Test Report

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

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

Equipment Under Test:	Multi-Protocol Wireless Module
Model:	MGM13P12A MGM13P12E
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: 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:	1 December 2017	Date:	1 December 2017
Issued by:	Emil Haverinen Testing Engineer	Checked by:	Rauno Repo Testing Engineer

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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

MGM13P 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 ZigBee.

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):	2405 - 2480 MHz
Channels:	15
Channel separation:	5 MHz
Effective conducted power:	19.02 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

Samples

Three samples were used in tests, samples are listed in table below.

EUT	Description
1. MGM13P12A	Original A variant, equipped with chip antenna
2. MGM13P12A	Modified A variant, Short RF cable added for conducted tests
3. MGM13P12E	Original E variant with RF connector 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.

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;

EUT 1. MGM13P12A

- Radiated Emissions Within the Restricted Bands (channels: 11, 19, 25, 26), Channel 26 was used only for band edge measurement.
- Conducted Emissions on Power Supply Lines tests (channel: 19)

Channel	Frequency (MHz)	Power setting
11	2405	200
19	2445	200
25	2475	200
26	2480	170

EUT 3. MGM13P12E

- Radiated Emissions Within the Restricted Bands (channels: 11, 19, 25, 26), Channel 26 was used only for band edge measurement.
- Conducted Emissions on Power Supply Lines tests (channel 19)

Channel	Frequency (MHz)	Power setting
11	2405	200
19	2445	200
25	2475	200
26	2480	140

EUT2. MGM13P12A and EUT3. MGM13P12E (All tests below, were made with both EUT's)

- Maximum Peak Conducted Output Power (channels: 11, 19, 25, 26)
- 6 dB Bandwidth (channels: 11, 19, 25, 26)
- Power Spectral Density (channels: 11, 19, 25, 26)
- 99% Occupied Bandwidth (channels: 11, 19, 25, 26)
- 100 kHz Bandwidth of Frequency Band Edges and Conducted Spurious Emissions tests (channels: 11, 19, 25, 26)

Channel	Frequency (MHz)	Power setting	
		MGM13P12A	MGM13P12E
11	2405	200	200
19	2445	200	200
25	2475	200	200
26	2480	170	170

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:	JAT	
Date:	18 October 2017	
Temperature:	23 ± 3°C	
Humidity:	20 - 60 % RH	
Barometric pressure:	1001 hPa	
Measurement uncertainty:	± 2.9 dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.207 (a)
RSS-GEN 8.8

Conducted disturbance voltage was measured with an artificial main network from 150 kHz to 30 MHz with 4.5 kHz steps and a resolution bandwidth of 9 kHz. Measurements were carried out with peak and average detectors.

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

*Decreases with the logarithm of the frequency.

Final measurements from the worst frequencies

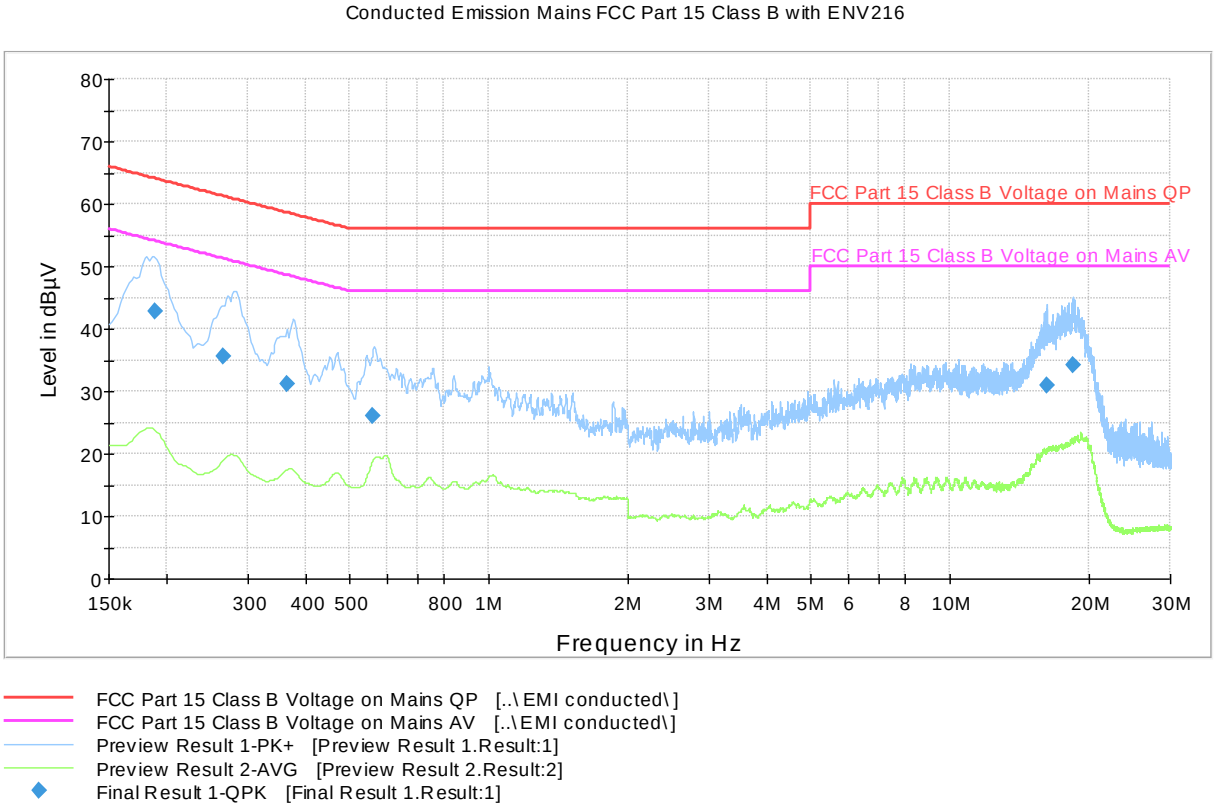

Figure 1: The measured curves with peak- and average detector (A).

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)
0.189750	42.7	1000.0	9.000	N	10.1	21.3	64.0
0.265250	35.6	1000.0	9.000	N	10.2	25.6	61.3
0.364750	31.2	1000.0	9.000	N	10.2	27.5	58.6
0.560500	26.1	1000.0	9.000	N	10.3	29.9	56.0
16.174250	30.8	1000.0	9.000	L1	10.4	29.2	60.0
18.424500	34.2	1000.0	9.000	N	10.6	25.8	60.0

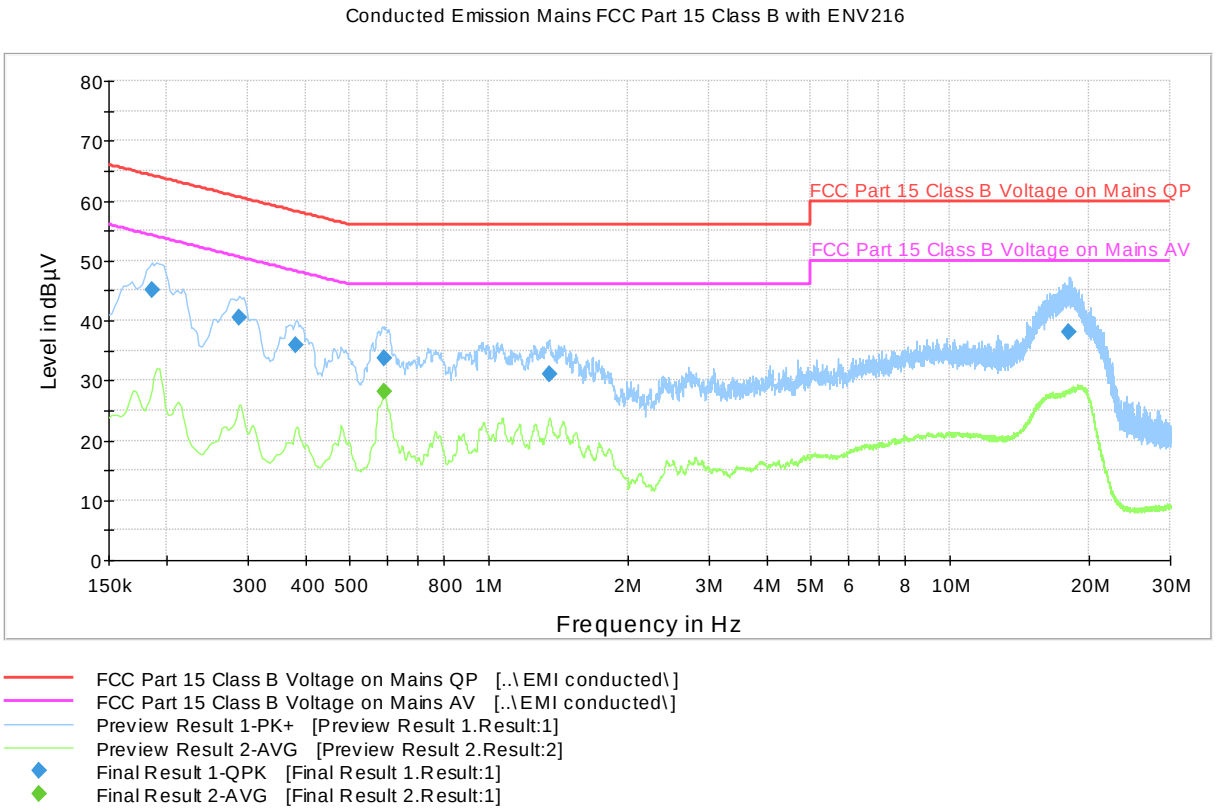

Figure 2: The measured curves with peak- and average detector (E).

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)
0.186500	45.0	1000.0	9.000	N	10.1	19.2	64.2
0.287750	40.5	1000.0	9.000	N	10.2	20.1	60.6
0.382500	35.9	1000.0	9.000	N	10.2	22.3	58.2
0.594250	33.7	1000.0	9.000	N	10.3	22.3	56.0
1.349500	31.0	1000.0	9.000	L1	9.9	25.0	56.0
18.127750	38.2	1000.0	9.000	N	10.6	21.8	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)
0.592750	28.2	1000.0	9.000	L1	10.1	17.8	46.0

The correction factor in the final result table contains the sum of the transducers (transient limiter + cables). The result value is the measured value corrected with the correction factor.

Maximum Peak Conducted Output Power

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	13 October 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 4: Maximum conducted output power (A)

Channel	Conducted Power [dBm]	Limit [dBm]	Margin [dBm]	Result
11 Low	19.02	30	10.98	PASS
19 Mid	18.72	30	11.28	PASS
25 High	18.58	30	11.42	PASS
26 High	16.51	30	13.49	PASS

Table 5: Maximum conducted output power (E)

Channel	Conducted Power [dBm]	Limit [dBm]	Margin [dBm]	Result
11 Low	18.50	30	11.50	PASS
19 Mid	18.19	30	11.81	PASS
25 High	18.04	30	11.96	PASS
26 High	15.83	30	14.17	PASS

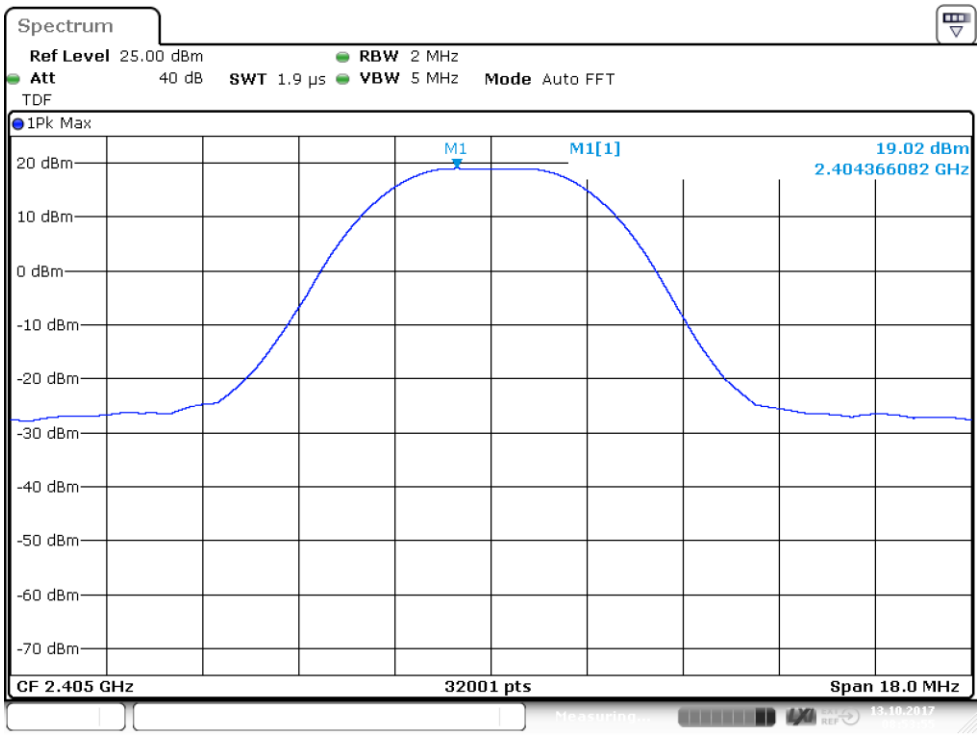

Figure 3: Conducted power, Channel 11 low (A)

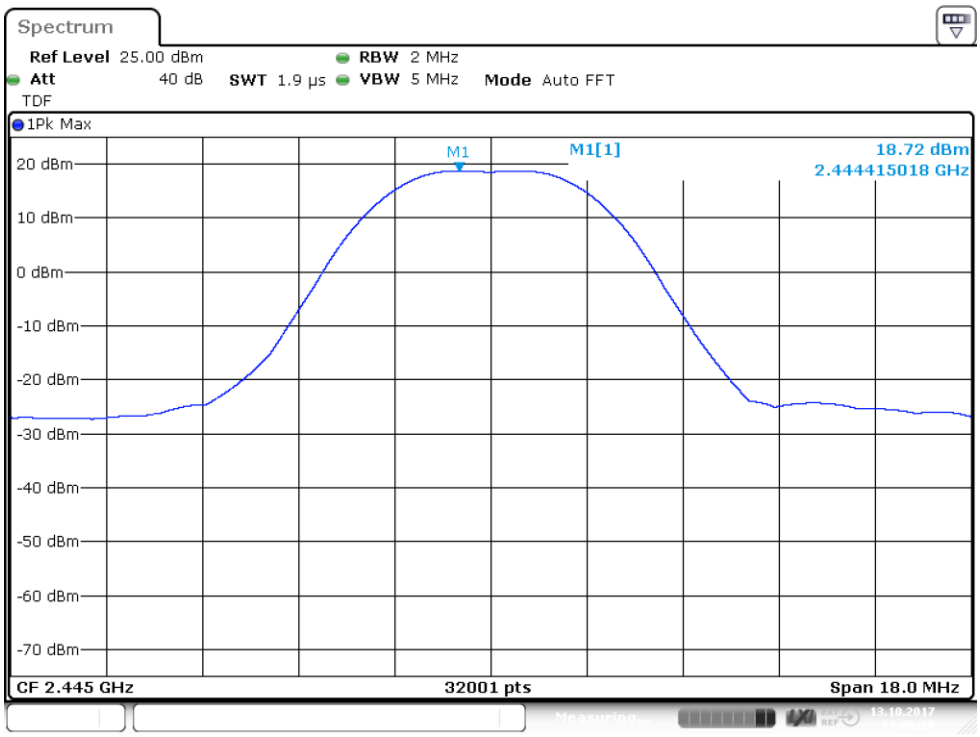

Figure 4: Conducted power, Channel 19 mid (A)

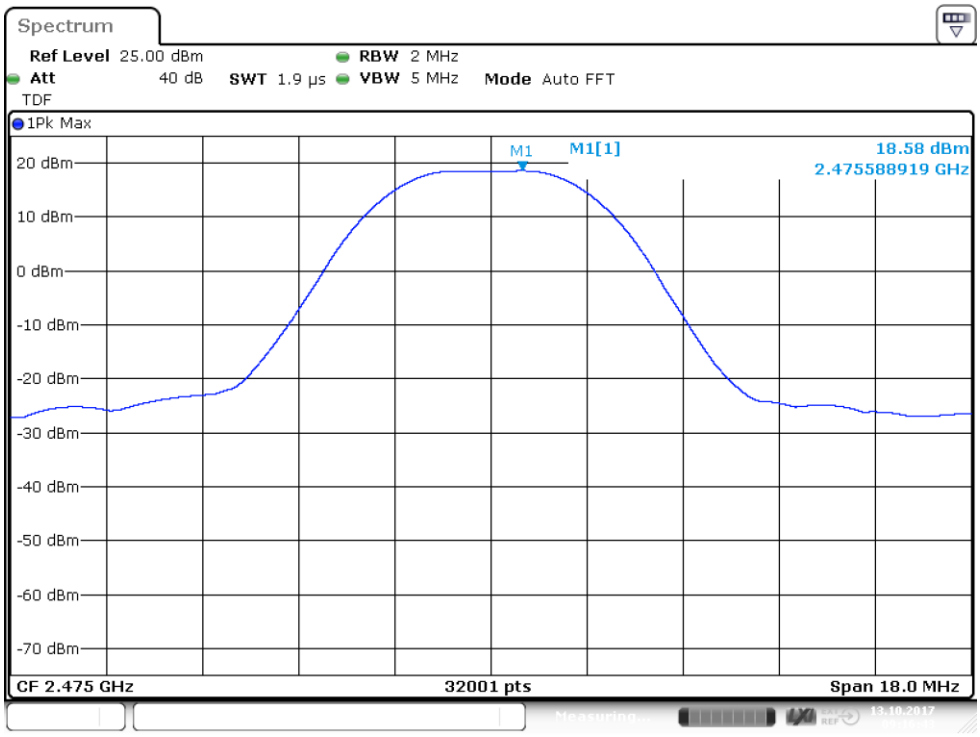

Figure 5: Conducted power, Channel 25 high (A)

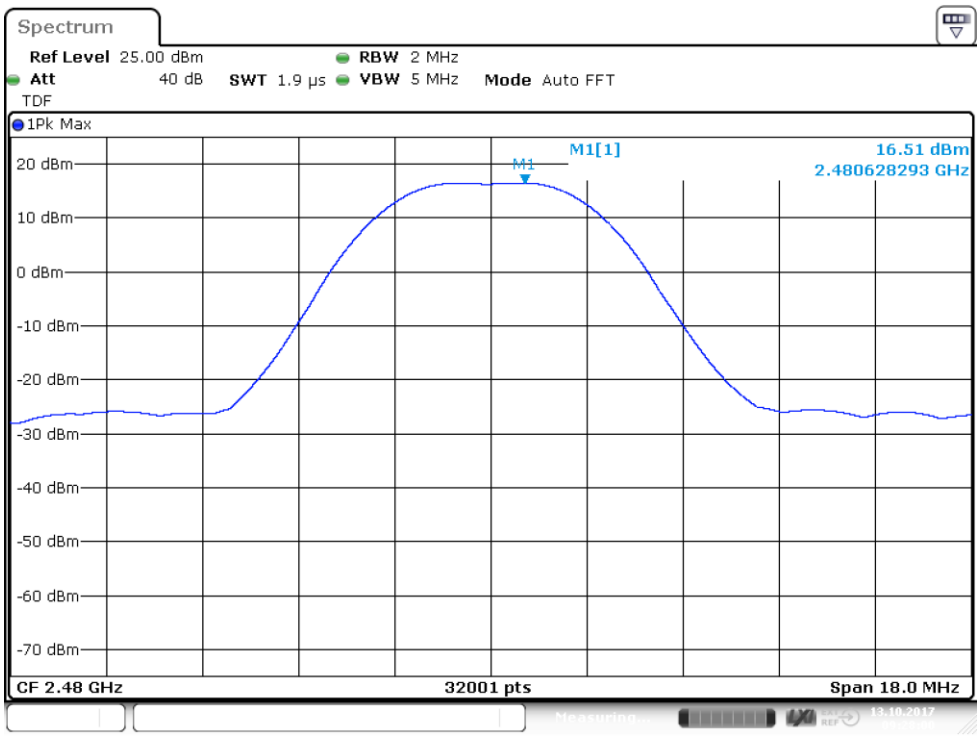

Figure 6: Conducted power, Channel 26 high (A)

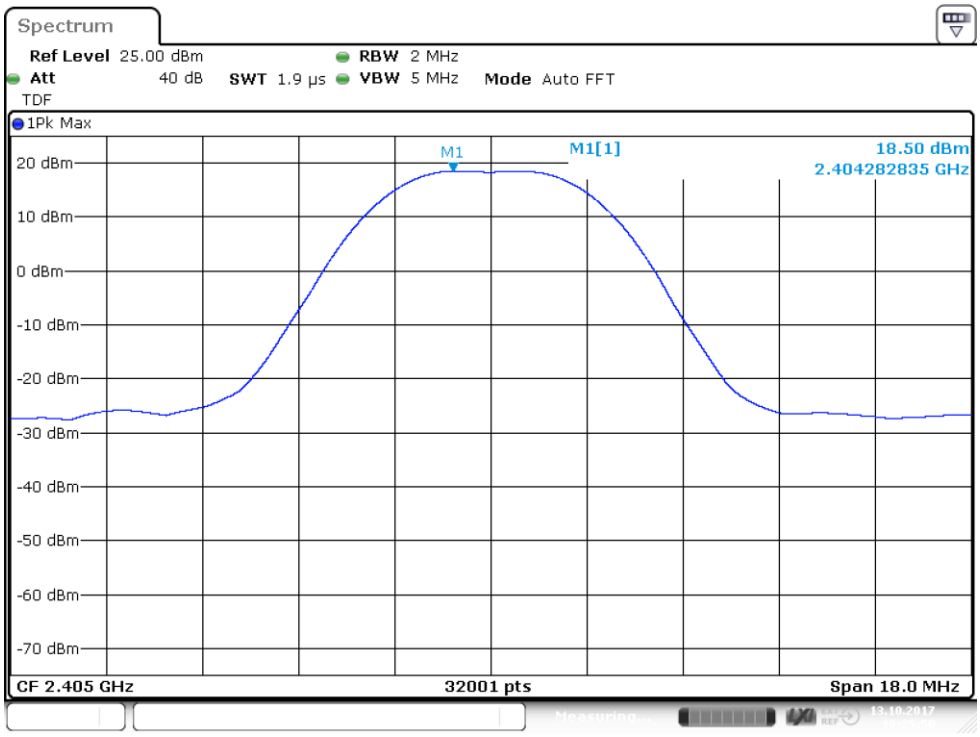

Figure 7: Conducted power, Channel 11 low (E)

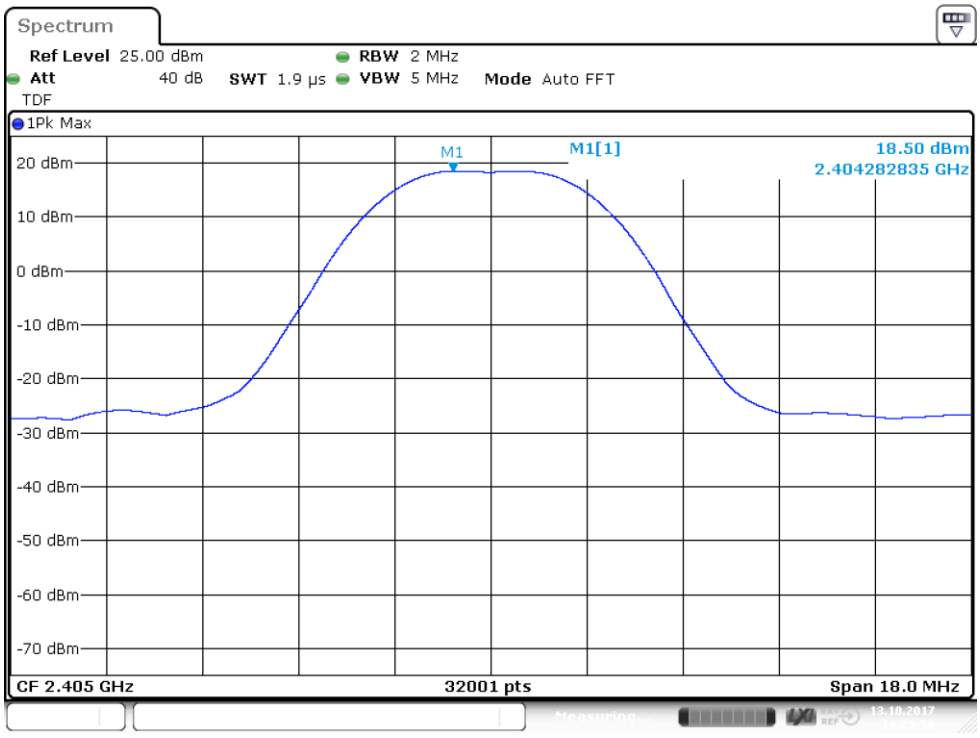

Figure 8: Conducted power, Channel 19 mid (E)

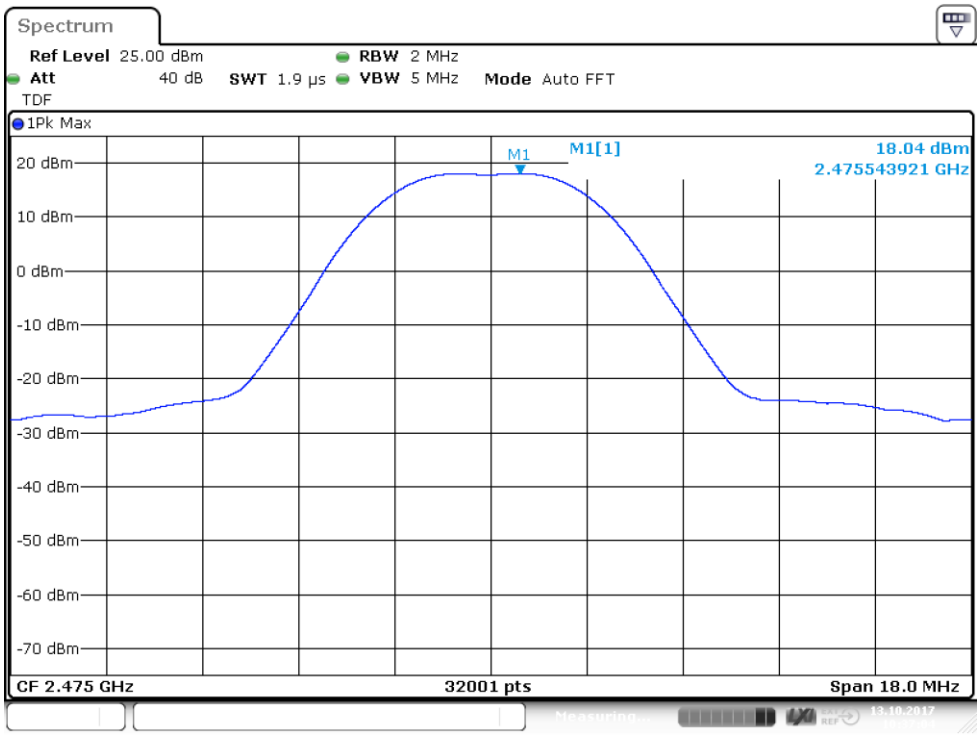

Figure 9: Conducted power, Channel 25 high (E)

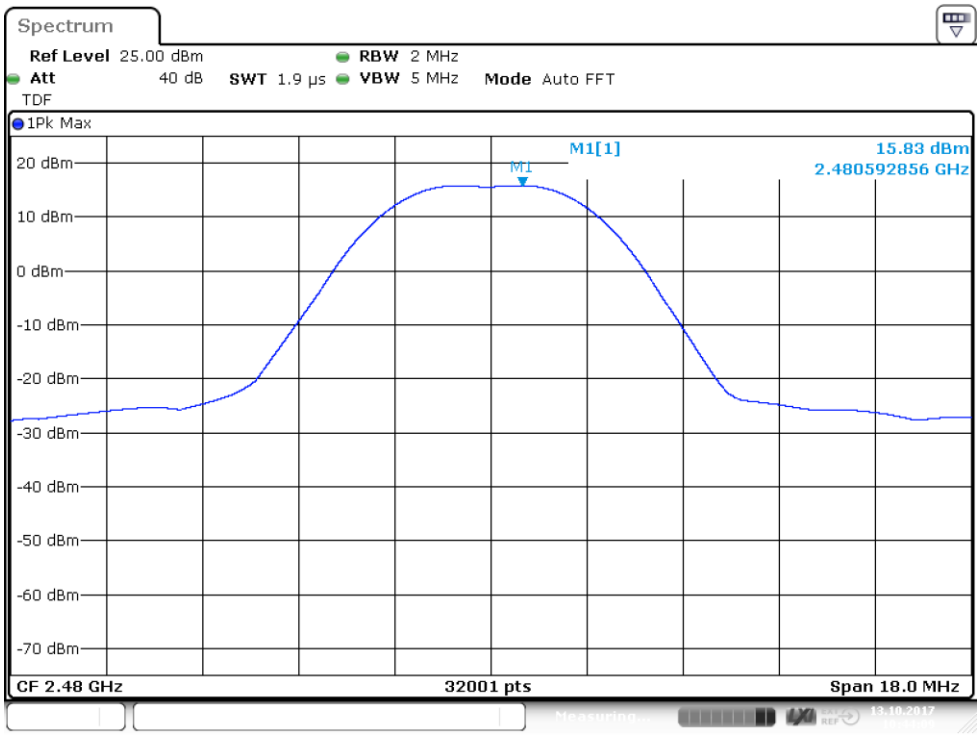

Figure 10: Conducted power, Channel 26 high (E)

Transmitter Radiated Spurious Emissions 30 - 26500 MHz

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	16. – 19. October 2017	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	
Measurement uncertainty:	± 4.51 dB	Level of confidence 95 % (k = 2)

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

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

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

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

Measurements were performed for both antenna variants.

