

Test Report



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

Equipment Under Test: Bluetooth Smart Module

Model: BGM121A
BGM121N
BGM123A
BGM123N

Manufacturer: Silicon Laboratories Finland Oy
Bertel Jungin aukio 3
FI-02600 ESPOO
FINLAND

Customer: Silicon Laboratories Finland Oy
Bertel Jungin aukio 3
FI-02600 ESPOO
FINLAND

FCC Rule Part: 15.247: 2015
IC Rule Part: RSS-247, Issue 2, 2017
RSS-GEN Issue 4, 2014

KDB: Guidance for Performing Compliance
Measurements on Digital Transmission Systems
(DTS) Operating Under §15.247 (June 9, 2015)

Date: 3 March 2017

Issued by:


Emil Haverinen
Testing Engineer

Date: 3 March 2017

Checked by:


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Testing Engineer

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Equipment Under Test (EUT)

| | |
|-------------|------------------------------------|
| Trade mark: | Silicon Labs |
| Model: | BGM121A, BGM121N, BGM123A, BGM123N |
| Type: | Bluetooth Smart Module |
| Serial no: | - |
| FCC ID: | QOQBGM12LMA |
| IC: | 5123A-BGM12LMA |

Description of the EUT

BGM121 and BGM123 are Bluetooth 4.1 compliant Bluetooth smart beacon modules. The only difference between A-variant and N-variant modules is that A has integrated antenna and N has RF connector for use of external antenna. Difference between BGM121 and BGM123 is that BGM123 has its transmit power limited to nominal of 3 dBm while BGM121 transmits at full power.

Classification of the device

| | |
|--|-------------------------------------|
| 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 to the EUT during testing.

Ratings and declarations

| | |
|----------------------------------|---------------------|
| Operating Frequency Range (OFR): | 2402 - 2480 MHz |
| Channels: | 40 |
| Channel separation: | 2 MHz |
| 99% Channel bandwidth: | 1.114327062 MHz |
| Effective conducted power: | 9.23 dBm (Peak) |
| Transmission technique: | DSSS |
| Modulation: | GFSK |
| Integral Antenna gain: | A-variant: 1 dBi |
| External Antenna gain: | N-variant: 2.14 dBi |

Power Supply

Operating voltage range: 2.0 - 3.8 VDC (tested with 3.32V regulated by the development board)

Separate AC/DC adaptor, LPS 0012ADU00 (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: 6 mm

Samples

Four samples were used in the testing (BGM121A + dev. board, BGM121A, BGM121N and BGM123N)

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. Tests were performed using power setting 104.

Conducted measurements were performed to N-variant while SMA adapter with a short cable was connected to EUTs RF connector.

Radiated measurements were performed to both variants. General 2.14 dBi antenna was connected to RF connector of BGM121N with a short RF cable. The BGM121A used its integrated 1 dBi antenna.

During transmitter spurious emissions test for BGM121A, the sample was removed from the development board and tested separately (1-18 GHz).

Actual tests were only performed to BGM121A and BGM121N because of the higher possible transmit power. RSS-247 5.4(4) and RSS-GEN 6.6 tests were performed also to BGM123N.

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

Test Facility

| | |
|--|--|
| <input type="checkbox"/> Testing Location / address: FCC registration number: 90598 | SGS Fimko Ltd Särkiniementie 3 FI-00210, HELSINKI FINLAND |
| <input checked="" type="checkbox"/> Testing Location / address: FCC registration number: 178986 Industry Canada registration number: 8708A-2 | SGS Fimko Ltd Karakaarenkuja 4 FI-02610, ESPOO FINLAND |

TEST RESULTS

Conducted Emissions In The Frequency Range 150 kHz - 30 MHz

Standard: ANSI C63.10 (2013)
Tested by: EHA
Date: 23.9.2016
Temperature: 21 °C
Humidity: 45 % RH
Barometric pressure: 1009 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.

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

*Decreases with the logarithm of the frequency.

Conducted Emission Mains FCC Part 15 Class B with ENV216

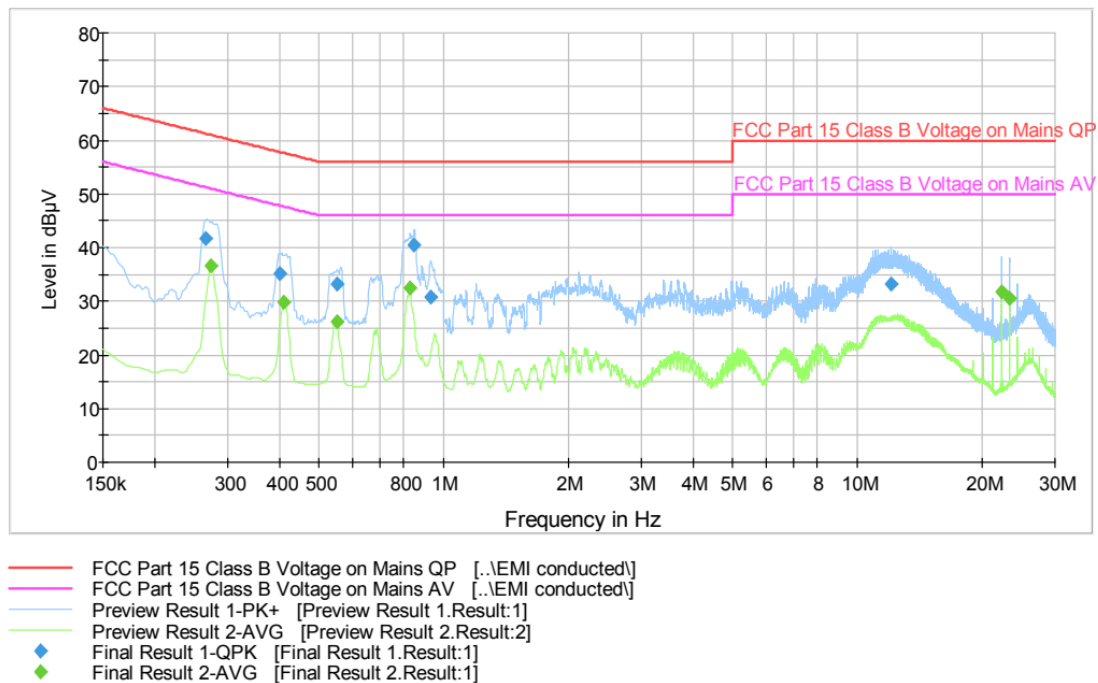


Figure 1: The measured curves with peak- and average detector

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

| Frequency (MHz) | QuasiPeak (dB μ V) | Meas. Time (ms) | Bandwidth (kHz) | Margin (dB) | Limit (dB μ V) |
|-----------------|------------------------|-----------------|-----------------|-------------|--------------------|
| 0.265500 | 41.6 | 1000.0 | 9.000 | 19.7 | 61.3 |
| 0.400000 | 35.2 | 1000.0 | 9.000 | 22.7 | 57.9 |
| 0.551500 | 33.2 | 1000.0 | 9.000 | 22.8 | 56.0 |
| 0.848000 | 40.5 | 1000.0 | 9.000 | 15.5 | 56.0 |
| 0.928250 | 30.9 | 1000.0 | 9.000 | 25.1 | 56.0 |
| 12.031000 | 33.2 | 1000.0 | 9.000 | 26.8 | 60.0 |

Table 2: Final Average measurements from the worst frequencies

| Frequency (MHz) | Average (dB μ V) | Meas. Time (ms) | Bandwidth (kHz) | Margin (dB) | Limit (dB μ V) |
|-----------------|----------------------|-----------------|-----------------|-------------|--------------------|
| 0.273250 | 36.7 | 1000.0 | 9.000 | 14.3 | 51.0 |
| 0.411500 | 29.7 | 1000.0 | 9.000 | 17.9 | 47.6 |
| 0.552000 | 26.1 | 1000.0 | 9.000 | 19.9 | 46.0 |
| 0.827750 | 32.4 | 1000.0 | 9.000 | 13.6 | 46.0 |
| 22.229250 | 31.7 | 1000.0 | 9.000 | 18.3 | 50.0 |
| 23.286000 | 30.5 | 1000.0 | 9.000 | 19.5 | 50.0 |

Maximum Peak Conducted Output Power

| | | |
|---------------------------------|--------------|----------------------------------|
| Standard: | ANSI C63.10 | (2013) |
| Tested by: | EHA | MIH |
| Date: | 1.11.2016 | 3.3.2017 |
| Temperature: | 23 ± 3 °C | 23 ± 3 °C |
| Humidity: | 30 - 60 % RH | 30 - 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 model BGM121

| Channel | Conducted Power [dBm] | Limit [dBm] | Margin [dBm] | Result |
|---------|-----------------------|-------------|--------------|--------|
| Low | 9.23 | 30 | 20.77 | PASS |
| Mid | 8.92 | 30 | 21.08 | PASS |
| High | 8.65 | 30 | 21.35 | PASS |

Table 4: Maximum conducted output power model BGM123

| Channel | Conducted Power [dBm] | Limit [dBm] | Margin [dBm] | Result |
|---------|-----------------------|-------------|--------------|--------|
| Low | -0.19 | 30 | 30.19 | PASS |
| Mid | 0.44 | 30 | 29.56 | PASS |
| High | -0.64 | 30 | 30.64 | PASS |



