Test report

409642-2TRFWL

Date of issue: December 4, 2020

Applicant:
Wagz, Inc.

Product:
Explore Smart Collar

Model:
Freedom Collar

FCC ID: 2ASHHSP03000ML008 IC ID: TBD

Specifications:

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

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NVLAP TESTING NVLAP LAB CODE 200116-0

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FCC Site Number	Test Firm Registration Number: 392943 Designation Number: US5058
ISED Test Site	2040B-3

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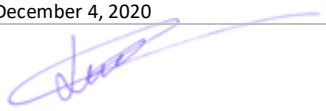
Tested by	James Cunningham, EMC/MIL/WL Supervisor
Reviewed by	Juan M Gonzalez, EMC & Wireless Divisions Manager
Review date	December 4, 2020
Reviewer signature	

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.
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Section 1 Report summary

1.1 Applicant

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

1.2 Manufacturer

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

1.3 Test specifications

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

1.4 Test methods

ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
558074 D01 DTS Measurement Guidance v03r02 (June 5, 2014)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

1.5 Exclusions

None

1.6 Statement of compliance

In the configuration tested, the EUT was found compliant.

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

See "Summary of test results" for full details.

1.7 Test report revision history

Table 1.7-1: *Test report revision history*

Revision #	Details of changes made to test report
409642-2TRFWL	Original report issued

Notes: None

Section 2 Summary of test results

2.1 FCC Part 15 Subpart C, general requirements

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

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

2.2 FCC Part 15.247

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

2.3 IC RSS-247, Issue 2

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

2.4 IC RSS-GEN, Issue 5

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

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

Section 3 Equipment under test (EUT) details

3.1 Sample information

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

3.2 EUT information

Product name	Explore Smart Collar
Model	SP03000ML008 (Freedom Collar)
Serial number	2042231015
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)	2412
Maximum frequency (MHz)	2462
Minimum output power (dBm)	11.44 (e.i.r.p.)
Maximum output power (dBm)	11.85 (e.i.r.p.)
Measured 6 dB bandwidth	2412MHz: 7590 kHz for 802.11b, 16444 kHz for 802.11g, 17163 kHz for 802.11n 2442 MHz: 7610 kHz for 802.11b, 16444 kHz for 802.11g, 17143 kHz for 802.11n 2462 MHz: 7592 kHz for 802.11b, 16424 kHz for 802.11g, 17123 kHz for 802.11n
Type of modulation	802.11b 1Mbps, 802.11g 6Mbps, 802.11n MCS0
Power requirements	3.8 V_{DC} battery
Antenna information	-4.5 dBi antenna gain on PCB

3.4 EUT exercise and monitoring details

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

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

Table 3.4-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number	Rev.
Test sample	Wagz, Inc.	Freedom Collar	2042231015	N/A

Table 3.4-2: *EUT interface ports*

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

Table 3.4-3: *Support equipment*

Description	Brand name	Model/Part number	Serial number	Rev.
Laptop	Dell	Inspiron 5548	9K643SS	N/A
3.8 V_{DC} battery	Samsung	INR18650-30Q	N/A	N/A

Table 3.4-4: *Inter-connection cables*

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

3.5 EUT setup diagram

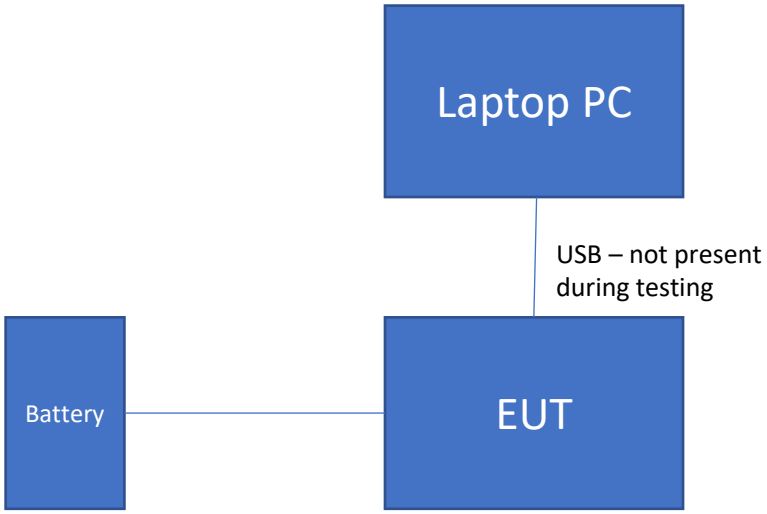


Figure 3.5-1: *Setup diagram*

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	2 yr	29 May 2021
Signal and Spectrum Analyzer	Rohde & Schwarz	FSV 40	E1120	2 yr	19 Nov 2021
Signal and spectrum analyzer	Rohde & Schwarz	FSW	E1302	1 yr	18 Sep 2021
Power sensor	ETS Lindgren	7002-006	E1061	1 yr	1 Dec 2020
EMI Test Receiver	Rohde & Schwarz	ESU40	E1121	1 yr	25 Nov 2020
EMI Test Receiver (newly calibrated)	Rohde & Schwarz	ESU40	E1121	1 yr	1 Dec 2021
System Controller	Sunol Sciences	SC104V	E1129	NCR	NCR
Bilog Antenna	Schaffner	CBL6111C	1480	1 yr	28 Oct 2021
DRG Horn (1-18 GHz)	ETS-Lindgren	3117-PA	E1139	2 yr	21 Mar 2021
2.4 GHz Notch Filter	Micro-Tonics	HPM50110-01	E1142	NCR	NCR
Low Noise Amplifier	Sage Millimeter, Inc.	SBL-1834034030-KFKF	E1228	1 yr	17 Nov 2021
DRG Horn (18-40 GHz)	EMCO	3116	E1013	2 yr	30 Sep 2020
Horn antenna (18-26 GHz)	Sage Millimeter, Inc.	SAR-2309-42-S2	E1143	2 yr	13 Nov 2022

Notes: NCR - no calibration required

Table 6.1-2: *Test Software*

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.00.00 (radiated emissions, 10m chamber)

Notes: None

Section 8 Testing data

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

8.1.1 Definition and limits

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

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

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

8.1.2 Test summary

Verdict	Pass		
Test date	November 11, 2020	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1007 mbar
Test location	Wireless workbench	Relative humidity	31 %
Test date	November 24, 2020	Temperature	22 °C
Test engineer	James Cunningham, EMC/MIL/WL Supervisor	Air pressure	1003 mbar
Test location	Wireless workbench	Relative humidity	53 %

8.1.1 Notes

6 dB occupied bandwidth measured at low, mid, and high channels at each modulation scheme. For 802.11g and 802.11n modulations, the delta marker function was used to find the occupied bandwidth.

8.1.2 Setup details

EUT setup configuration	Table top
Test facility	Nemko San Diego
Measurement method	558074 D01 DTS Measurement Guidance §8.2 ANSI C63.10 §11.8.1 using built-in marker function of the spectrum analyzer

Receiver/spectrum analyzer settings:

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

8.1.3 Test data

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

Test Frequency (MHz)		Bandwidth (kHz)	Limit (kHz)	Margin (kHz)
2412	1 Mbps	7590	> 500	7090
2412	6 Mbps	16444	> 500	15944
2412	MCS0	17163	> 500	16663
2442	1 Mbps	7610	> 500	7110
2442	6 Mbps	16444	> 500	15944
2442	MCS0	17143	> 500	16643
2462	1 Mbps	7592	> 500	7092
2462	6 Mbps	16424	> 500	15924
2462	MCS0	17123	> 500	16623

