

Test report

373054-2TRFWL

Date of issue: October 23, 2019

Applicant:

Garmin International

Product:

MFD

Model:

CL5 (radio) - M/N A3545 – Wi-Fi

Variants:

CL0-1 (radio) – M/N C3545

Specifications:

◆ **FCC 47 CFR Part 15 Subpart C, §15.247**

Operation in the 902–928 MHz, 2400–2483.5 MHz, 5725–5850 MHz

◆ **RSS-247, Issue 2, February 2017**

Digital Transmission Systems (DTSSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices

Test location

Company name	Nemko USA, Inc.
Address	2210 Faraday Ave, Suite 150
City	Carlsbad
Province	California
Postal code	92008
Country	USA
Telephone	+1 760 444 3500
Website	www.nemko.com
Site number	FCC: US5058; IC: 2040B-3

Tested by	Andres Martinez, Wireless Engineer
Reviewed by	Juan Manuel Gonzalez
Review date	October 23, 2019
Reviewer signature	

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko USA's ISO/IEC 17025 accreditation.

Copyright notification

Nemko USA Inc. authorizes the applicant to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Nemko USA Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.
© Nemko USA Inc.

Table of contents

Table of contents	3
Section 1. Report summary	4
1.1 Applicant and manufacturer	4
1.2 Test specifications	4
1.3 Test methods	4
1.4 Statement of compliance	4
1.5 Exclusions	4
1.6 Test report revision history	4
Section 2. Summary of test results	5
2.1 FCC Part 15 Subpart C, general requirements test results	5
2.2 FCC Part 15 Subpart C, intentional radiators test results	5
2.3 IC RSS-GEN, Issue 4, test results	5
2.4 IC RSS-247, Issue 2, test results	6
Section 3. Equipment under test (EUT) details	7
3.1 Sample information	7
3.2 EUT information	7
3.3 Technical information	7
3.4 Product description and theory of operation	8
3.5 EUT exercise details	8
3.6 EUT setup diagram	8
3.7 EUT sub assemblies	10
Section 4. Engineering considerations	11
4.1 Modifications incorporated in the EUT	11
4.2 Technical judgment	11
4.3 Deviations from laboratory tests procedures	11
Section 5. Test conditions	12
5.1 Atmospheric conditions	12
5.2 Power supply range	12
Section 6. Measurement uncertainty	13
6.1 Uncertainty of measurement	13
Section 7. Test equipment	14
7.1 Test equipment list	14
Section 8. Test Data	15
8.1 FCC 15.247(a) (2) and RSS-247 5.2(a) Minimum 6 dB bandwidth	15
8.2 FCC 15.247(b) and RSS-247 5.4 (d) Transmitter output power and e.i.r.p. requirements	19
8.3 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) emissions	21
8.4 FCC 15.247(e) and RSS-247 5.2(b) Power Spectrum Density	28
Section 9. Block diagrams of test set-ups	30
9.1 Radiated emissions set-up – Below 1GHz	30
9.2 Radiated emissions set-up – Above 1GHz	31

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Garmin International
Address	1200 East 151st Street
City	Olathe
Province/State	KS
Postal/Zip code	66062
Country	United States

1.2 Test specifications

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

1.3 Test methods

ANSI C64.3-2014	American National Standard for Methods of Measurement of Radio- Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed 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.

1.5 Exclusions

None

1.6 Test report revision history

Revision #	Details of changes made to test report
TRF	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass
§15.203	Antenna requirement	Pass
§15.205	Restricted bands of operation	Pass

Notes: None.

2.2 FCC Part 15 Subpart C, intentional radiators test results

Part	Test description	Verdict
§15.247(a)(1)	20 dB bandwidth of the hopping channel	Not applicable
§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-GEN, Issue 5, test results

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Pass
7.4	Receiver conducted emission limits	Pass
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass
8.10	Restricted Frequency Bands	Pass

Notes: None.

2.4 IC RSS-247, Issue 2, test results

Part	Test description	Verdict
5.1	Frequency hopping systems (FHSs)	
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	Digital modulation systems	
5.2 (a)	Minimum 6 dB bandwidth	Pass
5.2 (b)	Maximum power spectral density	Pass
5.3	Hybrid systems	
5.3 (a)	Digital modulation turned off	Not applicable
5.3 (b)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
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	Unwanted Emissions	Pass

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	April 7, 2019
Nemko sample ID number	373054

3.2 EUT information

Product name	MFD
Model	CL5 (radio) – M/N A3545
Model variant	CL0-1 – M/N C3545
Serial number	N/A

3.3 Technical information

All used IC test site(s) Reg. number	2040B-3
RSS number and Issue number	RSS-247, Issue 2, February 2017
Frequency band	2400-2483.5 MHz
Frequency Min (MHz)	2412
Frequency Max (MHz)	2462
RF power Max (W), Conducted/EIRP	18.4dB
Measured BW (kHz) (6 dB)	691
Measured BW (kHz) (99%)	1667
Power requirements	8 – 16 VDC
Antenna Information	Integral inverted F with 2dBi gain (same antenna for ANT and WIFI)
Software version	Beta software 1.01 (3c60a29d) Garmin LTD Copyright 2018-2-19

3.4 Product description and theory of operation

Engine and autopilot MFD.

3.5 EUT exercise details

Garmin MFD, Model: CL5 was tested while the WiFi radio was in transmit mode at its highest power. 3 frequencies were measured: 2412MHz (Low Channel), 2437MHz (Mid Channel) and 2462MHz (High Channel). Garmin provided two samples 1) conducted port sample and 2) a radiated sample. They provided touch screen instructions to set the transmitter Modes. 1) output power, 2) modulation type and 3) frequency.

For this testing output power was set at 100% for all three channels and all modulations were tested for output power to establish worst case scenarios for the remainder of the required testing.

Software information: Beta software 1.01 (3c60a29d) Garmin LTD Copyright 2018-2-19

3.6 EUT setup diagram



Figure 3.6-1: Radiated Emissions Test Setup – below 1GHz

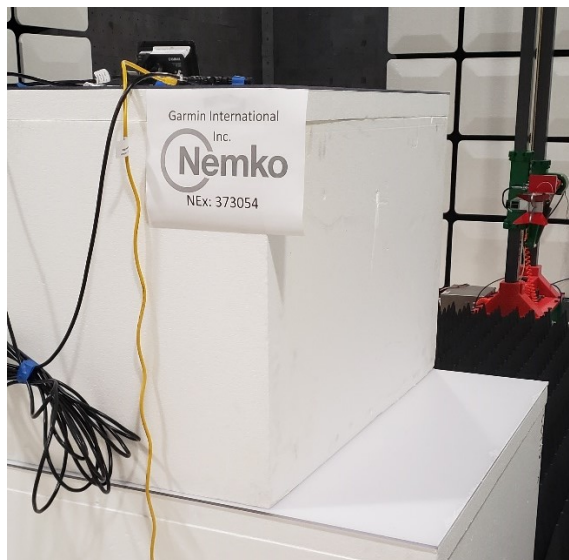


Figure 3.6-2: Radiated Emissions Test Setup – above 1GHz

3.7 EUT sub assemblies

Table 3.7-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number
NMEA Tee connectors	Garmin	N/A	N/A
Network Updater (LOAD)	Garmin	N/A	N/A
Remote Control	Garmin	CL0	N/A

