



PHOENIX
TESTLAB

Königswinkel 10

32825 Blomberg

Germany

Phone: +49 (0) 52 35 95 00-0

Fax: +49 (0) 52 35 95 00-10

Test Report

Report Number: F114368E1

Applicant:

Phoenix Contact GmbH & Co. KG

Manufacturer:

Phoenix Contact GmbH & Co. KG

Equipment under Test (EUT):

RB-TW-2400

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 (August 2011)** 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
- [6] **Publication Number 913591 (March 2007)** Measurement of radiated emissions at the edge of the band for a Part 15 RF Device

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		08 August 2012
	Name	Signature	Date
Authorized reviewer:	Thomas KÜHN		08 August 2012
	Name	Signature	Date

RESERVATION

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1 IDENTIFICATION

1.1 Applicant

Name:	PHOENIX CONTACT GmbH & Co. KG
Address:	Flachsmarktstr. 8 32825 Blomberg
Country:	Germany
Name for contact purposes:	Mr. Maik STEMME
Phone:	+49 52 81 – 946 – 33 81
Fax:	+49 52 81 – 946 – 3299
eMail Address:	mstemme@phoenixcontact.com
Applicant represented during the test by the following person:	Mr. Maik STEMME

1.2 Manufacturer

Name:	PHOENIX CONTACT GmbH & Co. KG
Address:	Flachsmarktstr. 8 32825 Blomberg
Country:	Germany
Name for contact purposes:	Mr. Maik STEMME
Phone:	+49 52 81 – 946 – 33 81
Fax:	+49 52 81 – 946 – 3299
eMail Address:	mstemme@phoenixcontact.com
Applicant represented during the test by the following person:	Mr. Maik STEMME

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)

Equipment under test: *	Short Range Device transceiver for automation applications
Model name: *	RB-TW-2400
FCC ID: *	YG3RAD2400A
IC: *	4720B-RAD2400A
Serial number: *	None
PCB identifier: *	9054212_01
Hardware version: *	01
Software version: *	062

1.5 Technical data of equipment

Channel 0 (RF band 1) ¹	RX:	2402.000 MHz	TX:	2402.000 MHz
Channel 29 (RF band 1) ¹	RX:	2440.290 MHz	TX:	2440.290 MHz
Channel 57 (RF band 8) ¹	RX:	2479.410 MHz	TX:	2479.410 MHz

Adaptive frequency hopping: ²	Yes					
Antenna types: ²	External					
Antenna gain: ²	Refer table below					
Antenna connector: ²	Hirose U.FL					
Power supply: ²	U _{nom} =	5.0 V DC	U _{min} =	3.7 V DC	U _{max} =	6.0 V DC
Type of modulation: ²	MSK / 2FSK					
Data rate of transmitter: ²	16, 125 or 250 kBaud (2FSK-modulation), 500 kBaud (MSK-modulation)					
Operating frequency range: ²	2402.000 MHz to 2479.410 MHz					
Number of channels: ²	55 ¹					
Temperature range: ²	-40 °C to +80 °C					
Lowest / highest Internal clock frequency: ²	16 MHz, 26 MHz					

¹) Refer to clause 2 of this report.

²) declared by the applicant.

The following external I/O cables were used:

Identification	Connector		Length
	EUT	Ancillary	
DC in (carrier board)	2 pole terminal block	-	2 m *
-	-	-	-

*: Length during the test if no other specified.

Used antennas:

Antenna name	Manufacturer	Antenna Type	Cable length / connector	Gain [dBi] *
RAD-ISM-2400-ANT-OMNI-2-1-RSMA	Phoenix Contact	Monopole	1.50 m / RSMA	2.0
RAD-ISM-2400-ANT-VAN-3-0-RSMA	Phoenix Contact	Patch antenna	1.50 m / RSMA	3.0
RAD-ISM-2459-ANT-FOOD-6-0	Phoenix Contact	Patch antenna	1.0 m / N	6.0
RAD-ISM-2400-ANT-OMNI-6-0	Phoenix Contact	Monopole	-- / N	6.0
RAD-ISM-2400-ANT-OMNI-6-0-SW	Phoenix Contact	Monopole	-- / N	6.0
RAD-ISM-2400-ANT-OMNI-9-0	Phoenix Contact	Monopole	-- / N	9.0
RAD-ISM-2400-ANT-PAN-8-0	Phoenix Contact	Patch antenna	-- / SMA	8.0

*: declared by the applicant (including cable attenuation)

1.6 Dates

Date of receipt of test sample:	16 November 2011
Start of test:	16 November 2011
End of test:	20 February 2012

2 OPERATIONAL STATES

The EUT is intended to be used in several automation applications. Because the EUT is a module, which will be implemented in a final application, it was mounted on a carrier board to connect the power supply and change the operation modes of the EUT from a Laptop with test software.

The tests were carried out with an unmodified sample marked with DUT2.

During the tests the test sample was powered with 5.0 V DC via the carrier board 9782052_01.

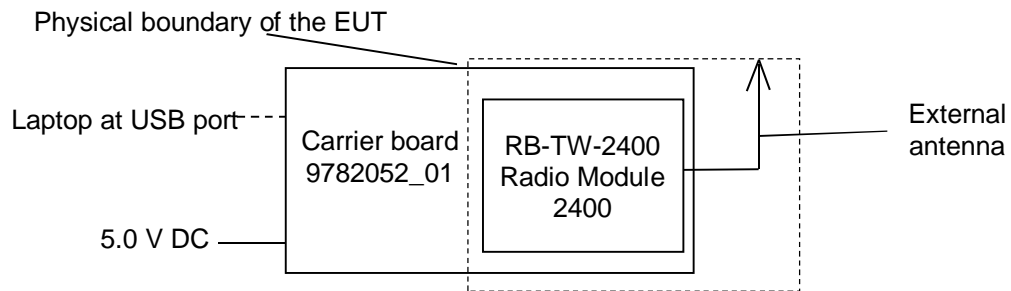
For all transmitter tests a power setting of 18 was used.

For selecting an operation mode, a personal computer with software delivered by the applicant was connected to the carrier board. After adjusting the operating mode, the personal computer was removed.

The EUT can be set to operate in 8 RF bands. The frequencies are shifted by 165 kHz from the lower to the higher band. The each band has 58 channels, for each used RF band 3 frequencies are not used for transmitting which results in usable 55 hopping channels. Therefore the lowest frequency used is 2402 MHz (channel 1 in RF band 1) and the highest frequency used is 2479.410 MHz (channel 58 in RF band 8).

The following operation modes were used during the tests:

Operation mode	Description of the operation mode	Modulation	Data rate [kBaud]
1	Continuous transmitting on 2402.000 MHz	2FSK	16
1a			125
1b		MSK	250
1c			500
2	Continuous transmitting on 2440.290 MHz	2FSK	16
2a			125
2b		MSK	250
2c			500
3	Continuous transmitting on 2479.410 MHz	2FSK	16
3a			125
3b		MSK	250
3c			500
4	Transmitter hopping on all channels	2FSK	16
4a			125
4b		MSK	250
4c			500
5	Continuous receiving on 2440.290 MHz		



Preliminary tests were performed in different data rates and different orthogonal directions, to find worst-case configuration and position. The data rate shown in the table below shows the found worst-case rate with respect to specific test item. The following table shows a list of the test modes used for the results, documented in this report. The radiated emission measurement was carried out in the orthogonal direction that emits the highest spurious emission levels.

The 3 orthogonal axes were defined as Pos. 1: EUT standing vertical on the longer side (of the carrier board), Pos. 2: EUT standing vertical on the shorter side (of the carrier board) and Pos. 3: EUT lying flat.

The following test modes were adjusted during the tests:

Test items	Operation mode
20 dB bandwidth	4c (500 kBaud)
Carrier frequency separation	4c (500 kBaud)
Number of hopping channels	4c (500 kBaud)
Dwell time	2, 2a, 2b, 2c (500, 250, 125 and 16 kBaud)
Maximum peak output power	1b, 2b, 3b (250 kBaud)
Band edge compliance	1c, 3c (500 kBaud)
Transmitter radiated emissions	1c, 2c, 3c (500 kBaud)
Conducted emissions on supply line	4c (500 kBaud)

3 ADDITIONAL INFORMATION

During the tests the EUT was not labelled with a label which fulfils the FCC / IC requirements. The measurements were carried out with a monopole antenna with the highest gain, as well as with a patch antenna with the highest gain. These measurements represent the worst case for both types of antennas.

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 to page
20 dB bandwidth	General	15.247 (a) (1)	A8.1 (a) [4]	Passed	10 et seq.
Carrier frequency separation	General	15.247 (a) (1)	A8.1 (b) [4]	Passed	13 et seq.
Number of hopping channels	2400.0 - 2483.5	15.247 (a) (1) (iii)	A8.1 (c) [4]	Passed	16 et seq.
Dwell time	2400.0 - 2483.5	15.247 (a) (1) (iii)	A8.1 (d) [4]	Passed	18 et seq.
Maximum peak output power	2400.0 - 2483.5	15.247 (b) (1)	A8.4 (2) [4]	Passed	22 et seq.
Band edge compliance	2400.0 - 2483.5	15.247 (d)	A8.5 [4]	Passed	25 et seq.
Radiated emissions (transmitter)	0.009 - 25,000	15.205 (a) 15.209 (a)	A8.5 [4] 2.5 [4]	Passed	34 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	7.2.2 [5]	Passed	63 et. seq.
Radiated emissions (receiver)	0.009 - 25,000	15.109 (a)	6 [5]	Passed	Annex C

5 TEST RESULTS

5.1 20 dB bandwidth

5.1.1 Method of measurement (20 dB 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. The EUT has to be switched on and the hopping function has to be disabled, the transmitter shall work with its maximum data rate.

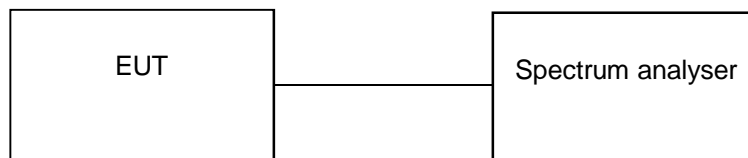
The following spectrum analyser settings shall be used:

- 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.

