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Test report

392487-1TRFWL

Date of issue: June 22, 2020

Applicant:

Carol Cole Company dba NuFace

Product:

NuFace

Model:

10760

FCC ID: 2AGNA-10760 **IC ID: 25861-10760**

Specifications:

- FCC 47 CFR Part 15, Subpart C – §15.247
- Industry Canada RSS-247, Issue 2

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	June 17, 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

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Section 1 Report summary

1.1 Applicant

Company name	Carol Cole Company dba NuFace
Address	1325 Sycamore Ave. Suite A
City	Vista
Province/State	CA
Postal/Zip code	92081
Country	USA

1.2 Manufacturer

Company name	Carol Cole Company dba NuFace
Address	1325 Sycamore Ave. Suite A
City	Vista
Province/State	CA
Postal/Zip code	92081
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 C64.10-2013	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
392487-1TRFWL	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	Pass
§15.31(e)	Variation of power source	Pass
§15.203	Antenna requirement	Pass

Notes: EUT is battery powered but charged via AC adaptor
The antenna is located within the protective cover of EUT on PCB

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

2.4 IC RSS-GEN, Issue 5

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

Section 3 Equipment under test (EUT) details

3.1 Sample information

Receipt date	June 1, 2020
Nemko sample ID number	NEx: 392487

3.2 EUT information

Product name	NuFace
Model	Trinity
Serial number	N/A
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)	0.50 dBm EIRP
Maximum output power (dBm)	-0.51 dBm EIRP
Measured 6 dB bandwidth	2402 MHz: 712.85 kHz 2441 MHz: 728.85 kHz 2480 MHz: 719.35 kHz
Type of modulation	GFSK
Emission classification	F1D
Power requirements	Test jig powered via AC adaptor
Antenna information	3 dBi gain antenna on PCB

3.4 EUT exercise and monitoring details

For Conducted measurements: The test configuration comprised the BLE PCB mounted on a test jig interfacing to a development board which, via batch files on the supporting laptop PC, configured the EUT to the correct transmitting modes required for testing.
For Radiated measurements - pretesting was performed to determine the worst case emissions profile in the X-Y-Z planes. Testing was performed with the PCB board in the X axis (or laying flat on the table)

Table 3.4-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number	Rev.
None				

Table 3.4-2: EUT interface ports

Description	Qty.
Debug port	1
DC power input	1

Table 3.4-3: Support equipment

Description	Brand name	Model/Part number	Serial number	Rev.
Development kit	Nordic Semiconductor	NRF52-DK	N/A	2.0.1
Controller laptop	Dell	P39F		
AC adaptor	HDP	HDP-QB05010C	1832	N/A

Table 3.4-4: Inter-connection cables

Cable description	From	To	Length (ft)
Programming cable	EUT Debug Port	Development kit	6 inches
AC adaptor	AC mains	EUT DC power input	3

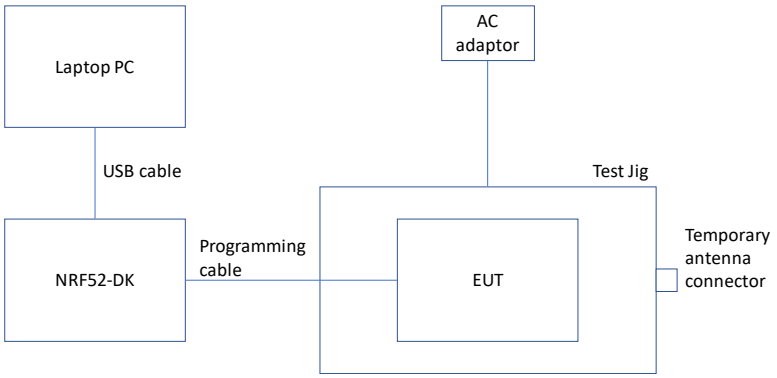

Figure 3.4-1: Test setup

3.5 EUT exercise details

EUT exercise details

A EUT was set to transmit at 100% duty cycle. Customer provided batch files which set the transmitter to a specific frequency (2402MHz, 2441MHz, 2480MHz).

For this test, the EUT will be configured as the receiver and a NRF52-DK development board will be configured as the transmitter. RF ports of each will be connected through cables, attenuators, signal injectors, etc. Error rate on the receiver will be monitored through a UART-to-USB connection between the EUT and a computer.

The software used to set the transmitter frequency and power was Nordic nRF command line tools v. 10.5.0.

For Radiated Spurious emissions the device was tested outside the Plastic formal enclosure as each frequency had to be set using the NRF53-DK development board and the provided software. Since the enclosure is plastic and the entire circuitry are contained on one PCB this was considered worst case.

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.
EMI Test Receiver	Rohde & Schwarz	ESCI 7	E1026	1 year	29 May 2020
Transient Limiter	Hewlett-Packard	11947A	684	1 year	20 Jan 2021
Two Line V-Network	Rohde & Schwarz	ENV216	E1019	1 year	12 Jul 2020
LISN	Solar	9348-50-R-24-BNC	384	1 year	8 Aug 2020
Signal and spectrum analyzer	Rohde & Schwarz	FSW	E1302	1 year	10 Jan 2021
Power sensor	ETS Lindgren	7002-006	E1061	18 months	1 Dec 2020
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

Table 6.1-2: Test Software

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.20.01 (AC conducted emissions)
Rohde & Schwarz	EMC 32 V10.60.15 (radiated emissions)

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	June 5, 2020	Temperature	21 °C
Test engineer	James Cunningham	Air pressure	1002 mbar
Test location	Ground plane	Relative humidity	67 %

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.

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

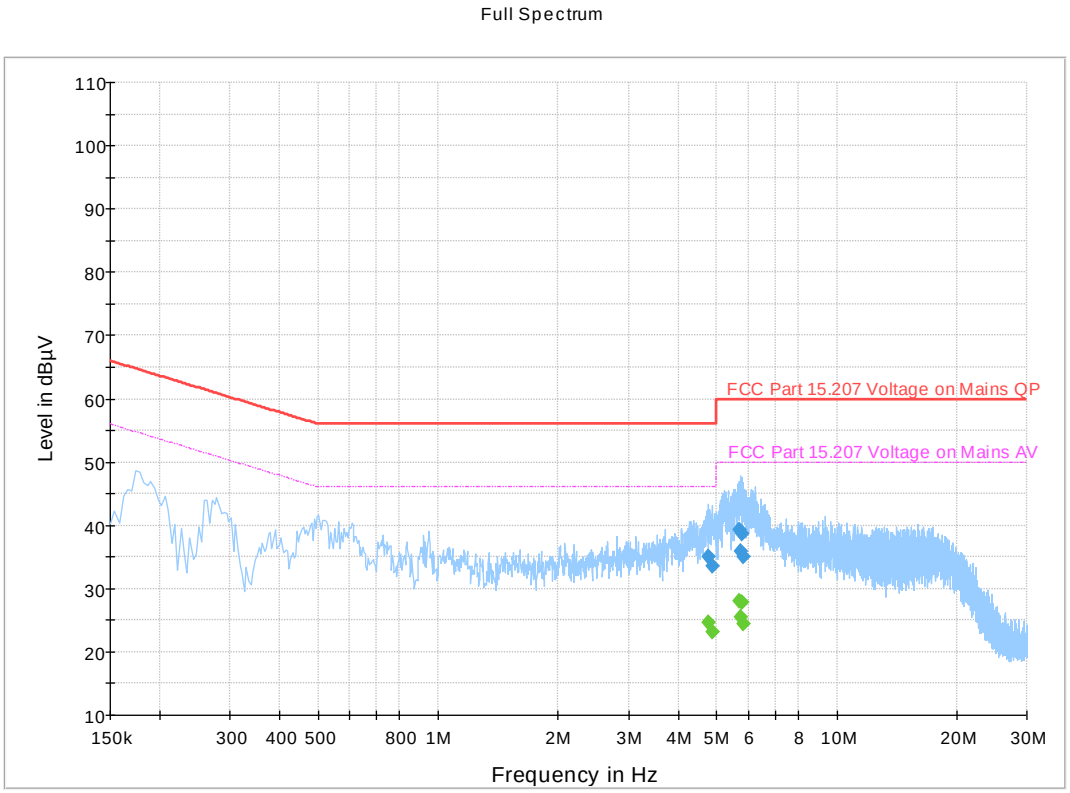

Figure 8.1-1: AC conducted emissions

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)
4.762000	---	24.58	46.00	21.42	5000.0	9.000	L1	ON	19.3
4.762000	35.13	---	56.00	20.87	5000.0	9.000	L1	ON	19.3
4.878000	---	23.17	46.00	22.83	5000.0	9.000	L1	ON	19.3
4.878000	33.65	---	56.00	22.35	5000.0	9.000	L1	ON	19.3
5.686000	---	28.09	50.00	21.91	5000.0	9.000	L1	ON	19.3
5.686000	39.20	---	60.00	20.80	5000.0	9.000	L1	ON	19.3
5.730000	36.00	---	60.00	24.00	5000.0	9.000	N	ON	19.3
5.730000	---	25.54	50.00	24.46	5000.0	9.000	N	ON	19.3
5.786000	38.73	---	60.00	21.27	5000.0	9.000	L1	ON	19.3
5.786000	---	27.83	50.00	22.17	5000.0	9.000	L1	ON	19.3
5.838000	---	24.50	50.00	25.50	5000.0	9.000	N	ON	19.3
5.838000	35.05	---	60.00	24.95	5000.0	9.000	N	ON	19.3

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

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	June 1, 2020	Temperature	22 °C
Test engineer	Juan Manuel Gonzalez	Air pressure	1001 mbar
Test location	Wireless bench	Relative humidity	49 %

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	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	712.85	> 500	212.85
2441	728.85	> 500	228.85
2480	719.35	> 500	219.35

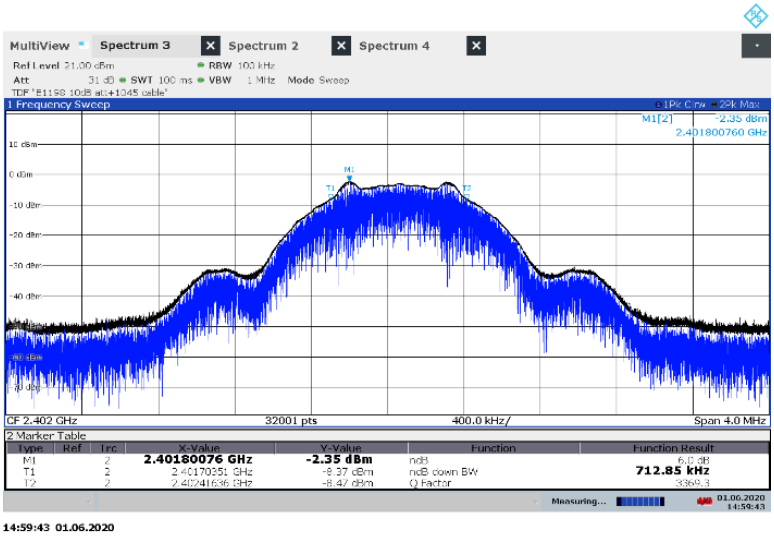

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Figure 8.2-1: 6 dB occupied bandwidth, 2402 MHz

