TEST REPORT

Part 15 Subpart C 15.247

Equipment under test Luminaire Control Wireless Module

Model name BTLEM

FCC ID TSW-BTLEM

Applicant SAMJIN LND Co., Ltd.

Manufacturer SAMJIN LND Co., Ltd.

Date of test(s) 2016.03.08 ~ 2016.03.22, 25

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	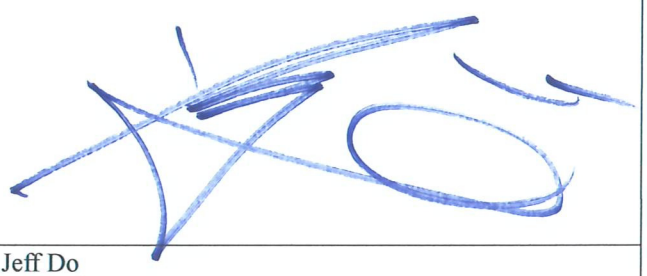
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Revision history

Revision	Date of issue	Test report No.	Description
-	2016.03.22	KES-RF-16T0036	Initial
1	2016.03.25	KES-RF-16T0036-R1	Add the AC conducted emissions test

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1. General information

Applicant:	SAMJIN LND Co., Ltd.
Applicant address:	64-17, Dongtangiheung-ro, Dongtan-myeon, Hwaseong-si, Gyeonggi-do, Korea
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FCC rule part(s):	15.247
FCC ID:	TSW-BTLEM
Test device serial No.:	☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

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

The device contains the following capabilities: Only Bluetooth LE

1.2. Information about derivative model

N/A

1.3. Device modifications

N/A

2. Summary of tests

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

Note:

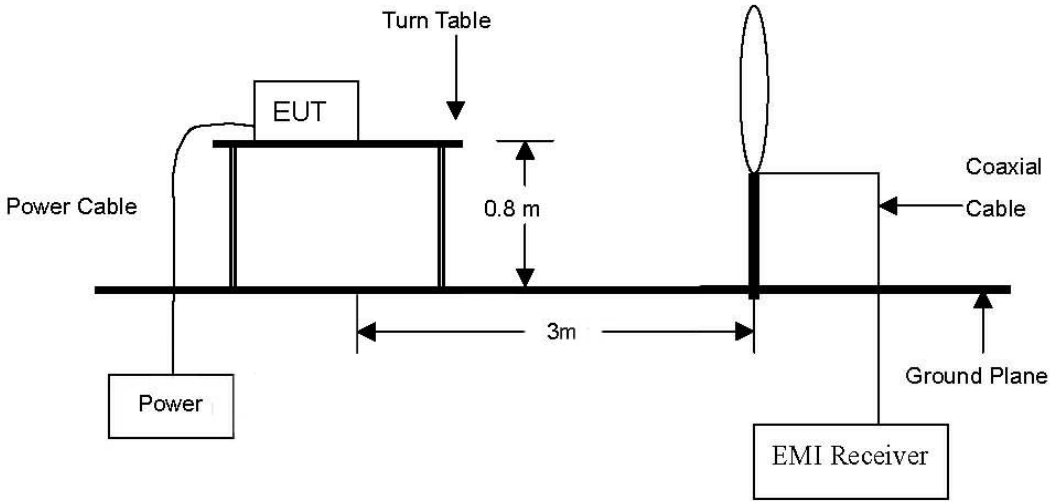
1. The EUT was tested per the guidance of KDB 558074 D01 v03r04. ANSI C63.10-2009 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing.
2. All modes of operation and data rates were investigated. The test results shown in the following sections represent the worst case emissions.

3. Test results

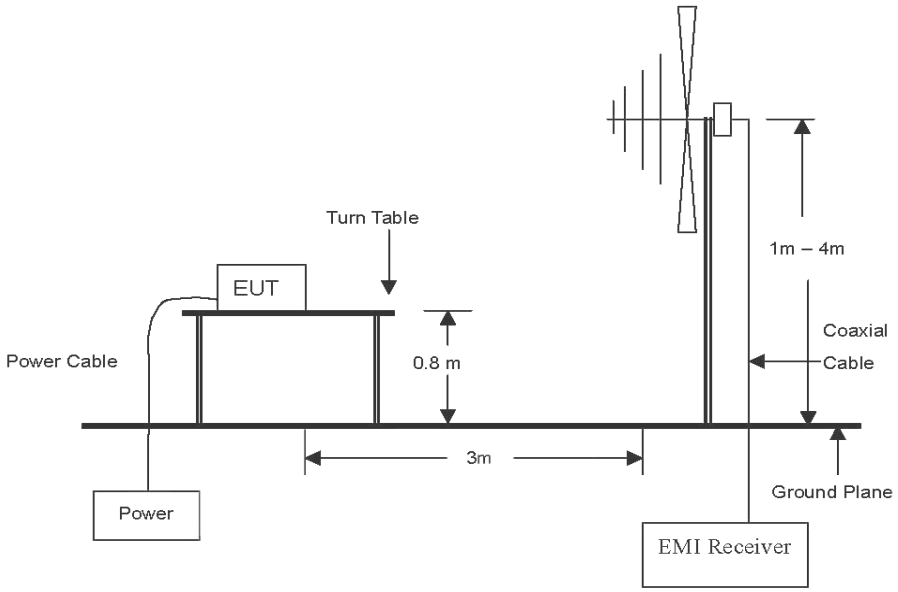
3.1 Radiated spurious emissions

Test setup

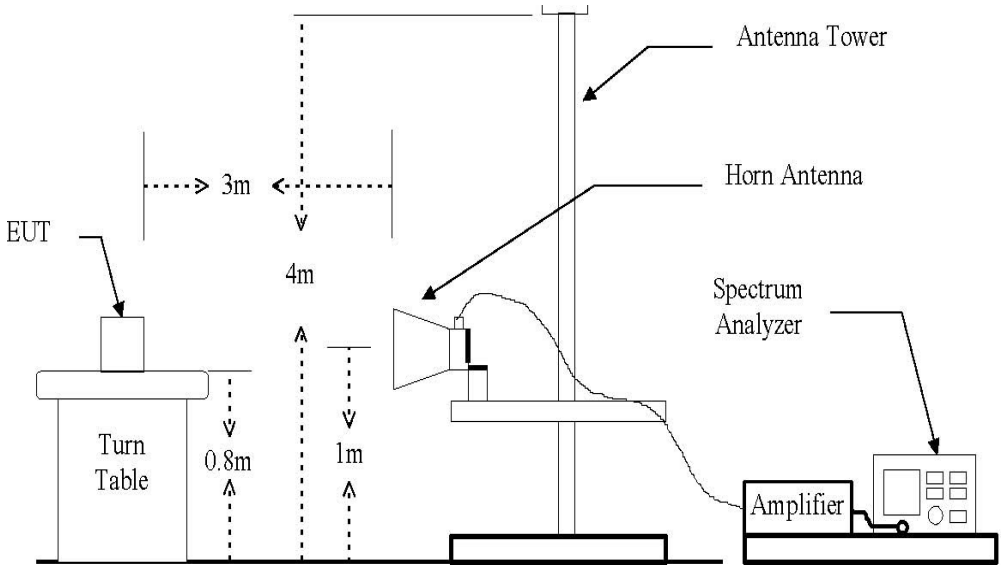
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 ㎑ to 30 ㎒ Emissions.



