ONE WORLD ○ OUR APPROVAL

Test report

409642-1TRFWL

Date of issue: November 20, 2020

Applicant:

Wagz, Inc.

Product:

Explore Smart Collar

Model:

Freedom Collar

FCC ID: 2ASHHSP03000ML008 IC ID: TBD

Specifications:

- FCC 47 CFR Part 15, Subpart C – §15.247
  Operation within the bands 902 – 928 MHz, 2400 – 2483.5 MHz, 5727 – 5850 MHz
- RSS-247, Issue 2, February 2017
  Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSSs) 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	James Cunningham, Wireless Supervisor
Reviewed by	Juan M Gonzalez, EMC & Wireless Divisions Manager
Review date	November 20, 2020
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.
This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the U.S. Government.

Copyright notification

Table of Contents

Section 1 Report summary

1.1 Applicant

Company name	Wagz, Inc.
Address	230 Commerce Way
City	Portsmouth
Province/State	NH
Postal/Zip code	03801
Country	USA

1.2 Manufacturer

Company name	Wagz, Inc.
Address	230 Commerce Way
City	Portsmouth
Province/State	NH
Postal/Zip code	03801
Country	USA

1.3 Test specifications

FCC 47 CFR Part 15, Subpart C – §15.247 IC RSS-247 Issue 2	Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz 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 v03r02 (June 5, 2014)	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
409642-1TRFWL	Original report issued

Notes:

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: EUT is DC powered via battery – battery is removed from the EUT for charging and placed into a separate charger. EUT transmitter is never connected to the AC mains
The antenna is PCB trace antenna, maximum gain -4.5 dBi.

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(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
6.7	Transmitter occupied bandwidth	Pass
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

Note: Per RSS-GEN Section 7, receiver radiated and conducted emissions are not applicable as the EUT is neither a scanning receiver nor operates as a stand-alone receiver.

Section 3 Equipment under test (EUT) details

3.1 Sample information

Receipt date	November 2, 2020
Nemko sample ID number	NEx: 409642

3.2 EUT information

Product name	Explore Smart Collar
Model	SP03000ML008 (Freedom Collar)
Serial number	2042231016
Part number	N/A

3.3 Technical information

Used IC test site(s) reg. number	2040A
RSS number and issue	RSS-247 issue 2 (February 2017)
Frequency band	2400 – 2483.5 MHz
Minimum frequency (MHz)	2402
Maximum frequency (MHz)	2480
Minimum output power (dBm)	0.55 dBm e.i.r.p.
Maximum output power (dBm)	-4.45 dBm e.i.r.p.
Measured 6 dB bandwidth	2402 MHz: 616 kHz 2440 MHz: 612 kHz 2480 MHz: 612 kHz
Type of modulation	GFSK
Emission classification	F1D
Power requirements	3.8 VDC battery
Antenna information	-4.5 dBi gain antenna on PCB

3.4 EUT exercise and monitoring details

The EUT was powered via 18650 battery. A supporting laptop was connected to the EUT via USB cable. Test software installed on the laptop was used to configure the EUT to the desired transmit frequency at maximum power. During testing, the USB cable and support laptop were removed.

Software Configuration was through EspRFtestTool where through the COM port the mode of operations was configured for testing. This same tool was used for BLE and for WiFi operation

Table 3.4-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number	Rev.
Test sample	Wagz, Inc.	Freedom Collar	2042231016	N/A

Table 3.4-2: EUT interface ports

Description	Qty.
DC power	1
USB (not used for normal operation)	1

Table 3.4-3: Support equipment

Description	Brand name	Model/Part number	Serial number	Rev.
Laptop	Dell	Inspiron 5548	9K643SS	N/A
18650 battery	N/A	N/A	N/A	N/A

Table 3.4-4: Inter-connection cables

Cable description	From	To	Length (ft)
USB	EUT	Laptop	0.6

USB cable was not present during testing.

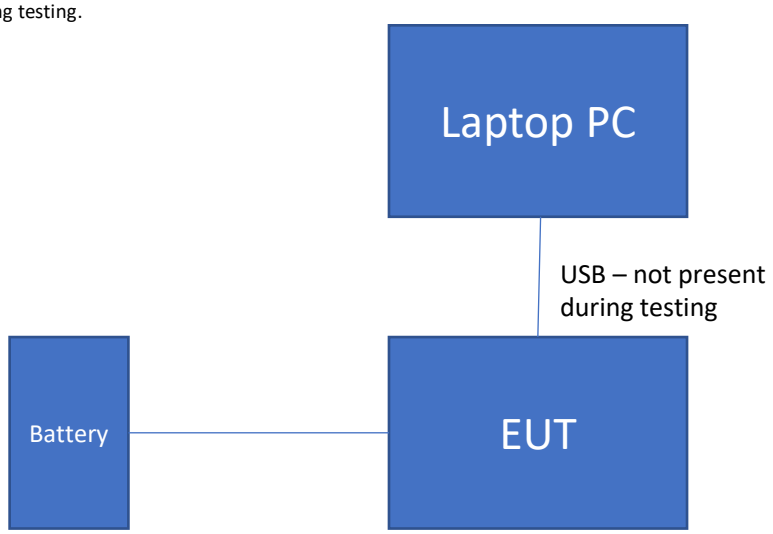

Figure 3.4-1: Test setup

Section 4 Engineering considerations

4.1 Modifications incorporated in the EUT

Two ferrites were applied to the battery leads. These battery leads were added for testing purposes only and are not part of the final product.

4.2 Technical judgment

None

4.3 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

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.

Test name	Measurement uncertainty, dB
Radiated spurious emissions	3.78
Powerline conducted emissions	1.38
All antenna port measurements	0.55
Conducted spurious emissions	1.13

Section 7 Test Equipment

Table 6.1-1: Test Equipment List

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMI Test Receiver	Rohde & Schwarz	ESU40	E1131	1 year	19 Nov 2020
System Controller	Sunol Sciences	SC104V	E1191	NCR	NCR
Bilog Antenna	Schaffner	CBL6111C	1480	1 year	21 Oct 2021
DRG Horn	ETS-Lindgren	3117-PA	E1139	1 year	21 Mar 2021
Transient Limiter	Hewlett Packard	11947A	684	1 year	20 Jan 2021
Horn antenna	EMCO	3116	E1013	1 year	21 Sept 2021

Notes: VBU – verify before use
NCR – no calibration required

Table 6.1-2: Test Software

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.60.15

Section 8 Testing data

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

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 3, 2020	Temperature	22 °C
Test engineer	James Cunningham	Air pressure	1007 mbar
Test location	3m semi-anechoic chamber	Relative humidity	60 %

8.1.3 Notes

Testing was performed in BLE mode and the EUT transmitting on a fixed channel at full power.

The measurement was performed as a radiated test with the EUT oriented to the position of maximum transmitter power (with respect to azimuth, antenna height and polarization).

8.1.4 Setup details

EUT setup configuration	Tabletop
Test facility	3 m semi anechoic chamber
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)	Margin (kHz)
2402	616.00	> 500	116.00
2440	612.00	> 500	112.00
2480	612.00	> 500	112.00

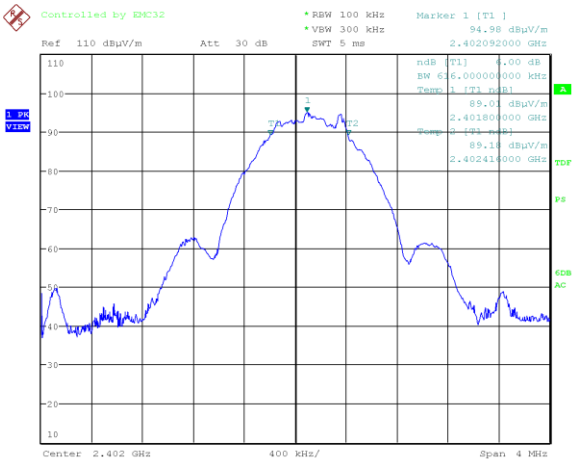

Figure 8.1-1: 6 dB occupied bandwidth, 2402 MHz

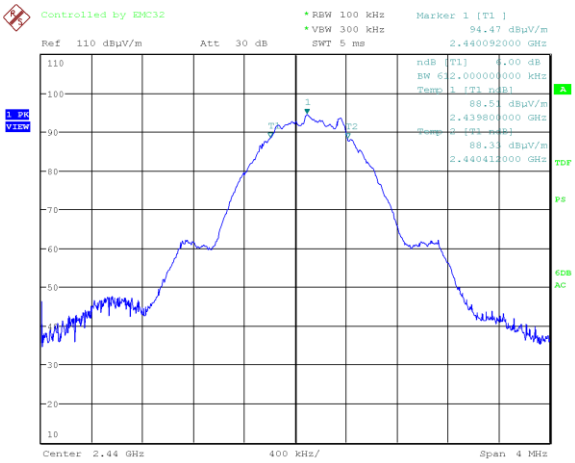

Figure 8.1-2: 6 dB occupied bandwidth, 2440 MHz

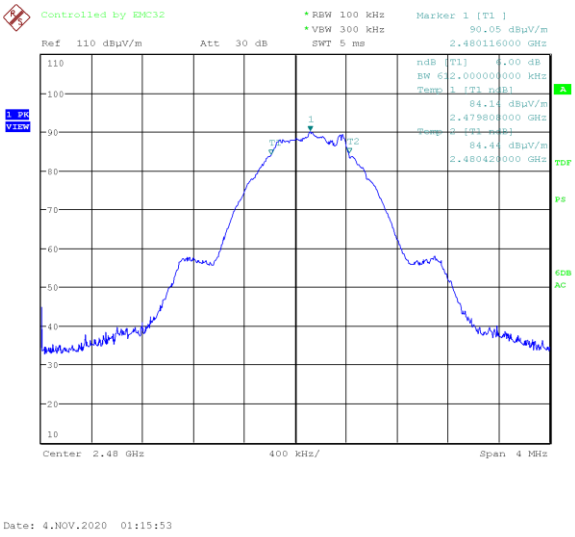

Figure 8.1-3: 6 dB occupied bandwidth, 2480 MHz

8.2 FCC 15.247(b) and RSS-247 5.4 (d) 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	November 3, 2020	Temperature	22 °C
Test engineer	James Cunningham	Air pressure	1007 mbar
Test location	3m semi-anechoic chamber	Relative humidity	60 %

8.2.3 Notes

Testing was performed in BLE mode and the EUT transmitting on a fixed channel at full power.

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
EIRP (dBm) = Field strength (dBµV/m @ 3 m) – 95.2 dB

The correction factors were included in the spectrum analyzer as a transducer factor.

The EIRP was maximized with respect to azimuth (0 – 360°), polarization (horizontal and vertical) and height (1 – 4 m).

The antenna gain declared by the manufacturer is -4.5 dBi.

Maximum conducted output power = EIRP (dBm) - Antenna Gain (dBi)

8.2.4 Setup details

EUT setup configuration	Tabletop
Test facility	3 m semi anechoic chamber
Measurement method	558074 D01 DTS Measurement Guidance §8.3.11 ANSI C63.10 §11.9.1.1 (RBW ≥ DTS bandwidth) - Radiated

8.2.5 Test data

Table 8.2-1: Output power

Test Frequency (MHz)	Measured Radiated Field Strength (dBµV/m @ 3m)	EIRP (dBm)	EIRP Limit (dBm)	Antenna Gain (dBi)	Maximum Conducted Output Power (dBm)	Conducted Output Power Limit (dBm)
2402	95.78	0.55	36.00	-4.5	5.05	30.00
2440	95.00	-0.23	36.00	-4.5	4.27	30.00
2480	90.78	-4.45	36.00	-4.5	0.05	30.00

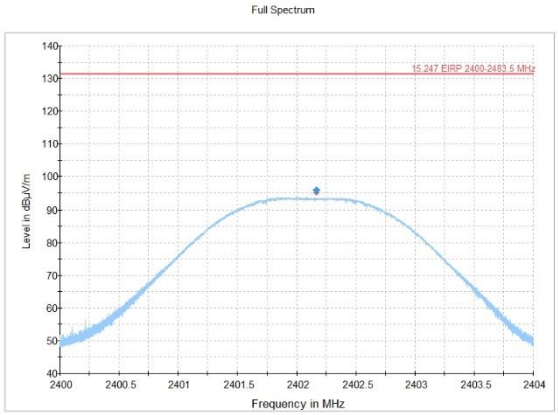

Figure 8.2-1: Output power, 2402 MHz

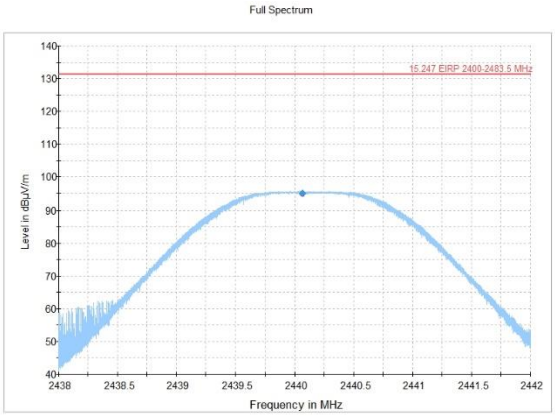

Figure 8.2-2: Output power, 2440 MHz

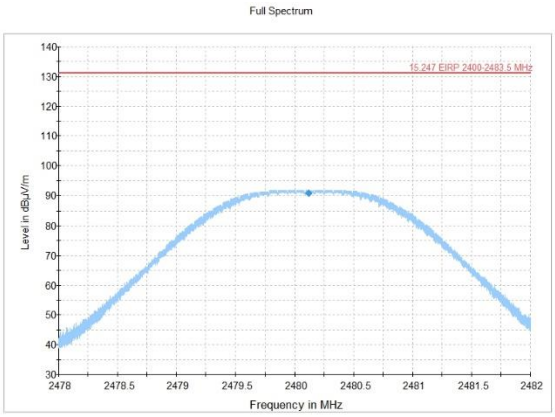

Figure 8.2-3: Output power, 2480 MHz

8.3 FCC 15.247(d) and RSS-247 5.5 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	November 3, 2020	Temperature	22 °C
Test engineer	James Cunningham	Air pressure	1007 mbar
Test location	3m semi-anechoic chamber	Relative humidity	60 %

8.3.3 Notes

The EUT was configured to transmit continuously on the lowest, and highest channels.

