

Wireless test report – 353421-2TRFWL

Applicant:

Thalmic Labs, Inc.

Product name:

Focals

Model:

Kona

Model variant:

Glasses

FCC ID:

2ACKV-TL1A

IC Registration number:

12013A-TL1A

Specifications:

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

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

◆ **RSS-247, Issue 2, Feb 2017, Section 5**

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

5) Standard specifications for frequency hopping systems and digital transmission systems operating in the
bands 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz

Date of issue: **November 21, 2018**

Test engineer(s): **Andrey Adelberg, Senior Wireless/EMC Specialist**

Signature:



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Test location(s)

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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 Canada's ISO/IEC 17025 accreditation.

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Thalmic Labs Inc
Address	24 Charles St West
City	Kitchener
Province/State	Ontario
Postal/Zip code	N2G 1H2
Country	Canada

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–585 MHz
RSS-247, Issue 2, Feb 2017, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.3 Test methods

558074 D01 DTS Meas Guidance v04 (April 5, 2017)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
DA 00-705, Released March 30, 2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen, Issue 5, April 2018	General Requirements for Compliance of Radio Apparatus

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.5 below. 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 #	Date of issue	Details of changes made to test report
TRF	November 21, 2018	Original report issued



Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Table 2.1-1: FCC general requirements results

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

Notes: EUT is a battery-operated device, the testing was performed using fresh batteries.

2.2 FCC Part 15 Subpart C, intentional radiators test results for frequency hopping spread spectrum systems

Table 2.2-1: FCC 15.247 results for FHSS

Part	Test description	Verdict
§15.247(a)(1)(i)	Requirements for operation in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Requirements for operation in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Requirements for operation in the 2400–2483.5 MHz band	Pass
§15.247(b)(1)	Maximum peak output power in the 2400–2483.5 MHz band and 5725–5850 MHz band	Pass
§15.247(b)(2)	Maximum peak output power in the 902–928 MHz band	Not applicable
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

2.3 FCC Part 15 Subpart C, intentional radiators test results for digital transmission systems (DTS)

Table 2.3-1: FCC 15.247 results for DTS

Part	Test description	Verdict
§15.247(a)(2)	Minimum 6 dB bandwidth	Pass
§15.247(b)(3)	Maximum peak output power 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	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

2.4 ISED RSS-Gen, Issue 5, test results

Table 2.4-1: RSS-Gen results

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Not applicable
7.4	Receiver conducted emission limits	Not applicable
6.9	Operating bands and selection of test frequencies	Pass
8.8	AC power-line conducted emissions limits	Not applicable

Notes: ¹ According to sections 5.2 and 5.3 of RSS-Gen, Issue 5 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

EUT is a battery-operated device, the testing was performed using fresh batteries.

2.5 ISED RSS-247, Issue 2, test results for frequency hopping spread spectrum systems (FHSS)

Table 2.5-1: RSS-247 results for FHSS

Part	Test description	Verdict
5.1 (a)	Bandwidth of a frequency hopping channel	Pass
5.1 (b)	Minimum channel spacing	Pass
5.1 (c)	Systems operating in the 902–928 MHz band	Not applicable
5.1 (d)	Systems operating in the 2400–2483.5 MHz band	Pass
5.1 (e)	Systems operating in the 5725–5850 MHz band	Not applicable
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)	Systems operating in the 902–928 MHz band	Not applicable
5.4 (b)	Systems operating in the 2400–2483.5 MHz band	Pass
5.4 (c)	Systems operating in the 5725–5850 MHz	Not applicable
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

Notes: None

2.6 ISED RSS-247, Issue 2, test results for digital transmission systems (DTS)

Table 2.6-1: RSS-247 results for DTS

Part	Test description	Verdict
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 (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

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	June 28, 2018
Nemko sample ID number	2

3.2 EUT information

Product name	Focals
Model	Kona
Model variant	Glasses
Serial number	None

3.3 Technical information

Applicant IC company number	12013A
IC UPN number	TL1A
All used IC test site(s) Reg. number	2040A-4
RSS number and Issue number	RSS-247 Issue 2, Feb 2017
Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2402
Frequency Max (MHz)	2480 (BLE), 2481 (BT)
RF power Min (W)	N/A
RF power Max (W), Conducted	0.001449 (1.61 dBm for BLE), 0.001445 (1.60 dBm for BT)
Field strength, Units @ distance	N/A
Measured BW (kHz) (99%)	1105 (BLE), 1112.1 (BT)
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	BLE: GFSK, BT: 3-EV5, 3-DH5, DM5
Emission classification (F1D, G1D, D1D)	F1D
Transmitter spurious, dB μ V/m @ 3 m	BLE: 44.37 (average) at 2483.5 MHz; BT: 34.65 (average) at 2483.5 MHz
Power requirements	Internal battery 3.85 V _{DC}
Antenna information	Internal antenna with maximum gain of +1 dBi

3.4 Product description and theory of operation

Wearable device that projects information to an embedded screen, transmitting data over wireless links.

3.5 EUT exercise details

EUT was modified with antenna port. Test rig was provided with connection to Laptop which provided DC power via USB port. Control of the radio was done using command line interface. EUT was tested in two modes: Bluetooth (BT: FHSS) and Bluetooth Low Energy (BLE: DTS).

3.6 EUT setup diagram

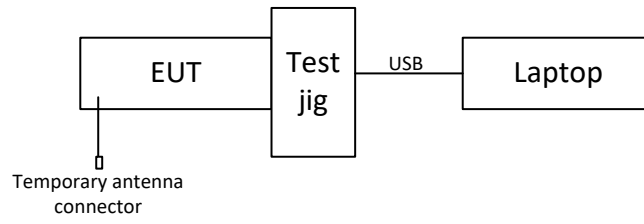


Figure 3.6-1: Setup diagram

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	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.

Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

UKAS Lab 34 and TIA-603-B have been used as guidance for measurement uncertainty reasonable estimations with regards to previous experience and validation of data. Nemko Canada, Inc. follows these test methods in order to satisfy ISO/IEC 17025 requirements for estimation of uncertainty of measurement for wireless products.

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of $K = 2$ with 95% certainty.

Table 6.1-1: Measurement uncertainty

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.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	Dec. 09/18
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	March 26/19
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	Aug. 31/18
Horn with Preamp (1–18 GHz)	ETS-Lindgren	3117	FA002840	1 year	Dec. 07/18
Horn antenna (18–40 GHz)	EMCO	3116	FA001847	1 year	Aug. 31/18
Pre-amplifier (18–26 GHz)	Narda	BBS-1826N612	FA001550	—	VOU
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	July 18/18

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

Section 8. Testing data

8.1 FCC 15.31(e) Variation of power source

8.1.1 Definitions and limits

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.1.2 Test date

Start date June 28, 2018

8.1.3 Observations, settings and special notes

EUT was connected to the laptop for testing purposes, which provided power for the operation. Final product will be powered from the internal battery.

8.1.4 Test data

EUT Power requirements: AC DC Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed? YES NO N/A
If EUT is battery operated, was the testing performed using fresh batteries? YES NO N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries? YES NO N/A

8.2 FCC 15.31(m) and RSS-Gen 6.9 Number of frequencies

8.2.1 Definitions and limits

FCC:

Measurements on intentional radiators or receivers shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table.

ISED:

Except where otherwise specified, measurements shall be performed for each frequency band of operation for which the radio apparatus is to be certified, with the device operating at the frequencies in each band of operation shown in table below. The frequencies selected for measurements shall be reported in the test report.

Table 8.2-1: Frequency Range of Operation

Frequency range over which the device operates (in each band)	Number of test frequencies required	Location of measurement frequency inside the operating frequency range
1 MHz or less	1	Center (middle of the band)
1–10 MHz	2	1 near high end, 1 near low end
Greater than 10 MHz	3	1 near high end, 1 near center and 1 near low end

Note: “near” means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

8.2.2 Test date

Start date June 28, 2018

8.2.3 Observations, settings and special notes

None

8.2.4 Test data

Table 8.2-2: Test channels selection for BLE

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
2400.0	2483.5	83.5	2402	2440	2480

Table 8.2-3: Test channels selection for BT

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
2400.0	2483.5	83.5	2402	2440	2481

8.3 FCC 15.203 and RSS-Gen, section 6.8 Antenna requirement

8.3.1 Definitions and limits

FCC:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

ISED:

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report.

8.3.2 Test date

Start date June 28, 2018

8.3.3 Observations, settings and special notes

None

8.3.4 Test data

Must the EUT be professionally installed? YES NO
Does the EUT have detachable antenna(s)? YES NO
If detachable, is the antenna connector(s) non-standard? YES NO N/A

8.4 FCC 15.247(a)(1) and RSS-247 5.1 Frequency Hopping Systems requirements

8.4.1 Definitions and limits

FCC:

- (1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.
- (iii) Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.
- (f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

ISED:

- a) The bandwidth of a frequency hopping channel is the 20 dB emission bandwidth, measured with the hopping stopped. The system's radio frequency (RF) bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hopset. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.
- b) FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400–2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.
- d) FHSs operating in the band 2400–2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

5.3 Hybrid systems

Hybrid systems employ a combination of both frequency hopping and digital transmission techniques and shall comply with the following:

- a) With the digital transmission operation of the hybrid system turned off, the frequency hopping operation shall have an average time of occupancy on any frequency not exceeding 0.4 seconds within a duration in seconds equal to the number of hopping frequencies multiplied by 0.4.

8.4.1 Test date

Start date July 3, 2018

8.4.2 Observations, settings and special notes

EUT is a system operating with an output power less than 125 mW.
 Spectrum analyser settings for carrier frequency separation:

Resolution bandwidth	≥ 1 % of the span
Video bandwidth	≥ RBW
Frequency span	wide enough to capture the peaks of two adjacent channels
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for number of hopping frequencies:

Resolution bandwidth	≥ 1 % of the span
Video bandwidth	≥ RBW
Frequency span	the frequency band of operation
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for time of occupancy (dwell time):

Resolution bandwidth	1 MHz
Video bandwidth	≥ RBW
Frequency span	Zero span
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for 20 dB bandwidth:

Resolution bandwidth	≥ 1% of the 20 dB bandwidth
Video bandwidth	≥ RBW
Frequency span	approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.4.3 Test data

Table 8.4-1: 20 dB bandwidth results

Frequency, MHz	20 dB bandwidth for 3-EV5, kHz	20 dB bandwidth for 3-DH5, kHz	20 dB bandwidth for DM5, kHz
2402	1176.0	1172.0	880.0
2440	1176.0	1178.0	890.0
2481	1178.0	1176.0	892.0

Table 8.4-2: 99% occupied bandwidth results

Frequency, MHz	99% occupied bandwidth for 3-EV5, kHz	99% occupied bandwidth for 3-DH5, kHz	99% occupied bandwidth for DM5, kHz
2402	1104.0	1110.0	848.0
2440	1104.0	1112.1	846.0
2481	1102.0	1112.0	848.0

Note: there is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

Table 8.4-3: Carrier frequency separation results

Modulation	Carrier frequency separation, kHz	Minimum limit*, kHz	Margin, kHz
3-EV5	1002	785	217
3-HD5	1004	785	219
DM5	1000	595	405

Note: for systems operating with an output power no greater than 125 mW minimum limit is either 25 kHz or 2/3 of 20 dB BW (whichever is greater).

Table 8.4-4: Number of hopping frequencies results

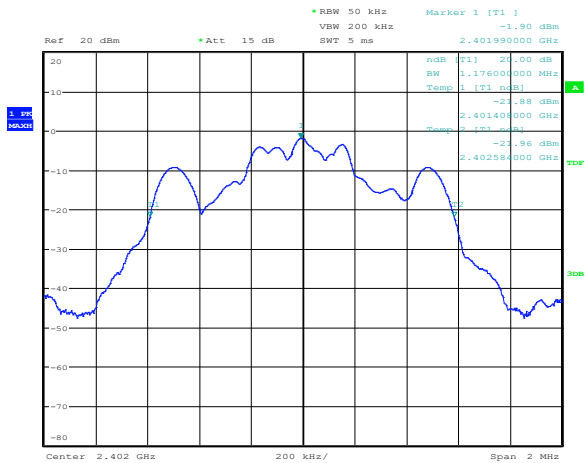
Number of hopping frequencies*	Minimum limit	Margin
80	15	65

Note: Channels are numbered 0x00 to 0x4F (0 to 79)

Table 8.4-5: Average time of occupancy results

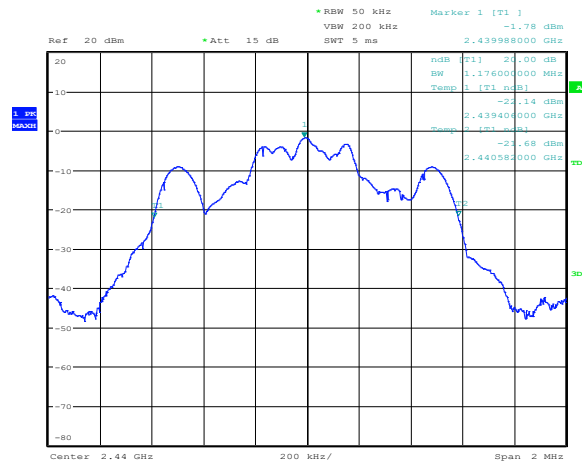
Modulation	Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
3-EV5	0.155	140	21.700	400.000	378.300
3-HD5	0.166	120	19.920	400.000	380.080
DM5	0.201	120	24.120	400.000	375.880

Measurement Period is 20 s



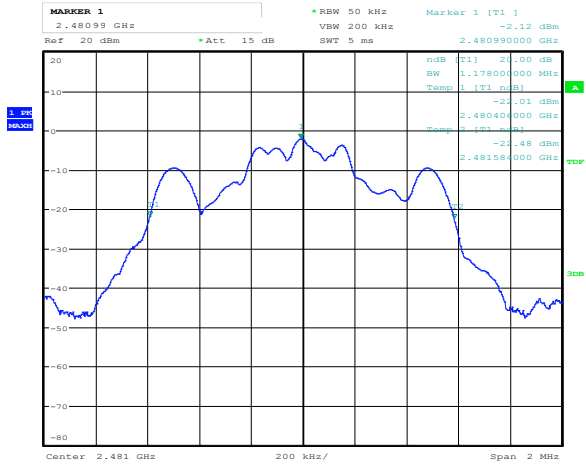
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Figure 8.4-1: 20 dB bandwidth on low channel, 3-EV5



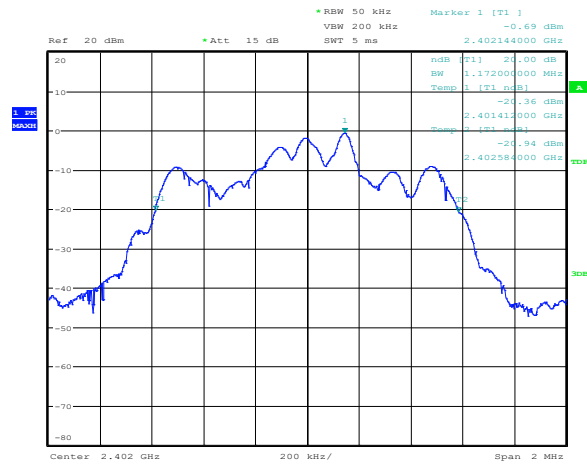
Date: 3.JUL.2018 10:47:45

Figure 8.4-2: 20 dB bandwidth on mid channel, 3-EV5



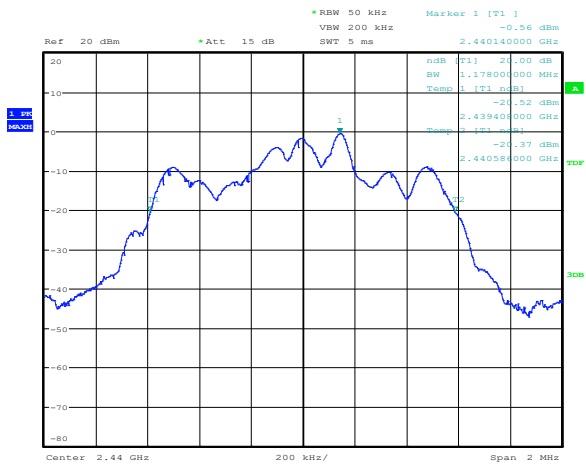
Date: 3.JUL.2018 14:29:42

Figure 8.4-3: 20 dB bandwidth on high channel, 3-EV5



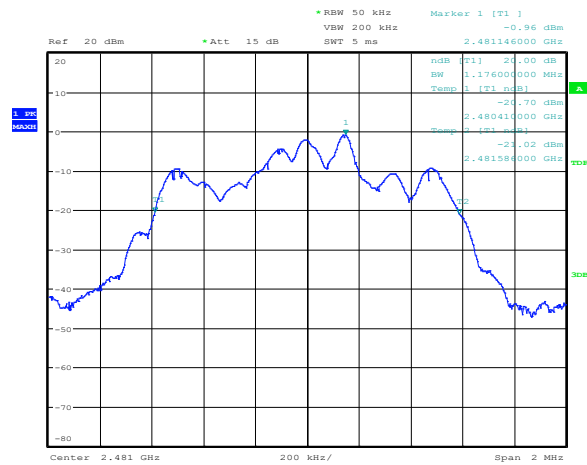
Date: 3.JUL.2018 10:35:02

Figure 8.4-4: 20 dB bandwidth on low channel, 3-DH5



Date: 3.JUL.2018 10:53:42

Figure 8.4-5: 20 dB bandwidth on mid channel, 3-DH5

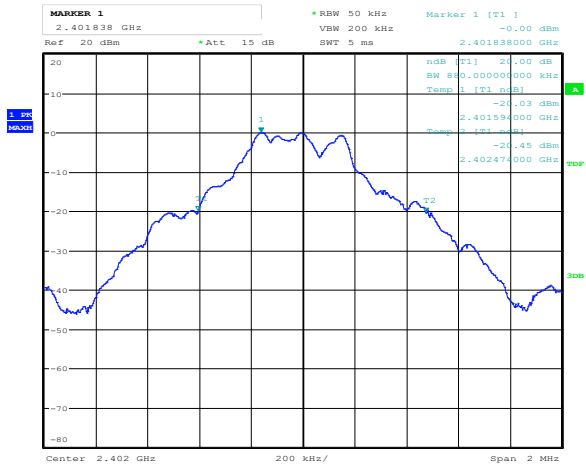


Date: 3.JUL.2018 14:36:14

Figure 8.4-6: 20 dB bandwidth on high channel, 3-DH5

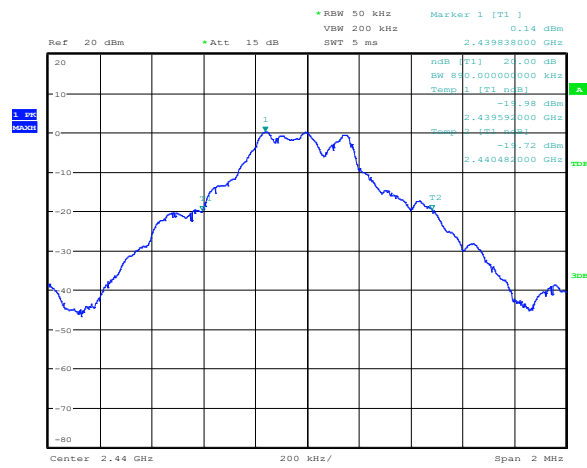
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Testing data
 FCC 15.247(a)(1) and RSS-247 5.1 Frequency Hopping Systems requirements
 FCC Part 15 Subpart C and RSS-247, Issue 2



