

Test Report



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

Equipment Under Test: Multi-Protocol Wireless Module

Model: MGM13P12A
MGM13P12E

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

Customer: Silicon Laboratories Finland Oy
Bertel Jungin aukio 3
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FCC Rule Part: 15.247: 2017
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 5, 2017)

Date: 12 February 2018

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Issued by:

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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	4
GENERAL REMARKS	5
Disclaimer	5
SUMMARY OF TESTING	6
EUT Test Conditions during Testing	6
TEST RESULTS	8
Conducted Emissions In The Frequency Range 150 kHz - 30 MHz	8
Maximum Peak Conducted Output Power	11
Transmitter Radiated Spurious Emissions 30 - 26500 MHz	16
Transmitter Band Edge Measurement and Conducted Spurious Emissions	37
6 dB Bandwidth of the Channel	45
Power Spectral Density	49
99% Occupied Bandwidth	53
TEST EQUIPMENT	58

Equipment Under Test (EUT)

Trade mark:	Silicon Labs
Model:	MGM13P12A, MGM13P12E
Type:	Multi-Protocol Wireless Module
Serial no:	-
FCC ID:	QOQMGM13P
IC:	5123A-MGM13P

Description of the EUT

MGM13P12 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:	17.62 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
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Samples

EUT	Description
MGM13P12A	Original A variant, equipped with chip antenna
MGM13P12E	Original E variant with RF pin for external antenna

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.

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

During radiated measurements, E variant was connected to WSTK development board and the A variant was having simplified board with reduced functionality.

Following channels and settings were used during the tests;

MGM13P12A

- Radiated Emissions Within the Restricted Bands (channels: 0, 19, 39)
- Conducted Emissions on Power Supply Lines tests (channel: 19)

Channel	Frequency (MHz)	Power setting	PHY	Low energy transmit	Packet Length	Advertise pulse interval
0	2402	200	125K Coded	PRBS9 (GFSK)	255	-
19	2440	200	125K Coded	PRBS9 (GFSK)	255	-
39	2480	200	125K Coded	PRBS9 (GFSK)	255	-

MGM13P12E

- Radiated Emissions Within the Restricted Bands (channels: 0, 19, 38, 39), channel 39 was used only for band edge measurement.
- Conducted Emissions on Power Supply Lines tests (channel 19)

Channel	Frequency (MHz)	Power setting	PHY	Low energy transmit	Packet Length	Advertise pulse interval
0	2402	200	125K Coded	PRBS9 (GFSK)	255	-
19	2440	200	125K Coded	PRBS9 (GFSK)	255	-
38	2478	200	125K Coded	PRBS9 (GFSK)	255	-
39	2480	200	-	PRBS9 (GFSK)	-	20ms

Summary of Testing

MGM13P12E

- Maximum Peak Conducted Output Power (channels: 0, 19, 38, 39)
- 6 dB Bandwidth (channels: 0, 19, 38, 39)
- Power Spectral Density (channels: 0, 19, 38, 39)
- 99% Occupied Bandwidth (channels: 0, 19, 38, 39)
- 100 kHz Bandwidth of Frequency Band Edges and Conducted Spurious Emissions tests (channels: 0, 19, 38, 39)

Channel	Frequency (MHz)	Power setting	PHY	Low energy transmit	Packet Length	Advertise pulse interval
		MGM13P32E				
0	2402	150	125K Coded	PRBS9 (GFSK)	255	-
0	2402	200	1M Coded	PRBS9 (GFSK)	255	
19	2440	150	125K Coded	PRBS9 (GFSK)	255	-
19	2440	200	1M Coded	PRBS9 (GFSK)	255	
38	2478	150	125K Coded	PRBS9 (GFSK)	255	-
39	2480	150	-	PRBS9 (GFSK)	-	20ms
39	2480	200	1M Coded	PRBS9 (GFSK)	255	-

Test Facility

Testing Laboratory / address: FCC registration number: 904175 Industry Canada registration number: 8708A-2	SGS Fimko Ltd Särkiniementie 3 FI-00210, HELSINKI FINLAND
Test Site:	Kara5m

TEST RESULTS

Conducted Emissions In The Frequency Range 150 kHz - 30 MHz

Standard: ANSI C63.10 (2013)
Tested by: JAT
Date: 14 September 2017
Temperature: $23 \pm 3^{\circ}\text{C}$
Humidity: 20 - 60 % RH
Barometric pressure: 1001 hPa
Measurement uncertainty: $\pm 2.9 \text{ dB}$ Level of confidence 95 % ($k = 2$)

FCC Rule: 15.207 (a)
RSS-GEN 8.8

Conducted disturbance voltage was measured with an artificial main network from 150 kHz to 30 MHz with 4.5 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 Emissions on Power Supply Lines

Final measurements from the worst frequencies

Conducted Emission Mains FCC Part 15 Class B with ENV216

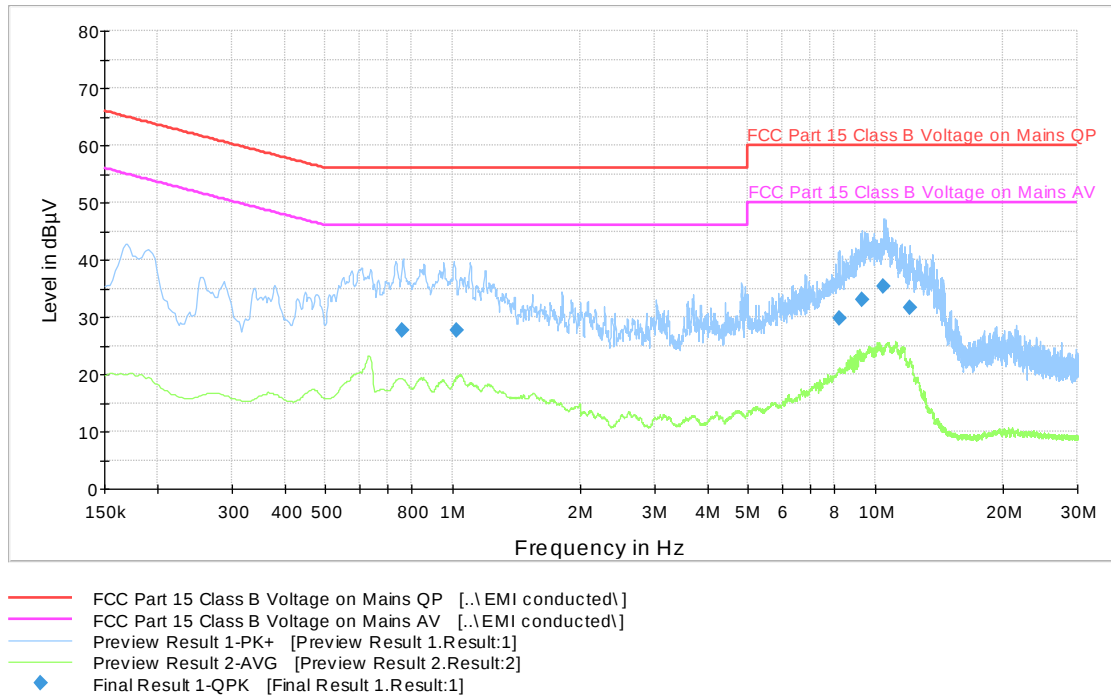


Figure 1: The measured curves with peak- and average detector (A).

Table 1: Final QuasiPeak measurements from the worst frequencies (A)

Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.758500	27.7	1000.0	9.000	L1	10.0	28.3	56.0
1.021250	27.8	1000.0	9.000	L1	10.0	28.2	56.0
8.202250	29.8	1000.0	9.000	L1	10.2	30.2	60.0
9.318500	33.1	1000.0	9.000	L1	10.3	26.9	60.0
10.445000	35.4	1000.0	9.000	L1	10.3	24.6	60.0
12.044000	31.5	1000.0	9.000	L1	10.3	28.5	60.0

Conducted Emissions on Power Supply Lines

Conducted Emission Mains FCC Part 15 Class B with ENV216

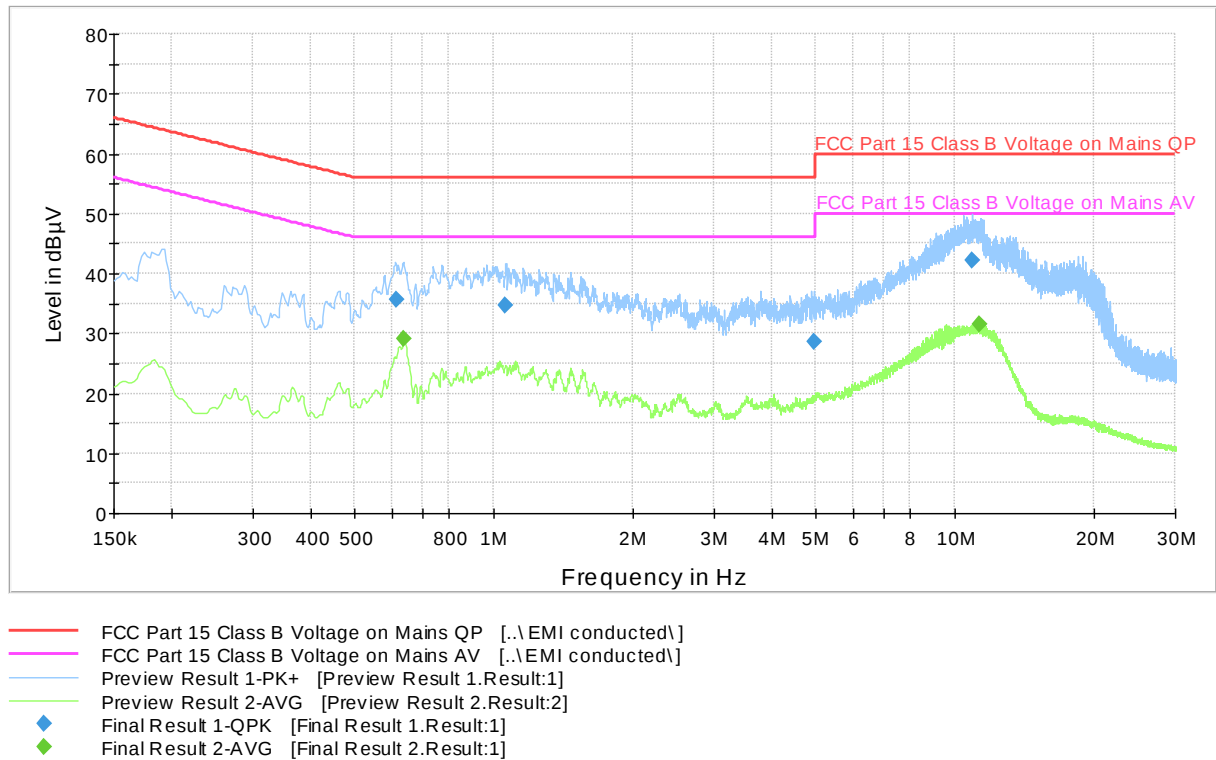


Figure 2: The measured curves with peak- and average detector (E).

Table 2: Final QuasiPeak measurements from the worst frequencies (E)

Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.613500	35.6	1000.0	9.000	N	10.3	20.4	56.0
1.060250	34.6	1000.0	9.000	L1	10.0	21.4	56.0
4.963750	28.6	1000.0	9.000	L1	10.1	27.4	56.0
10.862000	42.1	1000.0	9.000	L1	10.3	17.9	60.0

Table 3: Final Average measurements from the worst frequencies (E)

Frequency (MHz)	Average (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.637750	29.1	1000.0	9.000	N	10.3	16.9	46.0
11.262500	31.4	1000.0	9.000	L1	10.3	18.6	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: MIH
Date: 20 September – 21 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(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 4: Maximum conducted output power (E), power setting 150

Channel	Conducted Power [dBm]	Limit [dBm]	Margin [dBm]	Result
0 Low	13.87	30	16.13	PASS
19 Mid	13.75	30	16.25	PASS
38 High	13.51	30	16.49	PASS
39 High	13.58	30	16.42	PASS

Table 5: Maximum conducted output power (E), power setting 200, PHY 1M coded

Channel	Conducted Power [dBm]	Limit [dBm]	Margin [dBm]	Result
0 Low	17.62	30	12.38	PASS
19 Mid	17.41	30	12.59	PASS
39 High	17.24	30	12.76	PASS