8.3.4 Setup details

EUT setup configuration	Tabletop
Test facility	3 m semi anechoic chamber
Measurement details	Radiated 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

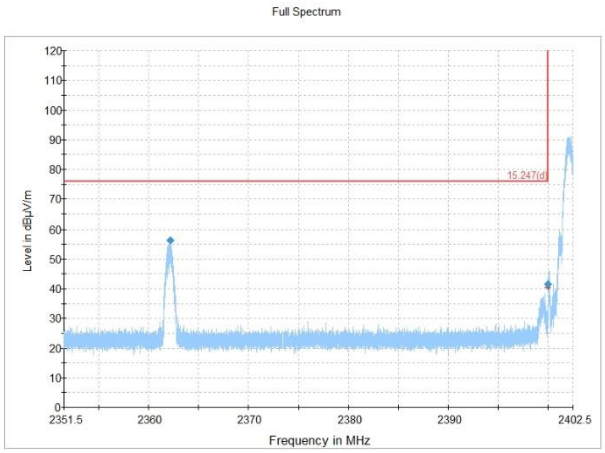

Figure 8.3-1: Radiated band edge measurement, 2402 MHz

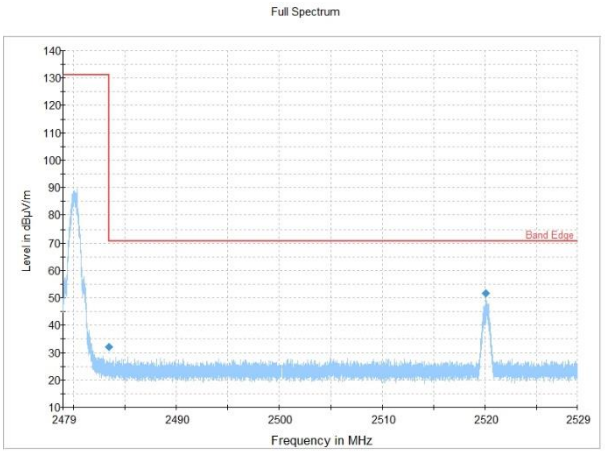

Figure 8.3-2: Radiated band edge measurement, 2480 MHz

8.4 FCC 15.247(d) and RSS-247 5.5 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	November 3, 2020	Temperature	22 °C
Test engineer	James Cunningham	Air pressure	1007 mbar
Test location	3m semi-anechoic chamber	Relative humidity	60 %

8.4.3 Notes

In each measurement, the limit was derived by subtracting 20 dB from the power spectral density measurements in Section 8.6. The test was performed as a radiated measurement.

8.4.4 Setup details

EUT setup configuration	Tabletop
Test facility	3 m semi-anechoic chamber
Measurement details	Radiated 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

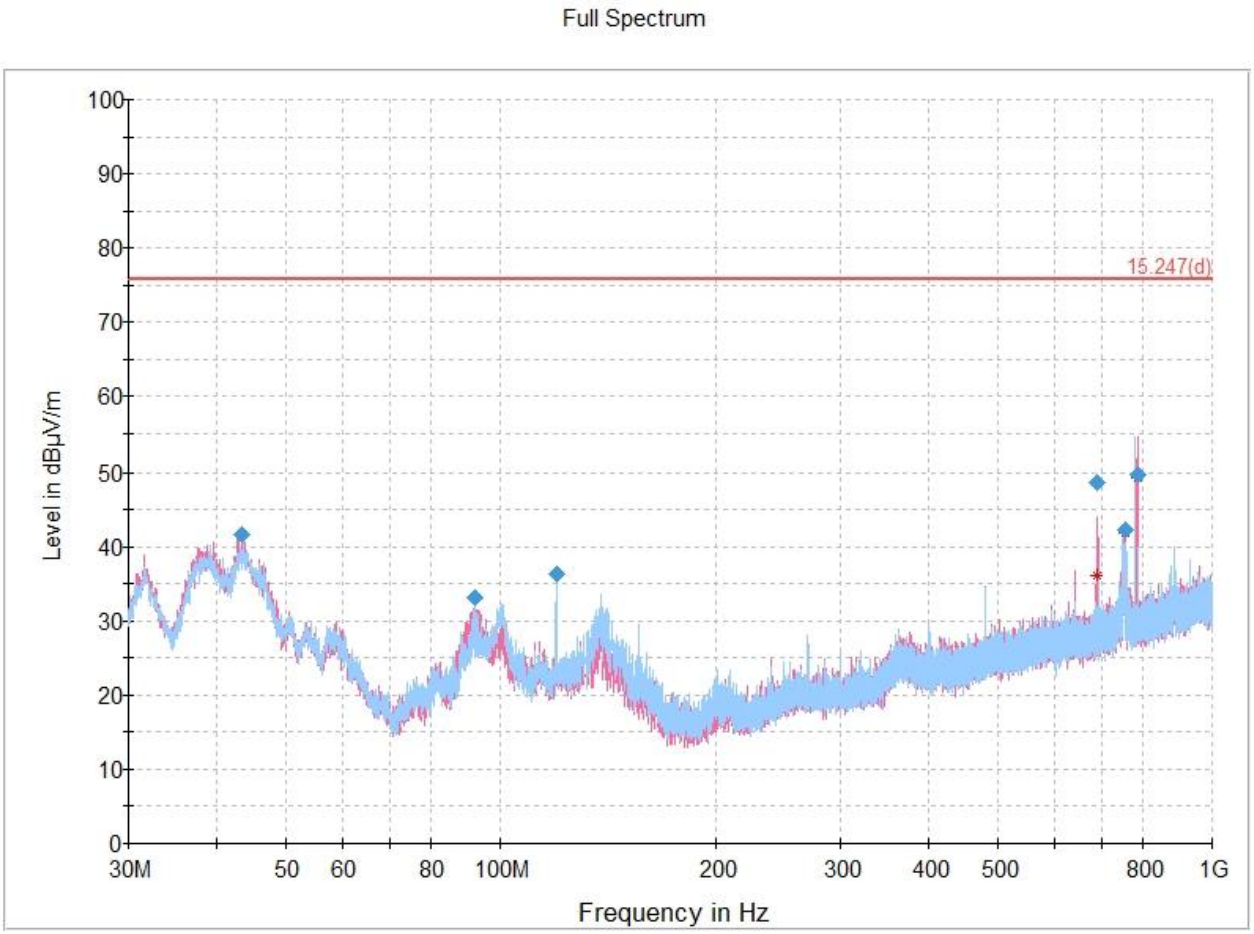

Figure 8.4-1: Radiated emissions, 30 – 1000 MHz, 2402 MHz

Table 8.4-1: Radiated emissions, 30 – 1000 MHz, 2402 MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
43.225667	41.53	75.78	34.25	5000.0	100.000	150.0	V	36.0	19.2
92.155333	33.15	75.78	42.64	5000.0	100.000	350.0	V	36.0	16.3
120.003667	36.28	75.78	39.50	5000.0	100.000	394.0	V	119.0	19.1
688.451333	48.52	75.78	27.25	5000.0	100.000	191.0	V	247.0	29.7
755.388333	42.17	75.78	33.61	5000.0	100.000	127.0	V	54.0	30.9
786.093333	49.77	75.78	26.01	5000.0	100.000	204.0	V	320.0	31.1

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

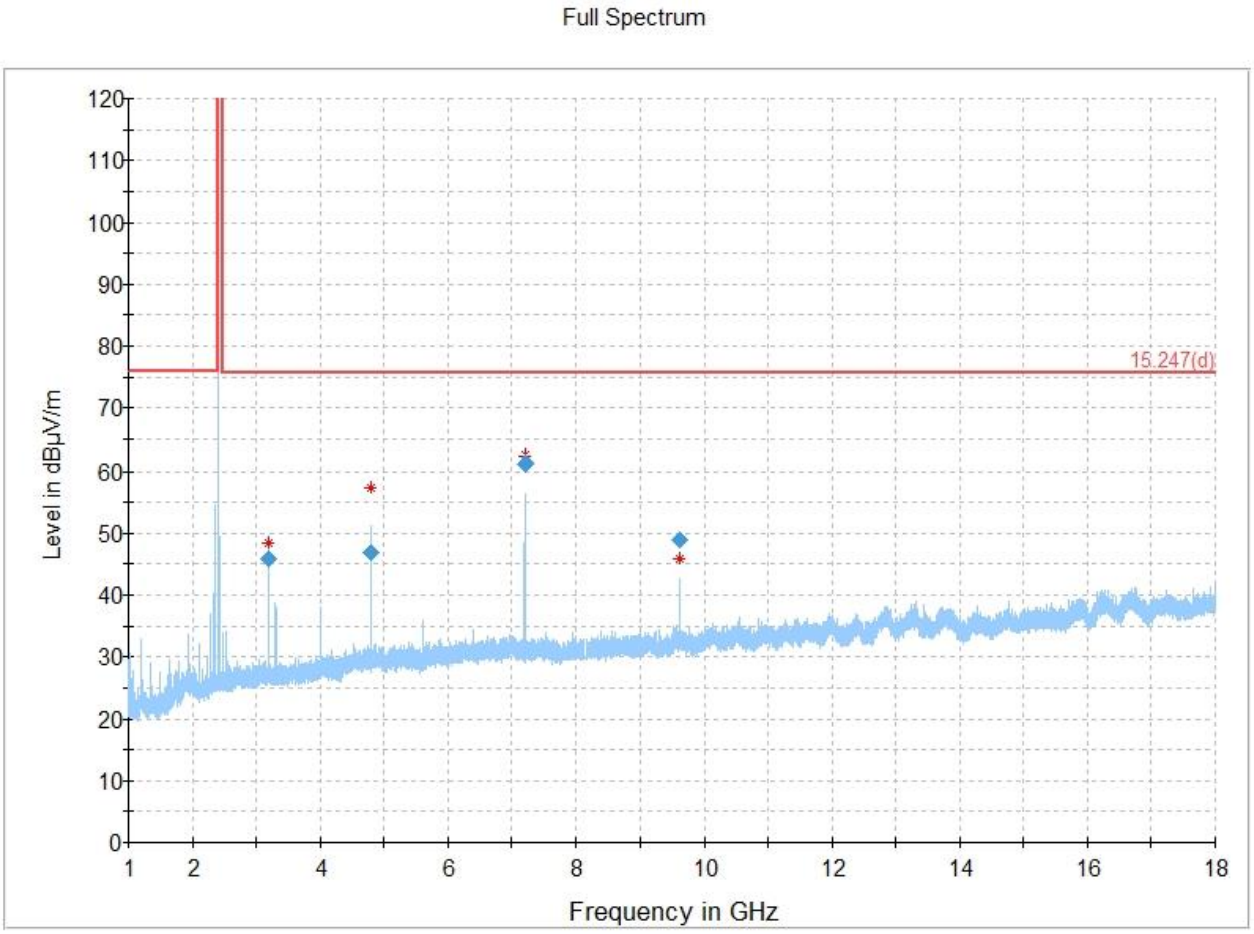

Figure 8.4-2: Radiated emissions, 1 – 18 GHz, 2402 MHz

Table 8.4-2: Radiated emissions, 1 – 18 GHz, 2402 MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
3202.843333	45.77	75.78	30.01	5000.0	100.000	128.0	V	161.0	-8.0
4804.216667	46.95	75.78	28.83	5000.0	100.000	101.0	V	115.0	-3.1
7206.346667	61.12	75.78	14.66	5000.0	100.000	204.0	V	283.0	-1.1
9608.443333	49.00	75.78	26.78	5000.0	100.000	105.0	H	11.0	1.8

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

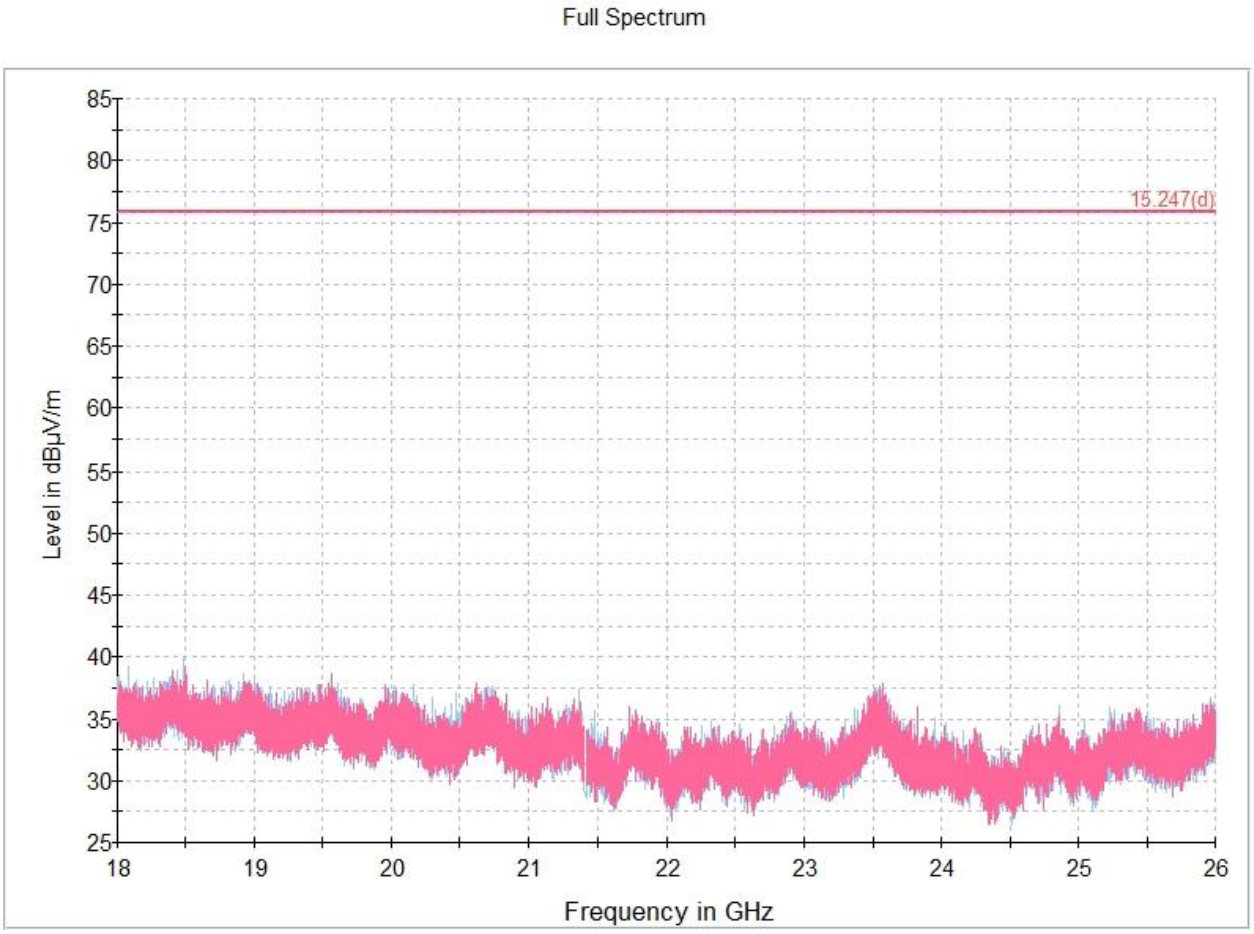

Figure 8.4-3: Radiated emissions, 18 – 26 GHz, 2402 MHz

Table 8.4-3: Radiated emissions, 18 – 26 GHz, 2402 MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
No emissions observed									

