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TEST REPORT

According to : FCC 47CFR part 15 subpart C § 15.247

Test Report No. : CTK-2016-00169
Date of Issue : 2016-02-12
FCC ID : 2AGTM-BI-4000
Model/Type No. : Bi-4000
Kind of Product : Bluetooth 4.0 Beacon
Applicant : IFFU Co., Ltd.
Applicant Address : 445-968 33, Annyeom-gil 112beon-gil, Jeongnam-myeon,
Hwaseong-si, Gyeonggi-do, Korea
Manufacturer : IFFU Co., Ltd.
Manufacturer Address : 445-968 33, Annyeom-gil 112beon-gil, Jeongnam-myeon,
Hwaseong-si, Gyeonggi-do, Korea
Contact Person : Jong Uk Shin / H/W Team Manager
Telephone : +82-54-477-1065
Received Date : 2015-12-31
Test period : Start : 2016-01-22 End : 2016-01-28
Test Results : ☒ In Compliance ☐ Not in Compliance

The test results presented in this report relate only to the object tested.

Tested by

Y. T. Lee

Young-taek Lee
Test Engineer
Date: 2016-02-12

Reviewed by

Y. J. Park

Young-Joon, Park
Technical Manager
Date: 2016-02-12



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REPORT REVISION HISTORY

Date	Revision	Page No
2016-02-12	Issued (CTK-2015-00169)	All

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1.0 General Product Description

Equipment model name : Bi-4000

Serial number : Prototype

EUT condition : Pre-production, not damaged

Antenna type : PCB antenna Gain -0.5 dBi

Frequency Range : 2402 MHz – 2480 MHz

RF output power : 1.33 dBm Peak Conducted

Number of channels : 40

Type of Modulation : GFSK (Bluetooth 4.0 - LE)

Rated Channel spacing : 2 MHz

Power Source : DC 3.0 V (Coin Battery)

1.1 Tested Frequency

	LOW	MID	HIGH
Frequency (MHz)	2 402	2 440	2 480



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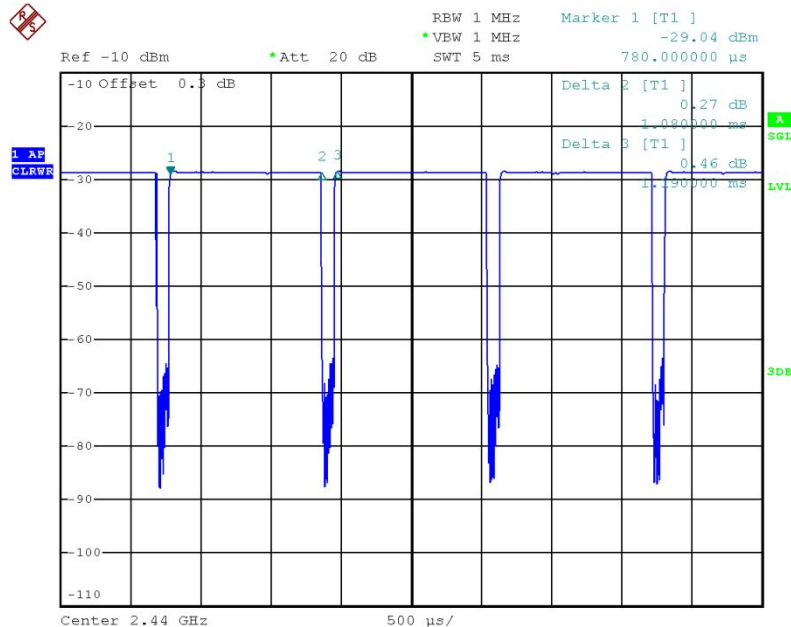
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1.2 Duty Cycle

Duty Cycle	90.8 %
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1.3 Model Differences

Not applicable

1.4 Device Modifications

The following modifications were necessary for compliance:

Not applicable

1.5 Peripheral Devices

Device	Manufacturer	Model No.	Serial No.
Notebook Computer	HP	HSTNN-I15C-5	5CG5114KD2
AC/DC ADAPTER	HP	PPP012D-S	WCN XF0AAR7S2XX
-	-	-	-



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1.6 Calibration Details of Equipment Used for Measurement

Test equipment and test accessories are calibrated on regular basis. The maximum time between calibrations is one year or what is recommended by the manufacturer, whichever is less. All test equipment calibrations are traceable to the Korea Research Institute of Standards and Science (KRISS), therefore, all test data recorded in this report is traceable to KRISS.

1.7 Test Facility

The measurement facility is located at 113, Yejik-ro, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea. The sites are constructed in conformance with the requirements of ANSI C63.7, ANSI C63.4 and CISPR Publication 22.

1.8 Laboratory Accreditations and Listings

Country	Agency	Scope of Accreditation	Registration Number	Logo
USA	FCC	FCC Part 15 & 18 EMI (Electromagnetic Interference / Emission)	805871	
JAPAN	VCCI	VCCI V-3 EMI (Electromagnetic Interference / Emission)	C-986 T-1843 R-3627 G-387	
KOREA	MSIP	EMI (Electromagnetic Interference / Emission) EMS (Electromagnetic Susceptibility / Immunity)	KR0025	



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2.0 Summary of tests

FCC Part Section(s)	Parameter	Limit	Test Condition	Status (note 1)
15.247(a)	6 dB Bandwidth	> 500 kHz	Conducted	C
15.247(b)	Maximum Output Power	< 1 Watt		C
15.247(d)	Conducted Spurious emission	> 20 dBc		C
15.247(d)	Band Edge	> 20 dBc		C
15.247(e)	Transmitter Power Spectral Density	< 8 dBm @ 3 kHz		C
				C
15.209	Field Strength of Harmonics	15.209(a)	Radiated	C
15.207	AC Conducted Emissions	15.207(a)	Line Conducted	NA(note 2)

Note 1: C=Complies NC=Not Complies NT=Not Tested NA=Not Applicable

Note 2: The equipment is operated on battery power only.

Note 3: The data in this test report are traceable to the national or international standards.

The sample was tested according to the following specification:
- FCC Part 15.247, ANSI C63.10-2013

The tests were performed according to the method of measurements prescribed in
558074 D01 DTS Meas Guidance v03r04.



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2.1 Technical Characteristic Test

2.1.1 6dB Bandwidth

Procedure:

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.

The spectrum analyzer is set to:

Center frequency = the highest, middle and the lowest channels

RBW = 100 kHz

VBW = 300 kHz ($VBW \geq 3 \times RBW$)

Trace = Max hold

Sweep = auto

Detector function = peak

Measurement Data:

Test mode : Continuous modulated carrier

Frequency (MHz)	Test Results	
	Measured Bandwidth (MHz)	Result
2 402	0.790	Complies
2 440	0.870	Complies
2 480	0.790	Complies

Minimum Standard:

6 dB Bandwidth > 500kHz

See next pages for actual measured spectrum plots.



