FCC Measurement/Technical Report on

Level Probing Radar
Optiwave 15xx series

FCC ID: 2AV6KH
IC: 1991B-H

Test Report Reference: MDE_KROHN_2102_FCC_02_REV_02

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.

Table of Contents

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 (10-1-23 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:
The tests were selected and performed with reference to the FCC Public Notice "Guidance for Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating under Section 15.247 of the FCC Rules, 558074 D01 15.247 Meas Guidance v05r02, 2019-04-02".
ANSI C63.10–2020 is applied.

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 5 & AMD 1 & AMD 2: 8.8
Occupied bandwidth	§ 15.247 (a) (2)	RSS-247 Issue 3: 5.2 (a)
Peak conducted output power	§ 15.247 (b) (3), (4)	RSS-247 Issue 3: 5.4 (d)
Transmitter spurious RF conducted emissions	§ 15.247 (d)	RSS-Gen Issue 5 & AMD 1 & AMD 2: 6.13 / 8.9/8.10; RSS-247 Issue 3: 5.5
Transmitter spurious radiated emissions	§ 15.247 (d); § 15.209 (a)	RSS-Gen Issue 5 & AMD 1 & AMD 2: 6.13 / 8.9/8.10; RSS-247 Issue 3: 5.5
Band edge compliance	§ 15.247 (d)	RSS-247 Issue 3: 5.5
Power density	§ 15.247 (e)	RSS-247 Issue 3: 5.2 (b)
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 5 & AMD 1 & AMD 2: 8.3
Receiver spurious emissions	–	–

1.3 MEASUREMENT SUMMARY

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, chapter 11.8.1 — **Final Result**

OP-Mode Radio Technology, Operating Frequency	Setup	Date	FCC	IC
Bluetooth LE 1 Mbps, high	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 1 Mbps, low	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 1 Mbps, mid	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 2 Mbps, high	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 2 Mbps, low	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 2 Mbps, mid	S01_AI01	2024-04-09	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 — **IC RSS-Gen & IC TRC-43; Ch. 6.7 & Ch. 8**

Occupied Bandwidth (99%)
The measurement was performed according to ANSI C63.10, chapter 6.9.3 — **Final Result**

OP-Mode Radio Technology, Operating Frequency	Setup	Date	FCC	IC
Bluetooth LE 1 Mbps, high	S01_AI01	2024-04-09	N/A	Performed
Bluetooth LE 1 Mbps, low	S01_AI01	2024-04-09	N/A	Performed
Bluetooth LE 1 Mbps, mid	S01_AI01	2024-04-09	N/A	Performed
Bluetooth LE 2 Mbps, high	S01_AI01	2024-04-09	N/A	Performed
Bluetooth LE 2 Mbps, low	S01_AI01	2024-04-09	N/A	Performed
Bluetooth LE 2 Mbps, mid	S01_AI01	2024-04-09	N/A	Performed

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, chapter 11.9.1.1 — **Final Result**

OP-Mode Radio Technology, Operating Frequency, Measurement method	Setup	Date	FCC	IC
Bluetooth LE 1 Mbps, high, conducted	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 1 Mbps, low, conducted	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 1 Mbps, mid, conducted	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 2 Mbps, high, conducted	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 2 Mbps, low, conducted	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 2 Mbps, mid, conducted	S01_AI01	2024-04-09	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, chapter 11.11 **Final Result**

OP-Mode Radio Technology, Operating Frequency	Setup	Date	FCC	IC
Bluetooth LE 1 Mbps, high	S01_AI01	2024-05-29	Passed	Passed
Bluetooth LE 1 Mbps, low	S01_AI01	2024-05-29	Passed	Passed
Bluetooth LE 1 Mbps, mid	S01_AI01	2024-05-29	Passed	Passed
Bluetooth LE 2 Mbps, high	S01_AI01	2024-05-29	Passed	Passed
Bluetooth LE 2 Mbps, low	S01_AI01	2024-05-29	Passed	Passed
Bluetooth LE 2 Mbps, mid	S01_AI01	2024-05-29	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, chapter 6.4, 6.5, 6.6.5 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Measurement range	Setup	Date	FCC	IC
Bluetooth LE 1 Mbps, low, 30 MHz - 1 GHz	S01_AJ01	2024-02-07	Passed	Passed
Bluetooth LE 1 Mbps, low, 1 GHz - 26 GHz	S01_AJ01	2024-05-27	Passed	Passed
Bluetooth LE 1 Mbps, mid, 9 kHz - 30 MHz	S01_AJ01	2024-02-06	Passed	Passed
Bluetooth LE 1 Mbps, mid, 30 MHz - 1 GHz	S01_AJ01	2024-02-07	Passed	Passed
Bluetooth LE 1 Mbps, mid, 1 GHz - 26 GHz	S01_AJ01	2024-05-27	Passed	Passed
Bluetooth LE 1 Mbps, high, 30 MHz - 1 GHz	S01_AJ01	2024-02-07	Passed	Passed
Bluetooth LE 1 Mbps, high, 1 GHz - 26 GHz	S01_AJ01	2024-05-27	Passed	Passed
Bluetooth LE 2 Mbps, low, 1 GHz - 26 GHz Comment: Only harmonics	S01_AJ01	2024-05-28	Passed	Passed
Bluetooth LE 2 Mbps, mid, 1 GHz - 26 GHz Comment: Only harmonics	S01_AJ01	2024-05-28	Passed	Passed
Bluetooth LE 2 Mbps, high, 1 GHz - 26 GHz Comment: Only harmonics	S01_AJ01	2024-05-28	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, chapter 11.11 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Band Edge	Setup	Date	FCC	IC
Bluetooth LE 1 Mbps, high, high	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 1 Mbps, low, low	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 2 Mbps, high, high	S01_AI01	2024-05-28	Passed	Passed
Bluetooth LE 2 Mbps, low, low	S01_AI01	2024-05-28	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, chapter 6.6.5 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Band Edge	Setup	Date	FCC	IC
Bluetooth LE 1 Mbps, high, high	S01_AJ01	2024-05-27	Passed	Passed
Bluetooth LE 2 Mbps, high, high	S01_AJ01	2024-05-28	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, chapter 11.10.2 **Final Result**

OP-Mode Radio Technology, Operating Frequency	Setup	Date	FCC	IC
Bluetooth LE 1 Mbps, high	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 1 Mbps, low	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 1 Mbps, mid	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 2 Mbps, high	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 2 Mbps, low	S01_AI01	2024-04-09	Passed	Passed
Bluetooth LE 2 Mbps, mid	S01_AI01	2024-04-09	Passed	Passed

N/A: Not applicable
N/P: Not performed

2 REVISION HISTORY / SIGNATURES

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
initial	2024-06-03	--	invalid
REV_01	2024-08-23	• Measurement reference for the test Peak Output Power corrected to ANSI C63.10 11.9.1.1 • Chapter 5.7.1: Clarification that the restricted band closest to the lower band edge is included in chapter 5.4 • Chapter 6.1: DC power supplies NGP800 added to equipment list. • Chapter 6.2: Test Equipment Software table updated.	invalid
REV_02	2024-10-02	• Duty Cycle correction factor updated. • Calculation of average transmitter unwanted emissions values updated	valid

COMMENT: -

(responsible for accreditation scope)
Dipl.-Ing. Robert Machulec

(responsible for testing and report)
Dipl.-Ing. Marco Kullik

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

3 ADMINISTRATIVE DATA

3.1 TESTING LABORATORY

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

The test facility is accredited by the following accreditation organisation:

Laboratory accreditation no:	DAkkS D-PL-12140-01-01| -02 | -03
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
ISED CAB Identifier	DE0007; ISED#: 3699A
Responsible for accreditation scope:	Dipl.-Ing. Robert Machulec
Report Template Version:	2023-09-29

3.2 PROJECT DATA

Responsible for testing and report:	Dipl.-Ing. Marco Kullik
Employees who performed the tests:	documented internally at 7Layers
Date of Report:	2024-10-02
Testing Period:	2024-02-06 to 2024-05-29

3.3 APPLICANT DATA

Company Name:	KROHNE Messtechnik GmbH
Address:	Ludwig-Krohne-Str. 5 47058 Duisburg Germany
Contact Person:	Mr. Charalambos Ouzounis

3.4 MANUFACTURER DATA

Company Name:	KROHNE Messtechnik GmbH
Address:	Am Schürmannshütt 19 47411 Moers Germany
Contact Person:	Mr. Charalambos Ouzounis

4 TEST OBJECT DATA

4.1 GENERAL EUT DESCRIPTION

Kind of Device product description	Level Probing Radar with BTLE
Product name	Optiwave 15xx series
Type	DN40
Declared EUT data by the supplier	
Voltage Type	DC
Voltage Level	24.0 V
Antenna / Gain	Integral antenna, 1.5 dBi gain
Tested Modulation Type	GFSK
General product description	see document "Operational description" provided by manufacturer
EUT ports (connected cables during testing):	DC Power supply port, appr. 1.6 m cable connected during testing
Tested data rates	1 Mbit, 2 Mbit
Special software used for testing	ELR_RADIO_APPROVAL software

4.2 EUT MAIN COMPONENTS

Sample Name	**Sample Code**	**Description**
EUT ai01	DE1153004ai01	15.247 BTLE Conducted Sample
Sample Parameter	**Value**	
Serial No.	-	
HW Version	Converter: 4008475901d HMI:4009669601a (optional)	
SW Version	Converter: 23.07.01 HMI: V0.00.01P31(optional)	
Comment	Local display variant	

Sample Name	**Sample Code**	**Description**
EUT aj01	DE1153004aj01	15.247 BTLE Radiated Sample
Sample Parameter	**Value**	
Serial No.	-	
HW Version	Converter: 4008475901d HMI:4009669601a (optional)	
SW Version	Converter: 23.07.01 HMI: V0.00.01P31(optional)	
Comment	IP68 variant	

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

4.3 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**
-	-	-

4.4 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, Type Model, HW, SW, S/N)**	**Description**
-	-	-

4.5 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**
S01_AI01	EUT ai01,	FCC 15.247 Conducted Setup
S01_AJ01	EUT aj01,	FCC 15.247 Radiated Test setup

4.6 OPERATING MODES / TEST CHANNELS

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

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

4.7 DUTY CYCLE

RF-Layer:
The maximum (worst-case) duty cycle on the RF-Layers was calculated by the applicant because it is determined by the application software.

The calculated value is: 20 %

The details of the calculation can be found in the document "OPTIWAVE 15xx - BLE duty cycle.pdf" issued by the applicant.

Therefore, the correction factor is: 20 * LOG (1/D) = 20 * LOG (0.2) = -14.0 dB

Frequency Spreading:

- Minimum number of channels: 2 (in 100 ms observation period)
- Minimum channel separation: 2 MHz (> 1 MHz RBW)
- Correction factor: 20 * LOG (0.5) = -6.0 dB

Overall Correction Factor:

- -14.0 dB + (-6 dB) = **- 20.0 dB**

4.8 PRODUCT LABELLING

4.8.1 FCC ID LABEL

Please refer to the documentation of the applicant.

4.8.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

5 TEST RESULTS

5.1 OCCUPIED BANDWIDTH (6 DB)

Standard **FCC Part 15 Subpart C**

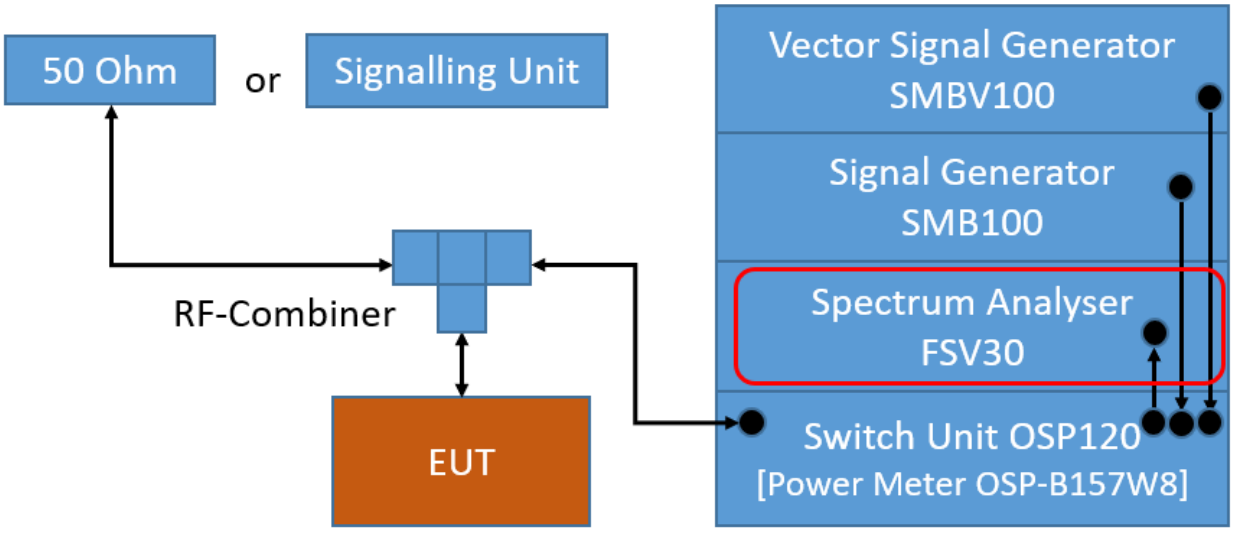
The test was performed according to:
ANSI C63.10, chapter 11.8.1

5.1.1 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 the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Analyser settings:
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Span: Two times nominal bandwidth
- Trace: Maxhold
- Sweeps: Till stable (min. 500, max. 15000)
- Sweeptime: Auto
- Detector: Peak



TS8997; Channel Bandwidth

5.1.2 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.

5.1.3 TEST PROTOCOL

Ambient temperature: 24°C
Air Pressure: 1012 hPa
Humidity: 46 %

BT LE 1 Mbit/s

Band / Mode	Channel No.	Frequency [MHz]	6 dB Bandwidth [MHz]	Limit [MHz]	Margin to Limit [MHz]
2.4 GHz ISM	0	2402	0.720	0.5	0.220
	19	2440	0.736	0.5	0.236
	39	2480	0.752	0.5	0.252

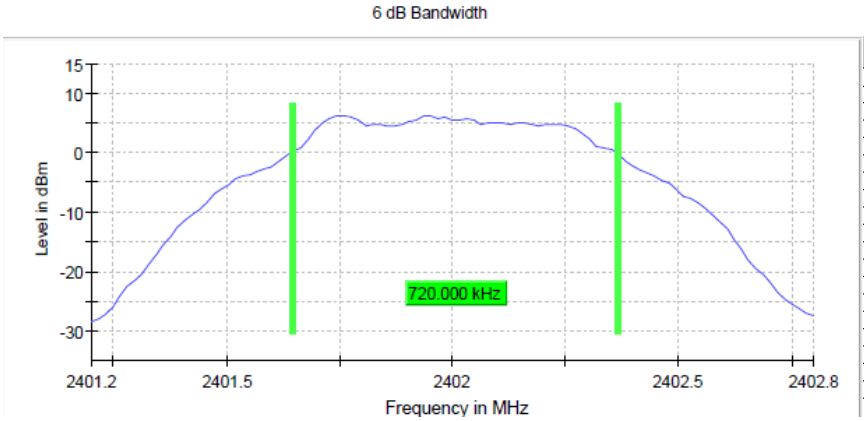
BT LE 2 Mbit/s

Band / Mode	Channel No.	Frequency [MHz]	6 dB Bandwidth [MHz]	Limit [MHz]	Margin to Limit [MHz]
2.4 GHz ISM	0	2402	1.404	0.5	0.904
	19	2440	1.300	0.5	0.800
	39	2480	1.326	0.5	0.826

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

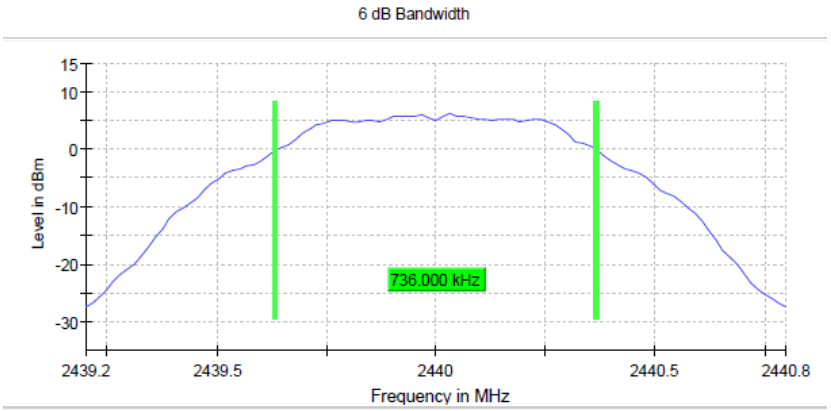
5.1.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =low (S01_AI01)



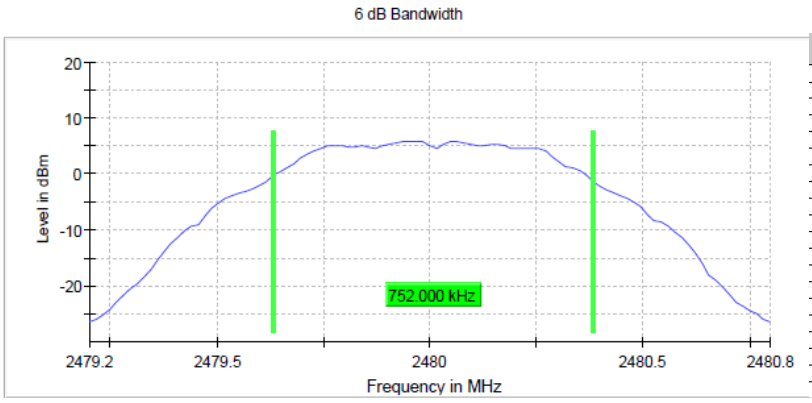
Setting	Instrument Value
Start Frequency	2.40120 GHz
Stop Frequency	2.40280 GHz
Span	1.600 MHz
RBW	100.000 kHz
VBW	300.000 kHz
SweepPoints	101
Sweeptime	41.920 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	18 / max. 150
Stable	5 / 5
Max Stable Difference	0.02 dB

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =mid (S01_AI01)



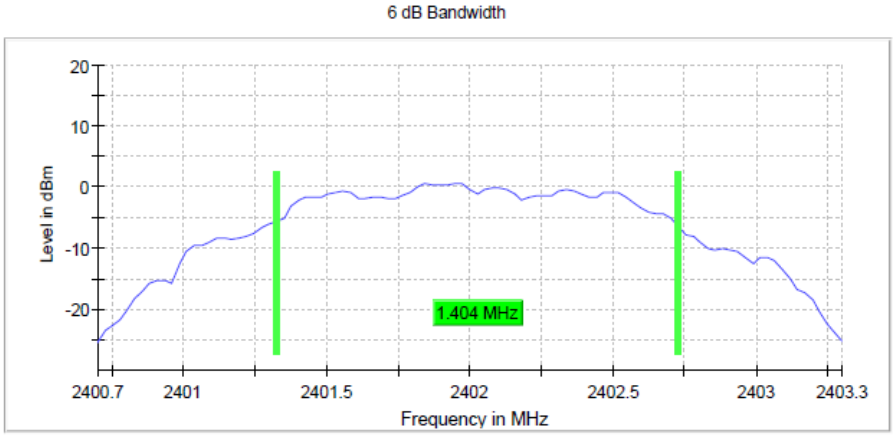
Setting	Instrument Value
Start Frequency	2.43920 GHz
Stop Frequency	2.44080 GHz
Span	1.600 MHz
RBW	100.000 kHz
VBW	300.000 kHz
SweepPoints	101
Sweeptime	41.920 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	14 / max. 150
Stable	5 / 5
Max Stable Difference	0.00 dB

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =high (S01_AI01)



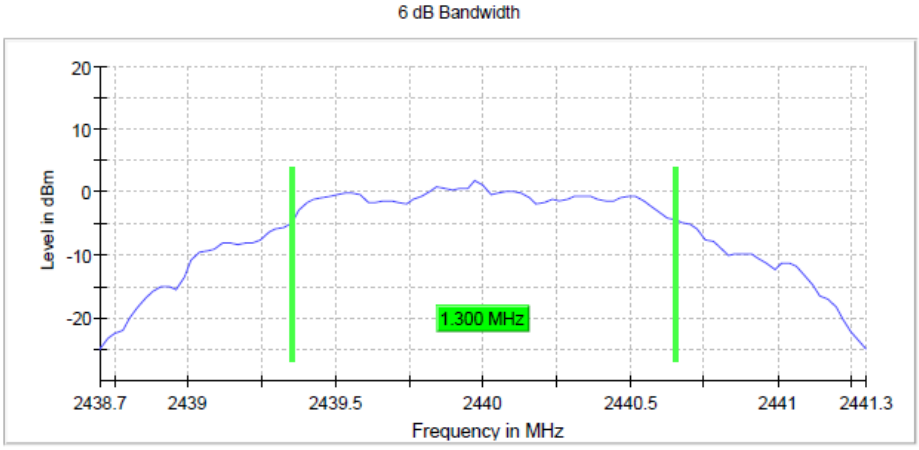
Setting	Instrument Value
Start Frequency	2.47920 GHz
Stop Frequency	2.48080 GHz
Span	1.600 MHz
RBW	100.000 kHz
VBW	300.000 kHz
SweepPoints	101
Sweeptime	41.920 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	11 / max. 150
Stable	5 / 5
Max Stable Difference	0.00 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =low (S01_AI01)



