# Test Report

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

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

| | |
|---|---|
| Equipment Under Test: | Multi-Protocol Wireless Module |
| Model: | MGM12P02GA<br>MGM12P02GE |
| Manufacturer: | Silicon Laboratories Finland Oy<br>Bertel Jungin aukio 3<br>FI-02600 ESPOO<br>FINLAND |
| Customer: | Silicon Laboratories Finland Oy<br>Bertel Jungin aukio 3<br>FI-02600 ESPOO<br>FINLAND |
| FCC Rule Part: | 15.247: 2016 |
| IC Rule Part: | RSS-247, Issue 2, 2017<br>RSS-GEN Issue 4, 2014 |
| KDB: | Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 (April 5, 2017) |

Date: 4 December 2017

Issued by:

Jani Tuomela
Testing Engineer

Date: 4 December 2017

Checked by:

Rauno Repo
Testing Engineer

**Table of Contents**

## Equipment Under Test (EUT)

| | |
|---|---|
| Trade mark: | Silicon Labs |
| Model: | MGM12P02GA, MGM12P02GE |
| Type: | Multi-Protocol Wireless Module |
| Serial no: | - |
| FCC ID: | QOQMGM12P0 |
| IC: | 5123A-MGM12P0 |

## Description of the EUT

MGM12P02G is a multi-protocol wireless module with two antenna variants. Variant A is equipped with chip antenna while the E variant has RF connector for the use of external antenna.

This test report contains test results for Bluetooth Low Energy.

## Classification of the device

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

## Modifications Incorporated in the EUT

One sample was modified to allow conducted measurements to be made.

## Ratings and declarations

| | |
|---|---|
| Operating Frequency Range (OFR): | 2402 - 2480 MHz |
| Channels: | 40 |
| Channel separation: | 2 MHz |
| Effective conducted power: | 8.73 dBm (Peak) |
| Modulation: | GFSK |
| Integral Antenna gain: | A-variant: 1 dBi |
| External Antenna gain: | E-variant: 2.14 dBi |

## Power Supply

Operating voltage range: 2.0 - 3.8 VDC (tested with 3.3V regulated by the development board)

Separate AC/DC adaptor, Huawei model: HW-050100E01 (115 V, 60 Hz input / 5 V output) was used during the tests to power up the development board which feeds the module (EUT) during AC emissions test. Supply is not provided by the manufacturer. In other tests the development board was supplied with laboratory power supply.

## Mechanical Size of the EUT

Height: 2 mm Width: 20 mm Length: 15 mm

## Samples

Two samples were used in the tests, one with original antenna assembly. One sample had RF connector with short RF cable and antenna attached to it.

## Disclaimer

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

# SUMMARY OF TESTING

| Test Specification | Description of Test | Result |
|---|---|---|
| §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)(2) / RSS-247 5.2(a) | 6 dB Bandwidth | **PASS** |
| §15.247(e) / RSS-247 5.2(b) | Power Spectral Density | **PASS** |
| RSS-GEN 6.6 | 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** |

## EUT Test Conditions during Testing

The EUT was in continuous transmit mode during all the tests. The hopping was stopped and the EUT was configured into the wanted channel using software provided by the manufacturer. Normal modulation and duty cycle was applied in all the tests.

Conducted measurements were performed while the EUT was connected to WSTK development board. Conducted measurements were performed to E variant sample.

Radiated measurements with A variant were performed while the EUT was placed on simplified board with reduced functionality.

Following channels were used during the tests when the hopping was stopped:

Channel Low (Ch 0) = 2402 MHz

Channel Mid (Ch 19) = 2440 MHz

Channel High (Ch 39) = 2480 MHz

Power setting 199 was used for A variant and power setting 186 for E variant during radiated measurements.

Power setting 92 was used for conducted measurements. Other settings in table below were same for all tests.

| PHY | Low energy transmit | Packet Length |
|---|---|---|
| 1M | PRBS9 (GFSK) | 255 |

## Test Facility

| | |
|---|---|
| Testing Laboratory / address:<br>FCC registration number: **904175** | SGS Fimko Ltd<br>Särkiniementie 3<br>FI-00210, HELSINKI<br>FINLAND |
| Test Site: | Kara5m |

# TEST RESULTS

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

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | EHA | |
| **Date:** | 2 August 2017 | |
| **Temperature:** | 22 °C | |
| **Humidity:** | 44 % 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 4.5 kHz steps and a resolution bandwidth of 9 kHz. Measurements were carried out with peak and average detectors. Conducted Emission was measured from the highest power level module MGM12P32

| 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.

**Final measurements from the worst frequencies**

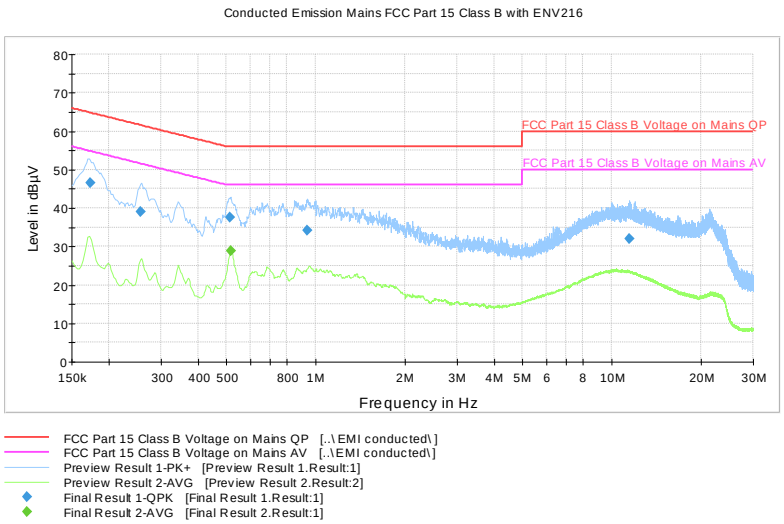


**Figure 1:** The measured curves with peak- and average detector.

**Table 1:** Final QuasiPeak measurements from the worst frequencies

| Frequency (MHz) | QuasiPeak (dBµV) | Meas. Time (ms) | Bandwidth (kHz) | Line | Corr. (dB) | Margin (dB) | Limit (dBµV) |
|---|---|---|---|---|---|---|---|
| 0.173000 | 46.5 | 1000.0 | 9.000 | L1 | 10.3 | 18.3 | 64.8 |
| 0.256500 | 38.9 | 1000.0 | 9.000 | L1 | 9.7 | 22.6 | 61.5 |
| 0.515250 | 37.5 | 1000.0 | 9.000 | L1 | 10.1 | 18.5 | 56.0 |
| 0.938000 | 34.2 | 1000.0 | 9.000 | L1 | 10.0 | 21.8 | 56.0 |
| 11.470250 | 32.0 | 1000.0 | 9.000 | L1 | 10.3 | 28.0 | 60.0 |

**Table 2:** Final Average measurements from the worst frequencies

| Frequency (MHz) | Average (dBµV) | Meas. Time (ms) | Bandwidth (kHz) | Line | Corr. (dB) | Margin (dB) | Limit (dBµV) |
|---|---|---|---|---|---|---|---|
| 0.517250 | 28.8 | 1000.0 | 9.000 | N | 10.3 | 17.2 | 46.0 |

The correction factor in the final result table contains the sum of the transducers (transient limiter + cables). 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:** | 23 November 2017 | |
| **Temperature:** | 23 ± 3 °C | |
| **Humidity:** | 20 - 60 % RH | |
| **Measurement uncertainty:** | ± 2.87dB | Level of confidence 95 % (k = 2) |

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

For systems using digital modulation in the 2400-2483.5 MHz bands the limit is 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power.

Measured values are peak values.

**Results:**

**Table 3:** Maximum conducted output power

| Channel | Conducted Power [dBm] | Limit [dBm] | Margin [dBm] | Result |
|---|---|---|---|---|
| Low | 8.73 | 30 | 21.27 | PASS |
| Mid | 8.22 | 30 | 21.78 | PASS |
| High | 7.99 | 30 | 22.01 | PASS |

