FCC Measurement/Technical Report on

SNM941 (SNM941-90)

FCC ID: JUP-WCSNM941
IC: 1756A-SNM941

According to FCC Part 15.247

Test Report Reference: MDE_7LUS_1601_FCCb

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

Deutsche Akkreditierungsstelle D-PL-12140-01-00

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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1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization
Certification for an Intentional Radiator.

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 (10-1-15 Edition). 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

Note: (DTS Equipment)
The tests were selected and performed with reference to the FCC Public Notice “Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247, 558074 D01 DTS Measurement Guidance v04, 2017-04-05”.

ANSI C63.10–2013 is applied.

Summary Test Results:

The EUT complied with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.

1.2 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for DTS (e.g. WLAN 2.4 GHz, BT LE) equipment from FCC and IC

DTS equipment

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 4: 8.8
Occupied bandwidth	§ 15.247 (a) (2)	RSS-247 Issue 2: 5.2 a)
Peak conducted output power	§ 15.247 (b) (3), (4)	RSS-247 Issue 2: 5.4 d)
Transmitter spurious RF conducted emissions	§ 15.247 (d)	RSS-Gen Issue 4: 6.13 / 8.9/8.10; RSS-247 Issue 2: 5.5
Transmitter spurious radiated emissions	§ 15.247 (d); § 15.209 (a)	RSS-Gen Issue 4: 6.13 / 8.9/8.10; RSS-247 Issue 2: 5.5
Band edge compliance	§ 15.247 (d)	RSS-247 Issue 2: 5.5
Power density	§ 15.247 (e)	RSS-247 Issue 2: 5.2 b)
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 2: 8.3
Receiver spurious emissions	–	–

1.3 MEASUREMENT SUMMARY / SIGNATURES

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 **§ 15.247 (a) (2)**

Occupied Bandwidth (6 dB)

The measurement was performed according to ANSI C63.10

OP-Mode	Setup	Final Result FCC	IC
Radio Technology, Operating Frequency			
Bluetooth LE, high	S01_ac02	Passed	Passed
Bluetooth LE, low	S01_ac02	Passed	Passed
Bluetooth LE, mid	S01_ac02	Passed	Passed
WLAN b, high	S01_ab01	Passed	Passed
WLAN b, low	S01_ab01	Passed	Passed
WLAN b, mid	S01_ab01	Passed	Passed
WLAN g, high	S01_ab01	Passed	Passed
WLAN g, low	S01_ab01	Passed	Passed
WLAN g, mid	S01_ab01	Passed	Passed
WLAN n 20 MHz, high	S01_ab01	Passed	Passed
WLAN n 20 MHz, low	S01_ab01	Passed	Passed
WLAN n 20 MHz, mid	S01_ab01	Passed	Passed
WLAN n 40 MHz, high	S01_ab01	Passed	Passed
WLAN n 40 MHz, low	S01_ab01	Passed	Passed
WLAN n 40 MHz, mid	S01_ab01	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 **-**

Occupied Bandwidth (99%)

The measurement was performed according to ANSI C63.10

OP-Mode	Setup	Final Result FCC	IC
Radio Technology, Operating Frequency			
Bluetooth LE, high	S01_ac02	N/A	Passed
Bluetooth LE, low	S01_ac02	N/A	Passed
Bluetooth LE, mid	S01_ac02	N/A	Passed
WLAN b, high	S01_ab01	N/A	Passed
WLAN b, low	S01_ab01	N/A	Passed
WLAN b, mid	S01_ab01	N/A	Passed
WLAN g, high	S01_ab01	N/A	Passed
WLAN g, low	S01_ab01	N/A	Passed
WLAN g, mid	S01_ab01	N/A	Passed
WLAN n 20 MHz, high	S01_ab01	N/A	Passed
WLAN n 20 MHz, low	S01_ab01	N/A	Passed
WLAN n 20 MHz, mid	S01_ab01	N/A	Passed
WLAN n 40 MHz, high	S01_ab01	N/A	Passed
WLAN n 40 MHz, low	S01_ab01	N/A	Passed
WLAN n 40 MHz, mid	S01_ab01	N/A	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247	§ 15.247 (b) (3)		
Peak Power Output			
The measurement was performed according to ANSI C63.10		**Final Result**	
OP-Mode	**Setup**	**FCC**	**IC**
Radio Technology, Operating Frequency, Measurement method			
Bluetooth LE, high, conducted	S01_ac02	Passed	Passed
Bluetooth LE, low, conducted	S01_ac02	Passed	Passed
Bluetooth LE, mid, conducted	S01_ac02	Passed	Passed
WLAN b, high, conducted	S01_ak02	Passed	Passed
WLAN b, low, conducted	S01_ak02	Passed	Passed
WLAN b, mid, conducted	S01_ak02	Passed	Passed
WLAN g, high, conducted	S01_ak02	Passed	Passed
WLAN g, low, conducted	S01_ak02	Passed	Passed
WLAN g, mid, conducted	S01_ak02	Passed	Passed
WLAN n 20 MHz, high, conducted	S01_ak02	Passed	Passed
WLAN n 20 MHz, low, conducted	S01_ak02	Passed	Passed
WLAN n 20 MHz, mid, conducted	S01_ak02	Passed	Passed
WLAN n 40 MHz, high, conducted	S01_ak02	Passed	Passed
WLAN n 40 MHz, low, conducted	S01_ak02	Passed	Passed
WLAN n 40 MHz, mid, conducted	S01_ak02	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247	§ 15.247 (d)		
Spurious RF Conducted Emissions			
The measurement was performed according to ANSI C63.10		**Final Result**	
OP-Mode	**Setup**	**FCC**	**IC**
Radio Technology, Operating Frequency			
Bluetooth LE, high	S01_ac02	Passed	Passed
Bluetooth LE, low	S01_ac02	Passed	Passed
Bluetooth LE, mid	S01_ac02	Passed	Passed
WLAN b, high	S01_ab01	Passed	Passed
WLAN b, low	S01_ab01	Passed	Passed
WLAN b, mid	S01_ab01	Passed	Passed
WLAN g, high	S01_ab01	Passed	Passed
WLAN g, low	S01_ab01	Passed	Passed
WLAN g, mid	S01_ab01	Passed	Passed
WLAN n 20 MHz, high	S01_ab01	Passed	Passed
WLAN n 20 MHz, low	S01_ab01	Passed	Passed
WLAN n 20 MHz, mid	S01_ab01	Passed	Passed
WLAN n 40 MHz, high	S01_ab01	Passed	Passed
WLAN n 40 MHz, low	S01_ab01	Passed	Passed
WLAN n 40 MHz, mid	S01_ab01	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 **§ 15.247 (d)**

Transmitter Spurious Radiated Emissions

The measurement was performed according to ANSI C63.10

OP-Mode	**Setup**	**Final Result FCC**	**IC**
Radio Technology, Operating Frequency, Measurement range			
Bluetooth LE, high, 1 GHz - 26 GHz	DE1221004af02	Passed	Passed
Bluetooth LE, high, 30 MHz - 1 GHz	DE1221004af02	Passed	Passed
Bluetooth LE, low, 1 GHz - 26 GHz	DE1221004af02	Passed	Passed
Bluetooth LE, low, 30 MHz - 1 GHz	DE1221004af02	Passed	Passed
Bluetooth LE, mid, 1 GHz - 26 GHz	DE1221004af02	Passed	Passed
Bluetooth LE, mid, 30 MHz - 1 GHz	DE1221004af02	Passed	Passed
Bluetooth LE, mid, 9 kHz - 30 MHz	DE1221004af02	Passed	Passed
WLAN b, high, 1 GHz - 26 GHz	DE1221004af02	Passed	Passed
WLAN b, high, 30 MHz - 1 GHz	DE1221004af02	Passed	Passed
WLAN b, low, 1 GHz - 26 GHz	DE1221004af02	Passed	Passed
WLAN b, low, 30 MHz - 1 GHz	DE1221004af02	Passed	Passed
WLAN b, mid, 1 GHz - 26 GHz	DE1221004af02	Passed	Passed
WLAN b, mid, 30 MHz - 1 GHz	DE1221004af02	Passed	Passed
WLAN b, mid, 9 kHz - 30 MHz	DE1221004af02	Passed	Passed
WLAN g, high, 1 GHz - 26 GHz Remark: tested 1-8GHz	DE1221004aj02	Passed	Passed
WLAN g, low, 1 GHz - 26 GHz Remark: tested 1-8GHz	DE1221004aj02	Passed	Passed
WLAN g, mid, 1 GHz - 26 GHz Remark: tested 1-8GHz	DE1221004aj02	Passed	Passed
WLAN n 20 MHz, high, 1 GHz - 26 GHz Remark: tested 1-8GHz	DE1221004aj02	Passed	Passed
WLAN n 20 MHz, low, 1 GHz - 26 GHz Remark: tested 1-8GHz	DE1221004aj02	Passed	Passed
WLAN n 20 MHz, mid, 1 GHz - 26 GHz Remark: tested 1-8GHz	DE1221004aj02	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247	§ 15.247 (d)		
Band Edge Compliance Conducted			
The measurement was performed according to ANSI C63.10		**Final Result**	
OP-Mode	**Setup**	**FCC**	**IC**
Radio Technology, Operating Frequency, Band Edge			
Bluetooth LE, high, high	S01_ac02	Passed	Passed
Bluetooth LE, low, low	S01_ac02	Passed	Passed
WLAN b, high, high	S01_ab01	Passed	Passed
WLAN b, low, low	S01_ab01	Passed	Passed
WLAN g, high, high	S01_ab01	Passed	Passed
WLAN g, low, low	S01_ab01	Passed	Passed
WLAN n 20 MHz, high, high	S01_ab01	Passed	Passed
WLAN n 20 MHz, low, low	S01_ab01	Passed	Passed
WLAN n 40 MHz, high, high	S01_ab01	Passed	Passed
WLAN n 40 MHz, low, low	S01_ab01	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247	§ 15.247 (d)		
Band Edge Compliance Radiated			
The measurement was performed according to ANSI C63.10		**Final Result**	
OP-Mode	**Setup**	**FCC**	**IC**
Radio Technology, Operating Frequency, Band Edge			
Bluetooth LE, high, high	DE1221004af02	Passed	Passed
WLAN b, high, high	DE1221004af02	Passed	Passed
WLAN g, high, high	DE1221004aj02	Passed	Passed
WLAN n 20 MHz, high, high	DE1221004aj02	Passed	Passed
WLAN n 40 MHz, high, high	DE1221004aj02	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 **§ 15.247 (e)**

Power Density

The measurement was performed according to ANSI C63.10

OP-Mode	**Setup**	**Final Result FCC**	**IC**
Radio Technology, Operating Frequency			
Bluetooth LE, high	S01_ac02	Passed	Passed
Bluetooth LE, low	S01_ac02	Passed	Passed
Bluetooth LE, mid	S01_ac02	Passed	Passed
WLAN b, high	S01_ak02	Passed	Passed
WLAN b, low	S01_ak02	Passed	Passed
WLAN b, mid	S01_ak02	Passed	Passed
WLAN g, high	S01_ak02	Passed	Passed
WLAN g, low	S01_ak02	Passed	Passed
WLAN g, mid	S01_ak02	Passed	Passed
WLAN n 20 MHz, high	S01_ak02	Passed	Passed
WLAN n 20 MHz, low	S01_ak02	Passed	Passed
WLAN n 20 MHz, mid	S01_ak02	Passed	Passed
WLAN n 40 MHz, high	S01_ak02	Passed	Passed
WLAN n 40 MHz, low	S01_ak02	Passed	Passed
WLAN n 40 MHz, mid	S01_ak02	Passed	Passed

(responsible for accreditation scope)
Dipl.-Ing. Marco Kullik

(responsible for testing and report)
Dipl.-Ing. Andreas Petz

7 layers GmbH, Borsigstr. 11
40880 Ratingen, Germany
Phone +49 (0)2102 749 0

2 ADMINISTRATIVE DATA

2.1 TESTING LABORATORY

Company Name:	7layers GmbH
Address:	Borsigstr. 11 40880 Ratingen Germany

This facility has been fully described in a report submitted to the FCC and accepted under the registration number 96716.

This facility has been fully described in a report submitted to the IC and accepted under the registration number: Site# 3699A-1.

The test facility is also accredited by the following accreditation organisation:

Laboratory accreditation no:	DAkkS D-PL-12140-01-00
Responsible for accreditation scope:	Dipl.-Ing. Marco Kullik
Report Template Version:	2017-07-14

2.2 PROJECT DATA

Responsible for testing and report:	Dipl.-Ing. Andreas Petz
Employees who performed the tests:	documented internally at 7Layers
Date of Report:	2017-09-28
Testing Period:	2017-01-11 to 2017-09-06

2.3 APPLICANT DATA

Company Name:	Trimble Inc.
Address:	935 Stewart Drive Sunnyvale, CA 94085 USA
Contact Person:	Mr. Eric Wilson

2.4 MANUFACTURER DATA

Company Name:	See Applicant

3 TEST OBJECT DATA

3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	Telematic device
Product name	SNM941
Type	SNM941-90
Declared EUT data by the supplier	
Voltage Type	DC
Voltage Level	Nominal 24 V DC, range: 7–32 V
General product description	Telematic device with built-in Wifi, Bluetooth, Bluetooth Low Energy, GPS and cellular technology.
Specific product description for the EUT	The EUT is a communication unit incl. telematics capabilities with a real-time, two-way data communication link and can be integrated in a fleet and asset management system also provided by the applicant.
The EUT provides the following ports:	4 permanent 50 Ohm connectors for external antenna Automotive style multi-pin connector (it comprises USB, RS232, CAN, etc., Digital I/O, Analogue I/O, LAN / Ethernet, DC.)
Tested data-rates / Modulations	BT LE: GFSK, 1 Mbps, 5 dBm WLAN: mode b: DSSS, BPSK, 1 Mbps, 14 / 17 dBm mode g: BPSK, 6 Mbps, 15 dBm mode n 20 MHz: MCS0, OFDM-BPSK, 6.5 Mbps, 14 dBm mode n 40 MHz: MCS0, OFDM-BPSK, 13.5 Mbps, 14 dBm Notes: Values in dBm is the set nominal output power. *) 14 dBm set for radiated tests, “peak power output” and “spectral density”, 17 dBm for remaining conducted tests.
Special software used for testing	LabTool (running on auxiliary laptop) – Used to set the radio into “Testmode”.

The main components of the EUT are listed and described in chapter 3.2 EUT Main components.

3.2 EUT MAIN COMPONENTS

Sample Name	Sample Code	Description
US Variant	DE1221004AB01	Standard sample
Sample Parameter	**Value**	
Serial No.	5644F0024	
HW Version	REV C	
SW Version	Alpha 0.0.8	
Comment		

Sample Name	Sample Code	Description
US Variant	DE1221004AF02	Standard sample
Sample Parameter	**Value**	
Serial No.	5719F00039	
HW Version	REV D	
SW Version	Beta 1.0.6	
Comment		

Sample Name	Sample Code	Description
US Variant	DE1221004AJ02	Standard sample
Sample Parameter	**Value**	
Serial No.	5719F00024	
HW Version	REV D	
SW Version	Beta 1.0.6	
Comment		

Sample Name	Sample Code	Description
US Variant	DE1221004AK02	Standard sample
Sample Parameter	**Value**	
Serial No.	5719F00018	
HW Version	REV D	
SW Version	Beta 1.0.6	
Comment		

Sample Name	Sample Code	Description
US Variant	DE1221004AC02	Standard sample
Sample Parameter	**Value**	
Serial No.	5719f00041	
HW Version	REV D	
SW Version	Beta 1.0.6	
Comment		

NOTE: The short description is used to simplify the identification of the EUT in this test report.

3.3 ANCILLARY EQUIPMENT

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

Device	**Details (Manufacturer, Type Model, OUT Code)**	**Description**
External Combi-Antenna	PulseLARSEN Antennas, GPSLPMB403, TPN 112057 Rev A, DE122100ANT	Ext. antenna for cellular, WLAN, BT and GNSS technologies. Max. antenna gain in the relevant frequency range: 4.5 dBi.

3.4 AUXILIARY EQUIPMENT

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it.
But nevertheless Auxiliary Equipment can influence the test results.

Device	**Details (Manufacturer, HW, SW, S/N)**	**Description**
Cable Harness	Trimble, 81533, Rev 07, –, –	Short Test Harness
Laptop	Dell Latitude D830, REV A02, Windows7 Engl., CN-0HN338-48643-88R-1522	Laptop used to control the devices

3.5 EUT SETUPS

This chapter describes the combination of EUTs and equipment used for testing. The rationale for selecting the EUTs, ancillary and auxiliary equipment and interconnecting cables, is to test a representative configuration meeting the requirements of the referenced standards.

Setup	Combination of EUTs	Description and Rationale
DE1221004aj02	US Variant Standard sample, Laptop, External Combi-Antenna, Cable Harness	Sample DE1221004AJ02 with ancillary and auxiliary equipment, used for radiated tests
S01_ac02	US Variant Standard sample, Laptop, Cable Harness,	Sample DE1221004AC02 with auxiliary equipment, used for conducted tests
DE1221004af02	US Variant Standard sample, Laptop, External Combi-Antenna, Cable Harness	Sample DE1221004AF02 with ancillary and auxiliary equipment, used for radiated tests
S01_ab01	US Variant Standard sample, Laptop, Cable Harness	Sample DE1221004AB01 with auxiliary equipment, used for conducted tests
S01_ak02	US Variant Standard sample, Laptop, Cable Harness	Sample DE1221004AK02 with auxiliary equipment, used for conducted tests

3.6 TEST CHANNELS

WLAN	2.4 GHz ISM 2400 - 2483.5 MHz		
20 MHz Test Channels:	low	mid	high
Channel:	1	6	11
Frequency [MHz]	2412	2437	2462

40 MHz Test Channels:	low	mid	high
Channel:	3	6	11
Frequency [MHz]	2422	2437	2462

BT LE Test Channels:	low	mid	high
Channel:	0	19	39
Frequency [MHz]	2402	2440	2480

3.7 PRODUCT LABELLING, FCC ID LABEL, LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

4 TEST RESULTS

4.1 OCCUPIED BANDWIDTH (6 DB)

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.1.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up 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 produce the worst-case (smallest) emission bandwidth.