Maximum Peak Conducted Output Power

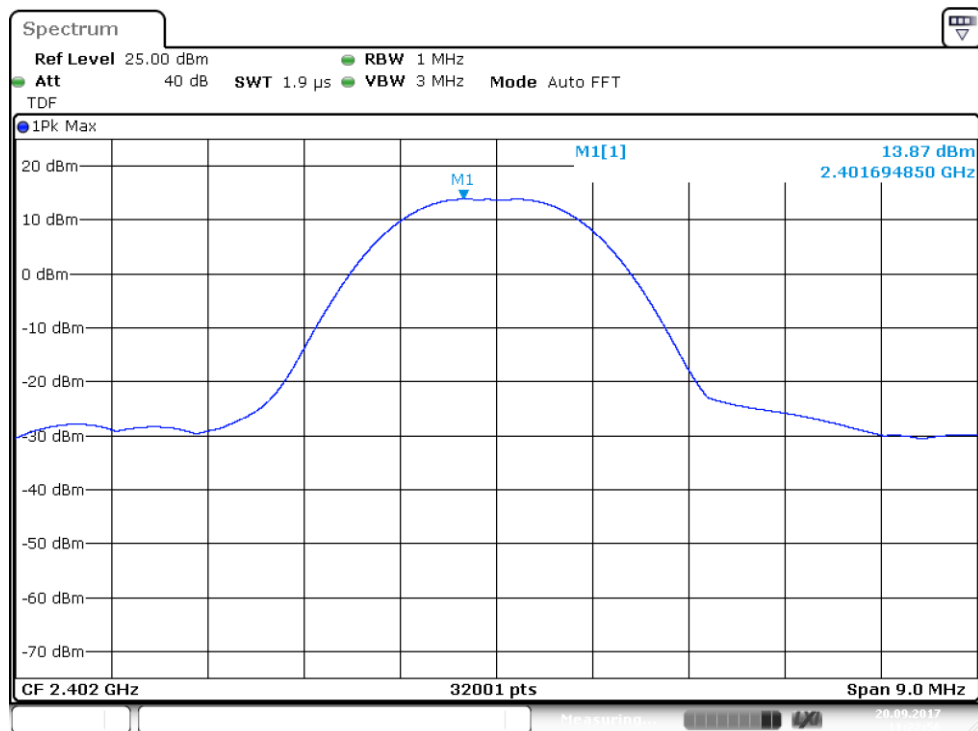


Figure 3: Conducted power, Channel 0 low (E), power setting 150

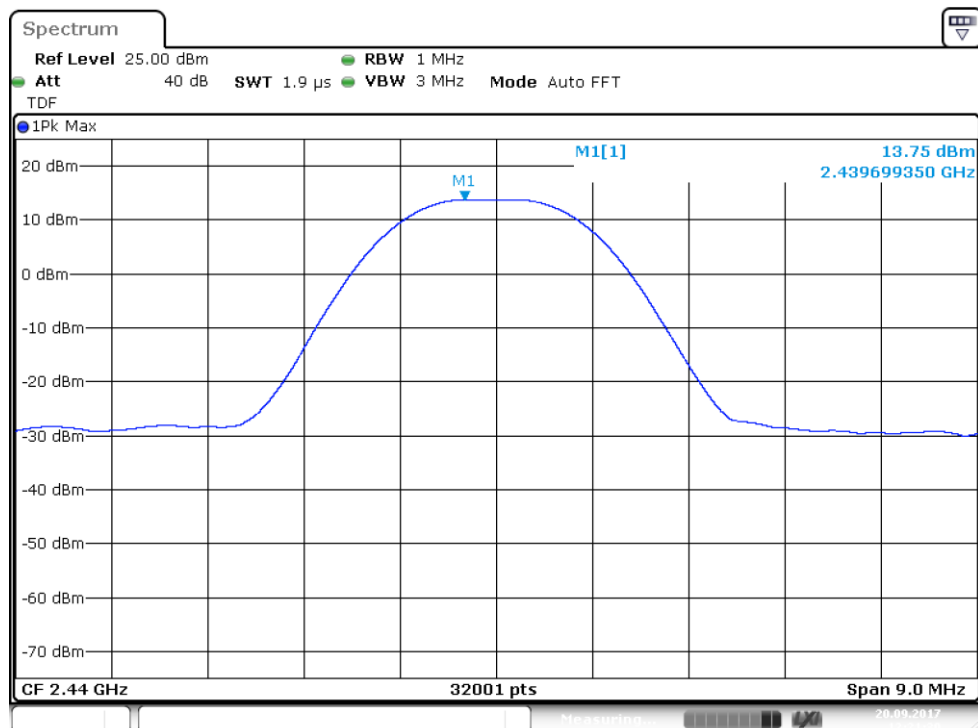


Figure 4: Conducted power, Channel 19 mid (E), power setting 150

Maximum Peak Conducted Output Power

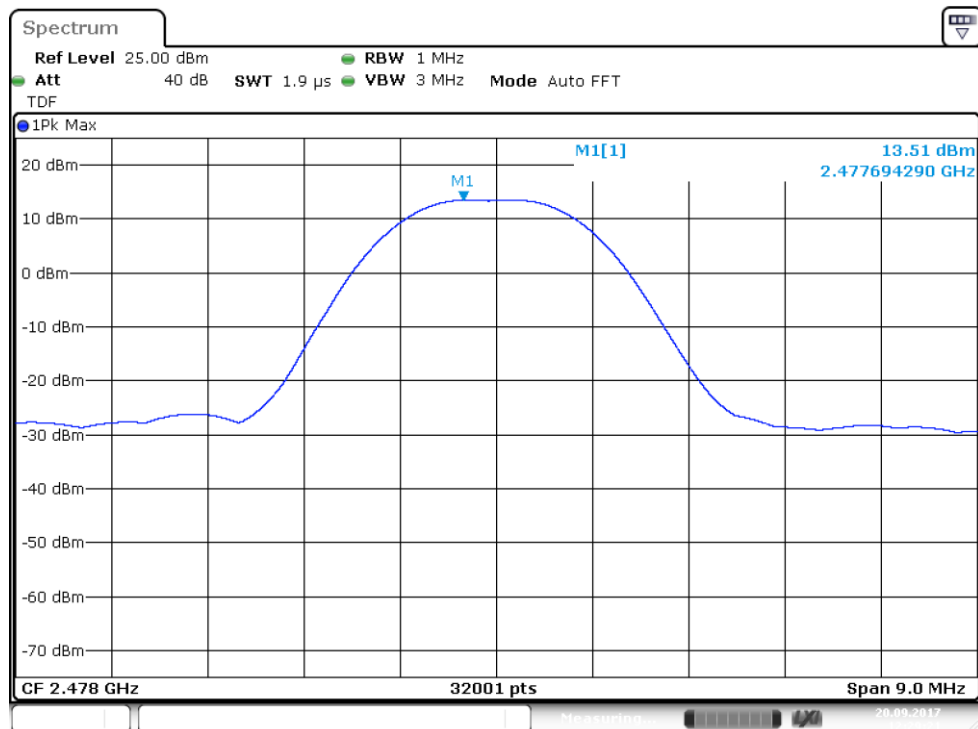


Figure 5: Conducted power, Channel 38 high (E), power setting 150

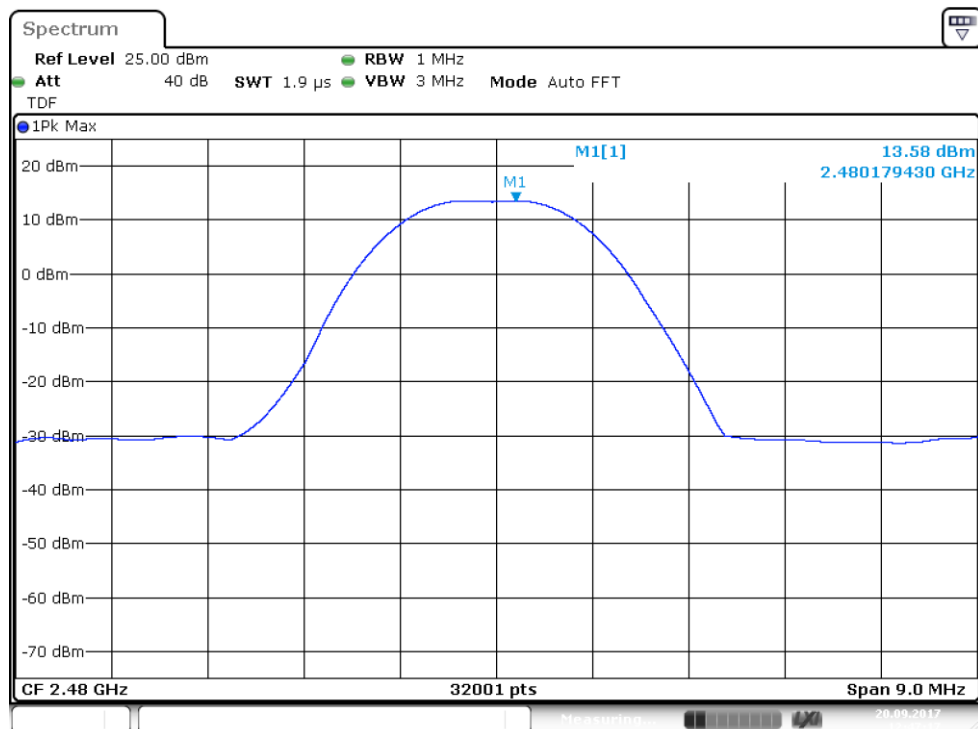


Figure 6: Conducted power, Channel 39 high (E), power setting 150

Maximum Peak Conducted Output Power

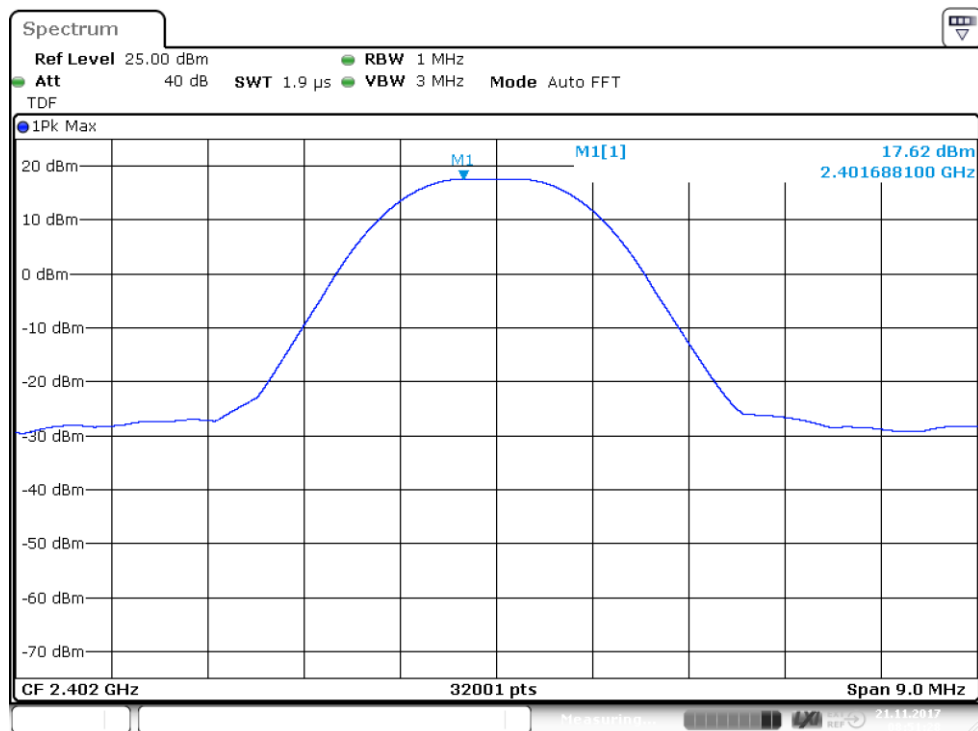


Figure 7: Conducted power, Channel 0 low (E), power settings 200, PHY 1M coded

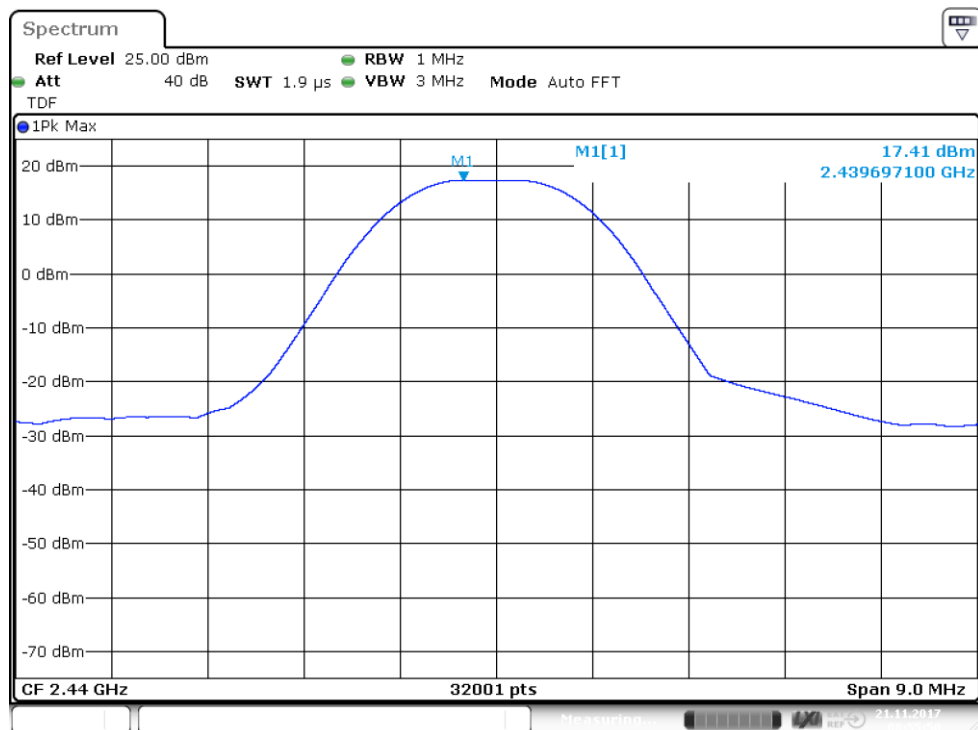


Figure 8: Conducted power, Channel 19 mid (E), power settings 200, PHY 1M coded

Maximum Peak Conducted Output Power

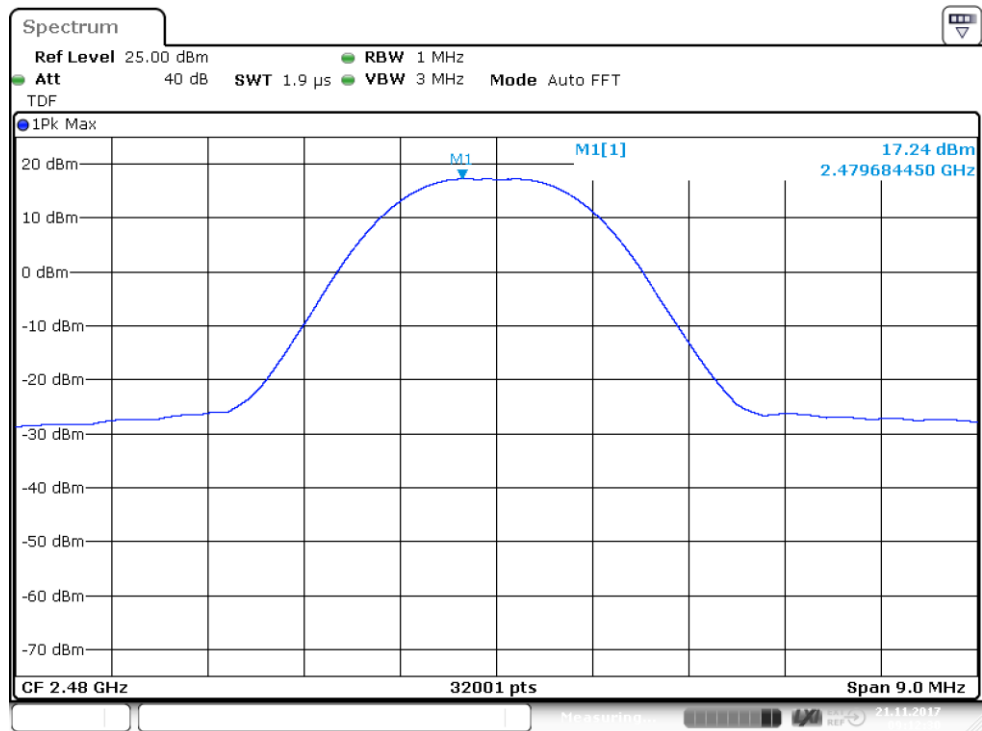


Figure 9: Conducted power, Channel 39 high (E), power settings 200, PHY 1M coded

Transmitter Radiated Spurious Emissions 30 - 26500 MHz

Standard: ANSI C63.10 (2013)
Tested by: MIH & JAT
Date: 12 September 2017 -
19 September 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 [μ V/m]	Limit [dB μ V/m]	Detector
30 - 80	100	40.0	Quasi-peak
88 - 216	150	43.5	Quasi-peak
216 - 960	200	46.0	Quasi-peak
960 - 1000	500	53.9	Quasi-peak
Above 1000	500	53.9	Average
Above 1000	5000	73.9	Peak

Transmitter Radiated Spurious Emissions

Low channel (0)

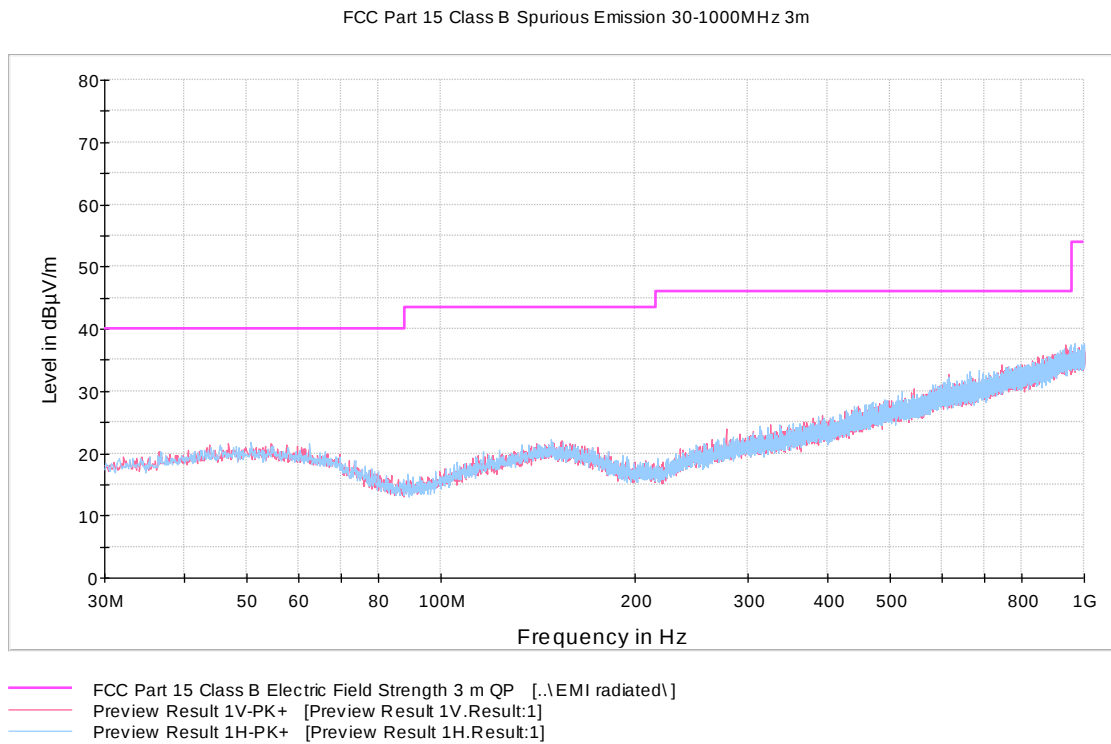


Figure 10: Channel 0 low 30 MHz – 1000 MHz (A)

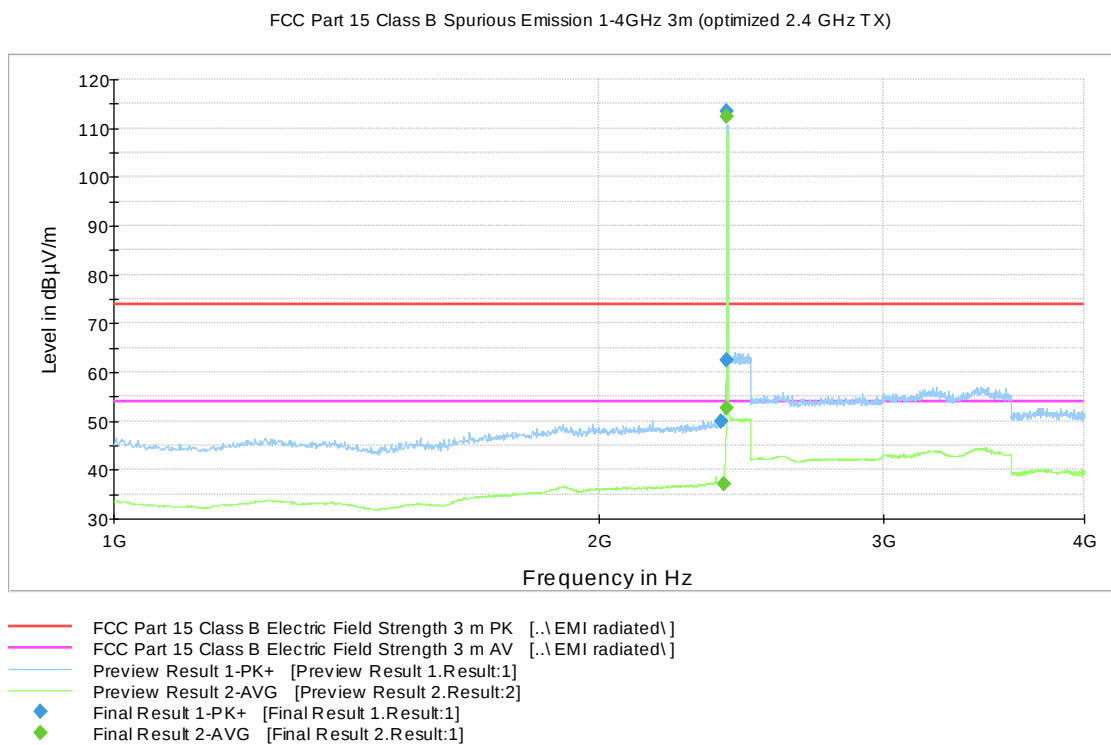


Figure 11: Channel 0 low 1 GHz – 4 GHz (A)

Transmitter Radiated Spurious Emissions

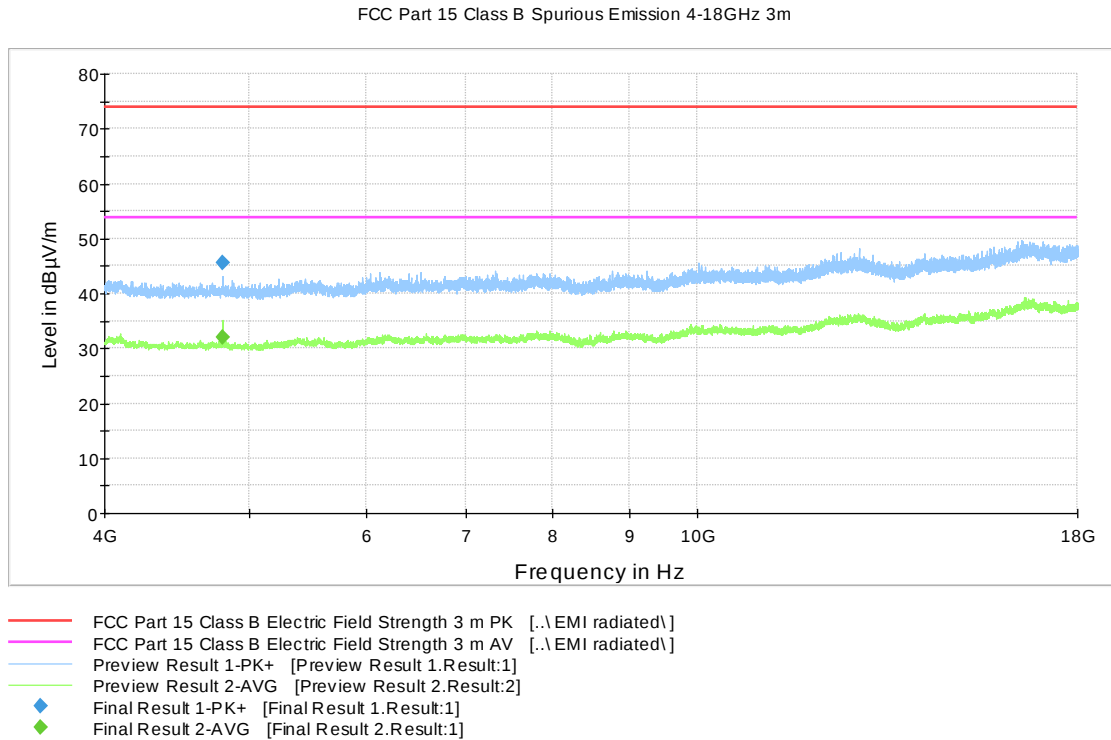


Figure 12: Channel 0 low 4 GHz – 18 GHz (A)

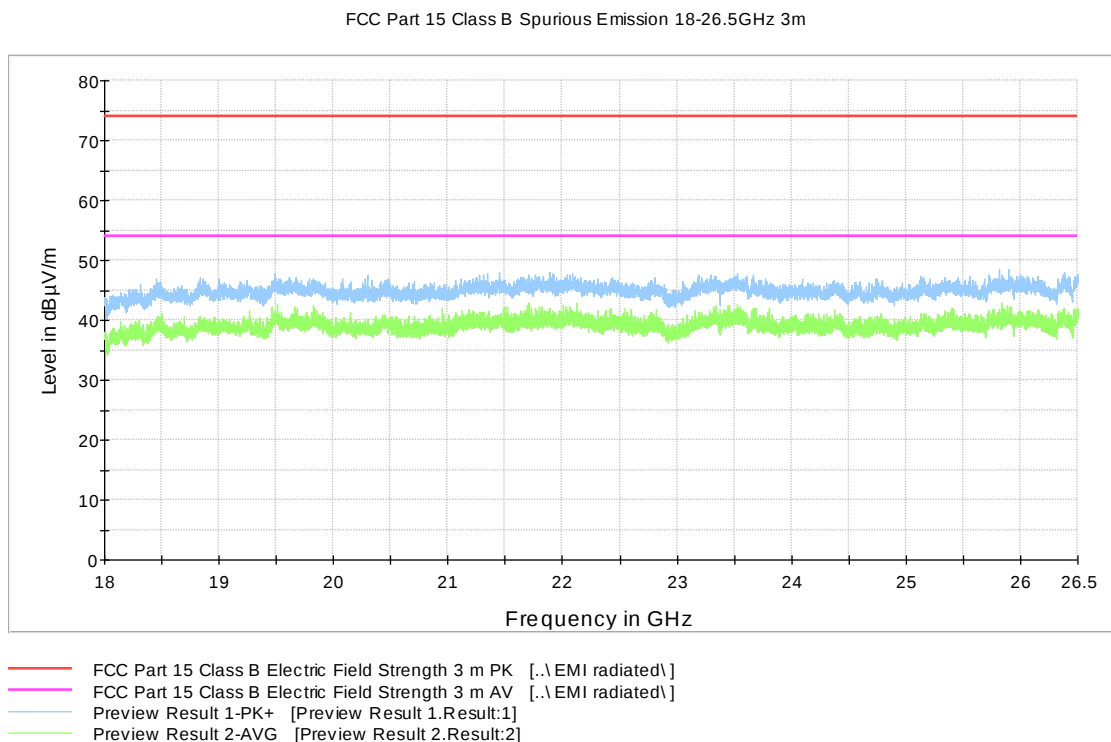


Figure 13: Channel 0 low 18 GHz – 26.5 GHz (A)

Transmitter Radiated Spurious Emissions

Table 6: Peak results, channel 0 low (A)

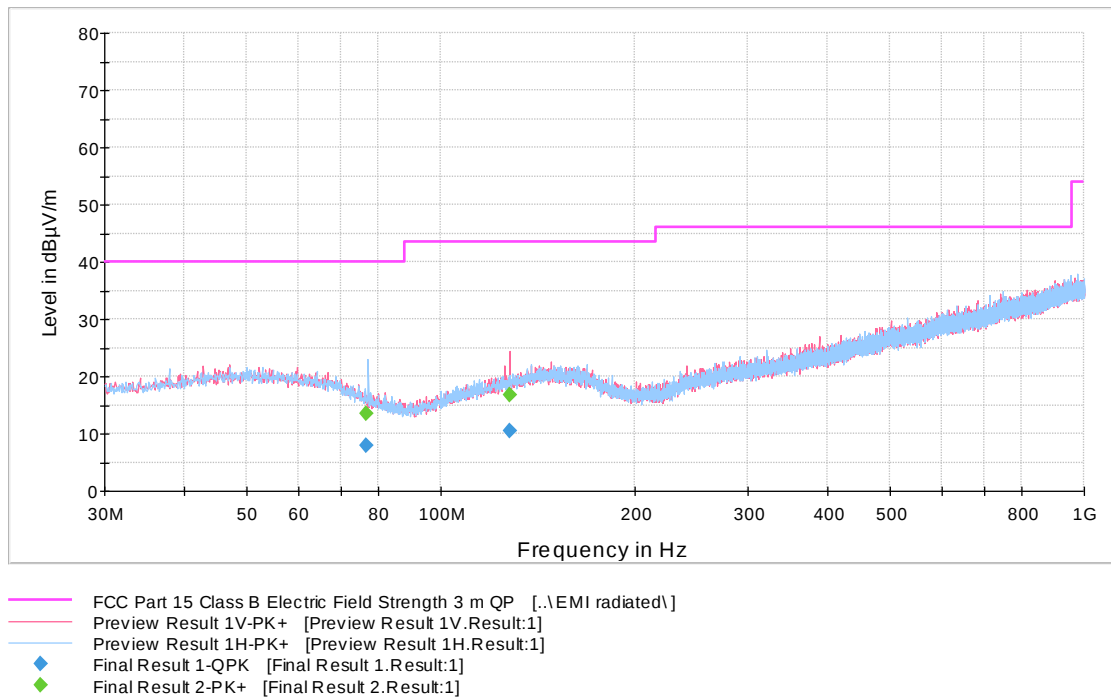
Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
2380.400000	49.9	1000.0	1000.000	315.0	V	37.0	14.5	24.0	73.9
2399.200000	62.4	1000.0	1000.000	311.0	V	157.0	14.7	31.0	93.4
4804.300000	45.6	1000.0	1000.000	150.0	H	101.0	8.3	28.3	73.9

Table 7: Average results, channel 0 low (A)

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
2389.200000	37.0	1000.0	1000.000	380.0	V	49.0	14.6	16.9	53.9
4803.700000	32.1	1000.0	1000.000	150.0	H	98.0	8.3	21.8	53.9

Middle channel (19)

FCC Part 15 Class B Spurious Emission 30-1000MHz 3m


Figure 14: Channel 19 mid 30 MHz – 1000 MHz (A)

Transmitter Radiated Spurious Emissions

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

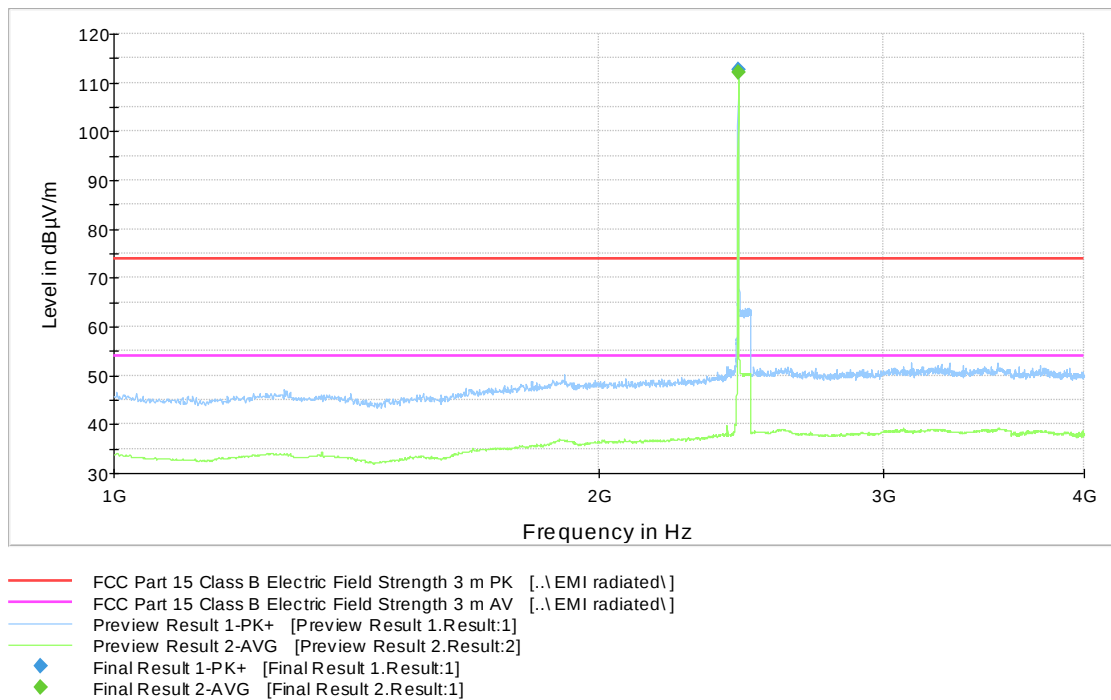


Figure 15: Channel 19 mid 1 GHz – 4 GHz (A)

FCC Part 15 Class B Spurious Emission 4-18GHz 3m

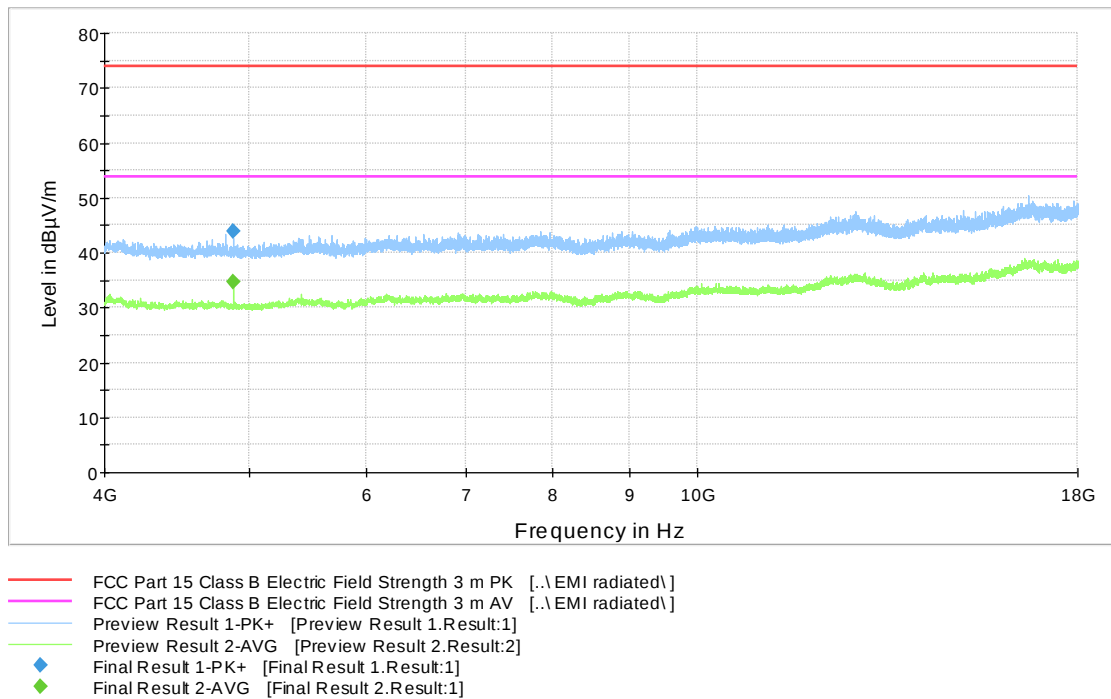


Figure 16: Channel 19 mid 4 GHz – 18 GHz (A)

