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# Test Report

Report Number:

**F152175E1**

Equipment under Test (EUT):

**24 GHz Anti-collision Aid System  
CRAT81**

Applicant:

**ATTINGIMUS Nachrichtentechnik GmbH & Co. KG**

Manufacturer:

**ATTINGIMUS Nachrichtentechnik GmbH & Co. KG**



Deutsche  
Akkreditierungsstelle  
D-PL-17186-01-01  
D-PL-17186-01-02  
D-PL-17186-01-03

## References

- [1] **ANSI C63.10: 2013** American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15 (July 2014)** Radio Frequency Devices
- [3] **RSS-210 Issue 8 (December 2010)** Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment
- [4] **RSS-Gen Issue 4 (November 2014)** General Requirements for Compliance of Radio Apparatus

## TEST RESULT

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test.

The complete test results are presented in the following.

|                      |               |                                                                                      |            |
|----------------------|---------------|--------------------------------------------------------------------------------------|------------|
| Test engineer:       | Thomas KÜHN   |  | 09/07/2015 |
|                      | Name          | Signature                                                                            | Date       |
| Authorized reviewer: | Bernd STEINER |  | 09/07/2015 |
|                      | Name          | Signature                                                                            | Date       |

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# 1 Identification

## 1.1 Applicant

|                                                                |                                             |
|----------------------------------------------------------------|---------------------------------------------|
| Name:                                                          | ATTINGIMUS Nachrichtentechnik GmbH & Co. KG |
| Address:                                                       | Rebenring 31<br>38106 Braunschweig          |
| Country:                                                       | Germany                                     |
| Name for contact purposes:                                     | Dr.-Ing. Wilfried PLAGGE                    |
| Phone:                                                         | +49 531 34 46 - 51                          |
| Fax:                                                           | +49 531 34 46 - 13                          |
| eMail Address:                                                 | wplagge@atingimus.de                        |
| Applicant represented during the test by the following person: | Dr.-Ing. Wilfried PLAGGE                    |

## 1.2 Manufacturer

|                                                                   |                                             |
|-------------------------------------------------------------------|---------------------------------------------|
| Name:                                                             | ATTINGIMUS Nachrichtentechnik GmbH & Co. KG |
| Address:                                                          | Rebenring 31<br>38106 Braunschweig          |
| Country:                                                          | Germany                                     |
| Name for contact purposes:                                        | Dr.-Ing. Wilfried PLAGGE                    |
| Phone:                                                            | +49 531 34 46 - 51                          |
| Fax:                                                              | +49 531 34 46 - 13                          |
| eMail Address:                                                    | wplagge@atingimus.de                        |
| Manufacturer represented during the test by the following person: | Dr.-Ing. Wilfried PLAGGE                    |

## 1.3 Test laboratory

The tests were carried out at: **PHOENIX TESTLAB GmbH**  
**Königswinkel 10**  
**32825 Blomberg**  
**Germany**

accredited by DGA Deutsche Gesellschaft Akkreditierungsstelle GmbH (DAkKS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-02, FCC Test site registration number 90877 and Industry Canada Test site registration IC3469A-1.

#### 1.4 EUT (Equipment Under Test)

|                              |                                  |
|------------------------------|----------------------------------|
| Test object: *               | 24 GHz Anti-collision Aid System |
| Model name / HVIN: *         | CRAT81                           |
| FCC ID: *                    | 2ABU7-CRAT81                     |
| PCB identifier: *            | 11765A-CRAT81                    |
| Serial number: *             | 01.0001                          |
| Hardware version: *          | CRAT81                           |
| Software version: *          | tit81                            |
| Lowest internal frequency: * | 12 MHz                           |

#### 1.5 Technical data of equipment

|                                |                                                                                                                             |                          |                    |                                                              |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------|--------------------------------------------------------------|
| Channel 1                      | RX:                                                                                                                         | 24.075 GHz to 24.175 GHz | TX:                | 24.075 GHz to 24.175 GHz                                     |
| Channel 2                      | RX:                                                                                                                         | -                        | TX:                | -                                                            |
| Duty cycle:*                   | 100 %                                                                                                                       |                          |                    |                                                              |
| Rated RF output power: *       | < +20 dBm (e.i.r.p.)                                                                                                        |                          |                    |                                                              |
| Antenna type:                  | Integral patch antenna                                                                                                      |                          |                    |                                                              |
| Alignment range: *             | 24.075 GHz to 24.175 GHz                                                                                                    |                          |                    |                                                              |
| Switching range: *             | 24.075 GHz to 24.175 GHz                                                                                                    |                          |                    |                                                              |
| Modulation: *                  | FMCW                                                                                                                        |                          |                    |                                                              |
| Bit rate of transmitter: *     | -                                                                                                                           |                          |                    |                                                              |
| Supply Voltage: *              | U <sub>Nom</sub> =                                                                                                          | 24.0 V <sub>DC</sub>     | U <sub>Min</sub> = | 10.0 V <sub>DC</sub> U <sub>Max</sub> = 30.0 V <sub>DC</sub> |
| Power Supply: *                | External                                                                                                                    |                          |                    |                                                              |
| Temperature range: *           | -40 °C to +85 °C                                                                                                            |                          |                    |                                                              |
| Ancillaries to be tested with: | An external power supply type Mini-PS-100-240AC/24DC/1 was used during conducted emission measurement on power supply line. |                          |                    |                                                              |

\*: Declared by the applicant.

#### The following external I/O cables were used:

| Identification                    | Connector          |                 | Length     |
|-----------------------------------|--------------------|-----------------|------------|
|                                   | EUT                | Ancillary       |            |
| Connection cable (DC and outputs) | 4 pole M12 plug    | -               | 2.5 m      |
| Manufacturer (Service) interface  | 4 pole LEMO socket | 5 pole M12 plug | Not used * |
| -                                 | -                  | -               | -          |

\*: As declared by the applicant, this interface is used during manufacturing only.

#### 1.6 Dates

|                                 |             |
|---------------------------------|-------------|
| Date of receipt of test sample: | 18 May 2015 |
| Start of test:                  | 18 May 2015 |
| End of test:                    | 20 May 2015 |

## 2 Operational states

All tests were carried out with an unmodified sample with integral antenna.

All measurements were carried out with the EUT supplied with 24.0 V<sub>DC</sub>, because pre-tests have shown that there is no noticeable difference of the output signal with respect to the supply voltage.

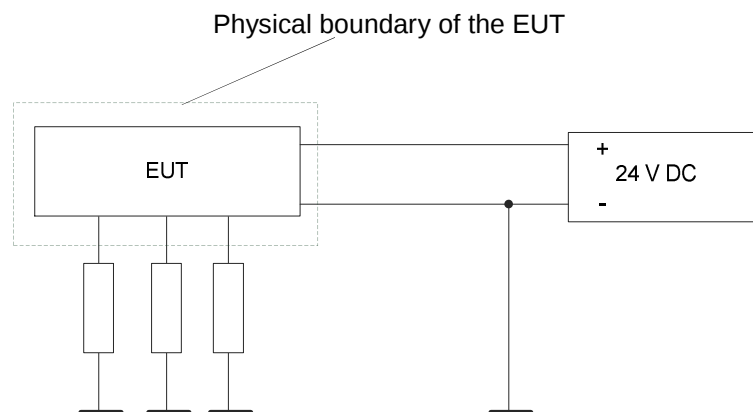
The EUT is an Anti-collision Aid System, which is intended to be used on container gantries. Because the final position of the EUT on the container gantry is unknown, the measurements were carried out in three orthogonal directions of the EUT. These positions were defined as follows:  
 Position 1: Antenna patch shows to the measuring antenna, EUT standing, connector shows downwards.  
 Position 2: Antenna patch shows upwards to the ceiling.  
 Position 3: Antenna patch shows to the measuring antenna, EUT standing, connector shows sideways.  
 For details of these positions refer also the photographs in annex A of this test report.

No tests in stand-by mode of the transmitter / receive mode were carried out, because the transmitter is operating continuously and has no stand-by mode.

The EUT has three open collector outputs, which were terminated with 1 k $\Omega$  during all tests.

For the whole frequency range a preliminary measurement in a fully anechoic chamber was carried out to determine the frequencies, which were radiated by the EUT. The final measurements on the detected frequencies were carried out on an outdoor test site without ground plane (for the frequency range 9 kHz to 30 MHz), on an open area test site with ground plane (for the frequency range 30 MHz to 1 GHz) or the fully anechoic chamber (for the frequency range 1 GHz to 110 GHz).

The physical boundaries of the Equipment Under Test are shown below.



### 3 Additional Information

The EUT used for the tests was not labeled.

### 4 Overview

| Application                              | Frequency range             | FCC 47 CFR<br>Part 15 section<br>[2]         | RSS-210, issue 8<br>[3]; RSS-Gen,<br>issue 4 [4] | Status  | Refer page |
|------------------------------------------|-----------------------------|----------------------------------------------|--------------------------------------------------|---------|------------|
| 20 dB / 99 %<br>bandwidth                | 24.075 GHz to<br>24.175 GHz | 15.215 (c)                                   | 6.6 [4]                                          | Passed  | 8 et seq.  |
| Band edge<br>compliance                  | 24.075 GHz to<br>24.175 GHz | 15.215 (c)                                   | 2.5 [4]                                          | Passed  | 10 et seq. |
| Field strength of<br>fundamental         | 24.075 GHz to<br>24.175 GHz | 15.245 (b)                                   | Annex 7 [3]                                      | Passed  | 14 et seq. |
| Field strength of<br>harmonics           | Restricted bands            | 15.245 (b) (1) (ii),<br>15.245 (b) (1) (iii) | Annex 7 [3]                                      | Passed  | 14 et seq. |
| Emissions outside<br>the specified bands | 9 kHz to<br>110 GHz         | 15.205 (a),<br>15.209 (a),<br>15.245 (3)     | Annex 7 (1) [3],<br>8.9 [4], 8.10 [4]            | Passed  | 14 et seq. |
| Conducted<br>emissions                   | 150 kHz to<br>30 MHz        | 15.207                                       | 8.8 [4]                                          | Passed  | 29 et seq. |
| Antenna<br>requirement                   | -                           | 15.203 [2]                                   | -                                                | Passed* | -          |

\*: Integrated antenna only, requirement fulfilled.

