

TEST REPORT

Part 15 Subpart C 15.247

Equipment under test Luminaire Control Wireless Module

Model name BTLEM4

FCC ID TSW-BTLEM4

Applicant SAMJIN LND Co., Ltd.

Manufacturer SAMJIN LND Co., Ltd.

Date of test(s) 2016.03.28 ~ 2016.03.31

Date of issue 2016.03.31

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Revision history

Revision	Date of issue	Test report No.	Description
-	2016.03.31	KES-RF-16T0040	Initial

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1. General information

Applicant: SAMJIN LND Co., Ltd.
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Test site: KES Co., Ltd.
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FCC rule part(s): 15.247
FCC ID: TSW-BTLEM4
Test device serial No.: ☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test Luminaire Control Wireless Module
Frequency range 2402 MHz ~ 2480 MHz
Model: BTLEM4
Derivative model -
Modulation technique GFSK
Number of channels 40
Antenna specification Antenna type: PCB, Peak gain: 1 dBi
Power source DC 5.0 V

1.2. Test configuration

The **SAMJIN LND Co., Ltd. Luminaire Control Wireless Module FCC ID: TSW-BTLEM4** was tested per the guidance of KDB 558074 D01 v03r04. ANSI C63.10-2009 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing.

1.3. Frequency/channel operations

Ch.	Frequency (MHz)	Rate(Mbps)
00	2 402	1
.	.	.
20	2 442	1
.	.	.
39	2 480	1

1.4. Accessory information

Applicant	Equipment	Manufacturer	Model	Power source
-	-	-	-	-

1.5. Device modifications

N/A

1.6. Derivation model information

N/A

2. Summary of tests

Reference	Parameter	Test results
15.247(a)(2)	6 dB bandwidth	Pass
15.247(b)(3)	Peak output power	Pass
15.247(e)	Power spectral density	Pass
15.205 15.209	Radiated restricted band and emission	Pass
15.247(d)	Conducted spurious emission and band edge	Pass
15.207(a)	AC conducted emissions	Pass

3. Test results

3.1. 6 dB bandwidth

Test procedure

KDB 558074 D01 v03r04 – Section 8.1 or 8.2

Section 8.1

1. RBW = 100 kHz.
2. VBW $\geq 3 \times$ RBW.
3. Detector = peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize
7. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

Section 8.2

The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW $\geq 3 \times$ RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB.

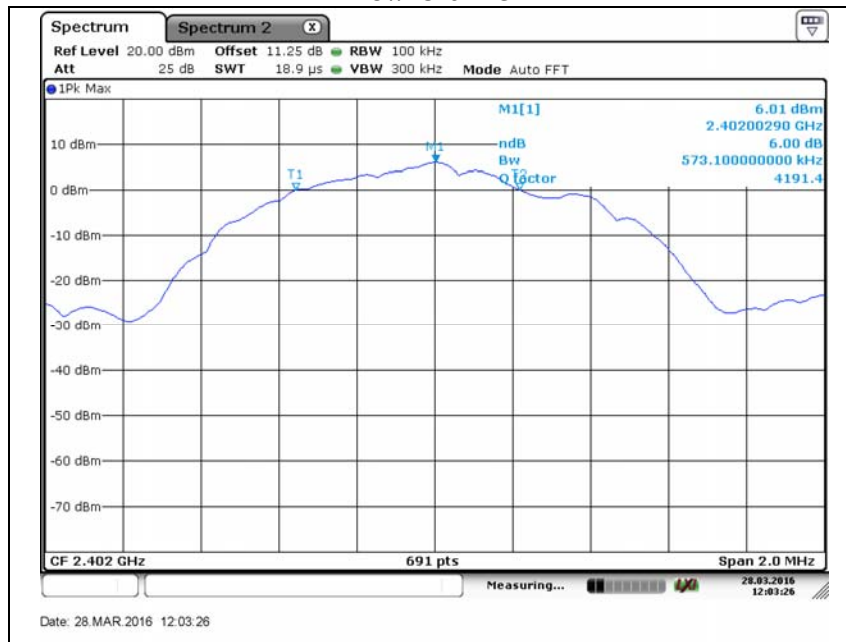
Limit

According to §15.247(a)(2), systems using digital modulation techniques may operate 902 ~ 928 MHz, 2 400 ~ 2 483.5 MHz, and 5 725 ~ 5 850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

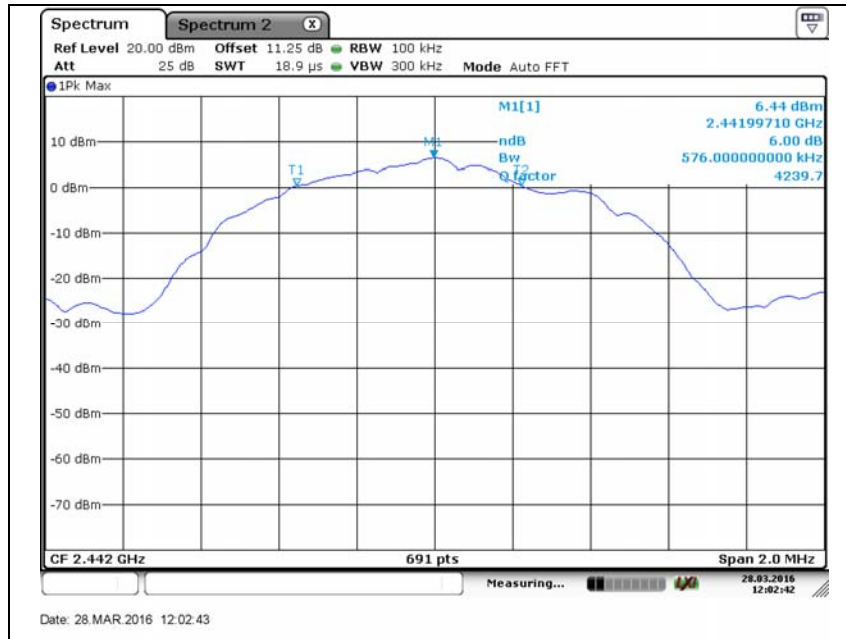
Test results

Frequency(MHz)	6 dB bandwidth(MHz)	Limit(MHz)
2 402	0.573	0.5
2 442	0.576	
2 480	0.582	

