

# Test Report



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

Equipment Under Test: Handheld PTT communication device

Type: Aina Kepler

Applicant: AINA Wireless Finland Oy  
Joensuunkatu 7 G  
FI-24100 Salo  
FINLAND

Manufacturer: AINA Wireless Finland Oy  
Joensuunkatu 7 G  
FI-24100 Salo  
FINLAND

FCC Rule Part: 15.247: 2018  
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: 15 May 2020

Issued by:

Pekka Kälviäinen  
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Date:

15 May 2020

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 30 days only.*

## RELEASE HISTORY

Version	Changes	Issued
1.0	Initial release	15 May 2020

## PRODUCT DESCRIPTION

### Equipment Under Test

Handheld PTT communication device

Type: Aina Kepler  
Serial no: NA2  
FCC ID: 2AH78-AKEPLER  
IC: 21419-AKEPLER

Cellular module: Quectel EC25-AF  
FCC ID: XMR201808EC25AF  
IC: 10224A-2018EC25AF

Battery: Rechargeable Li-Polymer Battery  
Type: VARTA Storage GmbH, EZPack XL

Charger: I.T.E Power Supply (used only during Conducted Emissions on Power  
Supply Lines test)  
Type: Friwo Gerätebau GmbH, FW8000USB/05

### General Description

The equipment under test (EUT) is hand held PTT communication device with 2.4GHz ISM, 13.56 MHz NFC, GNSS and cellular capabilities.

### Classification

Fixed device	<input type="checkbox"/>
Mobile Device (Human body distance > 20cm)	<input type="checkbox"/>
Portable Device (Human body distance < 20cm)	<input checked="" type="checkbox"/>

### Modifications Incorporated in the EUT

No modifications were applied during the tests.

### Ratings and declarations

Operating Frequency Range (OFR):	2413.0 – 2470.0 MHz
Channels:	20
Channel separation:	3 MHz
Transmission technique:	FHSS
Antenna type:	Johanson Technology, Mini 2.45 GHz Antenna, P/N: 2450AT18A100
Integral Antenna gain:	0.5 dBi

**Power Supply**

EUT:	Rechargeable Li-Polymer Battery
Nominal Voltage:	3.7 VDC
Battery:	
Rated capacity:	3.7V 2400mAh 8.9Wh
Charger:	
Rated input:	100-240VAC/50-60Hz/300-150mA (120V/60Hz was used)
Rated output:	5VDC/2200mA

**Mechanical Size of the EUT**

Height: 125 mm      Width: 80 mm      Depth: 45 mm

**Cables**

DC cable, EUT-charger      shielded, 1.0 m

**Peripherals**

none

## 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 <sup>(1)</sup>
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.*

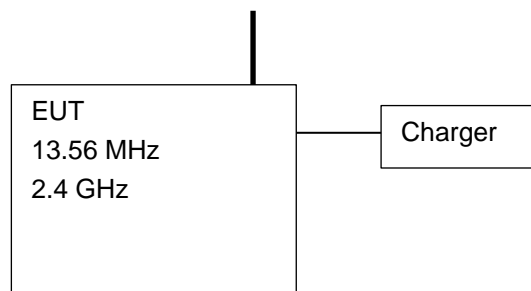
## EUT Test Conditions during Testing

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	continuous transmit
6 dB Bandwidth	continuous transmit
99% Occupied Bandwidth	continuous transmit
100 kHz Bandwidth of Frequency Band Edges, Conducted	continuous transmit, hopping
Radiated Emissions Within the Restricted Bands	continuous transmit

**Table 1:** Test frequencies

Channel	Frequency (MHz)
low	2413.0
middle	2440.0
high	2470.5
hopping mode	2413.0-2470.0

## Block Diagram



## Test Facility

Testing Laboratory / address: FCC designation number: <b>FI0002</b> ISED CAB identifier: <b>T004</b>	SGS Fimko Ltd Takomotie 8 FI-00380, HELSINKI FINLAND
Test Site:	<input type="checkbox"/> K10LAB, ISED Canada registration number: <b>8708A-1</b> <input checked="" type="checkbox"/> K5LAB, ISED Canada registration number: <b>8708A-2</b> <input type="checkbox"/> T10LAB



**TEST RESULTS****Antenna requirement**

**Standard:** FCC Rule §15.203  
**Tested by:** PKA  
**Date:** 28 November 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	<ol style="list-style-type: none"><li>1. Permanently attached antenna</li><li>2. Unique coupling to the intentional radiator</li><li>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.</li></ol>	<b>PASS</b>
Note	Option 1 is used	

**Conducted Emissions In The Frequency Range 150 kHz - 30 MHz****Conducted Emissions In The Frequency Range 150 kHz - 30 MHz**

**Standard:** ANSI C63.10 (2013)  
**Tested by:** PKA  
**Date:** 21 October 2019  
**Temperature:**  $23 \pm 3^{\circ}\text{C}$   
**Humidity:** 20 - 60 % RH  
**Barometric pressure:** 1001 hPa  
**Measurement uncertainty:**  $\pm 2.9 \text{ dB}$  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 (dB $\mu$ V)	
	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.

120V 60Hz AC input of the changer. All transmitters operate.

Full Spectrum

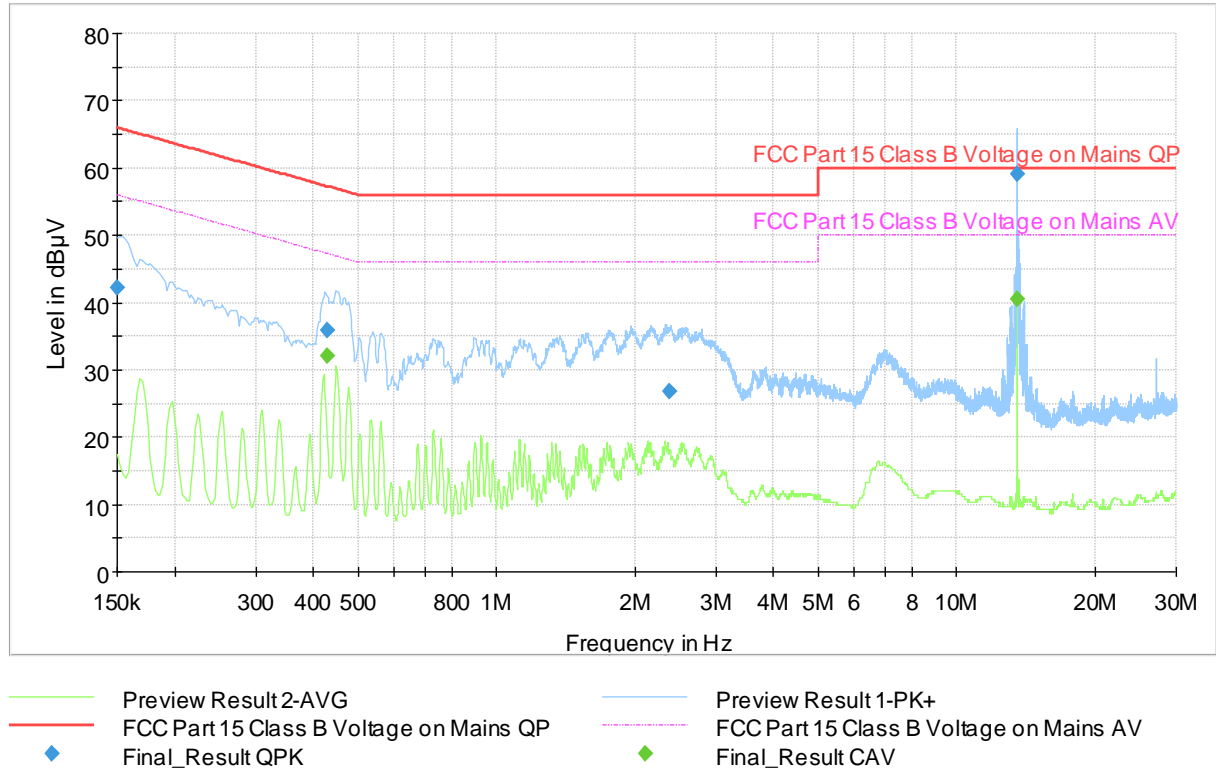


Figure 1: The measured curves with peak- and average detector

### 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)
0.150000	42.20	---	66.00	23.80	1000.0	9.000	L1	ON	9.6
0.428250	---	32.14	47.29	15.15	1000.0	9.000	N	ON	9.7
0.428250	35.93	---	57.29	21.36	1000.0	9.000	N	ON	9.7
2.381500	26.82	---	56.00	29.18	1000.0	9.000	N	ON	9.9
13.556750	---	40.50	50.00	9.50	1000.0	9.000	L1	ON	10.3
13.558500	59.06	---	60.00	0.94	1000.0	9.000	L1	ON	10.3

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****Maximum Peak Conducted Output Power**

**Standard:** ANSI C63.10 (2013)  
**Tested by:** MIH  
**Date:** 12 October 2019  
**Temperature:**  $23 \pm 3$  °C  
**Humidity:** 20 - 60 % RH  
**Measurement uncertainty:**  $\pm 2.87$  dB Level of confidence 95 % (k = 2)

**FCC Rule: 15.247(b)(1)**  
**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.

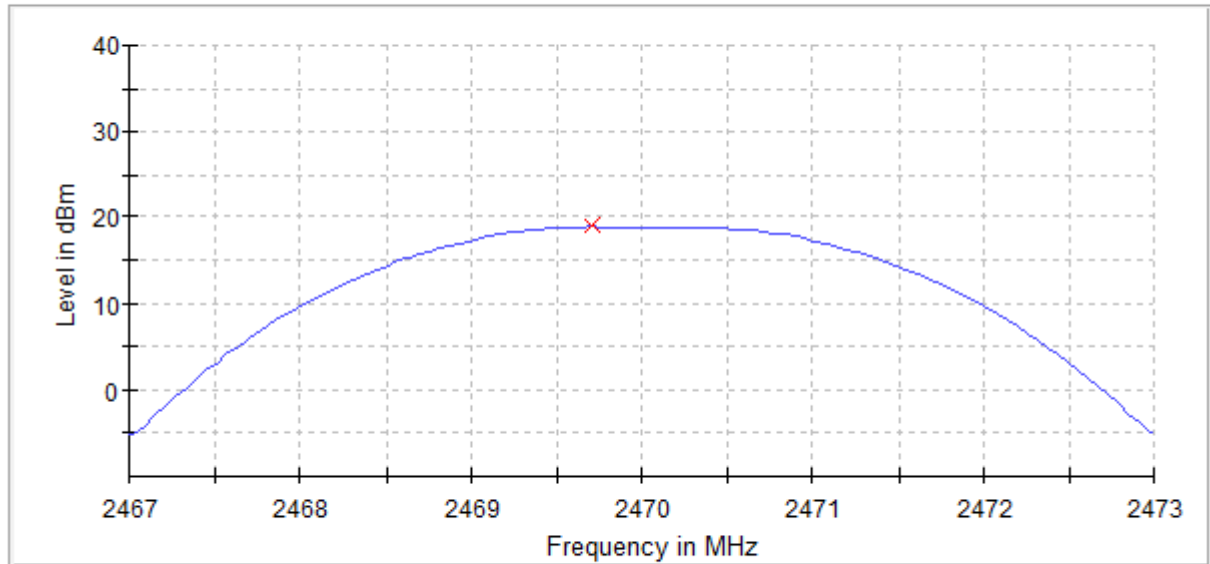
**Results:****Table 3:** Maximum conducted output power

Datarate	Channel	Conducted Power [dBm]	Limit [dBm]	Margin [dBm]	Result
0.5 Mbps	low	18.4	21	2.6	PASS
	mid	18.8	21	2.2	PASS
	high	19.0	21	2.0	PASS
2 Mbps	low	18.3	21	2.7	PASS
	mid	18.5	21	2.5	PASS
	high	18.3	21	2.7	PASS