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



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



Test procedure
KDB 558074 D01 v03r04 – section 12.1 and 12.2

Test settings
Peak Field Strength Measurements per Section 12.2.4 of KDB 558074 D01 v03r04
1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1 ㎒
3. VBW ≥ 3 ㎒
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize

Average Field Strength Measurements per Section 12.2.5.3 of KDB 558074 D01 v03r04
1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1 ㎒
3. VBW = 3 ㎑ > 1/T
4. Averaging type was set to RMS to ensure that video filtering was applied in the power domain.
5. Detector = peak
6. Sweep time = auto
7. Trace mode = max hold
8. Trace was allowed to run for at least 50 times (1/duty cycle) traces

Note:

1. The optional test procedures for antenna port conducted measurements of unwanted emissions per the guidance of KDB 558074 D01 v03r04 were not used to evaluate this device for compliance to radiated limits. All radiated spurious emissions levels were measured in a radiated test setup.
2. The spectrum is measured from 9 ㎑ to the 10th harmonic of the fundamental frequency of the transmitter using CISPR quasi peak detector below 1 ㎓. Above 1 ㎓, average and peak measurements were taken using linearly polarized horn antennas. The worst-case emissions are reported however emissions whose levels were not within 20 ㏈ of the respective limits were not reported.
3. Emissions below 18 ㎓ were measured at a 3 meter test distance while emissions above 18 ㎓ were measured at a 1 meter test distance with the application of a distance correction factor.
4. Average test would be performed if the peak result were greater than the average limit.
5. Field strength(㏈㎶/m) = Level(㏈㎶) + Correction factors(㏈/m) + Cable loss(㏈) + F_d(㏈)
6. Correction factors(㏈/m) = Antenna factor(㏈/m) + Cable loss(㏈) + or Amp. gain(㏈)
7. Margin(㏈) = Limit(㏈㎶/m) - Field strength(㏈㎶/m)
8. $f \leq 30$ ㎒, extrapolation factor of 40 ㏈/decade of distance. $F_d = 40\log(D_m / D_s)$
   $f > 30$ ㎒, extrapolation factor of 20 ㏈/decade of distance. $F_d = 20\log(D_m / D_s)$
   Where:
   F_d = Distance factor in ㏈
   D_m = Measurement distance in meters
   D_s = Specification distance in meters

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 (㎒)	Distance (Meters)	Radiated (㎶/m)
0.009 ~ 0.490	300	2 400 / F(㎑)
0.490 ~ 1.705	30	24 000 / F(㎑)
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 ㎒, 76 ~ 88 ㎒, 174 ~ 216 ㎒ or 470 ~ 806 ㎒. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

Test results (Below 30 ㎒)

Mode:	Bluetooth LE
Transfer rate:	1 Mbps
Distance of measurement:	3 meter
Operating frequency:	2 442 ㎒ (Worst case)
Channel:	20

Frequency (㎒)	Level (dB㎶)	Ant. Pol. (H/V)	Ant. factor (dB/m)	Cable loss (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No signal detected							

Test results (Below 1 000 ㎒)

Mode:	Bluetooth LE
Transfer rate:	1 Mbps
Distance of measurement:	3 meter
Operating frequency:	2 442 ㎒ (Worst case)
Channel:	20

Frequency (㎒)	Level (dB㎶)	Ant. Pol. (H/V)	Ant. factor (dB/m)	Cable loss (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
48.17	9.25	V	13.87	1.42	24.54	40.00	15.46
62.98	10.76	V	11.79	1.65	24.20	43.50	19.30
216.85	9.37	V	11.67	3.45	24.49	46.00	21.51
269.80	7.61	H	12.79	3.96	24.36	46.00	21.64
385.09	7.30	H	15.35	4.96	27.58	46.00	18.42
464.42	7.33	H	16.60	5.50	29.43	46.00	16.57

Note.
1. All spurious emission at channels are almost the same below 1 ㎓, so that middle channel was chosen at representative in final test.
2. Actual = Reading + Ant. factor + Cable loss
3. Detector mode: Quasi peak
4. To get a maximum emission level from the EUT, the EUT was moved throughout the XY, XZ and YZ planes.

Test results (Above 1 000 ㎒)

Mode: Bluetooth LE
Transfer rate: 1 Mbps
Distance of measurement: 3 meter
Operating frequency: 2 402 ㎒
Channel: 0

Frequency (㎒)	Level (dB㎶)	Detector mode	Ant. Pol. (H/V)	Correction factors (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2389.88	50.72	Peak	H	-0.95	49.77	74.00	24.23
2389.90	52.01	Peak	V	-0.95	51.06	74.00	22.94
4803.89	44.66	Peak	H	8.07	52.73	74.00	21.27
4804.29	45.55	Peak	V	8.07	53.62	74.00	20.38

Mode: Bluetooth LE
Transfer rate: 1 Mbps
Distance of measurement: 3 meter
Operating frequency: 2 442 ㎒
Channel: 20

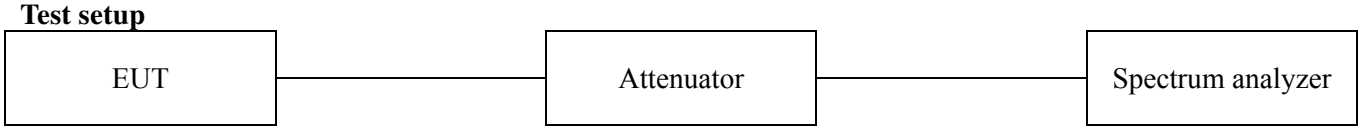
Frequency (㎒)	Level (dB㎶)	Detector mode	Ant. Pol. (H/V)	Correction factors (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
4883.98	43.70	Peak	H	8.64	52.34	74.00	21.66
4883.74	45.03	Peak	V	8.64	53.67	74.00	20.33

Mode: Bluetooth LE
Transfer rate: 1 Mbps
Distance of measurement: 3 meter
Operating frequency: 2 480 ㎒
Channel: 39

Frequency (㎒)	Level (dB㎶)	Detector mode	Ant. Pol. (H/V)	Correction factors (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2483.62	53.16	Peak	H	-0.45	52.71	74.00	21.29
2483.62	54.04	Peak	V	-0.45	53.59	74.00	20.41
4959.96	43.70	Peak	H	9.18	52.88	74.00	21.12
4957.30	44.71	Peak	V	9.17	53.88	74.00	20.12

3.2 Conducted spurious emissions & band edge

Test setup



Test procedure

Band edge

KDB 558074 D01 v03r04 – Section 11.3

Test settings

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 ㎑
4. VBW = 300 ㎑
5. Detector = Peak
6. Number of sweep points ≥ 2 × Span/RBW
7. Trace mode = max hold
8. Sweep time = auto couple
9. The trace was allowed to stabilize

Out of band emissions

Test settings

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

Note.

