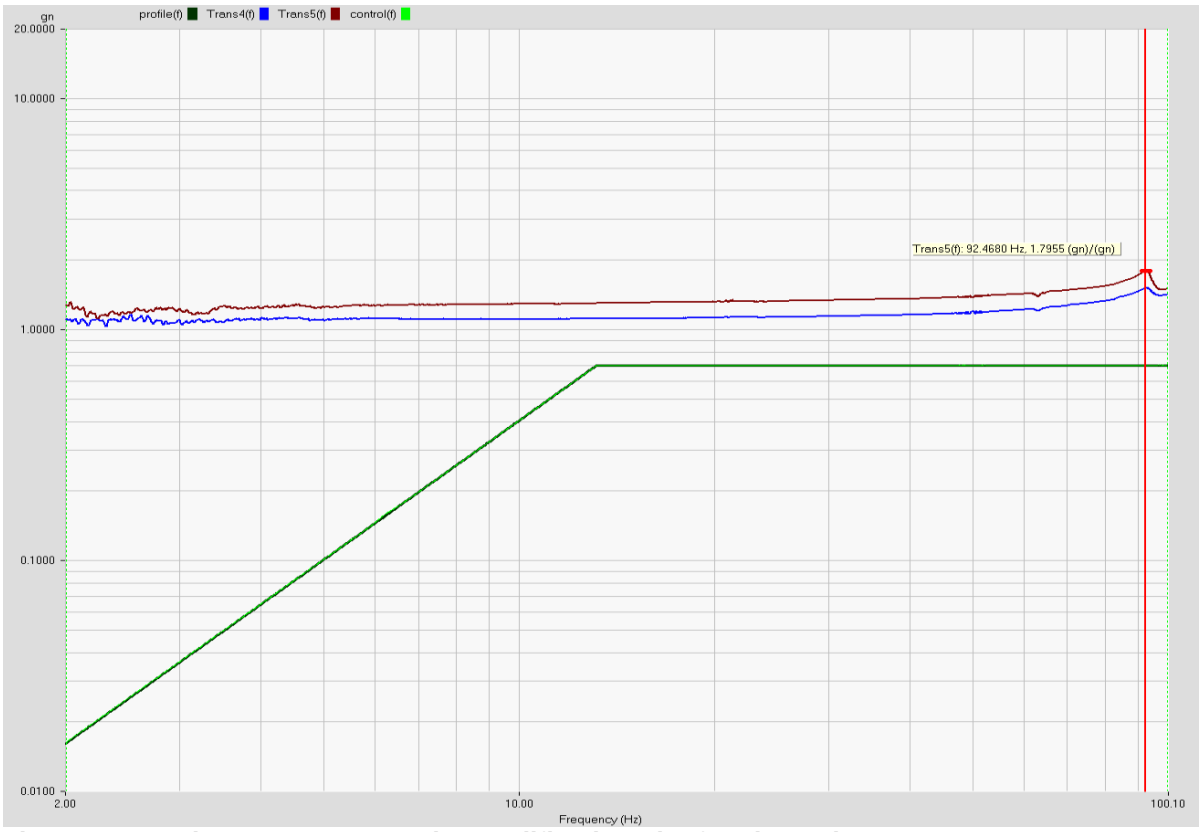



**Figure 31. X-axis resonance search. Amplification plot for channel 4 + 5.**

### 3.5.3.2 Y-axis vibration – Power Supply Unit

Photo 61. Setup

Accelerometer on left side (channel 7)

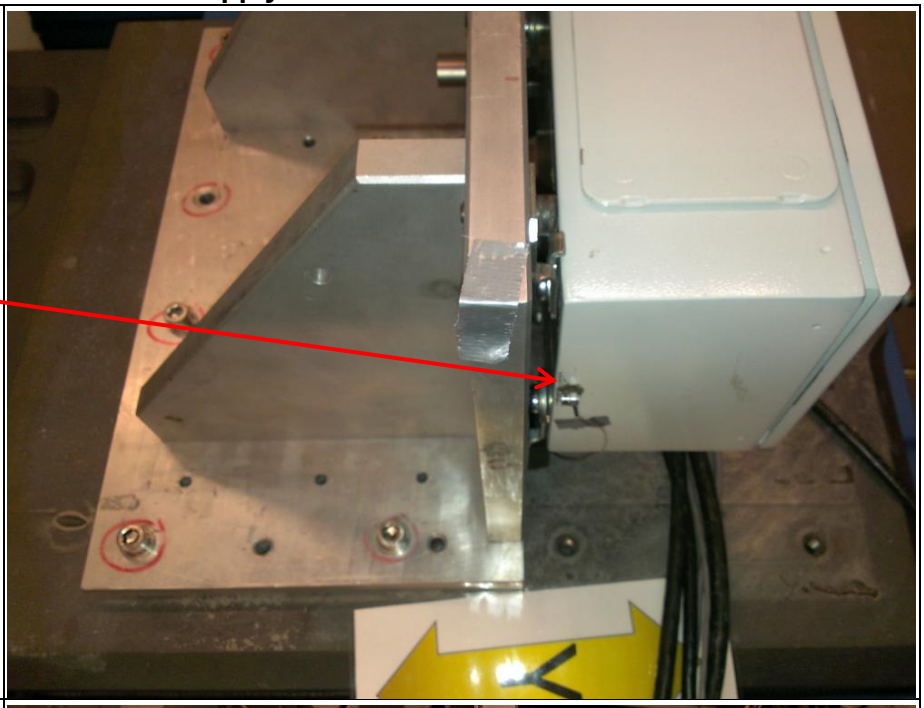
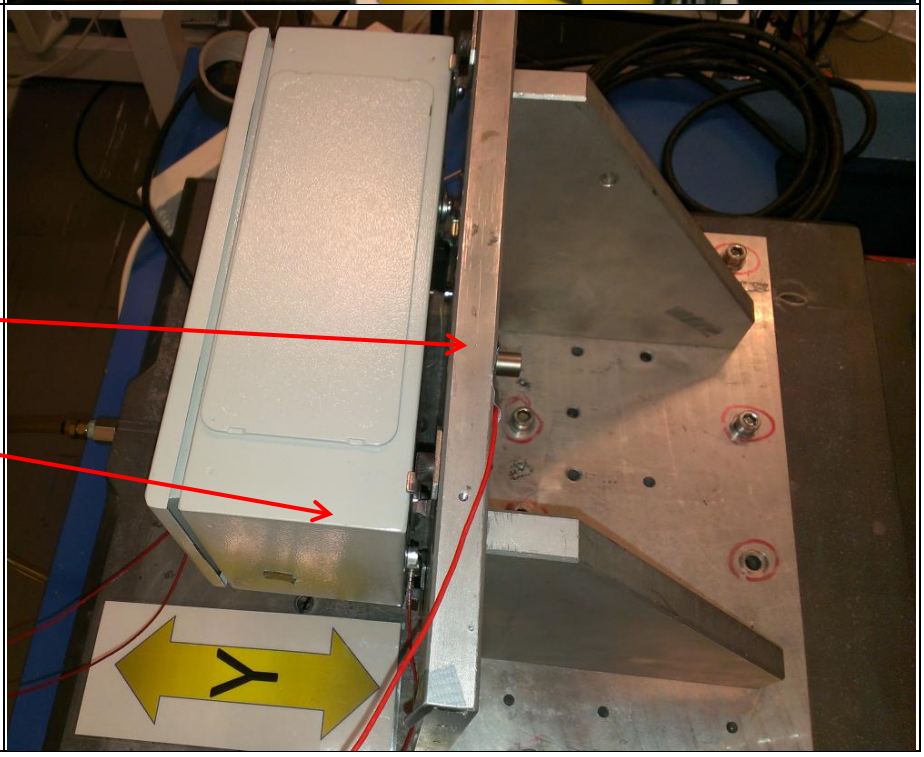


Photo 62. Setup

Control accelerometer on fixture (channel 1)

Accelerometer on back at right side (channel 4)



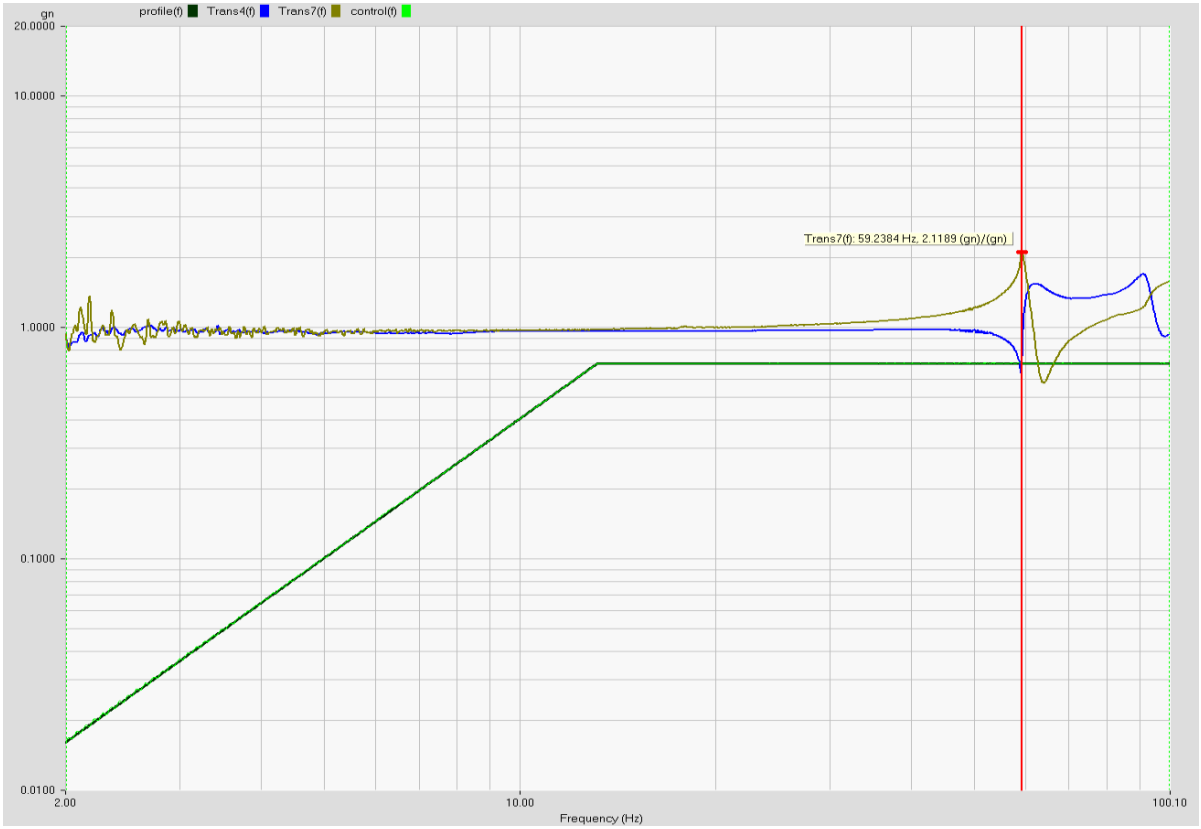
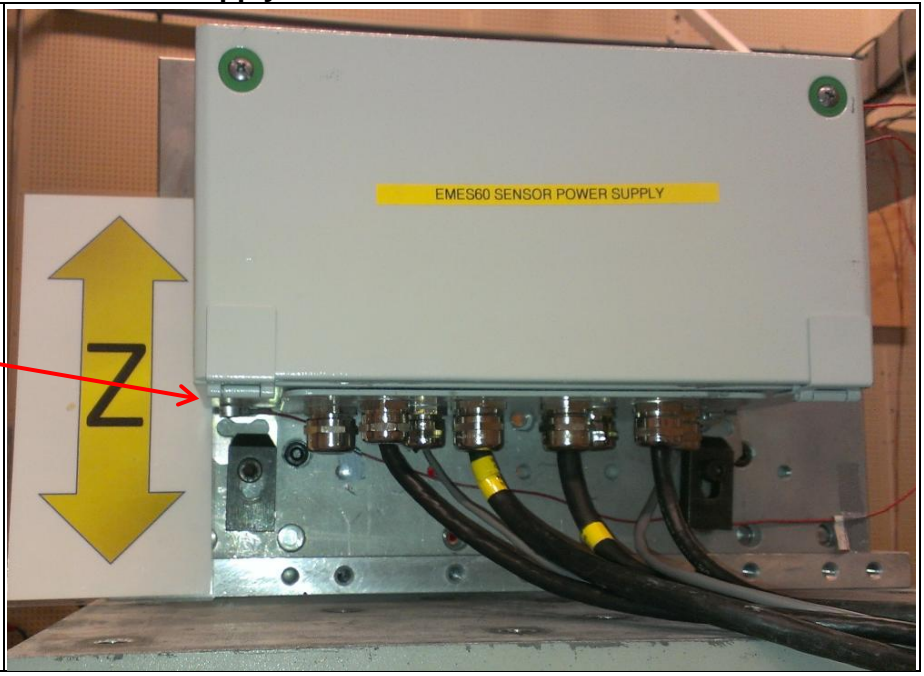


