

Test Report



INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 15 C

Equipment Under Test: Bluetooth Smart Module

Model: BGM111E

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

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

FCC Rule Part: 15.247: 2015
IC Rule Part: RSS-247, Issue 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: 30 September 2016

Issued by:

A blue ink signature of Emil Haverinen.

Emil Haverinen
Testing Engineer

Date: 30 September 2016

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Rauno Repo
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PRODUCT DESCRIPTION	3
Equipment Under Test (EUT)	3
Description of the EUT	3
Ratings and declarations	3
Power Supply	3
Mechanical Size of the EUT	3
Samples	3
GENERAL REMARKS	4
Disclaimer	4
SUMMARY OF TESTING	5
EUT Test Conditions During Testing	5
TEST RESULTS	6
Maximum Peak Conducted Output Power	6
Transmitter Radiated Spurious Emissions 30 – 26500 MHz	8
Transmitter Band Edge Measurement and Conducted Spurious Emissions	11
TEST EQUIPMENT	15

Equipment Under Test (EUT)

Trade mark: Silicon Labs
Model: BGM111E
Type: Bluetooth Smart Module
Serial no: -
FCC ID: QOQBGM111
IC: 5123A-BGM111

Description of the EUT

BGM111 is a Bluetooth 4.1 compliant Bluetooth smart beacon module with RF connector.

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
Effective conducted power: 8.32 dBm
Transmission technique: DSSS
Modulation: GFSK
External Antenna gain: 2.14 dBi

Power Supply

Operating voltage range: 2.0 - 3.8 VDC (tested with 3.3V regulated by the development board)

Mechanical Size of the EUT

Height: 2.2 mm	Width: 15.0 mm	Length: 15.0 mm
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Samples

Tests were performed with one sample; radiated measurements were performed with general type antenna attached to the RF connector of the EUT via short coaxial adapter. Conducted measurements were performed while short coaxial adapter was attached to the RF connector of the EUT. During the tests the EUT was set into continuous transmit and was set to the channel under test. Normal test modulation and maximum transmit power was used in all tests. No modifications were done during the tests.

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	N/T
§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	N/T
§15.247(e) / RSS-247 5.2(2)	Power Spectral Density	N/T
RSS-GEN 6.6	99% Occupied Bandwidth	N/T
§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

Some tests were not performed; this report will be used to apply for C2PC to original device which has been fully tested.

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. Normal modulation and duty cycle 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 19) = 2440 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

TEST RESULTS

Maximum Peak Conducted Output Power

Standard: ANSI C63.10 (2013)
Tested by: EHA
Date: 30.9.2016
Temperature: 23 °C
Humidity: 47 %
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:

Table 1: Maximum peak conducted output power

Channel	Conducted Power [dBm]	Limit [dBm]	Margin [dBm]	Result
Low	8.32	30	21.68	PASS
Mid	7.91	30	22.09	PASS
High	7.38	30	22.62	PASS

