TEST REPORT

FCC Part 15.247

Equipment under test	LK-BT
Model name	LK-BT240
Derivative Model name	BT60, BT120, BT240, LK-BT60, LK-BT120
FCC ID	2APJH-LK-BT240
Applicant	KLT Co., Ltd.
Manufacturer	KLT Co., Ltd.
Date of test(s)	2023.07.10 ~ 2023.07.11
Date of issue	2023.07.24

Issued to
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Test and report completed by :	**Report approval by :**
	
Do-won, Ahn Test engineer	Young-Jin Lee Technical manager

This test report is not related to KS Q ISO/IEC 17025 and KOLAS.

Revision history

Revision	Date of issue	Test report No.	Description
-	2023.07.24	KES-RF-23T0103	Initial

TABLE OF CONTENTS

1. General information

Applicant:	KLT Co., Ltd
Applicant address:	34-12, Bangchon-ro 955beon-gil, Tanhyeon-myeon, Paju-si, Gyeonggi-do, Republic of Korea
Test site:	KES Co., Ltd.
Test site address:	☐ 3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, 14057, Korea ☒ 473-29, Gayeo-ro, Yeoju-si, Gyeonggi-do, Korea
Test Facility	FCC Accreditation Designation No.: KR0100, Registration No.: 444148
FCC rule part(s):	15.247
FCC ID:	2APJH-LK-BT240
Test device serial No.:	☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test	LK-BT
Frequency range	2 402 ㎒ ~ 2 480 ㎒ (LE 1Mbps)
Model	LK-BT240
Derivative Model	BT60, BT120, BT240, LK-BT60, LK-BT120
Modulation technique	GFSK
Antenna specification	Dielectric Chip Antenna // Peak gain: 3.14 dBi
Power source	DC 4.5 V
Number of channels	2 402 ㎒ ~ 2 480 ㎒ (BLE 1 Mbps) : 40 ch
H/W Version	1.4
S/W Version	2.00
Serial Number	N/A

1.2. Test configuration

The **KLT Co., Ltd. // LK-BT // LK-BT240 // FCC ID: 2APJH-LK-BT240**
was tested according to the specification of EUT, the EUT must comply with following standards and KDB documents.

FCC Part 15.247
KDB 558074 D01 v05 r02
ANSI C63.10-2013

1.3. Derivative Model Information

Model	DIFFERENCE
BT60	All electronic circuits are the same. The difference of mechanical capacity grease volume is 60cc
BT120	All electronic circuits are the same. The difference of mechanical capacity grease volume is 120cc
BT240	All electronic circuits are the same. The difference of mechanical capacity grease volume is 240cc
LK-BT60	All electronic circuits are the same. Derivative models added due to ODM progress The difference of mechanical capacity grease volume is 60cc
LT-BT120	All electronic circuits are the same. Derivative models added due to ODM progress The difference of mechanical capacity grease volume is 120cc

1.4. Accessory information

Equipment	Manufacturer	Model	Serial No.	Power source
-	-	-	-	-

1.5. Sample calculation

Where relevant, the following sample calculation is provided

For all conducted test items :

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Offset(dB) = RF cable loss(dB) + attenuator factor(dB).
= 0.72 + 10 = 10.72 (dB)

For Radiation test :
Field strength level (dBμV/m) = Measured level (dBμV) + Antenna factor (dB) + Cable loss (dB) – Amplifier gain (dB)

1.6. Measurement Uncertainty

Test Item		Uncertainty
Uncertainty for Conduction emission test		2.22 dB
Uncertainty for Radiation emission test (include Fundamental emission)	Below 1㎓	4.04 dB
	Above 1㎓	5.32 dB
Note. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.		

1.7. Frequency/channel operations

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

2. Summary of tests

Section in FCC Part 15	Parameter	Test results
15.247(a)(2)	6 dB bandwidth	Pass
15.247(b)(3)	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	N/A(1)
15.203	Antenna Requirement	Pass

Note:

1. This product is powered by battery DC 4.5V.
2. By the request of the applicant, test was performed with condition below:
   Target power : Default

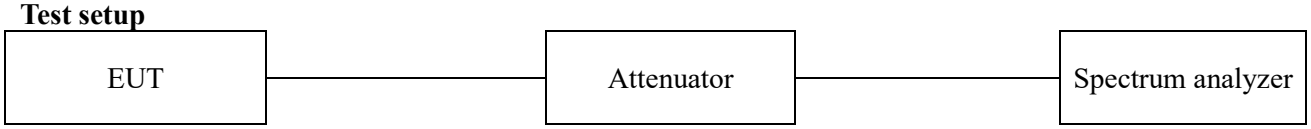
3. Test results

3.1. 6 dB bandwidth

Test procedure

ANSI C63.10 – section 11.8

Test setup



ANSI C63.10-2013 - Section 11.8.1

1. RBW = 100 ㎑.
2. VBW ≥ 3 × 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 ㏈ relative to the maximum level measured in the fundamental emission.

