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Acronyms

Acronym ID	Acronym Description
Avg COT	Average Channel Occupancy Time
Detector	Detector used
Equipment	Equipment Type
EUT	Equipment Under Test
Freq	Frequency
Freq Rng	Frequency Range
Freq Sep	Frequency Separation
Inband Peak Lvl	Inband Peak Level
Lvl	Level
Mod	Modulation
NHC	Number of Hopping Channels
NHp	Number of hops over the period
Occ Ch BW	Occupied Channel Bandwidth
Pol	Polarization
Unwanted Freq	Unwanted Emissions Frequency
Unwanted Lvl	Unwanted Emissions Level

Competences and guarantees

DEKRA Testing and Certification S.A.U. is a testing laboratory accredited by the National Accreditation Body (ENAC - Entidad Nacional de Acreditación) to perform the tests indicated in the Certificate No. 51/LE 147.

DEKRA Testing and Certification is a FCC-recognized accredited testing laboratory with appropriate scope of accreditation that covers the performed tests in this report.

DEKRA Testing and Certification is an ISED-recognized accredited testing laboratory, CABid: ES1909, with the appropriate scope of accreditation that covers the performed tests in this report.

In order to assure the traceability to other national and international laboratories, DEKRA Testing and Certification S.A.U. has a calibration and maintenance program for its measurement equipment.

DEKRA Testing and Certification S.A.U. guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and it is based on the knowledge and technical facilities available at DEKRA Testing and Certification S.A.U. at the time of performance of the test.

DEKRA Testing and Certification S.A.U. is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

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General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of DEKRA Testing and Certification S.A.U.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of DEKRA Testing and Certification S.A.U. and the Accreditation Bodies.

Uncertainty

Uncertainty (factor $k=2$) was calculated according to the DEKRA Testing and Certification S.A.U. internal document PODT000.

The total uncertainty of the measurement system for the radiated emissions of EUT from 30 MHz to 1 GHz is:
Measurement uncertainty $\leq \pm 5.35$ dB (with factor $k = 2$).

The total uncertainty of the measurement system for the radiated emissions of EUT from 1 GHz to 17 GHz is:
Measurement uncertainty $\leq \pm 4.32$ dB (with factor $k = 2$).

The total uncertainty of the measurement system for the radiated emissions of EUT from 17 GHz to 26 GHz is:
Measurement uncertainty $\leq \pm 5.51$ dB (with factor $k = 2$).

The total uncertainty of the measurement system for the conducted testing of EUT is:

RF Peak Output Power: Measurement uncertainty $\leq \pm 0.80$ dB
Accumulated Dwell Time: Measurement uncertainty $\leq \pm 0.16$ %
Minimum Frequency Occupation Time: Measurement uncertainty $\leq \pm 0.53$ %
Hopping Frequency Separation: Measurement uncertainty $\leq \pm 1.74$ %
Occupied Channel Bandwidth: Measurement uncertainty $\leq \pm 1.24$ %
Conducted Band-edge spurious emissions: Measurement uncertainty $\leq \pm 1.76$ dB

Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").
2. The sample consists of a telematics control unit with wireless technologies, used in automotive, equipped with one modem, OEM. This unit was designed for automotive usage and contains the following features: GSM, UMTS, LTE, 5G, GNSS, WiFi (a, b, g, n, ac), Bluetooth Low Energy (BTLE) and Bluetooth EDR.

HARMAN AUTOMOTIVE DIVISION
HARMAN BECKER AUTOMOTIVE SYSTEMS GMBH
BECKER-GÖRING-STRASSE 16
76307 KARLSBAD, GERMANY



Declaration of similarity

To whom it may concern,

We, **Harman Becker Automotive Systems GmbH**, located in
Becker-Goering-Str. 16; 76307 Karlsbad, Germany

Hereby declare that the following units: TKCMOD12E00, TKCMOD12N00,
TKCMOD11000, TKCMOD12C00, TKCMOD12J00, TKCMOD12R00,
TKCMOD12T00 and TKCMOD13C00

have integrated the same BT/Wifi chipset.

The different naming comes from country specific, features enabled or network
access device type.

Targeted countries	Product Name	Type	NAD-HW	GNSS	Bluetooth in WLAN	WLAN Services	CV2X
Rest of the world (offline variant)	TKCMOD11000	V046	EU	x	x		
EU + some other countries	TKCMOD12E00	V037, V042, V043, V044, V049	EU	x	x	x	
Canada/Mexico/USA	TKCMOD12N00	V038, V039, V047	NA	x	x	x	
China (without CV2X)	TKCMOD12C00	V105	CN	x	x	x	
Japan	TKCMOD12J00	V045	RW	x	x	x	
Armenia/Belarus/Kazakhstan/R ussia/Uzbekistan	TKCMOD12R00	V048	EU	x	x	x	
Turkey	TKCMOD12T00	V040	EU	x	x	x	
China (with CV2X)	TKCMOD13C00	V100	CN	x	x	x	x

This declaration is intended to be included in the test reports where applies

Regards

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DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Usage of samples

Samples undergoing test have been selected by: the client.

Id	Control Number	Description	Model	Serial No.	Date of Reception	Application
S/01	67003B_70.1	Telematic control unit	VW	358845890061449	2021-11-30	Element Under Test
S/01	67003B_32.1	BT_WLAN_2-3 - Audi	--	--	2021-09-23	Element Under Test
S/01	67003B_34.1	FAKRA cable 4 on 1 for antenna	--	--	2021-09-23	Element Under Test
S/01	67003B_35.1	Bumper antenna - Audi	--	--	2021-09-23	Element Under Test
S/01	67003B_37.1	BT_WLAN_2-3 - Audi	--	--	2021-09-23	Element Under Test
S/01	67003B_39.1	BT_WLAN_1 - Audi/Porsche	--	--	2021-09-23	Element Under Test
S/01	67003B_41.1	Roof antenna - Audi	--	--	2021-09-23	Element Under Test
S/01	67003B_43.1	FAKRA cable 4 on 1 for antenna	--	--	2021-09-23	Element Under Test
S/01	67003B_44.1	FAKRA cable for antenna	--	--	2021-09-23	Element Under Test
S/01	67003B_66.1	Battery	--	--	2021-11-30	Element Under Test
S/01	67003B_33.1	Metal panel	--	--	2021-09-23	Auxiliary Element
S/01	67003B_36.1	Metal panel	--	--	2021-09-23	Auxiliary Element
S/01	67003B_38.1	Metal panel	--	--	2021-09-23	Auxiliary Element
S/01	67003B_42.1	Metal panel	--	--	2021-09-23	Auxiliary Element
S/01	67003B_46.1	Harness	--	--	2021-09-23	Auxiliary Element
S/02	67003B_70.1	Telematic control unit	VW	358845890061449	2021-11-30	Element Under Test
S/02	67003B_14.1	GNSS antenna	--	--	2021-09-07	Element Under Test
S/02	67003B_15.1	BT_WLAN_3 antenna	--	--	2021-09-07	Element Under Test
S/02	67003B_16.1	LTE_4 antenna	--	--	2021-09-07	Element Under Test
S/02	67003B_17.1	BT_WLAN_2 antenna	--	--	2021-09-07	Element Under Test
S/02	67003B_18.1	BT_WLAN_1 antenna	--	--	2021-09-07	Element Under Test
S/02	67003B_19.1	LTE_3 antenna	--	--	2021-09-07	Element Under Test

Id	Control Number	Description	Model	Serial No.	Date of Reception	Application
S/02	67003B_20.1	BTLE Ant. Combiner (BT_LE_1)	--	--	2021-09-07	Element Under Test
S/02	67003B_21.1	BT_LE_1 antenna	--	--	2021-09-07	Element Under Test
S/02	67003B_22.1	BT_LE_1 antenna	--	--	2021-09-07	Element Under Test
S/02	67003B_23.1	LTE_1 antenna	--	--	2021-09-07	Element Under Test
S/02	67003B_24.1	LTE_2 antenna	--	--	2021-09-07	Element Under Test
S/02	67003B_27.1	ETH (H-MTD) cable	--	--	2021-09-07	Element Under Test
S/02	67003B_46.1	Harness	--	--	2021-09-23	Auxiliary Element
S/02	67003B_66.1	Battery	--	--	2021-11-30	Element Under Test
S/03	67003B_70.1	Telematic control unit	VW	358845890061449	2021-11-30	Element Under Test
S/03	67003B_46.1	Harness	--	--	2021-09-23	Auxiliary Element

Notes referenced to samples during the project:

Id	Type
S/01	Radiated. Configuration #1 (BT_WLAN_2 antenna).
S/02	Radiated. Configuration #2 (BT_WLAN_2 antenna).
S/03	Conducted. Configuration #1 and Configuration #2.

Test sample description

Ports..... :	Port name and description		Cable			
			Specified max length [m]	Attached during test	Shielded	Coupled to patient ⁽³⁾
	RF connector – code		[]	[X]	[]	
	RF connector – code		[X]	[X]	[]	
	RF connector – code		[X]	[]	[]	
Supplementary information to the ports..... :	.....					
Rated power supply	Voltage and Frequency		Reference poles			
			L1	L2	L3	N	PE
	[X]	DC: 12V car battery (4.8 VDC inside of TCU)				
Rated Power	12V DC					
Clock frequencies.....:	See Block diagram					
Other parameters	See Technical description					
Software version	X152					
Hardware version	C2.3					
Dimensions in cm (W x H x D) .....	.....					
Mounting position	[]	Table top equipment				
	[]	Wall/Ceiling mounted equipment				
	[]	Floor standing equipment				
	[]	Hand-held equipment				
	[X]	Other: automotive telematics control unit				
Modules/parts.....:	Module/parts of test item		Type		Manufacturer	
						
Accessories (not part of the test item)	Description		Type		Manufacturer	
	Cable Harness		.....		.....	
	2G/3G/4G/5G Antenna		.....		Hirschmann / Molex	
	eCall button/LED		.....		.....	
	SOS Loudspeaker		.....		.....	
	Wake-up unit Box		.....		.....	
Documents as provided by the applicant.....:	Description		File name		Issue date	
	Technical Description		.....		.....	

⁽³⁾ Only for Medical Equipment

Identification of the client

HARMAN BECKER AUTOMOTIVE SYSTEMS GMBH
BECKER-GOERING-STR. 16
76307 KARLSBAD GERMANY

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2021-12-15
Date (finish)	2022-02-25

Document history

Report number	Date	Description
67003RRF.009	2022-06-17	First release.
67003RRF.009A1	2022-10-21	First modification: update of typos. This modification test report cancels and replaces the test report 67003RRF.009.

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %

In the semi-anechoic chamber, the following limits were not exceeded during the test.

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %

In the chamber for conducted measurements, the following limits were not exceeded during the test:

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %

Remarks and comments

The model TKCMOD12N00 comes with two different configurations. Each configuration has different antennas. A summary stating the gains used for the tests is included below:

	Model	Antenna Gain (dBi)	Antenna type
Configuration 1	TKCMOD12N00	1.2 dBi	BT_WLAN_2 antenna
Configuration 2	TKCMOD12N00	3 dBi	BT_WLAN_2 antenna

More detailed information about the different configurations has been provided in the supporting documentation from the manufacturer.

The tests have been performed by the technical personnel: Miguel Manuel López, Javier Miguel Nadales and Nicolás Salguero.

Used instrumentation:

Equipment	Model	Manufacturer	Next Calibration
SHIELDED ROOM	S101	ETS LINDGREN	N.A.
SIGNAL AND SPECTRUM ANALYZER 10Hz-40GHz	FSV40	ROHDE AND SCHWARZ	2023-02-26
OPEN SWITCH UNIT UP TO 40GHz	OSP-B157Wx	ROHDE & SCHWARZ	2024-03-16
POWER SUPPLY DC 40 V / 40 A	NGPE 40/40	ROHDE AND SCHWARZ	N.A.
DIGITAL MULTIMETER	179	FLUKE	2022-10-19
TEMPERATURE AND HUMIDITY PROBE	HWg-STE	HW GROUP	2022-04-13
SOFTWARE	EMC32	ROHDE AND SCHWARZ	N.A.
SEMIANECHOIC ABSORBER LINED CHAMBER II	FACT 3 200 STP	ETS LINDGREN	N.A.
SHIELDED ROOM	S101	ETS LINDGREN	N.A.
SIGNAL AND SPECTRUM ANALYZER 2Hz-50GHz	FSW50	ROHDE AND SCHWARZ	2022-07-06
EMI TEST RECEIVER 9kHz-7GHz	ESR7	ROHDE AND SCHWARZ	2022-12-12
HYBRID BILOG ANTENNA 30MHz-6GHz	3142E	ETS LINDGREN	2023-04-30
HORN ANTENNA 1-18GHz	BBHA 9120 D	SCHWARZBECK MESS-ELEKTRONIK	2022-11-18
HORN ANTENNA 17-40GHz	BBHA 9170	SCHWARZBECK	2023-05-05

Equipment	Model	Manufacturer	Next Calibration
PRE-AMPLIFIER G>40dB 10MHz-6GHz	BLNA 0160-01N	BONN ELEKTRONIK	2022-03-09
PRE-AMPLIFIER G>40dB 1-18 GHz	BLMA 0118-1M	BONN ELEKTRONIK	2022-06-07
PRE-AMPLIFIER G>30dB 17-40GHz	BLMA 1840-4A	BONN ELEKTRONIK	2022-09-08
DC POWER SUPPLY 30V/5A	U8002A	KEYSIGHT TECHNOLOGIES	N.A.

Testing verdicts

Fail	F
Not applicable	N/A
Not measured	N/M
Pass	P

Summary

Bluetooth EDR

Requirement – Test case	FCC PART 15 PARAGRAPH / RSS-247	Verdict	Remark
RSS-247 5.1 (b) / FCC 15.247 (a)(1) 20 dB Bandwidth		P	
RSS-247 5.1 (b) / FCC 15.247 (a)(1) Carrier Frequency Separation		P	
RSS-247 5.1 (d) / FCC 15.247 (a)(1)(iii) Time of Occupancy (Dwell Time)		P	
RSS-247 5.1 (d) / FCC 15.247 (a)(1)(iii) Number of hopping channels		P	
RSS-247 5.4 (b) / FCC 15.247 (b) Maximum peak output power and antenna gain		P	
RSS-247 5.5 / FCC 15.247 (d) Band-edge emissions compliance (Transmitter)		P	
RSS-247 5.5 / FCC 15.247 (d) Emission limitations radiated (Transmitter)		P	
<u>Supplementary information and remarks:</u> None.			

Appendix A: Test results. Bluetooth EDR

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FCC 47 CFR PART 15.247 / RSS-247	18
<i>Occupied Channel Bandwidth 99%</i>	18
<i>RSS-247 5.1 (b) / FCC 15.247 (a)(1) 20 dB Bandwidth</i>	28
<i>RSS-247 5.1 (b) / FCC 15.247 (a)(1) Carrier Frequency Separation</i>	38
<i>RSS-247 5.1 (d) / FCC 15.247 (a)(1)(iii) Time of Occupancy (Dwell Time)</i>	42
<i>RSS-247 5.1 (d) / FCC 15.247 (a)(1)(iii) Number of hopping channels</i>	46
<i>RSS-247 5.4 (b) / FCC 15.247 (b) Maximum peak output power and antenna gain</i>	50
<i>RSS-247 5.5 / FCC 15.247 (d) Band-edge emissions compliance (Transmitter)</i>	53
<i>RSS-247 5.5 / FCC 15.247 (d) Emission limitations radiated (Transmitter)</i>	72

TEST CONDITIONS

(*): Data provided by the client.

POWER SUPPLY (*):

Vnominal:	12 Vdc
Type of Power Supply:	External DC (vehicle battery).

ANTENNAS (*):

Type of Antenna:	Dedicated external antenna.
Maximum Declared Antenna Gain:	
• Configuration #1:	+1.2 dBi
• Configuration #2:	+3 dBi

TEST FREQUENCIES (*):

Low Channel:	2402 MHz
Middle Channel:	2441 MHz
High Channel:	2480 MHz

CONDUCTED MEASUREMENTS:

The equipment under test was set up in a shielded room and it connected to the TS8997 RF test bench using a low-loss RF cable. The reading of the spectrum analyser is corrected considering the cable loss.



RADIATED MEASUREMENTS:

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (bilog antenna for the range from 30 MHz to 1000 MHz and 1 – 17 GHz Double ridge horn antenna) is situated at a distance of 3 m and at a distance of 1 m for the frequency range 17 GHz – 26 GHz (17 GHz – 40 GHz horn antenna).

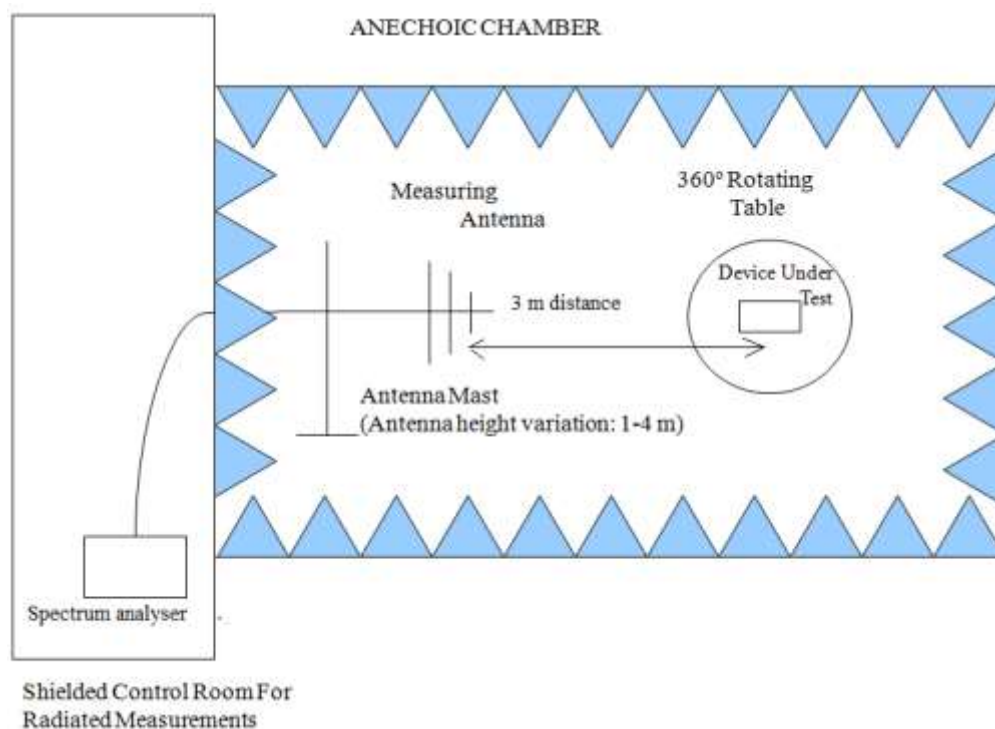
For radiated emissions in the range 17 GHz – 26 GHz performed at a distance closer than the distance specified in standard, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

The equipment under test was set up on a non-conductive platform above the ground plane and its situation and orientation were varied to find the maximum radiated emission. It was also rotated 360° and the antenna height was varied from 1 to 4 meters (up to 17GHz) to find the maximum radiated emission.

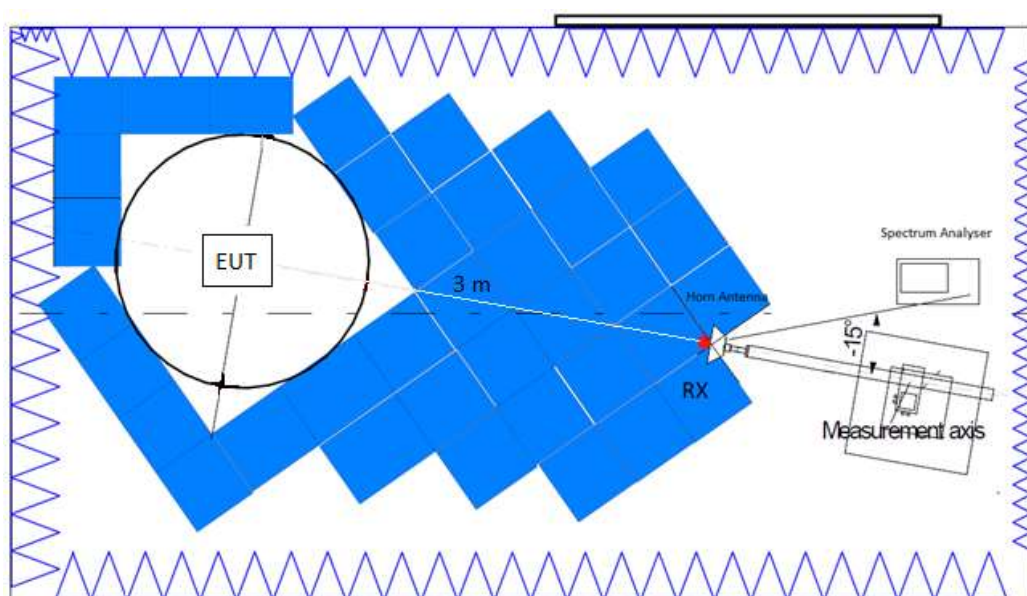
Measurements were made in both horizontal and vertical planes of polarization.

A resolution bandwidth / video bandwidth of 100 kHz / 300 kHz was used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

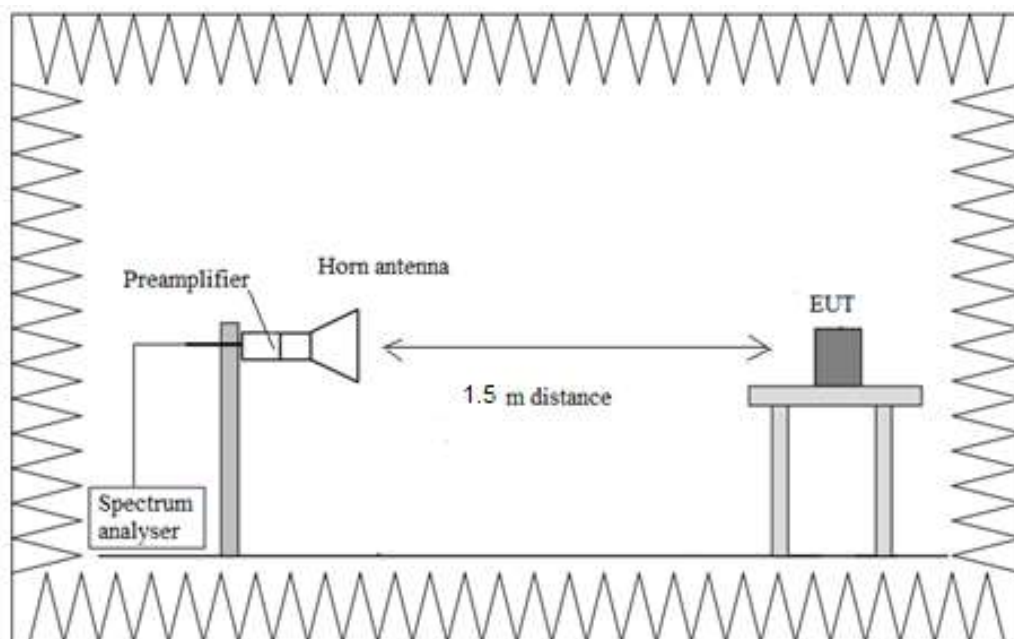
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup $f > 17$ GHz:



TEST CASES DETAILS

FCC 47 CFR Part 15.247 / RSS-247
Occupied Channel Bandwidth 99%

Results

Modulation: BT (GFSK 1-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Occ Ch BW (MHz)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	0.885
	2441.00000		0.880
	2480.00000		0.885

Modulation: BT (Pi/4 DQPSK 2-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Occ Ch BW (MHz)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	1.210
	2441.00000		1.210
	2480.00000		1.210

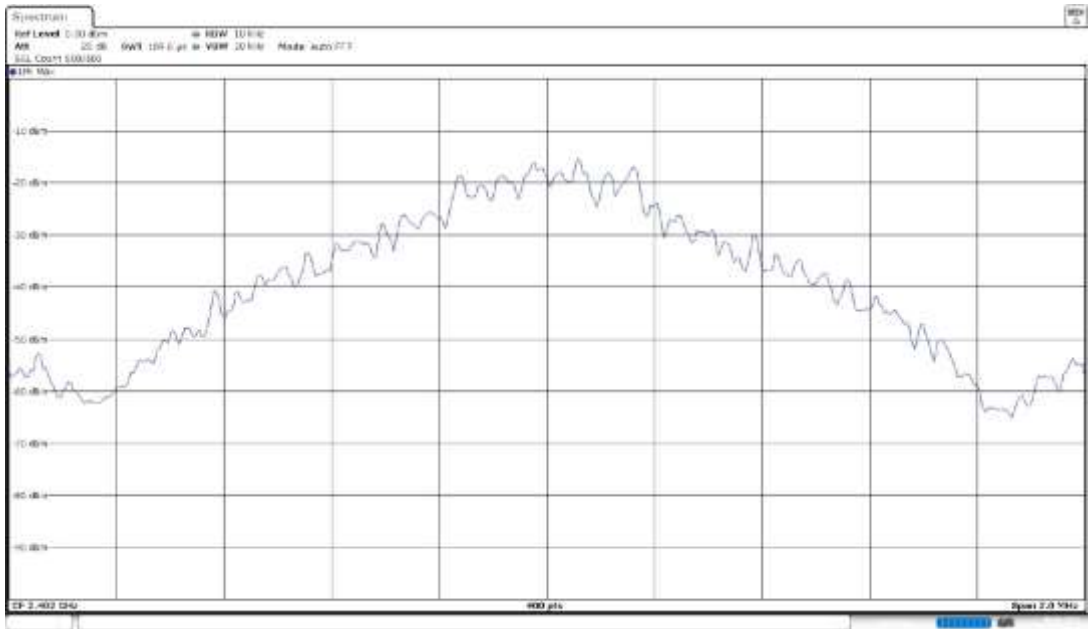
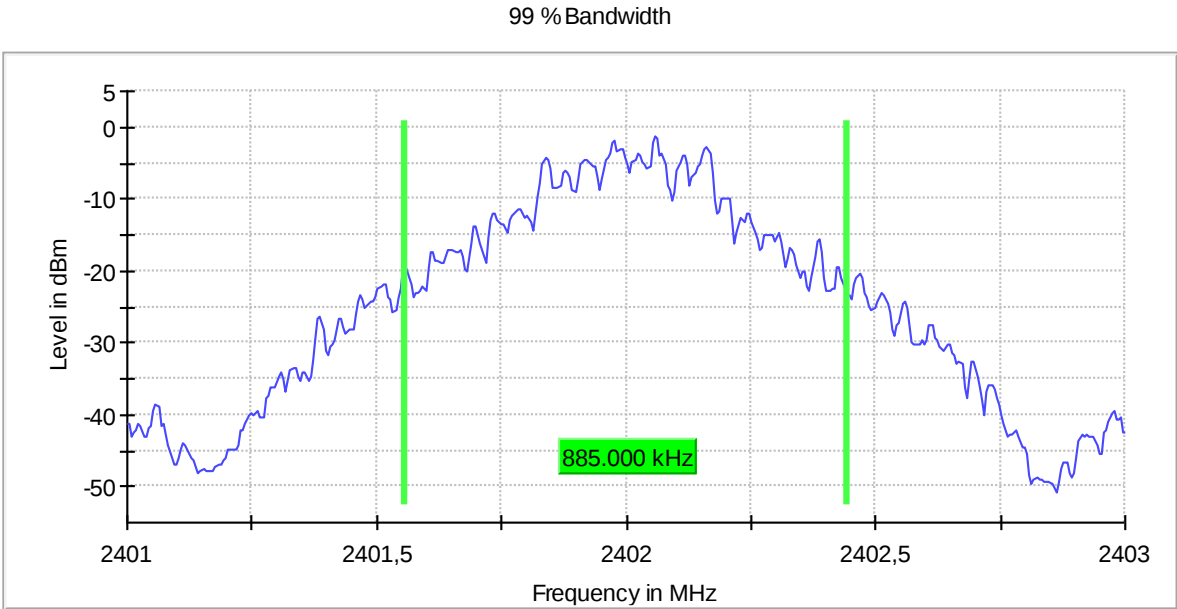
Modulation: BT (8DPSK 3-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Occ Ch BW (MHz)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	1.215
	2441.00000		1.215
	2480.00000		1.215

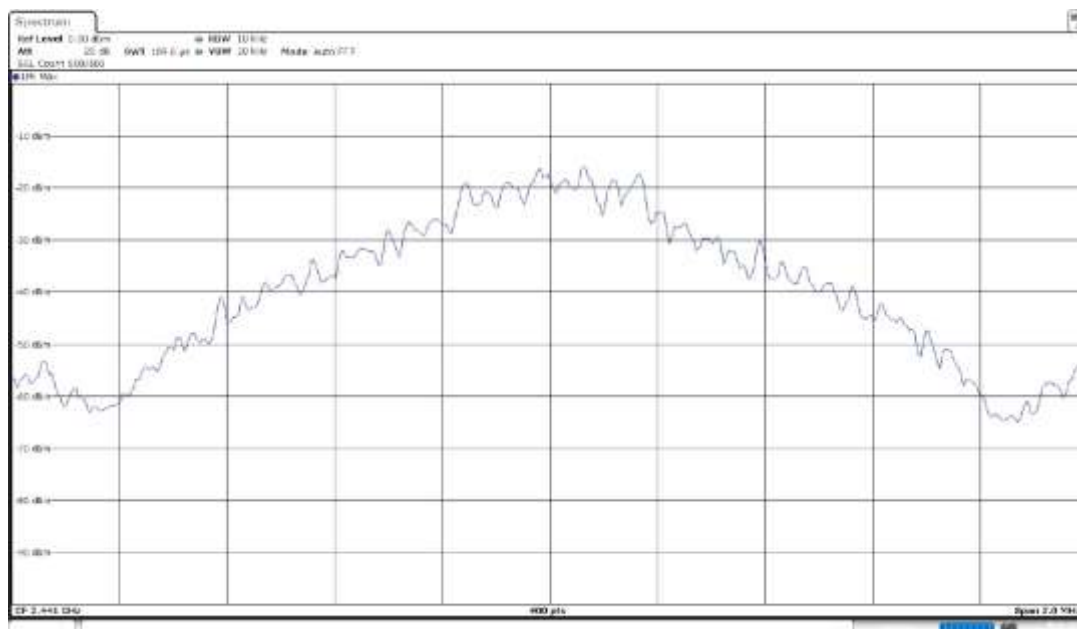
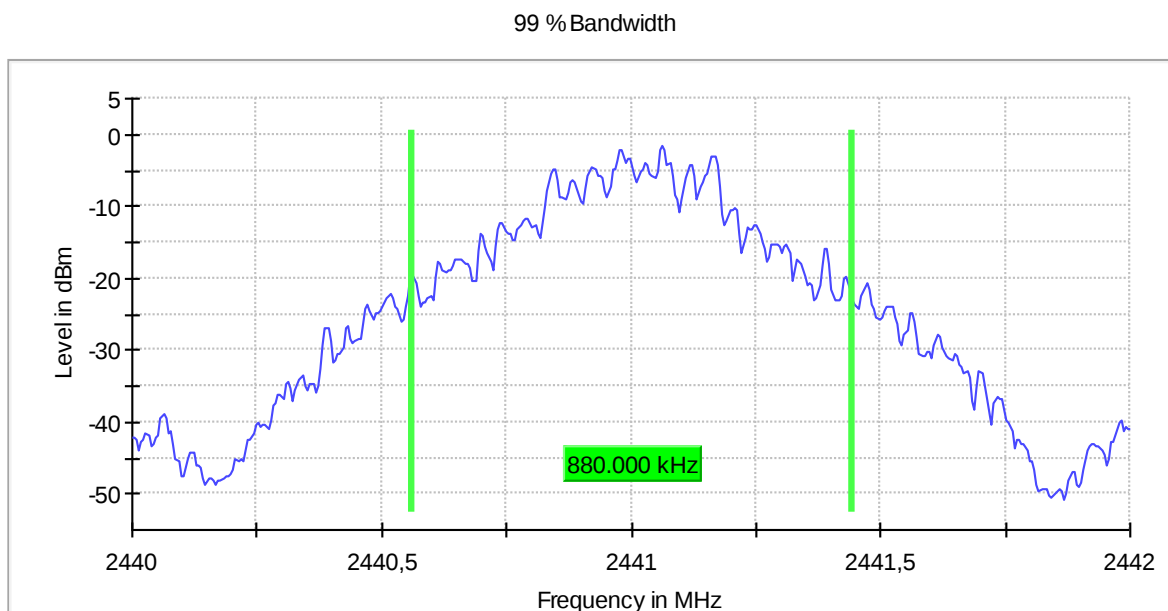
Attachments

Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2402.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5)

Plots:

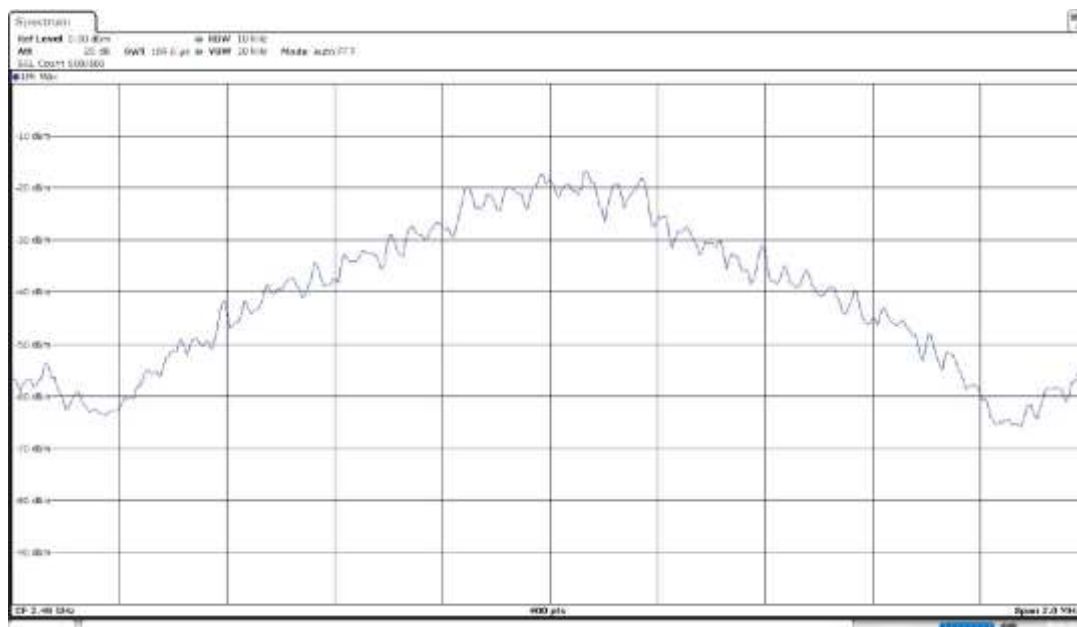
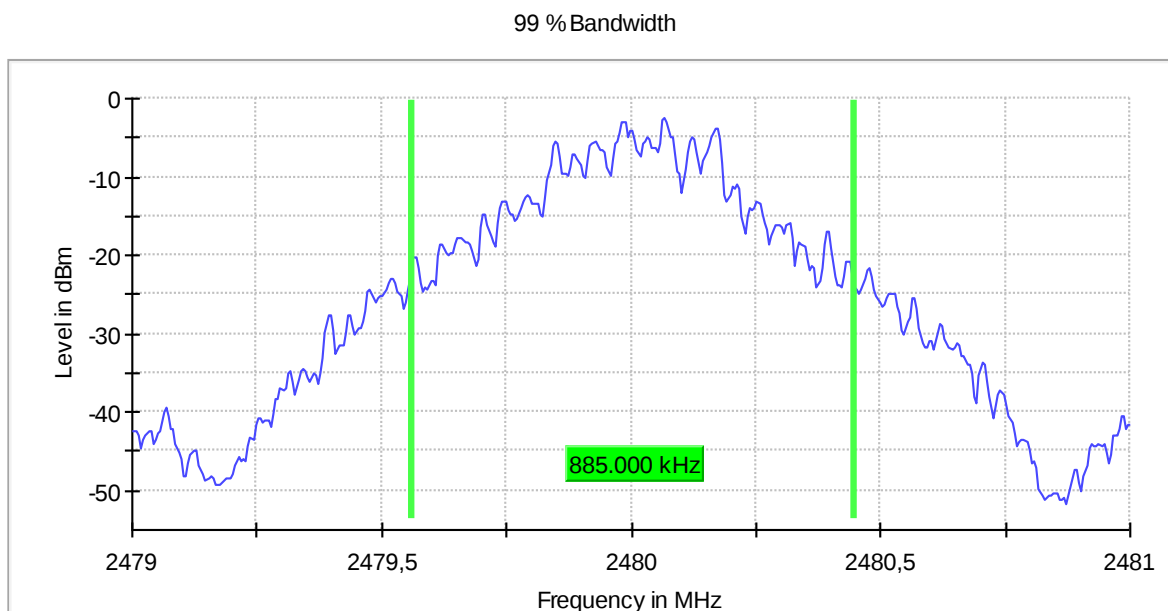


Plots:



Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5)

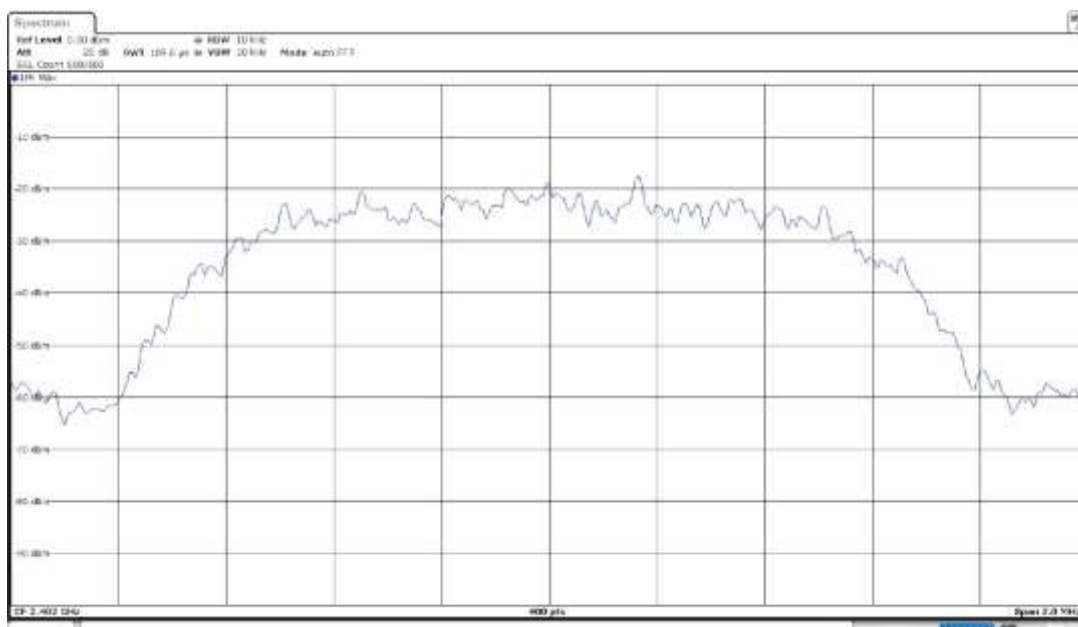
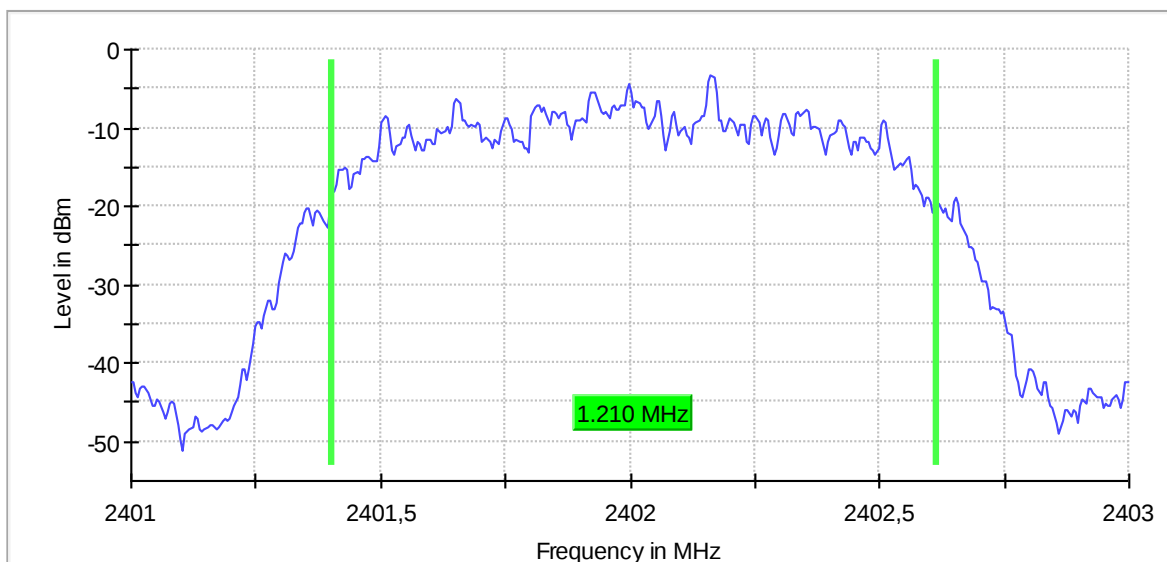
Plots:



Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2402.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5)

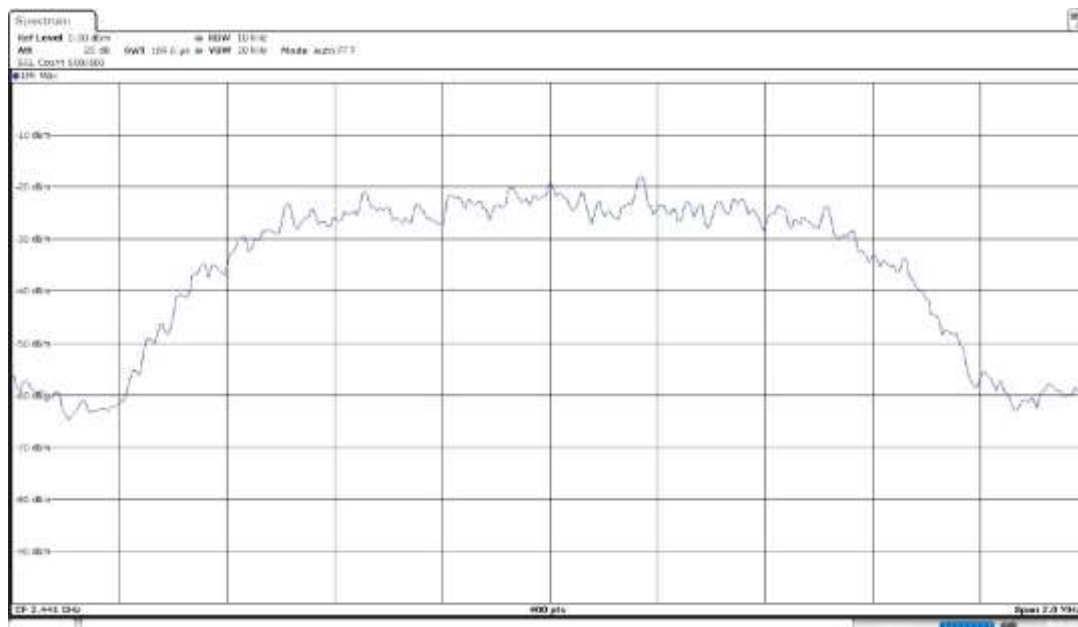
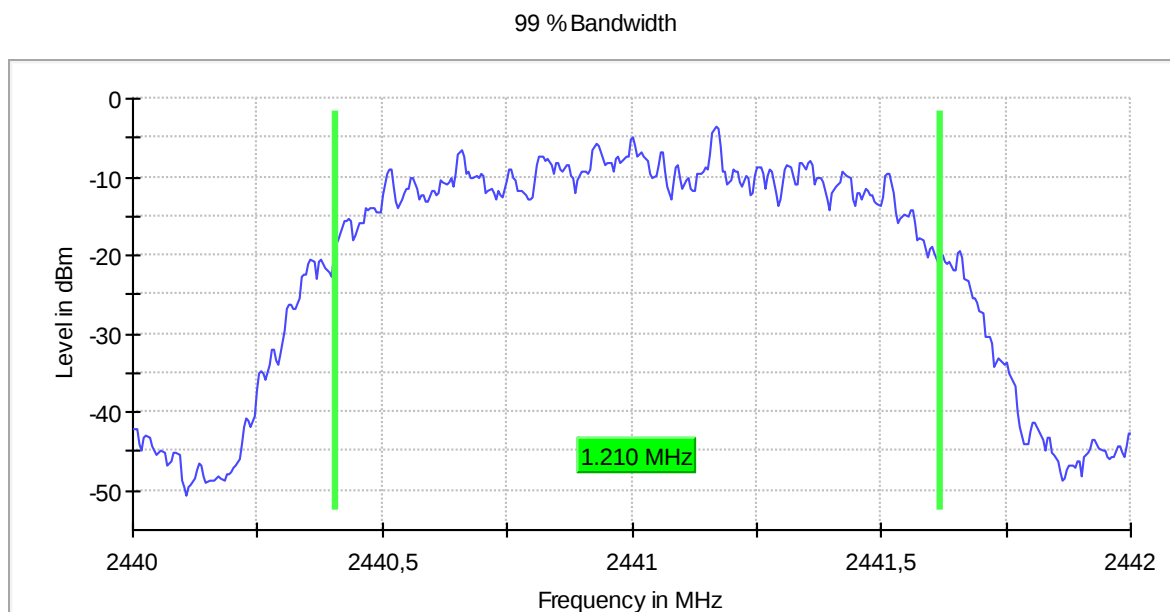
Plots:

99 % Bandwidth



Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2441.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5)

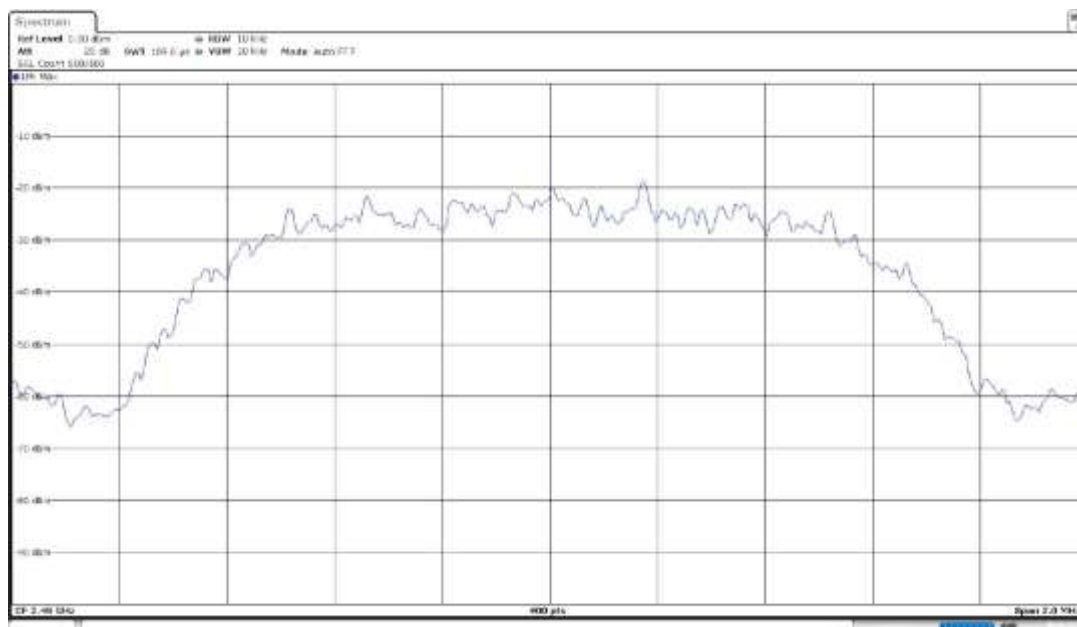
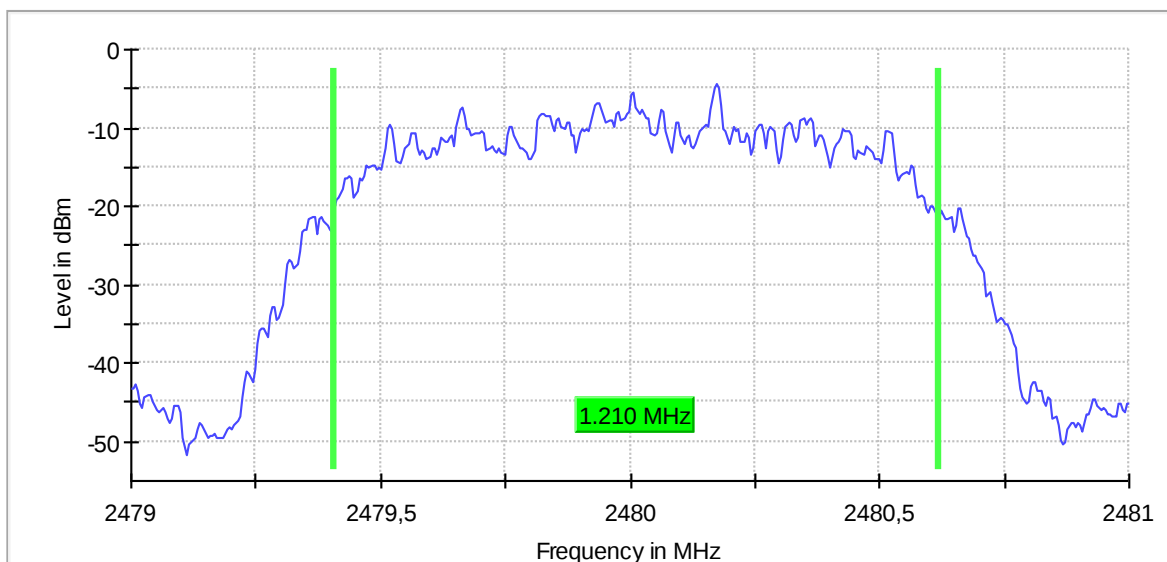
Plots:



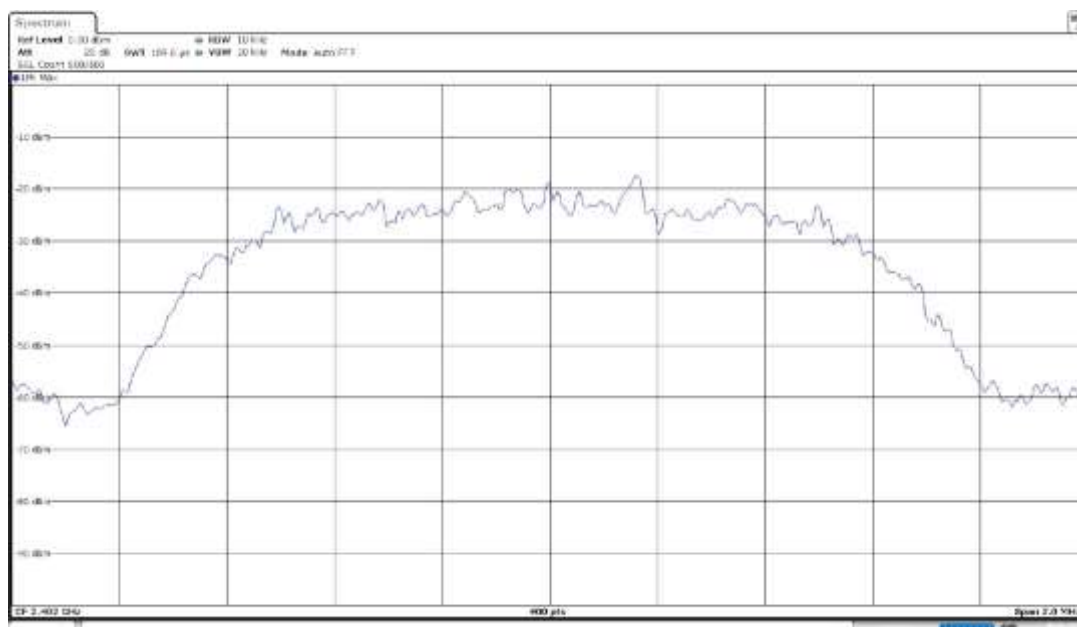
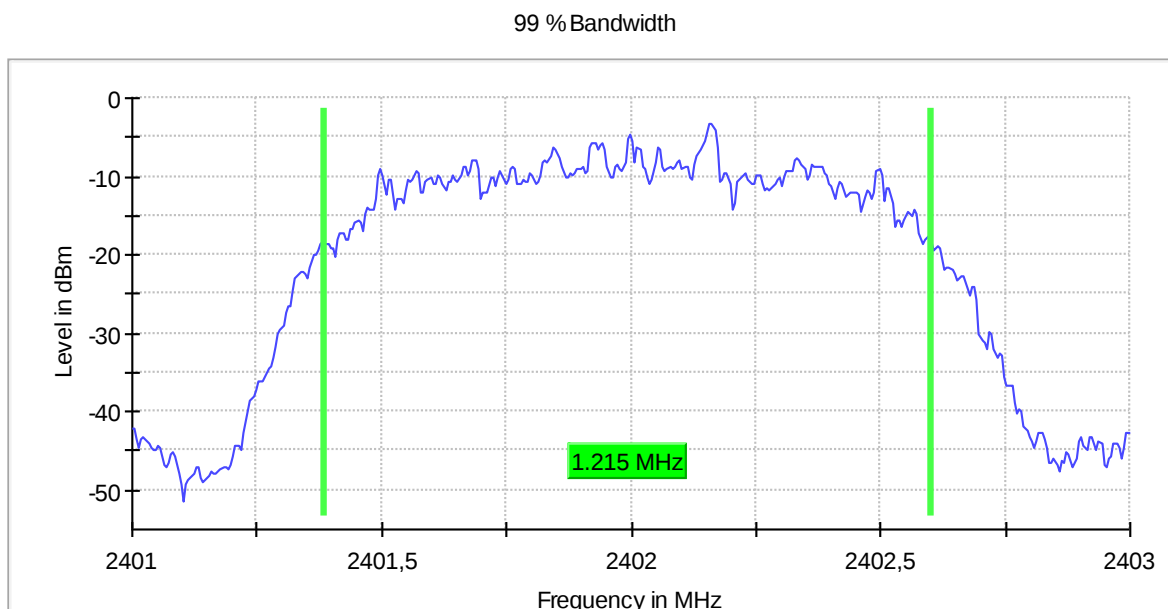
Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5)

Plots:

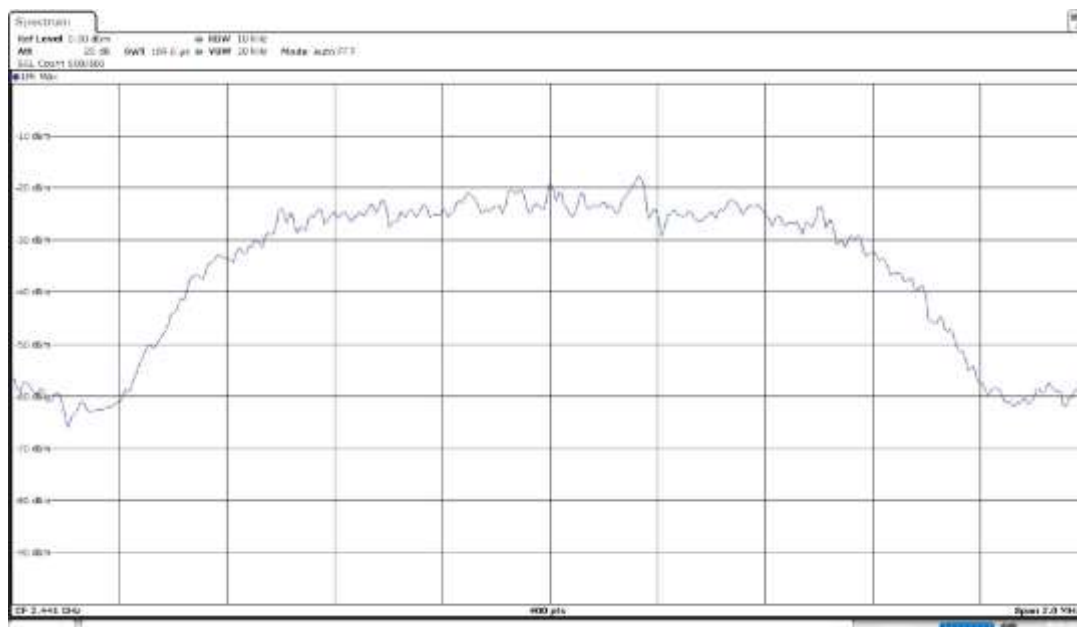
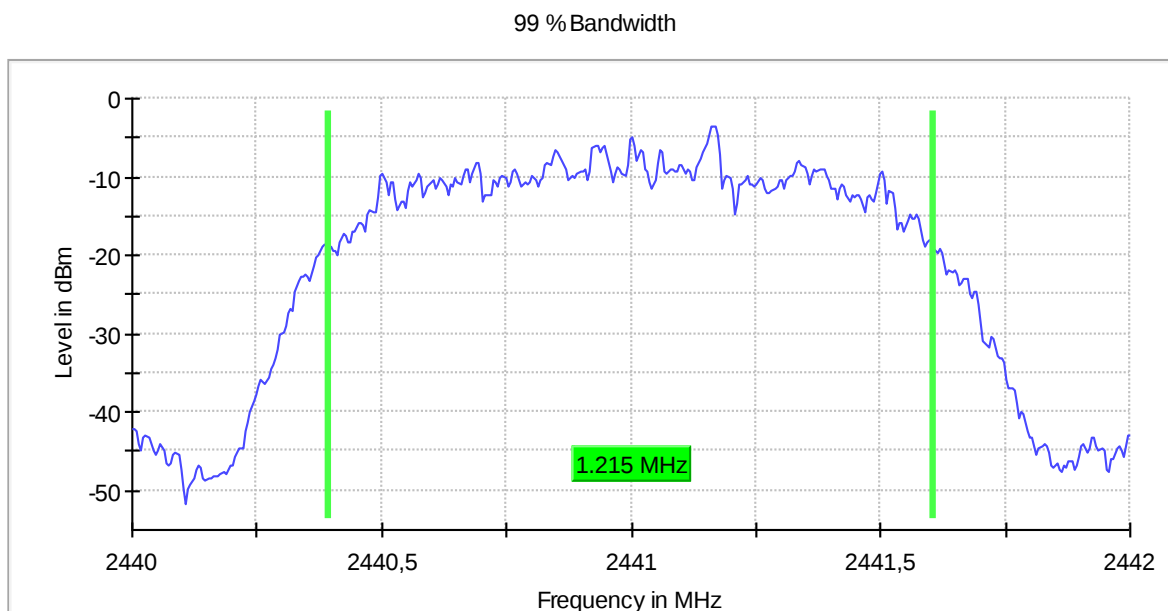
99 % Bandwidth



Plots:



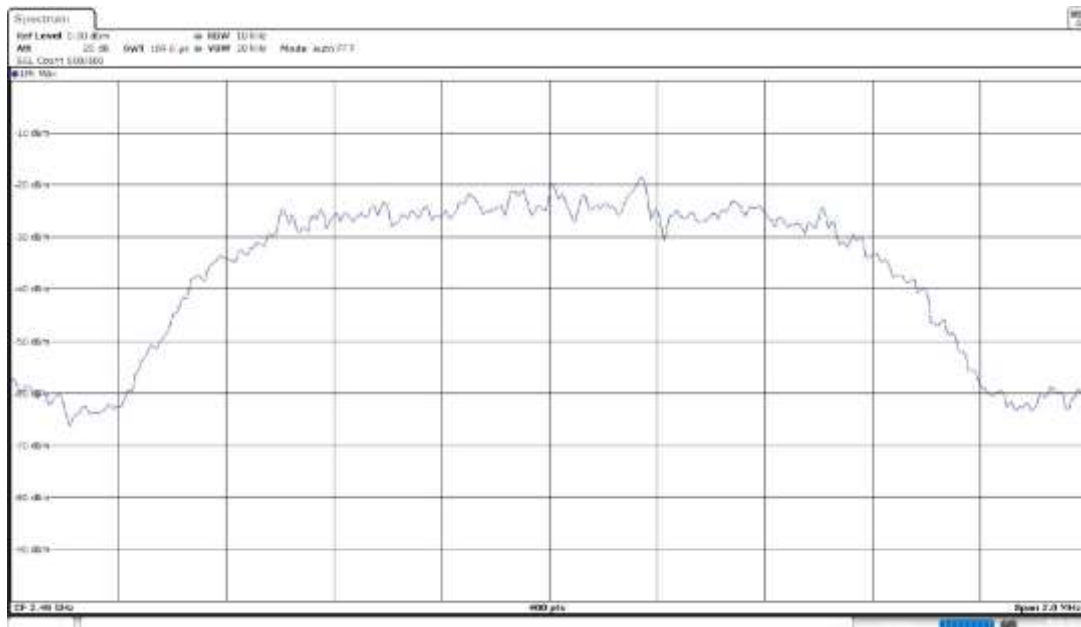
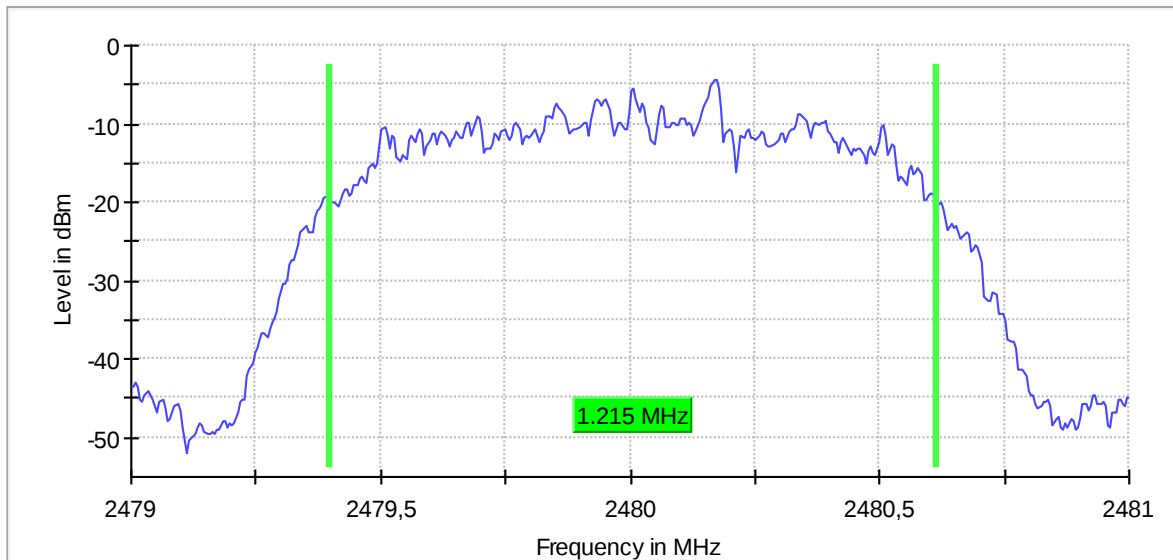
Plots:



Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (8DPSK 3-DH5)

Plots:

99 % Bandwidth



RSS-247 5.1 (b) / FCC 15.247 (a)(1) 20 dB Bandwidth

Limits

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.