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

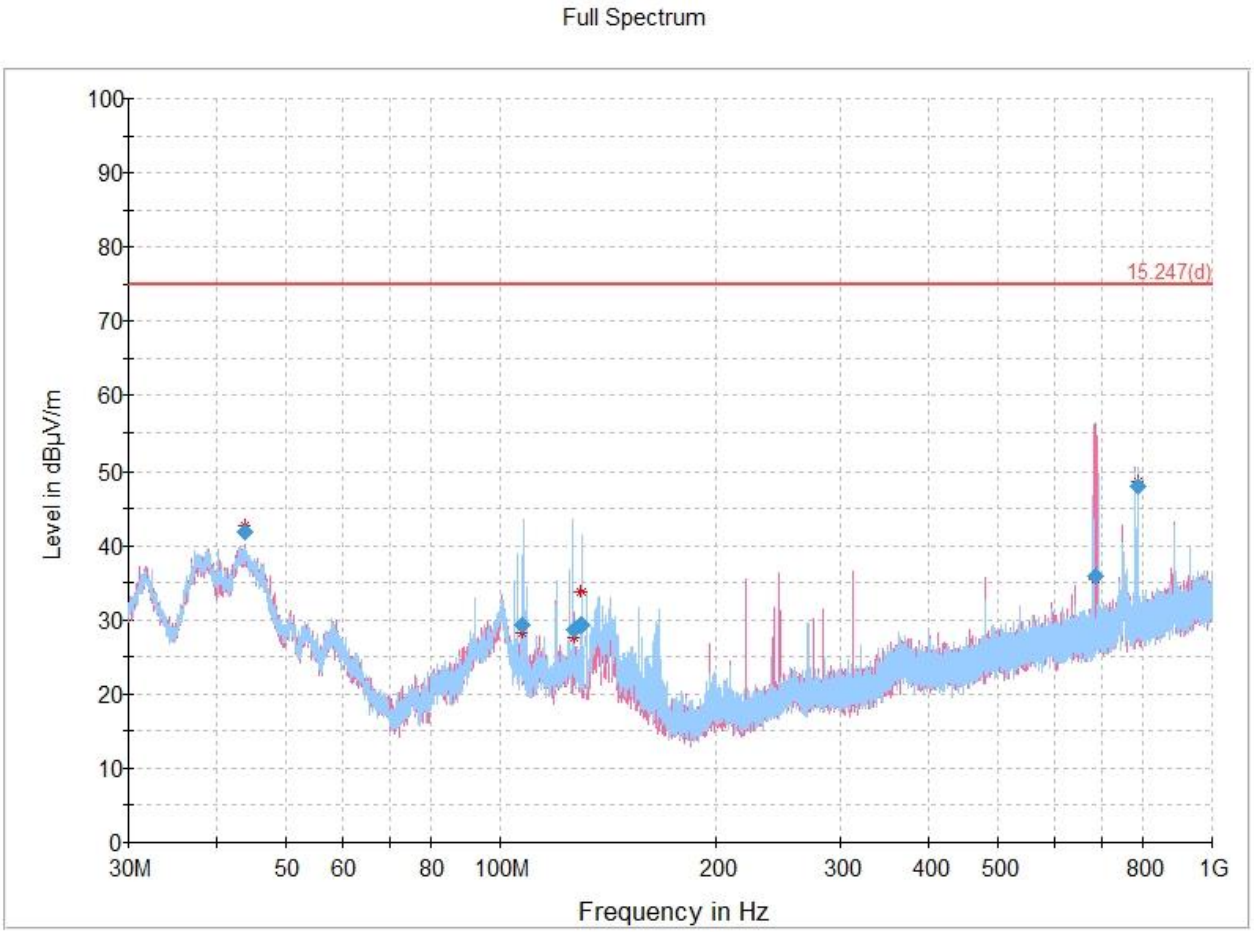

Figure 8.4-4: Radiated emissions, 30 – 1000 MHz, 2440 MHz

Table 8.4-4: Radiated emissions, 30 – 1000 MHz, 2440 MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
43.738667	41.84	75.00	33.16	5000.0	100.000	346.0	V	0.0	18.9
107.546333	29.35	75.00	45.65	5000.0	100.000	265.0	H	36.0	18.3
126.948000	28.59	75.00	46.41	5000.0	100.000	333.0	H	95.0	19.4
129.773333	29.22	75.00	45.78	5000.0	100.000	222.0	H	290.0	19.4
683.825333	35.90	75.00	39.10	5000.0	100.000	175.0	V	235.0	29.6
786.280333	47.92	75.00	27.08	5000.0	100.000	219.0	H	175.0	31.1

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

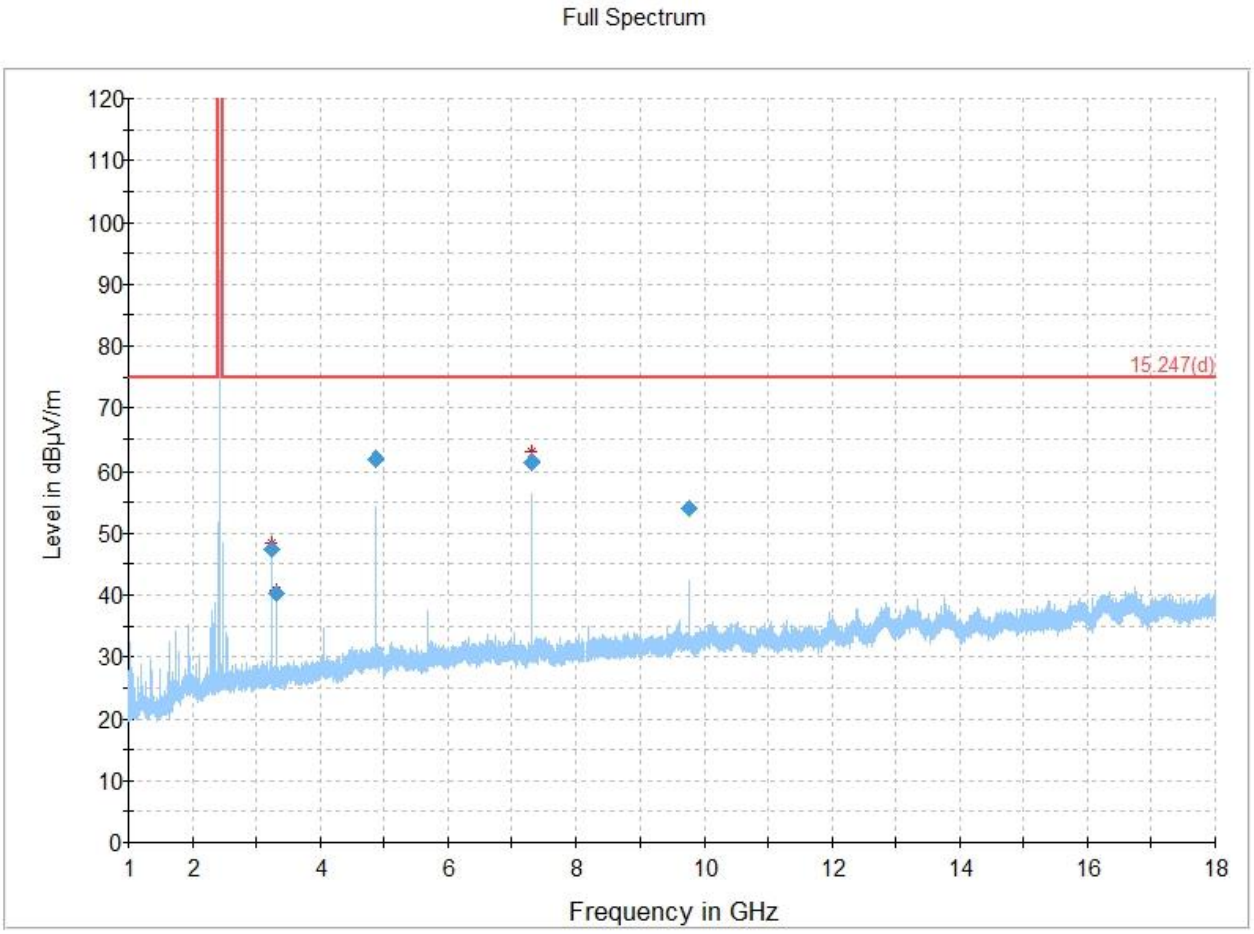

Figure 8.4-5: Radiated emissions, 1 – 18 GHz, 2440 MHz

Table 8.4-5: Radiated emissions, 1 – 18 GHz, 2440 MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
3253.486667	47.48	75.00	27.52	5000.0	100.000	224.0	H	328.0	-7.9
3311.223333	40.28	75.00	34.72	5000.0	100.000	234.0	H	125.0	-7.8
4880.206667	61.86	75.00	13.14	5000.0	100.000	109.0	H	0.0	-3.3
7320.300000	61.50	75.00	13.50	5000.0	100.000	214.0	V	292.0	-1.0
9760.426667	53.94	75.00	21.06	5000.0	100.000	109.0	H	0.0	1.5

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

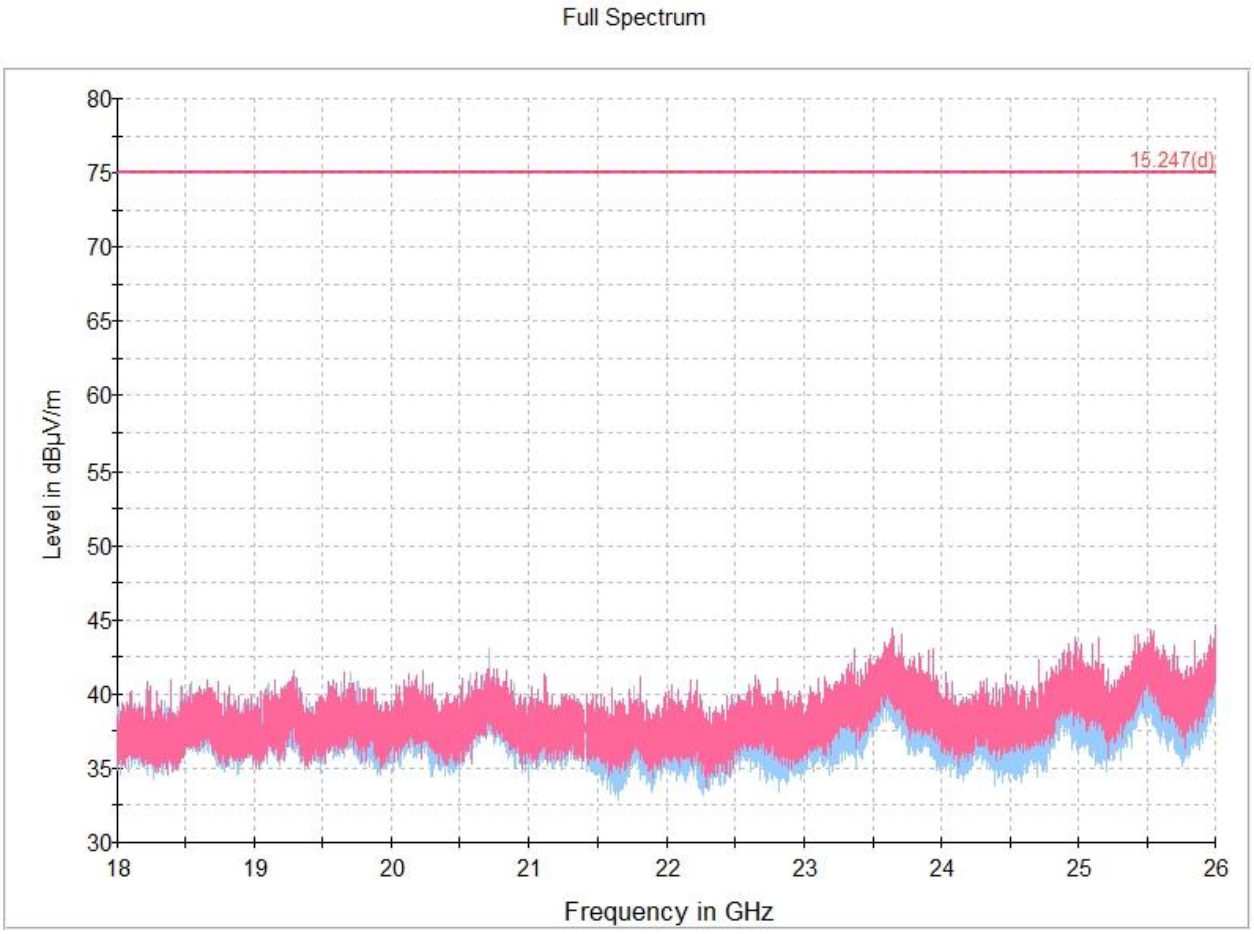

Figure 8.4-6: Radiated emissions, 18 – 26 GHz, 2440 MHz

Table 8.4-6: Radiated emissions, 18 – 26 GHz, 2440 MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
No emissions observed									

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

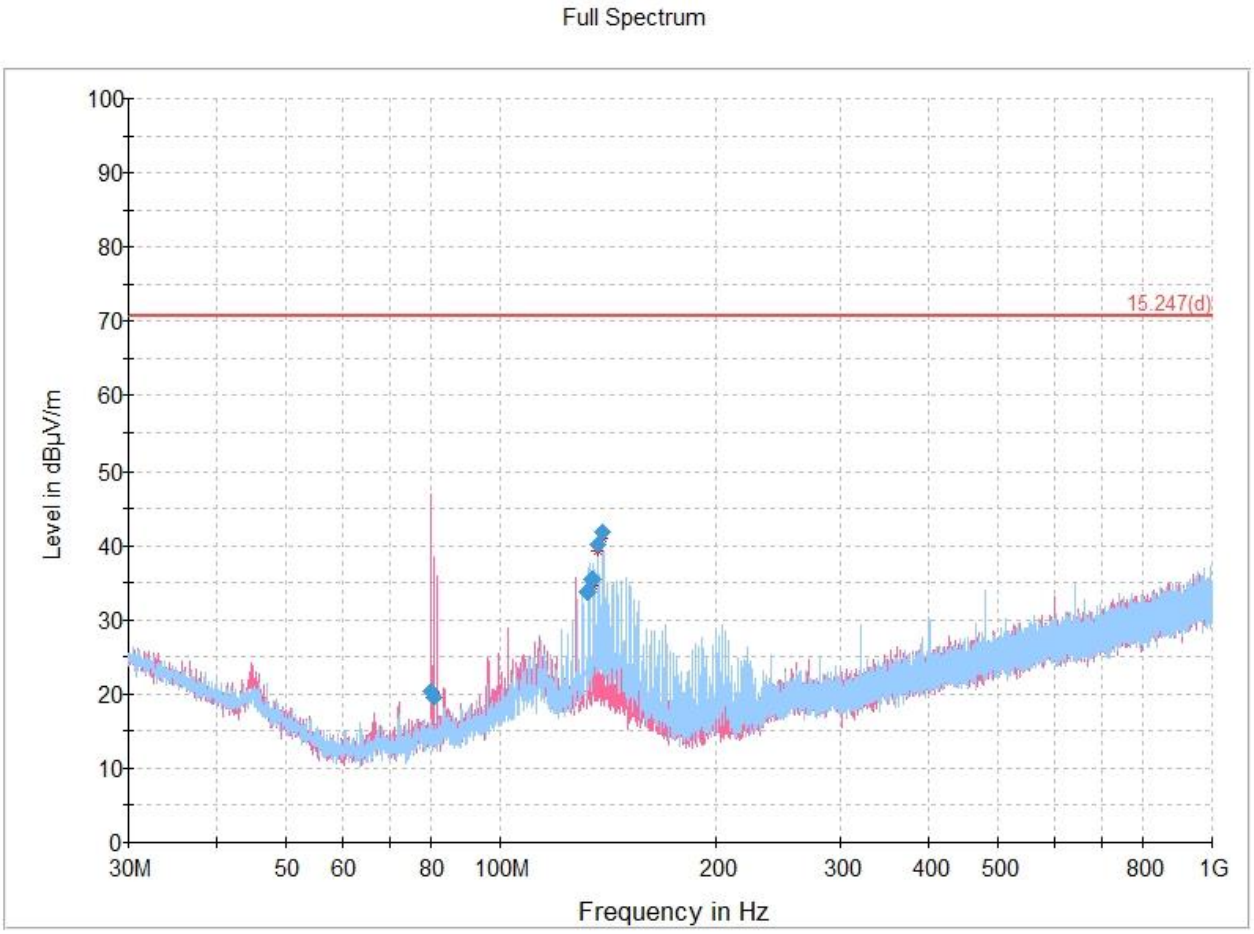

Figure 8.4-7: Radiated emissions, 30 – 1000 MHz, 2480 MHz

Table 8.4-7: Radiated emissions, 30 – 1000 MHz, 2480 MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
80.037333	20.43	70.78	50.34	5000.0	100.000	402.0	V	216.0	14.8
80.755667	19.64	70.78	51.14	5000.0	100.000	240.0	V	184.0	14.8
132.422333	33.71	70.78	37.09	5000.0	100.000	215.0	H	75.0	19.4
134.434667	35.37	70.78	35.41	5000.0	100.000	208.0	H	90.0	19.4
136.427000	40.10	70.78	30.68	5000.0	100.000	213.0	H	90.0	19.4
138.565667	41.73	70.78	29.05	5000.0	100.000	212.0	H	90.0	19.4

