

Test report

342504A-TRFWL

Date of issue: February 2, 2018

Applicant:
SmartDrive Systems Inc.

Product:
KEYFOB

Model:
KEYFOB

Variants:
N/A

FCC ID: 2AN4F-SR4KF

IC Registration number: 12169A-SR4KF

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 License-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-3

Tested by	Nikolay Shtin, Senior Wireless Engineer
Reviewed by	Juan Manuel Gonzalez
Review date	February 2, 2018
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.

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	SmartDrive Systems Inc.
Address	9450 Carroll Park Drive
City	San Diego
Province/State	California
Postal/Zip code	92121
Country	USA

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

Notes: ¹ EUT is battery powered and has no direct connection to the AC mains.

² 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 ¹
7.1.3	Receiver conducted emission limits	Not applicable ¹
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Not applicable ²
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 EUT is battery powered and has no direct connection to the AC mains.

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	December 28, 2017
Nemko sample ID number	N/A

3.2 EUT information

Product name	KEYFOB
Model	KEYFOB
Model variant	N/A
Serial number	N/A
FCC ID	2AN4F-SR4KF
IC Registration Number	12169A-SR4KF

3.3 Technical information

Applicant IC company number	12169A
IC UPN number	SR4KF
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)	2402
Frequency Max (MHz)	2480
RF power Min (W), Conducted/ERP/EIRP	N/A
RF power Max (W), Conducted /ERP/EIRP	0.000689
Field strength, Units @ distance	N/A
Measured BW (kHz) (6 dB)	714.3
Measured BW (kHz) (99%)	1028
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	GFSK
Emission classification (F1D, G1D, D1D)	F1D
Transmitter spurious, Units @ distance	56.24 dBμV/m @ 3m Peak / 51.77 dBμV/m @ 3m Average
Power requirements	3 VDC from 2032 Coin cell battery
Antenna information	PCB Antenna, peak gain is 0 dBi. The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

The Equipment Under Test (EUT) was an SmartDrive Systems Inc. Bluetooth Key Fob (Model: KEYFOB). The Key Fob is a wireless remote controller for use with SmartDrive's video event recorder. The EUT incorporates a low power radio operating in the 2400-2483.5 MHz ISM band.

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 a temporary RF output port (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

3.7 EUT sub assemblies

Table 3.7-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number

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

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMC Test Receiver	Rohde & Schwarz	ESU 40	E1121	1 yr.	7/28/2018
Antenna, Bilog	Schaffner-Chase	CBL6111C	1480	1 yr.	7/21/2018
Antenna, Horn	EMCO	3115	1033	1 yr.	7/27/2018
Spectrum Analyzer	Rohde & Schwarz	FSV40	E1120	1 yr.	7-27-2018
Signal Generator	Rohde & Schwarz	SMB 100A	E1128	1 yr.	9-13-2018
High-pass filter	Wainwright Instruments GMBH	WHKX12-2493-2770-18000- 60SS	N/A	N/A	Verified with FSV40
Band reject filter	Wainwright Instruments GMBH	WRCGV10-2363.5-2400- 2483.5-2520-60SS	N/A	N/A	Verified with FSV40

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	December 28, 2017	Temperature	20 °C
Test engineer	Nikolay Shtin	Air pressure	1007 mbar
Verdict	Pass	Relative humidity	51 %

8.1.3 Observations, settings and special notes

Spectrum analyzer settings:

Resolution bandwidth	100 kHz
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	5 MHz
Detector mode	Peak
Trace mode	Max Hold

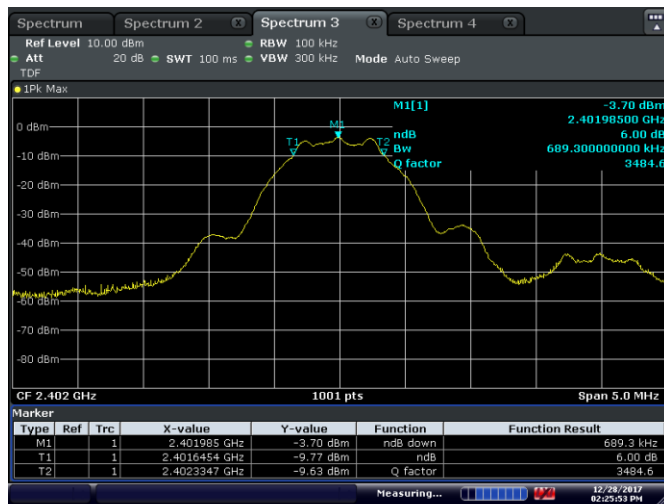
8.1.4 Test data

Table 8.1-1: 6 dB bandwidth results

Modulation	Frequency, MHz	6dB bandwidth, kHz	Limit, kHz	Margin, kHz
GFSK	2402	689.3	500	189.3
	2426	694.3	500	194.3
	2480	714.3	500	214.3