## 5 Test results

### 5.1 Bandwidth

#### 5.1.1 Method of measurement (bandwidth)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed or a test fixture shall be used. The EUT has to be switched on, the transmitter shall work with its maximum data rate.

The following spectrum analyser settings according to [1] shall be used:

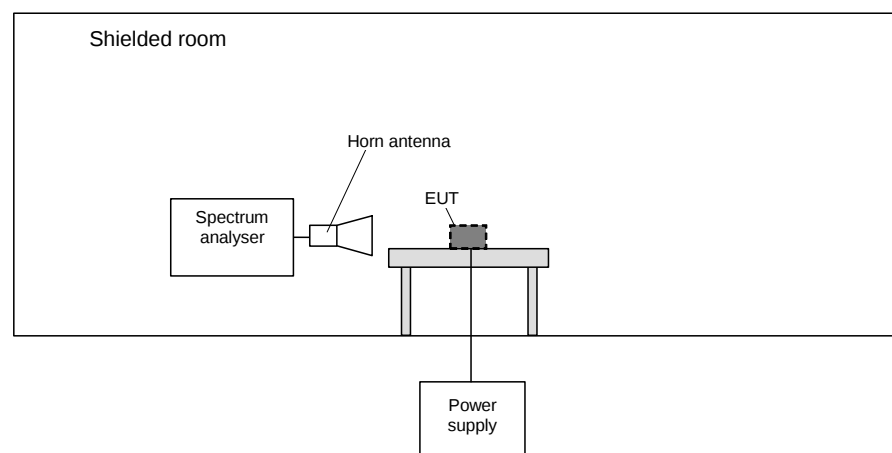
- Span: App. 2 to 5 times the 20 dB bandwidth, centred on the actual channel.
- Resolution bandwidth: 1 to 5 % of the occupied bandwidth.
- Video bandwidth: App. three times the resolution bandwidth.
- Sweep: Auto.
- Detector function: peak.
- Trace mode: Max hold.

#### 20 dB bandwidth:

After trace stabilisation the marker shall be set on the signal peak. The first display line has to be set on this value. The second display line has to be set 20 dB below the first line (or the peak marker). The frequency lines shall be set on the intersection points between the second display line and the measured curve.

#### 99 % bandwidth:

After trace stabilisation the marker shall be set on the signal peak. The power measurement function of the spectrum analyser has to be used to determine the 99 % bandwidth.



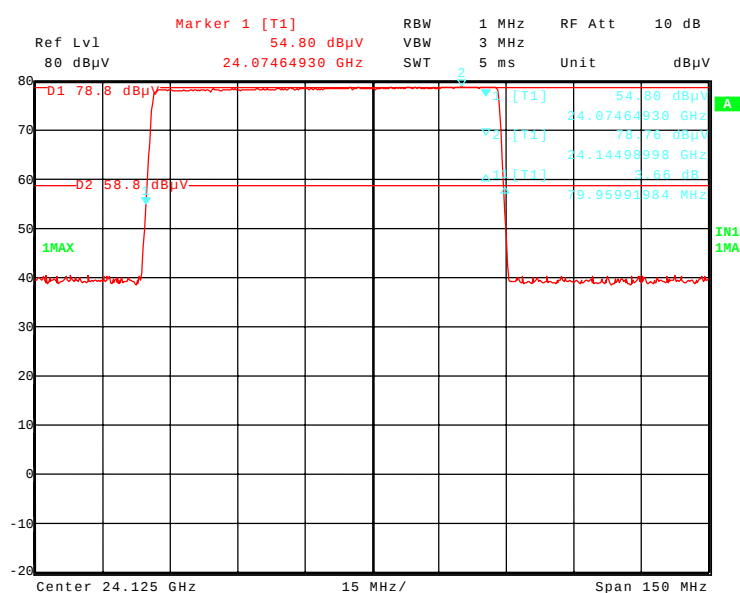
### 5.1.2 Test results (20 dB bandwidth)

|                     |       |                   |      |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 38 % |
|---------------------|-------|-------------------|------|

Position of EUT: The EUT was setup 30 cm in front of the measuring antenna

Supply voltage: During all measurements the EUT was supplied by an external 24 V<sub>DC</sub>-Power-Supply.

152175\_9.wmf: 20 dB bandwidth:



| $F_L$                   | $F_U$         | BW ( $F_U - F_L$ )      |
|-------------------------|---------------|-------------------------|
| 24.074649 GHz           | 24.154609 GHz | 79.960 MHz              |
| Measurement uncertainty |               | $< \pm 1 \cdot 10^{-7}$ |

Test: Passed

Test equipment used (see chapter 6):

29, 31, 52, 149, 165, 176

### 5.1.3 Test results (99 % bandwidth)

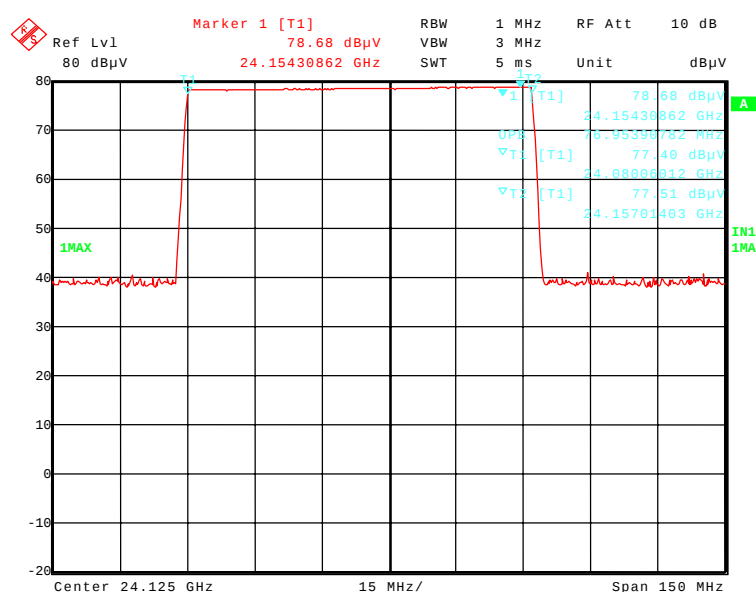
|                     |       |
|---------------------|-------|
| Ambient temperature | 21 °C |
|---------------------|-------|

|                   |      |
|-------------------|------|
| Relative humidity | 38 % |
|-------------------|------|

Position of EUT: The EUT was setup 30 cm in front of the measuring antenna

Supply voltage: During all measurements the EUT was supplied by an external 24 V<sub>DC</sub>-Power-Supply.

152175\_10.wmf: 99 % bandwidth:



| $F_L$                   | $F_U$         | BW ( $F_U - F_L$ )      |
|-------------------------|---------------|-------------------------|
| 24.080060 GHz           | 24.157014 GHz | 76.954 MHz              |
| Measurement uncertainty |               | $< \pm 1 \cdot 10^{-7}$ |

Test: Passed

Test equipment used (see chapter 6):

29, 31, 52, 149, 165, 176

## **5.2 Band-edge compliance**

### **5.2.1 Method of measurement (band-edge compliance)**

The same test setup as used for the final radiated emission measurement shall be used.  
The measurements shall be carried out with using a resolution bandwidth of 100 kHz.

The following spectrum analyser settings shall be used:

- Span: Wide enough to capture the peak level of the emission on the channel closest to the band-edge, as well as any modulation products, which fall outside the assigned frequency band.
- Resolution bandwidth: 100 kHz.
- Video bandwidth:  $\geq$  the resolution bandwidth.
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

After trace stabilisation the marker shall be set on the signal peak. The frequency line shall be set on the edge of the assigned frequency band. Set the second marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is higher than that at the band-edge. This frequency shall be measured with the EMI receiver as described in subclause 5.2.1 of this test report, but 100 kHz resolution bandwidth shall be used.

The measurement will be performed at the lower and upper end of the assigned frequency band.



The plots on the page before are showing the band-edge compliance for the lower and upper band-edge. The frequency line 1 (F1) shows the edge of the assigned frequency.

| Band-edge compliance (lower band edge)     |                        |                                |              |                        |                          |              |                     |                                   |                |
|--------------------------------------------|------------------------|--------------------------------|--------------|------------------------|--------------------------|--------------|---------------------|-----------------------------------|----------------|
| Result measured with the peak detector:    |                        |                                |              |                        |                          |              |                     |                                   |                |
| Frequency<br>GHz                           | Result<br>dB $\mu$ V/m | Limit<br>(3 m)<br>dB $\mu$ V/m | Margin<br>dB | Readings<br>dB $\mu$ V | Antenna<br>factor<br>1/m | Preamp<br>dB | Cable<br>loss<br>dB | Corr. factor from<br>3 m to 30 cm | Restr.<br>Band |
| 24.125000                                  | 115.8                  | 148.0                          | 32.2         | 94.0                   | 37.2                     | 0.0          | 4.6                 | 20.0 dB                           | Carrier        |
| 23.840480                                  | 44.8                   | 74.0                           | 29.2         | 22.9                   | 37.2                     | 0.0          | 4.7                 | 20.0 dB                           | Yes            |
| Result measured with the average detector: |                        |                                |              |                        |                          |              |                     |                                   |                |
| Frequency<br>GHz                           | Result<br>dB $\mu$ V/m | Limit<br>(3 m)<br>dB $\mu$ V/m | Margin<br>dB | Readings<br>dB $\mu$ V | Antenna<br>factor<br>1/m | Preamp<br>dB | Cable<br>loss<br>dB | Corr. factor from<br>3 m to 30 cm | Restr.<br>Band |
| 24.125000                                  | 78.4                   | 128.0                          | 49.6         | 56.6                   | 37.2                     | 0.0          | 4.6                 | 20.0 dB                           | Carrier        |
| 23.840480                                  | 24.0                   | 54.0                           | 30.0         | 2.1                    | 37.2                     | 0.0          | 4.7                 | 20.0 dB                           | Hor.           |
| Measurement uncertainty                    |                        |                                |              |                        |                          |              | -3.6 dB / +2.2 dB   |                                   |                |

