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Test report

403481-2TRFWL

Date of issue: July 28, 2020

Applicant:
CalAmp

Product:
Asset Tracker

Model:
LMU1300MB

FCC ID: APV-1300MB IC ID: 5843C-1300MB

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	July 28, 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.

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Section 1 Report summary

1.1 Applicant

Company name	CalAmp
Address	2200 Faraday Avenue, Suite 220
City	Carlsbad
Province/State	CA
Postal/Zip code	92008
Country	USA

1.2 Manufacturer

Company name	CalAmp
Address	2200 Faraday Avenue, Suite 220
City	Carlsbad
Province/State	CA
Postal/Zip code	92008
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
403481-2TRFWL	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	Pass
§15.31(e)	Variation of power source	Pass
§15.203	Antenna requirement	Pass

Notes: EUT is DC powered via vehicle battery
The antenna is PCB trace antenna, maximum gain 1.88 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	Pass

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	July 27, 2020
Nemko sample ID number	NEx: 403481

3.2 EUT information

Product name	Asset Tracker
Model	LMU1300MB
Serial number	U0H3K2499953C01 (Conducted port sample) U0H3K2499915C01 (Radiated sample)
Part number	LMU1300MB

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)	4.22 dBm
Maximum output power (dBm)	4.85 dBm
Measured 6 dB bandwidth	2402 MHz: 707.3 kHz 2440 MHz: 675.3 kHz 2480 MHz: 655.3 kHz
Type of modulation	GFSK
Emission classification	F1D
Power requirements	9-32 VDC battery
Antenna information	1.88 dBi gain antenna on PCB

3.4 EUT exercise and monitoring details

The EUT PCB was removed from its enclosure to permit access to the required debug interfaces and was controlled via test software running on the connected laptop PC to transmit at full power on the required frequencies.
Software version used for testing this device was 2.5.22.1. The software used was the Espressif RF test tool. This was used to control the ESP-32 chip during testing.

Table 3.4-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number	Rev.
Conducted antenna port sample	CalAmp	LMU1300MB	U0H3K2499953C01	N/A
Radiated sample	CalAmp	LMU1300MB	U0H3K2499915C01	N/A

Table 3.4-2: EUT interface ports

Description	Qty.
DC power	1
USB (not used for normal operation)	3

Table 3.4-3: Support equipment

Description	Brand name	Model/Part number	Serial number	Rev.
Laptop	Dell	Inspiron 5548	9K643SS	N/A
DC power supply	BK Precision	1697	260G13306	N/A

Table 3.4-4: Inter-connection cables

Cable description	From	To	Length (ft)
USB	EUT	Laptop	3
USB	EUT	Laptop	3
USB	EUT	Laptop	3
DC power	EUT	DC power supply	3

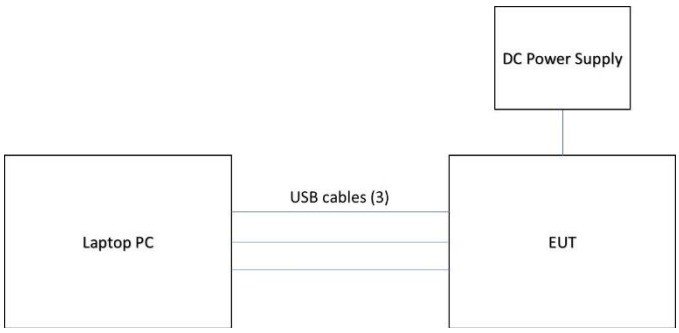

Figure 3.4-1: Test setup

Section 4 Engineering considerations

4.1 Modifications incorporated in the EUT

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

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.
Signal and spectrum analyzer	Rohde & Schwarz	FSW	E1302	1 year	10 Jan 2021
EMI Test Receiver	Rohde & Schwarz	ESU40	E1121	1 year	25 Nov 2020
System Controller	Sunol Sciences	SC104V	E1129	NCR	NCR
Bilog Antenna	Schaffner	CBL6111C	1480	1 year	18 Oct 2020
DRG Horn	ETS-Lindgren	3117-PA	E1160	1 year	30 Oct 2020
Pre-Amp as part of DRG Horn	ETS-Lindgren	3117-PA	Part of E1160	1 year	30 Oct 2020
2.4 GHz notch filter	Micro-Tonics	HPM50110-01	E1142	VBU	VBU
EMI Test Receiver	Rohde & Schwarz	ESCI7	E1026	2 years	29-May 2021
Two Line V-Network	Rohde & Schwarz	ENV216	E1019	1 years	04 Aug 2021
Transient Limiter	Hewlett Packard	11947A	684	1 year	20 Jan 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 15.207(a) and IC RSS-GEN, Issue 5 8.8 AC power line conducted emissions

8.1.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.207(a)
RSS-Gen → §8.8

For Low-power radio-frequency devices that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 Ω line impedance stabilization network (LISN). The lower limit applies at the boundary between the frequency ranges.

Table 8.1-1: Conducted emissions limit

Frequency of emission, MHz	Conducted limit, dBµV	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

Note: * - Decreases with the logarithm of the frequency.

8.1.2 Test summary

Verdict	Pass		
Test date	August 27, 2020	Temperature	22 °C
Test engineer	James Cunningham	Air pressure	998 mbar
Test location	Ground plane	Relative humidity	65 %

8.1.3 Notes

Testing was performed with the BLE transmitter operating on a fixed channel at full power. Low, middle and high channels were tested with the worst case (2402 MHz) reported here.

Testing was performed according to ANSI C63.10 §6.2.

8.1.4 Setup details

Port under test	AC mains
EUT setup configuration	Tabletop
Measurement details	A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	– Peak and Average (Preview measurement) – Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak and Average preview measurement) – 5000 ms (Quasi-peak final measurement) – 5000 ms (CAverage final measurement)

8.1.5 Test data

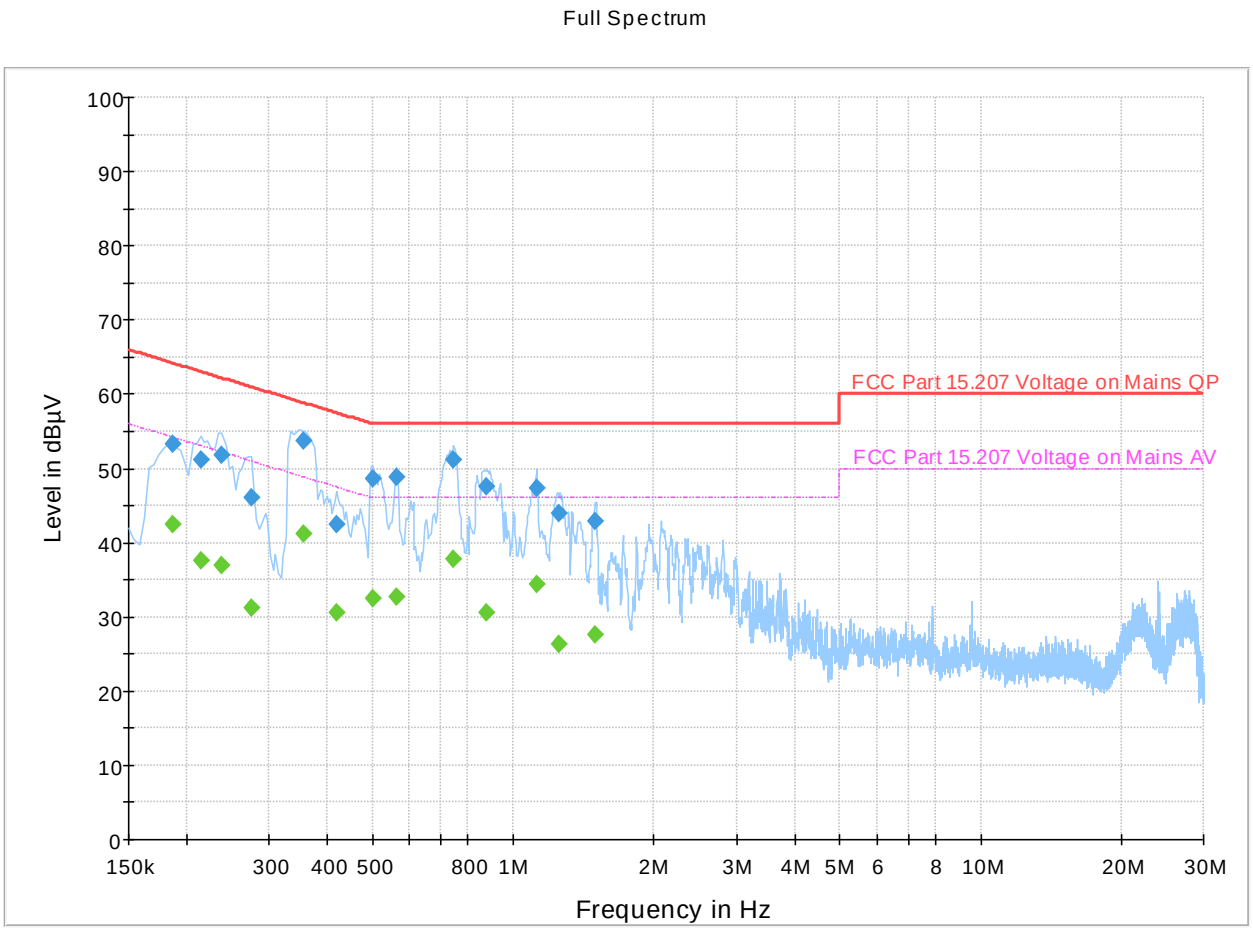

Figure 8.1-1: AC conducted emissions, 150 kHz – 30 MHz

Table 8.1-2: AC conducted emissions, 150 kHz – 30 MHz

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.186000	---	42.53	54.21	11.68	5000.0	9.000	N	ON	19.6
0.186000	53.29	---	64.21	10.93	5000.0	9.000	N	ON	19.6
0.214000	51.17	---	63.05	11.88	5000.0	9.000	N	ON	19.5
0.214000	---	37.52	53.05	15.53	5000.0	9.000	N	ON	19.5
0.238000	---	36.99	52.17	15.18	5000.0	9.000	N	ON	19.5
0.238000	51.85	---	62.17	10.32	5000.0	9.000	N	ON	19.5
0.274000	46.10	---	61.00	14.89	5000.0	9.000	L1	ON	19.5
0.274000	---	31.30	51.00	19.70	5000.0	9.000	L1	ON	19.5
0.354000	---	41.18	48.87	7.68	5000.0	9.000	N	ON	19.5
0.354000	53.66	---	58.87	5.21	5000.0	9.000	N	ON	19.5
0.418000	42.47	---	57.49	15.02	5000.0	9.000	N	ON	19.4
0.418000	---	30.63	47.49	16.85	5000.0	9.000	N	ON	19.4
0.502000	---	32.43	46.00	13.57	5000.0	9.000	L1	ON	19.4
0.502000	48.66	---	56.00	7.34	5000.0	9.000	L1	ON	19.4
0.562000	---	32.80	46.00	13.20	5000.0	9.000	N	ON	19.4
0.562000	48.92	---	56.00	7.08	5000.0	9.000	N	ON	19.4

Table 8.1-2: AC conducted emissions, 150 kHz – 30 MHz (continued)

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.746000	51.16	---	56.00	4.84	5000.0	9.000	N	ON	19.4
0.746000	---	37.79	46.00	8.21	5000.0	9.000	N	ON	19.4
0.874000	47.49	---	56.00	8.51	5000.0	9.000	L1	ON	19.4
0.874000	---	30.55	46.00	15.45	5000.0	9.000	L1	ON	19.4
1.122000	47.37	---	56.00	8.63	5000.0	9.000	N	ON	19.4
1.122000	---	34.35	46.00	11.65	5000.0	9.000	N	ON	19.4
1.254000	---	26.22	46.00	19.78	5000.0	9.000	N	ON	19.4
1.254000	43.88	---	56.00	12.12	5000.0	9.000	N	ON	19.4
1.494000	---	27.51	46.00	18.49	5000.0	9.000	L1	ON	19.4
1.494000	42.91	---	56.00	13.09	5000.0	9.000	L1	ON	19.4
0.750000	---	37.38	46.00	8.62	5000.0	9.000	N	ON	19.4
0.750000	50.81	---	56.00	5.19	5000.0	9.000	N	ON	19.4
0.886000	---	32.42	46.00	13.59	5000.0	9.000	L1	ON	19.4
0.886000	47.31	---	56.00	8.69	5000.0	9.000	L1	ON	19.4
1.122000	---	33.50	46.00	12.50	5000.0	9.000	L1	ON	19.4
1.122000	47.46	---	56.00	8.54	5000.0	9.000	L1	ON	19.4
1.266000	43.34	---	56.00	12.66	5000.0	9.000	N	ON	19.4
1.266000	---	26.83	46.00	19.17	5000.0	9.000	N	ON	19.4
1.342000	---	25.21	46.00	20.79	5000.0	9.000	N	ON	19.4
1.342000	41.48	---	56.00	14.52	5000.0	9.000	N	ON	19.4
1.386000	---	25.66	46.00	20.34	5000.0	9.000	L1	ON	19.4
1.386000	40.50	---	56.00	15.50	5000.0	9.000	L1	ON	19.4
1.506000	---	28.36	46.00	17.64	5000.0	9.000	L1	ON	19.4
1.506000	44.08	---	56.00	11.92	5000.0	9.000	L1	ON	19.4

Notes:
Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + transient limiter (dB)
The maximum measured value observed over a period of 5 seconds was recorded.

