

# InterLab<sup>®</sup>

## Final Report on HERMES

**Report Reference:** MDE\_HARMAN\_1504\_FCCb  
acc. Title 47 CFR chapter I part 15 subpart C  
FCC ID: T8GHERMES  
IC: 6434A-HERMES

**Date:** May 22, 2015

**Test Laboratory:**

7 layers AG  
Borsigstrasse 11  
40880 Ratingen  
Germany



**Note:**

The following test results relate only to the devices specified in this document. This report shall not be reproduced in parts without the written approval of the test laboratory.

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Chairman of the Supervisory Board:  
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Vorstand Board:  
Dr. H. Ansorge

Registergericht registered in:  
Düsseldorf, HRB 44096  
USt-IdNr VAT No.:  
DE 203159652  
TAX No. 147/5869/0385  
A Bureau Veritas Group Company

## 1 Administrative Data

### 1.1 Project Data

*Project Responsible:* Carsten Steinröder  
*Date Of Test Report:* 2015/05/22  
*Date of first test:* 2015/04/21  
*Date of last test:* 2015/05/22

### 1.2 Applicant Data

*Company Name:* Harman Becker Automotive Systems GmbH  
*Street:* Becker-Göring-Str. 16  
*City:* 76307 Karlsbad  
*Country:* Germany  
  
*Contact Person:* Mr. Stefan Blaschek  
*Department:* Regulatory Compliance Mgt.  
*Phone:* +49 7248 71 3382  
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*Mobile:* +49 172 94 191 49  
*E-Mail:* stefan.blaschek@harman.com

### 1.3 Test Laboratory Data

The following list shows all places and laboratories involved for test result generation:

#### 7 layers DE

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*Company Name :* 7 layers AG  
*Street :* Borsigstrasse 11  
*City :* 40880 Ratingen  
*Country :* Germany  
*Contact Person :* Mr. Michael Albert  
*Phone :* +49 2102 749 201  
*Fax :* +49 2102 749 444  
*E Mail :* Michael.Albert@7Layers.com

#### Laboratory Details

<i>Lab ID</i>	<i>Identification</i>	<i>Responsible</i>	<i>Accreditation Info</i>
Lab 1	Radiated Emissions	Mr. Marco Kullik Mr. Robert Machulec	DAkKS-Registration no. D-PL-12140-01-01
Lab 2	Regulatory Bluetooth RF Test Solution	Mr. Jimmy Chatheril Mr. Sören Berentzen	DAkKS-Registration no. D-PL-12140-01-01

**1.4 Signature of the Testing Responsible**



Carsten Steinröder  
 responsible for tests performed in: Lab 1, Lab 2

**1.5 Signature of the Accreditation Responsible**



Accreditation scope responsible person  
 responsible for Lab 1, Lab 2

**2 Test Object Data**

**2.1 General OUT Description**

The following section lists all OUTs (Object's Under Test) involved during testing.

**OUT: HERMES**

**Manufacturer:**

*Company Name:* Please see applicant data

*Contact Person:* -

**Parameter List:**

<i>Parameter name</i>	<i>Value</i>
Antenna Gain	1.82 (dBi)
DC Power Supply	12 (V)
highest channel (BT)	2480 (MHz)
lowest channel (BT)	2402 (MHz)
mid channel (BT)	2441 (MHz)

## 2.2 Detailed Description of OUT Samples

### **Sample : aa01**

<i>OUT Identifier</i>	HERMES		
<i>Sample Description</i>	radiated sample		
<i>HW Status</i>	C3		
<i>SW Status</i>	Test-SW		
<i>Low Voltage</i>	9 V	<i>Low Temp.</i>	-20 °C
<i>High Voltage</i>	16 V	<i>High Temp.</i>	+55 °C
<i>Nominal Voltage</i>	12 V	<i>Normal Temp.</i>	20 °C

#### **Parameter List:**

<i>Parameter Description</i>	<i>Value</i>
<b>Parameter for Scope FCC_v2</b>	
Antenna Gain	1.82 (dBi)
Frequency_high	2480 (MHz)
Frequency_low	2402 (MHz)
Frequency_mid	2441 (MHz)

### **Sample : ab01**

<i>OUT Identifier</i>	HERMES		
<i>Sample Description</i>	conducted sample		
<i>HW Status</i>	C3		
<i>SW Status</i>	Test-SW		
<i>Low Voltage</i>	9 V	<i>Low Temp.</i>	-20 °C
<i>High Voltage</i>	16 V	<i>High Temp.</i>	+55 °C
<i>Nominal Voltage</i>	12 V	<i>Normal Temp.</i>	20 °C

#### **Parameter List:**

<i>Parameter Description</i>	<i>Value</i>
<b>Parameter for Scope FCC_v2</b>	
Antenna Gain	1.82 (dBi)
Frequency_high	2480 (MHz)
Frequency_low	2402 (MHz)
Frequency_mid	2441 (MHz)

## 2.3 OUT Features

### Features for OUT: HERMES

<i>Designation</i>	<i>Description</i>	<i>Allowed Values</i>	<i>Supported Value(s)</i>
<b>Features for scope: FCC_v2</b>			
BT	EUT supports Bluetooth data rate of 1 Mbps with GFSK modulation in the band 2400 MHz - 2483.5 MHz		
DC	The OUT is powered by or connected to DC		
EDR2	EUT supports Bluetooth using data rate of 2 Mbps with PI/4 DQPSK modulation in the band 2400 MHz - 2483.5 MHz		
EDR3	EUT supports Bluetooth using data rate of 3 Mbps with 8DPSK modulation in the band 2400 MHz - 2483.5 MHz		
Iant	Integral Antenna: permanent fixed antenna, which may be built-in, designed as an indispensable part of the equipment		
TantC	temporary antenna connector, which may be only built-in for testing, designed as an example part of the equipment		

## 2.4 Setups used for Testing

For each setup a relation is given to determine if and which samples and auxiliary equipment is used. The left side list all OUT samples and the right side lists all auxiliary equipment for the given setup.

<i>Setup No.</i>	<i>List of OUT samples</i>		<i>List of auxiliary equipment</i>	
	<i>Sample No.</i>	<i>Sample Description</i>	<i>AE No.</i>	<i>AE Description</i>

### AA01\_rad (radiated test setup)

Sample: aa01                      radiated sample

### AB01\_cond (conducted test setup)

Sample: ab01                      conducted sample

### 3 Results

#### 3.1 General

**Documentation of tested devices:**

Available at the test laboratory.

**Interpretation of the test results:**

The results of the inspection are described on the following pages, where 'Conformity' or 'Passed' means that the certification criteria were verified and that the tested device is conform to the applied standard.

In cases where 'Declaration' is printed, the required documents are available in the manufacturers product documentation.

In cases where 'not applicable' is printed, the test case requirements are not relevant to the specific equipment implementation.

**Note:**

1) The laboratory environmental conditions are available and recorded in the Interlab System.

2) Special Software for testing:  
 The OUT was connected to a Laptop via Serial/USB connection to set the test modes.  
 The OUT could be set into Bluetooth Test Modes by using a customer specific program.  
 The specific test modes could be set and controlled by the signalling unit "CBT" by Rohde&Schwarz over the air.  
 The OUT was disconnected from the Laptop during testing.

#### 3.2 List of the Applicable Body

(Body for Scope: FCC\_v2)

<i>Designation</i>	<i>Description</i>
FCC47CFRChIPART15c247RADIO FREQUENCY DEVICES	Subpart C - Intentional Radiators; 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

#### 3.3 List of Test Specification

<i>Test Specification:</i>	<b>FCC part 2 and 15</b>
<i>Version</i>	10-1-13 Edition
<i>Title:</i>	PART 2 - GENERAL RULES AND REGULATIONS PART 15 - RADIO FREQUENCY DEVICES

### 3.4 Summary

<i>Test Case Identifier / Name</i> <i>Test (condition)</i>	<i>Result</i>	<i>Date of Test</i>	<i>Lab Ref.</i>	<i>Setup</i>
<b>15c.2 Spurious radiated emissions §15.247 (d), §15.35 (b), §15.209</b> 15c.2; Frequency = 2402 - 2480, Mode = BT transmit using GFSK/PSK Modulation, Maximum Output Power	Passed	2015/04/21	Lab 1	AA01_rad
<b>15c.3 Occupied bandwidth §15.247 (a) (1)</b> 15c.3; Occupeid Bandwidth Summary	Passed	2015/05/22	Lab 2	AB01_cond
<b>15c.4 Peak power output §15.247 (b) (1)</b> 15c.4; Peak power output Summary	Passed	2015/05/22	Lab 2	AB01_cond
<b>15c.5 Spurious RF conducted emissions §15.247 (d)</b> 15c.5; = BT transmit mode: Low/Mid/High Frequency	Passed	2015/05/22	Lab 2	AB01_cond
<b>15c.6 Band edge compliance §15.247 (d)</b> 15c.6; Band edge compliance Summary	Passed	2015/05/22	Lab 1	AB01_cond
<b>15c.7 Dwell time §15.247 (a) (1) (iii)</b> 15c.7; Dwell time Summary	Passed	2015/05/22	Lab 2	AB01_cond
<b>15c.8 Channel separation §15.247 (a) (1)</b> 15c.8; Channel separation Summary	Passed	2015/05/22	Lab 2	AB01_cond
<b>15c.9 Number of hopping frequencies §15.247 (a) (1) (iii)</b> 15c.9; Number of hopping frequencies Summary	Passed	2015/05/22	Lab 2	AB01_cond

