

Test Report



INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 15 C

Equipment Under Test: Bluetooth Smart Module

Model: BGM113

Manufacturer: Silicon Laboratories Finland Oy
Sinikalliontie 5A
FI-02630 Espoo
FINLAND

Customer: Silicon Laboratories Finland Oy
Sinikalliontie 5A
FI-02630 Espoo
FINLAND

FCC Rule Part: 15.247: 2015
IC Rule Part: RSS-247, Issue 1, 2015
RSS-GEN Issue 4, 2014

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

Date: March 10, 2016

Issued by:

A blue ink signature of Niko Kotsalo.

Niko Kotsalo
Testing Engineer

Date:

March 10, 2016

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Pekka Kälviäinen
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Equipment Under Test (EUT)

Bluetooth Smart Module

Model: BGM113
Type: -
Serial no: -
FCC ID: QOQ-BGM113
IC: 5123A-BGM113

Description of the EUT

BGM113 is Bluetooth Smart Module (Bluetooth 4.1) targeted for Bluetooth Smart applications. BGM113 integrates all of the necessary elements required for a Bluetooth Smart application: Bluetooth radio, software stack and GATT based profiles.

Classification of the device

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

Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing

Ratings and declarations

Operating Frequency Range (OFR): 2402 – 2480 MHz
Channels: 40
Channel separation: 2 MHz
99% Channel bandwidth: 1.099855282 MHz
Maximum peak conducted output power: 4.49 dBm
Transmission technique: DSSS
Modulation: GFSK
Integral Antenna gain: 0.5 dBi

Power Supply

Operating voltage range: 2.4 – 3.8 VDC

Mechanical Size of the EUT

Height: 1.9 mm	Width: 9.15 mm	Length: 15.73 mm
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Samples

Two samples were used in the testing. Normal commercial sample with integral antenna for radiated emissions and a sample with integral antenna removed and replaced with 50Ω coaxial cable and SMA-connector for conducted RF tests. During the tests the EUT was set to transmit continuously on the wanted channel under test. The EUT were programmed to the wanted test conditions with BGTool software that was provided by the customer. Normal test modulation and maximum transmit power was used in all tests. No modifications were done during the testing.

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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(4)	Maximum Peak Conducted Output Power	PASS
§15.247(a)(2) / RSS-247 5.2(1)	6 dB Bandwidth	PASS
§15.247(e) / RSS-247 5.2(2)	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. Hopping was stopped and the EUT was configured into the wanted channel. Normal modulation was applied in all the tests.

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

Channel Low (Ch 0) = 2402 MHz

Channel Mid (Ch 20) = 2442 MHz

Channel High (Ch 39) = 2480 MHz

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

Conducted Emissions In The Frequency Range 150 kHz – 30 MHz

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

Standard: ANSI C63.10 (2013)
Tested by: NKO
Date: 23.2.2016
Temperature: 22 °C
Humidity: 25 % RH
Barometric pressure: 985 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.

During the test the EUT was powered from the separate power supply Thandar TS3021S through the LISN. EUT were set to transmit continuously on the lowest channel (2402 MHz)

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 In The Frequency Range 150 kHz – 30 MHz

Conducted Emission Mains FCC Part 15 Class B with ENV216

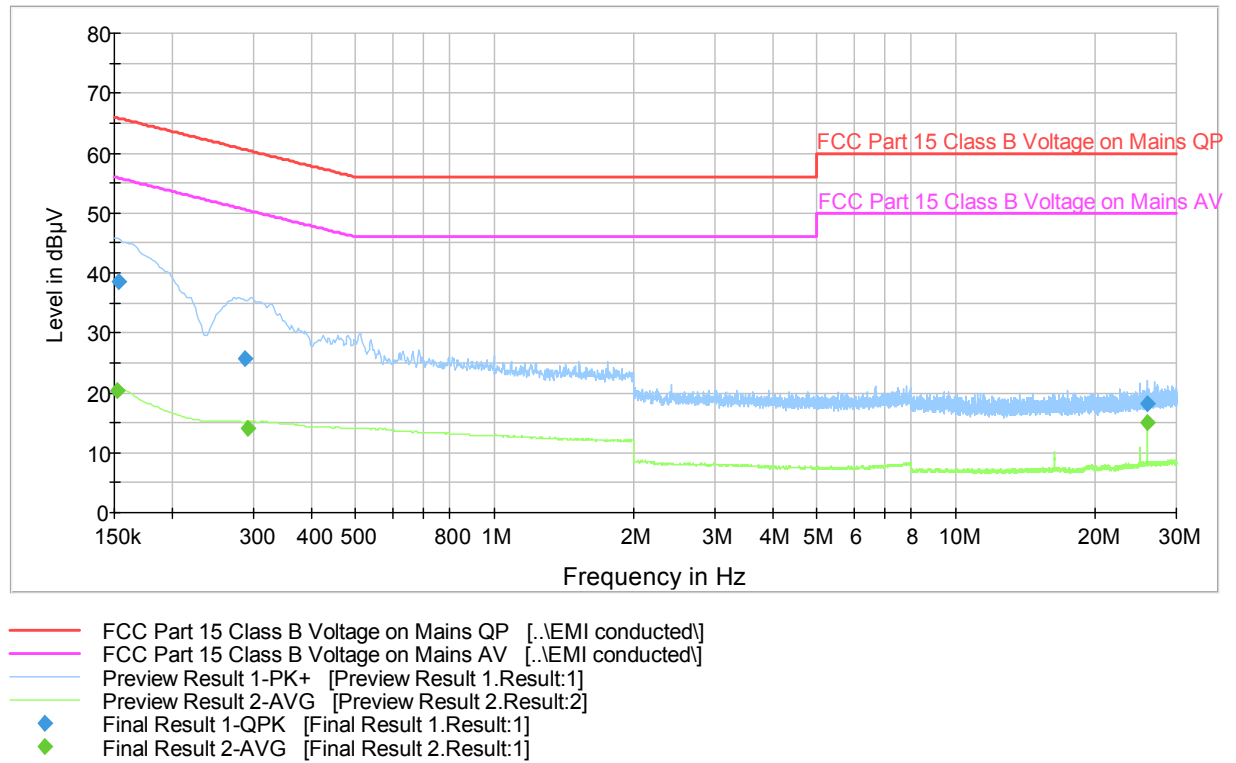


Figure 1. The measured curves with peak- and average detector

Final measurements from the worst frequencies

Table 1. Final QuasiPeak measurements from the worst frequencies.

Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)	Comment
0.153000	38.6	1000.0	9.000	On	L1	9.9	27.2	65.8	
0.288750	25.7	1000.0	9.000	On	N	9.8	34.8	60.6	
26.000250	18.3	1000.0	9.000	On	N	11.3	41.7	60.0	

Table 2. Final Average measurements from the worst frequencies.

Frequency (MHz)	Average (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)	Comment
0.152000	20.4	1000.0	9.000	On	L1	9.9	35.5	55.9	
0.292750	14.1	1000.0	9.000	On	N	9.8	36.4	50.4	
26.001250	15.1	1000.0	9.000	On	L1	11.3	34.9	50.0	

Maximum Peak Conducted Output Power

Maximum Peak Conducted Output Power

Standard: ANSI C63.10 (2013)
Tested by: NKO
Date: 3.3.2016
Temperature: 21 °C
Humidity: 25 %
Measurement uncertainty $\pm 2.87\text{dB}$ Level of confidence 95 % (k = 2)

FCC Rule: 15.247(b)(3)
RSS-247 5.4(4)

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.

Results:

Channel	Conducted Power [dBm]	Limit [dBm]	Margin [dBm]	Result
Low	4.49	30	25.51	PASS
Mid	4.49	30	25.51	PASS
High	4.23	30	25.77	PASS

Maximum Peak Conducted Output Power

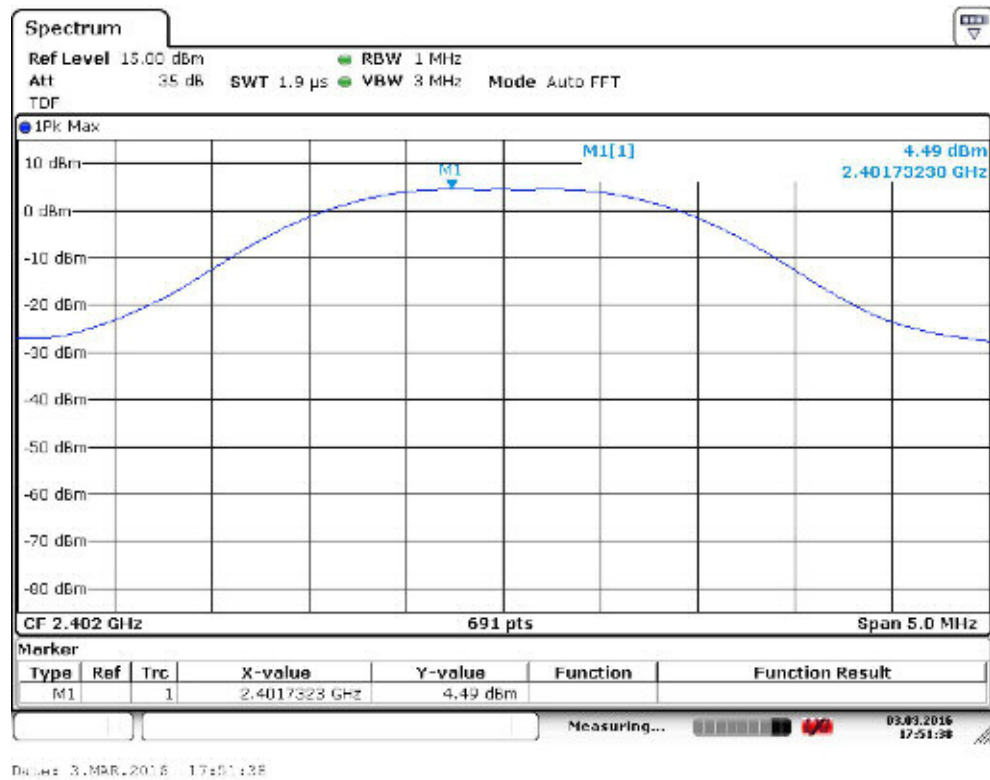


Figure 2. Maximum peak output power channel low.

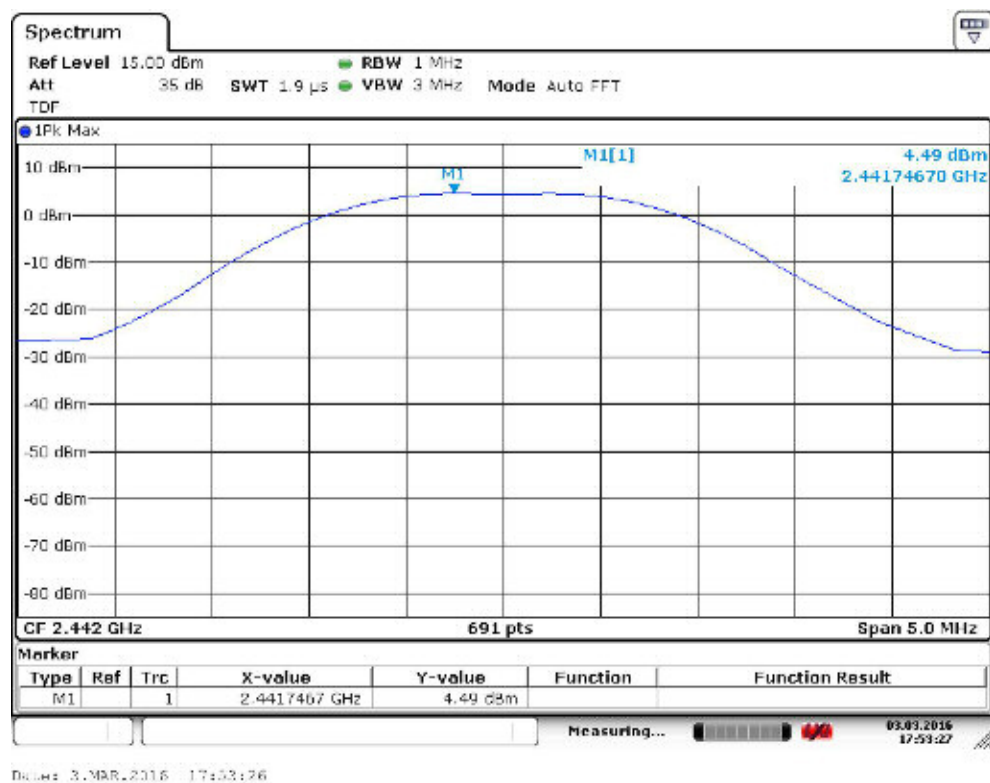
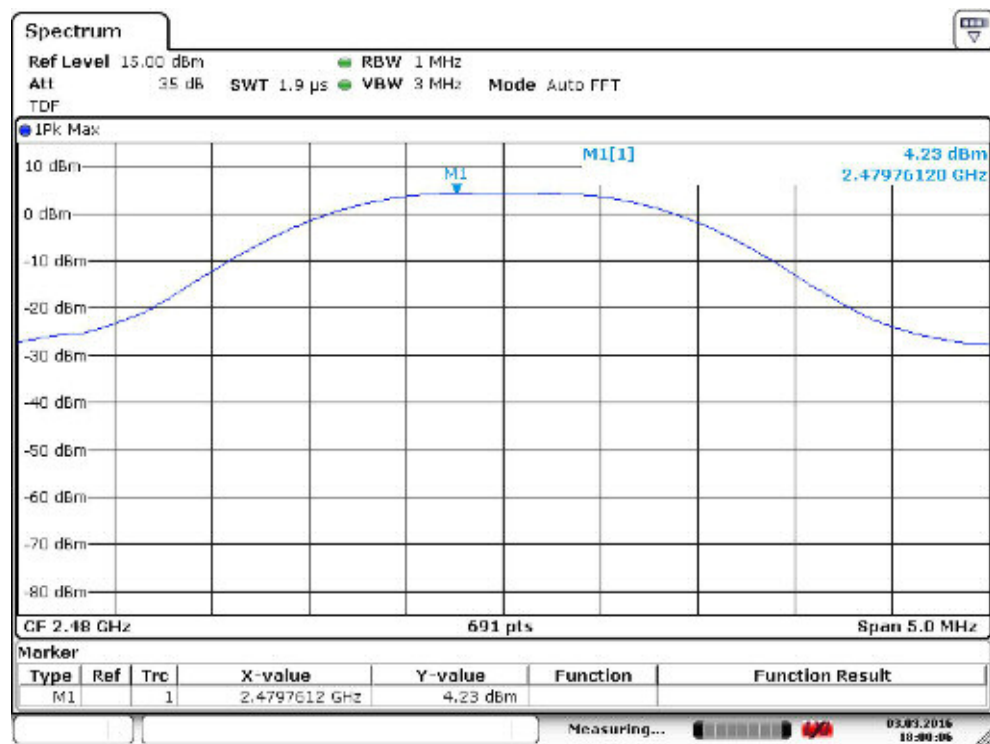


Figure 3. Maximum peak output power channel mid.

Maximum Peak Conducted Output Power



Date: 3.MAR.2016 18:00:06

Figure 4. Maximum peak output power channel high.

Transmitter Radiated Spurious Emissions 30 – 1000 MHz

Standard:	ANSI C63.10	(2013)
Tested by:	NKO	
Date:	29.9.2015 –	
	23.2.2016	
Humidity:	20 – 45 %	
Temperature:	21 – 25 °C	
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).
The QuasiPeak value is the measured value corrected with the correction factor.

Transmitter Radiated Spurious Emissions

Measured Peak Values In The Frequency Range 30 MHz - 1000 MHz.

