Test report

REP001839-1R2TRFWL

Date of issue: July 20, 2023

Applicant:
JTECH An HME Company

Product description:
LinkWear Smart Band

Model:
LWSB

PMN:
LWSB00100

FCC ID:
WDC-JLWSB

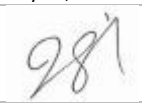
ISED certification number:
7752A-JLWSB

Specifications:

- FCC 47 CFR Part 15, Subpart C – §15.247
  Operation within the bands 902 – 928 MHz, 2400 – 2483.5 MHz, 5727 – 5850 MHz
- Industry Canada RSS-247, Issue 2
  Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

Lab and test locations

Company name	Nemko USA Inc.
Address	2210 Faraday Ave, Suite 150
City	Carlsbad
State	California
Postal code	92008
Country	USA
Telephone	+1 760 444 3500
Website	www.nemko.com
FCC Site Number	Test Firm Registration Number: 392943 Designation Number: US5058
ISED Test Site	2040B-3

Tested by	Martha Espinoza, Wireless Test Engineer
Reviewed by	James Cunningham, EMC/MIL/WL Supervisor
Review date	July 20, 2023
Reviewer signature	

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.
This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko USA's ISO/IEC 17025 accreditation.

Copyright notification

Table of Contents

Section 1 Report summary

1.1 Applicant

Company name	JTECH An HME Company
Address	1400 Northbrook Parkway, Suite 320
City	Suwanee
Province/State	GA
Postal/Zip code	30024
Country	USA

1.2 Manufacturer

Company name	JTECH An HME Company
Address	1400 Northbrook Parkway, Suite 320
City	Suwanee
Province/State	GA
Postal/Zip code	30024
Country	USA

1.3 Test specifications

FCC 47 CFR Part 15, Subpart C – §15.247	Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz
IC RSS-247 Issue 2	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.4 Test methods

ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
558074 D01 DTS Measurement Guidance v05r02 (April 2019)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

1.5 Exclusions

None

1.6 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See "Summary of test results" for full details.

1.7 Test report revision history

Table 1.7-1: *Test report revision history*

Revision #	Details of changes made to test report
REP001839-1TRFWL	Original report issued
REP001839-1R1TRFWL	Corrected model name on front page and Section 3.2
REP001839-1R1TRFWL	Updated following TCB reviewer comments

Notes: None

Section 2 Summary of test results

2.1 FCC Part 15 Subpart C, general requirements

Part	Test description	Verdict
§15.207(a)	Conducted limits	Not applicable
§15.31(e)	Variation of power source	Pass
§15.203	Antenna requirement	Pass

Notes: The integrated antenna is located within the protective cover of EUT
EUT is battery powered. All testing was performed with fresh batteries.

2.2 FCC Part 15.247

Part	Test description	Verdict
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Pass
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(b)(3)	Maximum peak output power of systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247(b)(4)	Transmitting antennas of directional gain greater than 6 dBi	Not applicable
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247(e)	Power spectral density for digitally modulated devices	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

2.3 IC RSS-247, Issue 2

Part	Test description	Verdict
5.1 (a)	Bandwidth of a frequency hopping channel	Not applicable
5.1 (b)	Minimum channel spacing for frequency hopping systems	Not applicable
5.1 (c)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.1 (d)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.1 (e)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
5.2 (a)	Minimum 6 dB bandwidth	Pass
5.2 (b)	Maximum power spectral density	Pass
5.3 (a)	Digital modulation turned off	Not applicable
5.3 (b)	Frequency hopping turned off	Not applicable
5.4 (a)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.4 (b)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.4 (c)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
5.4 (d)	Systems employing digital modulation techniques	Pass
5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Out-of-band emissions	Pass

2.4 IC RSS-GEN, Issue 5

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Not applicable
7.4	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for License-Exempt Radio Apparatus	Not applicable

Section 3 Equipment under test (EUT) details

3.1 Sample information

Receipt date	November 28, 2022
Nemko sample ID number	PRJ0013947

3.2 EUT information

Product name	LinkWear Smart Band
Model	LWSB
Serial number	N/A
Part number	N/A

3.3 Technical information

Frequency band	2400 – 2483.5 MHz
Minimum frequency (MHz)	2402
Maximum frequency (MHz)	2480
Type of modulation	GFSK
Power requirements	3.7 V DC battery powered
Antenna information	Integrated antenna. 0.5 dBi Max Gain P/N 2450AT18A100

3.4 EUT exercise and monitoring details

The EUT was controlled by a support laptop running Smart RF studio 7 tool and set to transmit BLE signals at 5 dBm power level while on the Low, Middle, and High channels.

Table 3.4-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number	Rev.
N/A	N/A	N/A	N/A	N/A

Table 3.4-2: *EUT interface ports*

Description	Qty.
Debug Port	1

Table 3.4-3: *Support equipment*

Description	Brand name	Model/Part number	Serial number	Rev.
PCB development kit	Texas Instrument	N/A	N/A	--
Laptop	Dell	N/A	N/A	--

Table 3.4-4: *Inter-connection cables*

Cable description	From	To	Length (m)
USB	Support laptop	EUT	0.5

3.5 EUT setup diagram

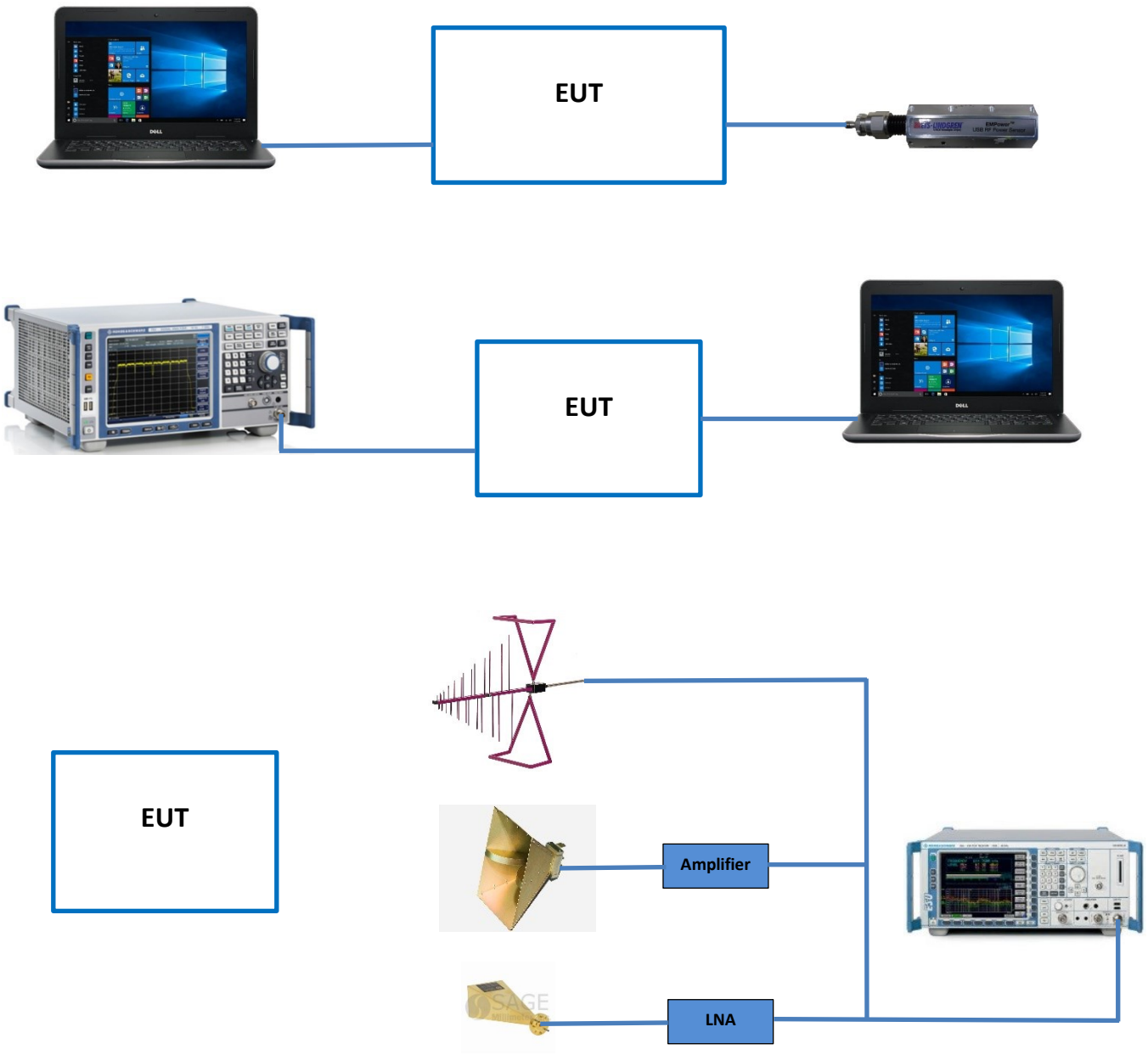


Figure 3.5-1: *Setup diagram*

Section 4 Engineering considerations

4.1 Surveyed power levels

The power settings in the Smart RF studio 7 is 5 dBm for all testing.

4.2 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.3 Technical judgment

None

4.4 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5 Test conditions

5.1 Atmospheric conditions

Temperature	15-30 °C
Relative humidity	20-75 %
Air pressure	86–106 kPa

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 6 Measurement uncertainty

6.1 Uncertainty of measurement

Nemko USA Inc. has calculated measurement uncertainty and is documented in EMC/MUC/001 "Uncertainty in EMC measurements." Measurement uncertainty was calculated using the methods described in CISPR 16-4-2 Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics, and limit modelling – Measurement instrumentation uncertainty. The expression of Uncertainty in EMC testing. Measurement uncertainty calculations assume a coverage factor of K=2 with 95% certainty.

Table 6.1-1: *Measurement uncertainty calculations*

Measurement		**U_{cispr} dB**	**U_{lab} dB**
Conducted disturbance at AC mains and other port power using a V-AMN	9 kHz to 150 kHz	3.8	2.9
	150 kHz to 30 MHz	3.4	2.3
Conducted disturbance at telecommunication port using AAN	150 kHz to 30 MHz	5.0	4.3
Conducted disturbance at telecommunication port using CVP	150 kHz to 30 MHz	3.9	2.9
Conducted disturbance at telecommunication port using CP	150 kHz to 30 MHz	2.9	1.4
Conducted disturbance at telecommunication port using CP and CVP	150 kHz to 30 MHz	4.0	3.1
Radiated disturbance (electric field strength in a SAC)	30 MHz to 1 GHz	6.3	5.5
Radiated disturbance (electric field strength in a FAR)	1 GHz to 6 GHz	5.2	4.7
Radiated disturbance (electric field strength in a FAR)	6 GHz to 18 GHz	5.5	5.0

Notes: Compliance assessment:

If U_{lab} is less than or equal to U_{cispr} then:

- compliance is deemed to occur is no measured disturbance level exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance level exceeds the disturbance limit

If U_{lab} is greater than U_{cispr} then:

- compliance is deemed to occur is no measured disturbance level, increased by (U_{lab} - U_{cispr}), exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance level, increased by (U_{lab} - U_{cispr}), exceeds the disturbance limit

V-AMN: V type artificial mains network
AAN: Asymmetric artificial network
CP: Current probe
CVP: Capacitive voltage probe
SAC: Semi-anechoic chamber
FAR: Fully anechoic room

Section 7 Test Equipment

Table 6.1-1: *Test Equipment List*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Signal and spectrum analyzer	Rohde & Schwarz	FSV40	E1120	2 years	12-09-2023
Power sensor	ETS Lindgren	7002-006	E1061	1 year	06-21-2023
EMI Test Receiver	Rohde & Schwarz	ESU40	E1131	1 year	03-02-2023
System Controller	Sunol Sciences	SC104V	E1191	NCR	NCR
Bilog Antenna (30-1000 MHz)	Schaffner	CBL 6111D	1763	2 years	04-01-2024
DRG Horn (1-18 GHz)	ETS-Lindgren	3117-PA	E1139	2 years	04-19-2023
Horn antenna (18-26 GHz)	Eravant	SAZ-2410-42-S1	EW107	1 year	11-22-2023
Low noise amplifier	Sage Millimeter, Inc.	SBL-1834034030-KFKF	E1228	VOU	VOU
2.4GHz notch filter	Micro-Tonics	HPM50110-01	E1142	NCR	NCR

Notes: NCR - no calibration required
VOU - verify on use

Table 6.1-2: *Test Software*

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.60.10 (AC conducted emissions)
Rohde & Schwarz	EMC 32 V10.60.15 (radiated emissions)

Notes: None

Section 8 Testing data

8.1 FCC 15.247(a)(2) and RSS-247 5.2(1) Minimum 6 dB bandwidth for systems using digital modulation techniques References

8.1.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(a)(2)
RSS-247 → §5.2(a)

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(2) Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

8.1.2 Test summary

Verdict	Pass		
Test date	November 30, 2022	Temperature	19 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1005 mbar
Test location	Wireless bench (Conducted)	Relative humidity	53 %

8.1.3 Notes

Testing was performed with the BLE transmitter operating on a fixed channel at 5 dBm (software set up).