ANSI C63.10-2013 - Section 11.8.2

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 in 11.8.1 (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, and 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.

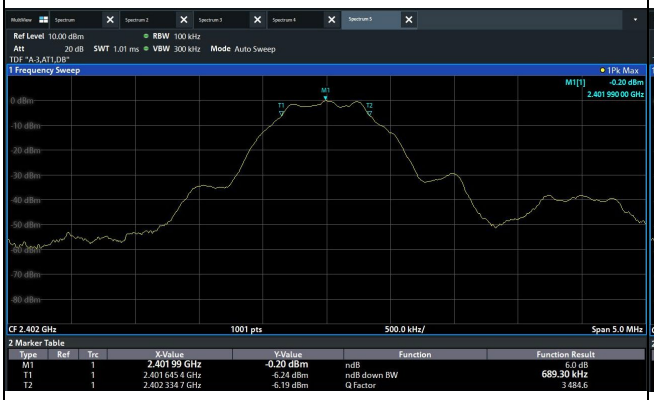
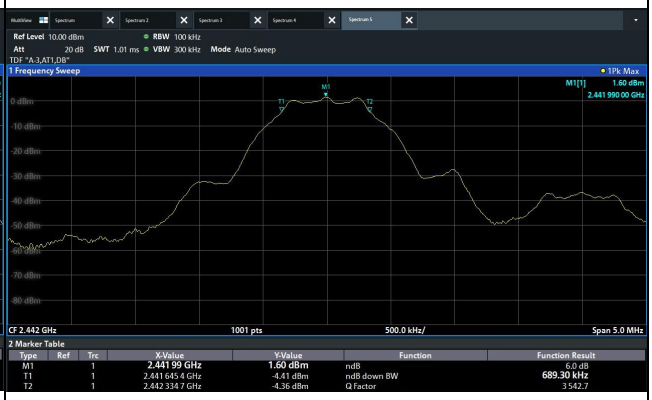
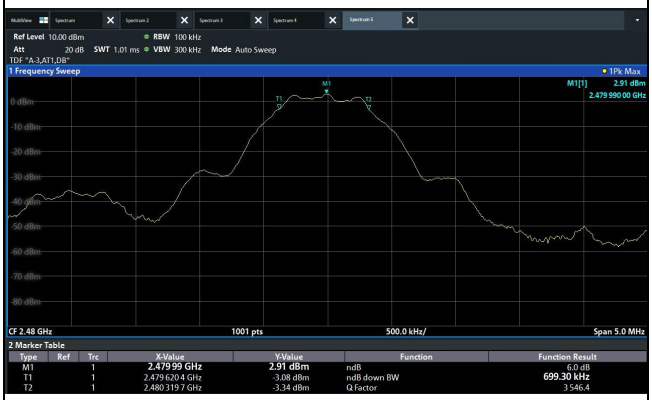
Limit

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

Test results

Mode	Frequency(㎒)	6 ㏈ bandwidth(㎒)	Limit(㎒)
BLE 1 Mbps	2 402	0.694	≥ 0.500
	2 442	0.689	
	2 480	0.699	

Test plot

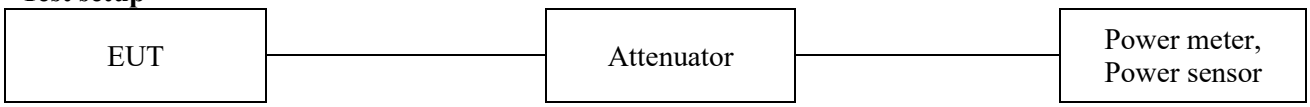
BLE 1 Mbps	
	
	N/A

3.2. Output power

Test procedure

ANSI C63.10-2013 - Section 11.9.1.3 and 11.9.2.3.2

Test setup



ANSI C63.10-2013 - Section 11.9.1.3

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 ba ndwidth and shall use a fast-responding diode detector.

ANSI C63.10-2013 - Section 11.9.2.3.2

Alternatively, measurements may be performed using a wideband gated RF power meter provided that the gate parameters are adjusted such that the power is measured only when the EUT is transmitting at its maximum power control level. Because the measurement is made only during the ON time of the transmitter, no duty cycle correction is required.