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

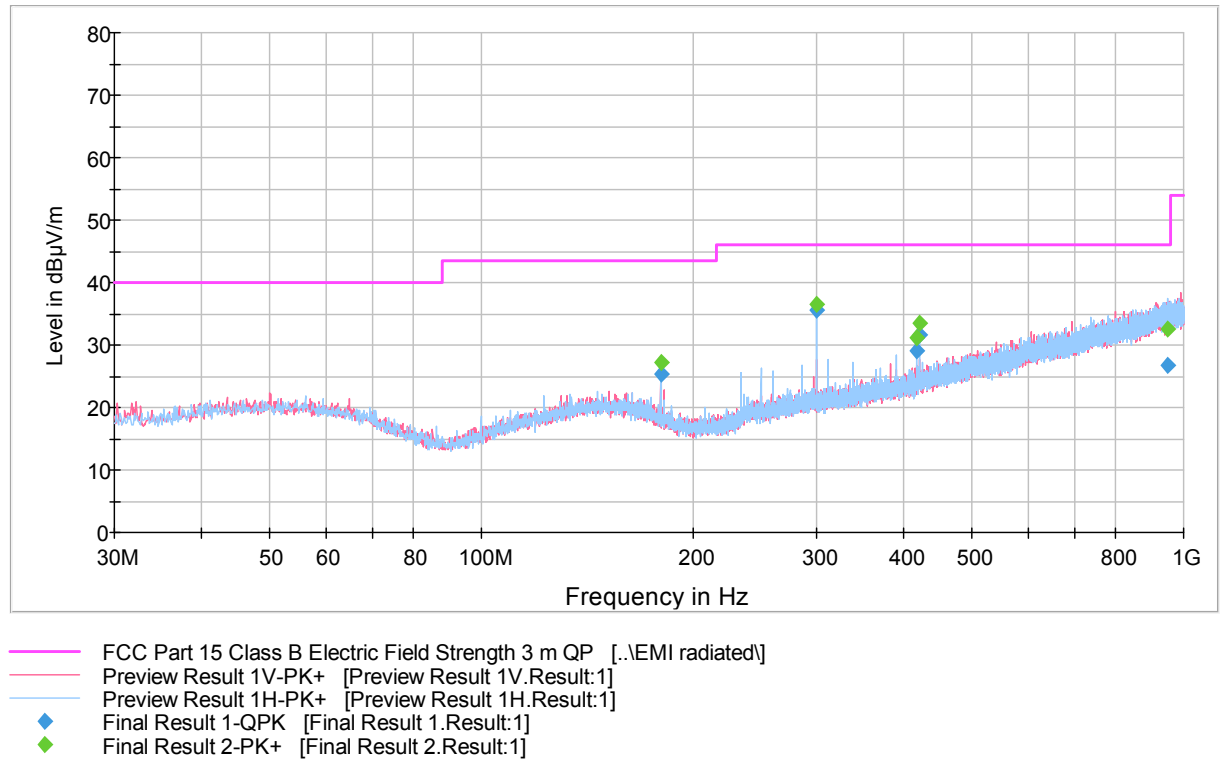


Figure 5. Radiated emissions with peak-detector channel low.

Final measurements from the worst frequencies

Table 3. Final measurements results from the worst frequencies channel low.

Frequency (MHz)	QuasiPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
180.002000	25.4	1000.0	120.000	100.0	V	0.0	13.0	18.1	43.5	
300.008000	35.6	1000.0	120.000	100.0	H	115.0	15.3	10.4	46.0	
416.020000	29.1	1000.0	120.000	100.0	H	212.0	18.3	16.9	46.0	
420.017000	31.7	1000.0	120.000	100.0	H	210.0	18.4	14.3	46.0	
948.196000	26.8	1000.0	120.000	400.0	H	329.0	27.8	19.2	46.0	

Transmitter Radiated Spurious Emissions

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

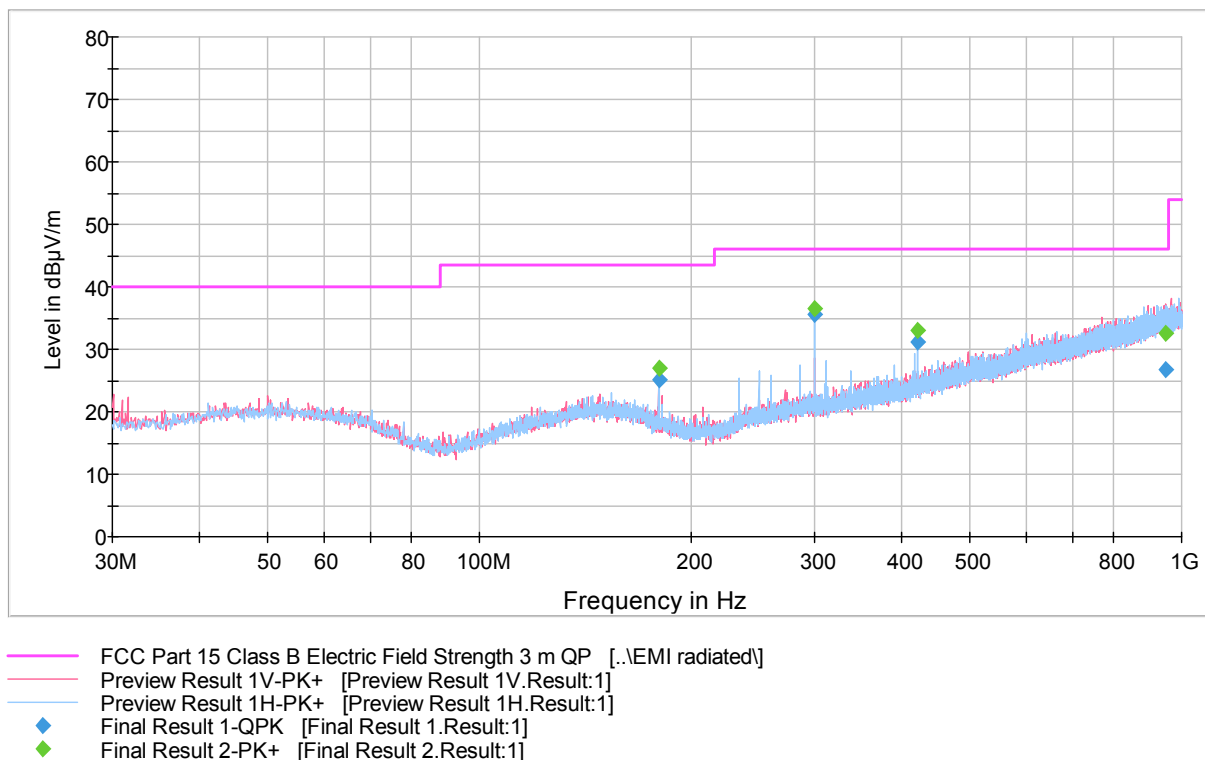


Figure 6. Radiated emissions with peak-detector channel mid.

Final measurements from the worst frequencies

Table 4. Final measurements results from the worst frequencies channel mid.

Frequency (MHz)	QuasiPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
180.022000	25.1	1000.0	120.000	100.0	V	0.0	13.0	18.4	43.5	
300.008000	35.5	1000.0	120.000	100.0	H	115.0	15.3	10.5	46.0	
420.017000	31.2	1000.0	120.000	100.0	H	207.0	18.4	14.8	46.0	
947.517000	26.8	1000.0	120.000	150.0	V	125.0	27.7	19.2	46.0	

Transmitter Radiated Spurious Emissions

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

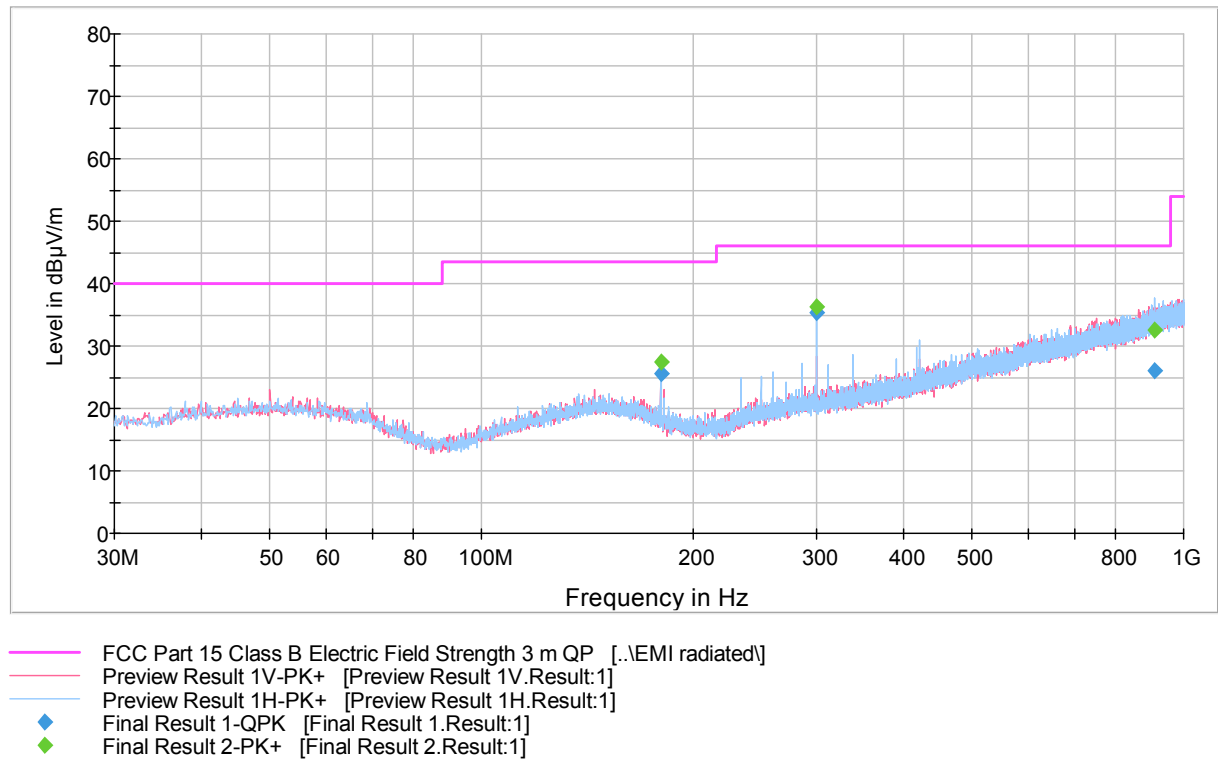


Figure 7. Radiated emissions with peak-detector channel mid..

Final measurements from the worst frequencies

Table 5. Final measurements results from the worst frequencies channel high.

Frequency (MHz)	QuasiPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
180.022000	25.7	1000.0	120.000	100.0	V	49.0	13.0	17.8	43.5	
300.011000	35.3	1000.0	120.000	100.0	H	114.0	15.3	10.7	46.0	
908.115000	26.1	1000.0	120.000	214.0	H	331.0	27.2	19.9	46.0	

Transmitter Radiated Spurious Emissions

Transmitter Radiated Spurious Emissions 1 000 – 26 500 MHz

Measured Peak and Average Values In The Frequency Range 1 000 MHz – 4 000 MHz.

The correction factor in the final result tables contains the sum of the transducers (antenna + amplifier + cables).
The Max Peak and Average values are measured values corrected with the correction factor.

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

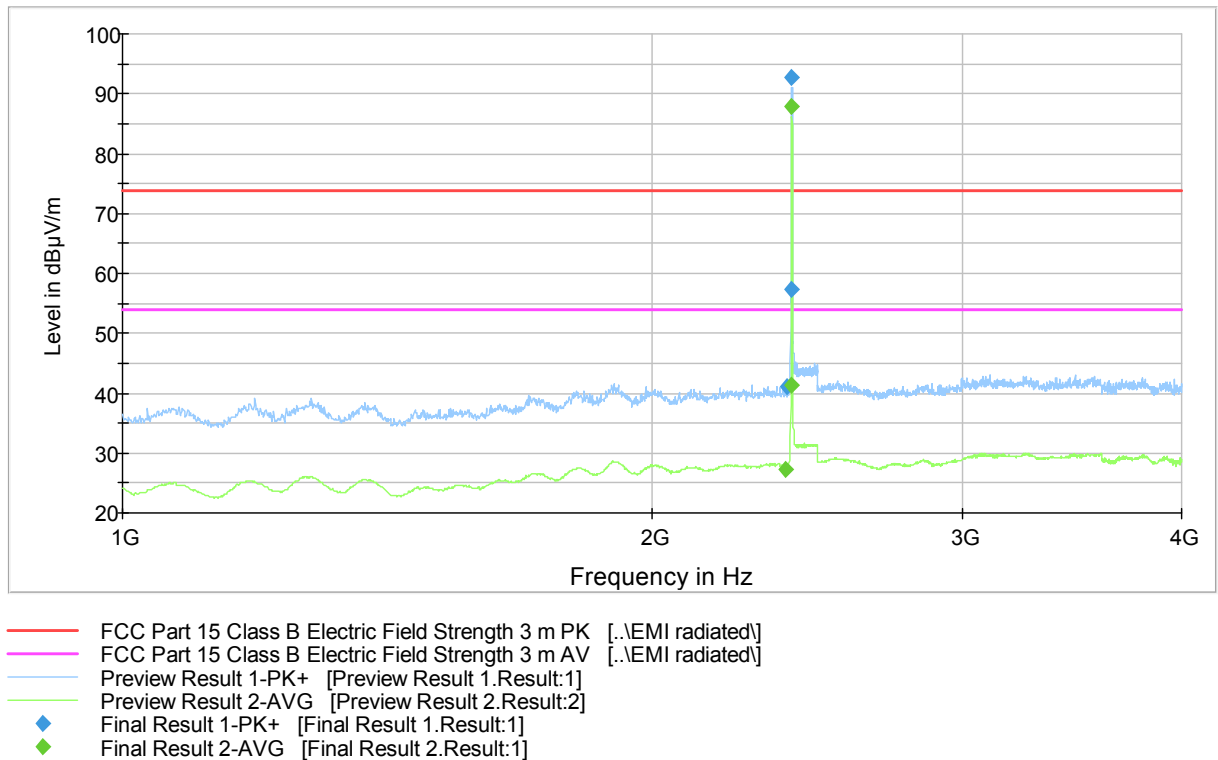


Figure 8. Radiated emissions measured with peak- and average detector channel low.

Final measurements from the worst frequencies

Table 6. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)	Comment
2384.600000	41.2	1000.0	1000.000	384.0	H	229.0	3.8	32.7	73.9	
2400.000000	57.4	1000.0	1000.000	150.0	H	232.0	3.9	16.5	73.9	
2402.000000	92.8	1000.0	1000.000	208.0	H	231.0	3.9	-18.9	73.9	Carrier

Table 7. Final Average results.