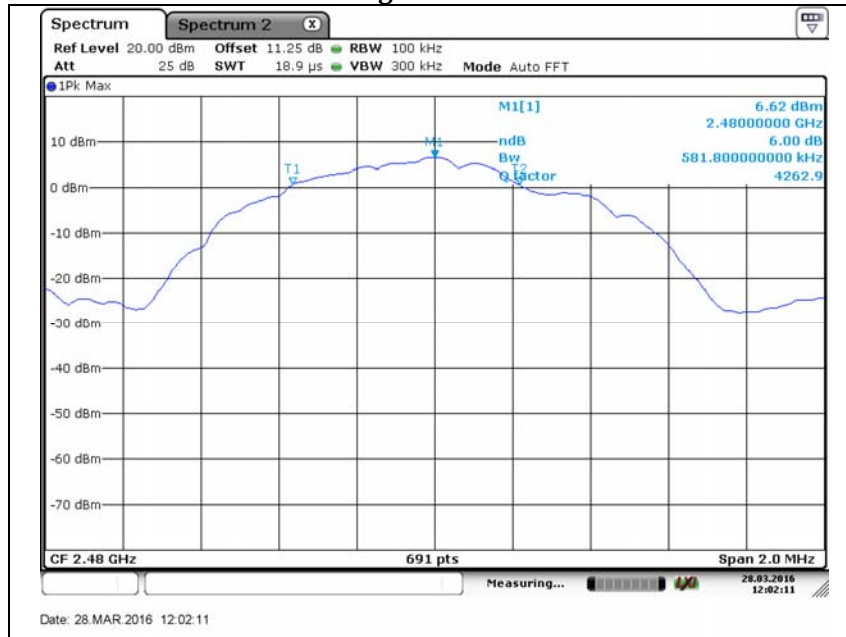
Low channel



Middle channel



High channel



3.2. Peak output power

Test procedure

KDB 558074 D01 v03r04 – section 9.1.1 or 9.1.2

Section 9.1.1

This procedure shall be used when the measurement instrument has available a resolution bandwidth that is greater than the DTS bandwidth.

1. Set the RBW $\geq$ DTS bandwidth.
2. Set VBW $\geq 3 \times$ RBW.
3. Set span $\geq 3 \times$ RBW
4. Sweep time = auto couple
5. Detector = peak
6. Trace mode = max hold
7. Allow trace to fully stabilize
8. Use peak marker function to determine the peak amplitude level

Section 9.1.2

The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall utilize a fast-responding diode detector.

Limit

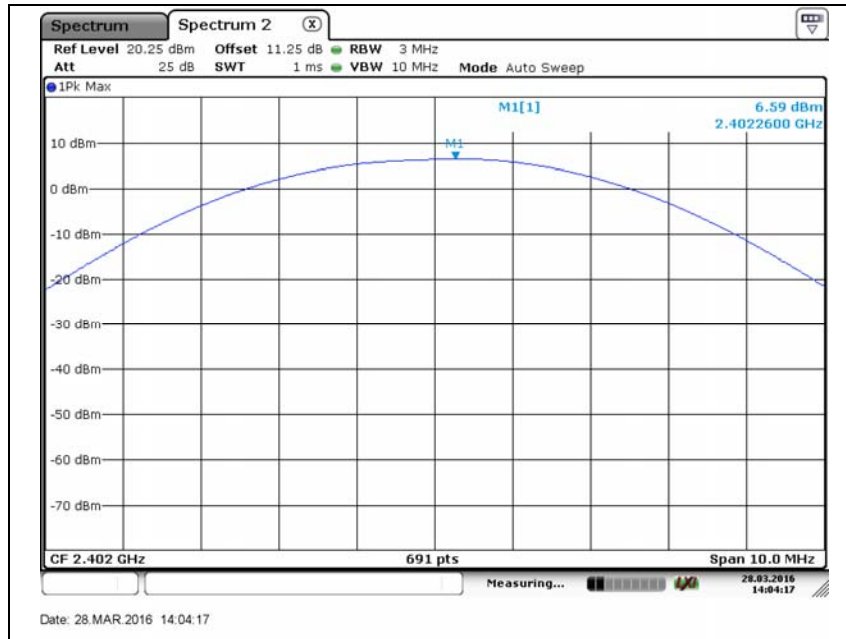
According to §15.247(b)(3), For systems using digital modulation in the 902~928 MHz, 2 400~2 483.5 MHz, and 5 725~5 850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted out-put power. Maximum Conducted Out-put Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

According to §15.247(b)(4), The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

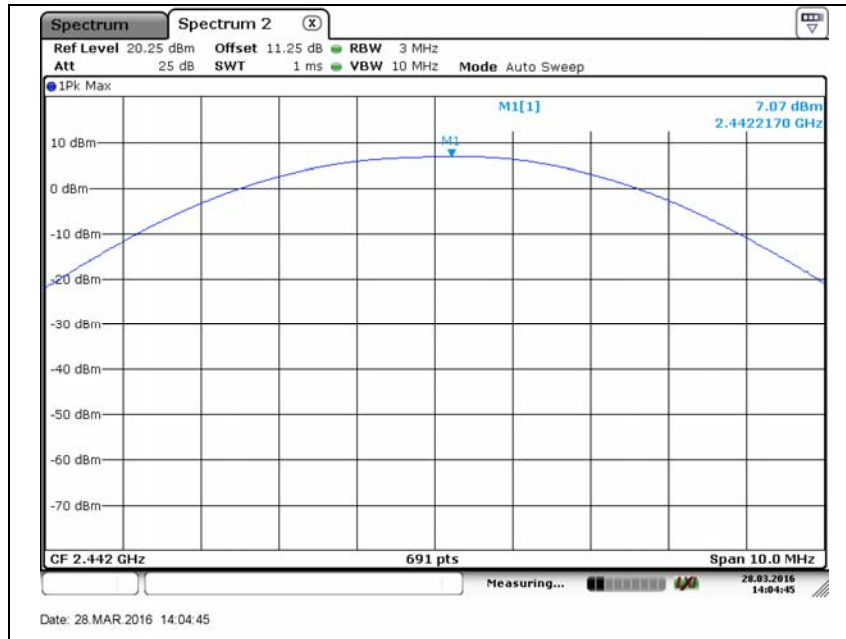
Test results

Frequency(MHz)	Peak output power(dBm)	Limit(dBm)
2 402	6.59	30
2 442	7.07	
2 480	7.28	

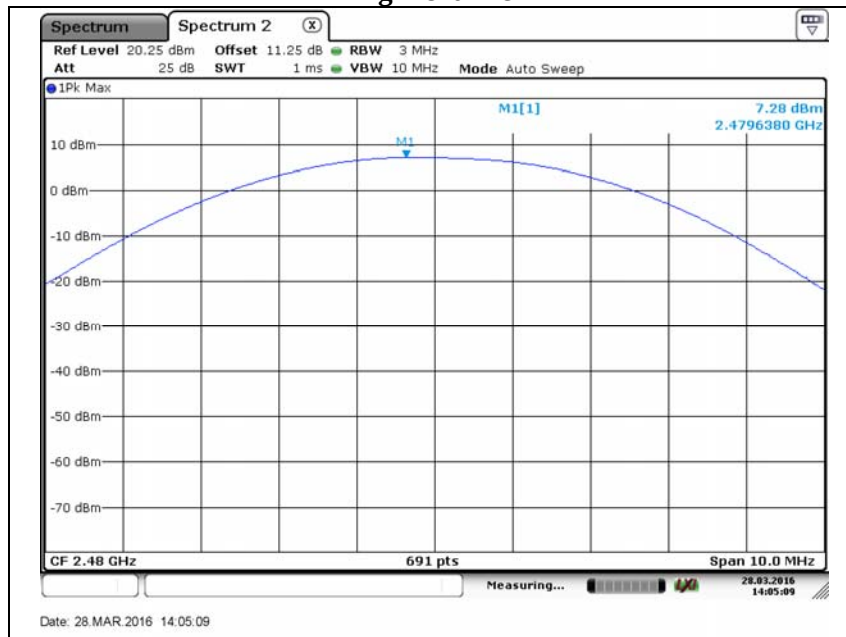
Low channel



Middle channel



High channel



3.3. Power spectral density

Test procedure

KDB 558074 D01 v03r04 – section 10.2

1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the DTS channel bandwidth.
3. Set the RBW : $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
4. Set the VBW $\geq 3 \times \text{RBW}$.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level.
10. If measured value exceeds limit, reduce RBW(no less than 3 kHz) and repeat.