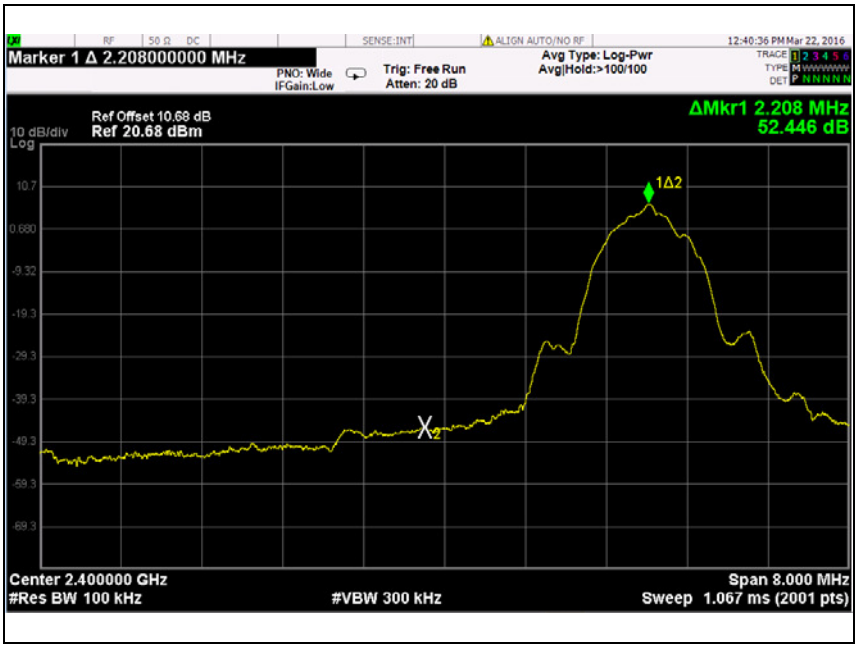
1. RBW was set to 1㎒ rather than 100㎑ in order to increase the measurement speed.
2. The display line shown in the following plots denotes the limit at 20dB below the fundamental emission level measured in a 100kHz bandwidth. However, since the traces in the following plots are measured with a 1MHz RBW, the display line may not necessarily appear to be 20dB below the level of the fundamental in a 1MHz bandwdith.
3. For plots showing conducted spurious emissions near the limit, the frequencies were investigated with a reduced RBW to ensure that no emissions were present.

Limit

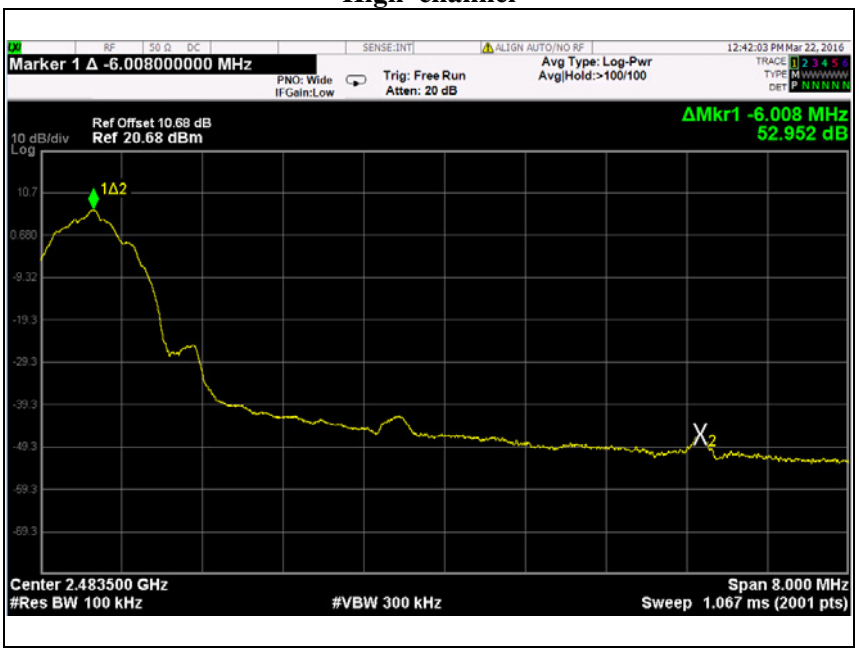
According to 15.247(d), in any 100 ㎑ bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 ㏈ below that in the 100 ㎑ bandwidth within the band 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 ㏈ instead of 20 ㏈. 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

