FCC Measurement/Technical Report on

Host-based multiradio module with Wi-Fi, Bluetooth and NFC

EMMY-W165

in WLAN 2.4 GHz and Bluetooth LE mode

FCC ID: EMMY-W165: XPYEMMYW165
IC: EMMY-W165: 8595A-EMMYW165

Test Report Reference: MDE_UBLOX_1623_FCCb

Test Laboratory:
7layers GmbH
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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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 1:
According to applicant's description:
"All product variants, EMMY-W161-A, EMMY-W163-A and EMMY-W165-A, share the same PCB design and have an identical TX/RX 5 GHz RF path, so that the re-use of test reports appears to us beneficial and applicable.
The EMMY-W161 and EMMY-W165 are very similar were the only difference is the type of band pass filter in the 2.4 GHz WLAN and Bluetooth receive/transmit RF-paths. EMMY-W161 is equipped with a BAW-type band pass filter and EMMY-W165 instead has a ceramic band pass filter. The same type of ceramic band pass filter is used on EMMY-W163 thus the 2.4 GHz WLAN receive/transmit RF-paths of EMMY-W165 are identical to EMMY-W163.
The 5 GHz WLAN receive/transmit RF-path is identical on all three variants of EMMY-W16x."

Note 2:
This report is focused on Bluetooth Low Energy mode and 2.4 GHz WLAN mode.

Note 3:
For 2.4 GHz WLAN mode were only "spot checks" performed to show evidence, that EMMY-W165 has the same or improved RF-characteristic compared to EMMY-W161 (please refer to Test Report "MDE_UBLOX_1551_FCCc"). Following "spot checks" were selected:

- output power: per modulation group: only channel with highest output power (from EMMY-W161)
- other conducted tests: repeat tests were the margin to Limit ≤ 1 dB (from EMMY-W161)

Note 4:
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 Meas Guidance v03r05, 2016-04-08". ANSI C63.10–2013 is applied.

Note 5:
Not all possible operating modes were tested. Worst case operating modes were determined at the beginning of the test period.

Note 6:
Bluetooth LE mode uses the same GFSK modulation like Bluetooth BDR mode, but
- fewer channels (up to 40 instead of up to 80) in the same frequency band
- and for this device lower output power (max. 5 dBm instead of max. 10 dBm).
Bluetooth BDR mode is therefore worse for "Transmitter spurious radiated emissions" and "Band Edge Compliance Radiated" and cover also Bluetooth LE mode.

Note 7:
Bluetooth LE Mode => GFSK modulation, for test "Transmitter spurious radiated emissions" and "Band Edge Compliance Radiated" please refer to test report "MDE_UBLOX_1623_FCCa", where the same EUT were tested in Bluetooth BDR mode.

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 1: 5.2 (1)
Peak conducted output power	§ 15.247 (b) (3), (4)	RSS-247 Issue 1: 5.4 (4)
Transmitter spurious RF conducted emissions	§ 15.247 (d)	RSS-Gen Issue 4: 6.13 / 8.9/8.10; RSS-247 Issue 1: 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 1: 5.5
Band edge compliance	§ 15.247 (d)	RSS-247 Issue 1: 5.5
Power density	§ 15.247 (e)	RSS-247 Issue 1: 5.2 (2)
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 4: 8.3
Receiver spurious emissions	–	–

1.3 MEASUREMENT SUMMARY / SIGNATURES

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 **§ 15.207**

Conducted Emissions at AC Mains

The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode	Setup	FCC	IC
Operating mode			
worst case, Bluetooth LE, mid	DE1015044 ab01	Passed	Passed

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 **Final Result**

OP-Mode	Setup	FCC	IC
Radio Technology, Operating Frequency			
Bluetooth LE, high	DE1015044 ac01	Passed	Passed
Bluetooth LE, low	DE1015044 ac01	Passed	Passed
Bluetooth LE, mid	DE1015044 ac01	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 **Final Result**

OP-Mode	Setup	FCC	IC
Radio Technology, Operating Frequency			
Bluetooth LE, high	DE1015044 ac01	N/A	Tested
Bluetooth LE, low	DE1015044 ac01	N/A	Tested
Bluetooth LE, mid	DE1015044 ac01	N/A	Tested

Remark: No applicable limit. Measurement results for information purpose.

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 Radio Technology, Operating Frequency, Measurement method	Setup	FCC	IC
Bluetooth LE, high, conducted	DE1015044 ac01	Passed	Passed
Bluetooth LE, low, conducted	DE1015044 ac01	Passed	Passed
Bluetooth LE, mid, conducted	DE1015044 ac01	Passed	Passed
WLAN b, mid, conducted	DE1015044 aa01	Passed	Passed
WLAN g, mid, conducted	DE1015044 aa01	Passed	Passed
WLAN n 20 MHz, mid, conducted	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, mid, conducted	DE1015044 aa01	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 Radio Technology, Operating Frequency	Setup	FCC	IC
Bluetooth LE, high	DE1015044 ac01	Passed	Passed
Bluetooth LE, low	DE1015044 ac01	Passed	Passed
Bluetooth LE, mid	DE1015044 ac01	Passed	Passed

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

Spurious RF Conducted Emissions in restricted bands
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode	**Setup**	**FCC**	**IC**
Radio Technology, Operating Frequency, Measurement range			
WLAN b, high, 1 GHz - 24 GHz	DE1015044 aa01	Passed	Passed
WLAN g, additional channels, 1 GHz - 24 GHz	DE1015044 aa01	Passed	Passed
WLAN n 20 MHz, additional channel, 1 GHz - 24 GHz	DE1015044 aa01	Passed	Passed
WLAN n 20 MHz, high, 1 GHz - 24 GHz	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, additional channel, 1 GHz - 24 GHz	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, high, 1 GHz - 24 GHz	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, low, 1 GHz - 24 GHz	DE1015044 aa01	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	DE1015044 ac01	Passed	Passed
Bluetooth LE, low, low	DE1015044 ac01	Passed	Passed

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

Band Edge Compliance Conducted at Restricted Band
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Band Edge	**Setup**	**FCC**	**IC**
WLAN g, additional channel, high	DE1015044 aa01	Passed	Passed
WLAN n 20 MHz, additional channel, high	DE1015044 aa01	Passed	Passed
WLAN n 20 MHz, high, high	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, additional channel, high	DE1015044 aa01	Passed	Passed
WLAN n 40 MHz, high, high	DE1015044 aa01	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 **Final Result**

OP-Mode Radio Technology, Operating Frequency	**Setup**	**FCC**	**IC**
Bluetooth LE, high	DE1015044 ac01	Passed	Passed
Bluetooth LE, low	DE1015044 ac01	Passed	Passed
Bluetooth LE, mid	DE1015044 ac01	Passed	Passed

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(responsible for accreditation scope)
Dipl.-Ing. Andreas Petz

(responsible for testing and report)
Dipl.-Ing. Wolfgang Richter

1.4 REVISION HISTORY

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
Draft	2016-09-29	--	N/A
initial	2016-09-30	--	valid

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-12140-01-01
Responsible for accreditation scope:	Dipl.-Ing. Andreas Petz
Report Template Version:	2016-06-07

2.2 PROJECT DATA

Responsible for testing and report:	Dipl.-Ing. Wolfgang Richter
Employees who performed the tests:	documented internally at 7Layers
Date of Report:	2016-09-30
Testing Period:	2016-08-17 to 2016-09-28

2.3 APPLICANT DATA

Company Name:	u-blox AG
Address:	Zürcherstrasse 68 8800 Thalwil Switzerland
Contact Person:	Mr. Giulio Comar

2.4 MANUFACTURER DATA

Company Name:	please see applicant data
Address:	
Contact Person:	

3 TEST OBJECT DATA

3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	WLAN 2.4 GHz, 5 GHz, BT, NFC, SRD (5.8 GHz) - Single Antenna
Product name	Host-based multiradio module with Wi-Fi, Bluetooth and NFC
Type	EMMY-W165
Declared EUT data by the supplier	
Voltage Type	DC
Voltage Level	normal: 3.3 V DC low: 3.0 V DC high: 3.6 V DC
Modulation Type	Bluetooth LE: GFSK WLAN: DSSS, OFDM, HT20 MCS0 – MCS7, HT40 MCS0 –MCS7 please see each test protocol
General product description	EMMY-W161, EMMY-W163 and EMMY-W165 are ultra-compact multi-radio modules providing Wi-Fi, Classic Bluetooth, Bluetooth low energy and NFC mode of operation. It is designed for both simultaneous and independent operations of: • Wi-Fi IEEE 802.11ac and a/b/g/n • Dual-mode Bluetooth 4.2 • NFC
Specific product description for the EUT	EMMY-W165: Shielded module, single antenna pin for WLAN 802.11 ac/a/b/g/n and Bluetooth communication
The EUT provides the following ports:	- DC power supply - antenna port - signal ports
Data rates	Bluetooth LE, GFSK: 1 Mbit/s WLAN b: please see chapter "WLAN Power Table" WLAN g: please see chapter "WLAN Power Table" WLAN n 20 MHz: please see chapter "WLAN Power Table" WLAN n 40 MHz: please see chapter "WLAN Power Table"
Power levels	Bluetooth LE: 5 dBm WLAN: please see chapter "WLAN Power Table"

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
DE1015044aa01	aa01	"#1" Conducted Sample
Sample Parameter	**Value**	
Antenna	Antenna connector on evaluation board (target platform): The following antennas are designated for 2.4 and 5 GHz WLAN transmission on EMMY-W165, as well as Bluetooth on EMMY-W165. - Table 2 of Test Object Specification:	

				Peak gain [dBi]	
#	Manufacturer	Part number	Antenna type	2.4 GHz band	5 GHz band
W1	Antenova	A10194 [1]	SMD chip antenna 10x10x0.9 [mm]	1.8	4.1
W2	Linx	ANT-DB1-RAF-RPS [4]	Dual-band dipole antenna	2.5	**4.6**
W3	Taoglas	GW.40.2153	Dual-band dipole antenna	**3.74**	2.5
W4	Taoglas	GW.59.3153 [5]	Dual-band dipole antenna	2.37	2.93
W5	Walsin	RFDPA870900SBLB8G1	Dual-band dipole antenna	2	3
W6	Linx	ANT-2.4-CW-RCT-RP [3]	Single-band dipole antenna	2.2	N/A
W7	Delock	88395 [6]	Dual-band dipole antenna	1.5	2.1

Serial No.	-
HW Version	03
SW Version	N/A
Comment	-

Sample Name	Sample Code	Description
DE1015044ab01	ab01	"#2" Radiated Sample
Sample Parameter	**Value**	
Integral Antenna	Antenna on evaluation board (target platform): Antenova, Type A10194, SMD chip antenna, 1.8 dBi Peak gain in 2.4 GHz band, 4.1 dBi Peak gain in 5 GHz band	
Serial No.	-	
HW Version	03	
SW Version	N/A	
Comment	-	

Sample Name	Sample Code	Description
DE1015044ac01	ac01	"#3" Conducted Sample

Sample Parameter	Value
Antenna	Antenna connector on evaluation board (target platform): The following antennas are designated for 2.4 and 5 GHz WLAN transmission on EMMY-W165, as well as Bluetooth on EMMY-W165. - Table 2 of Test Object Specification:

				Peak gain [dBi]	
#	Manufacturer	Part number	Antenna type	2.4 GHz band	5 GHz band
W1	Antenova	A10194 [1]	SMD chip antenna 10x10x0.9 [mm]	1.8	4.1
W2	Linx	ANT-DB1-RAF-RPS [4]	Dual-band dipole antenna	2.5	**4.6**
W3	Taoglas	GW.40.2153	Dual-band dipole antenna	**3.74**	2.5
W4	Taoglas	GW.59.3153 [5]	Dual-band dipole antenna	2.37	2.93
W5	Walsin	RFDPA870900SBLB8G1	Dual-band dipole antenna	2	3
W6	Linx	ANT-2.4-CW-RCT-RP [3]	Single-band dipole antenna	2.2	N/A
W7	Delock	88395 [6]	Dual-band dipole antenna	1.5	2.1

Serial No.	-
HW Version	03
SW Version	N/A
Comment	-

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

3.3 WLAN POWER TABLE

Declared Power limits vs channel for FCC

Modulation group	WLAN TX Power in dBm at frequency in MHz												
	2412	2417	2422	2427	2432	2437	2442	2447	2452	2457	2462	2467	2472
DSSS 1, 2, 5.5, 11 Mbps	18	18	18	18	18	18	18	18	18	18	18	15	13
OFDM 6, 9, 12, 18 Mbps	**12**	**15**	**15**	**15**	**15**	**15**	**15**	**15**	**15**	15	**12**	**9**	9
OFDM 24, 36 Mbps	**12**	**15**	**15**	**15**	**15**	**15**	**15**	**15**	**15**	15	**12**	**9**	9
OFDM 48, 54 Mbps	**12**	13	13	13	13	13	13	13	13	13	**12**	9	9
HT20 MCS0, MCS1, MCS2	**12**	15	**15**	**15**	**15**	**15**	**15**	**15**	**15**	**15**	12	**9**	9
HT20 MCS3, MCS4	**12**	15	**15**	**15**	**15**	**15**	**15**	**15**	**15**	**15**	12	9	9
HT20 MCS5, MCS6, MCS7	**12**	13	13	13	13	13	13	13	13	13	12	9	9

Modulation group	WLAN TX Power in dBm at frequency in MHz								
	2422	2427	2432	2437	2442	2447	2452	2457	2462
HT40 MCS0, MCS1, MCS2	11	11	**11**	**11**	**11**	**11**	10	-	-
HT40 MCS3, MCS4	11	11	**11**	**11**	**11**	**11**	10	-	-
HT40 MCS5, MCS6, MCS7	11	**11**	**11**	**11**	**11**	**11**	**10**	-	-

Remark:

1. Please see detailed EUT settings in the test protocols.
2. Bold marked are values, which are reduced compared to EMMY-W161.