Results

Modulation: BT (GFSK 1-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Emission Bandwidth (MHz)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	0.93
	2441.00000		0.93
	2480.00000		0.93

Verdict

Pass

Modulation: BT (Pi/4 DQPSK 2-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Emission Bandwidth (MHz)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	1.35
	2441.00000		1.35
	2480.00000		1.35

Verdict

Pass

Modulation: BT (8DPSK 3-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Emission Bandwidth (MHz)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	1.35
	2441.00000		1.35
	2480.00000		1.35

Verdict

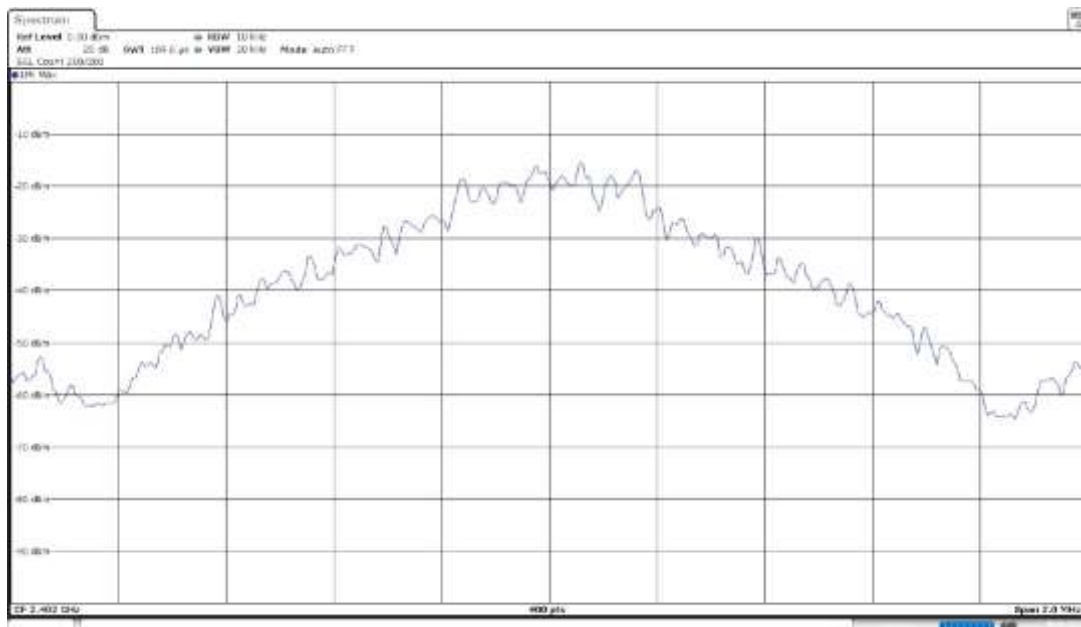
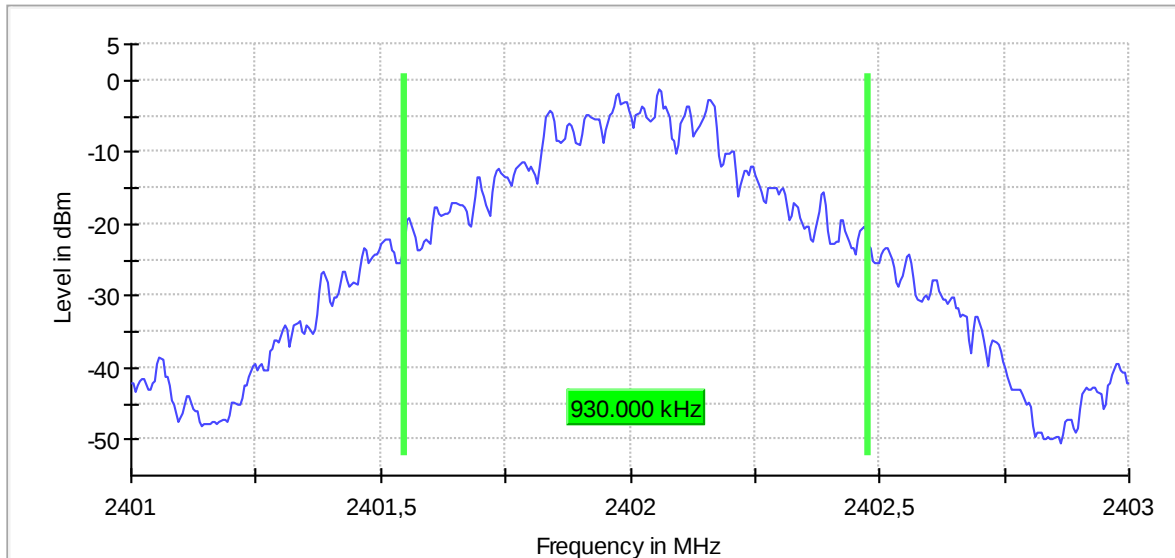
Pass

Attachments

Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2402.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5)

Plots:

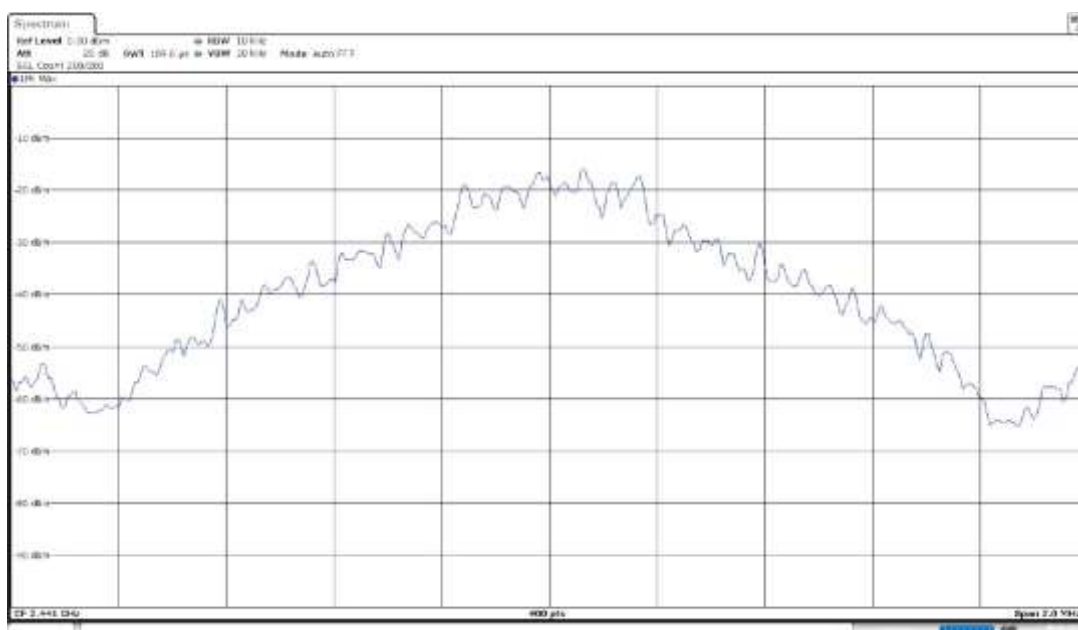
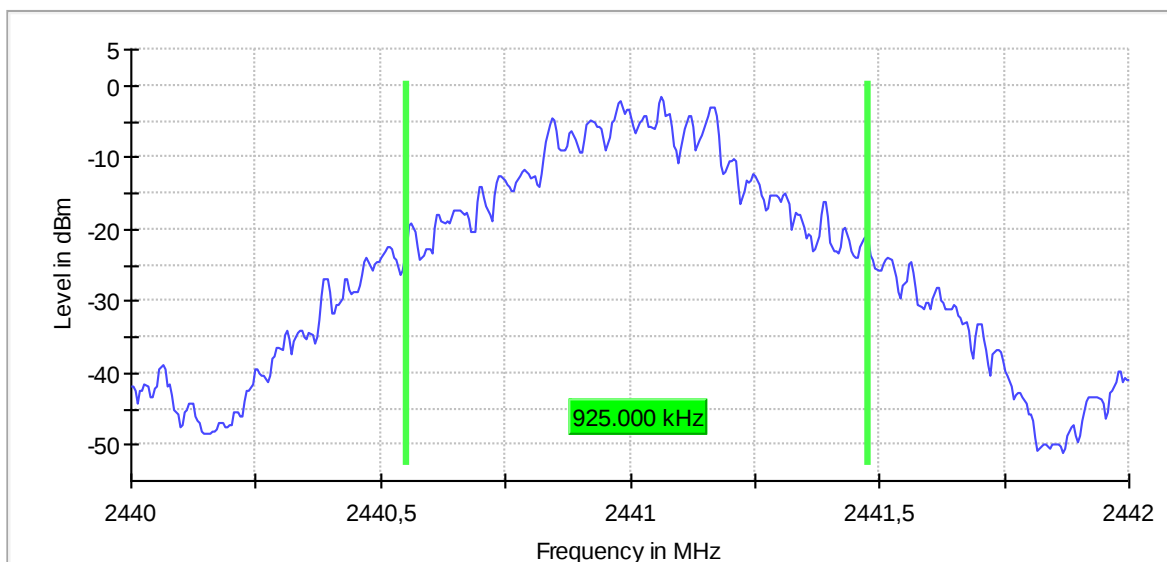
20 dB Bandwidth



Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2441.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5)

Plots:

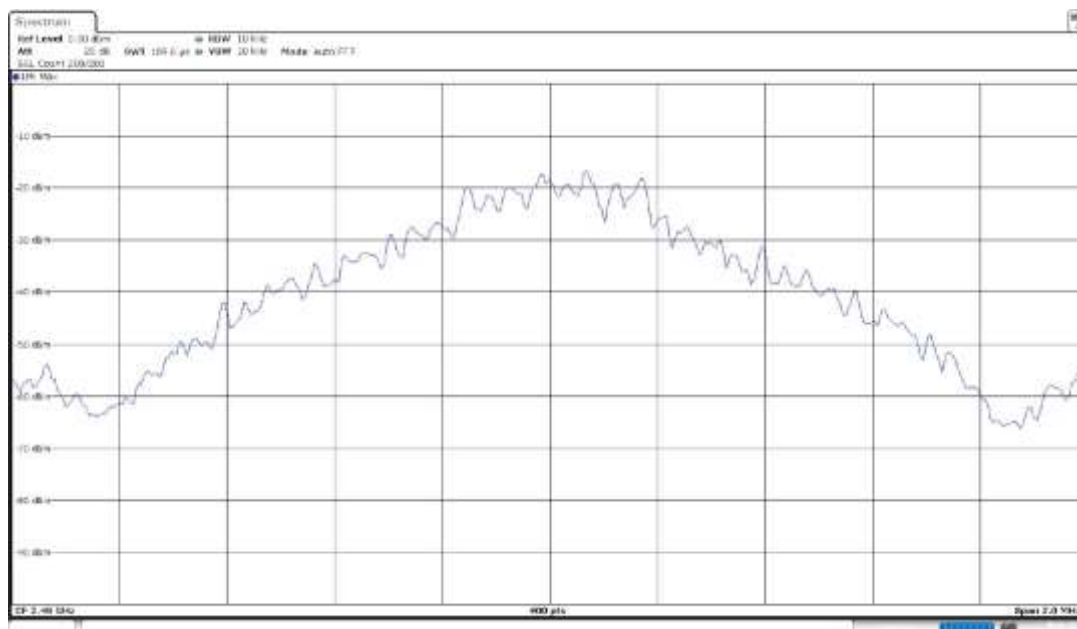
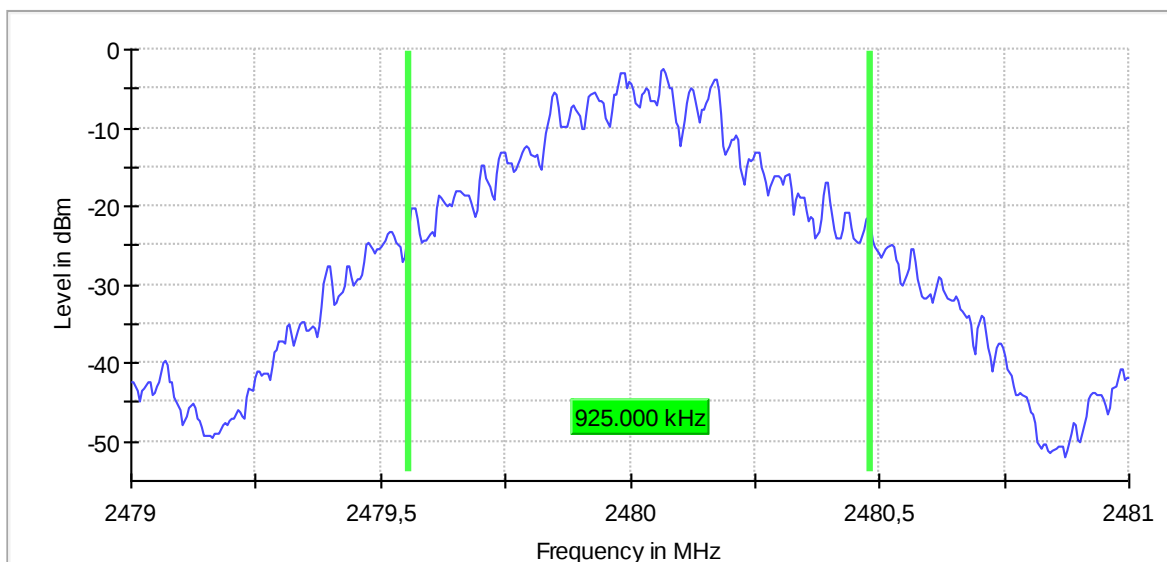
20 dB Bandwidth



Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5)

Plots:

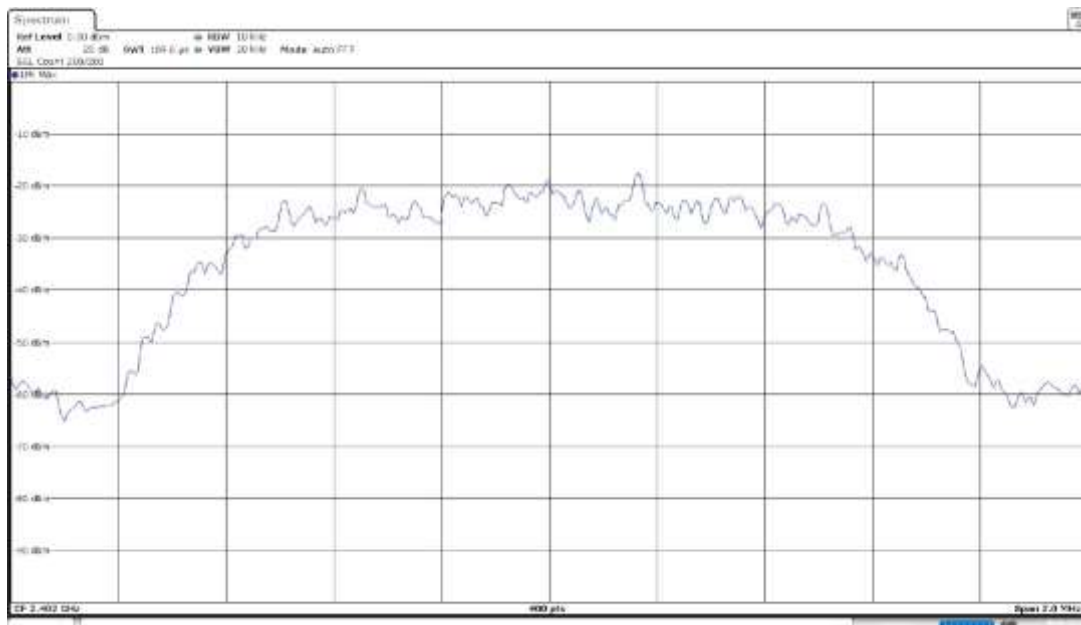
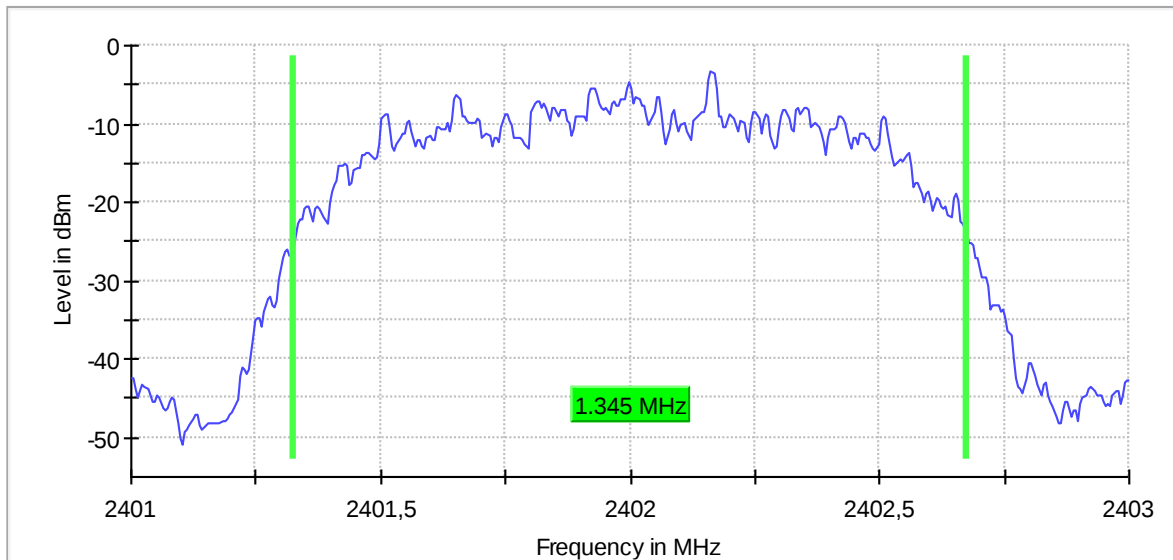
20 dB Bandwidth



Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2402.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5)

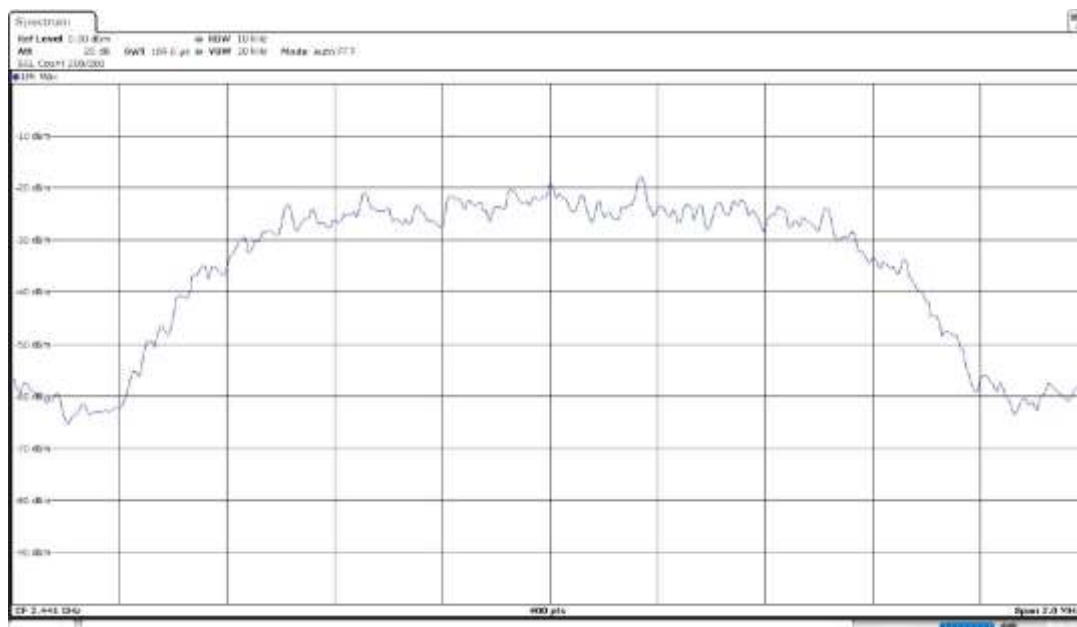
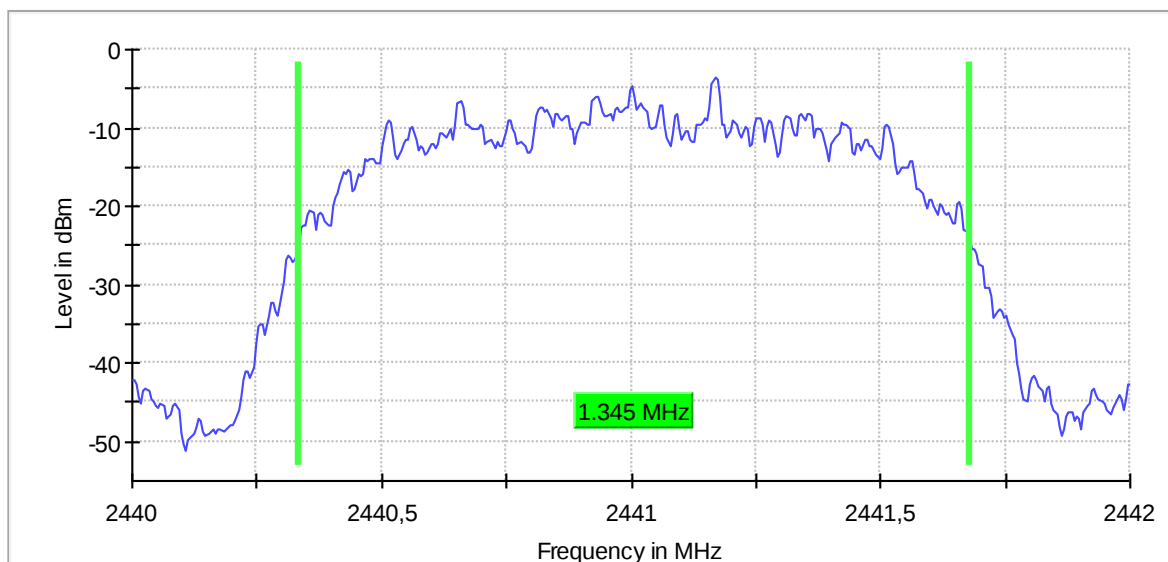
Plots:

20 dB Bandwidth



Plots:

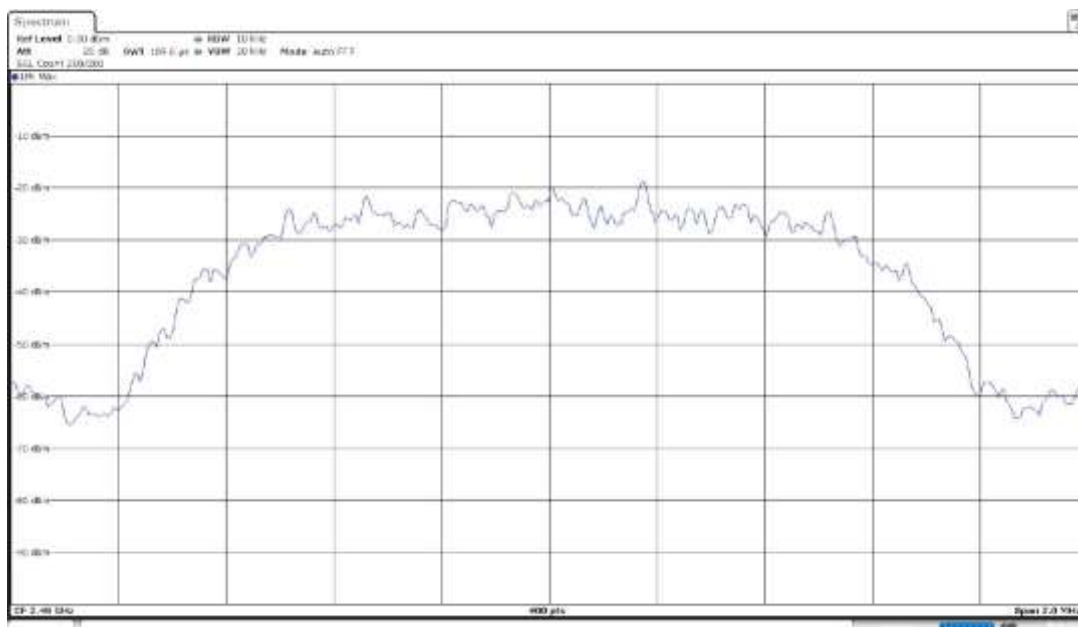
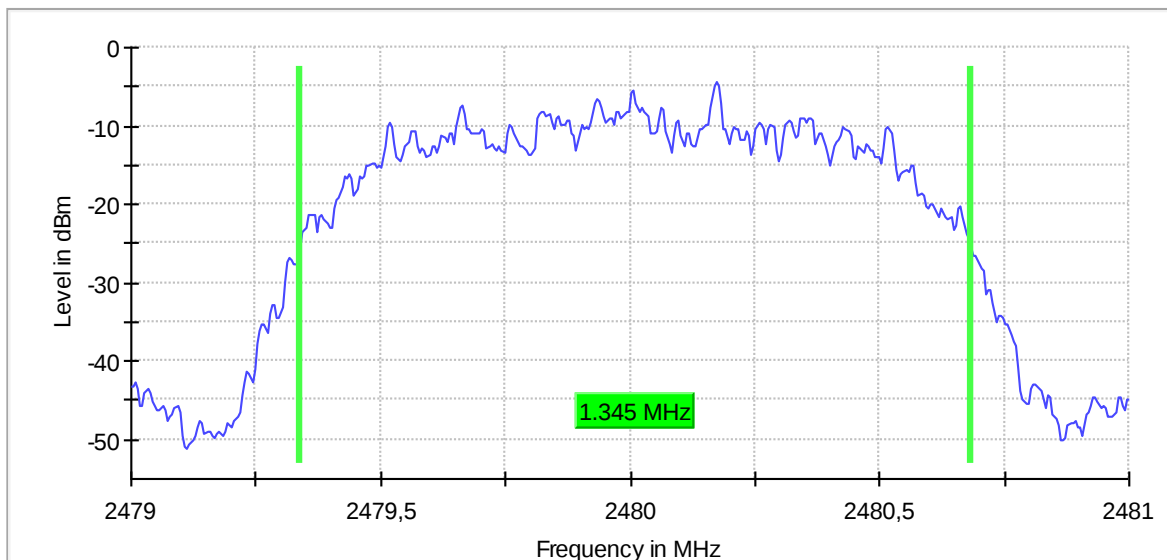
20 dB Bandwidth



Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5)

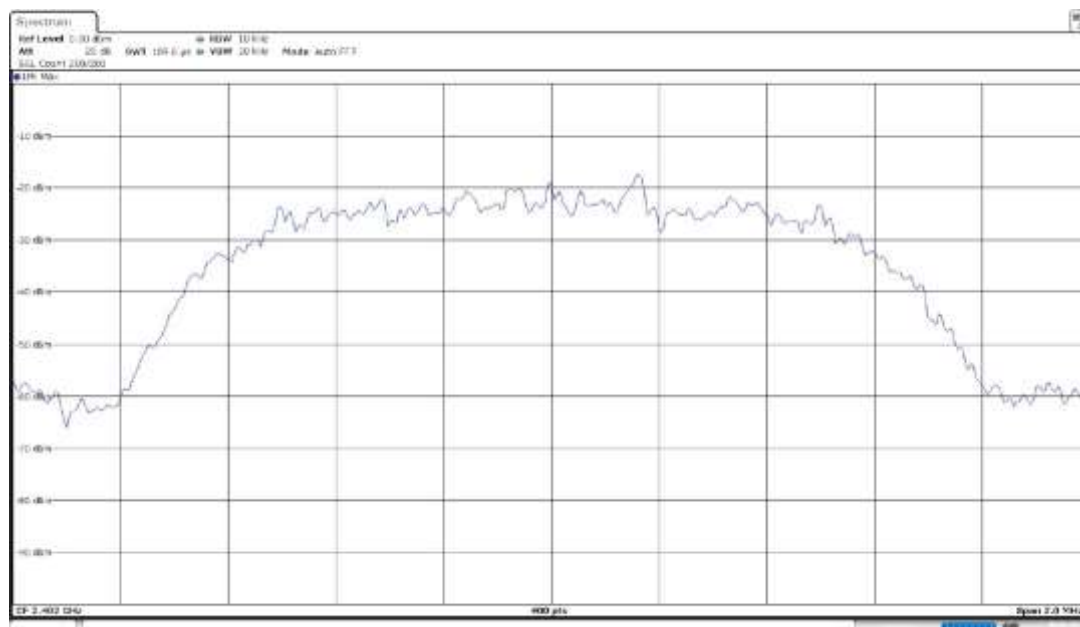
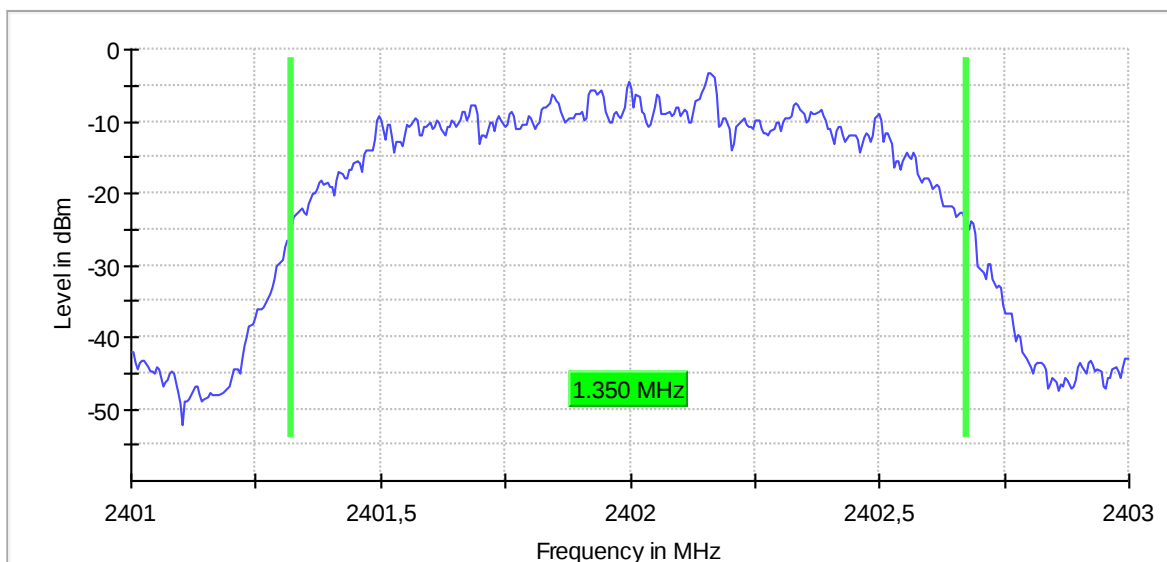
Plots:

20 dB Bandwidth



Plots:

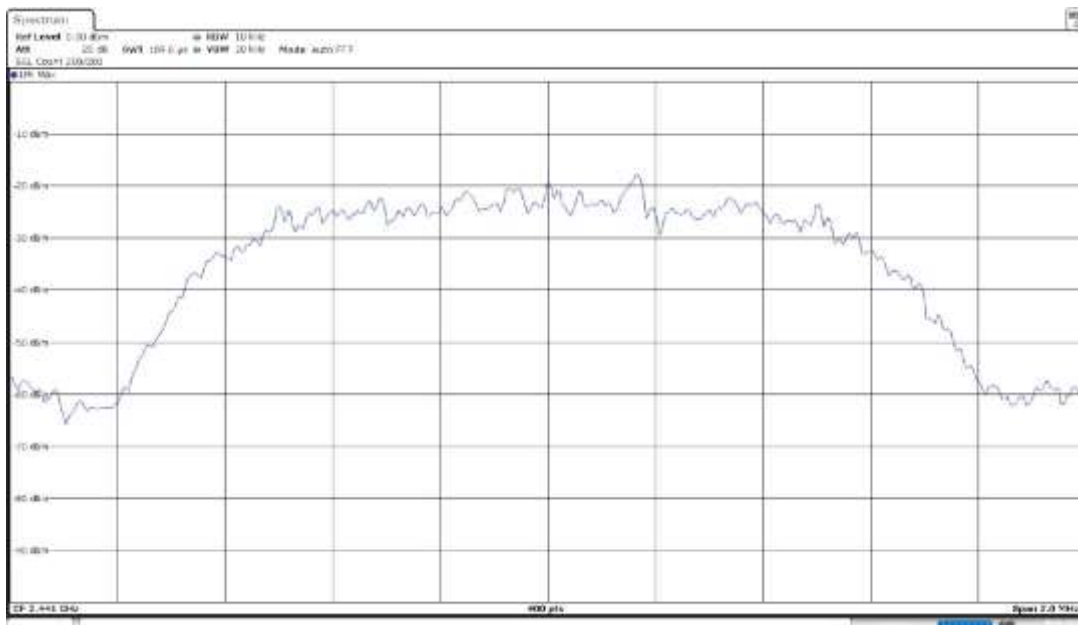
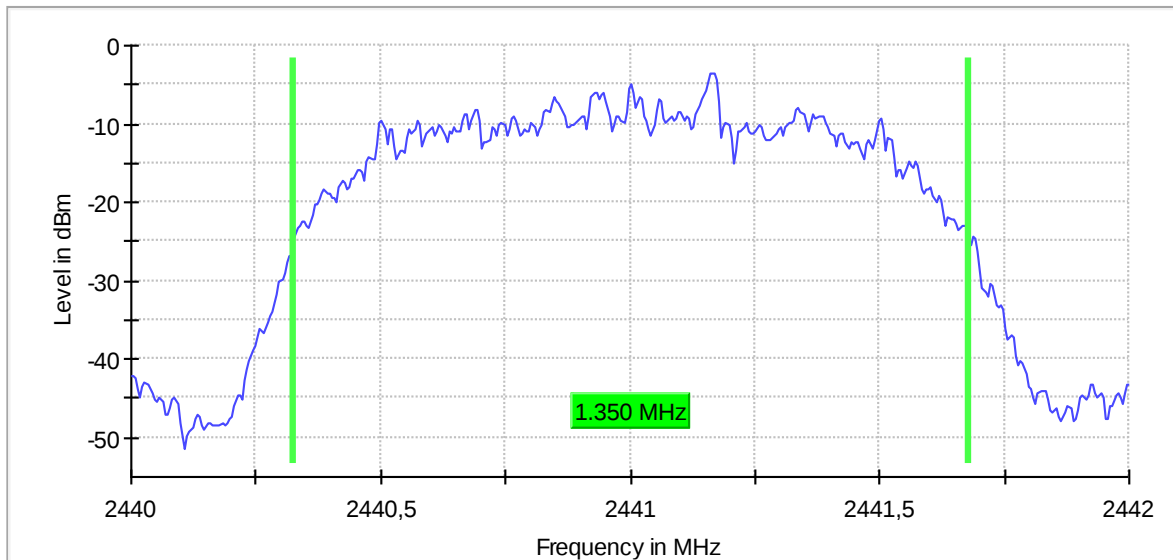
20 dB Bandwidth



Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2441.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (8DPSK 3-DH5)

Plots:

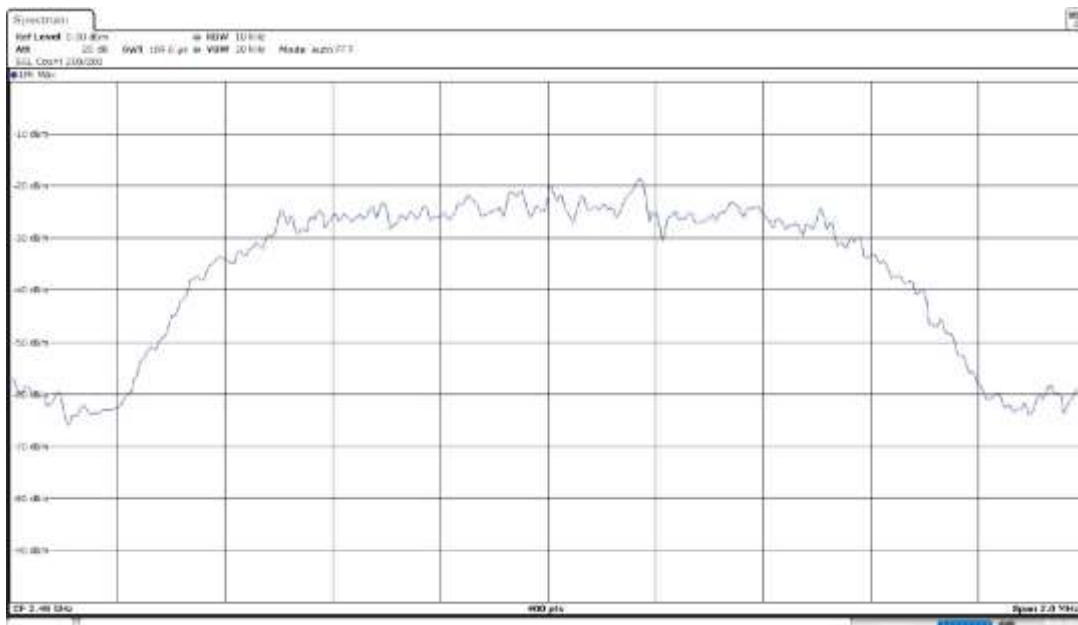
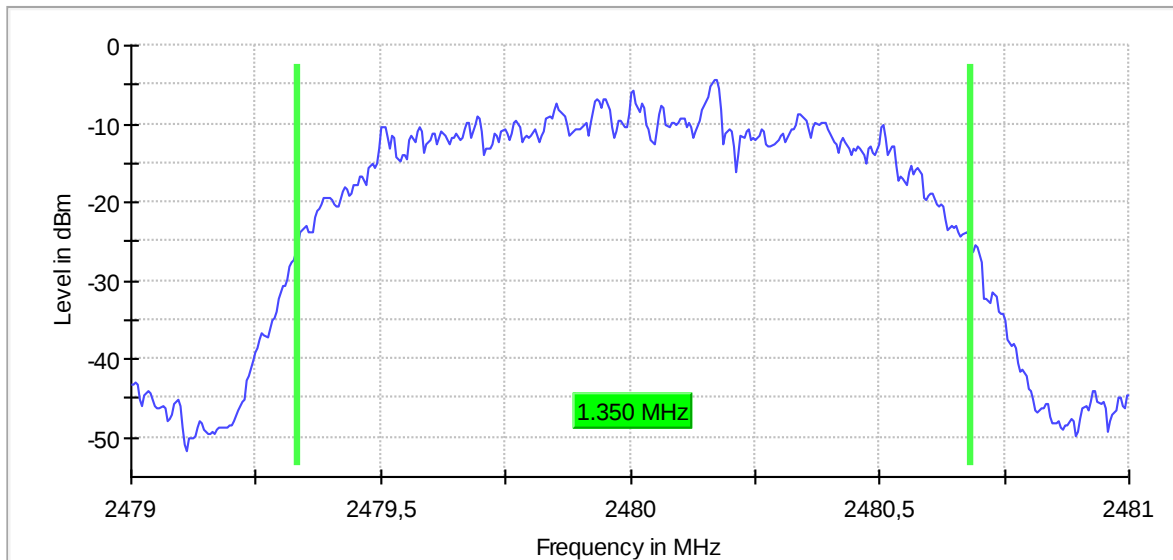
20 dB Bandwidth



Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (8DPSK 3-DH5)

Plots:

20 dB Bandwidth



RSS-247 5.1 (b) / FCC 15.247 (a)(1) Carrier Frequency Separation

Limits

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.

Results

Modulation: BT (GFSK 1-DH5)

Operation Band (MHz)	Equipment	Freq Sep (MHz)
[2400, 2483.5]	Frequency Hopping Spread Spectrum systems (DSS)	1.0002000

The hopping channel carrier frequencies are separated by a minimum two-thirds of the 20 dB bandwidth of the hopping channel.

Verdict

Pass

Modulation: BT (Pi/4 DQPSK 2-DH5)

Operation Band (MHz)	Equipment	Freq Sep (MHz)
[2400, 2483.5]	Frequency Hopping Spread Spectrum systems (DSS)	1.000200

The hopping channel carrier frequencies are separated by a minimum two-thirds of the 20 dB bandwidth of the hopping channel.

Verdict

Pass

Modulation: BT (8DPSK 3-DH5)

Operation Band (MHz)	Equipment	Freq Sep (MHz)
[2400, 2483.5]	Frequency Hopping Spread Spectrum systems (DSS)	1.014300

The hopping channel carrier frequencies are separated by a minimum two-thirds of the 20 dB bandwidth of the hopping channel.

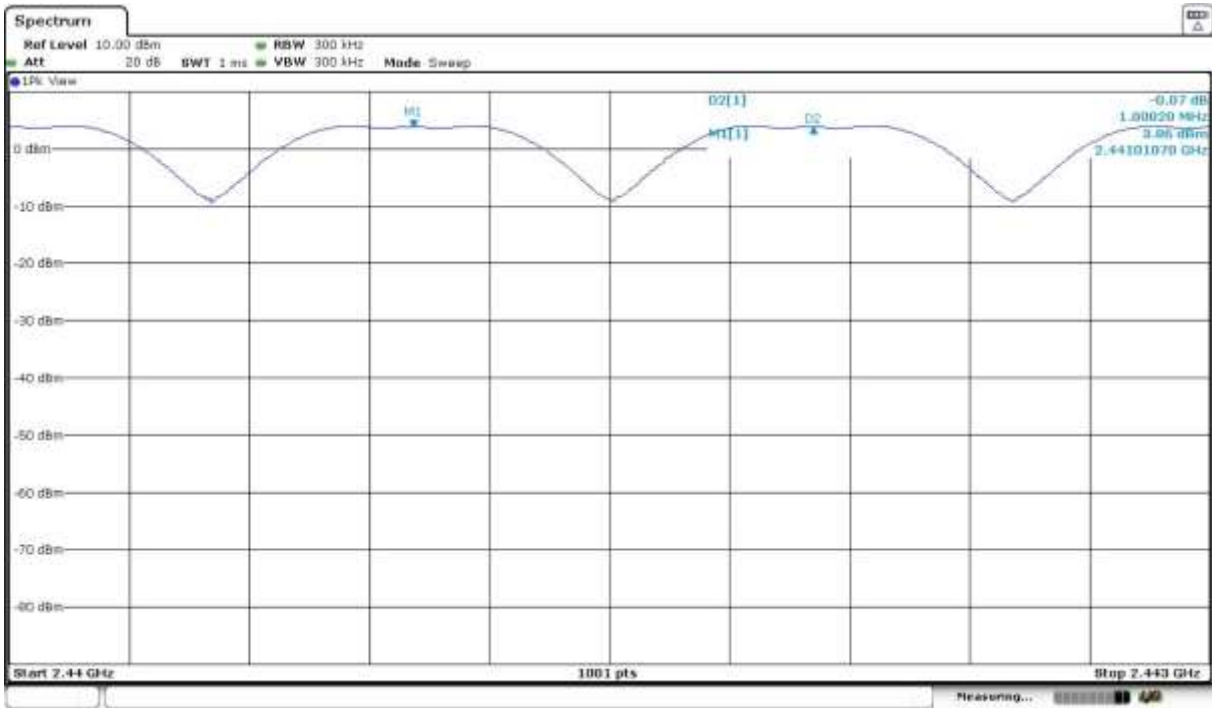
Verdict

Pass

Attachments

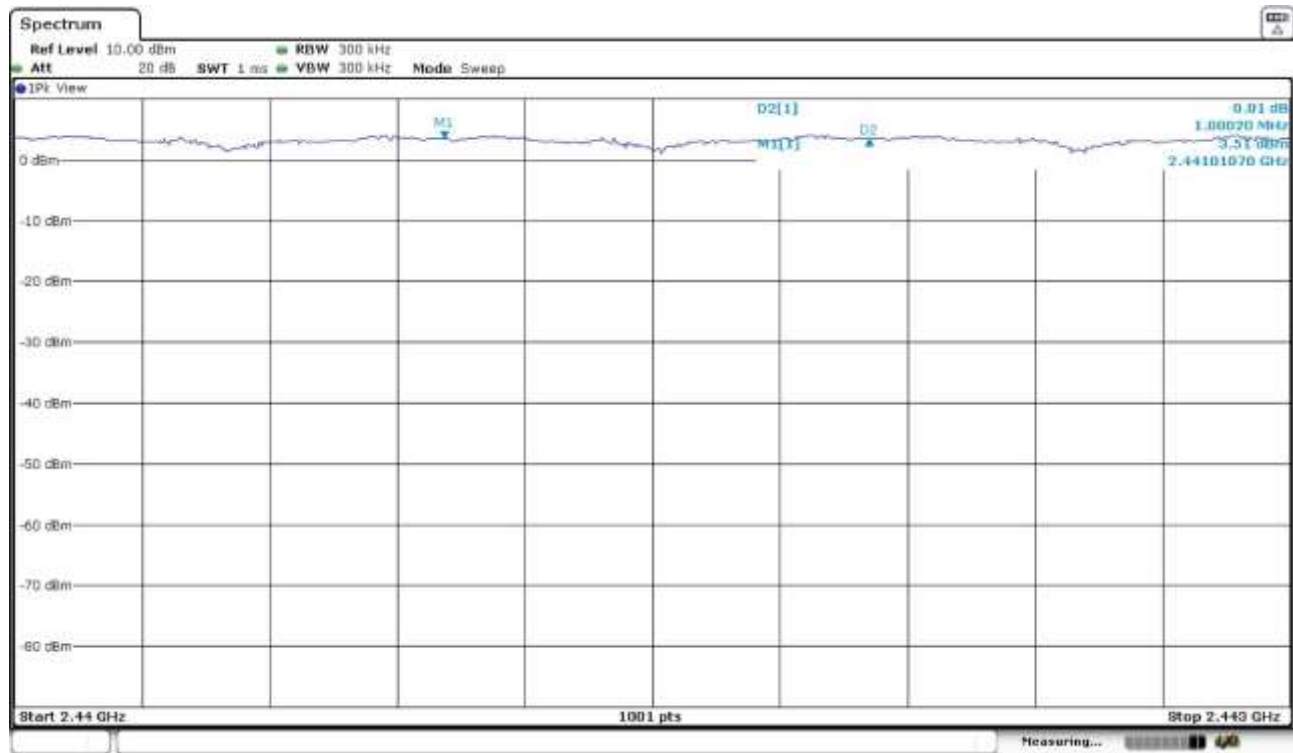
Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5)

Plots:



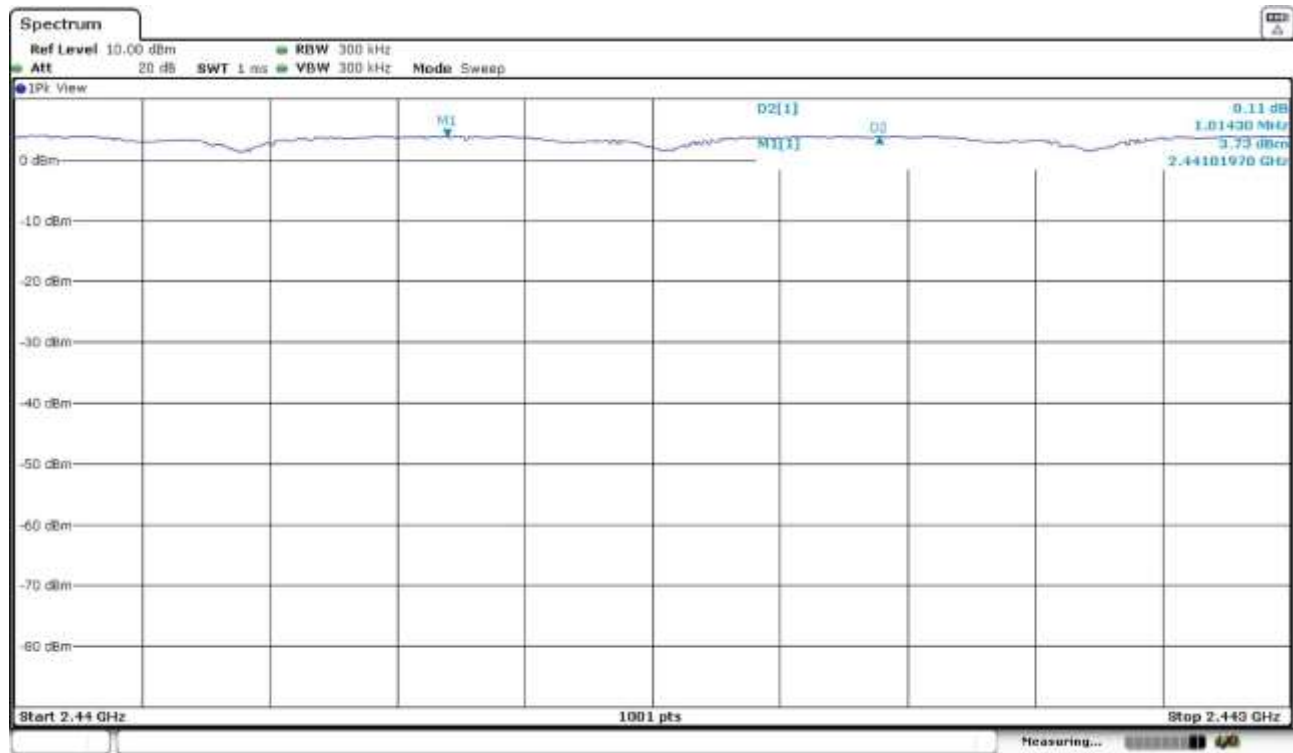
Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5)

Plots:



Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (8DPSK 3-DH5)

Plots:



RSS-247 5.1 (d) / FCC 15.247 (a)(1)(iii) Time of Occupancy (Dwell Time)

Limits

The average time of occupancy on any channel shall not be greater than 0.4 seconds (400 ms) within a period of 0.4 seconds multiplied by the number of hopping channels employed = $0.4 \times 79 = 31.6$ seconds.

Results

Modulation: BT (GFSK 1-DH5)

Operation Band (MHz)	Equipment	NHp	Avg COT (ms)
[2400, 2483.5]	Frequency Hopping Spread Spectrum systems (DSS)	103	301.44

Verdict

Pass

Modulation: BT (Pi/4 DQPSK 2-DH5)

Operation Band (MHz)	Equipment	NHp	Avg COT (ms)
[2400, 2483.5]	Frequency Hopping Spread Spectrum systems (DSS)	116	337.35

Verdict

Pass

Modulation: BT (8DPSK 3-DH5)

Operation Band (MHz)	Equipment	NHp	Avg COT (ms)
[2400, 2483.5]	Frequency Hopping Spread Spectrum systems (DSS)	113	330.76

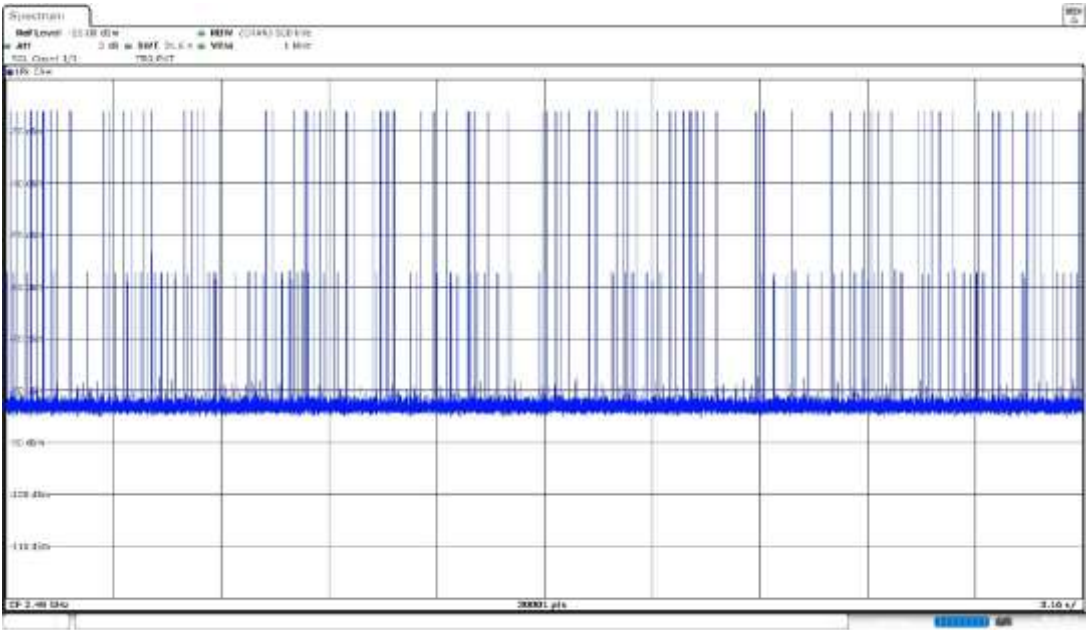
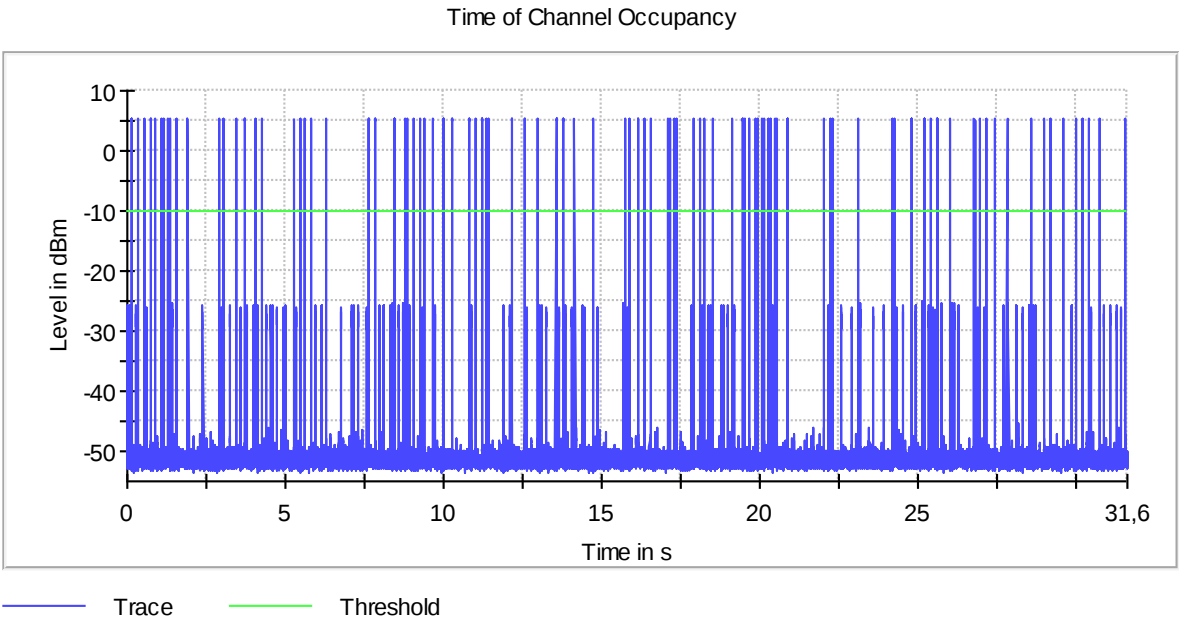
Verdict

Pass

Attachments

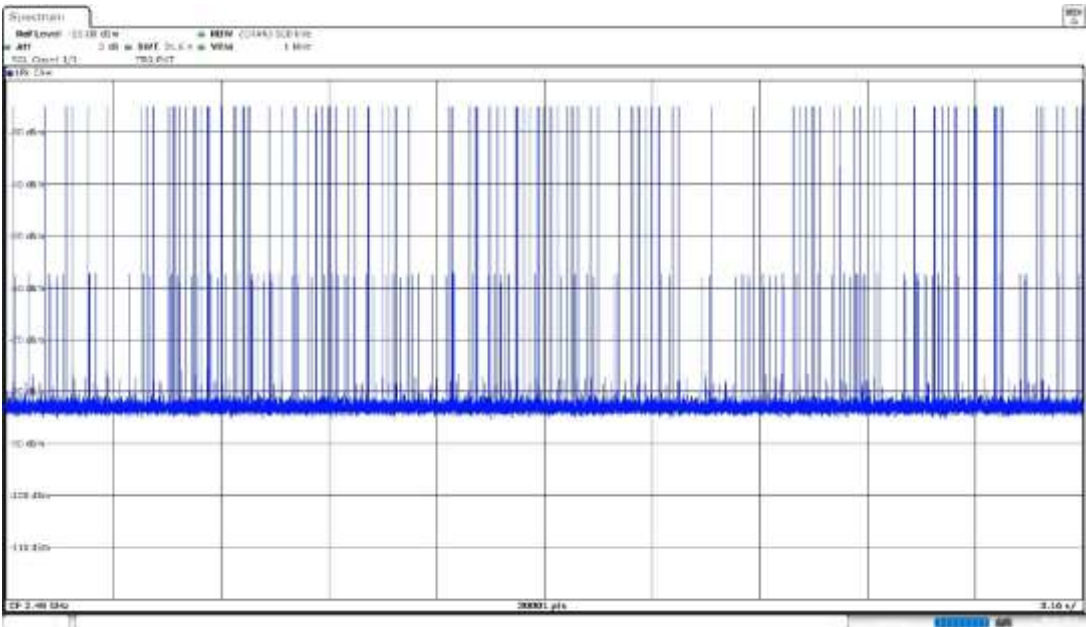
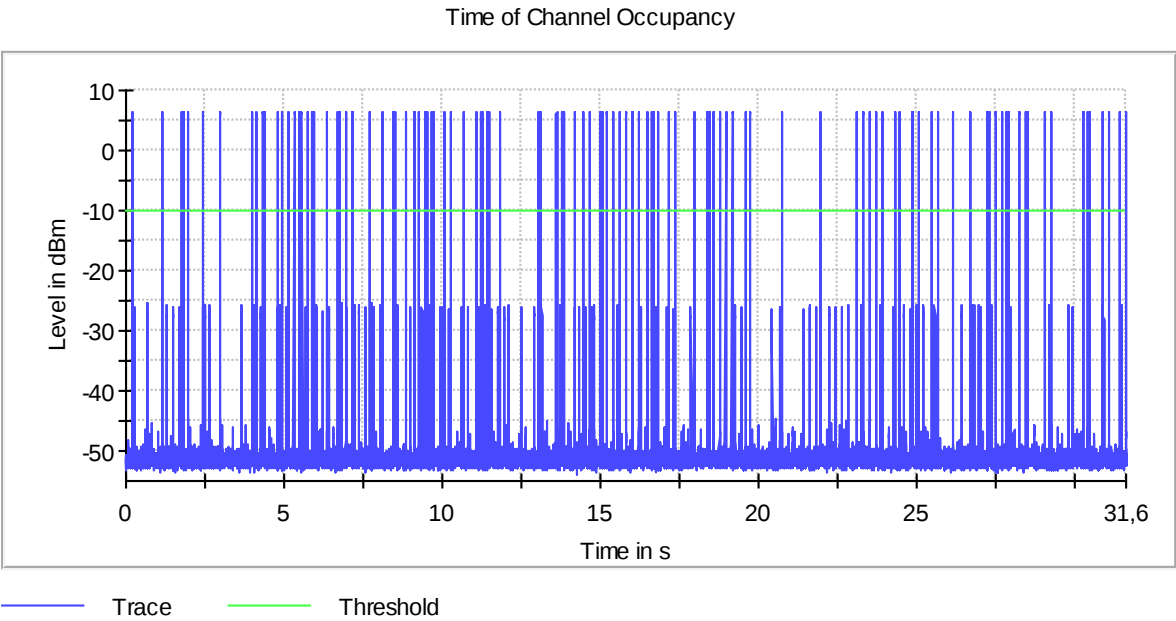
Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5)

Plots:



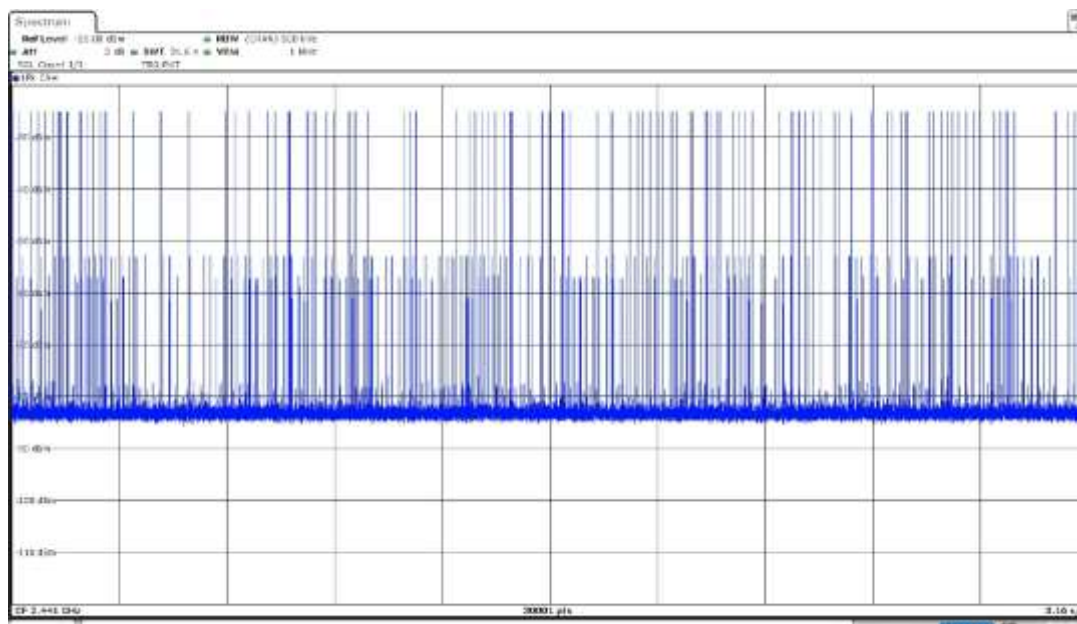
Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5)

Plots:



Plots:

— Trace — Threshold



RSS-247 5.1 (d) / FCC 15.247 (a)(1)(iii) Number of hopping channels

Limits

Frequency hopping system in the 2400-2483.5 MHz band shall use at least 15 channels.