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

Analyzer settings:

- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Span: BTLE: 3 MHz, WLAN: 30 / 50 MHz (for 20 / 40 MHz nominal bandwidth)
- Trace: Maxhold
- Sweeps: 2000
- Sweeptime: coupled (see measurement plot)
- Detector: Peak

4.1.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.247 (a) (2)
Systems using digital modulation techniques may operate in the 902-928 MHz and 2400-2483.5 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

4.1.3 TEST PROTOCOL

Ambient temperature: 22 °C
Air Pressure: 1012 hPa
Humidity: 43 %

BT LE GFSK

Band	Channel No.	Frequency [MHz]	6 dB Bandwidth [MHz]	Limit [MHz]	Margin to Limit [MHz]
2.4 GHz ISM	0	2402	0.709	0.5	0.209
	19	2440	0.709	0.5	0.209
	39	2480	0.709	0.5	0.209

WLAN b-Mode; 20 MHz

Band	Channel No.	Frequency [MHz]	6 dB Bandwidth [MHz]	Limit [MHz]	Margin to Limit [MHz]
2.4 GHz ISM	1	2412	10.2	0.5	9.7
	6	2437	10.1	0.5	9.6
	11	2462	10.1	0.5	9.6

WLAN g-Mode; 20 MHz

Band	Channel No.	Frequency [MHz]	6 dB Bandwidth [MHz]	Limit [MHz]	Margin to Limit [MHz]
2.4 GHz ISM	1	2412	16.6	0.5	16.1
	6	2437	16.7	0.5	16.2
	11	2462	16.6	0.5	16.1

WLAN n-Mode; 20 MHz

Band	Channel No.	Frequency [MHz]	6 dB Bandwidth [MHz]	Limit [MHz]	Margin to Limit [MHz]
2.4 GHz ISM	1	2412	17.8	0.5	17.3
	6	2437	17.9	0.5	17.4
	11	2462	17.8	0.5	17.3

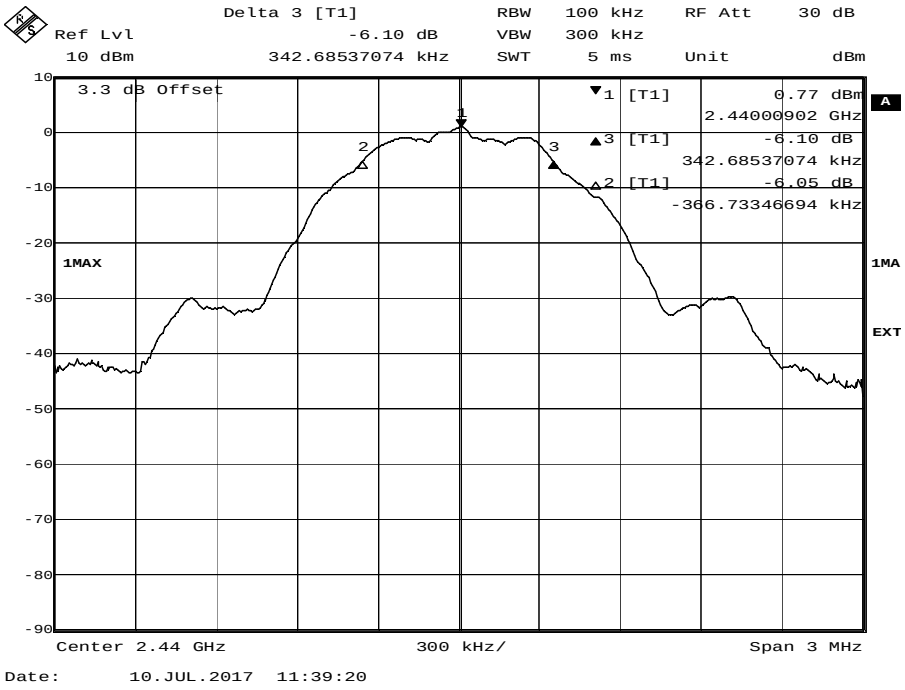
WLAN n-Mode; 40 MHz

Band	Channel No.	Frequency [MHz]	6 dB Bandwidth [MHz]	Limit [MHz]	Margin to Limit [MHz]
2.4 GHz ISM	3	2422	36.7	0.5	36.2
	6	2437	36.7	0.5	36.2
	11	2462	36.6	0.5	36.1

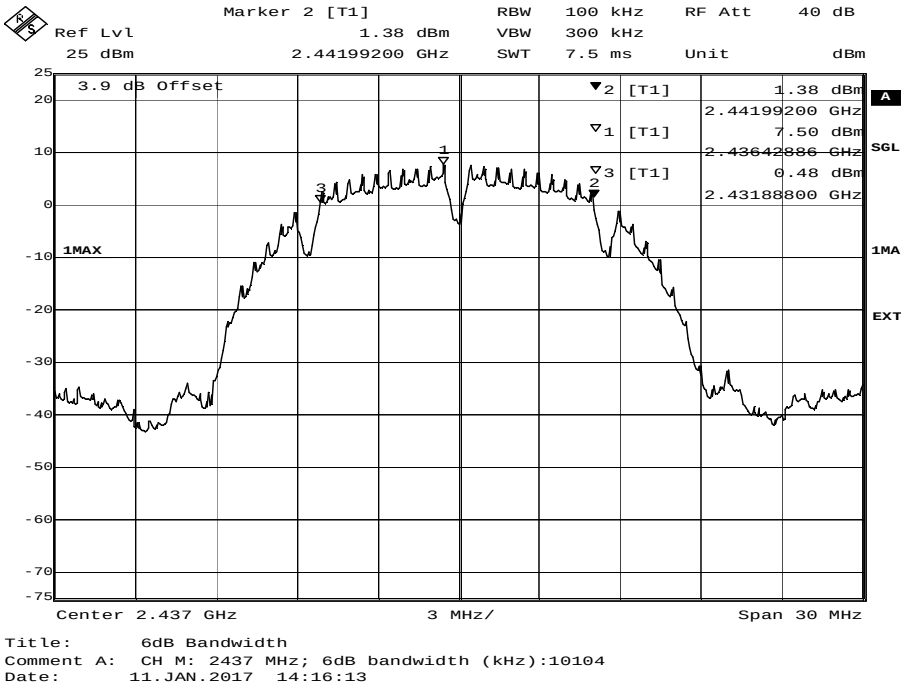
Remark: Please see next sub-clause for the measurement plot.

4.1.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

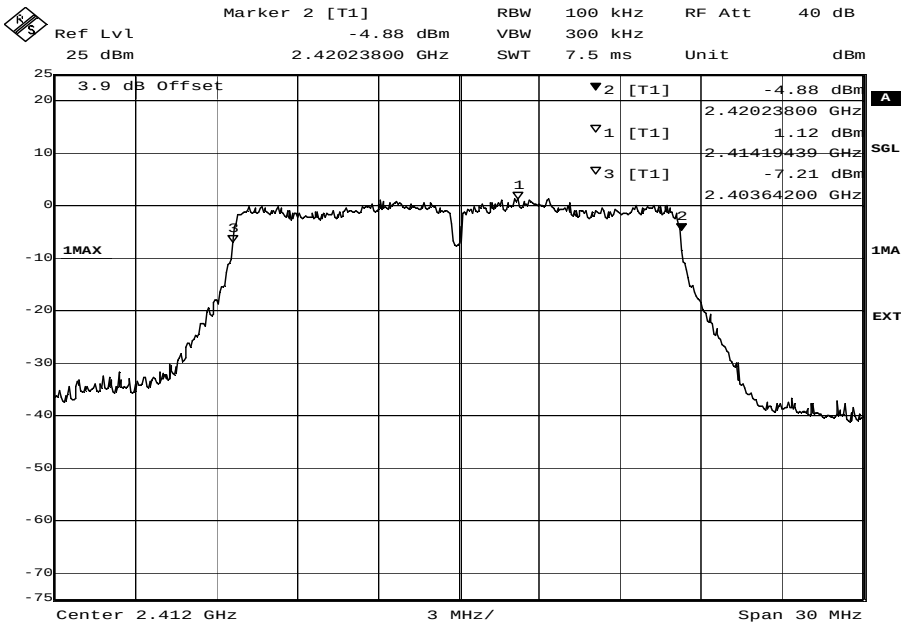
Radio Technology = Bluetooth LE, Operating Frequency = mid (S01_ac02)



Radio Technology = WLAN b, Operating Frequency = mid (S01_ab01)

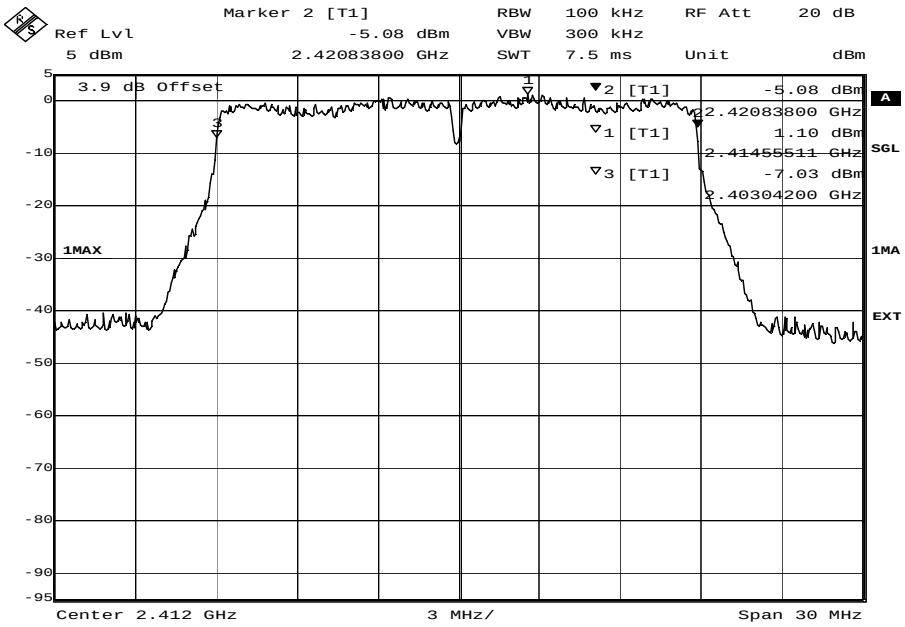


Radio Technology = WLAN g, Operating Frequency = low (S01_ab01)



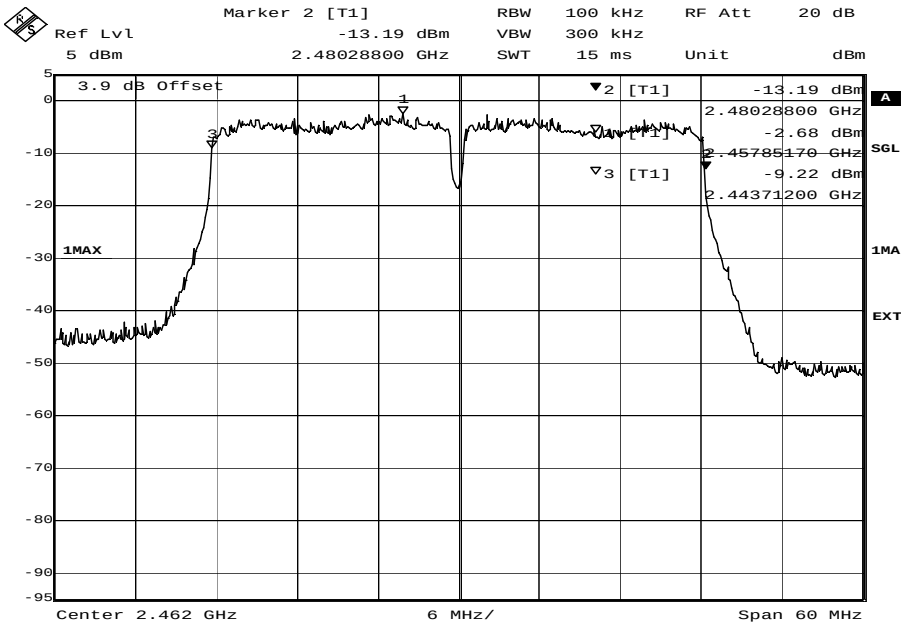
Title: 6dB Bandwidth
Comment A: CH B: 2412 MHz; 6dB bandwidth (kHz):16596
Date: 11.JAN.2017 15:40:36

Radio Technology = WLAN n 20 MHz, Operating Frequency = low (S01_ab01)



Title: 6dB Bandwidth
Comment A: CH B: 2412 MHz; 6dB bandwidth (kHz):17796
Date: 12.JAN.2017 08:53:43

Radio Technology = WLAN n 40 MHz, Operating Frequency = high (S01_ab01)



4.1.5 TEST EQUIPMENT USED

- Regulatory Bluetooth RF Test Solution

4.2 OCCUPIED BANDWIDTH (99%)

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.2.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up 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 EUT was connected to spectrum analyzer via a short coax cable with a known loss.
Analyzer settings:

- Resolution Bandwidth (RBW): BTLE: 30 kHz, WLAN: 500 kHz
- Video Bandwidth (VBW): BTLE: 300 kHz, WLAN: 2 MHz
- Span: BTLE: 3 MHz, WLAN: 30 / 50 MHz (for 20 / 40 MHz nominal bandwidth)
- Trace: Maxhold
- Sweeps: 2000
- Sweeptime: coupled (see measurement plot)
- Detector: Sample

The 99 % measurement function of the spectrum analyser function was used to determine the 99 % bandwidth.

4.2.2 TEST REQUIREMENTS / LIMITS

No applicable limit.

4.2.3 TEST PROTOCOL

Ambient temperature: 22 °C
Air Pressure: 1012 hPa
Humidity: 43 %

BT LE

Band	Channel No.	Frequency [MHz]	99 % Bandwidth [MHz]
2.4 GHz ISM	0	2402	1.040
	19	2440	1.046
	39	2480	1.046

WLAN b-Mode; 20 MHz

Band	Channel No.	Frequency [MHz]	99 % Bandwidth [MHz]
2.4 GHz ISM	1	2412	13.2
	6	2437	13.3
	11	2462	13.2

WLAN g-Mode; 20 MHz

Band	Channel No.	Frequency [MHz]	99 % Bandwidth [MHz]
2.4 GHz ISM	1	2412	16.9
	6	2437	17.1
	11	2462	17.1

WLAN n-Mode; 20 MHz

Band	Channel No.	Frequency [MHz]	99 % Bandwidth [MHz]
2.4 GHz ISM	1	2412	17.9
	6	2437	17.9
	11	2462	17.8

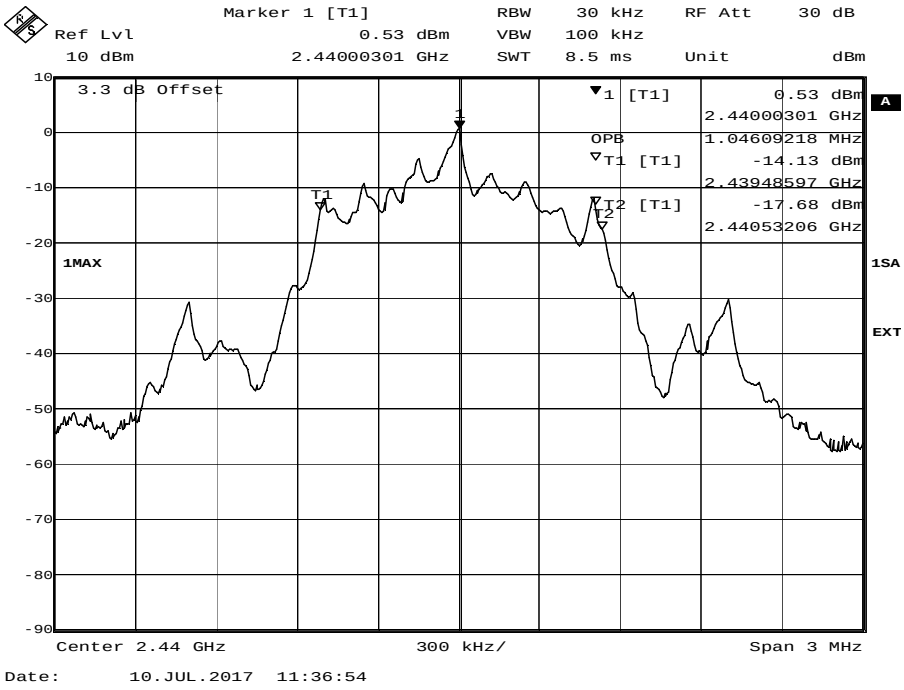
WLAN n-Mode; 40 MHz

Band	Channel No.	Frequency [MHz]	99 % Bandwidth [MHz]
2.4 GHz ISM	3	2422	36.2
	6	2437	36.2
	11	2462	36.2

Remark: Please see next sub-clause for the measurement plot.

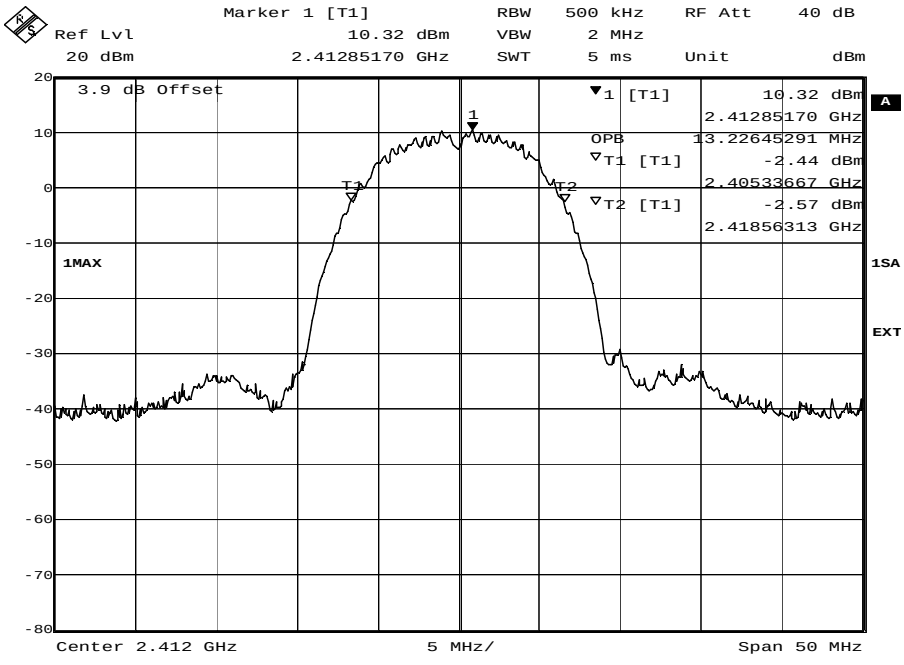
4.2.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

Radio Technology = Bluetooth LE, Operating Frequency = mid (S01_ac02)



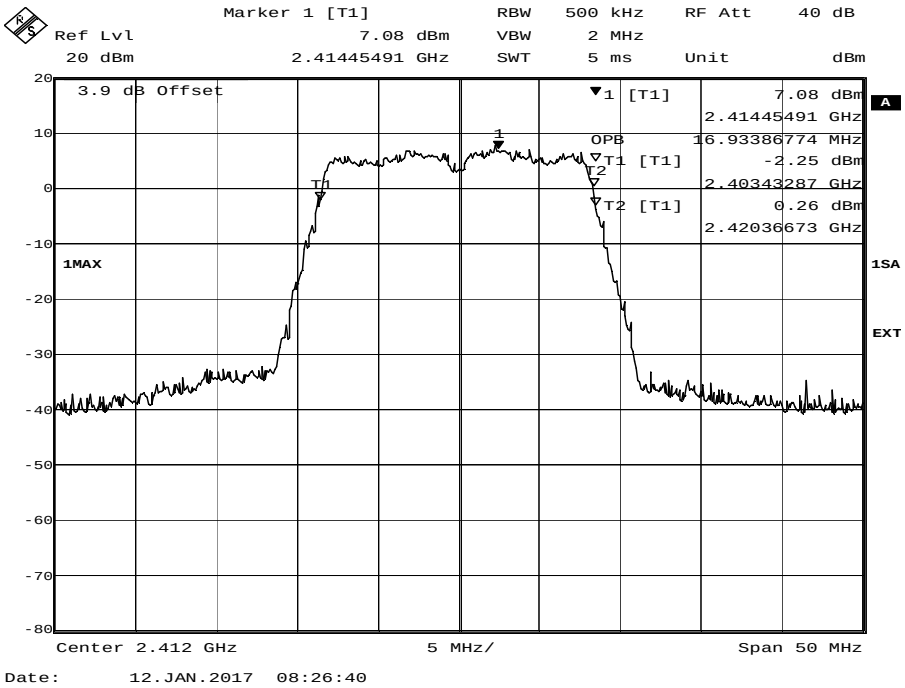
Date: 10.JUL.2017 11:36:54

Radio Technology = WLAN b, Operating Frequency = low (S01_ab01)

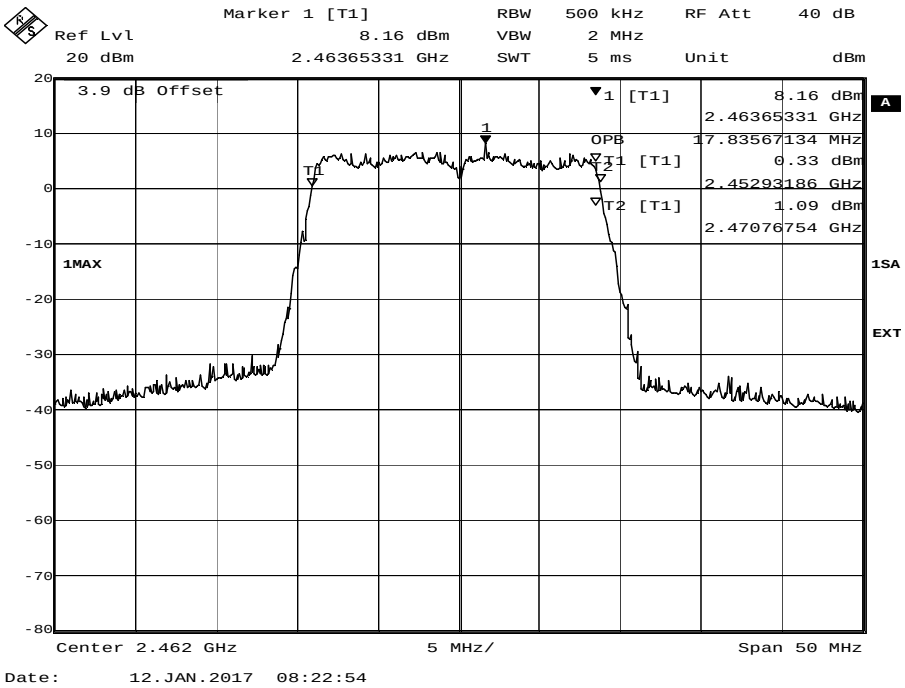


Date: 12.JAN.2017 08:30:21

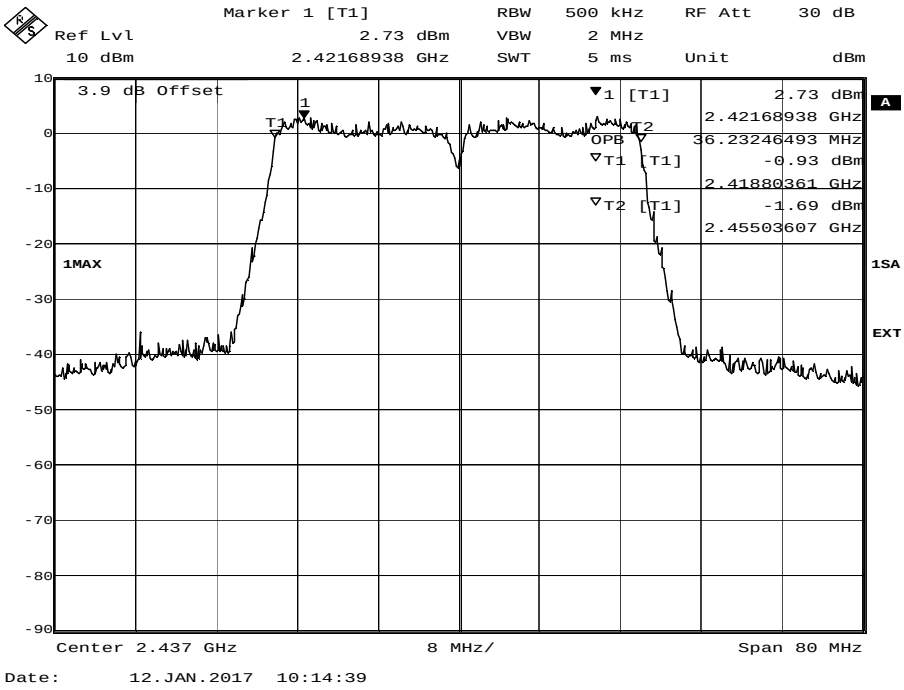
Radio Technology = WLAN g, Operating Frequency = low (S01_ab01)



Radio Technology = WLAN n 20 MHz, Operating Frequency = high (S01_ab01)



Radio Technology = WLAN n 40 MHz, Operating Frequency = mid (S01_ab01)



4.2.5 TEST EQUIPMENT USED

- Regulatory Bluetooth RF Test Solution

4.3 PEAK POWER OUTPUT

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.3.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up to perform the output power measurements. The results recorded were measured with the modulation which produces the worst-case (highest) output power. 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.