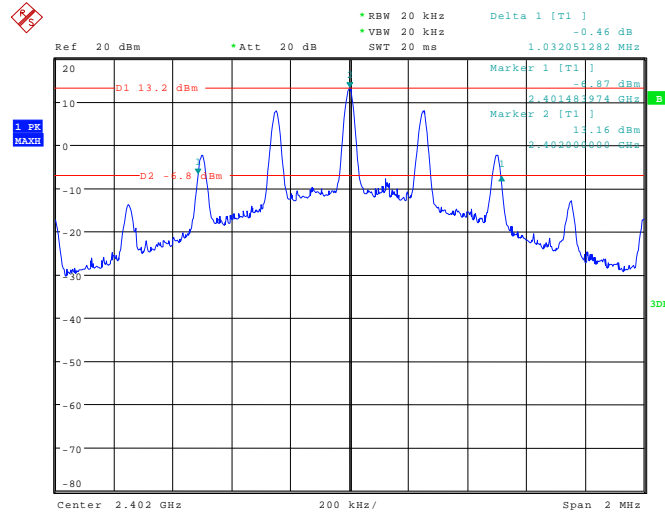
Test set-up:



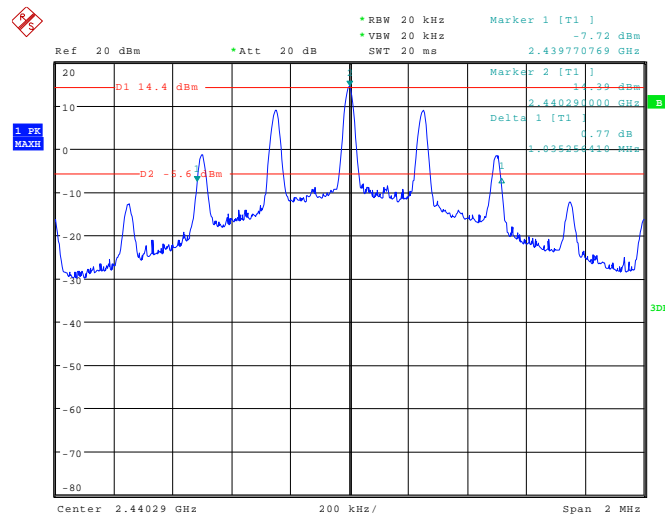
5.1.2 Test results (20 dB bandwidth)

Ambient temperature	20 °C	Relative humidity	27 %
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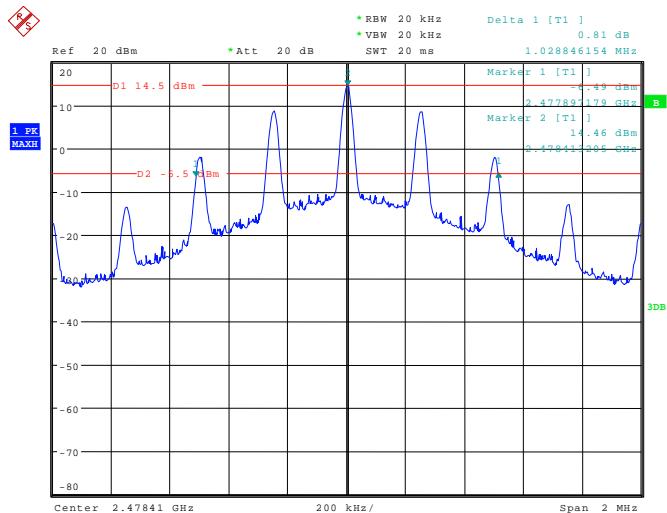
114368_50.wmf: 20 dB bandwidth at the lower end of the assigned frequency band:



114368_51.wmf: 20 dB bandwidth at the middle of the assigned frequency band:



114368_52.wmf: 20 dB bandwidth at the upper end of the assigned frequency band:



Operation mode: 1c, 2c, 3c (worst case) for 20 dB bandwidth

Channel number	Channel frequency [MHz]	20 dB bandwidth [kHz]
0 (RF band 1)	2402.000	1032.051
29 (RF band 1)	2440.290	1035.256
57 (RF band 8)	2479.410	1028.846
Measurement uncertainty		$<10^{-7}$

TEST EQUIPMENT USED FOR THE TEST:

165

5.2 Carrier frequency separation

5.2.1 Method of measurement (carrier frequency separation)

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.

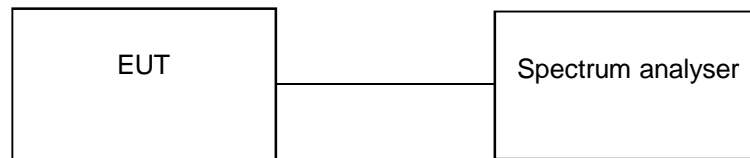
The following spectrum analyser settings shall be used:

- 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.

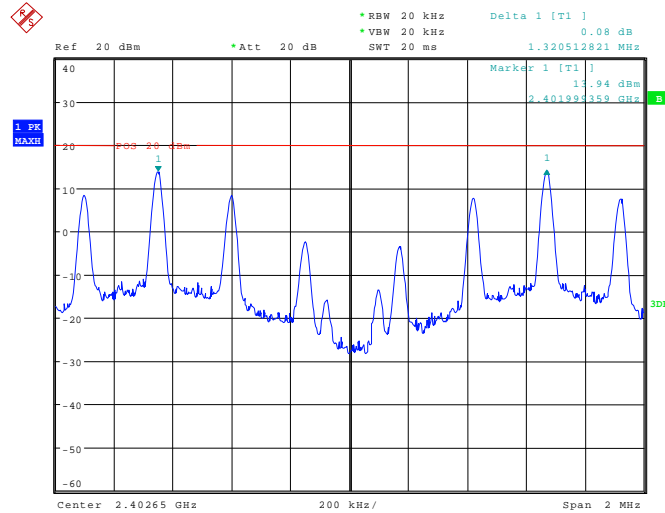
Test set-up:



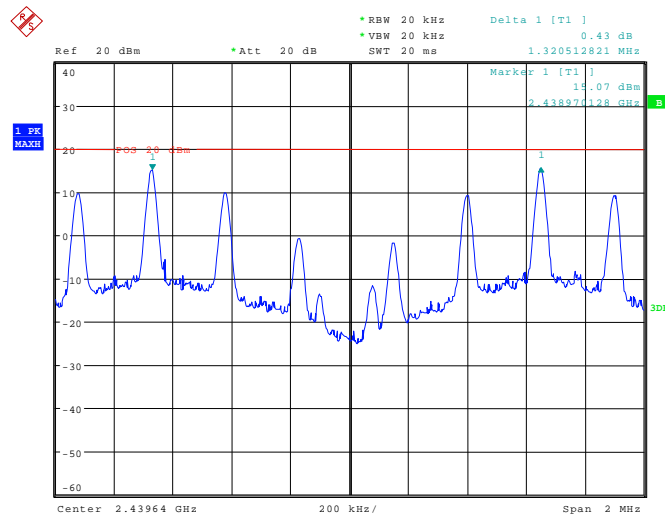
5.2.2 Test results (carrier frequency separation)

Ambient temperature	20 °C	Relative humidity	27 %
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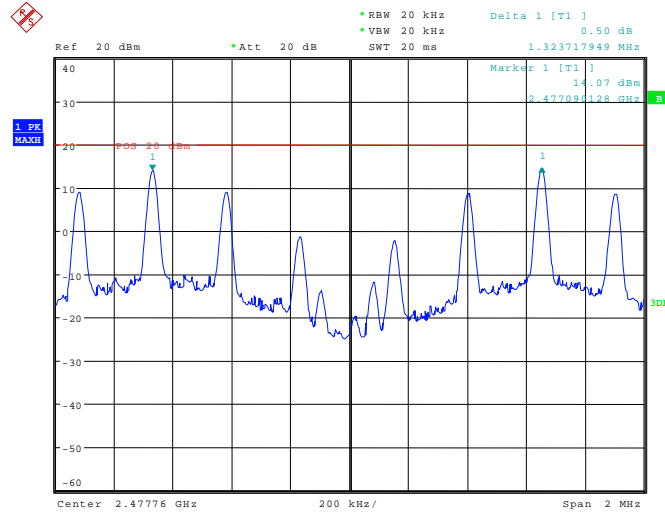
114368_53.wmf: Channel separation at the lower end of the assigned frequency band:



114368_54.wmf: Channel separation at the middle of the assigned frequency band:



114368_55.wmf: Channel separation at the upper end of the assigned frequency band:



Channel number	Channel frequency [MHz]	Channel separation [kHz]	Minimum limit [kHz]
Operation mode 4			
0 (RF band 1)	2402.000	1320.513	688.034 ($2/3$ of the 20 dB bandwidth)
29 (RF band 1)	2440.290	1320.513	690.171 ($2/3$ of the 20 dB bandwidth)
57 (RF band 8)	2479.410	1323.718	685.897 ($2/3$ of the 20 dB bandwidth)
Measurement uncertainty			$<10^{-7}$

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

165

5.3 Number of hopping frequencies

5.3.1 Method of measurement (number of hopping frequencies)

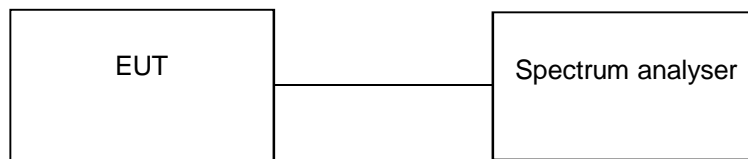
The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT 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.

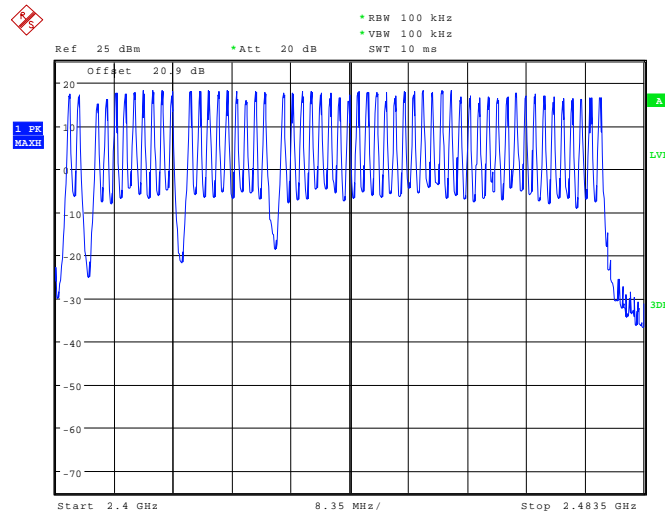
Test set-up:



5.3.2 Test results (number of hopping frequencies)

Ambient temperature	20 °C	Relative humidity	27 %
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114368_46.wmf: Number of hopping channels (RF band 1):



Number of hopping channels	Limit
55	At least 15

TEST EQUIPMENT USED FOR THE TEST:

165

5.4 Dwell time

5.4.1 Method of measurement (dwell time)

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:

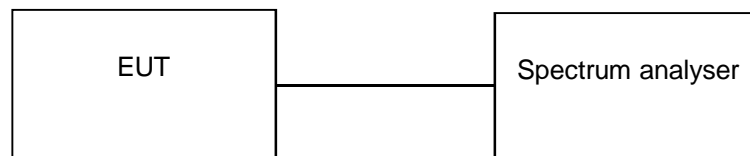
- Span: Zero, centred on a hopping channel.
- Resolution bandwidth: 1 MHz.
- Video bandwidth: \geq the resolution bandwidth.
- Sweep: As necessary to capture the entire dwell time per hopping channel.
- Detector function: peak.
- Trace mode: Max hold.

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 upper and lower end and 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.

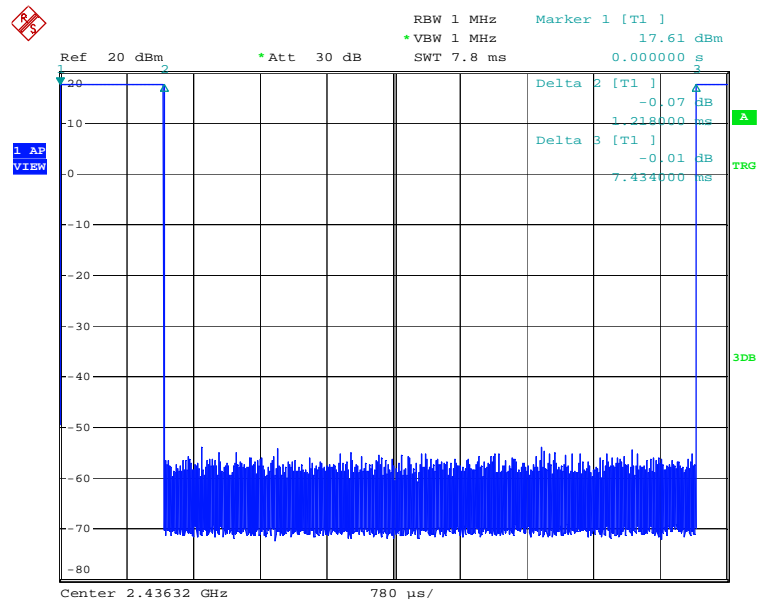
Test set-up:



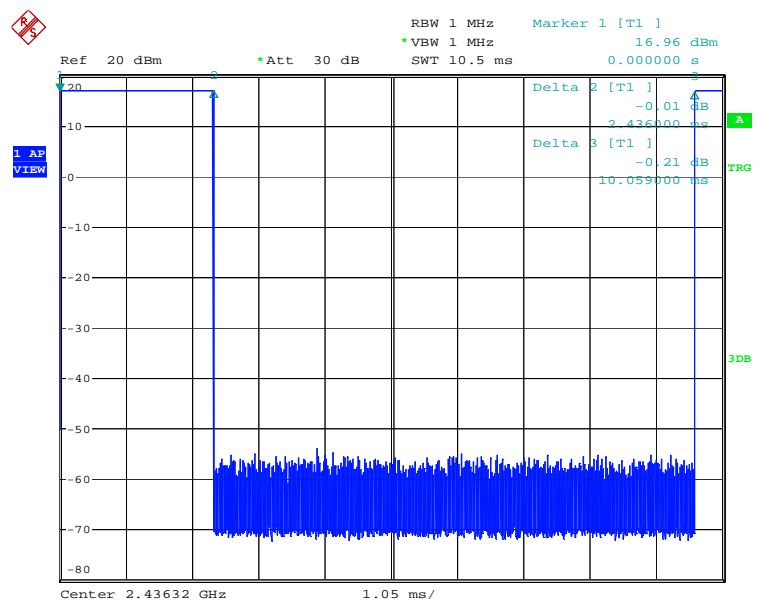
5.4.2 Test results (dwell time)

Ambient temperature	20 °C	Relative humidity	27 %
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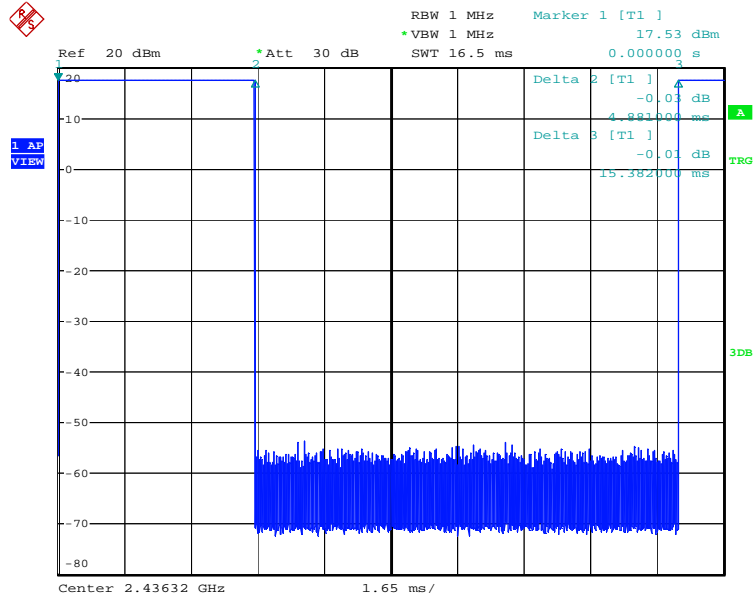
114368_dwell1.wmf: Dwell time at the middle of the assigned frequency band (operation mode 2):



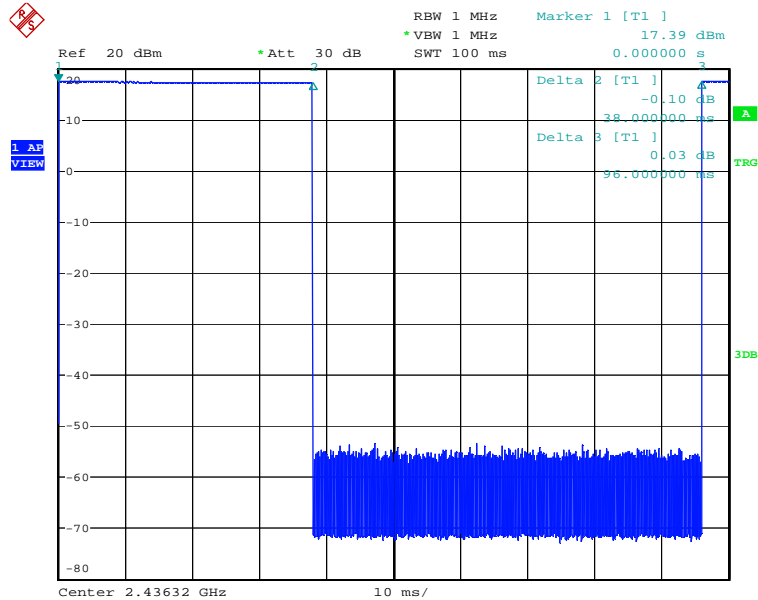
114368_dwell2.wmf: Dwell time at the middle of the assigned frequency band (operation mode 2a):



114368_dwell3.wmf: Dwell time at the middle of the assigned frequency band (operation mode 2b):



114368_dwell4.wmf: Dwell time at the middle of the assigned frequency band (operation mode 2c):



The dwell time is calculated with the following formula:

$$Dwell\ time = \frac{t_{pulse} * n_{hops}}{number\ of\ hopping\ channels} * 0.4\ s * number\ of\ hopping\ channels$$

$$Dwell\ time = t_{pulse} * n_{hops} * 0.4\ s$$

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].

Operation mode 2 (Data rate: 500 kBaud, n_{hops} : 134.517, number of hopping channels: 55)				
Channel number	Channel frequency [MHz]	t_{pulse} [ms]	Dwell time [ms]	Limit [ms]
25	2436.32	38.000	327.15	400
Operation mode 2a (Data rate 250 kBaud, n_{hops} : 99.414, number of hopping channels: 55)				
Channel number	Channel frequency [MHz]	t_{pulse} [ms]	Dwell time [ms]	Limit [ms]
25	2436.32	4.881	262.25	400
Operation mode 2b (Data rate: 125 kBaud, n_{hops} : 65.011, number of hopping channels: 55)				
Channel number	Channel frequency [MHz]	t_{pulse} [ms]	Dwell time [ms]	Limit [ms]
25	2436.32	2.436	200.14	400
Operation mode 2c (Data rate: 16 kBaud, n_{hops} : 10.417, number of hopping channels: 55)				
Channel number	Channel frequency [MHz]	t_{pulse} [ms]	Dwell time [ms]	Limit [ms]
25	2436.32	1.218	135.41	400
Measurement uncertainty			<10 ⁻⁷	

Test result:

Passed

TEST EQUIPMENT USED FOR THE TEST:

165

5.5 Maximum peak output power

5.5.1 Method of measurement (maximum peak output power)

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.

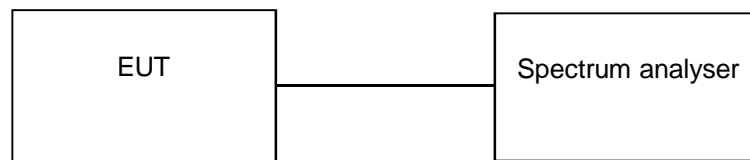
The following spectrum analyser settings shall be used:

- 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.

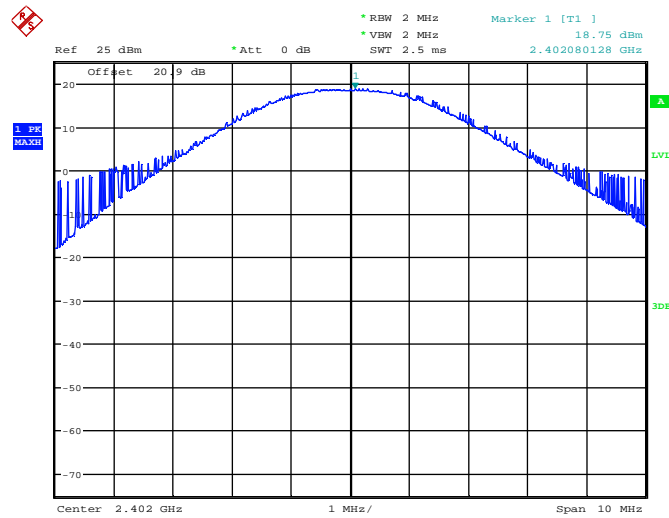
Test set-up:



5.5.2 Test results (maximum peak output power)

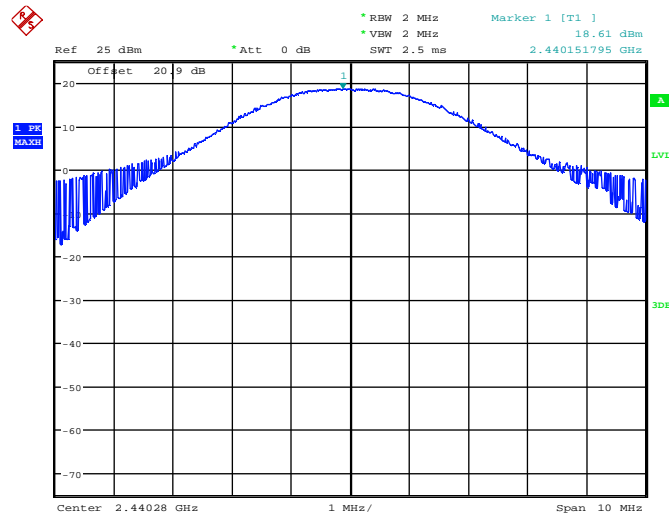
Ambient temperature	20 °C	Relative humidity	27 %
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114368_47.wmf: Maximum peak output power at the lower end of the assigned frequency band (operation mode 1):



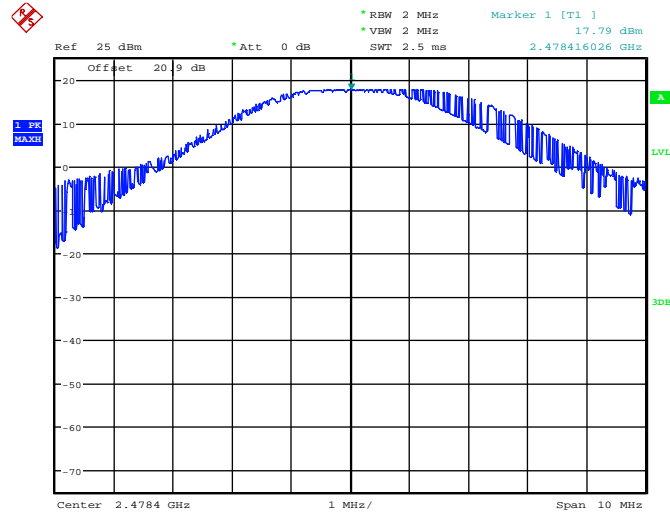
Date: 12.DEC.2011 13:45:31

114368_48.wmf: Maximum peak output power at the middle of the assigned frequency band (operation mode 2):



Date: 12.DEC.2011 13:51:22

114368_49.wmf: Maximum peak output power at the upper end of the assigned frequency band (operation mode 3):



Date: 12.DEC.2011 13:56:32

Operation mode	Channel number	Channel frequency [MHz]	Maximum peak output power [dBm]	Antenna gain max. [dBi]	Peak power limit [dBm]
1	0	2402.080128	18.75	9.0	27
2	29	2440.151795	18.61	9.0	27
3	57	2478.416026	17.79	9.0	27
Measurement uncertainty				+0.66 dB / -0.72 dB	

These values represent the worst case operation mode.

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

165

5.6 Band-edge compliance

5.6.1 Method of measurement (band-edge compliance (radiated))

The same test set-up as used for the final radiated emission measurement shall be used (refer also subclause 5.2.1 of this test report). 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 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 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 upper end of the assigned frequency band and with hopping on and off.