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

Low channel (11)

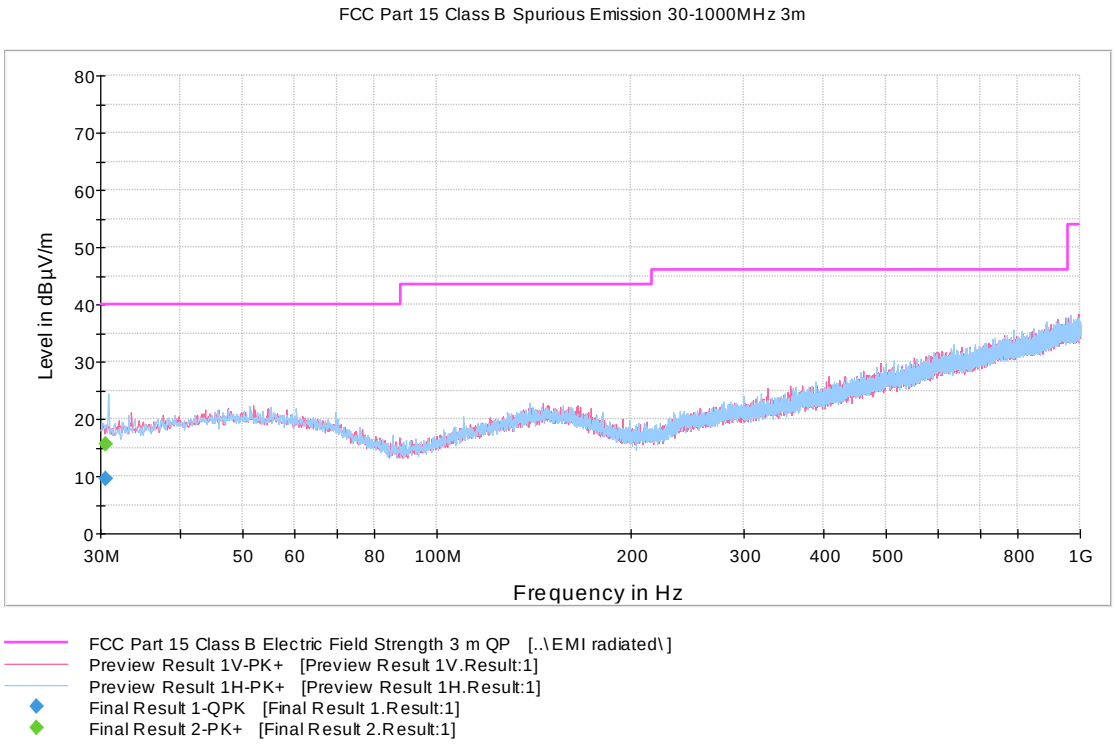

Figure 11: Channel 11 low 30 MHz – 1000 MHz (A)

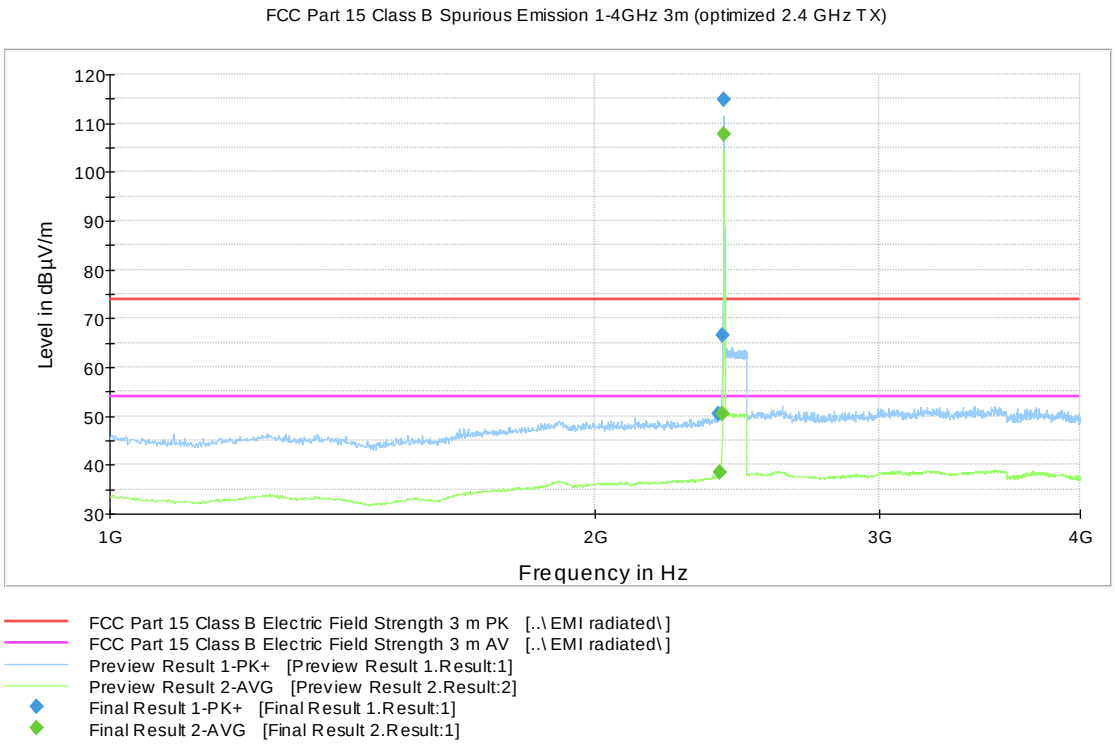

Figure 12: Channel 11 low 1 GHz – 4 GHz (A)

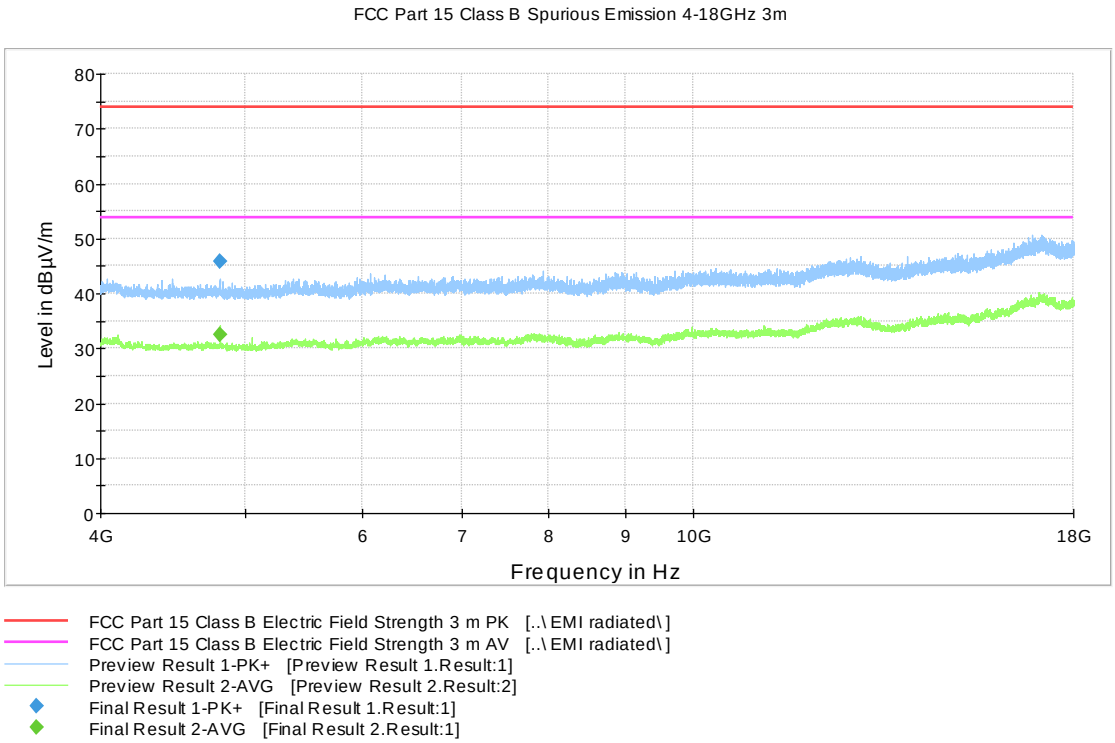

Figure 13: Channel 11 low 4 GHz – 18 GHz (A)

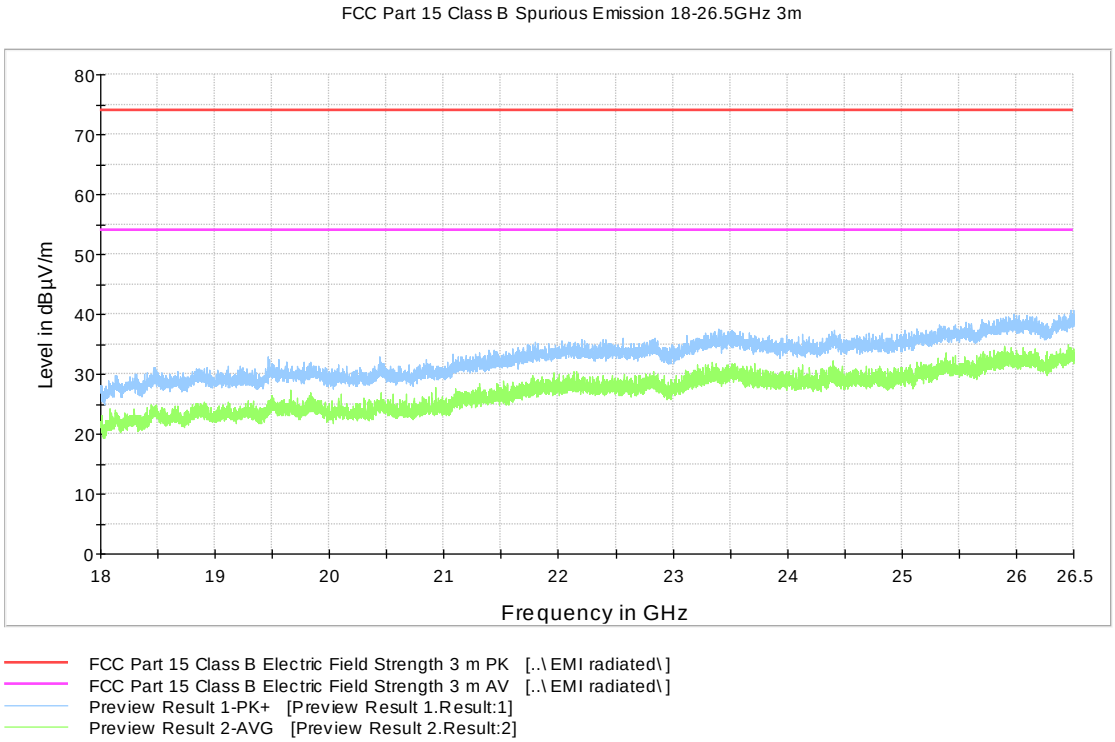

Figure 14: Channel 11 low 18 GHz – 26.5 GHz (A)

Table 6: Peak results, Channel 11 low (A)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2388.000000	50.4	1000.0	1000.000	340.0	V	188.0	14.6	23.5	73.9
2400.000000	66.7	1000.0	1000.000	178.0	H	246.0	14.7	7.2	73.9
4810.000000	45.9	1000.0	1000.000	192.0	H	47.0	8.4	28.0	73.9

Table 7: Average results, Channel 11 low (A)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2389.800000	38.3	1000.0	1000.000	285.0	H	248.0	14.6	15.6	53.9
2400.000000	50.5	1000.0	1000.000	273.0	H	248.0	14.7	3.4	53.9
4810.900000	32.5	1000.0	1000.000	150.0	H	47.0	8.4	21.4	53.9

Table 8: Quasi-peak results, Channel 11 low (A)

Frequency (MHz)	QuasiP (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
30.593000	9.4	1000.0	120.000	232.0	H	222.0	13.0	30.6	40.0

Middle channel (19)

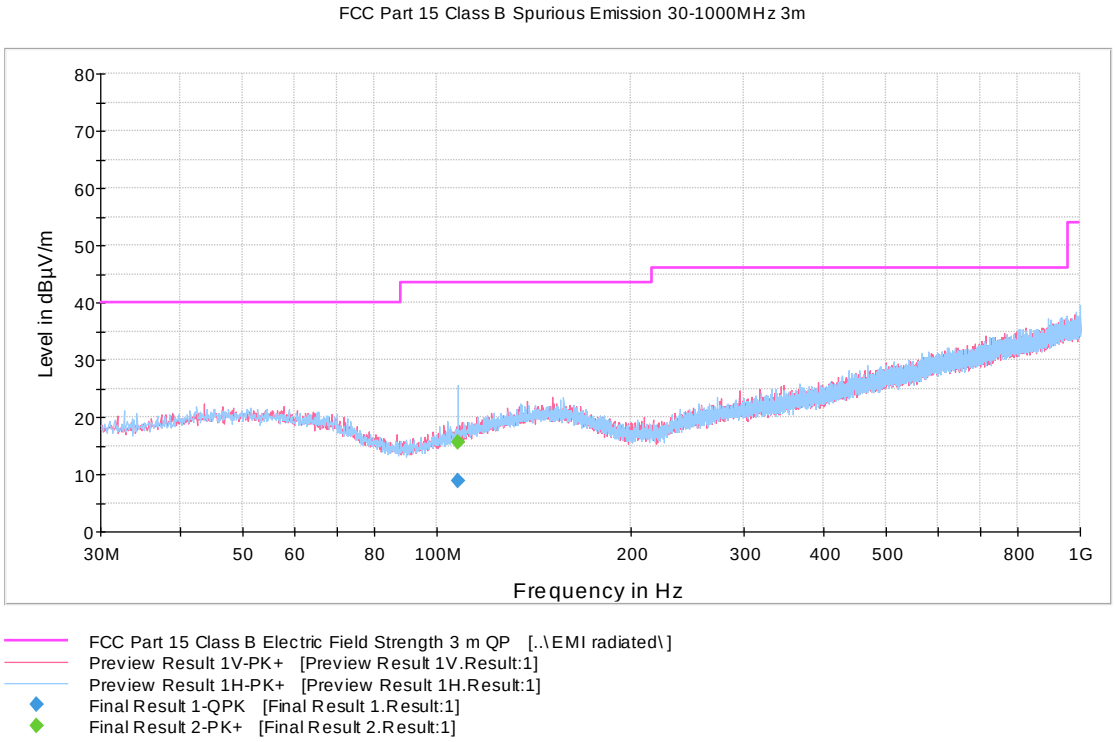

Figure 15: Channel 19 mid 30 MHz – 1000 MHz (A)

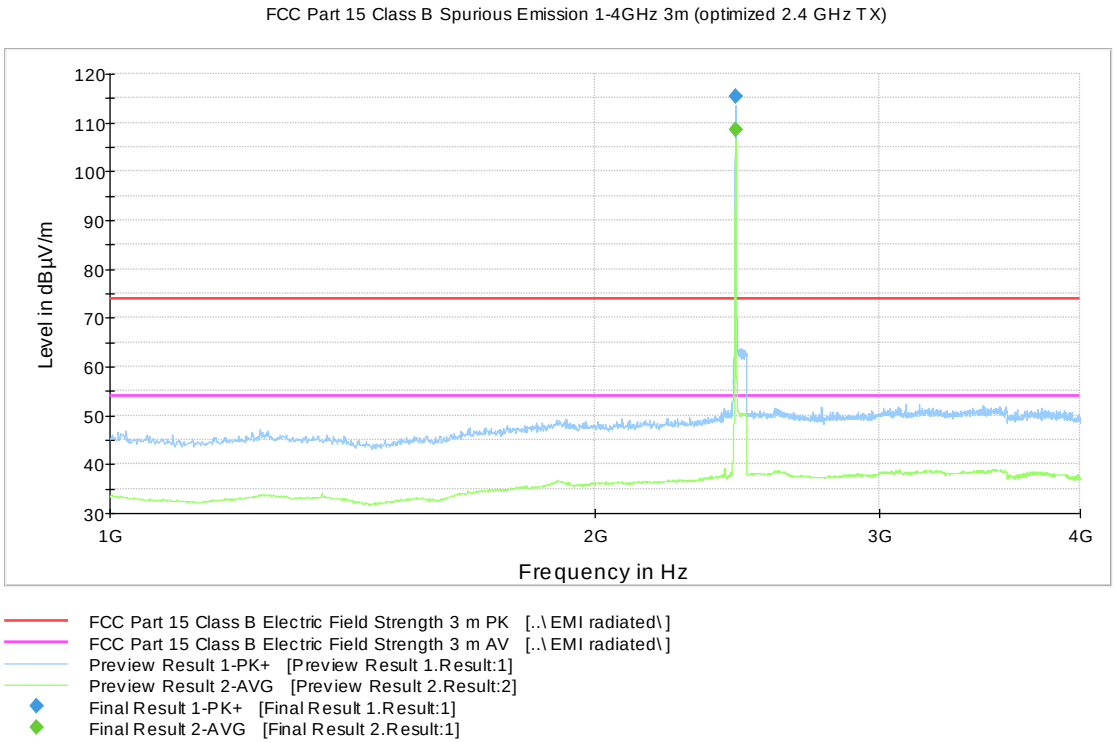

Figure 16: Channel 19 mid 1 GHz – 4 GHz (A)

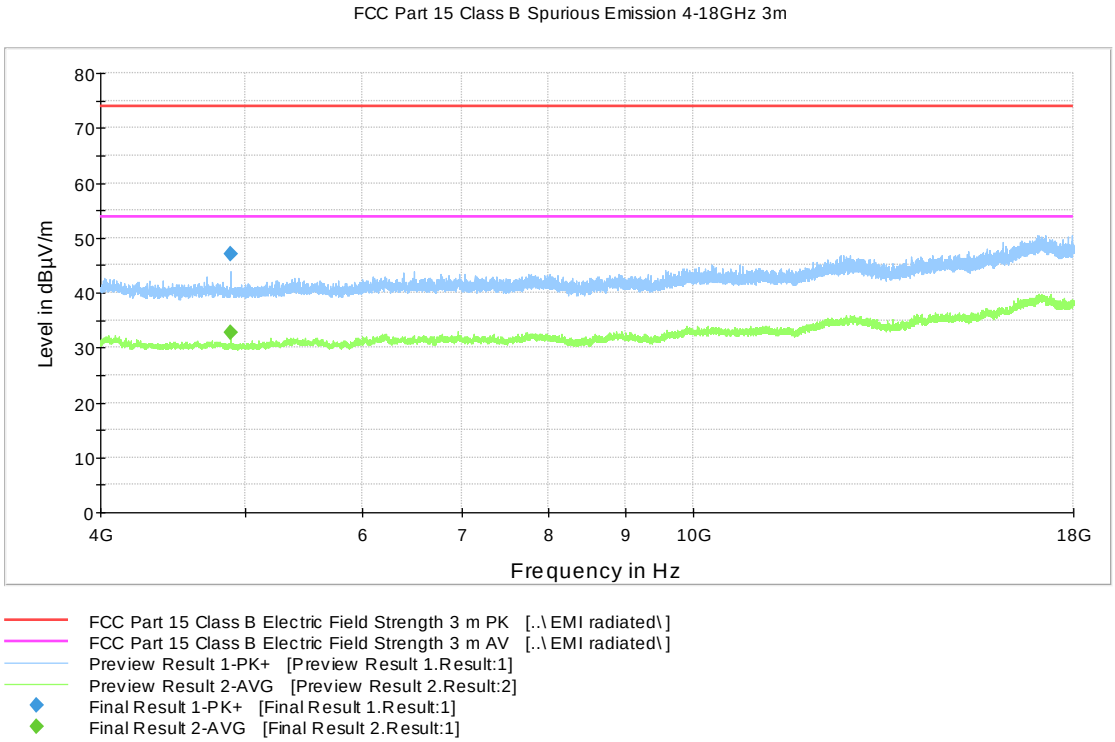

Figure 17: Channel 19 mid 4 GHz – 18 GHz (A)

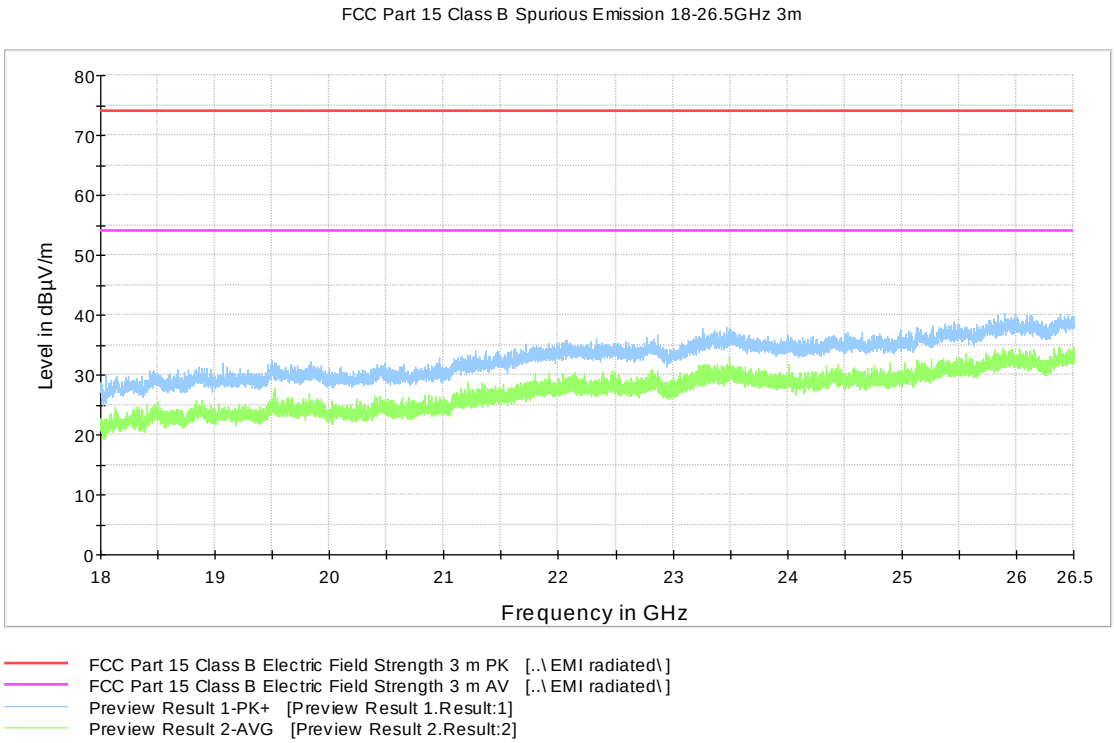

Figure 18: Channel 19 mid 18 GHz – 26.5 GHz (A)

Table 9: 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)
4889.900000	47.0	1000.0	1000.000	179.0	H	47.0	8.5	26.9	73.9

Table 10: 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)
4891.000000	32.8	1000.0	1000.000	150.0	H	56.0	8.5	21.1	53.9

Table 11: 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)
107.714000	8.7	1000.0	120.000	228.0	H	88.0	11.1	34.8	43.5

High channel (25)