Maximum Peak Conducted Output Power



Figure 2: Conducted power (ch low), BGM121



Figure 3: Conducted power (ch mid), BGM121



Maximum Peak Conducted Output Power



Figure 4: Conducted power (ch high), BGM121



Figure 5: Conducted power (ch low), BGM123



Maximum Peak Conducted Output Power



Figure 6: Conducted power (ch mid), BGM123



Figure 7: Conducted power (ch high), BGM123

Transmitter Radiated Spurious Emissions 30 - 26500 MHz

| | | |
|---------------------------------|-------------------|----------------------------------|
| Standard: | ANSI C63.10 | (2013) |
| Tested by: | RRE / EHA | |
| Date: | 17.8 - 25.10.2016 | |
| Temperature: | 23 ± 3 °C | |
| Humidity: | 30 - 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. Channel frequency 2442 MHz used as channel mid. (BGM121A)

| Frequency range [MHz] | Limit [$\mu\text{V}/\text{m}$] | Limit [$\text{dB}\mu\text{V}/\text{m}$] | 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, A-variant

Table 5: Quasi-peak results (ch low)

| Frequency (MHz) | QuasiPeak ($\text{dB}\mu\text{V}/\text{m}$) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit ($\text{dB}\mu\text{V}/\text{m}$) |
|-----------------|---|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|---|
| 180.002000 | 24.9 | 1000.0 | 120.000 | 147.0 | H | 259.0 | 13.0 | 18.6 | 43.5 |
| 300.028000 | 30.8 | 1000.0 | 120.000 | 100.0 | H | 297.0 | 15.3 | 15.2 | 46.0 |
| 941.894000 | 26.7 | 1000.0 | 120.000 | 100.0 | V | 284.0 | 27.7 | 19.3 | 46.0 |

Table 6: Peak results (ch low)

| Frequency (MHz) | MaxPeak ($\text{dB}\mu\text{V}/\text{m}$) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit ($\text{dB}\mu\text{V}/\text{m}$) |
|-----------------|---|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|---|
| 180.002000 | 26.7 | 1000.0 | 120.000 | 147.0 | H | 259.0 | 13.0 | - | - |
| 300.028000 | 32.3 | 1000.0 | 120.000 | 100.0 | H | 297.0 | 15.3 | - | - |
| 941.894000 | 32.6 | 1000.0 | 120.000 | 100.0 | V | 284.0 | 27.7 | - | - |
| 2388.600000 | 49.6 | 1000.0 | 1000.000 | 281.0 | H | 9.0 | 2.9 | 24.3 | 73.9 |
| 2400.000000 | 66.5 | 1000.0 | 1000.000 | 294.0 | H | 9.0 | 3.0 | 7.4 | 73.9 |
| 2402.000000 | 106.2 | 1000.0 | 1000.000 | 291.0 | H | 1.0 | 3.0 | - | - |
| 4803.600000 | 45.2 | 1000.0 | 1000.000 | 150.0 | H | 189.0 | -3.1 | 28.7 | 73.9 |

Table 7: Average results (ch low)

| Frequency (MHz) | Average (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 2388.600000 | 35.8 | 1000.0 | 1000.000 | 281.0 | H | 9.0 | 2.9 | 18.1 | 53.9 |
| 2400.000000 | 48.0 | 1000.0 | 1000.000 | 294.0 | H | 9.0 | 3.0 | 5.9 | 53.9 |
| 2402.000000 | 100.7 | 1000.0 | 1000.000 | 291.0 | H | 1.0 | 3.0 | - | - |
| 4803.600000 | 32.3 | 1000.0 | 1000.000 | 150.0 | H | 194.0 | -3.1 | 21.6 | 53.9 |

Middle channel, A-variant

Table 8: Quasi-peak results (ch mid)

| Frequency (MHz) | QuasiPeak (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|--------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 952.390000 | 26.8 | 1000.0 | 120.000 | 254.0 | V | 0.0 | 27.8 | 19.2 | 46.0 |

Table 9: Peak results (ch mid)

| Frequency (MHz) | MaxPeak (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 952.390000 | 32.5 | 1000.0 | 120.000 | 254.0 | V | 0.0 | 27.8 | 13.5 | 46.0 |
| 2441.750000 | 107.3 | 1000.0 | 1000.000 | 272.0 | H | 346.0 | 2.9 | - | - |
| 4884.600000 | 44.5 | 1000.0 | 1000.000 | 150.0 | H | 161.0 | -3.0 | 29.4 | 73.9 |

Table 10: Average results (ch mid)

| Frequency (MHz) | Average (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 2442.000000 | 102.8 | 1000.0 | 1000.000 | 279.0 | H | 345.0 | 2.9 | - | - |
| 4883.600000 | 31.8 | 1000.0 | 1000.000 | 150.0 | H | 160.0 | -3.0 | 22.1 | 53.9 |

High channel, A-variant

Table 11: Peak results (ch high)

| Frequency (MHz) | MaxPeak (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 2480.250000 | 107.7 | 1000.0 | 1000.000 | 240.0 | H | 0.0 | -6.9 | - | - |
| 2483.500000 | 64.6 | 1000.0 | 1000.000 | 246.0 | H | 333.0 | -6.9 | 9.3 | 73.9 |
| 4960.100000 | 43.9 | 1000.0 | 1000.000 | 150.0 | H | 162.0 | -3.1 | 30.0 | 73.9 |
| 17367.20000 | 51.3 | 1000.0 | 1000.000 | 400.0 | H | 18.0 | 13.9 | 22.6 | 73.9 |

Table 12: Average results (ch high)

| Frequency (MHz) | Average (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 2480.250000 | 102.1 | 1000.0 | 1000.000 | 240.0 | H | 0.0 | -6.9 | - | - |
| 2483.500000 | 47.9 | 1000.0 | 1000.000 | 246.0 | H | 333.0 | -6.9 | 6.0 | 53.9 |
| 4959.900000 | 30.0 | 1000.0 | 1000.000 | 150.0 | H | 18.0 | -3.1 | 23.9 | 53.9 |
| 17181.10000 | 39.1 | 1000.0 | 1000.000 | 150.0 | H | 319.0 | 14.2 | 14.8 | 53.9 |



Transmitter Radiated Spurious Emissions

Radiated Band Edge results, A-variant

FCC Part 15 Class B Spurious Emission 1-4GHz 3m (optimized 2.4 GHz TX)

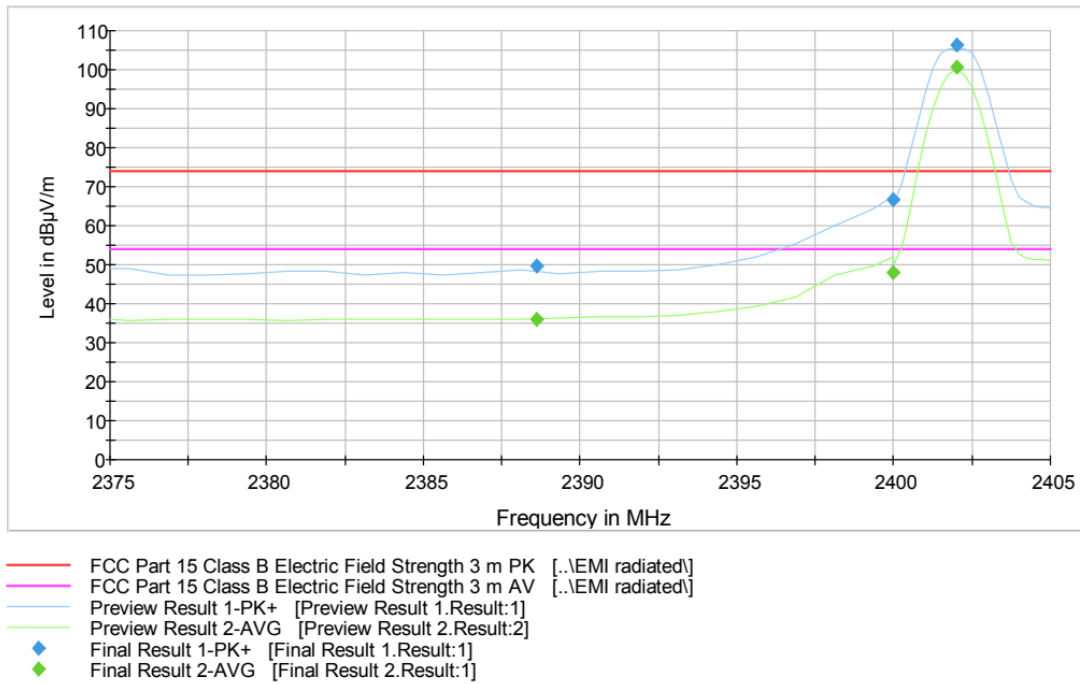


Figure 8: Radiated Band Edge measurement graph (ch low), A-variant

FCC Part 15 Class B Spurious Emission 1-4GHz 3m (optimized 2.4 GHz TX)