Maximum Peak Conducted Output Power

Result

DUT Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Result
2470.000000	19.0	21.0	PASS

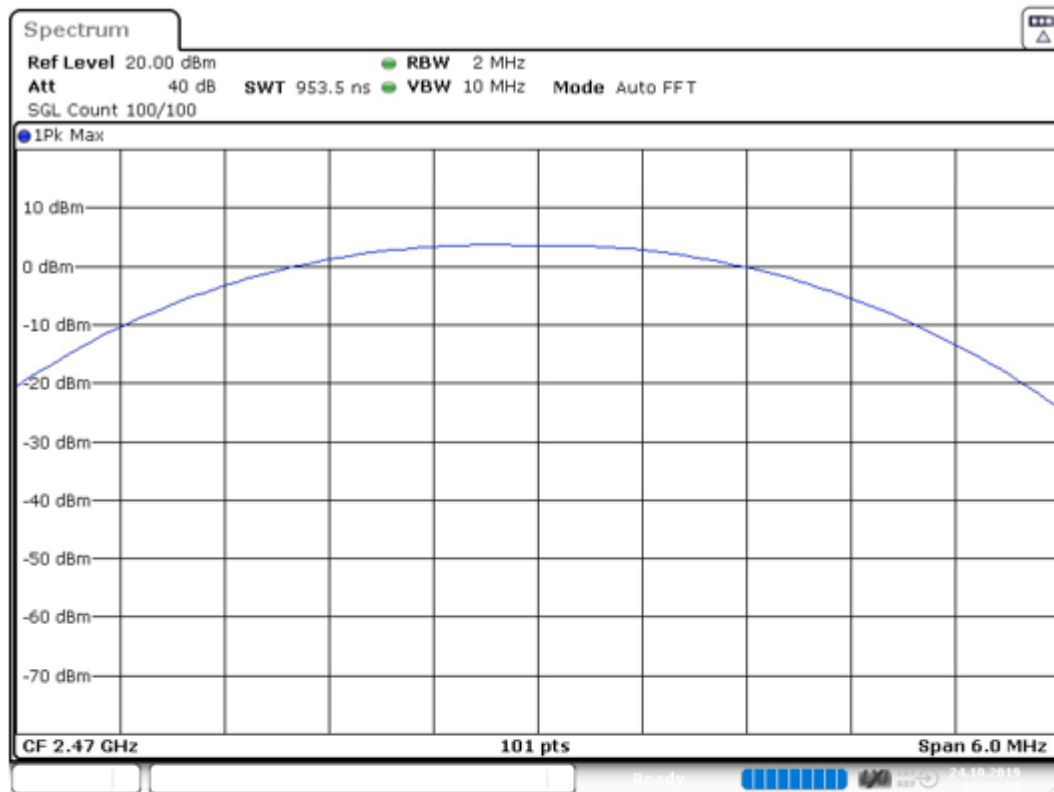


— Connector 1      × Peak Connector 1

Peak Power 1

**Figure 2:** Maximum conducted power, 0.5 Mbps channel high

## Maximum Peak Conducted Output Power



Date: 24.OCT.2019 12:29:05

## Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.46700 GHz	2.46700 GHz
Stop Frequency	2.47300 GHz	2.47300 GHz
Span	6.000 MHz	6.000 MHz
RBW	2.000 MHz	>= 1.095 MHz
VBW	10.000 MHz	>= 6.000 MHz
SweepPoints	101	~ 101
SweepTime	953.450 ns	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	0.07 dB	0.50 dB

Table 4: Measurement settings, maximum conducted output power

## Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

### Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

**Standard:** ANSI C63.10 (2013)  
**Tested by:** PKA, HEM  
**Date:** 14 - 18 October 2019  
**Temperature:**  $23 \pm 3$  °C  
**Humidity:** 20 - 60 % RH  
**Measurement uncertainty:**  $\pm 4.51$  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).

According to ANSI C63.10 (clause 5.3.2) and RSS-Gen (Clause 4.11) the measurements below 30 MHz can be performed at a closer distance than the EUT limit distance, the results shall be extrapolated to limit distance by using the square of an inverse linear distance extrapolation factor (40 dB/ decade). This method was used when performing measurements at a distance of 3 m instead of limit distances 300 m or 30 m.

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

Frequency range [MHz]	Limit [ $\mu$ V/m]	Limit [dB $\mu$ V/m]	Detector
0.009-0.490	2400/F(kHz)	300	Quasi-peak
0.490-1.705	24000/F(kHz)	30	Quasi-peak
1.705-30.0	30	30	Quasi-peak
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

## Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

**Table 5:** Quasipeak results below 1GHz, data rate 2 Mbps

Channel	Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
low	55.005	14.51	40.00	25.49	1000.0	120.000	118.0	H	49.0	17.7
	954.175	26.80	46.00	19.20	1000.0	120.000	138.0	V	230.0	27.8

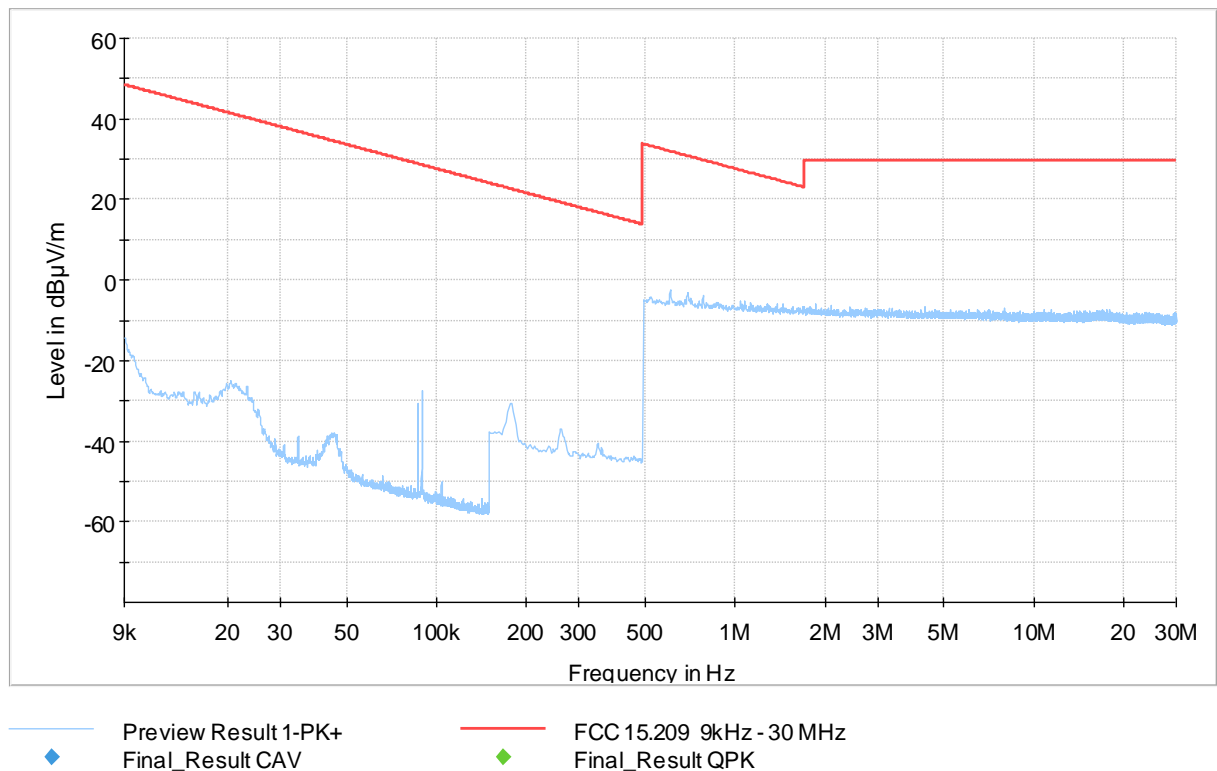
**Table 6:** Peak results above 1GHz, data rate 2 Mbps

Channel	Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
low	2381.000	58.64	73.90	15.26	1000.0	1000.000	164.0	V	97.0	13.6
	2390.000	-50.39	-20dBc	30.39	1000.0	1000.000	149.0	V	106.0	13.8
	2413.000	113.13	N/A Tx	---	1000.0	1000.000	218.0	H	144.0	13.8
	14474.975	57.42	73.90	16.48	1000.0	1000.000	159.0	H	339.0	18.4
	19303.425	59.22	73.90	14.58	1000.0	1000.000	139.0	V	0.0	6.0
mid	12197.475	53.35	73.90	20.55	1000.0	1000.000	164.0	V	317.0	16.8
high	2469.500	109.91	N/A Tx	---	1000.0	1000.000	116.0	V	102.0	13.8
	2489.300	53.33	73.90	20.57	1000.0	1000.000	189.0	V	129.0	13.8

**Table 7:** Average results above 1GHz, data rate 2 Mbps

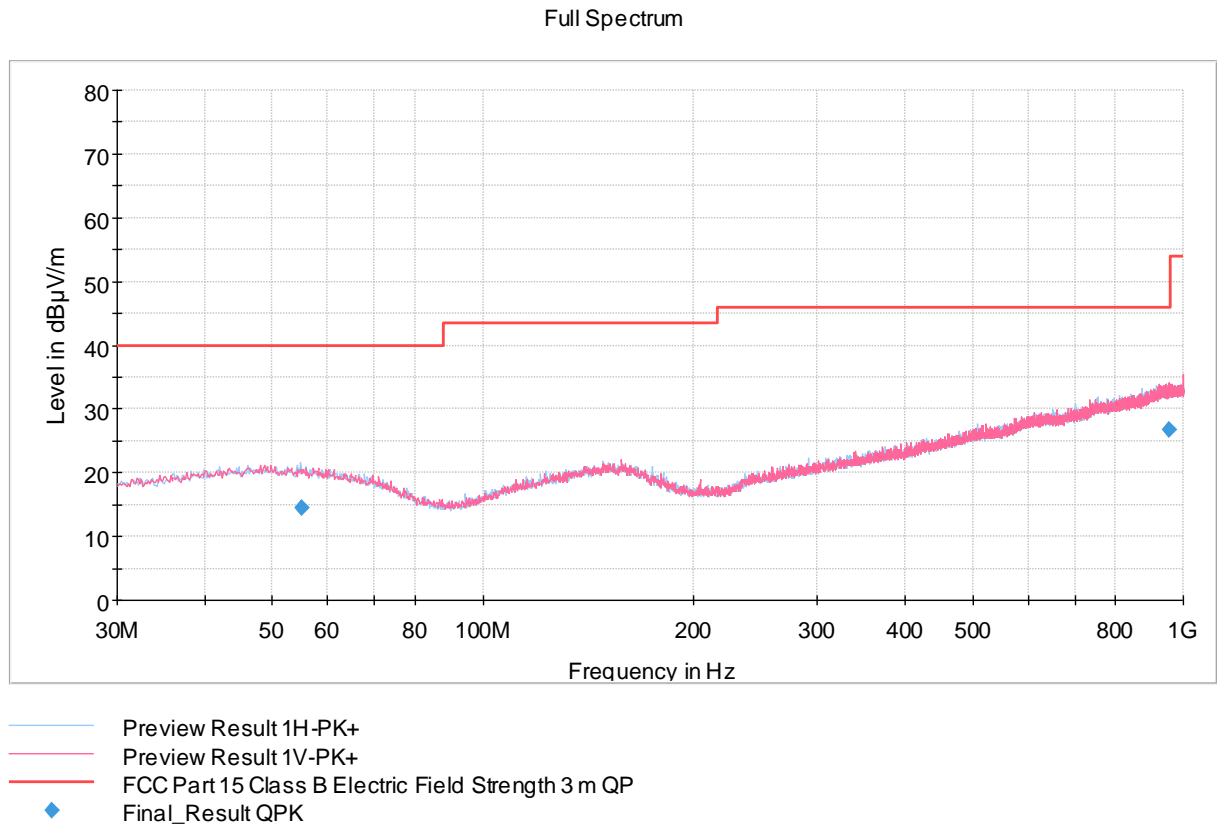
Channel	Frequency (MHz)	CAverag (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
low	14474.975	35.01	53.90	18.89	1000.0	1000.000	135.0	H	218.0	18.4
high	2488.900	36.68	53.90	17.22	1000.0	1000.000	214.0	V	118.0	13.8