| Band-edge compliance (upper band edge)     |                        |                                |              |                        |                          |              |                     |                                   |                |
|--------------------------------------------|------------------------|--------------------------------|--------------|------------------------|--------------------------|--------------|---------------------|-----------------------------------|----------------|
| Result measured with the peak detector:    |                        |                                |              |                        |                          |              |                     |                                   |                |
| Frequency<br>GHz                           | Result<br>dB $\mu$ V/m | Limit<br>(3 m)<br>dB $\mu$ V/m | Margin<br>dB | Readings<br>dB $\mu$ V | Antenna<br>factor<br>1/m | Preamp<br>dB | Cable<br>loss<br>dB | Corr. factor from<br>3 m to 30 cm | Restr.<br>Band |
| 24.125000                                  | 115.8                  | 148.0                          | 32.2         | 94.0                   | 37.2                     | 0.0          | 4.6                 | 20.0 dB                           | Carrier        |
| 24.175451                                  | 43.6                   | 98.0                           | 54.4         | 21.5                   | 37.2                     | 0.0          | 4.9                 | 20.0 dB                           | No             |
| Result measured with the average detector: |                        |                                |              |                        |                          |              |                     |                                   |                |
| Frequency<br>GHz                           | Result<br>dB $\mu$ V/m | Limit<br>(3 m)<br>dB $\mu$ V/m | Margin<br>dB | Readings<br>dB $\mu$ V | Antenna<br>factor<br>1/m | Preamp<br>dB | Cable<br>loss<br>dB | Corr. factor from<br>3 m to 30 cm | Restr.<br>Band |
| 24.125000                                  | 78.4                   | 128                            | 49.6         | 56.6                   | 37.2                     | 0.0          | 4.6                 | 20.0 dB                           | Carrier        |
| 24.175451                                  | 22.8                   | 88.0                           | 65.2         | 0.7                    | 37.2                     | 0.0          | 4.9                 | 20.0 dB                           | No             |
| Measurement uncertainty                    |                        |                                |              |                        |                          |              | -3.6 dB / +2.2 dB   |                                   |                |

Test: Passed

Test equipment used (see chapter 6):

29, 31, 52, 49, 165, 176

## 5.3 Radiated emissions

### 5.3.1 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into 5 stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 1 GHz.
- A final measurement carried out on an outdoor test side without reflecting ground plane and a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A final measurement carried out on an open area test side with reflecting ground plane and various antenna heights in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a variable antenna distance and height in the frequency range 1 GHz to 110 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 110 GHz.

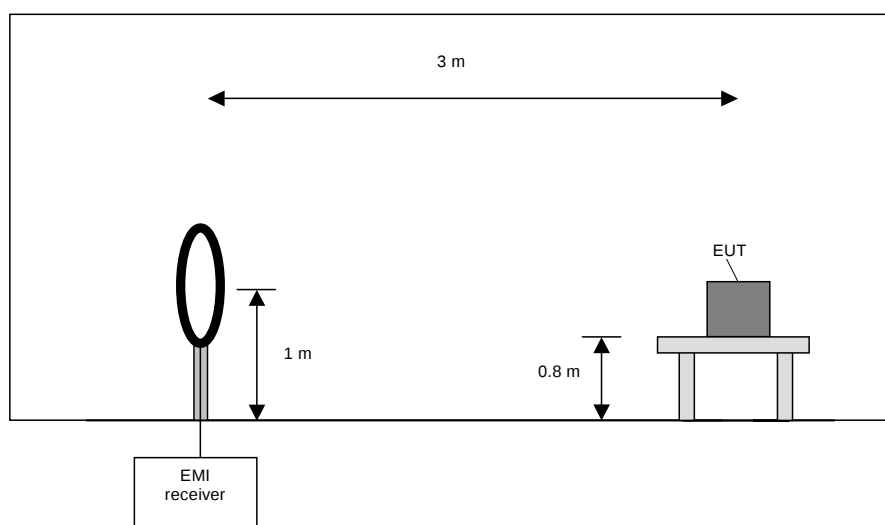
#### Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of 3 meters. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The setup of the Equipment under test will be in accordance to [1].

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyser while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The EMI Receiver will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to found the maximum emissions.

The resolution bandwidth of the spectrum analyser will be set to the following values:

| Frequency range   | Resolution bandwidth |
|-------------------|----------------------|
| 9 kHz to 150 kHz  | 200 Hz               |
| 150 kHz to 30 MHz | 10 kHz               |



#### Preliminary measurement procedure:

Prescans were performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

The following procedure will be used:

- 1) Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
- 2) Manipulate the system cables within the range to produce the maximum level of emission.
- 3) Rotate the EUT by 360 ° to maximize the detected signals.
- 4) Make a hardcopy of the spectrum.
- 5) Measure the frequencies of highest detected emission with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
- 6) Repeat steps 1) to 5) with the other orthogonal axes of the EUT (only if the EUT is a module or is used in a handheld application).
- 7) Rotate the measuring antenna and repeat steps 1) to 5).

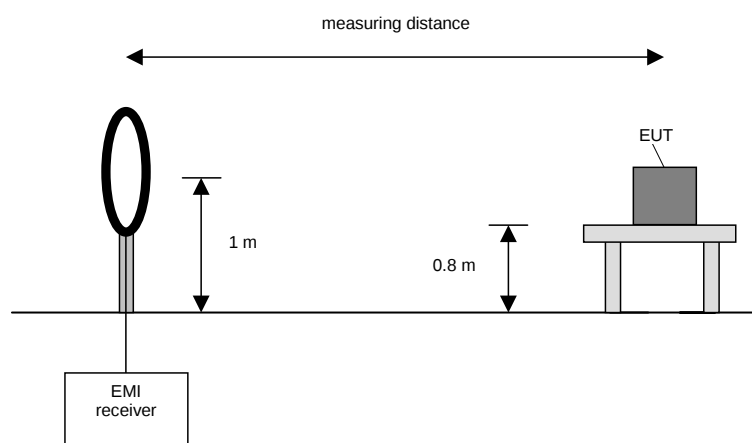
#### **Final measurement (9 kHz to 30 MHz):**

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m whichever is appropriate. In the case where larger measuring distances were required the results will be extrapolated based on the values measured on the closer distances according to [2]. The final measurement will be performed with a EMI Receiver set to Quasi Peak detector except for the frequency bands 30 kHz to 90 kHz and 110 kHz to 490 kHz where an average detector will be used according to [2].

On the during the preliminary measurement detected frequencies the final measurement will be performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum value is found.

The resolution bandwidth of the EMI Receiver will be set to the following values:

| Frequency range   | Resolution bandwidth |
|-------------------|----------------------|
| 9 kHz to 150 kHz  | 200 Hz               |
| 150 kHz to 30 MHz | 9 kHz                |



#### Final measurement procedure:

The following procedure will be used:

- 1) Monitor the frequency range with the measuring antenna at vertical orientation parallel to the EUT at an azimuth of 0 °.
- 2) Rotate the EUT by 360 ° to maximize the detected signals and note the azimuth and orientation.
- 3) Rotate the measuring antenna to find the maximum and note the value.
- 4) Rotate the measuring antenna and repeat steps 1) to 3) until the maximum value is found.
- 5) Repeat steps 1) to 4) with the other orthogonal axes of the EUT (only if the EUT is a module or is used in a handheld application).

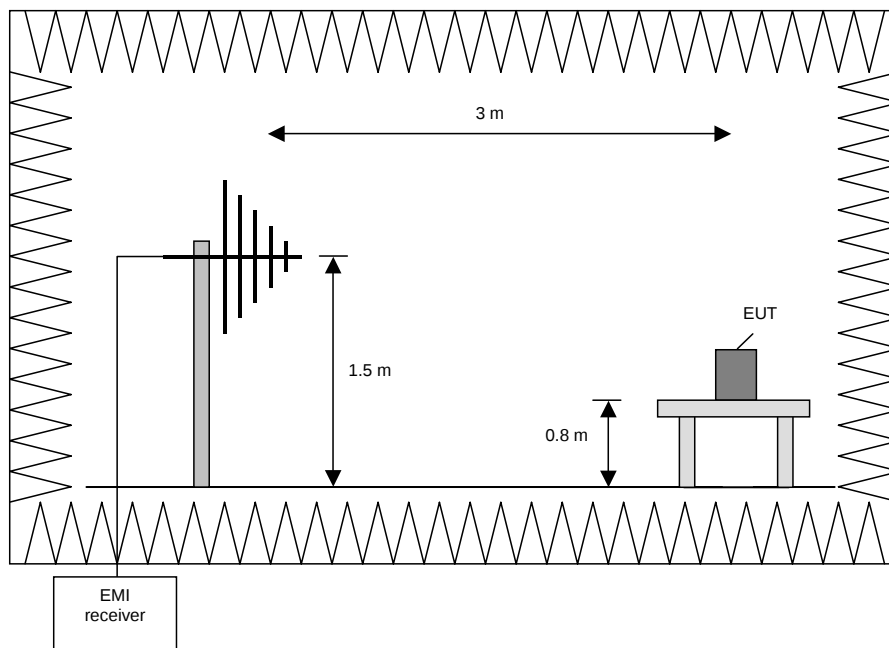
#### Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. Table top devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The setup of the Equipment under test will be in accordance to [1].

The frequency range 30 MHz to 1 GHz will be measured with an EMI Receiver set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °.

The resolution bandwidth of the EMI Receiver will be set to the following values:

| Frequency range   | Resolution bandwidth |
|-------------------|----------------------|
| 30 MHz to 230 MHz | 100 kHz              |
| 230 MHz to 1 GHz  | 100 kHz              |



#### Procedure preliminary measurement:

Prescans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz.