### 3.5 Detailed Results

#### 3.5.1 15c.2 Spurious radiated emissions §15.247 (d), §15.35 (b), §15.209

**Test: 15c.2; Frequency = 2402 - 2480, Mode = BT transmit using GFSK/PSK Modulation, Maximum Output Power**

*Result:* Passed  
*Setup No.:* AA01\_rad  
*Date of Test:* 2015/04/21 9:39  
*Body:* FCC47CFRChIPART15c247RADIO FREQUENCY DEVICES  
*Test Specification:* FCC part 2 and 15

#### Detailed Results:

Frequency range 9 kHz - 1 GHz

Modulation	TX Frequency (MHz)	Ant. Polar.	Limit QPK [dBµV]	Frequency [MHz]	Corrected value QPK [dBµV]	Margin QPK [dB]	Result
		Ver + Hor					Passed

Frequency range 1 GHz - 25 GHz

Modulation	TX Frequency (MHz)	Ant. Polar.	Limit PK [dBµV]	Limit AV [dBµV]	Frequency [MHz]	Corrected value PK [dBµV]	Corrected value AV [dBµV]	Margin PK [dB]	Margin AV [dB]	Result
		Ver + Hor	74	54						Passed

Remark 1: No (further) spurious emissions in the range 20 dB below the limit found.

Remark 2: For PSK modulation, the measurement was performed from 1 GHz up to 8 GHz because no significant spurious emissions were found outside this frequency range in GFSK modes.

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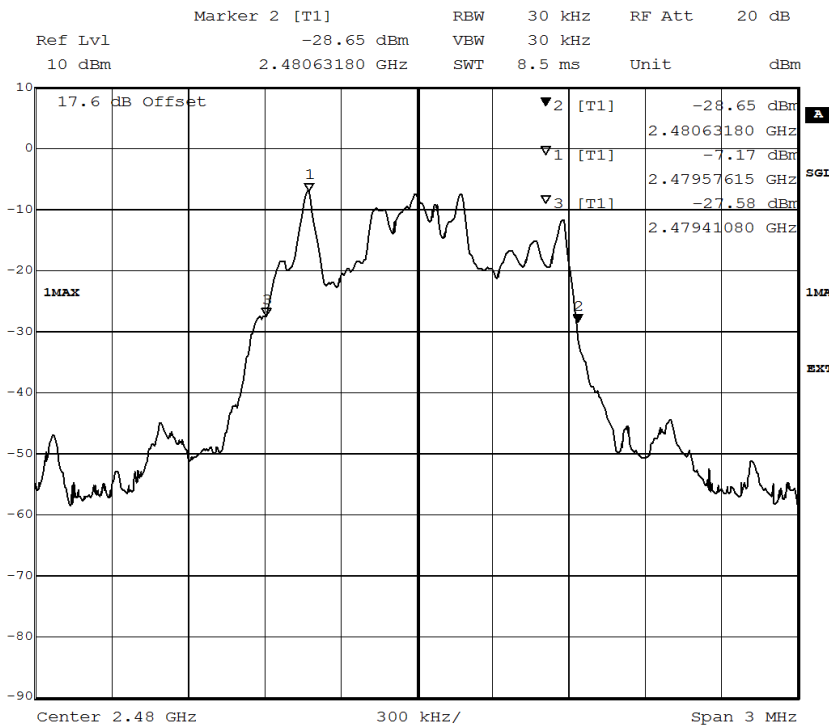
### 3.5.2 15c.3 Occupied bandwidth §15.247 (a) (1)

#### Test: 15c.3; Occupied Bandwidth Summary

<i>Result:</i>	Passed
<i>Setup No.:</i>	AB01_cond
<i>Date of Test:</i>	2015/05/22 8:23
<i>Body:</i>	FCC47CFRChIPART15c247RADIO FREQUENCY DEVICES
<i>Test Specification:</i>	FCC part 2 and 15

**Detailed Results:**

Modulation	Frequency	Occupied Bandwidth MHz
GFSK	2402 MHz	1.0460
	2441 MHz	1.0460
	2480 MHz	1.0460
PI/4 DQPSK	2402 MHz	1.1124
	2441 MHz	1.1124
	2480 MHz	1.1184
8DPSK	2402 MHz	1.2210
	2441 MHz	1.2210
	2480 MHz	1.2210



Title: 20dB Bandwidth  
 Comment A: CH T: 2480 MHz; 20dB bandwidth (kHz):1221  
 Date: 24.APR.2015 14:04:28

### 3.5.3 15c.4 Peak power output §15.247 (b) (1)

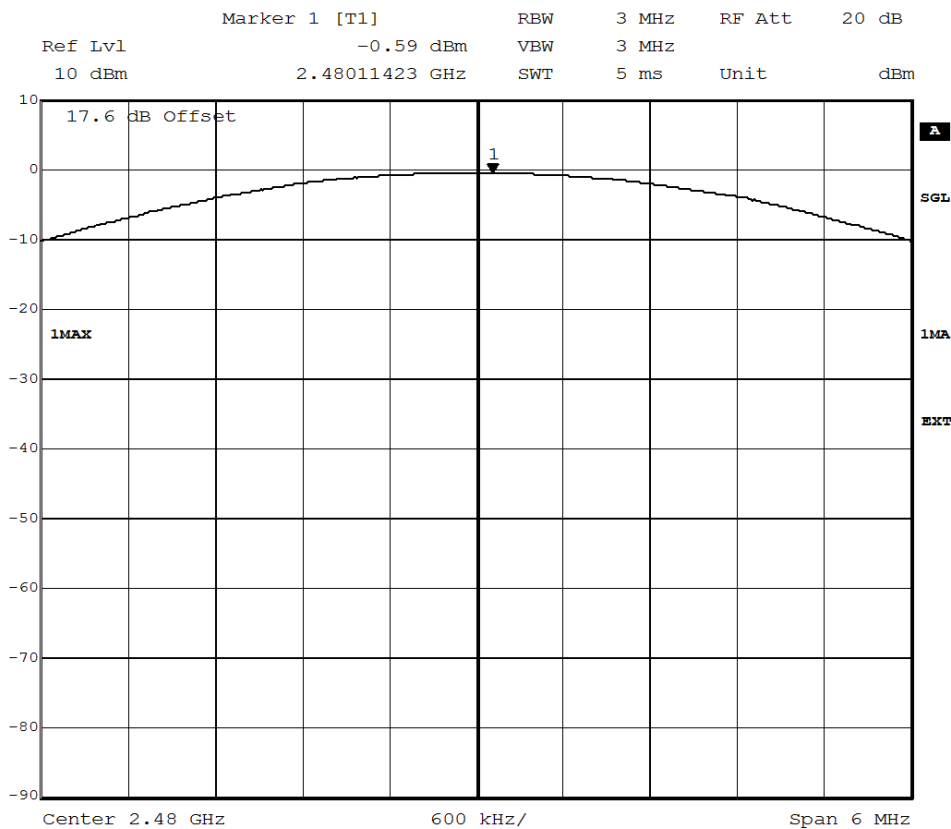
#### Test: 15c.4; Peak power output Summary

<i>Result:</i>	Passed
<i>Setup No.:</i>	AB01_cond
<i>Date of Test:</i>	2015/05/22 8:23
<i>Body:</i>	FCC47CFRChIPART15c247RADIO FREQUENCY DEVICES
<i>Test Specification:</i>	FCC part 2 and 15

**Detailed Results:**

		Conducted Transmitter Power					
Antenna Gain: 1.82 dBi		2402 MHz		2441 MHz		2480 MHz	
Modulation	Conditions	Output Power (dBm)	Output Power (mW)	Output Power (dBm)	Output Power (mW)	Output Power (dBm)	Output Power (mW)
GFSK	TN, VN	-2.05	0.62	-1.18	0.76	-0.59	0.87
$\pi/4$ DQPSK	TN, VN	-3.22	0.48	-2.24	0.60	-1.78	0.66
8-DPSK	TN, VN	-2.82	0.52	-2.37	0.58	-1.76	0.67