3.4 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**
Evaluation board	u-blox, u-blox EVB-W16, -	Target platform

3.5 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**
AC/DC power supply (115 V 60 Hz)	PeakTech, -, -, 081062045	PeakTech 6005D

3.6 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**
DE1015044aa01	DE1015044aa01, target platform, AC/DC power supply	Setup for conducted measurement
DE1015044ab01	DE1015044ab01, target platform, AC/DC power supply	Setup for radiated measurement
DE1015044ac01	DE1015044ac01, target platform, AC/DC power supply	Setup for conducted measurement

3.7 OPERATING MODES

This chapter describes the operating modes of the EUTs used for testing.

3.7.1 TEST CHANNELS

WLAN	2.4 GHz ISM 2400 - 2483.5 MHz		
20 MHz Test Channels:	**low**	**mid**	**high**
Channel:	1	6	13
Frequency [MHz]	2412	2437	2472

40 MHz Test Channels:	**low**	**mid**	**high**
Channel:	3	6	9
Frequency [MHz]	2422	2437	2452

	2.4 GHz ISM 2400 - 2483.5 MHz		
BT LE Test Channels:	**low**	**mid**	**high**
Channel:	0	19	39
Frequency [MHz]	2402	2440	2480

In case of testing another channel, the measurement summary state "additional channel" and the channel or centre frequency of the operating frequency is stated in the test protocol.

Duty cycle = 100 %

3.8 PRODUCT LABELLING

3.8.1 FCC ID LABEL

Please refer to the documentation of the applicant.

3.8.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

4 TEST RESULTS

4.1 CONDUCTED EMISSIONS AT AC MAINS

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.1.1TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C 63.10
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 EMC-32 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 & Average
- Frequency range: 150 kHz – 30 MHz
- Frequency steps: 2.5 kHz
- IF–Bandwidth: 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)
- 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.

4.1.2TEST 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).

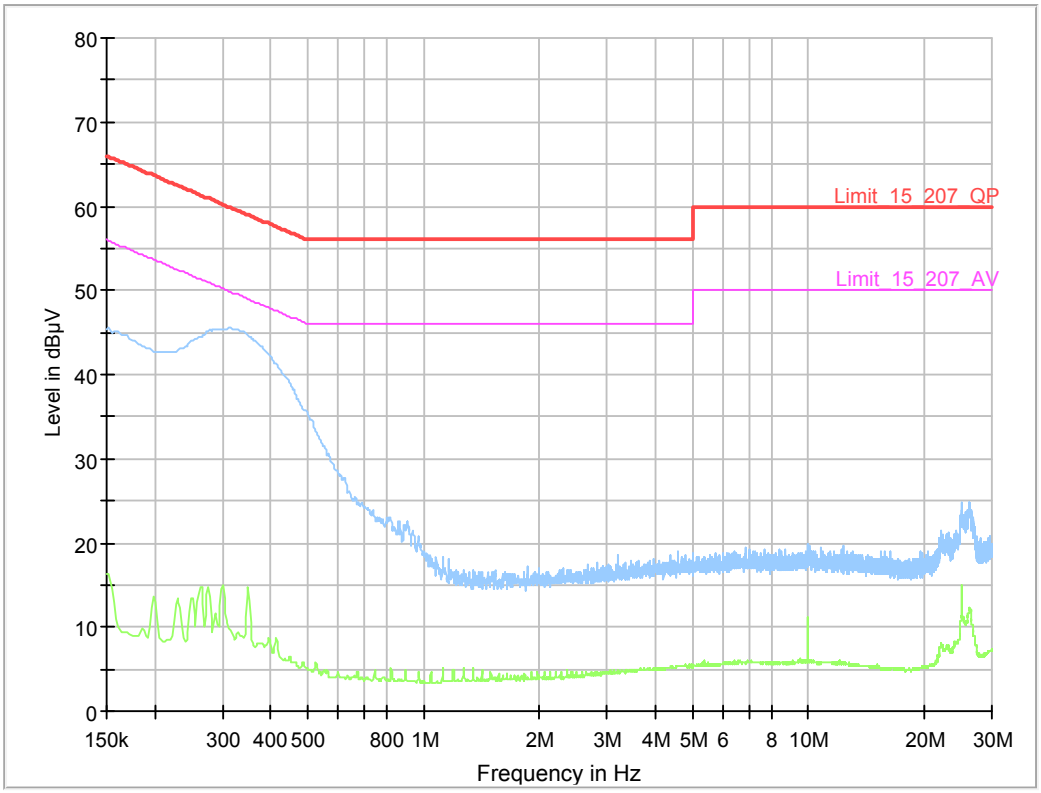
4.1.3TEST PROTOCOL

Temperature: 24 °C
Air Pressure: 992 hPa
Humidity: 34 %

Power line	Frequency [MHz]	Measured value QP [dBµV]	Measured value AV [dBµV]	QP Limit [dBµV]	AV Limit [dBµV]	Margin QP [dB]	Margin AV [dB]
N	-	-	-	-	-	> 20	> 20
L	-	-	-	-	-	> 20	> 20

Remark: Measured at 120 V 60 Hz input of lab power supply, Bluetooth LE, mid

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



Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
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Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
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4.1.5TEST EQUIPMENT USED

Conducted Emissions

4.2 OCCUPIED BANDWIDTH (6 DB)

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.2.1TEST 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: 3 MHz
- Trace: Maxhold
- Sweeps: 2000
- Sweep time: 5 ms (auto coupled)
- Detector: Peak

4.2.2TEST 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.

4.2.3TEST PROTOCOL

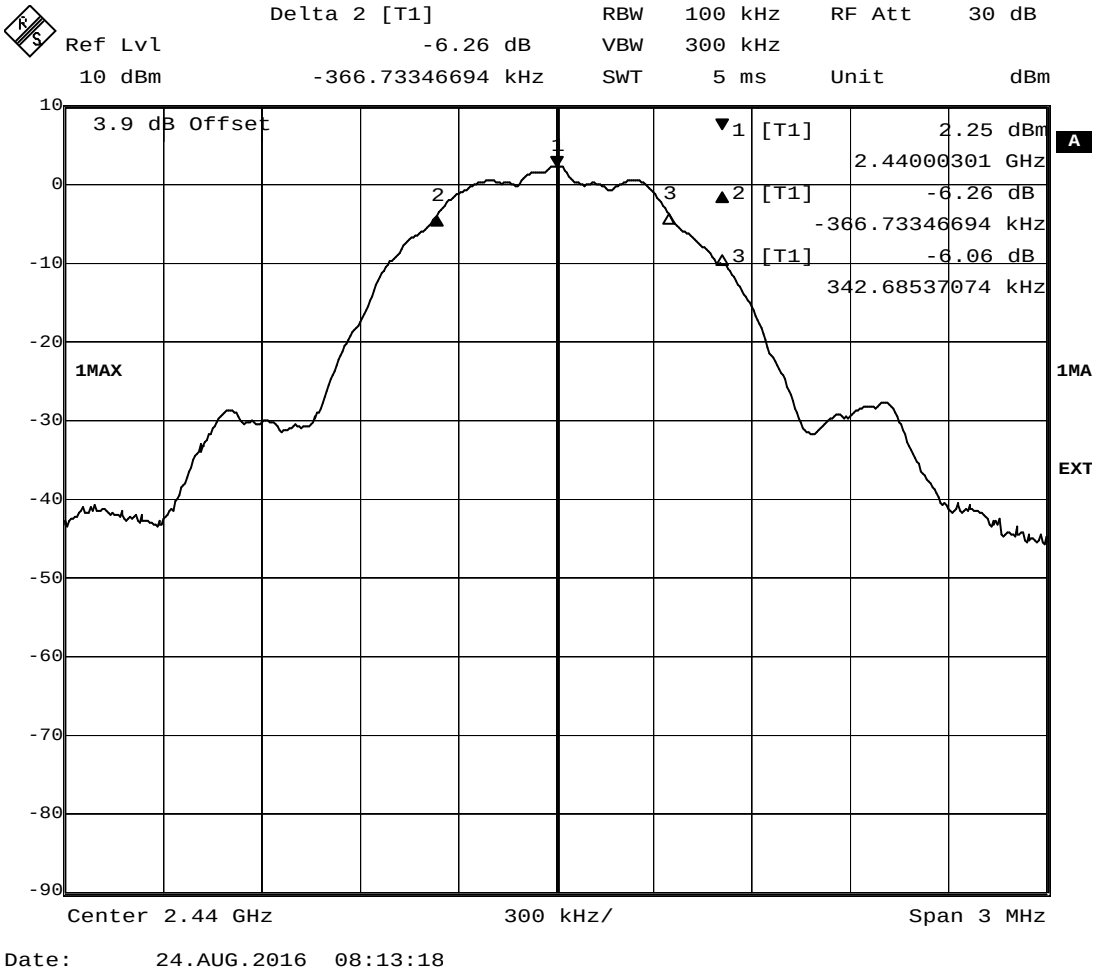
Ambient temperature: 26 °C
Air Pressure: 1017 hPa
Humidity: 46 %
BT LE GFSK

Band	Channel No.	Frequency [MHz]	6 dB Bandwidth [kHz]	Limit [kHz]	Margin to Limit [kHz]
2.4 GHz ISM	0.0	2402.0	709.4	500.0	207.4
	19.0	2440.0	709.4	500.0	**207.4**
	39.0	2480.0	709.4	500.0	207.4

Remark: -

4.2.4MEASUREMENT PLOT (SHOWING THE LOWEST VALUE, "WORST CASE")

Radio Technology = Bluetooth LE, Operating Frequency = mid



4.2.5TEST EQUIPMENT USED

Regulatory Bluetooth RF Test Solution

4.3 OCCUPIED BANDWIDTH (99%)

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.3.1TEST 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), 1 % to 5 % of OBW (6 dB):
  BT-LE: 30 kHz
- Video Bandwidth (VBW), approx. 3 x RBW:
  BT-LE: 100 kHz
- Span, 1.5 to 5 x OBW (6dB):
  BT-LE: 3 MHz
- Trace: Maxhold
- Sweeps: 2000
- Sweep time: 8.5 ms
- Detector: Sample

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

4.3.2TEST REQUIREMENTS / LIMITS

No applicable limit. Measurement results for information purpose.

4.3.3TEST PROTOCOL

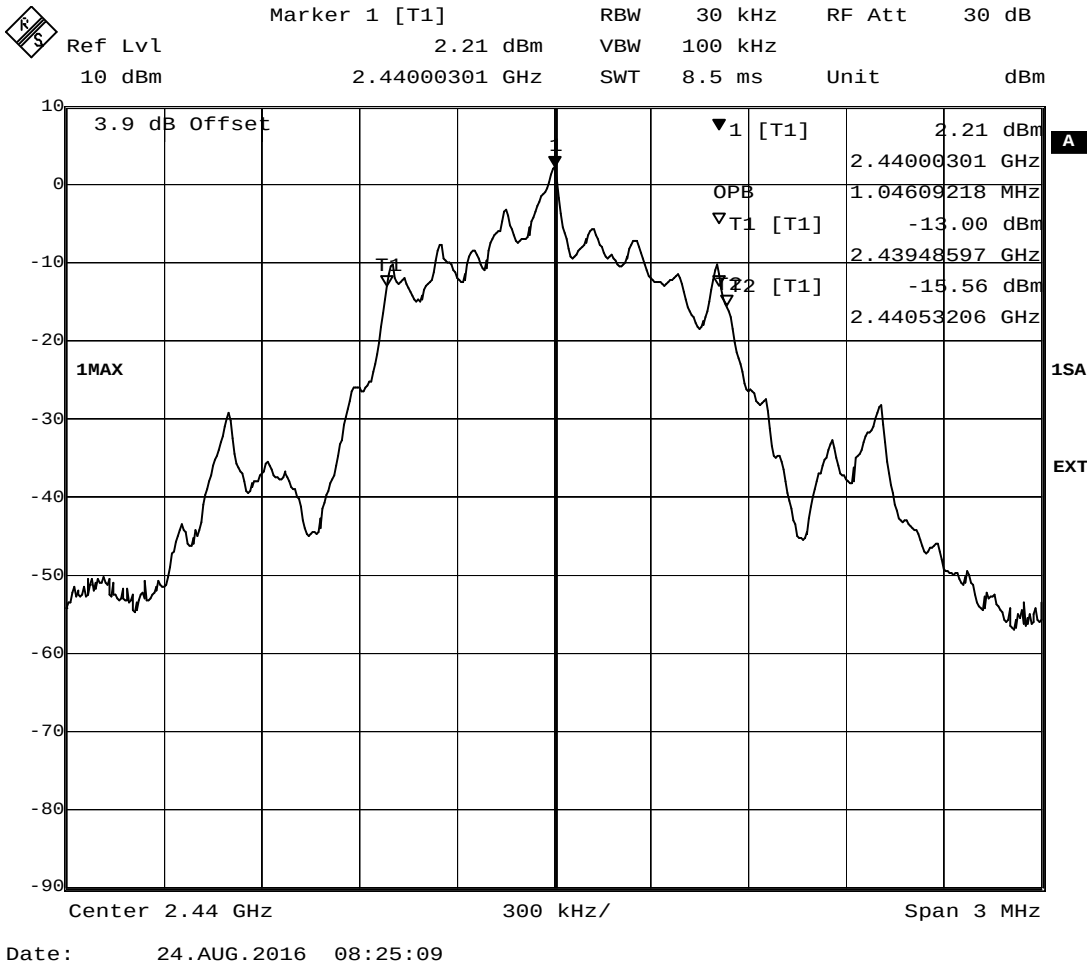
Ambient temperature: 24 °C
Air Pressure: 1013 hPa
Humidity: 44 %
BT LE

Band	Channel No.	Frequency [MHz]	99 % Bandwidth [kHz]
2.4 GHz ISM	0.0	2402.0	1046.1
	19.0	2440.0	**1046.1**
	39.0	2480.0	1046.1

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

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

Radio Technology = Bluetooth LE, Operating Frequency = mid



4.3.5TEST EQUIPMENT USED

Regulatory Bluetooth RF Test Solution

4.4 PEAK POWER OUTPUT

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.4.1TEST 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
- Sweep time: 5 ms
- Detector: Peak

The channel power function of the spectrum analyser was used (Used channel bandwidth = DTS bandwidth)

4.4.2TEST 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).

