

Test report

326540-2R2TRFWL

Date of issue: July 21, 2017

Applicant: HM Electronics, Inc.

Product: Advanced Vehicle Detection Board

Model: RFM100

Model variant: N/A

FCC ID: BYMRFM100

IC Registration number: 1860A-RFM100

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.
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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	James Morris, EMC and Divisions Manager
Review date	July 21, 2017
Reviewer signature	<i>James E Morris</i>

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.

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	HM Electronics, Inc.
Address	14110 Stowe Drive
City	Poway
Province/State	CA
Postal/Zip code	92064
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
R1TRF	Updated according to review comment
R2TRF	Updated according to review comment

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 ¹
§15.205	Restricted bands of operation	Pass

Notes: ¹ The EUT uses trace antennas on PCB.

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	Not applicable
7.1.3	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass
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.

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	March 27, 2017
Nemko sample ID number	326540

3.2 EUT information

Product name	Advanced Vehicle Detection Board
Model	RFM100
Model variant	N/A
Serial number	N/A (prototype)
FCC ID	BYMRFM100
IC Registration Number	1860A-RFM100

3.3 Technical information

Applicant IC company number	1860A
IC UPN number	RFM100
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	0.00066 (Conducted)
Field strength, Units @ distance	N/A
Measured BW (kHz) (6 dB)	709
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	GFSK
Emission classification (F1D, G1D, D1D)	W7D
Transmitter spurious, Units @ distance	71.35 dBμV/m @ 3m Peak / 39.78 dBμV/m @ 3m AVG
Power requirements	12VDC
Antenna information	trace antennas on PCB. Antenna gain is 1.1dBi. The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

Model RFM100 is a Bluetooth Module that when installed in other systems such as a timer or base station and used in conjunction with a ground loop, the RFM100 detects the presence or absence of vehicles on top of the ground loop. The RFM100 monitors and adjust certain health conditions of the ground loop. It also provides user alerts of changes on the ground loop's health status. These alerts are communicated through the Bluetooth communication link.

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).

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: AC Powerline Conducted Emissions Setup

3.7 EUT sub assemblies

Table 3.7-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number
Advanced Vehicle Detection Board	RFM100	G2997	N/A (prototype)

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	3.55

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: Equipment list

Asset Tag	Description	Manufacturer	Model	Serial #	Next Cal
752	Antenna, DRWG	EMCO	3115	9609-4943	04-May-2017
809	Multimeter	Fluke	111	77790102	29-Jun-2017
E1019	Two Line V-Network	Rohde & Schwarz	ENV216	101045	15-Jun-2017
E1035	Variac (Variable Transformer) 3KVA	Shanghai China	TDGC	N/A	VOU
1480	Antenna, Bilog	Schaffner-Chase	CBL6111C	2572	21-Jul-2017
E1120	Signal and Spectrum Analyzer	Rohde & Schwarz	FSV40	101395	25-May-2017
E1121	EMI Test Receiver	Rohde & Schwarz	ESU 40	100064	28-Apr-2018
N/A	10m Chamber Cable - HF	N/A	N/A	N/A	
N/A	10m Chamber Cable - LF	N/A	N/A	N/A	
N/A	RF Conducted Cables - HF	N/A	N/A	N/A	
317	Preamp	HP	8449B	N/A	
N/A	Attenuator	HP	8493A	05391	

Note: NCR - no calibration required, VOU - verify on use

Table 7.1-2: Equipment list

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	June 2, 2017	Temperature	22 °C
Test engineer	Mark Phillips	Air pressure	1004 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	$\geq 3 \times \text{RBW}$
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	0.698	0.50	0.198
	2442	0.703	0.50	0.203
	2480	0.709	0.50	0.209

Section 8
Test name
Specification

Testing data
 FCC 15.247(a) (2) and RSS-247 5.2(1) Minimum 6 dB bandwidth
 FCC 15 Subpart C and RSS-247, Issue 2