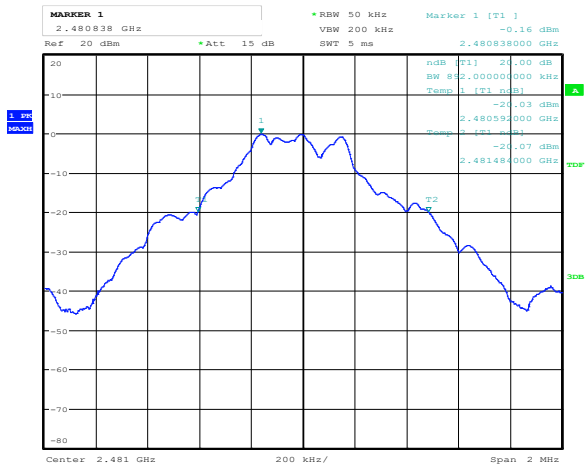
Date: 3.JUL.2018 10:44:44

Figure 8.4-7: 20 dB bandwidth on low channel, DM5



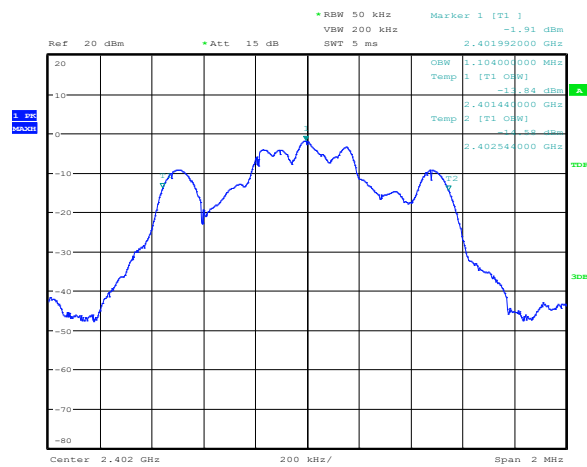
Date: 3.JUL.2018 10:55:05

Figure 8.4-8: 20 dB bandwidth on mid channel, DM5



Date: 3.JUL.2018 14:17:57

Figure 8.4-9: 20 dB bandwidth on high channel, DM5

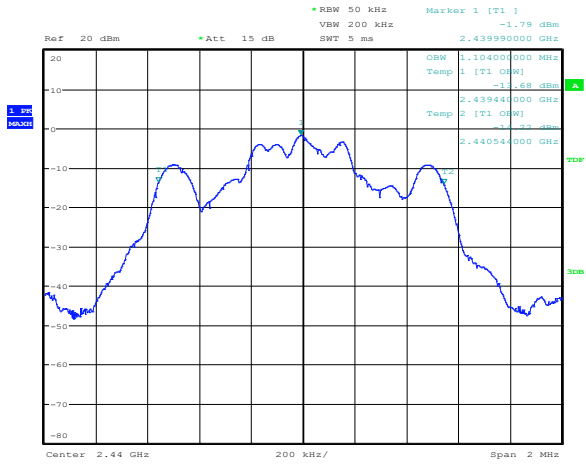


Date: 3.JUL.2018 10:38:16

Figure 8.4-10: 99% bandwidth on low channel, 3-EV5

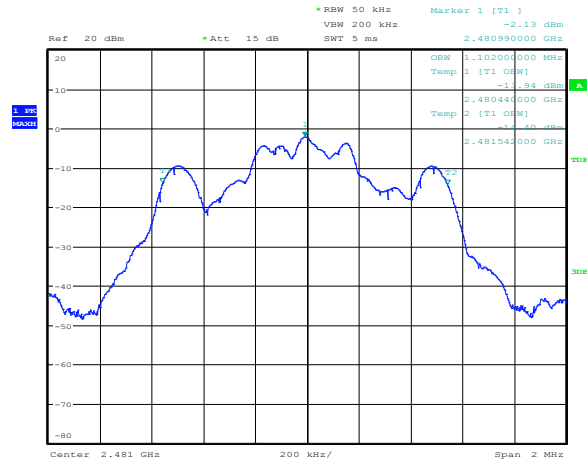
Section 8
Test name
Specification

Testing data
 FCC 15.247(a)(1) and RSS-247 5.1 Frequency Hopping Systems requirements
 FCC Part 15 Subpart C and RSS-247, Issue 2



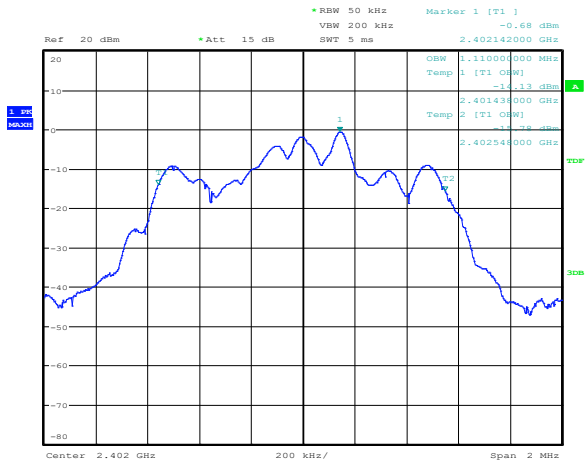
Date: 3.JUL.2018 10:48:46

Figure 8.4-11: 99% bandwidth on mid channel, 3-EV5



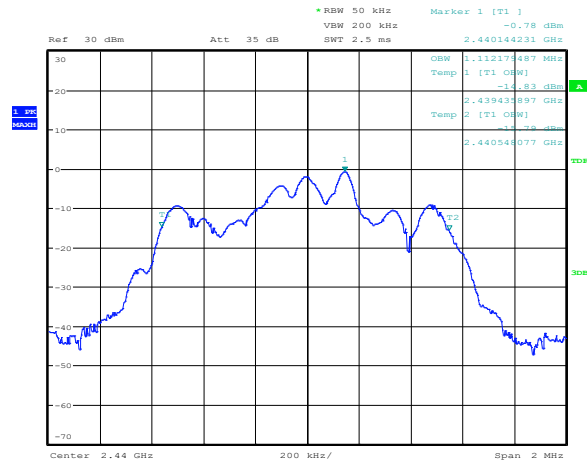
Date: 3.JUL.2018 14:30:50

Figure 8.4-12: 99% bandwidth on high channel, 3-EV5



Date: 3.JUL.2018 10:34:02

Figure 8.4-13: 99% bandwidth on low channel, 3-DH5

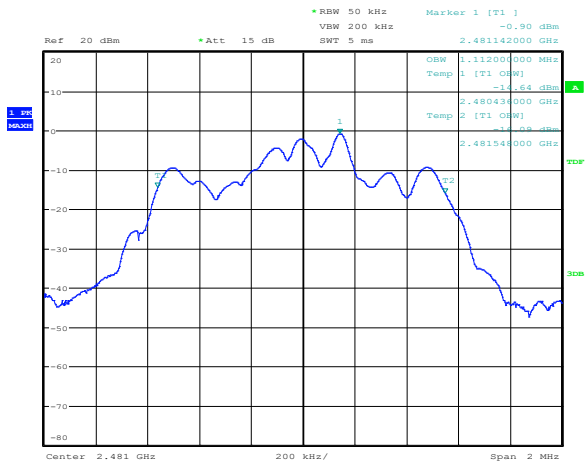


Date: 5.JUL.2018 15:13:50

Figure 8.4-14: 99% bandwidth on mid channel, 3-DH5

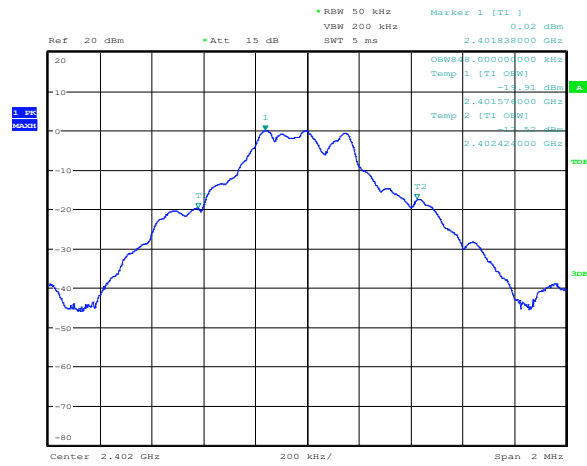
Section 8
Test name
Specification

Testing data
 FCC 15.247(a)(1) and RSS-247 5.1 Frequency Hopping Systems requirements
 FCC Part 15 Subpart C and RSS-247, Issue 2



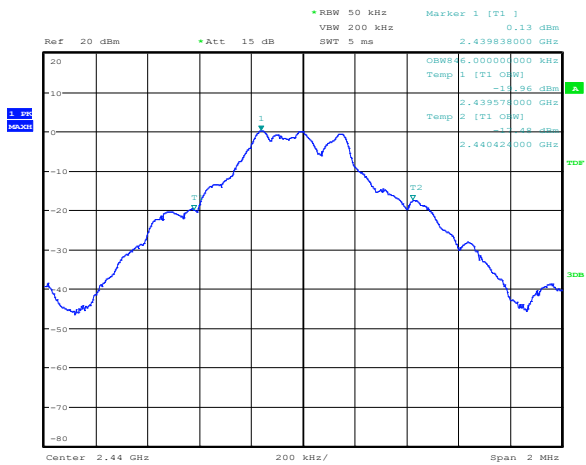
Date: 3.JUL.2018 14:35:07

Figure 8.4-15: 99% bandwidth on high channel, 3-DH5



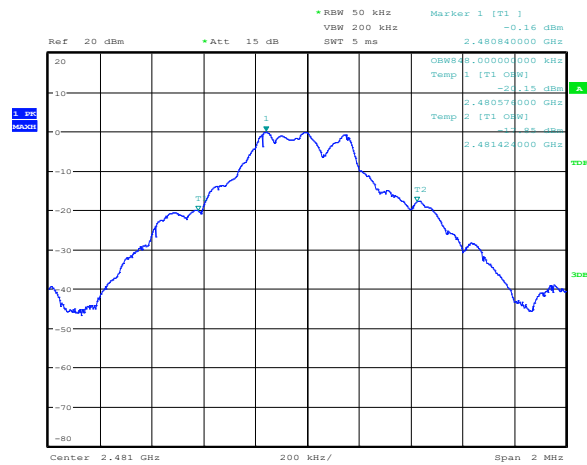
Date: 3.JUL.2018 10:43:26

Figure 8.4-16: 99% bandwidth on low channel, DM5



Date: 3.JUL.2018 10:56:18

Figure 8.4-17: 99% bandwidth on mid channel, DH5

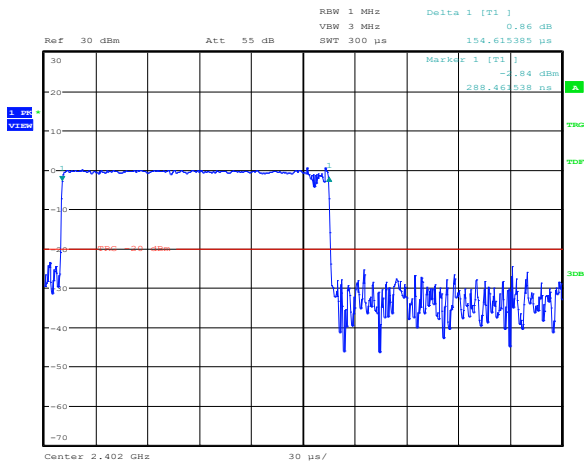


Date: 3.JUL.2018 14:11:13

Figure 8.4-18: 99% bandwidth on high channel, DM5

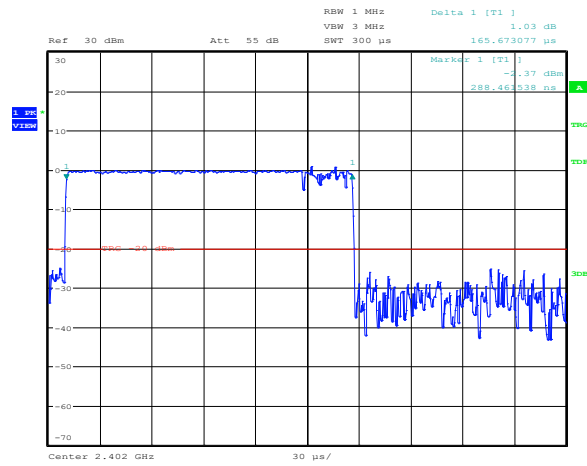
Section 8
Test name
Specification

Testing data
 FCC 15.247(a)(1) and RSS-247 5.1 Frequency Hopping Systems requirements
 FCC Part 15 Subpart C and RSS-247, Issue 2



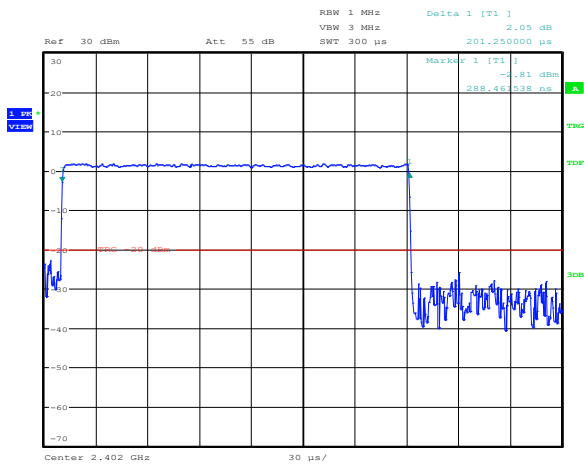
Date: 5.JUL.2018 15:23:38

Figure 8.4-19: Pulse width, 3-EV5



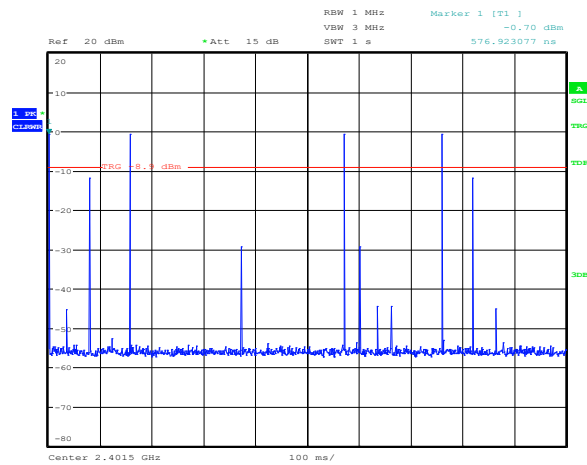
Date: 5.JUL.2018 15:24:27

Figure 8.4-20: Pulse width, 3-DH5



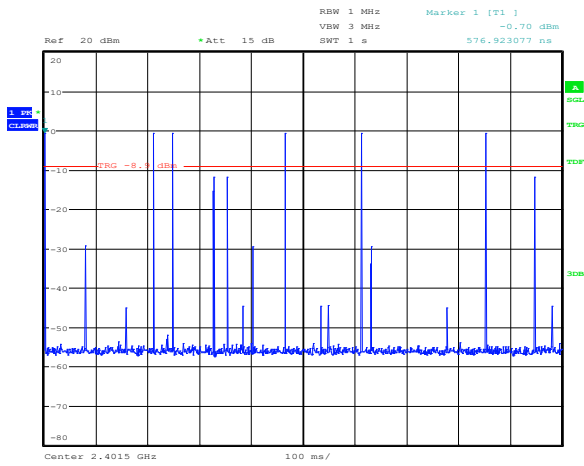
Date: 5.JUL.2018 15:24:57

Figure 8.4-21: Pulse width, DM5



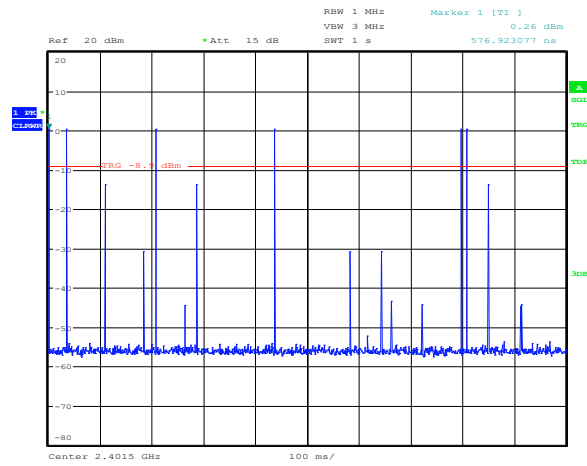
Date: 3.JUL.2018 15:07:16

Figure 8.4-22: Number of pulses within 1 s, 3-EV5



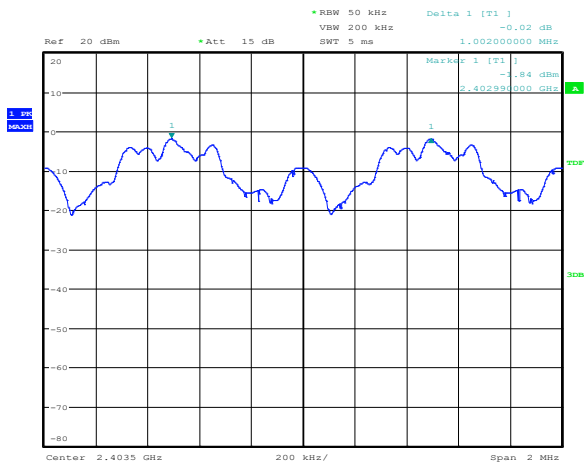
Date: 3.JUL.2018 15:07:44

Figure 8.4-23: Number of pulses within 1 s, 3-DH5



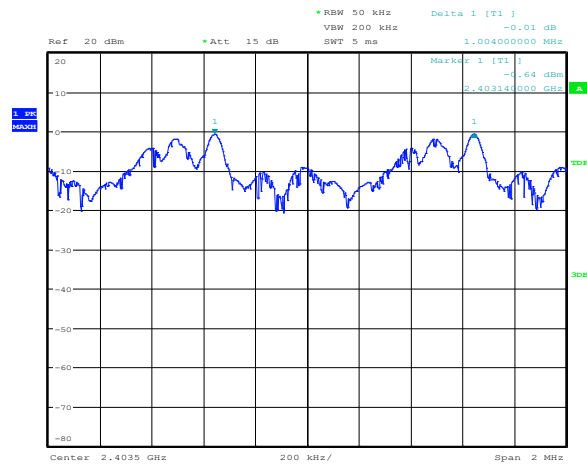
Date: 3.JUL.2018 15:10:04

Figure 8.4-24: Number of pulses within 1 s, DM5



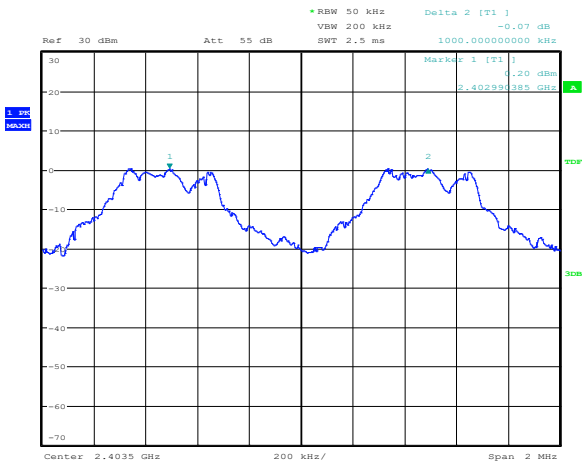
Date: 3.JUL.2018 14:44:56

Figure 8.4-25: Carrier frequency separation, 3-EV5



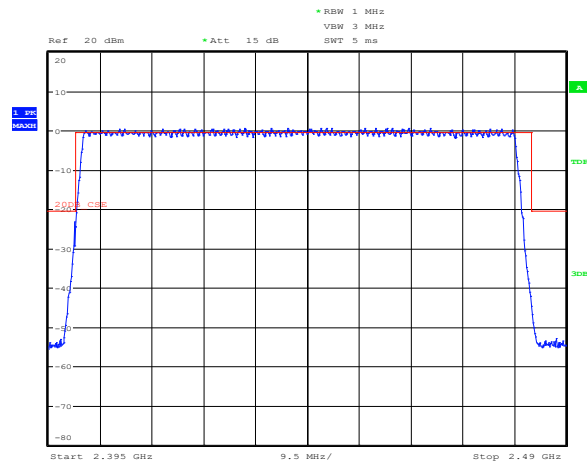
Date: 3.JUL.2018 14:47:09

Figure 8.4-26: Carrier frequency separation, 3-DH5



Date: 5.JUL.2018 15:17:31

Figure 8.4-27: Carrier frequency separation, DM5



Date: 3.JUL.2018 14:57:28

Figure 8.4-28: Number of hopping channels (80 total)

8.5 FCC 15.247(b) and RSS-247 5.4 (b) Transmitter output power and e.i.r.p. requirements for FHSS

8.5.1 Definitions and limits

FCC:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (1) For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt (30 dBm). For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts (21 dBm).
 - (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.