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

4.4.3TEST PROTOCOL

Ambient temperature: 23 °C
Air Pressure: 1017 hPa
Humidity: 41 %
BT LE

Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
2.4 GHz ISM	0	2402.0	3.2	30.0	**26.9**
	19	2440.0	2.9	30.0	27.1
	39	2480.0	2.8	30.0	27.2

Ambient temperature: 24 °C
Air Pressure: 1015 hPa
Humidity: 43 %

WLAN b-Mode; 20 MHz

Mode	Set EUT target power	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
DSSS, 11 Mbps		2412.0		30.0	
DSSS, 11 Mbps	18.0	2437.0	22.4	30.0	**7.6**
DSSS, 11 Mbps		2462.0		30.0	
DSSS, 11 Mbps		2467.0		30.0	
DSSS, 11 Mbps		2472.0		30.0	

WLAN g-Mode; 20 MHz

Mode	Set EUT target power	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
OFDM, 54 Mbps		2412.0		30.0	
OFDM, 36 Mbps		2417.0		30.0	
OFDM, 36 Mbps	15.0	2437.0	22.3	30.0	**7.7**
OFDM, 36 Mbps		2467.0		30.0	
OFDM, 54 Mbps		2472.0		30.0	

WLAN n-Mode; 20 MHz

Mode	Set EUT target power	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
OFDM, MCS6		2412.0		30.0	
OFDM, MCS3		2417.0		30.0	
OFDM, MCS3	15.0	2437.0	21.3	30.0	**8.7**
OFDM, MCS3		2467.0		30.0	
OFDM, MCS6		2472.0		30.0	

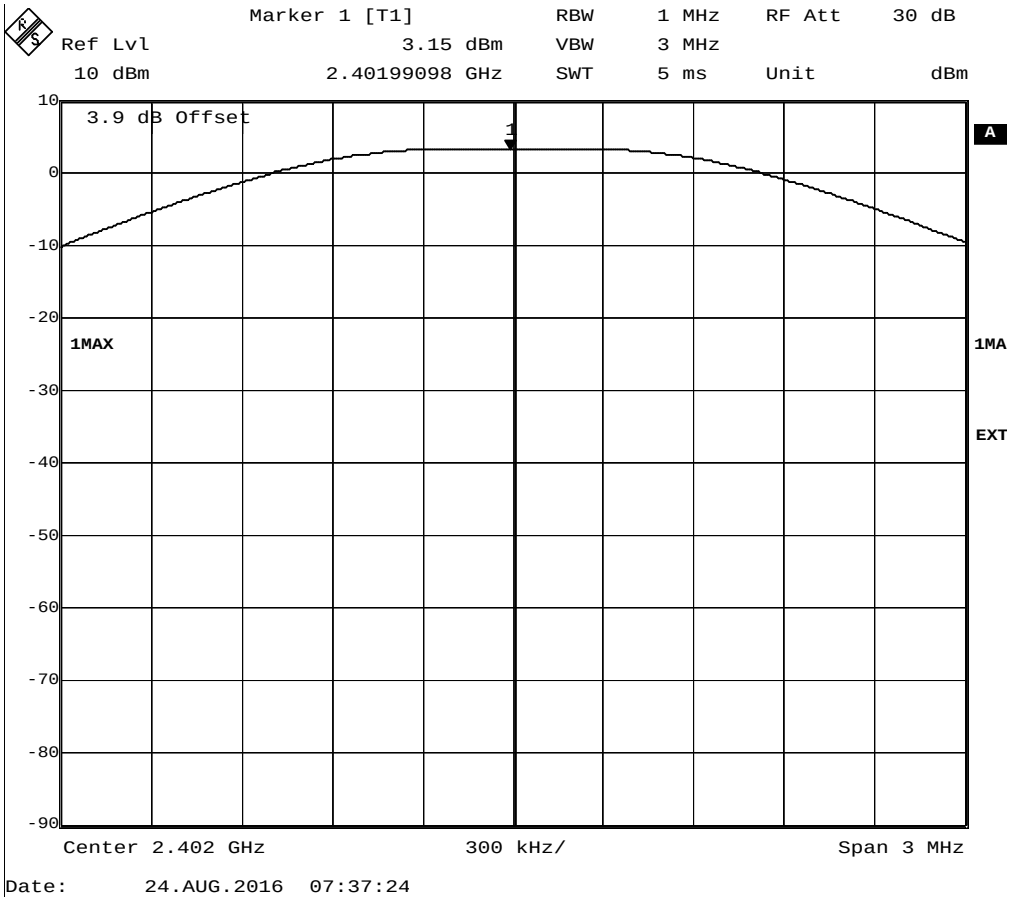
WLAN n-Mode; 40 MHz

Mode	Set EUT target power	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
OFDM, MCS6		2422.0		30.0	
OFDM, MCS4		2427.0		30.0	
OFDM, MCS4	11.0	2437.0	19.7	30.0	**10.3**
OFDM, MCS4		2447.0		30.0	
OFDM, MCS6		2462.0		30.0	

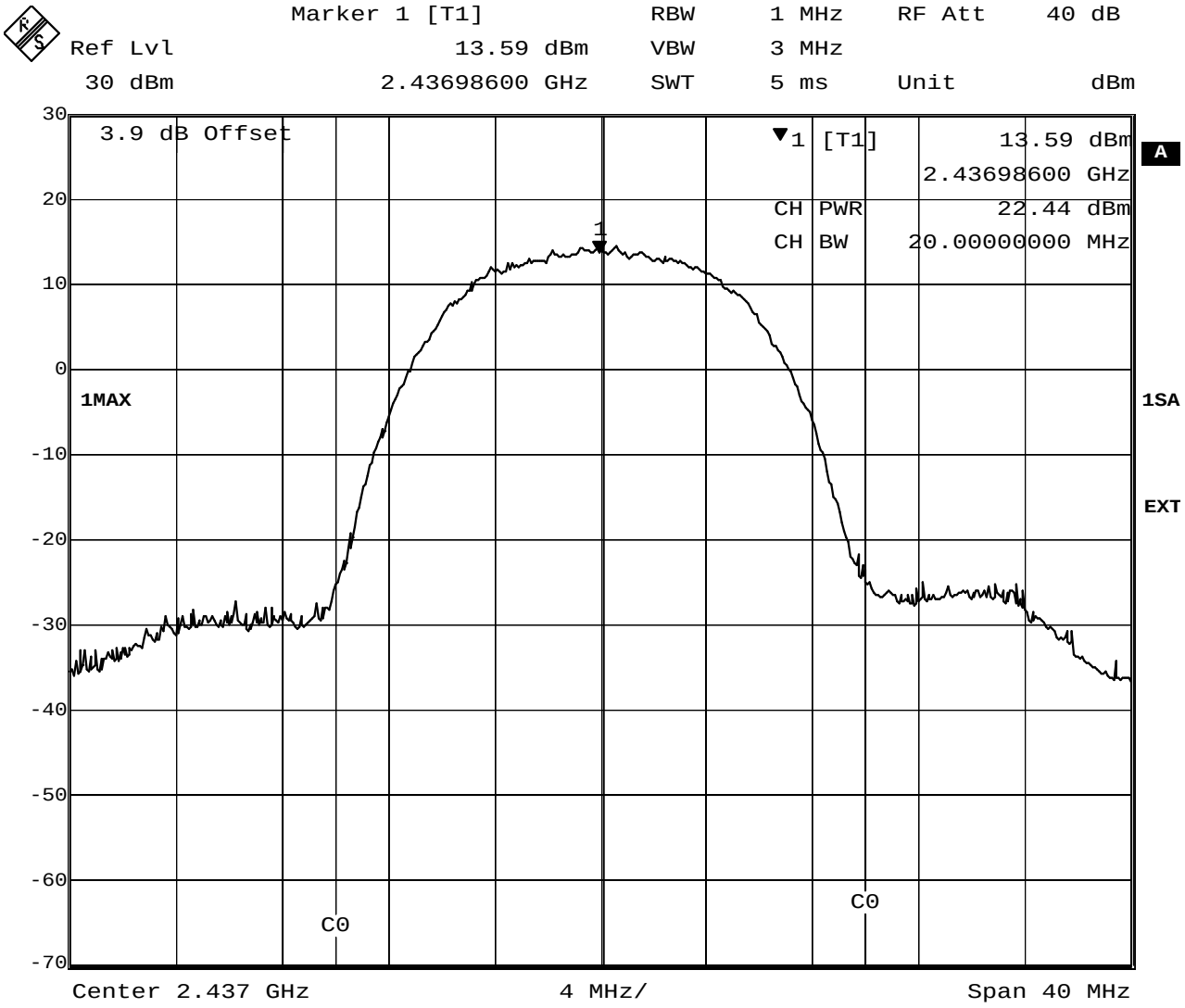
Remark: -

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

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

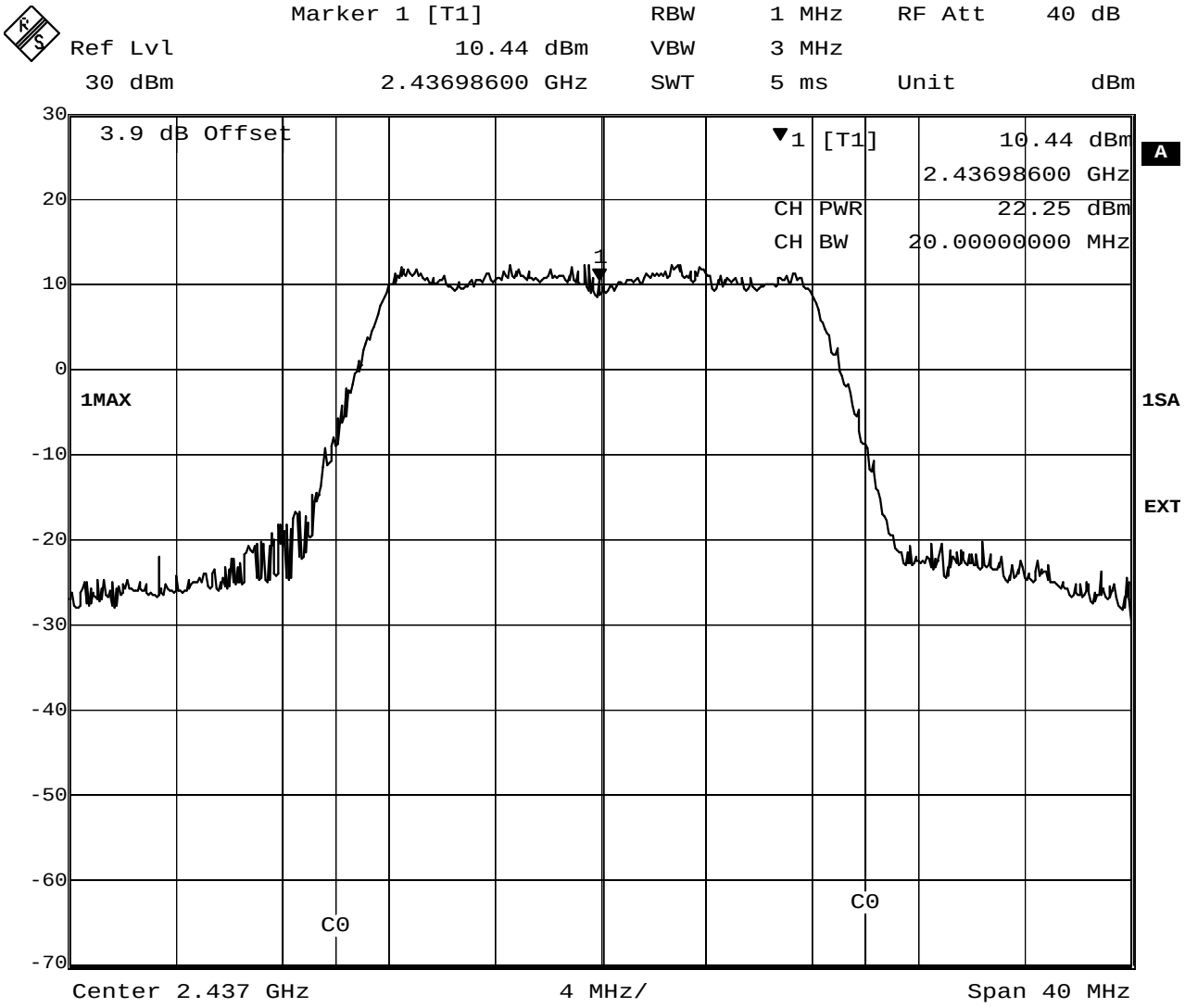


Radio Technology = WLAN b, Operating Frequency = mid,
Measurement method = conducted