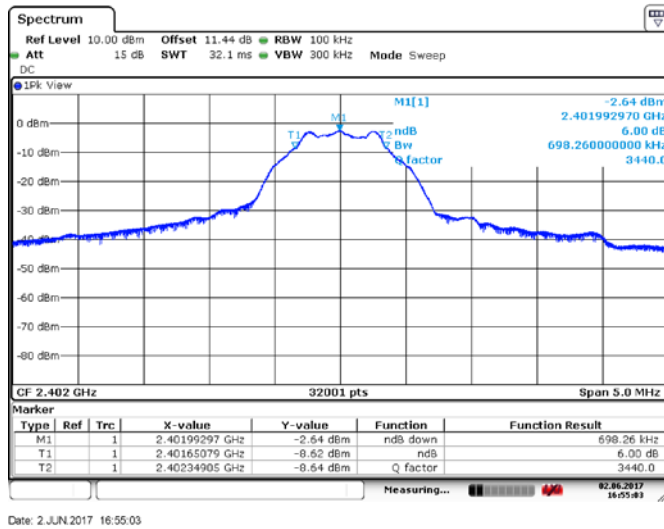


Figure 8.1-1: 6 dB bandwidth, Low CH

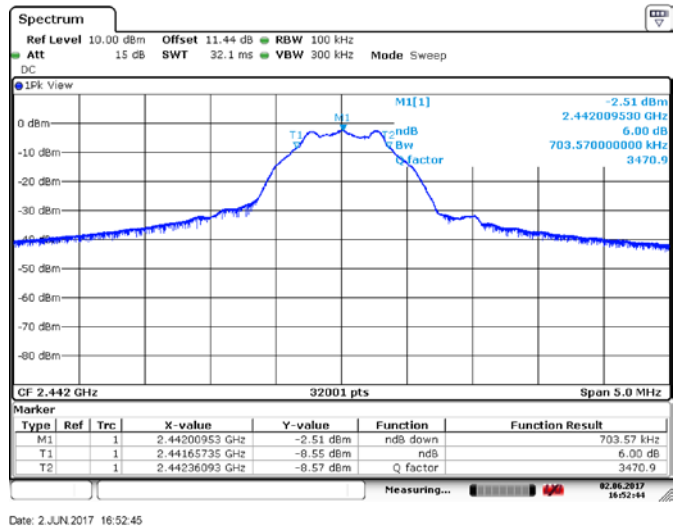


Figure 8.1-2: 6 dB bandwidth, Mid CH

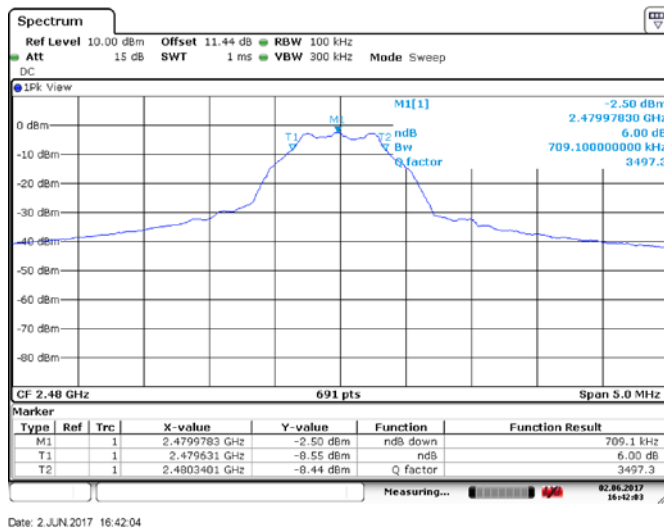


Figure 8.1-3: 6 dB bandwidth, High CH

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	June 2, 2017	Temperature	21 °C
Test engineer	Mark Phillips	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	57 %

8.2.3 Observations, settings and special notes

Peak Conducted Power Measured

Spectrum analyser settings:

Resolution bandwidth	≥ Channel BW (3MHz)
Video bandwidth	≥ 3 × RBW (10MHz)
Frequency span	≥ 3 × RBW (10MHz)
Detector mode	Peak
Trace mode	Max Hold

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					
12 VDC	2402	-1.93	30	31.93	1.1	-0.83	36	36.83
	2442	-1.75	30	31.75	1.1	-0.65	36	36.65
	2480	-1.94	30	31.94	1.1	-0.84	36	36.84

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	June 2, 2017	Temperature	21 °C
Test engineer	Mark Phillips	Air pressure	1005 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:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	AVG
Trace mode:	Max Hold