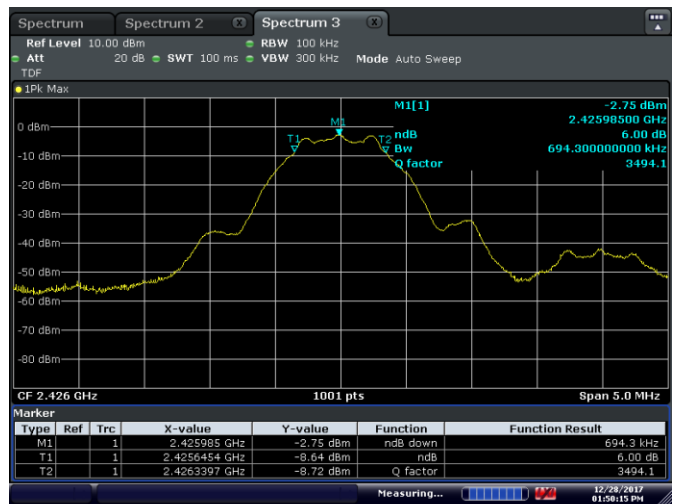
Section 8
Test name
Specification

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



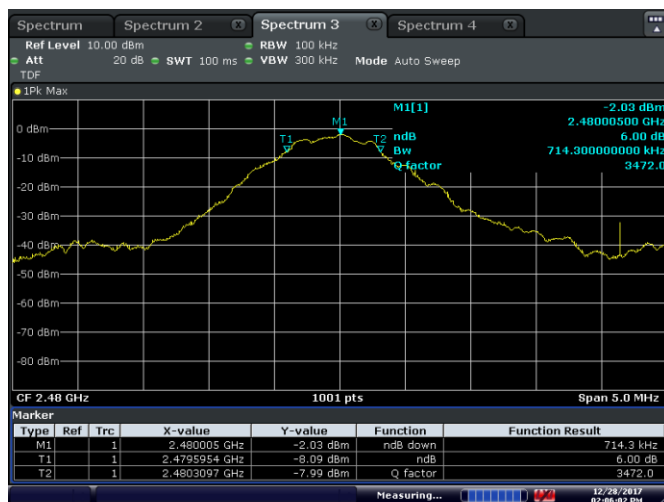
Date: 28 DEC 2017 14:25:53

Figure 8.1-1: 6 dB bandwidth, Low CH



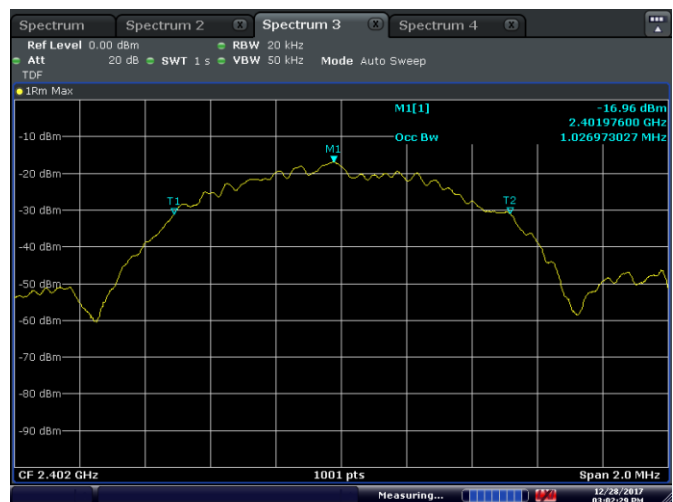
Date: 28 DEC 2017 13:50:15

Figure 8.1-2: 6 dB bandwidth, Mid CH



Date: 28 DEC 2017 14:06:02

Figure 8.1-3: 6 dB bandwidth, High CH



Date: 28 DEC 2017 15:02:28

Figure 8.1-4: 99% OBW, Low CH (representative)

Table 8.1-2: 99% OBW bandwidth results

Modulation	Frequency, MHz	99% OBW, MHz
GFSK	2402	1.026
	2426	1.028
	2480	1.022

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	December 28, 2017	Temperature	20 °C
Test engineer	Nikolay Shtin	Air pressure	1007 mbar
Verdict	Pass	Relative humidity	51 %

8.2.3 Observations, settings and special notes

Peak Conducted Power Measured

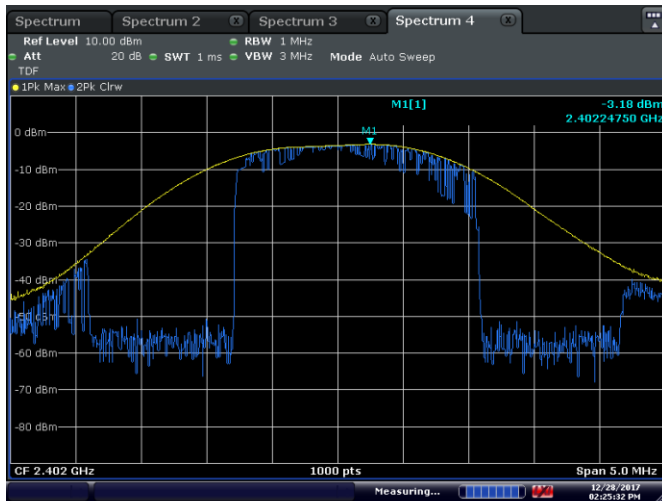
Spectrum analyzer settings:

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

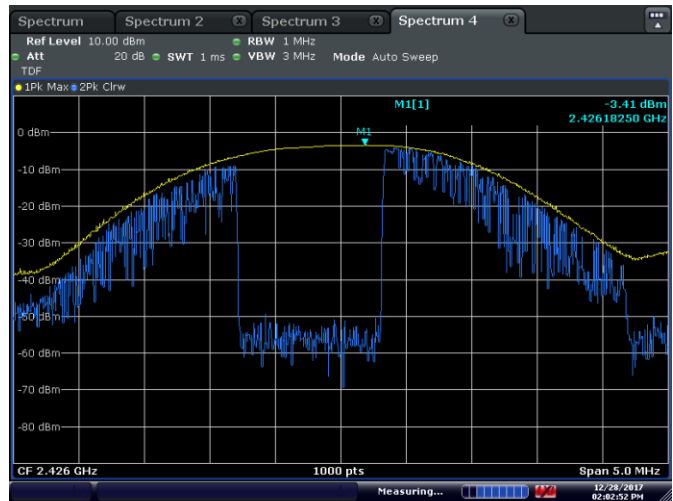
Table 8.2-1: Output power measurements results

Modulation	Frequency, MHz	Conducted output power, dBm		Margin, dB	Max Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
		Measured	Limit					
GFSK	2402	-3.18	30	33.18	0	-3.18	36	39.18
	2426	-3.41	30	33.41	0	-3.41	36	39.41
	2480	-1.62	30	31.62	0	-1.62	36	37.62



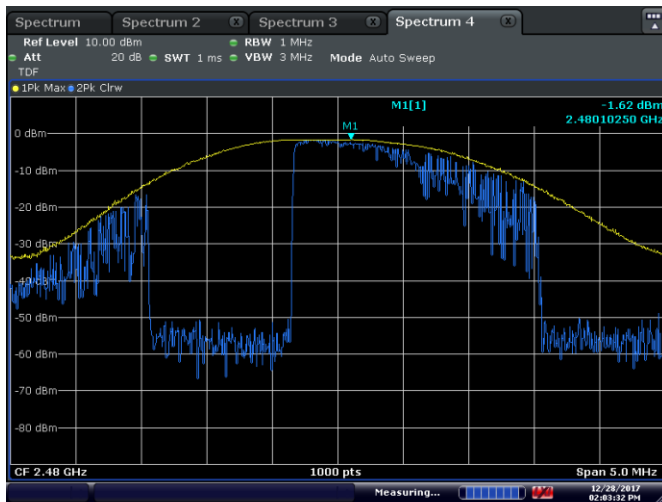
Date: 28 DEC 2017 14:25:32

Figure 8.2-1: Output Power, Low CH



Date: 28 DEC 2017 14:02:53

Figure 8.2-2: Output Power, Mid CH



Date: 28 DEC 2017 14:03:32

Figure 8.2-3: Output Power, High CH

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 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	December 28, 2017 and January 2-5, 2018	Temperature	20 °C
Test engineer	Nikolay Shtin	Air pressure	1007 mbar
Verdict	Pass	Relative humidity	51 %

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.
Antenna 0 path was selected for most radiated test cases as worst case.