8.1.4 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless Bench
Measurement method	558074 D01 DTS Measurement Guidance §8.2 ANSI C63.10 §11.8.1 using built-in marker function of the spectrum analyzer

Receiver/spectrum analyzer settings:

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.1.5 Test data

Table 8.1-1: *6 dB occupied bandwidth test data*

Test Frequency (MHz)	Bandwidth (kHz)	Limit (kHz)
2402	665.885	> 500
2440	669.917	> 500
2480	674.229	> 500

8.1.5 Test data, continued

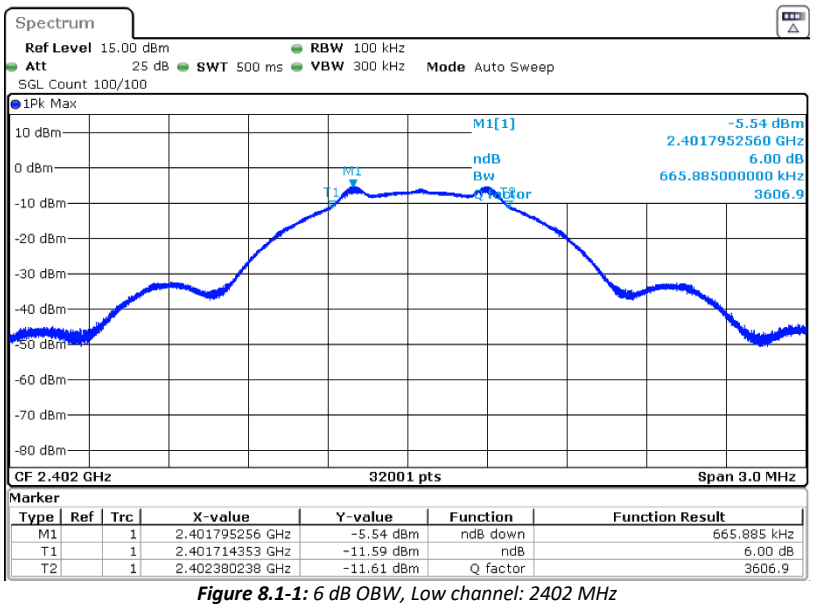


Figure 8.1-1: *6 dB OBW, Low channel: 2402 MHz*

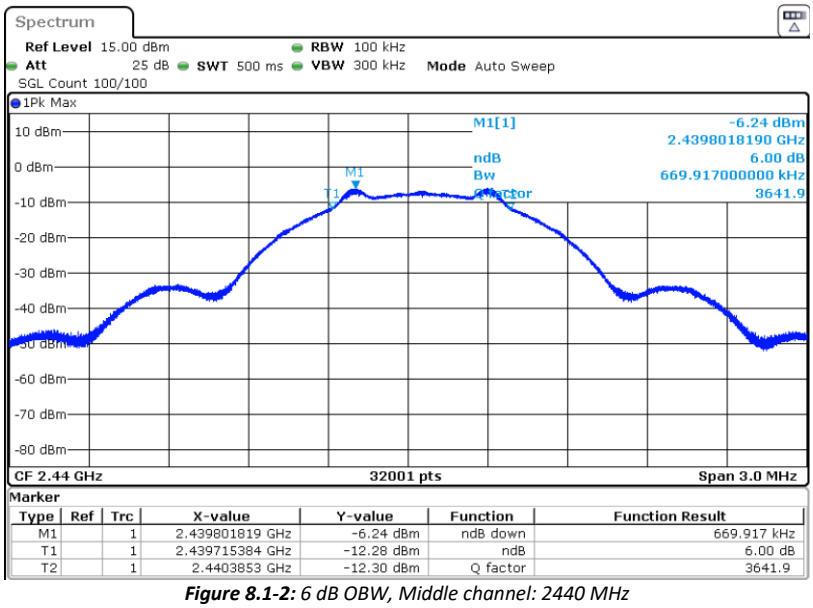


Figure 8.1-2: *6 dB OBW, Middle channel: 2440 MHz*

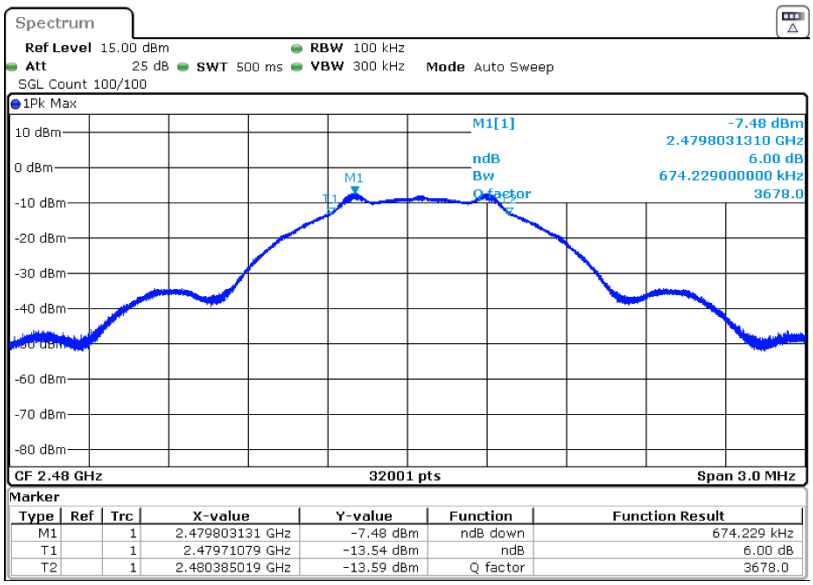


Figure 8.1-3: *6 dB OBW, High channel: 2480 MHz*

8.2 FCC 15.247(b) and RSS-247 5.4 (4) Transmitter output power and e.i.r.p. requirements

8.2.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(b)(2) / (3)

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(3) For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 W (30 dBm). As an alternative to a peak power measurement, compliance with the one-Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this Section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this Section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this Section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

RSS-247 → §5.4(d)

(d) For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

8.2.2 Test summary

Verdict	Pass		
Test date	December 1, 2022	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1006 mbar
Test location	Wireless bench (Conducted)	Relative humidity	57 %

8.2.3 Notes

Testing was performed with the BLE transmitter operating on a fixed channel at 5 dBm (software set up).
The attenuation of the interconnecting path was included in the power meter software as a correction factor.
The antenna gain 0.5 dBi.
EIRP = Conducted Power + Declared Antenna Gain

8.2.4 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless Bench
Measurement method	ANSI C63.10 §11.9.1.3 PKPM1 (Peak Power Meter) method

8.2.5 Test data

Table 8.2-1: *Output power*

Test Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	Conducted Limit (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)
2402	18.68	30.0	0.50	19.18	36.0
2440	18.32	30.0	0.50	18.82	36.0
2480	17.29	30.0	0.50	17.79	36.0

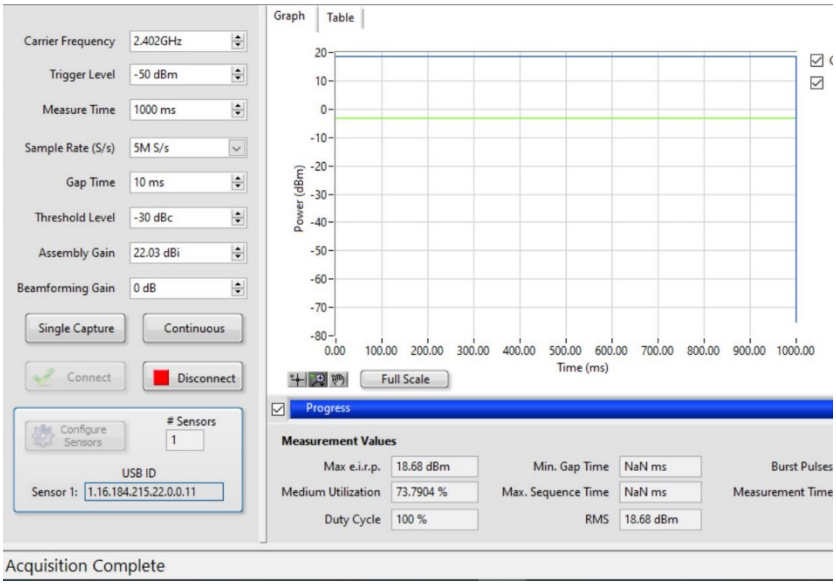


Figure 8.2-1: *Output power, Low channel: 2402 MHz*

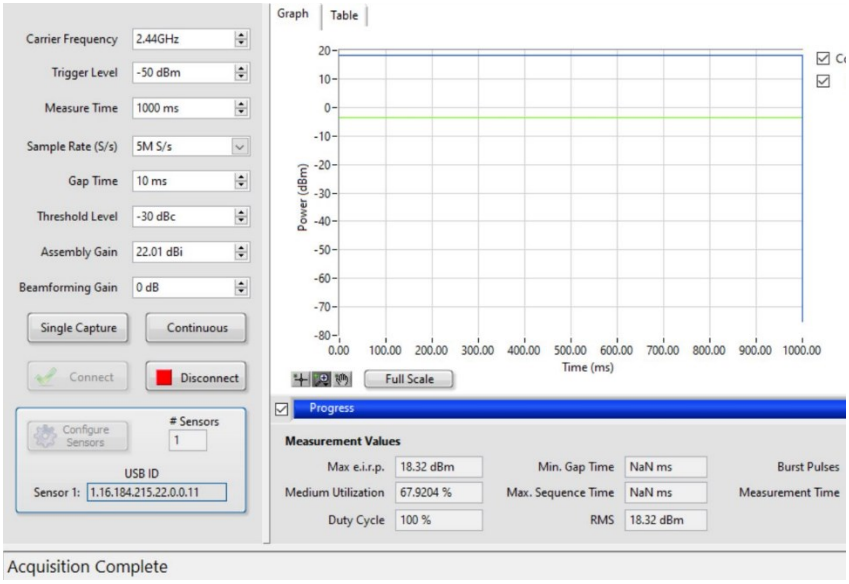


Figure 8.2-2: *Output power, Middle channel: 2440 MHz*

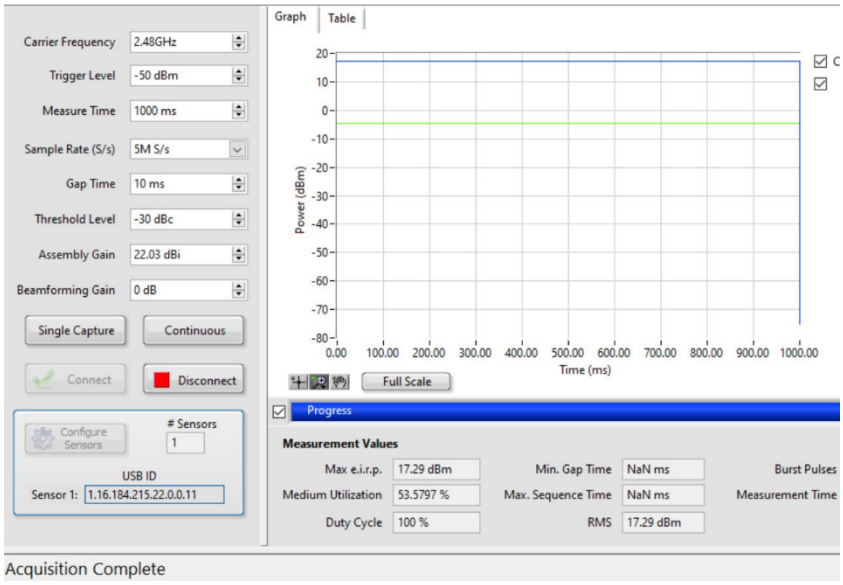


Figure 8.2-3: *Output power, High channel: 2480 MHz*

8.3 FCC Part 15.247(d) and RSS-247 5.5 Conducted band-edge spurious emissions.

8.3.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(d)

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

RSS-247 → §5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

8.3.2 Test summary

Verdict	Pass		
Test date	December 1, 2022	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1006 mbar
Test location	Wireless bench (Conducted)	Relative humidity	57 %

8.3.3 Notes

Testing was performed with the BLE transmitter operating on a fixed channel at 5 dBm (software set up).
For conducted measurements, an offset corresponding to the path losses was added in the spectrum analyzer.
In each measurement, the limit was derived by subtracting 20 dB from a power spectral density reference measurement and the frequency limit were the band limits: 2400 MHz for low channel and 2483.5 MHz for high channel.

