Test Report

FINAS
Finnish Accreditation Service
T004 (EN ISO/IEC 17025)

INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 15 C AND ISED CANADA REQUIREMENTS

Equipment Under Test:	Handheld control unit (transmitter)
Model:	DRC-MJ D3
Manufacturer:	Scanreco AB Stensätravägen 13 SE-127 39 Skärholmen, Sweden
Customer:	Scanreco AB Stensätravägen 13 SE-127 39 Skärholmen, Sweden
FCC Rule Part:	15.247: 2017
IC Rule Part:	RSS-247, Issue 2, 2017 RSS-GEN Issue 5 Amendment 1, 2019
KDB:	558074 D01 15.247 Meas Guidance v05r02 Guidance for Compliance Measurements on Digital Transmission Systems, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating Under §15.247 of the FCC rules (April 2, 2019)

Date:	12 August 2019	Date:	12 August 2019
Issued by:	Pekka Kälviäinen Testing Engineer	Checked by:	Rauno Repo Senior EMC/RF Specialist

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GENERAL REMARKS

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Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 90 days only. This document cannot be reproduced except in full, without prior approval of the Company.

RELEASE HISTORY

Version	Changes	Issued
1.0	Initial release	29 July 2019
1.1	spelling errors corrected Page 14: Measuring distance added (3m) Page 45: Calibration date of SMBV100A updated	12 August 2019

PRODUCT DESCRIPTION

Equipment Under Test

Trade mark:	Demag
Model:	DRC-MJ D3
Type:	-
Serial no:	*763198* (radiated measurements), *763199* (conducted measurements)
FCC ID:	N5OD3DRCMJ
IC:	6476A-D3DRCMJ

General Description

EUT is battery operated radio control system, designed for the wireless control of hoist units and cranes. EUT contains 2.4GHz radio part that supports frequency hopping (FHSS). When the device was connected to the charger, it could not be used.

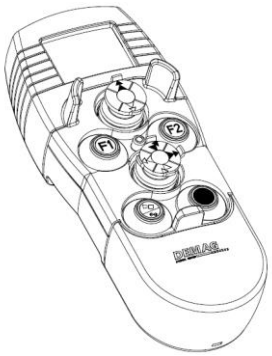

Figure 1: EUT

Classification

Fixed device	☐
Mobile Device (Human body distance > 20cm)	☒
Portable Device (Human body distance < 20cm)	☐

Modifications Incorporated in the EUT

No modifications were applied during the tests. Two EUTs were used during the tests, one for radiated and one for conducted measurements. Conducted measurements sample was having RF connector.

Ratings and declarations

Operating Frequency Range (OFR):	2405 - 2480 MHz
Channels:	16
Channel separation:	5 MHz
Transmission technique:	FHSS
Antenna type:	quarter wave
Integral Antenna gain:	0 dBi

Power Supply

Operating voltage:	2.4 Vdc, During the tests EUT was powered by 2 x 1.32 Vdc Ni-MH rechargeable battery back

Battery Charger, CMP power supply (MODEL: S008ACM0900090, P/N: 10231041-G)
Input: 100-240Vac, 50/60Hz 300mA
Output: 9.0Vdc, 900mA

Battery charger was used only during AC emissions test (115 V, 60 Hz input voltage was used)

Mechanical Size of the EUT

Height: 192 mm	Width: 75 mm	Depth: 65.5 mm	Weight: 405g

SUMMARY OF TESTING

Test Specification	Description of Test	Result
§15.203	Antenna requirement	PASS
§15.207(a) / RSS-GEN 8.8	Conducted Emissions on Power Supply Lines	PASS
§15.247(b)(3) / RSS-247 5.4(d)	Maximum Peak Conducted Output Power	PASS
§15.247(a)(1) / RSS-247 5.1	Hopping Channel Carrier Frequency Separation	PASS
§15.247(a)(1) / RSS-247 5.1	Number of Hopping Frequencies	PASS
§15.247(a)(1) / RSS-247 5.1	Average Time of Occupancy of Hopping Frequency	PASS
§15.247(a)(1) / RSS-247 5.1	20 dB Bandwidth	PASS
§15.247(a)(2) / RSS-247 5.2(a)	6 dB Bandwidth	PASS
§15.247(e) / RSS-247 5.2(b)	Power Spectral Density	N/T(1
RSS-GEN 6.7	99% Occupied Bandwidth	PASS
§15.247(d) / RSS-247 5.5	100 kHz Bandwidth of Frequency Band Edges and Conducted Spurious Emissions	PASS
§15.209(a), §15.247(d) / RSS-247 5.5	Radiated Emissions Within the Restricted Bands	PASS

1) Not applicable for FHSS

The decision rule applied for the tests results stated in this test report is according to the requirements of section 1.3 of ANSI C63.10-2013.

EUT Test Conditions during Testing

EUT was configured into the wanted test mode by pressing the device buttons in a specific order. In the tests, where continuous transmit was used the hopping was stopped and EUT was configured to wanted test channel. Max power was used during all tests. Charger was used only in Conducted Emissions on Power Supply Lines test.

Test	Operating mode
Conducted Emissions on Power Supply Lines	continuous transmit
Maximum Peak Conducted Output Power	continuous transmit
Hopping Channel Carrier Frequency Separation	Hopping
Number of Hopping Frequencies	Hopping
Average Time of Occupancy of Hopping Frequency	Hopping
20 dB Bandwidth	Hopping
6 dB Bandwidth	continuous transmit
99% Occupied Bandwidth	continuous transmit
100 kHz Bandwidth of Frequency Band Edges and Conducted Spurious Emissions	continuous transmit, hopping
Radiated Emissions Within the Restricted Bands	continuous transmit

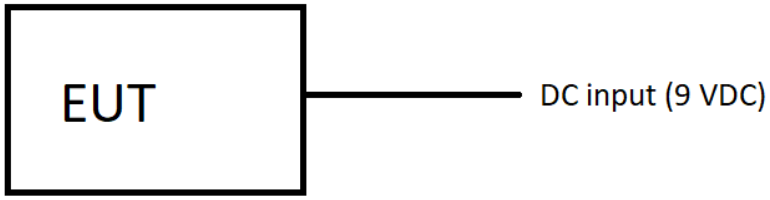

Figure 2: Test setup blocking diagram, charger was used only in Conducted Emissions on Power Supply Lines test

Table 1: Test frequencies

Channel	Frequency (MHz)
1, low	2405
8, middle	2440
16, high	2480
1-16, hopping mode	2405-2480

Test Facility

Testing Laboratory / address: FCC registration number: **904175**	SGS Fimko Ltd Särkiniementie 3 FI-00210, HELSINKI FINLAND
Test Site:	☐ K10LAB, ISED Canada registration number: **8708A-1** ☒ K5LAB, ISED Canada registration number: **8708A-2** ☐ L3LAB ☐ T10LAB

TEST RESULTS

Antenna requirement

Standard: FCC Rule §15.203
Tested by: JAT
Date: 2 July 2019

FCC Rule: 15.203

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.

Specification	Requirement (at least one of the following shall be applied)	Conclusion
§15.203	1. Permanently attached antenna 2. Unique coupling to the intentional radiator 3. Professionally installed radio. The installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.	**PASS**
Note	Option 1 is used	

Conducted Emissions In The Frequency Range 150 kHz - 30 MHz

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	2 July 2019	
Temperature:	23 ± 3°C	
Humidity:	20 - 60 % RH	
Barometric pressure:	1001 hPa	
Measurement uncertainty:	± 2.9 dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.207 (a)
RSS-GEN 8.8

Conducted disturbance voltage was measured with an artificial main network from 150 kHz to 30 MHz with 4 kHz steps and a resolution bandwidth of 9 kHz. Measurements were carried out with peak and average detectors.

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

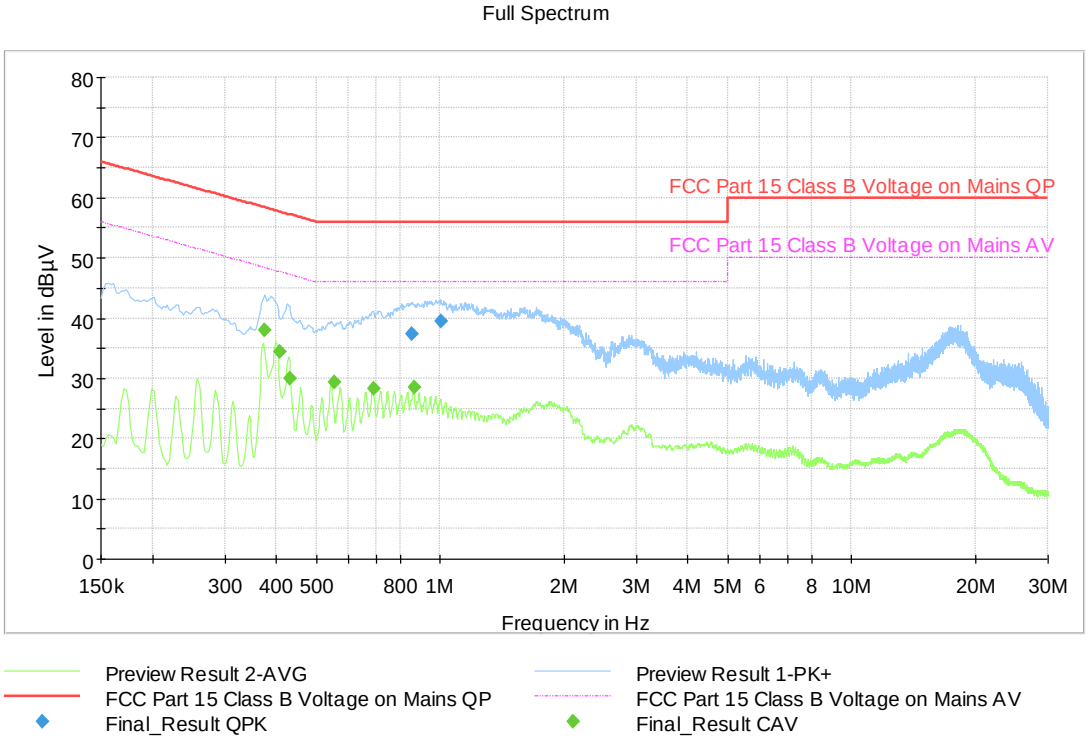

Figure 3: The measured curves with peak- and average detector

Final measurements from the worst frequencies

Table 2: Final QuasiPeak and Average measurements from the worst frequencies

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.374750	---	38.03	48.40	10.37	1000.0	9.000	N	ON	9.6
0.408000	---	34.38	47.69	13.31	1000.0	9.000	N	ON	9.7
0.433250	---	30.03	47.19	17.16	1000.0	9.000	N	ON	9.7
0.554750	---	29.42	46.00	16.58	1000.0	9.000	N	ON	9.7
0.690750	---	28.18	46.00	17.82	1000.0	9.000	L1	ON	9.7
0.853250	37.38	---	56.00	18.62	1000.0	9.000	N	ON	9.7
0.865250	---	28.43	46.00	17.57	1000.0	9.000	L1	ON	9.8
1.009000	39.45	---	56.00	16.55	1000.0	9.000	N	ON	9.8

The correction factor in the final result table contains the sum of the transducers.
The result value is the measured value corrected with the correction factor.

Maximum Peak Conducted Output Power

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	1 July 2019	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	
Measurement uncertainty:	± 2.87dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.247(b)(3)
RSS-247 5.4(d)

Test according to FCC title 47 part 15 §15.247(b), KDB 558074 D01 DTS Meas Guidance v05 and ANSI C63.10-2013 7.8.5

Measured values are peak values.

Results:

Table 3: Maximum conducted output power

Channel	Conducted Power [dBm]	Limit [dBm]	Margin [dBm]	Result
1 Low	20.2	21	0.8	PASS
8 Mid	20.1	21	0.9	PASS
16 High	18.4	21	2.6	PASS

