Test Report

Part 15 C & RSS-247 (Issue 2)

Equipment under test	Remote Control Unit
Model name	Bruno RF Remote
FCC ID	2AUD9-CS1532
IC ID	26638-CS1532
Applicant	Control Solutions LLC
Manufacturer	Hyun Seung I&C Co., LTD
Date of test(s)	2021.02.01 ~ 2021.02.25
Date of issue	2021.03.19

Issued to
Control Solutions LLC
2520 Diehl Road, Aurora IL 60502 United States Of America
Tel: 630-405-2788 / Fax: 630-806-7065

Issued by
KES Co., Ltd.
3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si,
Gyeonggi-do, 14057, Korea
473-21, Gayeo-ro, Yeoju-si, Gyeonggi-do, Korea
Tel: +82-31-425-6200 / Fax: +82-31-424-0450

Test and report completed by :	**Report approval by :**
Gu-Bong, Kang Test engineer	Young-Jin, Lee Technical manager

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Revision history

Revision	Date of issue	Test report No.	Description
-	2021.03.19	KES-RF1-21T0034	Initial

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RF-210021/022	KES-RF1-21T0034	21/3/19	Control Solutions LLC	Remote Control Unit	Bruno RF Remote	Hyunseung I&C Co., Ltd	한국	21/2/1	21/2/25	강구봉		part 15.247 / RSS-247 Issue 2	FCC / IC
RF-210023	KES-RF1-21T0035	21/3/19	Control Solutions LLC	Remote Control Unit	Bruno RF Remote	Hyunseung I&C Co., Ltd	한국	21/2/1	21/2/25	강구봉		EN 300 328 V 2.1.1	CE-DoC

1. General information

Applicant:	Control Solutions LLC
Applicant address:	2520 Diehl Road, Aurora IL 60502 United States Of America
Test site:	KES Co., Ltd.
Test site address:	3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, 14057, Korea 473-21, Gayeo-ro, Yeoju-si, Gyeonggi-do, Korea
Test Facility	FCC Accreditation Designation No.: KR0100, Registration No.: 444148
FCC rule part(s):	15.247
IC rule part(s):	RSS-247
FCC ID:	2AUD9-CS1532
IC Certification	26638-CS1532
Test device serial No.:	☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test	Remote Control Unit
Frequency range	2 405 ㎒ ~ 2 480 ㎒ (ZigBee)
Model:	Bruno RF Remote
Modulation technique	O-QPSK
Number of channels	2 405 ㎒ ~ 2 480 ㎒ (ZigBee): 16ch
Antenna specification	Antenna type : PCB pattern Antenna // Peak gain: 2.09 ㏈i
Power source	DC 3.0 V (Battery 1.5 V * 2)
H/W version	ASM002535B
S/W version	SWF0000385B

1.2. Test configuration

The **Control Solutions LLC // Remote Control Unit // Bruno RF Remote // FCC ID: 2AUD9-CS1532 IC ID: 26638-CS1532** was tested according to the specification of EUT, the EUT must comply with following standards and KDB documents.

FCC Part 15.247
ISED RSS-247 Issue 2 and RSS-Gen Issue 5
KDB 558074 D01 v05 r02
ANSI C63.10-2013

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1.3. Device modifications

Model name	Remark
Bruno RF Remote	There are no external or internal changes, and it is for the purpose of adding a model name.
CS1532	

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(㏈) = RF cable loss(㏈) + attenuator factor(㏈).
= 0.52 + 10 = 10.52 (㏈)

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

1.6. Measurement Uncertainty

Test Item		Uncertainty
Uncertainty for Conduction emission test		2.46 ㏈
Uncertainty for Radiation emission test (include Fundamental emission)	Below 1㎓	4.40 ㏈
	Above 1㎓	5.94 ㏈
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	2 405	ZigBee
⋮	⋮	⋮
07	2 440	ZigBee
⋮	⋮	⋮

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15	2 480	ZigBee

2. Summary of tests

Section in FCC Part 15	Section in RSS-247 & Gen	Parameter	Test results
-	RSS-Gen 6.7	99% occupied bandwidth	Pass
15.247(a)(2)	RSS-247 5.2 (a)	6 dB bandwidth	Pass
15.247(b)(3)	RSS-247 5.4 (d)	Output power	Pass
15.247(e)	RSS-247 5.2 (b)	Power spectral density	Pass
15.205 15.209	RSS-247 5.5 RSS-Gen 8.9, 8.10	Radiated restricted band and emission	Pass
15.247(d)	RSS-247 5.5	Conducted spurious emission and band edge	Pass
-	-	AC Conducted emissions	N/A(1)

Note.
1. This device uses a battery and does not have an AC conducted emissions test.