8.3.4 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless bench
Measurement details	Conducted band edge measurement performed as per C63.10 §6.10.4

Spectrum analyzer settings for conducted spurious emissions:

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.3.5 Test data

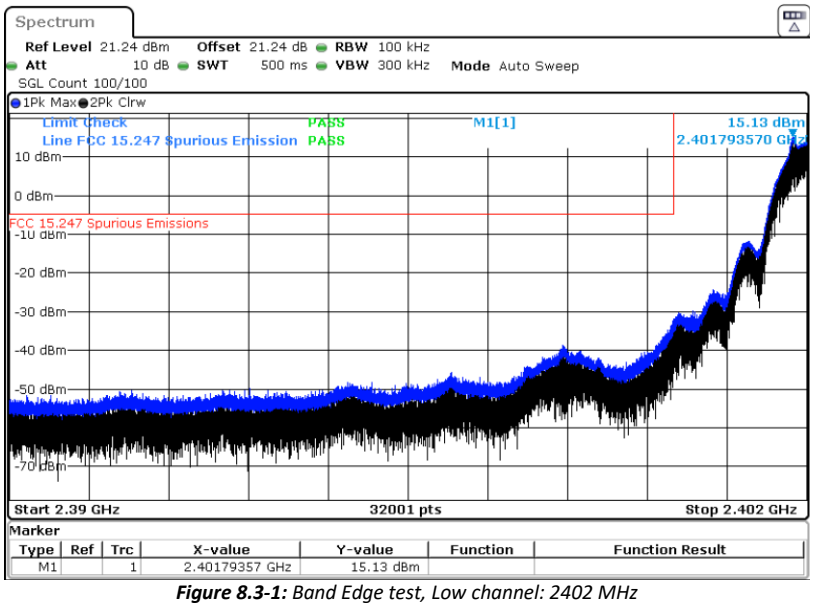


Figure 8.3-1: *Band Edge test, Low channel: 2402 MHz*

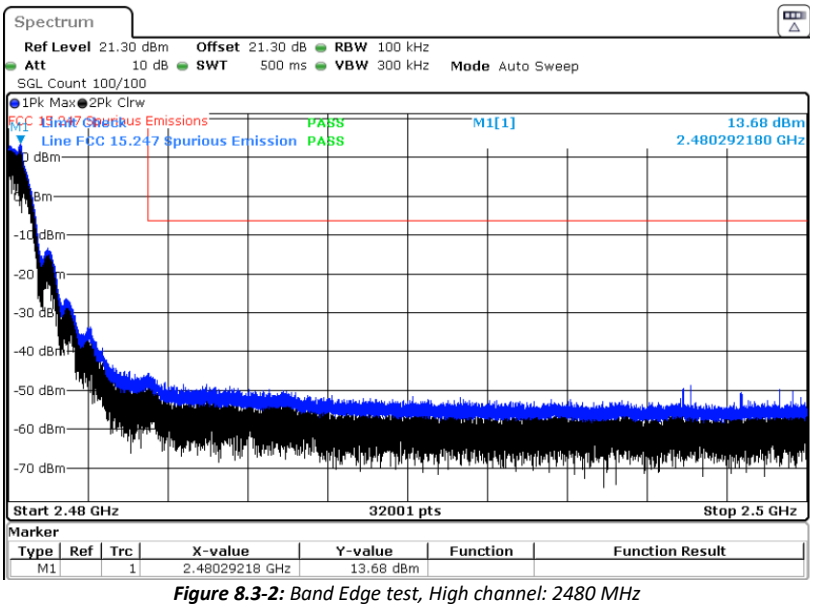


Figure 8.3-2: *Band Edge test, High channel: 2480 MHz*

8.4 FCC 15.247(d) and RSS-247 5.5 Conducted spurious emissions.

8.4.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(d)

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

RSS-247 → §5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

8.4.2 Test summary

Verdict	Pass		
Test date	December 1, 2022	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1006 mbar
Test location	Wireless bench (Conducted)	Relative humidity	57 %

8.4.3 Notes

Testing was performed with the BLE transmitter operating on a fixed channel at 5 dBm (software set up).
The spectrum was searched from 100 kHz to 26 GHz (above the 10th harmonic of the highest transmit frequency of 2480 MHz).
For conducted measurements, an offset corresponding to the path losses was added in the spectrum analyzer.
In each measurement, the limit was derived by subtracting 20 dB from a power spectral density reference measurement.

8.4.4 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless bench
Measurement details	Conducted spurious emissions measurement performed as per C63.10 §11.11.3

Spectrum analyzer settings for conducted spurious emissions:

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.4.5 Test data

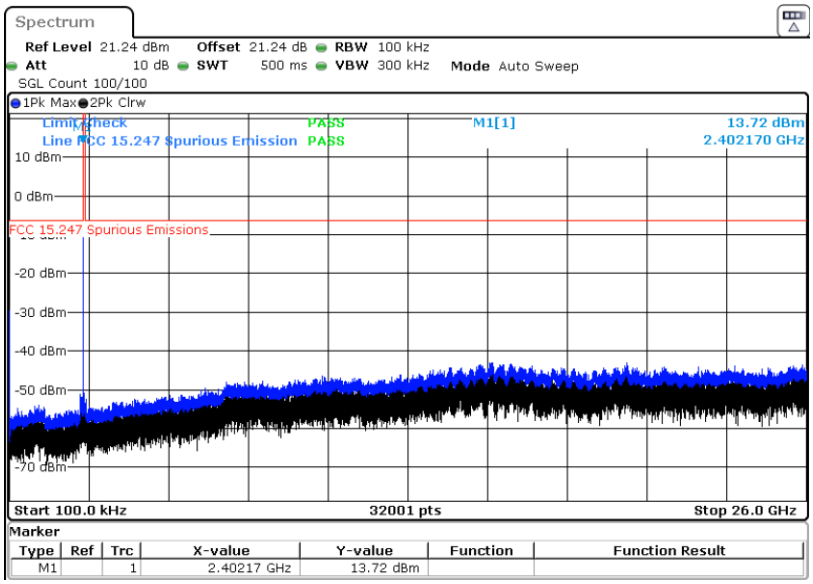


Figure 8.4-1: *Conducted spurious Emission, Low channel: 2402 MHz.*

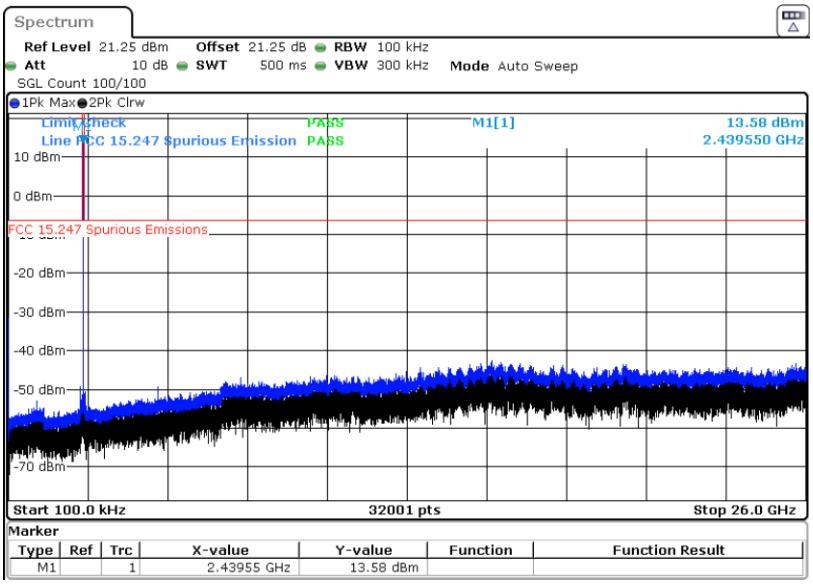


Figure 8.4-2: *Conducted spurious Emission, Middle channel: 2440 MHz.*

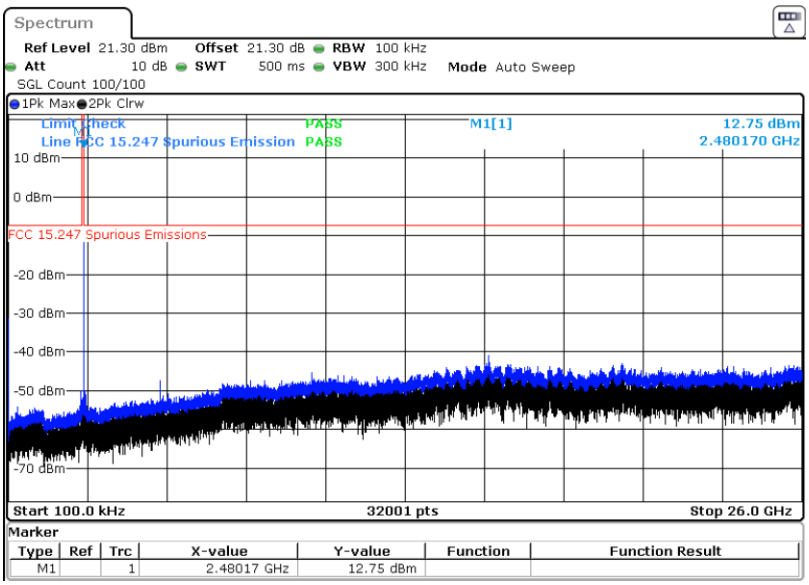


Figure 8.4-3: *Conducted spurious Emission, High channel: 2480 MHz.*

8.5 FCC 15.247(d) and RSS-247 5.5 Radiated restricted band-edges and spurious emission

8.5.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(d)

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

RSS-247 → §5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Table 8.5-1: *FCC §15.209– Radiated emission limits*

Frequency, MHz	Field strength of emissions		Measurement distance, m
	µV/m	dBµV/m	
0.009–0.490	2400/F	$67.6 - 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(F)$	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.
For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test.

Table 8.5-2: *FCC restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

8.5.2 Test summary

Verdict	Pass		
Test date	December 2, 2022; December 5, 2022	Temperature	19 °C; 20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1001 mbar; 1006 mbar
Test location	3m semi-anechoic chamber (Radiated)	Relative humidity	55 %; 58 %

8.5.3 Notes

Testing was performed with the BLE transmitter operating on a fixed channel at 5 dBm (software set up).
The spectrum was searched from 30 MHz to 26 GHz (10th harmonic approximately).
Radiated measurements were performed at a 3 m measurement distance.

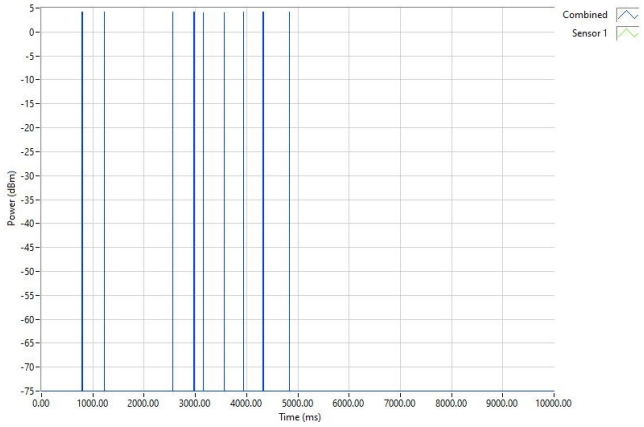
A correction factor related to duty cycle was added, specifically for transmitter 2nd harmonic. The duty cycle was measured using a sensor power and all the data for all operational modes was recorded. Different modes were tested, and the maximum duty cycle recorded was selected as the worst-case scenario. For this model the maximum duty cycle was:

The following operational use cases were investigated to identify the operational mode with the worst-case (highest) duty cycle operation:

- Message Smartband from UI Dashboard
- OTA update of Smartband
- Canned message from Smartband to hub, in response to message from UI Dashboard

The output of the transmitter was monitored using a fast-sampling power meter (5 MSamples/second) over a period of 10 seconds (sufficiently long for the user operation to complete). The power meter data was analyzed and the worst case duty cycle over a 100 ms period was identified.

For this EUT the maximum duty cycle was: “Monitor Call Button Keep Alive, occurs after pairing”. Below is the transmit power versus time:



And the exported record of transmitter on/off bursts:

Burst #	Combined Start Time (ms)	Combined Stop Time (ms)	Combined Power (dBm)	TxOn Time (ms)	TxOff Time (ms)
1	790.594	791.785	4.19	1.191	0.279
2	792.064	793.255	1.9	1.191	0.279
3	793.534	794.725	1.8	1.191	0.309
4	795.034	798.401	4.2	3.367	420.065
5	1218.466	1219.657	1.77	1.191	0.278
6	1219.935	1221.127	1.88	1.192	0.278
7	1221.405	1222.597	4.2	1.192	0.308
8	1222.905	1226.273	4.19	3.368	1330.109
9	2556.382	2557.574	1.88	1.192	0.278
10	2557.852	2559.044	4.17	1.192	0.278
11	2559.322	2560.514	1.74	1.192	0.308
12	2560.822	2564.19	4.2	3.368	402.932
13	2967.122	2968.313	4.2	1.191	0.279
14	2968.592	2969.783	1.88	1.191	0.279
15	2970.062	2971.253	1.76	1.191	0.309
16	2971.562	2974.93	4.17	3.368	174.505
17	3149.435	3150.627	3.92	1.192	0.278
18	3150.905	3152.097	1.39	1.192	0.278
19	3152.375	3153.567	1.45	1.192	0.308
20	3153.875	3157.243	3.77	3.368	400.011
21	3557.254	3558.446	1.74	1.192	0.278
22	3558.724	3559.916	1.63	1.192	0.278
23	3560.194	3561.386	3.72	1.192	0.308
24	3561.694	3565.062	3.94	3.368	374.062
25	3939.124	3940.316	1.92	1.192	0.278
26	3940.594	3941.785	1.89	1.191	0.279
27	3942.064	3943.256	4.19	1.192	0.308
28	3943.564	3946.932	4.19	3.368	373.099
29	4320.031	4321.223	4.21	1.192	0.278
30	4321.501	4322.693	1.9	1.192	0.278
31	4322.971	4324.163	1.88	1.192	0.308
32	4324.471	4327.839	4.2	3.368	506.395
33	4834.234	4835.425	1.89	1.191	0.278
34	4835.703	4836.895	1.93	1.192	0.278
35	4837.173	4838.365	4.19	1.192	0.308
36	4838.673	4842.041	4.2	3.368	5157.959

The worst-case duty cycle over 100 ms was calculated from the above data.

