FCC Part 15.247 RF TEST REPORT

Test Report Number……	**RBC-18070901-FCC-RF-BeaconSensor Rev1.0**
Applicant……	**Roambee Corporation**
Applicant Address……	**3120 De La Cruz Blvd Suite 121, Santa Clara, CA 95054**
Product Name……	BeeBeacon Damage
Model Number……	BB-SHK-1
Family Product/Model……	BeeBeacon ColdChain / BB-TPH-1 BeeBeacon VO Gas / BB-VOC-1 BeeBeacon Probe TPH / BB-FLEX-TPH BeeBeacon Probe VOC / BB-FLEX-VOC
FCC ID……	2ALG8BB-SENS
Date of EUT received……	07/12/2018
Date of Test……	07/16/2018 – 08/03/2018
Report Issue Date……	08/08/2018
Test Standards……	**47CFR Part 15.247: 2018**
Test Result……	Pass

Issued By:

Vista Laboratories, Inc.

1261 Puerta Del Sol, San Clemente, CA 92673 USA

www.vista-compliance.com

Tested by:	**Approved By:**
Sherwin Lee/Test Engineer	**David Zhang/Technical Manager**

Laboratory Introduction

Vista Labs is an A2LA accredited 17025 compliant regulatory compliance testing laboratories (Cert. number: 4848-01) and product certification service provider strategically located in Orange County, providing services in the electrical and telecommunication industries. Vista labs is also recognized testing facility for Australia (ACMA), Chinese Taipei (BSMI), Chinese Taipei (NCC), Hong Kong (OFCA), Israel (MOC), Korea (RRA), Singapore (IMDA), Vietnam (MIC), etc.

Our comprehensive testing services include safety testing, EMC emission and susceptibility testing, RF and wireless testing (including DFS).

As your partner, Vista investigates appropriate test standards, develops test plans, performs troubleshooting & failure analysis, reviews documentation, and provides test reports for a complete compliance testing and certification package.

Accredited Laboratory

A2LA has accredited

VISTA LABORATORIES, INC.

San Clemente, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated April 2017*).

Presented this 21st day of June 2018.

President and CEO
For the Accreditation Council
Certificate Number 4848.01
Valid to July 31, 2020

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

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REVISION HISTORY

Revision	Issue Date	Description	Note
Original	08/03/2018	Original release	N/A
Rev1.0	08/08/2018	Correct test lab information	N/A

1 General Information

1.1 Applicant

Applicant:	Roambee Corporation
Applicant address:	3120 De La Cruz Blvd #121, Santa Clara, CA 95054
Manufacturer:	Roambee Corporation
Manufacturer Address:	3120 De La Cruz Blvd #121, Santa Clara, CA 95054

1.2 Product information

Product Name	BeeBeacon Damage
Model Number	BB-SHK-1
Family Product/Model Number	BeeBeacon ColdChain / BB-TPH-1 BeeBeacon VO Gas / BB-VOC-1 BeeBeacon Probe TPH / BB-FLEX-TPH BeeBeacon Probe VOC / BB-FLEX-VOC
Serial Number	N/A
Frequency Band	BLE: 2402-2480MHz
Type of modulation	GFSK
Equipment Class/ Category	DTS
Maximum output power	2.501 dBm
Antenna Information	SMD chip antenna (P/N 2500AT44M0400) Gain: 2.5 dBi
Clock Frequencies	N/A
Port/Connectors	N/A
Input Power	Battery: 2*AAA (Alkaline 2000mAh)
Power Adapter Manu/Model	N/A
Power Adapter SN	N/A
Hardware version	N/A
Software version	N/A
Simultaneous Transmission	N/A
Additional Info	See following list of family models/differences

Product difference within family

Product Name	**Model Number**	**Configuration**
BeeBeacon Damage	BB-SHK-1	Beacon sensor BLE + BMI160
BeeBeacon ColdChain	BB-TPH-1	Beacon sensor BLE + BMI160 + BME280
BeeBeacon VO Gas	BB-VOC-1	Beacon sensor BLE + BMI160 + BME680
BeeBeacon Probe TPH	BB-FLEX-TPH	Beacon sensor BLE + BMI160 + FLEX BME280
BeeBeacon Probe VOC	BB-FLEX-VOC	Beacon sensor BLE + BMI160 + FLEX BME680

Note: The PCB of these models are almost the same, the major difference is the type of sensor they carry on the board varies depending on the actual required function. Different sensor combination creates these varieties. But the hardware construction, essential components and functionality are the same.
The BB-FLEX-TPH and BB-FLEX-VOC are with removable external FLEX BME280 or FLEX BME680 while other models are not. These physical difference does not affect the RF performance and characteristic.

1.3 Test standard and method

Test standard	47CFR Part 15.247: 2018
Test method	ANSI C63.10: 2013 558074 D01 DTS Meas Guidance v04 (April 5, 2017)

1.4 Test Purpose and statement

The purpose of this test report is intended to demonstrate the compliance of product listed in section 1.2, received from company listed in section 1.1, to the requirements of standard and method listed in section 1.3. Based on our test results, we conclude that the product tested complies with the requirements of the standards indicated.

2 Test site information

Lab performing tests	**Vista Laboratories, Inc.**
Lab Address	1261 Puerta Del Sol, San Clemente, CA 92673 USA
Phone Number	+1 (949) 393-1123
Website	www. Vista-compliance.com

Test condition	Test Engineer	Test Environment	Test Date
RF conducted	Sherwin Lee	23.5°C / 58.2%/996 mbar	07/16/2018 – 08/03/2018
Radiated	Sherwin Lee	23.5°C / 58.2%/996 mbar	07/16/2018 – 08/03/2018

3 Modification of EUT

For RF conducted measurement purpose, the original antenna of test sample was removed and replace with external SMA connector; a short serial wire cable was soldered onto the PCB for sending command from Laptop to EUT to enable RF test mode; the special test firmware is used for testing purpose.

For Radiated measurement, a short serial wire cable was soldered onto the PCB for sending command from Laptop to EUT to enable RF test mode; the special test firmware is used for testing purpose. No other physical modification was made.

4 Test configuration and operation

4.1 EUT test configuration

EUT is powered by internal battery. It is connected to a test laptop through serial cable to receive test command for RF measurement. Tera Term serial port software is used to send command to EUT to enable the RF test mode.

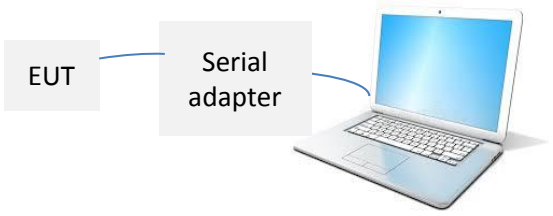
4.2 EUT test mode

Radio	Channel	Data Rates	Frequency (MHz)
BLE	1 (Low)	1 Mbps	2402
BLE	17 (Mid)	1 Mbps	2440
BLE	39 (High)	1 Mbps	2480
BLE	1 (Low)	2 Mbps	2402
BLE	17 (Mid)	2 Mbps	2440
BLE	39 (High)	2 Mbps	2480

4.3 Supporting Equipment

Index	Description	Model	S/N	Brand	Remark
1	Laptop	P29G003	G1H5102	Dell	N/A

4.4 EUT setup diagram



4.5 EUT operation

Tera Term serial port software is used to send command to EUT to enable the RF test mode.

4.6 Test software

Index	Description	Remark
1	Tera Term Ver.4.99	Serial utility software to send command to device for running RF test mode.
2	EMISoft Vasona 6.0049	EMC/Spurious emission test software used during testing

5 EUT and test setup pictures

5.1 EUT pictures

See FCC filing

5.2 EUT test setup pictures

See FCC filing

6 Test Summary

FCC Rules	Test Item	Test standard	Section in report	Verdict
§15.203	Antenna Requirement	47CFR Part 15.247	8.1	Pass
§15.247 (a)(2)	DTS (6 dB) Channel Bandwidth	47CFR Part 15.247	8.2	Pass
§15.247(b)(3)	Conducted Maximum Output Power	47CFR Part 15.247	8.3	Pass
§15.247(e)	Power Spectral Density	47CFR Part 15.247	8.4	Pass
§15.247(d)	Conducted Band-Edge & Unwanted Emissions	47CFR Part 15.247	8.5	Pass
§15.207 (a)	AC Power Line Conducted Emissions	47CFR Part 15.247	N/A	N/A 1)
§15.205, §15.209, §15.247(d)	Radiated Emissions & Unwanted Emissions into Restricted Frequency Bands	47CFR Part 15.247	8.6	Pass

Note:

1) EUT is powered by battery only. This item is not applicable.
2) RF conducted measurement is only performed on the main model: BeeBeacon Damage.
3) Radiated measurement is performed on all different models and maybe only the worst case result is presented.

7 Uncertainly of Measurement

Test item	Measurement Uncertainty (dB)
RF Output Power (Conducted)	±1.2 dB
Power Spectral Density	±0.9 dB
Unwanted Emission (conducted)	±2.6 dB
Occupied Channel Bandwidth	±5 %
Radiated Emission (30MHz-1GHz)	±4.6 dB
Radiated Emission (1-18GHz)	±4.9 dB
Radiated Emission (18-40GHz)	±3.5 dB

8 Test summary and result

8.1 Antenna Requirement

8.1.1 Requirement

Per § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

8.1.2 Result

Analysis:

- EUT use SMD chip antenna that is soldered permanently attached onto the PCB.
- There is no provision for connection to an external antenna.

Conclusion:

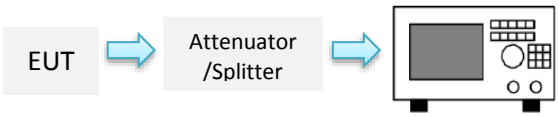
EUT complies with antenna requirement in § 15.203.

8.2 DTS (6 dB) Bandwidth

8.2.1 Requirement

Per § 15.247 (a)(2), systems using digital modulation techniques may operate in the 902-928MHz, 2400-2483.5MHz, and 5725-5850MHz bands. The minimum 6 dB bandwidth shall be at least 500 KHz.