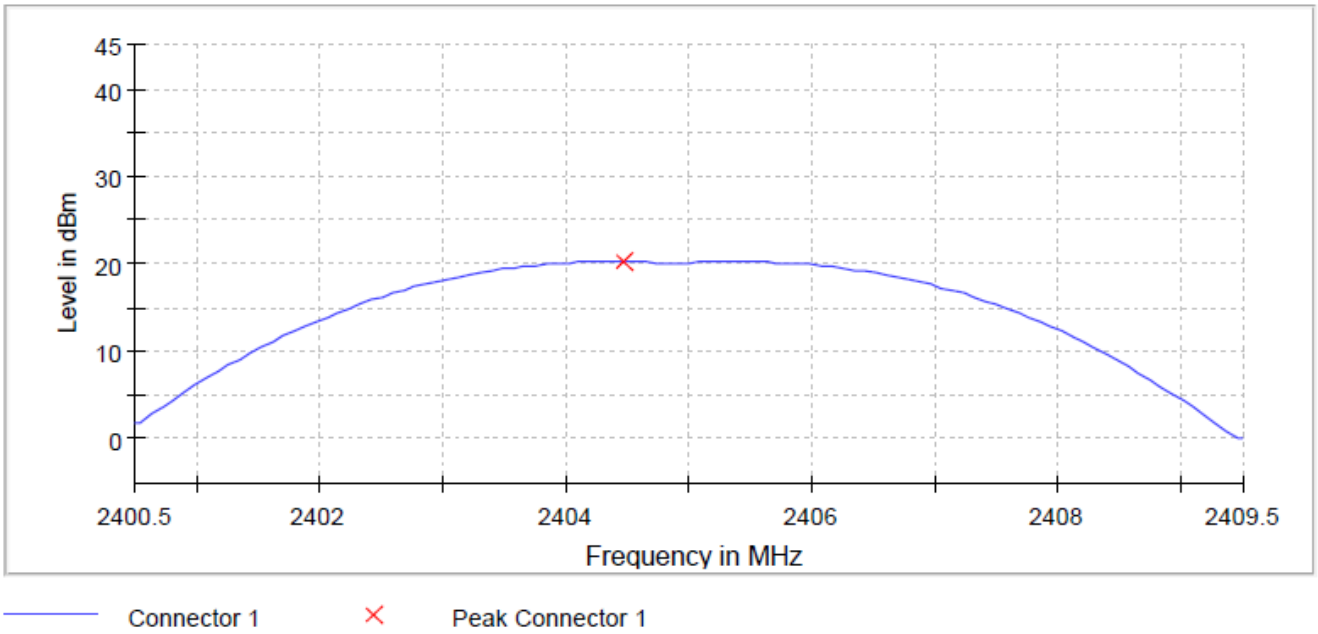

Figure 4: Conducted power, Channel LOW

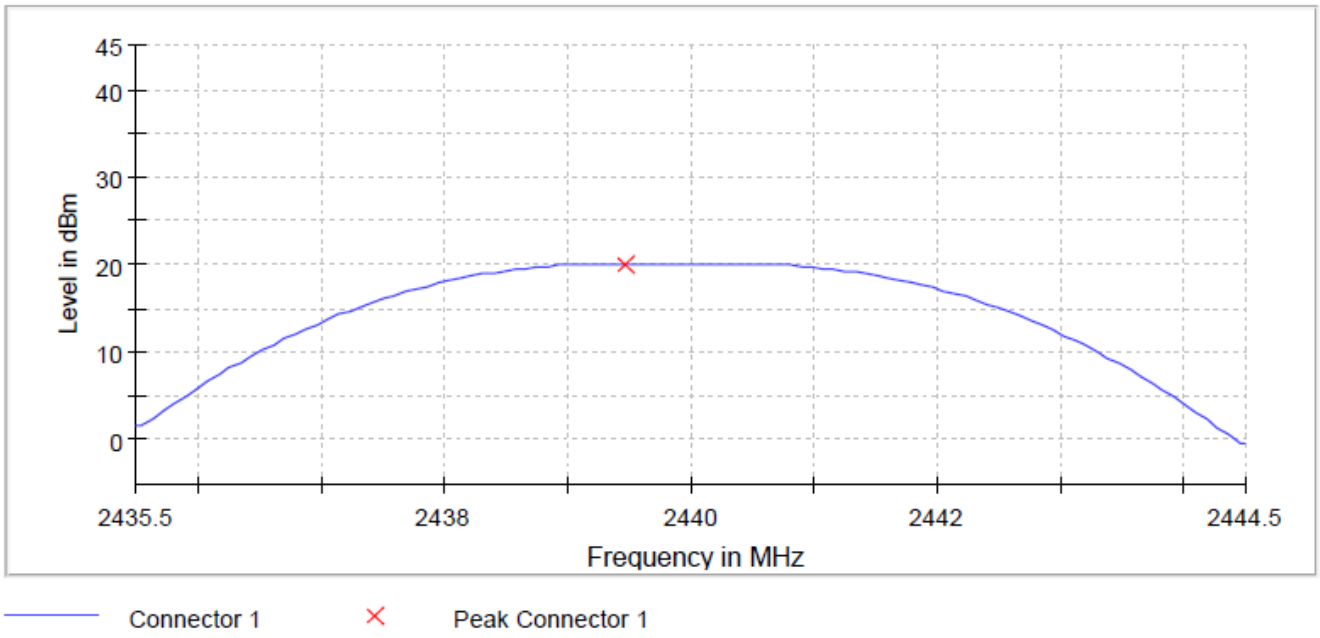

Figure 5: Conducted power, Channel MID

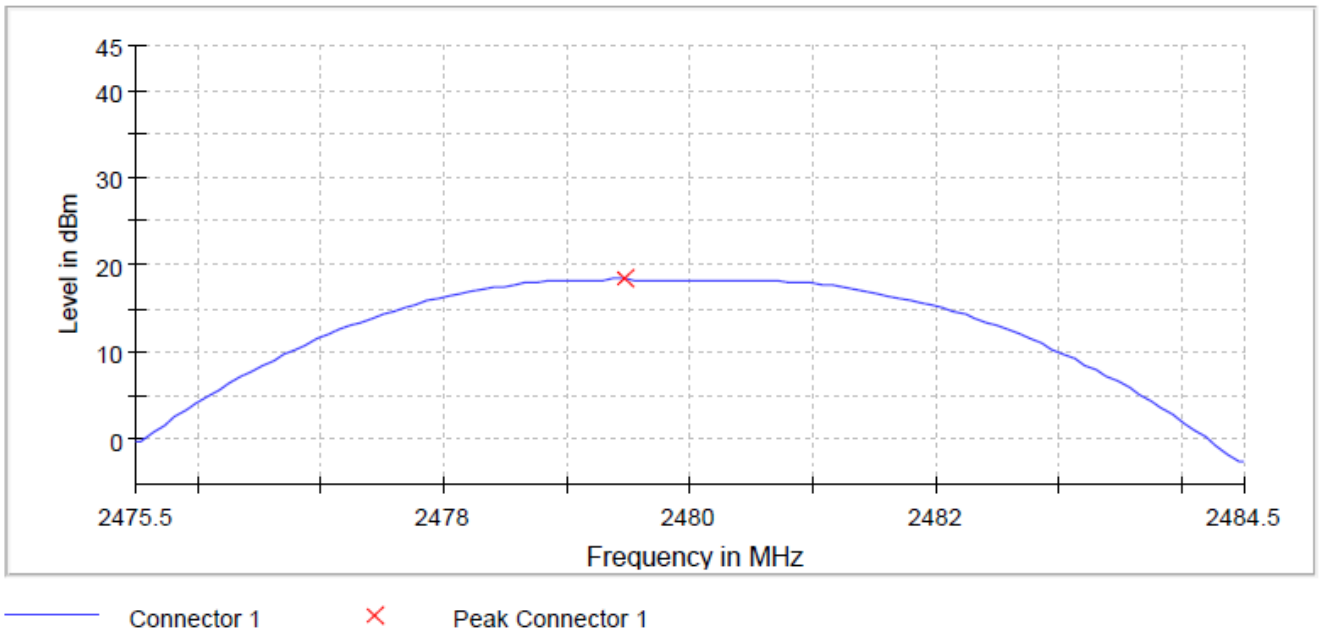

Figure 6: Conducted power, Channel HIGH

Table 4: Measurement settings, maximum conducted output power

Setting	Instrument Value	Target Value
Span	**9.000 MHz**	**9.000 MHz**
RBW	**3.000 MHz**	**>= 2.825 MHz**
VBW	**10.000 MHz**	**>= 9.000 MHz**
SweepPoints	**101**	**~ 101**
Sweeptime	**1.271 µs**	**AUTO**
Reference Level	**20.000 dBm**	**20.000 dBm**
Attenuation	**40.000 dB**	**AUTO**
Detector	**MaxPeak**	**MaxPeak**
SweepCount	**100**	**100**
Filter	**3 dB**	**3 dB**
Trace Mode	**Max Hold**	**Max Hold**
Sweeptype	**FFT**	**AUTO**
Preamp	**off**	**off**
Stablemode	**Trace**	**Trace**
Stablevalue	**0.50 dB**	**0.50 dB**
Run	**4 / max. 150**	**max. 150**
Stable	**3 / 3**	**3**
Max Stable Difference	**0.04 dB**	**0.50 dB**

Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	24 June – 2 July 2019	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	
Measurement uncertainty:	± 4.51 dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.247(d), 15.209(a)

RSS-247 5.5

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. In addition, 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)**.**

The correction factor in the final result table contains the sum of the transducers (antenna + amplifier + cables).

Peak values of emissions below 1000 MHz measured for reference as well as transmitter fundamental.

The measurements above 1 GHz were performed by using a peak detector and a Duty Cycle correction factor(dB) -21.37 dB, see chapter: Duty cycle correction factor, Transmit time in 100 ms.

The pre-measurements were performed with the EUT being in three orthogonal positions (X, Y, Z). Final measurements were done in worst position.

Measurement distance was 3 meters.

Frequency range [MHz]	Limit [µV/m]	Limit [dBµV/m]	Detector
30 - 80	100	40.0	Quasi-peak
88 - 216	150	43.5	Quasi-peak
216 - 960	200	46.0	Quasi-peak
960 - 1000	500	53.9	Quasi-peak
Above 1000	500	53.9	Average
Above 1000	5000	73.9	Peak

Results LOW channel

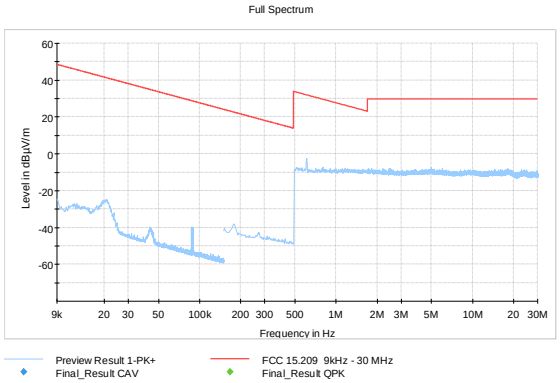

Figure 7: LOW channel **(**9 kHz – 30 MHz)

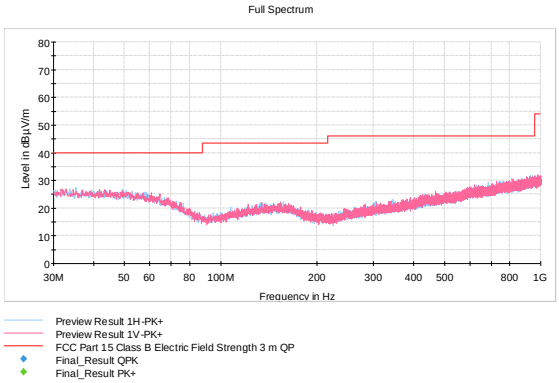

Figure 8: LOW channel (30 MHz – 1000 MHz)

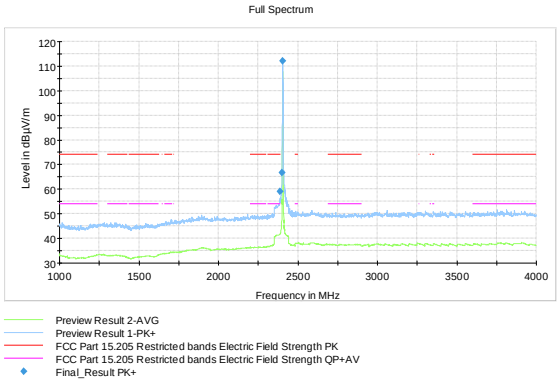

Figure 9: LOW channel (1 GHz – 4 GHz)

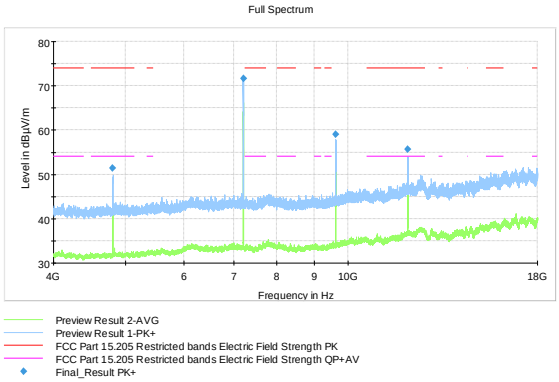

Figure 10: LOW channel (4 GHz – 18 GHz)

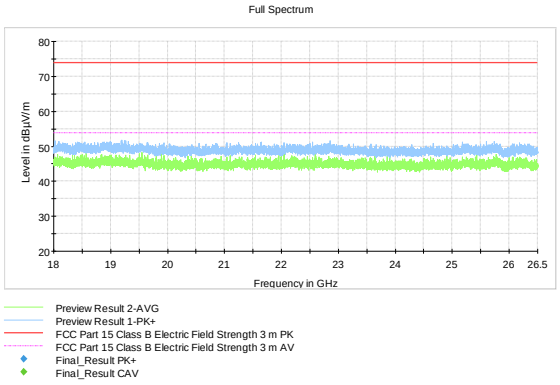

Figure 11: LOW channel (18 GHz – 26.5 GHz)

Table 5: Peak results LOW channel

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
2389.000000	59.03	73.90	14.87	1000.0	1000.000	130.0	V	273.0	14.0	-
2399.600000	66.62	92.08	25.46	1000.0	1000.000	116.0	V	259.0	14.1	limit -20dBc
2404.400000	112.08	-	-	1000.0	1000.000	154.0	V	295.0	14.1	Tx fundamental
4809.000000	51.39	73.90	22.51	1000.0	1000.000	144.0	V	169.0	7.2	-
7216.200000	71.57	92.08	20.51	1000.0	1000.000	140.0	H	259.0	10.3	limit -20dBc
9617.700000	59.06	92.08	33.02	1000.0	1000.000	137.0	H	154.0	13.6	limit -20dBc
12026.900000	55.73	73.90	18.17	1000.0	1000.000	181.0	H	223.0	16.8	-

Table 6: Average results LOW channel, calculated from Max Peak results (Max Peak result minus Duty Cycle correction factor(dB) -21.37 dB)

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
2389.000000	37.66	53.90	16.24	1000.0	1000.000	130.0	V	273.0	14.0	-
2399.600000	45.25	72.08	25.46	1000.0	1000.000	116.0	V	259.0	14.1	limit -20dBc
2404.400000	90.71	-	-	1000.0	1000.000	154.0	V	295.0	14.1	Tx fundamental
4809.000000	30.02	53.90	23.88	1000.0	1000.000	144.0	V	169.0	7.2	-
7216.200000	50.20	72.08	20.51	1000.0	1000.000	140.0	H	259.0	10.3	limit -20dBc
9617.700000	37.69	72.08	33.02	1000.0	1000.000	137.0	H	154.0	13.6	limit -20dBc
12026.900000	34.36	53.90	19.54	1000.0	1000.000	181.0	H	223.0	16.8	-

Results MID channel

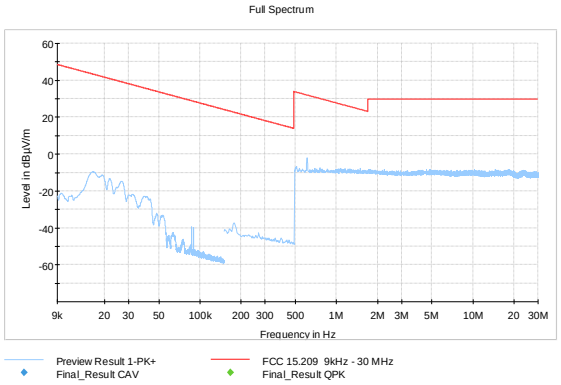

Figure 12: MID channel **(**9 kHz – 30 MHz)

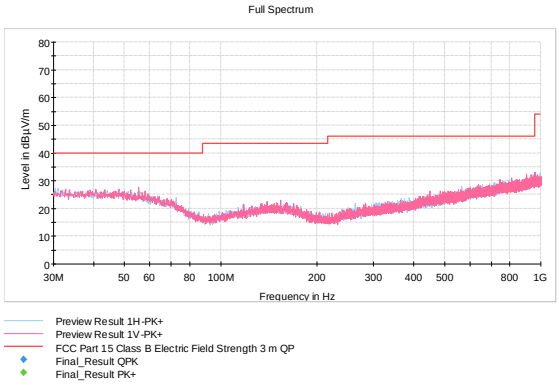

Figure 13: MID channel (30 MHz – 1000 MHz)

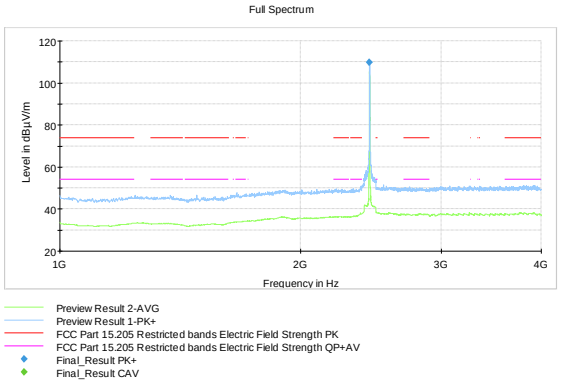

Figure 14: MID channel (1 GHz – 4 GHz)