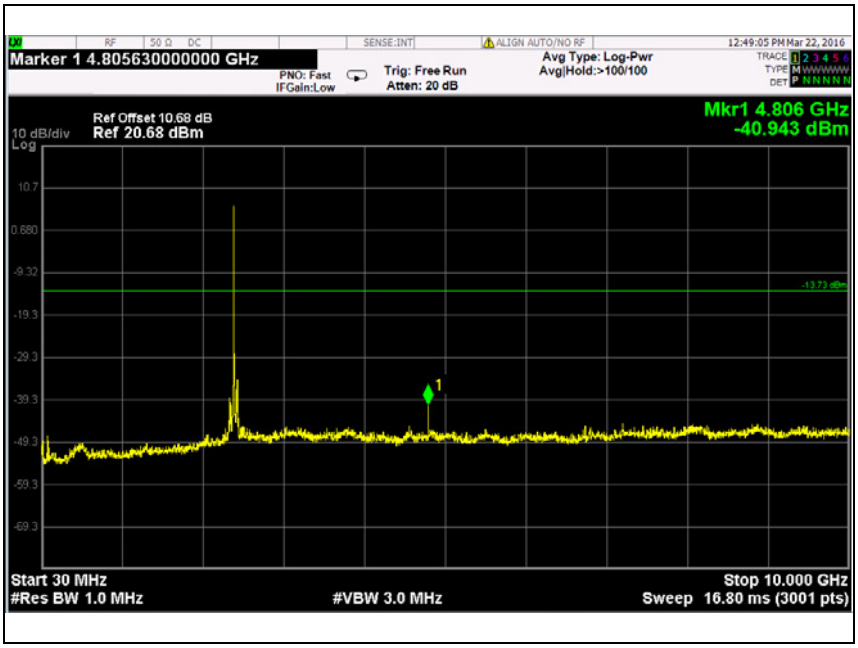


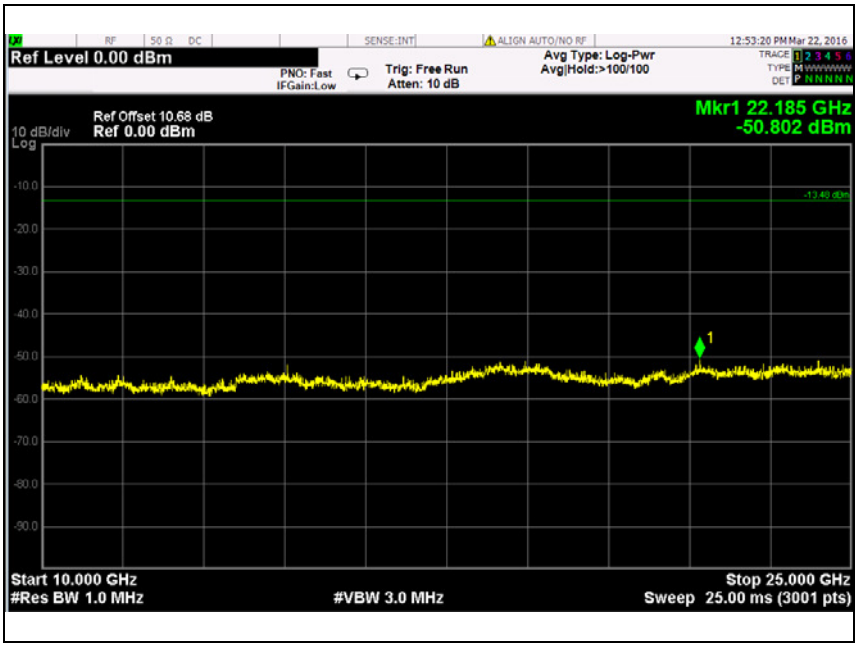
High channel



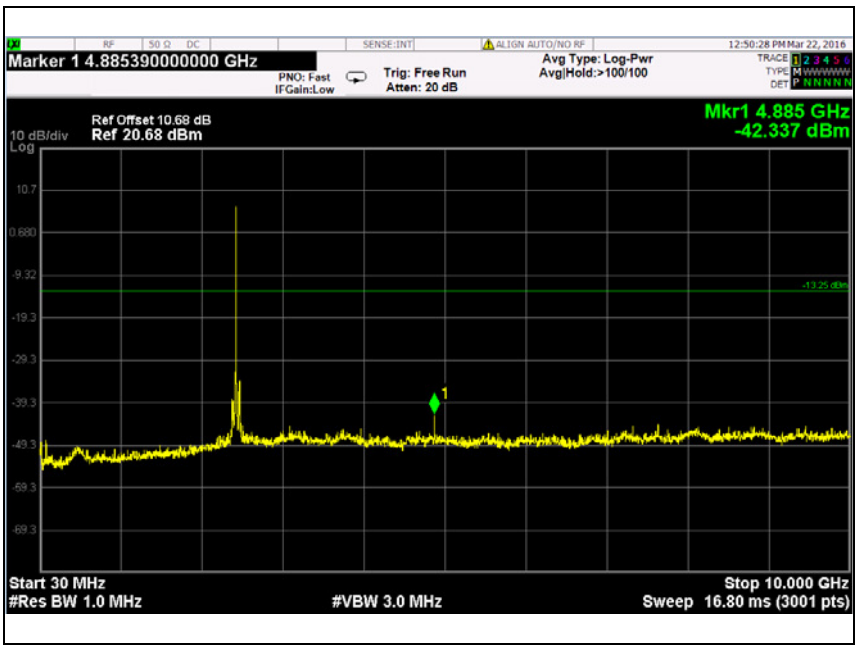
Test results (spurious emission)

