

# Test Report



## 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  
Stensåtravägen 13  
SE-127 39 Skärholmen, Sweden

Customer: Scanreco AB  
Stensåtravägen 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

Issued by:

  
Pekka Kälviäinen  
Testing Engineer

Date: 12 August 2019

Checked by:

  
Rauno Repo  
Senior EMC/RF Specialist

## Table of Contents

|                                                                          |    |
|--------------------------------------------------------------------------|----|
| GENERAL REMARKS .....                                                    | 3  |
| Disclaimer .....                                                         | 3  |
| RELEASE HISTORY.....                                                     | 4  |
| Page 14: Measuring distance added (3m) .....                             | 4  |
| PRODUCT DESCRIPTION .....                                                | 5  |
| Equipment Under Test .....                                               | 5  |
| General Description .....                                                | 5  |
| Ratings and declarations.....                                            | 5  |
| Power Supply.....                                                        | 6  |
| Mechanical Size of the EUT .....                                         | 6  |
| SUMMARY OF TESTING .....                                                 | 7  |
| EUT Test Conditions during Testing .....                                 | 7  |
| TEST RESULTS .....                                                       | 9  |
| Antenna requirement.....                                                 | 9  |
| Conducted Emissions In The Frequency Range 150 kHz - 30 MHz .....        | 10 |
| Maximum Peak Conducted Output Power .....                                | 12 |
| Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz.....            | 15 |
| Transmitter Band Edge Measurement and Conducted Spurious Emissions ..... | 23 |
| 20 dB Bandwidth of the Hopping Channel .....                             | 31 |
| Hopping Channel Carrier Frequencies Separation.....                      | 34 |
| Number of Hopping Channels .....                                         | 37 |
| Average Time of Occupancy of Hopping Frequency.....                      | 39 |
| 6 dB Bandwidth of the Channel .....                                      | 43 |
| 99% Occupied Bandwidth .....                                             | 46 |
| Duty cycle correction factor, Transmit time in 100 ms .....              | 49 |
| TEST EQUIPMENT .....                                                     | 50 |

**GENERAL REMARKS****Disclaimer**

*This document is issued by the Company under its General Conditions of service accessible at [http://www.sgs.com/terms and conditions.htm](http://www.sgs.com/terms_and_conditions.htm). attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.*

*Any holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. Any unauthorized alteration, forgery or falsification of the content or appearance of this document is unlawful and offenders may be prosecuted to the fullest extent of the law.*

*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<br>Page 14: Measuring distance added (3m)<br>Page 45: Calibration date of SMBV100A updated | 12 August 2019 |
|         |                                                                                                                      |                |

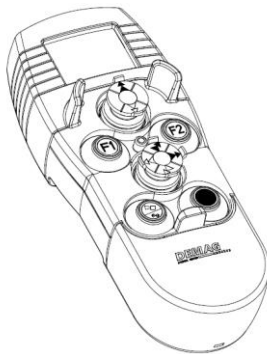
## PRODUCT DESCRIPTION

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

### 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 <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               |

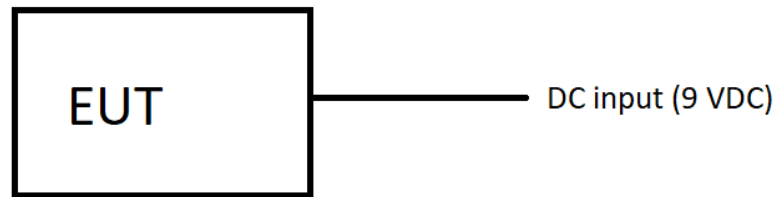
1) Not applicable for FHSS

*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

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:<br>FCC registration number: <b>904175</b> | SGS Fimko Ltd<br>Särkiniementie 3<br>FI-00210, HELSINKI<br>FINLAND                                                                                                                                                                                  |
| Test Site:                                                              | <input type="checkbox"/> K10LAB, ISED Canada registration number: <b>8708A-1</b><br><input checked="" type="checkbox"/> K5LAB, ISED Canada registration number: <b>8708A-2</b><br><input type="checkbox"/> L3LAB<br><input type="checkbox"/> 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<br>2. Unique coupling to the intentional radiator<br>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. | <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

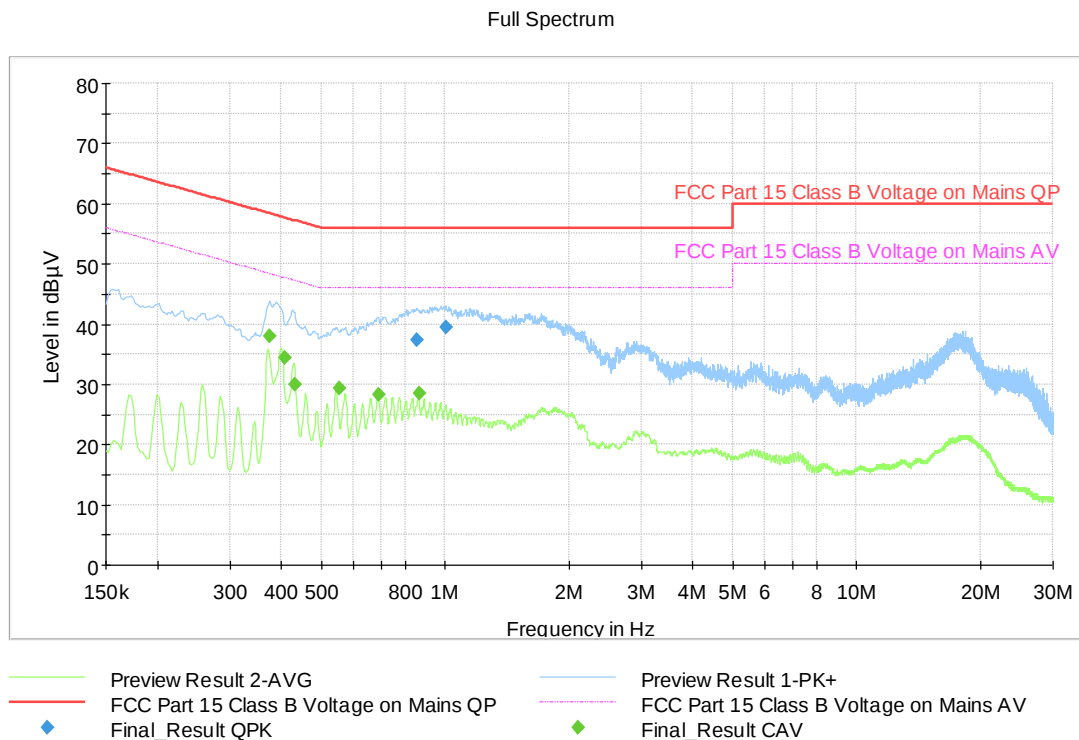
**Standard:** ANSI C63.10 (2013)  
**Tested by:** JAT  
**Date:** 2 July 2019  
**Temperature:** 23 ± 3°C  
**Humidity:** 20 - 60 % RH  
**Barometric pressure:** 1001 hPa  
**Measurement uncertainty:** ± 2.9 dB Level of confidence 95 % (k = 2)

#### 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:**  $23 \pm 3$  °C  
**Humidity:** 20 - 60 % RH  
**Measurement uncertainty:**  $\pm 2.87$  dB Level of confidence 95 % (k = 2)

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

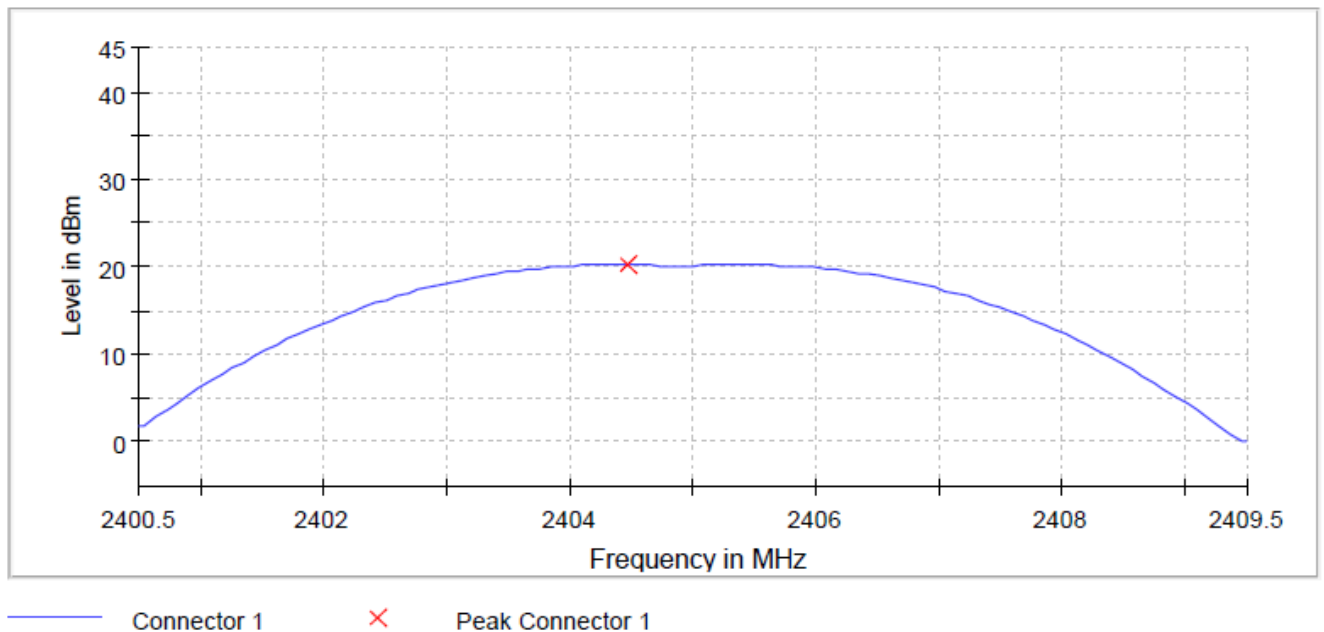
Test according to FCC title 47 part 15 §15.247(b), KDB 558074 D01 DTS Meas Guidance v05 and ANSI C63.10-2013 7.8.5

Measured values are peak values.

