

Test Report

Report Number: F130413E1

Applicant:

Hatox GmbH

Manufacturer:

Hatox GmbH

Equipment under Test (EUT):

**Transceiver module
H153V2**

Laboratory (CAB) accredited by
Deutsche Gesellschaft für Akkreditierung mbH
in compliance with DIN EN ISO/IEC 17025
under the Reg. No. DGA-PL-105/99-22,
FCC Test site registration number 90877 and
Industry Canada Test site registration IC3469A-1

REFERENCES

- [1] **ANSI C63.4-2009** American National Standard for Methods of Measuring of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
- [2] **FCC CFR 47 Part 15 (April 2013)** Radio Frequency Devices
- [3] **FCC Public Notice DA 00-705 (March 2000)**
- [4] **RSS-210 Issue 8 (December 2010)** Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment
- [5] **RSS-Gen Issue 3 (December 2010)** General Requirements and Information for the Certification 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: | Manuel BASTERT |  | 10 April 2013 |
| | Name | Signature | Date |
| Authorized reviewer: | Thomas KÜHN |  | 10 April 2013 |
| | Name | Signature | Date |

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Contents

| | Page |
|--|------|
| 1 IDENTIFICATION | 4 |
| 1.1 Applicant..... | 4 |
| 1.2 Manufacturer..... | 4 |
| 1.3 Test laboratory | 4 |
| 1.4 EUT (Equipment Under Test) | 5 |
| 1.5 Technical data of equipment..... | 5 |
| 1.6 Dates | 5 |
| 2 OPERATIONAL STATES..... | 6 |
| 3 ADDITIONAL INFORMATION..... | 7 |
| 4 OVERVIEW | 7 |
| 5 TEST RESULTS | 8 |
| 5.1 20 dB bandwidth | 8 |
| 5.1.1 Method of measurement..... | 8 |
| 5.1.2 Test results | 9 |
| 5.2 Carrier frequency separation | 11 |
| 5.2.1 Method of measurement..... | 11 |
| 5.2.2 Test results | 12 |
| 5.3 Number of hopping frequencies..... | 14 |
| 5.3.1 Method of measurement..... | 14 |
| 5.3.2 Test results | 14 |
| 5.4 Dwell time | 16 |
| 5.4.1 Method of measurement..... | 16 |
| 5.4.2 Test results | 17 |
| 5.5 Maximum peak output power..... | 18 |
| 5.5.1 Method of measurement..... | 18 |
| 5.5.2 Test results | 19 |
| 5.6 Radiated emissions..... | 21 |
| 5.6.1 Method of measurement..... | 21 |
| 5.6.2 Test results | 26 |
| 5.7 Conducted emissions on power supply lines (150 kHz to 30 MHz)..... | 38 |
| 5.7.1 Method of measurement..... | 38 |
| 5.7.2 Test results | 39 |
| 6 TEST EQUIPMENT AND ANCILLARIES USED FOR TESTS..... | 40 |
| 7 REPORT HISTORY | 41 |
| 8 LIST OF ANNEXES | 41 |

1 IDENTIFICATION

1.1 Applicant

| | |
|--|----------------------------------|
| Name: | Hatox GmbH |
| Address: | Kreuzstr. 70 75214 Birkenfeld |
| Country: | Germany |
| Name for contact purposes: | Mr. Thomas HAUG |
| Phone: | +49 7231 2980680 |
| Fax: | +49 7231 2980688 |
| eMail Address: | thomas.haug@hatox.com |
| Applicant represented during the test by the following person: | Mr. Thomas HAUG |

1.2 Manufacturer

| | |
|---|----------------------------------|
| Name: | Hatox GmbH |
| Address: | Kreuzstr. 70 75214 Birkenfeld |
| Country: | Germany |
| Name for contact purposes: | Mr. Thomas HAUG |
| Phone: | +49 7231 2980680 |
| Fax: | +49 7231 2980688 |
| eMail Address: | thomas.haug@hatox.com |
| Manufacturer represented during the test by the following person: | Mr. Thomas HAUG |

1.3 Test laboratory

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

Accredited by DGA Deutsche Gesellschaft für Akkreditierung mbH in compliance with DIN EN ISO/IEC 17025 under Reg. No. DGA-PL-105/99-22, FCC Test site registration number 90877 and Industry Canada Test site registration IC3469A-1.

1.4 EUT (Equipment Under Test)

| | |
|--|--------------------|
| Test object: * | Transceiver module |
| Model name: * | H153V2 |
| FCC ID: * | FCC-ID: SCAH153V2 |
| IC: * | IC: 10949A-H153V2 |
| PCB identifier: * | H153V2 |
| Serial number: * | 1000 |
| Hardware version: * | 2.0.0 |
| Software version: * | 1.0.0 |
| Lowest / highest internal clock frequency: * | 14.7456 MHz |

1.5 Technical data of equipment

| | | | | |
|--------------|-----|-------------|-----|-------------|
| Channel 1 | RX: | 902.500 MHz | TX: | 902.500 MHz |
| Channel 500 | RX: | 914.975 MHz | TX: | 914.975 MHz |
| Channel 1000 | RX: | 927.475 MHz | TX: | 927.475 MHz |

| | | | | | | |
|--------------------------|----------------------------|---------------------|--------------------|---------------------|--------------------|---------------------|
| Rated RF output power: * | <10 dBm | | | | | |
| Antenna type: * | Internal (helical antenna) | | | | | |
| Antenna gain: * | 0 dBi | | | | | |
| Modulation: * | FHSS (FSK) | | | | | |
| Supply Voltage: * | $U_{\text{nom}} =$ | 3.0 V _{DC} | $U_{\text{min}} =$ | 2.0 V _{DC} | $U_{\text{max}} =$ | 6.0 V _{DC} |
| Temperature range: * | -20 °C to + 75 °C | | | | | |
| Ancillary used for test: | Hatox programmer | | | | | |

* declared by the applicant.

1.6 Dates

| | |
|---------------------------------|------------------|
| Date of receipt of test sample: | 25 February 2013 |
| Start of test: | 25 February 2013 |
| End of test: | 27 February 2013 |

2 OPERATIONAL STATES

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

During the all tests the EUT was powered by an external power supply with 3 V_{DC}.

The operation mode could be chosen with the help of a temporary connected laptop PC and a programming adaptor.

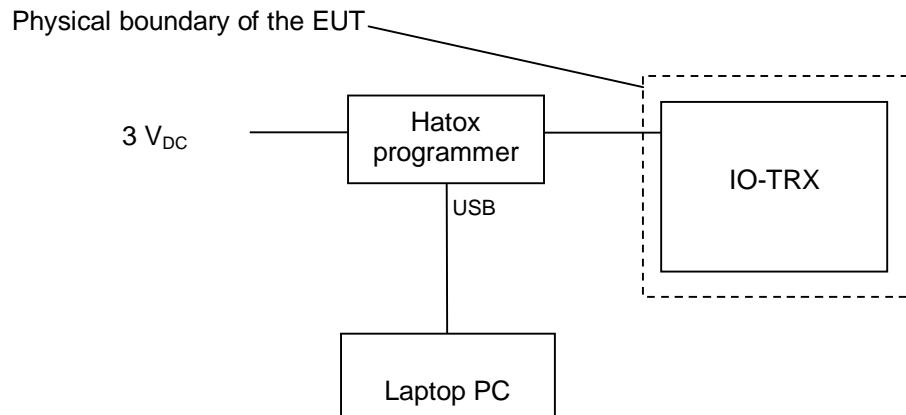
The conducted measurements were carried out at a temporary antenna connector equipped EUT.

For all measurements the output power of the EUT was set to its maximum value.

During the tests the EUT was not labelled with a label, which fulfils the FCC /IC requirements.

The following operation modes were used during the tests:

| Operation mode | Description of the operation mode |
|----------------|--|
| 1 | Transmit on 902.500 MHz (channel 1) |
| 2 | Transmit on 914.975 MHz (channel 500) |
| 3 | Transmit on 927.475 MHz (channel 1000) |
| 4 | Transmit on all channels (hopping enabled) |



3 ADDITIONAL INFORMATION

None.

4 OVERVIEW

| Application | Frequency range [MHz] | FCC 47 CFR Part 15 section [2] | RSS 210, Issue 8 [4] or RSS-Gen, Issue 3 [5] | Status | Refer page |
|------------------------------------|--------------------------|--|--|--------|------------|
| 20 dB bandwidth | General | 15.247 (a) (1) (i) | A8.1 (c) [4] | Passed | 8 et seq. |
| Carrier frequency separation | General | 15.247 (a) (1) (i) | - | Passed | 11 et seq. |
| Number of hopping channels | 902.0 – 928.0 | 15.247 (a) (1) (i) | A8.1 (c) [4] | Passed | 14 et seq. |
| Dwell time | 902.0 – 928.0 | 15.247 (a) (1) (i) | A8.1 (c) [4] | Passed | 16 et seq. |
| Maximum peak output power | 902.0 – 928.0 | 15.247 (b) (2) | A8.4 (1) [4] | Passed | 18 et seq. |
| Radiated emissions (transmitter) | 0.009 - 10,000 | 15.247 (d) 15.205 (a) 15.209 (a) | A8.5 [4] 2.5 [4] 7.2.2 [5] | Passed | 21 et seq. |
| Conducted emissions on supply line | 0.15 - 30 | 15.207 (a) | 7.2.4 [5] | Passed | 38 et seq. |

5 TEST RESULTS

5.1 20 dB bandwidth

5.1.1 Method of measurement

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. The EUT has to be switched on and the hopping function has to be disabled, the transmitter shall work with its maximum data rate.

The following spectrum analyser settings shall be used:

- Span: App. 2 to 3 times the 20 dB bandwidth, centred on the actual hopping channel.
- Resolution bandwidth: $\geq 1\%$ of the 20 dB bandwidth.
- 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 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.