Results

Modulation: BT (GFSK 1-DH5)

Operation Band (MHz)	Equipment	NHC
[2400, 2483.5]	Frequency Hopping Spread Spectrum systems (DSS)	79

Verdict

Pass

Modulation: BT (Pi/4 DQPSK 2-DH5)

Operation Band (MHz)	Equipment	NHC
[2400, 2483.5]	Frequency Hopping Spread Spectrum systems (DSS)	79

Verdict

Pass

Modulation: BT (8DPSK 3-DH5)

Operation Band (MHz)	Equipment	NHC
[2400, 2483.5]	Frequency Hopping Spread Spectrum systems (DSS)	79

Verdict

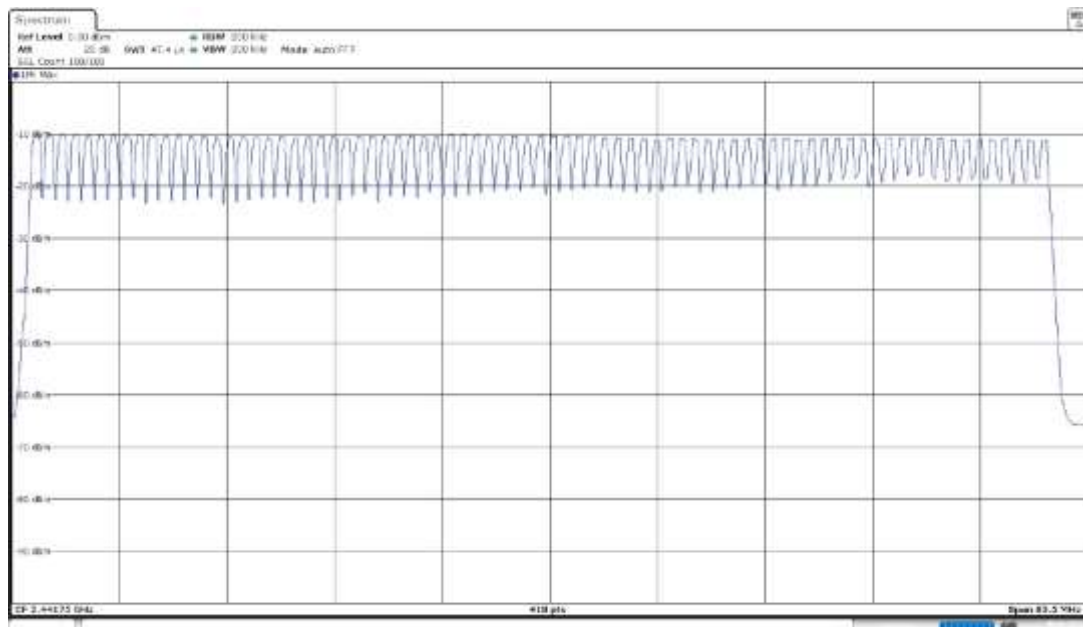
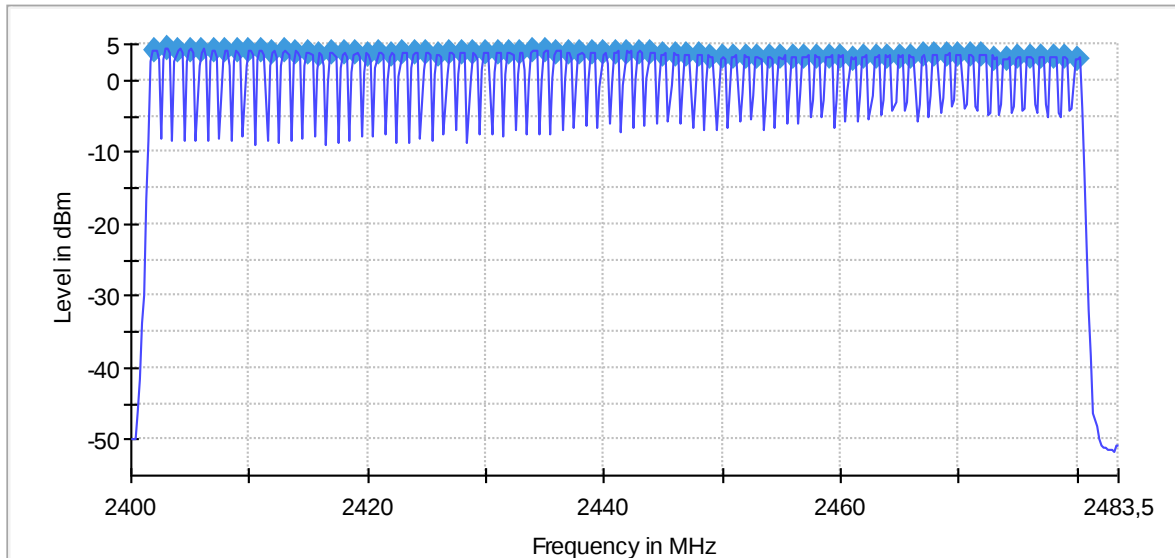
Pass

Attachments

Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5)

Plots:

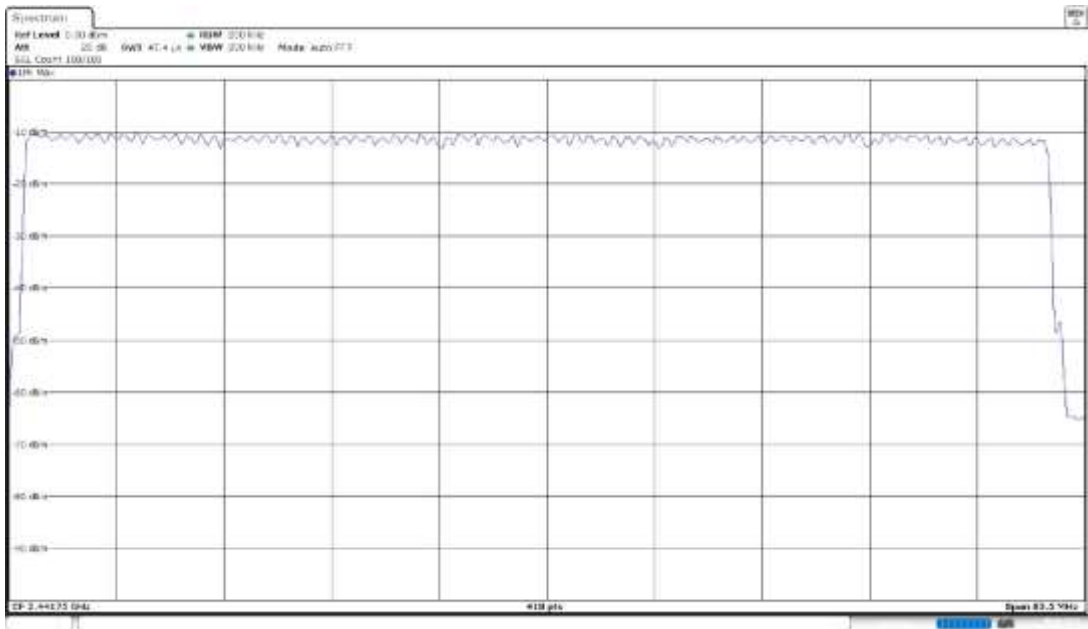
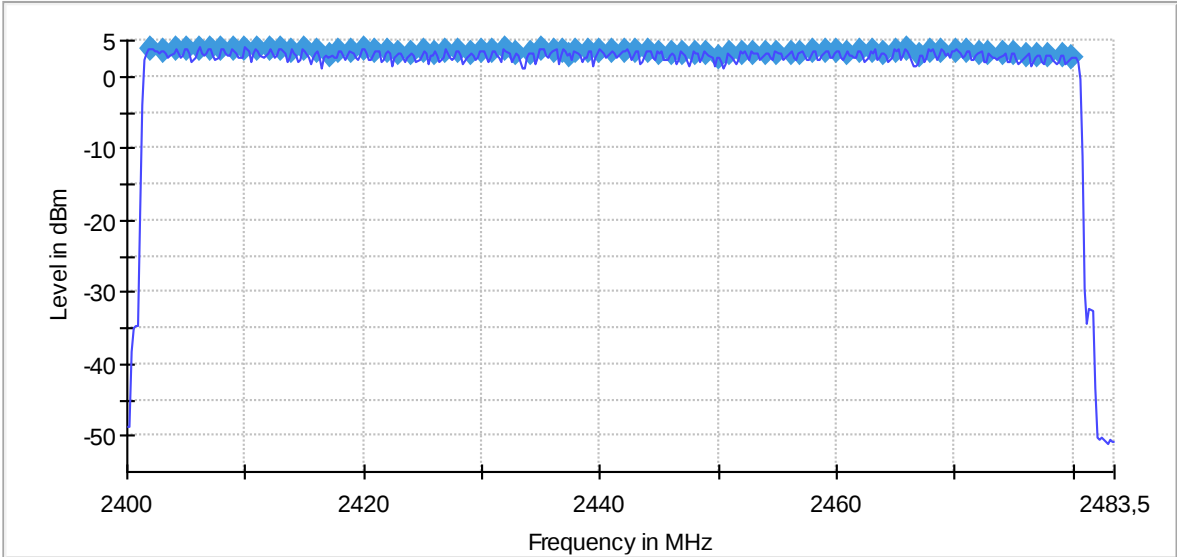
Sequence



Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5)

Plots:

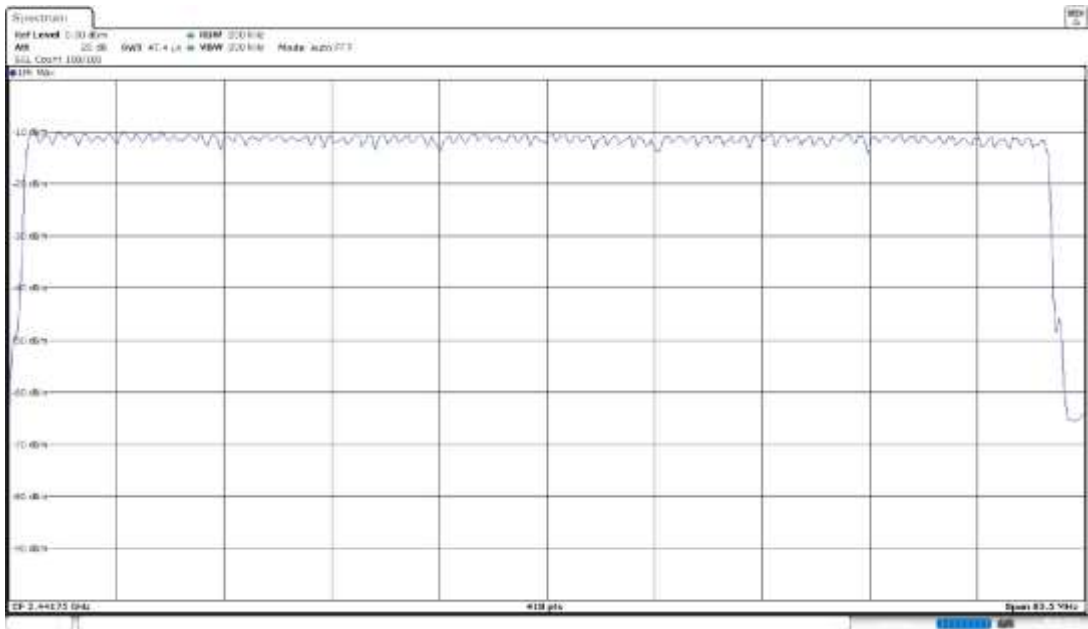
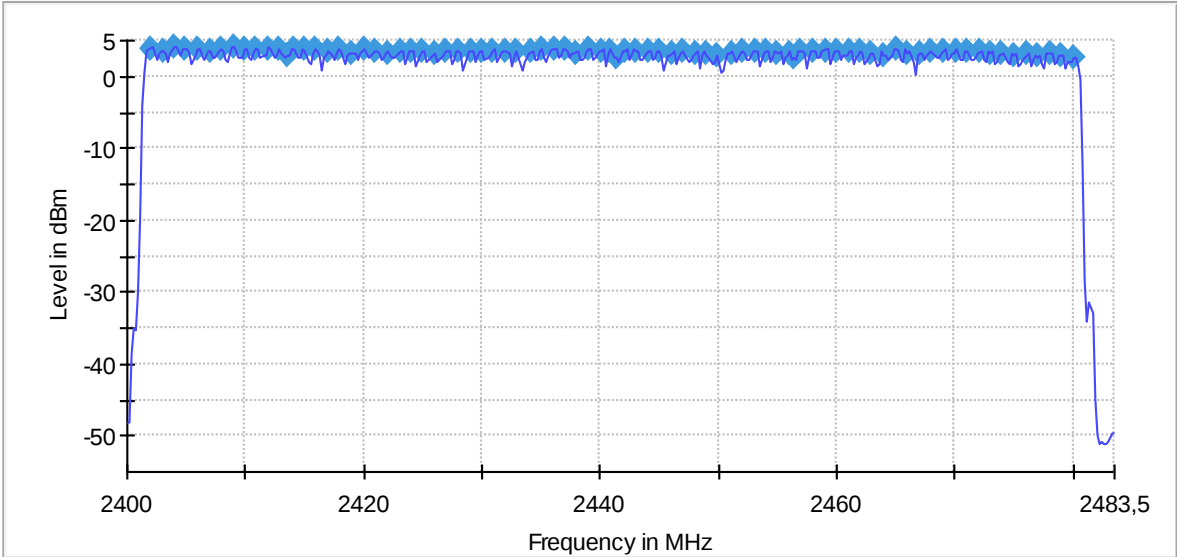
Sequence



Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (8DPSK 3-DH5)

Plots:

Sequence



RSS-247 5.4 (b) / FCC 15.247 (b) Maximum peak output power and antenna gain

Limits

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 hopping channels: 1 watt (30 dBm). The e.i.r.p. shall not exceed 4 W (RSS-247).

Results

The maximum peak conducted output power level of the fundamental emission was measured according to clause 7.8.5 "Output power test procedure for frequency-hopping spread-spectrum (FHSS) devices" of ANSI C63.10-2013.

The EIRP power (dBm) is calculated by adding the maximum declared antenna gain to the measured conducted power.

• Configuration 1

Maximum Declared Antenna Gain: +1.2 dBi

The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

Modulation: BT (GFSK 1-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Maximum Conducted Power (dBm)	Maximum EIRP Power (dBm)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	4.60	5.80
	2441.00000		4.20	5.40
	2480.00000		3.50	4.70

Verdict

Pass

Modulation: BT (Pi/4 DQPSK 2-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Maximum Conducted Power (dBm)	Maximum EIRP Power (dBm)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	6.50	7.70
	2441.00000		5.70	6.90
	2480.00000		5.20	6.40

Verdict

Pass

Modulation: BT (8DPSK 3-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Maximum Conducted Power (dBm)	Maximum EIRP Power (dBm)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	6.50	7.70
	2441.00000		6.20	7.40
	2480.00000		5.30	6.50

Verdict

Pass

• Configuration 2

Maximum Declared Antenna Gain: +3 dBi

The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

Modulation: BT (GFSK 1-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Maximum Conducted Power (dBm)	Maximum EIRP Power (dBm)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	4.60	7.60
	2441.00000		4.20	7.20
	2480.00000		3.50	6.50

Verdict

Pass

Modulation: BT (Pi/4 DQPSK 2-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Maximum Conducted Power (dBm)	Maximum EIRP Power (dBm)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	6.50	9.50
	2441.00000		5.70	8.70
	2480.00000		5.20	8.20

Verdict

Pass

Modulation: BT (8DPSK 3-DH5)

Operation Band (MHz)	Freq (MHz)	Equipment	Maximum Conducted Power (dBm)	Maximum EIRP Power (dBm)
[2400, 2483.5]	2402.00000	Frequency Hopping Spread Spectrum systems (DSS)	6.50	9.50
	2441.00000		6.20	9.20
	2480.00000		5.30	8.30

Verdict

Pass

RSS-247 5.5 / FCC 15.247 (d) Band-edge emissions compliance (Transmitter)

Limits

In any 100 kHz bandwidths outside the frequency band in which the 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, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Results

Radiated measurements were used to show compliance with the limits in the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

Modulation: BT (GFSK 1-DH5)

Verdict

Pass

Modulation: BT (Pi/4 DQPSK 2-DH5)

Verdict

Pass

Modulation: BT (8DPSK 3-DH5)

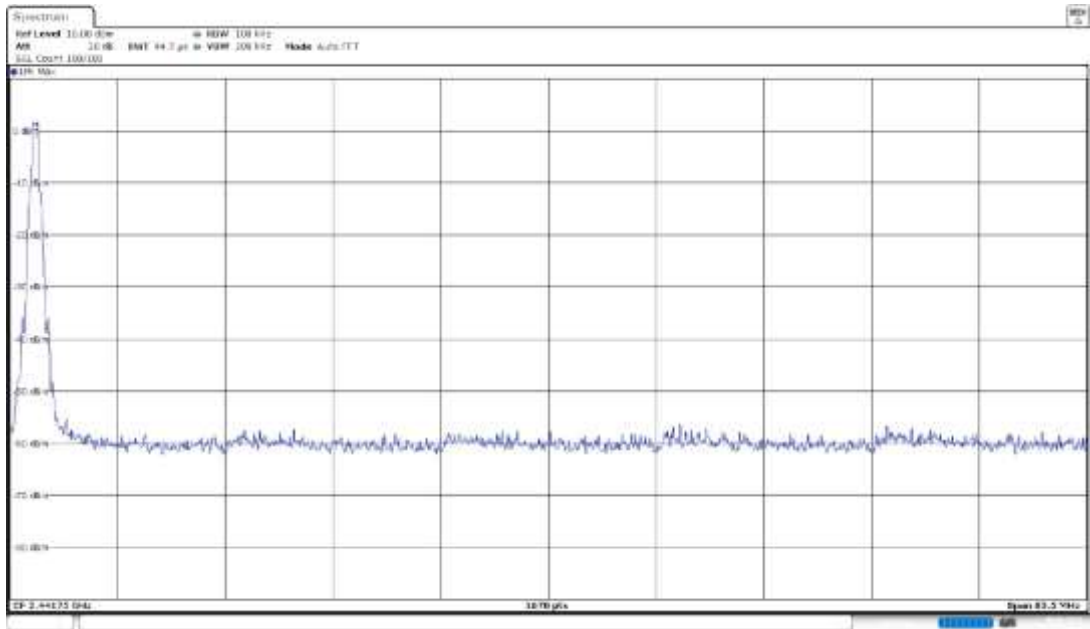
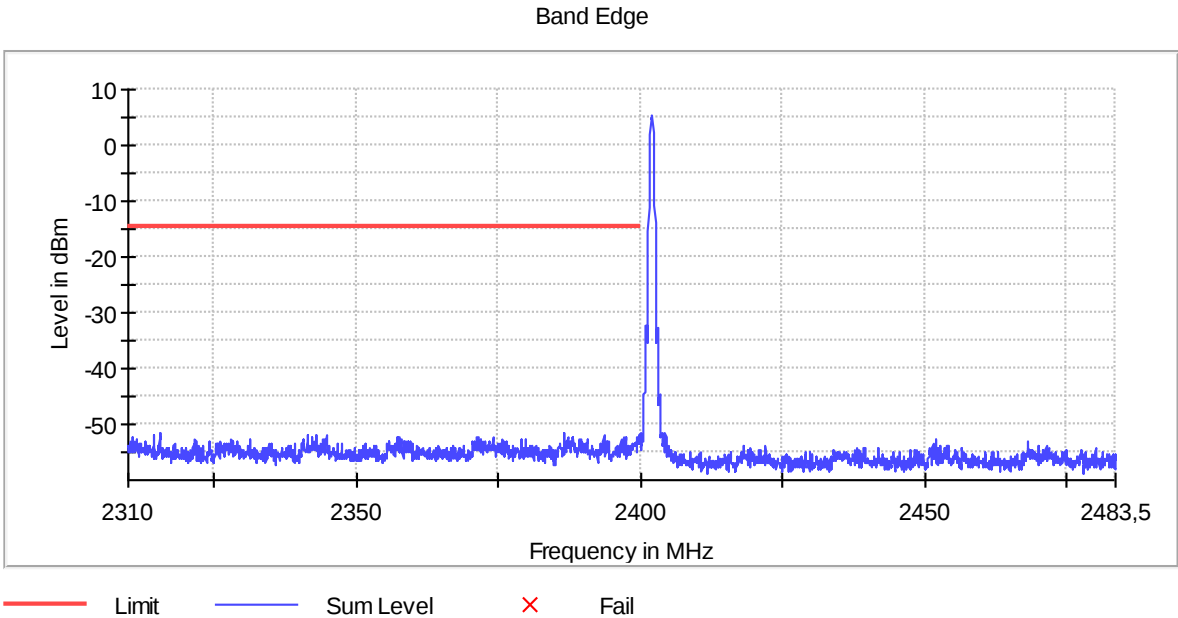
Verdict

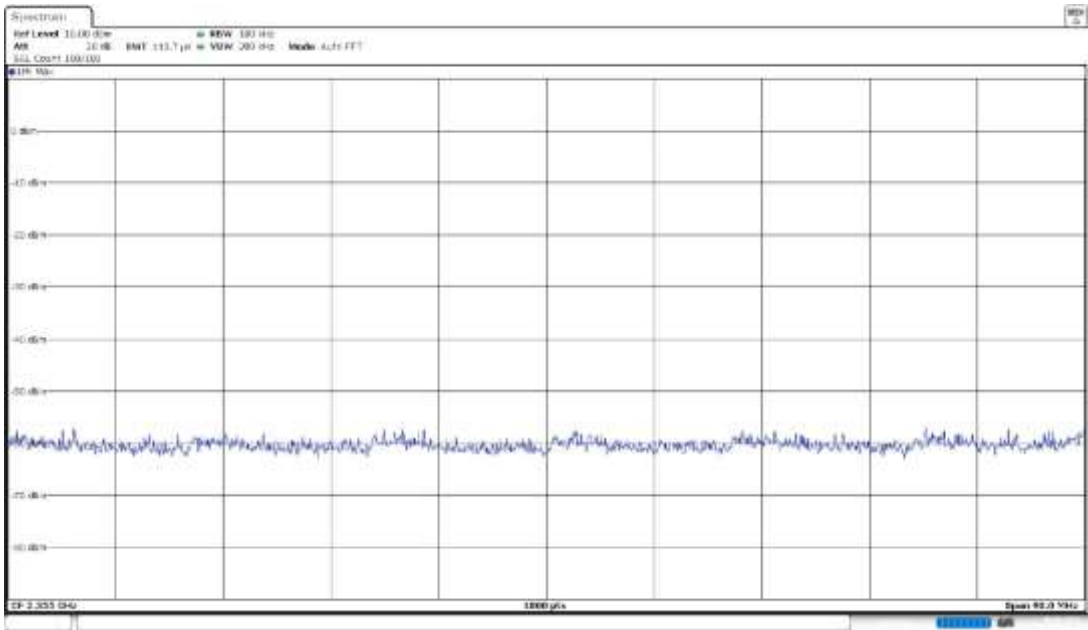
Pass

Attachments

Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2402.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5)

Plots:

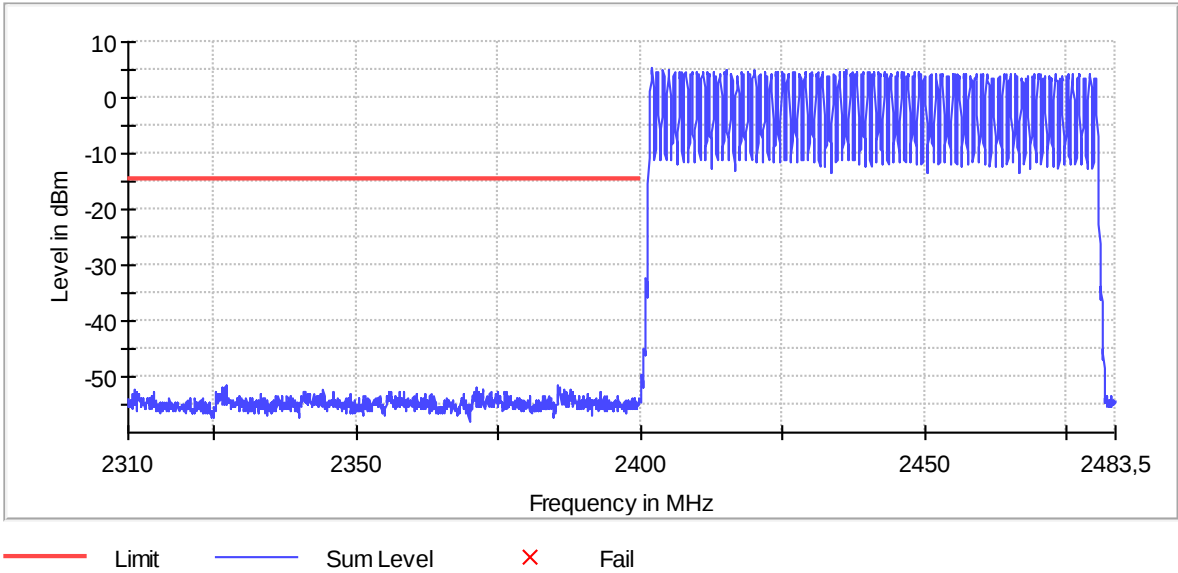


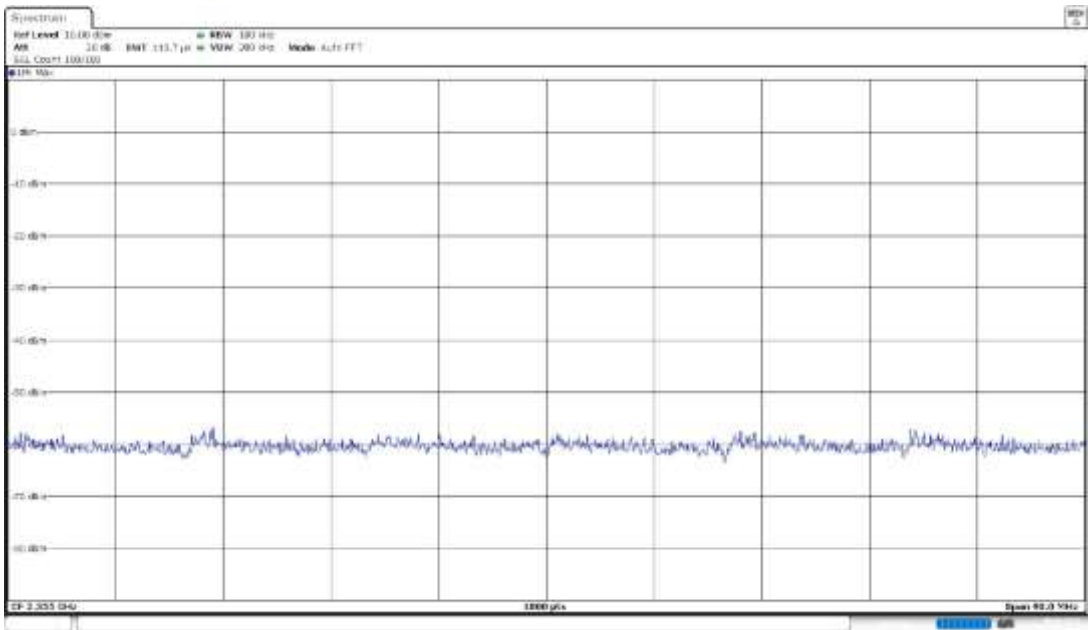
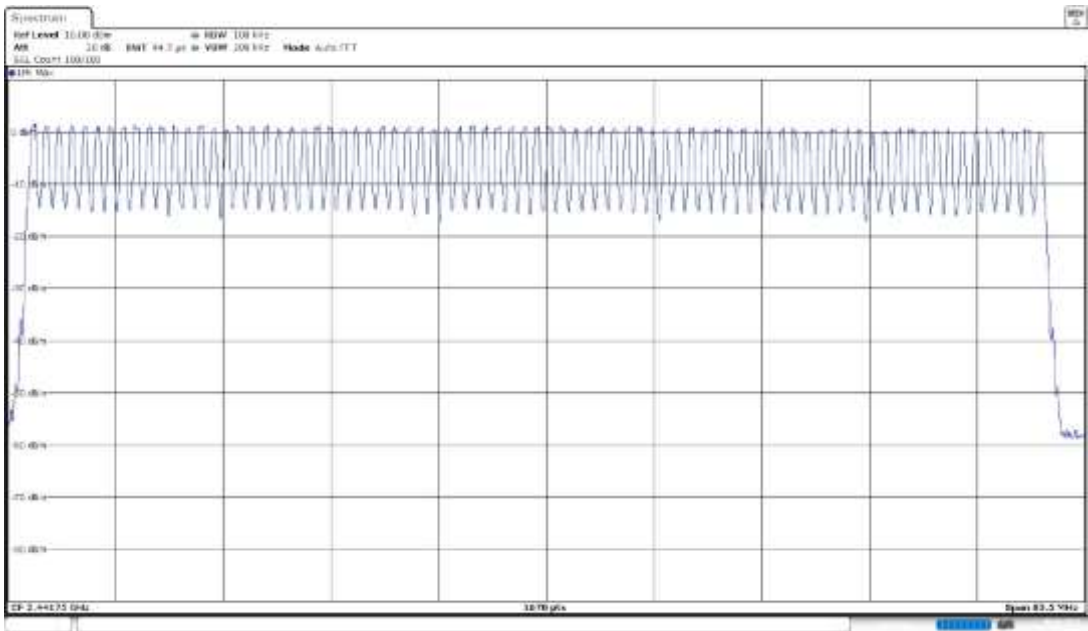


Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5) – hopping

Plots:

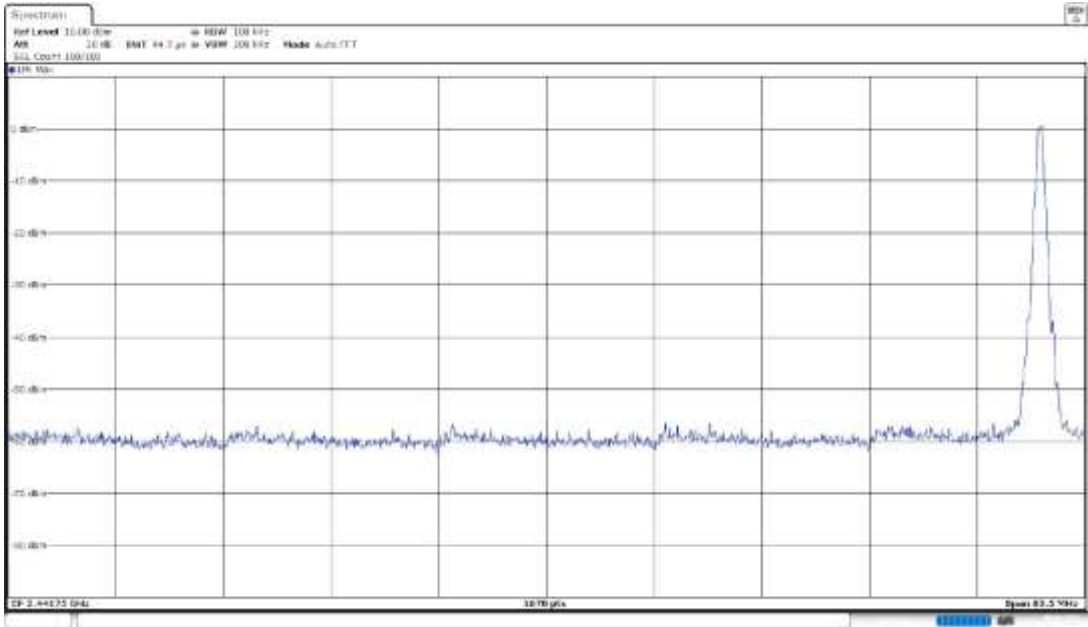
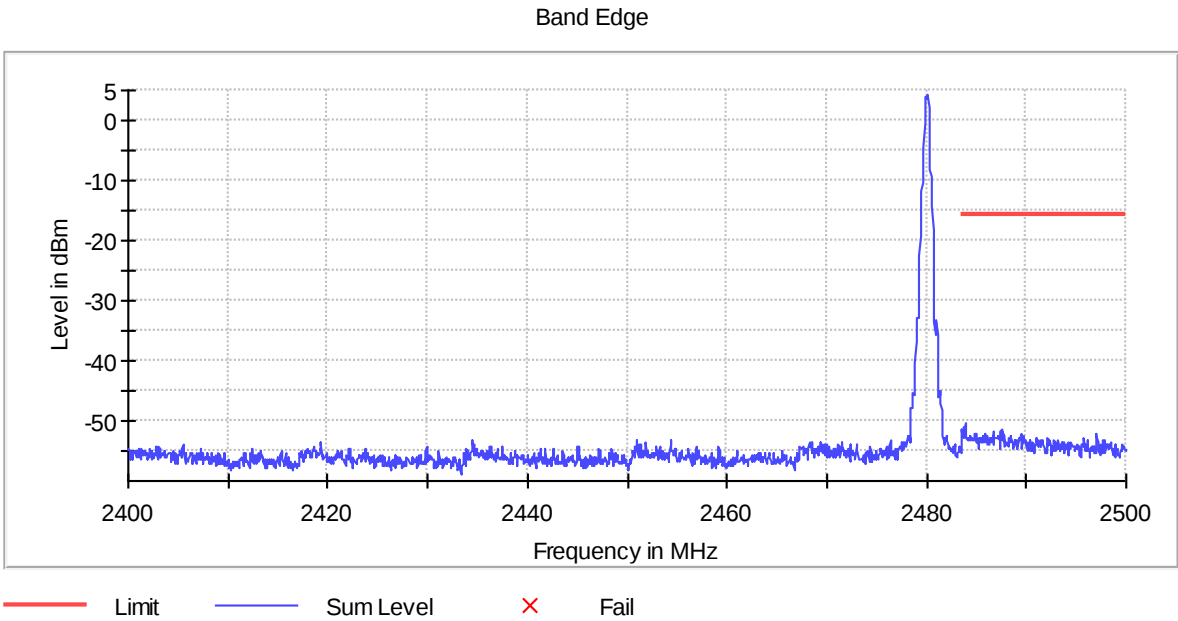
Band Edge

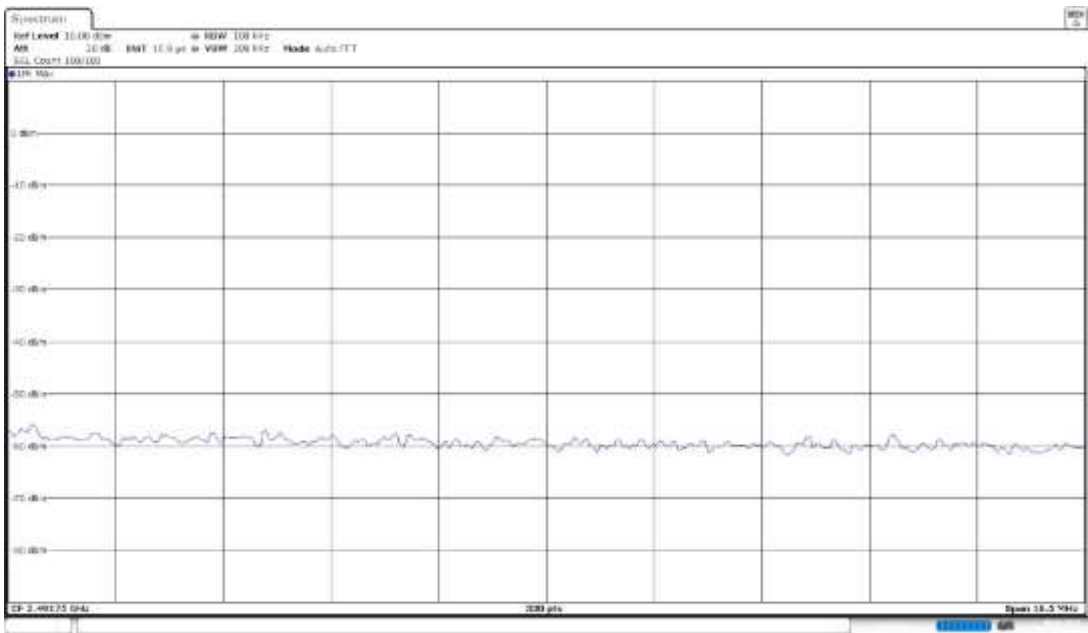




Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5)