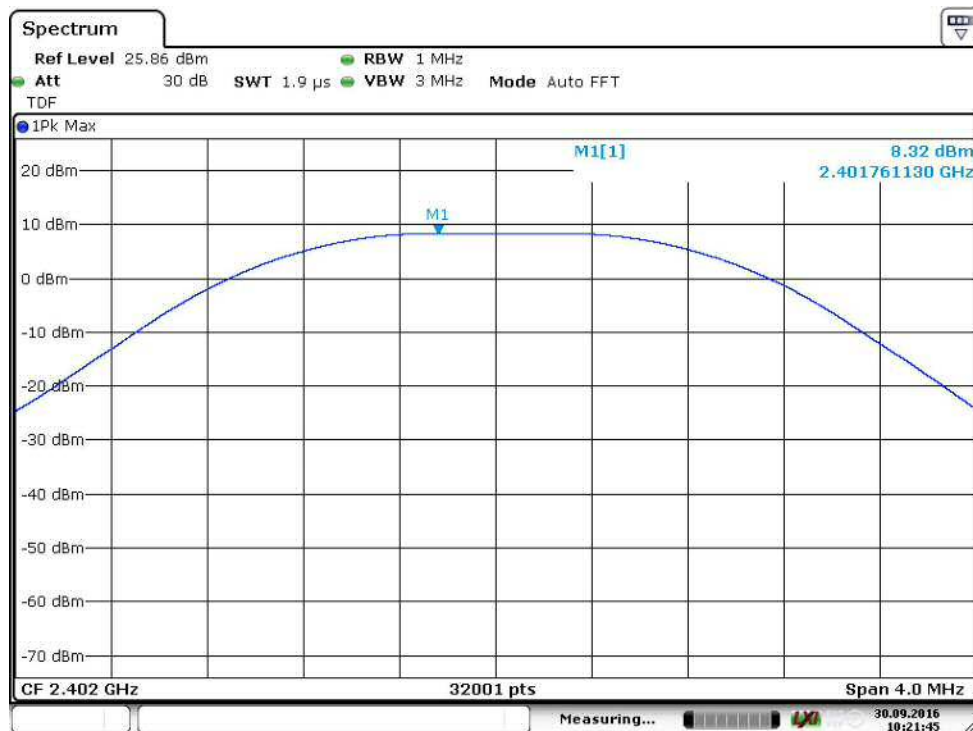


Figure 1: Channel Low

Maximum Peak Conducted Output Power

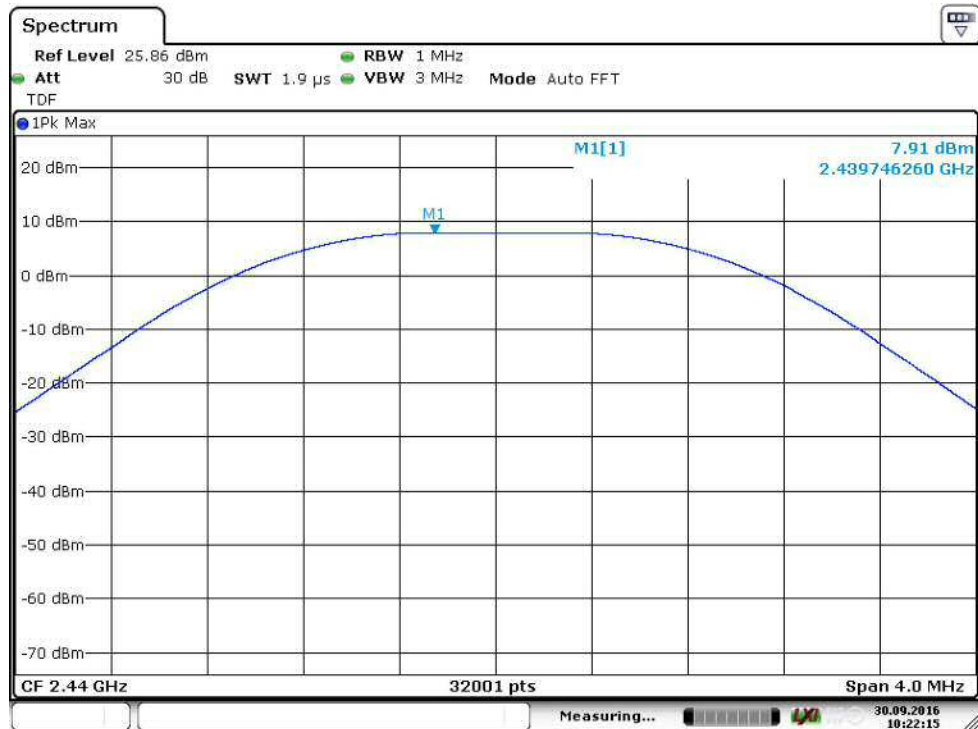


Figure 2: Channel Mid

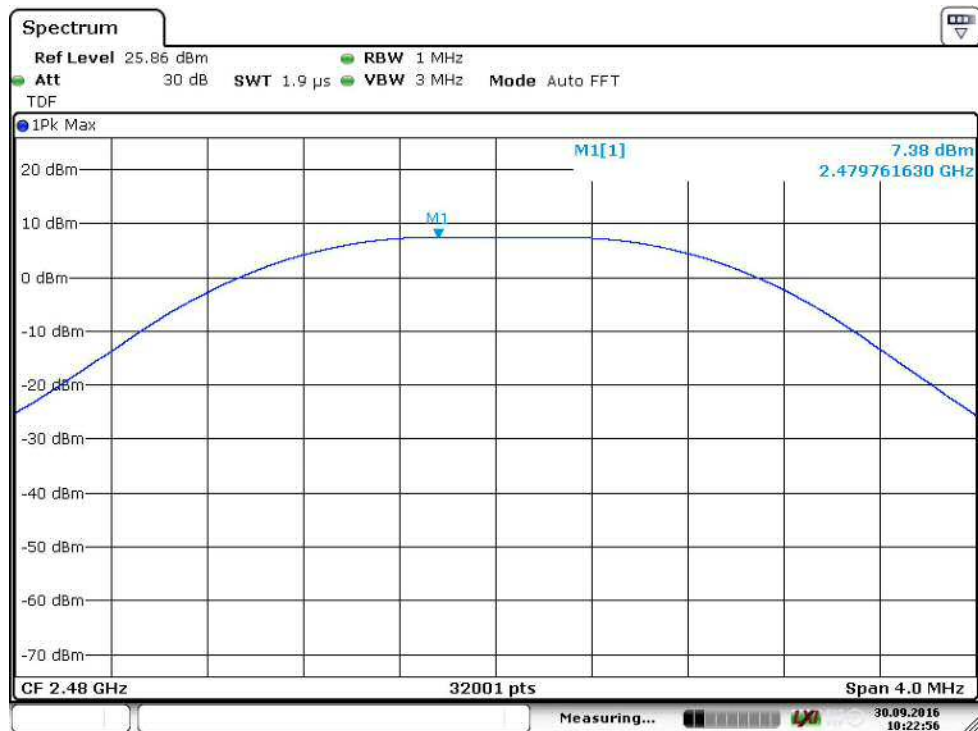


Figure 3: Channel High

Transmitter Radiated Spurious Emissions

Transmitter Radiated Spurious Emissions 30 – 26500 MHz

Standard: ANSI C63.10 (2013)
Tested by: EHA
Date: 27.9 - 28.9.2016
Humidity: 42 - 46 %
Temperature: 22 - 23 °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.

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

Low channel

Table 2: Quasi-peak results (ch low)

Frequency (MHz)	QuasiPeak (dB μ V/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dB μ V/m)
-	-	-	-	-	-	-	-	-	-

Table 3: Peak results (ch low)

Frequency (MHz)	MaxPeak (dB μ V/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dB μ V/m)
2386.800000	40.1	1000.0	1000.000	179.0	V	121.0	-7.1	33.8	73.9
2400.000000	67.8	1000.0	1000.000	228.0	V	122.0	-7.0	6.1	73.9
2402.000000	103.6	1000.0	1000.000	228.0	V	122.0	-7.0	-	-
4803.500000	49.7	1000.0	1000.000	150.0	V	26.0	-3.1	24.2	73.9
7205.100000	49.1	1000.0	1000.000	150.0	V	80.0	0.4	24.8	73.9