The following procedure will be used:

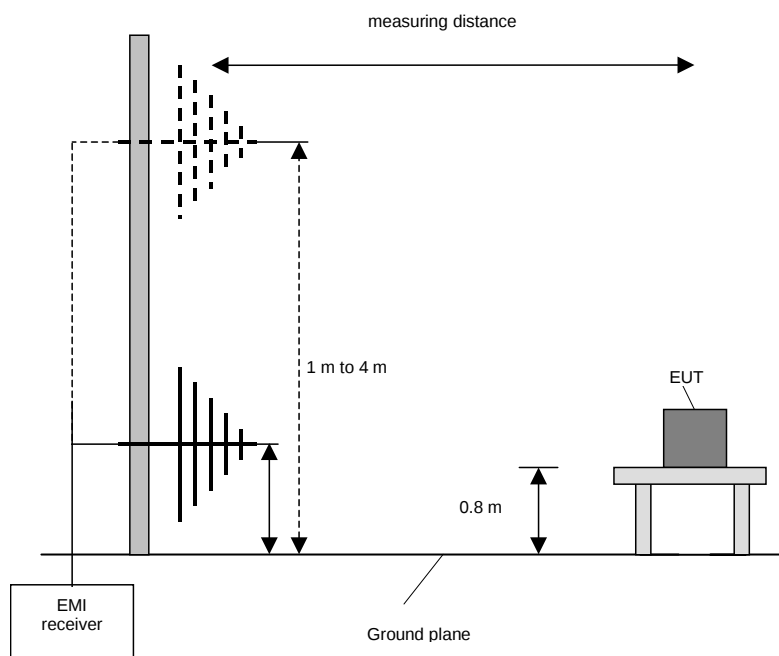
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Make a hardcopy of the spectrum.
5. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
6. Repeat 1) to 4) with the other orthogonal axes of the EUT (only if the EUT is a module or is used in a handheld application).
7. Repeat 1) to 5) with the vertical polarisation of the measuring antenna.

#### Final measurement (30 MHz to 1 GHz)

A final measurement on an open area test site will be performed on selected frequencies found in the preliminary measurement. During this test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarisation and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI Receiver will be set to the following values:

| Frequency range | Resolution bandwidth |
|-----------------|----------------------|
| 30 MHz to 1 GHz | 120 kHz              |



#### Procedure final measurement:

The following procedure will be used:

- 1) Measure on the selected frequencies at an antenna height of 1 m and a EUT azimuth of 23 °.
- 2) Move the antenna from 1 m to 4 m and note the maximum value at each frequency.
- 3) Rotate the EUT by 45 ° and repeat 2) until an azimuth of 337 ° is reached.
- 4) Repeat 1) to 3) for the other orthogonal antenna polarization.
- 5) Move the antenna and the turntable to the position where the maximum value is detected.
- 6) Measure while moving the antenna slowly +/- 1 m.
- 7) Set the antenna to the position where the maximum value is found.
- 8) Measure while moving the turntable +/- 45 °.
- 9) Set the turntable to the azimuth where the maximum value is found.
- 10) Measure with Final detector (QP and AV) and note the value.
- 11) Repeat 5) to 10) for each frequency.
- 12) Repeat 1) to 11) for each orthogonal axes of the EUT (only if the EUT is a module or is used in a handheld application).

#### **Preliminary and final measurement (1 GHz to 110 GHz)**

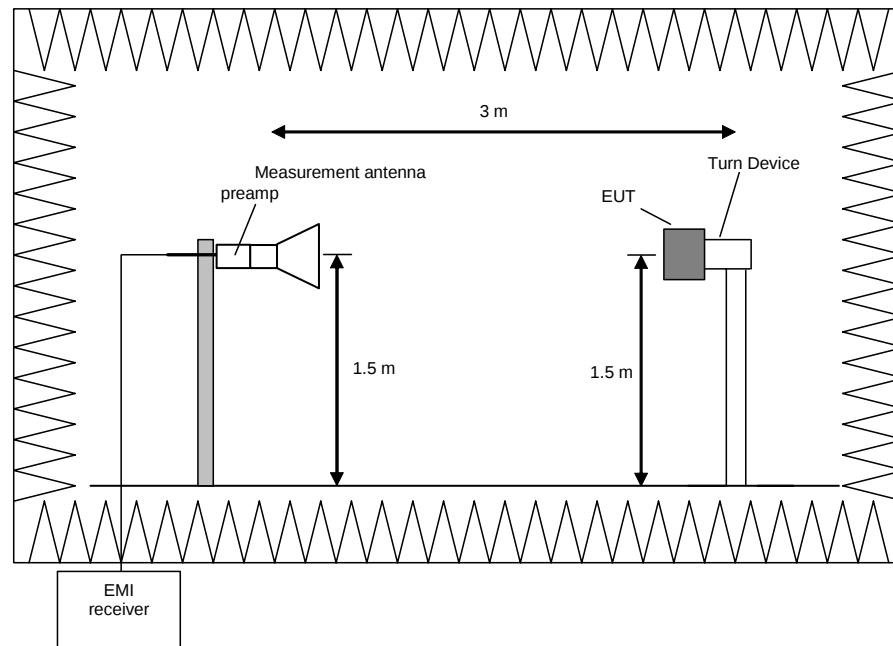
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5 m. The set-up of the Equipment under test will be in accordance to [1].

#### **Preliminary measurement (1 GHz to 40 GHz)**

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The spectrum analyser set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °. This measurement is repeated after raising the EUT in 30 ° steps according 6.6.5.4 in [1].

The resolution bandwidth of the EMI Receiver will be set to the following values:

| Frequency range    | Resolution bandwidth |
|--------------------|----------------------|
| 1 GHz to 4 GHz     | 100 kHz              |
| 4 GHz to 12 GHz    | 100 kHz              |
| 12 GHz to 18 GHz   | 100 kHz              |
| 18 GHz to 26.5 GHz | 100 kHz              |
| 26.5 GHz to 40 GHz | 100 kHz              |
| 40 GHz to 60 GHz   | 100 kHz              |
| 50 GHz to 75 GHz   | 100 kHz              |
| 75 GHz to 110 GHz  | 100 kHz              |



#### Procedure preliminary measurement:

Prescans were performed in the frequency range 1 to 40 GHz.

The following procedure will be used:

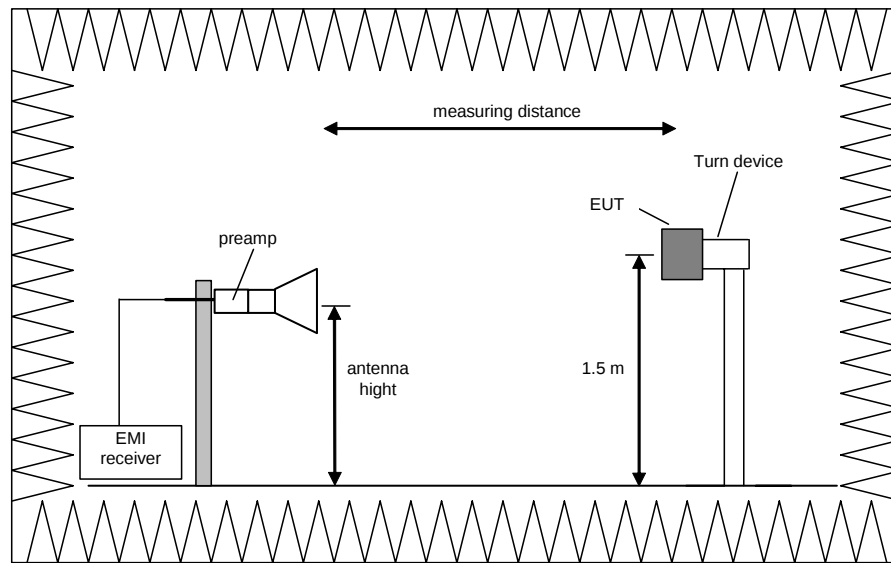
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
6. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
7. The measurement antenna polarisation, with the according EUT position (Turntable and Turn device) which produces the highest emission for each frequency will be used for the final measurement. The six closest values to the applicable limit will be used for the final measurement.

#### Final measurement (1 GHz to 110 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed by rotating the turntable through 0 to 360° in the worst-case EUT orientation which was obtained during the preliminary measurements.

The resolution bandwidth of the EMI Receiver will be set to the following values:

| Frequency range    | Resolution bandwidth |
|--------------------|----------------------|
| 1 GHz to 4 GHz     | 1 MHz                |
| 4 GHz to 12 GHz    | 1 MHz                |
| 12 GHz to 18 GHz   | 1 MHz                |
| 18 GHz to 26.5 GHz | 1 MHz                |
| 26.5 GHz to 40 GHz | 1 MHz                |
| 40 GHz to 60 GHz   | 1 MHz                |
| 50 GHz to 75 GHz   | 1 MHz                |
| 75 GHz to 110 GHz  | 1 MHz                |



Procedure of measurement:

The measurements were performed in the frequency range 1 GHz to 110 GHz.

The following procedure will be used:

- 1) Set the turntable and the turn device to obtain the worst-case emission for the first frequency identified in the preliminary measurements.
- 2) Set the measurement antenna polarisation to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
- 3) Set the spectrum analyser to EMI mode with peak and average detector activated.
- 4) Rotate the turntable from 0° to 360° to find the EUT angle that produces the highest emissions.
- 5) Note the highest displayed peak and average values
- 6) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.