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

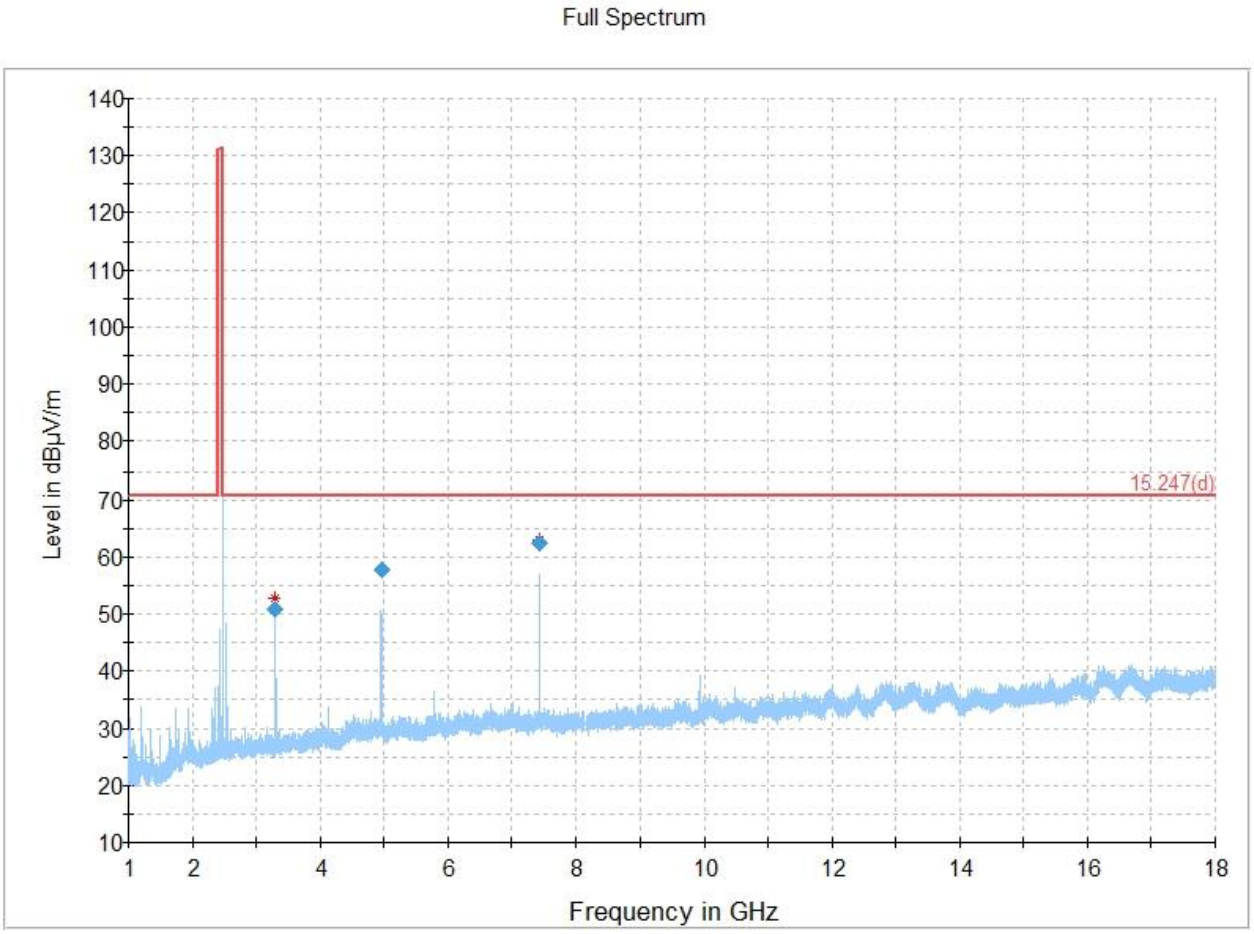

Figure 8.4-8: Radiated emissions, 1 – 18 GHz, 2480 MHz

Table 8.4-8: Radiated emissions, 1 – 18 GHz, 2480 MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
3306.831500	50.93	70.78	19.85	5000.0	100.000	266.0	H	138.0	-7.9
4960.216167	57.66	70.78	13.12	5000.0	100.000	105.0	V	166.0	-3.5
7440.338333	62.31	70.78	8.47	5000.0	100.000	194.0	V	292.0	-0.5

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

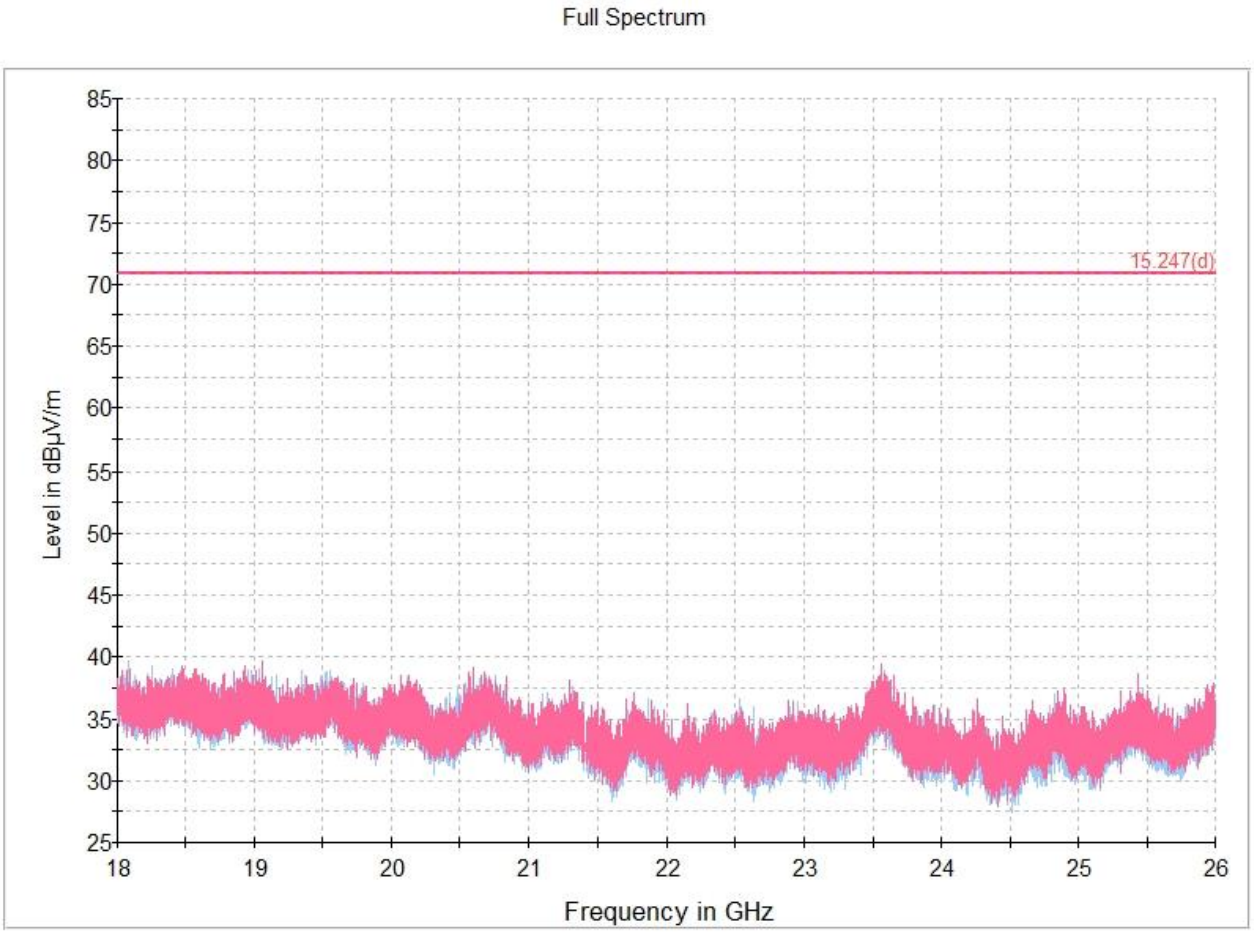

Figure 8.4-9: Radiated emissions, 18 – 26 GHz, 2480 MHz

Table 8.4-9: Radiated emissions, 18 – 26 GHz, 2480 MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
No emissions observed									

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

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

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 µV/m	Field strength of emissions dBµV/m	Measurement distance, 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	November 3, 2020	Temperature	22 °C
Test engineer	James Cunningham	Air pressure	1007 mbar
Test location	3m semi-anechoic chamber	Relative humidity	60 %

8.5.3 Notes

The EUT was configured to transmit continuously on the lowest, middle, and highest channels.

The spectrum was search from 30 MHz to 26 GHz (above the 10th harmonic of the highest transmit frequency of 2480 MHz).

Radiated measurements were performed at a 3 m measurement distance.

8.5.4 Setup details

EUT setup configuration	Tabletop
Test facility	3m semi anechoic chamber at 3 m measurement distance
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
Measurement time	5 s (final measurements)

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
Measurement time	5 s (final measurements)

8.5.5 Test data

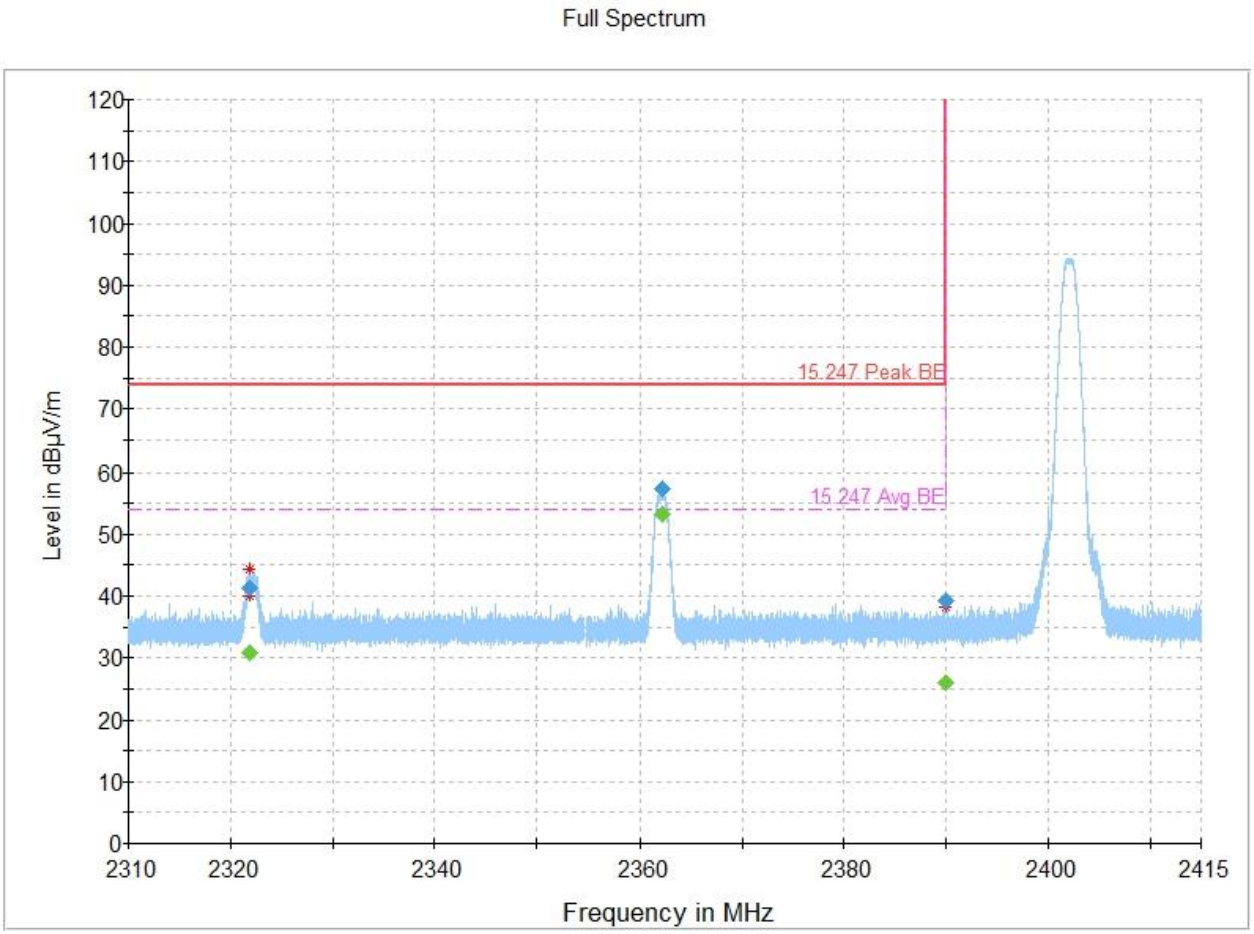

Figure 8.5-1: Radiated emissions, restricted band edge, low

Table 8.5-2: Radiated emissions, restricted band edge, low

Frequency (MHz)	QuasiPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2321.854500	---	30.72	53.90	23.18	5000.0	1000.000	286.0	V	96.0	-11.5
2321.854500	41.21	---	73.90	32.69	5000.0	1000.000	286.0	V	96.0	-11.5
2362.150000	57.25	---	73.90	16.65	5000.0	1000.000	98.0	H	11.0	-11.3
2362.150000	---	53.31	53.90	0.59	5000.0	1000.000	98.0	H	11.0	-11.3
2390.000000	39.16	---	73.90	34.74	5000.0	1000.000	123.0	H	20.0	-11.1
2390.000000	---	25.96	53.90	27.94	5000.0	1000.000	123.0	H	20.0	-11.1