Transmitter Radiated Spurious Emissions

FCC Part 15 Class B Spurious Emission 18-26.5GHz 3m

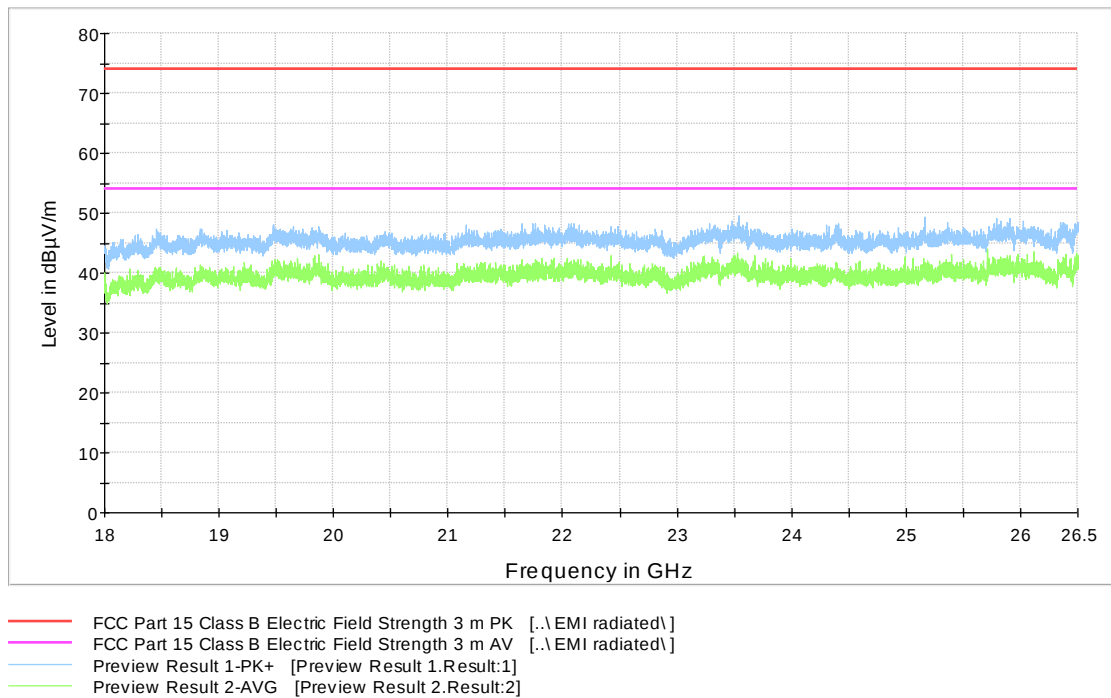


Figure 17: Channel 19 mid 18 GHz – 26.5 GHz (A)

Table 8: Peak results, channel 19 mid (A)

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
4880.100000	44.0	1000.0	1000.000	150.0	H	180.0	8.3	29.9	73.9

Table 9: Average results, channel 19 mid (A)

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
4880.200000	34.7	1000.0	1000.000	150.0	H	39.0	8.3	19.2	53.9

Table 10: Quasi-peak results, channel 19 mid (A)

Frequency (MHz)	QuasiP (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
76.545000	7.8	1000.0	120.000	311.0	H	133.0	10.8	32.2	40.0
127.790000	10.5	1000.0	120.000	287.0	V	250.0	13.1	33.0	43.5

Transmitter Radiated Spurious Emissions

High channel (39)

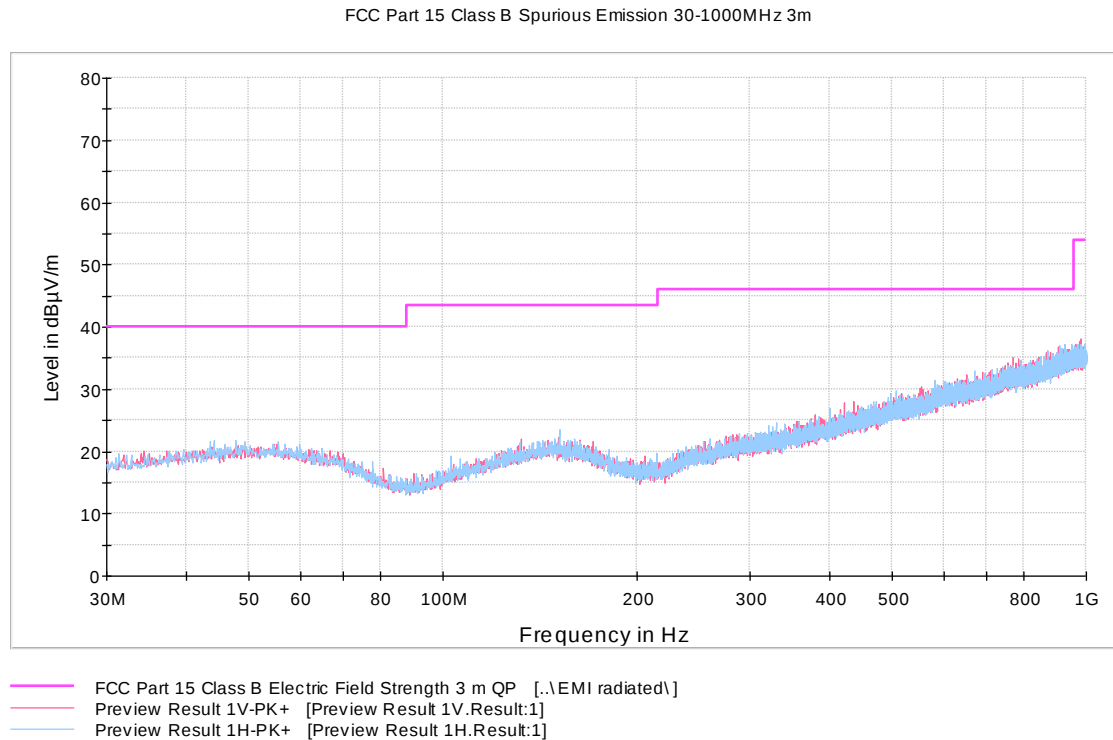


Figure 18: Channel 39 high 30 MHz – 1000 MHz (A)

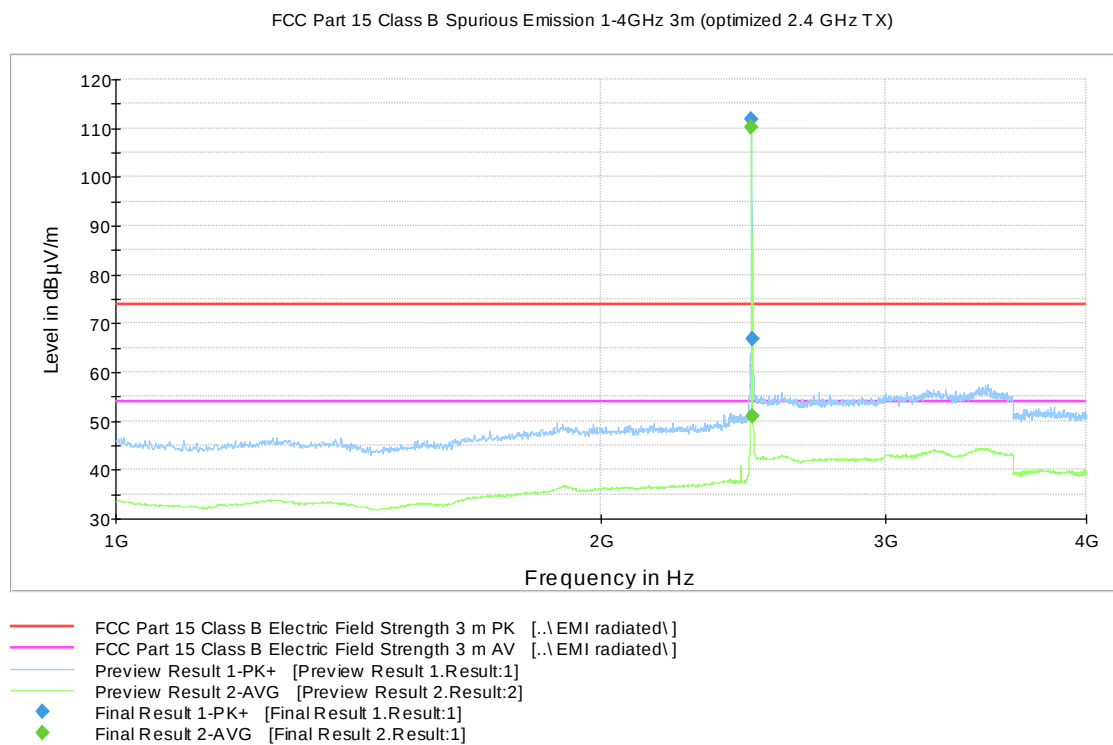


Figure 19: Channel 39 high 1 GHz – 4 GHz (A)

Transmitter Radiated Spurious Emissions

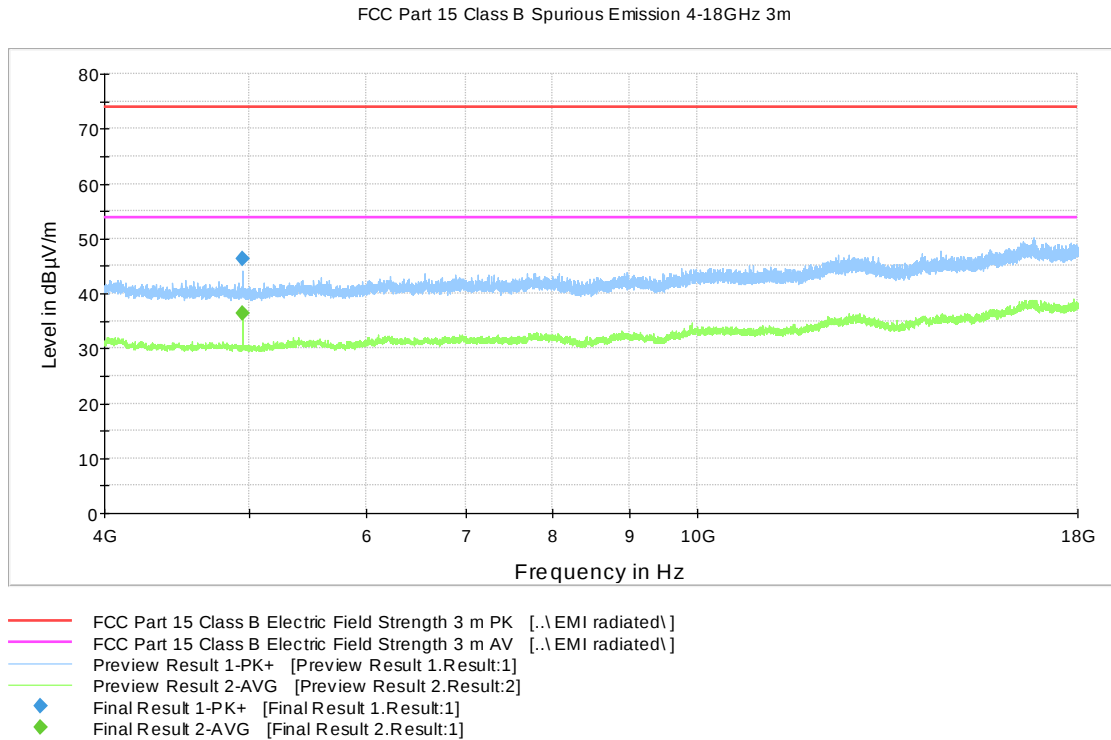


Figure 20: Channel 39 high 4 GHz – 18 GHz (A)

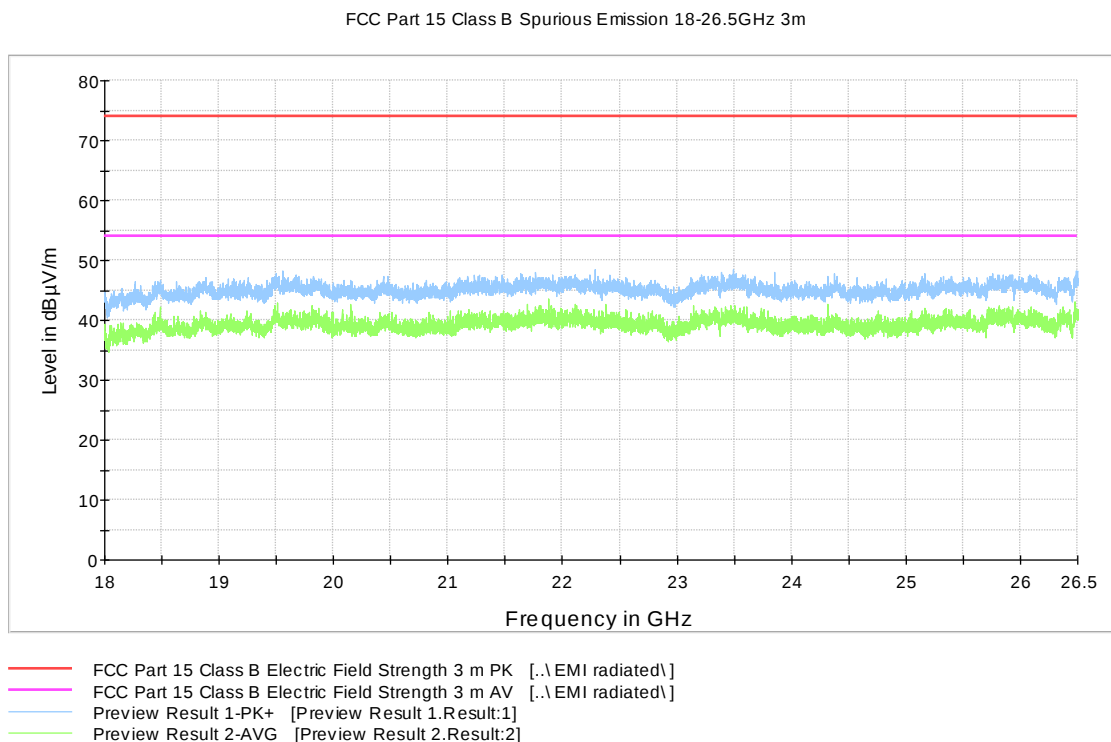


Figure 21: Channel 39 high 18 GHz – 26.5 GHz (A)

Transmitter Radiated Spurious Emissions

Table 11: Peak results, channel 39 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	67.0	1000.0	1000.000	179.0	H	230.0	14.7	6.9	73.9
4955.400000	46.3	1000.0	1000.000	150.0	H	44.0	8.2	27.6	73.9

Table 12: Average results, channel 39 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	51.0	1000.0	1000.000	296.0	H	232.0	14.7	2.9	53.9
4955.900000	36.4	1000.0	1000.000	150.0	H	43.0	8.2	17.5	53.9

Radiated Band Edge results

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

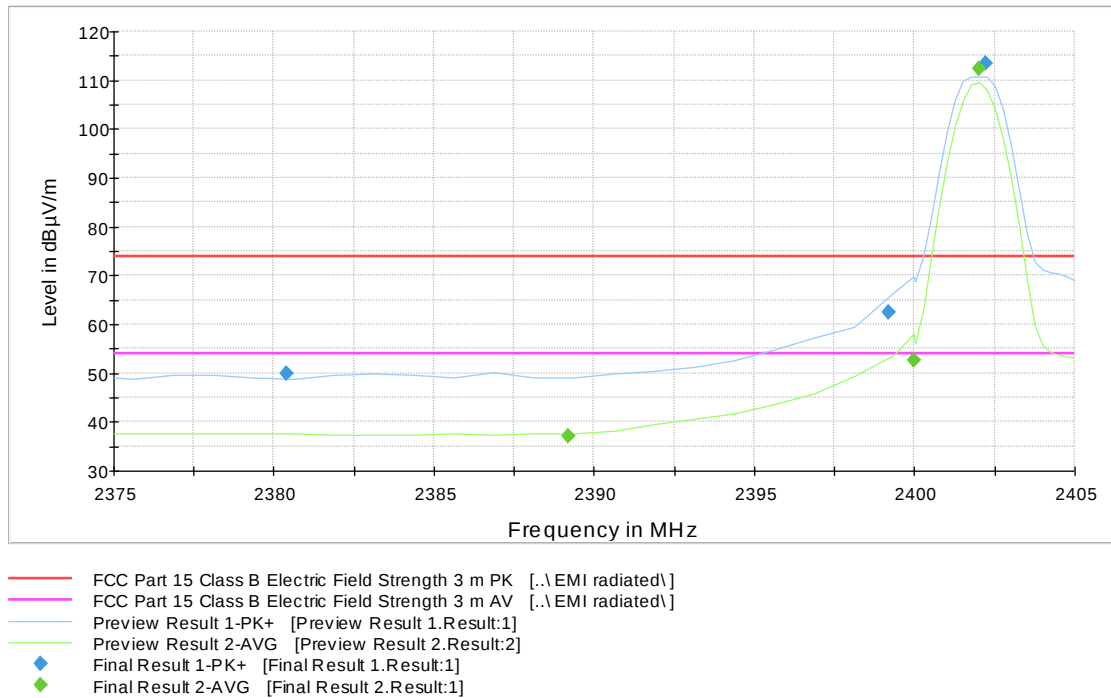

Figure 22: Radiated Band Edge measurement graph, Channel 0 low (A)

Table 13: Peak results, channel 0 low (A)

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
2380.400000	49.9	1000.0	1000.000	315.0	V	37.0	14.5	24.0	73.9
2399.200000	62.4	1000.0	1000.000	311.0	V	157.0	31.0	93.4	73.9

Table 14: Average results, channel 0 low (A)

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
2389.200000	37.0	1000.0	1000.000	380.0	V	49.0	14.6	16.9	53.9

Transmitter Radiated Spurious Emissions

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

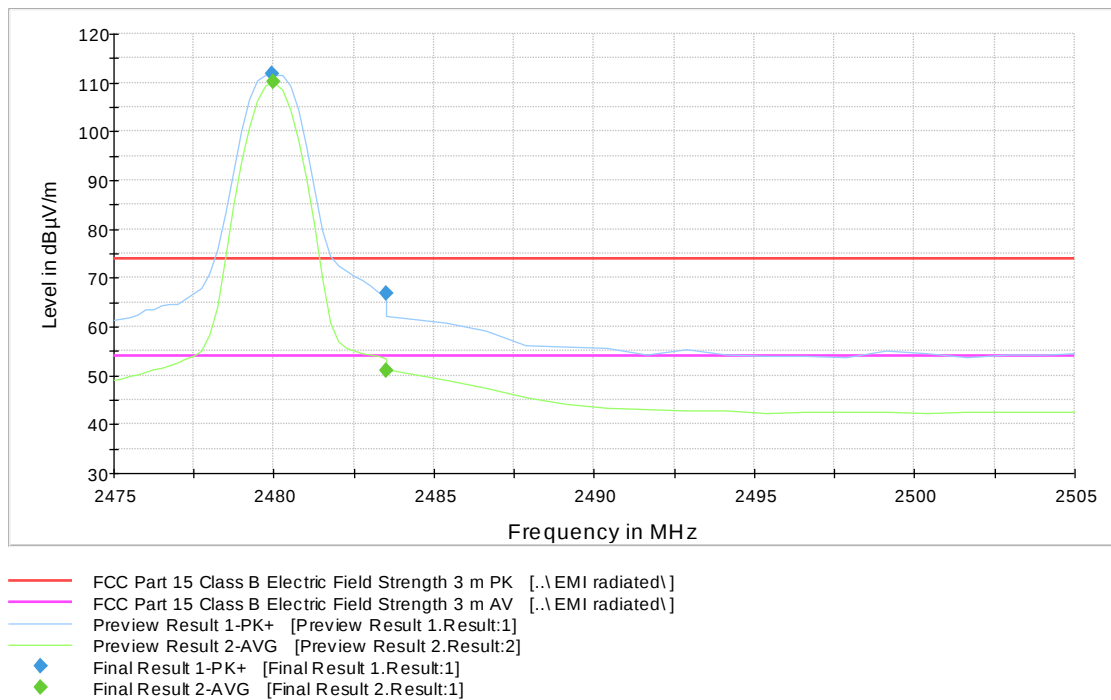


Figure 23: Radiated Band Edge measurement graph, Channel 39 high (A)

Table 15: Peak results, channel 39 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	67.0	1000.0	1000.000	179.0	H	230.0	14.7	6.9	73.9

Table 16: Average results, channel 39 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	51.0	1000.0	1000.000	296.0	H	232.0	14.7	2.9	53.9

Transmitter Radiated Spurious Emissions

Low channel (0)

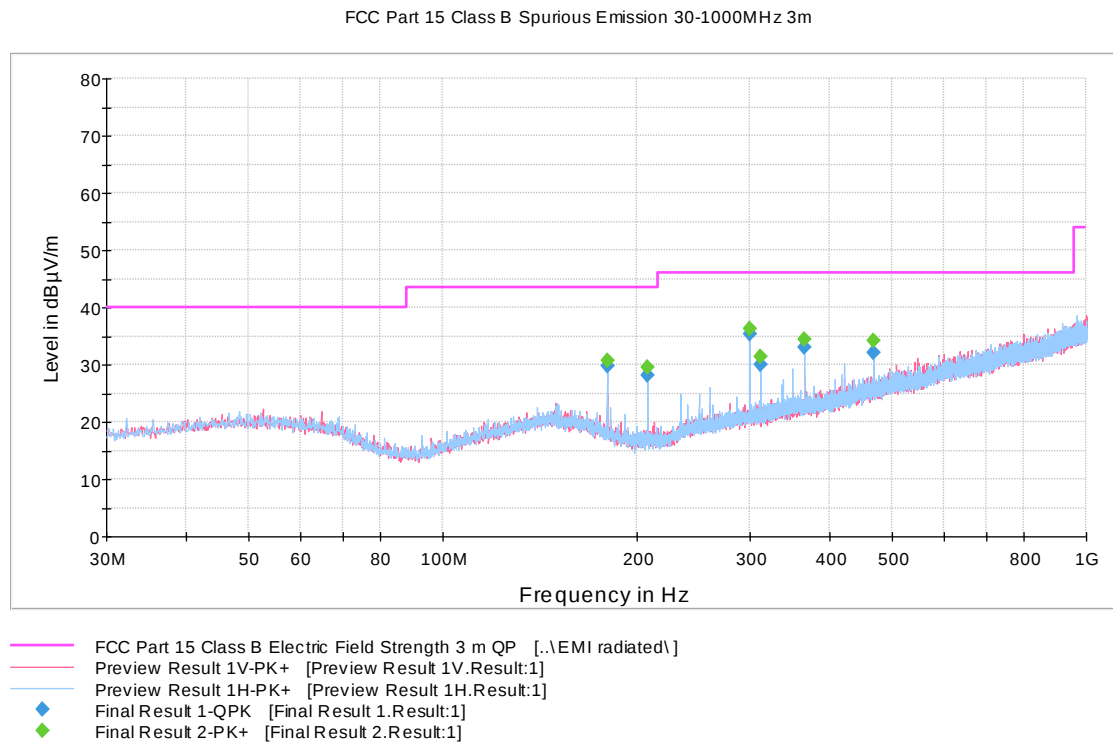


Figure 24: Channel 0 low 30 MHz – 1000 MHz (E)

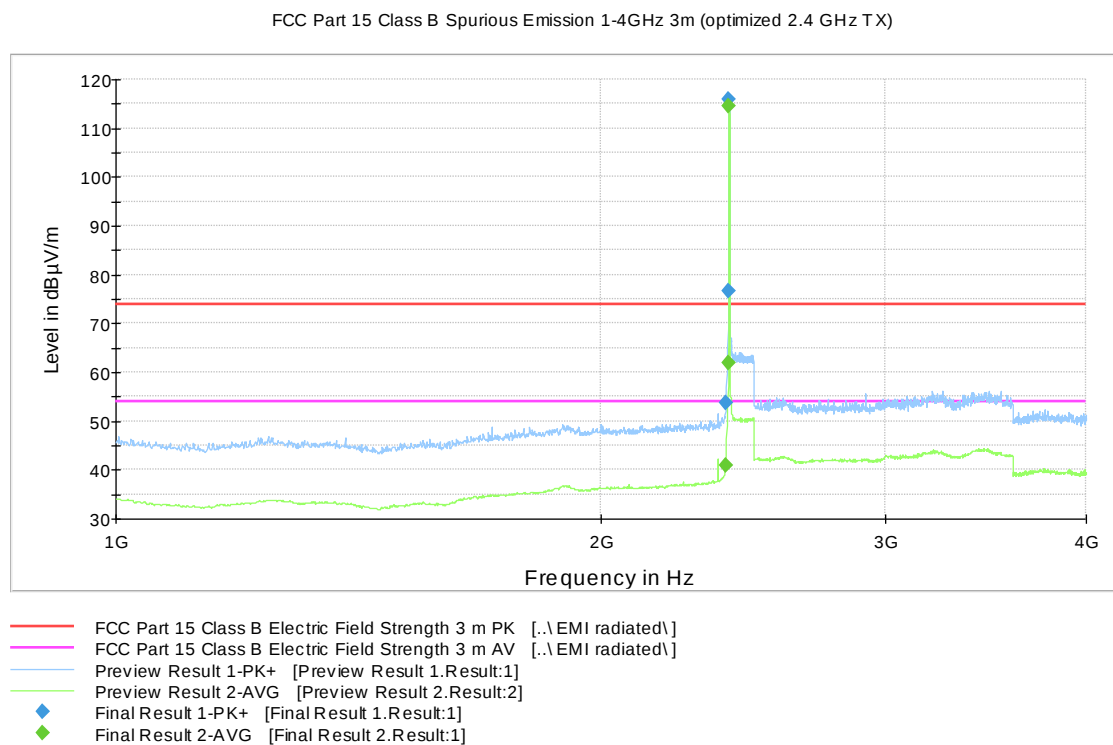


Figure 25: Channel 0 low 1 GHz – 4 GHz (E)