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 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

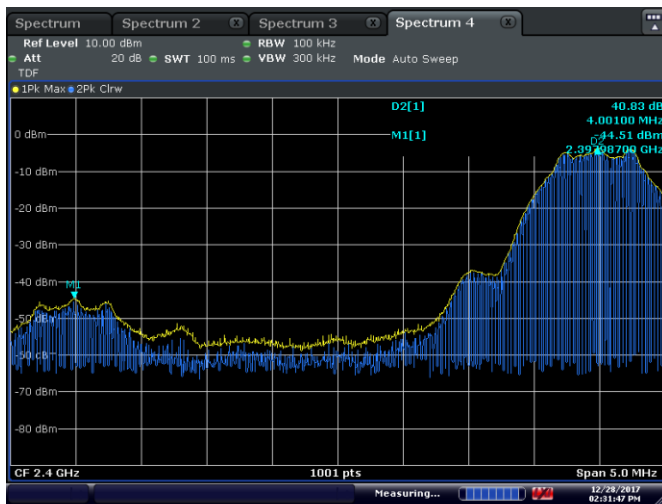


Figure 8.3.1: Band-edge Measurement, low channel



Figure 8.3.2: Band-edge Measurement, high channel

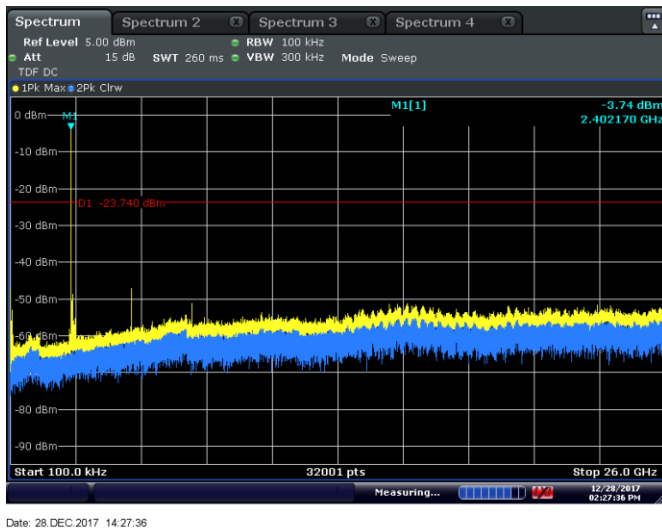


Figure 8.3.3: Conducted spurious emissions, low channel

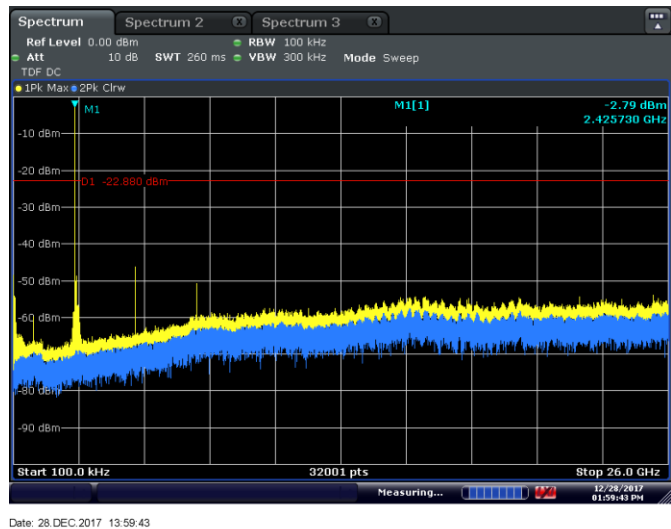
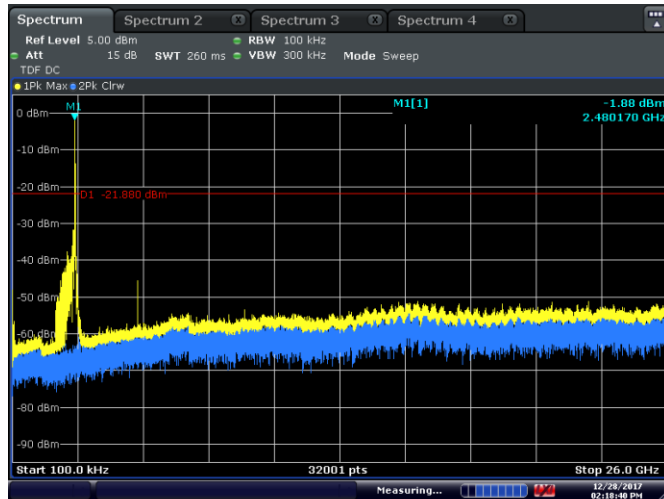
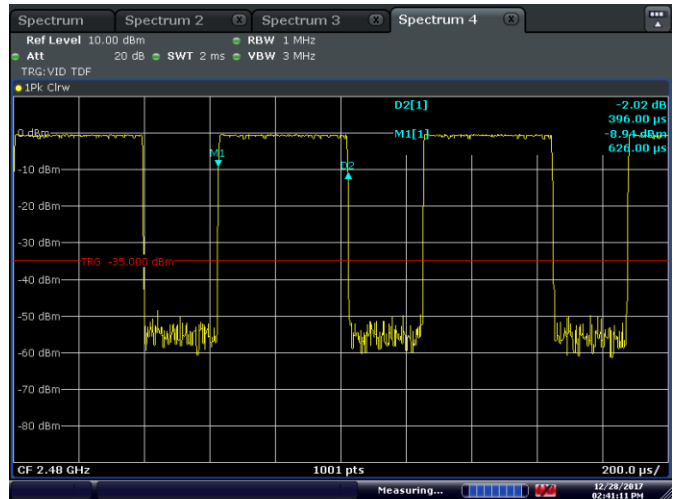