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	860–1060 mbar

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 $\pm 5\%$, for which the equipment was designed.
120VAC 60Hz

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
All antenna port measurements	0.55
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	1.38

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: Equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMC Test Receiver	Rohde & Schwarz	ESU 40	E1121	1 yr.	5/25/2020
Antenna, Bilog	Schaffner-Chase	CBL6111C	1480	1 yr.	4/18/2020
Antenna, Horn	ETS-Lindgren	3117-PA	E1139	1 yr.	03/21/2020
Spectrum Analyzer	Rohde & Schwarz	FSV40	E1120	1 yr.	8/24/2019
Signal Generator	Rohde & Schwarz	SMB 100A	E1128	1 yr.	12/20/2019
RF Power Sensor	ETS Lindgren	7002-006	E1061	1 yr.	05/31/2020
Temperature/humidity chamber	CSZ Inc.	ZPH-32-2-2-H/AC	S1179	1 yr.	04/20/2020

7.2 Conducted Port Power Measurements

Table 7.2-1: EIRP Power Measurements (with Antenna gain (2dB added))

802.11 b/g							
Frequency	Low (2412 MHz)		Mid (2437 MHz)		High (2462 MHz)		
Data Rates	Power With (Duty Cycle)	Power (RMS)	Power With (Duty Cycle)	Power (RMS)	Power With (Duty Cycle)	Power (RMS)	Duty Cycle (%)
1Mbps	15.82	15.3	18.29	17.52	16	15.5	96.1
2Mbps	15.7	15.02	18.3	17.35	15.98	15.32	92.63
5.5Mbps	15.8	14.5	18.24	16.94	16	14.88	83.7
11Mbps	15.9	14.11	18.4	16.51	16.12	14.46	75.7
6Mbps	12.6	11.8	17.77	17.02	12.95	12.14	88.8
9Mbps	12.6	11.55	17.8	16.8	13	11.89	84.3
12Mbps	12.7	11.33	17.86	16.6	13	11.7	80.24
18 Mbps	12.59	10.98	17.84	16.2	12.95	11.3	73.74
24 Mbps	12.7	10.58	17.82	15.81	13.03	10.93	68.12
36 Mbps	12.82	10.2	18.22	15.55	13.2	10.53	60.2
48 Mbps	12.84	9.75	18.32	15.12	13.2	10.1	54.55
54 Mbps	12.9	9.55	18.15	14.98	13.2	9.9	52.63

Section 8. Test Data

8.1 FCC 15.247(a) (2) and RSS-247 5.2(a) Minimum 6 dB bandwidth

8.1.1 Definitions and limits

FCC 15.247:

- (a) (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.

IC RSS-247

- 5.2 (a) The minimum 6 dB bandwidth shall be 500 kHz.

8.1.2 Test summary

Test date	July 18, 2019	Temperature	24 °C
Test engineer	Andres Martinez	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	45 %

8.1.3 Observations, settings and special notes

The following settings were set for CL5:

OBW 6dB, 802.11b with a data rate of 1Mbps and 802.11g with a data rate of 6Mbps.

OBW 99%, 802.11b with a data rate of 1Mbps and 802.11g with a data rate of 6Mbps.

Spectrum analyzer settings:

Resolution bandwidth	300 kHz
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	5 MHz
Detector mode	Peak
Trace mode	Max Hold

8.1.4 Test data

Table 8.1-1: 6 dB bandwidth results

Modulation	Frequency, MHz	6dB bandwidth, kHz	Limit, kHz	Result
802.11b @ 1Mbps	2412	6909	500	Pass
	2437	5952	500	Pass
	2462	5379	500	Pass

Modulation	Frequency, MHz	6dB bandwidth, kHz	Limit, kHz	Result
802.11g @ 6Mbps	2412	6855	500	Pass
	2437	6849	500	Pass
	2462	5262	500	Pass

Table 8.1-2: 99% dB bandwidth results

Modulation	Frequency, MHz	99% OBW, MHz
802.11b @ 1Mbps	2412	13.629
	2437	14.331
	2462	13.587

Modulation	Frequency, MHz	99% OBW, MHz
802.11g @ 6Mbps	2412	16.461
	2437	16.668
	2462	16.458

Section 8
Test name
Specification

Testing data
FCC 15.247(a) (2) and RSS-247 5.2(a) Minimum 6 dB bandwidth
FCC 15 Subpart C and RSS-247, Issue 2