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

8.2.1 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.

8.2.2 Test summary

Verdict	Pass		
Test date	August 3, 2020	Temperature	21 °C
Test engineer	James Cunningham	Air pressure	1005 mbar
Test location	Wireless bench	Relative humidity	65 %

8.2.3 Notes

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

8.2.4 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

8.2.5 Test data

Table 8.2-1: 6 dB occupied bandwidth test data

Test Frequency (MHz)	Bandwidth (kHz)	Limit (kHz)	Margin (kHz)
2402	707.3	> 500	207.3
2440	675.3	> 500	175.3
2480	655.3	> 500	155.3

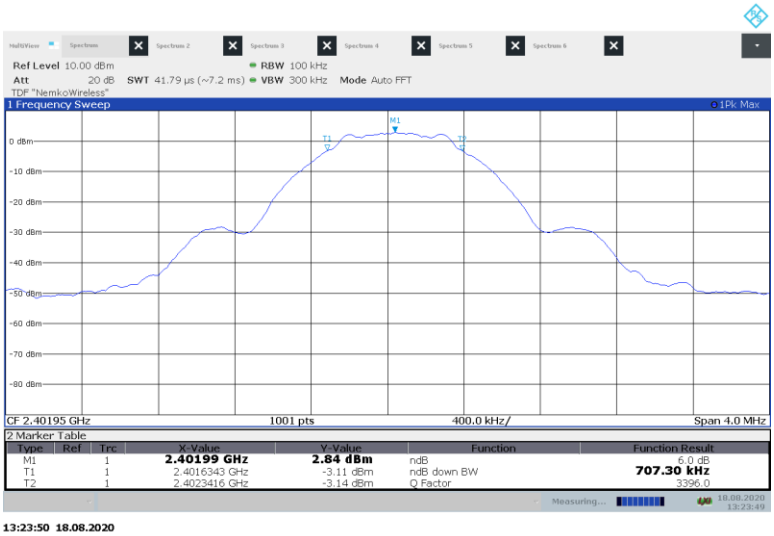

Figure 8.2-1: 6 dB occupied bandwidth, 2402 MHz

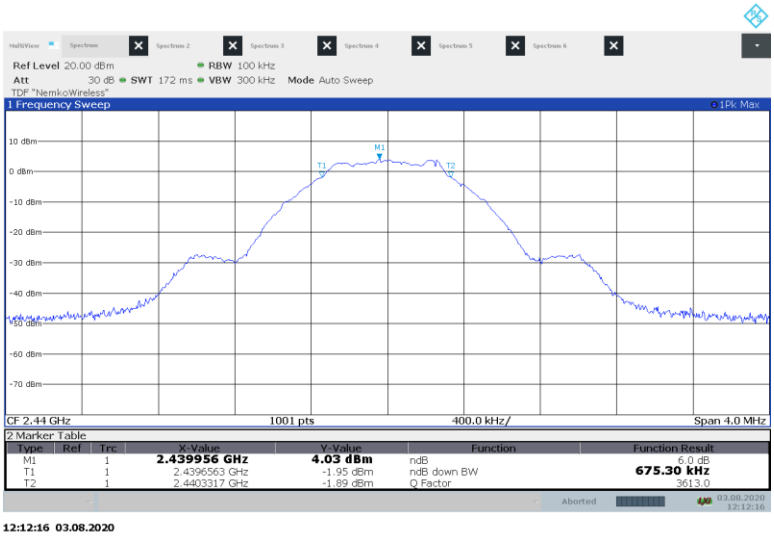

Figure 8.2-2: 6 dB occupied bandwidth, 2440 MHz

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

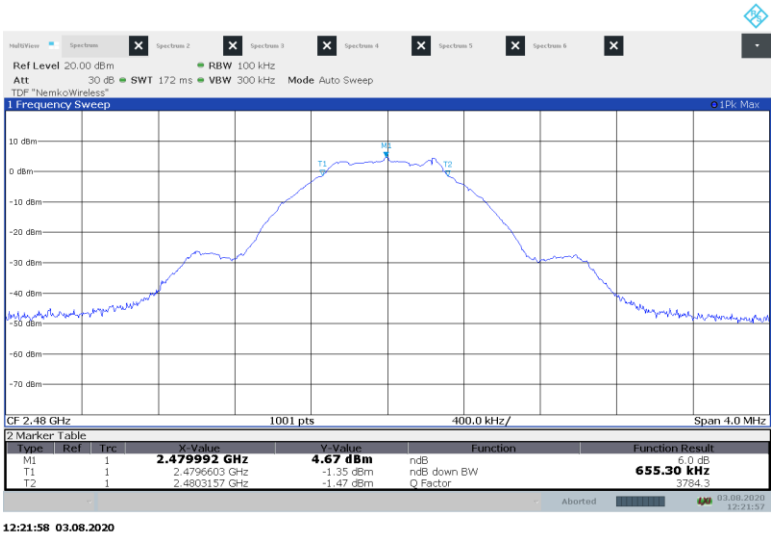

Figure 8.2-3: 6 dB occupied bandwidth, 2480 MHz

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

8.3.1 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.

8.3.2 Test summary

Verdict	Pass		
Test date	August 3, 2020	Temperature	21 °C
Test engineer	James Cunningham	Air pressure	1005 mbar
Test location	Wireless bench	Relative humidity	65 %

8.3.3 Notes

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

The attenuation of the interconnecting cable was included in the spectrum analyzer as a transducer factor.

The antenna gain is 1.88 dBi per client declaration.

EIRP = Conducted Power + Declared Antenna Gain

8.3.4 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless bench
Measurement method	558074 D01 DTS Measurement Guidance §8.3.11 ANSI C63.10 §11.9.1.1 (RBW ≥ DTS bandwidth)

8.3.5 Test data

Table 8.3-1: Output power

Test Frequency (MHz)	Measured Conducted Power (dBm)	Conducted Limit (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)
2402	4.22	30.0	1.88	6.10	36.0	29.90
2440	4.62	30.0	1.88	6.50	36.0	29.50
2480	4.85	30.0	1.88	6.73	36.0	29.27

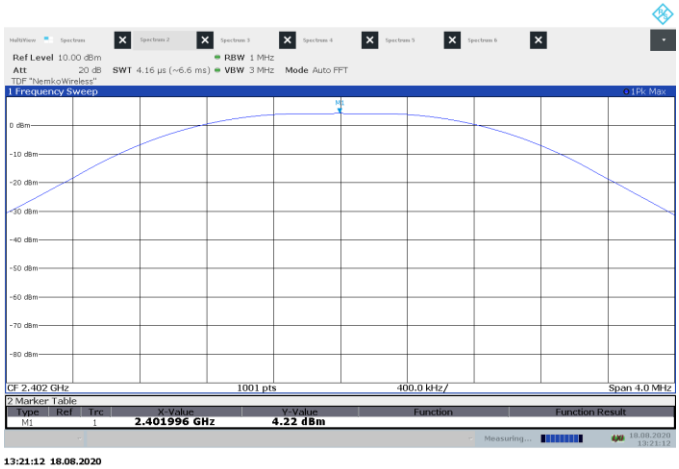

Figure 8.3-1: Output power, 2402 MHz

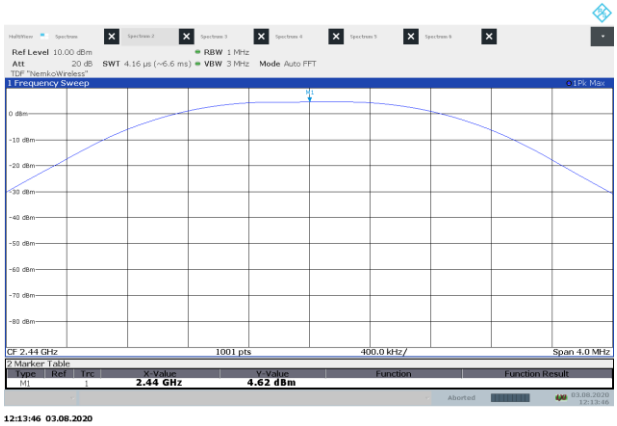

Figure 8.3-2: Output power, 2440 MHz

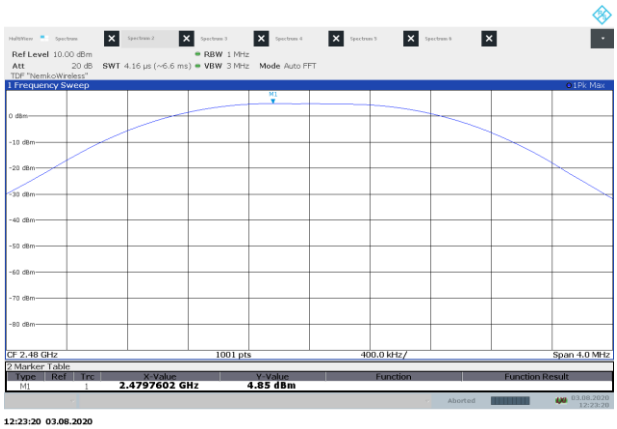

Figure 8.3-3: Output power, 2480 MHz

8.4 FCC 15.247(d) and RSS-247 5.5 Conducted band-edge 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

Test date	August 24, 2020	Temperature	21 °C
Test engineer	James Cunningham	Air pressure	1005 mbar
Test location	Wireless bench	Relative humidity	65 %

8.4.3 Notes

The EUT was configured to transmit continuously on the lowest, middle and highest channels with each supported modulation type.

The loss of the connected cable and attenuator was input into the spectrum analyzer as a transducer factor.

