

Test Report



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

Equipment Under Test: ZigBee module

Model: MGM12P22GA
MGM12P22GE

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
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FCC Rule Part: 15.247: 2016
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 (April 8, 2016)

Date: 31 July 2017

Issued by:

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Emil Haverinen
Testing Engineer

Date: 31 July 2017

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A blue ink signature of Rauno Repo.

Rauno Repo
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Table of Contents

PRODUCT DESCRIPTION	3
Equipment Under Test (EUT)	3
Description of the EUT	3
Ratings and declarations	3
Power Supply	3
Mechanical Size of the EUT	3
Samples	3
GENERAL REMARKS	4
Disclaimer	4
SUMMARY OF TESTING	5
EUT Test Conditions during Testing	5
TEST RESULTS	6
Conducted Emissions In The Frequency Range 150 kHz - 30 MHz	6
Maximum Peak Conducted Output Power	8
Transmitter Radiated Spurious Emissions 30 - 26500 MHz	11
Transmitter Band Edge Measurement and Conducted Spurious Emissions	28
6 dB Bandwidth of the Channel	33
Power Spectral Density	36
99% Occupied Bandwidth	39
TEST EQUIPMENT	42

Equipment Under Test (EUT)

Trade mark:	Silicon Labs
Model:	MGM12P22GA MGM12P22GE
Type:	ZigBee module
Serial no:	-
FCC ID:	QOQMGM12P2
IC:	5123A-MGM12P2

Description of the EUT

MGM12P22G is a ZigBee module with two variants, one with integrated chip antenna (-A) and one with RF antenna connector for use of external antenna (-E).

Classification of the device

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

Modifications Incorporated in the EUT

No modifications.

Ratings and declarations

Operating Frequency Range (OFR):	2405 - 2480 MHz
Channels:	16
Channel separation:	5 MHz
Effective conducted power:	9.51 dBm (Peak)
Modulation:	OQPSK
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
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Samples

Two samples were used in the tests, one of each variant.

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.

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

Conducted measurements were performed only to E-variant. Radiated measurements were performed to both antenna variants.

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

Channel Low (Ch 11) = 2405 MHz

Channel Mid (Ch 19) = 2445 MHz

Channel High(1) (Ch 25) = 2475 MHz

Channel High(2) (Ch 26) = 2480 MHz

Two high channels were tested. The power setting is maximum allowable in all other channels.

Test Facility

☐ Testing Location / address: FCC registration number: 90598	SGS Fimko Ltd Särkiniementie 3 FI-00210, HELSINKI FINLAND
☒ 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: JSU
Date: 20 March 2017
Temperature: 21 °C
Humidity: 25 % RH
Barometric pressure: 996 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.

Final measurements from the worst frequencies

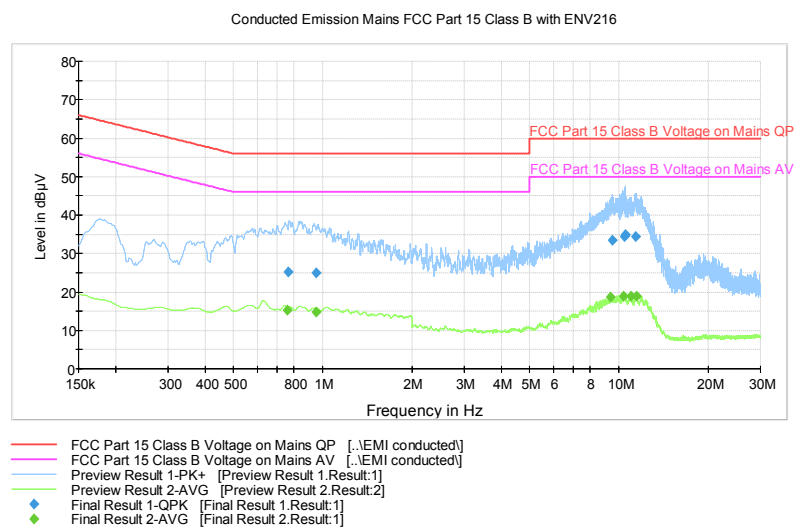


Figure 1: The measured curves with peak- and average detector.

Conducted Emissions on Power Supply Lines

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)
0.762500	25.1	1000.0	9.000	N	10.3	30.9	56.0
0.947750	25.0	1000.0	9.000	N	10.3	31.0	56.0
9.469500	33.4	1000.0	9.000	N	10.6	26.6	60.0
10.410000	34.4	1000.0	9.000	N	10.6	25.6	60.0
10.506250	34.8	1000.0	9.000	N	10.6	25.2	60.0
11.358250	34.3	1000.0	9.000	N	10.6	25.7	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)
0.759750	15.2	1000.0	9.000	N	10.3	30.8	46.0
0.948750	14.7	1000.0	9.000	N	10.3	31.3	46.0
9.374750	18.6	1000.0	9.000	L1	10.3	31.4	50.0
10.369250	19.0	1000.0	9.000	N	10.6	31.0	50.0
10.992250	18.8	1000.0	9.000	N	10.6	31.2	50.0
11.452750	18.9	1000.0	9.000	N	10.6	31.1	50.0

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

Maximum Peak Conducted Output Power

Standard: ANSI C63.10 (2013)
Tested by: EHA
Date: 28 March 2017 -
 29 June 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	9.51	30	20.49	PASS
Mid	9.11	30	20.89	PASS
High(1)	8.94	30	21.06	PASS
High(2)	9.35	30	20.65	PASS

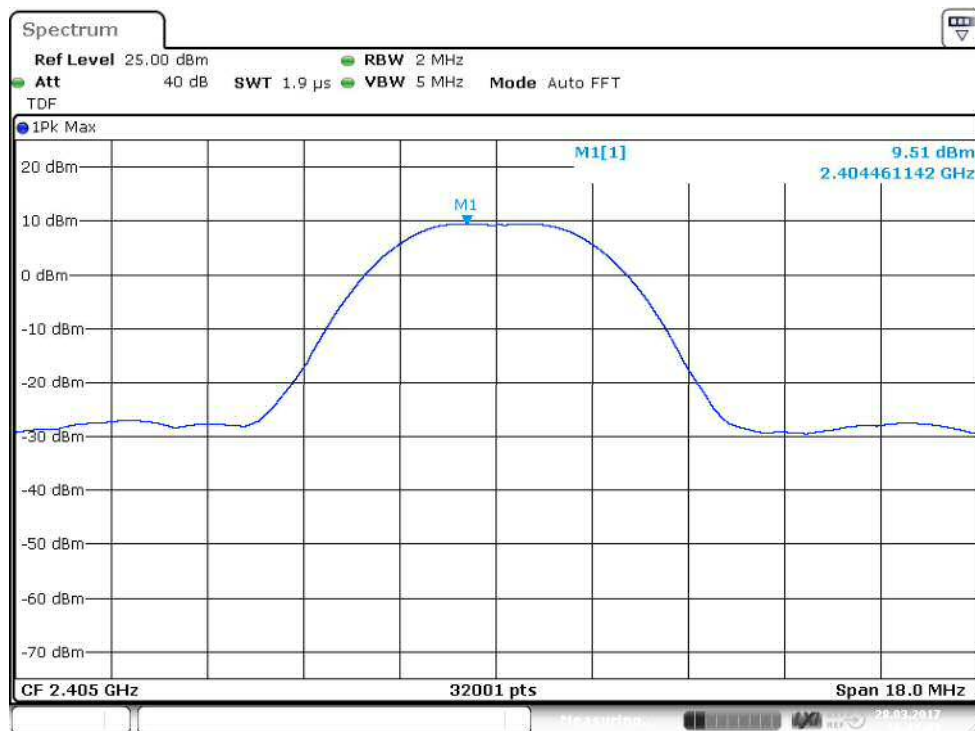


Figure 2: Conducted power (ch low)

Maximum Peak Conducted Output Power

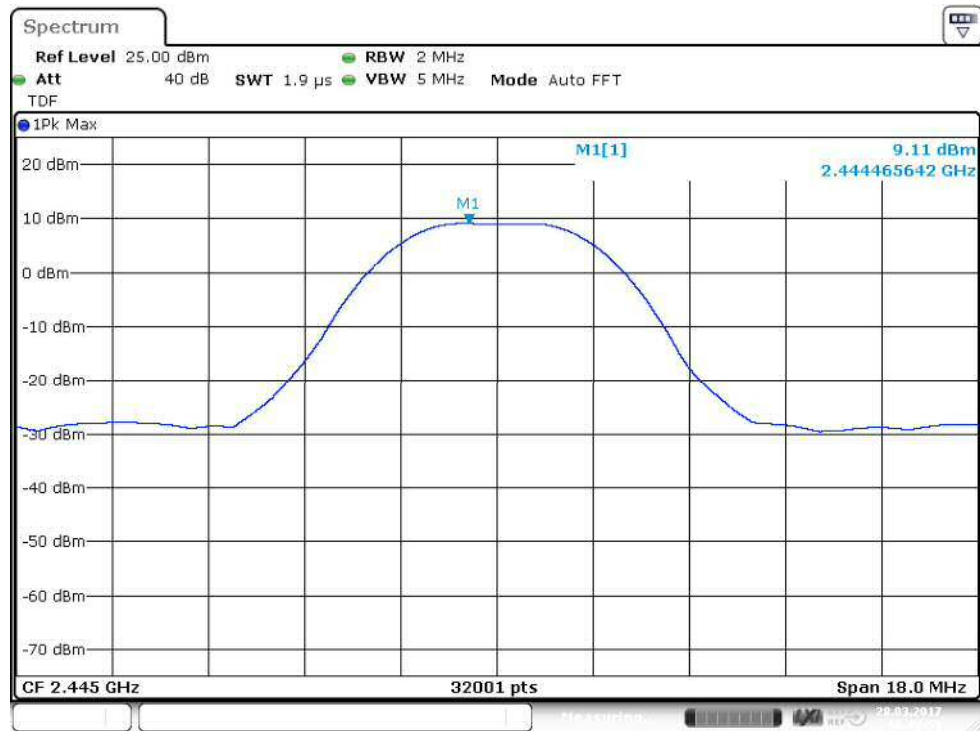


Figure 3: Conducted power (ch mid)

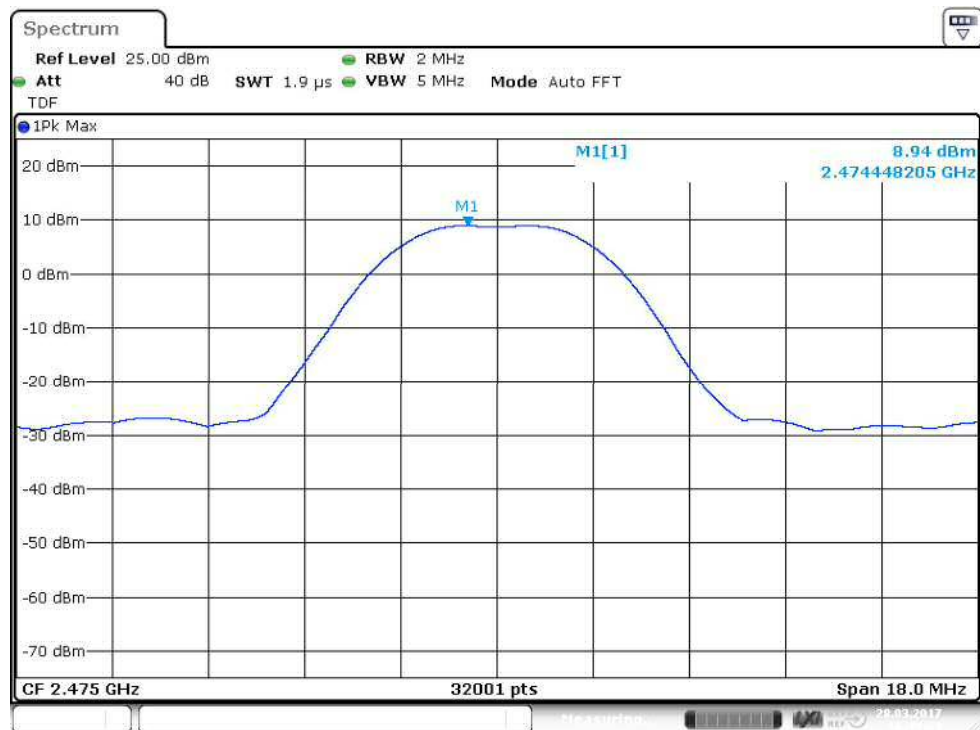


Figure 4: Conducted power (ch high(1))

Maximum Peak Conducted Output Power

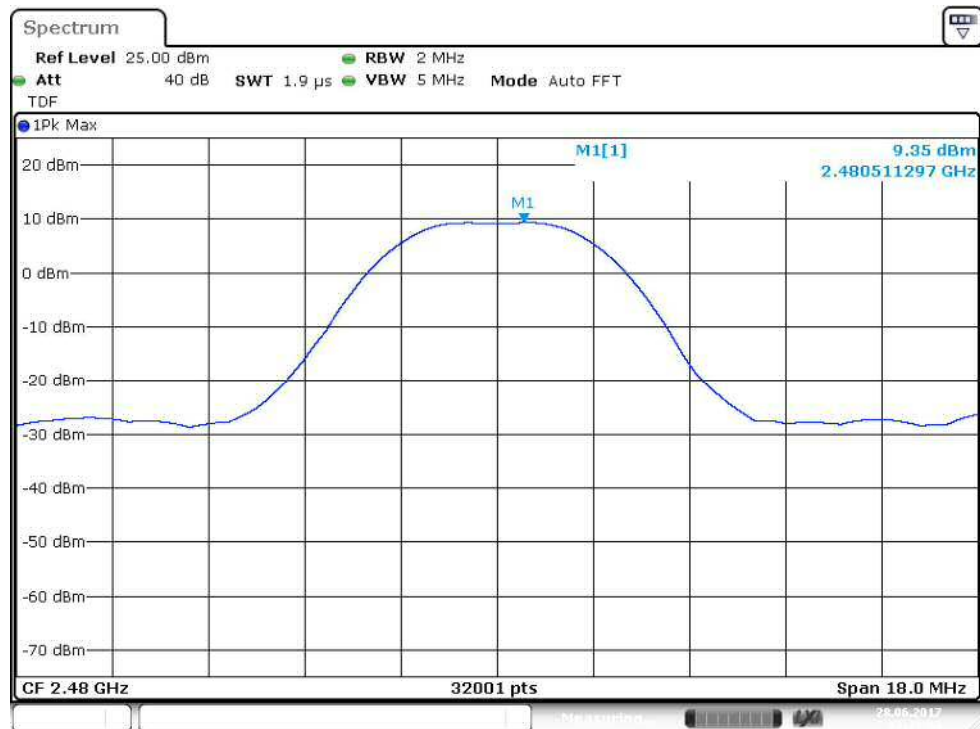


Figure 5: Conducted power (ch high(2))

Transmitter Radiated Spurious Emissions 30 - 26500 MHz

Standard: ANSI C63.10 (2013)
Tested by: EHA / JSU / PKA
Date: 10 - 31 March 2017
 12 June 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). Measurements were performed for both antenna variants.