8.1.5 Test data, continued

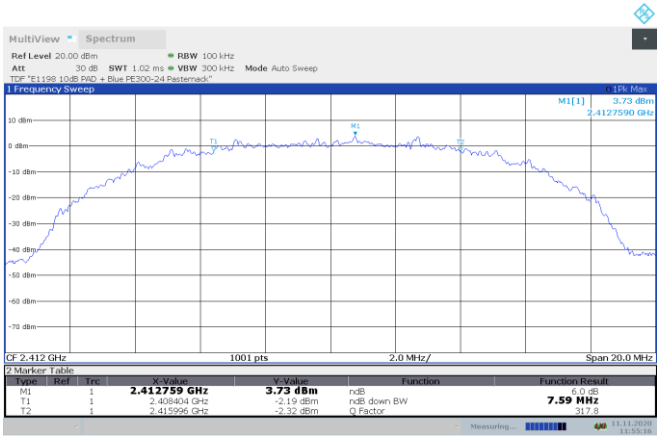


Figure 8.1-1: *6 dB occupied bandwidth, 2412 MHz, 802.11b modulation*

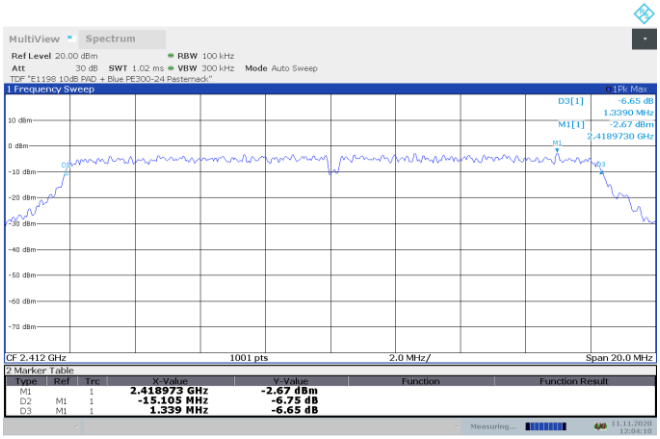


Figure 8.1-2: *6 dB occupied bandwidth, 2412 MHz, 802.11g modulation*

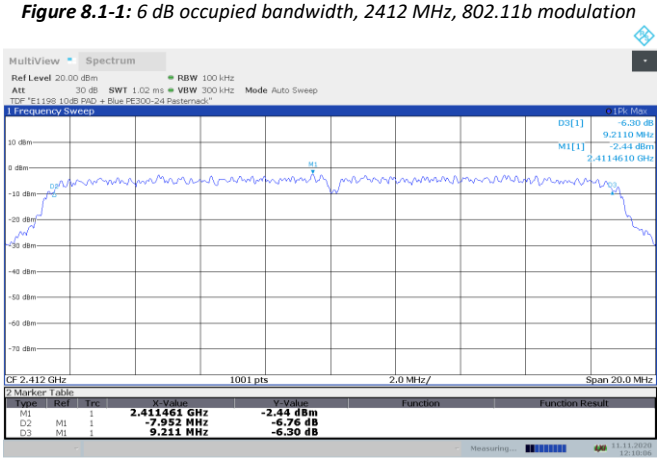


Figure 8.1-3: *6 dB occupied bandwidth, 2412 MHz, 802.11n modulation*

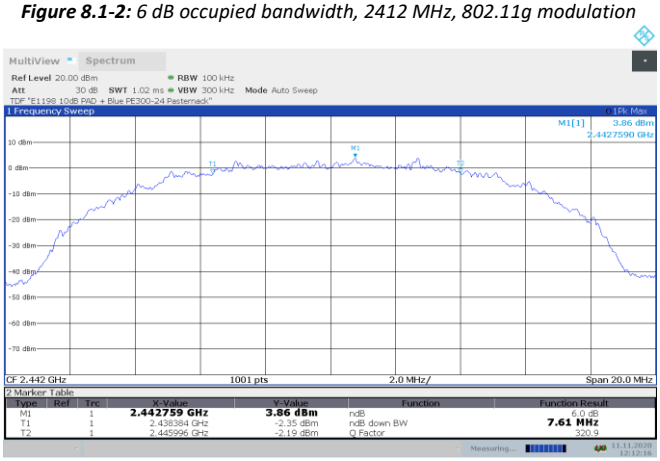


Figure 8.1-4: *6 dB occupied bandwidth, 2442 MHz, 802.11b modulation*

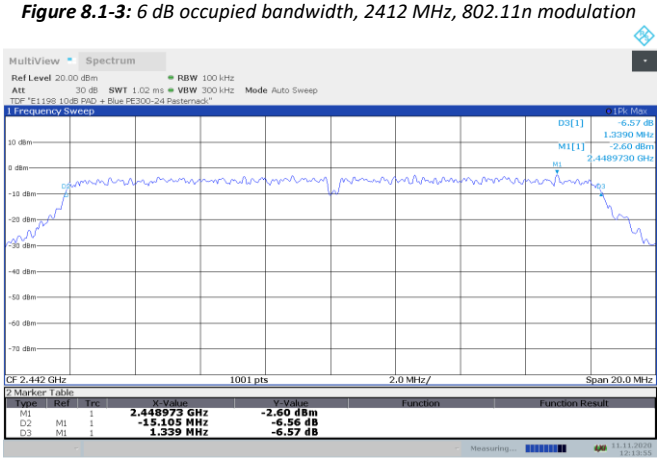


Figure 8.1-5: *6 dB occupied bandwidth, 2442 MHz, 802.11g modulation*

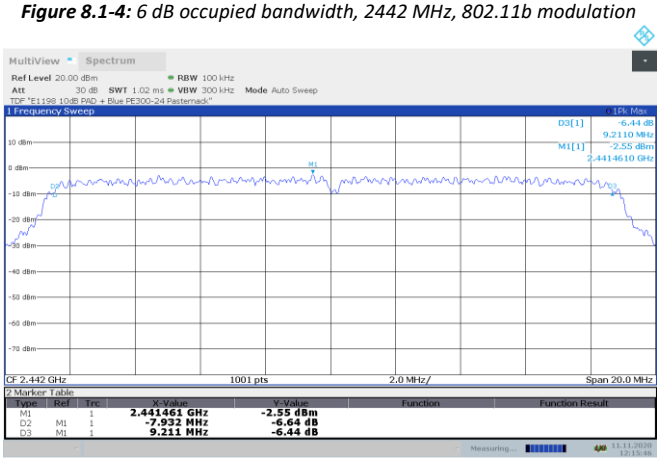


Figure 8.1-6: *6 dB occupied bandwidth, 2442 MHz, 802.11n modulation*

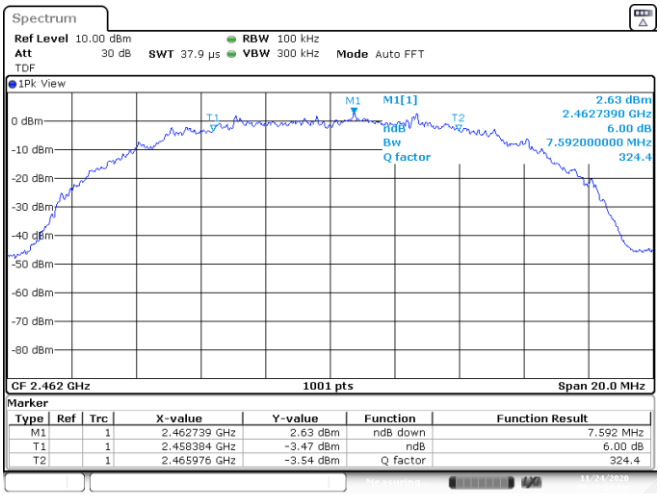


Figure 8.1-7: *6 dB occupied bandwidth, 2462 MHz, 802.11b modulation*

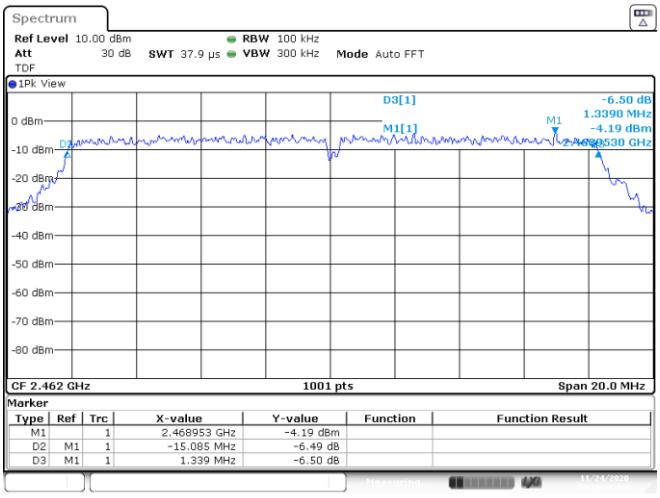


Figure 8.1-8: *6 dB occupied bandwidth, 2462 MHz, 802.11g modulation*

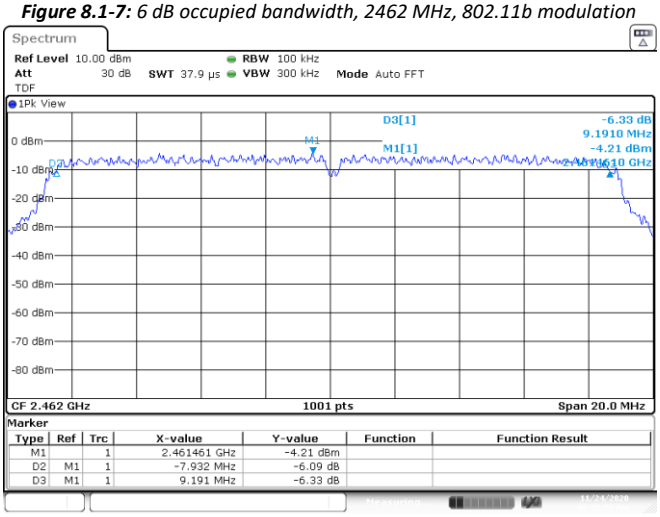


Figure 8.1-9: *6 dB occupied bandwidth, 2462 MHz, 802.11n modulation*

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

8.2.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(b)(3) / (4)

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

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

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

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

RSS-247 → §5.4(d)

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

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

8.2.2 Test summary

Verdict	Pass		
Test date	November 24, 2020	Temperature	22 °C
Test engineer	James Cunningham, EMC/MIL/WL Supervisor	Air pressure	1003 mbar
Test location	Wireless bench	Relative humidity	53 %

8.2.3 Notes

Testing was performed in WiFi 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.

8.2.4 Setup details

EUT setup configuration	Table top
Test facility	Nemko San Diego
Measurement method	ANSI C63.10 §11.9.1.2 Integrated band power method

8.2.5 Test data

Table 8.2-1: *Maximum peak conducted output power*

Test Frequency	Modulation scheme	Data rate	Maximum peak conducted output power limit (1 W = 30 dBm)	Antenna Gain (dBi)	Measured output	EIRP Total (dBm)	EIRP Margin
2412	802.11b	1 Mbps	30.0	-4.5	16.03	11.53	18.47
2412	802.11g	6 Mbps	30.0	-4.5	15.94	11.44	18.56
2412	802.11n	MCS0	30.0	-4.5	16.20	11.70	18.30
2442	802.11b	1 Mbps	30.0	-4.5	16.20	11.70	18.30
2442	802.11g	6 Mbps	30.0	-4.5	16.23	11.73	18.27
2442	802.11n	MCS0	30.0	-4.5	16.35	11.85	18.15
2462	802.11b	1 Mbps	30.0	-4.5	16.23	11.73	18.27
2462	802.11g	6 Mbps	30.0	-4.5	16.32	11.82	18.18
2462	802.11n	MCS0	30.0	-4.5	16.28	11.78	18.22