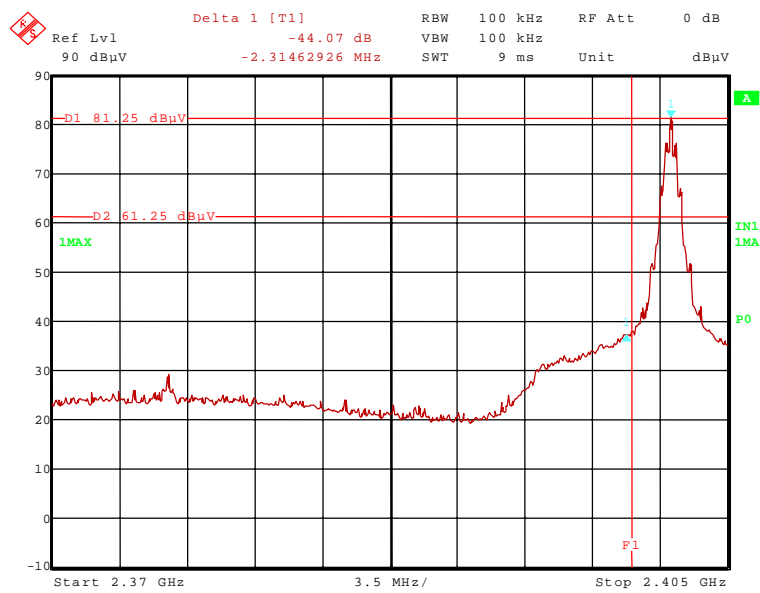
5.6.2 Test results (band-edge compliance (radiated)) with monopole antenna

Ambient temperature	20 °C	Relative humidity	29 %
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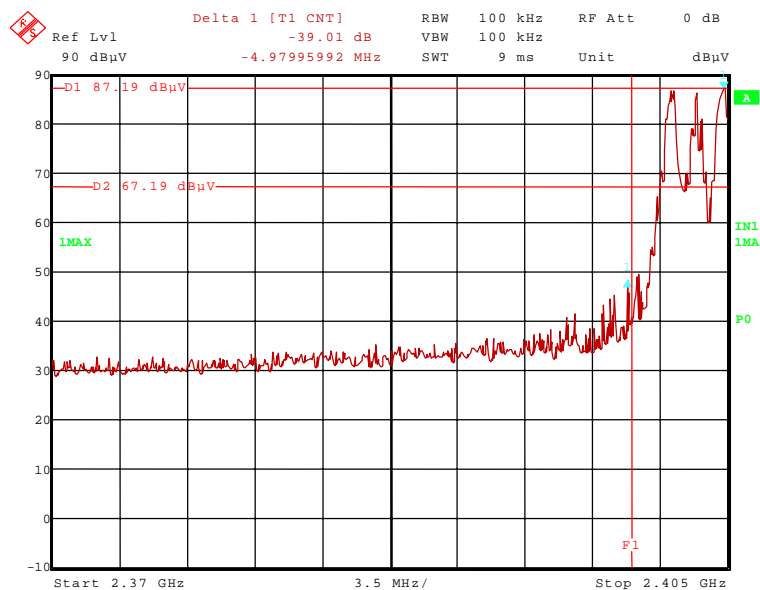
Remark: This measurement was carried out by using the antenna type RAD-ISM-2400-OMNI-9-0, because pre-tests have shown that this antenna causes the highest emissions of all monopole antennas in question.

MSK modulation

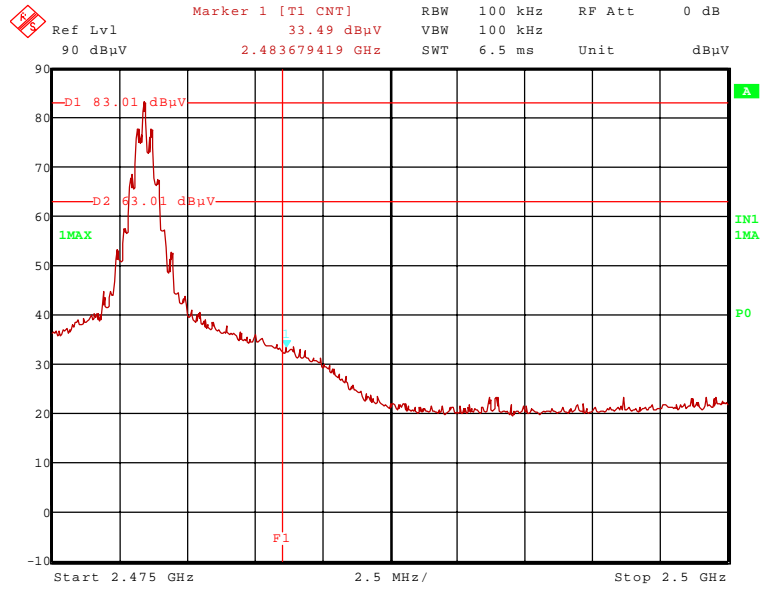
114368_3.wmf: Radiated band-edge compliance, lower band edge, hopping off:



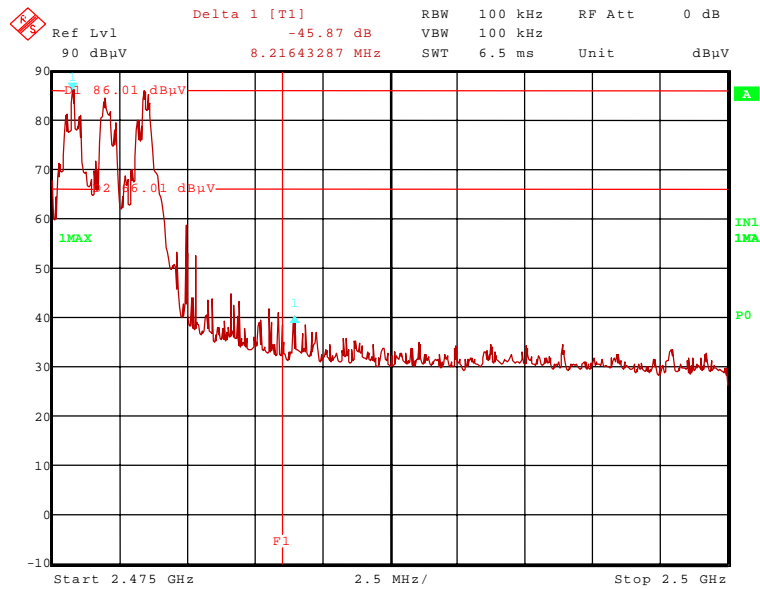
114368_4.wmf: Radiated band-edge compliance, lower band edge, hopping on:



114368 1.wmf: Radiated band-edge compliance, upper band edge, hopping off:



114368 2.wmf: Radiated band-edge compliance, upper band edge, hopping on:



The plots on the page before are showing the radiated band-edge compliance for the upper band-edge, with and without hopping. The display line 1 (D1) in these plots represents the highest level within the assigned frequency band. The display line 2 (D2) represents the 20 dB offset to this highest level and shows the compliance with FCC 47 CFR Part 15.247 (d). The frequency line 1 (F1) shows the edge of the assigned frequency.

Band-edge compliance (lower band edge. hopping disabled)										
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
2.4020	113.4	-	-	81.4	28.3	0.0	3.7	150	Vert.	-
2.3996	67.5	93.4	25.9	35.5	28.3	0.0	3.7	150	Hor.	No
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
2.4020	112.5	-	-	80.5	28.3	0.0	3.7	150	Vert.	-
2.3996	55.6	92.5	36.9	23.6	28.3	0.0	3.7	150	Hor.	No
Measurement uncertainty							+2.2 dB / -3.6 dB			

Band-edge compliance (lower band edge. hopping enabled)										
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
2.4020	113.4	-	-	81.4	28.3	0.0	3.7	150	Vert.	-
2.4002	81.2	93.4	12.3	49.2	28.3	0.0	3.7	150	Vert.	No
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
2.4020	112.5	-	-	80.5	28.3	0.0	3.7	150	Vert.	-
2.4002	42.1	92.5	50.4	10.1	28.3	0.0	3.7	150	Vert.	No
Measurement uncertainty							+2.2 dB / -3.6 dB			

Band-edge compliance (upper band edge. hopping disabled)										
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
2.4784	115.2	-	-	82.9	28.5	0.0	3.8	150	Vert.	-
2.4837	65.7	74.0	8.3	33.4	28.5	0.0	3.8	150	Vert.	Yes
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
2.4784	114.4	-	-	82.1	28.5	0.0	3.8	150	Vert.	-
2.4837	53.1	54.0	0.9	20.8	28.5	0.0	3.8	150	Vert.	Yes
Measurement uncertainty							+2.2 dB / -3.6 dB			

Band-edge compliance (upper band edge. hopping enabled)										
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
2.4784	115.2	-	-	82.9	28.5	0.0	3.8	150	Vert.	-
2.4844	70.8	74.0	3.2	38.5	28.5	0.0	3.8	150	Vert.	Yes
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
2.4784	114.4	-	-	82.1	28.5	0.0	3.8	150	Vert.	-
2.4844	41.7	54.0	12.3	9.4	28.5	0.0	3.8	150	Vert.	Yes
Measurement uncertainty							+2.2 dB / -3.6 dB			

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

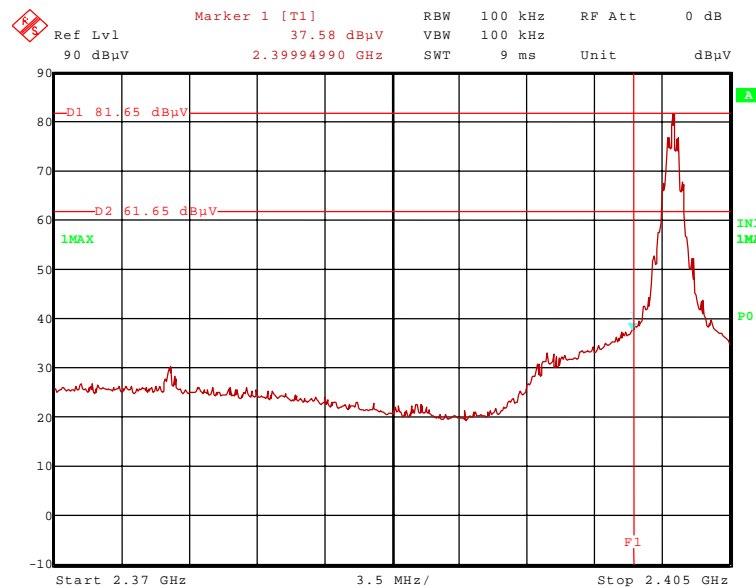
29, 31 – 34, 36, 44

5.6.3 Test results (band-edge compliance (radiated)) with patch antenna

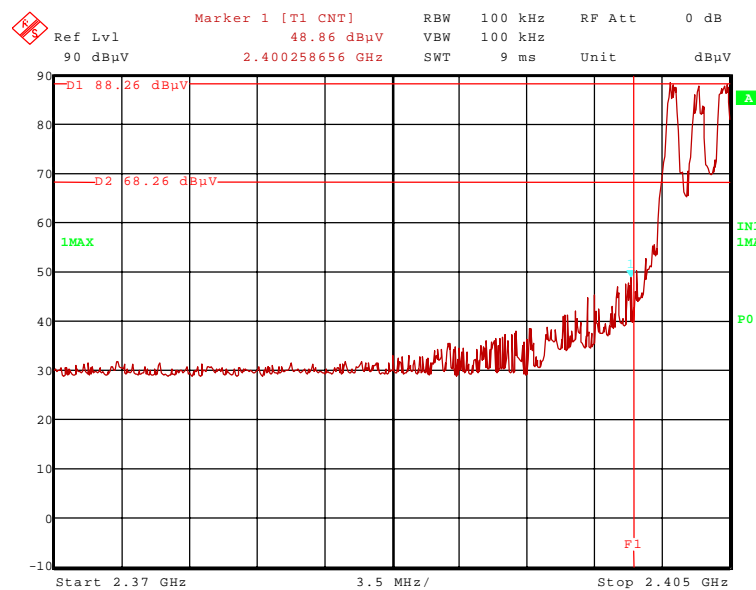
Ambient temperature	20 °C	Relative humidity	29 %
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Remark: This measurement was carried out by using the antenna type RAD-ISM-2400-ANT-PAN-8-0, because pre-tests have shown that this antenna causes the highest emissions of all patch antennas in question.