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

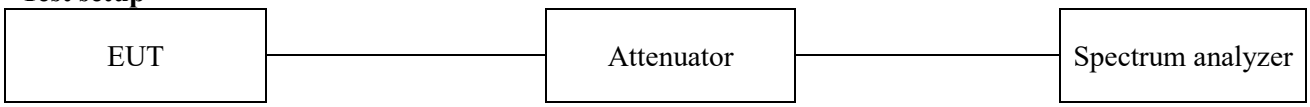
Measured output power (dBm)						
Mode	2 402 ㎒		2 442 ㎒		2 480 ㎒	
	Average	Peak	Average	Peak	Average	Peak
BLE 1 Mbps	-0.90	-0.15	0.89	1.61	2.23	2.91

3.3. Power spectral density

Test procedure

ANSI C63.10 – section 11.10.2

Test setup



ANSI C63.10 – section 11.10.2

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 ㎑ ≤ 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 within the RBW.
10. If measured value exceeds limit, reduce RBW(no less than 3 ㎑) and repeat.

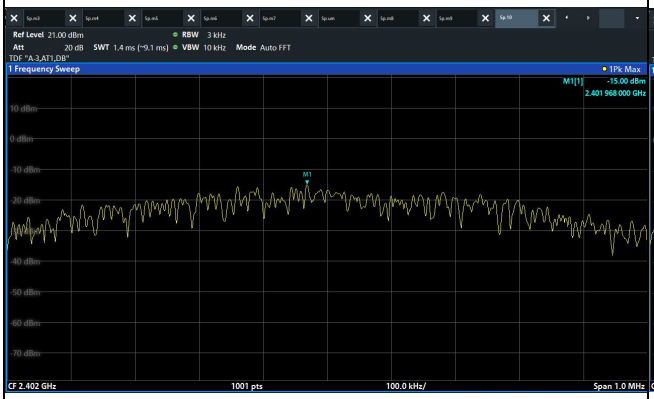
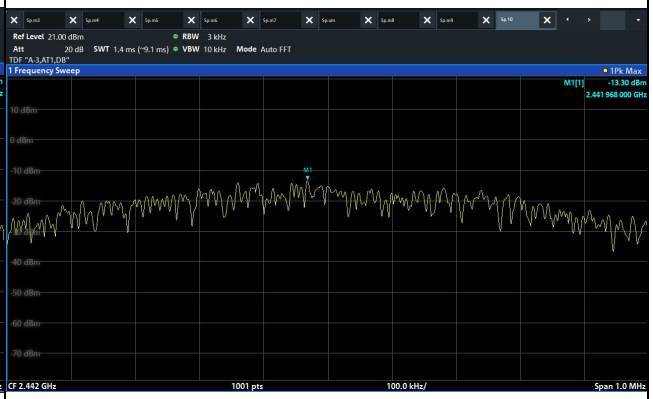
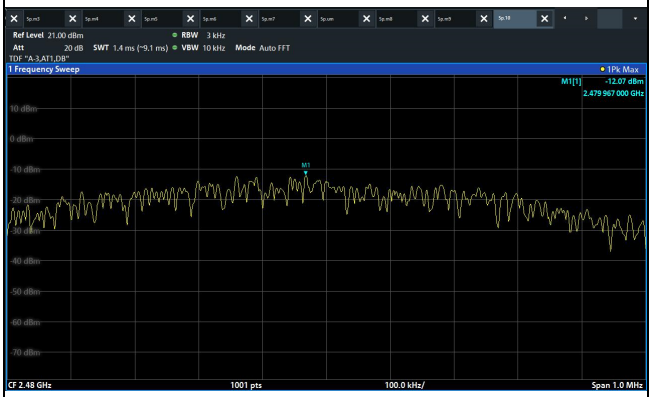
Limit

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

Mode	Frequency(㎒)	PSD(dBm/3㎑)	Limit(dBm/3㎑)
BLE 1 Mbps	2 402	-15.00	8
	2 442	-13.30	
	2 480	-12.07	