Analyzer settings:

- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Trace: Maxhold
- Sweeps: 2000
- Sweeptime: coupled (see measurement plot)
- Detector: Peak

For WLAN, the channel power function of the spectrum analyser was used (Used channel bandwidth = DTS bandwidth)

4.3.2 TEST REQUIREMENTS / LIMITS

DTS devices:
FCC Part 15, Subpart C, §15.247 (b) (3)
For systems using digital modulation techniques in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands: 1 watt.

==> Maximum conducted peak output power: 30 dBm (excluding antenna gain, if antennas with directional gains that do not exceed 6 dBi are used).

Frequency Hopping Systems:
FCC Part 15, Subpart C, §15.247 (b) (1)
For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

FCC Part 15, Subpart C, §15.247 (b) (2)
For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

Used conversion factor: Limit (dBm) = 10 log (Limit (W)/1mW)

4.3.3 TEST PROTOCOL

Ambient temperature: 22 °C
Air Pressure: 1012 hPa
Humidity: 43 %

BT LE

Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
2.4 GHz ISM	0	2402	1.9	30.0	28.2
	19	2440	1.3	30.0	28.7
	39	2480	1.6	30.0	28.4

WLAN b-Mode; 20 MHz

Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
2.4 GHz ISM	1	2412	14.7	30.0	15.3
	6	2437	14.4	30.0	15.6
	11	2462	14.6	30.0	15.4

WLAN g-Mode; 20 MHz

Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
2.4 GHz ISM	1	2412	22.4	30.0	7.6
	6	2437	22.2	30.0	7.8
	11	2462	22.4	30.0	7.6

WLAN n-Mode; 20 MHz

Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
2.4 GHz ISM	1	2412	22.1	30.0	7.9
	6	2437	22.0	30.0	8.0
	11	2462	21.8	30.0	8.2

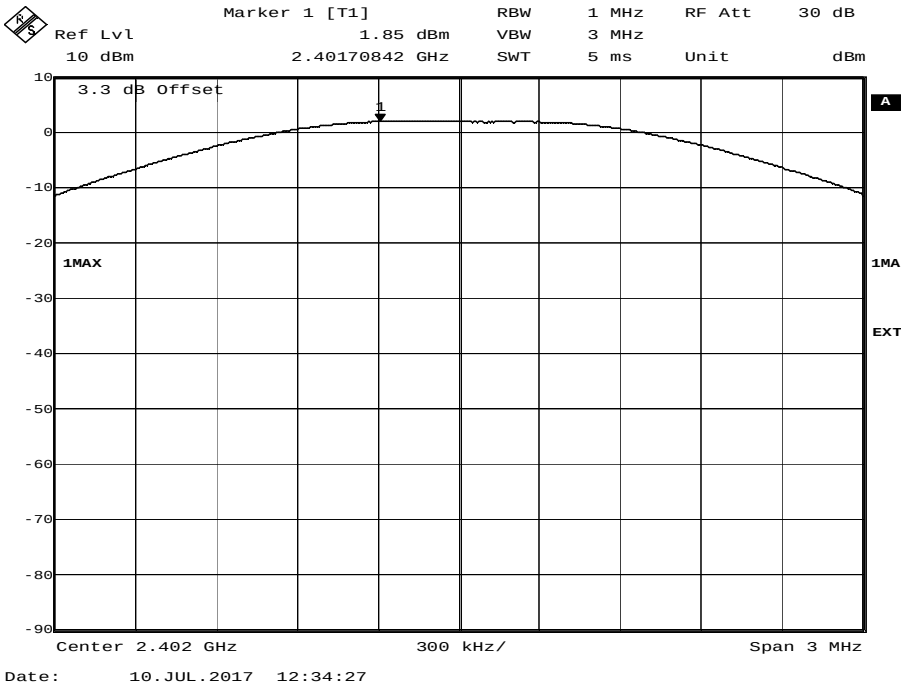
WLAN n-Mode; 40 MHz

Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
2.4 GHz ISM	3	2422	21.9	30.0	8.1
	6	2437	21.7	30.0	8.3
	11	2462	21.9	30.0	8.1

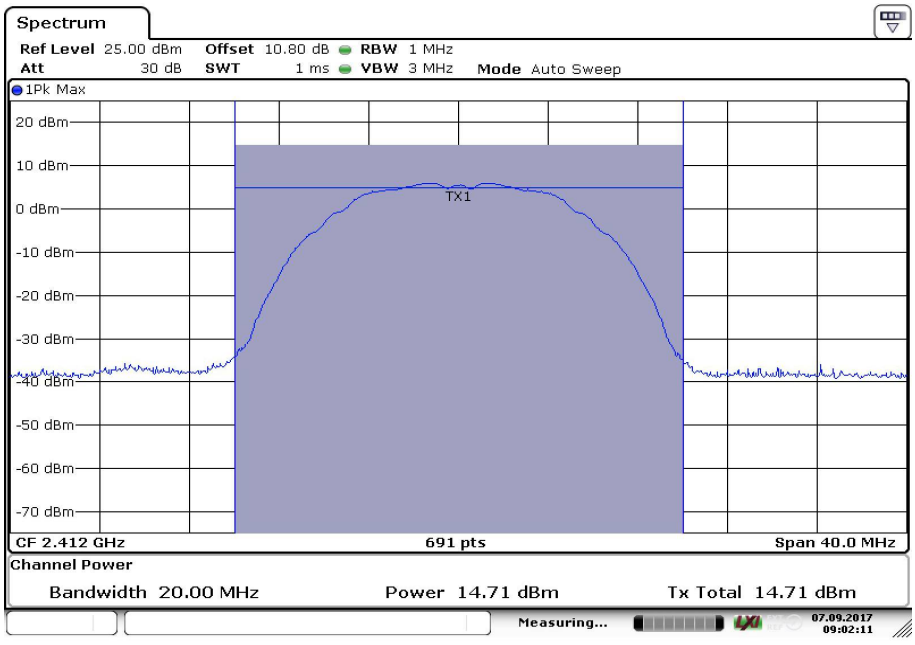
Remark: Please see next sub-clause for the measurement plot.

4.3.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

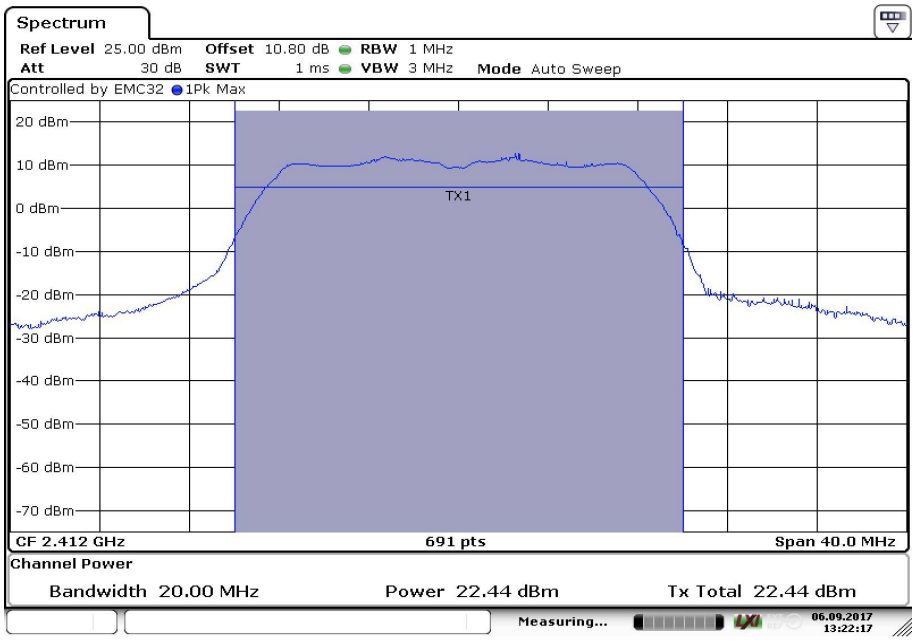
Radio Technology = Bluetooth LE, Operating Frequency = low, Measurement method = conducted (S01_ac02)



Radio Technology = WLAN b, Operating Frequency = low, Measurement method = conducted (S01_ak02)

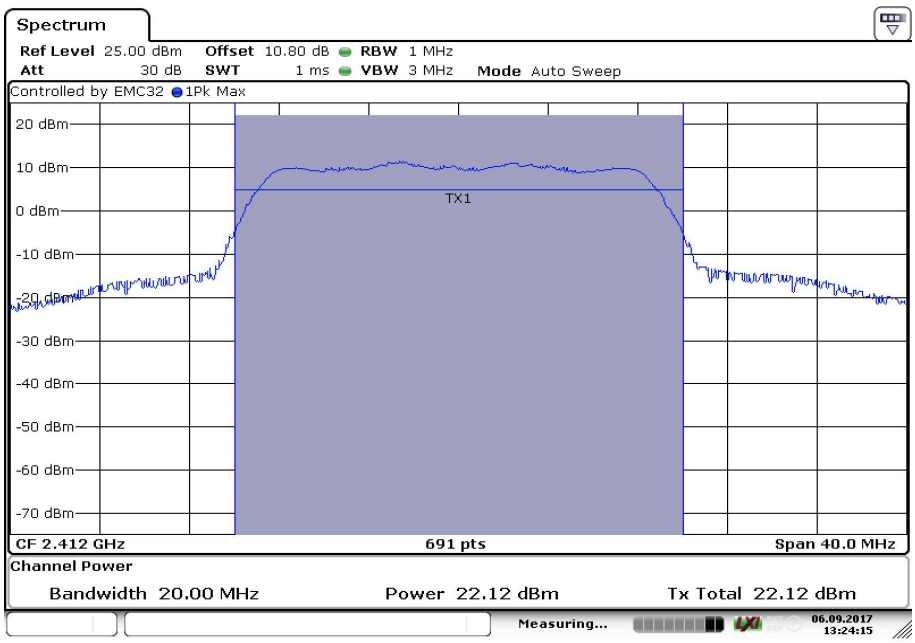


Radio Technology = WLAN g, Operating Frequency = low, Measurement method = conducted (S01_ak02)



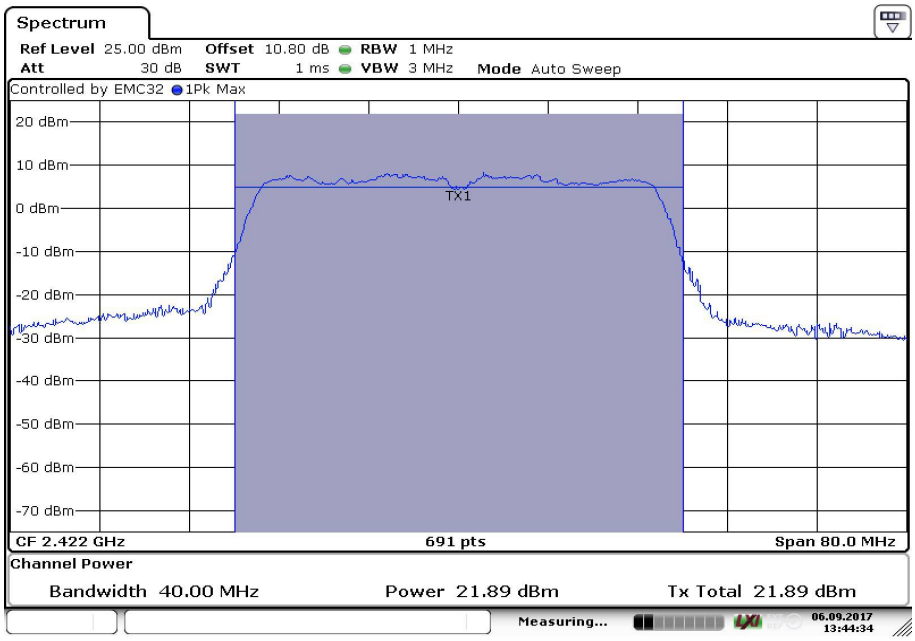
Date: 6.SEP.2017 13:22:18

Radio Technology = WLAN n 20 MHz, Operating Frequency = low, Measurement method = conducted (S01_ak02)



Date: 6.SEP.2017 13:24:15

Radio Technology = WLAN n 40 MHz, Operating Frequency = low, Measurement method = conducted (S01_ak02)



Date: 6.SEP.2017 13:44:35

4.3.5 TEST EQUIPMENT USED

- Regulatory Bluetooth RF Test Solution
- R&S TS8997

4.4 SPURIOUS RF CONDUCTED EMISSIONS

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.4.1 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:

- Frequency range: 30 – 25000 MHz
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Trace: Maxhold
- Sweeps: 2
- Sweep Time: 330 s
- Detector: Peak

The reference value for the measurement of the spurious RF conducted emissions is determined during the test “band edge compliance conducted”. This value is used to calculate the 20 dBc limit.

4.4.2 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, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

4.4.3 TEST PROTOCOL

Ambient temperature: 22 °C
Air Pressure: 1012 hPa
Humidity: 43 %

BT LE GFSK

Channel No	Channel Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
0	2402	4783.8	-53.2	PEAK	100	1.5	-18.5	34.7
19	2440	4883.8	-53.6	PEAK	100	0.9	-19.2	34.4
39	2480	3282.6	-54.7	PEAK	100	1.3	-18.7	36.0

WLAN b-Mode; 20 MHz

Channel No	Channel Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
1	2412	4783.8	-35.0	PEAK	100	8.9	-11.1	23.9
6	2437	4833.8	-34.5	PEAK	100	7.2	-12.8	21.7
11	2462	4883.9	-34.7	PEAK	100	8.0	-12.0	22.7

WLAN g-Mode; 20 MHz

Channel No	Channel Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
1	2412	6635.3	-35.7	PEAK	100	0.8	-19.2	16.5
6	2437	4833.8	-49.4	PEAK	100	0.0	-20.0	29.4
11	2462	4883.9	-49.5	PEAK	100	0.6	-19.5	30.1

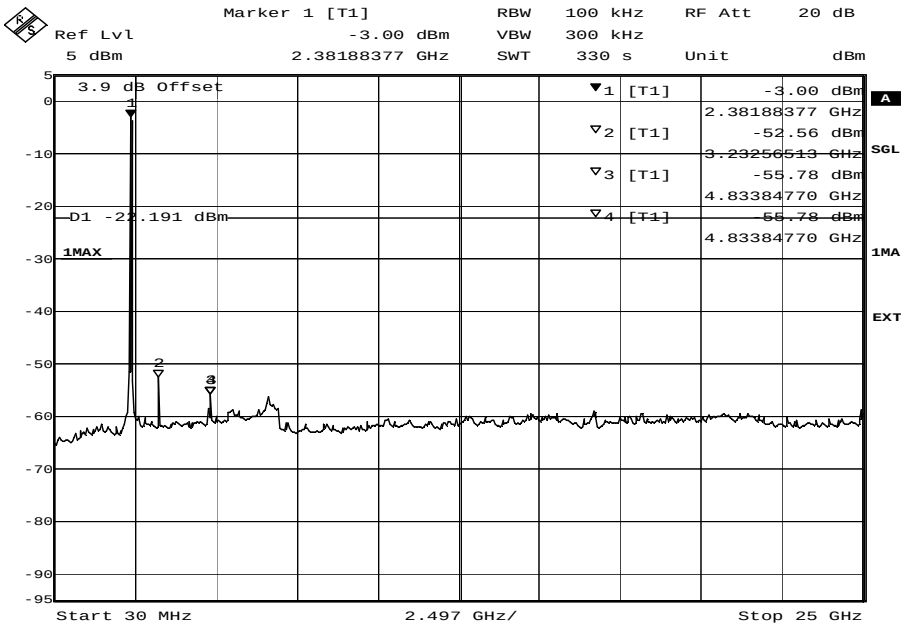
WLAN n-Mode; 20 MHz

Channel No	Channel Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
1	2412	4783.8	-52.6	PEAK	100	0.7	-19.3	33.3
6	2437	4833.8	-52.3	PEAK	100	-0.5	-20.5	31.9
11	2462	4883.9	-52.5	PEAK	100	0.4	-19.6	32.9

Remark: Please see next sub-clause for the measurement plot.