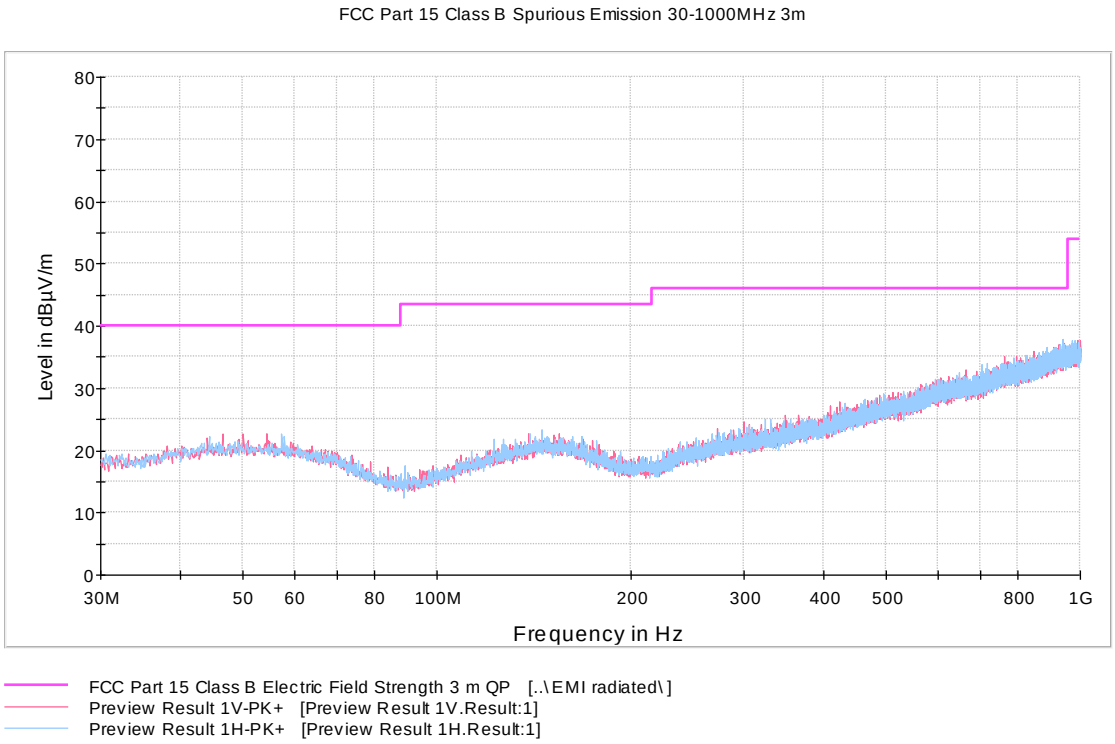

Figure 19: Channel 25 high 30 MHz – 1000 MHz (A)

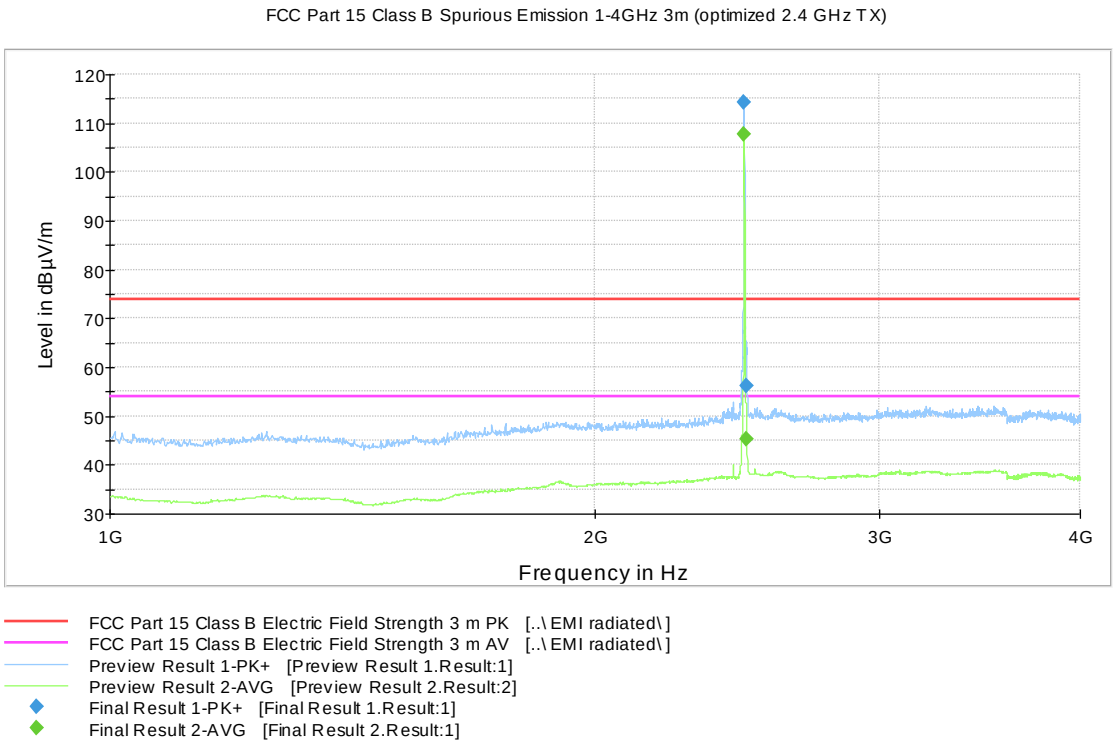

Figure 20: Channel 25 high 1 GHz – 4 GHz (A)

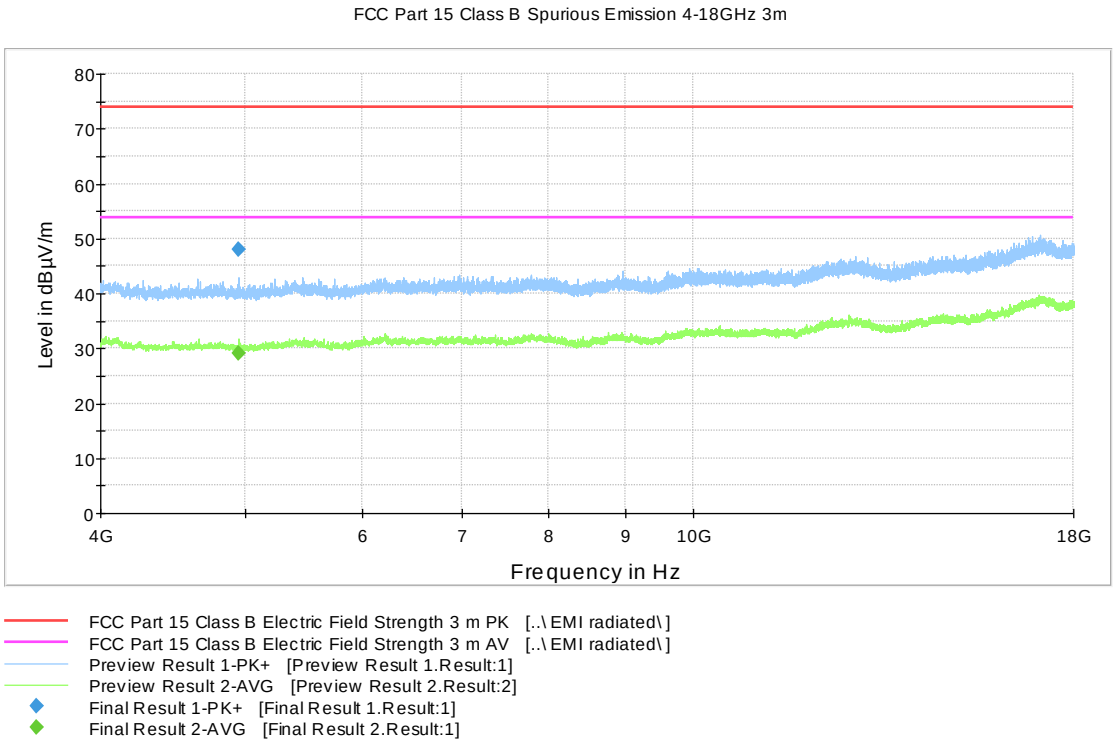

Figure 21: Channel 25 high 4 GHz – 18 GHz (A)

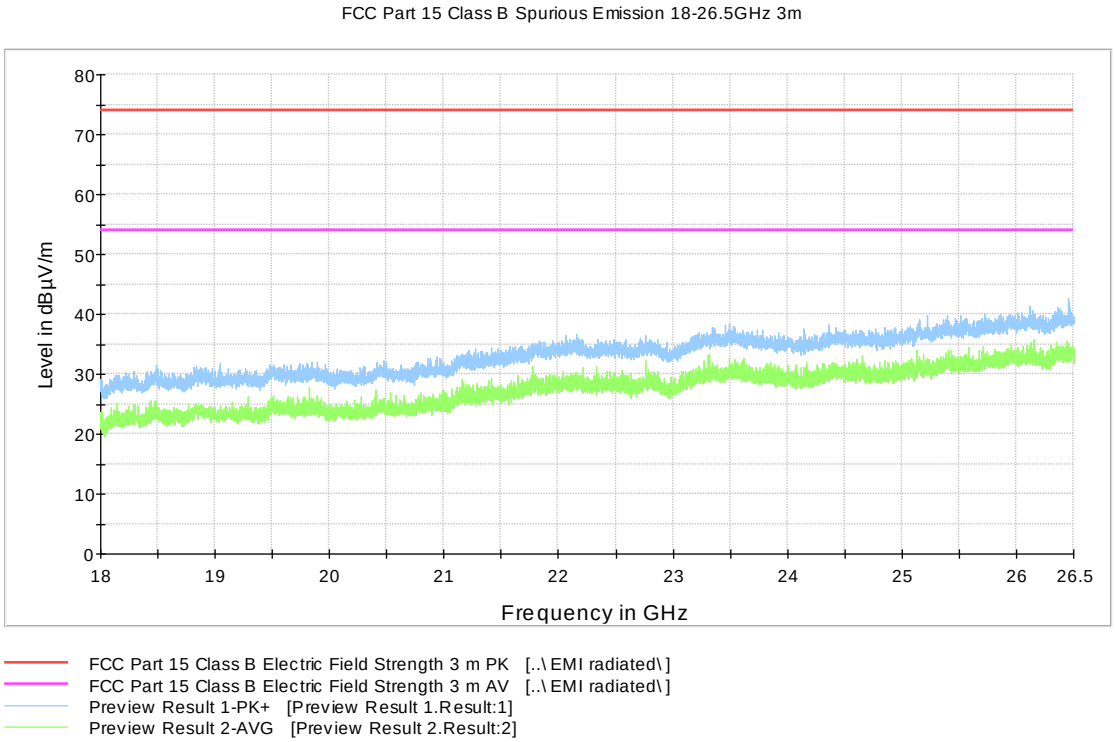

Figure 22: Channel 25 high 18 GHz – 26.5 GHz (A)

Table 12: Peak results, Channel 26 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	56.3	1000.0	1000.000	203.0	H	242.0	14.7	17.6	73.9
4949.900000	48.1	1000.0	1000.000	150.0	H	56.0	8.3	25.8	73.9

Table 13: Average results**, Channel 26** 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	45.2	1000.0	1000.000	291.0	H	240.0	14.7	8.7	53.9
4949.900000	29.2	1000.0	1000.000	328.0	H	55.0	8.3	24.7	53.9

Radiated Band Edge results

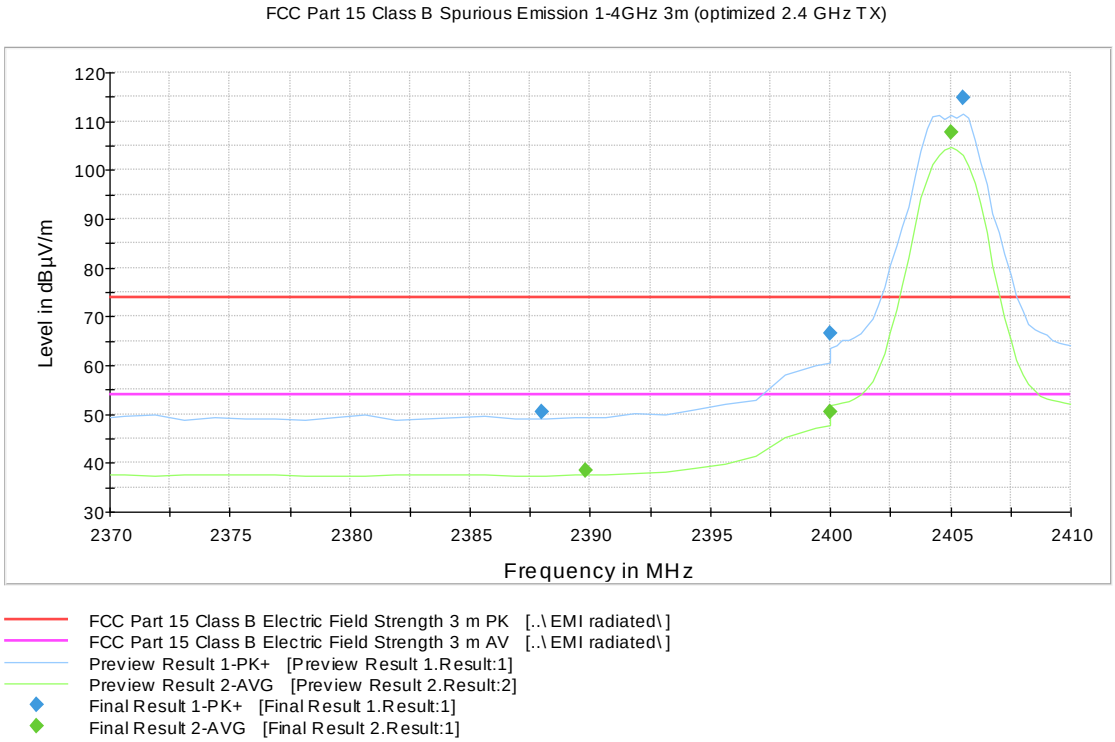

Figure 23: Radiated Band Edge measurement graph, Channel 11 low (A)

Table 14: Peak results, Channel 11 low (A)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2388.000000	50.4	1000.0	1000.000	340.0	V	188.0	14.6	23.5	73.9
2400.000000	66.7	1000.0	1000.000	178.0	H	246.0	14.7	7.2	73.9

Table 15: Average results, Channel 11 low (A)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2389.800000	38.3	1000.0	1000.000	285.0	H	248.0	14.6	15.6	53.9
2400.000000	50.5	1000.0	1000.000	273.0	H	248.0	14.7	3.4	53.9

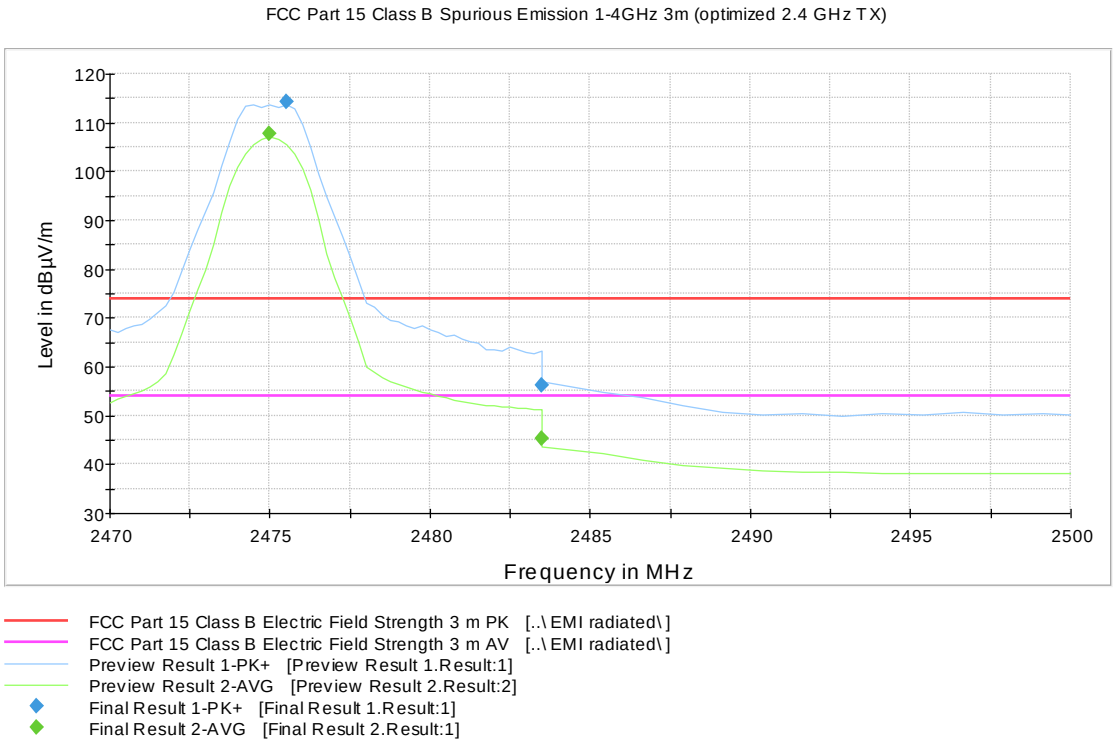

Figure 24: Radiated Band Edge measurement graph, Channel 25 high (A)

Table 16: Peak results, Channel 25 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	56.3	1000.0	1000.000	203.0	H	242.0	14.7	17.6	73.9

Table 17: Average results, Channel 25 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	45.2	1000.0	1000.000	291.0	H	240.0	14.7	8.7	53.9

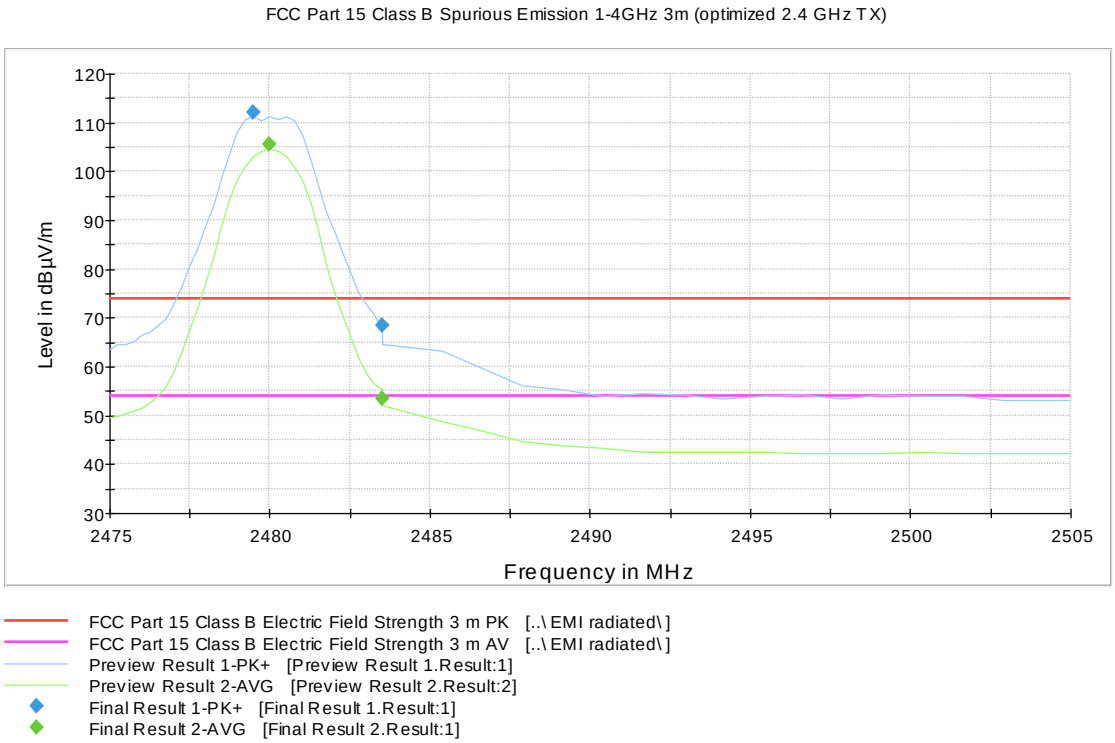

Figure 25: Radiated Band Edge measurement graph, Channel 26 high (A)

Table 18: Peak results, Channel 26 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	68.3	1000.0	1000.000	150.0	H	238.0	14.7	5.6	73.9

Table 19: Average results, Channel 26 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	53.3	1000.0	1000.000	259.0	H	239.0	14.7	0.6	53.9

Low channel (11)

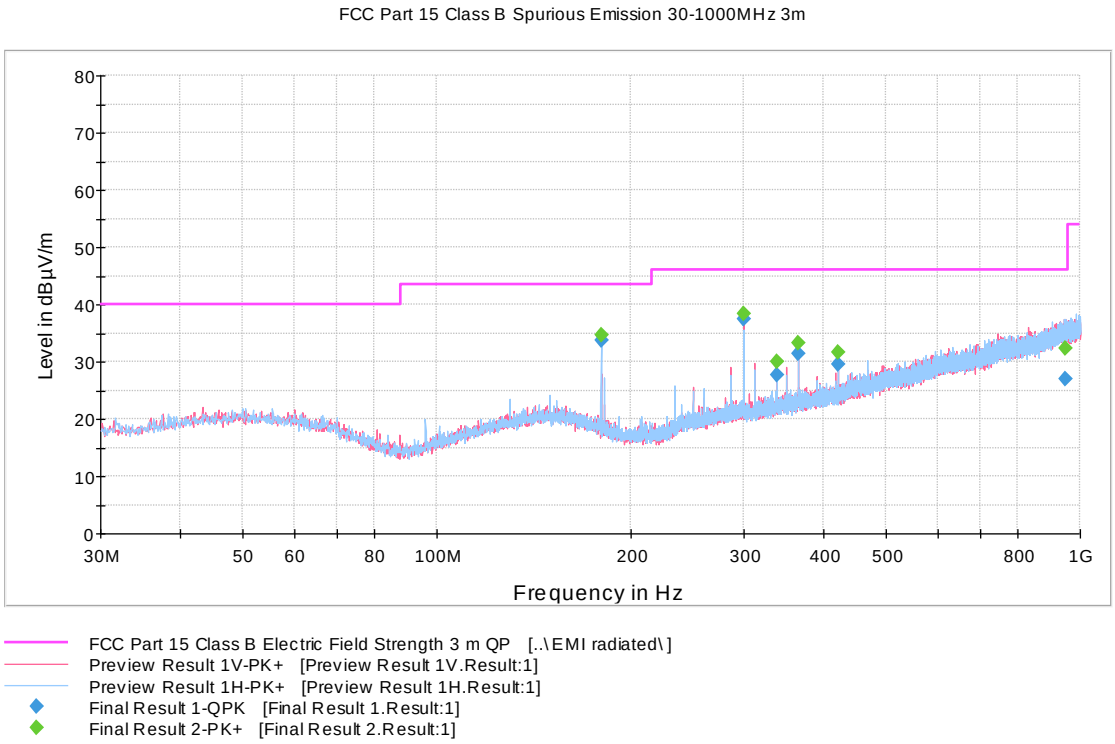

Figure 26: Channel 11 low 30 MHz – 1000 MHz (E)

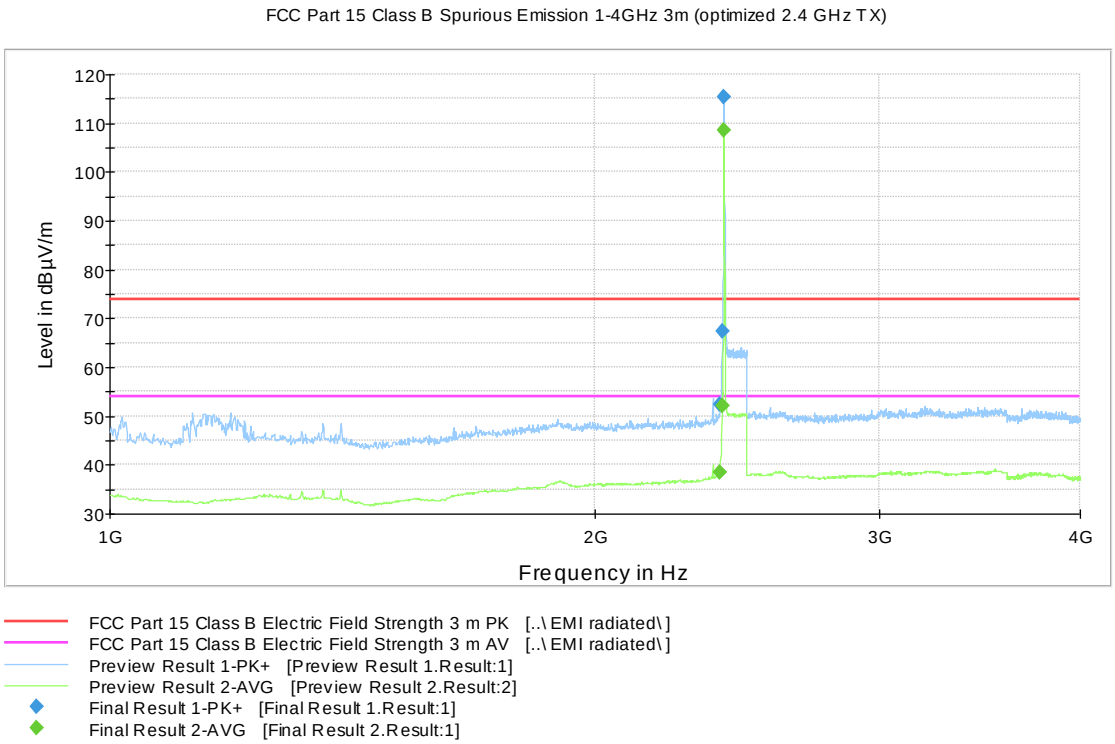

Figure 27: Channel 11 low 1 GHz – 4 GHz (E)

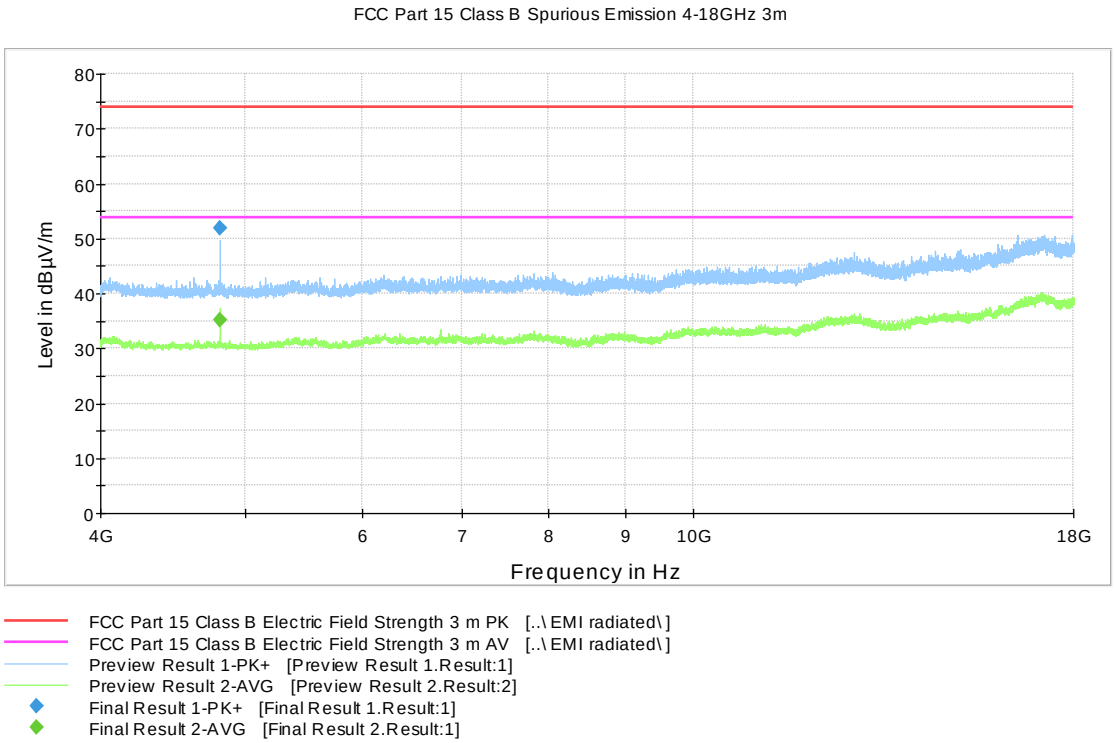

Figure 28: Channel 11 low 4 GHz – 18 GHz (E)