Full Spectrum

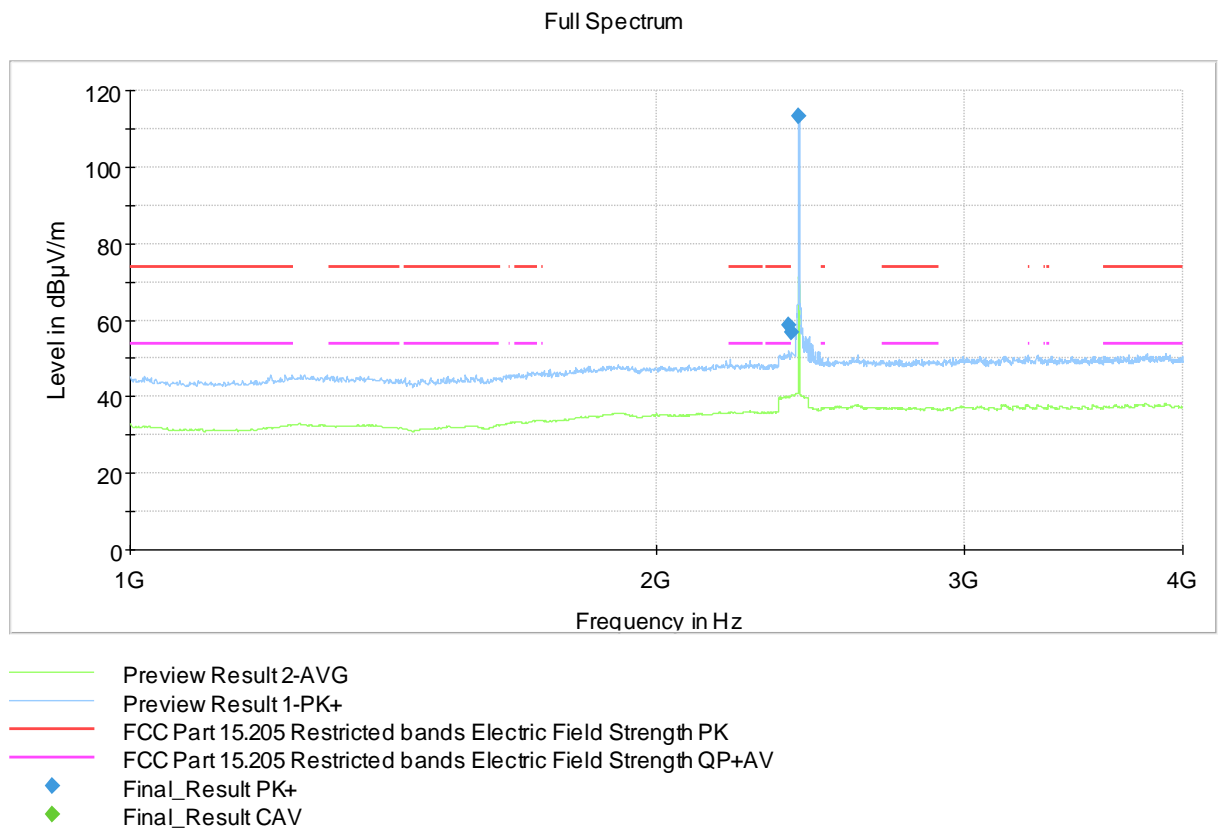

**Figure 3:** 9 kHz – 30 MHz, channel high



## Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

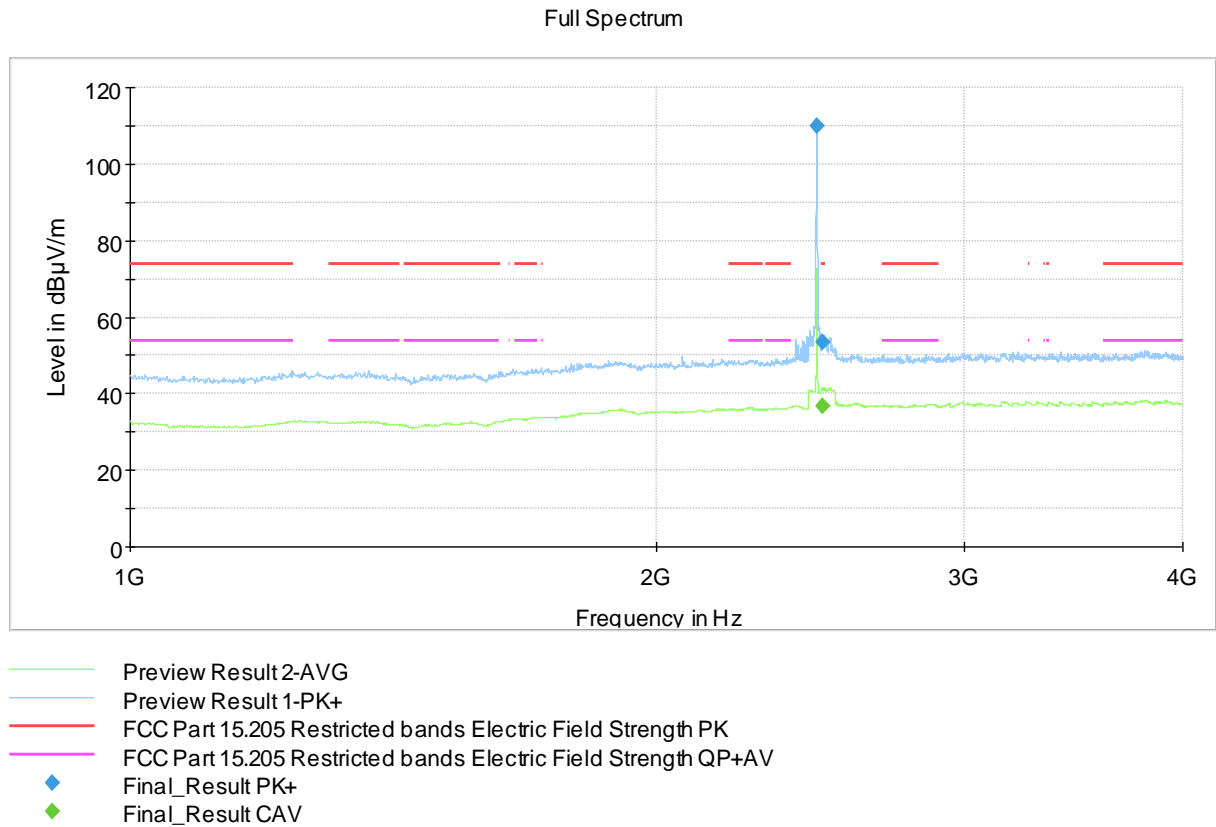


**Figure 4:** 30 MHz – 1000 MHz, channel low

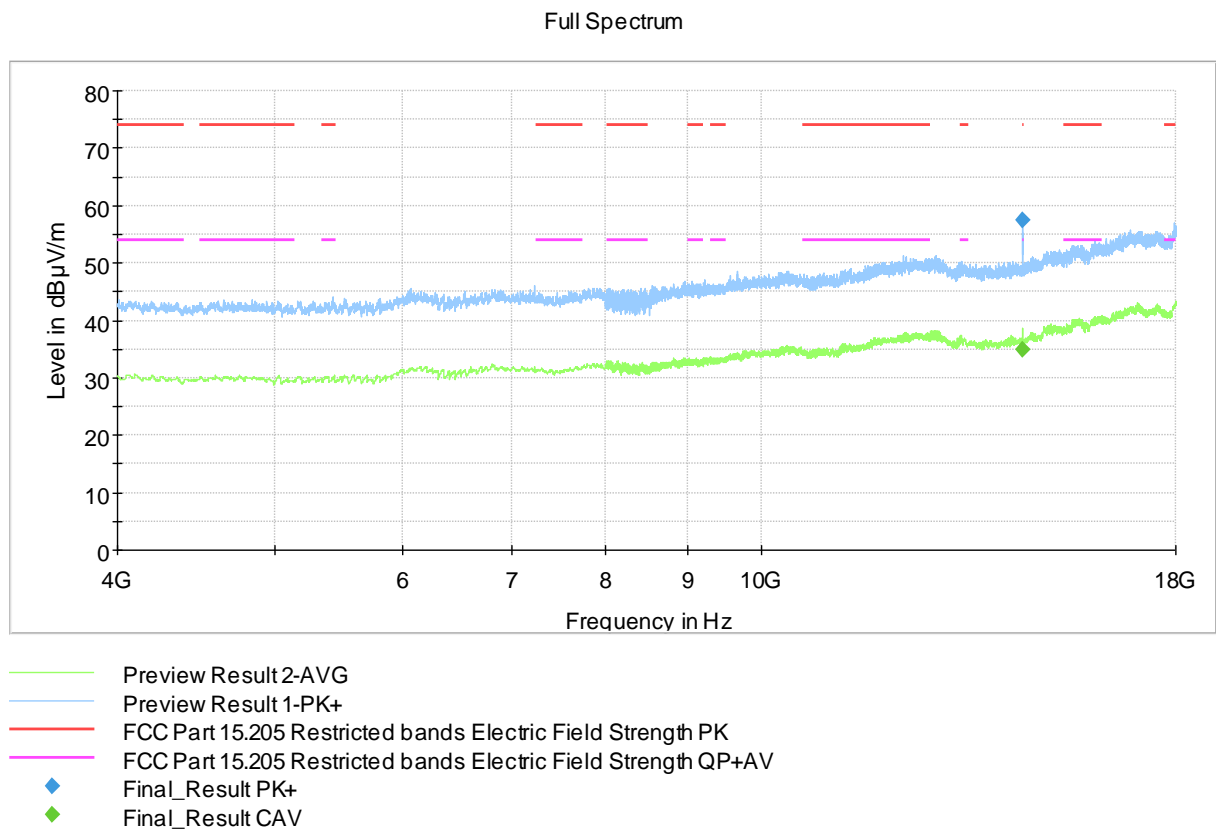


**Figure 5:** 1 GHz – 4 GHz, channel low, band edge

## Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

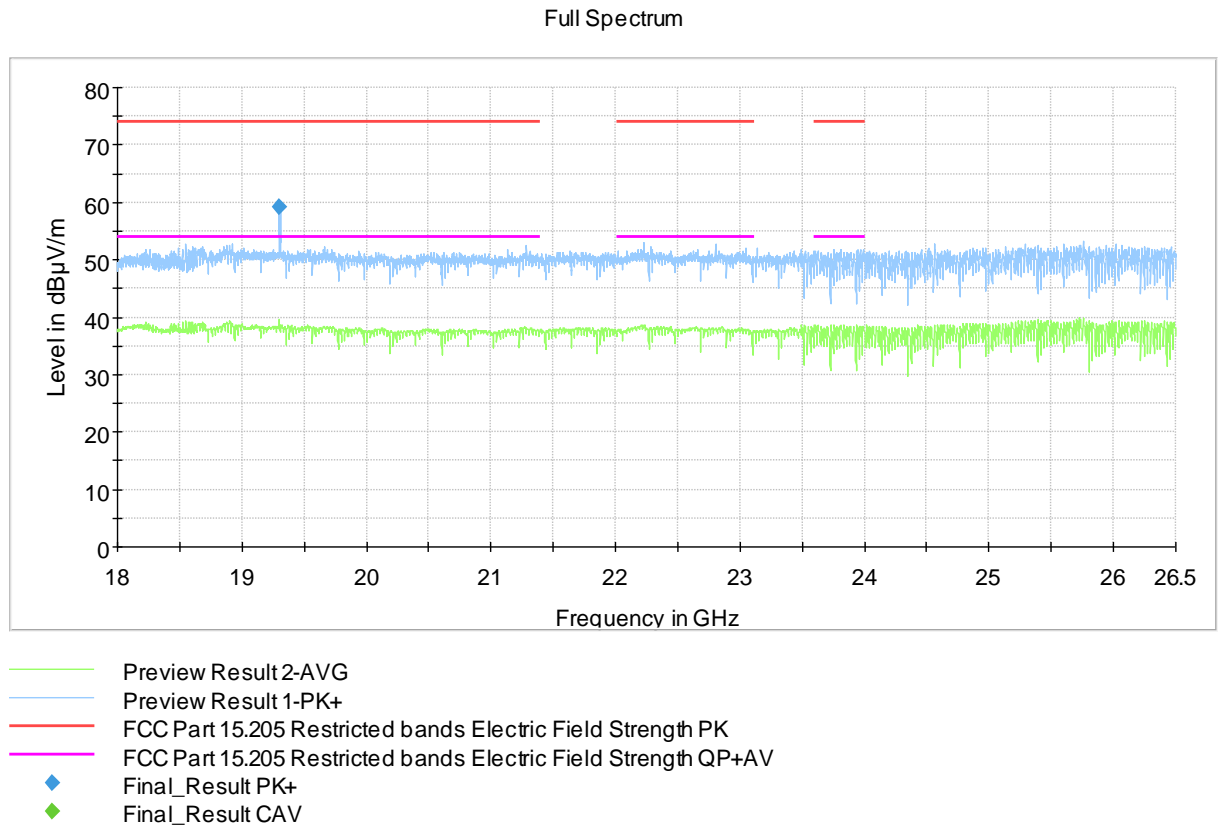


**Figure 6:** 1 GHz – 4 GHz, channel high, band edge



**Figure 7:** 4 GHz – 18 GHz, channel low

Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz



**Figure 8:** 18 GHz – 26.5 GHz, channel low

## Transmitter Band Edge Measurement, Conducted

**Standard:** ANSI C63.10 (2013)  
**Tested by:** MIH  
**Date:** 11 and 24 October 2019  
**Temperature:**  $23 \pm 3$  °C  
**Humidity:** 20 - 60 % RH  
**Measurement uncertainty:**  $\pm 2.87$  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 8:** Band edge attenuation, Continuous transmit mode

Datarate	Band Edge Attenuation	
	Lower Band Edge dBc	Upper Band Edge dBc
0.5 Mbps	-57.0	-60.5
2 Mbps	-56.2	-57.0
Limit: -20 dBc		

**Table 9:** Band edge attenuation, Hopping mode

Modem/Datarate	Band Edge Attenuation	
	Lower Band Edge dBc	Upper Band Edge dBc
0.5 Mbps	-59.0	-58.8
2 Mbps	-59.9	-60.0
Limit: -20 dBc		

## Transmitter Band Edge Measurement, Conducted

### Result

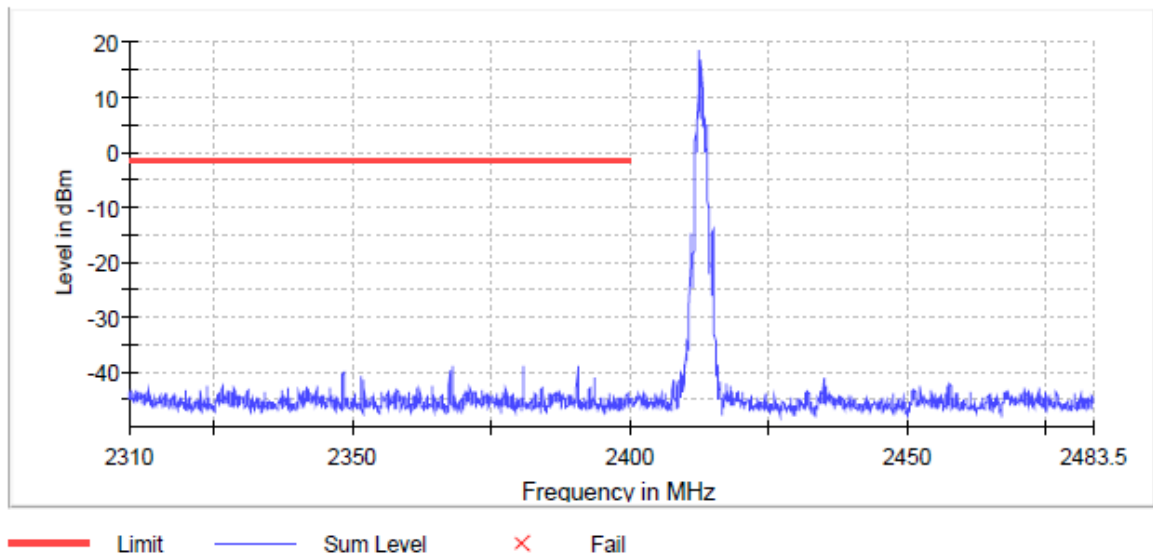
DUT Frequency (MHz)	Result
2413.000000	PASS

### Inband Peak

Frequency (MHz)	Level (dBm)
2412.525000	18.7

### Measurements

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2390.625000	-38.8	37.5	-1.3	PASS
2380.975000	-38.8	37.5	-1.3	PASS
2368.175000	-39.0	37.7	-1.3	PASS
2390.575000	-39.5	38.2	-1.3	PASS
2380.925000	-39.6	38.3	-1.3	PASS
2390.675000	-39.7	38.4	-1.3	PASS
2368.225000	-39.8	38.5	-1.3	PASS
2367.725000	-39.8	38.5	-1.3	PASS
2367.675000	-39.8	38.5	-1.3	PASS
2348.525000	-40.1	38.8	-1.3	PASS
2381.025000	-40.1	38.8	-1.3	PASS
2368.125000	-40.1	38.8	-1.3	PASS
2348.475000	-40.4	39.1	-1.3	PASS
2351.675000	-40.7	39.4	-1.3	PASS
2351.725000	-40.7	39.4	-1.3	PASS



**Figure 9:** Lower Band Edge, modem1, 2 Mbps, channel low

reported result = Inband Peak – maximum from Measurements = 18.7 - (-37.5) = 56.2 (-dBc)