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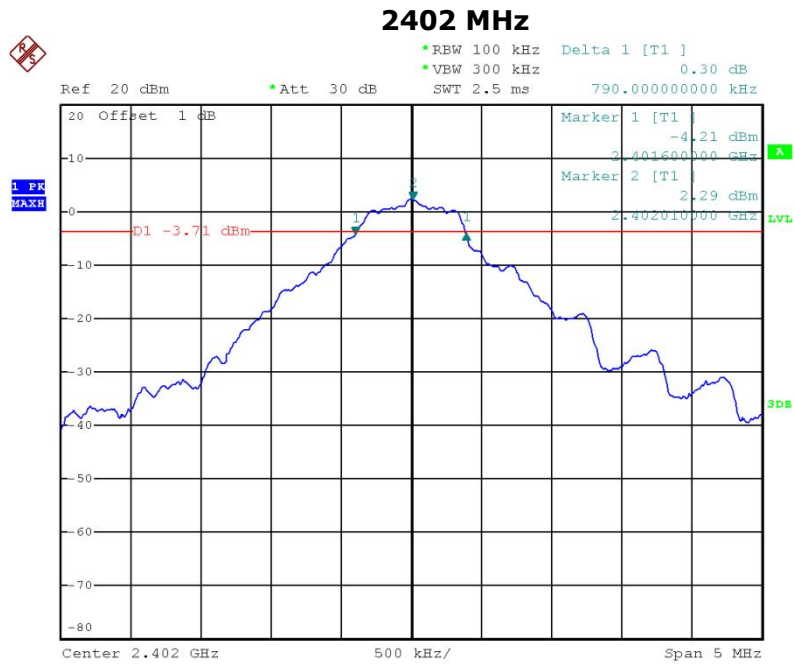
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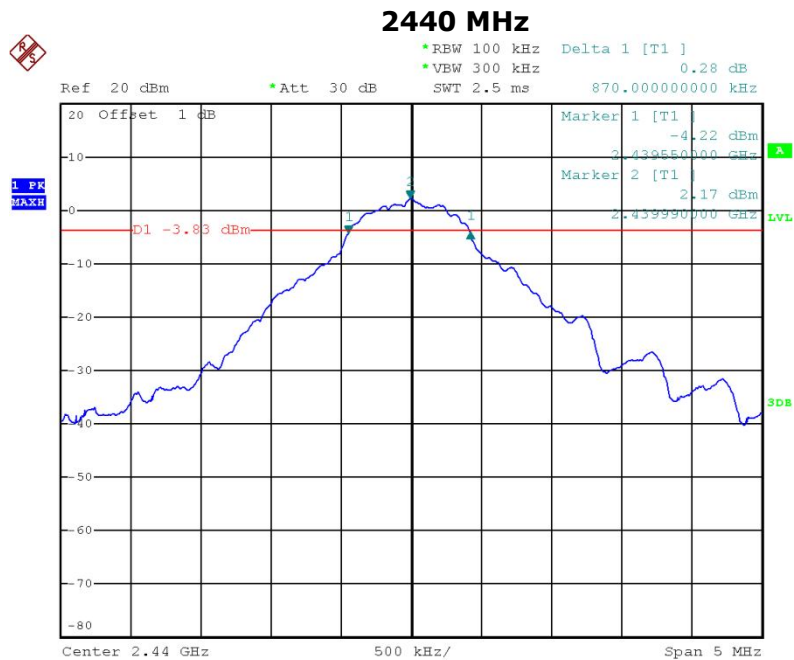
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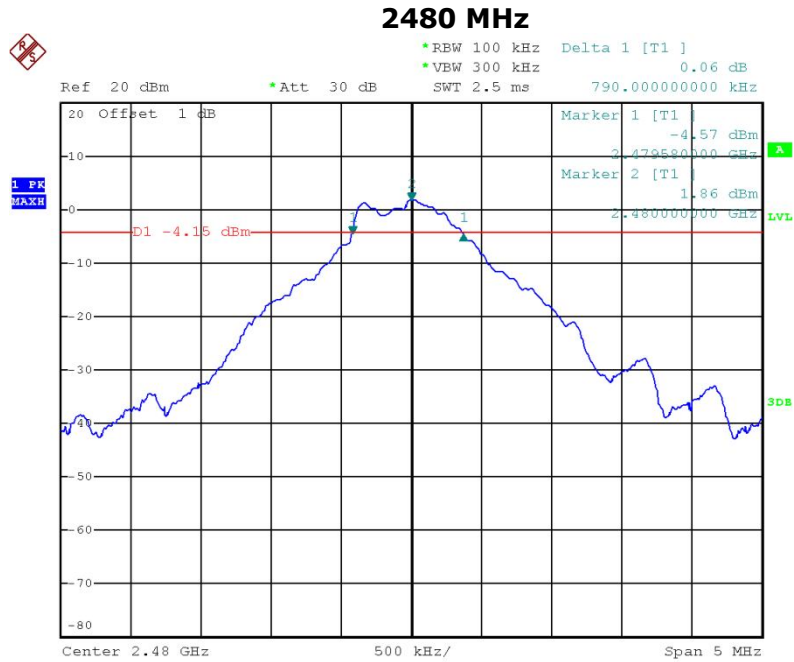
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2.1.2 Maximum peak Conducted Output Power

Test Location

RF Test Room

Test Procedures

Maximum Peak Output Power from the EUT were measured according to the dictates power measurement procedure in section 9.1.1 of KDB 558074.

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

- a) Set the RBW \geq DTS bandwidth
- b) Set the VBW $\geq 3 \times$ RBW
- c) Set the span $\geq 3 \times$ RBW
- d) Sweep time = auto couple
- e) Detector = peak
- e) Trace mode= max hold
- f) Allow trace to fully stabilize.
- g) Use peak marker function to determine the peak amplitude level.

Limit

< 1 W (30 dBm)

Test Results

Test mode : Continuous modulated carrier

Frequency (MHz)	Test results		
	Reading power(dBm)	Peak output power (mW)	Result
2 402	1.33	1.358	Complies
2 440	1.21	1.321	Complies
2 480	0.96	1.247	Complies

See next pages for actual measured spectrum plots.