8.2.2 Test setup



8.2.3 Test Procedure

According to section 8.2, Option 2, in KDB 558074 D01 DTS Meas Guidance v04

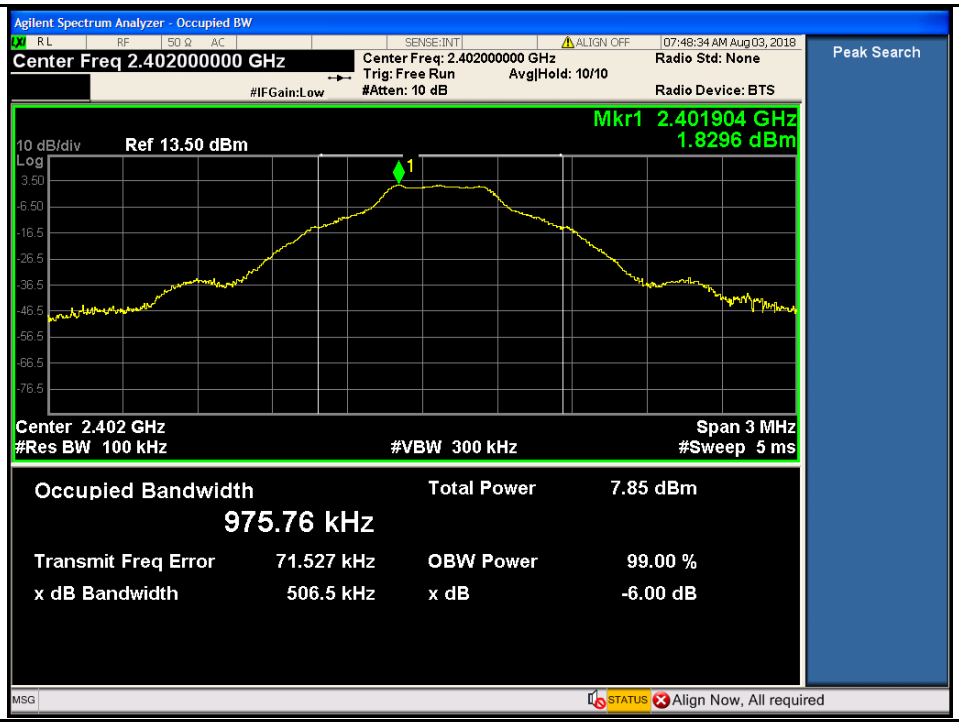
The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this 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.

1. Set RBW = 100 kHz.
2. Set the video bandwidth (VBW) ⩾ 3 x RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize.
7. Use automatic bandwidth measurement capability on instrument to obtain BW result.

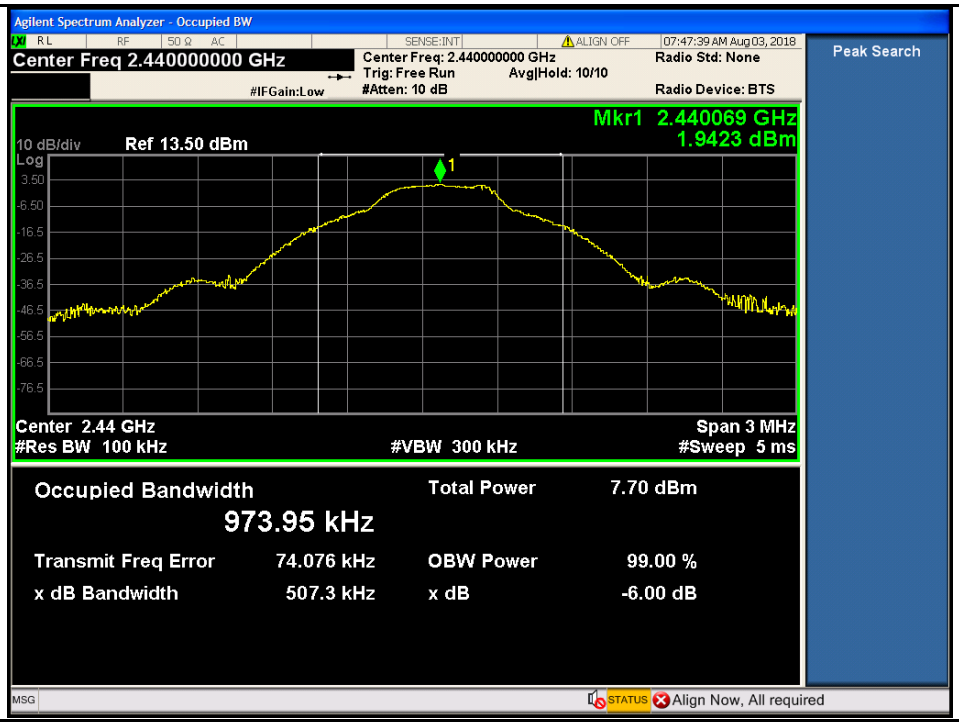
8.2.4 Test Result

Radio	Data rate	Test Frequency (MHz)	Measured Bandwidth (KHz)	Minimum Bandwidth (KHz)	Result
BLE	1Mbps	2402	506.5	500	Pass
	1Mbps	2440	507.3	500	Pass
	1Mbps	2480	513.6	500	Pass
	2Mbps	2402	773.1	500	Pass
	2Mbps	2440	807.0	500	Pass
	2Mbps	2480	858.8	500	Pass