Transmitter Radiated Spurious Emissions

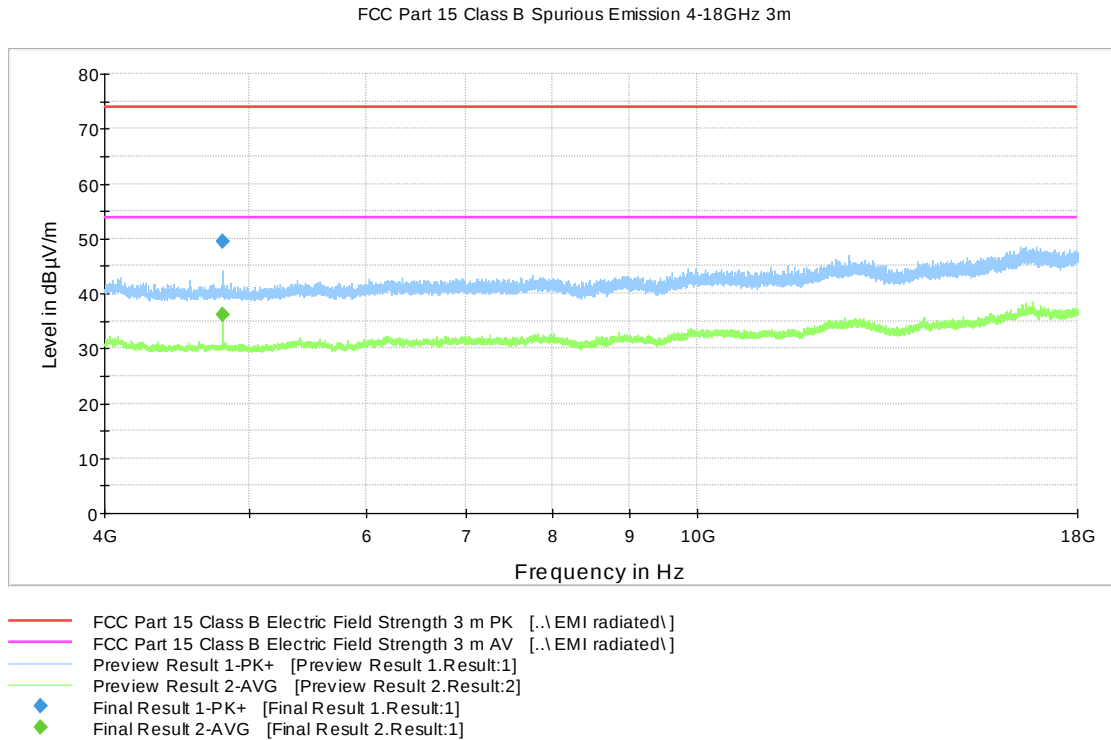


Figure 26: Channel 0 low 4 GHz – 18 GHz (E)

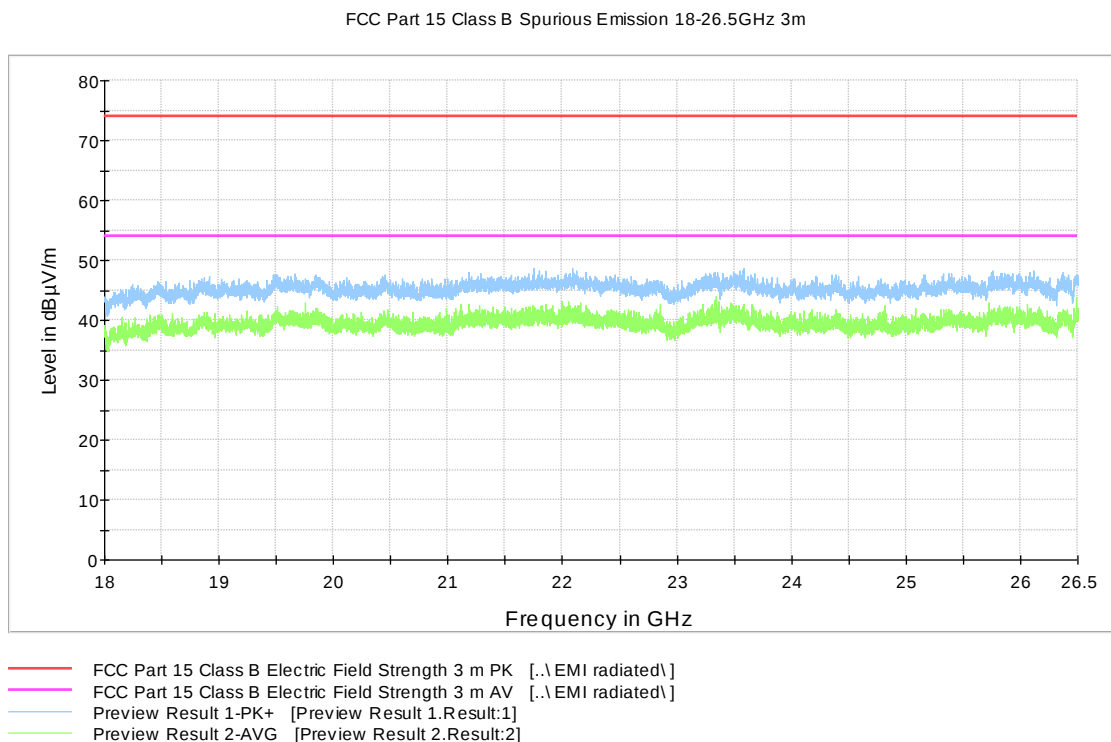


Figure 27: Channel 0 low 18 GHz – 26.5 GHz (E)

Transmitter Radiated Spurious Emissions

Table 17: Peak results, channel 0 low (E)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2390.000000	53.8	1000.0	1000.000	150.0	V	264.0	14.6	20.1	73.9
2400.000000	76.6	1000.0	1000.000	218.0	V	264.0	14.7	19.3	95.9
4803.900000	49.6	1000.0	1000.000	150.0	V	294.0	8.3	24.3	73.9

Table 18: Average results, channel 0 low (E)

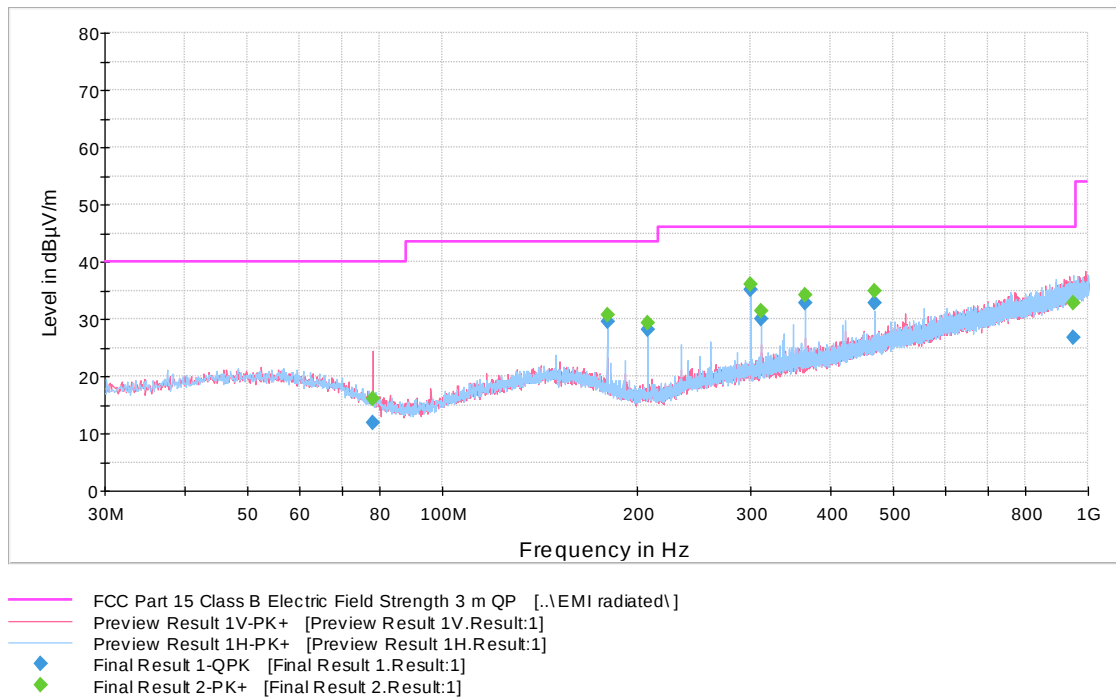
Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2390.000000	40.8	1000.0	1000.000	168.0	V	264.0	14.6	13.1	53.9
4803.800000	36.1	1000.0	1000.000	166.0	V	230.0	8.3	17.8	53.9

Table 19: Quasi-peak results, channel 0 low (E)

Frequency (MHz)	QuasiP (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
180.002000	29.7	1000.0	120.000	152.0	H	192.0	13.0	13.8	43.5
208.015000	28.1	1000.0	120.000	152.0	H	198.0	11.5	15.4	43.5
300.008000	35.3	1000.0	120.000	100.0	H	333.0	15.3	10.7	46.0
312.019000	29.9	1000.0	120.000	100.0	H	340.0	15.7	16.1	46.0
364.011000	33.0	1000.0	120.000	100.0	H	216.0	16.9	13.0	46.0
468.012000	32.1	1000.0	120.000	232.0	H	309.0	19.5	13.9	46.0

Middle channel (19)

FCC Part 15 Class B Spurious Emission 30-1000MHz 3m


Figure 28: Channel 19 mid 30 MHz – 1000 MHz (E)

Transmitter Radiated Spurious Emissions

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

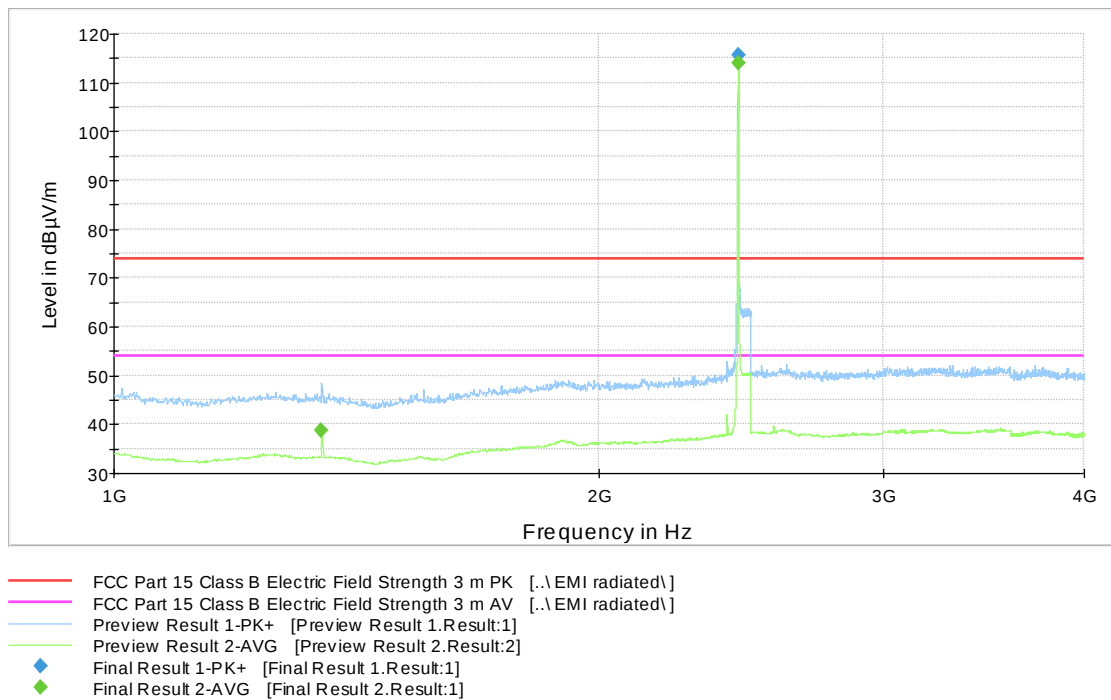


Figure 29: Channel 19 mid 1 GHz – 4 GHz (E)

FCC Part 15 Class B Spurious Emission 4-18GHz 3m

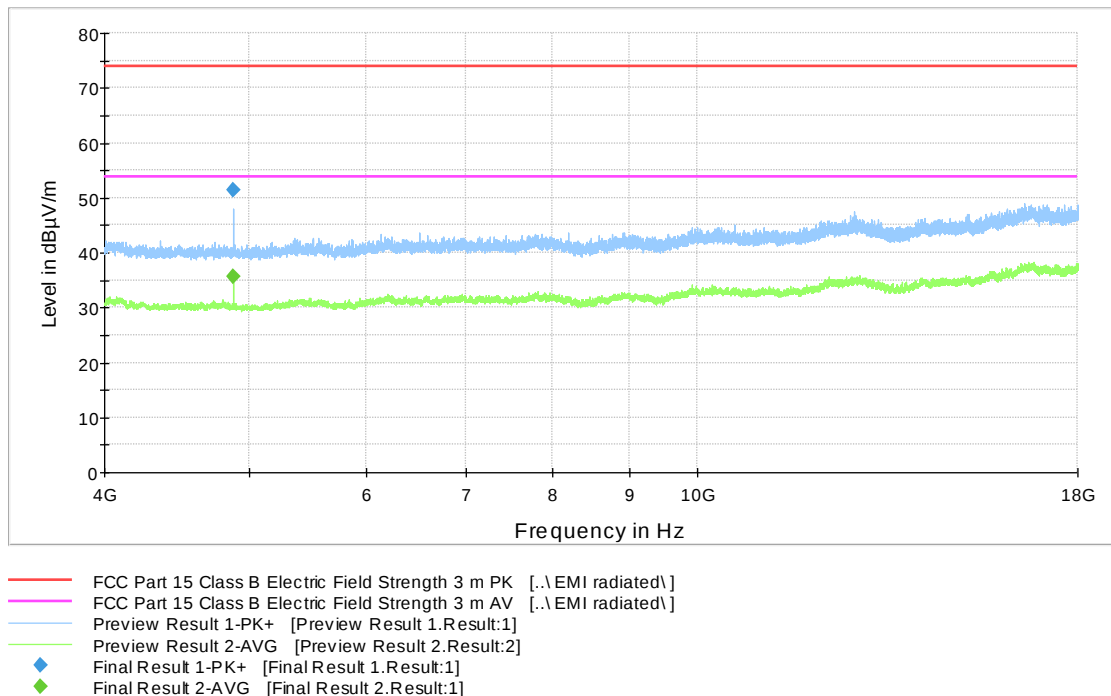


Figure 30: Channel 19 mid 4 GHz – 18 GHz (E)

Transmitter Radiated Spurious Emissions

FCC Part 15 Class B Spurious Emission 18-26.5GHz 3m

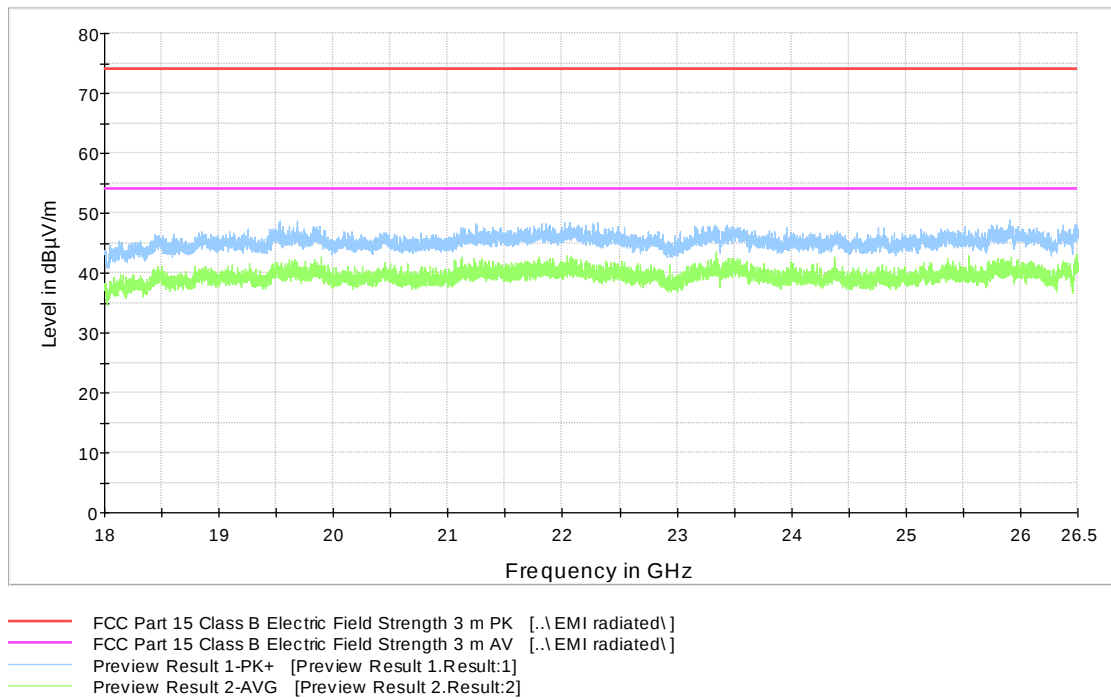


Figure 31: Channel 19 mid 18 GHz – 26.5 GHz (E)

Table 20: Peak results, channel 19 mid (E)

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
4880.000000	51.3	1000.0	1000.000	150.0	V	226.0	8.3	22.6	73.9

Table 21: Average results, channel 19 mid (E)

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1346.025000	38.7	1000.0	1000.000	203.0	V	271.0	10.8	15.2	53.9
4880.100000	35.6	1000.0	1000.000	179.0	V	232.0	8.3	18.3	53.9

Table 22: Quasi-peak results, channel 19 mid (E)

Frequency (MHz)	QuasiP (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
78.032000	11.9	1000.0	120.000	100.0	V	111.0	10.4	28.1	40.0
180.002000	29.6	1000.0	120.000	154.0	H	191.0	13.0	13.9	43.5
208.015000	28.1	1000.0	120.000	152.0	H	194.0	11.5	15.4	43.5
300.008000	35.2	1000.0	120.000	100.0	H	148.0	15.3	10.8	46.0
312.016000	29.9	1000.0	120.000	100.0	H	335.0	15.7	16.1	46.0
364.011000	32.8	1000.0	120.000	100.0	H	10.0	16.9	13.2	46.0
468.032000	32.8	1000.0	120.000	205.0	H	304.0	19.5	13.2	46.0
948.573000	26.7	1000.0	120.000	334.0	H	181.0	27.8	19.3	46.0

Transmitter Radiated Spurious Emissions

High channel (38)

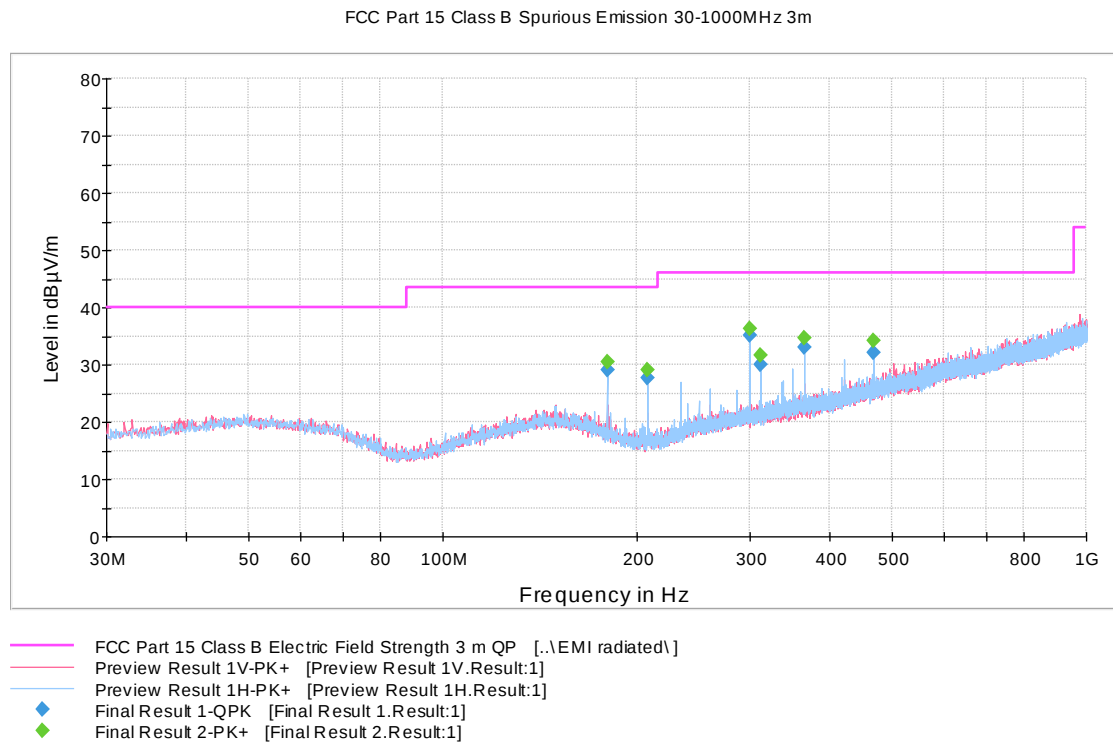


Figure 32: Channel 38 high 30 MHz – 1000 MHz (E)

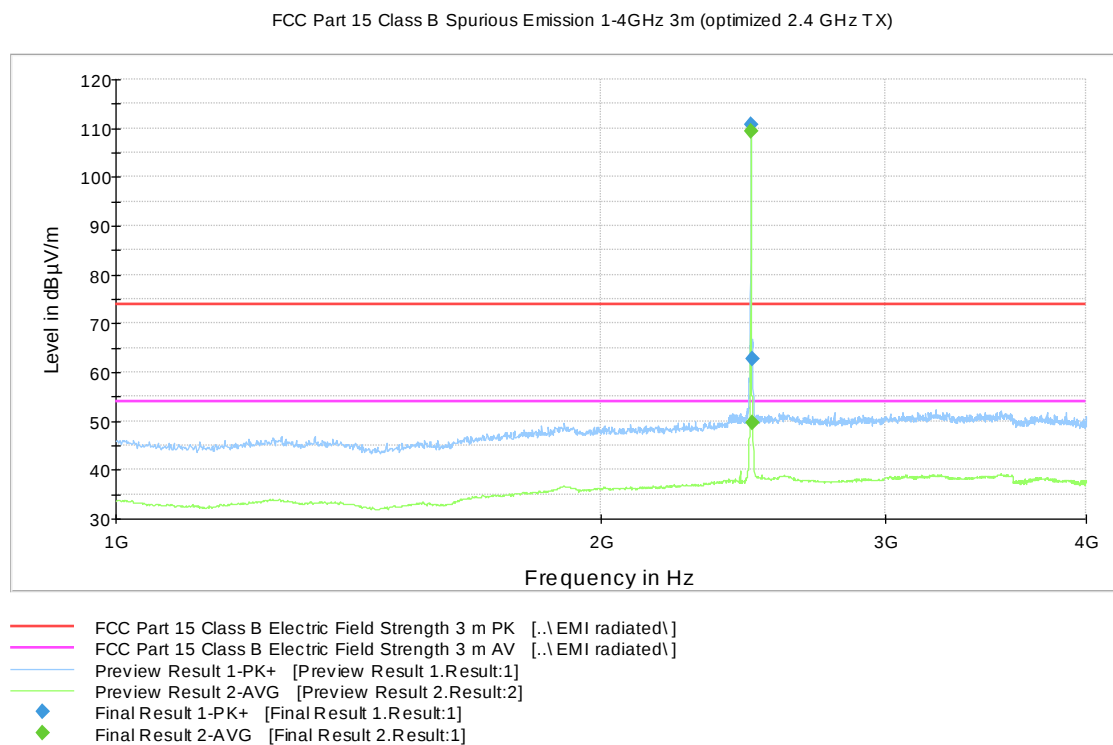


Figure 33: Channel 38 high 1 GHz – 4 GHz (E)