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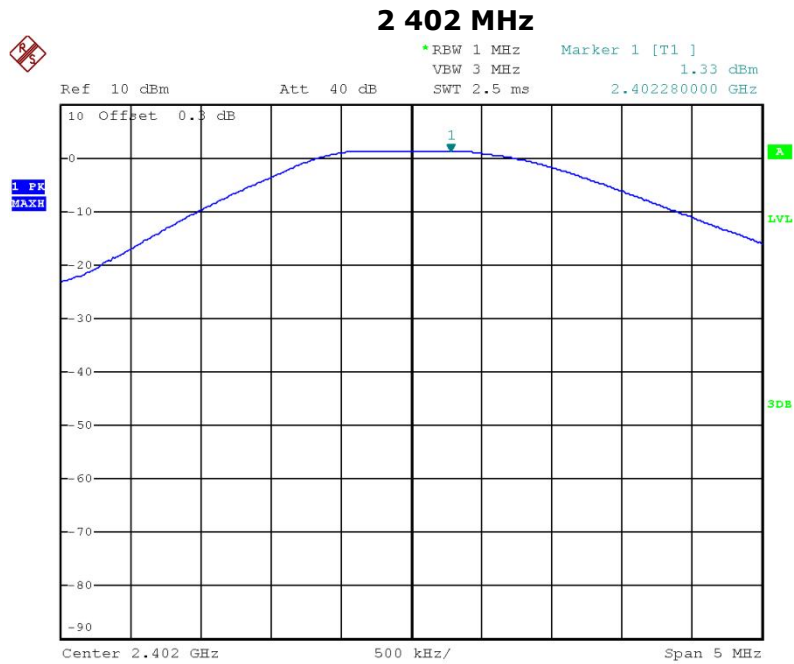
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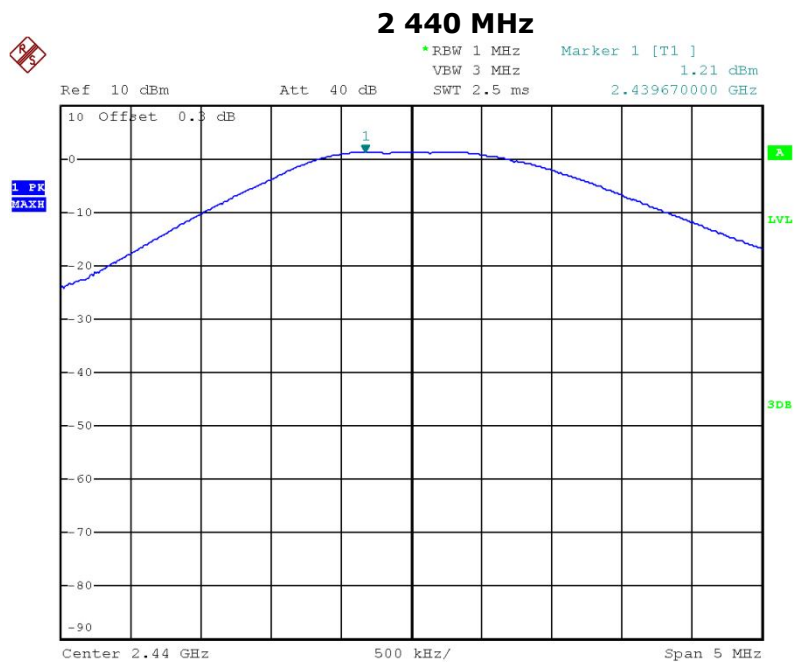
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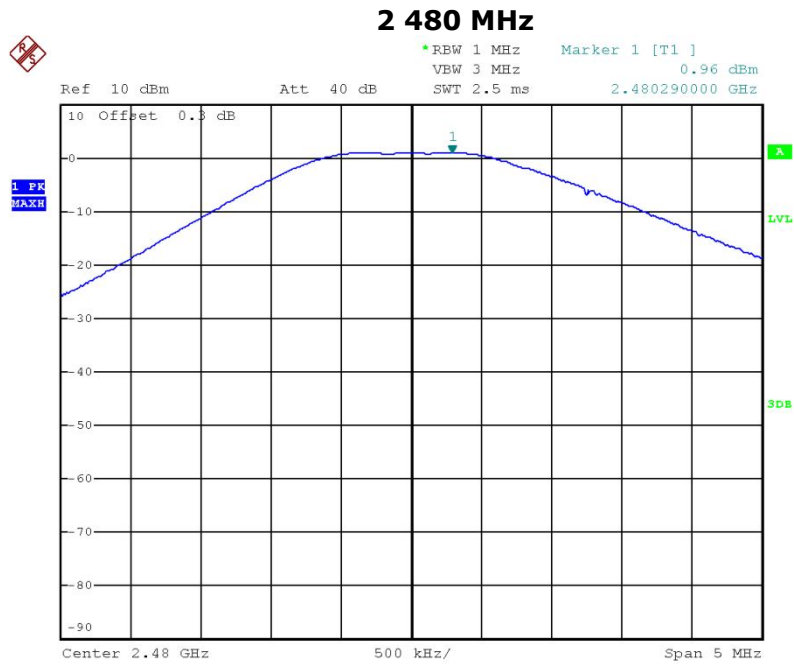
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2.1.3 Power Spectral Density

Procedure:

Power Spectral Density from the EUT were measured according to the dictates PKPSD measurement procedure in section 10.2 of KDB 558074.

This procedure shall be used if maximum peak conducted output power was used to demonstrate compliance.

- a) Set analyzer center frequency to DTS channel center frequency.
- b) Set the span to 1.5 times the DTS bandwidth.
- c) Set the RBW to : $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
- d) Set the VBW $\geq 3 \times \text{RBW}$
- e) Detector = peak
- f) Sweep time = auto couple
- g) Trace mode = max hold
- h) Allow trace to fully stabilize
- i) Use the peak marker function to determine the maximum amplitude level within the RBW.
- j) If measured value exceed limit, reduce RBW(no less than 3 kHz) and repeat.

Test mode : Continuous modulated carrier

Frequency (MHz)	Test Results	
	dBm	Result
2 402	1.59	Complies
2 440	1.51	Complies
2 480	1.24	Complies

Minimum Standard:

Power Spectral Density	< 8dBm @ 3 kHz BW
------------------------	-------------------

See next pages for actual measured spectrum plots.



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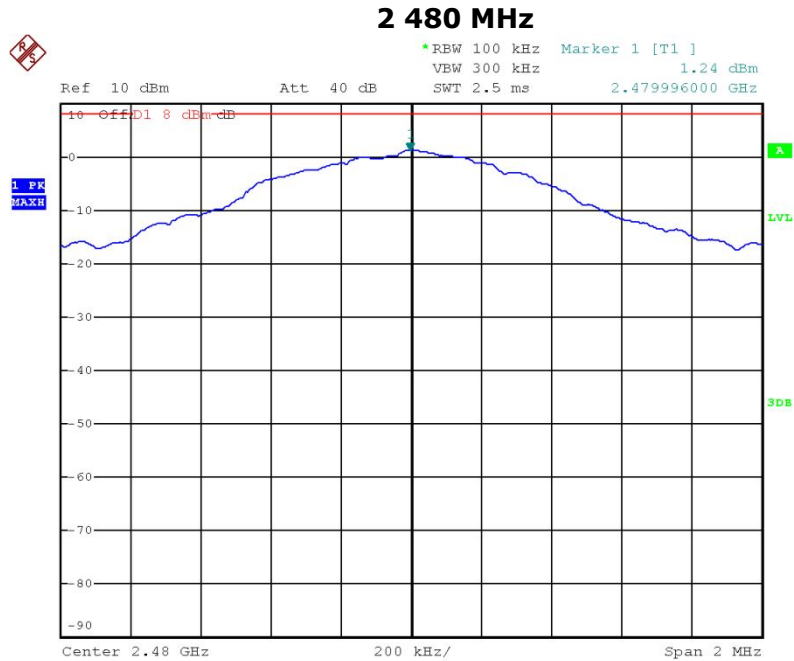
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2.1.4 Emissions in non-restricted bands

Procedure:

The peak output power measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 20 dBc). If maximum conducted (average) output power was used to demonstrate compliance as described in 9.2, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 30 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 30 dBc). In either case, attenuation to levels below the 15.209 general radiated emissions limits is not required.