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)	Comment
2380.800000	27.4	1000.0	1000.000	255.0	H	213.0	3.7	26.5	53.9	
2400.000000	41.3	1000.0	1000.000	211.0	H	229.0	3.9	12.6	53.9	
2402.000000	87.9	1000.0	1000.000	231.0	H	231.0	3.9	-34.0	53.9	Carrier

Transmitter Radiated Spurious Emissions

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

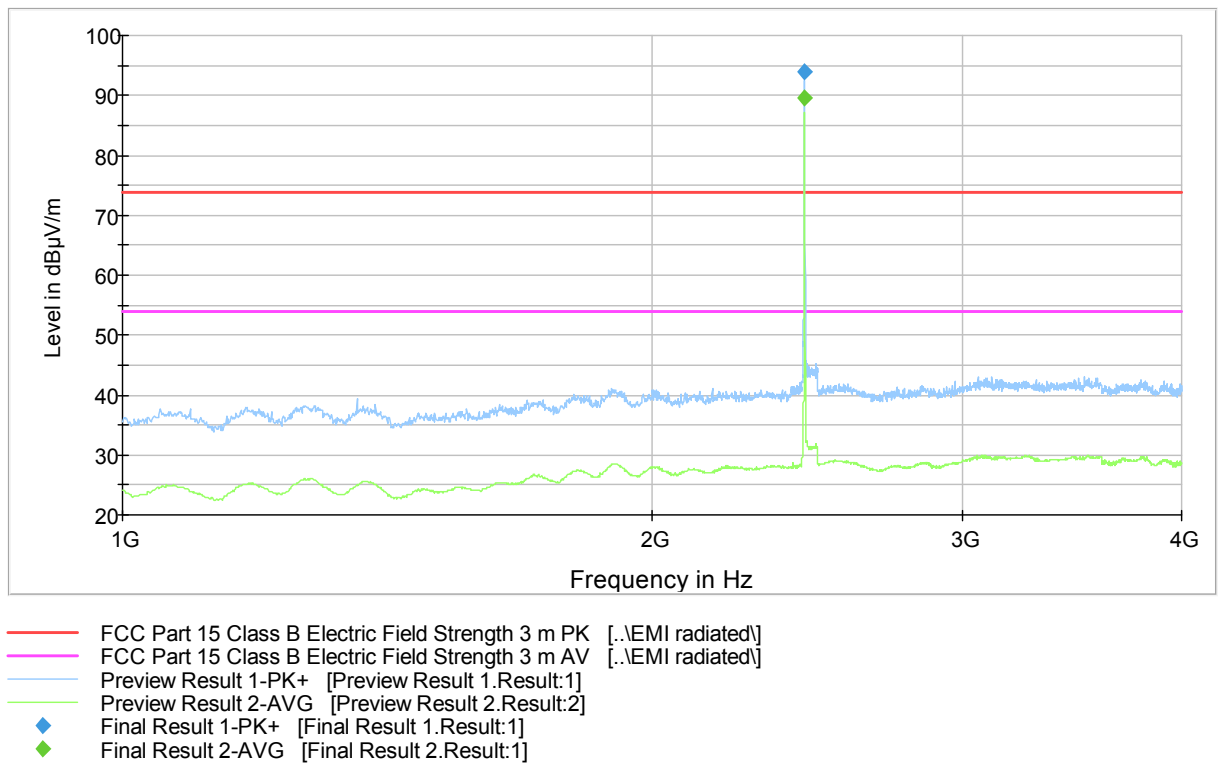


Figure 9. Radiated emissions measured with peak- and average detector channel mid.

Final measurements from the worst frequencies

Table 8. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
2441.750000	93.8	1000.0	1000.000	251.0	V	196.0	3.8	-19.9	73.9	Carrier

Table 9. Final Average results.

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
2442.000000	89.7	1000.0	1000.000	258.0	V	196.0	3.8	-35.8	53.9	Carrier

Transmitter Radiated Spurious Emissions

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

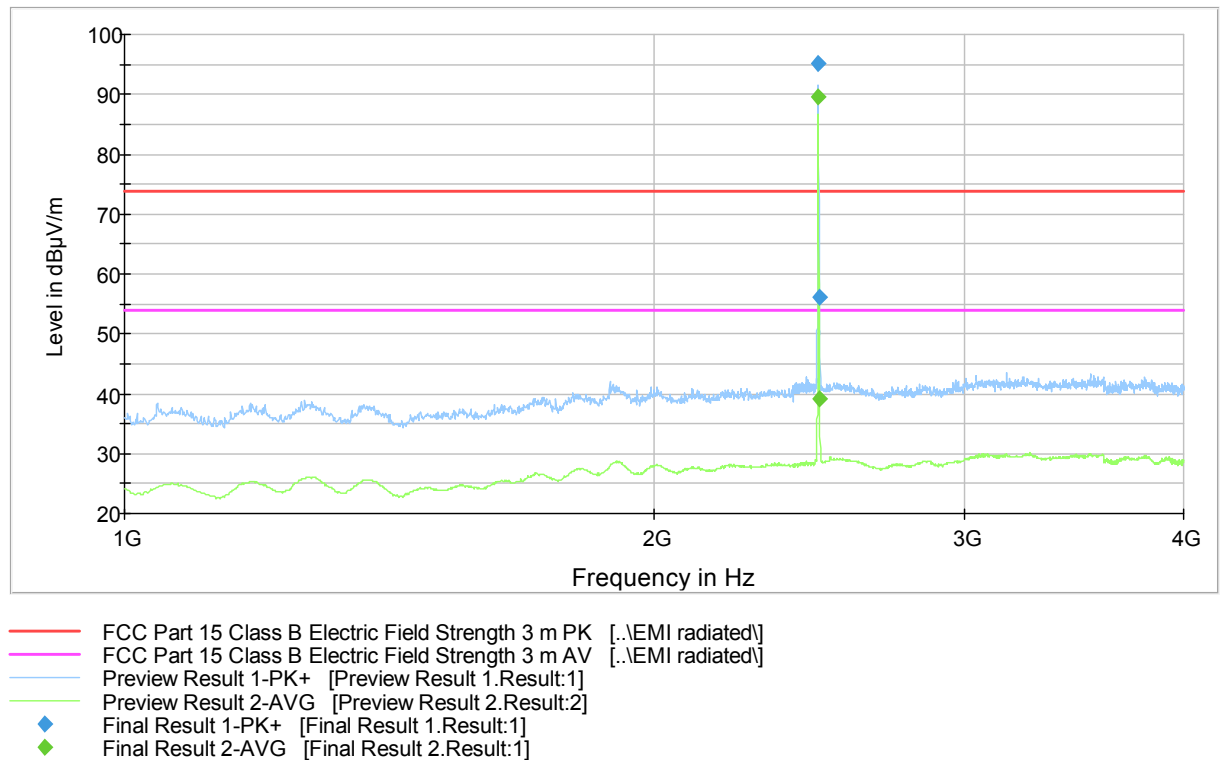


Figure 10. Radiated emissions measured with peak- and average detector channel high.

Final measurements from the worst frequencies

Table 10. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
2479.750000	95.1	1000.0	1000.000	232.0	H	268.0	4.2	-21.2	73.9	Carrier
2483.500000	56.2	1000.0	1000.000	272.0	V	200.0	4.2	17.7	73.9	

Table 11. Final Average results.

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
2480.000000	89.5	1000.0	1000.000	231.0	H	267.0	4.2	-35.6	53.9	Carrier
2483.500000	39.2	1000.0	1000.000	248.0	V	200.0	4.2	14.7	53.9	

Transmitter Radiated Spurious Emissions

Measured Peak and Average Values In The Frequency Range 4 000 MHz – 18 000 MHz

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

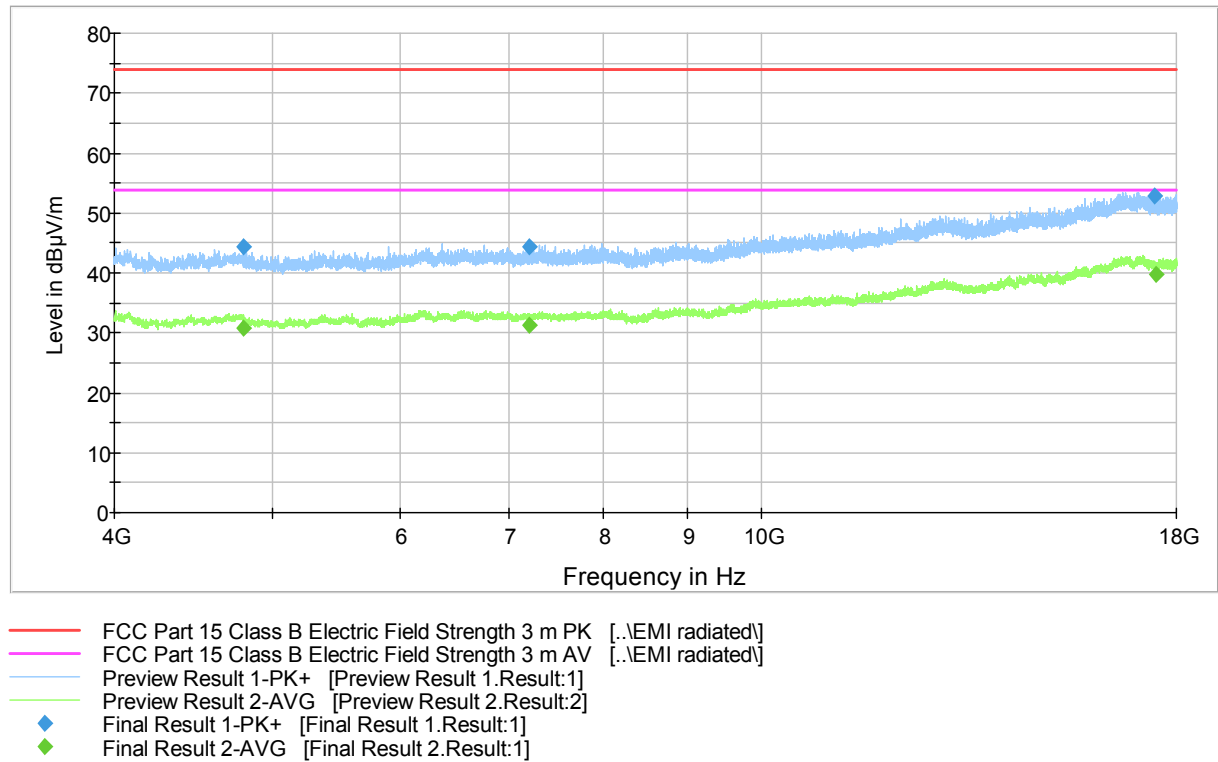


Figure 11. Radiated emissions measured with peak- and average detector channel low.

Final measurements from the worst frequencies

Table 12. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
4802.700000	44.2	1000.0	1000.000	361.0	H	3.0	10.0	29.7	73.9	
7201.900000	44.4	1000.0	1000.000	368.0	V	262.0	12.3	29.5	73.9	
17469.500000	52.9	1000.0	1000.000	344.0	V	313.0	25.3	21.0	73.9	

Table 13. Final Average results.

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
4804.100000	30.9	1000.0	1000.000	227.0	H	-4.0	10.0	23.0	53.9	
7205.700000	31.2	1000.0	1000.000	210.0	V	256.0	12.3	22.7	53.9	
17474.500000	39.7	1000.0	1000.000	248.0	V	302.0	25.3	14.2	53.9	

Transmitter Radiated Spurious Emissions

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

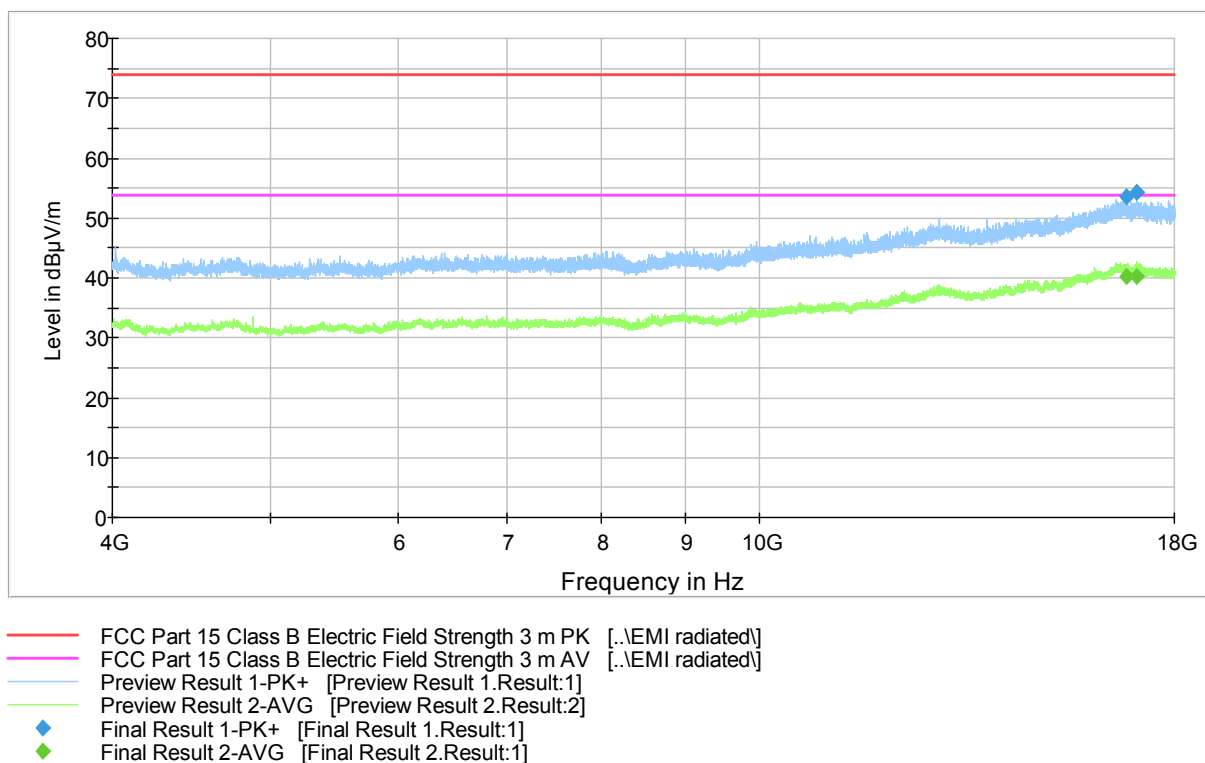


Figure 12. Radiated emissions measured with peak- and average detector channel mid.

Final measurements from the worst frequencies

Table 14. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
16803.400000	53.6	1000.0	1000.000	130.0	H	68.0	25.5	20.3	73.9	
17061.500000	54.3	1000.0	1000.000	226.0	H	64.0	25.8	19.6	73.9	

Table 15. Final Average results.

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
16806.200000	40.2	1000.0	1000.000	218.0	H	56.0	25.5	13.7	53.9	
17063.800000	40.2	1000.0	1000.000	256.0	V	9.0	25.8	13.7	53.9	

Transmitter Radiated Spurious Emissions

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

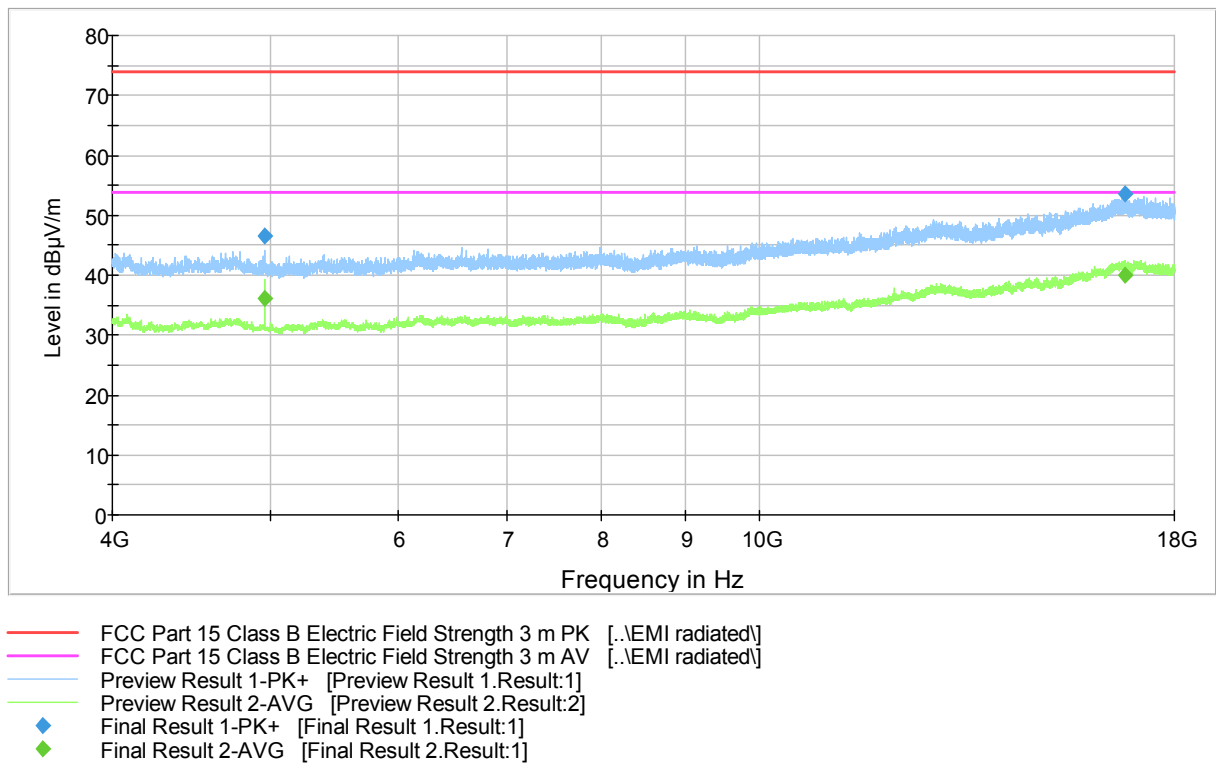


Figure 13. Radiated emissions measured with peak- and average detector channel high.

