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# Test Report

Report Number: F151496E5

Applicant:

**u-blox Malmö AB**

Manufacturer:

**u-blox Malmö AB**

Equipment under Test (EUT):

**ODIN-W2**



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

## REFERENCES

- [1] **ANSI C63.10-2013** American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15 (June 2015)** Radio Frequency Devices
- [3] **RSS-247 (May 2015)** Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- [4] **RSS-Gen Issue 4 (November 2014)** General Requirements for Compliance of Radio Apparatus

## TEST RESULT

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

Test engineer:	Paul NEUFELD		16 October 2015
	Name	Signature	Date
Authorized reviewer:	Bernd STEINER		16 October 2015
	Name	Signature	Date

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# 1 IDENTIFICATION

## 1.1 Applicant

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Applicant represented during the test by the following person:	None

## 1.2 Manufacturer

Name:	u-blox Malmö AB
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Country:	Sweden
Name for contact purposes:	Mr. Mats ANDERSSON
Phone:	+ 46 40 63 07 100
Fax:	+ 46 40 23 71 37
eMail Address:	mats.andersson@u-blox.com
Manufacturer represented during the test by the following person:	None

## 1.3 Test laboratory

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

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

#### 1.4 EUT (Equipment Under Test)

Test object: *	WLAN / Bluetooth module
Model / PMN: *	ODIN-W2
FCC ID: *	PVH0965
IC Company number / UPN: *	5325A-0965
HVIN	ODIN-W260 ODIN-W262
Serial number: *	#13, #5
PCB identifier: *	0965-02
Hardware version: *	2.1
Software version / FVIN: *	0.11

Channel 01	RX:	2412 MHz	TX:	2412 MHz
Channel 02	RX:	2417 MHz	TX:	2417 MHz
Channel 03	RX:	2422 MHz	TX:	2422 MHz
Channel 04	RX:	2427 MHz	TX:	2427 MHz
Channel 05	RX:	2432 MHz	TX:	2432 MHz
Channel 06	RX:	2437 MHz	TX:	2437 MHz
Channel 07	RX:	2442 MHz	TX:	2442 MHz
Channel 08	RX:	2447 MHz	TX:	2447 MHz
Channel 09	RX:	2452 MHz	TX:	2452 MHz
Channel 10	RX:	2457 MHz	TX:	2457 MHz
Channel 11	RX:	2462 MHz	TX:	2462 MHz

Fulfills WLAN specification: *	IEEE, 802.11b, 802.11g, 802.11n,					
Antenna type: *	See Table 1					
Antenna gain: *	See Table 1					
Antenna connector: *	See Table 1					
Power supply - EUT	3.3 V DC					
Power supply Host	U <sub>nom</sub> =	3.3 V DC	U <sub>min</sub> =	3.0 V DC	U <sub>max</sub> =	3.6 V DC
Type of modulation: *	802.11b: CCK, DQPSK, DBPSK 802.11g: OFDM 802.11n: OFDM					
Operating frequency range:*	2412 MHz to 2462 MHz, 5180 MHz to 5240 MHz, 5260 MHz to 5320 MHz, 5500 MHz to 5700 MHz, 5745 to 5825 MHz					
Number of channels: *	11					
Temperature range: *	-40 °C to +85 °C					
Lowest / highest internal clock frequency: *	24.000 MHz / 26.000 MHz					

\* declared by the applicant.

**Table 1 Antenna specifications**

Antenna name	Manufacturer	Type	Comment	Gain [dBi]
WCR-2400 -IP04 -IP10 -SMRP	Centurion	Monopole	10cm flying lead U.FL 25cm flying lead U.FL RSMA	2 dBi @ 2.4 GHz
SDM2-2400/1575	Mobile Mark	Patch	10cm cable/U.FL	2 dBi @ 2.4 GHz
PSTG0-2400HS -RSMA	Mobile Mark	Monopole	RSMA	0 dBi @ 2.4 GHz
FlatWhip-2400	ProAnt	Monopole	RSMA	3 dBi @ 2.4 GHz
InSide-2400	ProAnt	Patch	10cm cable/U.FL	3 dBi @ 2.4 GHz
InSide-WLAN	ProAnt	Patch	dual band 10cm cable/U.FL	3 dBi @ 2.4 GHz 3 dBi @ 5 GHz
Outside-2400	ProAnt	Patch	7 cm flying lead U.FL 10 cm flying lead U.FL 25 cm flying lead U.FL	3 dBi @ 2.4 GHz
Ex-IT 2400 -RP-SMA 28-001 -MHF 28-001	ProAnt	Monopole	RSMA 10 cm flying lead U.FL	3 dBi @ 2.4 GHz
Ex-IT WLAN -RP-SMA -MHF	ProAnt	Monopole	dual band RSMA 10cm flying lead U.FL	3 dBi @ 2.4 GHz 3 dBi @ 5 GHz
Ex-IT 2400 -MHF 70-001	ProAnt	Monopole	10cm flying lead U.FL	3 dBi @ 2.4 GHz
Ex-IT 2400 -RP-SMA 70-002	ProAnt	Monopole	RSMA	3 dBi @ 2.4 GHz
InSide Fold-2400	ProAnt	Patch	10 cm cable/U.FL	3 dBi @ 2.4 GHz
InSide Fold-WLAN	ProAnt	Patch	10 cm flying lead U.FL	2.5 dBi @ 2.4 GHz' 3 dBi @ 5 GHz
InSide-WLAN Square	ProAnt	Patch	Dual band; 10 cm cable/U.FL	3 dBi @ 2.4 GHz 3 dBi @ 5 GHz
OnBoard SMD 2400	ProAnt	Patch	SMD PIFA antenna on ODIN-W262	3 dBi @ 2.4 GHz <3 dBi @ 5 GHz
R380.500.125 R380.500.124 R380.500.139	Pulse	Monopole	.125: RSMA .124: RSMA+SEAL .139: RSMA+SEAL	2 dBi @ 2.4 GHz
SOA 2400/360/3/20/V	Huber+Suhner	Monopole	150 cm cable / RSMA (P/N 1324.99.033) 150 cm cable/MCX (P/N 1324.99.0036)	3 dBi @ 2.4 GHz
NanoBlue-IP04	Laird Technologies	Patch	10 cm cable/U.FL	2 dBi @ 2.4 GHz



The following external I/O cables were used:

Identification	Connector		Length
	EUT	Ancillary	
DC in (carrier board)		-	2 m *
USB interface (carrier board)	USB plug	Laptop PC	-

\*: Length during the test if not other specified.

## 1.5 Dates

Date of receipt of test sample:	10 March 2015
Start of test:	31 March 2015
End of test:	23 July 2015

## 2 OPERATIONAL STATES

The equipment under test (EUT) is a WLAN dual band and Bluetooth dual mode module soldered onto a carrier board. The WLAN / Bluetooth module is equipped with an U.FL antenna connector (Model ODIN-W260) or an integral antenna (Model ODIN-W262). The module version with the U.FL antenna connectors is able to operate in MIMO mode. The MIMO mode is only possible for 2.4 GHz operation with 802.11n modulation with 20MHz. The EUT with internal antenna has no MIMO. MIMO is also not possible in 5 GHz mode for both versions of the EUT nor for Bluetooth operation.

Because the ODIN-W2 is a module, which will be implemented in a final application, it was mounted on a carrier board (EVB-W2) to connect it to a Laptop with the test software. All tests were carried out with an unmodified sample.

With test software which was provided by the applicant the EUT could be set to a continuous transmit mode with a certain modulation scheme and data rate on a certain frequency. Furthermore the equipment could be set to receive mode on a certain frequency. This software was installed on a laptop PC, which was connected to the Equipment under test via the carrier board.

For this test report the EUT was tested as a WLAN device in the 2.4 GHz band which was able to operate according to the specification 802.11 b/g/n20. The table below shows the worst case modulation and data rate for appropriate test cases.

The following operation modes were identified as worst case condition and used during the tests:

Operation mode	Description of the operation mode	WLAN mode	WLAN channel	Modulation	Data rate
1	Continuous transmitting on 2412 MHz	b	1	CCK	1 MBit/s
2	Continuous transmitting on 2437 MHz	b	6	CCK	1 MBit/s
3	Continuous transmitting on 2462 MHz	b	11	CCK	1 MBit/s
4	Continuous transmitting on 2412 MHz	g	1	OFDM	6 MBit/s
5	Continuous transmitting on 2437 MHz	g	6	OFDM	6 MBit/s
6	Continuous transmitting on 2462 MHz	g	11	OFDM	6 MBit/s
7	Continuous transmitting on 2412 MHz	n 20 MHz SiSo	1	OFDM	6.5 MBit/s
8	Continuous transmitting on 2437 MHz	n 20 MHz SiSo	6	OFDM	6.5 MBit/s
9	Continuous transmitting on 2462 MHz	n 20 MHz SiSo	11	OFDM	6.5 MBit/s
10	Continuous transmitting on 2412 MHz	n 20 MHz MiMo	1	OFDM	6.5 MBit/s
11	Continuous transmitting on 2437 MHz	n 20 MHz MiMo	6	OFDM	6.5 MBit/s
12	Continuous transmitting on 2462 MHz	n 20 MHz MiMo	11	OFDM	6.5 MBit/s

Each test case was performed in the following operation modes

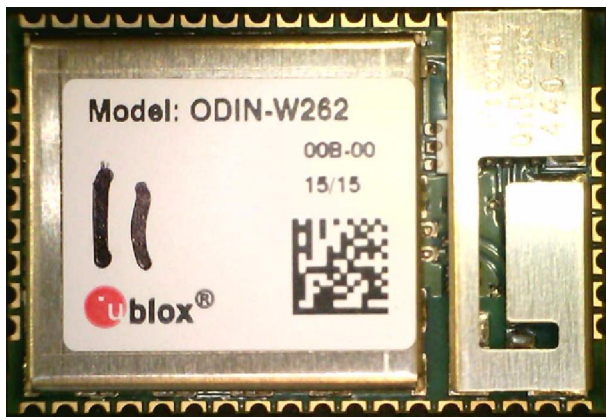
Test case	Operation mode
Maximum Peak Output Power	1 - 12
DTS Bandwidth	1 - 9
Peak Power Spectral Density	1 - 9
Band Edge Compliance	1, 3, 4, 6, 7, 9
Maximum Unwanted Emissions	1 - 9

### 3 ADDITIONAL INFORMATION

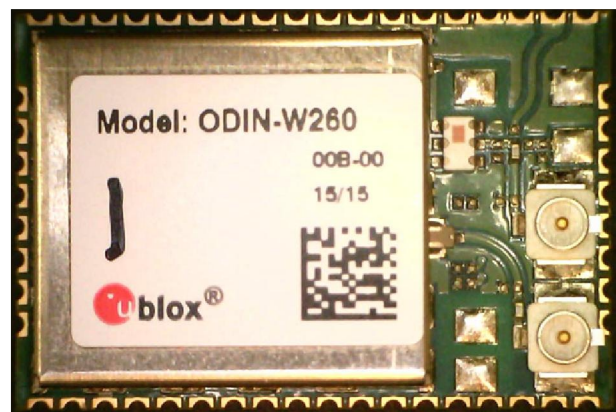
For the tests presented in this document via test software provided by the applicant the RF output power of the EUT was set to the values shown in the table below.

WLAN Mode	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11
b	13	13	14	14	14	14	14	13	12	12	11
g	12	14	14	17	17	17	17	17	16	14	12
N20 SiSo	11	12	14	15	17	17	17	17	17	13	12
N20 MiMo	11	14	16	17	17	17	17	17	17	17	15

This report contains the results of the EUT operating in the 2.4 GHz band only.



ODIN-W262 as marketed



ODIN-W260 as marketed

## 4 OVERVIEW

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [3] or RSS-Gen, Issue 3 [4]	Status	Refer page
Maximum Peak Output Power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (2) [3]	Passed	13 et seq
DTS Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (1) [3]	Passed	18 et seq
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (2) [3]	Passed	20 et seq
Band edge compliance	2400.0 - 2483.5	15.247 (d)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	22 et seq.
Radiated emissions (transmitter)	0.009 – 26,500	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	28 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Passed	59 et seq.

## 5 TEST RESULTS

### 5.1 Duty cycle

#### 5.1.1 Method of measurement

The measurement was performed as a conducted measurement.

##### **Acceptable measurement configurations**

The measurement procedures described herein are based on the use of radiated measurements.

The method described in chapter 11.6.0 b) of document [1] was used to perform the following test.

The measurement was only performed on only one frequency, because the timing behaviour was found to be independent of the selected channel.

The following measurement technique was used:

The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the on and off times of the transmitted signal.