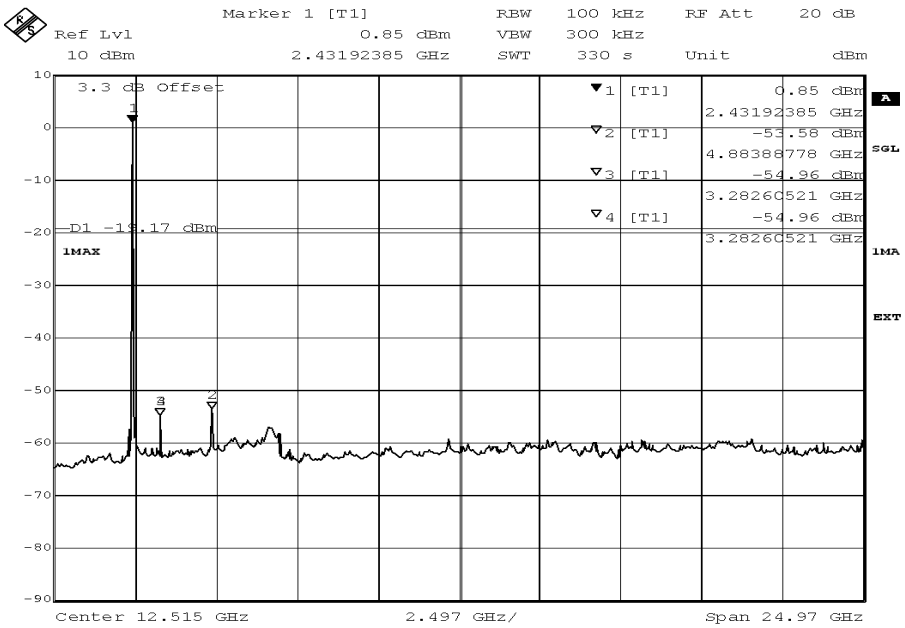
4.4.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

Radio Technology = WLAN n 40 MHz, Operating Frequency = low (S01_ab01)



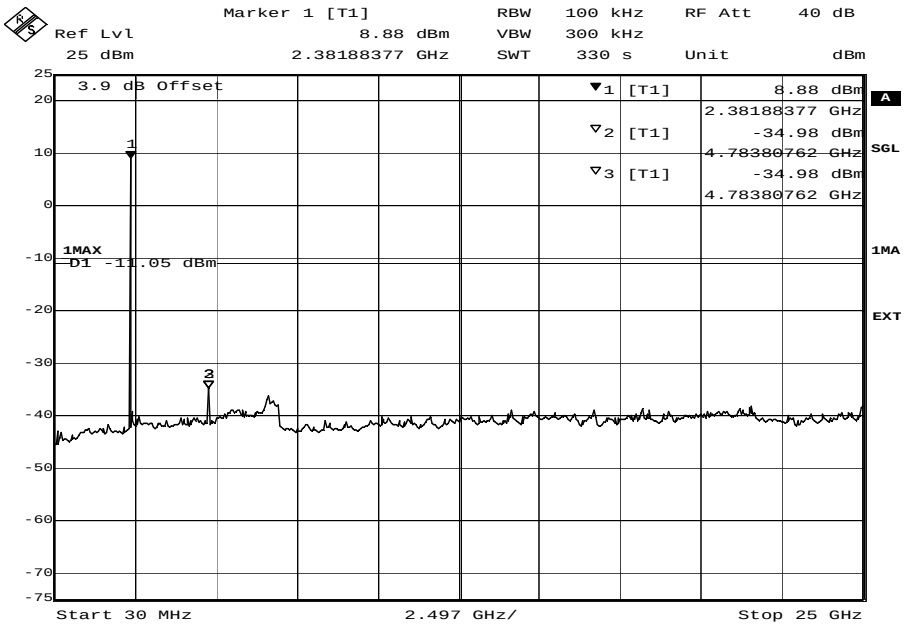
Title: spurious emissions
Comment A: CH B: 2412 MHz
Date: 12.JAN.2017 12:31:11

Radio Technology = Bluetooth LE, Operating Frequency = mid (S01_ac02)



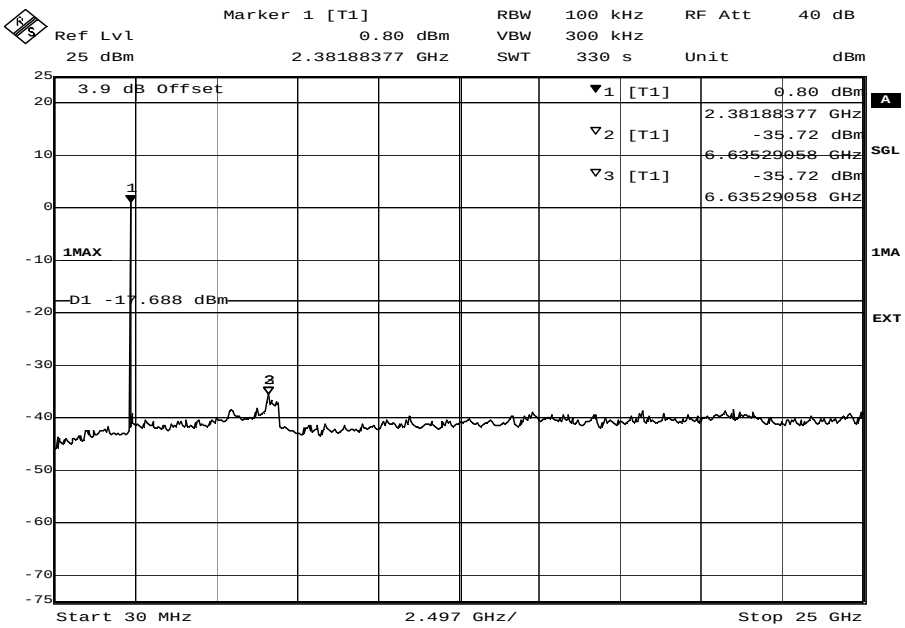
Title: spurious emissions
Comment A: CH M2: 2440 MHz
Date: 10.JUL.2017 10:56:54

Radio Technology = WLAN b, Operating Frequency = low (S01_ab01)



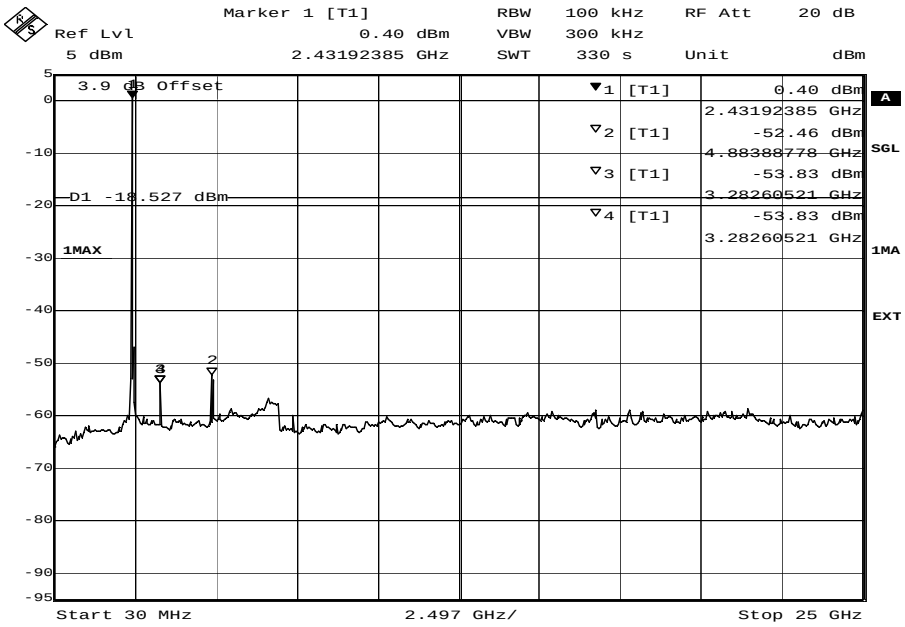
Title: spurious emissions
Comment A: CH B: 2412 MHz
Date: 11.JAN.2017 13:51:05

Radio Technology = WLAN g, Operating Frequency = low (S01_ab01)



Title: spurious emissions
Comment A: CH B: 2412 MHz
Date: 11.JAN.2017 15:38:43

Radio Technology = WLAN n 20 MHz, Operating Frequency = high (S01_ab01)



4.4.5 TEST EQUIPMENT USED

- Regulatory Bluetooth RF Test Solution

4.5 TRANSMITTER SPURIOUS RADIATED EMISSIONS

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.5.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m² 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 EMC32 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 also performed at 3 axes.
A pre-check is performed while the EUT is powered from a DC power source.

1. Measurement up to 30 MHz
The Loop antenna HFH2-Z2 is used.

Step 1: pre measurement
- Anechoic chamber
- Antenna distance: 3 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

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: 0.2 - 10 kHz
- Measuring time / Frequency step: 1 s

2. Measurement above 30 MHz and up to 1 GHz

Step 1: Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:
- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF–Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms

- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- 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: Adjustment 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 slowly vary by ± 45° 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 will also slowly vary by ± 100 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: ± 45 ° around the determined value
- Height variation range: ± 100 cm around the determined value
- Antenna Polarisation: max. value determined in step 1

Step 3: 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

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.

3. Measurement above 1 GHz

The following modifications apply to the measurement procedure for the frequency range above 1 GHz:

Step 1:

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

All steps were performed with one height (1.5 m) of the receiving antenna only.

The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90 °.

The turn table step size (azimuth angle) for the preliminary measurement is 45 °.

Step 2:

Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna instep 2 is omitted. Instead of this, a maximum search with a step size ± 45° for the elevation axis is performed.

The turn table azimuth will slowly vary by ± 22.5°.

The elevation angle will slowly vary by ± 45°

EMI receiver settings (for all steps):

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

Step 3:

Spectrum analyser settings for step 3:
- Detector: Peak / Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 1 s

4.5.2 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 in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
0.009 – 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 – 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 – 30	30@30m	3	29.5@30m

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 – 88	100@3m	3	40.0@3m
88 – 216	150@3m	3	43.5@3m
216 – 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m

The measured values above 26 GHz are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

§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: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

4.5.3 TEST PROTOCOL

Ambient temperature: 25-26 °C
Air Pressure: 1006 - 1010 hPa
Humidity: 42 - 43 %
BT low Energy
Applied duty cycle correction (AV): 0 dB

Ch. No.	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
39	2480	2486.5	59.6	PEAK	1000	74.0	14.4	RB
39	2480	2486.5	40.5	AV	1000	54.0	13.5	RB
0	2402	163.5	26.6	QP	120	43.5	16.9	RB
39	2480	164.7	31.7	QP	120	43.5	11.8	RB
39	2480	251.4	19.8	QP	120	46.0	26.2	RB
19	2440	163.5	30.5	QP	120	43.5	13.0	RB

Ambient temperature: 25 - 27 °C
Air Pressure: 1006 - 1010 hPa
Humidity: 39 - 46 %
WLAN b-Mode; 20 MHz
Applied duty cycle correction (AV): 0 dB

Ch. No.	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
1	2412	4823.7	56.6	PEAK	1000	74.0	17.4	RB
1	2412	4823.9	52.7	AV	1000	54.0	1.3	RB
6	2437	4873.9	55.9	PEAK	1000	74.0	18.1	RB
6	2437	4873.9	51.6	AV	1000	54.0	2.4	RB
11	2462	2696.5	50.6	PEAK	1000	74.0	23.4	RB
11	2462	2696.5	37.4	AV	1000	54.0	16.6	RB
11	2462	4924.0	57.9	PEAK	1000	74.0	16.1	RB
11	2462	4923.8	53.8	AV	1000	54.0	0.2	RB
1	2412	164.7	33.6	QP	120	43.5	9.9	RB
6	2437	164.7	34.7	QP	120	43.5	8.8	RB
6	2437	241.7	31.2	QP	120	46.0	14.8	RB
11	2462	164.4	30.9	QP	120	43.5	12.6	RB

WLAN g-Mode; 20 MHz
Applied duty cycle correction (AV): 0 dB

Ch. No.	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
1	2412	2389.5	42.4	AV	1000	54.0	11.6	RB
1	2412	2389.5	60.3	PEAK	1000	74.0	13.7	RB
1	2412	4824.7	43.3	AV	1000	54.0	10.7	RB
1	2412	4824.8	57.6	PEAK	1000	74.0	16.4	RB
6	2437	- - -	- - -	- - -	- - -	- - -	- - -	- - -
11	2462	- - -	- - -	- - -	- - -	- - -	- - -	- - -

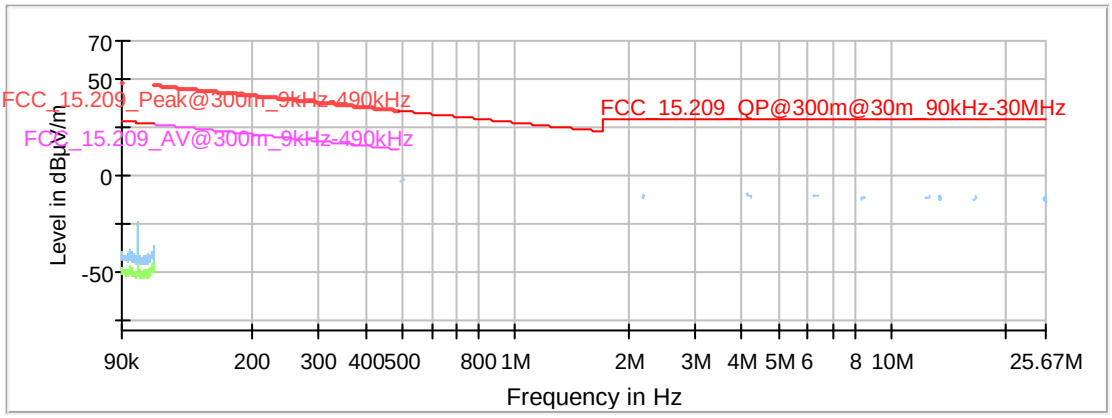
WLAN n-Mode; 20 MHz
Applied duty cycle correction (AV): 0 dB

Ch. No.	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
1	2412	2389.4	45.3	AV	1000	54.0	8.7	RB
1	2412	2389.7	62.7	PEAK	1000	74.0	11.3	RB
1	2412	2896.6	54.5	PEAK	1000	74.0	19.6	RB
1	2412	2896.6	41.2	AV	1000	54.0	12.8	RB
6	2437	- - -	- - -	- - -	- - -	- - -	- - -	- - -
11	2462	- - -	- - -	- - -	- - -	- - -	- - -	- - -

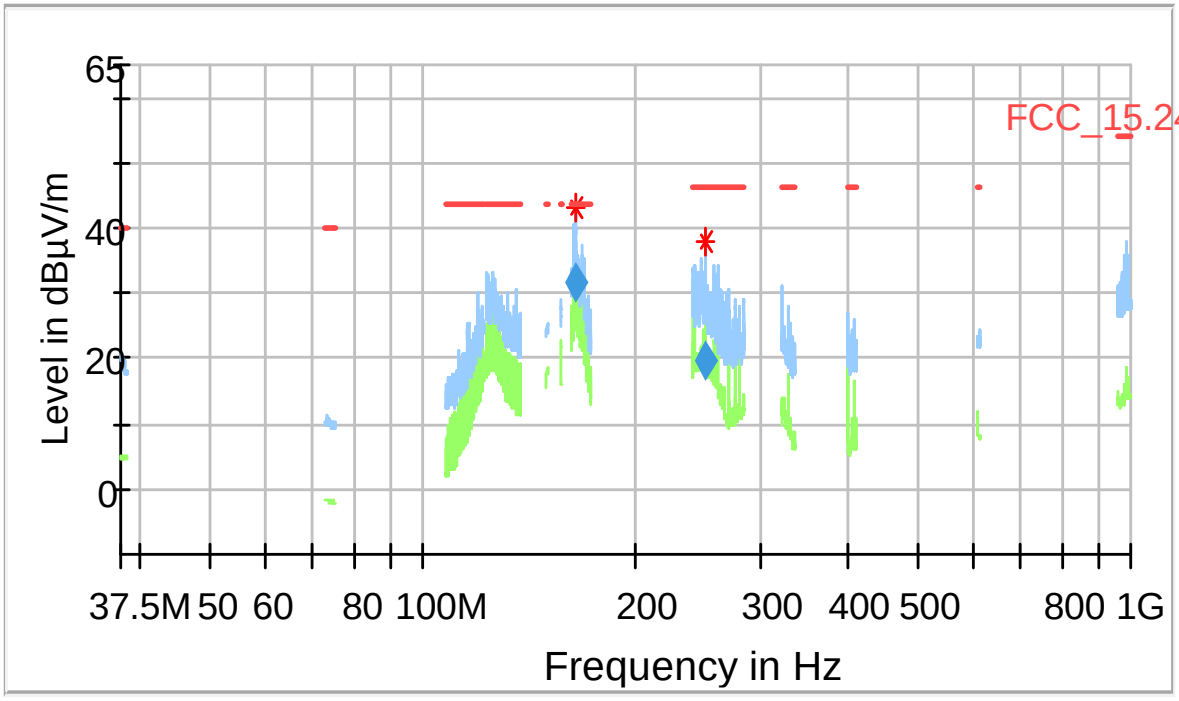
Remark: Please see next sub-clause for the measurement plot.

4.5.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

Radio Technology = WLAN b, Operating Frequency = mid, Measurement range = 9 kHz - 30 MHz (DE1221004af02)

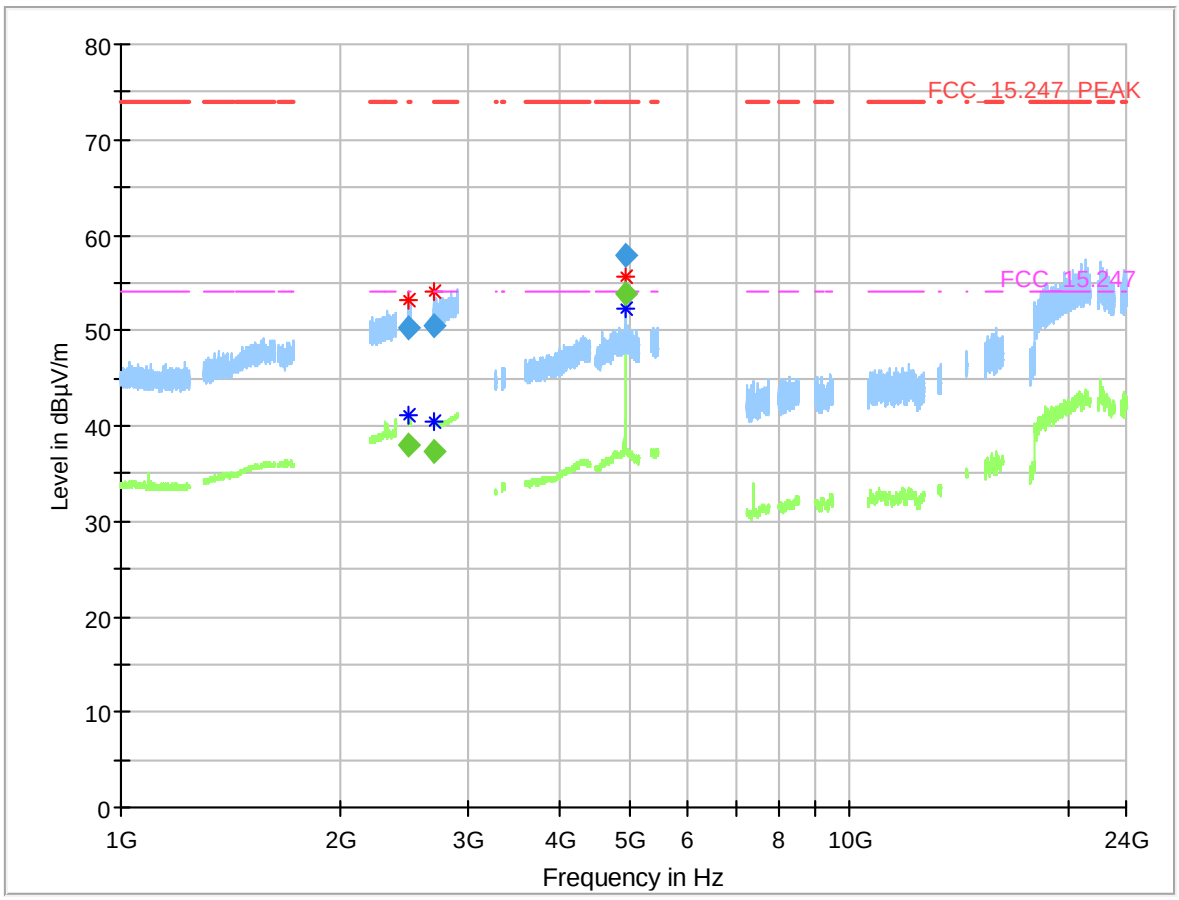


Radio Technology = Bluetooth LE, Operating Frequency = high, Measurement range = 30 MHz - 1 GHz (DE1221004af02)