<b>Max Conducted Output Power (FSK Modulation)</b>	<b>-0.59</b>	<b>dBm</b>	<b>0.87</b>	<b>mW</b>
<b>Max Conducted Output Power (PSK Modulation)</b>	<b>-1.76</b>	<b>dBm</b>	<b>0.67</b>	<b>mW</b>



Title: Peak outputpower Power  
 Comment A: CH T: 2480 MHz  
 Date: 24.APR.2015 13:17:48

### 3.5.4 15c.5 Spurious RF conducted emissions §15.247 (d)

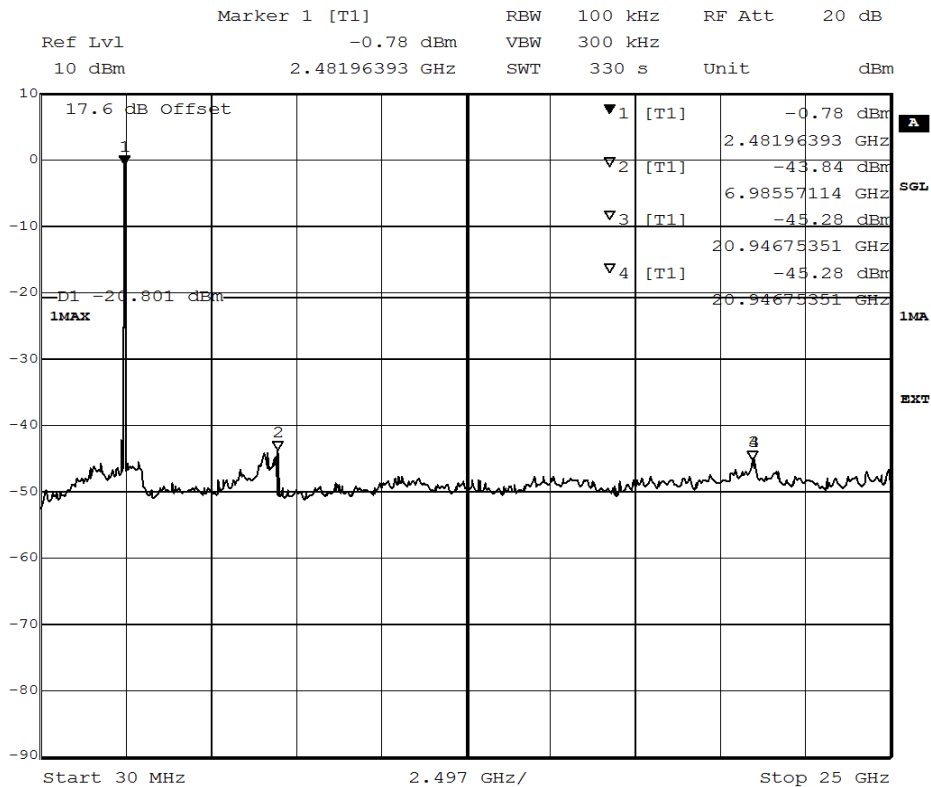
**Test: 15c.5; = BT transmit mode: Low/Mid/High Frequency**

<i>Result:</i>	Passed
<i>Setup No.:</i>	AB01_cond
<i>Date of Test:</i>	2015/05/22 8:24
<i>Body:</i>	FCC47CFRChIPART15c247RADIO FREQUENCY DEVICES
<i>Test Specification:</i>	FCC part 2 and 15

**Detailed Results:**

Mode / Channel	Frequency of emission MHz	Measured value dBm	Reference value dBm	Limit dBm	Margin to limit dB
GFSK / 2402	-		-2.53		None found
GFSK / 2441	-		-1.13		None found
GFSK / 2480	-		-0.78		None found
4 DQPSK / 2402	-		-5.57		None found
4 DQPSK / 2441	-		-4.32		None found
4 DQPSK / 2480	-		-4.19		None found
8DPSK / 2402	-		-5.49		None found
8DPSK / 2441	-		-4.70		None found
8DPSK / 2480	-		-4.85		None found

\* No further peaks found within 20 dB of the limit line.



Title: spurious emissions  
 Comment A: CH T: 2480 MHz  
 Date: 24.APR.2015 13:31:31

### 3.5.5 15c.6 Band edge compliance §15.247 (d)

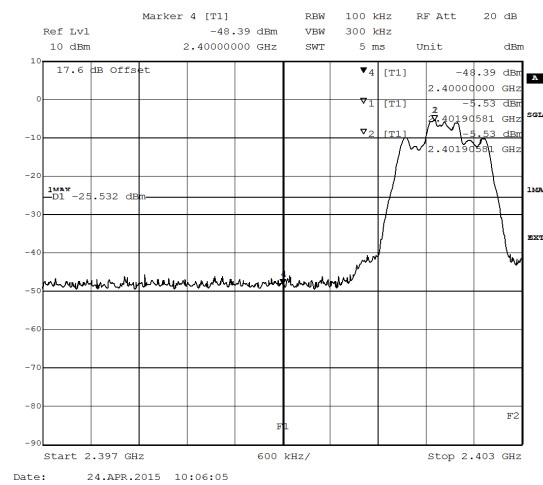
#### Test: 15c.6; Band edge compliance Summary

<i>Result:</i>	Passed
<i>Setup No.:</i>	AB01_cond
<i>Date of Test:</i>	2015/05/22 8:23
<i>Body:</i>	FCC47CFRChIPART15c247RADIO FREQUENCY DEVICES
<i>Test Specification:</i>	FCC part 2 and 15

**Detailed Results:**

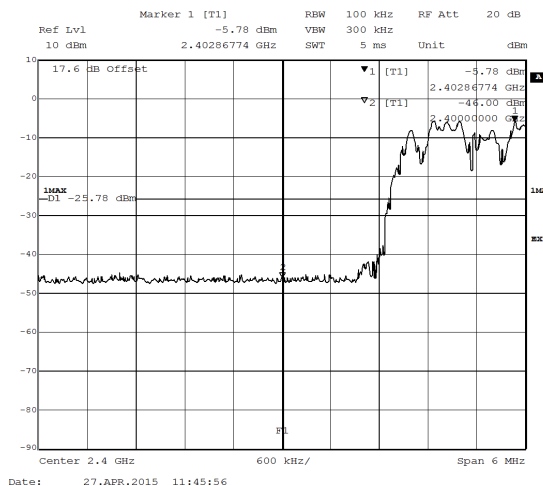
METHOD = CONDUCTED  
 non-hopping mode

Modulation	Frequency MHz	Measured value dBm	Reference value dBm	Limit dBm	Margin to limit dB
GFSK	2400	-46.55	-2.38	-22.38	24.17
4DQPSK	2400	-48.39	-5.53	-25.53	22.86
8DPSK	2400	-48.58	-5.50	-25.50	23.08
GFSK	2483.5	-50.21	-0.80	-20.80	29.41
4DQPSK	2483.5	-50.09	-4.20	-24.20	25.89
8DPSK	2483.5	-49.78	-4.45	-24.45	25.33



METHOD = CONDUCTED  
 hopping mode

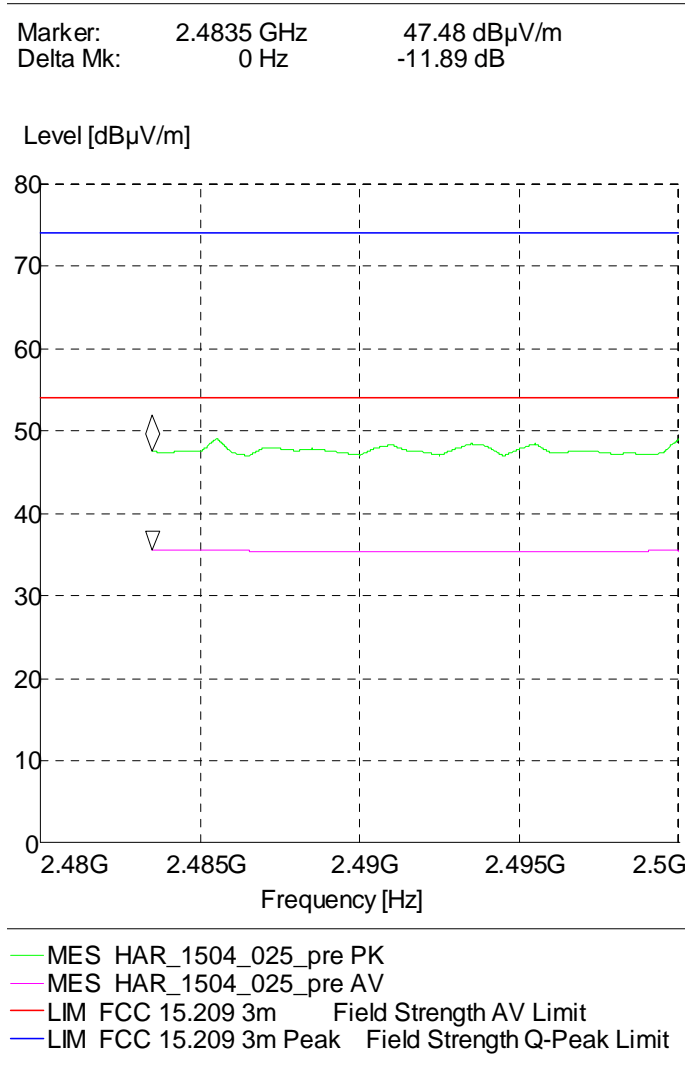
Modulation	Frequency MHz	Measured value dBm	Reference value dBm	Limit dBm	Margin to limit dB
GFSK	2400	-46.24	-2.48	-22.48	23.76
4DQPSK	2400	-46.70	-5.49	-25.49	21.21
8DPSK	2400	-46.00	-5.78	-25.78	20.22
GFSK	2483.5	-48.15	-1.13	-21.13	27.02
4DQPSK	2483.5	-47.74	-4.51	-24.51	23.23
8DPSK	2483.5	-48.09	-4.84	-24.84	23.25