Transmitter Radiated Spurious Emissions

Table 4: Average results (ch low)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2390.000000	27.9	1000.0	1000.000	231.0	V	120.0	-7.1	26.0	53.9
2400.000000	50.1	1000.0	1000.000	229.0	V	122.0	-7.0	3.8	53.9
2402.000000	98.4	1000.0	1000.000	228.0	V	123.0	-7.0	-	-
4804.000000	38.8	1000.0	1000.000	150.0	V	26.0	-3.1	15.1	53.9
7205.500000	36.6	1000.0	1000.000	166.0	V	73.0	0.4	17.3	53.9

Middle channel

Table 5: Quasi-peak results (ch mid)

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
109.940000	29.3	1000.0	120.000	100.0	V	272.0	11.4	14.2	43.5

Table 6: Peak results (ch mid)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
109.940000	31.2	1000.0	120.000	100.0	V	272.0	11.4	-	-
2440.250000	102.4	1000.0	1000.000	254.0	V	195.0	-7.2	-	-
4879.400000	49.1	1000.0	1000.000	166.0	V	72.0	-3.0	24.8	73.9
7320.800000	48.1	1000.0	1000.000	150.0	V	120.0	0.5	25.8	73.9

Table 7: Average results (ch mid)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2440.000000	97.1	1000.0	1000.000	254.0	V	194.0	-7.2	-	-
4879.900000	38.1	1000.0	1000.000	150.0	V	31.0	-3.0	15.8	53.9
7319.400000	35.5	1000.0	1000.000	150.0	V	123.0	0.5	18.4	53.9