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

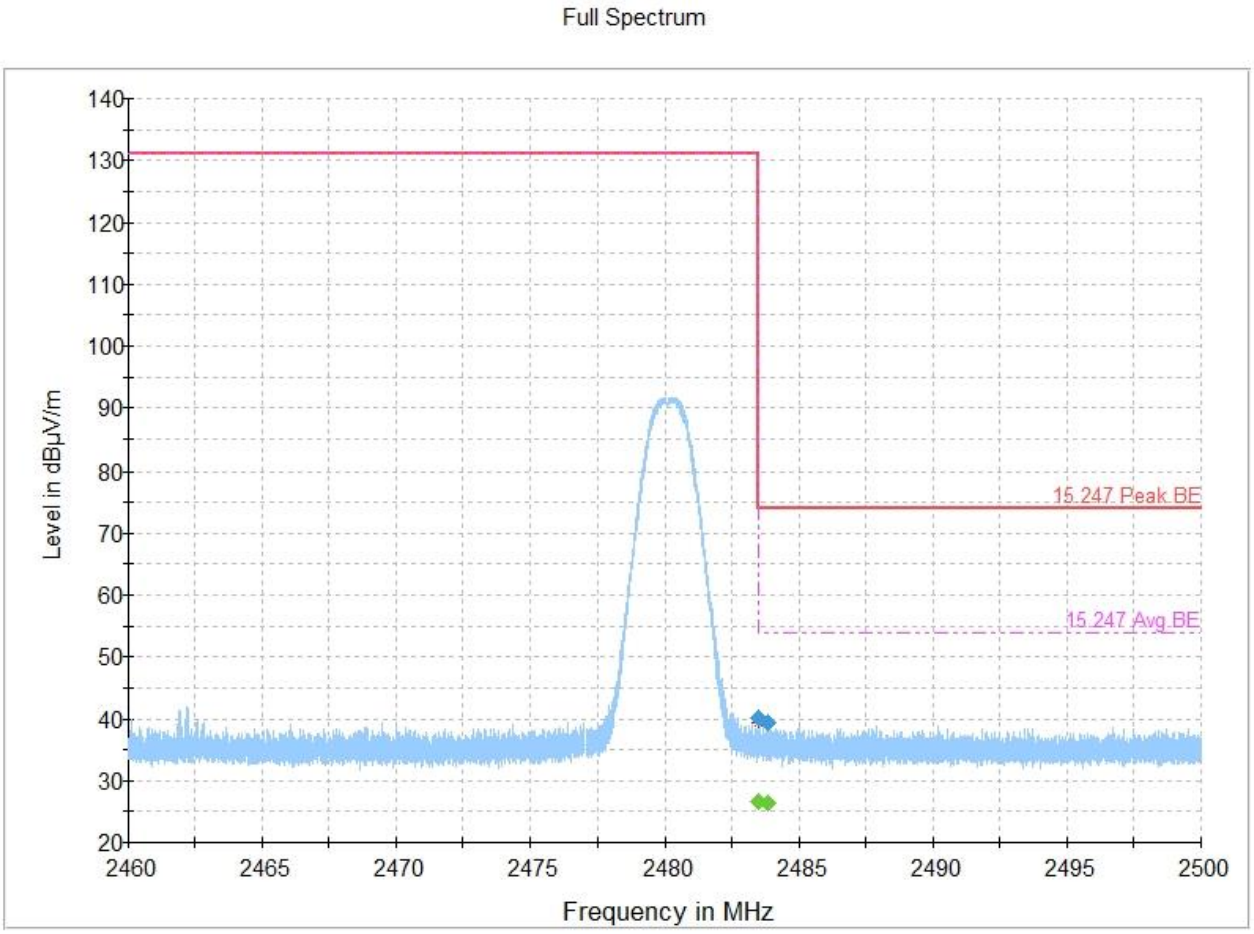

Figure 8.5-2: Radiated emissions, restricted band edge, high

Table 8.5-3: Radiated emissions, restricted band edge, high

Frequency (MHz)	QuasiPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.500000	---	26.58	53.90	27.32	5000.0	1000.000	100.0	H	346.0	-10.5
2483.500000	40.14	---	73.90	33.76	5000.0	1000.000	100.0	H	346.0	-10.5
2483.829333	---	26.27	53.90	27.63	5000.0	1000.000	136.0	H	294.0	-10.5
2483.829333	39.45	---	73.90	34.45	5000.0	1000.000	136.0	H	294.0	-10.5

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

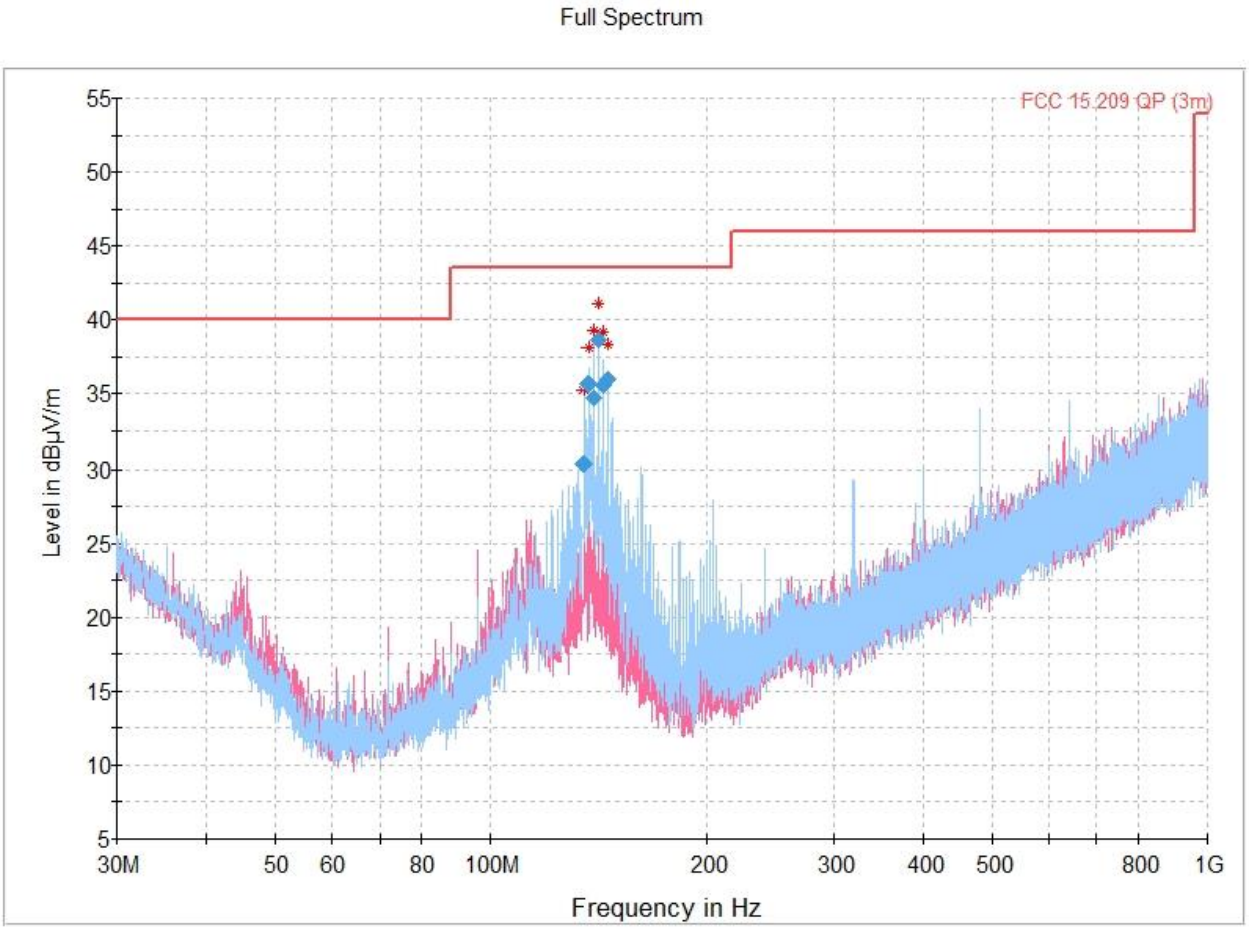

Figure 8.5-3: Radiated emissions, 2402 MHz, 30 – 1000 MHz

Table 8.5-4: Radiated emissions, 2402 MHz, 30 – 1000 MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
134.415000	30.38	43.50	13.12	5000.0	120.000	242.0	H	308.0	19.4
136.539667	35.67	43.50	7.83	5000.0	120.000	191.0	H	282.0	19.4
138.524667	34.73	43.50	8.77	5000.0	120.000	171.0	H	293.0	19.4
140.681667	38.62	43.50	4.88	5000.0	120.000	183.0	H	272.0	19.4
142.695667	35.52	43.50	7.98	5000.0	120.000	223.0	H	273.0	19.3
144.988000	36.03	43.50	7.47	5000.0	120.000	169.0	H	281.0	19.2

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

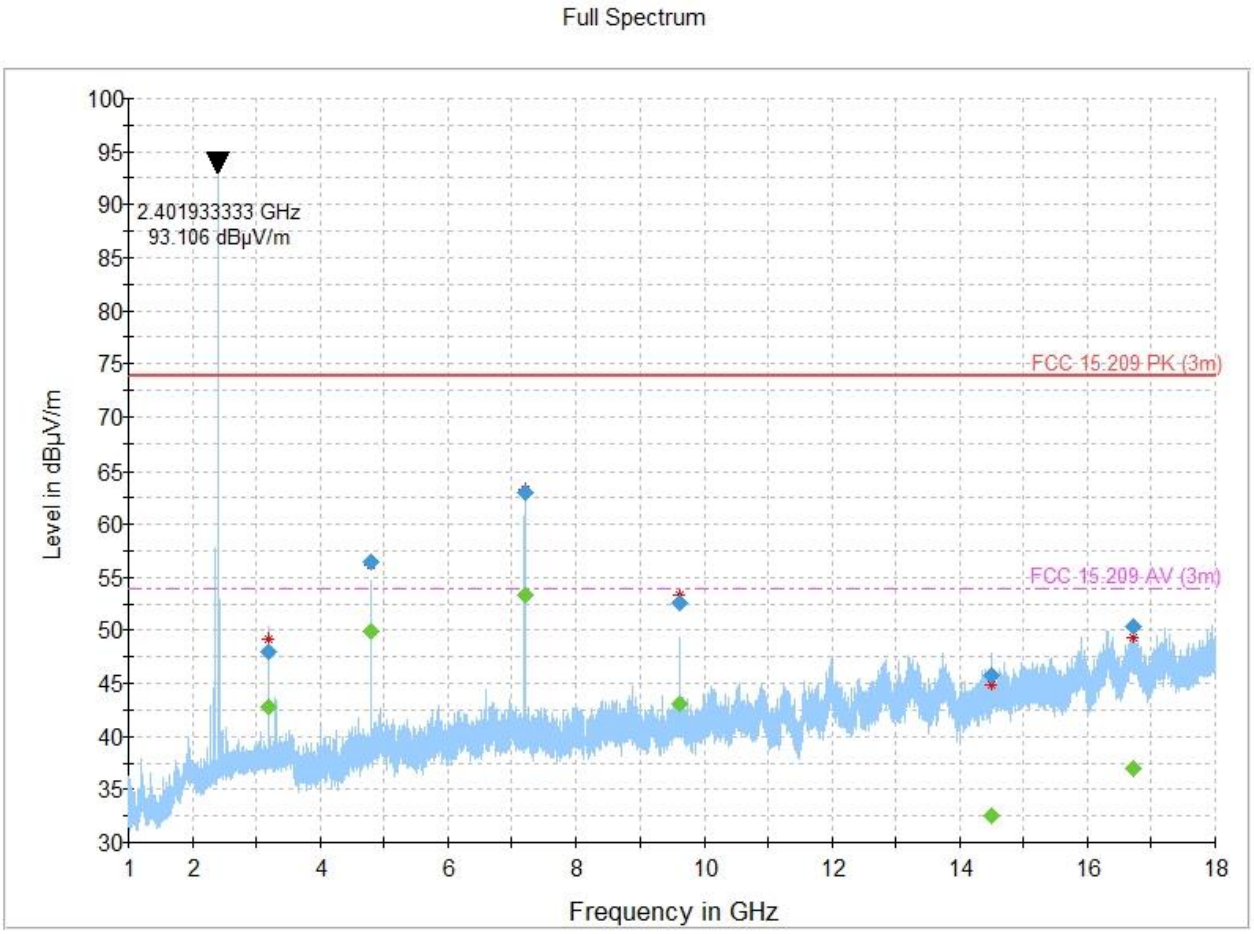

Figure 8.5-4: Radiated emissions, 2402 MHz, 1 - 18 GHz

Table 8.5-5: Radiated emissions, 2402 MHz, 1 - 18 GHz

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3202.993767	---	42.75	53.90	11.15	5000.0	1000.000	98.0	V	122.0	-8.0
3202.993767	48.05	---	73.90	25.85	5000.0	1000.000	98.0	V	122.0	-8.0
4804.281267	56.47	---	73.90	17.43	5000.0	1000.000	110.0	V	0.0	-3.1
4804.281267	---	49.92	53.90	3.98	5000.0	1000.000	110.0	V	0.0	-3.1
7206.383834	---	53.31	53.90	0.59	5000.0	1000.000	200.0	V	284.0	-1.1
7206.383834	63.00	---	73.90	10.90	5000.0	1000.000	200.0	V	284.0	-1.1
9608.256733	---	43.12	53.90	10.78	5000.0	1000.000	200.0	H	40.0	1.8
9608.256733	52.64	---	73.90	21.26	5000.0	1000.000	200.0	H	40.0	1.8
14484.793033	45.76	---	73.90	28.14	5000.0	1000.000	209.0	H	122.0	6.3
14484.793033	---	32.54	53.90	21.36	5000.0	1000.000	209.0	H	122.0	6.3
16724.986300	---	37.04	53.90	16.86	5000.0	1000.000	336.0	V	104.0	11.1
16724.986300	50.35	---	73.90	23.55	5000.0	1000.000	336.0	V	104.0	11.1

Notes: The marker highlights the wanted frequency of the transmitter and is not evaluated against the limits.
Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