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

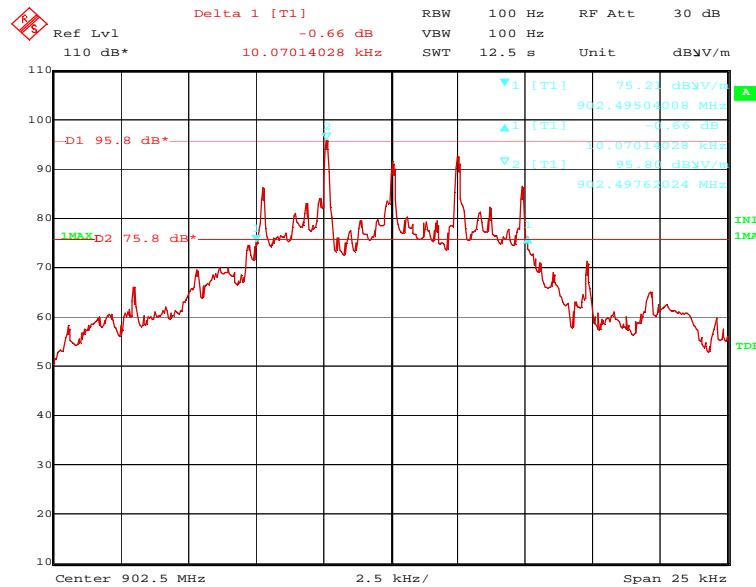
Test setup:



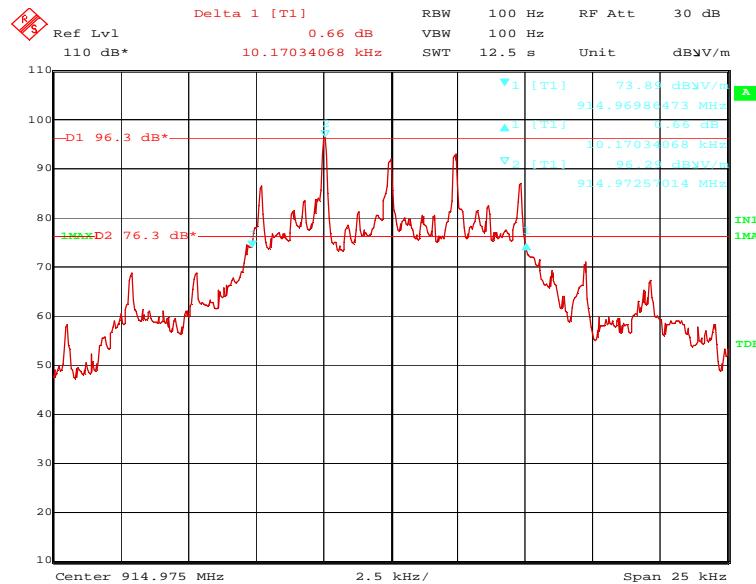
5.1.2 Test results

| | | | |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 27 % |
|---------------------|-------|-------------------|------|

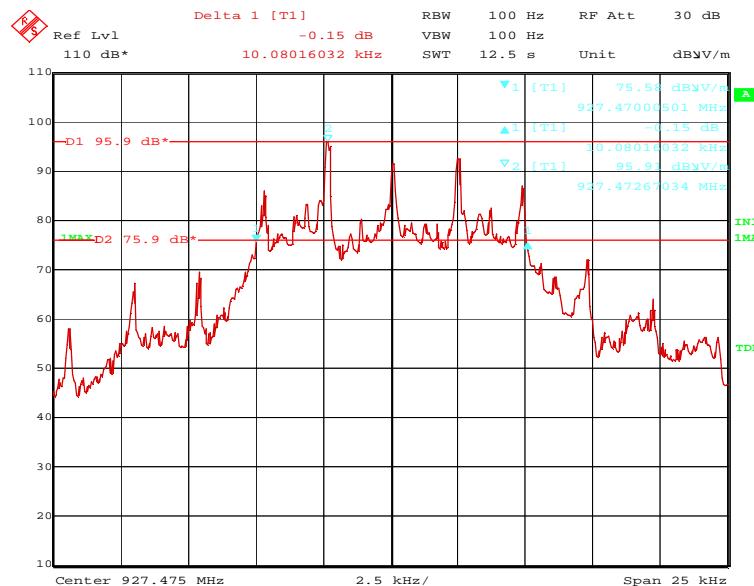
130413_3.wmf: 20 dB bandwidth at the lower end of the assigned frequency band:



130413_9.wmf: 20 dB bandwidth at the middle of the assigned frequency band:



130413_6.wmf: 20 dB bandwidth at the upper end of the assigned frequency band:



| Channel number | Channel frequency [MHz] | 20 dB bandwidth [kHz] |
|--|-------------------------|-----------------------|
| 1 | 902.500 | 10.070140 kHz |
| 500 | 914.975 | 10.170341 kHz |
| 1000 | 927.475 | 10.080160 kHz |
| Measurement uncertainty: +0.66 dB / -0.72 dB | | |

Test result: Passed.

TEST EQUIPMENT USED FOR THE TEST:

31

5.2 Carrier frequency separation

5.2.1 Method of measurement

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. The EUT has to be switched on and the hopping function has to be enabled.

The following spectrum analyser settings shall be used:

- Span: Wide enough to capture the peaks of two adjacent channels.
- Resolution bandwidth: $\geq 1\%$ of the span.
- Video bandwidth: \geq the resolution bandwidth.
- Sweep: Auto.
- Detector function: peak.
- Trace mode: Max hold.

After trace stabilisation the marker and the delta marker function will be used to determine the separation between the peaks of two adjacent channel signals.

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

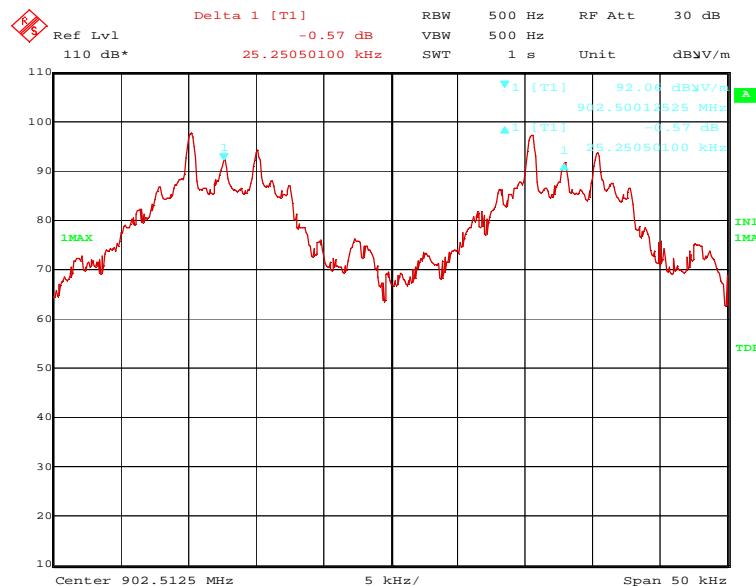
Test setup:



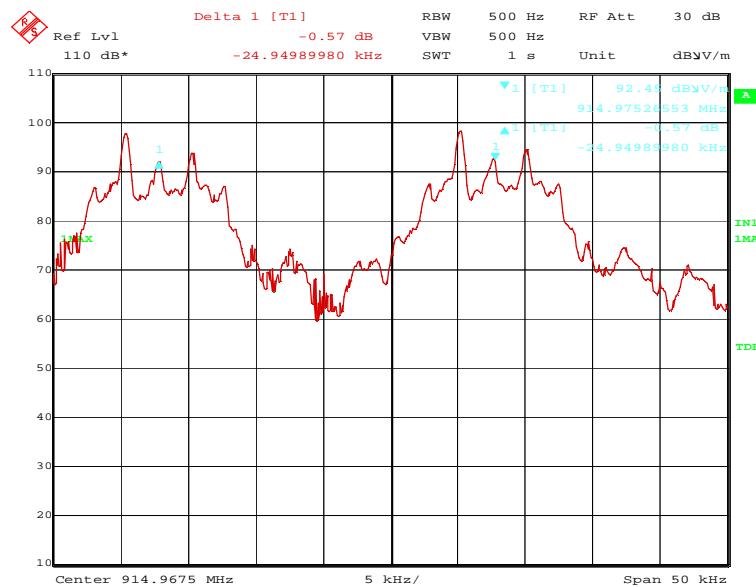
5.2.2 Test results

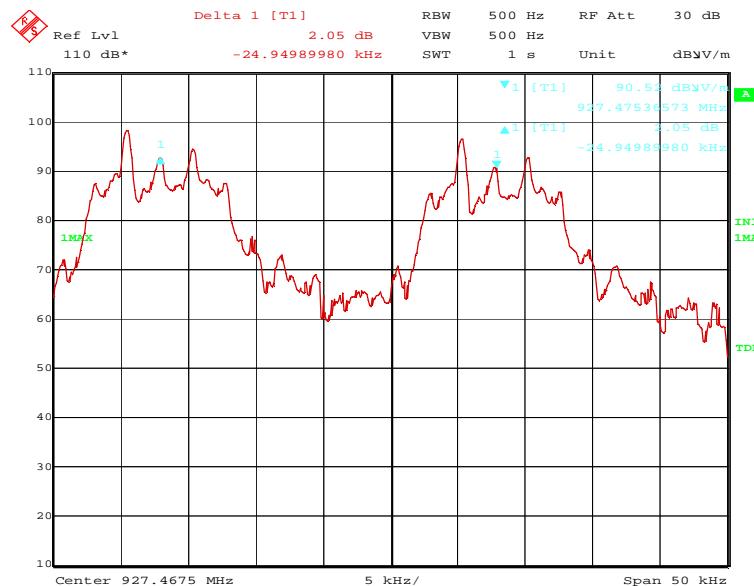
| | | | |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 27 % |
|---------------------|-------|-------------------|------|

130413_4.wmf: Channel separation at the lower end of the assigned frequency band:



130413_10.wmf: Channel separation at the middle of the assigned frequency band:



130413_5.wmf: Channel separation at the upper end of the assigned frequency band:


| Channel number | Channel frequency [MHz] | Channel separation [kHz] | Minimum limit [kHz] |
|-------------------------------------|-------------------------|--------------------------|----------------------------------|
| 1 | 902.500 | 25.250 kHz | 10.070 kHz (the 20 dB bandwidth) |
| 500 | 914.975 | 24.949 kHz | 10.170 kHz (the 20 dB bandwidth) |
| 1000 | 927.475 | 24.950 kHz | 10.080 kHz (the 20 dB bandwidth) |
| Measurement uncertainty: $<10^{-7}$ | | | |

Test result: Passed.

TEST EQUIPMENT USED FOR THE TEST:

31

5.3 Number of hopping frequencies

5.3.1 Method of measurement

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. The EUT has to be switched on and the hopping function has to be enabled.

The following spectrum analyser settings shall be used:

- Span: Equal to the assigned frequency band.
- Resolution bandwidth: $\geq 1\%$ of the span.
- Video bandwidth: \geq the resolution bandwidth.
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

After trace stabilisation the number of hopping channels could be counted. It might be possible to divide the span into some sub ranges in order to clearly show all hopping frequencies.