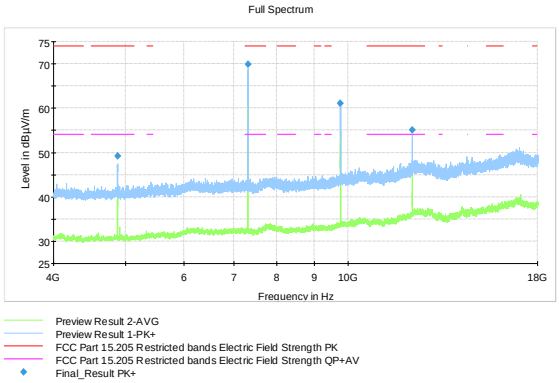

Figure 15: MID channel (4 GHz – 18 GHz)

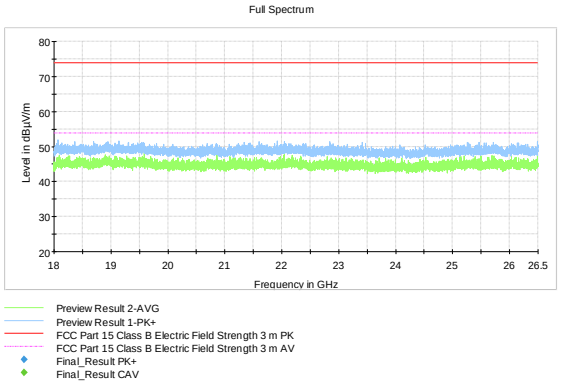

Figure 16: MID channel (18 GHz – 26.5 GHz)

Table 7: Peak results MID channel

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
2439.500000	109.74	-	-	1000.0	1000.000	131.0	V	302.0	13.9	Tx fundamental
4878.800000	49.18	73.90	24.72	1000.0	1000.000	122.0	H	145.0	7.2	-
7318.200000	69.86	73.90	4.04	1000.0	1000.000	136.0	H	256.0	10.2	-
9757.700000	61.09	89.74	28.65	1000.0	1000.000	141.0	H	147.0	13.9	limit -20dBc
12196.900000	55.01	73.90	18.89	1000.0	1000.000	100.0	H	228.0	16.9	-

Table 8: Average results MID channel, calculated from Max Peak results (Max Peak result minus Duty Cycle correction factor(dB) -21.37 dB)

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
2439.500000	88.37	-	-	1000.0	1000.000	131.0	V	302.0	13.9	Tx fundamental
4878.800000	27.81	53.90	26.09	1000.0	1000.000	122.0	H	145.0	7.2	-
7318.200000	48.49	53.90	5.41	1000.0	1000.000	136.0	H	256.0	10.2	-
9757.700000	39.72	68.37	28.65	1000.0	1000.000	141.0	H	147.0	13.9	limit -20dBc
12196.900000	33.64	53.90	20.26	1000.0	1000.000	100.0	H	228.0	16.9	-

Results HIGH channel

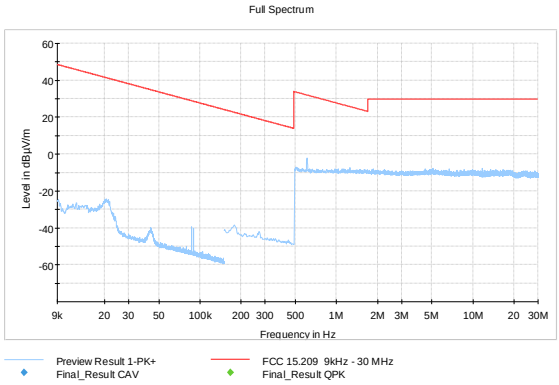

Figure 17: HIGH channel **(**9 kHz – 30 MHz)

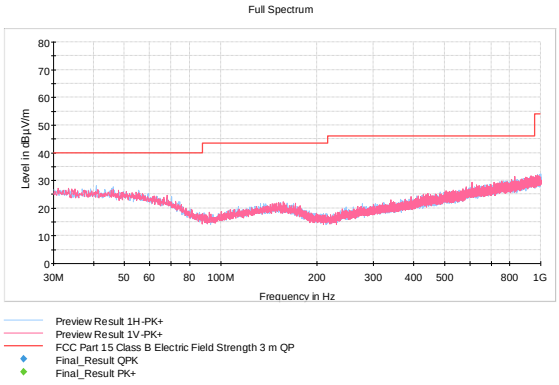

Figure 18: HIGH channel (30 MHz – 1000 MHz)

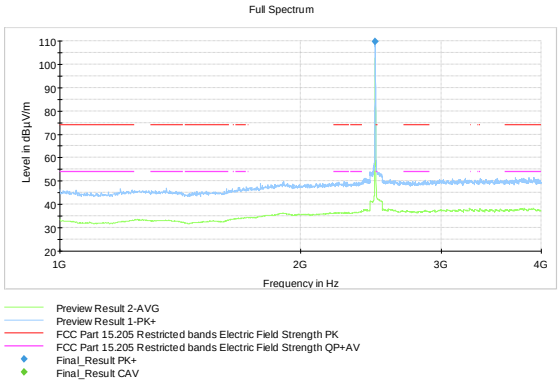

Figure 19: HIGH channel (1 GHz – 4 GHz)

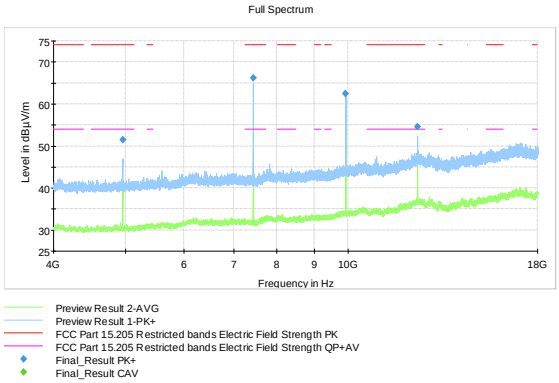

Figure 20: HIGH channel (4 GHz – 18 GHz)

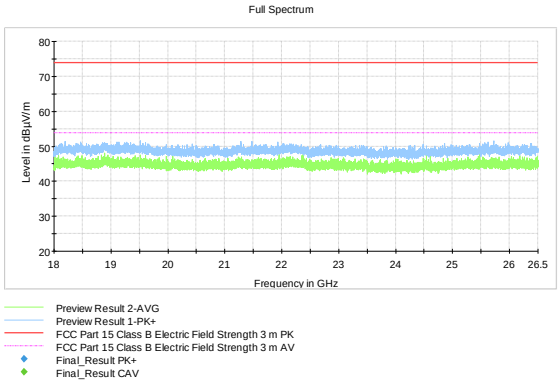

Figure 21: HIGH channel (18 GHz – 26.5 GHz)

Table 9: Peak results HIGH channel

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
2479.400000	109.63	-	-	1000.0	1000.000	148.0	V	318.0	14.1	Tx fundamental
4959.500000	51.43	73.90	22.47	1000.0	1000.000	158.0	V	152.0	7.1	-
7438.100000	66.15	73.90	7.75	1000.0	1000.000	122.0	H	254.0	10.3	-
9917.600000	62.53	89.63	27.10	1000.0	1000.000	136.0	H	139.0	14.1	limit -20dBc
12401.900000	54.51	73.90	19.39	1000.0	1000.000	115.0	H	140.0	17.1	-

Table 10: Average results HIGH channel, calculated from Max Peak results (Max Peak result minus Duty Cycle correction factor(dB) -21.37 dB)

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
2479.400000	88.26	-	-	1000.0	1000.000	148.0	V	318.0	14.1	Tx fundamental
4959.500000	30.06	53.90	23.84	1000.0	1000.000	158.0	V	152.0	7.1	-
7438.100000	44.78	53.90	9.12	1000.0	1000.000	122.0	H	254.0	10.3	-
9917.600000	41.16	68.26	27.10	1000.0	1000.000	136.0	H	139.0	14.1	limit -20dBc
12401.900000	33.14	53.90	20.76	1000.0	1000.000	115.0	H	140.0	17.1	-

Radiated lower and upper band edge results

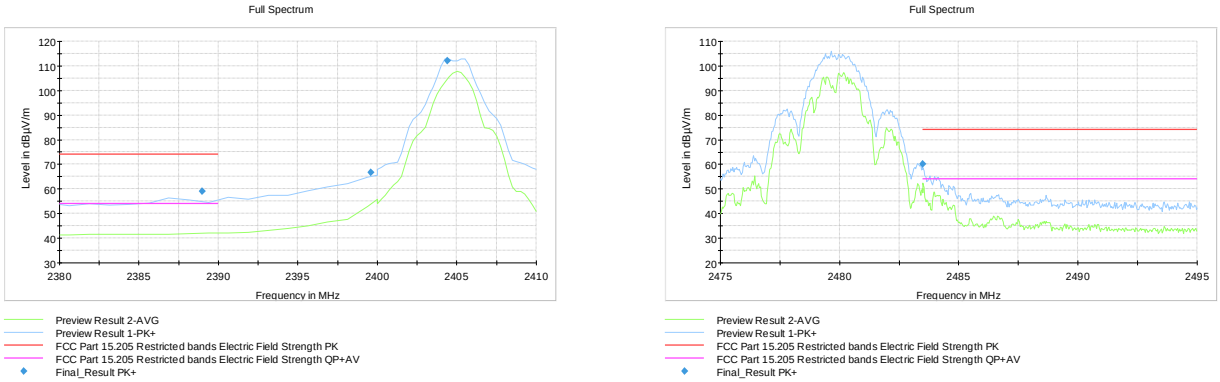

Figure 22: Radiated lower and upper band edge results

Table 11: Peak results Radiated lower and upper band edge results

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
2389.000000	59.03	73.90	14.87	1000.0	1000.000	130.0	V	273.0	14.0	-
2399.600000	66.62	92.08	25.46	1000.0	1000.000	116.0	V	259.0	14.1	limit -20dBc
2404.400000	112.08	-	-	1000.0	1000.000	154.0	V	295.0	14.1	Tx fundamental
2479.400000	109.63	-	-	1000.0	1000.000	148.0	V	318.0	14.1	Tx fundamental
2483.500000	60.06	73.90	13.84	1000.0	100.000	126.0	V	319.0	14.1	-

Table 12: Average results Radiated lower and upper band edge results. Results are calculated from Max Peak results (Max Peak result minus Duty Cycle correction factor(dB) -21.37 dB)

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
2389.000000	37.66	53.90	16.24	1000.0	1000.000	130.0	V	273.0	14.0	-
2399.600000	45.25	72.08	25.46	1000.0	1000.000	116.0	V	259.0	14.1	limit -20dBc
2404.400000	90.71	-	-	1000.0	1000.000	154.0	V	295.0	14.1	Tx fundamental
2479.400000	88.26	-	-	1000.0	1000.000	148.0	V	318.0	14.1	Tx fundamental
2483.500000	38.69	53.90	15.21	1000.0	100.000	126.0	V	319.0	14.1	-

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	1 July 2019	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	
Measurement uncertainty:	± 2.87 dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.247(d), 15.209(a)

RSS-247 5.5

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 Section 15.209(a) is not required. In addition, 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)).

Table 13: Band edge attenuation

Band Edge Attenuation	
Lower Band Edge	**Upper Band Edge**
-51.6 dBc	-44.1 dBc
Limit: -20 dBc	

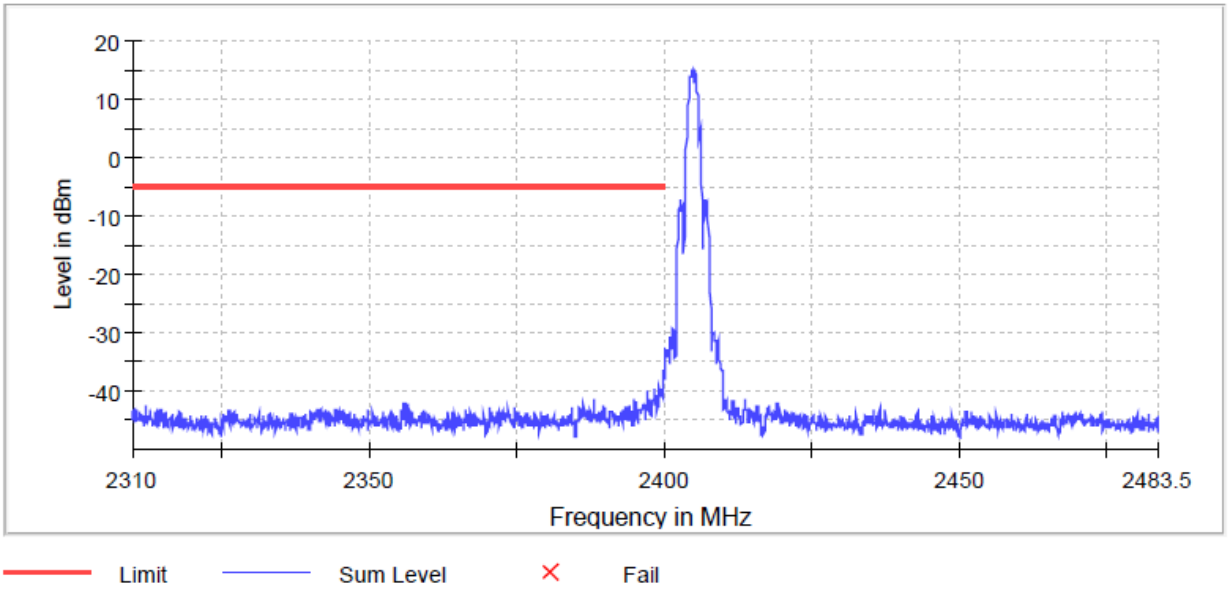

Figure 23: Lower Band Edge

Table 14: Lower band edge results

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2399.825000	-36.6	31.6	-5.0	PASS
2399.775000	-36.6	31.6	-5.0	PASS
2399.975000	-37.7	32.7	-5.0	PASS
2399.925000	-37.8	32.8	-5.0	PASS
2399.875000	-38.0	33.0	-5.0	PASS
2399.725000	-38.1	33.1	-5.0	PASS
2399.175000	-39.2	34.2	-5.0	PASS
2399.125000	-39.3	34.3	-5.0	PASS
2399.675000	-39.6	34.7	-5.0	PASS
2399.475000	-39.8	34.8	-5.0	PASS
2398.275000	-39.8	34.8	-5.0	PASS
2399.525000	-39.9	34.9	-5.0	PASS
2398.225000	-39.9	35.0	-5.0	PASS
2399.075000	-40.0	35.1	-5.0	PASS
2398.325000	-40.1	35.2	-5.0	PASS