Figure 8.3.4: Conducted spurious emissions, mid channel



Date: 28 DEC 2017 14:18:40

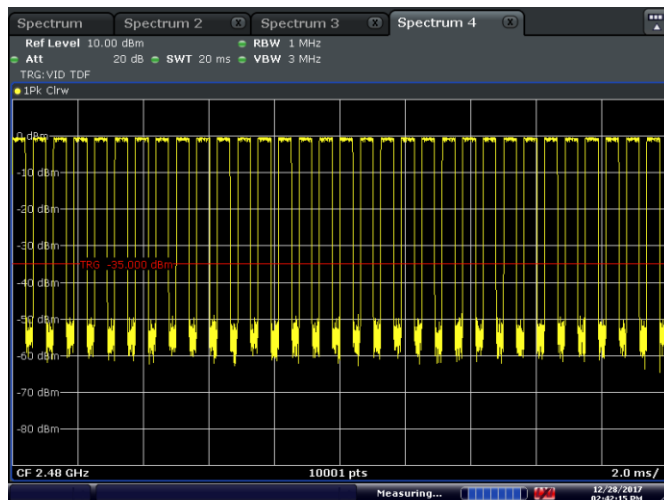
Figure 8.3.5: Conducted spurious emissions, high channel



Date: 28 DEC 2017 14:41:11

Figure 8.3.6: 2ms sweep (representative channel)

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



Date: 28 DEC 2017 14:42:16

Figure 8.3.7: 20ms sweep (representative channel)

Duty Cycle Calculation: $= 0.396 \text{ ms} \times 160 / 100 \text{ ms}$

Duty Cycle Correction Factor $= 20 \log (0.6336) = -3.96 \text{ dB}$

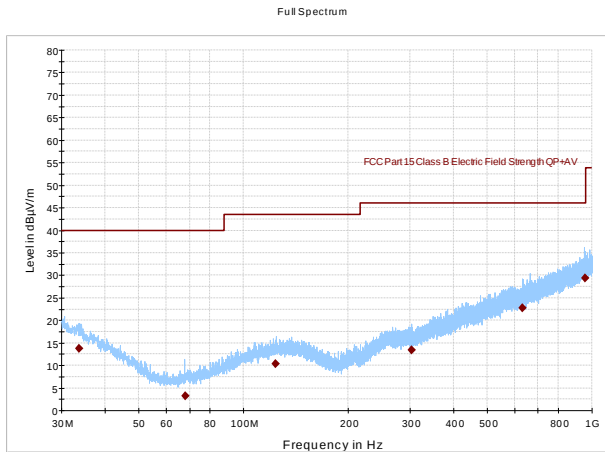


Figure 8.3.8: Radiated spurious emissions, low channel, 30-1000MHz

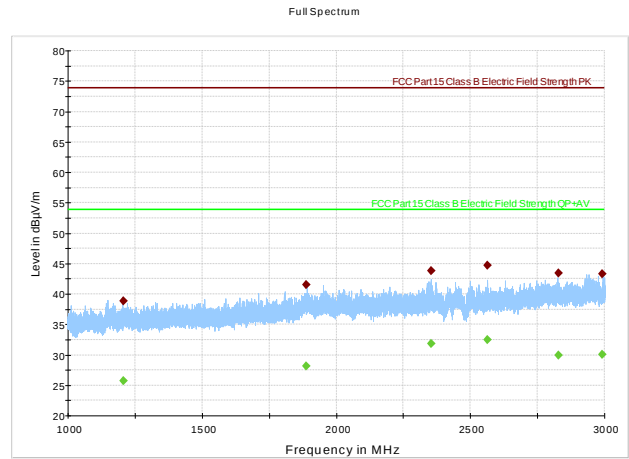


Figure 8.3.9: Radiated spurious emissions, low channel, 1-3GHz

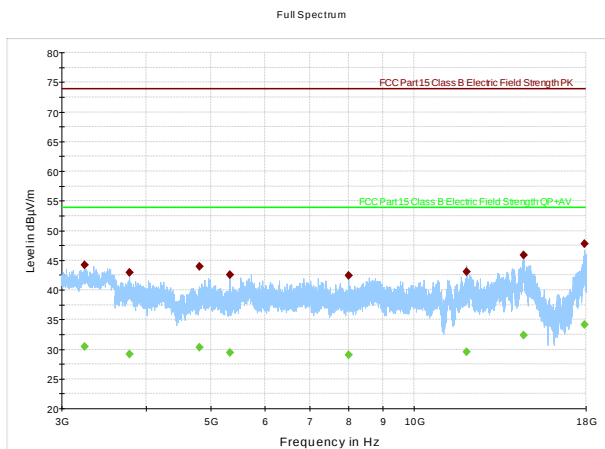


Figure 8.3.10: Radiated spurious emissions, low channel, 3-18GHz

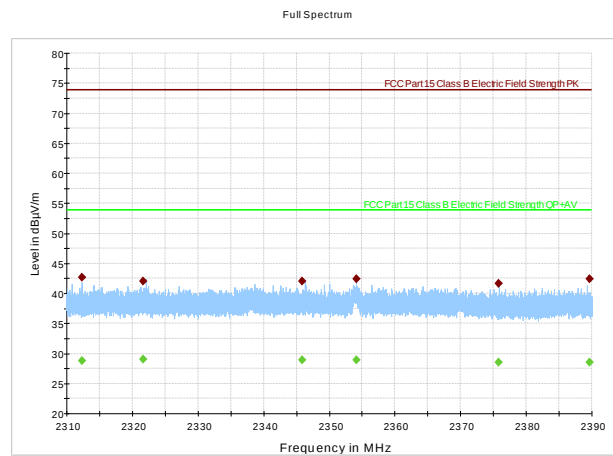


Figure 8.3.11: Radiated spurious emissions in the 2.31-2.39GHz Restricted Band, low channel

Table 8.3-4: 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)
33.748000	13.68	40.00	26.32	5000.0	120.000	249.0	V	0.0
68.053000	3.20	40.00	36.80	5000.0	120.000	235.8	H	215.0
123.279000	10.38	43.50	33.12	5000.0	120.000	145.5	V	272.0
302.897500	13.36	46.00	32.64	5000.0	120.000	291.5	V	129.0
631.161000	22.77	46.00	23.23	5000.0	120.000	181.3	V	206.0
953.323500	29.37	46.00	16.63	5000.0	120.000	364.7	V	16.0

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1206.46666	---	25.72	53.90	28.18	5000.0	1000.000	309.5	V	288.0
1206.46666	38.79	---	73.90	35.11	5000.0	1000.000	309.5	V	288.0
1888.06666	41.54	---	73.90	32.36	5000.0	1000.000	214.2	H	219.0
1888.06666	---	28.18	53.90	25.72	5000.0	1000.000	214.2	H	219.0
2354.00000	43.87	---	73.90	30.03	5000.0	1000.000	225.6	H	1.0
2354.00000	---	31.82	53.90	22.08	5000.0	1000.000	225.6	H	1.0
2562.26666	44.73	---	73.90	29.17	5000.0	1000.000	109.3	H	113.0
2562.26666	---	32.52	53.90	21.38	5000.0	1000.000	109.3	H	113.0
2827.53333	---	29.94	53.90	23.96	5000.0	1000.000	247.0	H	39.0
2827.53333	43.49	---	73.90	30.41	5000.0	1000.000	247.0	H	39.0
2991.80000	43.34	---	73.90	30.56	5000.0	1000.000	255.5	H	333.0
2991.80000	---	30.11	53.90	23.79	5000.0	1000.000	255.5	H	333.0