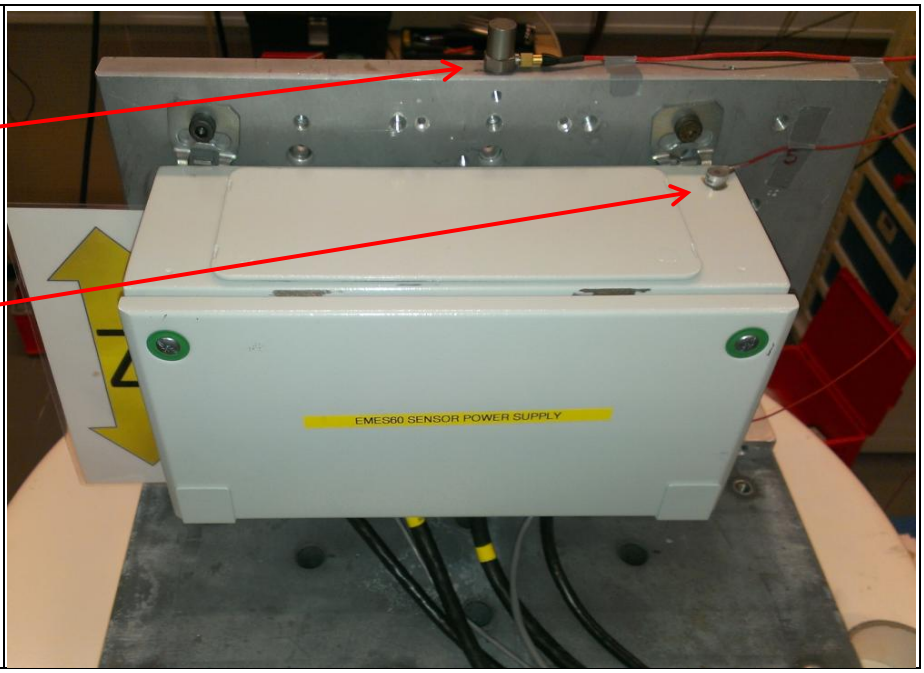

**Figure 32. Y-axis resonance search. Amplification plot for channel 4.**

### 3.5.3.3 Z-axis vibration – Power Supply Unit

Photo 63. Setup

Accelerometer on bottom at left side (channel 4)



| | |
|---|---|
| Photo 64. Setup<br><br>Control accelerometer on fixture (channel 1)<br><br>Accelerometer on top at right side (channel 5) |  |

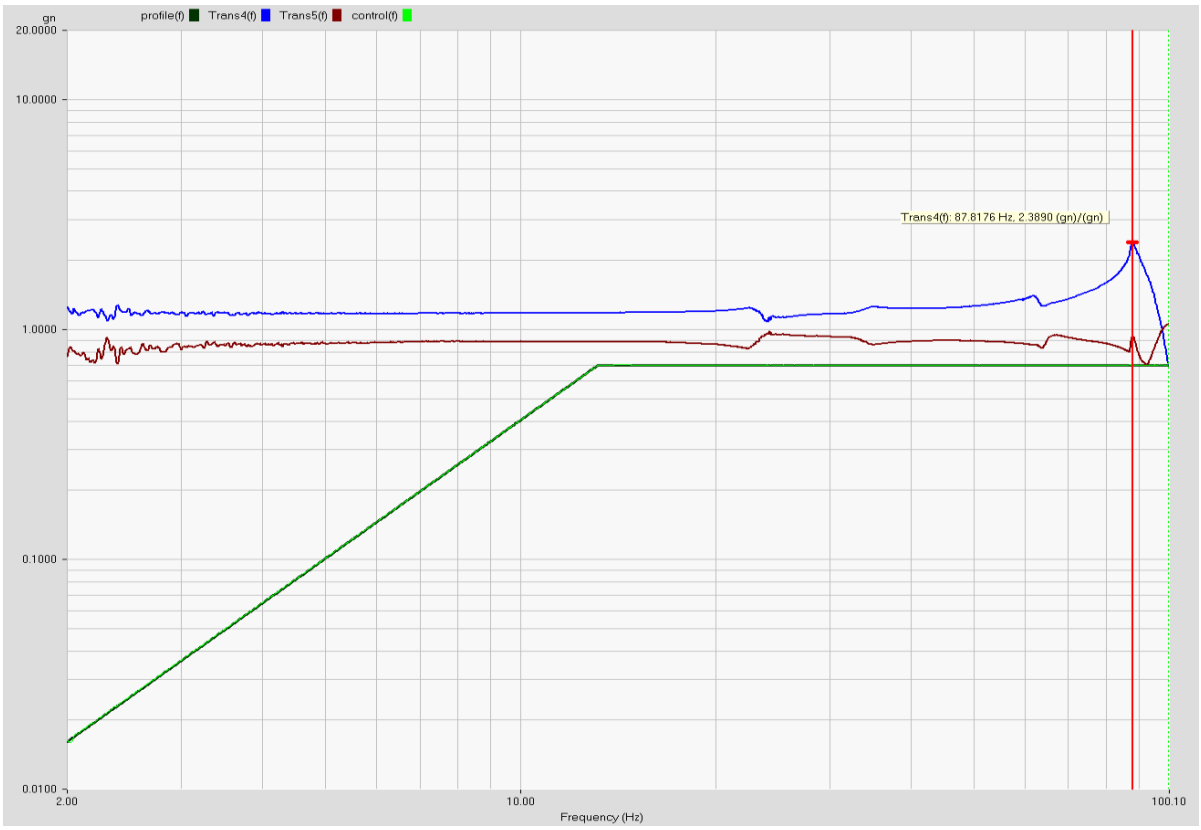



**Figure 33. Z-axis resonance search. Amplification plot for channel 4 + 5.**

### 3.5.4 Vibration - Sensor Unit

| | |
|---|---|
| **Test specimen** | Display Unit, Interface Unit, Power Supply Unit, Sensor unit |
| **Test specification** | IEC 60945:2002 Section 8.7 |
| **Test method** | IEC 60068-2-6:2007 test Fc |
| **Severity** | 2 Hz to 13.2 Hz – amplitude ±1 mm<br>13.2 Hz to 100 Hz – amplitude ±0.7 g |
| **Duration, sweep** | 0.5 octave per minute |
| **Duration, endurance** | 120 minutes |
| **Comments** | Test sequence: X, Y, Z |
| **Date of test** | 2014-12-22; 2014-12-23; 2015-01-19 |
| **Test personnel** | Stig Larsen |

Sections below show, for each axis, the test setup and result of the resonance search. The graphs from resonance search contain the vibration profile, acceleration measured by control accelerometer, and the amplification factor for vibration measured on test specimen.

Test specimen was fixed to vibrator using threaded holes next to the cable.

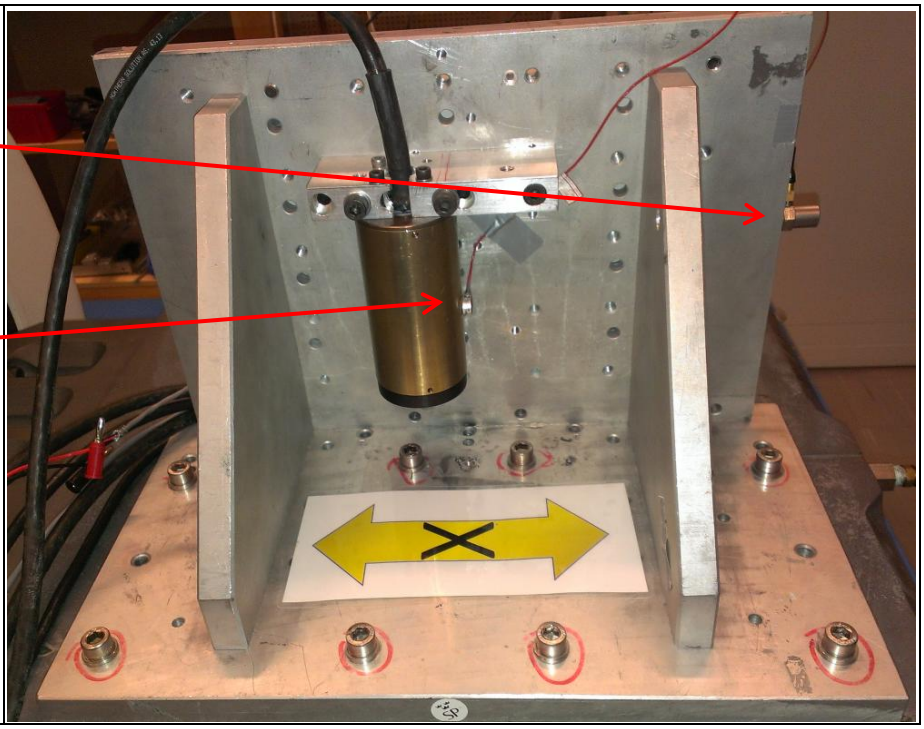
Summary of vibration test results are found in section 3.5.5.

