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Test report

339568-1TRFWL

Date of issue: November 10, 2017

Applicant: Verve Wireless, Inc.

Product: RF Beacon

Model: X v1.0 Model variant: N/A

FCC ID: 2ABMS-ROXX IC Registration number: 2ABMS-ROXX

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 (DTSs), Frequency Hopping Systems (FHSs) and Licence-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

Tested by	Mark Phillips, EMC Test Engineer
Reviewed by	Juan Manuel Gonzalez, Business Development Manager EMC/Wireless
Review date	November 10, 2017
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

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Verve Wireless, Inc
Address	5600 Avenida Encinas, Suite 120,
City	Carlsbad
Province/State	CA
Postal/Zip code	92008
Country	U.S.A.

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[1]	Not applicable
§15.31(e)	Variation of power source[3]	Pass
§15.203	Antenna requirement	Pass[2]
§15.205	Restricted bands of operation	Pass

Notes: [1] The EUT is Battery powered.

Notes:[2] The EUT uses trace antennas on PCB.

Notes:[3] The equipment was tested using a new or fully charged battery.

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 4, test results

Part	Test description	Verdict
7.1.2	Receiver radiated emission limits[1]	Not applicable
7.1.3	Receiver conducted emission limits[1]	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Not applicable
8.10	Restricted Frequency Bands	Pass

Notes: [1] According to sections 5.2 and 5.3 of RSS-Gen, Issue 4 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

Notes: [2] The EUT is Battery powered.

2.4 IC RSS-247, Issue 2, test results

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

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	October 13, 2017
Nemko sample ID number	339568

3.2 EUT information

Product name	RF Beacon
Model	X v1.0
Model variant	N/A
Serial number	N/A (prototype)
FCC ID	2ABMS-ROXX
IC Registration Number	23230-ROXX

3.3 Technical information

Applicant IC company number	23230
IC UPN number	X v1.0
All used IC test site(s) Reg. number	2040B
RSS number and Issue number	RSS-247, Issue 2, February 2017
Frequency band	2400-2483.5 MHz
Frequency Min (MHz)	2402
Frequency Max (MHz)	2480
RF power Min (W), Conducted/ERP/EIRP	N/A
RF power Max (W), Conducted/ERP/EIRP	-3.12dBm or 0.0004875 W (Conducted)
Field strength, Units @ distance	N/A
Measured BW (kHz) (6 dB)	636
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	GFSK
Emission classification (F1D, G1D, D1D)	W7D
Transmitter spurious, Units @ distance	97.24 dBµV/m @ 3m Peak
Power requirements	3.6VDC 8.1Ah Battery
Antenna information	trace antennas on PCB. Antenna gain is 5.85dBi. The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

The Model X v1.0 Verve Beacon (the "beacon") is a small, battery-powered device that transmits a Bluetooth® low-energy (BLE) signal that can be detected by other devices (e.g., smartphones or devices capable of receiving the signal). This signal identifies the beacon and broadcasts the ID to the receiving device.
The beacon works by periodically "waking up," transmitting this signal via short-range radio (BLE), and then returning to a low-power state. The beacon has no user interface (UI) or cellular or GPS capabilities. The beacon's identity is encoded within the signal it transmits.

3.5 EUT exercise details

A test software was used that allows the change of different RF modes/channels. EUT is set to fixed channel test mode with modulation.
RF conducted test was performed on unit with temporary RF output modification (50Ω SMA before antennas).
The parameters for the test SW are listed below:
CH: 02 for 2402MHZ (low CH)
CH: 26 for 2426MHZ(Mid CH)
CH: 80 for 2480MHZ(High CH)
Data Rate: Default for 1Mbps BLE
Power: 1 for 0 dBm

3.6 EUT setup diagram

Setup Photo in separate exhibit

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

Setup Photo in separate exhibit

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

Setup Photo in separate exhibit

Figure 3.6-3: Conducted Port Measurments Setup

3.7 EUT sub assemblies

Table 3.7-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number
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 ±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	3.55

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: Equipment list

Table 7.1-2: Conducted disturbance at mains port equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.

Notes: N/A - not applicable

Table 7.1-3: Radiated disturbance equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMC Test Receiver	Rohde & Schwarz	ESU 40	E1121	1 yr.	4-28-2018
Antenna, Bilog	Schaffner-Chase	CBL6111C	1480	1 yr.	11-28-2017
Antenna, Horn	EMCO	3115	1033	1 yr.	7-27-2018

Notes: None

Table 7.1-4: Antenna conducted port equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Spectrum Analyzer	Rohde & Schwarz	FSV40	E1120	1 yr.	7-27-2018
Power Sensor	ETS	7002-006	E1061	1 yr.	1-18-2018

Notes: None

Table 7.1-5: Radiated/Conducted disturbance test software details

Manufacturer of Software	Details
Rohde-Schwarz	EMC 32 V10.0

Notes: None

Section 8. Test Data

8.1 FCC 15.247(a) (2) and RSS-247 5.2(1) 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 (1) The minimum 6 dB bandwidth shall be 500 kHz.

8.1.2 Test summary

Test date	October 19, 2017	Temperature	21 °C
Test engineer	Mark Phillips	Air pressure	1003 mbar
Verdict	Pass	Relative humidity	58 %

8.1.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	1–5 % of Channel BW (no wider than 100 kHz)
Video bandwidth	≥3 × RBW
Frequency span	1.5 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	Margin, kHz
GFSK	2402	0.634	0.50	0.134
	2442	0.635	0.50	0.135
	2480	0.636	0.50	0.136