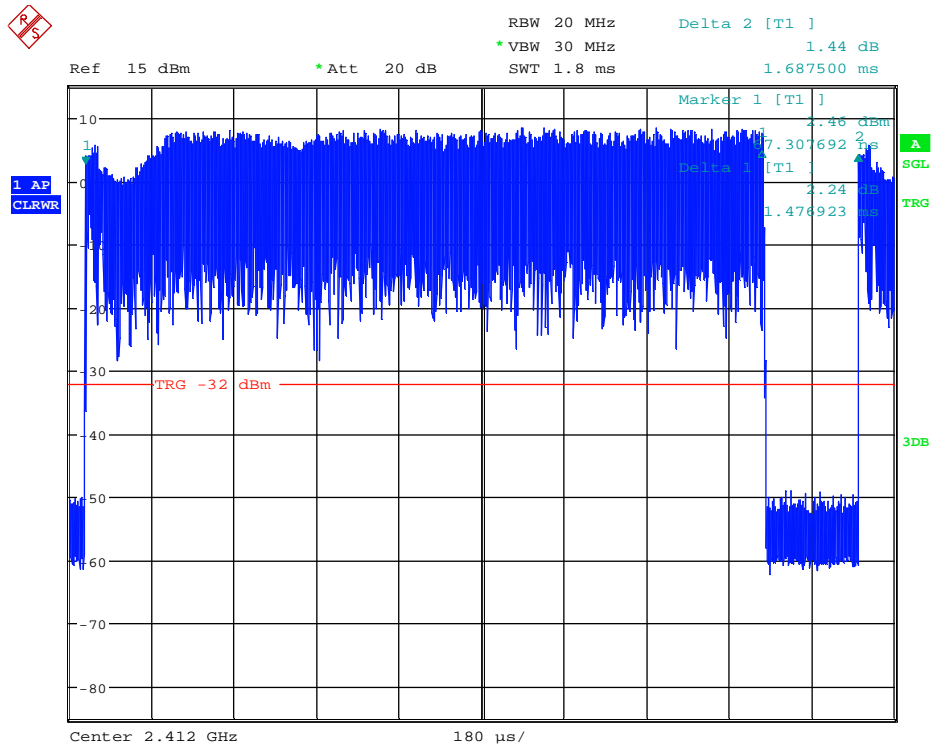
- Set the center frequency of the instrument to the center frequency of the transmission.
- Set  $RBW \geq OBW$  if possible; otherwise, set RBW to the largest available value.
- Set  $VBW \geq RBW$ .
- Set detector = peak or average.
- The zero-span measurement method shall not be used unless both RBW and VBW are  $> 50/T$  and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if  $T \leq 16.7$  microseconds.)

### 5.1.2 Test results

Ambient temperature	22 °C	Relative humidity	40 %
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The following plot only shows the worst case for the duty cycle correction, the other results are only submitted in the calculations below.

Odin\_DutyCycle\_n20\_1.wmf: Duty cycle measurement on channel 1 with 6.5 Mbps:



The following calculations for the settings are only submitted for the worst case, therefore the other results can be assumed to be passed as well.

$$T_{TX} = 1.688ms \quad (1)$$

$$\frac{50}{T_{TX}} = \frac{50}{1.688ms} = 29.620kHz \leq RBW \leq VBW \quad (2)$$

Measurement Points 5000 for 1.8 ms → 1.688 ms = 4688 measurement points → Signal has 4688 measurement points (and fulfils the requirement of at least 100 Points resolution for the signal)

$$T_{TX\_On} = 1.477ms \quad (3)$$

$$T_{TX\_Period} = 1.688ms \quad (4)$$

If power averaging (RMS) mode was used in step f), then the applicable correction factor is  $10 \log(1/x)$ , where x is the duty cycle.

$$x = \frac{1.477ms}{1.688ms} = 0.875 = 87.5\% \quad (5)$$

$$\text{Correction factor: } 10 \cdot \log\left(\frac{1}{x}\right) = 10 \cdot \log\left(\frac{1}{0.875}\right) = 10 \cdot \log\left(\frac{1}{0.875}\right) = 0.6dB \quad (6)$$

Therefore, for average measurements a correction factor of 0.6 dB is use in all tests with n20 modulation. The results for the other modulation are submitted without calculation below:

802.11b with 1 Mbps: 0.1 dB correction factor  
 802.11g with 6 Mbps: 0.3 dB correction factor  
 802.11n20 with 6.5 Mbps: 0.6 dB correction factor

**TEST EQUIPMENT USED FOR THE TEST:**

7

## 5.2 Maximum peak output power

### 5.2.1 Method of measurement

The EUT has to be connected to the power meter 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.

PKPM1 – Peak power meter method was used for this test. The procedure is described in chapter 11.9.1.3 of document [1].

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

Test set-up:





## 5.2.2 Test results

Ambient temperature	22 °C	Relative humidity	62 %
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The highest antenna array gain is 6.0 dBi for MIMO. Therefore no reduction of the Peak power limit is necessary.

Operation Mode	Antenna gain combined [dBi]	Maximum peak output power Port 1 [dBm]	Maximum peak output power Port 2 [dBm]	Maximum peak output power - Sum of both ports [dBm]	Margin [dB]	Peak power limit [dBm]
1	3.0	13.8	-	-	16.2	30
2	3.0	14.9	-	-	15.1	30
3	3.0	12.5	-	-	17.5	30
4	3.0	15.9	-	-	14.1	30
5	3.0	17.7	-	-	12.3	30
6	3.0	15.6	-	-	14.4	30
7	3.0	15.4	-	-	14.6	30
8	3.0	17.4	-	-	12.6	30
9	3.0	15.8	-	-	14.2	30
10	3.0	14.9	17.0	19.1	10.9	30
11	3.0	16.3	18.8	20.7	9.3	30
12	3.0	15.0	17.5	19.4	10.6	30
Measurement uncertainty			+0.66 dB / -0.72 dB			

Test: Passed

### TEST EQUIPMENT USED FOR THE TEST:

26, 27

## 5.3 DTS Bandwidth

### 5.3.1 Method of measurement

The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly connected to a spectrum analyser. The measurement procedure refers to part 11.8.1 of document [1].

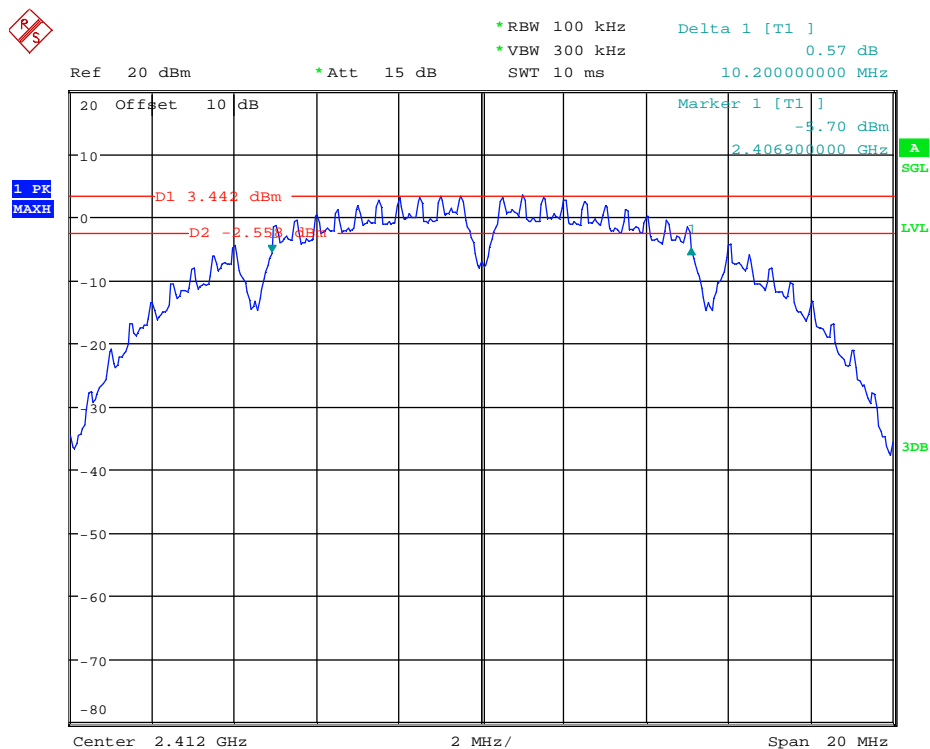
- Set RBW = 100 kHz.
- Set the video bandwidth (VBW)  $\geq 3 \times$  RBW.
- Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize.
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

### 5.3.2 Test result

Ambient temperature	22 °C	Relative humidity	59 %
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The following results were measured at the antenna port of the EUT. The plot shows an exemplary measurement result for the worst documented case. The other results are listed in the following table.

#### Odin\_6dB-BW\_b\_1: DTS Bandwidth (operation mode 1):



Operation Mode	Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	Result
1	2412	0.5	10.200	Passed
2	2437	0.5	10.200	Passed
3	2462	0.5	10.200	Passed
4	2412	0.5	15.150	Passed
5	2437	0.5	15.150	Passed
6	2462	0.5	15.200	Passed
7	2412	0.5	15.200	Passed
8	2437	0.5	15.200	Passed
9	2462	0.5	15.200	Passed
Measurement uncertainty			+0.66 dB / -0.72 dB	

Test: Passed

#### TEST EQUIPMENT USED FOR THE TEST:

7
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## 5.4 Peak Power Spectral Density

### 5.4.1 Method of measurement

The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly connected to a spectrum analyser. The measurement procedure refers to part 11.10.2 of document [1].

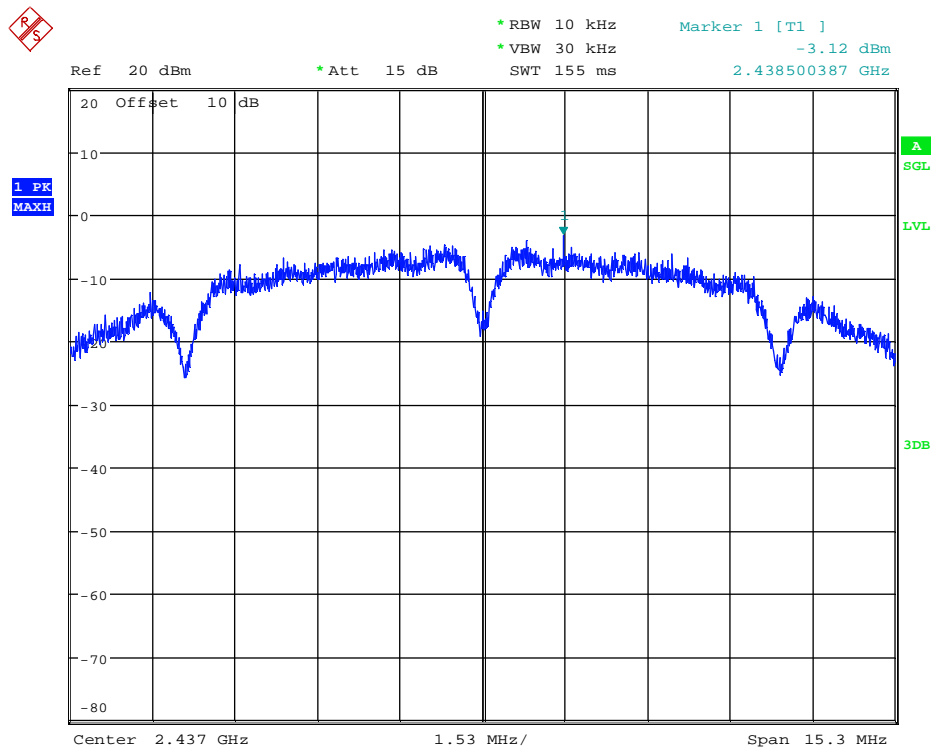
- Set analyser center frequency to DTS channel center frequency
- Set the span to 1.5 times the DTS bandwidth.
- Set the RBW to:  $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$ .
- Set the VBW  $\geq 3 \times \text{RBW}$ .
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level within the RBW.
- If measured value exceeds limit, reduce RBW (not less than 3 kHz) and repeat.

### 5.4.2 Test result

Ambient temperature	22 °C	Relative humidity	59 %
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The following results were measured at the antenna port of the EUT. The plot shows an exemplary measurement result for the worst documented case. The other results are listed in the following table.