Spurious emissions were measured while the EUT was set to fundamental frequencies of 2405 MHz (low), 2445 MHz (mid) and 2475 MHz (high)

Frequency range [MHz]	Limit [$\mu\text{V/m}$]	Limit [dB $\mu\text{V/m}$]	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

Low channel (A-variant)

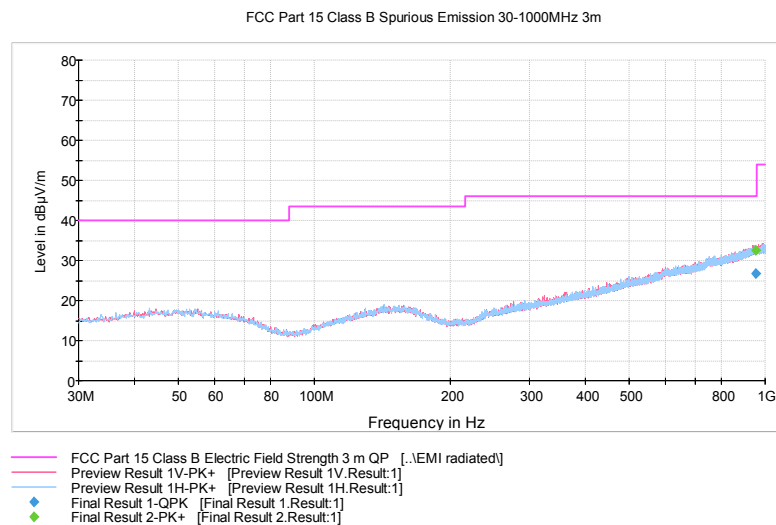


Figure 6: Low channel 30 MHz – 1000 MHz

Transmitter Radiated Spurious Emissions

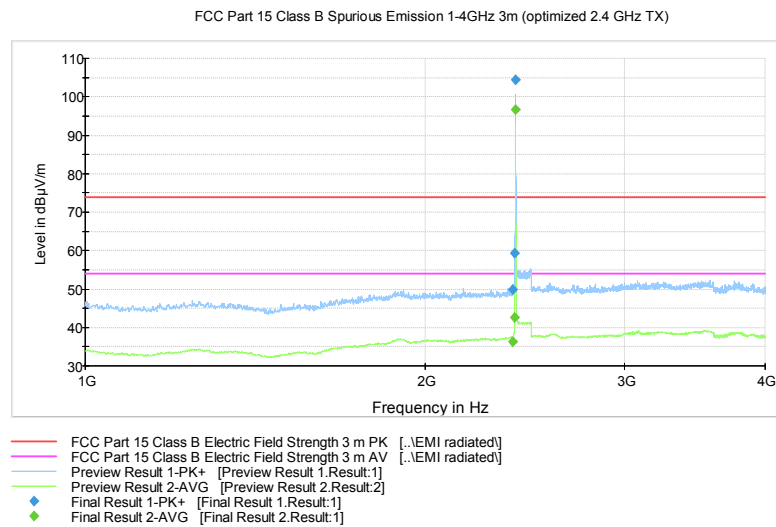


Figure 7: Low channel 1 GHz – 4 GHz

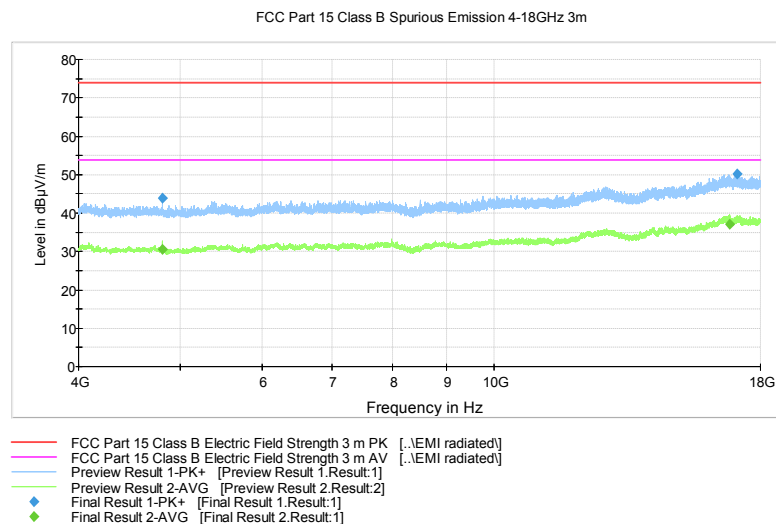


Figure 8: Low channel 4 GHz – 18 GHz

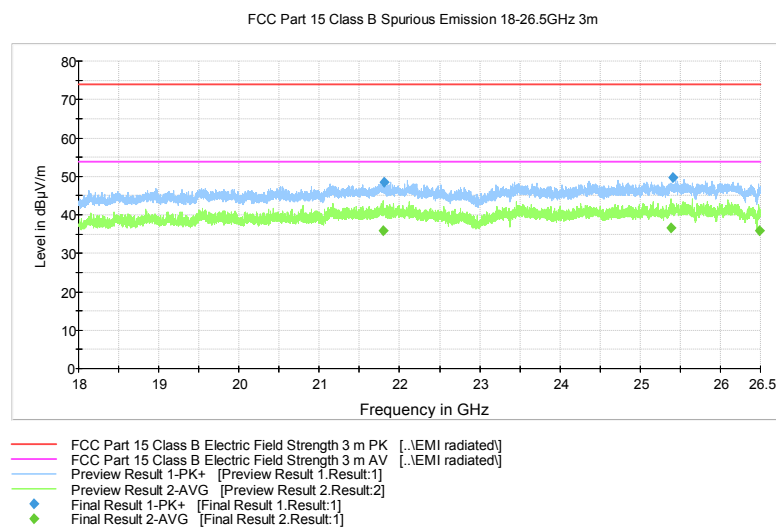


Figure 9: Low channel 18 GHz – 26.5 GHz

Transmitter Radiated Spurious Emissions

Table 4: Quasi-peak results (ch low)

Frequency (MHz)	QuasiPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
951.465000	26.8	1000.0	120.000	225.0	H	66.0	27.8	19.2	46.0

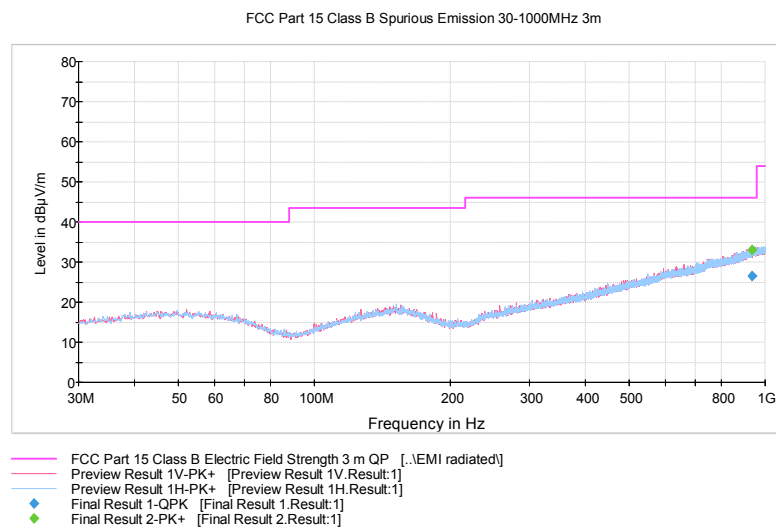
Table 5: Peak results (ch low)

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
2389.000000	49.9	1000.0	1000.000	150.0	V	275.0	14.6	24.0	73.9
2400.000000	59.3	1000.0	1000.000	165.0	H	64.0	14.7	14.6	73.9
4811.000000	44.0	1000.0	1000.000	272.0	V	332.0	8.3	29.9	73.9
17115.00000	50.3	1000.0	1000.000	150.0	H	190.0	27.3	23.6	73.9

Table 6: Average results (ch low)

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
2389.400000	36.4	1000.0	1000.000	279.0	V	325.0	14.6	17.5	53.9
2400.000000	42.5	1000.0	1000.000	178.0	H	64.0	14.7	11.4	53.9
4810.900000	30.5	1000.0	1000.000	259.0	V	315.0	8.3	23.4	53.9
16807.30000	37.1	1000.0	1000.000	400.0	H	236.0	26.8	16.8	53.9

Middle channel (A-variant)


Figure 10: Mid channel 30 MHz – 1000 MHz

Transmitter Radiated Spurious Emissions

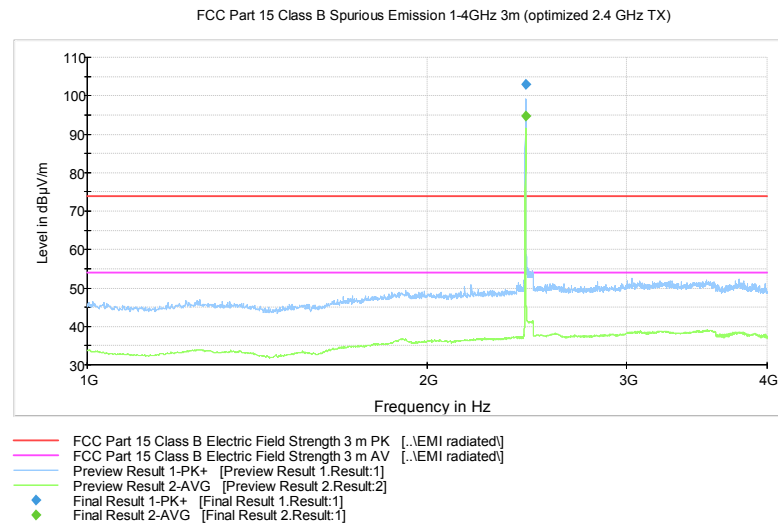


Figure 11: Mid channel 1 GHz – 4 GHz

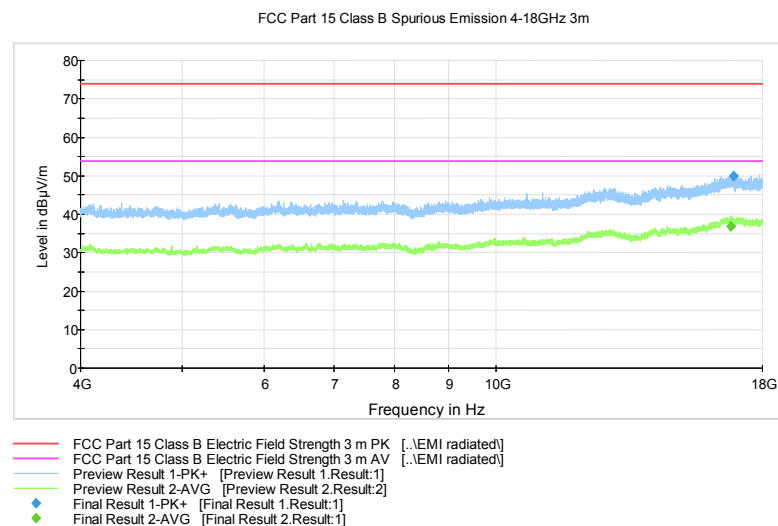


Figure 12: Mid channel 4 GHz – 18 GHz

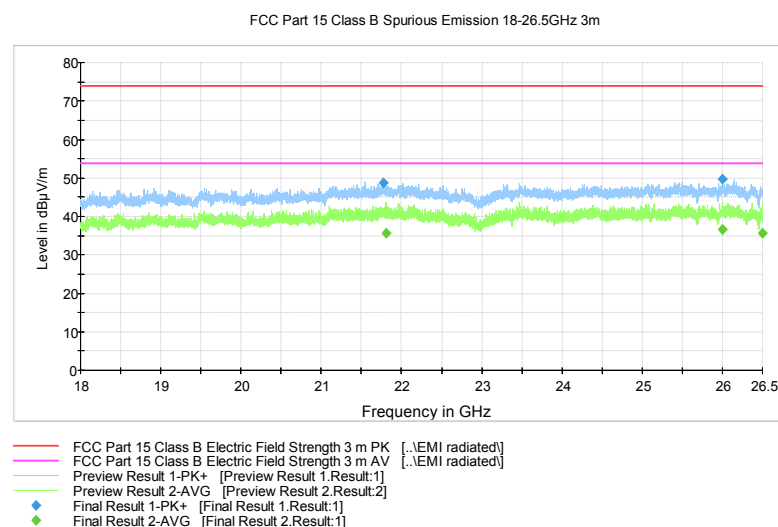


Figure 13: Mid channel 18 GHz – 26.5 GHz

Transmitter Radiated Spurious Emissions

Table 7: Quasi-peak results (ch mid)

Frequency (MHz)	QuasiPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
937.615000	26.6	1000.0	120.000	111.0	V	69.0	27.6	19.4	46.0

Table 8: Peak results (ch mid)

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
16893.30000	49.9	1000.0	1000.000	150.0	V	241.0	26.7	24.0	73.9
21772.95000	48.8	1000.0	1000.000	302.0	V	314.0	22.1	25.1	73.9
25995.10000	49.8	1000.0	1000.000	400.0	H	290.0	26.3	24.1	73.9

Table 9: 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)
16795.20000	36.9	1000.0	1000.000	150.0	V	319.0	26.8	17.0	53.9
21811.50000	35.6	1000.0	1000.000	100.0	V	70.0	22.2	18.3	53.9
26004.40000	36.6	1000.0	1000.000	100.0	H	126.0	26.4	17.3	53.9
26495.85000	35.8	1000.0	1000.000	100.0	H	216.0	26.2	18.1	53.9

High channel (A-variant)