8.2.5 Test Plots

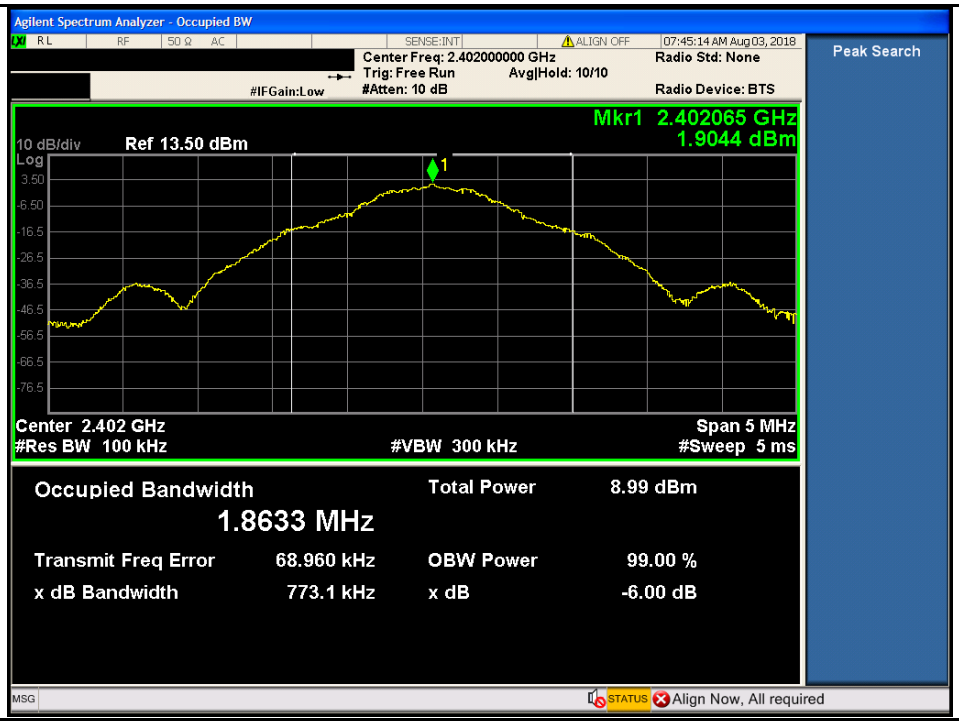


BLE-2402MHz-1Mbps

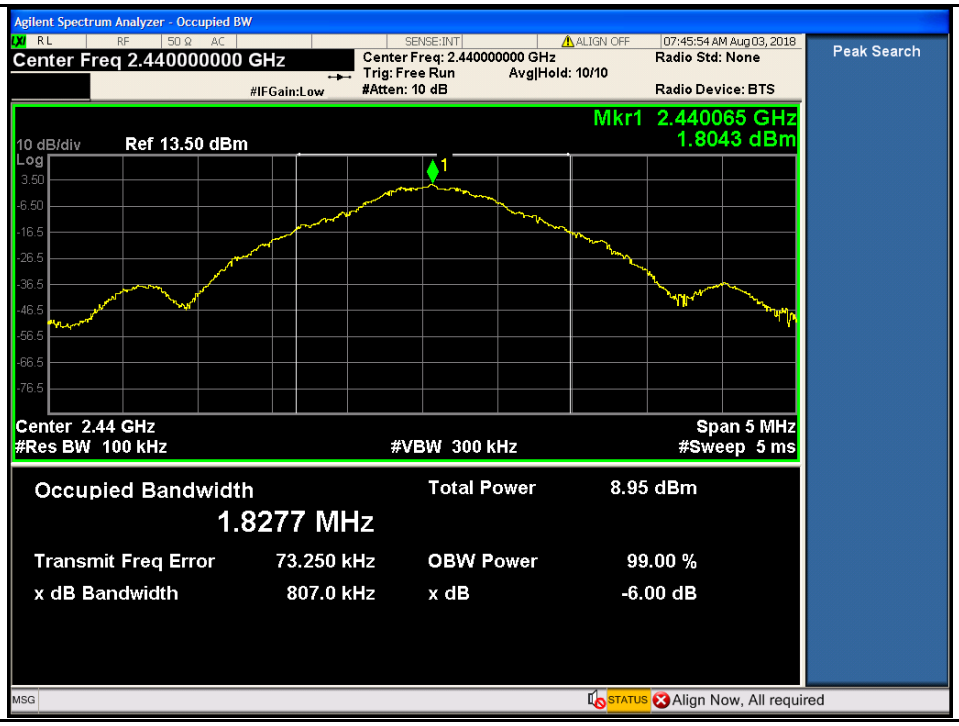


BLE-2440MHz-1Mbps

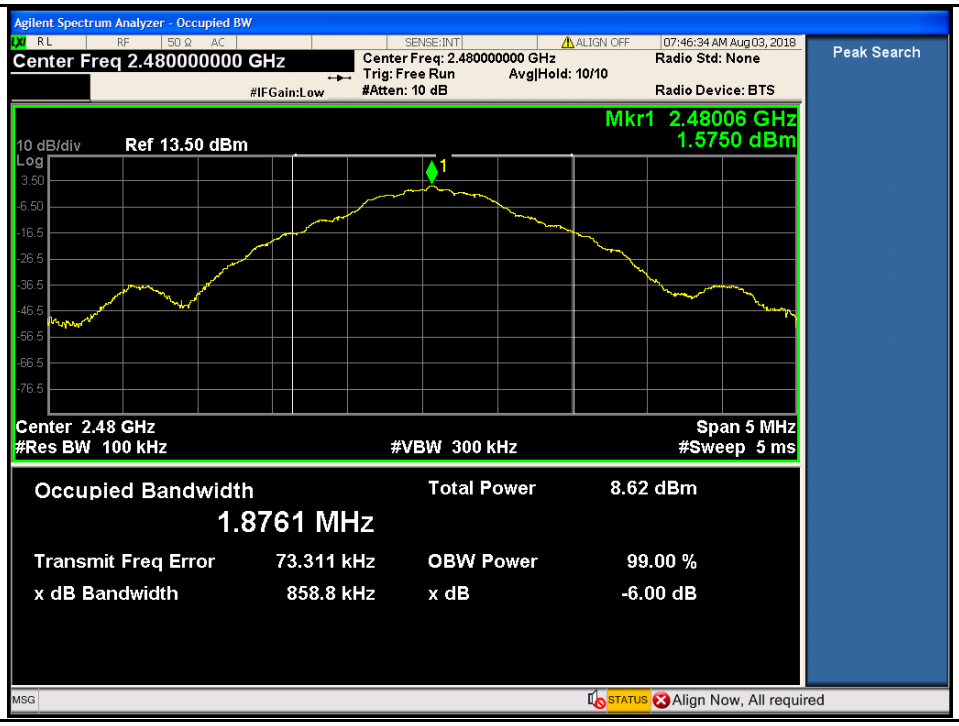
BLE-2480MHz-1Mbps



BLE-2402MHz-2Mbps



BLE-2440MHz-2Mbps



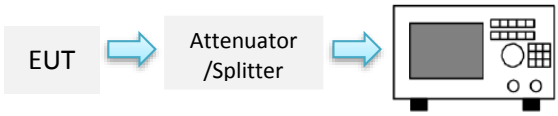
BLE-2480MHz-2Mbps

8.3 Maximum Output Power

8.3.1 Requirement

Per § 15.247 (b)(3), for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: the maximum output power is 1 Watt.

8.3.2 Test setup



8.3.3 Test Procedure

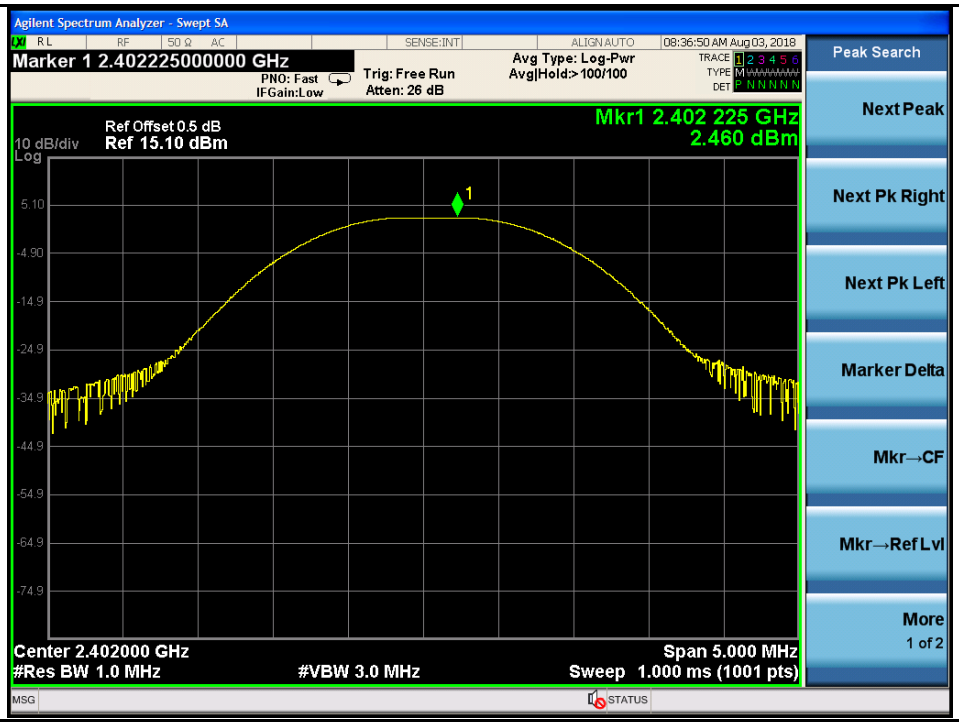
According to section 9.1.1 RBW≥DTS bandwidth, in KDB 558074 D01 DTS Meas Guidance v04

1. Set the RBW ⩾ DTS bandwidth.
2. Set VBW ⩾ 3 X 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.

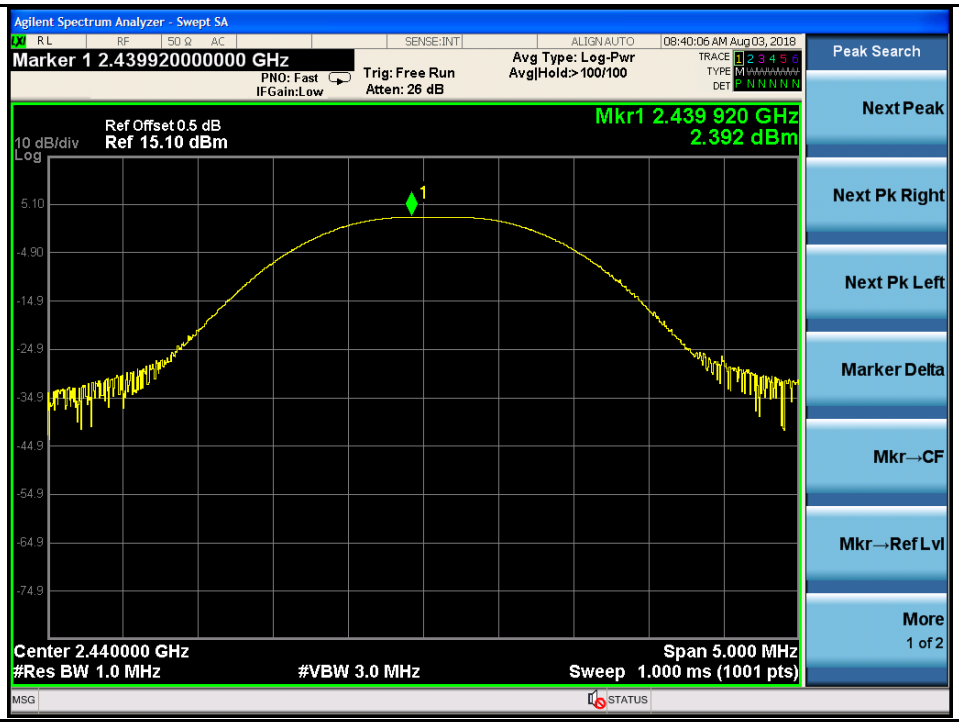
8.3.4 Test Result

Radio	Data rate	Test Frequency (MHz)	Measured Output Power (dBm)	Maximum Output Power (dBm)	Result
BLE	1Mbps	2402	2.460	30	Pass
	1Mbps	2440	2.392	30	Pass
	1Mbps	2480	2.170	30	Pass
	2Mbps	2402	2.501	30	Pass
	2Mbps	2440	2.430	30	Pass
	2Mbps	2480	2.212	30	Pass