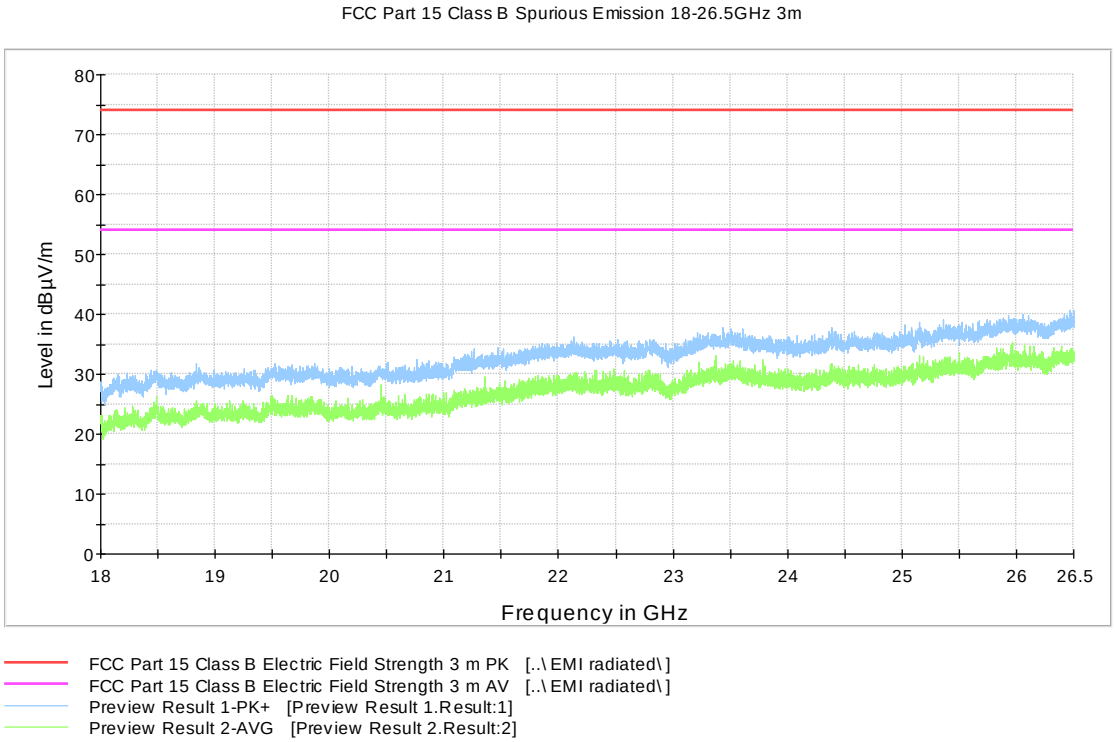

Figure 29: Channel 11 low 18 GHz – 26.5 GHz (E)

Table 20: Peak results, Channel 11 low (E)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2388.800000	52.4	1000.0	1000.000	217.0	V	249.0	14.6	21.5	73.9
2399.600000	67.2	1000.0	1000.000	178.0	V	279.0	14.7	6.7	73.9
4810.000000	51.9	1000.0	1000.000	150.0	V	9.0	8.4	22.0	73.9

Table 21: Average results, Channel 11 low (E)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2389.800000	38.6	1000.0	1000.000	150.0	V	42.0	14.6	15.3	53.9
2400.000000	52.1	1000.0	1000.000	150.0	V	269.0	14.7	1.8	53.9

Table 22: Quasi-peak results, Channel 11 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	33.7	1000.0	120.000	100.0	H	115.0	13.0	9.8	43.5
300.011000	37.4	1000.0	120.000	100.0	V	158.0	15.3	8.6	46.0
338.012000	27.7	1000.0	120.000	100.0	V	39.0	16.2	18.3	46.0
364.011000	31.5	1000.0	120.000	100.0	V	44.0	16.9	14.5	46.0
420.017000	29.6	1000.0	120.000	126.0	H	110.0	18.4	16.4	46.0
950.140000	27.0	1000.0	120.000	400.0	V	351.0	27.8	19.0	46.0

Middle channel (19)

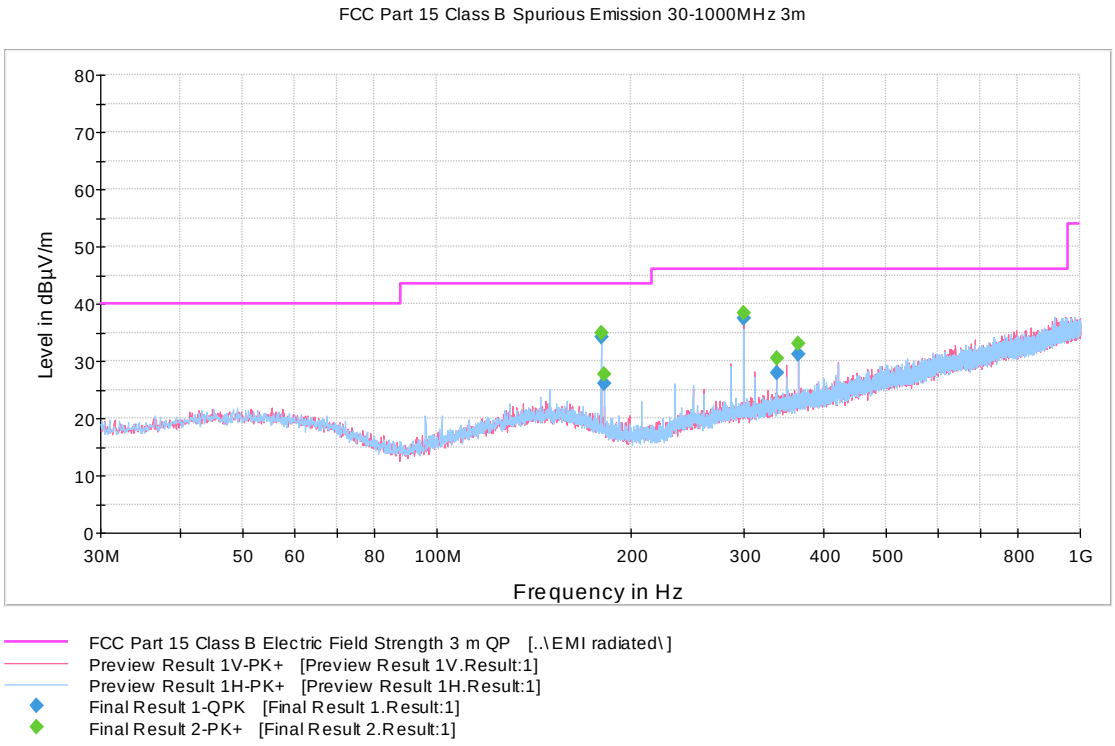

Figure 30: Channel 19 mid 30 MHz – 1000 MHz (E)

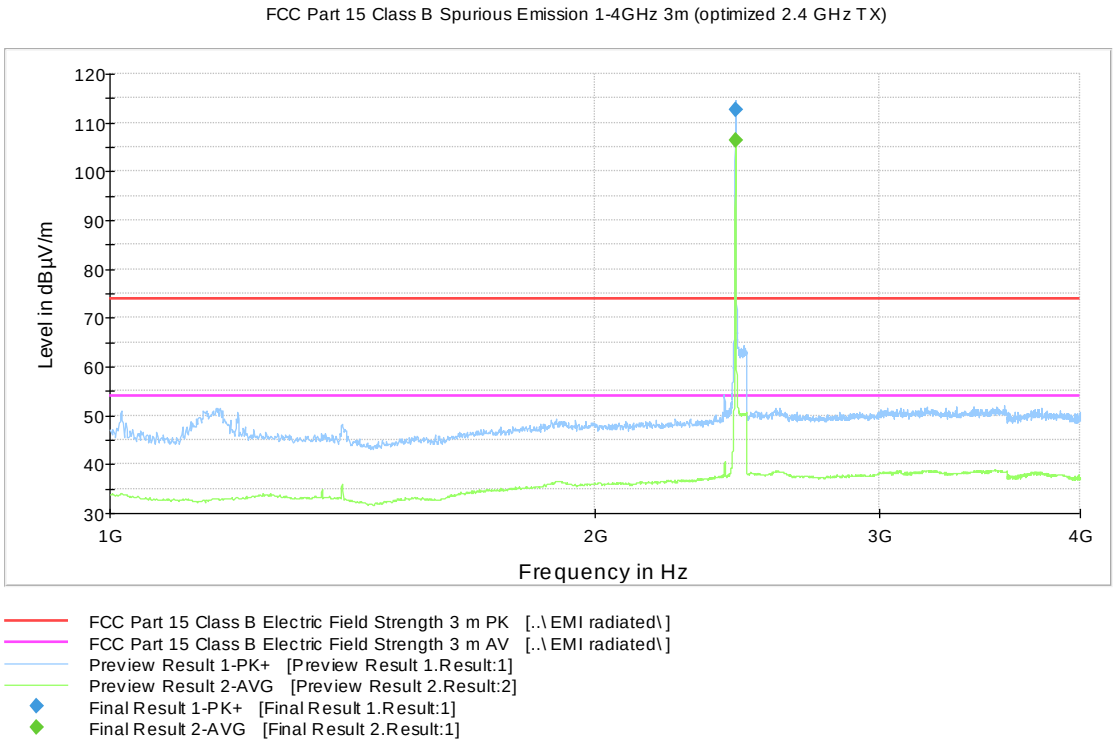

Figure 31: Channel 19 mid 1 GHz – 4 GHz (E)

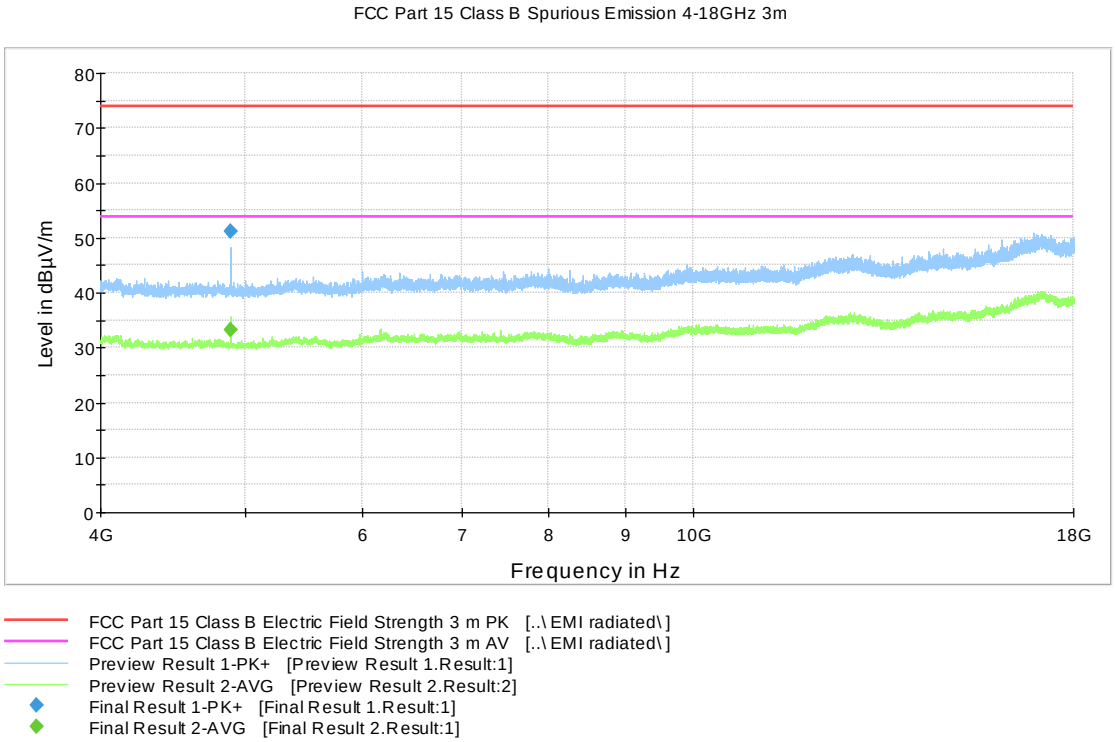

Figure 32: Channel 19 mid 4 GHz – 18 GHz (E)

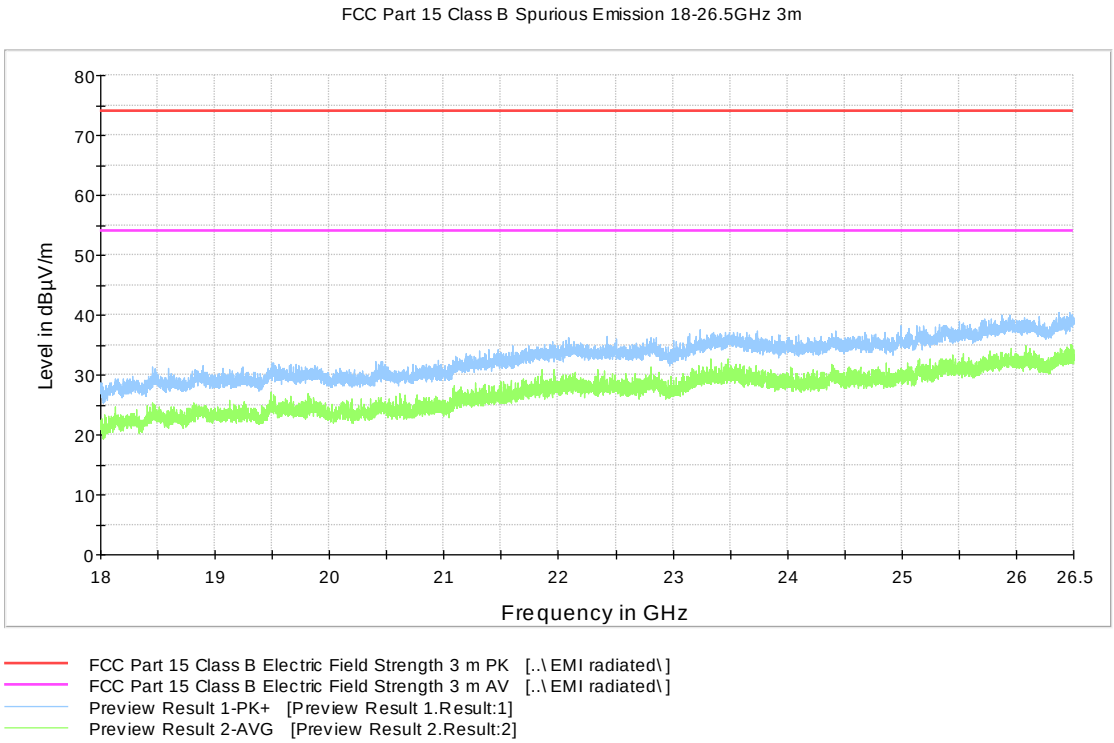

Figure 33: Channel 19 mid 18 GHz – 26.5 GHz (E)

Table 23: 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)
4889.900000	51.0	1000.0	1000.000	150.0	V	243.0	8.5	22.9	73.9

Table 24: 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)
4891.000000	33.3	1000.0	1000.000	192.0	V	248.0	8.5	20.6	53.9

Table 25: 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)
180.002000	34.1	1000.0	120.000	100.0	H	134.0	13.0	9.4	43.5
182.019000	26.0	1000.0	120.000	100.0	H	94.0	12.8	17.5	43.5
300.011000	37.5	1000.0	120.000	100.0	V	159.0	15.3	8.5	46.0
338.012000	27.9	1000.0	120.000	100.0	V	165.0	16.2	18.1	46.0
364.011000	31.2	1000.0	120.000	100.0	V	23.0	16.9	14.8	46.0

High channel (25)

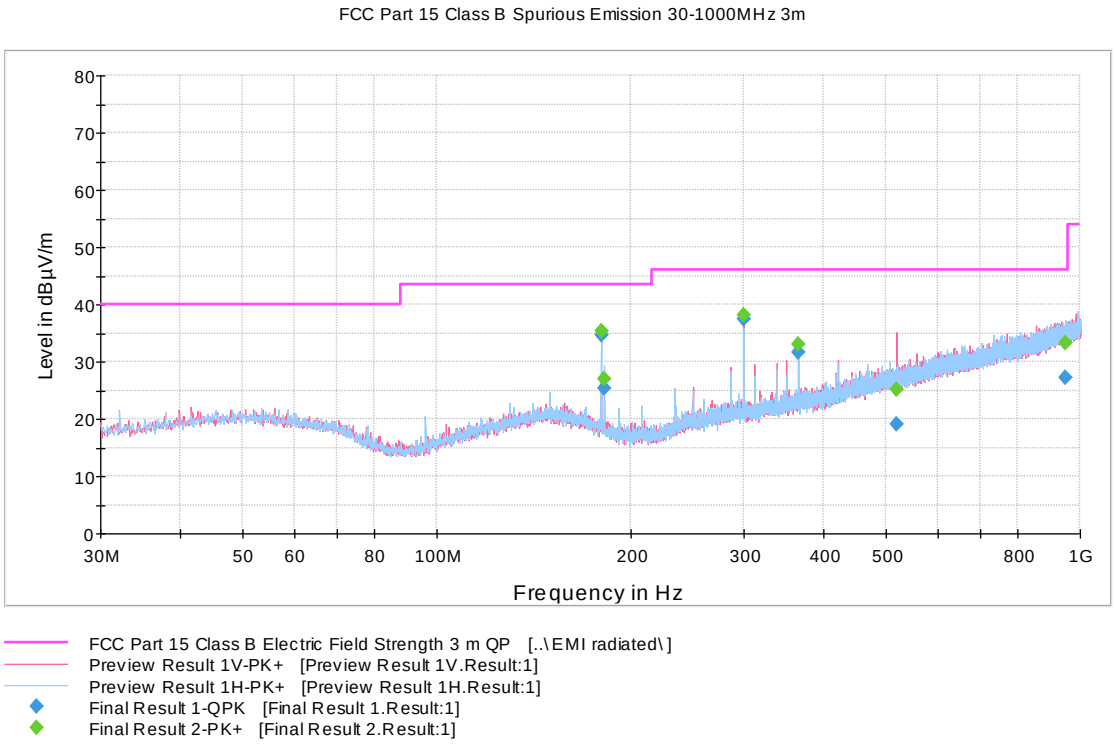

Figure 34: Channel 25 high 30 MHz – 1000 MHz (E)

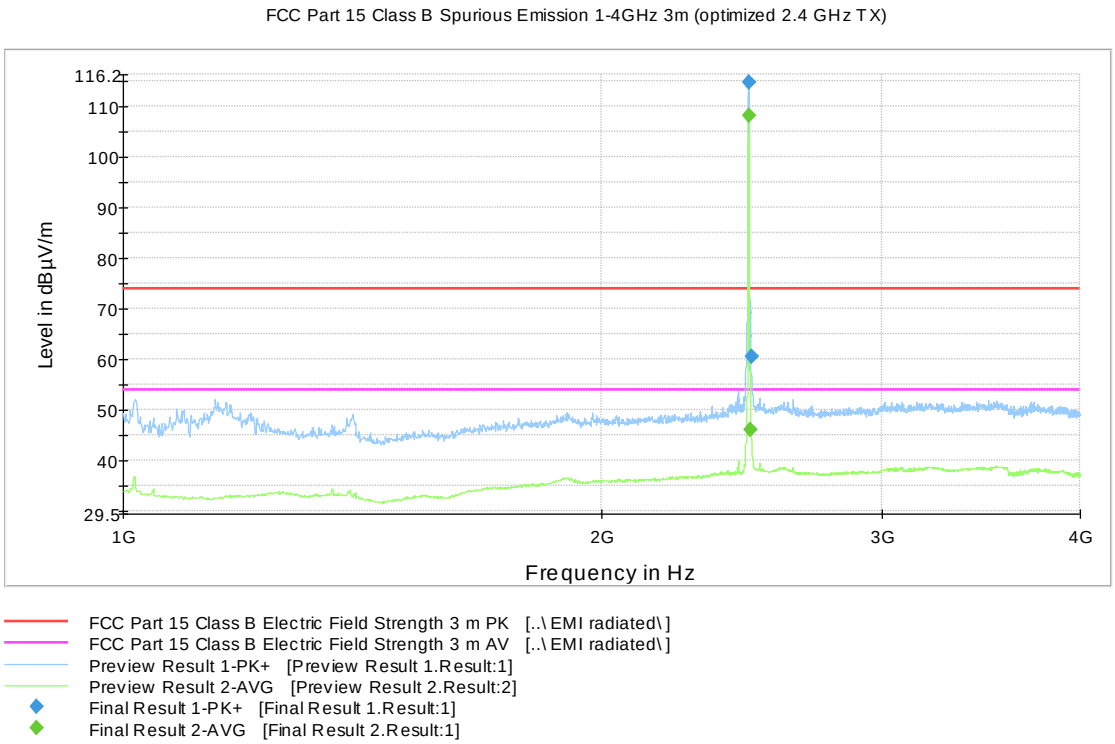

Figure 35: Channel 25 high 1 GHz – 4 GHz (E)

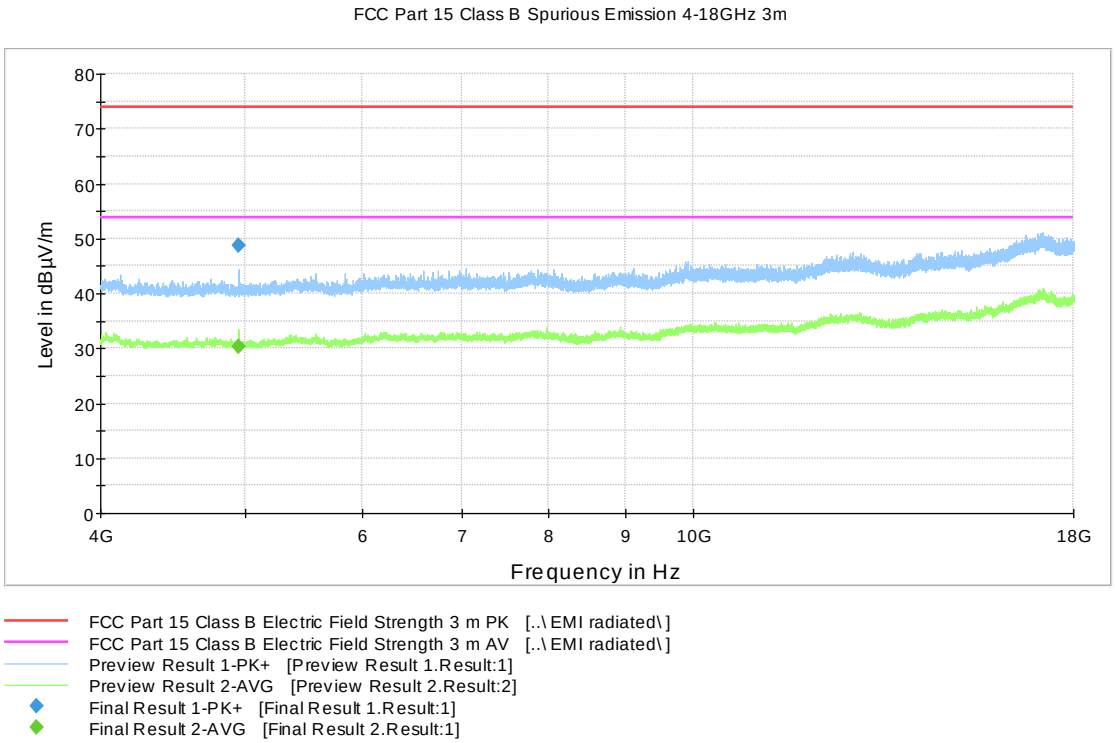

Figure 36: Channel 25 high 4 GHz – 18 GHz (E)

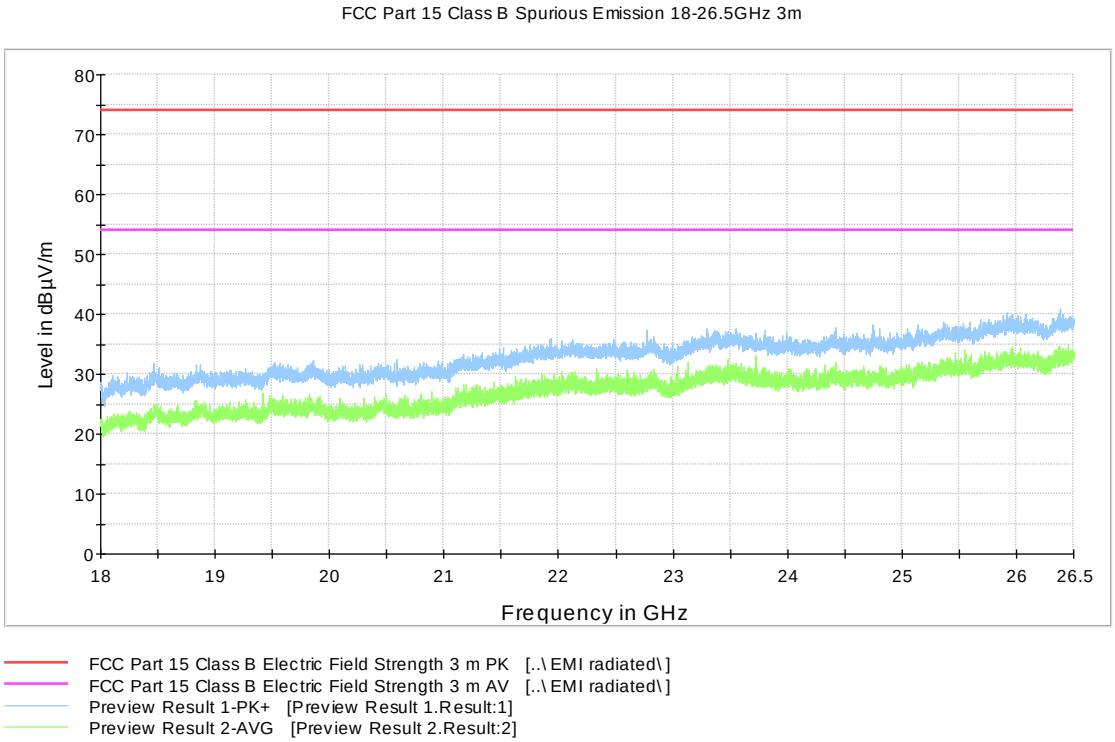

Figure 37: Channel 25 high 18 GHz – 26.5 GHz (E)