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
3245.30000	---	30.50	53.90	23.40	5000.0	1000.000	111.1	H	235.0
3245.30000	44.17	---	73.90	29.73	5000.0	1000.000	111.1	H	235.0
3784.90000	---	29.22	53.90	24.68	5000.0	1000.000	97.9	V	111.0
3784.90000	42.99	---	73.90	30.91	5000.0	1000.000	97.9	V	111.0
4804.20000	43.97	---	73.90	29.93	5000.0	1000.000	144.9	H	149.0
4804.20000	---	30.37	53.90	23.53	5000.0	1000.000	144.9	H	149.0
5335.10000	---	29.38	53.90	24.52	5000.0	1000.000	349.0	H	306.0
5335.10000	42.58	---	73.90	31.32	5000.0	1000.000	349.0	H	306.0
7994.70000	42.39	---	73.90	31.51	5000.0	1000.000	98.0	H	105.0
7994.70000	---	29.06	53.90	24.84	5000.0	1000.000	98.0	H	105.0
11975.5000	---	29.53	53.90	24.37	5000.0	1000.000	148.8	H	26.0
11975.5000	43.06	---	73.90	30.84	5000.0	1000.000	148.8	H	26.0
14527.3000	---	32.33	53.90	21.57	5000.0	1000.000	246.4	H	342.0
14527.3000	45.88	---	73.90	28.02	5000.0	1000.000	246.4	H	342.0
17929.2000	---	34.08	53.90	19.82	5000.0	1000.000	258.6	H	353.0
17929.2000	47.72	---	73.90	26.18	5000.0	1000.000	258.6	H	353.0

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
2312.27600	42.66	---	73.90	31.24	5000.0	1000.000	403.1	V	0.0
2312.27600	---	28.83	53.90	25.07	5000.0	1000.000	403.1	V	0.0
2321.60400	---	28.99	53.90	24.91	5000.0	1000.000	344.6	V	94.0
2321.60400	41.98	---	73.90	31.92	5000.0	1000.000	344.6	V	94.0
2345.85200	---	28.87	53.90	25.03	5000.0	1000.000	409.5	H	34.0
2345.85200	42.10	---	73.90	31.80	5000.0	1000.000	409.5	H	34.0
2354.08400	42.37	---	73.90	31.53	5000.0	1000.000	362.8	H	343.0
2354.08400	---	28.98	53.90	24.92	5000.0	1000.000	362.8	H	343.0
2375.75333	---	28.48	53.90	25.42	5000.0	1000.000	410.0	H	16.0
2375.75333	41.61	---	73.90	32.29	5000.0	1000.000	410.0	H	16.0
2389.62266	---	28.54	53.90	25.36	5000.0	1000.000	404.7	V	114.0
2389.62266	42.41	---	73.90	31.49	5000.0	1000.000	404.7	V	114.0

Note: No considerable EUT emissions were observed.

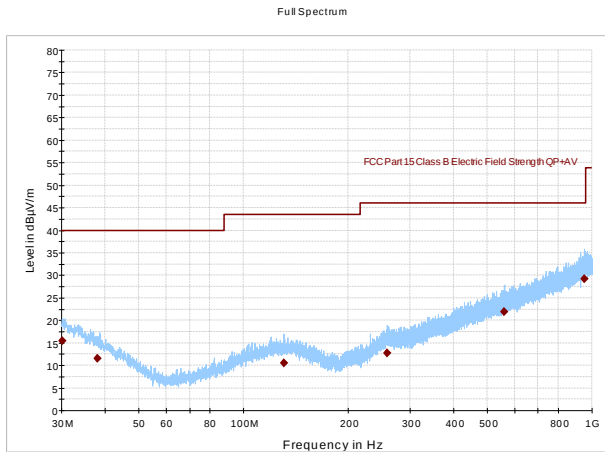


Figure 8.3.12: Radiated spurious emissions, mid channel, 30-1000MHz

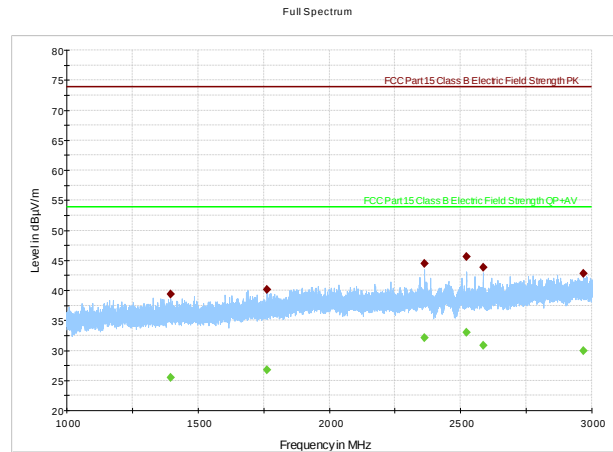


Figure 8.3.13: Radiated spurious emissions, mid channel, 1-3GHz

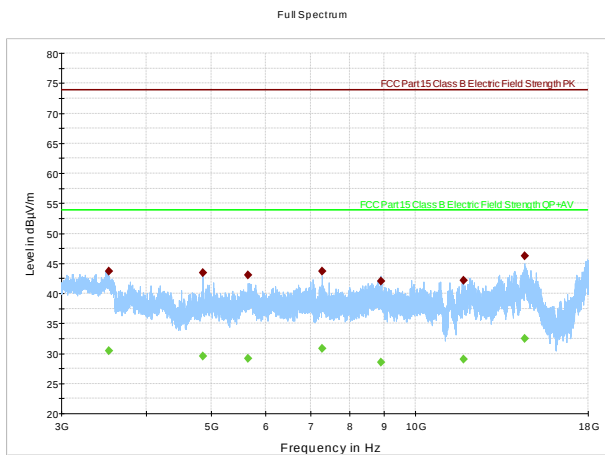


Figure 8.3.14: Radiated spurious emissions, mid channel, 3-18GHz

Table 8.3-5: Radiated field strength measurement results for mid channel 2426 MHz