## Measurement 1

Setting	Instrument Value	Target Value
Start Frequency	2.31000 GHz	2.31000 GHz
Stop Frequency	2.40000 GHz	2.40000 GHz
Span	90.000 MHz	90.000 MHz
RBW	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	1800	~ 1800
SweepTime	113.672 $\mu$ s	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	0.00 dB	0.50 dB

## Measurement 2

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	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	1670	~ 1670
SweepTime	94.727 $\mu$ s	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	11 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.15 dB	0.50 dB

**Table 10:** Measurement settings, lower band edge

## Transmitter Band Edge Measurement, Conducted

### Result

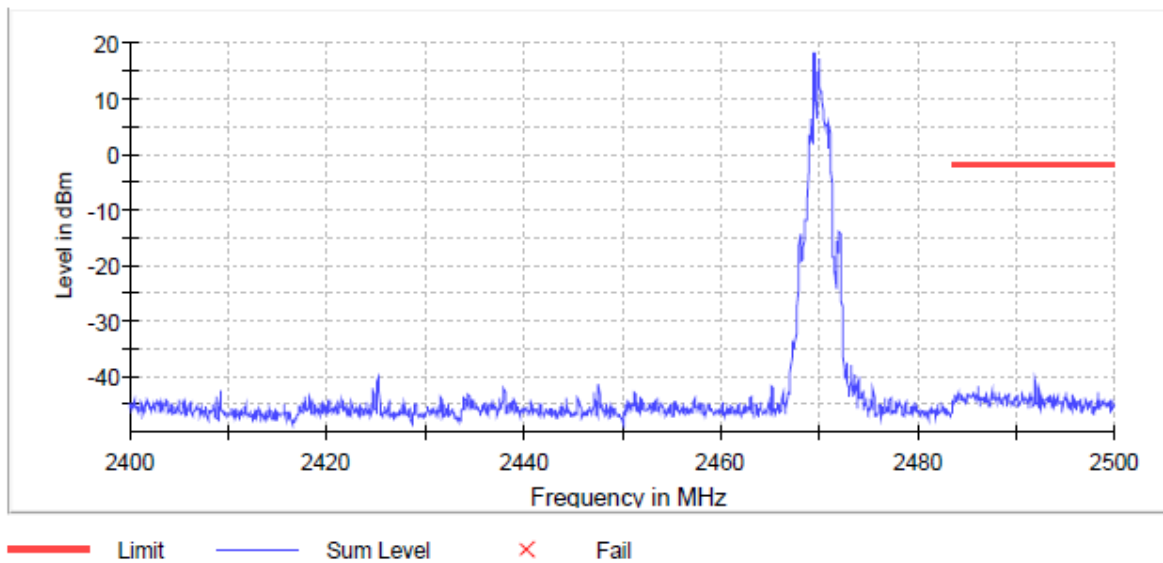
DUT Frequency (MHz)	Result
2470.000000	PASS

### Inband Peak

Frequency (MHz)	Level (dBm)
2469.525000	18.3

### Measurements

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2491.925000	-40.5	38.7	-1.7	PASS
2491.875000	-40.7	39.0	-1.7	PASS
2486.075000	-41.7	40.0	-1.7	PASS
2492.375000	-42.2	40.5	-1.7	PASS
2491.975000	-42.3	40.5	-1.7	PASS
2486.025000	-42.3	40.6	-1.7	PASS
2492.325000	-42.4	40.7	-1.7	PASS
2487.525000	-42.5	40.8	-1.7	PASS
2487.475000	-42.6	40.8	-1.7	PASS
2486.125000	-42.7	40.9	-1.7	PASS
2495.125000	-42.7	41.0	-1.7	PASS
2491.425000	-42.7	41.0	-1.7	PASS
2498.275000	-42.8	41.1	-1.7	PASS
2486.975000	-42.9	41.2	-1.7	PASS
2488.275000	-42.9	41.2	-1.7	PASS



**Figure 10:** Upper Band Edge, 2 Mbps, channel high

## Measurement 1

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	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	1670	~ 1670
SweepTime	94.727 $\mu$ s	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	8 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.00 dB	0.50 dB

## Measurement 2

Setting	Instrument Value	Target Value
Start Frequency	2.48350 GHz	2.48350 GHz
Stop Frequency	2.50000 GHz	2.50000 GHz
Span	16.500 MHz	16.500 MHz
RBW	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	330	~ 330
SweepTime	18.945 $\mu$ s	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	0.00 dB	0.50 dB