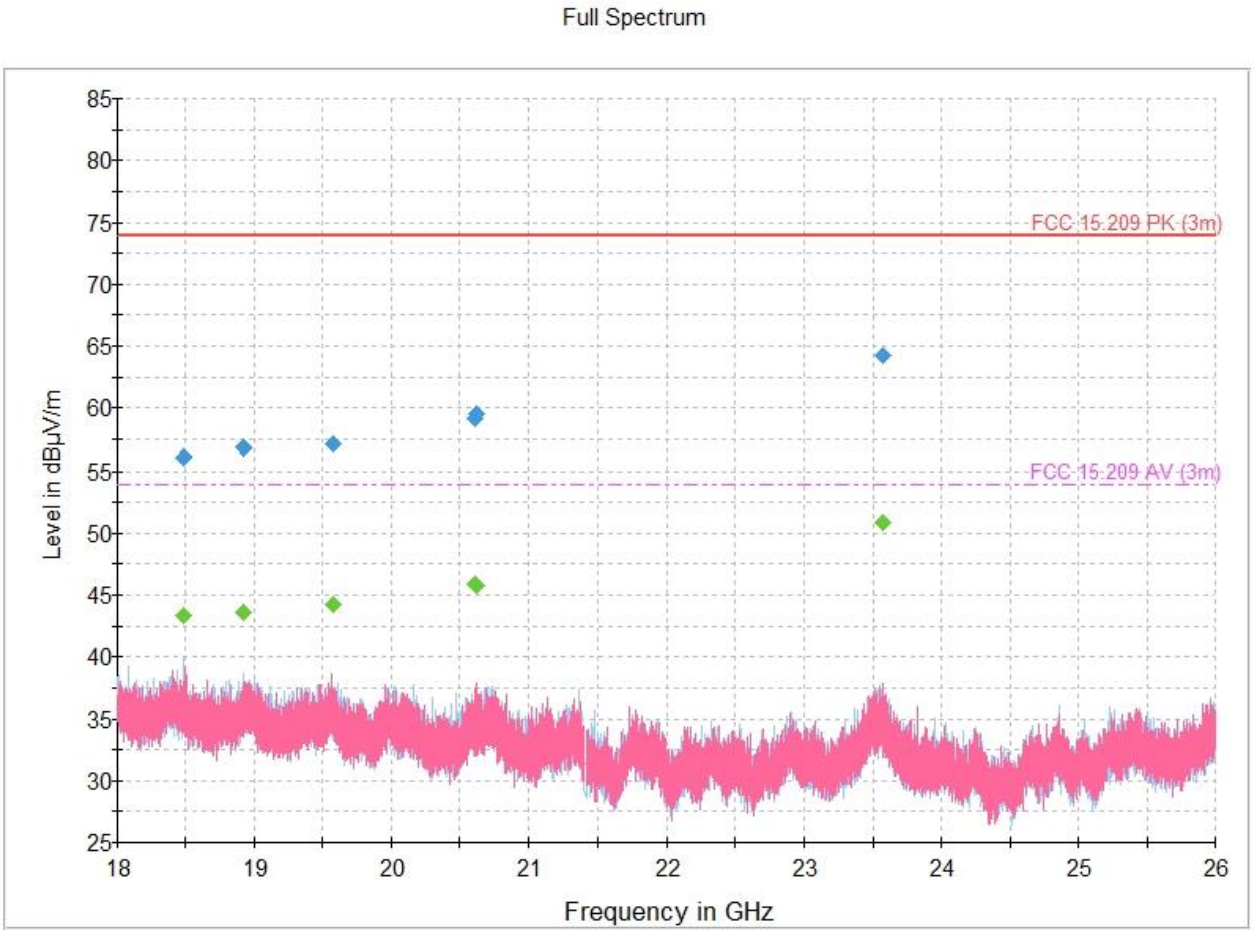

Figure 8.5-5: Radiated emissions, 2402 MHz, 18 - 26 GHz

Table 8.5-6: Radiated emissions, 2402 MHz, 18 - 26 GHz

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
18483.800000	---	43.37	53.90	10.53	5000.0	1000.000	278.0	H	44.0	22.7
18483.800000	56.06	---	73.90	17.84	5000.0	1000.000	278.0	H	44.0	22.7
18922.066667	---	43.65	53.90	10.25	5000.0	1000.000	384.0	H	347.0	23.5
18922.066667	56.86	---	73.90	17.04	5000.0	1000.000	384.0	H	347.0	23.5
19573.266667	57.08	---	73.90	16.82	5000.0	1000.000	296.0	V	112.0	24.0
19573.266667	---	44.29	53.90	9.61	5000.0	1000.000	296.0	V	112.0	24.0
20612.333333	---	45.89	53.90	8.01	5000.0	1000.000	402.0	V	116.0	25.8
20612.333333	59.11	---	73.90	14.79	5000.0	1000.000	402.0	V	116.0	25.8
20618.333333	---	45.81	53.90	8.09	5000.0	1000.000	241.0	V	44.0	25.8
20618.333333	59.47	---	73.90	14.43	5000.0	1000.000	241.0	V	44.0	25.8
23577.000000	64.27	---	73.90	9.63	5000.0	1000.000	129.0	V	0.0	30.3
23577.000000	---	50.83	53.90	3.07	5000.0	1000.000	129.0	V	0.0	30.3

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.
Pre-scans were performed with 100 kHz RBW. Final measurements were performed with a 1 MHz RBW.

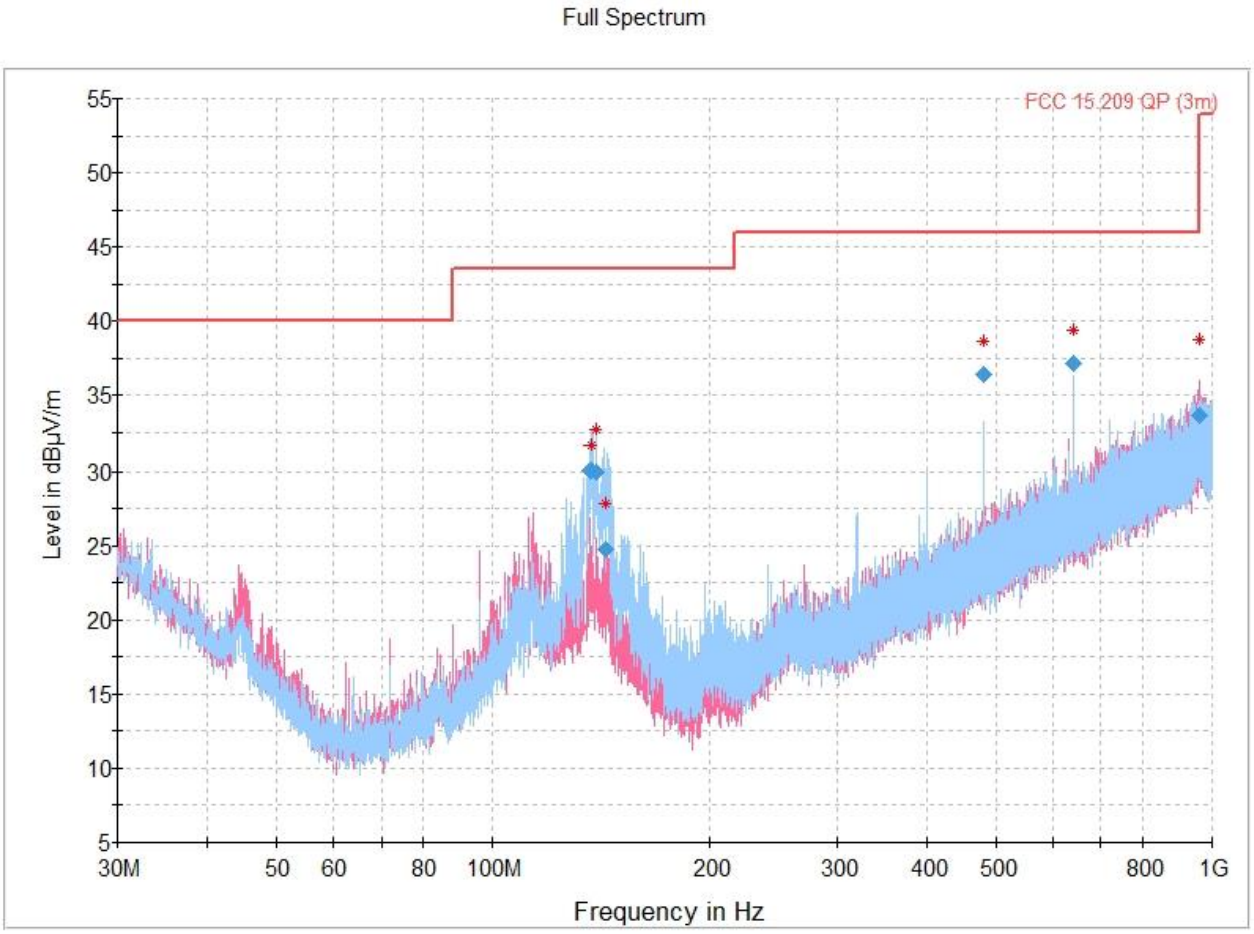

Figure 8.5-6: Radiated emissions, 2440 MHz, 30 – 1000 MHz

Table 8.5-7: Radiated emissions, 2440 MHz, 30 – 1000 MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
136.595667	30.03	43.50	13.47	5000.0	120.000	151.0	H	286.0	19.4
138.667667	29.98	43.50	13.52	5000.0	120.000	186.0	H	300.0	19.4
143.027667	24.75	43.50	18.75	5000.0	120.000	190.0	H	285.0	19.3
480.035333	36.46	46.00	9.54	5000.0	120.000	184.0	H	58.0	26.3
640.053000	37.18	46.00	8.82	5000.0	120.000	114.0	H	70.0	29.2
958.530333	33.65	46.00	12.35	5000.0	120.000	212.0	V	125.0	34.1

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

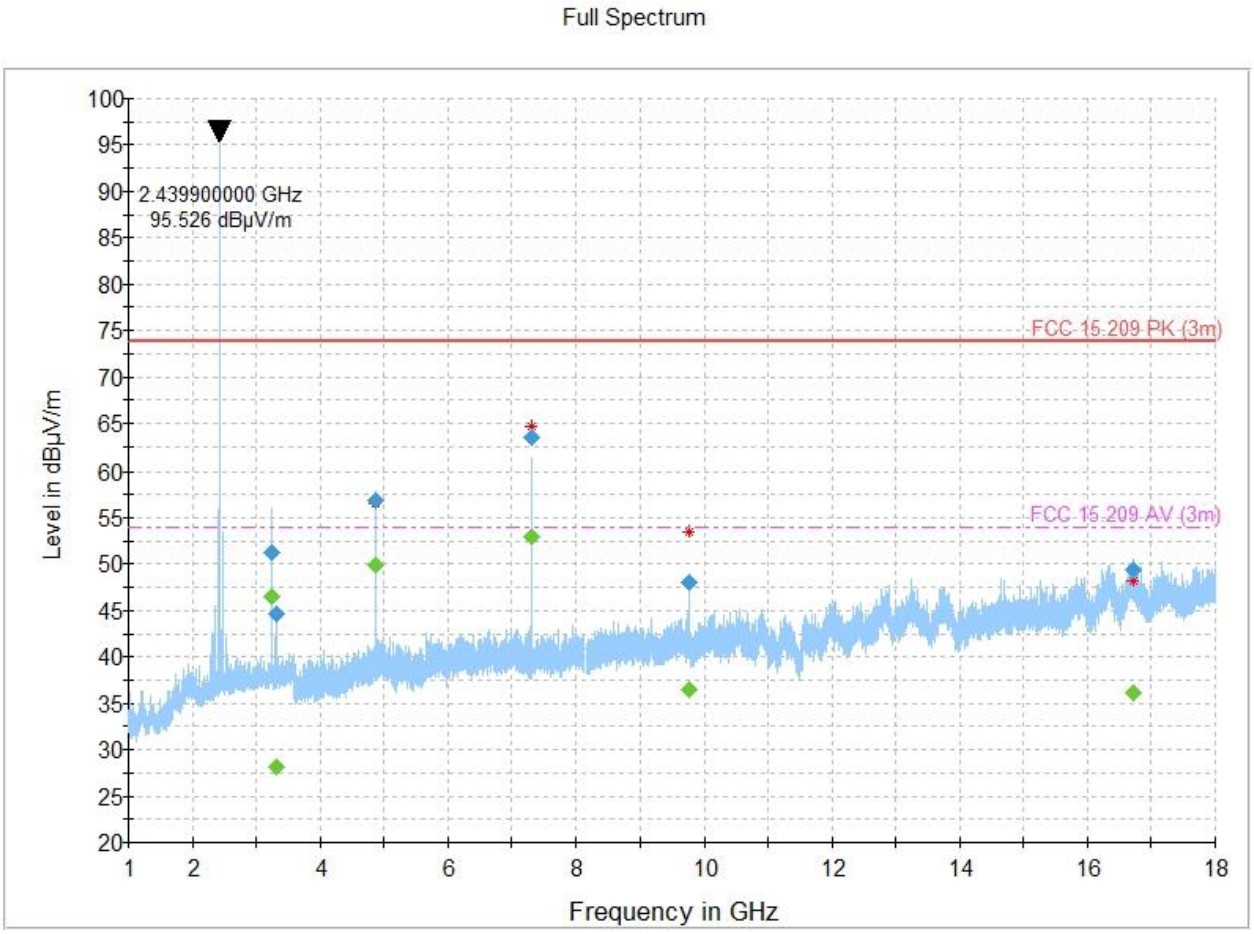

Figure 8.5-7: Radiated emissions, 2440 MHz, 1 - 18 GHz

Table 8.5-8: Radiated emissions, 2440 MHz, 1 - 18 GHz

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3253.679467	---	46.58	53.90	7.32	5000.0	1000.000	234.0	H	322.0	-7.9
3253.679467	51.24	---	73.90	22.66	5000.0	1000.000	234.0	H	322.0	-7.9
3312.137300	44.67	---	73.90	29.23	5000.0	1000.000	108.0	V	171.0	-7.8
3312.137300	---	28.19	53.90	25.71	5000.0	1000.000	108.0	V	171.0	-7.8
4880.226300	56.80	---	73.90	17.10	5000.0	1000.000	141.0	H	-1.0	-3.3
4880.226300	---	49.97	53.90	3.93	5000.0	1000.000	141.0	H	-1.0	-3.3
7320.265933	63.52	---	73.90	10.38	5000.0	1000.000	212.0	V	290.0	-1.0
7320.265933	---	52.97	53.90	0.93	5000.0	1000.000	212.0	V	290.0	-1.0
9760.159233	48.07	---	73.90	25.83	5000.0	1000.000	227.0	H	24.0	1.5
9760.159233	---	36.54	53.90	17.36	5000.0	1000.000	227.0	H	24.0	1.5
16724.870899	---	36.08	53.90	17.82	5000.0	1000.000	108.0	V	0.0	11.1
16724.870899	49.36	---	73.90	24.54	5000.0	1000.000	108.0	V	0.0	11.1

Notes: The marker highlights the wanted frequency of the transmitter and is not evaluated against the limits.
Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

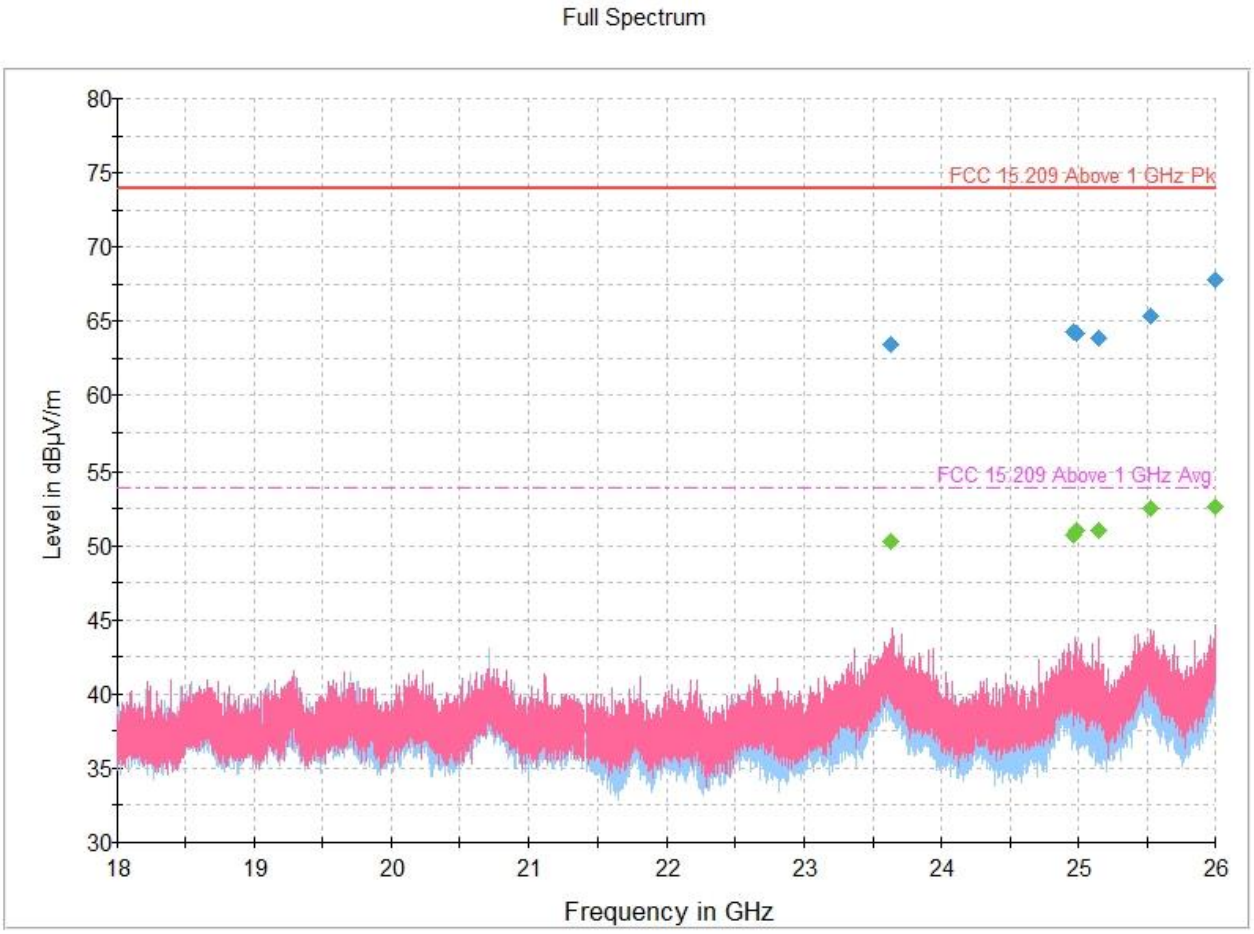

Figure 8.5-8: Radiated emissions, 2440 MHz, 18 - 26 GHz

Table 8.5-9: Radiated emissions, 2440 MHz, 18 - 26 GHz

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
23627.000000	63.40	---	73.90	10.50	5000.0	1000.000	390.0	V	158.0	29.9
23627.000000	---	50.32	53.90	3.58	5000.0	1000.000	390.0	V	158.0	29.9
24967.933333	64.33	---	73.90	9.57	5000.0	1000.000	216.0	V	160.0	29.1
24967.933333	---	50.73	53.90	3.17	5000.0	1000.000	216.0	V	160.0	29.1
24991.133333	64.22	---	73.90	9.68	5000.0	1000.000	355.0	V	107.0	29.2
24991.133333	---	50.97	53.90	2.93	5000.0	1000.000	355.0	V	107.0	29.2
25145.000000	63.91	---	73.90	9.99	5000.0	1000.000	259.0	V	226.0	29.1
25145.000000	---	51.03	53.90	2.87	5000.0	1000.000	259.0	V	226.0	29.1
25525.400000	65.36	---	73.90	8.54	5000.0	1000.000	193.0	V	41.0	30.9
25525.400000	---	52.47	53.90	1.43	5000.0	1000.000	193.0	V	41.0	30.9
25998.866667	67.74	---	73.90	6.16	5000.0	1000.000	402.0	V	127.0	33.5
25998.866667	---	52.57	53.90	1.33	5000.0	1000.000	402.0	V	127.0	33.5