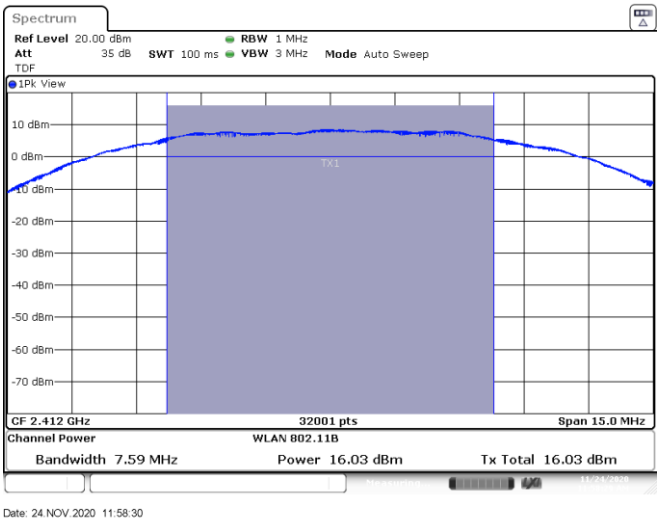


Figure 8.2-1: Integrated band power, 2412 MHz, 802.11b

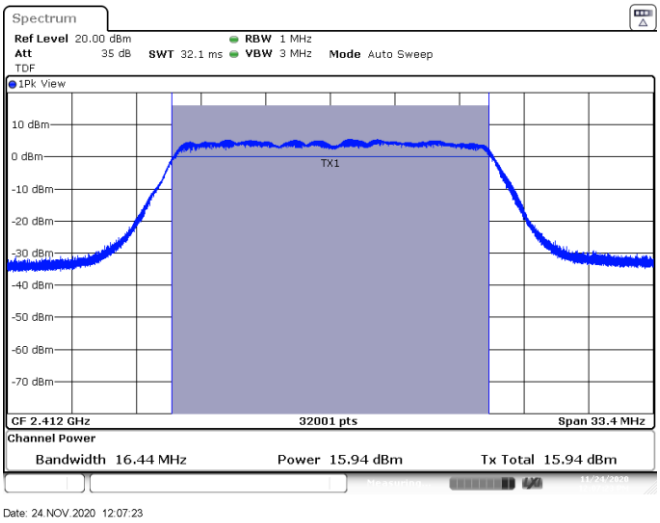


Figure 8.2-2: Integrated band power, 2412 MHz, 802.11g

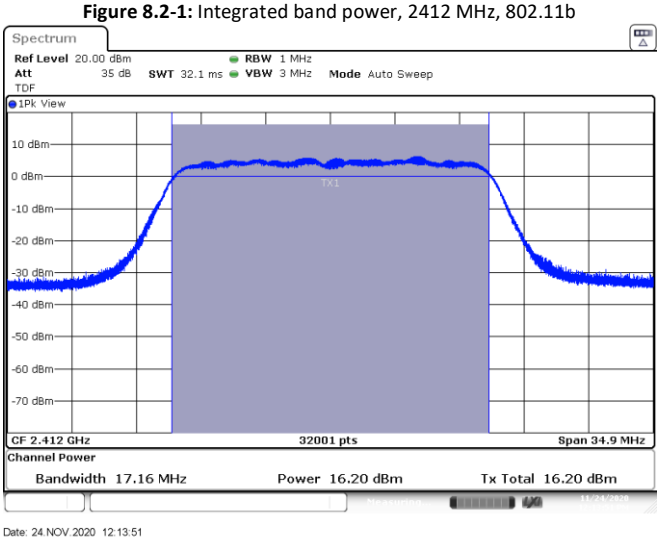


Figure 8.2-3: Integrated band power, 2412 MHz, 802.11n

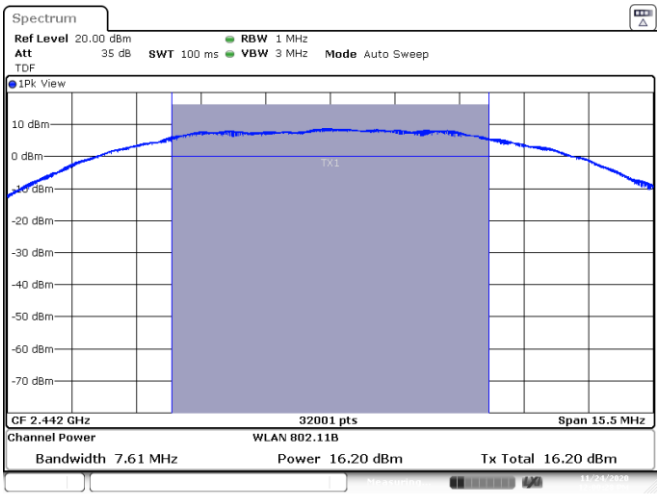


Figure 8.2-4: Integrated band power, 2442 MHz, 802.11b

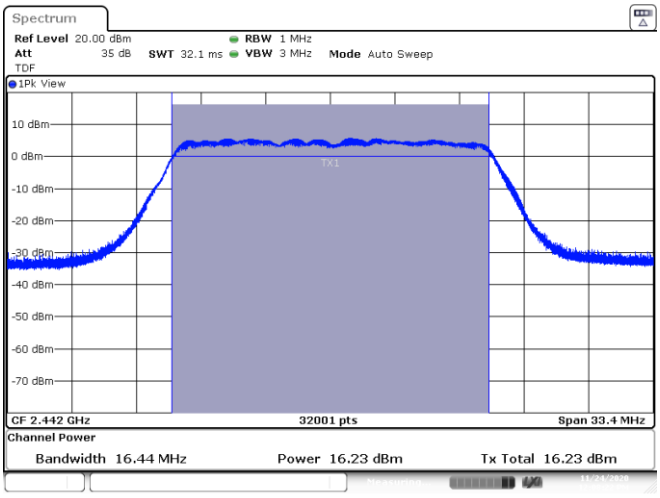


Figure 8.2-5: Integrated band power, 2442 MHz, 802.11g

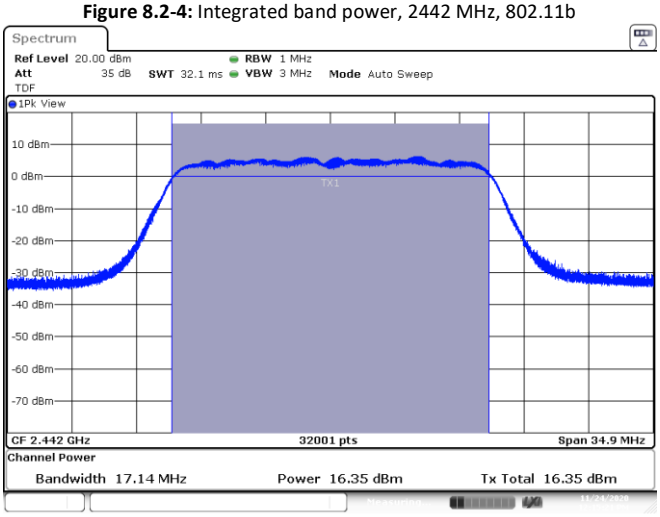


Figure 8.2-6: Integrated band power, 2442 MHz, 802.11n

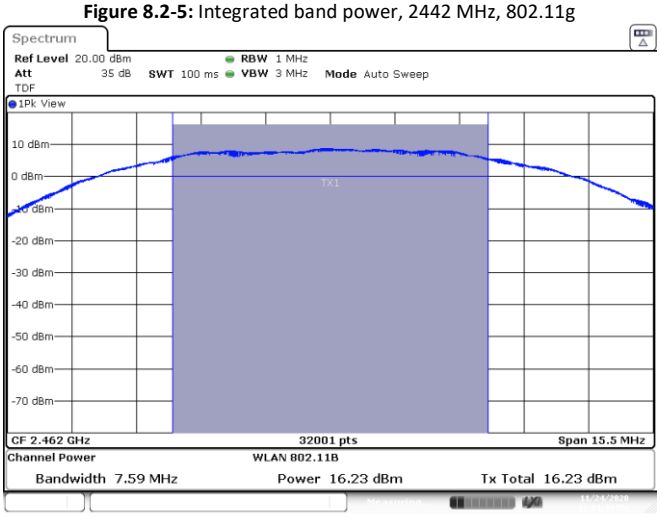


Figure 8.2-7: Integrated band power, 2462 MHz, 802.11b

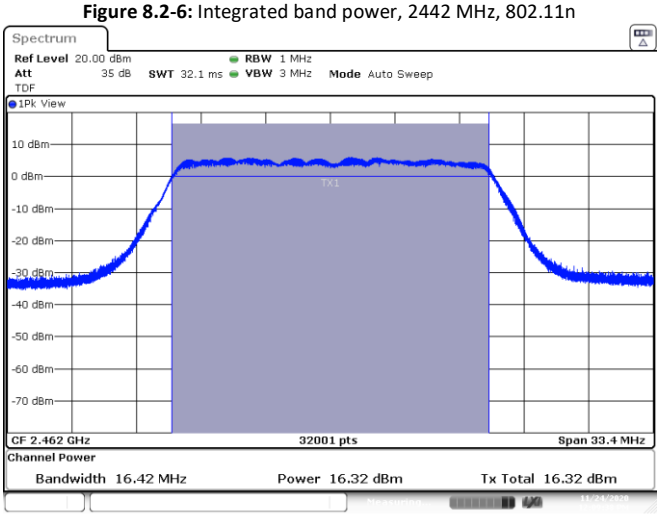


Figure 8.2-8: Integrated band power, 2462 MHz, 802.11g

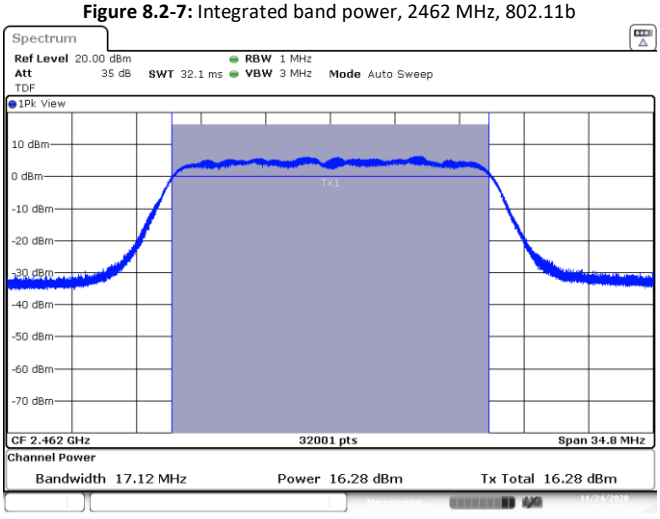


Figure 8.2-9: Integrated band power, 2462 MHz, 802.11n

8.3 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) emissions

8.3.1 Definition and limits

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

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

RSS-247 → §5.5

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

Table 8.3-1: *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 8.3-2: *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			

8.3.2 Test summary

Verdict	Pass		
Test date	November 24, 2020 (Conducted)	Temperature	21 °C
Test engineer	James Cunningham, EMC/MIL/WL Supervisor (Conducted)	Air pressure	1009 mbar
Test location	Wireless bench (Conducted)	Relative humidity	28 %
Test date	November 11, 2020 (Radiated)	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist (Radiated)	Air pressure	1006 mbar
Test location	10m semi-anechoic chamber (Radiated)	Relative humidity	30 %
Test date	November 13, 2020 (Radiated)	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist (Radiated)	Air pressure	1009 mbar
Test location	10m semi-anechoic chamber (Radiated)	Relative humidity	51 %
Test date	November 23, 2020 (Radiated)	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist (Radiated)	Air pressure	1003 mbar
Test location	10m semi-anechoic chamber (Radiated)	Relative humidity	53 %
Test date	November 25, 2020 (Radiated)	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist (Radiated)	Air pressure	1003 mbar
Test location	10m semi-anechoic chamber (Radiated)	Relative humidity	53 %
Test date	November 30, 2020 (Radiated)	Temperature	21 °C
Test engineer	David Hewitt, EMC Specialist (Radiated)	Air pressure	1009 mbar
Test location	10m semi-anechoic chamber (Radiated)	Relative humidity	28 %
Test date	December 2, 2020 (Radiated)	Temperature	21 °C
Test engineer	David Hewitt, EMC Specialist (Radiated)	Air pressure	1009 mbar
Test location	10m semi-anechoic chamber (Radiated)	Relative humidity	22 %

8.3.3 Notes

The EUT was configured to transmit continuously on the low, middle, and highest channels. The spectrum was search from 30 MHz to 26 GHz (above the 10th harmonic of the highest transmit frequency of 2462 MHz). Radiated measurements were performed at a 3 m measurement distance. For conducted measurements, the loss of the connected cable and attenuator was input into the spectrum analyzer as a transducer factor.