Maximum duty cycle = 6.94 %
Correction factor related to duty cycle: 23.17 dB (20 Log(Duty Cycle %))

8.5.4 Setup details

EUT setup configuration	Tabletop
Test facility	3M Chamber
Measurement details	Radiated spurious emissions measurement performed as per C63.10 §11.12

Receiver settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth	120 kHz
Video bandwidth	300 kHz
Detector mode	Peak (preview measurements) Quasi-Peak (final measurements)
Trace mode	Max Hold

Receiver settings for radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	Average and peak (final measurements)
Trace mode	Max Hold

8.5.5 Test data

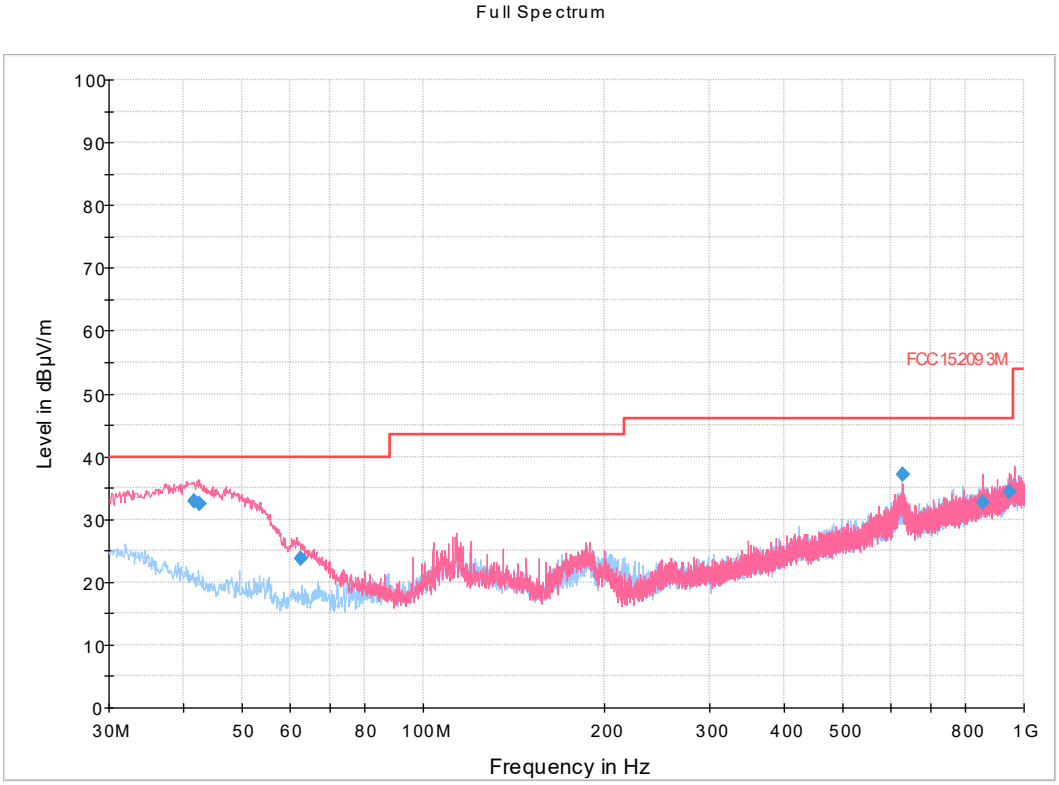


Figure 8.5-1: *Radiated spurious emissions plot, 30-1000 MHz, Low channel (2402 MHz)*

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
41.627000	32.88	40.00	7.12	5000.0	120.000	100.0	V	324.0	20.3
42.439000	32.48	40.00	7.52	5000.0	120.000	104.0	V	0.0	19.9
62.639000	23.86	40.00	16.14	5000.0	120.000	100.0	V	337.0	12.8
627.721000	37.19	46.00	8.81	5000.0	120.000	143.0	H	148.0	30.1
853.555000	32.75	46.00	13.25	5000.0	120.000	302.0	V	84.0	33.2
946.714000	34.49	46.00	11.51	5000.0	120.000	185.0	V	0.0	34.8

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.

Table 8.5-3: *Radiated spurious emissions results, 30-1000 MHz, Low channel (2402 MHz)*

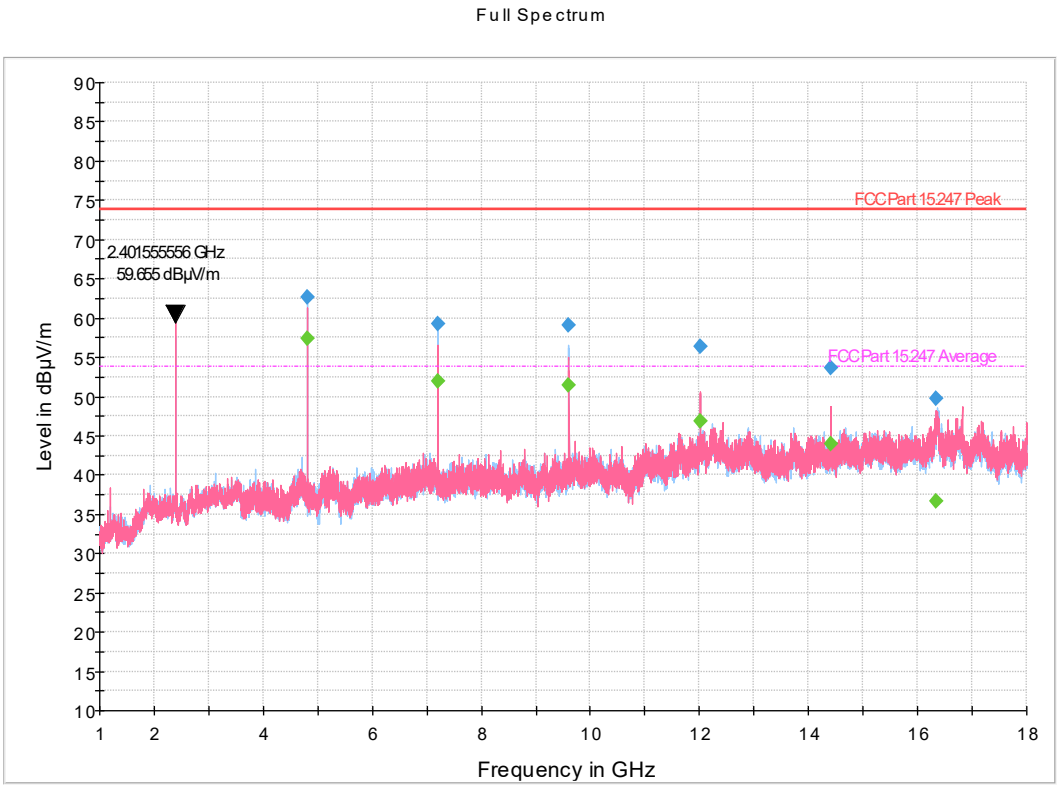


Figure 8.5-2: *Radiated spurious emissions plot, 1 – 18 GHz, Low channel (2402 MHz)*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band width (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4803.677778	62.57	---	73.90	11.33	5000.0	1000.0	195.0	H	197.0	-2.3
4803.677778	**---**	**39.40 (*)**	**53.90**	**14.50**	**5000.0**	**1000.0**	**195.0**	**H**	**197.0**	**-2.3**
7205.400000	---	52.04	53.90	1.86	5000.0	1000.0	195.0	H	11.0	0.4
7205.400000	59.18	---	73.90	14.72	5000.0	1000.0	195.0	H	11.0	0.4
9609.122222	59.10	---	73.90	14.80	5000.0	1000.0	178.0	H	289.0	3.5
9609.122222	---	51.38	53.90	2.52	5000.0	1000.0	178.0	H	289.0	3.5
12008.844444	56.34	---	73.90	17.56	5000.0	1000.0	165.0	V	293.0	6.2
12008.844444	---	46.78	53.90	7.12	5000.0	1000.0	165.0	V	293.0	6.2
14410.744444	---	44.05	53.90	9.85	5000.0	1000.0	155.0	V	289.0	10.0
14410.744444	53.65	---	73.90	20.25	5000.0	1000.0	155.0	V	289.0	10.0
16345.800000	49.80	---	73.90	24.10	5000.0	1000.0	293.0	H	11.0	13.2
16345.800000	---	36.66	53.90	17.24	5000.0	1000.0	293.0	H	11.0	13.2

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.
[4] Fundamental emission at ~ 2.4 GHz is attenuated by a notch filter to protect measurement equipment. This fundamental emission is not assessed against the limits.

(*) The average value was calculated by subtracting the worst case duty cycle correction factor (23.17 dB) from the peak measurement: 62.57 – 23.17 = 39.40 dBµV/m.

Table 8.5-4: *Radiated spurious emissions results, 1 – 18 GHz, Low channel (2402 MHz)*

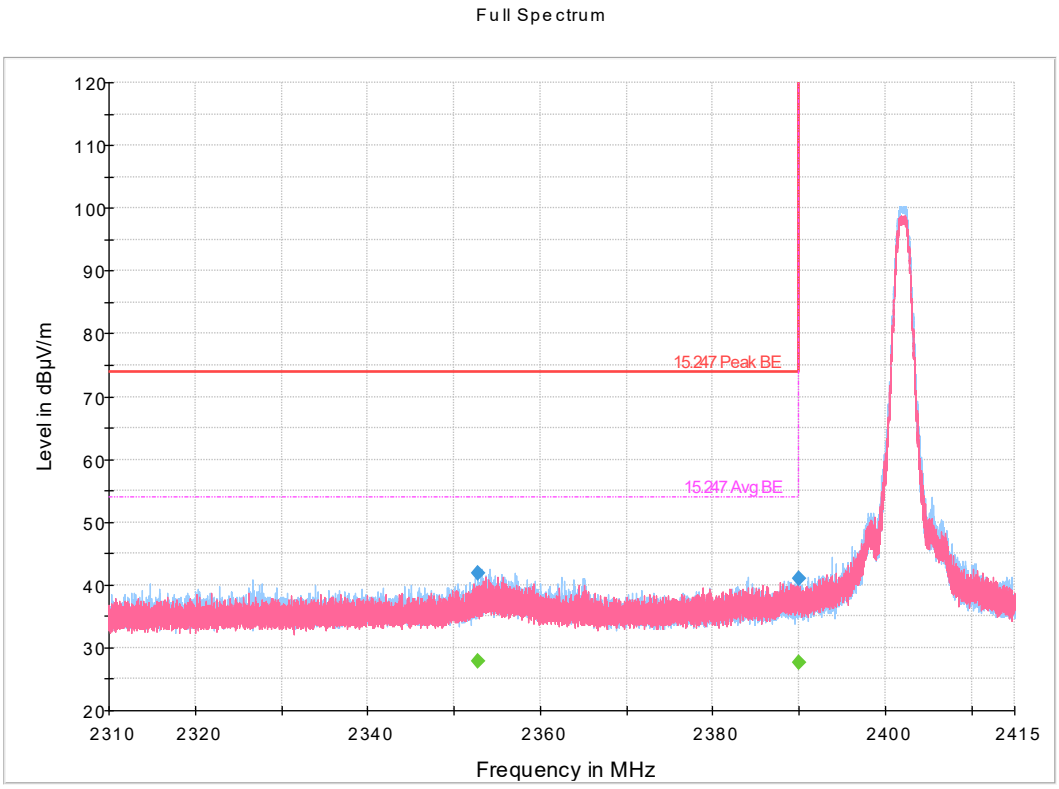


Figure 8.5-3: *Low band edge (Low channel: 2402 MHz) Radiated spurious emissions plot, 2310-2415 MHz.*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band width (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2352.815500	---	27.96	53.90	25.94	5000.0	1000.0	150.0	H	201.0	-10.1
2352.815500	41.77	---	73.90	32.13	5000.0	1000.0	150.0	H	201.0	-10.1
2390.000000	---	27.69	53.90	26.21	5000.0	1000.0	178.0	V	352.0	-10.0
2390.000000	40.94	---	73.90	32.96	5000.0	1000.0	178.0	V	352.0	-10.0

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.