Transmitter Radiated Spurious Emissions

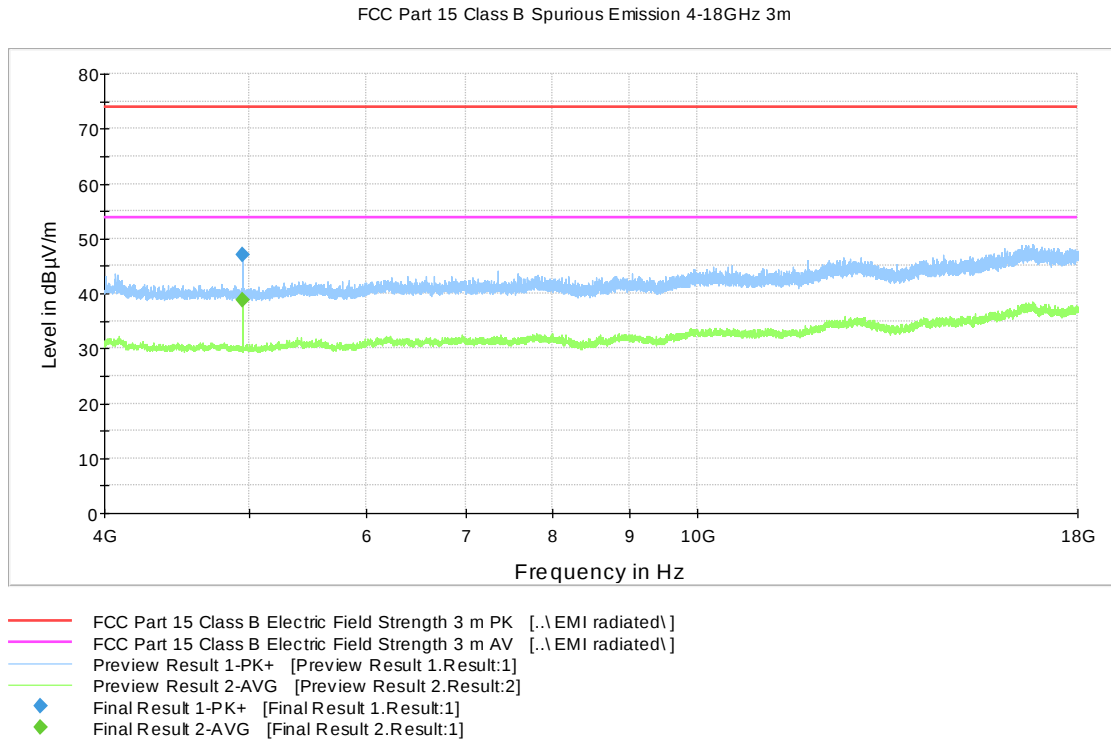


Figure 34: Channel 38 high 4 GHz – 18 GHz (E)

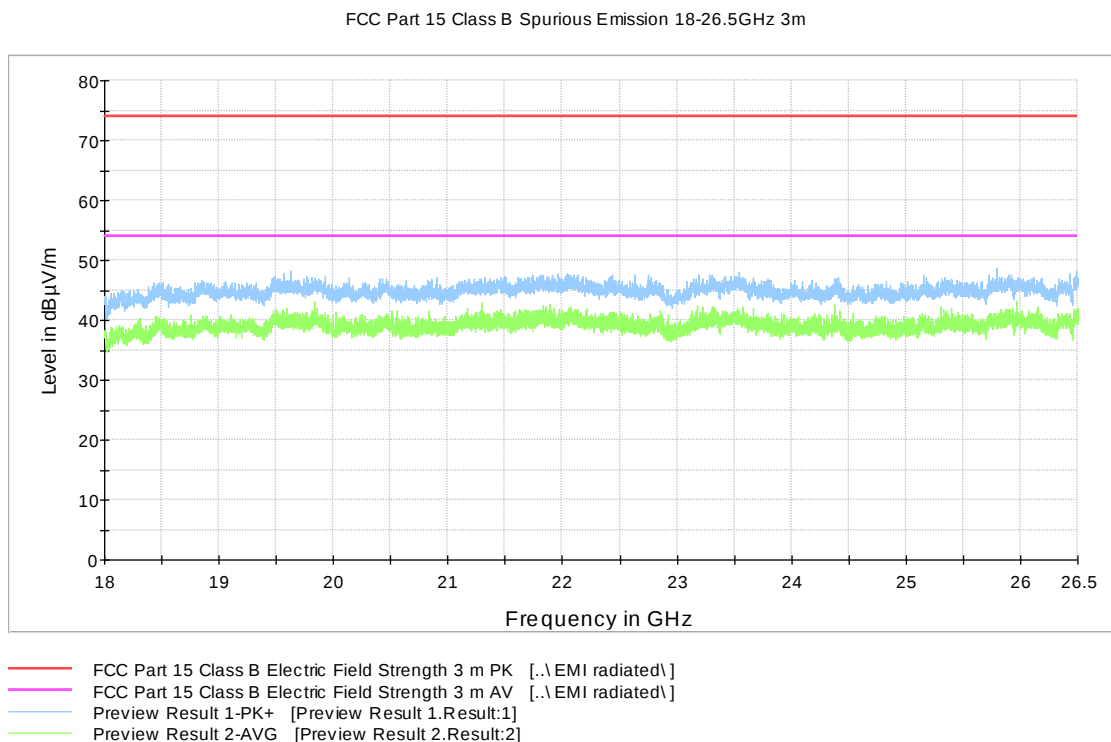


Figure 35: Channel 38 high 18 GHz – 26.5 GHz (E)

Transmitter Radiated Spurious Emissions

Table 23: Peak results, channel 38 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	62.7	1000.0	1000.000	150.0	V	267.0	14.7	11.2	73.9
4956.200000	47.0	1000.0	1000.000	150.0	V	223.0	8.2	26.9	73.9

Table 24: Average results, channel 38 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	49.7	1000.0	1000.000	150.0	V	0.0	14.7	4.2	53.9
4955.900000	38.7	1000.0	1000.000	150.0	V	239.0	8.2	15.2	53.9

Table 25: Quasi-peak results, channel 38 high (E)

Frequency (MHz)	QuasiP (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
180.002000	29.2	1000.0	120.000	178.0	H	188.0	13.0	14.3	43.5
208.015000	27.8	1000.0	120.000	152.0	H	189.0	11.5	15.7	43.5
300.008000	35.1	1000.0	120.000	100.0	H	325.0	15.3	10.9	46.0
312.019000	30.0	1000.0	120.000	100.0	H	333.0	15.7	16.0	46.0
364.011000	33.0	1000.0	120.000	100.0	H	210.0	16.9	13.0	46.0
468.012000	32.1	1000.0	120.000	178.0	H	315.0	19.5	13.9	46.0

Transmitter Radiated Spurious Emissions

Radiated Band Edge results

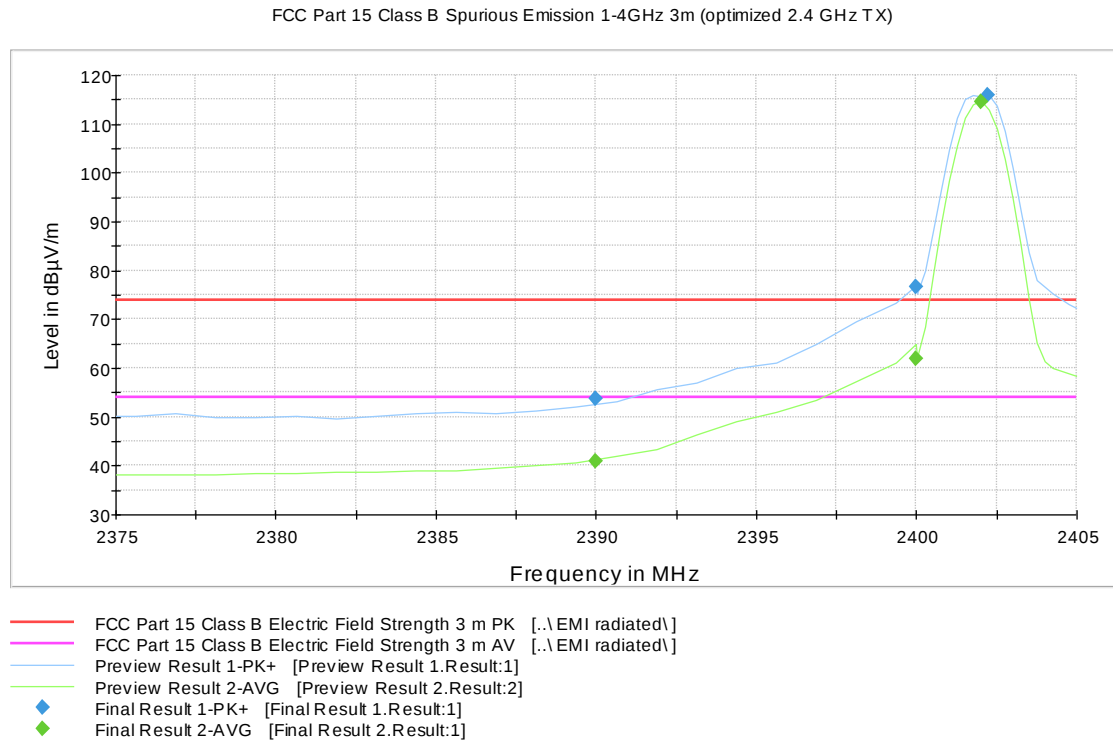


Figure 36: Radiated Band Edge measurement graph, Channel 0 low (E)

Table 26: Peak results, channel 0 low (E)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2390.000000	53.8	1000.0	1000.000	150.0	V	264.0	14.6	20.1	73.9
2400.000000	76.6	1000.0	1000.000	218.0	V	264.0	14.7	19.3	95.9

Table 27: Average results, channel 0 low (E)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2390.000000	40.8	1000.0	1000.000	168.0	V	264.0	14.6	13.1	53.9

Transmitter Radiated Spurious Emissions

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

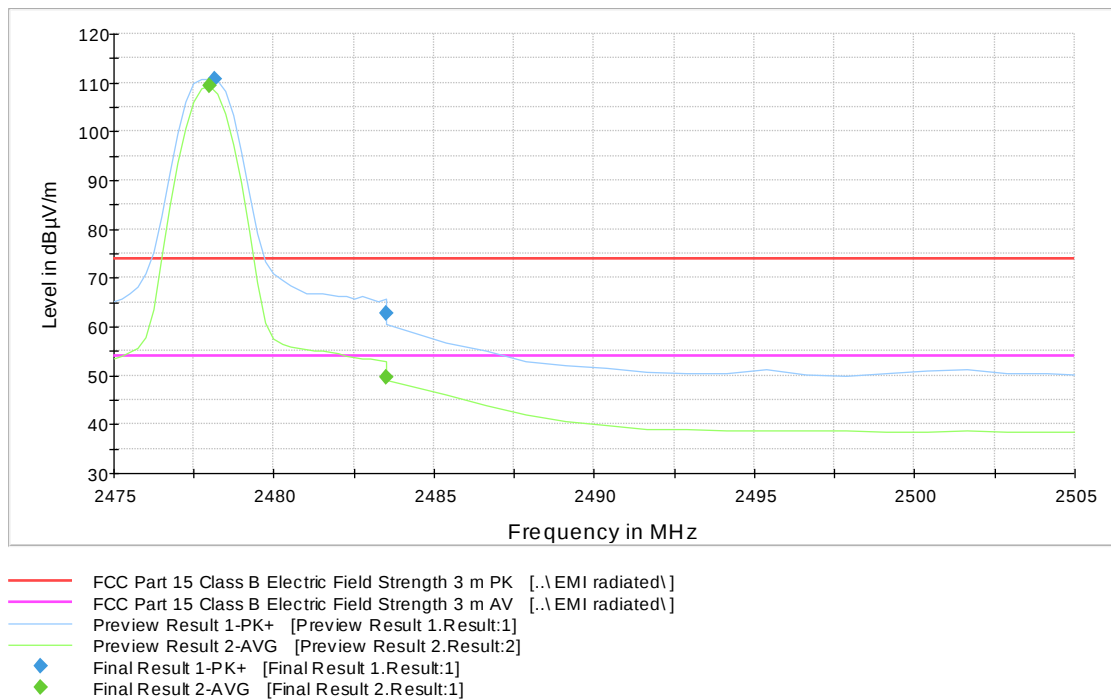


Figure 37: Radiated Band Edge measurement graph, Channel 38 high (E)

Table 28: Peak results, channel 38 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	62.7	1000.0	1000.000	150.0	V	267.0	14.7	11.2	73.9

Table 29: Average results, channel 38 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	49.7	1000.0	1000.000	150.0	V	0.0	14.7	4.2	53.9

Transmitter Radiated Spurious Emissions

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

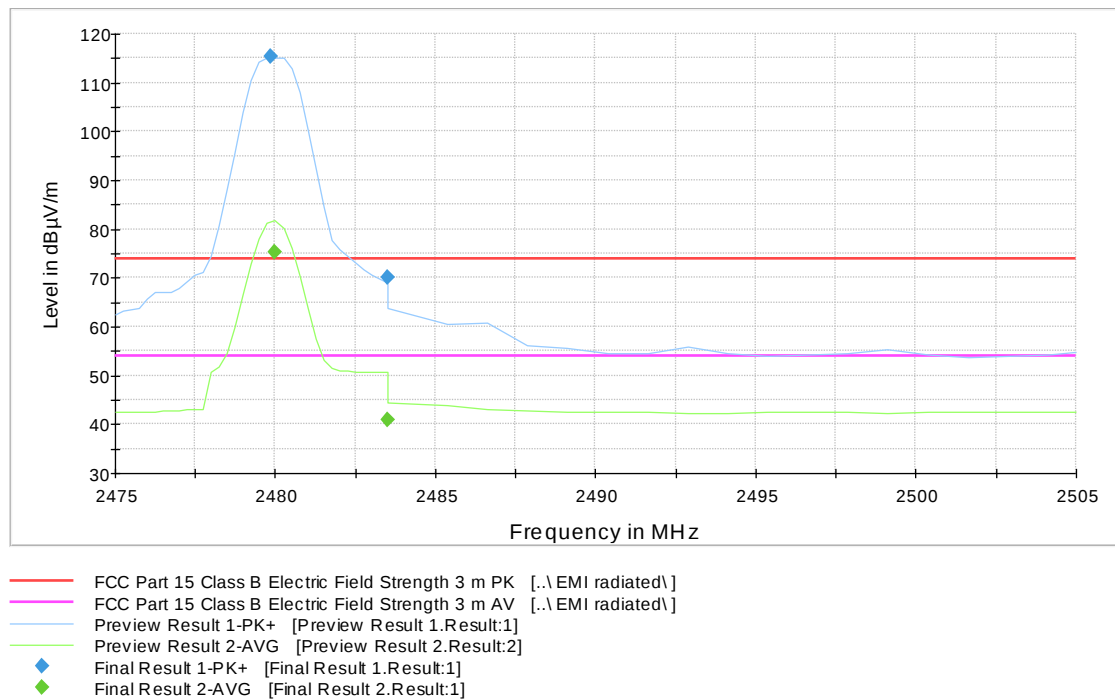


Figure 38: Radiated Band Edge measurement graph, Channel 39 high (E)

Table 30: Peak results, channel 39 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	70.2	1000.0	1000.000	150.0	V	0.0	14.7	3.7	73.9

Table 31: Average results, channel 39 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	40.8	1000.0	1000.000	150.0	V	0.0	14.7	13.1	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:	MIH	
Date:	11 September – 21 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 32: Band edge attenuation (E), power setting 150

Band Edge Attenuation		
Lower Band Edge (ch 0)	Upper Band Edge (ch 38)	Upper Band Edge (ch 39)
-49.26 dBc	-49.21 dBc	-50.98 dBc
Limit: -20 dBc		

Table 33: Band edge attenuation (E), power setting 200, PHY 1M coded

Band Edge Attenuation	
Lower Band Edge (ch 0)	Upper Band Edge (ch 39)
-53.93 dBc	-52.14 dBc
Limit: -20 dBc	

Table 40: Conducted spurious emissions Channel 0 low (E), power setting 150

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
804.05	-67.63	-9.60	-58.02	PASS
2399.98	-41.97	-9.60	-32.37	PASS
3870.84	-65.23	-9.60	-55.62	PASS
4804.40	-53.83	-9.60	-44.23	PASS
8486.50	-61.27	-9.60	-51.67	PASS
12905.64	-58.72	-9.60	-49.12	PASS
15849.02	-56.87	-9.60	-47.26	PASS
16093.23	-55.04	-9.60	-45.43	PASS
19499.25	-55.83	-9.60	-46.23	PASS
24817.33	-56.11	-9.60	-46.51	PASS
25448.88	-55.58	-9.60	-45.98	PASS

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Table 34: Conducted spurious emissions, channel 19 mid (E), power setting 150

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
794.14	-68.45	-9.37	-59.08	PASS
2393.11	-64.66	-9.37	-55.30	PASS
3743.22	-65.12	-9.37	-55.75	PASS
4880.43	-53.35	-9.37	-43.98	PASS
9103.36	-61.29	-9.37	-51.92	PASS
12493.44	-59.07	-9.37	-49.70	PASS
15499.34	-56.55	-9.37	-47.18	PASS
16126.79	-55.32	-9.37	-45.95	PASS
21102.61	-57.17	-9.37	-47.80	PASS
24148.36	-55.77	-9.37	-46.40	PASS
26276.62	-55.97	-9.37	-46.61	PASS

Table 35: Conducted spurious emissions, channel 38 high (E), power setting 150

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
845.18	-68.74	-9.64	-59.09	PASS
2272.63	-66.32	-9.64	-56.68	PASS
2483.76	-46.44	-9.64	-36.79	PASS
4956.36	-52.98	-9.64	-43.33	PASS
9831.12	-61.18	-9.64	-51.53	PASS
12507.88	-59.09	-9.64	-49.45	PASS
15519.59	-55.52	-9.64	-45.88	PASS
16143.01	-54.43	-9.64	-44.78	PASS
19515.47	-56.48	-9.64	-46.83	PASS
24444.41	-55.62	-9.64	-45.98	PASS
26227.36	-56.03	-9.64	-46.38	PASS

Table 36: Conducted spurious emissions, channel 39 high (E), power setting 150

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
950.85	-70.21	-7.57	-62.65	PASS
2070.73	-67.73	-7.57	-60.17	PASS
2485.18	-47.96	-7.57	-40.40	PASS
4960.39	-52.16	-7.57	-44.60	PASS
9205.92	-61.16	-7.57	-53.59	PASS
12480.69	-58.63	-7.57	-51.07	PASS
15513.69	-56.44	-7.57	-48.87	PASS
16135.70	-55.56	-7.57	-48.00	PASS
19197.01	-57.04	-7.57	-49.48	PASS
24461.85	-55.83	-7.57	-48.27	PASS
26113.46	-55.63	-7.57	-48.06	PASS

Transmitter Band Edge Measurement and Conducted Spurious Emissions

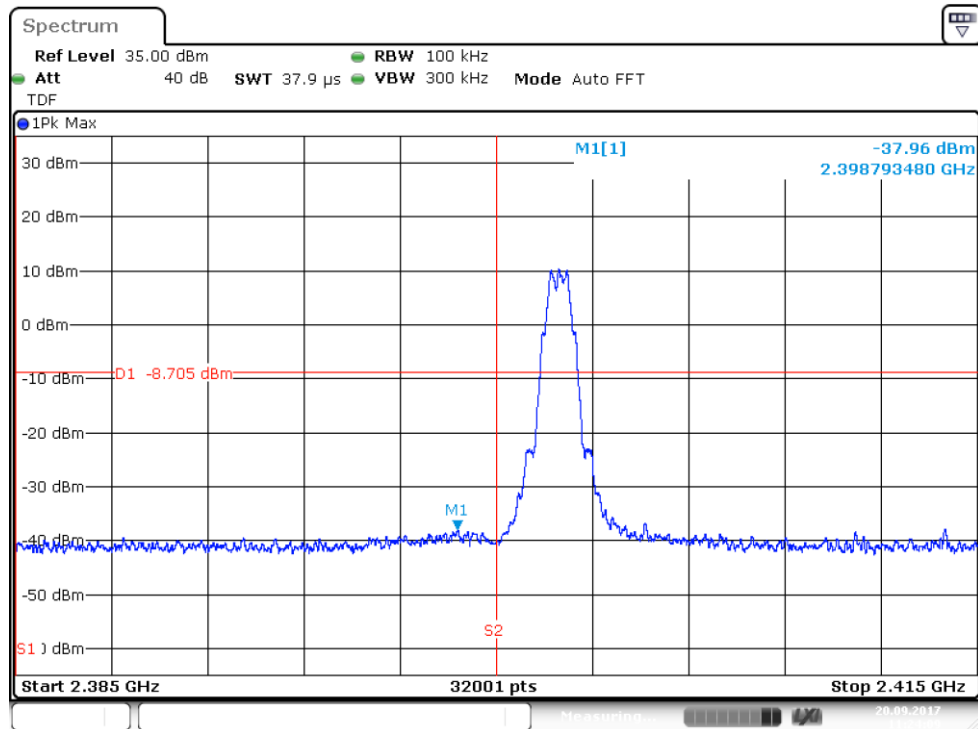


Figure 39: Lower Band Edge, channel 0 (E), power setting 150

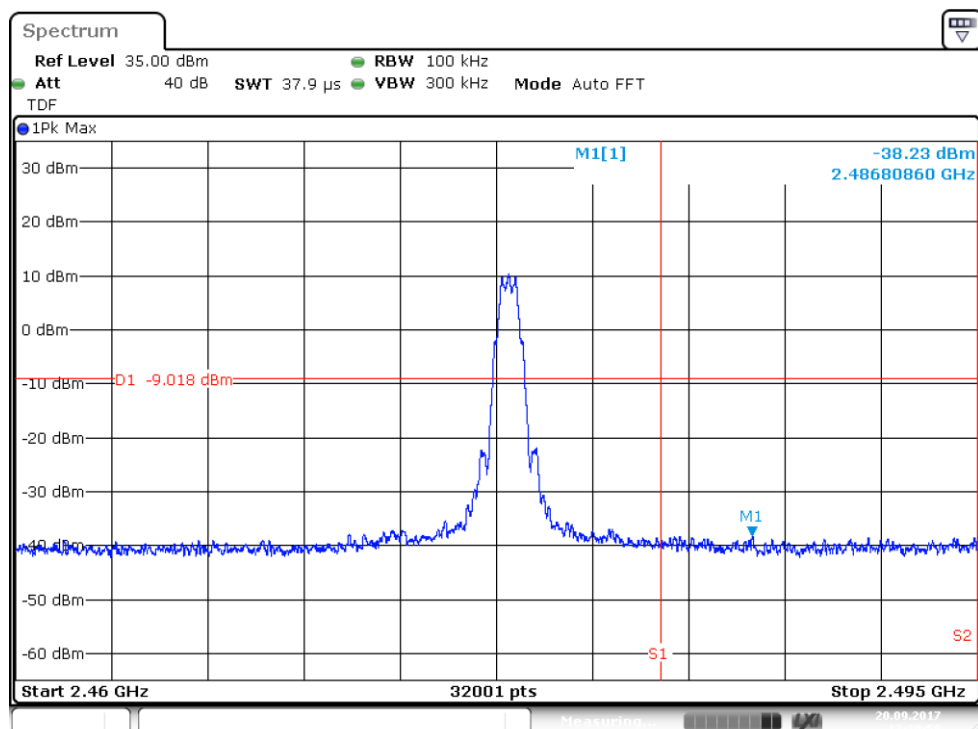


Figure 40: Upper Band Edge, channel 38 (E), power setting 150

Transmitter Band Edge Measurement and Conducted Spurious Emissions

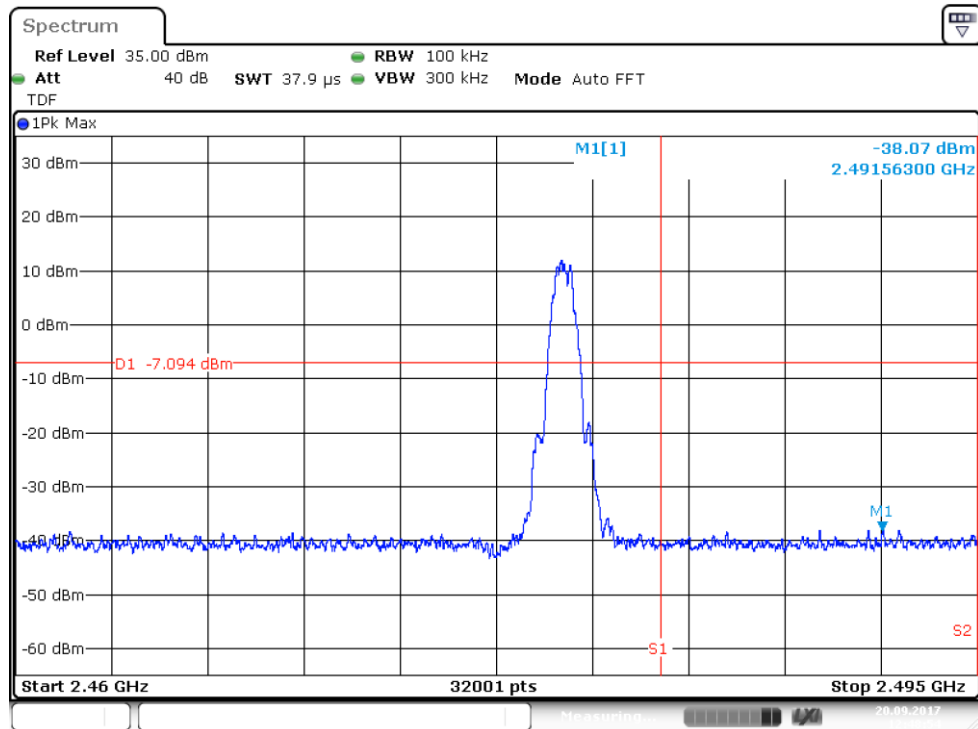


Figure 41: Upper Band Edge, channel 39 (E), power setting 150

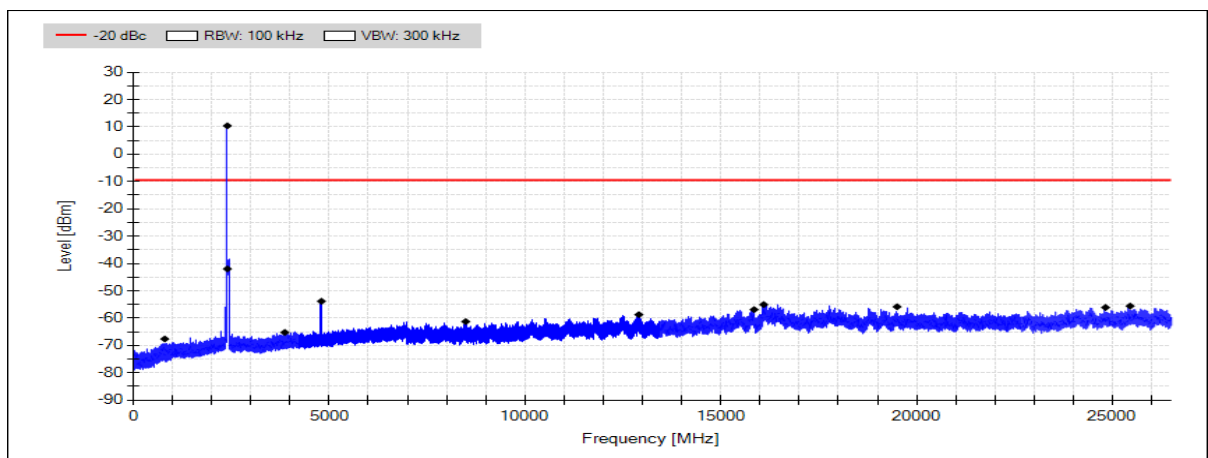


Figure 42: Conducted spurious emissions 30 - 26500 MHz channel 0 low (E), power setting 150