8.3.4 Setup details

EUT setup configuration	Tabletop
Test facility	Nemko San Diego
Measurement details	Conducted band edge measurement performed as per C63.10 §6.10.4 Conducted spurious emissions measurement performed as per C63.10 §11.11 Radiated spurious emissions measurement performed as per C63.10 §11.12

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)

8.3.5 Test data

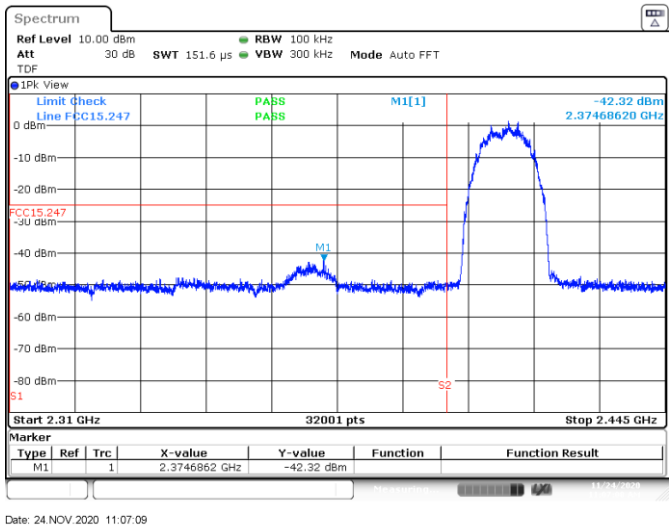


Figure 8.3-1: *Band edge measurement, 2412 MHz channel with 802.11b modulation*

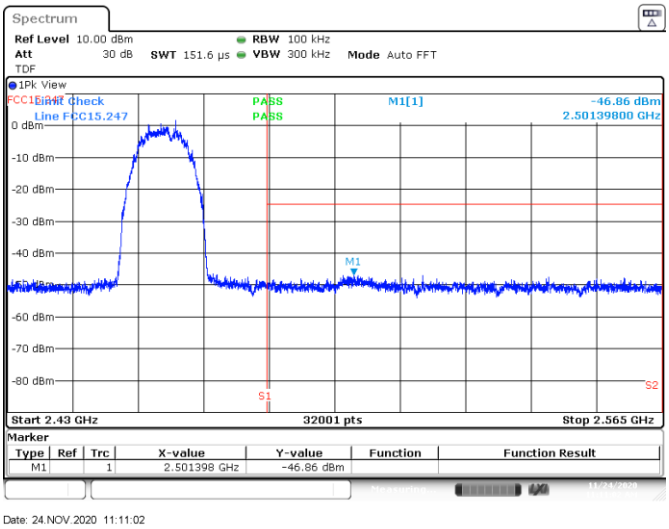


Figure 8.3-2: *Band edge measurement, 2462 MHz channel with 802.11b modulation*

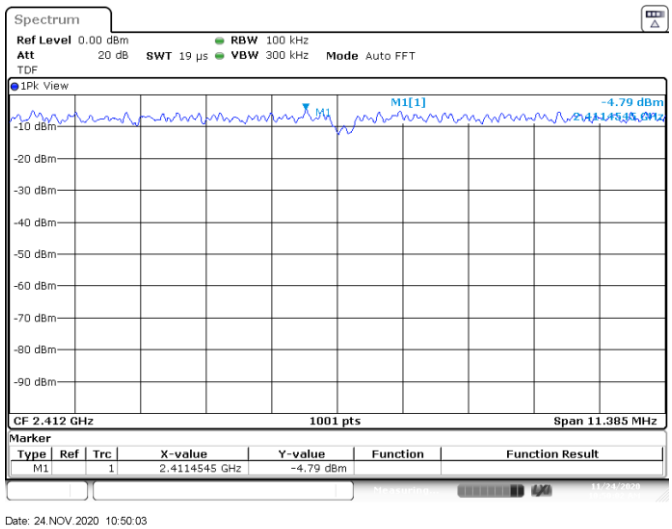


Figure 8.3-3: *Reference level measurement (C63.10 §11.11.2), 2412 MHz channel with 802.11b modulation*

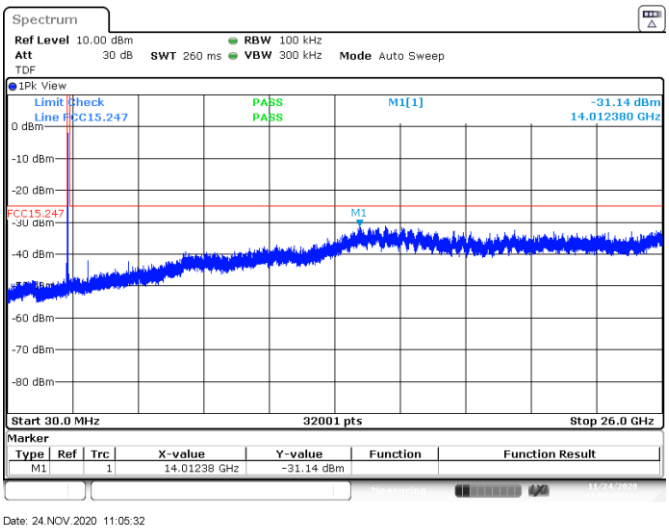


Figure 8.3-4: *Conducted spurious emissions (C63.10 §11.11.3), 2412 MHz channel with 802.11b modulation*

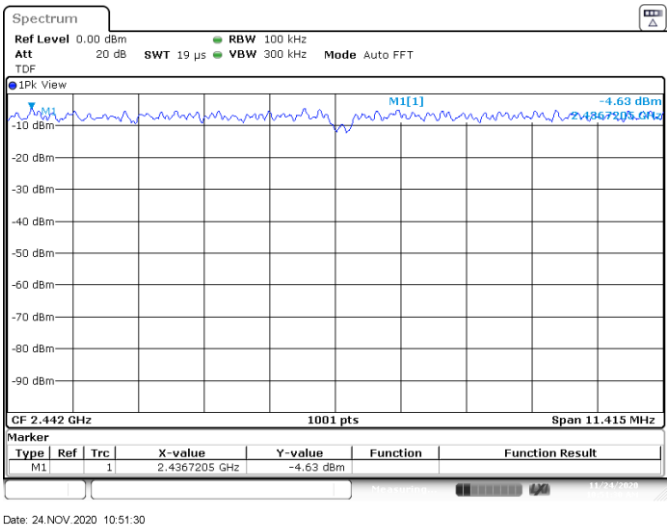


Figure 8.3-5: *Reference level measurement (C63.10 §11.11.2), 2442 MHz channel with 802.11b modulation*

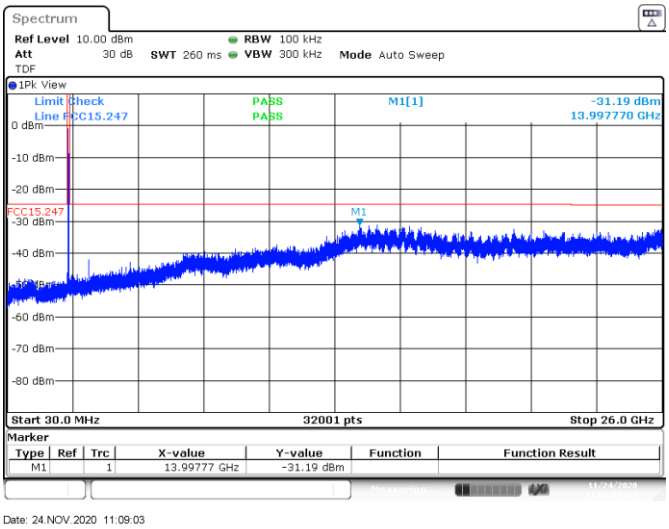


Figure 8.3-6: *Conducted spurious emissions (C63.10 §11.11.3), 2442 MHz channel with 802.11b modulation*

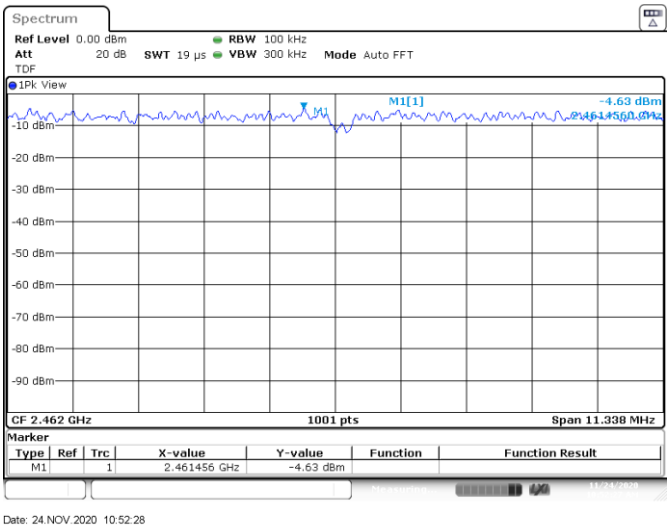


Figure 8.3-7: *Reference level measurement (C63.10 §11.11.2), 2462 MHz channel with 802.11b modulation*

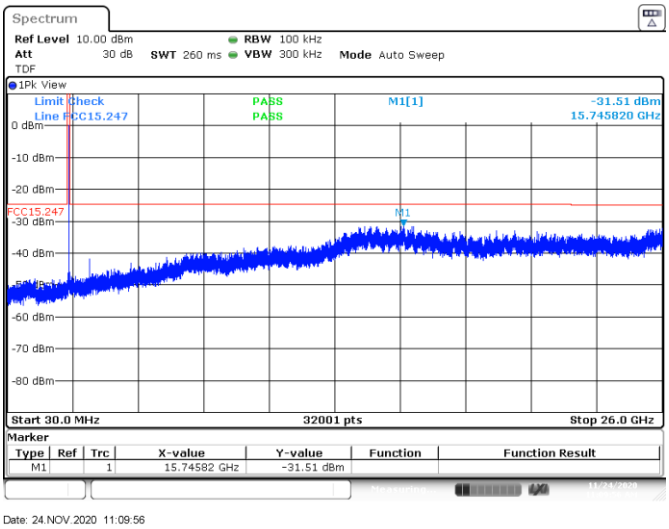


Figure 8.3-8: *Conducted spurious emissions (C63.10 §11.11.3), 2462 MHz channel with 802.11b modulation*

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

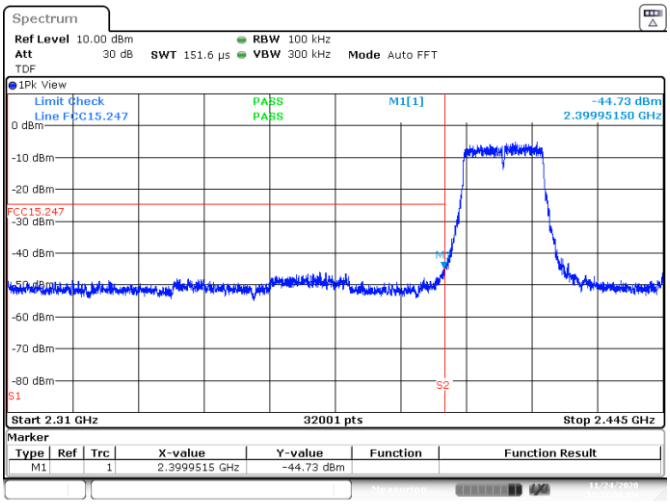


Figure 8.3-9: *Band edge measurement, 2412 MHz channel with 802.11g modulation*

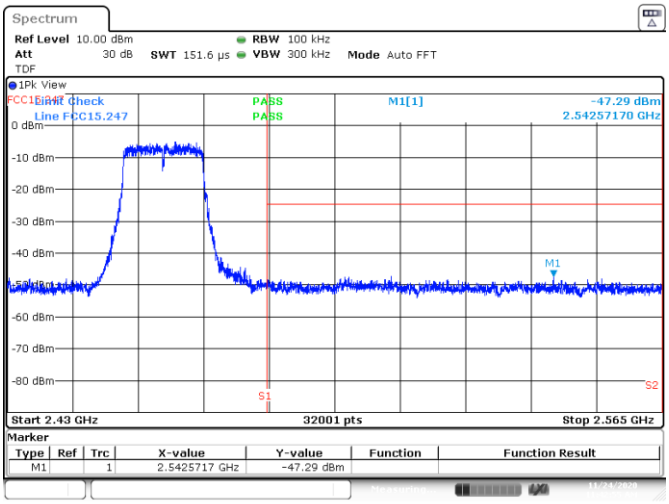


Figure 8.3-10: *Band edge measurement, 2462 MHz channel with 802.11g modulation*

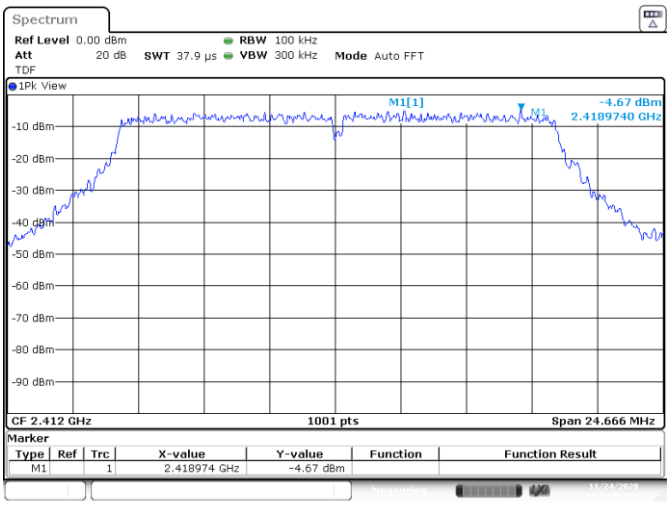


Figure 8.3-11: *Reference level measurement (C63.10 §11.11.2), 2412 MHz channel with 802.11g modulation*