Table 11: Measurement settings, upper band edge



## Transmitter Band Edge Measurement, Conducted

### Result

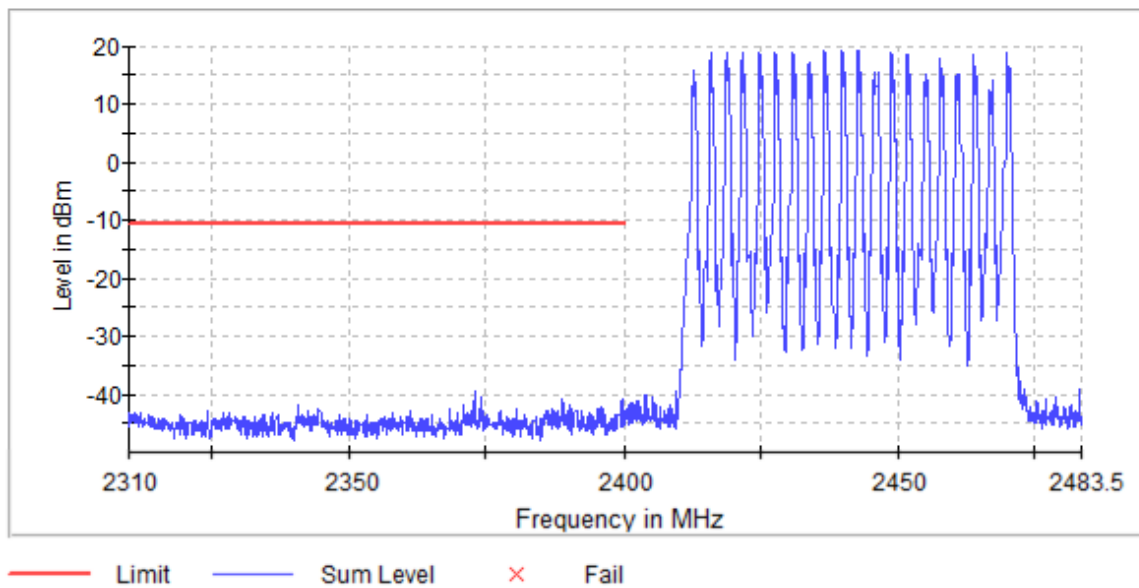
DUT Frequency (MHz)	Result
hopping	PASS

### Inband Peak

Frequency (MHz)	Level (dBm)
2442.725000	19.3

### Measurements

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2372.925000	-39.7	29.0	-10.7	PASS
2372.975000	-39.8	29.1	-10.7	PASS
2374.325000	-40.2	29.5	-10.7	PASS
2374.375000	-40.5	29.8	-10.7	PASS
2388.975000	-40.6	29.9	-10.7	PASS
2388.925000	-40.6	30.0	-10.7	PASS
2399.575000	-40.7	30.1	-10.7	PASS
2399.525000	-41.2	30.5	-10.7	PASS
2399.625000	-41.4	30.7	-10.7	PASS
2389.225000	-41.5	30.9	-10.7	PASS
2340.825000	-41.8	31.1	-10.7	PASS
2370.775000	-41.8	31.1	-10.7	PASS
2390.325000	-41.9	31.2	-10.7	PASS
2390.375000	-41.9	31.2	-10.7	PASS
2399.475000	-42.0	31.3	-10.7	PASS



**Figure 11:** Lower Band Edge, 0.5 Mbps, hopping mode

## Measurement 1

Setting	Instrument Value	Target Value
Start Frequency	2.31000 GHz	2.31000 GHz
Stop Frequency	2.40000 GHz	2.40000 GHz
Span	90.000 MHz	90.000 MHz
RBW	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	1800	~ 1800
SweepTime	113.672 $\mu$ s	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
Preamplifier	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	0.00 dB	0.50 dB

## Measurement 2

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	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	1670	~ 1670
SweepTime	94.727 $\mu$ s	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
Preamplifier	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	56 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.00 dB	0.50 dB

Table 12: Measurement settings, lower band edge, hopping mode

## Result

DUT Frequency (MHz)	Result
hopping	PASS

## Inband Peak

Frequency (MHz)	Level (dBm)
2442.725000	19.3

## Measurements

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2483.625000	-39.5	28.9	-10.7	PASS
2486.625000	-39.5	28.9	-10.7	PASS
2486.675000	-39.6	29.0	-10.7	PASS
2486.575000	-39.9	29.2	-10.7	PASS
2483.675000	-40.1	29.4	-10.7	PASS
2488.075000	-40.1	29.4	-10.7	PASS
2488.025000	-40.2	29.5	-10.7	PASS
2486.725000	-40.6	29.9	-10.7	PASS
2483.575000	-40.6	30.0	-10.7	PASS
2484.825000	-40.8	30.1	-10.7	PASS
2484.775000	-41.3	30.6	-10.7	PASS
2484.875000	-41.5	30.8	-10.7	PASS
2486.525000	-41.5	30.8	-10.7	PASS
2497.975000	-41.8	31.1	-10.7	PASS
2485.175000	-41.8	31.1	-10.7	PASS

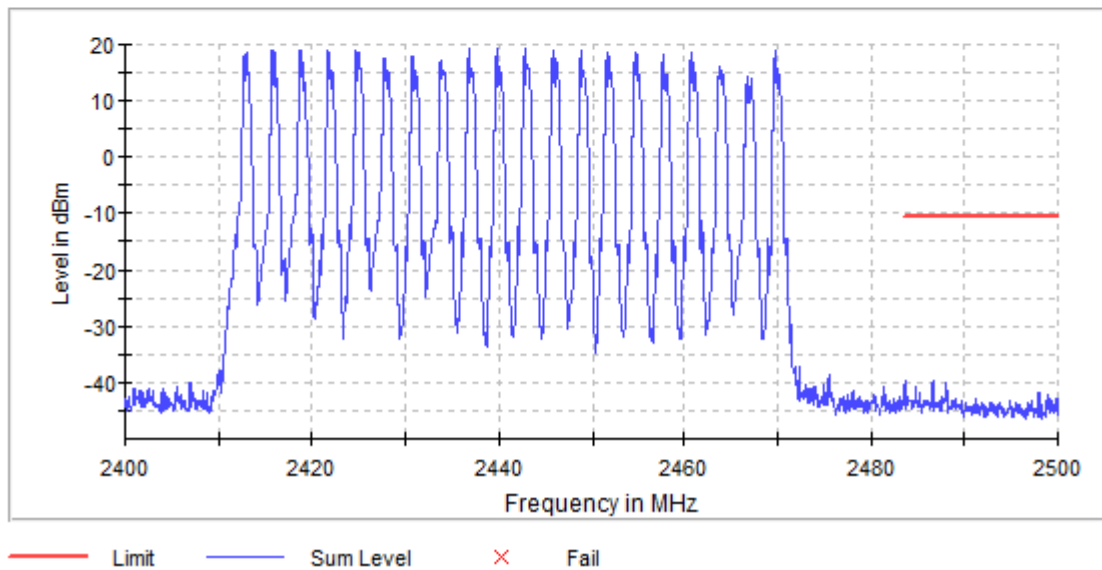


Figure 12: Upper band edge results, 0.5 Mbps, hopping mode

## Measurement 1

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	100.000 kHz	$\leq 100.000$ kHz
VBW	300.000 kHz	$\geq 300.000$ kHz
SweepPoints	1670	~ 1670
SweepTime	94.727 $\mu$ s	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	74 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.00 dB	0.50 dB

## Measurement 2

Setting	Instrument Value	Target Value
Start Frequency	2.48350 GHz	2.48350 GHz
Stop Frequency	2.50000 GHz	2.50000 GHz
Span	16.500 MHz	16.500 MHz
RBW	100.000 kHz	$\leq 100.000$ kHz
VBW	300.000 kHz	$\geq 300.000$ kHz
SweepPoints	330	~ 330
SweepTime	18.945 $\mu$ s	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	0.00 dB	0.50 dB

Table 13: Measurement settings, upper band edge

## 20 dB Bandwidth of the Hopping Channel

### 20 dB Bandwidth of the Hopping Channel

**Standard:** ANSI C63.10 (2013)  
**Tested by:** MIH  
**Date:** 11 and 24 October 2019  
**Temperature:**  $23 \pm 3$  °C  
**Humidity:** 20 - 60 % RH

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

#### Results:

**Table 14:** 20 dB bandwidth test results

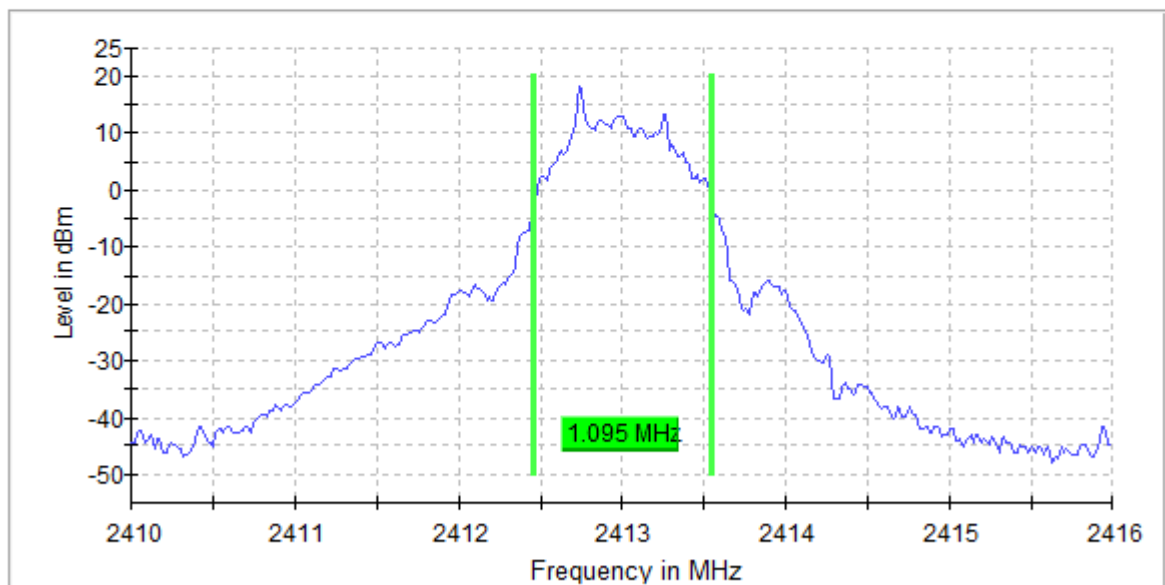
Datarate	Channel	20 dB BW [MHz]	Minimum limit [MHz]	Result
0.5 Mbps	low	1.095000	-	PASS
	mid	1.080000		PASS
	high	1.080000		PASS
2 Mbps	low	2.175000	-	PASS
	mid	2.175000		PASS
	high	2.100000		PASS

## 20 dB Bandwidth

DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Limit Max (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2413.000000	1.095000	---	---	2412.452500	2413.547500

(continuation of the "20 dB Bandwidth" table from [column 6](#) ...)