Figure 8.5-5: *Low band edge (Low channel: 2402 MHz) Radiated spurious emissions results, 2310-2415 MHz.*

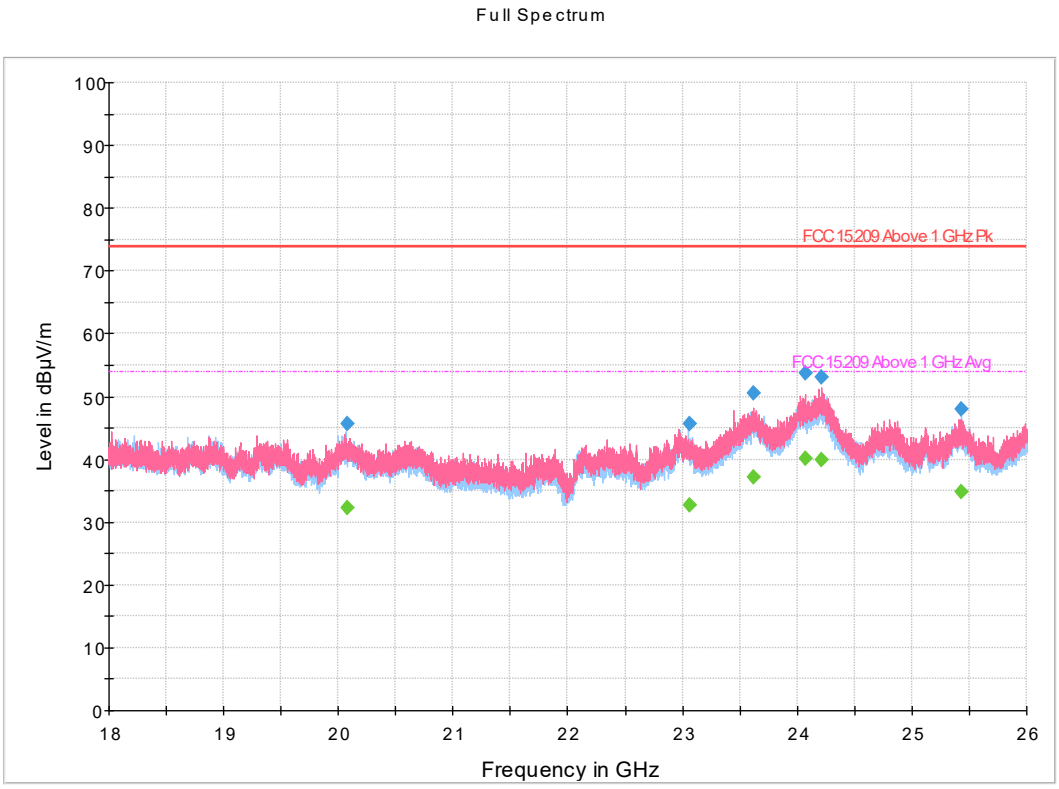


Figure 8.5-4: *Radiated spurious emissions plot, 18-26 GHz, Low channel (2402 MHz)*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band width (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
20072.700000	45.66	---	73.90	28.24	5000.0	1000.0	375.0	H	176.0	18.7
20072.700000	---	32.27	53.90	21.63	5000.0	1000.0	375.0	H	176.0	18.7
23059.000000	---	32.69	53.90	21.21	5000.0	1000.0	241.0	H	354.0	20.8
23059.000000	45.70	---	73.90	28.20	5000.0	1000.0	241.0	H	354.0	20.8
23615.000000	50.55	---	73.90	23.35	5000.0	1000.0	315.0	V	11.0	25.8
23615.000000	---	37.05	53.90	16.85	5000.0	1000.0	315.0	V	11.0	25.8
24070.000000	53.76	---	73.90	20.14	5000.0	1000.0	350.0	V	352.0	29.7
24070.000000	---	40.10	53.90	13.80	5000.0	1000.0	350.0	V	352.0	29.7
24214.600000	---	39.91	53.90	13.99	5000.0	1000.0	347.0	V	138.0	29.1
24214.600000	53.03	---	73.90	20.87	5000.0	1000.0	347.0	V	138.0	29.1
25430.800000	48.05	---	73.90	25.85	5000.0	1000.0	392.0	H	227.0	23.9
25430.800000	---	34.91	53.90	18.99	5000.0	1000.0	392.0	H	227.0	23.9

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.

Table 8.5-6: *Radiated spurious emissions results, 18 – 26 GHz, Low channel (2402 MHz)*

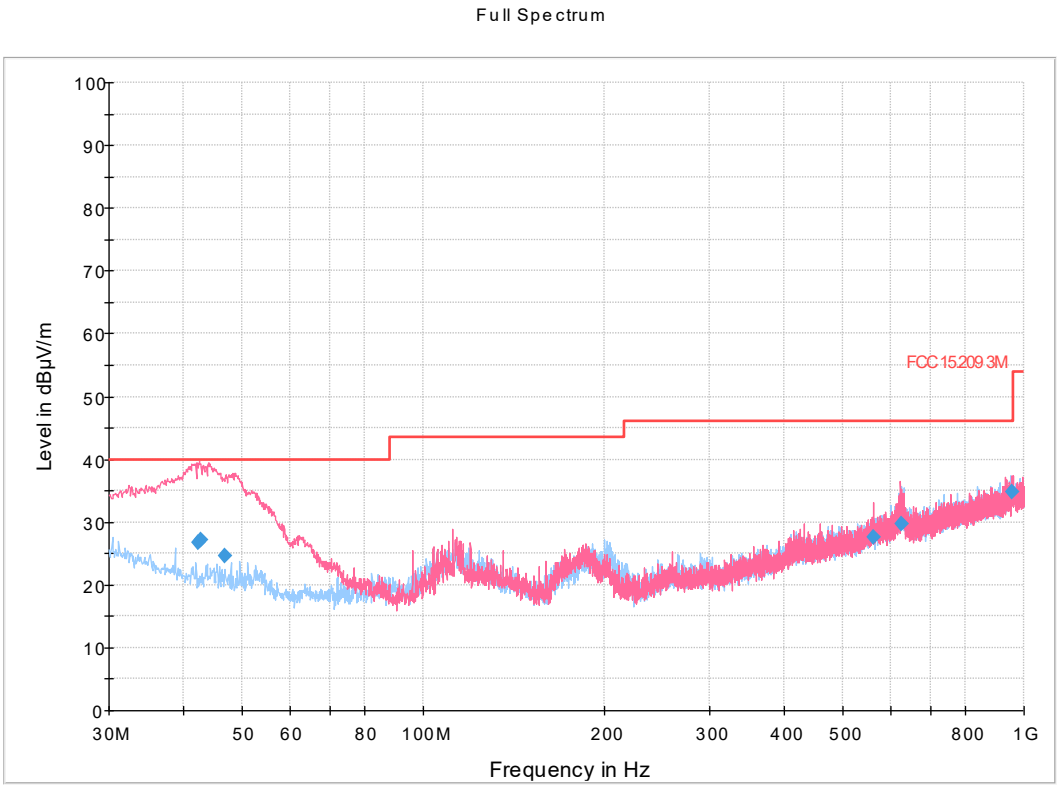


Figure 8.5-5: *Radiated spurious emissions plot, 30-1000 MHz, Mid channel (2440 MHz)*

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
42.336000	26.80	40.00	13.20	5000.0	120.000	104.0	V	290.0	19.9
42.688000	27.07	40.00	12.93	5000.0	120.000	100.0	V	299.0	19.8
46.773000	24.71	40.00	15.29	5000.0	120.000	104.0	V	323.0	17.7
562.753000	27.65	46.00	18.35	5000.0	120.000	283.0	V	350.0	29.1
624.760000	29.77	46.00	16.23	5000.0	120.000	308.0	V	0.0	30.0
954.712000	34.78	46.00	11.22	5000.0	120.000	154.0	V	148.0	35.0

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.

Table 8.5-7: *Radiated spurious emissions results, 30-1000 MHz, Mid channel (2440 MHz)*

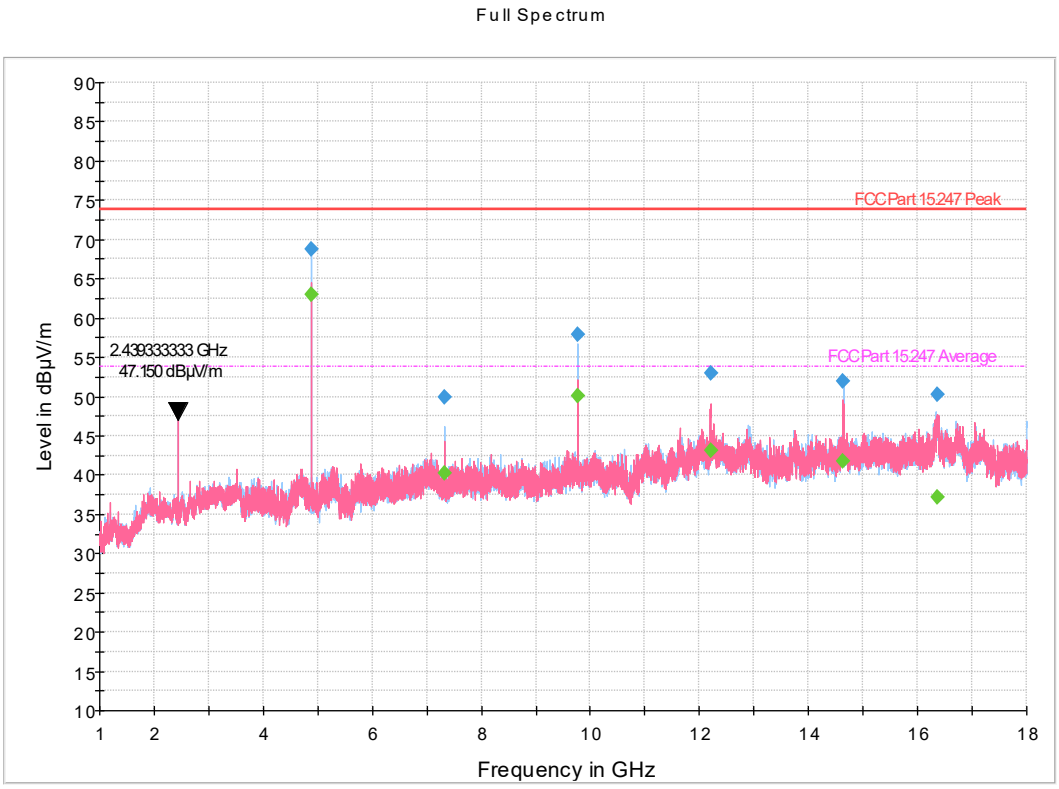


Figure 8.5-6: *Radiated spurious emissions plot, 1 – 18 GHz, Mid channel (2440 MHz)*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band width (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4880.577778	68.79	---	73.90	5.11	5000.0	1000.0	213.0	H	215.0	-2.3
4880.577778	**---**	**45.62 (*)**	**53.90**	**8.28**	**5000.0**	**1000.0**	**213.0**	**H**	**215.0**	**-2.3**
7319.277778	---	40.25	53.90	13.65	5000.0	1000.0	195.0	H	22.0	0.6
7319.277778	49.97	---	73.90	23.93	5000.0	1000.0	195.0	H	22.0	0.6
9759.066667	57.90	---	73.90	16.00	5000.0	1000.0	189.0	H	33.0	3.6
9759.066667	---	50.15	53.90	3.75	5000.0	1000.0	189.0	H	33.0	3.6
12199.111111	---	43.19	53.90	10.71	5000.0	1000.0	213.0	V	309.0	6.8
12199.111111	53.02	---	73.90	20.88	5000.0	1000.0	213.0	V	309.0	6.8
14638.755556	52.01	---	73.90	21.89	5000.0	1000.0	156.0	H	70.0	9.2
14638.755556	---	41.75	53.90	12.15	5000.0	1000.0	156.0	H	70.0	9.2
16352.055556	50.23	---	73.90	23.67	5000.0	1000.0	299.0	H	0.0	13.1
16352.055556	---	37.19	53.90	16.71	5000.0	1000.0	299.0	H	0.0	13.1

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.
[4] Fundamental emission at ~ 2.4 GHz is attenuated by a notch filter to protect measurement equipment. This fundamental emission is not assessed against the limits.

(*) The average value was calculated by subtracting the worst case duty cycle correction factor (23.17 dB) from the peak measurement: 68.79 – 23.17 = 45.62 dBµV/m.