High channel

Table 8: Quasi-peak results (ch high)

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
-	-	-	-	-	-	-	-	-	-

Table 9: Peak results (ch high)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2479.750000	101.5	1000.0	1000.000	267.0	V	195.0	-6.9	-	-
2483.500000	60.6	1000.0	1000.000	267.0	V	195.0	-6.9	13.3	73.9
4960.500000	49.1	1000.0	1000.000	150.0	V	82.0	-3.1	24.8	73.9
7440.600000	45.3	1000.0	1000.000	150.0	V	235.0	0.6	28.6	73.9

Table 10: Average results (ch high)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2480.000000	95.8	1000.0	1000.000	266.0	V	195.0	-6.9	-	-
2483.500000	43.1	1000.0	1000.000	266.0	V	195.0	-6.9	10.8	53.9
4959.900000	38.5	1000.0	1000.000	150.0	V	84.0	-3.1	15.4	53.9
7439.500000	33.6	1000.0	1000.000	167.0	V	214.0	0.6	20.3	53.9

Transmitter Radiated Spurious Emissions

Radiated Band Edge results

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

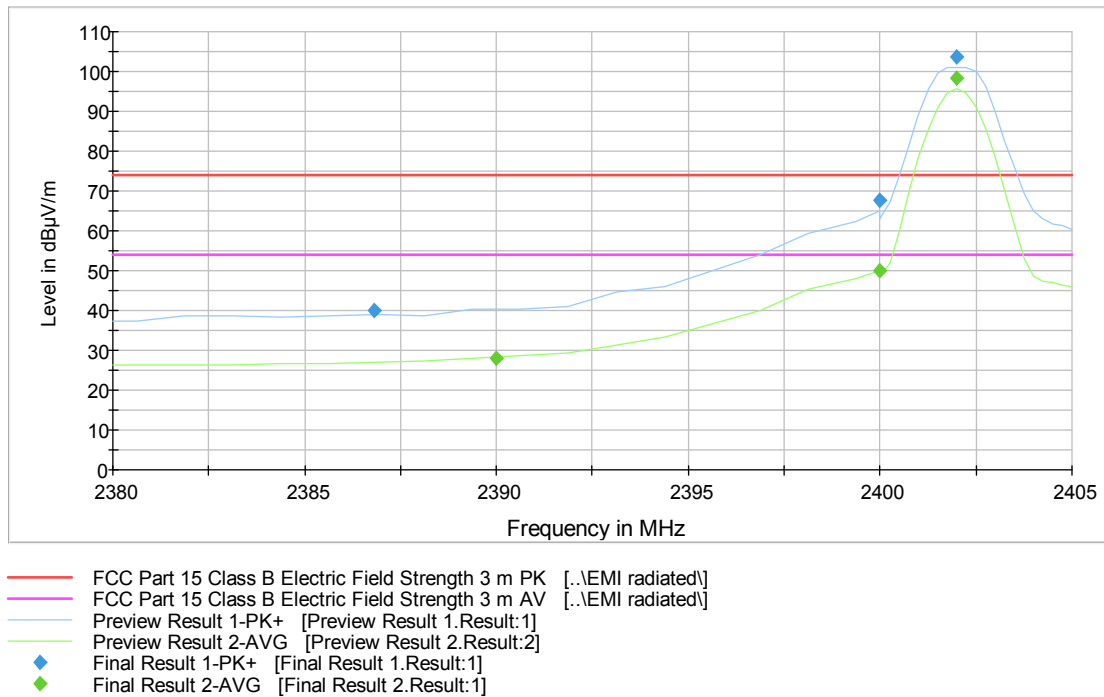


Figure 4: Radiated Band Edge measurement graph (ch low)

