

Test Report

Report Number: F122165E2

Applicant:

Lancom Systems GmbH

Manufacturer:

Atheros Communications, Inc.

Equipment under Test (EUT):

DNXA-116 2x2 802.11n PCIe module

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

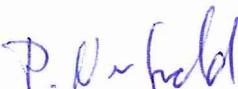
REFERENCES

- [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] **Publication Number 789033 (Mai 2012)** General UNII Test Procedures
- [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 Radiocommunication Equipment
- [6] **Publication Number 913591 (March 2007)** Measurement of radiated emissions at the edge of the band for a Part 15 RF Device
- [7] **Publication Number 662911 (October 2011)** Emission Testing of Transmitters with Multiple Outputs in the Same Band.

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:	Paul NEUFELD		26 September 2012
	Name	Signature	Date
Authorized reviewer:	Bernd STEINER		26 September 2012
	Name	Signature	Date

RESERVATION

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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 Dates	6
2 OPERATIONAL STATES.....	7
3 ADDITIONAL INFORMATION	8
1 OVERVIEW	8
2 TEST RESULTS	9
2.1 Maximum peak output power.....	9
2.1.1 Method of measurement (maximum peak output power).....	9
2.1.2 Test results (maximum peak output power)	10
2.2 Band-edge compliance.....	11
2.2.1 Method of measurement (band edges next to restricted bands (radiated))	11
2.2.2 Test result (band edges next to restricted bands (radiated)).....	11
2.3 Maximum unwanted emissions.....	13
2.3.1 Method of measurement (conducted emissions)	13
2.3.1.1 Limit calculations.....	14
2.3.2 Test results (conducted emissions).....	15
2.3.2.1 Antenna port 1.....	15
2.3.2.2 Antenna port 2.....	20
2.3.3 Method of measurement (radiated emissions)	24
2.3.4 Test results (radiated emissions) – cabinet emissions.....	27
2.3.4.1 Preliminary radiated emission measurement.....	27
2.3.4.2 Final radiated emission measurement (1 GHz to 25 GHz).....	31
3 TEST EQUIPMENT AND ANCILLARIES USED FOR TESTS.....	34
4 REPORT HISTORY	36
5 LIST OF ANNEXES	36

1 IDENTIFICATION

1.1 Applicant

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Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	Atheros Communications, Inc.
Address:	1700 Technology Drive San Jose, CA 95110
Country:	USA
Name for contact purposes:	-
Phone:	-
Fax:	-
eMail Address:	-
Applicant represented during the test by the following person:	-

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: *	AR5BHB116 2x2 802.11n PCIe module
Type: *	DNXA-116
FCC ID: *	NKR-DNXA116
IC: *	4441A-DNXA116
Serial number: *	C140099BX01
PCB identifier: *	2011.02.23 G 48DNXXA0B.0GA
Hardware version: *	-
Software version: *	-

Channel 36	RX:	5180 MHz	TX:	5180 MHz
Channel 40	RX:	5200 MHz	TX:	5200 MHz
Channel 44	RX:	5220 MHz	TX:	5220 MHz
Channel 48	RX:	5240 MHz	TX:	5240 MHz

Fulfils WLAN specification: *	IEEE, 802.11a, 802.11b, 802.11g, 802.11n
Antenna type: *	Swivel Type, Replacement Antenna
Antenna gain: *	3dBi @2.4 GHz; 5 dBi @5.x GHz
Antenna connector: *	SMA Reverse
Power supply	Powered by an 12 V AC/DC adapter
Type of modulation: *	802.11a:OFDM 802.11b: CCK, DQPSK, DBPSK 802.11g: OFDM 802.11n: OFDM
Operating frequency range:*	2412 MHz to 2462 MHz, 5180 to 5240 MHz, 5745 to 5825 MHz
Number of channels: *	20
Temperature range: *	0 °C to +40 °C
Lowest / highest Internal clock frequency: *	400 MHz / 5825 GHz

* declared by the applicant.

The following external I/O cables were used:

Identification	Connector		Length
	EUT	Ancillary	
AC/DC Adapter	DC plug	-	2 m *
Ethernet cable	Ethernet plug	-	-

*: Length during the test if no other specified.

1.5 Dates

Date of receipt of test sample:	20 June 2012
Start of test:	22 June 2012
End of test:	25 September 2012

2 OPERATIONAL STATES

The tested EUT is the RF-module as identified in the figure below as "Physical boundary of the EUT", not the entire "LANCOM L-322agn dual Wireless" access point. Two of these RF-modules are implemented in the access point. The module was implemented in the access-point to get it into operation.

The tests were carried out with an unmodified sample of the EUT. Parts of the tests were carried out conducted by connected directly to the antenna ports. For the radiated tests, the antenna ports were terminated symmetrically by $50\ \Omega$ resistors. If tests did not pass during conducted measurements, the measurements were repeated as radiated tests.

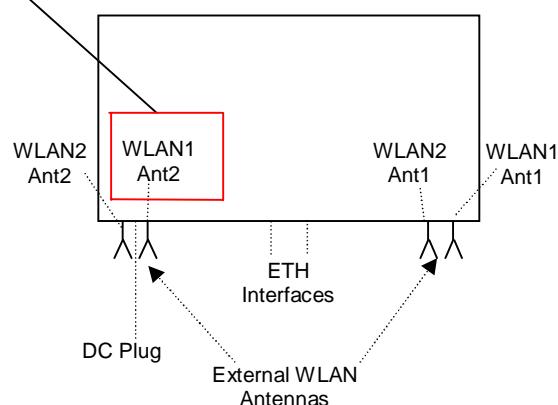
The operational states of the EUT were controlled by software. This software was provided by the applicant and installed on a laptop PC, which was connected to the EUT by an Ethernet cable. After adjusting the operation mode the Ethernet cable was removed.

During the tests the test samples were powered with 12 V, provided by a 100-240 V AC/DC adapter, which was provided by the applicant.

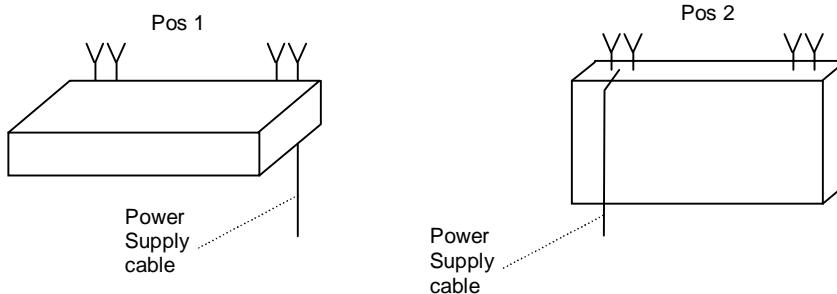
The following operation modes were used during the tests:

Operation mode	Description of the operation mode	WLAN mode	WLAN channel	Modulation	Data rate / Mbps
1	Continuous transmitting on 5180 MHz	a	36	OFDM	6 MBit/s
2	Continuous transmitting on 5220 MHz	a	44	OFDM	6 MBit/s
3	Continuous transmitting on 5240 MHz	a	48	OFDM	6 MBit/s
4	Continuous transmitting on 5180 MHz	n 20 MHz	36	OFDM	6.5 MBit/s
5	Continuous transmitting on 5220 MHz	n 20 MHz	44	OFDM	6.5 MBit/s
6	Continuous transmitting on 5240 MHz	n 20 MHz	48	OFDM	6.5 MBit/s
7	Continuous transmitting on 5180 MHz	n 40 MHz	36	OFDM	6.5 MBit/s
8	Continuous transmitting on 5240 MHz	n 40 MHz	48	OFDM	6.5 MBit/s

Physical boundary of the EUT



For the radiated tests, the worst case positioning of the EUT was investigated through measurements. The WLAN router has two possible operating positions:



Position 1: Device lying horizontally
 Position 2: Device mounted vertically

Preliminary tests were in the two positions, to find worst-case configuration and position. The radiated emission measurements were carried out in the orthogonal direction that emits the highest spurious emission levels. This was found to be Position 2.