The spectrum analyzer is set to:

Center frequency = the highest, middle and the lowest channels

RBW = 100 kHz

VBW = 300 kHz ($VBW \geq 3 \times RBW$)

Trace = Max hold

Detector function = peak

Sweep = auto

Measurement Data: Complies

- All conducted emission in any 100kHz bandwidth outside of the spread spectrum band was at least 20dB lower than the highest in-band spectral density. Therefore the applying equipment meets the requirement.

Minimum Standard:	> 20 dBc
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See next pages for actual measured spectrum plots.



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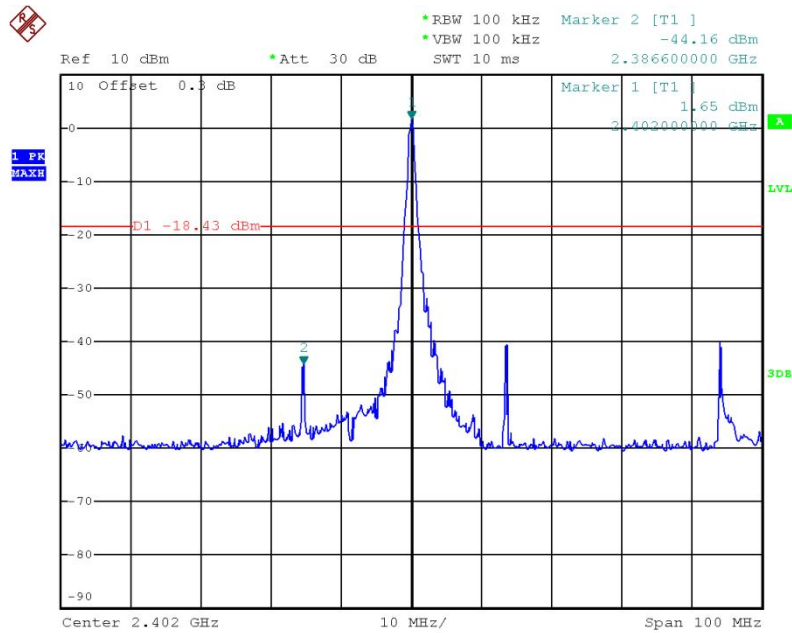
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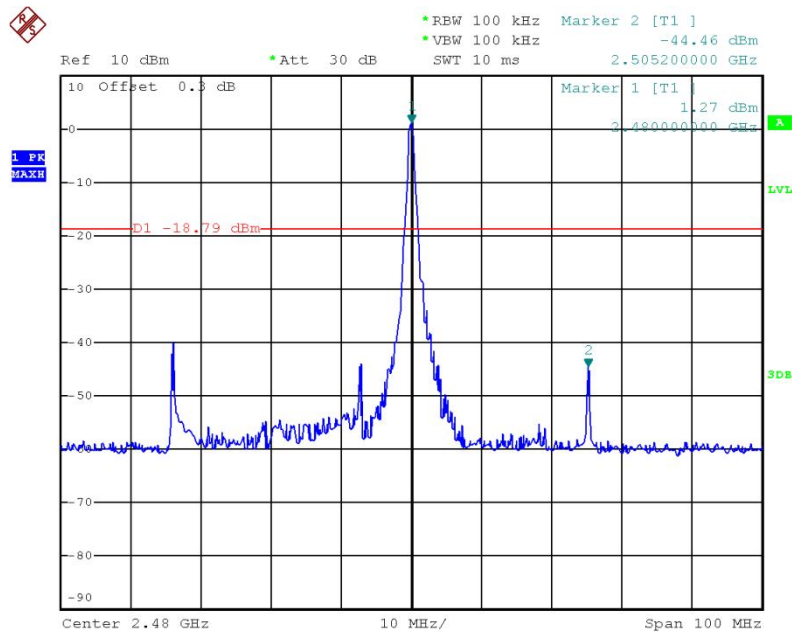
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Band-edge Measurements



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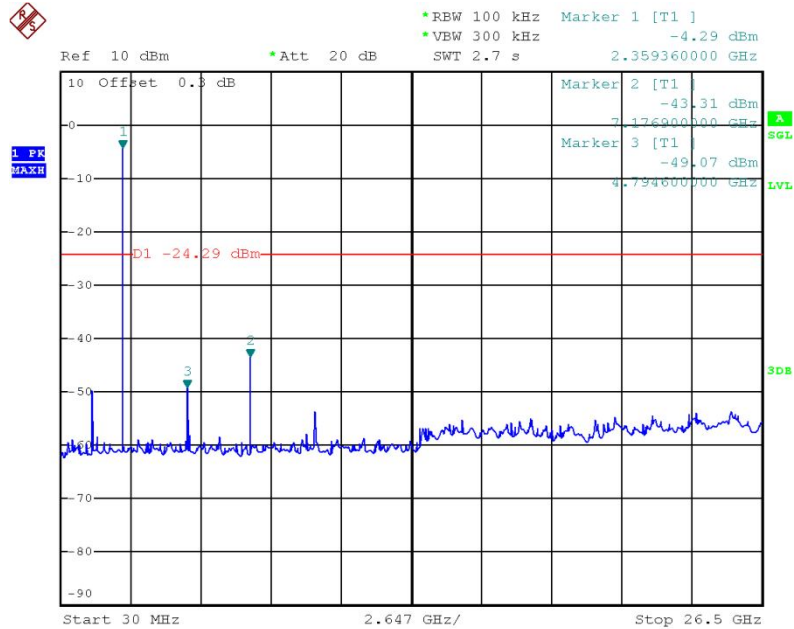


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Band - edge (at 20 dB blow) - Low channel Frequency Range = 30 MHz ~ 10th harmonic