Transmitter Band Edge Measurement and Conducted Spurious Emissions

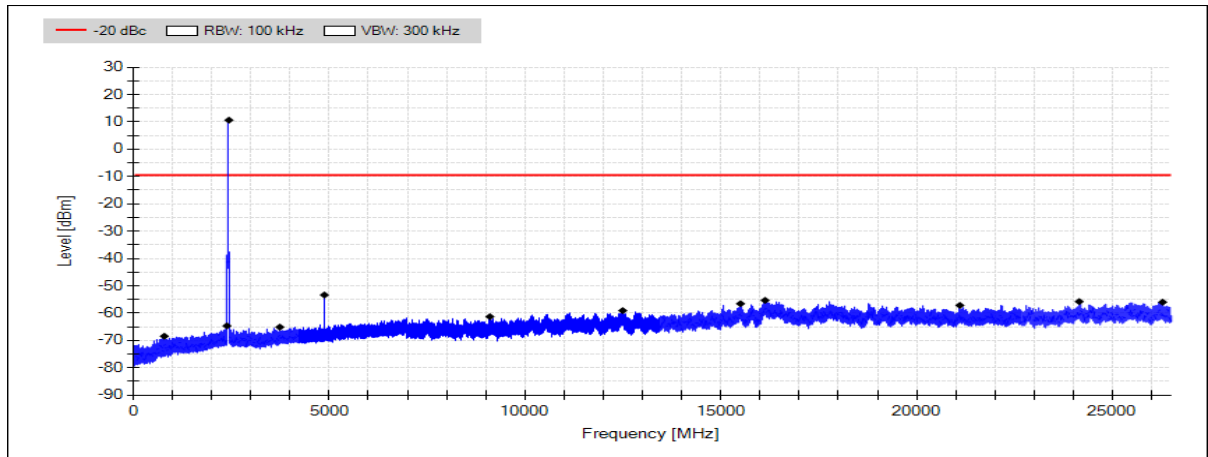


Figure 43: Conducted spurious emissions 30 - 26500 MHz channel 19 mid (E), power setting 150

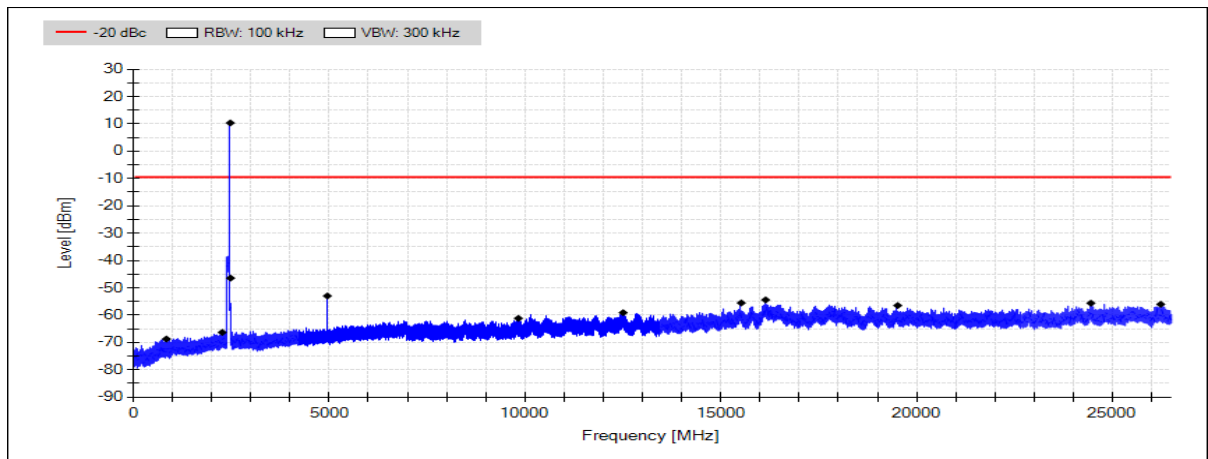


Figure 44: Conducted spurious emissions 30 - 26500 MHz channel 38 high (E), power setting 150

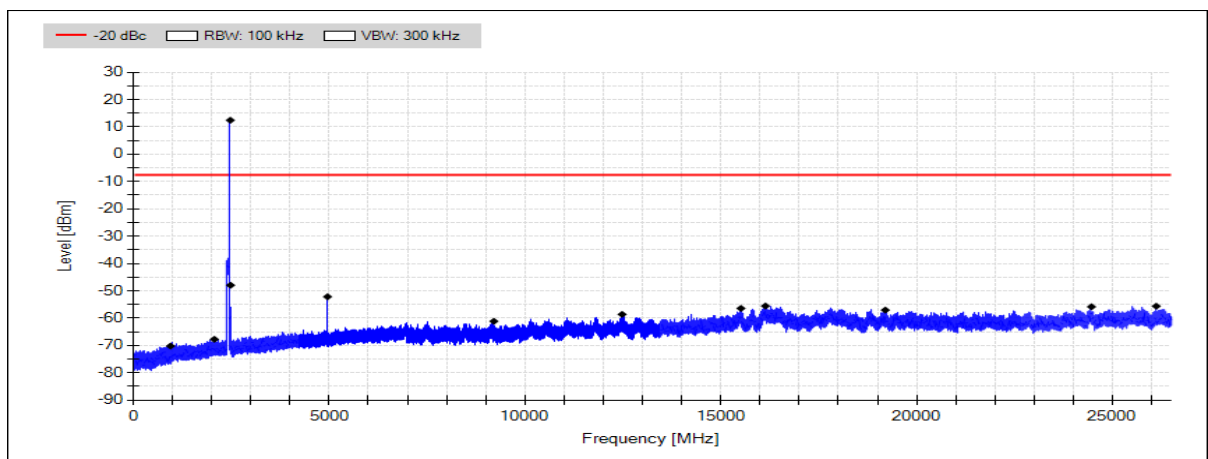


Figure 45: Conducted spurious emissions 30 - 26500 MHz channel 39 high (E), power setting 150

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Table 37: Conducted spurious emissions Channel 0 low (E), power setting 200, PHY 1M coded

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
828,91	-67,38	-2,45	-64,93	PASS
2399,89	-37,60	-2,45	-35,15	PASS
2555,56	-63,89	-2,45	-61,45	PASS
4804,40	-39,82	-2,45	-37,38	PASS
9839,08	-60,50	-2,45	-58,05	PASS
12533,94	-59,15	-2,45	-56,70	PASS
15519,78	-56,28	-2,45	-53,83	PASS
16170,20	-55,05	-2,45	-52,61	PASS
21718,71	-57,12	-2,45	-54,68	PASS
24853,24	-55,81	-2,45	-53,36	PASS
25491,91	-56,19	-2,45	-53,74	PASS

Table 38: Conducted spurious emissions, channel 19 mid (E), power setting 200, PHY 1M coded

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
953,85	-66,40	-2,60	-63,80	PASS
2363,27	-64,23	-2,60	-61,63	PASS
2487,03	-65,34	-2,60	-62,74	PASS
4880,43	-40,78	-2,60	-38,18	PASS
9793,71	-61,71	-2,60	-59,11	PASS
12855,58	-58,81	-2,60	-56,21	PASS
15850,52	-56,56	-2,60	-53,96	PASS
16151,26	-55,06	-2,60	-52,46	PASS
19207,23	-56,64	-2,60	-54,04	PASS
24438,97	-55,98	-2,60	-53,38	PASS
25479,92	-55,69	-2,60	-53,09	PASS

Table 39: Conducted spurious emissions, channel 39 high (E), power setting 200, PHY 1M coded

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
810,45	-66,92	-2,73	-64,18	PASS
2364,63	-64,62	-2,73	-61,88	PASS
2483,76	-41,66	-2,73	-38,92	PASS
4960,39	-39,83	-2,73	-37,09	PASS
9838,15	-61,14	-2,73	-58,41	PASS
12167,57	-58,89	-2,73	-56,16	PASS
15759,96	-56,49	-2,73	-53,75	PASS
16139,26	-54,72	-2,73	-51,98	PASS
19153,98	-56,76	-2,73	-54,03	PASS
24954,02	-56,19	-2,73	-53,46	PASS
25791,39	-55,94	-2,73	-53,21	PASS

Transmitter Band Edge Measurement and Conducted Spurious Emissions

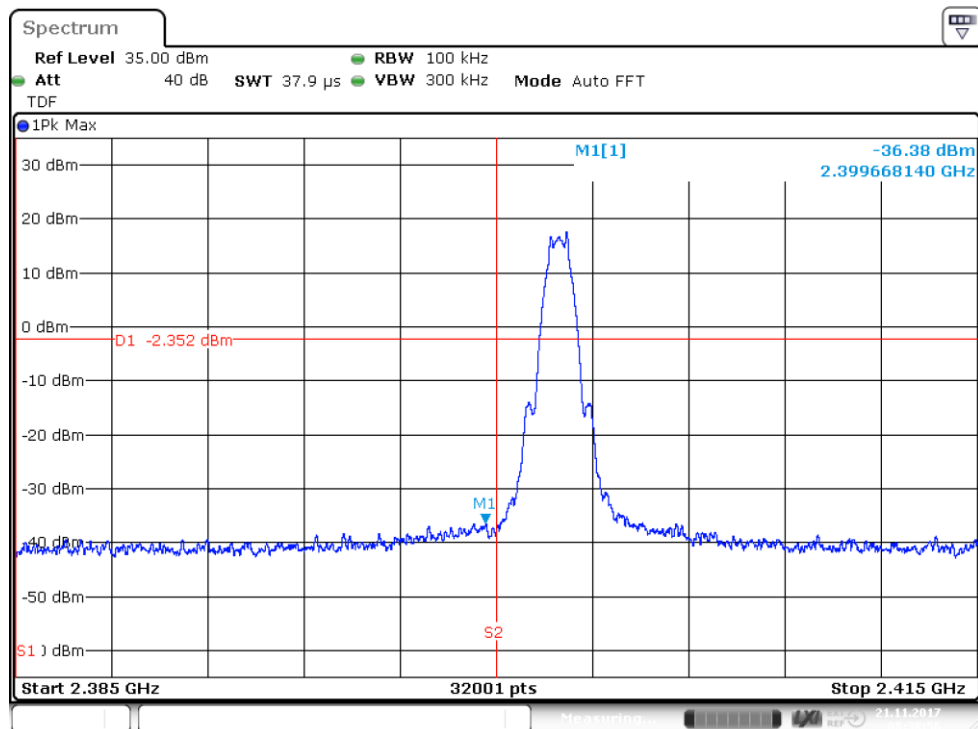


Figure 46: Lower Band Edge, channel 0 (E), power setting 200, PHY 1M coded

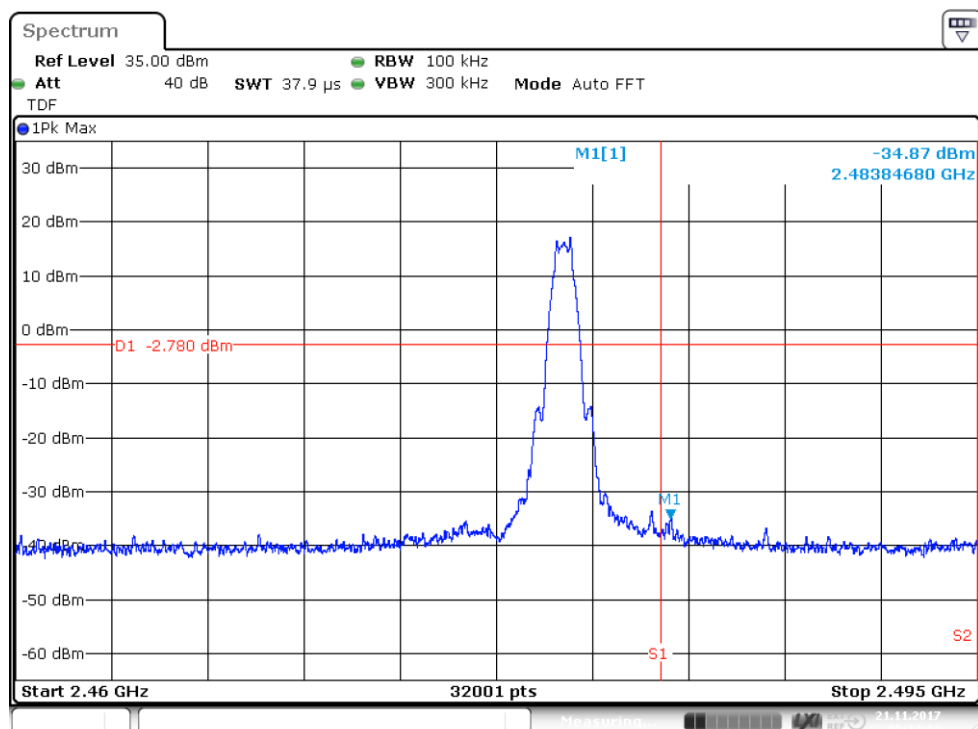


Figure 47: Upper Band Edge, channel 39 (E), power setting 200, PHY 1M coded

Transmitter Band Edge Measurement and Conducted Spurious Emissions

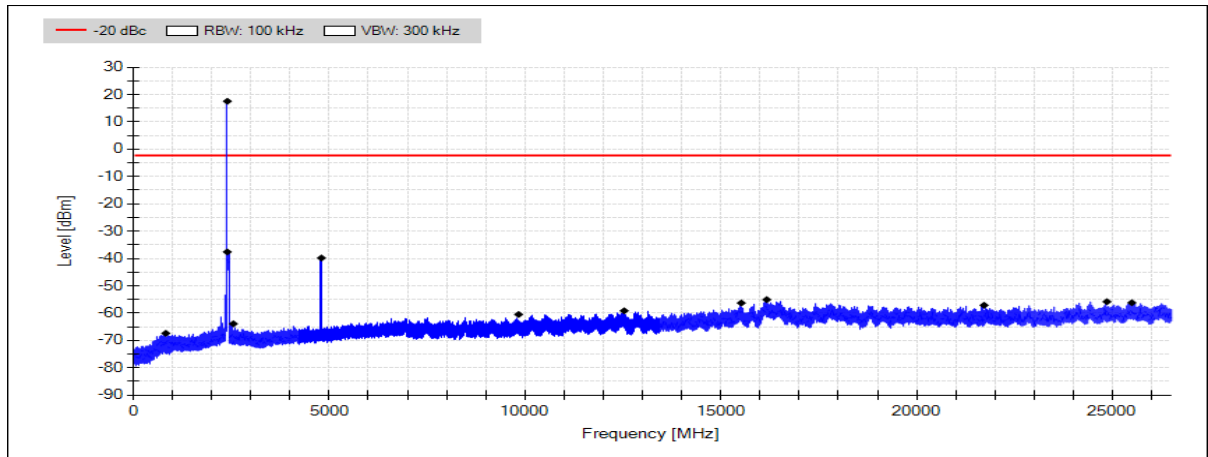


Figure 48: Conducted spurious emissions 30 - 26500 MHz channel 0 (E), power setting 200, PHY 1M coded

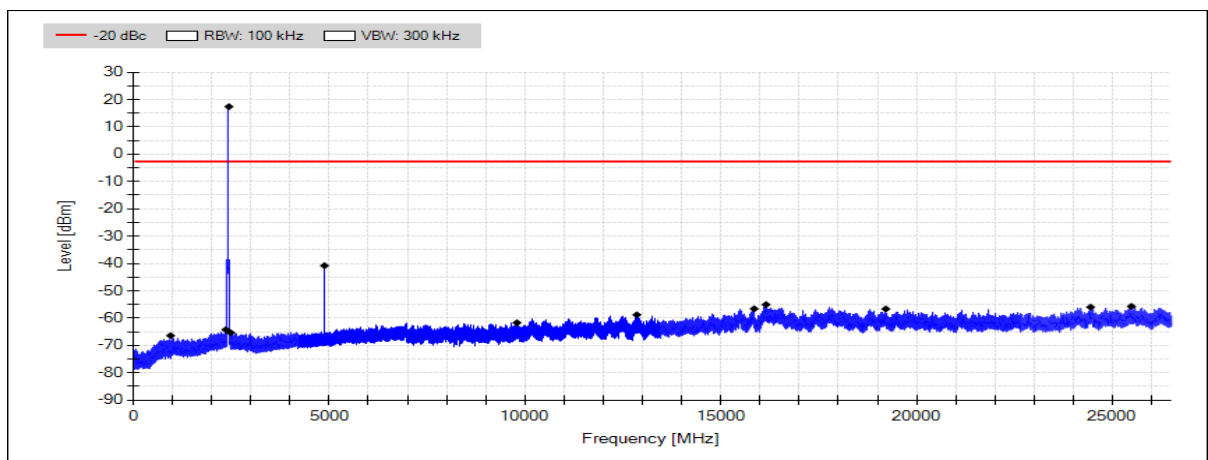


Figure 49: Conducted spurious emissions 30 - 26500 MHz channel 19 (E), power setting 200, PHY 1M coded

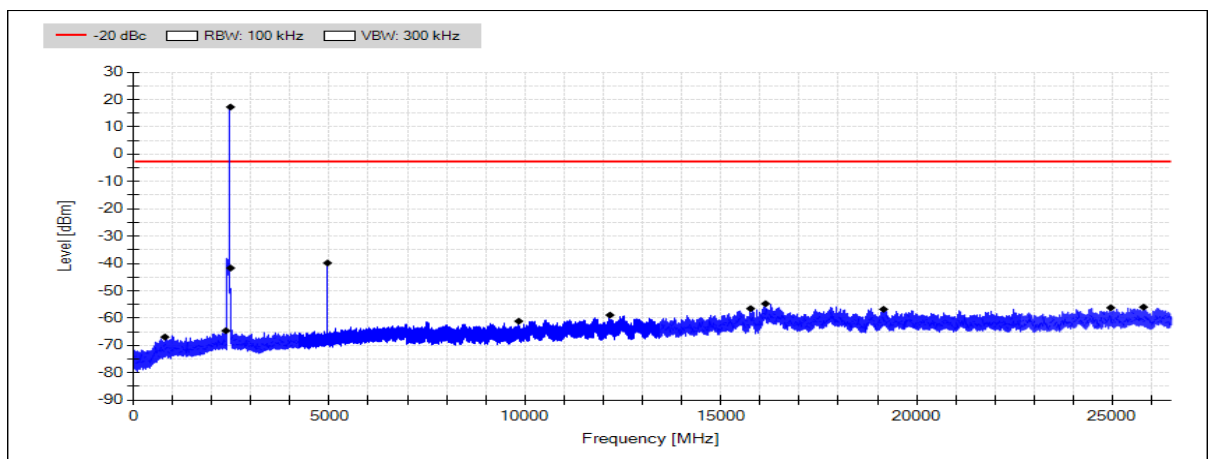


Figure 50: Conducted spurious emissions 30 - 26500 MHz channel 39 (E), power setting 200, PHY 1M coded

6 dB Bandwidth of the Channel

Standard: ANSI C63.10 (2013)
Tested by: MIH
Date: 11 September – 21 November 2017
Temperature: 23 ± 3 °C
Humidity: 20 - 60 % RH

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

Results:

Table 40: 6 dB bandwidth test results (E), power setting 150

Channel	6 dB BW [kHz]	Minimum limit [kHz]
0 Low	691.0	500
19 Mid	680.0	
38 High	674.0	
39 High	654.0	

Table 41: 6 dB bandwidth test results (E), power setting 200, PHY 1M coded

Channel	6 dB BW [kHz]	Minimum limit [kHz]
0 Low	654.0	500
19 Mid	652.0	
39 High	655.0	