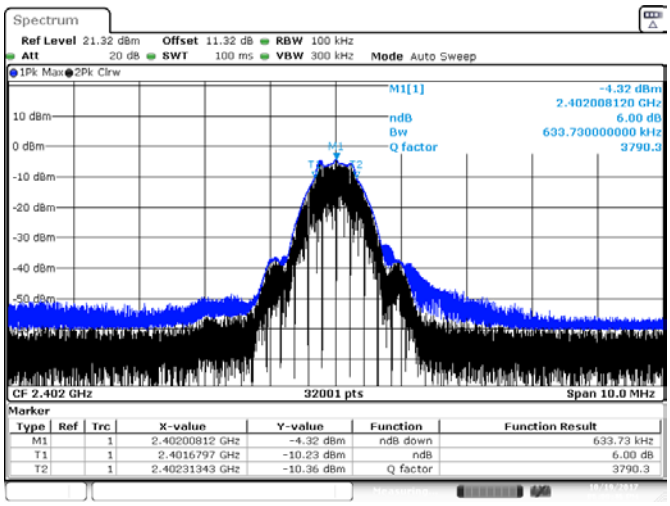


Figure 8.1-1: 6 dB bandwidth, Low CH

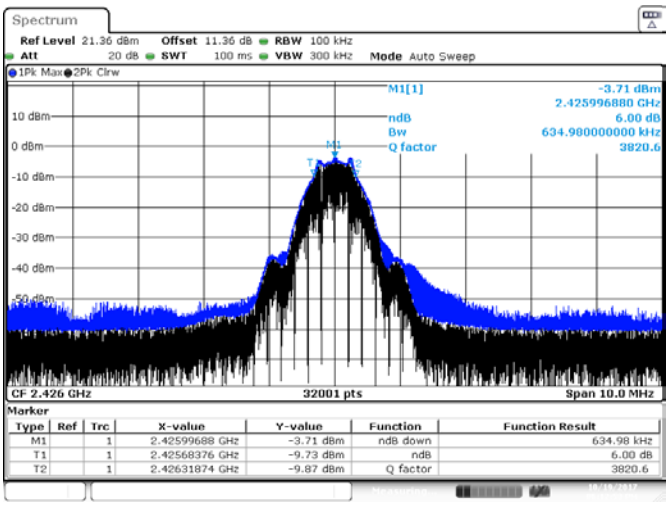


Figure 8.1-2: 6 dB bandwidth, Mid CH

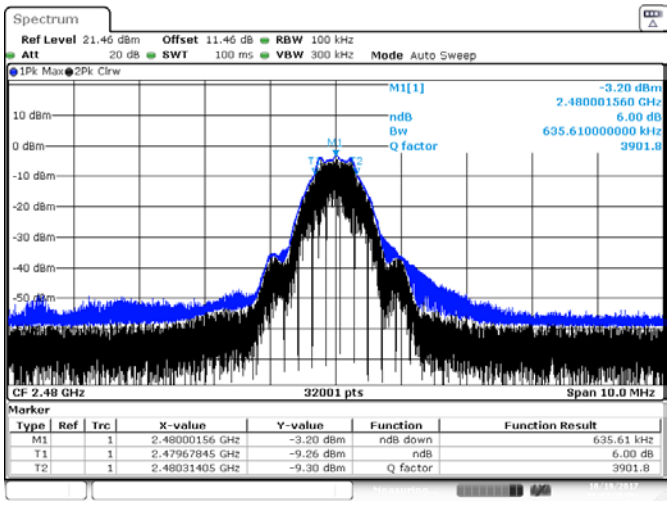


Figure 8.1-3: 6 dB bandwidth, High CH

8.2 FCC 15.247(b) and RSS-247 5.4 (4) 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

(4) 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	October 19, 2017	Temperature	21 °C
Test engineer	Mark Phillips	Air pressure	1003 mbar
Verdict	Pass	Relative humidity	58 %

8.2.3 Observations, settings and special notes

Peak Conducted Power Measured with Power Sensor.

8.2.4 Test data

Table 8.2-1: Output power measurements results

Power Source	Frequency, MHz	Conducted output power, dBm		Margin, dB	Max Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
		Measured	Limit					
Battery 3.6 VDC	2402	-3.92	30	33.92	5.85	1.93	36	34.07
	2426	-3.4	30	33.4	5.41	2.01	36	33.99
	2480	-3.12	30	33.12	4.87	1.75	36	34.25

Representative data (low Channel):

EMPower ETSI Burst Measurement System Report

Time of Measurement: 10/19/2017 7:06:40 PM

Number of Sensors: 1
Sensor 1 USB ID: 1.16.184.215.22.0.0.11

Operator: Juan Manuel Gonzalez

EUT Info: VERVE Nex 339568 Low CH 2402
Equipment ID: Radio Test Sample Conducted port Enabled
Serial Number: Eng. Sample

Settings:

Carrier Frequenc	Trigger Level (dB	Measure Time (n	Sample Rate (S/s	Gap Time (ms)	Threshold Level (	Assembly Gain (d	Beamforming Gain (dB)
2402000000	-50	100	5000000	0.001	-50	11.32	0

Results:

Max e.i.r.p. (dBm	Medium Utilisati	Duty Cycle (%)	Min. Gap Time (n	Max. Sequence T	RMS (dBm)
-3.92	0.38	96.052	0.089	2.134	-4.201

Data:

Burst #	Combined Start T	Combined Stop T	Combined Power	TxOn Time (ms)	TxOff Time (ms)	Sensor 1 Start Ti	Sensor 1 Stop Tir	Sensor 1 Power (dBm)
1	0	0.249	-4.03	0.249	0.0896	0	0.249	-15.49
2	0.3386	2.472	-4.02	2.1334	0.0894	0.3386	2.472	-15.48
3	2.5614	4.695	-4.03	2.1336	0.0898	2.5614	4.695	-15.49
4	4.7848	6.9182	-4.03	2.1334	0.0898	4.7848	6.9182	-15.49
5	7.008	9.1414	-4.03	2.1334	0.0896	7.008	9.1414	-15.49
6	9.231	11.3644	-4.02	2.1334	0.0896	9.231	11.3644	-15.48
7	11.454	13.5874	-4.02	2.1334	0.0898	11.454	13.5874	-15.48
8	13.6772	15.8106	-4.02	2.1334	0.0898	13.6772	15.8106	-15.48
9	15.9004	18.0336	-4.02	2.1332	0.0898	15.9004	18.0336	-15.48
10	18.1234	20.2564	-4.03	2.133	0.09	18.1234	20.2564	-15.49
11	20.3464	22.4796	-4.02	2.1332	0.0896	20.3464	22.4796	-15.48
12	22.5692	24.7026	-4.02	2.1334	0.0888	22.5692	24.7026	-15.48
13	24.7914	26.9258	-4.03	2.1344	0.0896	24.7914	26.9258	-15.49
14	27.0154	29.1488	-4.02	2.1334	0.0898	27.0154	29.1488	-15.48
15	29.2386	31.3718	-4.03	2.1332	0.0898	29.2386	31.3718	-15.49
16	31.4616	33.595	-4.02	2.1334	0.0898	31.4616	33.595	-15.48
17	33.6848	35.818	-4.03	2.1332	0.0898	33.6848	35.818	-15.49
18	35.9078	38.041	-4.02	2.1332	0.09	35.9078	38.041	-15.48
19	38.131	40.2644	-4.03	2.1334	0.0896	38.131	40.2644	-15.49
20	40.354	42.4872	-4.03	2.1332	0.0898	40.354	42.4872	-15.49
21	42.577	44.7104	-4.03	2.1334	0.0898	42.577	44.7104	-15.49
22	44.8002	46.9332	-4.03	2.133	0.09	44.8002	46.9332	-15.49
23	47.0232	49.1566	-4.03	2.1334	0.0898	47.0232	49.1566	-15.49
24	49.2464	51.3796	-4.03	2.1332	0.0898	49.2464	51.3796	-15.49
25	51.4694	53.6026	-4.03	2.1332	0.0898	51.4694	53.6026	-15.49
26	53.6924	55.8256	-4.02	2.1332	0.0898	53.6924	55.8256	-15.48
27	55.9154	58.0488	-4.03	2.1334	0.0896	55.9154	58.0488	-15.49
28	58.1384	60.2716	-4.03	2.1332	0.0898	58.1384	60.2716	-15.49
29	60.3614	62.4948	-4.02	2.1334	0.0898	60.3614	62.4948	-15.48
30	62.5846	64.7178	-4.02	2.1332	0.0898	62.5846	64.7178	-15.48
31	64.8076	66.9408	-4.03	2.1332	0.0898	64.8076	66.9408	-15.49
32	67.0306	69.164	-4.03	2.1334	0.0898	67.0306	69.164	-15.49
33	69.2538	71.387	-4.03	2.1332	0.0896	69.2538	71.387	-15.49
34	71.4766	73.6102	-4.03	2.1336	0.0898	71.4766	73.6102	-15.49
35	73.7	75.8332	-4.02	2.1332	0.0896	73.7	75.8332	-15.48
36	75.9228	78.0562	-4.03	2.1334	0.0892	75.9228	78.0562	-15.49
37	78.1454	80.2792	-4.03	2.1338	0.09	78.1454	80.2792	-15.49
38	80.3692	82.5026	-4.02	2.1334	0.0894	80.3692	82.5026	-15.48
39	82.592	84.7254	-4.02	2.1334	0.09	82.592	84.7254	-15.48
40	84.8154	86.9486	-4.03	2.1332	0.0896	84.8154	86.9486	-15.49
41	87.0382	89.1716	-4.03	2.1334	0.0898	87.0382	89.1716	-15.49
42	89.2614	91.3946	-4.02	2.1332	0.0896	89.2614	91.3946	-15.48
43	91.4842	93.6176	-4.03	2.1334	0.09	91.4842	93.6176	-15.49
44	93.7076	95.8408	-4.02	2.1332	0.0896	93.7076	95.8408	-15.48
45	95.9304	98.0638	-4.03	2.1334	0.0898	95.9304	98.0638	-15.49
46	98.1536	99.9998	-4.02	1.8462	0.0002	98.1536	99.9998	-15.48

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(4), 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 licence-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	October 19 and 20, 2020	Temperature	21 °C
Test engineer	Mark Phillips	Air pressure	1003 mbar
Verdict	Pass	Relative humidity	58 %

8.3.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.
EUT was set to transmit with 100 % duty cycle.

Spectrum analyser settings for conducted spurious emissions measurements:

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

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

Resolution bandwidth:	100KHz
Video bandwidth:	300 KHz
Detector mode:	PK
Trace mode:	Max Hold

8.3.4 Test data

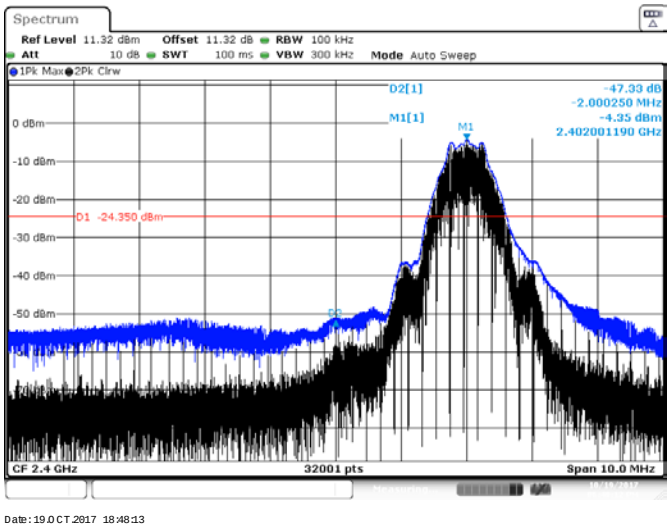


Figure 8.3.1: Bandedge Measurement, low channel

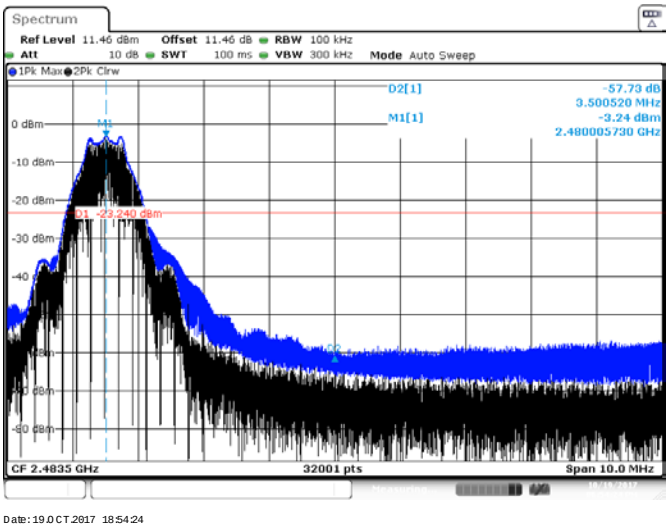
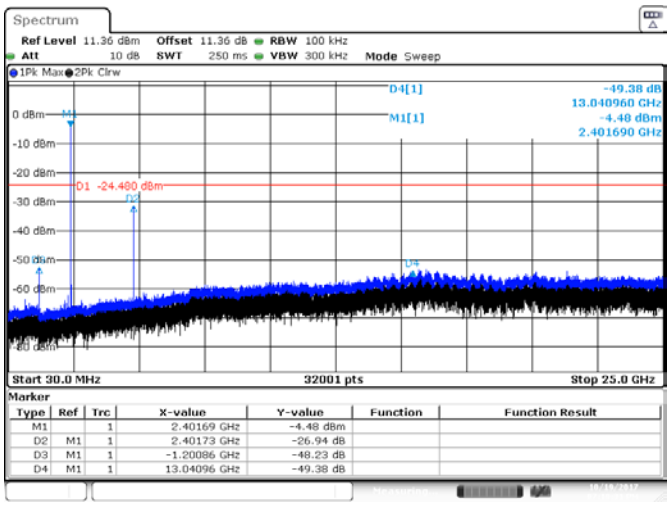