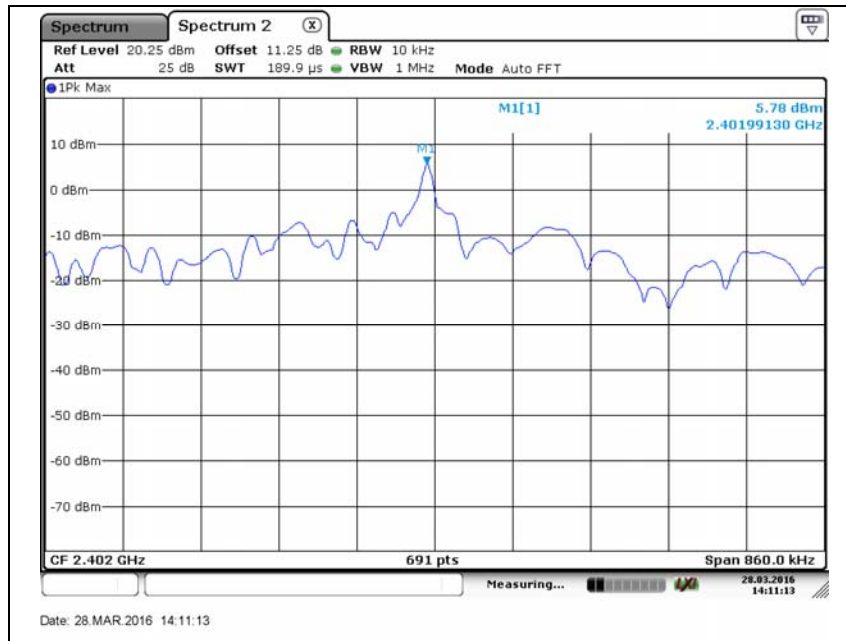
Limit

According to §15.247(e), For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