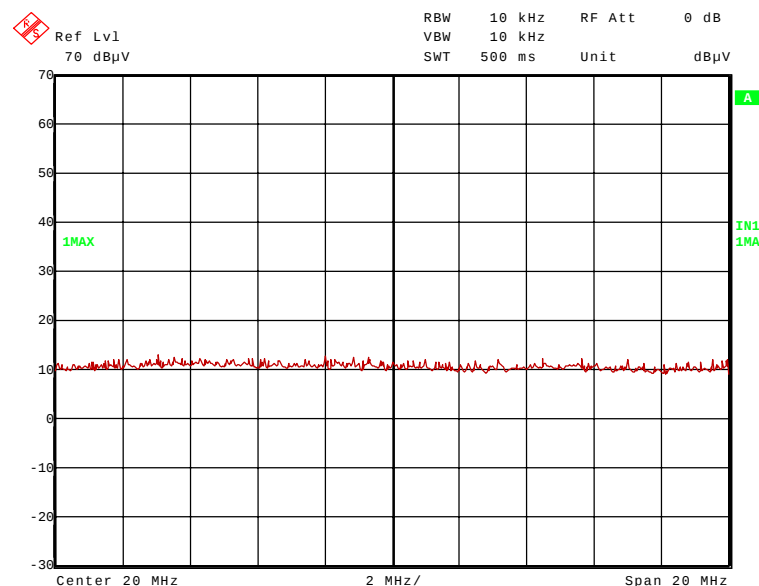
## 5.3.2 Test results (radiated emissions)

### 5.3.2.1 Preliminary radiated emission measurement

|                     |       |                   |      |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 38 % |
|---------------------|-------|-------------------|------|

|                     |                                                                                                                                      |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| Position of EUT:    | The EUT was setup on a non-conducting table of a height of 0.8 m. The distance between EUT and the antenna was 3 m (9 kHz to 1 GHz). |
| Cable guide:        | For further information refer to the pictures in annex A of this test report.                                                        |
| Test record:        | The test was carried out in normal operation mode of the EUT.                                                                        |
| Supply voltage:     | The EUT was supplied by an external 24.0 V <sub>DC</sub> -Power Supply.                                                              |
| Frequency range:    | The preliminary measurement was carried out in the frequency range 10 MHz to 110 GHz according to [2].                               |
| Measuring distance: | 10 MHz to 30 MHz: 3 m<br>30 MHz to 18 GHz and 26.5 to 40 GHz: 3 m<br>18 GHz to 26.5 GHz: 30 cm<br>40 GHz to 110 GHz: 30 cm           |

#### 152175\_1.wmf: Radiated emissions from 10 MHz to 30 MHz:

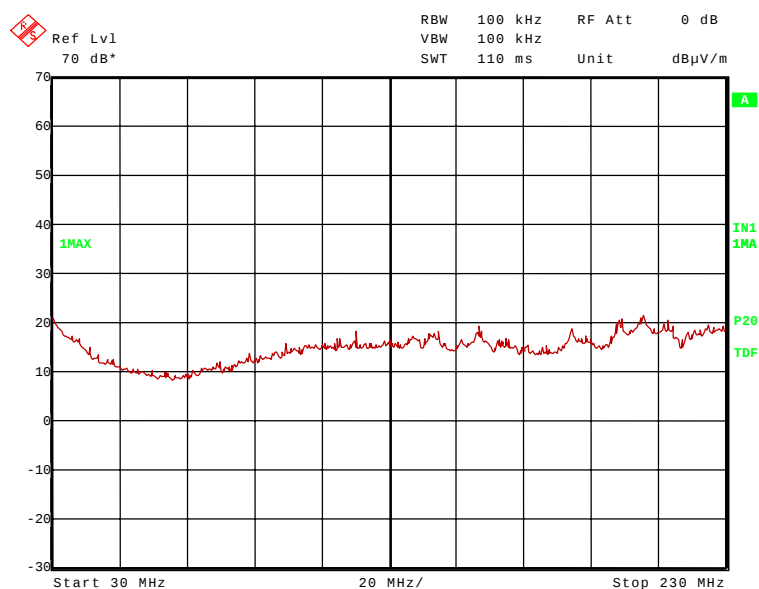


No significant emissions above the noise floor of the measuring system found, so no measurements on the outdoor test site were carried out.

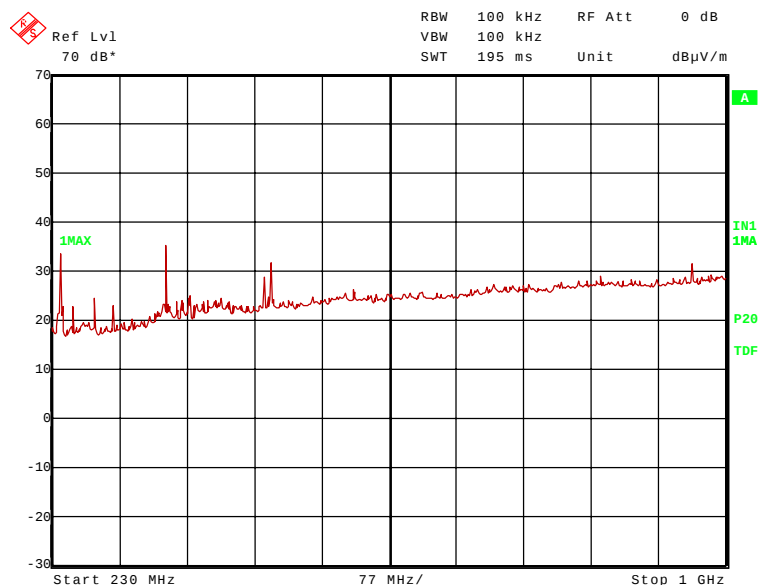
Test equipment used (see chapter 6):

29, 31 - 37, 43 - 45, 49, 52, 55, 146, 149, 150, 153 - 155, 159, 161, 165, 176

152175\_2.wmf: Radiated emissions from 30 MHz to 230 MHz:



152175\_3.wmf: Radiated emissions from 230 MHz to 1000 MHz:



The following frequencies were found outside the restricted bands during the preliminary radiated emission measurement:

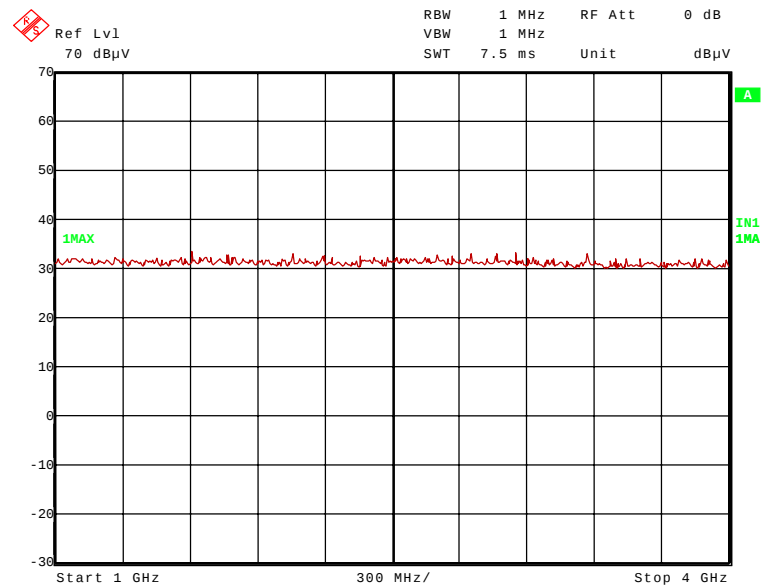
- 157.898 MHz, 203.549 MHz, 360.033 MHz and 480.044 MHz.

The following frequencies were found inside the restricted bands during the preliminary radiated emission measurement:

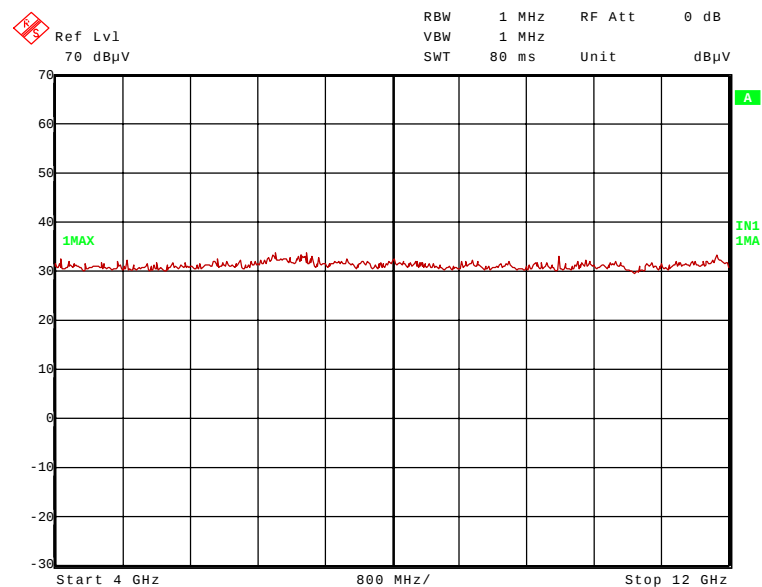
- 120.011 MHz, 240.022 MHz and 960.088 MHz.

These frequencies have to be measured on the open area test site. The result is presented in the following.