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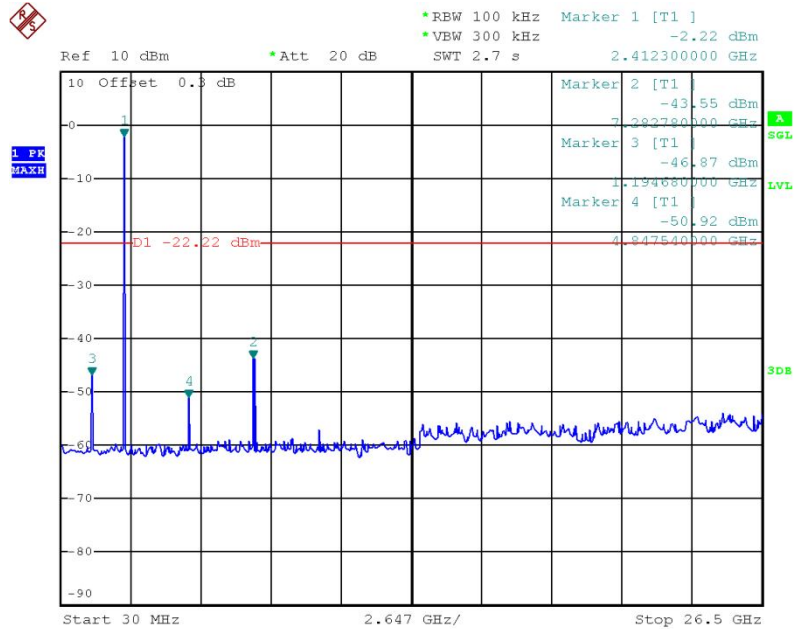


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Band – edge (at 20 dB blow) – Mid channel Frequency Range = 30 MHz ~ 10th harmonic



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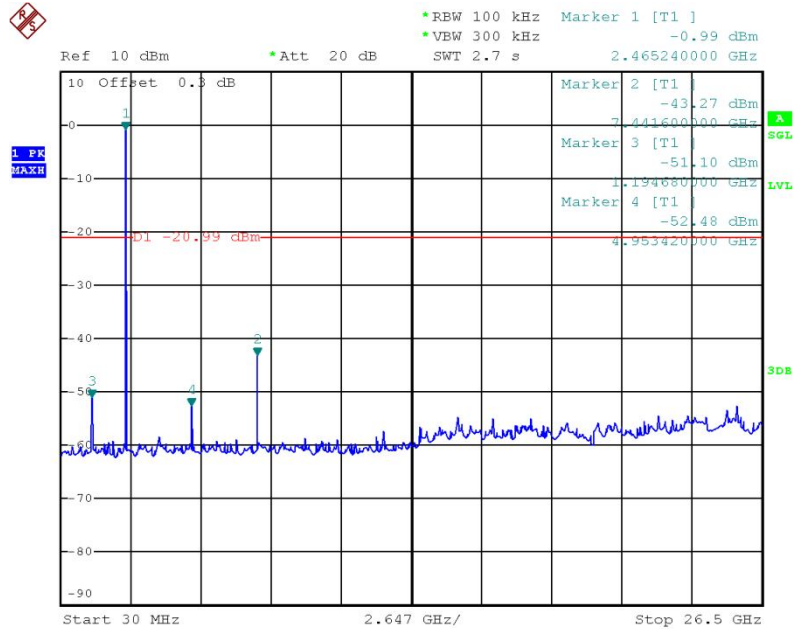
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Band - edge (at 20 dB blow) - High channel Frequency Range = 30 MHz ~ 10th harmonic



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2.1.5 Field Strength of Emissions

Test Location

- ☒ 10 m SAC (test distance : ☐ 10 m, ☒ 3 m)
☒ 3 m SAC (test distance : 3 m)

Test Procedures

- 1) In the frequency range of 9 kHz to 30 MHz, magnetic field is measured with Loop Antenna. The Test Antenna is positioned with its plane vertical at 1m distance from the EUT. The center of the Loop Test Antenna is 1m above the ground. During the measurement the Loop Test Antenna rotates about its vertical axis for maximum response at each azimuth about the EUT.
- 2) In the frequency range above 30 MHz, Bi-Log Test Antenna(30 MHz to 1 GHz) and Horn Test Antenna(above 1 GHz) are used. Test Antenna is 3m away from the EUT. Test Antenna height is carried from 1m to 4m above the ground to determine the maximum value of the field strength. The emissions levels at both horizontal and vertical polarizations should be tested.

The spectrum analyzer is set to:

Frequency Range = 9 kHz ~ 25 GHz (2.4 GHz 10th harmonic)

RBW = 1 MHz for $f \geq 1$ GHz, 100 kHz for $f < 1$ GHz, 9 kHz for $f < 30$ MHz

VBW \geq RBW

Sweep = auto



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Limit

§ 15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	MHz	MHz	GHz
0.09-0.11	8.37626-8.38675	73-74.6	399.9-410	2690-2900	10.6-12.7
¹ 0.495-0.505	8.41425-8.41475	74.8-75.2	608-614	3260-3267	13.25-13.4
2.1735-2.1905	12.29-12.293	108-121.94	960-1240	3332-3339	14.47-14.5
4.125-4.128	12.51975-12.52025	123-138	1300-1427	3345.8-3358	15.35-16.2
4.17725-4.17775	12.57675-12.57725	149.9-150.05	1435-1626.5	3600-4400	17.7-21.4
4.20725-4.20775	13.36-13.41	156.52475-156.52525	1645.5-1646.5	4500-5150	22.01-23.12
6.215-6.218	16.42-16.423	156.7-156.9	1660-1710	5350-5460	23.6-24
6.26775-6.26825	16.69475-16.69525	162.0125-167.17	1718.8-1722.2	7250-7750	31.2-31.8
6.31175-6.31225	16.80425-16.80475	167.72-173.2	2200-2300	8025-8500	36.43-36.5
8.291-8.294	25.5-25.67	240-285	2310-2390	9000-9200	² Above 38.6
8.362-8.366	37.5-38.25	322-335.4	2483.5-2500	9300-9500	

¹ Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.

² Above 38.6

§ 15.205 (b) Except as provided in paragraphs (d) and (e), the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.