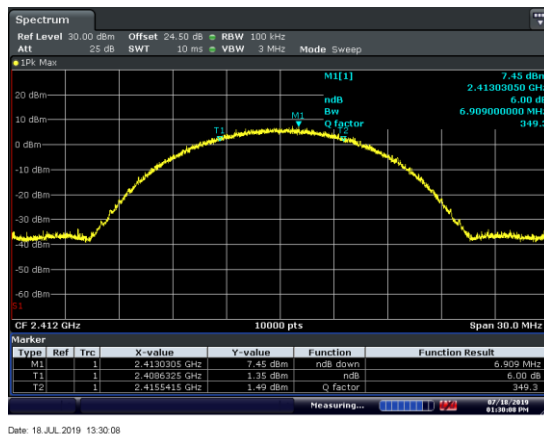


Figure 8.1-1: 6dB bandwidth, 2112MHz, 802.11b @ 11Mbps

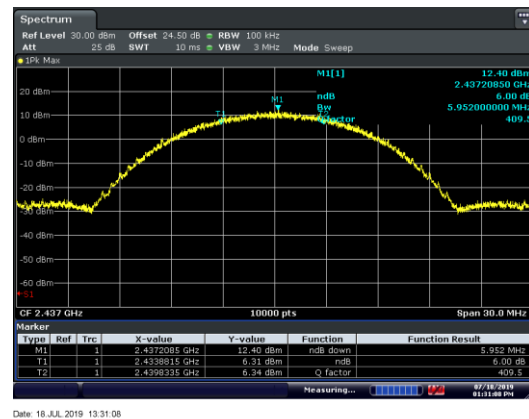


Figure 8.1-2: 6dB bandwidth, 2437MHz, 802.11b @ 11Mbps

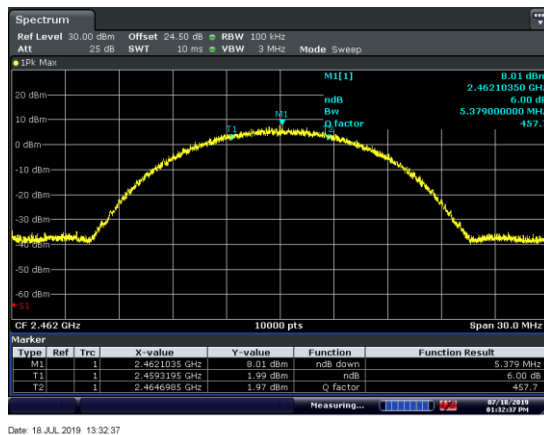


Figure 8.1-3: 6dB bandwidth, 2462MHz, 802.11b @ 11Mbps

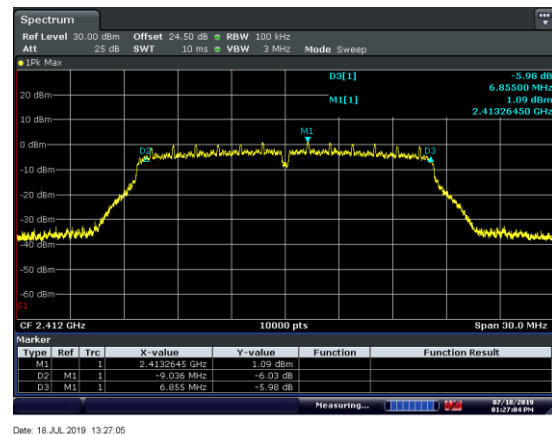


Figure 8.1-4: 6dB bandwidth, 2112MHz, 802.11g @ 6Mbps

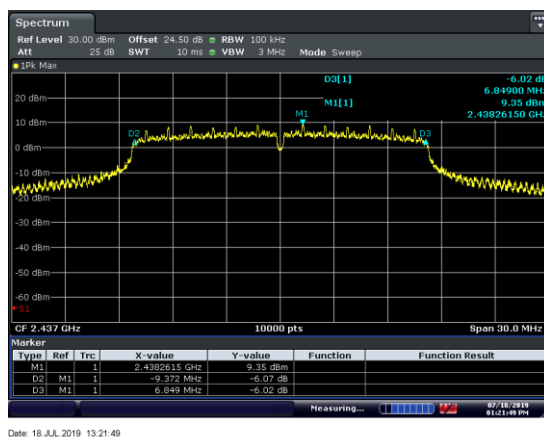


Figure 8.1-5: 6dB bandwidth, 2437MHz, 802.11g @ 6Mbps

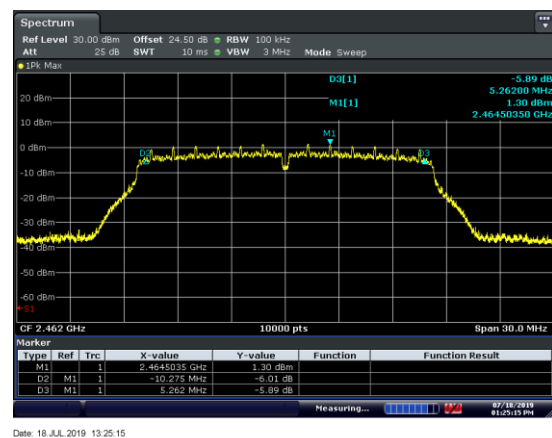


Figure 8.1-6: 6dB bandwidth, 2462MHz, 802.11g @ 6Mbps

Table 8.1-3: 6dB% OBW bandwidth results

Section 8
Test name
Specification

Testing data
FCC 15.247(a) (2) and RSS-247 5.2(a) Minimum 6 dB bandwidth
FCC 15 Subpart C and RSS-247, Issue 2

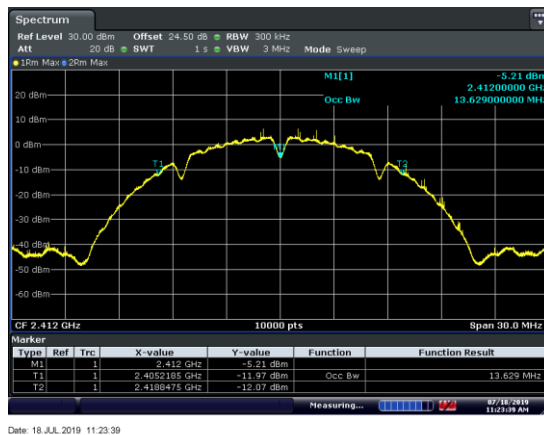


Figure 8.1-7: 99% bandwidth, 2112MHz, 802.11b @ 1Mbps

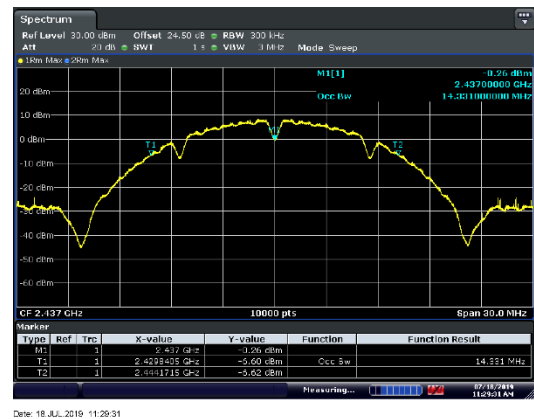


Figure 8.1-8: 99% bandwidth, 2437MHz, 802.11b @ 1Mbps

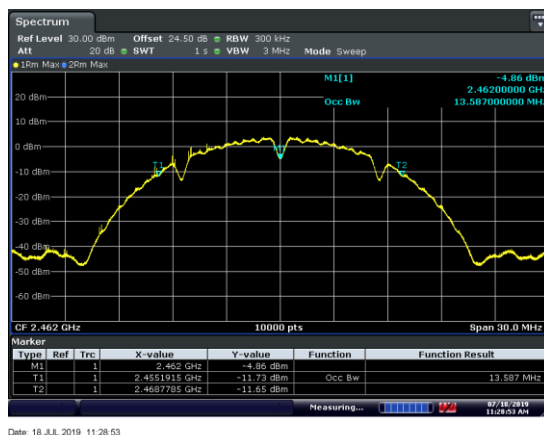


Figure 8.1-9: 99% bandwidth, 2462MHz, 802.11b @ 1Mbps



Figure 8.1-10: 99% bandwidth, 2112MHz, 802.11g @ 6Mbps

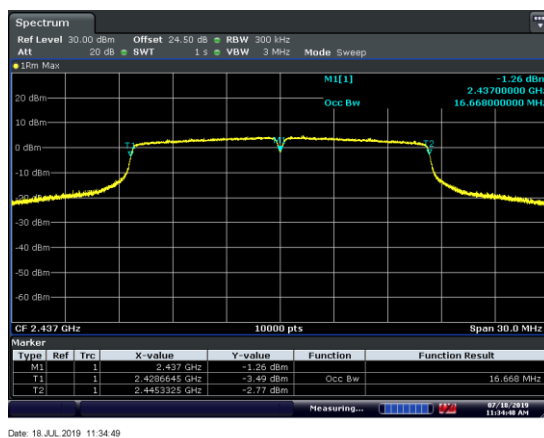


Figure 8.1-11: 99% bandwidth, 2437MHz, 802.11g @ 6Mbps

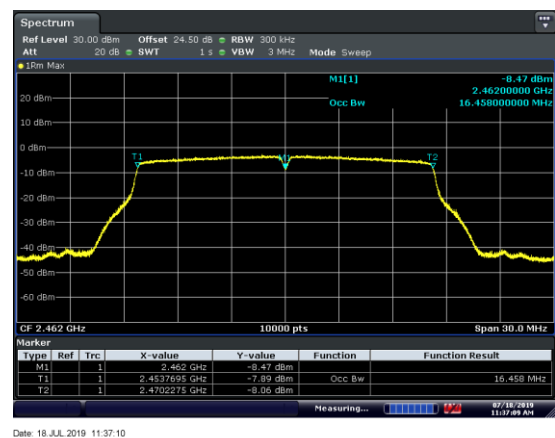


Figure 8.1-12: 99% bandwidth, 2462MHz, 802.11g @ 6Mbps

Table 8.1-4: 99% OBW bandwidth results

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

8.2.1 Definitions and limits

FCC:

- (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 Watt. 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.