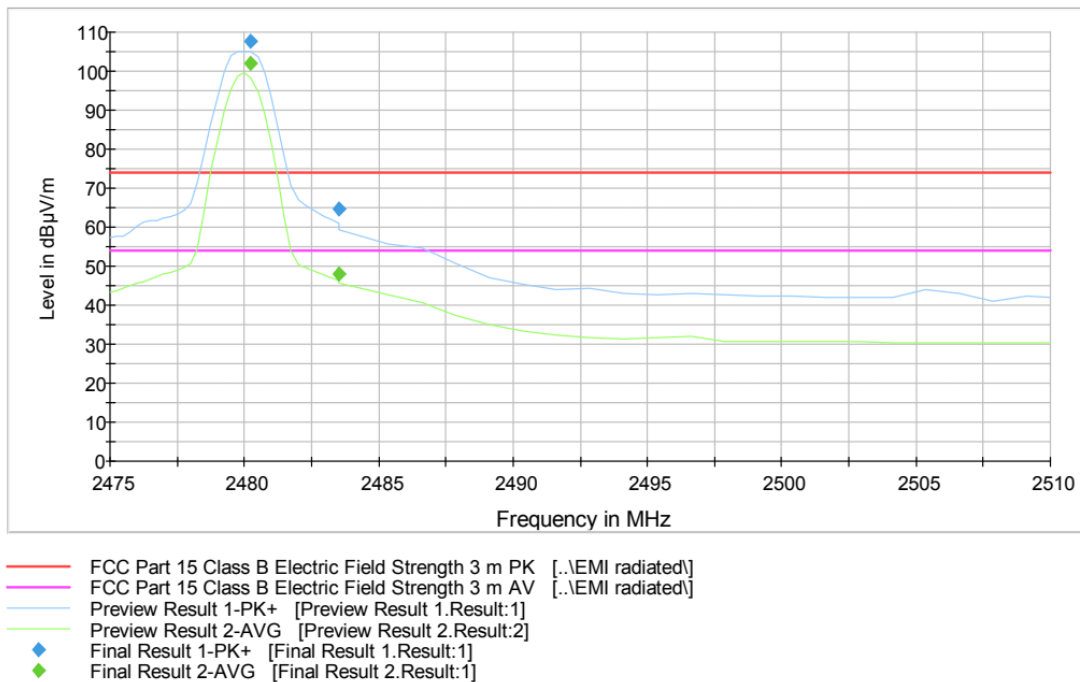


Figure 9: Radiated Band Edge measurement graph (ch high), A-variant

Low channel, N-variant

Table 13: Quasi-peak results (ch low)

| Frequency (MHz) | QuasiPeak (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|--------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 180.002000 | 27.4 | 1000.0 | 120.000 | 126.0 | H | 257.0 | 13.0 | 16.1 | 43.5 |
| 300.008000 | 35.1 | 1000.0 | 120.000 | 100.0 | H | 214.0 | 15.3 | 10.9 | 46.0 |
| 312.019000 | 30.1 | 1000.0 | 120.000 | 100.0 | H | 208.0 | 15.7 | 15.9 | 46.0 |
| 349.983000 | 30.0 | 1000.0 | 120.000 | 100.0 | H | 275.0 | 16.5 | 16.0 | 46.0 |
| 364.008000 | 29.9 | 1000.0 | 120.000 | 100.0 | H | 267.0 | 16.9 | 16.1 | 46.0 |
| 420.017000 | 28.2 | 1000.0 | 120.000 | 100.0 | H | 73.0 | 18.4 | 17.8 | 46.0 |

Table 14: Peak results (ch low)

| Frequency (MHz) | MaxPeak (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 180.002000 | 28.9 | 1000.0 | 120.000 | 126.0 | H | 257.0 | 13.0 | - | - |
| 300.008000 | 36.2 | 1000.0 | 120.000 | 100.0 | H | 214.0 | 15.3 | - | - |
| 312.019000 | 31.5 | 1000.0 | 120.000 | 100.0 | H | 208.0 | 15.7 | - | - |
| 349.983000 | 31.5 | 1000.0 | 120.000 | 100.0 | H | 275.0 | 16.5 | - | - |
| 364.008000 | 31.8 | 1000.0 | 120.000 | 100.0 | H | 267.0 | 16.9 | - | - |
| 420.017000 | 30.6 | 1000.0 | 120.000 | 100.0 | H | 73.0 | 18.4 | - | - |
| 2388.200000 | 49.0 | 1000.0 | 1000.000 | 256.0 | V | 316.0 | 2.9 | 24.9 | 73.9 |
| 2400.000000 | 65.5 | 1000.0 | 1000.000 | 335.0 | V | 177.0 | 3.0 | 8.4 | 73.9 |
| 2402.000000 | 103.8 | 1000.0 | 1000.000 | 191.0 | V | 202.0 | 3.0 | - | - |
| 4804.500000 | 51.8 | 1000.0 | 1000.000 | 258.0 | V | 283.0 | -3.1 | 22.1 | 73.9 |
| 7206.100000 | 44.9 | 1000.0 | 1000.000 | 257.0 | V | 211.0 | 0.4 | 29.0 | 73.9 |

Table 15: Average results (ch low)

| Frequency (MHz) | Average (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 2389.800000 | 35.8 | 1000.0 | 1000.000 | 150.0 | V | 219.0 | 2.9 | 18.1 | 53.9 |
| 2400.000000 | 47.5 | 1000.0 | 1000.000 | 191.0 | V | 202.0 | 3.0 | 6.4 | 53.9 |
| 2402.000000 | 98.6 | 1000.0 | 1000.000 | 190.0 | V | 201.0 | 3.0 | - | - |
| 4803.800000 | 39.7 | 1000.0 | 1000.000 | 257.0 | V | 280.0 | -3.1 | 14.2 | 53.9 |
| 7205.300000 | 31.6 | 1000.0 | 1000.000 | 259.0 | V | 155.0 | 0.4 | 22.3 | 53.9 |

Middle channel, N-variant

Table 16: Quasi-peak results (ch mid)

| Frequency (MHz) | QuasiPeak (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|--------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 113.297000 | 9.5 | 1000.0 | 120.000 | 179.0 | V | 148.0 | 11.8 | 34.0 | 43.5 |
| 300.008000 | 34.4 | 1000.0 | 120.000 | 126.0 | H | 206.0 | 15.3 | 11.6 | 46.0 |

Table 17: Peak results (ch mid)

| Frequency (MHz) | MaxPeak (dB μ V/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dB μ V/m) |
|-----------------|------------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------------|
| 113.297000 | 15.3 | 1000.0 | 120.000 | 179.0 | V | 148.0 | 11.8 | 28.2 | 43.5 |
| 300.008000 | 35.5 | 1000.0 | 120.000 | 126.0 | H | 206.0 | 15.3 | 10.5 | 46.0 |
| 2439.750000 | 103.1 | 1000.0 | 1000.000 | 320.0 | V | 357.0 | 2.9 | - | - |
| 4880.600000 | 49.4 | 1000.0 | 1000.000 | 232.0 | V | 281.0 | -3.0 | 24.5 | 73.9 |

Table 18: Average results (ch mid)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|-----------------|------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------|
| 2440.000000 | 96.5 | 1000.0 | 1000.000 | 267.0 | V | 356.0 | 2.9 | - | - |
| 4879.900000 | 39.5 | 1000.0 | 1000.000 | 296.0 | V | 173.0 | -3.0 | 14.4 | 53.9 |
| 7319.400000 | 31.4 | 1000.0 | 1000.000 | 257.0 | V | 271.0 | 0.5 | 22.5 | 53.9 |

High channel, N-variant

Table 19: Quasi-peak results (ch high)

| Frequency (MHz) | QuasiPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|-----------------|--------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------|
| 300.008000 | 34.1 | 1000.0 | 120.000 | 126.0 | H | 217.0 | 15.3 | 11.9 | 46.0 |
| 312.019000 | 30.2 | 1000.0 | 120.000 | 100.0 | H | 214.0 | 15.7 | 15.8 | 46.0 |
| 349.983000 | 29.9 | 1000.0 | 120.000 | 100.0 | H | 282.0 | 16.5 | 16.1 | 46.0 |
| 364.031000 | 30.1 | 1000.0 | 120.000 | 100.0 | H | 264.0 | 16.9 | 15.9 | 46.0 |
| 420.017000 | 28.5 | 1000.0 | 120.000 | 100.0 | H | 297.0 | 18.4 | 17.5 | 46.0 |
| 926.819000 | 26.4 | 1000.0 | 120.000 | 210.0 | H | 325.0 | 27.5 | 19.6 | 46.0 |

Table 20: Peak results (ch high)

| Frequency (MHz) | MaxPeak (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|-----------------|------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------|
| 300.008000 | 35.1 | 1000.0 | 120.000 | 126.0 | H | 217.0 | 15.3 | 10.9 | 46.0 |
| 312.019000 | 31.8 | 1000.0 | 120.000 | 100.0 | H | 214.0 | 15.7 | 14.2 | 46.0 |
| 349.983000 | 31.7 | 1000.0 | 120.000 | 100.0 | H | 282.0 | 16.5 | 14.3 | 46.0 |
| 364.031000 | 31.9 | 1000.0 | 120.000 | 100.0 | H | 264.0 | 16.9 | 14.1 | 46.0 |
| 420.017000 | 31.0 | 1000.0 | 120.000 | 100.0 | H | 297.0 | 18.4 | 15.0 | 46.0 |
| 926.819000 | 31.9 | 1000.0 | 120.000 | 210.0 | H | 325.0 | 27.5 | 14.1 | 46.0 |
| 2480.250000 | 103.5 | 1000.0 | 1000.000 | 303.0 | V | 1.0 | 3.1 | - | - |
| 2483.500000 | 59.6 | 1000.0 | 1000.000 | 167.0 | V | 1.0 | 3.2 | 14.3 | 73.9 |
| 4959.400000 | 45.2 | 1000.0 | 1000.000 | 260.0 | V | 274.0 | -3.1 | 28.7 | 73.9 |
| 17186.900000 | 52.3 | 1000.0 | 1000.000 | 400.0 | V | 147.0 | 14.2 | 21.6 | 73.9 |