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.224500	15.41	40.00	24.59	5000.0	120.000	181.7	H	271.0
38.096000	11.51	40.00	28.49	5000.0	120.000	187.4	H	355.0
130.717500	10.54	43.50	32.96	5000.0	120.000	345.2	V	215.0
257.619000	12.79	46.00	33.21	5000.0	120.000	180.0	H	325.0
560.255500	21.92	46.00	24.08	5000.0	120.000	198.1	H	114.0
951.017500	29.23	46.00	16.77	5000.0	120.000	274.9	H	272.0

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1395.66666	---	25.45	53.90	28.45	5000.0	1000.000	114.9	H	154.0
1395.66666	39.35	---	73.90	34.55	5000.0	1000.000	114.9	H	154.0
1761.46666	---	26.79	53.90	27.11	5000.0	1000.000	286.4	V	0.0
1761.46666	40.19	---	73.90	33.71	5000.0	1000.000	286.4	V	0.0
2361.73333	---	32.11	53.90	21.79	5000.0	1000.000	114.3	H	176.0
2361.73333	44.45	---	73.90	29.45	5000.0	1000.000	114.3	H	176.0
2522.40000	45.64	---	73.90	28.26	5000.0	1000.000	100.0	H	178.0
2522.40000	---	32.96	53.90	20.94	5000.0	1000.000	100.0	H	178.0
2585.60000	---	30.81	53.90	23.09	5000.0	1000.000	117.5	H	160.0
2585.60000	43.79	---	73.90	30.11	5000.0	1000.000	117.5	H	160.0
2968.06666	42.76	---	73.90	31.14	5000.0	1000.000	374.8	H	240.0
2968.06666	---	29.94	53.90	23.96	5000.0	1000.000	374.8	H	240.0

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
3521.30000	---	30.46	53.90	23.44	5000.0	1000.000	116.8	H	158.0
3521.30000	43.70	---	73.90	30.20	5000.0	1000.000	116.8	H	158.0
4851.50000	---	29.52	53.90	24.38	5000.0	1000.000	109.4	H	249.0
4851.50000	43.42	---	73.90	30.48	5000.0	1000.000	109.4	H	249.0
5661.80000	43.11	---	73.90	30.79	5000.0	1000.000	410.0	H	63.0
5661.80000	---	29.11	53.90	24.79	5000.0	1000.000	410.0	H	63.0
7278.10000	43.72	---	73.90	30.18	5000.0	1000.000	109.3	H	0.0
7278.10000	---	30.79	53.90	23.11	5000.0	1000.000	109.3	H	0.0
8887.50000	42.00	---	73.90	31.91	5000.0	1000.000	127.3	H	0.0
8887.50000	---	28.51	53.90	25.39	5000.0	1000.000	127.3	H	0.0
11782.7000	---	29.02	53.90	24.88	5000.0	1000.000	179.3	H	0.0
11782.7000	42.16	---	73.90	31.74	5000.0	1000.000	179.3	H	0.0
14503.1000	46.21	---	73.90	27.69	5000.0	1000.000	230.4	H	17.0
14503.1000	---	32.53	53.90	21.37	5000.0	1000.000	230.4	H	17.0

Note: No considerable EUT emissions were observed.

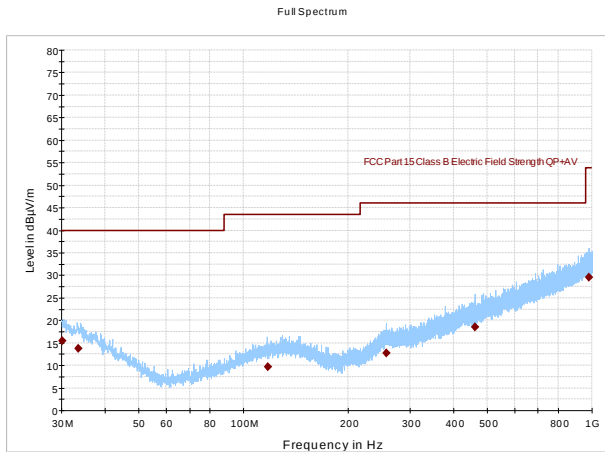


Figure 8.3.15: Radiated spurious emissions, high channel, 30-1000MHz

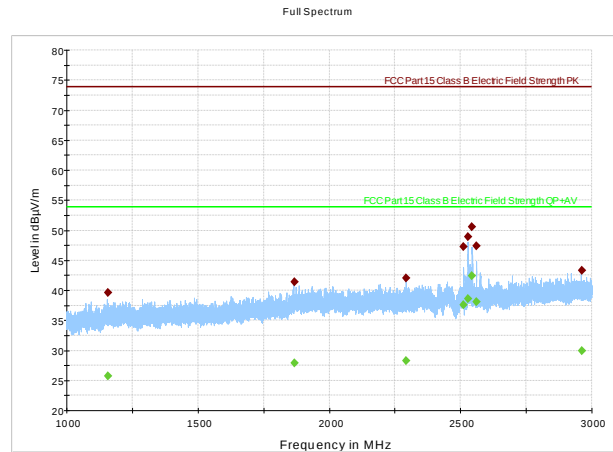


Figure 8.3.16: Radiated spurious emissions, high channel, 1-3GHz

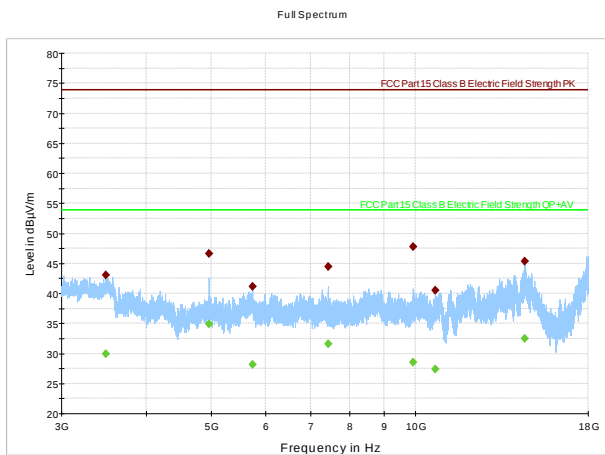


Figure 8.3.17: Radiated spurious emissions, high channel, 3-18GHz

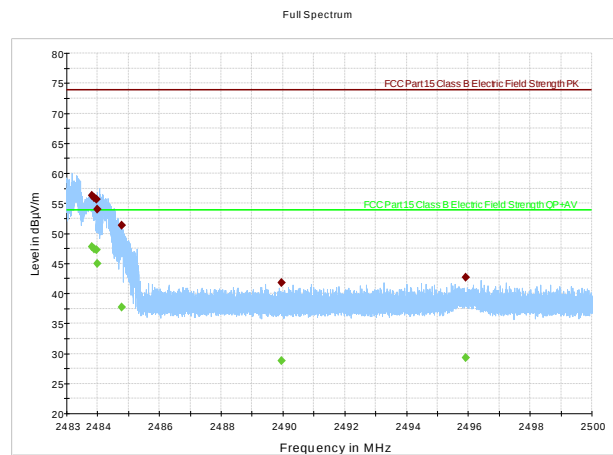


Figure 8.3.18: Radiated spurious emissions in the 2.4835-2.5GHz Restricted Band, high channel

Note: Final results for valid average emissions were calculated taking into account the EUT duty cycle and given in Table 8.3-7.