IC:

5.4 Transmitter Output Power and Equivalent Isotropically Radiated Power (E.I.R.P.) Requirements

- (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 1W. Except as provided in Section 5.4(5), the e.i.r.p. shall not exceed 4 W.

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

Test date	July 19, 2019	Temperature	24 °C
Test engineer	Andres Martinez, Wireless Engineer	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	45 %

8.2.3 Observations, settings and special notes

Power was measure using an RMS power meter on all three channels (2412MHz, 2437MHz, 2462MHz) with a data rate of 1Mbps and 6Mbps. The calculated Duty Cycle and antenna gain were added into the total power result.

EIRP = RMS + Duty Cycle + Antenna gain

Peak Conducted Power Measured

Spectrum analyzer settings:

Resolution bandwidth	≥ Channel BW (1MHz)
Video bandwidth	≥ 3 × RBW (3MHz)
Frequency span	≥ 3 × RBW (3MHz)
Detector mode	Peak
Trace mode	Max Hold

8.2.4 Test data

Table 8.2-1: Output power (EIRP) measurements results

Frequency, MHz	Conducted Power Output dBm	Conducted Specification Power Output dBm	Power Output (EIRP) dBm	Specification Power Output (EIRP) dBm	Power Output (Result)
2412 @ 1Mbps	13.82	30	15.82	36	PASS
2412 @ 6Mbps	10.6	30	12.6	36	PASS
2437 @ 1Mbps	16.29	30	18.29	36	PASS
2437 @ 6Mbps	15.77	30	17.77	36	PASS
2462 @ 1Mbps	14	30	16	36	PASS
2462 @ 6Mbps	10.95	30	12.95	36	PASS

Antenna gain for WIFI has been declared to be 2dBi

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

8.3.1 Definitions and limits

FCC:

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)).

IC:

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.

(a) Fundamental components of modulation of license-exempt radio apparatus shall not fall within the restricted bands of Table 8.4-1 except for apparatus complying under RSS-287;

(b) Unwanted emissions that fall into restricted bands of Table 6 shall comply with the limits specified in RSS-Gen; and

(c) Unwanted emissions that do not fall within the restricted frequency bands of Table 8.4-1 shall comply either with the limits specified in the applicable RSS or with those specified in this RSS-Gen.

Table 8.3-1: FCC §15.209 and RSS-Gen – 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: IC restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677–5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.3-2 and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 8.3-3: 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

Test date	August 9, 2019	Temperature	24 °C
Test engineer	Andres Martinez, Wireless Engineer	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	45 %

8.3.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to 18GHz.

EUT was set to transmit with the highest setting duty cycle, low channel (2412MHz), mid channel (2437MHz) and high channel (2462MHz).

Spectrum analyzer settings for conducted spurious emissions measurements:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyzer settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyzer settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyzer settings for average radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	AVG
Trace mode:	Max Hold