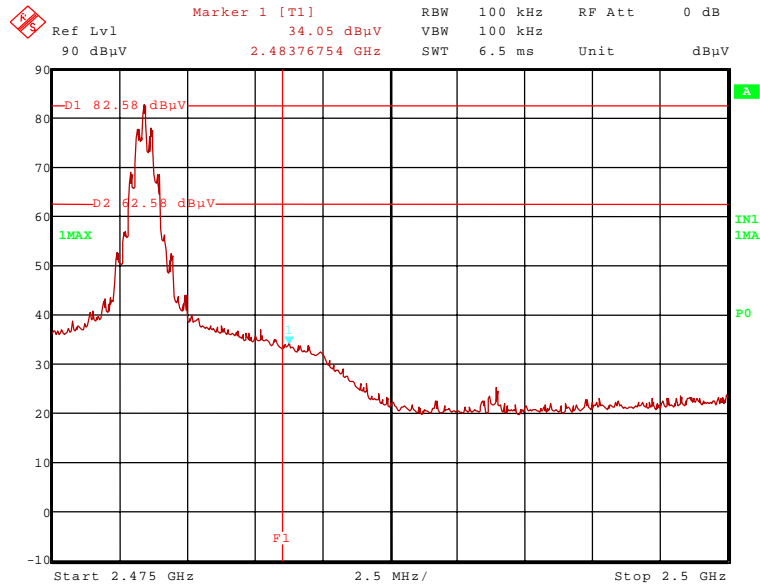
114368_7.wmf: Radiated band-edge compliance, lower band edge, hopping off:



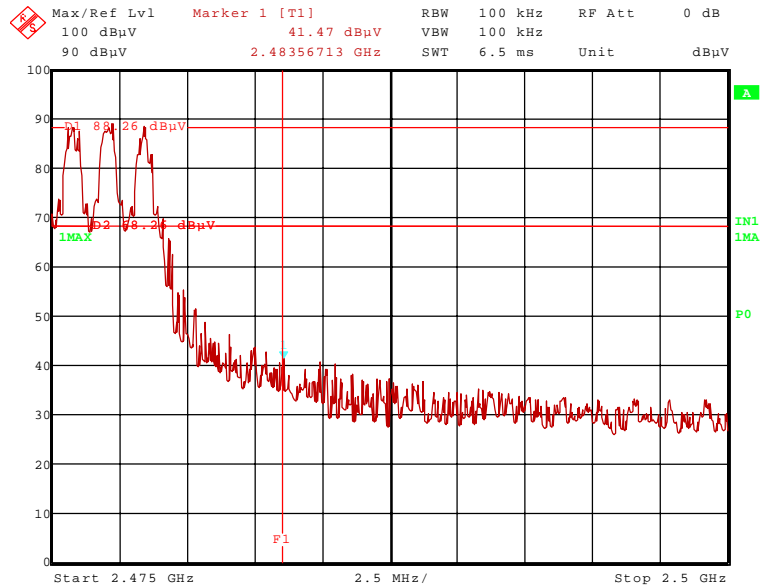
114368_4.wmf: Radiated band-edge compliance, lower band edge, hopping on:



114368 5.wmf: Radiated band-edge compliance, upper band edge, hopping off:



114368 6.wmf: Radiated band-edge compliance, upper band edge, hopping on:



The plots on the page before are showing the radiated band-edge compliance for the upper band-edge, with and without hopping. The display line 1 (D1) in these plots represents the highest level within the assigned frequency band. The display line 2 (D2) represents the 20 dB offset to this highest level and shows the compliance with FCC 47 CFR Part 15.247 (d). The frequency line 1 (F1) shows the edge of the assigned frequency.

Band-edge compliance (lower band edge. hopping disabled)										
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
2.4020	113.6	-	-	81.6	28.3	0.0	3.7	150	Vert.	-
2.4000	70.5	93.6	23.1	38.5	28.3	0.0	3.7	150	Vert.	No
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
2.4020	112.8	-	-	80.8	28.3	0.0	3.7	150	Vert.	-
2.4000	59.0	92.8	33.8	27.0	28.3	0.0	3.7	150	Vert.	No
Measurement uncertainty							+2.2 dB / -3.6 dB			

Band-edge compliance (lower band edge. hopping enabled)										
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
2.4020	113.6	-	-	81.6	28.3	0.0	3.7	150	Vert.	-
2.3999	80.8	93.6	12.8	48.8	28.3	0.0	3.7	150	Vert.	No
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
2.4020	112.8	-	-	80.8	28.3	0.0	3.7	150	Vert.	-
2.3999	42.1	92.8	50.7	10.1	28.3	0.0	3.7	150	Vert.	No
Measurement uncertainty							+2.2 dB / -3.6 dB			

Band-edge compliance (upper band edge. hopping disabled)										
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
2.4784	115.5	-	-	83.2	28.5	0.0	3.8	150	Vert.	-
2.4838	65.9	74.0	8.1	33.6	28.5	0.0	3.8	150	Vert.	Yes
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
2.4784	114.0	-	-	81.7	28.5	0.0	3.8	150	Vert.	-
2.4838	53.8	54.0	0.2	21.5	28.5	0.0	3.8	150	Vert.	Yes
Measurement uncertainty							+2.2 dB / -3.6 dB			

Band-edge compliance (upper band edge. hopping enabled)										
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
2.4784	115.5	-	-	83.2	28.5	0.0	3.8	150	Vert.	-
2.4840	73.6	74.0	0.4	41.3	28.5	0.0	3.8	150	Vert.	Yes
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
2.4784	114.0	-	-	81.7	28.5	0.0	3.8	150	Vert.	-
2.4840	41.5	54.0	12.5	9.2	28.5	0.0	3.8	150	Vert.	Yes
Measurement uncertainty							+2.2 dB / -3.6 dB			

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

29, 31 – 34, 36, 44

5.7 Radiated emissions

5.7.1 Method of measurement (radiated emissions)

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 site 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.

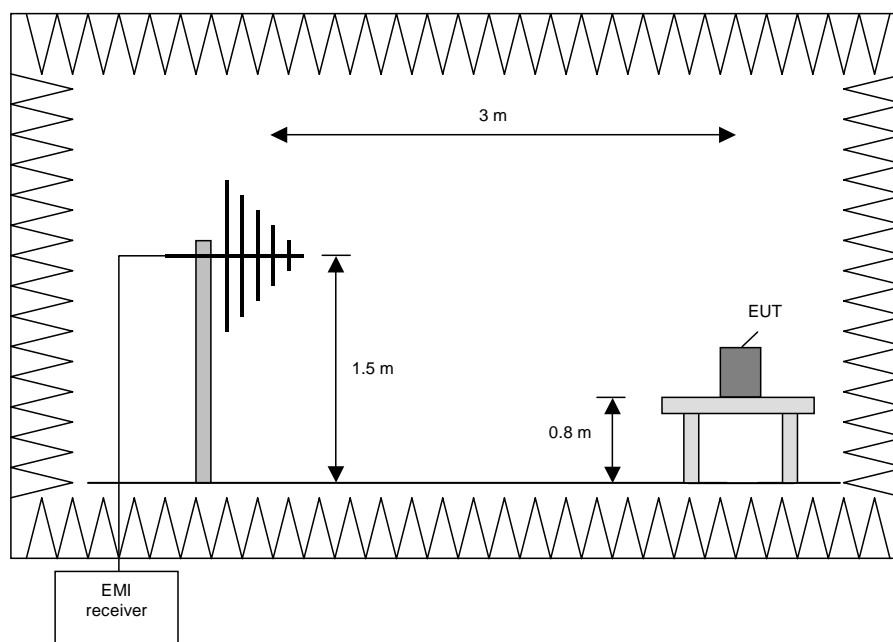
Preliminary measurement (30 MHz to 1 GHz)

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 setup 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 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:

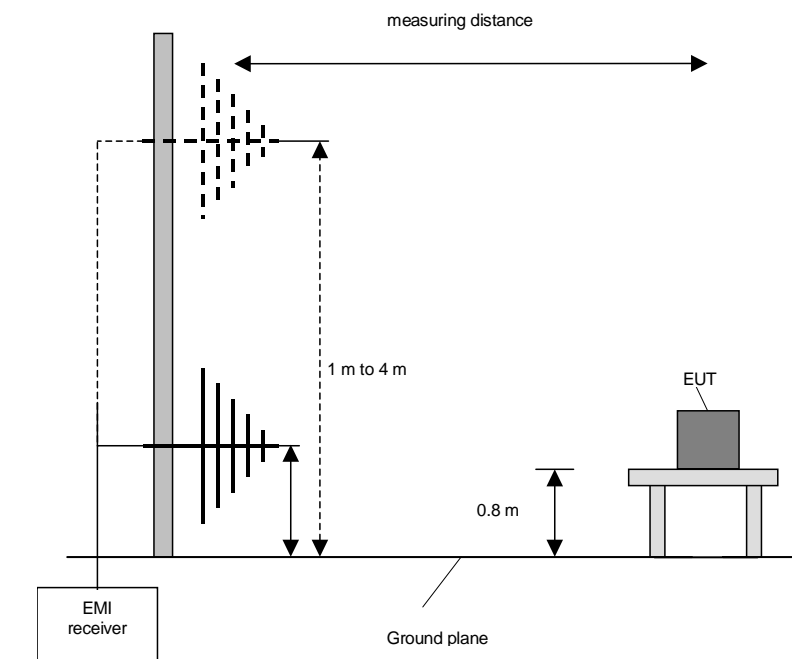
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Make a hardcopy of the spectrum.
5. Measure the frequency of the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

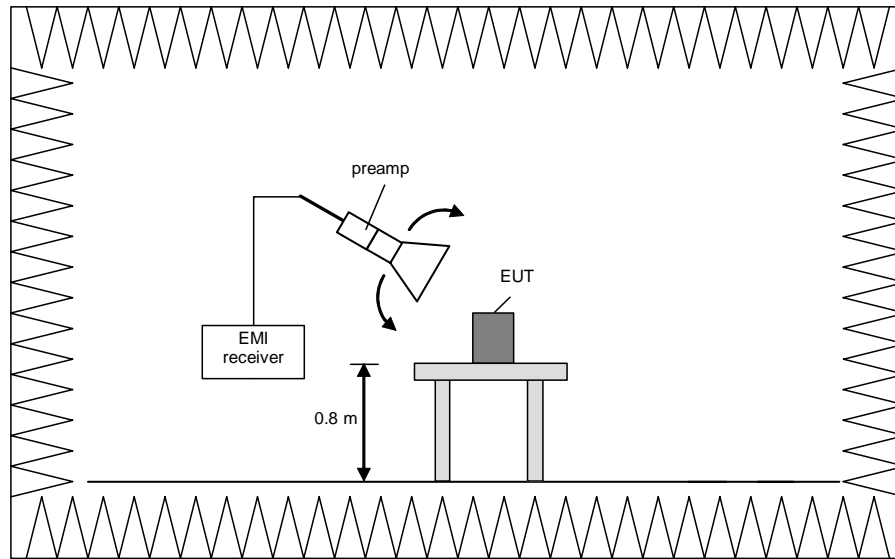
This measurement will be performed in a fully anechoic chamber. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The set up of the Equipment under test will be in accordance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

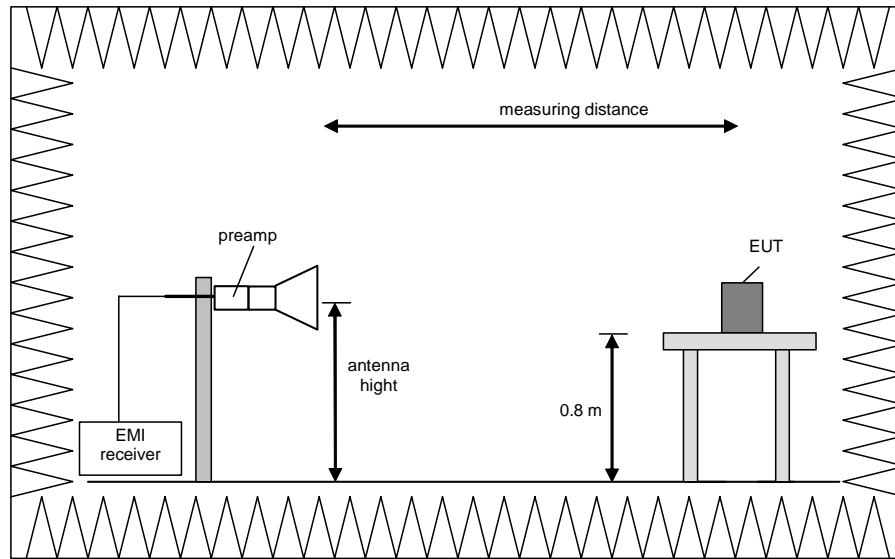


Final measurement (1 GHz to 110 GHz)

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.