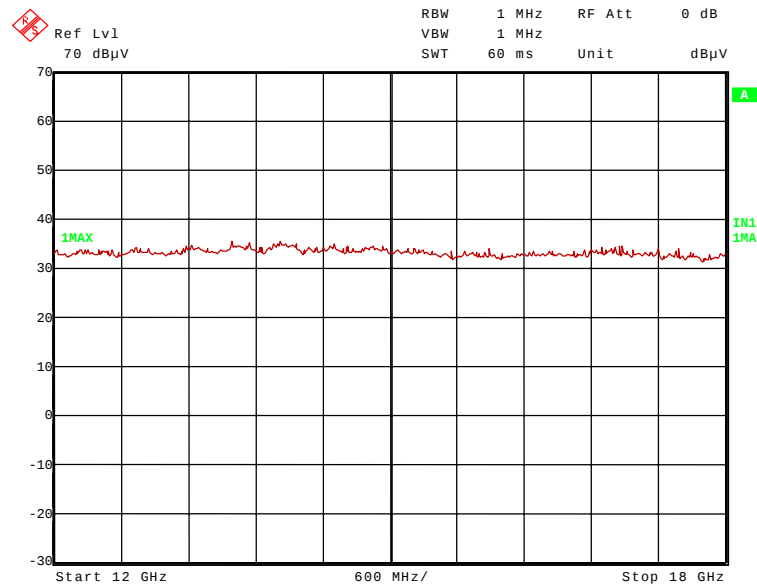
152175\_4.wmf: Radiated emissions from 1 GHz to 4 GHz:



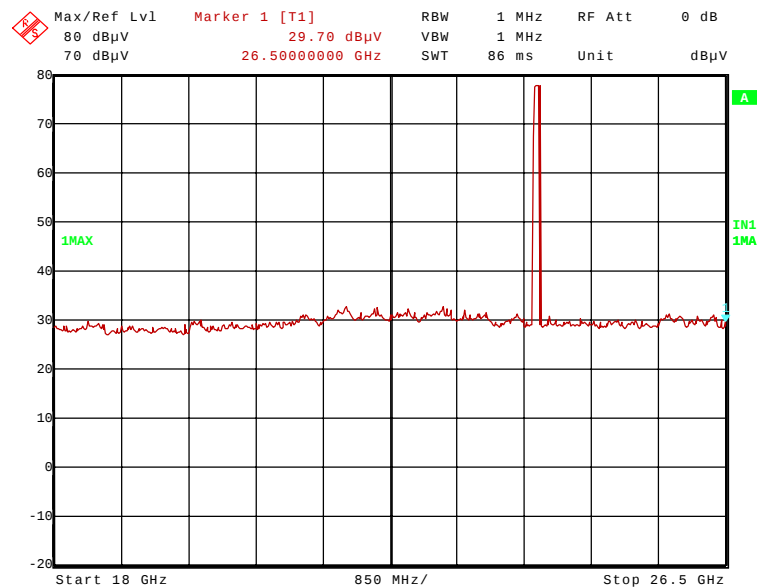
152175\_5.wmf: Radiated emissions from 4 GHz to 12 GHz:



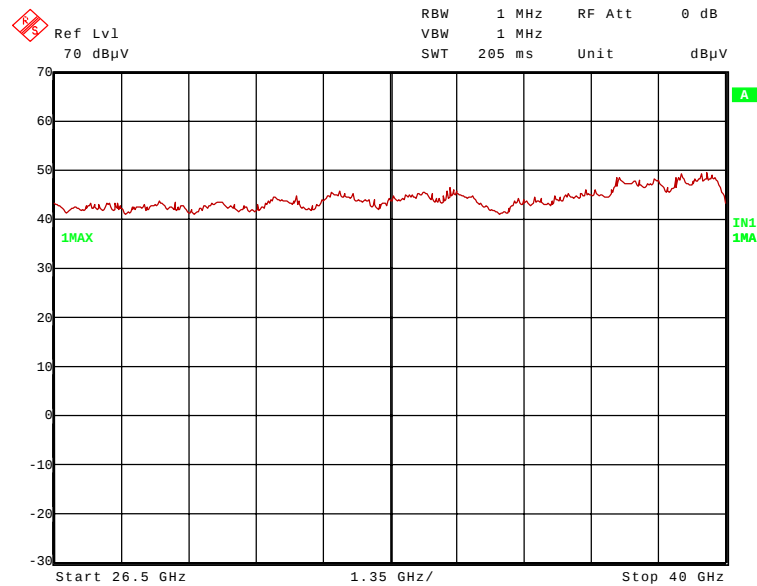
152175\_6.wmf: Radiated emissions from 12 GHz to 18 GHz:



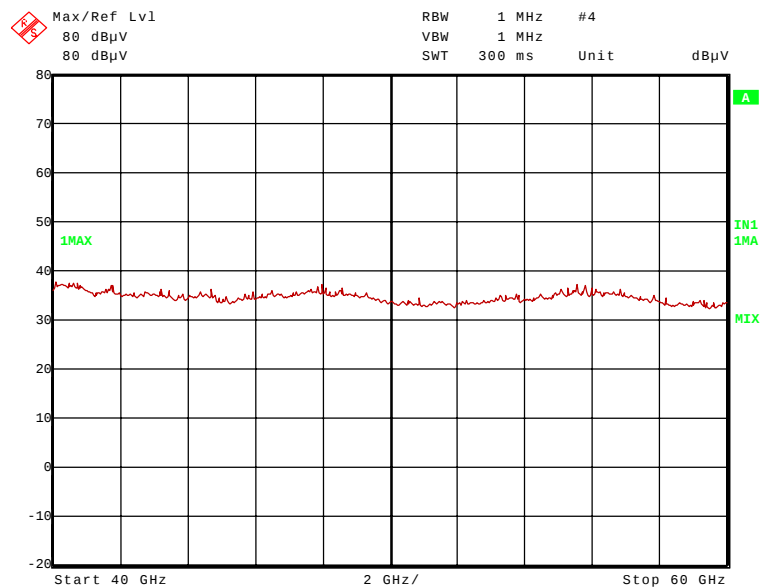
152175\_7.wmf: Radiated emissions from 18 GHz to 26.5 GHz:



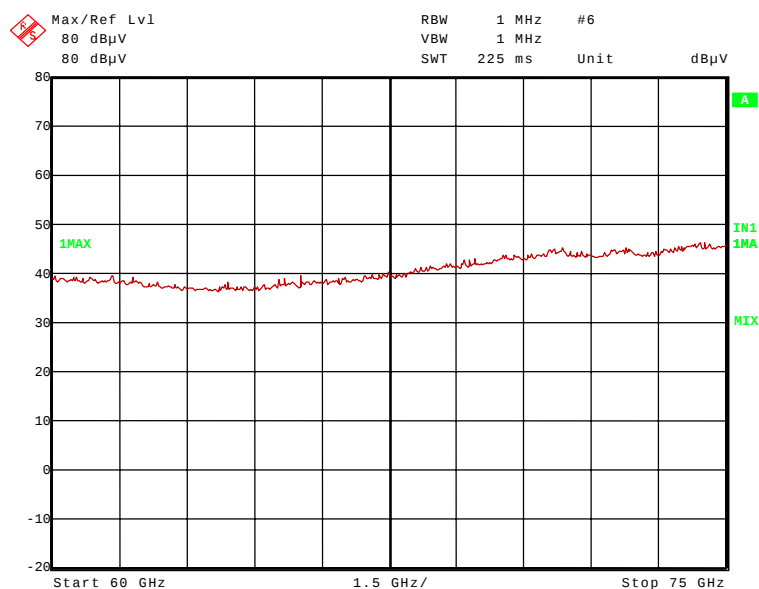
152175\_8.wmf: Radiated emissions from 26.5 GHz to 40 GHz:



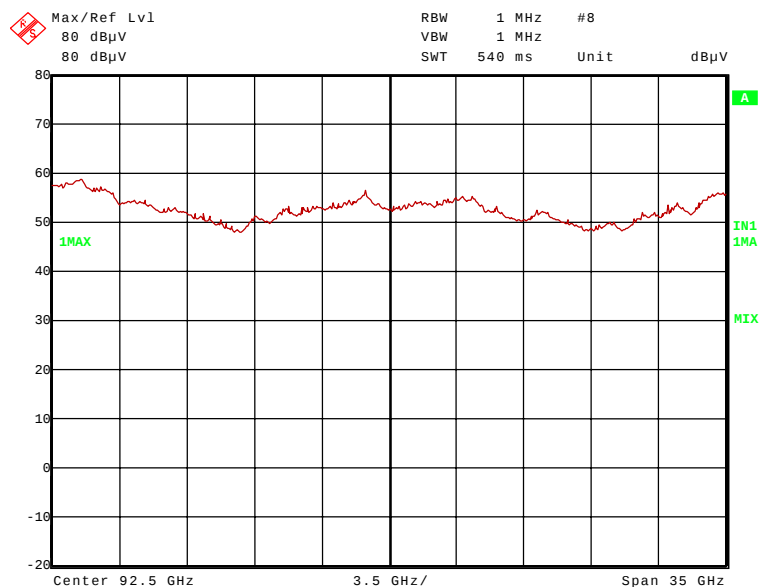
152175\_13.wmf: Radiated emissions from 40 GHz to 60 GHz:



152175\_14.wmf: Radiated emissions from 60 GHz to 75 GHz:



152175\_15.wmf: Radiated emissions from 75 GHz to 110 GHz:



No frequencies were found inside the restricted bands during the preliminary radiated emission measurement.

The following frequency was found outside the restricted bands during the preliminary radiated emission measurement:

- 24.125 GHz.

This frequency has to be measured in a final measurement. The results were presented in the following.

### 5.3.2.2 Final radiated emission measurement (30 MHz to 1 GHz)

|                     |       |                   |      |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 41 % |
|---------------------|-------|-------------------|------|

Position of EUT: The EUT was setup on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Test record: The test was carried out in normal operation mode of the EUT.

Supply voltage: During all measurements the EUT was supplied with 24.0 V<sub>DC</sub> by an external power supply.

Test results: The test results were calculated with the following formula:

$$\text{Result [dB}\mu\text{V/m]} = \text{reading [dB}\mu\text{V]} + \text{cable loss [dB]} + \text{antenna factor [dB/m]}$$

The results of the standard subsequent measurement on the open area test site are indicated in the table below. The limits as well as the measured results (levels) refer to the above mentioned standard while taking account of the specified requirements for a 3 m measuring distance.

The measurement time with the quasi-peak measuring detector is 5 seconds.