8.3.4 Test data

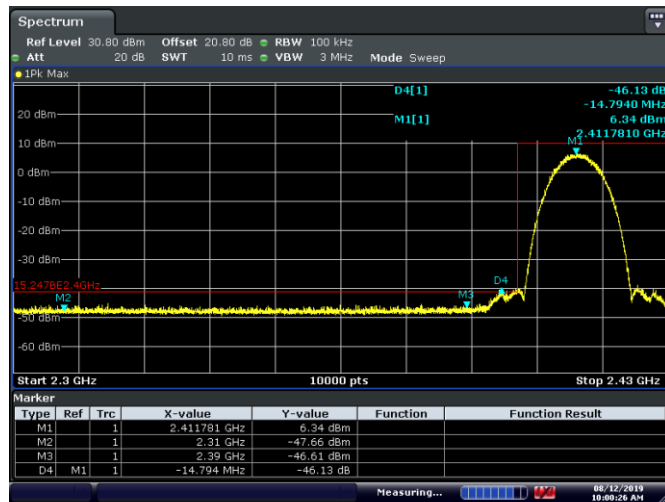


Figure 8.3.1: Band-edge Measurement, low channel @1Mbps

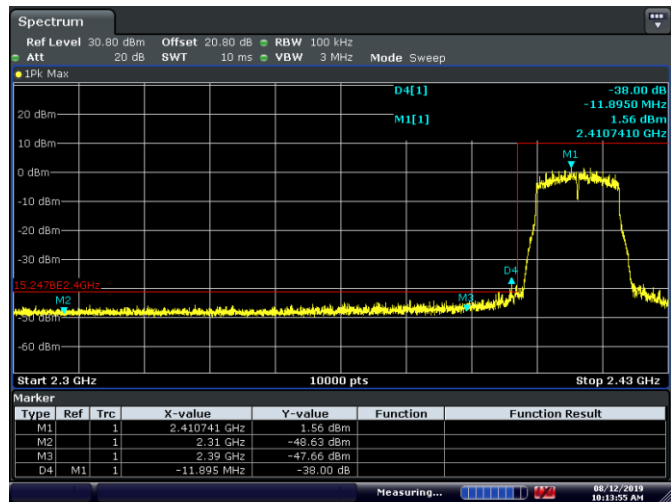


Figure 8.3.2: Band-edge Measurement, low channel @6Mbps

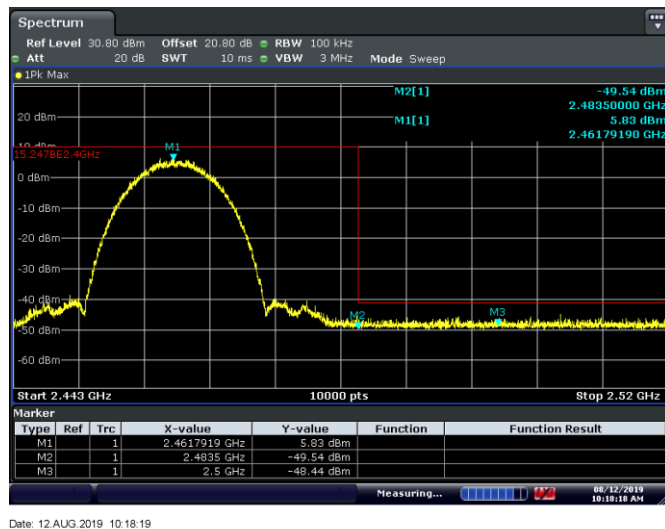


Figure 8.3.3: Band-edge Measurement, high channel @11Mbps

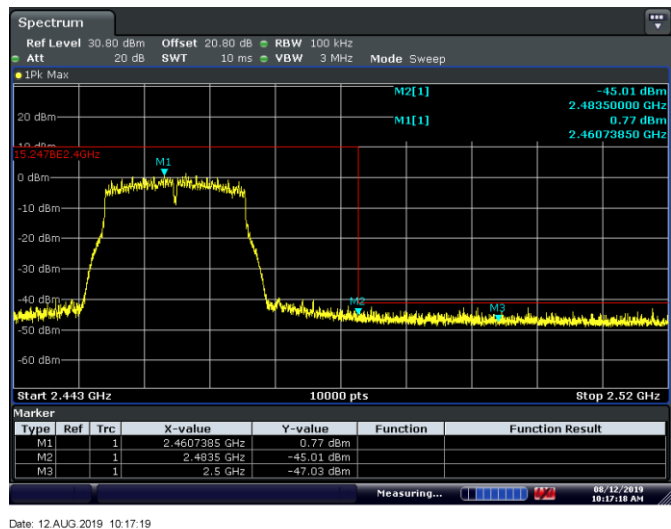


Figure 8.3.4: Band-edge Measurement, high channel @54Mbps

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

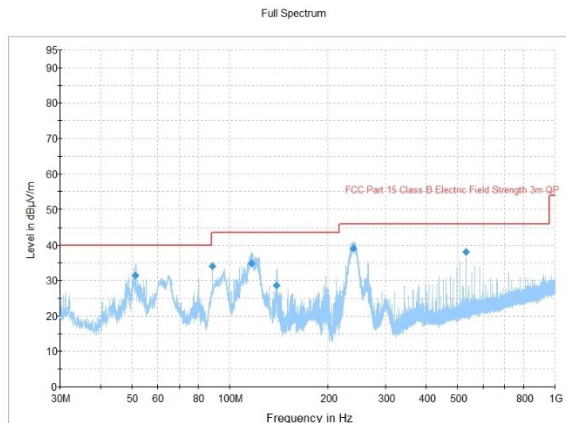


Figure 8.3.5: Radiated spurious emissions, 30-1000MHz

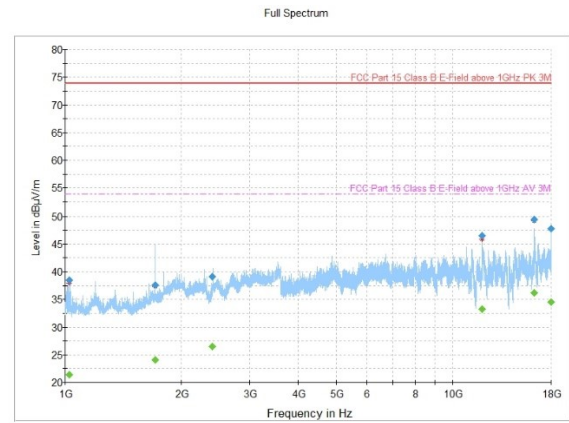


Figure 8.3.6: Radiated spurious, 2412MHz, 1GHz to 18GHz, 1Mbps

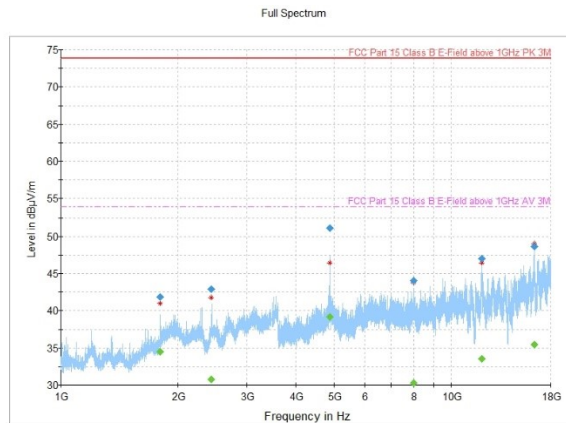


Figure 8.3.7: Radiated spurious, 2437MHz, 1GHz to 18GHz, 1Mbps

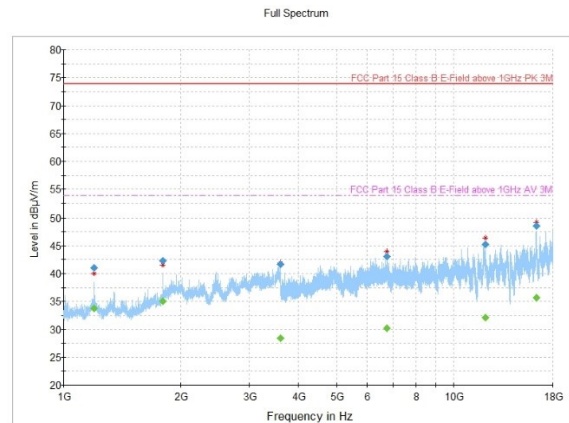


Figure 8.3.8: Radiated spurious, 2462MHz, 1GHz to 18GHz, 1Mbps

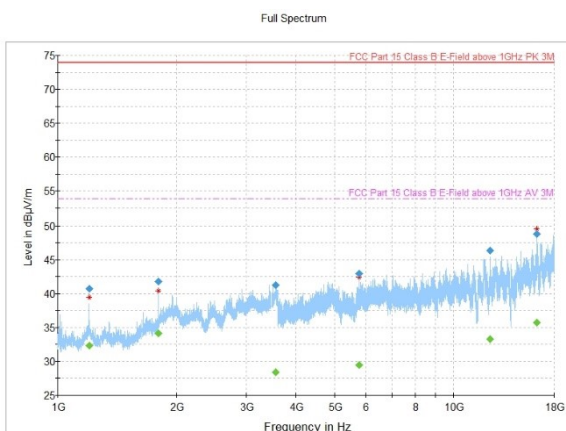


Figure 8.3.9: Radiated spurious, 2412MHz, 1GHz to 18GHz, 6Mbps

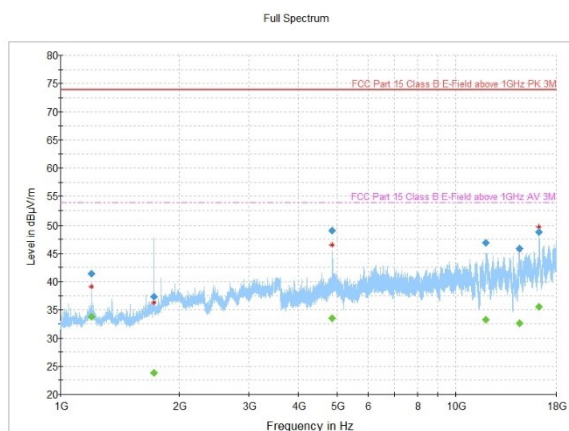


Figure 8.3.10: Radiated spurious, 2437MHz, 1GHz to 18GHz, 6 Mbps

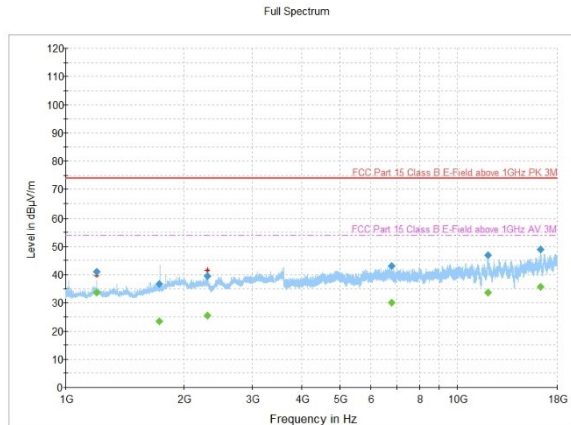


Figure 8.3.11: Radiated spurious, 2462MHz, 1GHz to 18GHz,6Mbps

Table 8.3-4: Radiated spurious emissions, 30-1000MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
51.364667	31.48	40.00	8.52	1000.0	120.000	102.0	V	123.0
88.458667	34.18	43.50	9.32	1000.0	120.000	111.0	V	284.0
116.891667	34.80	43.50	8.70	1000.0	120.000	102.0	V	258.0
139.020333	28.70	43.50	14.80	1000.0	120.000	230.0	H	303.0
239.086333	39.05	46.00	6.96	1000.0	120.000	132.0	H	156.0
530.843333	38.03	46.00	7.97	1000.0	120.000	106.0	V	316.0

Table 8.3-5: Radiated spurious, 2412MHz, 1GHz to 18GHz, 1Mbps

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/m)
1027.00000	---	21.37	53.90	32.53	5000.0	1000.000	100.0	V	88.0	-15.6
1027.00000	38.42	---	73.90	35.48	5000.0	1000.000	100.0	V	88.0	-15.6
1710.60000	---	24.08	53.90	29.82	5000.0	1000.000	159.0	V	313.0	-13.6
1710.60000	37.58	---	73.90	36.32	5000.0	1000.000	159.0	V	313.0	-13.6
2408.03333	39.09	---	73.90	34.81	5000.0	1000.000	245.0	V	235.0	-10.9
2408.03333	---	26.52	53.90	27.38	5000.0	1000.000	245.0	V	235.0	-10.9
11944.9000	46.56	---	73.90	27.34	5000.0	1000.000	118.0	H	109.0	3.4
11944.9000	---	33.21	53.90	20.69	5000.0	1000.000	118.0	H	109.0	3.4
16306.5666	49.47	---	73.90	24.43	5000.0	1000.000	124.0	H	239.0	10.3
16306.5666	---	36.23	53.90	17.67	5000.0	1000.000	124.0	H	239.0	10.3
17992.8000	47.80	---	73.90	26.10	5000.0	1000.000	234.0	H	68.0	11.3
17992.8000	---	34.54	53.90	19.36	5000.0	1000.000	234.0	H	68.0	11.3

Table 8.3-6: Radiated spurious, 2437MHz, 1GHz to 18GHz, 1Mbps

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/m)