Figure 8.3.2: Bandedge Measurement, high channel

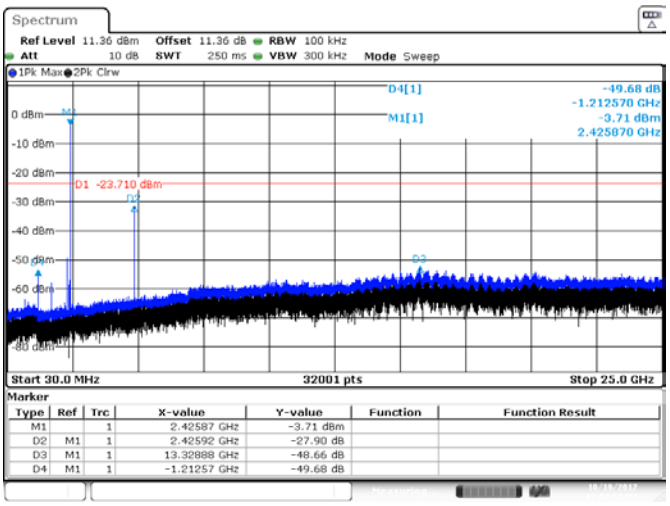
Table 8.3-4: *Reference PSD in 100kHz*

Modulation	Frequency, MHz	PSD dBm/100kHz
GFSK	2402	-4.35
	2426	-3.58
	2480	-3.24



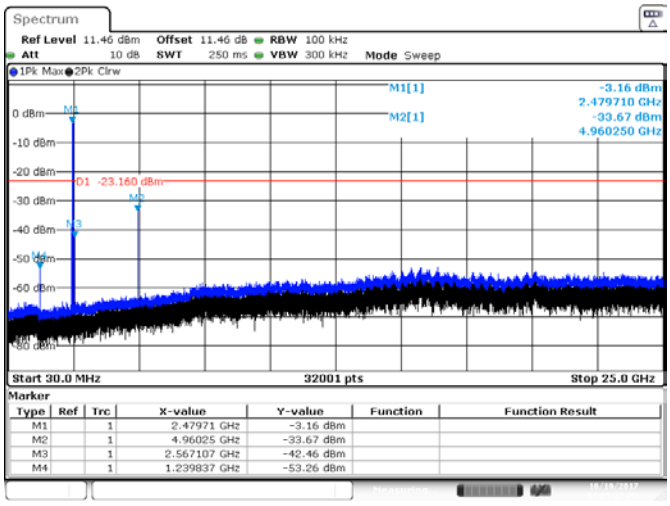
Date: 19.OCT.2017 19:10:31

Figure 8.3.3: Conducted spurious emissions, low channel



Date: 19.OCT.2017 19:07:52

Figure 8.3.4: Conducted spurious emissions, mid channel



Date: 19.OCT.2017 19:05:27

Figure 8.3.5: Conducted spurious emissions, high channel

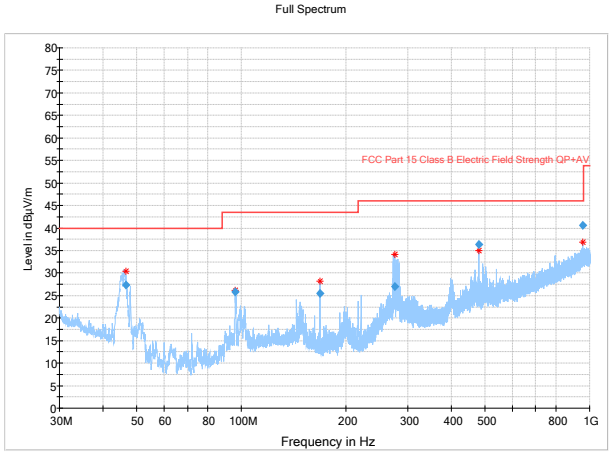


Figure 8.3.6: Radiated spurious emissions, low channel (worst Case), 30-1000MHz

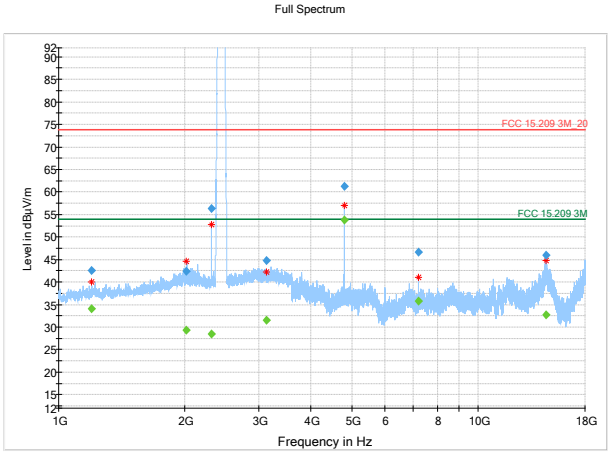


Figure 8.3.7: Radiated spurious emissions, low channel, 1-18GHz

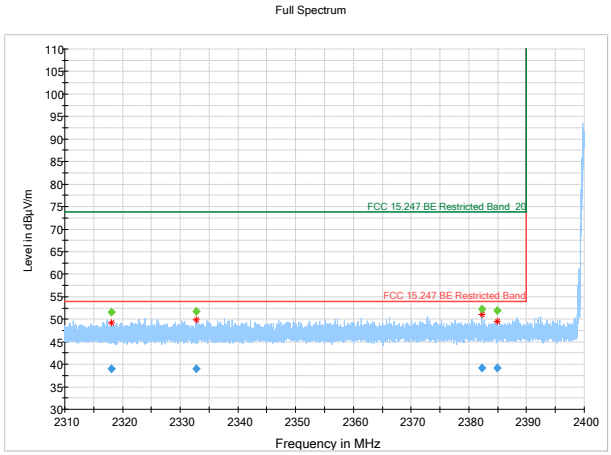


Figure 8.3.8: Radiated Bandedge in Restricted Band, low channel

Table 8.3-5: Radiated field strength measurement results for low channel 2402MHz

Final_Result for Radiated spurious emissions, low channel (worst Case), 30-1000MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
46.453500	27.35	40.00	12.65	5000.0	120.000	100.0	V	183.0	12.1
96.000000	25.76	43.50	17.74	5000.0	120.000	123.9	V	86.0	11.6
167.982500	25.50	43.50	18.00	5000.0	120.000	109.4	V	350.0	12.8
275.318000	27.09	46.00	18.91	5000.0	120.000	136.6	V	30.0	16.6
479.991500	36.37	46.00	9.63	5000.0	120.000	171.0	H	81.0	22.6
955.683000	40.63	46.00	5.37	5000.0	120.000	136.7	V	341.0	32.2

Final_Result for Radiated spurious emissions, low channel 1-18GHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1200.100000	42.65	---	73.90	31.25	5000.0	1000.000	154.5	V	357.0	0.3
1200.100000	---	34.09	53.90	19.81	5000.0	1000.000	154.5	V	357.0	0.3
2015.300000	---	29.38	53.90	24.52	5000.0	1000.000	382.0	V	170.0	3.4
2015.300000	42.48	---	73.90	31.42	5000.0	1000.000	382.0	V	170.0	3.4
2317.700000	---	28.40	53.90	25.50	5000.0	1000.000	164.3	V	230.0	3.4
2317.700000	56.26	---	73.90	17.64	5000.0	1000.000	164.3	V	230.0	3.4
3124.600000	44.75	---	73.90	29.15	5000.0	1000.000	410.0	H	178.0	6.4
3124.600000	---	31.46	53.90	22.44	5000.0	1000.000	410.0	H	178.0	6.4
4799.483333	---	53.70	53.90	0.20	5000.0	1000.000	152.1	H	162.0	10.9
4799.483333	61.24	---	73.90	12.66	5000.0	1000.000	152.1	H	162.0	10.9
7200.833333	46.71	---	73.90	27.19	5000.0	1000.000	226.7	H	192.0	18.1