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

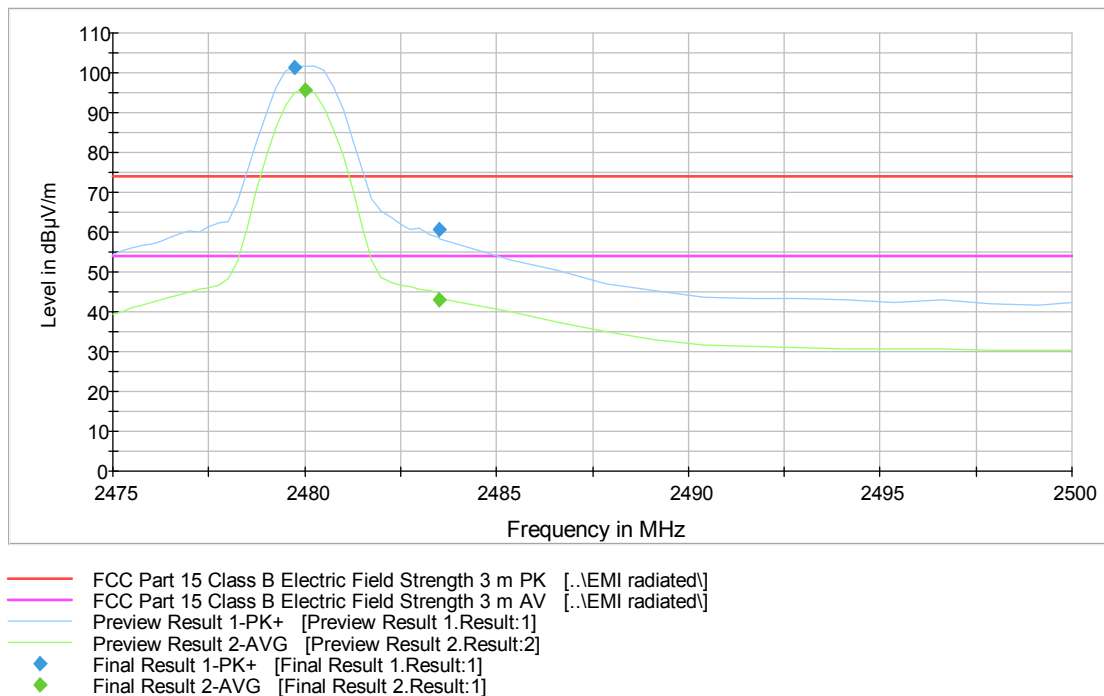


Figure 5: Radiated Band Edge measurement graph (ch high)

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Standard: ANSI C63.10 (2013)
Tested by: EHA
Date: 28.9.2016
Humidity: 22 %
Temperature: 42 °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 11: Band edge attenuation.

Band Edge Attenuation	
Lower Band Edge	Upper Band Edge
-46.31 dBc	-50.55 dBc
Limit: -30dBc	

Table 12: Conducted spurious emissions channel low

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
763.01	-69.92	-13.53	-56.39	PASS
2399.98	-42.39	-13.53	-28.86	PASS
2402.26	6.47	-	-	Carrier
3765.21	-65.11	-13.53	-51.59	PASS
4803.55	-42.54	-13.53	-29.02	PASS
7206.76	-54.89	-13.53	-41.36	PASS
12525.78	-58.15	-13.53	-44.62	PASS
15835.43	-56.67	-13.53	-43.14	PASS
16121.26	-55.20	-13.53	-41.67	PASS
19132.42	-57.44	-13.53	-43.91	PASS
24454.53	-55.88	-13.53	-42.35	PASS
25553.32	-56.39	-13.53	-42.86	PASS

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Table 13: Conducted spurious emissions channel mid

Frequency [MHz]	Level [dBm]	Limit [dBm]	Margin [dB]	Result
993.77	-70.18	-13.91	-56.27	PASS
2281.20	-67.98	-13.91	-54.07	PASS
2440.26	6.09	-	-	Carrier
3958.70	-65.47	-13.91	-51.57	PASS
4879.58	-41.45	-13.91	-27.54	PASS
7320.76	-56.42	-13.91	-42.51	PASS
12489.22	-59.03	-13.91	-45.12	PASS
15859.24	-57.04	-13.91	-43.13	PASS
16196.54	-55.33	-13.91	-41.43	PASS
21167.76	-57.10	-13.91	-43.19	PASS
24148.45	-56.18	-13.91	-42.27	PASS
25617.07	-56.61	-13.91	-42.70	PASS