1799.96666	41.83	---	73.90	32.07	5000.0	1000.000	292.0	H	62.0	-12.9
1799.96666	---	34.45	53.90	19.45	5000.0	1000.000	292.0	H	62.0	-12.9
2438.13333	---	30.78	53.90	23.12	5000.0	1000.000	106.0	V	191.0	-10.7
2438.13333	42.90	---	73.90	31.00	5000.0	1000.000	106.0	V	191.0	-10.7
4874.13333	---	39.20	53.90	14.70	5000.0	1000.000	118.0	V	220.0	-3.2
4874.13333	51.08	---	73.90	22.82	5000.0	1000.000	118.0	V	220.0	-3.2
8003.16666	---	30.30	53.90	23.60	5000.0	1000.000	211.0	H	-1.0	-0.1
8003.16666	44.05	---	73.90	29.85	5000.0	1000.000	211.0	H	-1.0	-0.1
11964.0333	---	33.49	53.90	20.41	5000.0	1000.000	162.0	V	285.0	3.5
11964.0333	47.04	---	73.90	26.86	5000.0	1000.000	162.0	V	285.0	3.5
16342.0000	48.65	---	73.90	25.25	5000.0	1000.000	148.0	V	199.0	10.1
16342.0000	---	35.41	53.90	18.49	5000.0	1000.000	148.0	V	199.0	10.1

Table 8.3-7: Radiated spurious, 2462MHz, 1GHz to 18GHz, 1Mbps

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/m)
1199.86666	---	33.81	53.90	20.09	5000.0	1000.000	181.0	V	350.0	-14.5
1199.86666	41.04	---	73.90	32.86	5000.0	1000.000	181.0	V	350.0	-14.5
1799.96666	---	35.06	53.90	18.84	5000.0	1000.000	290.0	H	236.0	-12.9
1799.96666	42.32	---	73.90	31.58	5000.0	1000.000	290.0	H	236.0	-12.9
3594.53333	---	28.39	53.90	25.51	5000.0	1000.000	154.0	H	287.0	-6.4
3594.53333	41.65	---	73.90	32.25	5000.0	1000.000	154.0	H	287.0	-6.4
6756.66666	---	30.25	53.90	23.65	5000.0	1000.000	227.0	V	24.0	-0.7
6756.66666	43.02	---	73.90	30.88	5000.0	1000.000	227.0	V	24.0	-0.7
12059.3333	45.16	---	73.90	28.74	5000.0	1000.000	224.0	H	5.0	3.9
12059.3333	---	32.06	53.90	21.84	5000.0	1000.000	224.0	H	5.0	3.9
16337.4333	48.54	---	73.90	25.36	5000.0	1000.000	115.0	H	158.0	10.1
16337.4333	---	35.68	53.90	18.22	5000.0	1000.000	115.0	H	158.0	10.1

Table 8.3-8: Radiated spurious, 2412MHz, 1GHz to 18GHz, 6Mbps

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/m)
1200.26666	---	32.28	53.90	21.62	5000.0	1000.000	180.0	V	267.0	-14.5
1200.26666	40.70	---	73.90	33.20	5000.0	1000.000	180.0	V	267.0	-14.5
1799.96666	---	34.13	53.90	19.77	5000.0	1000.000	200.0	H	337.0	-12.9
1799.96666	41.80	---	73.90	32.10	5000.0	1000.000	200.0	H	337.0	-12.9
3544.86666	---	28.35	53.90	25.55	5000.0	1000.000	140.0	V	310.0	-6.9
3544.86666	41.22	---	73.90	32.68	5000.0	1000.000	140.0	V	310.0	-6.9
5769.96666	---	29.49	53.90	24.41	5000.0	1000.000	269.0	V	214.0	-2.1
5769.96666	42.92	---	73.90	30.98	5000.0	1000.000	269.0	V	214.0	-2.1
12401.2000	46.34	---	73.90	27.56	5000.0	1000.000	167.0	V	57.0	4.8
12401.2000	---	33.30	53.90	20.60	5000.0	1000.000	167.0	V	57.0	4.8
16298.6333	48.80	---	73.90	25.10	5000.0	1000.000	177.0	H	281.0	10.3
16298.6333	---	35.71	53.90	18.19	5000.0	1000.000	177.0	H	281.0	10.3