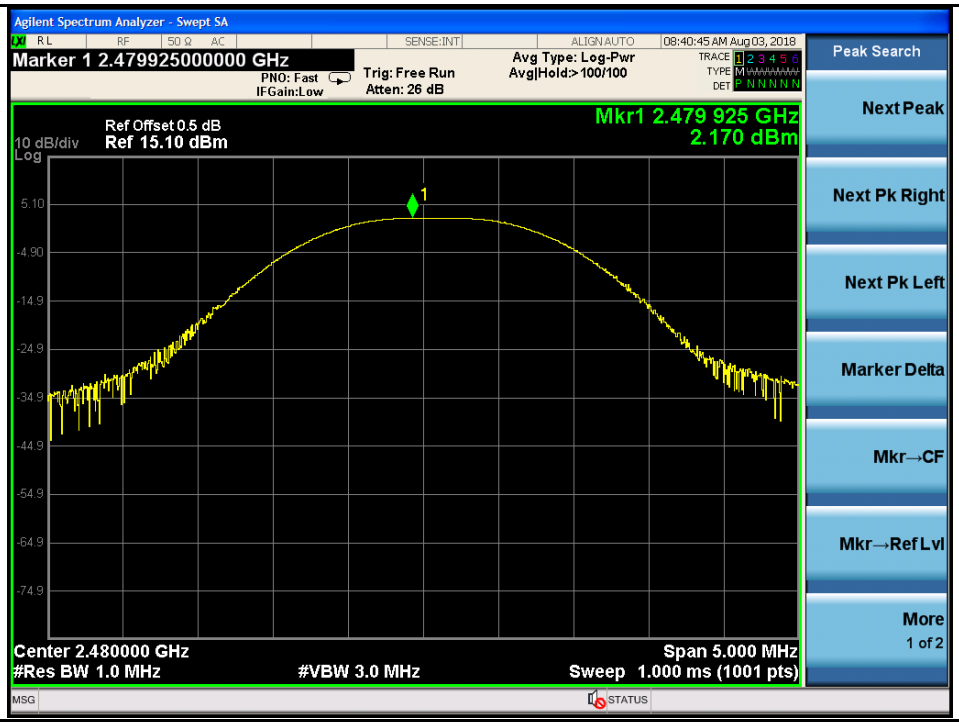
8.3.5 Test Plots



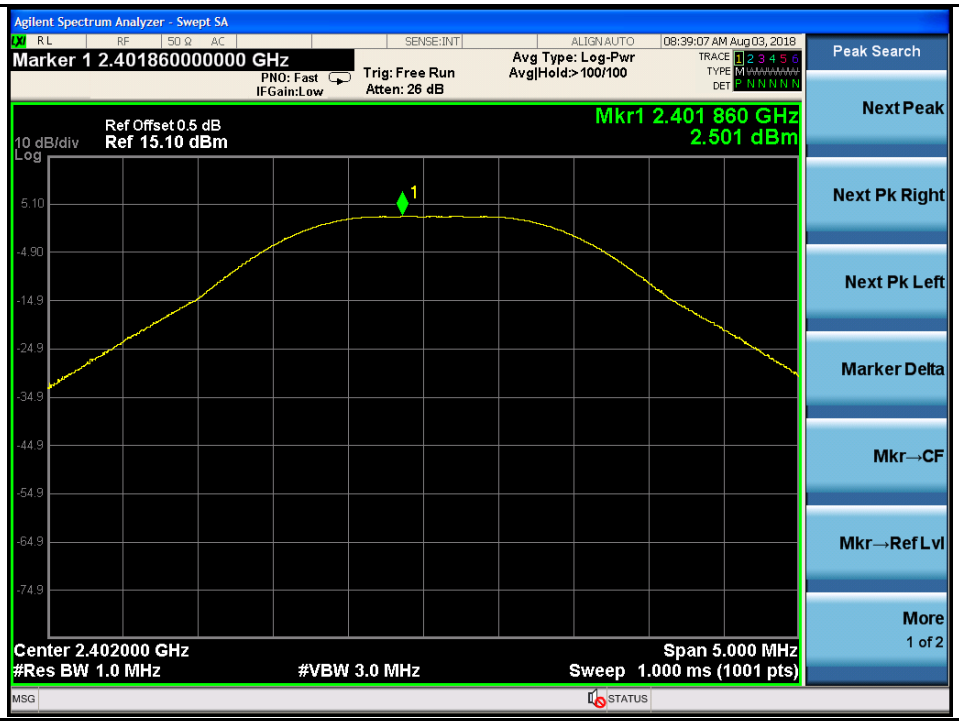
BLE-2402MHz-1Mbps



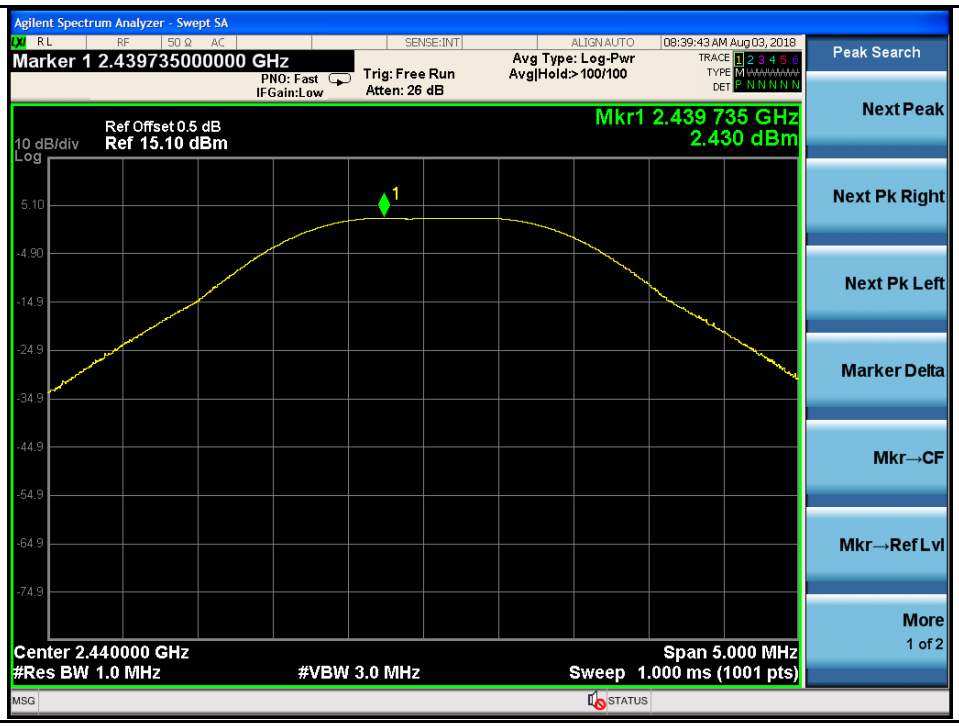
BLE-2440MHz-1Mbps



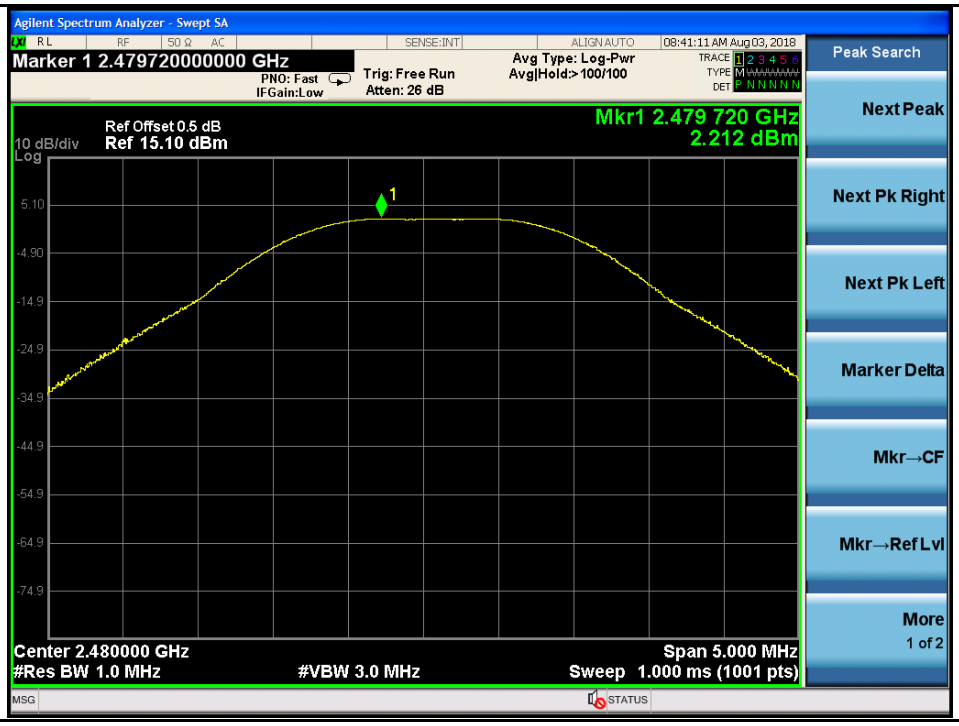
BLE-2480MHz-1Mbps



BLE-2402MHz-2Mbps



BLE-2440MHz-2Mbps



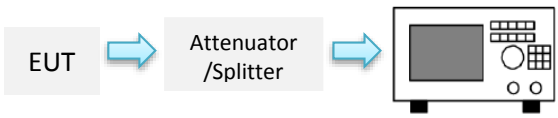
BLE-2480MHz-2Mbps

8.4 Power Spectral Density

8.4.1 Requirement

Per § 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.

8.4.2 Test setup



8.4.3 Test Procedure

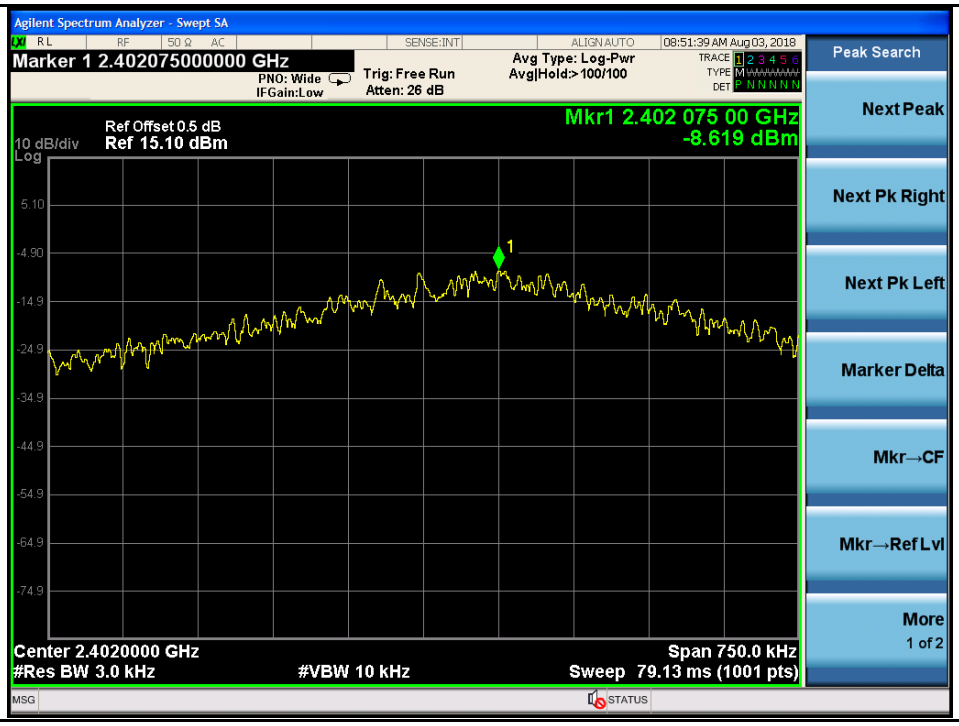
According to section 10.2 Method PKPSD, in KDB 558074 D01 DTS Meas Guidance v04

1. Set analyser centre frequency to DTS channel centre frequency.
2. Set the span to 1.5 X DTS bandwidth.
3. Set the RBW to: 3 kHz $\leqslant$ RBW $\leqslant$ 100 kHz.
4. Set the VBW $\geqslant$ 3 x 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 within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

8.4.4 Test Result

Radio	Data rate	Test Frequency (MHz)	Measured Output Power (dBm/3KHz)	Maximum Output Power (dBm/3KHz)	Result
BLE	1Mbps	2402	-8.619	8	Pass
	1Mbps	2440	-8.594	8	Pass
	1Mbps	2480	-7.962	8	Pass
	2Mbps	2402	-11.649	8	Pass
	2Mbps	2440	-11.135	8	Pass
	2Mbps	2480	-11.953	8	Pass