ISED:

For FHSs operating in the band 2400–2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W (30 dBm) if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W (21 dBm) if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W (36 dBm), except as provided in section 5.4(e).

Section 5.4(e)

Fixed point-to-point systems in the bands 2400–2483.5 MHz and 5725–5850 MHz are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding an e.i.r.p. of 4 W.

8.5.1 Test date

Start date	July 3, 2018
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8.5.2 Observations, settings and special notes

Spectrum analyser settings for output power:

Resolution bandwidth	> the 20 dB bandwidth of the emission being measured
Video bandwidth	≥ RBW
Frequency span	approximately 5 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.5.3 Test data

Table 8.5-1: Output power and EIRP results, for 3-EV5

Frequency, MHz	Output power, dBm	Output power limit*, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
2402	1.09	21.00	19.91	1.00	2.09	27.00	24.91
2440	1.20	21.00	19.80	1.00	2.20	27.00	24.80
2481	0.83	21.00	20.17	1.00	1.83	27.00	25.17

Note: Output power is limited by the alternative carrier frequency separation requirement.

EIRP = Output power + Antenna gain

Table 8.5-2: Output power and EIRP results, for 3-HD5

Frequency, MHz	Output power, dBm	Output power limit*, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
2402	1.10	21.00	19.90	1.00	2.10	27.00	24.90
2440	1.22	21.00	19.78	1.00	2.22	27.00	24.78
2481	0.83	21.00	20.17	1.00	1.83	27.00	25.17

Note: Output power is limited by the alternative carrier frequency separation requirement.

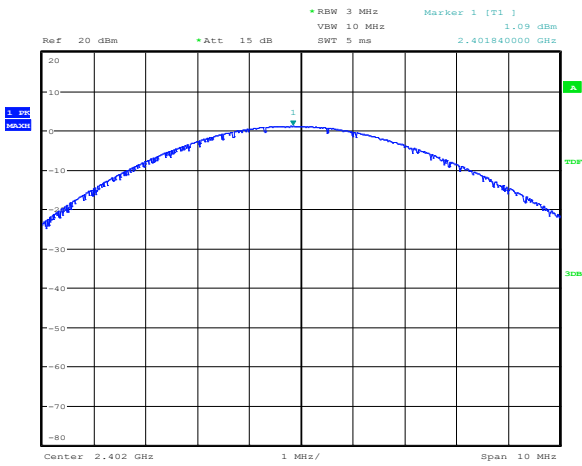
EIRP = Output power + Antenna gain

Table 8.5-3: Output power and EIRP results, for DM5

Frequency, MHz	Output power, dBm	Output power limit*, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
2402	1.51	21.00	19.49	1.00	2.51	27.00	24.49
2440	1.60	21.00	19.40	1.00	2.60	27.00	24.40
2481	1.30	21.00	19.70	1.00	2.30	27.00	24.70

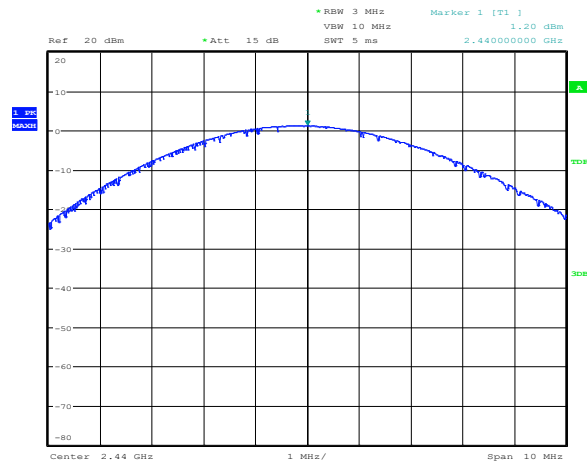
Note: Output power is limited by the alternative carrier frequency separation requirement.

EIRP = Output power + Antenna gain



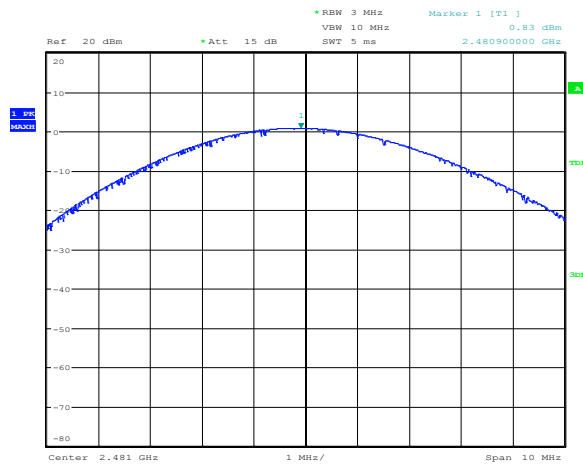
Date: 3.JUL.2018 10:39:10

Figure 8.5-1: Output power on low channel, 3-EV5



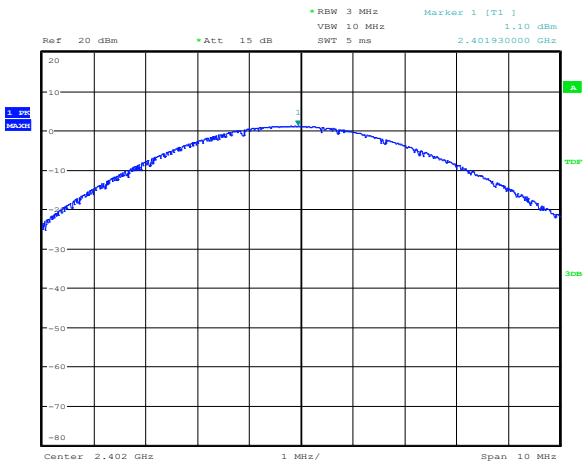
Date: 3.JUL.2018 10:49:29

Figure 8.5-2: Output power on mid channel, 3-EV5



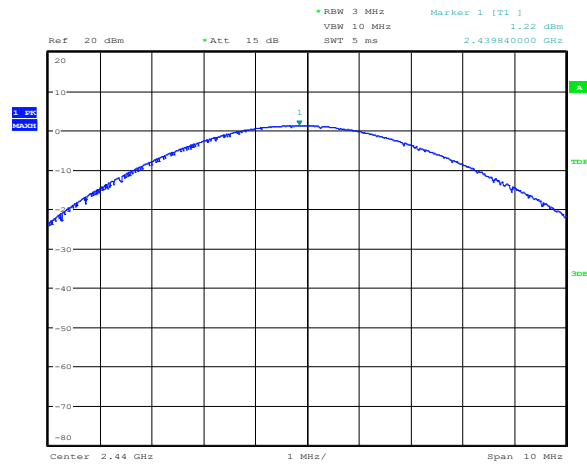
Date: 3.JUL.2018 14:31:41

Figure 8.5-3: Output power on high channel, 3-EV5



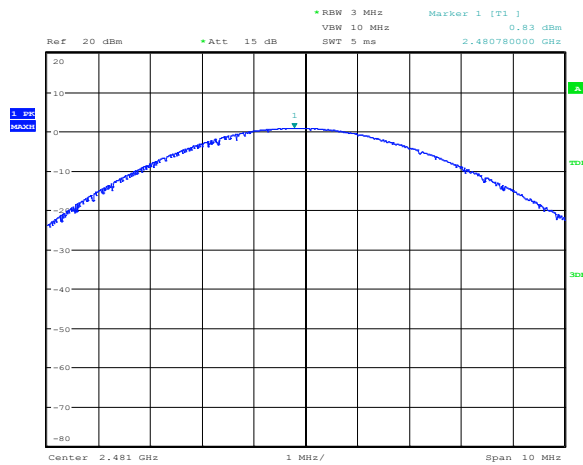
Date: 3.JUL.2018 10:32:30

Figure 8.5-4: Output power on low channel, 3-DH5



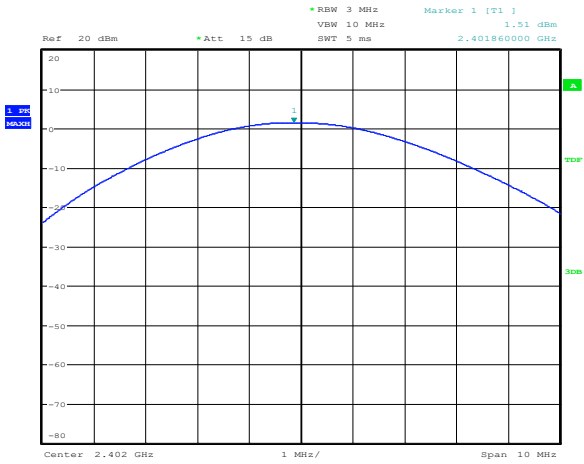
Date: 3.JUL.2018 10:50:57

Figure 8.5-5: Output power on mid channel, 3-DH5



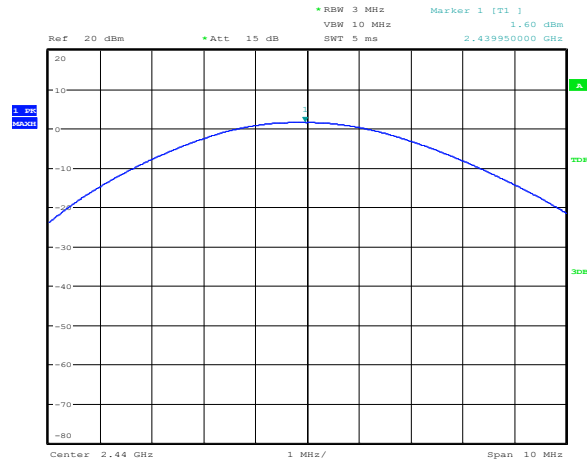
Date: 3.JUL.2018 14:32:39

Figure 8.5-6: Output power on high channel, 3-DH5



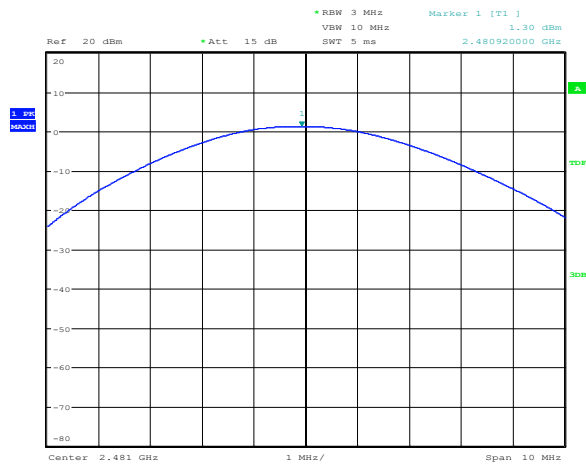
Date: 3.JUL.2018 10:41:28

Figure 8.5-7: Output power on low channel, DM5



Date: 3.JUL.2018 11:32:07

Figure 8.5-8: Output power on mid channel, DM5



Date: 3.JUL.2018 14:10:04

Figure 8.5-9: Output power on high channel, DM5

8.6 FCC 15.247(a)(2) and RSS-247 5.2(a) Minimum 6 dB bandwidth for DTS systems

8.6.1 Definitions and limits

FCC:

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.

ISED:

The minimum 6 dB bandwidth shall be 500 kHz.

8.6.1 Test date

Start date June 29, 2018

8.6.2 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	≥3 × RBW
Frequency span	5 MHz
Detector mode	Peak
Trace mode	Max Hold

8.6.3 Test data

Table 8.6-1: 6 dB bandwidth results

Frequency, MHz	6 dB bandwidth, kHz	Minimum limit, kHz	Margin, MHz
2402	675	500	175
2440	660	500	160
2480	670	500	170

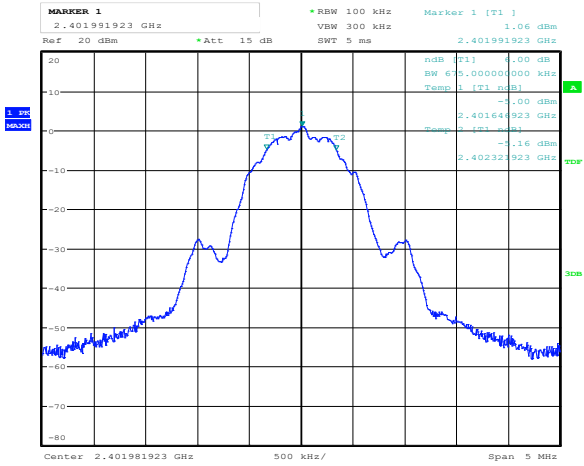
Table 8.6-2: 99% occupied bandwidth results

Frequency, MHz	99% occupied bandwidth, kHz
2402	1100
2440	1105
2480	1105

Note: there is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

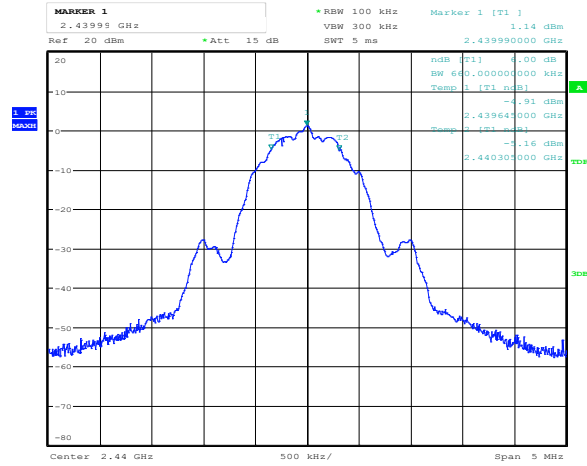
Section 8
Test name
Specification

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



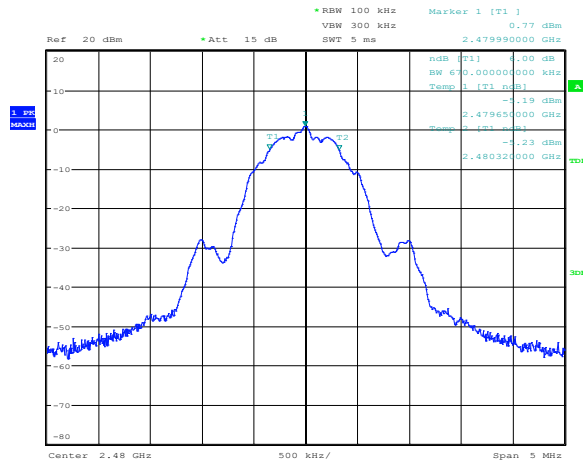
Date: 29 JUN 2018 13:46:48

Figure 8.6-1: 6 dB bandwidth on low channel



Date: 29 JUN 2018 13:50:04

Figure 8.6-2: 6 dB bandwidth on mid channel

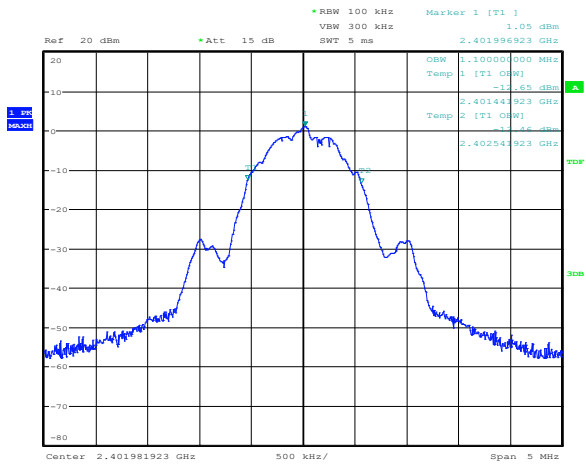


Date: 29 JUN 2018 13:51:00

Figure 8.6-3: 6 dB bandwidth on high channel

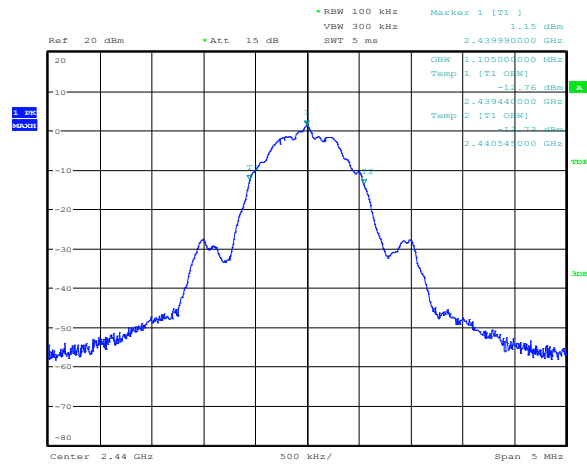
Section 8
Test name
Specification

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



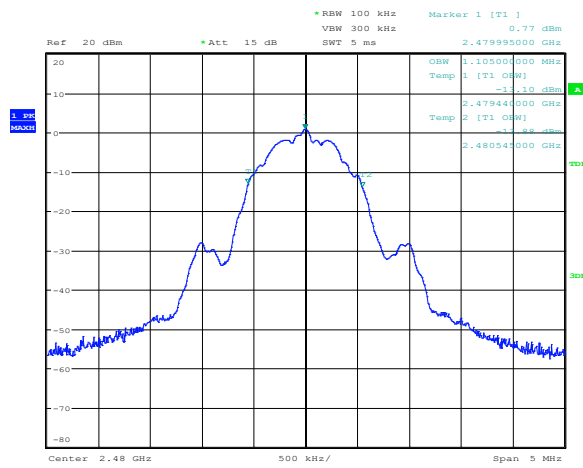
Date: 29.JUN.2018 13:46:21

Figure 8.6-4: 99% bandwidth on low channel



Date: 29.JUN.2018 13:49:35

Figure 8.6-5: 99% bandwidth on mid channel



Date: 29.JUN.2018 13:52:09

Figure 8.6-6: 99% bandwidth on high channel

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

8.7.1 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 2400–2483.5 MHz band: 1 W (30 dBm). As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.
 - (4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.
- (c) Operation with directional antenna gains greater than 6 dBi.
- (1) Fixed point-to-point operation:
- (i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.
 - (iii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.
- (2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:
- (i) Different information must be transmitted to each receiver.
 - (ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:
 - (A) The directional gain shall be calculated as the sum of $10 \log$ (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.
 - (B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.
 - (iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.
 - (iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.