Odin\_PwrSpecDens\_b\_6.wmf: Power Spectral Density (operation mode 1):



Operation Mode	Peak Frequency [MHz]	Power Spectral Density Limit [dBm/3kHz]	Power Spectral Density Reading [dBm / 10 kHz]	Array Gain [dB]	Power Spectral Density Level [dBm / 10kHz]	Margin [dB]	Result
1	2413.505	8	-4.4	0.0	-4.4	12.4	Passed
2	2438.500	8	-3.1	0.0	-3.1	11.1	Passed
3	2461.334	8	-6.5	0.0	-6.5	14.5	Passed
4	2413.879	8	-7.8	0.0	-7.8	15.8	Passed
5	2440.126	8	-4.6	0.0	-4.6	12.6	Passed
6	2461.375	8	-8.6	0.0	-8.6	16.6	Passed
7	2411.123	8	-10.9	0.0	-10.9	18.9	Passed
8	2438.249	8	-7.9	0.0	-7.9	15.9	Passed
9	2463.249	8	-9.9	0.0	-9.9	17.9	Passed
10	2410.746	8	-6.6	0.0	-6.6	14.6	Passed
11	2435.754	8	-3.7	0.0	-3.7	11.7	Passed
12	2458.872	8	-4.5	0.0	-4.5	12.5	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

7
---

## 5.5 Band-edge compliance

### 5.5.1 Method of measurement (band edges next to unrestricted bands (conducted))

The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly connected to a spectrum analyser. The measurement procedure refers to part 11.11.2 and 11.11.3 of document [1].

Measurement Procedure Reference – Reference Level:

- RBW = 100 kHz.
- VBW  $\geq$  300 kHz.
- Set the span to  $\geq$  1.5 times the DTS Bandwidth.
- Detector = Peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilise.
- Use the peak marker function to determine the the maximum PSD level.

Measurement Procedure – Unwanted Emissions

- Set the center frequency and span to encompass the frequency range to be measured.
- RBW = 100 kHz.
- VBW  $\geq$  300 kHz.
- Detector = Peak.
- Ensure that the number of measurement points  $\geq$  span/RBW.
- Sweep time = auto couple.
- Trace Mode = max hold.
- Allow the trace to stabilise.
- Use the peak marker function to determine the maximum amplitude level.

The measurement procedure at the band edges was simplified by performing the measurement in just one plot. Both, the in-band-emission and the unwanted emission were be encompassed by the span. After trace stabilization, the maximum peak was be determined by a peak detector and the value was marked by an appropriate limit line. The second limit line, which is 20 dB below the first, marks the limit for the emissions in the unrestricted band. A maximum-peak-detector marks the highest emission in the unrestricted band next to the band edge.

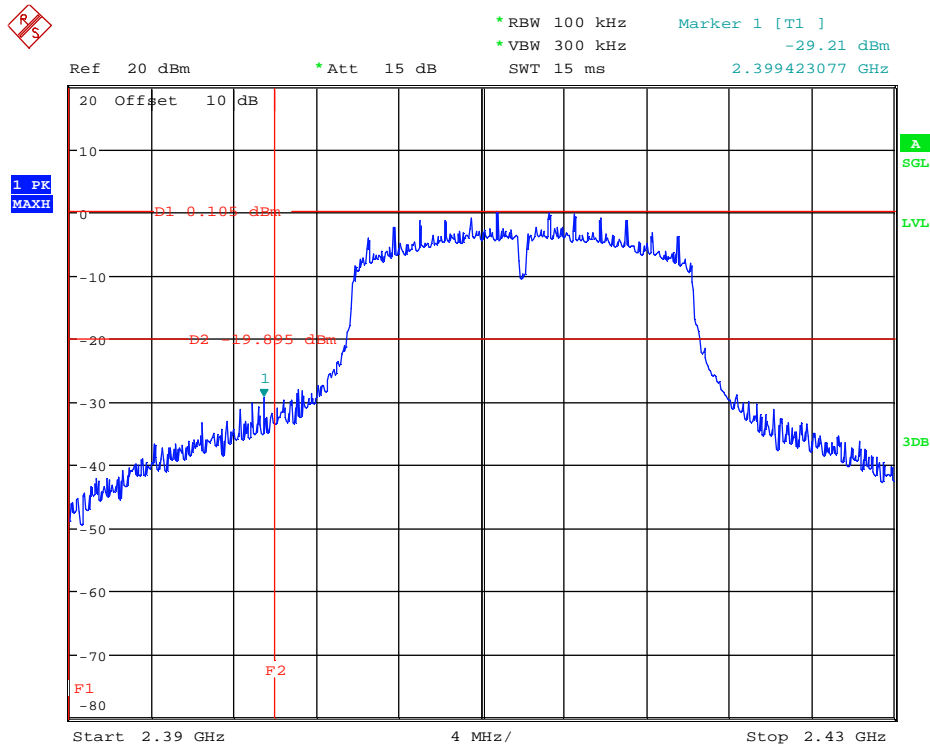
The measurements were performed at the lower end of the 2.4 GHz band.

### 5.5.2 Test result (band edges next to unrestricted bands (conducted))

Ambient temperature	22 °C	Relative humidity	59 %
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The following results were measured at the antenna port of the EUT. The plot shows an exemplary measurement result for the worst documented case. The other results are listed in the following table.

Odin\_BandEdgeUnrestr\_g\_1.wmf: conducted band-edge compliance (operation mode 4):



WLAN Mode	WLAN Channel	Antenna port	Emission Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Emission Level [dBm]	Margin [dB]	Result
b	1	1	2396.987	3.5	-16.5	-43.6	27.1	Passed
g	1	1	2399.423	0.1	-19.9	-29.2	9.3	Passed
n20	1	1	2399.551	-2.1	-22.1	-34.2	12.1	Passed
n20	1	2	2399.808	-0.3	-20.3	-36.7	16.4	Passed

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:
7

### 5.5.3 Method of measurement (band edges next to restricted bands (conducted))

The same test set-up as used for the final conducted emission measurement shall be used (refer also subclause 5.6.1 of this test report).

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. The level of the measured field strength shall be compared to the the general limits specified in § 15.205.

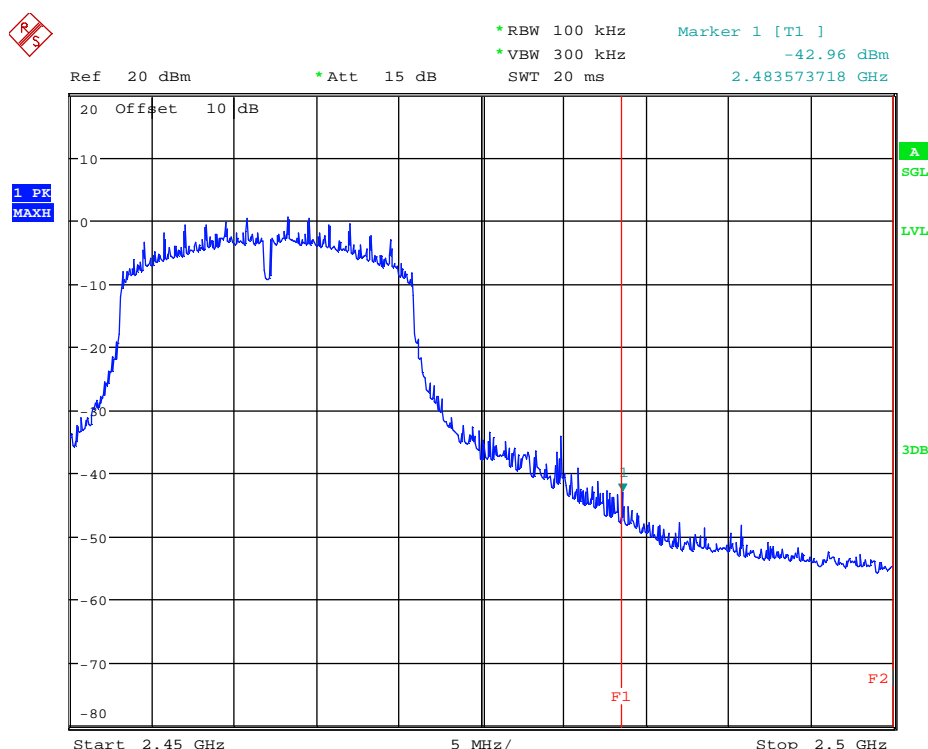
The measurement was performed at the lower and the upper end of the 2.4 GHz band.

### 5.5.4 Test result (band edges next to restricted bands (conducted))

Ambient temperature	22 °C	Relative humidity	59 %
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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.

Odin\_Port2\_BandEdgeRestr\_n20\_11.wmf: conducted band-edge compliance (operation mode 12):





Band Edge Compliance, b-mode, channel 1 (Operation mode 1)									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
b	1	2385.639	52.8	74.0	21.2	-45.4	3.0	Passed	Y
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
b	1	2385.527	42.8	54.0	11.2	-55.6	3.0	Passed	Y
Measurement uncertainty				+0.66 dB / -0.72 dB					

Band Edge Compliance, b-mode, channel 11 (Operation mode 3)									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
b	11	2484.451	54.6	74.0	19.4	-43.6	3.0	Passed	Y
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
b	11	2486.588	45.9	54.0	8.1	-52.5	3.0	Passed	Y
Measurement uncertainty				+0.66 dB / -0.72 dB					

Band Edge Compliance, g-mode, channel 1 (Operation mode 4)									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
g	1	2389.748	70.7	74.0	3.3	-27.6	3.0	Passed	Y
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
g	1	2389.986	49.2	54.0	4.8	-49.2	3.0	Passed	Y
Measurement uncertainty				+0.66 dB / -0.72 dB					

Band Edge Compliance, g-mode, channel 11 (Operation mode 6)									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
g	11	2483.711	71.5	74.0	2.5	-26.8	3.0	Passed	Y
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
g	11	2483.649	48.4	54.0	5.6	-50.2	3.0	Passed	Y
Measurement uncertainty				+0.66 dB / -0.72 dB					

Band Edge Compliance, n20-mode, channel 1 (Operation mode 7) (SISO mode)									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	1	2389.575	72.4	74.0	1.6	-28.9	6.0	Passed	Y
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	1	2389.975	47.5	54.0	6.5	-51.4	3.0	Passed	Y
Measurement uncertainty				+0.66 dB / -0.72 dB					

Band Edge Compliance, n20-mode, channel 11 (Operation mode 9) (SISO mode)									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	11	2483.656	73.4	74.0	0.6	-27.9	6.0	Passed	Y
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	11	2483.606	49.4	54.0	4.6	-49.5	3.0	Passed	Y
Measurement uncertainty				+0.66 dB / -0.72 dB					

Band Edge Compliance, n20-mode, channel 1 (Operation mode 10) – Port 1 (MIMO mode)									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	1	2389.575	72.4	74.0	1.6	-28.9	6.0	Passed	Y
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	1	2389.975	50.5	54.0	3.5	-51.4	6.0	Passed	Y
Measurement uncertainty				+0.66 dB / -0.72 dB					

Band Edge Compliance, n20-mode, channel 11 (Operation mode 12) – Port 1 (MIMO mode)									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	11	2483.656	73.4	74.0	0.6	-27.9	6.0	Passed	Y
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	11	2483.606	52.4	54.0	1.6	-49.5	6.0	Passed	Y
Measurement uncertainty				+0.66 dB / -0.72 dB					

Band Edge Compliance, n20-mode, channel 1 (Operation mode 10) – Port 2 (MIMO mode)									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	1	2389.948	68.4	74.0	5.6	-32.8	6.0	Passed	Y
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	1	2389.973	50.0	54.0	4.0	-51.9	6.0	Passed	Y
Measurement uncertainty				+0.66 dB / -0.72 dB					

Band Edge Compliance, n20-mode, channel 11 (Operation mode 12) – Port 2 (MIMO mode)									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	11	2483.524	73.8	74.0	0.2	-27.4	6.0	Passed	Y
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	11	2483.524	53.9	54.0	0.1	-48.0	6.0	Passed	Y
Measurement uncertainty				+0.66 dB / -0.72 dB					

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

7

## 5.6 Maximum unwanted emissions

### 5.6.1 Method of measurement (conducted emissions in the restricted bands)

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 11.12.2.2 in document [1].

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

Procedure for average measurement: 11.12.2.5.2 – Trace averaging across ON and OFF times of the EUT transmissions followed by duty cycle correction:

If continuous transmission of the EUT ( $D \geq 98\%$ ) cannot be achieved and the duty cycle is constant (duty cycle variations are less than  $\pm 2\%$ ), then the following procedure shall be used:

- The EUT shall be configured to operate at the maximum achievable duty cycle.
- Measure the duty cycle  $D$  of the transmitter output signal as described in 11.6 in [1].
- Set the RBW = 1 MHz (unless otherwise specified).
- Set the VBW  $\geq 3 \times$  RBW.
- Detector = power average (RMS).
- Ensure that the number of measurement points in the sweep to  $\geq 2 \times$  (span/RBW).
- Averaging type = power
- Sweep time = auto
- Perform a trace average of at least 100 traces
- Correct the resulting measurement value by addin the duty cycle correction value calculated in 5.1.2.

Peak measurement procedure: 11.12.2.4 in [1]

- Set the analyzer span to encompass the entire unwanted emission bandwidth.
- Set the RBW = specified in Table 2.
- Set the VBW  $\geq$  RBW.
- Set sweep time = auto.
- Detector = peak.
- Trace mode = max hold.
- Allow the trace to stabilize.
- Use the peak marker function to determine the peak power over the emission bandwidth.