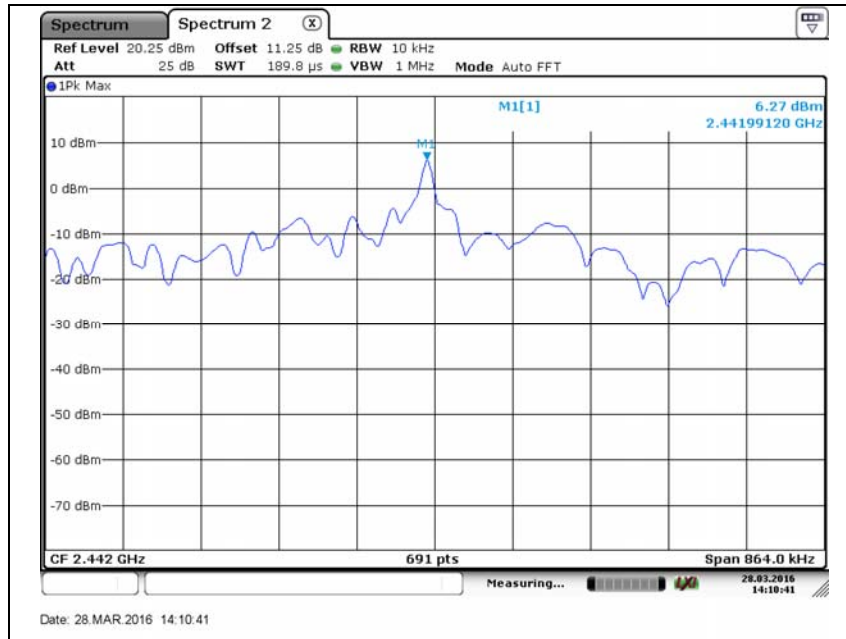
Test results

Frequency(MHz)	PSD (dBm)	Limit(dBm)
2 402	5.78	8
2 442	6.27	
2 480	6.48	

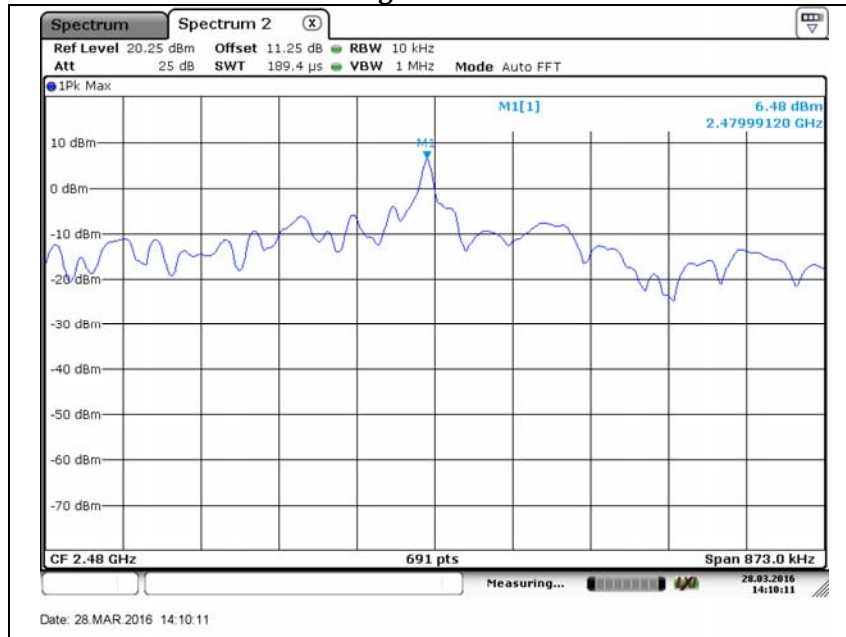
Low channel



Middle channel



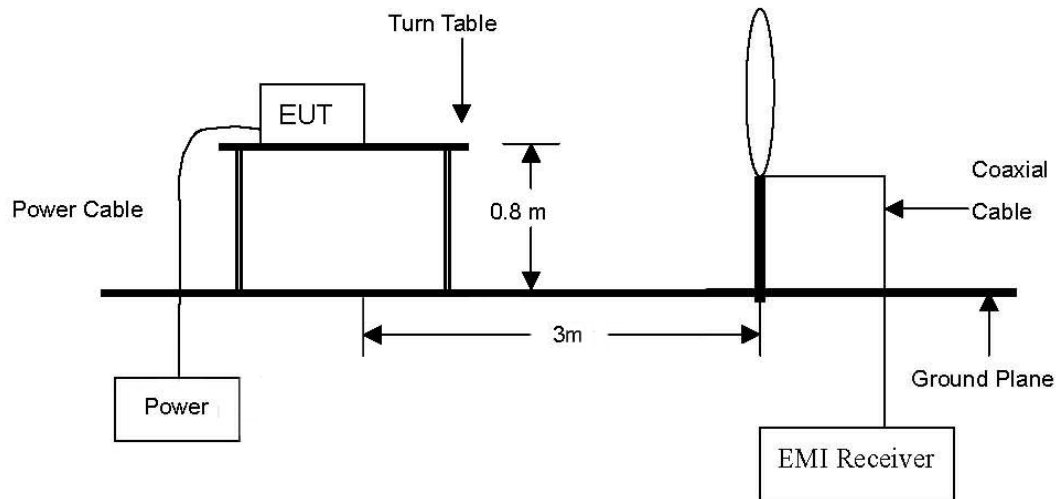
High channel



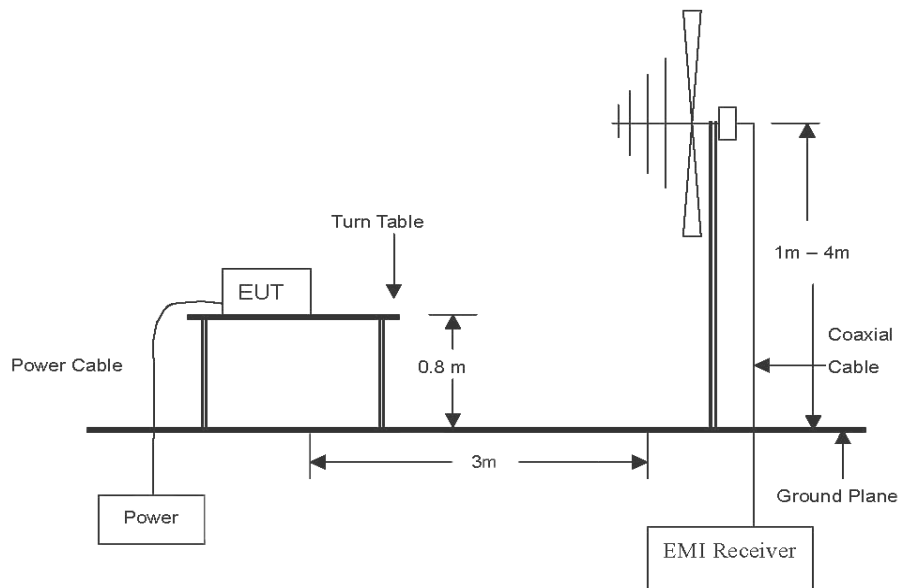
3.4. Radiated restricted band and emissions

Test setup

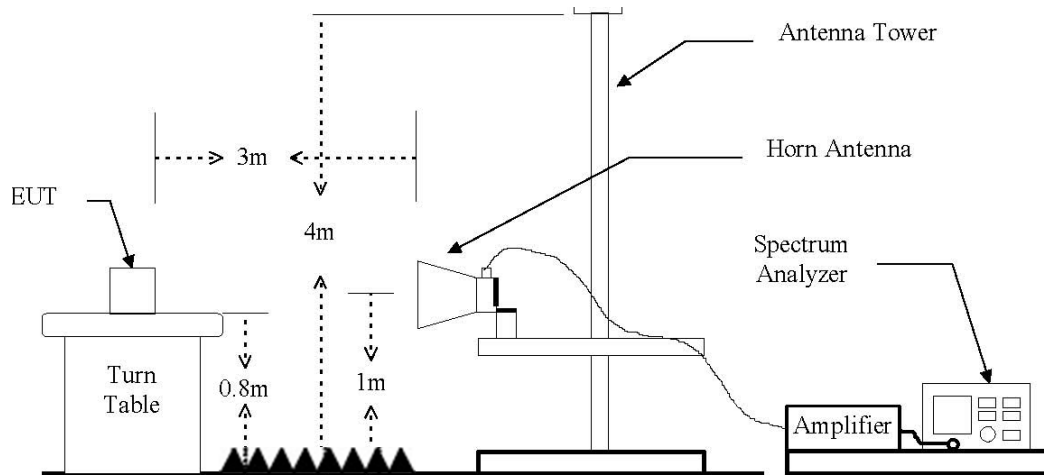
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 30 MHz to 1 GHz emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 1 GHz to the tenth harmonic of the highest fundamental frequency or to 40 GHz emissions, whichever is lower.



Test procedure below 30 MHz

1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
2. Then antenna is a loop antenna is fixed at one meter above the ground to determine the maximum value of the field strength. Both parallel and perpendicular of the antenna are set to make the measurement.
3. For each suspected emission, the EUT was arranged to its worst case and then the table was turned from 0 degrees to 360 degrees to find the maximum reading.
4. The test-receiver system was set to average or quasi peak detect function and Specified Bandwidth with Maximum hold mode.

Test procedure above 30 MHz

1. Spectrum analyzer settings for $f < 1$ GHz:
 - ① Span = wide enough to fully capture the emission being measured
 - ② RBW = 100 kHz
 - ③ VBW $\geq$ RBW
 - ④ Detector = quasi peak
 - ⑤ Sweep time = auto
 - ⑥ Trace = max hold
2. Spectrum analyzer settings for $f \geq 1$ GHz: Peak
 - ① Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
 - ② RBW = 1 MHz
 - ③ VBW $\geq$ 3 MHz
 - ④ Detector = peak
 - ⑤ Sweep time = auto
 - ⑥ Trace = max hold
 - ⑦ Trace was allowed to stabilize

3. Spectrum analyzer settings for $f \geq 1$ GHz: Average

- ① Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
- ② RBW = 1 MHz
- ③ VBW $\geq 3 \times$ RBW
- ④ Detector = RMS, if span/(# of points in sweep) $\leq$ (RBW/2). Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If this condition cannot be satisfied, then the detector mode shall be set to peak. Detector function = peak
- ⑤ Averaging type = power (i.e., RMS).
- ⑥ Sweep time = auto.
- ⑦ Perform a trace average of at least 100 traces.
- ⑧ A correction factor shall be added to the measurement results prior to comparing to the emission limit.

Note.

1. $f < 30$ MHz, extrapolation factor of 40 dB/decade of distance. $F_d = 40\log(D_m/D_s)$
 $f \geq 30$ MHz, extrapolation factor of 20 dB/decade of distance. $F_d = 20\log(D_m/D_s)$
Where:
 F_d = Distance factor in dB
 D_m = Measurement distance in meters
 D_s = Specification distance in meters
2. CF(Correction factors(dB)) = Antenna factor(dB/m) + Cable loss(dB) + or Amp. gain(dB) + or F_d (dB)
3. Field strength(dB μ V/m) = Level(dB μ V) + CF (dB) + or DCF(dB)
4. Margin(dB) = Limit(dB μ V/m) - Field strength(dB μ V/m)
5. Emissions below 18 GHz were measured at a 3 meter test distance while emissions above 18 GHz were measured at a 1 meter test distance with the application of a distance correction factor.
6. The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z, it was determined that **X orientation** was worst-case orientation; therefore, all final radiated testing was performed with the EUT in **X orientation**.
7. The worst-case emissions are reported however emissions whose levels were not within 20 dB of respective limits were not reported.