METHOD = RADIATED

Modulation	TX on	Ant. Polar.	Limit PK [dBμV]	Limit AV [dBμV]	Frequency [MHz]	Corrected value PK [dBμV]	Corrected value AV [dBμV]	Margin PK [dB]	Margin AV [dB]	Result
GFSK	2480 MHz	Ver + Hor	74	54	2483.5	47.36	35.47	26.64	18.53	Passed
PI/4 DQPSK	2480 MHz	Ver + Hor	74	54	2483.5	47.48	35.58	26.52	18.42	Passed
8DPSK	2480 MHz	Ver + Hor	74	54	2483.5	47.08	35.47	26.92	18.53	Passed



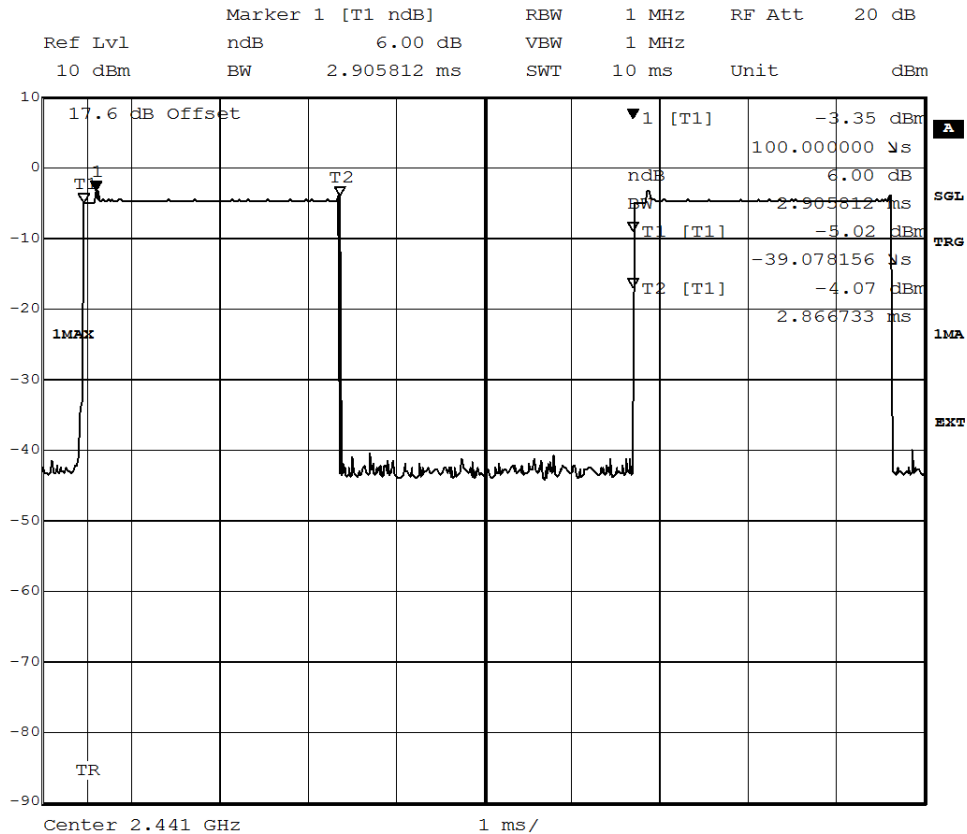
### 3.5.6 15c.7 Dwell time §15.247 (a) (1) (iii)

#### Test: 15c.7; Dwell time Summary

Result: Passed  
 Setup No.: AB01\_cond  
 Date of Test: 2015/05/22 8:23  
 Body: FCC47CFRChIPART15c247RADIO FREQUENCY DEVICES  
 Test Specification: FCC part 2 and 15

#### Detailed Results:

Modulation	Packet type	Time slot length	Dwell time	Dwell time ms
GFSK	DH5	2.91	time slot length * 1600/5 /79 * 31.6	371.94
4-DQPSK	2-DH5	2.91	time slot length * 1600/5 /79 * 31.6	371.94
8DPSK	3-DH5	2.91	time slot length * 1600/5 /79 * 31.6	371.94



Title: Dwell time  
 Comment A: CH M: 2441 MHz  
 Date: 27.APR.2015 09:16:32

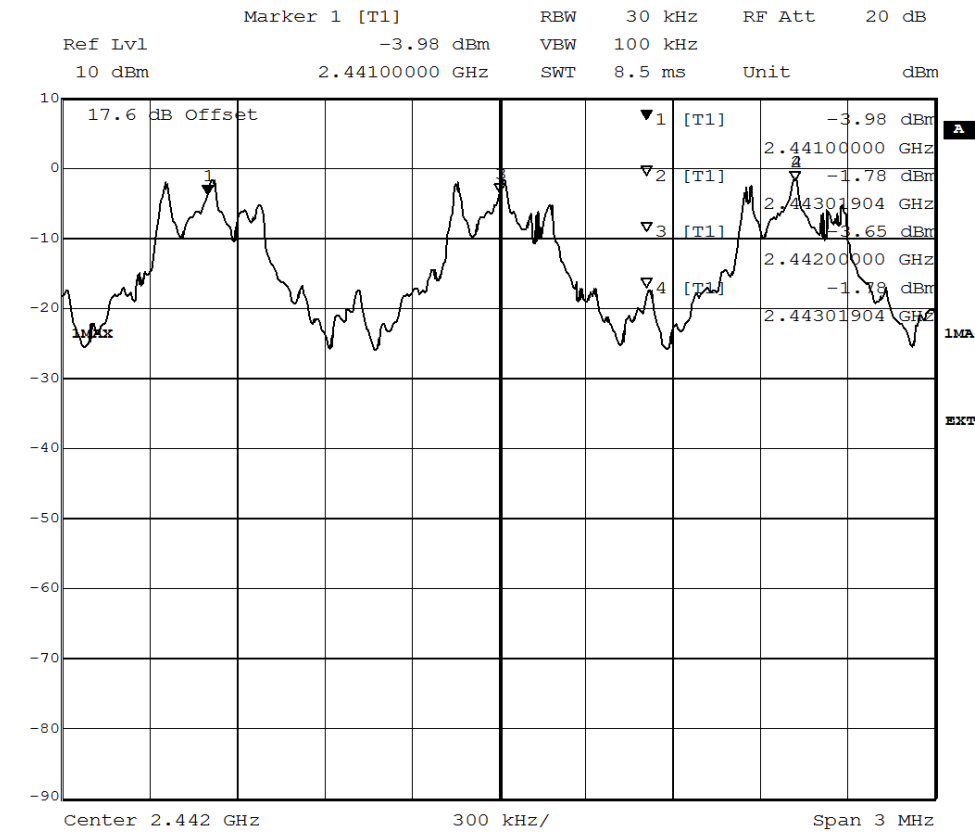
### 3.5.7 15c.8 Channel separation §15.247 (a) (1)

#### Test: 15c.8; Channel separation Summary

Result: Passed  
 Setup No.: AB01\_cond  
 Date of Test: 2015/05/22 8:24  
 Body: FCC47CFRChIPART15c247RADIO FREQUENCY DEVICES  
 Test Specification: FCC part 2 and 15