**Table 2 RBW as a function of frequency**

Frequency	RBW
9-150 kHz	200-300 Hz
0.15-30 MHz	9-10 kHz
30-1000 MHz	100-120 kHz
> 1000 MHz	1 MHz

### 5.6.1.1 Limit calculations

The following general procedure is described in chapter 11.12.2.2 in [1].

- a) Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency (see 11.12.2.3 through 11.12.2.5 for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).
- b) Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP (see 11.12.2.6 for guidance on determining the applicable antenna gain).
- c) Add the appropriate maximum ground reflection factor to the EIRP (6 dB for frequencies  $\leq 30$  MHz; 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive; and 0 dB for frequencies  $> 1000$  MHz).
- d) For MIMO devices, measure the power of each chain and sum the EIRP of all chains in linear terms (i.e., watts and mW).
- e) Convert the resultant EIRP to an equivalent electric field strength using the following relationship:

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

where

E is the electric field strength in dB $\mu$ V/m

EIRP is the equivalent isotropically radiated power in dBm

d is the specified measurement distance in m

- f) Compare the resultant electric field strength level with the applicable regulatory limit.
- g) C Perform the radiated spurious emission test.

Chapter 14 in [1] states, that for transmitters with multiple outputs in the same band, summing of emissions and accounting for array gain have to be considered.

For this test report the procedure of summing of emissions as described in 14.3.2.2 in [1] was used.

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

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

whereby N is the number of antennas.

For the actual EUT the highest combination of antenna gain and used number of ports results in an additional value, added to the conducted spurious emission level, of 6 dB. Whereby the antenna has a gain of 3 dBi and the number of used ports is 2.

## 5.6.2 Method of measurement (conducted emissions in the unrestricted bands)

In any 100 kHz outside the authorized frequency band, the power shall be attenuated by 20 dB, compared to the highest in band power in any 100 kHz. This shall be demonstrated by using the peak power procedure. The reference level shall be measured using the procedure described in 5.6.2.1 and the emission level according to procedure 5.6.2.2. The procedures are based on chapter 11.11.2 and 11.11.3 in [1].

For the 802.11n 20 MHz MIMO mode the level of the both ports were summed in linear value for each frequency step. The applicable plots show the result of that sum.

### 5.6.2.1 Reference level measurement

- a) Set instrument center frequency to DTS channel center frequency.
- b) Set the span to  $\geq 1.5$  times the DTS bandwidth.
- c) Set the RBW = 100 kHz.
- d) Set the VBW  $\geq 3 \times$  RBW.
- e) Detector = peak.
- f) Sweep time = auto couple.
- g) Trace mode = max hold.
- h) Allow trace to fully stabilize.
- i) Use the peak marker function to determine the maximum PSD level.

### 5.6.2.2 Emission level measurement

- a) Set the center frequency and span to encompass frequency range to be measured.
- b) Set the RBW = 100 kHz.
- c) Set the VBW  $\geq 3 \times$  RBW.
- d) Detector = peak.
- e) Ensure that the number of measurement points  $\geq$  span/RBW
- f) Sweep time = auto couple.
- g) Trace mode = max hold.
- h) Allow trace to fully stabilize.
- i) Use the peak marker function to determine the maximum amplitude level.

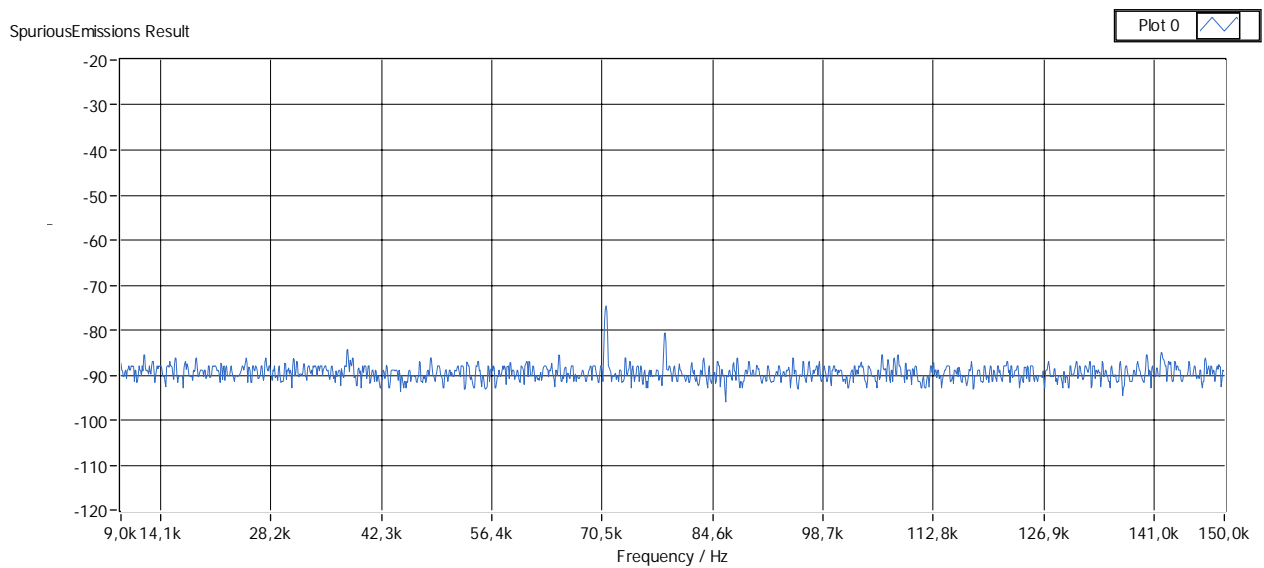
### 5.6.3 Test results (conducted emissions)

#### 5.6.3.1 Emissions below 1 GHz

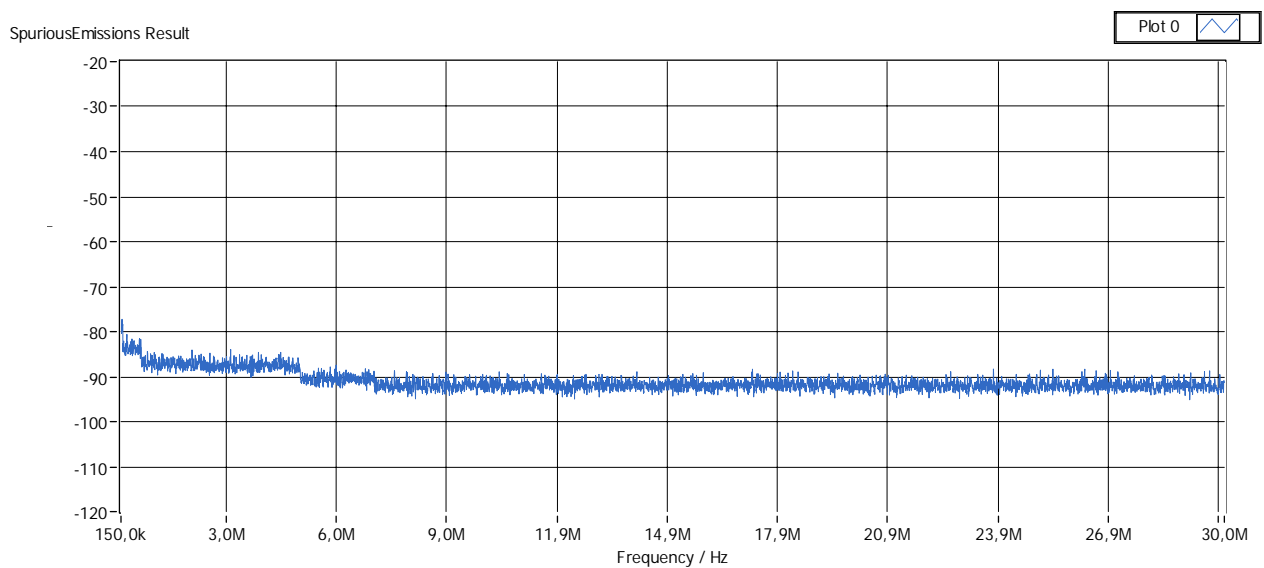
Ambient temperature	22 °C	Relative humidity	59 %
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The Emissions below 1 GHz were similar for all channels, modulations and data rates. Therefore only the results of an exemplary test case are submitted below.

Odin\_SpurEmiss9-150k\_b\_1.wmf: conducted spurious emissions (operation mode 1):




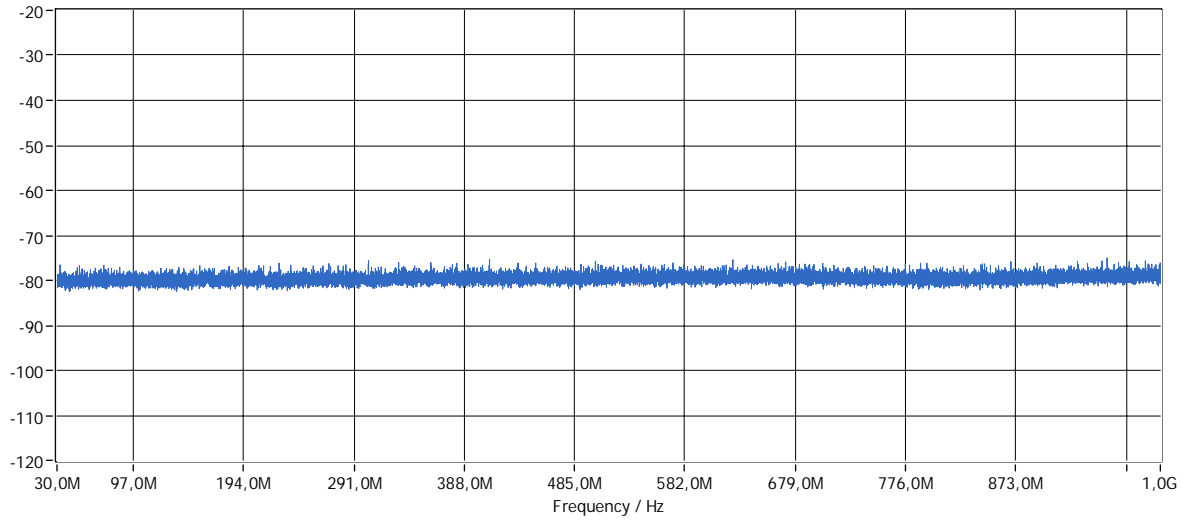
Odin\_SpurEmiss150k-30M\_b\_1.wmf: conducted spurious emissions (operation mode 1):



136117 30M-1G allModesWLAN b 1.wmf: conducted spurious emissions (operation mode 1):

SpuriousEmissions Result

Plot 0 



Spurious Emissions f < 1 GHz									
Peak Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Max Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
b	1	0.071	-9.1	30.6	39.6	-73.3	3.0	Passed	Y
b	1	0.079	-16.5	29.7	46.2	-80.8	3.0	Passed	Y
b	1	0.142	-18.3	24.6	42.9	-82.6	3.0	Passed	Y