7200.833333	---	35.82	53.90	18.08	5000.0	1000.000	226.7	H	192.0	18.1
14527.400000	46.03	---	73.90	27.87	5000.0	1000.000	107.4	H	72.0	30.9
14527.400000	---	32.67	53.90	21.23	5000.0	1000.000	107.4	H	72.0	30.9

Final_Result for Radiated Band edge in Restricted Band, low channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2318.022800	38.92	---	53.90	14.98	5000.0	100.000	114.6	V	-14.0	37.3
2318.022800	---	51.65	73.90	22.25	5000.0	100.000	114.6	V	-14.0	37.3
2332.819100	---	51.73	73.90	22.17	5000.0	100.000	243.4	V	21.0	37.3
2332.819100	39.03	---	53.90	14.87	5000.0	100.000	243.4	V	21.0	37.3
2382.323000	---	52.20	73.90	21.70	5000.0	100.000	152.6	V	328.0	37.5
2382.323000	39.23	---	53.90	14.67	5000.0	100.000	152.6	V	328.0	37.5
2384.970400	39.22	---	53.90	14.68	5000.0	100.000	98.0	V	43.0	37.5
2384.970400	---	51.83	73.90	22.07	5000.0	100.000	98.0	V	43.0	37.5

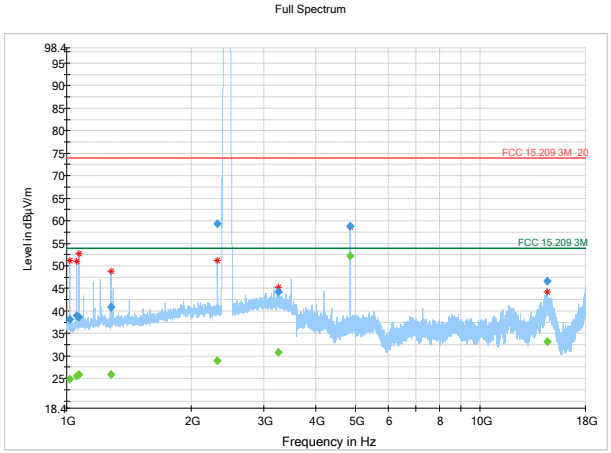


Figure 8.3.9: Radiated spurious emissions, mid channel, 1-18GHz

Table 8.3-6: Radiated field strength measurement results for mid channel 2426 MHz

Final_Result for Radiated spurious emissions, Mid channel 1-18GHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1018.500000	---	24.88	53.90	29.02	5000.0	1000.000	184.2	H	323.0	0.2
1018.500000	38.10	---	73.90	35.80	5000.0	1000.000	184.2	H	323.0	0.2
1055.100000	38.92	---	73.90	34.98	5000.0	1000.000	346.8	H	123.0	0.0
1055.100000	---	25.61	53.90	28.29	5000.0	1000.000	346.8	H	123.0	0.0
1069.200000	---	25.83	53.90	28.07	5000.0	1000.000	379.3	H	-2.0	0.0
1069.200000	38.56	---	73.90	35.34	5000.0	1000.000	379.3	H	-2.0	0.0
1279.800000	---	25.88	53.90	28.02	5000.0	1000.000	135.3	H	154.0	0.0
1279.800000	40.78	---	73.90	33.12	5000.0	1000.000	135.3	H	154.0	0.0
2317.300000	---	28.85	53.90	25.05	5000.0	1000.000	146.4	V	236.0	3.4
2317.300000	59.39	---	73.90	14.51	5000.0	1000.000	146.4	V	236.0	3.4
3246.600000	44.26	---	73.90	29.64	5000.0	1000.000	309.9	H	85.0	6.5
3246.600000	---	30.78	53.90	23.12	5000.0	1000.000	309.9	H	85.0	6.5
4852.483333	---	52.26	53.90	1.64	5000.0	1000.000	182.1	H	180.0	11.3
4852.483333	58.78	---	73.90	15.12	5000.0	1000.000	182.1	H	180.0	11.3
14533.500000	---	33.24	53.90	20.66	5000.0	1000.000	365.8	H	193.0	30.9
14533.500000	46.57	---	73.90	27.33	5000.0	1000.000	365.8	H	193.0	30.9