ISED:

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

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

e. Fixed point-to-point systems in the 2400–2483.5 MHz band are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding an e.i.r.p. of 4 W.

f. Transmitters operating in the band 2400–2483.5 MHz, may employ antenna systems that emit multiple directional beams simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers, provided that the emissions comply with the following:

i Different information must be transmitted to each receiver.

ii If the transmitter employs an antenna system that emits multiple directional beams, but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device (i.e. the sum of the power supplied to all antennas, antenna elements, staves, etc., and summed across all carriers or frequency channels) shall not exceed the applicable output power limit specified in sections 5.4(b) and 5.4(d). However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

iii If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the applicable power limit specified in sections 5.4(b) and 5.4(d). If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the applicable limit specified in sections 5.4(b) and 5.4(d). In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the applicable limit specified in sections 5.4(b) and 5.4(d) by more than 8 dB.

iv Transmitters that transmit a single directional beam shall operate under the provisions of sections 5.4(b), 5.4(d) and 5.4(e).

8.7.1 Test date

Start date June 29, 2018

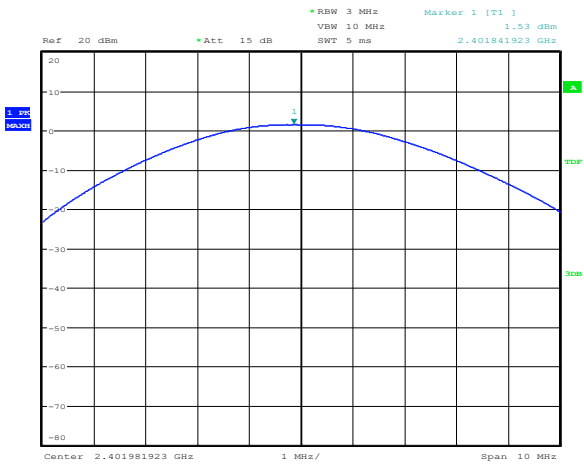
8.7.2 Observations, settings and special notes

The test was performed using peak method

8.7.3 Test data

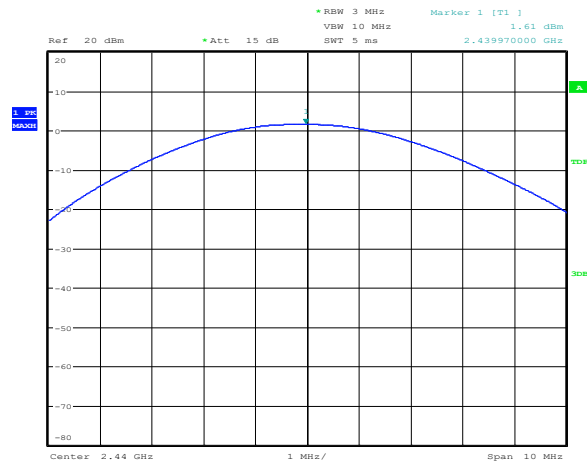
Table 8.7-1: Output power measurements results

Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	Limit					
2402	1.53	30.00	28.47	1.00	2.53	36.00	33.47
2440	1.61	30.00	28.39	1.00	2.61	36.00	33.39
2480	1.24	30.00	28.76	1.00	2.24	36.00	33.76



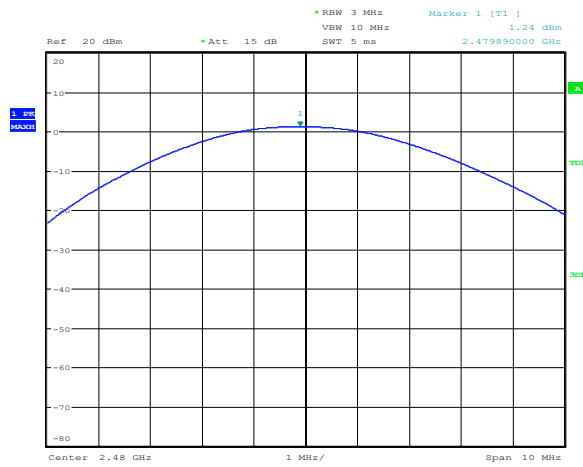
Date: 29.JUN.2018 13:47:15

Figure 8.7-1: Output power on low channel



Date: 29.JUN.2018 13:49:10

Figure 8.7-2: Output power on mid channel



Date: 29.JUN.2018 13:53:44

Figure 8.7-3: Output power on high channel

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

8.8.1 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)).

ISED:

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

Table 8.8-1: 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 × log ₁₀ (F)	300
0.490–1.705	24000/F	87.6 – 20 × 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 8.8-2: ISED restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	Above 38.6
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in Table 8.8-2 and above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

Table 8.8-3: 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			

8.8.1 Test date

Start date July 4, 2018

8.8.2 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.
Worst case FHSS modulation was selected for the radiated FHSS spurious emissions: DM5.
Radiated measurements were performed at a distance of 3 m.
Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is -20 dBc/100 kHz.
Conducted equivalent of the radiated limits within restricted bands was calculated as follows:
Peak field strength limit of 74 dBµV/m @ 3 m - 95.23 dB = -21.23 dBm (EIRP)
Average field strength limit of 54 dBµV/m @ 3 m - 95.23 dB = -41.23 dBm (EIRP)

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz and all conducted measurements outside restricted bands:

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

8.8.4 Test data

Table 8.8-4: Radiated field strength measurement results for FHSS

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	41.80	74.00	32.20	36.00	54.00	18.00
High	2483.5	43.56	74.00	30.44	37.40	54.00	16.60

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Table 8.8-5: Radiated field strength measurement results for DTS

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	42.24	74.00	31.76	36.44	54.00	17.56
High	2483.5	40.84	74.00	33.16	35.55	54.00	18.45

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Table 8.8-6: Conducted EIRP measurement results for FHSS 3-EV5

Channel	Frequency, MHz	Peak EIRP, dBm		Margin, dB	Average EIRP, dBm		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	-65.22	-21.23	43.99	-65.22	-41.23	23.99
High	2483.5	-27.41	-21.23	6.18	-61.29	-41.23	20.06

Notes: Antenna gain of minimum 2 dBi was added to the conducted measurement results. Where peak level was below average limit no average measurement was performed.

Table 8.8-7: Conducted EIRP measurement results for FHSS 3-DH5

Channel	Frequency, MHz	Peak EIRP, dBm		Margin, dB	Average EIRP, dBm		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	-63.74	-21.23	42.51	-63.74	-41.23	22.51
High	2483.5	-28.31	-21.23	7.08	-61.14	-41.23	19.91

Notes: Antenna gain of minimum 2 dBi was added to the conducted measurement results. Where peak level was below average limit no average measurement was performed.

Table 8.8-8: Conducted EIRP measurement results for FHSS DM5

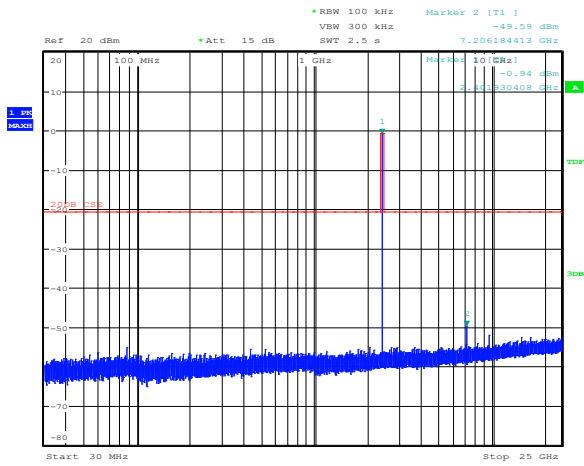
Channel	Frequency, MHz	Peak EIRP, dBm		Margin, dB	Average EIRP, dBm		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	-63.33	-21.23	42.10	-63.33	-41.23	22.10
High	2483.5	-28.02	-21.23	6.79	-60.58	-41.23	19.35

Notes: Antenna gain of minimum 2 dBi was added to the conducted measurement results. Where peak level was below average limit no average measurement was performed.

Table 8.8-9: Conducted EIRP measurement results for DTS

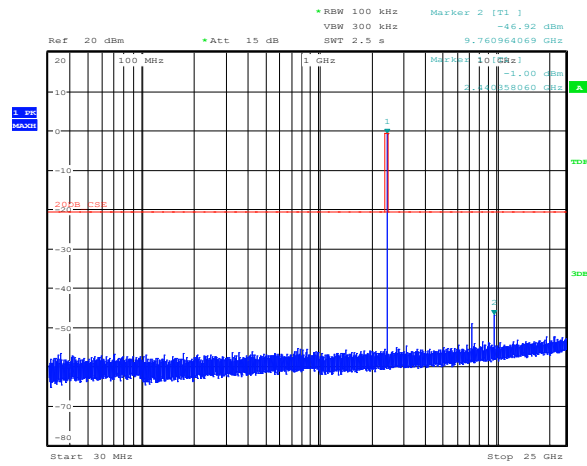
Channel	Frequency, MHz	Peak EIRP, dBm		Margin, dB	Average EIRP, dBm		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	-51.61	-21.23	30.38	-51.61	-41.23	10.38
High	2483.5	-50.86	-21.23	29.63	-50.86	-41.23	9.63

Notes: Antenna gain of minimum 2 dBi was added to the conducted measurement results. Where peak level was below average limit no average measurement was performed.



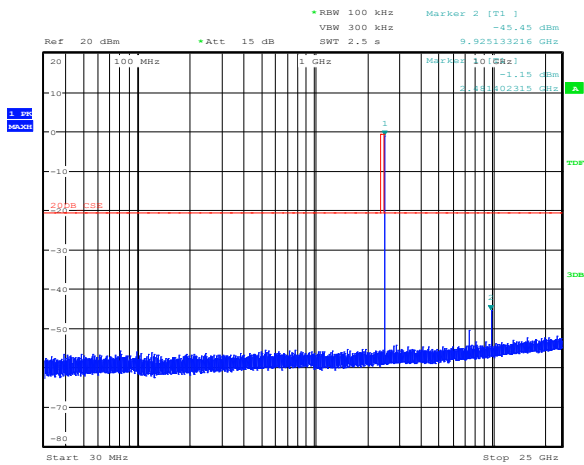
Date: 3.JUL.2018 15:23:28

Figure 8.8-1: Conducted spurious emissions for FHSS 3-EV5, low channel



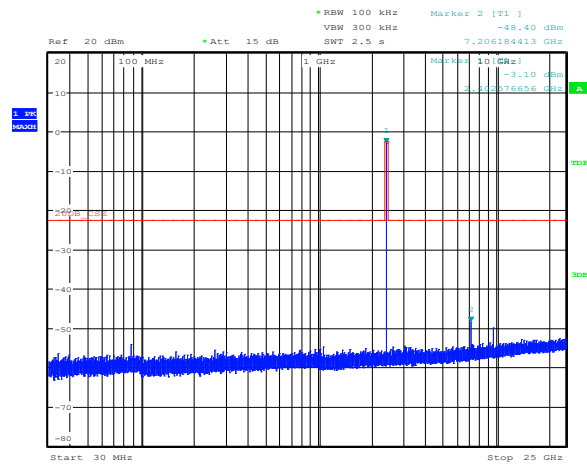
Date: 3.JUL.2018 15:21:12

Figure 8.8-2: Conducted spurious emissions for FHSS 3-EV5, mid channel



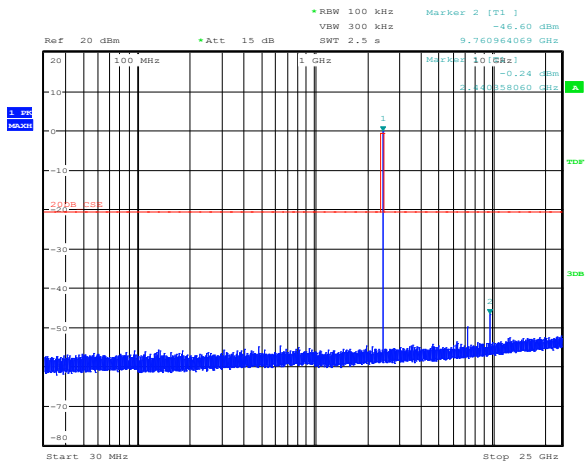
Date: 3.JUL.2018 15:28:51

Figure 8.8-3: Conducted spurious emissions for FHSS 3-EV5, high channel



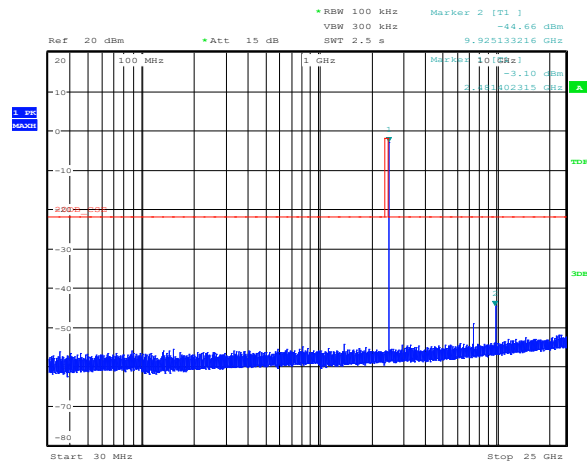
Date: 3.JUL.2018 15:33:27

Figure 8.8-4: Conducted spurious emissions for FHSS 3-DH5, low channel



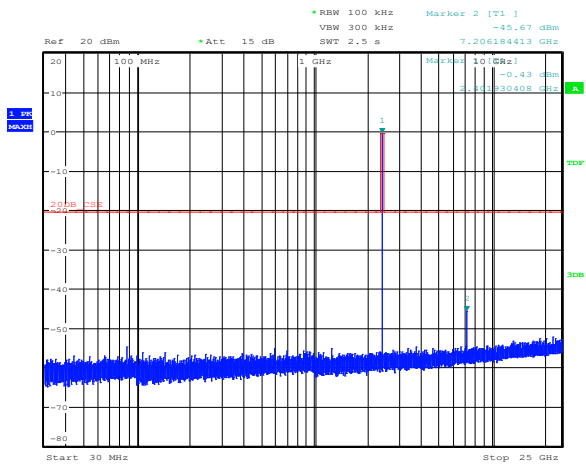
Date: 3.JUL.2018 15:45:21

Figure 8.8-5: Conducted spurious emissions for FHSS 3-DH5, mid channel



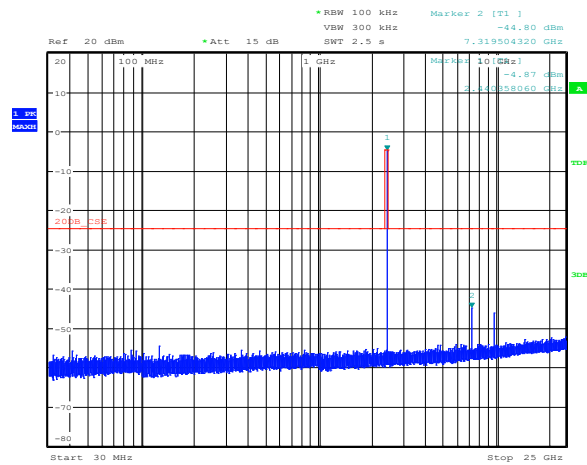
Date: 3.JUL.2018 15:53:36

Figure 8.8-6: Conducted spurious emissions for FHSS 3-DH5, high channel



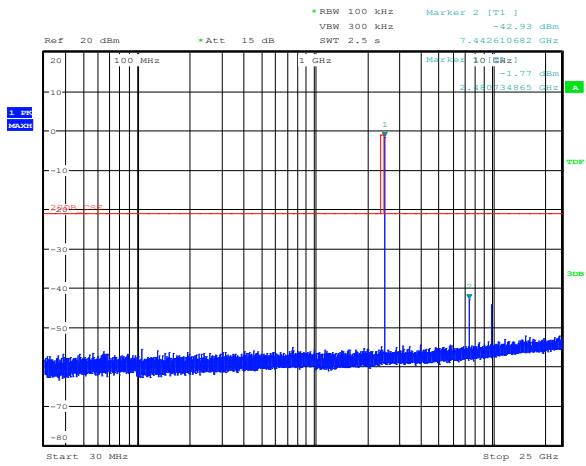
Date: 3.JUL.2018 15:56:28

Figure 8.8-7: Conducted spurious emissions for FHSS DM5, low channel



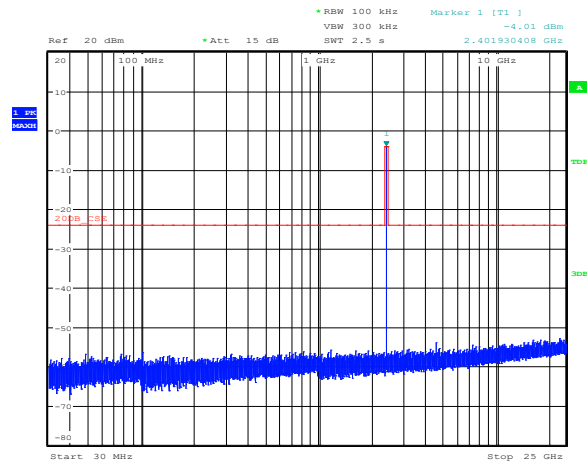
Date: 3.JUL.2018 16:00:44

Figure 8.8-8: Conducted spurious emissions for FHSS DM5, mid channel



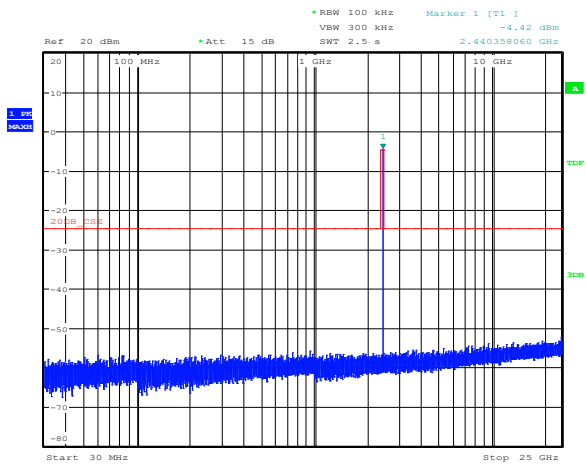
Date: 3.JUL.2018 16:04:36

Figure 8.8-9: Conducted spurious emissions for FHSS DM5, high channel



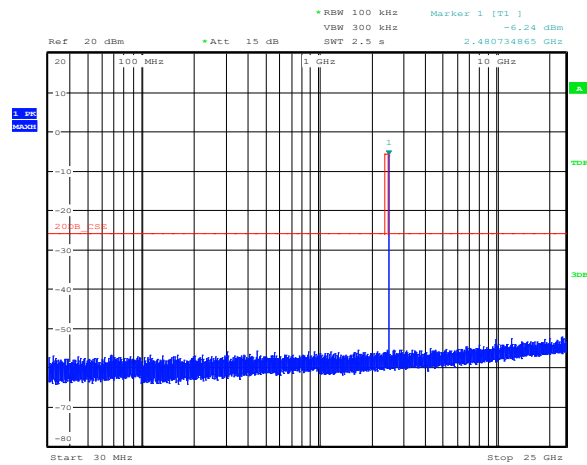
Date: 5.JUL.2018 16:14:37

Figure 8.8-10: Conducted spurious emissions for DTS, low channel



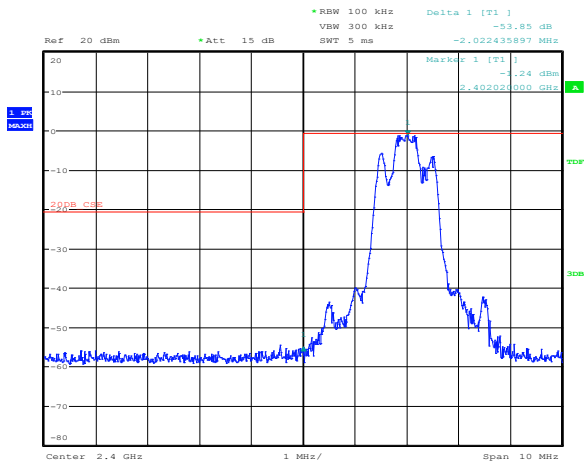
Date: 5.JUL.2018 16:13:46

Figure 8.8-11: Conducted spurious emissions for DTS, mid channel



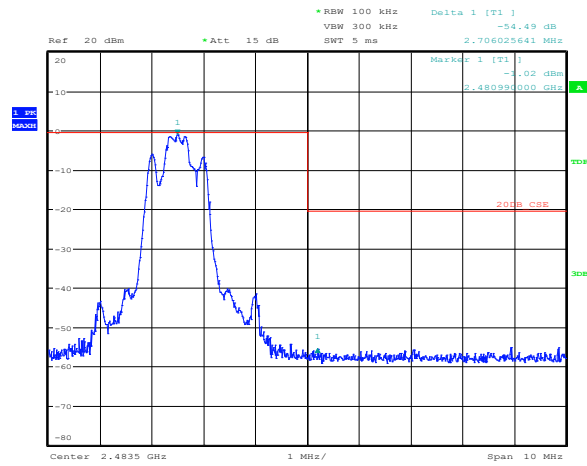
Date: 5.JUL.2018 16:12:18

Figure 8.8-12: Conducted spurious emissions for DTS, high channel



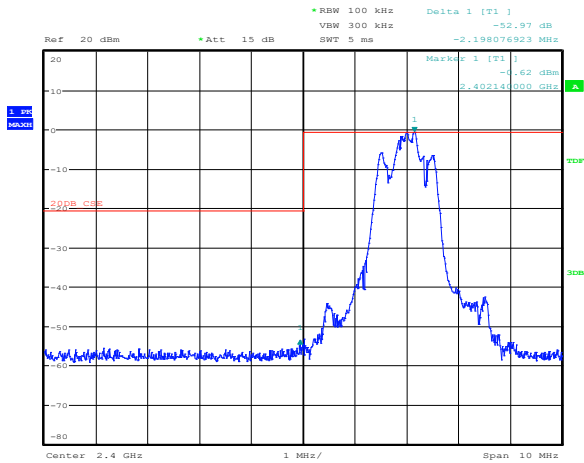
Date: 3.JUL.2018 10:39:53

Figure 8.8-13: Conducted spurious emissions for FHSS 3-EV5 at the lower band edge