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3. Test results

3.1. 99% Occupied Bandwidth

Test procedure

ANSI C63.10-2013 clause 6.9.2 and 6.9.3

Test setup

EUT	—	Attenuator	—	Spectrum analyzer

Test setting

1. Span = The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
2. RBW = The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW
3. VBW = shall be approximately three times the RBW
4. Sweep = auto
5. Detector function = Peak
6. Trace = Max hold

Limit

None; for reporting purpose only.

Test results

Frequency(㎒)	99% occupied bandwidth(㎒)	Limit(㎒)
2 405	2.292	-
2 440	2.300	
2 480	2.301	

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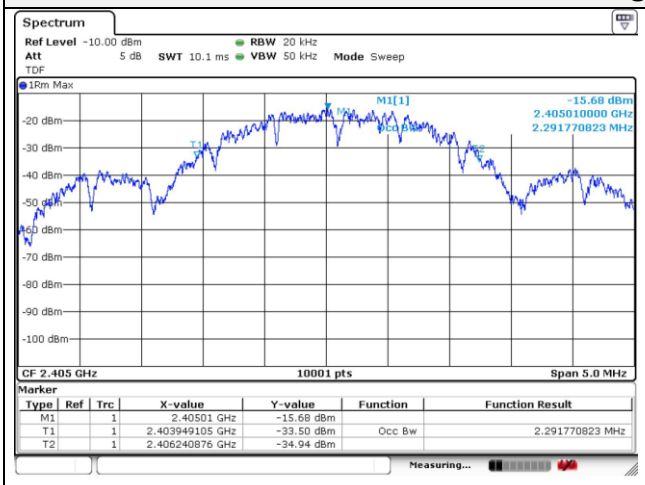
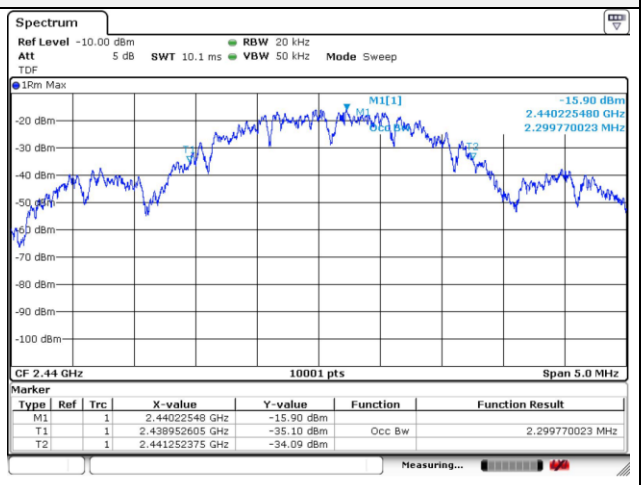
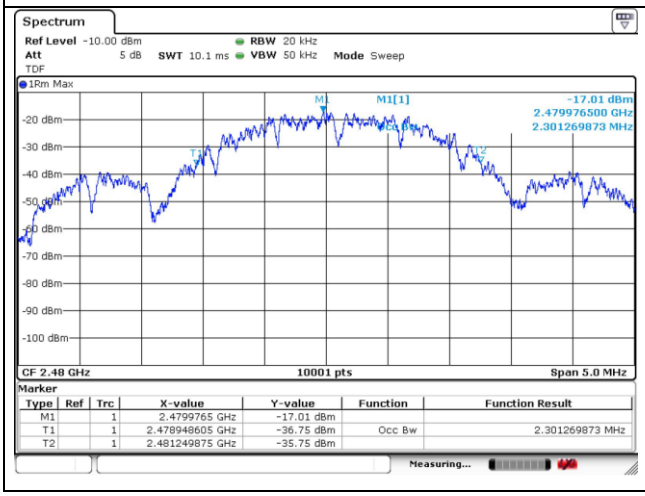
Test plots

ZigBee







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3.2. 6 dB bandwidth

Test procedure

ANSI C63.10-2013 - Section 11.8.2

Test setup

EUT	Attenuator	Spectrum analyzer

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 ㏈, if the functionality described above (i.e., RBW = 100 ㎑, 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 ㏈.