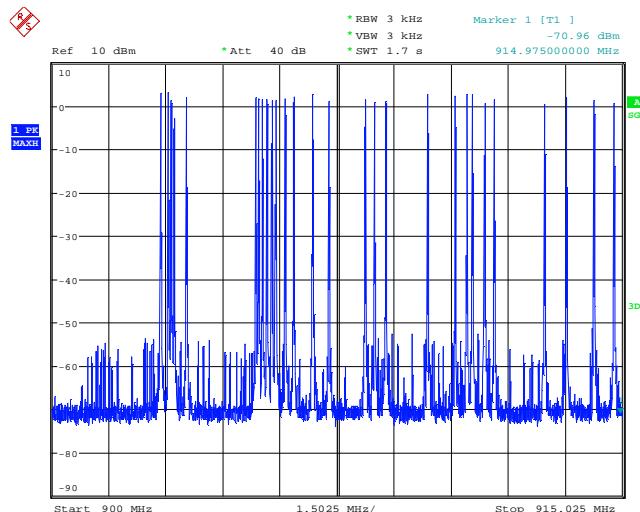
Test setup:

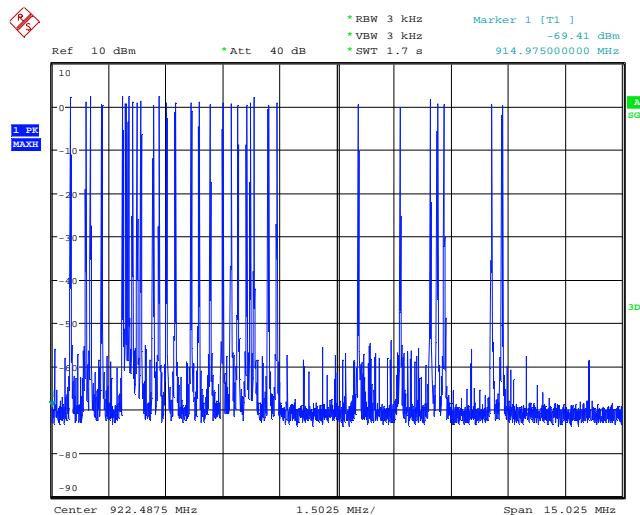


5.3.2 Test results

| | | | |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 28 % |
|---------------------|-------|-------------------|------|

130413_16.wmf: Number of hopping channels (part 1):



130413_17.wmf: Number of hopping channels (part 2):


Remark: Because of the small channel separation (25 kHz) the RBW was set to a smaller value than required in order to count the number of hopping channels.

| Number of hopping channels | Limit |
|----------------------------|-------------|
| Operation mode 4 | |
| 60 | At least 50 |

Test result: Passed.

TEST EQUIPMENT USED FOR THE TEST:

30

5.4 Dwell time

5.4.1 Method of measurement

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. The EUT has to be switched on and the hopping function has to be enabled.

The following spectrum analyser settings shall be used:

- Span: Zero, centred on a hopping channel.
- Resolution bandwidth: 1 MHz.
- Video bandwidth: \geq the resolution bandwidth.
- Sweep: As necessary to capture the entire dwell time per hopping channel.
- Detector function: peak.
- Trace mode: Max hold.

The marker and delta marker function of the spectrum analyser will be used to determine the dwell time.

The measurement will be performed at the middle of the assigned frequency band.

If the EUT is possible to operate with different mode of operation (data rates, modulation formats etc.) the test will be repeated with every different operation mode of the EUT.

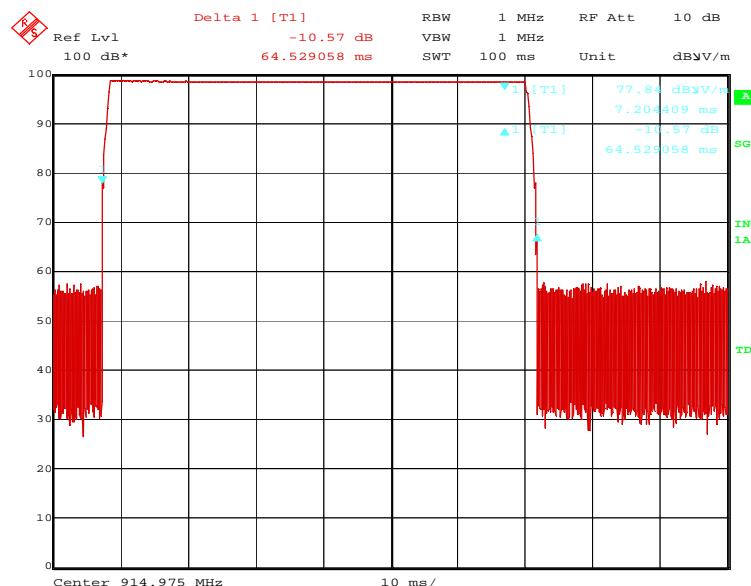
Test setup:



5.4.2 Test results

| | | | |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 27 % |
|---------------------|-------|-------------------|------|

130413_11.wmf: Dwell time at the middle of the assigned frequency band:



The dwell time is calculated with the following formula:

$$\text{Dwell time} = t_{\text{pulse}} \times n_{\text{hops}} / \text{number of hopping channels} \times 20 \text{ s}$$

Where:

t_{pulse} is the measured pulse time (pls. refer the plots of the spectrum analyser above) [s],
 n_{hops} is the number of hops per second in the actual operating mode of the transmitter [1/s].

The hopping rate of the system is 8.8 hops per second and the system uses 60 channels.

| Channel number | Channel frequency [MHz] | t_{pulse} [ms] | Dwell time [ms] | Limit [ms] |
|-------------------------------------|-------------------------|-------------------------|-----------------|------------|
| 500 | 914.975 | 64.529 | 189.285 | 400 |
| Measurement uncertainty: $<10^{-7}$ | | | | |

Test result: Passed.

TEST EQUIPMENT USED FOR THE TEST:

31

5.5 Maximum peak output power

5.5.1 Method of measurement

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. The EUT has to be switched on and the hopping function has to be disabled.

The following spectrum analyser settings shall be used:

- Span: Approx. 5 times the 20 dB bandwidth, centred on a hopping channel.
- Resolution bandwidth: > the 20 dB bandwidth of the emission being measured.
- 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 indicated level is the peak output power, which has to be corrected with the value of the cable loss and an external attenuation (if necessary).

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

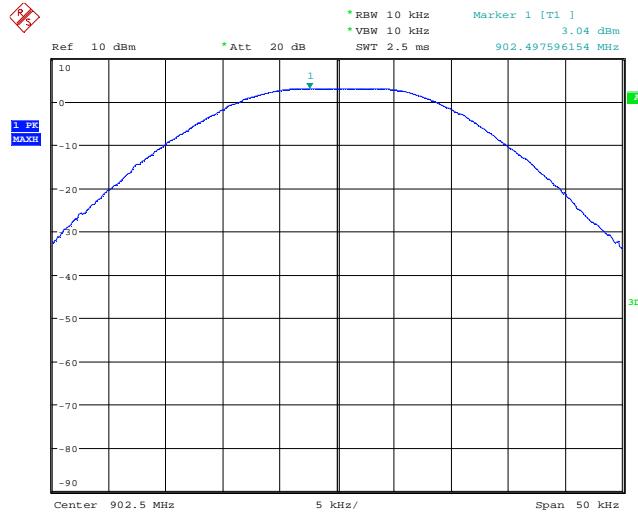
Test setup:



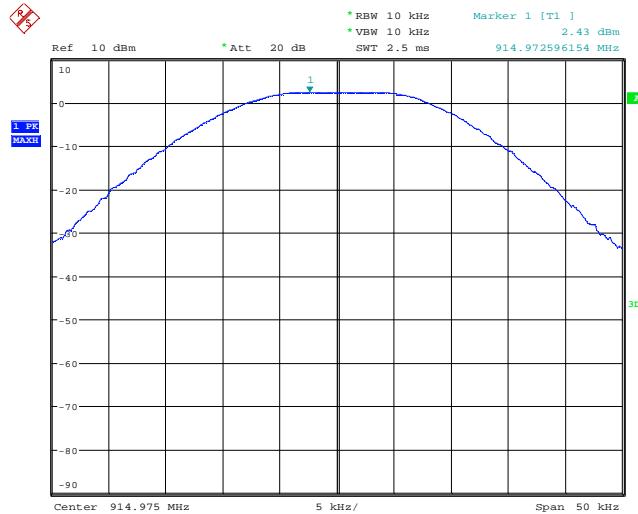
5.5.2 Test results

| | | | |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 27 % |
|---------------------|-------|-------------------|------|

130413_23.wmf: Maximum peak output power at 902.5 MHz:



130413_24.wmf: Maximum peak output power 914.975 MHz:



130413_25.wmf: Maximum peak output power at 927.475 MHz:


| Operation mode | Channel number | Channel frequency [MHz] | Maximum peak output power [dBm] | Antenna gain [dBi] | Peak power limit [dBm] |
|--|----------------|-------------------------|---------------------------------|--------------------|------------------------|
| 1 | 1 | 902.500 | 3.0 | 0.0 | 30.0 |
| 2 | 500 | 914.975 | 2.4 | 0.0 | 30.0 |
| 3 | 1000 | 917.475 | 1.5 | 0.0 | 30.0 |
| Measurement uncertainty: +0.66 dB / -0.72 dB | | | | | |

Test result: Passed.

TEST EQUIPMENT USED FOR THE TEST:

30

5.6 Radiated emissions

5.6.1 Method of measurement

The radiated emission measurement is subdivided into four stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 30 MHz to 1 GHz.
- A final measurement carried out on an open area test side with reflecting ground plane and various antenna height 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.

All measurements will be carried out with the EUT working on the middle of the assigned frequency band.