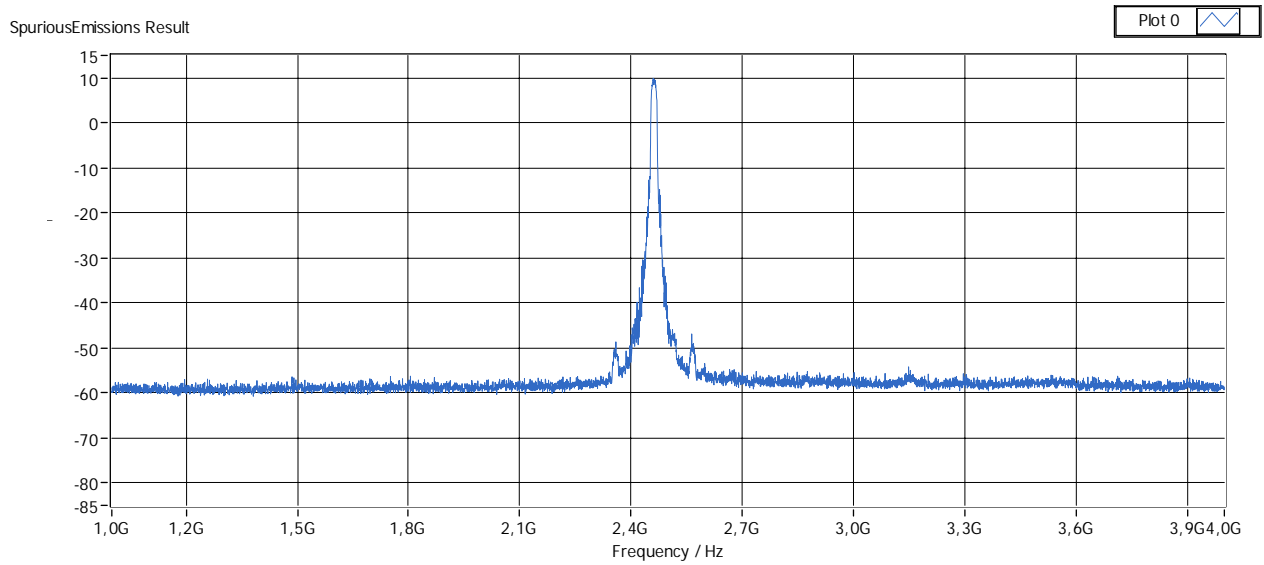


### 5.6.3.2 Emissions above 1 GHz

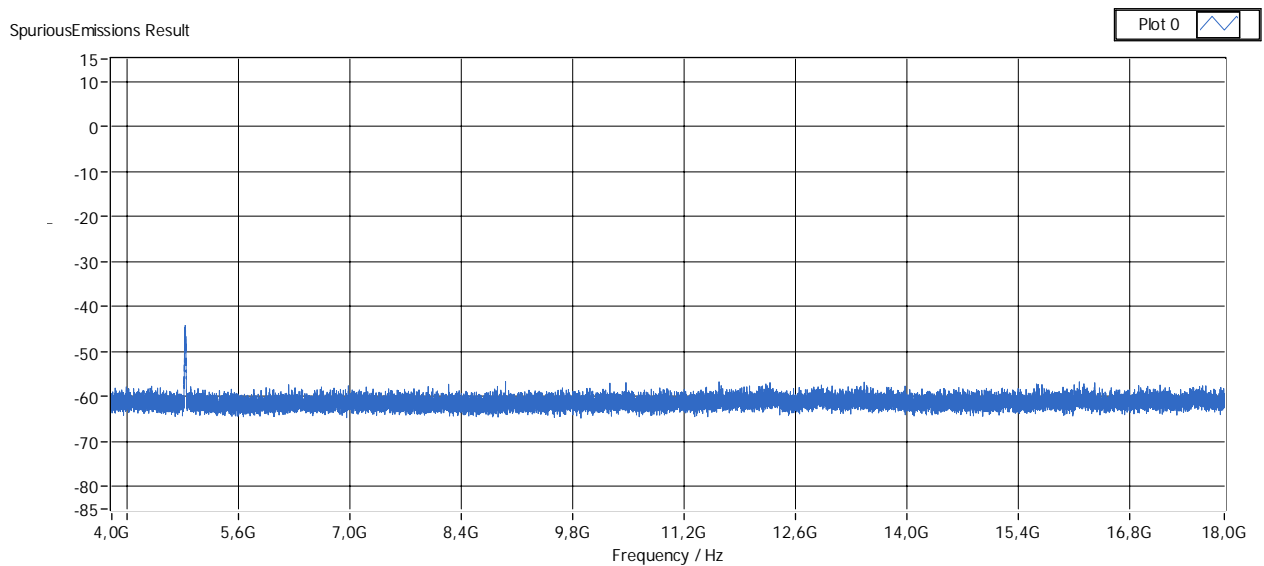
Ambient temperature	22 °C	Relative humidity	59 %
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The following results were measured at antenna port of the EUT. Each plot shows an exemplary measurement results for the worst documented case. The other results are listed in the following tables.

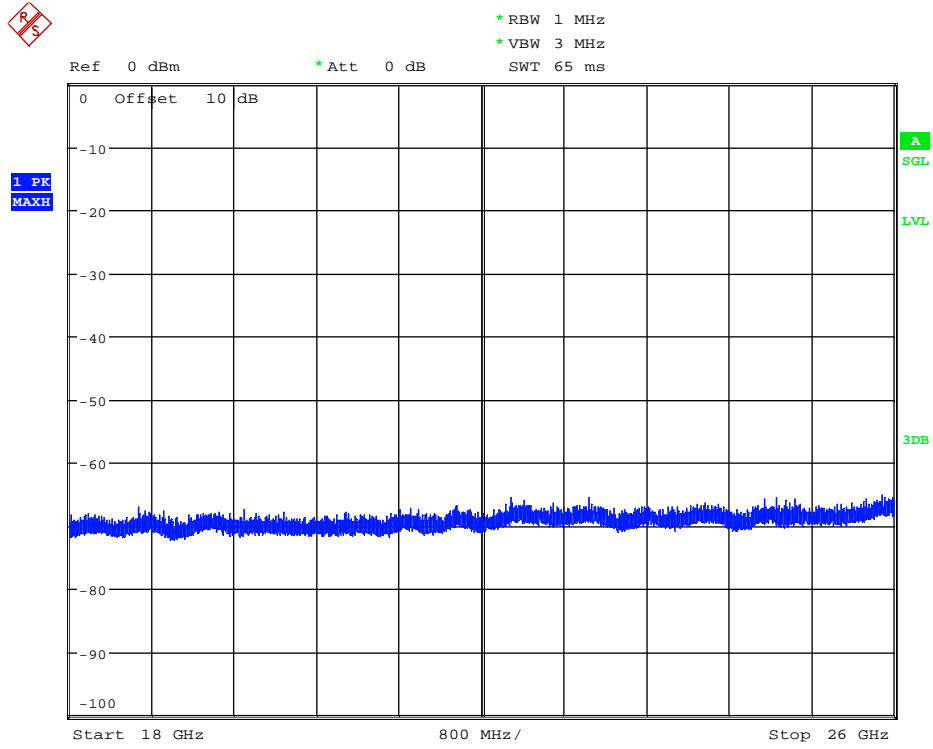
#### Odin SpurEmiss1-4G g 11.wmf: conducted spurious emissions (operation mode 6):



#### Odin SpurEmiss4-18G g 11.wmf: conducted spurious emissions (operation mode 6):



Odin\_SpurEmiss18-26G\_g\_11.wmf: conducted spurious emissions (operation mode 6):



<b>Spurious Emissions, g-mode, channel 1 (Operation mode 4)</b>									
Peak Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Max Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
g	1	4824.113	55.9	74.0	18.1	-42.4	3.0	Passed	Y
Average Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
g	1	4824.025	45.2	54.0	8.8	-53.4	3.0	Passed	Y
No emissions were found in the non-restricted Bands									

<b>Spurious Emissions, g-mode, channel 6 (Operation mode 5)</b>									
Peak Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Max Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
g	6	4873.725	58.1	74.0	15.9	-40.2	3.0	Passed	Y
Average Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
g	6	4874.012	47.4	54.0	6.6	-51.2	3.0	Passed	Y
No emissions were found in the non-restricted Bands									

Spurious Emissions, g-mode, channel 11 (Operation mode 6)									
Peak Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Max Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
g	11	4924.250	58.4	74.0	15.6	-39.9	3.0	Passed	Y
Average Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
g	11	4923.937	47.7	54.0	6.3	-50.9	3.0	Passed	Y
No emissions were found in the non-restricted Bands									

Spurious Emissions, n20-mode, channel 1 (Operation mode 7)									
Peak Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Max Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	1	4823.700	53.7	74	20.3	-44.6	3	Passed	Y
Average Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	1	4824.000	44.1	54.0	9.9	-54.8	3.0	Passed	Y
No emissions were found in the non-restricted Bands									

Spurious Emissions, n20-mode, channel 6 (Operation mode 8)									
Peak Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Max Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	6	4876.200	57.3	74	16.7	-40.9	3	Passed	Y
Average Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	6	4874.050	47.2	54.0	6.8	-51.7	3.0	Passed	Y
Emissions in the non-restricted Bands									

Spurious Emissions, n20-mode, channel 11 (Operation mode 9)									
Peak Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Max Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	11	4924.050	55.8	74	18.2	-42.5	3.0	Passed	Y
Average Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	11	4924.025	46.3	54.0	7.7	-52.6	3.0	Passed	Y
No emissions were found in the non-restricted Bands									

Spurious Emissions, n20-mode, channel 1 (Operation mode 10) MIMO									
Peak Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Max Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	1	4827.113	61.9	74.0	12.1	-40.7	6.0	Passed	Y
Average Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	1	4825.625	46.5	54.0	7.5	-55.4	6.0	Passed	Y
No emissions were found in the non-restricted Bands									

Spurious Emissions, n20-mode, channel 6 (Operation mode 11) MIMO									
Peak Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Max Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	6	4874.575	62.9	74.0	11.1	-39.7	6.0	Passed	Y
Average Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	6	4874.038	49.6	54.0	4.4	-52.3	6.0	Passed	Y
Emissions in the non-restricted Bands									

Spurious Emissions, n20-mode, channel 11 (Operation mode 12) MIMO									
Peak Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Max Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	11	4917.637	61.8	74.0	12.2	-40.7	6.0	Passed	Y
Average Emission – Restricted Band									
WLAN Mode	Channel	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result	Restricted Band?
n20	11	4918.125	46.5	54.0	7.5	-55.4	6.0	Passed	Y
No emissions were found in the non-restricted Bands									

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

7, 28, 32

#### 5.6.4 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into five stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 1 GHz.
- A final measurement carried out on an outdoor test site without reflecting ground plane and a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A final measurement carried out on an open area test 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 25 / 40 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 25 / 40 GHz.

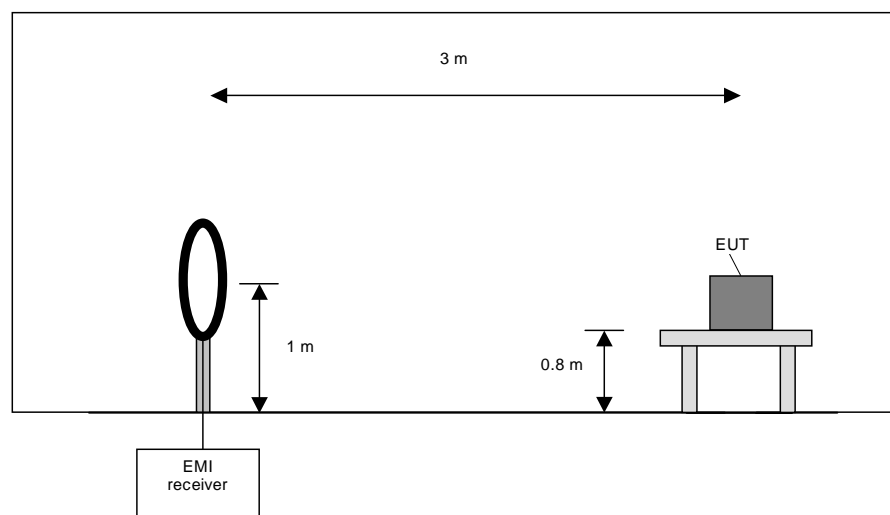
##### Preliminary measurement (9 kHz to 30 MHz):

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

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

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

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



Preliminary measurement procedure:

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

The following procedure will be used:

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

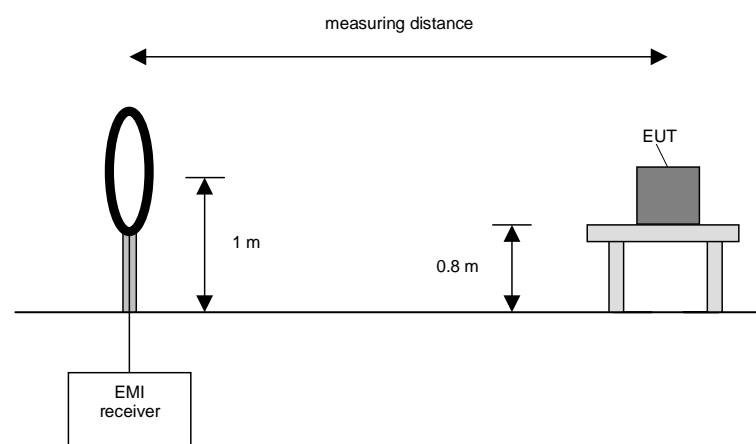
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances are required the results will be extrapolated based on the values measured on the closer distances according to Section 15.31 (f) (2) [2]. The final measurement will be performed with a EMI Receiver set to Quasi Peak detector except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an average detector will be used according Section 15.209 (d) [2].