8.3.4 Test data

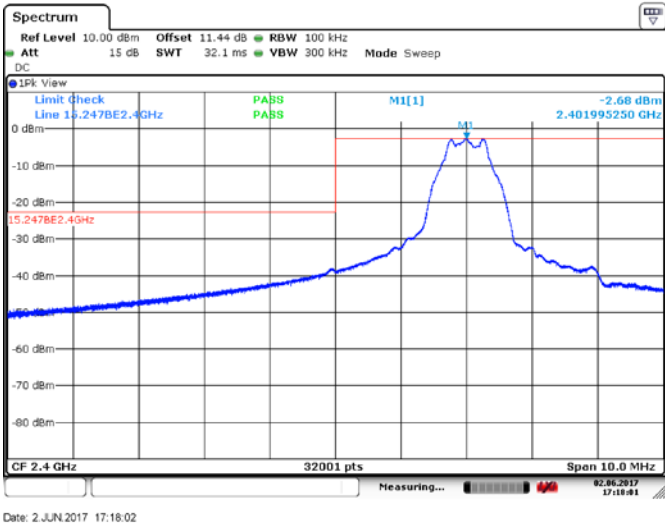


Figure 8.3.1: Bandedge Measurement, low channel

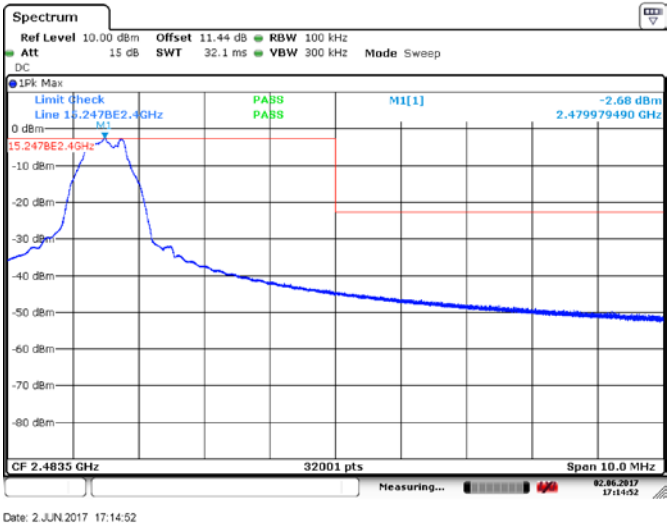


Figure 8.3.2: Bandedge Measurement, high channel

Table 8.3-4: Reference PSD in 100kHz

Modulation	Frequency, MHz	PSD dBm/100kHz
GFSK	2402	-2.68
	2440	-2.68
	2480	-2.68

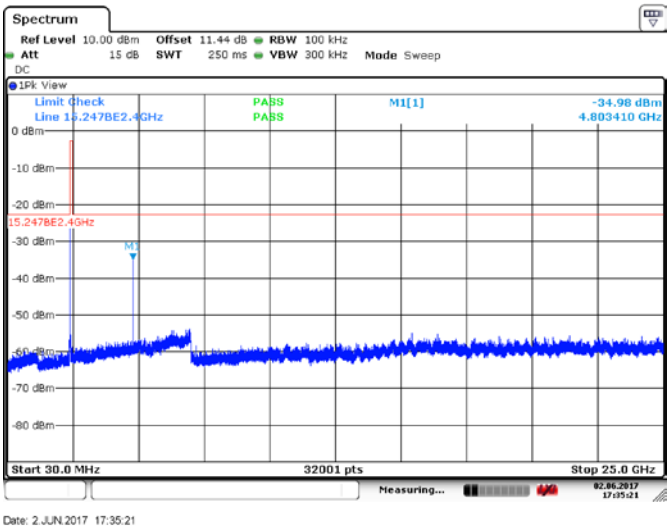


Figure 8.3.3: Conducted spurious emissions, low channel

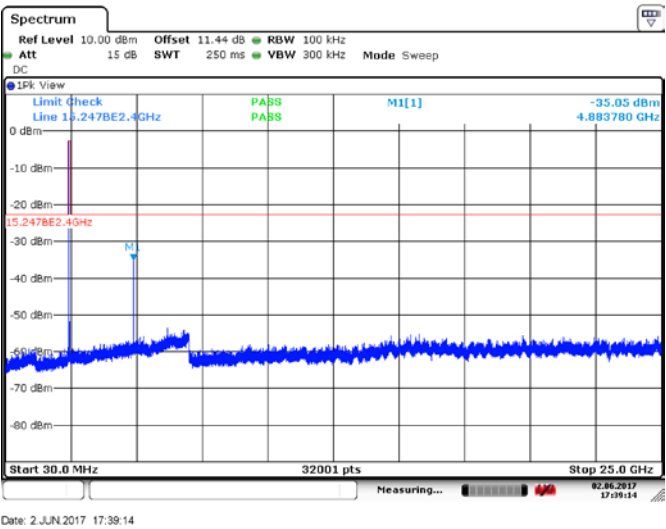


Figure 8.3.4: Conducted spurious emissions, mid channel

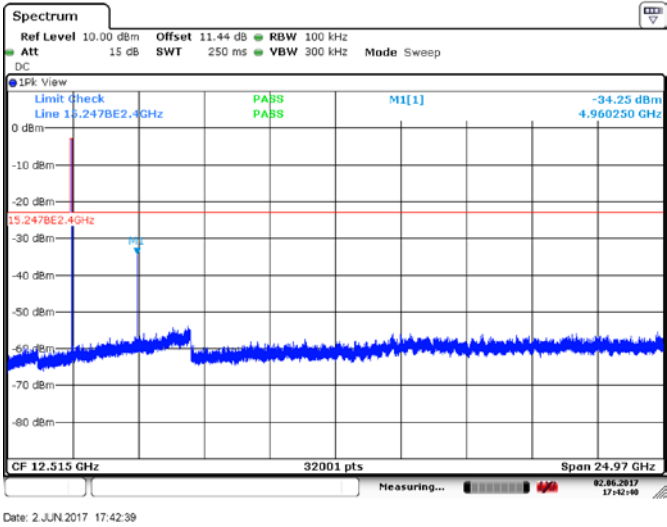


Figure 8.3.5: Conducted spurious emissions, high channel

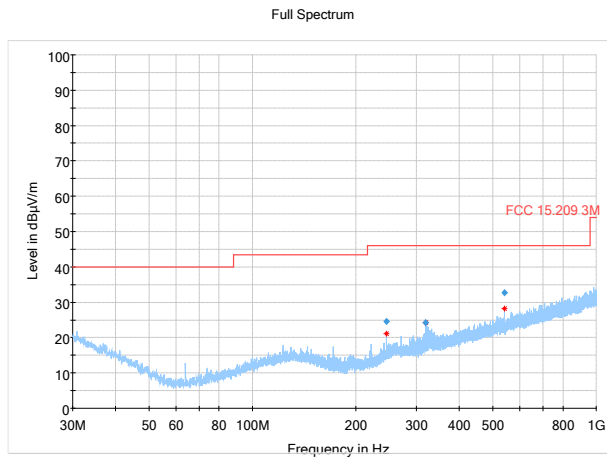


Figure 8.3.6: Radiated spurious emissions, low channel, 30-1000MHz

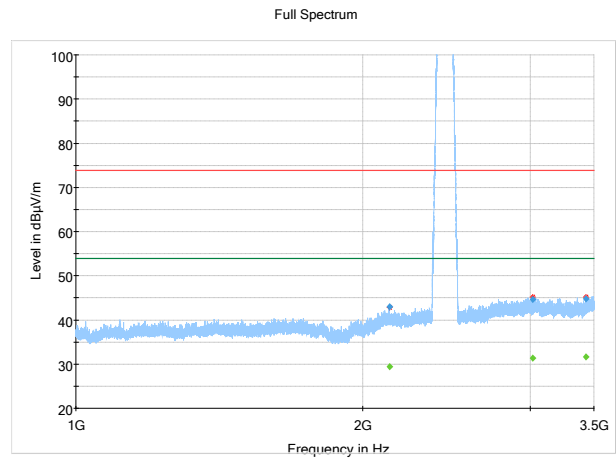


Figure 8.3.7: Radiated spurious emissions, low channel, 1-3.5GHz

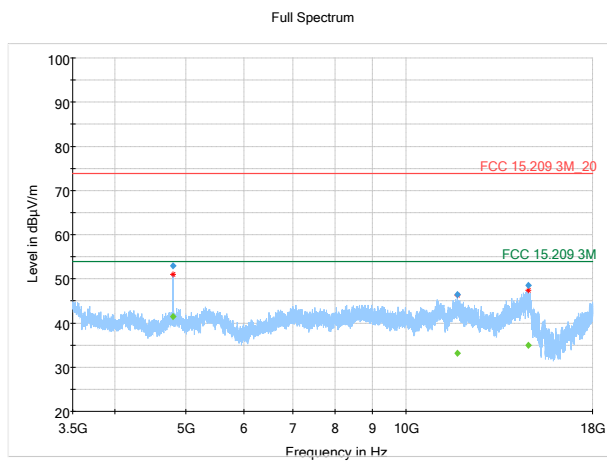


Figure 8.3.8: Radiated spurious emissions, low channel, 3.5 - 18GHz

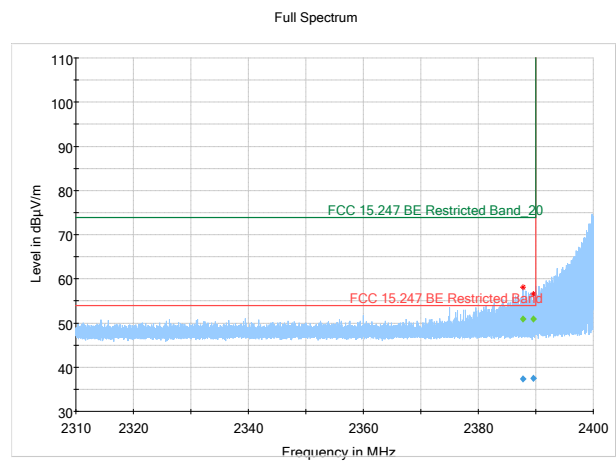


Figure 8.3.9: Radiated Bandedge in Restricted Band, low channel

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

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
245.756500	24.62	46.00	21.38	5000.0	120.000	120.4	H	74.0
318.395000	24.15	46.00	21.85	5000.0	120.000	169.8	H	0.0
540.636500	32.73	46.00	13.27	5000.0	120.000	197.3	H	58.0

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
3433.316667	44.79	---	73.90	29.11	5000.0	1000.000	261.2	H	109.0
3433.316667	---	31.56	53.90	22.34	5000.0	1000.000	261.2	H	109.0
2136.433333	43.02	---	73.90	30.88	5000.0	1000.000	112.7	H	292.0