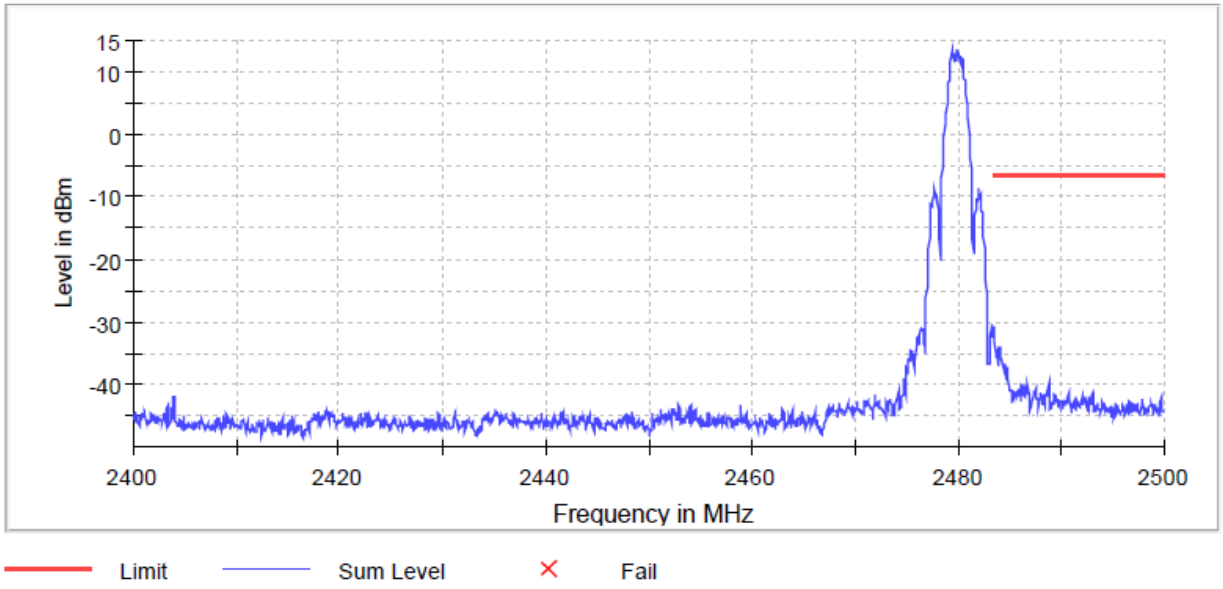

Figure 24: Upper Band Edge

Table 15: Upper band edge results

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2483.525000	-30.7	24.1	-6.6	PASS
2483.575000	-33.2	26.6	-6.6	PASS
2484.025000	-34.0	27.4	-6.6	PASS
2483.975000	-34.0	27.4	-6.6	PASS
2484.075000	-34.1	27.5	-6.6	PASS
2484.175000	-34.2	27.6	-6.6	PASS
2483.775000	-34.3	27.7	-6.6	PASS
2483.825000	-34.3	27.8	-6.6	PASS
2484.125000	-34.4	27.8	-6.6	PASS
2483.925000	-35.1	28.5	-6.6	PASS
2483.625000	-35.3	28.7	-6.6	PASS
2483.675000	-35.6	29.0	-6.6	PASS
2483.725000	-35.6	29.0	-6.6	PASS
2484.225000	-35.8	29.2	-6.6	PASS
2484.625000	-36.8	30.2	-6.6	PASS

Table 16: Band edge attenuation, Hopping mode

Band Edge Attenuation	
Lower Band Edge	**Upper Band Edge**
-54.5 dBc	-48.0 dBc
Limit: -20 dBc	

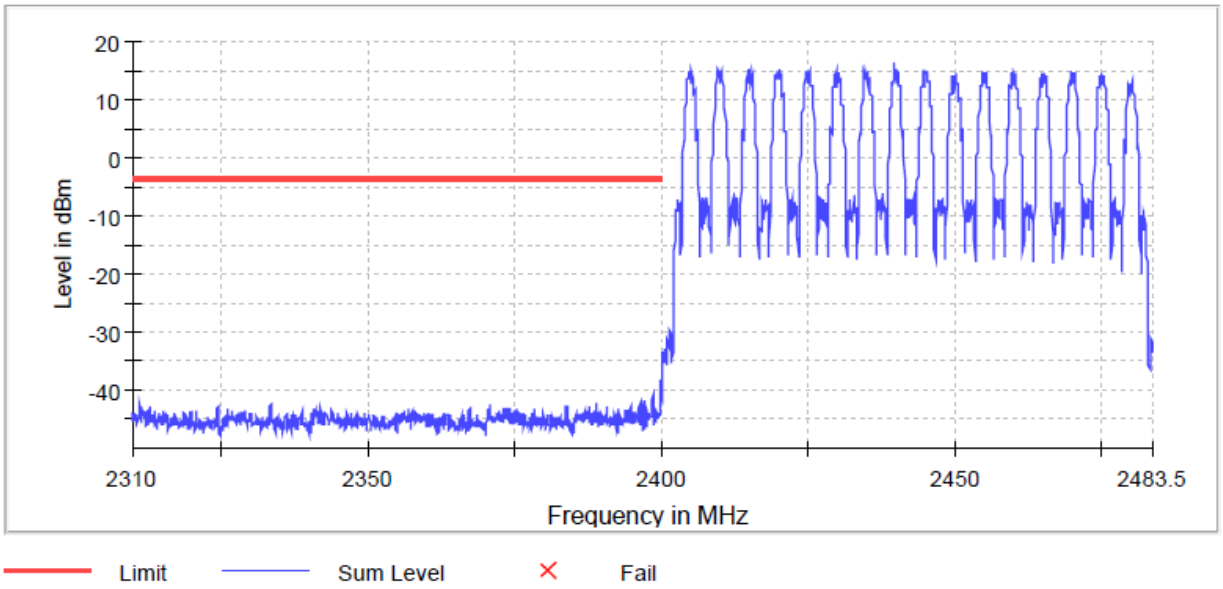

Figure 25: Lower Band Edge, hopping mode

Table 17: Lower band edge results, hopping mode

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2399.775000	-38.0	34.5	-3.6	PASS
2399.825000	-38.3	34.7	-3.6	PASS
2399.725000	-39.0	35.4	-3.6	PASS
2399.875000	-40.0	36.4	-3.6	PASS
2398.475000	-40.5	37.0	-3.6	PASS
2398.525000	-40.9	37.4	-3.6	PASS
2399.925000	-41.0	37.5	-3.6	PASS
2399.975000	-41.6	38.1	-3.6	PASS
2398.425000	-41.6	38.1	-3.6	PASS
2397.175000	-41.7	38.1	-3.6	PASS
2397.225000	-41.9	38.4	-3.6	PASS
2388.825000	-42.0	38.4	-3.6	PASS
2388.875000	-42.0	38.5	-3.6	PASS
2399.675000	-42.2	38.6	-3.6	PASS
2397.125000	-42.3	38.7	-3.6	PASS

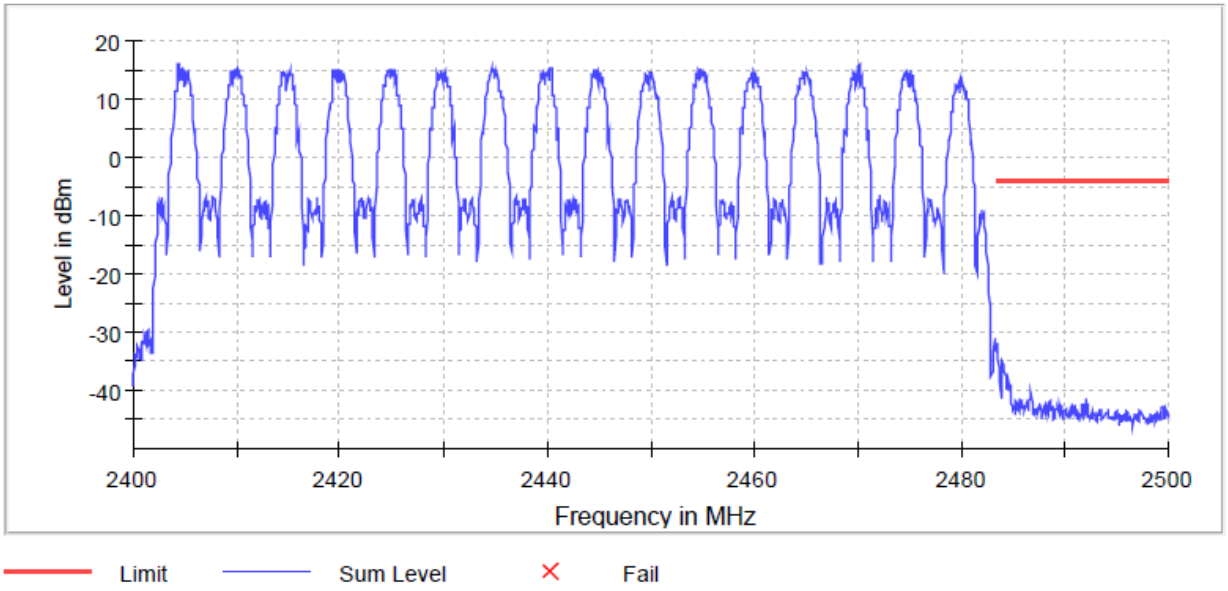

Figure 26: Upper Band Edge, hopping mode

Table 18: Upper band edge results, hopping mode

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2483.525000	-31.9	28.0	-3.9	PASS
2483.575000	-34.5	30.7	-3.9	PASS
2484.025000	-35.0	31.1	-3.9	PASS
2483.975000	-35.0	31.2	-3.9	PASS
2484.125000	-35.8	32.0	-3.9	PASS
2484.075000	-35.9	32.0	-3.9	PASS
2484.175000	-35.9	32.1	-3.9	PASS
2483.625000	-36.0	32.2	-3.9	PASS
2484.225000	-36.9	33.1	-3.9	PASS
2483.675000	-36.9	33.1	-3.9	PASS
2483.925000	-37.0	33.2	-3.9	PASS
2483.725000	-37.1	33.2	-3.9	PASS
2484.325000	-37.4	33.5	-3.9	PASS
2484.275000	-37.5	33.7	-3.9	PASS
2484.625000	-38.4	34.5	-3.9	PASS

Conducted spurious emissions results LOW channel

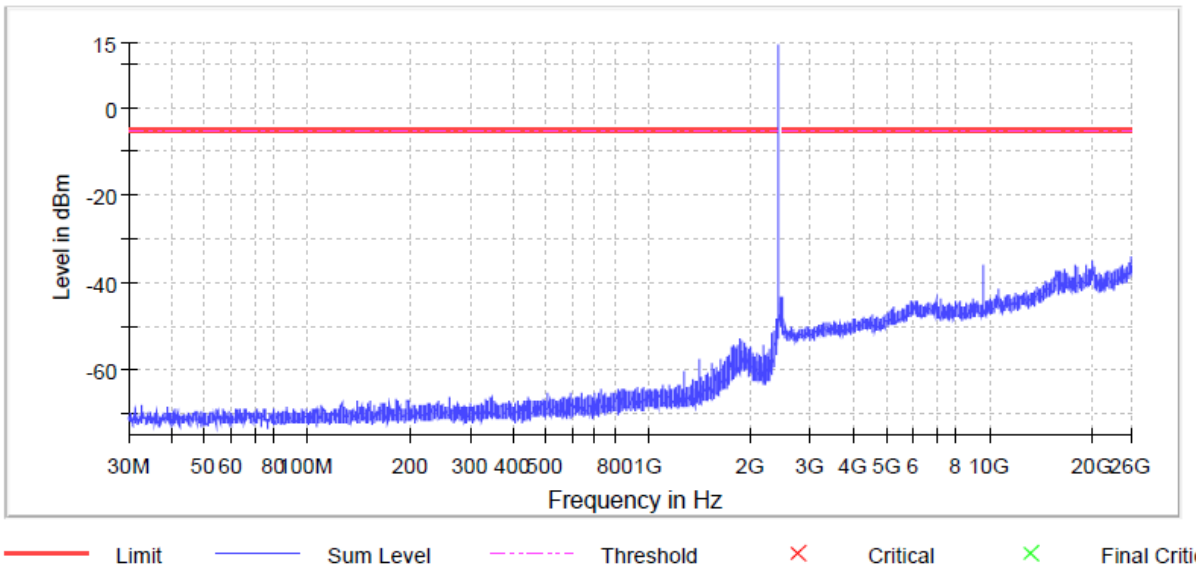

Figure 27: Conducted spurious emissions 30 - 26500 MHz LOW channel

Table 19: Pre measurements, conducted spurious emissions LOW channel

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)
25879.849138	-34.2	29.0	-5.2
25966.563521	-35.0	29.7	-5.2
20153.025460	-35.2	30.0	-5.2
25939.373418	-35.3	30.1	-5.2
20155.230063	-35.6	30.3	-5.2
25925.410932	-35.6	30.3	-5.2
25900.425432	-35.6	30.4	-5.2
25731.405870	-35.7	30.5	-5.2
25892.341888	-35.8	30.5	-5.2
25943.047756	-35.8	30.6	-5.2
25893.076755	-35.8	30.6	-5.2
25896.016226	-35.8	30.6	-5.2
25903.364903	-35.8	30.6	-5.2
25945.252359	-35.9	30.6	-5.2
25901.160300	-35.9	30.6	-5.2

Table 20: Final measurements, conducted spurious emissions LOW channel

No final measurements were made; no emissions near the limit.