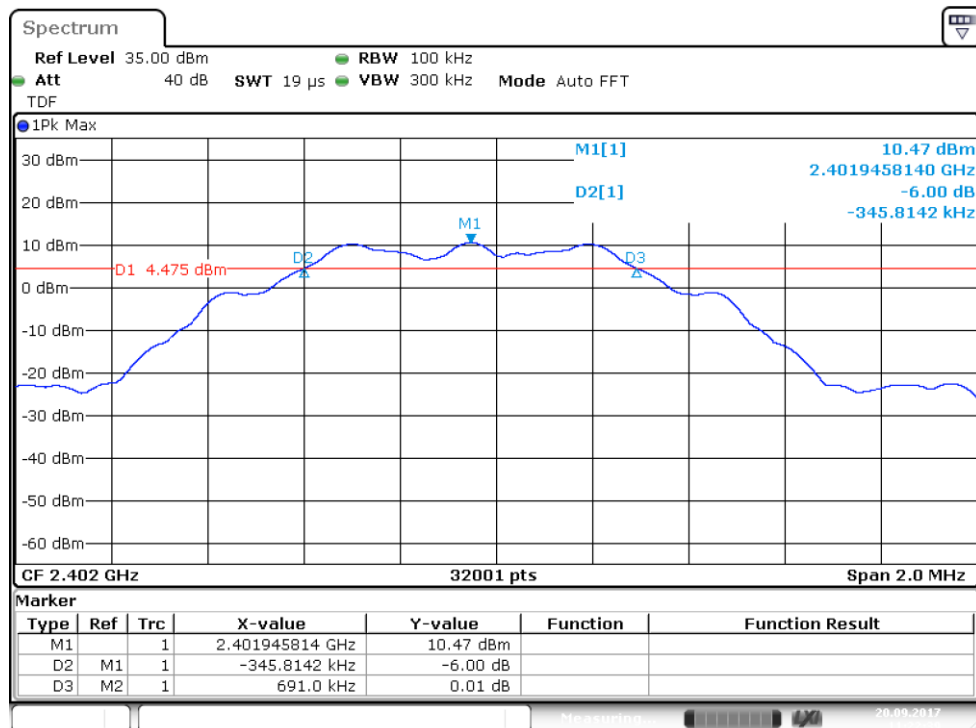


Figure 51: 6 dB bandwidth, channel 0 low (E), power setting 150

6 dB Bandwidth of the Channel

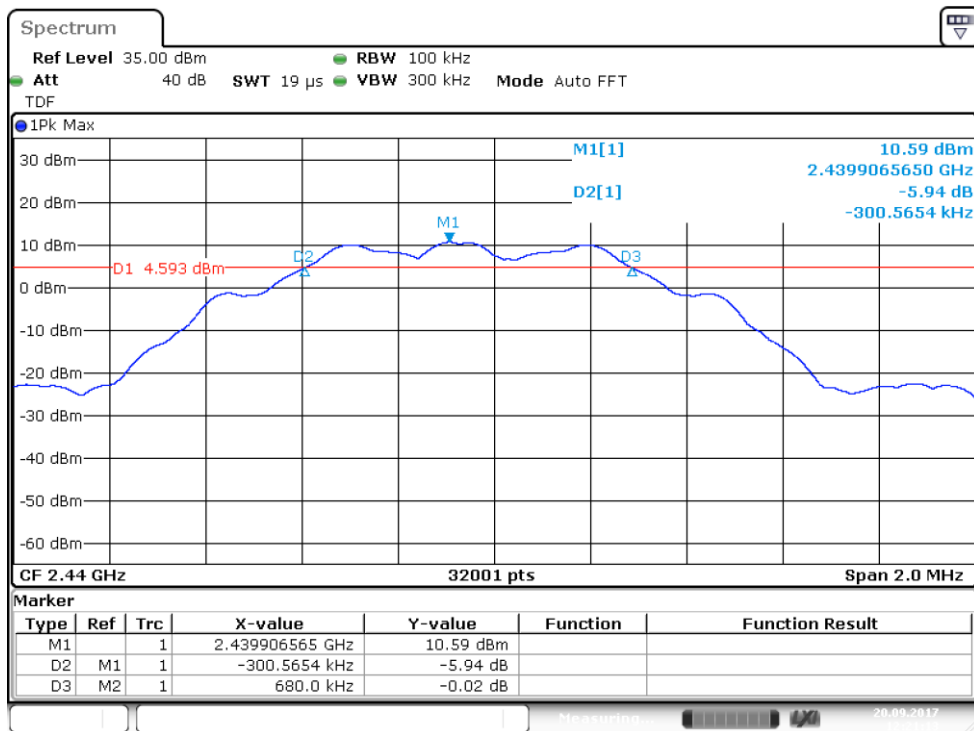


Figure 52: 6 dB bandwidth, channel 19 mid (E), power setting 150

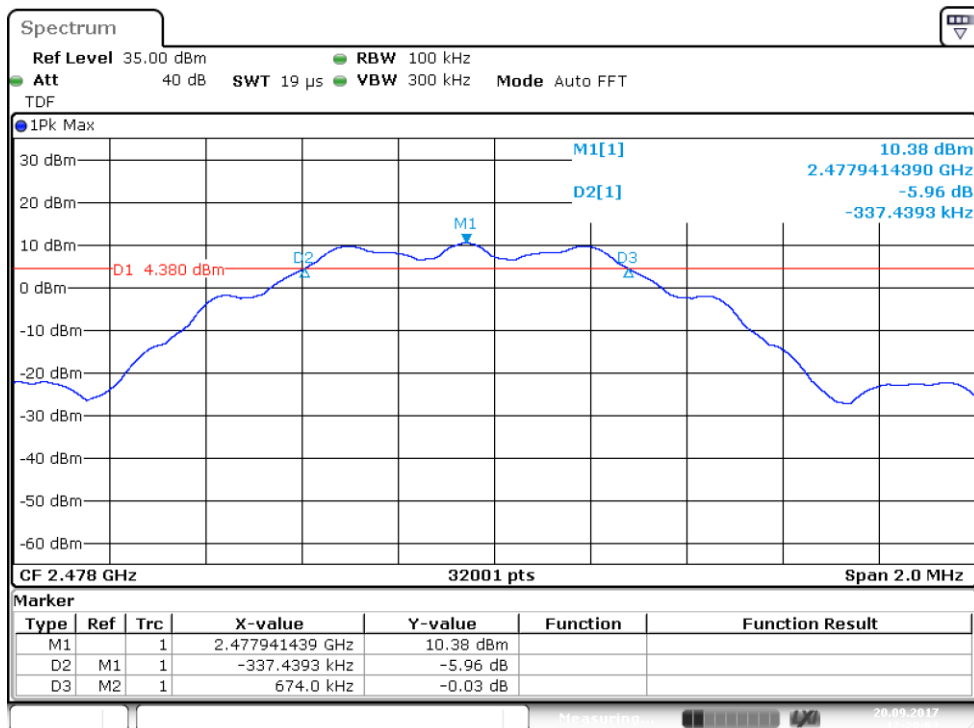


Figure 53: 6 dB bandwidth, channel 38 high (E), power setting 150

6 dB Bandwidth of the Channel

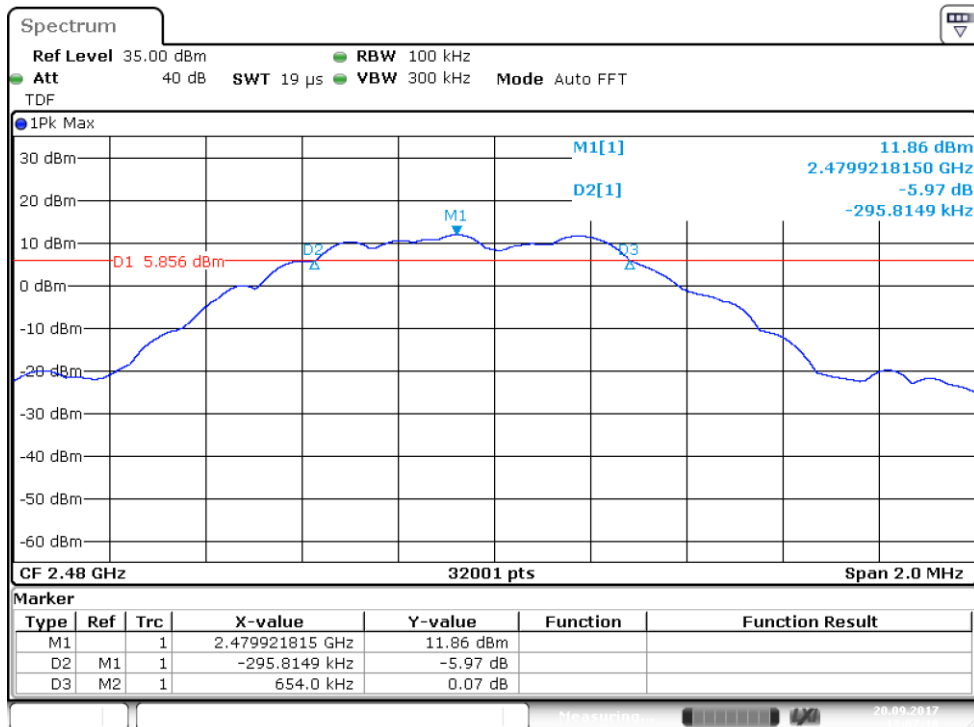


Figure 54: 6 dB bandwidth, channel 39 high (E), power setting 150

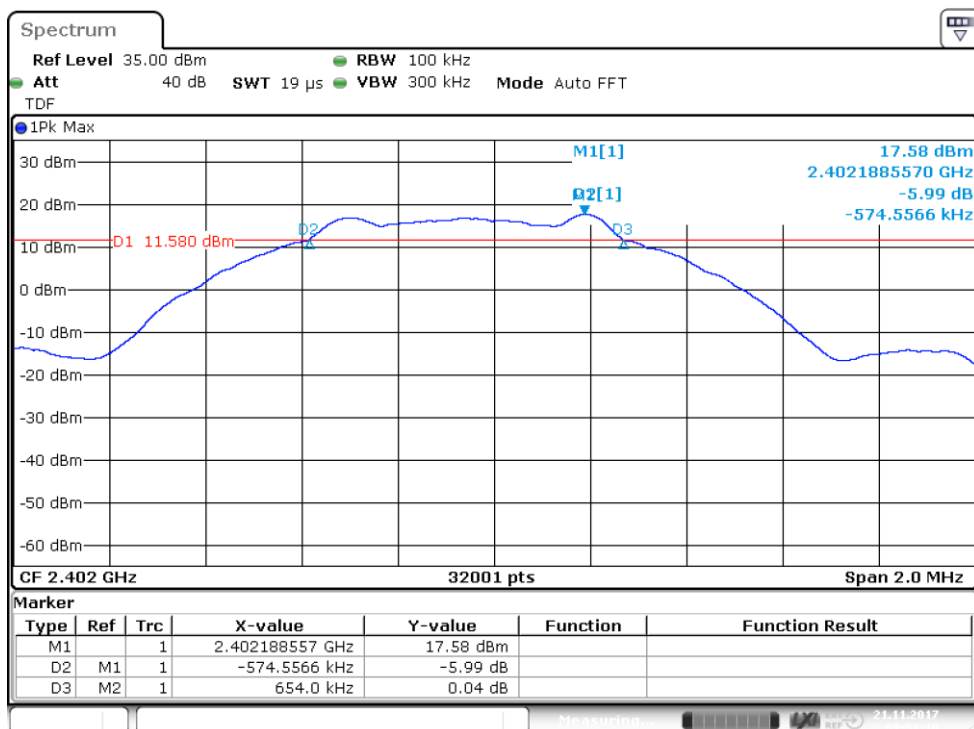


Figure 55: 6 dB bandwidth, channel 0 low (E), power setting 200, PHY 1M coded

6 dB Bandwidth of the Channel

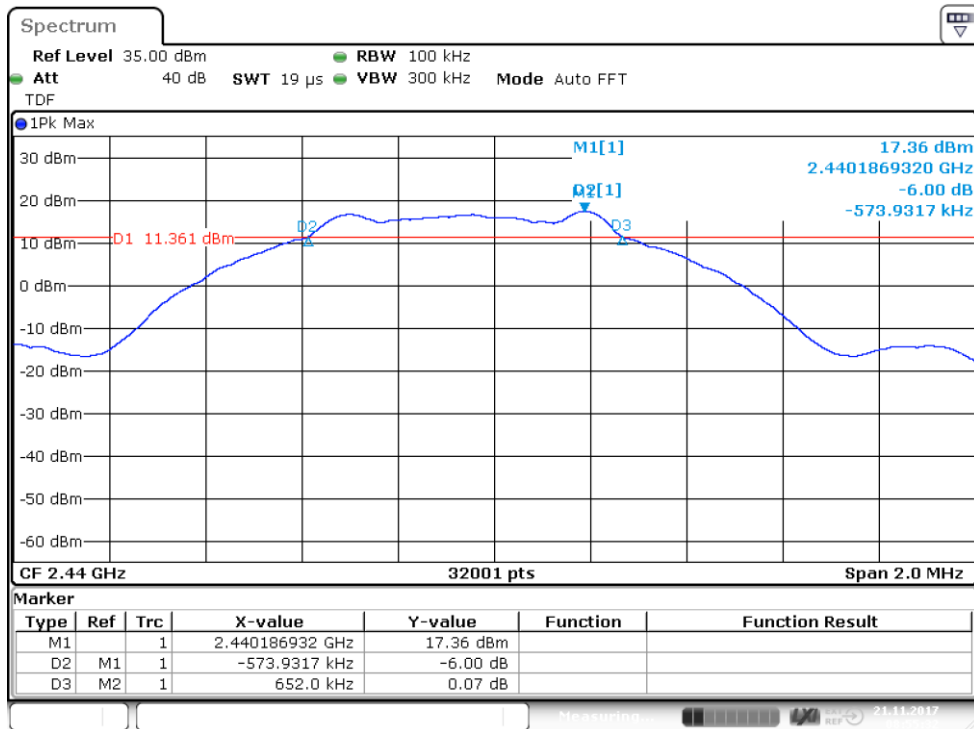


Figure 56: 6 dB bandwidth, channel 19 mid (E), power setting 200, PHY 1M coded

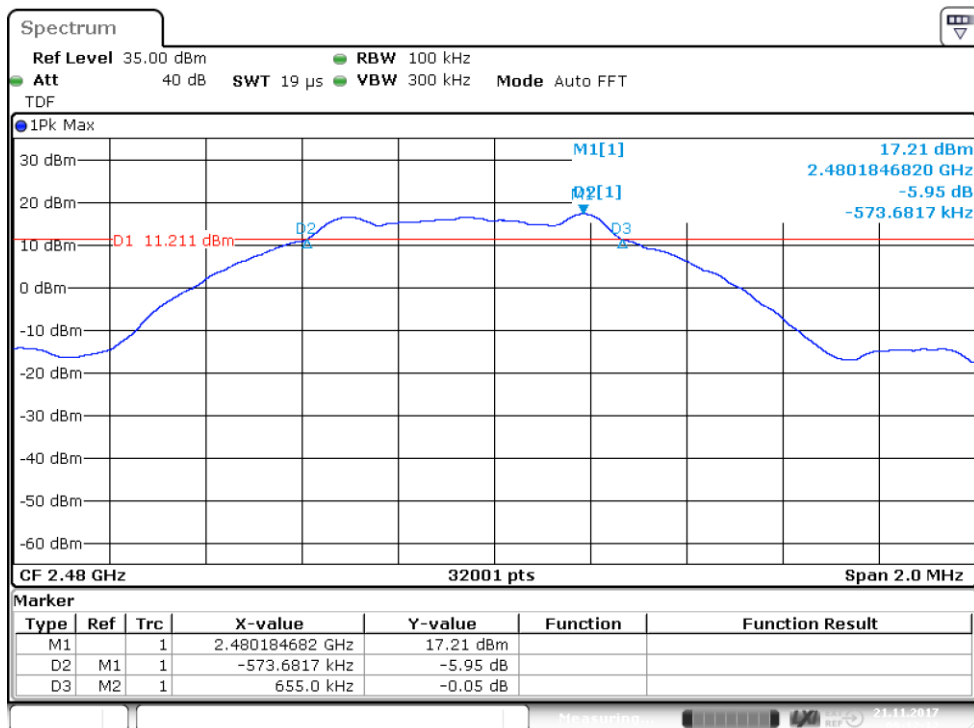


Figure 57: 6 dB bandwidth, channel 39 high (E), power setting 200, PHY 1M coded

Power Spectral Density

Standard: ANSI C63.10 (2013)
Tested by: MIH
Date: 11 September – 21 November 2017
Temperature: 23 ± 3 °C
Humidity: 20 - 60 % RH

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

Results:

Table 42: Power spectral density test results (E), power setting 150

Channel	PSD dBm/3 kHz	Maximum limit [dBm/3kHz]
0 Low	7.71	+8.00
19 Mid	7.54	
38 High	7.21	
39 High	-1.20	

Table 43: Power spectral density test results (E), power setting 200, HPY 1M coded

Channel	PSD dBm/3 kHz	Maximum limit [dBm/3kHz]
0 Low	1.24	+8.00
19 Mid	0.98	
39 High	0.84	

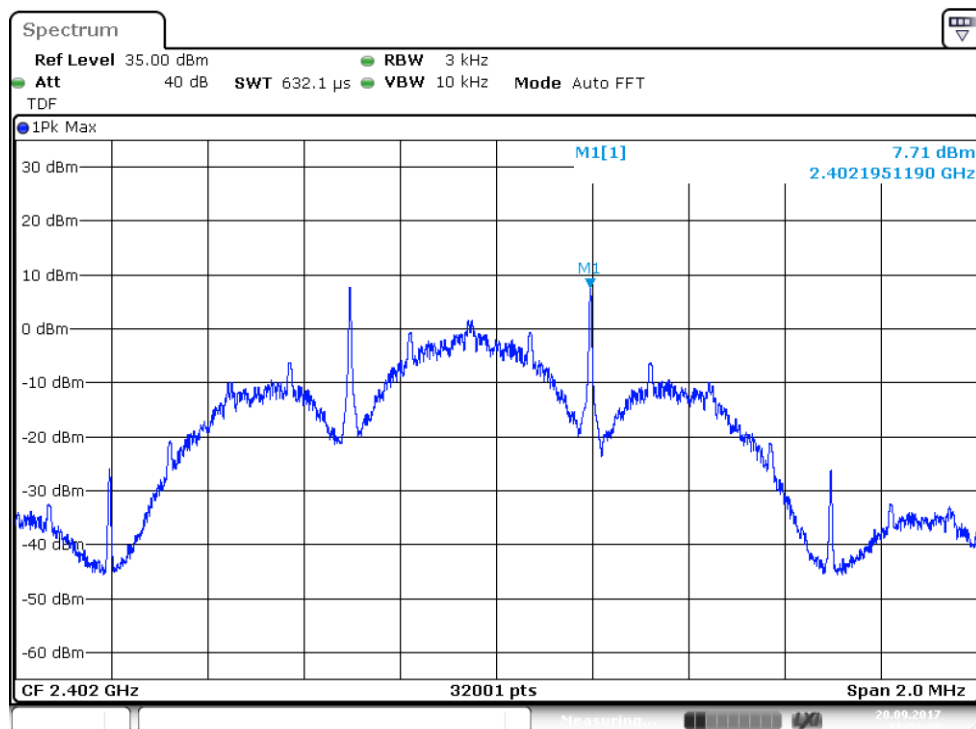


Figure 58: Power spectral density, channel 0 low (E), power setting 150

Power Spectral Density

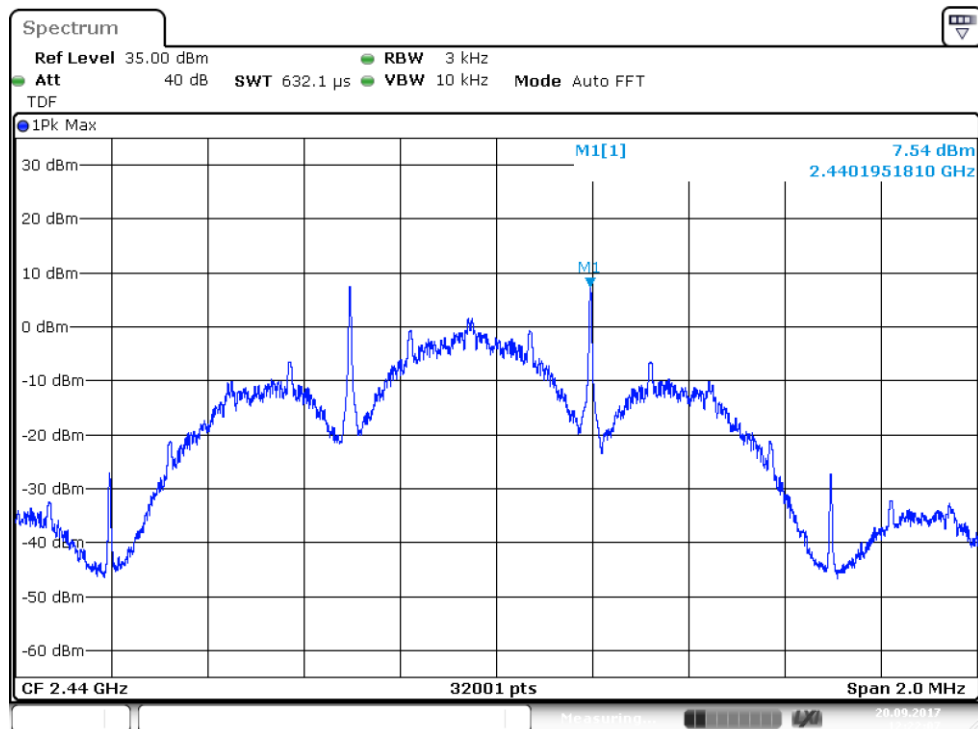


Figure 59: Power spectral density, channel 19 mid (E), power setting 150

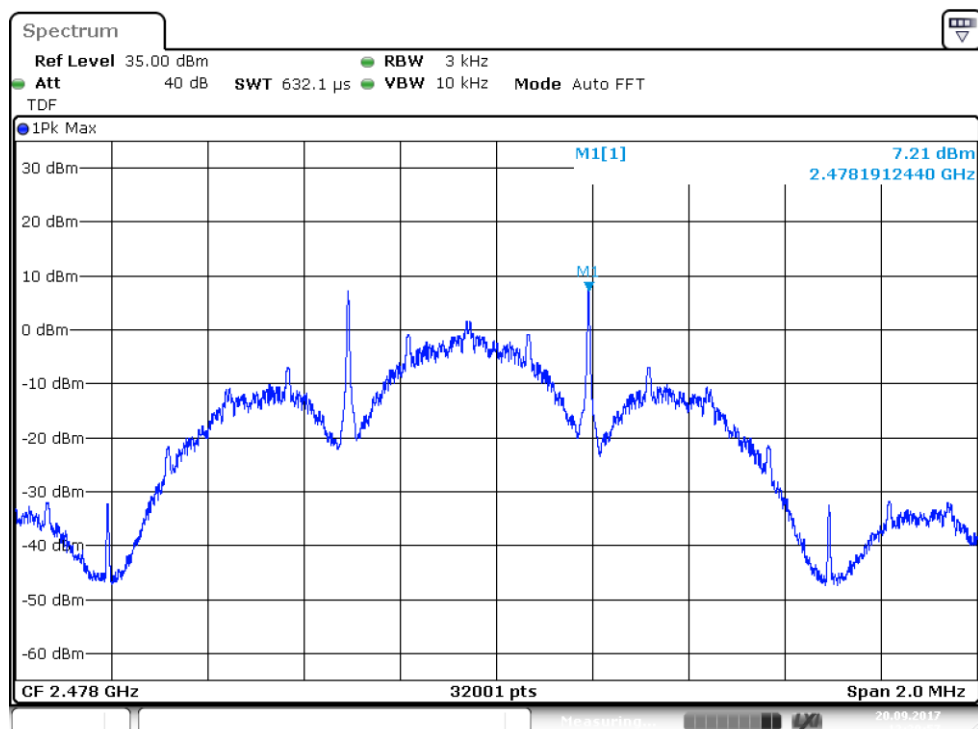


Figure 60: Power spectral density, channel 38 high (E), power setting 150

Power Spectral Density

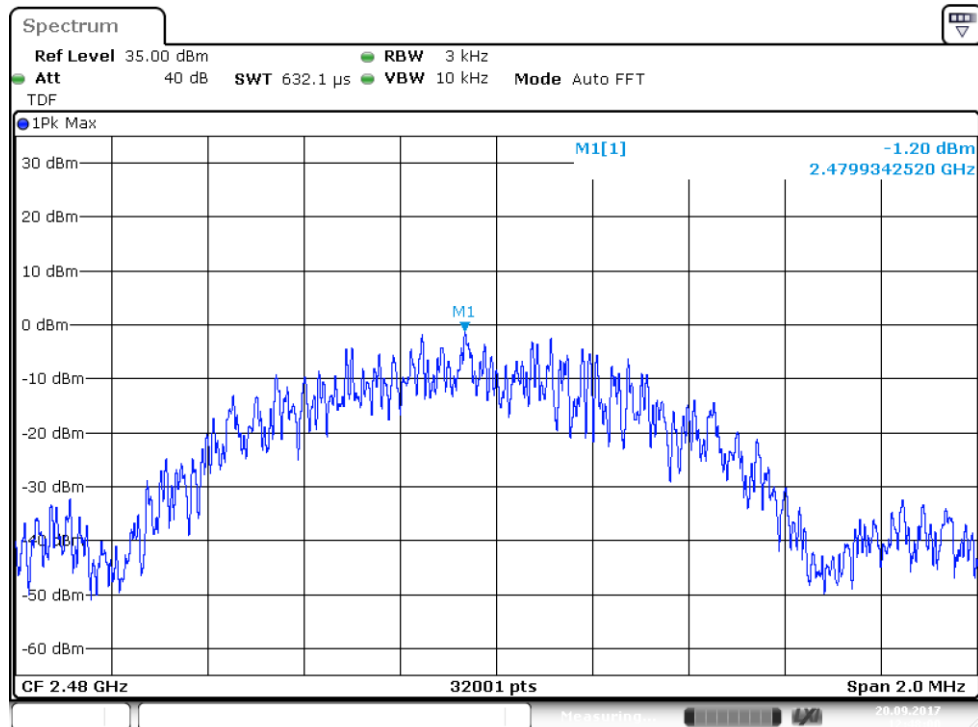


Figure 61: Power spectral density, channel 39 high (E), power setting 150

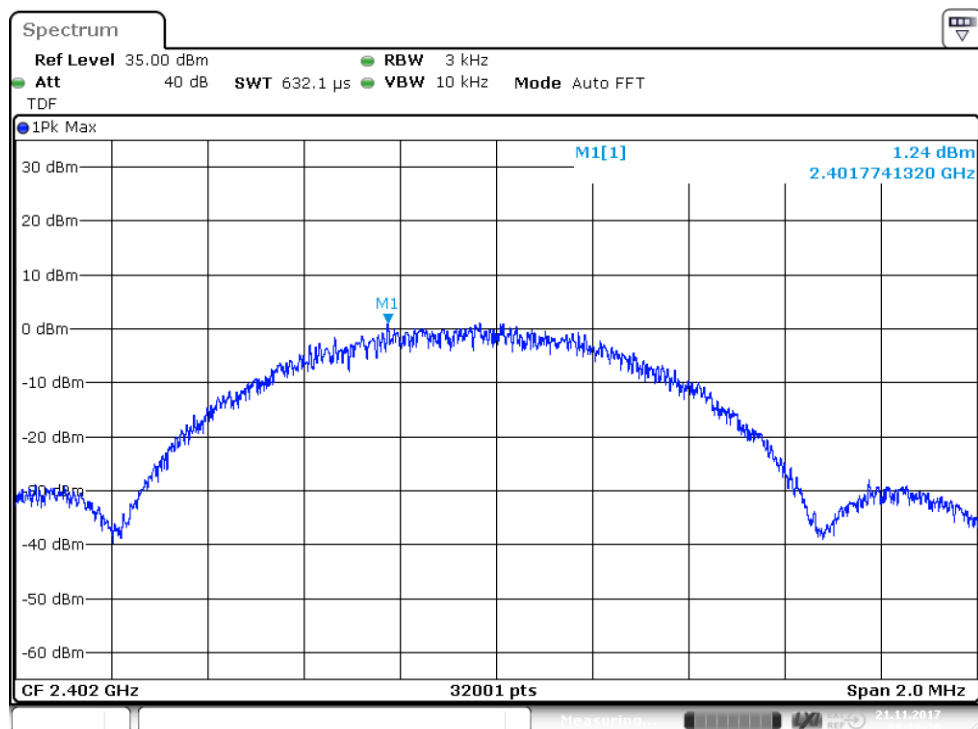


Figure 62: Power spectral density, channel 0 low (E), power setting 200, PHY 1M coded