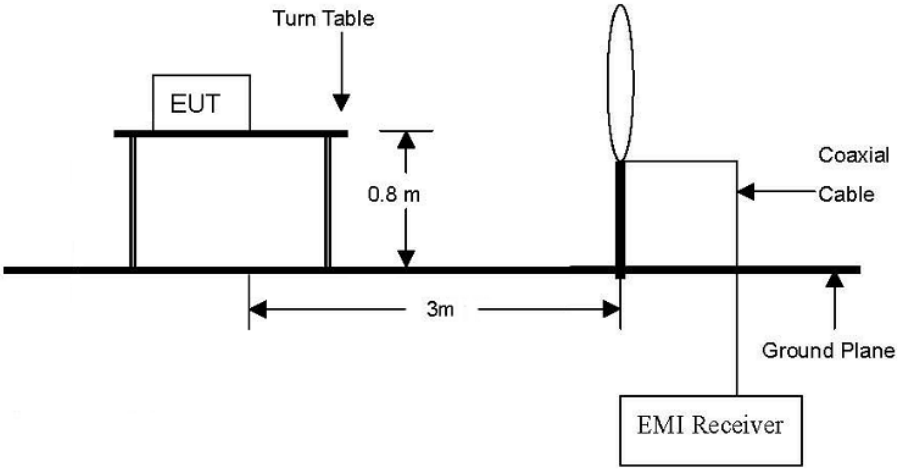
Test plot

BLE 1 Mbps	
	
	N/A

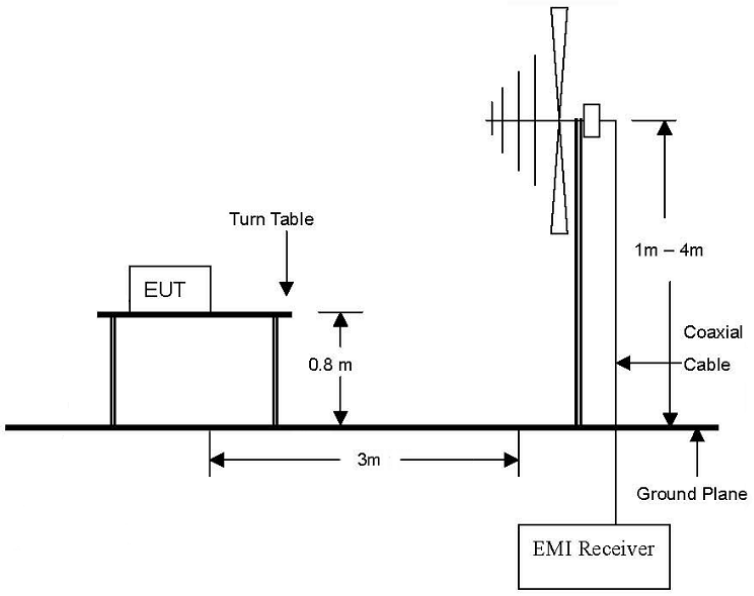
3.4. Radiated restricted band and emissions

Test setup

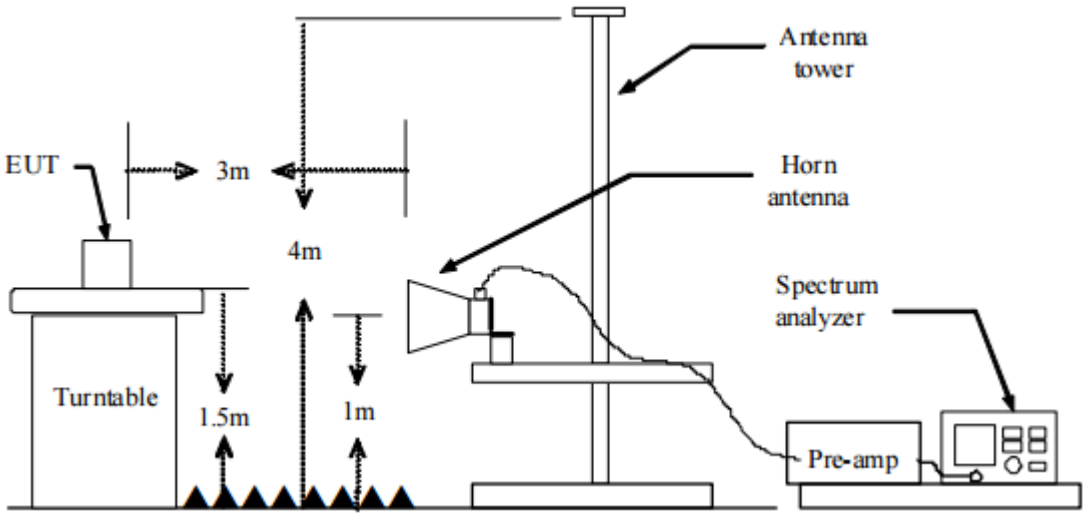
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 ㎑ to 30 ㎒ Emissions.