The following test modes were adjusted during the tests:

Test items	Operation mode
Band edge compliance	1, 4, 7
Radiated emissions (transmitter)	1 - 8

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
Band edge compliance	5150 - 5250	15.407 (b)	A8.5 [4]	Passed	11 et seq.
Radiated emissions (transmitter)	1000 - 40,000	15.205 (a) 15.209 (a)	7.2.2 [5], 2.5 [4]	Passed	13 et seq.

5 TEST RESULTS

5.1 Maximum peak output power

5.1.1 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.

Acceptable measurement configurations

The measurement procedures described herein are based on the use of an antenna-port conducted test configuration.

The testing was performed according to the procedure in the original test report, namely power measurement with a peak power meter.

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

Test set-up:



5.1.2 Test results (maximum peak output power)

Ambient temperature	21 °C	Relative humidity	40 %
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Operation Mode	Channel frequency [MHz]	Antenna gain combined [dBi]	Maximum peak output power chain0 [dBm]	Maximum peak output power chain1 [dBm]	Maximum peak output power – sum (both ports) [dBm]	Margin [dB]	Peak power limit [dBm]
1	5180	8.01	6.25	4.53	8,48	6,51	14.99
2	5220	8.01	5.95	4.01	8,10	6,89	14.99
3	5240	8.01	6.22	4.62	8,50	6,49	14.99
4	5180	8.01	6.19	4.79	8,56	6,43	14.99
5	5220	8.01	6.00	4.00	8,12	6,87	14.99
6	5240	8.01	6.29	4.20	8,38	6,61	14.99
7	5180	8.01	6.38	4.77	8,66	6,33	14.99
8	5240	8.01	6.06	4.10	8,20	6,79	14.99
Measurement uncertainty		+0.66 dB / -0.72 dB					

Note: conducted Power limit = (17 or 4 + 10logB)-(8.01-6)=14.99dBm

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

60

5.2 Band-edge compliance

5.2.1 Method of measurement (band edges next to restricted bands (radiated))

The same test set-up as used for the final radiated emission measurement shall be used (refer also subclause 5.3.3 of this test report).

The preliminary measurements are performed using the following settings:

- 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 authorized band of operation.
- Resolution bandwidth: = 100 kHz
- Video bandwidth: = 300 kHz
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

After trace stabilisation the marker shall be set on the signal peak. The frequency line shall be set on the edge of the assigned frequency band. Now 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 5.3.3 of this test report. The level of the measured field strength shall be compared to the general limits specified in § 15.205.

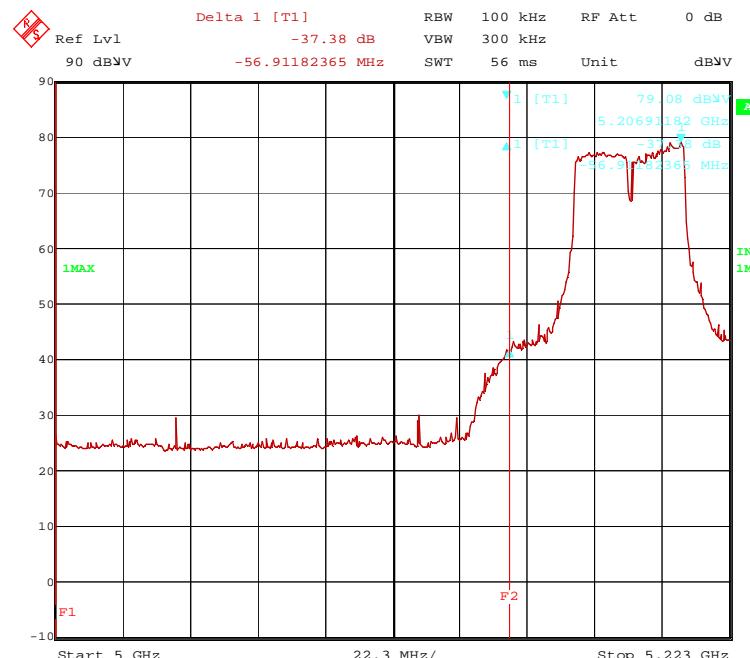
The measurement was performed at the lower end of the 5.15 – 5.25 GHz UNII-band.

5.2.2 Test result (band edges next to restricted bands (radiated))

Ambient temperature	21 °C	Relative humidity	55 %
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The plot shows an exemplary measurement result for the worst documented case. The other results are listed in the following table.

2165_144.wmf: Radiated band-edge compliance (operation mode 7):



Band-edge compliance (lower band edge. Mode 1, TX Power adjusted at 17 dBm)											
Result measured with the peak detector:											
Frequency MHz	Corr. value dB μ V/m	Limit dB μ V/m	Margin dB	Reading dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band	Pos.
5179	128.7	-	-	89.3	33.7	0.0	5.7	150	Vert.	carrier	2
5000	48.6	74.0	25.4	35.8	33.1	25.6	5.3	150	Vert.	Yes	2
Result measured with the average detector:											
Frequency GHz	Corr. value dB μ V/m	Limit dB μ V/m	Margin dB	Reading dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band	Pos.
5179	119.2			79.8	33.7	0.0	5.7	150	Vert.	carrier	2
5000	35.2	54.0	18.8	22.4	33.1	25.6	5.3	150	Vert.	Yes	2

Measurement uncertainty

+2.2 dB / -3.6 dB

Band-edge compliance (lower band edge, Mode 4. Tx-Power adjusted to 17 dBm)											
Result measured with the peak detector:											
Frequency MHz	Corr. value dB μ V/m	Limit dB μ V/m	Margin dB	Reading dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band	Pos.
5177	147.5	-	-	82.6	33.7	25.5	5.7	150	Vert.	carrier	2
5120	47.6	74.0	26.4	34.1	33.5	25.6	5.6	150	Vert.	Yes	2
Result measured with the average detector:											
Frequency GHz	Corr. value dB μ V/m	Limit dB μ V/m	Margin dB	Reading dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band	Pos.
5177	137.3			72.4	33.7	25.5	5.7	150	Vert.	carrier	2
5120	33.8	54.0	20.2	20.3	33.5	25.6	5.6	150	Vert.	Yes	2

Measurement uncertainty

+2.2 dB / -3.6 dB

Band-edge compliance (lower band edge. Mode 7, Tx-Power adjusted to 17 dBm)											
Result measured with the peak detector:											
Frequency MHz	Corr. value dB μ V/m	Limit dB μ V/m	Margin dB	Reading dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band	Pos.
5177	126.8	-	-	87.4	33.7	0.0	5.7	150	Vert.	carrier	2
5149	67.9	74.0	6.1	54.2	33.6	25.5	5.6	150	Vert.	Yes	2
Result measured with the average detector:											
Frequency GHz	Corr. value dB μ V/m	Limit dB μ V/m	Margin dB	Reading dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band	Pos.
5177	117.0	-	-	77.6	33.7	0.0	5.7	150	Vert.	carrier	2
5149	49.5	54.0	4.5	35.8	33.6	25.5	5.6	150	Vert.	Yes	2

Measurement uncertainty

+2.2 dB / -3.6 dB

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:											
29, 31 – 34, 36, 40, 41											

5.3 Maximum unwanted emissions

5.3.1 Method of measurement (conducted emissions)

The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly mounted to a spectrum analyser. The measurement procedure refers to part 5.4.2.2.2 in the 558074 D01 DTS Meas Guidance v.01.

In 5.4.1 it states, that attenuation below the general emission limits specified in §15.209(a) limits is not required. Therefore to simplify measurements, all emissions are compared to that limit.