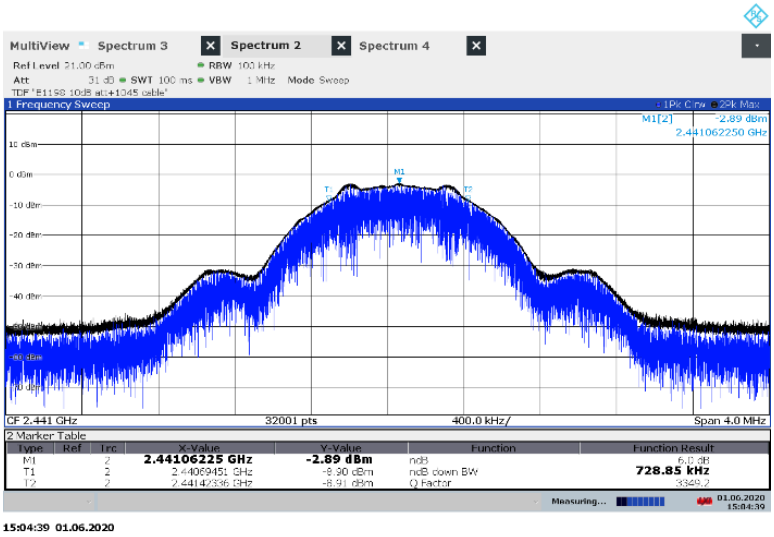

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Figure 8.2-2: 6 dB occupied bandwidth, 2441 MHz

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

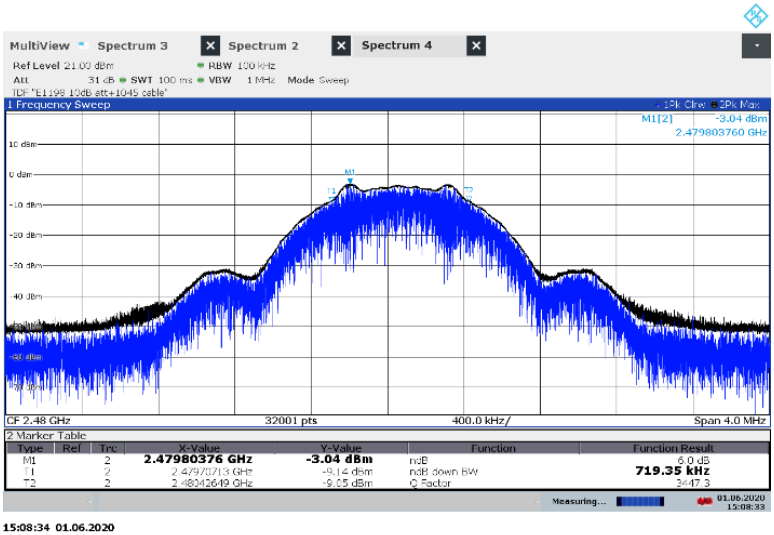

Figure 8.2-3: 6 dB occupied bandwidth, 2480 MHz

8.3 FCC 15.247(b) and RSS-247 5.4 (4) 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	June 2, 2020	Temperature	22 °C
Test engineer	Juan Manuel Gonzalez	Air pressure	1000 mbar
Test location	Wireless bench	Relative humidity	48 %

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 power meter software as a correction factor.

The antenna gain is 3 dBi per client declaration.

8.3.4 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless bench
Measurement method	ANSI C63.10 §11.9.1.3

8.3.5 Test data

Table 8.3-1: Output power

Test Frequency (MHz)	Conducted Power (dBm)	Conducted Limit (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)
2402	-2.50	30.0	3.00	0.50	36.0
2441	-3.10	30.0	3.00	-0.10	36.0
2480	-3.51	30.0	3.00	-0.51	36.0

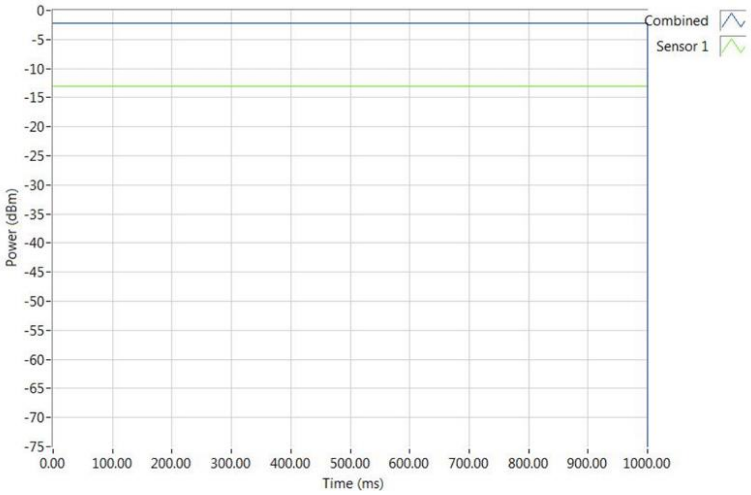

Figure 8.3-1: Output power, 2402 MHz

Maximum output power (dBm)	Medium Utilization (%)	Duty Cycle (%)
-2.50	0.603	100

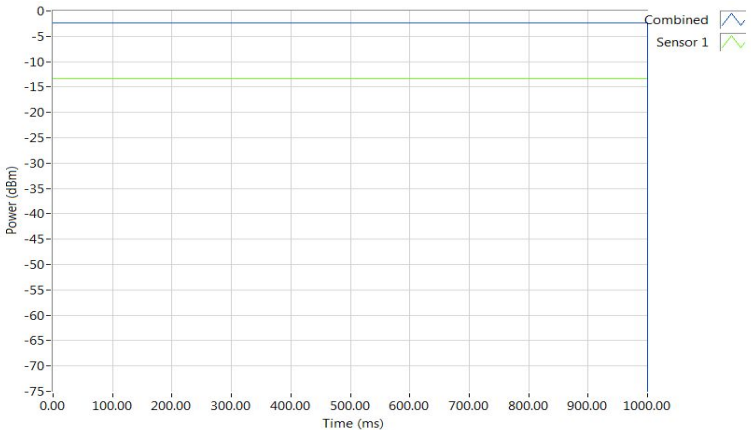

Figure 8.3-2: Output power, 2441 MHz

Maximum output power (dBm)	Medium Utilization (%)	Duty Cycle (%)
-3.10	0.573	100

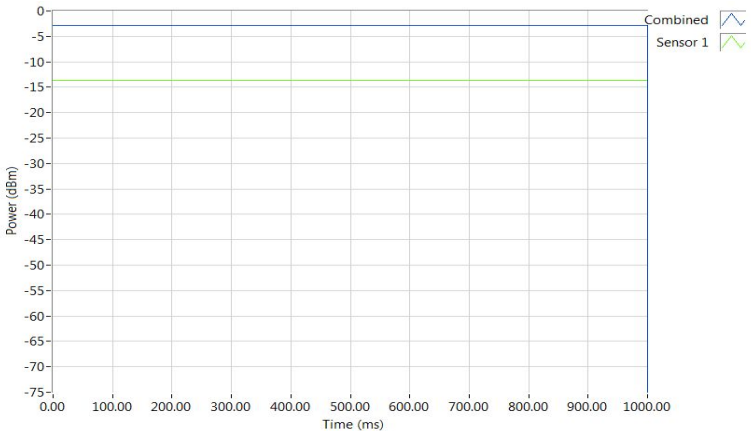

Figure 8.3-3: Output power, 2480 MHz

Maximum output power (dBm)	Medium Utilization (%)	Duty Cycle (%)
-3.51	0.525	100

8.4 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) 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.

Table 8.4-1: 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 8.4-2: 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			

8.4.2 Test summary

Verdict	Pass		
Test date	June 3, 2020 (conducted) June 8, 2020 (radiated)	Temperature	21°C
Test engineer	Juan Manuel Gonzalez (conducted) James Cunningham (radiated)	Air pressure	1002 mbar
Test location	Wireless bench 3m semi-anechoic chamber	Relative humidity	51 %

8.4.3 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).

Radiated measurements were performed at a 3 m measurement distance. Pretesting was performed in X, Y and Z axis and final testing and results were in the worst case configuration with the EUT standing upright. The upright configuration was considered the Y configuration

For conducted measurements, 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	Measurement performed as per C63.10 §11.11

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

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)

Summary of Conducted Port Bandedge Emissions:

Test Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Total Power (dBm)	Conversion Factor (dBm to dBµV/m)	EIRP (dBµV/m)	EIRP Limit (dBµV/m)
2390	-63.0	3.00	-60	95.23	35.23	54
2483.5	-59.5	3.00	-56.5	95.23	38.73	54

NOTE: The Peak measurement results are below the average limit therefore no RMS measurements were pursued for Bandedge final measurements