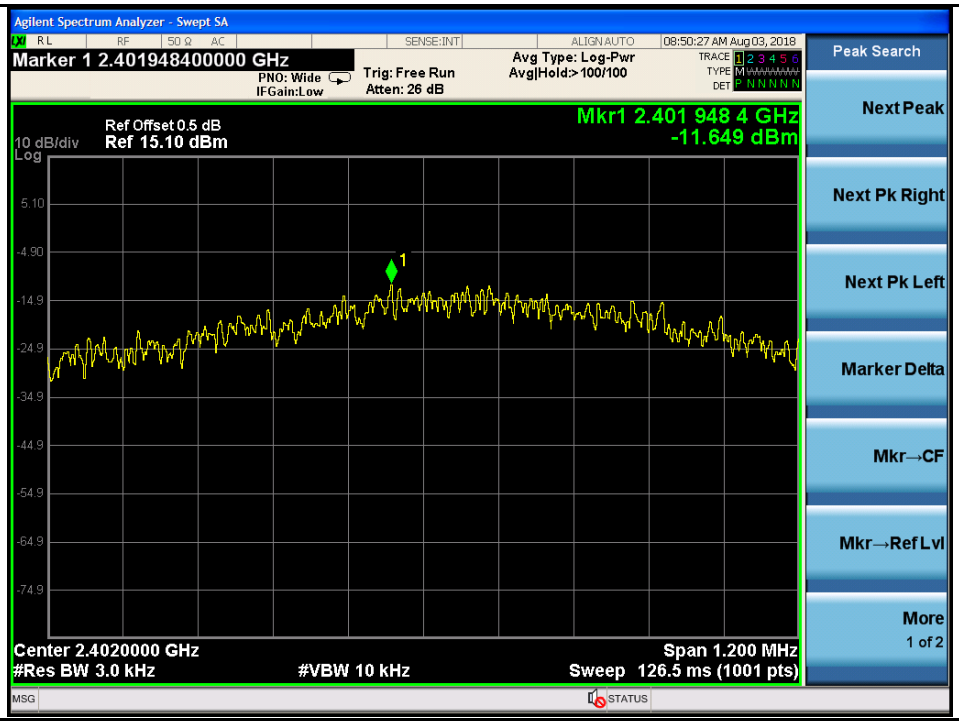
8.4.5 Test Plots



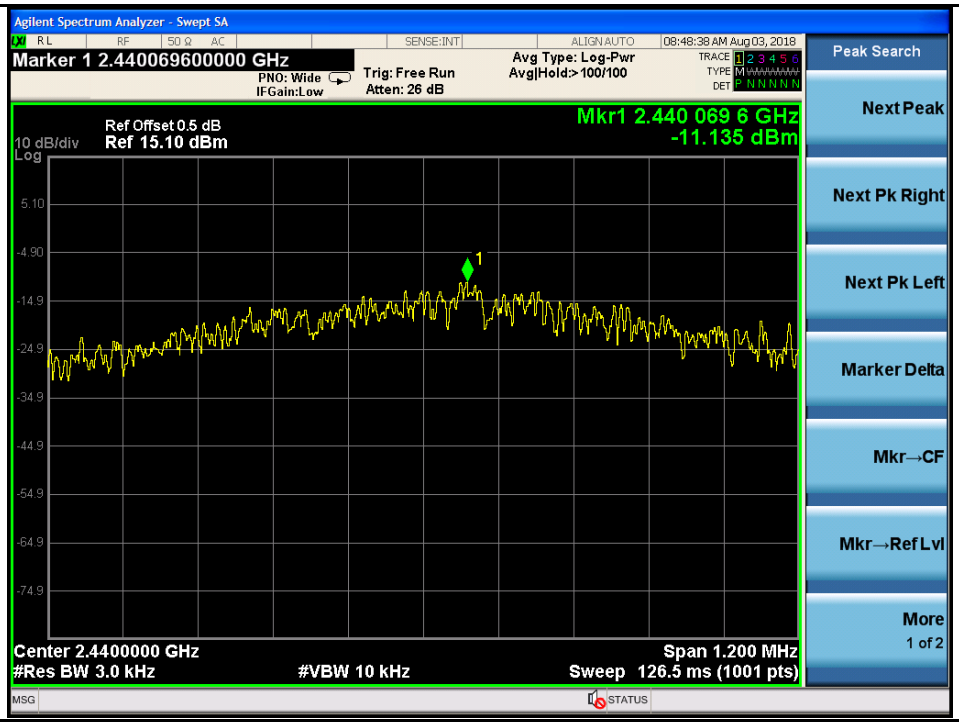
BLE-2402MHz-1Mbps

BLE-2440MHz-1Mbps

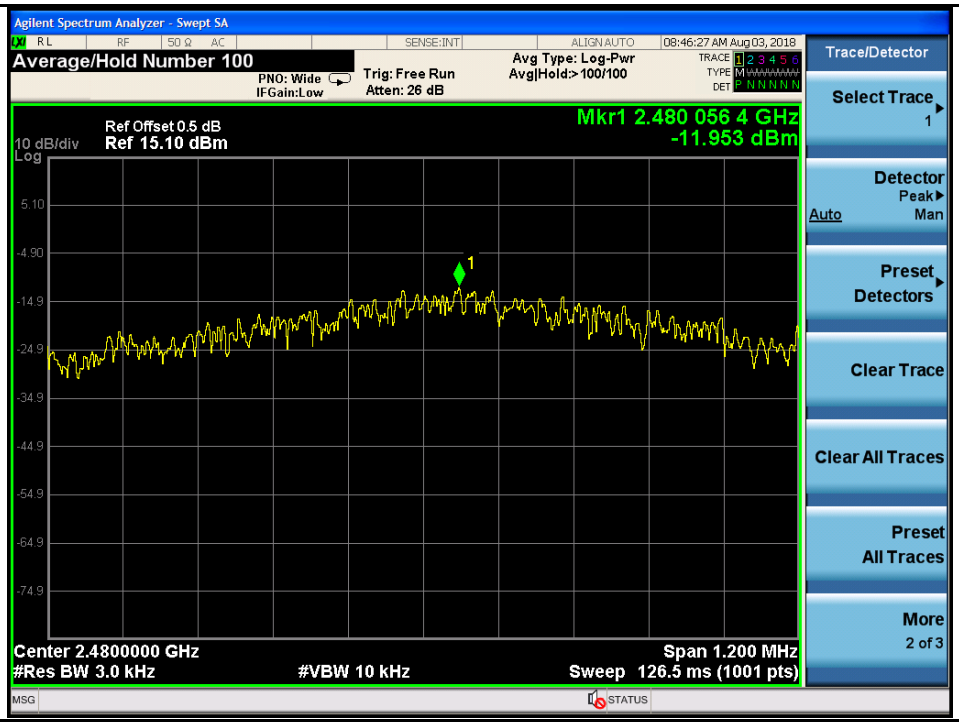
BLE-2480MHz-1Mbps



BLE-2402MHz-2Mbps



BLE-2440MHz-2Mbps



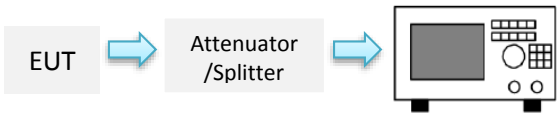
BLE-2480MHz-2Mbps

8.5 Conducted Band-Edge & Unwanted Emissions Measurement

8.5.1 Requirement

Per § 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.

8.5.2 Test setup



8.5.3 Test Procedure

According to section 11.3 Emission level measurement, in KDB 558074 D01 DTS Meas Guidance v04

1. Set the centre frequency and span to encompass frequency range to be measured.
2. Set the RBW = 100 kHz.
3. Set the VBW ⩾ 3 X RBW.
4. Detector = peak.
5. Sweep time = auto couple.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.
8. Use the peak marker function to determine the maximum amplitude level.

8.5.4 Test Result

See test plots

8.5.5 Test Plots

Conducted Band-Edge - BLE-2402MHz-1Mbps

Conducted Band-Edge - BLE-2480MHz-1Mbps

Conducted Band-Edge - BLE-2402MHz-2Mbps

Conducted Band-Edge - BLE-2480MHz-2Mbps

Conducted Unwanted Emission - BLE-2402MHz-1Mbps

Conducted Unwanted Emission -Edge - BLE-2440MHz-1Mbps

Conducted Unwanted Emission - BLE-2480MHz-1Mbps

Conducted Unwanted Emission - BLE-2402MHz-2Mbps

Conducted Unwanted Emission - BLE-2480MHz-1Mbps

Conducted Unwanted Emission - BLE-2402MHz-2Mbps

8.6 Radiated Band-Edge & Spurious Emissions into Restricted Frequency Bands

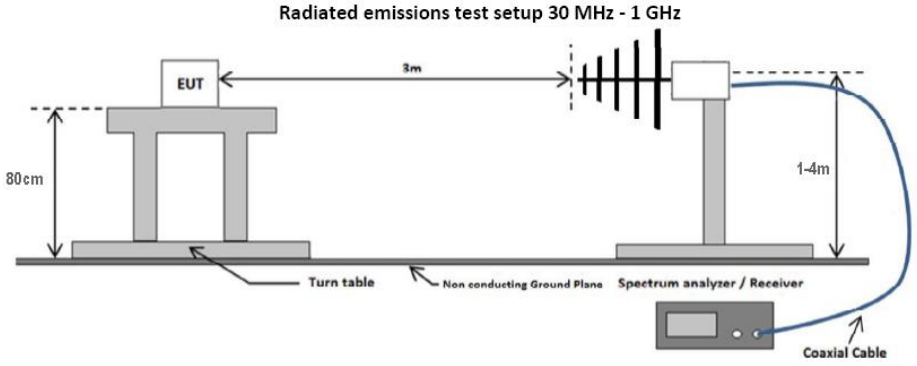
8.6.1 Requirement

Per § 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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

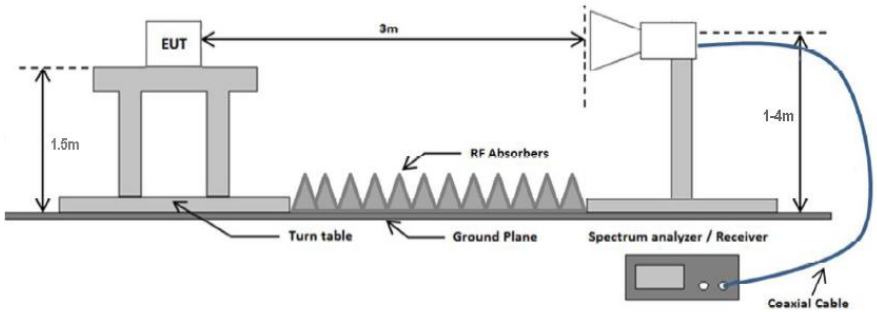
Frequency range (MHz)	Field Strength (µV/m)
0.009~0.490	2400/F(KHz)
0.490~1.705	24000/F(KHz)
1.705~30.0	30
30 – 88	100
88 – 216	150
216 - 960	200
Above 960	500

8.6.2 Test setup

Radiated emissions test setup 30 MHz - 1 GHz



Radiated emissions test setup above 1 GHz



8.6.3 Test Procedure

According to section 12.2.7 Radiated spurious emission measurements in KDB 558074 D01 DTS Meas Guidance v04 and the procedures for maximizing and measuring radiated emissions that are described in ANSI C63.10 was followed. Boresight antenna mast was used during the scanning to point to EUT to maximize the emission.