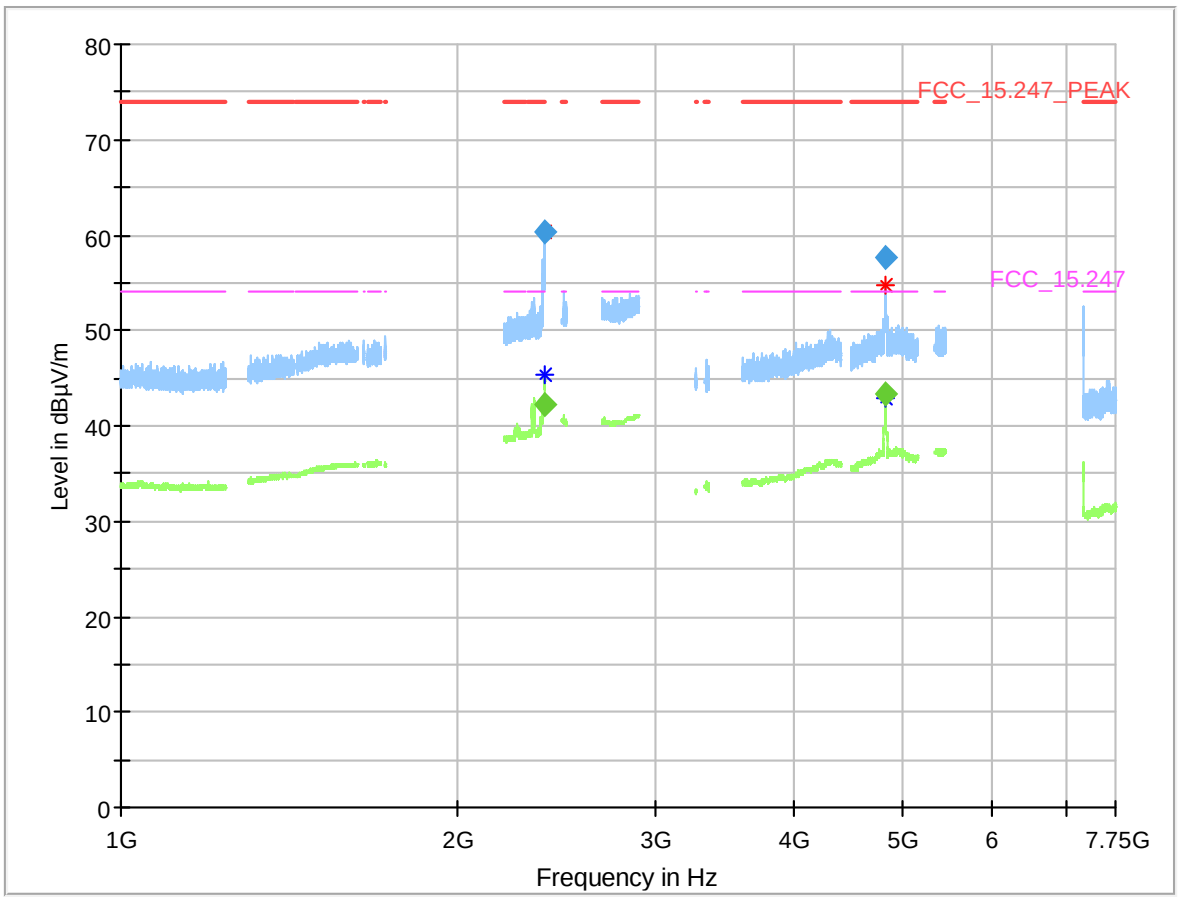
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
164.682500	31.72	43.50	11.78	1000.0	120.000	264.0	H	91.0	9.1
251.430000	19.79	46.00	26.21	1000.0	120.000	108.0	H	26.0	11.7

Radio Technology = WLAN b, Operating Frequency = high, Measurement range = 1 GHz - 26 GHz (DE1221004af02)



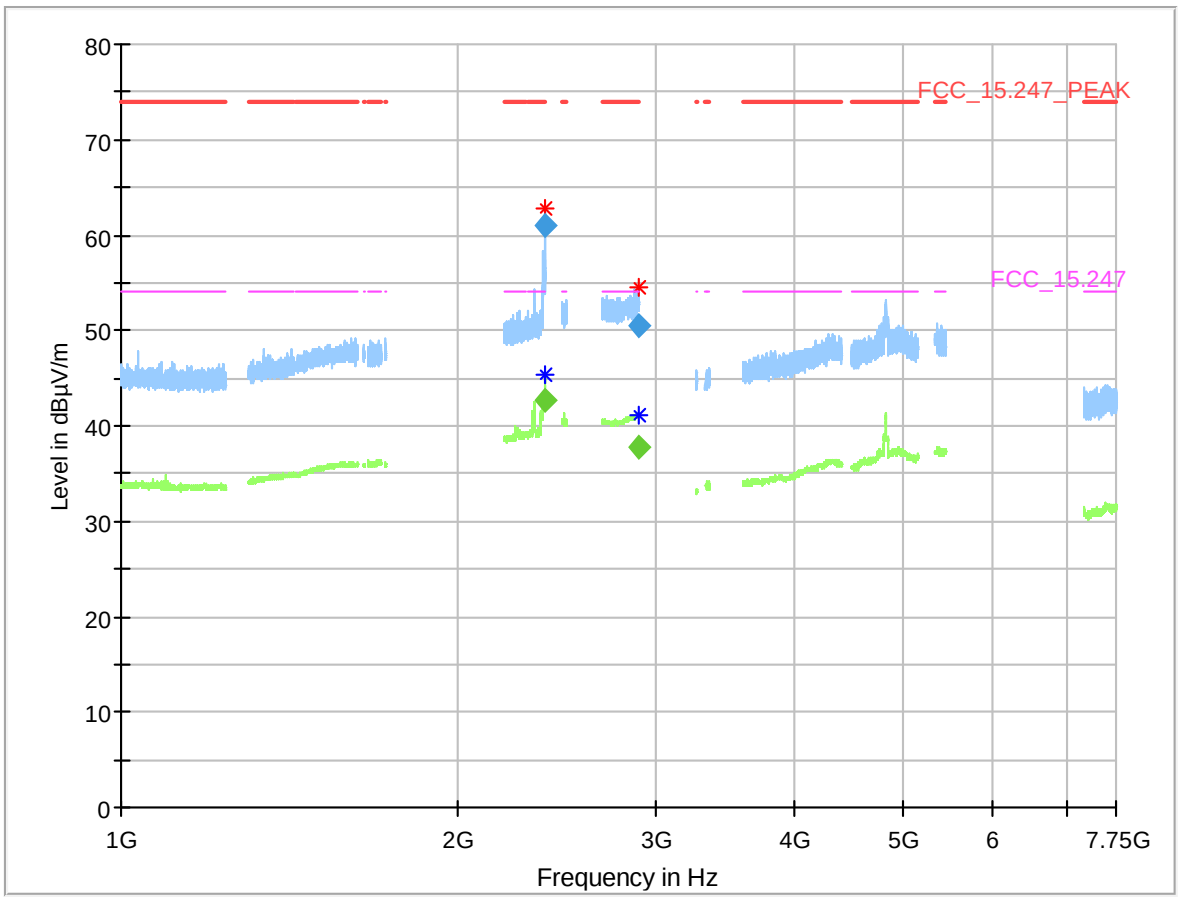
Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
2483.747500	50.21	---	74.00	23.79	1000.0	1000.000	150.0	V	113.0	-4.3
2483.830000	---	37.98	54.00	16.02	1000.0	1000.000	150.0	H	26.0	74.8
2696.510000	---	37.35	54.00	16.65	1000.0	1000.000	150.0	H	-79.0	94.8
2696.510000	50.58	---	74.00	23.42	1000.0	1000.000	150.0	H	-191.0	74.9
4923.800000	---	53.76	54.00	0.24	1000.0	1000.000	150.0	H	-24.0	-11.9
4923.962500	57.91	---	74.00	16.09	1000.0	1000.000	150.0	H	-21.0	-11.9

Radio Technology = WLAN g, Operating Frequency = low, Measurement range = 1 GHz - 26 GHz (DE1221004aj02)



Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
2389.520000	---	42.35	54.00	11.65	1000.0	1000.000	150.0	H	-31.0	-4.0
2389.520000	60.30	---	74.00	13.70	1000.0	1000.000	150.0	H	-24.0	88.9
4824.675000	---	43.32	54.00	10.68	1000.0	1000.000	150.0	V	-186.0	-15.0
4824.837500	57.56	---	74.00	16.44	1000.0	1000.000	150.0	V	-186.0	-15.0

Radio Technology = WLAN n 20 MHz, Operating Frequency = low, Measurement range = 1 GHz - 26 GHz (DE1221004aj02)



Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
2389.440000	---	45.28	54.00	8.72	1000.0	1000.000	150.0	H	-41.0	93.4
2389.680000	62.70	---	74.00	11.30	1000.0	1000.000	150.0	H	-20.0	101.4
2896.640000	54.45	---	74.00	19.55	1000.0	1000.000	150.0	V	50.0	94.8
2896.640000	---	41.17	54.00	12.83	1000.0	1000.000	150.0	V	80.0	104.8

4.5.5 TEST EQUIPMENT USED

- Radiated Emissions

4.6 BAND EDGE COMPLIANCE CONDUCTED

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.6.1 TEST DESCRIPTION

For the conducted measurement, the Equipment Under Test (EUT) is placed in a shielded room. The reference power was measured in the test case “Spurious RF Conducted Emissions”. The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Lower Band Edge:
  Minimum frequency: 2397.0 MHz
  Upper Band Edge
  Maximum frequency: 2485.0 MHz
- Detector: Peak
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweeptime: 5 ms
- Sweeps: 2000
- Trace: Maxhold

4.6.2 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. ...
If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. 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 conducted measurement 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...”

4.6.3 TEST PROTOCOL

Ambient temperature: 22 °C
Air Pressure: 1012 hPa
Humidity: 43 %

BT LE GFSK

Channel No.	Channel Center Frequency [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
0	2402	2400.0	-46.2	PEAK	100	1.5	-18.5	27.7
39	2480	2483.5	-52.2	PEAK	100	1.4	-18.6	33.6

WLAN b-Mode; 20 MHz

Channel No.	Channel Center Frequency [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
1	2412	2400.0	-40.3	PEAK	100	9.0	-11.1	29.2
11	2462	2483.5	-43.2	PEAK	100	8.4	-11.6	31.6

WLAN g-Mode; 20 MHz

Channel No.	Channel Center Frequency [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
1	2412	2400.0	-35.0	PEAK	100	2.3	-17.7	17.3
11	2462	2483.5	-47.1	PEAK	100	1.3	-18.7	28.4

WLAN n-Mode; 20 MHz

Channel No.	Channel Center Frequency [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
1	2412	2400.0	-41.5	PEAK	100	1.3	-18.7	22.8
11	2462	2483.5	-49.4	PEAK	100	1.5	-18.5	30.9

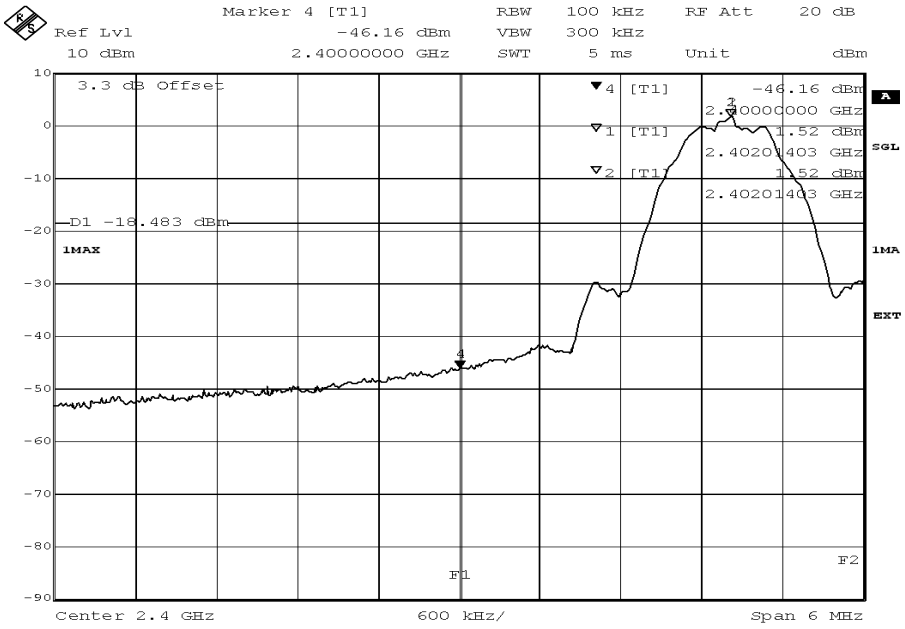
WLAN n-Mode; 40 MHz

Channel No.	Channel Center Frequency [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
3	2422	2400.0	-43.0	PEAK	100	-2.2	-22.2	20.8
11	2462	2483.5	-43.2	PEAK	100	-2.8	-22.8	20.4

Remark: Please see next sub-clause for the measurement plot.

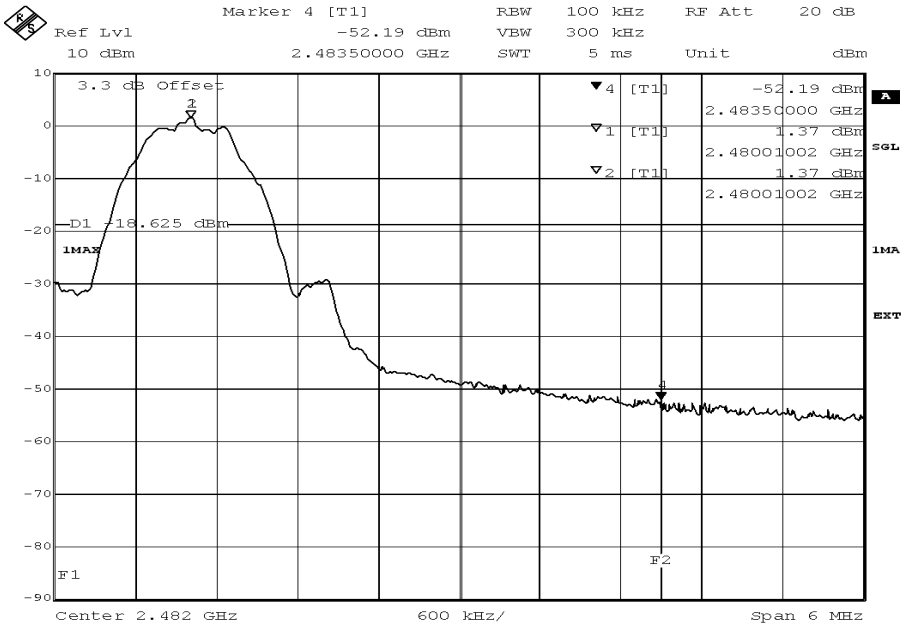
4.6.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

Radio Technology = Bluetooth LE, Operating Frequency = low, Band Edge = low (S01_ac02)



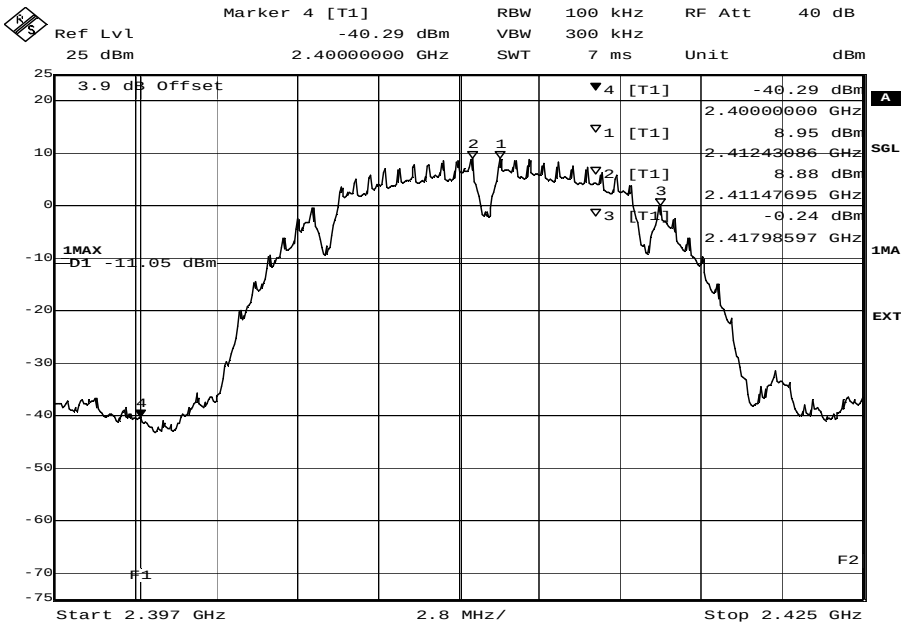
Title: Band Edge Compliance
Comment A: CH B: 2402 MHz
Date: 10.JUL.2017 10:26:06

Radio Technology = Bluetooth LE, Operating Frequency = high, Band Edge = high (S01_ac02)



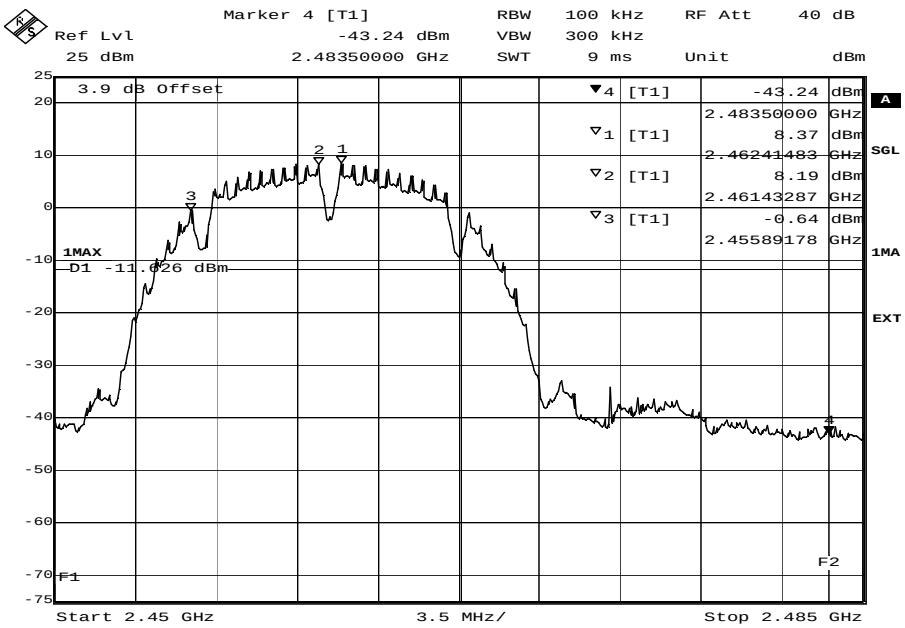
Title: Band Edge Compliance
Comment A: CH T:2480 MHz
Date: 10.JUL.2017 10:59:24

Radio Technology = WLAN b, Operating Frequency = low, Band Edge = low (S01_ab01)



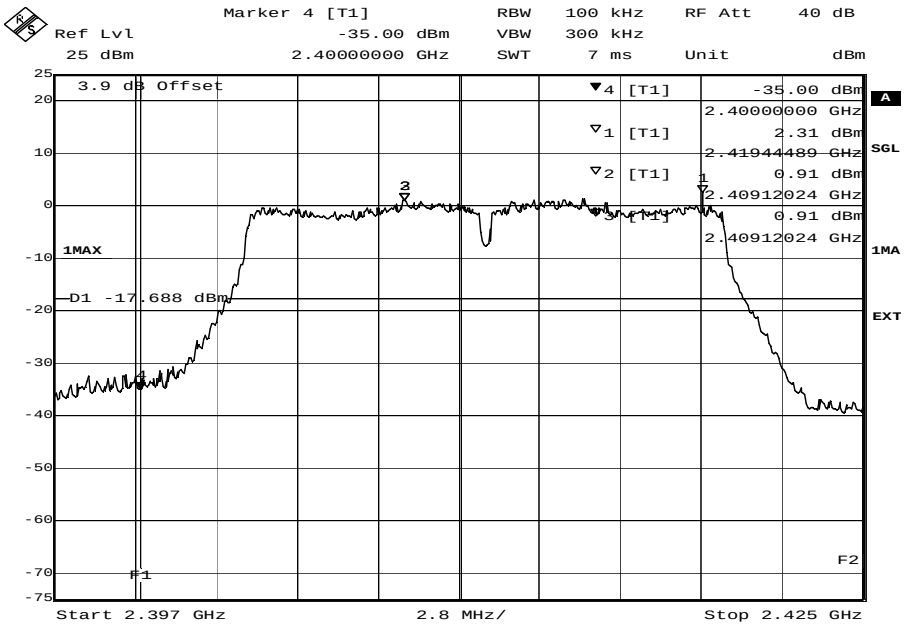
Title: Band Edge Compliance
Comment A: CH B: 2412 MHz
Date: 11.JAN.2017 13:39:26

Radio Technology = WLAN b, Operating Frequency = high, Band Edge = high (S01_ab01)