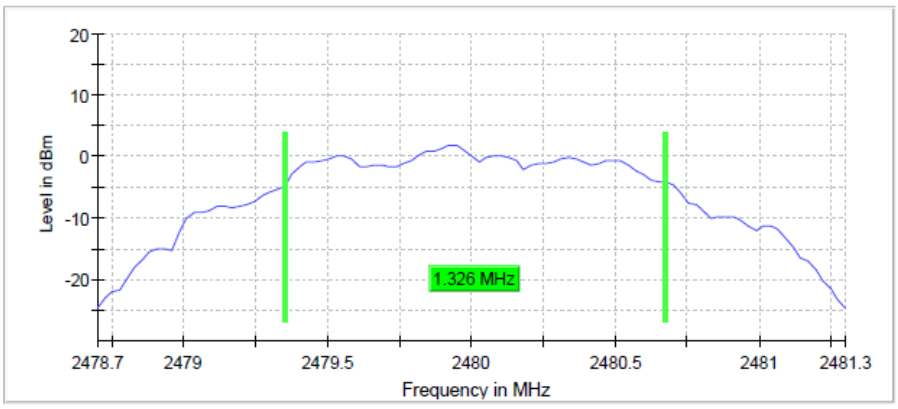
Setting	Instrument Value
Start Frequency	2.40070 GHz
Stop Frequency	2.40330 GHz
Span	2.600 MHz
RBW	100.000 kHz
VBW	300.000 kHz
SweepPoints	101
Sweeptime	41.890 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	14 / max. 150
Stable	5 / 5
Max Stable Difference	0.00 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =mid (S01_AI01)



Setting	Instrument Value
Start Frequency	2.43870 GHz
Stop Frequency	2.44130 GHz
Span	2.600 MHz
RBW	100.000 kHz
VBW	300.000 kHz
SweepPoints	101
Sweeptime	41.890 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	13 / max. 150
Stable	5 / 5
Max Stable Difference	0.11 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =high (S01_AI01)



Setting	Instrument Value
Start Frequency	2.47870 GHz
Stop Frequency	2.48130 GHz
Span	2.600 MHz
RBW	100.000 kHz
VBW	300.000 kHz
SweepPoints	101
Sweeptime	41.890 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	21 / max. 150
Stable	5 / 5
Max Stable Difference	0.01 dB

5.1.5 TEST EQUIPMENT USED

- R&S TS8997

5.2 OCCUPIED BANDWIDTH (99%)

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10, chapter 6.9.3

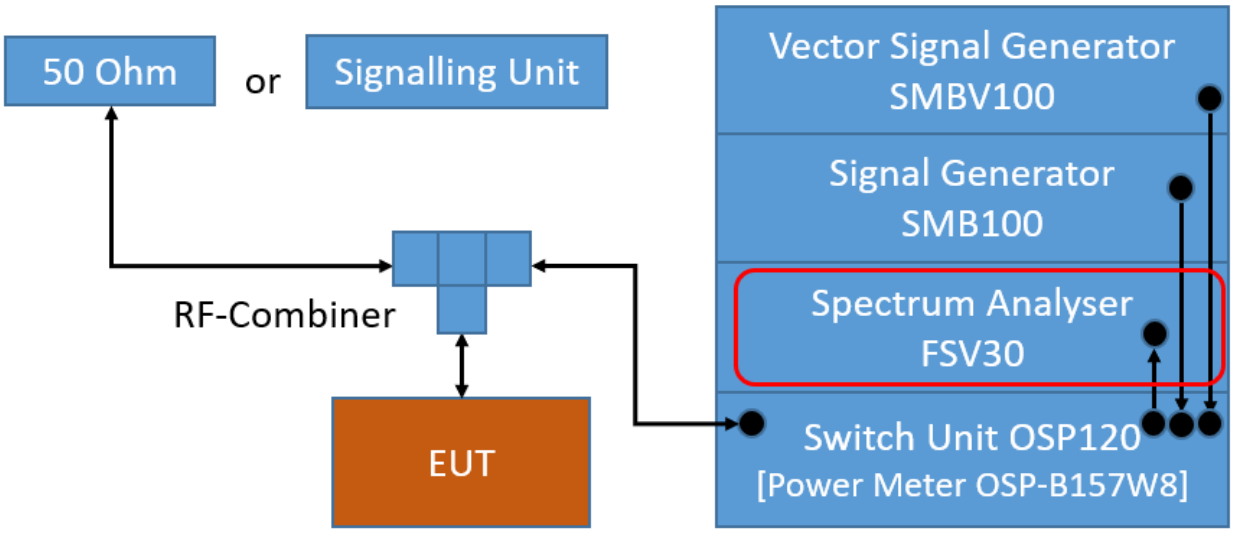
5.2.1 TEST DESCRIPTION

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 the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Analyser settings:

- Resolution Bandwidth (RBW): 1 to 5 % of the OBW
- Video Bandwidth (VBW): ≥ 3 times the RBW
- Span: 1.5 to 5 times the OBW
- Trace: Maxhold
- Sweeps: Till stable (min. 500, max. 75000)
- Sweeptime: Auto
- Detector: Peak



TS8997; Channel Bandwidth

5.2.2 TEST REQUIREMENTS / LIMITS

No applicable limit:

5.2.3 TEST PROTOCOL

Ambient temperature: 24°C
Air Pressure: 1012 hPa
Humidity: 46 %

BT LE 1 Mbit/s

Band	Channel No.	Frequency [MHz]	99 % Bandwidth [MHz]
2.4 GHz ISM	0	2402	1.015
	19	2440	1.015
	39	2480	1.025

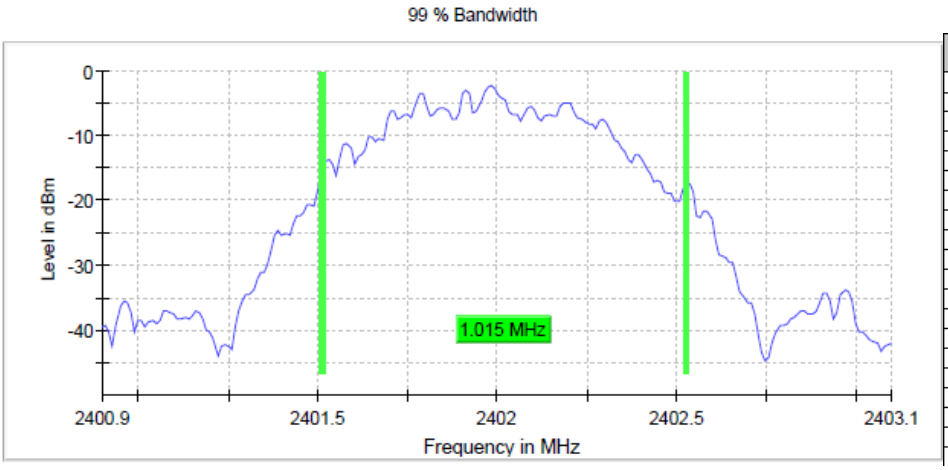
BT LE 2 Mbit/s

Band	Channel No.	Frequency [MHz]	99 % Bandwidth [MHz]
2.4 GHz ISM	0	2402	2.017
	19	2440	2.017
	39	2480	2.017

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

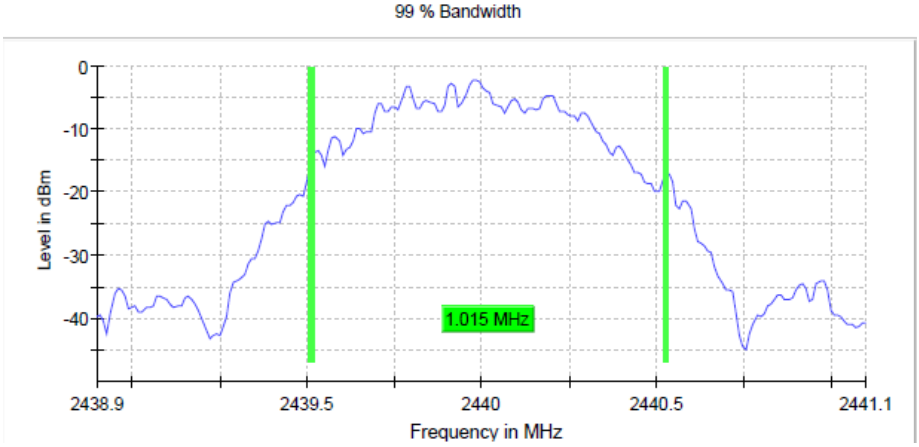
5.2.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =low (S01_AI01)



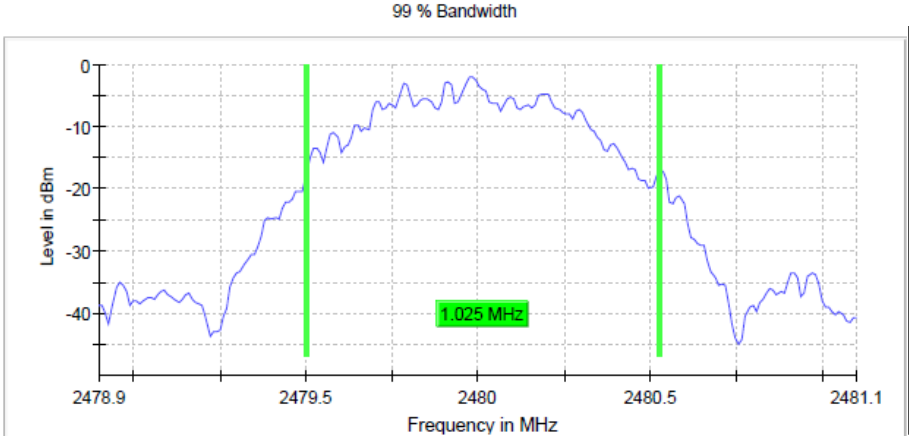
Setting	Instrument Value
Start Frequency	2.40090 GHz
Stop Frequency	2.40310 GHz
Span	2.200 MHz
RBW	20.000 kHz
VBW	100.000 kHz
SweepPoints	220
Sweeptime	210.000 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.30 dB
Run	6 / max. 150
Stable	3 / 3
Max Stable Difference	0.13 dB

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =mid (S01_AI01)



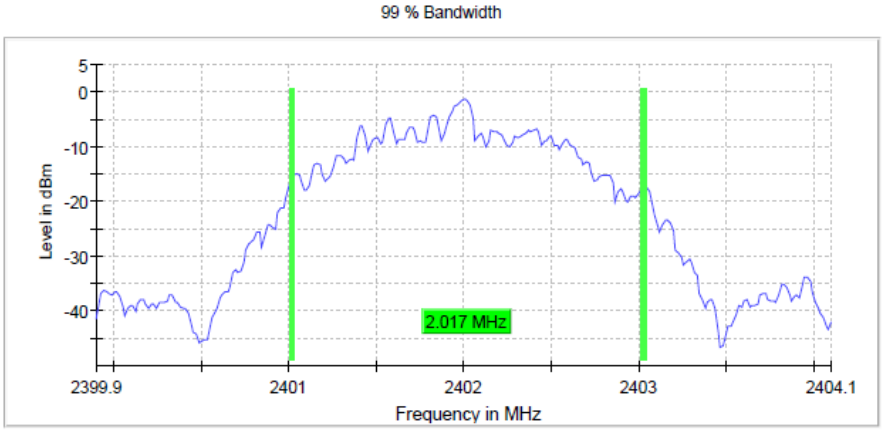
Setting	Instrument Value
Start Frequency	2.43890 GHz
Stop Frequency	2.44110 GHz
Span	2.200 MHz
RBW	20.000 kHz
VBW	100.000 kHz
SweepPoints	220
Sweeptime	210.000 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.30 dB
Run	6 / max. 150
Stable	3 / 3
Max Stable Difference	0.06 dB

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =high (S01_AI01)



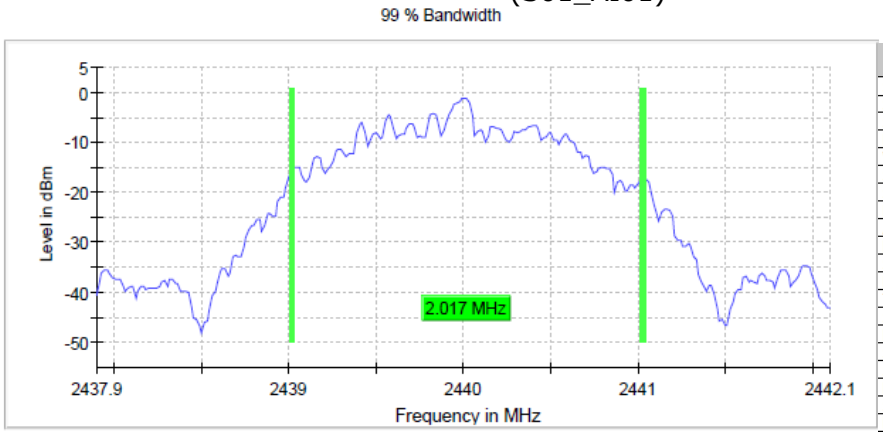
Setting	Instrument Value
Start Frequency	2.47890 GHz
Stop Frequency	2.48110 GHz
Span	2.200 MHz
RBW	20.000 kHz
VBW	100.000 kHz
SweepPoints	220
Sweeptime	210.000 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.30 dB
Run	6 / max. 150
Stable	3 / 3
Max Stable Difference	0.06 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =low (S01_AI01)



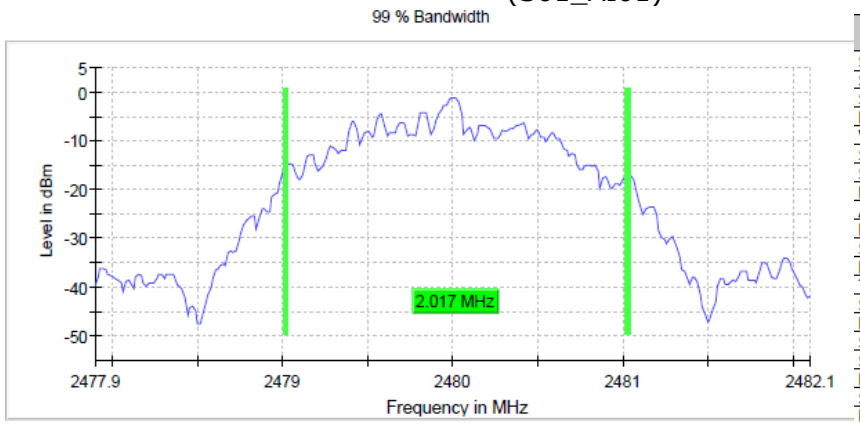
Setting	Instrument Value
Start Frequency	2.39990 GHz
Stop Frequency	2.40410 GHz
Span	4.200 MHz
RBW	30.000 kHz
VBW	100.000 kHz
SweepPoints	280
Sweeptime	140.000 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.30 dB
Run	16 / max. 150
Stable	3 / 3
Max Stable Difference	0.05 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =mid (S01_AI01)



Setting	Instrument Value
Start Frequency	2.43790 GHz
Stop Frequency	2.44210 GHz
Span	4.200 MHz
RBW	30.000 kHz
VBW	100.000 kHz
SweepPoints	280
Sweeptime	140.000 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.30 dB
Run	7 / max. 150
Stable	3 / 3
Max Stable Difference	0.04 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =high (S01_AI01)



Setting	Instrument Value
Start Frequency	2.47790 GHz
Stop Frequency	2.48210 GHz
Span	4.200 MHz
RBW	30.000 kHz
VBW	100.000 kHz
SweepPoints	280
Sweeptime	140.000 µs
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	FFT
Preamp	off
Stablemode	Trace
Stablevalue	0.30 dB
Run	7 / max. 150
Stable	3 / 3
Max Stable Difference	0.11 dB

5.2.5 TEST EQUIPMENT USED

- R&S TS8997

5.3 PEAK POWER OUTPUT

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10, chapter 11.9.1.1

5.3.1 TEST DESCRIPTION

DTS EQUIPMENT:
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.

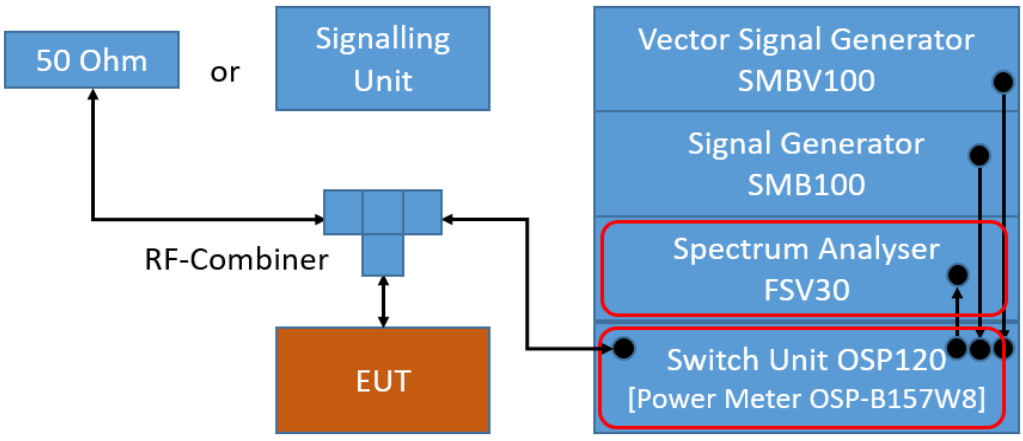
Maximum peak conducted output power (e.g. Bluetooth Low Energy):

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.
The reference level of the spectrum analyser was set higher than the output power of the EUT.

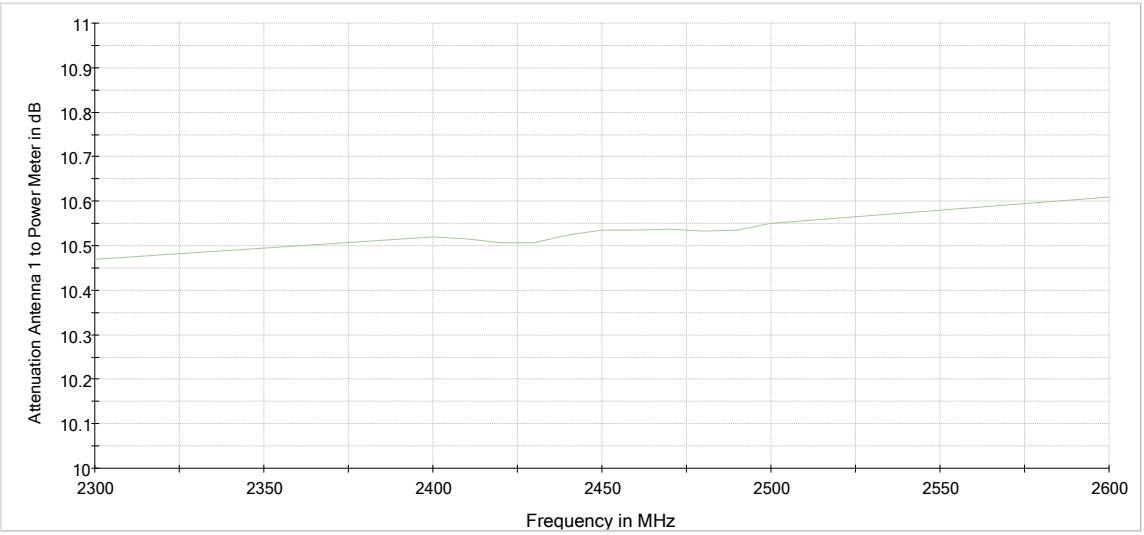
Analyser settings:
- Resolution Bandwidth (RBW): ≥ DTS bandwidth
- Video Bandwidth (VBW): ≥ 3 times RBW or maximum of analyzer
- Span: ≥ 3 times RBW
- Trace: Maxhold
- Sweeps: Till stable (min. 300, max. 15000)
- Sweeptime: Auto
- Detector: Peak

Maximum conducted average output power (e.g. WLAN):

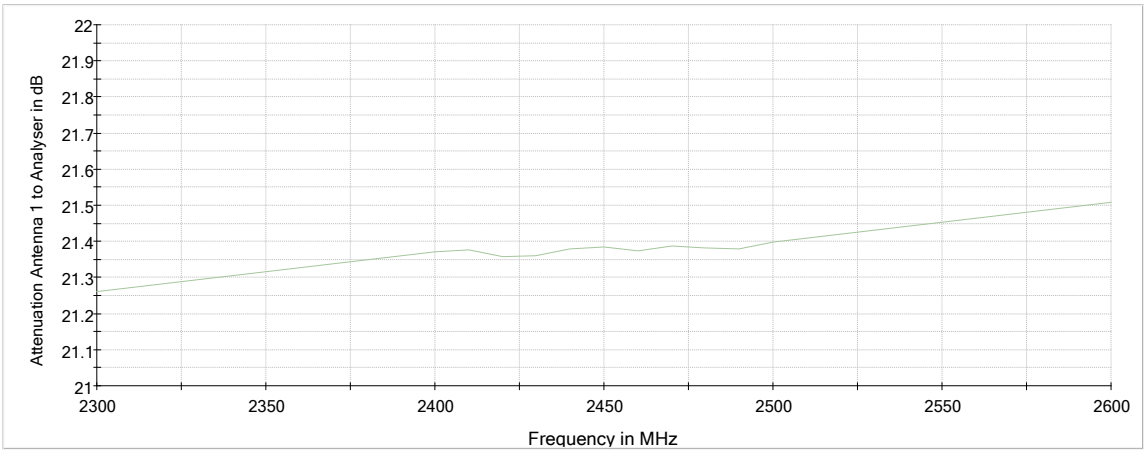
The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.
Measurement is performed using the gated RF average power meter integrated in the OSP 120 module OSP-B157W8 with signal bandwidth >300 MHz.