8.4.5 Test data

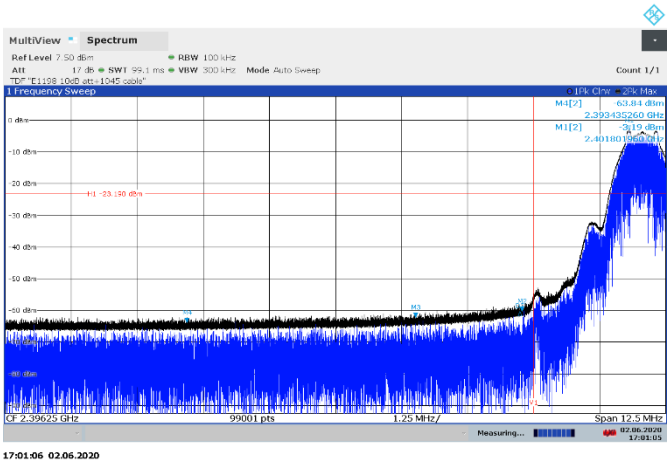

Figure 8.4-1: Band edge measurement, low channel

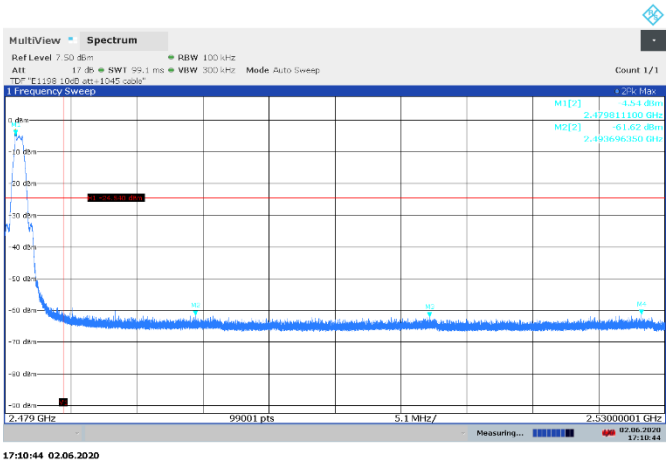

Figure 8.4-2: Band edge measurement, high channel

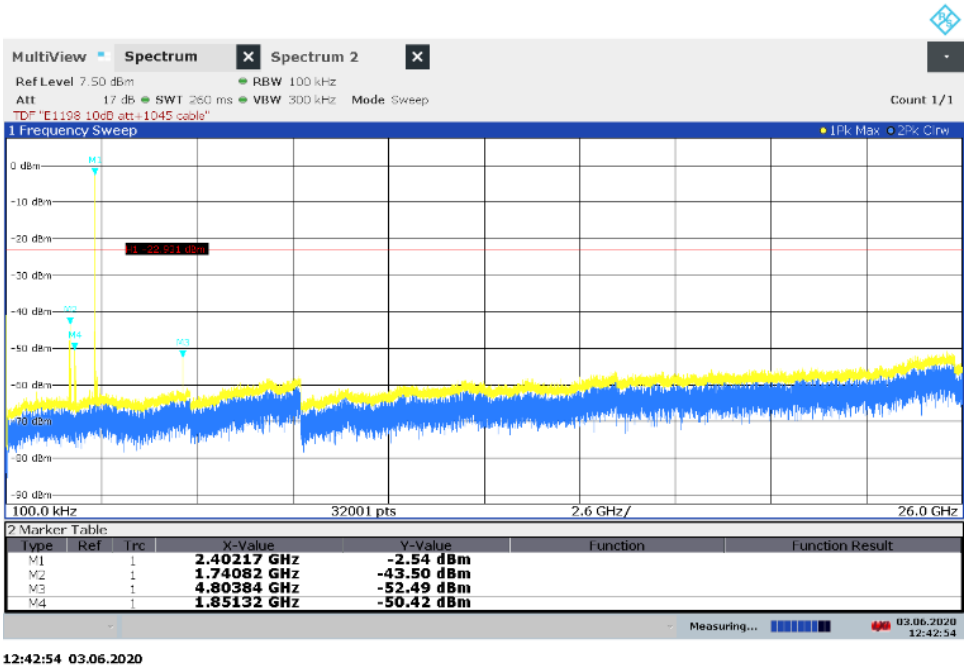

Figure 8.4-3: Conducted spurious emissions, low channel

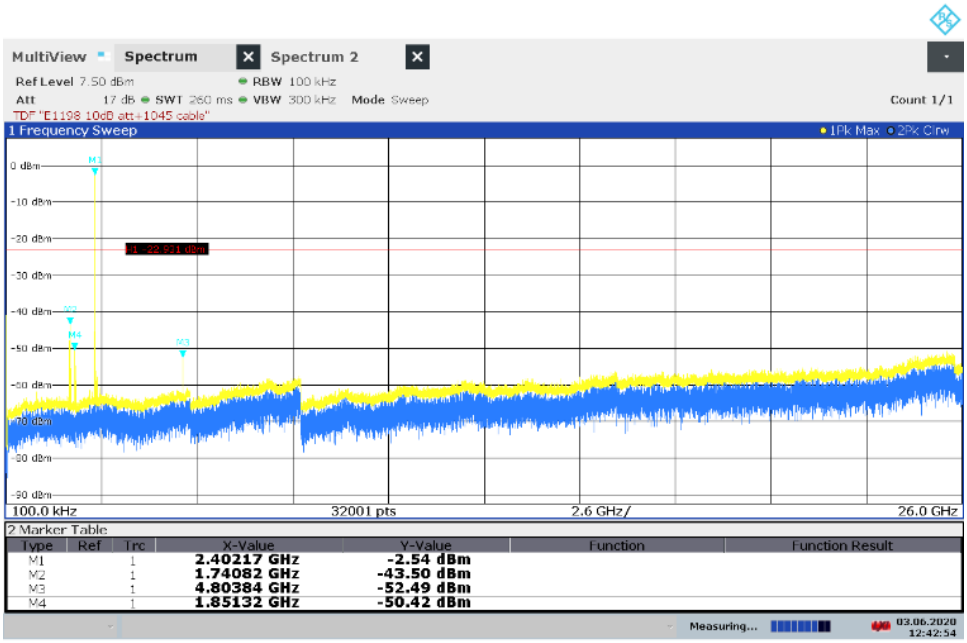

Figure 8.4-4: Conducted spurious emissions, middle channel

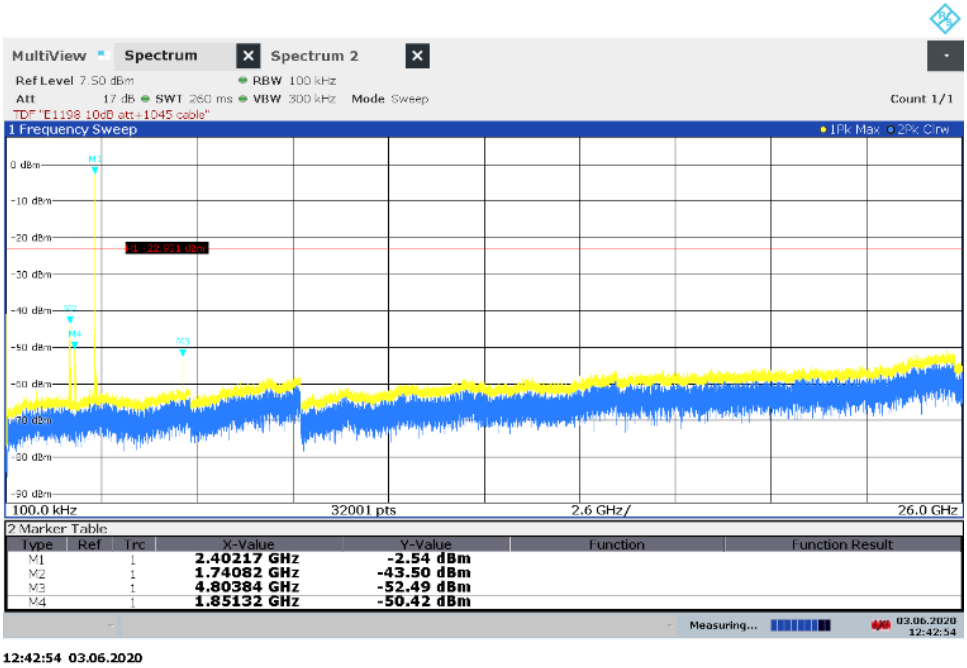

Figure 8.4-5: Conducted spurious emissions, high channel

Note: Peaks within 2400-2483.5MHz are transmitter fundamentals.

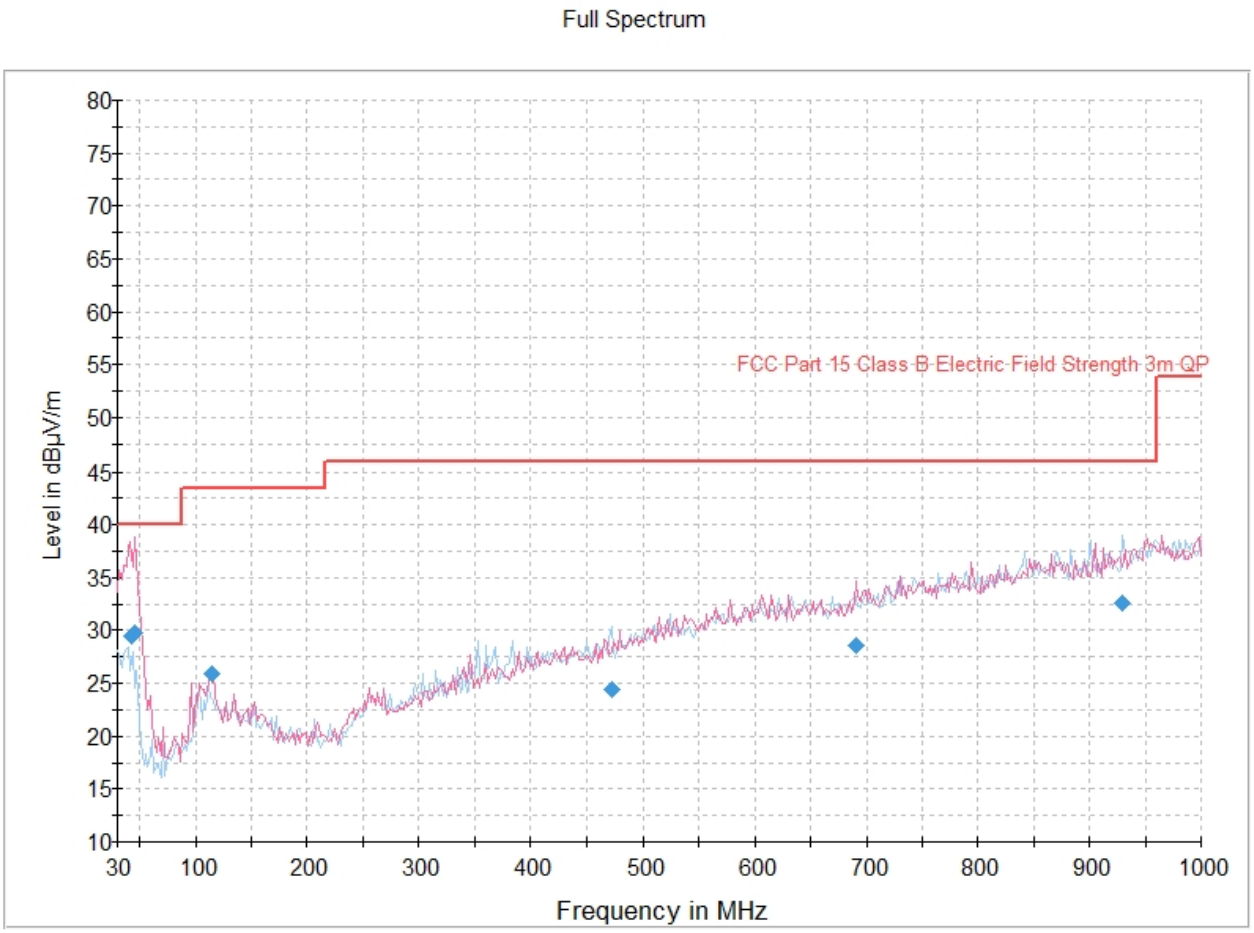

Figure 8.4-6: Radiated emissions, low channel, 30 – 1000 MHz

Table 8.4-2: Radiated emissions, low channel, 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)
42.743327	29.49	40.00	10.51	3000.0	120.000	134.0	V	281.0	19.5
45.311102	29.73	40.00	10.27	3000.0	120.000	121.0	V	188.0	18.1
115.211062	25.85	43.50	17.65	3000.0	120.000	367.0	V	0.0	18.9
472.462525	24.46	46.00	21.54	3000.0	120.000	361.0	H	132.0	26.2
690.481844	28.65	46.00	17.35	3000.0	120.000	394.0	V	339.0	29.8
929.780040	32.64	46.00	13.36	3000.0	120.000	258.0	H	10.0	33.0

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.
The FCC Part 15 Class B limits are identical to the general limits of Part 15.209