2136.433333	---	29.37	53.90	24.53	5000.0	1000.000	112.7	H	292.0
3019.483333	44.59	---	73.90	29.31	5000.0	1000.000	228.9	V	166.0
3019.483333	---	31.40	53.90	22.50	5000.0	1000.000	228.9	V	166.0

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
4804.466667	52.96	---	73.90	20.94	5000.0	1000.000	142.5	H	259.0
4804.466667	---	41.45	53.90	12.45	5000.0	1000.000	142.5	H	259.0
11765.416667	---	33.17	53.90	20.73	5000.0	1000.000	383.6	H	304.0
11765.416667	46.45	---	73.90	27.45	5000.0	1000.000	383.6	H	304.0
14697.166667	48.54	---	73.90	25.36	5000.0	1000.000	116.9	H	0.0
14697.166667	---	35.00	53.90	18.90	5000.0	1000.000	116.9	H	0.0

Frequency (MHz)	Average (dBμV/m)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
2387.775000	---	50.93	73.90	22.97	5000.0	1000.000	135.0	H	212.0
2387.775000	37.39	---	53.90	16.51	5000.0	1000.000	135.0	H	212.0
2389.590000	---	50.84	73.90	23.06	5000.0	1000.000	191.3	H	-58.0
2389.590000	37.43	---	53.90	16.47	5000.0	1000.000	191.3	H	-58.0

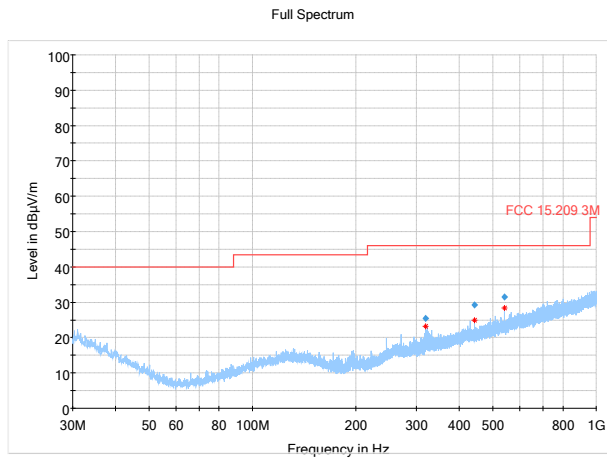


Figure 8.3.10: Radiated spurious emissions, mid channel, 30-1000MHz

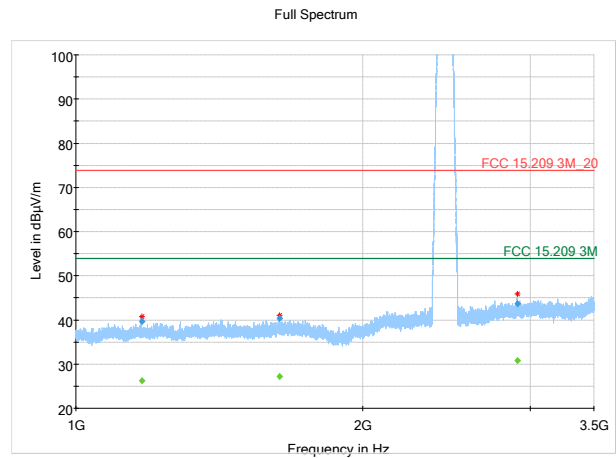


Figure 8.3.11: Radiated spurious emissions, mid channel, 1-3.5GHz

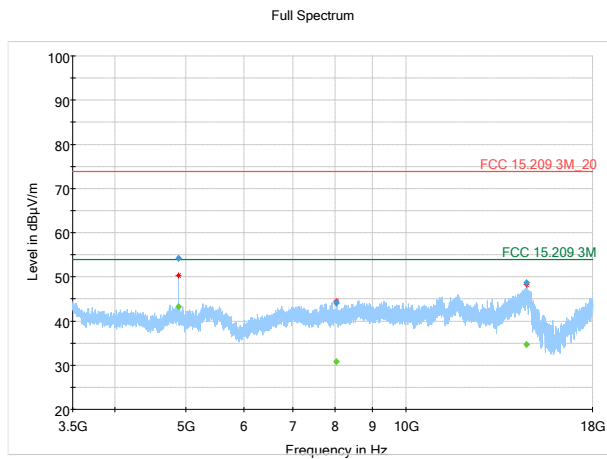


Figure 8.3.12: Radiated spurious emissions, Mid channel, 3.5 - 18GHz

Table 8.3-6: Radiated field strength measurement results for mid channel 2442 MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
319.476500	25.35	46.00	20.65	5000.0	120.000	337.3	H	267.0	17.1
442.375500	29.27	46.00	16.73	5000.0	120.000	183.4	H	124.0	20.6
540.725000	31.44	46.00	14.56	5000.0	120.000	182.0	H	171.0	22.7