TS8997; Output Power



Attenuation of the measurement path to Power Meter



Attenuation of the measurement path to Analyser

5.3.2 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)

5.3.3 TEST PROTOCOL

Ambient temperature: 24°C
Air Pressure: 1012 hPa
Humidity: 46 %
BT LE 1 Mbit/s

Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]	E.I.R.P [dBm]
2.4 GHz ISM	0	2402	4.2	30.0	25.8	5.7
	19	2440	4.4	30.0	25.6	5.9
	39	2480	4.6	30.0	25.4	6.1

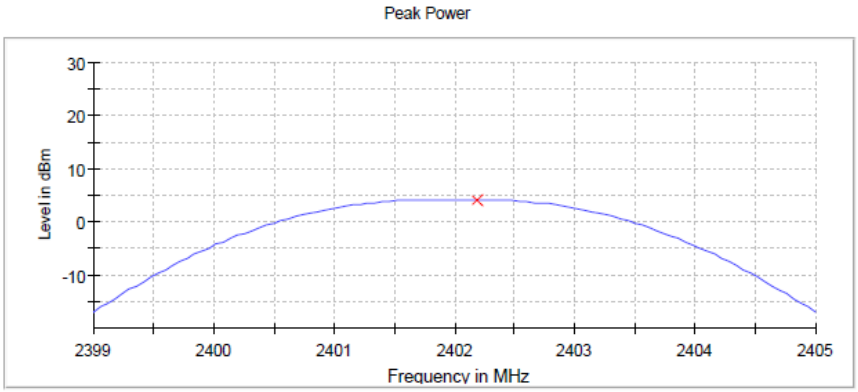
BT LE 2 Mbit/s

Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]	E.I.R.P [dBm]
2.4 GHz ISM	0	2402	4.2	30.0	25.8	5.7
	19	2440	4.4	30.0	25.6	5.9
	39	2480	4.5	30.0	25.5	6.0

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

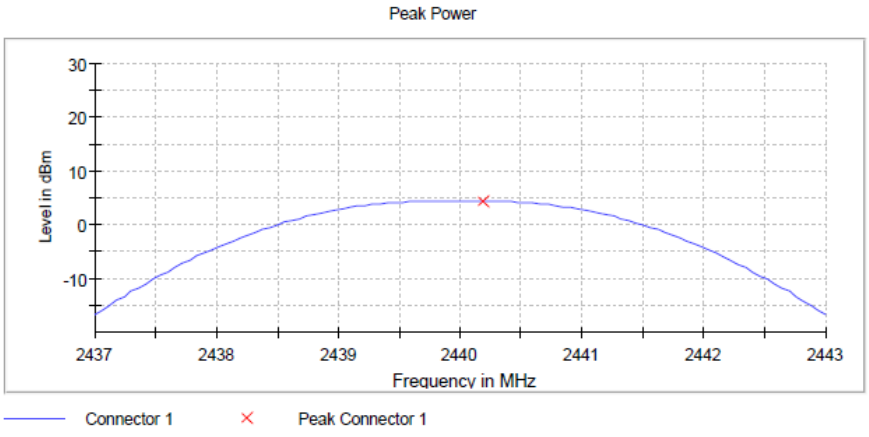
5.3.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =low
Measurement Method = conducted
(S01_AI01)



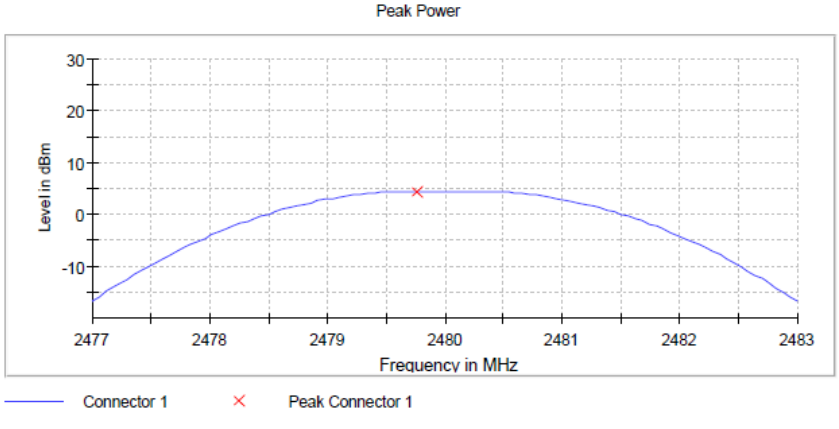
Setting	Instrument Value
Start Frequency	2.39900 GHz
Stop Frequency	2.40500 GHz
Span	6.000 MHz
RBW	2.000 MHz
VBW	10.000 MHz
SweepPoints	101
Sweeptime	1.000 ms
Reference Level	10.000 dBm
Attenuation	20.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	3 / 3
Max Stable Difference	0.04 dB

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =mid
Measurement Method = conducted
(S01_AI01)



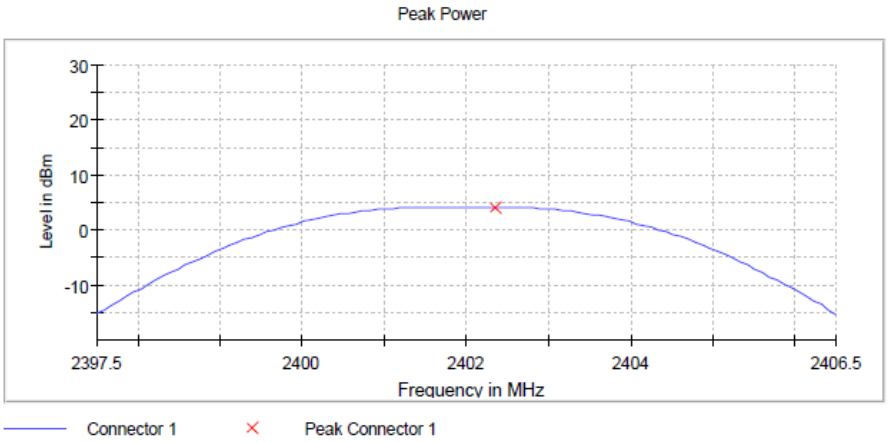
Setting	Instrument Value
Start Frequency	2.43700 GHz
Stop Frequency	2.44300 GHz
Span	6.000 MHz
RBW	2.000 MHz
VBW	10.000 MHz
SweepPoints	101
Sweeptime	1.000 ms
Reference Level	10.000 dBm
Attenuation	20.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	3 / 3
Max Stable Difference	0.04 dB

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =high
Measurement Method = conducted
(S01_AI01)



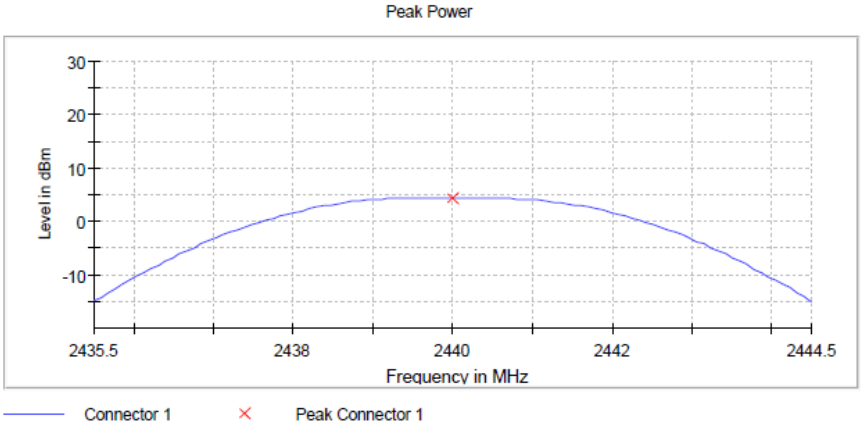
Setting	Instrument Value
Start Frequency	2.47700 GHz
Stop Frequency	2.48300 GHz
Span	6.000 MHz
RBW	2.000 MHz
VBW	10.000 MHz
SweepPoints	101
Sweeptime	1.000 ms
Reference Level	10.000 dBm
Attenuation	20.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	3 / 3
Max Stable Difference	0.05 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =low,
Measurement Method = conducted
(S01_AI01)



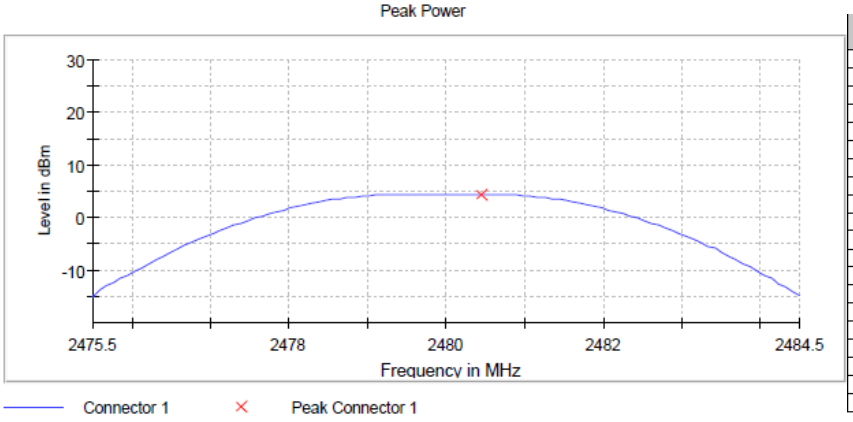
Setting	Instrument Value
Start Frequency	2.39750 GHz
Stop Frequency	2.40650 GHz
Span	9.000 MHz
RBW	3.000 MHz
VBW	10.000 MHz
SweepPoints	101
Sweeptime	1.000 ms
Reference Level	10.000 dBm
Attenuation	20.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	3 / 3
Max Stable Difference	0.04 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =mid
Measurement Method = conducted
(S01_AI01)



Setting	Instrument Value
Start Frequency	2.43550 GHz
Stop Frequency	2.44450 GHz
Span	9.000 MHz
RBW	3.000 MHz
VBW	10.000 MHz
SweepPoints	101
Sweeptime	1.000 ms
Reference Level	10.000 dBm
Attenuation	20.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	3 / 3
Max Stable Difference	0.05 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =high
Measurement Method = conducted
(S01_AI01)



Setting	Instrument Value
Start Frequency	2.47550 GHz
Stop Frequency	2.48450 GHz
Span	9.000 MHz
RBW	3.000 MHz
VBW	10.000 MHz
SweepPoints	101
Sweeptime	1.000 ms
Reference Level	10.000 dBm
Attenuation	20.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	3 / 3
Max Stable Difference	0.08 dB

5.3.5 TEST EQUIPMENT USED

- R&S TS8997

5.4 SPURIOUS RF CONDUCTED EMISSIONS

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10, chapter 11.11

5.4.1 TEST DESCRIPTION

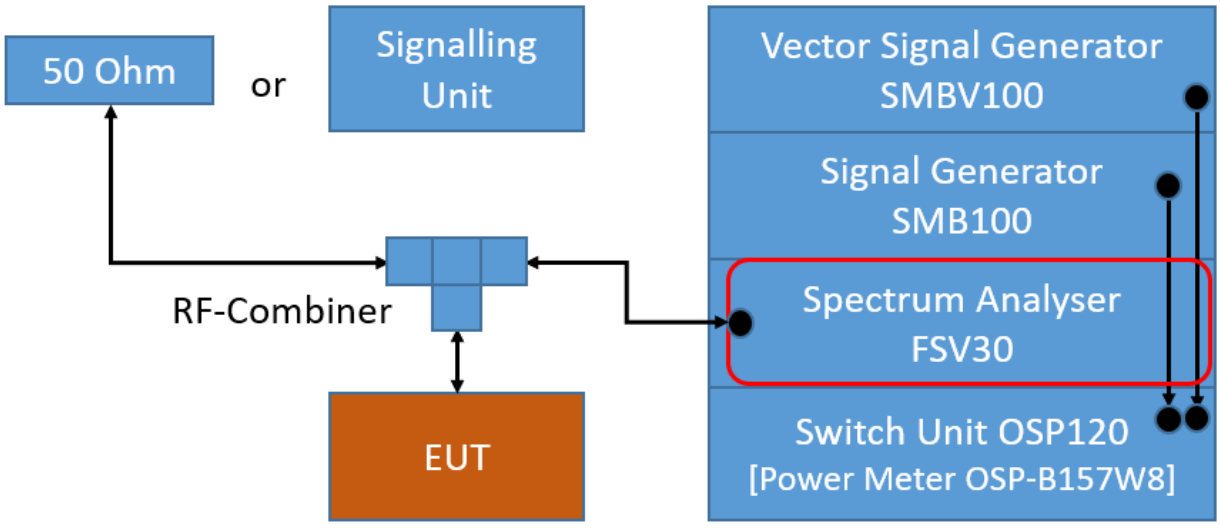
The Equipment Under Test (EUT) was set up to perform the spurious emissions measurements.

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

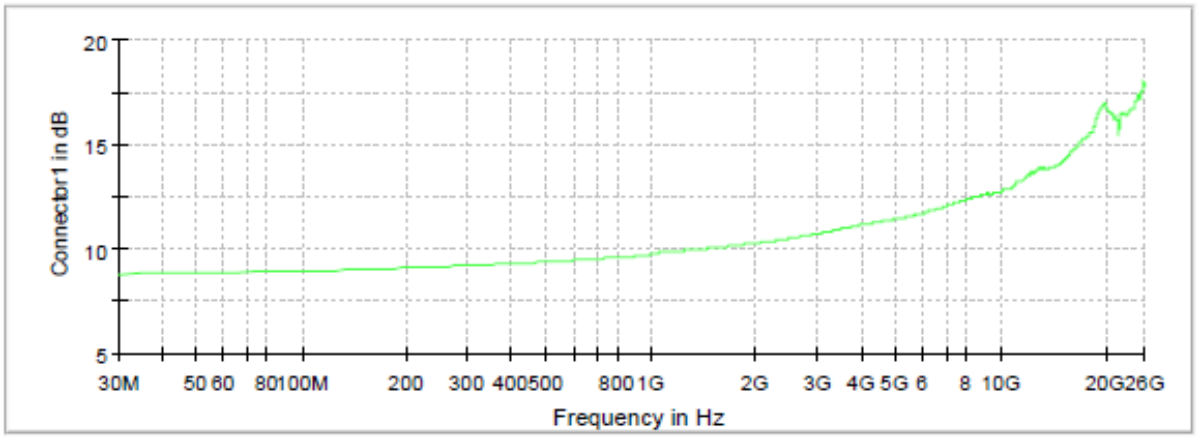
Analyser settings:

- Frequency range: 30 – 26000 MHz
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Trace: Maxhold
- Sweeps: Till Stable (max. 120)
- Sweep Time: Auto
- 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 or 30 dBc limit.



TS8997; Spurious RF Conducted Emissions



Attenuation of the measurement part

5.4.2 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.

5.4.3 TEST PROTOCOL

Ambient temperature: 24 °C
Air Pressure: 1012 hPa
Humidity: 40 %
BT LE 1 Mbit/s

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	2395.0	-52.4	PEAK	100	2.7	-17.3	35.1
0	2402	4767.2	-59.8	PEAK	100	2.7	-17.3	42.5
0	2402	4807.2	-30.2	PEAK	100	2.7	-17.3	12.9
0	2402	4837.1	-60.9	PEAK	100	2.7	-17.3	43.6
0	2402	4847.1	-59.5	PEAK	100	2.7	-17.3	42.2
0	2402	7205.8	-17.7	PEAK	100	2.7	-17.3	0.4
0	2402	9604.4	-36.4	PEAK	100	2.7	-17.3	19.1
0	2402	9614.4	-60.9	PEAK	100	2.7	-17.3	43.6
0	2402	12003.0	-60.9	PEAK	100	2.7	-17.3	43.6
0	2402	12013.0	-32.8	PEAK	100	2.7	-17.3	15.5
0	2402	14411.7	-51.6	PEAK	100	2.7	-17.3	34.3
0	2402	16810.3	-46.8	PEAK	100	2.7	-17.3	29.5
0	2402	16820.3	-46.0	PEAK	100	2.7	-17.3	28.7
0	2402	19218.9	-59.0	PEAK	100	2.7	-17.3	41.7
0	2402	21617.5	-42.5	PEAK	100	2.7	-17.3	25.2
19	2440	7315.7	-19.9	PEAK	100	3.0	-17.0	2.9
19	2440	4837.1	-61.4	PEAK	100	3.0	-17.0	44.4
19	2440	4877.1	-33.2	PEAK	100	3.0	-17.0	16.2
19	2440	4887.1	-62.5	PEAK	100	3.0	-17.0	45.5
19	2440	4917.1	-58.8	PEAK	100	3.0	-17.0	41.8
19	2440	7325.7	-25.6	PEAK	100	3.0	-17.0	8.6
19	2440	9754.3	-48.3	PEAK	100	3.0	-17.0	31.3
19	2440	9764.3	-43.9	PEAK	100	3.0	-17.0	26.9
19	2440	12192.9	-61.2	PEAK	100	3.0	-17.0	44.2
19	2440	12202.9	-31.6	PEAK	100	3.0	-17.0	14.6
19	2440	14641.5	-47.6	PEAK	100	3.0	-17.0	30.6
19	2440	17080.1	-50.0	PEAK	100	3.0	-17.0	33.0
19	2440	19518.7	-53.0	PEAK	100	3.0	-17.0	36.0
19	2440	21957.3	-45.4	PEAK	100	3.0	-17.0	28.4
19	2440	21967.3	-55.6	PEAK	100	3.0	-17.0	38.6
39	2480	2488.5	-57.7	PEAK	100	3.7	-16.3	41.4
39	2480	2518.5	-57.3	PEAK	100	3.7	-16.3	41.0
39	2480	2668.4	-62.4	PEAK	100	3.7	-16.3	46.1
39	2480	4957.1	-30.8	PEAK	100	3.7	-16.3	14.5
39	2480	4997.1	-57.9	PEAK	100	3.7	-16.3	41.6
39	2480	7435.7	-17.7	PEAK	100	3.7	-16.3	1.4
39	2480	7445.7	-20.2	PEAK	100	3.7	-16.3	3.9
39	2480	9914.2	-50.8	PEAK	100	3.7	-16.3	34.5
39	2480	9924.2	-46.2	PEAK	100	3.7	-16.3	29.9
39	2480	12402.8	-36.9	PEAK	100	3.7	-16.3	20.6
39	2480	14881.4	-55.8	PEAK	100	3.7	-16.3	39.5
39	2480	17360.0	-50.4	PEAK	100	3.7	-16.3	34.1
39	2480	19838.5	-52.8	PEAK	100	3.7	-16.3	36.5
39	2480	22317.1	-50.2	PEAK	100	3.7	-16.3	33.9
39	2480	22327.1	-50.9	PEAK	100	3.7	-16.3	34.6