#### Detailed Results:

Modulation	Channel Separation
GFSK	1 MHz
PI/4 DQPSK	1 MHz
8DPSK	1 MHz



Date: 27.APR.2015 09:42:10

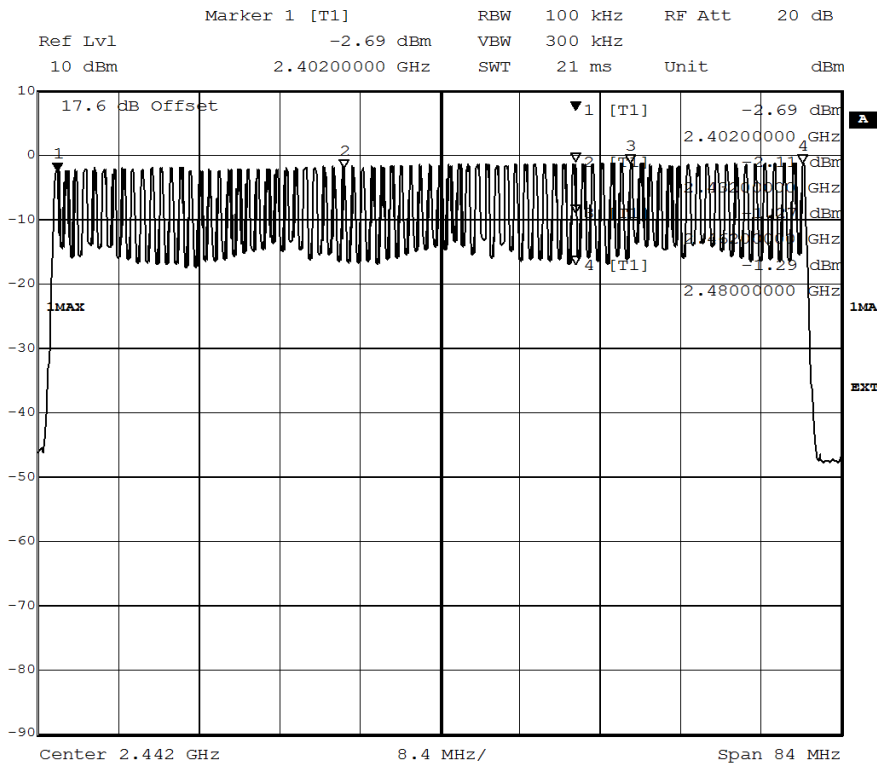
### 3.5.8 15c.9 Number of hopping frequencies §15.247 (a) (1) (iii)

#### Test: 15c.9; Number of hopping frequencies Summary

Result: Passed  
 Setup No.: AB01\_cond  
 Date of Test: 2015/05/22 8:24  
 Body: FCC47CFRChIPART15c247RADIO FREQUENCY DEVICES  
 Test Specification: FCC part 2 and 15

#### Detailed Results:

Modulation	Number of hopping channels
GFSK	79
PI/4 DQPSK	79
8DPSK	79



Title: Number of hopping frequencies  
 Comment A: CH H: Hopping  
 Date: 27.APR.2015 09:53:25

## 4 Test Equipment Details

### 4.1 List of Used Test Equipment

The calibration, hardware and software states are shown for the testing period.

#### Test Equipment Anechoic Chamber

<b>Lab ID:</b>	<b>Lab 1</b>		
<i>Manufacturer:</i>	Frankonia		
<i>Description:</i>	Anechoic Chamber for radiated testing		
<i>Type:</i>	10.58x6.38x6.00 m <sup>3</sup>		
	<i>Calibration Details</i>	<i>Last Execution</i>	<i>Next Exec.</i>
	NSA (FCC)	2014/01/09	2017/01/09

#### Single Devices for Anechoic Chamber

<i>Single Device Name</i>	<i>Type</i>	<i>Serial Number</i>	<i>Manufacturer</i>
Air compressor	none	-	Atlas Copco
Anechoic Chamber	10.58 x 6.38 x 6.00 m <sup>3</sup>	none	Frankonia
	<i>Calibration Details</i>		<i>Last Execution</i> <i>Next Exec.</i>
	FCC listing 96716 3m Part15/18		2014/01/09 2017/01/08
Controller Maturo	MCU	961208	Maturo GmbH
EMC camera	CE-CAM/1	-	CE-SYS
EMC camera Nr.2	CCD-400E	0005033	Mitsubishi
Filter ISDN	B84312-C110-E1		Siemens&Matsushita
Filter Universal 1A	BB4312-C30-H3	-	Siemens&Matsushita

### Test Equipment Auxiliary Equipment for Radiated emissions

**Lab ID:** Lab 1  
**Description:** Equipment for emission measurements  
**Serial Number:** see single devices

### Single Devices for Auxiliary Equipment for Radiated emissions

Single Device Name	Type	Serial Number	Manufacturer
Antenna mast	AM 4.0	AM4.0/180/11920 513	Maturo GmbH
Biconical Broadband Antenna	SBA 9119	9119-005	Schwarzbeck
Biconical dipole	VUBA 9117	9117-108	Schwarzbeck
Broadband Amplifier 18MHz-26GHz	JS4-18002600-32-5P	849785	Miteq
Broadband Amplifier 1GHz-4GHz	AFS4-01000400-1Q-10P-4	-	Miteq
Broadband Amplifier 30MHz-18GHz	JS4-00101800-35-5P	896037	Miteq
Cable "ESI to EMI Antenna"	EcoFlex10	W18.01- 2+W38.01-2	Kabel Kusch
Cable "ESI to Horn Antenna"	UFB311A+UFB293C	W18.02- 2+W38.02-2	Rosenberger Micro-Coax
Double-ridged horn	HF 906	357357/001	Rohde & Schwarz GmbH & Co. KG
	<i>Calibration Details</i>		<i>Last Execution Next Exec.</i>
	Standard Calibration		2012/05/18 2015/05/17
Double-ridged horn	HF 906	357357/002	Rohde & Schwarz GmbH & Co. KG
	<i>Calibration Details</i>		<i>Last Execution Next Exec.</i>
	Standard Calibration		2012/06/26 2015/06/25
High Pass Filter	4HC1600/12750-1.5-KK	9942011	Trilithic
High Pass Filter	5HC2700/12750-1.5-KK	9942012	Trilithic
High Pass Filter	5HC3500/12750-1.2-KK	200035008	Trilithic
High Pass Filter	WHKX 7.0/18G-8SS	09	Wainwright
Horn Antenna Schwarzbeck 15-26 GHz BBHA 9170	BBHA 9170	BBHA9170262	
Log.-per. Antenna	HL 562 Ultralog	100609	Rohde & Schwarz GmbH & Co. KG
	<i>Calibration Details</i>		<i>Last Execution Next Exec.</i>
	Standard Calibration		2012/12/18 2015/12/17
Log.-per. Antenna	HL 562 Ultralog	830547/003	Rohde & Schwarz GmbH & Co. KG
Loop Antenna	HFH2-Z2	829324/006	Rohde & Schwarz GmbH & Co. KG
	<i>Calibration Details</i>		<i>Last Execution Next Exec.</i>
	DKD Calibration		2014/11/27 2017/11/27
Standard Gain / Pyramidal Horn Antenna 26,5 GHz	3160-09	00083069	EMCO Elektronik GmbH

**Single Devices for Auxiliary Equipment for Radiated emissions (continued)**

Single Device Name	Type	Serial Number	Manufacturer
Standard Gain / Pyramidal Horn Antenna 40 GHz	3160-10	00086675	EMCO Elektronik GmbH
Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	TD1.5- 10kg/024/379070 9	Maturo GmbH

**Test Equipment Auxiliary Test Equipment**

<b>Lab ID:</b>	<b>Lab 1</b>
<b>Manufacturer:</b>	see single devices
<b>Description:</b>	Single Devices for various Test Equipment
<b>Type:</b>	various
<b>Serial Number:</b>	none

**Single Devices for Auxiliary Test Equipment**

Single Device Name	Type	Serial Number	Manufacturer
Broadband Power Divider N (Aux)	1506A / 93459	LM390	Weinschel Associates
Broadband Power Divider SMA	WA1515	A855	Weinschel Associates
Digital Multimeter 03 (Multimeter)	Fluke 177	86670383	Fluke Europe B.V.
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Customized calibration			2013/12/04 2015/12/03
Fibre optic link Satellite (Aux)	FO RS232 Link	181-018	Pontis
Fibre optic link Transceiver (Aux)	FO RS232 Link	182-018	Pontis
Isolating Transformer	LTS 604	1888	Thalheimer Transformatorenwerke GmbH
Notch Filter Ultra Stable (Aux)	WRCA800/960-6EEK	24	Wainwright
Signal Analyzer	FSV30	103005	Rohde & Schwarz GmbH & Co. KG
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Standard			2014/02/10 2016/02/09
Spectrum Analyser	FSP3	836722/011	Rohde & Schwarz GmbH & Co. KG
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Standard			2012/06/13 2015/06/12
Spectrum Analyser	FSU26	200418	Rohde & Schwarz GmbH & Co.KG
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Standard calibration			2014/07/29 2015/07/28
Vector Signal Generator	SMIQ 03B	832492/061	Rohde & Schwarz GmbH & Co.KG