#### Result measured with the quasi-peak detector:

| Spurious emissions inside restricted bands  |                        |                       |              |                        |                        |                  |              |                |       |      |
|---------------------------------------------|------------------------|-----------------------|--------------|------------------------|------------------------|------------------|--------------|----------------|-------|------|
| Frequency<br>MHz                            | Result<br>dB $\mu$ V/m | Limit<br>dB $\mu$ V/m | Margin<br>dB | Readings<br>dB $\mu$ V | Antenna factor<br>dB/m | Cable loss<br>dB | Height<br>cm | Azimuth<br>deg | Pol.  | Pos. |
| 120.011                                     | 27.1                   | 43.5                  | 16.4         | 13.5                   | 12.4                   | 1.2              | 258.0        | 271.0          | Hor.  | 2    |
| 240.022                                     | 40.4                   | 46.0                  | 5.6          | 27.5                   | 11.2                   | 1.7              | 125.0        | 112.0          | Hor.  | 2    |
| 960.088                                     | 30.2                   | 54.0                  | 23.8         | 2.9                    | 23.8                   | 3.5              | 100.0        | 315.0          | Vert. | 1    |
| Spurious emissions outside restricted bands |                        |                       |              |                        |                        |                  |              |                |       |      |
| Frequency<br>MHz                            | Result<br>dB $\mu$ V/m | Limit<br>dB $\mu$ V/m | Margin<br>dB | Readings<br>dB $\mu$ V | Antenna factor<br>dB/m | Cable loss<br>dB | Height<br>cm | Azimuth<br>deg | Pol.  | Pos. |
| 157.898                                     | 18.3                   | 43.5                  | 25.2         | 5.6                    | 11.3                   | 1.4              | 221.0        | 106.0          | Hor.  | 2    |
| 203.549                                     | 19.4                   | 43.5                  | 24.1         | 8.8                    | 9.1                    | 1.5              | 100.0        | 53.0           | Vert. | 1    |
| 360.033                                     | 38.4                   | 46.0                  | 7.6          | 22.0                   | 14.3                   | 2.1              | 100.0        | 245.0          | Hor.  | 2    |
| 480.044                                     | 33.5                   | 46.0                  | 12.5         | 14.1                   | 17.0                   | 2.4              | 200.0        | 234.0          | Hor.  | 2    |
| Measurement uncertainty                     |                        |                       |              | +2.2 dB / -3.6 dB      |                        |                  |              |                |       |      |

Test: Passed

Test equipment used (see chapter 6):

14 - 20

### 5.3.2.3 Final radiated emission measurement (1 GHz to 110 GHz)

|                     |       |                   |      |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 38 % |
|---------------------|-------|-------------------|------|

Position of EUT: The EUT was setup on a non-conducting table of a height of 1.5 m. The distance between EUT and antenna was 30 cm.

Test record: The test was carried out in normal operation mode of the EUT.

Supply voltage: During all measurements the EUT was supplied with 24.0 V<sub>DC</sub> by an external power supply.

Resolution bandwidth: For all measurements a resolution bandwidth of 1 MHz was used.

Test results: The test results were calculated with the following formula:

$$\text{Result [dB}\mu\text{V/m]} = \text{reading [dB}\mu\text{V]} + \text{cable loss [dB]} + \text{antenna factor [dB/m]} - \text{Preamp [dB]} + \text{measuring distance correction factor [dB]}$$

#### Result measured with the peak detector:

| Frequency<br>GHz        | Result<br>dB $\mu$ V/m | Limit<br>dB $\mu$ V/m | Margin<br>dB | Readings<br>dB $\mu$ V | Antenna<br>factor<br>1/m | Preamp<br>dB | Cable<br>loss<br>dB | Corr.<br>Factor*<br>dB | Height<br>cm | Pol. | Pos. | Restr.<br>Band |
|-------------------------|------------------------|-----------------------|--------------|------------------------|--------------------------|--------------|---------------------|------------------------|--------------|------|------|----------------|
| 24.125                  | 115.8                  | 148.0                 | 32.2         | 94.0                   | 37.2                     | 0.0          | 4.6                 | -20.0                  | 85           | Hor. | 1    | carrier        |
| Measurement uncertainty |                        |                       |              |                        |                          |              |                     | +2.2 dB / -3.6 dB      |              |      |      |                |

\*: Measuring distance correction factor from 3 m to 30 cm

#### Result measured with the average detector:

| Frequency<br>GHz        | Result<br>dB $\mu$ V/m | Limit<br>dB $\mu$ V/m | Margin<br>dB | Readings<br>dB $\mu$ V | Antenna<br>factor<br>1/m | Preamp<br>dB | Cable<br>loss<br>dB | Corr.<br>Factor*<br>dB | Height<br>cm | Pol. | Pos. | Restr.<br>Band |
|-------------------------|------------------------|-----------------------|--------------|------------------------|--------------------------|--------------|---------------------|------------------------|--------------|------|------|----------------|
| 24.125                  | 78.4                   | 128                   | 49.6         | 56.6                   | 37.2                     | 0.0          | 4.6                 | -20.0                  | 85           | Hor. | 1    | carrier        |
| Measurement uncertainty |                        |                       |              |                        |                          |              |                     | +2.2 dB / -3.6 dB      |              |      |      |                |

\*: Measuring distance correction factor from 3 m to 30 cm

Test: Passed

Test equipment used (see chapter 6):

29, 31 - 34, 37, 52, 146, 165, 176

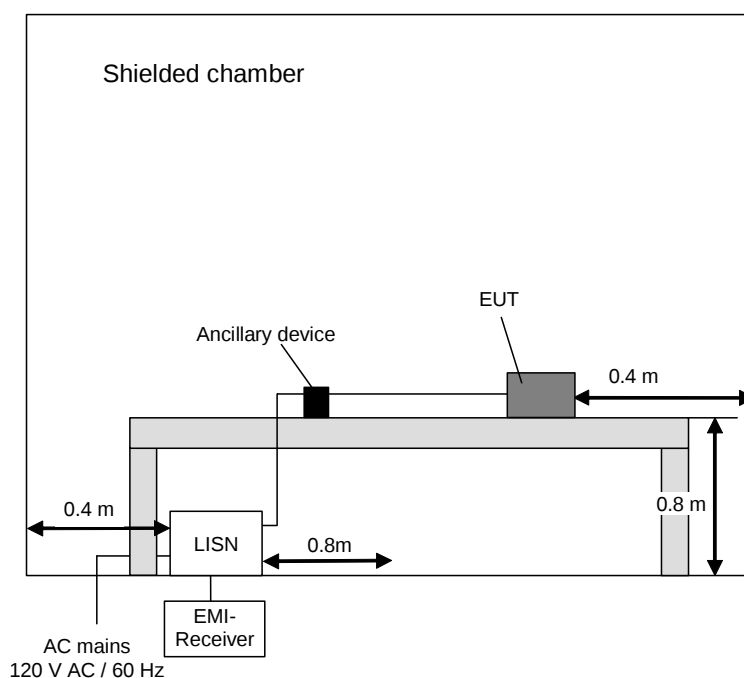
## 5.4 Conducted emissions on power supply line (150 kHz – 30 MHz)

### 5.4.1 Method of measurement of conducted emission

This test will be carried out in a shielded chamber. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm above the ground plane. Floor-standing devices will be placed directly on the ground plane. The setup of the Equipment under test will be in accordance to [1].

The frequency range 150 kHz to 30 MHz will be measured with an EMI Receiver set to MAX Hold mode with peak and average detector and a resolution bandwidth of 9 kHz. A scan will be carried out on the phase (or plus pole in case of DC powered devices) of the AC mains network. If levels detected 10 dB below the appropriate limit, this emission will be measured with the average and quasi-peak detector on all lines.

| Frequency range   | Resolution bandwidth |
|-------------------|----------------------|
| 150 kHz to 30 MHz | 9 kHz                |



#### 5.4.2 Test results (conducted emission measurement on AC mains)

|                      |       |                    |      |
|----------------------|-------|--------------------|------|
| Ambient temperature: | 20 °C | Relative humidity: | 39 % |
|----------------------|-------|--------------------|------|

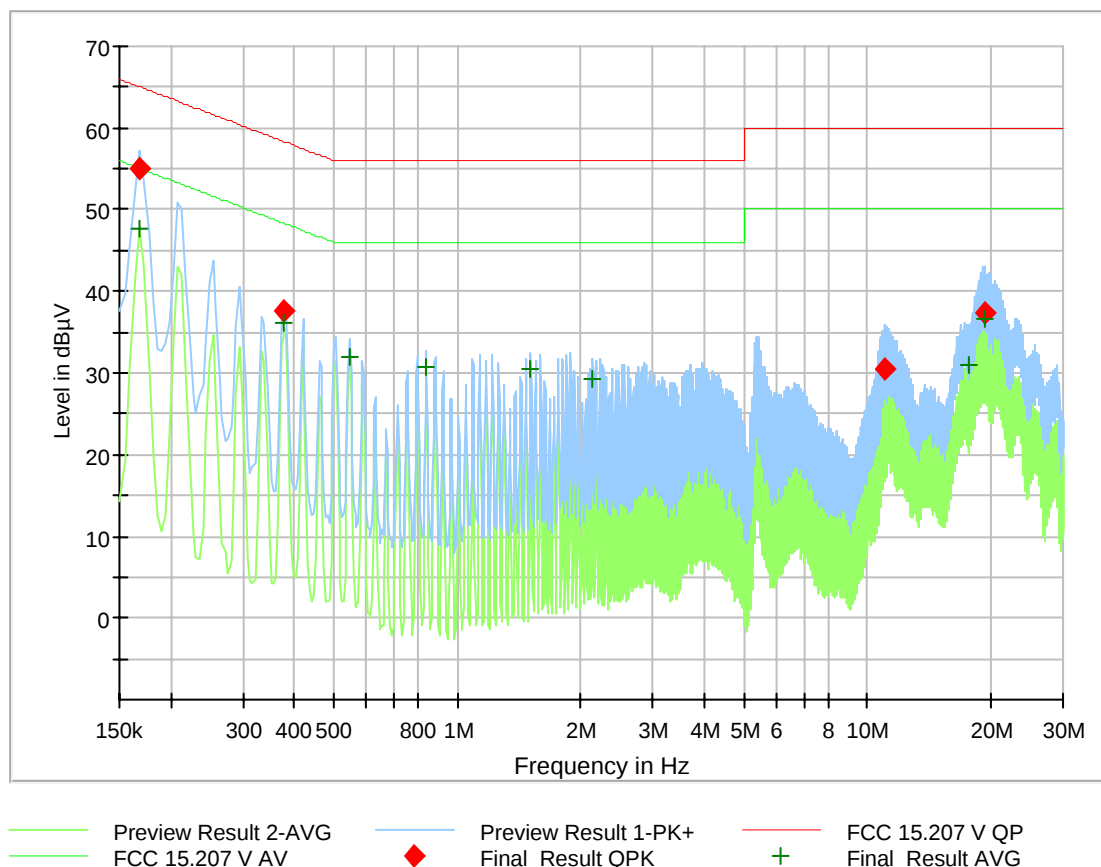
Position of EUT: The EUT was setup on a wooden table of a height of 0.8 m.