If emissions were detected during the preliminary measurements, they were measured using the following measurement procedures:

Procedure for average measurement: 5.4.2.2.2.1 – Power Averaging:

- Set the analyzer span to encompass the entire unwanted emission bandwidth.
- Set the RBW = 1 MHz.
- Set the VBW \geq 3 MHz.
- Detector = power average (RMS).
- Ensure that the number of measurement points in the sweep to $\geq 2 \times$ (span/RBW).
- Manually set the sweep time to: $\geq 10 \times$ (number of measurement points in sweep) \times (transmission symbol period).
- Perform the measurement over a single sweep.
- Use the peak marker function to determine the maximum average power level in any 1 MHz of the unwanted emission.

Peak Measurement – Applicability of §15.35 (b),(c): Procedure in 5.4.2.2.3 – Peak Measurement

- Set the analyzer span to encompass the entire unwanted emission bandwidth.
- Set the RBW = span.
- Set the VBW \geq RBW.
- Set sweep time = auto couple.
- Detector = peak.
- Allow the trace to stabilize.
- Use the peak marker function to determine the peak power over the emission bandwidth.

The measurements were carried out at each antenna port.

5.3.1.1 Limit calculations

Chapter 5.4.2.2.1 provides the following formula for converting EIRP to equivalent electric field strength:

$$E = EIRP - 20\log(d) + 104.8 \quad (1)$$

Where:

E = electric field strength, in $\text{dB}\mu\text{V/m}$
 EIRP = equivalent isotropic radiated power, in dBm
 d = specified measurement distance, in meters

With the aid of this formula and the appropriate parts of [2], the EIRP limits in Table 1 were calculated.

Table 1 EIRP Limit calculations from Radiated Limits

Frequency MHz	Field strength $\mu\text{V/m}$	Meas Distance m	RBW	EIRP Limit dBm
0.009 – 0.490	2400/F (kHz)	300	200 – 300 Hz	6.3 – 20logF (kHz)
0.490 – 1.705	24000/F (kHz)	30	200 – 300 Hz	6.3 – 20logF (kHz)
1.705 – 30	30	30	9 – 10 kHz	-51.7
30 – 88	100	3	100 kHz	-60
88 – 216	150	3	100 kHz	-56.4
216 – 960	200	3	100 kHz	-54
960 – 1000	500	3	100 kHz	-46
≥ 1000	500	3	1 MHz	-41.3

Document [7] states, that for transmitters with multiple outputs in the same band, summing of emissions and accounting for array gain have to be considered.

For combining emissions from multiple outputs, the spurious emissions at each output have to be measured and $10\log(N)$ has to be added to the resulting value, whereby N refers to the number of outputs.

To account for directional gain which might occur in case of N transmit antennas, the directional has to be calculated as

$$G_{Dir} = G_{Ant} + 10\log(N)dBi,$$

whereby N is the number of antennas.

For the actual EUT with two antenna ports, a value of 8.15 dB has to be added to spurious emission values. Of which 3 dB result from the combined output from two outputs and 5.15 dBi is the directional gain.

To simplify the measurement, the EIRP limits were reduced for the aforementioned value. These results in an adjusted EIRP Limit table as shown in

Table 2 Adjusted EIRP Limits

Frequency MHz	EIRP Limit dBm
0.009 – 0.490	-1.85 – 20logF (kHz)
0.490 – 1.705	-1.85 – 20logF (kHz)
1.705 – 30	-59.85
30 – 88	-68.15
88 – 216	-64.55
216 – 960	-62.12
960 – 1000	-54.15
≥ 1000	-49.45

5.3.2 Test results (conducted emissions)

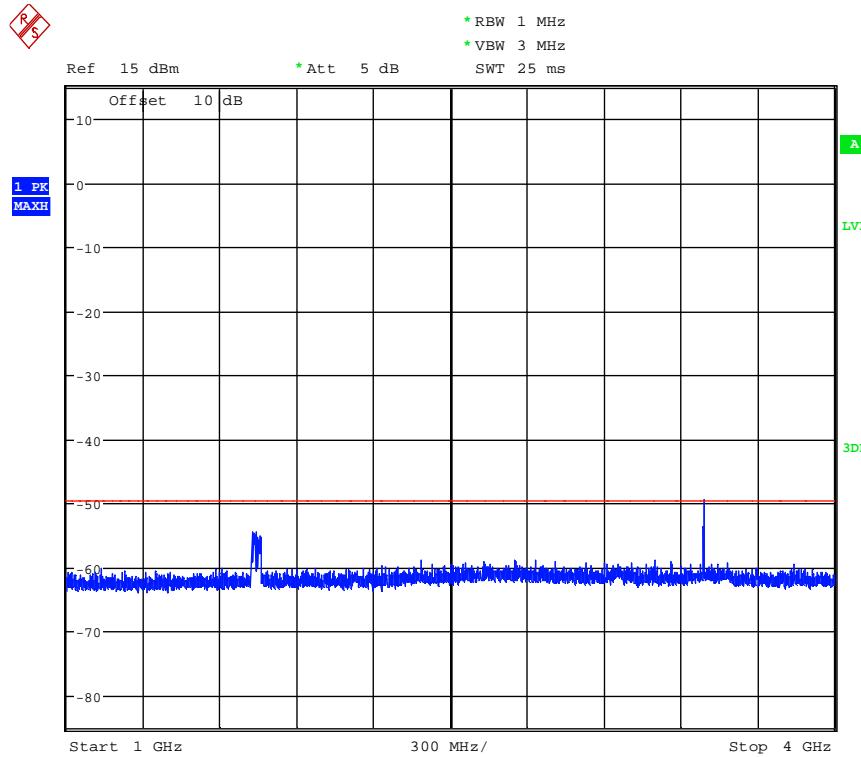
The measurements were only performed for frequencies above 1 GHz, because the device was already tested according to 15.109.

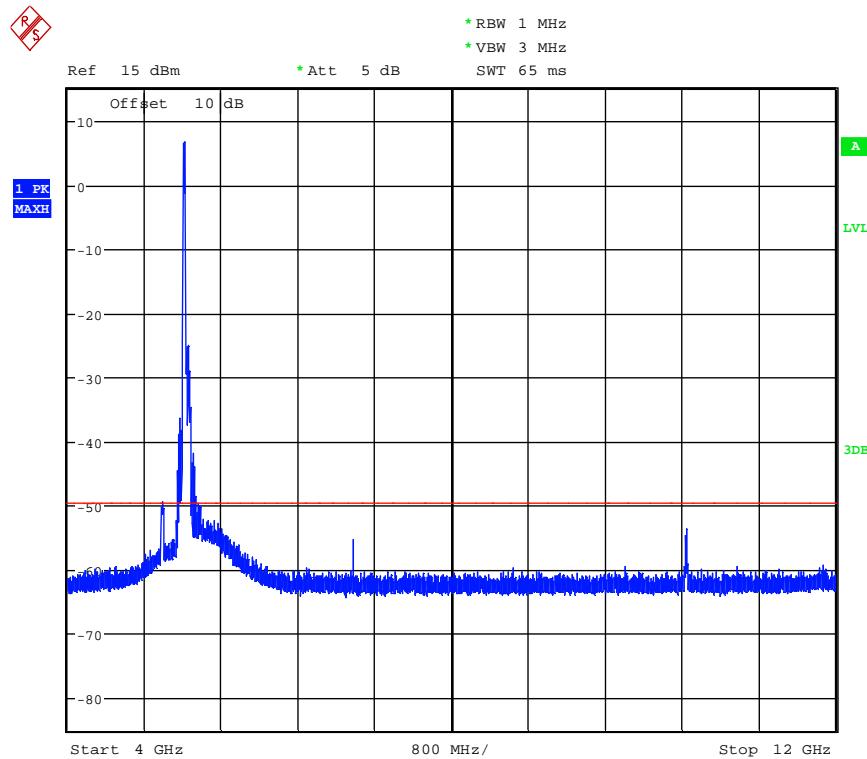
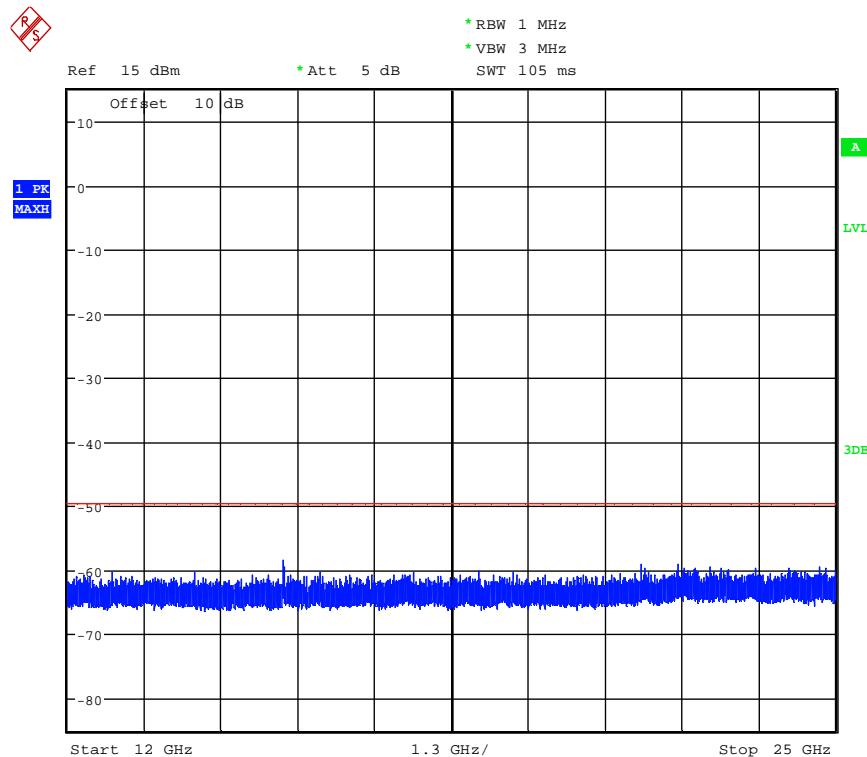
5.3.2.1 Antenna port 1