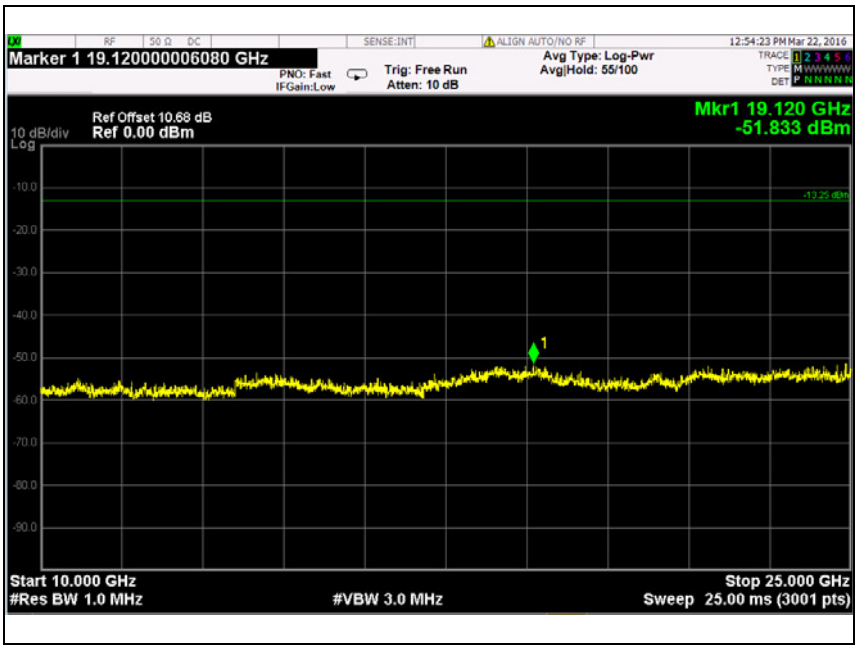
Low channel



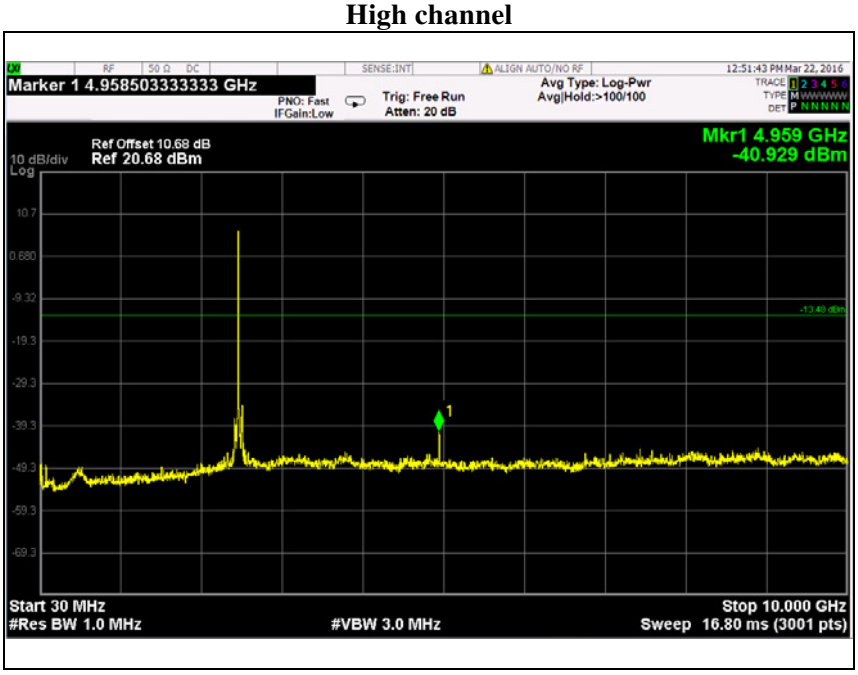


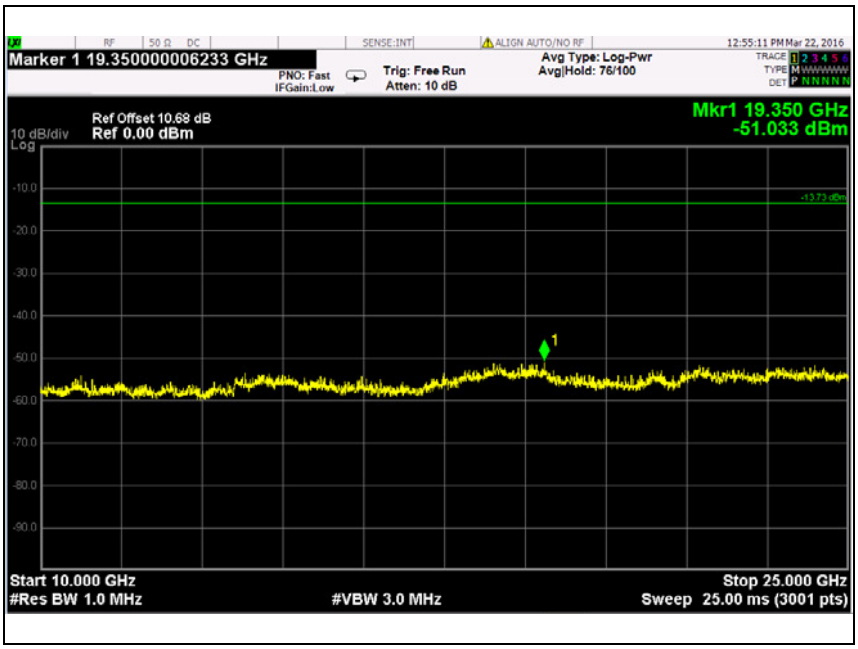
Middle channel





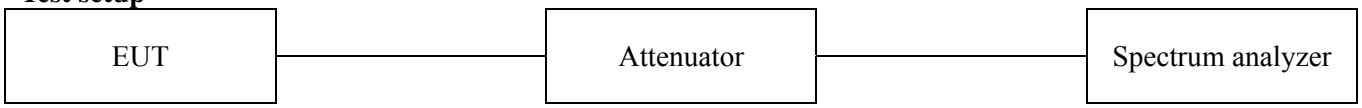
High channel





3.3. 6 dB bandwidth

Test setup



Test procedure

KDB 558074 D01 v03r04 – Section 8.2

Test Settings

1. The signal analyzers' automatic bandwidth measurement capability of the spectrum analyzer was used to perform the 6dB bandwidth measurement. The "X" dB bandwidth was set to X = 6. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. RBW = 100 ㎑.
3. VBW ≥ 3 × RBW.
4. Detector = peak.
5. Trace mode = max hold.
6. Sweep = auto couple.
7. The trace was allowed to stabilize.

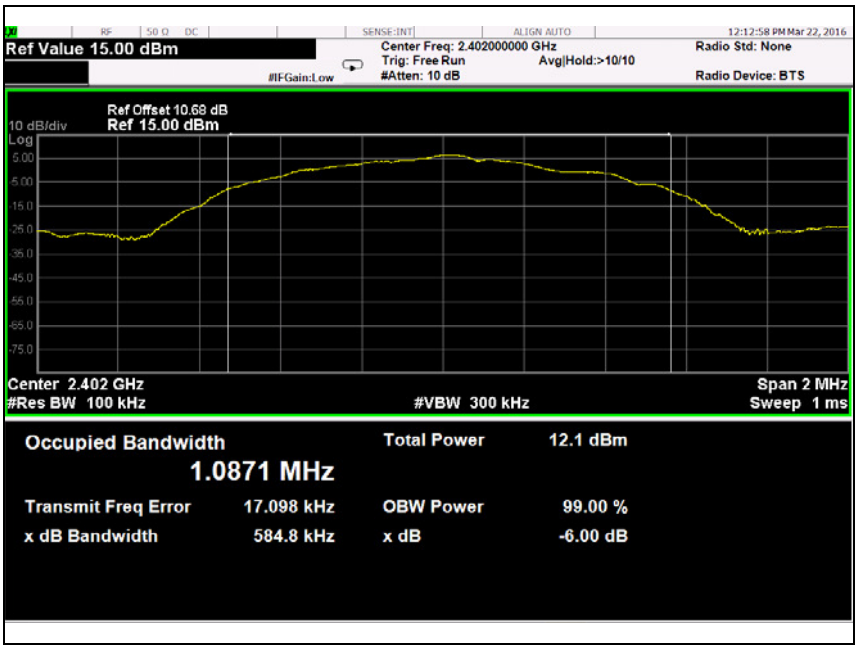
Limit

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

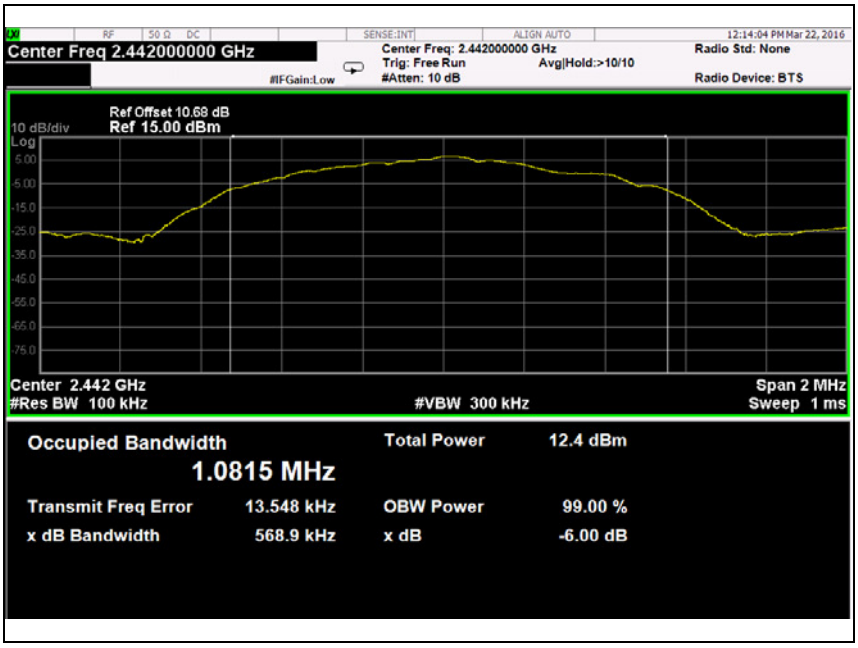
Test results

Test Mode	Frequency(㎒)	6 dB bandwidth(㎒)	Limit(㎒)
LE	2 402	0.585	0.5
	2 442	0.569	
	2 480	0.605	