Conducted spurious emissions results MID channel

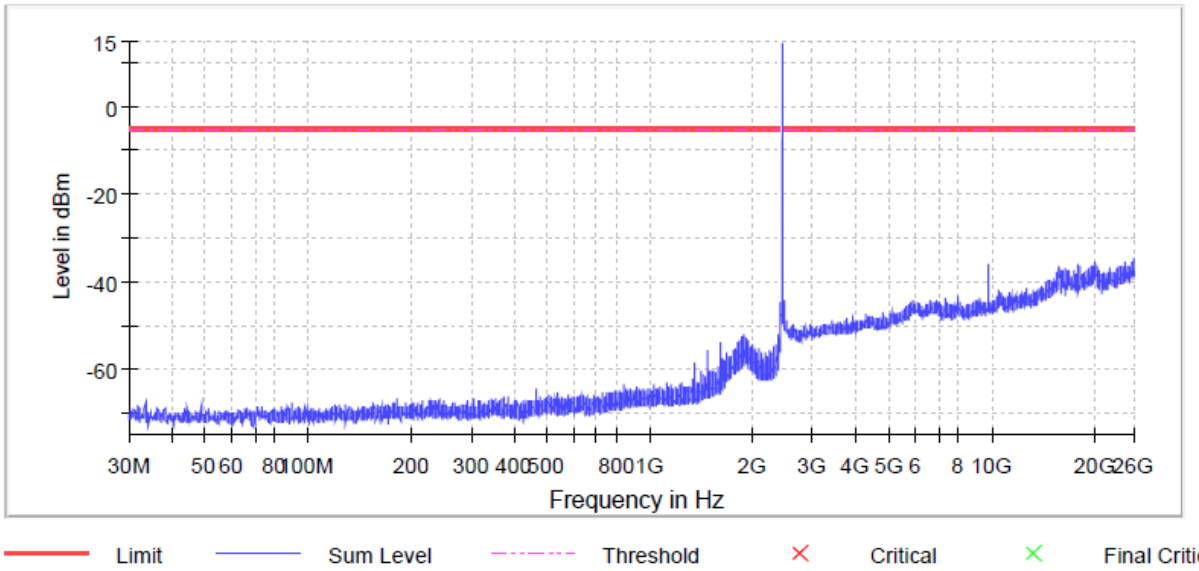

Figure 28: Conducted spurious emissions 30 - 26500 MHz MID channel

Table 21: Pre measurements, conducted spurious emissions MID channel

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)
25916.592521	-34.4	29.1	-5.3
25887.197814	-34.5	29.2	-5.3
25882.053741	-35.0	29.7	-5.3
25879.849138	-35.2	29.9	-5.3
25953.335904	-35.3	30.0	-5.3
20142.002445	-35.4	30.1	-5.3
25827.673534	-35.4	30.1	-5.3
25847.514960	-35.5	30.2	-5.3
25840.901152	-35.5	30.3	-5.3
25919.531991	-35.6	30.3	-5.3
24582.807717	-35.6	30.3	-5.3
25915.122785	-35.6	30.3	-5.3
25884.258343	-35.6	30.3	-5.3
25837.226813	-35.6	30.3	-5.3
25873.235329	-35.7	30.4	-5.3

Table 22: Final measurements, conducted spurious emissions MID channel

No final measurements were made; no emissions near the limit.

Conducted spurious emissions results HIGH channel

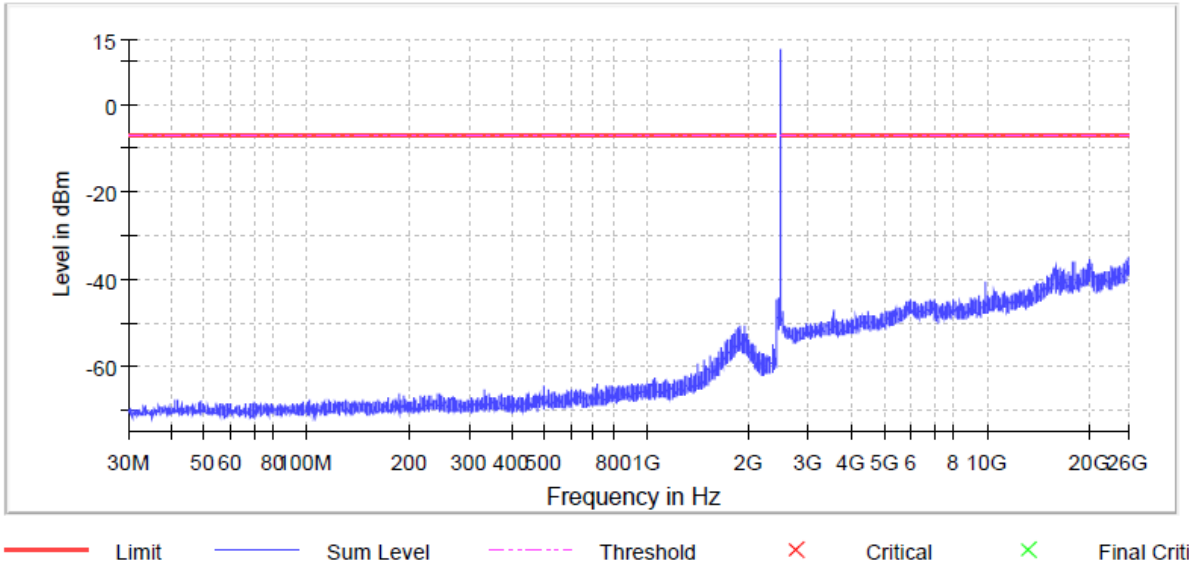

Figure 29: Conducted spurious emissions 30 - 26500 MHz HIGH channel

Table 23: Pre measurements, conducted spurious emissions HIGH channel

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)
2483.867434	-30.3	23.2	-7.1
25846.780093	-35.1	28.0	-7.1
25888.667549	-35.2	28.1	-7.1
25886.462946	-35.2	28.1	-7.1
20153.025460	-35.7	28.6	-7.1
25925.410932	-35.7	28.6	-7.1
25812.976180	-35.8	28.6	-7.1
25846.045225	-35.8	28.7	-7.1
25870.295858	-35.9	28.8	-7.1
25902.630035	-35.9	28.8	-7.1
25862.212314	-35.9	28.8	-7.1
25793.869621	-35.9	28.8	-7.1
25912.183315	-36.0	28.9	-7.1
17848.480477	-36.0	28.9	-7.1
25862.947181	-36.0	28.9	-7.1

Table 25: Final measurements, conducted spurious emissions HIGH channel

No final measurements were made; no emissions near the limit.

Table 24: Measurement settings, band edge

Setting	Instrument Value	Target Value
Span	83.500 MHz	83.500 MHz
RBW	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	1670	~ 1670
Sweeptime	94.727 µs	AUTO
Reference Level	20.000 dBm	20.000 dBm
Attenuation	40.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	14 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.25 dB	0.50 dB

Table 25: Measurement settings, spurious emissions

Setting	Instrument Value	Target Value
RBW	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	32100	~ 47400
Sweeptime	32.100 ms	AUTO
Reference Level	-10.000 dBm	-30.000 dBm
Attenuation	20.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	30	30
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	1.00 dB	1.00 dB
Run	10 / max. 40	max. 40
Stable	1 / 1	1
Max Stable Difference	0.78 dB	1.00 dB

20 dB Bandwidth of the Hopping Channel

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	1 July 2019	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	

FCC Rule: §15.247(a)(1)(iii)
RSS-247 5.1

Results:

Table 26: 20 dB bandwidth test results

Channel	20 dB BW [kHz]	Minimum limit [kHz]	Result
Low	2825	-	PASS
Mid	2800		PASS
High	2825		PASS

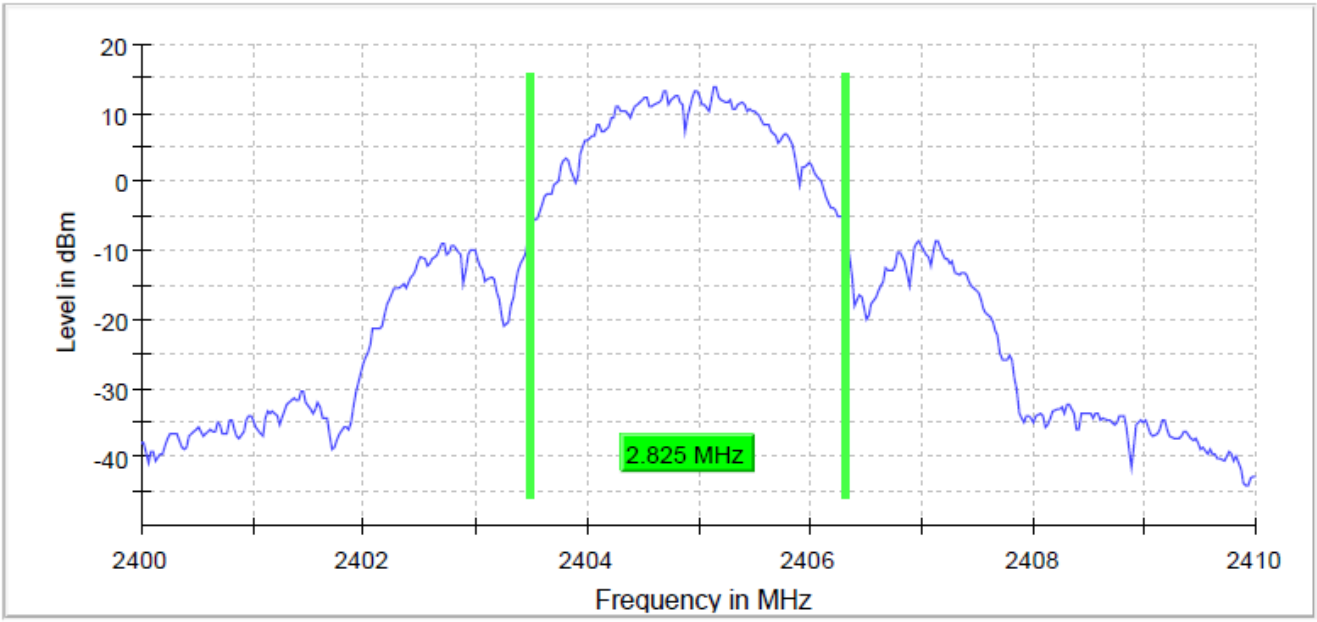

Figure 30: 20 dB channel BW, channel LOW

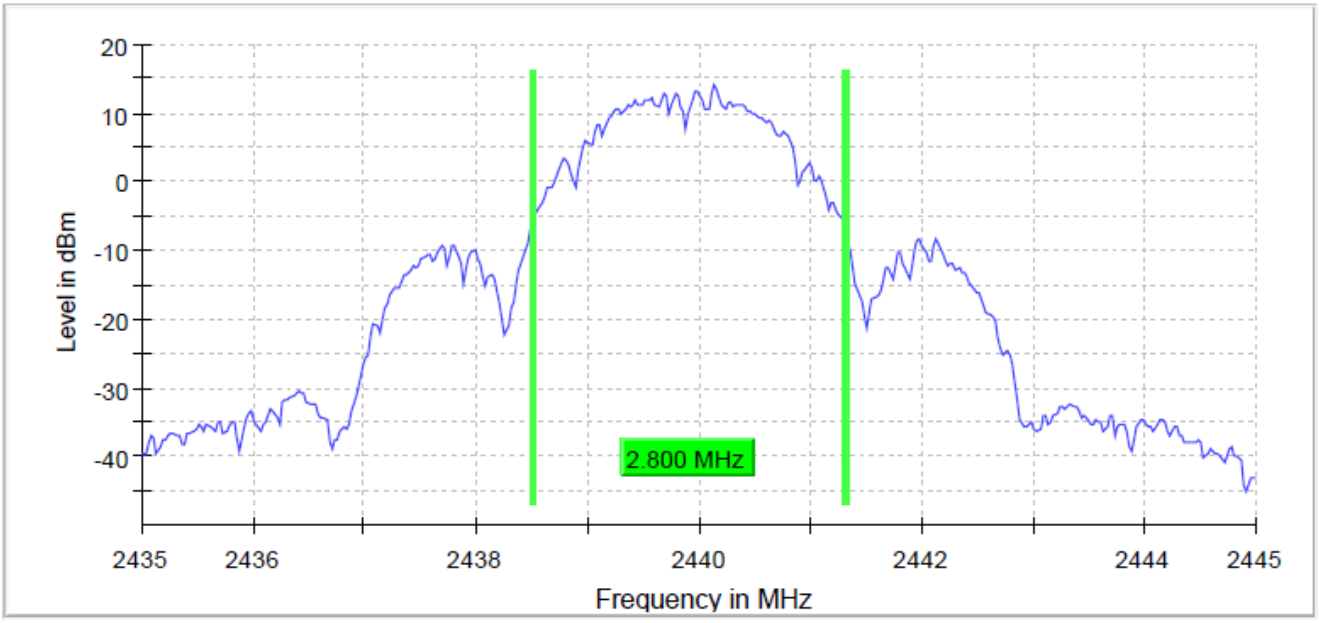

Figure 31: 20 dB channel BW, channel MID

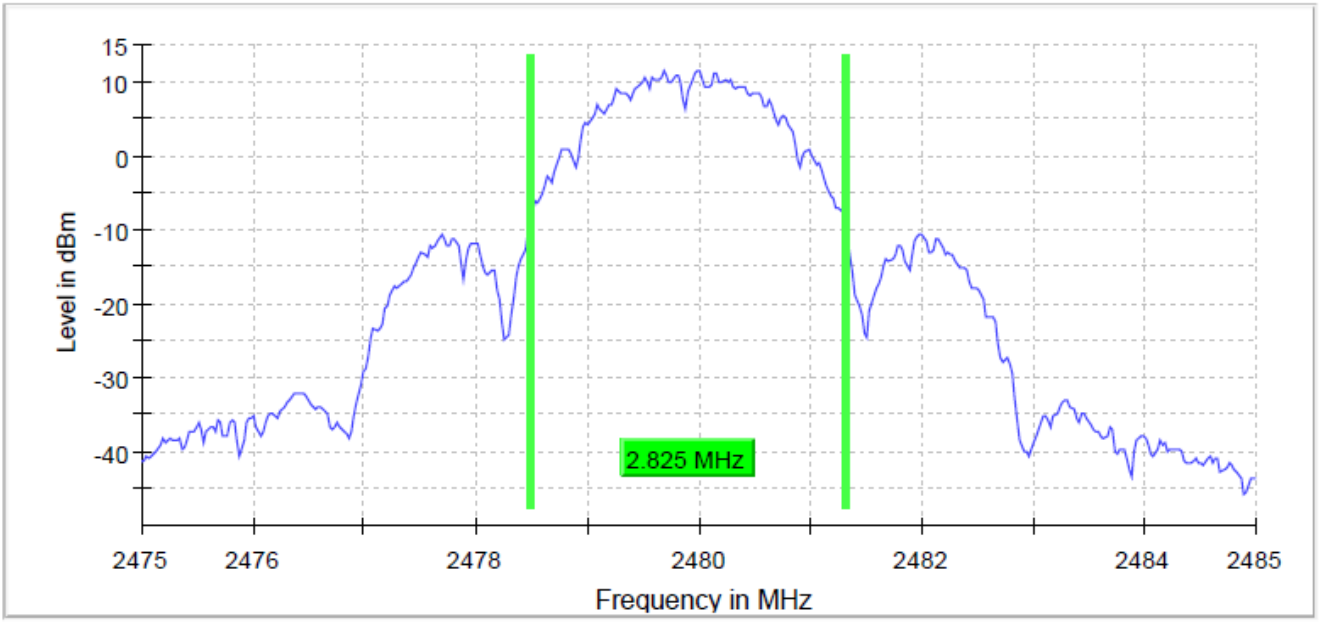

Figure 32: 20 dB channel BW, channel HIGH

Table 27: Measurement settings, 20 dB bandwidth

Setting	Instrument Value	Target Value
Span	**10.000 MHz**	**10.000 MHz**
RBW	**50.000 kHz**	**>= 50.000 kHz**
VBW	**200.000 kHz**	**>= 1500.000**
SweepPoints	**400**	**~ 400**
Sweeptime	**37.930 µs**	**AUTO**
Reference Level	**10.000 dBm**	**10.000 dBm**
Attenuation	**30.000 dB**	**AUTO**
Detector	**MaxPeak**	**MaxPeak**
SweepCount	**200**	**200**
Filter	**3 dB**	**3 dB**
Trace Mode	**Max Hold**	**Max Hold**
Sweeptype	**FFT**	**AUTO**
Preamp	**off**	**off**
Stablemode	**Trace**	**Trace**
Stablevalue	**0.50 dB**	**0.50 dB**
Run	**30 / max. 150**	**max. 150**
Stable	**5 / 5**	**5**
Max Stable Difference	**0.33 dB**	**0.50 dB**

Hopping Channel Carrier Frequencies Separation

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	1 July 2019	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	

FCC Rule: 15.247(a)(1)
RSS-247 5.1

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.