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1172.600000	---	26.25	53.90	27.65	5000.0	1000.000	140.3	H	200.0
1172.600000	39.62	---	73.90	34.28	5000.0	1000.000	140.3	H	200.0
1637.166667	40.33	---	73.90	33.57	5000.0	1000.000	395.7	H	188.0
1637.166667	---	27.22	53.90	26.68	5000.0	1000.000	395.7	H	188.0
2908.066667	43.73	---	73.90	30.17	5000.0	1000.000	188.7	H	0.0
2908.066667	---	30.83	53.90	23.07	5000.0	1000.000	188.7	H	0.0

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
4883.500000	---	43.30	53.90	10.60	5000.0	1000.000	137.7	H	256.0
4883.500000	54.16	---	73.90	19.74	5000.0	1000.000	137.7	H	256.0
8036.633333	44.03	---	73.90	29.87	5000.0	1000.000	110.8	H	16.0
8036.633333	---	30.83	53.90	23.07	5000.0	1000.000	110.8	H	16.0
14609.683333	48.63	---	73.90	25.27	5000.0	1000.000	172.9	H	106.0
14609.683333	---	34.74	53.90	19.16	5000.0	1000.000	172.9	H	106.0

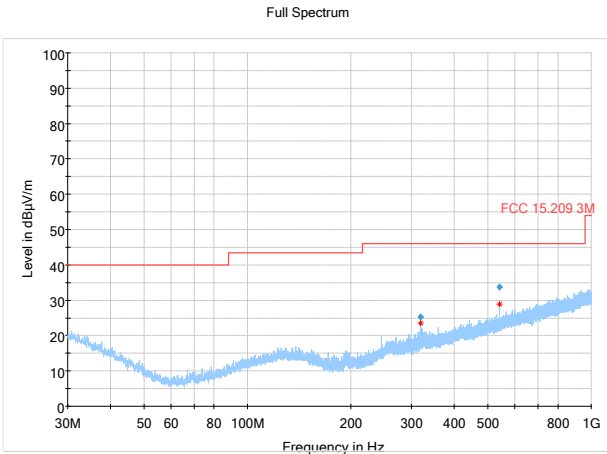


Figure 8.3.13: Radiated spurious emissions, high channel, 30-1000MHz

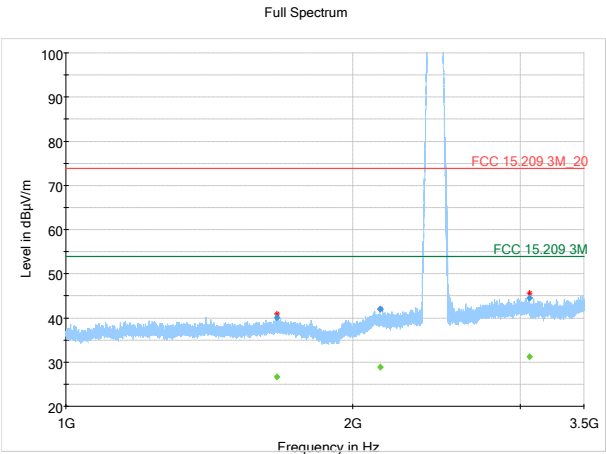


Figure 8.3.14: Radiated spurious emissions, high channel, 1-3.5GHz

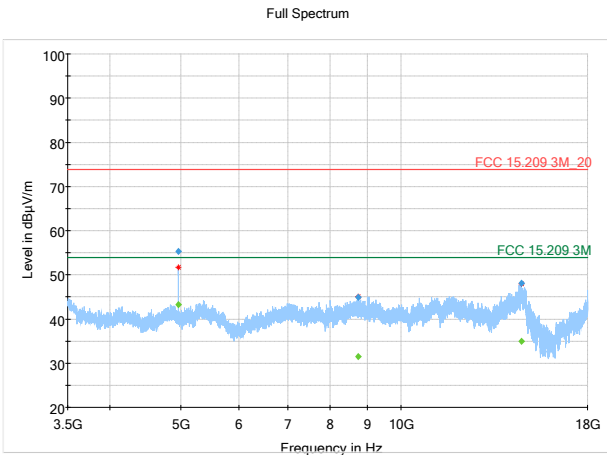


Figure 8.3.15: Radiated spurious emissions, high channel, 3.5 - 18GHz

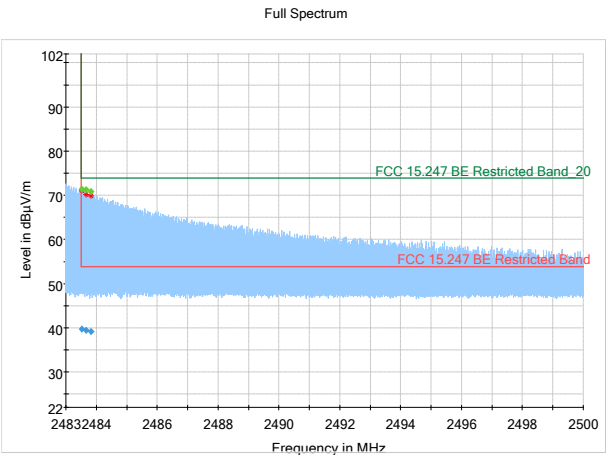


Figure 8.3.16: Radiated Bandwidth in Restricted Band, high channel

Figure

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

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
319.468000	25.25	46.00	20.75	5000.0	120.000	388.0	H	293.0
540.676500	33.70	46.00	12.30	5000.0	120.000	141.8	H	169.0