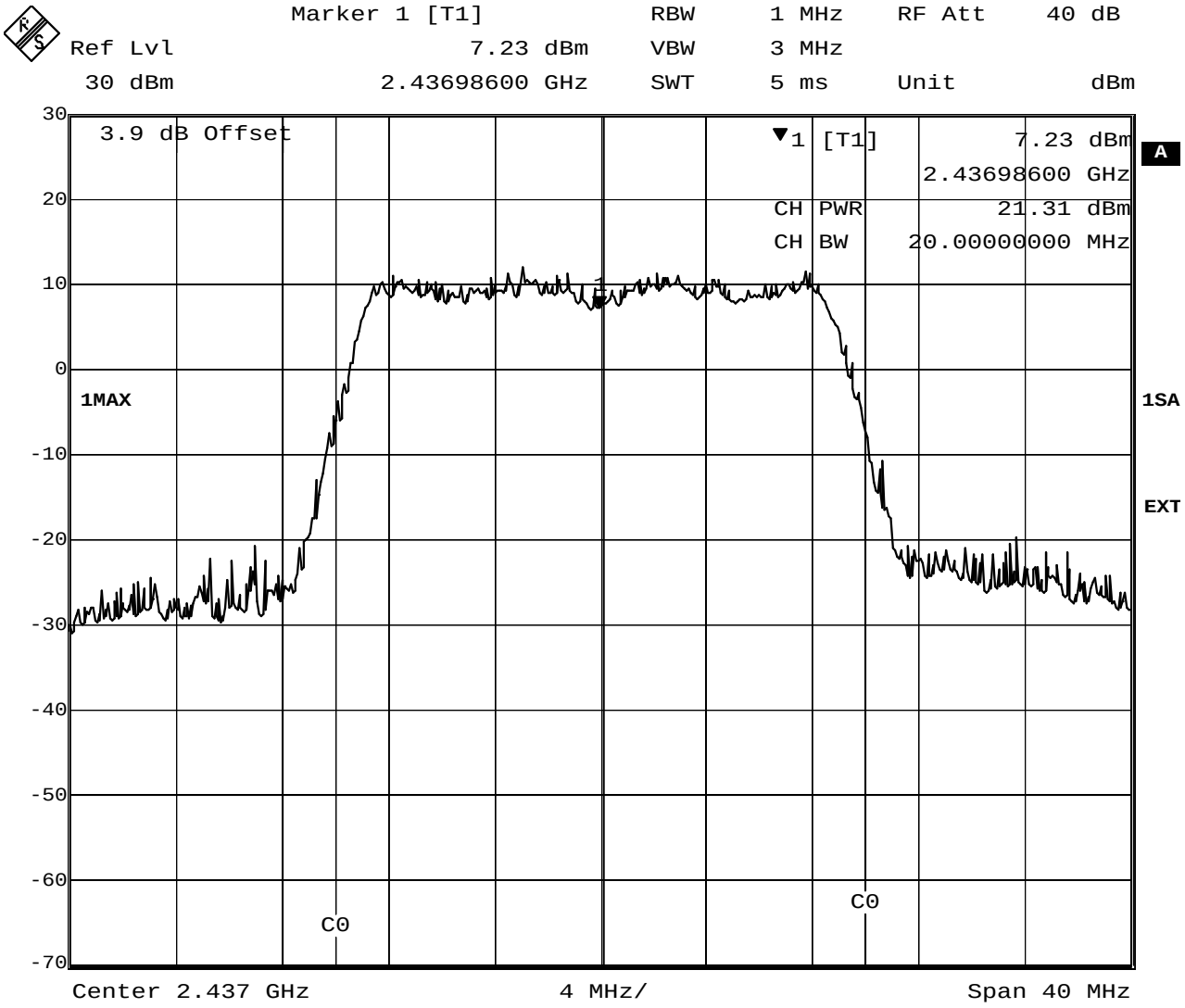
Title: Peak outputpower Power
Comment A: CH B: 2402 MHz
Date: 23.SEP.2016 16:29:16

Radio Technology = WLAN g, Operating Frequency = mid,
Measurement method = conducted



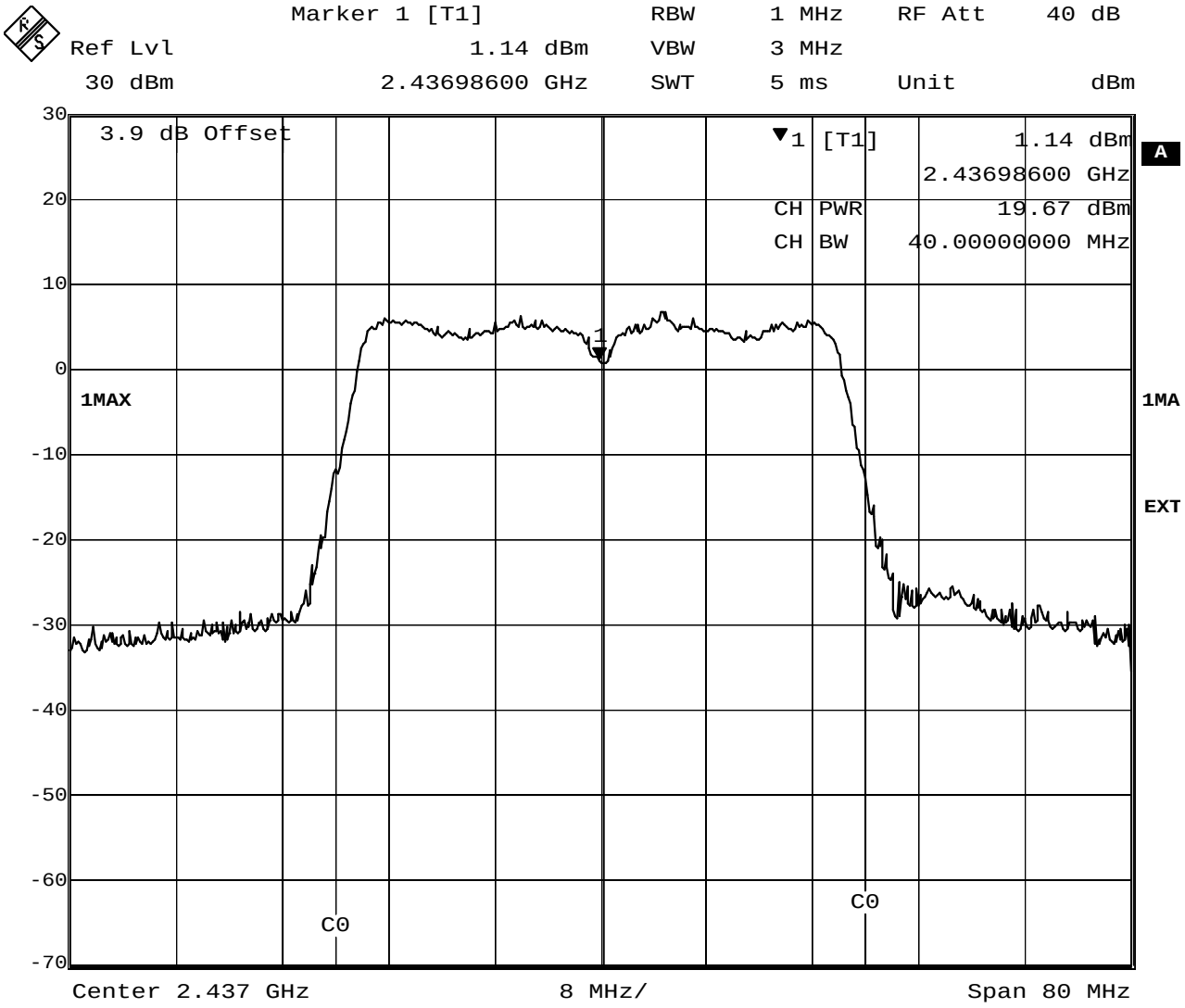
Title: Peak outputpower Power
Comment A: CH B: 2402 MHz
Date: 23.SEP.2016 16:19:32

Radio Technology = WLAN n 20 MHz, Operating Frequency = mid,
Measurement method = conducted



Title: Peak outputpower Power
Comment A: CH B: 2402 MHz
Date: 23.SEP.2016 16:32:25

Radio Technology = WLAN n 40 MHz, Operating Frequency = mid,
Measurement method = conducted



Title: Peak outputpower Power
Comment A: CH B: 2402 MHz
Date: 23.SEP.2016 16:42:15

4.4.5TEST EQUIPMENT USED

Regulatory Bluetooth RF Test Solution

4.5 SPURIOUS RF CONDUCTED EMISSIONS

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.5.1TEST 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.

4.5.2TEST 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.

4.5.3TEST PROTOCOL

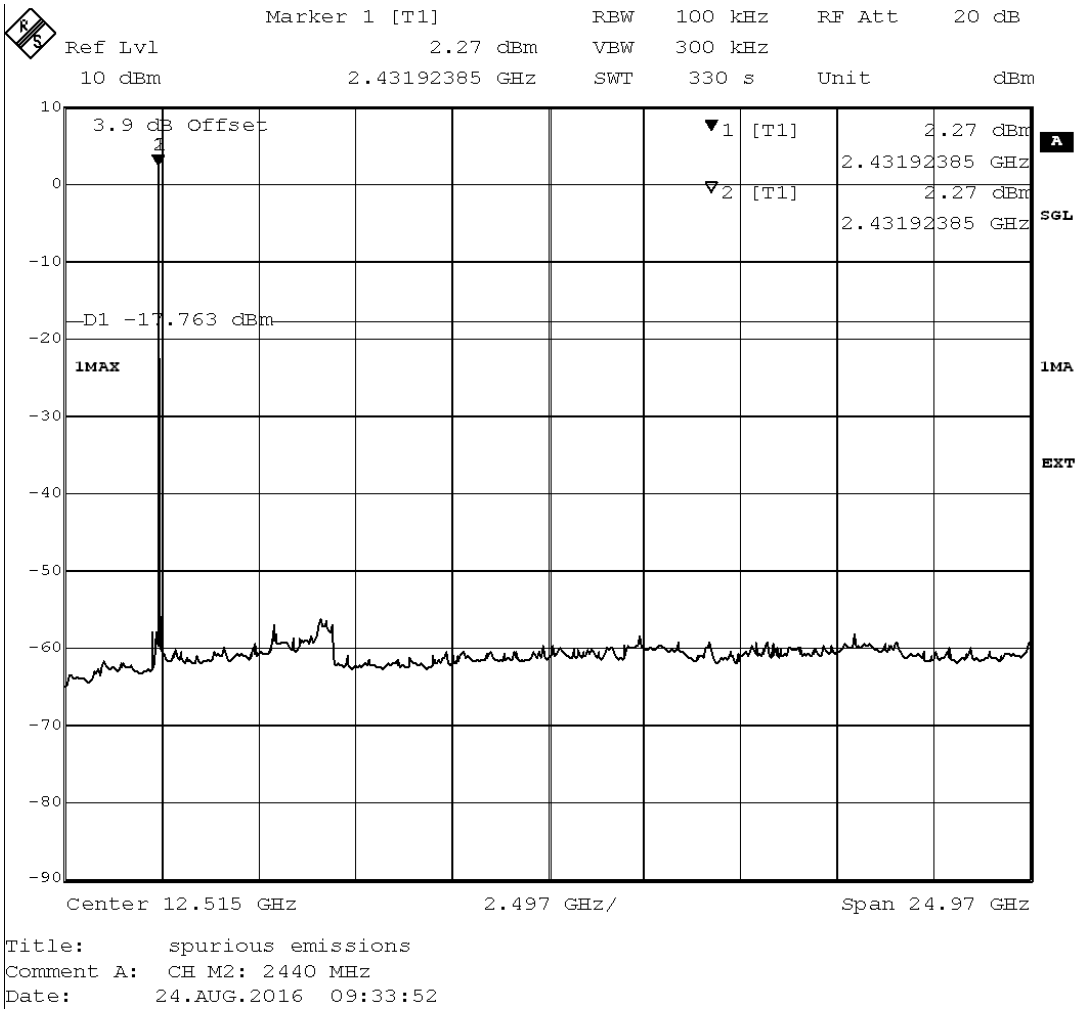
Ambient temperature: 23 °C
Air Pressure: 1017 hPa
Humidity: 41 %
BT LE GFSK

Channel No	Channel Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
0.0	2402.0	-	-	PEAK	100.0	2.5	-17.5	> 20 dB
19.0	2440.0	-	-	PEAK	100.0	2.3	-17.7	**> 20 dB**
39.0	2480.0	-	-	PEAK	100.0	3.5	-15.5	> 20 dB

Remark: -

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

Radio Technology = Bluetooth LE, Operating Frequency = mid



4.5.5TEST EQUIPMENT USED

Regulatory Bluetooth RF Test Solution

4.6 SPURIOUS RF CONDUCTED EMISSIONS IN RESTRICTED BANDS

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.6.1TEST DESCRIPTION

The Equipment Under Test (EUT) was set up to perform the conducted spurious emissions measurements. The antenna port of the EUT was connected to spectrum analyzer via a short coax cable with a known cable loss C_L. The measured voltage U_{meas} at the 50 Ohm input of the analyser was used to calculate the EUT output power at the antenna port:
$P = U_{meas} + C_L - 107$

where
P is the output power in dBm
U_{meas} is the measured voltage at the 50 Ohm input of the analyzer in dBµV
C_L is the cable loss of the used cable.