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 ㎑.

According to RSS-247 5.2 (a), the minimum 6 dB bandwidth shall be 500 kHz.

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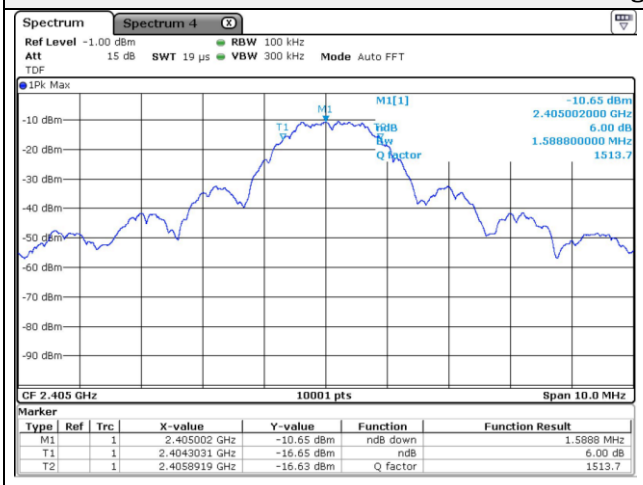
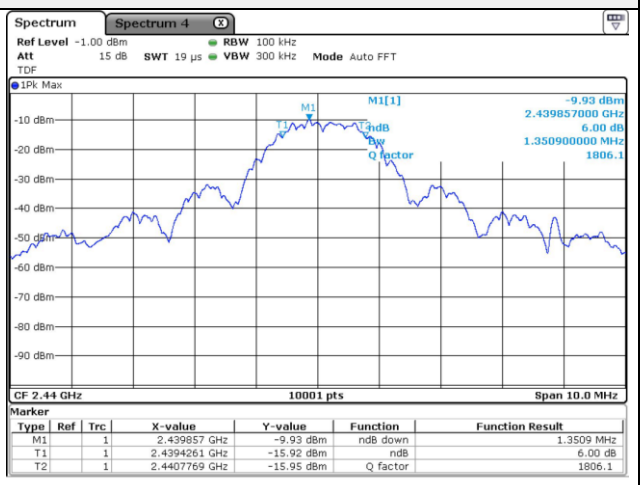
Test results

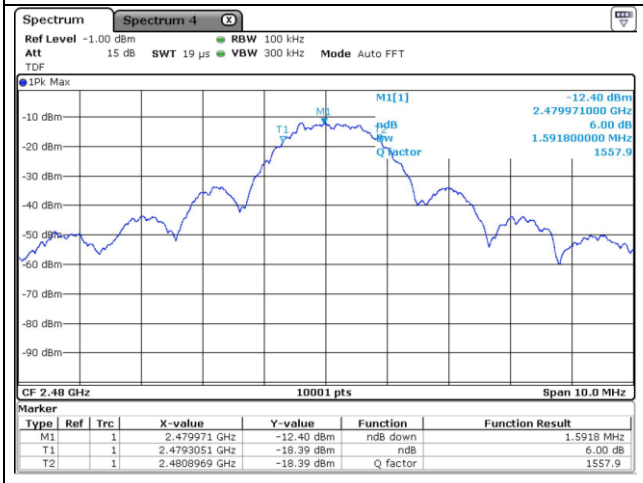
Mode: ZigBee

Frequency(㎒)	6 ㏈ bandwidth(㎒)	Limit(㎒)
2 405	1.589	≥ 0.500
2 440	1.351	
2 480	1.592	

ZigBee







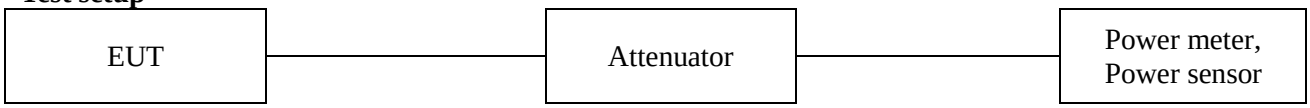
N/A

3.3. 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.