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 tenth harmonic of the highest fundamental frequency or to 40 ㎓ emissions, whichever is lower.



Test procedure

Radiated emissions from the EUT were measured according to the dictates in section 11.11 & 11.12 of ANSI C63.10-2013.

Test procedure below 30 ㎒

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, ground parallel and perpendicular of the antenna are set to make the measurement. It was determined that **parallel** was worst-case orientation; therefore, all final radiated testing was performed with the EUT in **parallel.**
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 ㎒

1. The EUT was placed on the top of a rotating table 0.8 meters(30-1000MHz) / 1.5 meters(above 1GHz)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. The antenna is a bi-log antenna, a horn antenna ,and its height are varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations 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 antenna was tuned to heights from 1 meter to 4 meters and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
4. The test receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

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

7. Spectrum analyzer settings for $f \geq 1$ ㎓: Average
   ① Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
   ② RBW = 1 ㎒
   ③ VBW ≥ 3 × RBW
   ④ Detector = RMS, if span/(# of points in sweep) ≤ (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.
   ⑤ Averaging type = power(i.e., RMS)
      1) As an alternative, the detector and averaging type may be set for linear voltage averaging.
      2) Some instruments require linear display mode in order to use linear voltage averaging. Log or ㏈ averaging shall not be used.
   ⑥ Sweep = auto
   ⑦ Trace = max hold
   ⑧ Perform a trace average of at least 100 traces.
   ⑨ A correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100 percent duty cycle. The correction factor is computed as follows:
      1) If power averaging (RMS) mode was used in step ⑤, then the applicable correction factor is 10 log(1/x), where x is the duty cycle.
      2) If linear voltage averaging mode was used in step ⑤, then the applicable correction factor is 20 log(1/x), where x is the duty cycle.
      3) If a specific emission is demonstrated to be continuous (≥ 98 percent duty cycle) rather than turning on and off with the transmit cycle, then no duty cycle correction is required for that emission.

Note.

1. f<30 ㎒, extrapolation factor of 40 ㏈/decade of distance. $F_d = 40\log(D_m/Ds)$
   f ≥30 ㎒, extrapolation factor of 20 ㏈/decade of distance. $F_d = 20\log(D_m/Ds)$
   Where:
   F_d = Distance factor in ㏈
   D_m = Measurement distance in meters
   D_s = Specification distance in meters
2. Field strength(㏈㎶/m) = Level(㏈㎶) + CF (㏈) + or DCF(㏈)
3. Margin(㏈) = Limit(㏈㎶/m) - Field strength(㏈㎶/m)
4. 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.
7. 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.**
8. The worst-case emissions are reported however emissions whose levels were not within 20 ㏈ of respective limits were not reported.
9. According to exploratory test no any obvious emission were detected from 9 ㎑ to 30 ㎒. Although these tests were performed other than open field site, adequate comparison measurements were confirmed against 30 m open field site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 414788.

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	2400/F(㎑)
0.490 ~ 1.705	30	24000/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.

Duty cycle

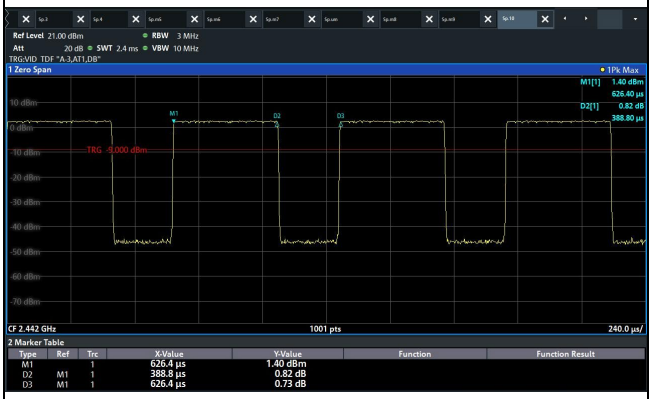
Regarding to KDB 558074 D01_v04, 6.0, the maximum duty cycles of all modes were investigated and set the spectrum analyzer as below.

Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value. Set detector = peak or average. The zero-span measurement method shall not be used unless both RBW and VBW are > 50/T and the number of sweep points across duration T exceeds 100.