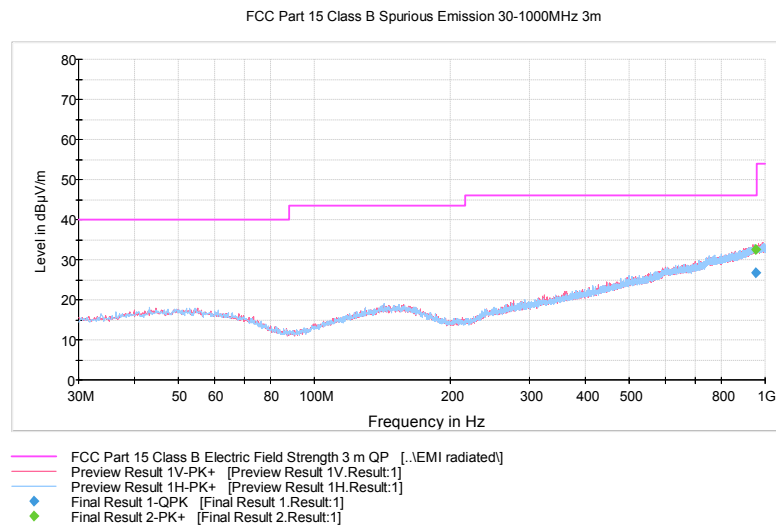


Figure 14: High channel 30 MHz – 1000 MHz

Transmitter Radiated Spurious Emissions

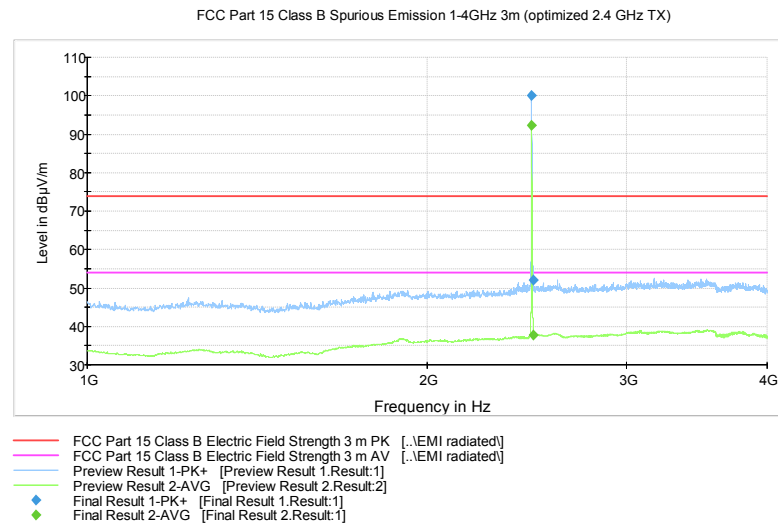


Figure 15: High channel 1 GHz – 4 GHz

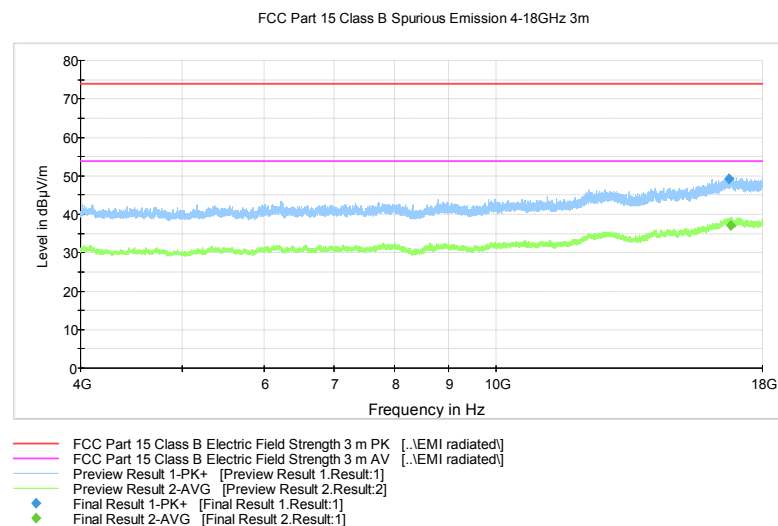


Figure 16: High channel 4 GHz – 18 GHz

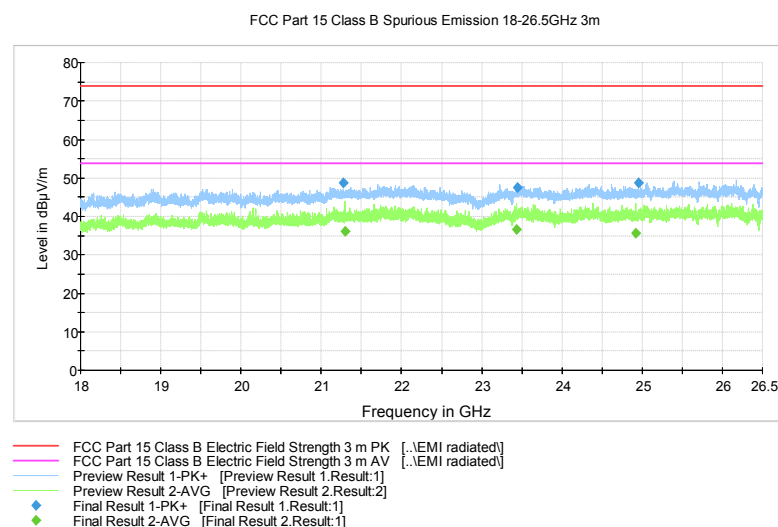


Figure 17: High channel 18 GHz – 26.5 GHz

Transmitter Radiated Spurious Emissions

Table 10: 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)
959.085000	26.9	1000.0	120.000	227.0	V	0.0	27.8	19.1	46.0

Table 11: 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)
2474.500000	100.1	1000.0	1000.000	150.0	H	250.0	14.6	-26.2	73.9
2483.500000	52.1	1000.0	1000.000	150.0	H	242.0	14.7	21.8	73.9
16730.30000	49.3	1000.0	1000.000	150.0	V	0.0	26.5	24.6	73.9

Table 12: 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)
2475.000000	92.4	1000.0	1000.000	150.0	H	249.0	14.6	-38.5	53.9
2483.500000	37.8	1000.0	1000.000	150.0	H	248.0	14.7	16.1	53.9
16800.60000	37.1	1000.0	1000.000	400.0	H	290.0	26.8	16.8	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)

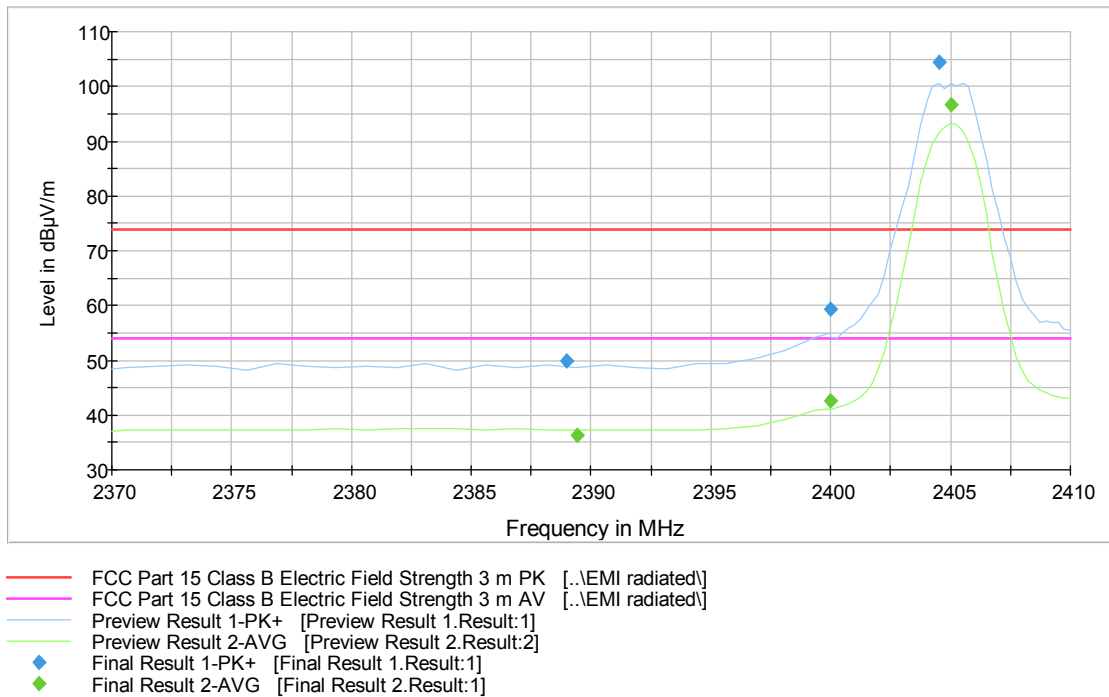


Figure 18: Radiated Band Edge measurement graph (ch low)

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

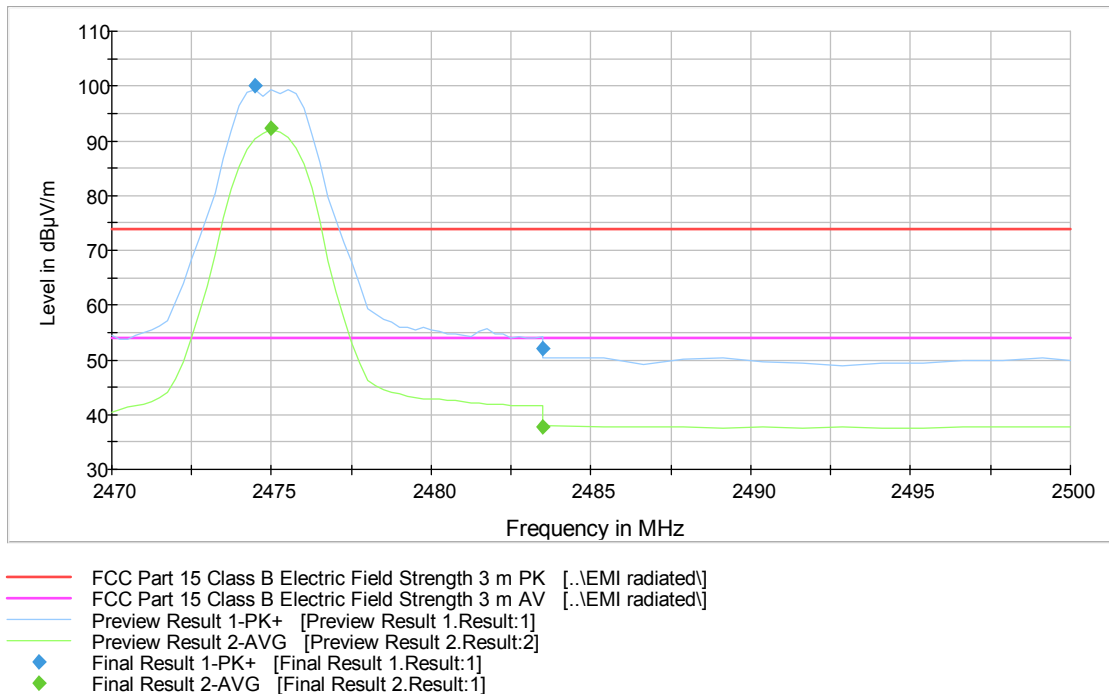


Figure 19: Radiated Band Edge measurement graph (ch high(1))

Transmitter Radiated Spurious Emissions

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

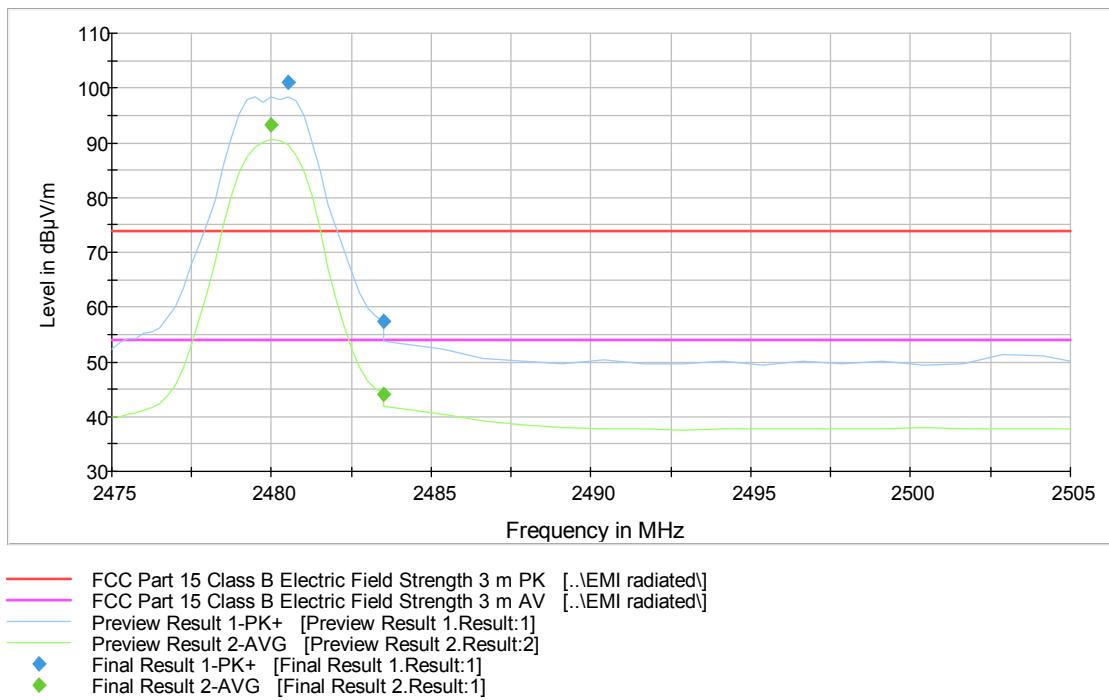


Figure 20: Radiated Band Edge measurement graph (ch high(2))

Table 13: Peak results (2480 MHz)

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
2483.500000	57.3	1000.0	1000.000	150.0	H	335.0	14.7	16.6	73.9

Table 14: Average results (2480 MHz)

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
2483.500000	44.0	1000.0	1000.000	241.0	H	338.0	14.7	9.9	53.9

Transmitter Radiated Spurious Emissions

Low channel (E-variant)