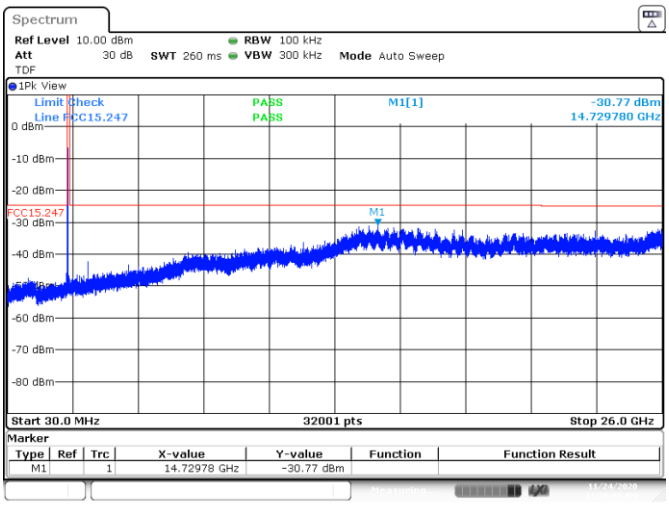


Figure 8.3-12: *Conducted spurious emissions (C63.10 §11.11.3), 2412 MHz channel with 802.11g modulation*

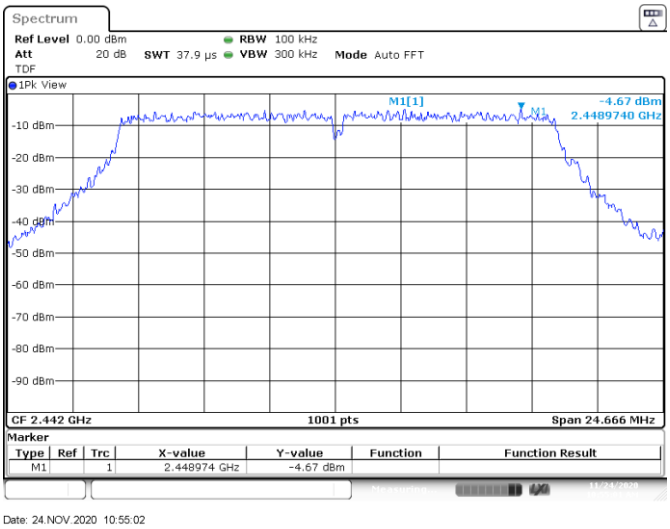


Figure 8.3-13: *Reference level measurement (C63.10 §11.11.2), 2442 MHz channel with 802.11g modulation*

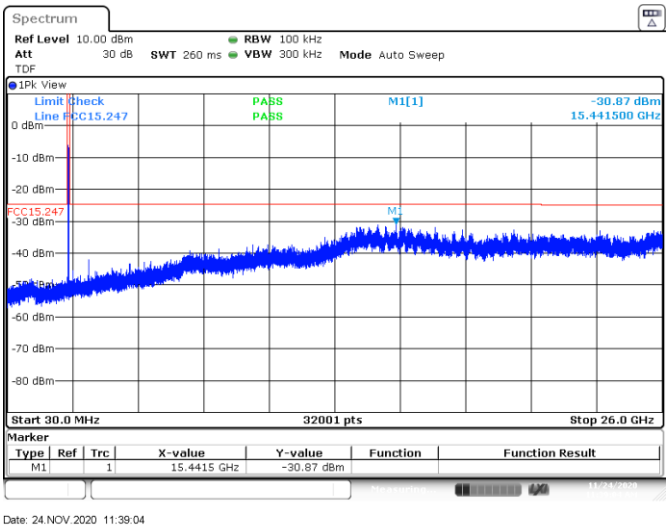


Figure 8.3-14: *Conducted spurious emissions (C63.10 §11.11.3), 2442 MHz channel with 802.11g modulation*

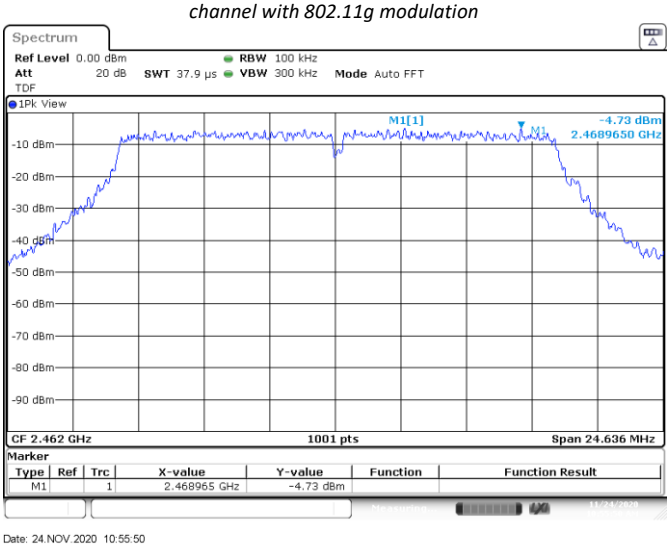


Figure 8.3-15: *Reference level measurement (C63.10 §11.11.2), 2462 MHz channel with 802.11g modulation*

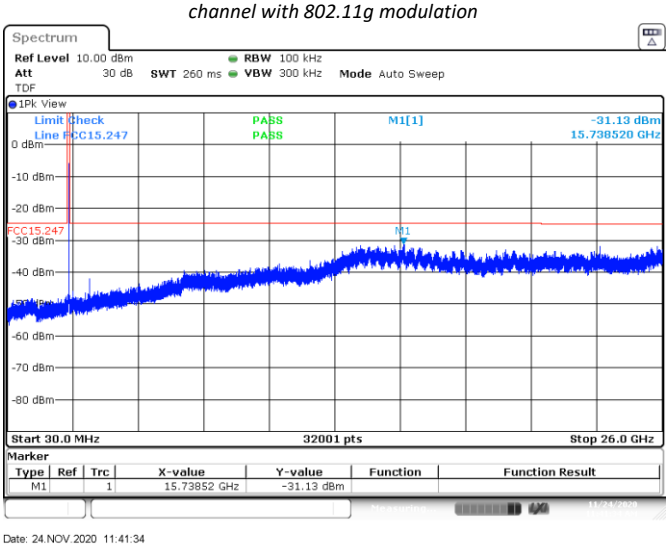
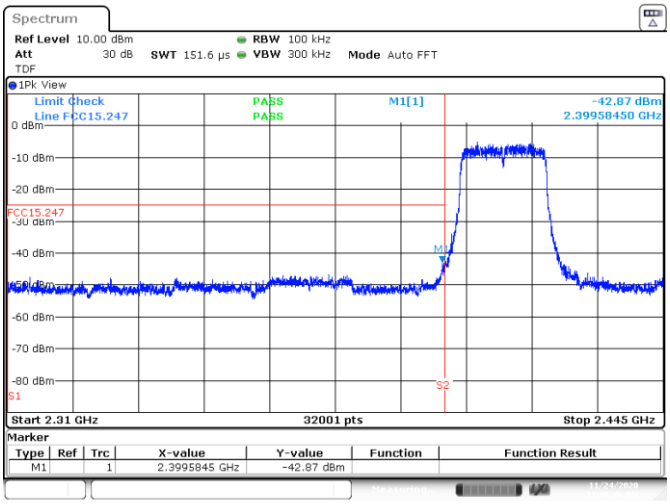


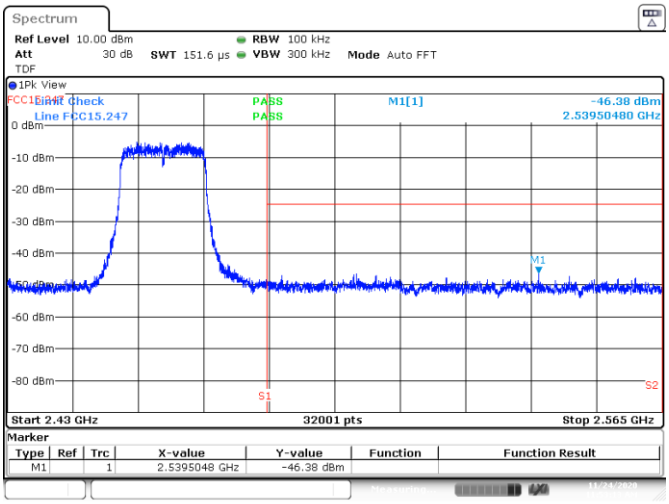
Figure 8.3-16: *Conducted spurious emissions (C63.10 §11.11.3), 2462 MHz channel with 802.11g modulation*