Notes:
Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.
Pre-scans were performed with 100 kHz RBW. Final measurements were performed with a 1 MHz RBW.

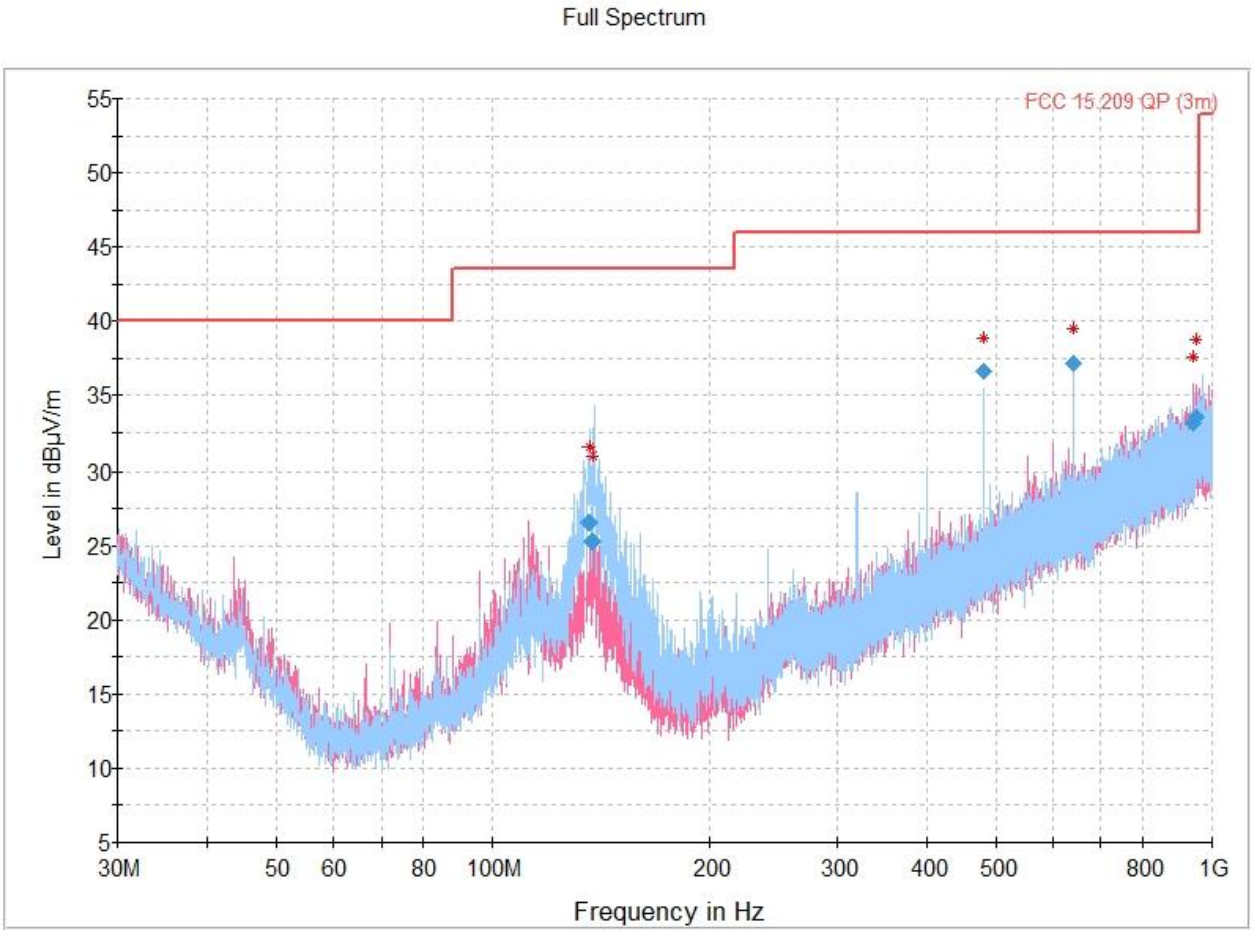

Figure 8.5-9: Radiated emissions, 2480 MHz, 30 – 1000 MHz

Table 8.5-10: Radiated emissions, 2480 MHz, 30 – 1000 MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
136.231667	26.52	43.50	16.98	5000.0	120.000	172.0	H	258.0	19.4
137.187000	25.25	43.50	18.25	5000.0	120.000	187.0	H	283.0	19.4
480.035333	36.60	46.00	9.40	5000.0	120.000	176.0	H	58.0	26.3
640.013000	37.21	46.00	8.79	5000.0	120.000	122.0	H	33.0	29.2
940.377667	33.08	46.00	12.92	5000.0	120.000	276.0	V	0.0	33.5
951.065667	33.57	46.00	12.43	5000.0	120.000	384.0	V	152.0	33.9

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

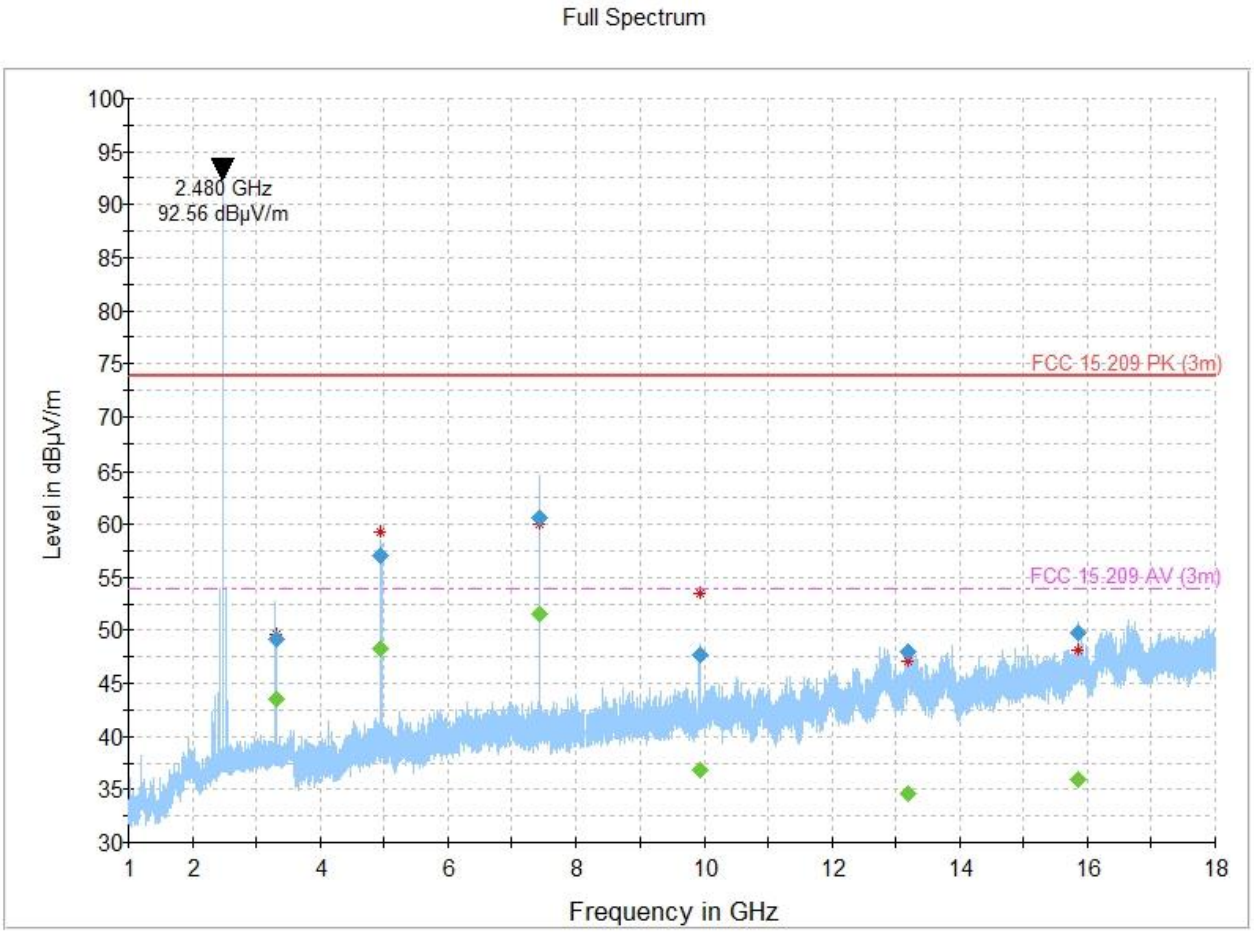

Figure 8.5-10: Radiated emissions, 2480 MHz, 1 - 18 GHz

Table 8.5-11: Radiated emissions, 2480 MHz, 1 - 18 GHz

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3306.979467	---	43.54	53.90	10.36	5000.0	1000.000	217.0	H	322.0	-7.9
3306.979467	49.15	---	73.90	24.75	5000.0	1000.000	217.0	H	322.0	-7.9
4959.722067	57.12	---	73.90	16.78	5000.0	1000.000	128.0	V	153.0	-3.5
4959.722067	---	48.30	53.90	5.60	5000.0	1000.000	128.0	V	153.0	-3.5
7439.698300	60.63	---	73.90	13.27	5000.0	1000.000	210.0	V	300.0	-0.5
7439.698300	---	51.58	53.90	2.32	5000.0	1000.000	210.0	V	300.0	-0.5
9920.408167	---	36.86	53.90	17.04	5000.0	1000.000	212.0	H	24.0	1.3
9920.408167	47.62	---	73.90	26.28	5000.0	1000.000	212.0	H	24.0	1.3
13177.053666	---	34.68	53.90	19.22	5000.0	1000.000	197.0	V	220.0	6.9
13177.053666	47.94	---	73.90	25.96	5000.0	1000.000	197.0	V	220.0	6.9
15845.615300	49.75	---	73.90	24.15	5000.0	1000.000	149.0	H	130.0	8.5
15845.615300	---	35.99	53.90	17.91	5000.0	1000.000	149.0	H	130.0	8.5

Notes:
The marker highlights the wanted frequency of the transmitter and is not evaluated against the limits.
Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.
The wanted transmitter signal at 2480 MHz was not evaluated against the limit.

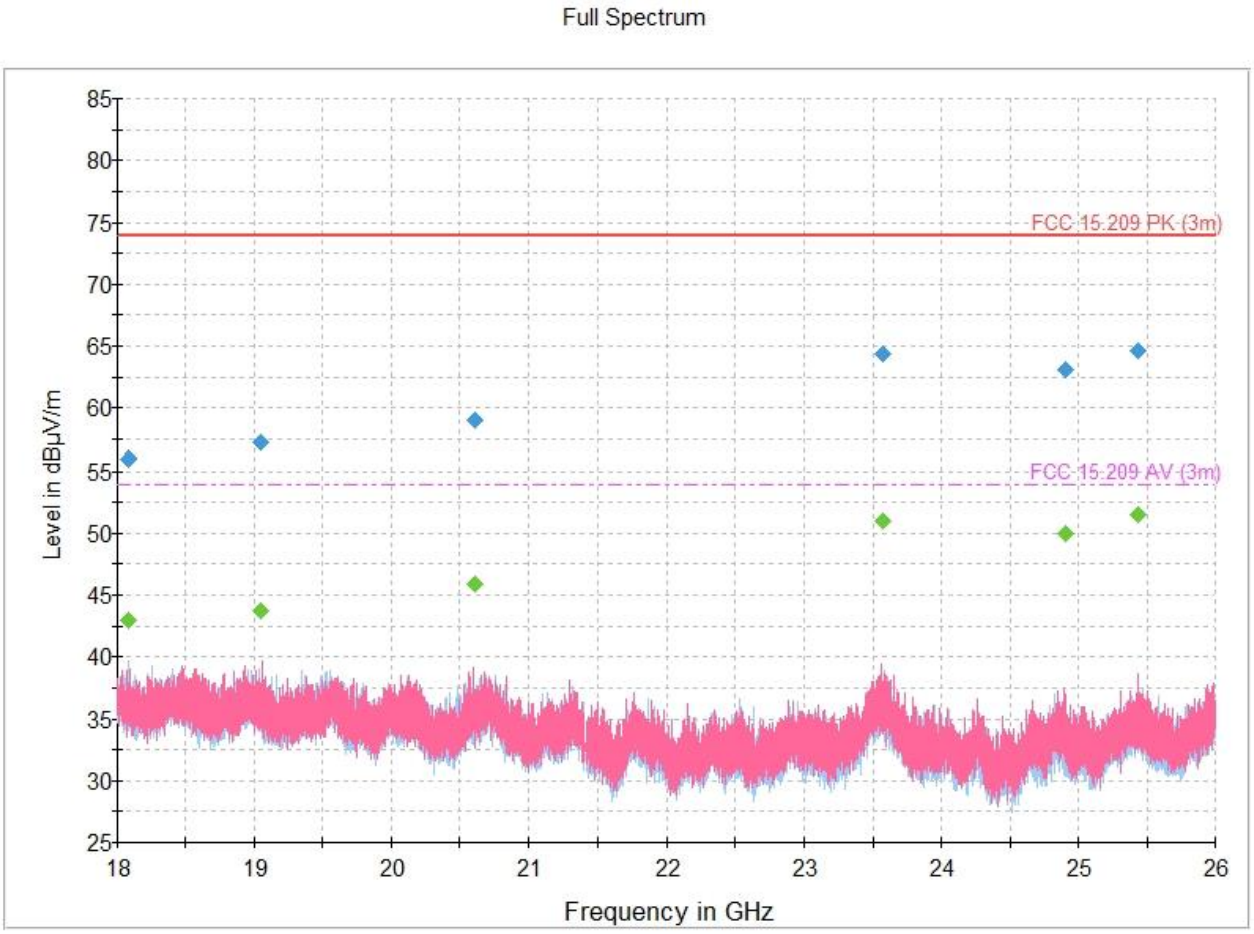

Figure 8.5-11: Radiated emissions, 2480 MHz, 18 - 26 GHz

Table 8.5-12: Radiated emissions, 2480 MHz, 18 - 26 GHz

Frequency (MHz)	QuasiPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
18076.466667	---	43.02	53.90	10.88	5000.0	1000.000	333.0	H	76.0	22.5
18076.466667	55.99	---	73.90	17.91	5000.0	1000.000	333.0	H	76.0	22.5
19043.533333	---	43.78	53.90	10.12	5000.0	1000.000	308.0	V	0.0	23.3
19043.533333	57.23	---	73.90	16.67	5000.0	1000.000	308.0	V	0.0	23.3
20603.800000	58.98	---	73.90	14.92	5000.0	1000.000	169.0	V	24.0	25.7
20603.800000	---	45.88	53.90	8.02	5000.0	1000.000	169.0	V	24.0	25.7
23575.666667	64.37	---	73.90	9.53	5000.0	1000.000	119.0	V	25.0	30.3
23575.666667	---	50.96	53.90	2.94	5000.0	1000.000	119.0	V	25.0	30.3
24906.866667	---	49.99	53.90	3.91	5000.0	1000.000	402.0	V	346.0	28.8
24906.866667	63.12	---	73.90	10.78	5000.0	1000.000	402.0	V	346.0	28.8
25433.800000	---	51.55	53.90	2.35	5000.0	1000.000	288.0	V	24.0	30.1
25433.800000	64.57	---	73.90	9.33	5000.0	1000.000	288.0	V	24.0	30.1