T_{on} time (㎳)	Period (㎳)	Duty cycle (Linear)	Duty cycle (%)	Duty cycle correction factor (dB)
0.39	0.63	0.62	61.90	2.08

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

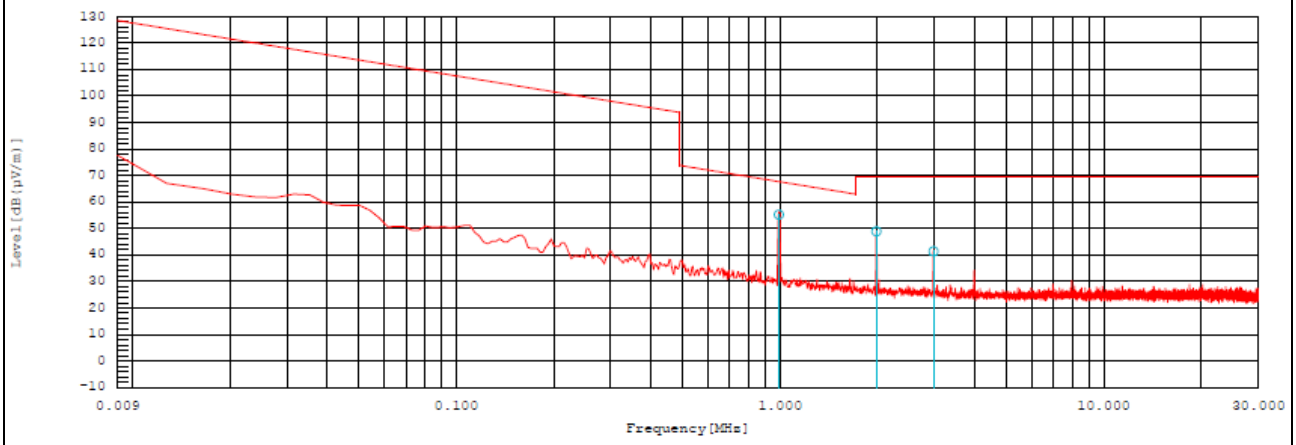
DCF(Duty cycle correction factor (㏈)) = 10log(1/duty cycle)

Middle channel


Test results (Below 30 ㎒)

Mode:	BLE_1 Mbps
Channel	39 (Worst case)
Distance of measurement:	3 meter

Parallel



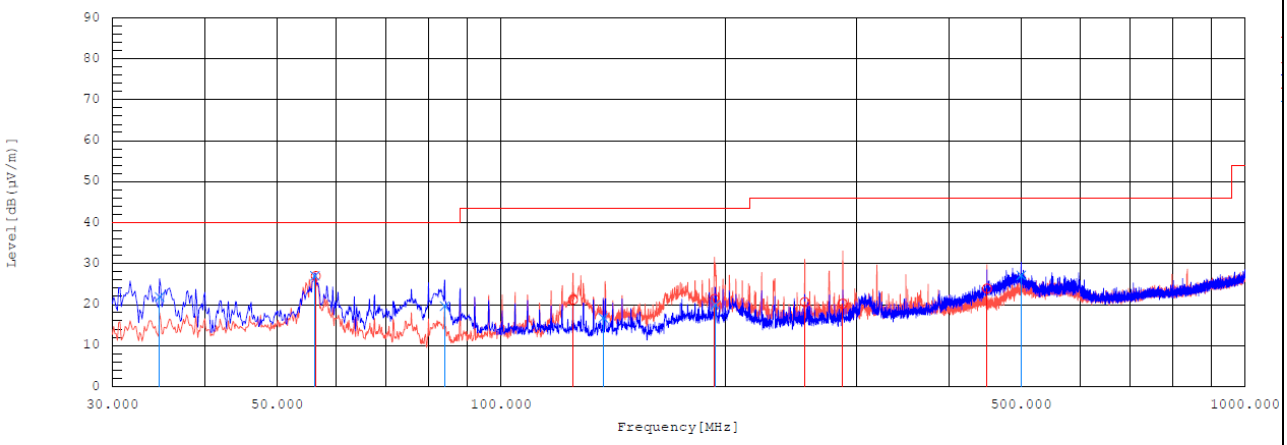
Final Result

No.	Frequency [MHz]	Reading QP [dB(µV)]	c.f [dB(1/m)]	Result QP [dB(µV/m)]	Limit QP [dB(µV/m)]	Margin QP [dB]	Angle [deg]	Remark
1	0.991	34.9	20.3	55.2	67.7	12.5	291.6	
2	1.985	28.7	20.2	48.9	69.5	20.6	294.6	
3	2.982	21.8	19.6	41.4	69.5	28.1	302.4	

Test results (Below 1 000 ㎒)