Table 21: Average results (ch high)

| Frequency (MHz) | Average (dBµV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Azimuth (deg) | Corr. (dB) | Margin (dB) | Limit (dBµV/m) |
|-----------------|------------------|-----------------|-----------------|-------------|--------------|---------------|------------|-------------|----------------|
| 2480.000000 | 98.8 | 1000.0 | 1000.000 | 280.0 | V | 0.0 | 3.1 | - | - |
| 2483.500000 | 41.4 | 1000.0 | 1000.000 | 165.0 | V | 1.0 | 3.2 | 12.5 | 53.9 |
| 4959.900000 | 33.8 | 1000.0 | 1000.000 | 245.0 | V | 278.0 | -3.1 | 20.1 | 53.9 |
| 7439.300000 | 31.0 | 1000.0 | 1000.000 | 232.0 | V | 265.0 | 0.6 | 22.9 | 53.9 |
| 17184.600000 | 38.9 | 1000.0 | 1000.000 | 400.0 | H | 119.0 | 14.2 | 15.0 | 53.9 |



Transmitter Radiated Spurious Emissions

Radiated Band Edge results, N-variant

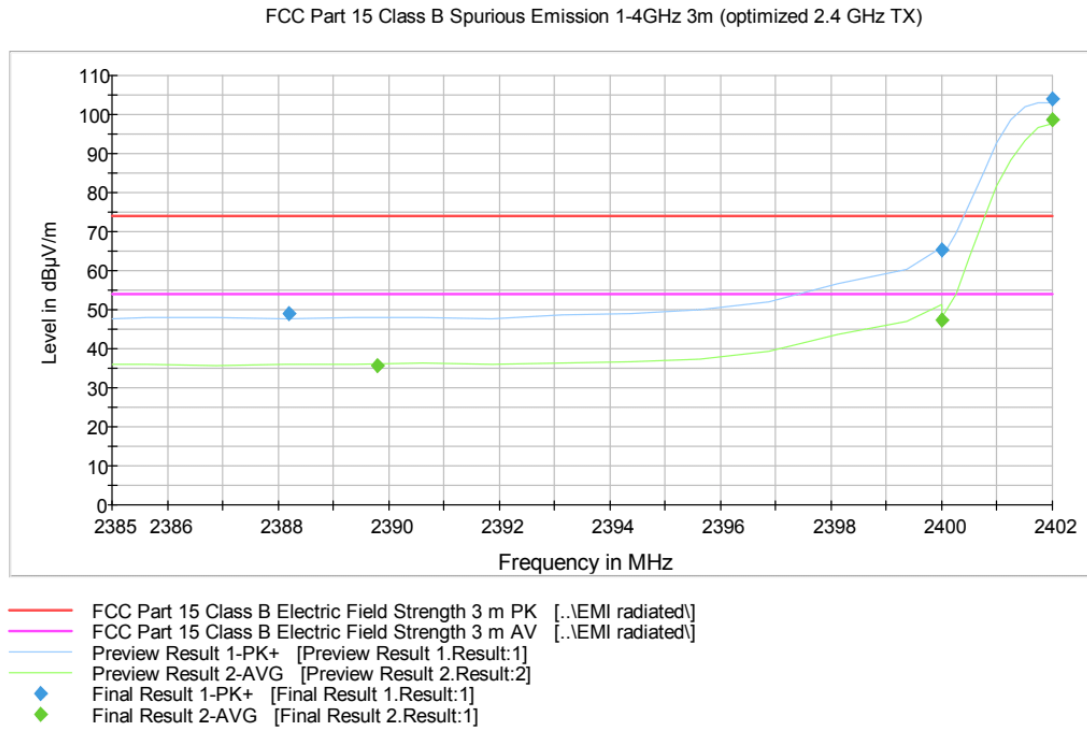


Figure 10: Radiated Band Edge measurement graph (ch low), N-variant

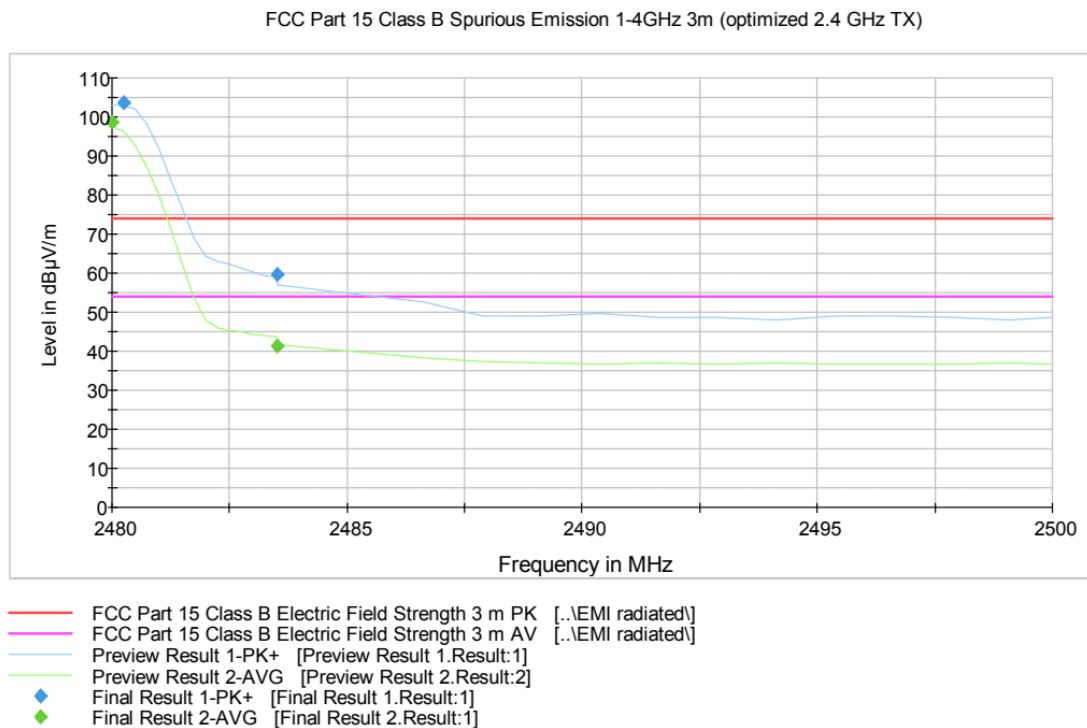


Figure 11: Radiated Band Edge measurement graph (ch high), N-variant

Transmitter Band Edge Measurement and Conducted Spurious Emissions

| | | |
|---------------------------------|------------------|----------------------------------|
| Standard: | ANSI C63.10 | (2013) |
| Tested by: | EHA | |
| Date: | 22.9 - 21.9.2016 | |
| Temperature: | 23 - 24 °C | |
| Humidity: | 40 - 43 % | |
| 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 22: Band edge attenuation

| Band Edge Attenuation | |
|-----------------------|-----------------|
| Lower Band Edge | Upper Band Edge |
| -51.25 dBc | -55.01 dBc |
| Limit: -20dBc | |

Table 23: Conducted spurious emissions channel low

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|-----------------|-------------|-------------|-------------|---------|
| 946.61 | -69.24 | -11.31 | -57.94 | PASS |
| 2399.98 | -45.06 | -11.31 | -33.75 | PASS |
| 2402.24 | 8.69 | - | - | Carrier |
| 3749.10 | -65.72 | -11.31 | -54.42 | PASS |
| 4803.46 | -42.70 | -11.31 | -31.39 | PASS |
| 7206.76 | -57.99 | -11.31 | -46.68 | PASS |
| 12468.69 | -58.63 | -11.31 | -47.33 | PASS |
| 15474.69 | -56.69 | -11.31 | -45.39 | PASS |
| 16157.26 | -55.32 | -11.31 | -44.02 | PASS |
| 19179.76 | -57.28 | -11.31 | -45.97 | PASS |
| 24464.10 | -56.61 | -11.31 | -45.31 | PASS |
| 25414.95 | -55.27 | -11.31 | -43.96 | PASS |

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Table 24: Conducted spurious emissions channel mid

| Frequency [MHz] | Level [dBm] | Limit [dBm] | Margin [dB] | Result |
|-----------------|-------------|-------------|-------------|---------|
| 863.86 | -69.25 | -11.64 | -57.61 | PASS |
| 2363.49 | -64.30 | -11.64 | -52.66 | PASS |
| 2440.24 | 8.36 | - | - | Carrier |
| 2516.65 | -65.22 | -11.64 | -53.58 | PASS |
| 4879.49 | -45.20 | -11.64 | -33.56 | PASS |
| 7319.26 | -56.22 | -11.64 | -44.58 | PASS |
| 12541.81 | -58.54 | -11.64 | -46.90 | PASS |
| 15834.68 | -57.17 | -11.64 | -45.53 | PASS |
| 16316.82 | -54.99 | -11.64 | -43.35 | PASS |
| 20024.52 | -57.10 | -11.64 | -45.46 | PASS |
| 24905.93 | -55.41 | -11.64 | -43.77 | PASS |
| 26282.72 | -56.06 | -11.64 | -44.42 | PASS |