Table 8.5-8: *Radiated spurious emissions results, 1 – 18 GHz, Mid channel (2440 MHz)*

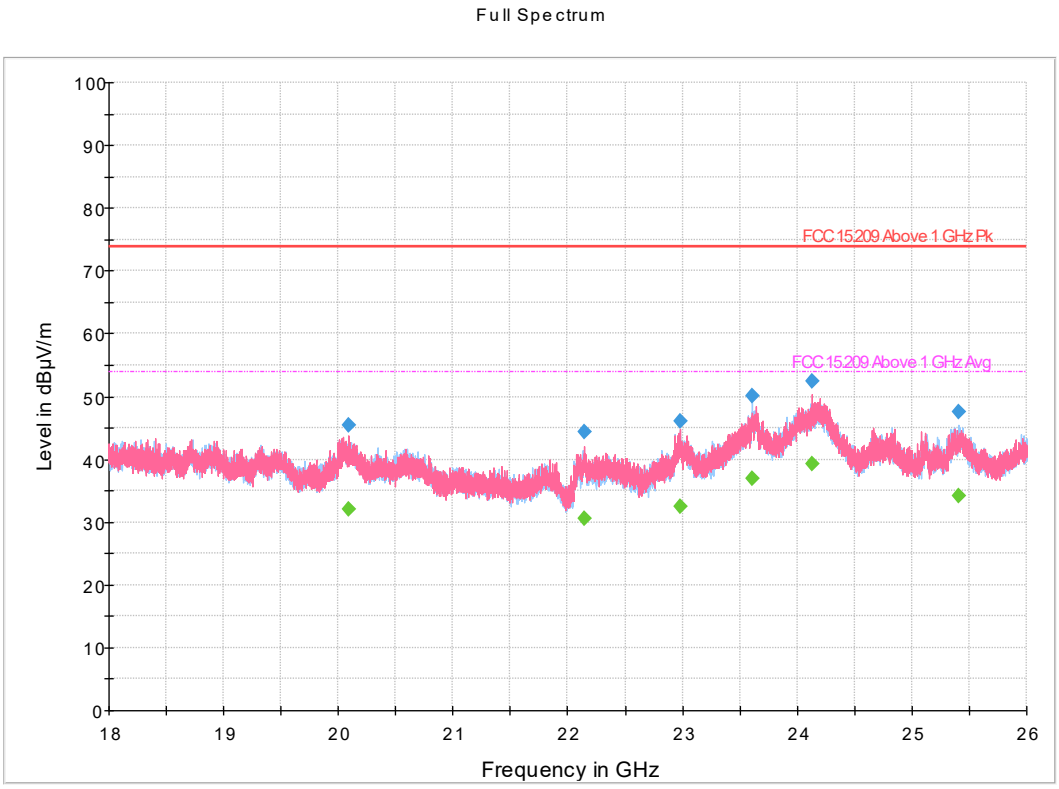


Figure 8.5-7: *Radiated spurious emissions plot, 18-26 GHz, Mid channel (2440MHz)*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band width (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
20088.800000	---	32.16	53.90	21.74	5000.0	1000.0	299.0	V	259.0	18.8
20088.800000	45.40	---	73.90	28.50	5000.0	1000.0	299.0	V	259.0	18.8
22144.800000	---	30.64	53.90	23.26	5000.0	1000.0	138.0	V	356.0	19.8
22144.800000	44.45	---	73.90	29.45	5000.0	1000.0	138.0	V	356.0	19.8
22977.100000	---	32.49	53.90	21.41	5000.0	1000.0	145.0	V	235.0	21.0
22977.100000	46.16	---	73.90	27.74	5000.0	1000.0	145.0	V	235.0	21.0
23605.600000	---	36.85	53.90	17.05	5000.0	1000.0	353.0	H	0.0	25.8
23605.600000	50.10	---	73.90	23.80	5000.0	1000.0	353.0	H	0.0	25.8
24128.700000	52.41	---	73.90	21.49	5000.0	1000.0	246.0	V	0.0	29.5
24128.700000	---	39.35	53.90	14.55	5000.0	1000.0	246.0	V	0.0	29.5
25408.000000	47.52	---	73.90	26.38	5000.0	1000.0	377.0	H	342.0	23.7
25408.000000	---	34.27	53.90	19.63	5000.0	1000.0	377.0	H	342.0	23.7

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.

Table 8.5-9: *Radiated spurious emissions results, 18 – 26 GHz, Mid channel (2440 MHz)*

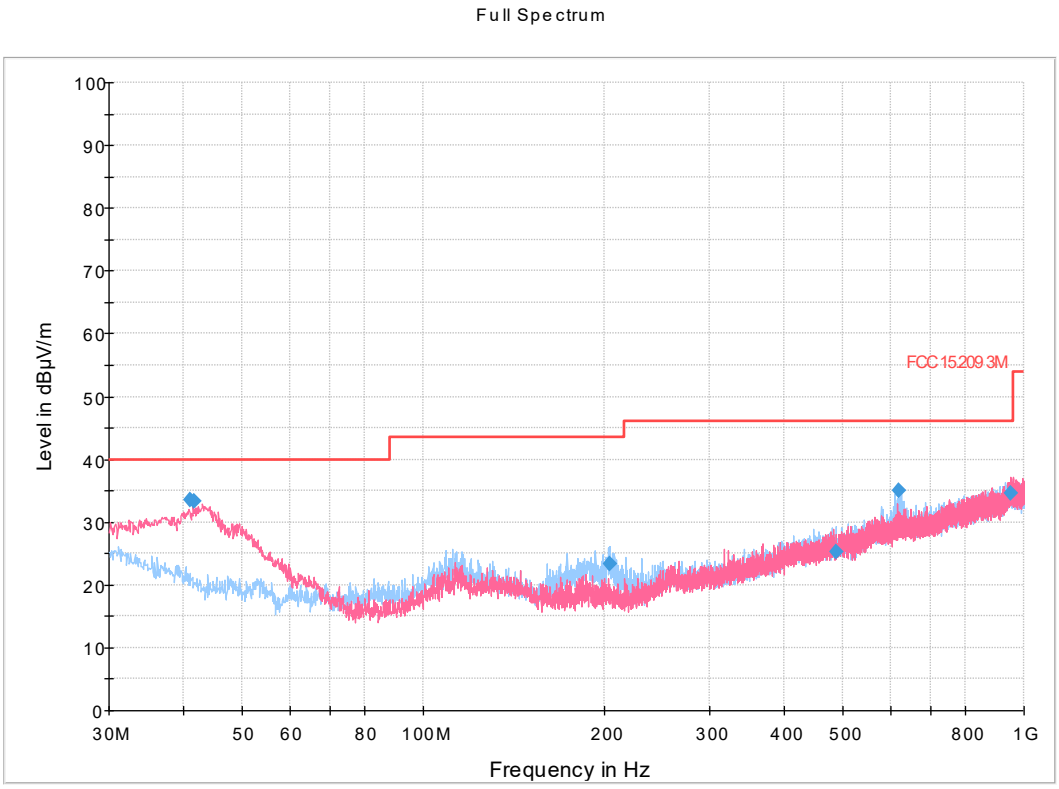


Figure 8.5-8: *Radiated spurious emissions plot, 30-1000 MHz, High channel (2480 MHz)*

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
41.006000	33.44	40.00	6.56	5000.0	120.000	104.0	V	11.0	20.7
41.581000	33.40	40.00	6.60	5000.0	120.000	100.0	V	21.0	20.4
204.017000	23.28	43.50	20.22	5000.0	120.000	141.0	H	38.0	18.0
487.732000	25.30	46.00	20.70	5000.0	120.000	362.0	H	48.0	27.0
618.460000	35.00	46.00	11.00	5000.0	120.000	148.0	H	110.0	29.6
949.396000	34.71	46.00	11.29	5000.0	120.000	130.0	V	86.0	35.0

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.

Table 8.5-10: *Radiated spurious emissions results, 30-1000 MHz, High channel (2480 MHz)*

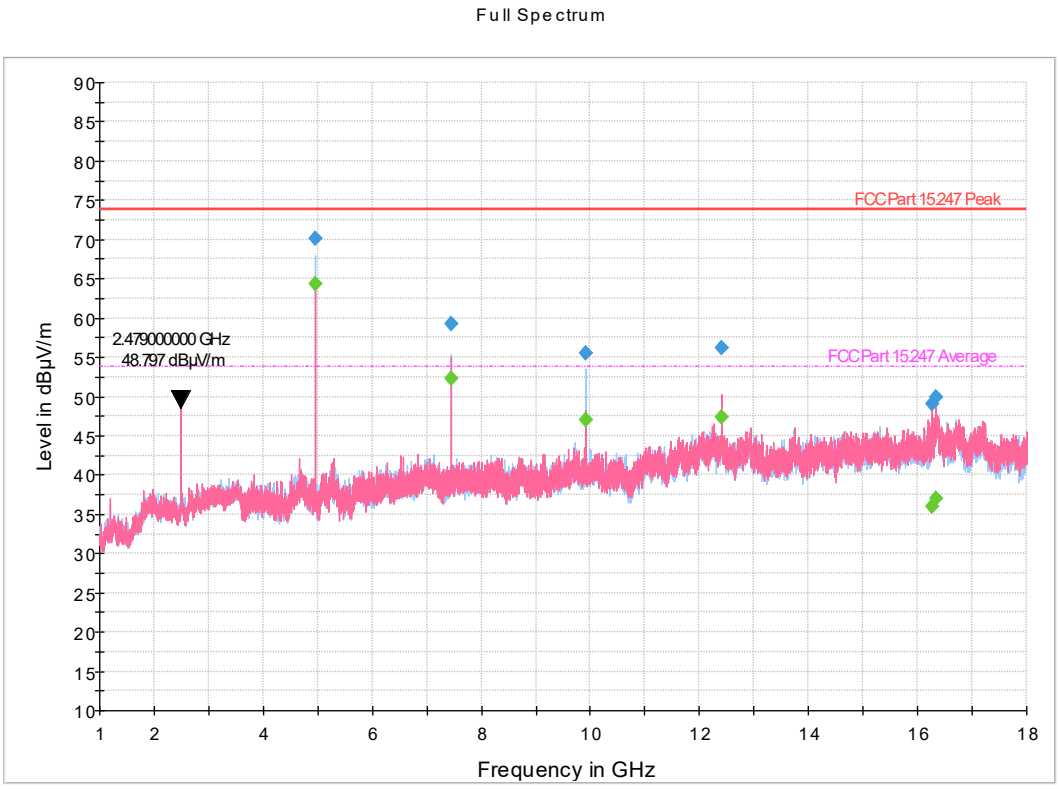


Figure 8.5-9: *Radiated spurious emissions plot, 1 – 18 GHz, High channel (2480 MHz)*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band width (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4959.511111	70.21	---	73.90	3.69	5000.0	1000.0	214.0	H	196.0	-2.4
4959.511111	**---**	**47.04 (*)**	**53.90**	**6.86**	**5000.0**	**1000.0**	**214.0**	**H**	**196.0**	**-2.4**
7439.366667	---	52.31	53.90	1.59	5000.0	1000.0	186.0	H	22.0	1.2
7439.366667	59.26	---	73.90	14.64	5000.0	1000.0	186.0	H	22.0	1.2
9921.188889	55.53	---	73.90	18.37	5000.0	1000.0	182.0	H	314.0	3.3
9921.188889	---	47.09	53.90	6.81	5000.0	1000.0	182.0	H	314.0	3.3
12401.300000	56.17	---	73.90	17.73	5000.0	1000.0	211.0	V	296.0	7.3
12401.300000	---	47.40	53.90	6.50	5000.0	1000.0	211.0	V	296.0	7.3
16255.211111	---	36.02	53.90	17.88	5000.0	1000.0	225.0	V	175.0	13.1
16255.211111	49.08	---	73.90	24.82	5000.0	1000.0	225.0	V	175.0	13.1
16337.700000	49.84	---	73.90	24.06	5000.0	1000.0	213.0	V	225.0	13.2
16337.700000	---	37.03	53.90	16.87	5000.0	1000.0	213.0	V	225.0	13.2

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.
[4] Fundamental emission at ~ 2.4 GHz is attenuated by a notch filter to protect measurement equipment. This fundamental emission is not assessed against the limits.

(*) The average value was calculated by subtracting the worst case duty cycle correction factor (23.17 dB) from the peak measurement: 70.21 – 23.17 = 47.04 dBµV/m.