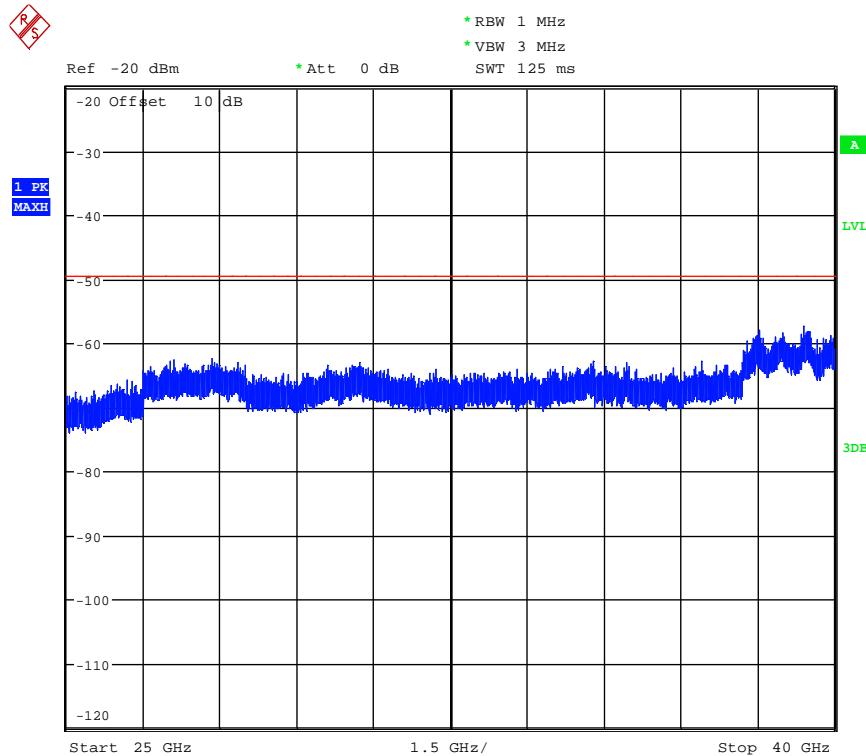
Ambient temperature	22 °C	Relative humidity	57 %
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The following results were measured at antenna port 1 of the EUT. The plots shows exemplary measurement results for the worst documented case. The other results are listed in the following table.

122165_UNII_Em1-4G_a_1mid.wmf: conducted spurious emissions (operation mode 2):



122165 UNII Em4-12G_a_1mid.wmf: conducted spurious emissions (operation mode 2):

122165 UNII Em12G-25G_a_1mid.wmf: conducted spurious emissions (operation mode 2):


122165 UNII_SpurEm25G-40G_a_1mid.wmf: conducted spurious emissions (operation mode 2):


Spurious Emissions, a-mode, channel 36 (Operation mode 1)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
1715	-29.5	-49.5	-47.5	-65.3	18.0	15.8
3460	-29.5	-49.5	-46.4	-51.4	16.9	1.9
4990	-29.5	-49.5	-46.8	-66.3	17.3	16.8
6920	-29.5	-49.5	-49.8	-57.1	20.3	7.6

Spurious Emissions, a-mode, channel 44 (Operation mode 2)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
1775	-29.5	-49.5	-47.8	-67.6	18.3	18.1
1885	-29.5	-49.5	-47.0	-69.3	17.5	19.8
3487	-29.5	-49.5	-47.2	-52.4	17.7	2.9
4993	-29.5	-49.5	-47.5	-66.4	18.0	16.9
6973	-29.5	-49.5	-50.5	-57.7	21.0	8.2

Spurious Emissions, a-mode, channel 48 (Operation mode 3)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
1775	-29.5	-49.5	-46.7	-64.1	17.2	14.6
3487	-29.5	-49.5	-47.1	-52.5	17.6	3.0
4993	-29.5	-49.5	-47.5	-66.1	18.0	16.6
6973	-29.5	-49.5	-50.7	-58.9	21.2	9.4

Spurious Emissions, n20-mode, channel 36 (Operation mode 4)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
1718	-29.5	-49.5	-46.4	-65.2	16.9	15.7
3460	-29.5	-49.5	-46.3	-51.5	16.8	2.0
4996	-29.5	-49.5	-47.3	-66.4	17.8	16.9
6920	-29.5	-49.5	-50.0	-57.4	20.5	7.9

Spurious Emissions, n20-mode, channel 44 (Operation mode 5)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
1731	-29.5	-49.5	-45.6	-63.9	16.1	14.4
3487	-29.5	-49.5	-47.0	-52.7	17.5	3.2
4988	-29.5	-49.5	-47.5	-66.4	18.0	16.9
6973	-29.5	-49.5	-49.9	-57.7	20.4	8.2

Spurious Emissions, n20-mode, channel 48 (Operation mode 6)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
1760	-29.5	-49.5	-46.5	-64.3	17.0	14.8
3487	-29.5	-49.5	-46.7	-52.5	17.2	3.0
4997	-29.5	-49.5	-47.4	-66.2	17.9	16.7
6973	-29.5	-49.5	-50.8	-59.0	21.3	9.5

Spurious Emissions, n40-mode, channel 40 (Operation mode 7)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
1.717	-29.5	-49.5	-47.3	-66.4	17.8	16.9
3460	-29.5	-49.5	-46.5	-51.4	17.0	1.9
4994	-29.5	-49.5	-47.3	-66.4	17.8	16.9
6920	-29.5	-49.5	-50.1	-57.6	20.6	8.1