Table 26: Peak results, Channel 25 high (E)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2484.100000	60.5	1000.0	1000.000	150.0	V	337.0	14.7	13.4	73.9
4949.900000	48.8	1000.0	1000.000	150.0	V	255.0	8.3	25.1	73.9

Table 27: Average results, Channel 25 high (E)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2483.700000	46.1	1000.0	1000.000	150.0	V	339.0	14.7	7.8	53.9
4950.900000	30.4	1000.0	1000.000	150.0	V	283.0	8.3	23.5	53.9

Table 28: Quasi-peak results, Channel 25 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	34.6	1000.0	120.000	100.0	H	117.0	13.0	8.9	43.5
181.999000	25.3	1000.0	120.000	100.0	H	65.0	12.8	18.2	43.5
300.011000	37.5	1000.0	120.000	100.0	V	148.0	15.3	8.5	46.0
364.008000	31.5	1000.0	120.000	100.0	V	35.0	16.9	14.5	46.0
518.831000	19.2	1000.0	120.000	100.0	V	35.0	20.7	26.8	46.0
950.093000	27.1	1000.0	120.000	152.0	H	199.0	27.8	18.9	46.0

Radiated Band Edge results

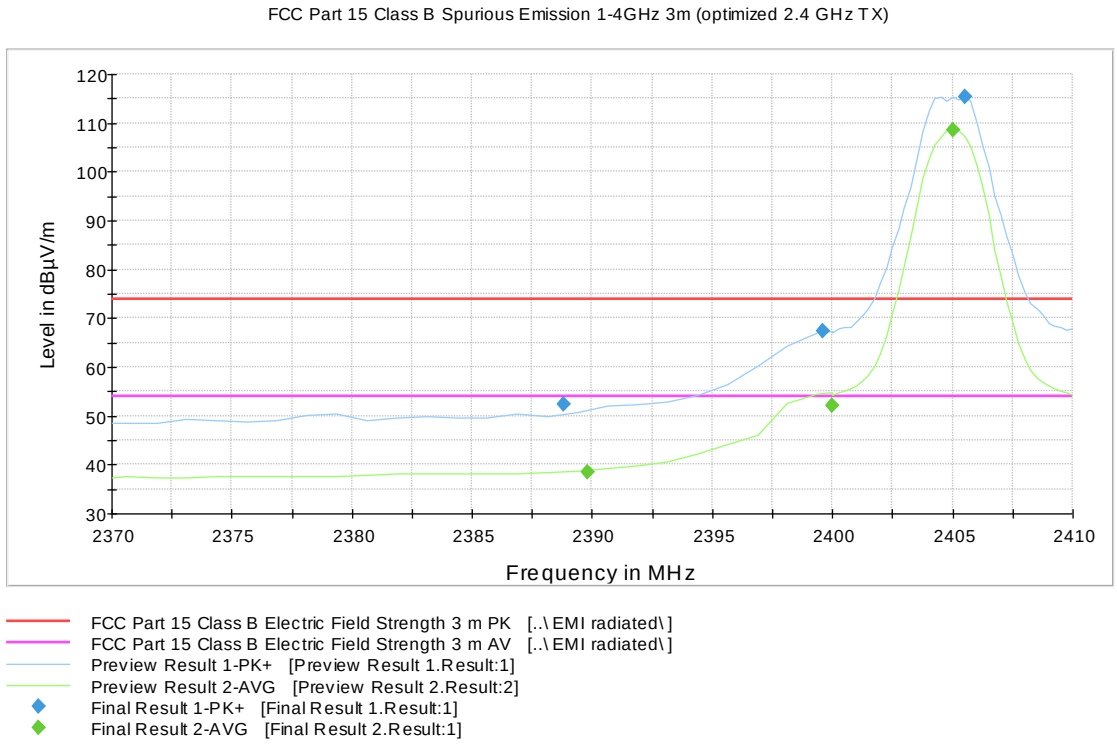

Figure 38: Radiated Band Edge measurement graph, Channel 11 low (E)

Table 29: Peak results, Channel 11 low (E)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2388.800000	52.4	1000.0	1000.000	217.0	V	249.0	14.6	21.5	73.9
2399.600000	67.2	1000.0	1000.000	178.0	V	279.0	14.7	6.7	73.9

Table 30: Average results, Channel 11 low (E)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2389.800000	38.6	1000.0	1000.000	150.0	V	42.0	14.6	15.3	53.9
2400.000000	52.1	1000.0	1000.000	150.0	V	269.0	14.7	1.8	53.9

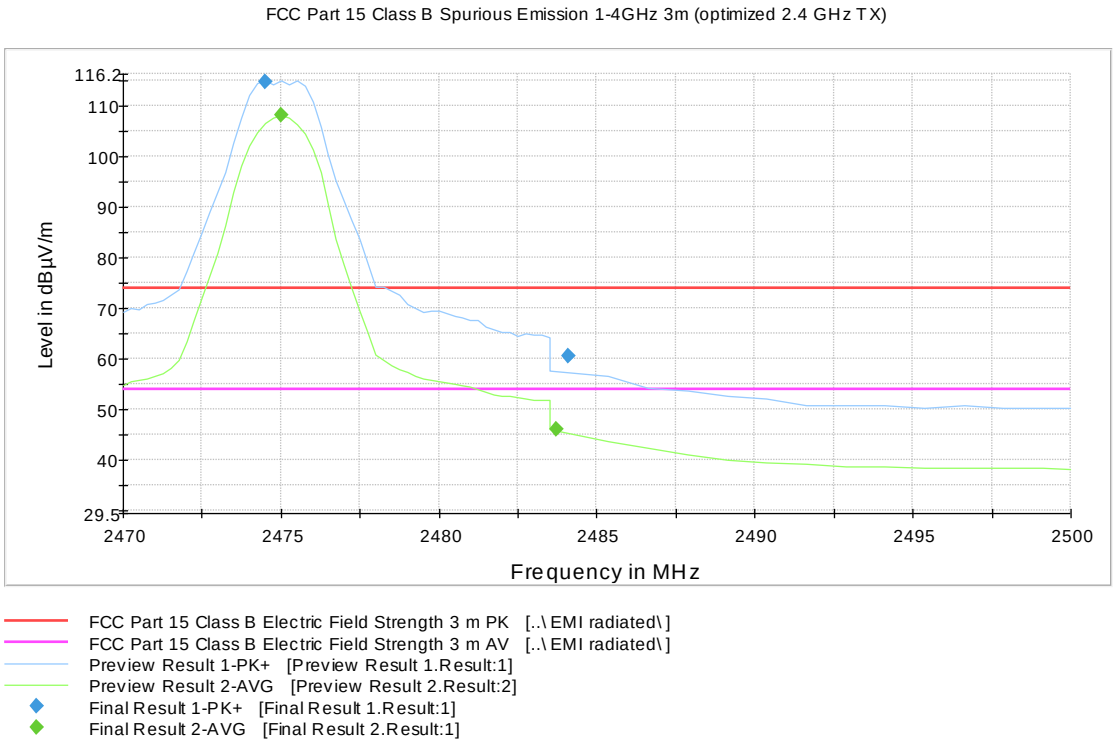

Figure 39: Radiated Band Edge measurement graph, Channel 25 high (E)

Table 31: Peak results, Channel 25 high (E)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2484.100000	60.5	1000.0	1000.000	150.0	V	337.0	14.7	13.4	73.9

Table 32: Average results, Channel 25 high (E)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2483.700000	46.1	1000.0	1000.000	150.0	V	339.0	14.7	7.8	53.9

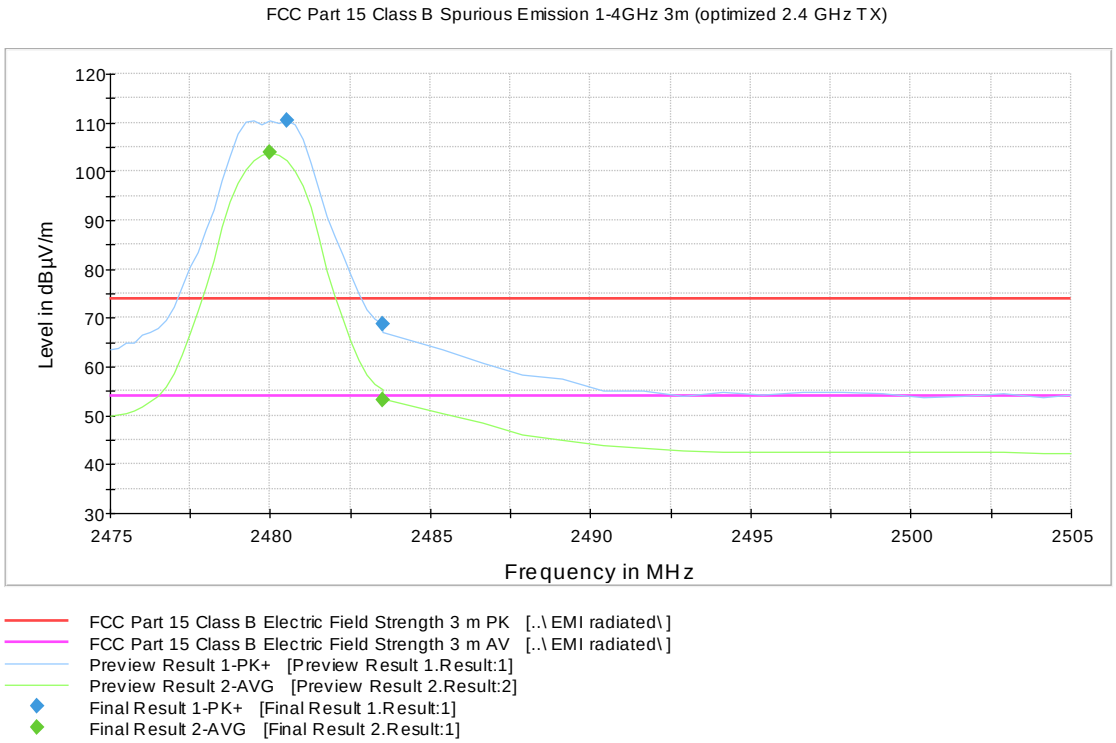

Figure 40: Radiated Band Edge measurement graph, Channel 26 high (E)

Table 33: Peak results, Channel 26 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	68.6	1000.0	1000.000	150.0	V	13.0	14.7	5.3	73.9

Table 34: Average results, Channel 26 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	53.3	1000.0	1000.000	150.0	V	12.0	14.7	0.6	53.9

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	13 October 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 35: Band edge attenuation (A)

Band Edge Attenuation		
Lower Band Edge (ch 11)	**Upper Band Edge (ch 25)**	**Upper Band Edge (ch 26)**
-52.02 dBc	-52.20 dBc	-47.42 dBc
Limit: -20 dBc		

Table 36: Band edge attenuation (E)

Band Edge Attenuation		
Lower Band Edge (ch 11)	**Upper Band Edge (ch 25)**	**Upper Band Edge (ch 26)**
-51.35 dBc	-52.44 dBc	-47.45 dBc
Limit: -20 dBc		

Table 37: Conducted spurious emissions, Channel 11 low (A)

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
959.16	-66.50	-5.05	-61.44	PASS
2399.85	-41.57	-5.05	-36.52	PASS
2559.16	-64.34	-5.05	-59.28	PASS
4810.87	-38.70	-5.05	-33.64	PASS
9514.16	-61.20	-5.05	-56.14	PASS
12529.81	-58.98	-5.05	-53.92	PASS
15833.36	-56.14	-5.05	-51.09	PASS
17781.33	-55.39	-5.05	-50.34	PASS
19949.33	-56.74	-5.05	-51.69	PASS
24147.60	-56.73	-5.05	-51.68	PASS
25522.10	-55.70	-5.05	-50.65	PASS

Table 38: Conducted spurious emissions, Channel 19 mid (A)

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
977.83	-66.29	-5.24	-61.06	PASS
1779.27	-63.87	-5.24	-58.63	PASS
2483.86	-55.80	-5.24	-50.56	PASS
4888.96	-39.32	-5.24	-34.09	PASS
9576.31	-60.86	-5.24	-55.62	PASS
12954.58	-58.52	-5.24	-53.28	PASS
15843.77	-56.80	-5.24	-51.56	PASS
16116.01	-54.57	-5.24	-49.33	PASS
19777.21	-57.46	-5.24	-52.23	PASS
24455.19	-56.25	-5.24	-51.02	PASS
25869.72	-55.56	-5.24	-50.32	PASS

Table 39: Conducted spurious emissions, Channel 25 high (A)

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
915.57	-66.12	-5.31	-60.81	PASS
2397.62	-63.19	-5.31	-57.88	PASS
2483.52	-46.21	-5.31	-40.89	PASS
4950.92	-39.51	-5.31	-34.20	PASS
9156.04	-61.54	-5.31	-56.23	PASS
11134.39	-58.41	-5.31	-53.10	PASS
15479.00	-57.08	-5.31	-51.77	PASS
16150.04	-55.17	-5.31	-49.86	PASS
19505.44	-57.27	-5.31	-51.96	PASS
24458.56	-56.32	-5.31	-51.00	PASS
25709.08	-56.40	-5.31	-51.09	PASS

Table 40: Conducted spurious emissions, Channel 26 high (A)

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
749.91	-68.09	-7.61	-60.48	PASS
2359.03	-65.23	-7.61	-57.62	PASS
2483.62	-37.82	-7.61	-30.21	PASS
4958.99	-44.57	-7.61	-36.96	PASS
8503.56	-61.04	-7.61	-53.43	PASS
12480.88	-58.32	-7.61	-50.71	PASS
15491.75	-55.90	-7.61	-48.29	PASS
16116.57	-55.81	-7.61	-48.20	PASS
19198.13	-57.17	-7.61	-49.56	PASS
24469.81	-56.27	-7.61	-48.66	PASS
25754.73	-56.44	-7.61	-48.83	PASS

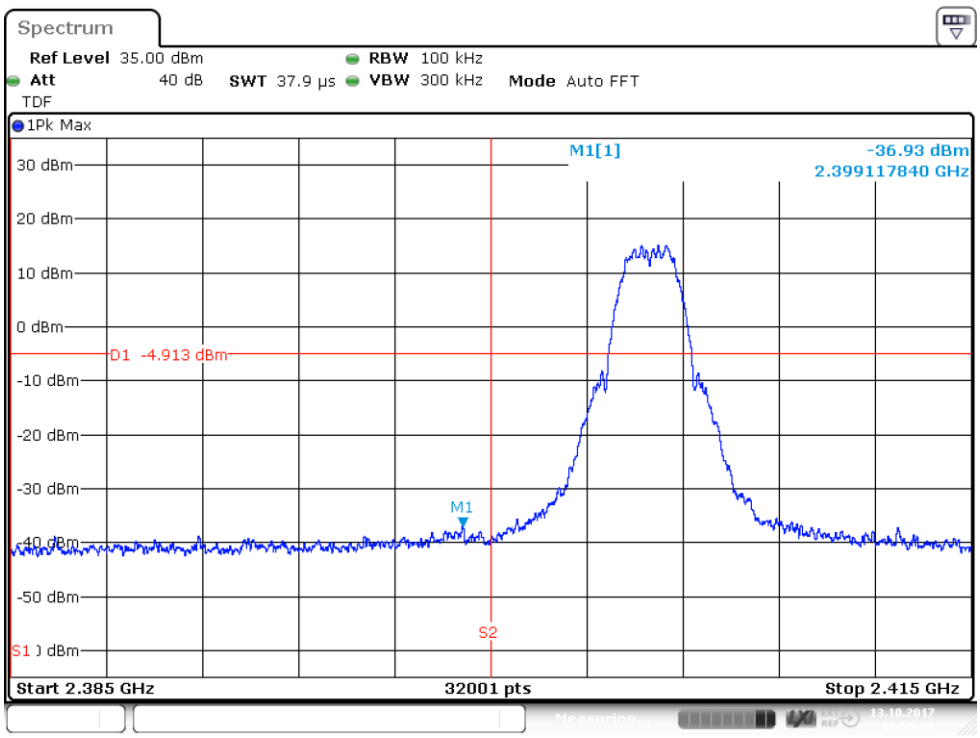

Figure 41: Lower Band Edge, Channel 11 low (A)

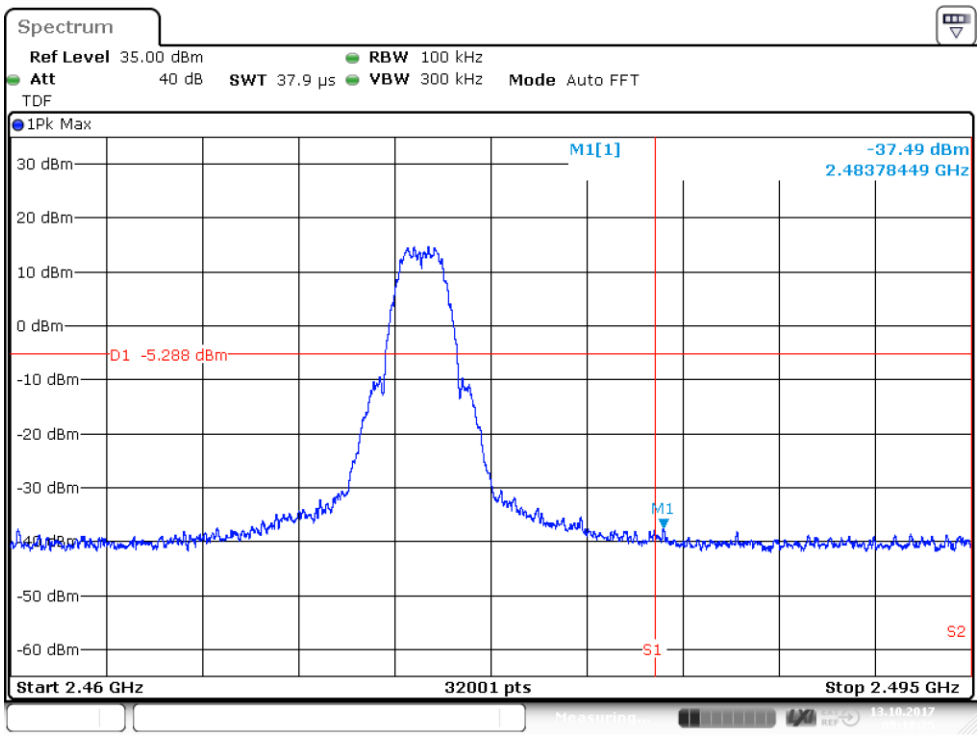

Figure 42: Upper Band Edge, Channel 25 (A)

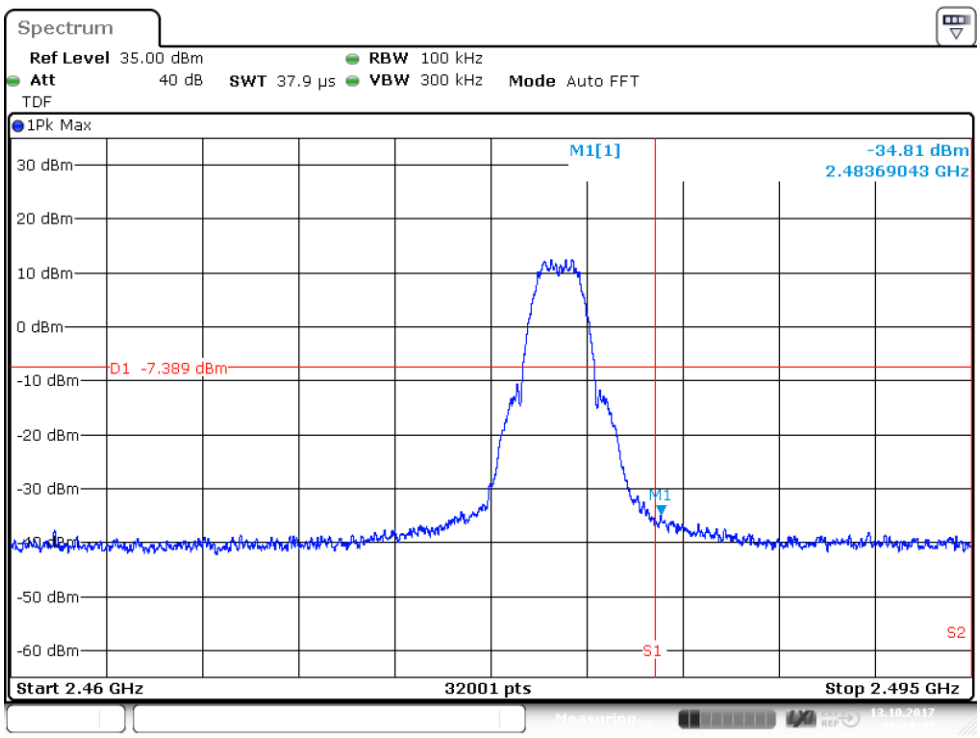

Figure 43: Upper Band Edge, Channel 26 (A)

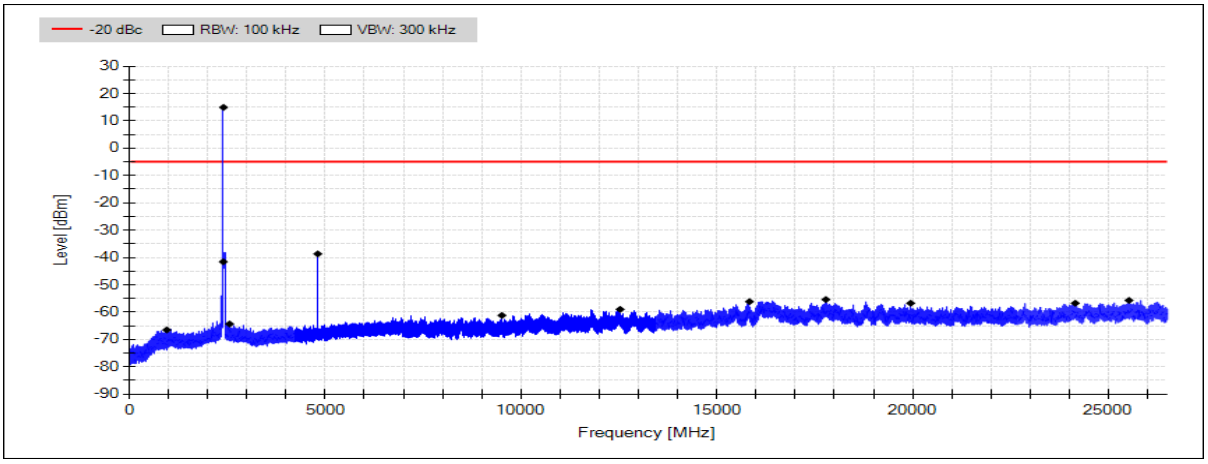

Figure 44: Conducted spurious emissions 30 - 26500 MHz Channel 11 low (A)

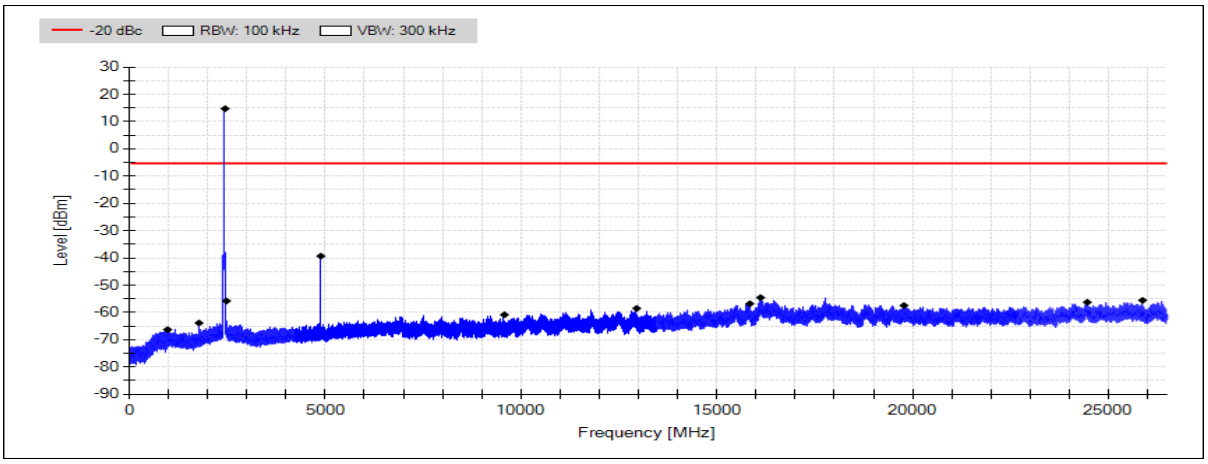

Figure 45: Conducted spurious emissions 30 - 26500 MHz channel 19 mid (A)

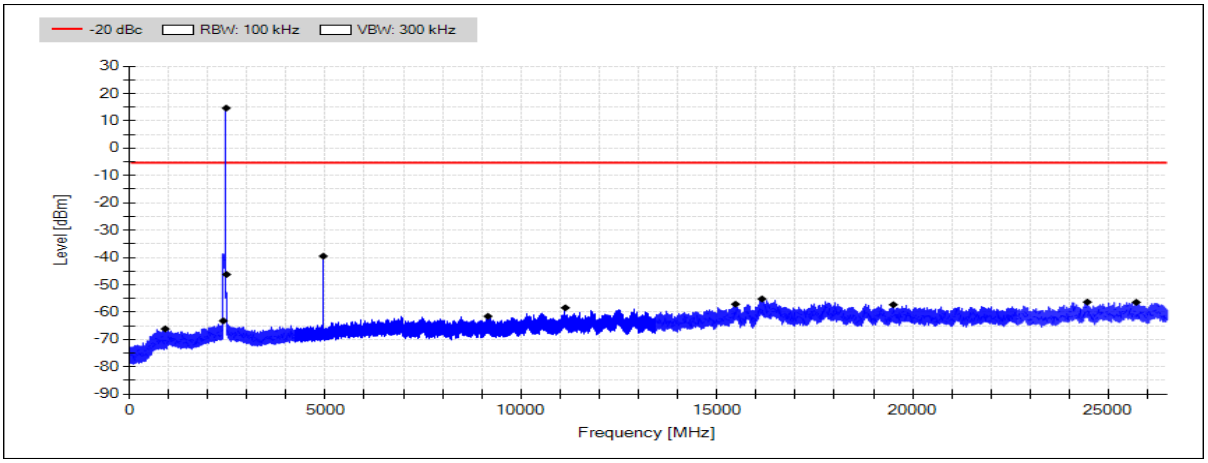

Figure 46: Conducted spurious emissions 30 - 26500 MHz Channel 25 high (A)