### Results:

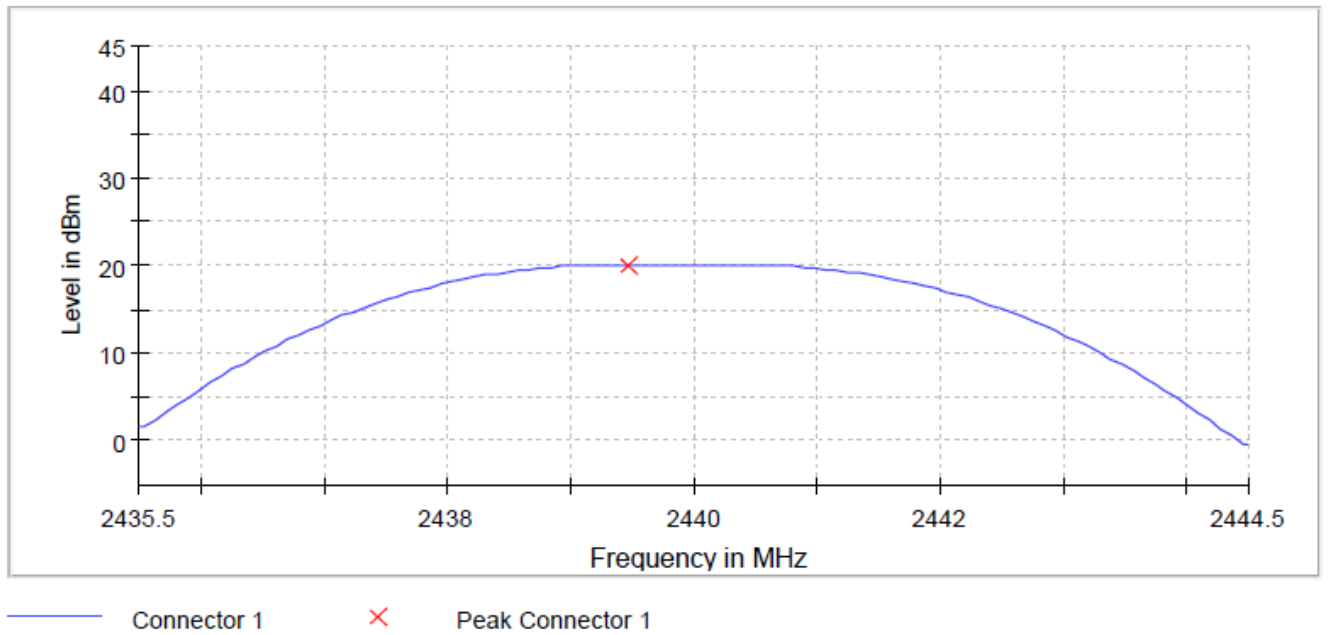
**Table 3:** Maximum conducted output power

| 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   |

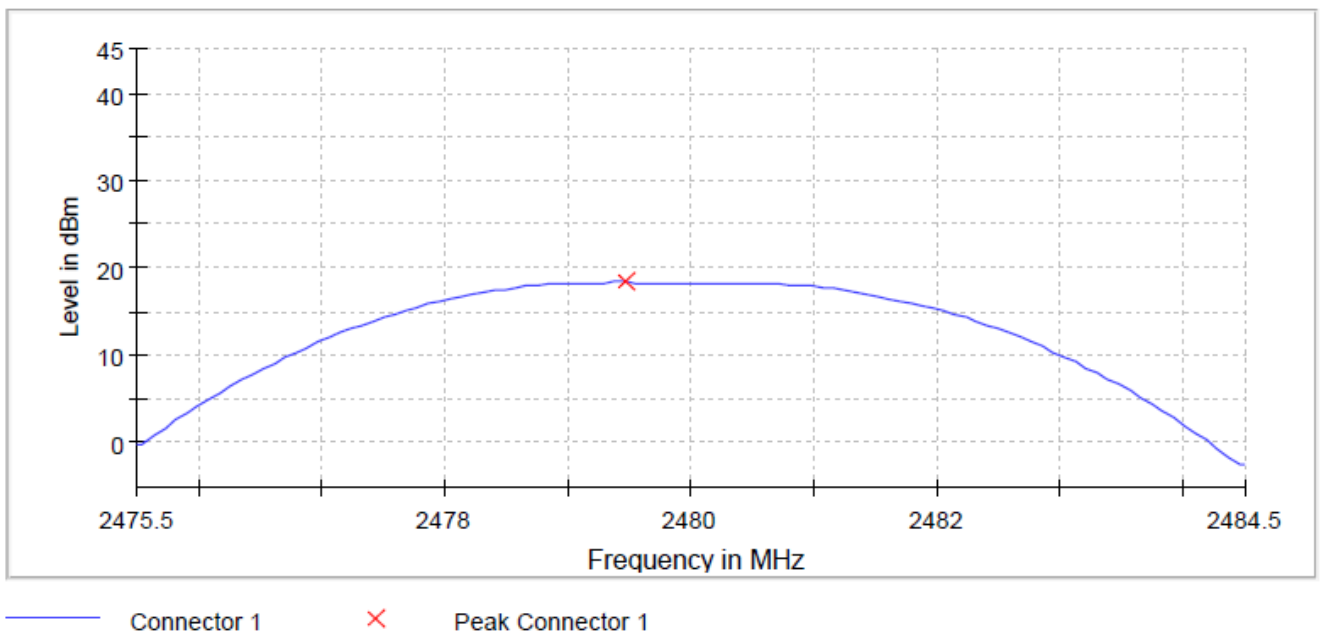


**Figure 4:** Conducted power, Channel LOW

## Maximum Peak Conducted Output Power



**Figure 5:** Conducted power, Channel MID



**Figure 6:** Conducted power, Channel HIGH

## Maximum Peak Conducted Output Power

**Table 4:** Measurement settings, maximum conducted output power

| Setting               | Instrument Value | Target Value     |
|-----------------------|------------------|------------------|
| Span                  | 9.000 MHz        | 9.000 MHz        |
| RBW                   | 3.000 MHz        | $\geq 2.825$ MHz |
| VBW                   | 10.000 MHz       | $\geq 9.000$ MHz |
| SweepPoints           | 101              | ~ 101            |
| SweepTime             | 1.271 $\mu$ 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 | 0.04 dB          | 0.50 dB          |

## 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:** JAT  
**Date:** 24 June – 2 July 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).

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.

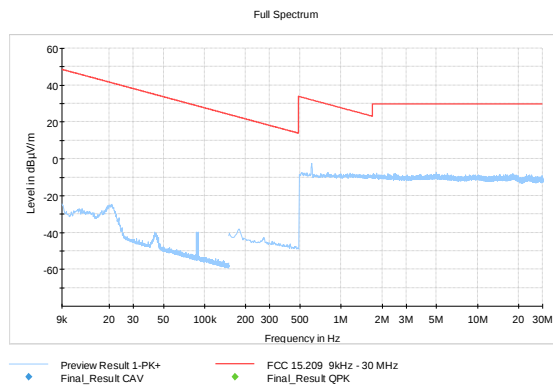
The pre-measurements were performed with the EUT being in three orthogonal positions (X, Y, Z). Final measurements were done in worst position.

Measurement distance was 3 meters.

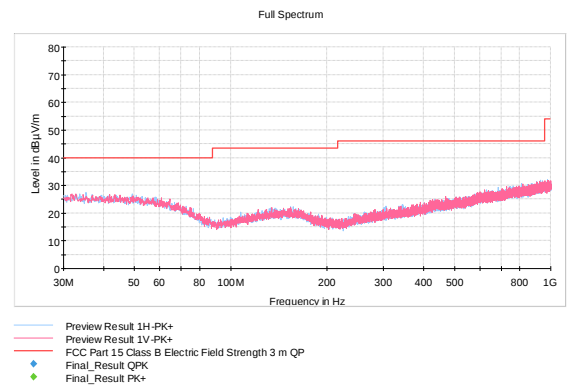
| Frequency range [MHz] | Limit [ $\mu$ V/m] | Limit [dB $\mu$ V/m] | Detector   |
|-----------------------|--------------------|----------------------|------------|
| 30 - 80               | 100                | 40.0                 | Quasi-peak |
| 88 - 216              | 150                | 43.5                 | 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       |

## Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

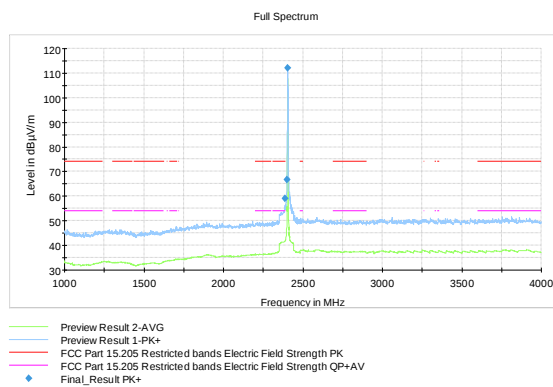
### Results LOW channel



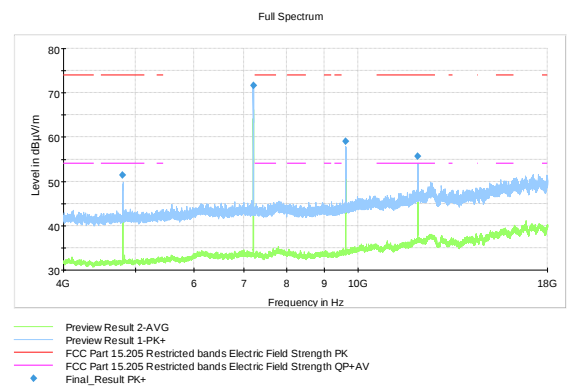
**Figure 7: LOW channel (9 kHz – 30 MHz)**



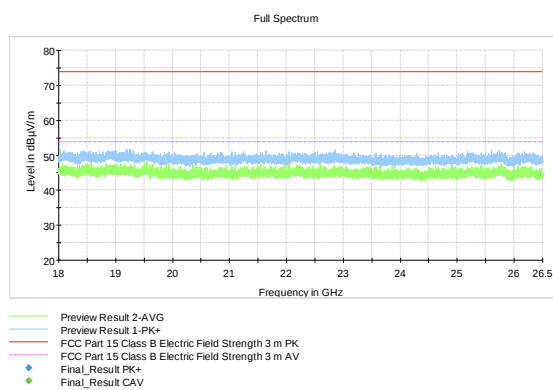
**Figure 8: LOW channel (30 MHz – 1000 MHz)**



**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)**

## Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

**Table 5:** Peak results LOW channel

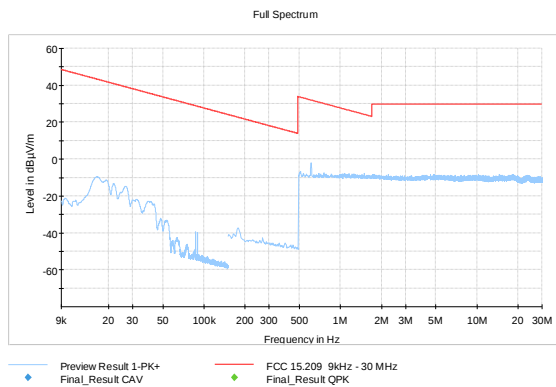
| Frequency (MHz) | MaxPeak (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Meas. Time | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) | Comment        |
|-----------------|------------------|----------------|-------------|------------|-----------------|-------------|-----|---------------|--------------|----------------|
| 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)

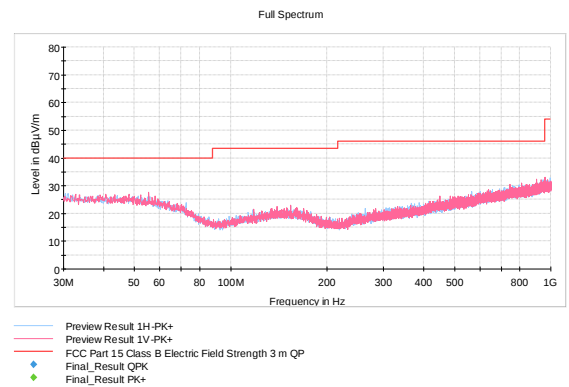
| Frequency (MHz) | Average (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Meas. Time | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) | Comment        |
|-----------------|------------------|----------------|-------------|------------|-----------------|-------------|-----|---------------|--------------|----------------|
| 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         | -              |

## Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

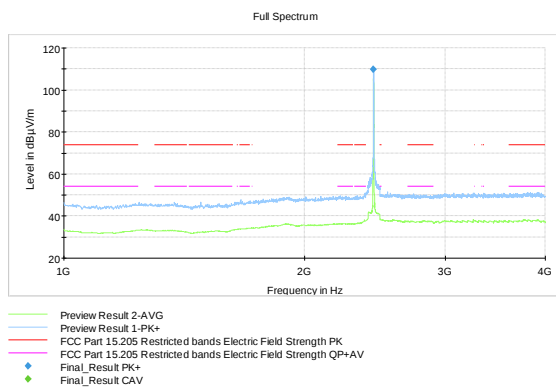
### Results MID channel



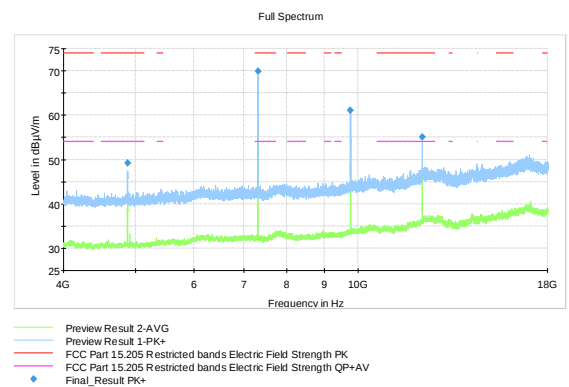
**Figure 12:** MID channel (9 kHz – 30 MHz)



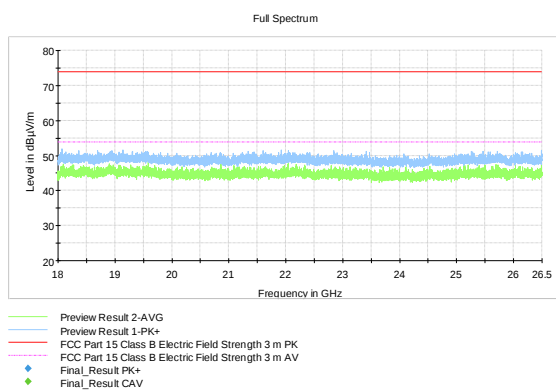
**Figure 13:** MID channel (30 MHz – 1000 MHz)



**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)

## Transmitter Radiated Spurious Emissions 9 kHz – 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)

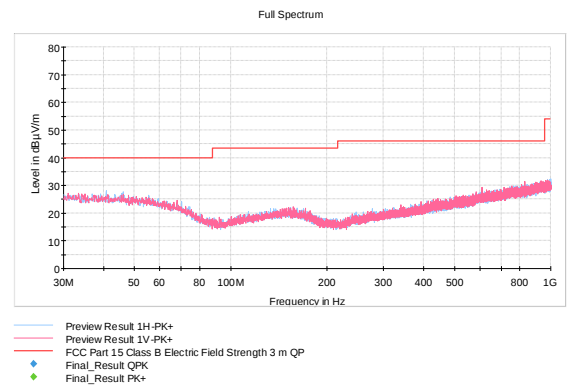
| Frequency (MHz) | Average (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Meas. Time | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) | Comment        |
|-----------------|------------------|----------------|-------------|------------|-----------------|-------------|-----|---------------|--------------|----------------|
| 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         | -              |

## Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

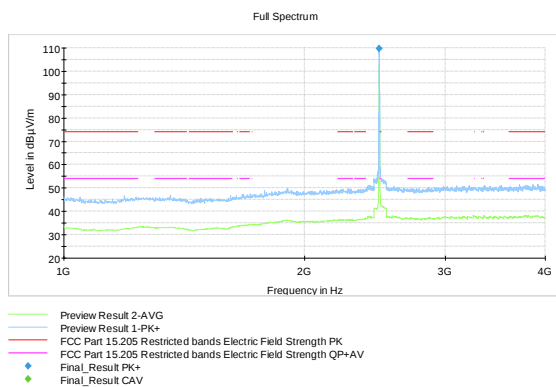
### Results HIGH channel



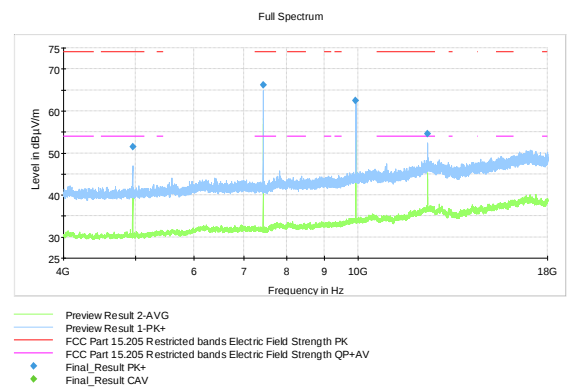
**Figure 17: HIGH channel (9 kHz – 30 MHz)**



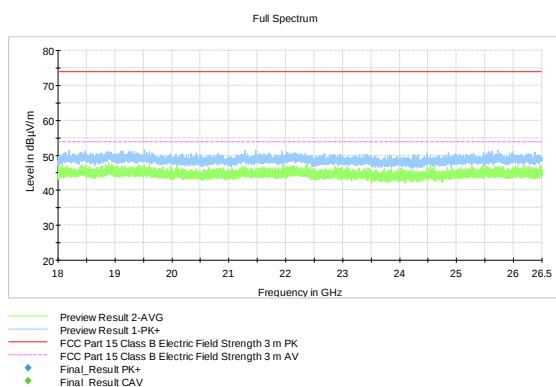
**Figure 18: HIGH channel (30 MHz – 1000 MHz)**



**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)**

## Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

**Table 9:** Peak results HIGH channel

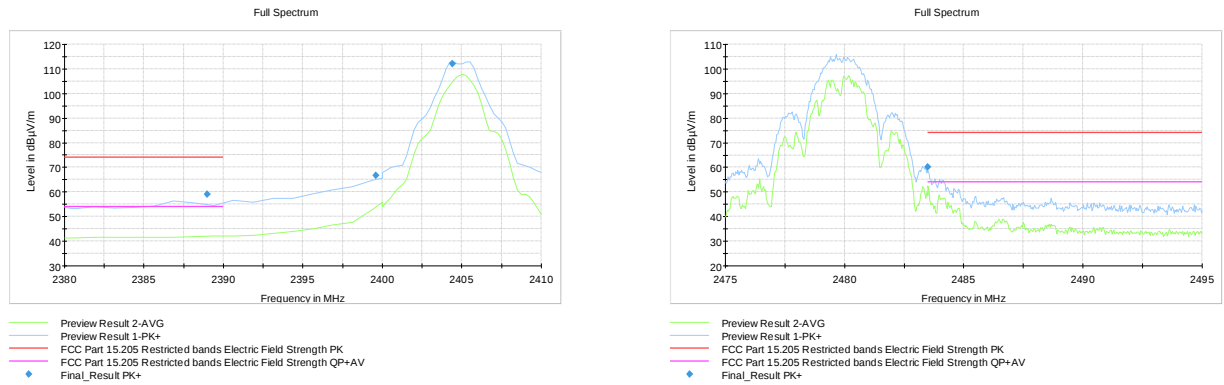
| Frequency (MHz) | MaxPeak (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Meas. Time | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) | Comment        |
|-----------------|------------------|----------------|-------------|------------|-----------------|-------------|-----|---------------|--------------|----------------|
| 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         | -              |

## Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

### 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:**  $23 \pm 3$  °C  
**Humidity:** 20 - 60 % RH  
**Measurement uncertainty:**  $\pm 2.87$  dB Level of confidence 95 % (k = 2)