Table 8.3-6: 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)
30.160000	15.43	40.00	24.57	5000.0	120.000	352.0	H	34.0
33.602500	13.76	40.00	26.24	5000.0	120.000	310.9	H	128.0
117.520500	9.69	43.50	33.81	5000.0	120.000	225.1	V	341.0
257.151000	12.75	46.00	33.25	5000.0	120.000	197.3	V	214.0
462.332500	18.47	46.00	27.53	5000.0	120.000	289.3	H	353.0
979.661500	29.49	53.90	24.41	5000.0	120.000	308.3	V	300.0

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1157.13333	---	25.70	53.90	28.20	5000.0	1000.000	252.3	V	34.0
1157.13333	39.66	---	73.90	34.24	5000.0	1000.000	252.3	V	34.0
1866.46666	41.34	---	73.90	32.56	5000.0	1000.000	335.9	V	193.0
1866.46666	---	27.93	53.90	25.97	5000.0	1000.000	335.9	V	193.0
2291.26666	---	28.29	53.90	25.61	5000.0	1000.000	268.0	H	304.0
2291.26666	42.01	---	73.90	31.89	5000.0	1000.000	268.0	H	304.0
2511.80000	---	37.56	53.90	16.34	5000.0	1000.000	100.0	H	115.0
2511.80000	47.26	---	73.90	26.64	5000.0	1000.000	100.0	H	115.0
2527.93333	48.87	---	73.90	25.03	5000.0	1000.000	109.0	H	116.0
2527.93333	---	38.64	53.90	15.26	5000.0	1000.000	109.0	H	116.0
2543.86666	---	42.44	53.90	11.46	5000.0	1000.000	109.2	H	112.0
2543.86666	50.58	---	73.90	23.32	5000.0	1000.000	109.2	H	112.0
2559.86666	---	38.07	53.90	15.83	5000.0	1000.000	109.3	H	116.0
2559.86666	47.44	---	73.90	26.46	5000.0	1000.000	109.3	H	116.0
2963.46666	---	29.91	53.90	23.99	5000.0	1000.000	377.2	V	0.0
2963.46666	43.36	---	73.90	30.54	5000.0	1000.000	377.2	V	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)
3490.60000	43.08	---	73.90	30.82	5000.0	1000.000	99.9	V	312.0
3490.60000	---	29.98	53.90	23.92	5000.0	1000.000	99.9	V	312.0
4959.50000	---	34.86	53.90	19.04	5000.0	1000.000	126.3	H	222.0
4959.50000	46.60	---	73.90	27.30	5000.0	1000.000	126.3	H	222.0
5752.00000	41.14	---	73.90	32.76	5000.0	1000.000	100.0	V	331.0
5752.00000	---	28.15	53.90	25.75	5000.0	1000.000	100.0	V	331.0
7439.30000	---	31.54	53.90	22.36	5000.0	1000.000	110.7	H	349.0
7439.30000	44.47	---	73.90	29.43	5000.0	1000.000	110.7	H	349.0
9917.20000	---	28.52	53.90	25.38	5000.0	1000.000	205.4	V	335.0
9917.20000	47.76	---	73.90	26.14	5000.0	1000.000	205.4	V	335.0
10700.0000	40.48	---	73.90	33.42	5000.0	1000.000	116.4	H	26.0
10700.0000	---	27.36	53.90	26.54	5000.0	1000.000	116.4	H	26.0
14493.3000	45.32	---	73.90	28.58	5000.0	1000.000	136.0	H	26.0
14493.3000	---	32.54	53.90	21.36	5000.0	1000.000	136.0	H	26.0

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
2483.82770	---	47.81	53.90	6.09	5000.0	1000.000	109.1	H	115.0
2483.82770	56.24	---	73.90	17.66	5000.0	1000.000	109.1	H	115.0
2483.88430	55.87	---	73.90	18.03	5000.0	1000.000	107.4	H	112.0
2483.88430	---	47.45	53.90	6.45	5000.0	1000.000	107.4	H	112.0
2483.96873	---	47.32	53.90	6.58	5000.0	1000.000	107.5	H	114.0
2483.96873	55.72	---	73.90	18.18	5000.0	1000.000	107.5	H	114.0
2483.99413	54.05	---	73.90	19.85	5000.0	1000.000	250.7	H	26.0
2483.99413	---	44.95	53.90	8.95	5000.0	1000.000	250.7	H	26.0
2484.78366	---	37.75	53.90	16.15	5000.0	1000.000	109.3	H	116.0
2484.78366	51.29	---	73.90	22.61	5000.0	1000.000	109.3	H	116.0
2489.94526	41.77	---	73.90	32.13	5000.0	1000.000	278.0	V	102.0
2489.94526	---	28.73	53.90	25.17	5000.0	1000.000	278.0	V	102.0
2495.90563	42.62	---	73.90	31.28	5000.0	1000.000	404.7	V	323.0
2495.90563	---	29.32	53.90	24.58	5000.0	1000.000	404.7	V	323.0

Table 8.3-7: Final radiated average results for high channel 2480MHz

Frequency (MHz)	Measurement (dBμV/m)	DCCF (dB)	Final Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Comment
2483.827700	47.81	3.96	51.77	53.90	2.13	Pass
2483.884300	47.45	3.96	51.41	53.90	2.49	Pass
2483.968733	47.32	3.96	51.28	53.90	2.62	Pass
2483.994133	44.95	3.96	48.91	53.90	4.99	Pass
4959.500000	34.86	3.96	38.82	53.90	15.08	Pass

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	December 28, 2016	Temperature	20 °C
Test engineer	Nikolay Shtin	Air pressure	1007 mbar
Verdict	Pass	Relative humidity	51 %