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

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

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



Final measurement procedure:

The following procedure will be used:

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

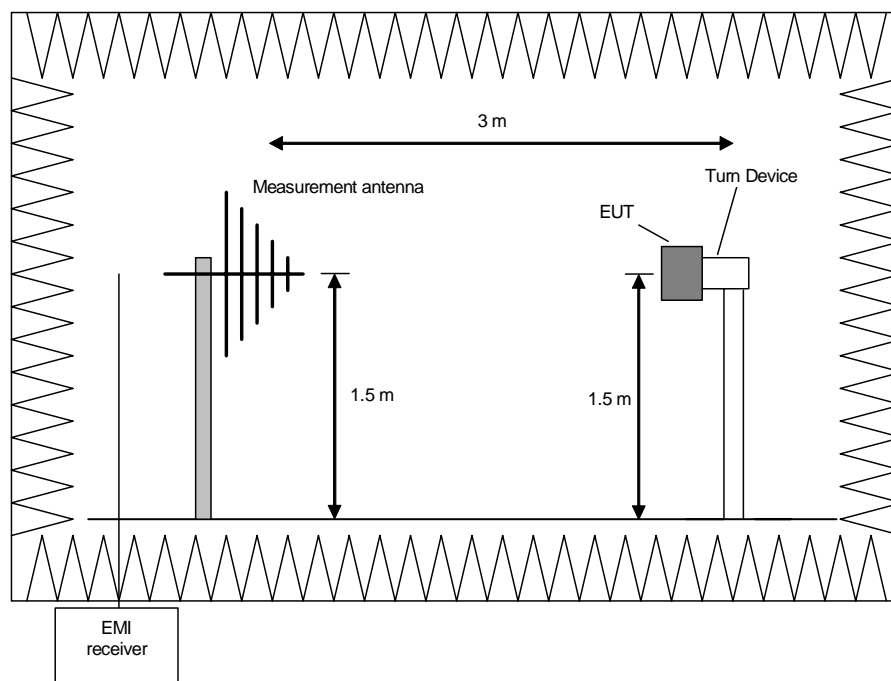
**Preliminary measurement (30 MHz to 1 GHz)**

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. Table top devices will set up on a non-conducting turn device on the height of 1.5m. 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 [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 °. This measurement is repeated after raising the EUT in 30° steps according 6.6.5.4 in [1].

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

Frequency range	Resolution bandwidth
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:

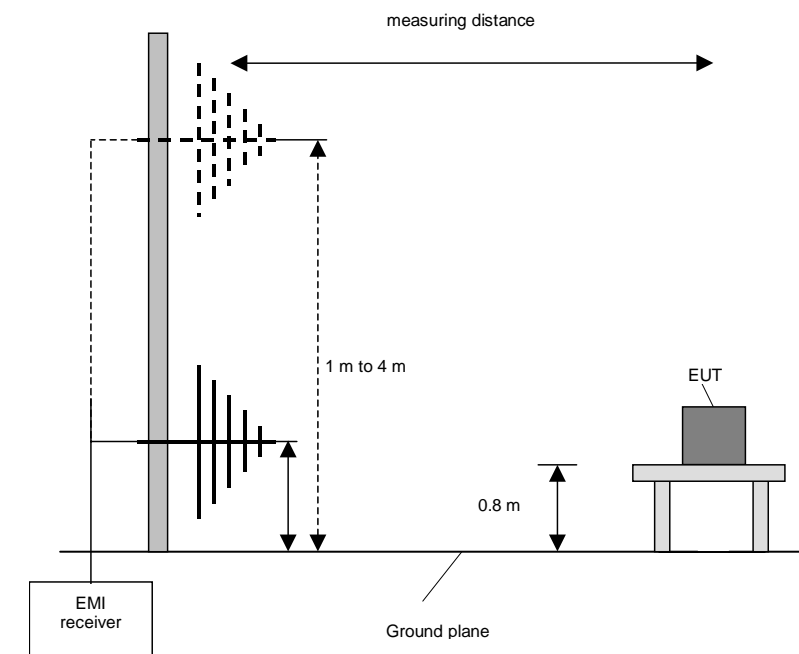
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Repeat 1) to 3) with the vertical polarisation of the measuring antenna.
5. Make a hardcopy of the spectrum.
6. Repeat 1) to 5) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
7. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.

**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 40 GHz)**

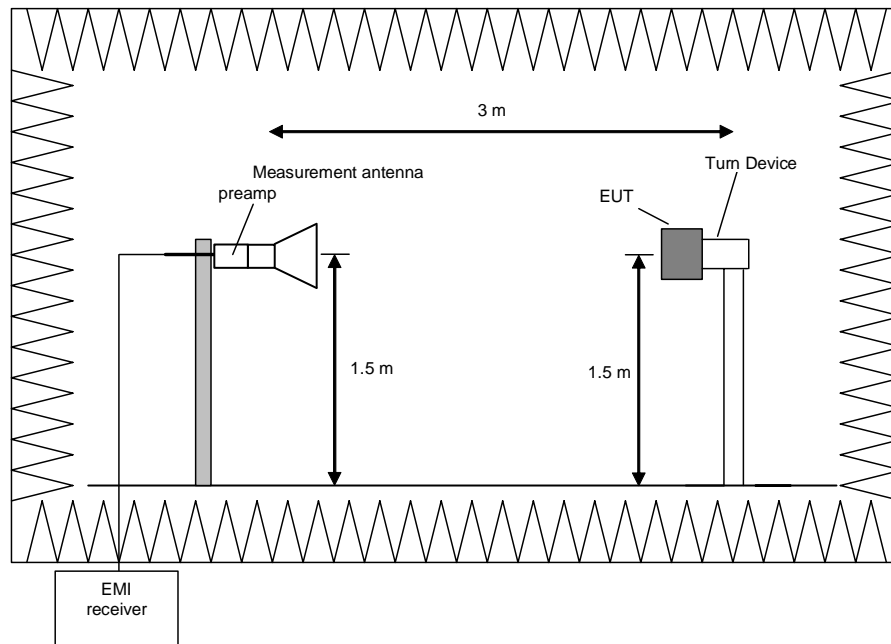
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

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

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

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

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	100 kHz
4 GHz to 12 GHz	100 kHz
12 GHz to 18 GHz	100 kHz
18 GHz to 25 / 26.5 GHz	100 kHz
26.5 GHz to 40 GHz	100 kHz



#### Procedure preliminary measurement:

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

The following procedure will be used:

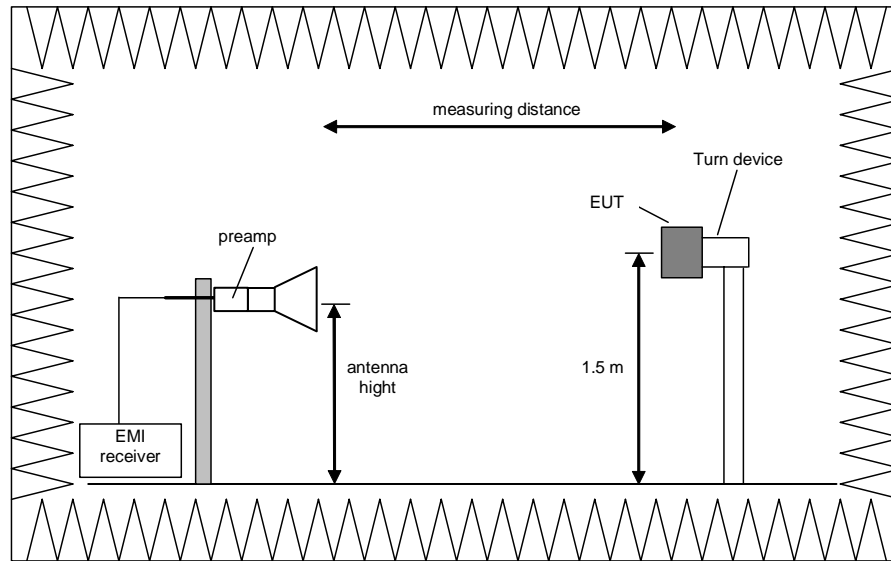
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an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

#### Final measurement (1 GHz to 25 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 by rotating the turntable through 0 to 360° in the worst-case EUT orientation which was obtained during the preliminary measurements.

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

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 25 / 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz



Procedure of measurement:

The measurements were performed in the frequency ranges 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 25 GHz.

The following procedure will be used:

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

## 5.6.5 Test results (radiated emissions) – antenna emissions with each antenna type

### 5.6.5.1 Preliminary radiated emission measurement

The preliminary tests were performed during the conducted testing. In this test case only the final tests for the frequencies identified as failed during the conducted measurements are repeated as radiated tests.

### 5.6.5.2 Final radiated emission measurement (1 GHz to 25 GHz)

Ambient temperature	22 °C	Relative humidity	55 %
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Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 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 Testset-up fotos.

Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 3.3 V via an laboratory power supply. Because the external filters of the anechoic chamber prevented the start and operation of the EUT, an electrolytic capacitor [100 µF] was implemented between the power supply lines.

Remark: The following measurements were failed during the conducted measurements and are repeated with each antenna type incorporating the highest gain for its type.

The results for cabinet emission are submitted in 5.6.6.

#### 5.6.5.2.1 Results for monopole antenna Ex-IT WLAN SMA

used antenna: Ex-IT WLAN SMA with 3 dBi gain

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

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

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4824	55.8	74.0	18.2	43.5	32.6	25.6	5.3	150	Hor.	60°
Measurement uncertainty				+2.2 dB / -3.6 dB						

##### Result measured with the average detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4824	53.7	54.0	0.3	41.3	32.6	25.6	5.3	150	Hor.	60°
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 MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4874	51.8	74.0	22.2	39.5	32.7	25.6	5.2	150	Hor.	60°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4874	48.6	54.0	5.4	36.2	32.7	25.6	5.2	150	Hor.	60°
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 MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4924	55.0	74.0	19.0	42.5	32.8	25.6	5.3	150	Hor.	60°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4924	52.6	54.0	1.4	40.0	32.8	25.6	5.3	150	Hor.	60°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Transmitter operates at the lower end of the assigned frequency band (operation mode 4)**

**Result measured with the peak detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	71.5	74.0	2.5	39.5	28.3	0.0	3.7	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	50.7	54.0	3.3	18.4	28.3	0.0	3.7	150	Hor.	90°
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	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	70.3	74.0	3.7	37.9	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	50.6	54.0	3.4	17.9	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Transmitter operates at the lower end of the assigned frequency band (operation mode 7)**

**Result measured with the peak detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	71.4	74.0	2.6	39.3	28.3	0.0	3.7	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	50.2	54.0	3.8	17.6	28.3	0.0	3.7	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Transmitter operates at the upper end of the assigned frequency band (operation mode 9)**

**Result measured with the peak detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	73.8	74.0	0.2	41.5	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	51.8	54.0	2.2	18.8	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Transmitter operates at the lower end of the assigned frequency band (operation mode 10)**

**Result measured with the peak detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	65.2	74.0	8.8	33.2	28.3	0.0	3.7	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	47.3	54.0	6.7	14.7	28.3	0.0	3.7	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Transmitter operates at the upper end of the assigned frequency band (operation mode 12)**

**Result measured with the peak detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	71.7	74.0	2.3	39.3	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	52.7	54.0	1.3	19.7	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						



### 5.6.5.2.2 Results for patch antenna InSide 2400 ProAnt

Used antenna: InSide 2400 ProAnt Patch (3 dBi gain) with 10 cm cable

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

Result measured with the peak detector:

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4824	53.3	74.0	20.7	41.1	32.6	25.6	5.3	150	Hor.	150°
Measurement uncertainty				+2.2 dB / -3.6 dB						

Result measured with the average detector:

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4824	50.7	54.0	3.3	38.3	32.6	25.6	5.3	150	Hor.	150°
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 MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4874	53.1	74.0	20.9	40.8	32.7	25.6	5.2	150	Hor.	150°
Measurement uncertainty				+2.2 dB / -3.6 dB						

Result measured with the average detector:

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4874	49.8	54.0	4.2	37.4	32.7	25.6	5.2	150	Hor.	150°
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 MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4924	55.4	74.0	18.6	42.9	32.8	25.6	5.3	150	Hor.	150°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4924	52.8	54.0	1.2	40.2	32.8	25.6	5.3	150	Hor.	150°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Transmitter operates at the lower end of the assigned frequency band (operation mode 4)**

**Result measured with the peak detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	60.8	74.0	13.2	28.8	28.3	0.0	3.7	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	46.3	54.0	7.7	13.9	28.3	0.0	3.7	150	Hor.	90°
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	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	66.5	74.0	7.5	34.2	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	47.8	54.0	6.2	15.1	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Transmitter operates at the lower end of the assigned frequency band (operation mode 7)**

**Result measured with the peak detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	61.8	74.0	12.2	29.8	28.3	0.0	3.7	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	47.1	54.0	6.9	14.5	28.3	0.0	3.7	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Transmitter operates at the upper end of the assigned frequency band (operation mode 9)**

**Result measured with the peak detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	69.5	74.0	4.5	37.2	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	49.9	54.0	4.1	17.0	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Transmitter operates at the lower end of the assigned frequency band (operation mode 10)**

**Result measured with the peak detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	59.2	74.0	14.8	27.2	28.3	0.0	3.7	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2390	45.8	54.0	8.2	13.2	28.3	0.0	3.7	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Transmitter operates at the upper end of the assigned frequency band (operation mode 12)**

**Result measured with the peak detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	66.9	74.0	7.1	34.5	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
2484	48.0	54.0	6.0	15.1	28.6	0.0	3.8	150	Hor.	90°
Measurement uncertainty				+2.2 dB / -3.6 dB						

Test: Passed

<b>TEST EQUIPMENT USED FOR THE TEST:</b>
5, 6, 8 - 15, 17-19, 25, 29, 33

## 5.6.6 Test results (radiated emissions) – cabinet emissions

### 5.6.6.1 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 or an EUT turn device of a height of 1.5 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 Testsetup Foto annex.