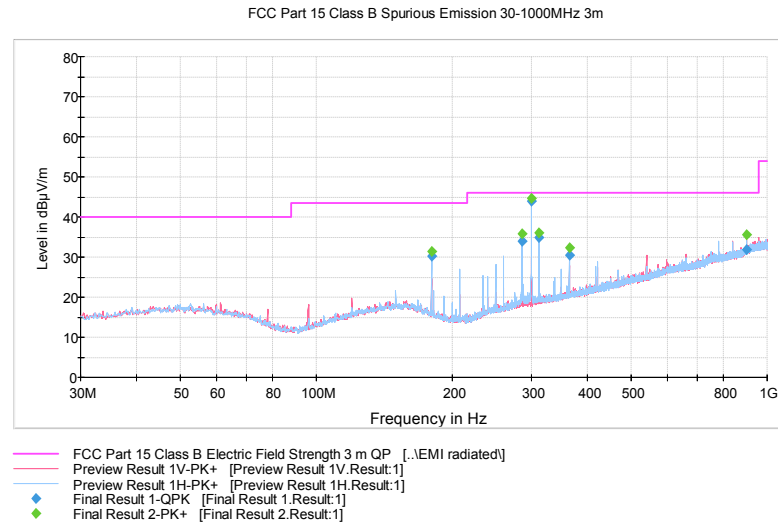


Figure 21: Low channel 30 MHz – 1000 MHz

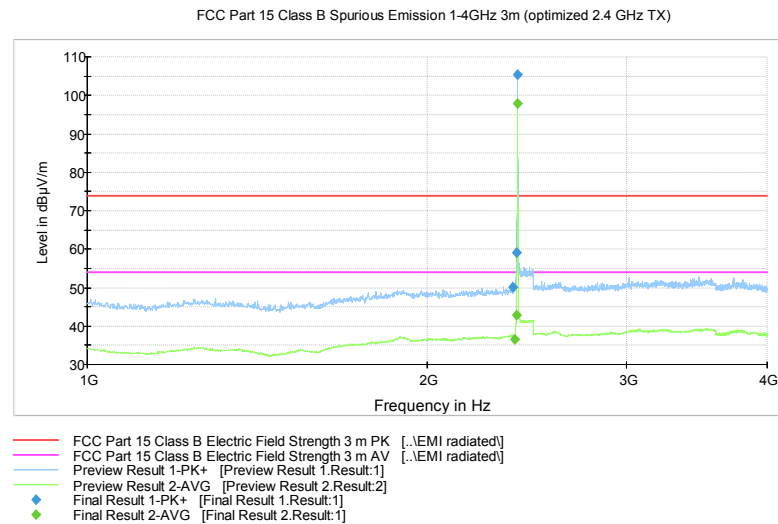


Figure 22: Low channel 1 GHz – 4 GHz

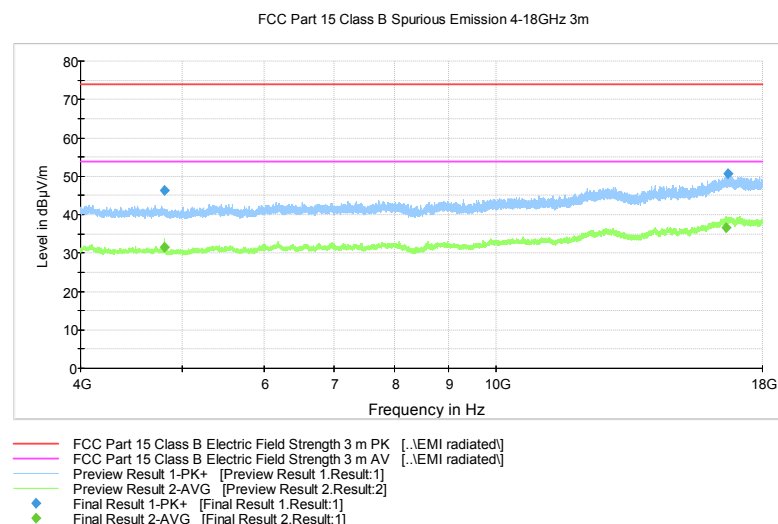


Figure 23: Low channel 4 GHz – 18 GHz

Transmitter Radiated Spurious Emissions

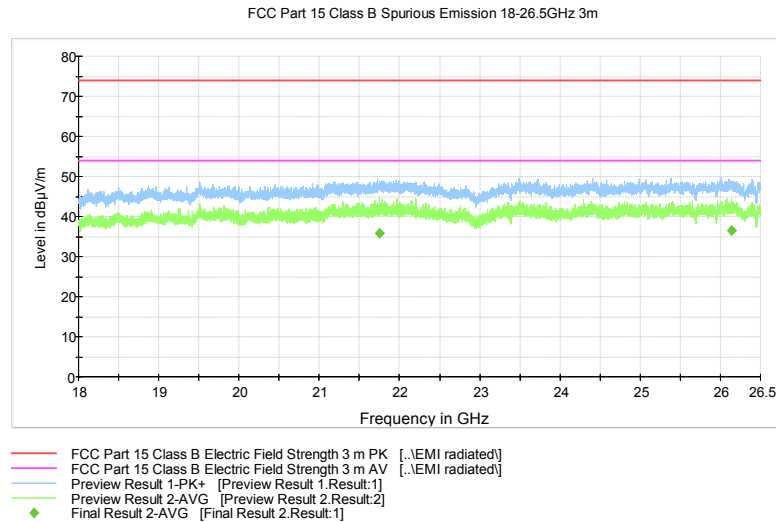


Figure 24: Low channel 18 GHz – 26.5 GHz

Table 15: Quasi-peak results (ch low)

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
180.015000	30.2	1000.0	120.000	207.0	H	15.0	13.0	13.3	43.5
286.015000	34.0	1000.0	120.000	100.0	H	85.0	14.9	12.0	46.0
300.015000	44.1	1000.0	120.000	100.0	H	88.0	15.3	1.9	46.0
312.015000	35.0	1000.0	120.000	100.0	H	87.0	15.7	11.0	46.0
364.015000	30.6	1000.0	120.000	100.0	H	4.0	16.9	15.4	46.0
900.055000	31.8	1000.0	120.000	111.0	V	150.0	27.0	14.2	46.0

Table 16: Peak results (ch low)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2383.800000	50.2	1000.0	1000.000	282.0	V	225.0	14.5	23.7	73.9
2400.000000	59.1	1000.0	1000.000	255.0	V	206.0	14.7	14.8	73.9
4809.000000	46.2	1000.0	1000.000	179.0	V	332.0	8.3	27.7	73.9
16698.20000	50.7	1000.0	1000.000	400.0	H	47.0	26.5	23.2	73.9

Table 17: Average results (ch low)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2389.800000	36.5	1000.0	1000.000	150.0	V	202.0	14.6	17.4	53.9
2400.000000	42.7	1000.0	1000.000	205.0	V	201.0	14.7	11.2	53.9
4811.000000	31.4	1000.0	1000.000	179.0	V	332.0	8.3	22.5	53.9
16605.80000	36.7	1000.0	1000.000	150.0	V	319.0	26.3	17.2	53.9

Transmitter Radiated Spurious Emissions

Middle channel (E-variant)

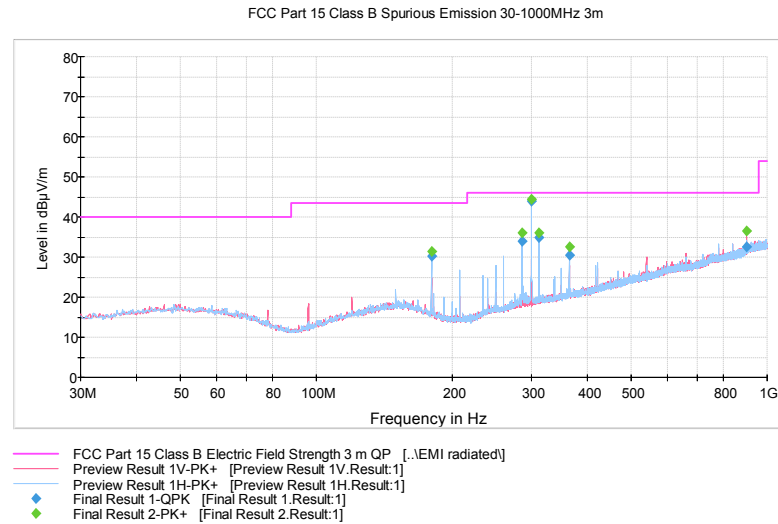


Figure 25: Mid channel 30 MHz – 1000 MHz

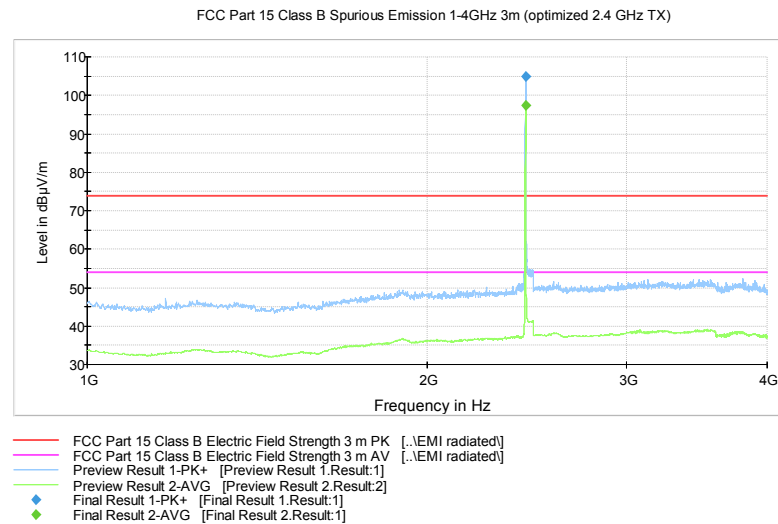


Figure 26: Mid channel 1 GHz – 4 GHz

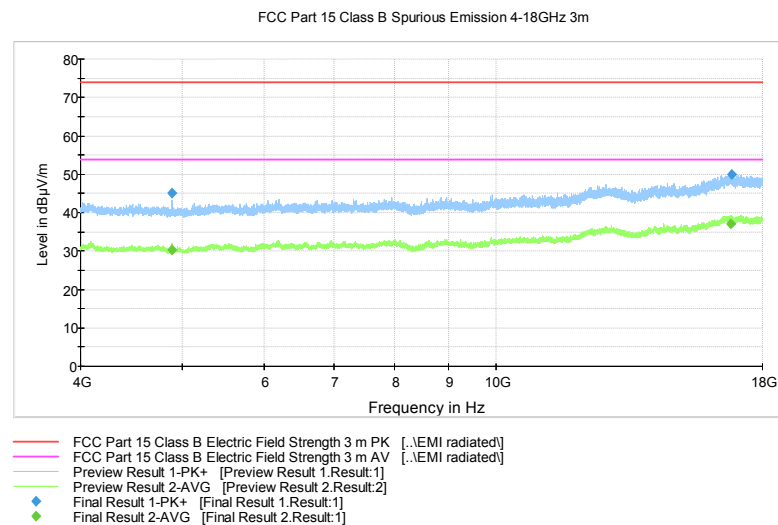


Figure 27: Mid channel 4 GHz – 18 GHz

Transmitter Radiated Spurious Emissions

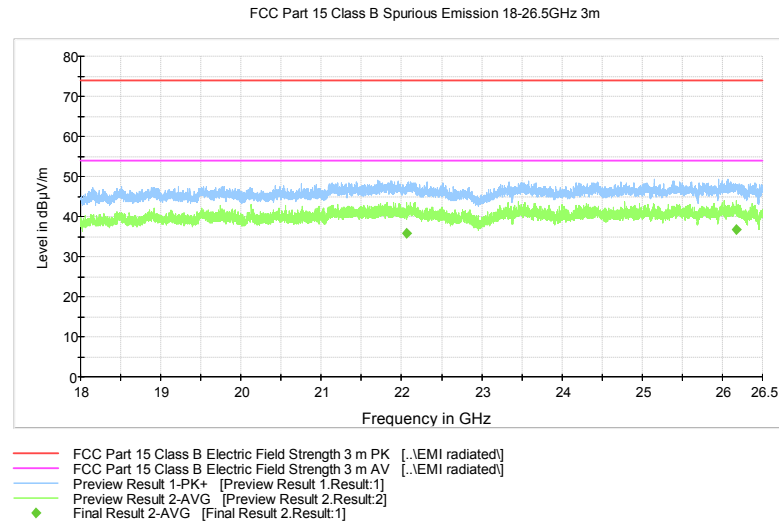


Figure 28: Mid channel 18 GHz – 26.5 GHz

Table 18: Quasi-peak results (ch mid)

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
180.015000	30.1	1000.0	120.000	172.0	H	15.0	13.0	13.4	43.5
286.015000	34.0	1000.0	120.000	100.0	H	91.0	14.9	12.0	46.0
300.015000	43.9	1000.0	120.000	100.0	H	90.0	15.3	2.1	46.0
312.015000	34.8	1000.0	120.000	100.0	H	96.0	15.7	11.2	46.0
364.015000	30.4	1000.0	120.000	100.0	H	10.0	16.9	15.6	46.0
900.055000	32.6	1000.0	120.000	100.0	V	169.0	27.0	13.4	46.0

Table 19: Peak results (ch mid)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
4889.900000	45.1	1000.0	1000.000	179.0	V	332.0	8.3	28.8	73.9
16825.50000	50.0	1000.0	1000.000	150.0	H	26.0	26.8	23.9	73.9

Table 20: 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)
4891.100000	30.2	1000.0	1000.000	150.0	V	331.0	8.3	23.7	53.9
16793.60000	37.1	1000.0	1000.000	150.0	H	348.0	26.8	16.8	53.9
22068.25000	35.9	1000.0	1000.000	257.0	H	329.0	22.4	18.0	53.9
26172.70000	36.8	1000.0	1000.000	240.0	H	151.0	26.4	17.1	53.9

Transmitter Radiated Spurious Emissions

High channel (E-variant)