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According to RSS-247 5.4 (d), For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. The e.i.r.p. shall not exceed 4 W, except as provided in Section 5.4(e).
As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is 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 transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

Test results

Mode: ZigBee

Frequency(㎒)	Peak output power(㏈m)	Average output power(㏈m)	PK E.I.R.P (㏈m)	Limit(㏈m)	E.I.R.P Limit for ISED(㏈m)
2 405	-6.03	-7.04	-3.94	30	36.02
2 440	-6.04	-7.13	-3.95		
2 480	-7.12	-8.67	-5.03		

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3.4. Power spectral density

Test procedure

ANSI C63.10-2013 - Section 11.10.2

Test setup

EUT	—	Attenuator	—	Spectrum analyzer

Section 10.2 & ANSI C63.10-2013 - Section 11.10.2

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 ㎑ ≤ RBW ≤ 100 ㎑
d. Set the VBW ≥ [3 × 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 exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat.

Limit

According to §15.247(e), For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 ㏈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.

According to RSS-247 5.2 (b), The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of Section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

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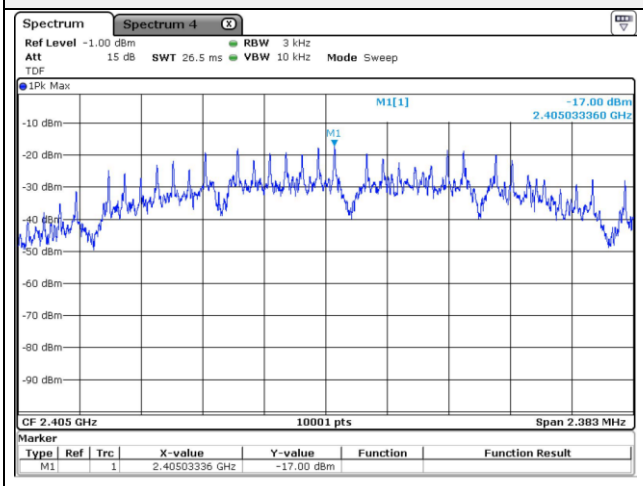
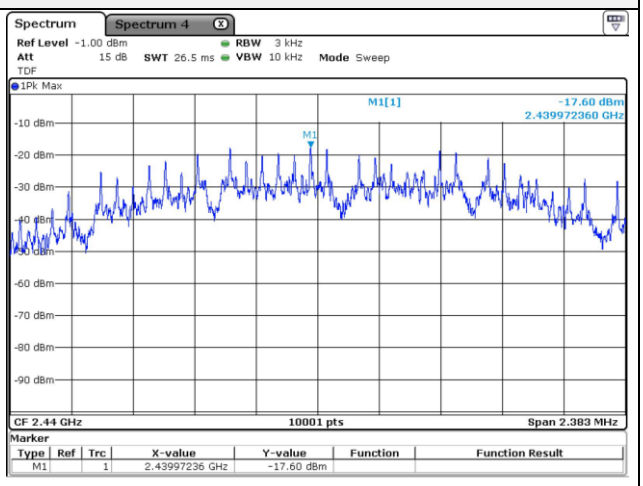
Results