**Test record:** All results are shown in the following.

**Supply voltage:** During all measurements the host of the EUT was powered with 3.3 V via an laboratory power supply. Because the external filters of the anechoic chamber prevented the start and operation of the EUT, an electrolytic capacitor [100 µF] was implemented between the power supply lines.

**Remark:** Document [1] states in 11.12.2.1, that in case of conducted measurements, additional radiated cabinet emission measurements must be performed. The measurements were performed at the worst case modulation, namely 802.11b mode with at channel 1, 6 and 11.

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

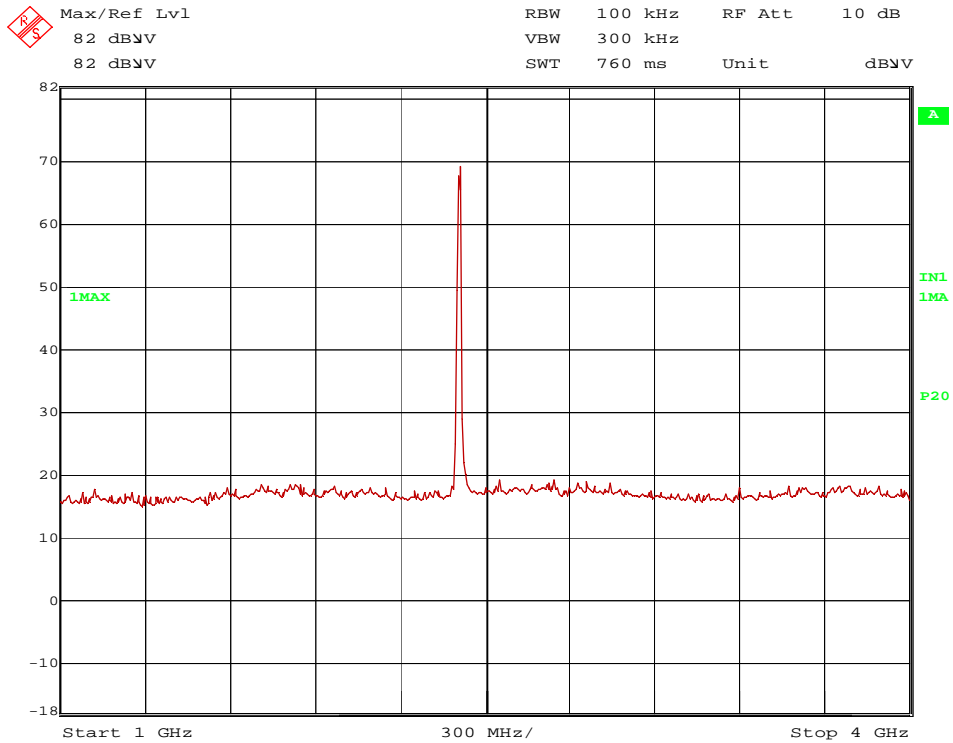
The Emissions below 1 GHz were equal for all antenna ports, transmit frequencies, modulation schemes and data rates. Therefore only the results of an exemplary test case are submitted below.

The lowest internal clock frequency was 24 MHz therefore the radiated measurements were performed starting at 150 kHz.

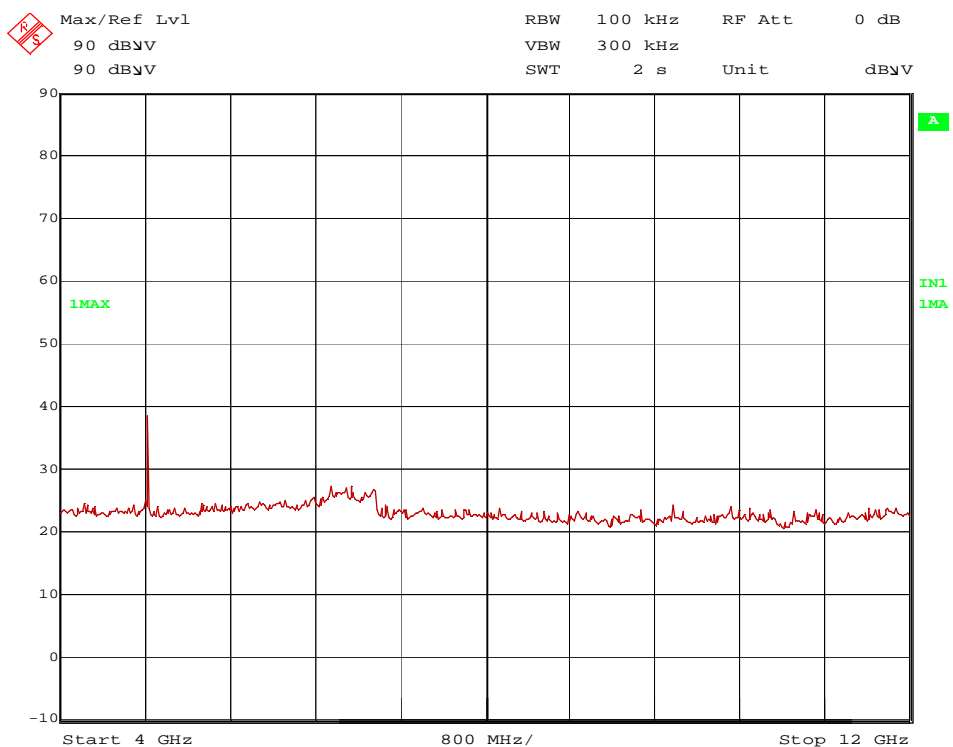
No emissions could be found in the frequency band below 1 GHz.

**Transmitter operates at the middle of the assigned frequency band (operation mode 1)**

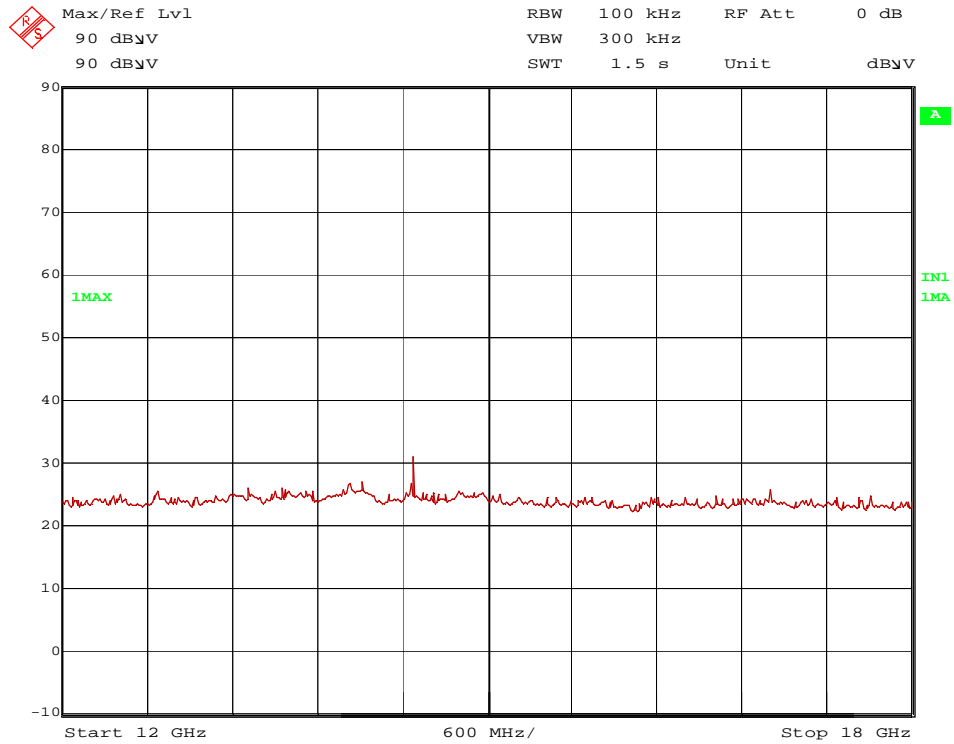
151496\_1M\_ch1\_1-4G\_120°.wmf: Spurious emissions from 1 GHz to 4 GHz (operation mode 1):



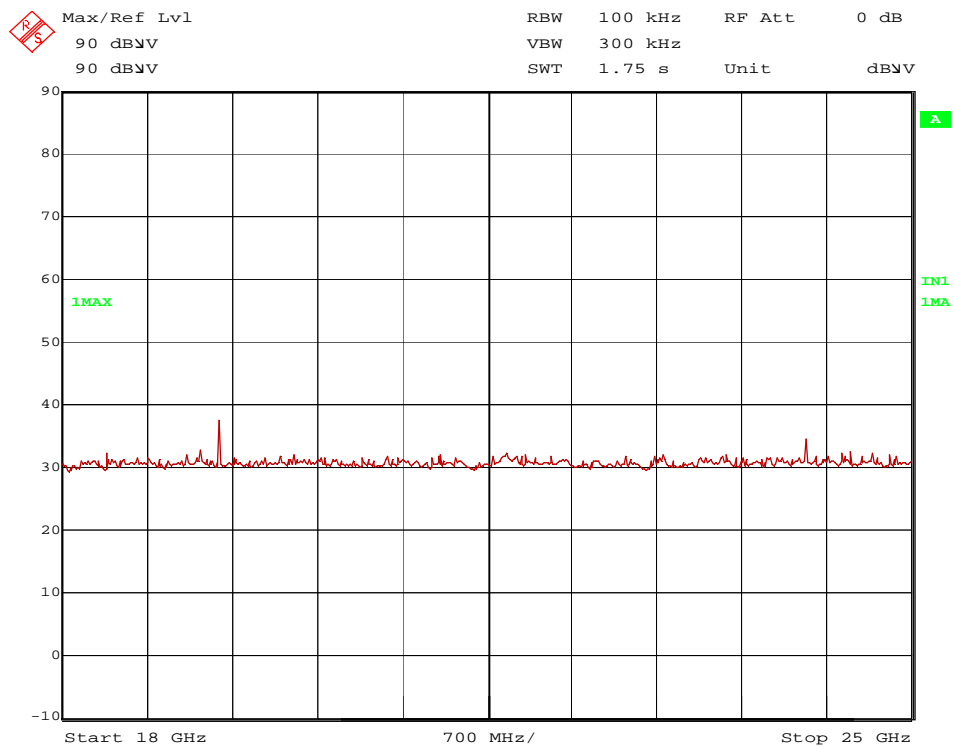
151496\_1M\_ch1\_4-12G\_0°.wmf: Spurious emissions from 4 GHz to 12 GHz (operation mode 1):



151496 SpurEm12-18 1M ch1 Vert 30°.wmf: Spurious emissions from 12 to 18 GHz (operation mode 1):



151496 SpurEm18-25 1M ch1 Ver 0°.wmf: Spurious emissions from 18 – 25 GHz (operation mode 1):



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

- 4824 MHz and 19296 MHz.

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

- 14772 MHz and 24120 MHz.

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

<b>TEST EQUIPMENT USED FOR THE TEST:</b>
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6, 8 - 15, 17-20, 22 - 25, 28, 29, 33
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### 5.6.6.2 Final radiated emission measurement (9 kHz to 1 GHz)

No emissions could be found in the final measurement on the open area test site, therefore no results for the final measurements are submitted.

### 5.6.6.3 Final radiated emission measurement (1 GHz to 25 GHz)

Ambient temperature	22 °C	Relative humidity	55 %
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Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 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 test setup photos.

Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 3.3 V via an laboratory power supply. Because the external filters of the anechoic chamber prevented the start and operation of the EUT, an electrolytic capacitor [100 µF] was implemented between the power supply lines.

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

Additional information: For simplification all values were compared to the restricted band limits.