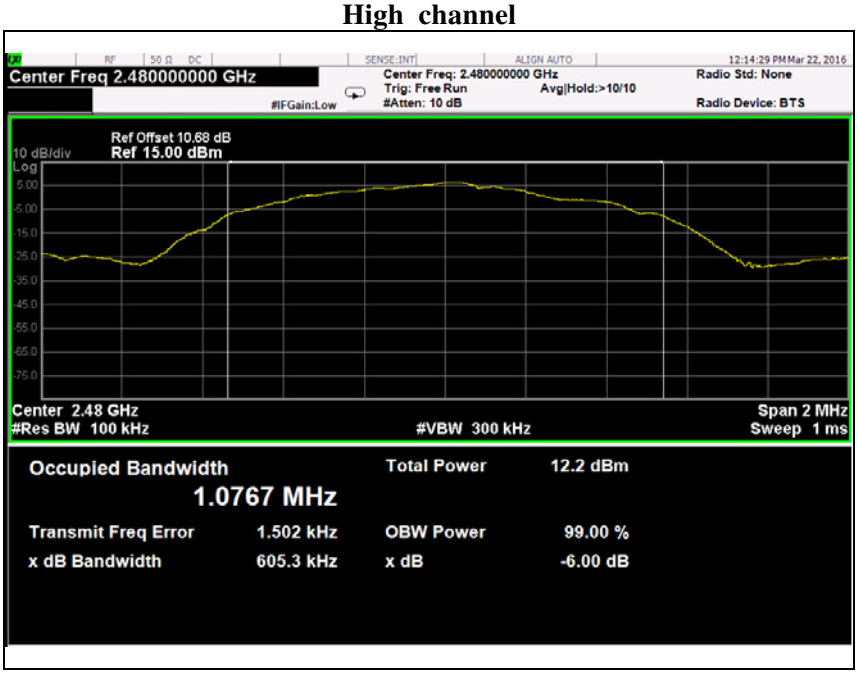
Low channel



Middle channel

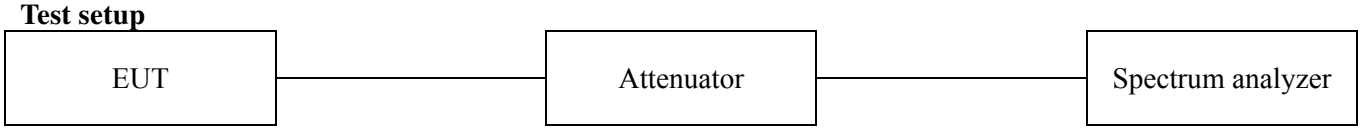


High channel



3.4. Output power

Test setup



Test procedure

KDB 558074 D01 v03r04 – section 9.1.1

All data rates and modes were investigated for conducted spurious emissions. Only the conducted emissions of the configuration that produced the worst case emissions are reported in this section.

Test Settings

1. Set the RBW ≥ DTS bandwidth.
2. Set VBW ≥ 3 RBW.
3. Set span ≥ 3 x 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.

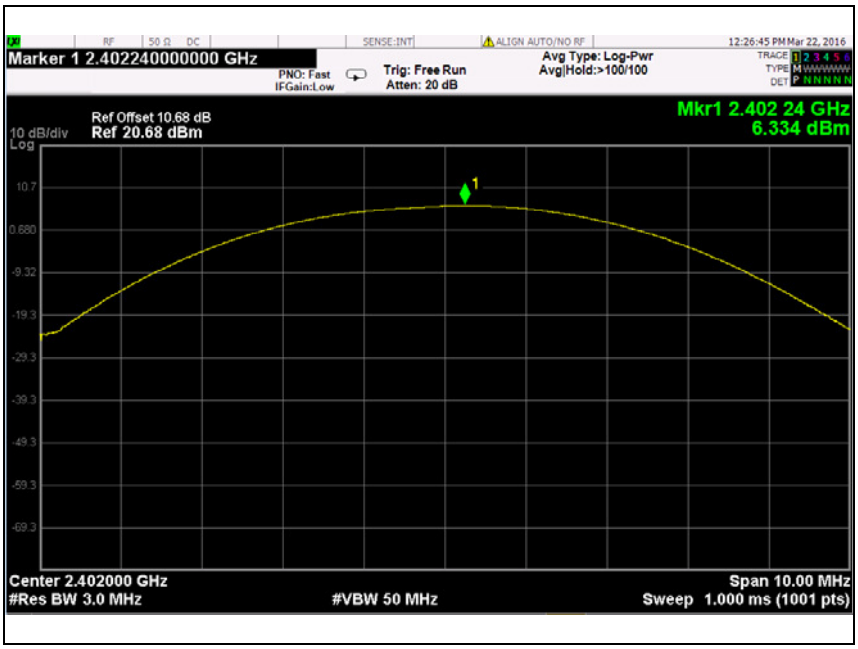
Limit

According to §15.247(b)(3), For systems using digital modulation in the 902~928 ㎒, 2 400~2 483.5 ㎒, and 5 725~5 850 ㎒ 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 ㏈i. Except as shown in paragraph (c) of this section, if transmit-ting antennas of directional gain greater than 6 ㏈i 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 ㏈i.

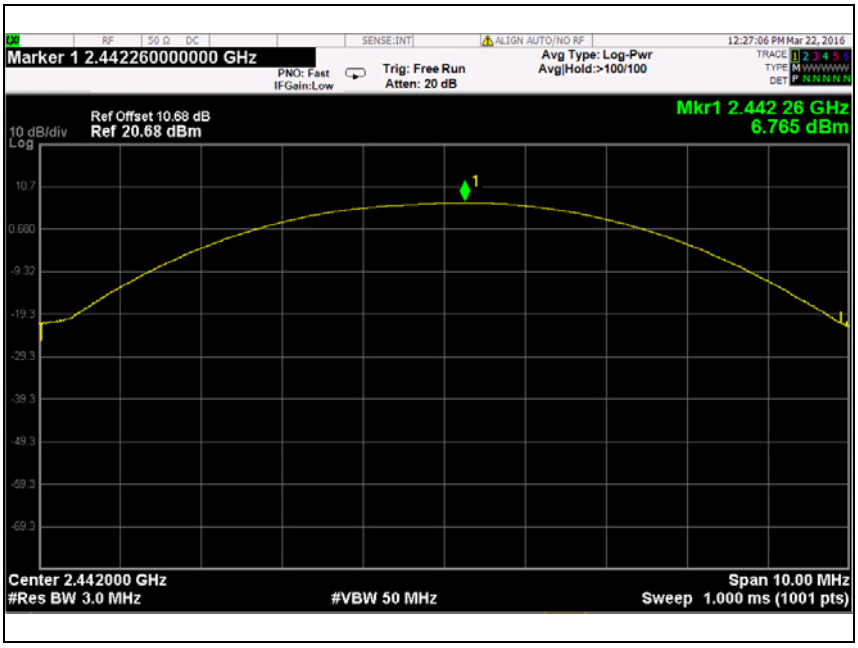
Test results

Test Mode	Frequency(㎒)	Conducted power (dBm)	Limit(dBm)
LE	2 402	6.33	30
	2 442	6.77	
	2 480	6.52	