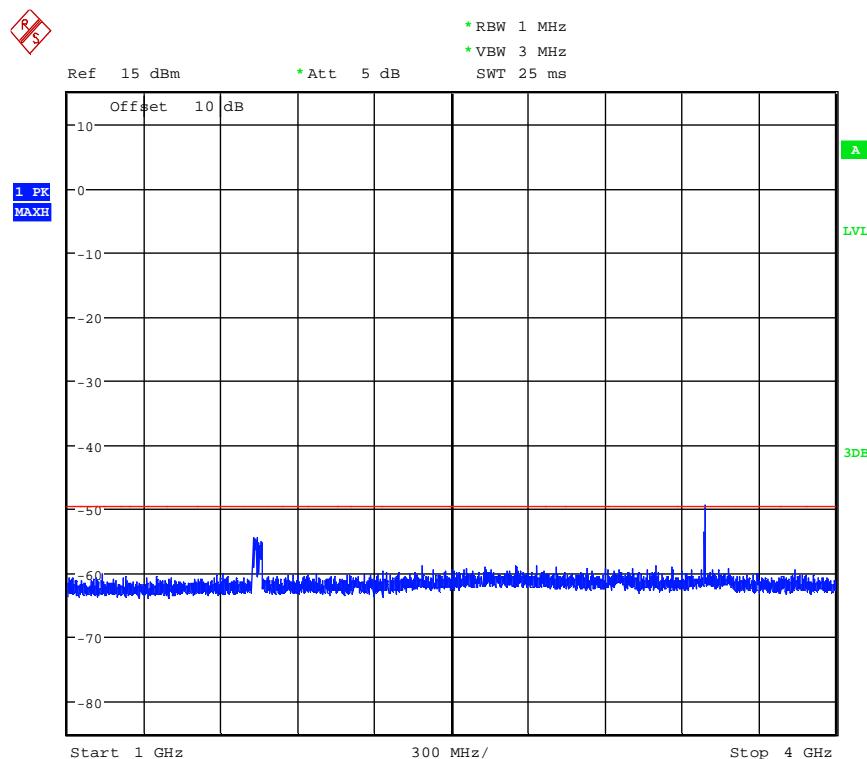
Spurious Emissions, n40-mode, channel 48 (Operation mode 8)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
1730	-29.5	-49.5	-46.3	-65.3	16.8	15.8
3448	-29.5	-49.5	-47.1	-52.6	17.6	3.1
4983	-29.5	-49.5	-47.6	-66.3	18.1	16.8
6973	-29.5	-49.5	-50.0	-58.5	20.5	9.0

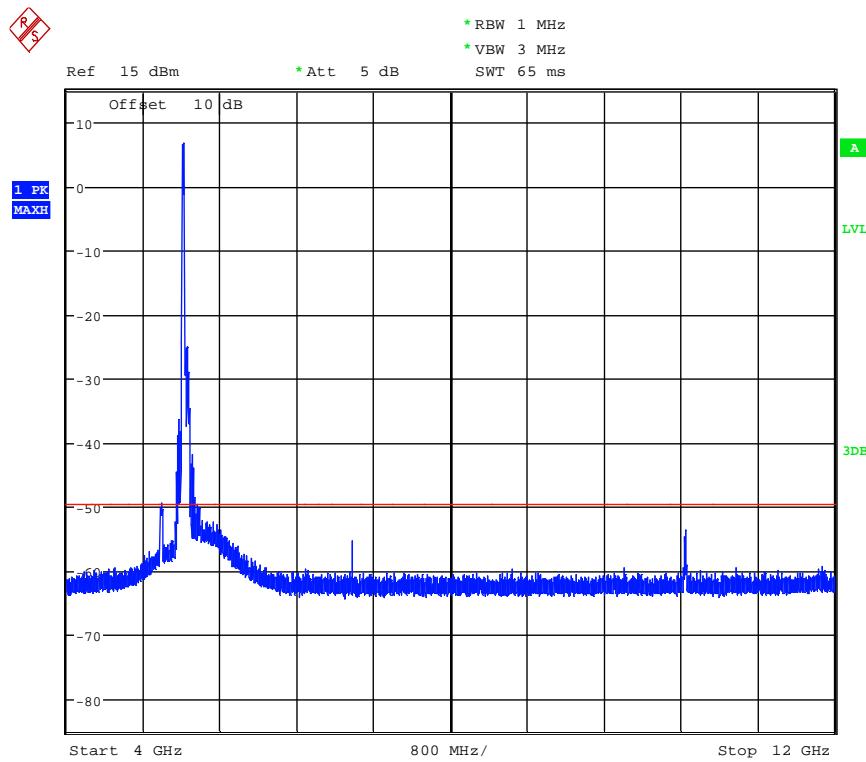
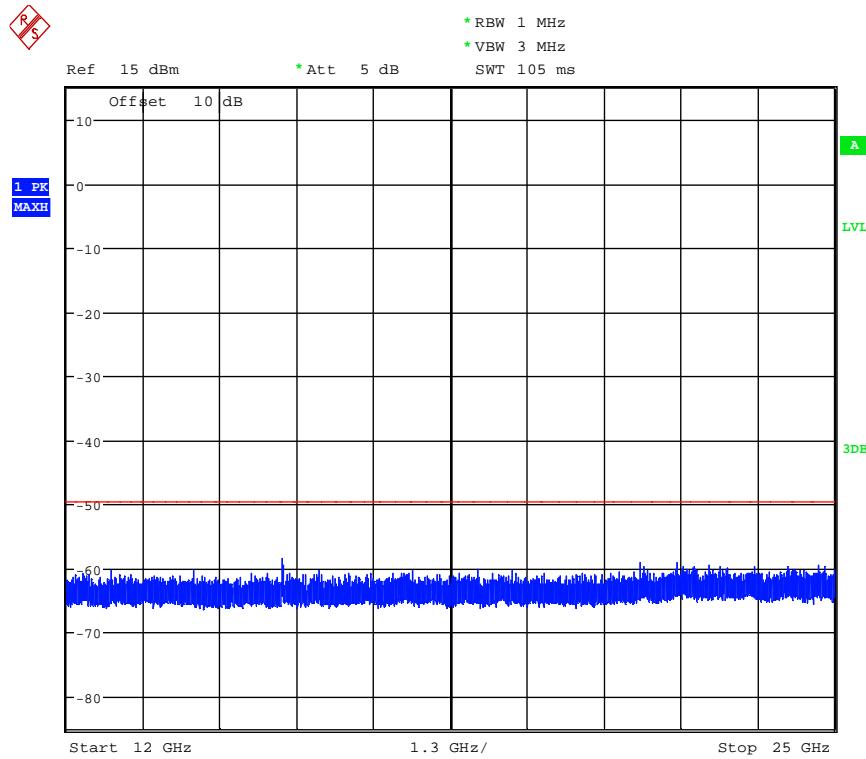
5.3.2.2 Antenna port 2

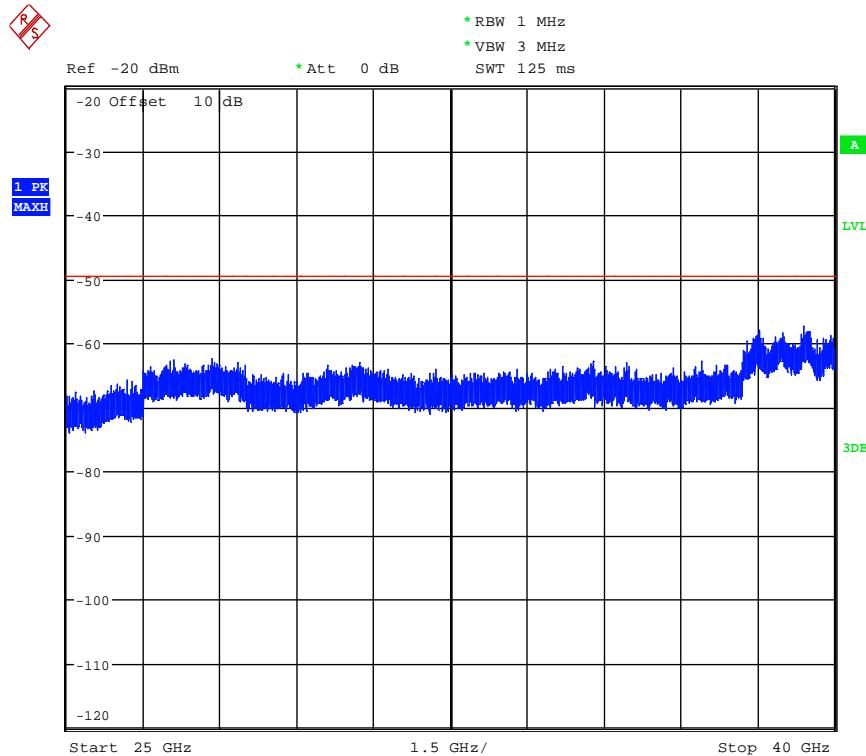
Ambient temperature	21 °C	Relative humidity	46 %
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The following results were measured at antenna port 2 of the EUT. The plots shows exemplary measurement results for the worst documented case. The other results are listed in the following table.