Final measurements from the worst frequencies

Table 16. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
4960.000000	46.5	1000.0	1000.000	100.0	H	65.0	9.9	27.4	73.9	
16769.300000	53.5	1000.0	1000.000	264.0	H	166.0	25.5	20.4	73.9	

Table 17. Final Average results.

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
4959.900000	36.2	1000.0	1000.000	146.0	H	340.0	9.9	17.7	53.9	
16794.100000	40.0	1000.0	1000.000	264.0	H	136.0	25.5	13.9	53.9	

Transmitter Radiated Spurious Emissions

Measured Peak and Average Values In The Frequency Range 18 000 MHz – 26 500 MHz.

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

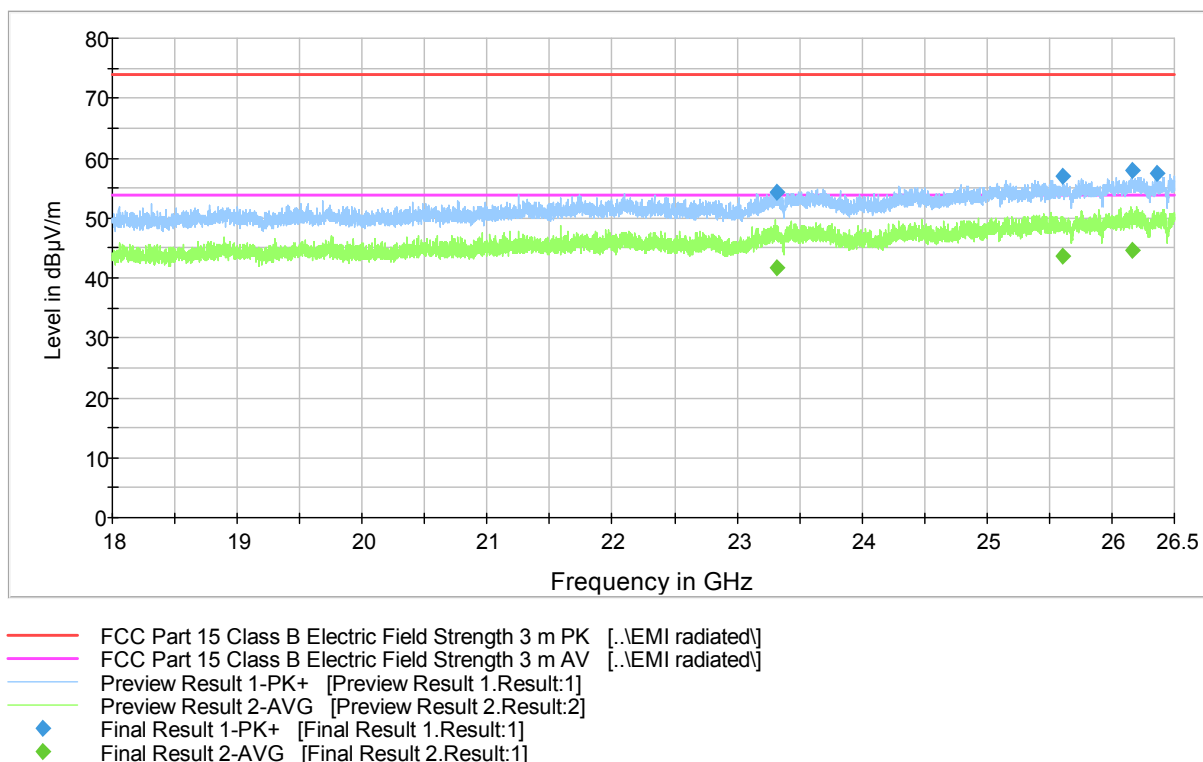


Figure 14. Radiated emissions measured with peak- and average detector channel low.

Final measurements from the worst frequencies

Table 18. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
23316.500000	54.2	1000.0	1000.000	137.0	H	80.0	31.6	19.7	73.9	
25600.450000	56.9	1000.0	1000.000	229.0	V	213.0	34.3	17.0	73.9	
26163.050000	58.0	1000.0	1000.000	155.0	H	41.0	35.2	15.9	73.9	
26361.500000	57.5	1000.0	1000.000	295.0	H	20.0	35.6	16.4	73.9	

Table 19. Final Average results.

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
23313.900000	41.8	1000.0	1000.000	153.0	H	100.0	31.6	12.1	53.9	
25602.450000	43.7	1000.0	1000.000	145.0	V	201.0	34.3	10.2	53.9	
26160.800000	44.7	1000.0	1000.000	149.0	H	30.0	35.2	9.2	53.9	
26164.250000	44.5	1000.0	1000.000	150.0	H	49.0	35.2	9.4	53.9	

Transmitter Radiated Spurious Emissions

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

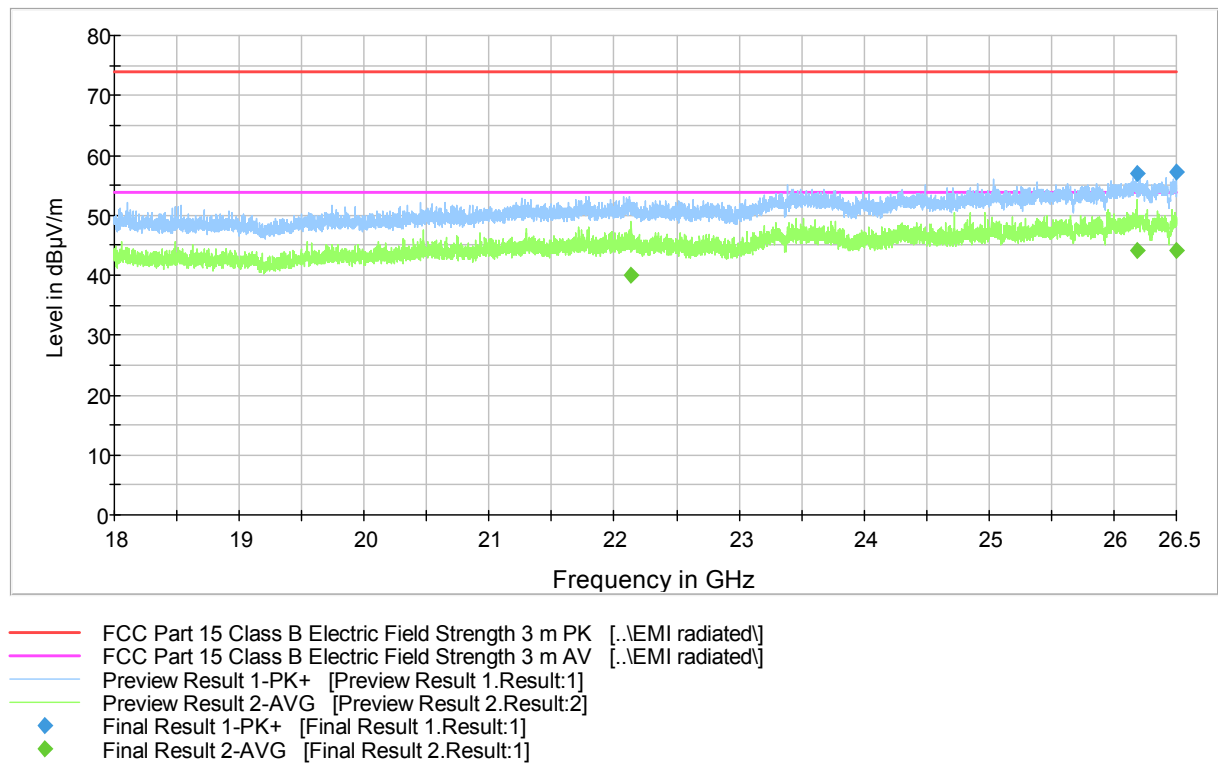


Figure 15. Measured curve with peak- and average detector channel mid.

Final measurements from the worst frequencies

Table 20. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)	Comment
26189.200000	56.9	1000.0	1000.000	381.0	H	339.0	35.3	17.0	73.9	
26499.300000	57.2	1000.0	1000.000	377.0	H	151.0	35.8	16.7	73.9	

Table 21. Final Average results.

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)	Comment
22135.300000	40.1	1000.0	1000.000	386.0	H	227.0	28.9	13.8	53.9	
26184.000000	44.1	1000.0	1000.000	150.0	H	3.0	35.3	9.8	53.9	
26496.900000	44.1	1000.0	1000.000	150.0	H	120.0	35.8	9.8	53.9	

Transmitter Radiated Spurious Emissions

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

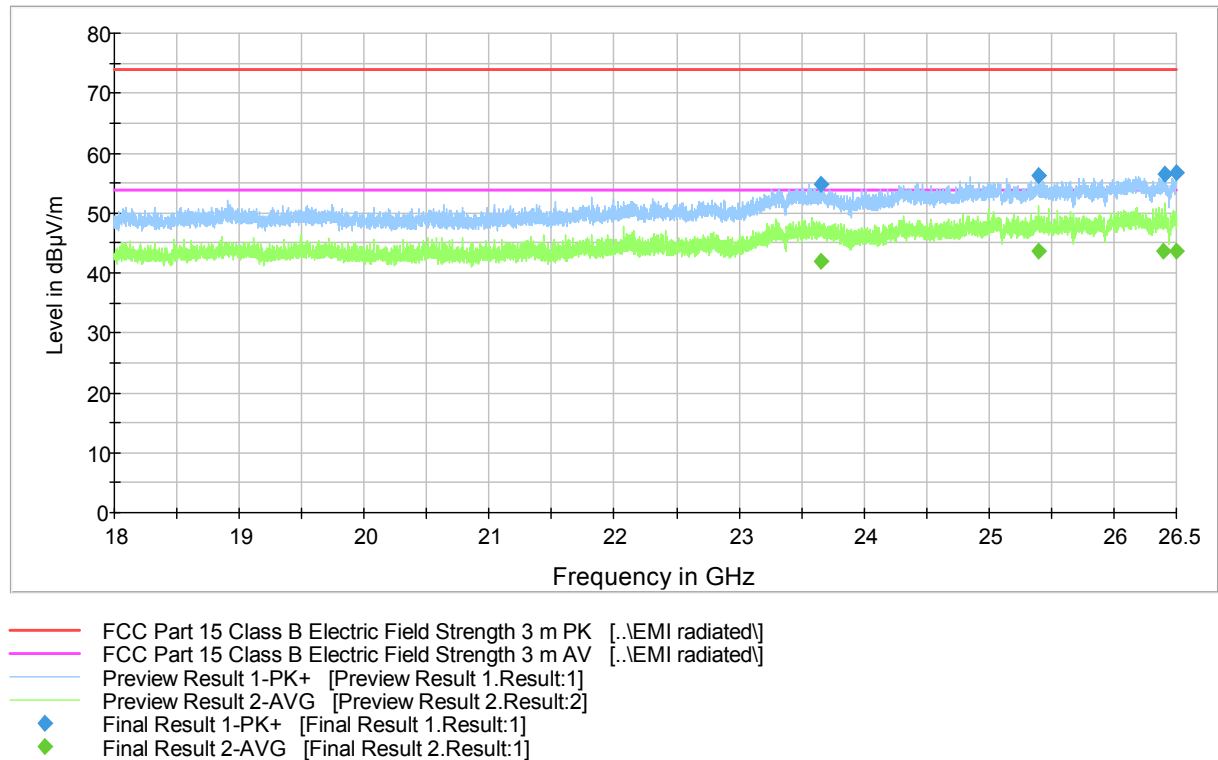


Figure 16. Radiated emissions measured with peak- and average detector channel high.

Final measurements from the worst frequencies

Table 22. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
23654.200000	54.9	1000.0	1000.000	400.0	H	127.0	31.9	19.0	73.9	
25397.000000	56.2	1000.0	1000.000	177.0	H	260.0	34.0	17.7	73.9	
26409.600000	56.5	1000.0	1000.000	232.0	V	266.0	35.8	17.4	73.9	
26495.300000	56.6	1000.0	1000.000	388.0	H	165.0	35.8	17.3	73.9	

Table 23. Final Average results.

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)	Comment
23657.600000	41.9	1000.0	1000.000	153.0	H	116.0	31.9	12.0	53.9	
25400.000000	43.6	1000.0	1000.000	304.0	H	225.0	34.0	10.3	53.9	
26400.800000	43.7	1000.0	1000.000	150.0	V	283.0	35.8	10.2	53.9	
26494.700000	43.7	1000.0	1000.000	100.0	H	147.0	35.8	10.2	53.9	

Transmitter Radiated Spurious Emissions

Radiated band edge measurement results

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

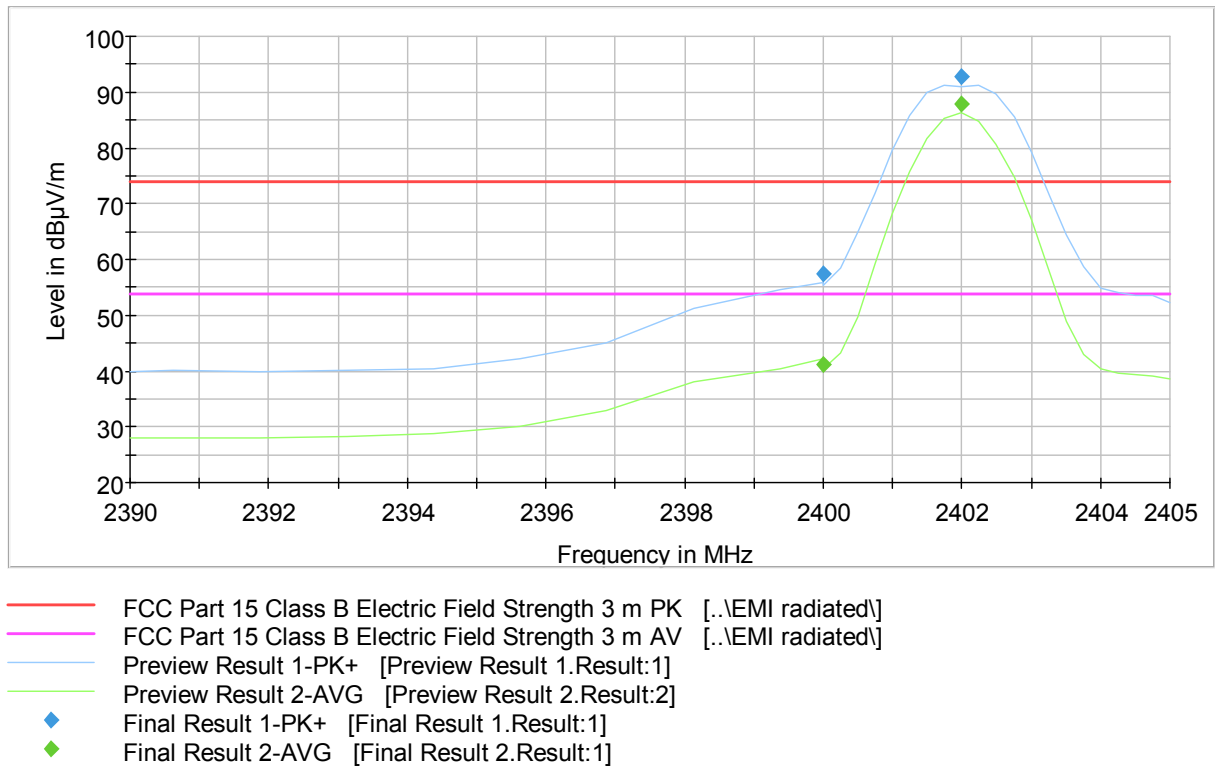


Figure 17. Radiated channel low band edge measured with peak- and average detector.