Power Spectral Density

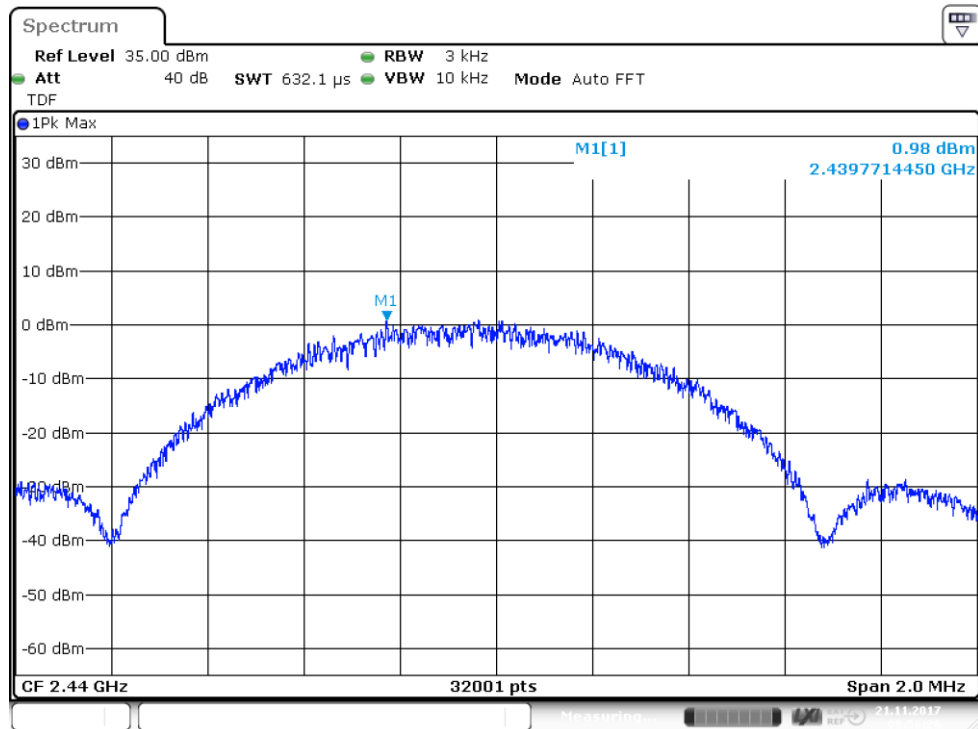


Figure 63: Power spectral density, channel 19 mid (E), power setting 200, 1M coded

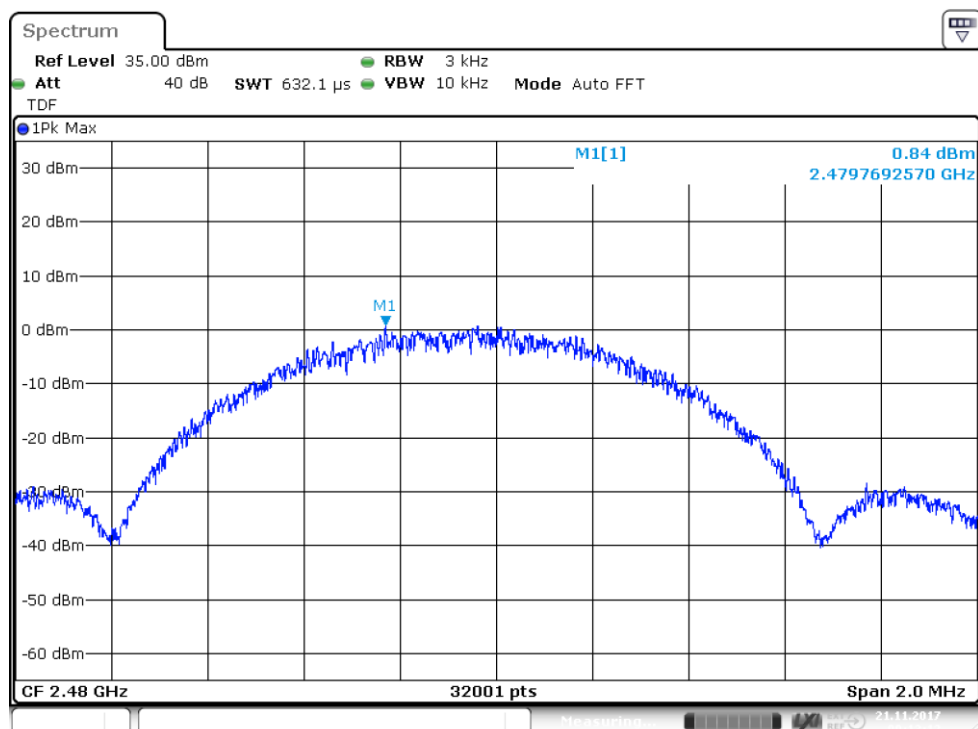


Figure 64: Power spectral density, channel 39 high (E), power setting 200, PHY 1M coded

99% Occupied Bandwidth

Standard: RSS-GEN (2014)
Tested by: MIH
Date: 11 September – 21 November 2017
Temperature: 23 ± 3 °C
Humidity: 20 - 60 % RH

RSS-GEN 6.6

Results:

Table 44: 99% occupied bandwidth test results (E), power setting 150

Channel	Limit	99 % BW [MHz]	Result
0 Low	-	1.054217056	PASS
19 Mid	-	1.058341927	PASS
38 High	-	1.044842349	PASS
39 High	-	1.035467642	PASS

Table 45: 99% occupied bandwidth test results (E), power setting 200, PHY 1M coded

Channel	Limit	99 % BW [MHz]	Result
0 Low	-	1.042967407	PASS
19 Mid	-	1.047842255	PASS
39 High	-	1.046092310	PASS

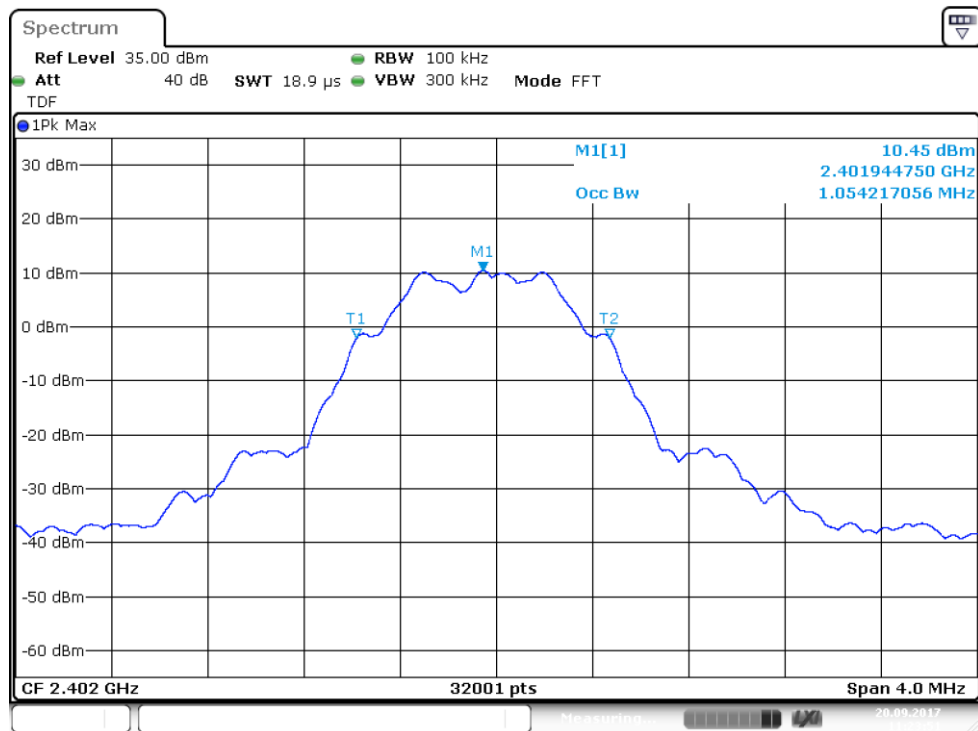


Figure 65: 99% OBW, Channel 0 low (E), power setting 150

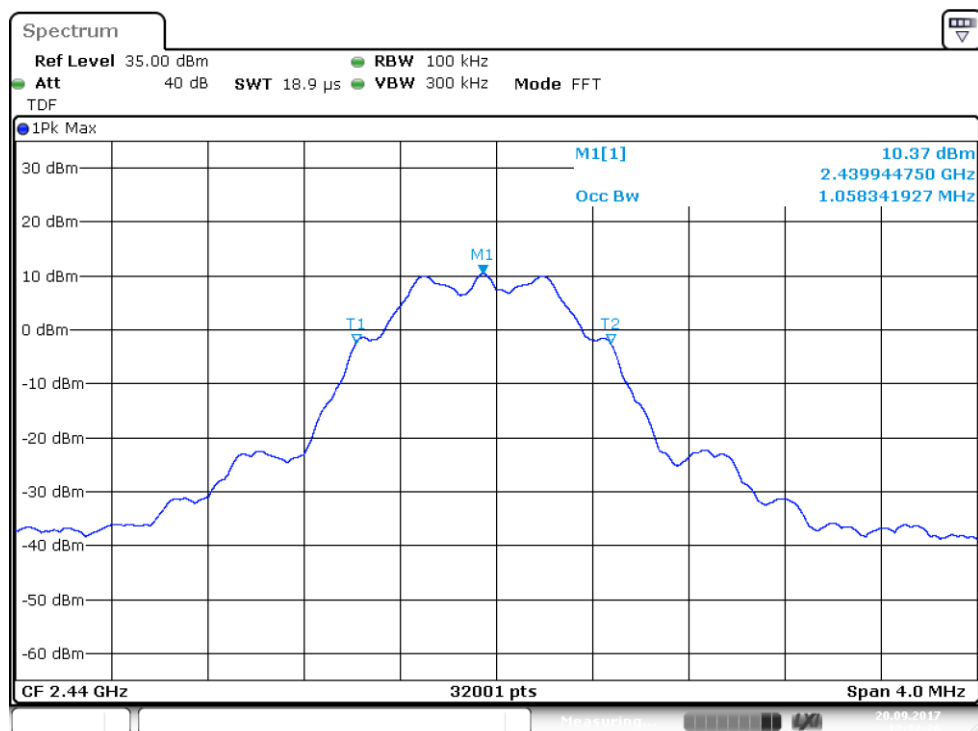


Figure 66: 99% OBW, Channel 19 mid (E), power setting 150

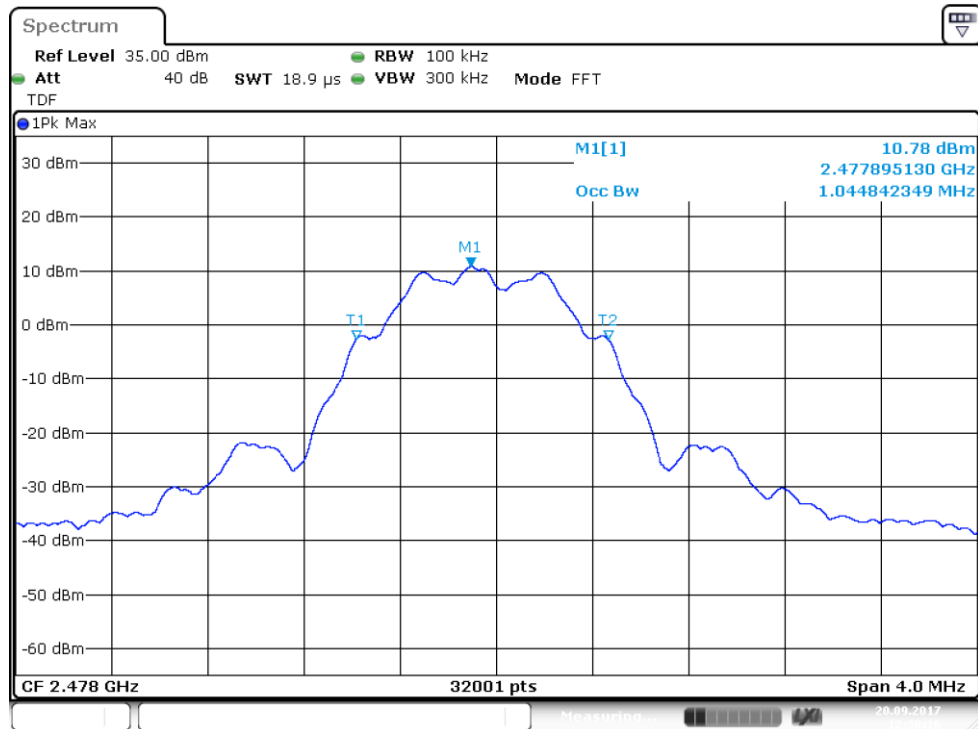


Figure 67: 99% OBW, Channel 38 high (E), power setting 150

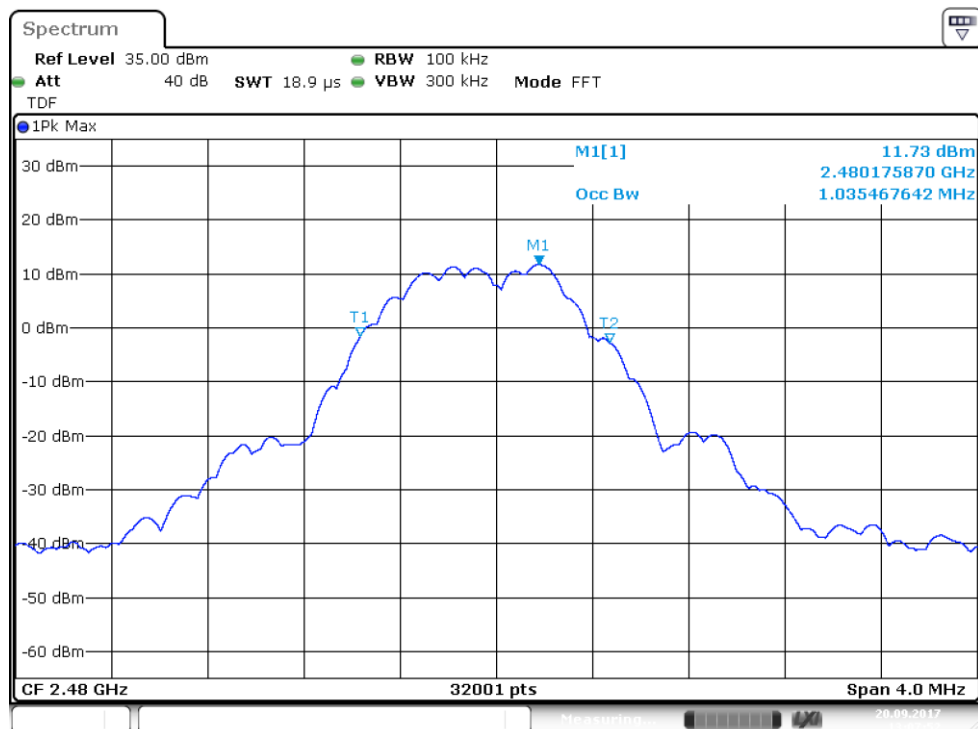


Figure 68: 99% OBW, Channel 39 high (E), power setting 150

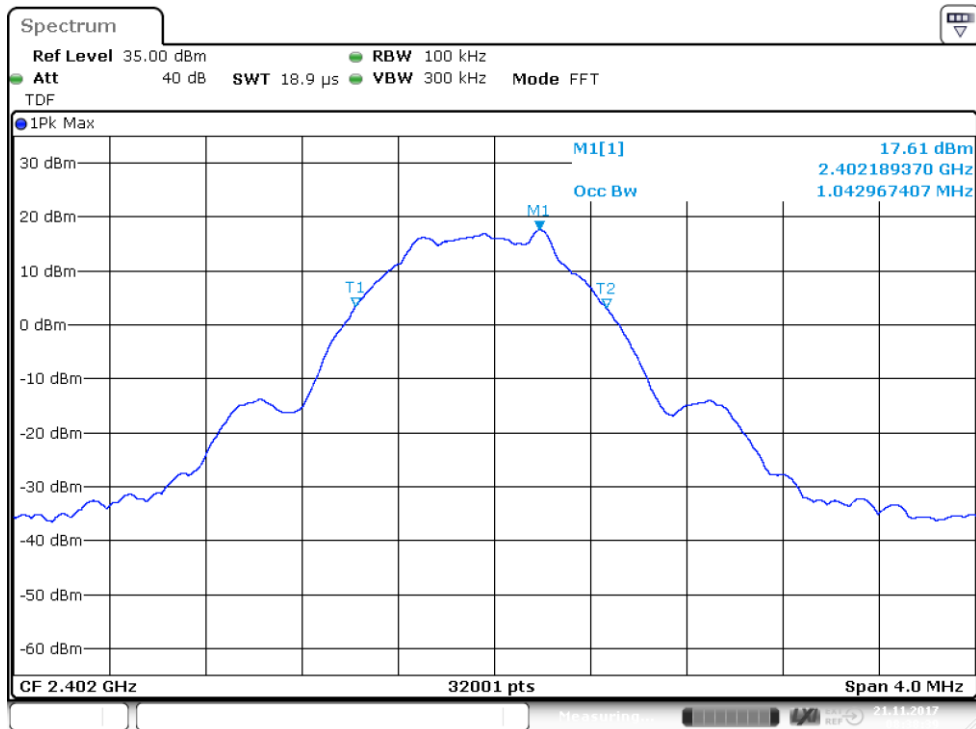


Figure 69: 99% OBW, Channel 0 low (E), power setting 200, PHY 1M coded

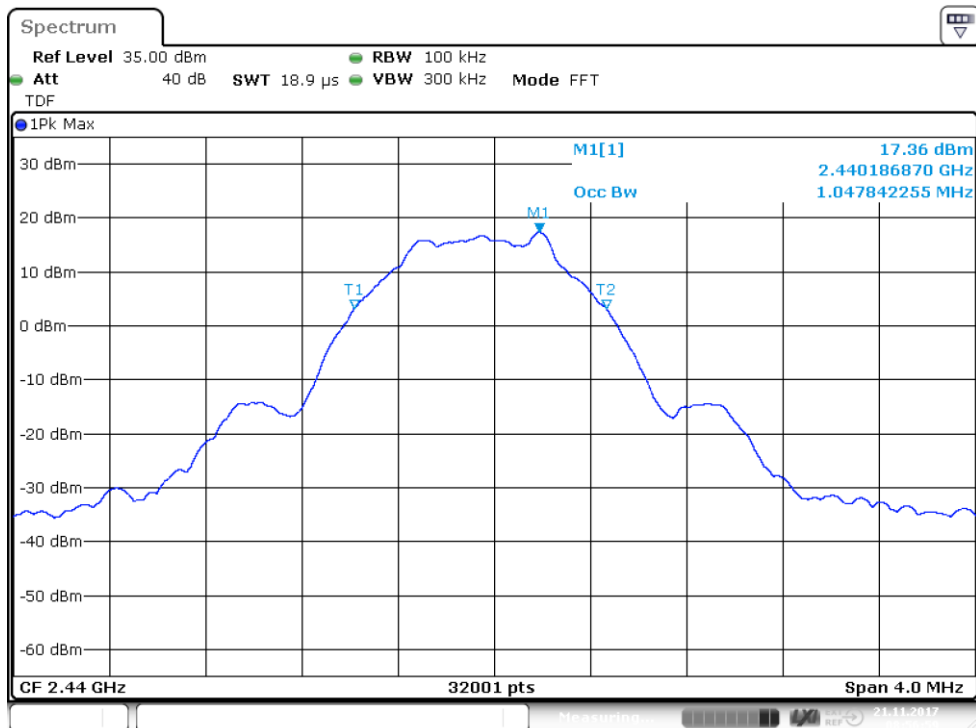


Figure 70: 99% OBW, Channel 19 mid (E), power setting 200, PHY 1M coded

99 % Occupied Bandwidth

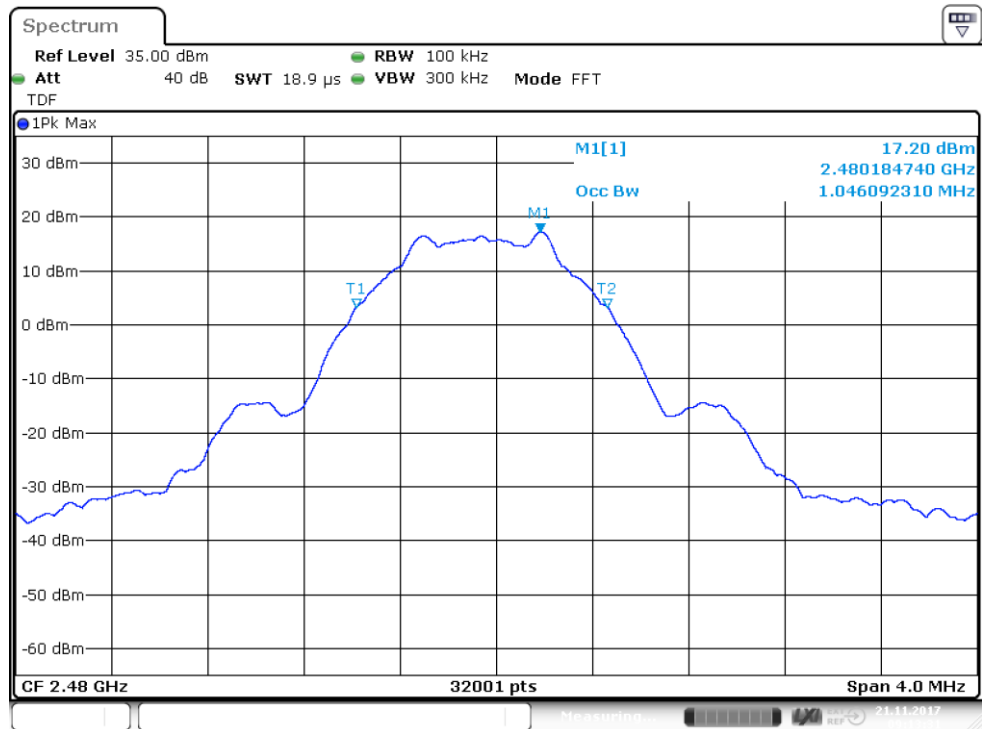


Figure 71: 99% OBW, Channel 39 high (E), power setting 200, PHY 1M coded

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	PASTERNAK	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