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

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	November 3, 2020	Temperature	22 °C
Test engineer	James Cunningham	Air pressure	1007 mbar
Test location	3m semi-anechoic chamber	Relative humidity	60 %

8.6.3 Notes

Testing was performed in BLE mode and the EUT transmitting on a fixed channel at full power.

The measurement was performed as a radiated test with the EUT oriented to the position of maximum transmitter power (with respect to azimuth, antenna height and polarization).

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Power Spectral Density (dBm/3 kHz) = Field strength (dBµV/m/3 kHz @ 3 m) – 95.2 dB

The correction factors were included in the spectrum analyzer as a transducer factor.

The antenna gain declared by the manufacturer is -4.5 dBi.

Maximum conducted power spectral density= Radiated power spectral density (dBm/3 kHz) - Antenna Gain (dBi)

The antenna gain declared by the manufacturer is -4.5 dBi.

8.6.4 Setup details

EUT setup configuration	Tabletop
Test facility	3 m semi anechoic chamber
Measurement details	Measurement performed as per C63.10 §11.10.2 (Method PKPSD)

Receiver/spectrum analyzer settings:

Resolution bandwidth	100 kHz (3 kHz ≤ RBW ≤ 100 kHz) – 100 kHz chosen as worst case
Video bandwidth	300 kHz (≥ 3 x RBW)
Frequency span	1.5 x DTS bandwidth
Detector mode	Peak
Trace mode	Max hold

8.6.5 Test data

Table 8.6-1: Power spectral density of DTS

Transmitter Frequency (MHz)	Measured Field Strength (dBµV/m/3 kHz @ 3 m)	Radiated Power Spectral Density (dBm/100kHz)	Antenna Gain (dBi)	Conducted Power Spectral Density (dBm/100kHz)	Limit (dBm/3 kHz)
2402	95.20	-0.03	-4.5	4.47	8.00
2440	94.72	-0.51	-4.5	3.99	8.00
2480	90.17	-5.06	-4.5	-0.56	8.00

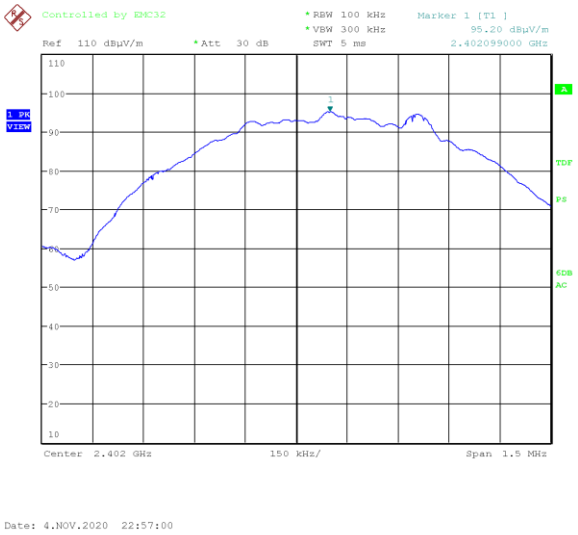

Figure 8.6-1: Power spectral density of digital transmission system, 2402 MHz

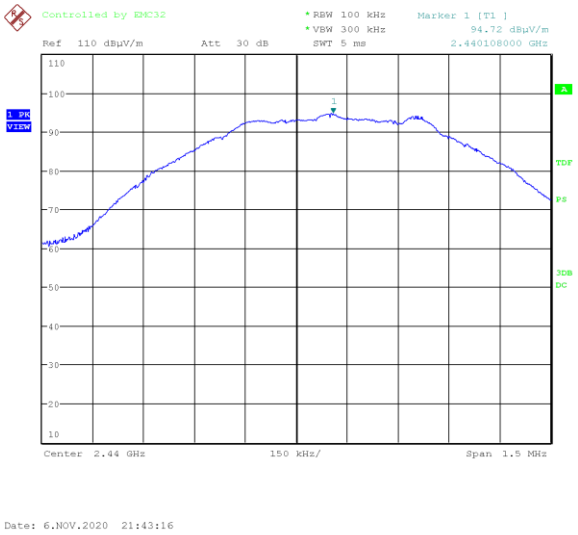

Figure 8.6-2: Power spectral density of digital transmission system, 2440 MHz

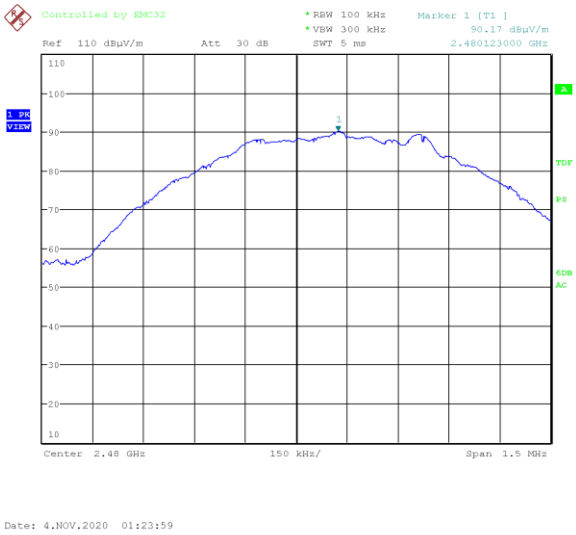

Figure 8.6-3: Power spectral density of digital transmission system, 2480 MHz

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

Verdict	Pass		
Test date	November 3, 2020	Temperature	22 °C
Test engineer	James Cunningham	Air pressure	1007 mbar
Test location	3m semi-anechoic chamber	Relative humidity	60 %

8.7.3 Notes

Testing was performed in BLE mode and the EUT transmitting on a fixed channel at full power.

The measurement was performed as a radiated test with the EUT oriented to the position of maximum transmitter power (with respect to azimuth, antenna height and polarization).

8.7.4 Setup details

EUT setup configuration	Tabletop
Test facility	3 m semi anechoic chamber
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	100 kHz
Video bandwidth	300 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.7.5 Test data

Test Frequency (MHz)	99%Bandwidth (MHz)
2402	1.012
2440	1.028
2480	1.024

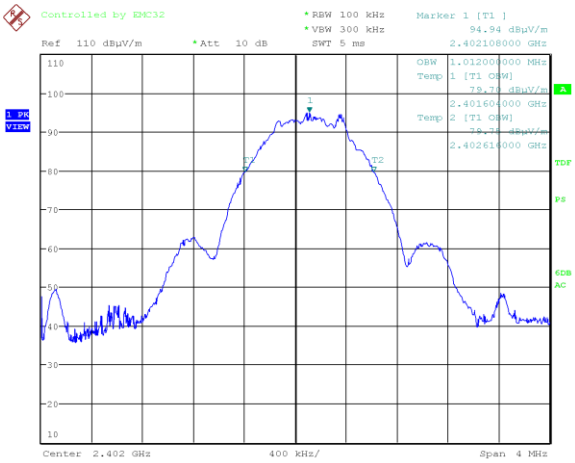

Figure 8.7-1: 99% bandwidth, 2402 MHz

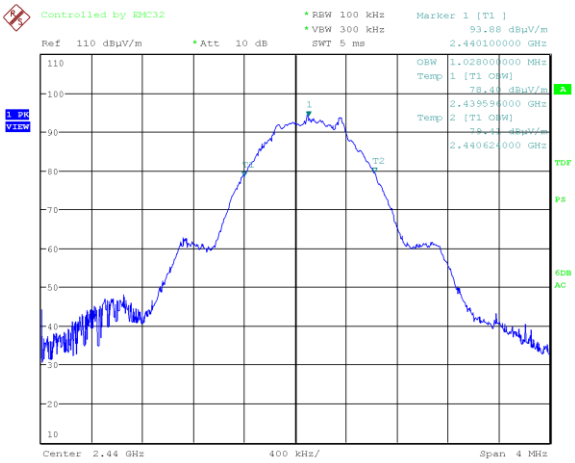

Figure 8.7-2: 99% bandwidth, 2440 MHz

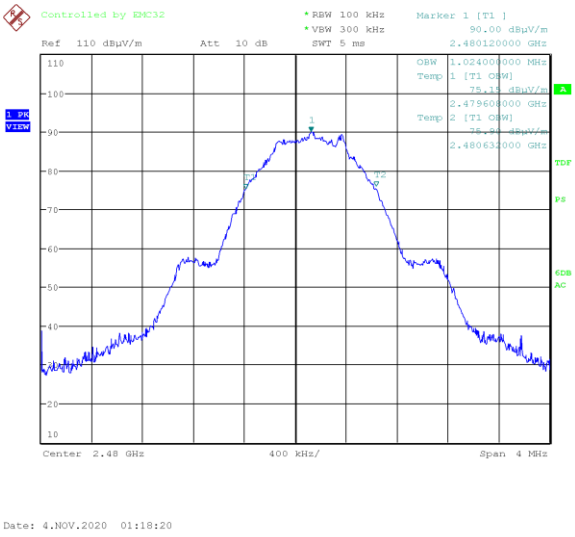

Figure 8.7-3: 99% bandwidth, 2480 MHz

Section 9 Block diagrams of test set-ups

9.1 Radiated emissions set-up

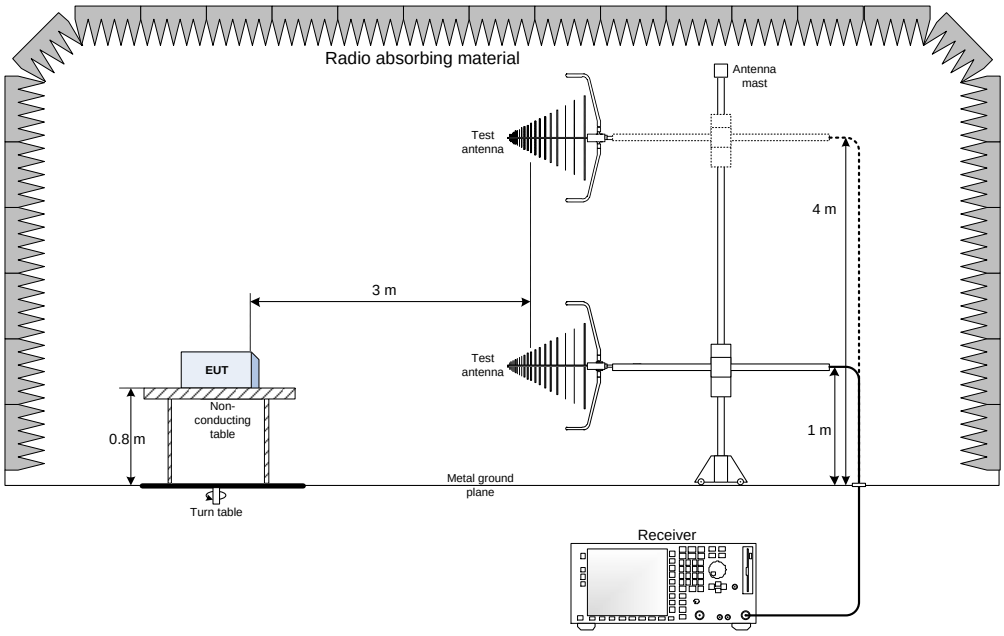

Figure 9.1-1 30 MHz - 1000 MHz Setup

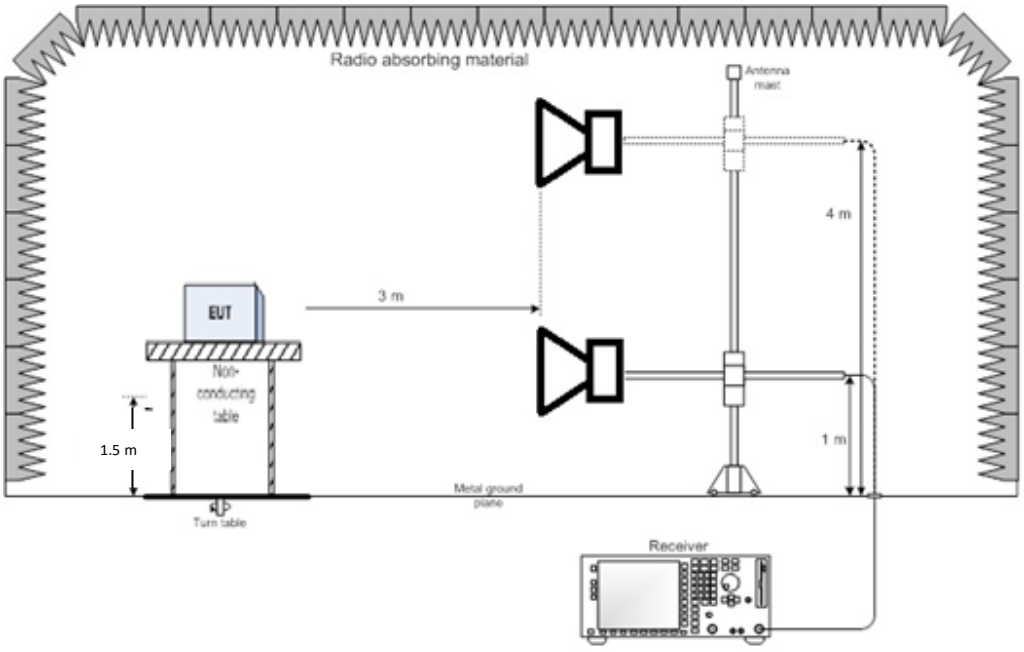

Figure 9.1-2 1 GHz - 26 GHz Setup

Thank you for choosing