Final measurements from the worst frequencies

Table 24. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)	Comment
2384.600000	41.2	1000.0	1000.000	384.0	H	229.0	3.8	32.7	73.9	
2400.000000	57.4	1000.0	1000.000	150.0	H	232.0	3.9	16.5	73.9	
2402.000000	92.8	1000.0	1000.000	208.0	H	231.0	3.9	-18.9	73.9	Carrier

Table 25. Final Average results.

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)	Comment
2380.800000	27.4	1000.0	1000.000	255.0	H	213.0	3.7	26.5	53.9	
2400.000000	41.3	1000.0	1000.000	211.0	H	229.0	3.9	12.6	53.9	
2402.000000	87.9	1000.0	1000.000	231.0	H	231.0	3.9	-34.0	53.9	Carrier

Transmitter Radiated Spurious Emissions

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

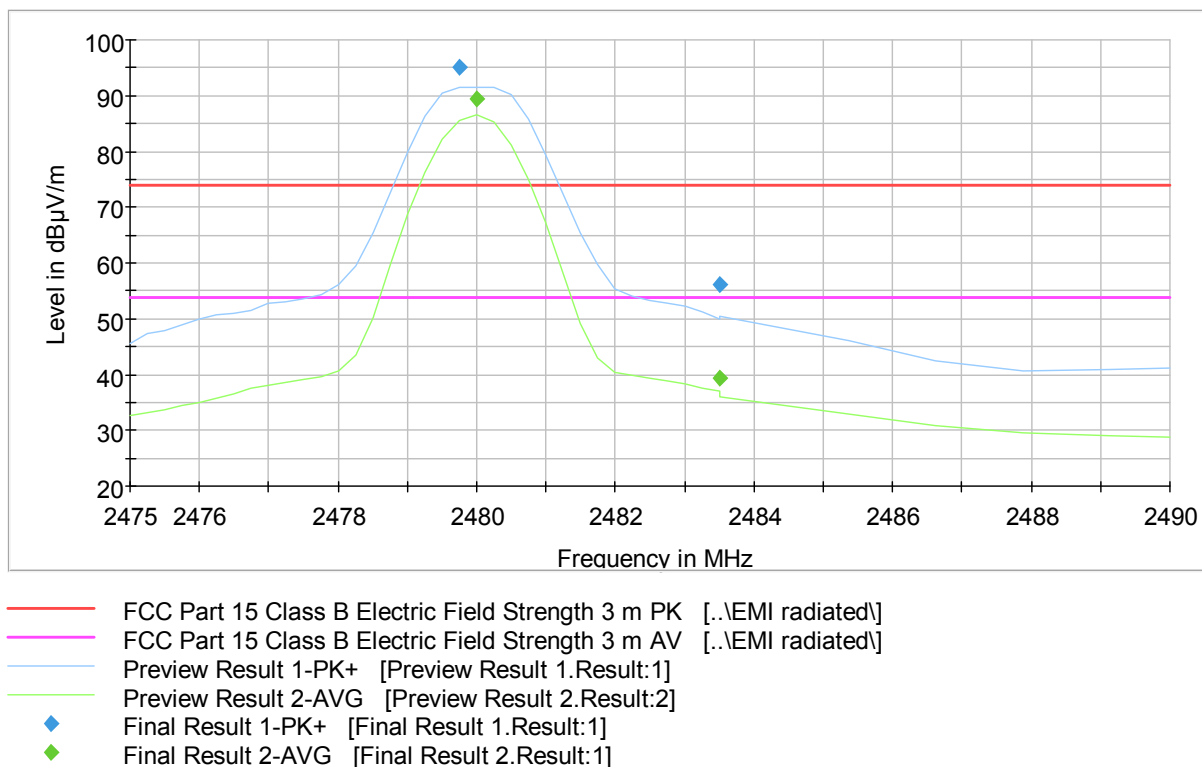


Figure 18. Radiated higher band edge measured with peak- and average detector.

Final measurements from the worst frequencies

Table 26. Final Max Peak results.

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)	Comment
2479.750000	95.1	1000.0	1000.000	232.0	H	268.0	4.2	-21.2	73.9	Carrier
2483.500000	56.2	1000.0	1000.000	272.0	V	200.0	4.2	17.7	73.9	

Table 27. Final Average results.

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)	Comment
2480.000000	89.5	1000.0	1000.000	231.0	H	267.0	4.2	-35.6	53.9	Carrier
2483.500000	39.2	1000.0	1000.000	248.0	V	200.0	4.2	14.7	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: NKO
Date: 3.3.2016
Humidity: 25 %
Temperature: 21 °C
Measurement uncertainty ± 2.87 dB Level of confidence 95 % (k = 2)

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

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

Table 28. Band edge attenuation.

Band Edge Attenuation	
Lower Band Edge	Upper Band Edge
-41.60 dBc	-38.18 dBc
Limit: -20dBc	

Table 29. Conducted spurious emissions.

Conducted Spurious Emissions					
Channel	Frequency	Measured Attenuation [dBm]	EIRP Limit [dBc]	Margin [dB]	Result
-	-	-	-20.0	-	-
-	-	-	-20.0	-	-
-	-	-	-20.0	-	-

No significant emissions were detected close to the limit.

Transmitter Band Edge Measurement and Conducted Spurious Emissions

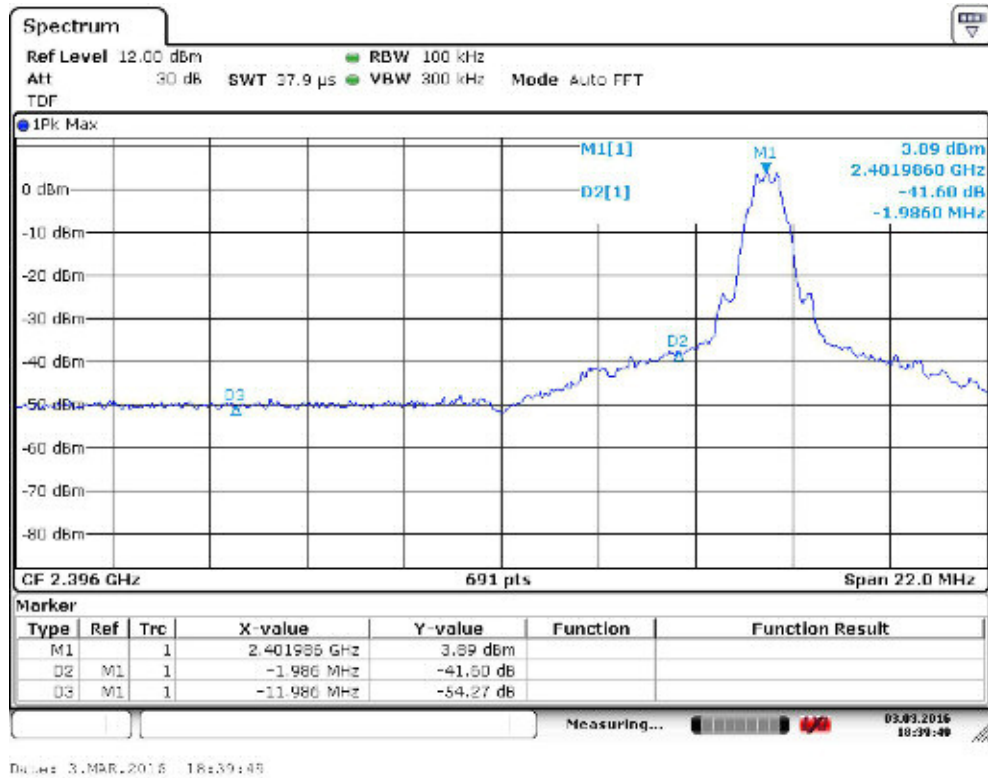


Figure 19. Lower Band Edge.

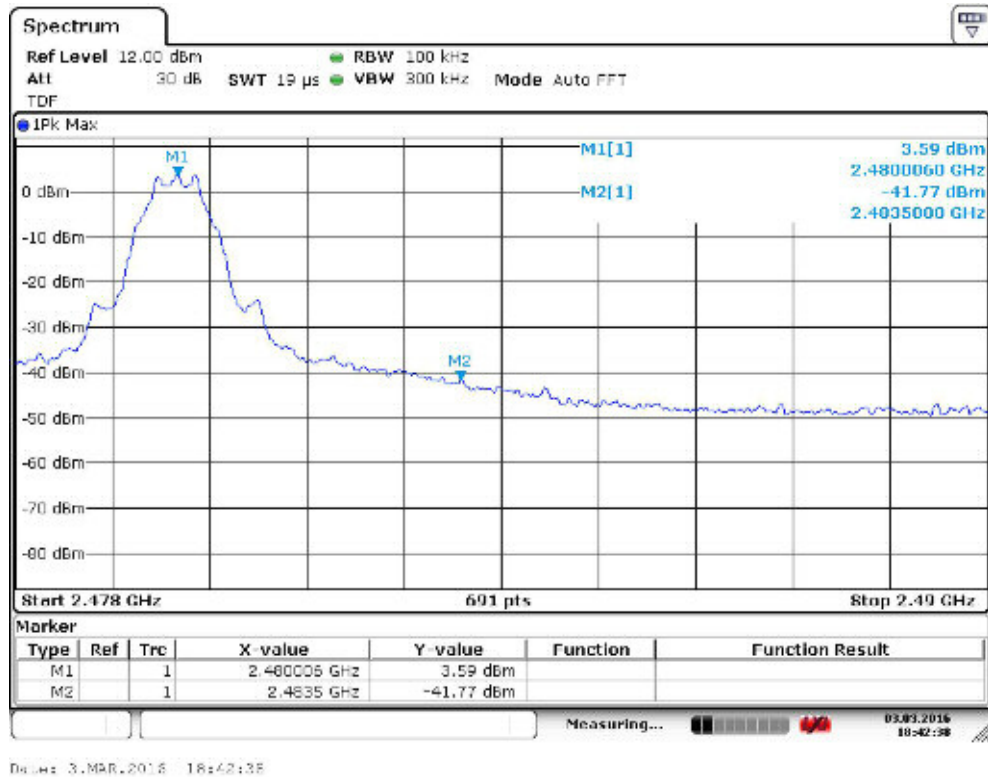


Figure 20. Upper Band Edge.

Transmitter Band Edge Measurement and Conducted Spurious Emissions

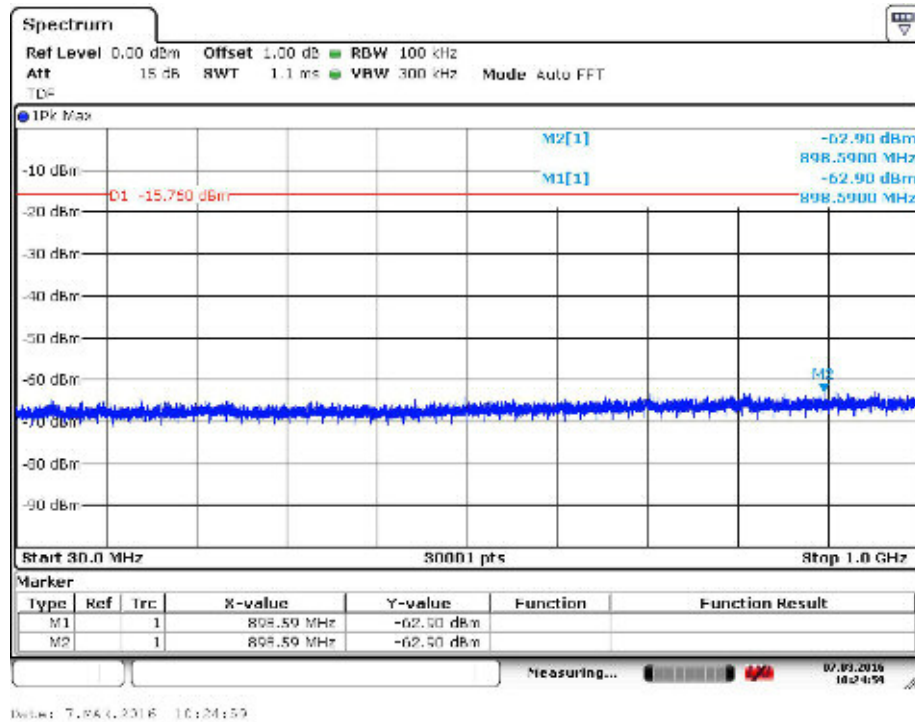


Figure 21. Conducted Spurious Emissions 30 – 1 000 MHz channel low.

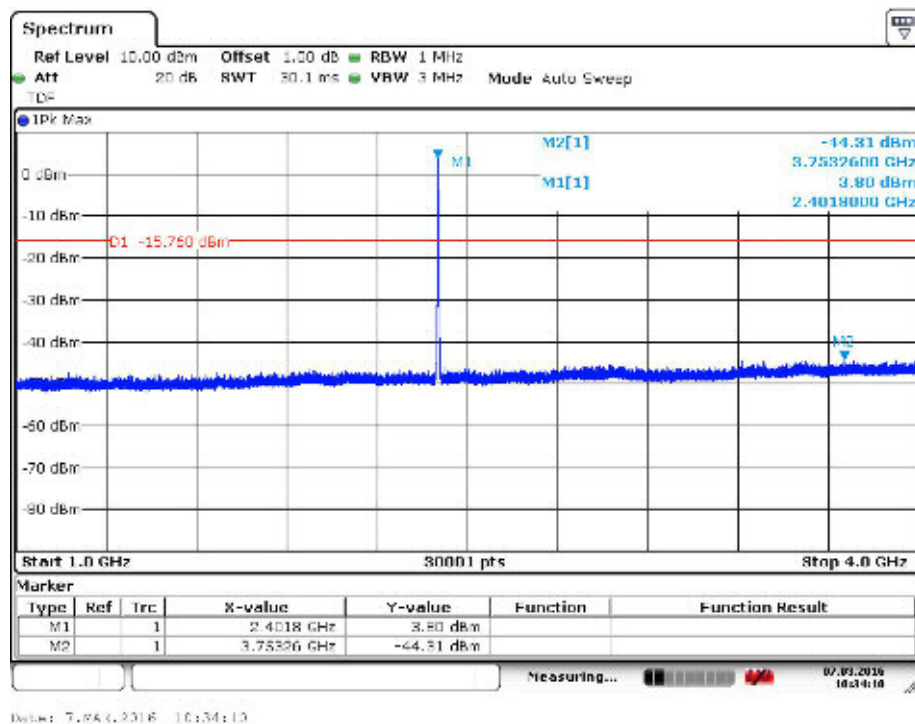


Figure 22. Conducted Spurious Emissions 1 000 – 4 000 MHz. Channel Low.