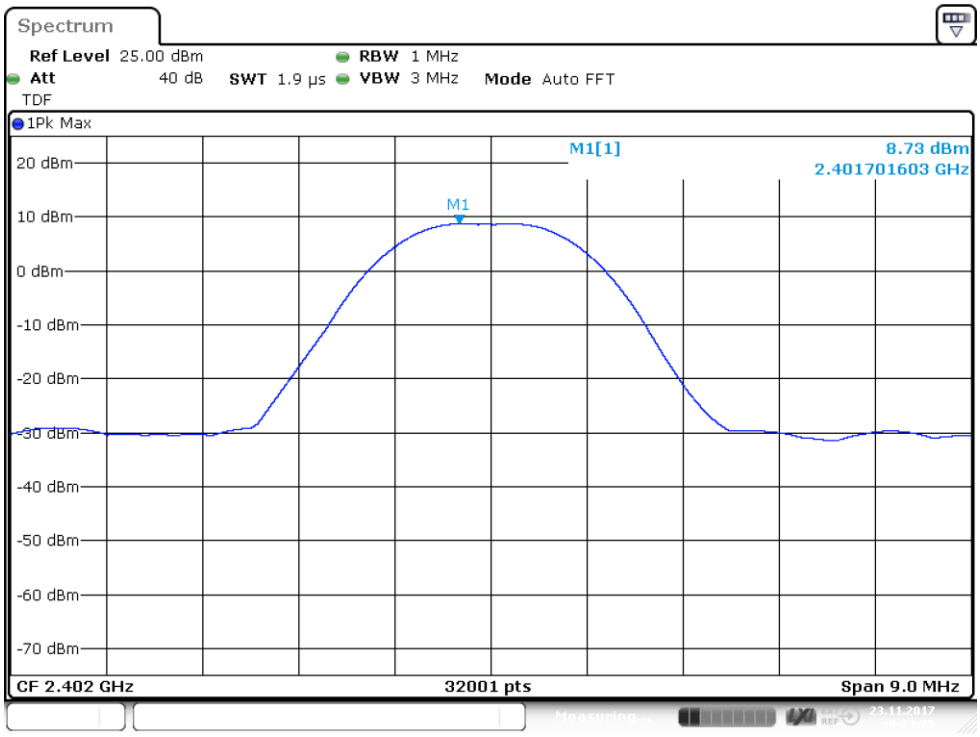


**Figure 2:** Conducted power (ch low)

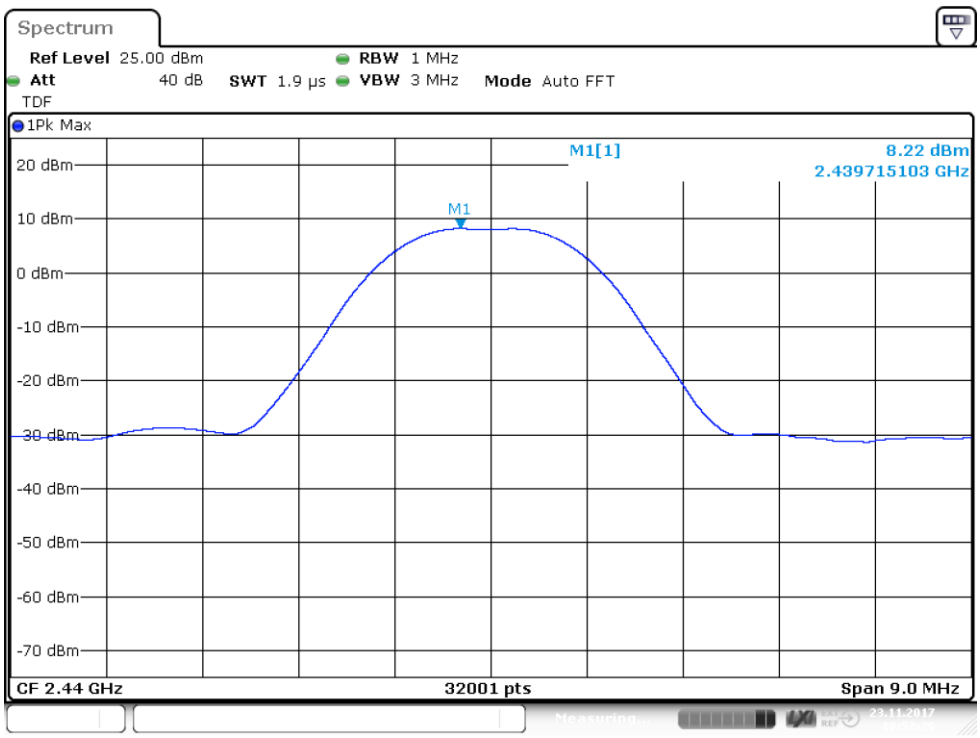


**Figure 3:** Conducted power (ch mid)

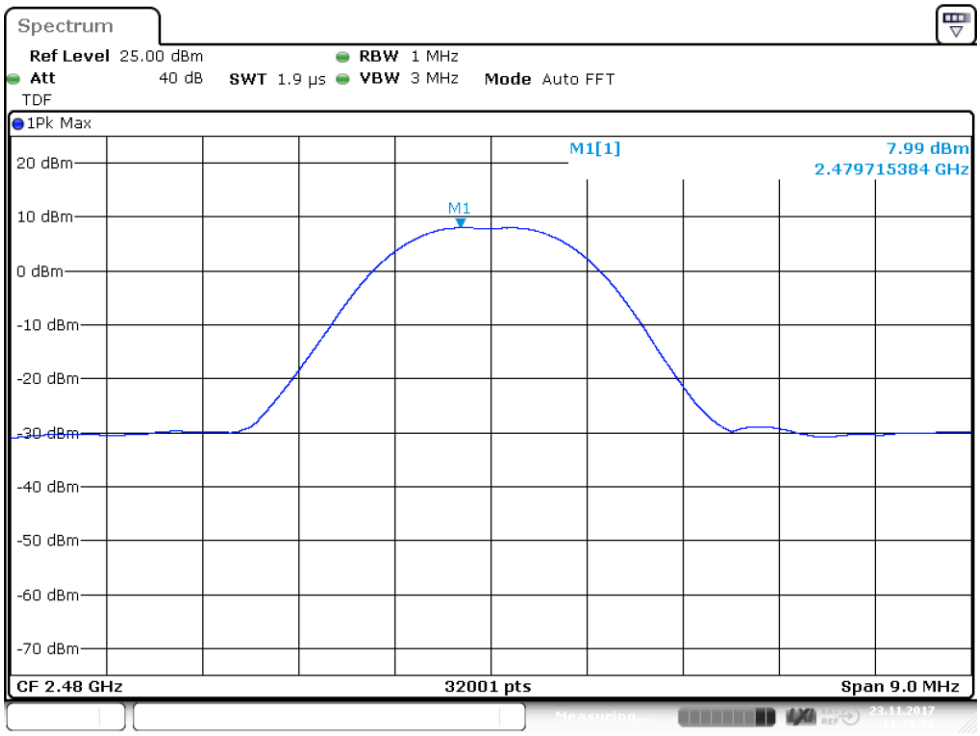


**Figure 4:** Conducted power (ch high)

## Transmitter Radiated Spurious Emissions 30 - 26500 MHz

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | EHA & JAT | |
| **Date:** | 26 July 2017 - 8 August 2017 | |
| **Temperature:** | 23 ± 3 °C | |
| **Humidity:** | 20 - 60 % RH | |
| **Measurement uncertainty:** | ± 4.51 dB | Level of confidence 95 % (k = 2) |

**FCC Rule: 15.247(d), 15.209(a)**
**RSS-247 5.5**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a)**.**

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

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

Measurements were performed for both antenna variants.

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

**Low channel**

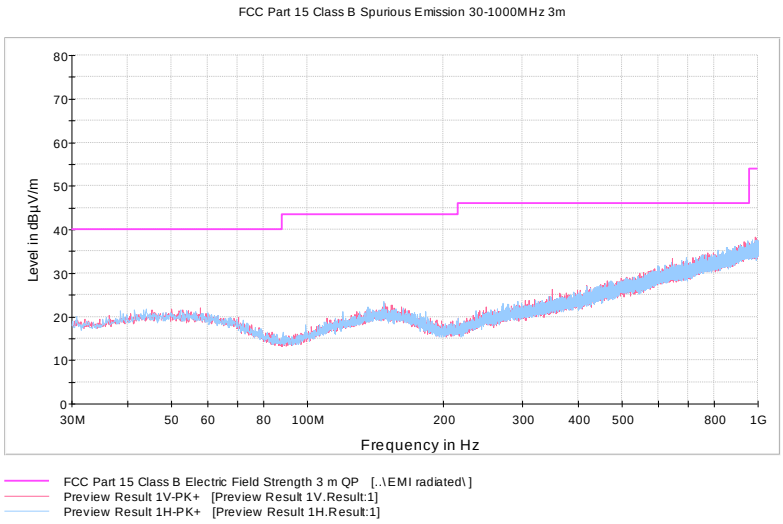


**Figure 5:** Low channel 30 MHz – 1000 MHz (A)

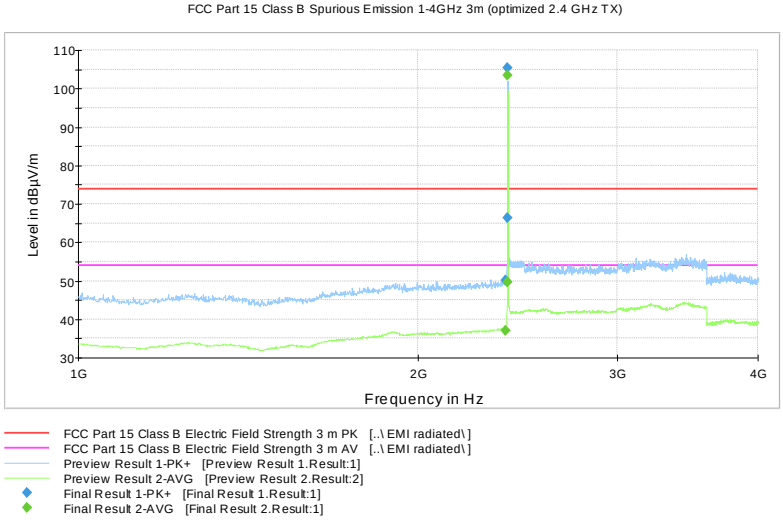


**Figure 6:** Low channel 1 GHz – 4 GHz (A)

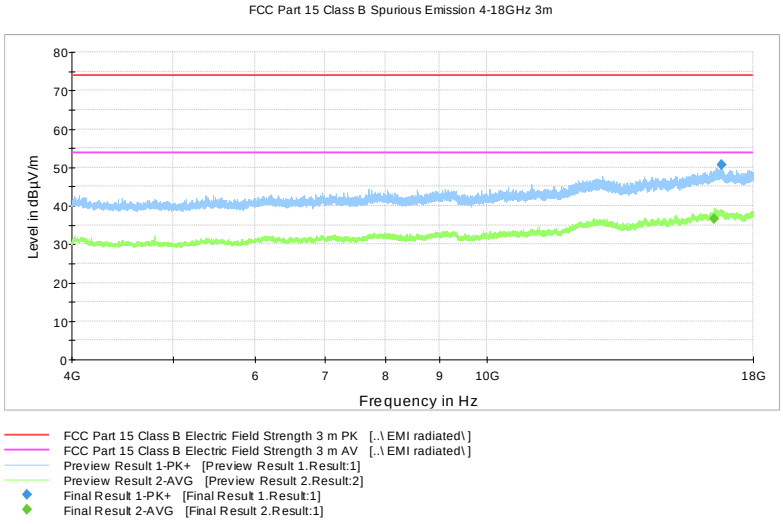


**Figure 7:** Low channel 4 GHz – 18 GHz (A)

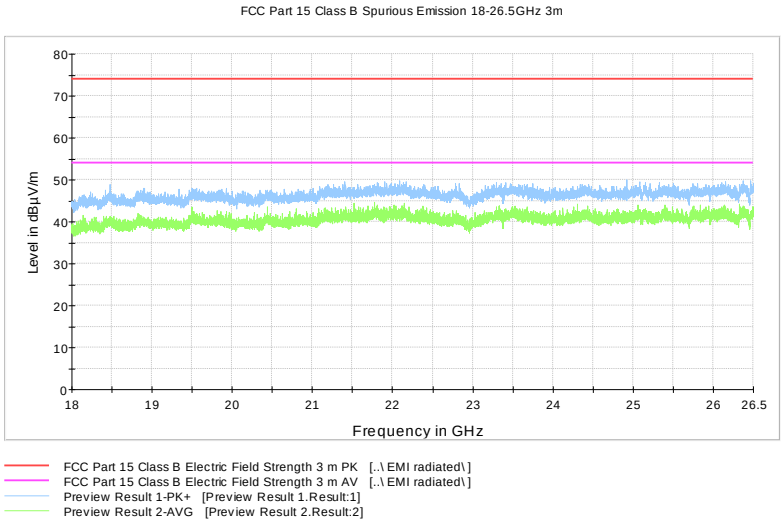


**Figure 8:** Low channel 18 GHz – 26.5 GHz (A)

**Table 4:** Peak results (ch low) (A)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2389.400000 | 50.2 | 1000.0 | 1000.000 | 150.0 | H | 58.0 | 14.6 | 23.7 | 73.9 |
| 2400.000000 | 66.4 | 1000.0 | 1000.000 | 275.0 | H | 290.0 | 14.7 | 18.9 | 85.3 |
| 16798.20000 | 50.8 | 1000.0 | 1000.000 | 245.0 | V | 0.0 | 26.8 | 23.1 | 73.9 |

**Table 5:** Average results (ch low) (A)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2389.600000 | 37.0 | 1000.0 | 1000.000 | 380.0 | V | 180.0 | 14.6 | 16.9 | 53.9 |
| 2400.000000 | 49.7 | 1000.0 | 1000.000 | 197.0 | H | 253.0 | 14.7 | 4.2 | 53.9 |
| 16523.60000 | 36.6 | 1000.0 | 1000.000 | 166.0 | V | 187.0 | 26.1 | 17.3 | 53.9 |