8.4.4 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

8.4.5 Test data

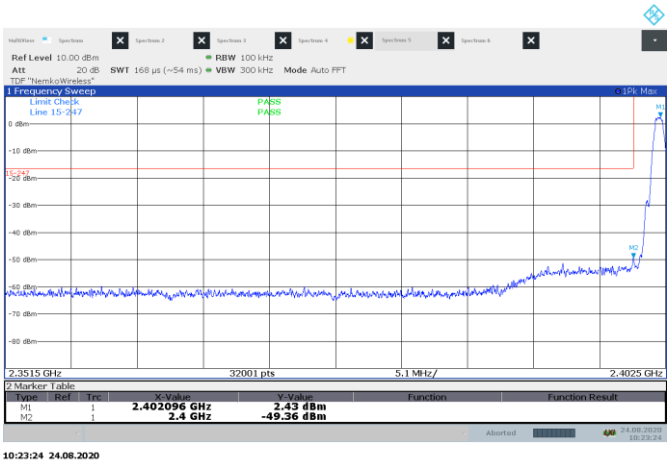

Figure 8.4-1: Conducted band edge measurement, 2402 MHz

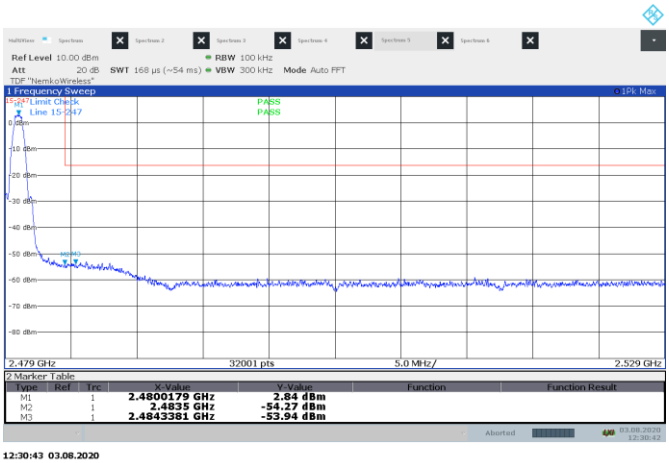

Figure 8.4-2: Conducted band edge measurement, 2480 MHz

8.5 FCC 15.247(d) and RSS-247 5.5 Conducted 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.

8.5.2 Test summary

Test date	August 24, 2020	Temperature	21 °C
Test engineer	James Cunningham	Air pressure	1005 mbar
Test location	Wireless bench	Relative humidity	65 %

8.5.3 Notes

In each measurement, the limit was derived by subtracting 20 dB from the power spectral density measurements in Section 8.7

8.5.4 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

8.5.5 Test data

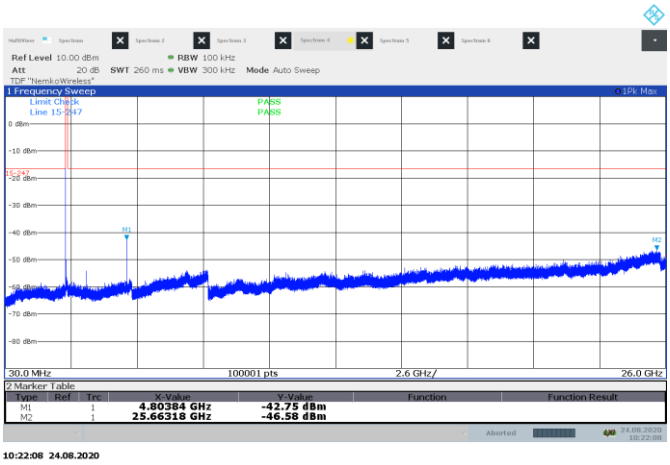

Figure 8.5-1: Conducted spurious emissions, 2402 MHz

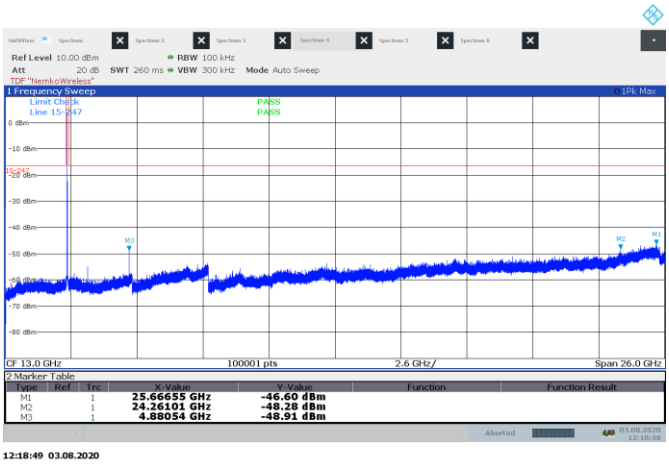

Figure 8.5-2: Conducted spurious emissions, 2440 MHz

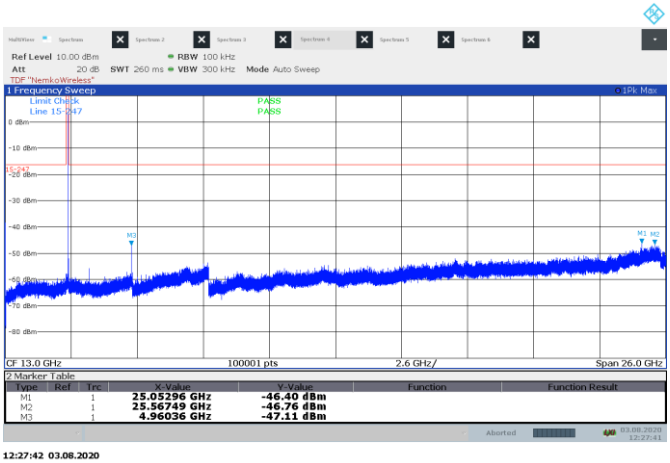

Figure 8.5-3: Conducted spurious emissions,, 2480 MHz

Note: For conducted emissions plots above, peaks within 2400-2483.5MHz are transmitter fundamentals signals and are not evaluated against the relevant limits.

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

8.6.1 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 8.6-1: 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 8.6-2: 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			

8.6.2 Test summary

Verdict	Pass		
Test date	August 17, 2020 August 21, 2020	Temperature	21 °C 22 °C
Test engineer	James Cunningham	Air pressure	1005 mbar 1006 mbar
Test location	Wireless bench (Conducted) 3m semi-anechoic chamber (Radiated)	Relative humidity	62 % 65 %

8.6.3 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.

8.6.4 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)

8.6.5 Test data

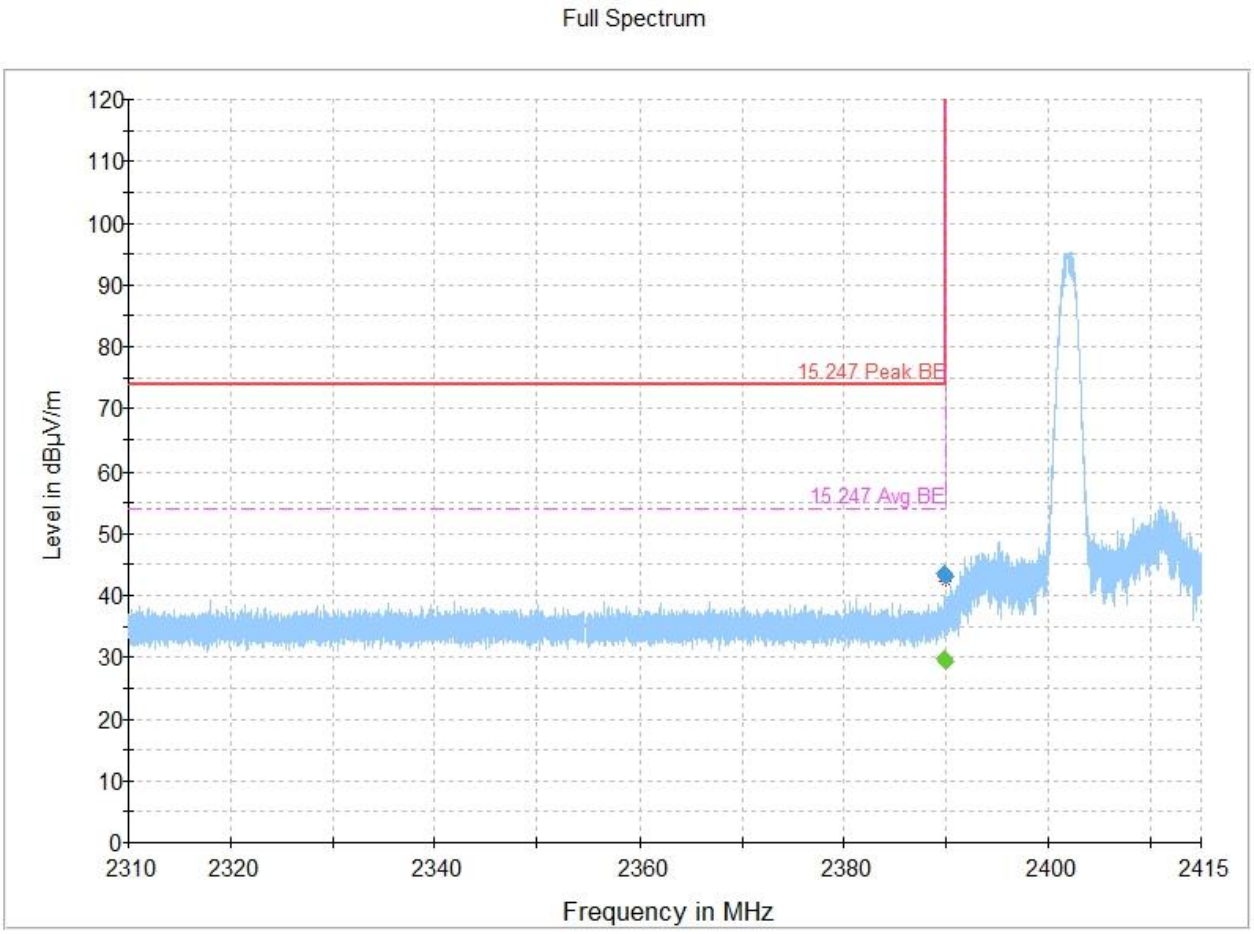

Figure 8.6-1: Radiated emissions, restricted band edge, low

Table 8.6-2: 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)
2389.807000	---	29.75	53.90	24.15	5000.0	1000.000	141.0	H	131.0	-10.4
2389.807000	43.65	---	73.90	30.25	5000.0	1000.000	141.0	H	131.0	-10.4
2390.000000	---	29.23	53.90	24.67	5000.0	1000.000	105.0	H	117.0	-10.4
2390.000000	42.98	---	73.90	30.92	5000.0	1000.000	105.0	H	117.0	-10.4

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.

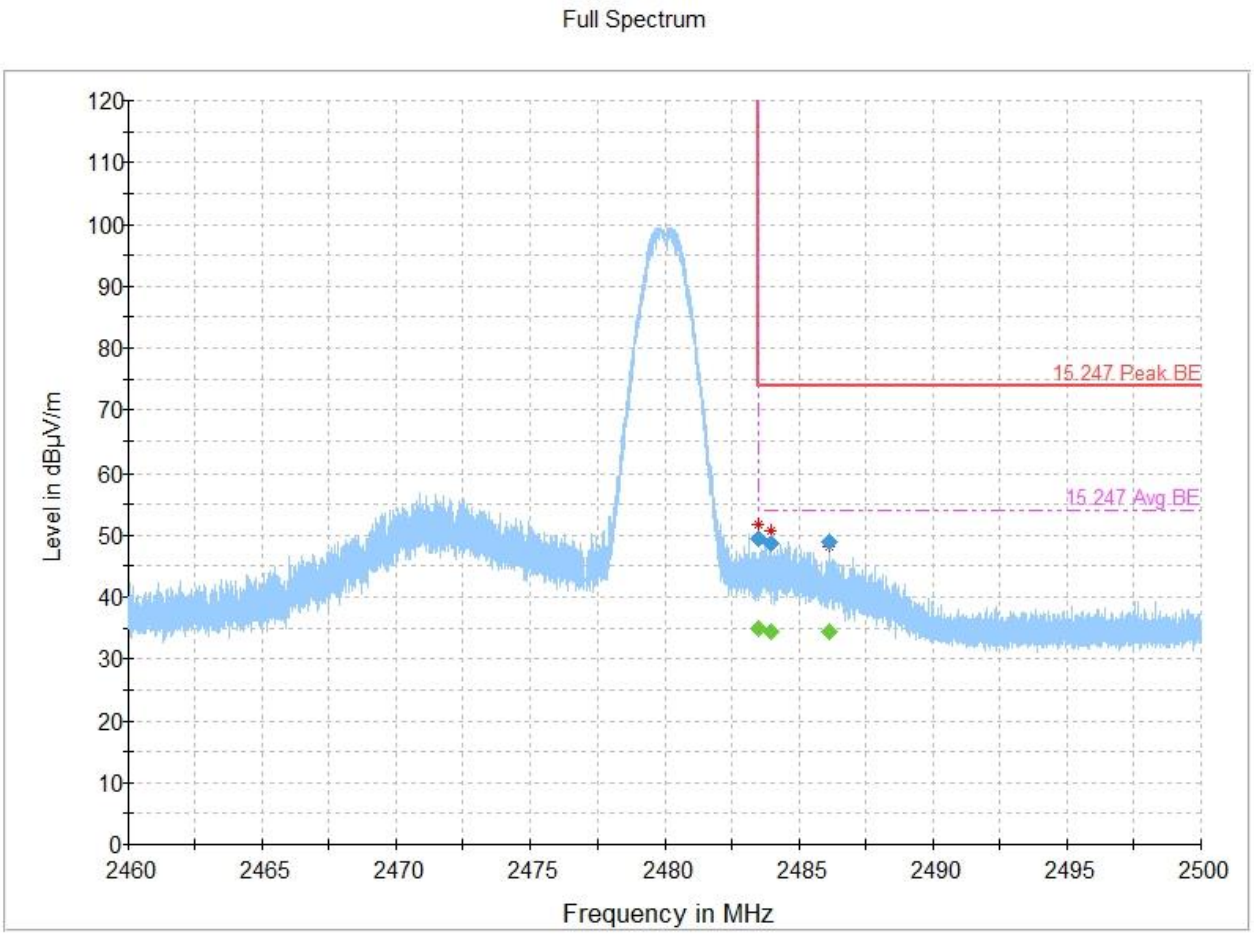

Figure 8.6-2: Radiated emissions, restricted band edge, high

Table 8.6-3: 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	---	35.00	53.90	18.90	5000.0	1000.000	174.0	H	132.0	-10.0
2483.500000	49.31	---	73.90	24.59	5000.0	1000.000	174.0	H	132.0	-10.0
2483.918667	---	34.28	53.90	19.62	5000.0	1000.000	176.0	H	130.0	-10.0
2483.918667	48.58	---	73.90	25.32	5000.0	1000.000	176.0	H	130.0	-10.0
2486.141333	---	34.50	53.90	19.40	5000.0	1000.000	102.0	H	126.0	-10.0
2486.141333	49.00	---	73.90	24.90	5000.0	1000.000	102.0	H	126.0	-10.0

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.