Transmitter Band Edge Measurement and Conducted Spurious Emissions

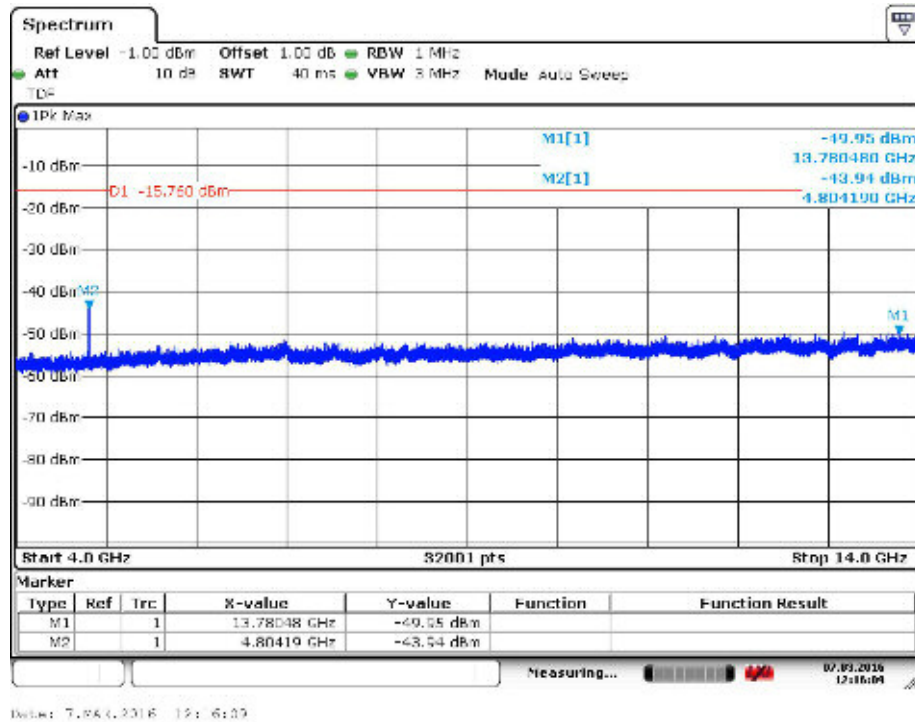


Figure 23. Conducted Spurious Emissions 4 000 – 14 000 MHz channel low.

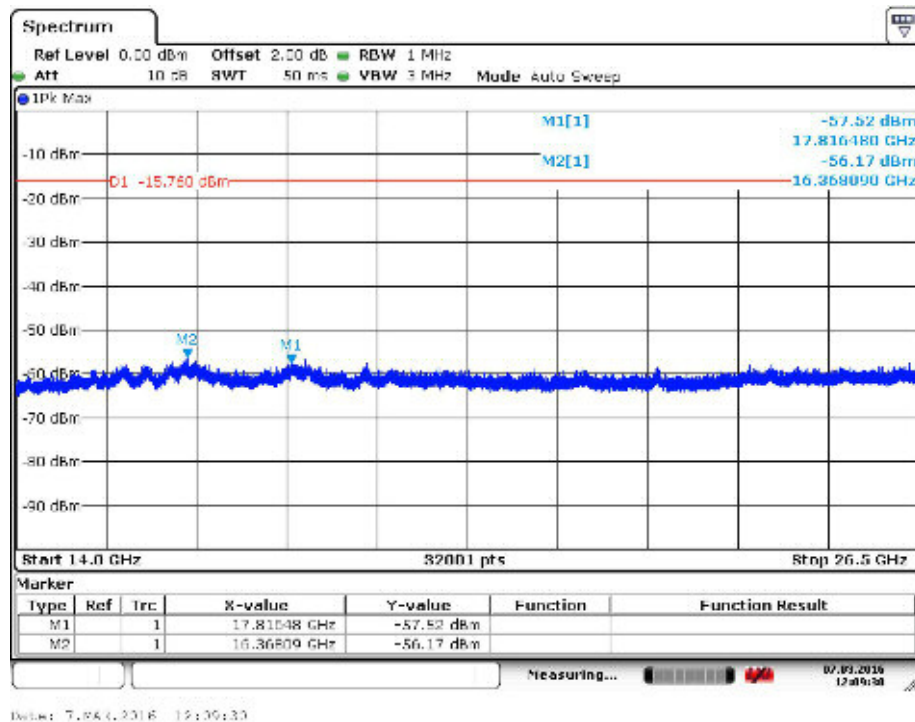


Figure 24. Conducted Spurious Emissions 14 000 – 26 500 MHz channel low.

Transmitter Band Edge Measurement and Conducted Spurious Emissions

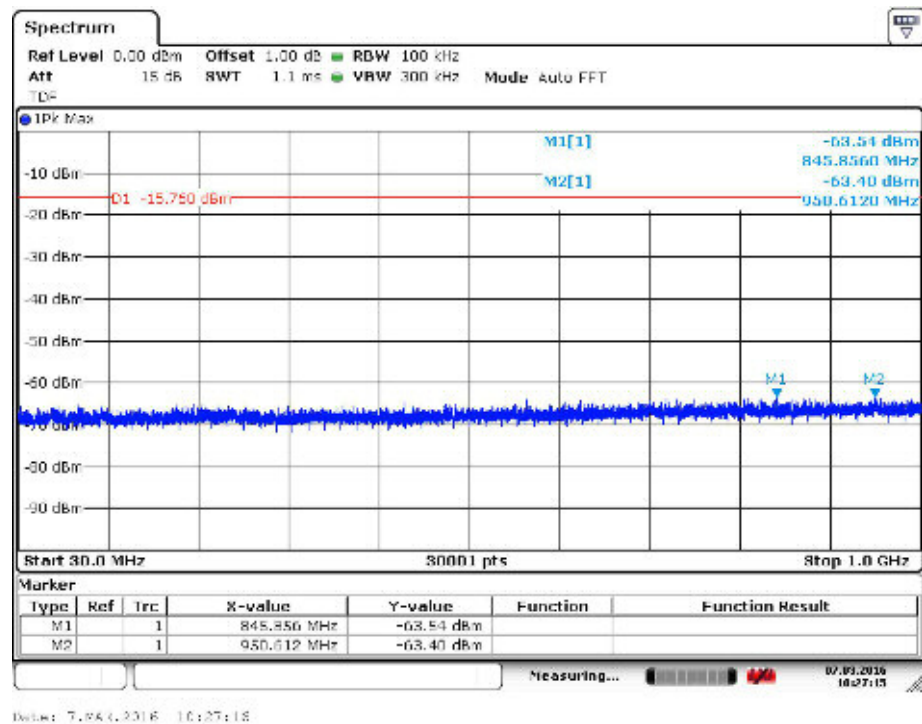


Figure 25. Conducted Spurious Emissions 30 – 1 000 MHz channel mid.

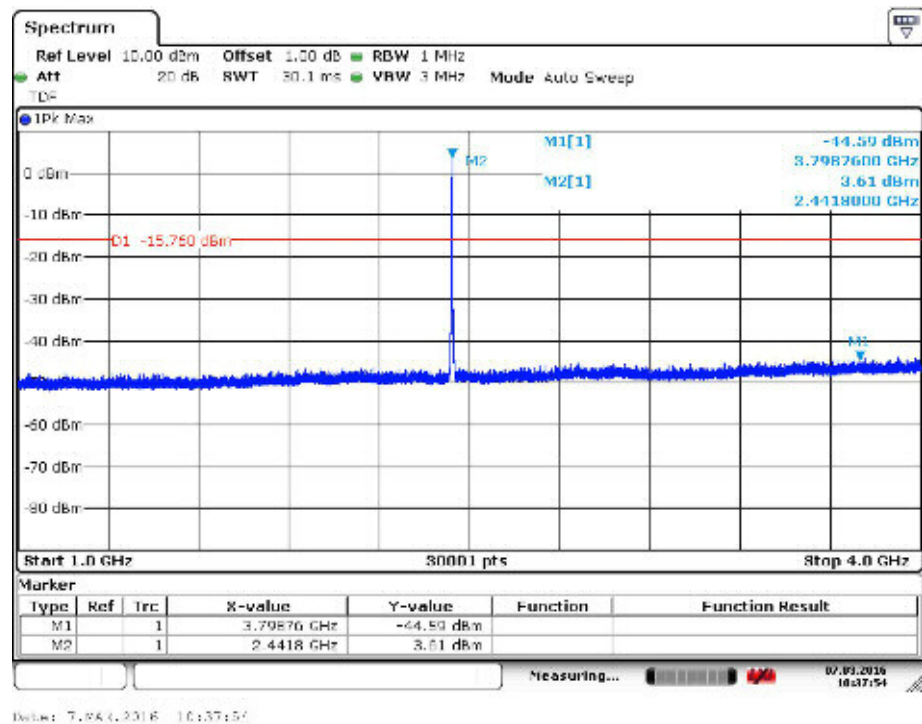


Figure 26. Conducted Spurious Emissions 1 000 – 4 000 MHz channel mid.

Transmitter Band Edge Measurement and Conducted Spurious Emissions

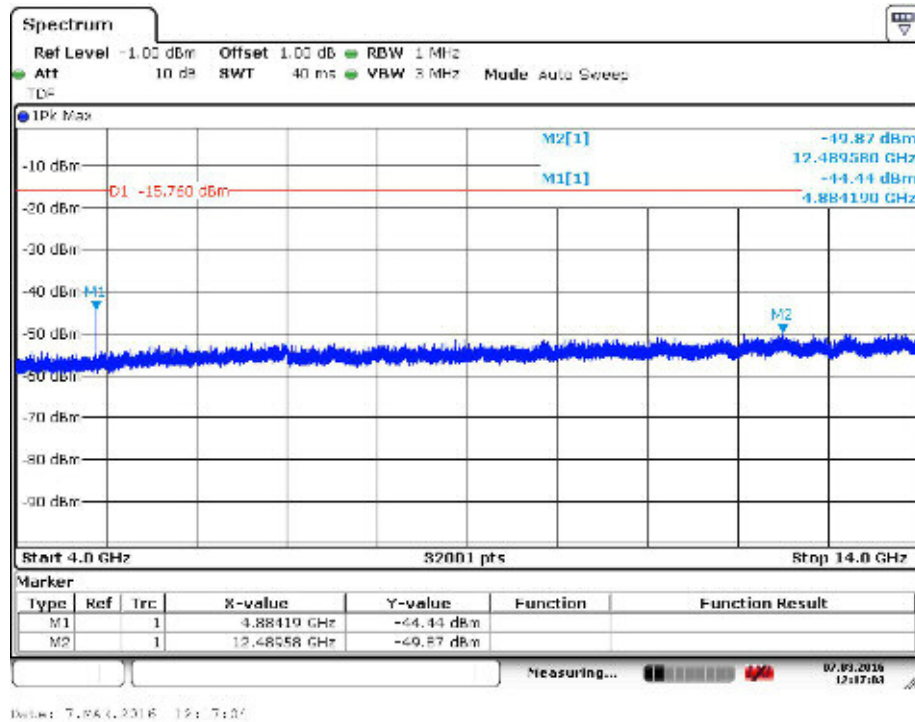


Figure 27. Conducted Spurious Emissions 4 000 – 14 000 MHz channel mid.

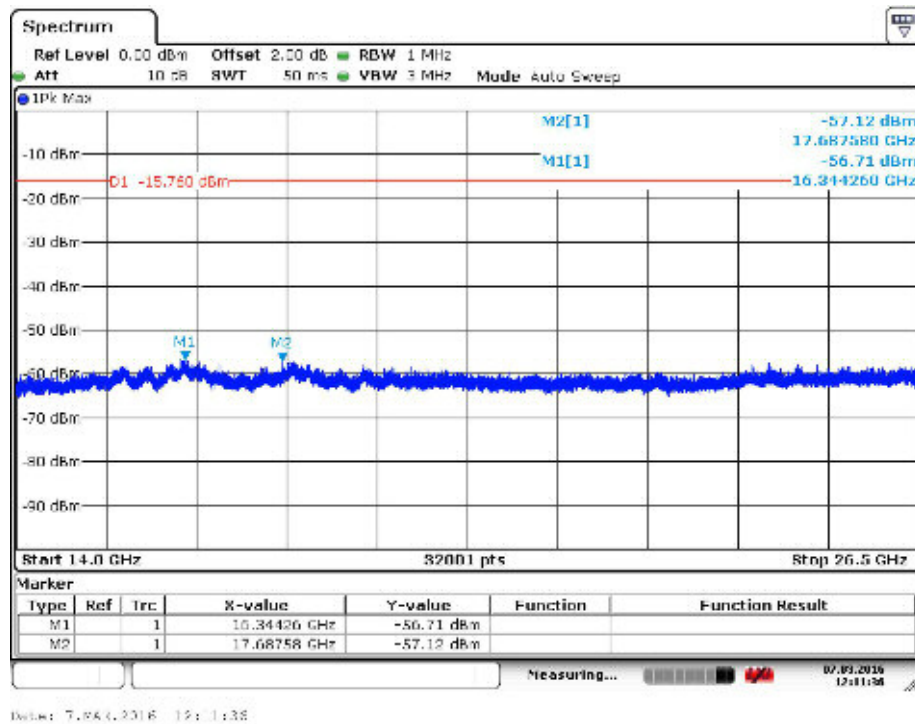


Figure 28. Conducted Spurious Emissions 14 000 – 26 500 MHz channel mid.

Transmitter Band Edge Measurement and Conducted Spurious Emissions

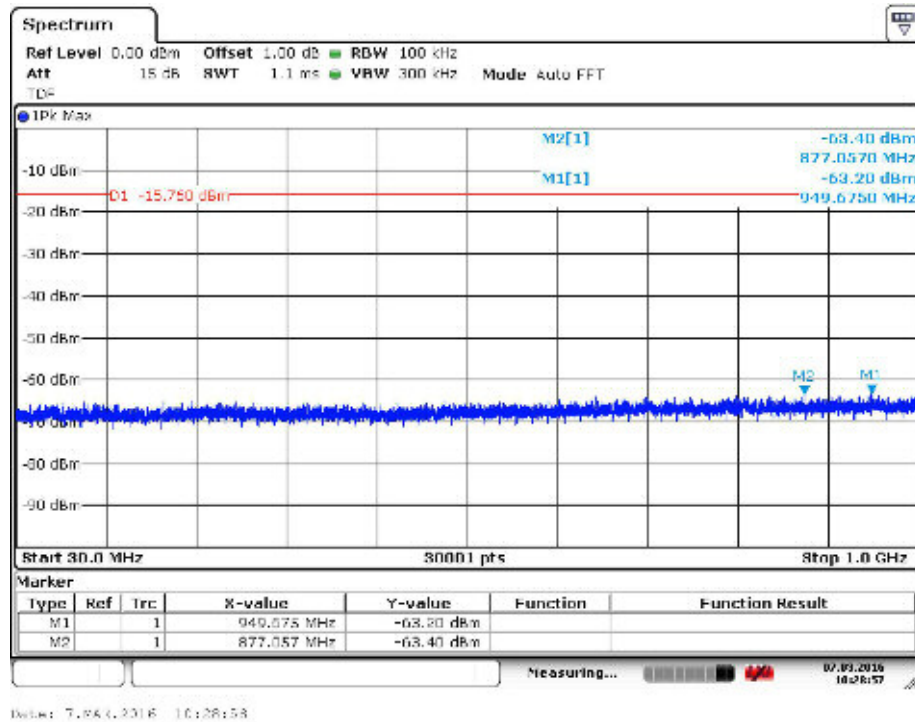


Figure 29. Conducted Spurious Emissions 30 – 1 000 MHz channel high.