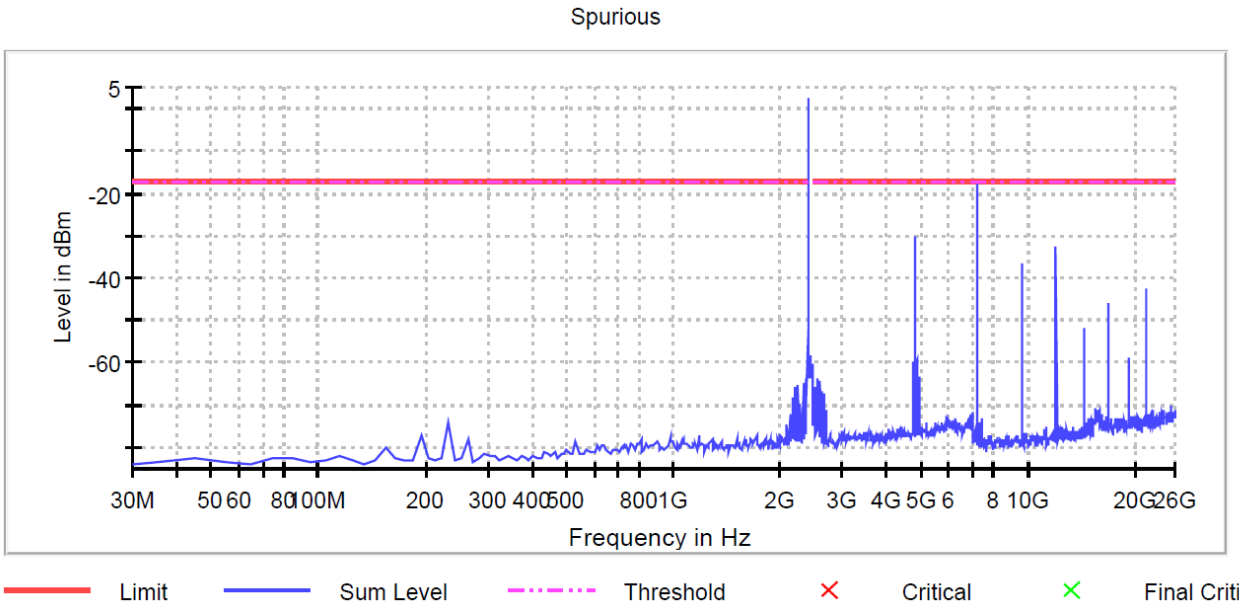
BT LE 2 Mbit/s

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	2395.0	-34.0	PEAK	100	3.3	-16.7	17.3
0	2402	4797.2	-60.7	PEAK	100	3.3	-16.7	44.0
0	2402	4807.2	-33.6	PEAK	100	3.3	-16.7	16.9
0	2402	4837.1	-62.5	PEAK	100	3.3	-16.7	45.8
0	2402	7205.8	-20.3	PEAK	100	3.3	-16.7	3.6
0	2402	7215.8	-61.8	PEAK	100	3.3	-16.7	45.1
0	2402	9604.4	-38.1	PEAK	100	3.3	-16.7	21.4
0	2402	9614.4	-41.1	PEAK	100	3.3	-16.7	24.4
0	2402	12003.0	-35.4	PEAK	100	3.3	-16.7	18.7
0	2402	12013.0	-34.4	PEAK	100	3.3	-16.7	17.7
0	2402	14411.7	-54.1	PEAK	100	3.3	-16.7	37.4
0	2402	16810.3	-48.9	PEAK	100	3.3	-16.7	32.2
0	2402	16820.3	-53.1	PEAK	100	3.3	-16.7	36.4
0	2402	21617.5	-47.6	PEAK	100	3.3	-16.7	30.9
0	2402	21627.5	-53.9	PEAK	100	3.3	-16.7	37.2
19	2440	4877.1	-31.2	PEAK	100	3.0	-17.0	14.2
19	2440	4887.1	-60.9	PEAK	100	3.0	-17.0	43.9
19	2440	4917.1	-59.5	PEAK	100	3.0	-17.0	42.5
19	2440	7315.7	-18.9	PEAK	100	3.0	-17.0	1.9
19	2440	7325.7	-21.1	PEAK	100	3.0	-17.0	4.1
19	2440	9754.3	-47.6	PEAK	100	3.0	-17.0	30.6
19	2440	9764.3	-45.2	PEAK	100	3.0	-17.0	28.2
19	2440	12192.9	-33.7	PEAK	100	3.0	-17.0	16.7
19	2440	12202.9	-31.2	PEAK	100	3.0	-17.0	14.2
19	2440	14641.5	-47.6	PEAK	100	3.0	-17.0	30.6
19	2440	17080.1	-48.5	PEAK	100	3.0	-17.0	31.5
19	2440	19518.7	-51.0	PEAK	100	3.0	-17.0	34.0
19	2440	19528.7	-55.6	PEAK	100	3.0	-17.0	38.6
19	2440	21957.3	-49.2	PEAK	100	3.0	-17.0	32.2
19	2440	21967.3	-49.7	PEAK	100	3.0	-17.0	32.7
39	2480	2488.5	-46.5	PEAK	100	3.0	-17.0	29.5
39	2480	2518.5	-55.3	PEAK	100	3.0	-17.0	38.3
39	2480	4957.1	-33.1	PEAK	100	3.0	-17.0	16.1
39	2480	4997.1	-58.4	PEAK	100	3.0	-17.0	41.4
39	2480	7435.7	-18.2	PEAK	100	3.0	-17.0	1.2
39	2480	7445.7	-18.8	PEAK	100	3.0	-17.0	1.8
39	2480	9914.2	-51.5	PEAK	100	3.0	-17.0	34.5
39	2480	9924.2	-47.6	PEAK	100	3.0	-17.0	30.6
39	2480	12392.8	-39.2	PEAK	100	3.0	-17.0	22.2
39	2480	12402.8	-36.7	PEAK	100	3.0	-17.0	19.7
39	2480	14881.4	-54.5	PEAK	100	3.0	-17.0	37.5
39	2480	17360.0	-54.6	PEAK	100	3.0	-17.0	37.6
39	2480	19838.5	-56.8	PEAK	100	3.0	-17.0	39.8
39	2480	22317.1	-45.3	PEAK	100	3.0	-17.0	28.3
39	2480	22327.1	-54.6	PEAK	100	3.0	-17.0	37.6

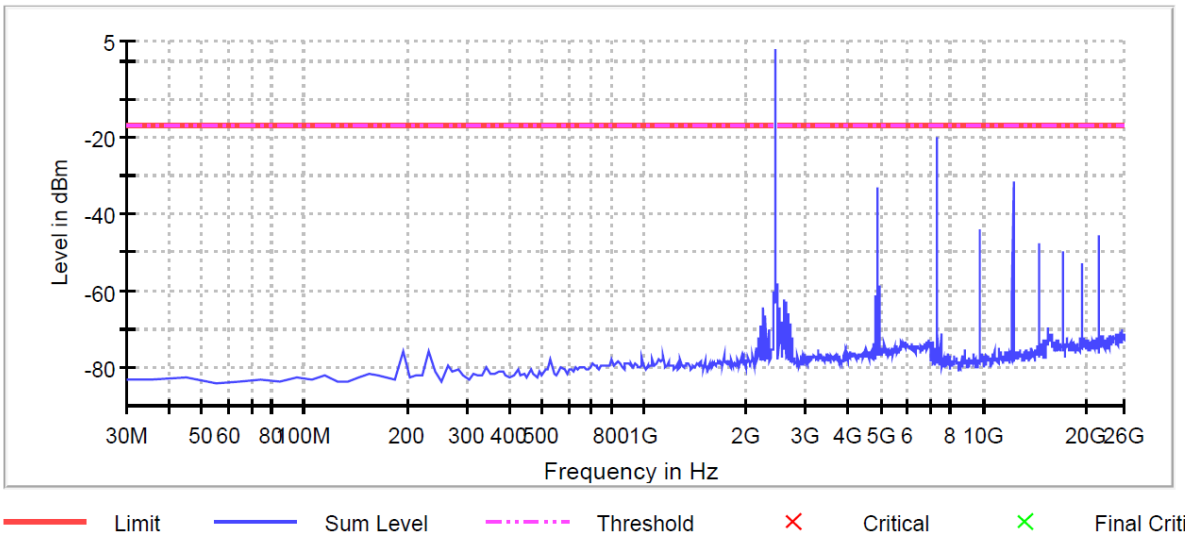
Remark: Please see next sub-clause for the measurement plot.

5.4.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

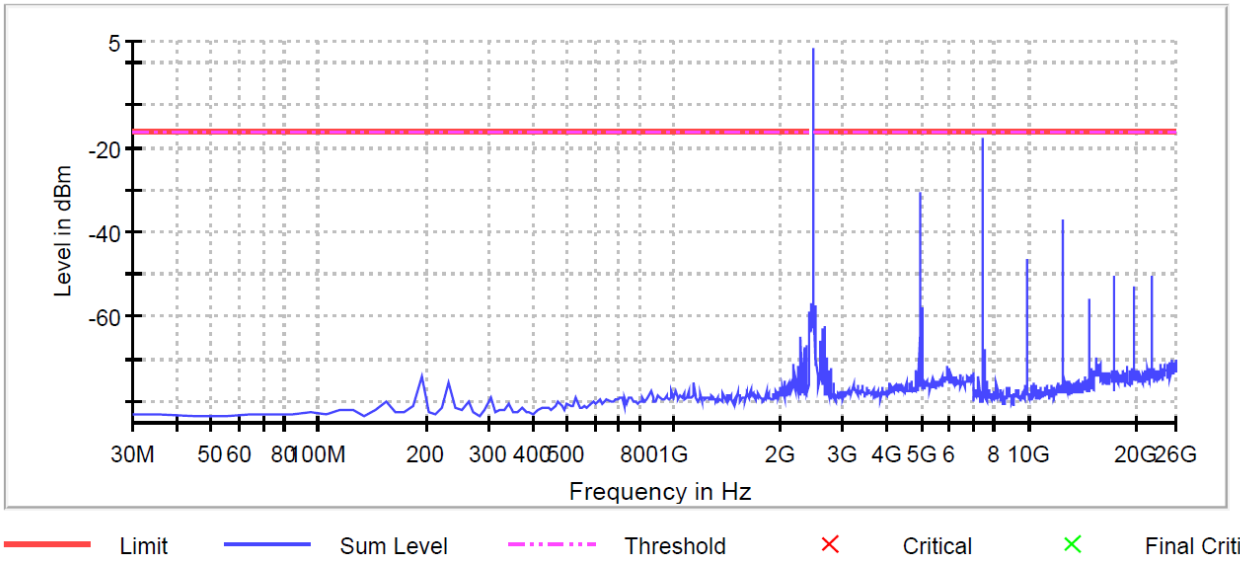
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =low (S01_AI01)



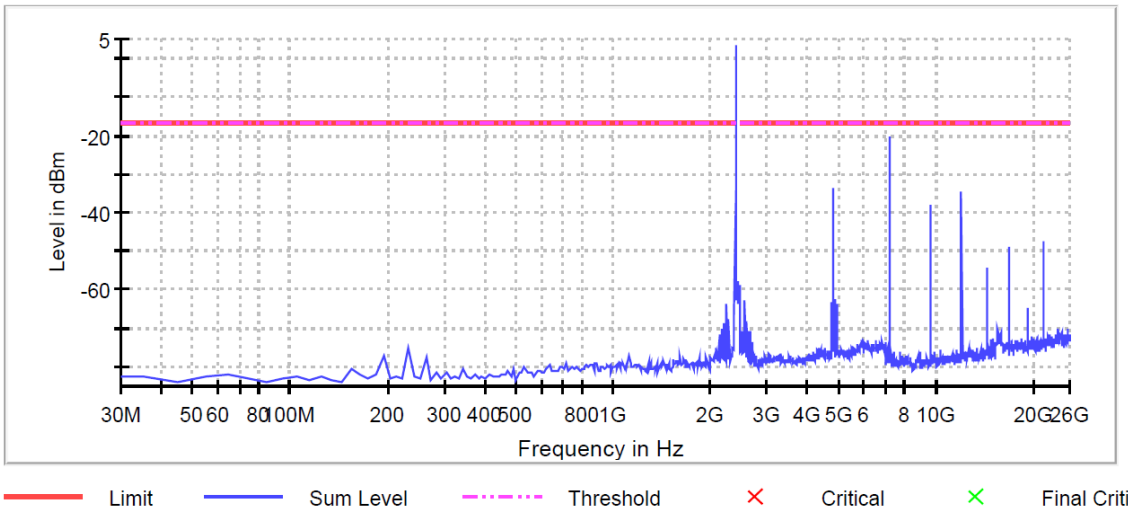
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =mid (S01_AI01)



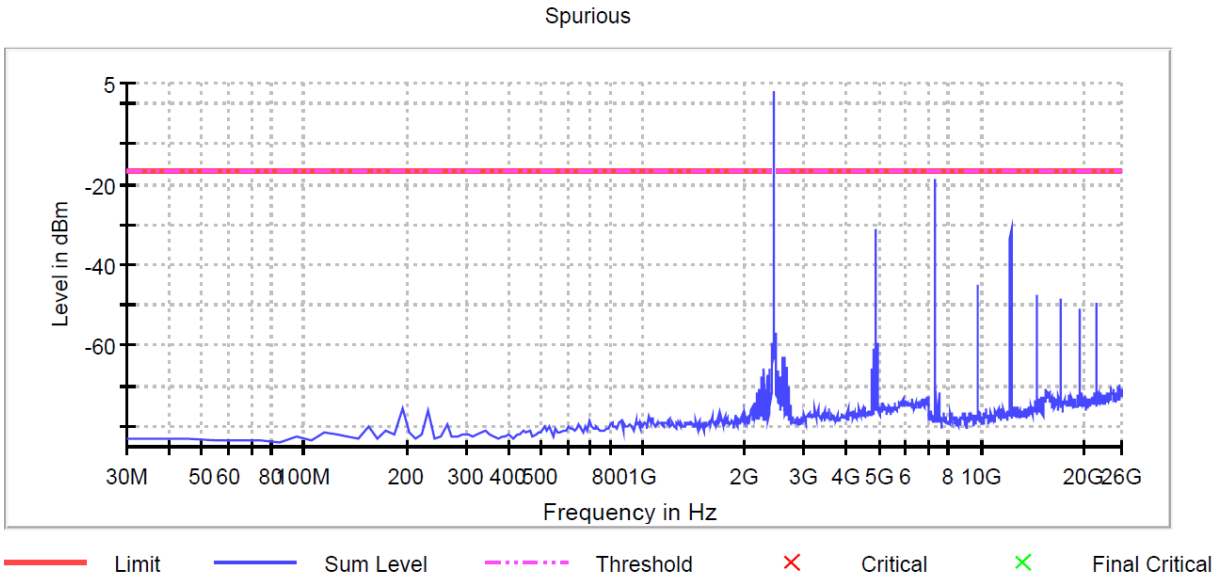
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =high (S01_AI01)



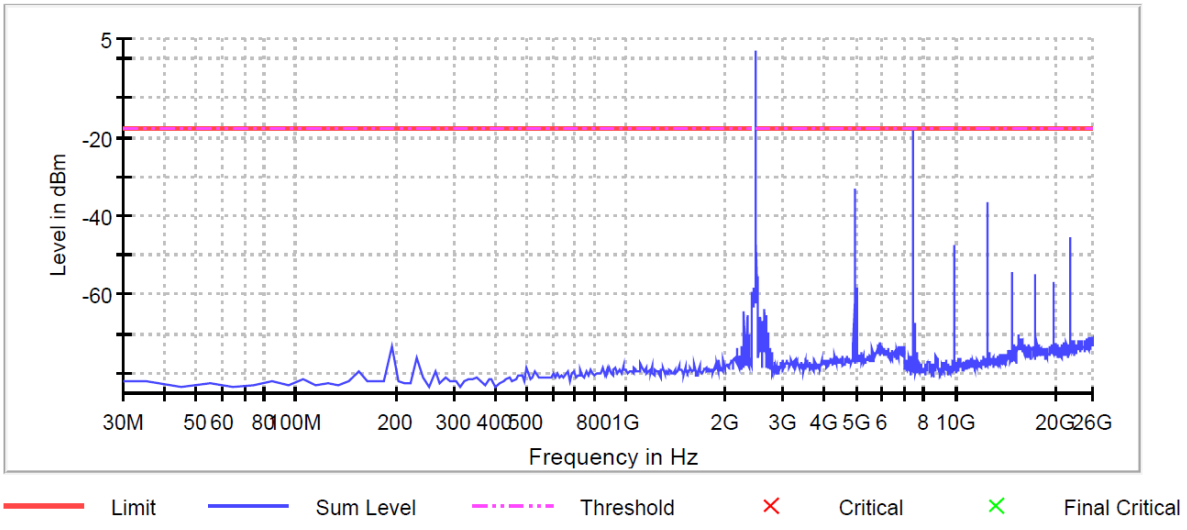
Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =low (S01_AI01)



Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =mid (S01_AI01)



Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =high (S01_AI01)



5.4.5 TEST EQUIPMENT USED

- R&S TS8997

5.5 TRANSMITTER SPURIOUS RADIATED EMISSIONS

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10, chapter 6.4, 6.5, 6.6.5

5.5.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The measurements were performed according the following sub-chapters of ANSI C63.10:

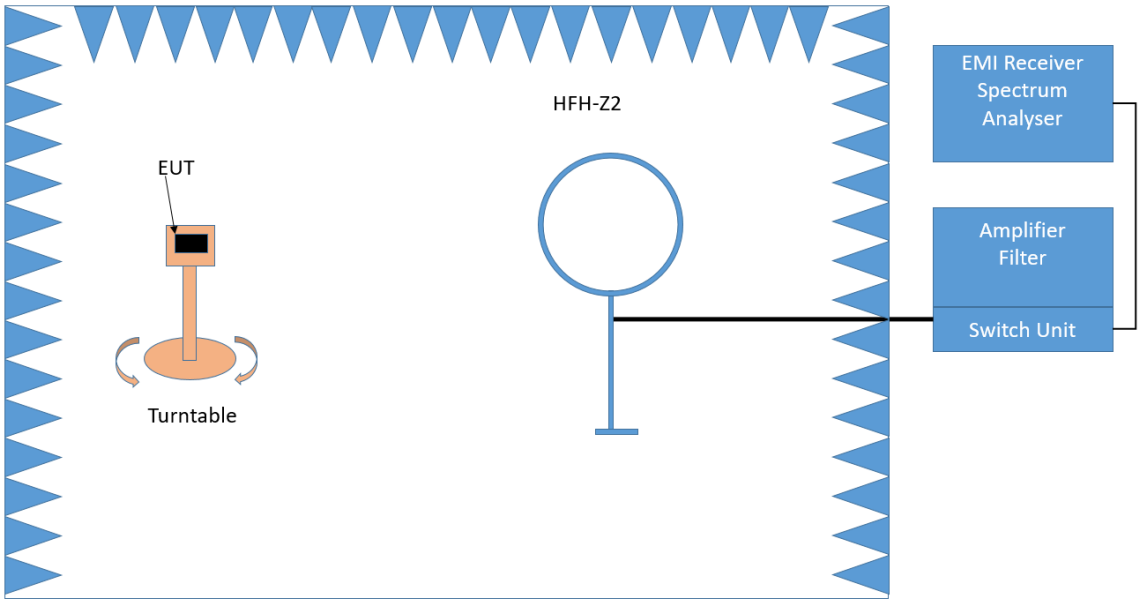
- < 30 MHz: Chapter 6.4
- 30 MHz – 1 GHz: Chapter 6.5
- > 1 GHZ: Chapter 6.6 (procedure according 6.6.5 used)

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.

Below 1 GHz:

The Equipment Under Test (EUT) was set up on a non-conductive table in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.

1. Measurement up to 30 MHz



Test Setup; Spurious Emission Radiated (SAC), 9 kHz – 30 MHz

The Loop antenna HFH2-Z2 is used.

Step 1: pre measurement

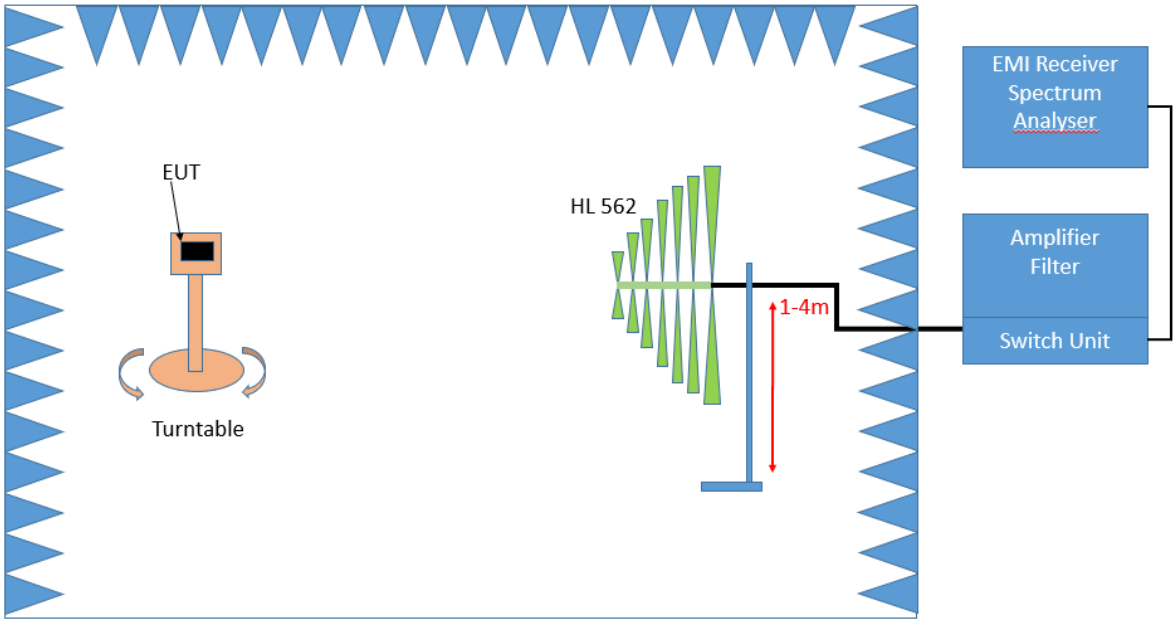
- Anechoic chamber
- Antenna distance: 3 m
- Antenna height: 1 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

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.

- Detector: Quasi-Peak (9 kHz – 150 kHz, Peak / Average 150 kHz- 30 MHz)
- 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



Test Setup; Spurious Emission Radiated (SAC), 30 MHz- 1GHz

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 – 4 m
- Height variation step size: 1.5 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 360°. 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 between 1 – 4 meter. 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: 360 °
- Height variation range:1 – 4 m
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector

With the settings determined in step 2, the final measurement will be performed:
EMI receiver settings for step 3:

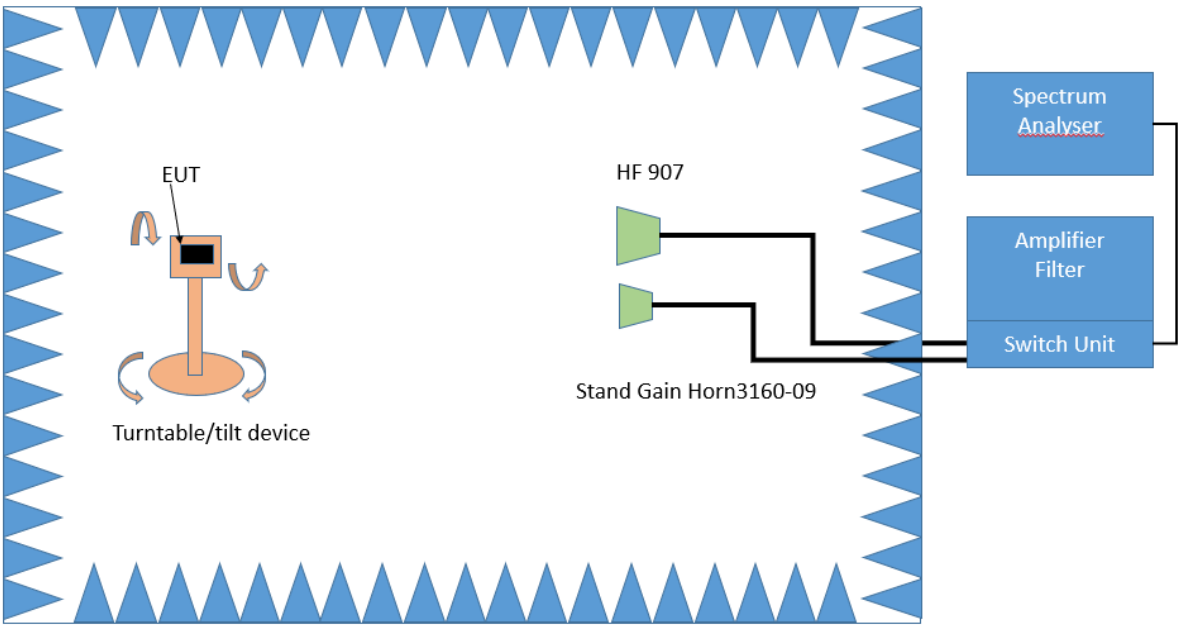
- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

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.