The maximum transmit isotropically antenna gain G_i (in dBi) was added to the measured output power P to determine the equivalent isotropically radiated power EIRP.
$EIRP = P + G_i$

where
P is the output power in dBm
G_i is maximum transmit antenna gain in dBi.

The resultant EIRP level was converted to an equivalent electric filed strength using the following relationship:
$E = EIRP - 20 \log d + 104.8$

where
E is the electric field strength in dBµV/m
EIRP is the equivalent isotropically radiated power in dBm
d is the specified measurement distance in m.

The appropriate maximum ground reflection factor was added to the EIRP:
6 dB for frequencies ≤ 30 MHz;
4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive; and
0 dB for frequencies > 1000 MHz).

Frequency range [MHz]	measurement distance d [m]	-20 log d [dB]	ground reflection factor [dB]
0,009 – 0,49	300	-49,54	6
0,49 – 30	30	-29,54	6
30 – 1000	3	-9,54	4,7
>1000	3	-9,54	0

1. Measurement up to 30 MHz

Step 1: pre measurement

This is a preliminary test to identify the highest amplitudes relative to the limit.

- Detector: Peak-Maxhold/ Quasipeak (FFT-based)
- 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 EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: final measurement

EMI receiver settings:

- Detector: Peak / Average / Quasi-Peak (depending on frequency)
- Frequency range: 0.009 – 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF–Bandwidth: 0.2 - 10 kHz (depending on frequency)
- Measuring time / Frequency step: 1 s

2. Measurement above 30 MHz and up to 1 GHz

Step 1: pre measurement

This is a preliminary test to identify the highest amplitudes relative to the limit.

Settings:

- 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

Step 2: final measurement

EMI receiver settings:

- 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

Step 1: pre measurement

Settings:

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

Step 2: final measurement

Spectrum analyzer settings:

- Detector: Peak / Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 1 s

4.6.2TEST 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

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

§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)

4.6.3TEST PROTOCOL

Ambient temperature: 21–25 °C
Air Pressure: 1002–1020 hPa
Humidity: 38–45 %
WLAN b-Mode; 20 MHz

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]
DSSS, 2Mbit / 13 dBm	2472.0	2485.881500 4943.733333	50.4 48.8	AV AV	1000	54 54	**3.6** **5.2**

Remark: -

Ambient temperature: 21–25 °C
Air Pressure: 1002–1020 hPa
Humidity: 38–45 %
WLAN g-Mode; 20 MHz

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]
OFDM 9Mbit / 15 dBm	2417.0	2389.146667 2389.146667 2389.946667 2389.946667	47.4 66.2 47.9 67.4	AV Peak AV Peak	1000	54 74 54 74	6.6 7.8 6.1 6.6
OFDM, 9Mbit / 12 dBm	2462.0	2483.500000	60.0 46.7	Peak AV	1000	74 54	14.0 7.3
OFDM, 9Mbit / 9 dBm	2467.0	2483.505500 2483.505500 2484.237000 2484.237000 2484.776000 2484.776000 2484.814500 2484.814500 2485.139000 2485.139000	51.6 65.8 51.2 66.8 50.8 66.4 50.8 66.4 50.5 66.5	AV Peak AV Peak AV Peak AV Peak AV Peak	1000	54 74 54 74 54 74 54 74 54 74	**2.4** 8.3 2.8 7.3 3.2 7.6 3.3 7.6 3.5 7.5
OFDM, 48Mbit / 9 dBm	2467.0	2483.879500	46.0	AV	1000	54	8.0

Remark: -

Ambient temperature: 21–25 °C
Air Pressure: 1002–1020 hPa
Humidity: 38–45 %
WLAN n-Mode; 20 MHz

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]
HT20, MCS2 / 15 dBm	2457.0	2483.500000	67.0 49.7	PEAK AV	1000	74 54	7.0 4.3
HT20, MCS2 / 9 dBm	2467.0	2483.747500	48.9	AV	1000	54	5.1
HT20, MCS2 / 9 dBm	2472.0	2483.527500 2483.527500 2483.692500 2483.692500 2484.022500 2484.022500 2484.242500 2484.242500	48.8 71.2 48.9 71.0 48.7 69.5 48.7 68.7	AV Peak AV Peak AV Peak AV Peak	1000	54 74 54 74 54 74 54 74	5.2 **2.8** 5.1 3.0 5.3 4.5 5.3 5.3
HT20, MCS4 / 12 dBm	2462.0	2484.072000	67.0 50.6	PEAK AV	1000	74 54	7.0 3.4
HT20, MCS6 / 12 dBm	2462.0	2483.676000	67.1 51.2	Peak AV	1000	74 54	6.9 2.8
HT20, MCS6 / 9 dBm	2467.0	2483.665000	65.0 50.6	Peak AV	1000	74 54	9.0 3.4

Remark: -

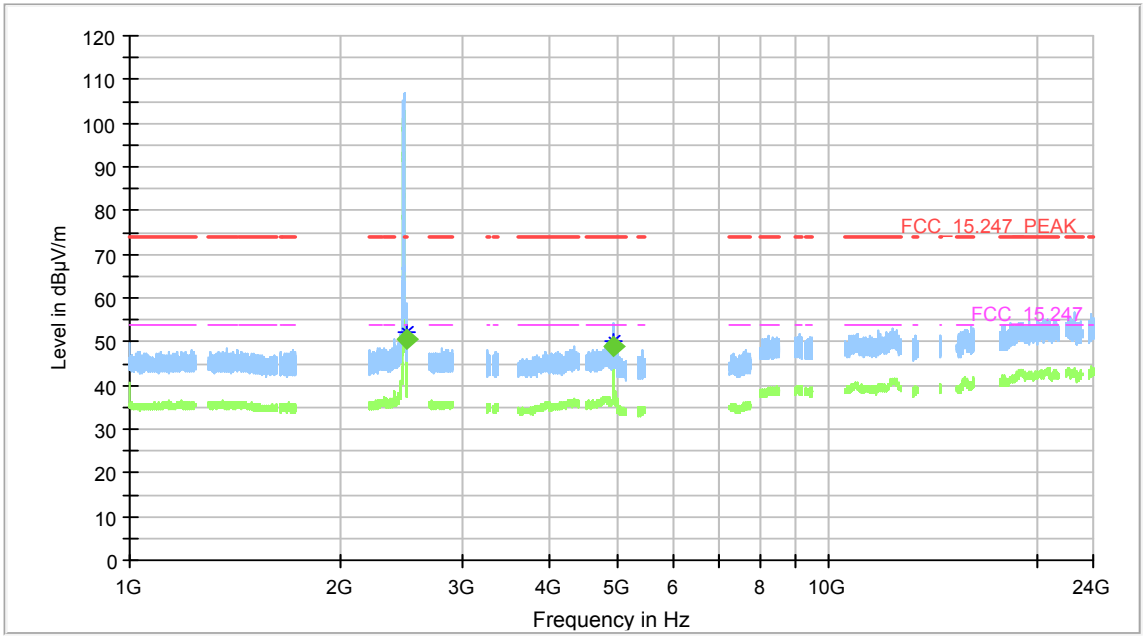
Ambient temperature: 21–25 °C
Air Pressure: 1002–1020 hPa
Humidity: 38–45 %
WLAN n-Mode; 40 MHz

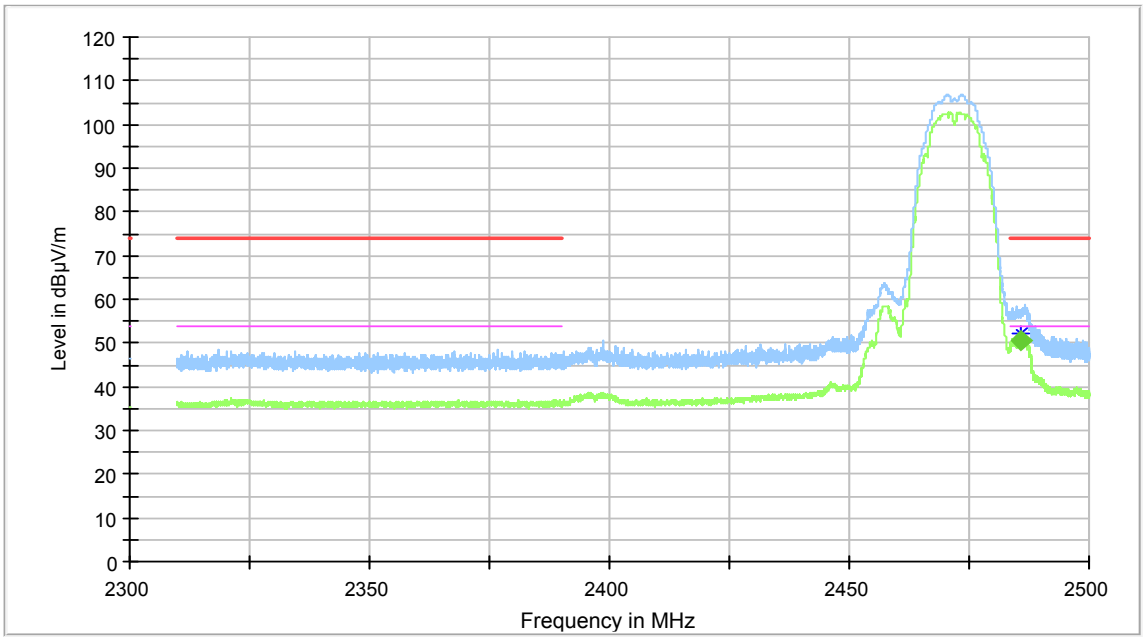
Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]
HT40, MCS0 / 11 dBm	2422.0	2389.866667 2389.866667	67.0 54.8	PEAK AV	1000	74 54	7.0 2.2
HT40, MCS0 / 11 dBm	2442.0	2483.511000 2483.511000	65.2 48.4	Peak AV	1000	74 54	8.8 5.6
HT40, MCS0 / 11 dBm	2447.0	2484.077500 2483.533000	68.0 52.3	Peak AV	1000	74 54	6.0 1.7
HT40, MCS0 / 10 dBm	2452.0	2483.879500 2483.879500 2484.759500 2484.759500	52.6 68.1 52.4 66.4	AV Peak AV Peak	1000	54 74 54 74	**1.4** 5.9 1.6 7.6
HT40, MCS3 / 10 dBm	2452.0	2483.604500 2483.604500	53.5 67.5	AV Peak	1000	54 74	1.5 7.5
HT40, MCS6 / 11 dBm	2427.0	2389.866667 2389.866667	65.9 50.0	Peak AV	1000	74 54	8.1 4.0
HT40, MCS6 / 11 dBm	2447.0	2484.088500 2484.088500	65.8 51.7	Peak AV	1000	74 54	8.2 2.3
HT40, MCS6 / 10 dBm	2452.0	2483.934500 2483.934500	65,5 51.6	Peak AV	1000	74 54	8.5 2.4