#### 3.5.4.1 X-axis vibration – Sensor Unit

Photo 65. Setup

Control accelerometer on fixture (channel 1)

Accelerometer on specimen side (channel 4)



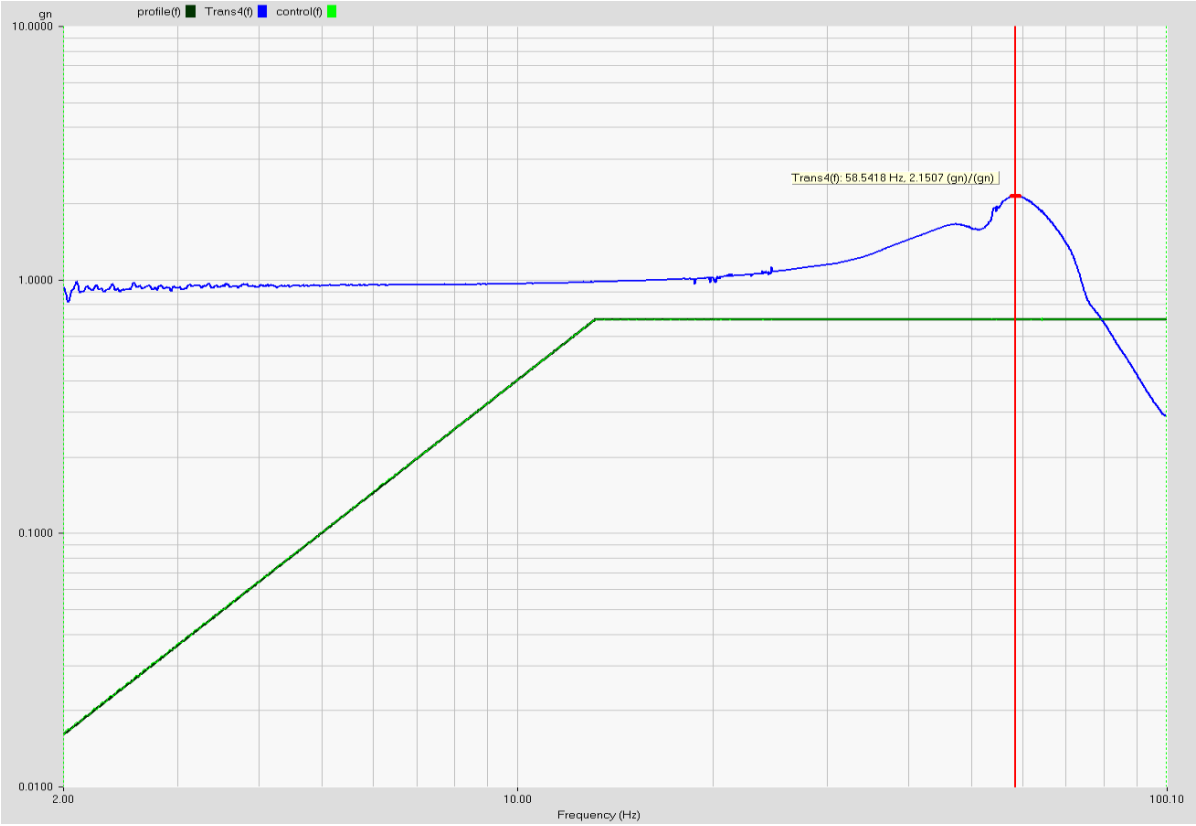
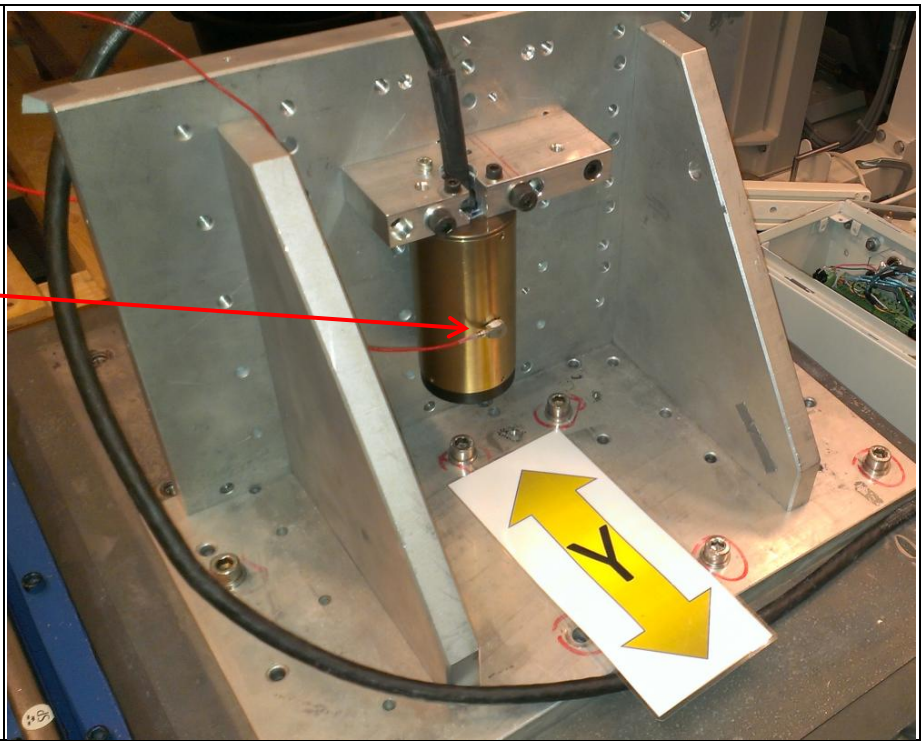


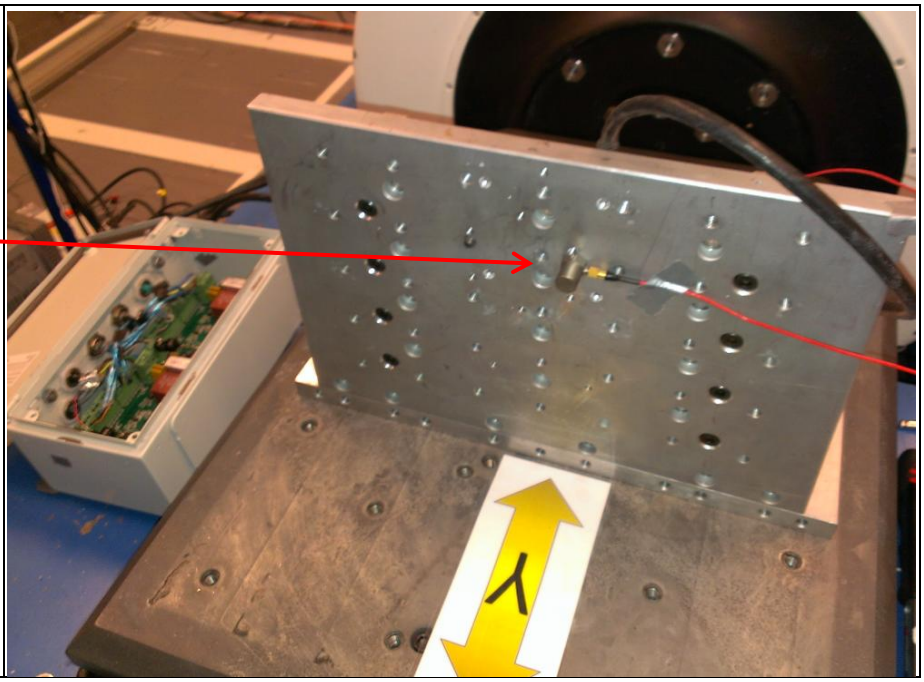

**Figure 34. X-axis resonance search. Amplification plot for channel 4.**

### 3.5.4.2 Y-axis vibration – Sensor Unit

Photo 66. Setup

Accelerometer on specimen side (channel 4)



| | |
|---|---|
| Photo 67. Setup<br><br>Control accelerometer on fixture (channel 1) |  |