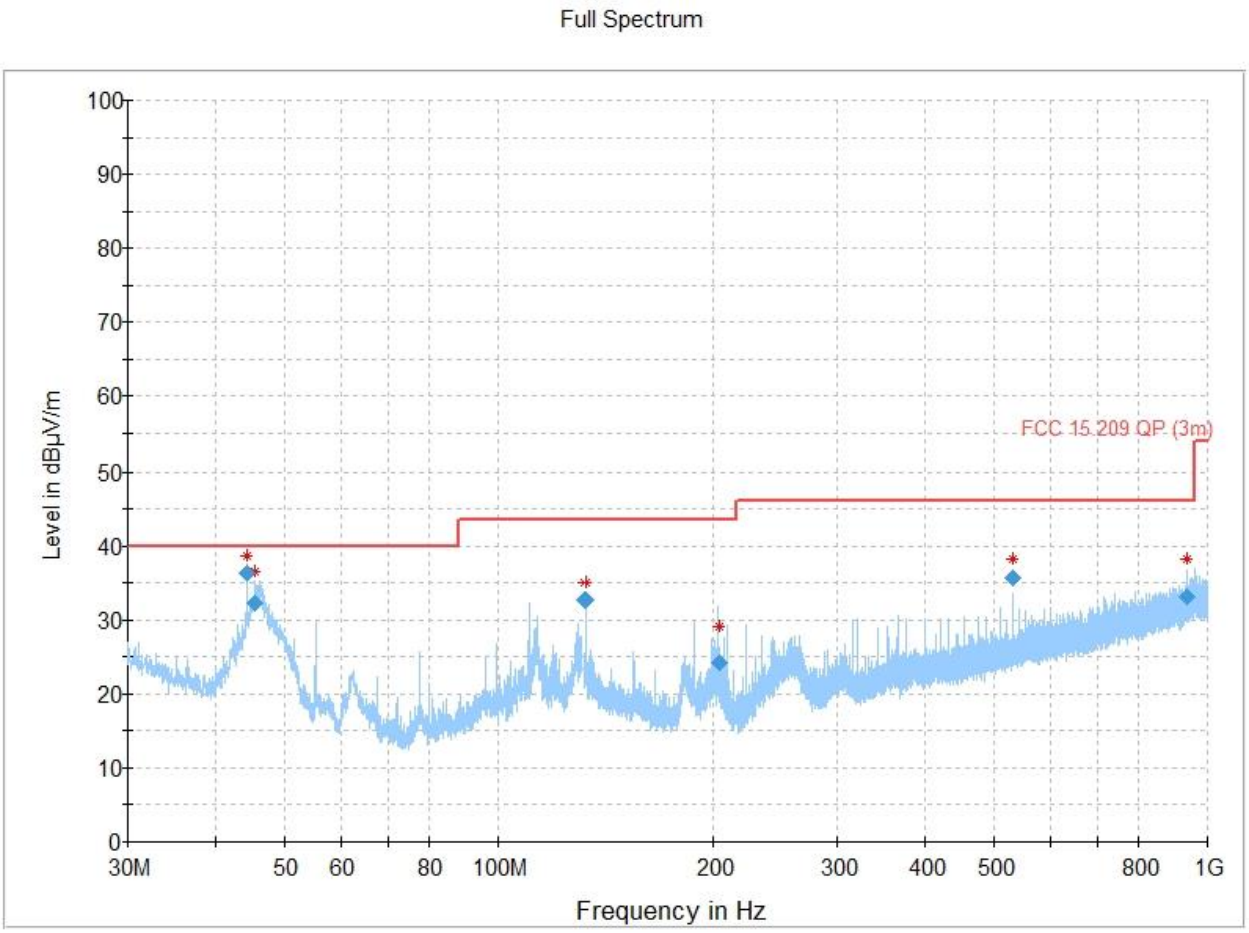

Figure 8.6-3: Radiated emissions, 2402 MHz, 30 – 1000 MHz

Table 8.6-4: 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)
44.246667	36.22	40.00	3.78	5000.0	120.000	104.0	V	282.0	18.7
45.466000	32.37	40.00	7.63	5000.0	120.000	111.0	V	0.0	18.1
132.703000	32.68	43.50	10.82	5000.0	120.000	232.0	H	248.0	19.4
204.236333	24.29	43.50	19.21	5000.0	120.000	107.0	H	269.0	17.7
530.863333	35.66	46.00	10.34	5000.0	120.000	151.0	H	233.0	27.2
934.598667	33.12	46.00	12.88	5000.0	120.000	193.0	V	234.0	33.3

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.

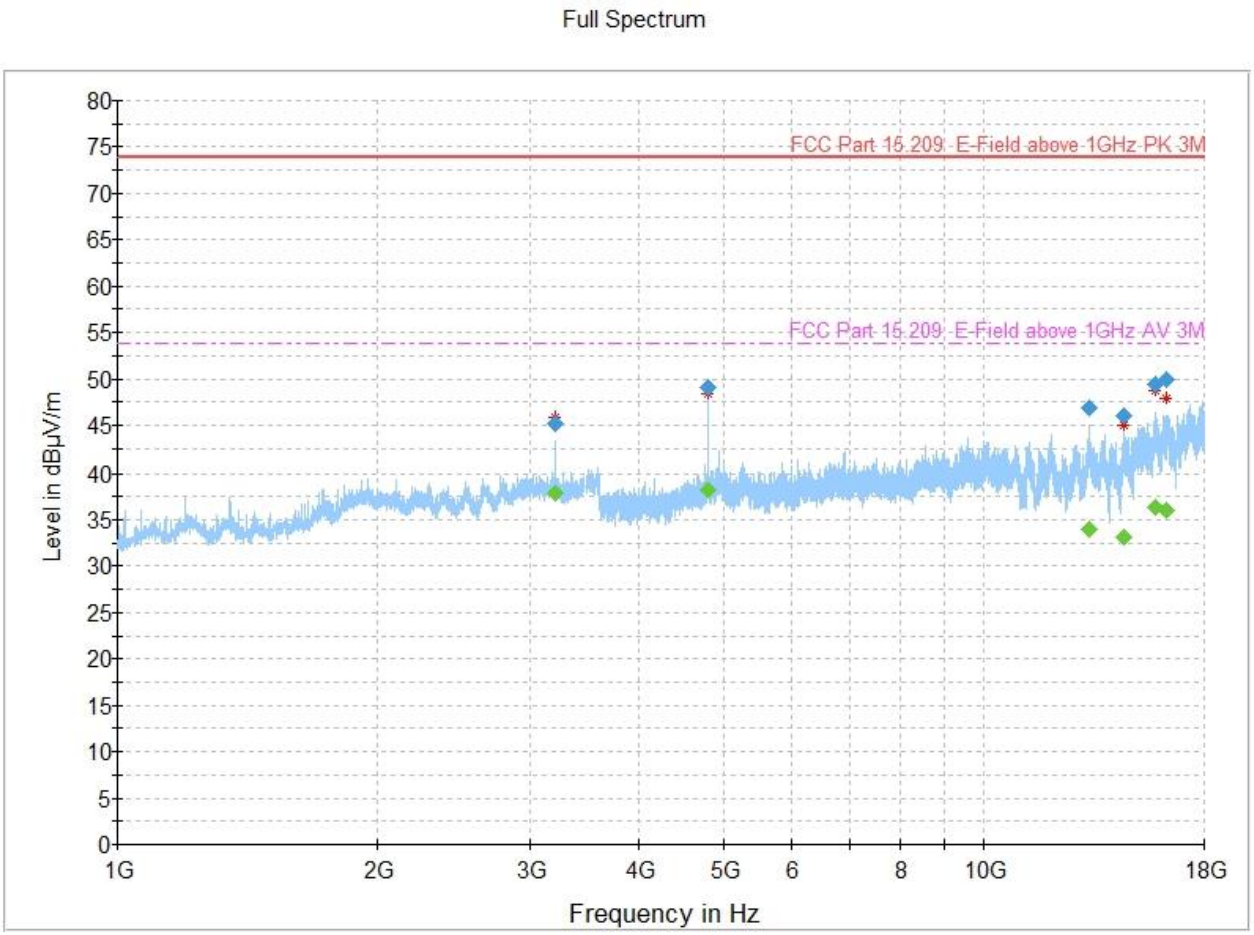

Figure 8.6-4: Radiated emissions, 2402 MHz, 1 - 18 GHz

Table 8.6-5: 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)
3205.329800	---	37.81	53.90	16.09	5000.0	1000.000	151.0	H	295.0	-7.7
3205.329800	45.15	---	73.90	28.75	5000.0	1000.000	151.0	H	295.0	-7.7
4807.457800	49.09	---	73.90	24.81	5000.0	1000.000	141.0	V	61.0	-2.6
4807.457800	---	38.26	53.90	15.64	5000.0	1000.000	141.0	V	61.0	-2.6
13242.758700	---	33.89	53.90	20.01	5000.0	1000.000	249.0	H	87.0	7.3
13242.758700	46.93	---	73.90	26.97	5000.0	1000.000	249.0	H	87.0	7.3
14522.254050	---	33.18	53.90	20.72	5000.0	1000.000	321.0	H	0.0	7.6
14522.254050	46.04	---	73.90	27.86	5000.0	1000.000	321.0	H	0.0	7.6
15781.801800	49.39	---	73.90	24.51	5000.0	1000.000	296.0	V	35.0	9.1
15781.801800	---	36.32	53.90	17.58	5000.0	1000.000	296.0	V	35.0	9.1
16303.778900	---	36.08	53.90	17.82	5000.0	1000.000	240.0	V	247.0	10.9
16303.778900	49.92	---	73.90	23.98	5000.0	1000.000	240.0	V	247.0	10.9

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.
A 2.4 GHz notch filter was used to suppress the transmitter carrier