122165 UNII Em1-4G a 1mid.wmf: conducted spurious emissions (operation mode 2):



122165 UNII_Em4-12G_a_1mid.wmf: conducted spurious emissions (operation mode 2):

122165 UNII_Em12G-25G_a_1mid.wmf: conducted spurious emissions (operation mode 2):


122165 UNII_SpurEm25G-40G_a_1mid.wmf: conducted spurious emissions (operation mode 2):


Spurious Emissions, a-mode, channel 36 (Operation mode 1)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
3456	-29.5	-49.5	-50.7	-61.5	21.2	12.0
6920	-29.5	-49.5	-52.2	-61.9	22.7	12.4

Spurious Emissions, a-mode, channel 44 (Operation mode 2)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
3486	-29.5	-49.5	-51.5	-62.6	22.0	13.1
6973	-29.5	-49.5	-52.5	-62.8	23.0	13.3
10440	-29.5	-49.5	-48.3	-67.2	18.8	17.7

Spurious Emissions, a-mode, channel 48 (Operation mode 3)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
3487	-29.5	-49.5	-51.3	-62.7	21.8	13.2
6974	-29.5	-49.5	-52.3	-64.1	22.8	14.6
10481	-29.5	-49.5	-48.3	-67.5	18.8	18.0

Spurious Emissions, n20-mode, channel 36 (Operation mode 4)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
3461	-29.5	-49.5	-51.0	-61.6	21.5	12.1
6918	-29.5	-49.5	-51.7	-61.9	22.2	12.4

Spurious Emissions, n20-mode, channel 44 (Operation mode 5)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
3487	-29.5	-49.5	-50.7	-62.5	21.2	13.0
6973	-29.5	-49.5	-52.3	-62.8	22.8	13.3
10440	-29.5	-49.5	-48.7	-67.7	19.2	18.2

Spurious Emissions, n20-mode, channel 48 (Operation mode 6)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
3487	-29.5	-49.5	-51.5	-62.5	22	13.0

Spurious Emissions, n40-mode, channel 36 (Operation mode 7)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
3459	-29.5	-49.5	-50.4	-61.4	20.9	11.9
6920	-29.5	-49.5	-52.5	-62.4	23.0	12.9

Spurious Emissions, n40-mode, channel 48 (Operation mode 8)						
Unwanted Emission Frequency MHz	Max Peak Limit dBm	Average Limit dBm	Max Peak Emission dBm	Average Emission dBm	Peak Margin dB	Average Margin dB
3487	-29.5	-49.5	-51.4	-62.7	21.9	13.2

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

30, 80

5.3.3 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 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 and final measurement (1 GHz to 110 GHz)

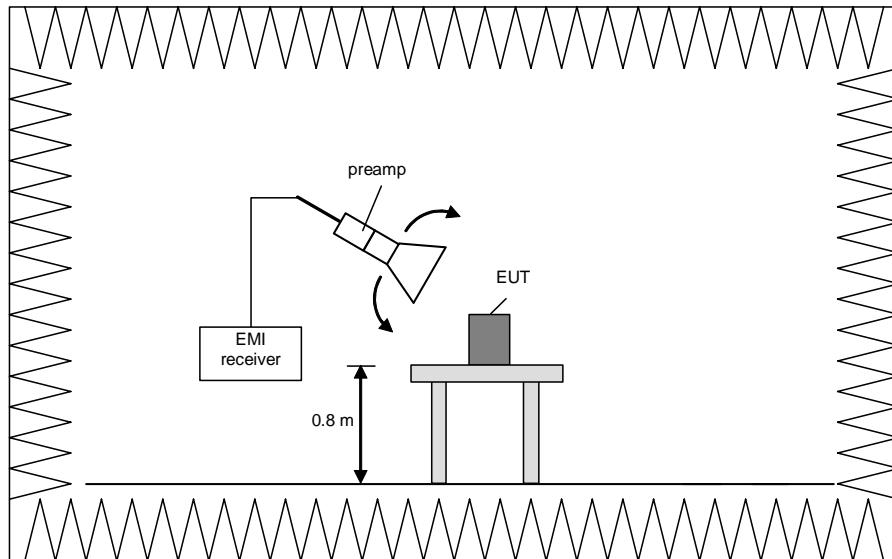
This measurement will be performed in a fully anechoic chamber. Tabletop devices will be set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The set up of the Equipment under test will be in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

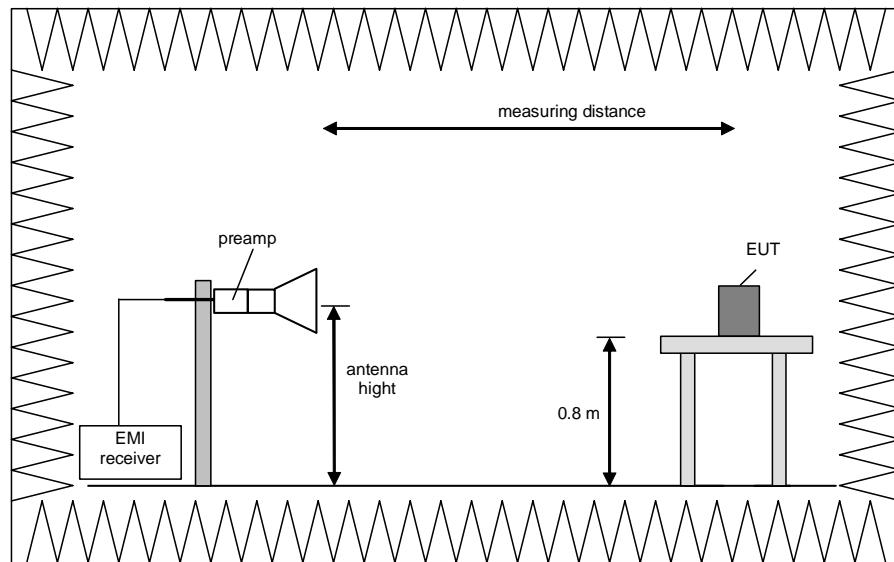


Final measurement (1 GHz to 110 GHz)

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.

5.3.4 Test results (radiated emissions) – cabinet emissions

5.3.4.1 Preliminary radiated emission measurement

Ambient temperature	21 °C	Relative humidity	51 %
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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 with 12 V via an AC/DC Adapter.