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1666.500000	40.08	---	73.90	33.82	5000.0	1000.000	234.6	V	320.0
1666.500000	---	26.69	53.90	27.21	5000.0	1000.000	234.6	V	320.0
2138.233333	---	28.84	53.90	25.06	5000.0	1000.000	209.1	V	319.0
2138.233333	41.99	---	73.90	31.91	5000.0	1000.000	209.1	V	319.0
3066.933333	44.45	---	73.90	29.45	5000.0	1000.000	162.3	H	48.0
3066.933333	---	31.16	53.90	22.74	5000.0	1000.000	162.3	H	48.0

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
4960.583333	---	43.19	53.90	10.71	5000.0	1000.000	128.6	H	278.0
4960.583333	55.34	---	73.90	18.56	5000.0	1000.000	128.6	H	278.0
8740.733333	---	31.52	53.90	22.38	5000.0	1000.000	101.7	H	167.0
8740.733333	44.98	---	73.90	28.92	5000.0	1000.000	101.7	H	167.0
14607.983333	---	34.98	53.90	18.92	5000.0	1000.000	191.8	H	282.0
14607.983333	48.09	---	73.90	25.81	5000.0	1000.000	191.8	H	282.0

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)
2483.517933	---	71.35	73.90	2.55	5000.0	1000.000	121.6	H	106.0	37.8
2483.517933	39.78	---	53.90	14.12	5000.0	1000.000	121.6	H	106.0	37.8
2483.659033	---	71.29	73.90	2.61	5000.0	1000.000	118.3	H	104.0	37.8
2483.659033	39.44	---	53.90	14.46	5000.0	1000.000	118.3	H	104.0	37.8
2483.830167	---	70.82	73.90	3.08	5000.0	1000.000	117.9	H	104.0	37.8
2483.830167	39.17	---	53.90	14.73	5000.0	1000.000	117.9	H	104.0	37.8

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	June 2, 2017	Temperature	22 °C
Test engineer	Mark Phillips	Air pressure	1002 mbar
Verdict	Pass	Relative humidity	56 %

8.4.3 Observations, settings and special notes

3kHz RBW

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	-16.65	8	24.65	1.1	-15.55	14	29.55
	2442	-16.71	8	24.71	1.1	-15.61	14	29.61
	2480	-16.49	8	24.49	1.1	-15.39	14	29.39

Section 8
Test name
Specification

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

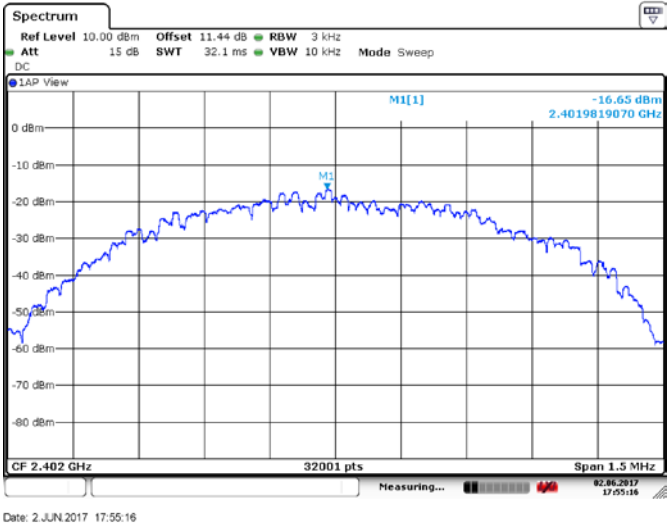


Figure 8.4-1: PSD, Low CH

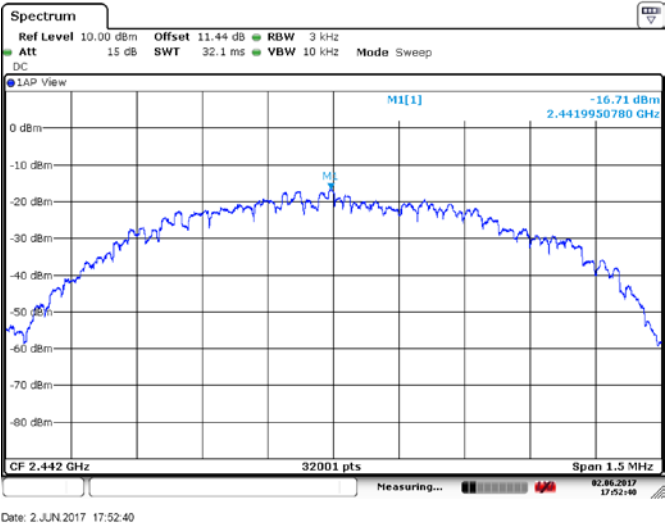


Figure 8.4-2: PSD, Mid CH

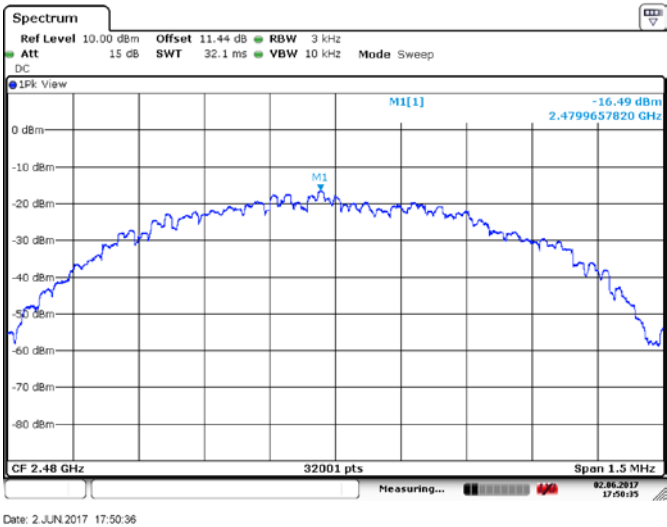


Figure 8.4-3: PSD, High CH

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 μ H/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 μ H line impedance stabilization network (LISN).