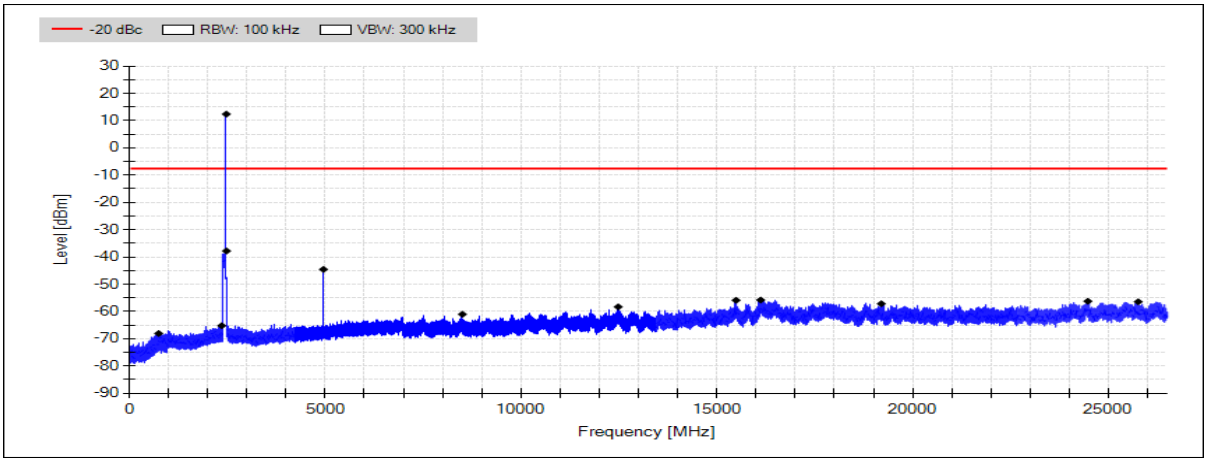

Figure 47: Conducted spurious emissions 30 - 26500 MHz Channel 26 high (A)

Table 41: Conducted spurious emissions Channel 11 low (E)

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
949.09	-66.61	-5.48	-61.13	PASS
2399.85	-40.56	-5.48	-35.08	PASS
2519.63	-63.73	-5.48	-58.25	PASS
4810.96	-40.48	-5.48	-35.00	PASS
8486.03	-61.06	-5.48	-55.58	PASS
11825.11	-58.95	-5.48	-53.47	PASS
15542.28	-56.44	-5.48	-50.96	PASS
16130.36	-54.90	-5.48	-49.42	PASS
19220.73	-56.83	-5.48	-51.35	PASS
24131.01	-56.01	-5.48	-50.53	PASS
25810.94	-55.56	-5.48	-50.08	PASS

Table 42: Conducted spurious emissions, channel 19 mid (E)

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
868.77	-67.07	-5.80	-61.27	PASS
2261.29	-64.23	-5.80	-58.43	PASS
2484.04	-57.14	-5.80	-51.34	PASS
4890.93	-41.08	-5.80	-35.27	PASS
9693.40	-61.43	-5.80	-55.62	PASS
11172.17	-58.89	-5.80	-53.08	PASS
15490.81	-56.91	-5.80	-51.11	PASS
16146.39	-55.06	-5.80	-49.26	PASS
21189.88	-57.17	-5.80	-51.36	PASS
24452.75	-56.49	-5.80	-50.69	PASS
25751.97	-56.16	-5.80	-50.36	PASS

Table 43: Conducted spurious emissions, Channel 25 high (E)

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
873.65	-65.96	-6.16	-59.80	PASS
2398.67	-62.50	-6.16	-56.34	PASS
2483.76	-47.78	-6.16	-41.62	PASS
4948.95	-41.00	-6.16	-34.84	PASS
8948.86	-60.49	-6.16	-54.33	PASS
12515.28	-59.21	-6.16	-53.05	PASS
15838.80	-56.83	-6.16	-50.67	PASS
16485.19	-55.62	-6.16	-49.46	PASS
19743.65	-56.54	-6.16	-50.38	PASS
24159.51	-55.58	-6.16	-49.42	PASS
25119.83	-55.95	-6.16	-49.79	PASS

Table 44: Conducted spurious emissions, Channel 26 high (E)

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
999.14	-68.06	-7.97	-60.10	PASS
1779.67	-57.35	-7.97	-49.38	PASS
2483.52	-37.15	-7.97	-29.19	PASS
4958.99	-46.80	-7.97	-38.83	PASS
9184.63	-61.30	-7.97	-53.33	PASS
12972.95	-58.88	-7.97	-50.92	PASS
15501.12	-56.67	-7.97	-48.70	PASS
17790.33	-54.78	-7.97	-46.82	PASS
19188.29	-56.88	-7.97	-48.92	PASS
24458.47	-55.43	-7.97	-47.46	PASS
25617.35	-56.31	-7.97	-48.34	PASS

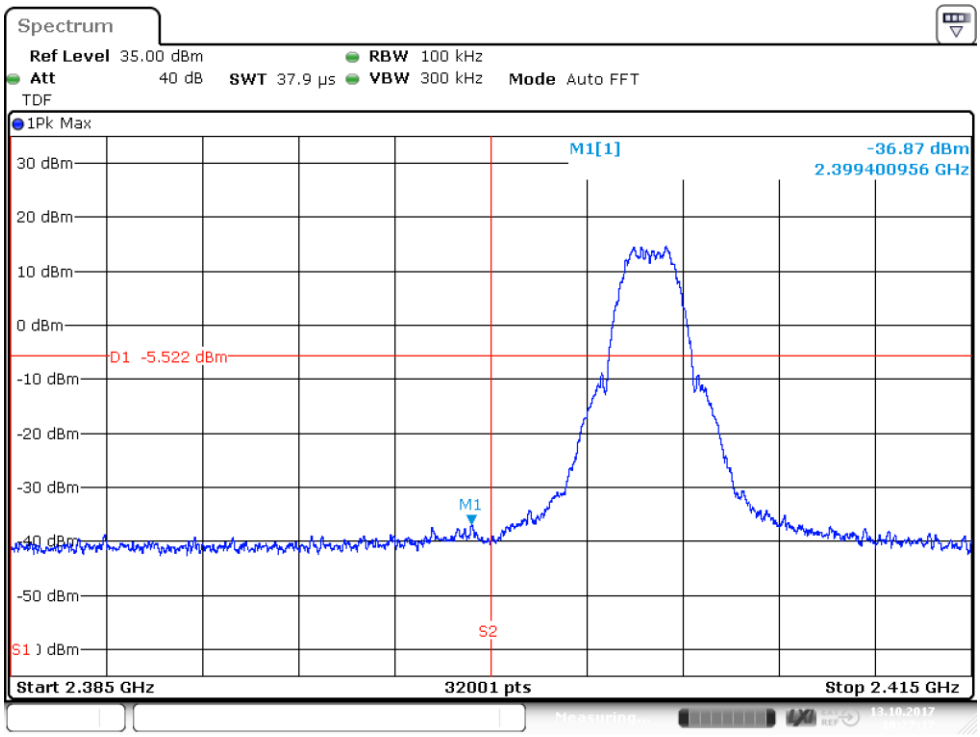

Figure 48: Lower Band Edge, Channel 11 (E)

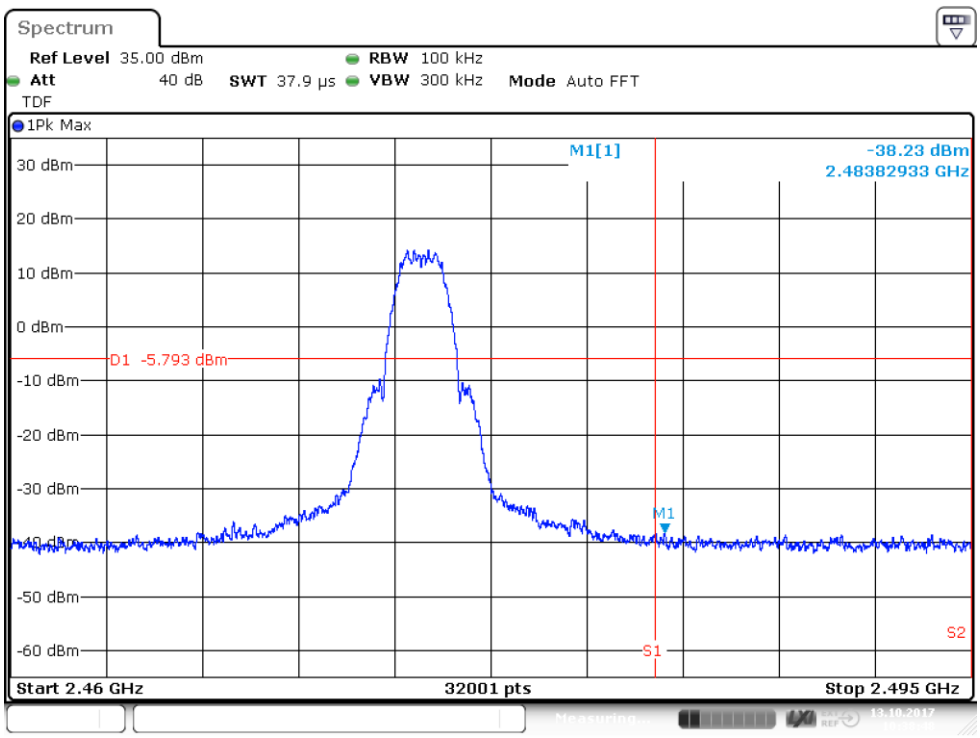

Figure 49: Upper Band Edge, Channel 25 (E)

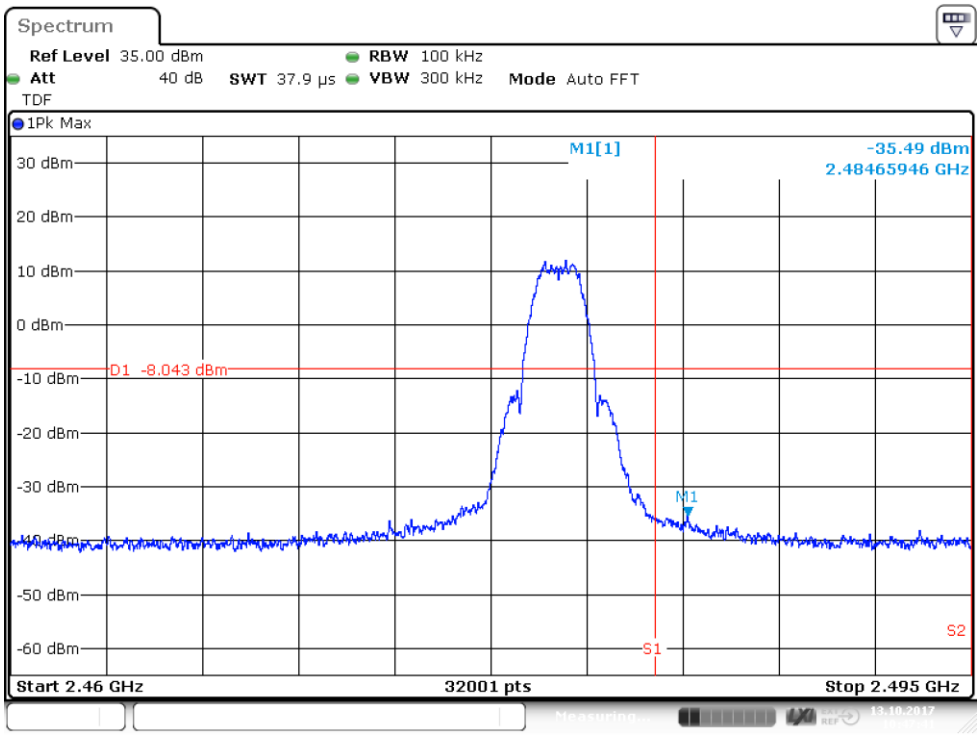

Figure 50: Upper Band Edge, Channel 26 (E)

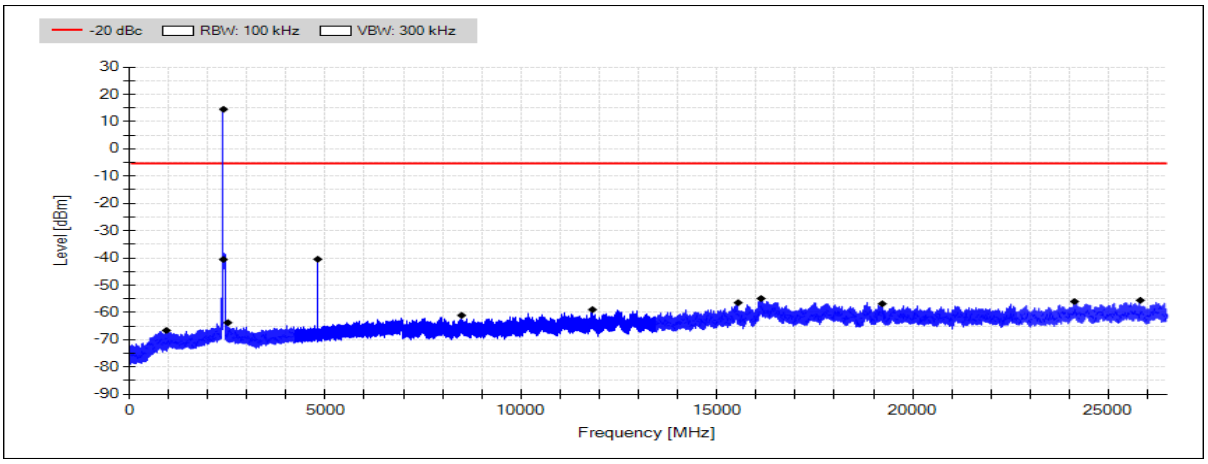

Figure 51: Conducted spurious emissions 30 - 26500 MHz Channel 11 low (E)

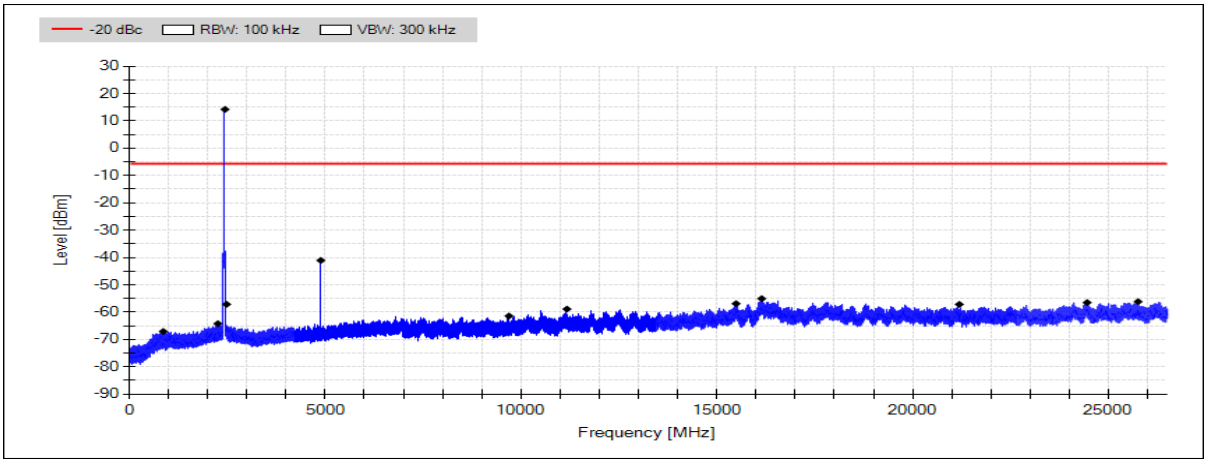

Figure 52: Conducted spurious emissions 30 - 26500 MHz channel 19 mid (E)

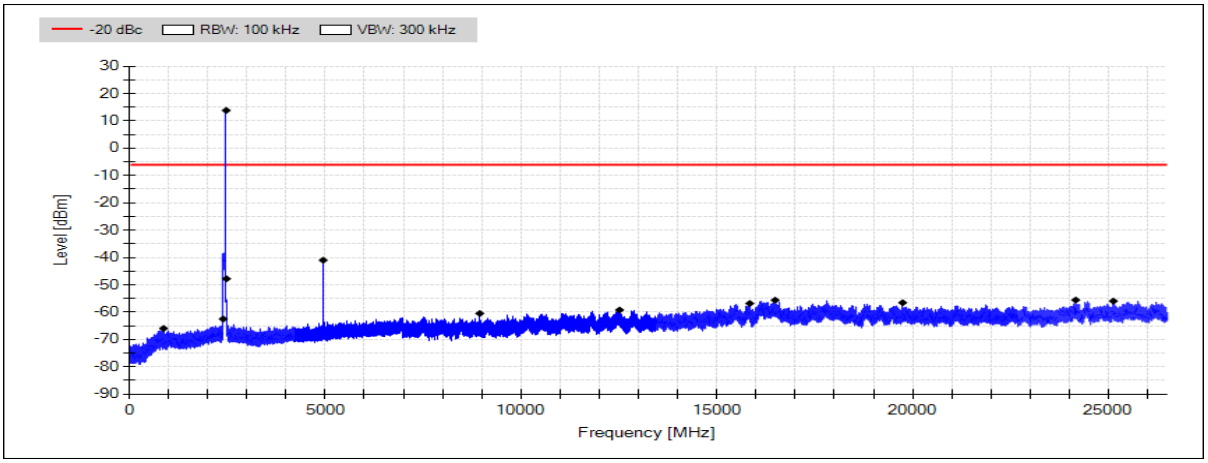

Figure 53: Conducted spurious emissions 30 - 26500 MHz Channel 25 high (E)

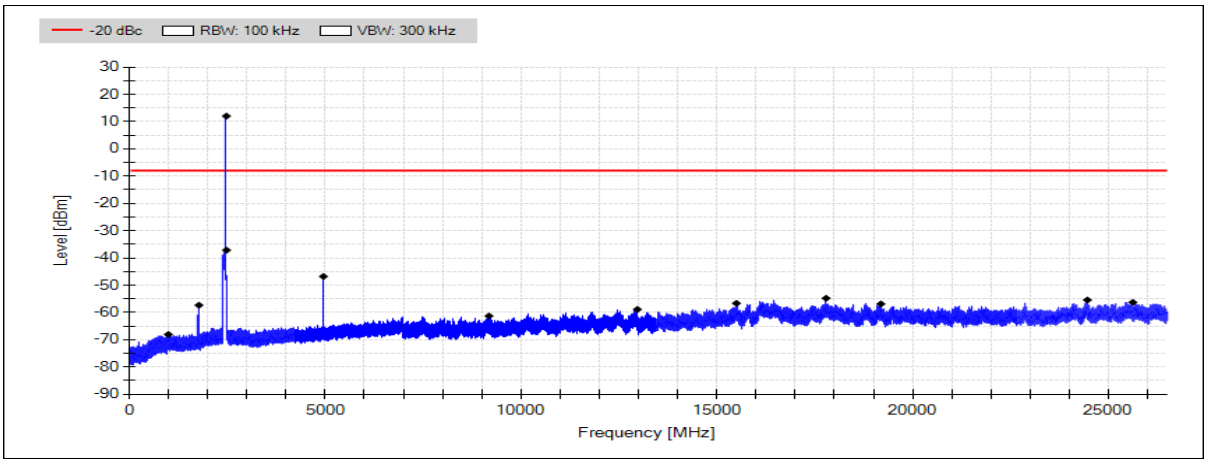

Figure 54: Conducted spurious emissions 30 - 26500 MHz Channel 26 high (E)

6 dB Bandwidth of the Channel

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	13 October 2017	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	

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

Results:

Table 45: 6 dB bandwidth test results (A)

Channel	6 dB BW [kHz]	Minimum limit [kHz]
11 Low	1692	500
19 Mid	1692	
25 High	1678	
26 High	1684	

Table 46: 6 dB bandwidth test results (E)

Channel	6 dB BW [kHz]	Minimum limit [kHz]
11 Low	1690	500
19 Mid	1679	
25 High	1680	
26 High	1674	

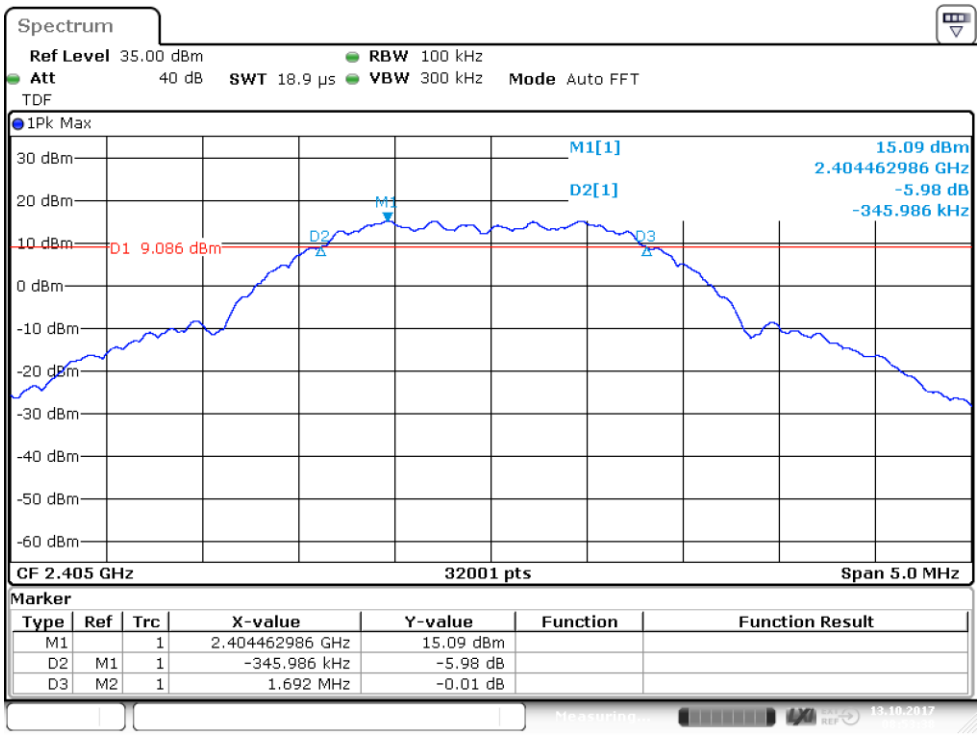

Figure 55: 6 dB bandwidth, Channel 11 low (A)

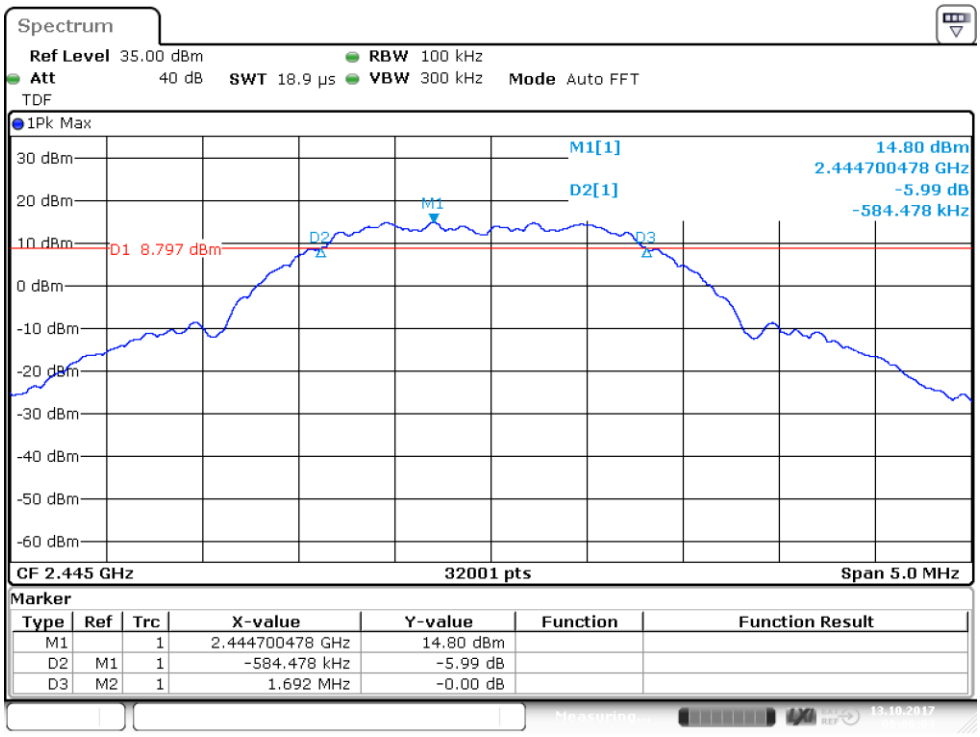

Figure 56: 6 dB bandwidth, channel 19 mid (A)

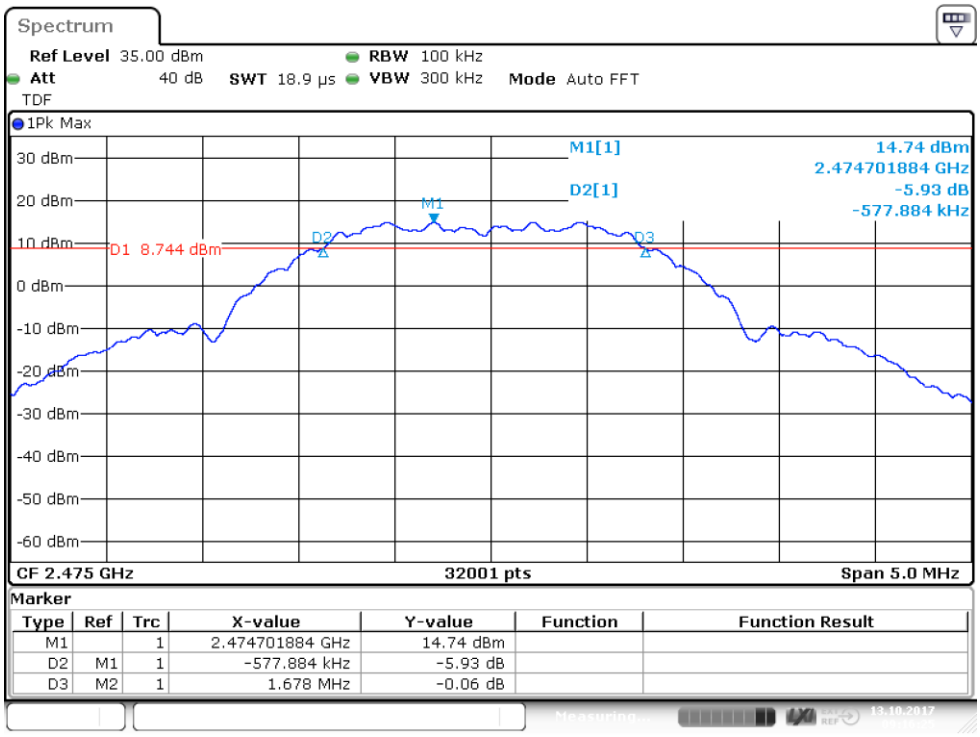

Figure 57: 6 dB bandwidth, Channel 25 high (A)