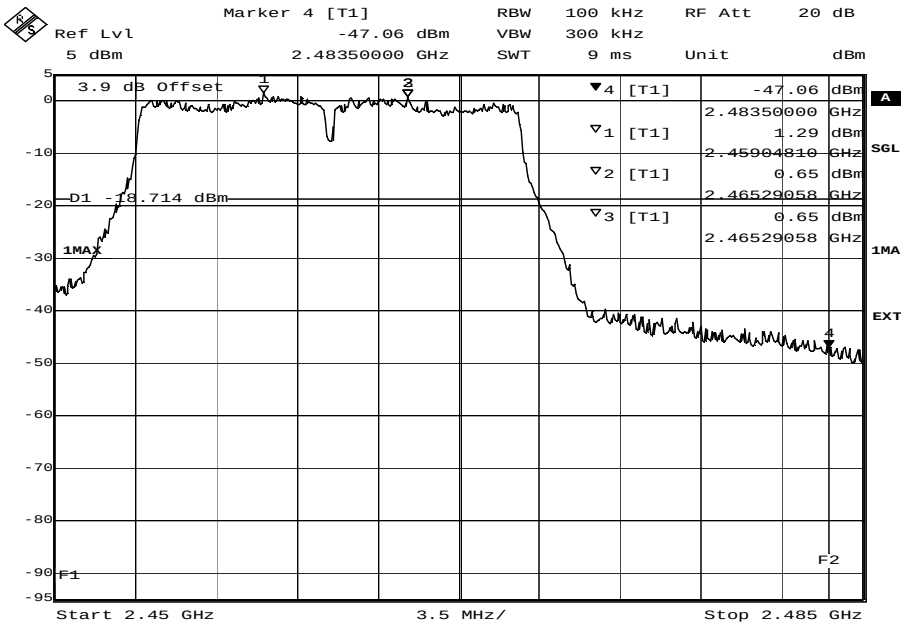
Title: Band Edge Compliance
Comment A: CH T: 2462 MHz
Date: 11.JAN.2017 14:28:46

Radio Technology = WLAN g, Operating Frequency = low, Band Edge = low (S01_ab01)



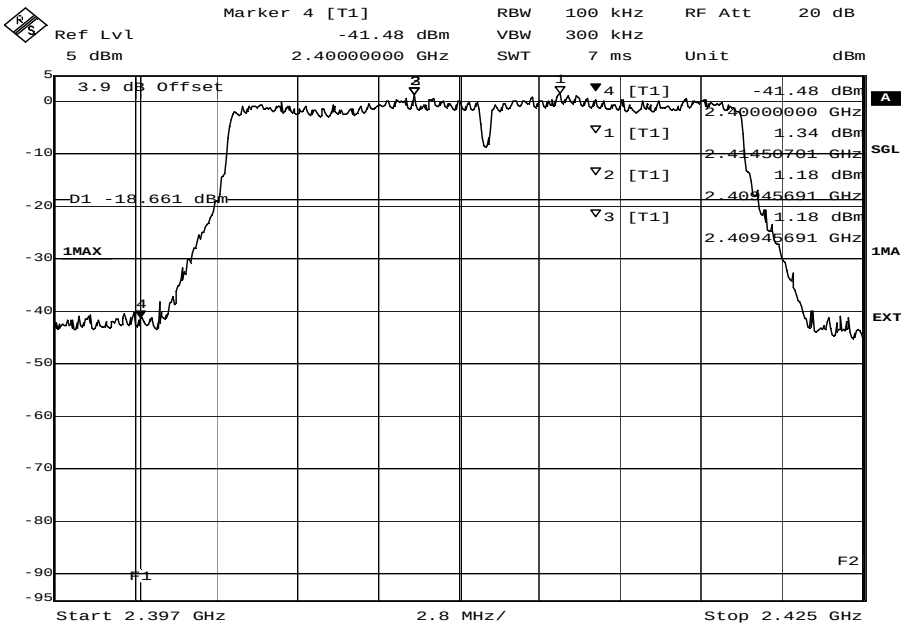
Title: Band Edge Compliance
Comment A: CH B: 2412 MHz
Date: 11.JAN.2017 15:27:04

Radio Technology = WLAN g, Operating Frequency = high, Band Edge = high (S01_ab01)



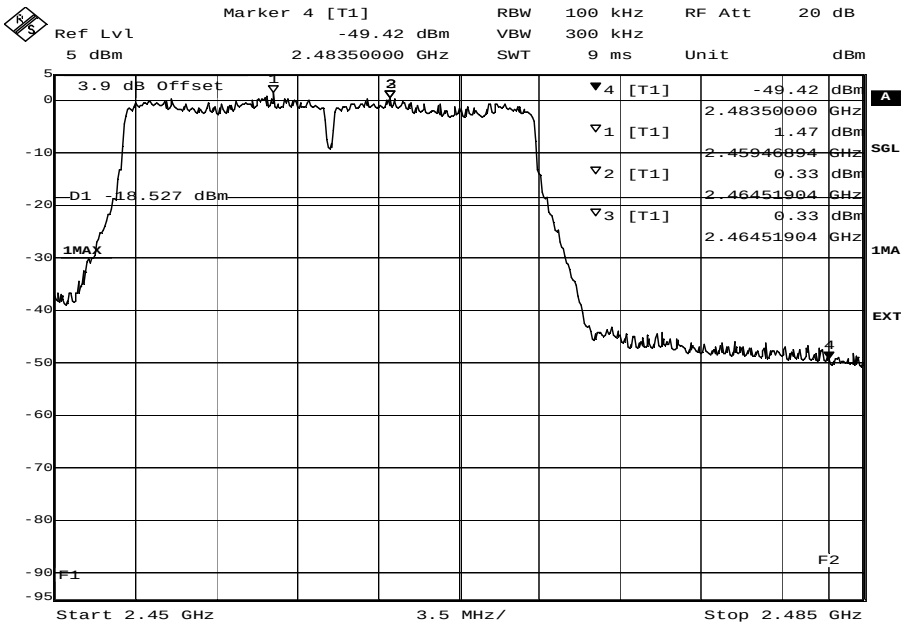
Title: Band Edge Compliance
Comment A: CH T: 2462 MHz
Date: 11.JAN.2017 16:21:30

Radio Technology = WLAN n 20 MHz, Operating Frequency = low, Band Edge = low (S01_ab01)



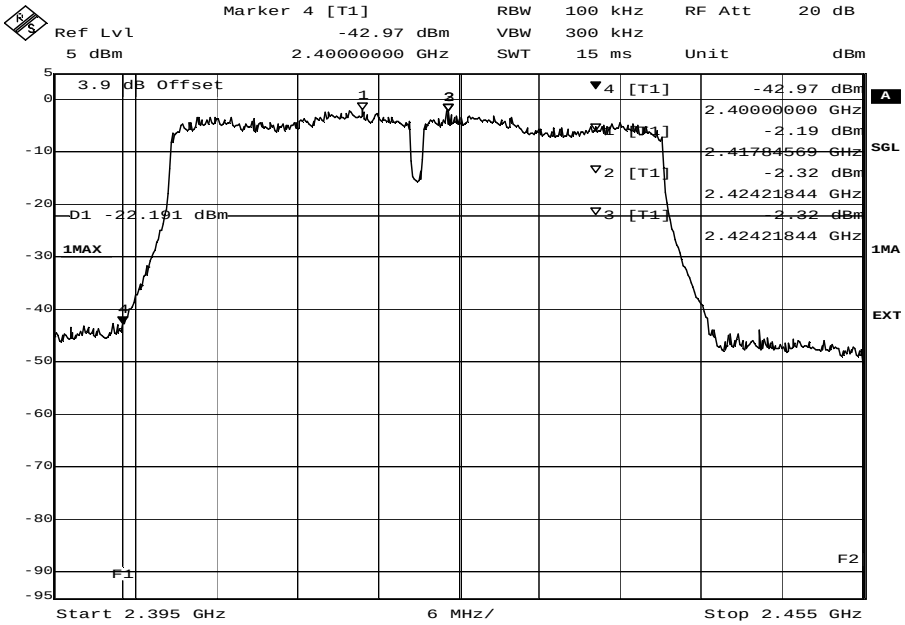
Title: Band Edge Compliance
Comment A: CH B: 2412 MHz
Date: 12.JAN.2017 08:40:17

Radio Technology = WLAN n 20 MHz, Operating Frequency = high, Band Edge = high (S01_ab01)



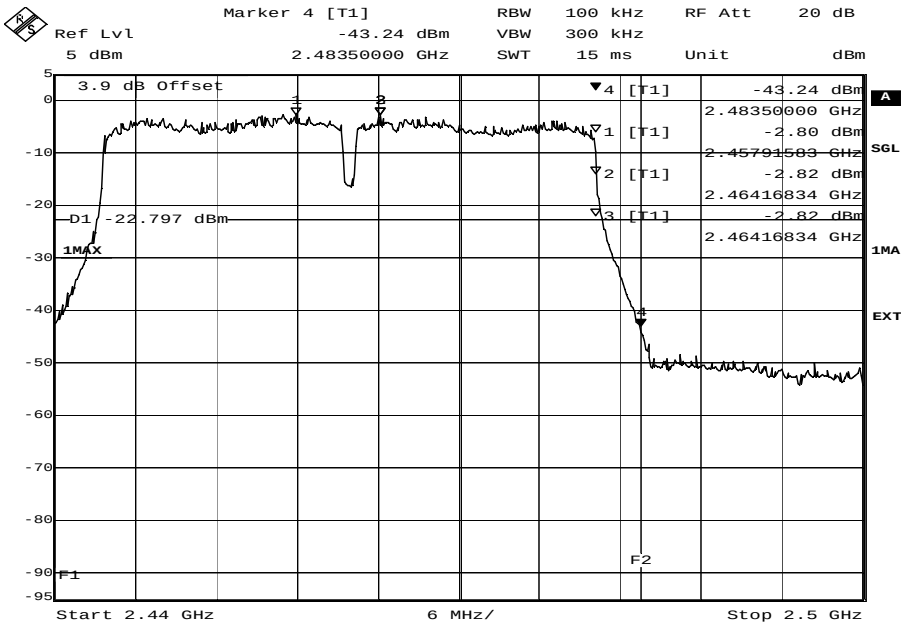
Title: Band Edge Compliance
Comment A: CH T: 2462 MHz
Date: 12.JAN.2017 09:33:29

Radio Technology = WLAN n 40 MHz, Operating Frequency = low, Band Edge = low (S01_ab01)



Title: Band Edge Compliance
Comment A: CH B: 2412 MHz
Date: 12.JAN.2017 12:19:32

Radio Technology = WLAN n 40 MHz, Operating Frequency = high, Band Edge = high (S01_ab01)



Title: Band Edge Compliance
Comment A: CH T: 2462 MHz
Date: 12.JAN.2017 11:31:28

4.6.5 TEST EQUIPMENT USED

- Regulatory Bluetooth RF Test Solution

4.7 BAND EDGE COMPLIANCE RADIATED

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.7.1 TEST DESCRIPTION

Please see test description for the test case “Spurious Radiated Emissions”

4.7.2 TEST REQUIREMENTS / LIMITS

For band edges connected to a restricted band, the limits are specified in Section 15.209(a)

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

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
0.009 – 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 – 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 – 30	30@30m	3	29.5@30m

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 – 88	100@3m	3	40.0@3m
88 – 216	150@3m	3	43.5@3m
216 – 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m

The measured values above 26 GHz are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

§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: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

4.7.3 TEST PROTOCOL

Ambient temperature: 25 - 27 °C
Air Pressure: 1006 - 1010 hPa
Humidity: 39 - 46 %

BT LE GFSK
Applied duty cycle correction (AV):
0 dB

Ch. No.	Ch. Center Freq. [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
39	2480	2483.5	60.5	PEAK	1000	74.0	13.5	BE
39	2480	2483.5	37.4	AV	1000	54.0	16.6	BE

WLAN b-Mode; 20 MHz
Applied duty cycle correction (AV): 0 dB

Ch. No.	Ch. Center Freq. [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
11	2462	2483.5	53.2	PEAK	1000	74.0	20.9	BE
11	2462	2483.5	41.1	AV	1000	54.0	12.9	BE

WLAN g-Mode; 20 MHz
Applied duty cycle correction (AV): 0 dB

Ch. No.	Ch. Center Freq. [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
11	2462	2483.5	55.4	PEAK	1000	74.0	18.6	BE
11	2462	2483.5	41.6	AV	1000	54.0	12.4	BE

WLAN n-Mode; 20 MHz
Applied duty cycle correction (AV): 0 dB

Ch. No.	Ch. Center Freq. [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
11	2462	2483.5	59.0	PEAK	1000	74.0	15.0	BE
11	2462	2483.5	40.0	AV	1000	54.0	14.0	BE

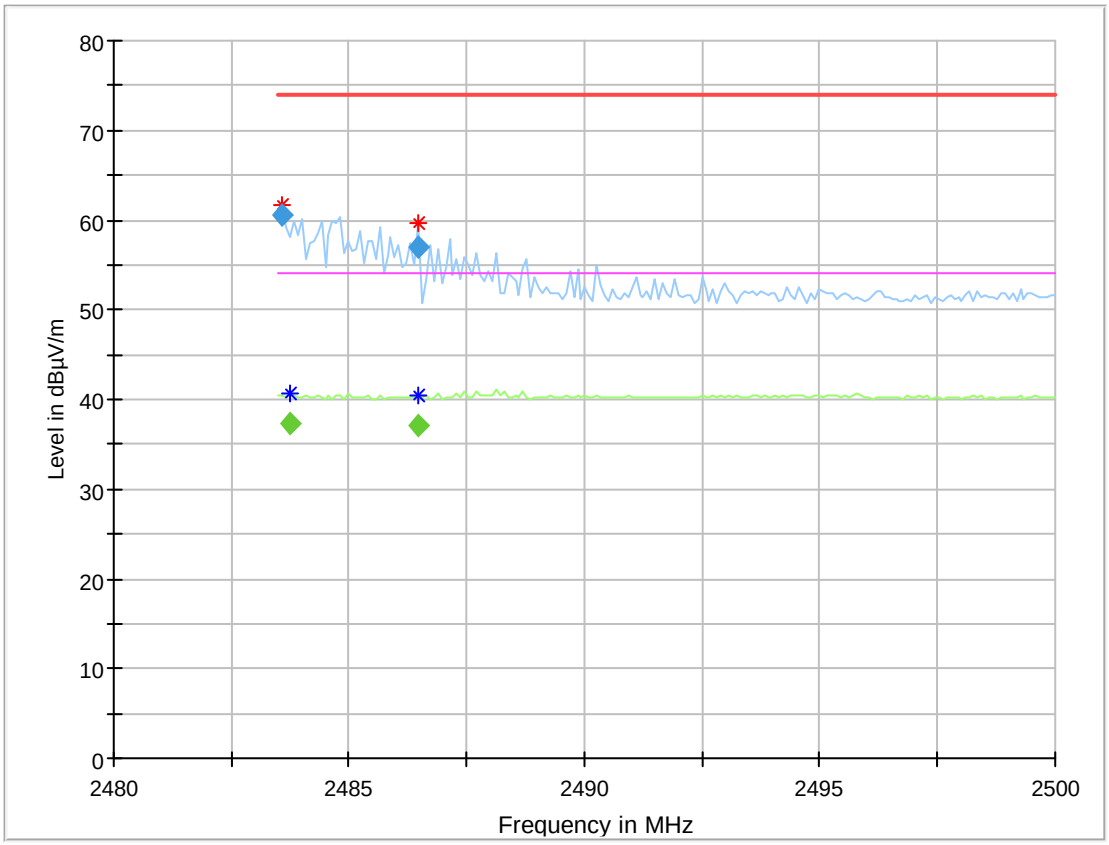
WLAN n-Mode; 40 MHz
Applied duty cycle correction (AV): 0 dB

Ch. No.	Ch. Center Freq. [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
11	2462	2483.5	55.2	PEAK	1000	74.0	18.8	BE
11	2462	2483.5	38.1	AV	1000	54.0	15.9	BE

Remark: Please see next sub-clause for the measurement plot.

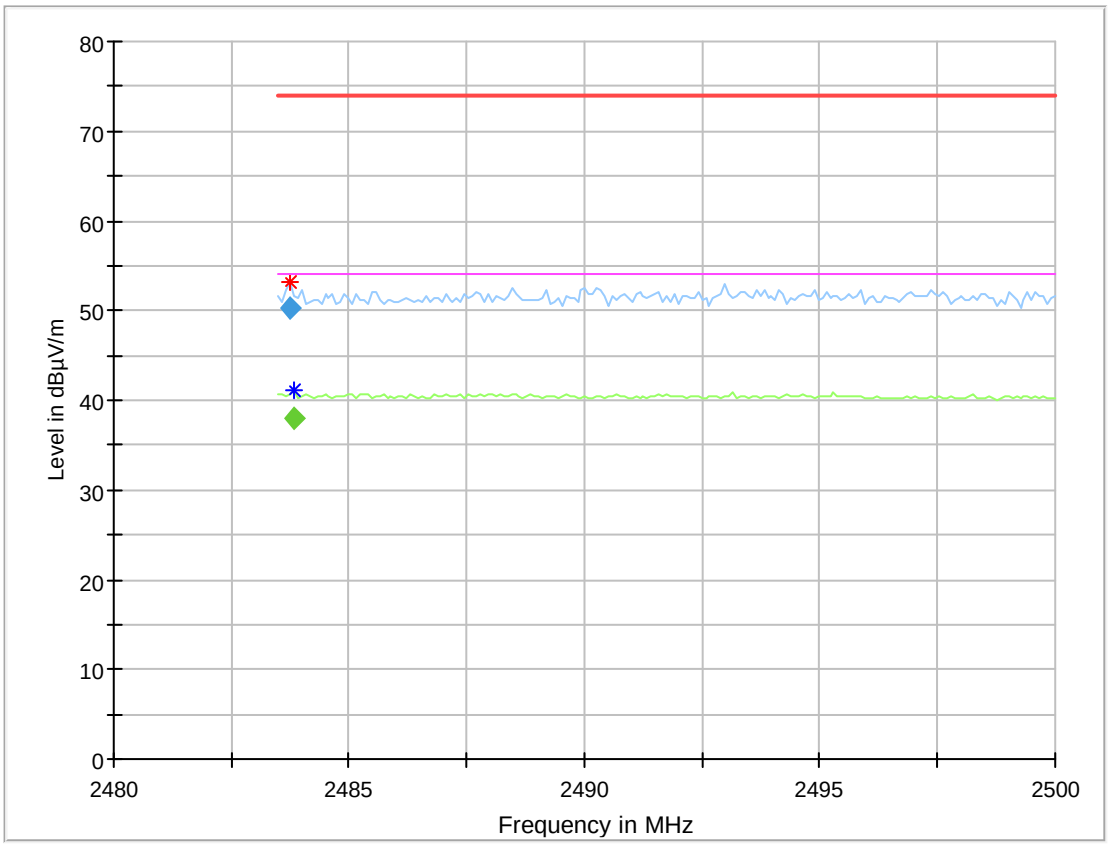
4.7.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

Radio Technology = Bluetooth LE, Operating Frequency = high, Band Edge = high (DE1221004af02)