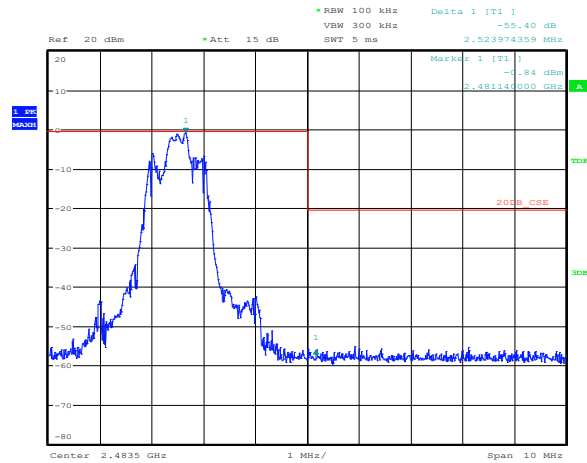
Date: 3.JUL.2018 14:26:58

Figure 8.8-14: Conducted spurious emissions for FHSS 3-EV5 at the upper band edge



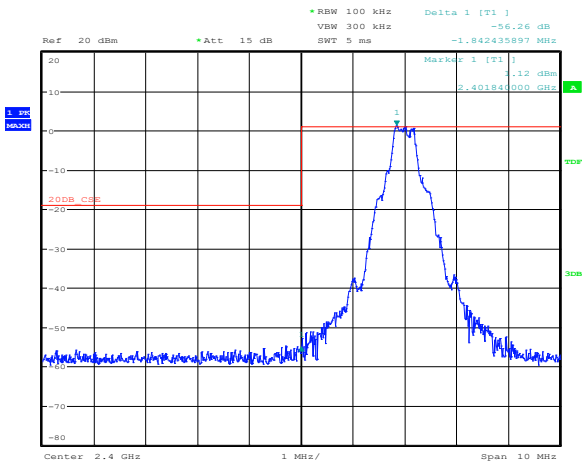
Date: 3.JUL.2018 10:31:37

Figure 8.8-15: Conducted spurious emissions for FHSS 3-DH5 at the lower band edge



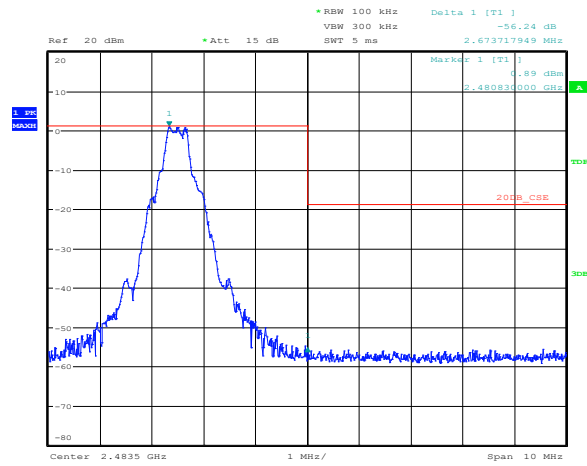
Date: 3.JUL.2018 14:25:20

Figure 8.8-16: Conducted spurious emissions for FHSS 3-DH5 at the upper band edge



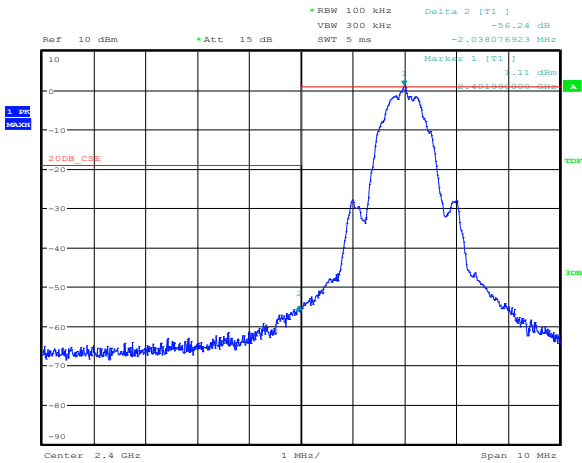
Date: 3.JUL.2018 10:40:47

Figure 8.8-17: Conducted spurious emissions for FHSS DM5 at the lower band edge



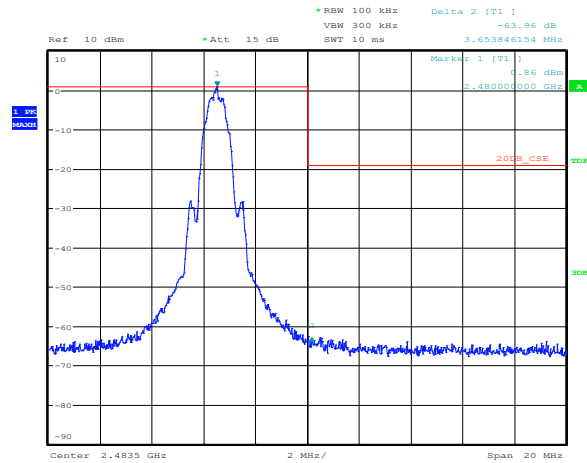
Date: 3.JUL.2018 14:19:04

Figure 8.8-18: Conducted spurious emissions for FHSS DM5 at the upper band edge



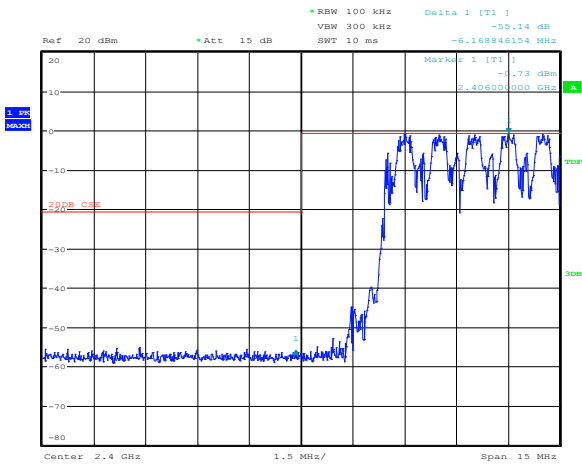
Date: 29.JUN.2018 13:45:11

Figure 8.8-19: Conducted spurious emissions for DTS at the lower band edge



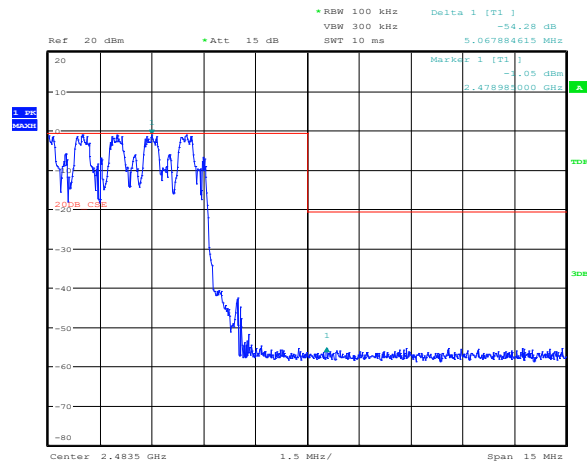
Date: 29.JUN.2018 13:43:43

Figure 8.8-20: Conducted spurious emissions for DTS at the upper band edge



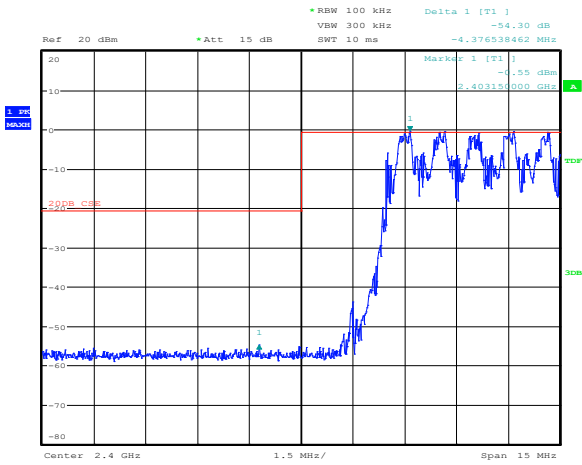
Date: 3.JUL.2018 09:31:11

Figure 8.8-21: Conducted spurious emissions for FHSS 3-EV5 at the lower band edge, hopping



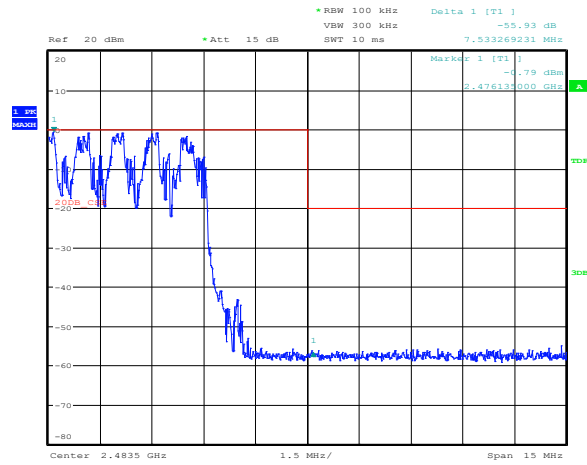
Date: 3.JUL.2018 09:46:40

Figure 8.8-22: Conducted spurious emissions for FHSS 3-EV5 at the upper band edge, hopping



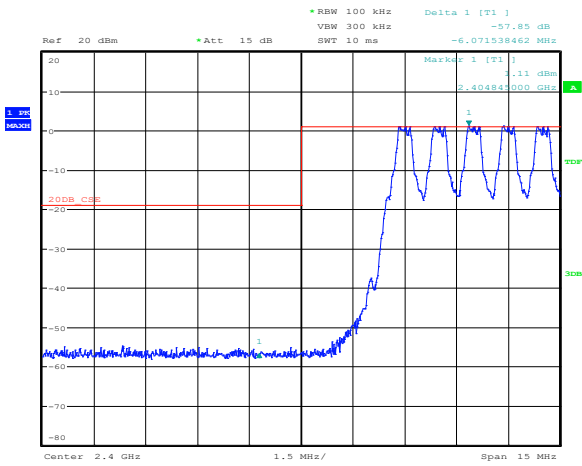
Date: 3.JUL.2018 09:35:10

Figure 8.8-23: Conducted spurious emissions for FHSS 3-DH5 at the lower band edge, hopping



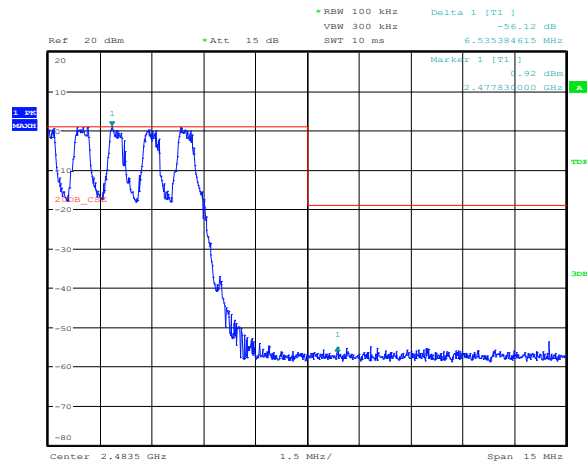
Date: 3.JUL.2018 09:44:52

Figure 8.8-24: Conducted spurious emissions for FHSS 3-DH5 at the upper band edge, hopping



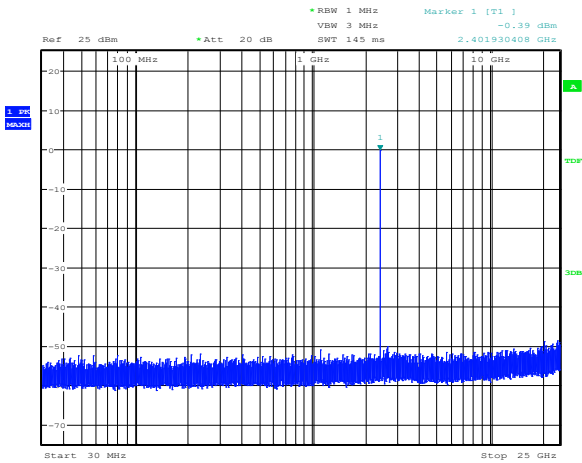
Date: 3.JUL.2018 09:39:23

Figure 8.8-25: Conducted spurious emissions for FHSS DM5 at the lower band edge, hopping



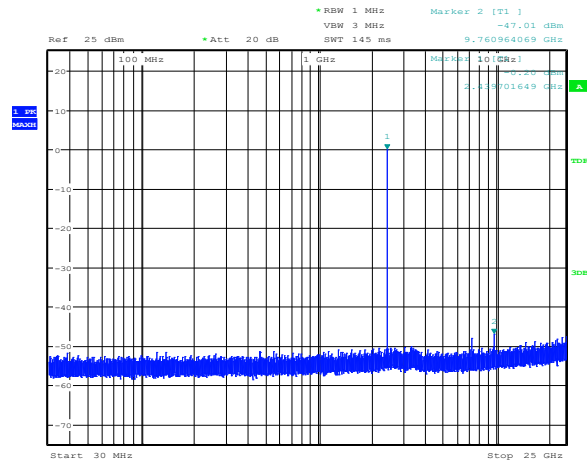
Date: 3.JUL.2018 09:42:53

Figure 8.8-26: Conducted spurious emissions for FHSS DM5 at the upper band edge, hopping



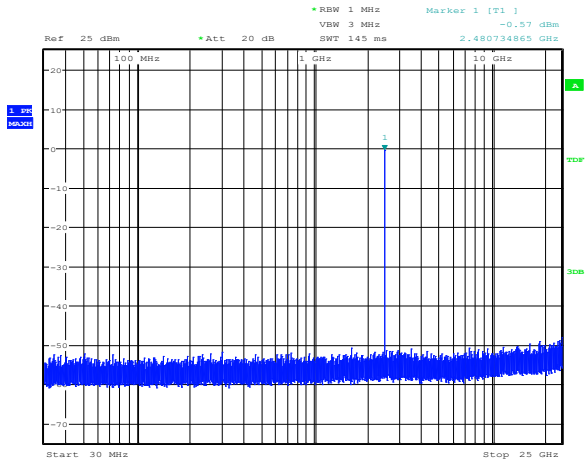
Date: 5.JUL.2018 15:41:53

Figure 8.8-27: Conducted spurious emissions within restricted bands for FHSS 3-EV5, low channel



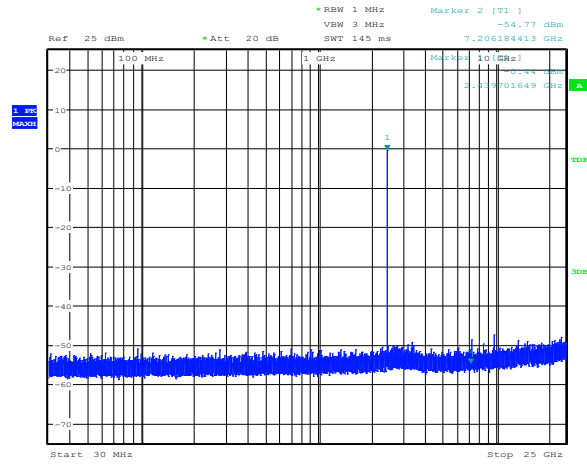
Date: 5.JUL.2018 15:44:23

Figure 8.8-28: Conducted spurious emissions within restricted bands for FHSS 3-EV5, mid channel



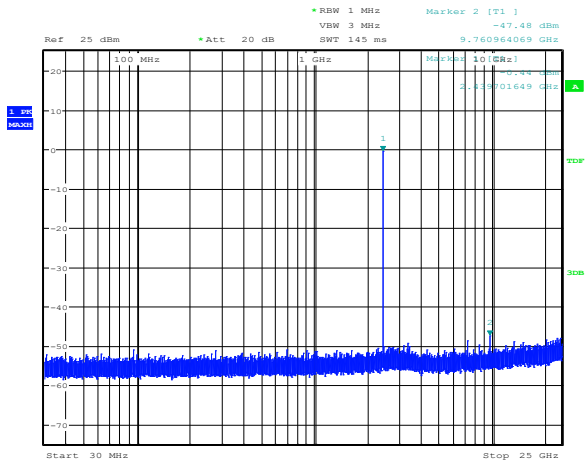
Date: 5.JUL.2018 15:45:17

Figure 8.8-29: Conducted spurious emissions within restricted bands for FHSS 3-EV5, high channel



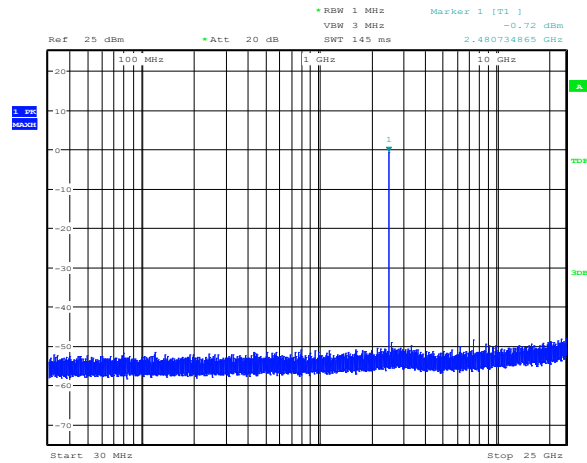
Date: 5.JUL.2018 15:35:34

Figure 8.8-30: Conducted spurious emissions within restricted bands for FHSS 3-DH5, low channel