Limit

According to 15.209(a), for an intentional radiator devices, the general required of field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values :

Frequency (MHz)	Distance (Meters)	Radiated ($\mu\text{V}/\text{m}$)
0.009 ~ 0.490	300	2 400 / F(kHz)
0.490 ~ 1.705	30	24 000 / F(kHz)
1.705 ~ 30.0	30	30
30 ~ 88	3	100**
88 ~ 216	3	150**
216 ~ 960	3	200**
Above 960	3	500

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54 ~ 72 MHz, 76 ~ 88 MHz, 174 ~ 216 MHz or 470 ~ 806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

Duty cycle

T _{on} time (ms)	Period (ms)	Duty cycle (Linear)	Duty cycle (%)	Minimum VBW (kHz)	Duty cycle correction factor (dB)
0.40	0.63	0.63	63.0	2.50	2.00

Note

Duty cycle (Linear) = T_{on} time/Period

Minimum VBW(kHz) = 1/T_{on}, where T is on time in second

DCF(Duty cycle correction factor (dB)) = 10log(1/duty cycle)

Test results (Below 30 MHz)

Mode:	BLE
Transfer rate:	1 Mbps
Distance of measurement:	3 meter
Channel:	39 (Worst case)

Frequency (MHz)	Level (dBμV)	Ant. Pol. (H/V)	CF (dB)	F _d (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
No spurious emissions were detected within 20 dB of the limit							

Test results (Below 1 000 MHz)

Mode:	BLE
Transfer rate:	1 Mbps
Distance of measurement:	3 meter
Channel:	39 (Worst case)

Frequency (MHz)	Level (dBμV)	Ant. Pol. (H/V)	CF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
49.86	9.60	V	15.69	25.29	40.00	14.71
218.68	7.42	H	15.75	23.17	46.00	22.83
268.70	6.42	V	17.29	23.71	46.00	22.29
295.71	5.91	V	18.17	24.08	46.00	21.92
339.66	6.84	H	19.44	26.28	46.00	19.72
452.85	6.34	H	22.64	28.98	46.00	17.02



Test results (Above 1 000 MHz)

Mode: BLE
Transfer rate: 1 Mbps
Distance of measurement: 3 meter
Channel: 00

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2384.55	43.92	Peak	H	-0.44	-	43.48	74.00	30.52
2384.29	43.80	Peak	V	-0.98	-	42.82	74.00	31.18
4804.30	51.55	Peak	H	8.07	-	59.62	74.00	14.38
4804.30	37.96	Avg	H	8.07	2.00	48.03	54.00	5.97
4804.30	48.76	Peak	V	8.07	-	56.83	74.00	17.17
4804.30	34.25	Avg	V	8.07	2.00	44.32	54.00	9.68

Mode: BLE
Transfer rate: 1 Mbps
Distance of measurement: 3 meter
Channel: 20

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4885.40	49.92	Peak	H	8.65	-	58.57	74.00	15.43
4885.40	38.33	Avg	H	8.65	2.00	48.98	54.00	5.02
4885.40	49.04	Peak	V	8.65	-	57.69	74.00	16.31
4885.40	36.52	Avg	V	8.65	2.00	47.17	54.00	6.83

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Mode: BLE
Transfer rate: 1 Mbps
Distance of measurement: 3 meter
Channel: 39

Frequency (MHz)	Level (dB μ V)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2483.53	42.63	Peak	H	-0.45	-	42.18	74.00	31.82
2483.53	43.79	Peak	V	-0.45	-	43.34	74.00	30.66
4960.60	50.37	Peak	H	9.19	-	59.56	74.00	14.44
4960.60	38.40	Avg	H	9.19	2.00	49.59	54.00	4.41
4960.60	48.32	Peak	V	9.19	-	57.51	74.00	16.49
4960.60	35.40	Avg	V	9.19	2.00	46.59	54.00	7.41

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The test results in the report only apply to the tested sample.

3.5 Conducted spurious emissions & band edge

Test procedure

Band edge

KDB 558074 D01 v03r04 – Section 11.3

1. Start and stop frequency were set such that the band edge would be placed in the center of the plot
2. Span was set large enough so as to capture all out of band emissions near the band edge
3. RBW = 100 kHz
4. VBW = 300 kHz
5. Detector = Peak
6. Number of sweep points $\geq 2 \times \text{Span/RBW}$
7. Trace mode = max hold
8. Sweep time = auto
9. The trace was allowed to stabilize

Out of band emissions

KDB 558074 D01 v03r04 – Section 11.3

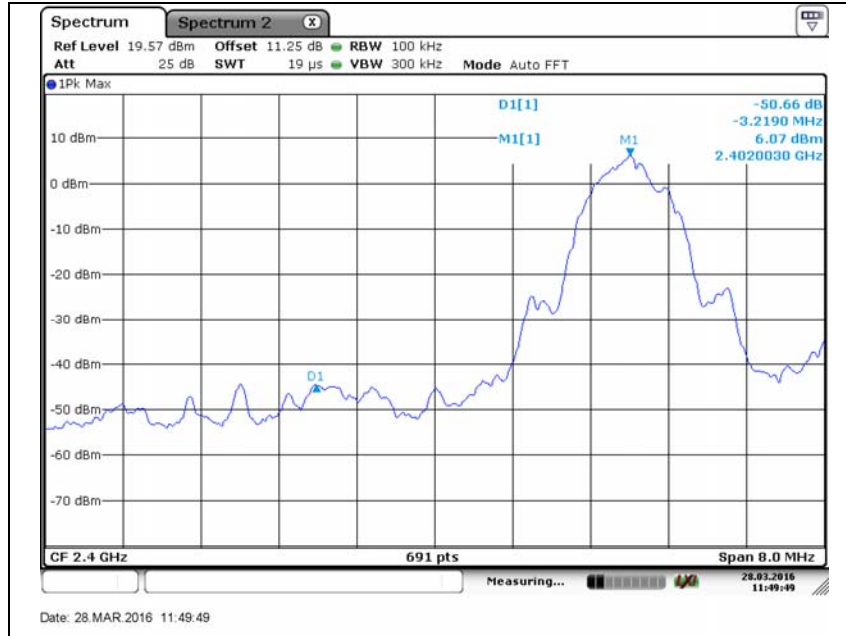
1. Start frequency was set to 30 MHz and stop frequency was set to 25 GHz for 2.4 GHz frequencies and 40 GHz for 5 GHz frequencies (separated into two plots per channel)
2. RBW = 100 kHz
3. VBW = 300 kHz
4. Detector = Peak
5. Trace mode = max hold
6. Sweep time = auto couple
7. The trace was allowed to stabilize