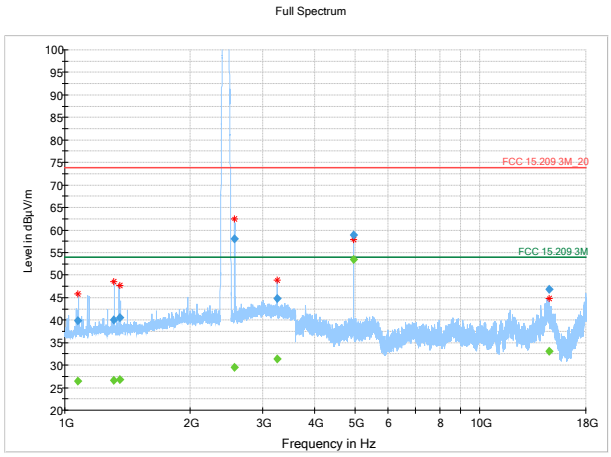


Figure 8.3.10: Radiated spurious emissions, high channel, 1-18GHz

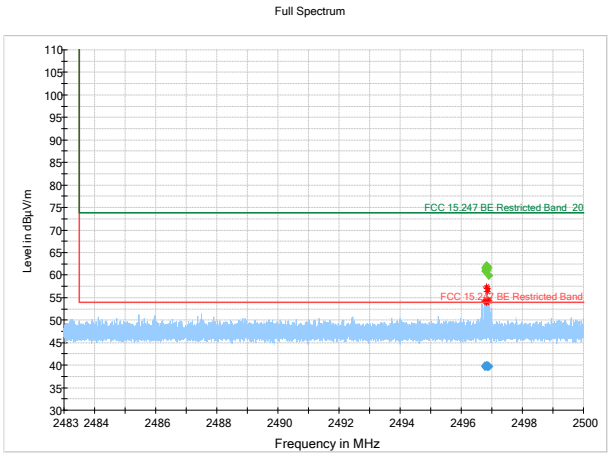


Figure 8.3.11: Radiated Bandedge in Restricted Band, high channel

Figure

Table 8.3-7: Radiated field strength measurement results for high channel 2480MHz

Final_Result for Radiated spurious emissions, high channel 1-18GHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1073.400000	---	26.40	53.90	27.50	5000.0	1000.000	360.0	H	82.0	0.1
1073.400000	39.87	---	73.90	34.03	5000.0	1000.000	360.0	H	82.0	0.1
1311.000000	40.00	---	73.90	33.90	5000.0	1000.000	382.0	H	90.0	0.1
1311.000000	---	26.62	53.90	27.28	5000.0	1000.000	382.0	H	90.0	0.1
1357.500000	40.50	---	73.90	33.40	5000.0	1000.000	162.6	H	301.0	0.2
1357.500000	---	26.74	53.90	27.16	5000.0	1000.000	162.6	H	301.0	0.2
2566.800000	57.98	---	73.90	15.92	5000.0	1000.000	167.9	V	216.0	3.8
2566.800000	---	29.52	53.90	24.38	5000.0	1000.000	167.9	V	216.0	3.8
3248.100000	44.73	---	73.90	29.17	5000.0	1000.000	404.7	V	150.0	6.5
3248.100000	---	31.44	53.90	22.46	5000.0	1000.000	404.7	V	150.0	6.5
4960.350000	58.91	---	73.90	14.99	5000.0	1000.000	185.7	H	207.0	11.9
4960.350000	---	53.53	53.90	0.37	5000.0	1000.000	185.7	H	207.0	11.9
14690.800000	46.90	---	73.90	27.00	5000.0	1000.000	401.0	H	120.0	30.9
14690.800000	---	33.14	53.90	20.76	5000.0	1000.000	401.0	H	120.0	30.9

Final_Result for Radiated Band edge in Restricted Band, high channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2496.765467	39.76	---	53.90	14.14	5000.0	100.000	167.4	V	194.0	37.9
2496.765467	---	60.98	73.90	12.92	5000.0	100.000	167.4	V	194.0	37.9
2496.772267	39.77	---	53.90	14.13	5000.0	100.000	134.2	V	196.0	37.9
2496.772267	---	61.59	73.90	12.31	5000.0	100.000	134.2	V	196.0	37.9
2496.815900	---	62.10	73.90	11.80	5000.0	100.000	145.2	V	200.0	37.9
2496.815900	39.83	---	53.90	14.07	5000.0	100.000	145.2	V	200.0	37.9
2496.827800	---	61.96	73.90	11.94	5000.0	100.000	182.2	V	196.0	37.9
2496.827800	39.79	---	53.90	14.11	5000.0	100.000	182.2	V	196.0	37.9
2496.839133	---	61.99	73.90	11.91	5000.0	100.000	126.3	V	196.0	37.9
2496.839133	39.80	---	53.90	14.10	5000.0	100.000	126.3	V	196.0	37.9
2496.857267	---	61.03	73.90	12.87	5000.0	100.000	164.0	V	159.0	37.9
2496.857267	39.76	---	53.90	14.14	5000.0	100.000	164.0	V	159.0	37.9
2496.872000	39.78	---	53.90	14.12	5000.0	100.000	153.0	V	194.0	37.9
2496.872000	---	61.63	73.90	12.27	5000.0	100.000	153.0	V	194.0	37.9
2496.903733	39.72	---	53.90	14.18	5000.0	100.000	147.4	V	198.0	37.9
2496.903733	---	59.89	73.90	14.01	5000.0	100.000	147.4	V	198.0	37.9

8.4 FCC 15.247(e) and RSS-247 5.2(2) 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	October 20, 2017	Temperature	21 °C
Test engineer	Mark Phillips	Air pressure	1001 mbar
Verdict	Pass	Relative humidity	54 %

8.4.3 Observations, settings and special notes

This is an antenna conducted port test using method 10.2 (Peak PSD) per KDB 558074 (V04):