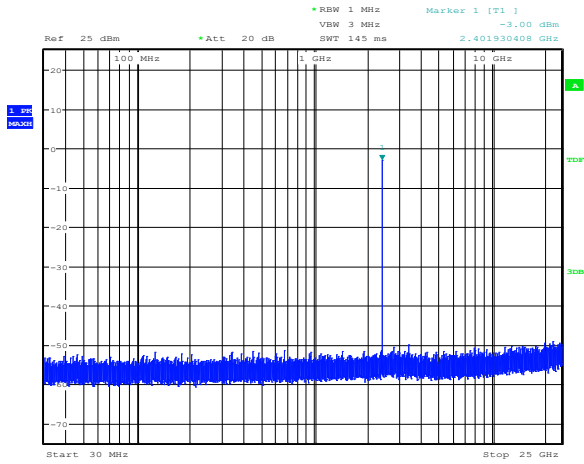
Date: 5.JUL.2018 15:35:44

Figure 8.8-31: Conducted spurious emissions within restricted bands for FHSS 3-DH5, mid channel



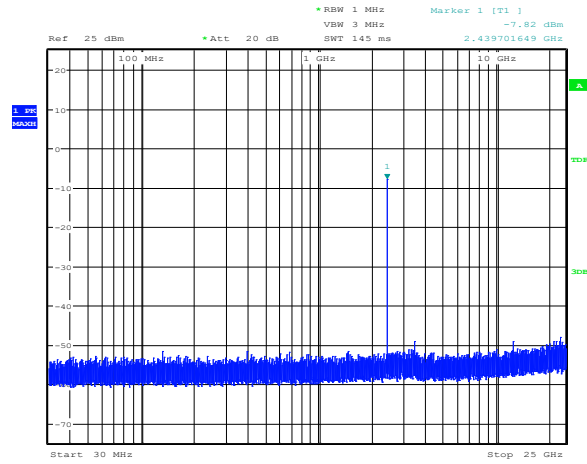
Date: 5.JUL.2018 15:38:56

Figure 8.8-32: Conducted spurious emissions within restricted bands for FHSS 3-DH5, high channel



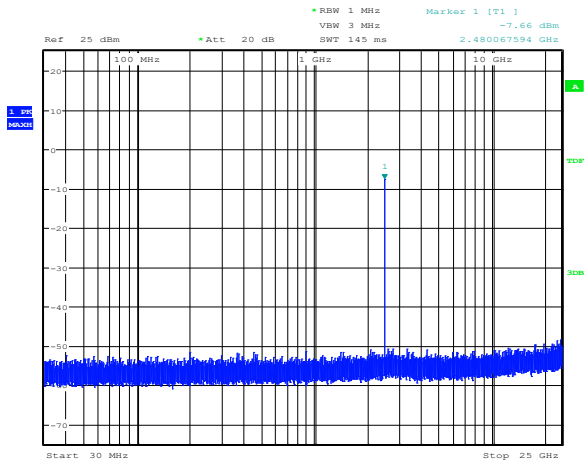
Date: 5.JUL.2018 16:07:53

Figure 8.8-33: Conducted spurious emissions within restricted bands for FHSS DM5, low channel



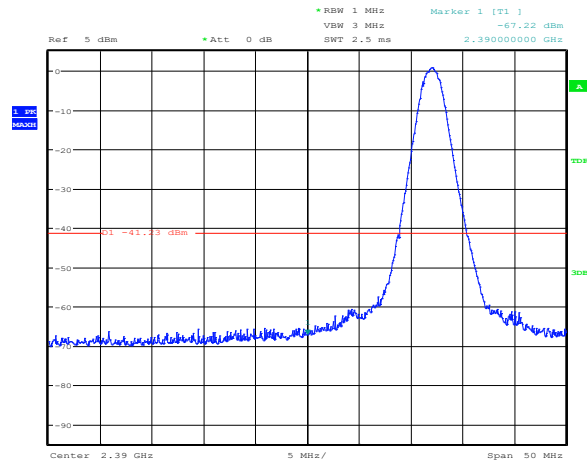
Date: 5.JUL.2018 16:08:57

Figure 8.8-34: Conducted spurious emissions within restricted bands for FHSS DM5, mid channel



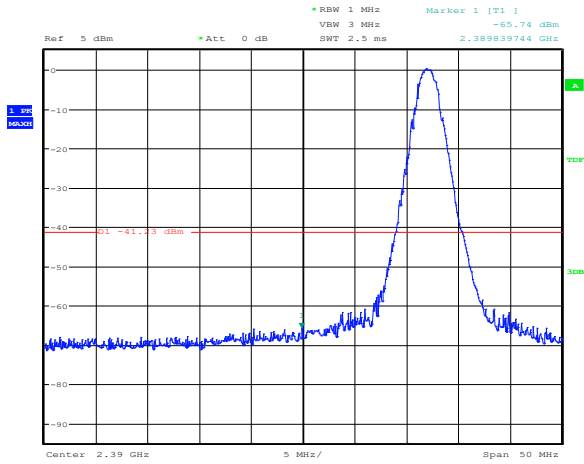
Date: 5.JUL.2018 16:09:52

Figure 8.8-35: Conducted spurious emissions within restricted bands for FHSS DM5, high channel



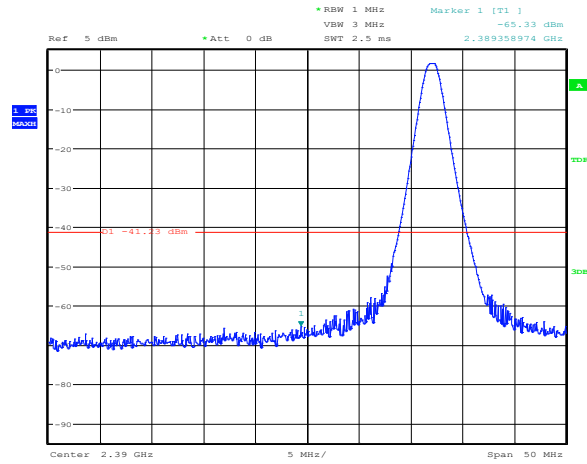
Date: 5.JUL.2018 15:57:57

Figure 8.8-36: Conducted spurious emissions within restricted bands at the lower band edge for FHSS 3-EV5, low channel



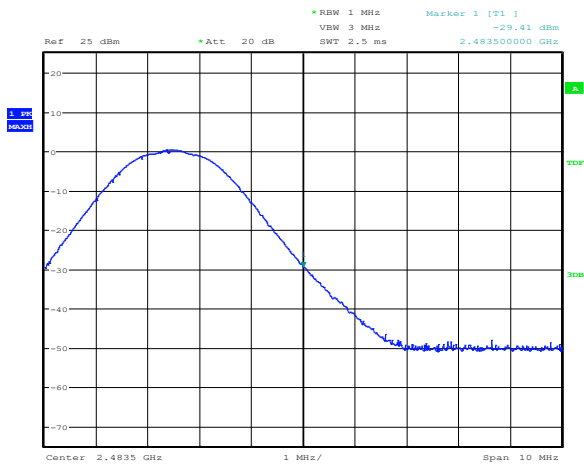
Date: 5.JUL.2018 15:58:35

Figure 8.8-37: Conducted spurious emissions within restricted bands at the lower band edge for FHSS 3-DH5, low channel



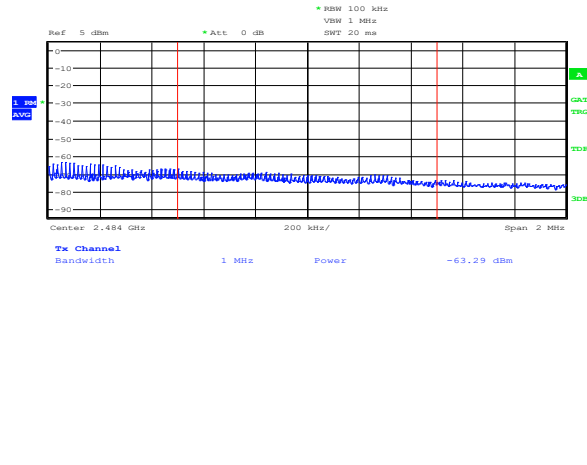
Date: 5.JUL.2018 15:59:04

Figure 8.8-38: Conducted spurious emissions within restricted bands at the lower band edge for FHSS DM5, low channel



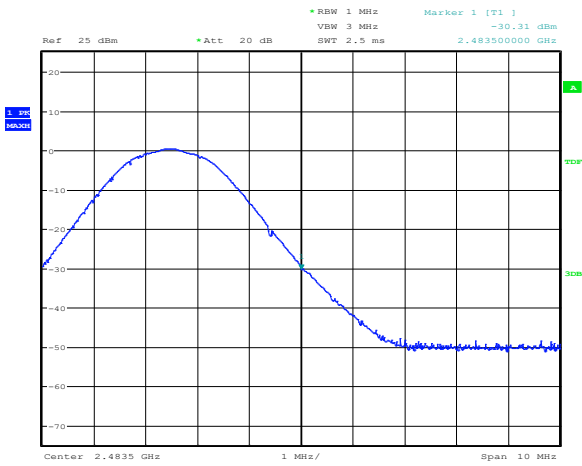
Date: 5.JUL.2018 15:46:35

Figure 8.8-39: Conducted spurious emissions within restricted bands at the upper band edge for FHSS 3-EV5, high channel - peak



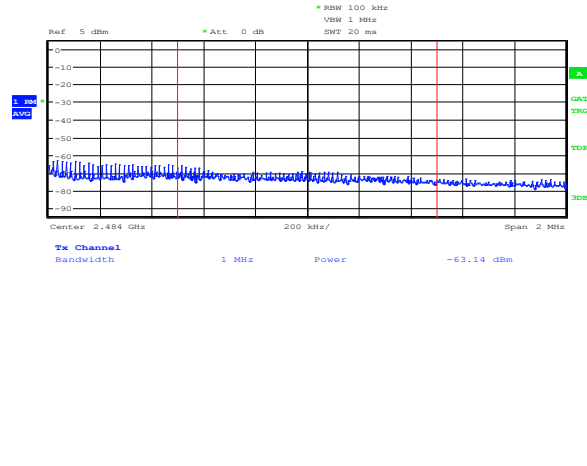
Date: 5.JUL.2018 15:56:24

Figure 8.8-40: Conducted spurious emissions within restricted bands at the upper band edge for FHSS 3-EV5, high channel - average



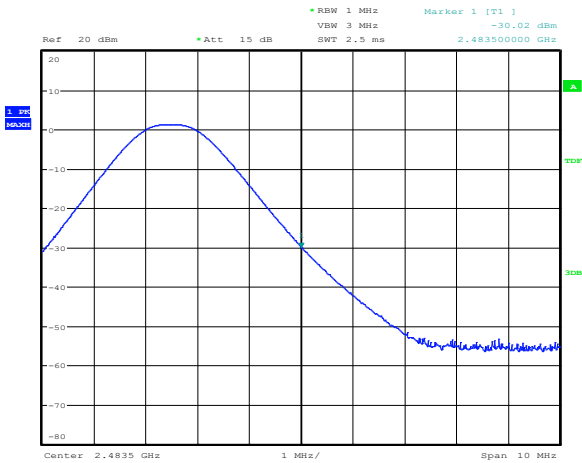
Date: 5.JUL.2018 15:47:41

Figure 8.8-41: Conducted spurious emissions within restricted bands at the upper band edge for FHSS 3-DH5, high channel - peak



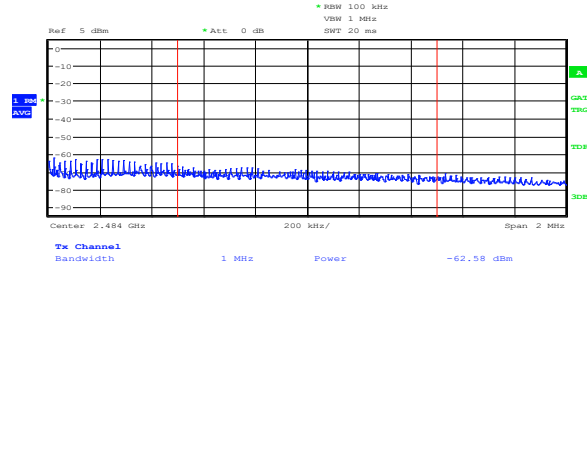
Date: 5.JUL.2018 15:55:32

Figure 8.8-42: Conducted spurious emissions within restricted bands at the upper band edge for FHSS 3-DH5, high channel - average



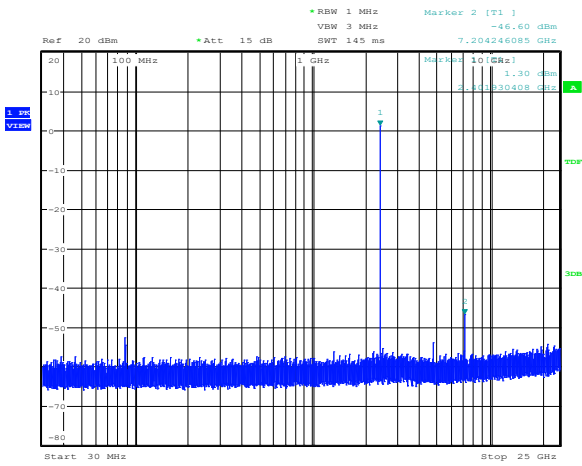
Date: 6.JUL.2018 10:09:08

Figure 8.8-43: Conducted spurious emissions within restricted bands at the upper band edge for FHSS DM5, high channel - peak



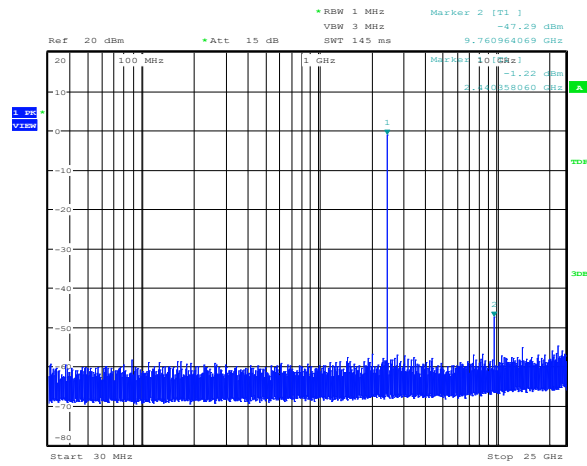
Date: 5.JUL.2018 15:54:47

Figure 8.8-44: Conducted spurious emissions within restricted bands at the upper band edge for FHSS DM5, high channel - average



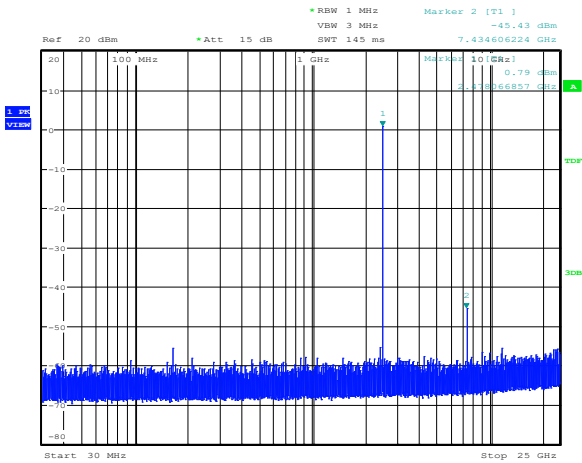
Date: 5.JUL.2018 16:18:41

Figure 8.8-45: Conducted spurious emissions within restricted bands for DTS, low channel



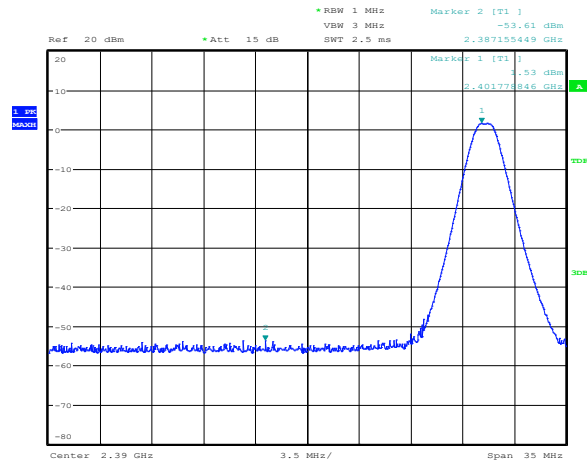
Date: 5.JUL.2018 16:21:40

Figure 8.8-46: Conducted spurious emissions within restricted bands for DTS, mid channel



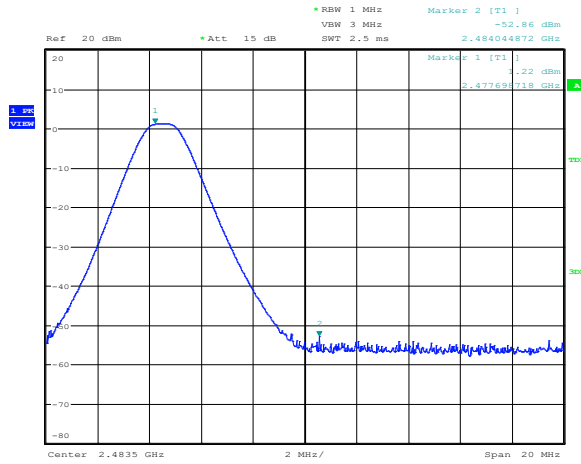
Date: 5.JUL.2018 16:22:18

Figure 8.8-47: Conducted spurious emissions within restricted bands for DTS, high channel



Date: 5.JUL.2018 16:24:18

Figure 8.8-48: Conducted spurious emissions within restricted bands at the lower band edge for DTS, low channel



Date: 5. JUL. 2018 16:23:35

Figure 8.8-49: Conducted spurious emissions within restricted bands at the lower band edge for DTS, high channel