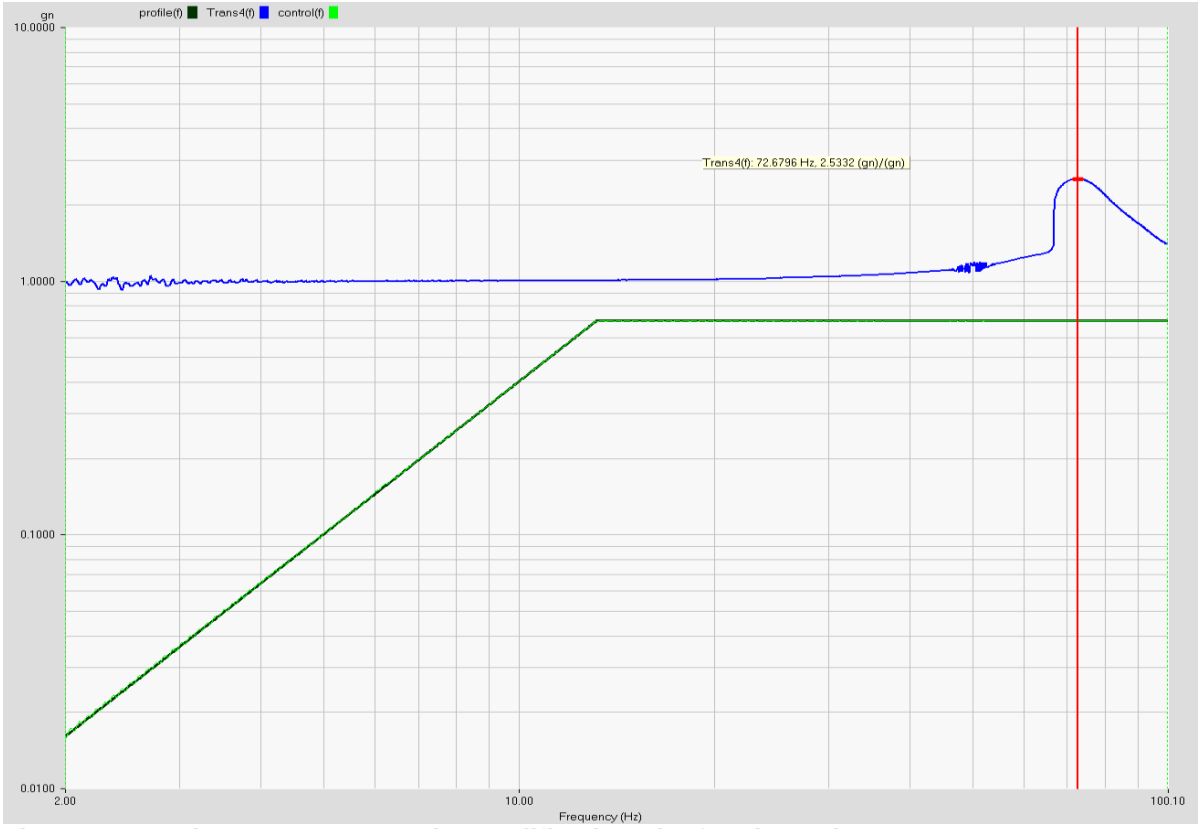


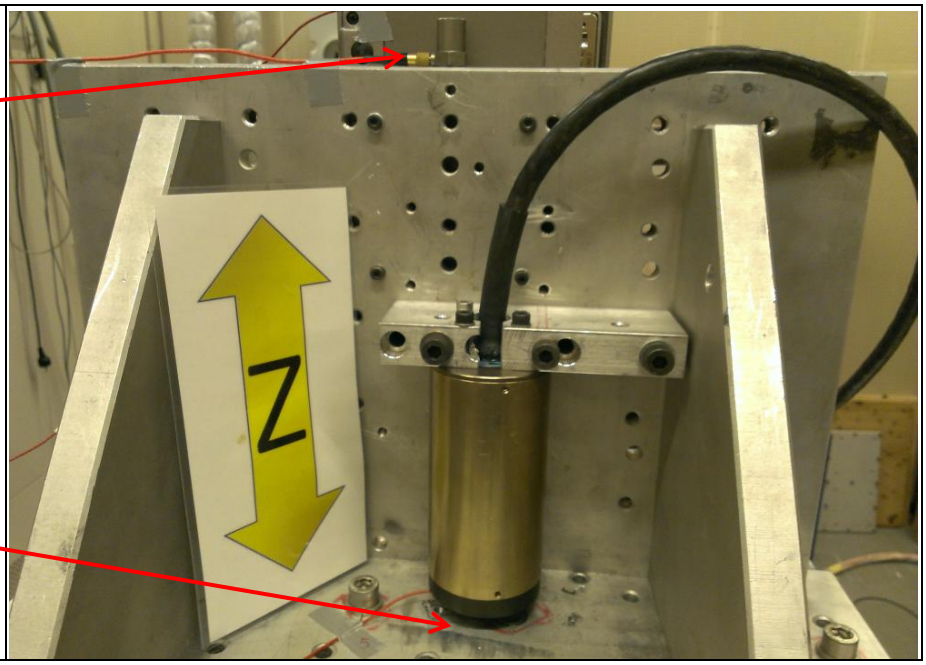

**Figure 35. Y-axis resonance search. Amplification plot for channel 4.**

### 3.5.4.3 Z-axis vibration – Sensor Unit

Photo 68. Setup

Control accelerometer on fixture (channel 1)

Accelerometer on bottom of specimen (channel 5)



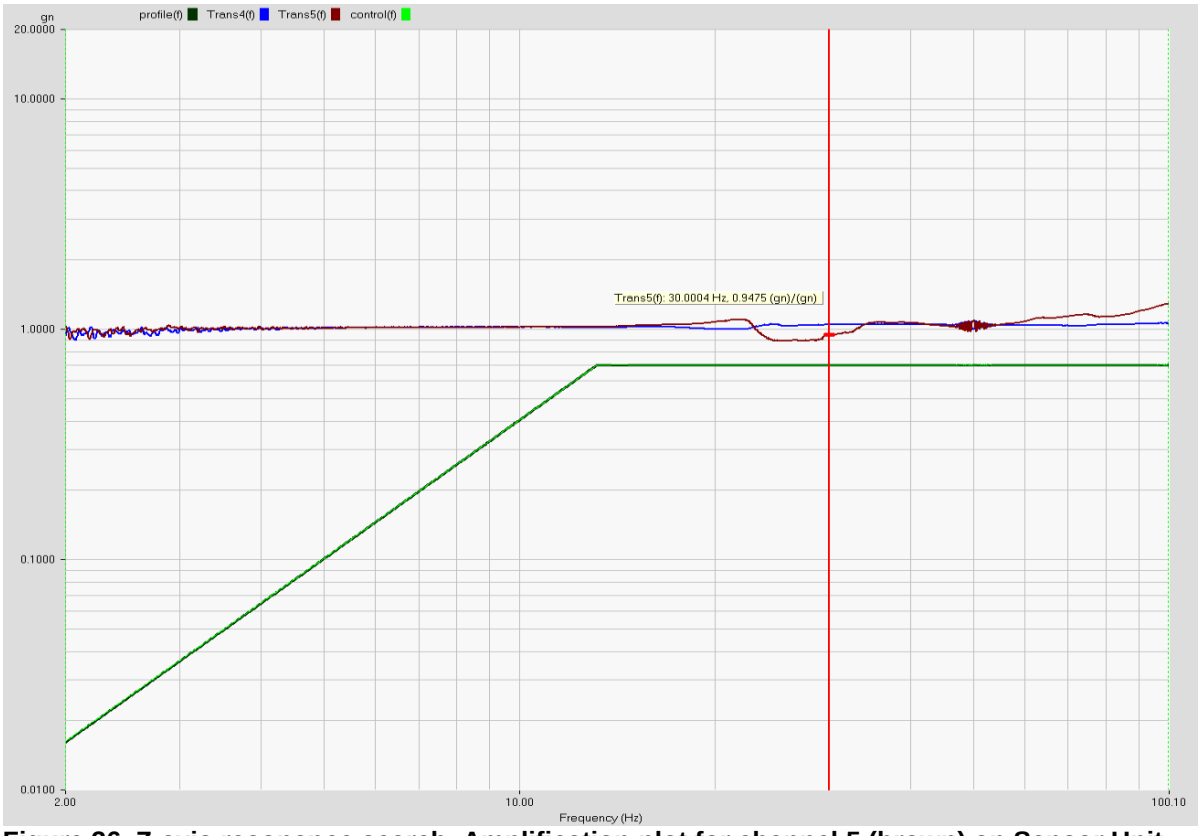




**Figure 36. Z-axis resonance search. Amplification plot for channel 5 (brown) on Sensor Unit.**

### 3.5.5 Summary of Vibration test results

No change in actual operating state or stored data was observed. The test specimens were operational and functional during and after the test.

Test parameters and results for the individual test specimens are found in the tables below.

| | Resonance frequency | Measured amplification factor | Test parameter for endurance test | Result |
|---|---|---|---|---|
| **X-axis** | No resonance | - | 2 hours at 30 Hz | PASSED |
| **Y-axis** | No resonance | - | 2 hours at 30 Hz | PASSED |
| **Z-axis** | No resonance | - | 2 hours at 30 Hz | PASSED |

**Table 53. Vibration test summary, Display Unit**

| | Resonance frequency | Measured amplification factor | Test parameter for endurance test | Result |
|---|---|---|---|---|
| **X-axis** | 73.8 Hz | 1.7 $g_n/g_n$ | 2 hours at 73.8 Hz | PASSED |
| **Y-axis** | 48.1 Hz | 6.8 $g_n/g_n$ | 2 hours at 48.1 Hz | PASSED |
| **Z-axis** | > 100 Hz | 2.1 $g_n/g_n$ at 100 Hz | 2 hours at 100 Hz | PASSED |

**Table 54. Vibration test summary, Interface Unit**

| | Resonance frequency | Measured amplification factor | Test parameter for endurance test | Result |
|---|---|---|---|---|
| **X-axis** | 92.5 Hz | 1.8 $g_n/g_n$ | 2 hours at 92.5 Hz | PASSED |
| **Y-axis** | 59.2 Hz | 2.1 $g_n/g_n$ | 2 hours at 59.2 Hz | PASSED |
| **Z-axis** | 87.8 Hz | 2.4 $g_n/g_n$ | 2 hours at 87.8 Hz | PASSED |

**Table 55. Vibration test summary, Power Supply Unit**

| | Resonance frequency | Measured amplification factor | Test parameter for endurance test | Result |
|---|---|---|---|---|
| **X-axis** | 58.5 Hz | 2.2 $g_n/g_n$ | 2 hours at 58.5 Hz | PASSED |
| **Y-axis** | 72.7 Hz | 2.5 $g_n/g_n$ | 2 hours at 72.7 Hz | PASSED |
| **Z-axis** | No resonance | - | 2 hours at 30 Hz | PASSED |

**Table 56. Vibration test summary, Sensor Unit**

### 3.5.6 Test equipment for Vibration test

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Dactron, Shaker Control System | LDS Test & Meas. | LAS 200 | 900489 |
| Accelerometer B&K 2166452 (channel 1) | Bruel&Kjaer | 4399 | 50005 |
| Accelerometer 12064 (channel 2) | Endevco | 7251A-100 | 50007 |
| Accelerometer DW34 (channel 4) | Endevco | 7250A-10 | 17376 |
| Accelerometer DW35 (channel 5) | Endevco | 7250A-10 | 17377 |
| Accelerometer DW36 (channel 6) | Endevco | 7250A-10 | 17375 |
| Accelerometer 8534 (channel 7) | Wilcoxon Research | TM212S | 50008 |
| Accelerometer 8535 (channel 8) | Wilcoxon Research | TM212S | 50009 |
| Isotron power supply | Endevco | Isotron 2793 | 18221 |
| Shaker power amplifier | Gearing & Watson | DSA4-20K | 17144 |
| Electrodynamic shaker | Gearing & Watson | V2634 | 17145 |
| Shaker head expander | Gearing & Watson | HE-S18 | 17149 |

**Table 57. Test equipment for Vibration test.**

# 4 SUPPLEMENTARY TESTS

## 4.1 Compass safe distance

### 4.1.1 Compass safe distance – Display Unit

| | |
|---|---|
| **Test specimen** | Display Unit |
| **Test specification** | IEC 60945:2002, section 11.2 |
| **Test method** | IEC 61000-4-8:2009 |
| **Comments** | Tested at SP Borås |
| **Temp / Humidity** | 22°C / 30% |
| **Date of measurements** | 2014-12-09 |
| **Test personnel** | Bengt Andersson |

#### 4.1.1.1 Test setup

The test of the compass safe distance was performed on each unit of the EUT. During the test the position of the which gives the most significant compass error position was selected. The safe distance was measured from the closest boundary of the test object to the Nano Tesla probe.