Above 1 GHz:

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.

3. Measurement above 1 GHz



Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

Step 1:
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 °.
Spectrum analyser settings:
- Detector: Peak, Average
- RBW = 1 MHz
- VBW = 3 MHz

Step 2:
The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°
Spectrum analyser settings:
- Detector: Peak

Step 3:
Spectrum analyser settings for step 3:
- Detector: Peak / CISPR Average
- Measured frequencies: in step 1 determined frequencies
- RBW = 1 MHz
- VBW = 3 MHz
- Measuring time: 1 s

5.5.2 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)

5.5.3 TEST PROTOCOL

Ambient temperature: 22–24 °C
Air Pressure: 999 – 1010 hPa
Humidity: 36– 42 %
BT LE 1 Mbit/s

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
0	2402	240.0	22.8	QP	120	46.0	23.2	RB
0	2402	323.7	14.6	QP	120	46.0	31.4	RB
0	2402	1440.0	25.8	AV	1000	54.0	28.2	RB
0	2402	1440.0	52.3	PEAK	1000	74.0	21.7	RB
0	2402	4803.7	38.3 *)	AV	1000	54.0	13.7	RB
0	2402	4803.7	58.3	PEAK	1000	74.0	13.7	RB
0	2402	12009.0	40.6	AV	1000	54.0	13.4	RB
0	2402	12009.0	54.4	PEAK	1000	74.0	19.6	RB
0	2402	19500.9	35.9	AV	1000	54.0	18.1	RB
0	2402	19500.9	57.9	PEAK	1000	74.0	16.1	RB
19	2440	200.0	35.4	QP	120	43.5	8.1	RB
19	2440	240.0	35.6	QP	120	46.0	10.4	RB
19	2440	840.7	17.7	QP	120	46.0	28.3	RB

19	2440	4879.9	40.3 *)	AV	1000	54.0	13.7	RB
19	2440	4879.9	60.3	PEAK	1000	74.0	13.7	RB
19	2440	7320.0	47.7 *)	AV	1000	54.0	6.3	RB
19	2440	7320.0	67.7	PEAK	1000	74.0	6.3	RB
39	2480	73.9	14.8	QP	120	40.0	25.2	RB
39	2480	110.9	12.0	QP	120	43.5	31.6	RB
39	2480	168.3	9.4	QP	120	43.5	34.1	RB
39	2480	240.0	31.0	QP	120	46.0	15.0	RB
39	2480	258.7	15.4	QP	120	46.0	30.6	RB
39	2480	328.4	12.6	QP	120	46.0	33.4	RB
39	2480	400.0	31.6	QP	120	46.0	14.4	RB
39	2480	960.0	30.1	QP	120	54.0	23.9	RB
39	2480	2483.6	35.3 *)	AV	1000	54.0	18.7	RB
39	2480	2483.6	55.3	PEAK	1000	74.0	18.7	RB
39	2480	4960.2	41.1 *)	AV	1000	54.0	12.9	RB
39	2480	4960.2	61.1	PEAK	1000	74.0	12.9	RB
39	2480	7440.0	47.6 *)	AV	1000	54.0	6.4	RB
39	2480	7440.0	67.6	PEAK	1000	74.0	6.4	RB
39	2480	13338.5	37.3	AV	1000	54.0	13.7	RB
39	2480	13338.5	53.2	PEAK	1000	74.0	20.8	RB
39	2480	19000.1	35.7	AV	1000	54.0	18.3	RB
39	2480	19000.1	57.3	PEAK	1000	74.0	16.7	RB

Ambient temperature: 26 °C
Air Pressure: 1010 hPa
Humidity: 46 %
BT LE 2 Mbit/s

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
0	2402	4803.7	41.2 *)	AV	1000	54.0	12.8	RB
0	2402	4803.7	56.1	PEAK	1000	74.0	17.9	RB
0	2402	12009.0	40.6	AV	1000	54.0	13.5	RB
0	2402	12009.0	54.4	PEAK	1000	74.0	19.5	RB
0	2402	19500.9	35.9	AV	1000	54.0	18.1	RB
0	2402	19500.9	57.9	PEAK	1000	74.0	16.1	RB
19	2440	4879.5	37.0 *)	AV	1000	54.0	14.0	RB
19	2440	4879.5	57.0	PEAK	1000	74.0	14.0	RB
19	2440	7318.8	44.1 *)	AV	1000	54.0	9.9	RB
19	2440	7318.8	64.1	PEAK	1000	74.0	9.9	RB
39	2480	2483.6	41.3 *)	AV	1000	54.0	12.7	RB
39	2480	2483.6	61.3	PEAK	1000	74.0	12.7	RB
39	2480	4959.6	44.0 *)	AV	1000	54.0	10.0	RB
39	2480	4959.6	58.9	PEAK	1000	74.0	15.1	RB
39	2480	7438.7	38.9 *)	AV	1000	54.0	15.1	RB
39	2480	7438.7	65.9	PEAK	1000	74.0	8.1	RB
39	2480	12397.4	37.8	AV	1000	54.0	16.2	RB
39	2480	12397.4	55.2	PEAK	1000	74.0	18.8	RB
39	2480	14400.0	40.4	AV	1000	54.0	13.6	RB
39	2480	14400.0	54.6	PEAK	1000	74.0	19.4	RB
39	2480	22315.1	39.3	AV	1000	54.0	14.7	RB
39	2480	22315.2	57.2	PEAK	1000	74.0	16.8	RB

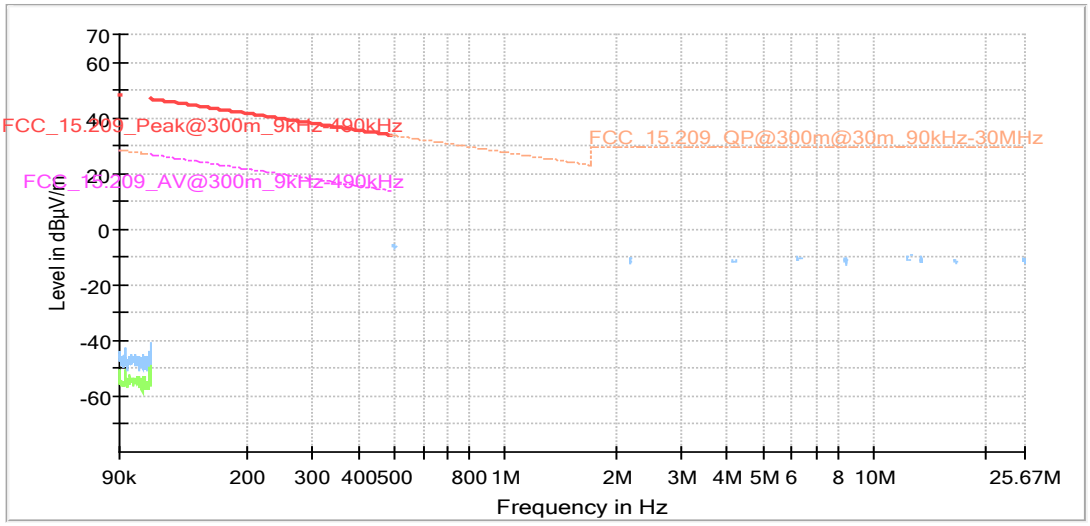
The average values > 1 MHz – related to the fundamental frequency (harmonics) - are calculated according to KDB 558074 D01 v05r02, chapter 11 "Frequently Asked questions" answer 3 a) in conjunction with ANSI C63.10, chapter 11.12.2.4. These values are marked with a *)

The calculation factor is calculated to: **-20.0 dB**, for details please see chapter 4.7 of this report.

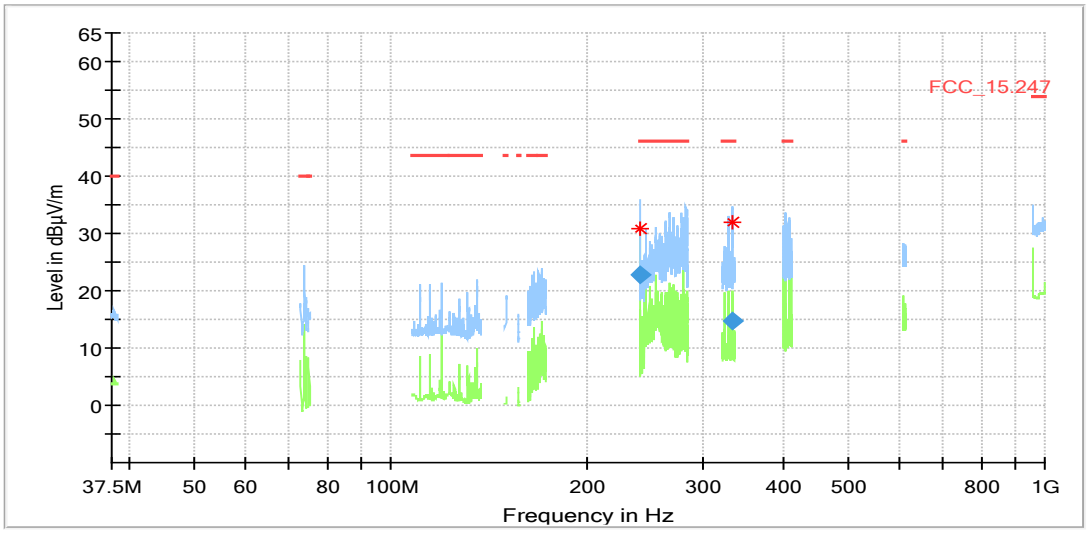
Remark: Please see next sub-clause for the measurement plot.

5.5.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =mid
Frequency Range = 9 kHz – 30 MHz
(S01_AJ01)



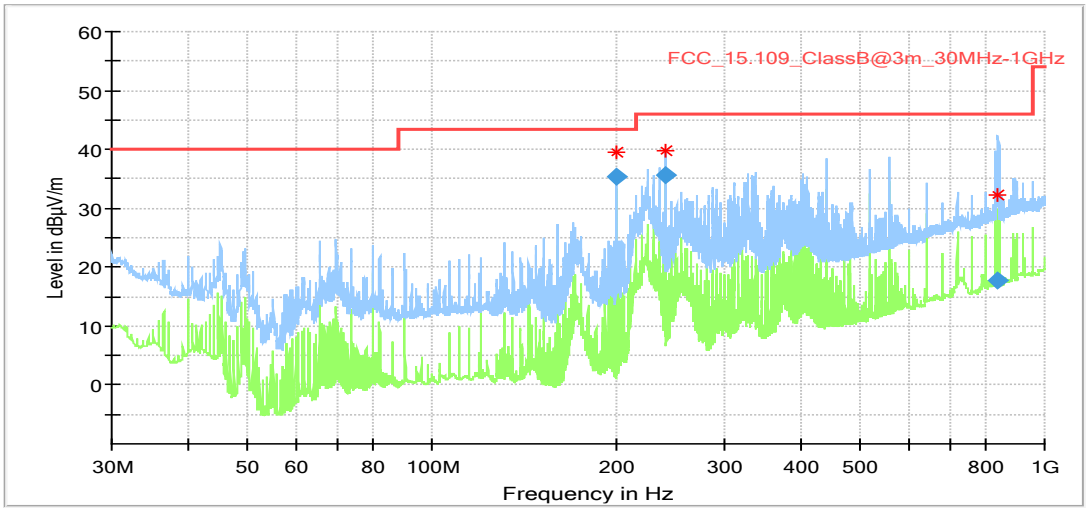
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =low
Frequency Range = 30 MHz – 1 GHz
(S01_AJ01)



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
240.000000	22.84	46.00	23.16	1000.0	120.000	270.0	V	0.0	12.3
332.680000	14.59	46.00	31.41	1000.0	120.000	100.0	V	274.0	15.8

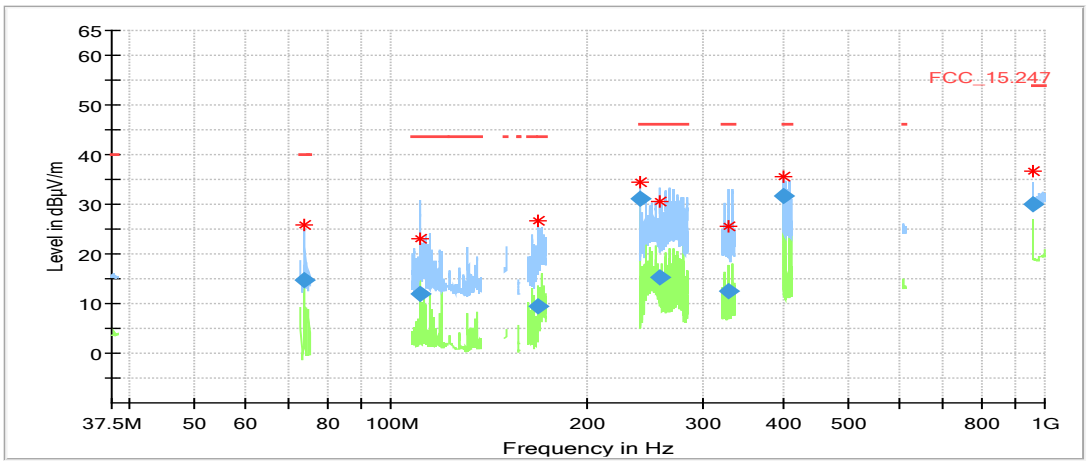
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =mid
Frequency Range = 30 MHz – 1 GHz
(S01_AJ01)



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
200.010000	35.41	43.50	8.09	1000.0	120.000	106.0	V	101.0	10.6
240.000000	35.57	46.00	10.43	1000.0	120.000	108.0	V	169.0	12.3
840.660000	17.66	46.00	28.34	1000.0	120.000	340.0	V	316.0	26.7

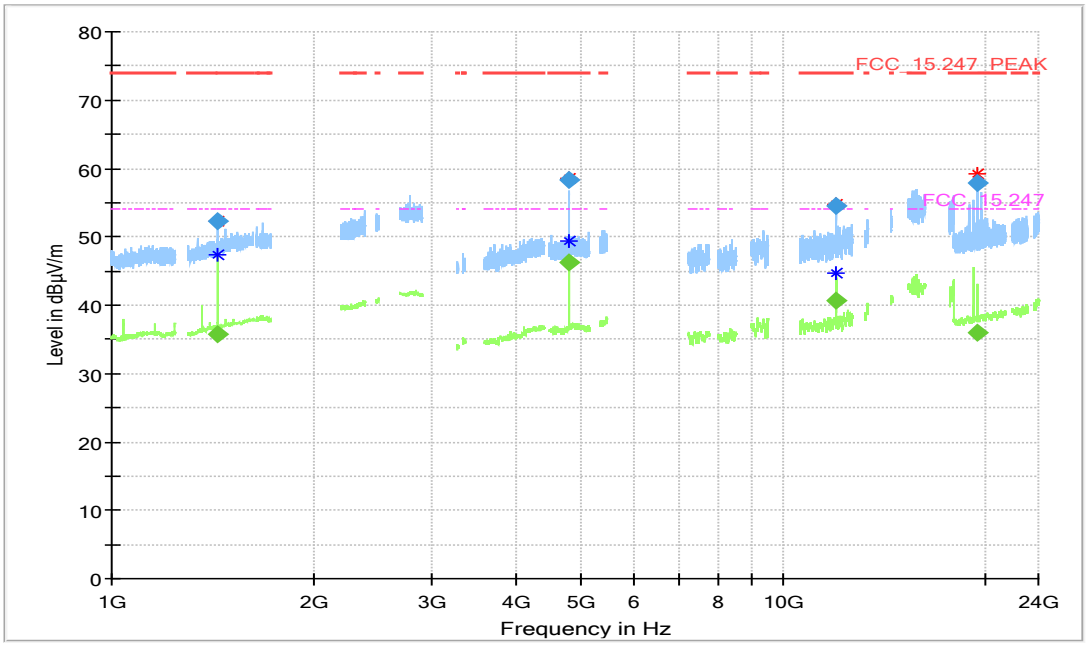
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =high
Frequency Range = 30 MHz – 1 GHz
(S01_AJ01)



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
73.930000	14.84	40.00	25.16	1000.0	120.000	110.0	V	111.0	9.3
110.850000	11.95	43.50	31.55	1000.0	120.000	109.0	V	68.0	11.7
168.320000	9.42	43.50	34.08	1000.0	120.000	105.0	V	46.0	9.9
240.000000	31.03	46.00	14.97	1000.0	120.000	244.0	V	101.0	12.3
258.660000	15.35	46.00	30.65	1000.0	120.000	121.0	H	266.0	12.9
328.420000	12.55	46.00	33.45	1000.0	120.000	100.0	V	28.0	15.7
400.020000	31.60	46.00	14.40	1000.0	120.000	105.0	H	109.0	17.8
960.030000	30.10	54.00	23.90	1000.0	120.000	226.0	H	128.0	28.3

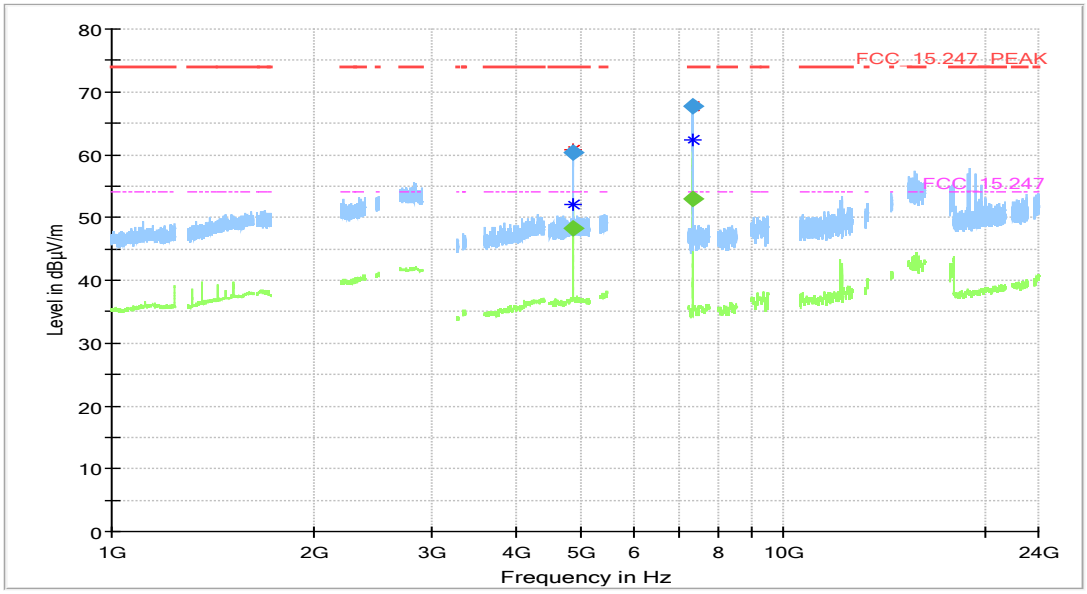
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =low
Frequency Range = 1 GHz – 26 GHz
(S01_AJ01)



Final_Result

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)	Corr. (dB/m)
1439.979	---	35.8	54.00	18.25	1000.0	1000.000	150.0	H	-99.0	78.0	4.3
1439.979	52.3	---	74.00	21.66	1000.0	1000.000	150.0	H	-99.0	78.0	4.3
4803.713	---	46.4	54.00	7.64	1000.0	1000.000	150.0	H	31.0	-12.0	6.1
4803.713	58.3	---	74.00	15.67	1000.0	1000.000	150.0	H	31.0	-12.0	6.1
12008.995	---	40.6	54.00	13.43	1000.0	1000.000	150.0	H	60.0	15.0	-6.0
12008.995	54.5	---	74.00	19.47	1000.0	1000.000	150.0	H	60.0	15.0	-6.0
19500.930	---	35.9	54.00	18.06	1000.0	1000.000	150.0	V	-21.0	-1.0	17.3
19500.930	57.9	---	74.00	16.09	1000.0	1000.000	150.0	V	-21.0	-1.0	17.3