## Middle channel

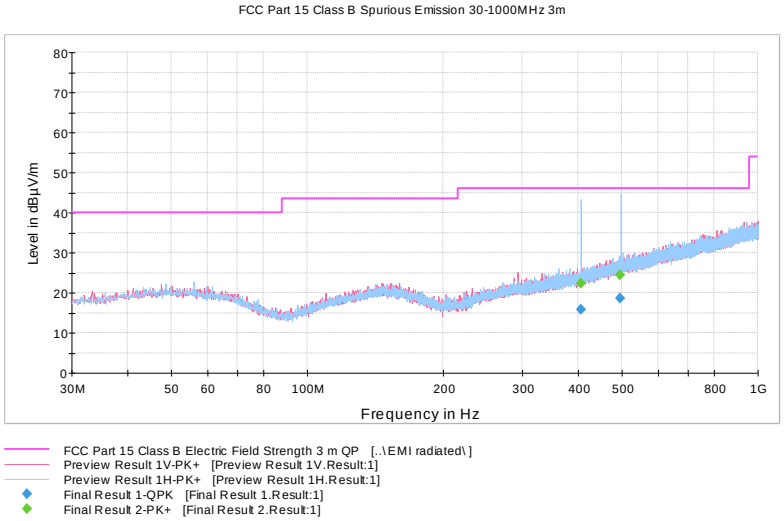


**Figure 9:** Mid channel 30 MHz – 1000 MHz (A)

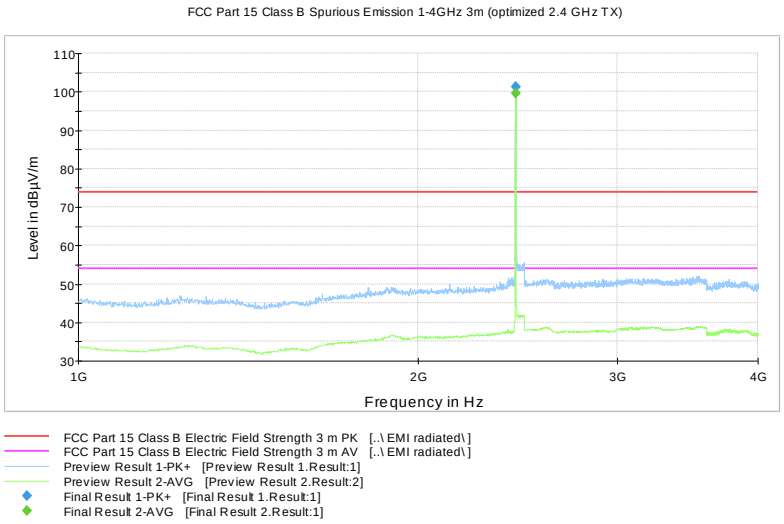


**Figure 10:** Mid channel 1 GHz – 4 GHz (A)

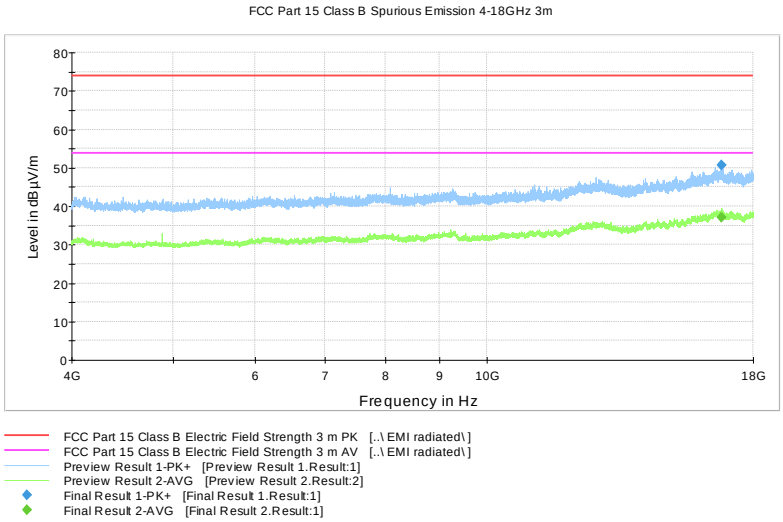


**Figure 11:** Mid channel 4 GHz – 18 GHz (A)

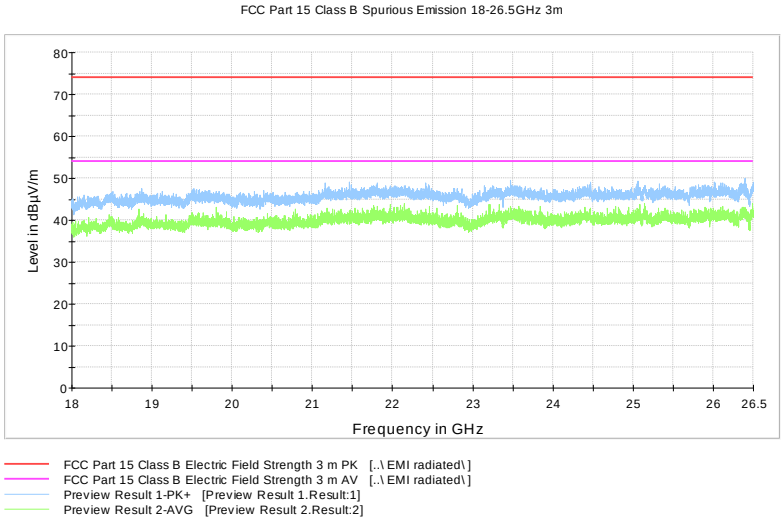


**Figure 12:** Mid channel 18 GHz – 26.5 GHz (A)

**Table 6:** Peak results (ch mid) (A)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 16802.30000 | 50.6 | 1000.0 | 1000.000 | 400.0 | V | 113.0 | 26.8 | 23.3 | 73.9 |

**Table 7:** Average results (ch mid) (A)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 16793.60000 | 37.0 | 1000.0 | 1000.000 | 400.0 | V | 344.0 | 26.8 | 16.9 | 53.9 |

**Table 8:** Quasi-peak results (ch mid) (A)

| Frequency (MHz) | QuasiP (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 405.141000 | 15.8 | 1000.0 | 120.000 | 100.0 | H | 122.0 | 17.9 | 30.2 | 46.0 |
| 495.411000 | 18.6 | 1000.0 | 120.000 | 178.0 | H | 209.0 | 20.2 | 27.4 | 46.0 |

## High channel

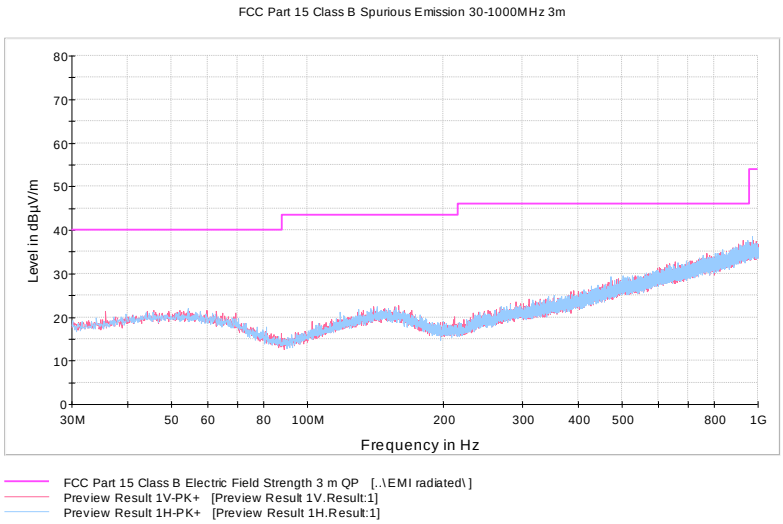


**Figure 13:** High channel 30 MHz – 1000 MHz (A)

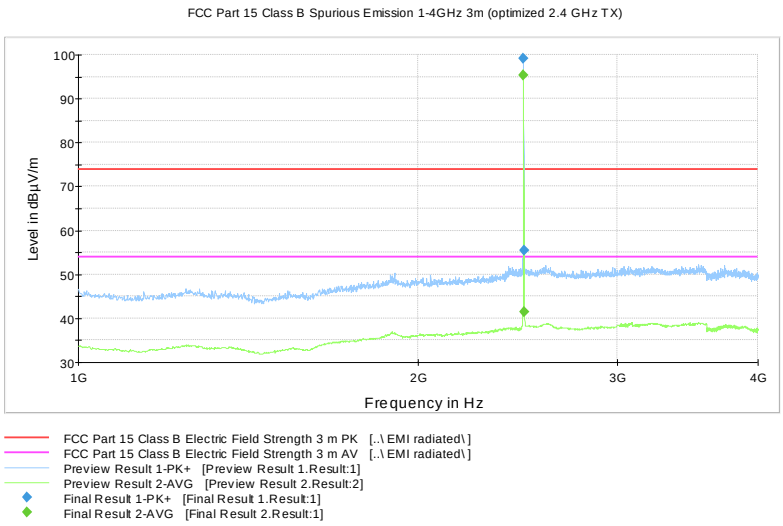


**Figure 14:** High channel 1 GHz – 4 GHz (A)

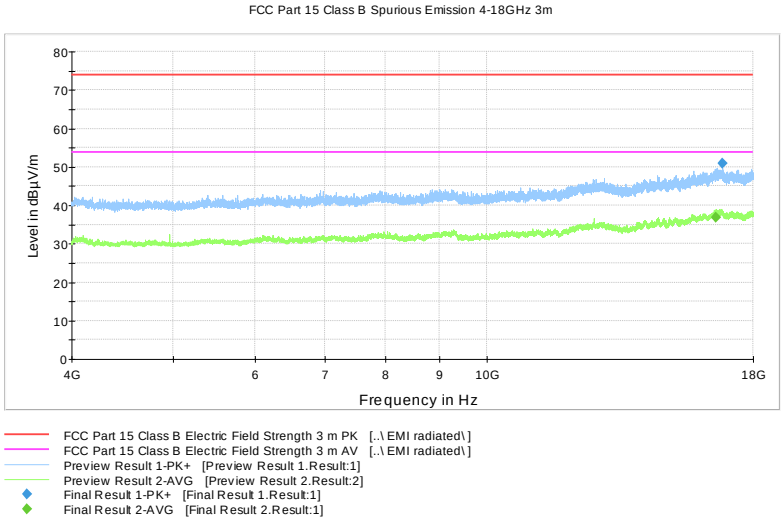


**Figure 15:** High channel 4 GHz – 18 GHz (A)

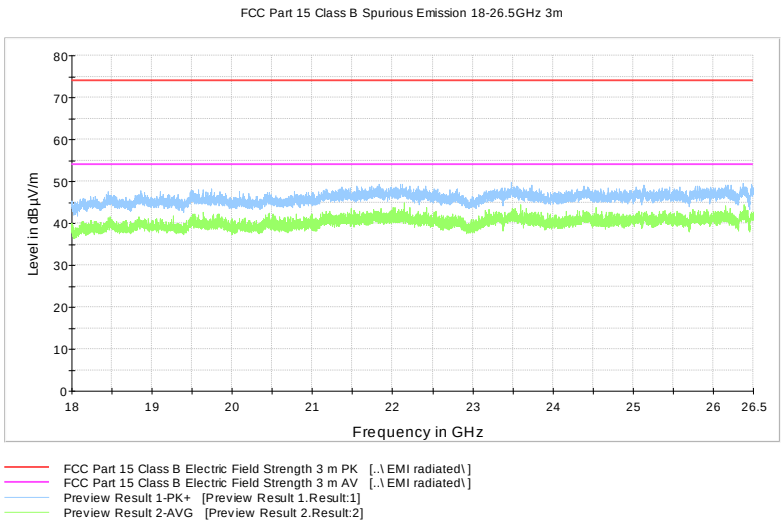


**Figure 16:** High channel 18 GHz – 26.5 GHz (A)

**Table 9:** Peak results (ch high) (A)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2483.500000 | 55.4 | 1000.0 | 1000.000 | 265.0 | H | 264.0 | 14.7 | 18.5 | 73.9 |
| 16806.40000 | 50.8 | 1000.0 | 1000.000 | 323.0 | V | 136.0 | 26.8 | 23.1 | 73.9 |

**Table 10:** Average results (ch high) (A)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2483.500000 | 41.4 | 1000.0 | 1000.000 | 254.0 | H | 263.0 | 14.7 | 12.5 | 53.9 |
| 16596.20000 | 36.8 | 1000.0 | 1000.000 | 150.0 | H | 119.0 | 26.2 | 17.1 | 53.9 |

## Radiated Band Edge results

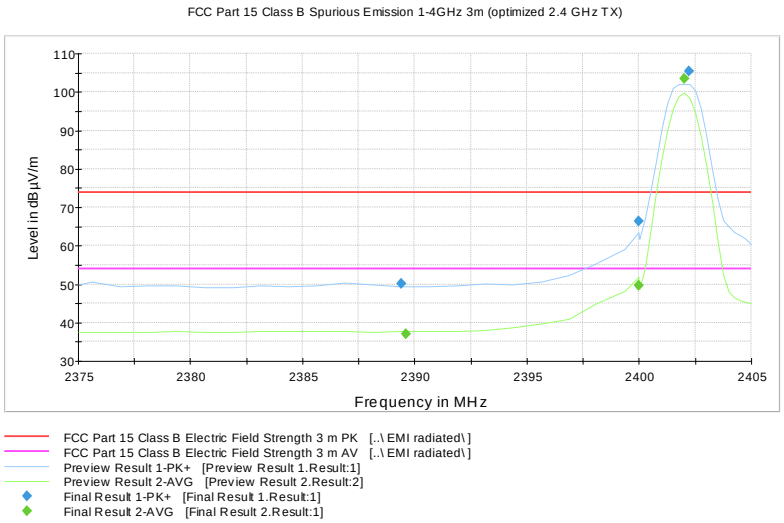


**Figure 17:** Radiated Band Edge measurement graph (ch low) (A)

**Table 11:** Peak results (ch low) (A)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2389.400000 | 50.2 | 1000.0 | 1000.000 | 150.0 | H | 58.0 | 14.6 | 23.7 | 73.9 |
| 2400.000000 | 66.4 | 1000.0 | 1000.000 | 275.0 | H | 290.0 | 14.7 | 18.9 | 85.3 |

**Table 12:** Average results (ch low) (A)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2389.600000 | 37.0 | 1000.0 | 1000.000 | 380.0 | V | 180.0 | 14.6 | 16.9 | 53.9 |
| 2400.000000 | 49.7 | 1000.0 | 1000.000 | 197.0 | H | 253.0 | 14.7 | 4.2 | 53.9 |

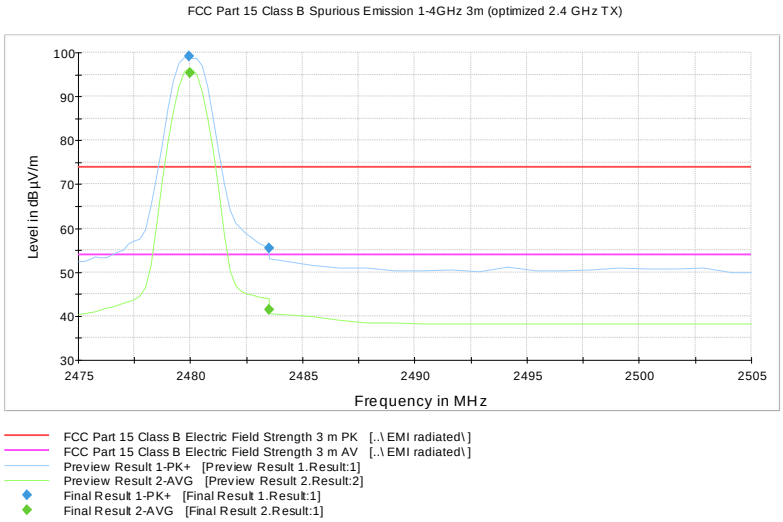


**Figure 18:** Radiated Band Edge measurement graph (ch high) (A)

**Table 13:** Peak results (ch high) (A)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2483.500000 | 55.4 | 1000.0 | 1000.000 | 265.0 | H | 264.0 | 14.7 | 18.5 | 73.9 |