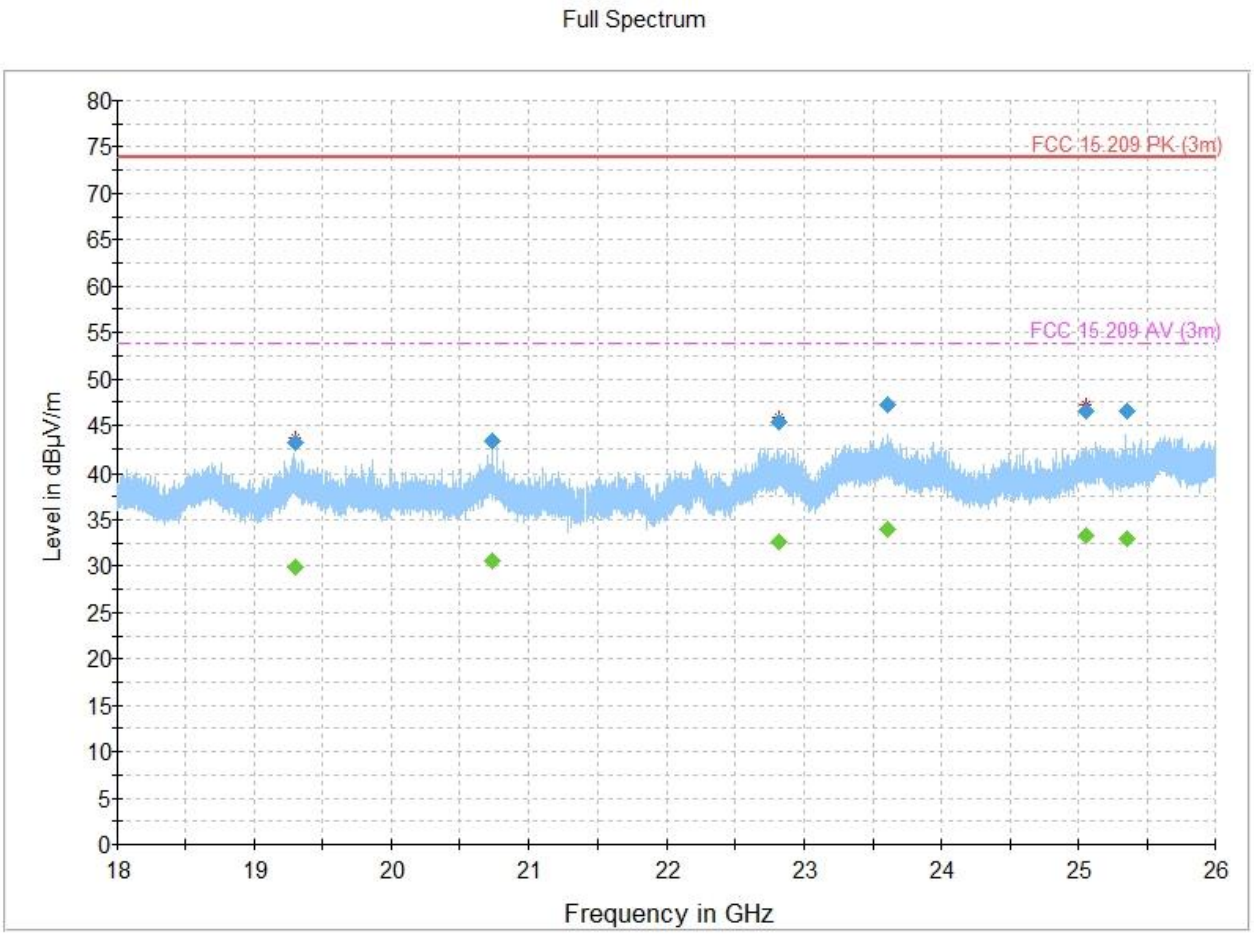

Figure 8.6-5: Radiated emissions, 2402 MHz, 18 - 26 GHz

Table 8.6-6: 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)
19294.833333	---	29.96	53.90	23.94	5000.0	1000.000	345.0	H	155.0	14.9
19294.833333	43.08	---	73.90	30.82	5000.0	1000.000	345.0	H	155.0	14.9
20731.433333	43.35	---	73.90	30.55	5000.0	1000.000	252.0	H	101.0	15.8
20731.433333	---	30.61	53.90	23.29	5000.0	1000.000	252.0	H	101.0	15.8
22811.233333	45.41	---	73.90	28.49	5000.0	1000.000	267.0	V	167.0	17.0
22811.233333	---	32.53	53.90	21.37	5000.0	1000.000	267.0	V	167.0	17.0
23610.766667	---	33.92	53.90	19.98	5000.0	1000.000	301.0	V	48.0	20.3
23610.766667	47.19	---	73.90	26.71	5000.0	1000.000	301.0	V	48.0	20.3
25057.633333	46.56	---	73.90	27.34	5000.0	1000.000	272.0	H	169.0	19.0
25057.633333	---	33.24	53.90	20.66	5000.0	1000.000	272.0	H	169.0	19.0
25351.300000	46.62	---	73.90	27.28	5000.0	1000.000	199.0	H	49.0	18.6
25351.300000	---	32.90	53.90	21.00	5000.0	1000.000	199.0	H	49.0	18.6

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.

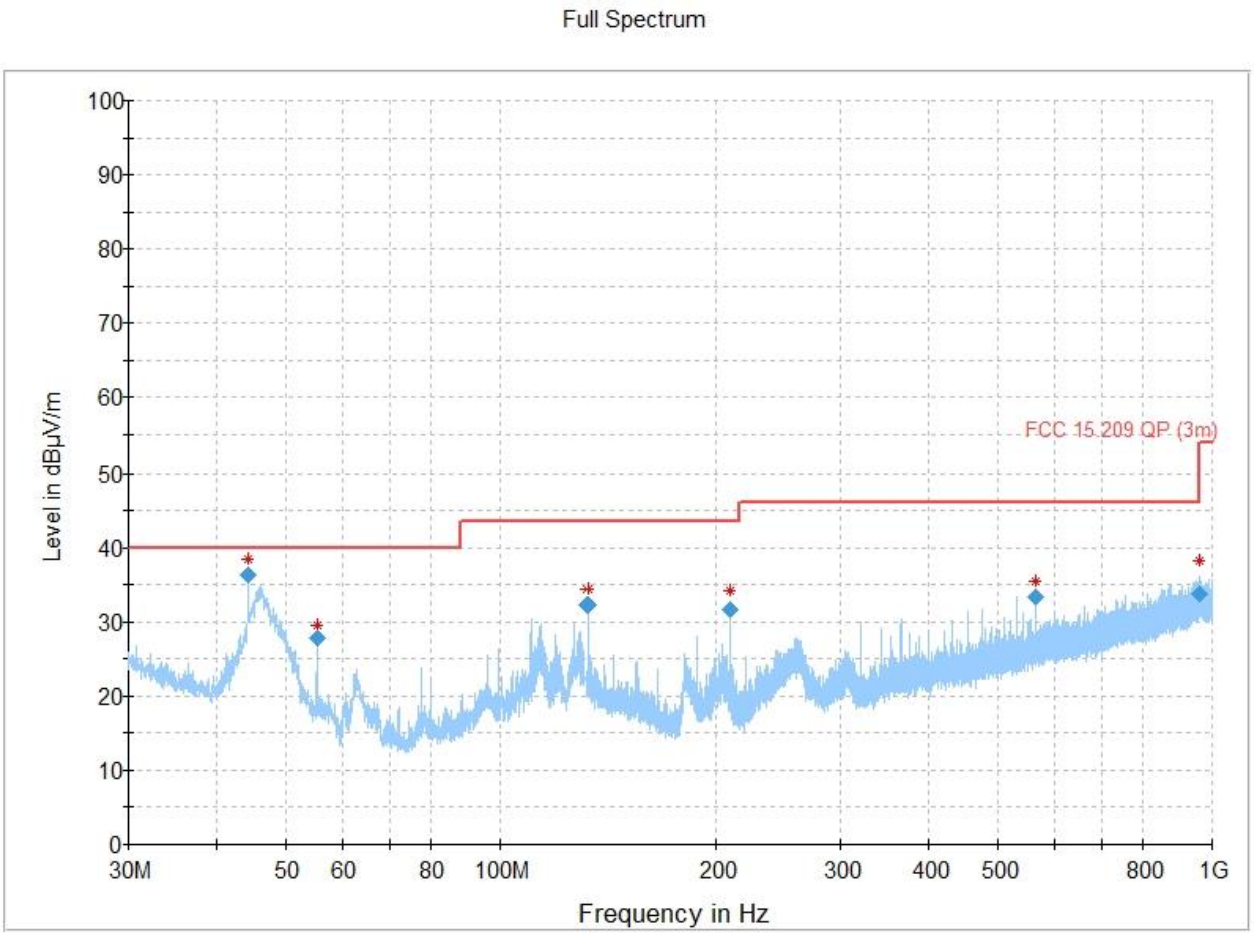

Figure 8.6-6: Radiated emissions, 2440 MHz, 30 – 1000 MHz

Table 8.6-7: 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)
44.246667	36.26	40.00	3.74	5000.0	120.000	111.0	V	322.0	18.7
55.297000	27.76	40.00	12.24	5000.0	120.000	128.0	V	281.0	13.5
132.703000	32.36	43.50	11.14	5000.0	120.000	204.0	H	258.0	19.4
210.149000	31.72	43.50	11.78	5000.0	120.000	135.0	H	288.0	17.9
564.029667	33.43	46.00	12.57	5000.0	120.000	275.0	H	262.0	28.0
959.791333	33.82	46.00	12.18	5000.0	120.000	346.0	H	33.0	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.