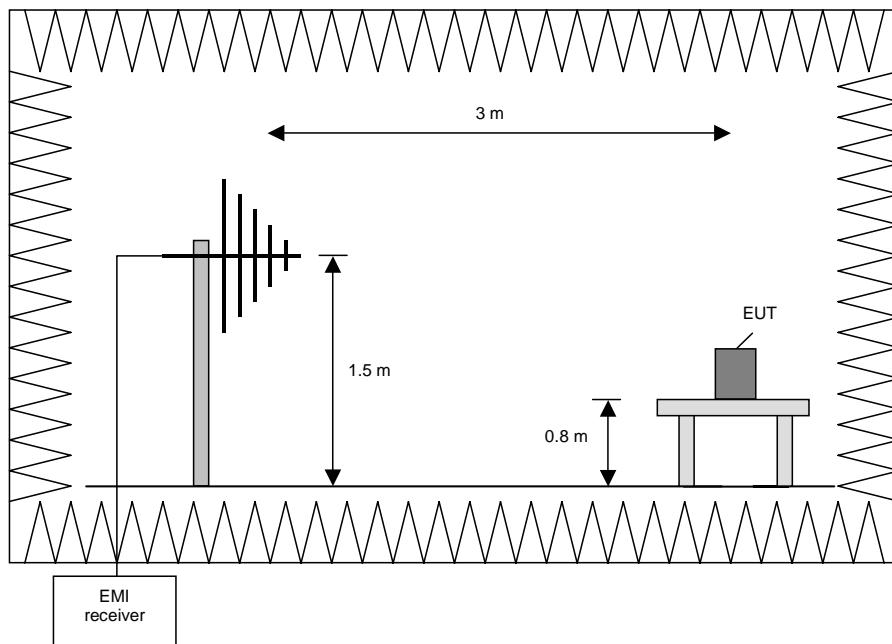
Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. 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 set up of the Equipment under test will be in accordance to ANSI C63.4-2009 [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 200 MHz | 100 kHz |
| 200 MHz to 1 GHz | 100 kHz |



Procedure preliminary measurement:

Prescans were performed in the frequency range 30 MHz to 200 MHz and 200 MHz to 1 GHz.

The following procedure will be used:

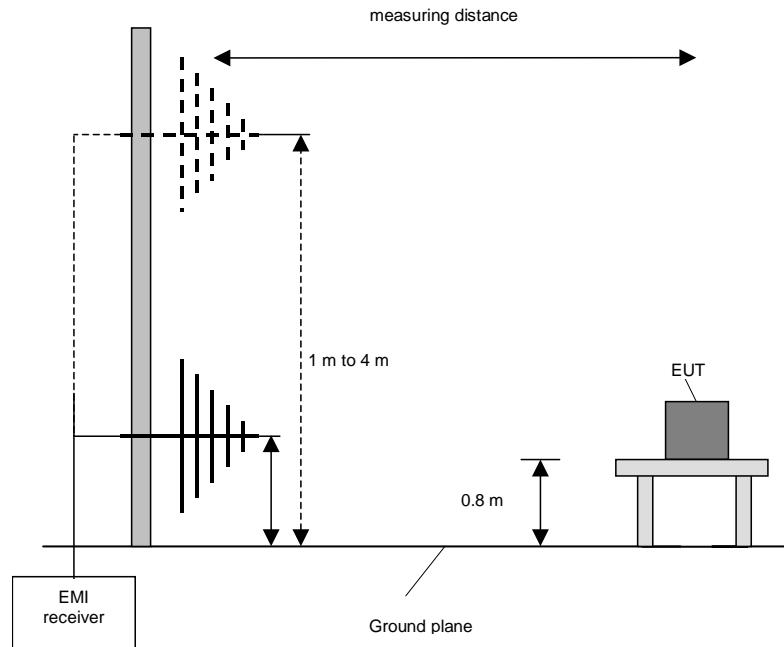
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Make a hardcopy of the spectrum.
5. Measure the frequency of the 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 (because of EUT is a module and might be used in a handheld equipment 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 (because of EUT is a module and might be used in a handheld equipment application).

Preliminary and final measurement (1 GHz to 110 GHz)

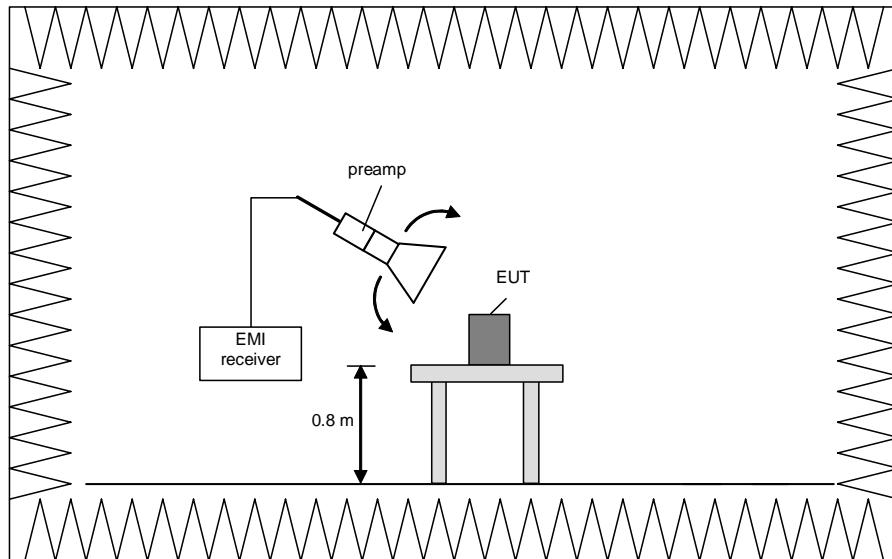
This measurement will be performed in a fully anechoic chamber. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The set up of the Equipment under test will be in accordance to ANSI C63.4-2009 [1].

Preliminary measurement (1 GHz to 110 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, the antenna close to the EUT and while moving the antenna over all sides of the EUT. With the spectrum analyser in CLEAR / WRITE mode the cone of the emission should be found and than the measuring distance will be set to 3 m with the receiving antenna moving in this cone of emission. At this position the final measurement will be carried out.

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 |

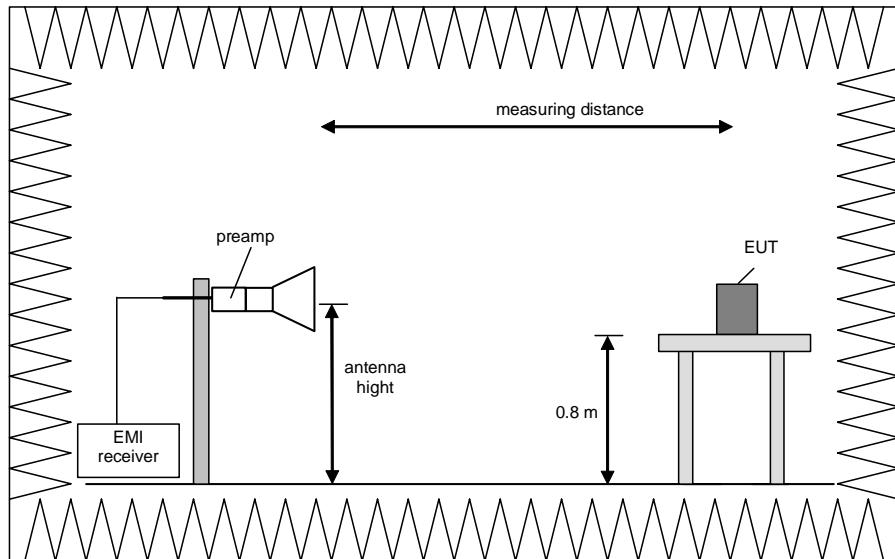


Final measurement (1 GHz to 110 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. 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 ° in order to have the antenna inside the cone of radiation.

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 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 26.5 GHz, 26.5 GHz to 40 GHz, 40 GHz to 60 GHz, 60 GHz to 75 GHz and 75 GHz to 110 GHz.

The following procedure will be used:

- 1) Monitor the frequency range at horizontal polarisation and move the antenna over all sides of the EUT (if necessary move the EUT to another orthogonal axis).
- 2) Change the antenna polarisation and repeat 1) with vertical polarisation.
- 3) Make a hardcopy of the spectrum.
- 4) Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
- 5) Change the analyser mode to Clear / Write and found the cone of emission.
- 6) Rotate and move the EUT, so that the measuring distance can be enlarged to 3 m and the antenna will be still inside the cone of emission.
- 7) Measure the level of the detected frequency with the correct resolution bandwidth, with the antenna polarisation and azimuth and the peak and average detector, which causes the maximum emission.
- 8) Repeat steps 1) to 7) for the next antenna spot if the EUT is larger than the antenna beamwidth.

Step 1) to 6) are defined as preliminary measurement.

5.6.2 Test results

5.6.2.1 Preliminary radiated emission measurement

| | | | |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 27 % |
|---------------------|-------|-------------------|------|

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.

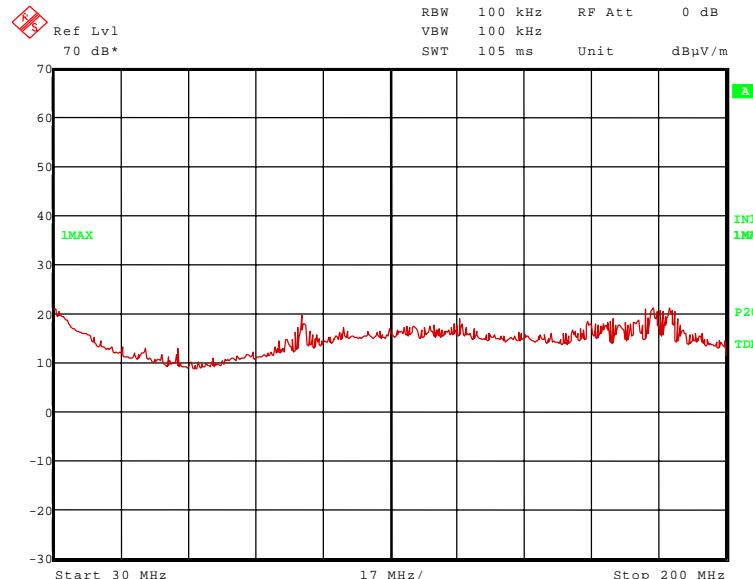
Test record: All results of the three positions are shown in the following.

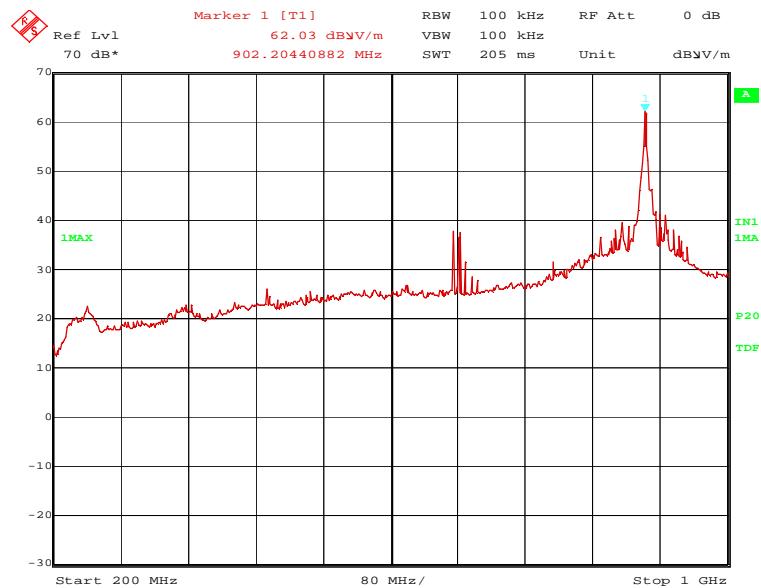
Supply voltage: During all measurements the EUT was supplied with 3.0 V DC by an external power supply.