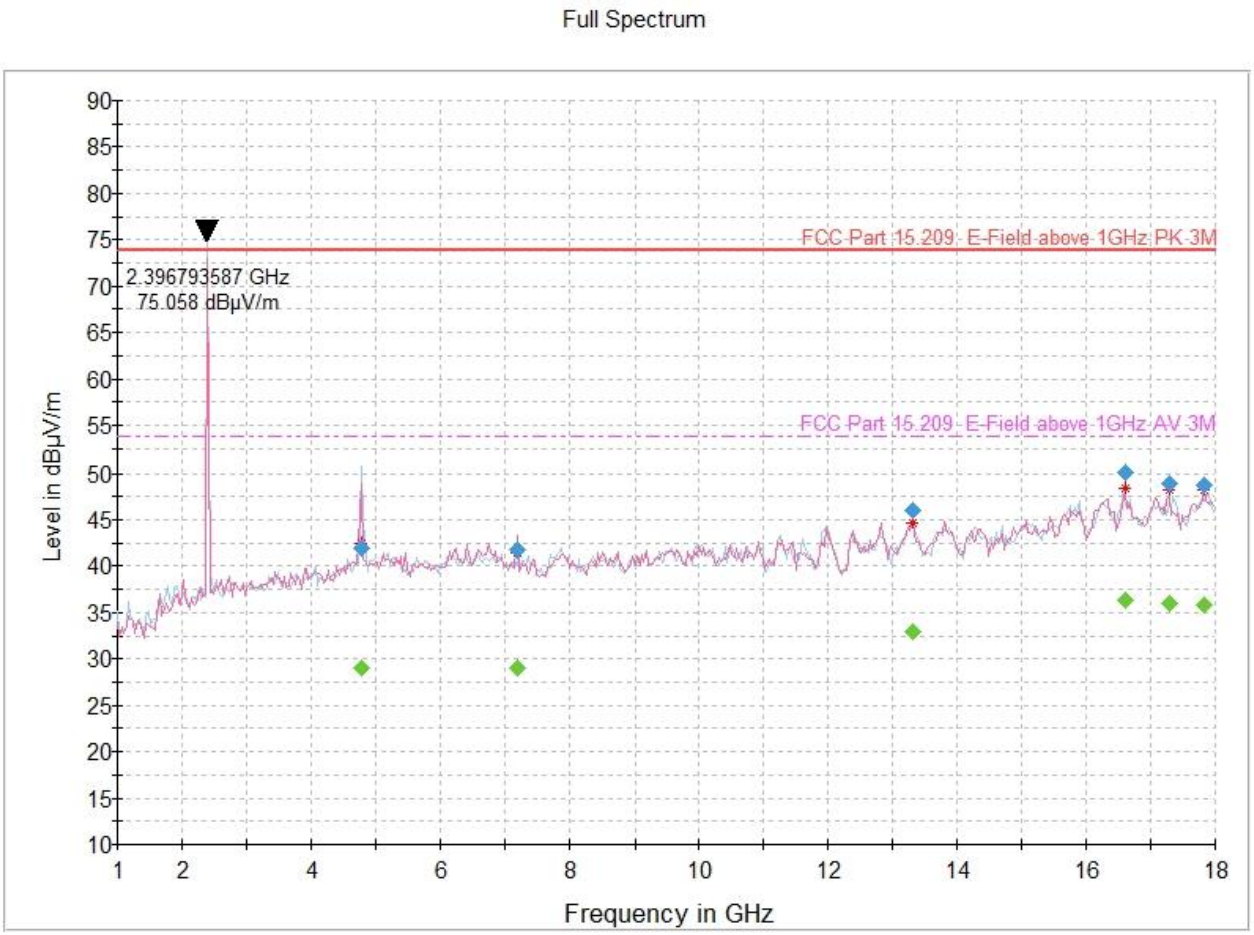

Figure 8.4-7: Radiated emissions, low channel, 1 - 18 GHz

Table 8.4-3: Radiated emissions, low channel, 1 - 18 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)
4783.163126	42.01	---	73.90	31.89	3000.0	1000.000	242.0	H	162.0	-2.6
4783.163126	---	29.07	53.90	24.83	3000.0	1000.000	242.0	H	162.0	-2.6
7205.200802	---	29.05	53.90	24.85	3000.0	1000.000	118.0	V	239.0	-1.0
7205.200802	41.83	---	73.90	32.07	3000.0	1000.000	118.0	V	239.0	-1.0
13300.597194	---	32.87	53.90	21.03	3000.0	1000.000	98.0	V	242.0	7.8
13300.597194	46.02	---	73.90	27.88	3000.0	1000.000	98.0	V	242.0	7.8
16598.806413	50.04	---	73.90	23.86	3000.0	1000.000	100.0	V	69.0	10.4
16598.806413	---	36.27	53.90	17.63	3000.0	1000.000	100.0	V	69.0	10.4
17284.569138	48.89	---	73.90	25.01	3000.0	1000.000	145.0	V	288.0	12.6
17284.569138	---	35.95	53.90	17.95	3000.0	1000.000	145.0	V	288.0	12.6
17828.059319	48.69	---	73.90	25.21	3000.0	1000.000	98.0	V	242.0	13.2
17828.059319	---	35.75	53.90	18.15	3000.0	1000.000	98.0	V	242.0	13.2

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.

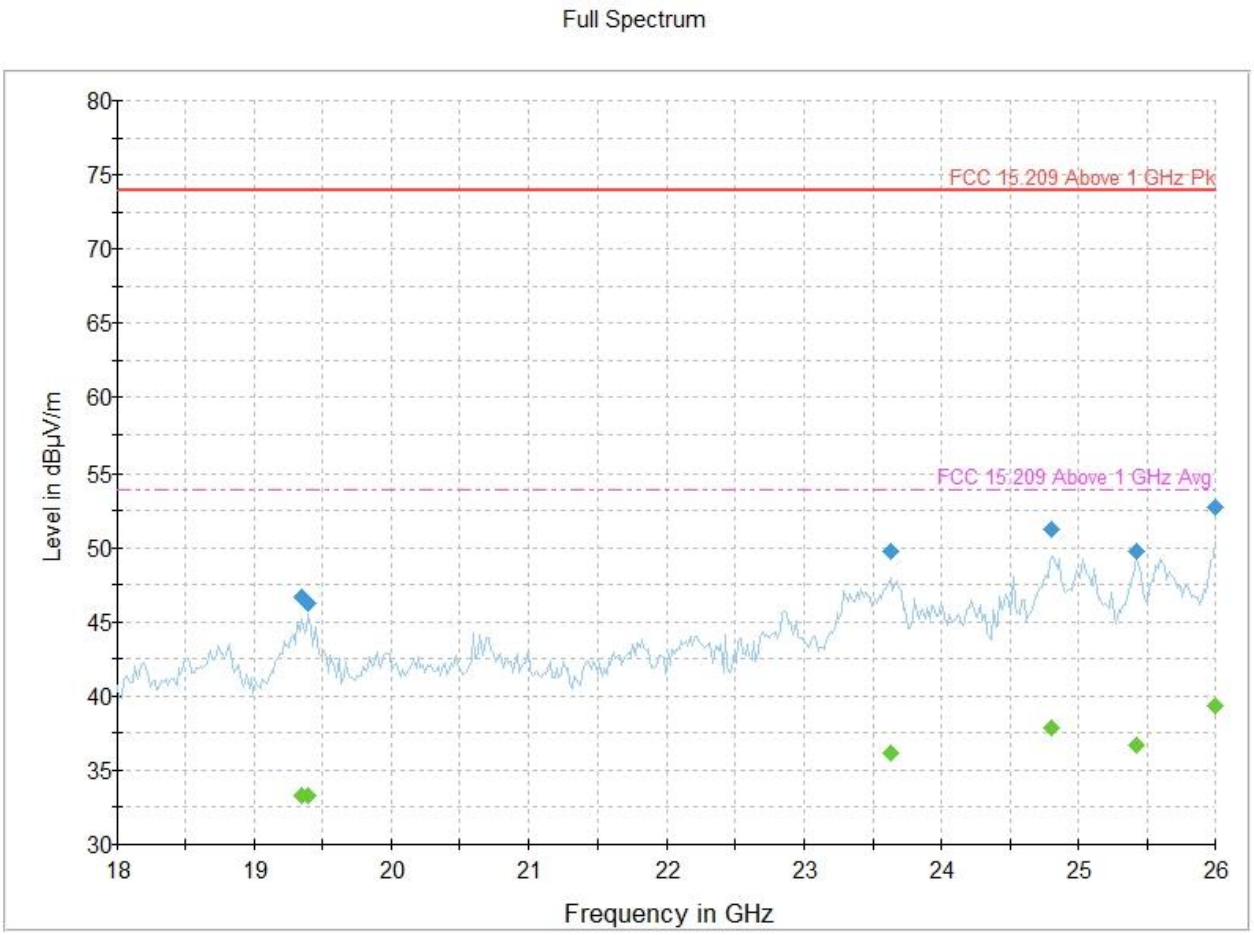

Figure 8.4-8: Radiated emissions, low channel, 18 - 26 GHz

Table 8.4-4: Radiated emissions, low channel, 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)
19339.293387	46.69	---	73.90	27.21	3000.0	1000.000	385.0	V	125.0	15.1
19339.293387	---	33.30	53.90	20.60	3000.0	1000.000	385.0	V	125.0	15.1
19392.589579	46.26	---	73.90	27.64	3000.0	1000.000	288.0	V	50.0	14.9
19392.589579	---	33.28	53.90	20.62	3000.0	1000.000	288.0	V	50.0	14.9
23630.254509	---	36.19	53.90	17.71	3000.0	1000.000	295.0	H	0.0	20.2
23630.254509	49.70	---	73.90	24.20	3000.0	1000.000	295.0	H	0.0	20.2
24807.027254	---	37.87	53.90	16.03	3000.0	1000.000	282.0	V	24.0	18.5
24807.027254	51.24	---	73.90	22.66	3000.0	1000.000	282.0	V	24.0	18.5
25424.645691	---	36.72	53.90	17.18	3000.0	1000.000	142.0	H	110.0	18.8
25424.645691	49.72	---	73.90	24.18	3000.0	1000.000	142.0	H	110.0	18.8
25999.800000	---	39.36	53.90	14.54	3000.0	1000.000	134.0	V	271.0	20.6
25999.800000	52.75	---	73.90	21.15	3000.0	1000.000	134.0	V	271.0	20.6

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.