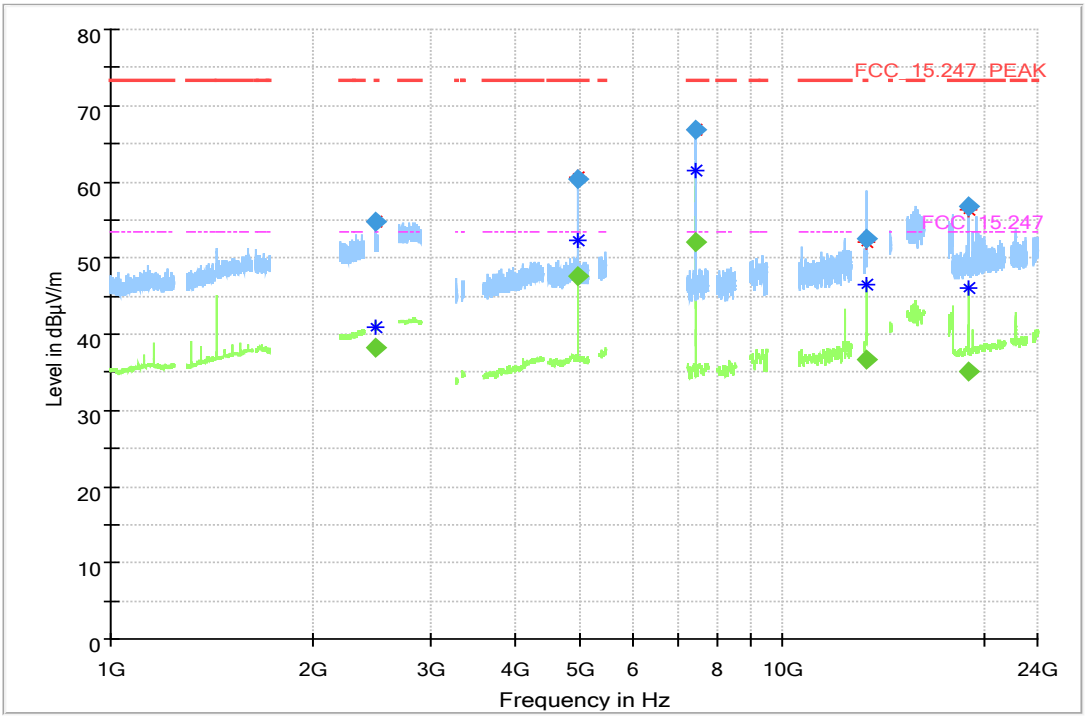
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =mid
Frequency Range = 1 GHz – 26 GHz
(S01_AJ01)



Final_Result

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)	Corr. (dB/m)
4879.925	---	48.3	54.00	5.71	1000.0	1000.000	150.0	H	-34.0	88.0	6.1
4879.925	60.3	---	74.00	13.69	1000.0	1000.000	150.0	H	-34.0	88.0	6.1
7320.000	---	53.0	54.00	0.96	1000.0	1000.000	150.0	V	-121.0	99.0	-13.5
7320.000	67.7	---	74.00	6.26	1000.0	1000.000	150.0	V	-121.0	99.0	-13.5

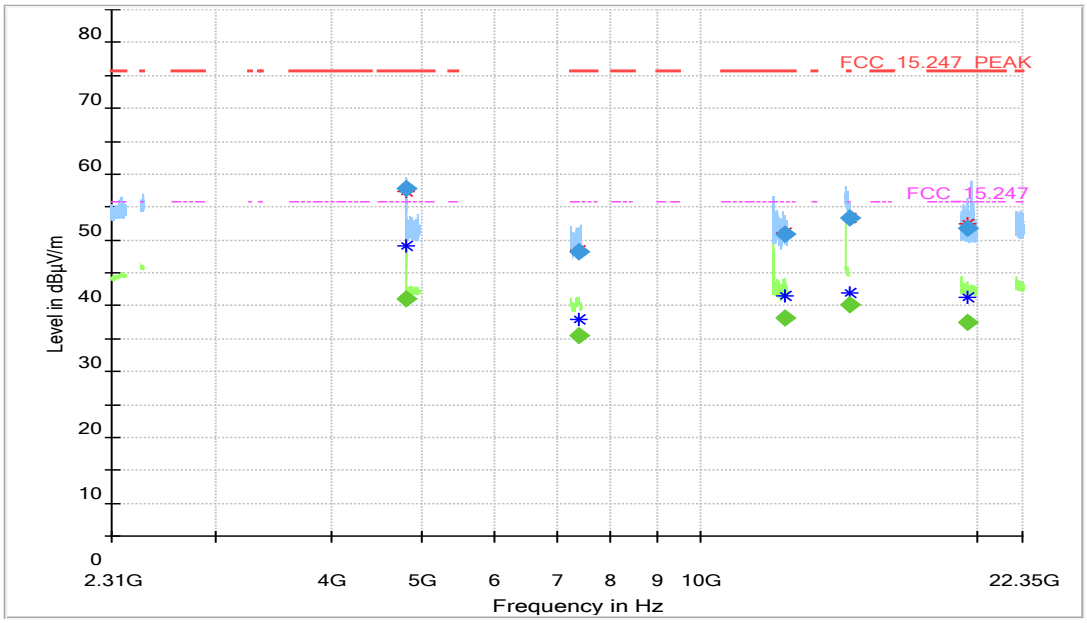
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =high
Frequency Range = 1 GHz – 26 GHz
(S01_AJ01)



Final_Result

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)	Corr. (dB/m)
2483.583	---	38.8	54.00	15.20	1000.0	1000.000	150.0	V	21.0	4.0	7.8
2483.583	55.3	---	74.00	18.66	1000.0	1000.000	150.0	V	21.0	4.0	7.8
4960.200	---	48.3	54.00	5.71	1000.0	1000.000	150.0	H	-31.0	83.0	5.9
4960.200	61.1	---	74.00	12.91	1000.0	1000.000	150.0	H	-31.0	83.0	5.9
7440.000	---	52.8	54.00	1.25	1000.0	1000.000	150.0	V	-120.0	96.0	-12.1
7440.000	67.6	---	74.00	6.42	1000.0	1000.000	150.0	V	-120.0	96.0	-12.1
13338.500	---	37.3	54.00	16.66	1000.0	1000.000	150.0	H	-118.0	78.0	-2.8
13338.500	53.2	---	74.00	20.85	1000.0	1000.000	150.0	H	-118.0	78.0	-2.8
19000.110	---	35.7	54.00	18.30	1000.0	1000.000	150.0	H	-41.0	86.0	16.9
19000.110	57.3	---	74.00	16.66	1000.0	1000.000	150.0	H	-41.0	86.0	16.9

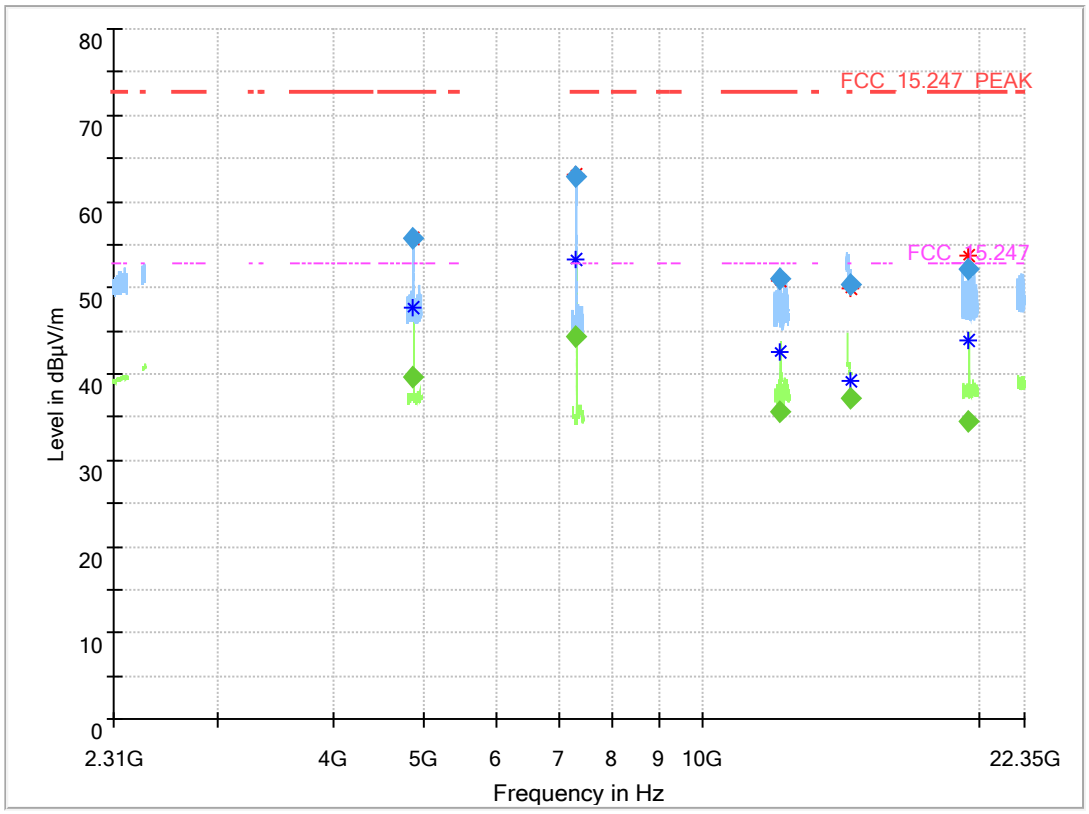
Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =low
Frequency Range = 1 GHz – 26 GHz, only harmonics
(S01_AJ01)



Final_Result

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)	Corr. (dB/m)
4803.716	---	39.4	54.00	14.64	1000.0	1000.000	150.0	H	71.0	-4.0	6.1
4803.716	56.1	---	74.00	17.87	1000.0	1000.000	150.0	H	71.0	-4.0	6.1
7385.338	---	33.6	54.00	20.35	1000.0	1000.000	150.0	V	19.0	105.0	-11.0
7385.338	46.5	---	74.00	27.48	1000.0	1000.000	150.0	V	19.0	105.0	-11.0
12340.221	---	36.3	54.00	17.66	1000.0	1000.000	150.0	H	1.0	92.0	-3.4
12340.221	49.1	---	74.00	24.87	1000.0	1000.000	150.0	H	1.0	92.0	-3.4
14499.500	---	38.5	54.00	15.51	1000.0	1000.000	150.0	H	-98.0	98.0	-3.6
14499.500	51.6	---	74.00	22.38	1000.0	1000.000	150.0	H	-98.0	98.0	-3.6
19500.333	---	35.8	54.00	18.20	1000.0	1000.000	150.0	H	52.0	78.0	17.3
19500.333	50.1	---	74.00	23.90	1000.0	1000.000	150.0	H	52.0	78.0	17.3

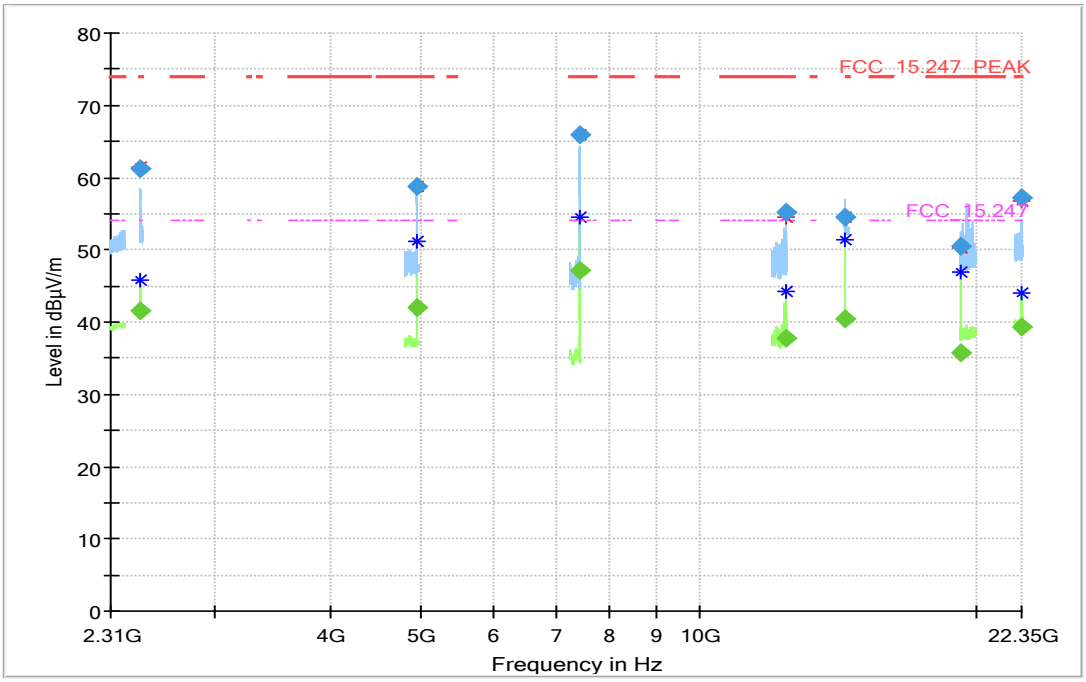
Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =mid
Frequency Range = 1 GHz – 26 GHz, only harmonics
(S01_AJ01)



Final_Result

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)	Corr. (dB/m)
4879.450	---	41.0	54.00	13.03	1000.0	1000.000	150.0	V	79.0	86.0	6.2
4879.450	57.0	---	74.00	16.99	1000.0	1000.000	150.0	V	79.0	86.0	6.2
7318.822	---	45.6	54.00	8.42	1000.0	1000.000	150.0	V	-146.0	89.0	-13.5
7318.822	64.1	---	74.00	9.88	1000.0	1000.000	150.0	V	-146.0	89.0	-13.5
12197.770	---	36.9	54.00	17.08	1000.0	1000.000	150.0	H	67.0	12.0	-5.4
12197.770	52.3	---	74.00	21.73	1000.0	1000.000	150.0	H	67.0	12.0	-5.4
14498.500	---	38.5	54.00	15.48	1000.0	1000.000	150.0	H	-58.0	15.0	-3.7
14498.500	51.6	---	74.00	22.39	1000.0	1000.000	150.0	H	-58.0	15.0	-3.7
19501.168	---	35.8	54.00	18.16	1000.0	1000.000	150.0	H	22.0	90.0	17.3
19501.168	53.4	---	74.00	20.61	1000.0	1000.000	150.0	H	22.0	90.0	17.3

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =high
Frequency Range = 1 GHz – 26 GHz, only harmonics
(S01_AJ01)



Final_Result

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)	Corr. (dB/m)
2483.583	---	41.7	54.00	12.33	1000.0	1000.000	150.0	V	11.0	-15.0	7.8
2483.583	61.3	---	74.00	12.68	1000.0	1000.000	150.0	V	11.0	-15.0	7.8
4959.610	---	42.0	54.00	12.04	1000.0	1000.000	150.0	H	142.0	6.0	5.9
4959.610	58.9	---	74.00	15.14	1000.0	1000.000	150.0	H	142.0	6.0	5.9
7438.721	---	47.2	54.00	6.82	1000.0	1000.000	150.0	V	-121.0	105.0	-12.1
7438.721	65.9	---	74.00	8.09	1000.0	1000.000	150.0	V	-121.0	105.0	-12.1
12397.377	---	37.8	54.00	16.15	1000.0	1000.000	150.0	H	58.0	15.0	-4.7
12397.377	55.2	---	74.00	18.78	1000.0	1000.000	150.0	H	58.0	15.0	-4.7
14400.000	---	40.4	---	---	1000.0	1000.000	150.0	H	150.0	86.0	-1.4
14400.000	54.6	---	---	---	1000.0	1000.000	150.0	H	150.0	86.0	-1.4
19253.306	---	35.8	54.00	18.23	1000.0	1000.000	150.0	H	-39.0	15.0	17.1
19253.306	50.4	---	74.00	23.58	1000.0	1000.000	150.0	H	-39.0	15.0	17.1
22315.062	---	39.3	54.00	14.70	1000.0	1000.000	150.0	H	-101.0	-15.0	19.3
22315.062	57.2	---	74.00	16.85	1000.0	1000.000	150.0	H	-101.0	-15.0	19.3

5.5.5 TEST EQUIPMENT USED

- Radiated Emissions FAR 2.4 GHz FCC
- Radiated Emissions SAC H-Field
- Radiated Emissions SAC up to 1 GHz

5.6 BAND EDGE COMPLIANCE CONDUCTED

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10, chapter 11.11

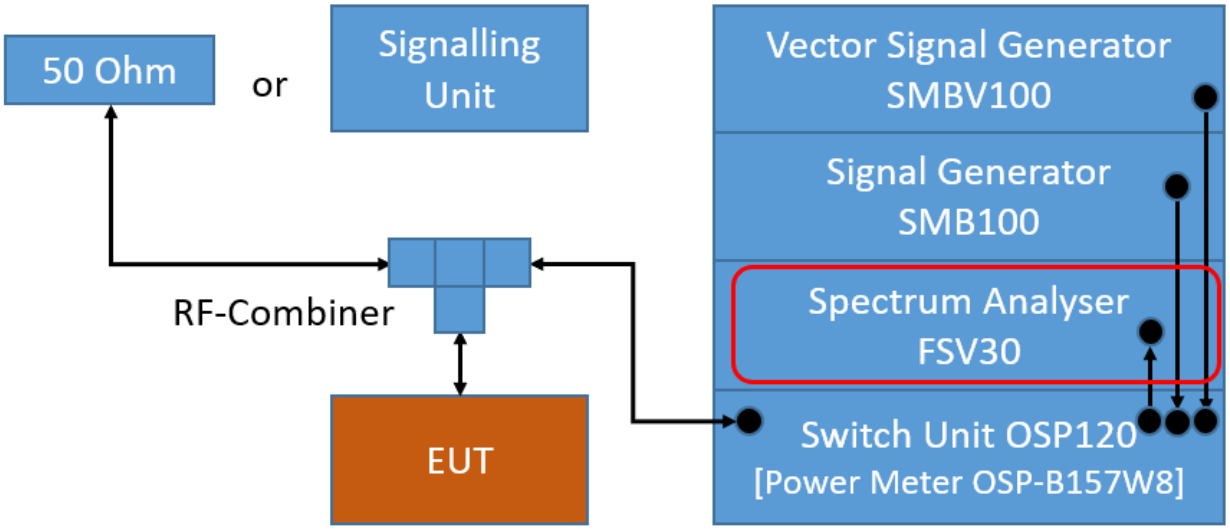
5.6.1 TEST DESCRIPTION

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".

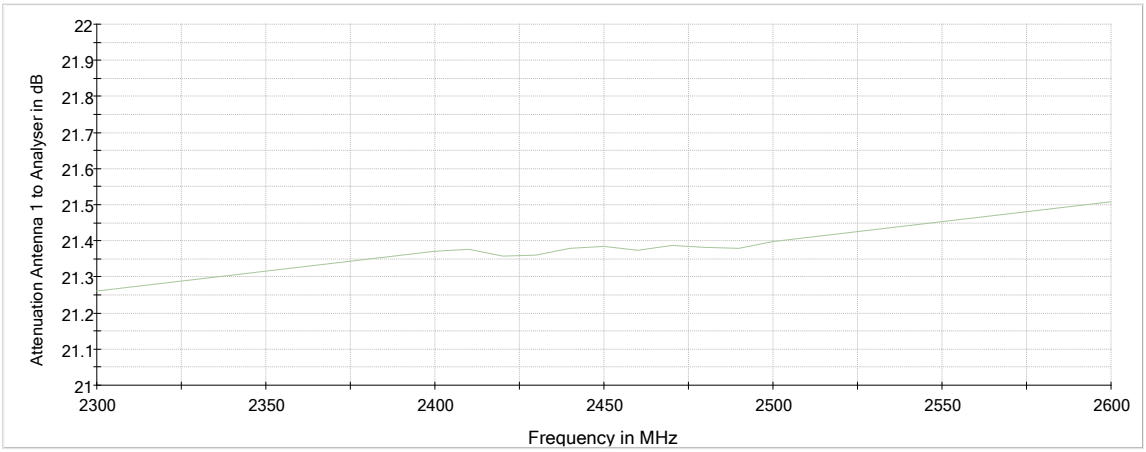
The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Analyser settings:

- Lower Band Edge:
  Measured range: 2310.0 MHz to 2483.5 MHz
  Upper Band Edge
  Measured range: 2400.0 MHz to 2500 MHz
- Detector: Peak
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweeptime: Auto
- Sweeps: Till stable (min. 300, max. 15000)
- Trace: Maxhold



TS8997; Band Edge Conducted



Attenuation of the measurement path

5.6.2 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..."