Cable guide: The cable of the EUT was fixed on the wooden table. For further information of the cable guide refer to the pictures in annex A of this test report.

Test record: The test was carried out in normal operation mode of the EUT.

Power supply: During this test the EUT was powered with 24 V<sub>DC</sub> by the Mini-PS-100-240AC/24DC/1, which was itself supplied with 120 V<sub>AC</sub> / 60 Hz.

The curves in the diagram only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by ♦ and the average measured points by "+".



Data record name: 152175vAC

| Frequency<br>(MHz)      | QuasiPeak<br>(dBμV) | Average<br>(dBμV) | Limit<br>(dBμV)   | Margin<br>(dB) | Meas.<br>Time<br>(ms) | Bandwidth<br>(kHz) | Line | PE  | Transducer<br>(dB) |
|-------------------------|---------------------|-------------------|-------------------|----------------|-----------------------|--------------------|------|-----|--------------------|
| 0.167100                | 55.1                | ---               | 65.1              | 10.0           | 5000.0                | 9.000              | N    | GND | 10.0               |
| 0.167100                | ---                 | 47.6              | 55.1              | 7.5            | 5000.0                | 9.000              | N    | FLO | 10.0               |
| 0.376800                | ---                 | 36.2              | 48.4              | 12.2           | 5000.0                | 9.000              | N    | GND | 10.0               |
| 0.376800                | 37.5                | ---               | 58.4              | 20.9           | 5000.0                | 9.000              | N    | GND | 10.0               |
| 0.544200                | ---                 | 32.0              | 46.0              | 14.0           | 5000.0                | 9.000              | N    | GND | 10.0               |
| 0.837600                | ---                 | 30.7              | 46.0              | 15.3           | 5000.0                | 9.000              | N    | GND | 10.0               |
| 1.507200                | ---                 | 30.6              | 46.0              | 15.4           | 5000.0                | 9.000              | N    | GND | 10.0               |
| 2.134500                | ---                 | 29.3              | 46.0              | 16.7           | 5000.0                | 9.000              | N    | GND | 10.2               |
| 11.053500               | 30.4                | ---               | 60.0              | 29.6           | 5000.0                | 9.000              | L1   | GND | 11.2               |
| 17.586600               | ---                 | 30.9              | 50.0              | 19.1           | 5000.0                | 9.000              | L1   | GND | 11.8               |
| 19.378500               | ---                 | 36.6              | 50.0              | 13.4           | 5000.0                | 9.000              | N    | GND | 12.0               |
| 19.423500               | 37.3                | ---               | 60.0              | 22.7           | 5000.0                | 9.000              | N    | GND | 12.0               |
| Measurement uncertainty |                     |                   | +6.7 dB / -6.0 dB |                |                       |                    |      |     |                    |

Test: Passed

Test equipment used (see chapter 6):

1 - 5

## 6 Test equipment and ancillaries used for tests

| No. | Test equipment                                         | Type               | Manufacturer                      | Serial No.        | PM. No. | Cal. Date                            | Cal. due |
|-----|--------------------------------------------------------|--------------------|-----------------------------------|-------------------|---------|--------------------------------------|----------|
| 1   | Shielded chamber M4                                    | -                  | Siemens AG                        | B83117-S1-X158    | 480088  | Weekly verification (system cal.)    |          |
| 2   | EMI Receiver                                           | ESIB 26            | Rohde & Schwarz                   | 1088.7490         | 481182  | 03/21/2014                           | 03/2016  |
| 3   | LISN                                                   | NSLK8128           | Schwarzbeck                       | 8128161           | 480138  | 02/27/2015                           | 02/2016  |
| 4   | Transient Limiter                                      | CFL 9206A          | Teseq GmbH                        | 38268             | 481982  | Weekly verification (system cal.)    |          |
| 5   | EMI Software                                           | EMC32              | Rohde & Schwarz                   | -                 | 481800  | -                                    | -        |
| 14  | Open area test site                                    | -                  | Phoenix Test-Lab                  | -                 | 480085  | Weekly verification (system cal.)    |          |
| 15  | EMI Receiver                                           | ESIB 7             | Rohde & Schwarz                   | 1088.7490K07      | 480521  | 03/06/2015                           | 03/2017  |
| 16  | Controller                                             | HD100              | Deisel                            | 100/670           | 480139  | -                                    | -        |
| 17  | Turntable                                              | DS420HE            | Deisel                            | 420/620/80        | 480087  | -                                    | -        |
| 18  | Antenna support                                        | AS615P             | Deisel                            | 615/310           | 480086  | -                                    | -        |
| 19  | Antenna                                                | CBL6111 D          | Chase                             | 25761             | 480894  | 09/18/2014                           | 09/2017  |
| 20  | EMI Software                                           | ES-K1              | Rohde & Schwarz                   | -                 | 480111  | -                                    | -        |
| 29  | Fully anechoic chamber M20                             | -                  | Albatross Projects                | B83107-E2439-T232 | 480303  | Weekly verification (system cal.)    |          |
| 31  | Measuring receiver                                     | ESI 40             | Rohde & Schwarz                   | 100064            | 480355  | 03/02/2015                           | 03/2016  |
| 32  | Controller                                             | MCU                | Maturo                            | MCU/043/971107    | 480832  | -                                    | -        |
| 33  | Turntable                                              | DS420HE            | Deisel                            | 420/620/80        | 480315  | -                                    | -        |
| 34  | Antenna support                                        | AS615P             | Deisel                            | 615/310           | 480187  | -                                    | -        |
| 35  | Antenna                                                | CBL6112 B          | Chase                             | 2688              | 480328  | 04/14/2014                           | 04/2017  |
| 36  | Antenna                                                | 3115 A             | EMCO                              | 9609-4918         | 480183  | 11/10/2014                           | 11/2017  |
| 37  | Turn device                                            | TDF 1.5- 10Kg      | Maturo                            | -                 | 482034  | -                                    | -        |
| 43  | RF-cable No. 36                                        | Sucoflex 106B      | Suhner                            | 0522/6B           | 480571  | Weekly verification (system cal.)    |          |
| 44  | RF-cable No. 3                                         | Sucoflex 106B      | Suhner                            | 0563/6B           | 480670  | Weekly verification (system cal.)    |          |
| 45  | RF-cable No. 40                                        | Sucoflex 106B      | Suhner                            | 0708/6B           | 481330  | Weekly verification (system cal.)    |          |
| 49  | Preamplifier                                           | JS3-00101200-23-5A | Miteq                             | 681851            | 480337  | Six month verification (system cal.) |          |
| 52  | Power supply                                           | TOE 8752           | Toellner                          | 31566             | 480010  | -                                    | -        |
| 55  | Loop antenna                                           | HFH2-Z2            | Rohde & Schwarz                   | 100417            | 481912  | 09/22/2014                           | 09/2015  |
| 146 | Standard Gain Horn 11.9 GHz – 18 GHz                   | 18240-20           | Flann Microwave                   | 483               | 480294  | Six month verification (system cal.) |          |
| 149 | Standard Gain Horn 17.9 GHz – 26.7 GHz                 | 20240-20           | Flann Microwave                   | 410               | 480296  | Six month verification (system cal.) |          |
| 150 | Standard Gain Horn 26.4 GHz – 40.1 GHz                 | 22240-20           | Flann Microwave                   | 469               | 480299  | Six month verification (system cal.) |          |
| 153 | Harmonic mixer with Standard Gain Horn 40 GHz – 60 GHz | FZ-Z60 / 24240-20  | Rohde & Schwarz / Flann Microwave | 100071 / 133313   | 480481  | Six month verification (system cal.) |          |

| No. | Test equipment                                          | Type               | Manufacturer                      | Serial No.      | PM. No. | Cal. Date                            | Cal. due |
|-----|---------------------------------------------------------|--------------------|-----------------------------------|-----------------|---------|--------------------------------------|----------|
| 154 | Harmonic mixer with Standard Gain Horn 50 GHz – 75 GHz  | FS-Z75 / 25240-20  | Rohde & Schwarz / Flann Microwave | 100045 / 135181 | 480480  | Six month verification (system cal.) |          |
| 155 | Harmonic mixer with Standard Gain Horn 75 GHz – 110 GHz | FS-Z110 / 27240-20 | Rohde & Schwarz / Flann Microwave | 100049 / 138294 | 480482  | Six month verification (system cal.) |          |
| 159 | Preamplifier                                            | JS3-12001800-16-5A | Miteq                             | 571667          | 480343  | 06/18/2014                           | 06/2015  |
| 160 | Preamplifier                                            | JS3-18002600-20-5A | Miteq                             | 658697          | 480342  | 06/18/2014                           | 06/2015  |
| 161 | Preamplifier                                            | JS3-26004000-25-5A | Miteq                             | 563593          | 480344  | 06/18/2014                           | 06/2015  |
| 165 | RF-cable 1m                                             | KPS-1533-400-KPS   | Insulated Wire                    | -               | 480300  | Six month verification (system cal.) |          |
| 176 | Multimeter                                              | 971A               | Hewlett Packard                   | JP39009358      | 480721  | 12/16/2013                           | 12/2015  |

## 7 Report history

| Report Number | Date       | Comment          |
|---------------|------------|------------------|
| F152175E1     | 09/07/2015 | Document created |
|               |            |                  |
|               |            |                  |

## 8 List of annexes

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 152175\_12.JPG: CRAT81, connector view, service interface opened

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 152175\_6.JPG: CRAT81, PCB 1, bottom view  
 152175\_7.JPG: CRAT81, PCB 2, top view  
 152175\_9.JPG: CRAT81, PCB 2, top view, shielding removed  
 152175\_8.JPG: CRAT81, PCB 2, bottom view (antenna patch)