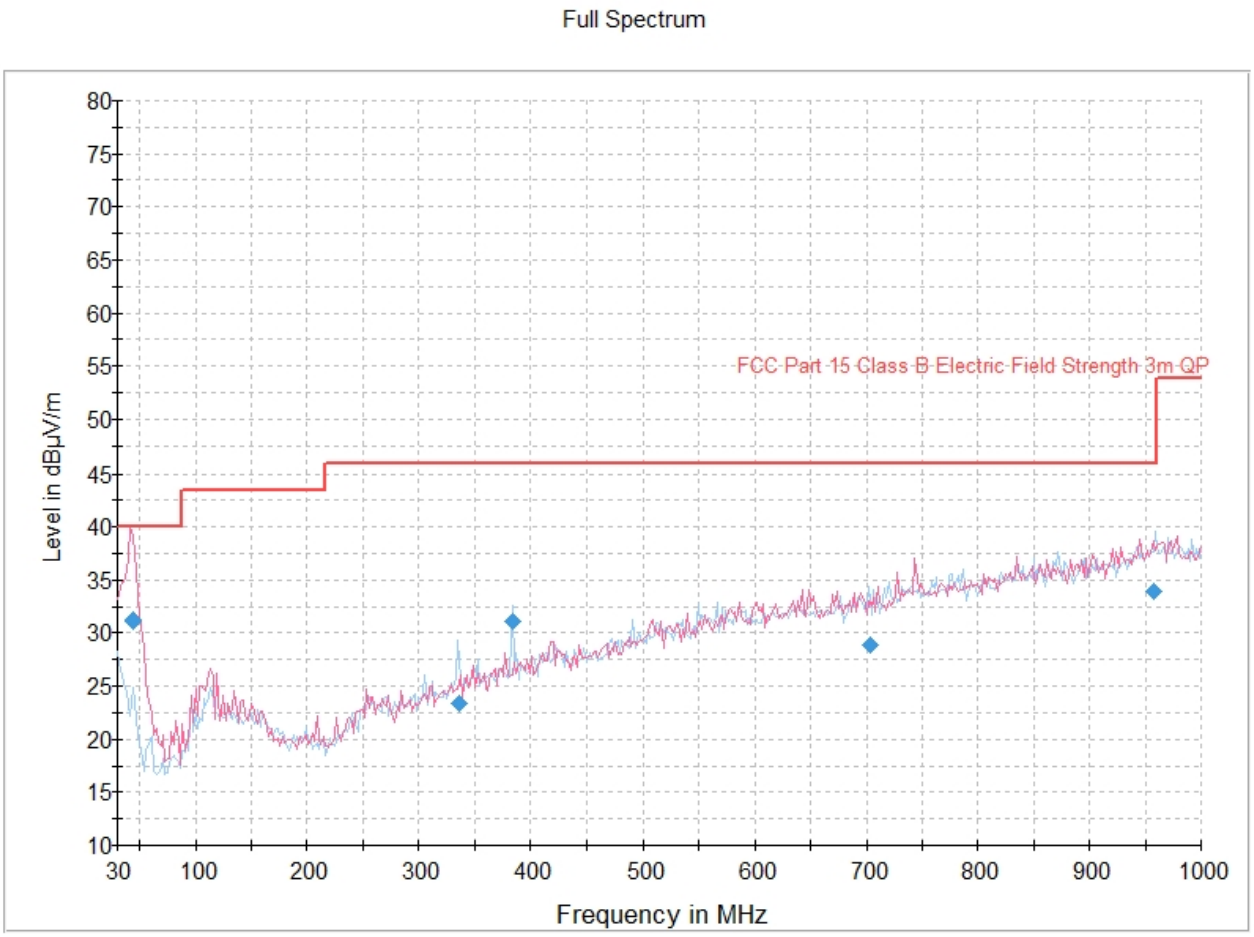

Figure 8.4-9: Radiated emissions, middle channel, 30 – 1000 MHz

Table 8.4-5: Radiated emissions, middle channel, 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)
43.727214	31.15	40.00	8.85	3000.0	120.000	100.0	V	353.0	18.9
43.743327	31.20	40.00	8.80	3000.0	120.000	100.0	V	339.0	18.9
335.950381	23.34	46.00	22.66	3000.0	120.000	268.0	H	225.0	22.8
383.987575	31.17	46.00	14.83	3000.0	120.000	100.0	H	-1.0	24.2
704.025170	28.90	46.00	17.10	3000.0	120.000	199.0	H	0.0	30.0
958.218357	33.90	46.00	12.10	3000.0	120.000	138.0	H	244.0	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.
The FCC Part 15 Class B limits are identical to the general limits of Part 15.209

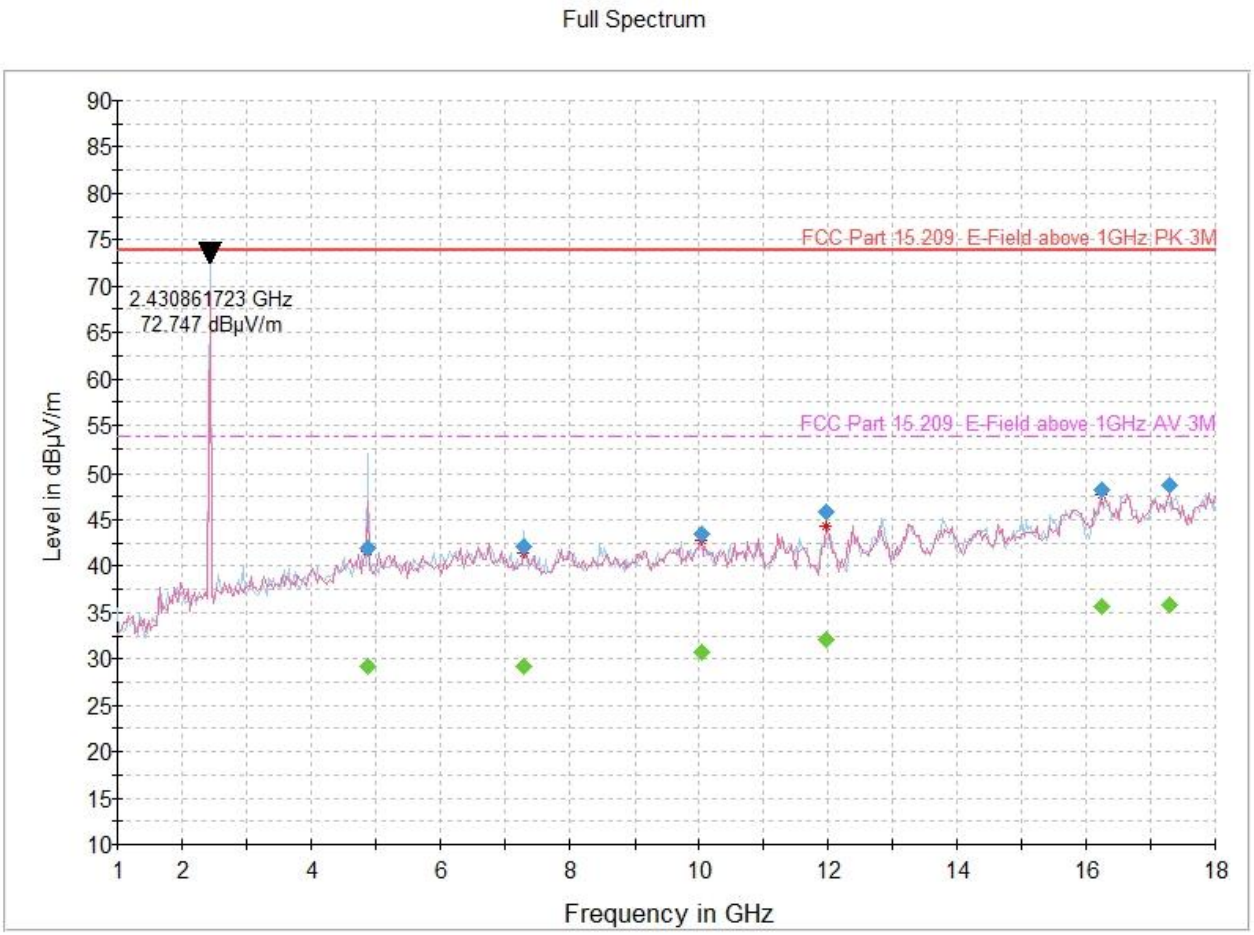

Figure 8.4-10: Radiated emissions, middle channel, 1 - 18 GHz

Table 8.4-6: Radiated emissions, middle channel, 1 - 18 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)
4783.163126	42.01	---	73.90	31.89	3000.0	1000.000	242.0	H	162.0	-2.6
4783.163126	---	29.07	53.90	24.83	3000.0	1000.000	242.0	H	162.0	-2.6
7205.200802	---	29.05	53.90	24.85	3000.0	1000.000	118.0	V	239.0	-1.0
7205.200802	41.83	---	73.90	32.07	3000.0	1000.000	118.0	V	239.0	-1.0
13300.597194	---	32.87	53.90	21.03	3000.0	1000.000	98.0	V	242.0	7.8
13300.597194	46.02	---	73.90	27.88	3000.0	1000.000	98.0	V	242.0	7.8
16598.806413	50.04	---	73.90	23.86	3000.0	1000.000	100.0	V	69.0	10.4
16598.806413	---	36.27	53.90	17.63	3000.0	1000.000	100.0	V	69.0	10.4
17284.569138	48.89	---	73.90	25.01	3000.0	1000.000	145.0	V	288.0	12.6
17284.569138	---	35.95	53.90	17.95	3000.0	1000.000	145.0	V	288.0	12.6
17828.059319	48.69	---	73.90	25.21	3000.0	1000.000	98.0	V	242.0	13.2
17828.059319	---	35.75	53.90	18.15	3000.0	1000.000	98.0	V	242.0	13.2

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.