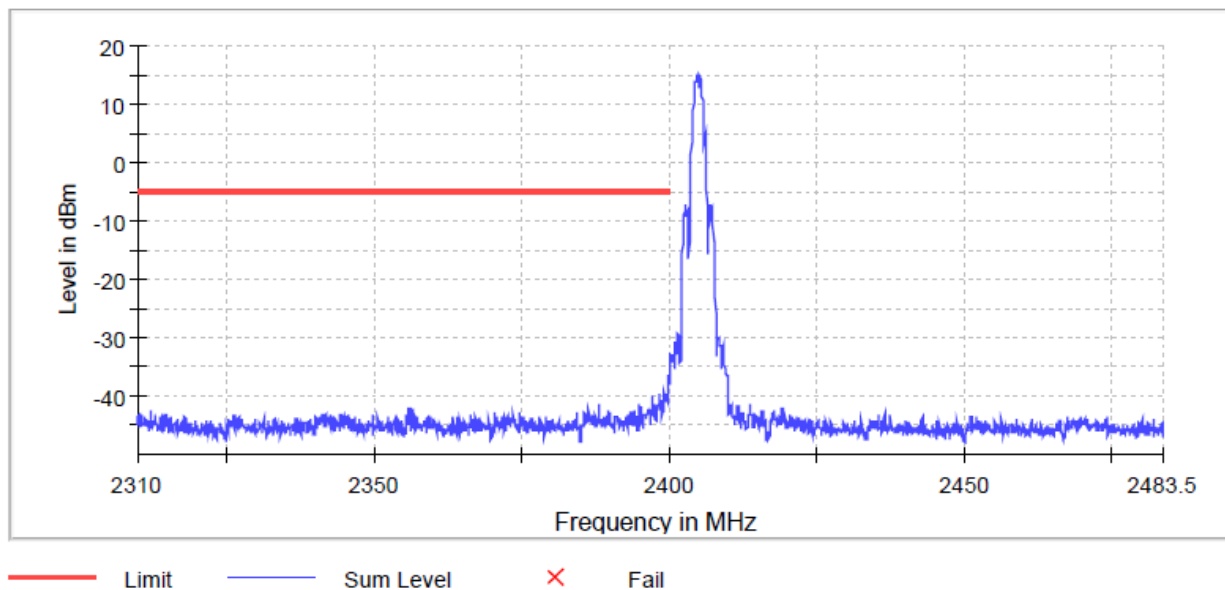
**FCC Rule: 15.247(d), 15.209(a)**

**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 13:** Band edge attenuation

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

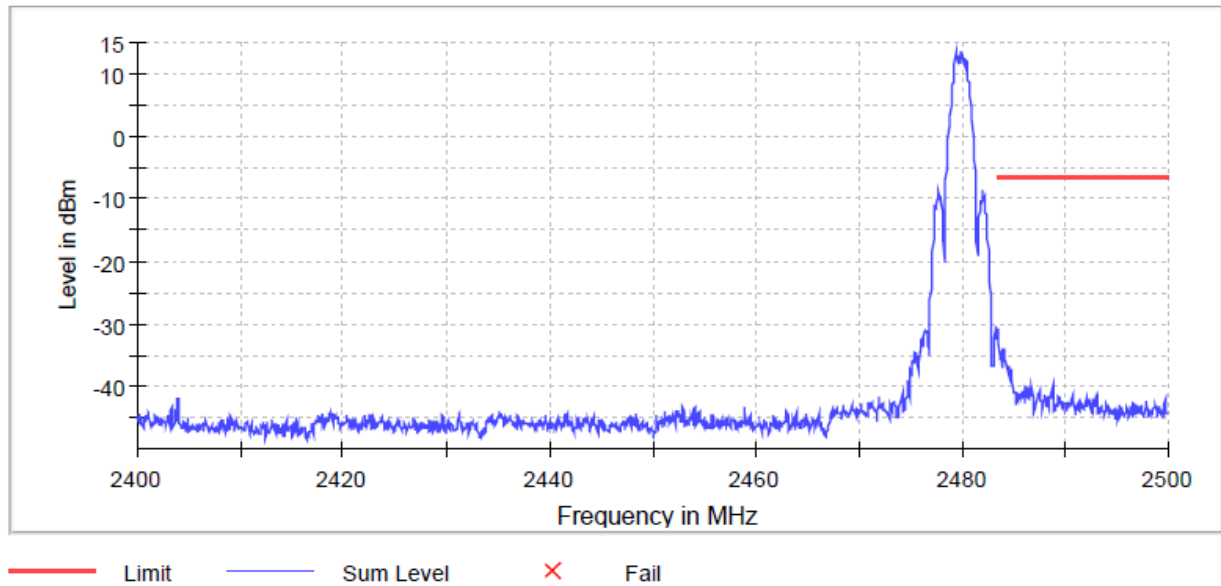


**Figure 23:** Lower Band Edge

## Transmitter Band Edge Measurement and Conducted Spurious Emissions

**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

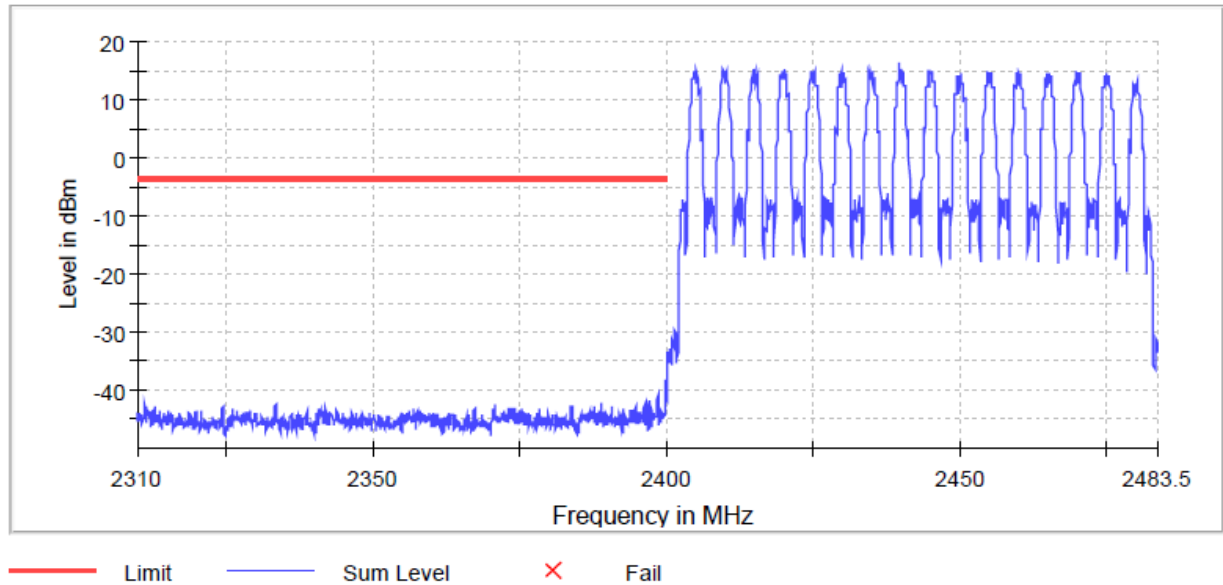
**Table 15:** Upper band edge results

| 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   |

## Transmitter Band Edge Measurement and Conducted Spurious Emissions

**Table 16:** Band edge attenuation, Hopping mode

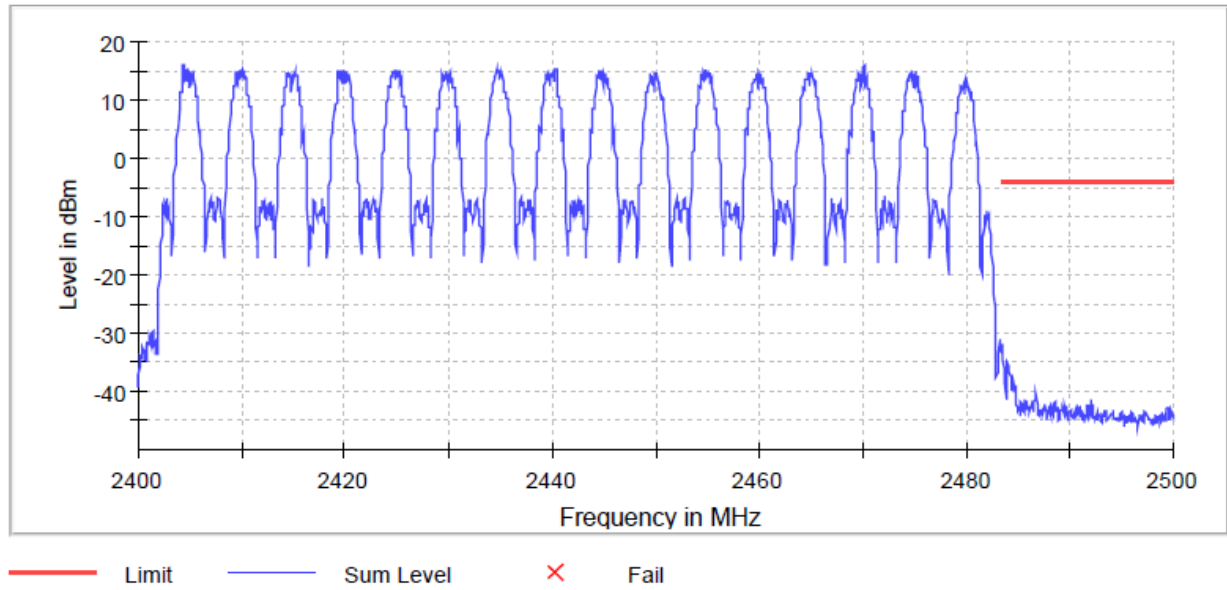
| Band Edge Attenuation |                 |
|-----------------------|-----------------|
| Lower Band Edge       | Upper Band Edge |
| -54.5 dBc             | -48.0 dBc       |
| Limit: -20 dBc        |                 |


**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   |

## Transmitter Band Edge Measurement and Conducted Spurious Emissions



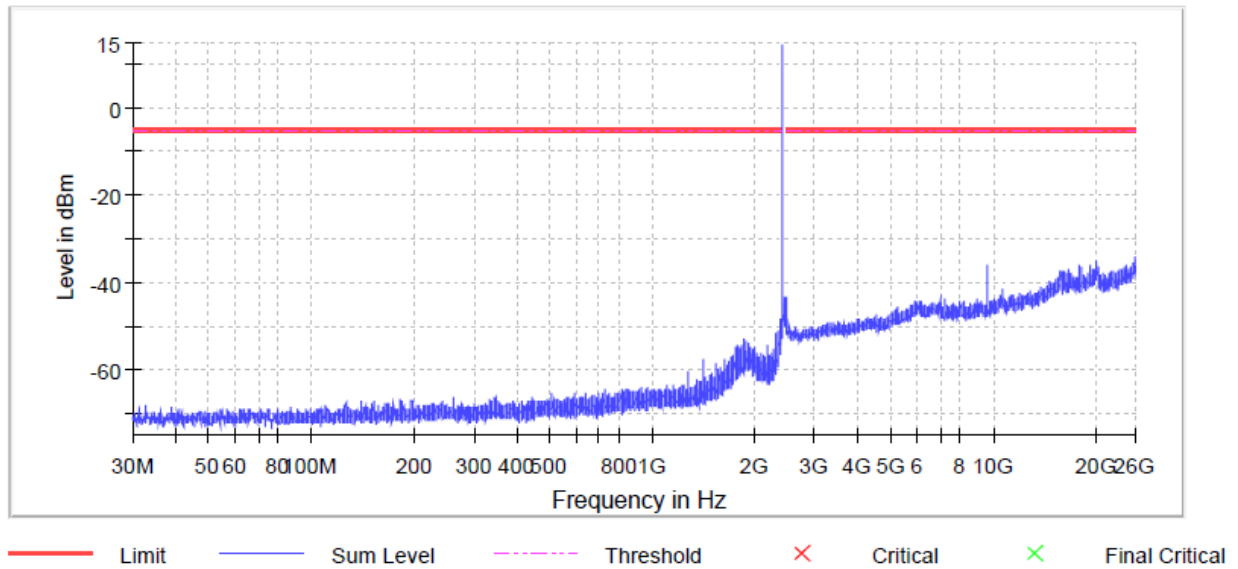
**Figure 26:** Upper Band Edge, hopping mode

**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   |

## Transmitter Band Edge Measurement and Conducted Spurious Emissions

### 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

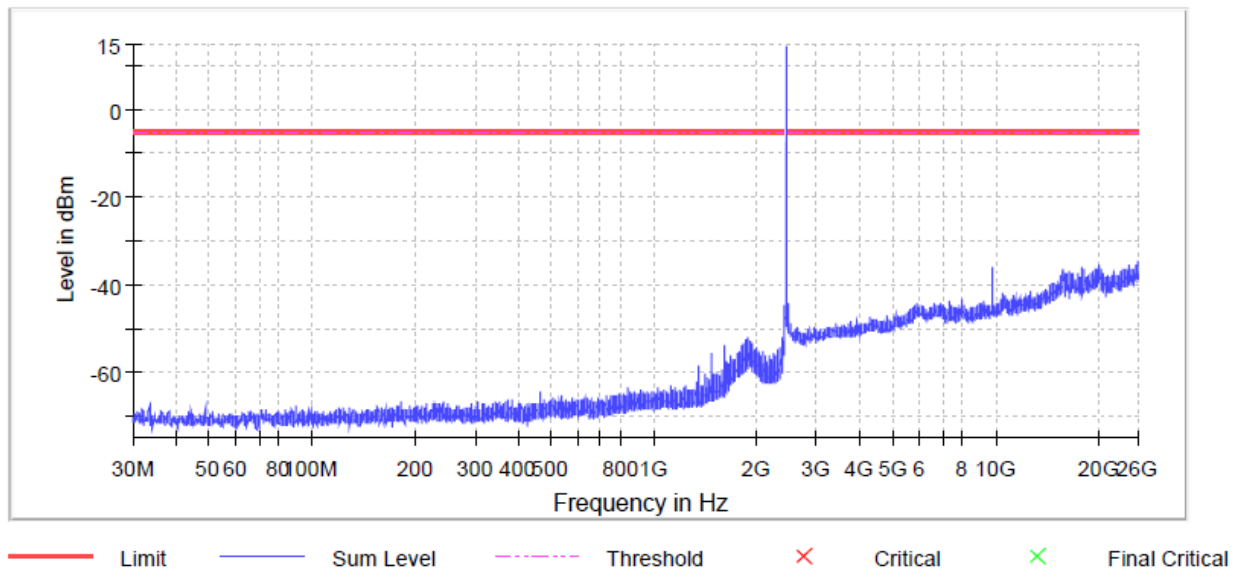
| Frequency (MHz) | Level (dBm) | Margin (dB) | Limit (dBm) |
|-----------------|-------------|-------------|-------------|
| 25879.849138    | -34.2       | 29.0        | -5.2        |
| 25966.563521    | -35.0       | 29.7        | -5.2        |
| 20153.025460    | -35.2       | 30.0        | -5.2        |
| 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.