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§ 15.209 (a) Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table :

Frequency(MHz)	Field Strength uV/m@3m	Field Strength dBuV/m@3m	Deasurement Distance (meters)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705-30	30	-	30
30-88	100**	40	3
88-216	150**	43.5	3
216-960	200**	46	3
Above 960	500	54	3

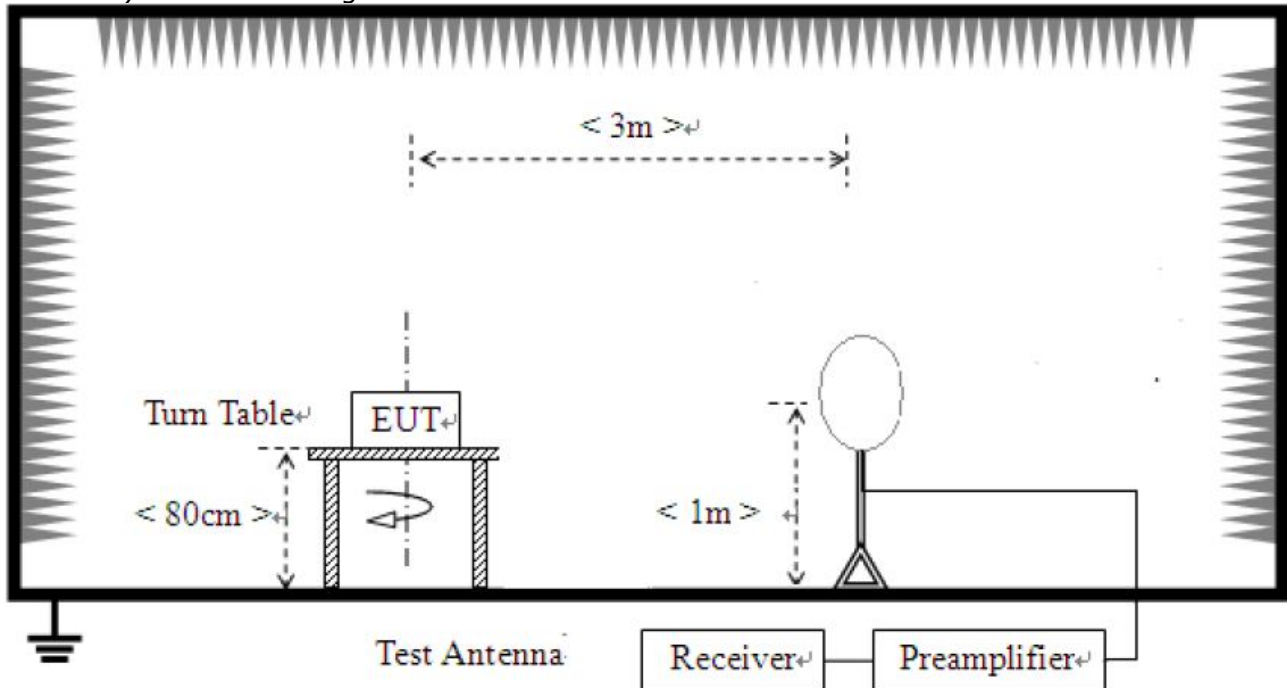
** Except as provided in 15.209(g).fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72MHz, 76-88MHz, 174-216MHz, 470-806MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g.15.231 and 15.241.

Note :

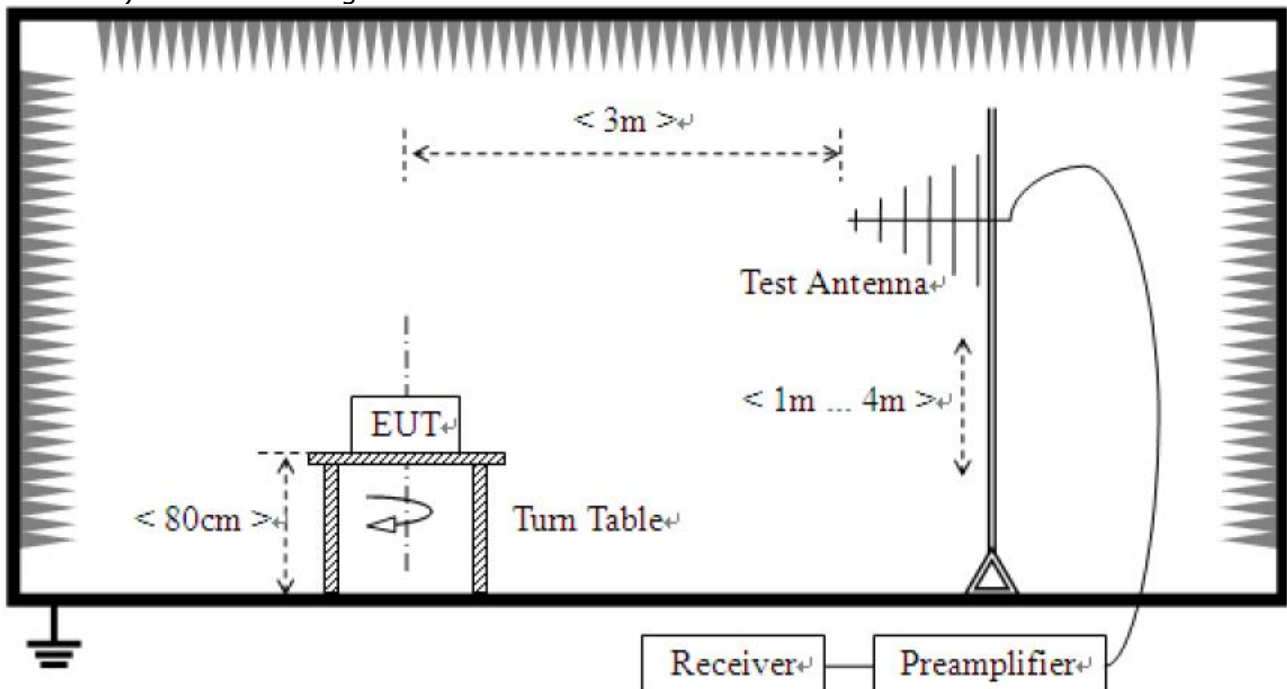
- 1) For above 1 GHz, the emission limit in this paragraph is based on measurement instrumentation employing an average detector, measurement using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit.
- 2) For above 1 GHz, limit field strength of harmonics : 54 dBuV/m@3m (AV) and 74 dBuV/m@3m (PK)
- 3) For measurement above 1GHz, the resolution bandwidth is set to 1 MHz and video bandwidth is set to 1 MHz for peak measurement and 10 Hz for average measurement.(Duty Cycle is > 98%,)
- 4) Duty Cycle is < 98%, VBW setting will need to > 1/T.