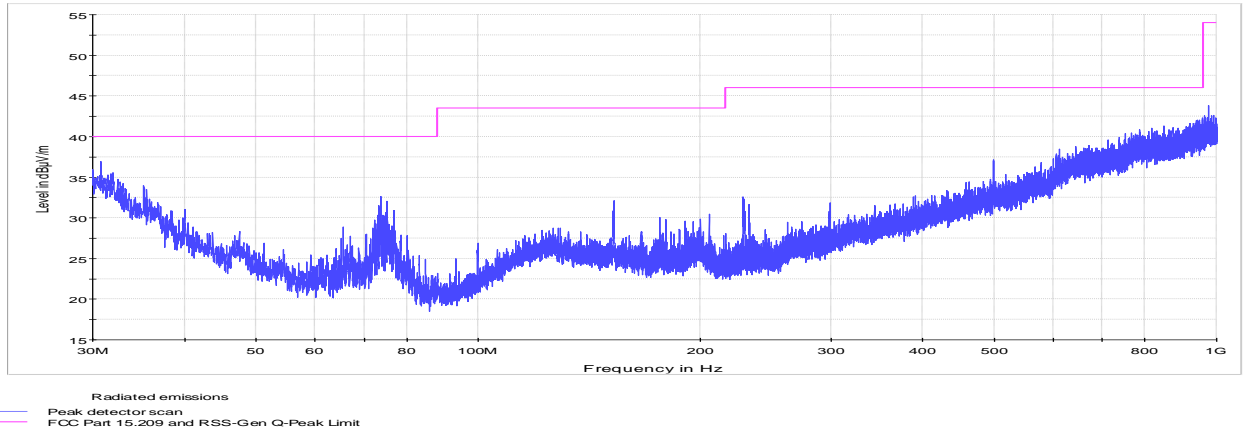


Figure 8.8-50: Radiated spurious emissions below 1 GHz for FHSS, low channel

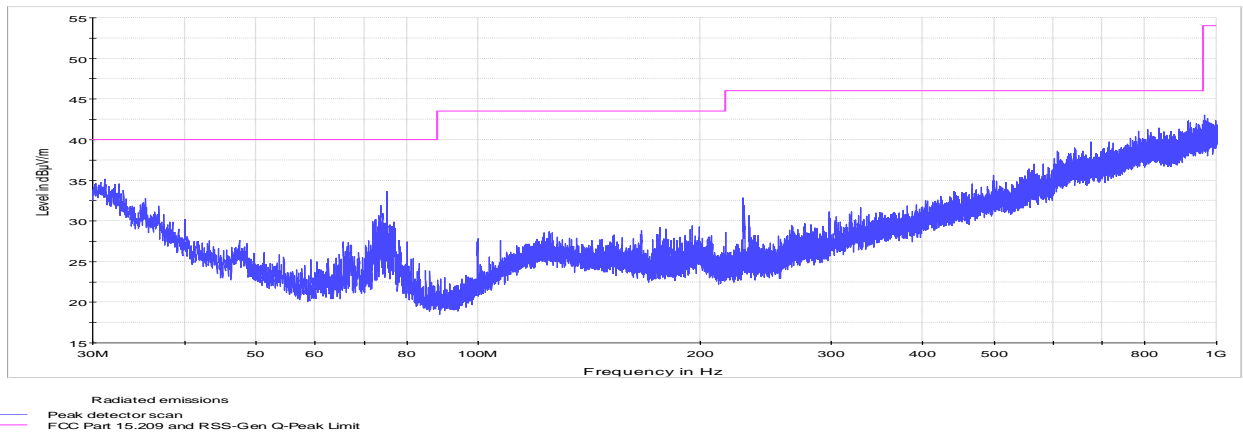


Figure 8.8-51: Radiated spurious emissions below 1 GHz for FHSS, mid channel

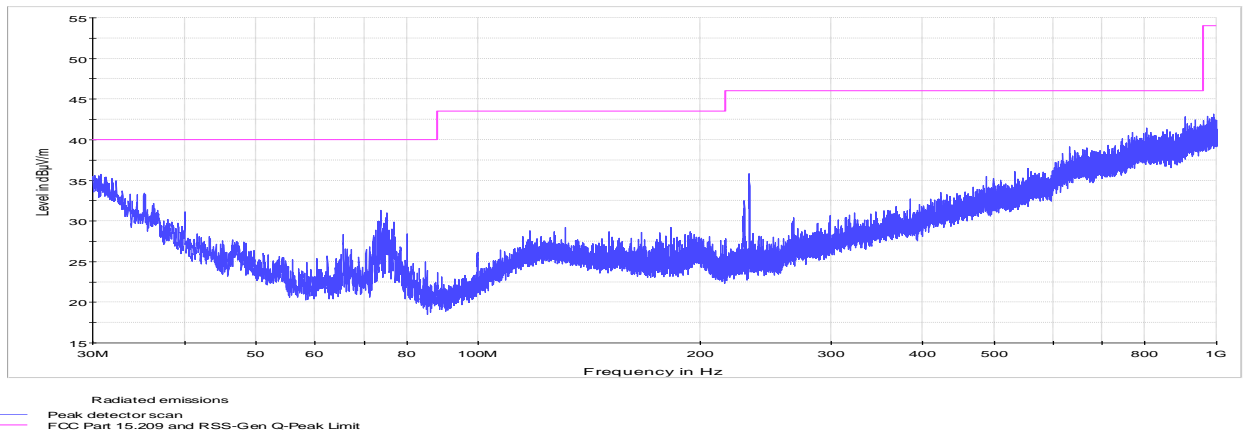


Figure 8.8-52: Radiated spurious emissions below 1 GHz for FHSS, high channel

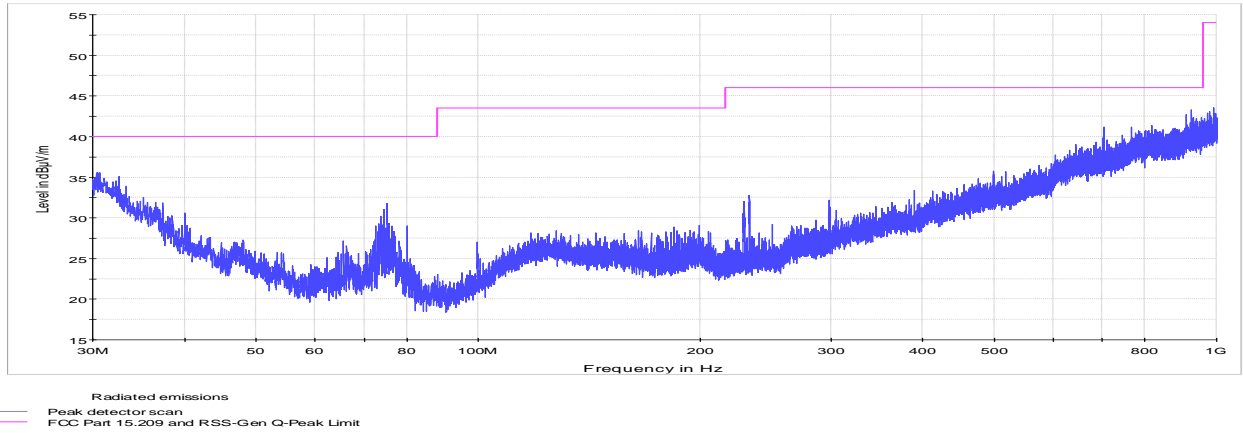


Figure 8.8-53: Radiated spurious emissions below 1 GHz for DTS, low channel

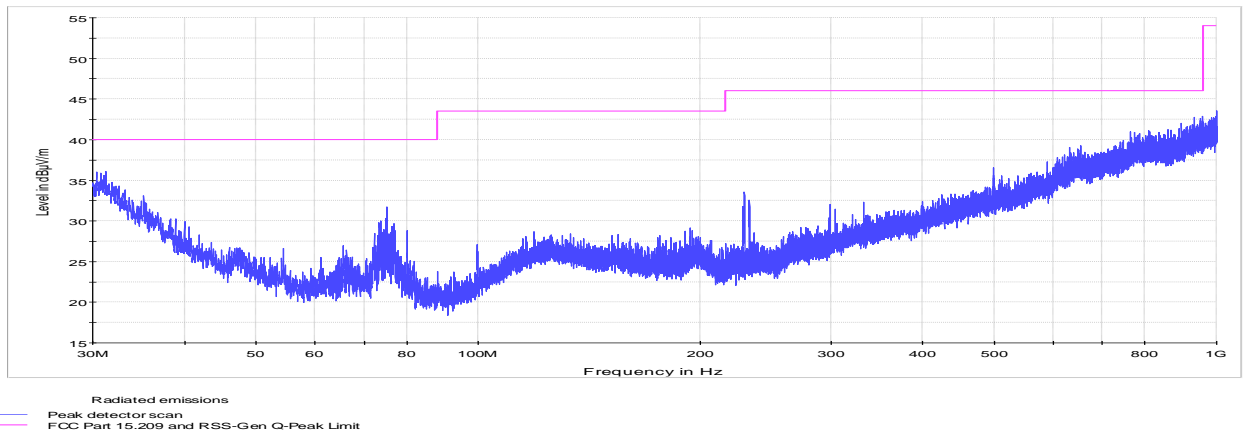


Figure 8.8-54: Radiated spurious emissions below 1 GHz for DTS, mid channel

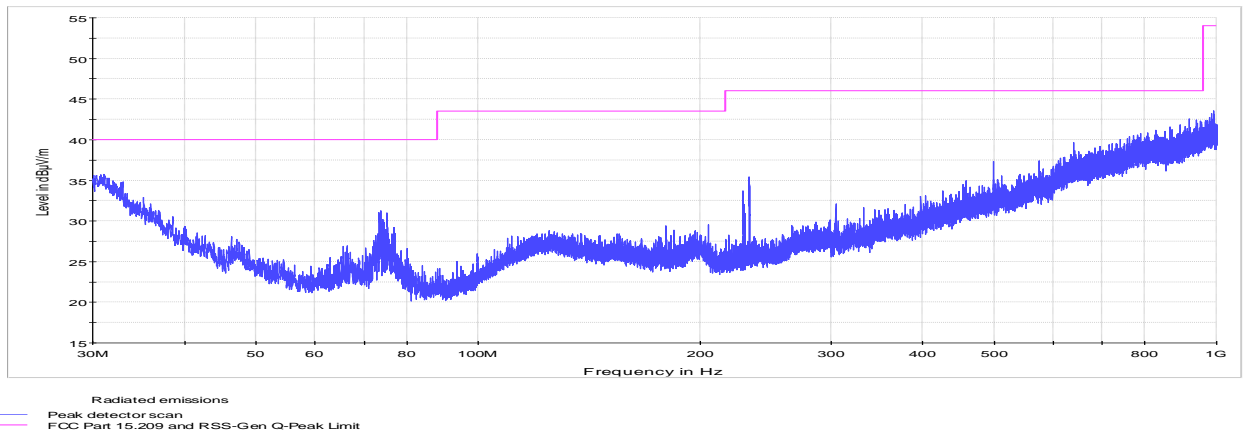


Figure 8.8-55: Radiated spurious emissions below 1 GHz for DTS, high channel

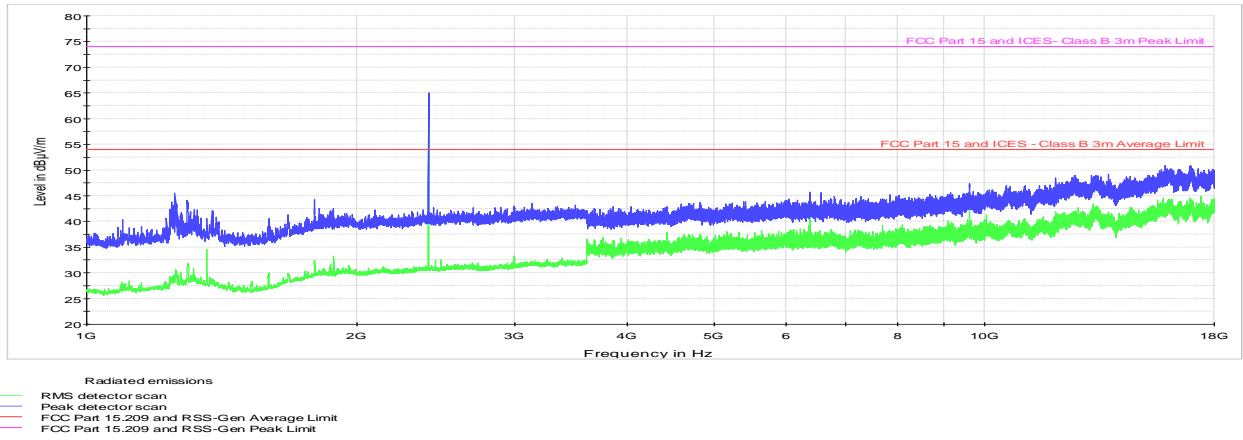


Figure 8.8-56: Radiated spurious emissions above 1 GHz for FHSS, low channel

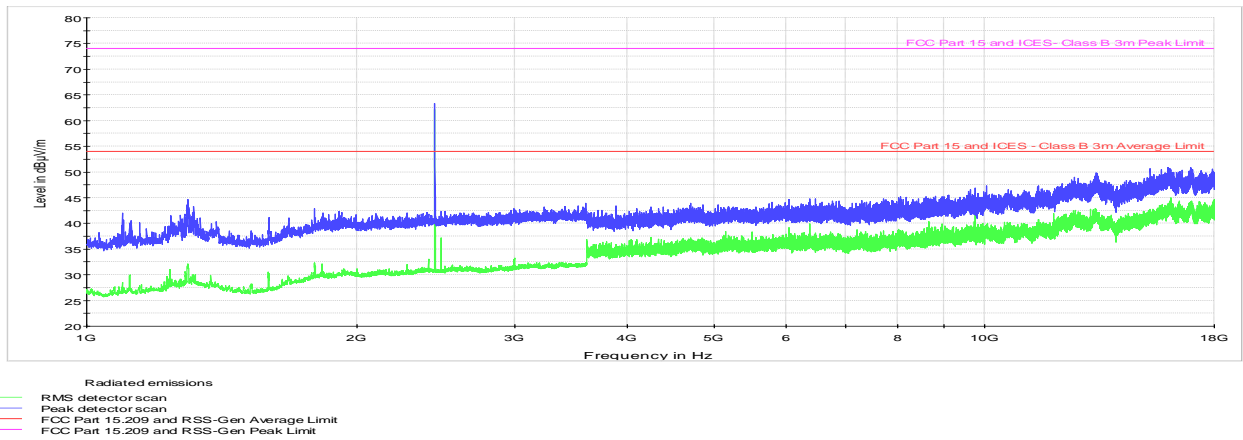


Figure 8.8-57: Radiated spurious emissions above 1 GHz for FHSS, mid channel

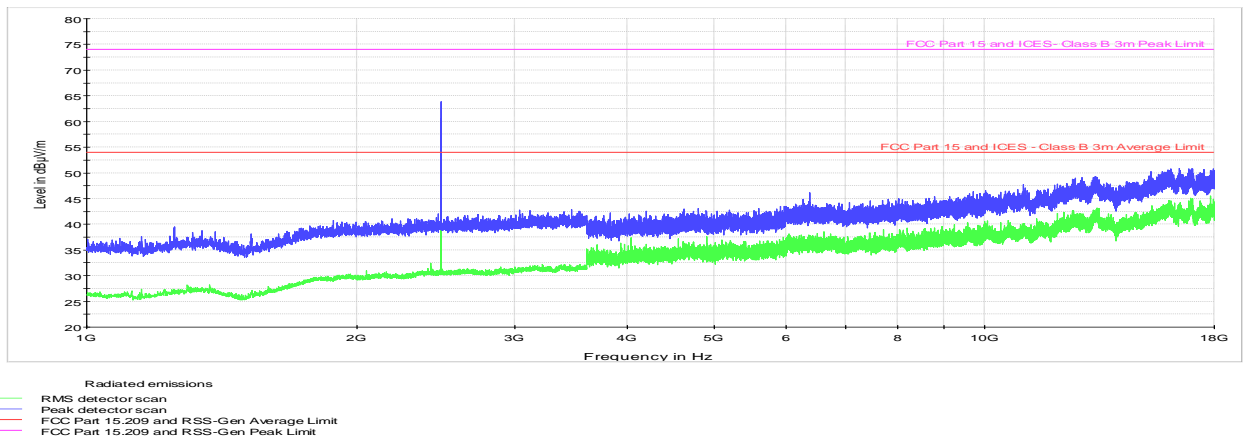


Figure 8.8-58: Radiated spurious emissions above 1 GHz for FHSS, high channel

Note: scans were performed up to 25 GHz, no spurious emissions from the EUT's radio were detected.