Table 8.5-1: Conducted emissions limit

Frequency of emission (MHz)	Conducted limit (dB μ V)	
	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	June 2, 2017	Temperature	21 °C
Test engineer	Rodel Resolme	Air pressure	1004 mbar
Verdict	Pass	Relative humidity	55 %

8.5.3 Observations, settings and special notes

This is tested with High CH TX on.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

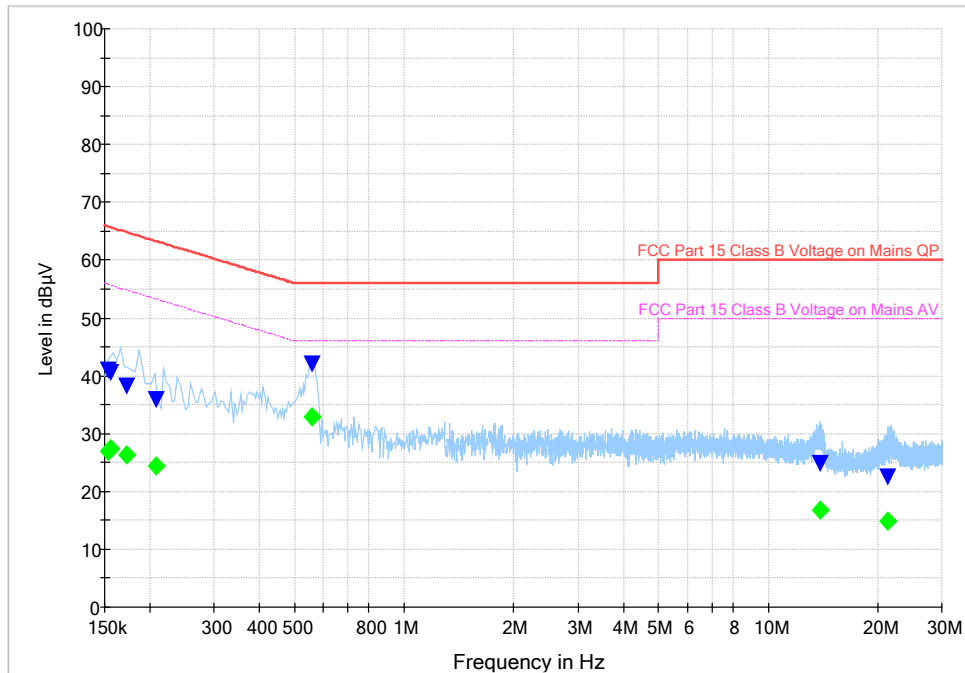
A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

Test receiver settings:

Frequency span	150 kHz to 30 MHz
Detector mode	Peak and Average (preview mode); Quasi-Peak (final measurements)
Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Trace mode	Max Hold
Measurement time	1000 ms

8.5.4 Test data

Full Spectrum



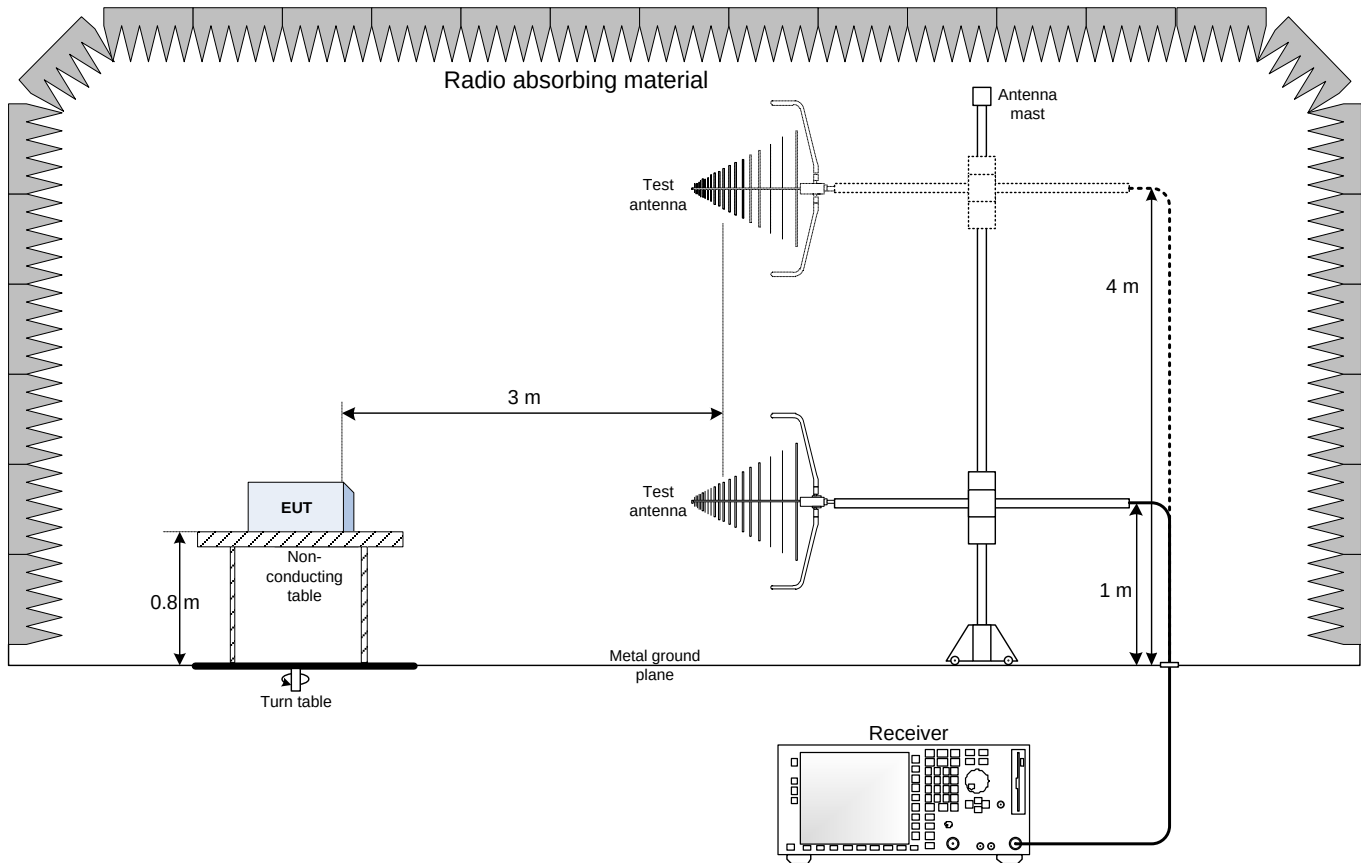
Plot 8.5-1: Conducted emissions High Channel