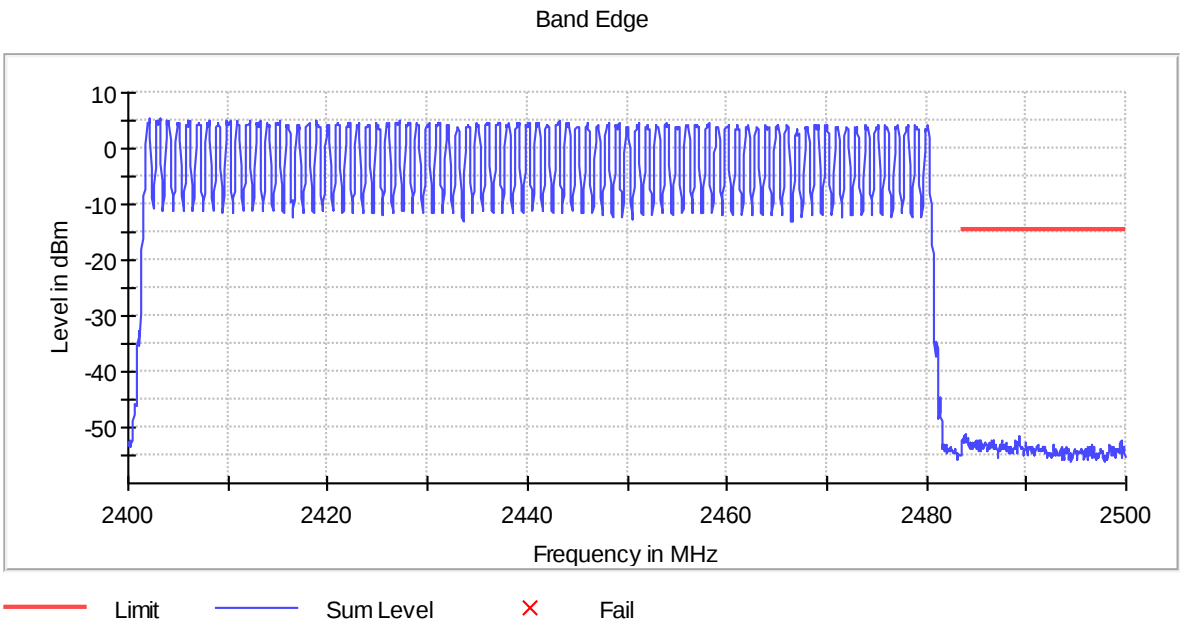
Plots:

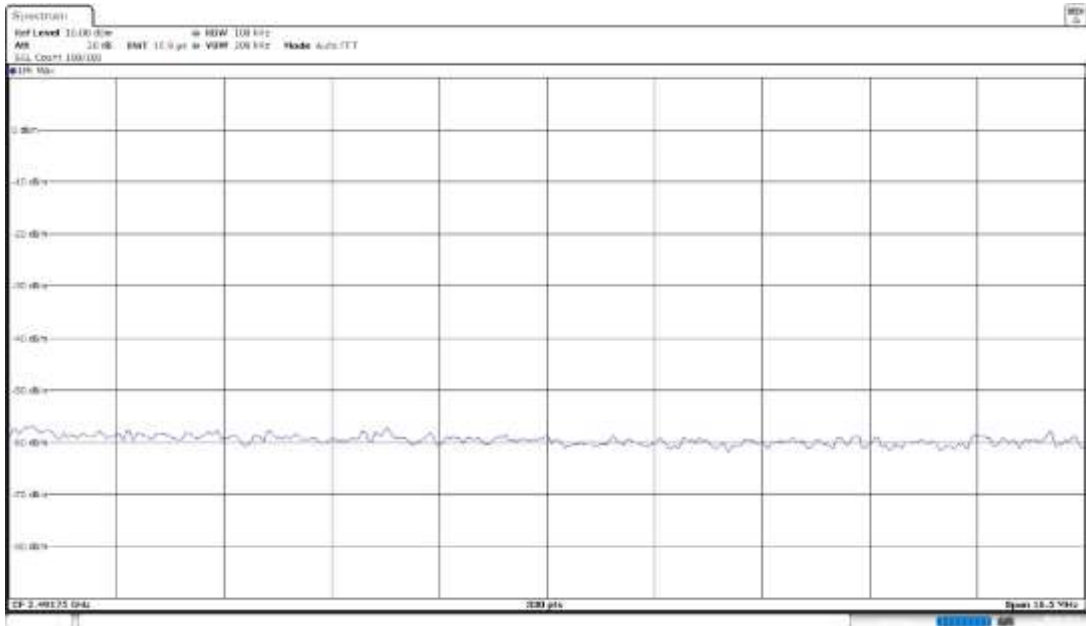
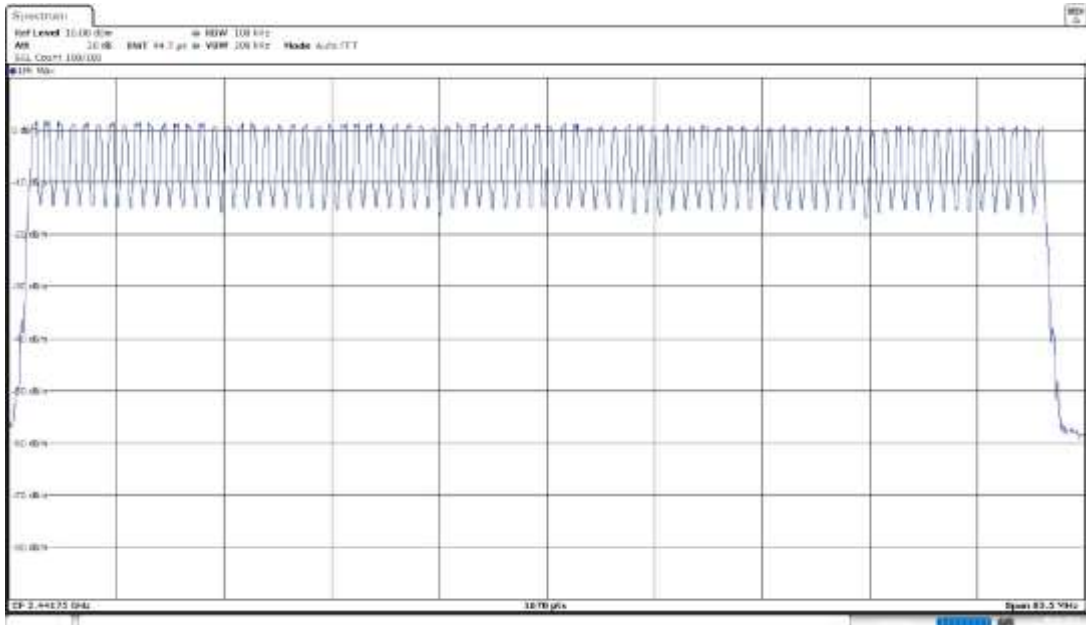




Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5) – hopping

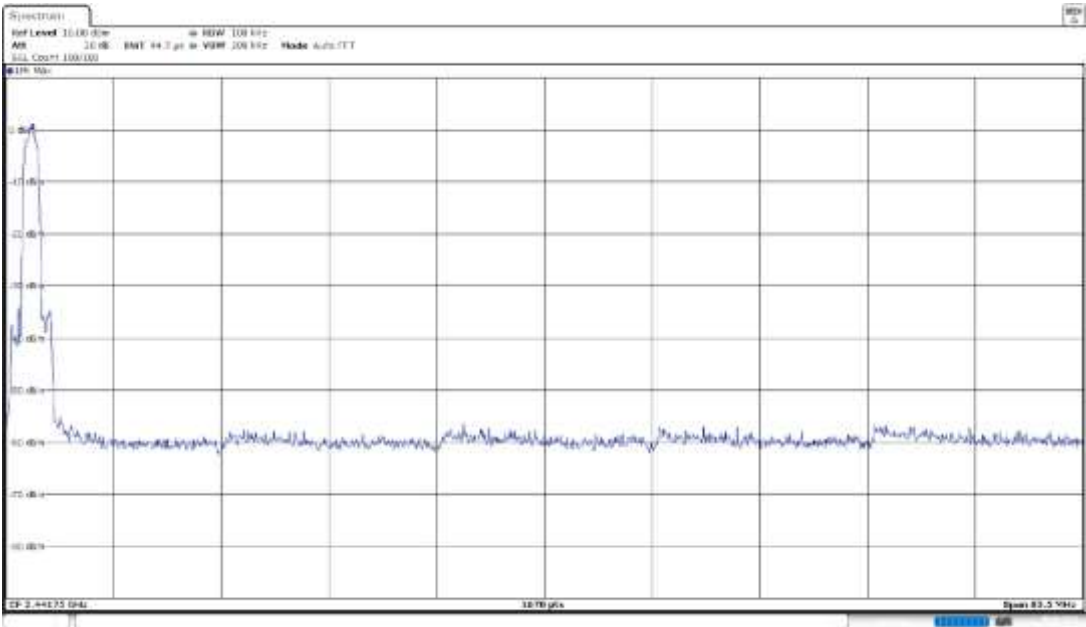
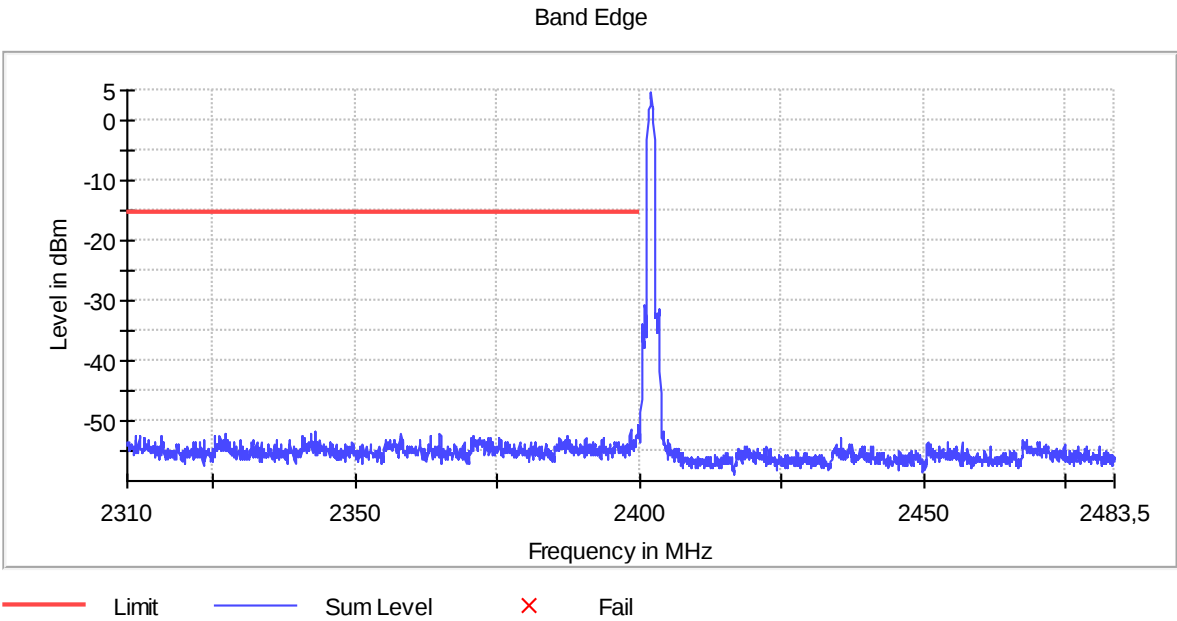
Plots:

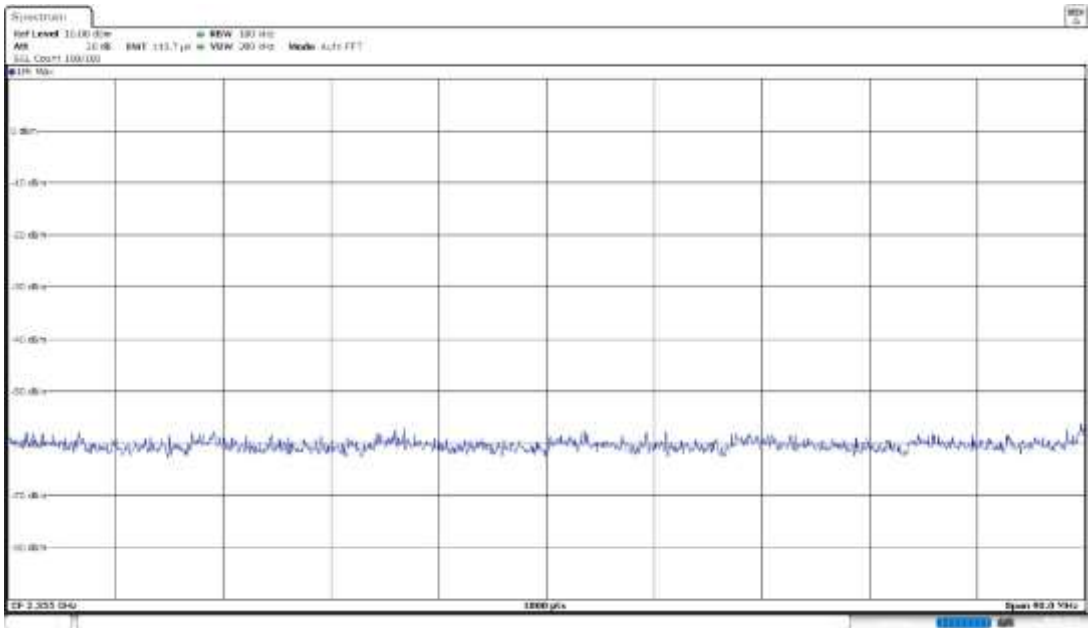




Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2402.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5)

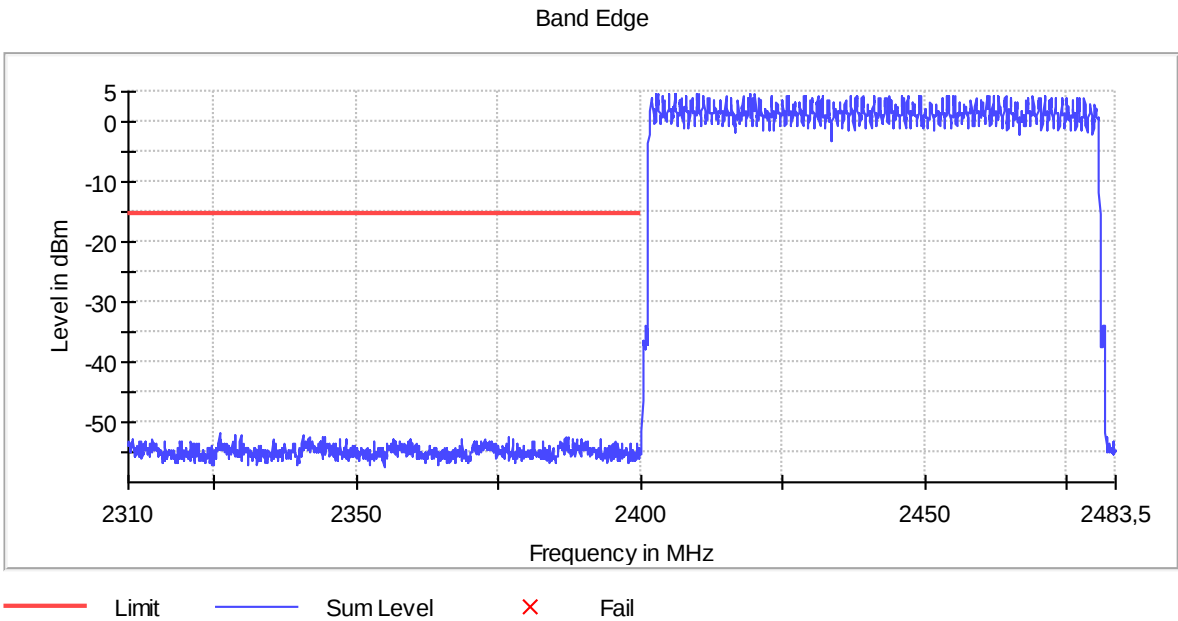
Plots:

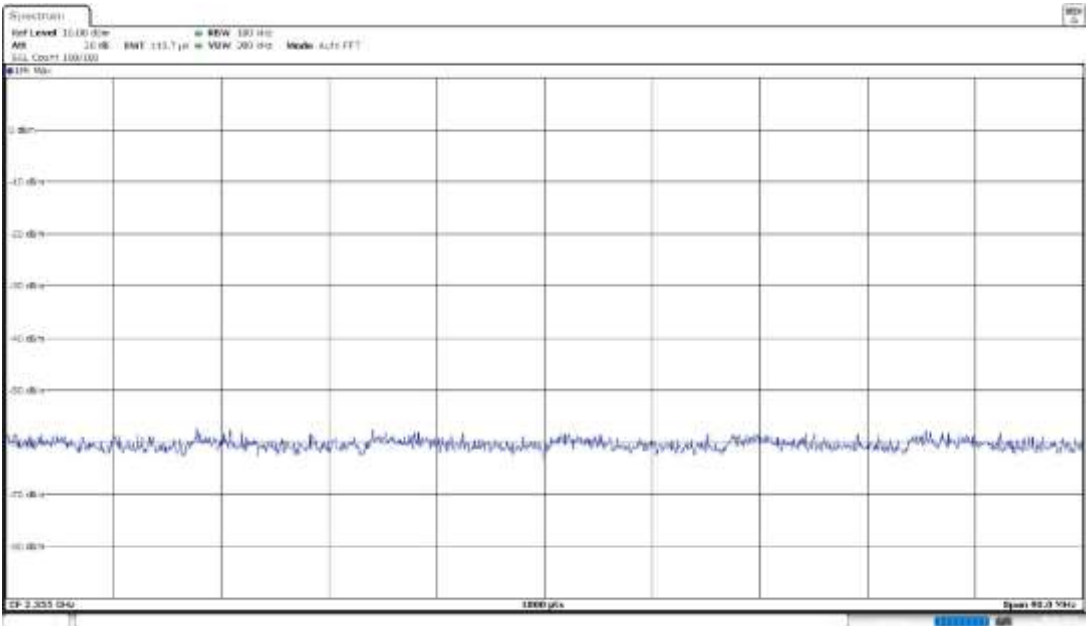
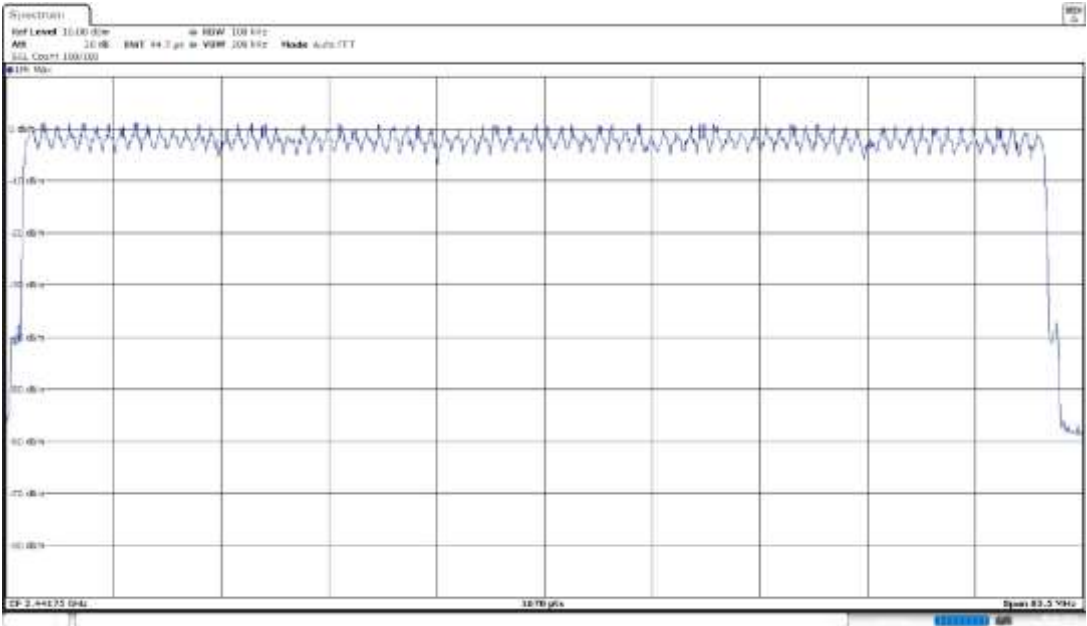




Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5) – hopping

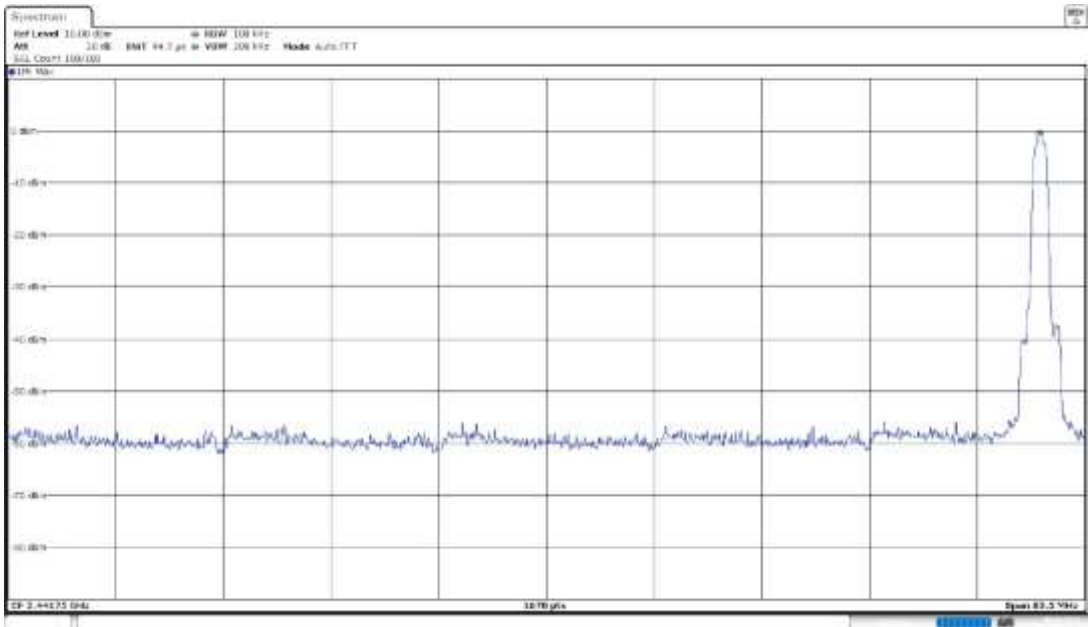
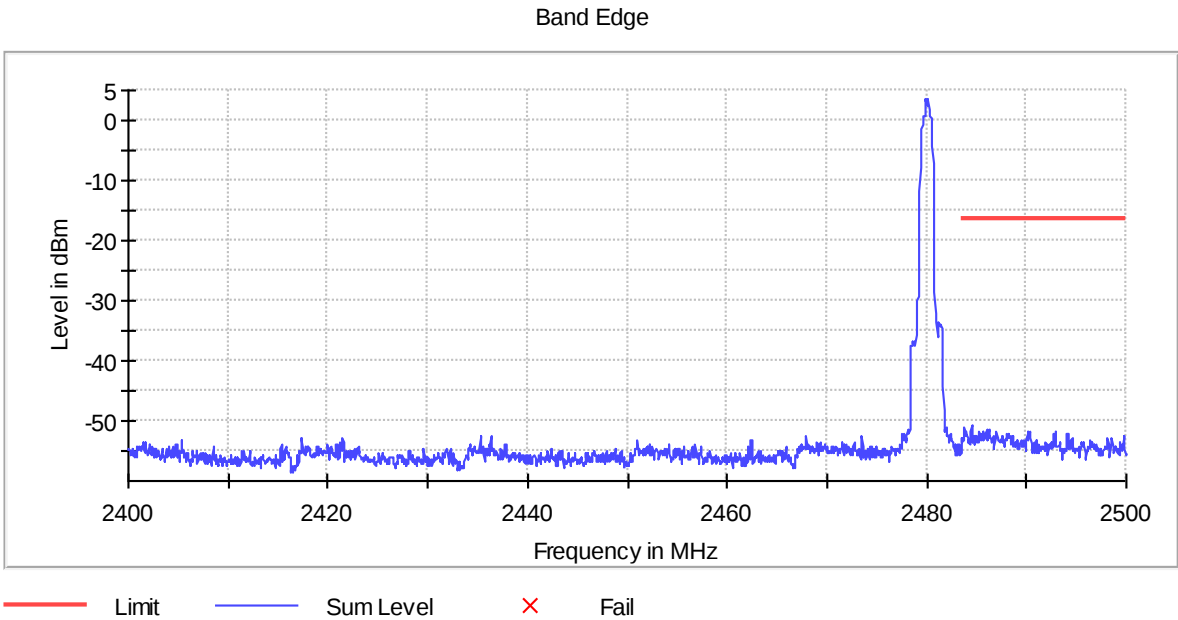
Plots:

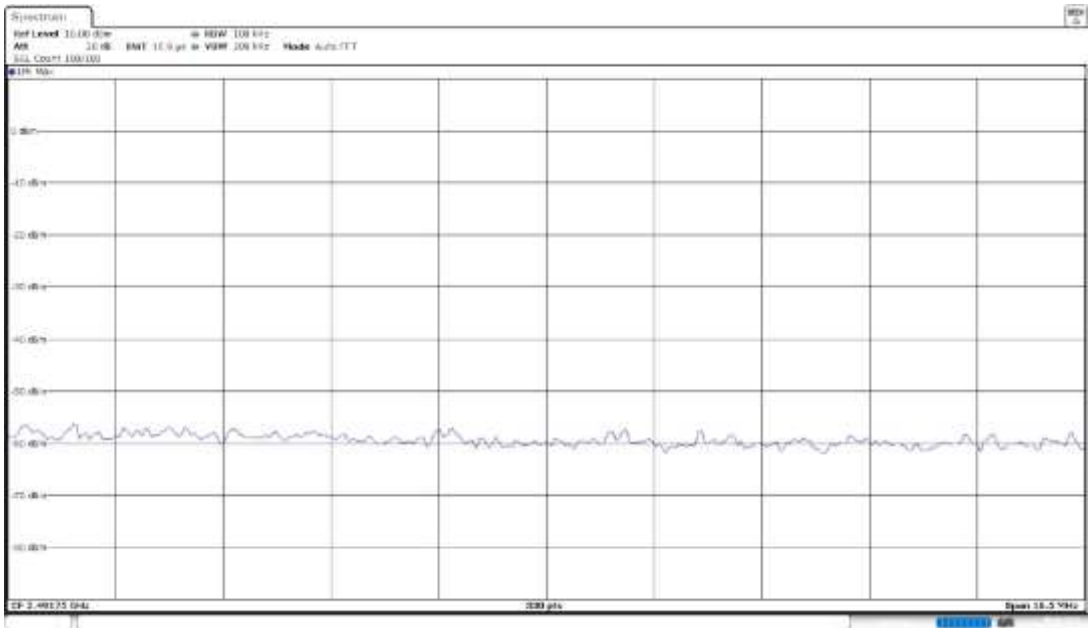




Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5)

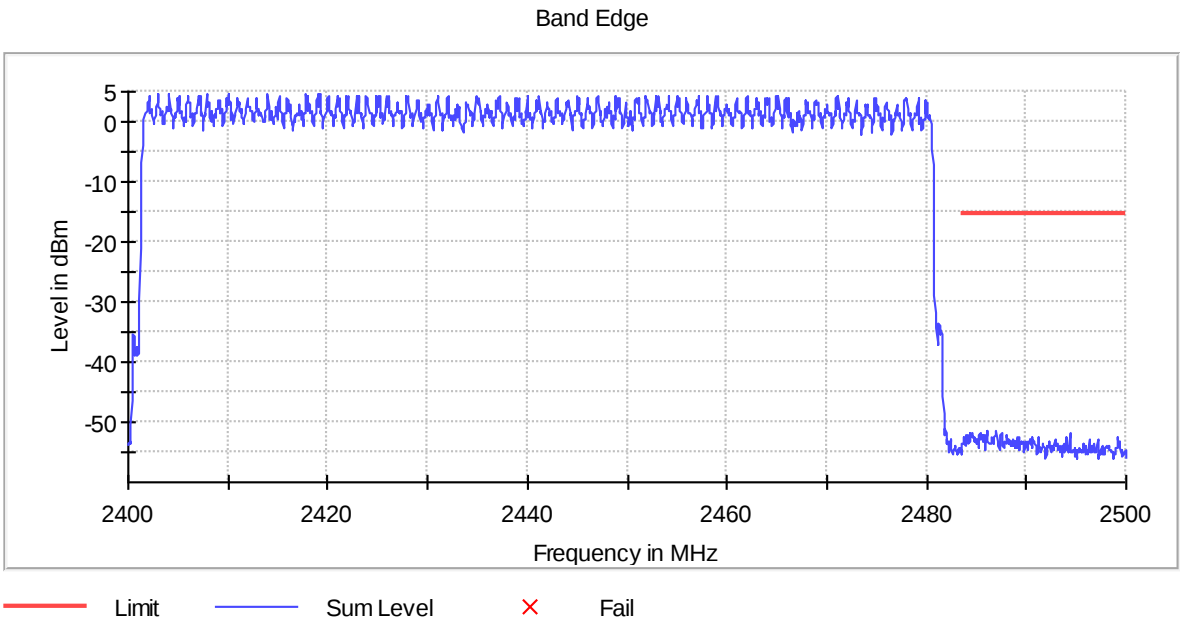
Plots:

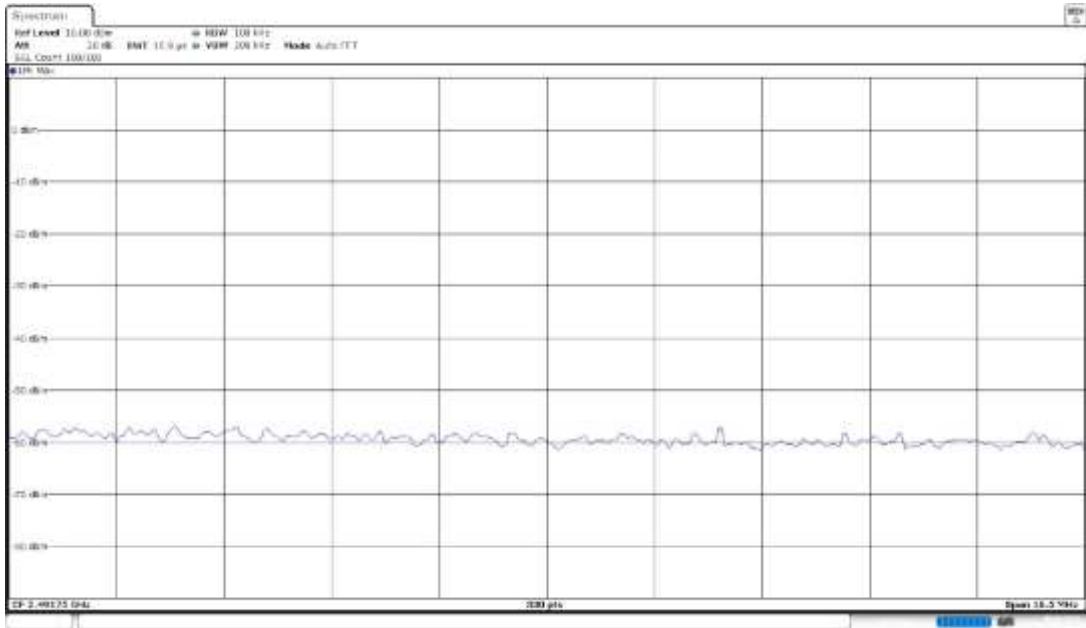
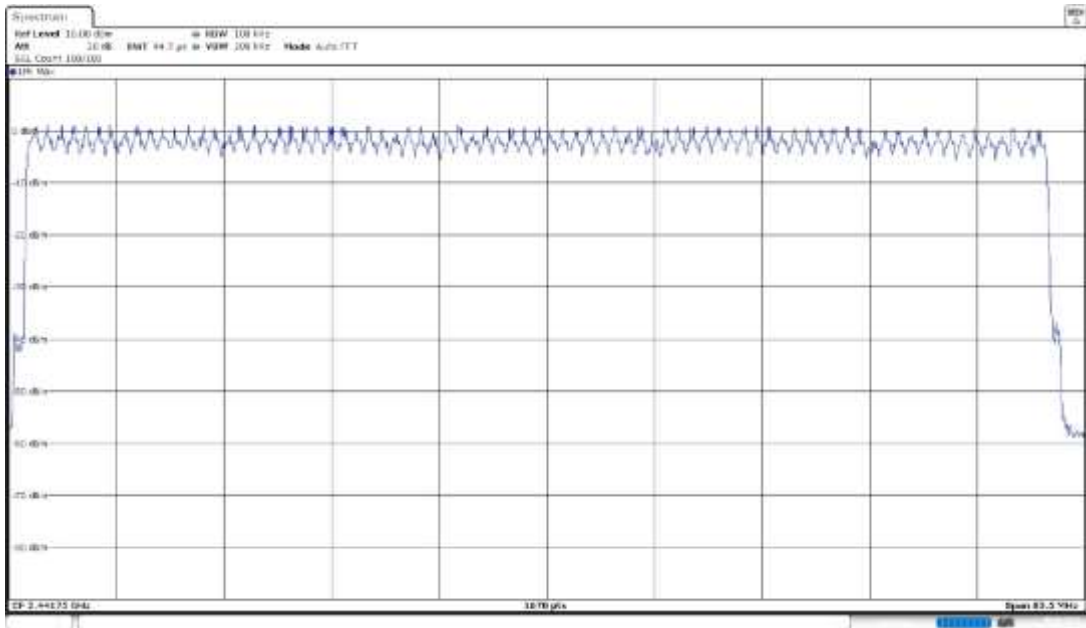