Limit

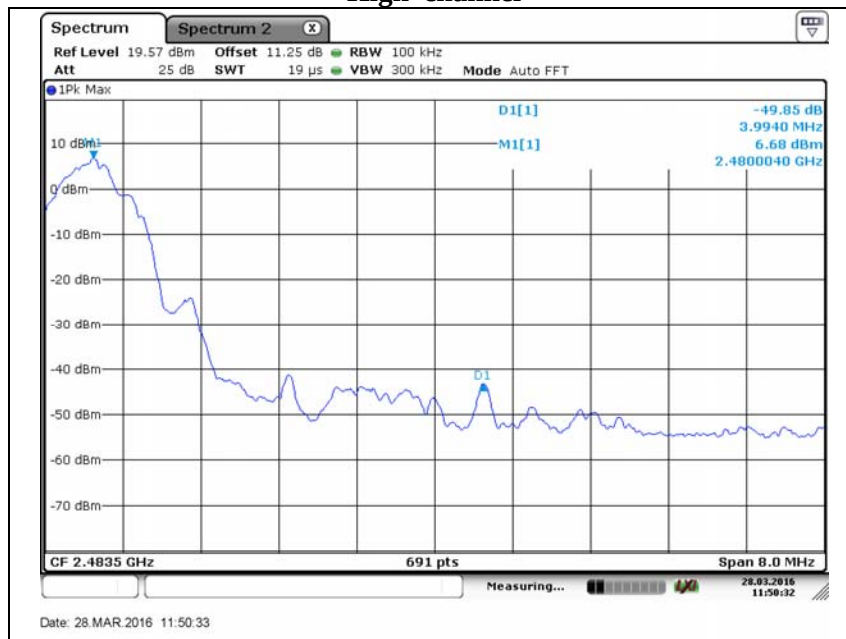
According to 15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within 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 emission which in the restricted band, as define in section 15.205(a), must also comply the radiated emission limits specified in section 15.209(a) (see section 15.205(c))

Test results (band edge)

Low channel

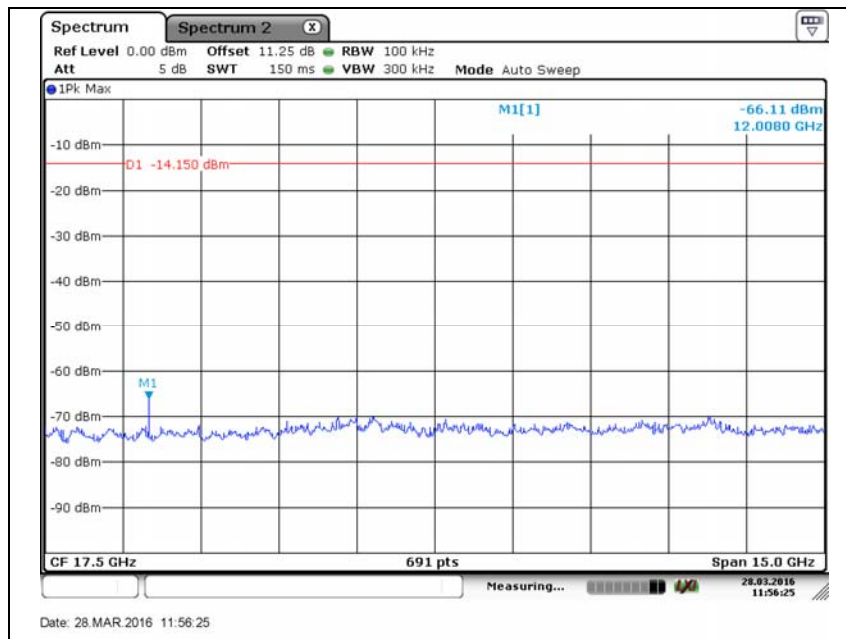
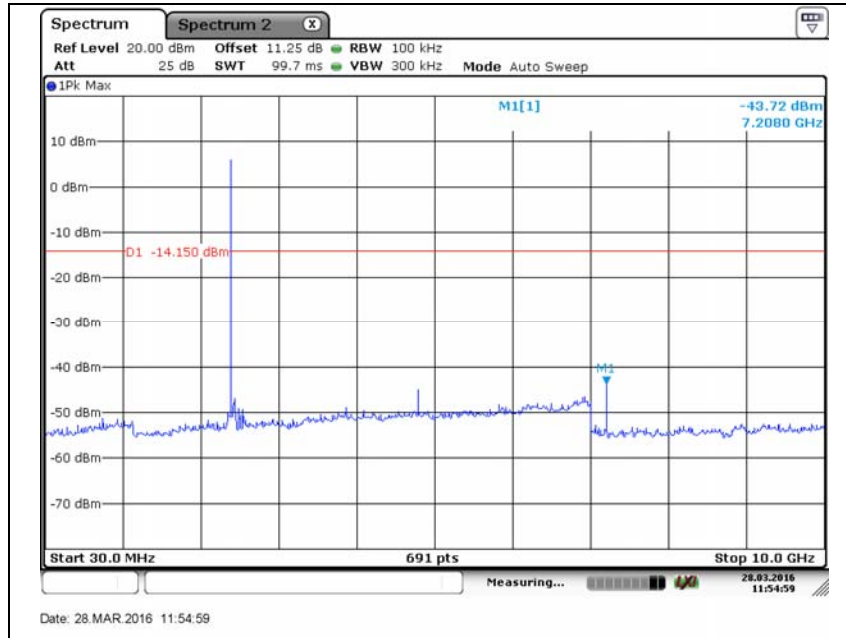


High channel

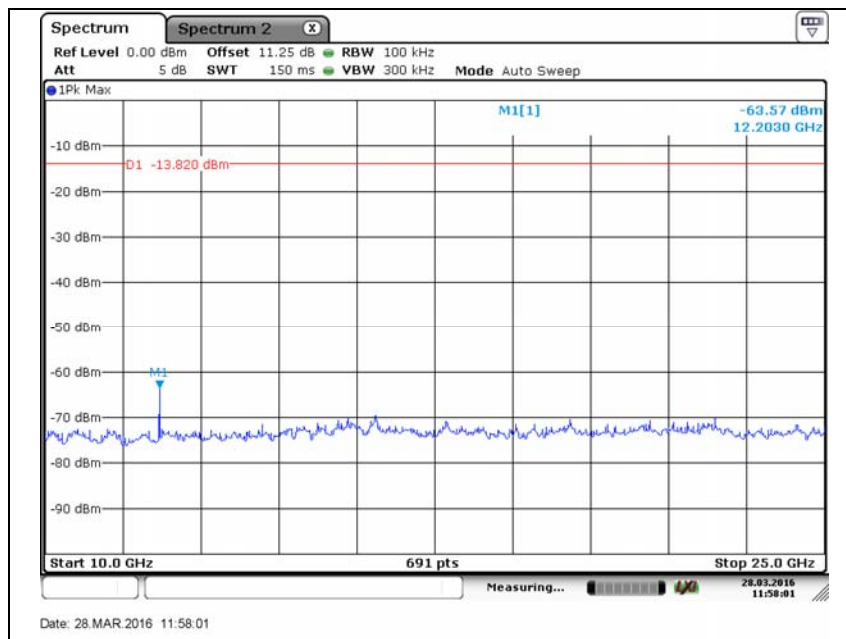
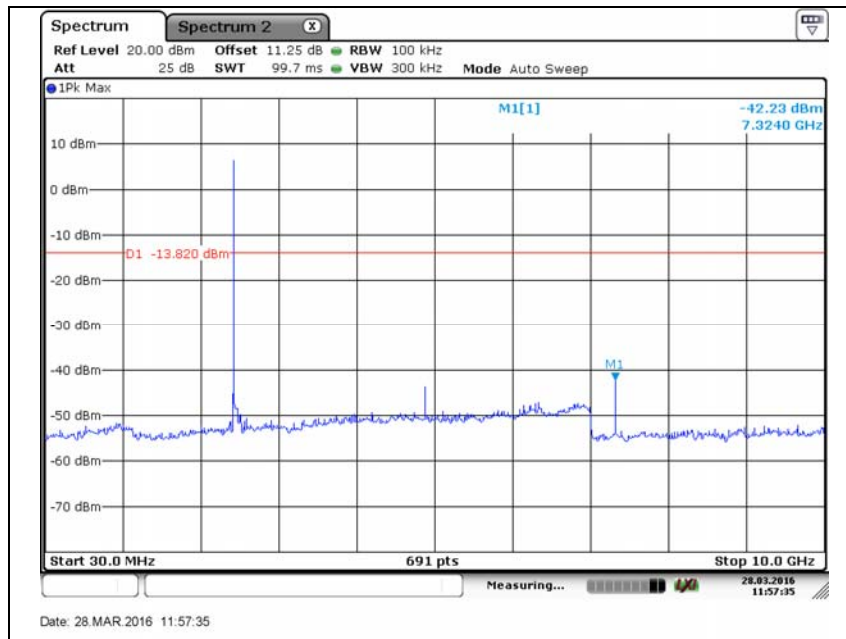