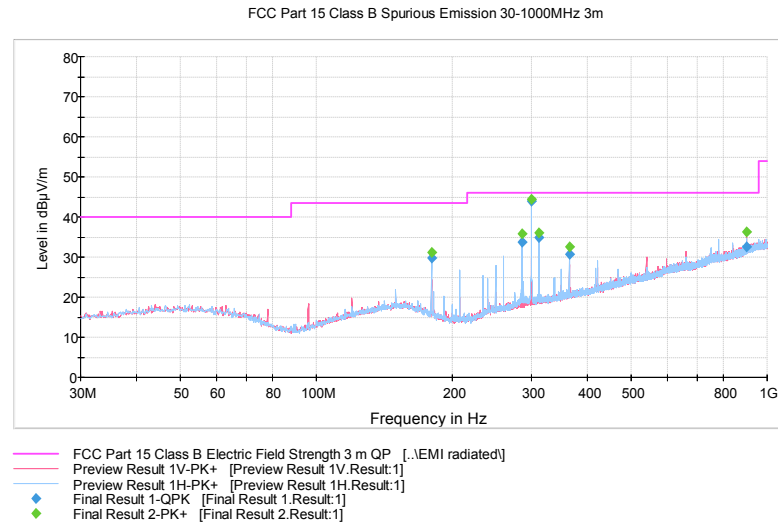


Figure 29: High channel 30 MHz – 1000 MHz

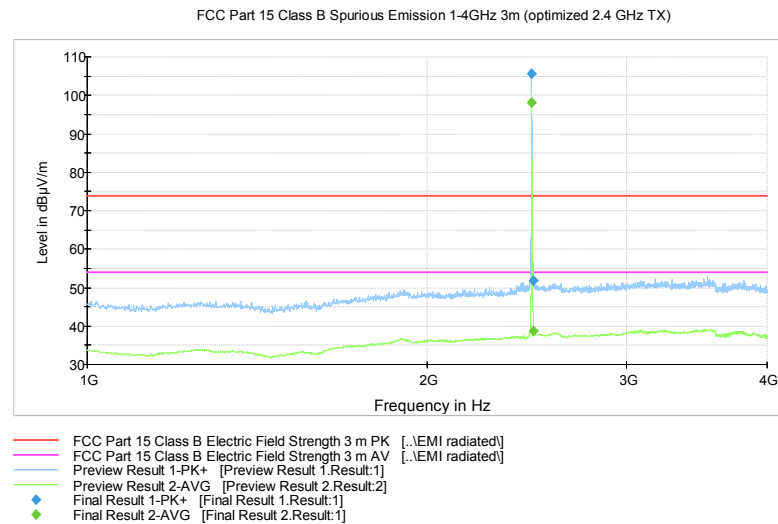


Figure 30: High channel 1 GHz – 4 GHz

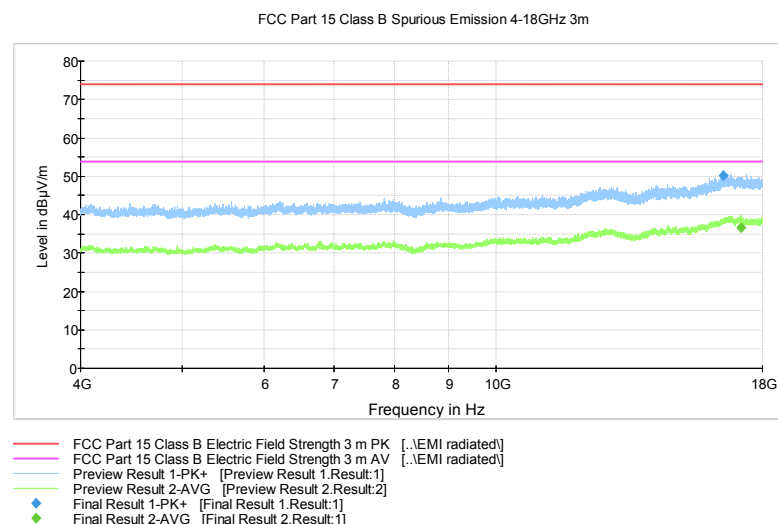


Figure 31: High channel 4 GHz – 18 GHz

Transmitter Radiated Spurious Emissions

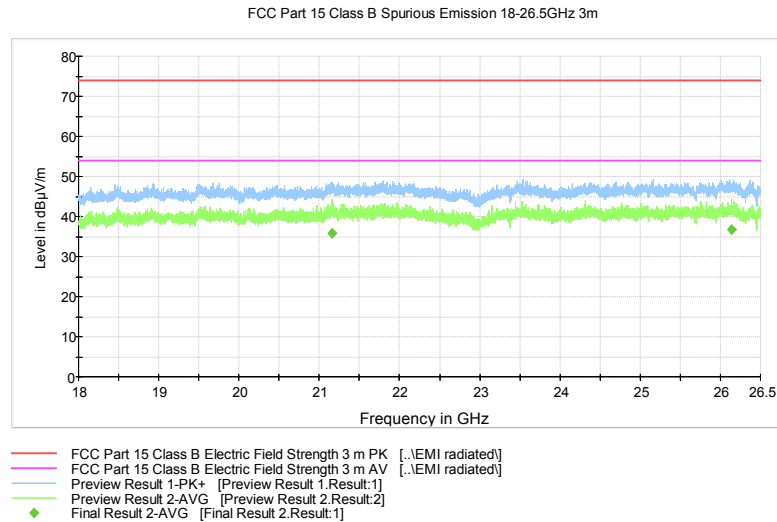


Figure 32: High channel 18 GHz – 26.5 GHz

Table 21: 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)
179.995000	29.8	1000.0	120.000	206.0	H	31.0	13.0	13.7	43.5
286.015000	33.8	1000.0	120.000	111.0	H	90.0	14.9	12.2	46.0
300.015000	43.9	1000.0	120.000	100.0	H	88.0	15.3	2.1	46.0
312.015000	34.8	1000.0	120.000	100.0	H	94.0	15.7	11.2	46.0
364.015000	30.7	1000.0	120.000	100.0	H	0.0	16.9	15.3	46.0
900.055000	32.5	1000.0	120.000	111.0	V	176.0	27.0	13.5	46.0

Table 22: 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)
2484.300000	51.9	1000.0	1000.000	150.0	V	5.0	14.7	22.0	73.9
16521.10000	50.1	1000.0	1000.000	150.0	H	98.0	26.1	23.8	73.9

Table 23: 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)
2483.500000	38.8	1000.0	1000.000	178.0	V	216.0	14.7	15.1	53.9
17185.00000	36.6	1000.0	1000.000	150.0	H	348.0	27.0	17.3	53.9
21154.80000	35.7	1000.0	1000.000	265.0	V	251.0	20.6	18.2	53.9
26140.95000	36.7	1000.0	1000.000	150.0	H	11.0	26.4	17.2	53.9

Transmitter Radiated Spurious Emissions

Radiated Band Edge results (E-variant)

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

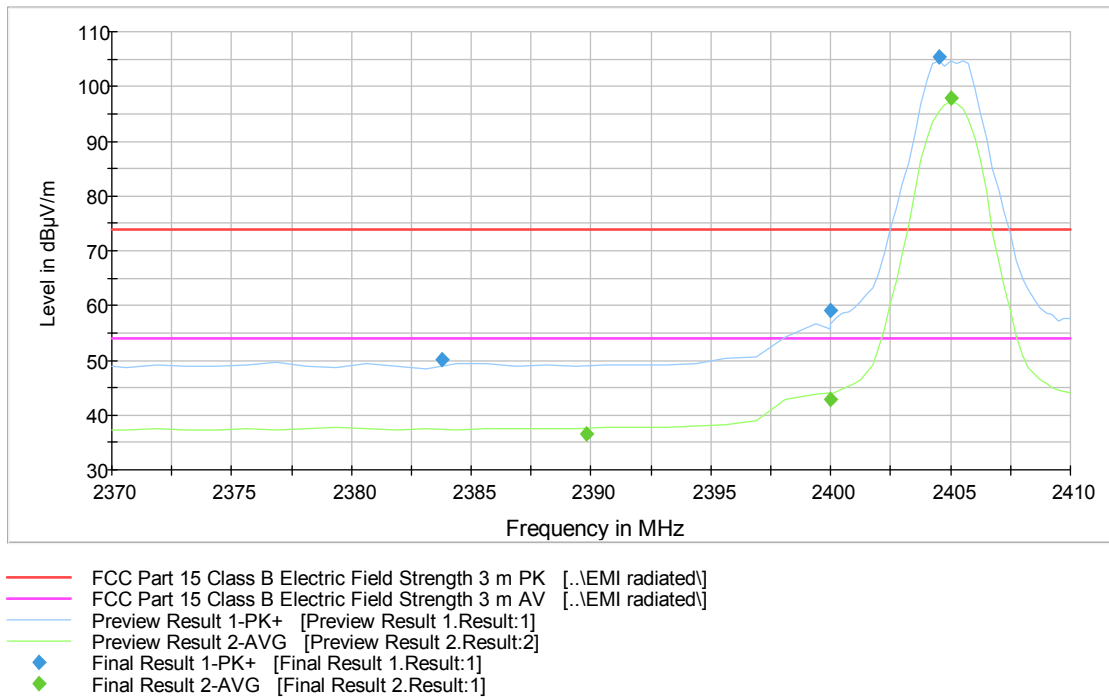


Figure 33: Radiated Band Edge measurement graph (ch low)

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

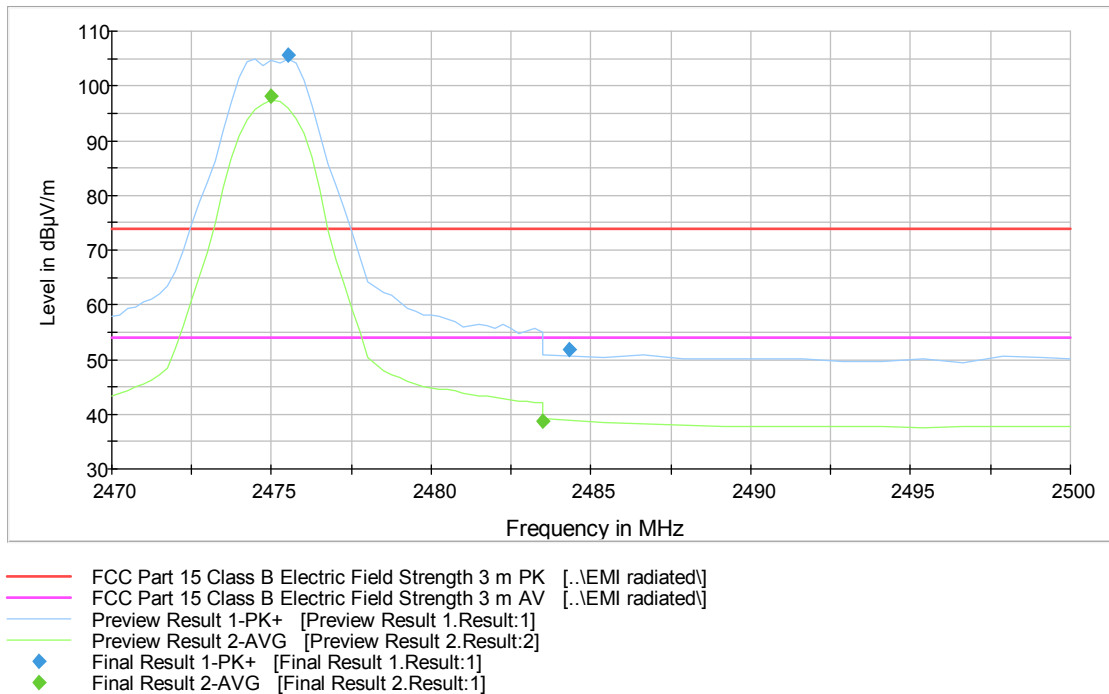


Figure 34: Radiated Band Edge measurement graph (ch high(1))

Transmitter Radiated Spurious Emissions

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

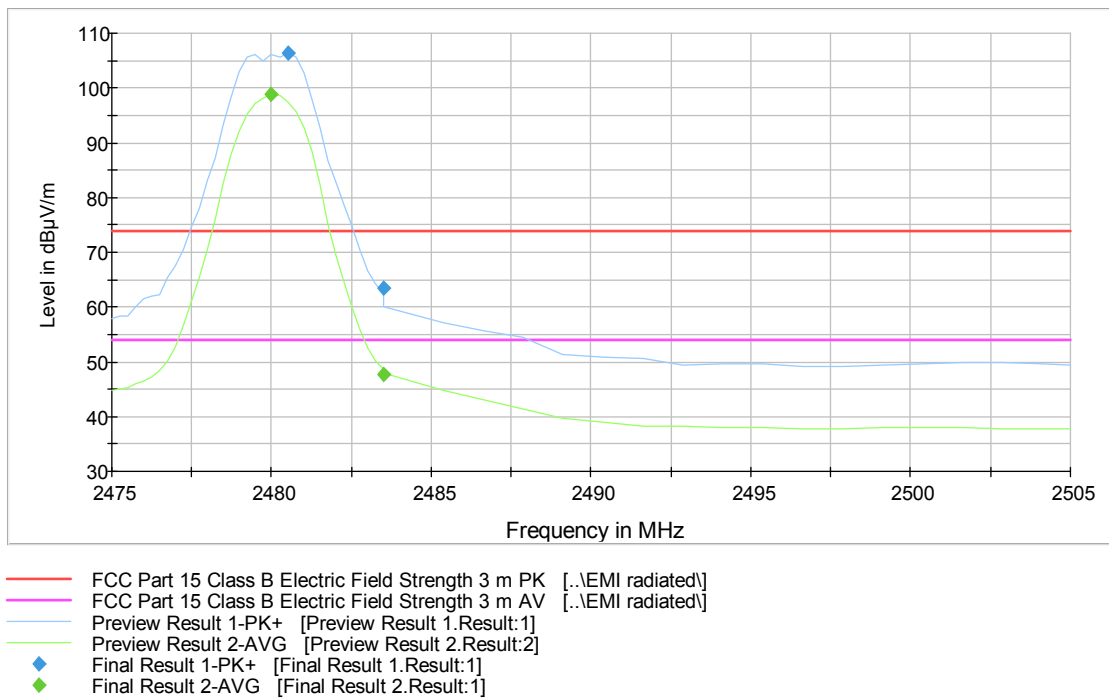


Figure 35: Radiated Band Edge measurement graph (ch high(2))

Table 24: Peak results (2480 MHz)

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
2483.500000	63.5	1000.0	1000.000	191.0	V	0.0	14.7	10.4	73.9

Table 25: Average results (2480 MHz)

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
2483.500000	47.7	1000.0	1000.000	191.0	V	0.0	14.7	6.2	53.9

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Standard: ANSI C63.10 (2013)
Tested by: EHA
Date: 28 March 2017 -
29 June 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 26: Band edge attenuation

Band Edge Attenuation		
Lower Band Edge	Upper Band Edge (high(1))	Upper Band Edge (high(2))
-46.59	-46.48	-46.24
Limit: -20 dBc		

Table 27: Conducted spurious emissions (ch low)

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
911.90	-69.94	-12.07	-57.87	PASS
2399.54	-50.63	-12.07	-38.55	PASS
3829.99	-66.17	-12.07	-54.10	PASS
6955.05	-63.02	-12.07	-50.95	PASS
8514.91	-61.66	-12.07	-49.58	PASS
12818.55	-59.97	-12.07	-47.90	PASS
15830.27	-57.32	-12.07	-45.24	PASS
16156.23	-55.06	-12.07	-42.99	PASS
19175.54	-57.80	-12.07	-45.72	PASS
24107.01	-57.46	-12.07	-45.39	PASS
25593.91	-56.78	-12.07	-44.70	PASS

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Table 28: Conducted spurious emissions (ch mid)

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
770.31	-70.65	-12.39	-58.26	PASS
2291.48	-67.68	-12.39	-55.30	PASS
2484.09	-63.19	-12.39	-50.80	PASS
4888.96	-53.82	-12.39	-41.43	PASS
8479.56	-61.75	-12.39	-49.36	PASS
12522.50	-59.50	-12.39	-47.11	PASS
15845.65	-57.18	-12.39	-44.79	PASS
16168.98	-56.02	-12.39	-43.63	PASS
19504.97	-57.47	-12.39	-45.08	PASS
24433.53	-57.10	-12.39	-44.71	PASS
26156.02	-57.22	-12.39	-44.83	PASS

Table 29: Conducted spurious emissions (ch high(1))

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
776.62	-70.48	-12.51	-57.97	PASS
1991.67	-68.18	-12.51	-55.68	PASS
2483.71	-58.67	-12.51	-46.16	PASS
4948.95	-52.85	-12.51	-40.35	PASS
8835.33	-62.45	-12.51	-49.94	PASS
12468.22	-59.78	-12.51	-47.27	PASS
15804.40	-57.18	-12.51	-44.67	PASS
16148.45	-56.01	-12.51	-43.50	PASS
19167.85	-57.69	-12.51	-45.18	PASS
24161.85	-57.28	-12.51	-44.78	PASS
25451.98	-56.86	-12.51	-44.36	PASS