Test Setup:

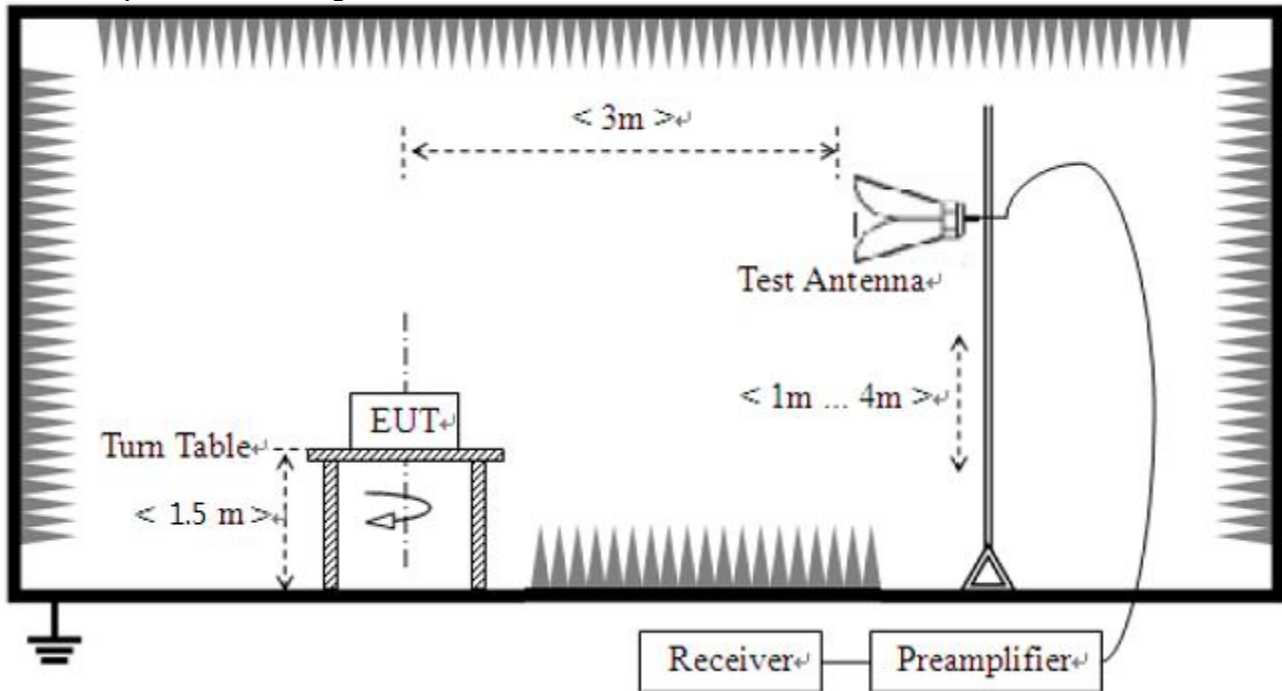
1) For field strength of emissions from 9 kHz to 30 MHz



2) For field strength of emissions from 30 MHz to 1 GHz



3) For field strength of emissions above 1 GHz



Test Results

1) 9 kHz to 30 MHz

EUT	Bluetooth 4.0 Beacon	Measurement Detail	
Model	Bi-4000	Frequency Range	9 kHz – 30 MHz
Test mode	Continuous modulated carrier	Detector function	Quasi-Peak

The requirements are:

☒ Complies

Frequency (MHz)	Measured Data (dBuV/m)	Margin (dB)	Remark
-	-	-	See note

Note :

The amplitude of spurious emissions that are attenuated by more than 20 dB below the permissible value has no need to be reported.

Distance extrapolation factor = $40 \log (\text{specific distance} / \text{test distance})$ (dB)

2) 30 MHz to 1 GHz

Test mode : Continuous modulated carrier, High Channel(2480 MHz)

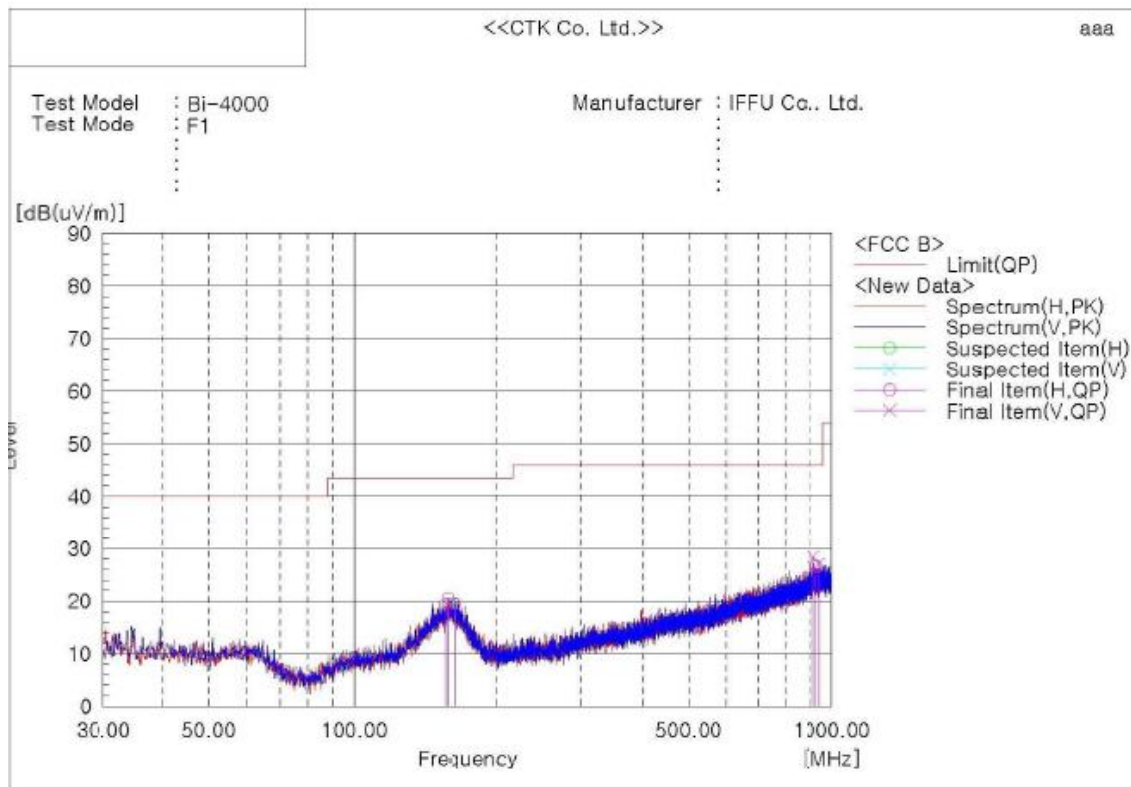
EUT	Bluetooth 4.0 Beacon	Measurement Detail	
Model	Bi-4000	Frequency Range	Below 1000MHz
Mode	Continuous modulated carrier (Worst case : low channel)	Detector function	Quasi-Peak

The requirements are:

☒ Complies

Frequency (MHz)	Measured Data (dBuV/m)	Margin (dB)	Remark
916.822	28.4	17.6	Peak

Test Data



Final Result

No.	Frequency (P)	Reading QP	c.f	Result QP	Limit QP	Margin QP	Height	Angle
	[MHz]	[dB(uV)]	[dB(1/m)]	[dB(uV/m)]	[dB(uV/m)]	[dB]	[cm]	[deg]
1	916.822	V 30.2	-1.8	28.4	46.0	17.6	174.8	100.8
2	929.432	H 28.3	-1.6	26.7	46.0	19.3	172.5	139.6
3	943.982	V 28.6	-1.5	27.1	46.0	18.9	174.8	211.7
4	157.191	H 27.4	-6.8	20.6	43.5	22.9	172.5	252.2
5	155.130	H 26.3	-7.0	19.3	43.5	24.2	172.5	177.3
6	163.860	H 26.4	-7.0	19.4	43.5	24.1	172.5	8.7



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3) above 1 GHz

EUT	Bluetooth 4.0 Beacon	Measurement Detail	
Model	Bi-4000	Frequency Range	1-25GHz
Channel	Low (2 402 MHz)	Detector function	Average / Peak

Remarks

We have tested three mode (X, Y, Z). The worst mode (X axis) for final test.