Test results (spurious emission)

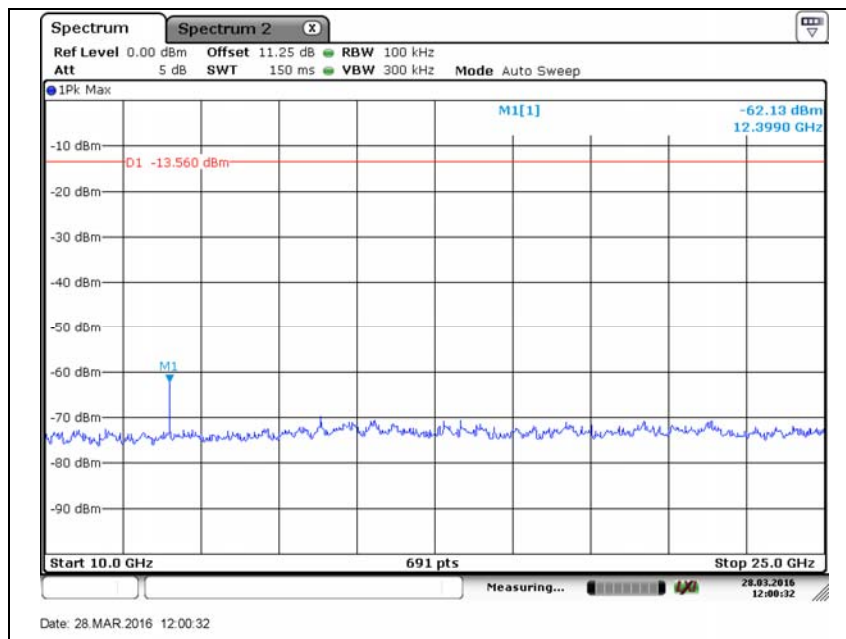
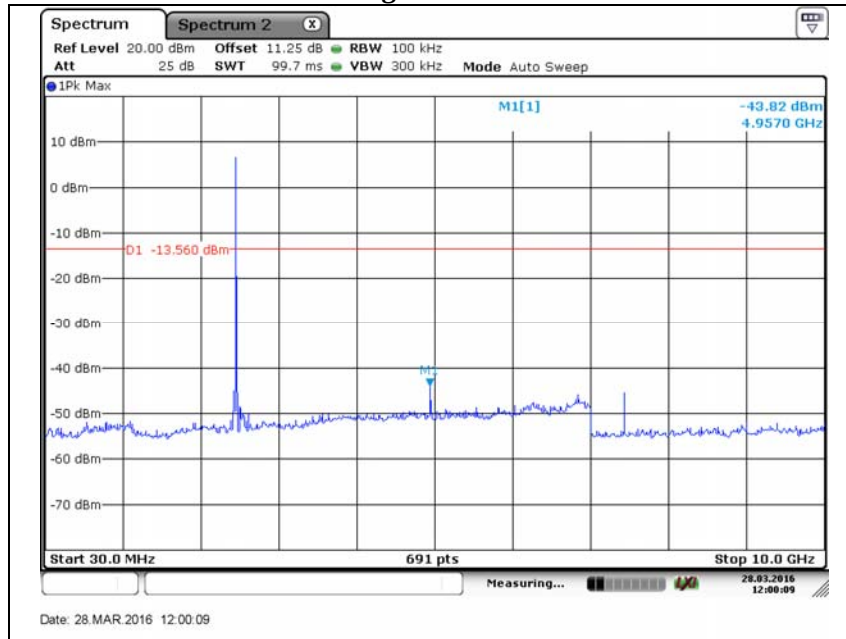
Low channel



Middle channel



High channel



3.6. AC conducted emissions

Limit

According to 15.207(a), for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50uH/50 ohm line impedance stabilization network (LISN). Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequencies ranges.

Frequency of Emission (MHz)	Conducted limit (dBμV/m)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

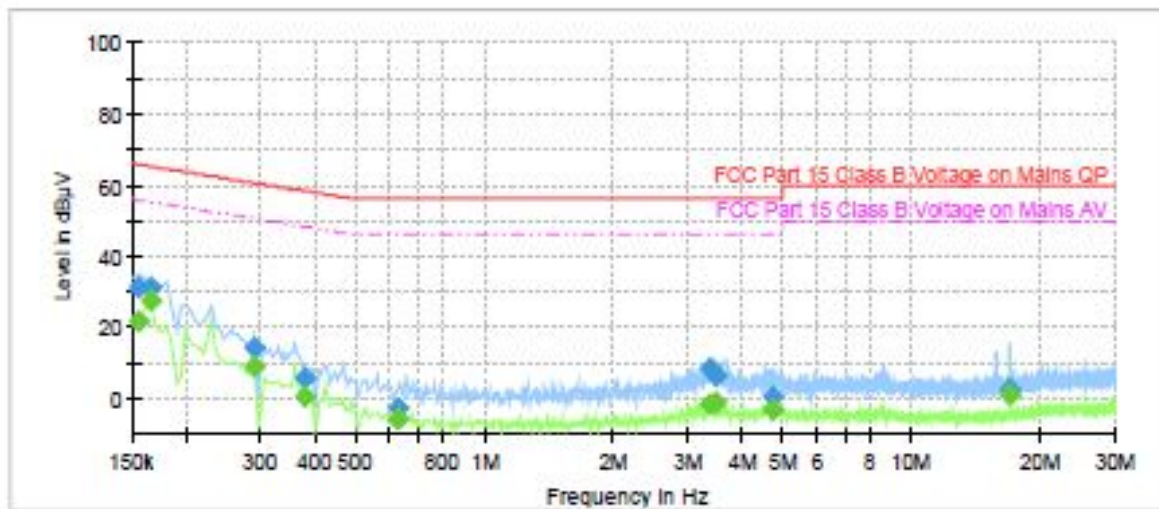
Note:

1. All AC line conducted spurious emission are measured with a receiver connected to a grounded LISN while the EUT is operating at its maximum duty cycle, at maximum power, and the appropriate frequencies. All data rates and modes were investigated for conducted spurious emission. Only the conducted emissions of the configuration that produced the worst case emissions are reported in this section.
3. Both Cable loss and LISN factor are included in measurement level(QP Level or AV Level).