Remark: -

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

Radio Technology = WLAN b-Mode, 2Mbit / 13 dBm, Operating Frequency = high

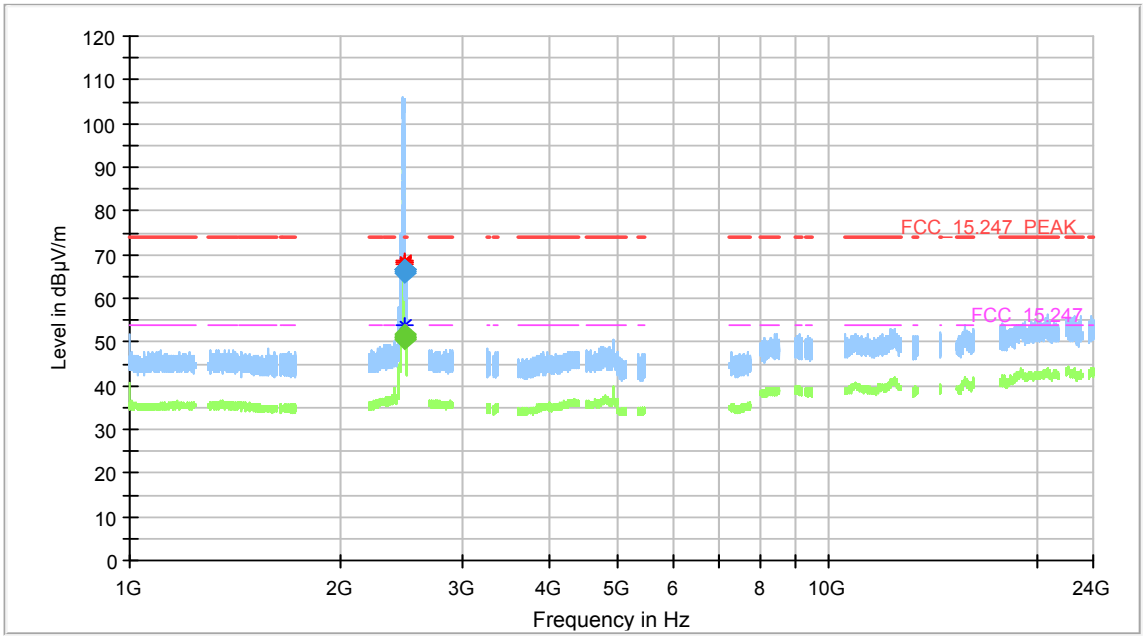


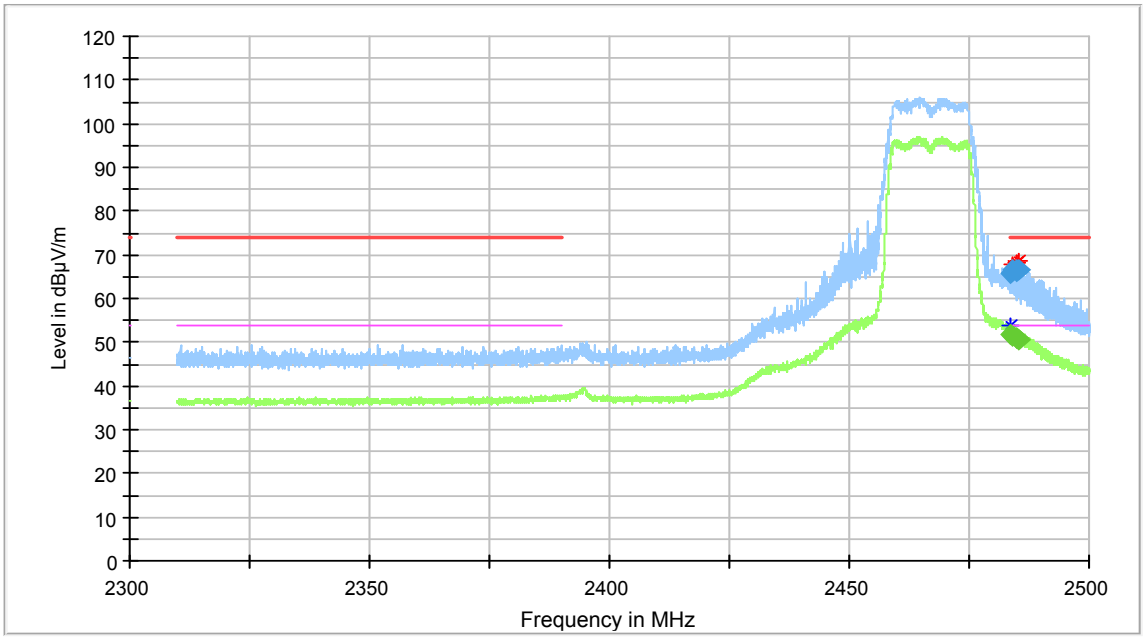


Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
2485.881500	---	50.36	54.00	3.64	1000.0	1000.000	-5.8
4943.733333	---	48.80	54.00	5.20	1000.0	1000.000	-5.8

Radio Technology = WLAN g-Mode, 9Mbit / 9 dBm, Operating Frequency = 2467.0 MHz

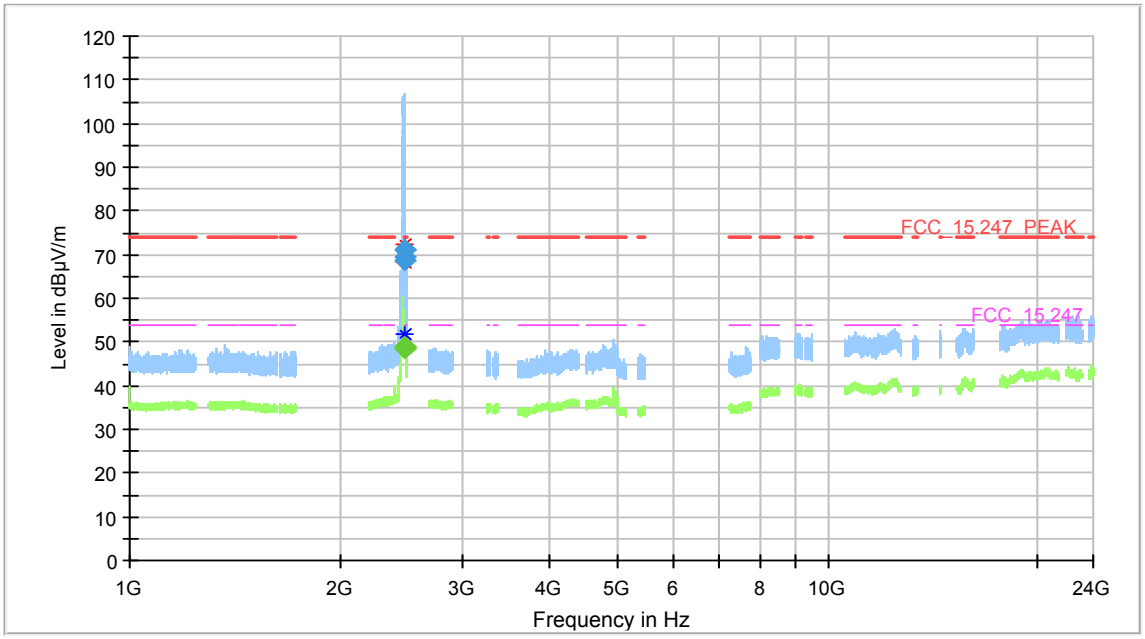


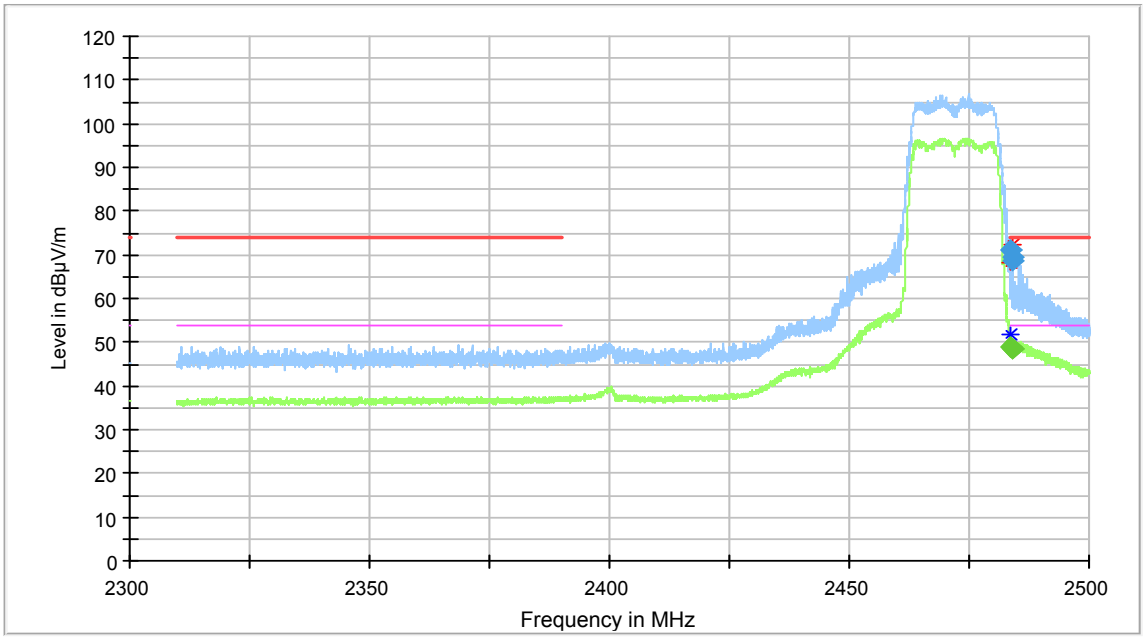


Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
2483.505500	---	51.63	54.00	**2.37**	1000.0	1000.000	-5.8
2483.505500	65.74	---	74.00	8.26	1000.0	1000.000	-5.8
2484.237000	---	51.21	54.00	2.79	1000.0	1000.000	-5.8
2484.237000	66.77	---	74.00	7.23	1000.0	1000.000	-5.8
2484.776000	---	50.79	54.00	3.21	1000.0	1000.000	-5.8
2484.776000	66.41	---	74.00	7.59	1000.0	1000.000	-5.8
2484.814500	---	50.77	54.00	3.23	1000.0	1000.000	-5.8
2484.814500	66.36	---	74.00	7.64	1000.0	1000.000	-5.8
2485.139000	---	50.49	54.00	3.51	1000.0	1000.000	-5.8
2485.139000	66.52	---	74.00	7.48	1000.0	1000.000	-5.8

Radio Technology = WLAN n-Mode HT20, MCS2 / 9 dBm, Operating Frequency = high

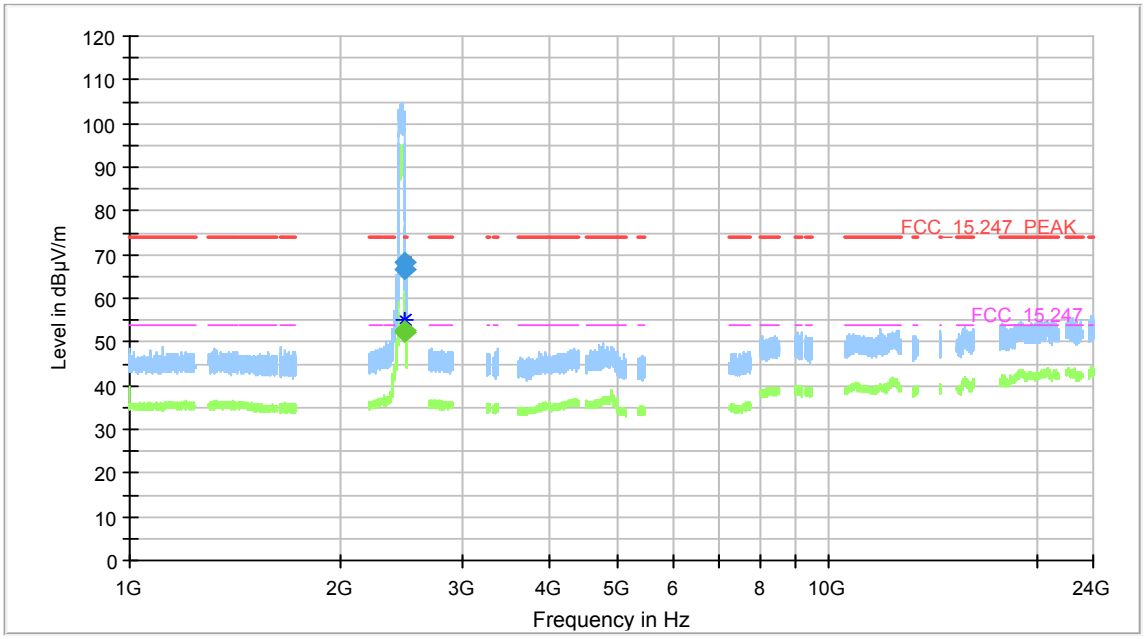


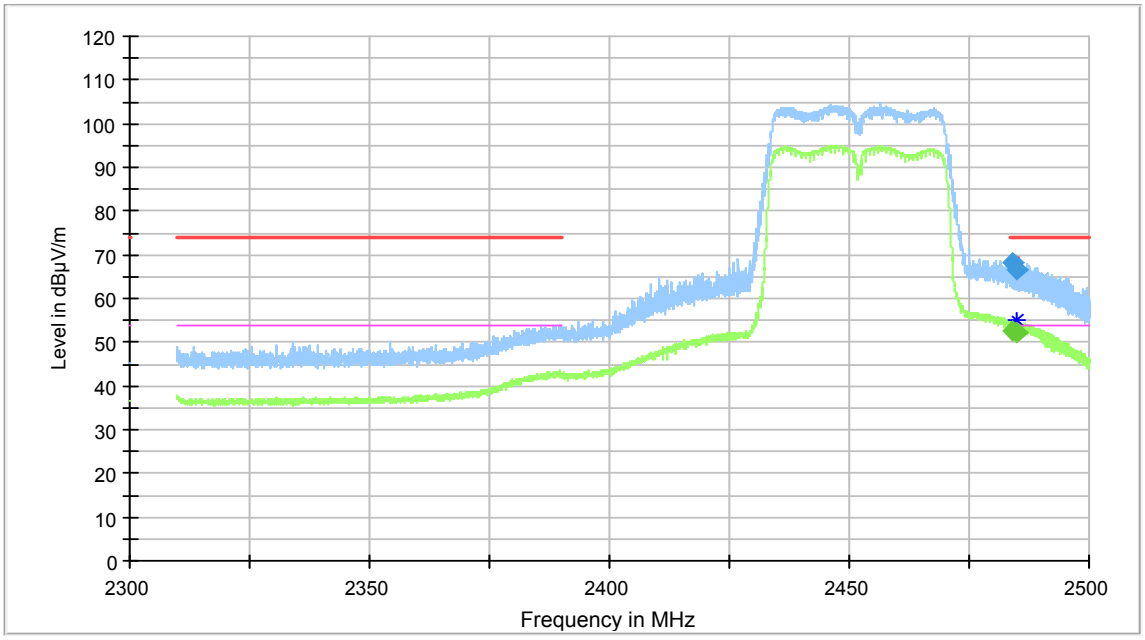


Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
2483.527500	---	48.84	54.00	5.16	1000.0	1000.000	-5.8
2483.527500	71.18	---	74.00	**2.82**	1000.0	1000.000	-5.8
2483.692500	---	48.94	54.00	5.06	1000.0	1000.000	-5.8
2483.692500	70.97	---	74.00	3.03	1000.0	1000.000	-5.8
2484.022500	---	48.67	54.00	5.33	1000.0	1000.000	-5.8
2484.022500	69.49	---	74.00	4.51	1000.0	1000.000	-5.8
2484.242500	---	48.67	54.00	5.33	1000.0	1000.000	-5.8
2484.242500	68.70	---	74.00	5.30	1000.0	1000.000	-5.8

Radio Technology = WLAN n-Mode HT40, MCS0 / 10 dBm, Operating Frequency = 2452.0 MHz





Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
2483.879500	---	52.63	54.00	**1.37**	1000.0	1000.000	-5.8
2483.879500	68.05	---	74.00	5.95	1000.0	1000.000	-5.8
2484.759500	---	52.38	54.00	1.62	1000.0	1000.000	-5.8
2484.759500	66.38	---	74.00	7.62	1000.0	1000.000	-5.8

4.6.5TEST EQUIPMENT USED

Radiated Emissions

4.7 BAND EDGE COMPLIANCE CONDUCTED

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.7.1TEST 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:

- Frequency Range 30 MHz – 25 GHz
- Detector: Peak
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweeptime: 330 s
- Sweeps: 2
- Trace: Maxhold

4.7.2TEST 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..."