The magnetic normalization is performed in the magnetic main axle of the EUT. The DC magnetization field was 80 A/m with an stabilizing 50 Hz AC magnetic field of 1.43 kA/m.

Rounding up of the measured safe distance is made to the nearest + 5 cm according to the standard.

| Maximum allowed compass deviation | |
|---|---|
| **Standard compass** | **Steering, standby steering and emergency compass** |
| 5.4° corresponding 94 nT magnetic flux density | 18° corresponding 313 nT magnetic flux density |

**Table 58. Maximum allowed compass deviation.**

The measurement procedure for each EUT unit are as the following:

1. Measurement of unpowered EUT in the magnetic condition it was received.
2. Measurement after magnetic normalizing with the EUT unpowered.
3. Measurement of the EUT in powered condition and in normal working mode

**Photo 69. Magnetization in Helmholtz coil.**

#### 4.1.1.2 Test results

**Photo 70. Maximum deviation at virgin, after magnetization and in normal operation mode.**

| Condition of test object | Standard compass (5.4°) [cm] | Steering, standard steering and emergency compass (18°) [cm] |
|---|---|---|
| Unpowered as received | 36 | 22 |
| After magnetization, unpowered | 58 | 34 |
| In powered condition (energized) | 54 | 31 |

**Table 59. Measurements for compass safe distance test.**

| Results | Standard compass (5.4°) [cm] | Steering, standard steering and emergency compass (18°) [cm] |
|---|---|---|
| Minimum compass safe distances after rounding up to nearest 5 cm | 60 ± 5 | 35 ± 5 |

**Table 60. Results for compass safe distance test.**

### 4.1.2 Compass safe distance – Interface Unit

| | |
|---|---|
| **Test specimen** | Interface Unit |
| **Test specification** | IEC 60945:2002, section 11.2 |
| **Test method** | IEC 61000-4-8:2009 |
| **Comments** | Tested at SP Borås |
| **Temp / Humidity** | 22°C / 30% |
| **Date of measurements** | 2014-12-09 |
| **Test personnel** | Bengt Andersson |

#### 4.1.2.1 Test setup

The test of the compass safe distance was performed on each unit of the EUT. During the test the position of the which gives the most significant compass error position was selected. The safe distance was measured from the closest boundary of the test object to the Nano Tesla probe.

The magnetic normalization is performed in the magnetic main axle of the EUT. The DC magnetization field was 80 A/m with an stabilizing 50 Hz AC magnetic field of 1.43 kA/m.

Rounding up of the measured safe distance is made to the nearest + 5 cm according to the standard.

| Maximum allowed compass deviation | |
|---|---|
| **Standard compass** | **Steering, standby steering and emergency compass** |
| 5.4° corresponding 94 nT magnetic flux density | 18° corresponding 313 nT magnetic flux density |

**Table 61. Maximum allowed compass deviation.**

The measurement procedure for each EUT unit are as the following:

4. Measurement of unpowered EUT in the magnetic condition it was received.
5. Measurement after magnetic normalizing with the EUT unpowered.
6. Measurement of the EUT in powered condition and in normal working mode

**Photo 71. Magnetization in Helmholtz coil. (Photo of Power Supply Unit)**

#### 4.1.2.2 Test results


**Photo 72. Maximum deviation at virgin, after magnetization and in normal operation mode.**

| Condition of test object | Standard compass (5.4°) [cm] | Steering, standard steering and emergency compass (18°) [cm] |
|---|---|---|
| Unpowered as received | 73 | 26 |
| After magnetization, unpowered | 114 | 71 |
| In powered condition (energized) | 112 | 72 |

**Table 62. Measurements for compass safe distance test.**

| Results | Standard compass (5.4°) [cm] | Steering, standard steering and emergency compass (18°) [cm] |
|---|---|---|
| Minimum compass safe distances after rounding up to nearest 5 cm | 115 ± 15 | 75 ± 5 |

**Table 63. Results for compass safe distance test.**

### 4.1.3 Compass safe distance – Power Supply Unit

| | |
|---|---|
| **Test specimen** | Power Supply Unit |
| **Test specification** | IEC 60945:2002, section 11.2 |
| **Test method** | IEC 61000-4-8:2009 |
| **Comments** | Tested at SP Borås |
| **Temp / Humidity** | 22°C / 30% |
| **Date of measurements** | 2014-12-09 |
| **Test personnel** | Bengt Andersson |

#### 4.1.3.1 Test setup

The test of the compass safe distance was performed on each unit of the EUT. During the test the position of the which gives the most significant compass error position was selected. The safe distance was measured from the closest boundary of the test object to the Nano Tesla probe.

The magnetic normalization is performed in the magnetic main axle of the EUT. The DC magnetization field was 80 A/m with an stabilizing 50 Hz AC magnetic field of 1.43 kA/m.

Rounding up of the measured safe distance is made to the nearest + 5 cm according to the standard.

| Maximum allowed compass deviation | |
|---|---|
| **Standard compass** | **Steering, standby steering and emergency compass** |
| 5.4° corresponding 94 nT magnetic flux density | 18° corresponding 313 nT magnetic flux density |

**Table 64. Maximum allowed compass deviation.**

The measurement procedure for each EUT unit are as the following:

7. Measurement of unpowered EUT in the magnetic condition it was received.
8. Measurement after magnetic normalizing with the EUT unpowered.
9. Measurement of the EUT in powered condition and in normal working mode

**Photo 73. Magnetization in Helmholtz coil.**

#### 4.1.3.2 Test results

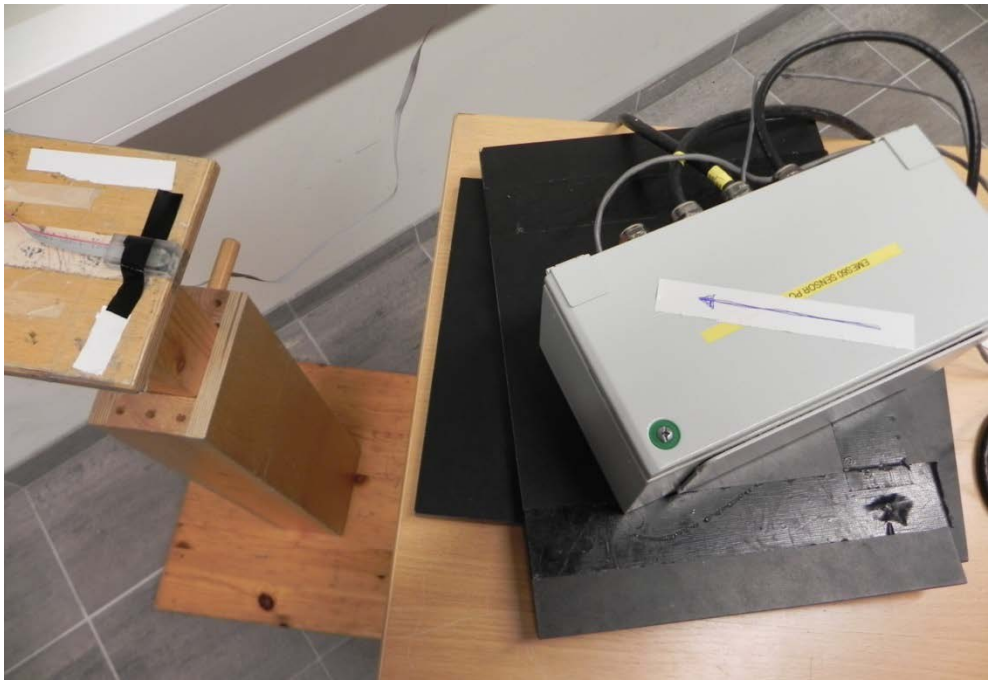


**Photo 74. Maximum deviation at virgin, after magnetization and in normal operation mode.**

| Condition of test object | Standard compass (5.4°) [cm] | Steering, standard steering and emergency compass (18°) [cm] |
|---|---|---|
| **Unpowered as received** | 53 | 26 |
| **After magnetization, unpowered** | 111 | 69 |
| **In powered condition (energized)** | 115 | 67 |

**Table 65. Measurements for compass safe distance test.**

| Results | Standard compass (5.4°) [cm] | Steering, standard steering and emergency compass (18°) [cm] |
|---|---|---|
| **Minimum compass safe distances after rounding up to nearest 5 cm** | 115 ± 10 | 70 ± 5 |

**Table 66. Results for compass safe distance test.**

### 4.1.4 Test equipment

| Measurement equipment | SP number |
|---|---|
| Test site Edison | 504 114 |
| Alpha lab Milligauss meter | 901 494 |
| Hand held compass for magnetic vector analysis | - |
| Helmholtz coil | 901 506 |
| EM Test Netwave | 600 681 |
| Software netwave control v5.1.2.0 | - |
| Temperature and humidity meter Testo 625 | 504 117 |

**Table 67. Test equipment for compass safe distance test.**

## 4.2 Protection against accidental access to dangerous voltages

| | |
|---|---|
| **Test specimen** | Display Unit, Interface Unit, Power Supply Unit, Sensor Unit |
| **Test specification** | IEC 60945:2002, section 12.1 |
| **Test method** | IEC 60529:2001 |
| **Test finger** | Joined test finger: diameter: 12 mm, length: 80 mm |
| **Comments** | None |
| **Date of measurements** | 2015-02-04 |
| **Test personnel** | David Busk |

### 4.2.1 Test setup

According to IEC 60529, table 1, first characteristic numeral 2: protected against access to hazardous parts with a finger.

The test is carried out by inserting the test finger through any openings of the enclosure of the test specimen.

### 4.2.2 Test results

The enclosure of the test specimen has no openings greater than Ø12 mm. Thus it is evident that the test finger cannot penetrate the enclosure and get access to dangerous voltages.

| Test finger | Result |
|---|---|
| Ø12 mm, 80 mm length | PASSED |

**Table 68. Test results for protection against accidental access to dangerous voltages.**

### 4.2.3 Test equipment

| Description | Supplier | Model | Tag no. |
|---|---|---|---|
| Jointed test finger | Shen Zhen Autostrong Ins. co., LTD | AUTO-B | 50053 |

**Table 69. Test equipment for protection against accidental access to dangerous voltages.**

# 5 MEASURING UNCERTAINTIES

Compliancy evaluation is based on a shared risk principle with respect to the measurement uncertainty.