Set the span to 1.5 x DTS bandwidth.
Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
Set the VBW ≥ 3 x RBW.
Detector = peak.
Sweep time = auto couple.
Trace mode = max hold.
Allow trace to fully stabilize.
Use the peak marker function to determine the maximum amplitude level within the RBW.
If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

8.4.4 Test data

Table 8.4-1: Power Spectrum Density

Modulation	Frequency, MHz	Conducted PSD@3kHz, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
		Measured	Limit					
GFSK	2402	-4.20	8	12.2	5.85	1.93	14	12.07
	2426	-3.58	8	11.58	5.41	2.01	14	11.99
	2480	-3.10	8	11.1	4.87	1.75	14	12.25

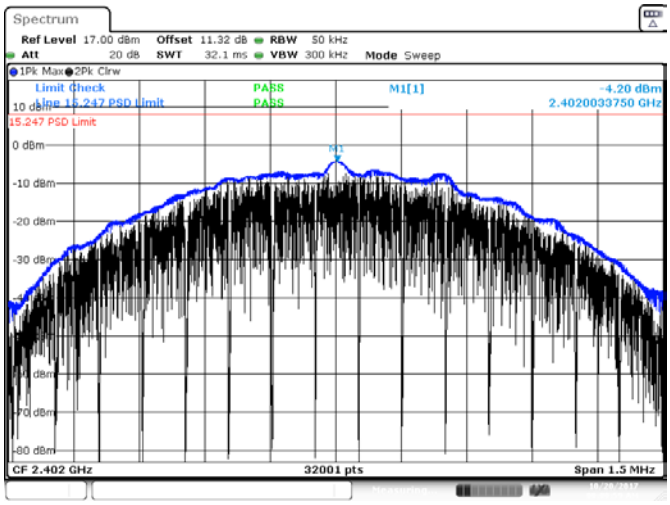


Figure 8.4-1: PSD, Low CH

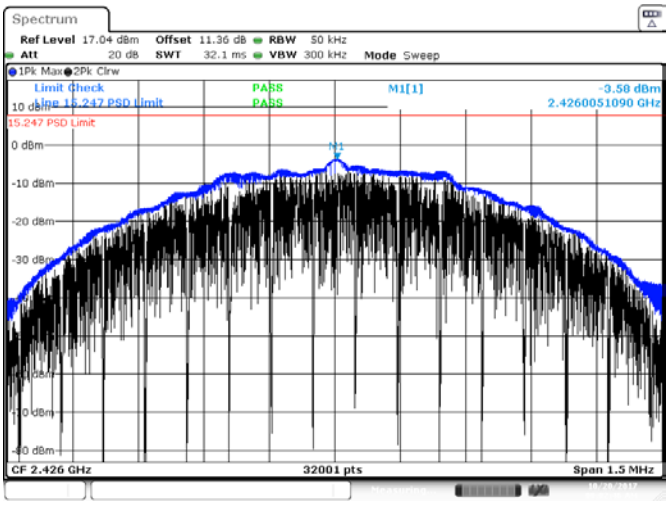


Figure 8.4-2: PSD, Mid CH

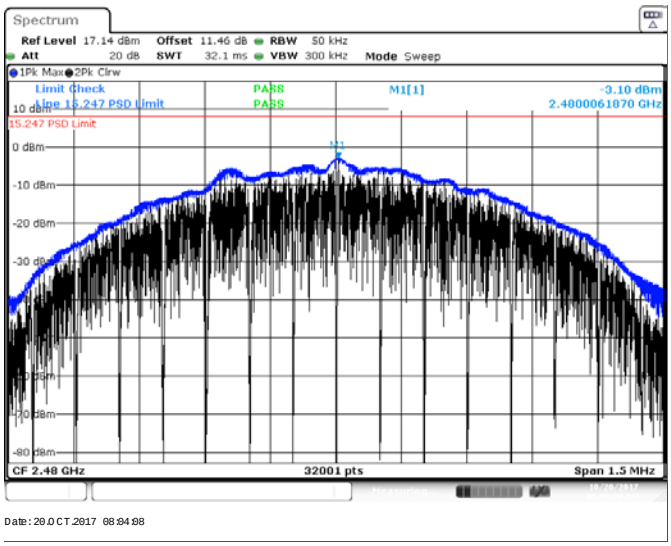


Figure 8.4-3: PSD, High CH

8.5 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits

8.5.1 Definitions and limits

Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator 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). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

The conducted emissions shall be measured with a 50 Ω/50 µH line impedance stabilization network (LISN).

Table 8.5-1: 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.

8.5.2 Test summary

Test date		Temperature	
Test engineer		Air pressure	
Verdict	N/A	Relative humidity	