5.6.3 TEST PROTOCOL

Ambient temperature: 24°C
Air Pressure: 1012 hPa
Humidity: 46 %

BT LE 1 Mbit/s

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	-47.0	PEAK	100	4.0	-16.0	31.0
39	2480	2483.5	-47.4	PEAK	100	4.1	-15.9	31.5

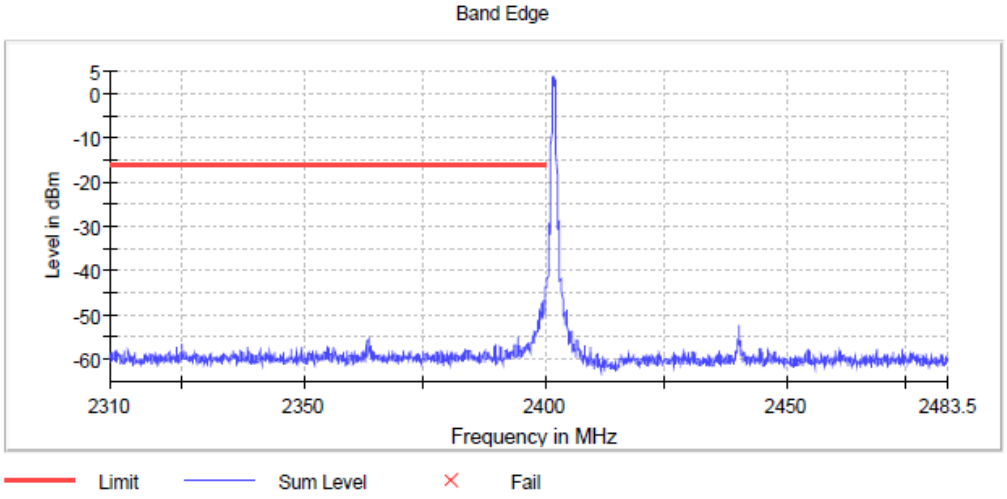
BT LE 2 Mbit/s

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	-29.8	PEAK	100	3.8	-16.2	13.6
39	2480	2483.5	-42.7	PEAK	100	4.1	-15.9	26.8

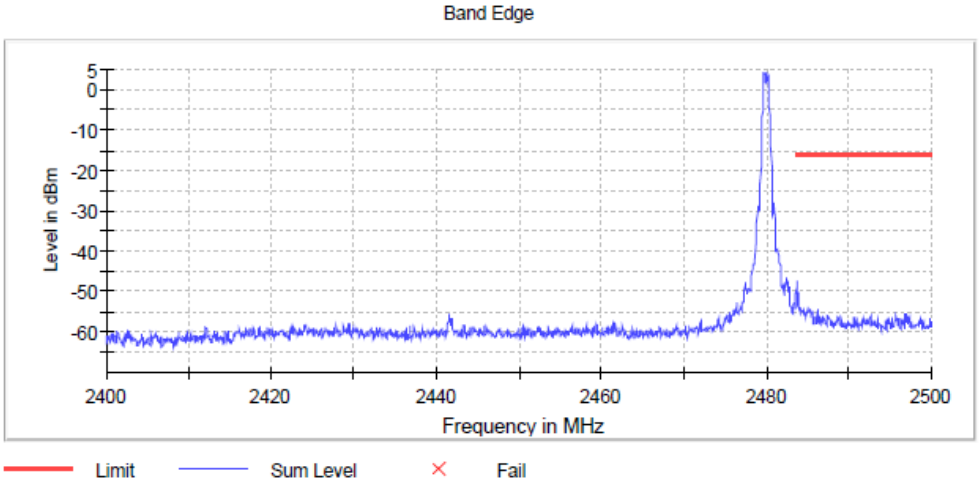
Remark: Please see next sub-clause for the measurement plot.

5.6.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

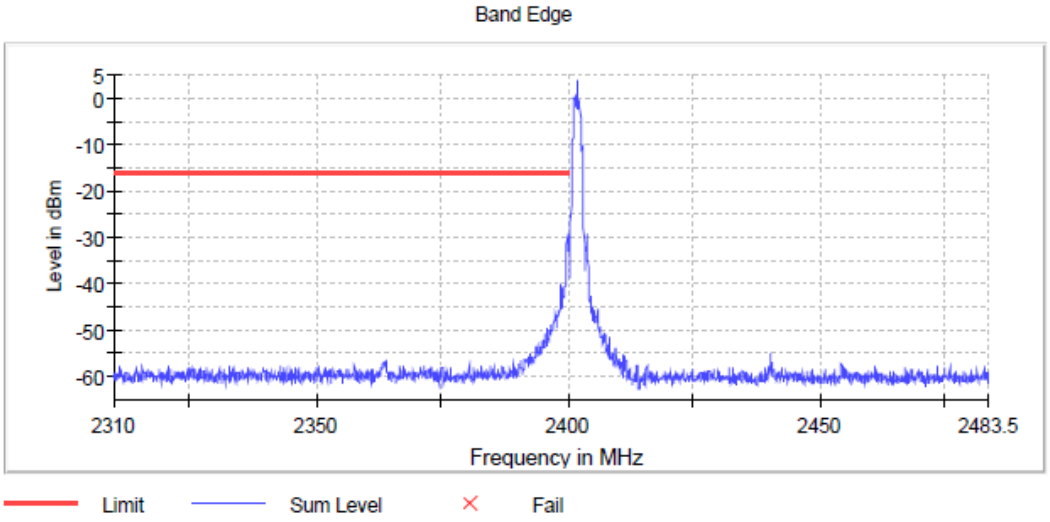
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =low
Band Edge = low
(S01_AI01)



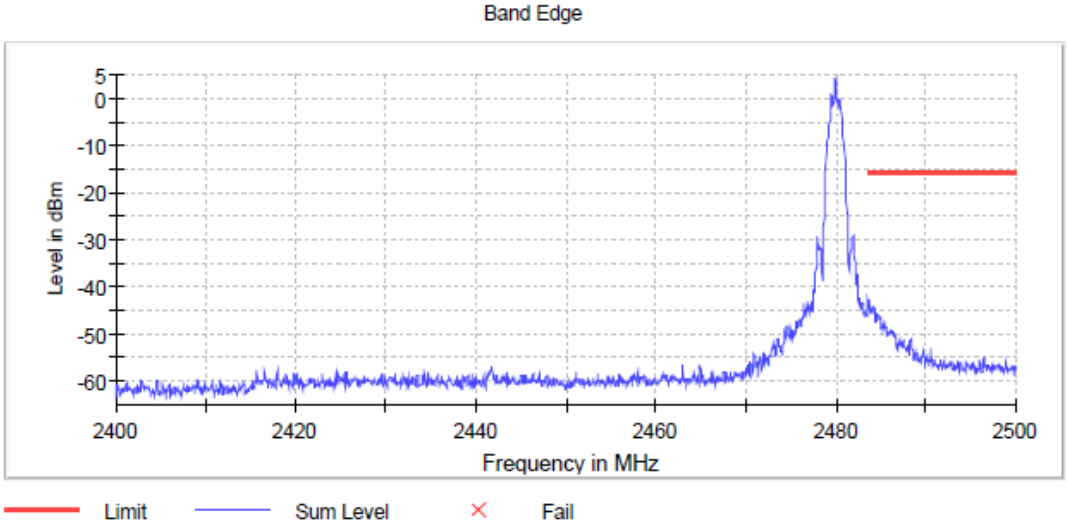
adio Technology = Bluetooth LE 1 Mbps, Operating Frequency =high
Band Edge = high
(S01_AI01)



Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =low
Band Edge = low
(S01_AI01)



adio Technology = Bluetooth LE 2 Mbps, Operating Frequency =high
Band Edge = high
(S01_AI01)



5.6.5 TEST EQUIPMENT USED

- R&S TS8997

5.7 BAND EDGE COMPLIANCE RADIATED

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10, chapter 6.6.5

5.7.1 TEST DESCRIPTION

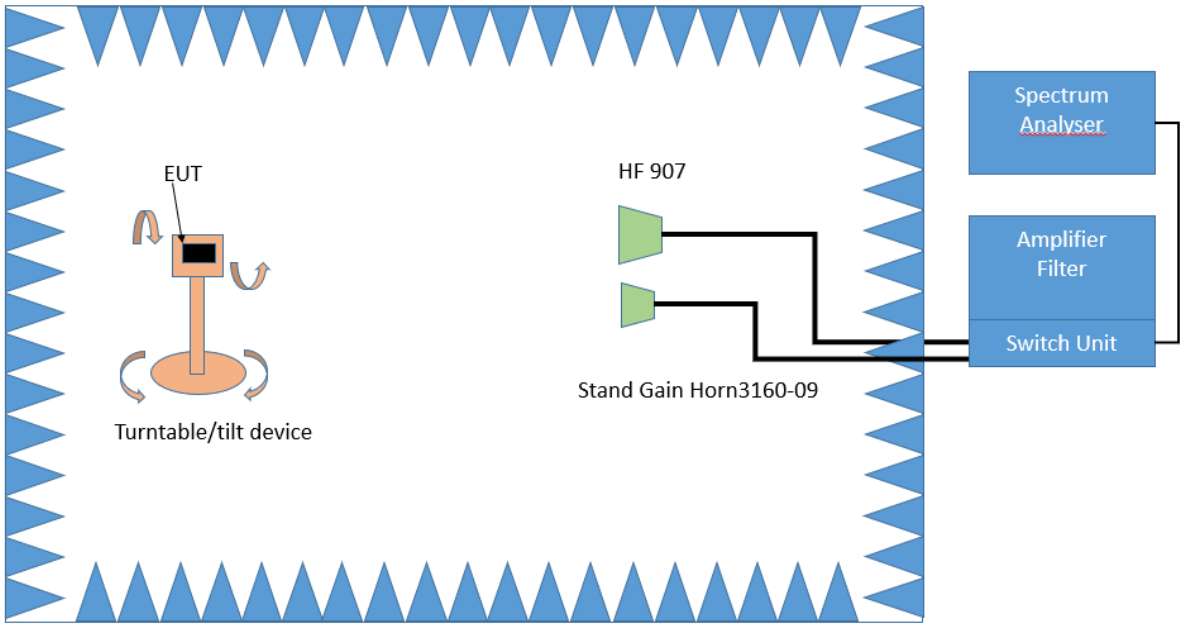
The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The measurements were performed according the following sub-chapter of ANSI C63.10:

- Chapter 6.10.5

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 (procedure according to ANSI C63.10, chapter 6.6.5.

Note: The restricted band measurement closest to the lower band edge from 2310-2390 MHz is included in test case "Transmitter Spurious Emissions Radiated" (Chapter 5.5).

3. Measurement above 1 GHz



Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

Step 1:
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 °.
Spectrum analyser settings:
- Detector: Peak, Average
- RBW = 1 MHz
- VBW = 3 MHz

Step 2:
The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°
Spectrum analyser settings:
- Detector: Peak
Step 3:
Spectrum analyser settings for step 3:
- Detector: Peak / CISPR Average
- Measured frequencies: in step 1 determined frequencies
- RBW = 1 MHz
- VBW = 3 MHz
- Measuring time: 1 s

5.7.2 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)

5.7.3 TEST PROTOCOL

Ambient temperature: 23 - 26 °C
Air Pressure: 1010 - 1014 hPa
Humidity: 38 – 46 %
BT LE 1 Mbit/s
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]
39	2480	2483.5	55.3	PEAK	1000	74.0	18.7
39	2480	2483.5	38.8	AV	1000	54.0	15.2

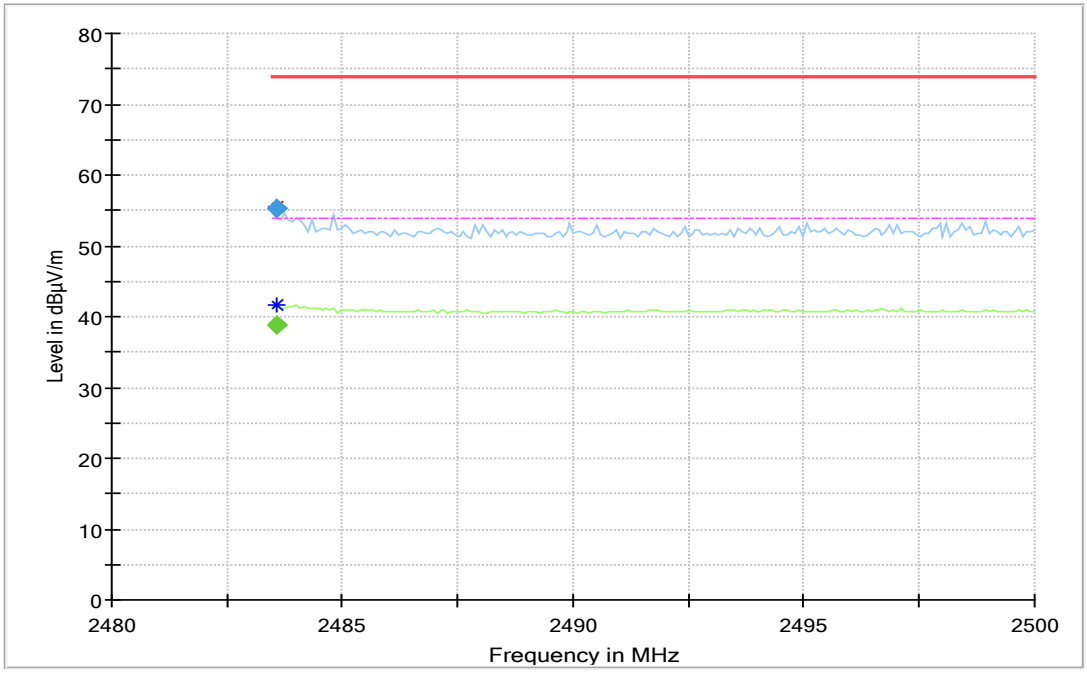
BT LE 2 Mbit/s
Applied duty cycle correction (AV): 0 dB

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]
39	2480	2483.5	61.3	PEAK	1000	74.0	12.7
39	2480	2483.5	41.7	AV	1000	54.0	12.3

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

5.7.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

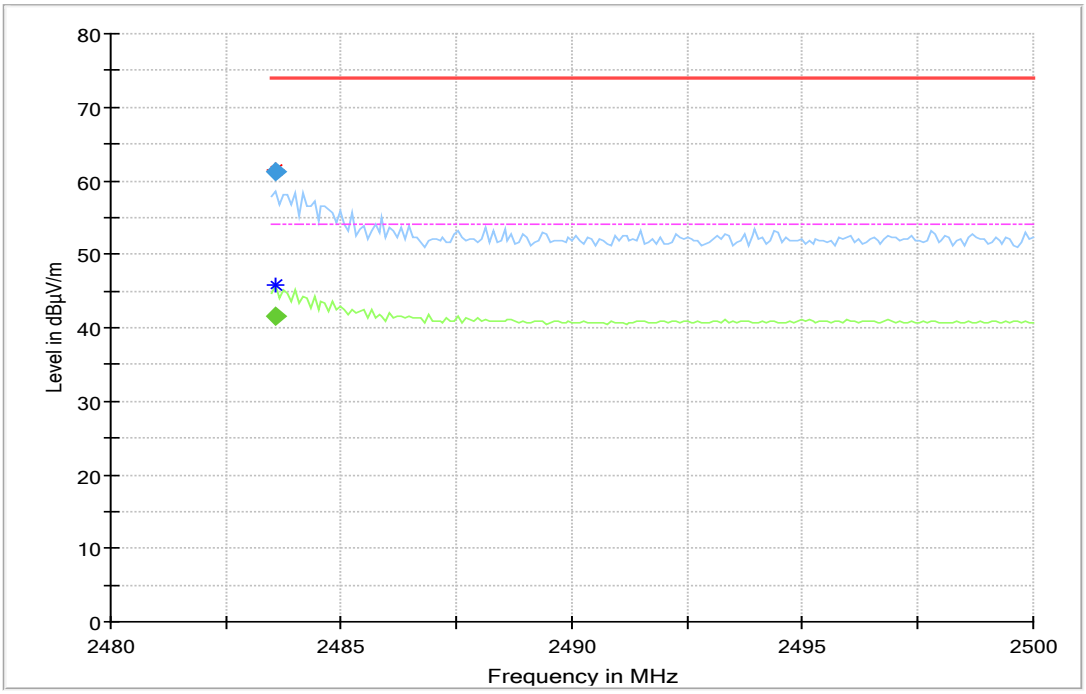
Modulation= Bluetooth LE 1 Mbps, Operating Channel = high, Band Edge = high (S01_AJ1)



Final_Result

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)	Corr. (dB/m)
2483.583	---	38.8	54.00	15.20	1000.0	1000.000	150.0	V	21.0	4.0	7.8
2483.583	55.3	---	74.00	18.66	1000.0	1000.000	150.0	V	21.0	4.0	7.8

Modulation= Bluetooth LE 2 Mbps, Operating Channel = high, Band Edge = high (S01_AJ01)



Final_Result

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)	Corr. (dB/m)
2483.583	---	41.7	54.00	12.33	1000.0	1000.000	150.0	V	11.0	-15.0	7.8
2483.583	61.3	---	74.00	12.68	1000.0	1000.000	150.0	V	11.0	-15.0	7.8

5.7.5 TEST EQUIPMENT USED

- Radiated Emissions FAR 2.4 GHz FCC

5.8 POWER DENSITY

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10, chapter 11.10.2

5.8.1 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.

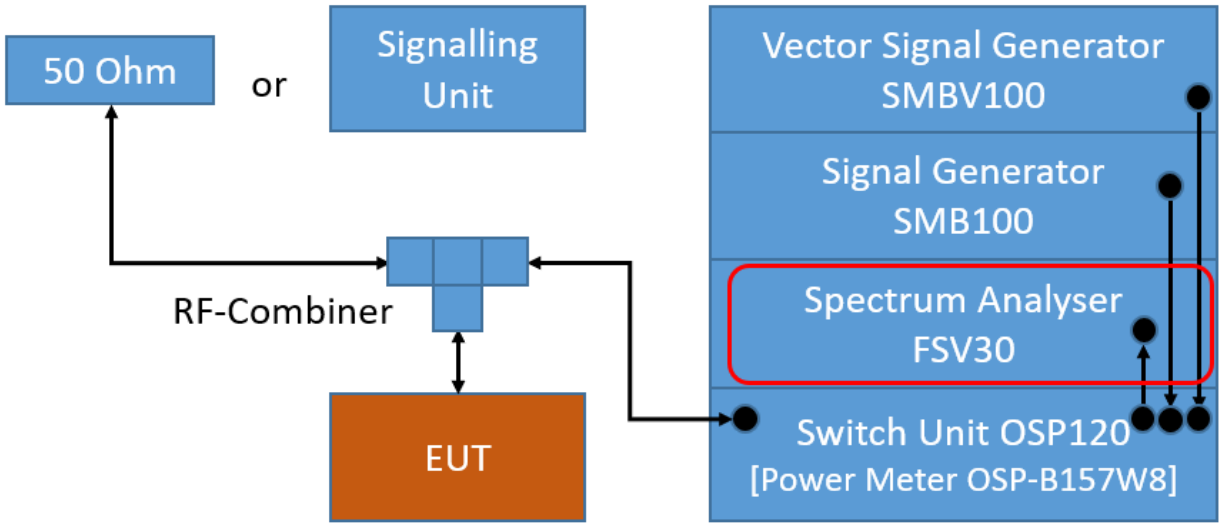
The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Maximum Peak Power Spectral Density (e.g. Bluetooth low energy):

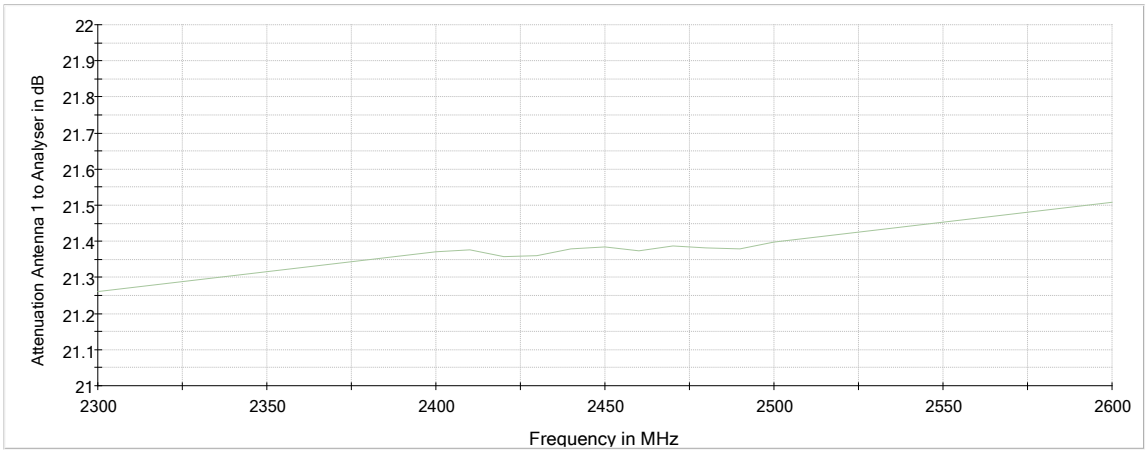
Analyser settings:
- Resolution Bandwidth (RBW): 100 kHz, 10 kHz or 3 kHz
- Video Bandwidth (VBW): ≥ 3 times RBW
- Trace: Maxhold
- Sweeps: Till stable (min. 200, max. 15000)
- Sweeptime: Auto
- Detector: Peak

Maximum Average Power Spectral Density (e.g. WLAN):

Analyser settings:
- Resolution Bandwidth (RBW): 100 kHz, 10 kHz or 3 kHz
- Video Bandwidth (VBW): ≥ 3 times RBW
- Sweep Points: ≥ 2 times span / RBW
- Trace: Maxhold
- Sweeps: Till stable (max. 150)
- Sweeptime: ≤ Number of Sweep Points x minimum transmission duration
- Detector: RMS



TS8997; Power Spectral Density



Attenuation of the measurement path

5.8.2 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.