Mode:	BLE_1 Mbps
Channel	39 (Worst case)
Distance of measurement:	3 meter

Horizontal // Vertical



Final Result

No.	Frequency [MHz]	Pol	Reading QP [dB(μV)]	c.f [dB(1/m)]	Result QP [dB(μV/m)]	Limit QP [dB(μV/m)]	Margin QP [dB]	Height [cm]	Angle [deg]	Remark
1	34.729	V	36.1	-14.3	21.8	40.0	18.2	100.0	332.7	
2	56.190	V	39.4	-12.4	27.0	40.0	13.0	105.0	291.5	
3	56.311	H	39.4	-12.4	27.0	40.0	13.0	400.0	130.2	
4	83.956	V	36.8	-17.2	19.6	40.0	20.4	154.0	89.6	
5	124.939	H	36.8	-15.6	21.2	43.5	22.3	187.0	140.0	
6	137.185	V	32.8	-16.1	16.7	43.5	26.8	100.0	337.3	
7	193.445	H	34.6	-13.2	21.4	43.5	22.1	100.0	152.5	
8	194.051	V	33.1	-13.2	19.9	43.5	23.6	181.0	46.2	
9	256.010	H	31.6	-11.0	20.6	46.0	25.4	100.0	0.0	
10	288.020	H	30.5	-10.3	20.2	46.0	25.8	100.0	330.5	
11	450.010	H	30.2	-6.3	23.9	46.0	22.1	205.0	229.7	
12	499.965	V	32.5	-5.4	27.1	46.0	18.9	100.0	137.5	

Test results (Above 1 000 ㎒)

Mode: BLE_1 Mbps

Channel 00

Distance of measurement: 3 meter

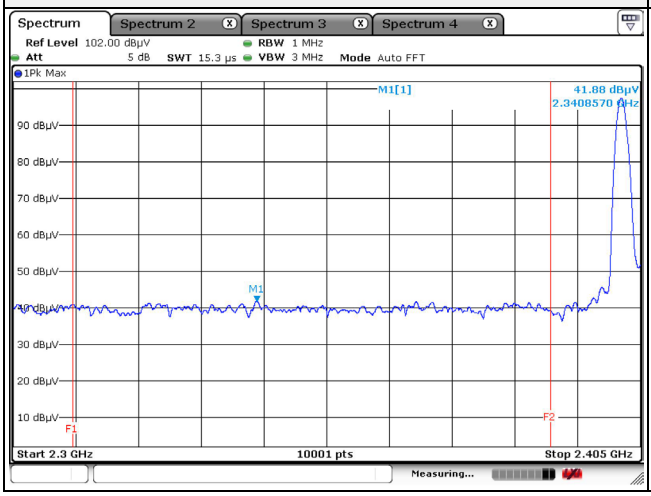
- **Spurious**

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
1 085.69	45.00	Peak	H	-9.52	-	35.48	74.00	38.52
1 342.27	46.02	Peak	V	-7.51	-	38.51	74.00	35.49

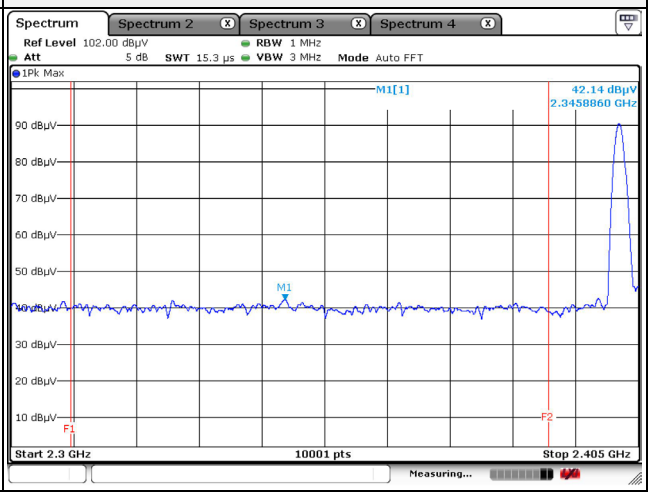
- **Band edge**

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 340.86	41.88	Peak	H	-0.96	-	40.92	74.00	33.08
2 345.89	42.14	Peak	V	-0.93	-	41.21	74.00	32.79