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



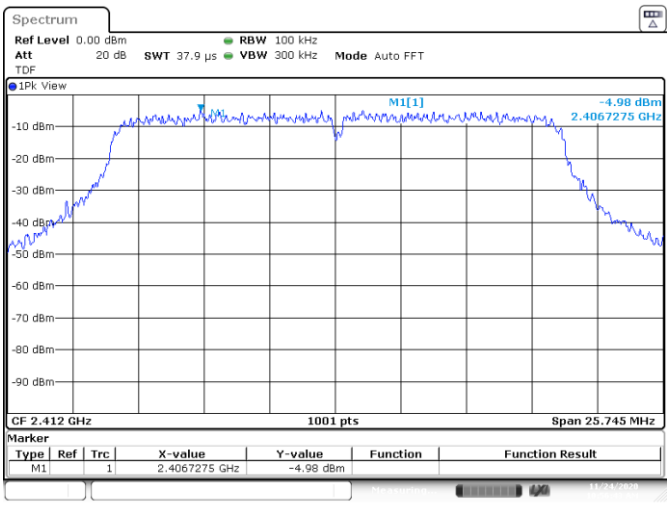
Date: 24.NOV.2020 11:46:47

Figure 8.3-17: *Band edge measurement, 2412 MHz channel with 802.11n modulation*



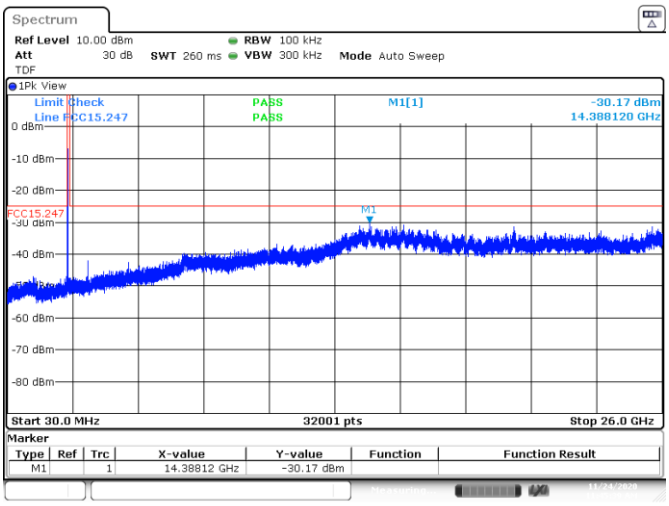
Date: 24.NOV.2020 11:53:13

Figure 8.3-18: *Band edge measurement, 2462 MHz channel with 802.11n modulation*



Date: 24.NOV.2020 10:56:43

Figure 8.3-19: *Reference level measurement (C63.10 §11.11.2), 2412 MHz channel with 802.11n modulation*



Date: 24.NOV.2020 11:45:39

Figure 8.3-20: *Conducted spurious emissions (C63.10 §11.11.3), 2412 MHz channel with 802.11n modulation*

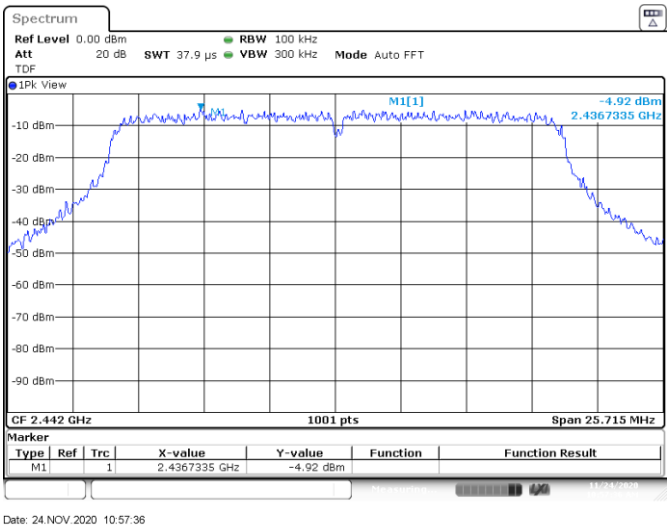


Figure 8.3-21: *Reference level measurement (C63.10 §11.11.2), 2442 MHz channel with 802.11n modulation*

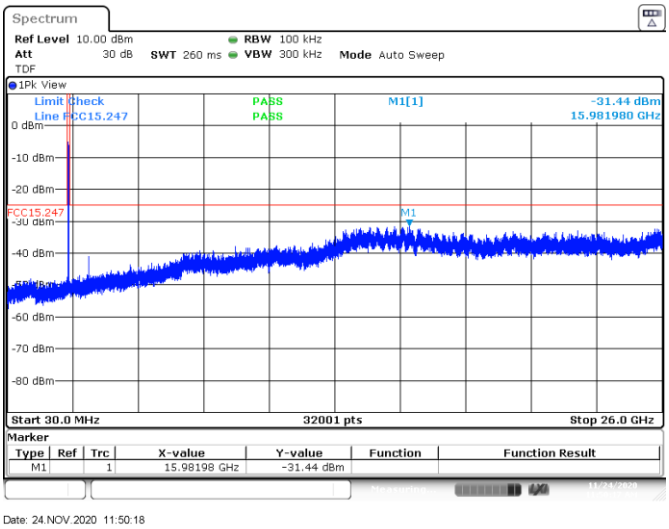


Figure 8.3-22: *Conducted spurious emissions (C63.10 §11.11.3), 2442 MHz channel with 802.11n modulation*

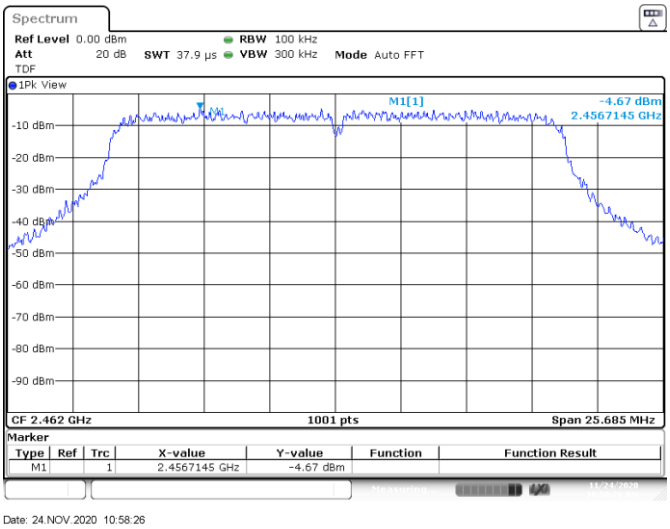


Figure 8.3-23: *Reference level measurement (C63.10 §11.11.2), 2462 MHz channel with 802.11n modulation*

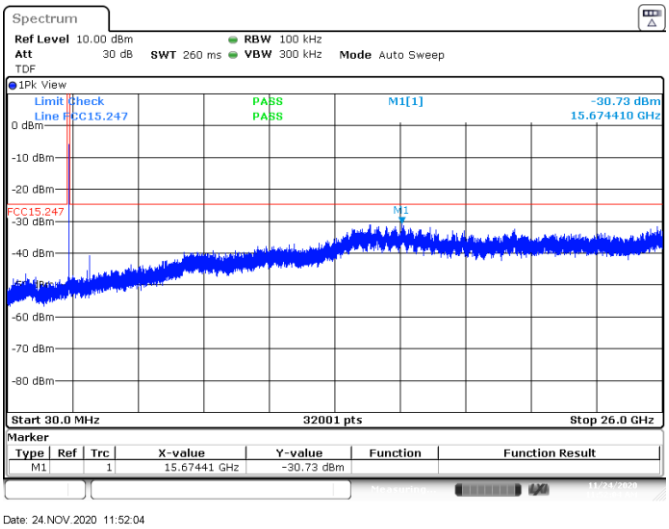
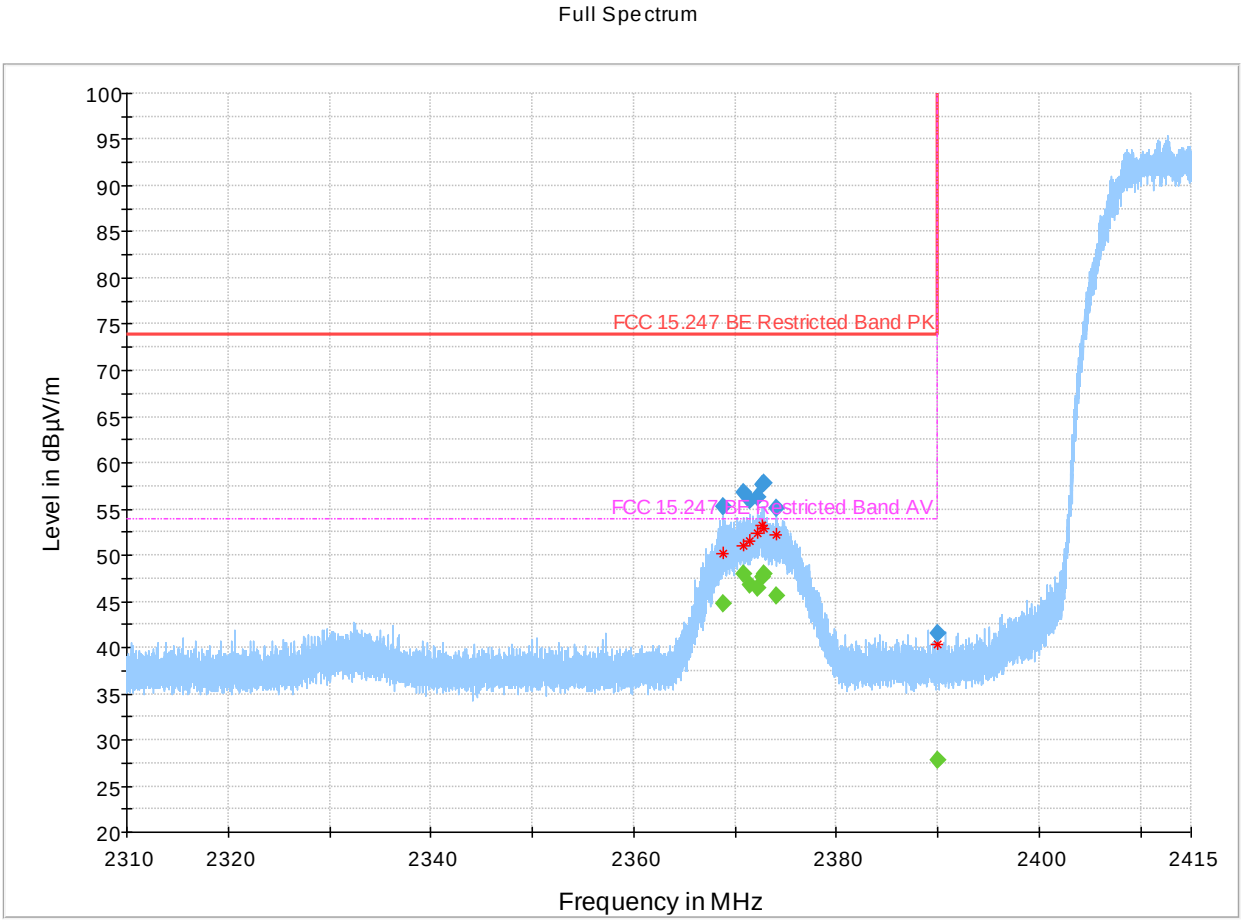


Figure 8.3-24: *Conducted spurious emissions (C63.10 §11.11.3), 2462 MHz channel with 802.11n modulation*