**Table 14:** Average results (ch high) (A)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2483.500000 | 41.4 | 1000.0 | 1000.000 | 254.0 | H | 263.0 | 14.7 | 12.5 | 53.9 |

## Low channel

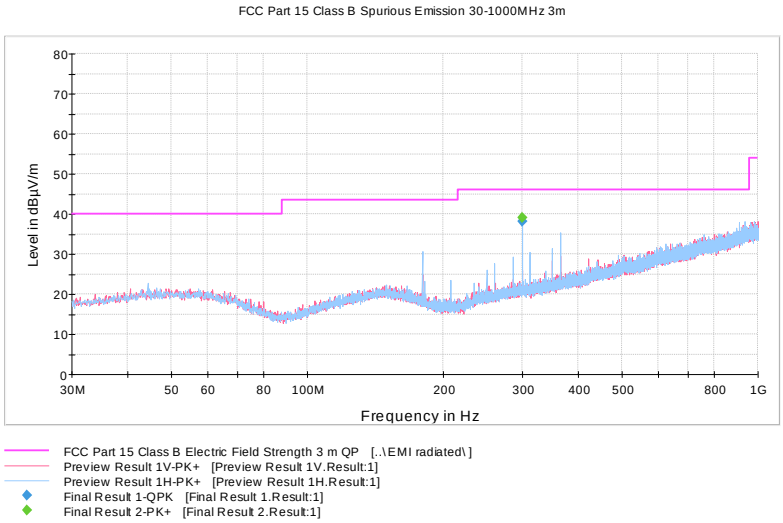


**Figure 19:** Low channel 30 MHz – 1000 MHz (E)

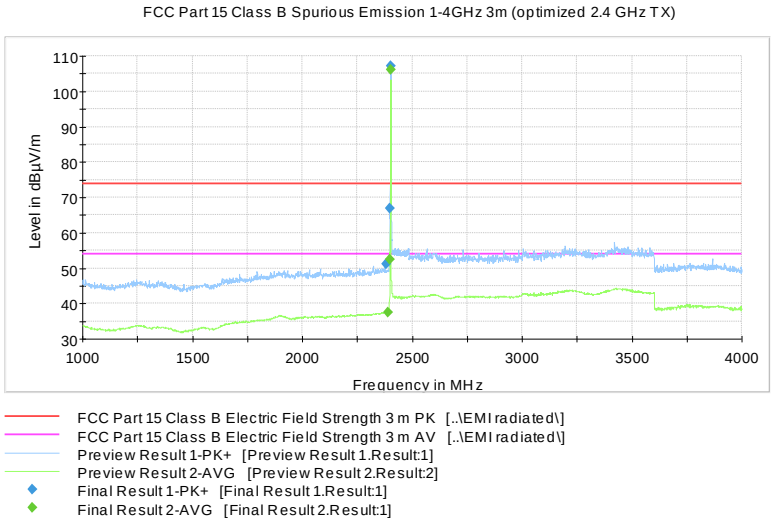


**Figure 20:** Low channel 1 GHz – 4 GHz (E)

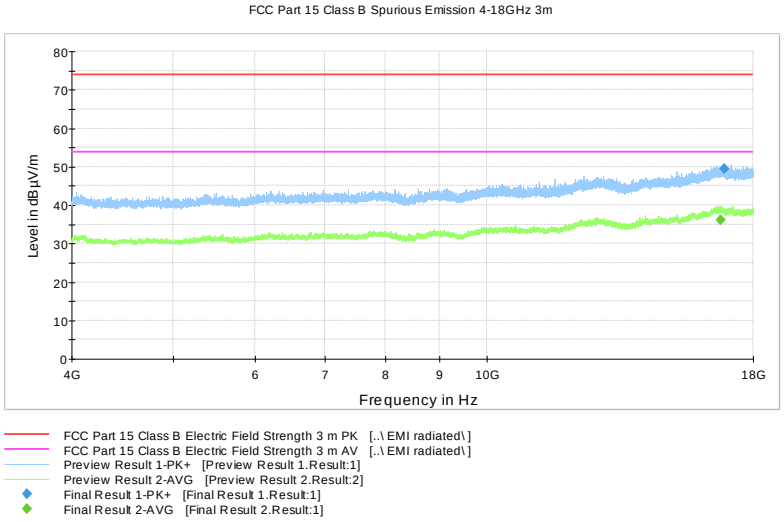


**Figure 21:** Low channel 4 GHz – 18 GHz (E)

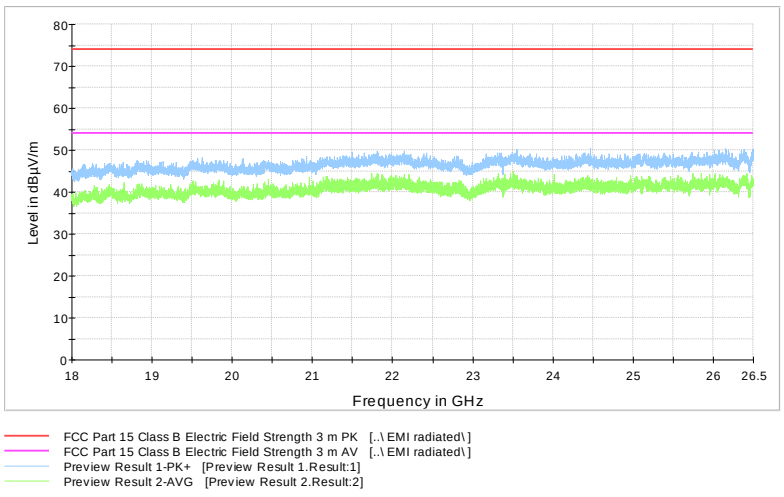


**Figure 22:** Low channel 18 GHz – 26.5 GHz (E)

**Table 15:** Peak results (ch low) (E)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2383.800000 | 51.1 | 1000.0 | 1000.000 | 379.0 | H | 33.0 | 14.5 | 22.8 | 73.9 |
| 2400.000000 | 66.8 | 1000.0 | 1000.000 | 236.0 | V | 291.0 | 14.7 | 20.2 | 87.0 |
| 16874.90000 | 49.5 | 1000.0 | 1000.000 | 150.0 | V | 82.0 | 26.8 | 24.4 | 73.9 |

**Table 16:** Average results (ch low) (E)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2389.800000 | 37.5 | 1000.0 | 1000.000 | 279.0 | V | 298.0 | 14.6 | 16.4 | 53.9 |
| 2400.000000 | 52.5 | 1000.0 | 1000.000 | 258.0 | V | 293.0 | 14.7 | 1.4 | 53.9 |
| 16751.60000 | 36.2 | 1000.0 | 1000.000 | 150.0 | V | 0.0 | 26.6 | 17.7 | 53.9 |

**Table 17:** Quasi-peak results (ch low) (E)

| Frequency (MHz) | QuasiP (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 300.011000 | 38.1 | 1000.0 | 120.000 | 100.0 | H | 15.0 | 15.3 | 7.9 | 46.0 |

**Middle channel**

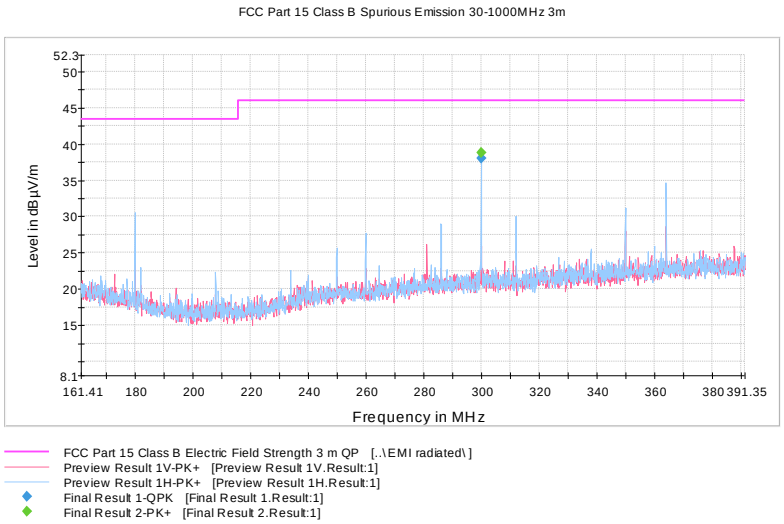


**Figure 23:** Mid channel 30 MHz – 1000 MHz (E)

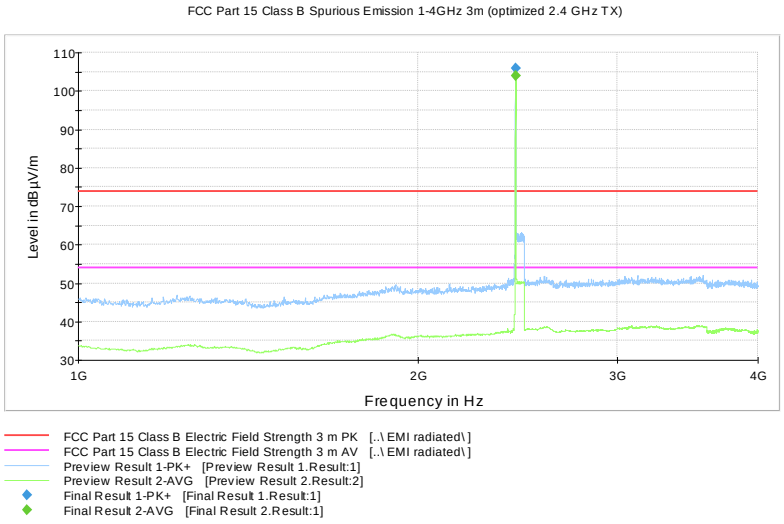


**Figure 24:** Mid channel 1 GHz – 4 GHz (E)

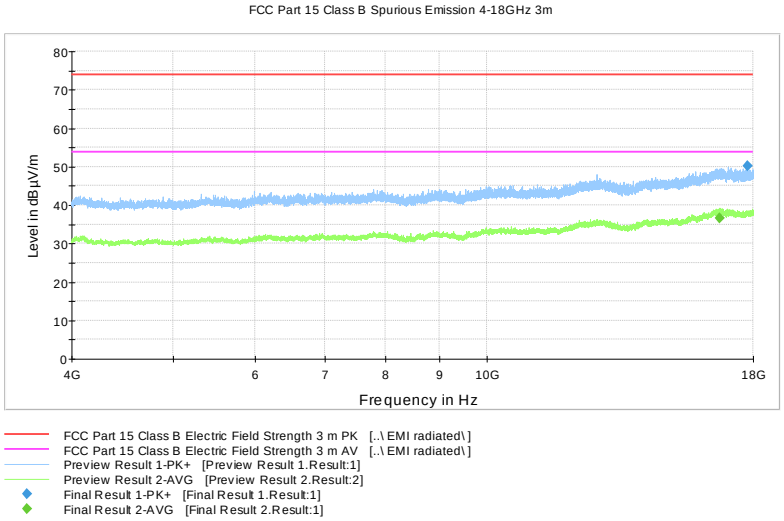


**Figure 25:** Mid channel 4 GHz – 18 GHz (E)

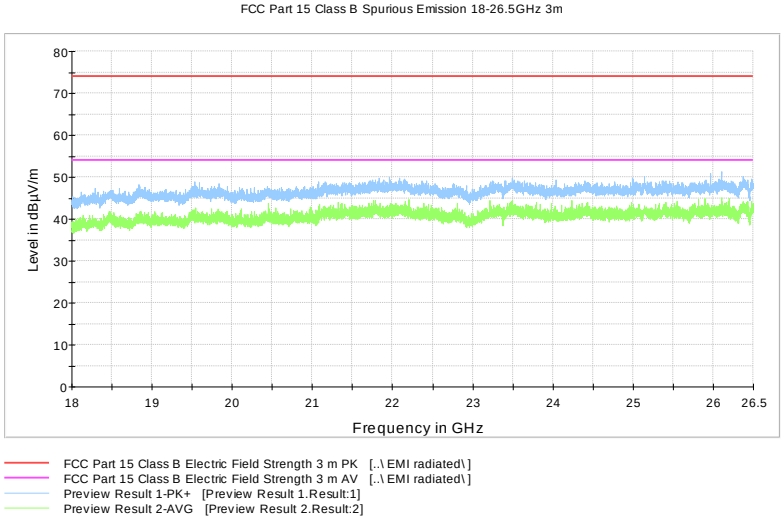


**Figure 26:** Mid channel 18 GHz – 26.5 GHz (E)

**Table 18:** Peak results (ch mid) (E)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 17781.80000 | 50.2 | 1000.0 | 1000.000 | 150.0 | V | 114.0 | 27.6 | 23.7 | 73.9 |