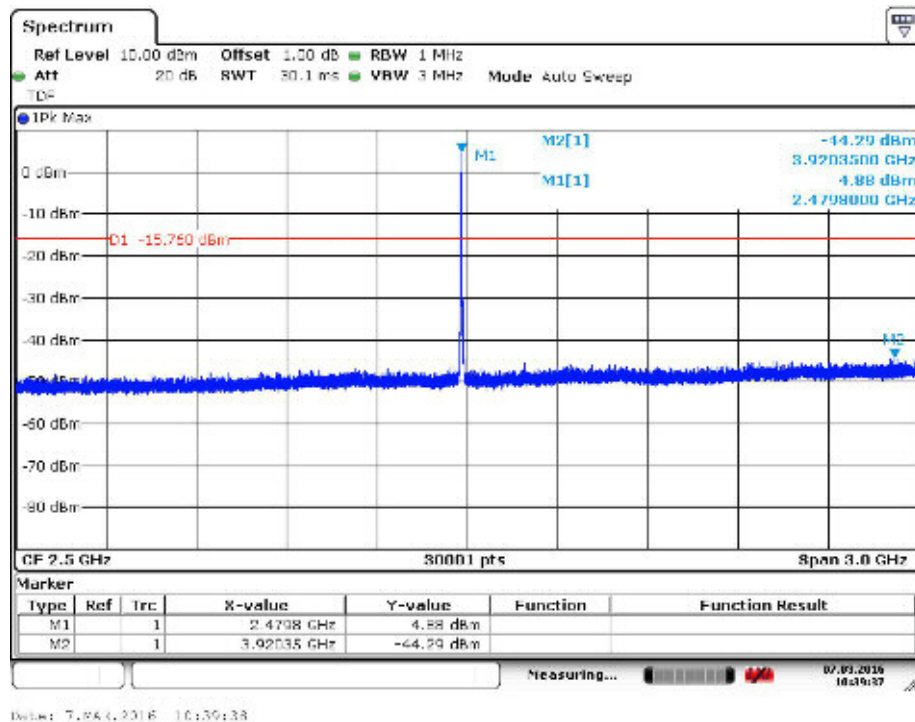


Figure 30. Conducted Spurious Emissions 1 000 – 4 000 MHz channel high.

Transmitter Band Edge Measurement and Conducted Spurious Emissions

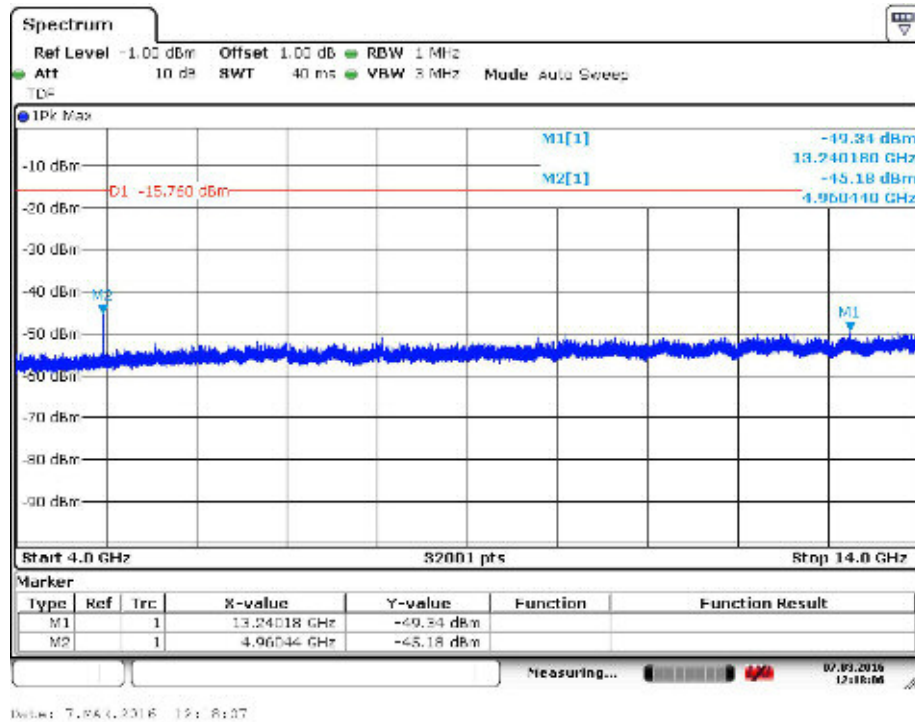


Figure 31. Conducted Spurious Emissions 4 000 – 14 000 MHz channel high.

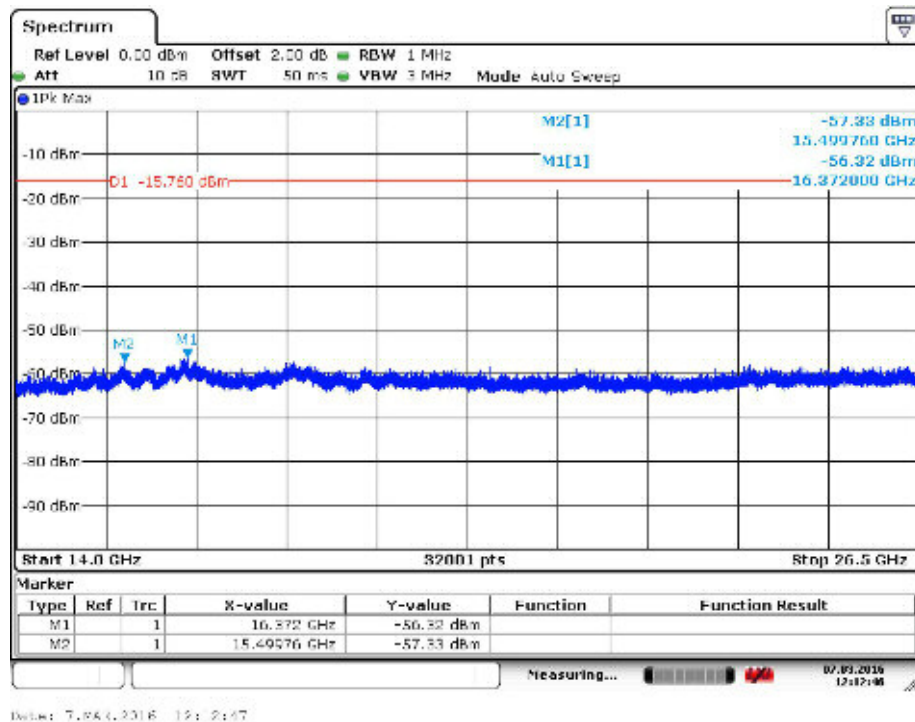


Figure 32. Conducted Spurious Emissions 14 000 – 26 500 MHz channel high.

6 dB Bandwidth of the Channel

Standard: ANSI C63.10 (2013)
Tested by: NKO
Date: 3.3.2016
Humidity: 25 %
Temperature: 21 °C

FCC Rule: 15.247(a)(2)
RSS-247 5.2(1)

Results:

Table 30. 6 dB bandwidth test results.

Channel	6 dB BW [kHz]	Minimum limit [kHz]
Low	680.20	500
Mid	672.90	
High	680.20	

6 dB Bandwidth of the Channel

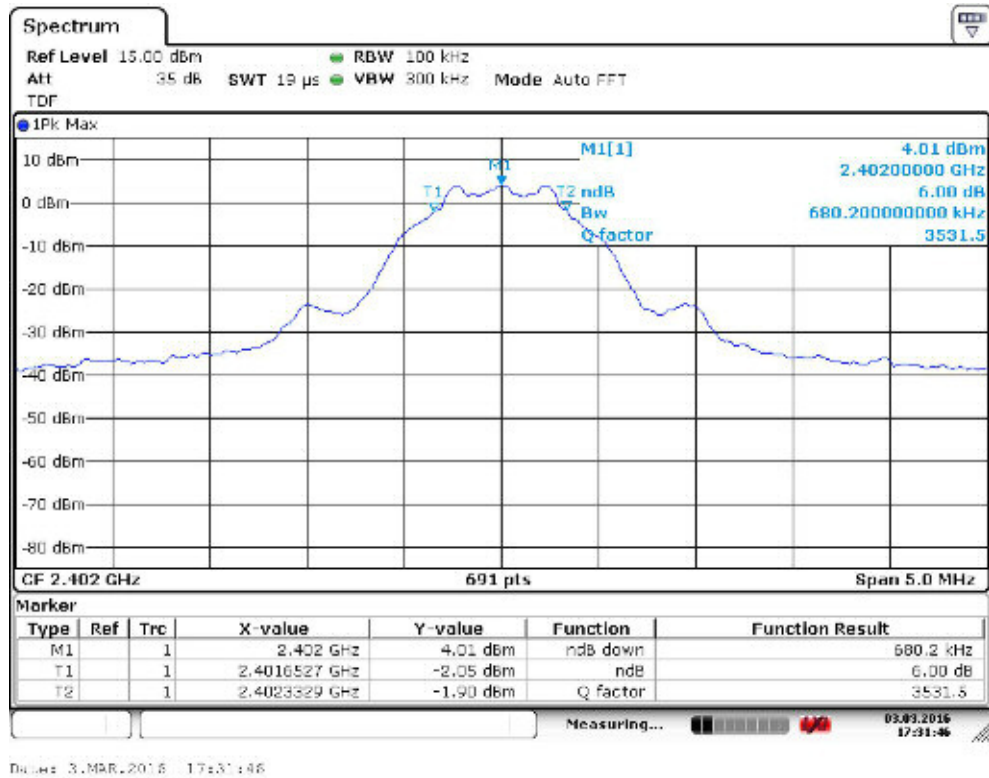


Figure 33. 6 dB bandwidth of the channel low.

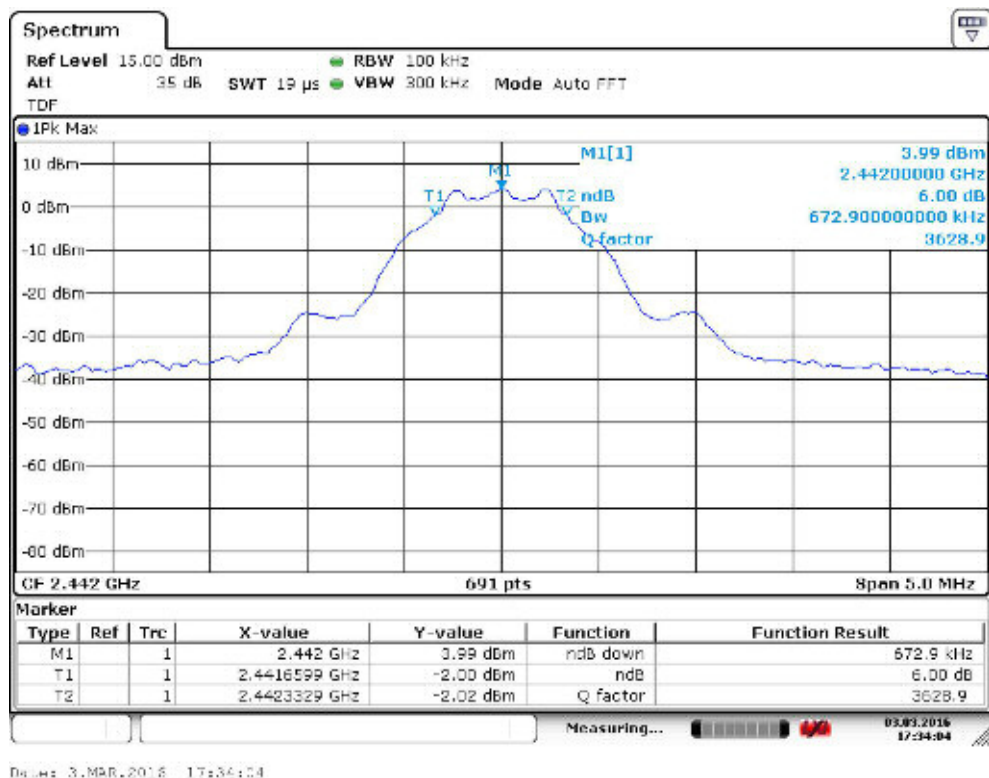


Figure 34. 6 dB bandwidth of the channel mid.

6 dB Bandwidth of the Channel

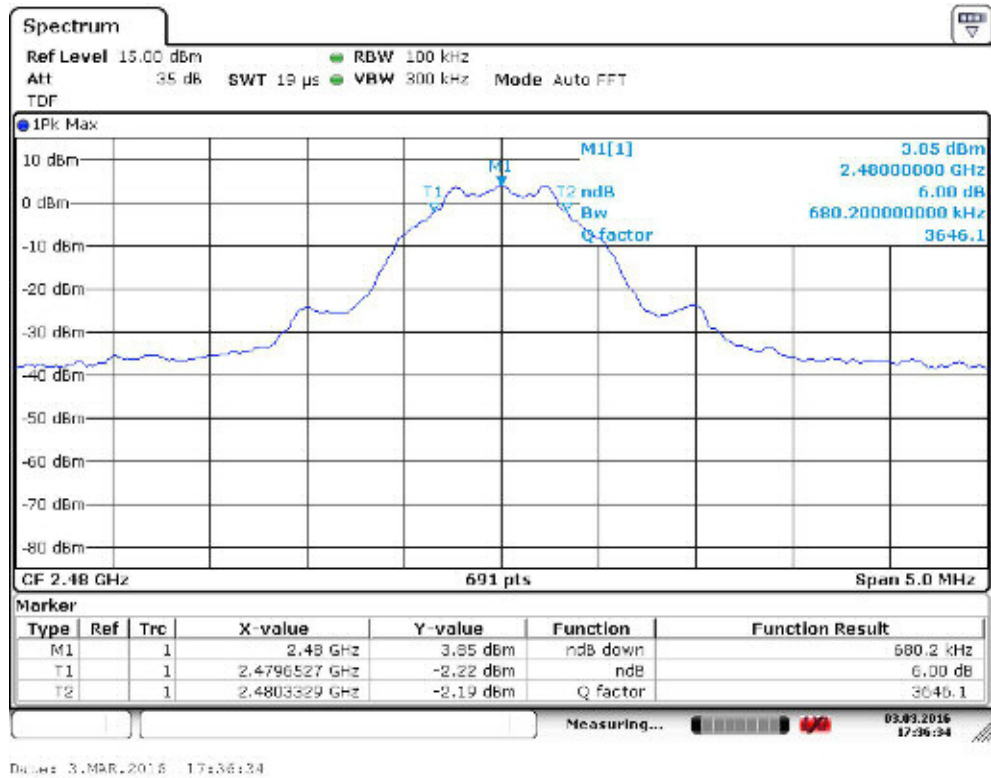


Figure 35. 6 dB bandwidth of the channel high.

Power Spectral Density

Standard: ANSI C63.10 (2013)
Tested by: NKO
Date: 3.3.2016
Humidity: 25 %
Temperature: 21 °C

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

Results:

Table 31. Power Spectral Density test results.