Table 25: Conducted spurious emissions channel high

| Frequency [MHz] | Level [dBm] | Limit [dBc] | Margin [dB] | Result |
|-----------------|-------------|-------------|-------------|---------|
| 947.85 | -68.88 | -11.78 | -57.10 | PASS |
| 1643.30 | -66.06 | -11.78 | -54.29 | PASS |
| 2480.24 | 8.22 | - | - | Carrier |
| 2483.52 | -50.57 | -11.78 | -38.80 | PASS |
| 4959.55 | -47.22 | -11.78 | -35.45 | PASS |
| 7440.75 | -58.40 | -11.78 | -46.62 | PASS |
| 12520.16 | -58.50 | -11.78 | -46.72 | PASS |
| 15503.00 | -56.25 | -11.78 | -44.47 | PASS |
| 16157.54 | -54.38 | -11.78 | -42.61 | PASS |
| 19834.40 | -56.85 | -11.78 | -45.08 | PASS |
| 24461.75 | -56.47 | -11.78 | -44.69 | PASS |
| 26251.08 | -56.33 | -11.78 | -44.56 | PASS |



Transmitter Band Edge Measurement and Conducted Spurious Emissions

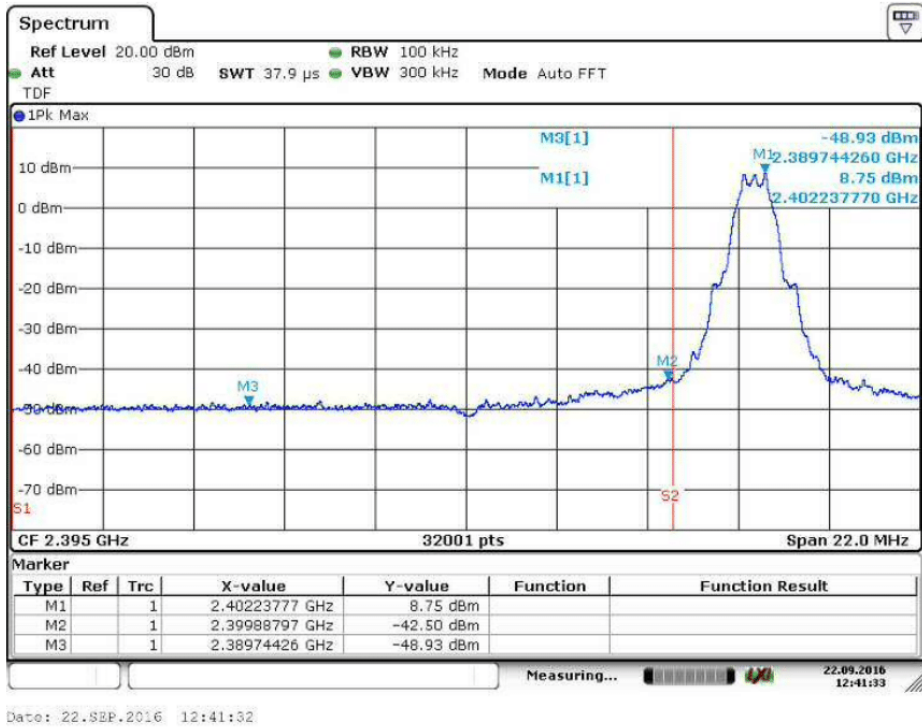


Figure 12: Lower Band Edge

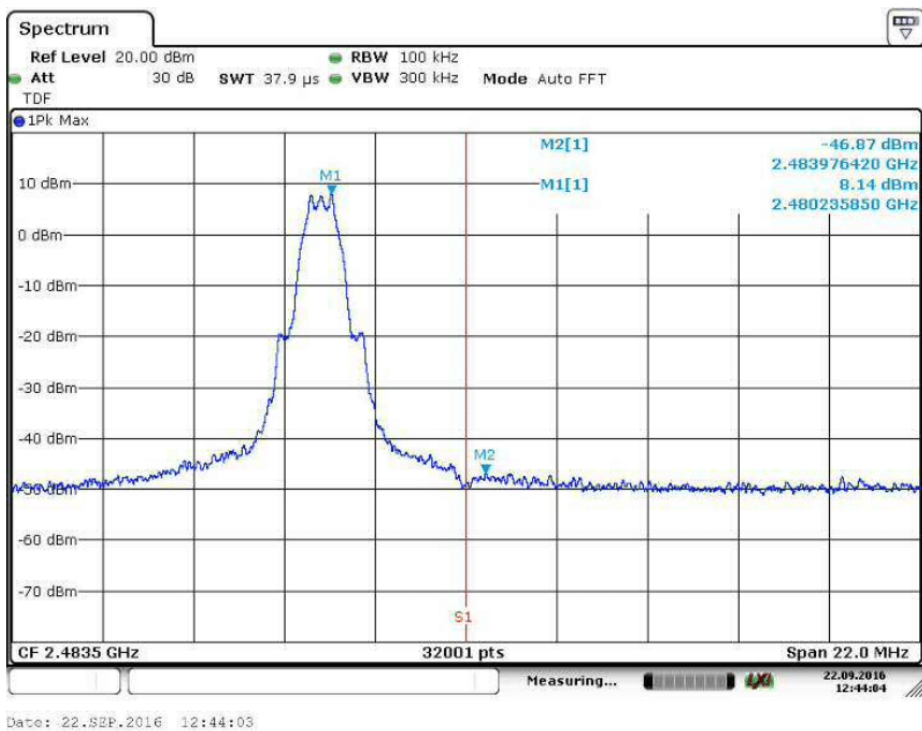


Figure 13: Upper Band Edge.