Test result

Table 28: Hopping channel carrier frequencies separation test result

DUT Frequency [MHz]	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)	Channel Separation (MHz)	Minimum limit (MHz)	Result
2405.000000	2404.826733	2409.876238	5.049505	1.883333	PASS
2440.000000	2439.826733	2444.876238	5.049505	1.883333	PASS
2480.000000	2474.826733	2479.876238	5.049505	1.883333	PASS

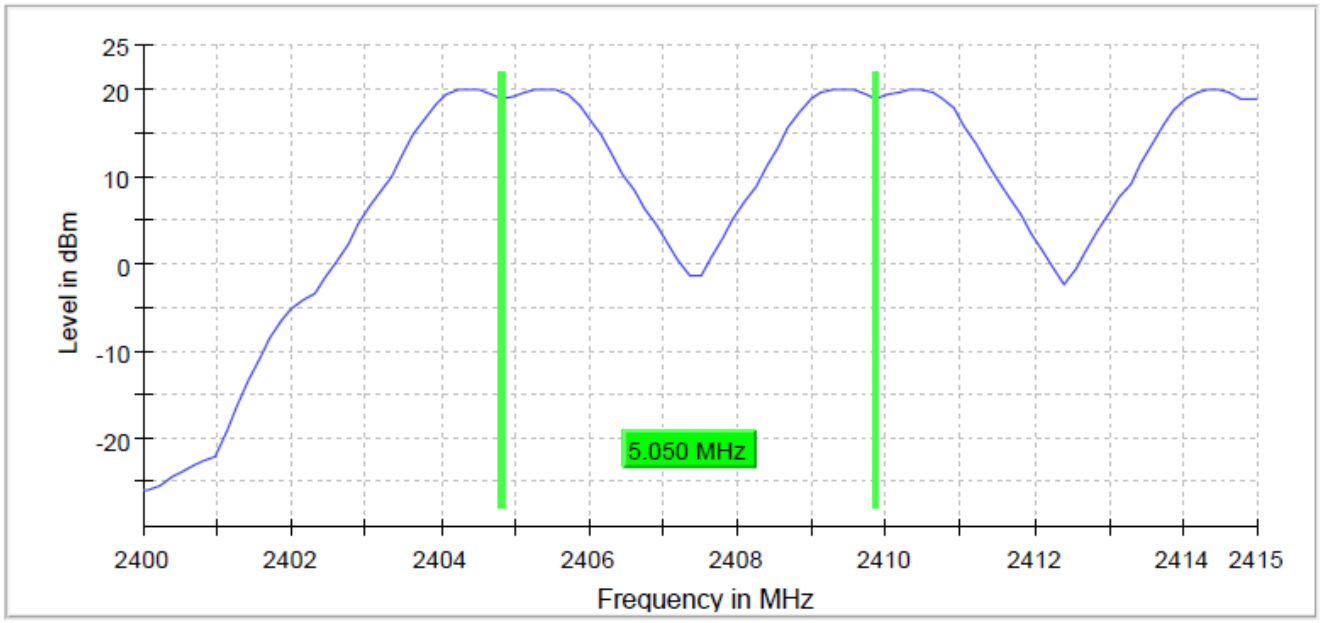

Figure 33: Measured hopping channels carrier frequency separation, DUT frequency 2405MHz

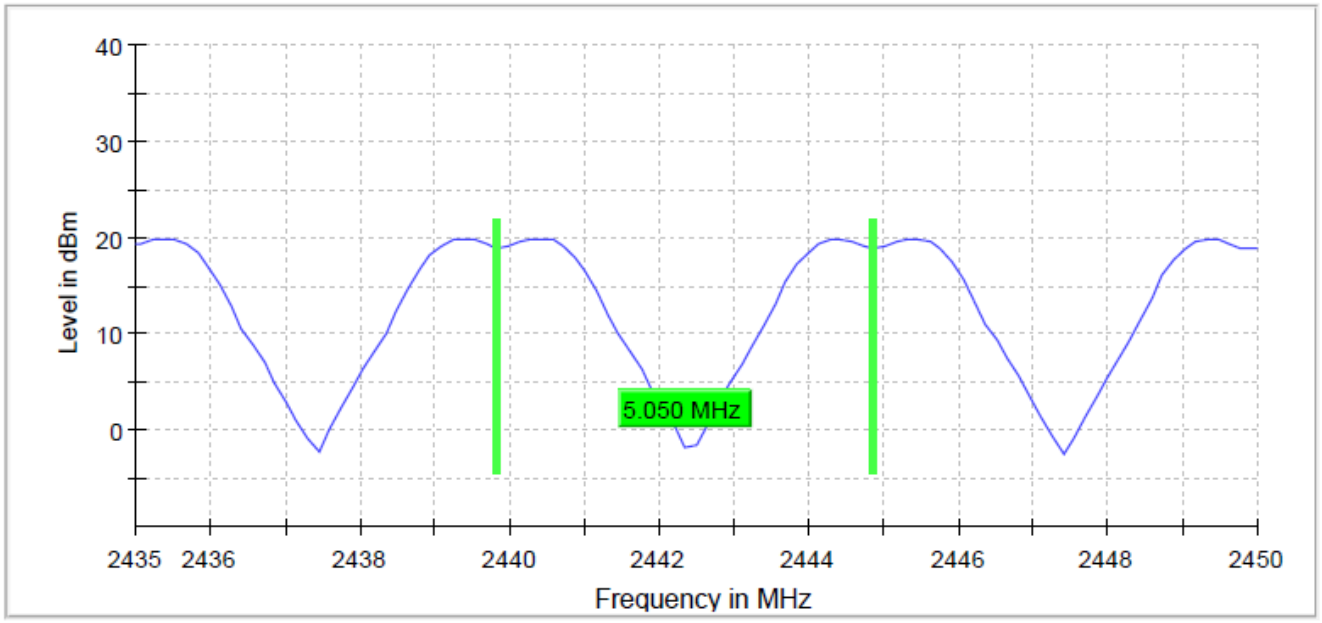

Figure 34: Measured hopping channels carrier frequency separation, DUT frequency 2440MHz

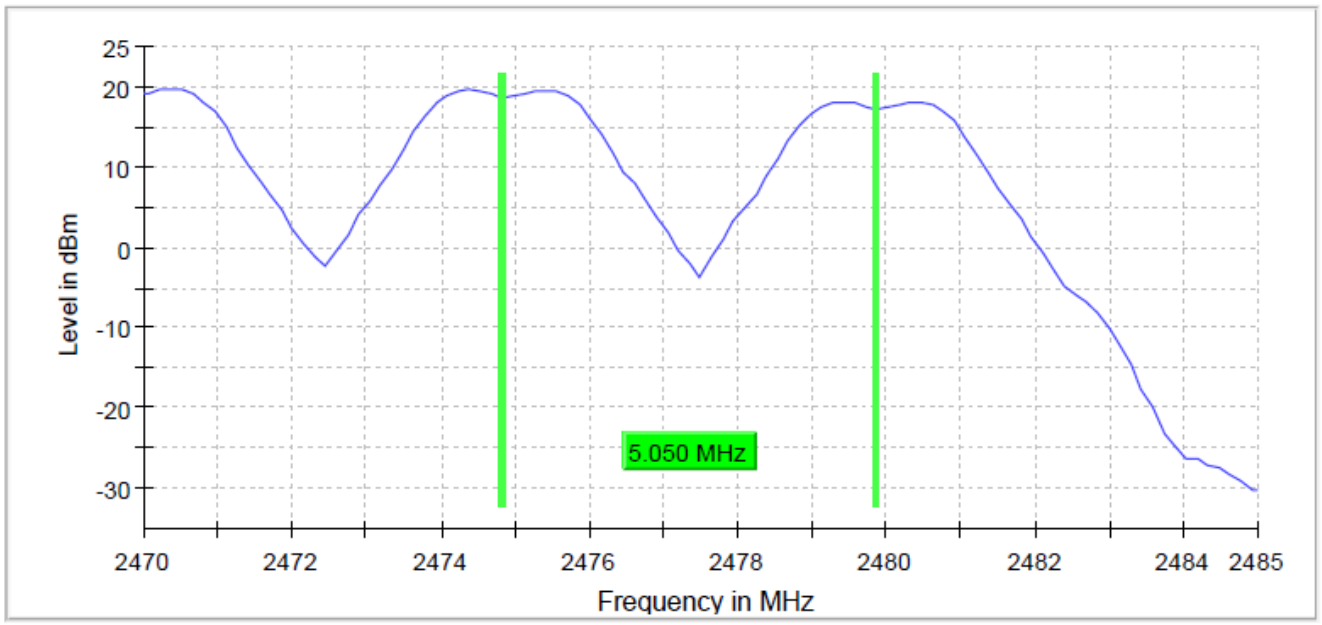

Figure 35: Measured hopping channels carrier frequency separation, DUT frequency 2480MHz

Table 29: Measurement settings, Hopping channel carrier frequencies separation

Setting	Instrument Value	Target Value
Span	15.000 MHz	15.000 MHz
RBW	1.000 MHz	<= 1.500 MHz
VBW	1.000 MHz	>= 1.000 MHz
SweepPoints	101	~ 15
Sweeptime	1.000 ms	AUTO
Reference Level	10.000 dBm	10.000 dBm
Attenuation	30.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	200	200
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	Sweep
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	11 / max. 150	max. 150
Stable	10 / 10	10
Max Stable Difference	0.08 dB	0.50 dB

Number of Hopping Channels

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	1 July 2019	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	

FCC Rule: 15.247(a)(1)(iii)
RSS-247 5.1

For frequency hopping systems operating in the 2400-2483.5 MHz band shall use at least 15 channels.

Test result

Table 30: Number of hopping channels

Operating frequency [MHz]	Number of channels	Minimum Limit	Result
2405 - 2480	16	15	PASS

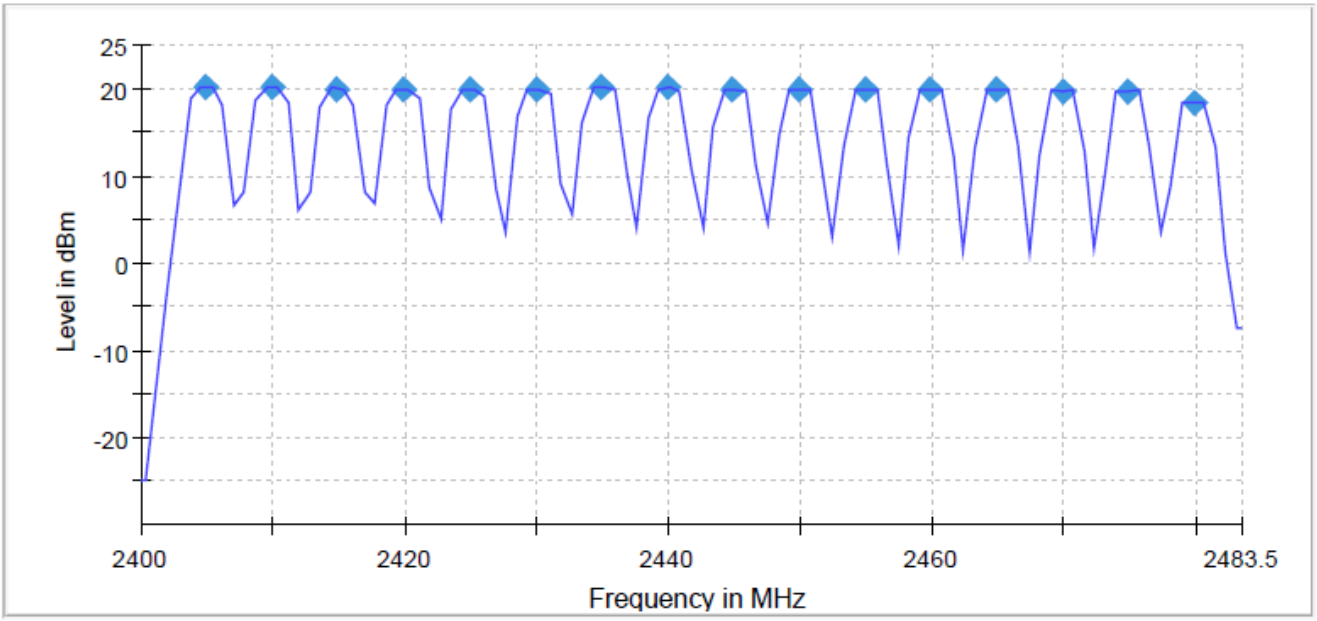

Figure 36: Number of hopping channels

Table 31: Measurement settings**,** Number of hopping channels

Setting	Instrument Value	Target Value
Start Frequency	2.40000 GHz	2.40000 GHz
Stop Frequency	2.48350 GHz	2.48350 GHz
Span	83.500 MHz	83.500 MHz
RBW	1.000 MHz	<= 1.495 MHz
VBW	1.000 MHz	>= 1.000 MHz
SweepPoints	101	~ 84
Sweeptime	11.377 µs	AUTO
Reference Level	10.000 dBm	10.000 dBm
Attenuation	30.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	9 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.49 dB	0.50 dB

Average Time of Occupancy of Hopping Frequency

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	1 July 2019	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	

FCC Rule: 15.247(a)(1)(iii)
RSS-247 5.1

For frequency hopping systems operating 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.