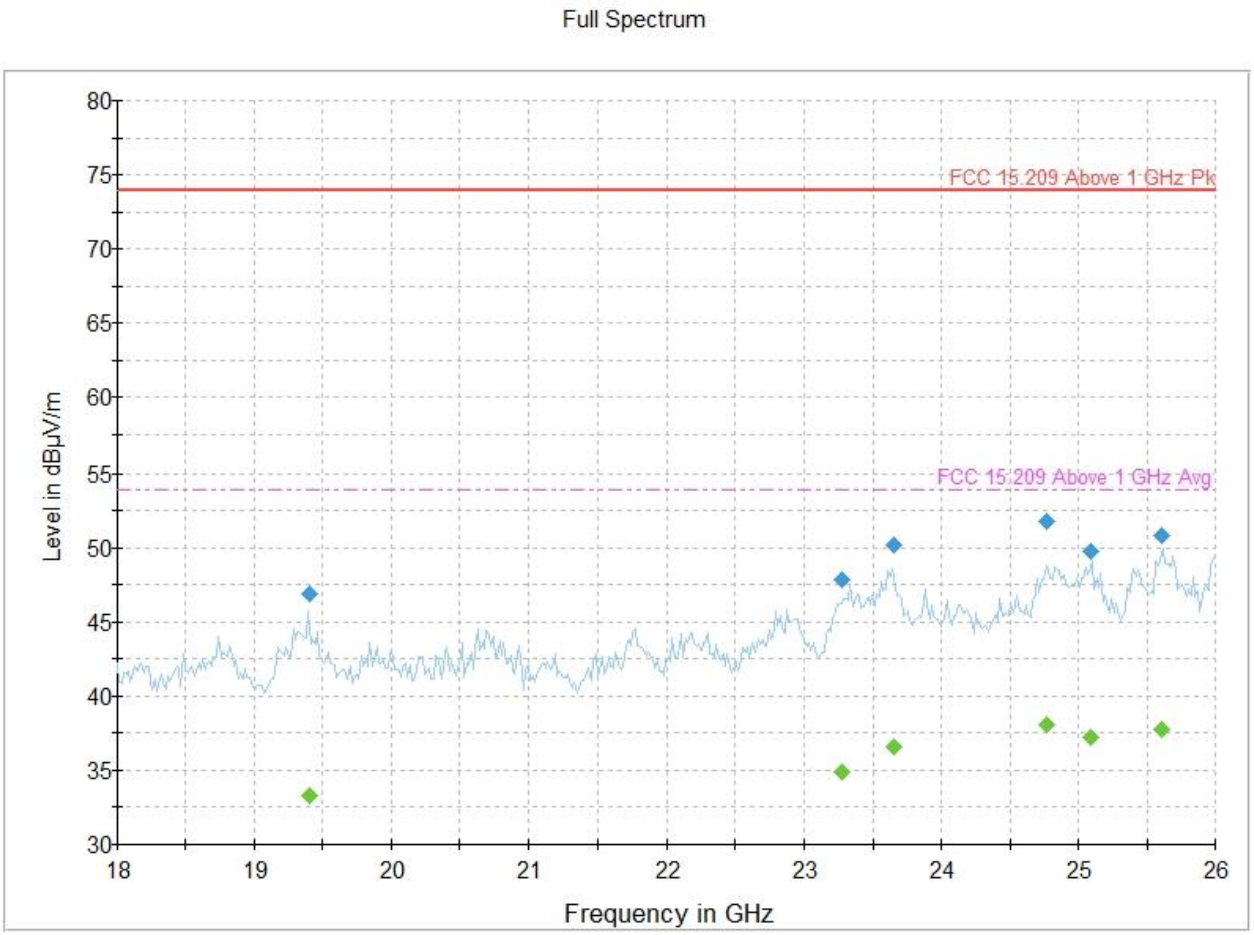

Figure 8.4-11: Radiated emissions, middle channel, 18 - 26 GHz

Table 8.4-7: Radiated emissions, middle channel, 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)
19339.293387	46.69	---	73.90	27.21	3000.0	1000.000	385.0	V	125.0	15.1
19339.293387	---	33.30	53.90	20.60	3000.0	1000.000	385.0	V	125.0	15.1
19392.589579	46.26	---	73.90	27.64	3000.0	1000.000	288.0	V	50.0	14.9
19392.589579	---	33.28	53.90	20.62	3000.0	1000.000	288.0	V	50.0	14.9
23630.254509	---	36.19	53.90	17.71	3000.0	1000.000	295.0	H	0.0	20.2
23630.254509	49.70	---	73.90	24.20	3000.0	1000.000	295.0	H	0.0	20.2
24807.027254	---	37.87	53.90	16.03	3000.0	1000.000	282.0	V	24.0	18.5
24807.027254	51.24	---	73.90	22.66	3000.0	1000.000	282.0	V	24.0	18.5
25424.645691	---	36.72	53.90	17.18	3000.0	1000.000	142.0	H	110.0	18.8
25424.645691	49.72	---	73.90	24.18	3000.0	1000.000	142.0	H	110.0	18.8
25999.800000	---	39.36	53.90	14.54	3000.0	1000.000	134.0	V	271.0	20.6
25999.800000	52.75	---	73.90	21.15	3000.0	1000.000	134.0	V	271.0	20.6

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.

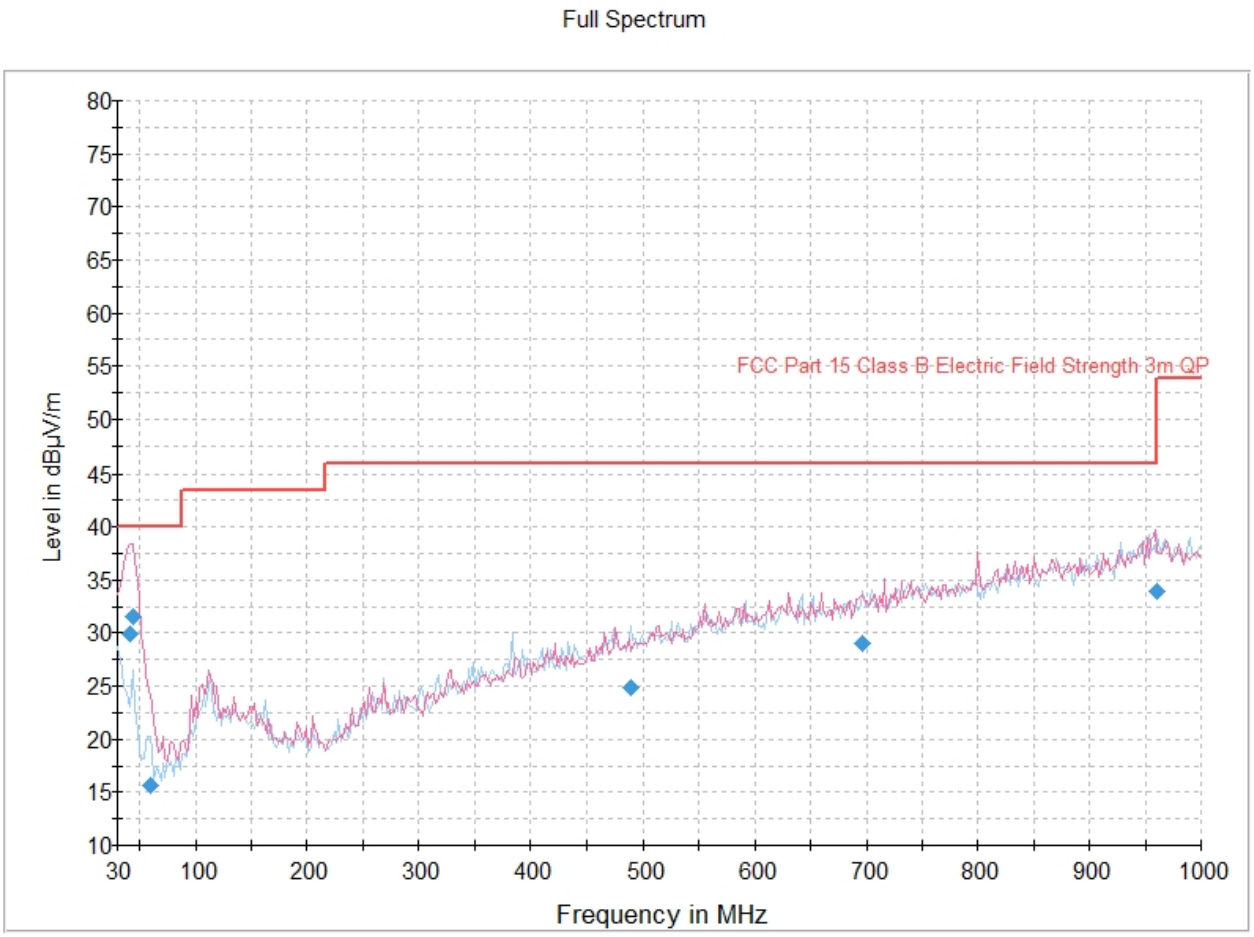

Figure 8.4-12: Radiated emissions, high channel, 30 – 1000 MHz

Table 8.4-8: Radiated emissions, high channel, 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)
41.743327	29.89	40.00	10.11	3000.0	120.000	110.0	V	12.0	20.0
44.367214	31.50	40.00	8.50	3000.0	120.000	100.0	V	0.0	18.6
59.142204	15.69	40.00	24.31	3000.0	120.000	162.0	V	227.0	12.6
488.477515	24.85	46.00	21.15	3000.0	120.000	223.0	H	175.0	26.4
696.993507	28.98	46.00	17.02	3000.0	120.000	218.0	H	305.0	30.1
960.618357	33.91	53.90	19.99	3000.0	120.000	392.0	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.
The FCC Part 15 Class B limits are identical to the general limits of Part 15.209