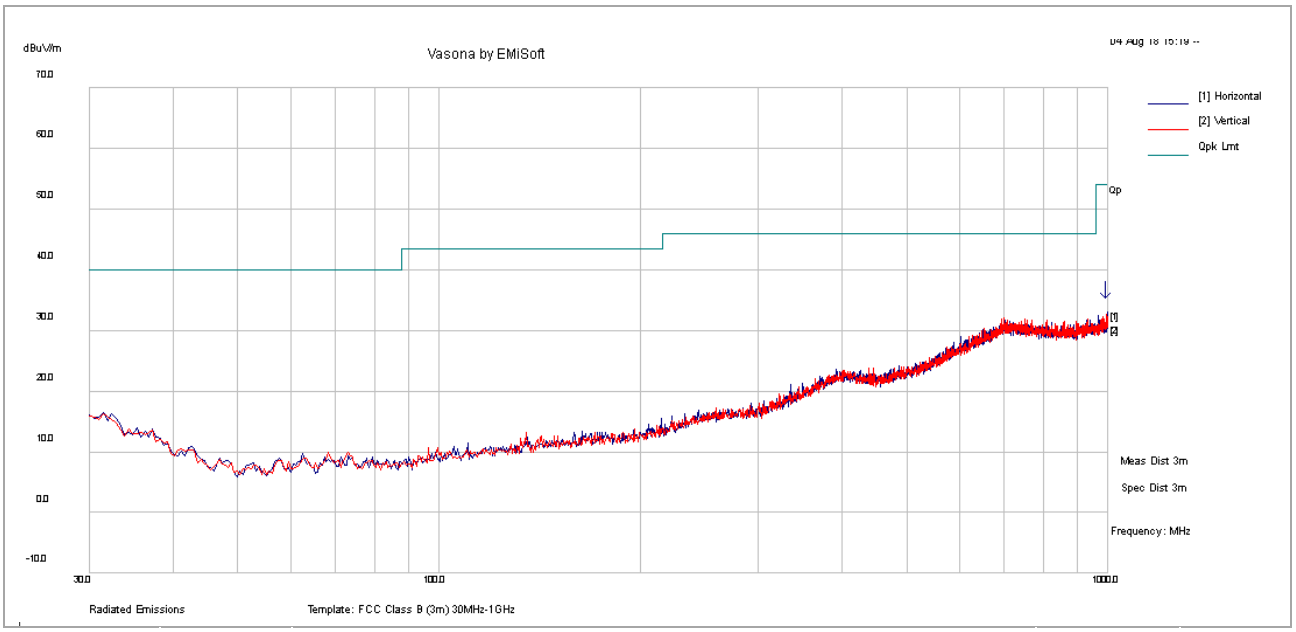
1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. The test was carried out at the selected frequency points obtained from the EUT characterization. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:
   a. Vertical or horizontal polarization (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
   b. The EUT was then rotated to the direction that gave the maximum emission.
   c. Finally, the antenna height was adjusted to the height that gave the maximum emission.
3. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-Peak detection at frequency below 1GHz.
4. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and video bandwidth is 3MHz with Peak detection for Peak measurement at frequency above 1GHz.

   The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and the video bandwidth is 10Hz with Peak detection for Average Measurement as below at frequency above 1GHz.
5. Steps 2 and 3 were repeated for the next frequency point, until all selected frequency points were measured.

8.6.4 Test Result

30-1000MHz test result

Test Standard:	**47CFR 15.209**	**Mode:**	**BLE-2440MHz-2Mbps**
Frequency Range:	**30-1000MHz**	**Test Date:**	**07/18/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**Sherwin Lee**
Remark:	BeeBeacon Damage	**Test Result:**	**Pass**



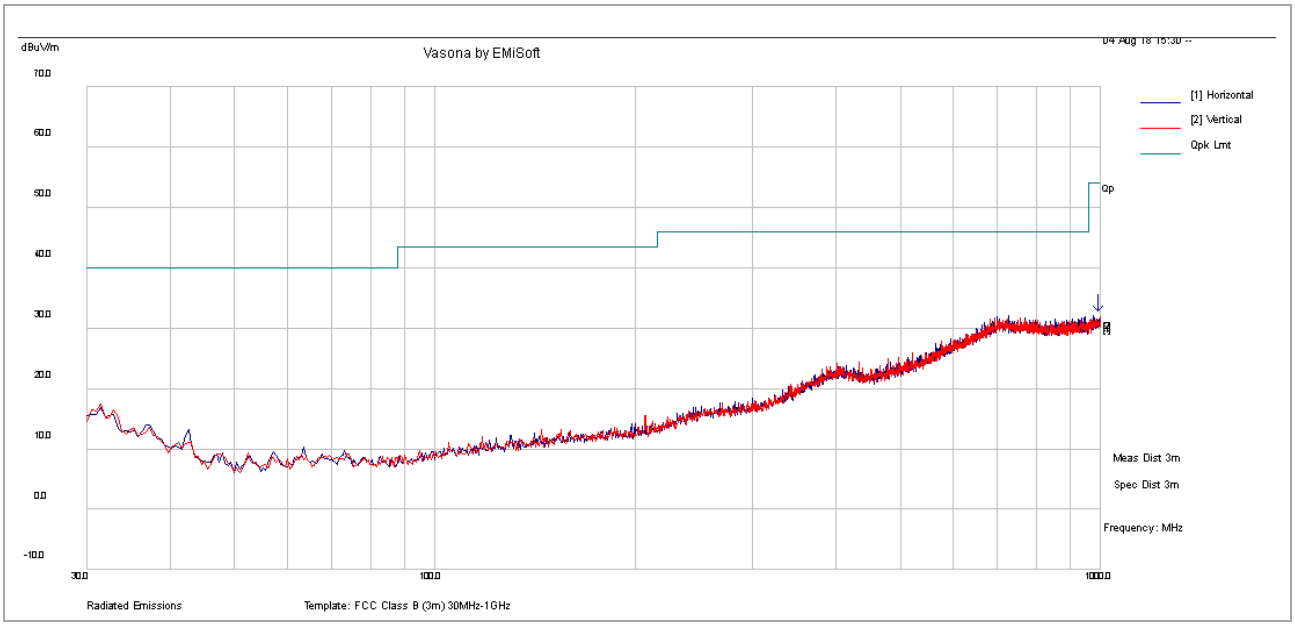
Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
-	-	-	-	-	-	-	-	-	-	-

Note:

1) For below 1GHz, all different channel and modes were verified but only the worst case result is shown here.

2) No emission was found within 6 dB below the limit. Final measurement is not necessary.

Test Standard:	**47CFR 15.209**	**Mode:**	**BLE-2440MHz-2Mbps**
Frequency Range:	**30-1000MHz**	**Test Date:**	**07/18/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**Sherwin Lee**
Remark:	BeeBeacon ColdChain	**Test Result:**	**Pass**



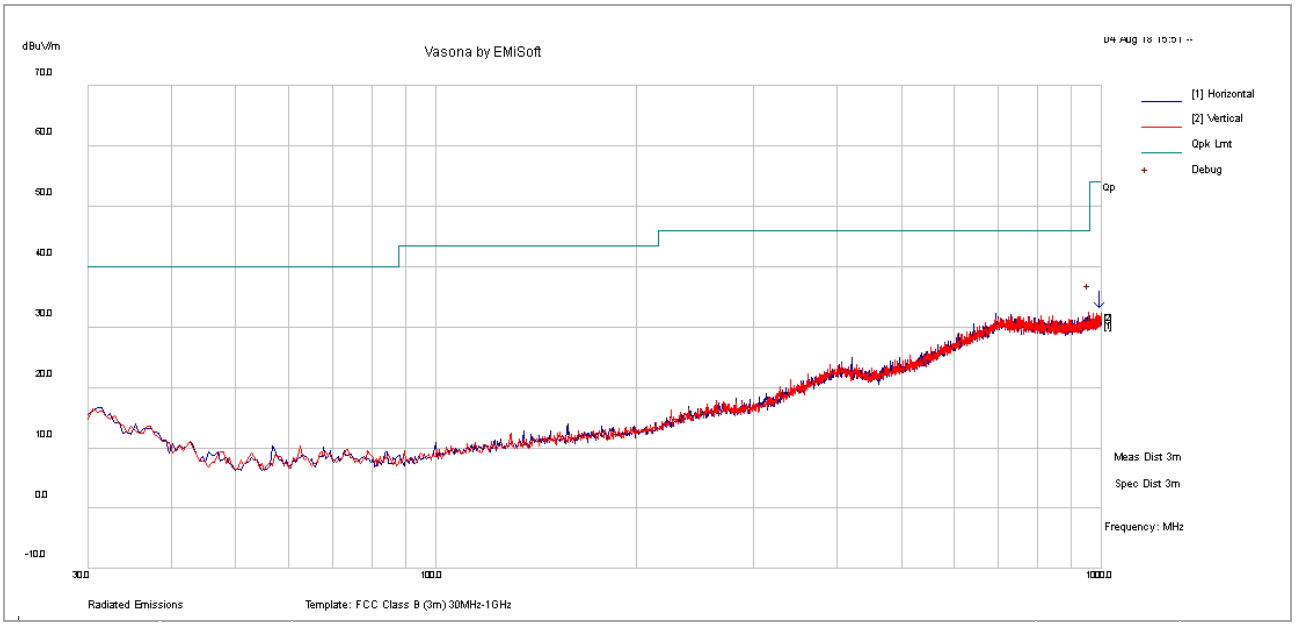
Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
-	-	-	-	-	-	-	-	-	-	-

Note:

1) For below 1GHz, all different channel and modes were verified but only the worst case result is shown here.

2) No emission was found within 6 dB below the limit. Final measurement is not necessary.