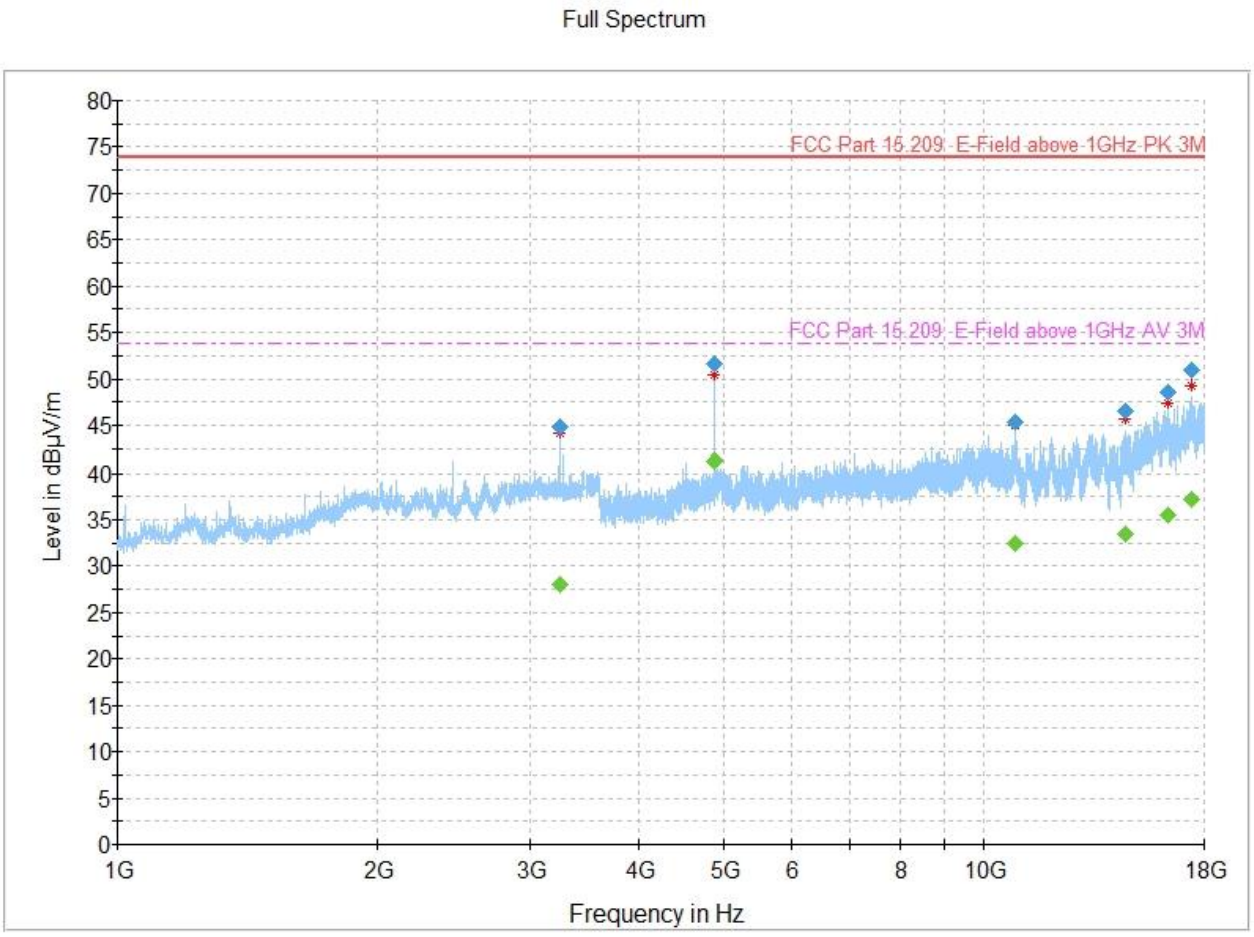

Figure 8.6-7: Radiated emissions, 2440 MHz, 1 - 18 GHz

Table 8.6-8: 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)
3255.794750	44.85	---	73.90	29.05	5000.0	1000.000	159.0	H	300.0	-7.5
3255.794750	---	28.10	53.90	25.80	5000.0	1000.000	159.0	H	300.0	-7.5
4879.440550	---	41.31	53.90	12.59	5000.0	1000.000	336.0	H	126.0	-2.7
4879.440550	51.62	---	73.90	22.28	5000.0	1000.000	336.0	H	126.0	-2.7
10884.320900	---	32.49	53.90	21.41	5000.0	1000.000	161.0	H	0.0	2.4
10884.320900	45.42	---	73.90	28.48	5000.0	1000.000	161.0	H	0.0	2.4
14576.674350	---	33.51	53.90	20.39	5000.0	1000.000	211.0	V	121.0	7.5
14576.674350	46.49	---	73.90	27.41	5000.0	1000.000	211.0	V	121.0	7.5
16351.709900	48.50	---	73.90	25.40	5000.0	1000.000	251.0	H	344.0	10.6
16351.709900	---	35.49	53.90	18.41	5000.0	1000.000	251.0	H	344.0	10.6
17402.400850	50.91	---	73.90	22.99	5000.0	1000.000	376.0	H	357.0	11.6
17402.400850	---	37.25	53.90	16.65	5000.0	1000.000	376.0	H	357.0	11.6

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.
A 2.4 GHz notch filter was used to suppress the transmitter carrier

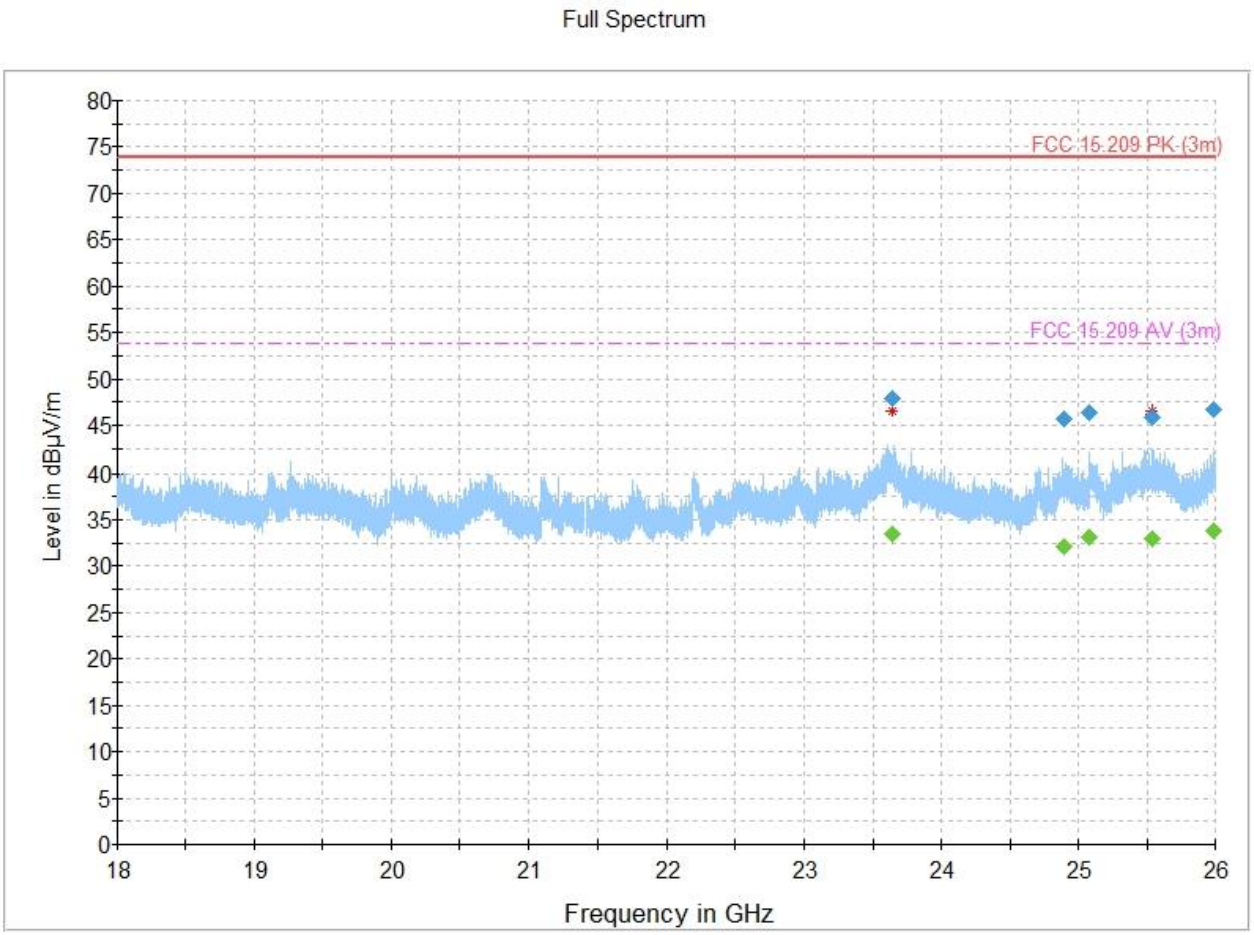

Figure 8.6-8: Radiated emissions, 2440 MHz, 18 - 26 GHz

Table 8.6-9: 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)
23647.300000	47.97	---	73.90	25.93	5000.0	1000.000	351.0	V	128.0	20.0
23647.300000	---	33.41	53.90	20.49	5000.0	1000.000	351.0	V	128.0	20.0
24894.366667	45.72	---	73.90	28.18	5000.0	1000.000	189.0	H	286.0	18.7
24894.366667	---	32.17	53.90	21.73	5000.0	1000.000	189.0	H	286.0	18.7
25083.233333	---	33.05	53.90	20.85	5000.0	1000.000	383.0	V	140.0	19.0
25083.233333	46.29	---	73.90	27.61	5000.0	1000.000	383.0	V	140.0	19.0
25537.166667	---	32.92	53.90	20.98	5000.0	1000.000	190.0	H	22.0	19.2
25537.166667	45.86	---	73.90	28.04	5000.0	1000.000	190.0	H	22.0	19.2
25543.766667	45.80	---	73.90	28.10	5000.0	1000.000	410.0	H	0.0	19.2
25543.766667	---	32.96	53.90	20.94	5000.0	1000.000	410.0	H	0.0	19.2
25988.500000	46.72	---	73.90	27.18	5000.0	1000.000	287.0	H	218.0	20.5
25988.500000	---	33.80	53.90	20.10	5000.0	1000.000	287.0	H	218.0	20.5

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.

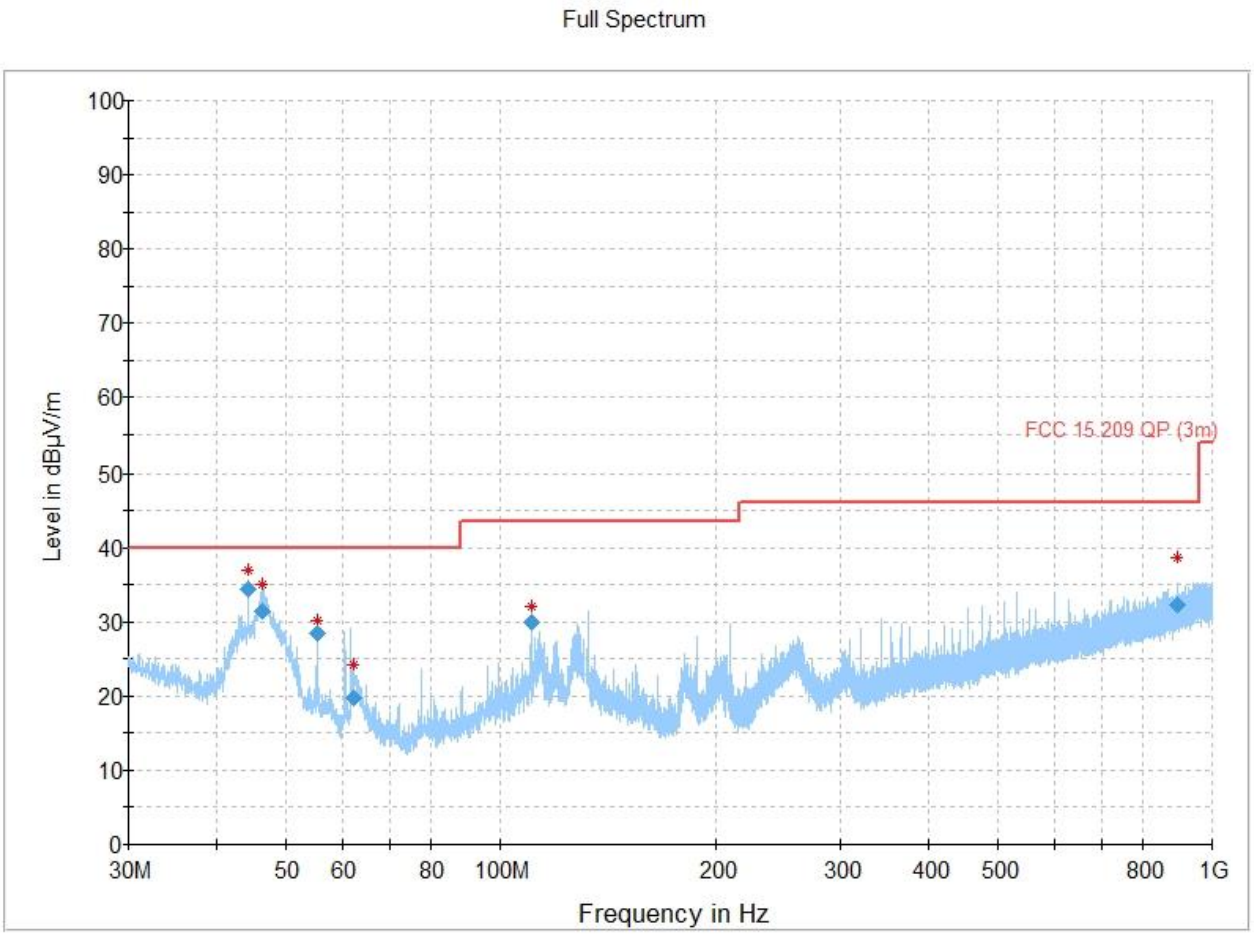

Figure 8.6-9: Radiated emissions, 2480 MHz, 30 – 1000 MHz

Table 8.6-10: 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)
44.246667	34.49	40.00	5.51	5000.0	120.000	107.0	V	0.0	18.7
46.348333	31.44	40.00	8.56	5000.0	120.000	111.0	V	300.0	17.6
55.304667	28.42	40.00	11.58	5000.0	120.000	114.0	V	259.0	13.5
62.219000	19.81	40.00	20.19	5000.0	120.000	100.0	V	270.0	12.5
110.594667	29.99	43.50	13.51	5000.0	120.000	206.0	H	91.0	18.6
893.780333	32.27	46.00	13.73	5000.0	120.000	243.0	V	222.0	32.6

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.