**Table 19:** Average results (ch mid) (E)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 16718.20000 | 36.7 | 1000.0 | 1000.000 | 400.0 | V | 220.0 | 26.5 | 17.2 | 53.9 |

**Table 20:** Quasi-peak results (ch mid) (E)

| Frequency (MHz) | QuasiP (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 300.008000 | 38.1 | 1000.0 | 120.000 | 100.0 | H | 6.0 | 15.3 | 7.9 | 46.0 |

**High channel**

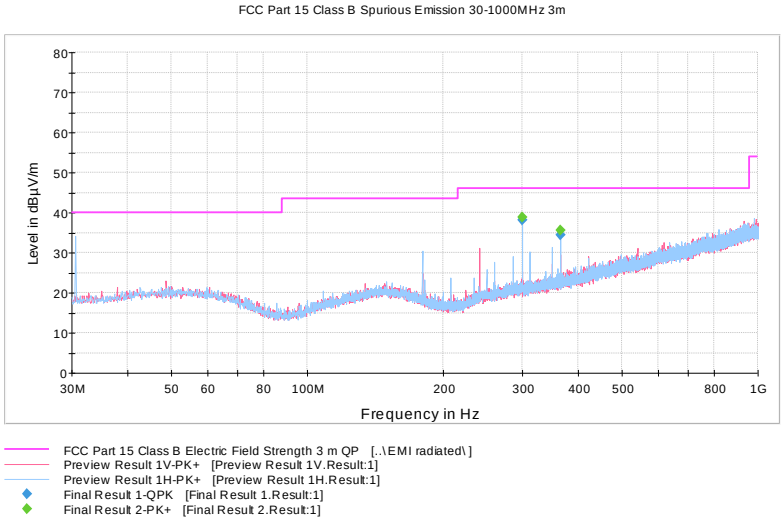


**Figure 27:** High channel 30 MHz – 1000 MHz (E)

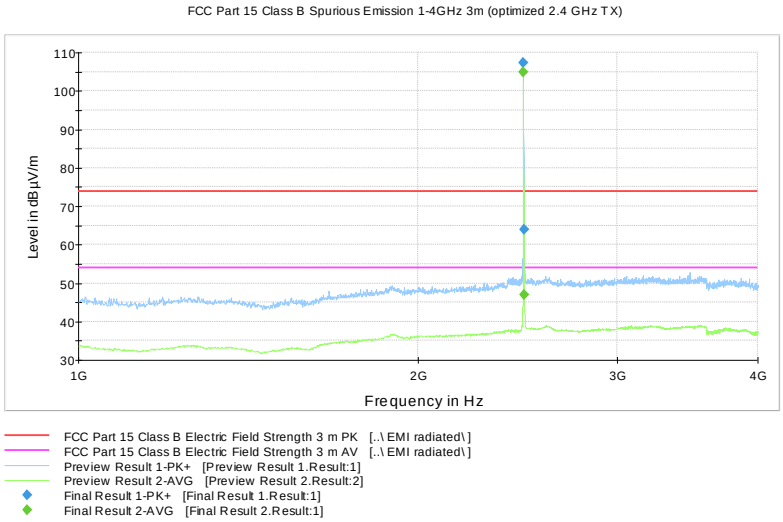


**Figure 28:** High channel 1 GHz – 4 GHz (E)

7

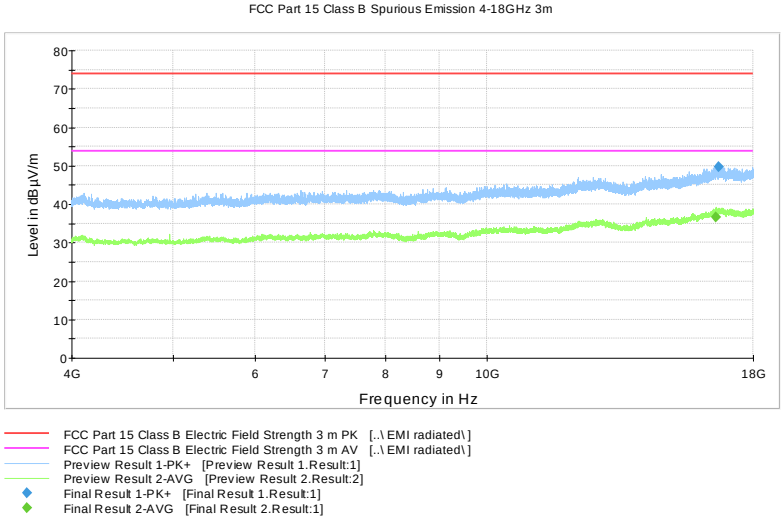


**Figure 29:** High channel 4 GHz – 18 GHz (E)

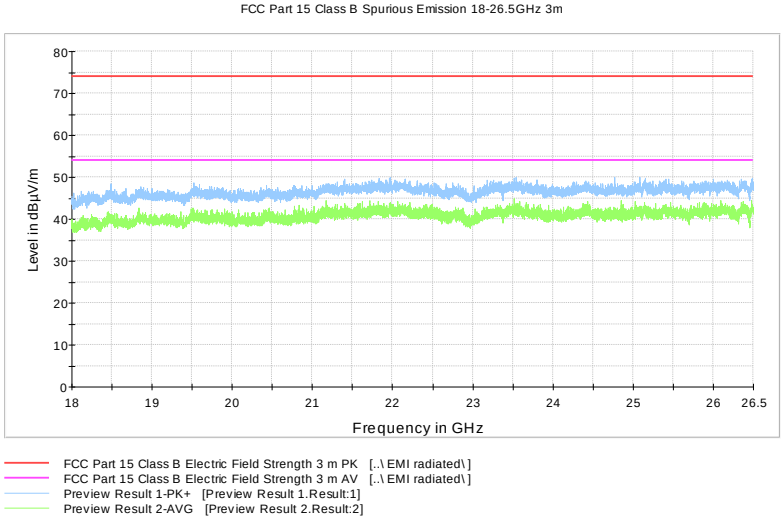


**Figure 30:** High channel 18 GHz – 26.5 GHz (E)

**Table 21:** Peak results (ch high) (E)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2483.500000 | 63.8 | 1000.0 | 1000.000 | 268.0 | V | 0.0 | 14.7 | 10.1 | 73.9 |
| 16694.50000 | 49.6 | 1000.0 | 1000.000 | 284.0 | V | 161.0 | 26.4 | 24.3 | 73.9 |

**Table 22:** Average results (ch high) (E)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2483.500000 | 47.0 | 1000.0 | 1000.000 | 241.0 | V | 325.0 | 14.7 | 6.9 | 53.9 |
| 16580.80000 | 36.6 | 1000.0 | 1000.000 | 400.0 | V | 307.0 | 26.2 | 17.3 | 53.9 |

**Table 23:** Quasi-peak results (ch mid) (E)

| Frequency (MHz) | QuasiP (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 300.008000 | 38.1 | 1000.0 | 120.000 | 100.0 | H | 6.0 | 15.3 | 7.9 | 46.0 |
| 364.011000 | 34.4 | 1000.0 | 120.000 | 100.0 | H | 42.0 | 16.9 | 11.6 | 46.0 |

## Radiated Band Edge results

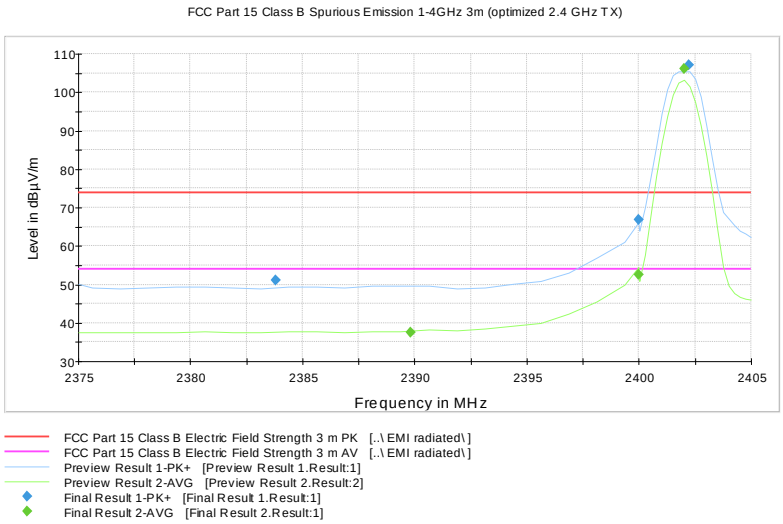


**Figure 31:** Radiated Band Edge measurement graph (ch low) (E)

**Table 24:** Peak results (ch low) (E)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2383.800000 | 51.1 | 1000.0 | 1000.000 | 379.0 | H | 33.0 | 14.5 | 22.8 | 73.9 |
| 2400.000000 | 66.8 | 1000.0 | 1000.000 | 236.0 | V | 291.0 | 14.7 | 20.2 | 87.0 |

**Table 25:** Average results (ch low) (E)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2389.800000 | 37.5 | 1000.0 | 1000.000 | 279.0 | V | 298.0 | 14.6 | 16.4 | 53.9 |
| 2400.000000 | 52.5 | 1000.0 | 1000.000 | 258.0 | V | 293.0 | 14.7 | 1.4 | 53.9 |

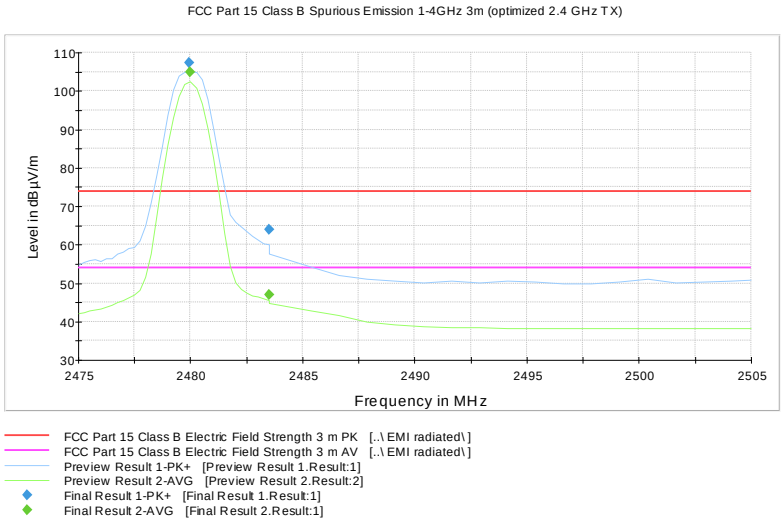


**Figure 32:** Radiated Band Edge measurement graph (ch high) (E)

**Table 26:** Peak results (ch high) (E)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2483.500000 | 63.8 | 1000.0 | 1000.000 | 268.0 | V | 0.0 | 14.7 | 10.1 | 73.9 |

**Table 27:** Average results (ch high) (E)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|---|---|---|---|---|---|---|---|---|---|
| 2483.500000 | 47.0 | 1000.0 | 1000.000 | 241.0 | V | 325.0 | 14.7 | 6.9 | 53.9 |

## Transmitter Band Edge Measurement and Conducted Spurious Emissions

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | JAT | |
| **Date:** | 23 November 2017 | |
| **Temperature:** | 23 ± 3 °C | |
| **Humidity:** | 20 - 60 % RH | |
| **Measurement uncertainty:** | ± 2.87 dB | Level of confidence 95 % (k = 2) |

**FCC Rule: 15.247(d), 15.209(a)**
**RSS-247 5.5**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

**Table 28:** Band edge attenuation

| Band Edge Attenuation | |
|---|---|
| **Lower Band Edge** | **Upper Band Edge** |
| -47.14 dBc | -45.49 dBc |
| **Limit: -20 dBc** | |