Table 8.5-11: *Radiated spurious emissions results, 1 – 18 GHz, High channel (2480 MHz)*

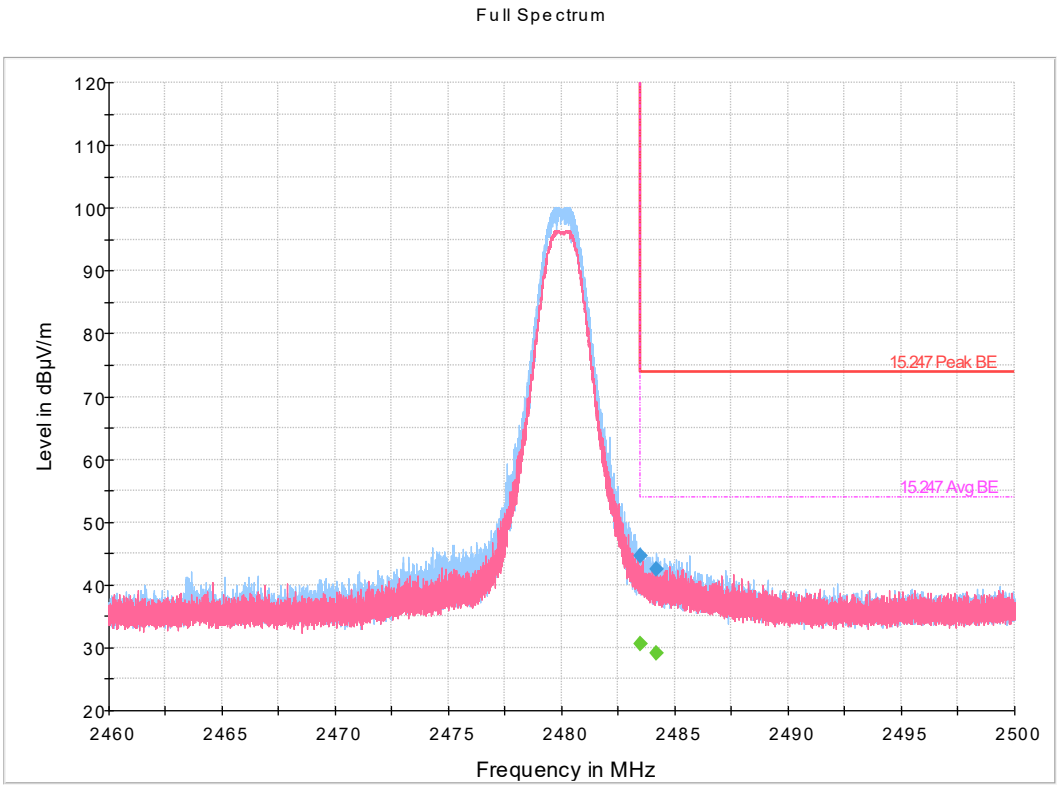


Figure 8.5-10: *High band edge (High channel: 2480 MHz) Radiated spurious emissions plot, 2460-2500 MHz.*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band width (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2483.500000	---	30.65	53.90	23.25	5000.0	1000.0	372.0	H	286.0	-9.7
2483.500000	44.55	---	73.90	29.35	5000.0	1000.0	372.0	H	286.0	-9.7
2484.153333	---	29.16	53.90	24.74	5000.0	1000.0	372.0	H	287.0	-9.7
2484.153333	42.46	---	73.90	31.44	5000.0	1000.0	372.0	H	287.0	-9.7

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.

Figure 8.5-12: *High band edge (High channel: 2480 MHz) Radiated spurious emissions results, 2460-2500 MHz.*

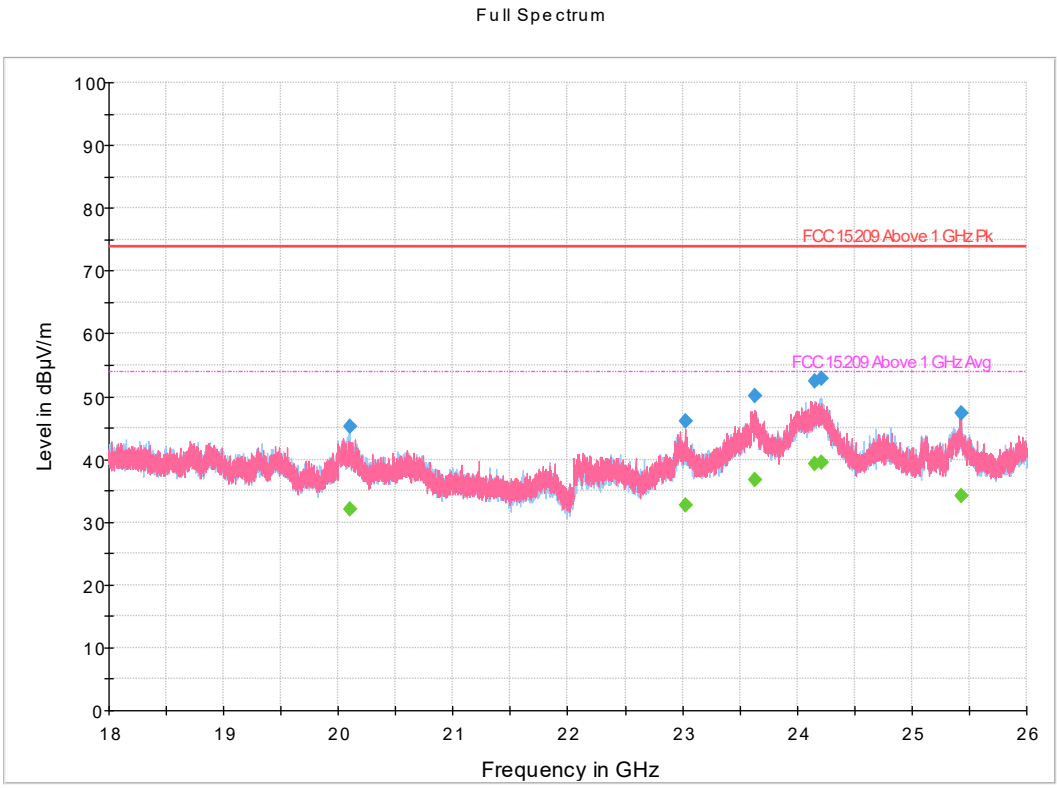


Figure 8.5-11: *Radiated spurious emissions plot, 18-26 GHz, High channel (2480 MHz)*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Band width (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
20105.000000	---	32.16	53.90	21.74	5000.0	1000.0	156.0	H	96.0	18.8
20105.000000	45.29	---	73.90	28.61	5000.0	1000.0	156.0	H	96.0	18.8
23027.400000	---	32.65	53.90	21.25	5000.0	1000.0	334.0	V	189.0	20.9
23027.400000	45.98	---	73.90	27.92	5000.0	1000.0	334.0	V	189.0	20.9
23633.900000	---	36.64	53.90	17.26	5000.0	1000.0	262.0	V	148.0	25.7
23633.900000	50.17	---	73.90	23.73	5000.0	1000.0	262.0	V	148.0	25.7
24157.300000	---	39.37	53.90	14.53	5000.0	1000.0	104.0	H	320.0	29.4
24157.300000	52.49	---	73.90	21.41	5000.0	1000.0	104.0	H	320.0	29.4
24211.900000	---	39.55	53.90	14.35	5000.0	1000.0	173.0	H	175.0	29.1
24211.900000	52.88	---	73.90	21.02	5000.0	1000.0	173.0	H	175.0	29.1
25435.500000	---	34.28	53.90	19.62	5000.0	1000.0	165.0	V	300.0	23.9
25435.500000	47.28	---	73.90	26.62	5000.0	1000.0	165.0	V	300.0	23.9

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] FCC 15.209 Limits are equivalent to FCC 15.247 Limits.

Table 8.5-13: *Radiated spurious emissions results, 18 – 26 GHz, High channel (2480 MHz)*

8.6 FCC 15.247(e) and RSS-247 5.2(b) Power spectral density of digital transmission system

8.6.1 References

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(e) / ANSI C63.10: 2013

(e) For digitally modulated systems, the 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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this Section. The same method of determining the conducted output power shall be used to determine the power spectral density.

RSS-247 → §5.2(b)

(a) The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of Section 5.4(4), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

8.6.2 Test summary

Verdict	Pass		
Test date	December 1, 2022	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1006 mbar
Test location	Wireless bench (Conducted)	Relative humidity	57 %

8.6.3 Notes

Testing was performed with the BLE transmitter operating on a fixed channel at 5 dBm (software set up).
For conducted measurements, an offset corresponding to the path losses was added in the spectrum analyzer.

8.6.4 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless Bench
Measurement details	Measurement performed as per C63.10 §11.10.2 (Method PKPSD)

Receiver/spectrum analyzer settings:

Resolution bandwidth	3 kHz
Video bandwidth	10 kHz (≥ 3 x RBW)
Frequency span	1 MHz (1.5 x DTS bandwidth)
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.6.5 Test data

Table 8.6-1: *Power spectral density of DTS*

Transmitter Frequency (MHz)	Measured Level (dBm/3 kHz)	Limit (dBm/3 kHz)
2402	6.21	8.00
2440	5.90	8.00
2480	4.48	8.00

8.6.6 Test data, continued

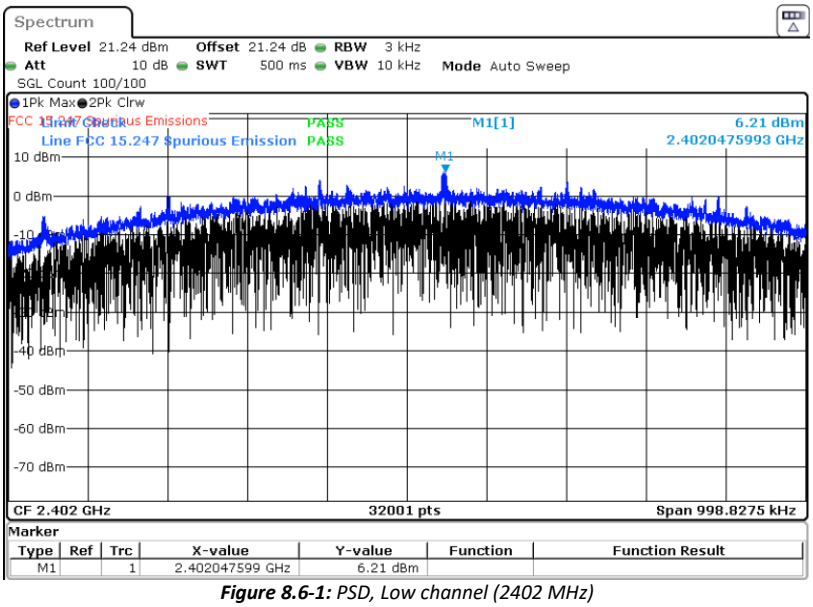


Figure 8.6-1: *PSD, Low channel (2402 MHz)*

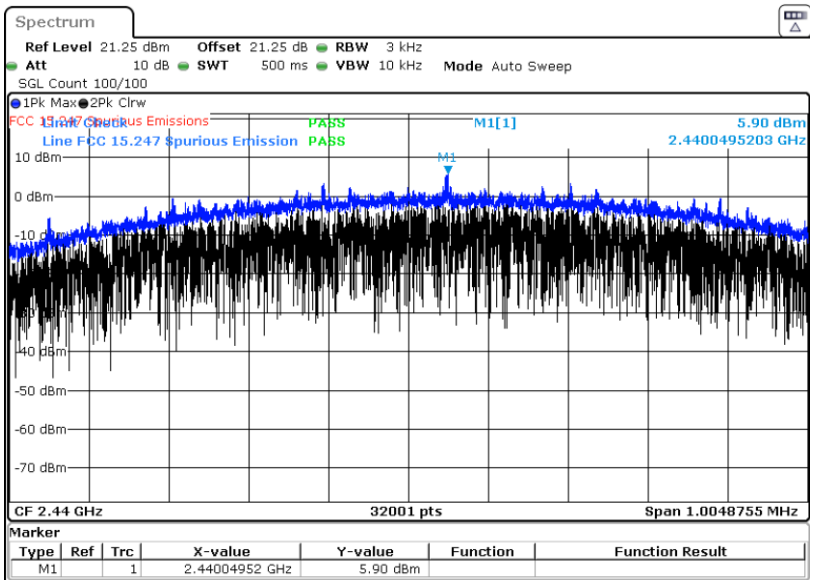


Figure 8.6-2: *PSD, Middle channel (2440 MHz)*

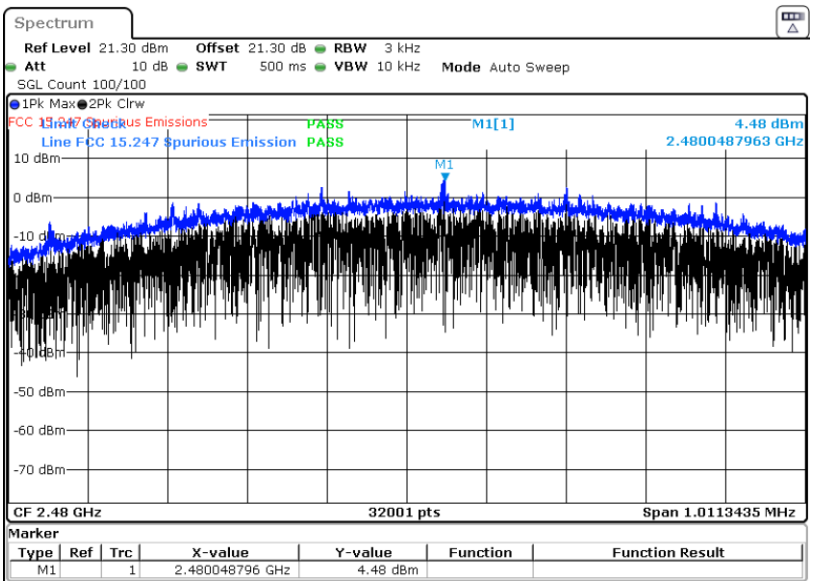


Figure 8.6-3: *PSD, High channel (2480 MHz)*

8.7 RSS-GEN 6.7 Occupied bandwidth (or 99% emission bandwidth)

8.7.1 References

RSS-Gen → §6.7

The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

8.7.2 Test summary

Test date	November 30, 2022	Temperature	19 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1005 mbar
Test location	Wireless bench (Conducted)	Relative humidity	53 %

8.7.3 Notes

Testing was performed with the BLE transmitter operating on a fixed channel at 5 dBm (software set up).