Table 14: Conducted spurious emissions channel high

Frequency [MHz]	Level [dBm]	Limit [dBc]	Margin [dB]	Result
908.99	-68.91	-14.46	-54.44	PASS
2205.82	-68.03	-14.46	-53.56	PASS
2480.26	5.54	-	-	Carrier
2483.52	-47.21	-14.46	-32.75	PASS
4959.55	-41.50	-14.46	-27.04	PASS
7439.35	-58.08	-14.46	-43.61	PASS
11803.37	-58.94	-14.46	-44.48	PASS
15495.97	-57.11	-14.46	-42.65	PASS
16148.82	-55.34	-14.46	-40.87	PASS
21828.30	-57.53	-14.46	-43.06	PASS
24435.60	-55.97	-14.46	-41.50	PASS
25621.89	-55.46	-14.46	-40.99	PASS

Transmitter Band Edge Measurement and Conducted Spurious Emissions

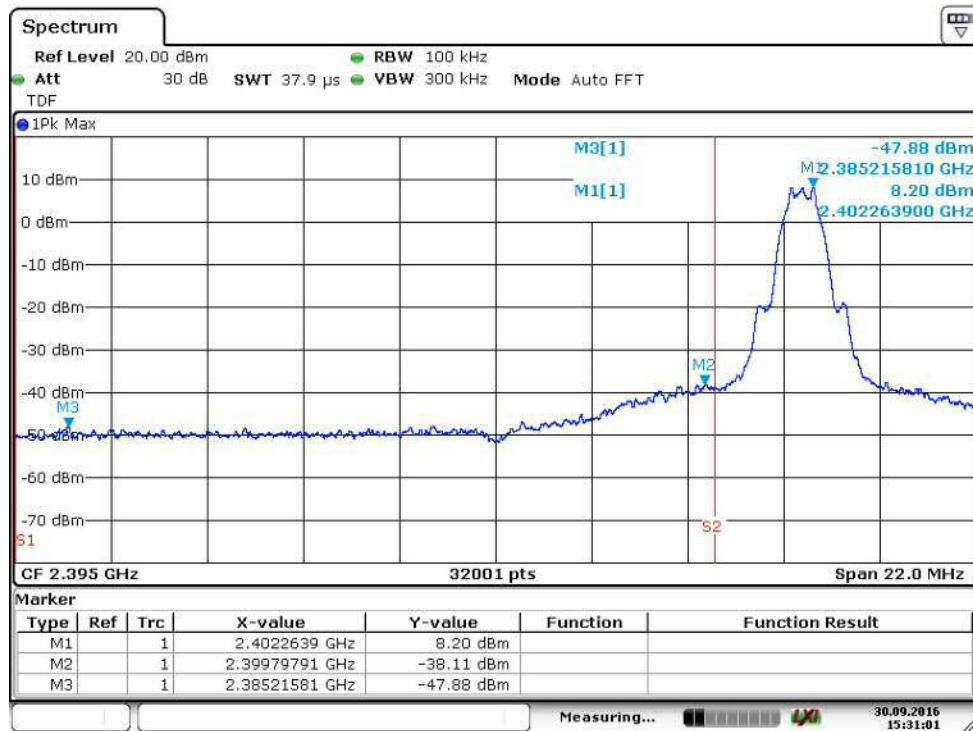


Figure 1: Lower Band Edge

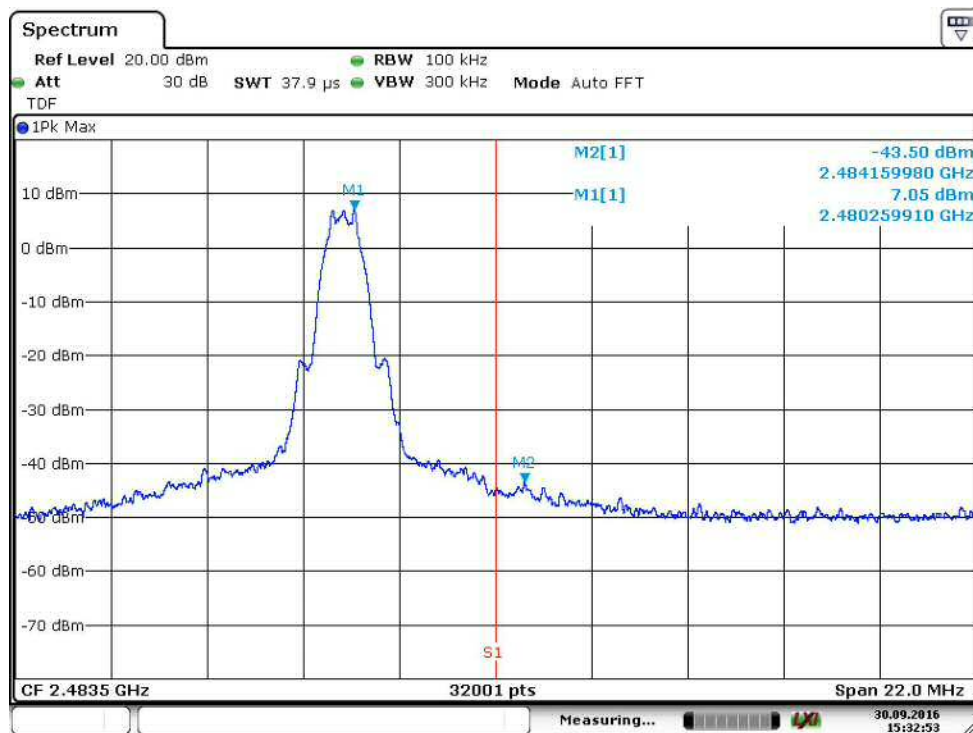


Figure 2: Upper Band Edge

Transmitter Band Edge Measurement and Conducted Spurious Emissions