Table 30: Conducted spurious emissions (ch high(2))

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
933.97	-69.99	-11.97	-58.02	PASS
1717.28	-65.18	-11.97	-53.21	PASS
2483.76	-46.57	-11.97	-34.60	PASS
4961.05	-54.17	-11.97	-42.20	PASS
7479.66	-61.19	-11.97	-49.22	PASS
12515.37	-59.56	-11.97	-47.59	PASS
15804.12	-57.29	-11.97	-45.32	PASS
16164.01	-55.11	-11.97	-43.14	PASS
19154.64	-57.17	-11.97	-45.20	PASS
24825.30	-56.80	-11.97	-44.83	PASS
26102.58	-55.67	-11.97	-43.70	PASS

Transmitter Band Edge Measurement and Conducted Spurious Emissions

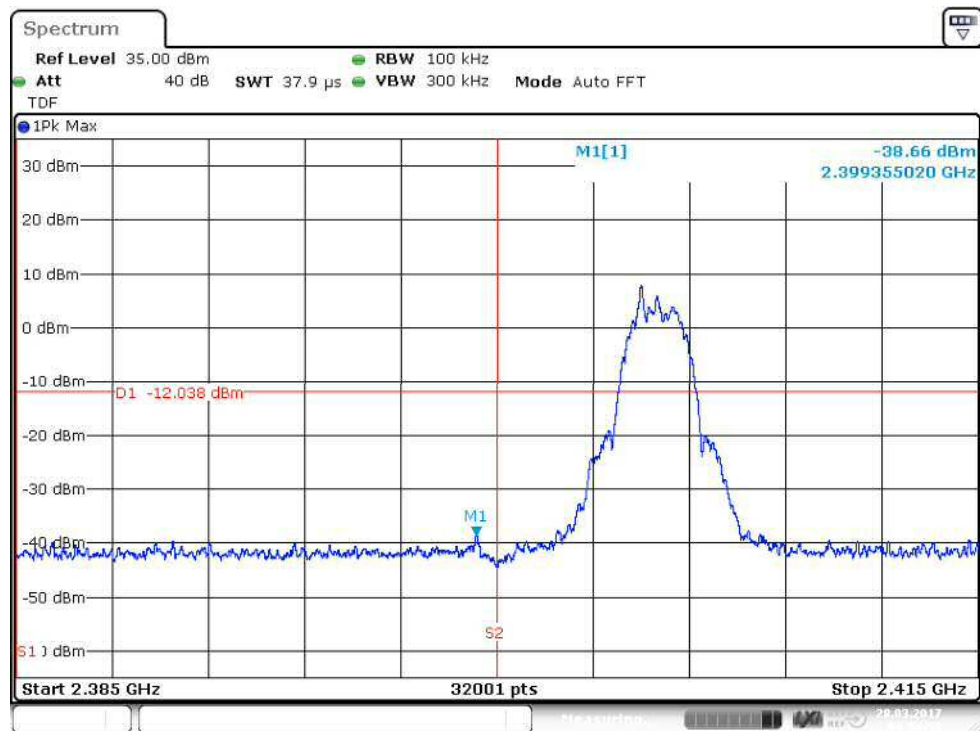


Figure 36: Lower Band Edge

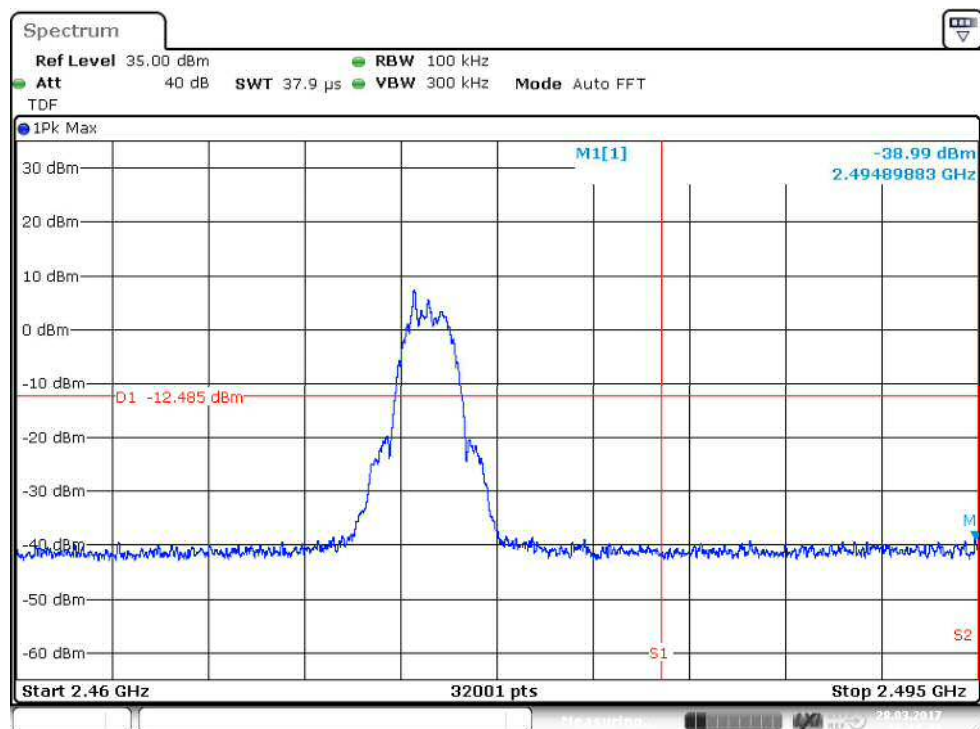


Figure 37: Upper Band Edge (high (1))

Transmitter Band Edge Measurement and Conducted Spurious Emissions

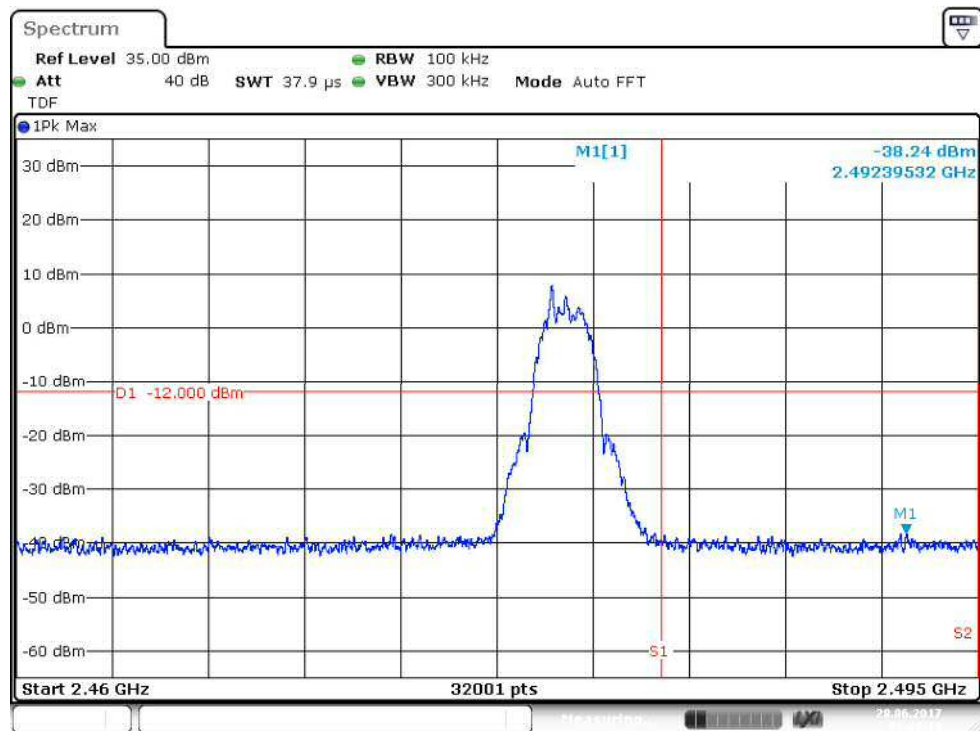


Figure 38: Upper Band Edge (high(2))

Transmitter Band Edge Measurement and Conducted Spurious Emissions

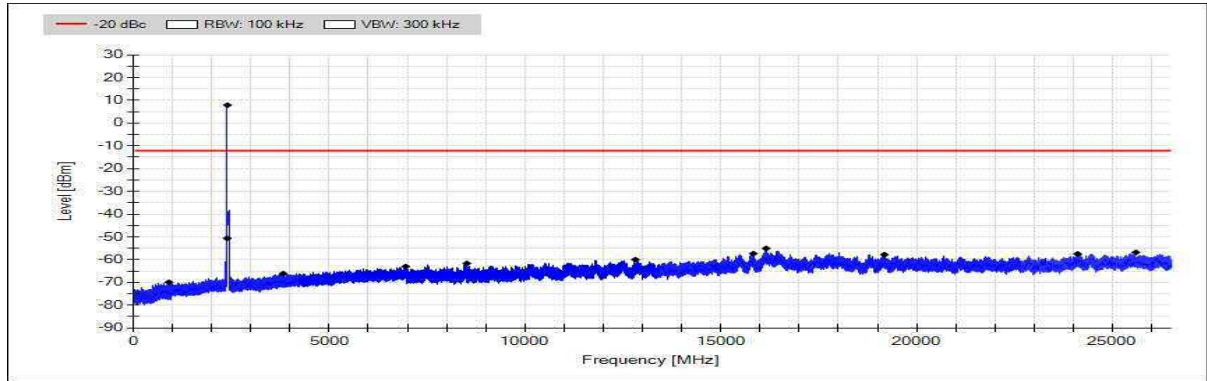


Figure 39: Conducted spurious emissions 30 - 26500 MHz channel low

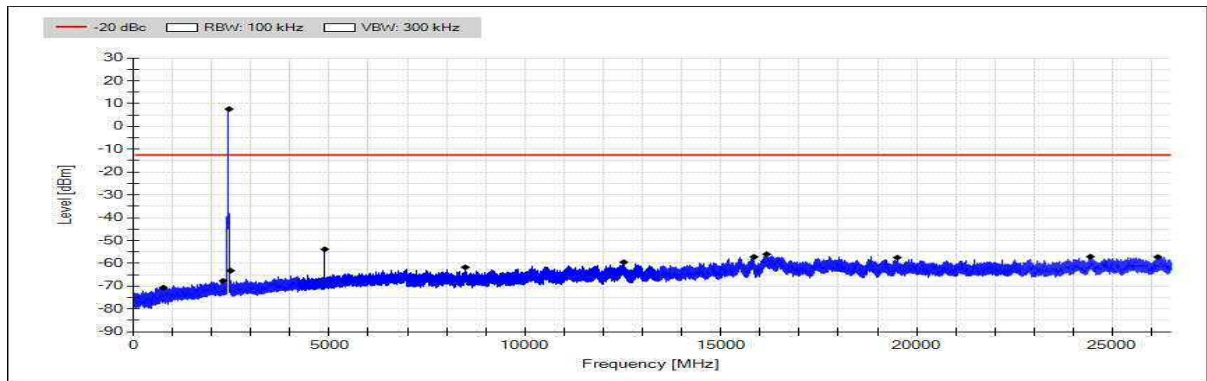


Figure 40: Conducted spurious emissions 30 - 26500 MHz channel mid

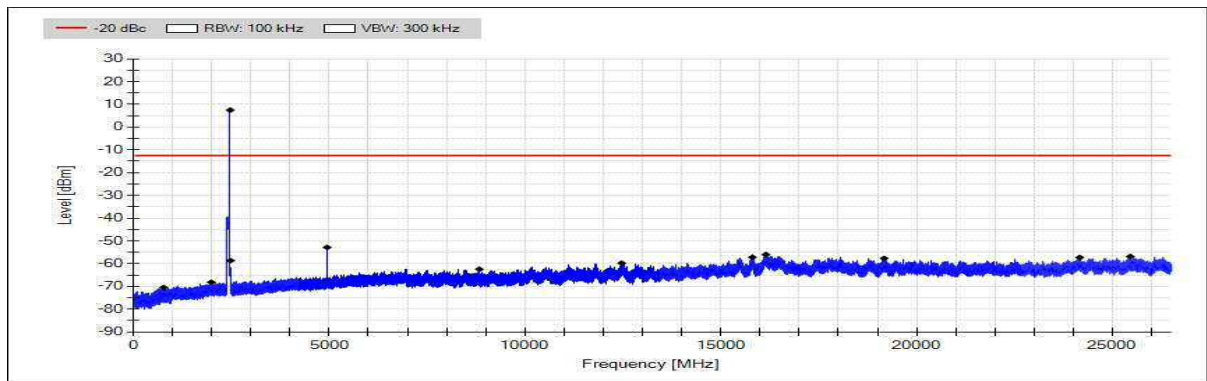


Figure 41: Conducted spurious emissions 30 - 26500 MHz channel high(1)

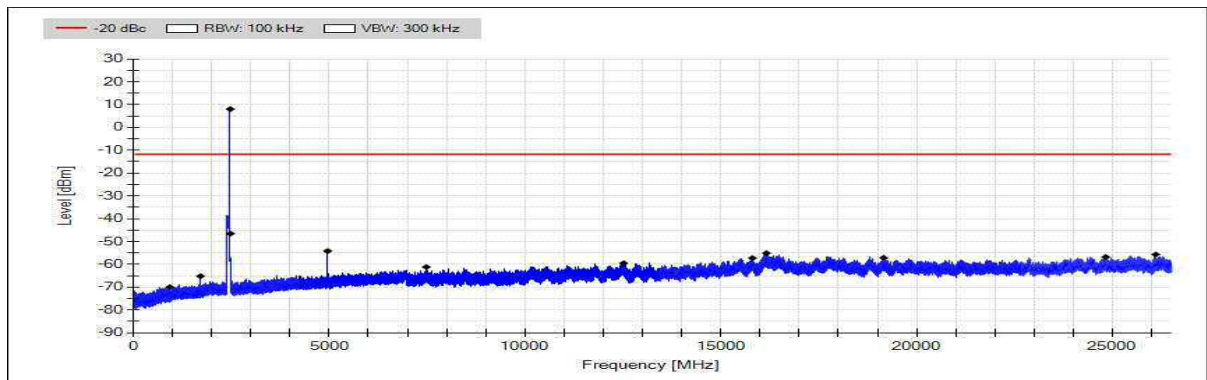


Figure 42: Conducted spurious emissions 30 - 26500 MHz channel high(2)

6 dB Bandwidth of the Channel

Standard: ANSI C63.10 (2013)
Tested by: EHA
Date: 28 March 2017 -
 29 June 2017
Temperature: 23 ± 3 °C
Humidity: 20 - 60 % RH

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

Results:

Table 31: 6 dB bandwidth test results

Channel	6 dB BW [kHz]	Minimum limit [kHz]
Low	1322	500
Mid	1319	
High(1)	1316	
High(2)	1319	