Remark: As pre-tests have shown, the emissions in the frequency range 10 MHz to 30 MHz are not depending on the transmitter operation mode. Therefore the emissions in this frequency range were measured only with the transmitter operates in operation mode 2.

Transmitter operates at 902.5 MHz (operation mode 1)

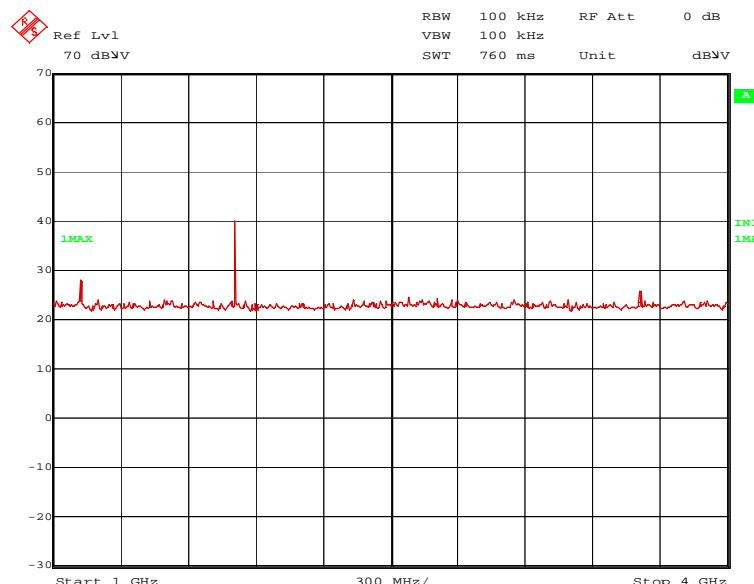
130413_2.wmf: Spurious emissions from 30 MHz to 200 MHz (operation mode 1):

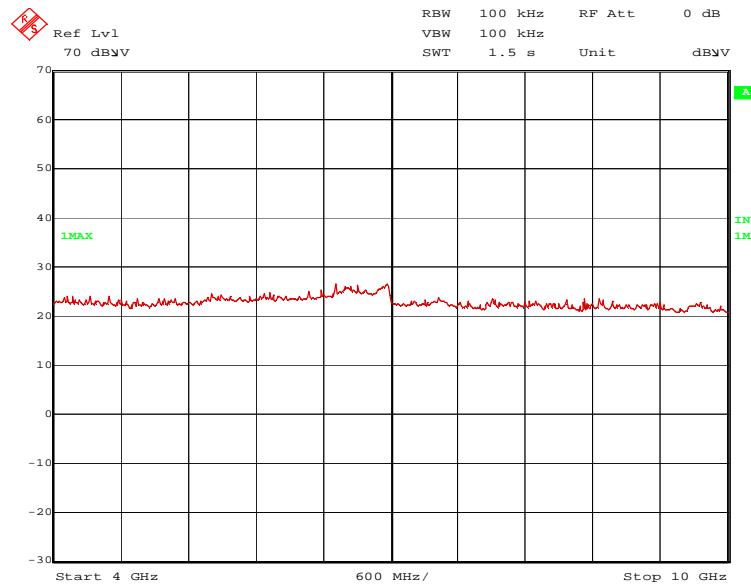


130413_1.wmf: Spurious emissions from 200 MHz to 1 GHz (operation mode 1, carrier notched):


| Frequencies found | Frequency in MHz |
|--------------------------|--|
| Outside restricted bands | 181.892, 183.755, 457.134, 673.941, 681.319, 878.873, 902.500, 915.738 |
| Inside restricted bands | None |

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

130413_19.wmf: Spurious emissions from 1 GHz to 4 GHz (operation mode 1):


130413_20.wmf: Spurious emissions from 4 GHz to 10 GHz (operation mode 1):


| Frequencies found | Frequency in MHz |
|--------------------------|--------------------|
| Outside restricted bands | 1805.000 |
| Inside restricted bands | 1123.690, 3610.000 |

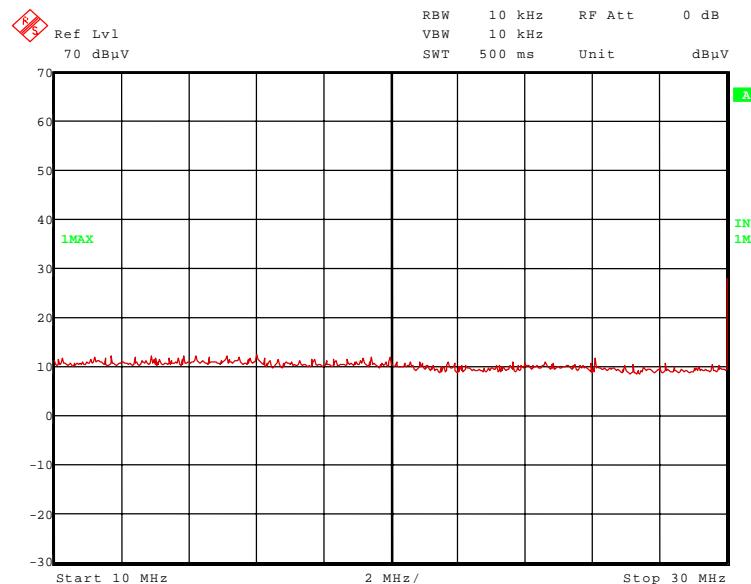
These frequencies have to be measured in a final measurement. The results were presented in the following.

TEST EQUIPMENT USED FOR THE TEST:

29, 31 - 36, 43, 44, 45, 49, 55, 73, 75, 83

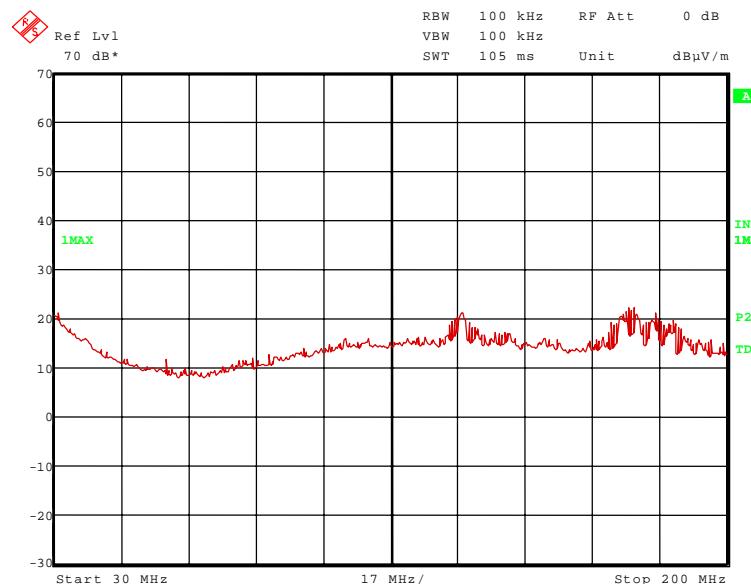
Transmitter operates at 914.975 MHz (operation mode 2)

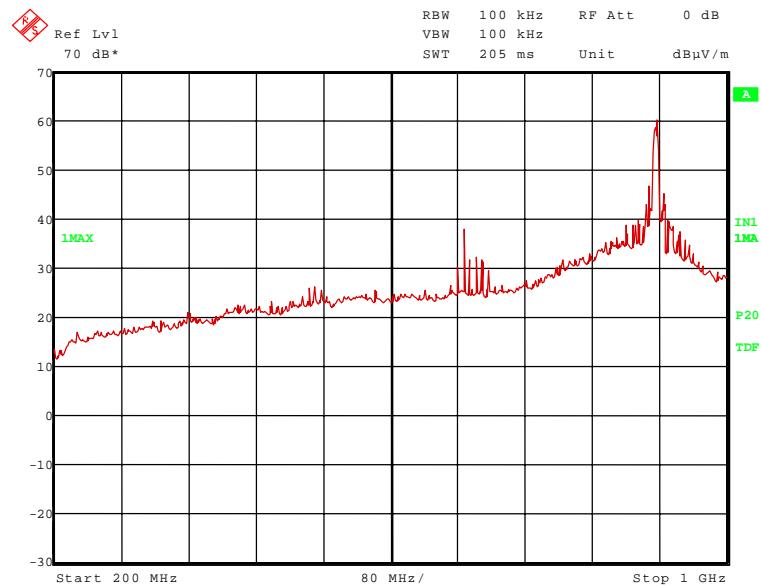
130413_14.wmf: Spurious emissions from 10 MHz to 30 MHz (operation mode 2):



No significant frequencies above the noise floor of the system were found during the preliminary radiated emission test, so no measurements were carried out on the outdoor test site.