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

#### **Result measured with the peak detector:**

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4824	53.5	74.0	20.5	41.2	32.6	25.6	5.3	150	Hor.	0°
14472	45.5	74.0	28.5	36.8	33.7	26.9	1.9	150	Ver.	30°
19296	46.1	74.0	27.9	44.6	37.1	37.8	2.2	150	Ver.	90°
24120	43.3	74.0	30.7	42.2	37.2	38.4	2.3	150	Ver.	0°
Measurement uncertainty				+2.2 dB / -3.6 dB						

#### **Result measured with the average detector:**

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle
4824	50.8	54.0	3.2	38.4	32.6	25.6	5.3	150	Hor.	0°
14472.00	37.8	54.0	16.2	29.0	33.7	26.9	1.9	150	Ver.	30°
19296.00	40.6	54.0	13.4	39.0	37.1	37.8	2.2	150	Ver.	90°
24120.00	34.3	54.0	19.7	33.1	37.2	38.4	2.3	150	Ver.	0°
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 MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle	
4874	51.4	74.0	22.6	39.1	32.7	25.6	5.2	150	Hor.	0°	
14622	44.8	74.0	29.2	36.2	33.7	27.0	1.9	150	Ver.	30°	
19496	46.9	74.0	27.1	45.0	37.1	37.5	2.3	150	Ver.	90°	
24370	43.2	74.0	30.8	42.2	37.2	38.4	2.2	150	Ver.	0°	
Measurement uncertainty					+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle	
4874	48.1	54.0	5.9	35.7	32.7	25.6	5.2	150	Hor.	0°	
14622	36.2	54.0	17.8	27.5	33.7	27.0	1.9	150	Ver.	30°	
19496	41.9	54.0	12.1	39.9	37.1	37.5	2.3	150	Ver.	90°	
24370	34.0	54.0	20.0	32.9	37.2	38.4	2.2	150	Ver.	0°	
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 MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle	
4924	52.5	74.0	21.5	40.0	32.8	25.6	5.3	150	Hor.	0°	
19696	46.7	74.0	27.3	45.1	37.1	37.7	2.2	150	Ver.	90°	
24620	43.2	74.0	30.8	42.1	37.2	38.4	2.3	150	Ver.	0°	
Measurement uncertainty					+2.2 dB / -3.6 dB						

**Result measured with the average detector:**

Frequency MHz	Meas. Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Readings dB $\mu$ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	EUT angle	
4924	48.8	54.0	5.2	36.1	32.8	25.6	5.3	150	Hor.	0°	
19696	40.9	54.0	13.1	39.2	37.1	37.7	2.2	150	Ver.	90°	
24620	34.0	54.0	20.1	32.8	37.2	38.4	2.3	150	Ver.	0°	
Measurement uncertainty					+2.2 dB / -3.6 dB						

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:
6, 8 - 15, 17-20, 22 - 25, 28, 29, 33

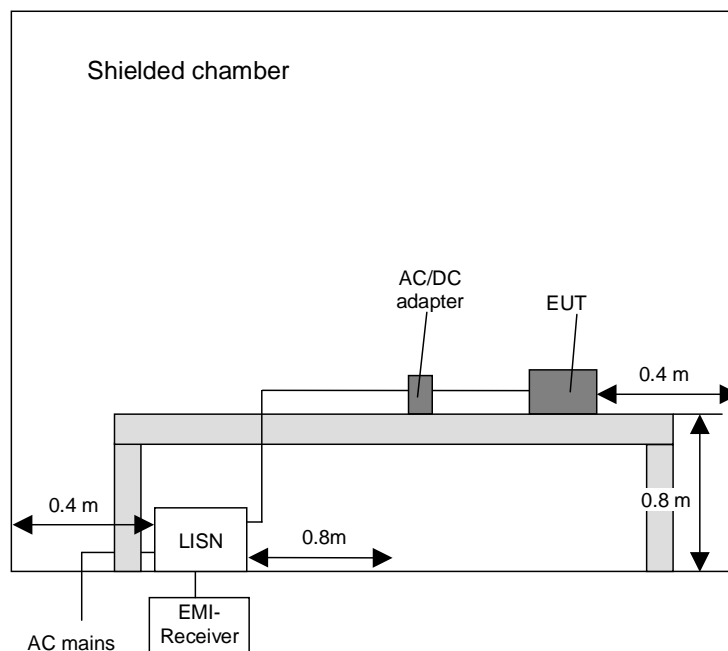
## 5.7 Conducted emissions on power supply lines (150 kHz to 30 MHz)

### 5.7.1 Method of measurement

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

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

Frequency range	Resolution bandwidth
150 kHz to 30 MHz	9 kHz



### 5.7.2 Test results (conducted emissions on power supply lines)

Ambient temperature	20 °C	Relative humidity	52 %
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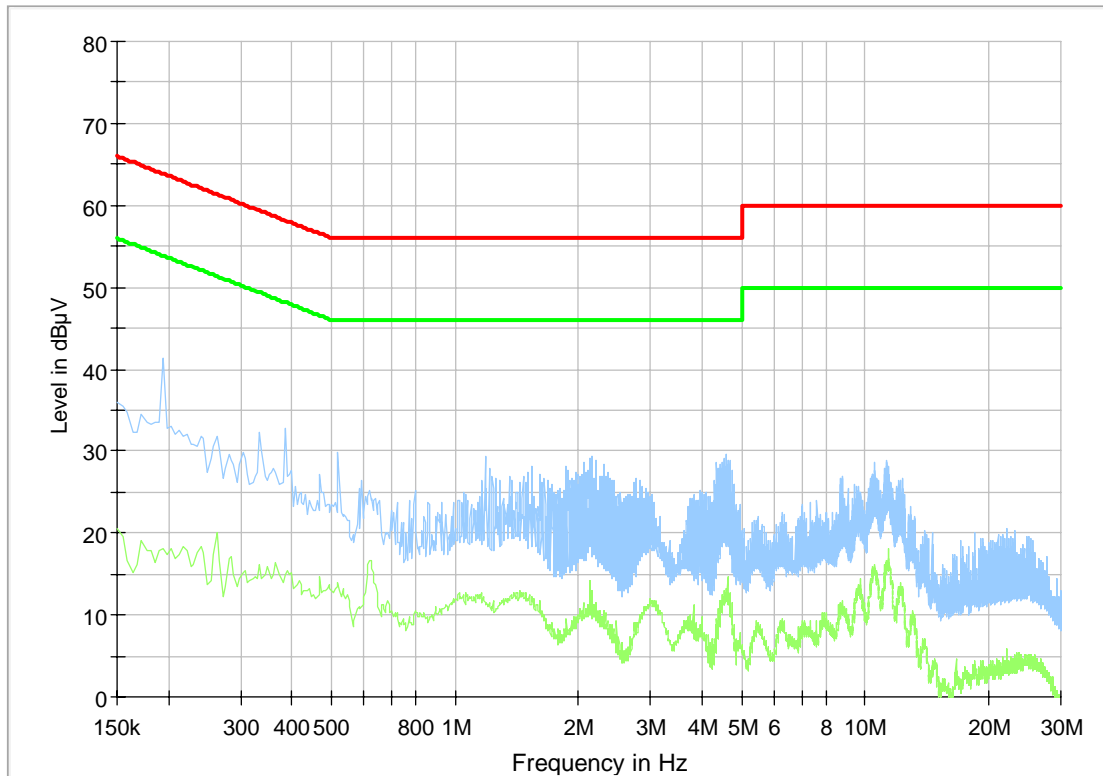
**Position of EUT:** For the test the EUT was powered by an typical AC/DC power supply. The EUT was set to continuous retransmitting ping frames on channel 6 sent from the laptop PC. The frames with 1400 Byte payload were sent every 10 ms. The laptop PC with the inserted EUT was set-up on a non-conducting table of a height of 0.8 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:** Measurement performed with US 120V/60Hz. For the test a power supply type 273-316 from enerCELL was used.

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



— Preview Result 2-AVG     — Preview Result 1-PK+     — FCC 15.207 V QP  
— FCC 15.207 V AV     ◆ Final\_Result QPK     + Final\_Result AVG

Data record name: 151496\_FCC\_WLAN2.4\_AC

### Final\_Result

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
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Test: Passed

TEST EQUIPMENT USED FOR THE TEST:
1 – 5

## 6 TEST EQUIPMENT AND ANCILLARIES USED FOR TESTS

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. Due
1	Shielded chamber M47	-	Albatross Projects	B83117-C6439-T262 -	480662	Weekly verification (system cal.)	
2	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	03/21/2014	03/2016
3	LISN	NSLK8128	Schwarzbeck	8128155	480058	03/19/2015	03/2016
4	High pass filter	HR 0.13- 5ENN	FSY Microwave Inc.	DC 0109 SN 002	480340	Weekly verification (system cal.)	
5	EMI Software	ES-K1	Rohde & Schwarz	-	480111	-	-
6	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Weekly verification (system cal.)	
7	Spectrum analyser	FSU	Rohde & Schwarz	200125	480956	03/09/2015	03/2016
8	Measuring receiver	ESI 40	Rohde & Schwarz	100064	480355	02/26/2014	02/2016
9	Controller	MCU	Maturo	MCU/043/971107	480832	-	-
10	Turntable	DS420HE	Deisel	420/620/80	480315	-	-
11	Antenna support	AS615P	Deisel	615/310	480187	-	-
12	Antenna	CBL6112 B	Chase	2688	480328	04/14/2014	04/2017
13	Antenna	3115 A	EMCO	9609-4918	480183	10/11/2014	11/2017
14	Standard Gain Horn 11.9 GHz – 18 GHz	18240-20	Flann Microwave	483	480294	Six month verification (system cal.)	
15	Standard Gain Horn 17.9 GHz – 26.7 GHz	20240-20	Flann Microwave	411	480297	Six month verification (system cal.)	
16	Standard Gain Horn Antenne 26.4 – 40.1 GHz	22240-20	Flann Microwave	469	480229	Six month verification (system cal.)	
17	RF-cable No. 3	Sucoflex 106B	Huber&Suhner	0563/6B / Kabel 3	480670	Weekly verification (system cal.)	
18	RF-cable No. 40	Sucoflex 106B	Huber&Suhner	0708/6B / Kabel 40	481330	Weekly verification (system cal.)	
19	RF-cable No. 36	Sucoflex 106B	Huber&Suhner	500003/6B / Kabel 36-	481680	Weekly verification (system cal.)	
20	RF-cable 1 m	KPS-1533- 400-KPS	Insulated Wire	-	480300	Six month verification (system cal.)	
21	RF-cable 2 m	KPS-1533- 800-KPS	Insulated Wire	-	480302	Six month verification (system cal.)	
22	Preamplifier	JS3- 00101200- 23-5A	Miteq	681851	480337	Six month verification (system cal.)	
23	Preamplifier	JS3- 12001800- 16-5A	Miteq	571667	480343	Six month verification (system cal.)	
24	Preamplifier	JS3- 18002600- 20-5A	Miteq	658697	480342	Six month verification (system cal.)	
25	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	02/2014	02/2016
26	Power Meter	NRVD	Rohde & Schwarz	833697/030	480589	03/2015	03/2016
27	Peak Power Sensor	NRV-Z32	Rohde & Schwarz	849745/016	480551	03/2015	03/2016
28	4 GHz High Pass Filter	WHKX4.0/18 G-8SS	Wainwright Instruments	1	480587	Weekly verification (system cal.)	

29	Single Control Unit	SCU	Maturo GmbH	SCU/006/971107	480831	Calibration not necessary	
30	High-pass Filter	H26G40G1	Microwave Circuits, Inc.	33471	480593	Six month verification (system cal.)	
31	Temperature Test Chamber	MK 240	Binder	05-79022	480462	02/18/2014	08/2015
32	Low Pass Filter	WLJ1.0G-5EE-300W	Wainwright Instruments GmbH	6	481298	Yearly verification (system cal.)	
33	Turn Device	TDF 1.5-10Kg	Maturo	-	482034	-	

## 7 REPORT HISTORY

Report Number	Date	Comment
F151496E5	16 October 2015	Document created

## 8 LIST OF ANNEXES

### ANNEX A TEST SET-UP PHOTOS 5 pages

- 151496\_19: Test setup - Radiated emission. Antennas terminated (fully anechoic chamber)
- 151496\_16: Test setup - Radiated emission. Antennas terminated (fully anechoic chamber)
- 151496\_17: Test setup - Radiated emission. Antennas terminated (fully anechoic chamber)
- 151496\_18: Test setup - Radiated emission. Antennas terminated (fully anechoic chamber)
- 151496\_20: Test setup – conducted emissions on power supply lines

### ANNEX B EXTERNAL PHOTOGRAPHS 6 pages

- 151496\_01.jpg: Carrier Board + EUT – Top View (Odin-W260)
- 151496\_02.jpg: Carrier Board – Bottom View (Odin-W260)
- 151496\_07.jpg: EUT – Top View (Odin-W260)
- 151496\_06.jpg: Carrier Board + EUT – Top View (Odin-W262)
- 151496\_02.jpg: Carrier Board – Bottom View (Odin-W262)
- 151496\_08.jpg: EUT – Top View (Odin-W262)

### ANNEX C INTERNAL PHOTOGRAPHS 4 pages

- 151496\_03.jpg: EUT – Top View –Shielding removed (Odin-W260)
- 151496\_04.jpg: EUT – Bottom View (Odin-W260)
- 151496\_05.jpg: EUT – Top View –Shielding removed (Odin-W262)
- 151496\_04.jpg: EUT – Bottom View (Odin-W262)