Test result

Table 32: Result

DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2405.000000	PASS	70	302.554	-3.0
2440.000000	PASS	70	302.554	-3.0
2480.000000	PASS	70	302.519	-3.0

Table 33: Periode

DUT Frequency (MHz)	Min (ms)	Max (ms)	Mean (ms)
2405.000000	90.255	90.295	90.275
2440.000000	90.254	90.294	90.275
2480.000000	90.258	90.298	90.275

Table 34: Transmit Time per Hop

DUT Frequency (MHz)	Min (ms)	Max (ms)	Limit Max for Max (ms)	Limit Min for Max (ms)	Mean (ms)
2405.000000	4.261	4.262	400.000	0.000	4.261
2440.000000	4.261	4.262	400.000	0.000	4.261
2480.000000	4.260	4.261	400.000	0.000	4.261

Table 35: Dwell time

DUT Frequency (MHz)	Min (ms)	Max (ms)	Mean (ms)
2405.000000	4.261	4.262	4.261
2440.000000	4.261	4.262	4.261
2480.000000	4.260	4.261	4.261

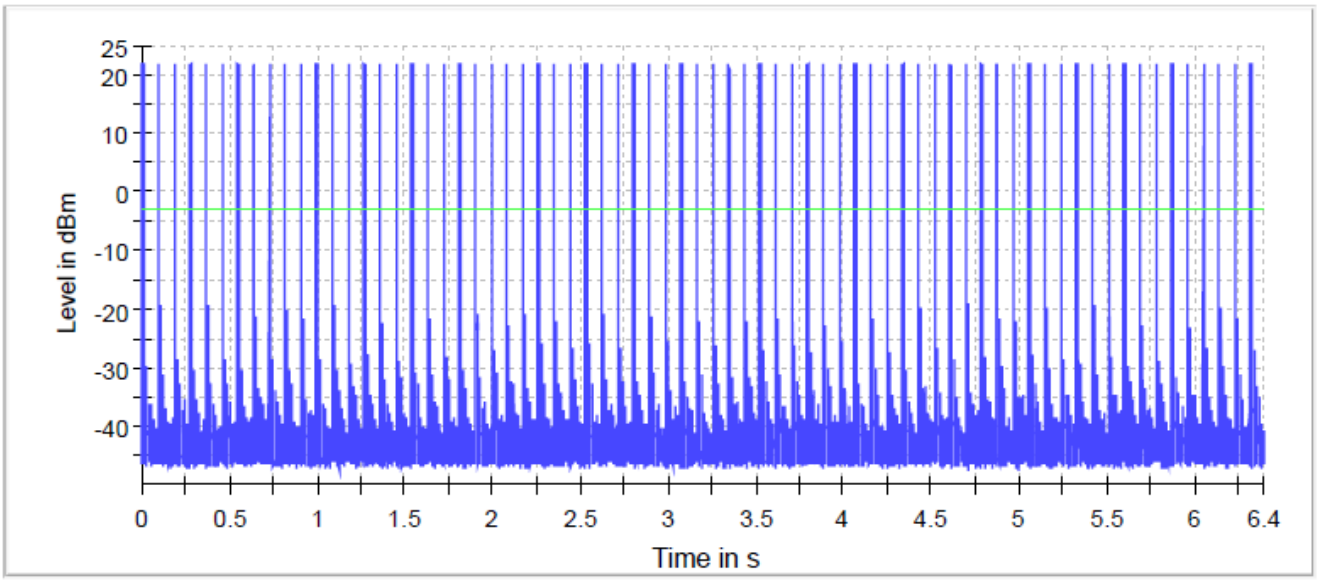

Figure 37: Time of channel occupancy LOW channel

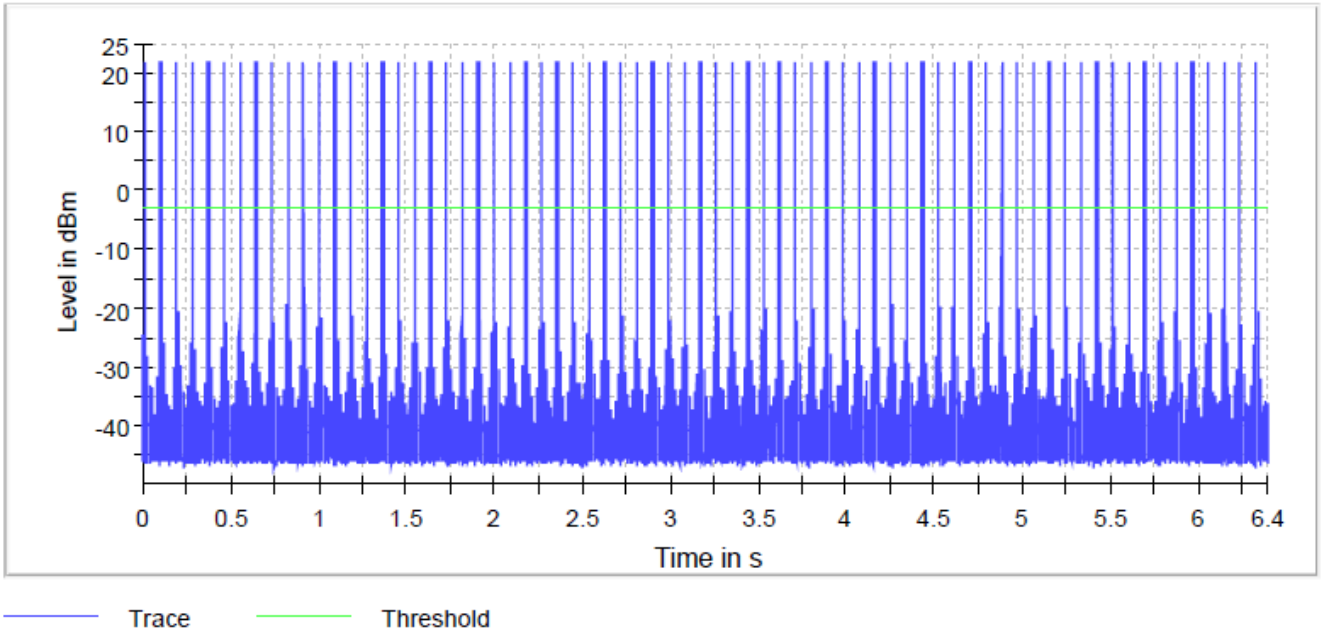

Figure 38: Time of channel occupancy MID channel

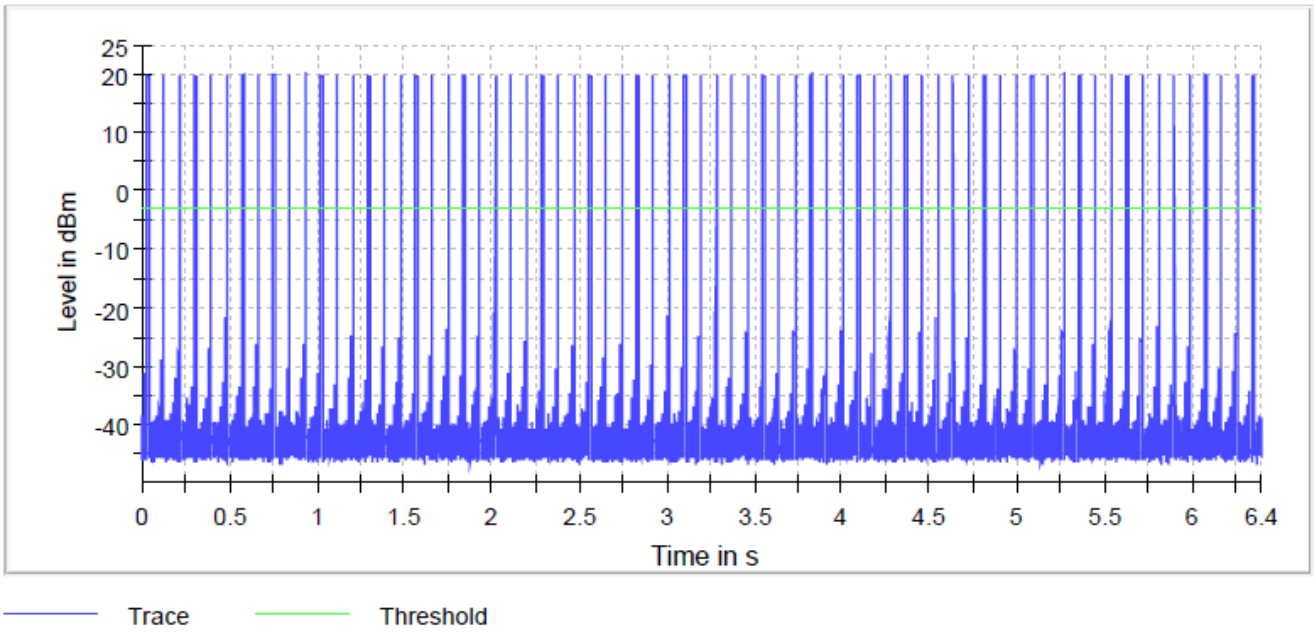

Figure 39: Time of channel occupancy HIGH channel

Table 36: Measurement settings, Time of channel occupancy

Setting	Instrument Value	Target Value
Span	ZeroSpan	ZeroSpan
RBW	2.000 MHz	~ 2.500 MHz
VBW	5.000 MHz	~ 6.000 MHz
SweepPoints	30001	~ 30001
Sweeptime	6.400 s	6.400 s
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	0.000 dB	0.000 dB
Detector	MaxPeak	MaxPeak
SweepCount	1	1
Filter	Channel	Channel
Trace Mode	Clear Write	Clear Write
Sweeptype	Sweep	AUTO
Preamp	off	off
Trigger	External	External
Trigger Offset	0.000 s	0.000 s
OSP settings		
Measurement Time	6.400 s	6.400 s
Tracepoints	6400000	6400000
Time resolution	1.000 µs	1.000 µs
Detector	RMS	RMS

6 dB Bandwidth of the Channel

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	1 July 2019	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	

FCC Rule: 15.247(a)(2)
RSS-247 5.2(a)

Results:

Table 37: 6 dB bandwidth test results

DUT Frequency (MHz)	6 dB BW [kHz]	Minimum limit [kHz]
2405.000000	1600	500
2440.000000	1700	
2480.000000	1700	