## Transmitter Band Edge Measurement and Conducted Spurious Emissions

### 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

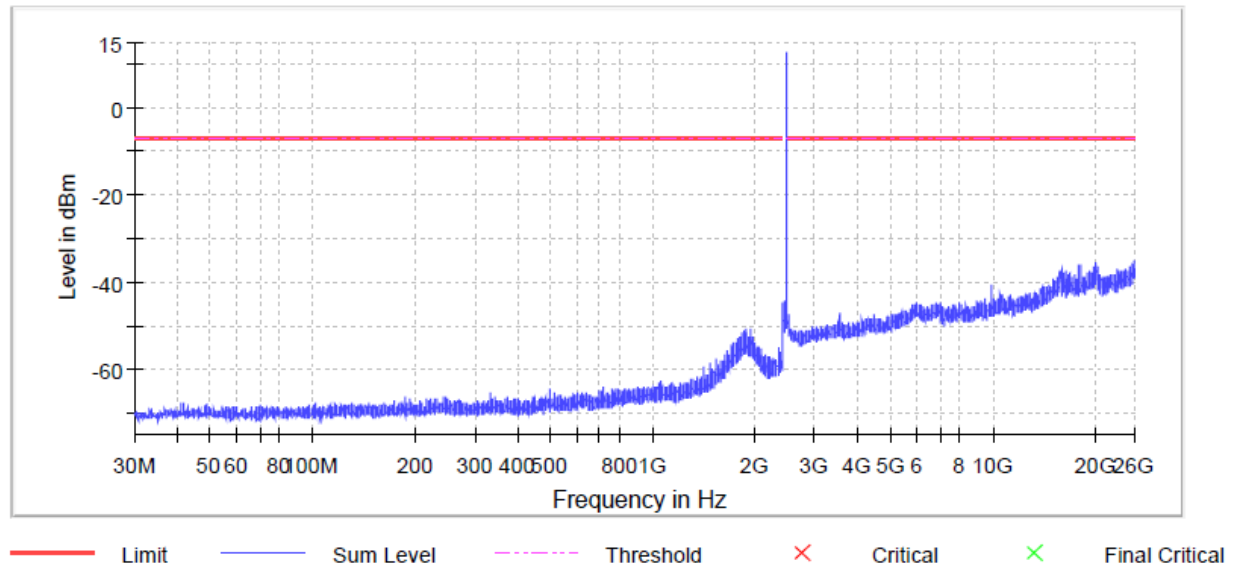
| Frequency (MHz) | Level (dBm) | Margin (dB) | Limit (dBm) |
|-----------------|-------------|-------------|-------------|
| 25916.592521    | -34.4       | 29.1        | -5.3        |
| 25887.197814    | -34.5       | 29.2        | -5.3        |
| 25882.053741    | -35.0       | 29.7        | -5.3        |
| 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.

## Transmitter Band Edge Measurement and Conducted Spurious Emissions

### 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.

## Transmitter Band Edge Measurement and Conducted Spurious Emissions

**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

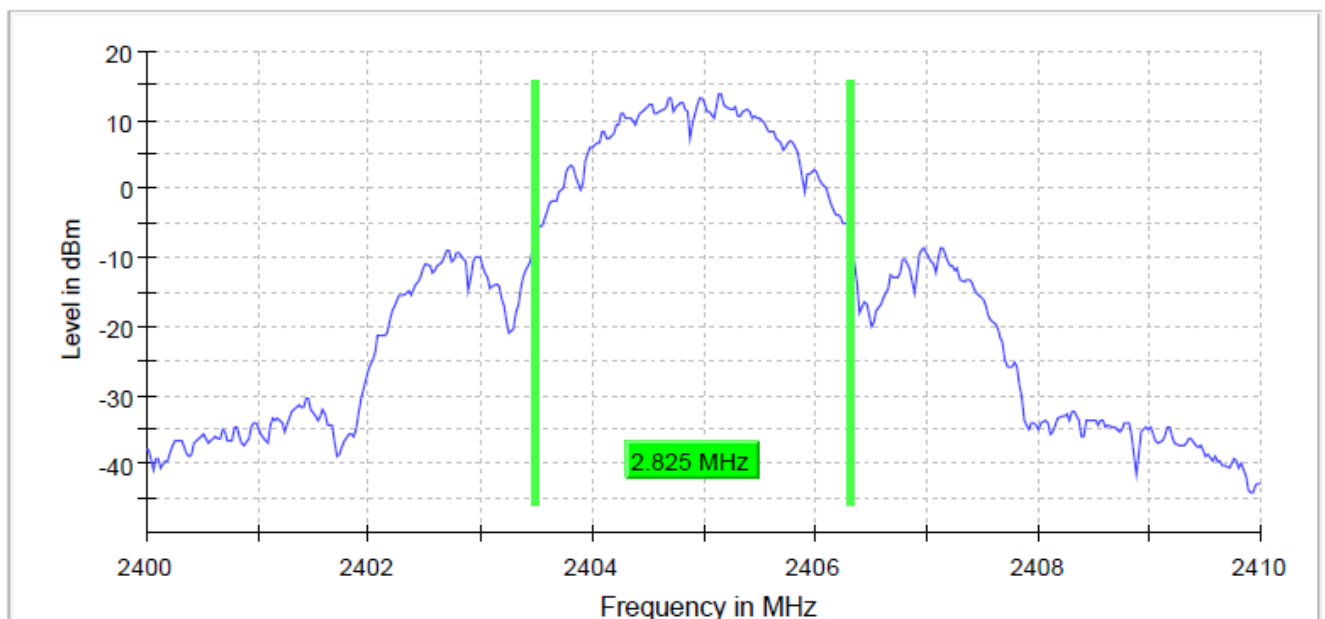
**Standard:** ANSI C63.10 (2013)  
**Tested by:** JAT  
**Date:** 1 July 2019  
**Temperature:**  $23 \pm 3$  °C  
**Humidity:** 20 - 60 % RH

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

### Results:

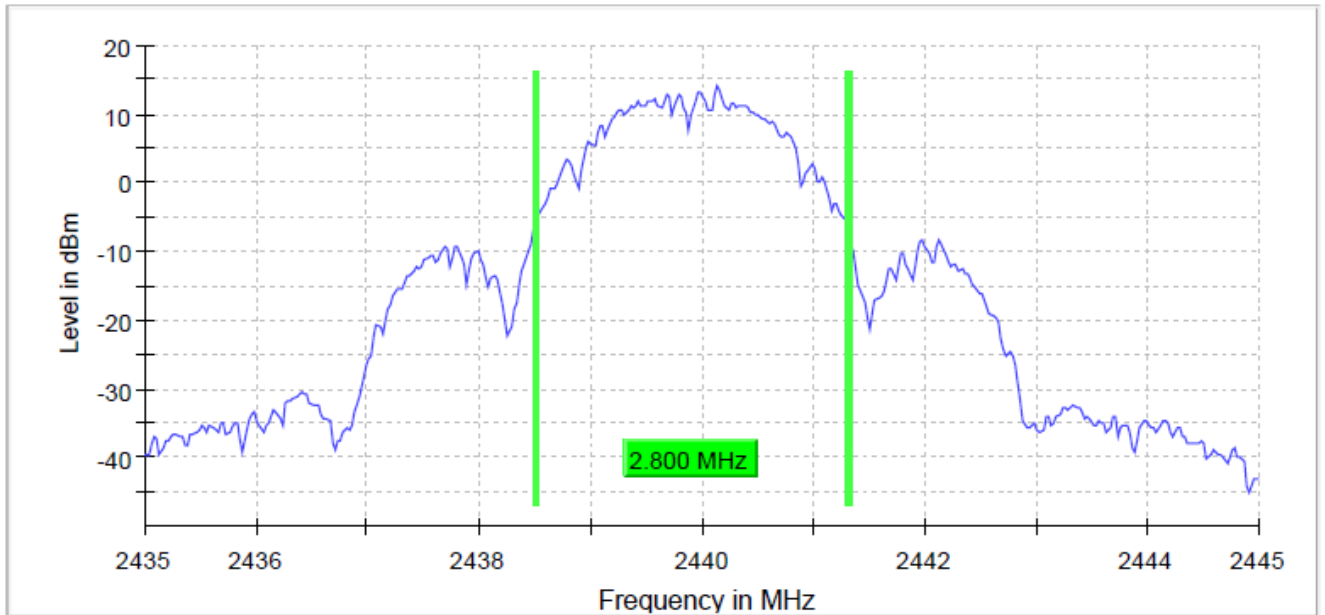
**Table 26:** 20 dB bandwidth test results

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

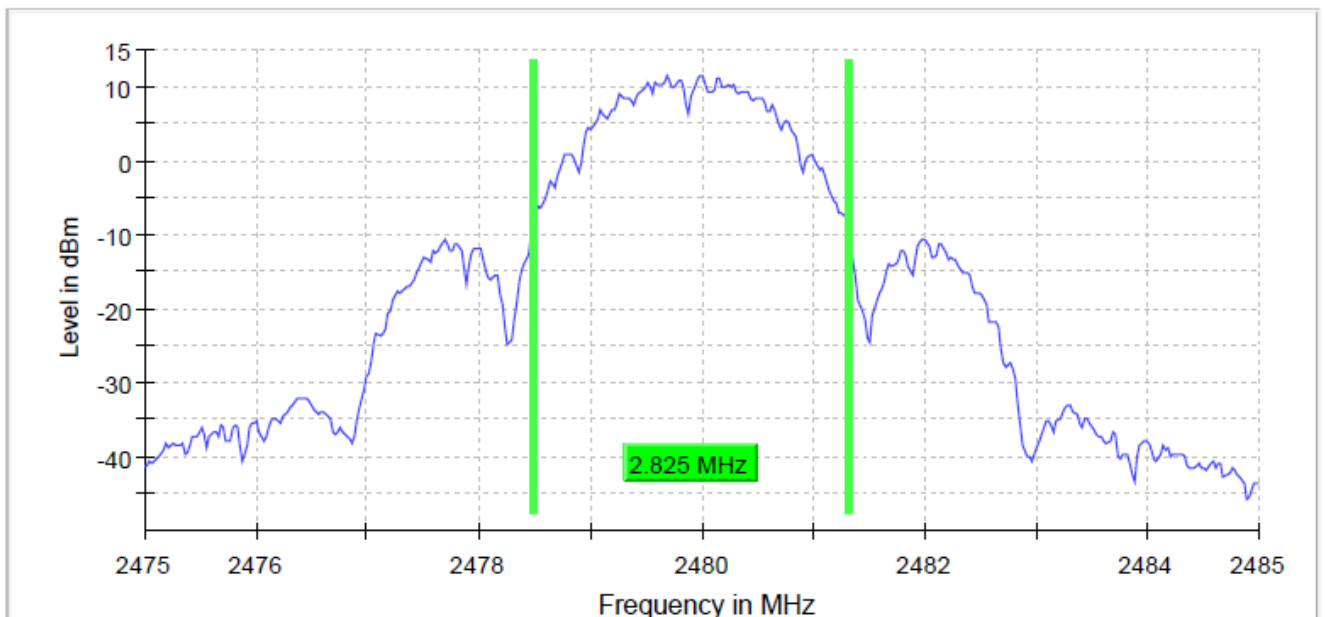


**Figure 30:** 20 dB channel BW, channel LOW

## 20 dB Bandwidth of the Hopping Channel



**Figure 31:** 20 dB channel BW, channel MID



**Figure 32:** 20 dB channel BW, channel HIGH

## 20 dB Bandwidth of the Hopping Channel

**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 $\mu$ 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                   | 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:**  $23 \pm 3$  °C  
**Humidity:** 20 - 60 % RH