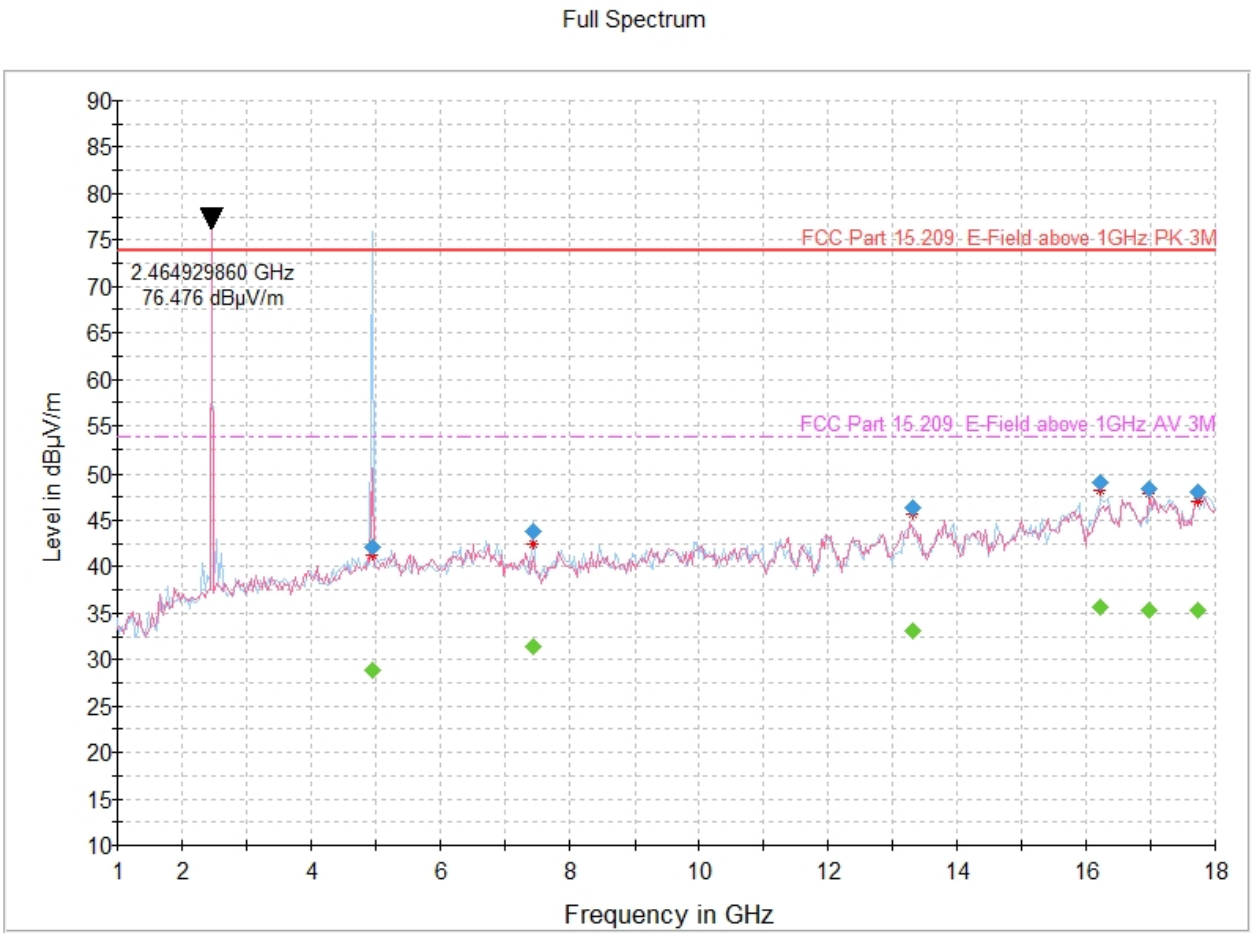

Figure 8.4-13: Radiated emissions, high channel, 1 - 18 GHz

Table 8.4-9: Radiated emissions, high channel, 1 - 18 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)
4954.303808	42.04	---	73.90	31.86	3000.0	1000.000	239.0	H	103.0	-3.0
4954.303808	---	28.92	53.90	24.98	3000.0	1000.000	239.0	H	103.0	-3.0
7440.877756	43.73	---	73.90	30.17	3000.0	1000.000	155.0	H	116.0	-0.1
7440.877756	---	31.42	53.90	22.48	3000.0	1000.000	155.0	H	116.0	-0.1
13305.397194	---	33.09	53.90	20.81	3000.0	1000.000	145.0	H	288.0	7.7
13305.397194	46.37	---	73.90	27.53	3000.0	1000.000	145.0	H	288.0	7.7
16228.056914	---	35.67	53.90	18.23	3000.0	1000.000	410.0	H	0.0	10.3
16228.056914	49.01	---	73.90	24.89	3000.0	1000.000	410.0	H	0.0	10.3
16974.355912	48.43	---	73.90	25.47	3000.0	1000.000	260.0	V	214.0	9.9
16974.355912	---	35.35	53.90	18.55	3000.0	1000.000	260.0	V	214.0	9.9
17729.854910	48.09	---	73.90	25.81	3000.0	1000.000	402.0	V	0.0	12.8
17729.854910	---	35.27	53.90	18.63	3000.0	1000.000	402.0	V	0.0	12.8

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.

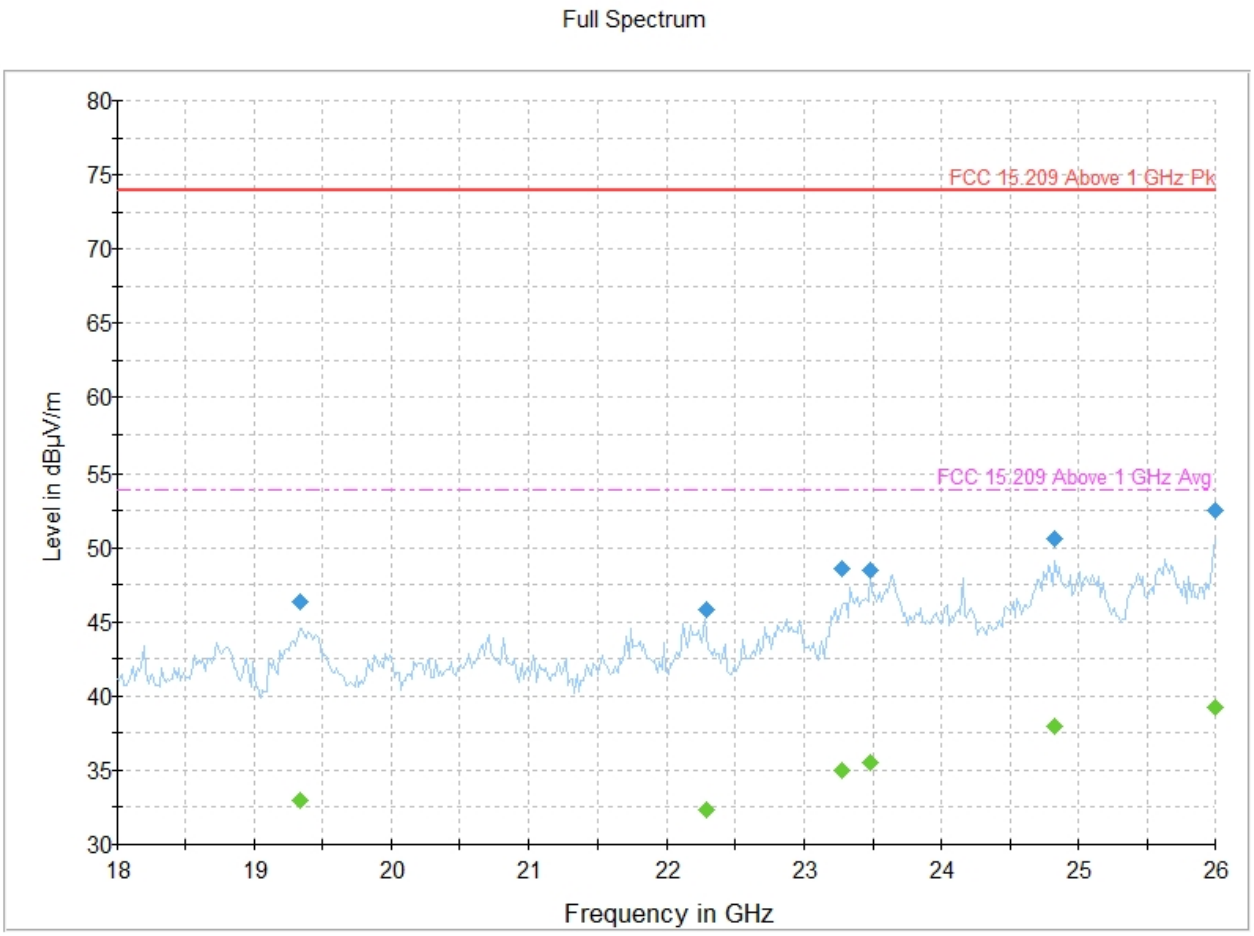

Figure 8.4-14: Radiated emissions, high channel, 18 - 26 GHz

Table 8.4-10: Radiated emissions, high channel, 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)
19332.461323	46.37	---	73.90	27.53	3000.0	1000.000	242.0	V	187.0	15.1
19332.461323	---	32.97	53.90	20.93	3000.0	1000.000	242.0	V	187.0	15.1
22282.361122	45.80	---	73.90	28.10	3000.0	1000.000	261.0	H	184.0	15.7
22282.361122	---	32.34	53.90	21.56	3000.0	1000.000	261.0	H	184.0	15.7
23278.749098	48.62	---	73.90	25.28	3000.0	1000.000	242.0	H	0.0	18.7
23278.749098	---	34.96	53.90	18.94	3000.0	1000.000	242.0	H	0.0	18.7
23480.365932	48.46	---	73.90	25.44	3000.0	1000.000	108.0	V	151.0	20.2
23480.365932	---	35.48	53.90	18.42	3000.0	1000.000	108.0	V	151.0	20.2
24827.459319	50.57	---	73.90	23.33	3000.0	1000.000	331.0	H	170.0	18.5
24827.459319	---	37.93	53.90	15.97	3000.0	1000.000	331.0	H	170.0	18.5
25999.800000	52.50	---	73.90	21.40	3000.0	1000.000	329.0	H	107.0	20.6
25999.800000	---	39.19	53.90	14.71	3000.0	1000.000	329.0	H	107.0	20.6

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.

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

8.5.1 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)

(b) 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).

8.5.2 Test summary

Verdict	Pass		
Test date	June 3, 2020	Temperature	21 °C
Test engineer	Juan Manuel Gonzalez	Air pressure	1002 mbar
Test location	Wireless bench	Relative humidity	51 %

8.5.3 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.

8.5.4 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless bench
Measurement details	Measurement performed as per C63.10 §11.10.2 (Peak PSD)

Receiver/spectrum analyzer settings:

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

8.5.5 Test data

Table 8.5-1: Power spectral density of DTS

Transmitter Frequency (MHz)	Measured Level (dBm/3 kHz)	Limit (dBm/3 kHz)	Margin (dB)
2400	-2.20	8.00	10.20
2441	-2.78	8.00	10.78
2480	-2.67	8.00	10.67

Notes: None

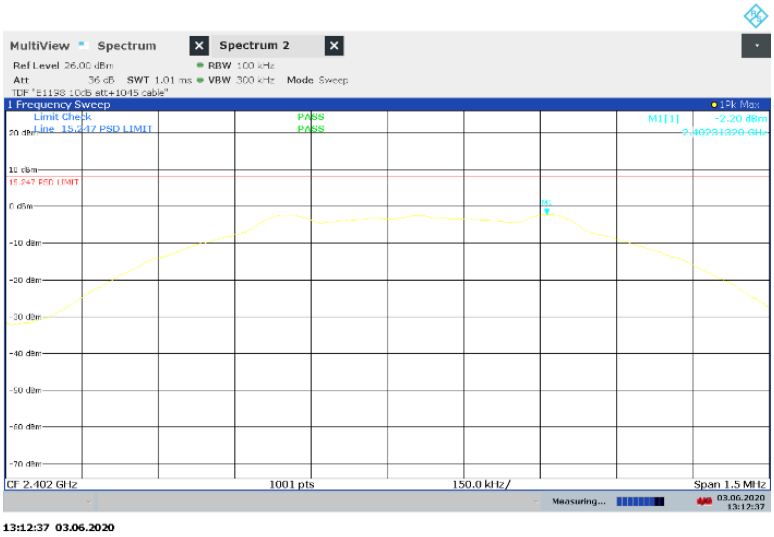

Figure 8.5-1: Power spectral density of digital transmission system, 2402 MHz

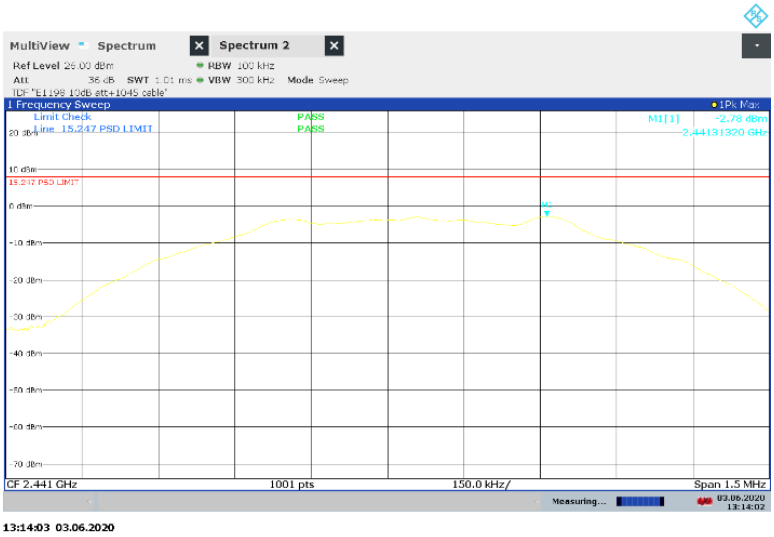

Figure 8.5-2: Power spectral density of digital transmission system, 2441 MHz

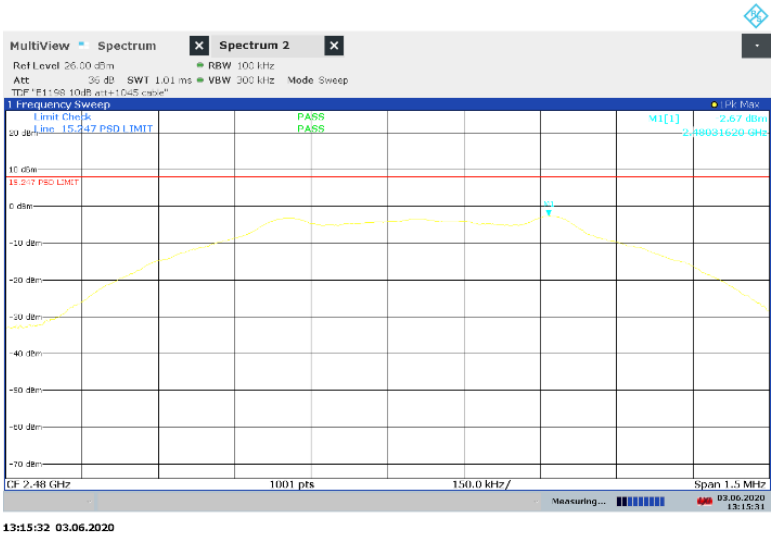

Figure 8.5-3: Power spectral density of digital transmission system, 2480 MHz

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

8.6.1 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.