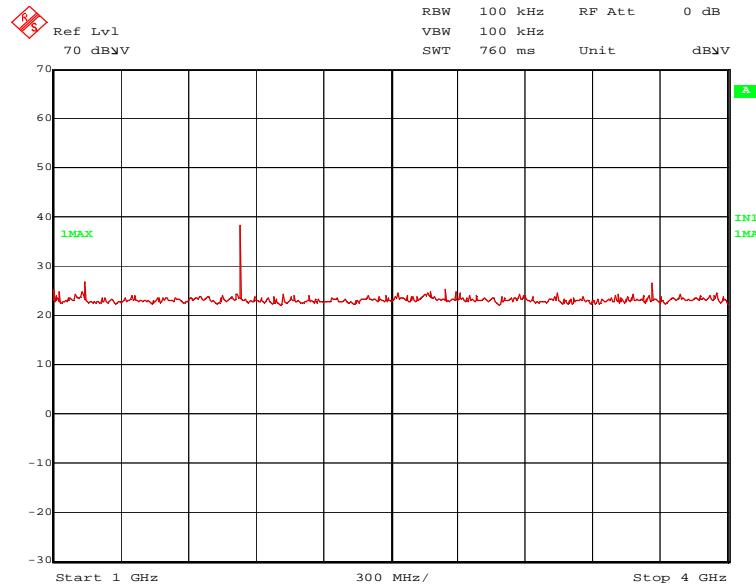
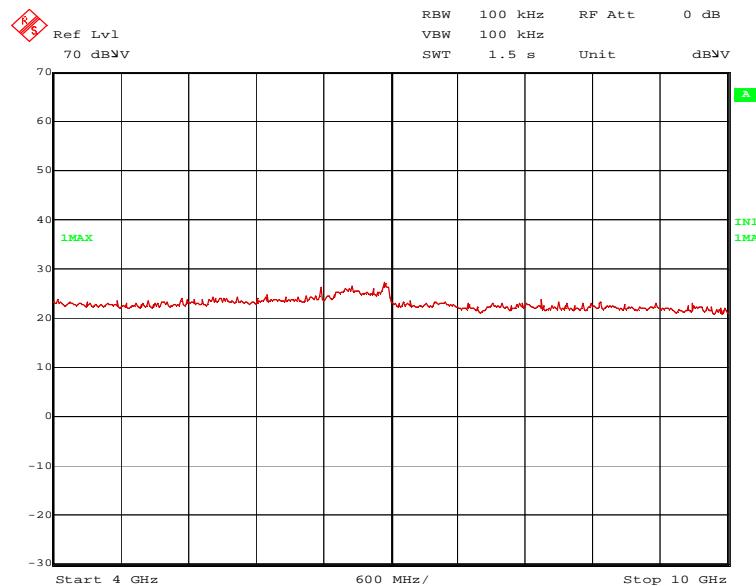
130413_13.wmf: Spurious emissions from 30 MHz to 200 MHz (operation mode 2):



130413_12.wmf: Spurious emissions from 200 MHz to 1 GHz (operation mode 2, carrier notched):


| Frequencies found | Frequency in MHz |
|--------------------------|---|
| Outside restricted bands | 181.360, 183.800, MHz, 686.500, 693.810, 701.230, 914.975 |
| Inside restricted bands | 132.345 |

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

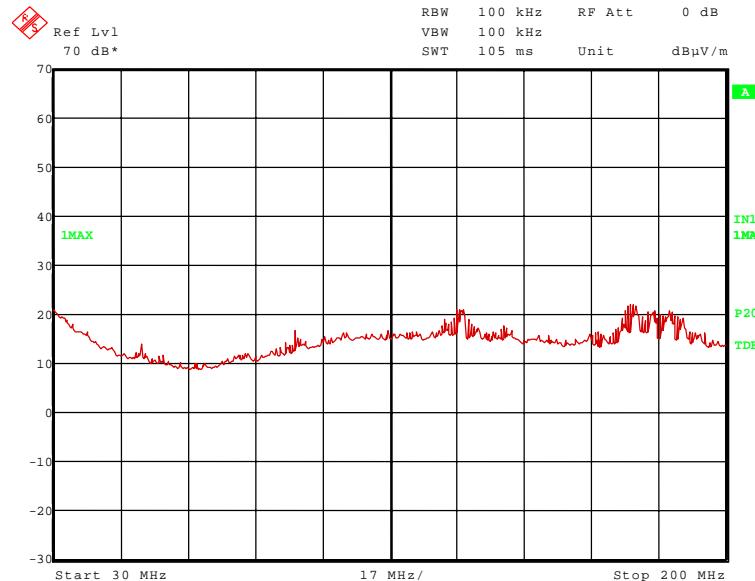
130413_15.wmf: Spurious emissions from 1 GHz to 4 GHz (operation mode 2):

130413_18.wmf: Spurious emissions from 4 GHz to 10 GHz (operation mode 2):


| Frequencies found | Frequency in MHz |
|--------------------------|--------------------|
| Outside restricted bands | 1829.950 |
| Inside restricted bands | 1137.435, 3659.900 |

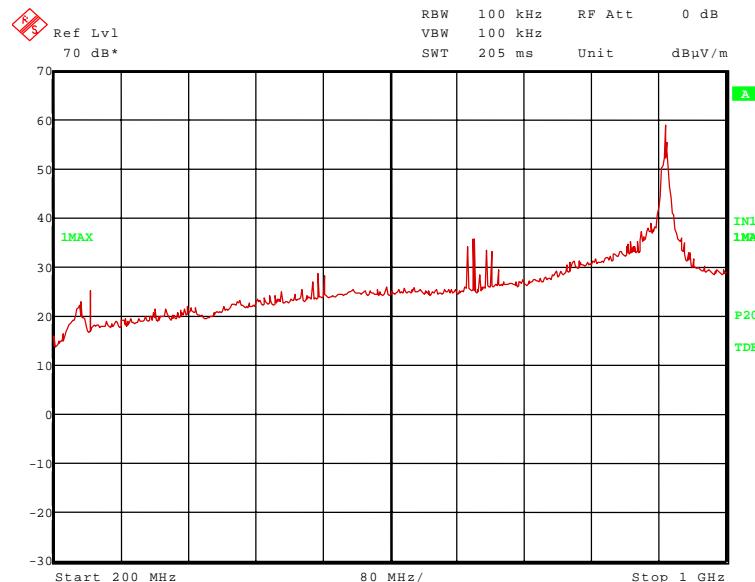
These frequencies have to be measured in a final measurement. The results were presented in the following.

Transmitter operates at 927.475 MHz (operation mode 3)

130413_8.wmf: Spurious emissions from 30 MHz to 200 MHz (operation mode 3):

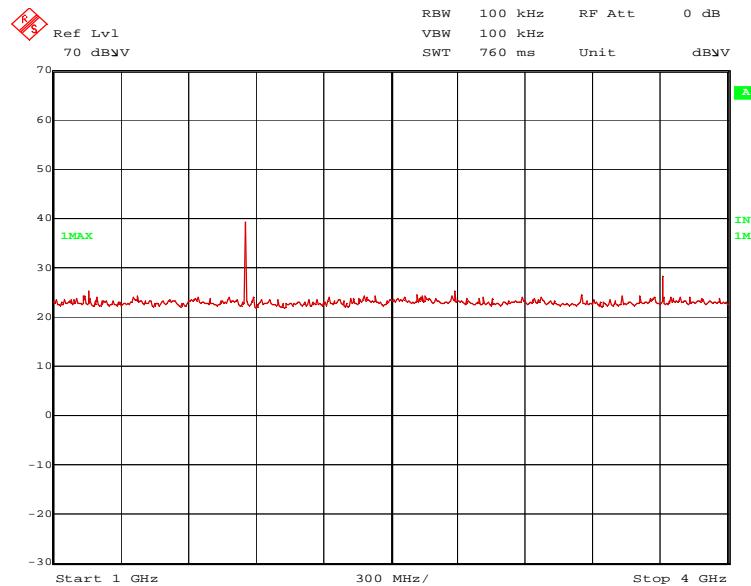
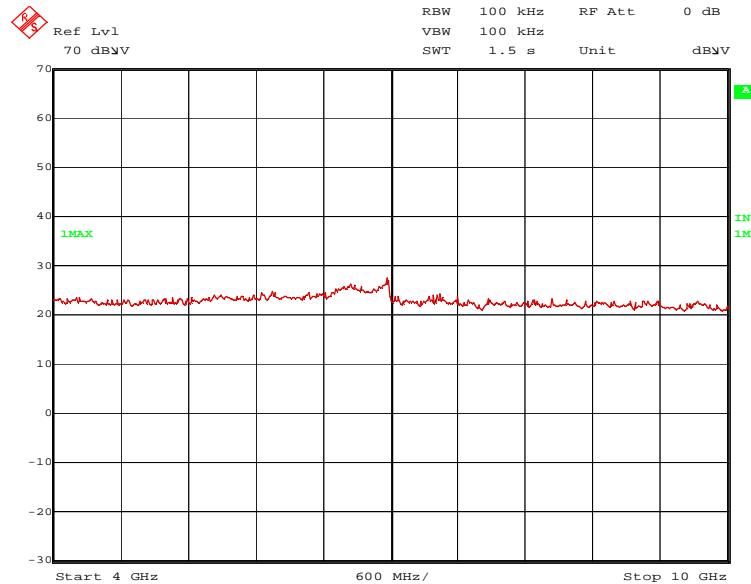


130413_7.wmf: Spurious emissions from 200 MHz to 1 GHz (operation mode 3, carrier notched):



| Frequencies found | Frequency in MHz |
|--------------------------|--|
| Outside restricted bands | 181.244, 228.909, 514.596, 691.548, 698.918, 927.475 |
| Inside restricted bands | 132.981, 244.866 |

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

130413_21.wmf: Spurious emissions from 1 GHz to 4 GHz (operation mode 3):

130413_22.wmf: Spurious emissions from 4 GHz to 10 GHz (operation mode 3):


| Frequencies found | Frequency in MHz |
|--------------------------|------------------|
| Outside restricted bands | 1854.950 |
| Inside restricted bands | 3709.900 |

These frequencies have to be measured in a final measurement. The results were presented in the following.

5.6.2.2 Final radiated emission measurement (30 MHz to 1 GHz) with internal antenna

| | | | |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 26 % |
|---------------------|-------|-------------------|------|

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: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied with 3 V_{DC} 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 1 second.