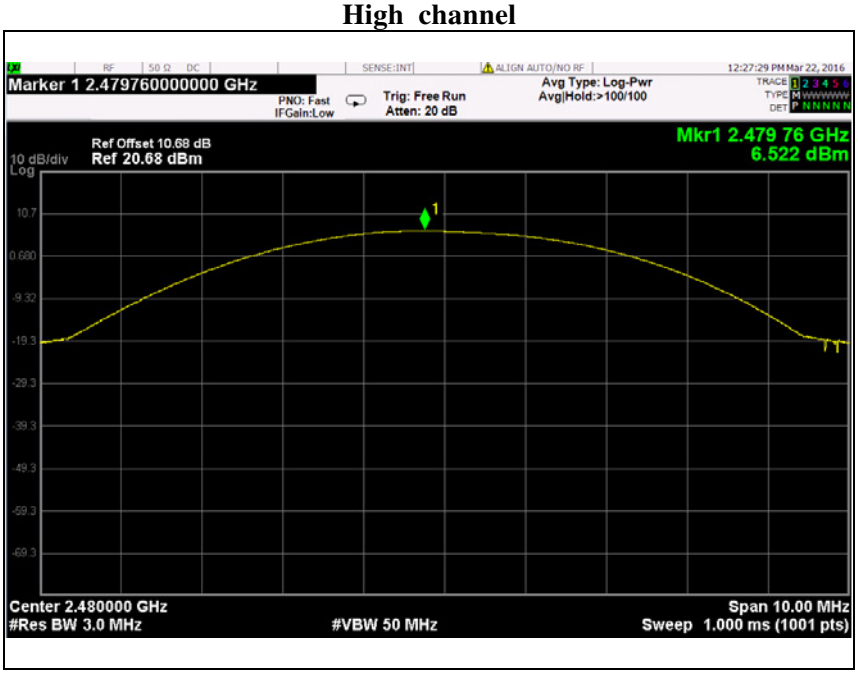
Low channel



Middle channel

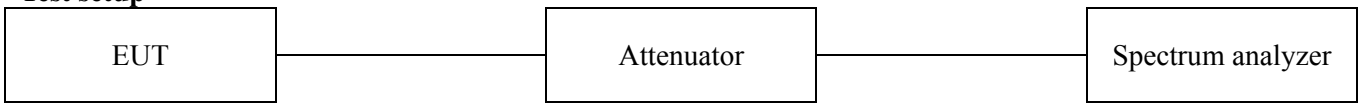


High channel



3.5. Power spectral density

Test setup



Test procedure

KDB 558074 D01 v03r04 – section 10.2

Test Settings

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 ㎑ ≤ RBW ≤ 100 ㎑
4. Set the VBW ≥ 3 × 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 ㎑) and repeat.

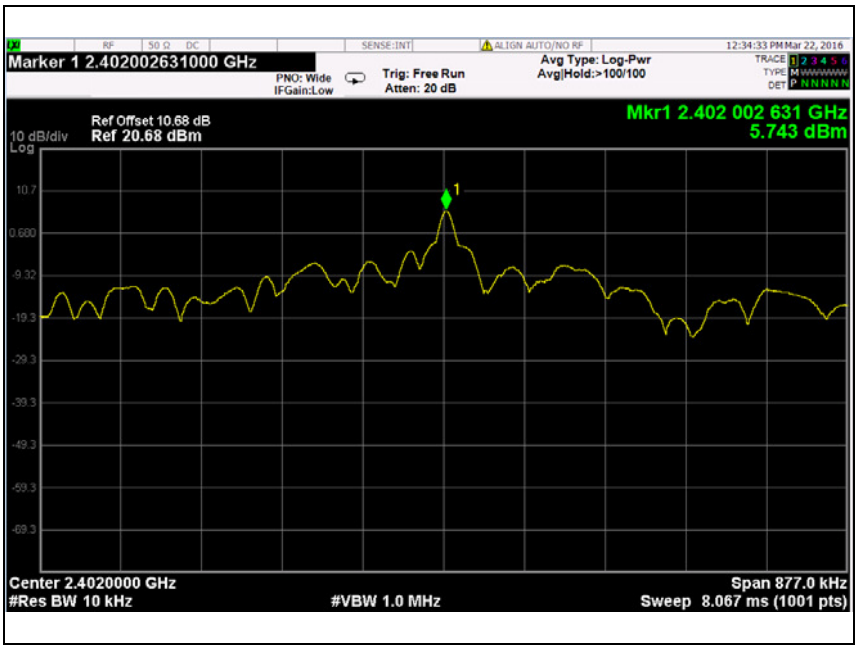
Limit

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 ㏈m in any 3 ㎑ 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.

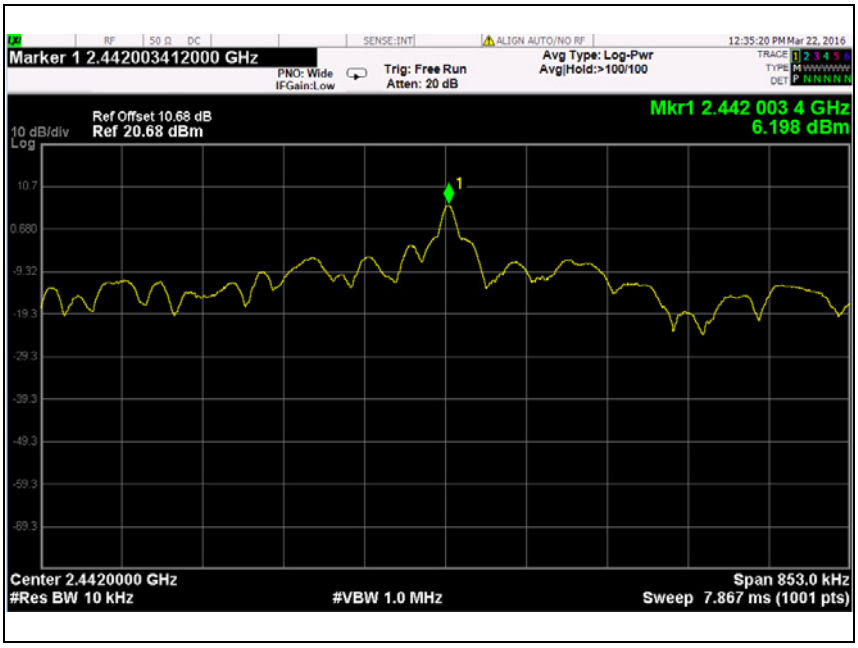
Test results

Test Mode	Frequency(㎒)	PPSD (dBm)	Limit(dBm)
LE	2 402	5.74	8
	2 442	6.20	
	2 480	5.92	

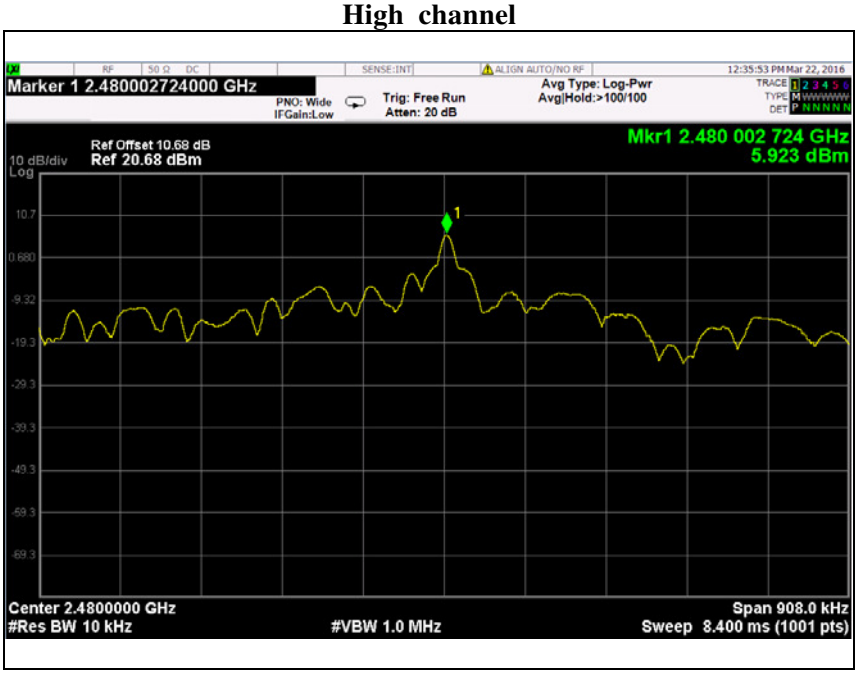
Low channel



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 ㎑ to 30 ㎒, 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 (㎒)	Conducted limit (dB㎶/m)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