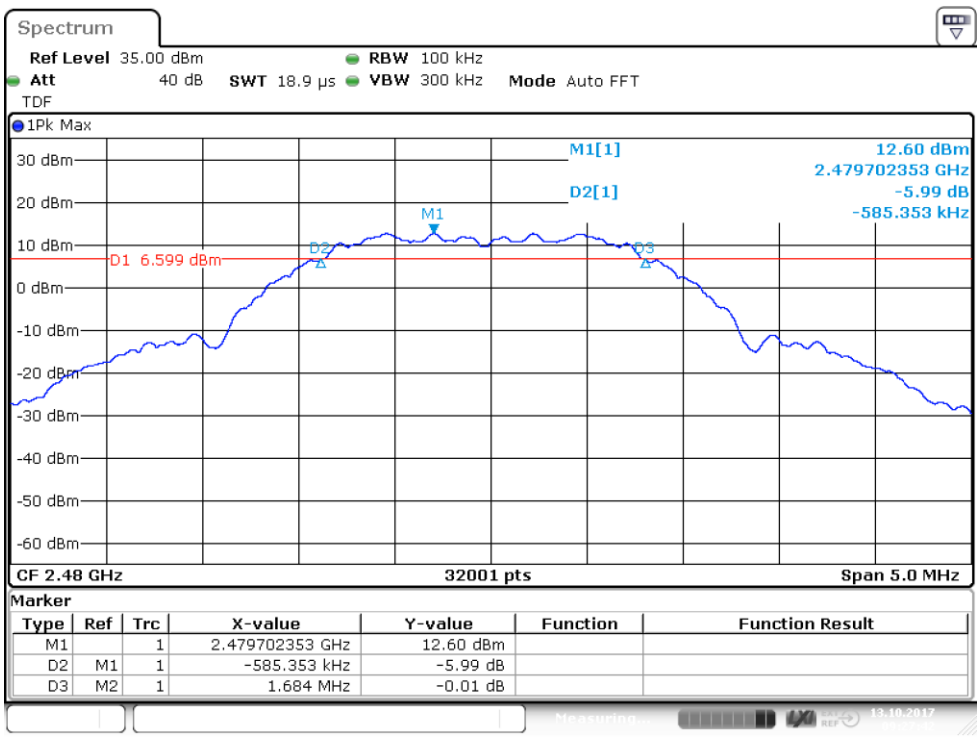

Figure 58: 6 dB bandwidth, Channel 26 high (A)

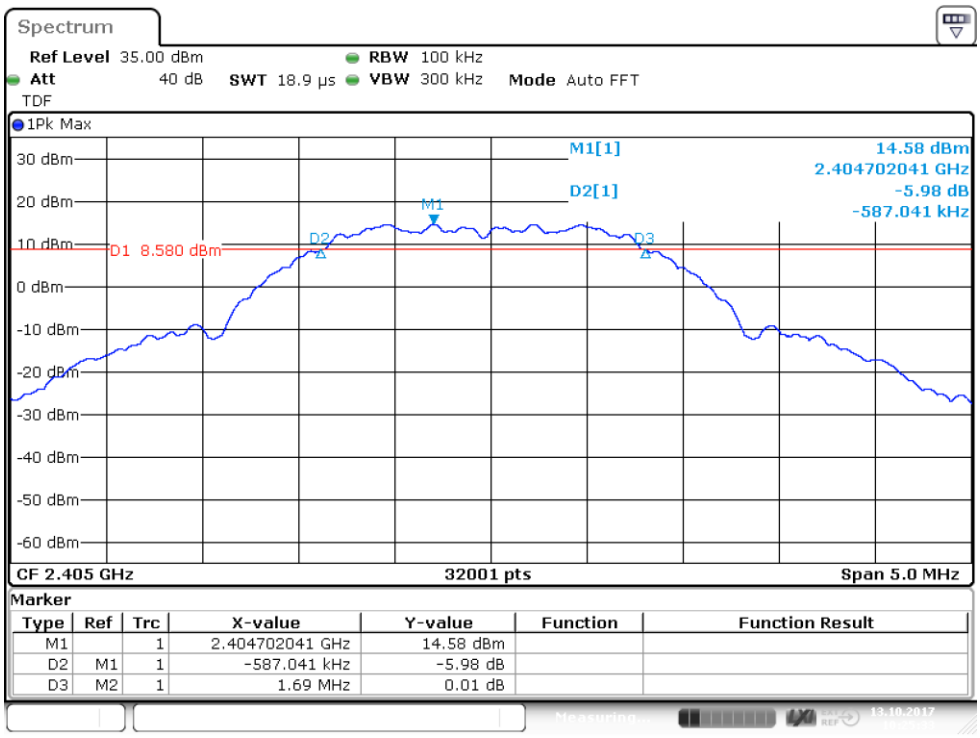

Figure 59: 6 dB bandwidth, Channel 11 low (E)

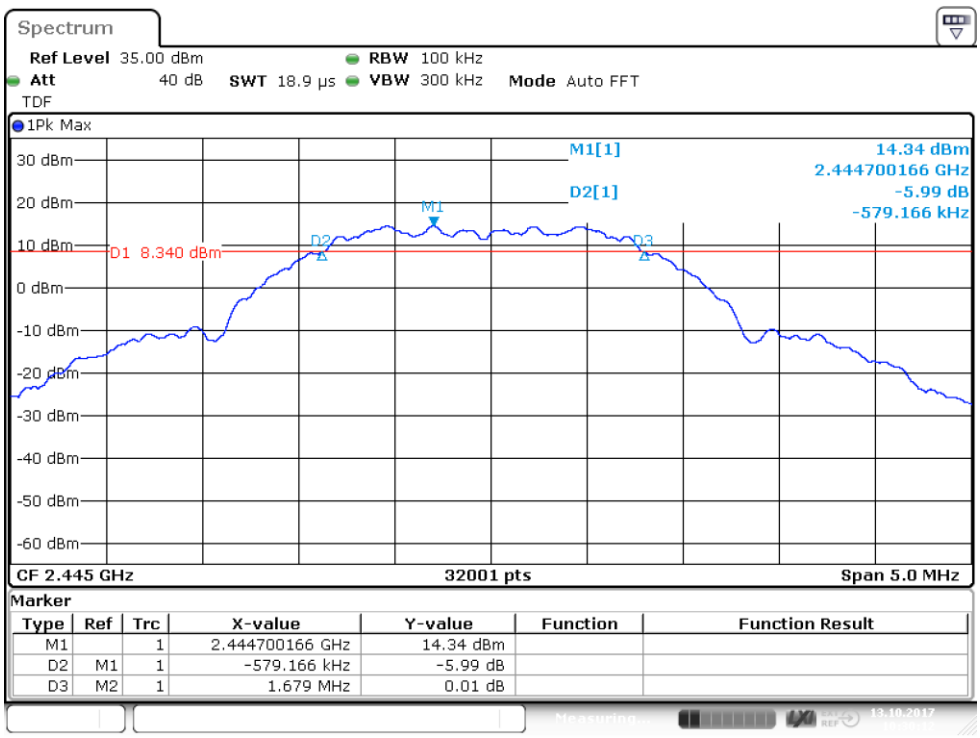

Figure 60: 6 dB bandwidth, channel 19 mid (E)

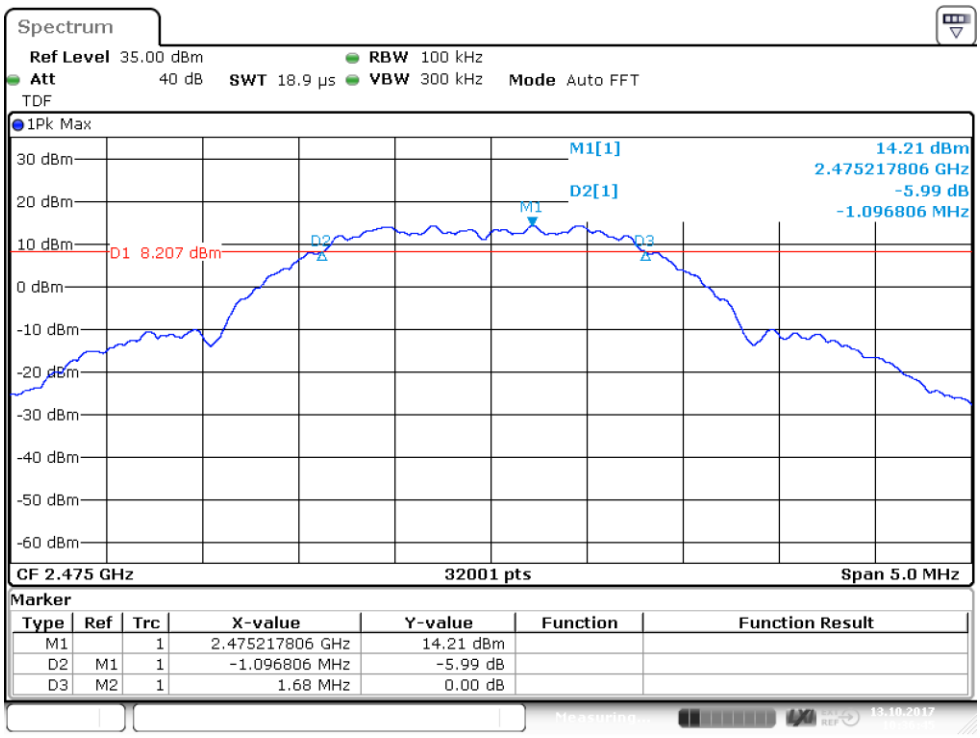

Figure 61: 6 dB bandwidth, Channel 25 high (E)

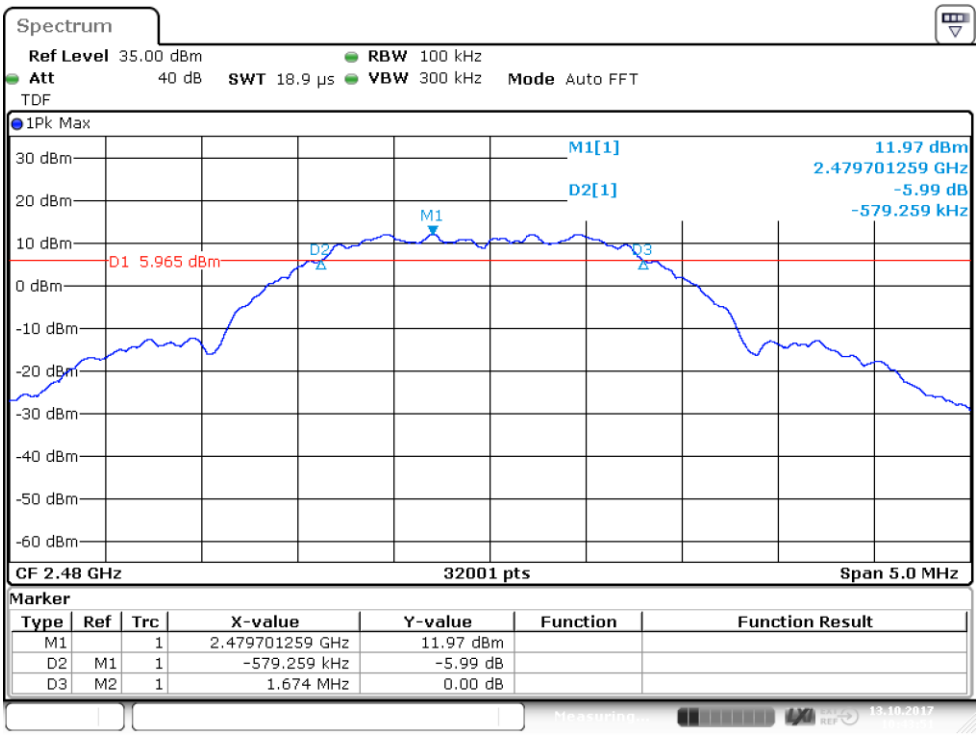

Figure 62: 6 dB bandwidth, Channel 26 high (E)

Power Spectral Density

Standard:	ANSI C63.10	(2013)
Tested by:	JAT	
Date:	13 October 2017	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	

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

Results:

Table 47: Power spectral density test results (A)

Channel	PSD dBm/3 kHz	Maximum limit [dBm/3kHz]
11 Low	3.69	+8.00
19 Mid	3.38	
25 High	3.23	
26 High	1.18	

Table 48: Power spectral density test results (E)

Channel	PSD dBm/3 kHz	Maximum limit [dBm/3kHz]
11 Low	3.18	+8.00
19 Mid	2.83	
25 High	2.71	
26 High	0.48	

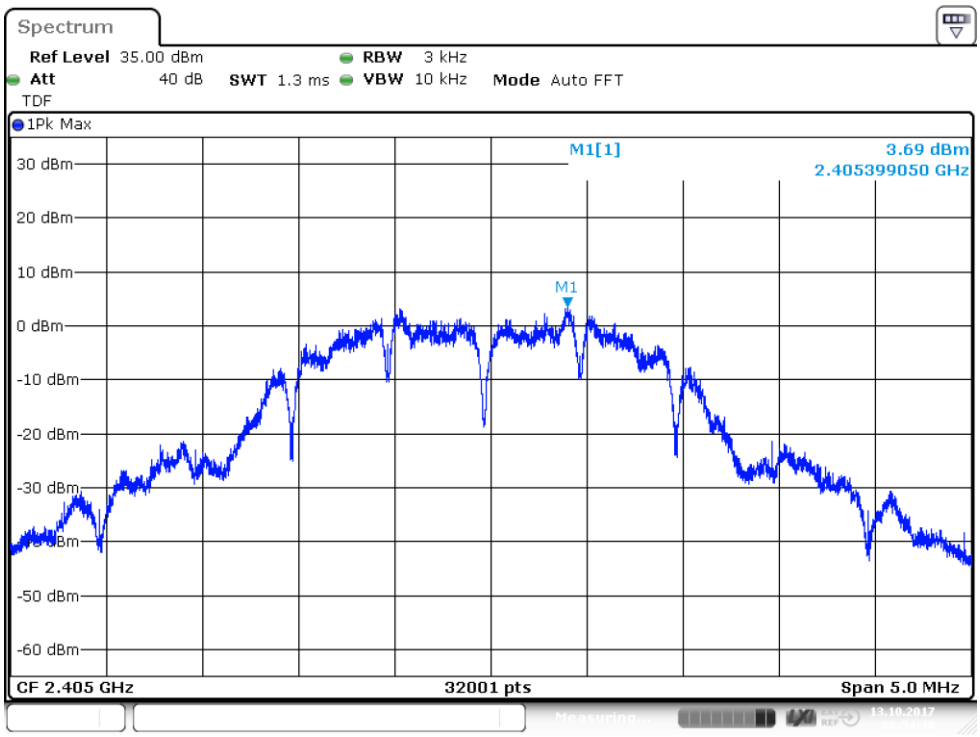

Figure 63: Power spectral density, Channel 11 low (A)

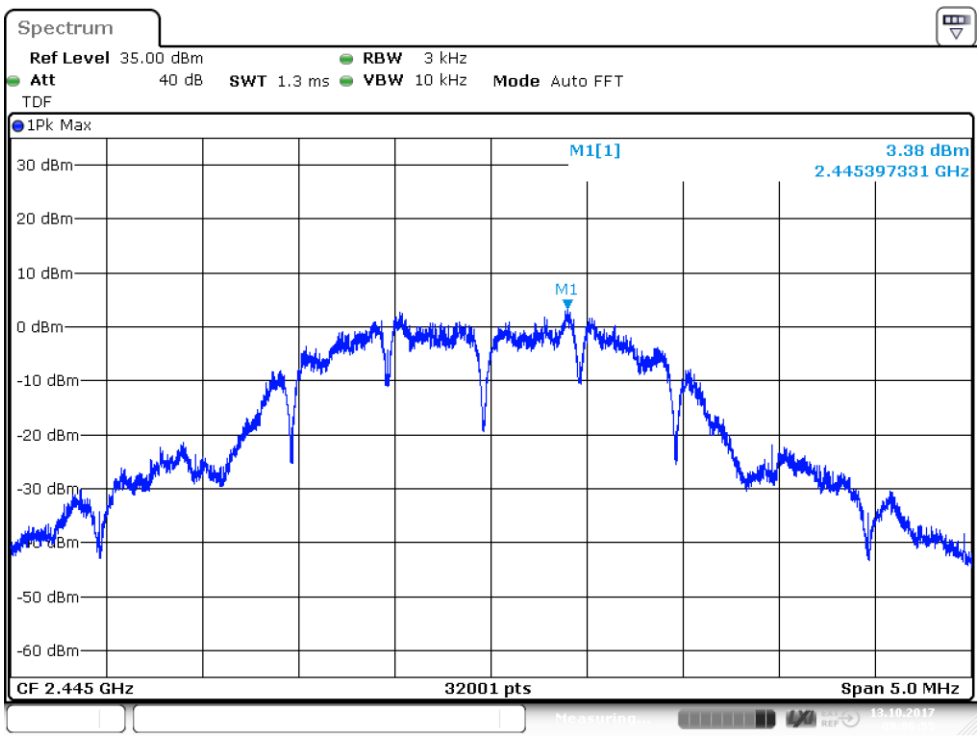

Figure 64: Power spectral density, channel 19 mid (A)

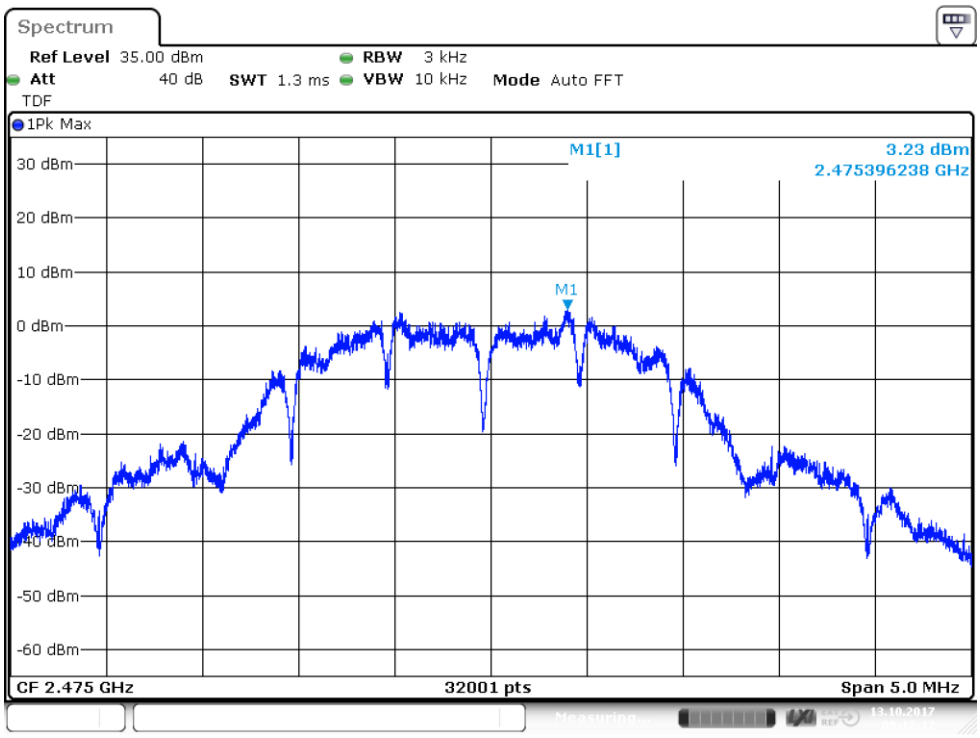

Figure 65: Power spectral density, Channel 25 high (A)

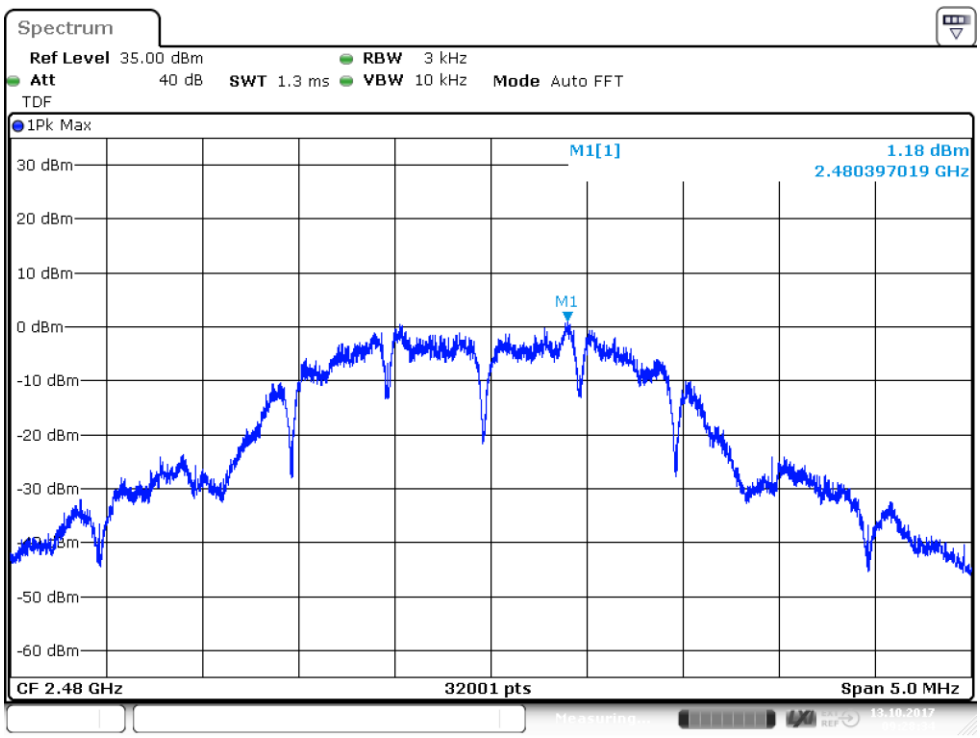

Figure 66: Power spectral density, Channel 26 high (A)

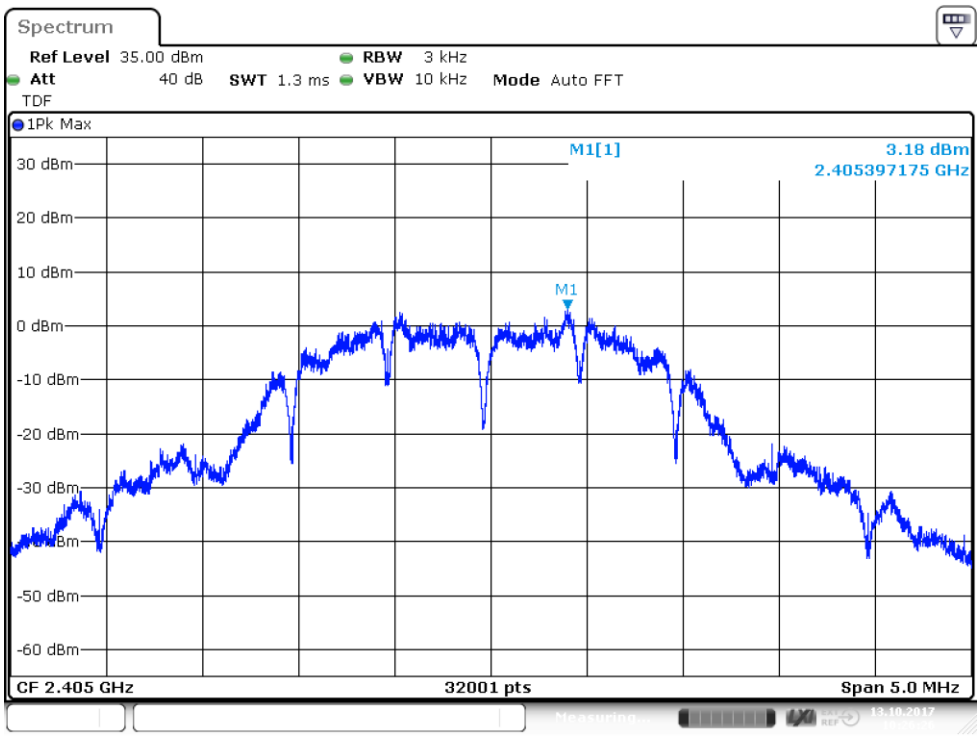

Figure 67: Power spectral density, Channel 11 low (E)

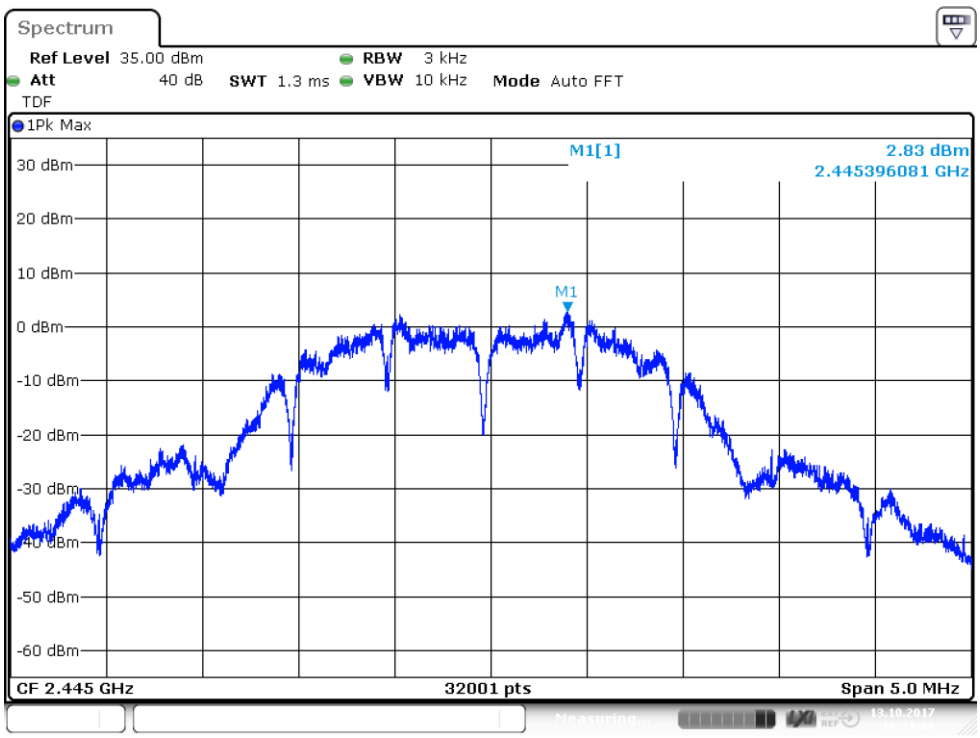

Figure 68: Power spectral density, channel 19 mid (E)