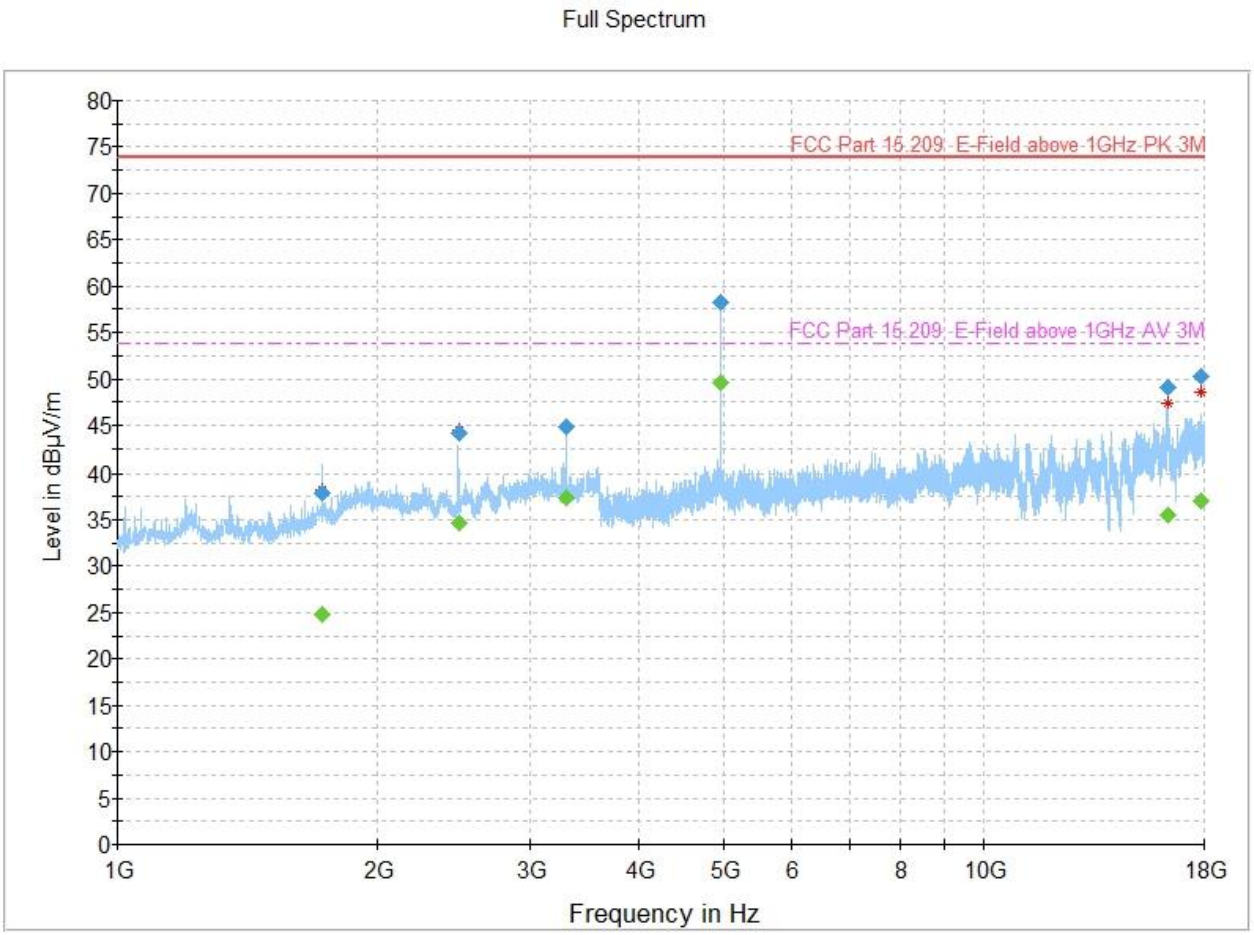

Figure 8.6-10: Radiated emissions, 2480 MHz, 1 - 18 GHz

Table 8.6-11: 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)
1726.988950	37.90	---	73.90	36.00	5000.0	1000.000	254.0	V	344.0	-12.9
1726.988950	---	24.72	53.90	29.18	5000.0	1000.000	254.0	V	344.0	-12.9
2480.361500	---	34.61	53.90	19.29	5000.0	1000.000	200.0	H	136.0	-10.0
2480.361500	44.11	---	73.90	29.79	5000.0	1000.000	200.0	H	136.0	-10.0
3306.839850	---	37.30	53.90	16.60	5000.0	1000.000	174.0	H	301.0	-7.5
3306.839850	44.86	---	73.90	29.04	5000.0	1000.000	174.0	H	301.0	-7.5
4959.437650	---	49.68	53.90	4.22	5000.0	1000.000	113.0	V	86.0	-3.0
4959.437650	58.30	---	73.90	15.60	5000.0	1000.000	113.0	V	86.0	-3.0
16355.684700	49.12	---	73.90	24.78	5000.0	1000.000	340.0	V	84.0	10.6
16355.684700	---	35.51	53.90	18.39	5000.0	1000.000	340.0	V	84.0	10.6
17833.061650	---	37.05	53.90	16.85	5000.0	1000.000	361.0	H	287.0	13.3
17833.061650	50.33	---	73.90	23.57	5000.0	1000.000	361.0	H	287.0	13.3

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.
A 2.4 GHz notch filter was used to suppress the transmitter carrier

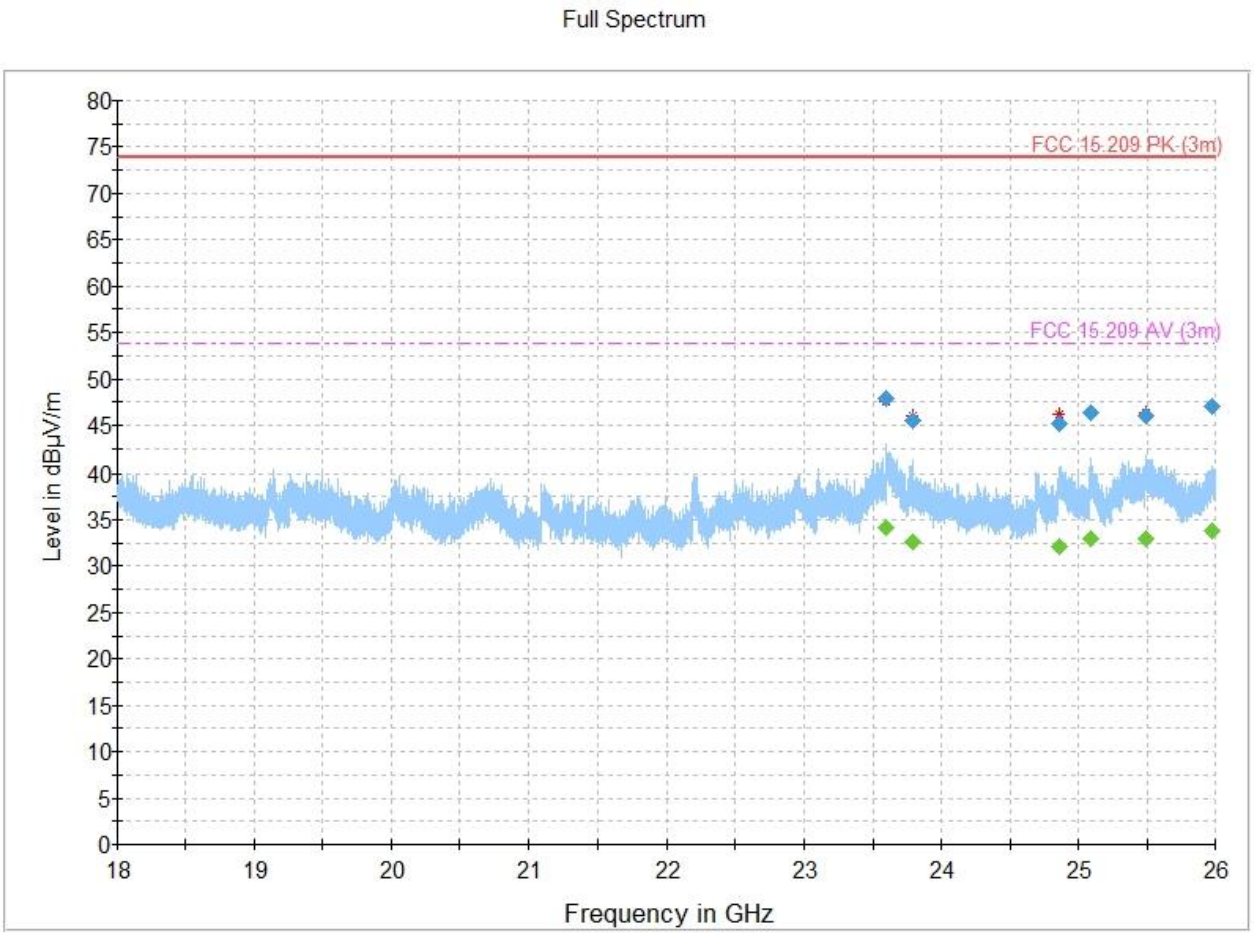

Figure 8.6-11: Radiated emissions, 2480 MHz, 18 - 26 GHz

Table 8.6-12: 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)
23596.366667	47.83	---	73.90	26.07	5000.0	1000.000	309.0	V	10.0	20.5
23596.366667	---	34.09	53.90	19.81	5000.0	1000.000	309.0	V	10.0	20.5
23790.500000	45.44	---	73.90	28.46	5000.0	1000.000	174.0	V	214.0	18.7
23790.500000	---	32.59	53.90	21.31	5000.0	1000.000	174.0	V	214.0	18.7
24867.033333	45.19	---	73.90	28.71	5000.0	1000.000	262.0	V	207.0	18.6
24867.033333	---	32.10	53.90	21.80	5000.0	1000.000	262.0	V	207.0	18.6
25095.300000	46.31	---	73.90	27.59	5000.0	1000.000	189.0	H	100.0	19.0
25095.300000	---	33.01	53.90	20.89	5000.0	1000.000	189.0	H	100.0	19.0
25496.633333	46.05	---	73.90	27.85	5000.0	1000.000	307.0	V	0.0	19.0
25496.633333	---	32.91	53.90	20.99	5000.0	1000.000	307.0	V	0.0	19.0
25977.566667	47.08	---	73.90	26.82	5000.0	1000.000	156.0	H	237.0	20.4
25977.566667	---	33.82	53.90	20.08	5000.0	1000.000	156.0	H	237.0	20.4

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.

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

8.7.1 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).

8.7.2 Test summary

Verdict	Pass		
Test date	August 3, 2020	Temperature	21 °C
Test engineer	James Cunningham	Air pressure	1005 mbar
Test location	Wireless bench	Relative humidity	65 %

8.7.3 Notes

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

The EUT antenna port was connected to the spectrum analyzer via low loss cable and a suitable attenuator. The loss of this assembly was corrected for via a transducer factor in the spectrum analyzer.