### Test Equipment Digital Signalling Devices

**Lab ID:** Lab 1  
**Description:** Signalling equipment for various wireless technologies.

#### Single Devices for Digital Signalling Devices

Single Device Name	Type	Serial Number	Manufacturer
CMW500	CMW500	107500	Rohde & Schwarz GmbH & Co.KG
	<i>Calibration Details</i>		<i>Last Execution Next Exec.</i>
	Standard calibration		2014/01/27 2016/01/26
Digital Radio Communication Tester	CMD 55	831050/020	Rohde & Schwarz GmbH & Co. KG
	<i>Calibration Details</i>		<i>Last Execution Next Exec.</i>
	DKD calibration		2014/12/02 2017/12/01
Universal Radio Communication Tester	CMU 200	102366	Rohde & Schwarz GmbH & Co. KG
	<i>HW/SW Status</i>		<i>Date of Start Date of End</i>
	Hardware: B11, B21V14, B21-2, B41, B52V14, B52-2, B53-2, B56V14, B68 3v04, PCMCIA, U65V04		2007/07/16
	Software: K21 4v21, K22 4v21, K23 4v21, K24 4v21, K42 4v21, K43 4v21, K53 4v21, K56 4v22, K57 4v22, K58 4v22, K59 4v22, K61 4v22, K62 4v22, K63 4v22, K64 4v22, K65 4v22, K66 4v22, K67 4v22, K68 4v22, K69 4v22		
	Firmware: µP1 8v50 02.05.06		
	---		
Universal Radio Communication Tester	CMU 200	837983/052	Rohde & Schwarz GmbH & Co. KG
	<i>Calibration Details</i>		<i>Last Execution Next Exec.</i>
	DKD calibration		2014/12/03 2017/12/02
	<i>HW/SW Status</i>		<i>Date of Start Date of End</i>
	HW options: B11, B21V14, B21-2, B41, B52V14, B52-2, B53-2, B54V14, B56V14, B68 3v04, B95, PCMCIA, U65V02		2007/01/02
	SW options: K21 4v11, K22 4v11, K23 4v11, K24 4v11, K27 4v10, K28 4v10, K42 4v11, K43 4v11, K53 4v10, K65 4v10, K66 4v10, K68 4v10,		
	Firmware: µP1 8v40 01.12.05		
	---		
	SW: K62, K69		2008/11/03
Vector Signal Generator	SMU200A	100912	Rohde & Schwarz GmbH & Co. KG



### Test Equipment Emission measurement devices

**Lab ID:** Lab 1  
**Description:** Equipment for emission measurements  
**Serial Number:** see single devices

#### Single Devices for Emission measurement devices

Single Device Name	Type	Serial Number	Manufacturer
EMI Receiver / Spectrum Analyser	ESR 7	101424	Rohde & Schwarz
	<i>Calibration Details</i>		<i>Last Execution</i> <i>Next Exec.</i>
	Initial Factory Calibration		2014/11/13 2016/11/12
Personal Computer	Dell	30304832059	Dell
Power Meter	NRVD	828110/016	Rohde & Schwarz GmbH & Co.KG
	<i>Calibration Details</i>		<i>Last Execution</i> <i>Next Exec.</i>
	Standard calibration		2014/05/13 2015/05/10
	Standard calibration		2015/05/11 2016/05/10
Sensor Head A	NRV-Z1	827753/005	Rohde & Schwarz GmbH & Co.KG
	<i>Calibration Details</i>		<i>Last Execution</i> <i>Next Exec.</i>
	Standard calibration		2014/05/13 2015/05/10
	Standard calibration		2015/05/11 2016/05/10
Signal Generator	SMR 20	846834/008	Rohde & Schwarz GmbH & Co. KG
	<i>Calibration Details</i>		<i>Last Execution</i> <i>Next Exec.</i>
	Standard Calibration		2014/06/24 2017/06/23
Spectrum Analyser	FSW 43	103779	Rohde & Schwarz
	<i>Calibration Details</i>		<i>Last Execution</i> <i>Next Exec.</i>
	Initial Factory Calibration		2014/11/17 2016/11/16
Spectrum Analyzer	ESIB 26	830482/004	Rohde & Schwarz GmbH & Co. KG
	<i>Calibration Details</i>		<i>Last Execution</i> <i>Next Exec.</i>
	Standard Calibration		2014/01/07 2016/01/31
	<i>HW/SW Status</i>		<i>Date of Start</i> <i>Date of End</i>
	Firmware-Update 4.34.4 from 3.45 during calibration		2009/12/03

### Test Equipment Multimeter 12

**Lab ID:** Lab 2  
**Description:** Ex-Tech 520  
**Serial Number:** 05157876

#### Single Devices for Multimeter 12

Single Device Name	Type	Serial Number	Manufacturer
Digital Multimeter 12 (Multimeter)	EX520	05157876	Extech Instruments Corp.
	<i>Calibration Details</i>		<i>Last Execution</i> <i>Next Exec.</i>
	Customized calibration		2013/12/04 2015/12/03

### Test Equipment Regulatory Bluetooth RF Test Solution

**Lab ID:** Lab 2  
**Description:** Regulatory Bluetooth RF Tests  
**Type:** Bluetooth RF  
**Serial Number:** 001

### Single Devices for Regulatory Bluetooth RF Test Solution

Single Device Name	Type	Serial Number	Manufacturer
ADU 200 Relay Box 7	Relay Box	A04380	Ontrak Control Systems Inc.
Bluetooth Signalling Unit CBT	CBT	100302	Rohde & Schwarz GmbH & Co.KG
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Standard calibration			2014/08/29 2015/08/28
Power Meter NRVD	NRVD	832025/059	
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Standard calibration			2014/08/29 2015/08/28
Power Sensor NRV Z1 A	PROBE	832279/013	
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Standard calibration			2014/08/28 2015/08/27
Power Supply	NGSM 32/10	2725	
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Standard calibration			2013/06/20 2015/06/19
Rubidium Frequency Normal MFS	Datum MFS	002	Datum GmbH
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Standard calibration			2014/08/29 2015/08/28
Signal Analyser FSIQ26	1119.6001.26	832695/007	Rohde & Schwarz GmbH & Co.KG
Vector Signal Generator SMIQ03B	SMIQ03B	832870/017	
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Standard calibration			2013/06/21 2016/06/20

### Test Equipment Shielded Room 07

**Lab ID:** Lab 2  
**Description:** Shielded Room 4m x 6m

### Test Equipment T/A Logger 13

**Lab ID:** Lab 1  
**Description:** Luft Opus10 TPR  
**Type:** Opus10 TPR  
**Serial Number:** 13936

### Single Devices for T/A Logger 13

Single Device Name	Type	Serial Number	Manufacturer
ThermoAirpressure Datalogger 13 (Environ)	Opus10 TPR (8253.00)	13936	Luftt Mess- und Regeltechnik GmbH
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Customized calibration			2015/02/27 2017/02/26

### Test Equipment T/H Logger 12

**Lab ID:** Lab 1  
**Description:** Lufft Opus10  
**Serial Number:** 12482

#### Single Devices for T/H Logger 12

Single Device Name	Type	Serial Number	Manufacturer
ThermoHygro Datalogger 12 (Environ)	Opus10 THI (8152.00)	12482	Lufft Mess- und Regeltechnik GmbH
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Customized calibration			2015/03/10 2017/03/09

### Test Equipment T/H Logger 15

**Lab ID:** Lab 2  
**Description:** Lufft Opus10  
**Serial Number:** 13985

#### Single Devices for T/H Logger 15

Single Device Name	Type	Serial Number	Manufacturer
ThermoHygro Datalogger 15 (Environ)	Opus10 THI (8152.00)	13985	Lufft Mess- und Regeltechnik GmbH
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Customized calibration			2015/03/10 2017/03/09

### Test Equipment Temperature Chamber 01

**Lab ID:** Lab 2  
**Manufacturer:** see single devices  
**Description:** Temperature Chamber KWP 120/70  
**Type:** Weiss  
**Serial Number:** see single devices

#### Single Devices for Temperature Chamber 01

Single Device Name	Type	Serial Number	Manufacturer
Temperature Chamber Weiss 01	KWP 120/70	59226012190010	Weiss Umwelttechnik GmbH
<i>Calibration Details</i>			<i>Last Execution</i> <i>Next Exec.</i>
Customized calibration			2014/03/12 2016/03/11

## **5 Annex**

### **5.1 Additional Information for Report**

Summary of Test Results

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The EUT complied with all performed tests as listed in the summary section of this report.