The requirements are:

☒ Complies

Frequency (MHz)	Measured Data (dBuV/m)	Margin (dB)	Remark
4 804	53.7	0.3	Average

Test Data

Frequency [MHz]	Reading [dBuV/m]		Pol.	Height [m]	Correction Factor	Limits [dBuV/m]	Result [dBuV/m]	Margin [dB]	
	AV / Peak				Antenna + Amp. Gain + Cable	AV / Peak	AV / Peak	AV / Peak	
4804.00	49.6	54.4	V	1.5	4.2	54.0 : 74.0	53.7 : 58.6	0.3	15.4
7206.00	33.9	44.1	V	1.5	9.2	54.0 : 74.0	43.1 : 53.3	10.9	20.8

Restricted band edge test data

Measured frequency range : 2310-2390 MHz, 2483.5-2500 MHz

Frequency [MHz]	Reading [dBuV/m]		Pol.	Height [m]	Correction Factor	Limits [dBuV/m]		Result [dBuV/m]		Margin [dB]	
	AV / Peak				Antenna + Amp. Gain + Cable	AV / Peak		AV / Peak		AV / Peak	
2390.00	34.6	57.7	V	1.5	-2.6	54.0	74.0	32.0	55.1	22.0	18.9



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EUT	Bluetooth 4.0 Beacon	Measurement Detail	
Model	Bi-4000	Frequency Range	1-25GHz
Channel	Mid (2 440 MHz)	Detector function	Average / Peak

Remarks

We have tested three mode (X, Y, Z). The worst mode (X axis) for final test.

The requirements are:

☒ Complies

Frequency (MHz)	Measured Data (dBuV/m)	Margin (dB)	Remark
4 880	52.4	1.6	Average

Test Data

Frequency [MHz]	Reading [dBuV/m] AV / Peak		Pol.	Height [m]	Correction Factor	Limits [dBuV/m] AV / Peak		Result [dBuV/m] AV / Peak		Margin [dB] AV / Peak	
					Antenna + Amp. Gain + Cable						
4880.00	48.2	54.6	V	1.5	4.1	54.0	74.0	52.4	58.7	1.6	15.3
7320.00	31.1	40.0	V	1.5	9.3	54.0	74.0	40.4	49.3	13.6	24.7



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EUT	Bluetooth 4.0 Beacon	Measurement Detail	
Model	Bi-4000	Frequency Range	1-25GHz
Channel	High (2 480 MHz)	Detector function	Average / Peak

Remarks

We have tested three mode (X, Y, Z). The worst mode (X axis) for final test.

The requirements are:

☒ Complies

Frequency (MHz)	Measured Data (dBuV/m)	Margin (dB)	Remark
7 440	43.9	10.1	Average

Test Data

Frequency [MHz]	Reading [dBuV/m] AV / Peak		Pol.	Height [m]	Correction Factor	Limits [dBuV/m] AV / Peak		Result [dBuV/m] AV / Peak		Margin [dB] AV / Peak	
					Antenna + Amp. Gain + Cable						
4960.00	39.2	47.0	V	1.5	4.0	54.0	74.0	43.2	50.9	10.8	23.1
7440.00	34.5	44.3	V	1.5	9.4	54.0	74.0	43.9	53.7	10.1	20.3

Restricted band edge test data

Measured frequency range : 2310-2390 MHz, 2483.5-2500 MHz

Frequency [MHz]	Reading [dBuV/m] AV / Peak		Pol.	Height [m]	Correction Factor	Limits [dBuV/m] AV / Peak		Result [dBuV/m] AV / Peak		Margin [dB] AV / Peak	
					Antenna + Amp. Gain + Cable						
2483.50	38.3	61.4	V	1.5	-2.5	54.0	74.0	35.8	58.9	18.2	15.1



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2.1.6 AC Conducted Emissions

Test Location

Shielded Room

Frequency Range of Measurement

150 kHz to 30 MHz

Instrument Settings

IF Band Width: 9 kHz

Test Procedures

The EUT was placed on a non-metallic table 0.8m above the metallic, grounded floor and 0.4m from the reference ground plane wall. The distance to other metallic surfaces was at least 0.8m.

Amplitude measurements were performed with a quasi-peak detector and an average detector.

Limit

- 15.207(a)

Frequency (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15 ~ 0.5	66 to 56*	56 to 46*
0.5 ~ 5	56	46
5 ~ 30	60	50

* Decreases with the logarithm of the frequency.

Test Results

The requirements are:

☒ Not Applicable



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APPENDIX A – Test Equipment Used For Tests

	Name of Equipment	Manufacturer	Model No.	Serial No.	Date of Calibration	Due Date
1	Spectrum Analyzer	Rohde & Schwarz	FSP-30	100994	2015-11-02	2016-11-02
2	EMI Test Receiver	Rohde & Schwarz	ESCI7	100814	2015-11-02	2016-11-02
3	EMI Test Receiver	Rohde & Schwarz	ESR	101088	2015-06-12	2016-06-12
4	EMI Test Receiver	Rohde & Schwarz	ESU40	100336	2015-05-15	2016-05-15
5	Bilog Antenna	Schaffner	CBL6111C	2551	2015-04-24	2017-04-24
6	Double Ridged Guide Antenna	ETS-Lindgren	3117	00154525	2015-09-02	2017-09-02
7	Double Ridged Guide Antenna	ETS-Lindgren	3116	00062916	2015-09-04	2017-09-04
8	Active Loop Antenna	SCHWARZBECK	FMZB 1513	1513-126	2015-05-19	2016-05-19
9	Attenuator	Rohde & Schwarz	DNF	272.4110.50-2	2015-11-03	2016-11-03
10	PREAMPLIFIER	Agilent	8449B	3008A02011	2015-12-08	2016-12-08
11	AMPLIFIER	Sonoma Instrument Co.	310	291721	2016-02-02	2017-02-02
12	Band Reject Filter	Wainwright Instruments GmbH	WRCGV 2400/2483-2375/2505-50/10EE	2	2015-05-14	2016-05-14
13	Signal Generator	Rohde & Schwarz	SMB100A	175528	2016-01-20	2017-01-20
14	DC POWER SUPPLY	HP	E3632A	MY40011638	2015-11-02	2016-11-02