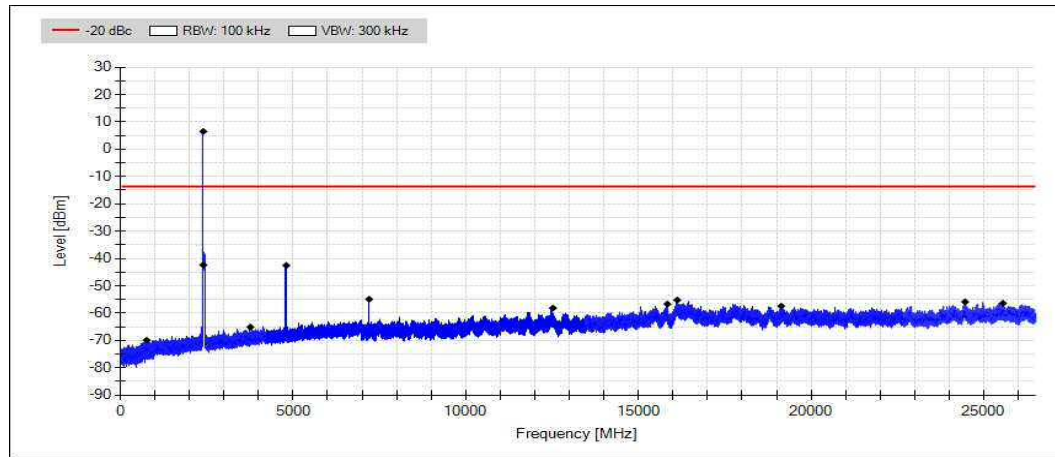


Figure 3: Conducted spurious emissions 30 - 26500 MHz channel low

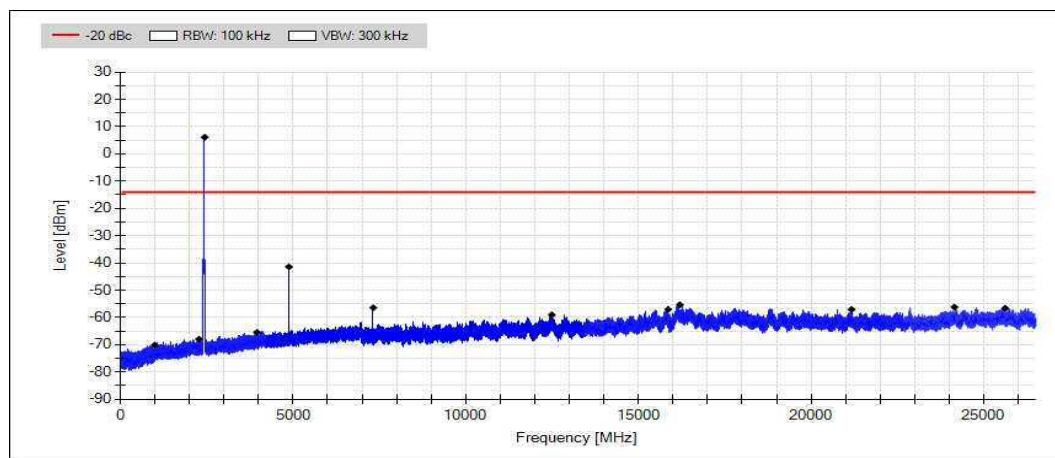


Figure 4: Conducted spurious emissions 30 - 26500 MHz channel mid

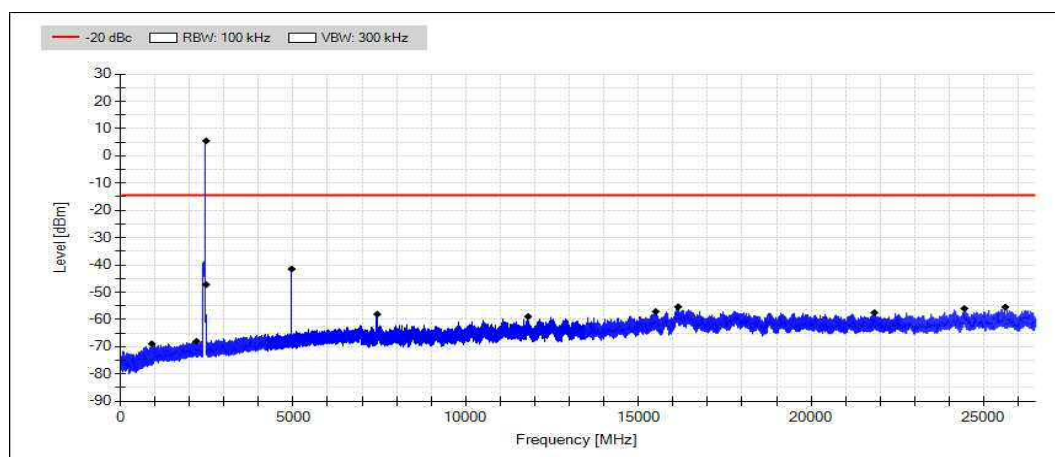


Figure 5: Conducted spurious emissions 30 - 26500 MHz channel high

TEST EQUIPMENT

Equipment	Manufacturer	Type	Inv or serial	Prev Calib	Next Calib
MONITORING ANTENNA	A.H. SYSTEMS	SAS-200/518	inv:7873	-	-
MONITORING SPECTRUM ANALYZER	AGILENT	E7405A	inv:9746	2016-01-07	2018-01-07
ANTENNA MAST	MATURO	TAM 4.0E	inv:10181	-	-
TURNTABLE	MATURO	DS430 UPGRADED	inv:10182	-	-
MAST & TURNTABLE CONTROLLER	MATURO	NCD	inv:10183	-	-
PREAMPLIFIER	ALC MICROWAVE	AWB-2018-40-08	sn:14	2016-08-30	2017-08-30