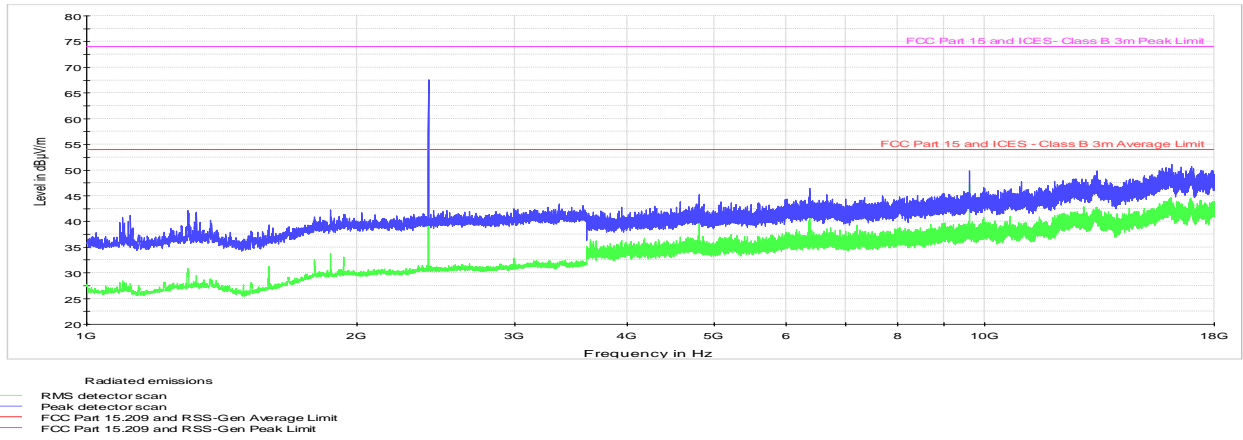


Figure 8.8-59: Radiated spurious emissions above 1 GHz for DTS, low channel

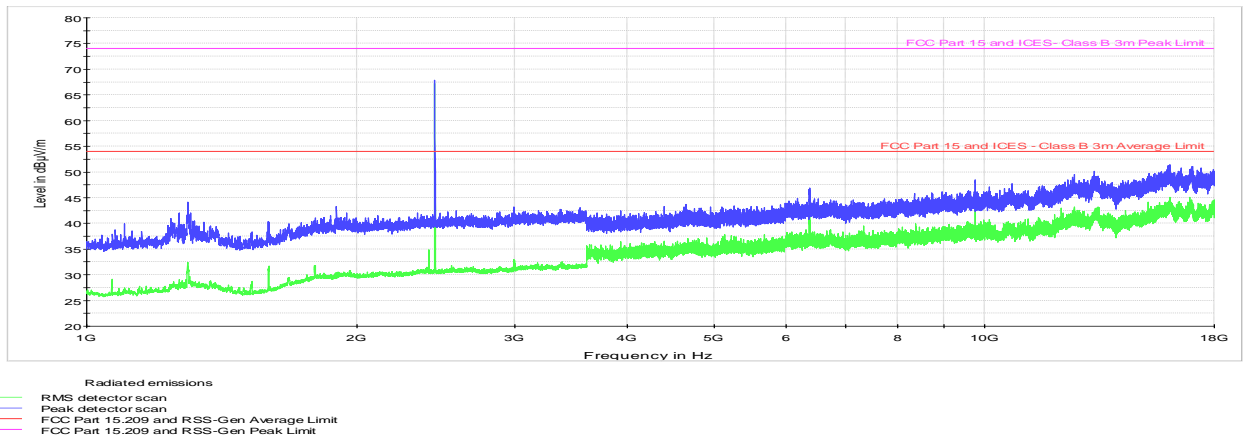


Figure 8.8-60: Radiated spurious emissions above 1 GHz for DTS, mid channel

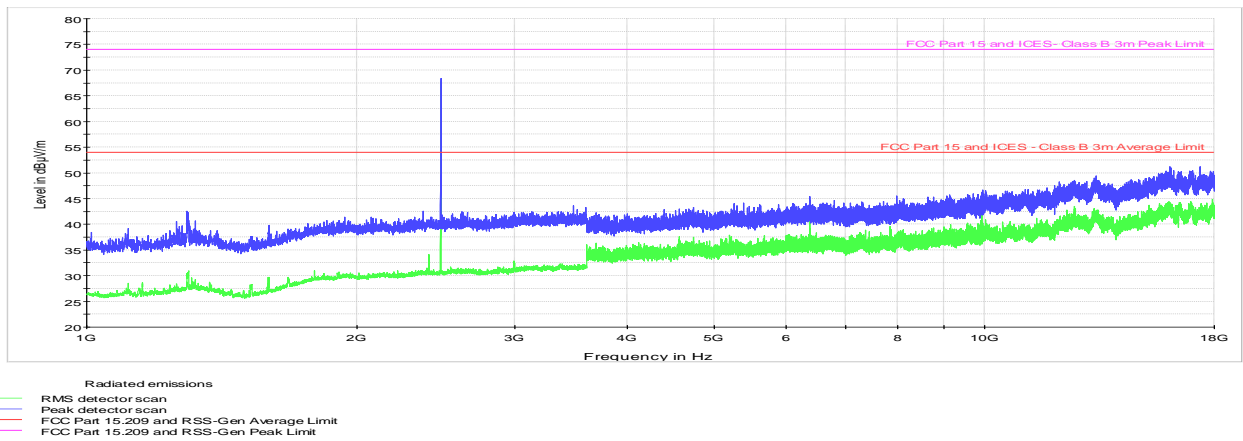
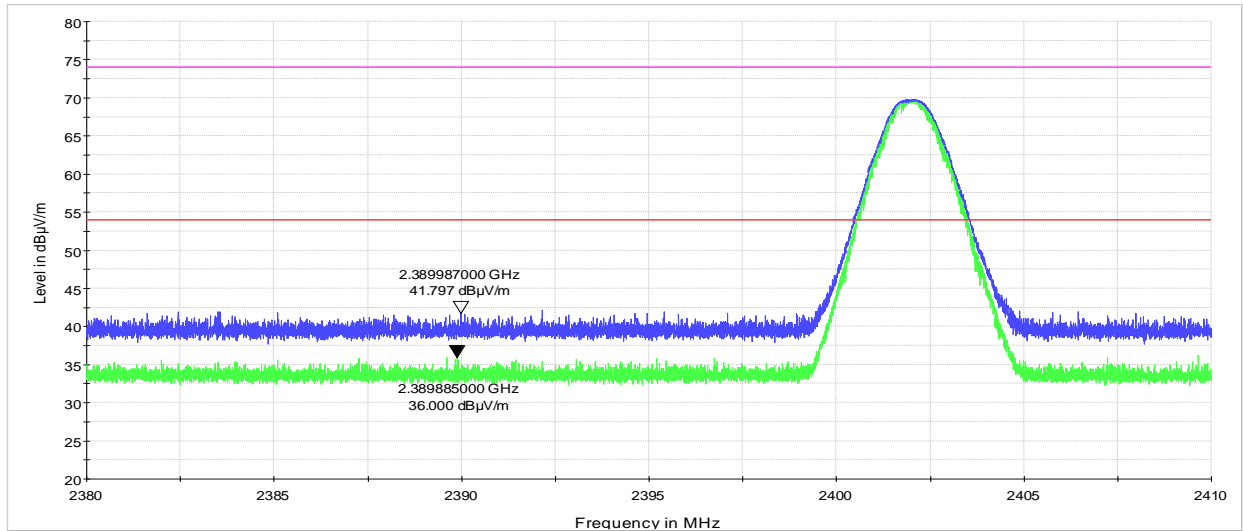


Figure 8.8-61: Radiated spurious emissions above 1 GHz for DTS, high channel

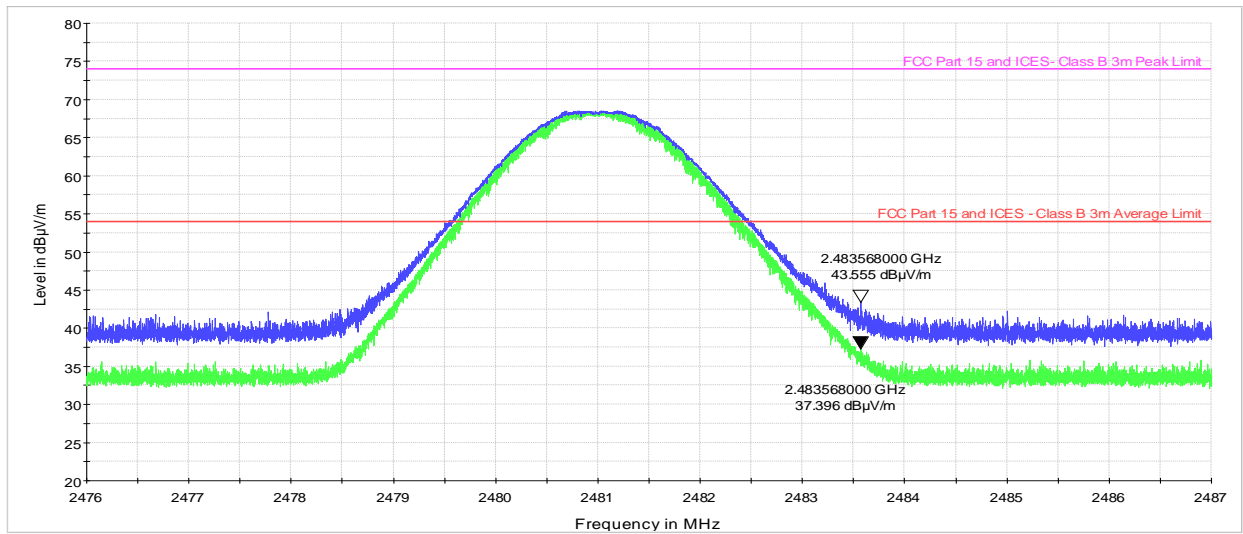
Note: scans were performed up to 25 GHz, no spurious emissions from the EUT's radio were detected.



Radiated emissions

- RMS detector scan
- Peak detector scan
- FCC Part 15.209 and RSS-Gen Average Limit
- FCC Part 15.209 and RSS-Gen Peak Limit

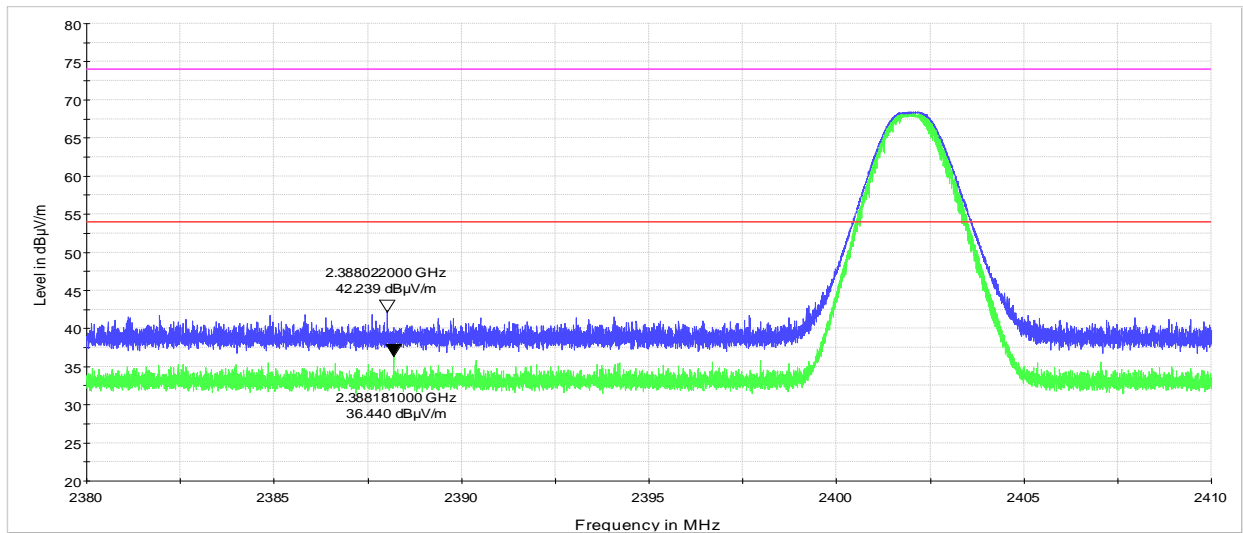
Figure 8.8-62: Radiated spurious emissions at the lower band edge for FHSS, low channel



Radiated emissions

- RMS detector scan
- Peak detector scan
- FCC Part 15.209 and RSS-Gen Average Limit
- FCC Part 15.209 and RSS-Gen Peak Limit

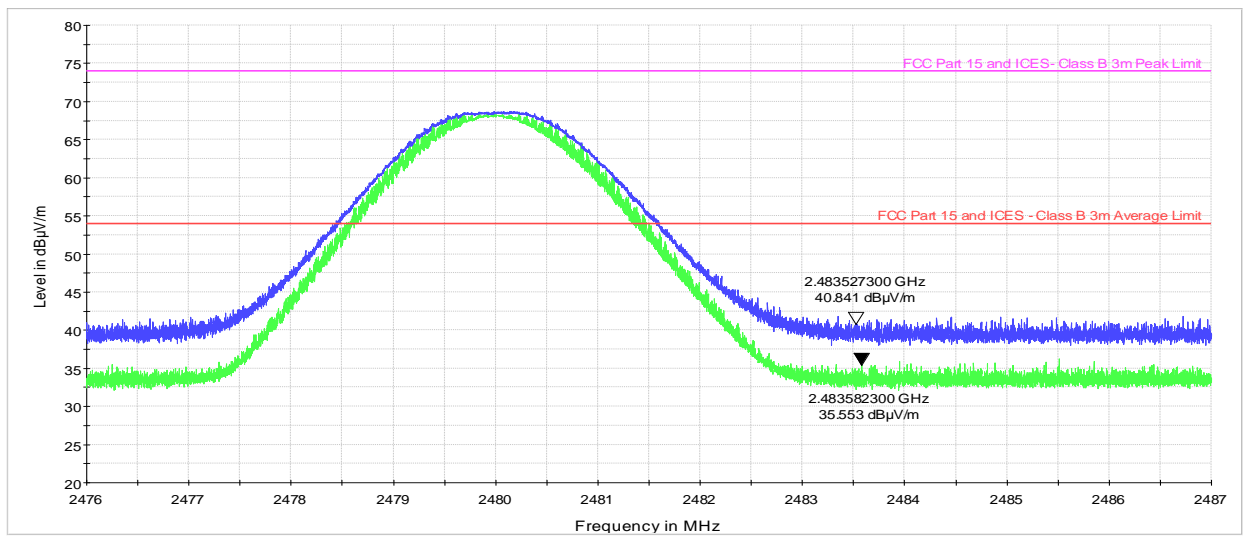
Figure 8.8-63: Radiated spurious emissions at the upper band edge for FHSS, high channel



Radiated emissions

- RMS detector scan
- Peak detector scan
- FCC Part 15.209 and RSS-Gen Average Limit
- FCC Part 15.209 and RSS-Gen Peak Limit

Figure 8.8-64: Radiated spurious emissions at the lower band edge for DTS, low channel



Radiated emissions

- RMS detector scan
- Peak detector scan
- FCC Part 15.209 and RSS-Gen Average Limit
- FCC Part 15.209 and RSS-Gen Peak Limit

Figure 8.8-65: Radiated spurious emissions at the upper band edge for DTS, high channel

8.9 FCC 15.247(e) and RSS-247 5.2(b) Power spectral density for digitally modulated devices

8.9.1 Definitions and limits

FCC:

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.

ISED:

The transmitter power spectral density conducted from the transmitter 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 section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

8.9.1 Test date

Start date June 29, 2018

8.9.2 Observations, settings and special notes

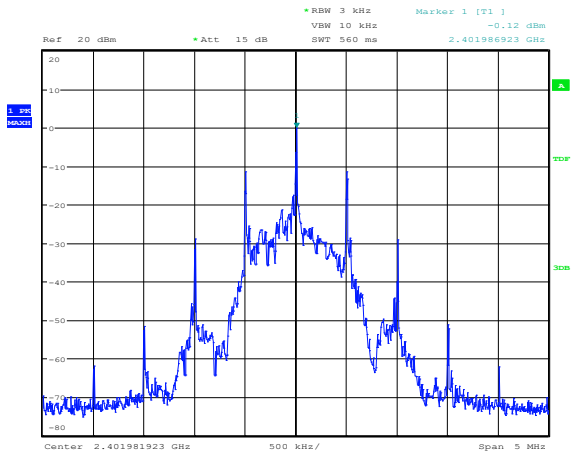
The test was performed using method PKPSD (peak PSD).
Spectrum analyser settings:

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

8.9.3 Test data

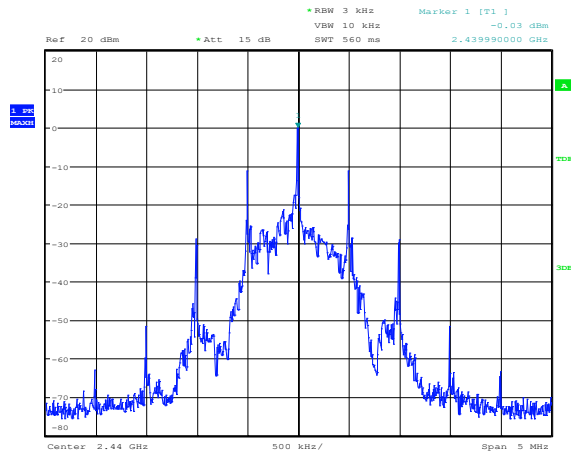
Table 8.9-1: PSD measurements results

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2402	-0.12	8.00	8.12
2440	-0.03	8.00	8.03
2480	-0.64	8.00	8.64



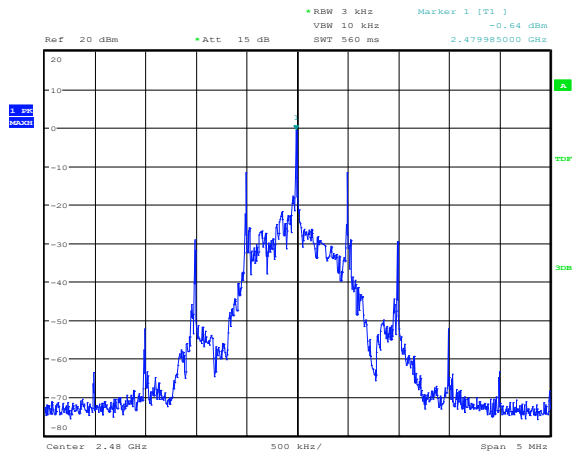
Date: 29.JUN.2018 13:47:53

Figure 8.9-1: PSD sample plot on low channel



Date: 29.JUN.2018 13:48:53

Figure 8.9-2: PSD sample plot on mid channel

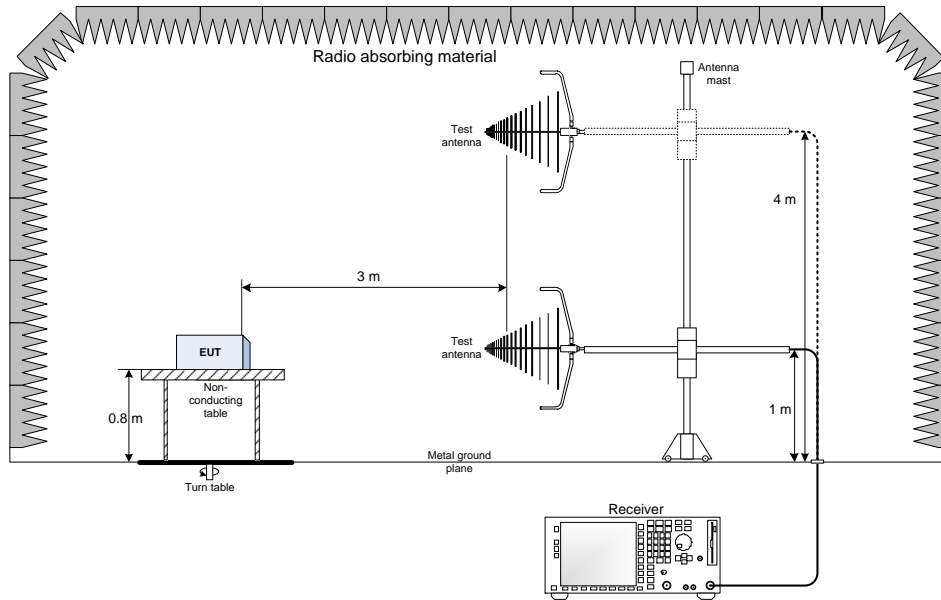


Date: 29.JUN.2018 13:54:06

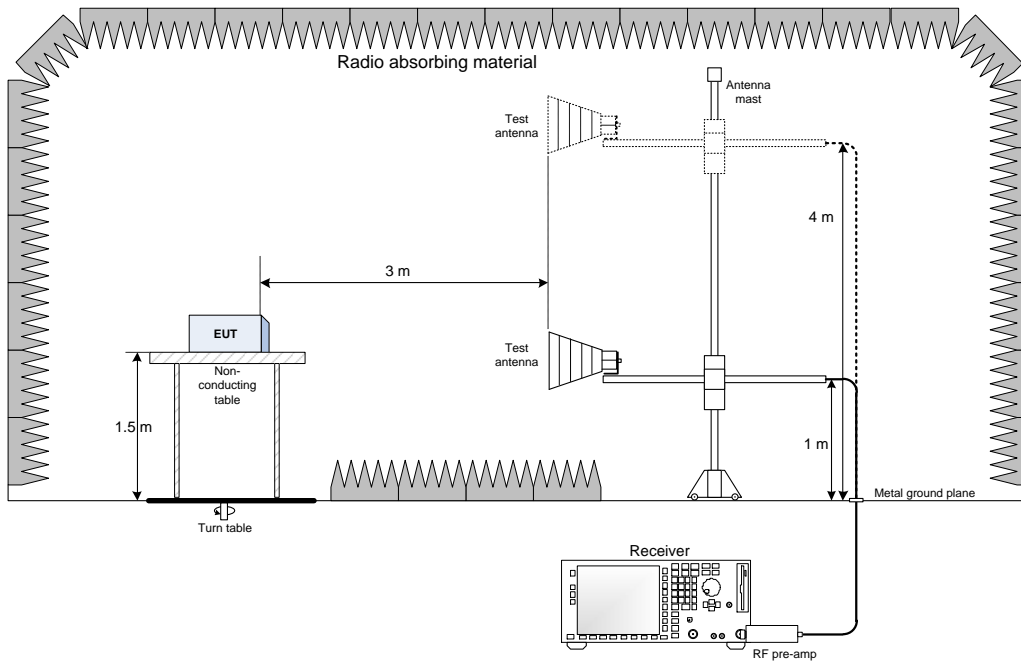
Figure 8.9-3: PSD sample plot on high channel

Section 9. Block diagrams of test set-ups

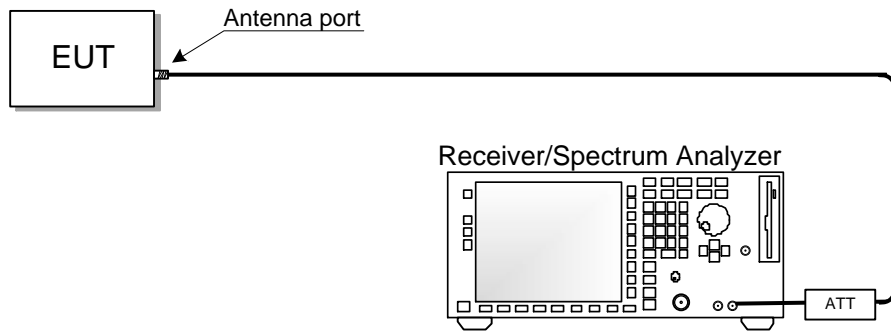
9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Antenna port set-up



End of report