Table 8.5-2: Quasi-Peak and Average conducted emissions results High Channel

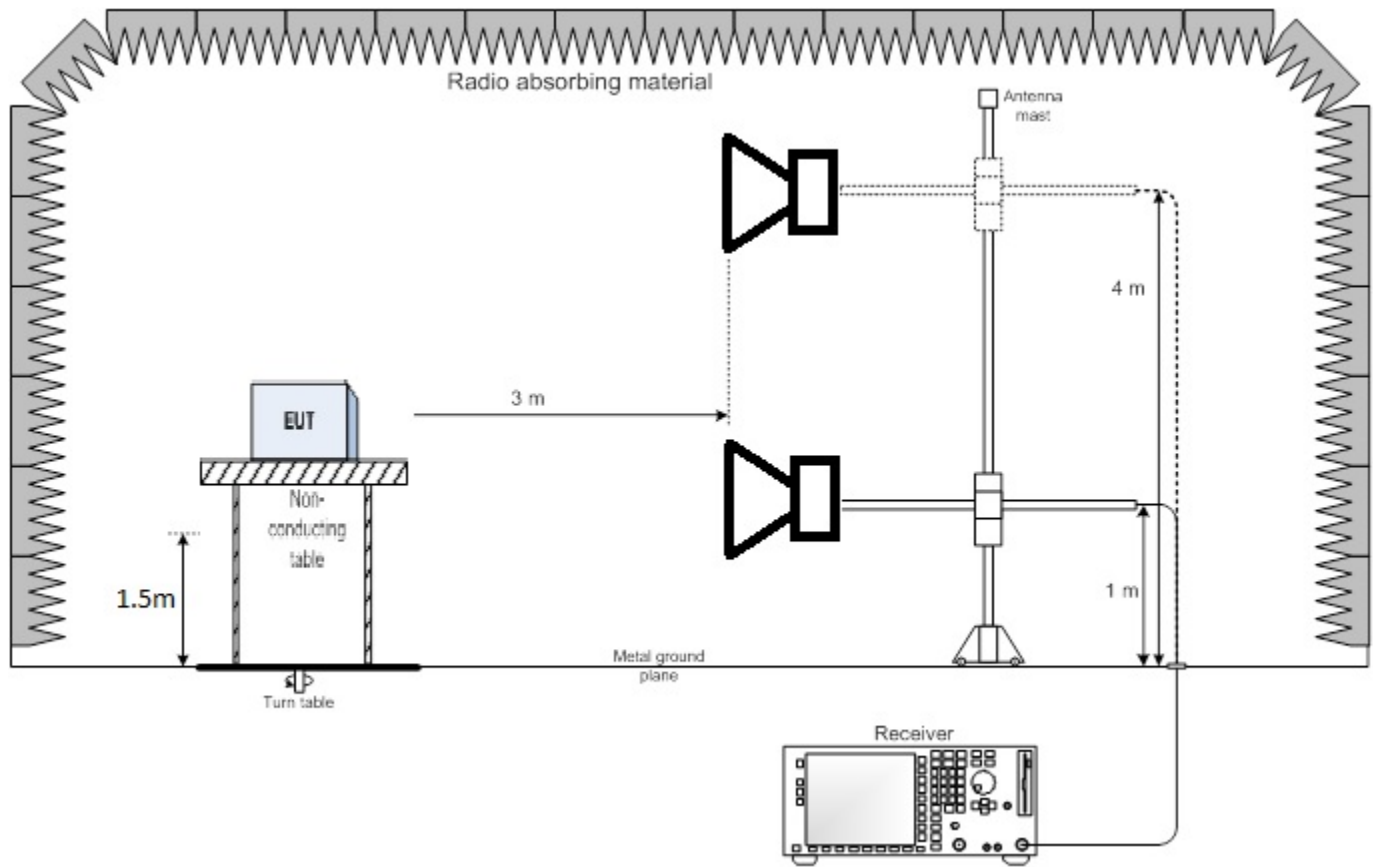
Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line
0.154000	---	27.04	55.78	28.74	5000.0	9.000	L1
0.154000	40.98	---	65.78	24.80	5000.0	9.000	L1
0.156500	---	27.31	55.65	28.34	5000.0	9.000	N
0.156500	40.65	---	65.65	25.00	5000.0	9.000	N
0.172500	38.28	---	64.84	26.56	5000.0	9.000	N
0.172500	---	26.23	54.84	28.61	5000.0	9.000	N
0.208500	35.92	---	63.27	27.34	5000.0	9.000	L1
0.208500	---	24.40	53.27	28.87	5000.0	9.000	L1
0.556500	42.06	---	56.00	13.94	5000.0	9.000	L1
0.556500	---	32.89	46.00	13.11	5000.0	9.000	L1
13.852500	24.94	---	60.00	35.06	5000.0	9.000	L1
13.852500	---	16.73	50.00	33.27	5000.0	9.000	L1
21.288500	---	14.97	50.00	35.03	5000.0	9.000	N
21.288500	22.54	---	60.00	37.46	5000.0	9.000	N

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