Transmitter Band Edge Measurement and Conducted Spurious Emissions

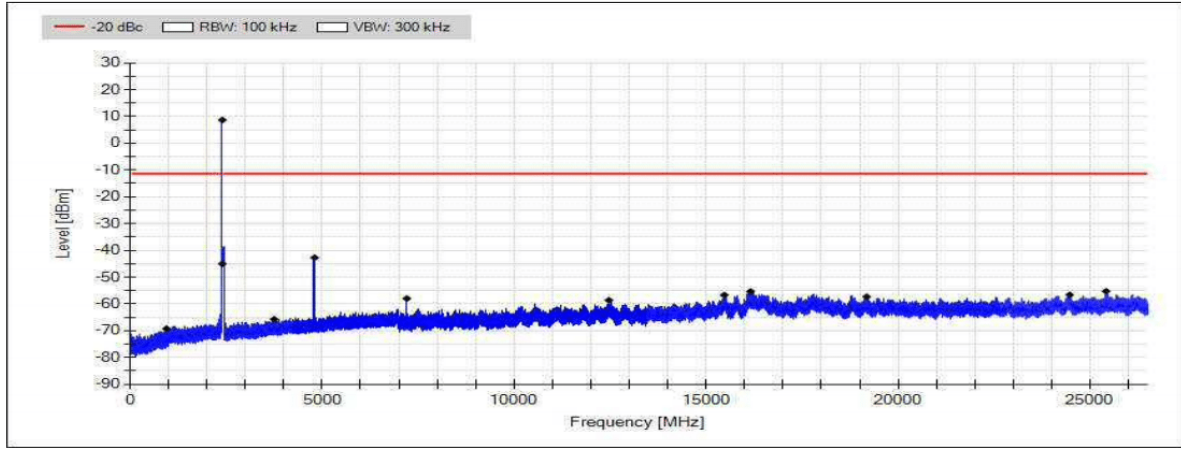


Figure 14: Conducted spurious emissions 30 - 26500 MHz channel low

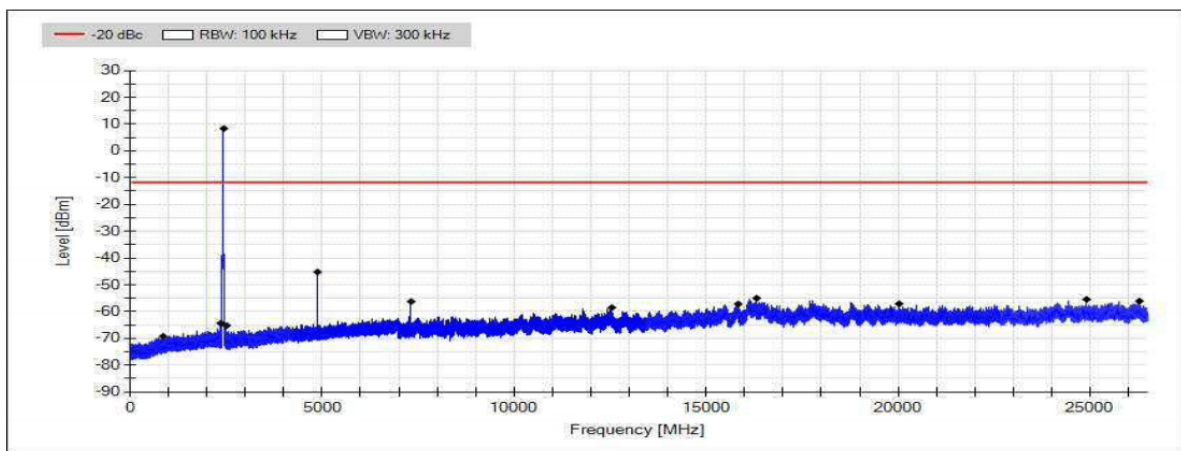


Figure 15: Conducted spurious emissions 30 - 26500 MHz channel mid

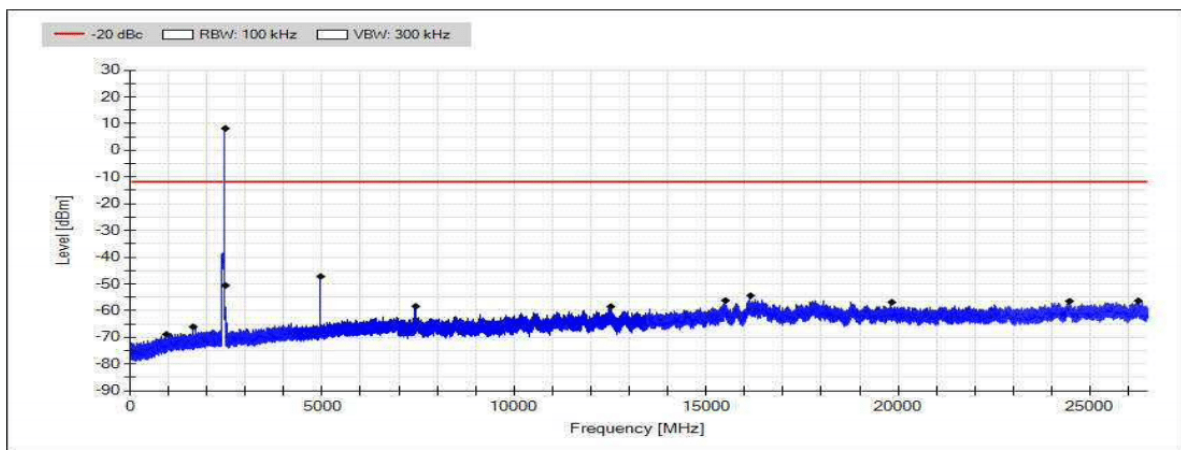


Figure 16: Conducted spurious emissions 30 - 26500 MHz channel high



6 dB Bandwidth of the Channel

6 dB Bandwidth of the Channel

Standard: ANSI C63.10 (2013)
 Tested by: EHA
 Date: 21.9.2016
 Temperature: 24 °C
 Humidity: 43 %

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

Results:

Table 26: 6 dB bandwidth test results

| Channel | 6 dB BW [kHz] | Minimum limit [kHz] |
|---------|---------------|---------------------|
| Low | 740.13 | 500 |
| Mid | 740.60 | |
| High | 737.01 | |

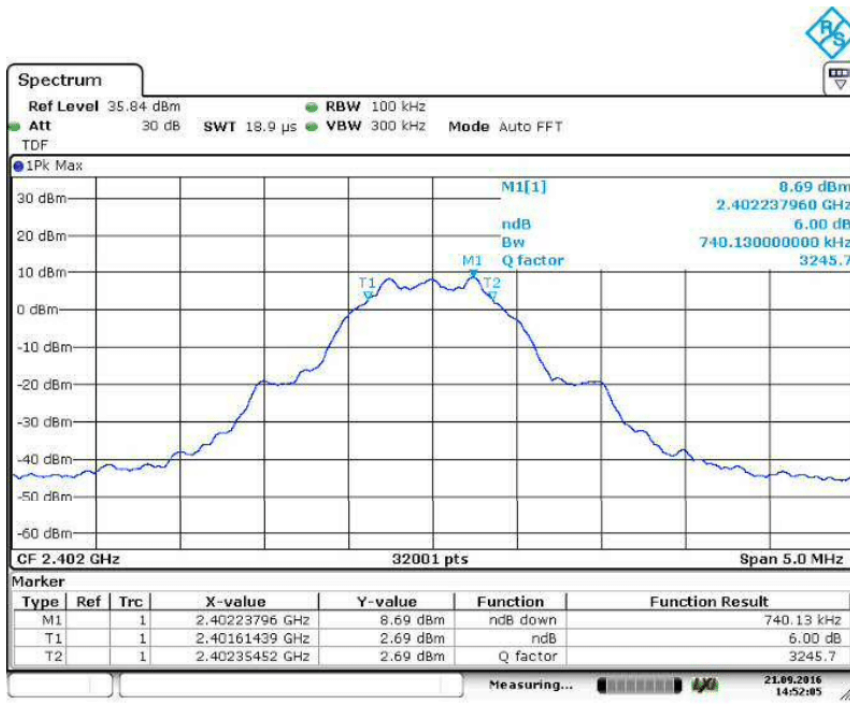


Figure 17: 6 dB bandwidth channel low



6 dB Bandwidth of the Channel



Figure 18: 6 dB bandwidth channel mid



Figure 19: 6 dB bandwidth channel high



Power Spectral Density

Power Spectral Density

Standard: ANSI C63.10 (2013)
Tested by: EHA
Date: 21.9.2016
Temperature: 24 °C
Humidity: 43 %

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

Results:

Table 27: Power spectral density test results

| Channel | PSD dBm/10 kHz | Maximum limit [dBm/3kHz] |
|---------|----------------|--------------------------|
| Low | -1.39 | +8.00 |
| Mid | -1.84 | |
| High | -1.98 | |