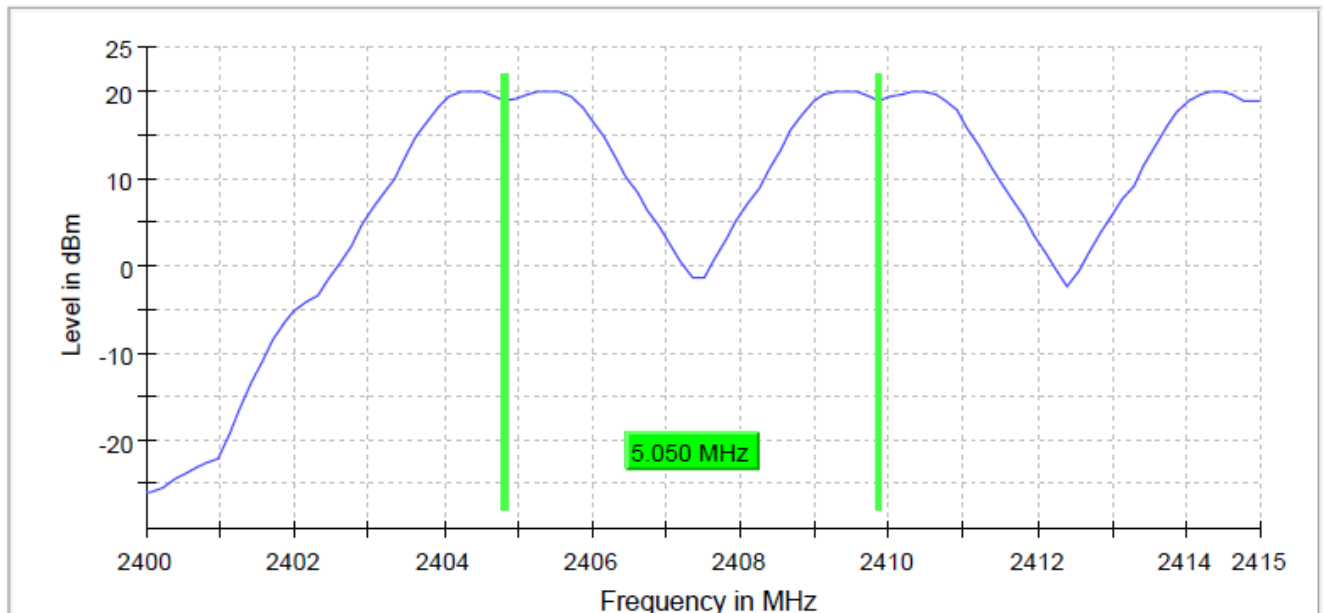
#### FCC Rule: 15.247(a)(1) RSS-247 5.1

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

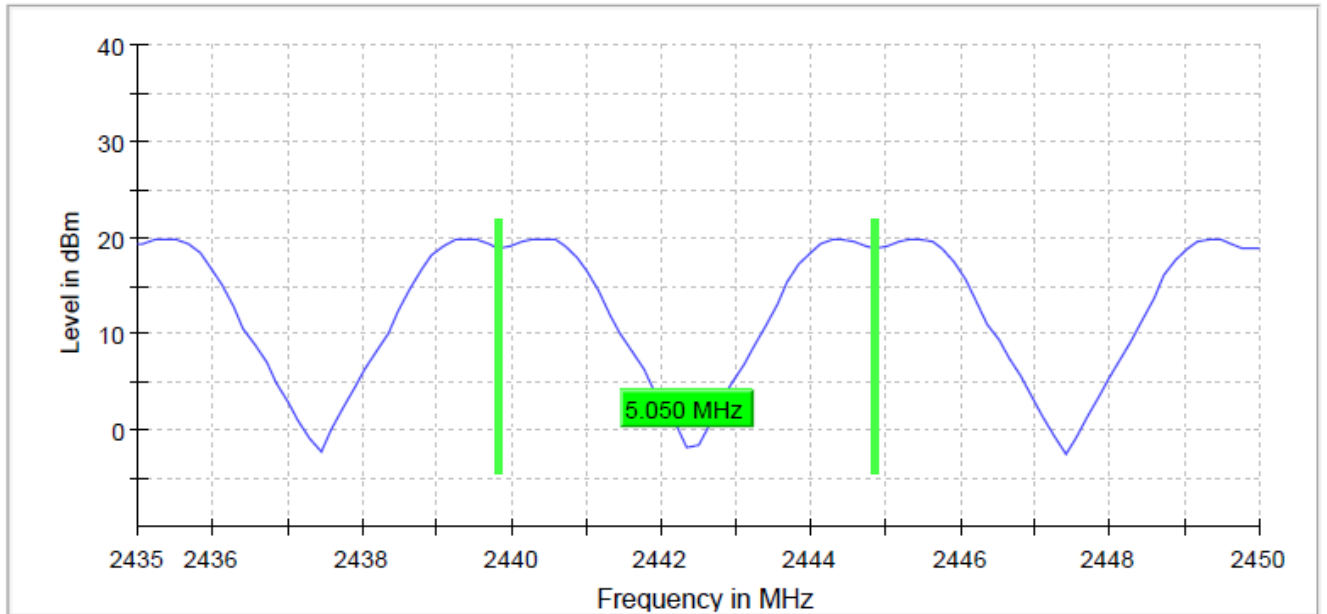
**Table 28:** Hopping channel carrier frequencies separation test result

| 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   |

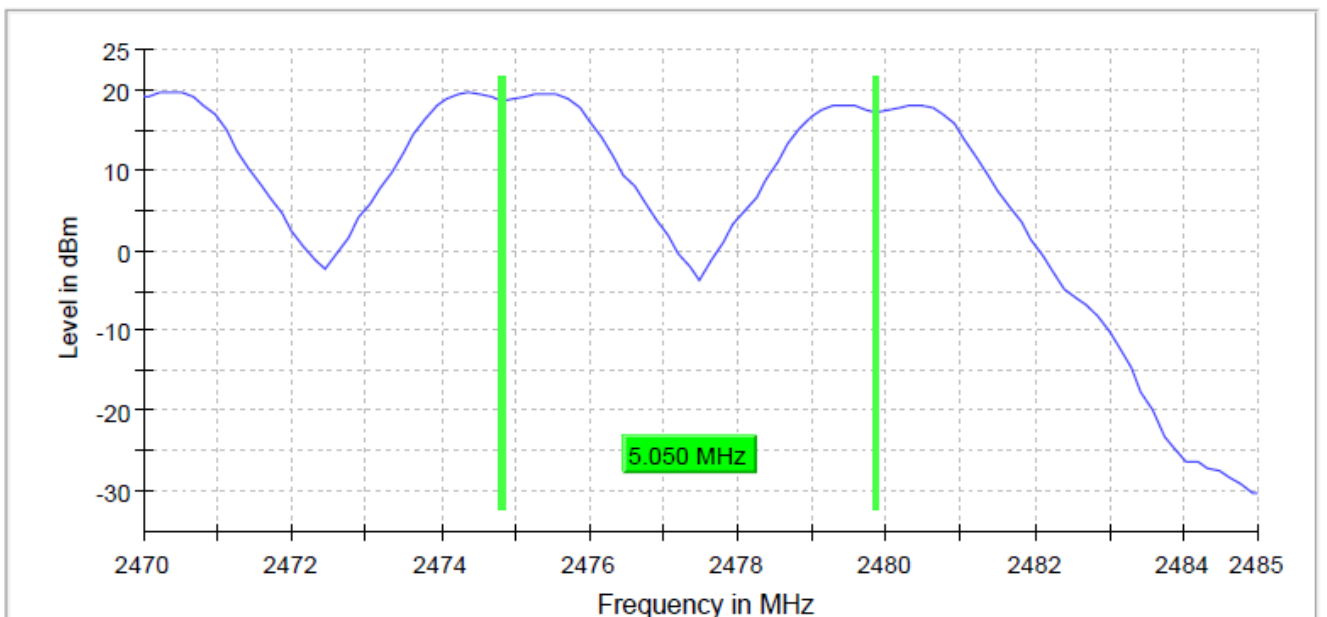


**Figure 33:** Measured hopping channels carrier frequency separation, DUT frequency 2405MHz

# Hopping Channel Carrier Frequencies Separation



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



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

## Hopping Channel Carrier Frequencies Separation

**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        | $\leq 1.500$ MHz |
| VBW                   | 1.000 MHz        | $\geq 1.000$ 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:**  $23 \pm 3$  °C  
**Humidity:** 20 - 60 % RH

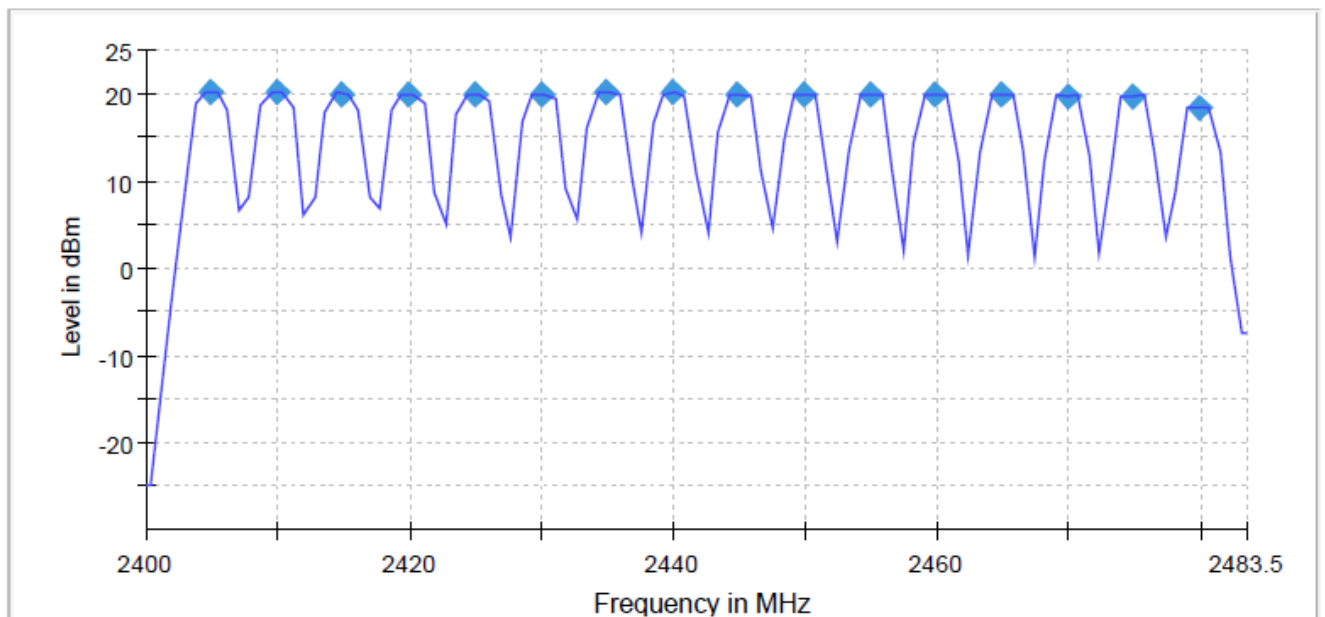
**FCC Rule: 15.247(a)(1)(iii)**  
**RSS-247 5.1**

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 $\mu$ s   | 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         |
| Preamplifier          | 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    |