Test Standard:	**47CFR 15.209**	**Mode:**	**BLE-2440MHz-2Mbps**
Frequency Range:	**30-1000MHz**	**Test Date:**	**07/18/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**Sherwin Lee**
Remark:	BeeBeacon VO Gas	**Test Result:**	**Pass**



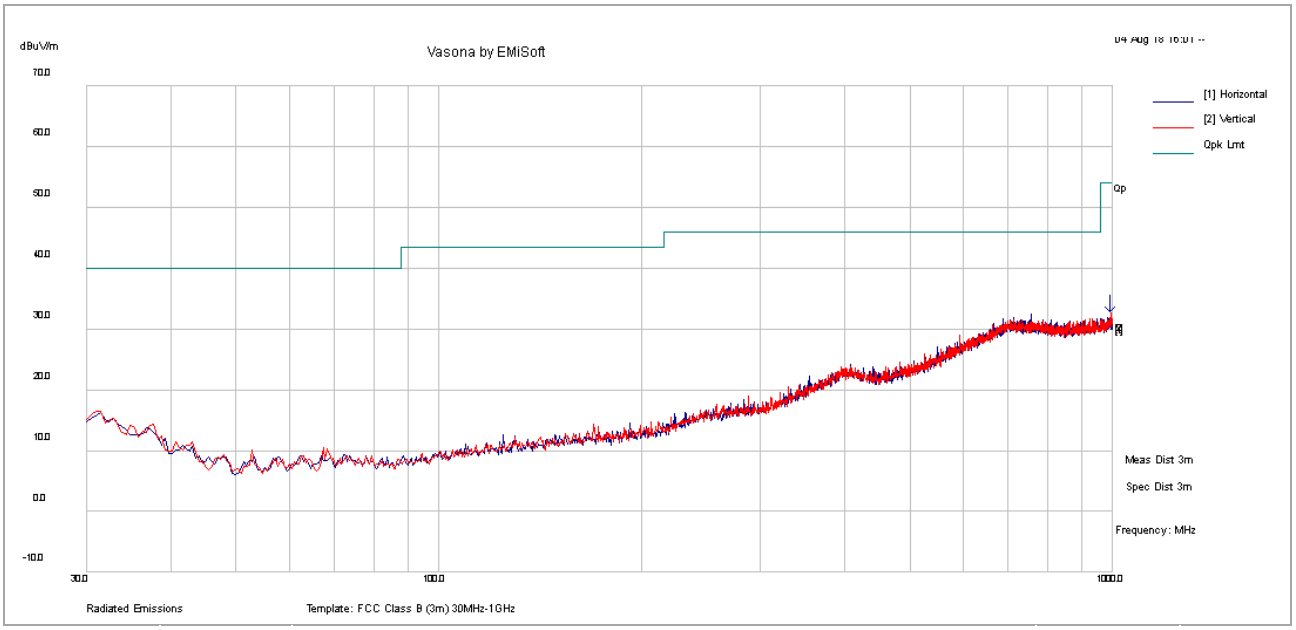
Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
956.30	29.30	7.80	-6.60	30.50	QP	V	232	178	46.00	-15.40

Note:

1) For below 1GHz, all different channel and modes were verified but only the worst case result is shown here.

2) No emission was found within 6 dB below the limit. Final measurement is not necessary.

Test Standard:	**47CFR 15.209**	**Mode:**	**BLE-2440MHz-2Mbps**
Frequency Range:	**30-1000MHz**	**Test Date:**	**07/18/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**Sherwin Lee**
Remark:	BeeBeacon Probe TPH	**Test Result:**	**Pass**



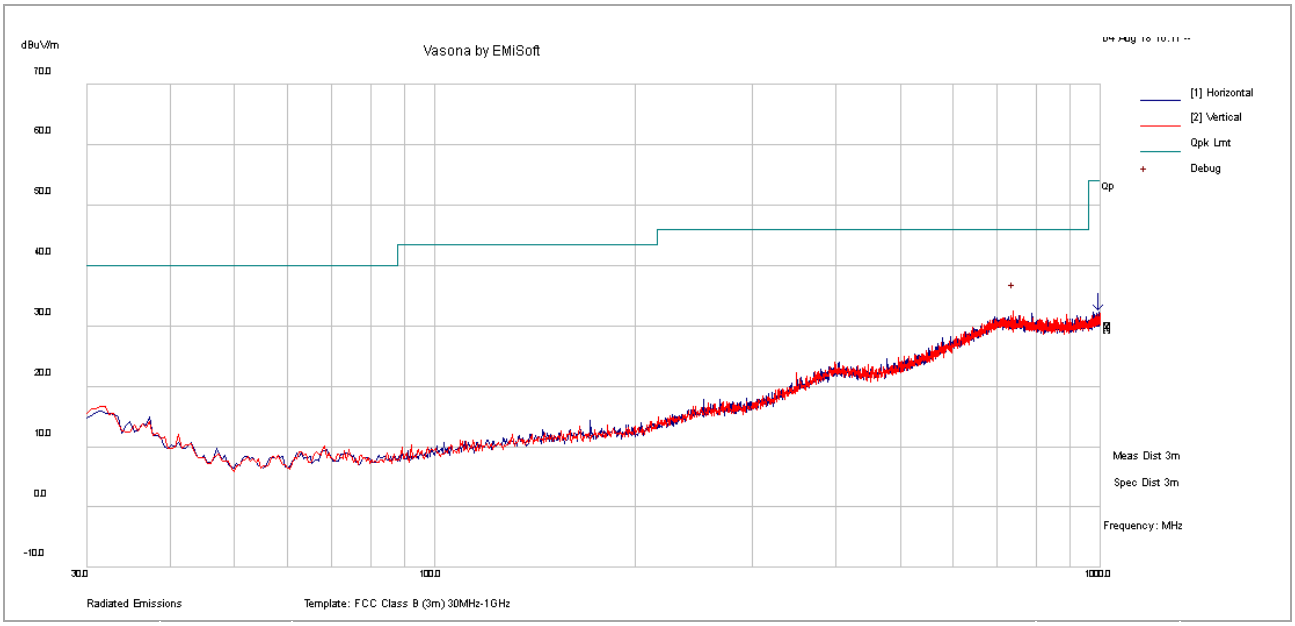
Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
-	-	-	-	-	-	-	-	-	-	-

Note:

1) For below 1GHz, all different channel and modes were verified but only the worst case result is shown here.

2) No emission was found within 6 dB below the limit. Final measurement is not necessary.

Test Standard:	**47CFR 15.209**	**Mode:**	**BLE-2440MHz-2Mbps**
Frequency Range:	**30-1000MHz**	**Test Date:**	**07/18/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**Sherwin Lee**
Remark:	BeeBeacon Probe VOC	**Test Result:**	**Pass**



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
739.56	29.60	7.20	-6.50	30.40	QP	V	198	271	46.00	-15.60

Note:

1) For below 1GHz, all different channel and modes were verified but only the worst case result is shown here.

2) No emission was found within 6 dB below the limit. Final measurement is not necessary.

1GHz – 25GHz Test Result

Model: BeeBeacon Damage (configuration: Beacon sensor BLE + BM160)

Test Mode: BLE -2402MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
6576.41	37.84	8.00	-2.48	43.36	Peak	H	100	41	74	-30.64	Pass
4804.31	43.78	6.87	-5.54	45.11	Peak	V	112	62	74	-28.89	Pass
6576.41	25.94	8.00	-2.48	31.46	Average	H	100	41	54	-22.54	Pass
4804.31	36.27	6.87	-5.54	37.60	Average	V	112	62	54	-16.40	Pass

Test Model: BLE -2440MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
7320.86	34.31	9.18	-1.40	42.08	Peak	H	130	255	74	-31.92	Pass
17579.33	18.46	17.27	11.72	47.45	Peak	V	161	189	74	-26.55	Pass
7320.86	22.95	9.18	-1.40	30.73	Average	H	130	255	54	-23.27	Pass
17579.33	6.13	17.27	11.72	35.12	Average	V	161	189	54	-18.88	Pass

Test Mode: BLE -2480MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4963.67	38.62	6.91	-5.69	39.84	Peak	V	297	350	74	-34.16	Pass
10138.73	29.68	11.46	0.82	41.96	Peak	V	300	298	74	-32.04	Pass
4963.67	26.80	6.91	-5.69	28.02	Average	V	297	350	54	-25.98	Pass
10138.73	17.90	11.46	0.82	30.18	Average	V	300	298	54	-23.82	Pass

Model: BeeBeacon ColdChain (configuration: Beacon sensor BLE + BMI160 + BME280)

Test Mode: BLE -2402MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4804.03	45.90	6.87	-5.54	47.24	Peak	V	117	162	74	-26.76	Pass
14928.25	21.84	15.90	5.53	43.28	Peak	H	190	154	74	-30.72	Pass
4804.03	41.23	6.87	-5.54	42.57	Average	V	117	162	54	-11.43	Pass
14928.25	9.42	15.90	5.53	30.85	Average	H	190	154	54	-23.15	Pass

Test Model: BLE -2440MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4879.95	47.28	6.89	-5.55	48.62	Peak	V	104	170	74	-25.38	Pass
10142.03	29.55	11.47	0.82	41.84	Peak	H	188	177	74	-32.16	Pass
4879.95	42.00	6.89	-5.55	43.34	Average	V	104	170	54	-10.66	Pass
10142.03	17.56	11.47	0.82	29.85	Average	H	188	177	54	-24.15	Pass

Test Mode: BLE -2480MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4962.04	39.99	6.91	-5.69	41.21	Peak	H	243	62	74	-32.80	Pass
7439.73	35.76	9.67	-1.14	44.29	Peak	H	166	57	74	-29.71	Pass
4962.04	27.08	6.91	-5.69	28.30	Average	H	243	62	54	-25.70	Pass
7439.73	23.66	9.67	-1.14	32.19	Average	H	166	57	54	-21.81	Pass

Model: BeeBeacon VO Gas (configuration: Beacon sensor BLE + BMI160 + BM680)

Test Mode: BLE -2402MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4804.16	41.77	6.87	-5.54	43.10	Peak	H	151	157	74	-30.90	Pass
7204.73	34.40	9.18	-1.40	42.18	Peak	V	282	33	74	-31.82	Pass
4804.16	32.73	6.87	-5.54	34.06	Average	V	151	157	54	-19.94	Pass
7204.73	23.10	9.18	-1.40	30.88	Average	H	282	33	54	-23.12	Pass

Test Model: BLE -2440MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
7320.59	34.90	9.42	-1.18	43.15	Peak	H	373	0	74	-30.85	Pass
17612.32	18.40	17.31	11.72	47.43	Peak	H	264	49	74	-26.57	Pass
7320.59	22.99	9.42	-1.18	31.23	Average	H	373	0	54	-22.77	Pass
17612.32	6.01	17.31	11.72	35.04	Average	H	264	49	54	-18.96	Pass

Test Mode: BLE -2480MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4962.36	38.54	6.91	-5.69	39.76	Peak	V	203	317	74	-34.24	Pass
10144.98	17.59	11.47	0.83	29.89	Peak	H	280	158	54	-24.11	Pass
4962.36	26.92	6.91	-5.69	28.14	Average	V	203	317	54	-25.86	Pass
10144.98	29.55	11.47	0.83	41.85	Average	H	280	158	74	-32.15	Pass