## 5.1 EMC

| *EMC tests* | Frequency [MHz] | Polarization | Expanded Uncertainty [dB] (k=2) |
|---|---|---|---|
| Radiated emission | 30 - 200<br>200 - 3000<br>30 - 200<br>200 - 3000 | Vertical<br>Vertical<br>Horizontal<br>Horizontal | **4.73**<br>**4.97**<br>**4.72**<br>**5.08** |
| Radiated emission (magnetic loop antenna) | 0.15 - 30 | | **3.60** |
| Conducted emission | 0.01 - 30 | | **3.44** |
| Conducted Immunity | | | **2.90** |
| Radiated Immunity | | | **1.92** |
| Electrostatic discharge | Ipeak, ±10 %<br>I at 30 ns, ±30 %<br>I at 60 ns, ±30 % | | |
| Surges, common and differential mode | Voltage Uopen circuit, ±10 %<br>Wave shape, ±20 %<br>Current Uat 50 ohm, ±20 %<br>Source impedance 2 Ohm, ±20 % | | |
| Electrical fast transients/burst | Voltage Uopen circuit, ±10 %<br>Voltage Uat 50 ohm, ±10 %<br>Wave shape 5/50 ns, ±20 %<br>Source impedance Zq, ±20 % | | |

## 5.2 Climatic test

Uncertainty, temperature:

Fluctuation, temporal, in centre of working space: ± 0.5 K

Spatial: ± 2.0 K

Ucertainty, humidity: ± 2.3%RH

## 5.3 Mechanical tests

Uncertainty in acceleration measurement was ± 3.9%.

Uncertainty in frequency measurement 5-100 Hz was ± 0.5 Hz.

Uncertainty in frequency measurement >100 Hz was ± 0.5%.

Measuring uncertainty is evident from SP-METHOD 1606, rev.7.

## 5.4 Supplementary tests

### 5.4.1 Compass safe distance

Measurement and test instrument uncertainties are described in the quality assurance documentation ”SP-QD 10885”. The uncertainties are calculated with a coverage factor k=2 (95% level of confidence). The measurement uncertainties can be found in the table below:

| **Standard** | **Method** | **Uncertainty** |
|---|---|---|
| ISO 964/IEC 61000-4-8 | Distance measurement | ± 15 cm |
| ISO 964/IEC 61000-4-8 | Magnetic DC field | Reading ±20 nT |

# Appendix 1

Dual Marine Interface Test conditions provided by client

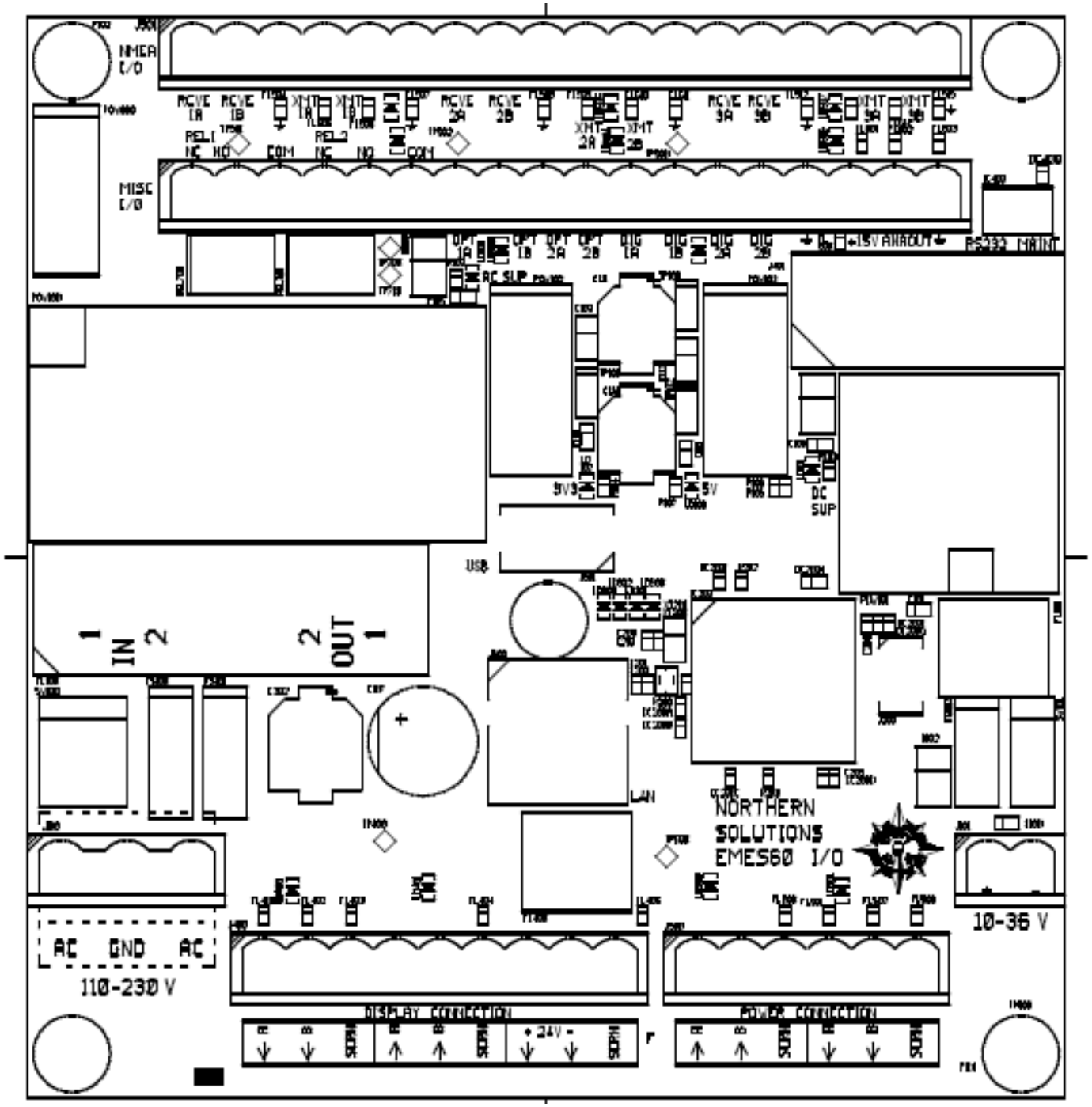
| | |
|---|---|
| Document name: | Dual Marine Interface |
| Document last modified: | 2015-03-22 |
| Document author: | Leonid Boldyrev |
| Number of pages: | 9 |

# Dual Marine Interface

*Revision 22032015*

## Table of Contents

## PCB Layout




## Display

Connect the display units by the display cables to terminals “Display connection”

## Power supply

EMES60 Dual Interface Unit consists of 2 totally identical and independent Interface PCBs.
EMES Interface has 24VDC and 110/220VAC power inputs on each PCB.

## Auxiliary equipment

24VDC linear power supply, 2 channels, Max current 1A@24V each

## Connections

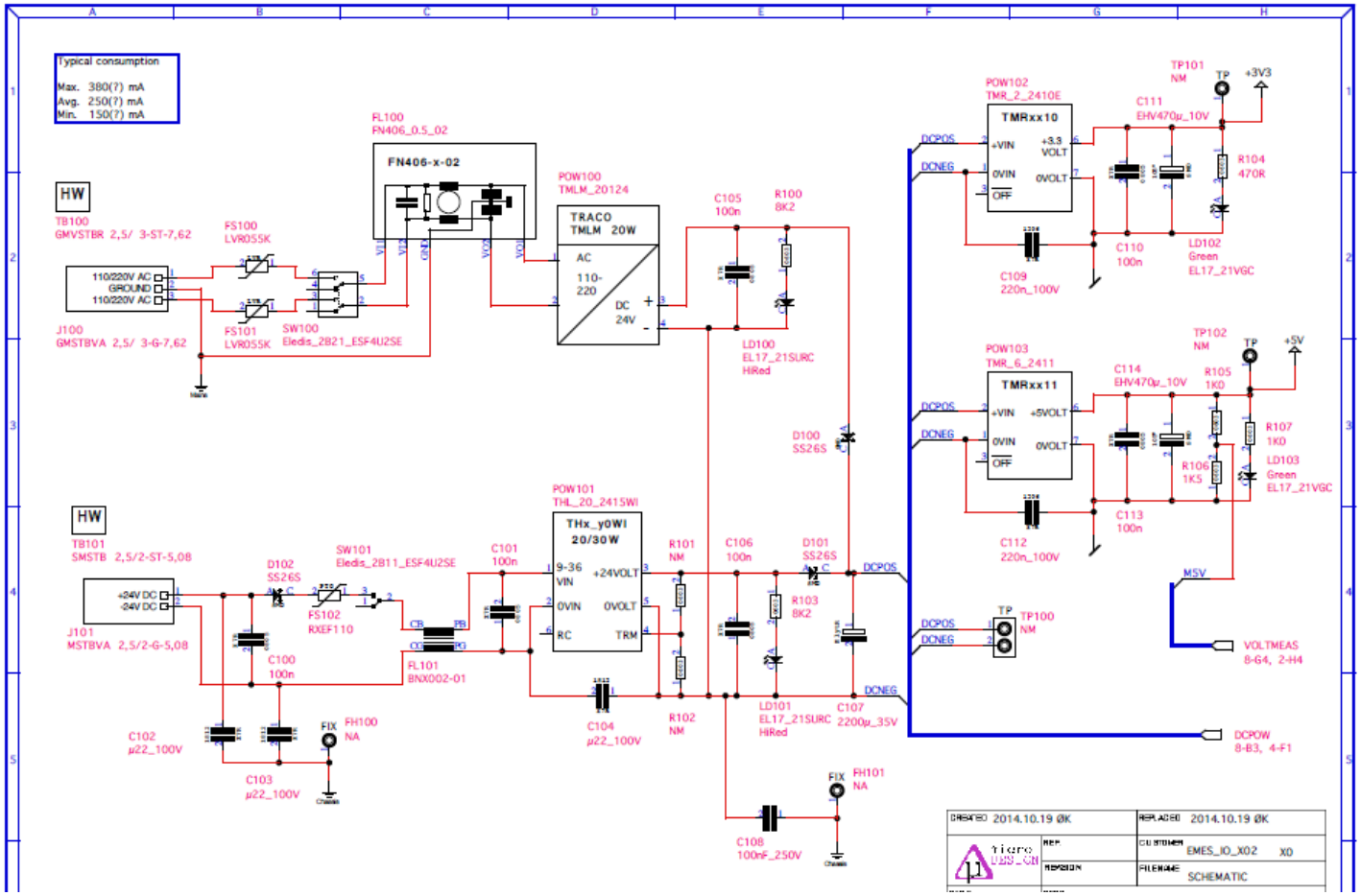
Connect two 3-wires cable to terminals 110/220V AC and ground terminal on both boards. Observe the ground lead. Connect this cable to the mains.