PREAMPLIFIER	MERCURY SYSTEMS	ALS1826-41-12	-	2016-09-02	2017-09-02
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESU 26	inv:8453	2016-06-10	2017-06-10
SIGNAL ANALYZER	ROHDE & SCHWARZ	FSV40	inv:9093	2016-06-10	2017-06-10
ANTENNA	SCHWARZBECK	VULB 9168	inv:8911	2014-11-04	2016-11-04
ANTENNA	EMCO	3117	inv:7293	2016-03-16	2018-03-06
ANTENNA	EMCO	3160-09	inv:7294	2016-03-16	2017-03-16
HIGH PASS FILTER	WAINWRIGHT	WHKX4.0/18G-10SS	sn:10	2016-01-22	2017-01-22
ATTENUATOR 10 dB	HUBER & SUHNER	6610.19.AA	sn:7	2016-02-02	2017-02-02
ATTENUATOR 10 dB	PASTERNAK	PE7090-10	-	2016-04-01	2017-04-01
AC POWER SOURCE	CALIFORNIA INSTRUMENTS	5001 iX Series II	inv:7826	-	-
DC POWER SOURCE	MASCOT	-	inv:3733	-	-
MULTIMETER	FLUKE	23	inv:8252	2015-10-20	2016-10-20

All used measurement equipment was calibrated (if required).