8.7.4 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless Bench
Measurement details	Measurement performed as per C63.10 §6.9.3 using the built-in function of the spectrum analyzer

Receiver/spectrum analyzer settings:

Resolution bandwidth	1 – 5 % of OBW
Video bandwidth	3*RBW
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.7.5 Test data

Table 8.7-1: *99% Occupied bandwidth*

Transmitter Frequency (MHz)	99%Bandwidth (MHz)
2402	1.094809537
2440	1.098559420
2480	1.094497047

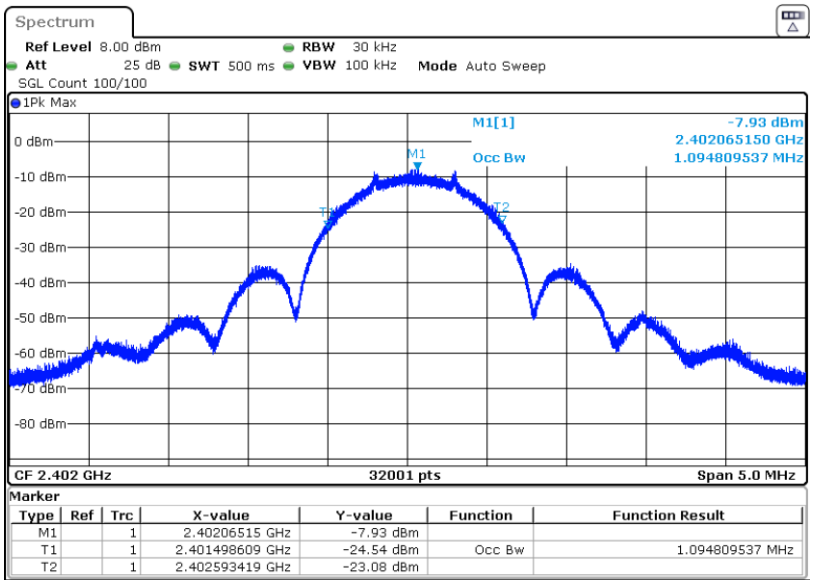


Figure 8.7-1: *99% OBW, Low channel (2402 MHz)*

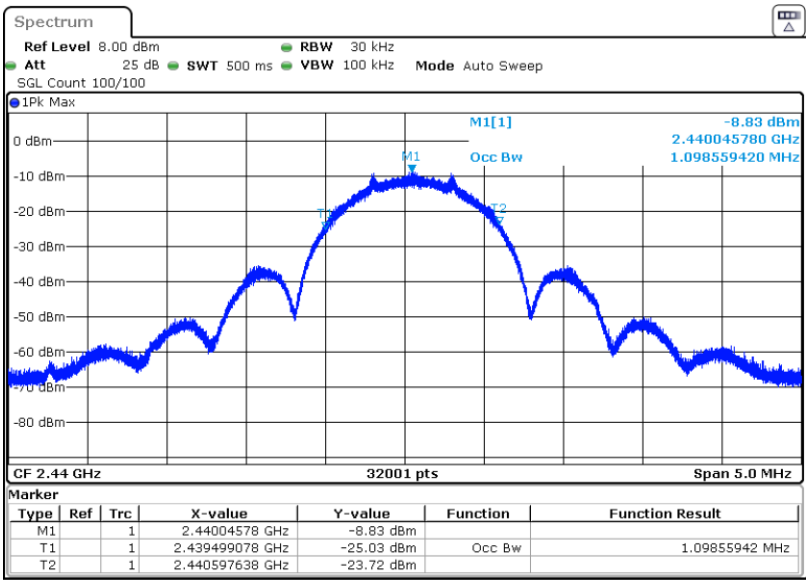


Figure 8.7-2: *99% OBW, Middle channel (2440 MHz)*

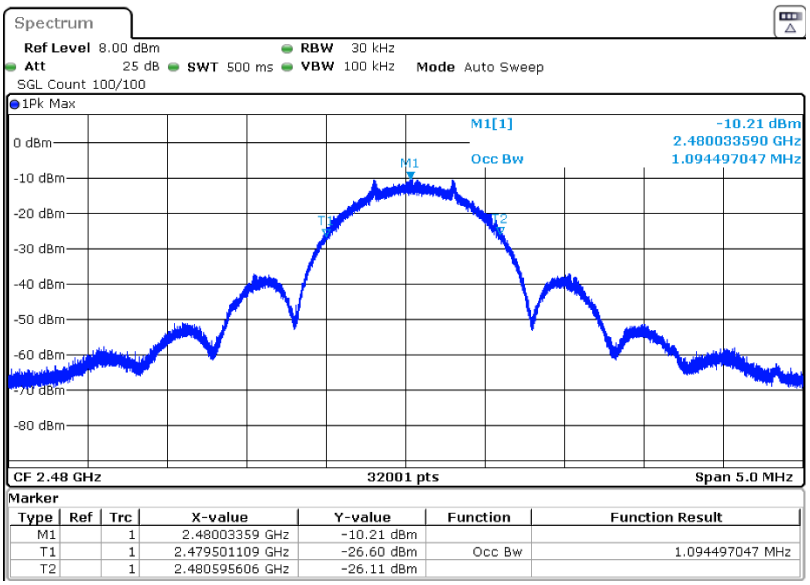


Figure 8.7-3: *99% OBW, High channel (2480 MHz)*

Section 9 Block diagrams of test set-ups

9.1 Radiated emissions set-up

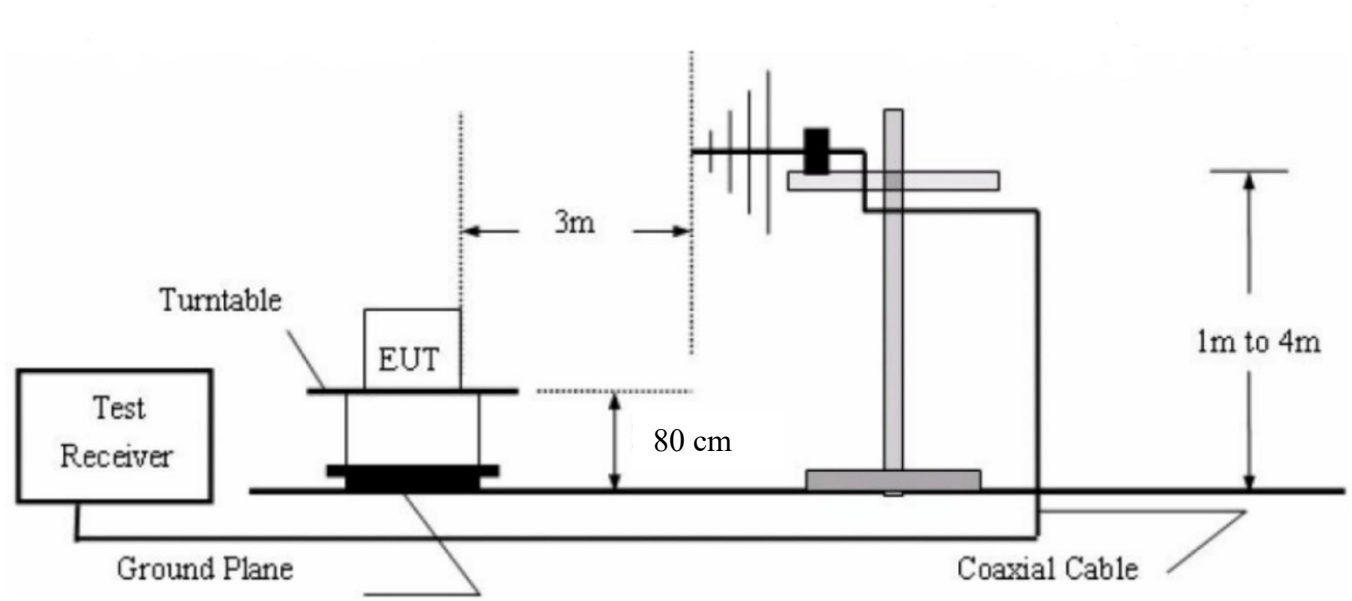


Figure 9.1-1: *30 MHz - 1000 MHz Setup*

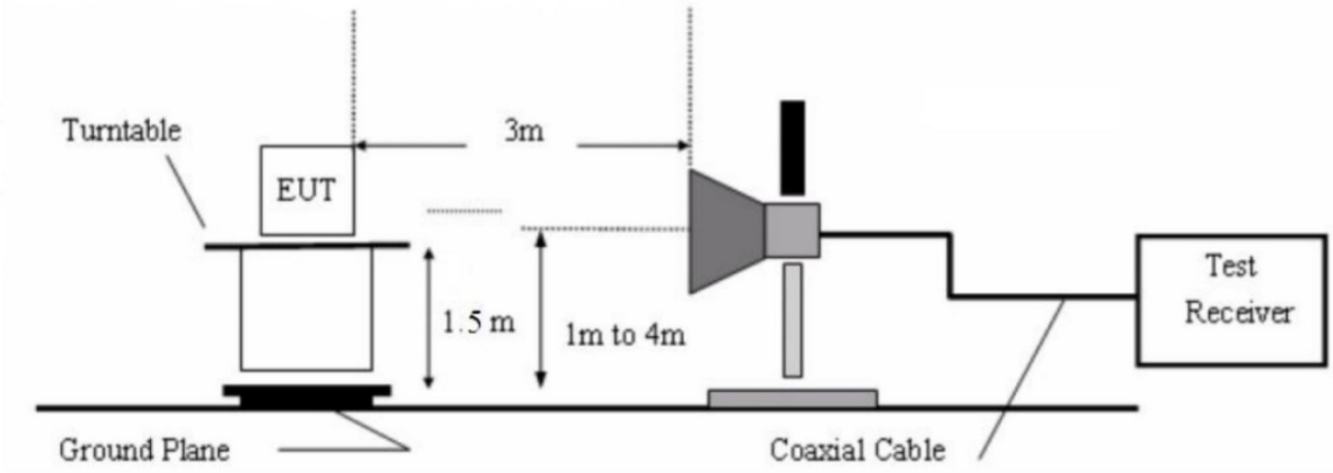


Figure 9.1-2: *1 GHz - 26 GHz Setup*

9.2 Conducted emissions set-up

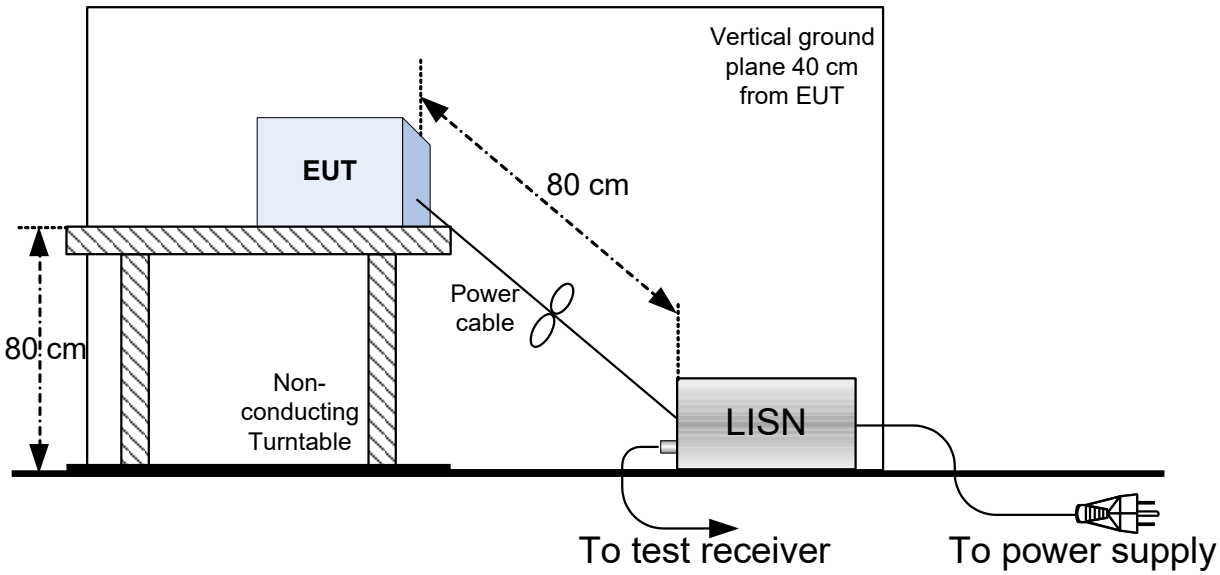


Figure 9.2-1: *150 kHz to 30 MHz Conducted Emissions Setup*