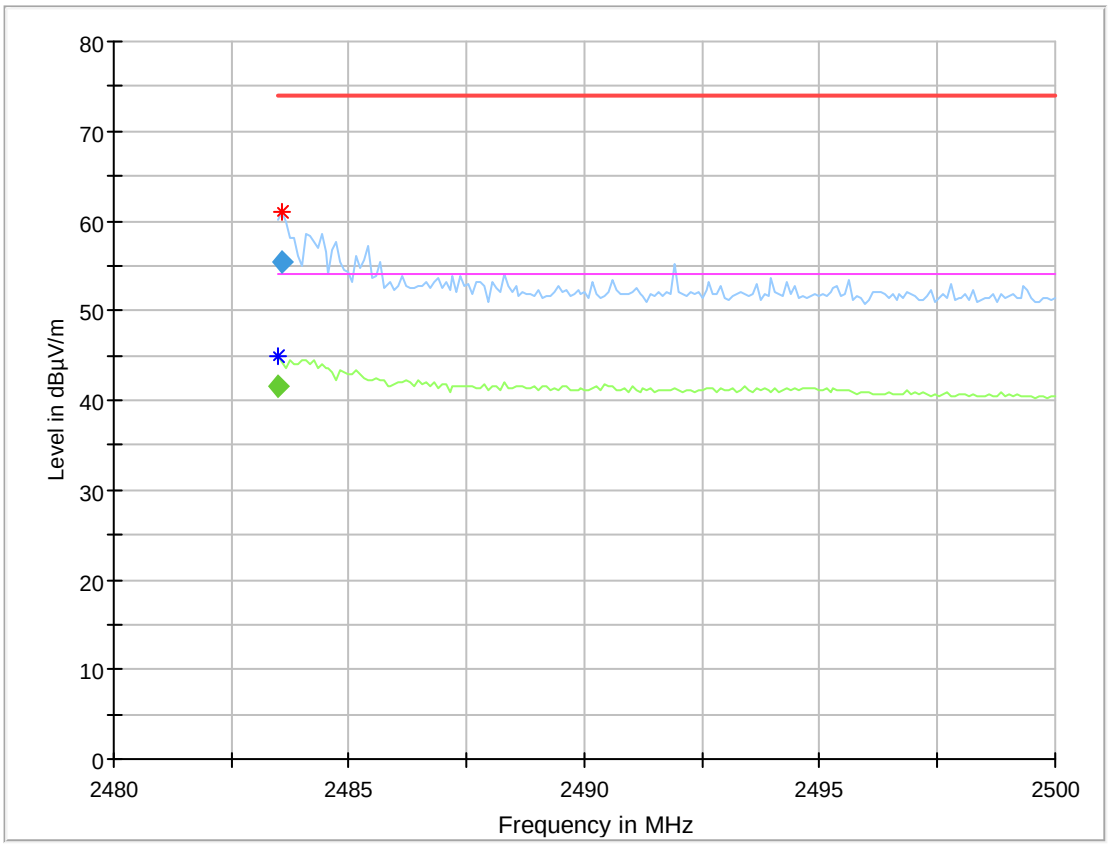
Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
2483.582500	60.54	---	74.00	13.46	1000.0	1000.000	150.0	H	31.0	80.7
2483.747500	---	37.37	54.00	16.63	1000.0	1000.000	150.0	H	26.0	77.8

Radio Technology = WLAN b, Operating Frequency = high, Band Edge = high (DE1221004af02)



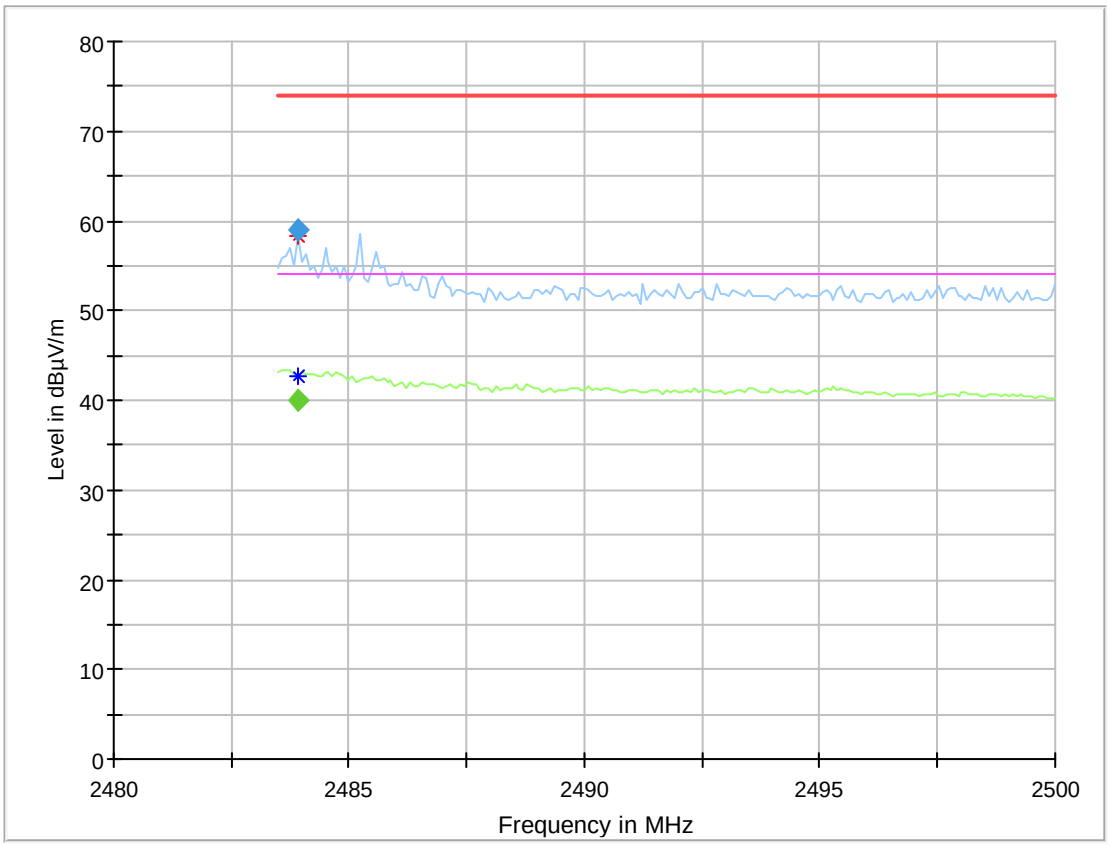
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
2483.747500	53.15	---	74.00	20.85	1000.0	1000.000	150.0	V	113.0	-4.1
2483.830000	---	41.12	54.00	12.88	1000.0	1000.000	150.0	H	26.0	74.7

Radio Technology = WLAN g, Operating Frequency = high, Band Edge = high (DE1221004aj02)



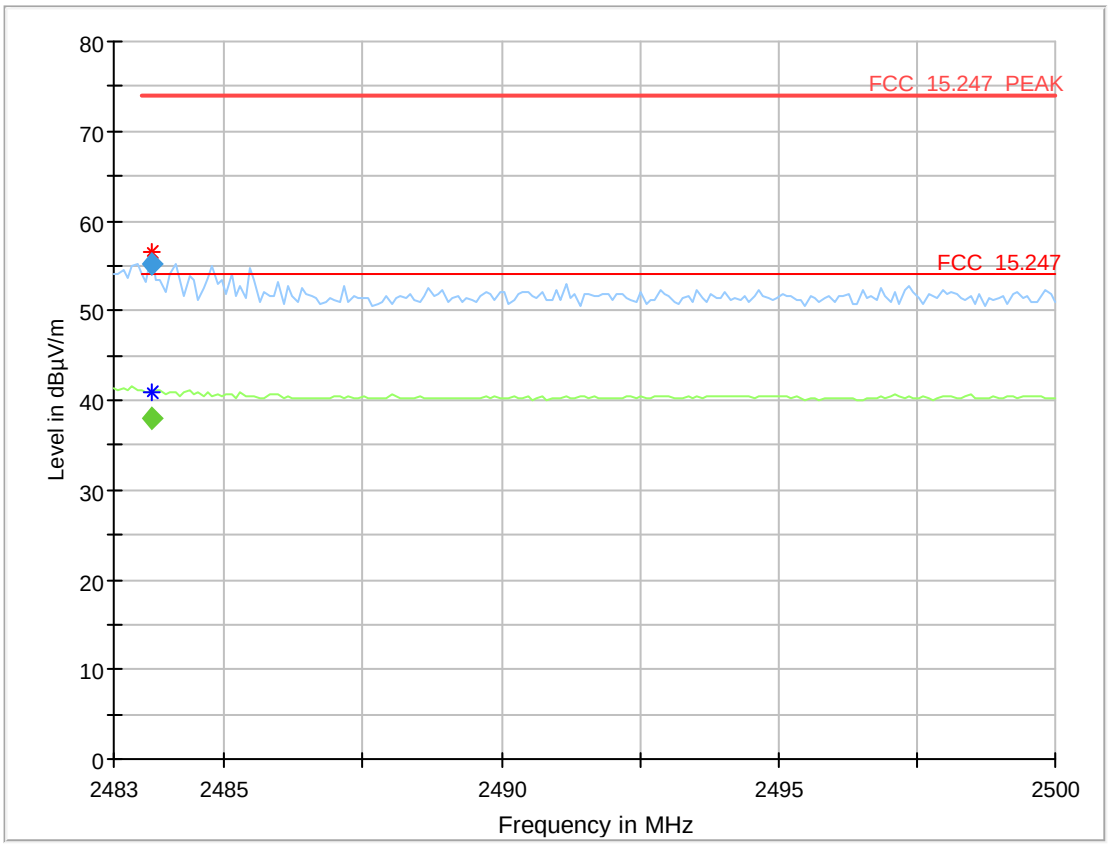
Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
2483.500000	---	41.61	54.00	12.39	1000.0	1000.000	150.0	H	-64.0	74.8
2483.582500	55.39	---	74.00	18.61	1000.0	1000.000	150.0	H	-66.0	92.8

Radio Technology = WLAN n 20 MHz, Operating Frequency = high, Band Edge = high (DE1221004aj02)



Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
2483.912500	---	39.99	54.00	14.01	1000.0	1000.000	150.0	H	-64.0	78.0
2483.912500	58.99	---	74.00	15.01	1000.0	1000.000	150.0	V	-175.0	-11.9

Radio Technology = WLAN n 40 MHz, Operating Frequency = high, Band Edge = high (DE1221004aj02)



Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
2483.680000	---	38.10	---	---	1000.0	1000.000	150.0	H	145.0	78.0
2483.680000	55.15	---	74.00	18.85	1000.0	1000.000	150.0	H	-41.0	74.8

4.7.5 TEST EQUIPMENT USED

- Radiated Emissions

4.8 POWER DENSITY

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.8.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up in a shielded room to perform the Power Density measurements.
The results recorded were measured with the modulation which produces the worst-case (highest) power density.

The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Resolution Bandwidth (RBW): 3 kHz
- Video Bandwidth (VBW): 10 kHz
- Trace: Maxhold
- Sweeps: 2000
- Sweeptime: coupled (see measurement plot)
- Detector: Peak

4.8.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.247 (e)

For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.
...
The same method of determining the conducted output power shall be used to determine the power spectral density.

4.8.3 TEST PROTOCOL

Ambient temperature: 22 °C
Air Pressure: 1012 hPa
Humidity: 43 %

BT LE

Channel No.	Frequency [MHz]	Power Density [dBm / 3kHz]	Limit [dBm / 3kHz]	Margin to Limit [dB]
0	2402	0.5	8.0	7.5
19	2440	0.0	8.0	8.0
39	2480	0.3	8.0	7.7

WLAN b-Mode; 20 MHz; 1 Mbit/s (17 dBm)

Channel No.	Frequency [MHz]	Power Density [dBm / 3kHz]	Limit [dBm / 3kHz]	Margin to Limit [dB]
1	2412	-12.3	8.0	20.3
6	2437	-12.4	8.0	20.4
11	2462	-12.4	8.0	20.4

WLAN g-Mode; 20 MHz; 6 Mbit/s (15 dBm)

Channel No.	Frequency [MHz]	Power Density [dBm / 3kHz]	Limit [dBm / 3kHz]	Margin to Limit [dB]
1	2412	-10.8	8.0	18.8
6	2437	-10.9	8.0	18.9
11	2462	-10.9	8.0	18.9

WLAN n-Mode; 20 MHz; MCS0 (14 dBm)

Channel No.	Frequency [MHz]	Power Density [dBm / 3kHz]	Limit [dBm / 3kHz]	Margin to Limit [dB]
1	2412	-10.5	8.0	18.5
6	2437	-11.6	8.0	19.6
11	2462	-11.2	8.0	19.2

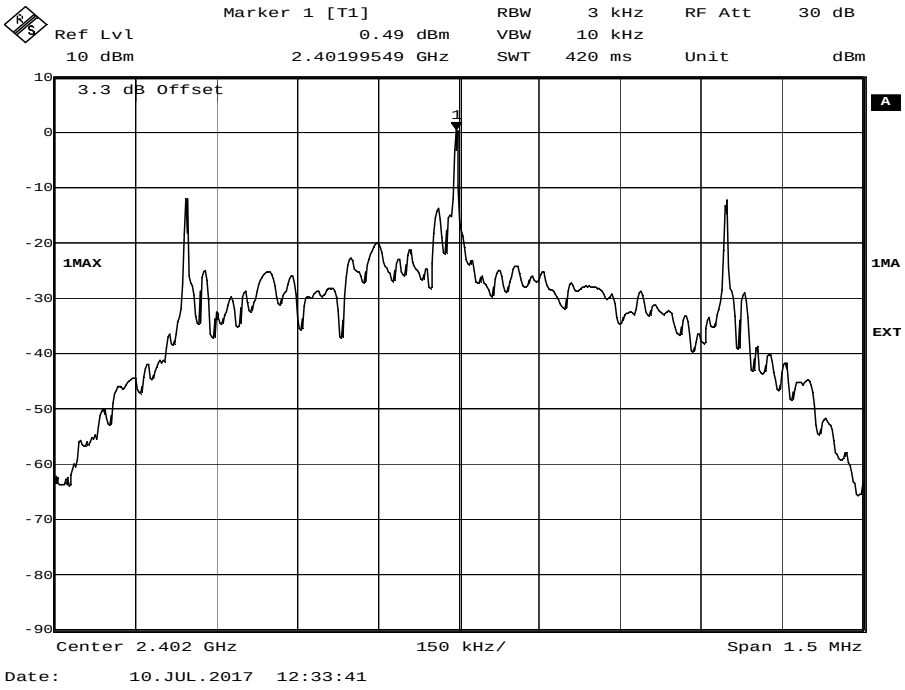
WLAN n-Mode; 40 MHz; MCS0 (14 dBm)

Channel No.	Frequency [MHz]	Power Density [dBm / 3kHz]	Limit [dBm / 3kHz]	Margin to Limit [dB]
3	2422	-14.4	8.0	22.1
6	2437	-14.5	8.0	22.5
11	2462	-14.4	8.0	22.4

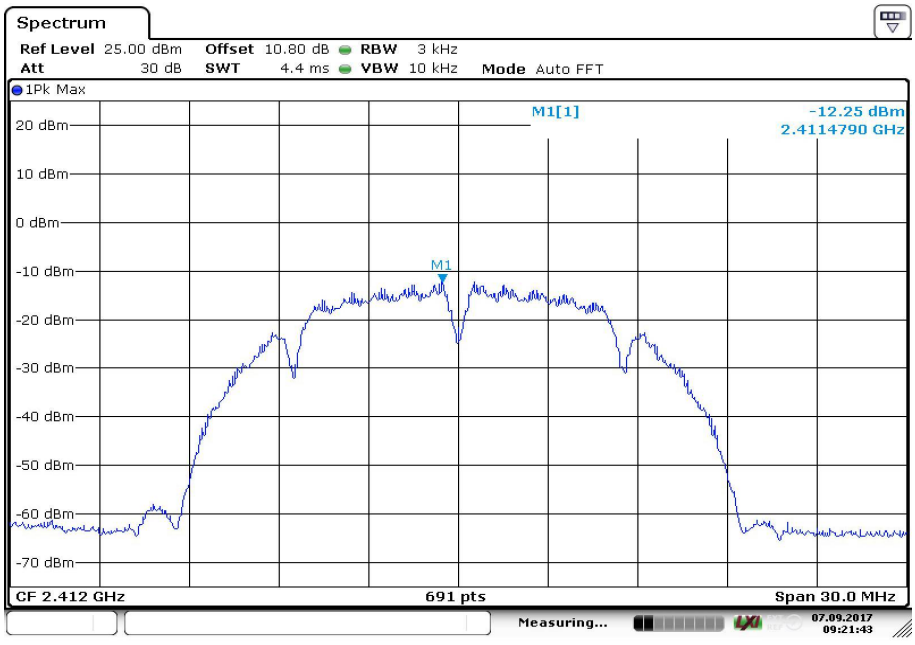
Remark: Please see next sub-clause for the measurement plot.

4.8.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

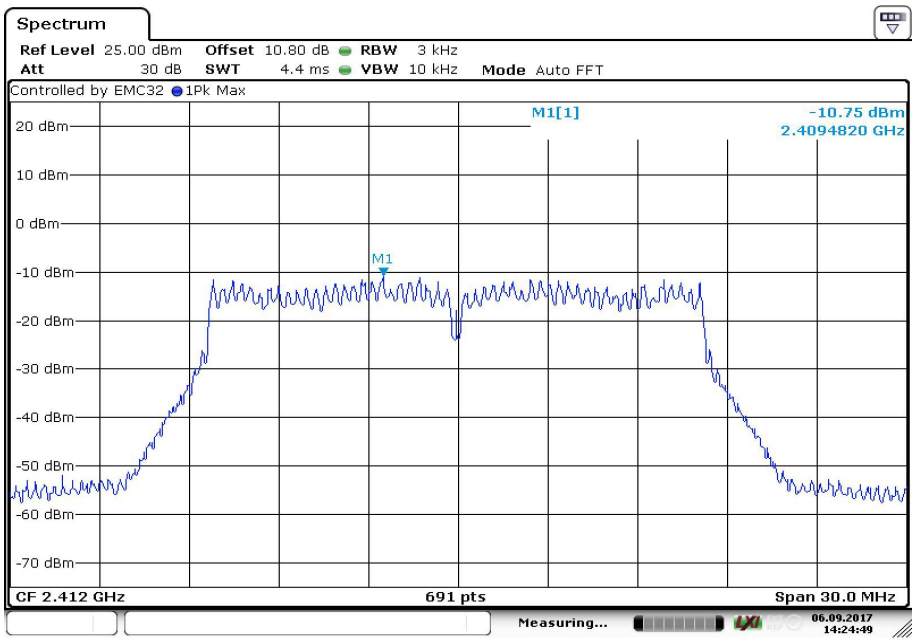
Radio Technology = Bluetooth LE, Operating Frequency = low (S01_ac02)



Radio Technology = WLAN b, Operating Frequency = low (S01_ak02)

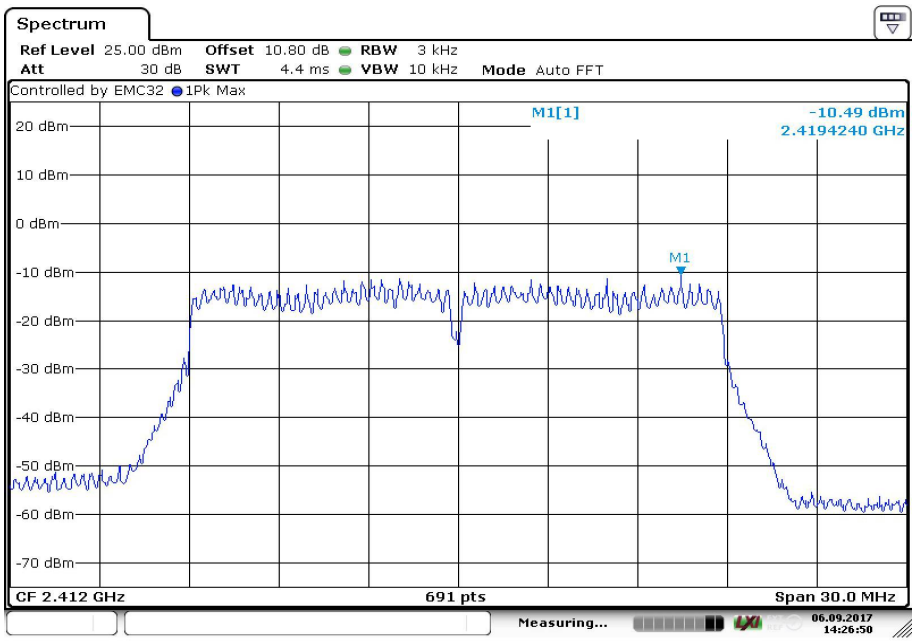


Radio Technology = WLAN g, Operating Frequency = low (S01_ak02)