**Table 29:** Conducted spurious emissions (ch low)

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|---|---|---|---|---|
| 752.70 | -69.31 | -11.39 | -57.91 | PASS |
| 2399.85 | -46.66 | -11.39 | -35.26 | PASS |
| 3739.72 | -65.38 | -11.39 | -53.98 | PASS |
| 4804.40 | -58.45 | -11.39 | -47.06 | PASS |
| 9198.23 | -60.97 | -11.39 | -49.58 | PASS |
| 12498.13 | -58.91 | -11.39 | -47.52 | PASS |
| 15806.83 | -57.11 | -11.39 | -45.71 | PASS |
| 16152.76 | -54.93 | -11.39 | -43.54 | PASS |
| 19833.27 | -56.28 | -11.39 | -44.89 | PASS |
| 24441.31 | -56.22 | -11.39 | -44.82 | PASS |
| 25422.92 | -55.45 | -11.39 | -44.05 | PASS |

**Table 30:** Conducted spurious emissions (ch mid)

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|---|---|---|---|---|
| 945.85 | -69.02 | -11.85 | -57.17 | PASS |
| 1780.15 | -54.29 | -11.85 | -42.44 | PASS |
| 3759.52 | -65.00 | -11.85 | -53.15 | PASS |
| 4879.49 | -58.81 | -11.85 | -46.96 | PASS |
| 7509.00 | -61.17 | -11.85 | -49.32 | PASS |
| 12877.43 | -58.84 | -11.85 | -46.99 | PASS |
| 15836.36 | -57.11 | -11.85 | -45.26 | PASS |
| 16304.91 | -55.24 | -11.85 | -43.39 | PASS |
| 19159.32 | -56.79 | -11.85 | -44.94 | PASS |
| 24455.28 | -56.77 | -11.85 | -44.92 | PASS |
| 25870.09 | -55.96 | -11.85 | -44.11 | PASS |

**Table 31:** Conducted spurious emissions (ch high)

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|---|---|---|---|---|
| 789.74 | -69.24 | -12.11 | -57.13 | PASS |
| 2331.34 | -67.65 | -12.11 | -55.54 | PASS |
| 2483.86 | -51.16 | -12.11 | -39.05 | PASS |
| 4960.39 | -58.02 | -12.11 | -45.92 | PASS |
| 8481.72 | -59.48 | -12.11 | -47.37 | PASS |
| 12442.06 | -59.10 | -12.11 | -46.99 | PASS |
| 15531.59 | -56.70 | -12.11 | -44.59 | PASS |
| 17752.93 | -55.55 | -12.11 | -43.44 | PASS |
| 19161.95 | -56.35 | -12.11 | -44.24 | PASS |
| 24143.67 | -56.43 | -12.11 | -44.32 | PASS |
| 26203.83 | -54.92 | -12.11 | -42.82 | PASS |

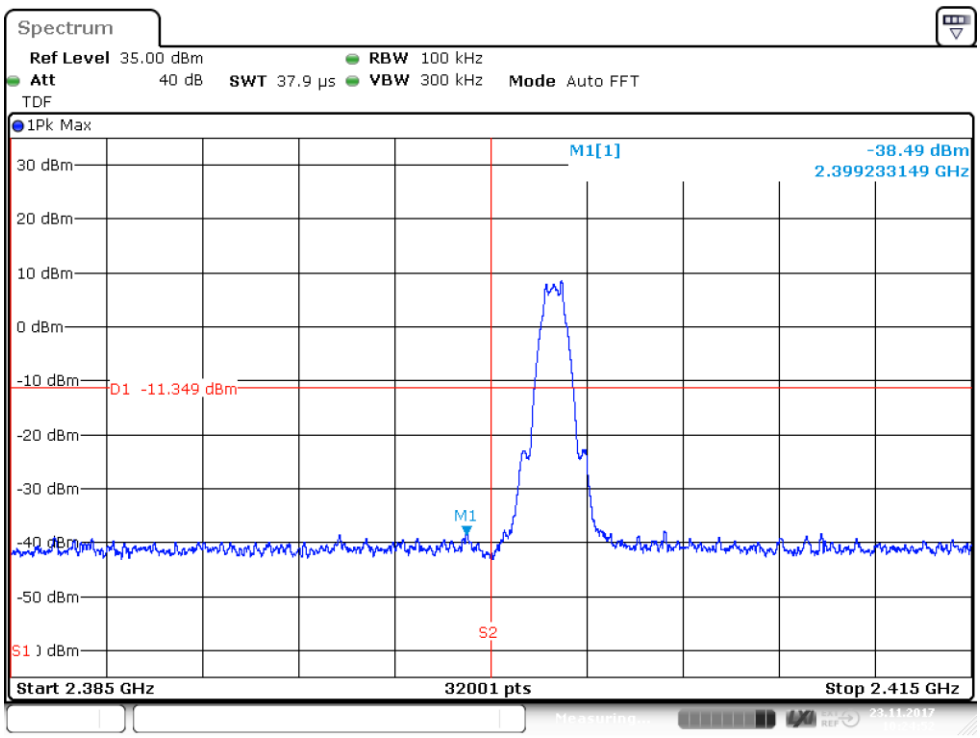


**Figure 33:** Lower Band Edge

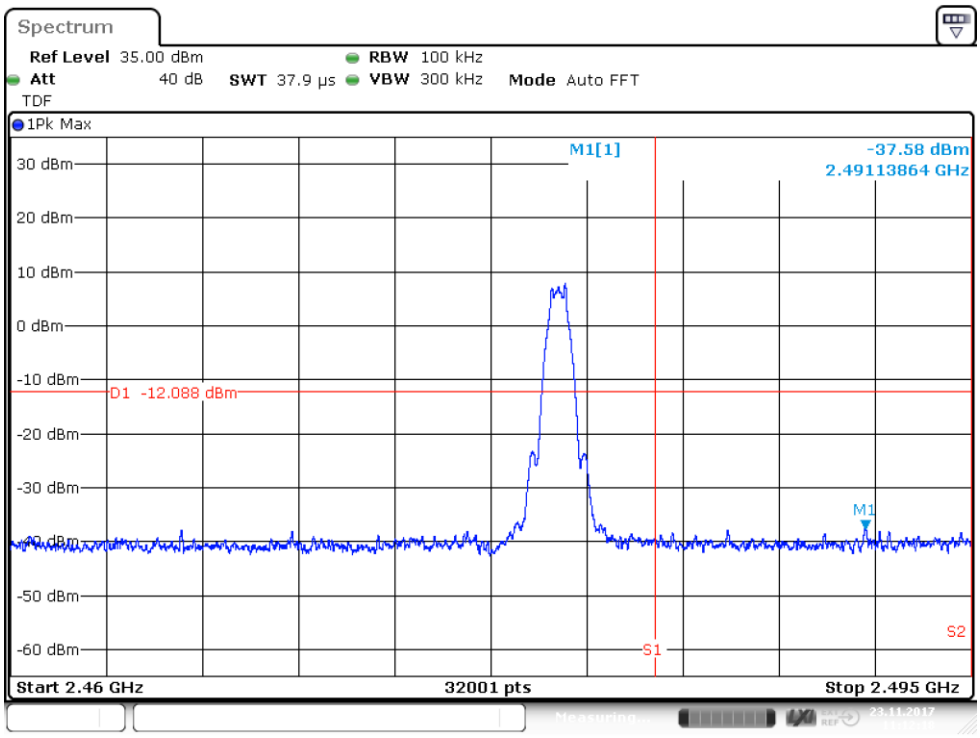


**Figure 34:** Upper Band Edge

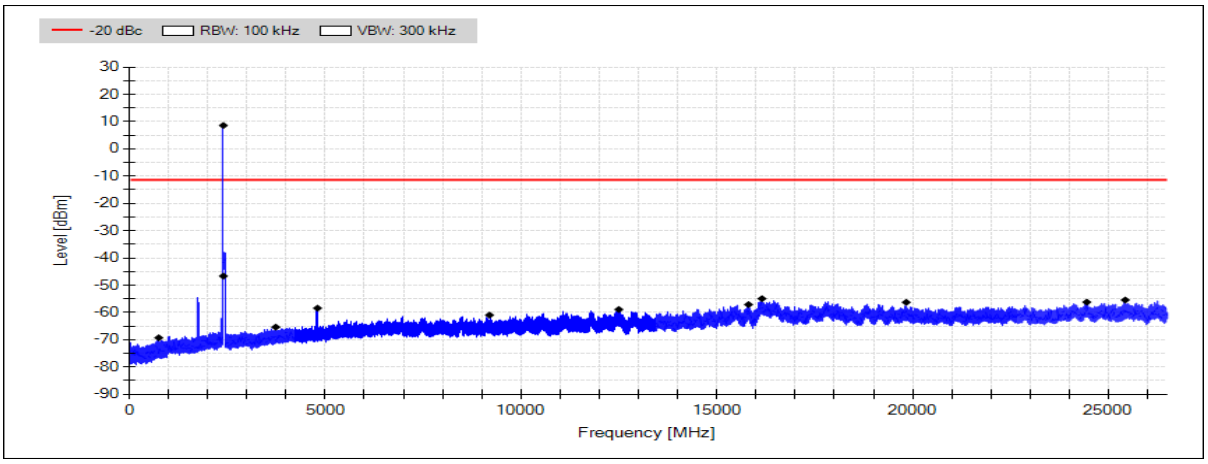


**Figure 35:** Conducted spurious emissions 30 - 26500 MHz channel low

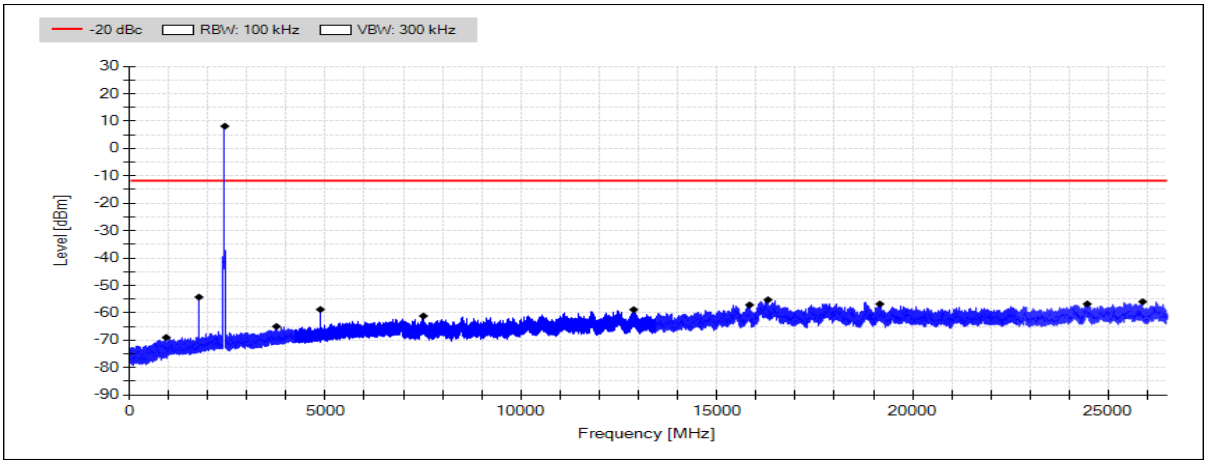


**Figure 36:** Conducted spurious emissions 30 - 26500 MHz channel mid

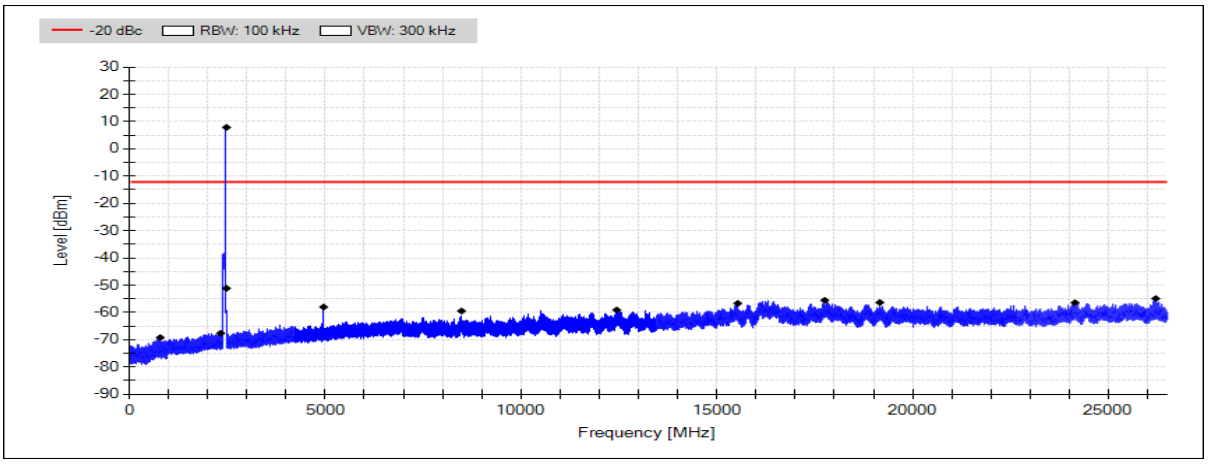


**Figure 37:** Conducted spurious emissions 30 - 26500 MHz channel high

## 6 dB Bandwidth of the Channel

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | JAT | |
| **Date:** | 23 November 2017 | |
| **Temperature:** | 23 ± 3 °C | |
| **Humidity:** | 20 - 60 % RH | |