FCC Part 15, Subpart C, §15.247 (f)

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques.
…
The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

5.8.3 TEST PROTOCOL

Ambient temperature: 24°C
Air Pressure: 1012 hPa
Humidity: 46 %

BT LE 1 Mbit/s

Band	Channel No.	Frequency [MHz]	Power Density [dBm / RBW]	RBW [kHz]	Limit [dBm/3kHz]	Margin to Limit [dB]
2.4 GHz ISM	0	2402	-6.3	10.0	8.0	14.3
	19	2440	-6.1	10.0	8.0	14.1
	39	2480	-6.0	10.0	8.0	14.0

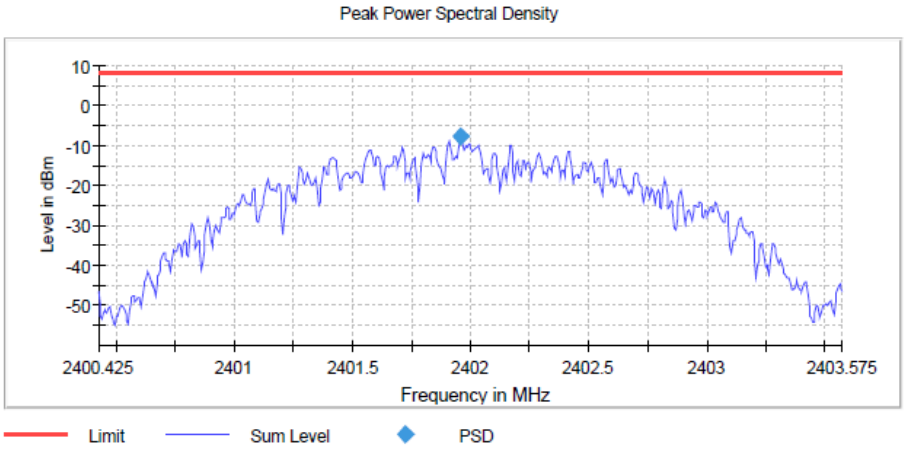
BT LE 2 Mbit/s

Band	Channel No.	Frequency [MHz]	Power Density [dBm / RBW]	RBW [kHz]	Limit [dBm/3kHz]	Margin to Limit [dB]
2.4 GHz ISM	0	2402	-7.9	10.0	8.0	15.9
	19	2440	-7.7	10.0	8.0	15.7
	39	2480	-7.6	10.0	8.0	15.6

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

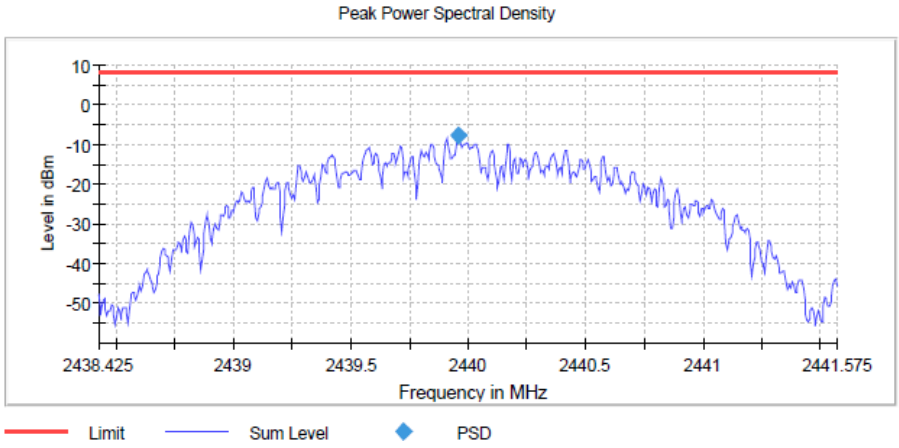
5.8.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =low (S01_AI01)



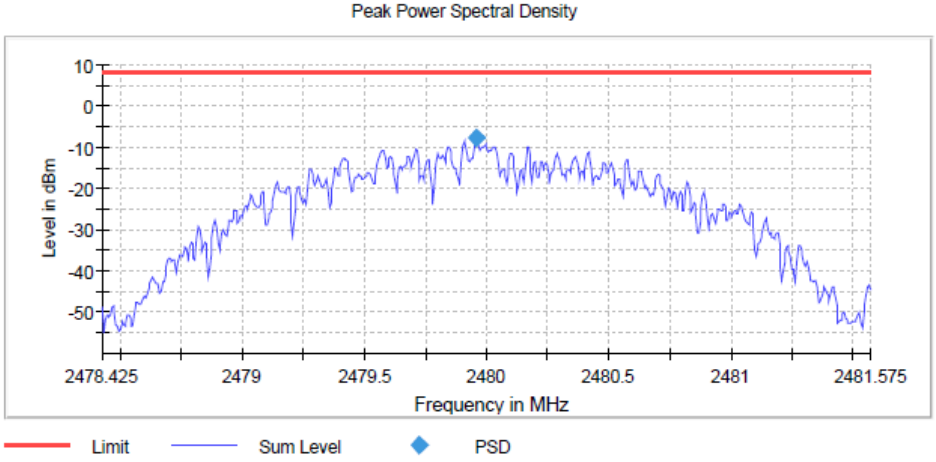
Setting	Instrument Value
Start Frequency	2.40043 GHz
Stop Frequency	2.40358 GHz
Span	3.150 MHz
RBW	10.000 kHz
VBW	30.000 kHz
SweepPoints	630
Sweeptime	3.150 ms
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	2 / 2
Max Stable Difference	0.13 dB

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =mid (S01_AI01)



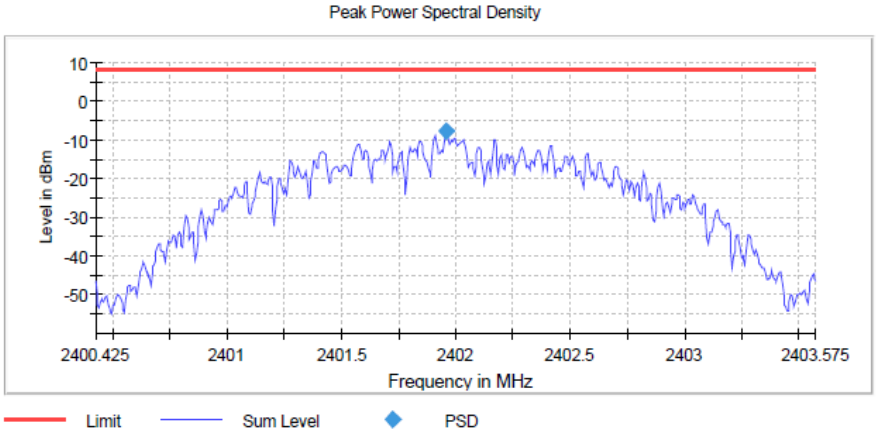
Setting	Instrument Value
Start Frequency	2.43843 GHz
Stop Frequency	2.44158 GHz
Span	3.150 MHz
RBW	10.000 kHz
VBW	30.000 kHz
SweepPoints	630
Sweeptime	3.150 ms
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	2 / 2
Max Stable Difference	0.23 dB

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency =high (S01_AI01)



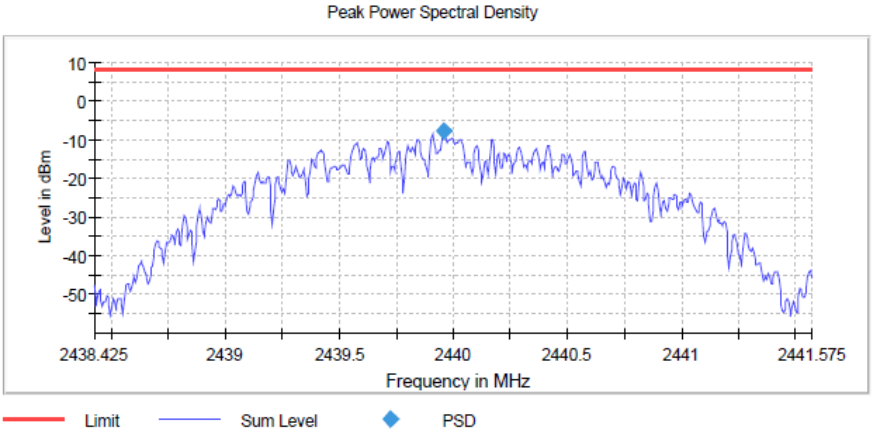
Setting	Instrument Value
Start Frequency	2.47843 GHz
Stop Frequency	2.48158 GHz
Span	3.150 MHz
RBW	10.000 kHz
VBW	30.000 kHz
SweepPoints	630
Sweeptime	3.150 ms
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	2 / 2
Max Stable Difference	0.29 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =low (S01_AI01)



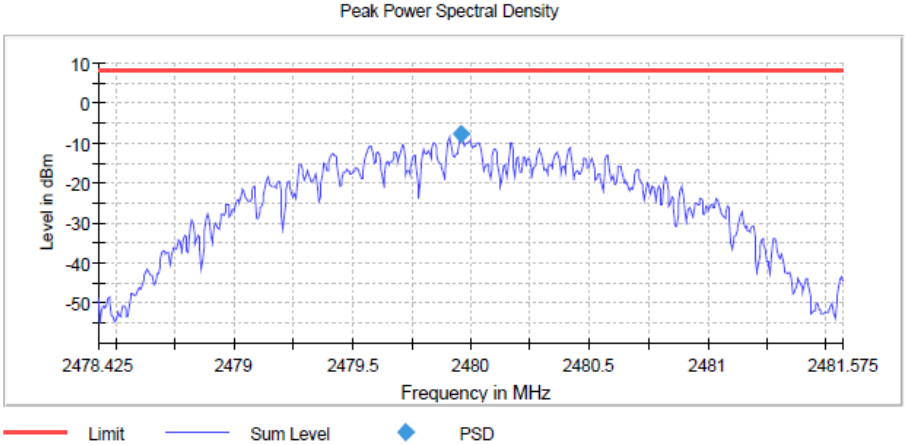
Setting	Instrument Value
Start Frequency	2.40043 GHz
Stop Frequency	2.40358 GHz
Span	3.150 MHz
RBW	10.000 kHz
VBW	30.000 kHz
SweepPoints	630
Sweeptime	3.150 ms
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	2 / 2
Max Stable Difference	0.13 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =mid (S01_AI01)



Setting	Instrument Value
Start Frequency	2.43843 GHz
Stop Frequency	2.44158 GHz
Span	3.150 MHz
RBW	10.000 kHz
VBW	30.000 kHz
SweepPoints	630
Sweeptime	3.150 ms
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	2 / 2
Max Stable Difference	0.23 dB

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency =high (S01_AI01)



Setting	Instrument Value
Start Frequency	2.47843 GHz
Stop Frequency	2.48158 GHz
Span	3.150 MHz
RBW	10.000 kHz
VBW	30.000 kHz
SweepPoints	630
Sweeptime	3.150 ms
Reference Level	0.000 dBm
Attenuation	10.000 dB
Detector	MaxPeak
SweepCount	100
Filter	3 dB
Trace Mode	Max Hold
Sweeptype	Sweep
Preamp	off
Stablemode	Trace
Stablevalue	0.50 dB
Run	4 / max. 150
Stable	2 / 2
Max Stable Difference	0.29 dB

5.8.5 TEST EQUIPMENT USED

- R&S TS8997

6 TEST EQUIPMENT

6.1 TEST EQUIPMENT HARDWARE

1 R&S TS8997
2.4 and 5 GHz Bands Conducted Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH	13936	2023-12	2025-12
1.2	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	107695	2021-06	2024-06
1.3	EX520	Digital Multimeter 12	Extech Instruments Corp	05157876	2022-06	2024-06
1.4	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2023-08	2025-08
1.5	Temperature Chamber VT 4002	Temperature Chamber Vötsch 03	Vötsch	58566002150010	2022-05	2024-05
1.6	FSW43	Signal Analyser	Rohde & Schwarz GmbH & Co. KG	102013	2023-07	2025-07
1.7	Opus10 THI (8152.00)	T/H Logger 14	Lufft Mess- und Regeltechnik GmbH	13993	2023-12	2025-12
1.8	HMP2020	Programmable Power Supply	Rohde & Schwarz GmbH & Co. KG	101992	N/A	N/A
1.9	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2023-01	2026-01
1.10	OSP120	Contains Power Meter and Switching Unit OSP-B157W8 PLUS	Rohde & Schwarz	101158	2021-08	2024-08
1.11	CS-RUB6	Rubidium Frequency Standard	Rohde & Schwarz GmbH & Co. KG	100321	2023-10	2024-10

2 Radiated Emissions FAR 2.4 GHz FCC
Radiated emission tests for 2.4 GHz ISM devices in a fully anechoic room

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH	13936	2023-12	2025-12
2.2	NGP800	DC Power Supply	Rohde & Schwarz GmbH & Co. KG	100900	N/A	N/A
2.3	Innco Systems CO3000	Controller for bore sight mast FAC	innco systems GmbH	CO3000/1460/54740522/P	N/A	N/A
2.4	AMF-7D00101800-30-10P-R	Broadband Amplifier 100 MHz - 18 GHz	Miteq		N/A	N/A
2.5	Anechoic Chamber 03	FAR, 8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	N/A	N/A

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.6	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2023-08	2025-08
2.7	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785	N/A	N/A
2.8	FSW43	Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	103779	2023-04	2025-04
2.9	EP 1200/B, NA/B1	AC Source, Amplifier with integrated variable Oscillator	Spitzenberger & Spies GmbH & Co. KG	B6278	N/A	N/A
2.10	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069	N/A	N/A
2.11	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright Instruments GmbH	09	N/A	N/A
2.12	MA3000/0800-XP-ET-compact	Bore Sight Antenna Mast	innco systems GmbH	9210522	N/A	N/A
2.13	TT 1.5 WI	Turn Table	Maturo GmbH	-	N/A	N/A
2.14	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008	N/A	N/A
2.15	Opus 20 THI (8120.00)	ThermoHygro Datalogger	Lufft Mess- und Regeltechnik GmbH	115.0318.0802.033	2023-08	2025-08
2.16	TD1.5-10kg	EUT Tilt Device (Rohacell)	Maturo GmbH	TD1.5-10kg/024/3790709	N/A	N/A
2.17	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324	N/A	N/A
2.18	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2021-09	2024-09

3 Radiated Emissions SAC H-Field

Radiated emission tests in the H-Field in a semi anechoic room

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
3.1	N5000/NP	Filter for EUT, 2 Lines, 250 V, 16 A	ETS-LINDGREN	241515	N/A	N/A
3.2	NGP800	DC Power Supply	Rohde & Schwarz GmbH & Co. KG	101178	N/A	N/A
3.3	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH	13936	2023-12	2025-12
3.4	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603		
3.5	Anechoic Chamber 01	SAC/FAR, 10.58 m x 6.38 m x 6.00 m	Frankonia Germany EMC Solution GmbH	none	N/A	N/A
3.6	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2023-08	2025-08

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
3.7	Opus10 THI (8152.00)	T/H Logger 10	Lufft Mess- und Regeltechnik GmbH	12488	2023-12	2025-12
3.8	EP 1200/B, NA/B1	AC Source, Amplifier with integrated variable Oscillator	Spitzenberger & Spies GmbH & Co. KG	B6278	N/A	N/A
3.9	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99	N/A	N/A
3.10	HFH2-Z2	Loop Antenna + 3 Axis Tripod	Rohde & Schwarz GmbH & Co. KG	829324/006		
3.11	CS-RUB6	Rubidium Frequency Standard	Rohde & Schwarz GmbH & Co. KG	100321	2023-10	2024-10

4 Radiated Emissions SAC up to 1 GHz

Radiated emission tests up to 1 GHz in a semi anechoic room

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
4.1	N5000/NP	Filter for EUT, 2 Lines, 250 V, 16 A	ETS-LINDGREN	241515	N/A	N/A
4.2	NGP800	DC Power Supply	Rohde & Schwarz GmbH & Co. KG	101178	N/A	N/A
4.3	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH	13936	2023-12	2025-12
4.4	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603		
4.5	Anechoic Chamber 01	SAC/FAR, 10.58 m x 6.38 m x 6.00 m	Frankonia Germany EMC Solution GmbH	none	N/A	N/A
4.6	HL 562 ULTRALOG	Biconical-log-per antenna (30 MHz - 3 GHz) with HL 562E biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2021-09	2024-09
4.7	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2023-08	2025-08
4.8	Opus10 THI (8152.00)	T/H Logger 10	Lufft Mess- und Regeltechnik GmbH	12488	2023-12	2025-12
4.9	EP 1200/B, NA/B1	AC Source, Amplifier with integrated variable Oscillator	Spitzenberger & Spies GmbH & Co. KG	B6278	N/A	N/A
4.10	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99	N/A	N/A
4.11	CS-RUB6	Rubidium Frequency Standard	Rohde & Schwarz GmbH & Co. KG	100321	2023-10	2024-10

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
4.12	AM 4.0	Antenna Mast 4 m	Maturo GmbH	AM4.0/180/1192 0513	N/A	N/A

The calibration interval is the time interval between "Last Calibration" and "Calibration Due"

6.2 TEST EQUIPMENT SOFTWARE

Semi-Anechoic Chamber:	
Software	Version
EMC32 Measurement Software	10.60.10
INNCO Mast Controller	1.02.62
INNCO Mast Height	34.10
INNCO Mast Elevation	36.11
MATURO Controller	1.24
MATURO Mast	12.19
MATURO Turn-Table	30.10
Fully-Anechoic Chamber:	
Software	Version
EMC32 Measurement Software	10.60.10
MATURO Controller	1.30
MATURO Turn-Unit	11.10
MATURO Mast	12.10
MATURO Turntable	12.11
INNCO Controller	1.03.02
INNCO Mast Height	34.10
INNCO Mast Elevation	36.11
TS 8997	
WMS32 Measurement Software	11.60.00 (till 2024-03-19), 11.70.00 + Hotfix 01
Conducted AC Emissions:	
Software	Version
EMC32 Measurement Software	10.60.20

7 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.

7.1 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.

7.2 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

7.3 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.

7.4 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.

7.5 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.

7.6 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				-9.5	3	1.0
27.0	43.4	-11.2	4.4				-9.5	3	1.0
28.0	43.4	-11.1	4.5				-9.5	3	1.0
29.0	43.5	-11.0	4.6				-9.5	3	1.0
30.0	43.5	-10.9	4.7				-9.5	3	1.0
31.0	43.5	-10.8	4.7				-9.5	3	1.0
32.0	43.5	-10.7	4.8				-9.5	3	1.0
33.0	43.6	-10.7	4.9				-9.5	3	1.0
34.0	43.6	-10.6	5.0				-9.5	3	1.0
35.0	43.6	-10.5	5.1				-9.5	3	1.0
36.0	43.6	-10.4	5.1				-9.5	3	1.0
37.0	43.7	-10.3	5.2				-9.5	3	1.0
38.0	43.7	-10.2	5.3				-9.5	3	1.0
39.0	43.7	-10.2	5.4				-9.5	3	1.0
40.0	43.8	-10.1	5.5				-9.5	3	1.0

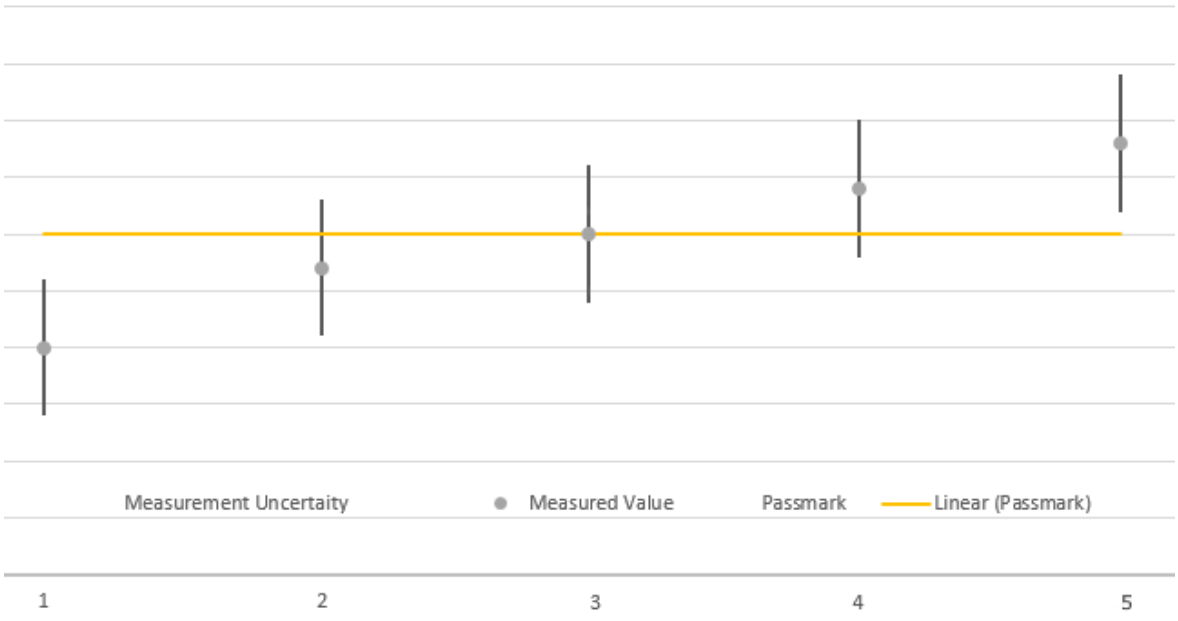
Sample calculation

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.

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

The measurement uncertainties for all parameters are calculated with an expansion factor (coverage factor) k = 1.96. This means, that the true value is in the corresponding interval with a probability of 95 %.



The verdicts in this test report are given according the above diagram:

Case	Measured Value	Uncertainty Range	Verdict
1	below pass mark	below pass mark	Passed
2	below pass mark	within pass mark	Passed
3	on pass mark	within pass mark	Passed
4	above pass mark	within pass mark	Failed
5	above pass mark	above pass mark	Failed

That means, the laboratory applies, as decision rule (see ISO/IEC 17025:2017), the so-called shared risk principle.

9 PHOTO REPORT

Please see separate photo report.

**********END OF TEST REPORT**********