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Technical Report Summary

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Type of Authorization :

Certification for an Intentional Radiator (Frequency Hopping Spread Spectrum).

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15. The following subparts are applicable to the results in this test report:

- Part 2, Subpart J - Equipment Authorization Procedures, Certification
- Part 15, Subpart C – Intentional Radiators
- § 15.201 Equipment authorization requirement
- § 15.207 Conducted limits
- § 15.209 Radiated emission limits; general requirements
- § 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz

Additional documents

The tests were selected and performed with reference to the FCC Public Notice DA 00-705, released March 30, 2000. Instead of applying ANSI C63.4-1992 which is referenced in the FCC Public Note, the newer ANSI C63.4-2009 is applied.

\*\*\*\*\*  
 FCC and IC Correlation of measurement requirements  
 \*\*\*\*\*

The following table shows the correlation of measurement requirements for FHSS equipment (e.g. Bluetooth) from FCC and IC Standards.

Measurement	FCC reference	IC reference
Conducted emissions on AC mains	§ 15.207	RSS-Gen Issue 4: 8.8
Occupied bandwidth	§ 15.247 (a) (1)	RSS-210 Issue 8: A8.1 (b)
Peak power output	§ 15.247 (b) (1),(4)	RSS-210 Issue 8: A8.4 (2)
Spurious RF conducted emissions	§ 15.247 (d)	RSS-Gen Issue 4: 6.13/8.9/8.10; RSS-210 Issue 8: A8.5
Spurious radiated emissions	§ 15.247 (d)	RSS-Gen Issue 4: 6.13 / 8.9/8.10; RSS-210 Issue 8: A8.5
Band edge compliance	§ 15.247 (d)	RSS-210 Issue 8: A8.5
Dwell time	§ 15.247 (a)(1)(iii)	RSS-210 Issue 8: A8.1 (d)
Channel separation	§ 15.247 (a)(1)	RSS-210 Issue 8: A8.1 (b)
No. of hopping frequencies	§ 15.247 (a)(1)(iii)	RSS-210 Issue 8: A8.1 (d)
Hybrid systems (only)	§ 15.247 (e), (f)	RSS-210 Issue 8: A8.3
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 4: 8.3
Receiver spurious emissions	- - -	RSS-210 Issue 8: 2.3; RSS Gen Issue 4: 5 / 7 *)

\*) Receivers are exempted from certification besides if operating in stand-alone mode in the frequency range 30-960 MHz or if these are scanner receivers.

Description of Methods of Measurements

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Conducted emissions (AC power line)

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Standard FCC Part 15, Subpart C

The test was performed according to: ANSI C 63.4,

Test Description

The test set-up was made in accordance to the general provisions of ANSI C 63.4. The Equipment Under Test (EUT) was setup in a shielded room to perform the conducted emissions measurements in a typical installation configuration. The EUT was powered from 50μH || 50 Ohm Line Impedance Stabilization Network (LISN). The LISN's unused connections were terminated with 50 Ohm loads. The measurement procedure consists of two steps. It is implemented into the EMI test software ES-K1 from R&S.

Step 1: Preliminary scan

Intention of this step is, to determine the conducted EMI-profile of the EUT.

EMI receiver settings:

- Detector: Peak - Maxhold
- Frequency range: 150 kHz – 30 MHz
- Frequency steps: 5 kHz
- IF-Bandwidth: 9 kHz
- Measuring time / Frequency step: 20 ms
- Measurement on phase + neutral lines of the power cords.

On basis of this preliminary scan the highest amplitudes and the corresponding frequencies relative to the limit are identified. Emissions above the limit and emissions which are in the 10 dB range below the limit are considered.

Step 2: Final measurement

Intention of this step is, to determine the highest emissions with the settings defined in the test specification for the frequencies identified in step 1.

EMI receiver settings:

- Detector: Quasi-Peak
- IF - Bandwidth: 9 kHz
- Measuring time: 1 s / frequency

At each frequency determined in step 1, four measurements are performed in the following combinations:

- 1) Neutral lead - reference ground (PE grounded)
- 2) Phase lead - reference ground (PE grounded)
- 3) Neutral lead - reference ground (PE floating)
- 4) Phase lead - reference ground (PE floating)

The highest value is reported.

Test Requirements / Limits

FCC Part 15, Subpart C, §15.207

Frequency Range (MHz)	QP Limit (dBμV)	AV Limit (dBμV)
0.15 – 0.5	66 to 56	56 to 46
0.5 – 5	56	46
5 – 30	60	50

Used conversion factor: Limit (dBμV) = 20 log (Limit (μV)/1μV).

## Occupied bandwidth

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Standard FCC Part 15, Subpart C

The test was performed according to: FCC §15.31

### Test Description

The Equipment Under Test (EUT) was setup to perform the occupied bandwidth measurements. The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical. The results recorded were measured with the modulation which produces the worst-case (widest) occupied bandwidth. The resolution bandwidth for measuring the reference level and the occupied bandwidth was 30 kHz. The EUT was connected to the spectrum analyzer via a short coax cable.

### Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (a) (1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Implication by the test laboratory:

Since the Bluetooth technology defines a fixed channel separation of 1 MHz this design parameter defines the maximum allowed occupied bandwidth depending on the EUT's output power:

1. Under the provision that the system operates with an output power not greater than 125 mW (21.0 dBm):  
Implicit Limit: Max. 20 dB BW =  $1.0 \text{ MHz} / 2/3 = 1.5 \text{ MHz}$
2. If the system output power exceeds 125 mW (21.0 dBm):  
Implicit Limit: Max. 20 dB BW = 1.0 MHz

Used conversion factor: Output power (dBm) =  $10 \log (\text{Output power (W)} / 1\text{mW})$

The measured output power of the system is below 125 mW (21.0 dBm). For the results, please refer to the related chapter of this report. Therefore the limit is determined as 1.5 MHz.

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## Peak power output

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Standard FCC Part 15, Subpart C

The test was performed according to: FCC §15.31

### Test Description

The Equipment Under Test (EUT) was set up to perform the output power measurements. The resolution bandwidth for measuring the output power was set to 3 MHz. The reference level of the spectrum analyzer was set higher than the output power of the EUT. The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

### Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (b) (1)

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:  
(1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt.

Used conversion factor: Limit (dBm) = 10 log (Limit (W)/1mW)  
==> Maximum Output Power: 30 dBm

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#### Spurious RF conducted emissions

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Standard FCC Part 15, Subpart C

The test was performed according to: FCC §15.31

#### Test Description

The Equipment Under Test (EUT) was set up to perform the spurious emissions measurements. The EUT was connected to spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Detector: Peak-Maxhold
- Frequency range: 30 – 25000 MHz
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweep Time: 330 s

The reference value for the measurement of the spurious RF conducted emissions is determined during the test "band edge compliance" (cf. chapter 3.6). This value is used to calculate the 20 dBc limit.

#### Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (c)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power

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#### Spurious radiated emissions

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Standard FCC Part 15, Subpart C

The test was performed according to: ANSI C 63.4,

#### Test Description

The test set-up was made in accordance to the general provisions of ANSI C63.4 in a typical installation configuration.

The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m<sup>2</sup> in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.

The measurement procedure is implemented into the EMI test software ES-K1 from R&S. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is performed at 2 axes. A pre-check is also performed while the EUT is powered from both AC and DC (battery) power in order to find the worst-case operating condition.

1. Measurement up to 30 MHz

The Loop antenna HFH2-Z2 is used.

Step 1: pre-measurement

- Anechoic chamber
- Antenna distance: 10 m



- Detector: Peak-Maxhold
- Frequency range: 0.009 – 0.15 and 0.15 – 30 MHz
- Frequency steps: 0.1 kHz and 5 kHz
- IF-Bandwidth: 0.2 kHz and 10 kHz
- Measuring time / Frequency step: 100 ms

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

#### Step 2: final measurement

For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is to find the maximum emission level.

- Open area test side
- Antenna distance: according to the Standard
- Detector: Quasi-Peak
- Frequency range: 0.009 – 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF-Bandwidth: 200 Hz – 10 kHz
- Measuring time / Frequency step: 100 ms

## 2. Measurement above 30 MHz and up to 1 GHz

### Step 1: Preliminary scan

Preliminary test to identify the highest amplitudes relative to the limit.