8.5.3 Observations, settings and special notes

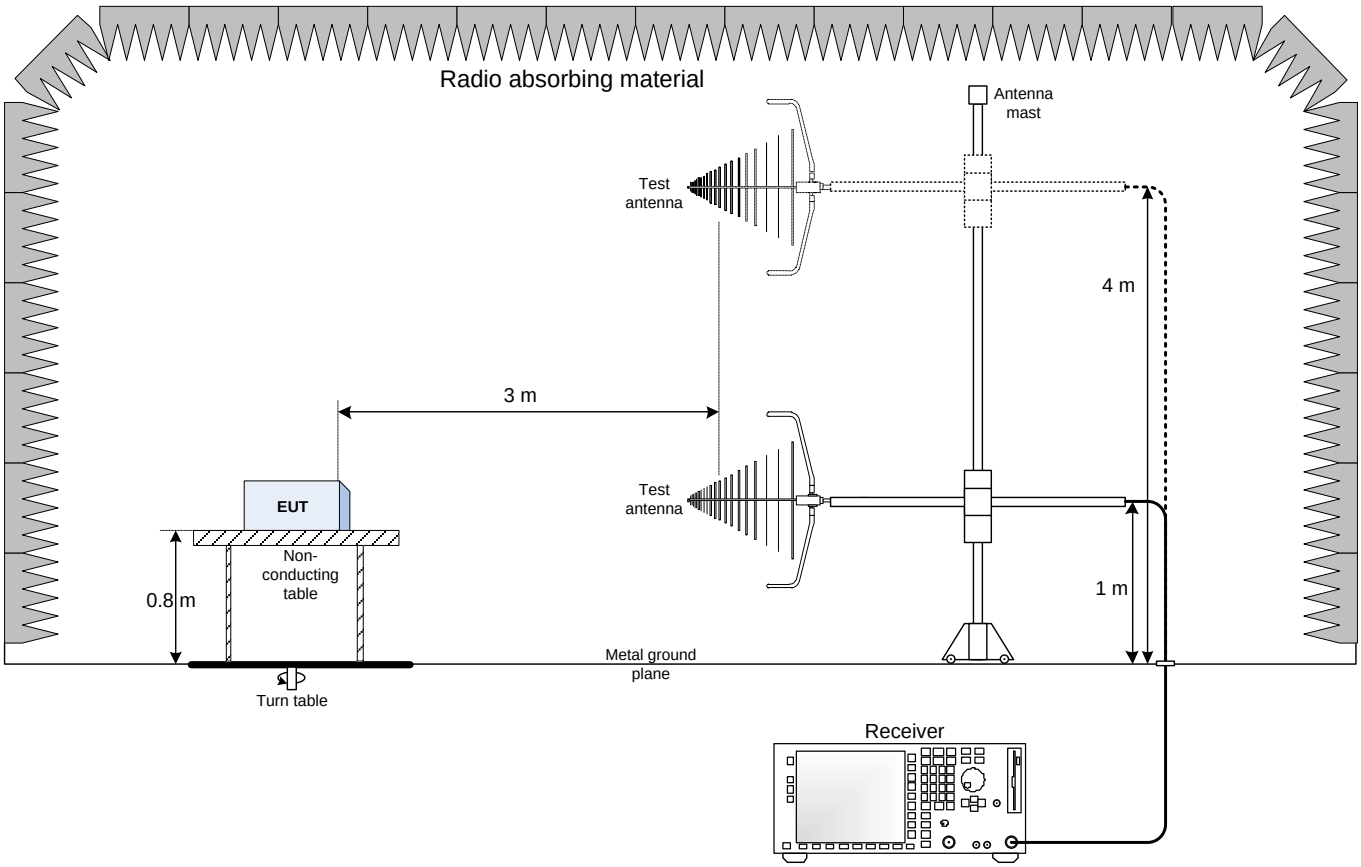
N/A.- EUT is battery powered

8.5.4 Test data

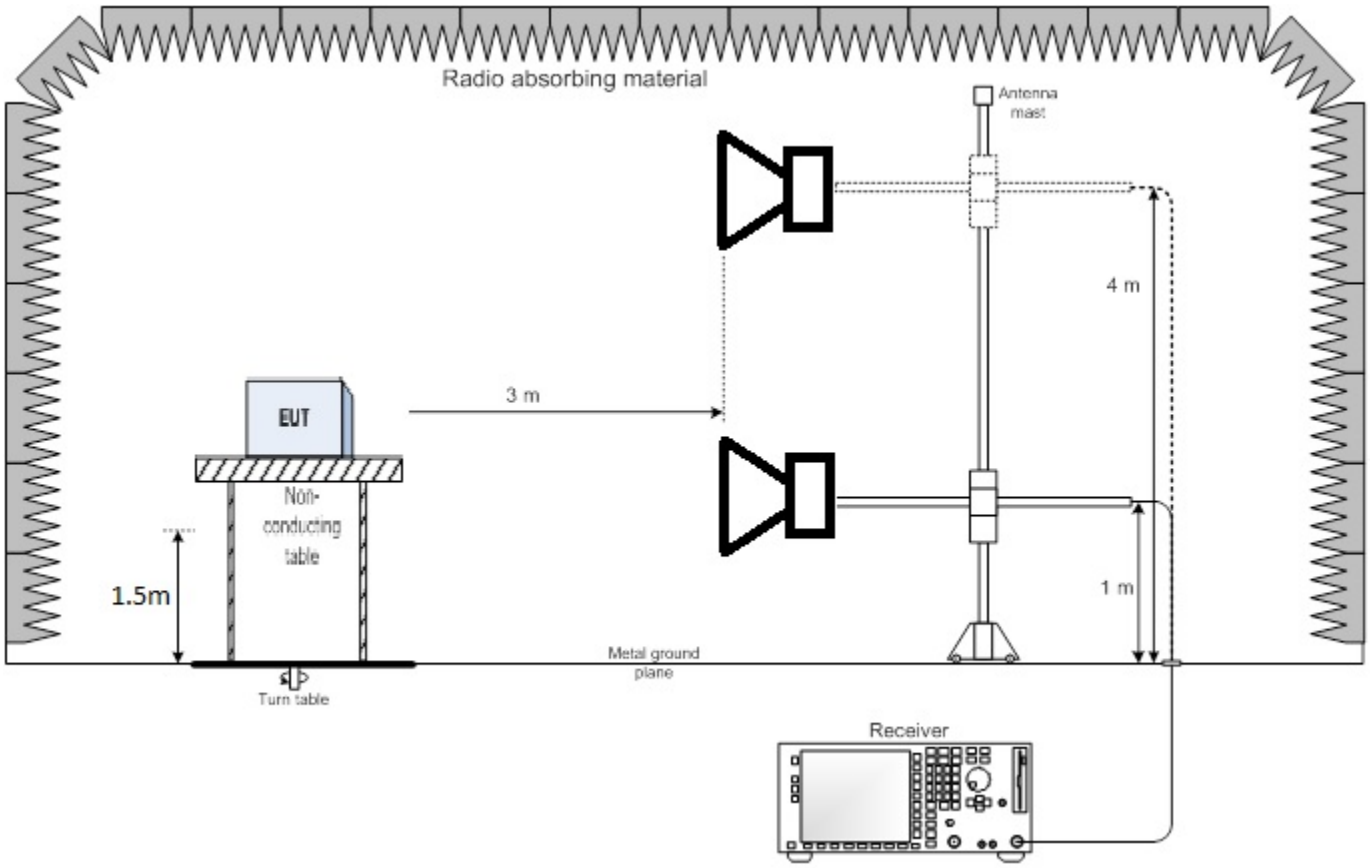
N/A

Section 9. Block diagrams of test set-ups

9.1 Radiated emissions set-up – Below 1GHz



9.2 Radiated emissions set-up – Above 1GHz



9.3 Conducted emissions set-up