8.4.3 Observations, settings and special notes

100kHz RBW

8.4.4 Test data

Table 8.4-1: Power Spectrum Density

Modulation	Frequency, MHz	Conducted PSD@50kHz, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
		Measured	Limit					
GFSK	2402	-3.58	8	11.58	0	-3.58	14	17.58
	2426	-2.57	8	10.57	0	-2.57	14	16.57
	2480	-2.61	8	10.61	0	-2.61	14	16.61

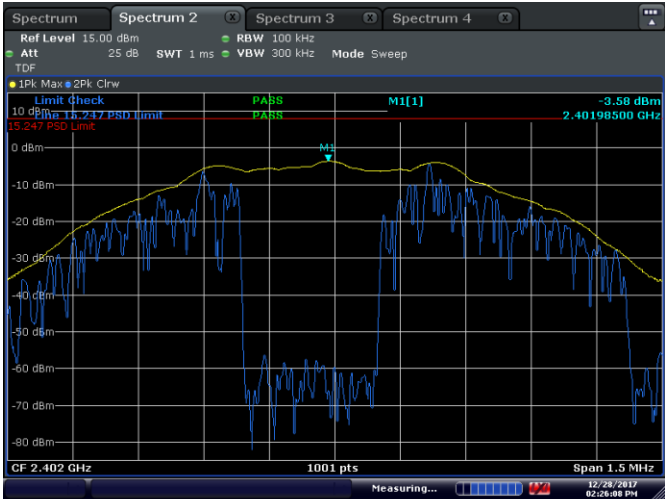


Figure 8.4-1: PSD, Low CH

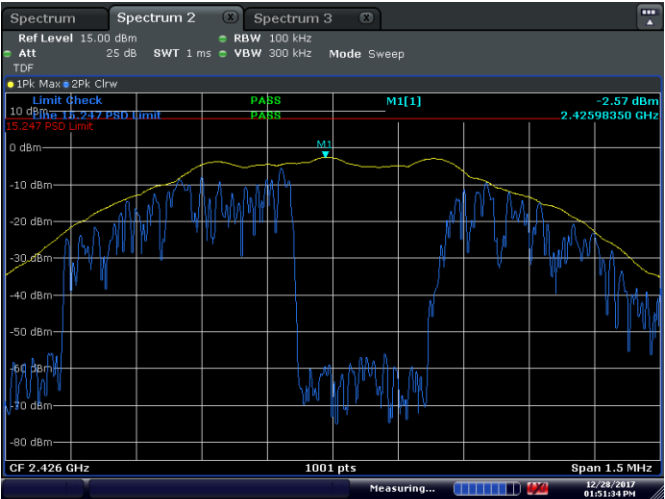


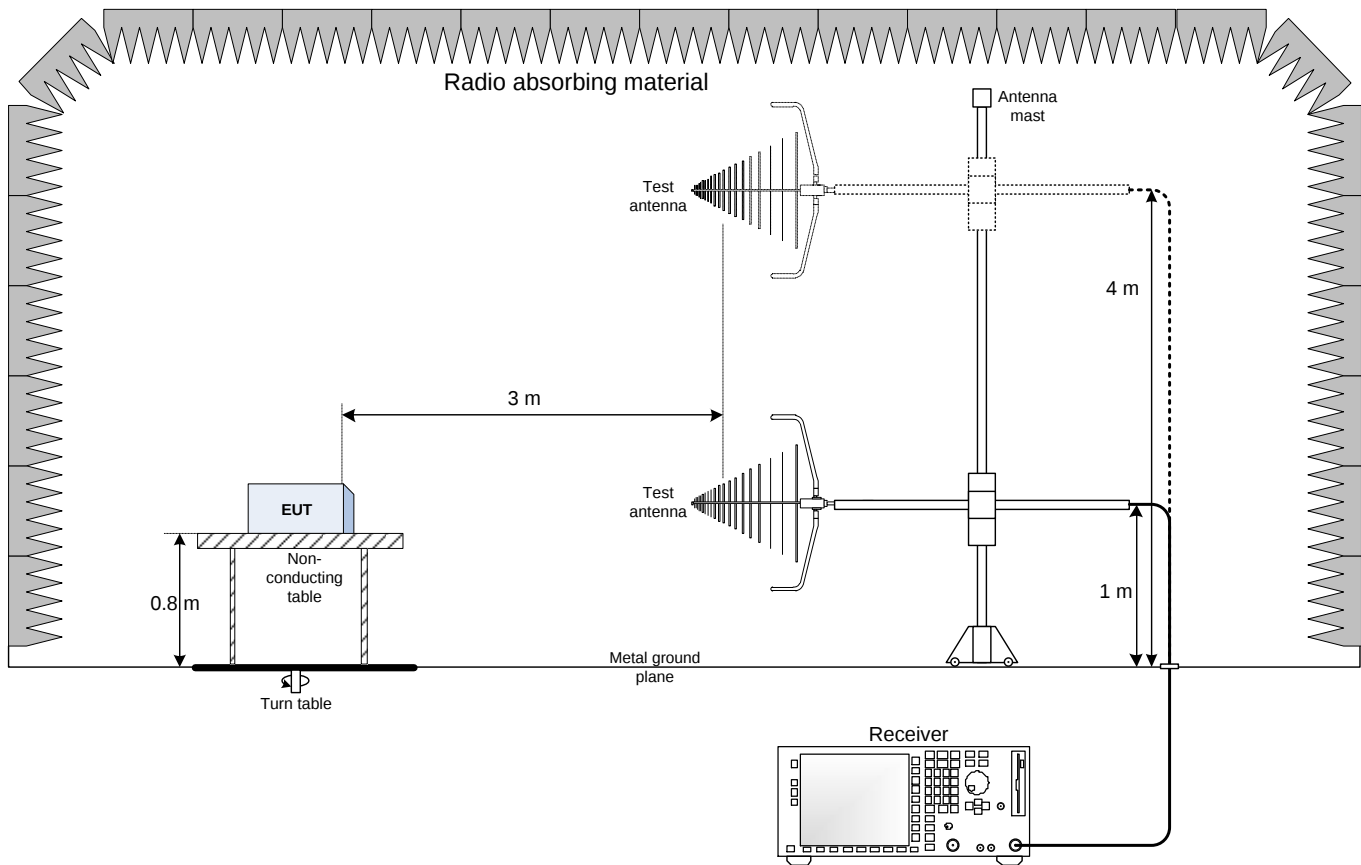
Figure 8.4-2: PSD, Mid CH



Figure 8.4-3: PSD, High CH

Section 9. Block diagrams of test set-ups

9.1 Radiated emissions set-up – Below 1GHz



9.2 Radiated emissions set-up – Above 1GHz