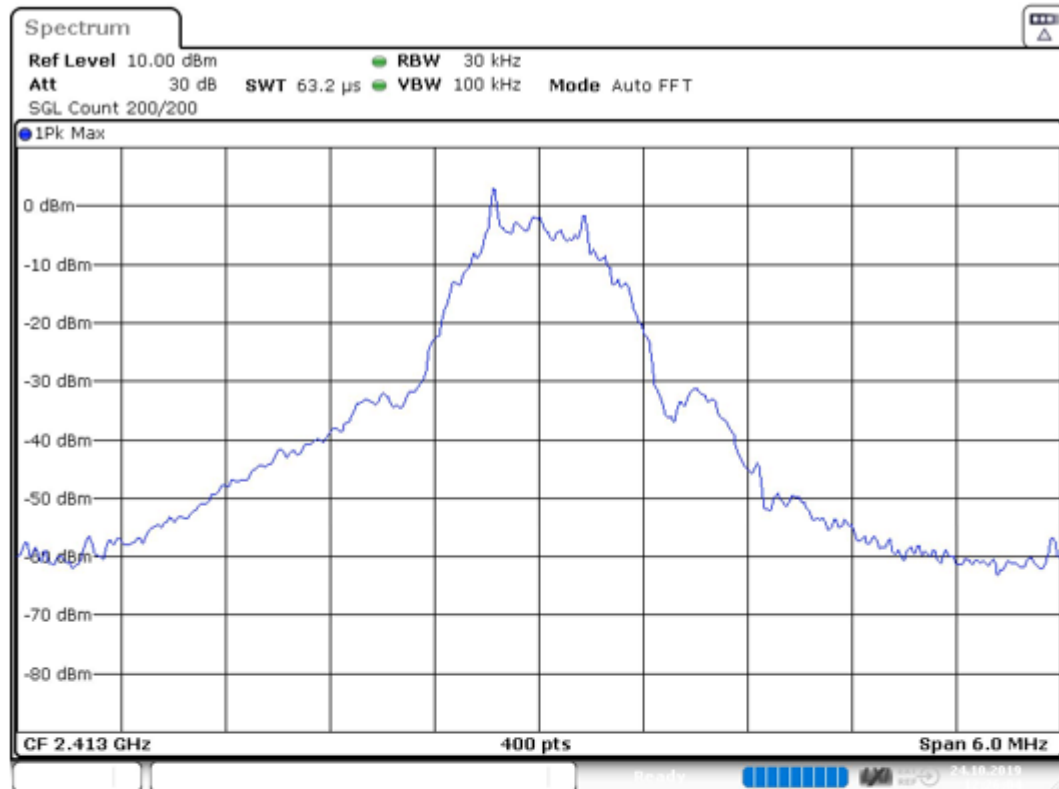
DUT Frequency (MHz)	Max Level (dBm)	Result
2413.000000	18.2	PASS



Bandwidth

**Figure 13:** 20 dB channel BW, 0.5 Mbps channel low

## 20 dB Bandwidth of the Hopping Channel



Date: 24.OCT.2019 12:26:04

### Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.41000 GHz	2.41000 GHz
Stop Frequency	2.41600 GHz	2.41600 GHz
Span	6.000 MHz	6.000 MHz
RBW	30.000 kHz	$\geq 30.000$ kHz
VBW	100.000 kHz	$\geq 90.000$ kHz
SweepPoints	400	$\sim 400$
SweepTime	63.216 $\mu$ s	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	28 / max. 150	max. 150
Stable	5 / 5	5
Max Stable Difference	0.00 dB	0.50 dB

**Table 15:** Measurement settings, 20 dB bandwidth

## Hopping Channel Carrier Frequencies Separation

## Hopping Channel Carrier Frequencies Separation

**Standard:** ANSI C63.10 (2013)  
**Tested by:** PKA  
**Date:** 6 August 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 16:** Hopping channel carrier frequencies separation test result

Datarate	DUT Frequency [MHz]	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)	Channel Separation (MHz)	Minimum limit (MHz)	Result
0.5 Mbps	2413.0 – 2470.0	2439.985149	2443.014851	3.029702	0.72	PASS
2 Mbps	2413.0 – 2470.0	2466.896040	2469.925743	3.029703	1.40	PASS



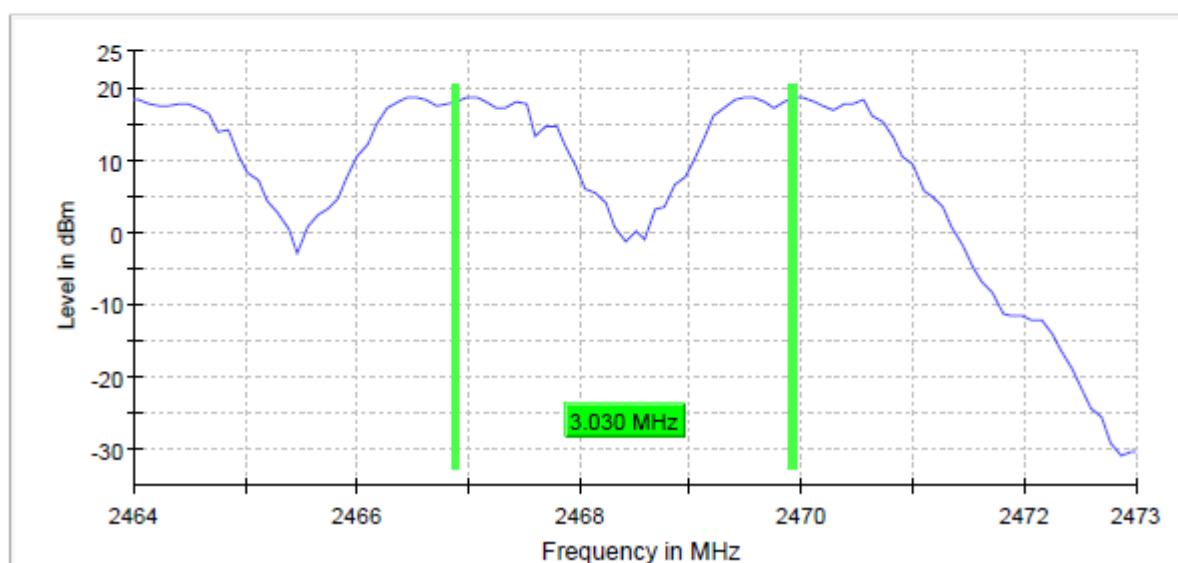
## Hopping Channel Carrier Frequencies Separation

### Result

DUT Frequency (MHz)	Frequency Separation (MHz)	Limit Min (MHz)	Limit Max (MHz)	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)
2470.000000	3.029703	1.400000	---	2466.896040	2469.925743

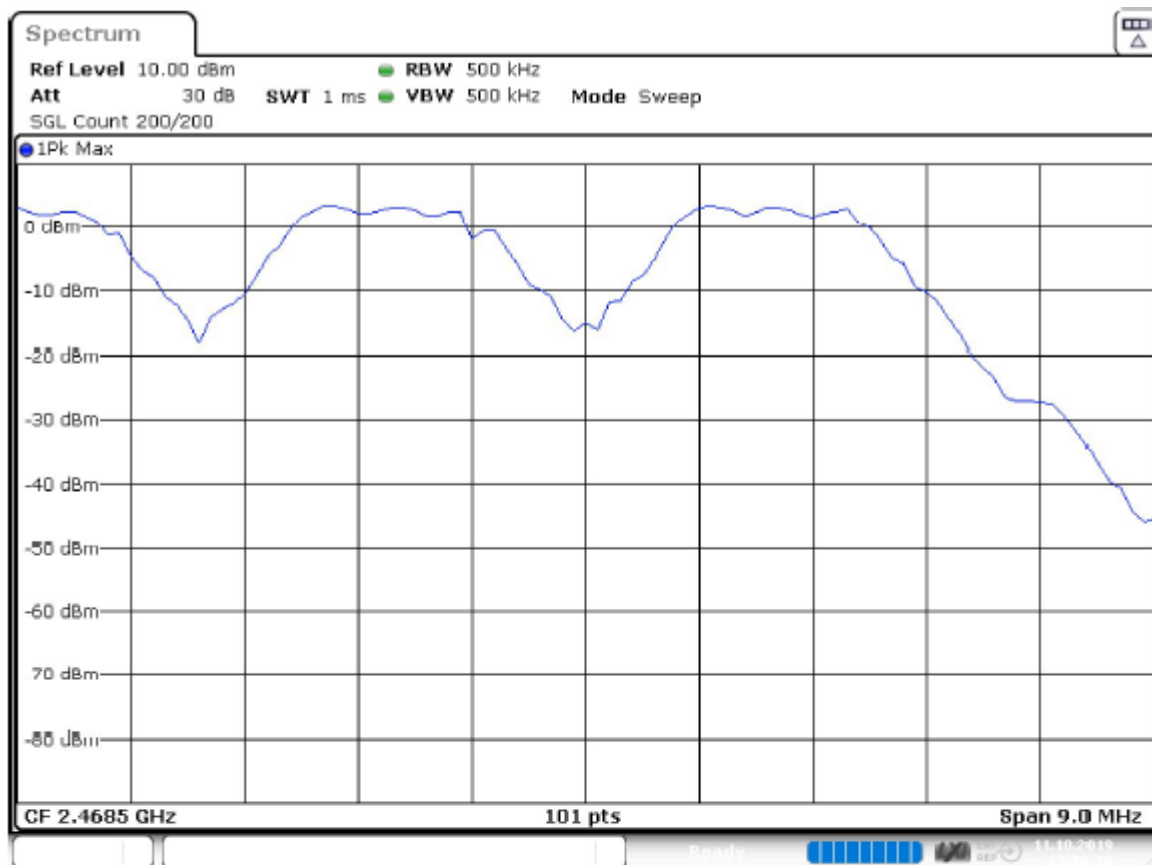
(continuation of the "Result" table from column 6 ...)

DUT Frequency (MHz)	Result
2470.000000	PASS



**Figure 14:** Measured hopping channels carrier frequency separation, 2 Mbps

## Hopping Channel Carrier Frequencies Separation



Date: 11.OCT.2019 13:56:30

## Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.46400 GHz	2.46400 GHz
Stop Frequency	2.47300 GHz	2.47300 GHz
Span	9.000 MHz	9.000 MHz
RBW	500.000 kHz	<= 900.000 kHz
VBW	500.000 kHz	>= 500.000 kHz
SweepPoints	101	~ 18
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	69 / max. 150	max. 150
Stable	10 / 10	10
Max Stable Difference	0.00 dB	0.50 dB

**Table 17:** Measurement settings, measured hopping channels carrier frequency separation

## Number of Hopping Channels

**Standard:** ANSI C63.10 (2013)  
**Tested by:** MIH  
**Date:** 24 October 2019  
**Temperature:** 23 ± 3 °C  
**Humidity:** 20 - 60 % RH

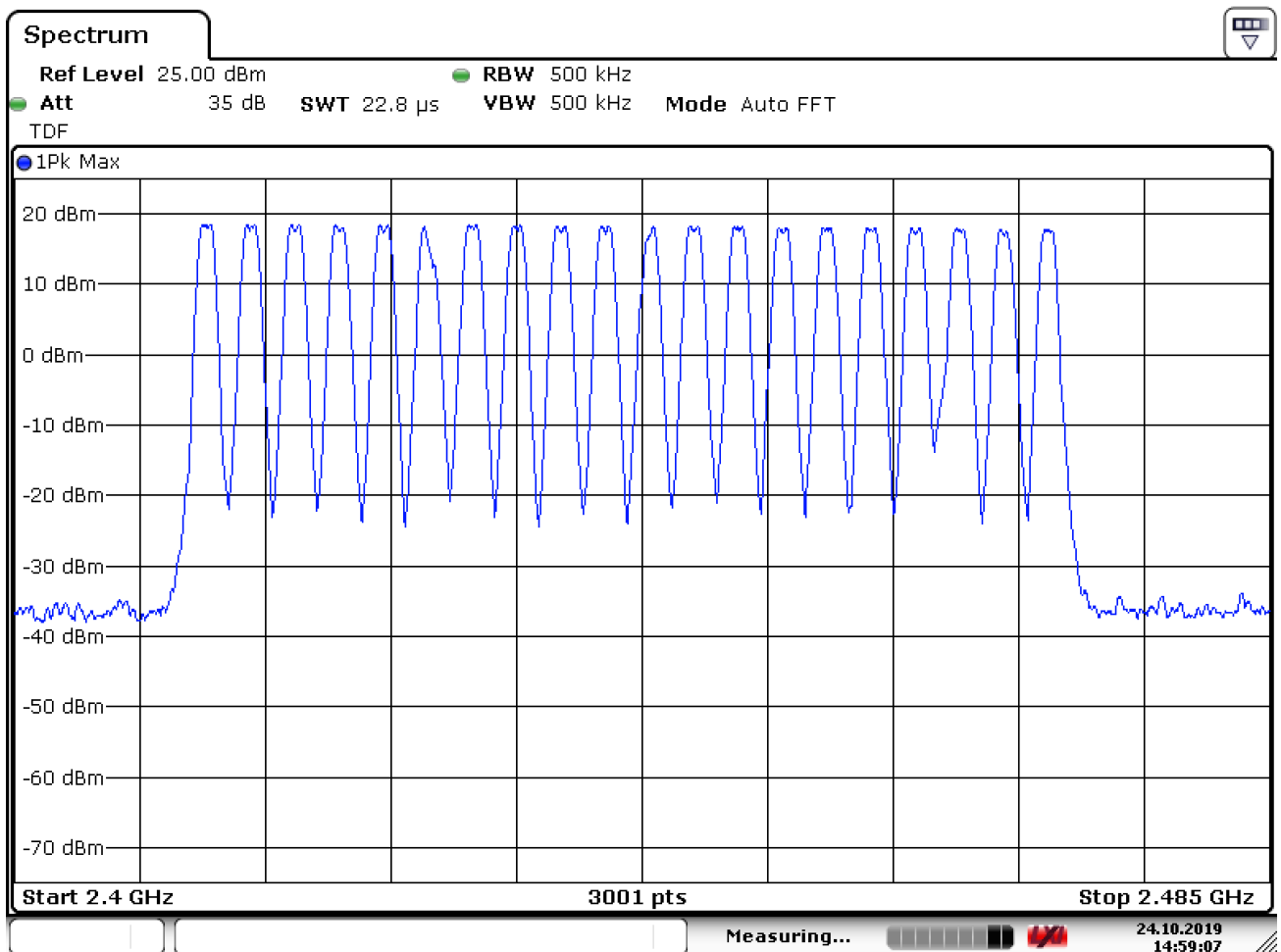
### FCC Rule: 15.247(a)(1)(iii) RSS-247 5.1