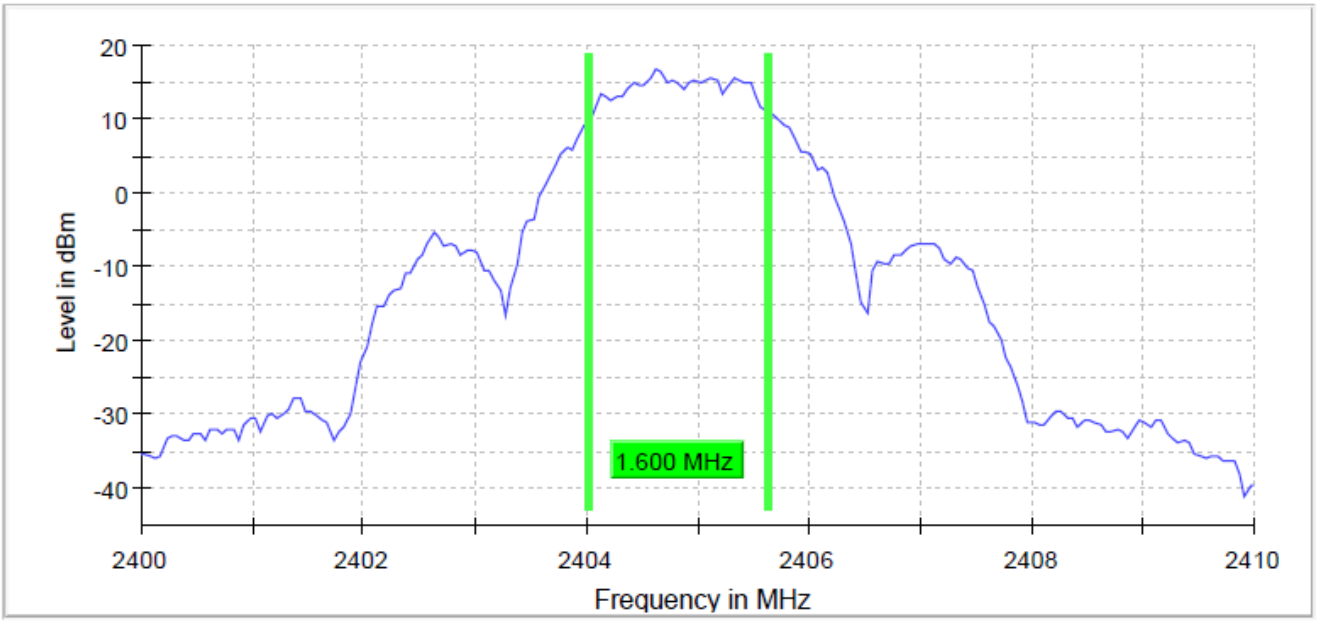

Figure 40: 6 dB bandwidth, channel LOW

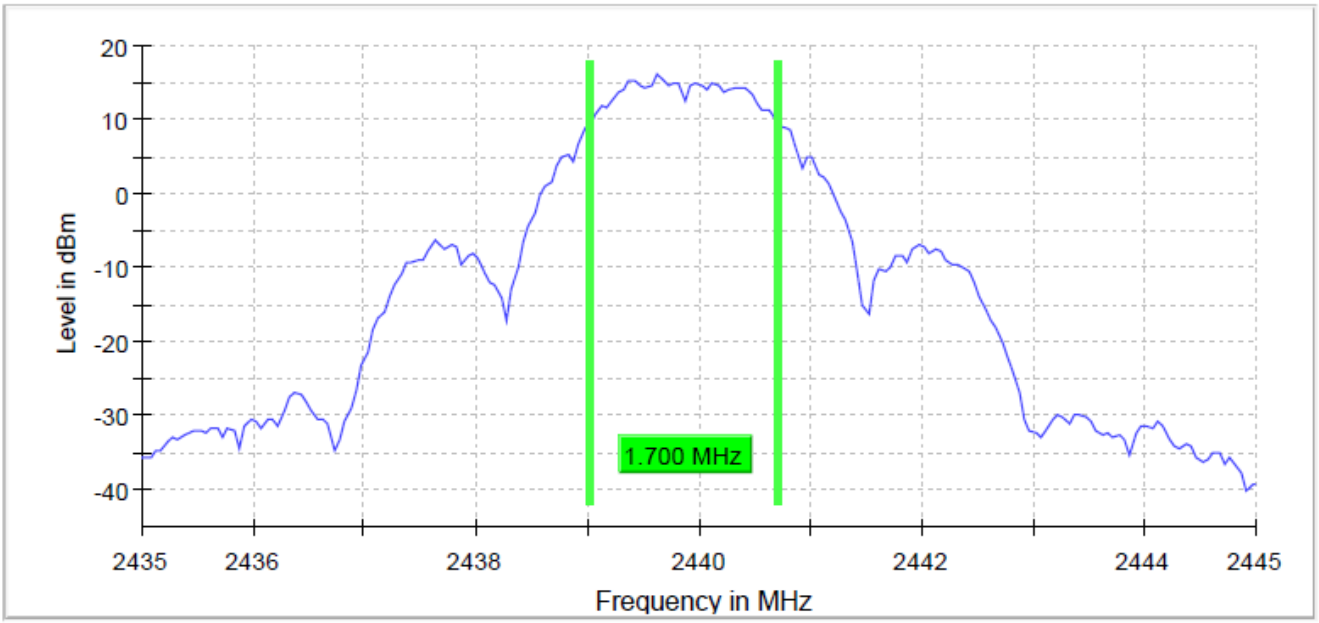

Figure 41: 6 dB bandwidth, channel MID

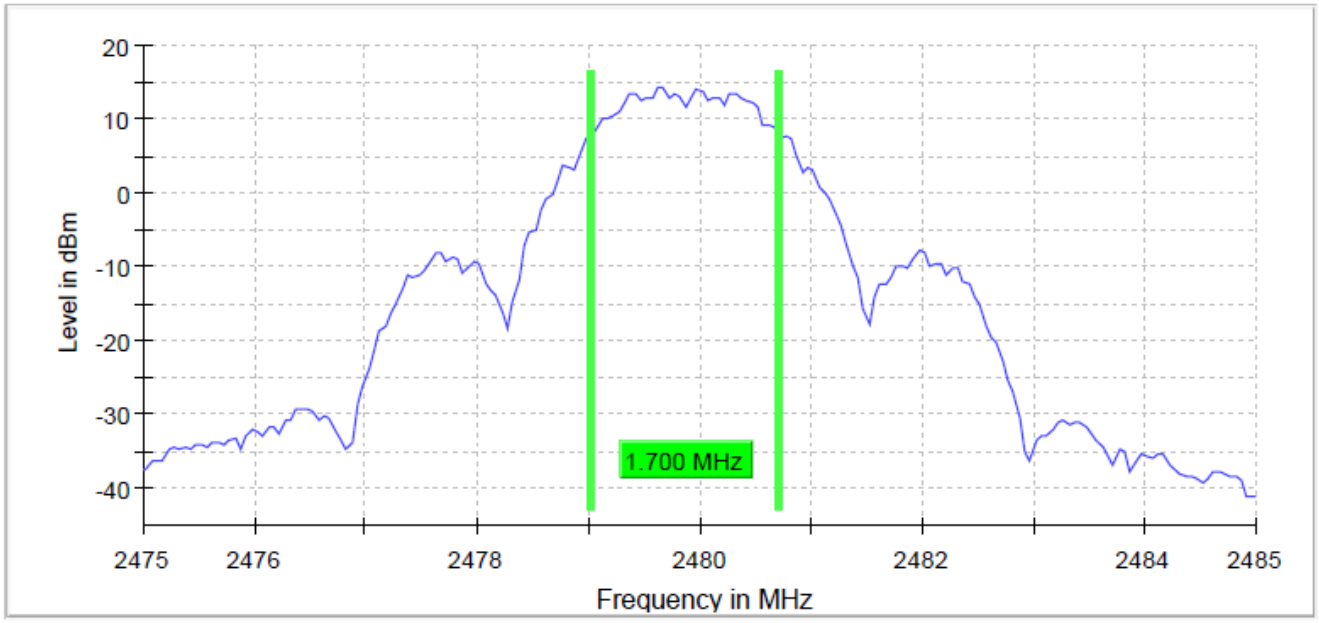

Figure 42: 6 dB bandwidth, channel HIGH

Table 38: Measurement settings, 6 dB bandwidth

Setting	Instrument Value	Target Value
Span	10.000 MHz	10.000 MHz
RBW	100.000 kHz	~ 100.000 kHz
VBW	300.000 kHz	~ 300.000 kHz
SweepPoints	200	~ 200
Sweeptime	18.945 µs	AUTO
Reference Level	10.000 dBm	10.000 dBm
Attenuation	30.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	500	500
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	19 / max. 150	max. 150
Stable	5 / 5	5
Max Stable Difference	0.28 dB	0.50 dB

99% Occupied Bandwidth

Standard:	RSS-GEN	(2019)
Tested by:	JAT	
Date:	1 July 2019	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	

RSS-GEN 6.6

Results

Table 39: 99% occupied bandwidth test results

Channel	Limit	99 % BW [MHz]	Result
Low	-	2.60000	PASS
Mid	-	2.60000	PASS
High	-	2.60000	PASS

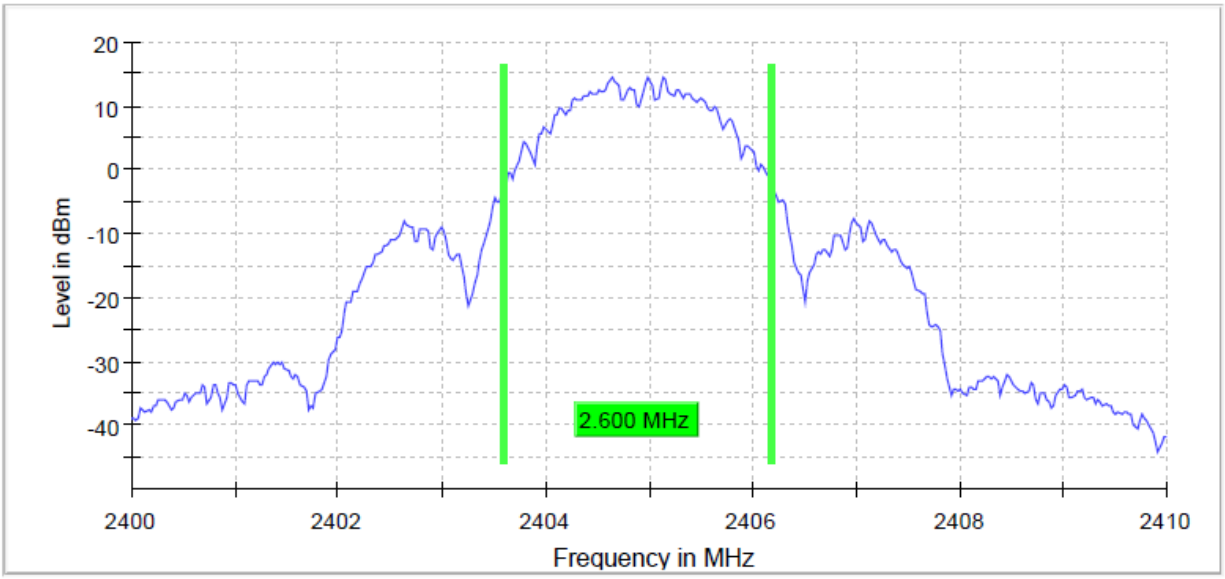

Figure 43: 99% OBW, channel LOW

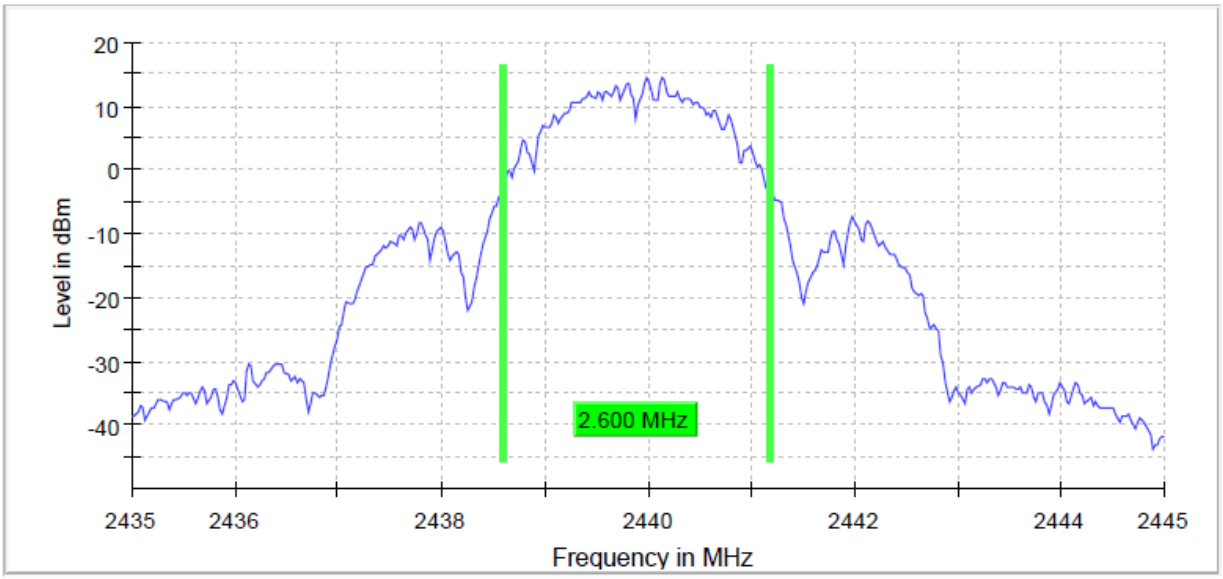

Figure 44: 99% OBW, channel MID

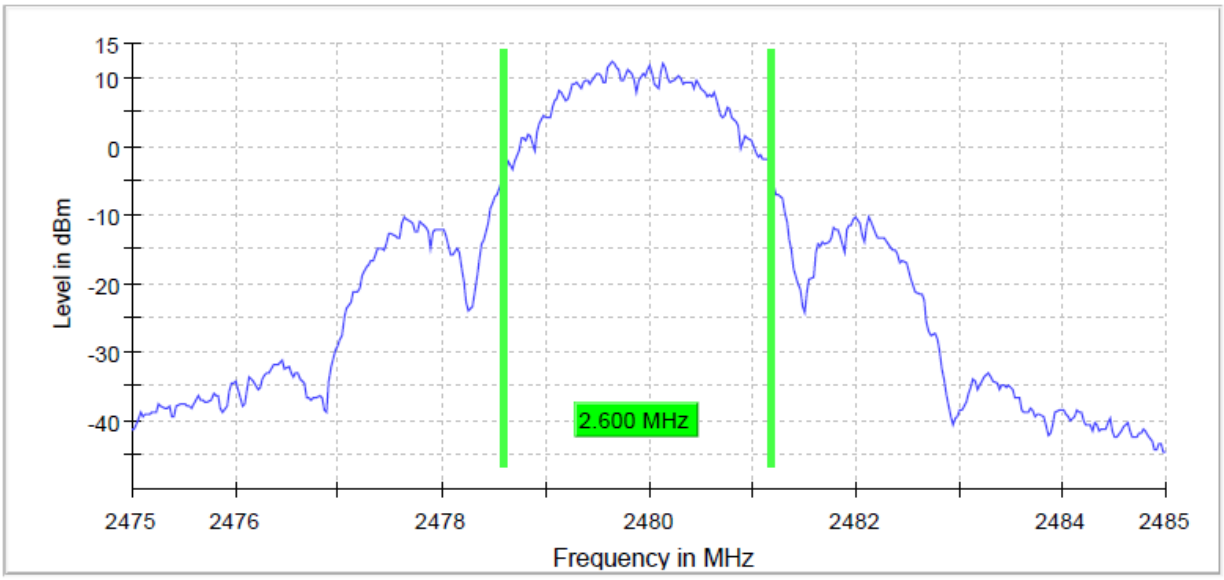

Figure 45: 99% OBW, channel HIGH

Table 40: Measurements settings, 99% occupied bandwidth

Setting	Instrument Value	Target Value
Span	10.000 MHz	10.000 MHz
RBW	50.000 kHz	>= 50.000 kHz
VBW	200.000 kHz	>= 150.000 kHz
SweepPoints	400	~ 400
Sweeptime	37.930 µs	AUTO
Reference Level	10.000 dBm	10.000 dBm
Attenuation	30.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	500	500
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.30 dB	0.30 dB
Run	31 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.08 dB	0.30 dB

Duty cycle correction factor, Transmit time in 100 ms

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	27 June 2019	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	

Spectrum analyzer with zero span was used to investigate spectrum.

15.35(c) Unless otherwise specified, e.g.§ 15.255(b), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to notification or verification.

Results

Pulse period (T) =90.27ms
Pulses/100ms=2
Length of one pulse = 4.27ms
Duty Cycle Correction Factor = 20*log(Tocc/100) = 20*log(2*4.27/100)=-21.37dB

TEST EQUIPMENT

RF-Test Equipment

Equipment	Manufacturer	Type	Inv or serial	Prev Calib	Next Calib
ANTENNA	A.H. SYSTEMS	SAS-200/518	inv:7873	-	-
SPECTRUM ANALYZER	AGILENT	E7405A	inv:9746	2018-01-08	2020-01-08
RF PREAMPLIFIER	CIAO	CA118-3123	inv:10278	2018-11-26	2019-11-26
RF PREAMPLIFIER	CIAO	CA1840-5019	inv:10593	2018-09-12	2019-09-12
TEMPERATURE/ HUMIDITY METER	DAVIS	VantagePro	inv:5296	2018-09-18	2019-09-18
POWER SUPPLY	DELTA	SM 130-25D	inv:10406	-	-
TEMPERATURE/ HUMIDITY SENSOR	EDS	OW-ENV-TH	inv:10517	2018-11-13	2019-11-13
TEMPERATURE/ HUMIDITY SENSOR	EDS	OW-ENV-TH	inv:10516	2018-11-13	2019-11-13
ANTENNA	EMCO	3117, 1-18GHz	inv:7293	2018-03-14	2020-03-14
ANTENNA	ETS LINDGREN	3160-10, 26.5-40GHz	inv:9151	2018-08-09	2019-08-09
ATTENUATOR	INMET	10 dB, DC-40 GHz	inv:10347	2019-04-01	2021-04-01
TURNTABLE	MATURO	DS430 UPGRADED	inv:10182	-	-
MAST & TURNTABLE CONTROLLER	MATURO	NCD	inv:10183	-	-
ANTENNA MAST	MATURO	TAM 4.0E	inv:10181	-	-
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW26	inv:10679	2019-06-28	2020-06-27
SPECTRUM ANALYZER	ROHDE & SCHWARZ	FSV40	inv:10881	2019-02-07	2021-02-07
ANTENNA	ROHDE & SCHWARZ	HFH2-Z2 , 335.4711.52	inv:8013	2018-10-30	2020-10-30
OSP BASE UNIT	ROHDE & SCHWARZ	OSP120	inv:10882	2019-02-28	2021-02-28
OSP-B157W 8 PORT	ROHDE & SCHWARZ	OSP-B157W8	inv:10883	2019-02-06	2021-02-06
OSP-B157WX	ROHDE & SCHWARZ	OSP-B157WX	inv:10884	2019-02-13	2021-02-13
RF SIGNAL GENERATOR	ROHDE & SCHWARZ	SMB100A	inv:9288	2017-02-10	2020-02-10
VECTOR SIGNAL GENERATOR	ROHDE & SCHWARZ	SMBV100A	inv:9290	2019-06-27	2022-06-27
ANTENNA	SCHWARZBECK	VULB 9168, 30-2000MHz	inv:8911	2018-10-25	2020-10-25
POWER SUPPLY	THANDAR	PL330TP	inv:9787	-	-
POWER SUPPLY	THANDAR	TS3021S	sn:099610	-	-
FILTER	WAINWRIGHT	HP, WHKX4.0/18G-10SS	inv:10403	2019-04-01	2021-04-01

Conducted Emissions

Equipment	Manufacturer	Type	Inv or serial	Prev Calib	Next Calib
POWER SUPPLY	CALIFORNIA INSTR.	5001i-400	inv:9488	-	-
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
LISN	ROHDE & SCHWARZ	ENV216	inv:9611	2019-03-01	2020-03-01
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW26	inv:10679	2019-06-28	2020-06-27