Channel	PSD dBm/10 kHz	Maximum limit [dBm/3kHz]
Low	-0.02	+8.00
Mid	-0.05	
High	-0.19	

Power Spectral Density

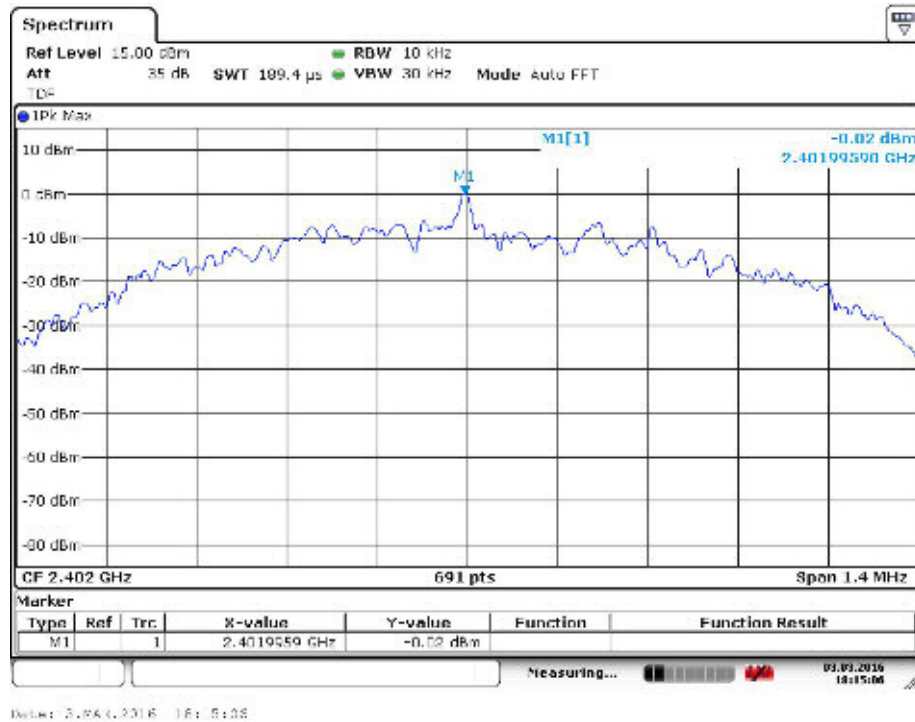


Figure 36. Power Spectral Density of the channel low.

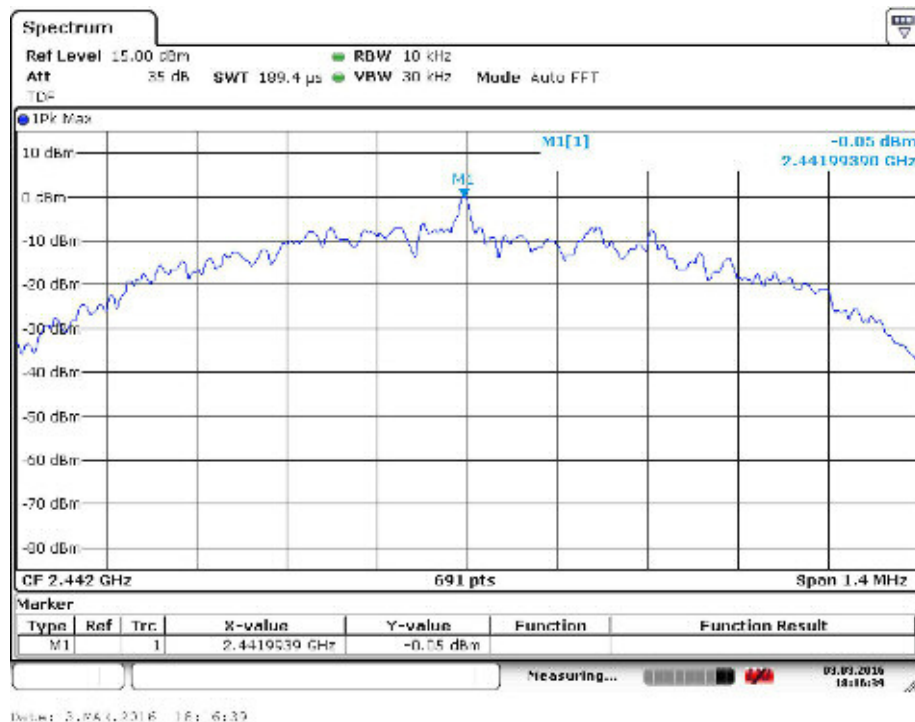


Figure 37. Power Spectral Density of the channel mid.

Power Spectral Density

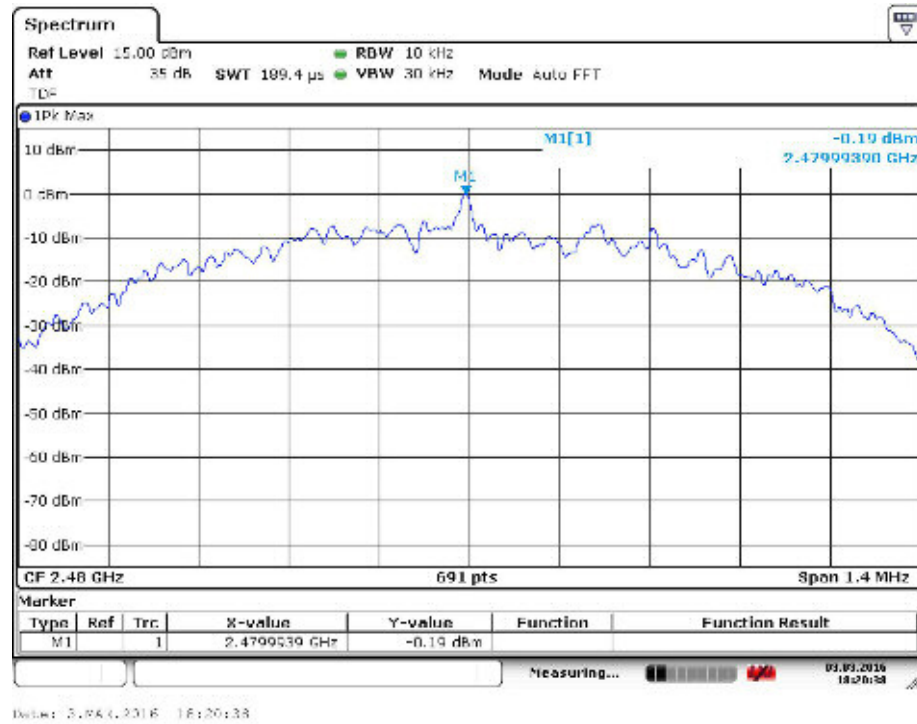


Figure 38. Power Spectral Density of the channel high.

99% Occupied Bandwidth

Standard: RSS-GEN (2014)
Tested by: NKO
Date: 3.3.2016
Humidity: 25 %
Temperature: 21 °C

RSS-GEN 6.6

Table 32. 99 % OBW test results.

Channel	Limit	99 % BW [MHz]	Result
Low	-	1.099855282	PASS
Mid	-	1.092619392	PASS
High	-	1.092619392	PASS

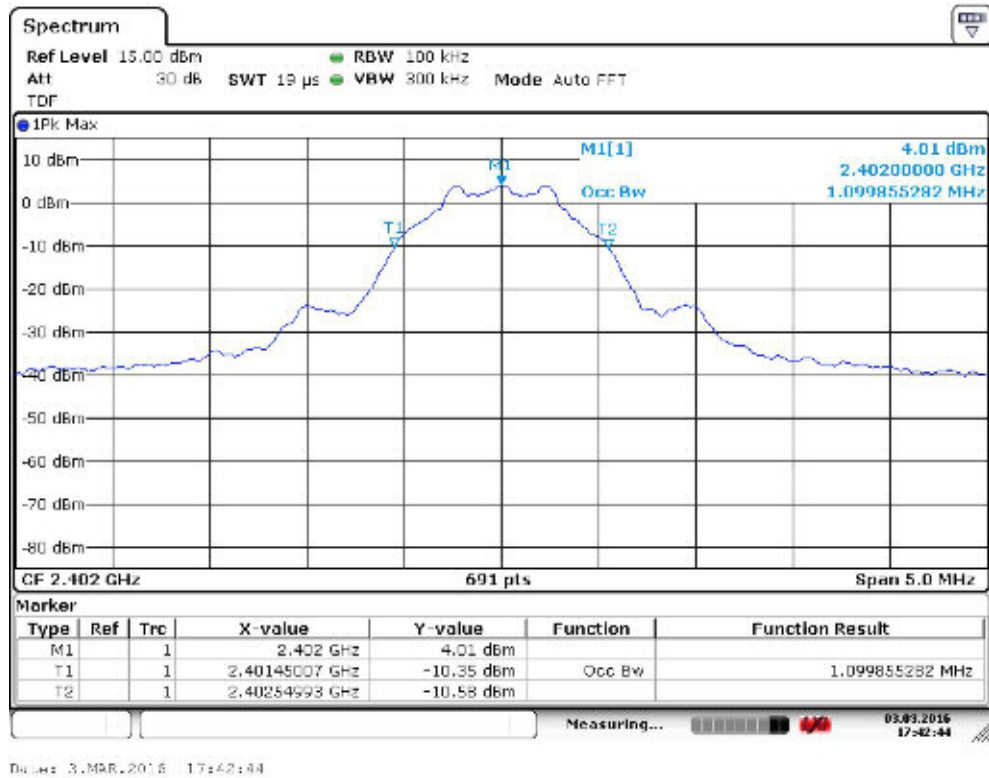


Figure 39. 99 % OBW channel low.

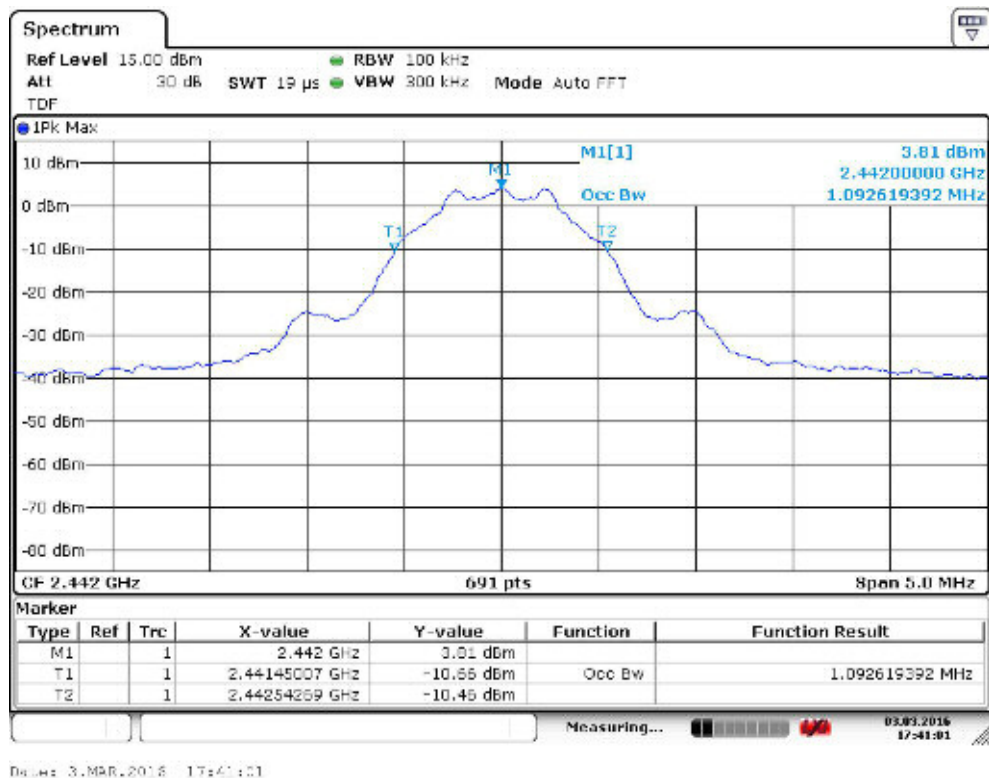


Figure 40. 99 % OBW channel mid.

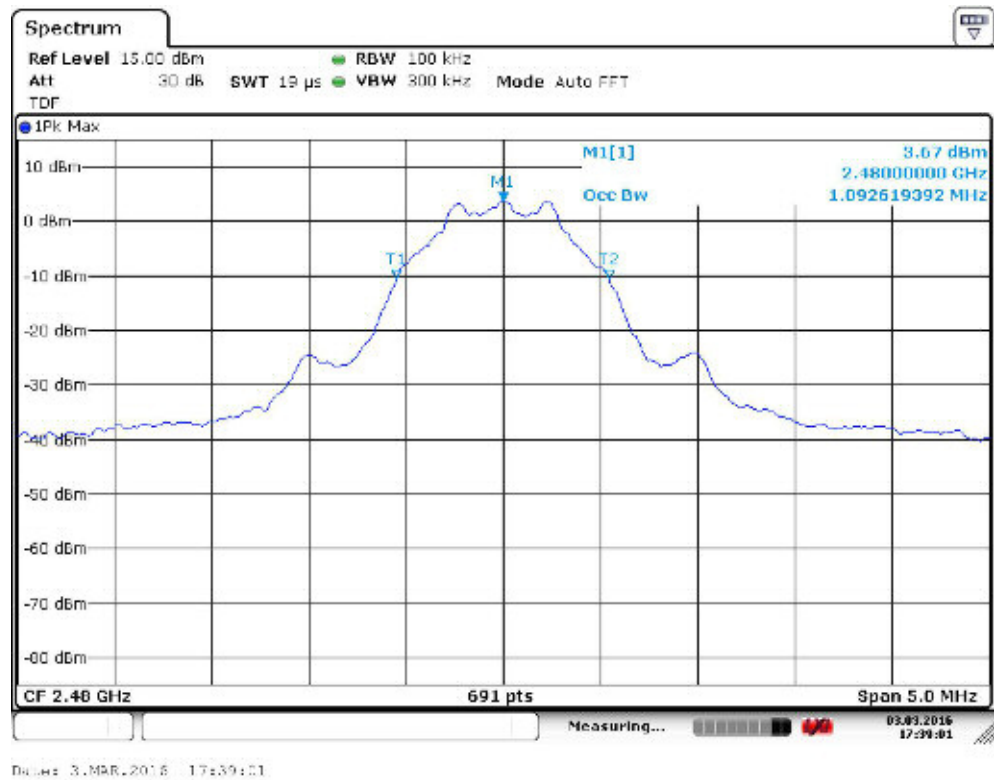


Figure 41. 99 % OBW channel high.

TEST EQUIPMENT

Equipment	Manufacturer	Type	Serial no	Inv.no	Cal. due [yyyy-mm-dd]
EMI RECEIVER	ROHDE & SCHWARZ	ESU 26	100185	8453	2016-07-01
SIGNAL ANALYZER	ROHDE & SCHWARZ	FSV40	101068	9093	2016-07-01
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
ANTENNA (30-1000 MHz)	SCHWARZBECK	VULB 9168	8168-503	8911	2016-05-04
ANTENNA MAST	DEISEL	MA240	240/455	5017	-
TURNTABLE	DEISEL	DS420	-	5015	-
CONTROLLER	COMTEST	HD100	100/457	5018	-
ANTENNA (1-18 GHz)	EMCO	3117	29617	7293	2017-03-03
ANTENNA (18-26.5 GHz)	EMCO	3160- 09	030232-022	7294	2016-06-28
PREAMPLIFIER (0.5-26GHz)	HP	83017A	3950M00102	5226	2016-08-26
ATTENUATOR 10 dB	HUBER & SUHNER	6810.17B	-	-	2016-08-26
HIGH PASS FILTER	WAINWRIGHT	WHKX	10	8267	2016-08-26
AC Power Source	CALIFORNIA INSTRUMENTS	5001 iX Series II	58209	7826	-

All used measurement equipment was calibrated (if required).