8.7.4 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	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

8.7.5 Test data

Table 8.7-1: Power spectral density of DTS

Transmitter Frequency (MHz)	Measured Level (dBm/3 kHz)	Limit (dBm/3 kHz)	Margin (dB)
2402	3.17	8.00	4.83
2440	3.53	8.00	4.47
2480	3.66	8.00	4.34

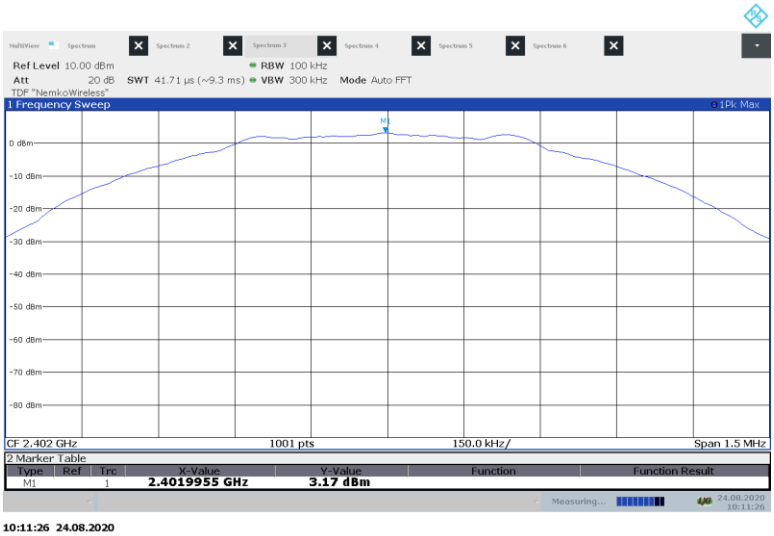

Figure 8.7-1: Power spectral density of digital transmission system, 2402 MHz

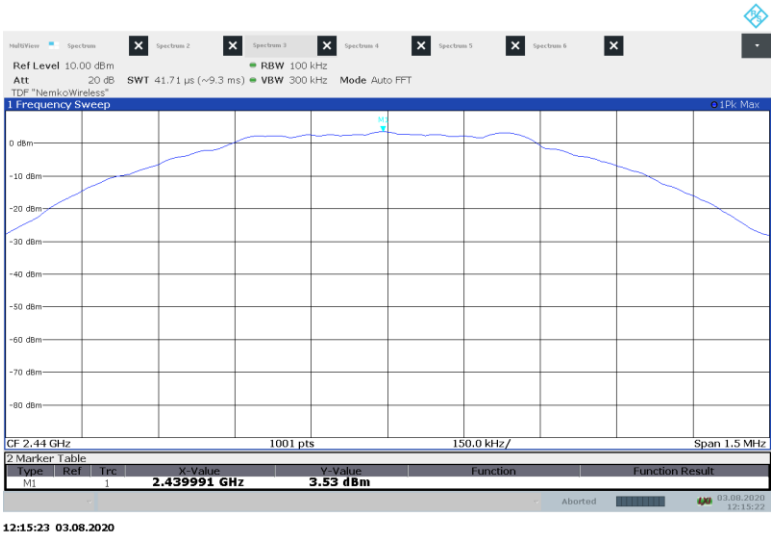

Figure 8.7-2: Power spectral density of digital transmission system, 2440 MHz

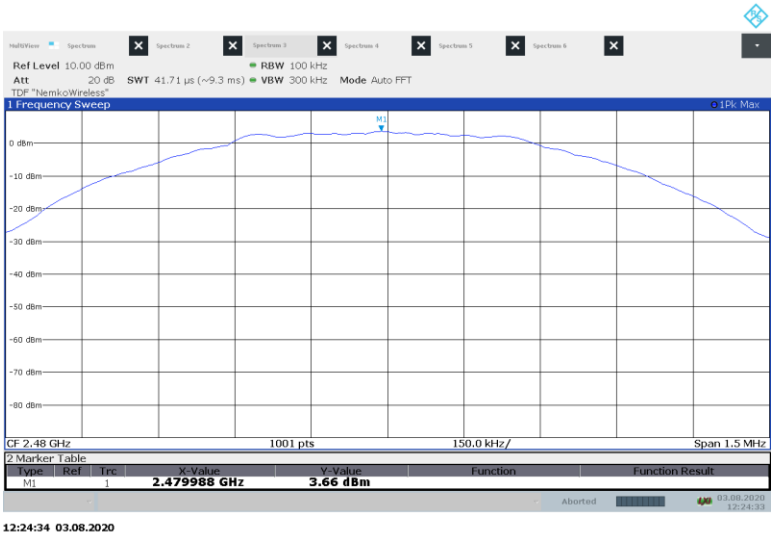

Figure 8.7-3: Power spectral density of digital transmission system, 2480 MHz

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

8.8.1 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.

8.8.2 Test summary

Verdict	Pass		
Test date	August 3, 2020	Temperature	21 °C
Test engineer	James Cunningham	Air pressure	1005 mbar
Test location	Wireless bench	Relative humidity	65 %

8.8.3 Notes

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

8.8.4 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	100 kHz
Video bandwidth	300 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.8.5 Test data

Test Frequency (MHz)	99%Bandwidth (MHz)
2404	1.0423
2440	1.0521
2480	1.0554

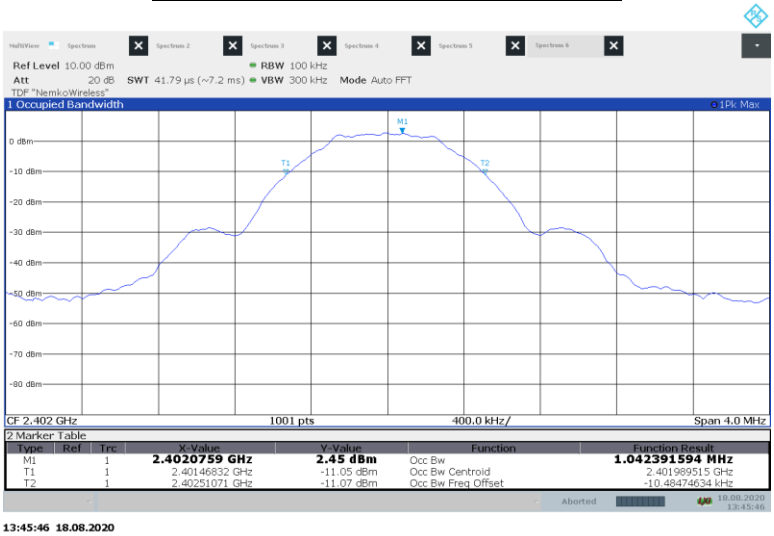

Figure 8.8-1: 99% bandwidth, 2402 MHz

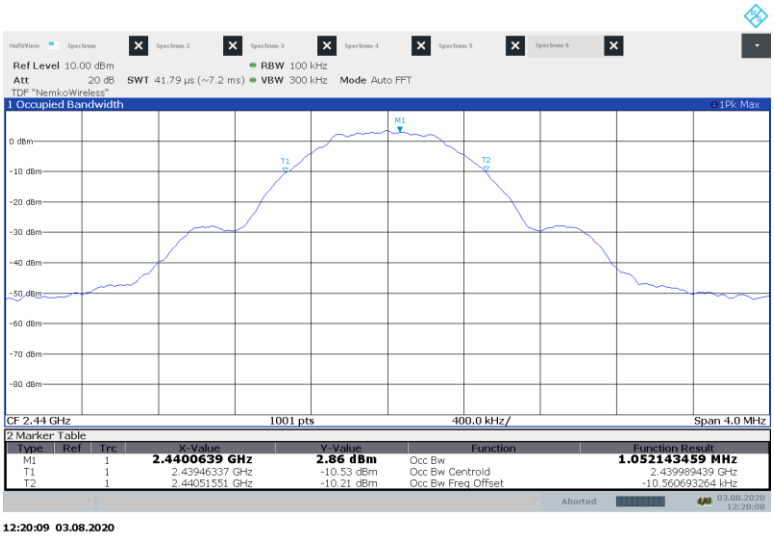

Figure 8.8-2: 99% bandwidth, 2440 MHz

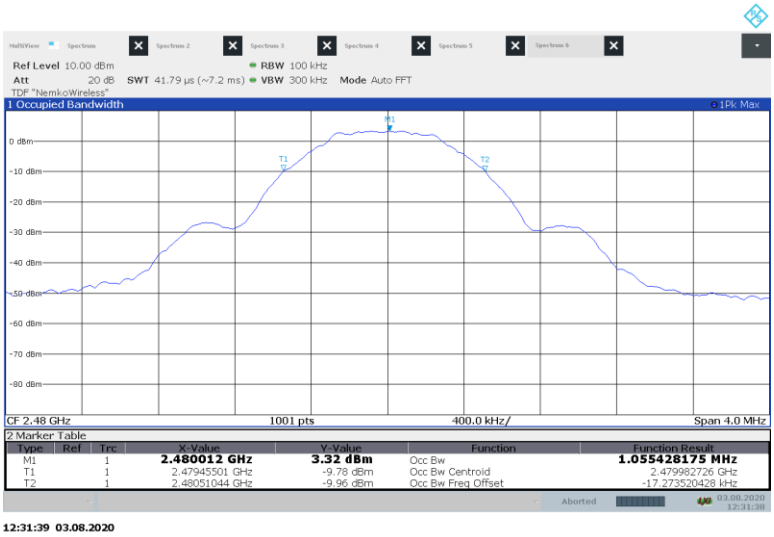

Figure 8.8-3: 99% bandwidth, 2480 MHz

Section 9 Block diagrams of test set-ups

9.1 Radiated emissions set-up

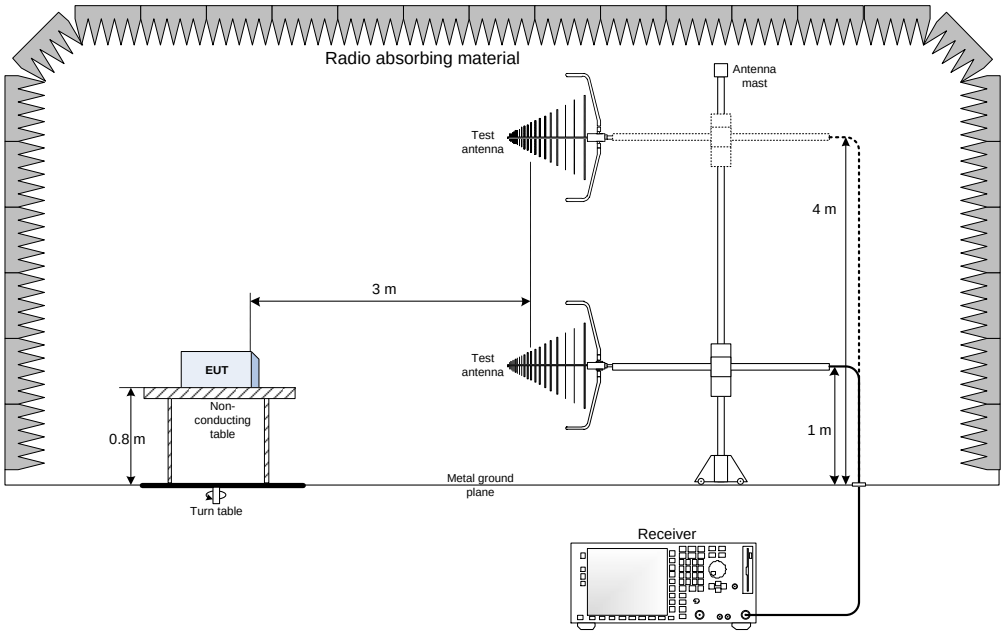

Figure 9.1-1 30 MHz - 1000 MHz Setup

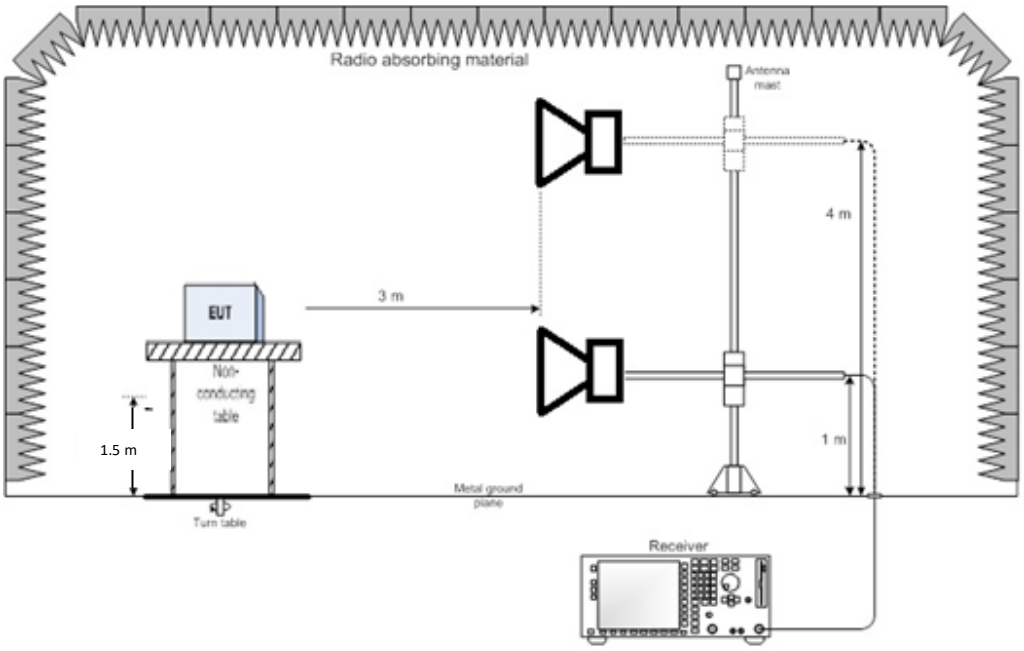

Figure 9.1-2 1 GHz - 26 GHz Setup

Thank you for choosing