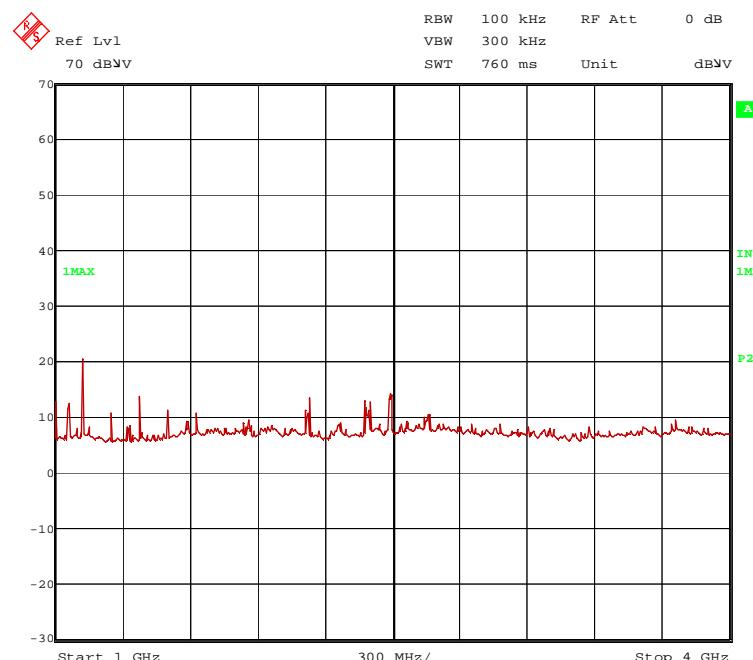
Remark: Document [3] states in G-3-b-i, that in case of conducted measurements, additional radiated cabinet emission measurements must be performed. The measurements were performed at the worst case modulation, namely 802.11n mode with 20 MHz at channel 36, 44 and 48.

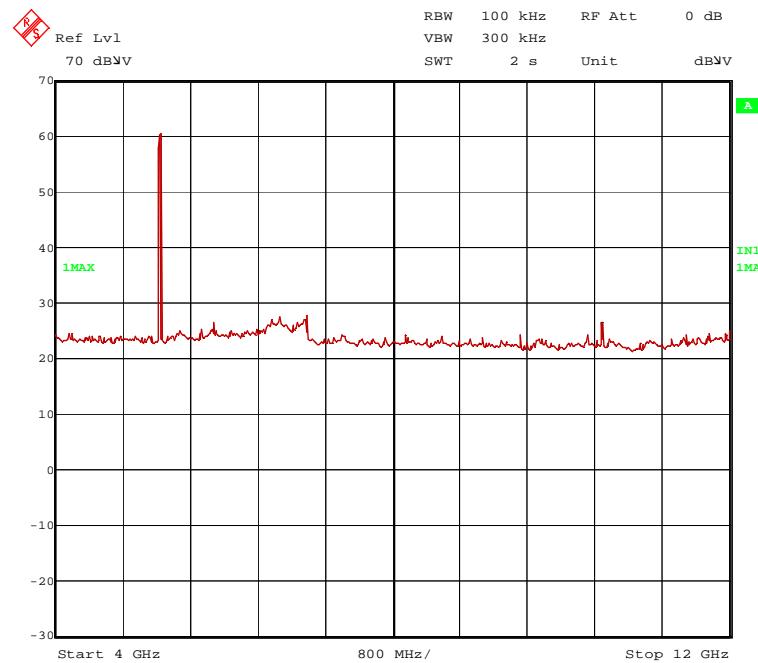
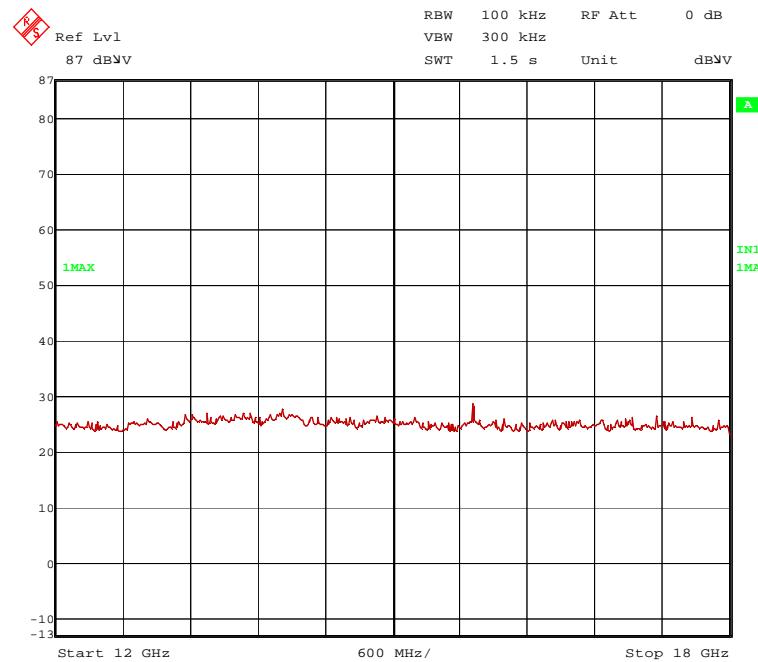
The measurements were only performed for frequencies above 1 GHz, because the device was already tested according to 15.109.

Only the plots of the worst case emissions are submitted for every frequency range above 1 GHz in the preliminary results.

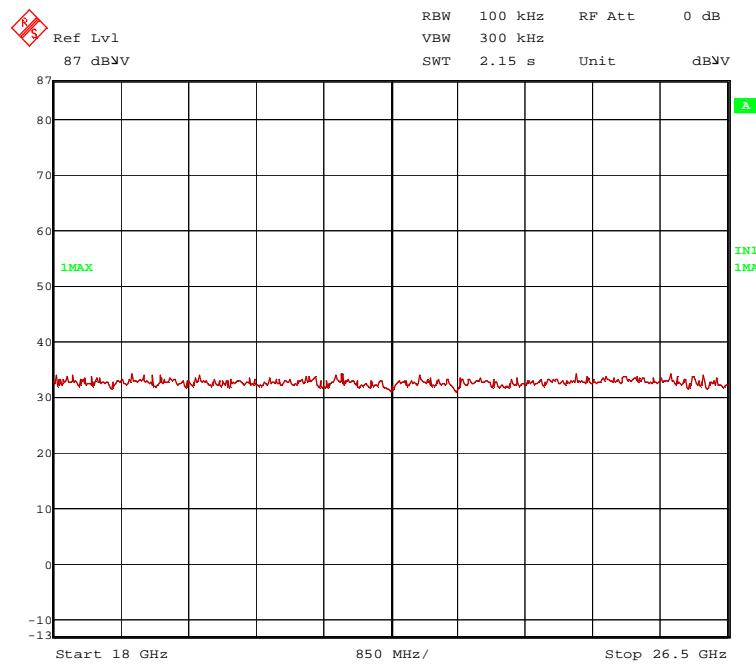
Transmitter operates at the upper end of the assigned frequency band (n20-mode)

2165_150.WMF: Spurious emissions from 1 GHz to 4 GHz (operation mode 6):

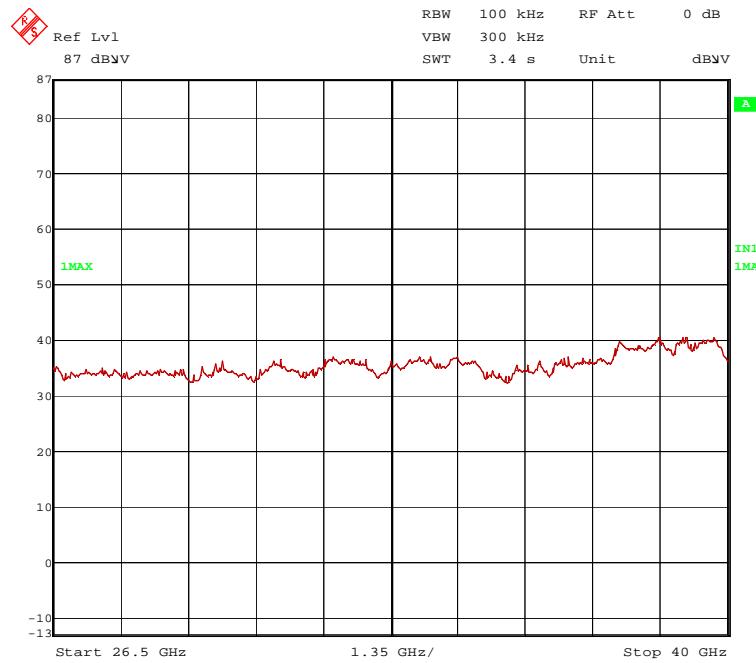


2165_156.WMF: Spurious emissions from 4 GHz to 12 GHz (operation mode 6):

122165_164.wmf: Spurious emissions from 12 GHz to 18 GHz (operation mode 6):


2165_165.WMF.wmf: Spurious emissions from 18 GHz to 26.5 GHz (operation mode 7):



2165_171.WMF.WMF.wmf: Spurious emissions from 26.5 GHz to 40 GHz (operation mode 7):



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

- 1125 MHz, 1375 MHz, 2488 MHz, 15727 MHz

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

- 5248 MHz and 10489 MHz.