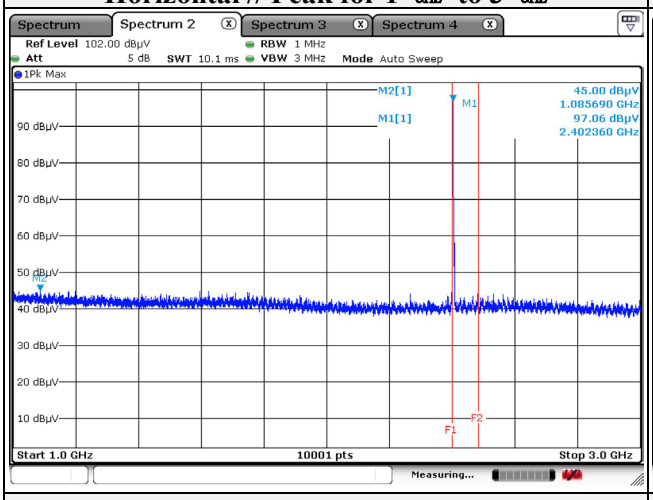
Restricted band // Horizontal // Peak



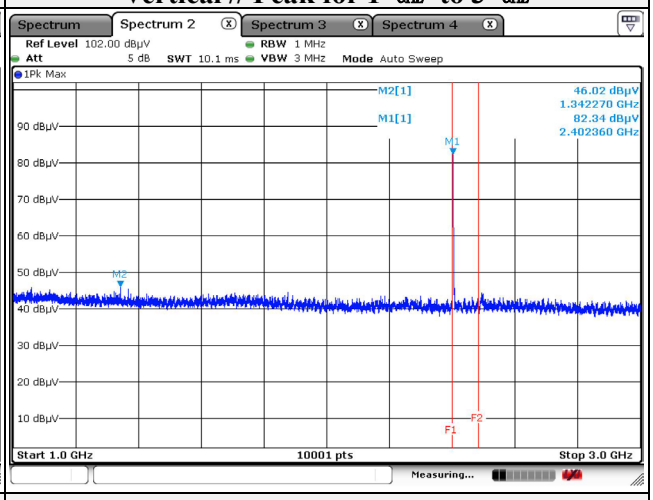
Restricted band // Vertical // Peak



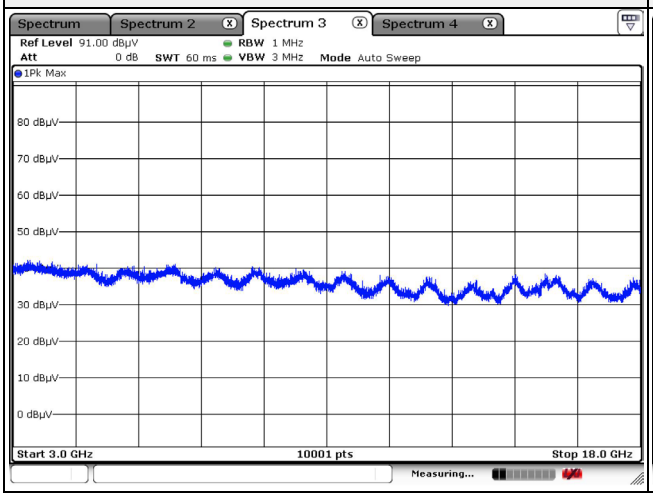
Horizontal // Peak for 1 ㎓ to 3 ㎓



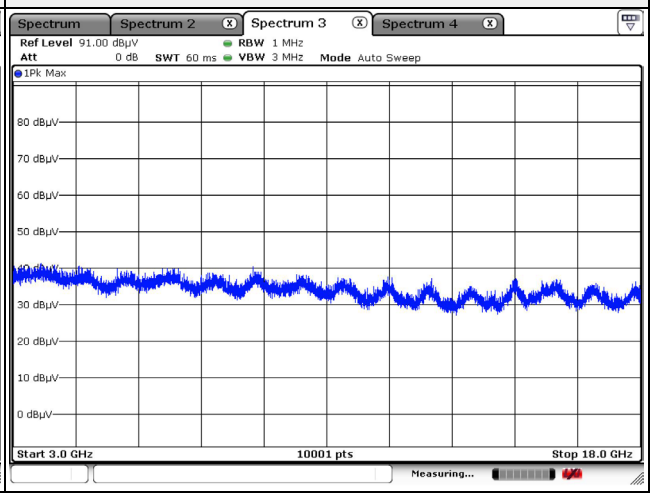
Vertical // Peak for 1 ㎓ to 3 ㎓



Horizontal // Peak for 3 ㎓ to 18 ㎓



Vertical // Peak for 3 ㎓ to 18 ㎓



Note.
1. Average test would be performed if the peak result were greater than the average limit.
2. No spurious emission were detected above 3 ㎓.