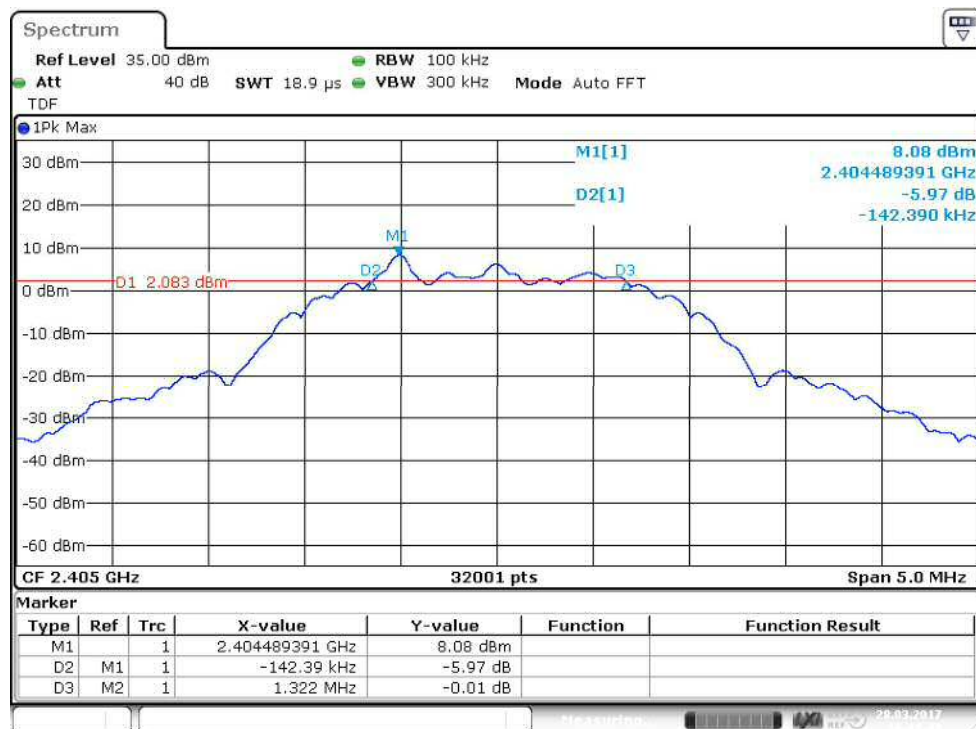


Figure 43: 6 dB bandwidth (ch low)

6 dB Bandwidth of the Channel

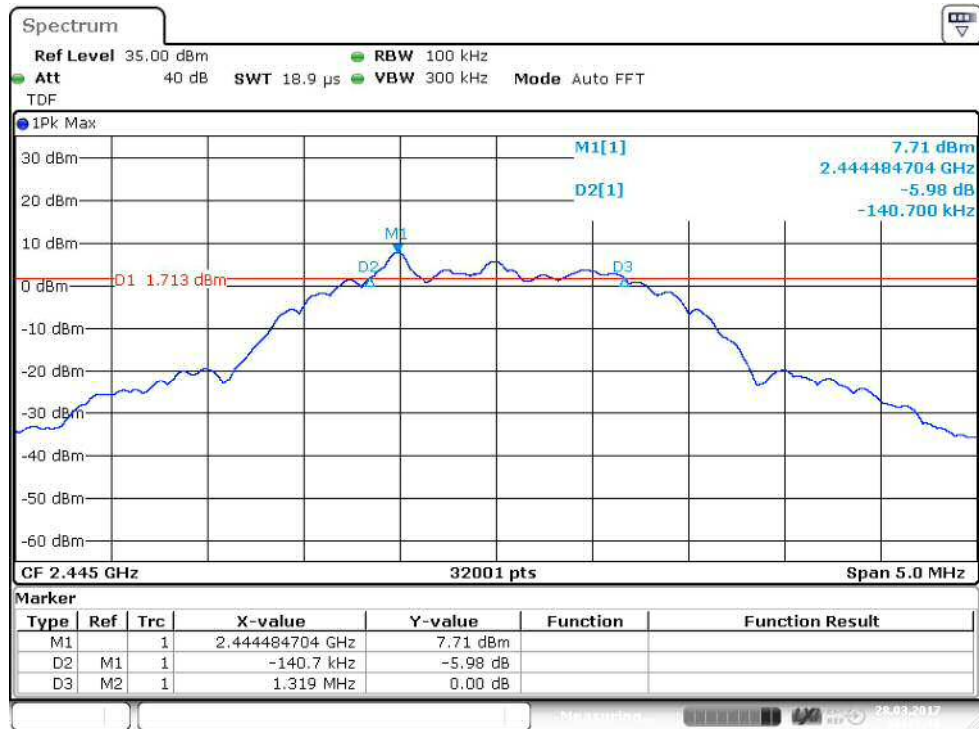


Figure 44: 6 dB bandwidth (ch mid)

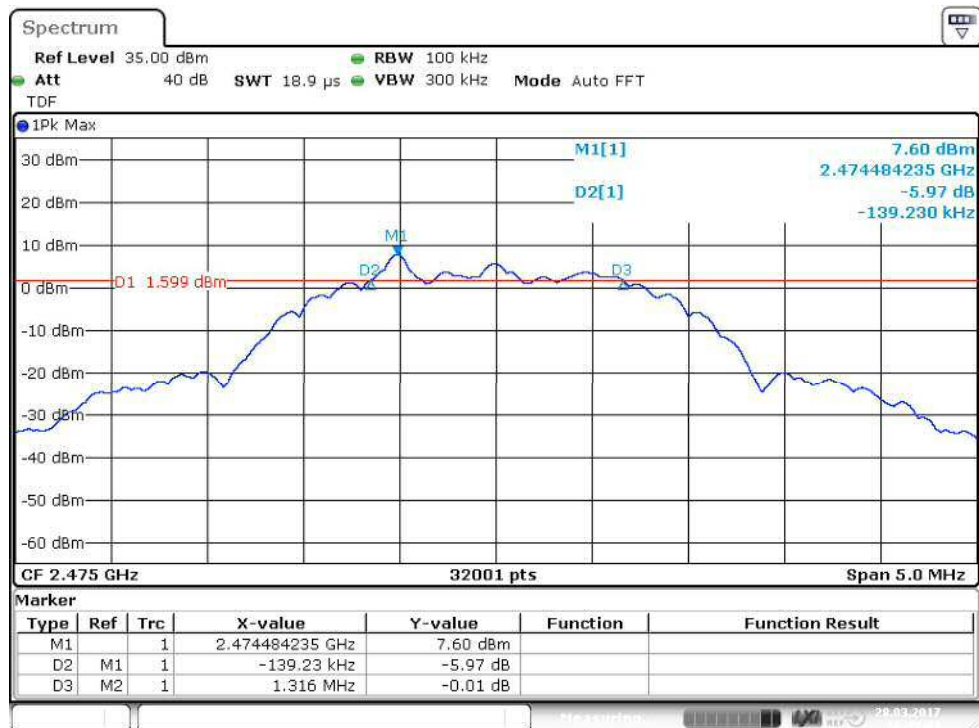


Figure 45: 6 dB bandwidth (ch high(1))

6 dB Bandwidth of the Channel

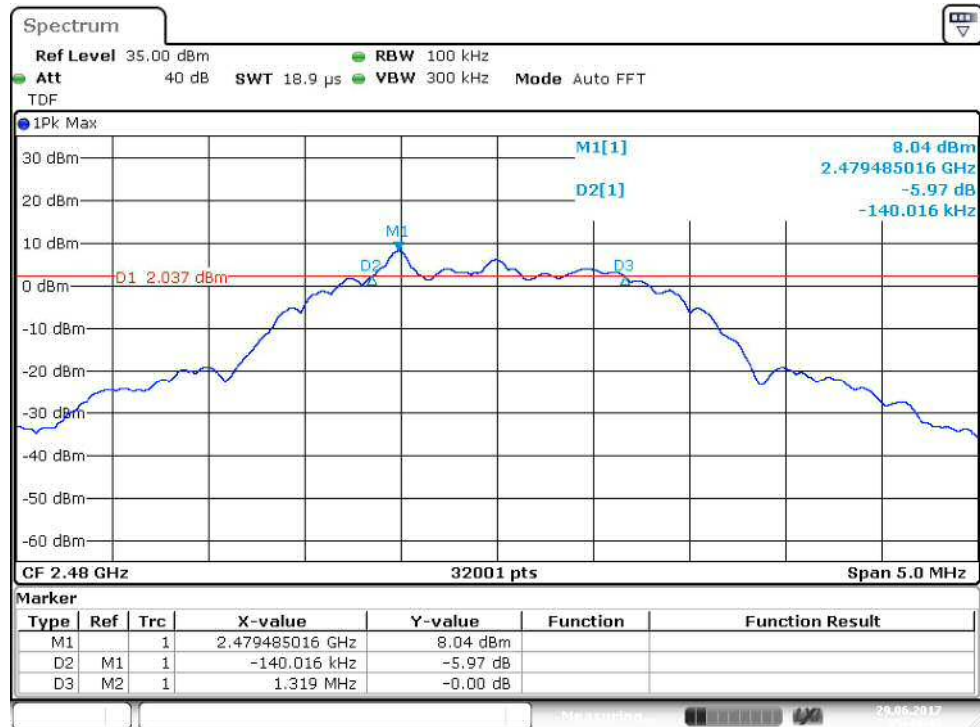


Figure 46: 6 dB bandwidth (ch high(2))

Power Spectral Density

Standard: ANSI C63.10 (2013)
Tested by: EHA
Date: 28 March 2017 - 29 June 2017
Temperature: 23 ± 3 °C
Humidity: 20 - 60 % RH

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

Results:

Table 32: Power spectral density test results

Channel	PSD dBm/3 kHz	Maximum limit [dBm/3kHz]
Low	-1.74	+8.00
Mid	-2.01	
High(1)	-2.22	
High(2)	-1.53	

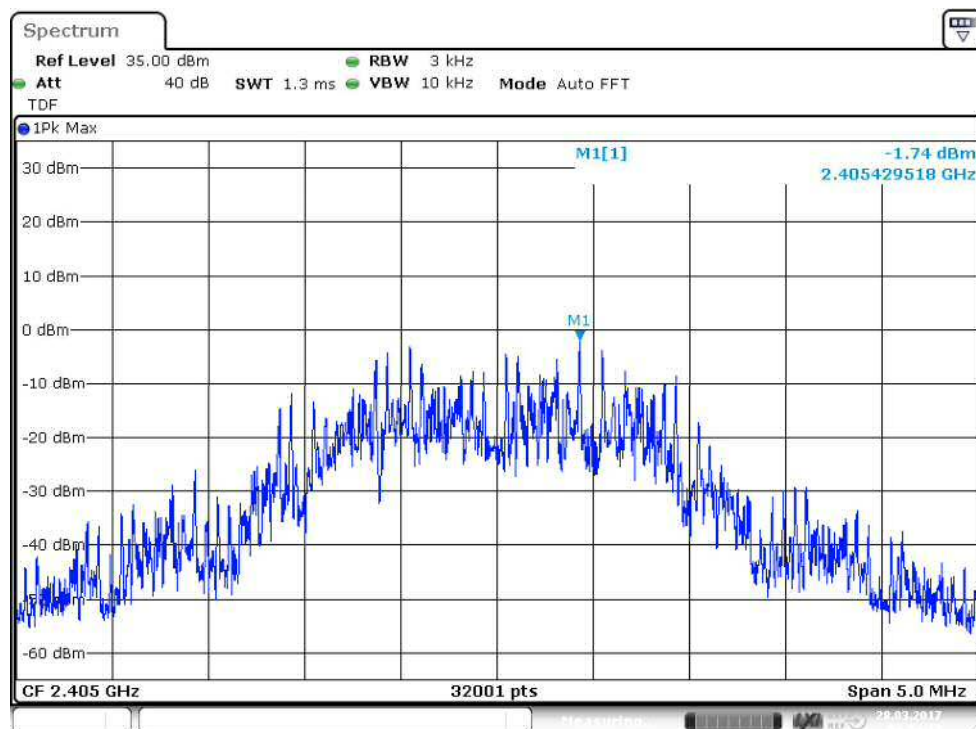


Figure 47: Power spectral density (ch low)

Power Spectral Density

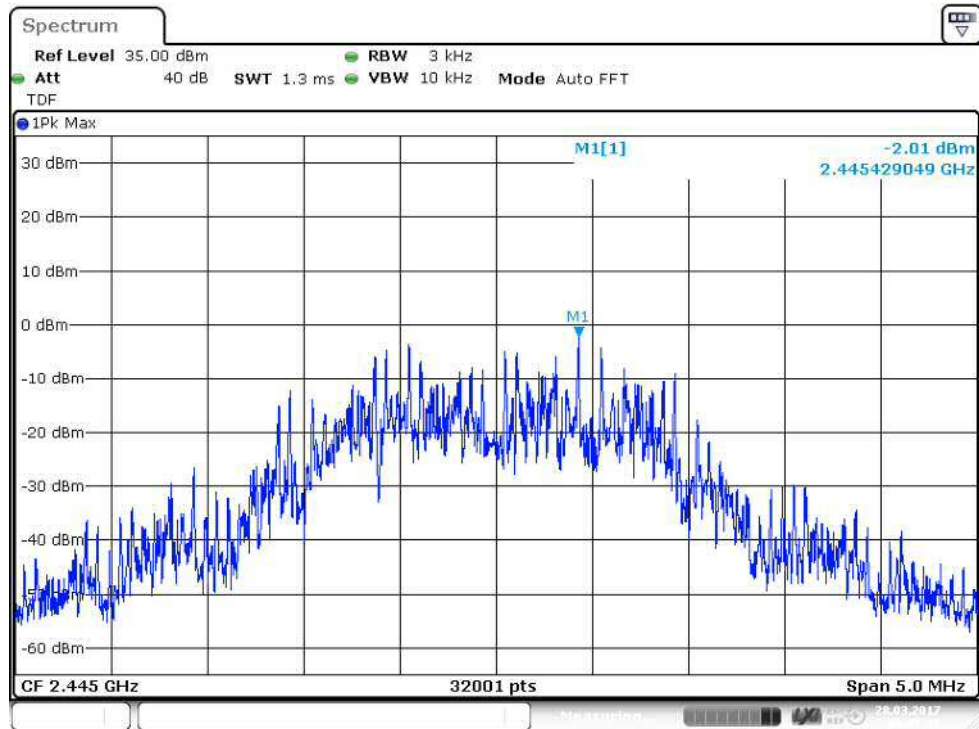


Figure 48: Power spectral density (ch mid)