5.7.2 Test results (radiated emissions) with monopole antenna

Remark: This measurement was carried out by using the antenna type RAD-ISM-2400-OMNI-9-0, because pre-tests have shown that this antenna causes the highest emissions of all monopole antennas in question.

5.7.2.1 Preliminary radiated emission measurement (9 kHz to 1 GHz) with monopole antenna

Ambient temperature	20 °C	Relative humidity	30 %
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Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

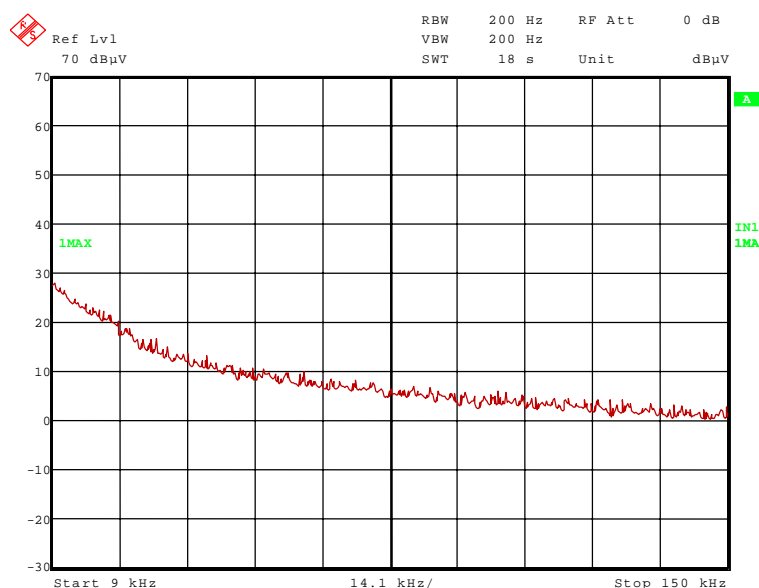
Cable guide: The cable of the EUT is running vertically to the false floor. For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

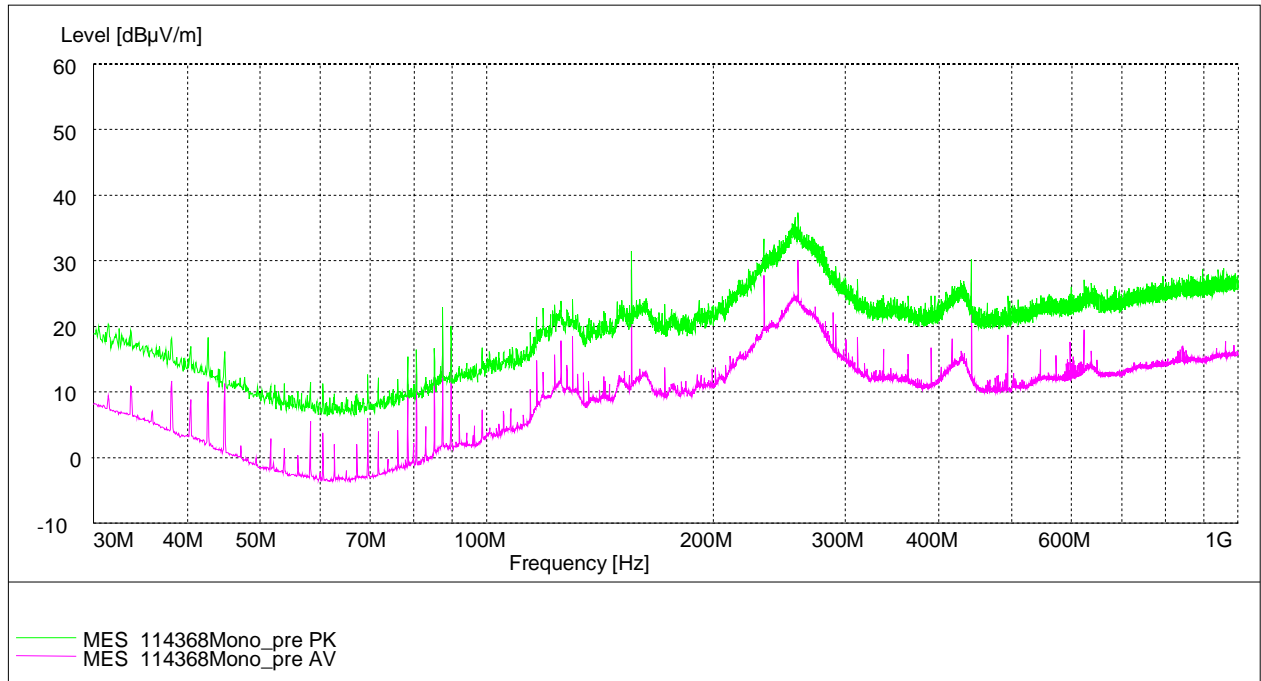
Supply voltage: During all measurements the EUT was supplied with 5.0 V_{DC} via the carrier board.

Remark: As pre-tests have shown, the emissions in the frequency range 9 kHz to 1 GHz are not depending on the transmitter operation mode. Therefore the emissions in this frequency range were documented only with the transmitter operates in operation mode 2.

114368_33.wmf: Spurious emissions from 9 kHz to 150 kHz (operation mode 2):



Spurious emissions from 30 MHz to 1 GHz (operation mode 2):



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

- 254.988 MHz and 259.992 MHz.

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

- 87.440 MHz, 156.000 MHz and 441.984 MHz.

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

TEST EQUIPMENT USED FOR THE TEST:

29, 31 – 35, 43, 55

5.7.2.2 Preliminary radiated emission measurement (1 GHz to 25 GHz) with monopole antenna

Ambient temperature	20 °C	Relative humidity	30 %
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Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

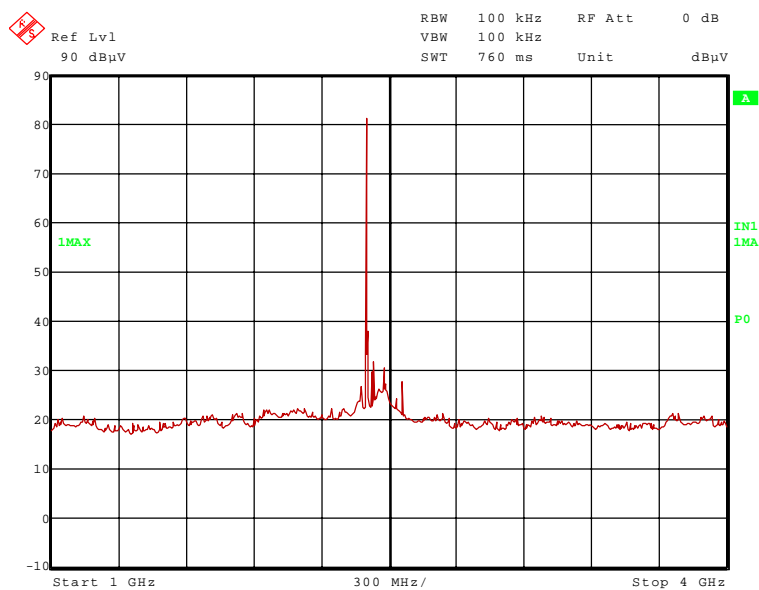
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

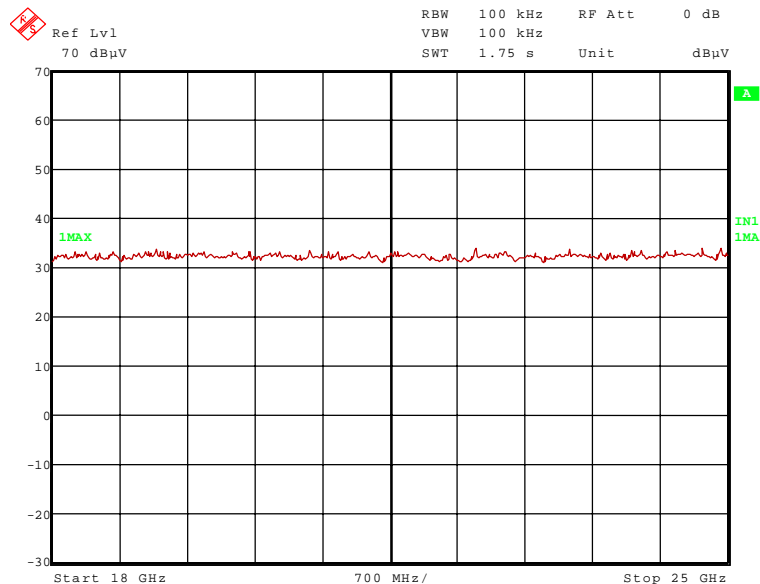
Supply voltage: During all measurements the EUT was supplied with 5.0 V_{DC} via the carrier board.

Transmitter operates at the lower end of the assigned frequency band (operation mode 1)

114368 15.wmf: Spurious emissions from 1 GHz to 4 GHz:



114368_27.wmf: Spurious emissions from 18 GHz to 25 GHz:



The following frequency was found inside the restricted bands during the preliminary radiated emission test:

- 2.3760 GHz.

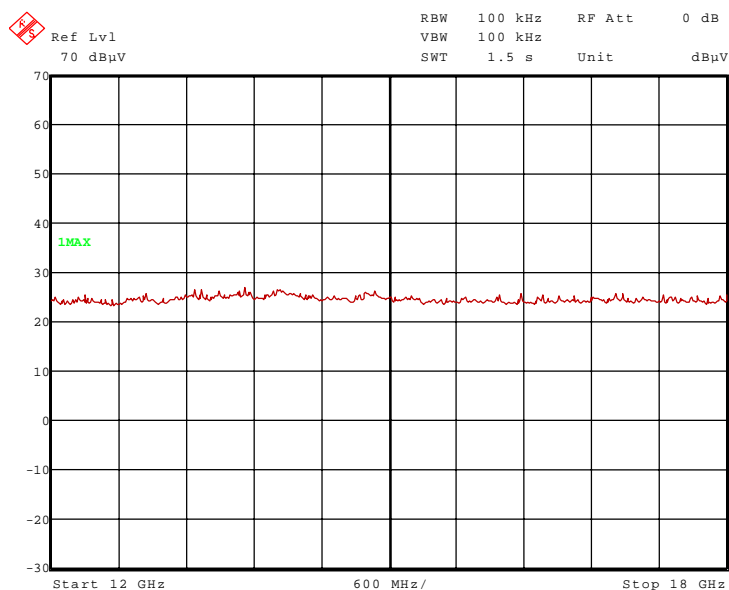
The following frequencies were found outside the restricted bands during the preliminary radiated emission test:

- 2.4020 GHz and 2.5573 GHz.