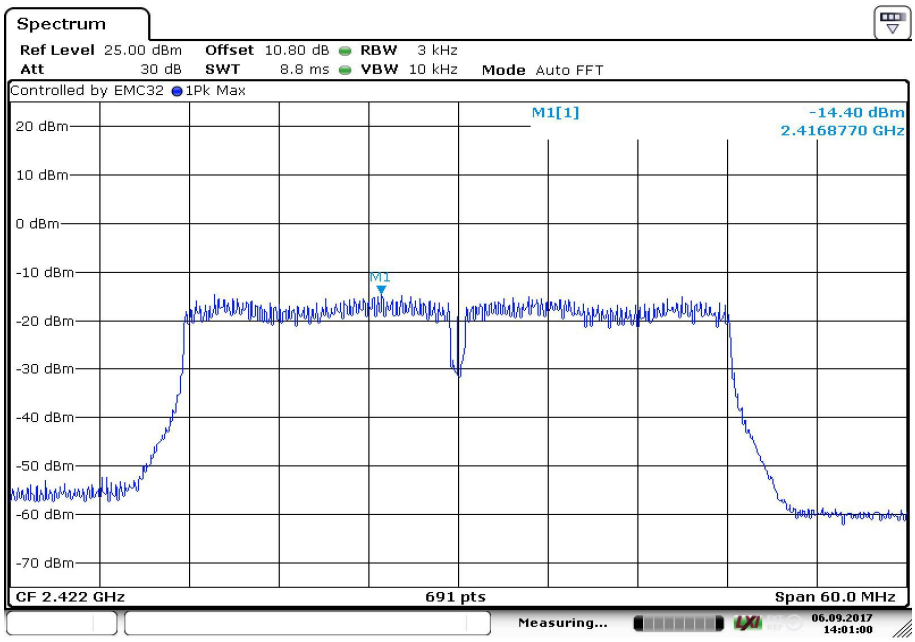
Date: 6.SEP.2017 14:24:49

Radio Technology = WLAN n 20 MHz, Operating Frequency = low (S01_ak02)



Date: 6.SEP.2017 14:26:51

Radio Technology = WLAN n 40 MHz, Operating Frequency = low (S01_ak02)



Date: 6.SEP.2017 14:01:01

4.8.5 TEST EQUIPMENT USED

- Regulatory Bluetooth RF Test Solution
- R&S TS8997

5 TEST EQUIPMENT

1 R&S TS8997
EN300328/301893 Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	107695	2017-07	2020-07
1.2	MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2017-07	2018-07
1.3	1515 / 93459	Broadband Power Divider SMA (Aux)	Weinschel Associates	LN673		
1.4	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2016-02	2018-02
1.5	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2016-02	2018-02
1.6	VT 4002	Climatic Chamber	Vötsch	58566002150010	2016-03	2018-03
1.7	A8455-4	4 Way Power Divider (SMA)		-		
1.8	Opus10 THI (8152.00)	ThermoHygro Datalogger 03 (Environ)	Lufft Mess- und Regeltechnik GmbH	7482	2017-03	2019-03
1.9	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2016-10	2019-10
1.10	OSP120	Switching Unit with integrated power meter	Rohde & Schwarz	101158	2016-11	2018-11

2 Radiated Emissions
Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	NRV-Z1	Sensor Head A	Rohde & Schwarz	827753/005	2017-05	2018-05
2.2	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2016-09	2017-09
2.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-04	2019-04
2.4	Anechoic Chamber	10.58 x 6.38 x 6.00 m^3	Frankonia	none	2016-05	2019-05
2.5	HL 562	Ultralog new biconicals	Rohde & Schwarz	830547/003	2015-06	2018-06
2.6	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
2.7	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.8	Fully Anechoic Room	8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	2015-06	2018-06
2.9	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2016-02	2018-02
2.10	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
2.11	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2016-12	2018-12
2.12	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069		
2.13	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
2.14	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
2.15	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
2.16	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
2.17	TT 1.5 WI	Turn Table	Maturo GmbH	-		
2.18	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz	100609	2016-04	2019-04
2.19	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronic GmbH	00086675		
2.20	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
2.21	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2014-11	2017-11
2.22	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2017-03	2019-03
2.23	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2016-11	2018-11
2.24	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
2.25	AS 620 P	Antenna mast	HD GmbH	620/37		
2.26	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
2.27	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2015-12	2017-12
2.28	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
2.29	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
2.30	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2015-05	2018-05

3 Regulatory Bluetooth RF Test Solution
Regulatory Bluetooth RF Tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
3.1	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2016-09	2017-09
3.2	EX520	Digital Multimeter 12 (Multimeter)	Extech Instruments Corp	05157876	2016-02	2018-02
3.3	NRV Z1 A	Power Sensor	Rohde & Schwarz	832279/013	2016-08	2017-08
3.4	Opus10 THI (8152.00)	T/H Logger 15	Lufft Mess- und Regeltechnik GmbH	13985	2017-04	2019-04
3.5	SMP03	Signal Generator 2 GHz - 27 GHz	Rohde & Schwarz	833680/003	2017-09	2020-09
3.6	TOCT Switching Unit		7layers, Inc.	040107		
3.7	KWP 120/70	Temperature Chamber Weiss 01	Weiss	59226012190010	2016-03	2018-03
3.8	ADU 200 Relay Box 7	used for automated testing (EMMI) only	Ontrak Control Systems Inc	A04380		
3.9	CBT	IL BT RF Test Solution	Rohde & Schwarz	100302	2017-02	2018-02
3.10	NRVD	Powermeter	Rohde & Schwarz	832025/059	2016-08	2017-08
3.11	FSIQ26	Signal Analyser	Rohde & Schwarz	832695/007	2016-09	2018-09
3.12	SMP02	Signal Generator SMP	Rohde & Schwarz	833286/0014	2016-05	2019-05
3.13	SMIQ03B	Signal Generator	Rohde & Schwarz	832870/017	2016-06	2019-06
3.14	CBT	Bluetooth Tester	Rohde & Schwarz	100589	2015-01	2018-01
3.15	NGSM 32/10	Power Supply	Rohde & Schwarz	2725	2017-06	2019-06

The calibration interval is the time interval between “Last Calibration” and “Calibration Due”

6 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas as well as the insertion loss of the LISN.

6.1 LISN R&S ESH3-Z5 (150 KHZ – 30 MHZ)

Frequency		Corr.	LISN insertion loss ESH3-Z5	cable loss (incl. 10 dB atten-uator)
MHz		dB	dB	dB
0.15		10.1	0.1	10.0
5		10.3	0.1	10.2
7		10.5	0.2	10.3
10		10.5	0.2	10.3
12		10.7	0.3	10.4
14		10.7	0.3	10.4
16		10.8	0.4	10.4
18		10.9	0.4	10.5
20		10.9	0.4	10.5
22		11.1	0.5	10.6
24		11.1	0.5	10.6
26		11.2	0.5	10.7
28		11.2	0.5	10.7
30		11.3	0.5	10.8

Sample calculation

U_{LISN} (dB µV) = U (dB µV) + Corr. (dB)
U = Receiver reading
LISN Insertion loss = Voltage Division Factor of LISN
Corr. = sum of single correction factors of used LISN, cables, switch units (if used)
Linear interpolation will be used for frequencies in between the values in the table.

6.2 ANTENNA R&S HFH2-Z2 (9 KHZ – 30 MHZ)

Frequency	AF HFH-Z2)	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-40 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
0.009	20.50	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.01	20.45	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.015	20.37	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.02	20.36	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.025	20.38	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.03	20.32	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.05	20.35	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.08	20.30	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.1	20.20	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.2	20.17	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.3	20.14	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.49	20.12	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.490001	20.12	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.5	20.11	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.8	20.10	-39.6	0.1	0.1	0.1	0.1	-40	30	3
1	20.09	-39.6	0.1	0.1	0.1	0.1	-40	30	3
2	20.08	-39.6	0.1	0.1	0.1	0.1	-40	30	3
3	20.06	-39.6	0.1	0.1	0.1	0.1	-40	30	3
4	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
5	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
6	20.02	-39.5	0.2	0.1	0.1	0.1	-40	30	3
8	19.95	-39.5	0.2	0.1	0.1	0.1	-40	30	3
10	19.83	-39.4	0.2	0.1	0.2	0.1	-40	30	3
12	19.71	-39.4	0.2	0.1	0.2	0.1	-40	30	3
14	19.54	-39.4	0.2	0.1	0.2	0.1	-40	30	3
16	19.53	-39.3	0.3	0.1	0.2	0.1	-40	30	3
18	19.50	-39.3	0.3	0.1	0.2	0.1	-40	30	3
20	19.57	-39.3	0.3	0.1	0.2	0.1	-40	30	3
22	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
24	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
26	19.54	-39.3	0.3	0.1	0.2	0.1	-40	30	3
28	19.46	-39.2	0.3	0.1	0.3	0.1	-40	30	3
30	19.73	-39.1	0.4	0.1	0.3	0.1	-40	30	3

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -40 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values

6.3 ANTENNA R&S HL562 (30 MHZ – 1 GHZ)

(d_{Limit} = 3 m)

Frequency	AF R&S HL562	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
30	18.6	0.6	0.29	0.04	0.23	0.02	0.0	3	3
50	6.0	0.9	0.39	0.09	0.32	0.08	0.0	3	3
100	9.7	1.2	0.56	0.14	0.47	0.08	0.0	3	3
150	7.9	1.6	0.73	0.20	0.59	0.12	0.0	3	3
200	7.6	1.9	0.84	0.21	0.70	0.11	0.0	3	3
250	9.5	2.1	0.98	0.24	0.80	0.13	0.0	3	3
300	11.0	2.3	1.04	0.26	0.89	0.15	0.0	3	3
350	12.4	2.6	1.18	0.31	0.96	0.13	0.0	3	3
400	13.6	2.9	1.28	0.35	1.03	0.19	0.0	3	3
450	14.7	3.1	1.39	0.38	1.11	0.22	0.0	3	3
500	15.6	3.2	1.44	0.39	1.20	0.19	0.0	3	3
550	16.3	3.5	1.55	0.46	1.24	0.23	0.0	3	3
600	17.2	3.5	1.59	0.43	1.29	0.23	0.0	3	3
650	18.1	3.6	1.67	0.34	1.35	0.22	0.0	3	3
700	18.5	3.6	1.67	0.42	1.41	0.15	0.0	3	3
750	19.1	4.1	1.87	0.54	1.46	0.25	0.0	3	3
800	19.6	4.1	1.90	0.46	1.51	0.25	0.0	3	3
850	20.1	4.4	1.99	0.60	1.56	0.27	0.0	3	3
900	20.8	4.7	2.14	0.60	1.63	0.29	0.0	3	3
950	21.1	4.8	2.22	0.60	1.66	0.33	0.0	3	3
1000	21.6	4.9	2.23	0.61	1.71	0.30	0.0	3	3

(d_{Limit} = 10 m)

30	18.6	-9.9	0.29	0.04	0.23	0.02	-10.5	10	3
50	6.0	-9.6	0.39	0.09	0.32	0.08	-10.5	10	3
100	9.7	-9.2	0.56	0.14	0.47	0.08	-10.5	10	3
150	7.9	-8.8	0.73	0.20	0.59	0.12	-10.5	10	3
200	7.6	-8.6	0.84	0.21	0.70	0.11	-10.5	10	3
250	9.5	-8.3	0.98	0.24	0.80	0.13	-10.5	10	3
300	11.0	-8.1	1.04	0.26	0.89	0.15	-10.5	10	3
350	12.4	-7.9	1.18	0.31	0.96	0.13	-10.5	10	3
400	13.6	-7.6	1.28	0.35	1.03	0.19	-10.5	10	3
450	14.7	-7.4	1.39	0.38	1.11	0.22	-10.5	10	3
500	15.6	-7.2	1.44	0.39	1.20	0.19	-10.5	10	3
550	16.3	-7.0	1.55	0.46	1.24	0.23	-10.5	10	3
600	17.2	-6.9	1.59	0.43	1.29	0.23	-10.5	10	3
650	18.1	-6.9	1.67	0.34	1.35	0.22	-10.5	10	3
700	18.5	-6.8	1.67	0.42	1.41	0.15	-10.5	10	3
750	19.1	-6.3	1.87	0.54	1.46	0.25	-10.5	10	3
800	19.6	-6.3	1.90	0.46	1.51	0.25	-10.5	10	3
850	20.1	-6.0	1.99	0.60	1.56	0.27	-10.5	10	3
900	20.8	-5.8	2.14	0.60	1.63	0.29	-10.5	10	3
950	21.1	-5.6	2.22	0.60	1.66	0.33	-10.5	10	3
1000	21.6	-5.6	2.23	0.61	1.71	0.30	-10.5	10	3

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -20 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

6.4 ANTENNA R&S HF907 (1 GHZ – 18 GHZ)

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay + cable inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit, atten-uator & pre-amp)	cable loss 4 (to receiver)		
MHz	dB (1/m)	dB	dB	dB	dB	dB		
1000	24.4	-19.4	0.99	0.31	-21.51	0.79		
2000	28.5	-17.4	1.44	0.44	-20.63	1.38		
3000	31.0	-16.1	1.87	0.53	-19.85	1.33		
4000	33.1	-14.7	2.41	0.67	-19.13	1.31		
5000	34.4	-13.7	2.78	0.86	-18.71	1.40		
6000	34.7	-12.7	2.74	0.90	-17.83	1.47		
7000	35.6	-11.0	2.82	0.86	-16.19	1.46		

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (inside chamber)	cable loss 3 (outside chamber)	cable loss 4 (switch unit, atten-uator & pre-amp)	cable loss 5 (to receiver)	used for FCC 15.247
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	
3000	31.0	-23.4	0.47	1.87	0.53	-27.58	1.33	
4000	33.1	-23.3	0.56	2.41	0.67	-28.23	1.31	
5000	34.4	-21.7	0.61	2.78	0.86	-27.35	1.40	
6000	34.7	-21.2	0.58	2.74	0.90	-26.89	1.47	
7000	35.6	-19.8	0.66	2.82	0.86	-25.58	1.46	

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (High Pass)	cable loss 3 (pre-amp)	cable loss 4 (inside chamber)	cable loss 5 (outside chamber)	cable loss 6 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	dB
7000	35.6	-57.3	0.56	1.28	-62.72	2.66	0.94	1.46
8000	36.3	-56.3	0.69	0.71	-61.49	2.84	1.00	1.53
9000	37.1	-55.3	0.68	0.65	-60.80	3.06	1.09	1.60
10000	37.5	-56.2	0.70	0.54	-61.91	3.28	1.20	1.67
11000	37.5	-55.3	0.80	0.61	-61.40	3.43	1.27	1.70
12000	37.6	-53.7	0.84	0.42	-59.70	3.53	1.26	1.73
13000	38.2	-53.5	0.83	0.44	-59.81	3.75	1.32	1.83
14000	39.9	-56.3	0.91	0.53	-63.03	3.91	1.40	1.77
15000	40.9	-54.1	0.98	0.54	-61.05	4.02	1.44	1.83
16000	41.3	-54.1	1.23	0.49	-61.51	4.17	1.51	1.85
17000	42.8	-54.4	1.36	0.76	-62.36	4.34	1.53	2.00
18000	44.2	-54.7	1.70	0.53	-62.88	4.41	1.55	1.91

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

6.5 ANTENNA EMCO 3160-09 (18 GHZ – 26.5 GHZ)

Frequency	AF EMCO 3160-09	Corr.	cable loss 1 (inside chamber)	cable loss 2 (pre-amp)	cable loss 3 (inside chamber)	cable loss 4 (switch unit)	cable loss 5 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB
18000	40.2	-23.5	0.72	-35.85	6.20	2.81	2.65
18500	40.2	-23.2	0.69	-35.71	6.46	2.76	2.59
19000	40.2	-22.0	0.76	-35.44	6.69	3.15	2.79
19500	40.3	-21.3	0.74	-35.07	7.04	3.11	2.91
20000	40.3	-20.3	0.72	-34.49	7.30	3.07	3.05
20500	40.3	-19.9	0.78	-34.46	7.48	3.12	3.15
21000	40.3	-19.1	0.87	-34.07	7.61	3.20	3.33
21500	40.3	-19.1	0.90	-33.96	7.47	3.28	3.19
22000	40.3	-18.7	0.89	-33.57	7.34	3.35	3.28
22500	40.4	-19.0	0.87	-33.66	7.06	3.75	2.94
23000	40.4	-19.5	0.88	-33.75	6.92	3.77	2.70
23500	40.4	-19.3	0.90	-33.35	6.99	3.52	2.66
24000	40.4	-19.8	0.88	-33.99	6.88	3.88	2.58
24500	40.4	-19.5	0.91	-33.89	7.01	3.93	2.51
25000	40.4	-19.3	0.88	-33.00	6.72	3.96	2.14
25500	40.5	-20.4	0.89	-34.07	6.90	3.66	2.22
26000	40.5	-21.3	0.86	-35.11	7.02	3.69	2.28
26500	40.5	-21.1	0.90	-35.20	7.15	3.91	2.36

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

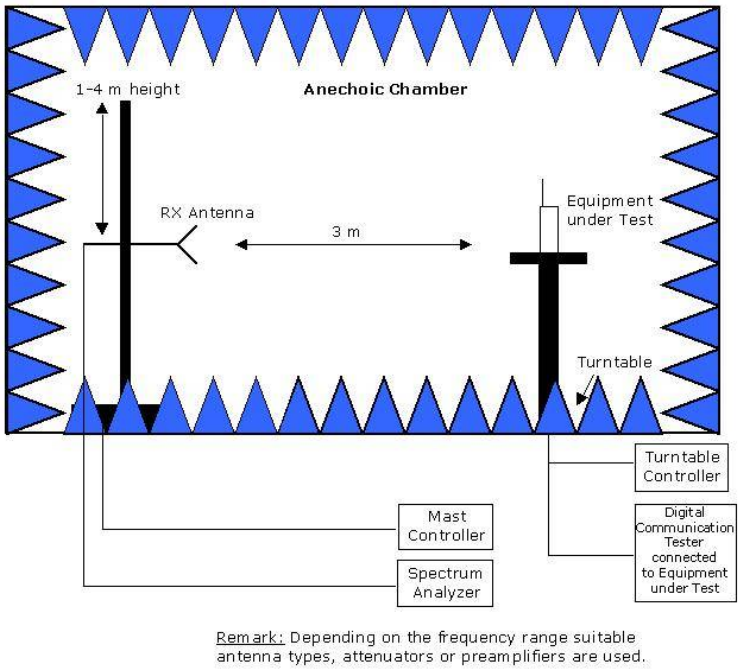
6.6 ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

Frequency	AF EMCO 3160-10	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
GHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
26.5	43.4	-11.2	4.4				-15.6	3	0.5
27.0	43.4	-11.2	4.4				-15.6	3	0.5
28.0	43.4	-11.1	4.5				-15.6	3	0.5
29.0	43.5	-11.0	4.6				-15.6	3	0.5
30.0	43.5	-10.9	4.7				-15.6	3	0.5
31.0	43.5	-10.8	4.7				-15.6	3	0.5
32.0	43.5	-10.7	4.8				-15.6	3	0.5
33.0	43.6	-10.7	4.9				-15.6	3	0.5
34.0	43.6	-10.6	5.0				-15.6	3	0.5
35.0	43.6	-10.5	5.1				-15.6	3	0.5
36.0	43.6	-10.4	5.1				-15.6	3	0.5
37.0	43.7	-10.3	5.2				-15.6	3	0.5
38.0	43.7	-10.2	5.3				-15.6	3	0.5
39.0	43.7	-10.2	5.4				-15.6	3	0.5
40.0	43.8	-10.1	5.5				-15.6	3	0.5

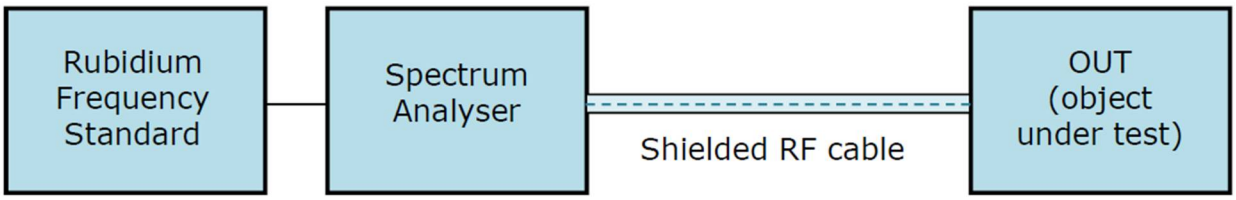
Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
distance correction = -20 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

7 SETUP DRAWINGS



Drawing 1: Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting groundplane.



Drawing 2: Setup for conducted radio tests.

8 MEASUREMENT UNCERTAINTIES

Test Case	Parameter	Uncertainty
AC Power Line	Power	± 3.4 dB
Field Strength of spurious radiation	Power	± 5.5 dB
6 dB / 20 dB / 26 dB / 99% Bandwidth	Power Frequency	± 2.9 dB ± 11.2 kHz
Conducted Output Power	Power	± 2.2 dB
Band Edge Compliance	Power Frequency	± 2.2 dB ± 11.2 kHz
Frequency Stability	Frequency	± 25 Hz
Power Spectral Density	Power	± 2.2 dB

9 PHOTO REPORT

Please see separate photo report.