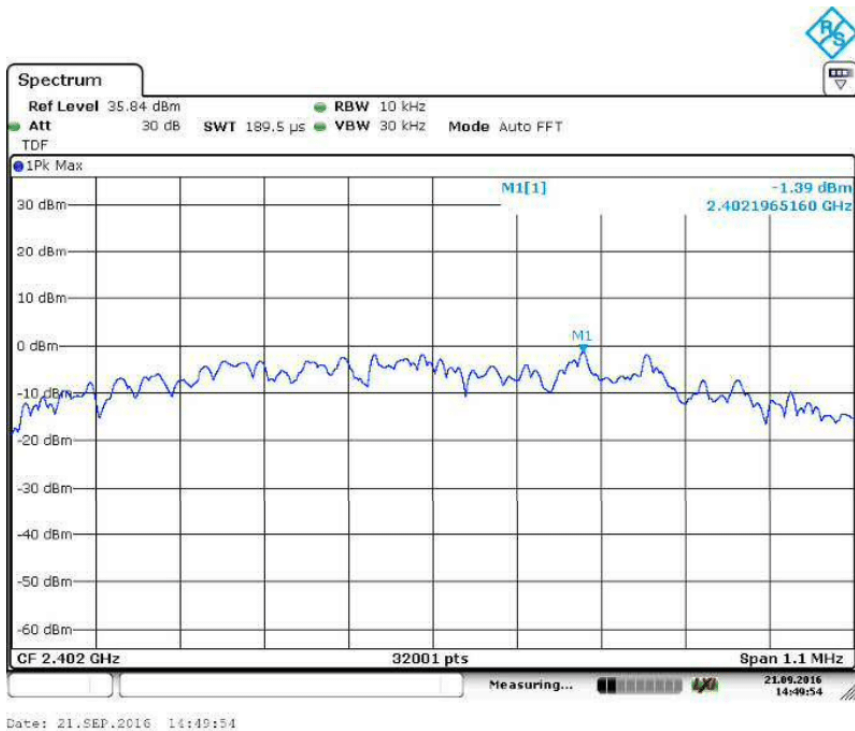


Figure 20: Power spectral density channel low



Power Spectral Density

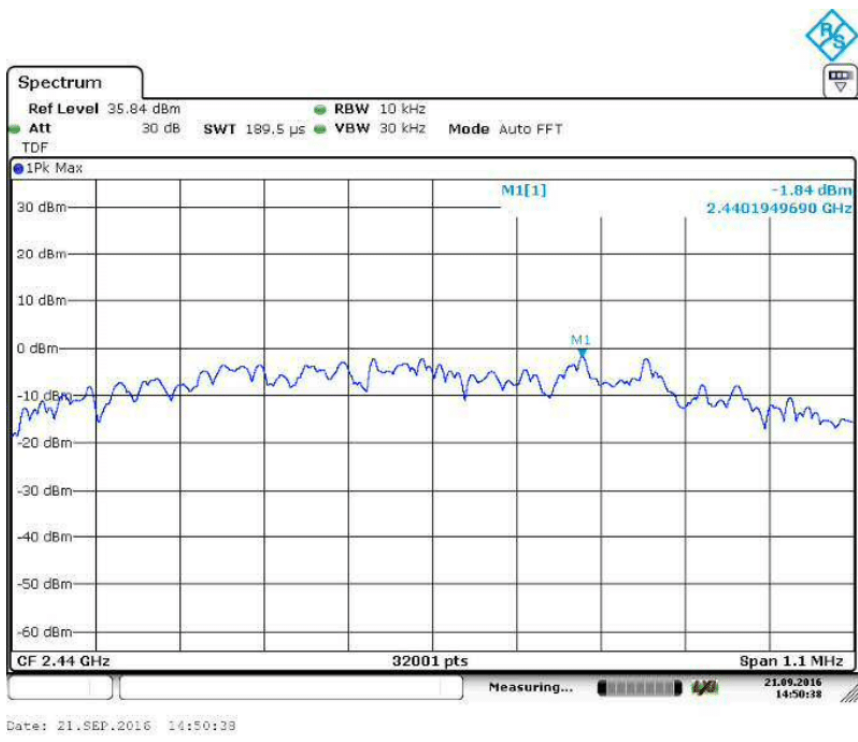


Figure 21: Power spectral density channel mid

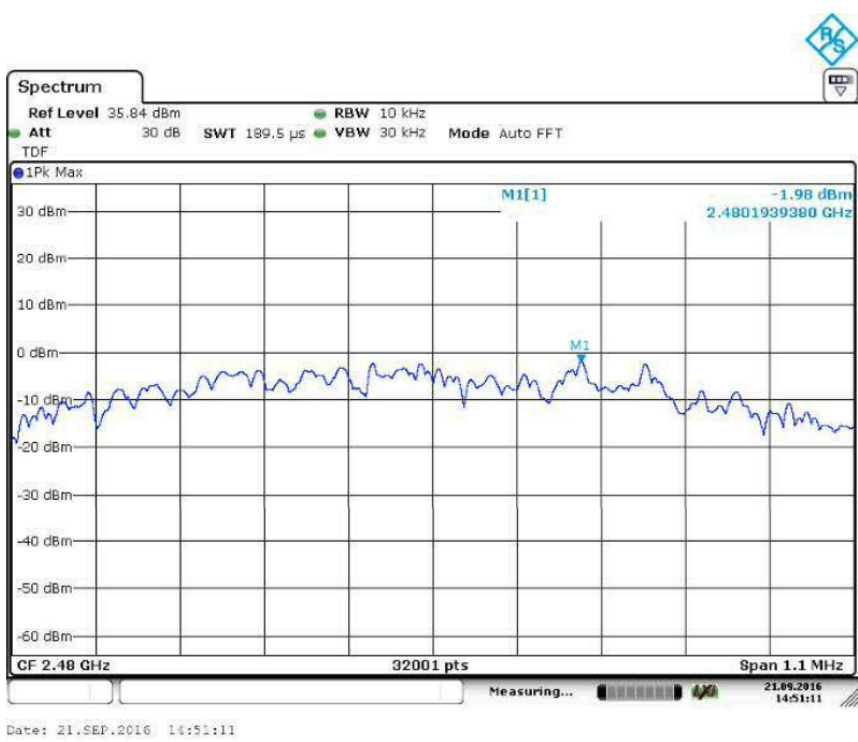


Figure 22: Power spectral density channel high

99% Occupied Bandwidth

Standard: RSS-GEN (2014)
Tested by: RRE MIH
Date: 18.8.2016 3.3.2017
Temperature: 23 ± 3 °C 23 ± 3 °C
Humidity: 30 - 60 % RH 30 - 60 % RH

RSS-GEN 6.6

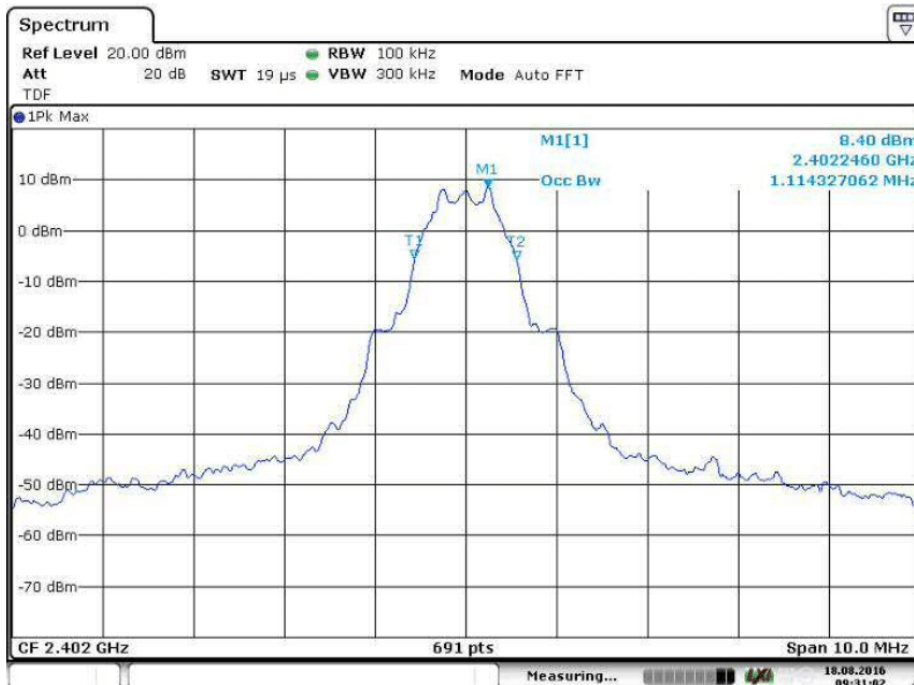
Channel frequency of 2442 MHz used as channel mid.

Table 28: 99% occupied bandwidth test results, model BGM121

| Channel | Limit | 99 % BW [MHz] | Result |
|---------|-------|---------------|--------|
| Low | - | 1.114327062 | PASS |
| Mid | - | 1.114327062 | PASS |
| High | - | 1.114327062 | PASS |

Table 29: 99% occupied bandwidth test results, model BGM123

| Channel | Limit | 99 % BW [MHz] | Result |
|---------|-------|---------------|--------|
| Low | - | 1.094653292 | PASS |
| Mid | - | 1.094653292 | PASS |
| High | - | 1.097153214 | PASS |