Test results

Common Information

Test Description: Conducted Emission
Model No.: BTLEM4
Mode: +
Operator Name: KES

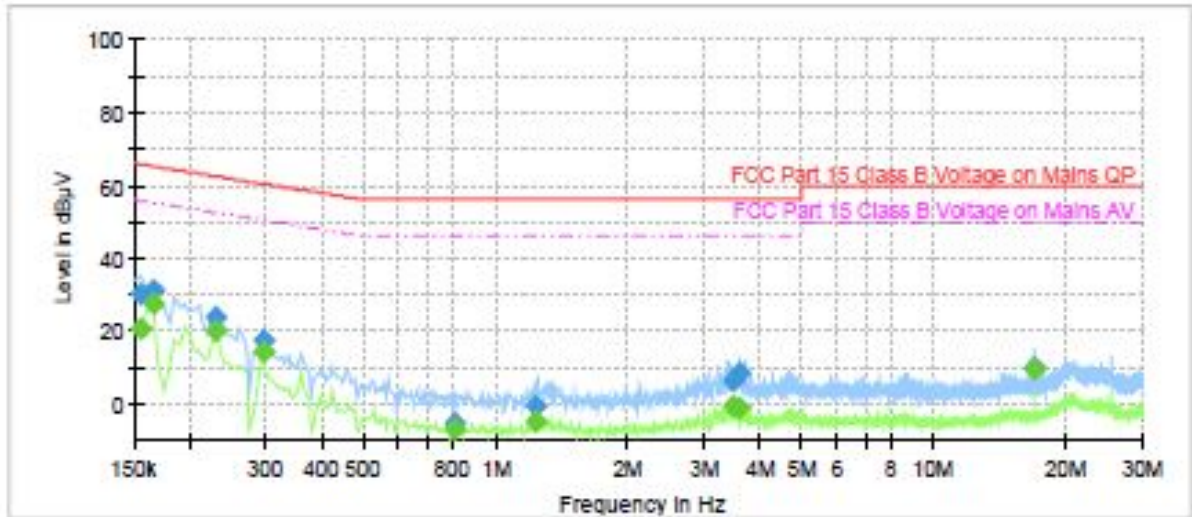


Final Result

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.155000	31.35	---	65.73	34.38	1000.0	9.000	L1	9.7
0.155000	---	21.87	55.73	33.86	1000.0	9.000	L1	9.7
0.165000	31.22	---	65.21	33.99	1000.0	9.000	L1	9.7
0.165000	---	27.60	55.21	27.61	1000.0	9.000	L1	9.7
0.290000	14.32	---	60.52	46.20	1000.0	9.000	L1	9.7
0.290000	---	9.16	50.52	41.36	1000.0	9.000	L1	9.7
0.380000	---	0.65	48.28	47.63	1000.0	9.000	L1	9.7
0.380000	5.62	---	58.28	52.66	1000.0	9.000	L1	9.7
0.625000	---	-5.59	46.00	51.59	1000.0	9.000	L1	9.7
0.625000	-2.78	---	56.00	58.78	1000.0	9.000	L1	9.7
3.385000	---	-1.41	46.00	47.41	1000.0	9.000	L1	9.8
3.385000	8.69	---	56.00	47.31	1000.0	9.000	L1	9.8
3.495000	6.41	---	56.00	49.59	1000.0	9.000	L1	9.8
3.495000	---	-0.94	46.00	46.94	1000.0	9.000	L1	9.8
4.740000	0.47	---	56.00	55.53	1000.0	9.000	L1	9.8
4.740000	---	-2.92	46.00	48.92	1000.0	9.000	L1	9.8
16.995000	---	1.15	50.00	48.85	1000.0	9.000	L1	10.1
16.995000	2.72	---	60.00	57.28	1000.0	9.000	L1	10.1

Common Information

Test Description: Conducted Emission
Model No.: BTLEM4
Mode: -
Operator Name: KES



Final Result

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.155000	30.45	---	65.73	35.28	1000.0	9.000	N	9.6
0.155000	---	20.62	55.73	35.11	1000.0	9.000	N	9.6
0.165000	31.00	---	65.21	34.21	1000.0	9.000	N	9.6
0.165000	---	27.46	55.21	27.75	1000.0	9.000	N	9.6
0.230000	---	20.37	52.45	32.08	1000.0	9.000	N	9.6
0.230000	23.85	---	62.45	38.60	1000.0	9.000	N	9.6
0.295000	---	14.10	50.38	36.28	1000.0	9.000	N	9.6
0.295000	17.69	---	60.38	42.69	1000.0	9.000	N	9.6
0.810000	-5.01	---	56.00	61.01	1000.0	9.000	N	9.7
0.810000	---	-7.07	46.00	53.07	1000.0	9.000	N	9.7
1.235000	---	-4.91	46.00	50.91	1000.0	9.000	N	9.7
1.235000	-0.36	---	56.00	56.36	1000.0	9.000	N	9.7
3.495000	---	-0.61	46.00	46.61	1000.0	9.000	N	9.7
3.495000	6.21	---	56.00	49.79	1000.0	9.000	N	9.7
3.590000	---	-0.85	46.00	46.85	1000.0	9.000	N	9.7
3.590000	8.47	---	56.00	47.53	1000.0	9.000	N	9.7
16.990000	---	9.57	50.00	40.43	1000.0	9.000	N	10.1
16.990000	10.20	---	60.00	49.80	1000.0	9.000	N	10.1

Appendix A. Measurement equipment

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due.
Spectrum analyzer	R&S	FSV30	101389	1 year	2017.01.25
8360B Series Swept Signal Generator	HP	83630B	3844A00786	1 year	2017.01.25
Loop antenna	R&S	HFH2-Z2.335.4711.52	826532	2 years	2017.03.03
Trilog-broadband antenna	Schwarzbeck	VULB 9168	9168-461	2 years	2017.04.03
Horn Antenna	A.H.	SAS-571	414	2 years	2017.02.09
Horn Antenna	Schwarzbeck	BBHA9170	BBHA9170550	2 years	2017.04.30
Preamplifier	SCHWARZBECK	BBV-9718	9718-246	1 year	2016.10.23
Broadband Amplifier	SCHWARZBECK	BBV-9721	PS9721-003	1 year	2017.01.25
Low Pass Filter	Wainwright Instrument	WLK1.0/18G-10TT	1	1 year	2016.07.24
High Pass Filter	Wainwright Instrument	WHJS3000-10TT	1	1 year	2016.07.24
Attenuator	Agilent	8493C	78799	1 year	2016.07.24
EMI Test Receiver	R & S	ESR3	101781	1 year	2016.05.06

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
Notebook	Samsung Electronics	NP-QX411L	HJV993BB905283V