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

**Results:**

**Table 32:** 6 dB bandwidth test results

| Channel | 6 dB BW [kHz] | Minimum limit [kHz] |
|---|---|---|
| Low | 646.0 | 500 |
| Mid | 651.0 | |
| High | 647.0 | |

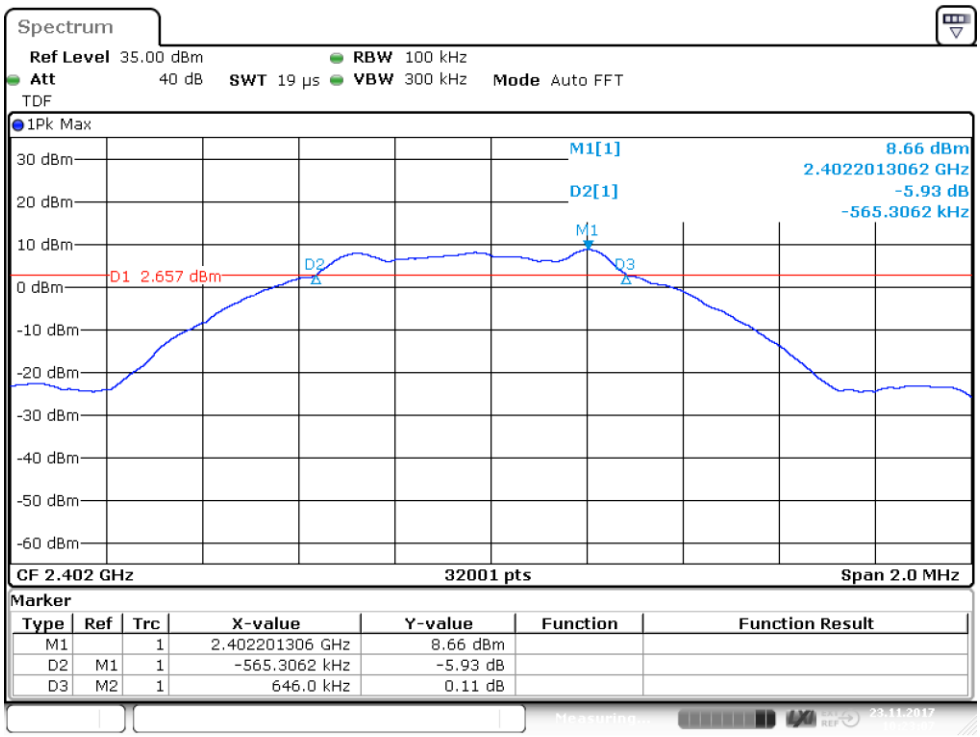


**Figure 38:** 6 dB bandwidth (ch low)

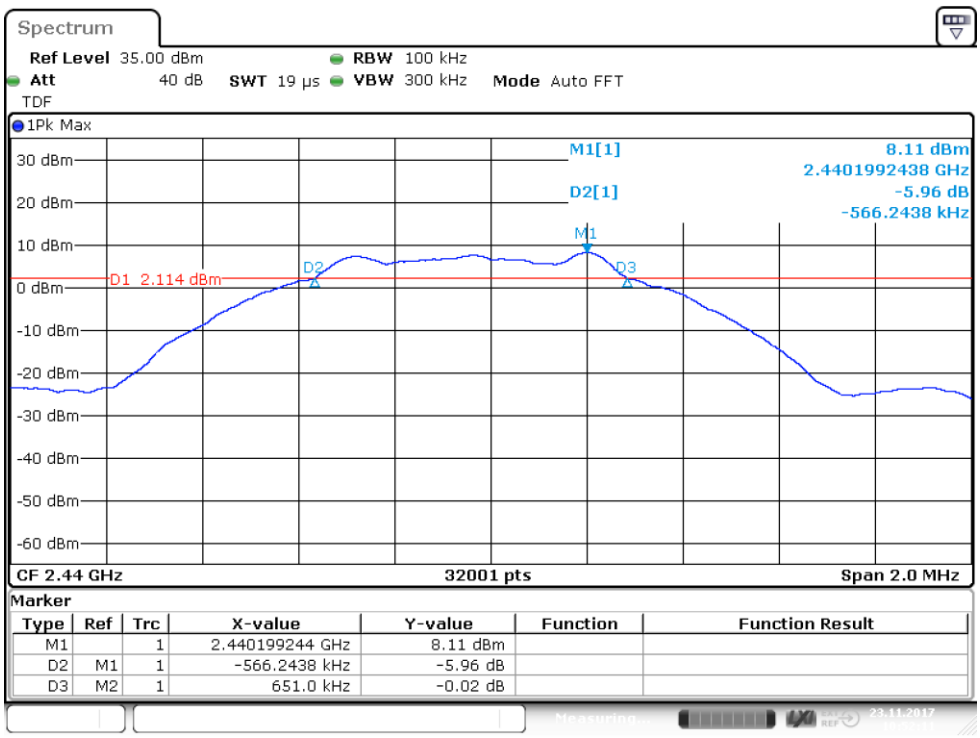


**Figure 39:** 6 dB bandwidth (ch mid)

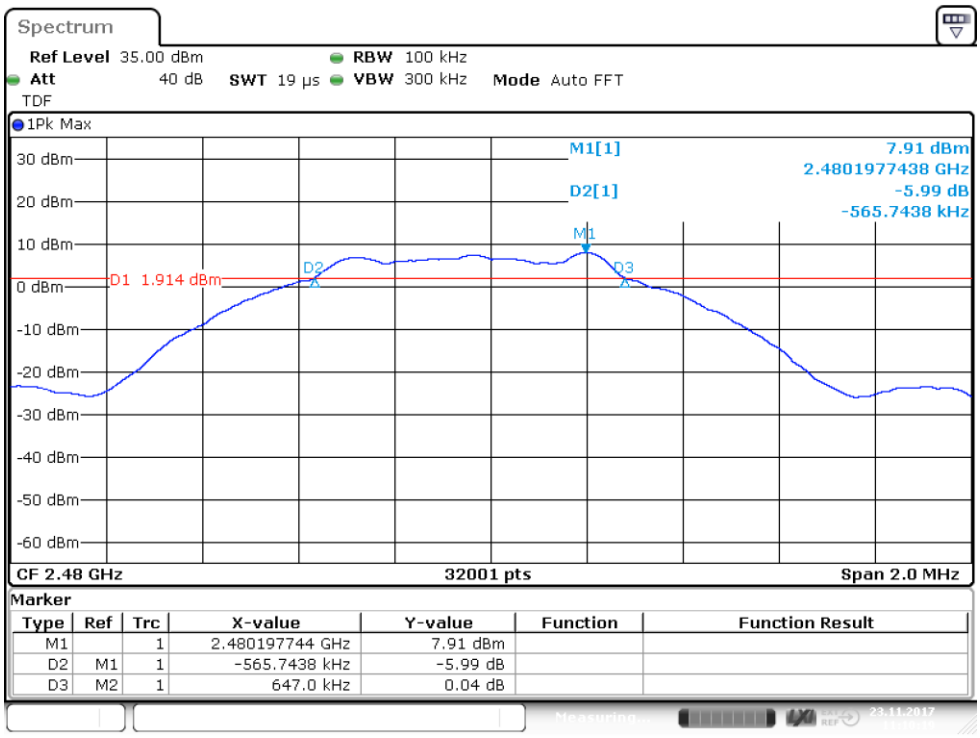


**Figure 40:** 6 dB bandwidth (ch high)

## Power Spectral Density

| | | |
|---|---|---|
| **Standard:** | ANSI C63.10 | (2013) |
| **Tested by:** | JAT | |
| **Date:** | 23 November 2017 | |
| **Temperature:** | 23 ± 3 °C | |
| **Humidity:** | 20 - 60 % RH | |

**FCC Rule: 15.247(e)**
**RSS-247 5.2(b)**

**Results:**

**Table 33:** Power spectral density test results

| Channel | PSD dBm/3 kHz | Maximum limit [dBm/3kHz] |
|---|---|---|
| Low | -7.69 | +8.00 |
| Mid | -8.24 | |
| High | -8.46 | |