4.7.3TEST PROTOCOL

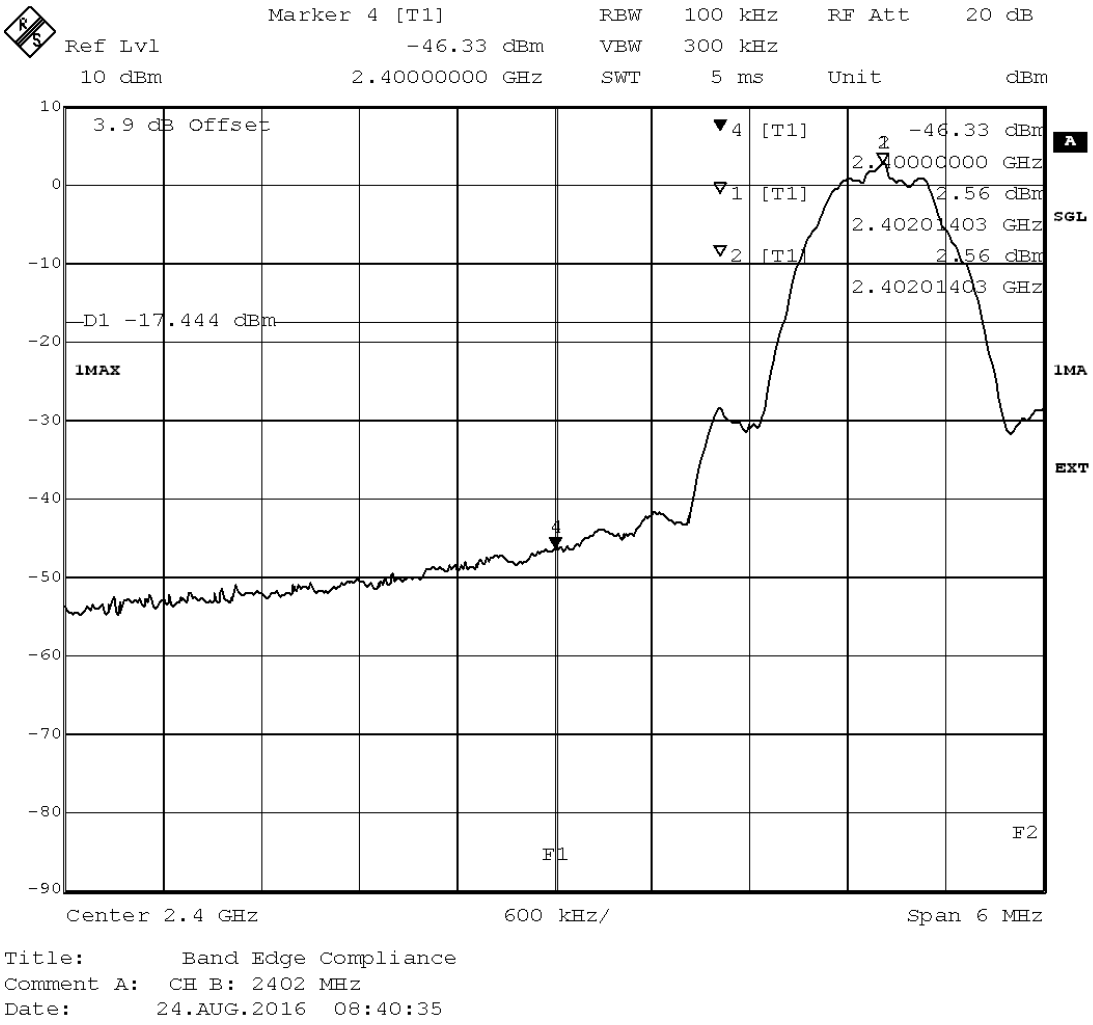
Ambient temperature: 22 °C
Air Pressure: 1015 hPa
Humidity: 43 %
BT LE GFSK

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]
0.0	2402.0	2400.0	-46.3	PEAK	100.0	2.6	-17.4	**28.9**
39.0	2480.0	2483.5	-50.9	PEAK	100.0	3.5	-16.5	34.4

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

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

Radio Technology = Bluetooth LE, Operating Frequency = low, Band Edge = low



4.7.5TEST EQUIPMENT USED

Regulatory Bluetooth RF Test Solution

4.8 BAND EDGE COMPLIANCE CONDUCTED AT RESTRICTED BAND

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.8.1TEST DESCRIPTION

Please see test description for the test case "Spurious RF Conducted Emissions in restricted bands"

4.8.2TEST 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

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

§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)

4.8.3TEST PROTOCOL

Ambient temperature: 21–25 °C
Air Pressure: 1002–1020 hPa
Humidity: 38–45 %
WLAN g-Mode; 20 MHz

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
OFDM, 9Mbit / 12 dBm	2462.0	2483.8135 2483.8135	66.7 47.9	Peak AV	1000	74 54	7.3 6.1	BE
OFDM, 9Mbit / 9 dBm	2467.0	2484.237000 2483.505500	66.8 51.6	Peak AV	1000	74 54	7.2 **2.4**	BE
OFDM, 48Mbit / 9 dBm	2467.0	2483.692500 2483.692500	63.3 46.8	Peak AV	1000	74 54	10.7 7.2	BE

Ambient temperature: 21–25 °C
Air Pressure: 1002–1020 hPa
Humidity: 38–45 %
WLAN n-Mode; 20 MHz

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
HT20, MCS2 / 15 dBm	2457.0	2484.820000 2483.500000	64.5 49.7	Peak AV	1000	74 54	9.5 4.3	BE
HT20, MCS2 / 9 dBm	2467.0	2484.776000 2484.747500	64.1 48.9	Peak AV	1000	74 54	9.9 5.1	BE
HT20, MCS2 / 9 dBm	2472.0	2483.527500 2483.962500	71.2 48.9	Peak AV	1000	74 54	2.8 5.1	BE
HT20, MCS6 / 12 dBm	2462.0	2485.496500 2483.676000	69.5 51.2	Peak AV	1000	74 54	4.5 2.8	BE
HT20, MCS6 / 9 dBm	2467.0	2484.528500 2484.528500	69.4 51.8	Peak AV	1000	74 54	4.6 **2.2**	BE

Remark: -

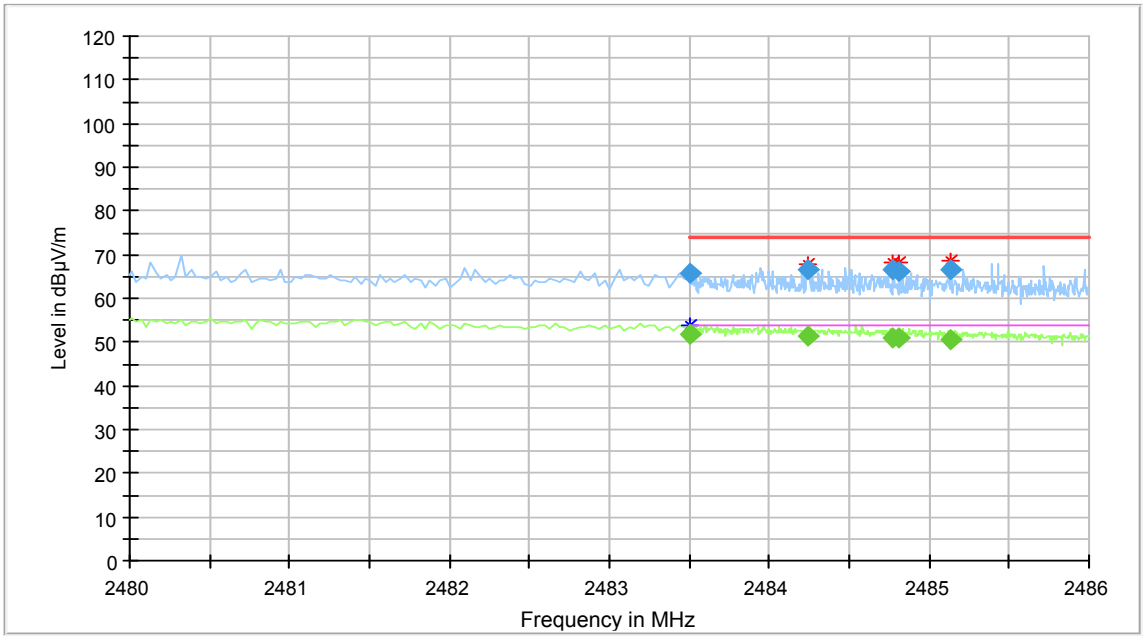
Ambient temperature: 21–25 °C
Air Pressure: 1002–1020 hPa
Humidity: 38–45 %
WLAN n-Mode; 40 MHz

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
HT40, MCS0 / 11 dBm	2442.0	2483.511000 2483.511000	65.2 48.4	Peak AV	1000	74 54	8.8 5.6	BE
HT40, MCS0 / 11 dBm	2447.0	2484.077500 2483.533000	68.0 52.3	Peak AV	1000	74 54	6.0 1.7	BE
HT40, MCS6 / 11 dBm	2447.0	2484.088500 2484.088500	65.8 51.7	Peak AV	1000	74 54	8.2 2.3	BE
HT40, MCS0 / 10 dBm	2452.0	2483.879500 2483.879500 2484.759500 2484.759500	52.6 68.1 52.4 66.4	AV Peak AV Peak	1000	54 74 54 74	**1.4** 5.9 1.6 7.6	BE
HT40, MCS3 / 10 dBm	2452.0	2483.604500 2483.604500	53.5 67.5	AV Peak	1000	54 74	1.5 7.5	BE
HT40, MCS6 / 10 dBm	2452.0	2483.934500 2483.934500	65,5 51.6	Peak AV	1000	74 54	8.5 2.4	BE

Remark: -

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

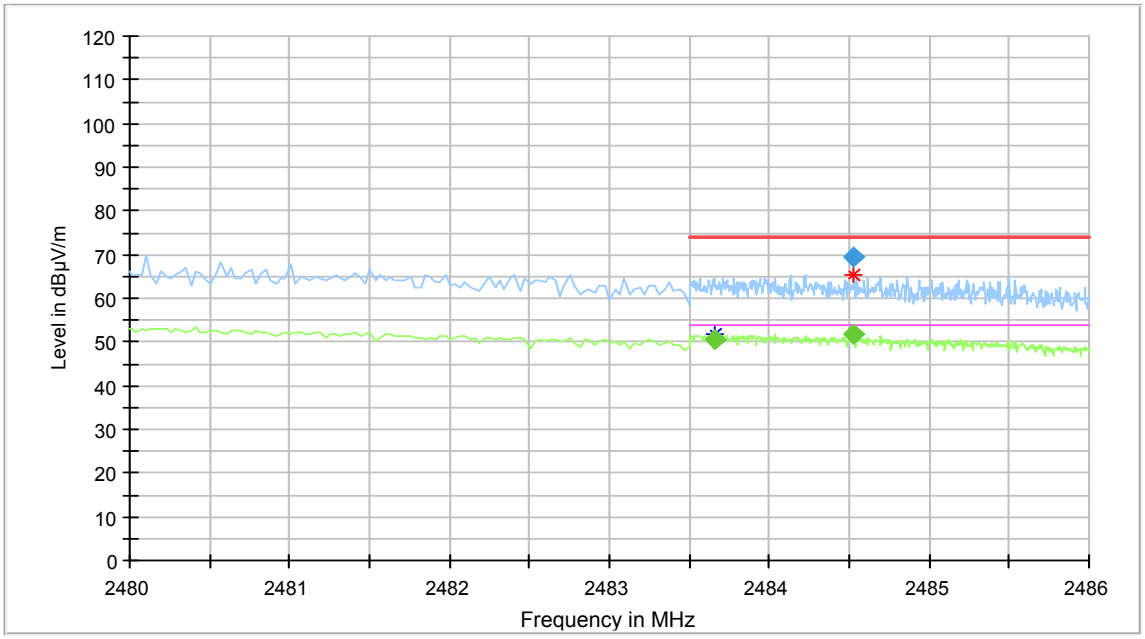
Radio Technology = WLAN g-Mode, 9Mbit / 9 dBm, Operating Frequency = 2467.0 MHz