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



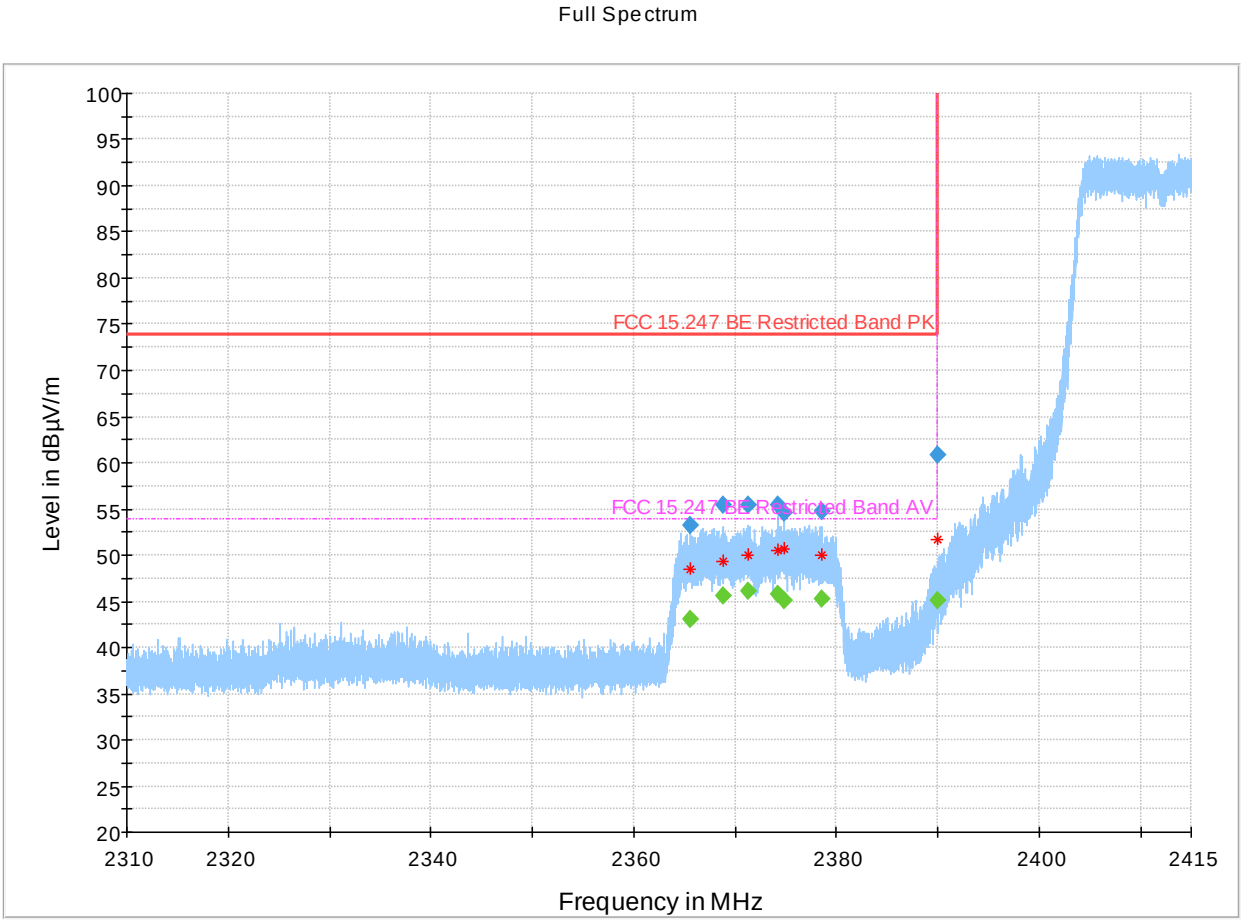
The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).

Figure 8.3-25: *Radiated emissions, 2412 MHz channel with 802.11b modulation, Restricted band-edge spectral plot*

Table 8.3-2: *Radiated emissions, 2412 MHz channel with 802.11b modulation, Restricted band-edge results*

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)
2368.891000	---	44.76	53.90	9.14	5000.0	1000.000	98.0	V	126.0	-10.4
2368.891000	55.25	---	73.90	18.65	5000.0	1000.000	98.0	V	126.0	-10.4
2370.781000	---	47.94	53.90	5.96	5000.0	1000.000	130.4	V	227.0	-10.4
2370.781000	56.83	---	73.90	17.07	5000.0	1000.000	130.4	V	227.0	-10.4
2371.442500	---	46.74	53.90	7.17	5000.0	1000.000	130.2	V	230.0	-10.4
2371.442500	55.87	---	73.90	18.03	5000.0	1000.000	130.2	V	230.0	-10.4
2372.296500	---	46.50	53.90	7.40	5000.0	1000.000	109.3	V	226.0	-10.4
2372.296500	56.26	---	73.90	17.64	5000.0	1000.000	109.3	V	226.0	-10.4
2372.674500	---	47.70	53.90	6.20	5000.0	1000.000	128.0	V	228.0	-10.4
2372.674500	57.71	---	73.90	16.19	5000.0	1000.000	128.0	V	228.0	-10.4
2372.779500	---	48.04	53.90	5.86	5000.0	1000.000	129.4	V	227.0	-10.4
2372.779500	57.87	---	73.90	16.03	5000.0	1000.000	129.4	V	227.0	-10.4
2374.060500	---	45.60	53.90	8.30	5000.0	1000.000	166.3	V	223.0	-10.3
2374.060500	55.11	---	73.90	18.79	5000.0	1000.000	166.3	V	223.0	-10.3
2390.000000	---	27.82	150.00	122.18	5000.0	1000.000	98.0	V	348.0	-10.3
2390.000000	41.57	---	150.00	108.43	5000.0	1000.000	98.0	V	348.0	-10.3

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)
[3] The maximum measured value observed over a period of 5 seconds was recorded.



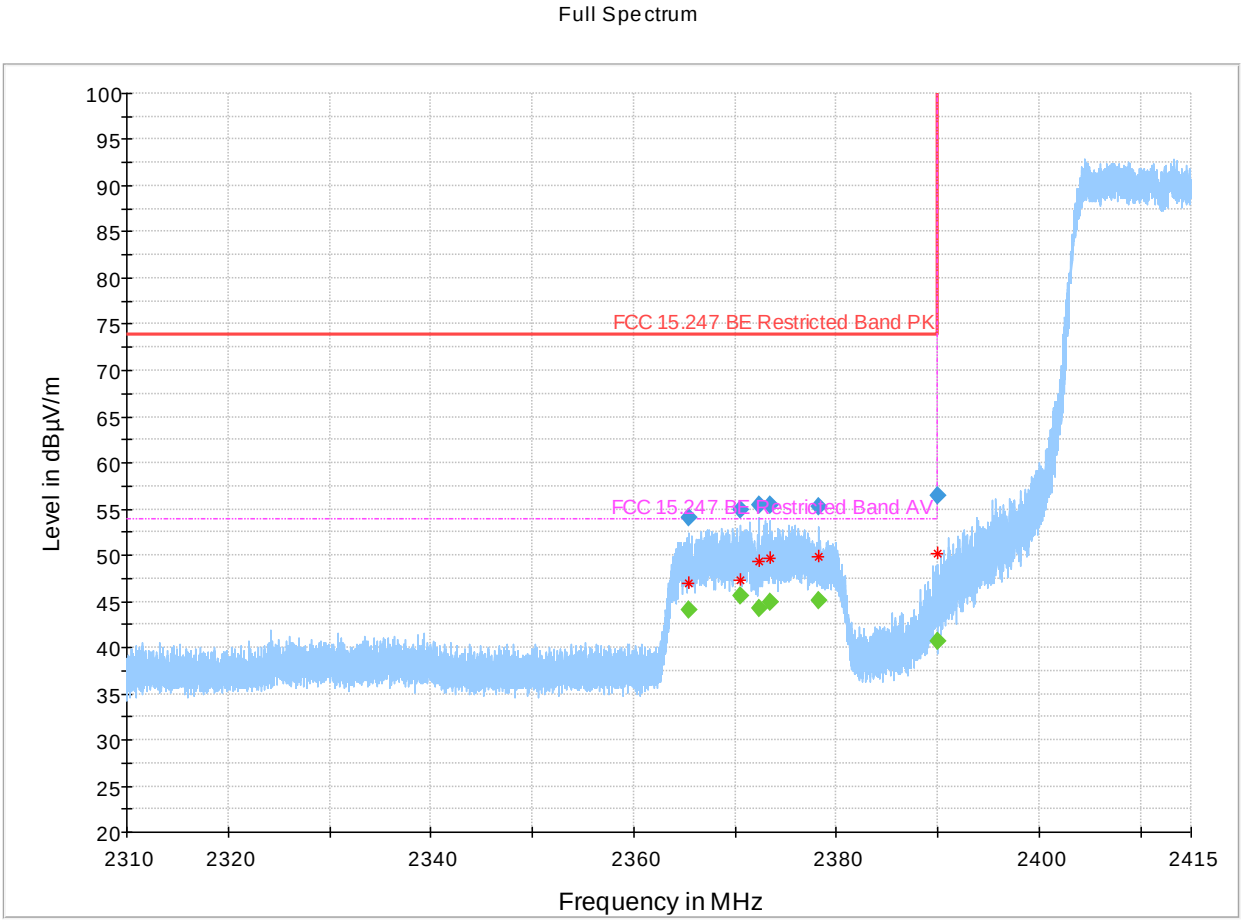
The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).

Figure 8.3-26: *Radiated emissions, 2412 MHz channel with 802.11g modulation, Restricted band-edge spectral plot*

Table 8.3-3: *Radiated emissions, 2412 MHz channel with 802.11g modulation, Restricted band-edge results*

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)
2365.517000	---	43.01	53.90	10.89	5000.0	1000.000	109.3	V	147.0	-10.4
2365.517000	53.25	---	73.90	20.65	5000.0	1000.000	109.3	V	147.0	-10.4
2368.831500	---	45.58	53.90	8.32	5000.0	1000.000	127.8	V	227.0	-10.4
2368.831500	55.50	---	73.90	18.40	5000.0	1000.000	127.8	V	227.0	-10.4
2371.239500	---	46.16	53.90	7.74	5000.0	1000.000	130.1	V	227.0	-10.4
2371.239500	55.38	---	73.90	18.52	5000.0	1000.000	130.1	V	227.0	-10.4
2374.263500	---	45.75	53.90	8.15	5000.0	1000.000	130.6	V	226.0	-10.3
2374.263500	55.39	---	73.90	18.51	5000.0	1000.000	130.6	V	226.0	-10.3
2374.855000	---	45.12	53.90	8.78	5000.0	1000.000	133.5	V	216.0	-10.3
2374.855000	54.65	---	73.90	19.25	5000.0	1000.000	133.5	V	216.0	-10.3
2378.631500	---	45.27	53.90	8.63	5000.0	1000.000	131.0	V	227.0	-10.3
2378.631500	54.77	---	73.90	19.13	5000.0	1000.000	131.0	V	227.0	-10.3
2390.000000	---	45.17	150.00	104.83	5000.0	1000.000	98.0	V	349.0	-10.3
2390.000000	60.90	---	150.00	89.10	5000.0	1000.000	98.0	V	349.0	-10.3

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)
[3] The maximum measured value observed over a period of 5 seconds was recorded.