8.6.2 Test summary

Verdict	Pass		
Test date	June 1, 2020	Temperature	22 °C
Test engineer	Juan Manuel Gonzalez	Air pressure	1002 mbar
Test location	Wireless bench	Relative humidity	49 %

8.6.3 Notes

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

8.6.4 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

8.6.5 Test data

Test Frequency (MHz)	99%Bandwidth
2402	1.0753
2441	1.0786
2480	1.0835

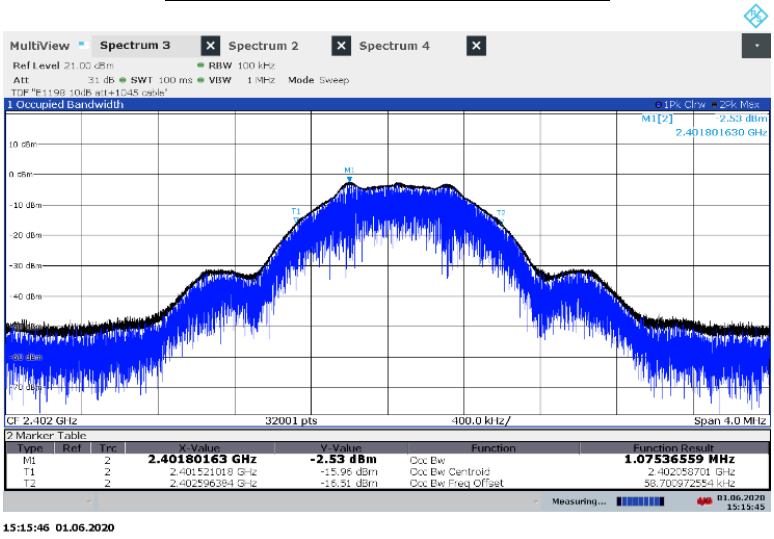

Figure 8.6-1: 99% bandwidth, 2402 MHz

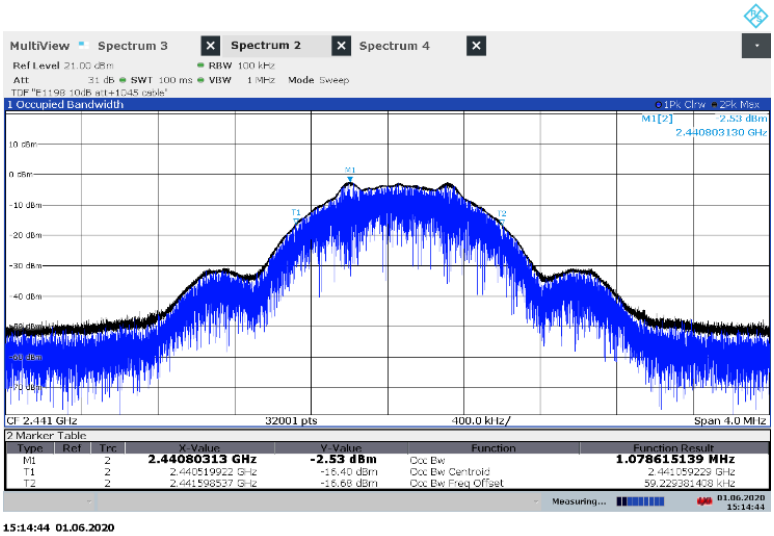

Figure 8.6-2: 99% bandwidth, 2441 MHz

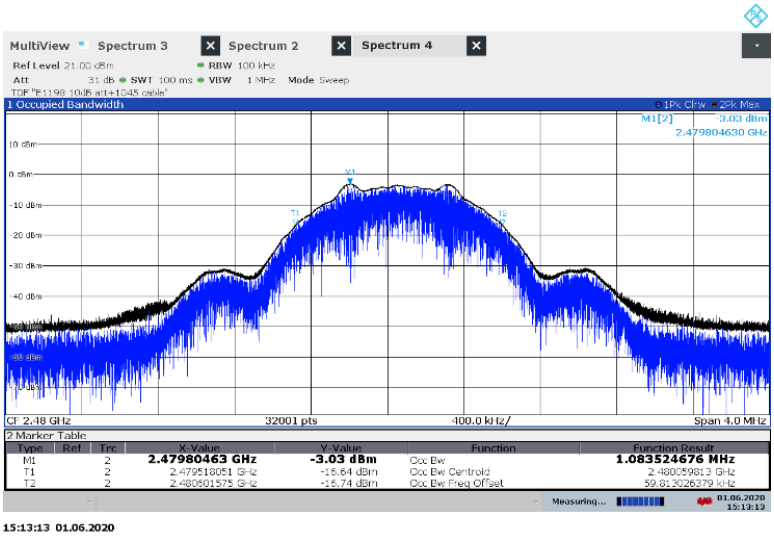

Figure 8.6-3: 99% bandwidth, 2480 MHz

Section 9 Block diagrams of test set-ups

9.1 Radiated emissions set-up

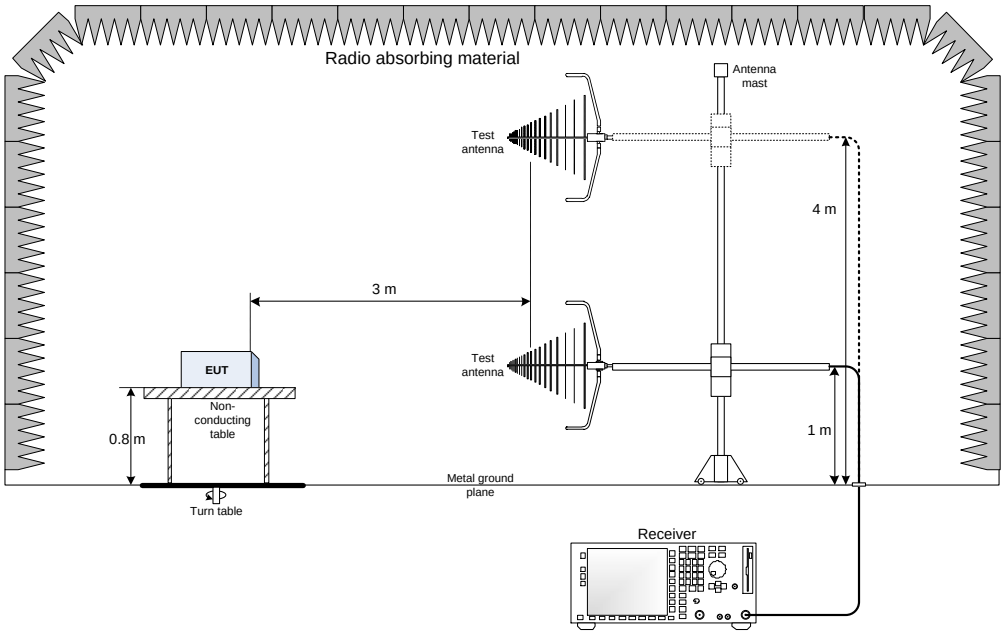

Figure 9.1-1 30 MHz - 1000 MHz Setup

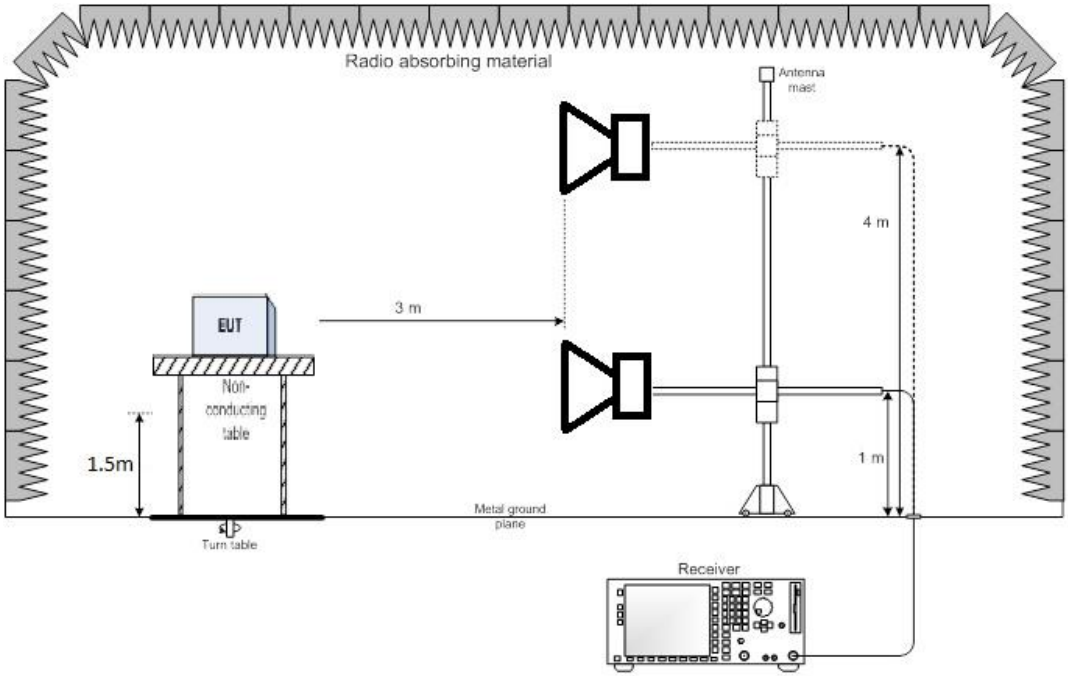

Figure 9.1-2 1 GHz - 26 GHz Setup

Thank you for choosing