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

TEST EQUIPMENT USED FOR THE TEST:
29, 31 – 37, 39 - 44, 46, 49 – 51, 55, 72, 73

5.3.4.2 Final radiated emission measurement (1 GHz to 25 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: 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 powered with 12 V via an AC/DC adapter.

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 4)

Result measured with the peak detector:

Frequency MHz	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.
5177	66.7			66.7	0.0	0.0	0.0	150	Vert.	carrier	2
1125	50.9	74.0	23.1	23.8	24.6	0.0	2.5	150	Vert.	Yes	2
1375	46.8	74.0	27.2	18.9	25.0	0.0	2.9	150	Hor.	Yes	2
2496	55.7	74.0	18.3	23.4	28.5	0.0	3.8	150	Vert.	Yes	2
10361	60.6	74.0	13.4	38.6	37.6	23.9	8.3	150	Vert.	No	2
Measurement uncertainty						+2.2 dB / -3.6 dB					

Result measured with the average detector:

Frequency MHz	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.
5177	56.8			56.8	0.0	0.0	0.0	150	Vert.	carrier	2
1125	44.3	54.0	9.7	17.2	24.6	0.0	2.5	150	Vert.	Yes	2
1375	39.2	54.0	14.8	11.3	25.0	0.0	2.9	150	Hor.	Yes	2
2496	39.5	54.0	14.5	7.2	28.5	0.0	3.8	150	Vert.	Yes	2
10361	45.9	54.0	8.1	23.9	37.6	23.9	8.3	150	Vert.	No	2
Measurement uncertainty						+2.2 dB / -3.6 dB					

Transmitter operates at the middle of the assigned frequency band (operation mode 5)

Result measured with the peak detector:

Frequency MHz	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.
5223	70.6			70.6	0.0	0.0	0.0	150	Vert.	carrier	2
1125	50.9	74.0	23.1	23.8	24.6	0.0	2.5	150	Vert.	Yes	2
1375	46.6	74.0	27.4	18.7	25.0	0.0	2.9	150	Hor.	Yes	2
2499	55.7	74.0	18.3	23.4	28.5	0.0	3.8	150	Vert.	Yes	2
10448	59.2	74.0	14.8	37.3	37.5	23.9	8.3	150	Hor.	No	2
15661	53.2	74.0	20.8	44.2	33.7	27.2	2.5	150	Vert.	Yes	2
Measurement uncertainty						+2.2 dB / -3.6 dB					

Result measured with the average detector:

Frequency MHz	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.
5223	60.0			60.0	0.0	0.0	0.0	150	Vert.	carrier	2
1125	44.8	54.0	9.2	17.7	24.6	0.0	2.5	150	Vert.	Yes	2
1375	39.3	54.0	14.7	11.4	25.0	0.0	2.9	150	Hor.	Yes	2
2499	39.5	54.0	14.5	7.2	28.5	0.0	3.8	150	Vert.	Yes	2
10448	44.2	54.0	9.8	22.3	37.5	23.9	8.3	150	Vert.	No	2
15661	35.5	54.0	18.5	26.5	33.7	27.2	2.5	150	Vert.	Yes	2
Measurement uncertainty						+2.2 dB / -3.6 dB					

Transmitter operates at the upper end of the assigned frequency band (operation mode 6)

Result measured with the peak detector:

Frequency MHz	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.
5246	135.3			70.3	33.7	25.5	5.8	150	Vert.	carrier	2
1125	51.2	74.0	22.8	24.1	24.6	0.0	2.5	150	Vert.	Yes	2
1375	20.4	74.0	53.6	19.0	25.0	26.5	2.9	150	Hor.	Yes	2
2488	29.4	74.0	44.6	23.6	28.5	26.5	3.8	150	Vert.	Yes	2
10489	59.1	115.3	56.2	37.0	37.5	23.9	8.5	150	Vert.	No	2
15727	54.9	74.0	19.1	45.9	33.7	27.2	2.5	150	Vert.	Yes	2
Measurement uncertainty						+2.2 dB / -3.6 dB					

Result measured with the average detector:

Frequency MHz	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.
5246	126.6			61.6	33.7	25.5	5.8	150	Vert.	carrier	2
1125	44.9	54.0	9.2	17.8	24.6	0.0	2.5	150	Vert.	Yes	2
1375	13.1	54.0	40.9	11.7	25.0	26.5	2.9	150	Hor.	Yes	2
2488	12.2	54.0	41.8	6.4	28.5	26.5	3.8	150	Vert.	Yes	2
10489	44.6	106.6	62.0	22.5	37.5	23.9	8.5	150	Vert.	No	2
15727	36.0	54.0	18.0	27.0	33.7	27.2	2.5	150	Vert.	Yes	
Measurement uncertainty						+2.2 dB / -3.6 dB					

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

29, 31 – 37, 39 - 44, 46, 49 – 51, 55, 72, 73

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
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	MA240-0	Inn-Co GmbH	MA240-0/030/6600603	480086	-	-
19	Antenna	CBL6111 D	Chase	25761	480894	09/28/2011	09/2014
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 A	EMCO	9609-4918	480183	11/09/2011	11/2014
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.)	
40	Standard Gain Horn Antenne 26.4 – 40.1 GHz	22240-20	Flann Microwave	469	480229	Six month verification (system cal.)	
41	RF-cable No. 3	Sucoflex 106B	Huber&Suhner	0563/6B / Kabel 3	480670	Weekly verification (system cal.)	
42	RF-cable No. 40	Sucoflex 106B	Huber&Suhner	0708/6B / Kabel 40	481330	Weekly 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	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	02/16/2012	02/2014
60	Power Meter	NRVD	Rohde & Schwarz	833697/030	480589	02/15/2012	02/2014
72	4 GHz High Pass Filter	WHKX4.0/18 G-8SS	Wainwright Instruments	1	480587	Weekly verification (system cal.)	
73	Single Control Unit	SCU	Maturo GmbH	SCU/006/971107	480831	Calibration not necessary	
80	High-pass Filter	H26G40G1	Microwave Circuits, Inc.	33471	480593	Six month verification (system cal.)	

7 REPORT HISTORY

Report Number	Date	Comment
F122165E2	26 September 2012	Document created

8 LIST OF ANNEXES

ANNEX A TEST SET-UP PHOTOS 4 pages

120195_03: Test setup - Radiated emission, Antennas terminated (fully anechoic chamber)
 120195_05: Test setup - Radiated emission (fully anechoic chamber)
 120195_15: Test setup - conducted measurement

ANNEX B EXTERNAL PHOTOGRAPHS 2 pages

122165_06.JPG: EUT, 3D view 1
 122165_07.JPG: EUT, 3D view 2
 122165_16.JPG: EUT, label foto

ANNEX C INTERNAL PHOTOGRAPHS 7 pages

122165_08.JPG: EUT - internal, top view
 122165_09.JPG: EUT - internal, top view
 122165_10.JPG: EUT, main PCB, top view
 122165_11.JPG: EUT, main PCB, bottom view
 122165_12.JPG: EUT, RF PCB, top view – with shielding
 122165_14.JPG: EUT, RF PCB, top view – without shielding
 120195_13.JPG: EUT, RF PCB, bottom view

ANNEX D CO-LOCATION TESTS 13 pages