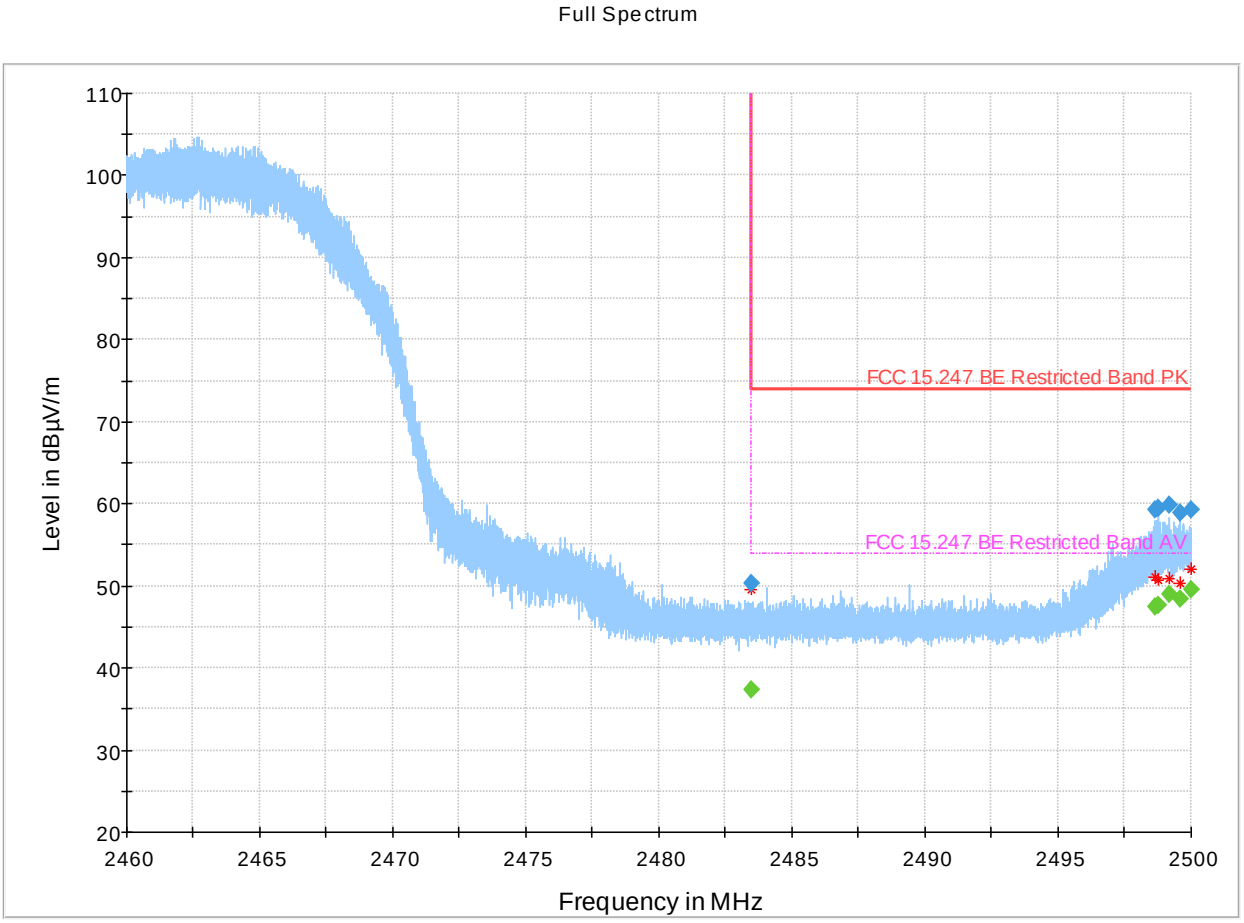
The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).

Figure 8.3-27: *Radiated emissions, 2412 MHz channel with 802.11n modulation, Restricted band-edge spectral plot*

Table 8.3-4: *Radiated emissions, 2412 MHz channel with 802.11n modulation, Restricted band-edge results*

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)
2365.475000	---	43.99	53.90	9.91	5000.0	1000.000	117.3	V	217.0	-10.4
2365.475000	54.09	---	73.90	19.81	5000.0	1000.000	117.3	V	217.0	-10.4
2370.595500	---	45.56	53.90	8.34	5000.0	1000.000	128.8	V	228.0	-10.4
2370.595500	54.99	---	73.90	18.91	5000.0	1000.000	128.8	V	228.0	-10.4
2372.366500	---	44.21	53.90	9.69	5000.0	1000.000	129.1	V	226.0	-10.4
2372.366500	55.42	---	73.90	18.48	5000.0	1000.000	129.1	V	226.0	-10.4
2373.493500	---	44.89	53.90	9.01	5000.0	1000.000	119.4	V	216.0	-10.3
2373.493500	55.48	---	73.90	18.42	5000.0	1000.000	119.4	V	216.0	-10.3
2378.218500	---	45.10	53.90	8.80	5000.0	1000.000	133.6	V	227.0	-10.3
2378.218500	55.20	---	73.90	18.70	5000.0	1000.000	133.6	V	227.0	-10.3
2390.000000	---	40.64	150.00	109.36	5000.0	1000.000	109.3	V	345.0	-10.3
2390.000000	56.42	---	150.00	93.58	5000.0	1000.000	109.3	V	345.0	-10.3

Notes:
[1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)
[3] The maximum measured value observed over a period of 5 seconds was recorded.



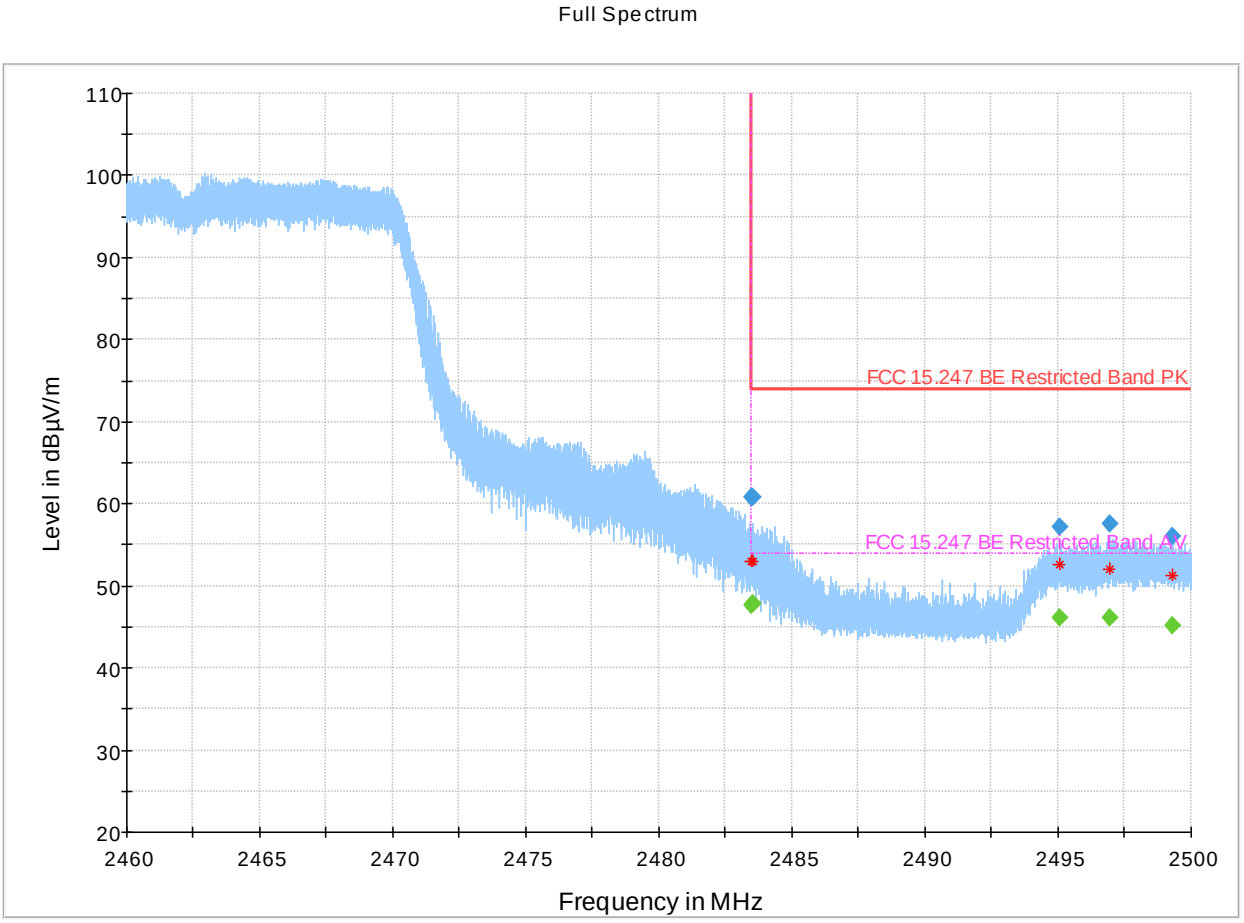
The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).

Figure 8.3-28: *Radiated emissions, 2462 MHz channel with 802.11b modulation, Restricted band-edge spectral plot*

Table 8.3-5: *Radiated emissions, 2462 MHz channel with 802.11b modulation, Restricted band-edge results*

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)
2483.500000	---	37.40	53.90	16.50	5000.0	1000.000	111.2	H	298.0	0.2
2483.500000	50.37	---	73.90	23.53	5000.0	1000.000	111.2	H	298.0	0.2
2498.628000	---	47.53	53.90	6.37	5000.0	1000.000	139.4	H	272.0	0.3
2498.628000	59.33	---	73.90	14.57	5000.0	1000.000	139.4	H	272.0	0.3
2498.792000	---	47.64	53.90	6.26	5000.0	1000.000	149.6	H	286.0	0.3
2498.792000	59.46	---	73.90	14.44	5000.0	1000.000	149.6	H	286.0	0.3
2499.181333	---	48.96	53.90	4.94	5000.0	1000.000	124.6	H	26.0	0.3
2499.181333	59.81	---	73.90	14.09	5000.0	1000.000	124.6	H	26.0	0.3
2499.609333	---	48.42	53.90	5.48	5000.0	1000.000	142.3	H	271.0	0.3
2499.609333	58.85	---	73.90	15.05	5000.0	1000.000	142.3	H	271.0	0.3
2499.984000	---	49.53	53.90	4.37	5000.0	1000.000	125.2	H	26.0	0.3
2499.984000	59.23	---	73.90	14.67	5000.0	1000.000	125.2	H	26.0	0.3

Notes:
[1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)
[3] The maximum measured value observed over a period of 5 seconds was recorded.



The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).

Figure 8.3-29: *Radiated emissions, 2462 MHz channel with 802.11g modulation, Restricted band-edge spectral plot*

Table 8.3-6: *Radiated emissions, 2462 MHz channel with 802.11g modulation, Restricted band-edge results*

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)
2483.500000	60.75	---	73.90	13.15	5000.0	1000.000	127.9	H	295.0	0.2
2483.500000	---	47.66	53.90	6.24	5000.0	1000.000	127.9	H	295.0	0.2
2483.532000	60.76	---	73.90	13.14	5000.0	1000.000	125.1	H	287.0	0.2
2483.532000	---	47.85	53.90	6.05	5000.0	1000.000	125.1	H	287.0	0.2
2495.053333	57.18	---	73.90	16.72	5000.0	1000.000	126.0	H	289.0	0.3
2495.053333	---	46.12	53.90	7.78	5000.0	1000.000	126.0	H	289.0	0.3
2496.914667	---	46.13	53.90	7.77	5000.0	1000.000	129.7	H	289.0	0.3
2496.914667	57.50	---	73.90	16.40	5000.0	1000.000	129.7	H	289.0	0.3
2499.268000	---	45.11	53.90	8.79	5000.0	1000.000	119.3	H	26.0	0.3
2499.268000	55.95	---	73.90	17.95	5000.0	1000.000	119.3	H	26.0	0.3

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)
[3] The maximum measured value observed over a period of 5 seconds was recorded.