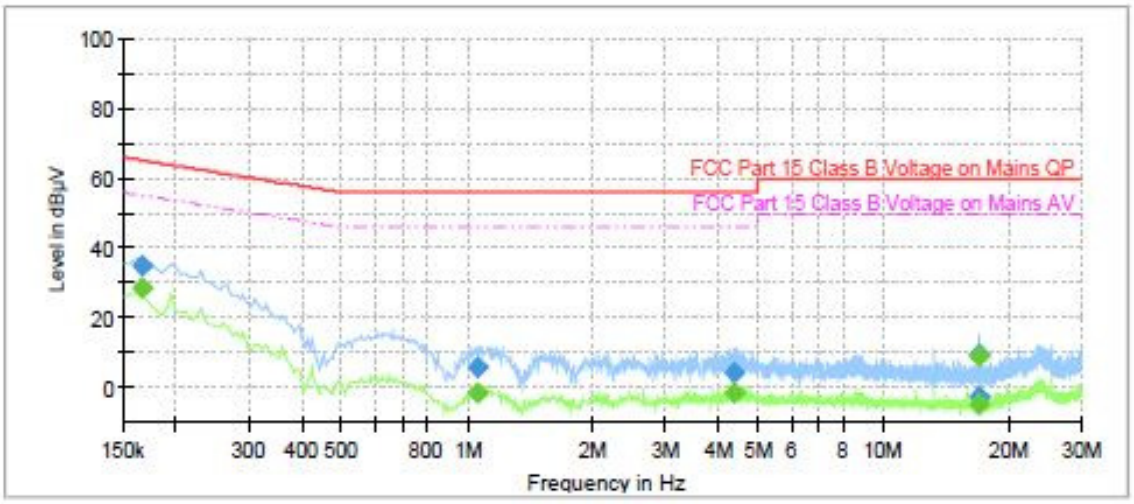
Note:

1. All modes of operation, data rates, and test channels were investigated and the worst-case emissions are reported in middle Channel. The emissions found were not affected by the choice of channel used during testing.
2. The limit for Class B device(s) from 150 ㎑ to 30 ㎒ are specified in Section 15.207 of the Title 47 CFR.
3. Both Cable loss and LISN factor are included in measurement level(QP Level or AV Level).
4. Deviations to the Specifications: None.

Test results

Common Information

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



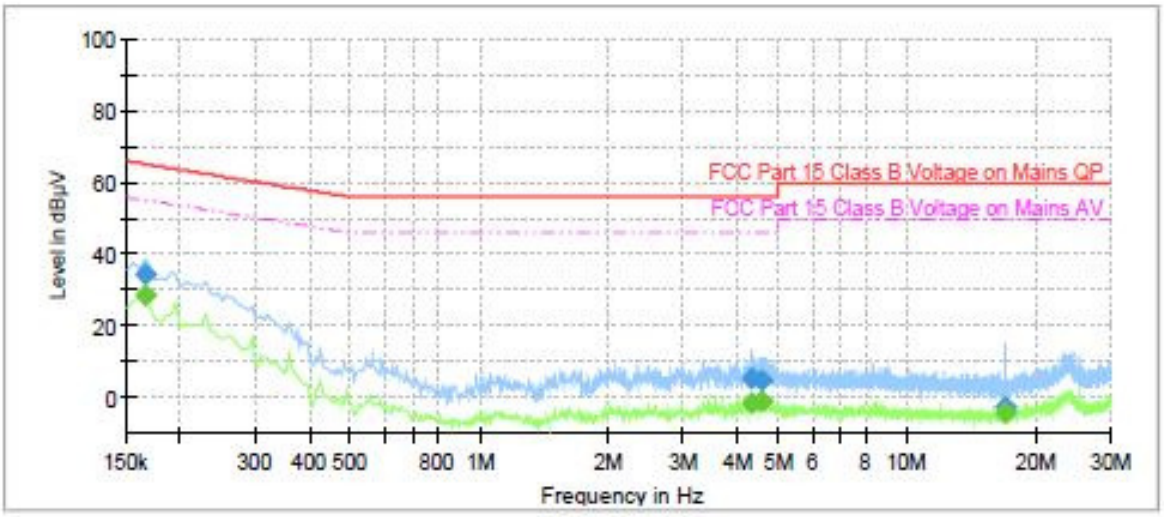
Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.165000	---	28.52	55.21	26.69	1000.0	9.000	L1	9.7
0.165000	34.79	---	65.21	30.42	1000.0	9.000	L1	9.7
1.060000	---	-1.69	46.00	47.69	1000.0	9.000	L1	9.7
1.060000	6.04	---	56.00	49.96	1000.0	9.000	L1	9.7
4.370000	---	-1.57	46.00	47.57	1000.0	9.000	L1	9.8
4.370000	4.15	---	56.00	51.85	1000.0	9.000	L1	9.8
17.045000	---	9.17	50.00	40.83	1000.0	9.000	L1	10.1
17.045000	9.59	---	60.00	50.41	1000.0	9.000	L1	10.1
17.050000	---	-4.59	50.00	54.59	1000.0	9.000	L1	10.1
17.050000	-2.55	---	60.00	62.55	1000.0	9.000	L1	10.1

Note;
Both Cable loss and LISN factor are included in measurement level(QP Level or AV Level).

Common Information

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



Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.165000	---	28.46	55.21	26.75	1000.0	9.000	N	9.6
0.165000	34.57	---	65.21	30.64	1000.0	9.000	N	9.6
4.360000	---	-1.34	46.00	47.34	1000.0	9.000	N	9.8
4.360000	5.36	---	56.00	50.64	1000.0	9.000	N	9.8
4.575000	---	-1.22	46.00	47.22	1000.0	9.000	N	9.8
4.575000	4.96	---	56.00	51.04	1000.0	9.000	N	9.8
16.995000	---	-4.43	50.00	54.43	1000.0	9.000	N	10.1
16.995000	-2.46	---	60.00	62.46	1000.0	9.000	N	10.1

Note;
Both Cable loss and LISN factor are included in measurement level(QP Level or AV Level).

Appendix A. Measurement equipment

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due.
Spectrum analyzer	Agilent	N9010A	MY51440103	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
EMI Test Receiver	R & S	ESR3	101783	1 year	2016.05.06
LISN	R & S	ENV216	101137	1 year	2017.02.04

Peripheral devices

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