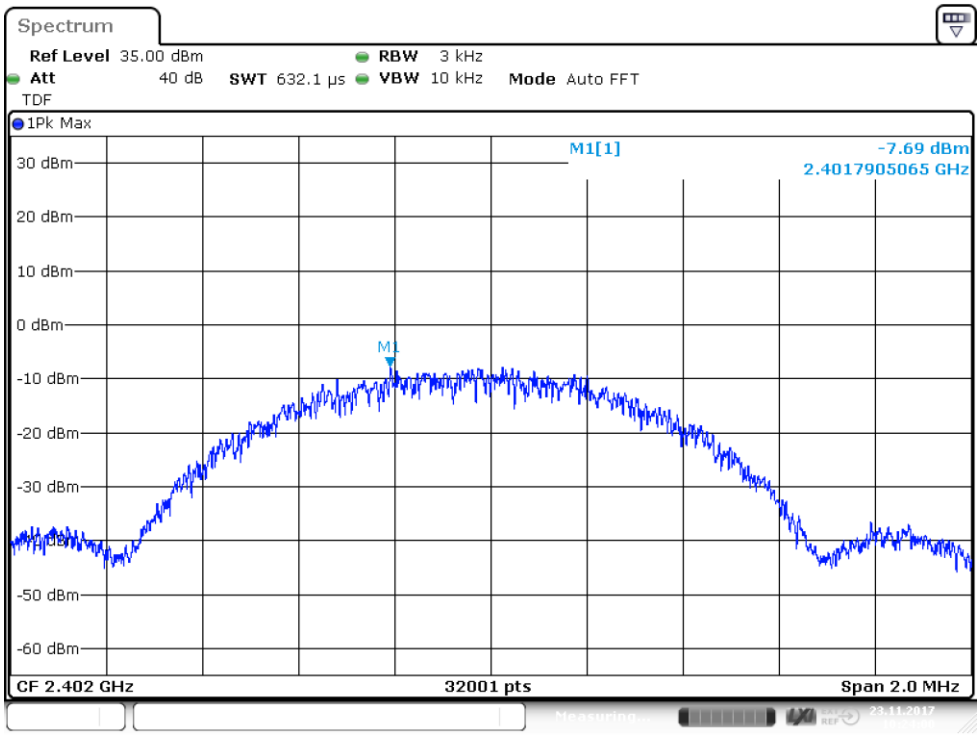


**Figure 41:** Power spectral density (ch low)

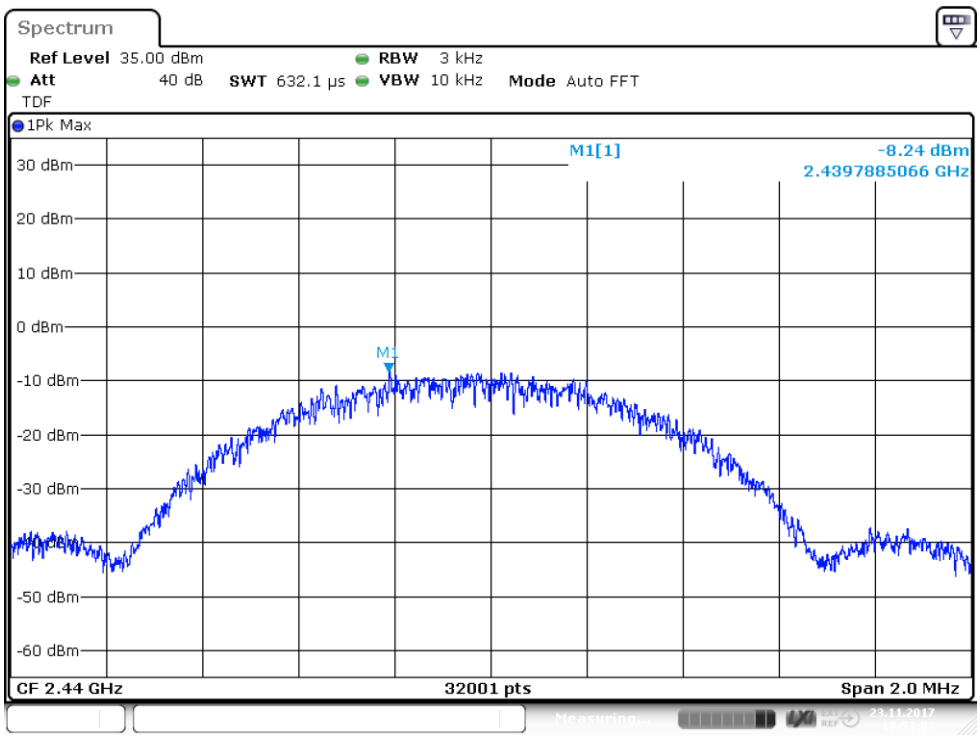


**Figure 42:** Power spectral density (ch mid)

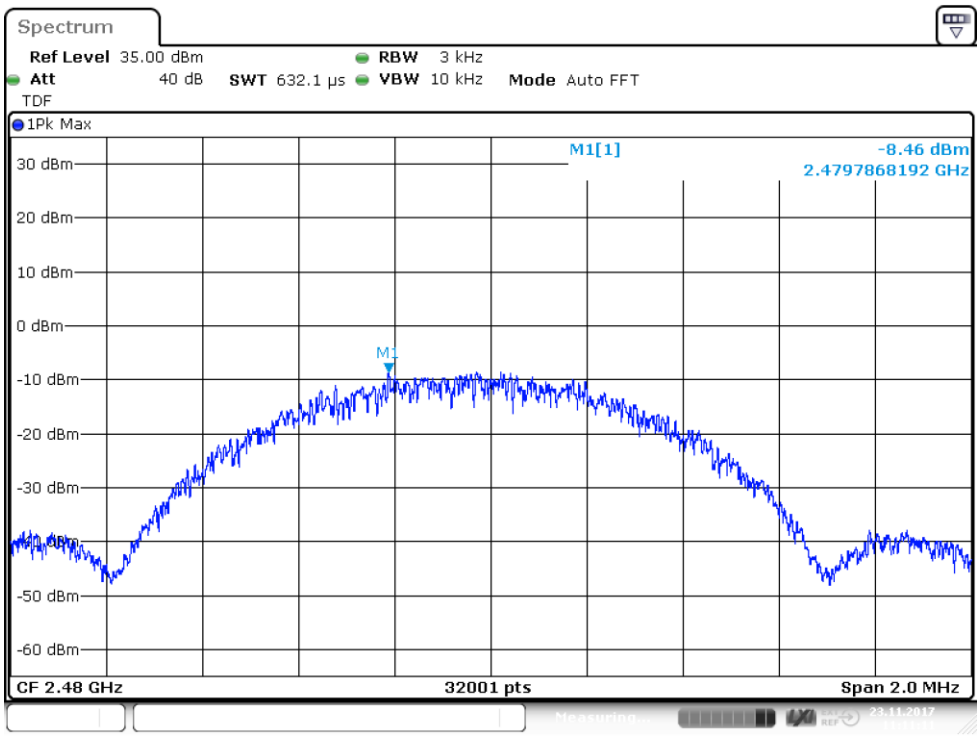


**Figure 43:** Power spectral density (ch high)

## 99% Occupied Bandwidth

| | | |
|---|---|---|
| **Standard:** | RSS-GEN | (2014) |
| **Tested by:** | JAT | |
| **Date:** | 23 November 2017 | |
| **Temperature:** | 23 ± 3 °C | |
| **Humidity:** | 20 - 60 % RH | |

**RSS-GEN 6.6**

**Table 34:** 99% occupied bandwidth test results

| Channel | Limit | 99 % BW [MHz] | Result |
|---|---|---|---|
| Low | - | 1.045217337 | PASS |
| Mid | - | 1.043842380 | PASS |
| High | - | 1.049342208 | PASS |

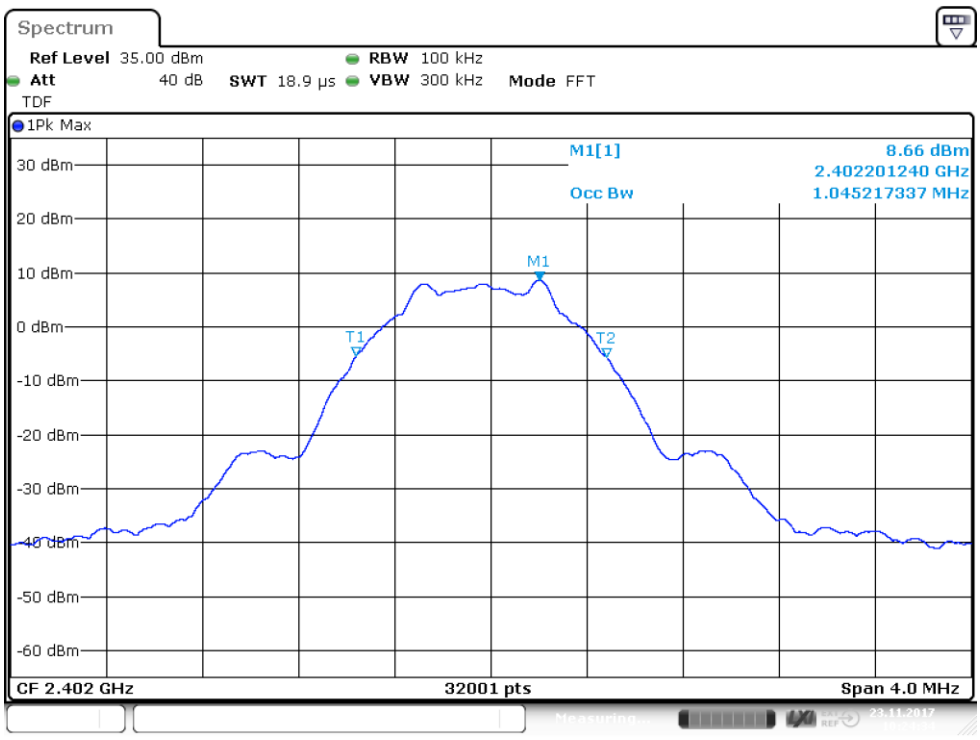


**Figure 44:** 99% OBW (ch low)

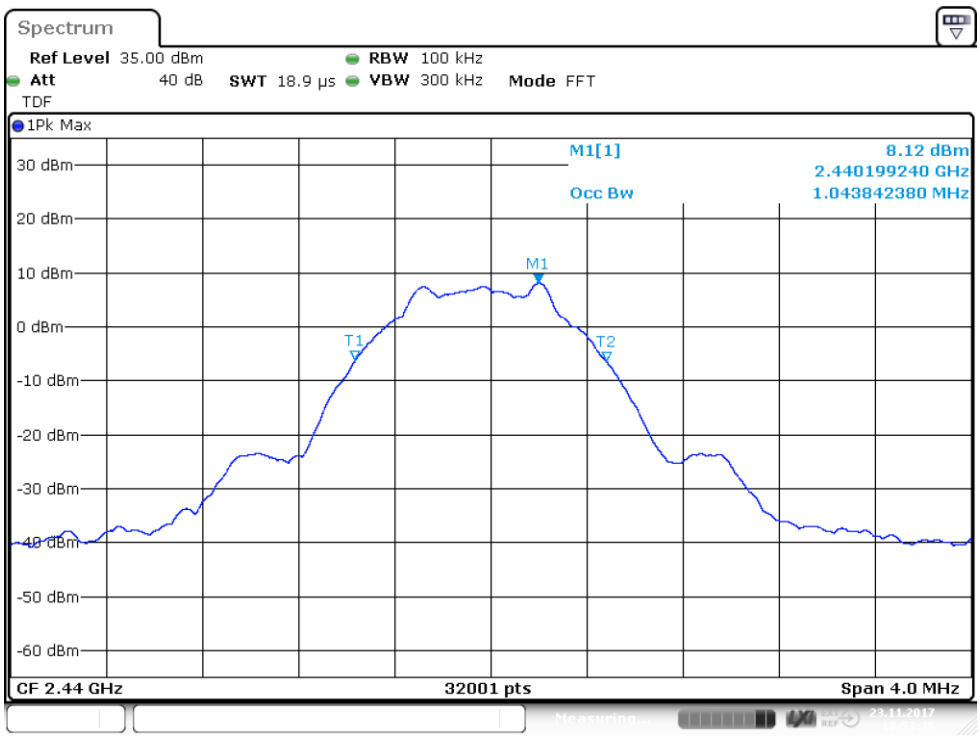


**Figure 45:** 99% OBW (ch mid)

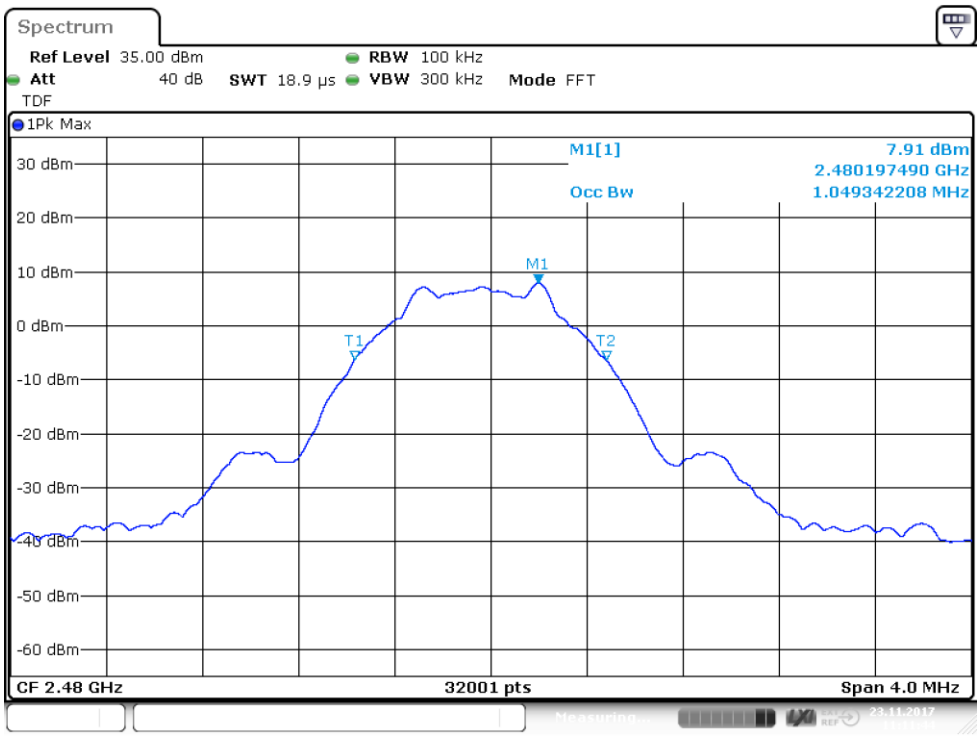


**Figure 46:** 99% OBW (ch high)

# 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 | 2016-01-07 | 2018-01-07 |
| PREAMPLIFIER | CIAO | CA118-3123 | inv:10278 | 2016-11-28 | 2017-11-28 |
| POWER SUPPLY | DELTA | SM 130-25D | inv:10406 | - | - |
| ANTENNA | EMCO | 3117 | inv:7293 | 2016-03-16 | 2018-03-06 |
| ANTENNA | EMCO | 3160-09 | inv:7294 | 2017-03-16 | 2018-03-16 |
| ANTENNA | ETS LINDGREN | 3160-10 | inv:9151 | 2013-08-06 | 2018-08-06 |
| TURNTABLE | MATURO | DS430 UPGRADED | inv:10182 | - | - |
| MAST & TURNTABLE CONTROLLER | MATURO | NCD | inv:10183 | - | - |
| ANTENNA MAST | MATURO | TAM 4.0E | inv:10181 | - | - |
| ATTENUATOR | PASTERNACK | 10dB DC-40GHz | - | - | - |
| TEST SOFTWARE | ROHDE & SCHWARZ | EMC-32 | - | - | - |
| EMI TEST RECEIVER | ROHDE & SCHWARZ | ESU 26 | inv:8453 | 2017-07-10 | 2018-07-10 |
| SIGNAL ANALYZER | ROHDE & SCHWARZ | FSV40 | inv:9093 | 2017-07-07 | 2018-07-07 |
| ANTENNA | SCHWARZBECK | VULB 9168 | inv:8911 | 2016-10-25 | 2018-10-25 |
| TEMPERATURE/ HUMIDITY METER | VAISALA | HMT 333 | inv:8638 | 2017-02-21 | 2018-02-21 |
| HIGH PASS FILTER | WAINWRIGHT | WHKX4.0/18G-10SS | inv:10403 | 2017-03-01 | 2019-03-01 |