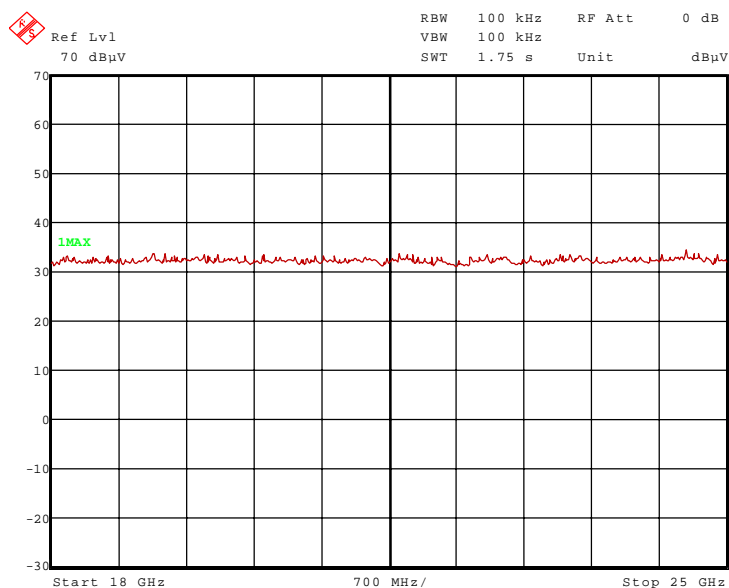
These frequencies have to be measured in a final measurement. The results were presented in the following.

TEST EQUIPMENT USED FOR THE TEST:
29, 31 –34, 36, 37, 39, 44, 46, 49 - 51, 72

114368_31.wmf: Spurious emissions from 12 GHz to 18 GHz:



114368_28.wmf: Spurious emissions from 18 GHz to 25 GHz:



No frequency was found inside the restricted bands during the preliminary radiated emission test.

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

- 2.4403 GHz.

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

5.7.2.3 Final radiated emission test (30 MHz to 1 GHz) with monopole antenna

Ambient temperature	20 °C	Relative humidity	30 %
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Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied with 5.0 V_{DC} via the carrier board.

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 test results were calculated with the following formula:

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

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.
87.440	24.3	40.0	15.7	13.9	9.3	1.1	200.0	134.0	Hor.	3
156.000	39.0	43.5	4.5	26.1	11.5	1.4	104.0	1.0	Vert.	3
441.984	33.4	46.0	12.6	14.6	16.4	2.4	155.0	206.0	Vert.	3
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.
254.988	34.4	46.0	11.6	20.0	12.6	1.8	162.0	90.0	Vert.	3
259.992	38.6	46.0	7.4	24.3	12.5	1.8	155.0	87.0	Vert.	3
Measurement uncertainty				+2.2 dB / -3.6 dB						

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

14 – 20

5.7.2.4 Final radiated emission measurement (1 GHz to 25 GHz) with monopole antenna

Ambient temperature	20 °C	Relative humidity	30 %
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Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied with 5.0 V_{DC} via the carrier board.

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

Transmitter operates at the lower end of the assigned frequency band (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.
2.3760	61.6	74.0	12.4	29.7	28.2	0.0	3.7	150	Hor.	Yes	3
2.4020	113.4	-	-	81.4	28.3	0.0	3.7	150	Vert.	-	3
2.5573	64.6	93.4	28.8	32.1	28.6	0.0	3.9	150	Hor.	No	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.
2.3760	53.6	54.0	0.4	21.7	28.2	0.0	3.7	150	Hor.	Yes	3
2.4020	112.5	-	-	80.5	28.3	0.0	3.7	150	Vert.	-	3
2.5573	51.1	92.5	41.4	18.6	28.6	0.0	3.9	150	Hor.	No	3
Measurement uncertainty							+2.2 dB / -3.6 dB				

Transmitter operates at the middle of the assigned frequency band (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.
2.4403	114.0	-	-	81.9	28.4	0.0	3.7	150	Vert.	-	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.
2.4403	113.2	-	-	81.1	28.4	0.0	3.7	150	Vert.	-	3
Measurement uncertainty						+2.2 dB / -3.6 dB					

Transmitter operates at the upper end of the assigned frequency band (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.
2.4784	115.2	-	-	82.9	28.5	0.0	3.8	150	Vert.	-	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.
2.4784	114.4	-	-	82.1	28.5	0.0	3.8	150	Vert.	-	3
Measurement uncertainty						+2.2 dB / -3.6 dB					

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

29, 31 –34, 36, 37, 39, 44, 46, 49 - 51, 72

5.7.3 Test results (radiated emissions) with patch antenna

Remark: This measurement was carried out by using the antenna type RAD-ISM-2400-OMNI-9-0, because pre-tests have shown that this antenna causes the highest emissions of all patch antennas in question.

5.7.3.1 Preliminary radiated emission measurement with patch antenna (9 kHz to 1 GHz)

Ambient temperature	20 °C	Relative humidity	30 %
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Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

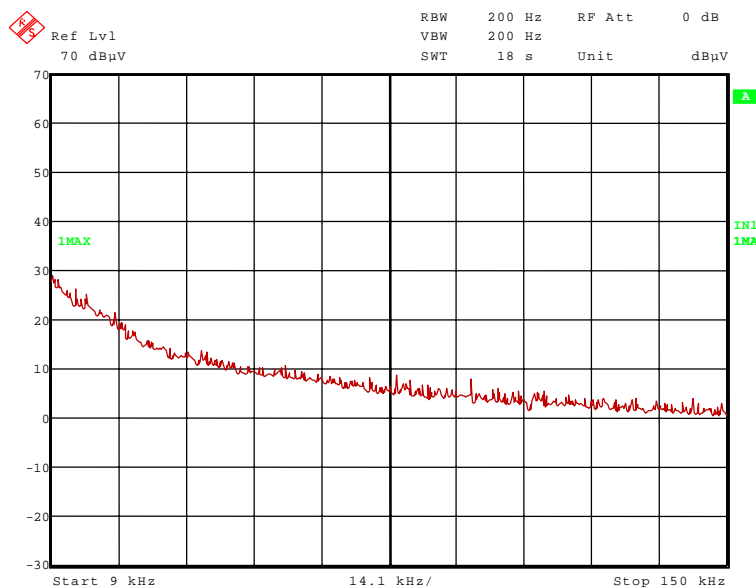
Cable guide: The cable of the EUT is running vertically to the false floor. For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

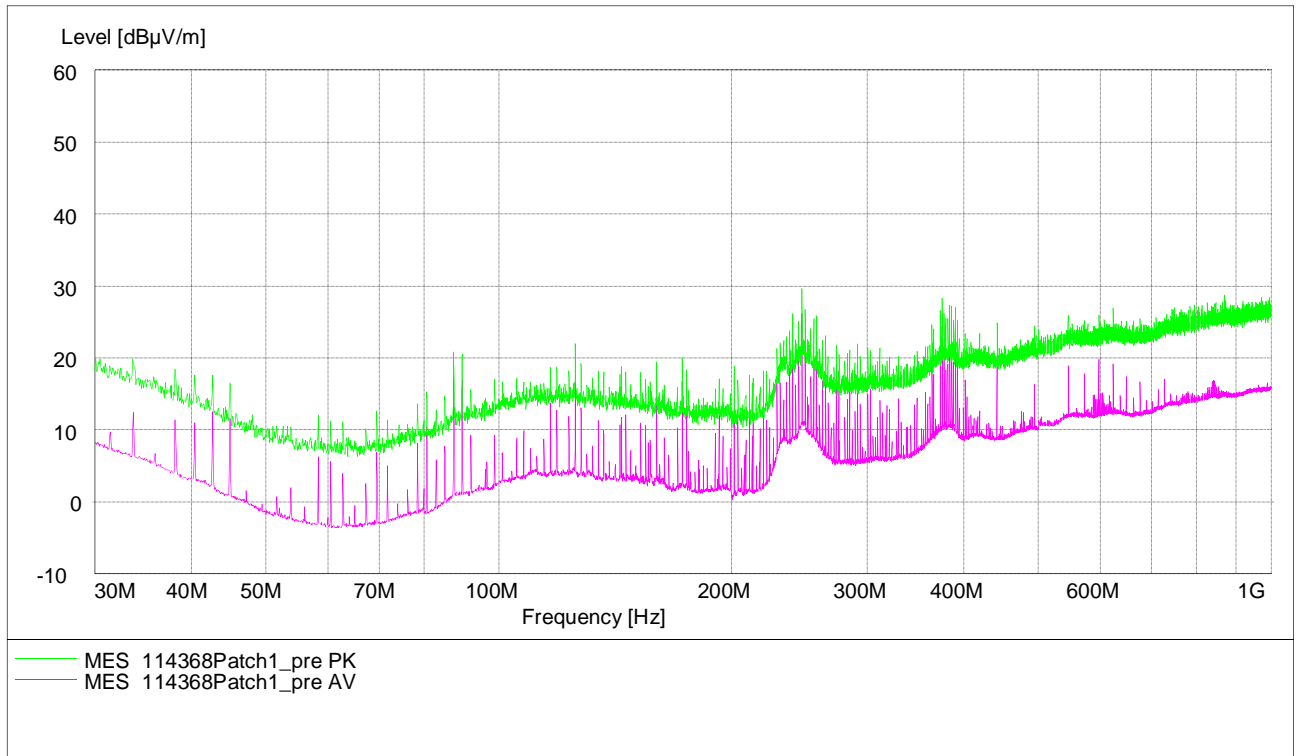
Supply voltage: During all measurements the EUT was supplied with 5.0 V_{DC} via the carrier board.

Remark: As pre-tests have shown, the emissions in the frequency range 9 kHz to 1 GHz are not depending on the transmitter operation mode. Therefore the emissions in this frequency range were documented only with the transmitter operates in operation mode 2.

114368_38.wmf: Spurious emissions from 9 kHz to 150 kHz (operation mode 2):



Spurious emissions from 30 MHz to 1000 MHz (operation mode 2):



The following frequency was found inside the restricted bands during the preliminary radiated emission test:

- 246.720 MHz.

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

- 87.480 MHz and 374.640 MHz.

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

TEST EQUIPMENT USED FOR THE TEST:
29, 31 – 35, 43, 55

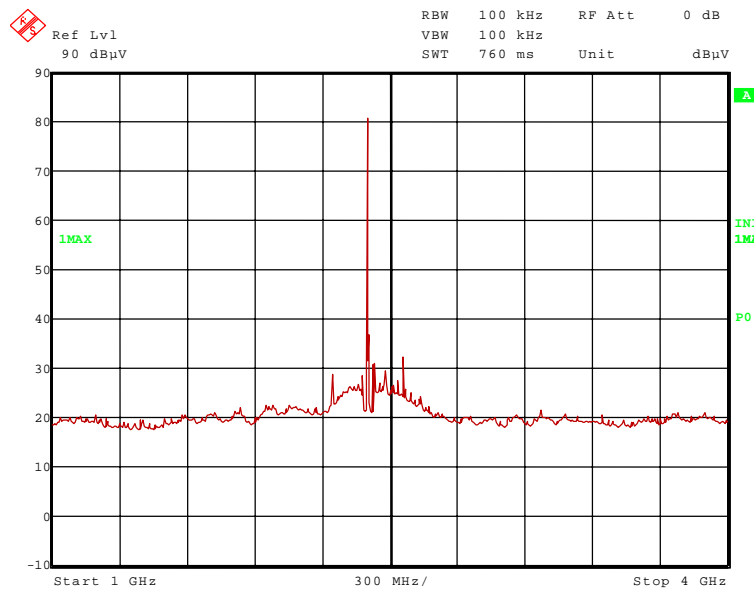
5.7.3.2 Preliminary radiated emission measurement with patch antenna (1 GHz to 25 GHz)

Ambient temperature	20 °C	Relative humidity	35 %
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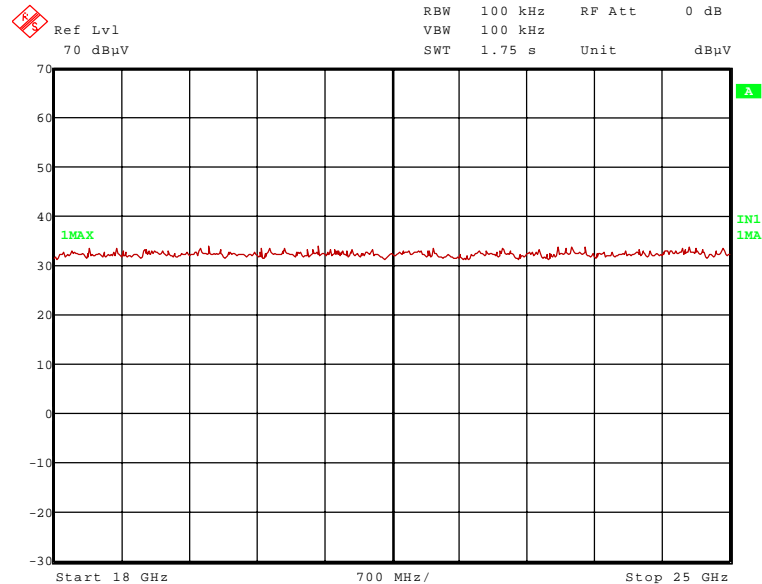
- Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.
- Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.
- Test record: All results are shown in the following.
- Supply voltage: During all measurements the EUT was supplied with 5.0 V_{DC} via the carrier board.