Table 8.3-9: Radiated spurious, 2412MHz, 1GHz to 18GHz, 6 Mbps

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/m)
1199.86666	41.42	---	73.90	32.48	5000.0	1000.000	180.0	V	352.0	-14.5
1199.86666	---	33.73	53.90	20.17	5000.0	1000.000	180.0	V	352.0	-14.5
1721.73333	37.34	---	73.90	36.56	5000.0	1000.000	272.0	H	244.0	-13.5
1721.73333	---	23.76	53.90	30.14	5000.0	1000.000	272.0	H	244.0	-13.5
4872.03333	49.07	---	73.90	24.83	5000.0	1000.000	250.0	H	154.0	-3.2
4872.03333	---	33.52	53.90	20.38	5000.0	1000.000	250.0	H	154.0	-3.2
11943.3666	46.86	---	73.90	27.04	5000.0	1000.000	292.0	V	331.0	3.4
11943.3666	---	33.24	53.90	20.66	5000.0	1000.000	292.0	V	331.0	3.4
14541.6666	45.85	---	73.90	28.05	5000.0	1000.000	100.0	H	289.0	6.3
14541.6666	---	32.65	53.90	21.25	5000.0	1000.000	100.0	H	289.0	6.3
16305.4666	48.83	---	73.90	25.07	5000.0	1000.000	245.0	V	69.0	10.3
16305.4666	---	35.58	53.90	18.32	5000.0	1000.000	245.0	V	69.0	10.3

Table 8.3-10: Radiated spurious, 2412MHz, 1GHz to 18GHz, 6 Mbps

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/m)
1199.86666	---	33.60	53.90	20.30	5000.0	1000.000	183.0	V	25.0	-14.5
1199.86666	41.00	---	73.90	32.90	5000.0	1000.000	183.0	V	25.0	-14.5
1736.23333	36.66	---	73.90	37.24	5000.0	1000.000	200.0	V	266.0	-13.2
1736.23333	---	23.51	53.90	30.39	5000.0	1000.000	200.0	V	266.0	-13.2
2303.16666	39.44	---	73.90	34.46	5000.0	1000.000	197.0	H	157.0	-11.5
2303.16666	---	25.51	53.90	28.39	5000.0	1000.000	197.0	H	157.0	-11.5
6785.13333	43.11	---	73.90	30.79	5000.0	1000.000	197.0	H	153.0	-0.9
6785.13333	---	29.97	53.90	23.93	5000.0	1000.000	197.0	H	153.0	-0.9
12000.1333	---	33.54	53.90	20.36	5000.0	1000.000	157.0	V	91.0	3.6
12000.1333	46.98	---	73.90	26.92	5000.0	1000.000	157.0	V	91.0	3.6
16337.3666	49.04	---	73.90	24.86	5000.0	1000.000	188.0	V	10.0	10.1
16337.3666	---	35.67	53.90	18.23	5000.0	1000.000	188.0	V	10.0	10.1

8.4 FCC 15.247(e) and RSS-247 5.2(b) Power Spectrum Density

8.4.1 Definitions and limits

FCC and IC:

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.

8.4.2 Test summary

Test date	July 18, 2019	Temperature	24 °C
Test engineer	Andres Martinez, Wireless Engineer	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	45 %

8.4.3 Observations, settings and special notes

EUT was tested on all 3 channels (2412MHz, 2437MHz and 2462MHz) with a data rate of 1Mbps and 6Mbps.
Offset = Antenna gain + Attenuator + Cable loss

8.4.4 Test data

Table 8.4-1: Power Spectrum Density

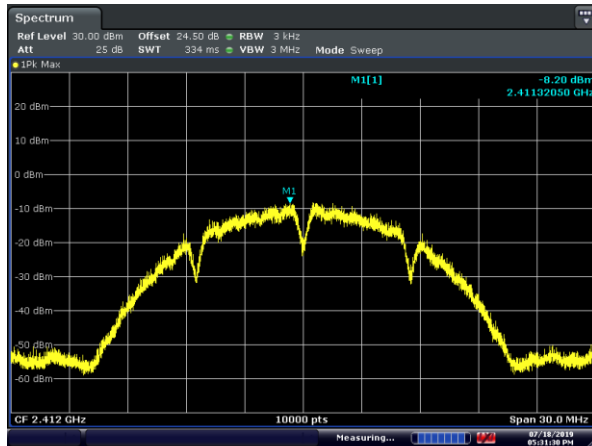
Data Rate	Frequency, MHz	Conducted PSD@50kHz, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP Result
		Measured	Limit					
1Mbps	2412	-8.20	8	16.20	Included	-8.20	8	Pass
	2437	-1.74	8	9.74	Included	-1.74	8	Pass
	2462	-7.68	8	15.68	Included	-7.68	8	Pass

Table 8.4-2: Power Spectrum Density

Data Rate	Frequency, MHz	Conducted PSD@50kHz, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP Result
		Measured	Limit					
6Mbps	2412	-12.61	8	20.61	0	-12.61	8	Pass
	2437	-4.53	8	12.53	0	-4.53	8	Pass
	2462	-12.27	8	20.27	0	-12.27	8	Pass

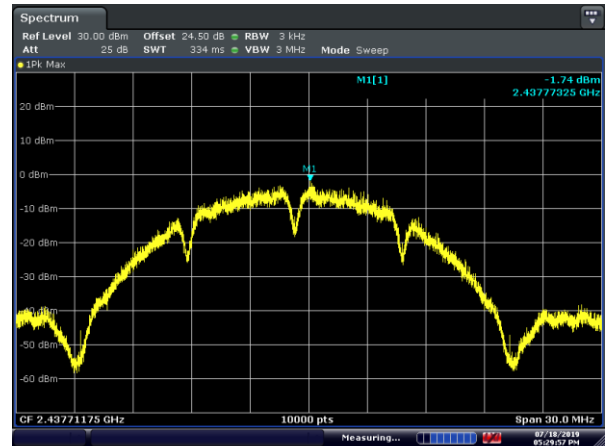
Section 8
Test name
Specification

Testing data
 FCC 15.247(e) and RSS-247 5.2(b) Power Spectrum Density
 FCC Part 15 Subpart C and RSS-247, Issue 2