Connect two 2-wires cable to terminals +24VDC (red wire) and -24VDC (black wire). Observe the ground lead. Connect this cable to the lab power supply: red banana plug to plus 24, black banana plug to minus.
All cables are 3m long.

## Verification

Observation
The Interface board and display must start normally; refer to the verification rules below.

## Schematic diagram



# DIG1A/B, DIG2A/B

## Auxiliary equipment

5VDC linear power supply (Power5VDC)

## Connections

Connect the 2-wires cable to DIG1A (red wire) and DIG1B (black wire) input terminals.
Connect Red banana plug to plus, black banana plug to minus of the 5VDC power supply.
Cable length: 10m or 3m, depending on the test requirements.

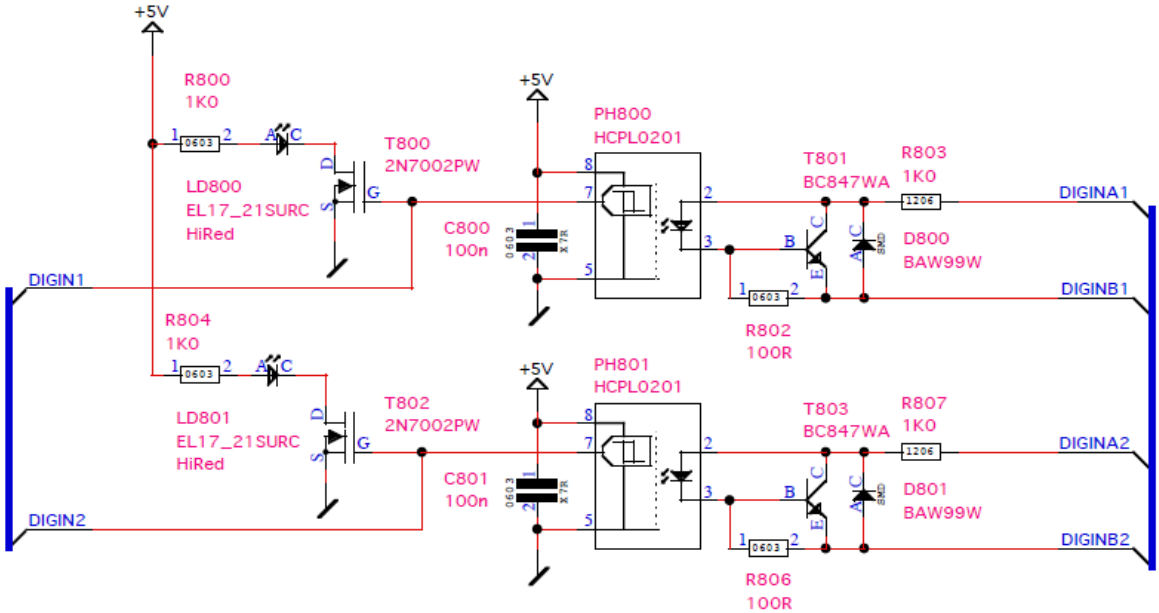
## Verification

Method: observation

State1: Power5VDC off
LD800 (red) off
LD300 (green) off
LD301 (green) off
LD302 (green) on
LD303 (red) on

State2: Power5VDC on
LD800 (red) on
LD300 (green) off
LD301 (green) on
LD302 (green) off
LD303 (red) off

## Schematic diagram



# Relays REL1/REL2

EMES60 has 2 identical electromechanical relays (potential free) on each Interface PCB, indicated as REL1NC/REL1NO/REL1COM and REL2NC/REL2NO/REL2COM. Totally -4 relays in the entire system.

## Auxiliary equipment

Multimeter in continuity test mode

## Connections

Connect the 3-wires cable to REL1NC (red) /REL1NO (black) /REL1COM (transparent)
Cable length: 10m or 3m, depending on the test requirements.
Attach red multimeter probe to transparent wire
During the verification: attach black multimeter probe alternatively to red and black wire – to read the status of the relay contacts NC and NO

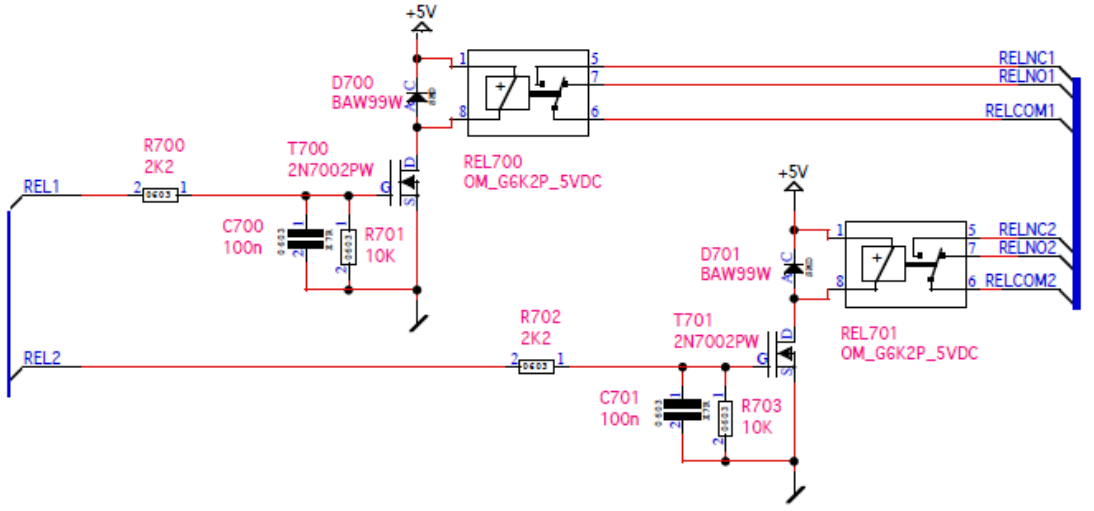
## Verification

Multimeter readouts

State1: Interface board is powered, Power5VDC off
REL1NC (red wire) –> REL1COM (transparent wire) = disconnected
REL1NO (black wire) –> REL1COM (transparent wire) = connected

State2: Interface board is powered, Power5VDC on
REL1NC (red wire) –> REL1COM (transparent wire) = connected
REL1NO (black wire) –> REL1COM (transparent wire) = disconnected

## Schematic diagram



# Optocoupler outputs

## Auxiliary equipment

Multimeter in Voltmeter mode

## Connections

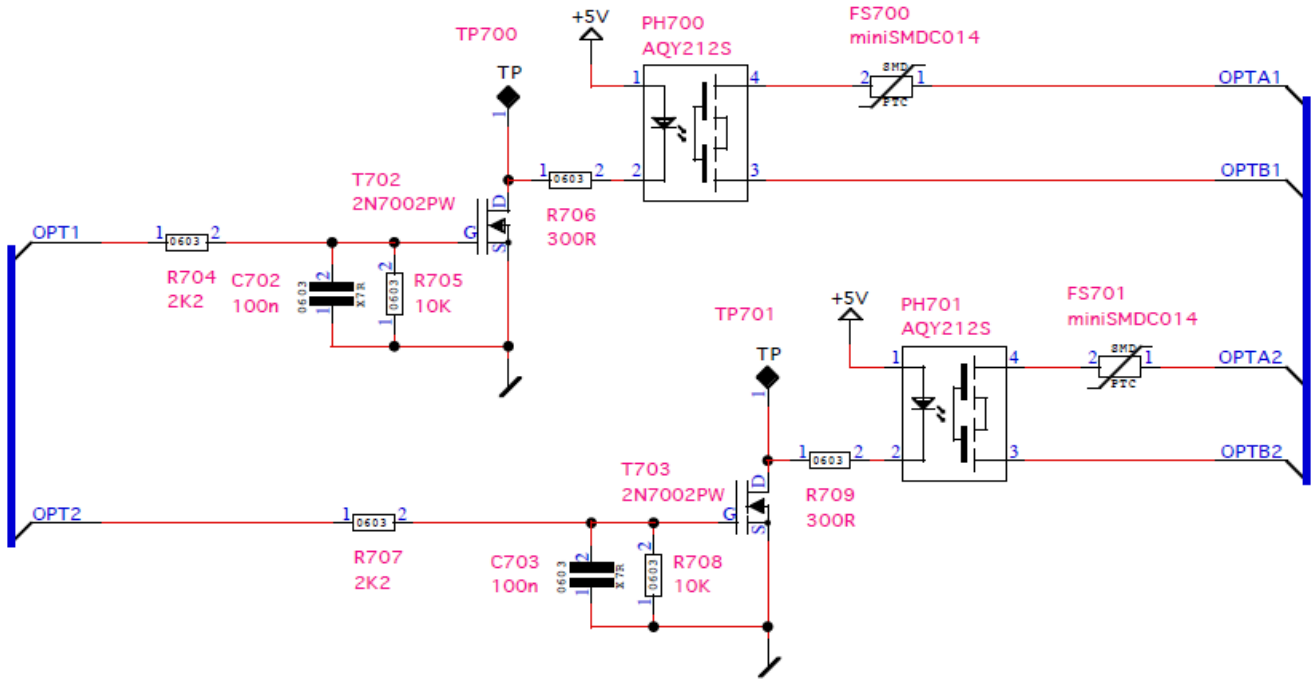
Connect the 2-wires test cable to OPT1A (red wire)/OPT1B (black wire) output terminals.
Attach short piece of wire between terminal +15V and OPT1A.
Attach short piece of wire between terminal ground and OPT1B.
Test cable length: 10m or 3m, depending on the test requirements.
Attach red wire to multimeter plus probe, black wire to minus probe.

## Verification

State1: Interface board is powered, Power5VDC off
Voltmeter readout: Red wire (OPT1A) -> Black wire (OPT1B) 15V

State2: Interface board is powered, Power5VDC on
Voltmeter readout: Red wire (OPT1A) -> Black wire (OPT1B) 0V

## Schematic diagram



## Analog output (programmable between 0-10V/4-20mA)

EMES60 has one analog output on each Interface PCB, indicated as ANAOUT.  Totally the entire system has 2 outputs.