Transmitter operates at 902.5 MHz (operation mode 1)

Result measured with the quasi-peak detector:

| Transmitter operates on the lower end of the assigned frequency band (operation mode 1) | | | | | | | | | | |
|---|------------------------|-----------------------|--------------|------------------------|---------------------------|------------------|--------------|----------------|-------|------|
| Spurious emissions outside restricted bands | | | | | | | | | | |
| Frequency MHz | Result dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor dB/m | Cable loss dB | Height cm | Azimuth deg | Pol. | Pos. |
| 902.500 | 107.2 | - | - | 81.3 | 22.5 | 3.4 | 100.0 | 85.0 | Hor. | 1 |
| 181.892 | 17.9 | 87.2 | 69.3 | 7.1 | 9.3 | 1.5 | 100.0 | 37.0 | Vert. | 2 |
| 183.755 | 16.7 | 87.2 | 70.5 | 6.0 | 9.2 | 1.5 | 100.0 | 59.0 | Vert. | 3 |
| 457.134 | 25.2 | 87.2 | 62.0 | 6.1 | 16.7 | 2.4 | 176.0 | 153.0 | Hor. | 1 |
| 673.941 | 42.2 | 87.2 | 45.0 | 19.5 | 19.8 | 2.9 | 122.0 | 166.0 | Hor. | 3 |
| 681.319 | 41.7 | 87.2 | 45.5 | 19.0 | 19.8 | 2.9 | 114.0 | 164.0 | Hor. | 3 |
| 878.873 | 35.5 | 87.2 | 51.7 | 10.1 | 22.0 | 3.4 | 100.0 | 86.0 | Hor. | 1 |
| 915.738 | 37.3 | 87.2 | 49.9 | 11.0 | 22.9 | 3.4 | 100.0 | 86.0 | Hor. | 1 |
| Spurious emissions inside restricted bands | | | | | | | | | | |
| Frequency MHz | Result dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor dB/m | Cable loss dB | Height cm | Azimuth deg | Pol. | Pos. |
| - | - | - | - | - | - | - | - | - | - | - |

Measurement uncertainty: +2.2 dB / -3.6 dB

Transmitter operates at 914.975 MHz (operation mode 2)
Result measured with the quasi-peak detector:

| Transmitter operates on the lower end of the assigned frequency band (operation mode 1) | | | | | | | | | | |
|---|------------------------|-----------------------|--------------|------------------------|---------------------------|------------------|--------------|----------------|-------|------|
| Spurious emissions outside restricted bands | | | | | | | | | | |
| Frequency MHz | Result dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor dB/m | Cable loss dB | Height cm | Azimuth deg | Pol. | Pos. |
| 914.975 | 106.3 | | | 80.1 | 22.8 | 3.4 | 109.0 | 126.0 | Vert. | 2 |
| 181.360 | 23.1 | 86.3 | 63.2 | 12.3 | 9.3 | 1.5 | 100.0 | 225.0 | Vert. | 3 |
| 183.800 | 11.1 | 86.3 | 75.2 | 0.4 | 9.2 | 1.5 | 100.0 | 315.0 | Vert. | 1 |
| 686.500 | 35.1 | 86.3 | 51.2 | 12.2 | 19.9 | 3.0 | 114.0 | 164.0 | Hor. | 3 |
| 701.230 | 32.1 | 86.3 | 54.2 | 9.0 | 20.1 | 3.0 | 125.0 | 271.0 | Hor. | 1 |
| Spurious emissions inside restricted bands | | | | | | | | | | |
| Frequency MHz | Result dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor dB/m | Cable loss dB | Height cm | Azimuth deg | Pol. | Pos. |
| 132.345 | 29.3 | 43.5 | 14.2 | 15.9 | 12.1 | 1.3 | 175.0 | 138.0 | Vert. | 3 |

Measurement uncertainty: +2.2 dB / -3.6 dB

Transmitter operates at 927.475 MHz (operation mode 3)
Result measured with the quasi-peak detector:

| Transmitter operates on the lower end of the assigned frequency band (operation mode 1) | | | | | | | | | | |
|---|------------------------|-----------------------|--------------|------------------------|---------------------------|------------------|--------------|----------------|-------|------|
| Spurious emissions outside restricted bands | | | | | | | | | | |
| Frequency MHz | Result dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor dB/m | Cable loss dB | Height cm | Azimuth deg | Pol. | Pos. |
| 927.475 | 105.0 | - | - | 78.2 | 23.4 | 3.4 | 100.0 | 245.0 | Hor. | 1 |
| 181.244 | 17.1 | 85.0 | 67.9 | 6.3 | 9.3 | 1.5 | 100.0 | 180.0 | Vert. | 1 |
| 228.909 | 15.8 | 85.0 | 69.2 | 3.9 | 10.3 | 1.6 | 165.0 | 180.0 | Hor. | 1 |
| 514.596 | 37.2 | 85.0 | 47.8 | 17.0 | 17.6 | 2.6 | 172.0 | 90.0 | Hor. | 3 |
| 691.548 | 41.7 | 85.0 | 43.3 | 18.8 | 19.9 | 3.0 | 124.0 | 115.0 | Hor. | 1 |
| 698.918 | 44.3 | 85.0 | 40.7 | 21.3 | 20.0 | 3.0 | 122.0 | 116.0 | Hor. | 1 |
| Spurious emissions inside restricted bands | | | | | | | | | | |
| Frequency MHz | Result dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor dB/m | Cable loss dB | Height cm | Azimuth deg | Pol. | Pos. |
| 132.981 | 18.5 | 43.5 | 25.0 | 5.2 | 12.0 | 1.3 | 325.0 | 199.0 | Vert. | 3 |
| 244.866 | 21.4 | 46.0 | 24.6 | 7.9 | 11.8 | 1.7 | 134.0 | 109.0 | Vert. | 3 |

Measurement uncertainty: +2.2 dB / -3.6 dB

Test result: Passed.

TEST EQUIPMENT USED FOR THE TEST:

14 - 20

5.6.2.3 Final radiated emission measurement (1 GHz to 40 GHz) with internal antenna

| | | | |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 27 % |
|---------------------|-------|-------------------|------|

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: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied with 3 V_{DC} by an external power supply.

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

Transmitter operates at 902.5 MHz (operation mode 1)

Result measured with the peak detector:

| Frequency GHz | Corr. Value dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor 1/m | Preamp dB | Cable loss dB | Height cm | Pol. | Restr. Band | Pos. |
|--|-----------------------------|-----------------------|--------------|------------------------|--------------------------|--------------|---------------------|--------------|-------|----------------|------|
| 902.500 | 107.2 | - | - | 84.1 | 20.6 | 0.0 | 2.5 | 150 | Vert. | - | 3 |
| 1123.690 | 35.4 | 74.0 | 38.6 | 34.8 | 24.6 | 26.5 | 2.5 | 150 | Vert. | Yes | 3 |
| 1805.000 | 46.2 | 87.2 | 41.0 | 43.2 | 26.5 | 26.5 | 3.0 | 150 | Vert. | No | 3 |
| 3610.000 | 43.4 | 74.0 | 30.6 | 33.7 | 31.3 | 26.2 | 4.6 | 150 | Vert. | Yes | 3 |
| Measurement uncertainty: +2.2 dB / -3.6 dB | | | | | | | | | | | |

Result measured with the average detector:

| Frequency GHz | Corr. Value dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor 1/m | Preamp dB | Cable loss dB | Height cm | Pol. | Restr. Band | Pos. |
|--|-----------------------------|-----------------------|--------------|------------------------|--------------------------|--------------|---------------------|--------------|-------|----------------|------|
| 902.500 | 107.2 | - | - | 84.1 | 20.6 | 0.0 | 2.5 | 150 | Vert. | - | 3 |
| 1123.690 | 23.5 | 54.0 | 30.5 | 22.9 | 24.6 | 26.5 | 2.5 | 150 | Vert. | Yes | 3 |
| 1805.000 | 38.9 | 87.2 | 48.3 | 35.9 | 26.5 | 26.5 | 3.0 | 150 | Vert. | No | 3 |
| 3610.000 | 30.8 | 54.0 | 23.2 | 21.1 | 31.3 | 26.2 | 4.6 | 150 | Vert. | Yes | 3 |
| Measurement uncertainty: +2.2 dB / -3.6 dB | | | | | | | | | | | |

Transmitter operates at 914.975 MHz (operation mode 2)

Result measured with the peak detector:

| Frequency GHz | Corr. Value dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor 1/m | Preamp dB | Cable loss dB | Height cm | Pol. | Restr. Band | Pos. |
|--|-----------------------------|-----------------------|--------------|------------------------|--------------------------|--------------|---------------------|--------------|-------|----------------|------|
| 914.975 | 106.3 | - | - | 83.2 | 20.7 | 0.0 | 2.6 | 150 | Vert. | - | 3 |
| 1137.435 | 34.4 | 74.0 | 39.6 | 33.8 | 24.6 | 26.5 | 2.5 | 150 | Hor. | Yes | 3 |
| 1829.950 | 45.9 | 86.3 | 40.4 | 42.4 | 26.7 | 26.5 | 3.3 | 150 | Vert. | No | 3 |
| 3659.900 | 43.6 | 74.0 | 30.4 | 33.8 | 31.5 | 26.2 | 4.5 | 150 | Hor. | Yes | 3 |
| Measurement uncertainty: +2.2 dB / -3.6 dB | | | | | | | | | | | |

Result measured with the average detector:

| Frequency GHz | Corr. Value dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor 1/m | Preamp dB | Cable loss dB | Height cm | Pol. | Restr. Band | Pos. |
|--|-----------------------------|-----------------------|--------------|------------------------|--------------------------|--------------|---------------------|--------------|-------|----------------|------|
| 914.975 | 106.3 | - | - | 83.2 | 20.7 | 0.0 | 2.6 | 150 | Vert. | - | 3 |
| 1137.435 | 18.5 | 54.0 | 35.5 | 17.9 | 24.6 | 26.5 | 2.5 | 150 | Hor. | Yes | 3 |
| 1829.950 | 38.7 | 86.3 | 47.6 | 35.2 | 26.7 | 26.5 | 3.3 | 150 | Vert. | No | 3 |
| 3659.900 | 31.6 | 54.0 | 22.4 | 21.8 | 31.5 | 26.2 | 4.5 | 150 | Hor. | Yes | 3 |
| Measurement uncertainty: +2.2 dB / -3.6 dB | | | | | | | | | | | |

Transmitter operates at 927.475 MHz (operation mode 3)

Result measured with the peak detector:

| Frequency GHz | Corr. Value dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor 1/m | Preamp dB | Cable loss dB | Height cm | Pol. | Restr. Band | Pos. |
|--|-----------------------------|-----------------------|--------------|------------------------|--------------------------|--------------|---------------------|--------------|-------|----------------|------|
| 927.475 | 105.0 | - | - | 81.4 | 20.9 | 0.0 | 2.7 | 150 | Vert. | - | 3 |
| 1854.950 | 46.5 | 85.0 | 38.5 | 42.4 | 27.0 | 26.5 | 3.6 | 150 | Vert. | No | 3 |
| 3709.900 | 43.9 | 74.0 | 30.1 | 33.7 | 31.8 | 26.2 | 4.6 | 150 | Vert. | Yes | 3 |
| Measurement uncertainty: +2.2 dB / -3.6 dB | | | | | | | | | | | |

Result measured with the average detector:

| Frequency GHz | Corr. Value dB μ V/m | Limit dB μ V/m | Margin dB | Readings dB μ V | Antenna factor 1/m | Preamp dB | Cable loss dB | Height cm | Pol. | Restr. Band | Pos. |
|--|-----------------------------|-----------------------|--------------|------------------------|--------------------------|--------------|---------------------|--------------|-------|----------------|------|
| 927.475 | 105.0 | - | - | 81.4 | 20.9 | 0.0 | 2.7 | 150 | Vert. | - | 3 |
| 1854.950 | 39.0 | 85.0 | 46.0 | 34.9 | 27.0 | 26.5 | 3.6 | 150 | Vert. | No | 3 |
| 3709.900 | 32.4 | 54.0 | 21.6 | 22.2 | 31.8 | 26.2 | 4.6 | 150 | Vert. | Yes | 3 |
| Measurement uncertainty: +2.2 dB / -3.6 dB | | | | | | | | | | | |

Test result: Passed.