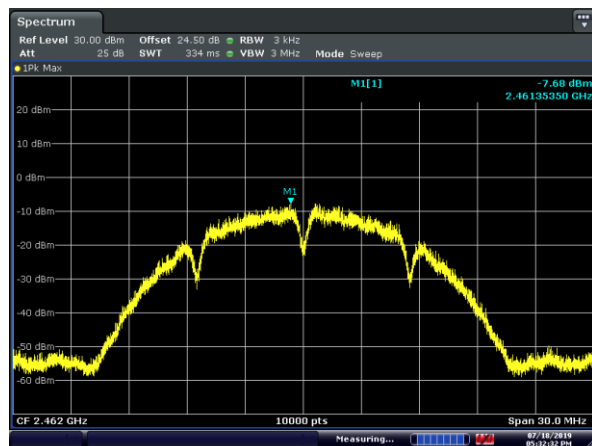
Date: 18 JUL 2019 17:31:31

Figure 8.4-1: PSD, Low CH @ 1Mbps



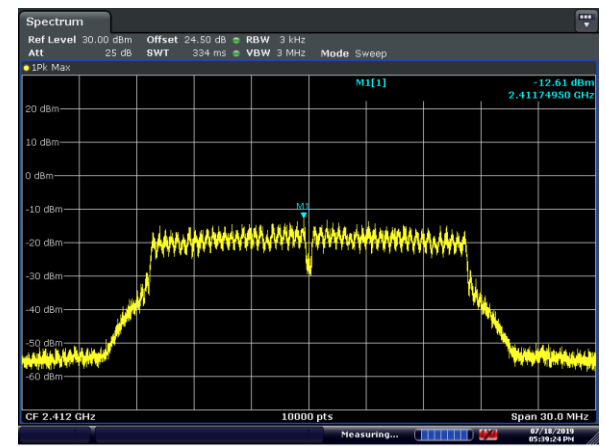
Date: 18 JUL 2019 17:29:57

Figure 8.4-2: PSD, Mid CH @ 1Mbps



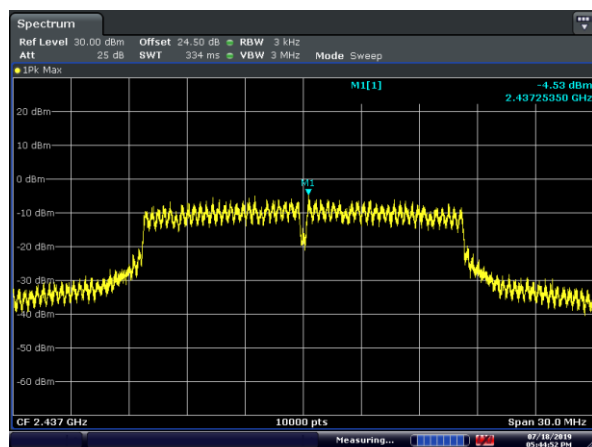
Date: 18 JUL 2019 17:32:32

Figure 8.4-3: PSD, High CH @ 1Mbps



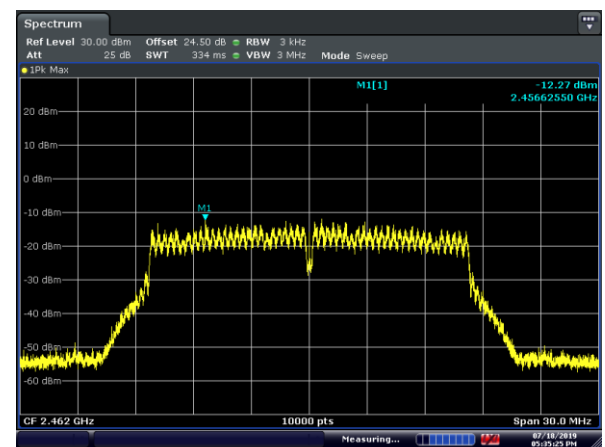
Date: 18 JUL 2019 17:39:25

Figure 8.4-4: PSD, High CH @ 6Mbps



Date: 18 JUL 2019 17:44:53

Figure 8.4-5: PSD, High CH @ 6Mbps

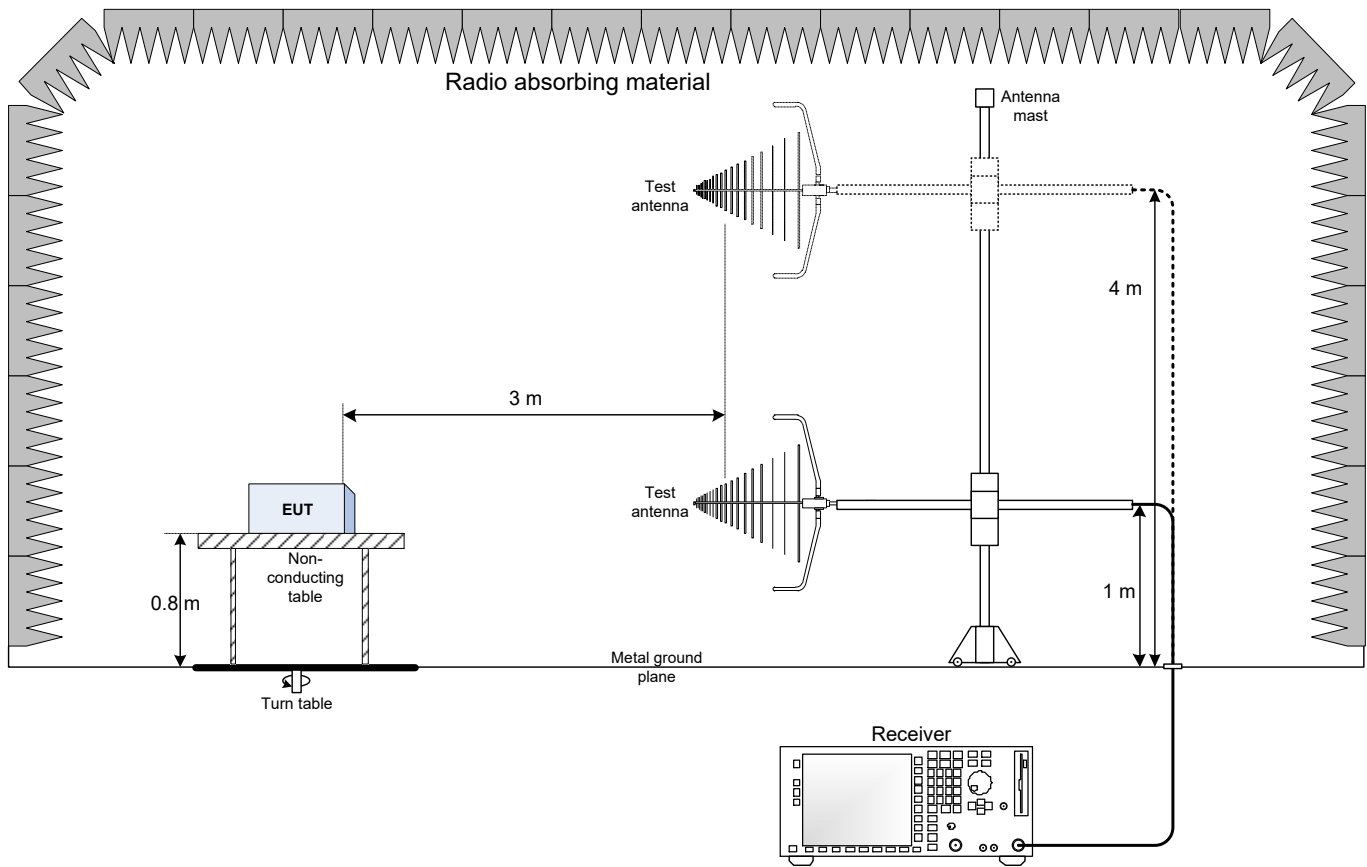


Date: 18 JUL 2019 17:35:26

Figure 8.4-6: PSD, High CH @ 6Mbps

Section 9. Block diagrams of test set-ups

9.1 Radiated emissions set-up – Below 1GHz



9.2 Radiated emissions set-up – Above 1GHz