Model: BeeBeacon Probe TPH (configuration: Beacon sensor BLE + BMI160 + FLEX BME280)

Test Mode: BLE -2402MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4804.17	40.92	6.87	-5.54	42.25	Peak	H	161	183	74	-31.75	Pass
7203.01	35.83	9.18	-1.40	43.61	Peak	V	206	74	74	-30.39	Pass
4804.17	33.82	6.87	-5.54	35.15	Average	V	161	183	54	-18.85	Pass
7203.01	24.91	9.18	-1.40	32.69	Average	H	206	74	54	-21.31	Pass

Test Model: BLE -2440MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4880.05	48.19	6.89	-5.55	49.53	Peak	V	209	99	74	-24.47	Pass
10147.79	30.22	11.47	0.83	42.52	Peak	H	309	113	74	-31.48	Pass
4880.05	41.04	6.89	-5.55	42.38	Average	V	209	99	54	-11.62	Pass
10147.79	18.84	11.47	0.83	31.14	Average	H	309	113	74	-42.86	Pass

Test Mode: BLE -2480MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4961.78	38.54	6.91	-5.69	39.76	Peak	V	188	82	74	-34.24	Pass
10648.39	27.58	12.1	1.7	41.38	Peak	H	362	31	74	-32.62	Pass
4961.78	26.92	6.91	-5.69	28.14	Average	V	188	82	54	-25.86	Pass
10648.39	15.31	12.1	1.7	29.11	Average	H	362	31	74	-44.89	Pass

Model: BeeBeacon Probe VOC(configuration: Beacon sensor BLE + BMI160 + FLEX BME680)

Test Mode: BLE -2402MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4804.08	42.98	6.87	-5.54	44.31	Peak	H	188	106	74	-29.69	Pass
7204.22	33.22	9.18	-1.40	41.00	Peak	V	271	176	74	-33.00	Pass
4804.08	32.09	6.87	-5.54	33.42	Average	V	188	106	54	-20.58	Pass
7204.22	24.01	9.18	-1.40	31.79	Average	H	271	176	54	-22.21	Pass

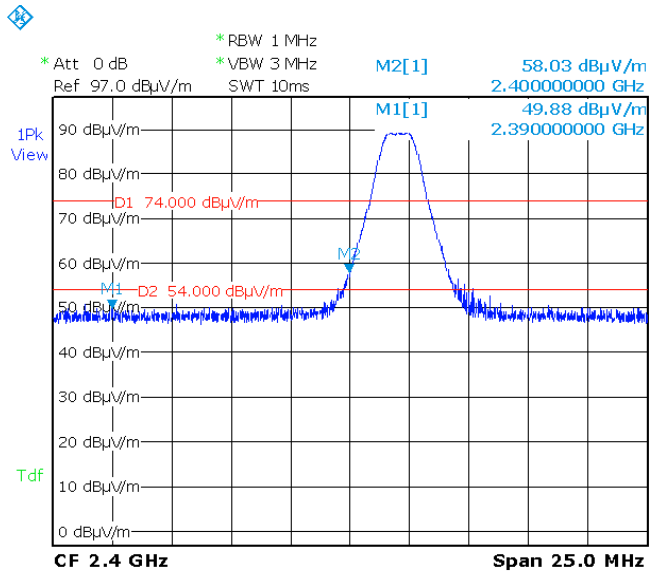
Test Model: BLE -2440MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4880.37	46.92	6.89	-5.55	48.26	Peak	V	209	99	74	-25.74	Pass
7320.33	38.96	9.42	-1.18	47.2	Peak	H	102	273	74	-26.80	Pass
4880.37	38.77	6.89	-5.55	40.11	Average	V	209	99	54	-13.89	Pass
7320.33	30.31	9.42	-1.18	38.55	Average	H	102	273	74	-35.45	Pass

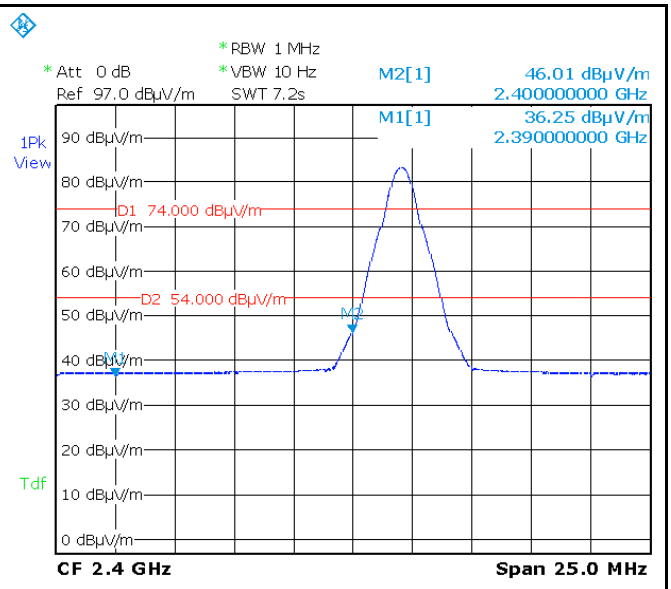
Test Mode: BLE -2480MHz-2Mbps

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass/Fail
4962.17	39.08	6.91	-5.69	40.3	Peak	V	188	82	74	-33.70	Pass
14936.46	21.55	15.92	5.52	42.99	Peak	H	189	4	74	-31.01	Pass
4962.17	27.89	6.91	-5.69	29.11	Average	V	188	82	54	-24.89	Pass
14936.46	9.41	15.92	5.52	30.85	Average	H	189	4	74	-43.15	Pass

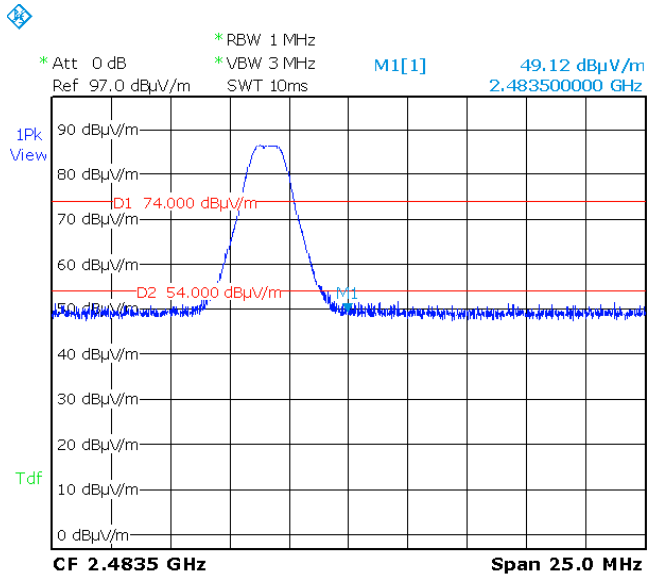
Radiated Band Edge measurement result



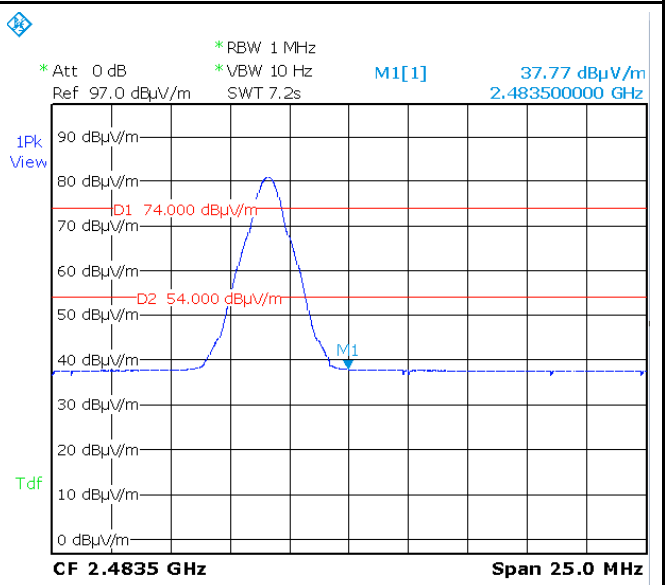
BLE-2402MHz-2Mbps-Band Edge (Peak)



BLE-2402MHz-2Mbps-Band Edge (Average)



BLE-2480MHz-2Mbps-Band Edge (Peak)



BLE-2480MHz-2Mbps-Band Edge (Average)

Note:

1) Both Horizontal and vertical polarities were investigated.
2) There is no difference on the radiated band-edge result between the variants due to their same construction on the RF section, so only the worst case result on the model of BeeBeacon Damage is presented here.

9 Test instrument list

Equipment	Manufacturer	Model	Serial Number	Cal. Date	Cal. Due
Semi-Anechoic Chamber	ETS-Lindgren	10M	VL001	5/11/2018	5/11/2019
Shielding Control Room	ETS-Lindgren	Series 81	VL006	N/A	N/A
Spectrum Analyzer	Keysight	N9020A	MY50110074	5/4/2018	5/4/2019
EMC Test Receiver	R&S	ESL6	100230	5/7/2018	5/7/2019
Bi-Log Antenna	ETS-Lindgren	3142E	217921	11/15/2017	11/15/2018
Horn Antenna	AH Systems	SAS-571	433	8/14/2017	8/14/2018
Horn Antenna	Electro-Metrics	EM-6961	6292	5/2/2018	5/2/2019
Horn Antenna (18-40GHz)	Com-Power	AH-840	101109	5/2/2018	5/2/2019
Preamplifier	RF Bay, Inc.	LPA-10-20	11180621	N/A	N/A
True RMS Multi-meter	UNI-T	UT181A	C173014829	5/10/2018	5/10/2019
Temp / Humidity / Pressure Meter	PCE Instruments	PCE-THB 40	R062028	5/9/2018	5/9/2019
RF Attenuator	Pasternack	PE7005-3	VL061	N/A	N/A
Preamplifier 100KHz - 40GHz	Aeroflex	33711-392-77150-11	064	N/A	N/A
EM Center Control	ETS-Lindgren	7006-001	160136	N/A	N/A
Turn Table	ETS-Lindgren	2181-3.03	VL002	N/A	N/A
Boresight Antenna Tower	ETS-Lindgren	2171B	VL003	N/A	N/A
Loop Antenna (9k-30MHz)	Com-Power	AL-130	121012	5/9/18	5/9/19