Date: 18.AUG.2016 09:31:02

Figure 23: 99% OBW channel low, BGM121



99 % Occupied Bandwidth

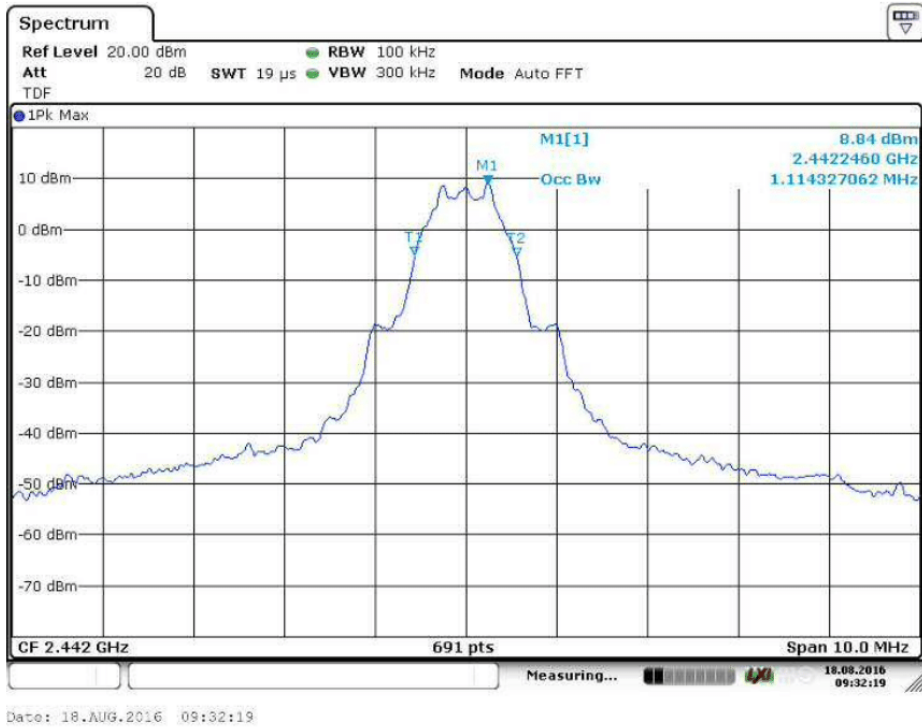


Figure 24: 99% OBW channel mid, BGM121

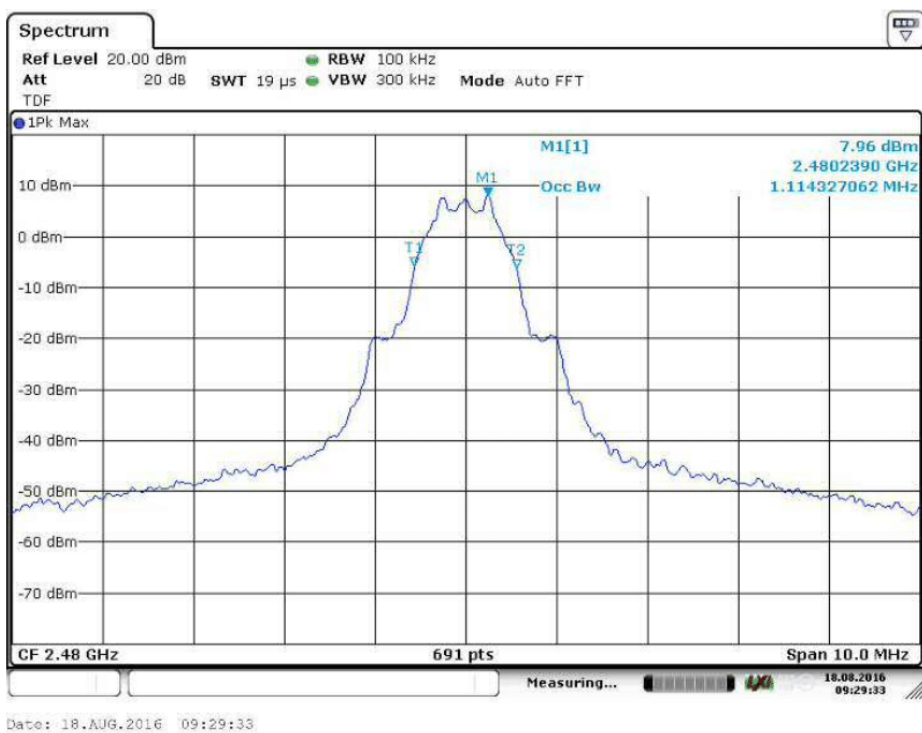


Figure 25: 99% OBW channel high, BGM121



99 % Occupied Bandwidth

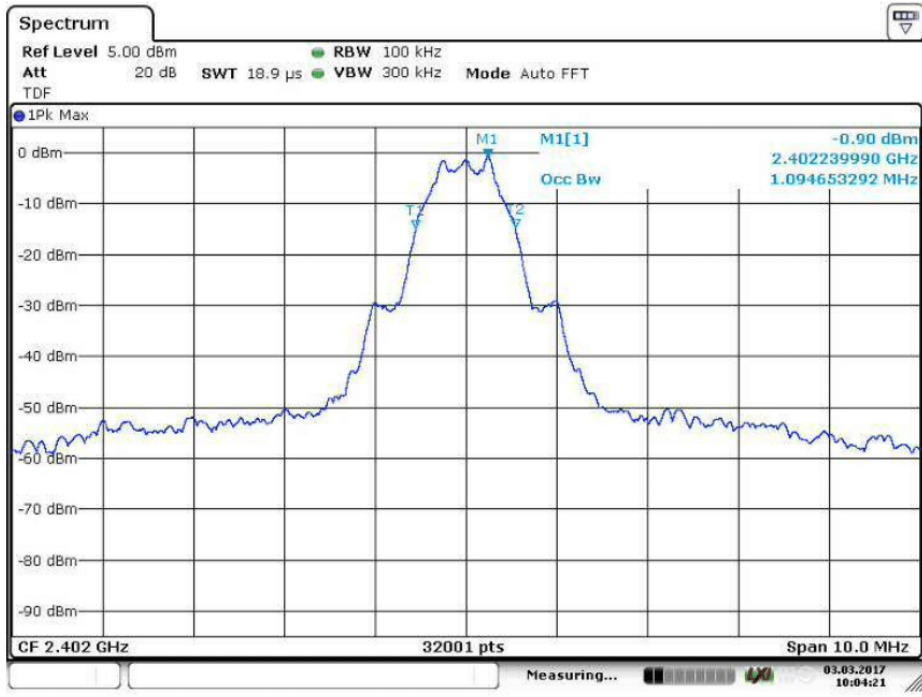


Figure 26: 99% OBW channel low, BGM123

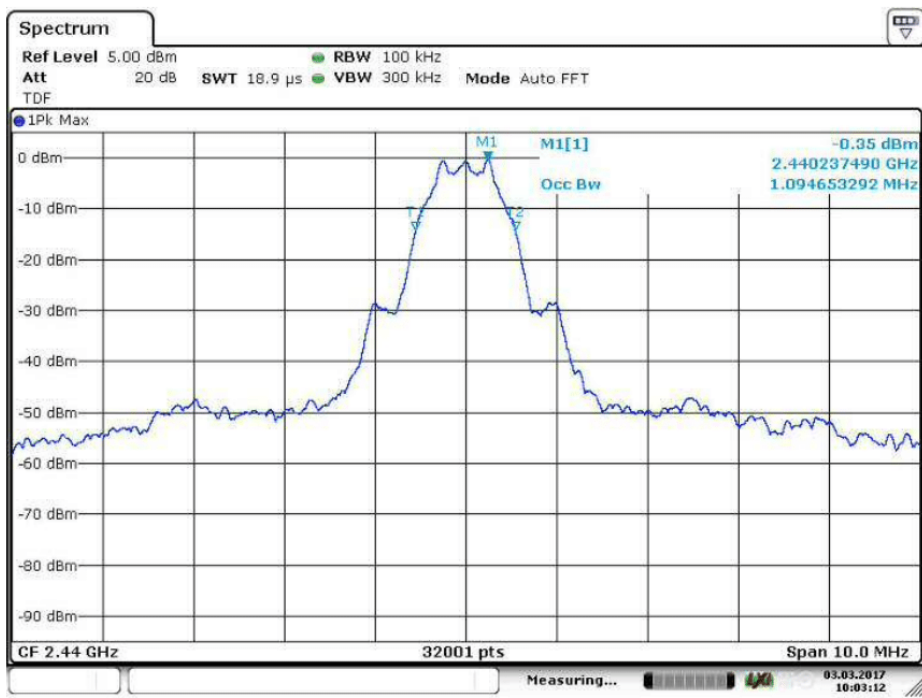


Figure 27: 99% OBW channel mid, BGM123

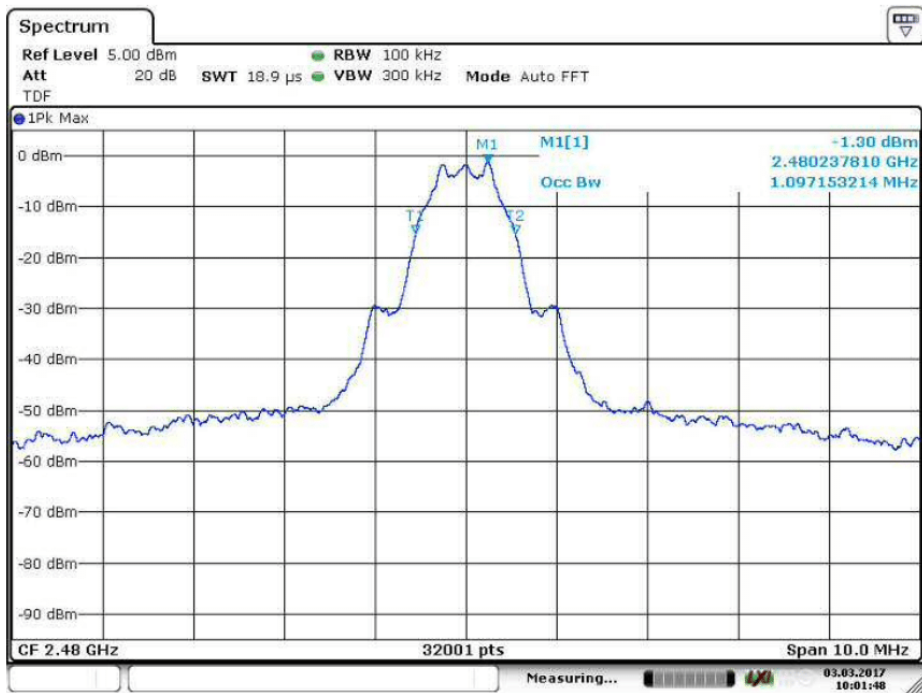


Figure 28: 99% OBW channel high, BGM123

TEST EQUIPMENT

| Equipment | Manufacturer | Type | Inv or serial | Prev Calib | Next Calib |
|------------------------------|------------------------|-------------------|---------------|------------|---------------|
| MONITORING ANTENNA | A.H. SYSTEMS | SAS-200/518 | inv:7873 | - | - |
| MONITORING SPECTRUM ANALYZER | AGILENT | E7405A | inv:9746 | 2016-01-07 | 2018-01-07 |
| ANTENNA MAST | MATURO | TAM 4.0E | inv:10181 | - | - |
| TURNTABLE | MATURO | DS430 UPGRADED | inv:10182 | - | - |
| MAST & TURNTABLE CONTROLLER | MATURO | NCD | inv:10183 | - | - |
| PREAMPLIFIER | ALC MICROWAVE | AWB-2018-40-08 | sn:14 | 2016-08-30 | 2017-08-30 |
| PREAMPLIFIER | MERCURY SYSTEMS | ALS1826-41-12 | - | 2016-09-02 | 2017-09-02 |
| TEST SOFTWARE | ROHDE & SCHWARZ | EMC-32 | - | - | - |
| EMI TEST RECEIVER | ROHDE & SCHWARZ | ESU 26 | inv:8453 | 2016-06-10 | 2017-06-10 |
| SIGNAL ANALYZER | ROHDE & SCHWARZ | FSV40 | inv:9093 | 2016-06-10 | 2017-06-10 |
| ANTENNA | SCHWARZBECK | VULB 9168 | inv:8911 | 2014-11-04 | 2016-11-04 *) |
| ANTENNA | EMCO | 3117 | inv:7293 | 2016-03-16 | 2018-03-06 |
| ANTENNA | EMCO | 3160-09 | inv:7294 | 2016-03-16 | 2017-03-16 |
| HIGH PASS FILTER | WAINWRIGHT | WHKX4.0/18G-10SS | sn:10 | 2016-01-22 | 2017-01-22 *) |
| ATTENUATOR 10 dB | HUBER & SUHNER | 6610.19.AA | sn:7 | 2016-02-02 | 2017-02-02 *) |
| AC POWER SOURCE | CALIFORNIA INSTRUMENTS | 5001 iX Series II | inv:7826 | - | - |
| LISN | ROHDE & SCHWARZ | ENV216 | inv:9611 | 2016-02-24 | 2017-02-24 *) |

*) The newest calibration dates are not updated here because the tests with these devices were made between this calibration time period.