Transmitter operates at the lower end of the assigned frequency band (operation mode 1)

114368_9.wmf: Spurious emissions from 1 GHz to 4 GHz:



114368_26.wmf: Spurious emissions from 18 GHz to 25 GHz:



The following frequency was found inside the restricted bands during the preliminary radiated emission test:

- 2.2437 GHz.

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

- 2.4020 GHz and 2.5571 GHz.

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 –34, 36, 37, 39, 44, 46, 49 - 51, 72

5.7.3.3 Final radiated emission test (30 MHz to 1 GHz) with patch antenna

Ambient temperature	20 °C	Relative humidity	35 %
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Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied with 5.0 V_{DC} via the carrier board.

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 test results were calculated with the following formula:

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

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.
87.480	31.8	40.0	8.2	21.4	9.3	1.1	200.0	243.0	Hor.	3
374.640	20.6	46.0	25.4	3.6	14.8	2.2	132.0	103.0	Vert.	3
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.
246.720	26	46.0	20.0	12.4	11.9	1.7	100.0	90.0	Hor.	3
Measurement uncertainty				+2.2 dB / -3.6 dB						

Test result: Passed

TEST EQUIPMENT USED FOR THE TEST:

14 – 20

5.7.4 Final radiated emission measurement (1 GHz to 25 GHz) with patch antenna

Ambient temperature	21 °C	Relative humidity	32 %
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Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied with 5.0 V_{DC} via the carrier board.

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

Transmitter operates at the lower end of the assigned frequency band (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.
2.2437	54.9	74.0	19.1	23.7	27.7	0.0	3.5	150	Vert.	Yes	3
2.4020	113.6	-	-	81.6	28.3	0.0	3.7	150	Vert.	-	3
2.5571	57.7	93.6	35.9	25.2	28.6	0.0	3.9	150	Vert.	No	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.
2.2437	41.6	54.0	12.4	10.4	27.7	0.0	3.5	150	Vert.	Yes	3
2.4020	112.8	-	-	80.8	28.3	0.0	3.7	150	Vert.	-	3
2.5571	44.8	92.8	48.0	12.3	28.6	0.0	3.9	150	Vert.	No	3
Measurement uncertainty						+2.2 dB / -3.6 dB					

Transmitter operates at the middle of the assigned frequency band (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.
2.2859	59.4	74.0	14.6	28.0	27.8	0.0	3.6	150	Vert.	Yes	3
2.4403	115.2	-	-	83.1	28.4	0.0	3.7	150	Vert.	-	3
2.5214	59.4	95.2	35.8	27.0	28.6	0.0	3.8	150	Vert.	No	3
2.5994	59.9	95.2	35.3	27.4	28.6	0.0	3.9	150	Vert.	No	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.
2.2859	45.7	54.0	8.3	14.3	27.8	0.0	3.6	150	Vert.	Yes	3
2.4403	114.4	-	-	82.3	28.4	0.0	3.7	150	Vert.	-	3
2.5214	45.8	94.4	48.6	13.4	28.6	0.0	3.8	150	Vert.	No	3
2.5994	46.1	94.4	48.3	13.6	28.6	0.0	3.9	150	Vert.	No	3
Measurement uncertainty						+2.2 dB / -3.6 dB					

Transmitter operates at the upper end of the assigned frequency band (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.
2.4784	115.5	-	-	83.2	28.5	0.0	3.8	150	Vert.	-	3
2.5571	66.9	95.5	28.6	34.4	28.6	0.0	3.9	150	Hor.	No	3
4.9568	47.1	74.0	26.9	34.5	32.9	25.6	5.3	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.
2.4784	114.0	-	-	81.7	28.5	0.0	3.8	150	Vert.	-	3
2.5571	53.5	94.0	40.5	21.0	28.6	0.0	3.9	150	Hor.	No	3
4.9568	37.5	54.0	16.5	24.9	32.9	25.6	5.3	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, 37, 39, 44, 46, 49 - 51, 72

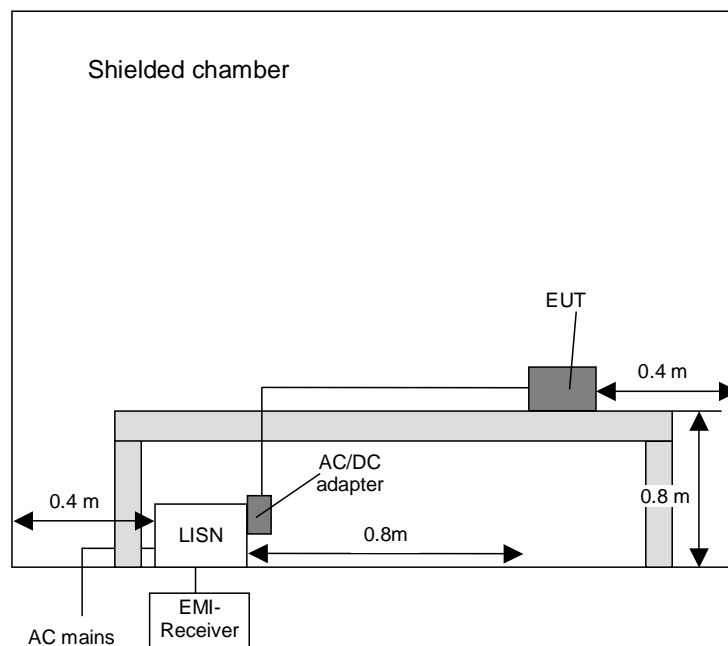
5.8 Conducted emissions on power supply lines (150 kHz to 30 MHz)

5.8.1 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 80 cm 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



5.8.2 Test results (conducted emissions on power supply lines)

Ambient temperature	20 °C	Relative humidity	35 %
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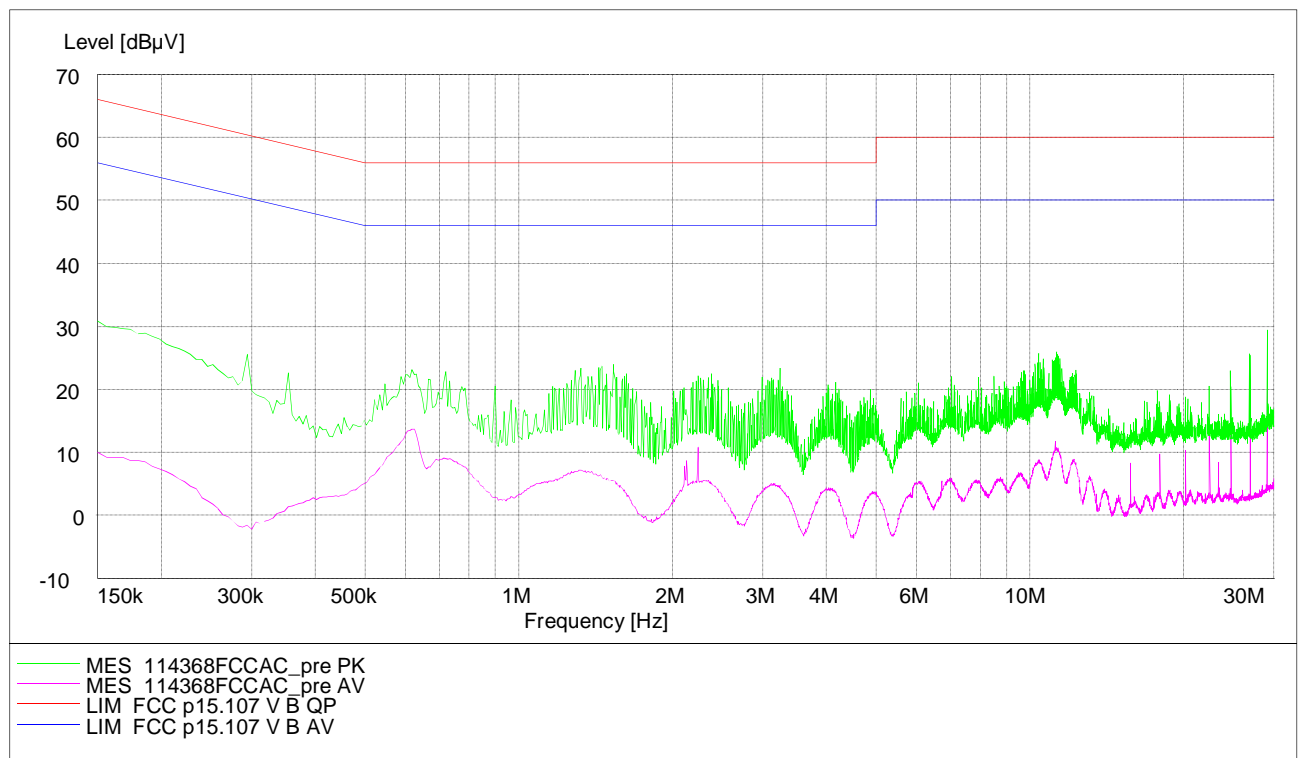
Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m.

Cable guide: For further information of the cable guide refer to the pictures in annex A of this test report.

Test record: The EUT operates in operation mode 4. All results are shown in the following.

Supply voltage: During the measurement the EUT was supplied 5.0 V DC via the carrier board, which was supplied with 6.0 V DC by an AC / DC adaptor type enercell 273-316, which was supplied by 120 V AC / 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.



Test: 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
14	Open area test site	-	Phoenix Test-Lab	-	480085	Weekly verification (system cal.)	
15	Measuring receiver	ESIB7	Rohde & Schwarz	100304	480521	03/15/2010	03/2012
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 A	Chase	1643	480147	08/01/2009	08/2012
20	EMI Software	ES-K1	Rohde & Schwarz	-	480111	-	-
29	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Weekly verification (system cal.)	
30	Spectrumanalyser	FSU	Rohde & Schwarz	200125	480956	04/15/2010	04/2012
31	Measuring receiver	ESI 40	Rohde & Schwarz	100064	480355	03/17/2010	03/2012
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	2917	480447	09/28/2010	09/2013
36	Antenna	3115 A	EMCO	9609-4918	480183	04/11/2010	11/2013
37	Standard Gain Horn 11.9 GHz – 18 GHz	18240-20	Flann Microwave	483	480294	Six month verification (system cal.)	
39	Standard Gain Horn 17.9 GHz – 26.7 GHz	20240-20	Flann Microwave	411	480297	Six month verification (system cal.)	
43	RF-cable No. 30	RTK 081	Rosenberger	-	410141	Weekly verification (system cal.)	
44	RF-cable No. 31	RTK 081	Rosenberger	-	410142	Weekly verification (system cal.)	
46	RF-cable 1 m	KPS-1533-400-KPS	Insulated Wire	-	480301	Six month verification (system cal.)	
49	Preamplifier	JS3-00101200-23-5A	Miteq	681851	480337	Six month verification (system cal.)	
50	Preamplifier	JS3-12001800-16-5A	Miteq	571667	480343	Six month verification (system cal.)	
51	Preamplifier	JS3-18002600-20-5A	Miteq	658697	480342	Six month verification (system cal.)	
55	Antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	03/10/2010	03/2012
72	4 GHz High Pass Filter	WHKX4.0/18 G-8SS	Wainwright Instruments	1	480587	Weekly verification (system cal.)	