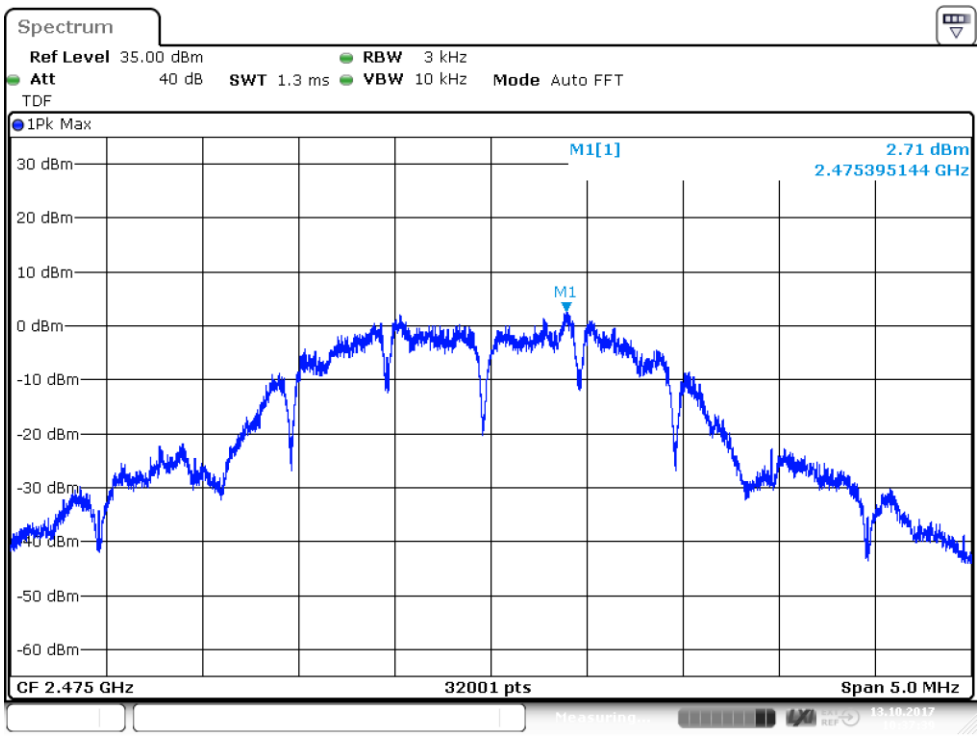

Figure 69: Power spectral density, Channel 25 high (E)

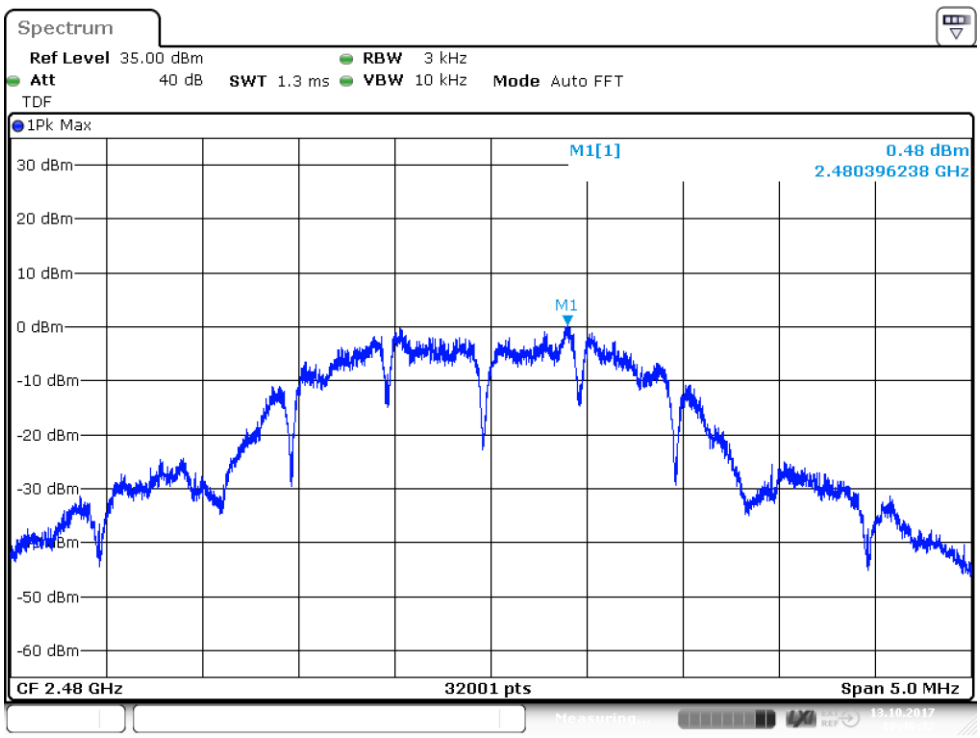

Figure 70: Power spectral density, Channel 26 high (E)

99% Occupied Bandwidth

Standard:	RSS-GEN	(2014)
Tested by:	JAT	
Date:	13 October 2017	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 % RH	

RSS-GEN 6.6

Results:

Table 49: 99% occupied bandwidth test results (A)

Channel	Limit	99 % BW [MHz]	Result
11 Low	-	2.247429768	PASS
19 Mid	-	2.256179494	PASS
25 High	-	2.264929221	PASS
26 High	-	2.262741789	PASS

Table 50: 99% occupied bandwidth test results (E)

Channel	Limit	99 % BW [MHz]	Result
11 Low	-	2.251179651	PASS
19 Mid	-	2.264616731	PASS
25 High	-	2.264616731	PASS
26 High	-	2.281178713	PASS

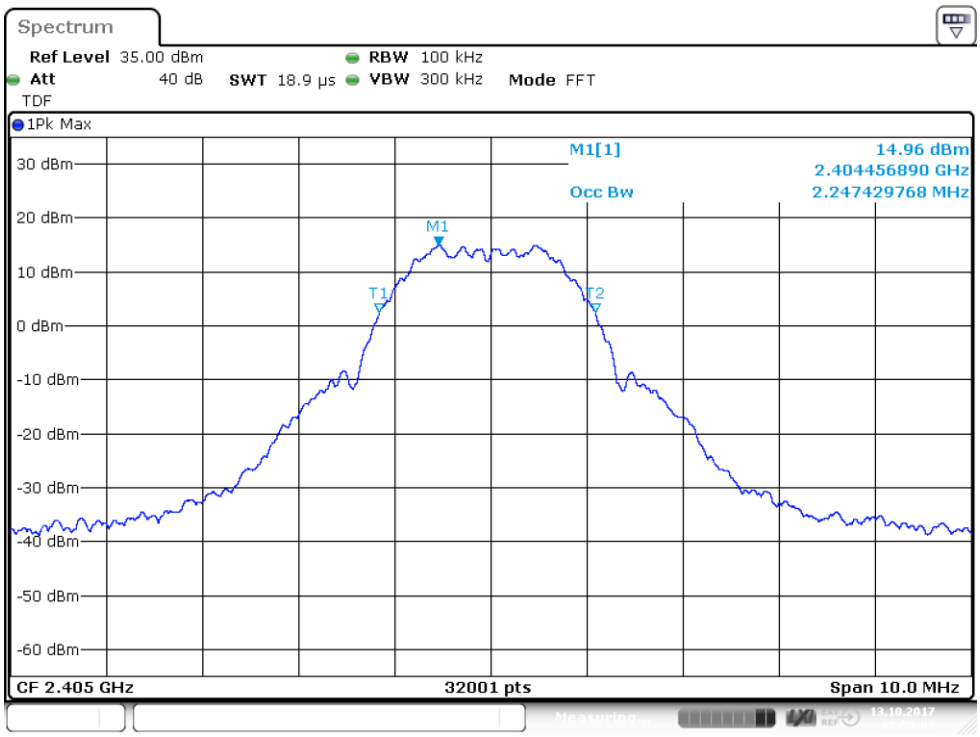

Figure 71: 99% OBW, Channel 11 low (A)

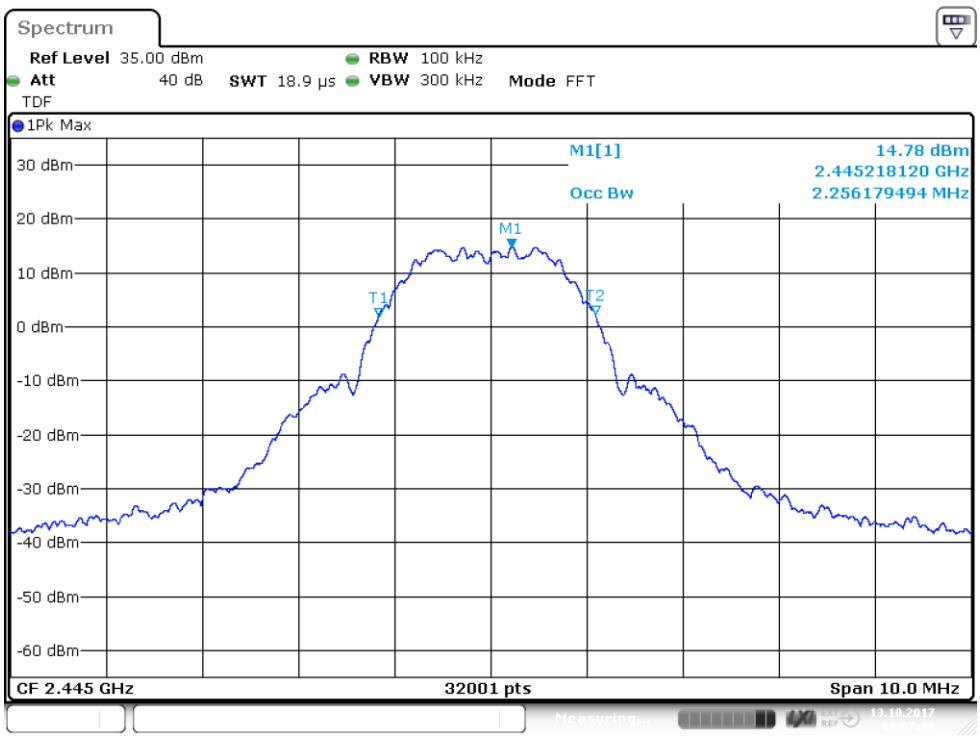

Figure 72: 99% OBW, Channel 19 mid (A)

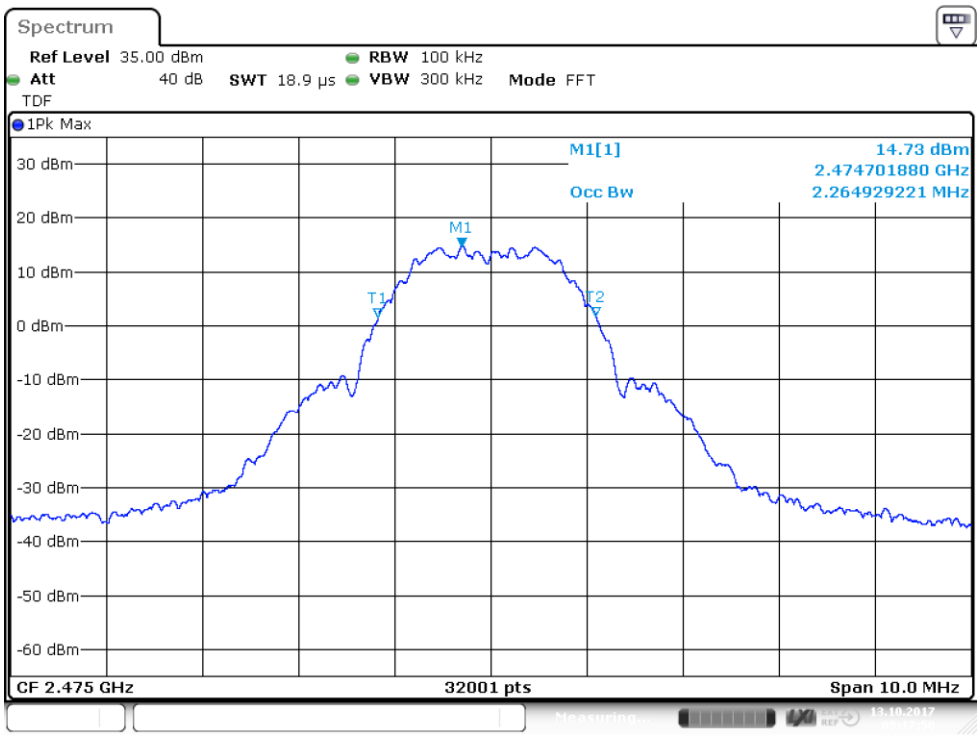

Figure 73: 99% OBW, Channel 25 high (A)

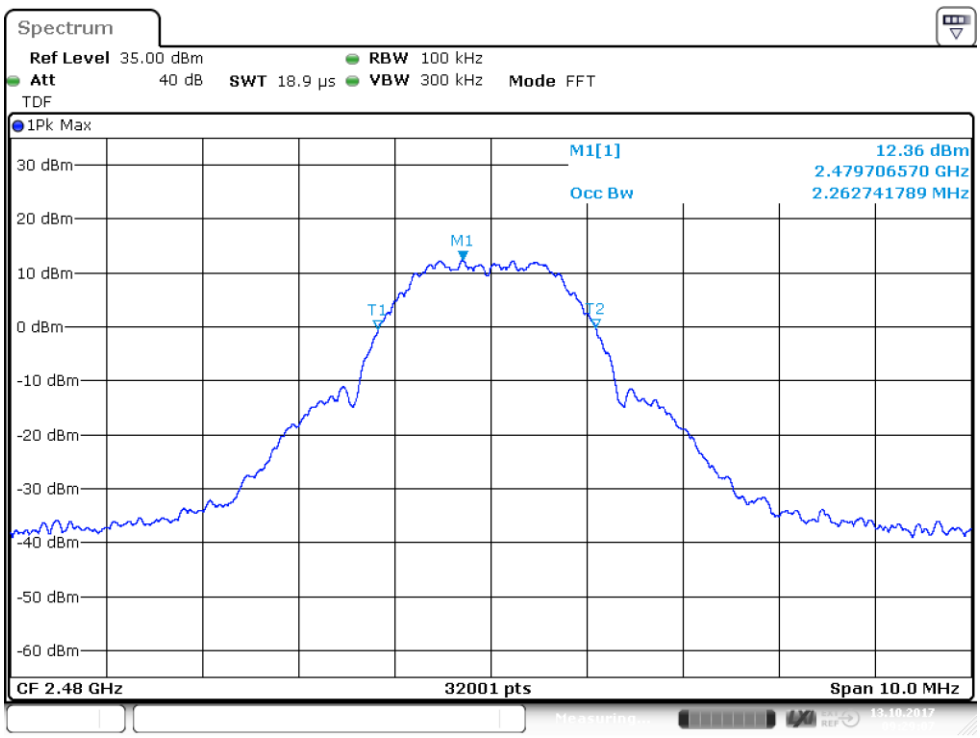

Figure 74: 99% OBW, Channel 26 high (A)

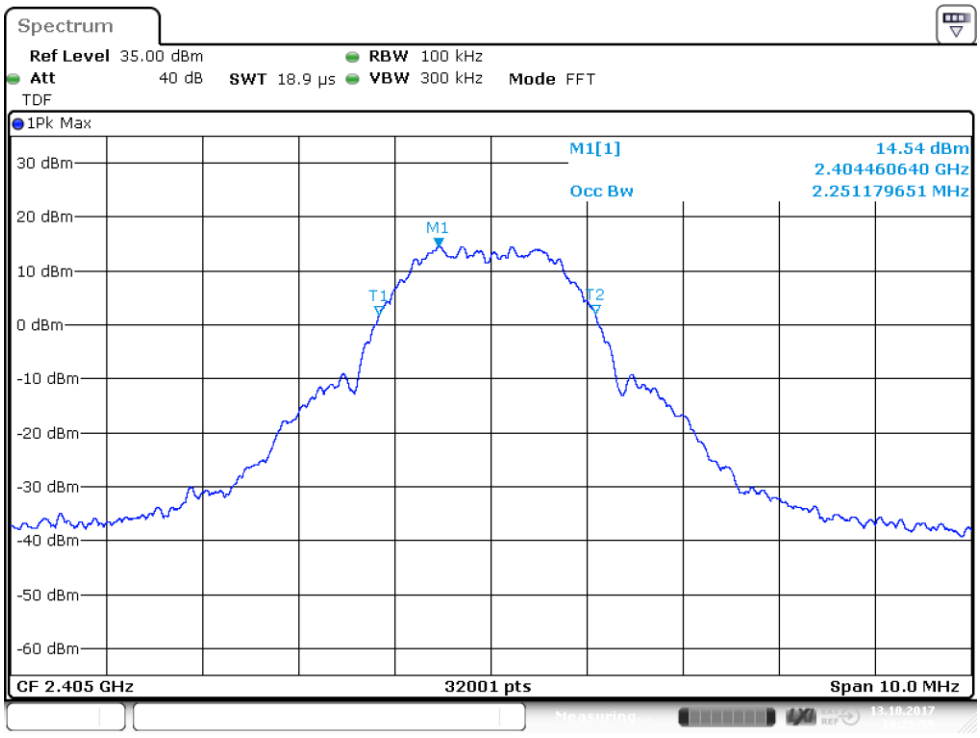

Figure 75: 99% OBW, Channel 11 low (E)

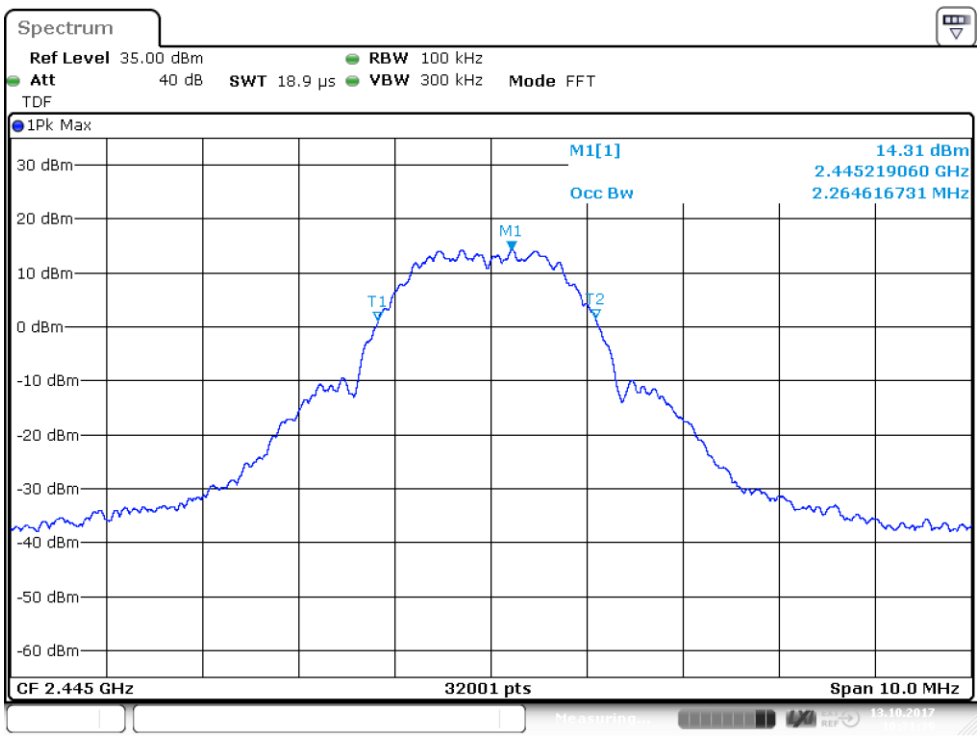

Figure 76: 99% OBW, Channel 19 mid (E)

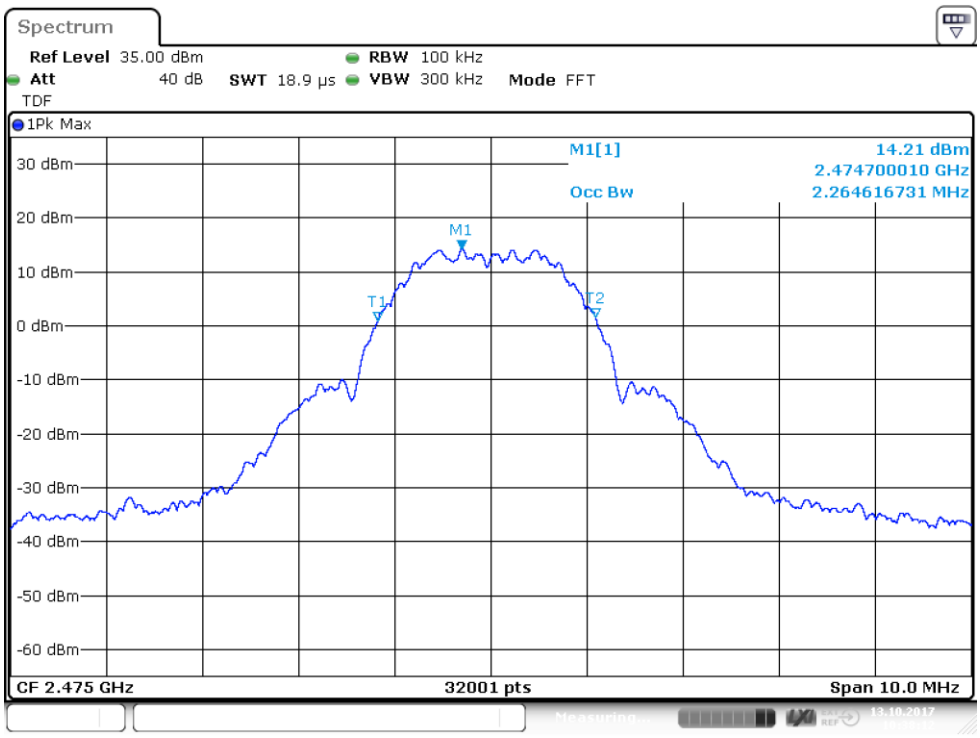

Figure 77: 99% OBW, Channel 25 high (E)

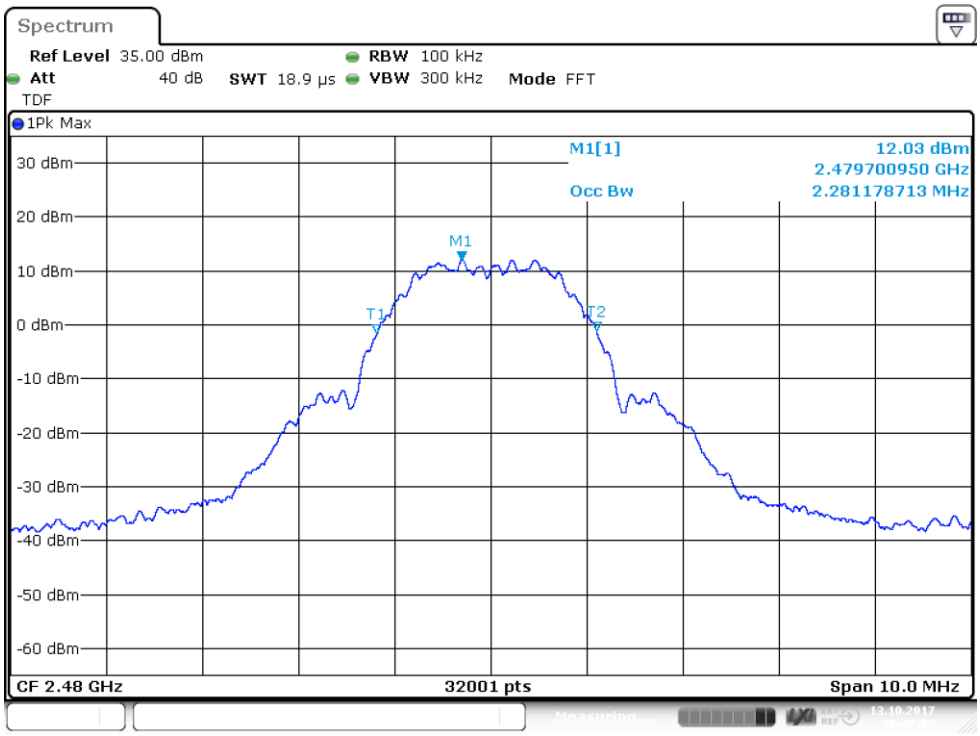

Figure 78: 99% OBW, Channel 26 high (E)

TEST EQUIPMENT

RF-Test Equipment

Equipment	Manufacturer	Type	Inv or serial	Prev Calib	Next Calib
ANTENNA	A.H. SYSTEMS	SAS-200/518	inv:7873	-	-
SPECTRUM ANALYZER	AGILENT	E7405A	inv:9746	2016-01-07	2018-01-07
PREAMPLIFIER	CIAO	CA118-3123	inv:10278	2016-11-28	2017-11-28
POWER SUPPLY	DELTA	SM 130-25D	inv:10406	-	-
ANTENNA	EMCO	3117	inv:7293	2016-03-16	2018-03-06
ANTENNA	EMCO	3160-09	inv:7294	2017-03-16	2018-03-16
ANTENNA	ETS LINDGREN	3160-10	inv:9151	2013-08-06	2018-08-06
TURNTABLE	MATURO	DS430 UPGRADED	inv:10182	-	-
MAST & TURNTABLE CONTROLLER	MATURO	NCD	inv:10183	-	-
ANTENNA MAST	MATURO	TAM 4.0E	inv:10181	-	-
ATTENUATOR	PASTERNACK	10dB DC-40GHz	-	-	-
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESU 26	inv:8453	2017-07-10	2018-07-10
SIGNAL ANALYZER	ROHDE & SCHWARZ	FSV40	inv:9093	2017-07-07	2018-07-07
ANTENNA	SCHWARZBECK	VULB 9168	inv:8911	2016-10-25	2018-10-25
TEMPERATURE/ HUMIDITY METER	VAISALA	HMT 333	inv:8638	2017-02-21	2018-02-21
HIGH PASS FILTER	WAINWRIGHT	WHKX4.0/18G-10SS	inv:10403	2017-03-01	2019-03-01