#### Settings for step 1:

- Detector: Peak-Maxhold
- Frequency range: 30 – 1000 MHz
- Frequency steps: 60 kHz
- IF-Bandwidth: 120 kHz
- Measuring time / Frequency step: 100  $\mu$ s (BT Timing 1.25 ms)
- Turntable angle range:  $-180$  to  $+180^\circ$
- Turntable step size:  $90^\circ$
- Height variation range: 1 – 3 m
- Height variation step size: 2 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

#### Step 2: second measurement

For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is, to find out the approximate turntable angle and antenna height for each frequency.

- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range:  $-180$  to  $+180^\circ$
- Turntable step size:  $45^\circ$
- Height variation range: 1 – 4 m
- Height variation step size: 0.5 m
- Polarisation: horizontal + vertical

After this step the EMI test system has determined the following values for each frequency (of step 1):

- Frequency
- Azimuth value (of turntable)
- Antenna height

The last two values have now the following accuracy:

- Azimuth value (of turntable):  $45^\circ$
- Antenna height: 0.5 m

#### Step 3: final measurement

In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.

For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will be slowly varied by  $\pm 22.5^\circ$  around this value. During this action the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position the antenna height is also slowly varied by  $\pm 25$  cm around the antenna height determined. During this action the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.

- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range:  $-22.5^\circ$  to  $+22.5^\circ$  around the determined value

- Height variation range: -0.25 m to +0.25 m around the determined value
- Step 4: final measurement with QP detector
- With the settings determined in step 3, the final measurement will be performed:
- EMI receiver settings for step 4:
  - Detector: Quasi-Peak (< 1 GHz)
  - Measured frequencies: in step 1 determined frequencies
  - IF - Bandwidth: 120 kHz
  - Measuring time: 1 s

### 3. Measurement above 1 GHz

The following modifications apply to the measurement procedure for the frequency range above 1 GHz: The measurement distance was reduced to 1.4 m. The results were extrapolated by the extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements, inverse linear-distance squared for the power reference level measurements). Due to the fact that in this frequency range a double ridged wave guided horn antenna (up to 18 GHz) and a standard gain horn antenna (18–25 GHz) are used, the steps 2–4 are omitted. Step 1 was performed with one height of the receiving antenna only.

- EMI receiver settings:
- Detector: Peak, Average
  - IF Bandwidth = 1 MHz

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement. For the enhanced data rate packets the test is performed as worst-case-check in order to verify that emissions have a comparable level as found at basic data rate. Typically, the measurement for these packets is performed in the frequency range 1 to 8 GHz but it depends on the emissions found during the test for the basic data rate. Please refer to the results for the used frequency range.

### Test Requirements / Limits

#### FCC Part 15, Subpart C, §15.247 (d)

... In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

#### FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency (MHz)	Limit (µV/m)	Measurement distance (m)	Limit @ 10 m distance (dBµV/m)
0.009 – 0.49	2400/F(kHz)	300	48.5..13.8 + 59.1 dB = 107.6..72.9
0.49 – 1.705	24000/F(kHz)	30	33.8..23.0 + 19.1 dB = 52.9..42.1
1.705 - 30	30	30	29.5 + 19.1 = 48.6

Frequency (MHz)	Limit (µV/m)	Measurement distance (m)	Limit (dBµV/m)
30 - 88	100	3	40.0
88 - 216	150	3	43.5
216 - 960	200	3	46.0
above 960	500	3	54.0

#### §15.35(b)

..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor:  $\text{Limit (dB}\mu\text{V/m)} = 20 \log (\text{Limit } (\mu\text{V/m})/1\mu\text{V/m)}$

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### Band edge compliance

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Standard    FCC Part 15, Subpart C

The test was performed according to: ANSI C 63.4, FCC §15.31

### Test Description

The procedure to show compliance with the band edge requirement is divided into two measurements:

1. Show compliance of the lower band edge by a conducted measurement and
2. show compliance of the higher band edge by a radiated and conducted measurement.

For the first measurement the EUT is set to transmit on the lowest channel (2402 MHz). The lower band edge is 2400 MHz.

Analyzer settings:

- Detector: Peak
- RBW= 100 kHz
- VBW= 300 kHz

For the second measurement the EUT is set to transmit on the highest channel (2480 MHz). The higher band edge is 2483.5 MHz.

Analyzer settings for conducted measurement:

- Detector: Peak
- RBW= 100 kHz
- VBW= 300 kHz

EMI receiver settings for radiated measurement:

- Detector: Peak, Average
- IF Bandwidth = 1 MHz

#### Test Requirements / Limits

FCC Part 15.247 (d)

"In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

...

Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c))."

For the measurement of the lower band edge the RF power at the band edge shall be "at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power..."

For the measurement of the higher band edge the limit is "specified in Section 15.209(a)".

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#### Dwell time

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Standard FCC Part 15, Subpart C

The test was performed according to: FCC §15.31

#### Test Description

The Equipment Under Test (EUT) was set up to perform the dwell time measurements. The EUT was connected to the spectrum analyzer via a short coax cable. The dwell time is independent from the modulation pattern. The dwell time is calculated by:

Dwell time = time slot length \* hop rate / number of hopping channels \* 31.6 s

with:

- hop rate = 1600 \* 1/s for DH1 packets = 1600 s<sup>-1</sup>
- hop rate = 1600/3 \* 1/s for DH3 packets = 533.33 s<sup>-1</sup>
- hop rate = 1600/5 \* 1/s for DH5 packets = 320 s<sup>-1</sup>
- number of hopping channels = 79
- 31.6 s = 0.4 seconds multiplied by the number of hopping channels = 0.4 s \* 79

The highest value of the dwell time is reported.

#### Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (a) (1) (iii)

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Since the Bluetooth technology uses 79 channels this period is calculated to be 31.6 seconds.

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#### Channel separation

Standard FCC Part 15, Subpart C

The test was performed according to: FCC §15.31

#### Test Description

The Equipment Under Test (EUT) was set up to perform the channel separation measurements. The channel separation is independent from the modulation pattern.

The EUT was connected to spectrum analyzer via a short coax cable.

Analyzer settings:

- Detector: Peak-Maxhold
- Span: 3 MHz
- Centre Frequency: a mid frequency of the 2.4 GHz ISM band
- Resolution Bandwidth (RBW): 30 kHz
- Video Bandwidth (VBW): 100 kHz
- Sweep Time: Coupled

#### Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (a) (1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

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#### Number of hopping frequencies

Standard FCC Part 15, Subpart C

The test was performed according to: FCC §15.31

#### Test Description

The Equipment Under Test (EUT) was set up to perform the number of hopping frequencies measurement. The number of hopping frequencies is independent from the modulation pattern.

The EUT was connected to spectrum analyzer via a short coax cable.

Analyzer settings:

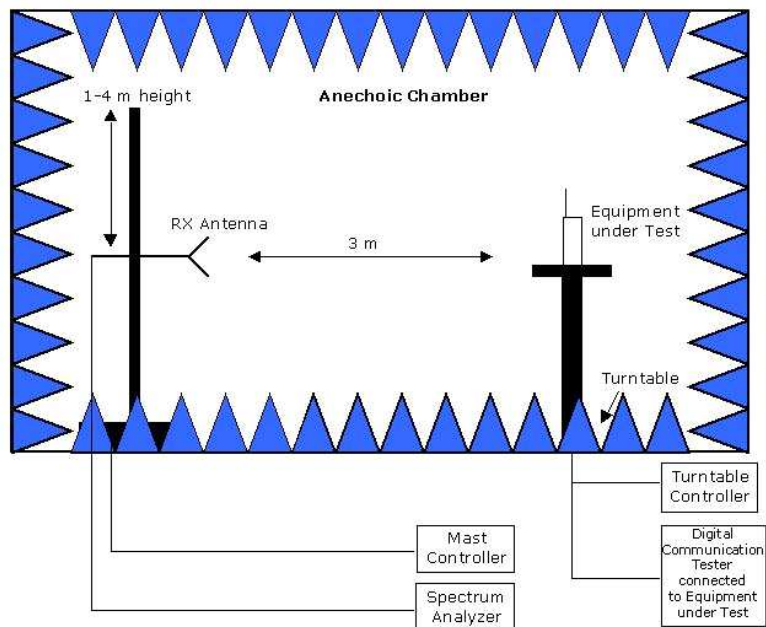
- Detector: Peak-Maxhold
- Centre frequency: 2442 MHz

- Frequency span: 84 MHz
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweep Time: Coupled

#### Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (a) (iii)  
Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

#### Setup Drawings



Remark: Depending on the frequency range suitable antenna types, attenuators or preamplifiers are used.

Setup in the Anechoic chamber:  
Measurements below 1 GHz: Semi-anechoic, conducting ground plane.  
Measurements above 1 GHz: Fully-anechoic, absorbers on all surfaces

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