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

### Test result

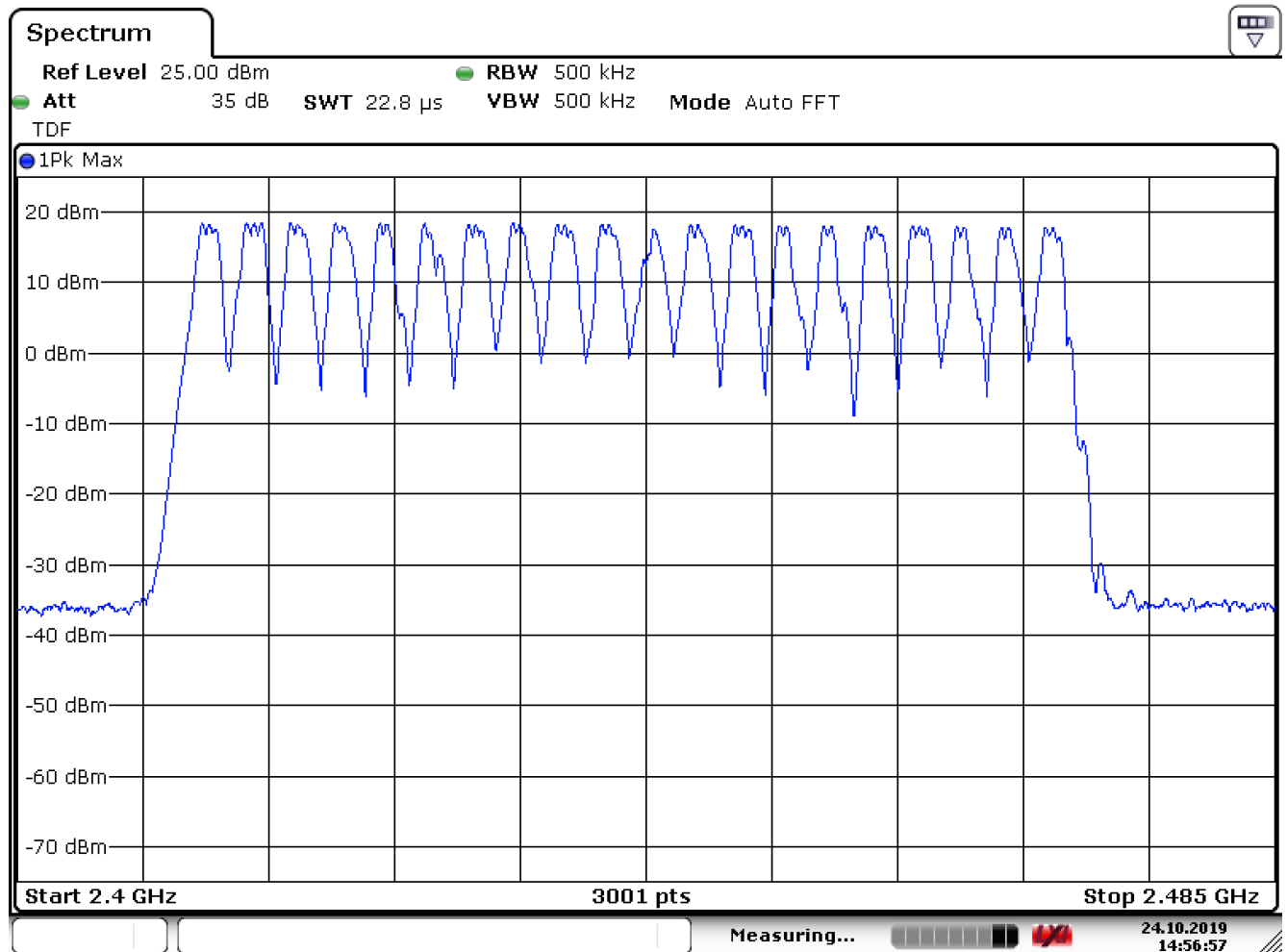
**Table 18:** Number of hopping channels

Datarate	Operating frequency [MHz]	Number of channels	Minimum Limit	Result
0.5 Mbps	2413.0 – 2470.0	20	15	PASS
2 Mbps	2413.0 – 2470.0	20	15	PASS



**Table 19:** Number of hopping channels, 0.5 Mbps

## Number of Hopping Channels



**Table 20:** Number of hopping channels, 2 Mbps

**Average Time of Occupancy of Hopping Frequency****Average Time of Occupancy of Hopping Frequency**

**Standard:** ANSI C63.10 (2013)  
**Tested by:** MIH  
**Date:** 11 and 24 October 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 21: Result**

Datarate	Channel	Result	Number of Hops	Average time of occupancy (ms)
0.5 Mbps	low	PASS	39	22.038
	mid	PASS	38	21.969
	high	PASS	38	21.482
2 Mbps	low	PASS	40	4.482
	mid	PASS	40	4.483
	high	PASS	40	4.480

## Average Time of Occupancy of Hopping Frequency

### Result

DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2413.000000	PASS	39	22.038	0.0

### Periode

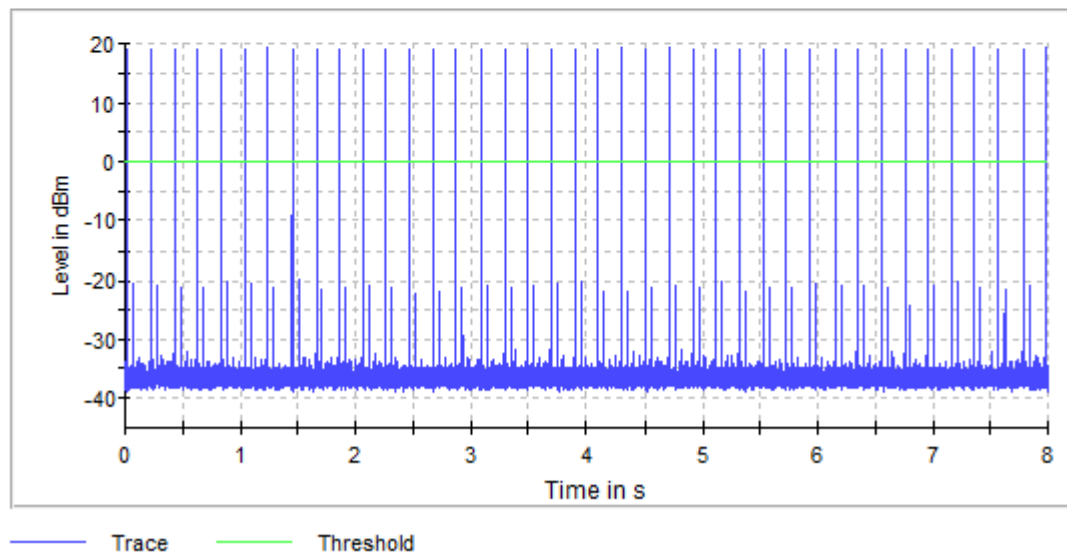
Min (ms)	Max (ms)	Mean (ms)
203.879	203.881	203.880

### Transmit Time per Hop

Min (ms)	Max (ms)	Limit Max for Max (ms)	Limit Min for Max (ms)	Mean (ms)
0.55	0.55	400.000	0.000	0.551

### DwellTime

Min (ms)	Max (ms)	Mean (ms)
0.55	0.55	0.551



Time of Channel Occupancy

**Figure 15:** Time of channel occupancy, 0.5 Mbps, channel low

## Average Time of Occupancy of Hopping Frequency

### Measurement

Setting	Instrument Value	Target Value
Center Frequency	2.41300 GHz	2.41300 GHz
Span	Zero Span	Zero Span
RBW	1.500 MHz	~ 1.500 MHz
VBW	3.000 MHz	~ 3.000 MHz
SweepPoints	30001	~ 30001
SweepTime	8.000 s	8.000 s
Reference Level	-20.000 dBm	-20.000 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

Setting	Instrument Value	Target Value
Measurement Time	8.000 s	8.000 s
Tracepoints	8000000	8000000
Time resolution	1.000 $\mu$ s	1.000 $\mu$ s
Detector	RMS	RMS

**Table 22:** Measurement settings, Time of channel occupancy

## 6 dB Bandwidth of the Channel

**Standard:** ANSI C63.10 (2013)  
**Tested by:** MIH  
**Date:** 11 and 24 October 2019  
**Temperature:**  $23 \pm 3$  °C  
**Humidity:** 20 - 60 % RH

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

### Results:

**Table 23:** 6 dB bandwidth test results

Datarate	Channel	6 dB BW [MHz]	Minimum limit [MHz]	Result
0.5 Mbps	low	0.750000	0.500	PASS
	mid	0.750000		PASS
	high	0.750000		PASS
2 Mbps	low	1.150000	0.500	PASS
	mid	1.250000		PASS
	high	0.950000		PASS

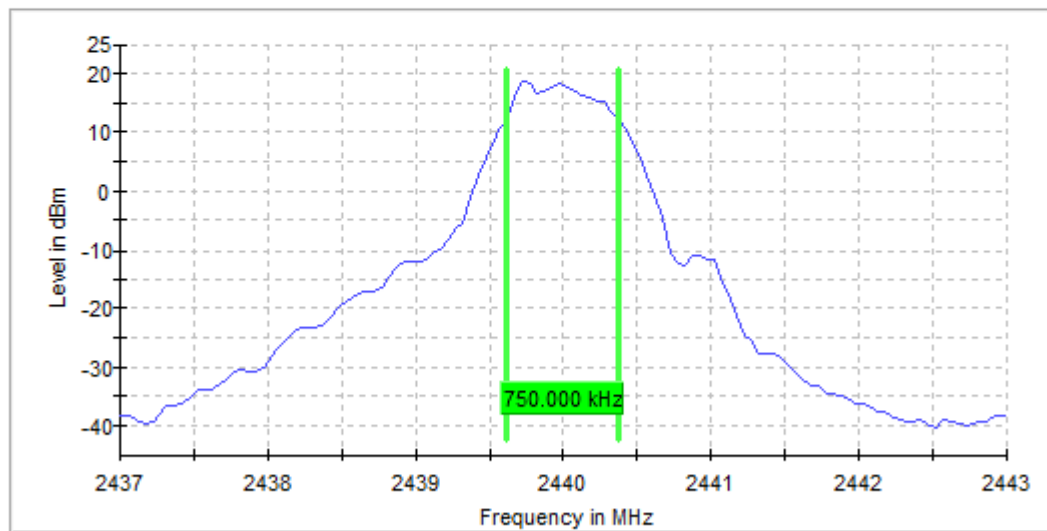


## 6 dB Bandwidth

DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Limit Max (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2440.000000	0.750000	---	---	2439.625000	2440.375000