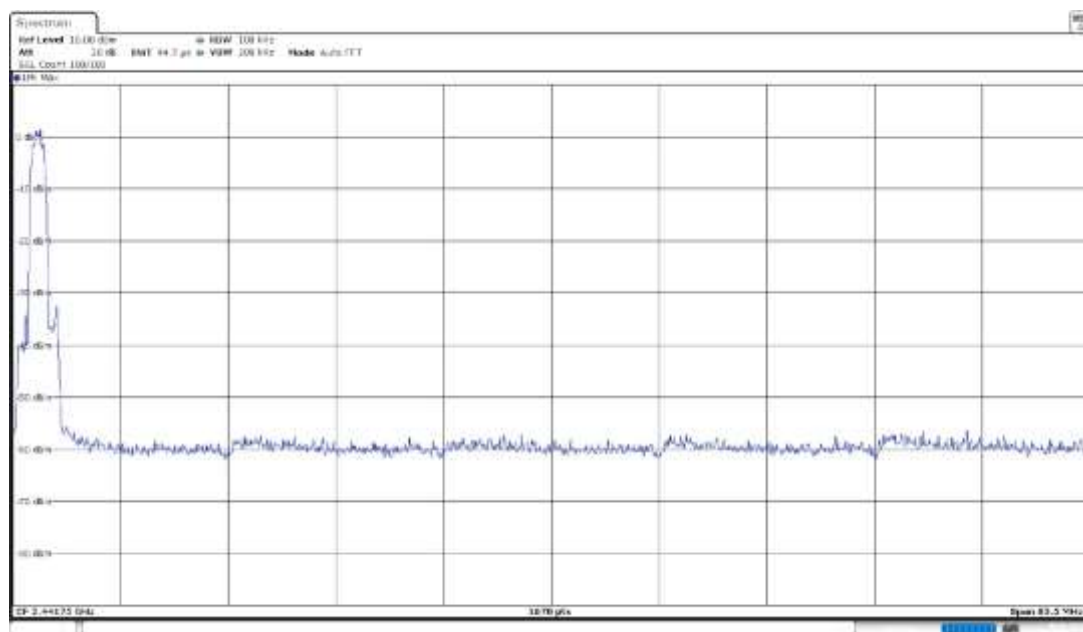
Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5) – hopping

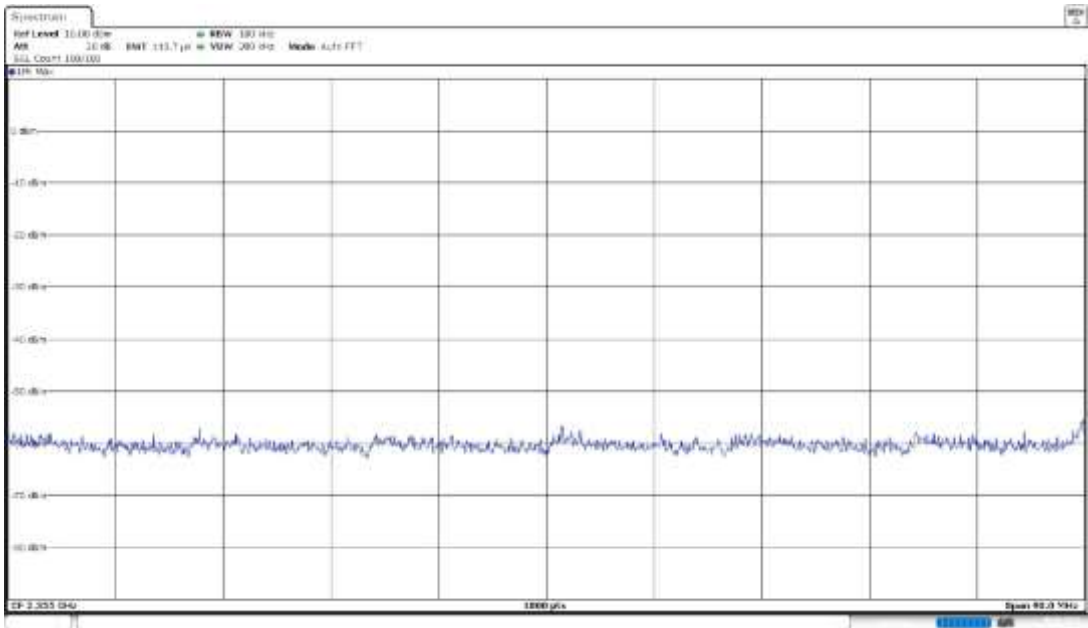
Plots:





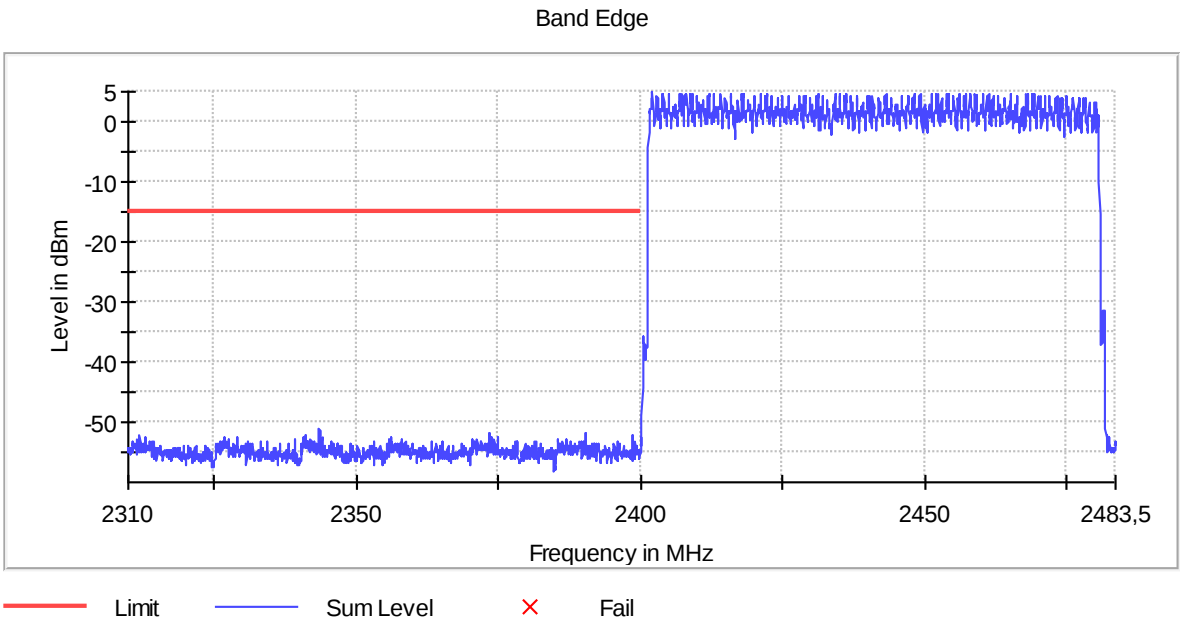
Plots:

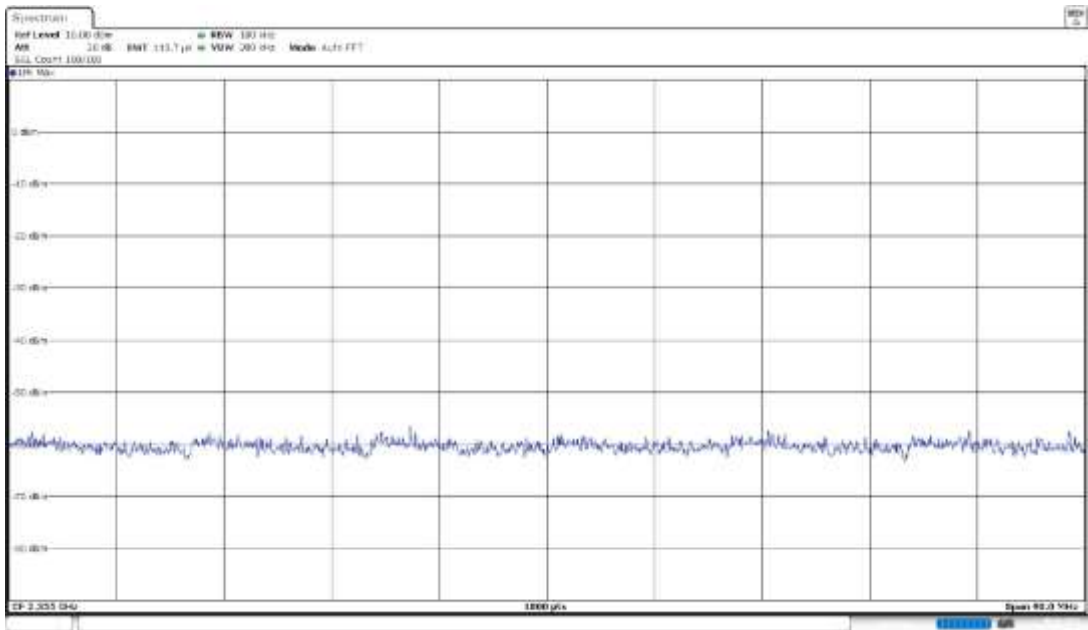
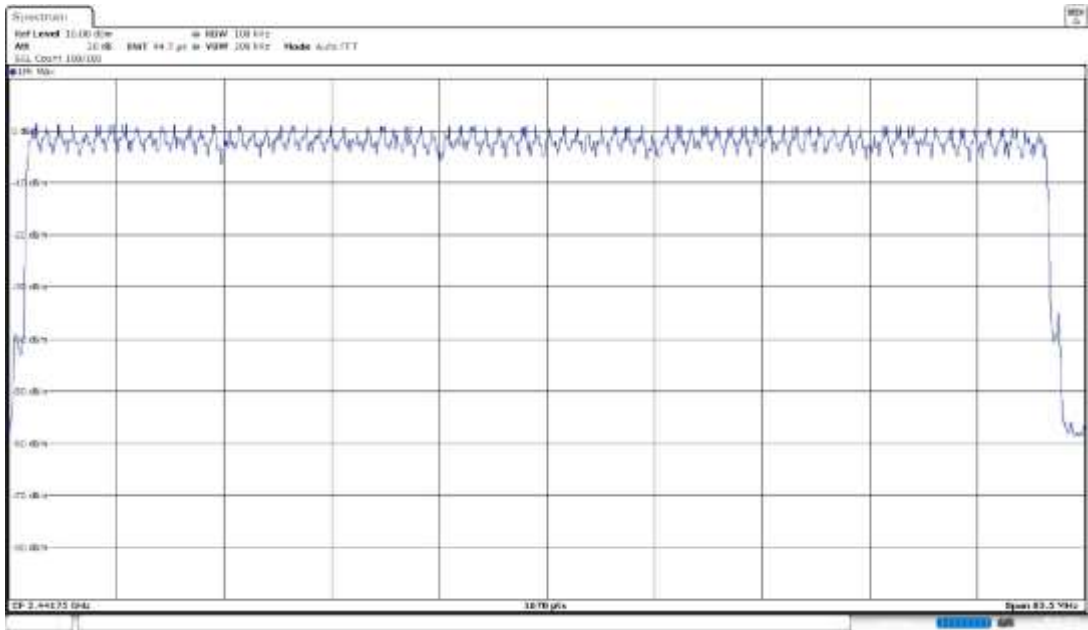




Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (8DPSK 3-DH5) – hopping

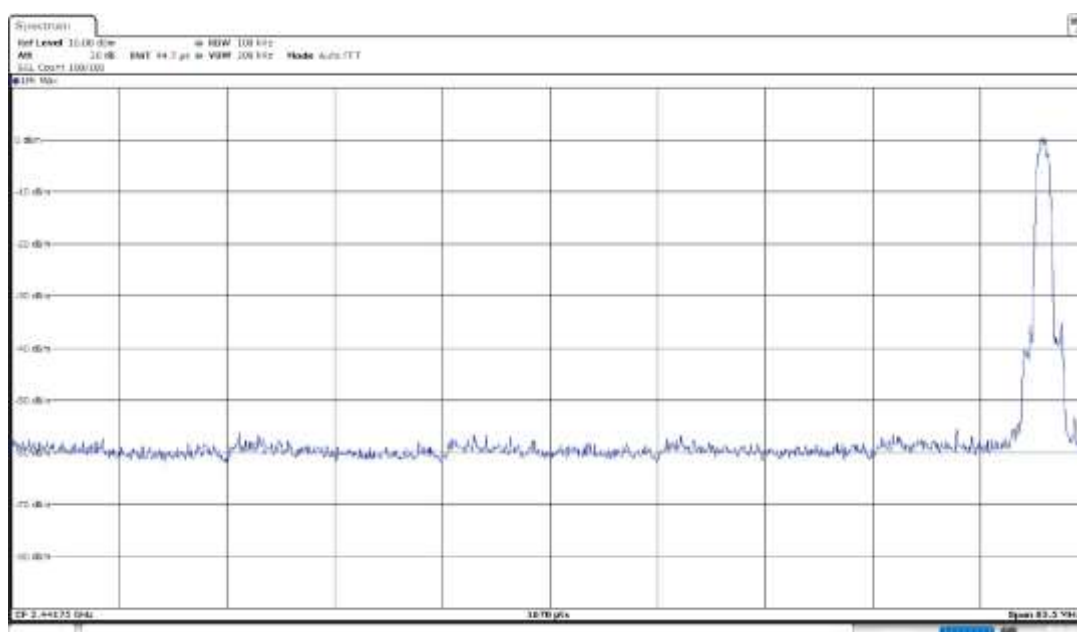
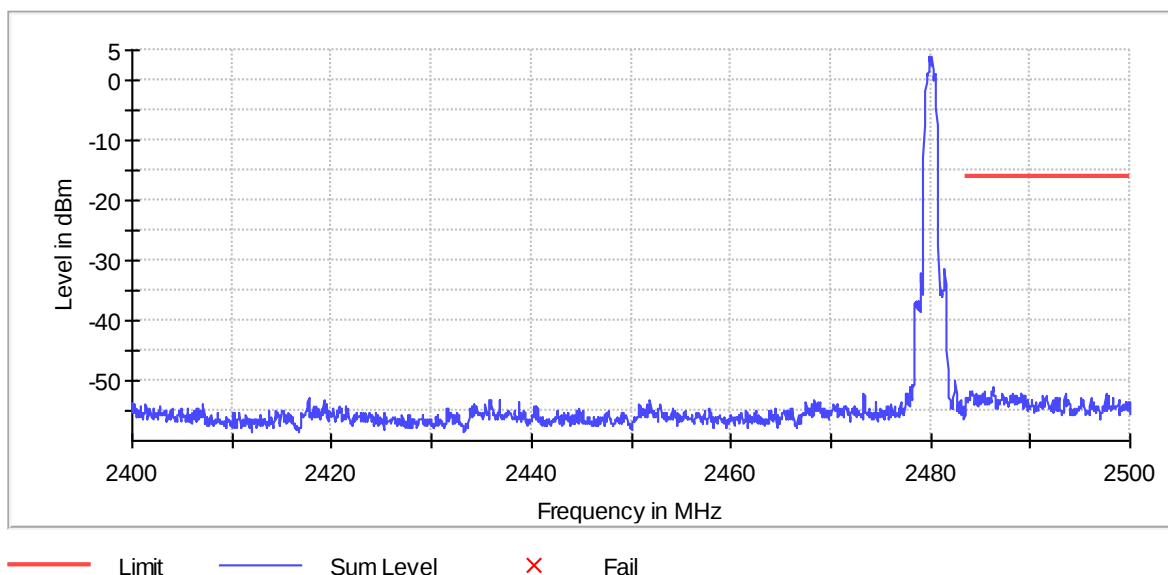
Plots:

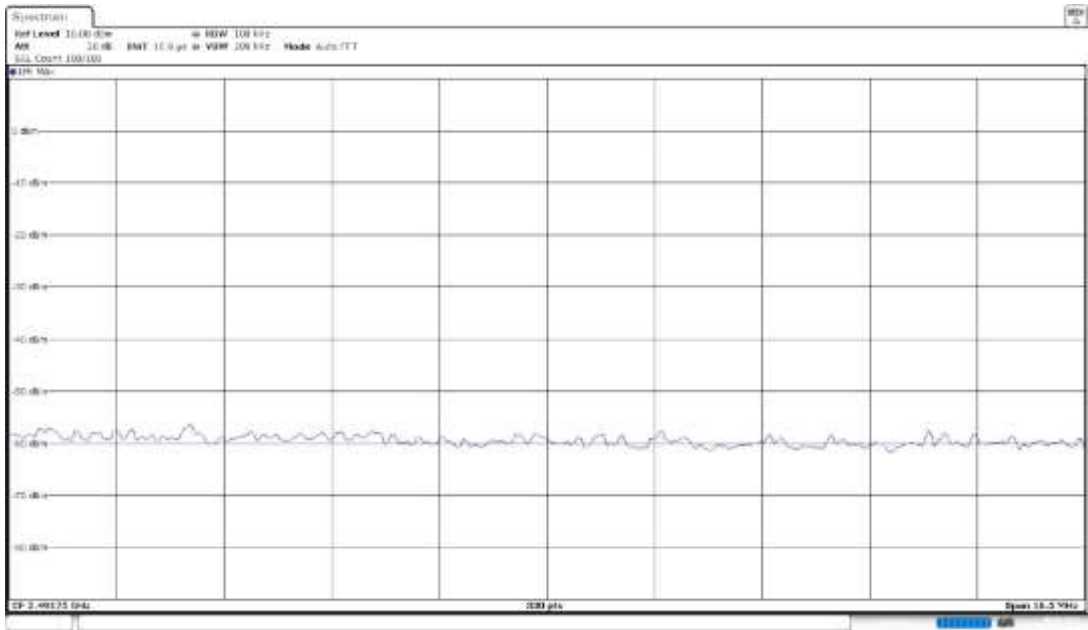




Plots:

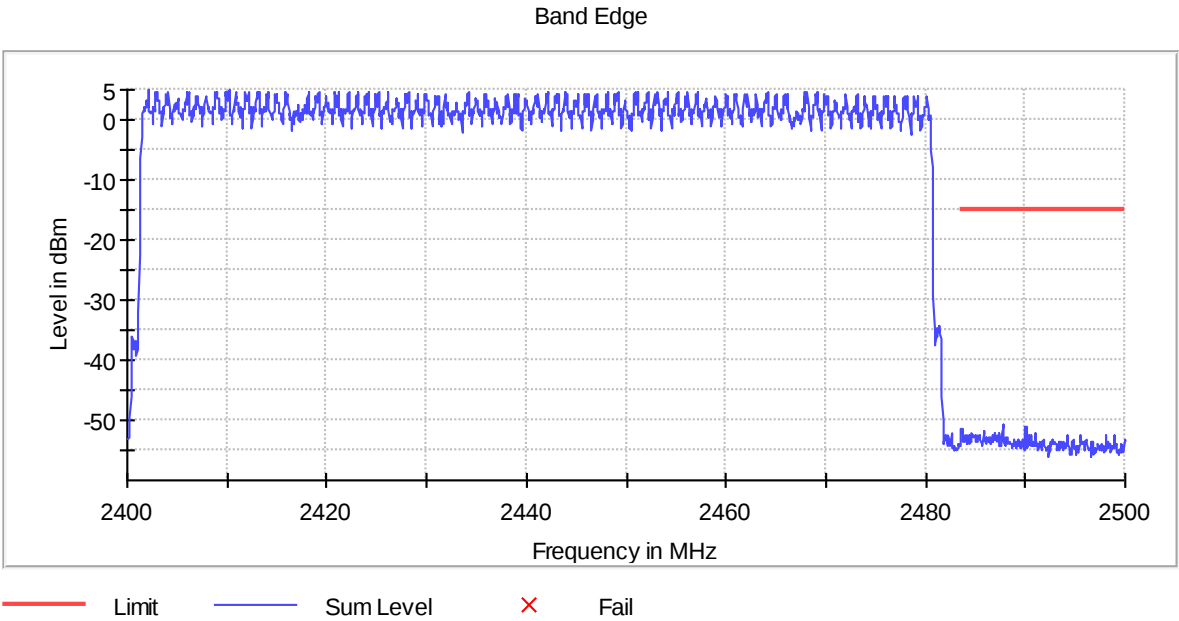
Band Edge

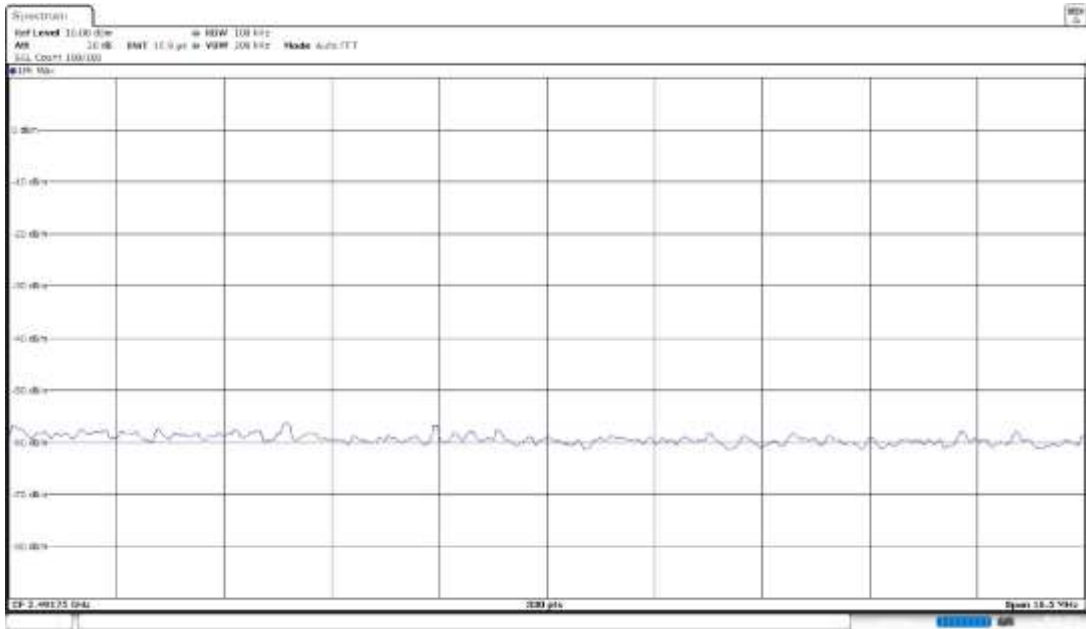
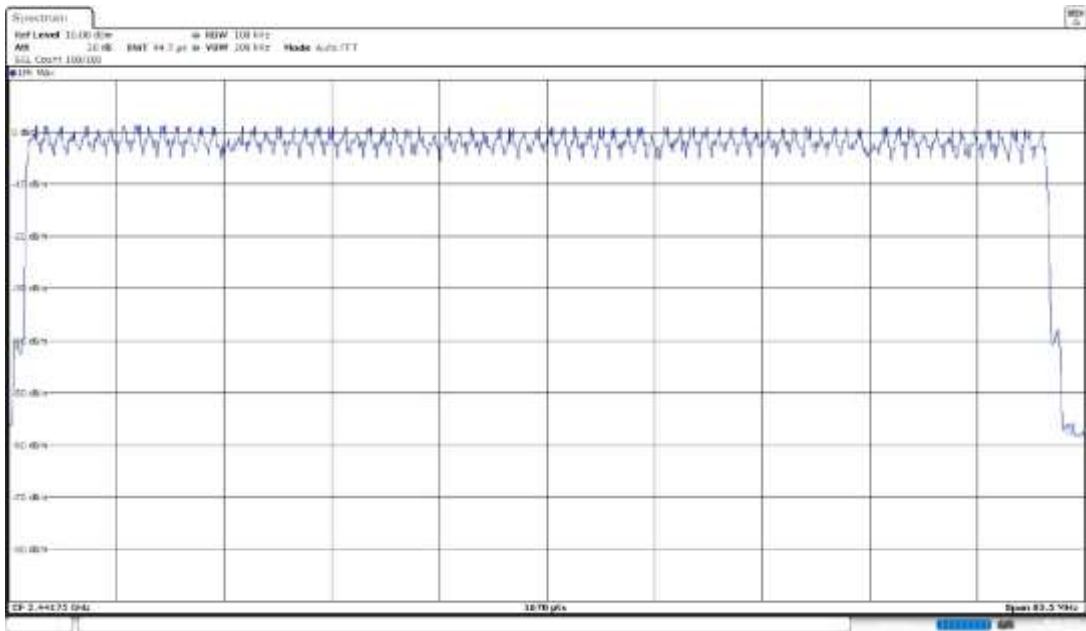




Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (8DPSK 3-DH5) – hopping

Plots:





RSS-247 5.5 / FCC 15.247 (d) Emission limitations radiated (Transmitter)

Limits

Radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c) / RSS-Gen):

Frequency Range (MHz)	Field strength ($\mu\text{V/m}$)	Field strength (dB $\mu\text{V/m}$)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
Above 960	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit specified when measuring with peak detector function, corresponding to 20 dB above the indicated values in the table.

RSS-247:

Attenuation below the general field strength limits specified in RSS-Gen is not required.

- Configuration 1**

Results

Frequency range 30 MHz – 1 GHz:

The spurious frequencies detected do not depend either on the operating channel or the modulation mode.

Spurious frequencies detected at less than 20 dB below the limit:

Freq Rng (GHz)	Unwanted Freq (MHz)	Unwanted Lvl (dB $\mu\text{V/m}$)	Pol	Detector
[0.03, 1]	124.9953	37.85	H	QP
	259.9870	32.12	H	QP
	374.9967	40.00	H	QP
	450.0100	41.84	H	QP
	625.0303	33.37	V	QP

Verdict

Pass

Frequency range 1 GHz – 26 GHz:

Spurious frequencies with peak levels above the average limit (54 dB μ V/m at 3 m) are measured with average detector for average compliance checking.

Modulation: BT (GFSK 1-DH5)

Spurious frequencies detected at less than 20 dB below the limit:

Freq (MHz)	Freq Rng (GHz)	Unwanted Freq (MHz)	Unwanted Lvl (dB μ V/m)	Pol	Detector
2441.00000	[3, 17]	4881.9238	41.65	H	Peak

Modulation: BT (Pi/4 DQPSK 2-DH5)

Spurious frequencies detected at less than 20 dB below the limit:

Freq (MHz)	Freq Rng (GHz)	Unwanted Freq (MHz)	Unwanted Lvl (dB μ V/m)	Pol	Detector
2441.00000	[3, 17]	4881.9732	42.87	V	Peak

Modulation: BT (8DPSK 3-DH5)

Spurious frequencies detected at less than 20 dB below the limit:

Freq (MHz)	Freq Rng (GHz)	Unwanted Freq (MHz)	Unwanted Lvl (dB μ V/m)	Pol	Detector
2402.00000	[3, 17]	4804.0725	42.25	V	Peak

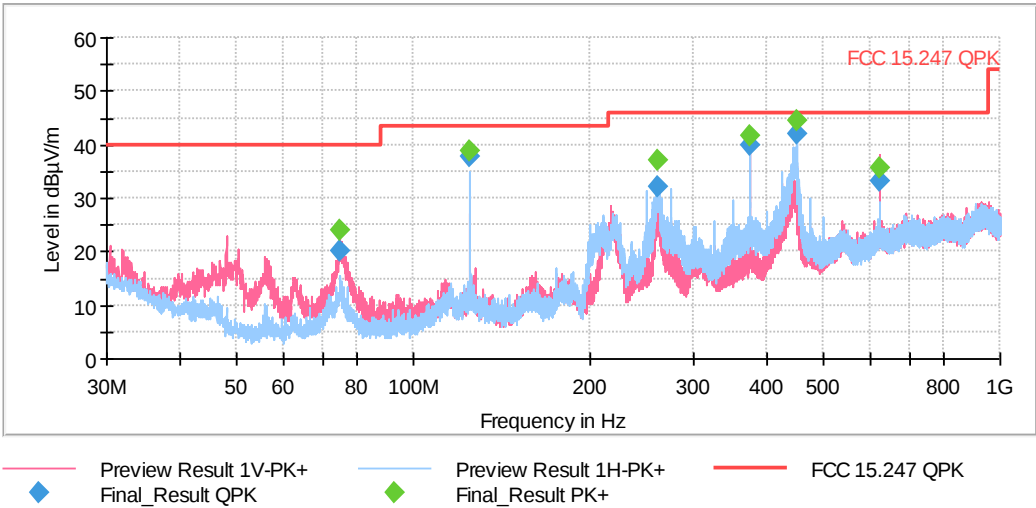
Verdict

Pass

Attachments

Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5), Frequency Range (GHz) = [0.03, 1]

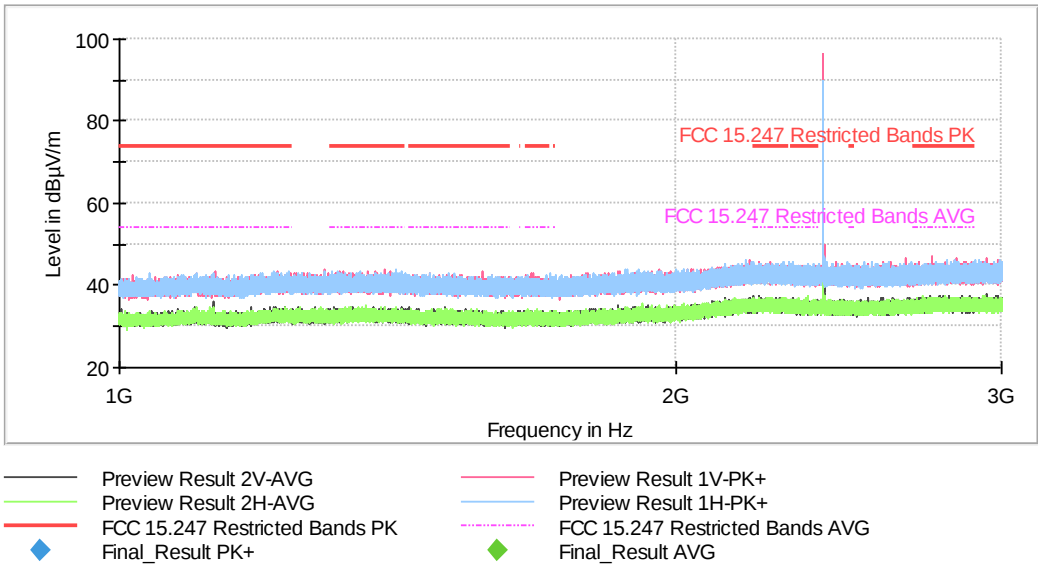
Plots:



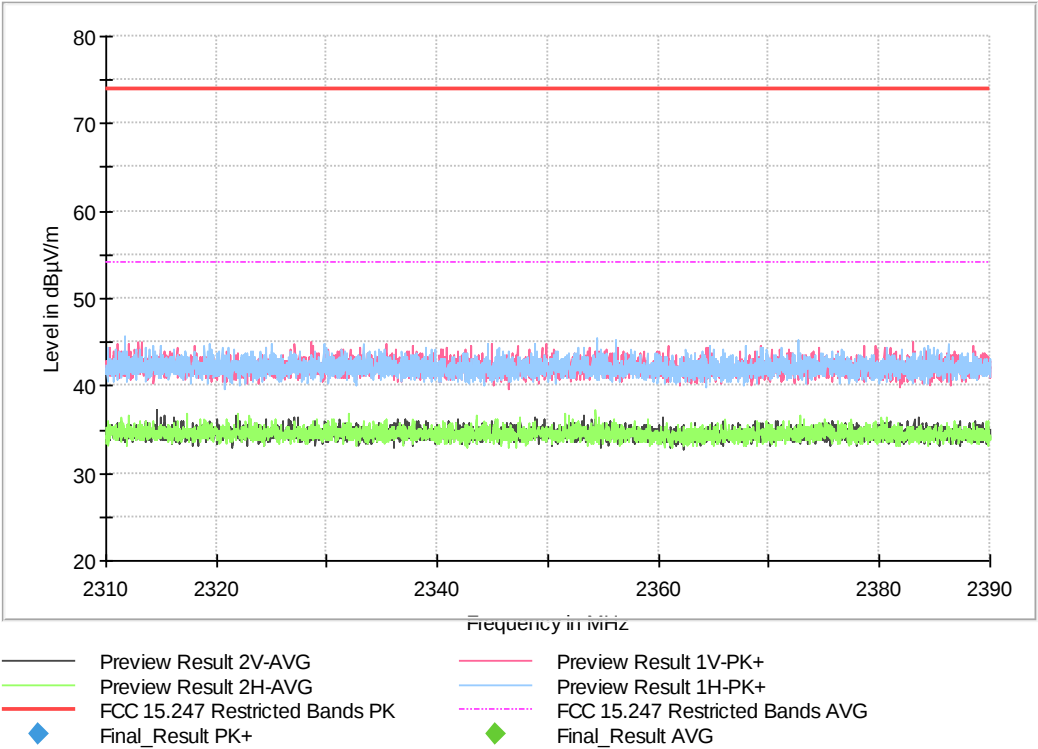
This plot is valid for Low, Middle and High Channels.

Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2402.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5), Frequency Range (GHz) = [1, 3]

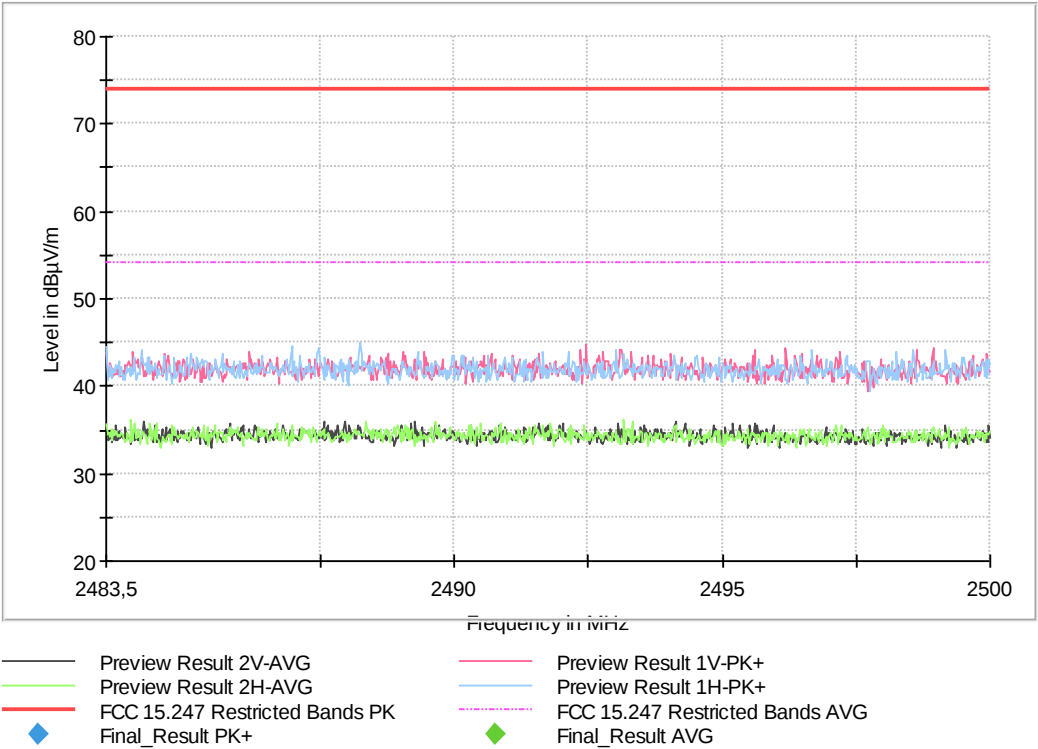
Plots:



Full Spectrum

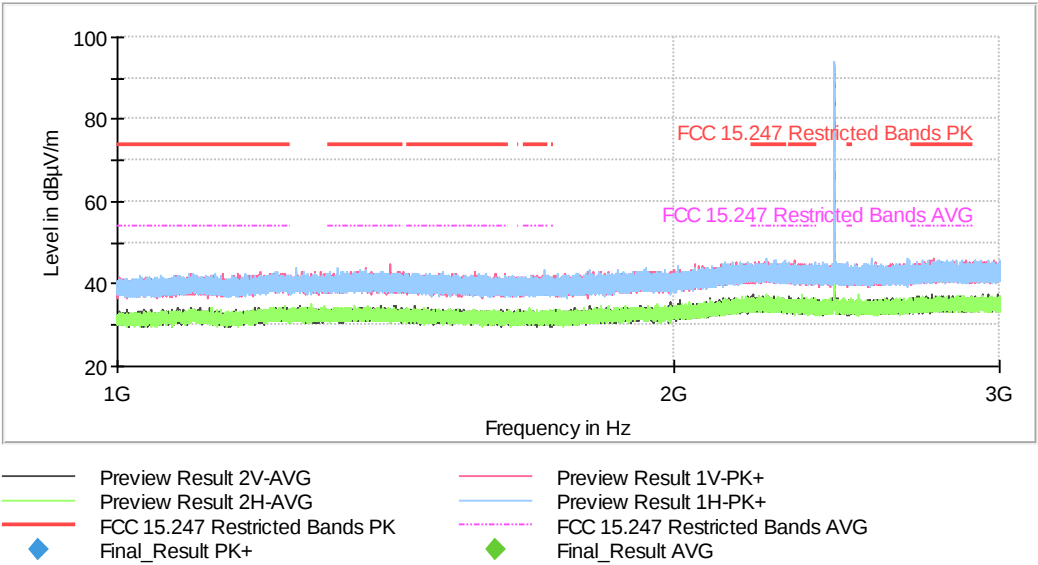


Full Spectrum

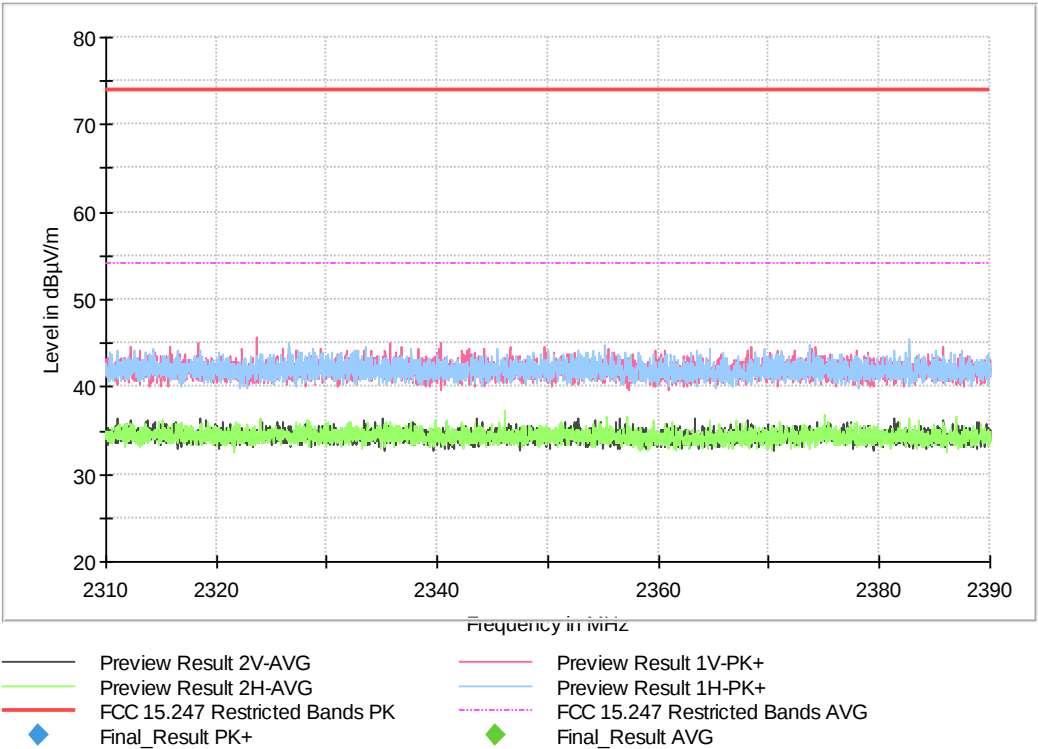


Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2441.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5), Frequency Range (GHz) = [1, 3]

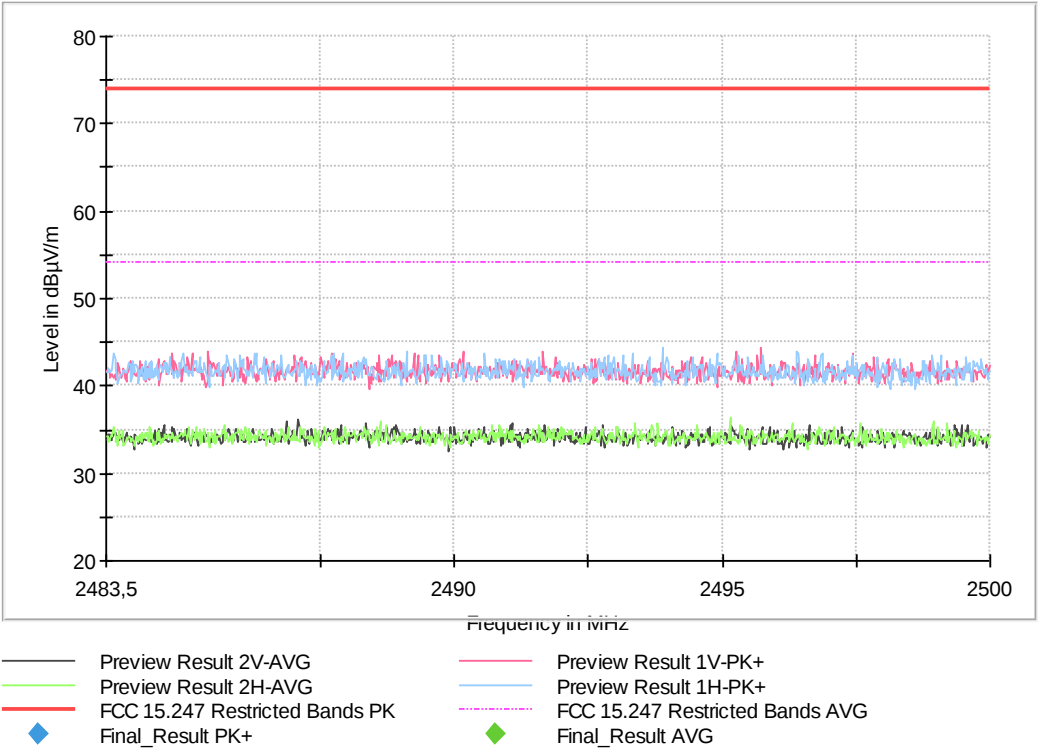
Plots:



Full Spectrum

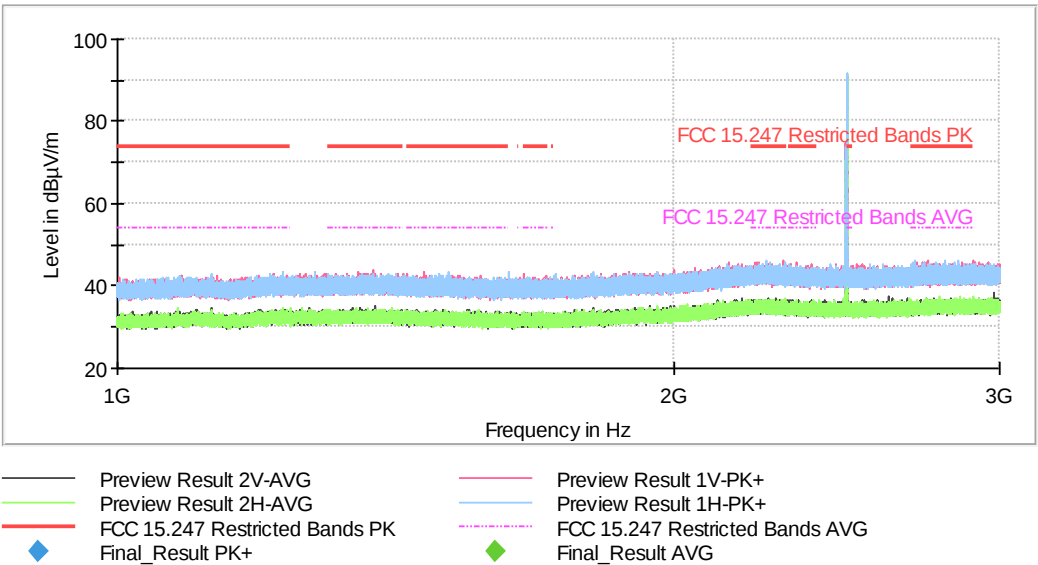


Full Spectrum

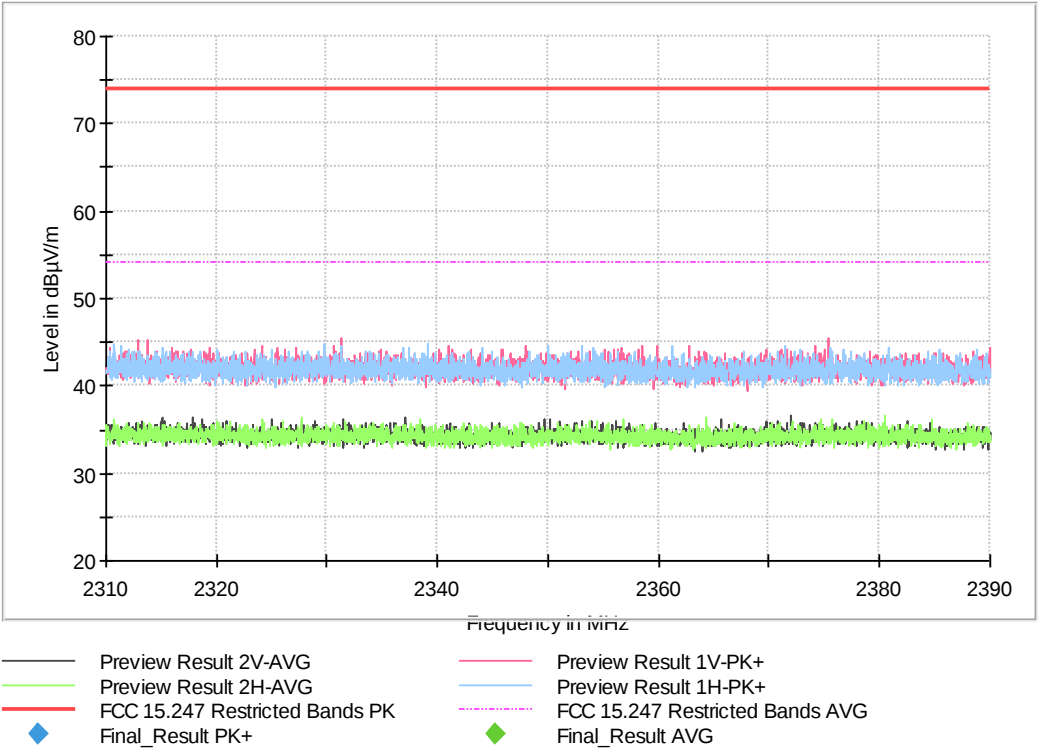


Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5), Frequency Range (GHz) = [1, 3]

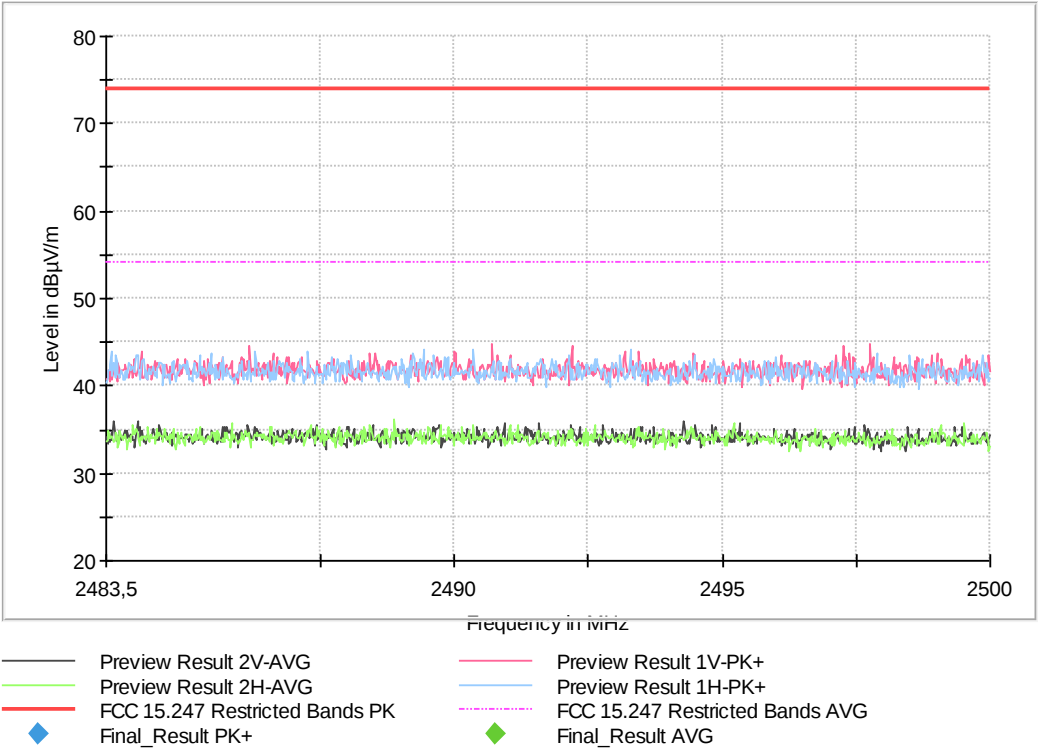
Plots:



Full Spectrum

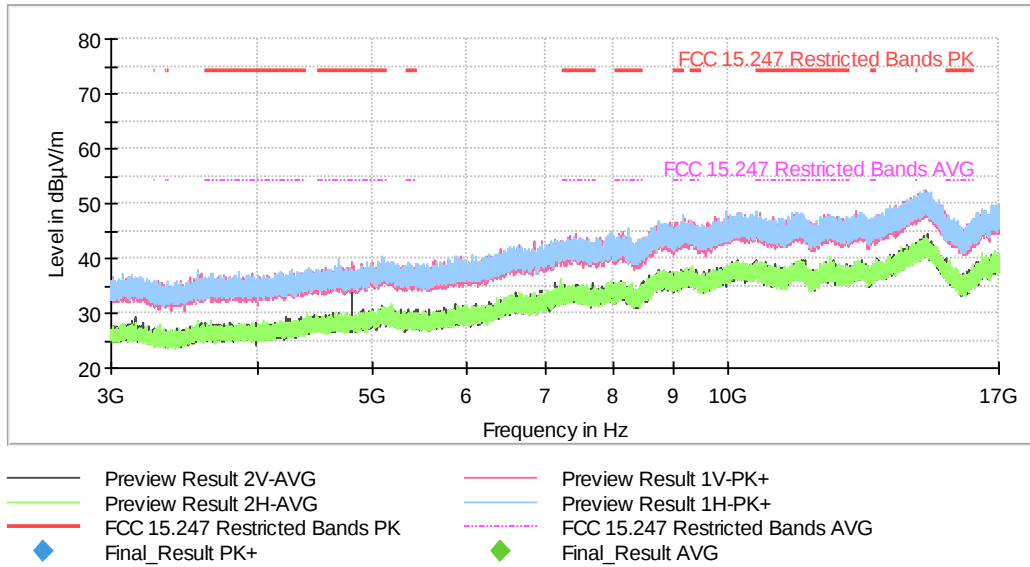


Full Spectrum



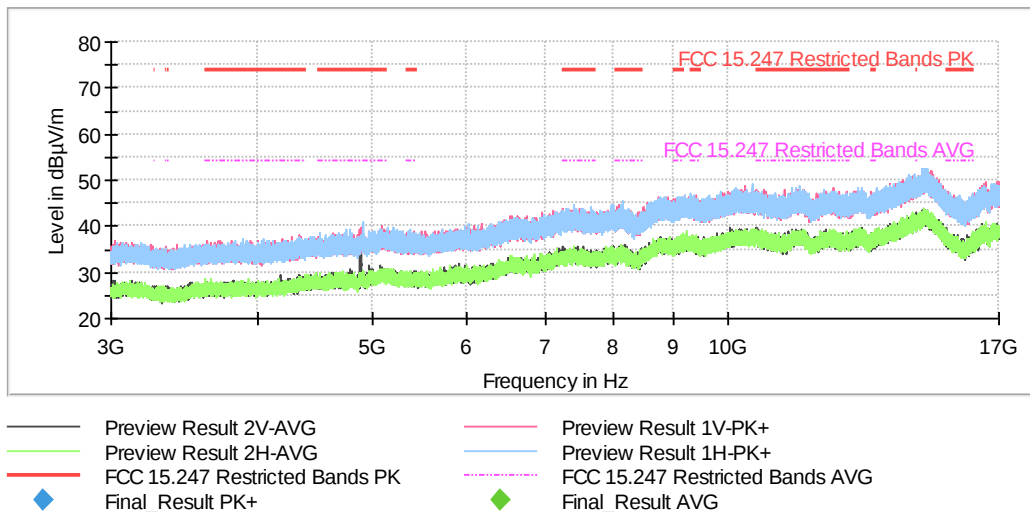
Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2402.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5), Frequency Range (GHz) = [3, 17]

Plots:



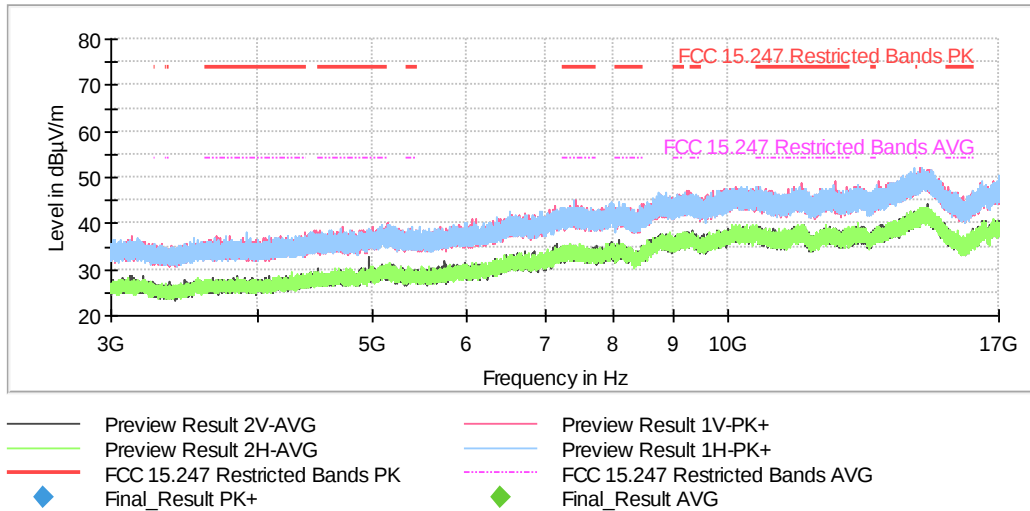
Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2441.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5), Frequency Range (GHz) = [3, 17]

Plots:



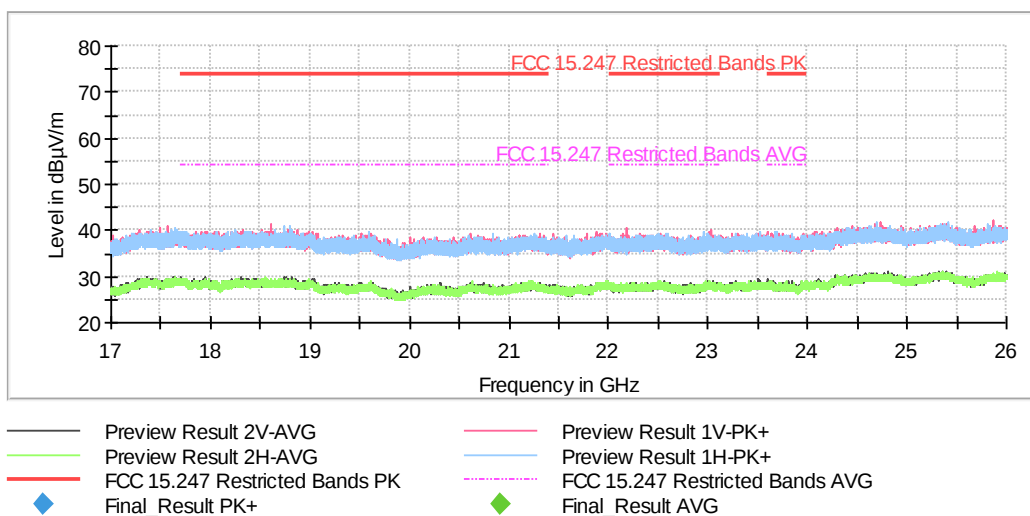
Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5), Frequency Range (GHz) = [3, 17]

Plots:



Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (GFSK 1-DH5), Frequency Range (GHz) = [17, 26]

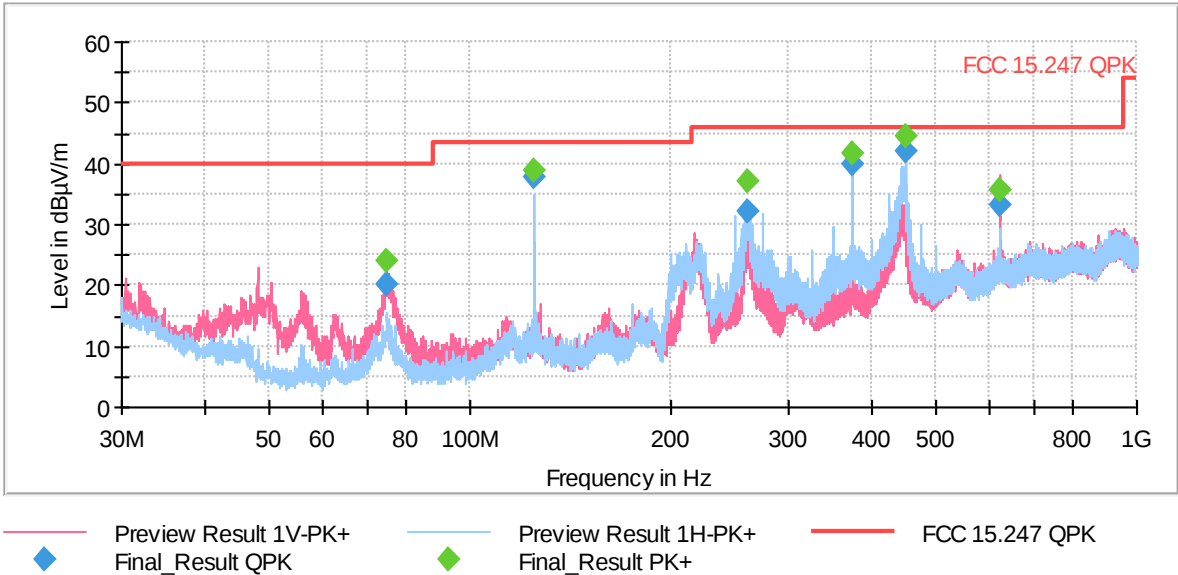
Plots:



This plot is valid for Low, Middle and High Channels.

Operation Band (MHz) = [2400, 2483.5], Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5), Frequency Range (GHz) = [0.03, 1]

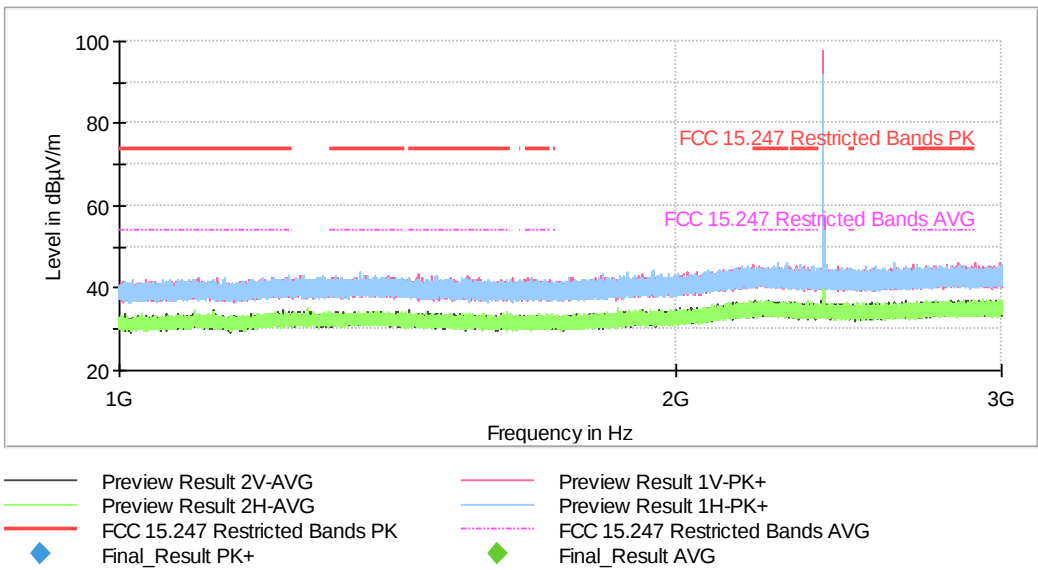
Plots:



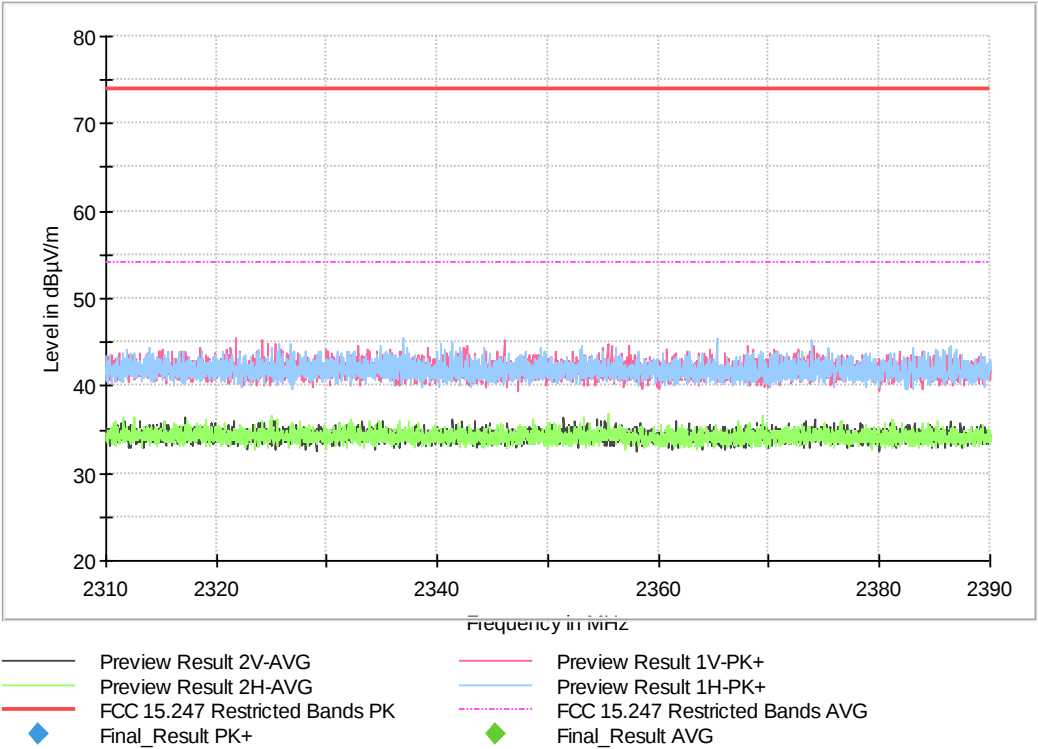
This plot is valid for Low, Middle and High Channels.

Operation Band (MHz) = [2400, 2483.5], Frequency (MHz) = 2402.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (Pi/4 DQPSK 2-DH5), Frequency Range (GHz) = [1, 3]

Plots:



Full Spectrum



Full Spectrum