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
2483.505500	---	51.63	54.00	**2.37**	1000.0	1000.000	-5.8
2483.505500	65.74	---	74.00	8.26	1000.0	1000.000	-5.8
2484.237000	---	51.21	54.00	2.79	1000.0	1000.000	-5.8
2484.237000	66.77	---	74.00	7.23	1000.0	1000.000	-5.8
2484.776000	---	50.79	54.00	3.21	1000.0	1000.000	-5.8
2484.776000	66.41	---	74.00	7.59	1000.0	1000.000	-5.8
2484.814500	---	50.77	54.00	3.23	1000.0	1000.000	-5.8
2484.814500	66.36	---	74.00	7.64	1000.0	1000.000	-5.8
2485.139000	---	50.49	54.00	3.51	1000.0	1000.000	-5.8
2485.139000	66.52	---	74.00	7.48	1000.0	1000.000	-5.8

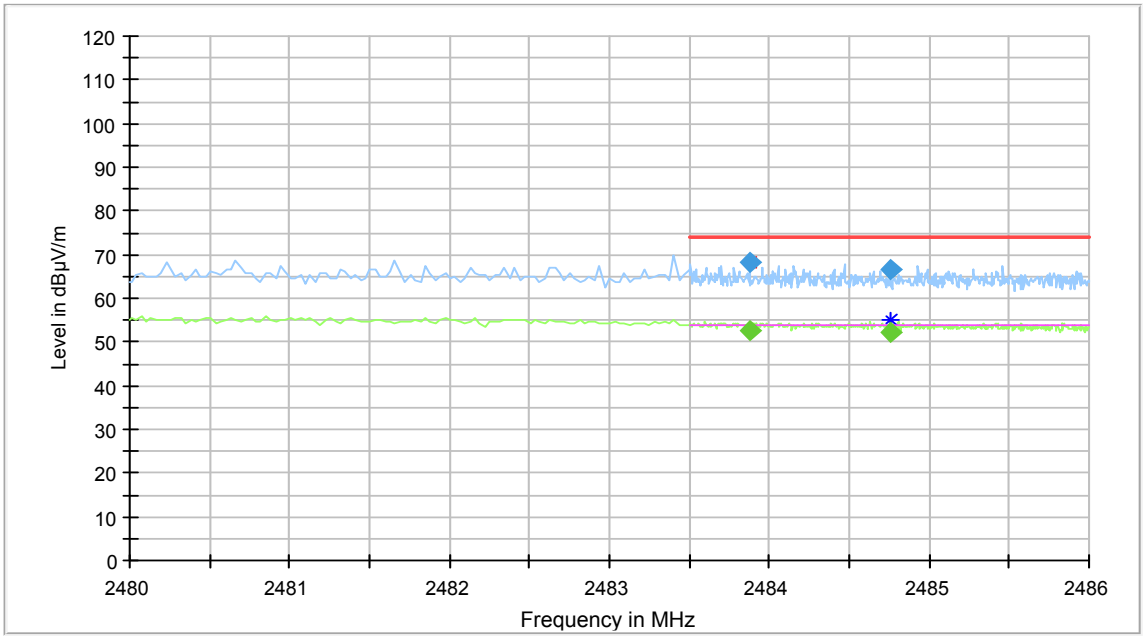
Radio Technology = WLAN n-Mode HT20, MCS6 / 9 dBm, Operating Frequency = 2467.0 MHz



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
2483.665000	---	50.56	54.00	3.44	1000.0	1000.000	-5.8
2484.528500	---	51.77	54.00	**2.23**	1000.0	1000.000	-5.8
2484.528500	69.35	---	74.00	4.65	1000.0	1000.000	-5.8

Radio Technology = WLAN n-Mode HT40, MCS0 / 10 dBm, Operating Frequency = 2452.0 MHz



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
2483.879500	---	52.63	54.00	**1.37**	1000.0	1000.000	-5.8
2483.879500	68.05	---	74.00	5.95	1000.0	1000.000	-5.8
2484.759500	---	52.38	54.00	1.62	1000.0	1000.000	-5.8
2484.759500	66.38	---	74.00	7.62	1000.0	1000.000	-5.8

4.8.5TEST EQUIPMENT USED

Radiated Emissions

4.9 POWER DENSITY

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.9.1TEST 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
- Sweep time: 420 ms (BT-LE)
- Detector: Peak

4.9.2TEST 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.

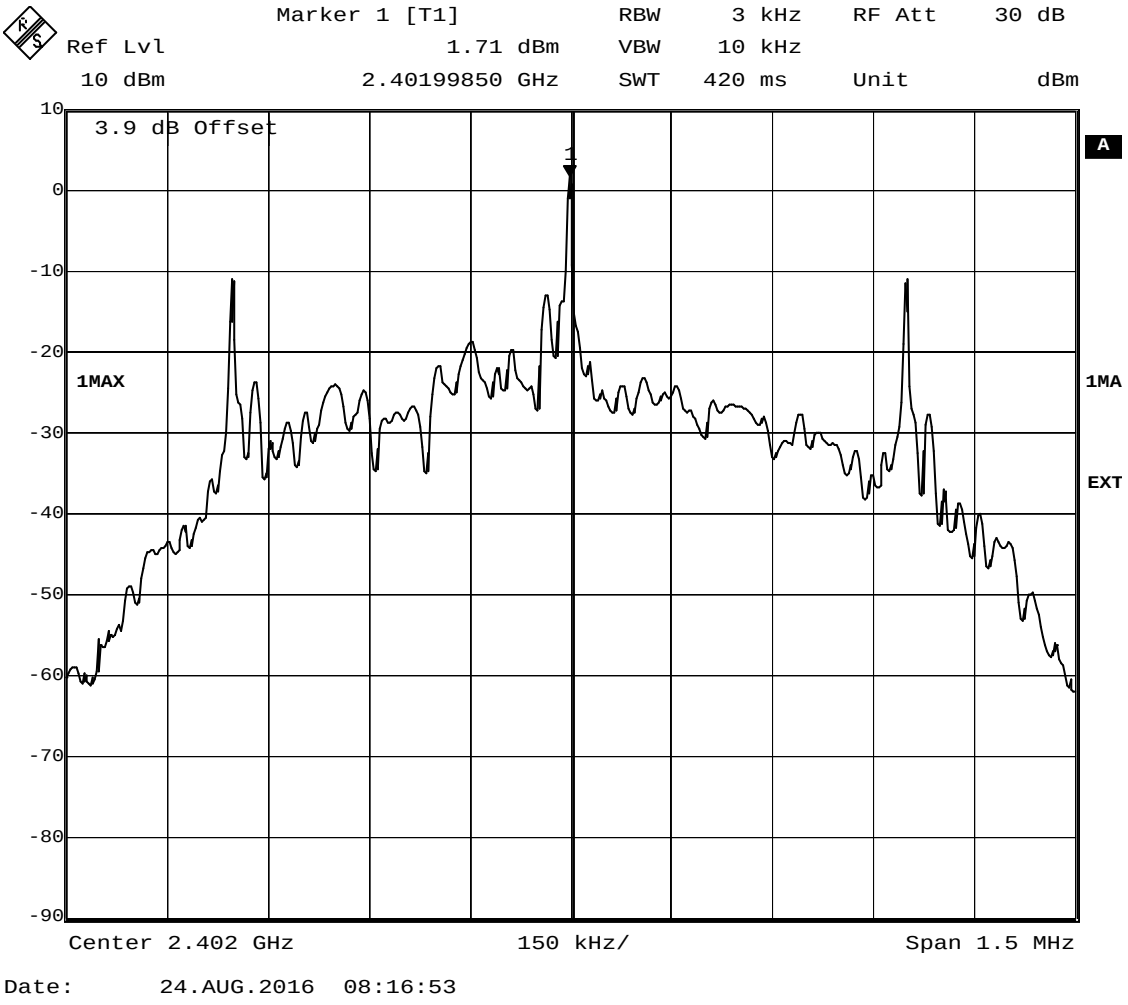
4.9.3TEST PROTOCOL

Ambient temperature: 22 °C
Air Pressure: 1015 hPa
Humidity: 43 %
BT LE

Band	Channel No.	Frequency [MHz]	Power Density [dBm / 3kHz]	Limit [dBm / 3kHz]	Margin to Limit [dB]
2.4 GHz ISM	0	2402.0	1.7	8.0	**6.3**
	19	2440.0	1.4	8.0	6.6
	39	2480.0	1.3	8.0	6.7

4.9.4MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

Radio Technology = Bluetooth LE, Operating Frequency = mid



4.9.5TEST EQUIPMENT USED

R&S TS8997

5 TEST EQUIPMENT

1 Conducted Emissions
Shielded Room 02

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
	ESH 3-Z5	Two-Line V-Network	Rohde & Schwarz	828304/029	2015-03	2017-03
	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2014-11	2016-11
	EP 1200/B, NA/B1	Amplifier with integrated variable Oscillator	Spitzenberger & Spieß	B6278	2015-07	2018-07
	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2015-12	2017-12
	Opus10 THI (8152.00)	ThermoHygro Datalogger 02 (Environ)	Lufft Mess- und Regeltechnik GmbH	7489	2015-02	2017-02
	ESH 3-Z5	Two-Line V-Network	Rohde & Schwarz	829996/002	2015-03	2017-03
	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2015-02	2017-02
	CMD 55	Digital Radio Communication Tester	Rohde & Schwarz	831050/020	2014-12	2017-12
	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
	CMW 500	CMW 500	Rohde & Schwarz	107500	2015-07	2017-07

2 Radiated Emissions
Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069		
	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
	Fully Anechoic Room	8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	2015-07	2018-07

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2014-11	2016-11
	TT 1.5 WI	Turn Table	Maturo GmbH	-		
	Anechoic Chamber	10.58 x 6.38 x 6.00 m³	Frankonia	none	2014-01	2017-01
	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2015-12	2017-12
	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
	AS 620 P	Antenna mast	HD GmbH	620/37		
	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
	HL 562	Ultralog new biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2015-06	2018-06
	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2015-03	2017-03
	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
	HFH2-Z2	Loop Antenna	Rohde & Schwarz GmbH & Co. KG	829324/006	2014-11	2017-11
	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2014-11	2016-11
	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2015-02	2017-02
	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronik GmbH	00086675		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz GmbH & Co. KG	100609	2016-04	2019-04
	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
	HF 907	Double-ridged horn	Rohde & Schwarz GmbH & Co. KG	102444	2015-05	2018-05

3 R&S TS8997
EN300328/301893 Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
	OSP120	Switching Unit with integrated power meter	Rohde & Schwarz GmbH & Co. KG	101158	2015-08	2016-08
	A8455-4	4 Way Power Divider (SMA)		-		
	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2016-02	2018-02
	Opus10 THI (8152.00)	ThermoHygro Datalogger 03 (Environ)	Lufft Mess- und Regeltechnik GmbH	7482	2015-02	2017-02
	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz GmbH & Co. KG	107695	2014-06	2017-06
	VT 4002	Climatic Chamber	Vötsch	5856600215001 0	2016-03	2018-03
	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2016-02	2018-02
	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz GmbH & Co. KG	259291	2016-08	2019-08
	1515 / 93459	Broadband Power Divider SMA (Aux)	Weinschel Associates	LN673		
	Datum, Model: MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2016-06	2017-06

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.

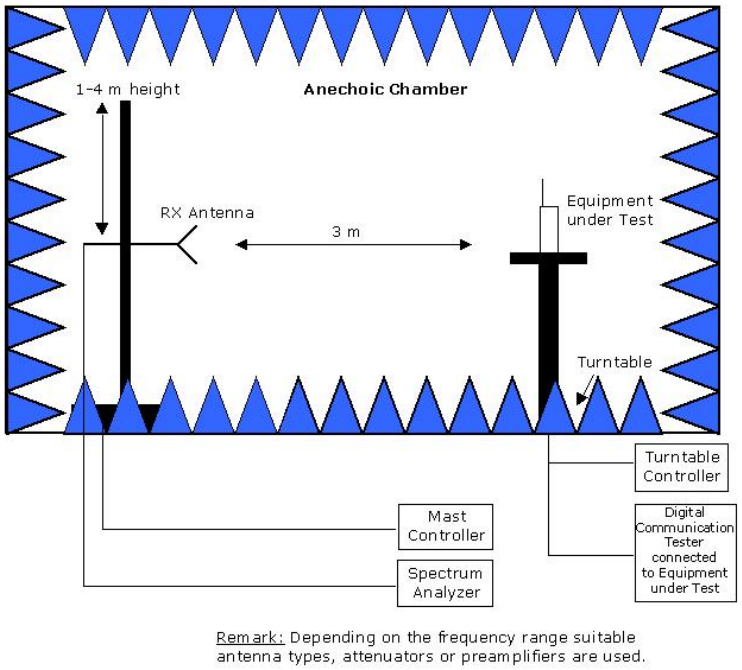
6.6 ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

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

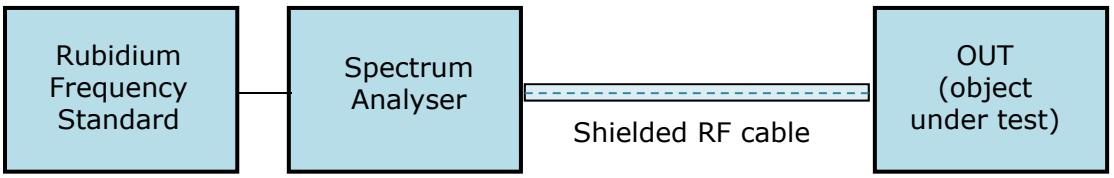
Sample calculation

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 interpolarisation 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 ground plane.



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 / 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.