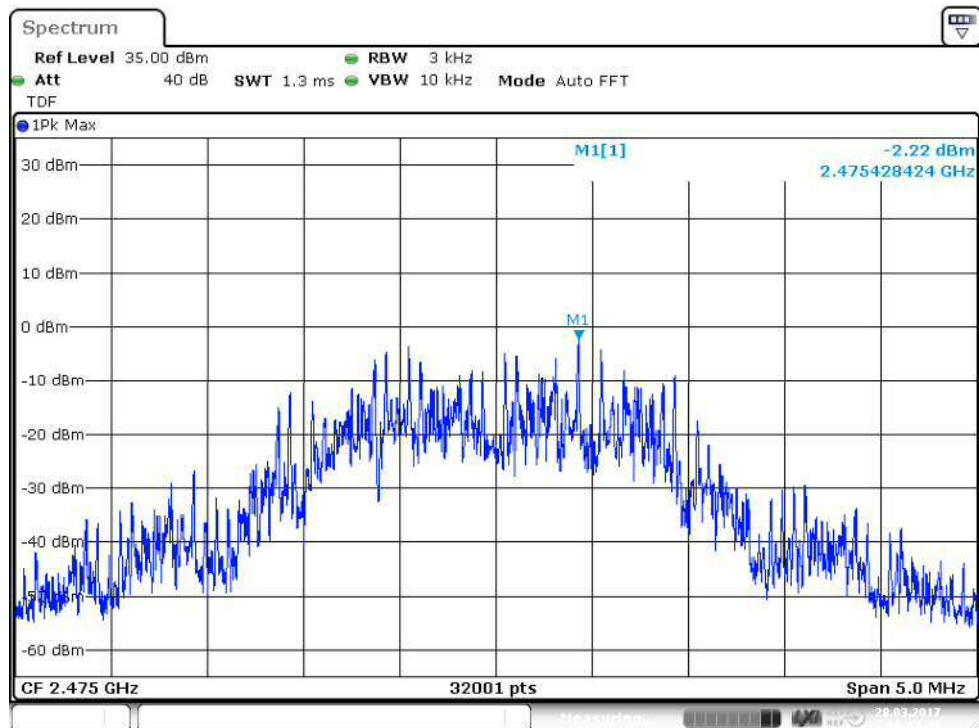


Figure 49: Power spectral density (ch high(1))

Power Spectral Density

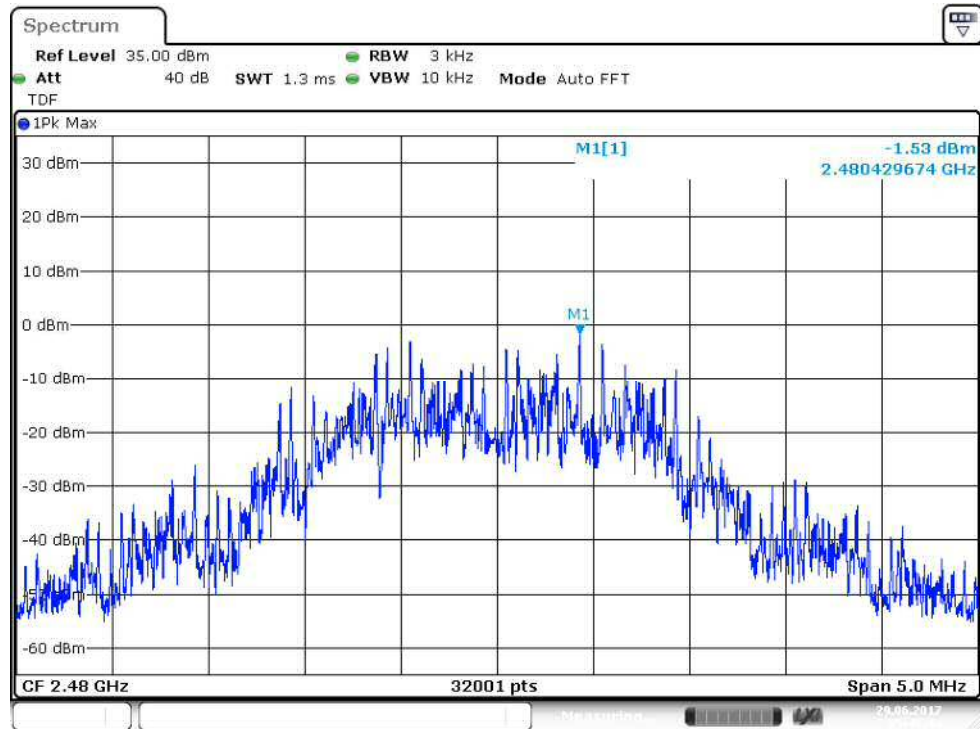


Figure 50: Power spectral density (ch high(2))

99% Occupied Bandwidth

Standard: RSS-GEN (2014)
Tested by: EHA
Date: 28 March 2017 -
29 June 2017
Temperature: 23 ± 3 °C
Humidity: 20 - 60 % RH

RSS-GEN 6.6

Table 33: 99% occupied bandwidth test results

Channel	Limit	99 % BW [MHz]	Result
Low	-	2.218993156	PASS
Mid	-	2.229930315	PASS
High(1)	-	2.240554983	PASS
High(2)	-	2.232742727	PASS

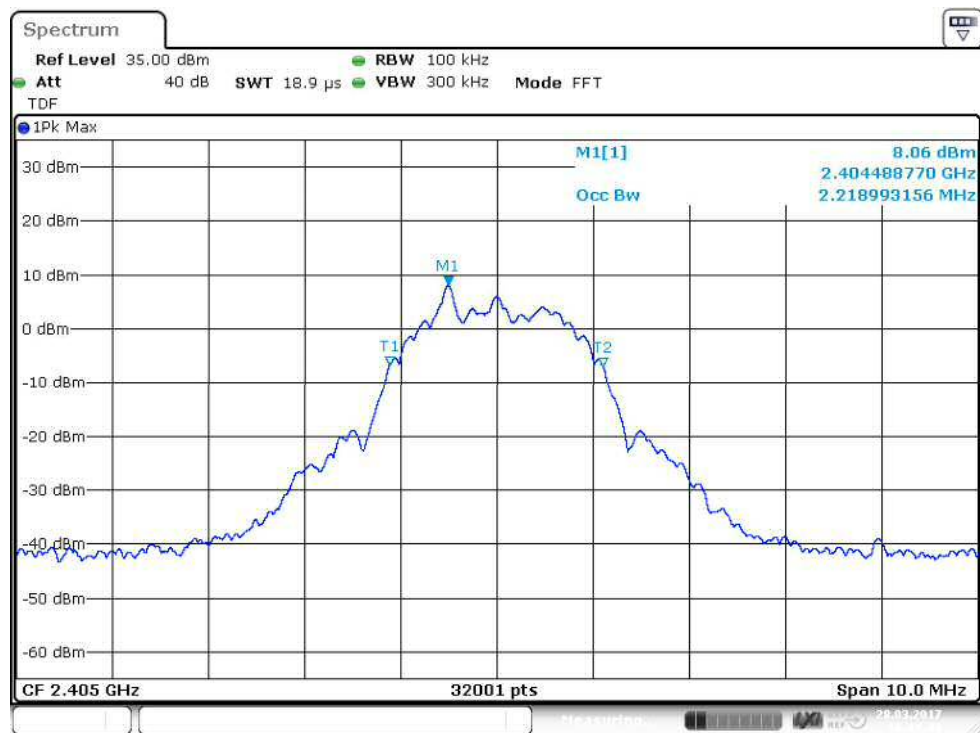
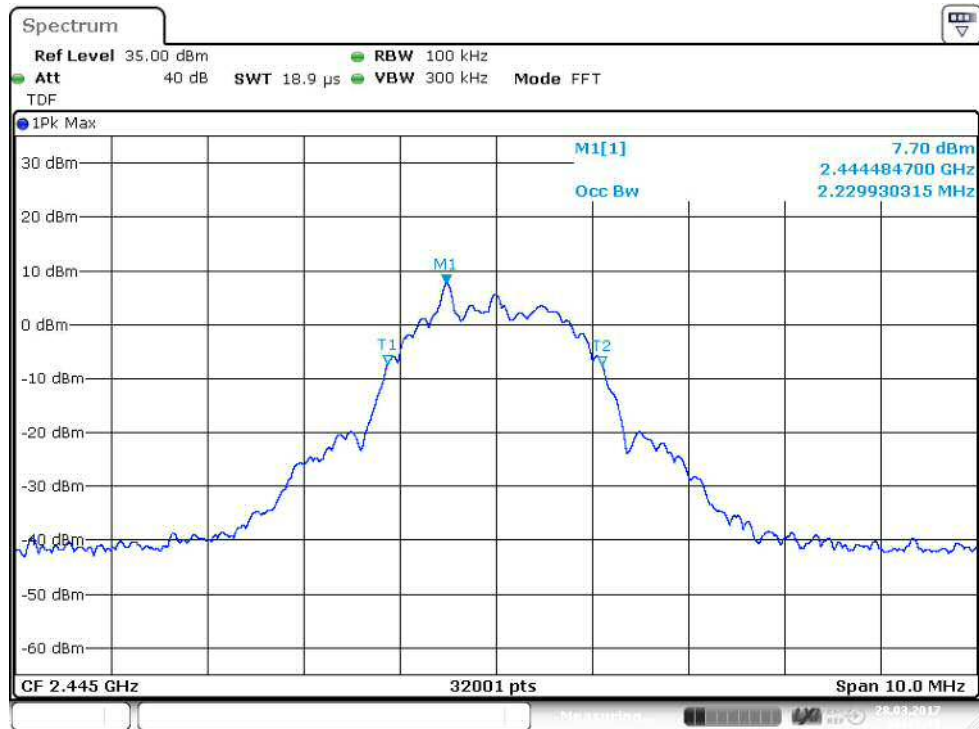
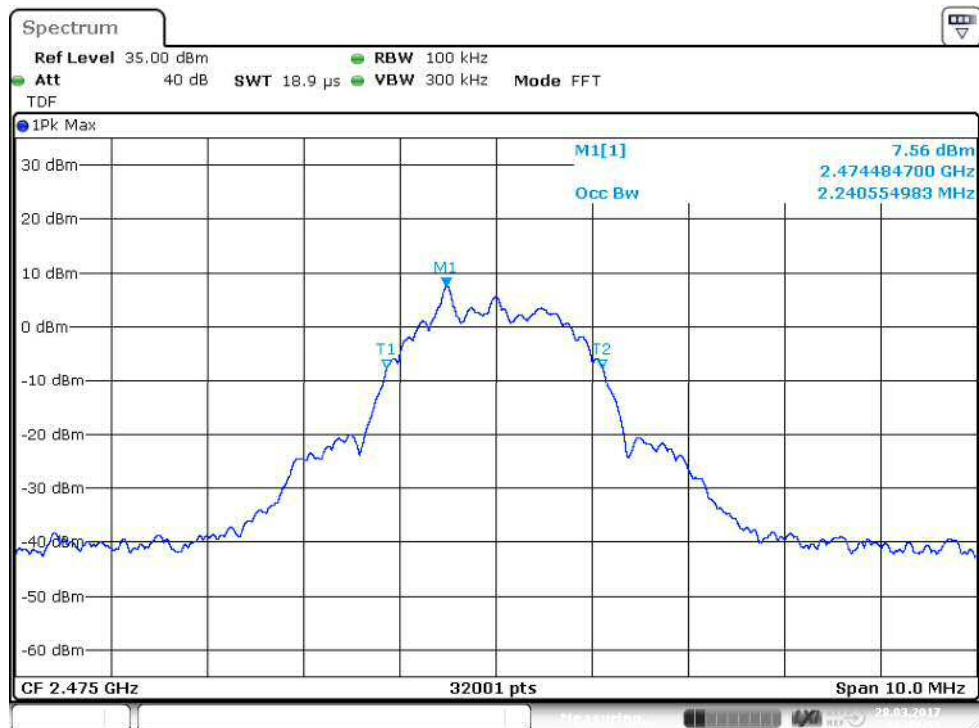


Figure 51: 99% OBW (ch low)


Figure 52: 99% OBW (ch mid)

Figure 53: 99% OBW (ch high(1))

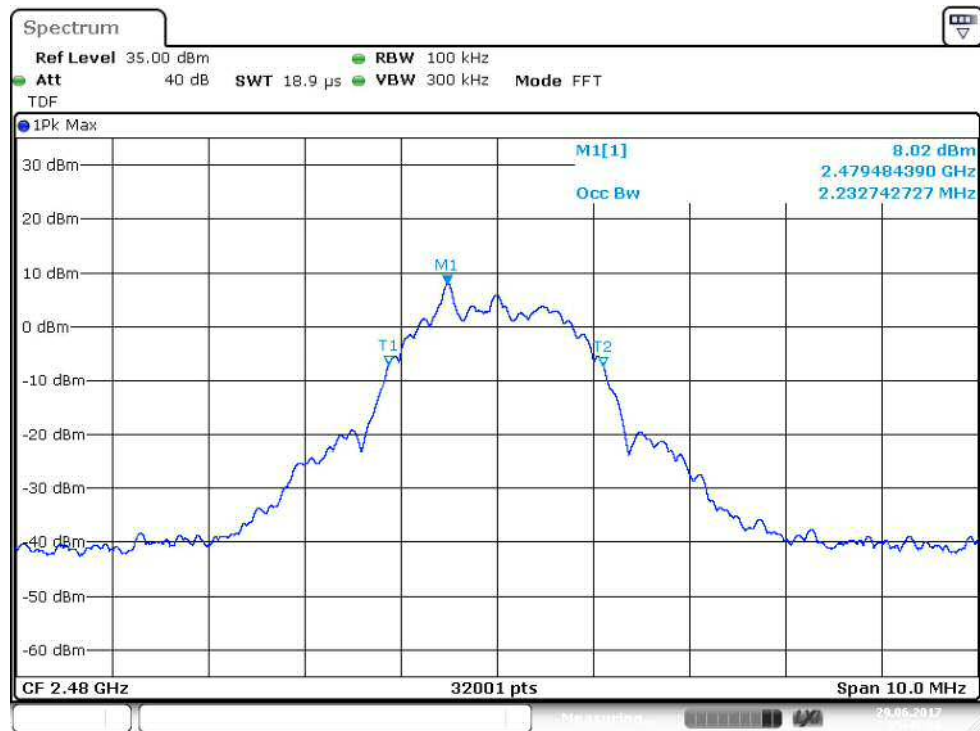


Figure 54: 99% OBW (ch high(2))

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
TURNTABLE	MATURO	DS430 UPGRADED	inv:10182	-	-
MAST & TURNTABLE CONTROLLER	MATURO	NCD	inv:10183	-	-
ANTENNA MAST	MATURO	TAM 4.0E	inv:10181	-	-
ATTENUATOR	PASTERNAK	10dB DC-40GHz	-	-	-
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESU 26	inv:8453	2016-06-10	2017-07-10
SIGNAL ANALYZER	ROHDE & SCHWARZ	FSV40	inv:9093	2016-06-10	2017-07-10
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