(continuation of the "6 dB Bandwidth" table from [column 6 ...](#))

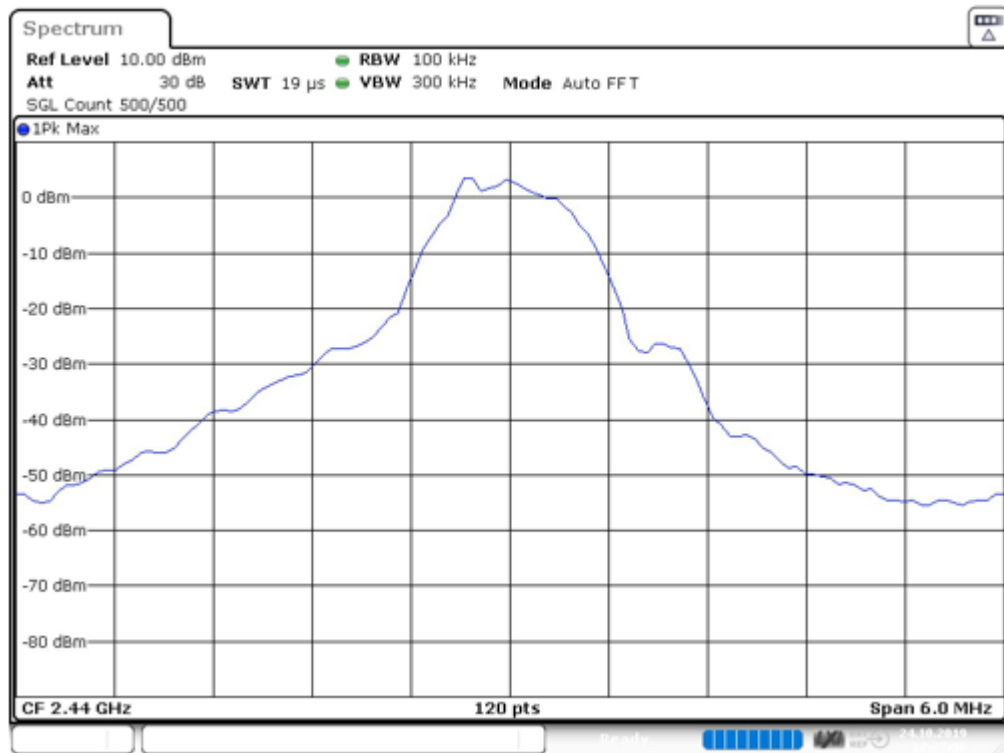
DUT Frequency (MHz)	Max Level (dBm)	Result
2440.000000	18.8	PASS



Bandwidth

Figure 16: 6 dB bandwidth, 0.5 Mbps, channel mid

## 6 dB Bandwidth of the Channel



Date: 24.OCT.2019 12:27:50

## Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.43700 GHz	2.43700 GHz
Stop Frequency	2.44300 GHz	2.44300 GHz
Span	6.000 MHz	6.000 MHz
RBW	100.000 kHz	~ 100.000 kHz
VBW	300.000 kHz	~ 300.000 kHz
SweepPoints	120	~ 120
Swepttime	18.984 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	28 / max. 150	max. 150
Stable	5 / 5	5
Max Stable Difference	0.00 dB	0.50 dB

Table 24: Measurement settings, 6 dB bandwidth

## 99% Occupied Bandwidth

**Standard:** RSS-GEN (2019)  
**Tested by:** MIH  
**Date:** 11 and 24 October 2019  
**Temperature:** 23 ± 3 °C  
**Humidity:** 20 - 60 % RH

### RSS-GEN 6.6

## Results

**Table 25:** 99% occupied bandwidth test results

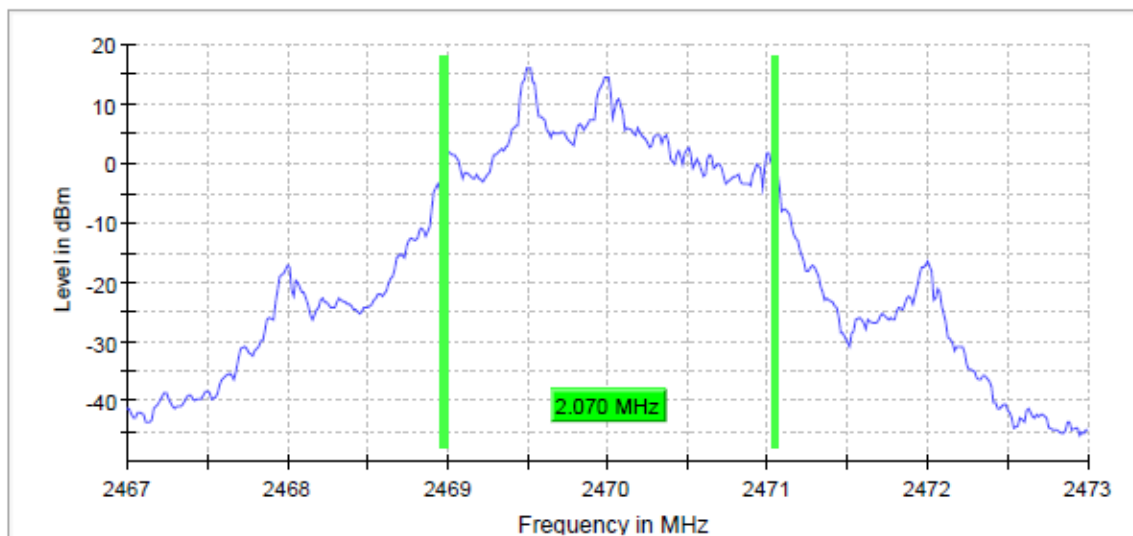
Datarate	Channel	99% BW [MHz]	Limit	Result
0.5 Mbps	low	1.035000	-	PASS
	mid	1.035000		PASS
	high	1.035000		PASS
2 Mbps	low	2.040000	-	PASS
	mid	2.040000		PASS
	high	2.070000		PASS

## 99 % Bandwidth

DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Limit Max (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2470.000000	2.070000	---	---	2468.972500	2471.042500

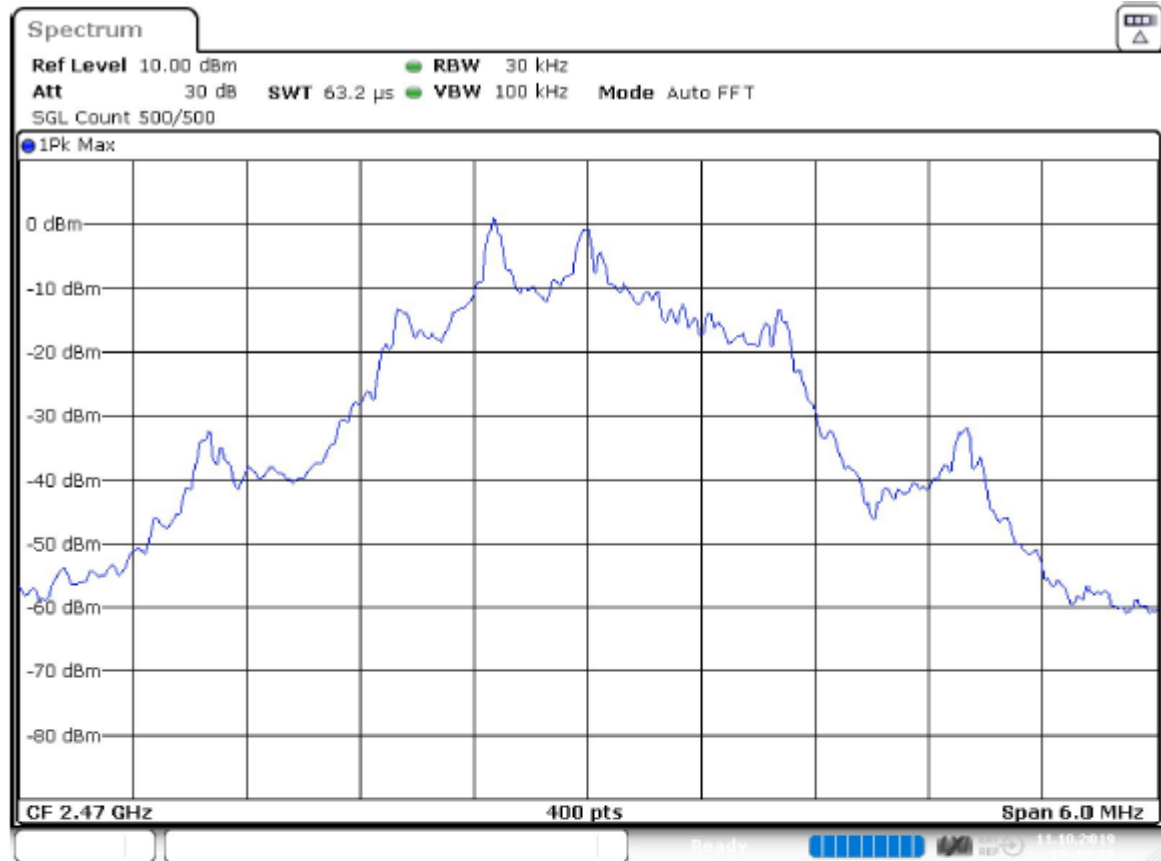
(continuation of the "99 % Bandwidth" table from column 6 ...)

DUT Frequency (MHz)	Result
2470.000000	PASS



Bandwidth

**Figure 17:** 99% OBW, 2 Mbps, channel high



Date: 11.OCT.2019 13:48:58

## Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.46700 GHz	2.46700 GHz
Stop Frequency	2.47300 GHz	2.47300 GHz
Span	6.000 MHz	6.000 MHz
RBW	30.000 kHz	$\geq 30.000$ kHz
VBW	100.000 kHz	$\geq 90.000$ kHz
SweepPoints	400	$\sim 400$
Sweptime	63.216 $\mu$ s	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	18 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.00 dB	0.30 dB

**Table 26:** Measurements settings, 99% occupied bandwidth

## TEST EQUIPMENT

## RF-Test Equipment

Equipment	Manufacturer	Type	Inv or serial	Prev Calib	Next Calib
ANTENNA	A.H. SYSTEMS	SAS-200/518	inv:7873	NCR	-
SPECTRUM ANALYZER	AGILENT	E7405A	inv:9746	2018-01-08	2020-01-08
RF PREAMPLIFIER	CIAO	CA118-3123	inv:10278	2019-10-09	2020-10-09
RF PREAMPLIFIER	CIAO	CA1840-5019	inv:10593	2019-10-08	2020-10-08
TEMPERATURE/ HUMIDITY METER	DAVIS	VantagePro	inv:5296	2018-09-18	-
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	EMCO	3160-09, 18-26.5GHz	inv:7294	2019-03-11	2020-03-11
ATTENUATOR	PASTERNAK	PE 7004-4	inv:10126	2019-04-01	2021-04-01
ATTENUATOR	HUBER&SUHNER	6606.19.AA (A4)	inv:10393	2019-04-01	2021-04-01
TURNTABLE	MATURO	DS430 UPGRADED	inv:10182	NCR	-
MAST & TURNTABLE CONTROLLER	MATURO	NCD	inv:10183	NCR	-
ANTENNA MAST	MATURO	TAM 4.0E	inv:10181	NCR	-
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	NCR	-
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	2019-06-25	2020-06-22
ANTENNA	SCHWARZBECK	VULB 9168, 30-2000MHz	inv:8911	2018-10-25	2020-10-25
POWER SUPPLY	THANDAR	PL330TP	inv:9787	NCR	-
POWER SUPPLY	THANDAR	TS3021S	sn:099610	NCR	-
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	NCR	-
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	NCR	-
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

NCR = No calibration required

## END OF TEST REPORT