TEST EQUIPMENT USED FOR THE TEST:

29, 31 - 34, 36, 44, 45, 49, 73

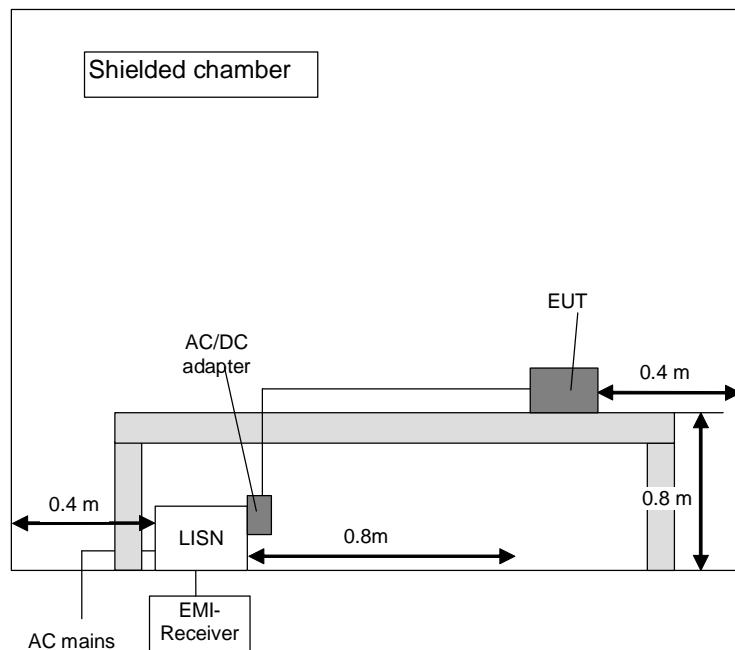
5.7 Conducted emissions on power supply lines (150 kHz to 30 MHz)

5.7.1 Method of measurement

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 0.8 m above the ground plane. Floor-standing devices will be placed directly on the ground plane. The set up of the Equipment under test will be in accordance to ANSI C63.4-2009 [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.

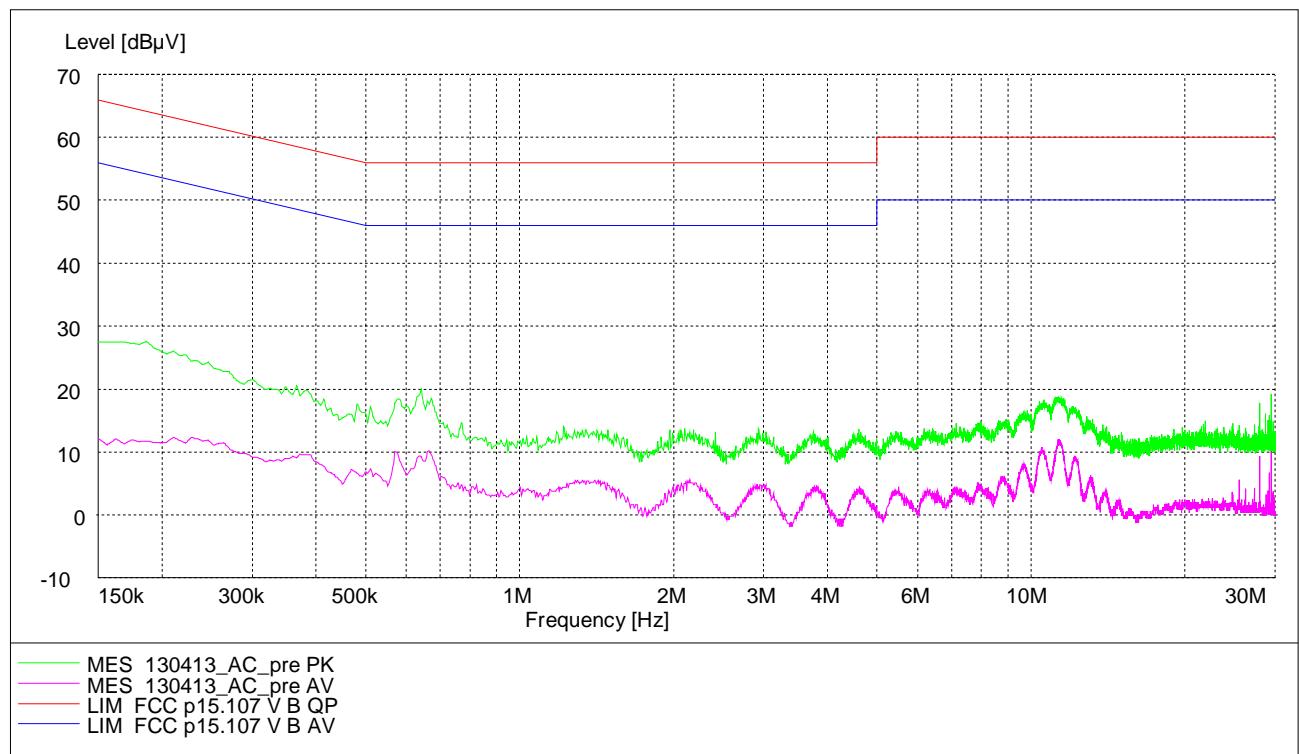
| Frequency range | Resolution bandwidth |
|-------------------|----------------------|
| 150 kHz to 30 MHz | 9 kHz |



5.7.2 Test results

| | | | |
|---------------------|-------|-------------------|------|
| Ambient temperature | 21 °C | Relative humidity | 26 % |
|---------------------|-------|-------------------|------|

- Position of EUT: The EUT was setup on a non-conducting table of a height of 0.8 m.
- Cable guide: The cables of the EUT were fixed on the non-conducting table. For further information of the cable guide refer to the pictures in annex A of this test report.
- Test record: All results are shown in the following. This test was carried out in
- Supply voltage: During all measurements the EUT was supplied with 3.0 V_{DC} by an AC / DC adaptor type FW3288, which was supplied by 120 V AC / 60 Hz.



Test result: Passed.

| |
|-----------------------------------|
| TEST EQUIPMENT USED FOR THE TEST: |
| 1 - 4, 20 |

6 TEST EQUIPMENT AND ANCILLARIES USED FOR TESTS

| No. | Test equipment | Type | Manufacturer | Serial No. | PM. No. | Cal. Date | Cal. due |
|-----|----------------------------|--------------------------|-----------------------------|-------------------|---------|--------------------------------------|----------|
| 1 | Shielded chamber M47 | - | Albatross Projects | B83117-C6439-T262 | 480662 | Weekly verification (system cal.) | |
| 2 | EMI Receiver | ESIB 26 | Rohde & Schwarz | 1088.7490 | 481182 | 03/09/2012 | 03/2014 |
| 3 | LISN | NSLK8128 | Schwarzbeck | 8128161 | 480138 | 12/20/2012 | 12/2013 |
| 4 | High pass filter | HR 0.13-5ENN | FSY Microwave Inc. | DC 0109 SN 002 | 480340 | Weekly verification (system cal.) | |
| 14 | Open area test site | - | Phoenix Test-Lab | - | 480085 | Weekly verification (system cal.) | |
| 15 | Measuring receiver | ESIB7 | Rohde & Schwarz | 100304 | 480521 | 02/15/2012 | 02/2014 |
| 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 | | |
| 20 | EMI Software | ES-K1 | Rohde & Schwarz | - | 480111 | - | - |
| 29 | Fully anechoic chamber M20 | - | Albatross Projects | B83107-E2439-T232 | 480303 | Weekly verification (system cal.) | |
| 30 | Spectrum analyser | FSU | Rohde & Schwarz | 200125 | 480956 | 02/15/2012 | 02/2014 |
| 31 | Measuring receiver | ESI 40 | Rohde & Schwarz | 100064 | 480355 | 02/13/2012 | 02/2014 |
| 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 | 04/21/2011 | 04/2014 |
| 36 | Antenna | 3115 B | EMCO | 9609-4922 | 480184 | 09/28/2011 | 09/2014 |
| 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.) | |
| 55 | Loop antenna | HFH2-Z2 | Rohde & Schwarz | 832609/014 | 480059 | 02/16/2012 | 02/2014 |
| 73 | High Pass Filter | WHJS1000C 11/60EF | Wainwright Instruments GmbH | 1 | 480413 | Weekly verification (system cal.) | |
| 75 | High Pass Filter | WHKX4.0/18 G-8SS | Wainwright Instruments GmbH | 1 | 480587 | Weekly verification (system cal.) | |
| 83 | Tunable Notch Filter | WRCA800/90 0-0.2/40-6EEK | Wainwright Instruments GmbH | 15 | 480414 | Weekly verification (system cal.) | |

7 REPORT HISTORY

| Report Number | Date | Comment |
|---------------|---------------|------------------|
| F130413E1 | 10 April 2013 | Document created |
| | | |

8 LIST OF ANNEXES

ANNEX A TEST SETUP PHOTOS 10 pages

| | |
|---------------|--|
| 130413_1.jpg | Test setup fully anechoic chamber (Position 1) |
| 130413_2.jpg | Test setup fully anechoic chamber (Position 2) |
| 130413_3.jpg | Test setup fully anechoic chamber (Position 3) |
| 130413_4.jpg | Test setup fully anechoic chamber |
| 130413_5.jpg | Test setup fully anechoic chamber |
| 130413_6.jpg | Test setup fully anechoic chamber |
| 130413_7.jpg | Test setup open area test site (Position 1) |
| 130413_8.jpg | Test setup open area test site (Position 2) |
| 130413_9.jpg | Test setup open area test site (Position 3) |
| 130413_15.jpg | Test setup shielded chamber |

ANNEX B INTERNAL PHOTOS 6 pages

| | |
|---------------|---|
| 130413_10.jpg | H153V2, 3D view 1 |
| 130413_11.jpg | H153V2, 3D view 2 |
| 130413_12.jpg | H153V2, PCB bottom and type plate view |
| 130413_13.jpg | Supply and programming PCB connected to H153V2, bottom view |
| 130413_14.jpg | Ancillary programmer (connected to programming PCB) |
| 130413_15.jpg | H153V2, shielding removed |