## Auxiliary equipment

Multimeter

## Connections

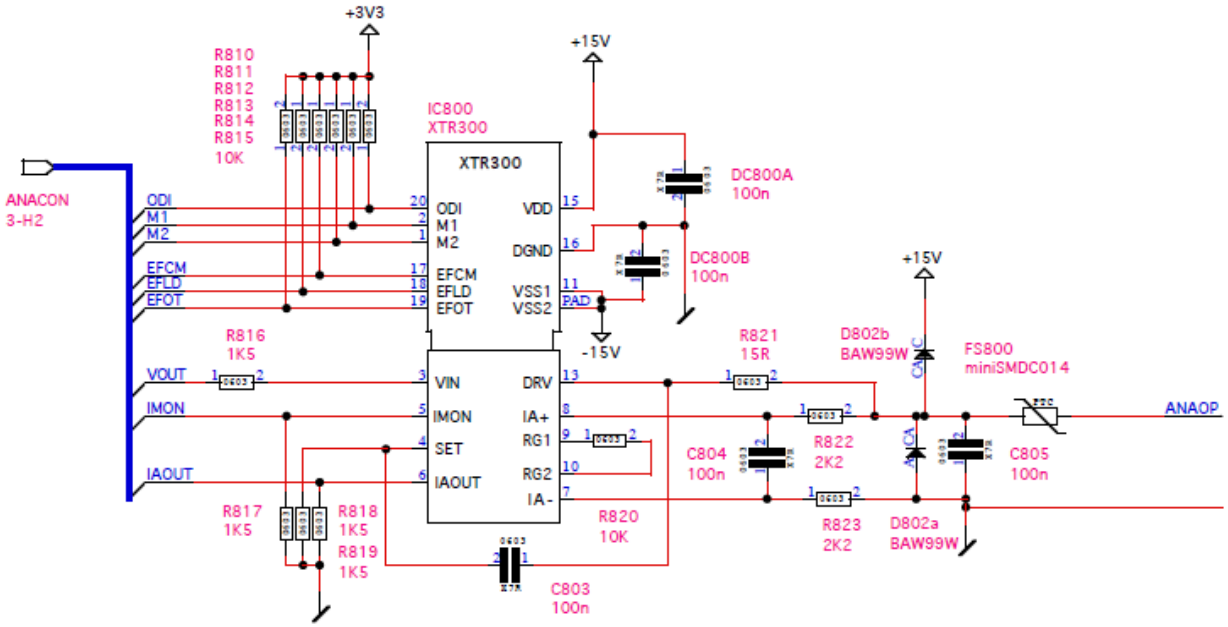
Attach the red wire (with crocodile clip) to the ANAOUT terminal. Attach the black wire to the ground terminal.
Connect the positive multimeter probe to the red wire, negative probe – to the black wire.

## Verification

State1: Interface board is powered, Power5VDC off
Multimeter is in voltage mode. The readout is 5V

State2: Interface board is powered, Power5VDC on
Multimeter is in current mode. The readout is 16mA

## Schematic diagram



# IEC61162-1/2 comptaible input/output

EMES60 has 5 totally identical IEC61162-1/2 compatible serial COM lines on each Interface board.
For each Interface PCB:
1 line dedictaed to communication between the display and the Interface unit
1 line dedictaed to communication between the sensor and the Interface unit
3 lines dedictaed to communication between the Interface unit and external equipment.

Totally the entire EMES60 system has 10 such input/outputs.

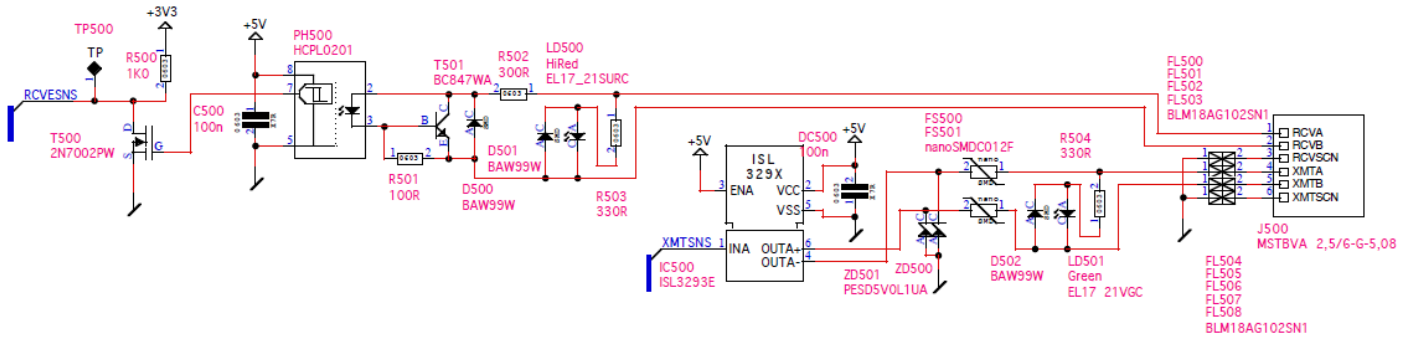
## Connections

During the test the sensor and displays will be connected to the Interface PCBs.
The test setup will provide serial communication between all units.

## Verification

It will be possible to monitor the messages coming from the sensor to the display unit by observing the information displayed on the Display Unit. Continuous update of the echosounding echogram (left side) and speed data (right side) will indicate normal operation of all interfaces (Sensor Unit ->Interface Unit -> Display Unit)

## Schematic diagram



# Appendix 2

Supplemental info for Interface and Power Supply Units provided by client

| | |
|---|---|
| Document name: | EMC Modifications |
| Document last modified: | 2015-04-28 |
| Document author: | Leonid Boldyrev |
| Number of pages: | 2 |

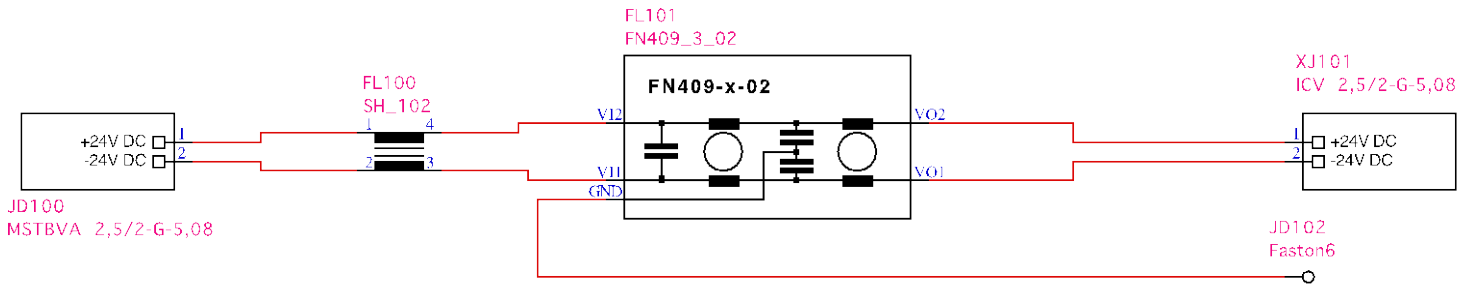
To comply with the EMC requirements, the following changes were made on the DUTs during the tests

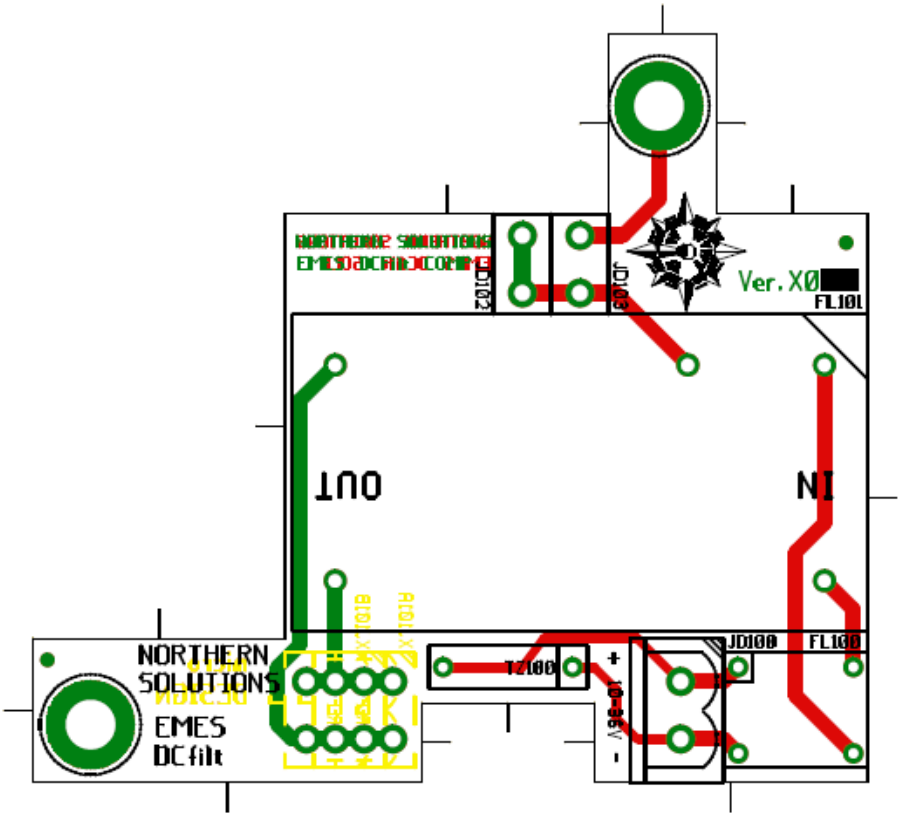
| Test | Date | Interface Unit | Power supply unit |
|---|---|---|---|
| Radiated emission | 2014-11-25 (start of testing) | No change | NEC/TOKIN SH_102 filter on DC Power |
| Conducted emission | 2015-04-28 (end of testing) | Schaffner Type FN409_3_02 on DC Power | NEC/TOKIN SH_102 filter removed from DC power.<br>Schaffner Type FN409_3_02 inserted on DC power.<br>(Only tested with Schaffner in the final) |

The above described modifications will be implemented in the production units in the following way:

- **Interface and Power supply units**

Two filters (ref specifications below) will be mounted on a Daughter Board, EMES_DCFilt, fitted on top of the EMES_IO board and EMES_POW_DIR board. This daughter board plugs into the DC input terminal of EMES_IO J101 with a terminal on the bottom side, XJ101.
On top of the Daughter Board, there is a new terminal, JD100, for the DC supply. There is also a Faston terminal, JD102 to connect System Ground.






FL100 is a NEC/TOKIN SH_102 Common Mode Filter necessary to properly control Radiated Noise.

http://www.nec-tokin.com/english/guide/dc/dc-sh-e.pdf

FL101 is a Schaffner Type FN409_3_02, required to reduce Conducted Noise to a satisfactory level.

http://schaffner.com/en/product-storage/datasheets/fn-409.html

The EMES_IO and EMES_POW_DIR Boards will be revised and re-approved at a later stage with similar components on-board.

For Northern Solutions AS,


Leonid Boldyrev, general manager