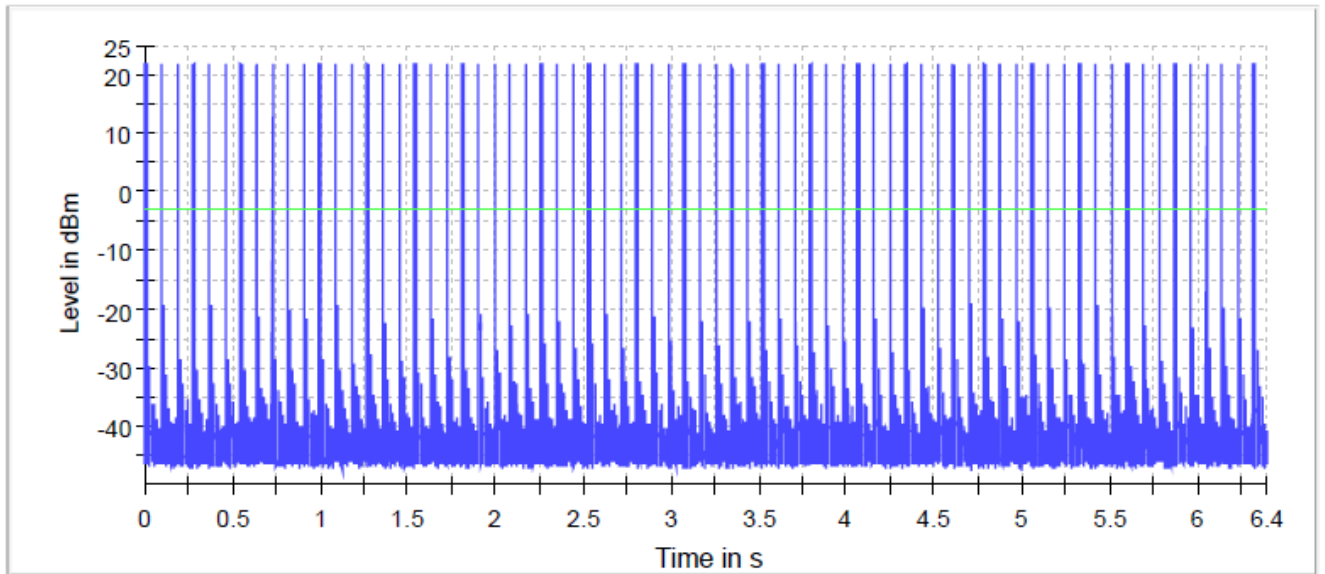
**Table 34:** Transmit Time per Hop

| 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     |

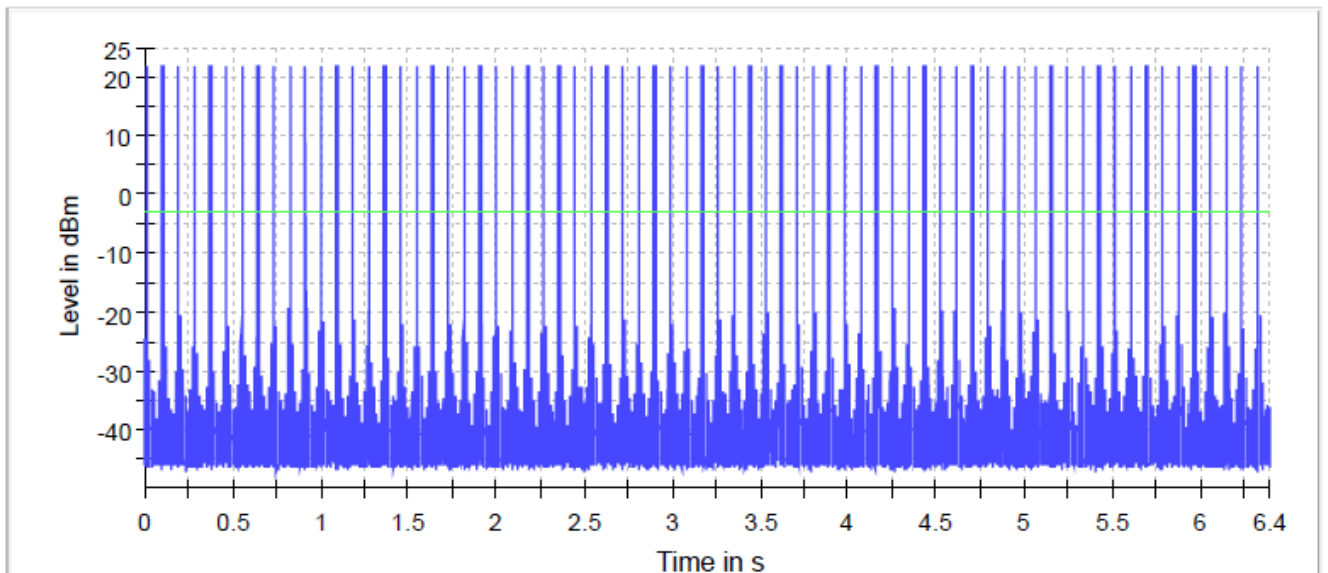
**Table 35:** Dwell time

| 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     |

**Average Time of Occupancy of Hopping Frequency**



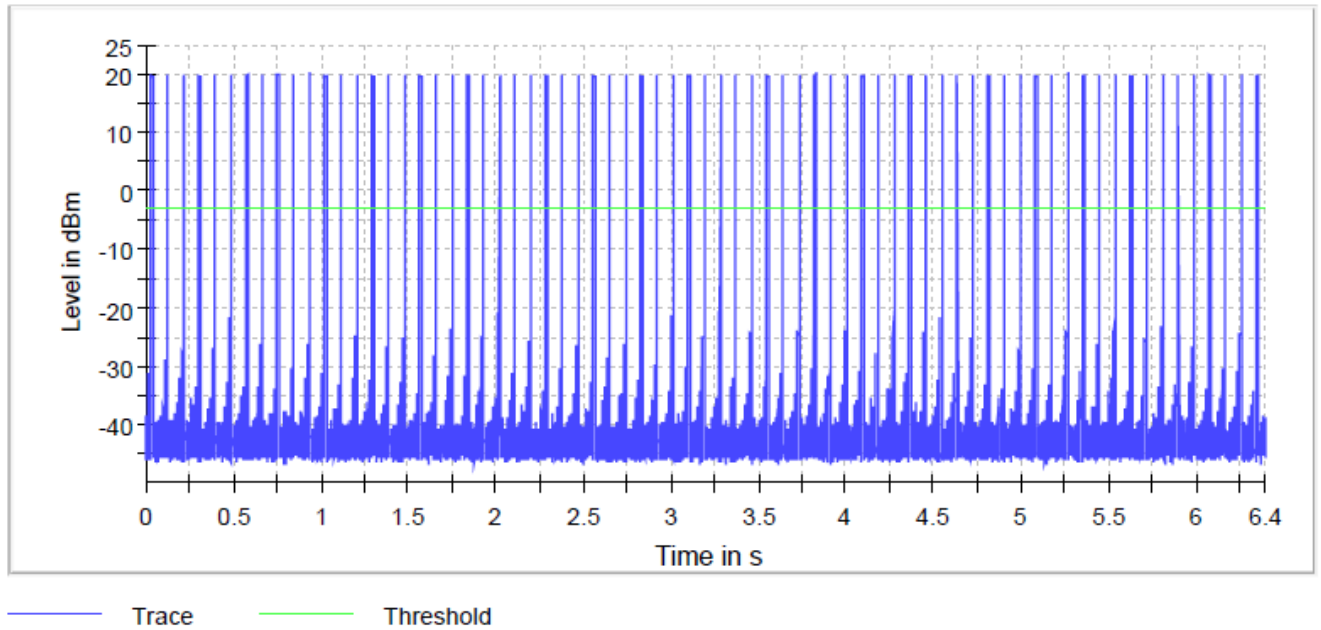
**Figure 37:** Time of channel occupancy LOW channel



— Trace      — Threshold

**Figure 38:** Time of channel occupancy MID channel

Average Time of Occupancy of Hopping Frequency



**Figure 39:** Time of channel occupancy HIGH channel

## Average Time of Occupancy of Hopping Frequency

**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 $\mu$ s    | 1.000 $\mu$ s |
| Detector         | RMS              | RMS           |

## 6 dB Bandwidth of the Channel

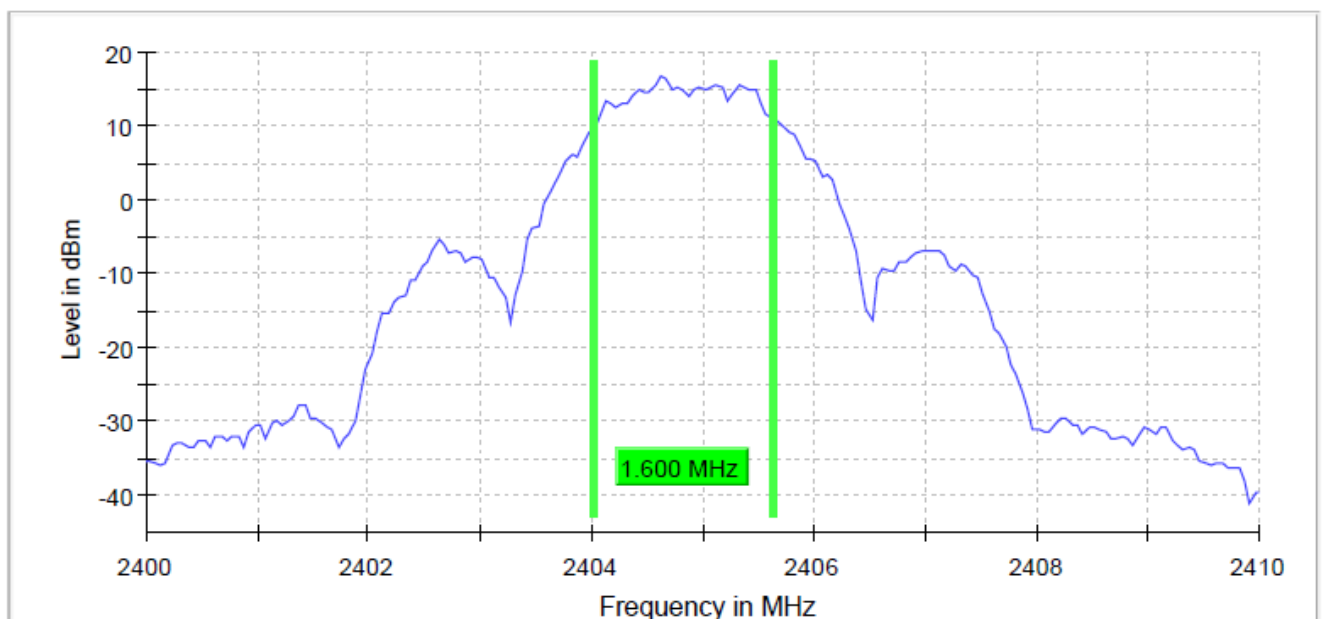
Standard: ANSI C63.10 (2013)  
Tested by: JAT  
Date: 1 July 2019  
Temperature:  $23 \pm 3$  °C  
Humidity: 20 - 60 % RH

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

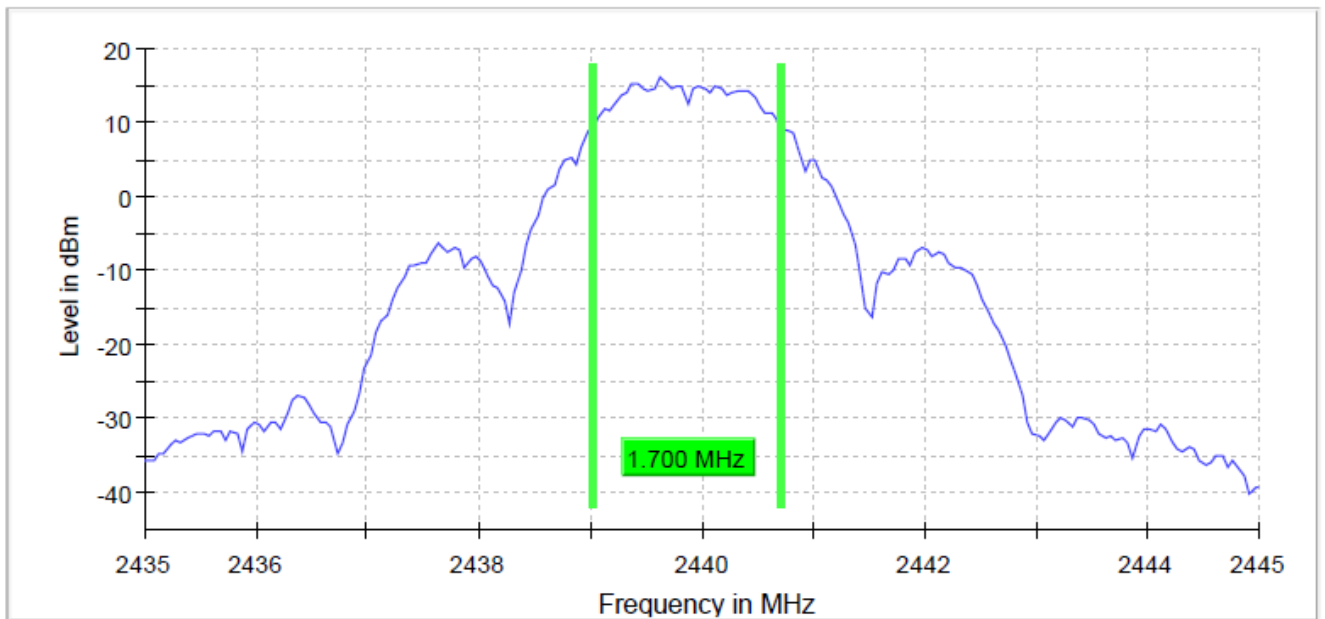
### Results:

**Table 37:** 6 dB bandwidth test results

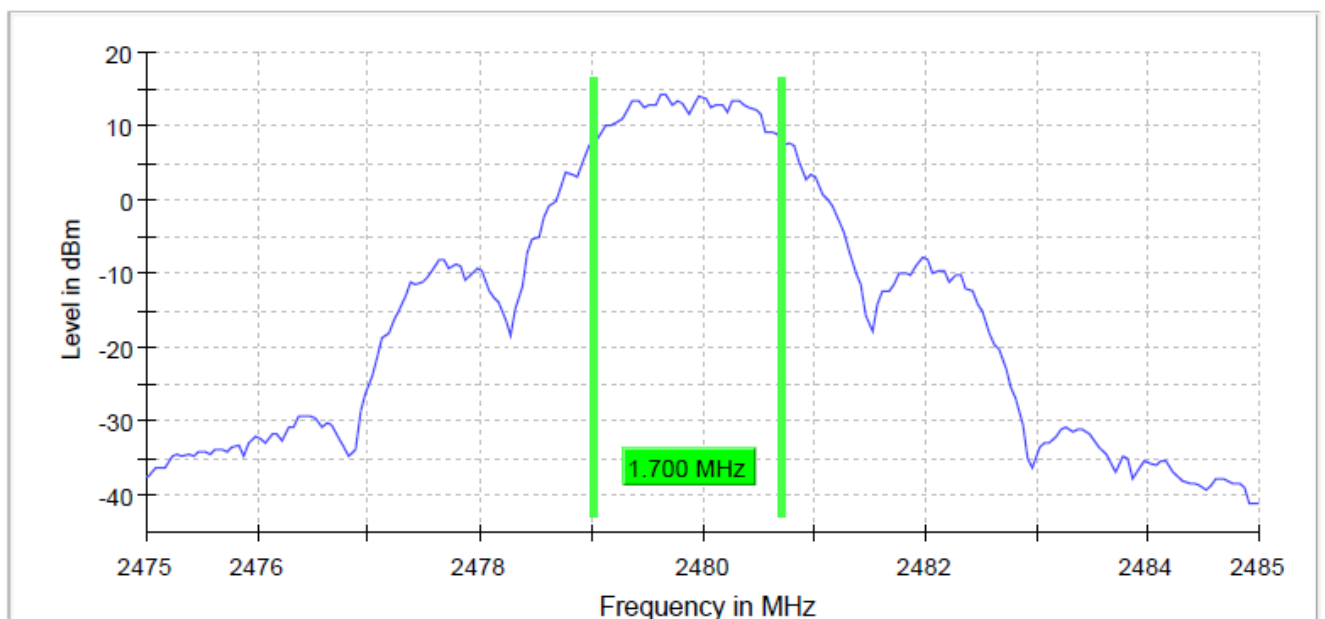
| DUT Frequency (MHz) | 6 dB BW [kHz] | Minimum limit [kHz] |
|---------------------|---------------|---------------------|
| 2405.000000         | 1600          | 500                 |
| 2440.000000         | 1700          |                     |
| 2480.000000         | 1700          |             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



**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 $\mu$ 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           | 0.50 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

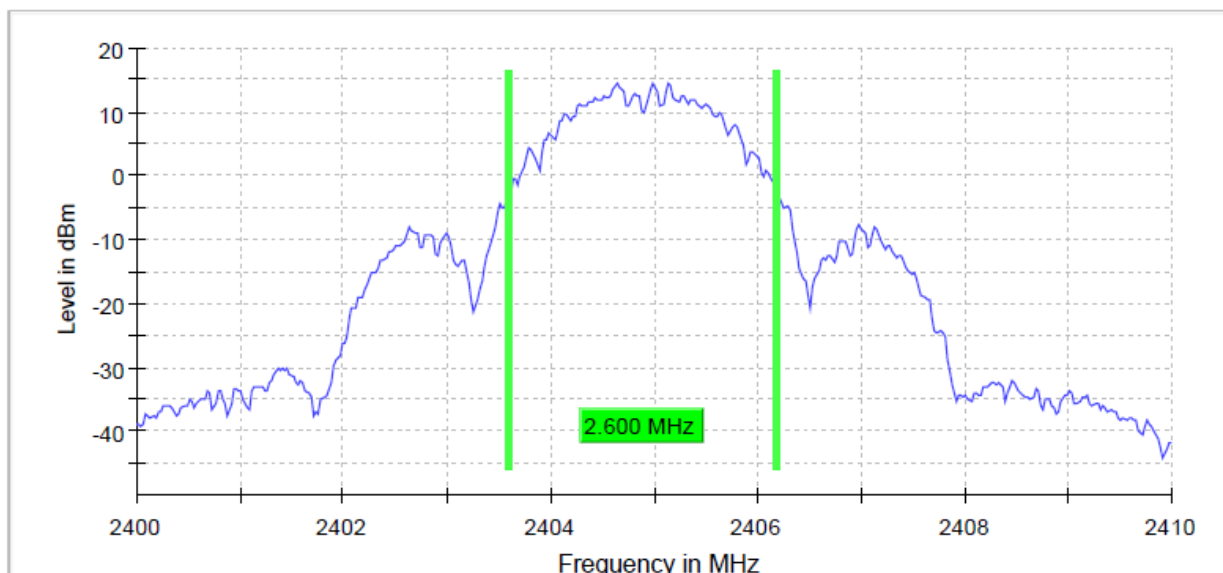
Standard: RSS-GEN (2019)  
Tested by: JAT  
Date: 1 July 2019  
Temperature:  $23 \pm 3$  °C  
Humidity: 20 - 60 % RH

RSS-GEN 6.6

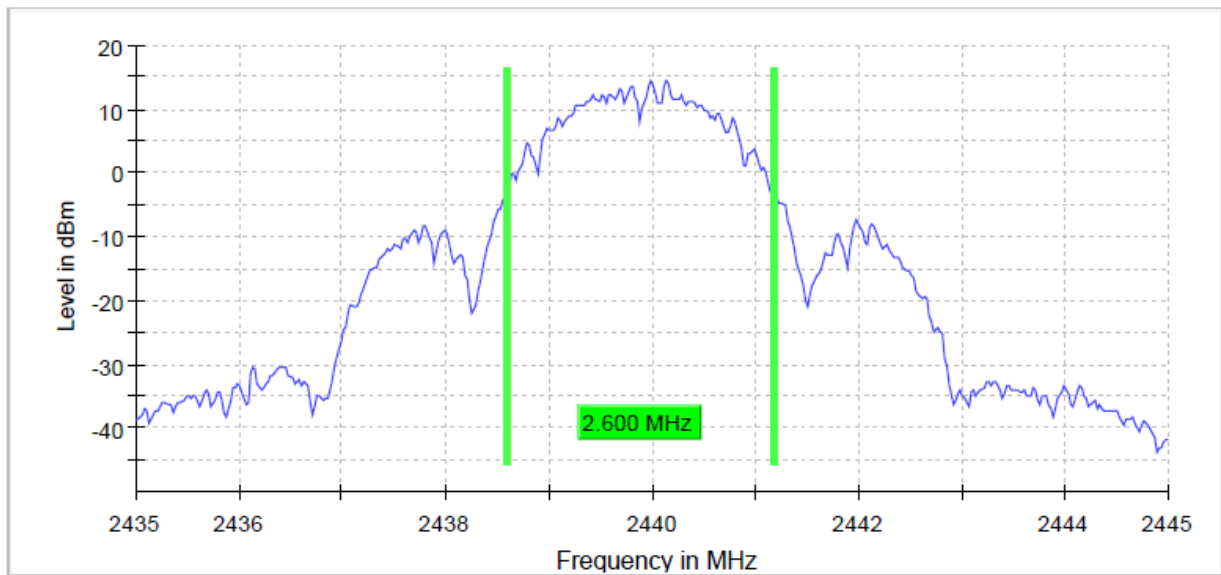
## Results

**Table 39:** 99% occupied bandwidth test results

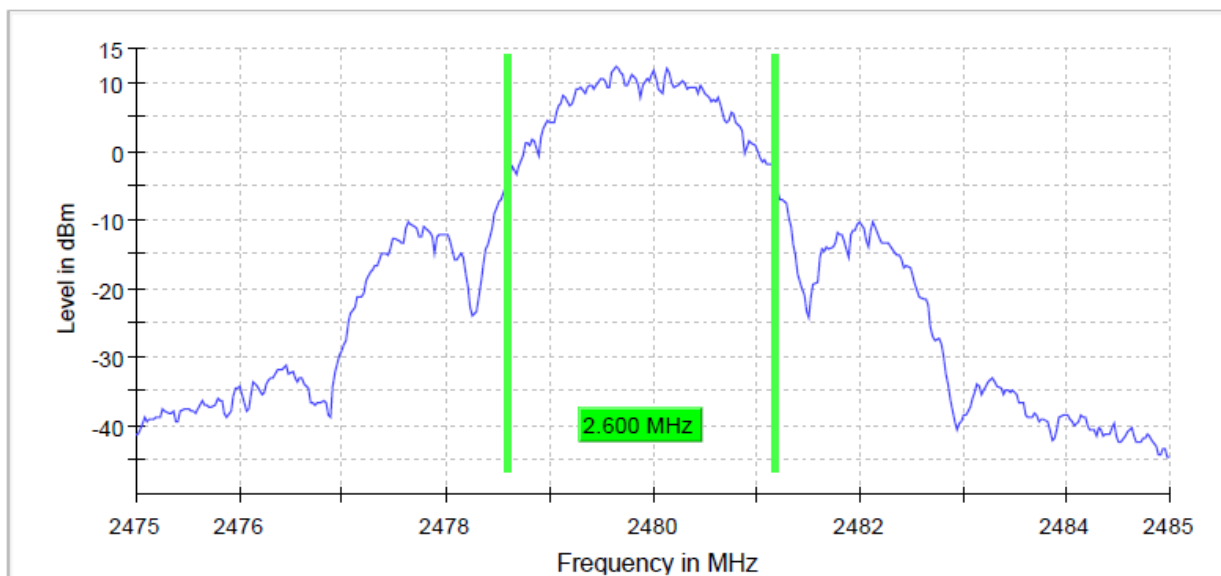
| Channel | Limit | 99 % BW [MHz] | Result |
|---------|-------|---------------|--------|
| Low     | -     | 2.60000       | PASS   |
| Mid     | -     | 2.60000       | PASS   |
| High    | -     | 2.60000       | PASS   |



**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 $\mu$ 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                   | 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**

|                     |              |        |
|---------------------|--------------|--------|
| <b>Standard:</b>    | ANSI C63.10  | (2013) |
| <b>Tested by:</b>   | JAT          |        |
| <b>Date:</b>        | 27 June 2019 |        |
| <b>Temperature:</b> | 23 ± 3 °C    |        |
| <b>Humidity:</b>    | 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 =  $20 \cdot \log(T_{occ}/100) = 20 \cdot \log(2 \cdot 4.27/100) = -21.37\text{dB}$

## 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            | 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 |