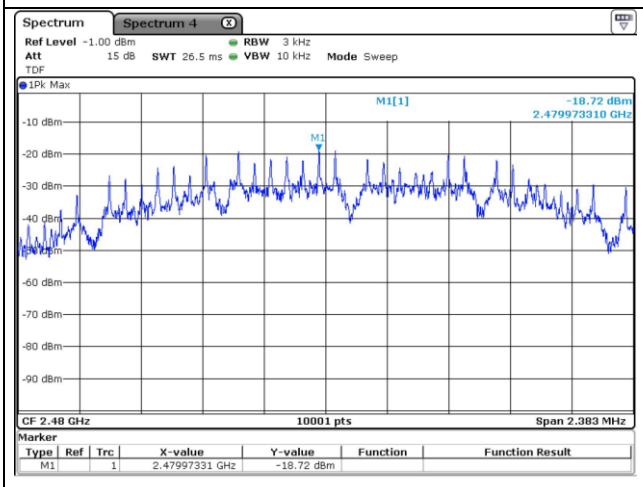
Mode: ZigBee

Frequency(㎒)	PSD (dBm)	Limit(dBm)
2 405	-17.00	8
2 440	-17.60	
2 480	-18.72	

LE







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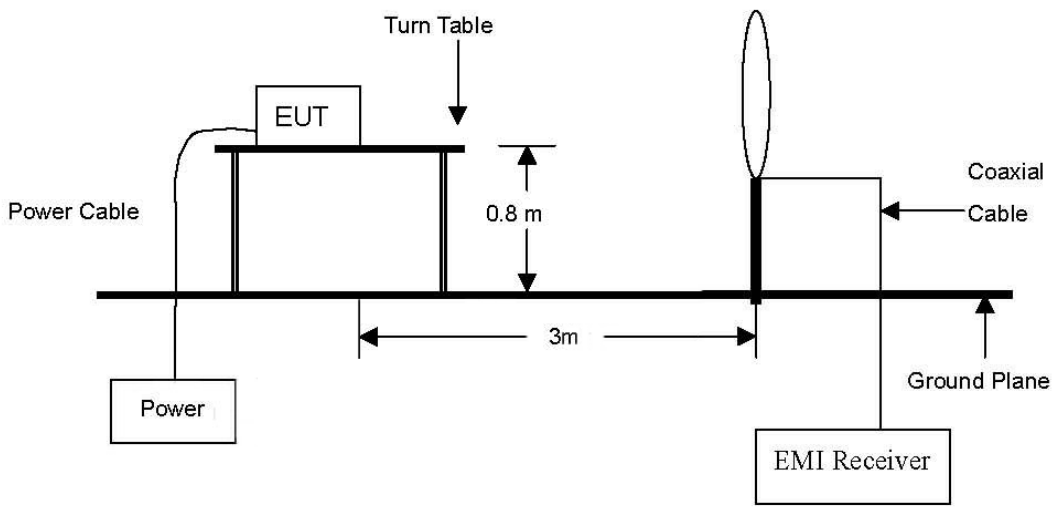
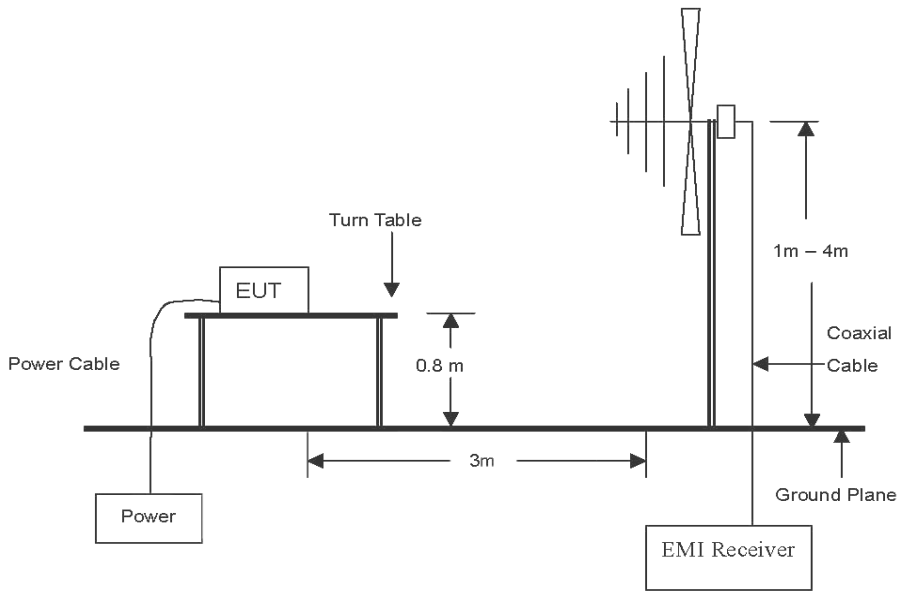
3.5. Radiated restricted band and emissions

Test setup

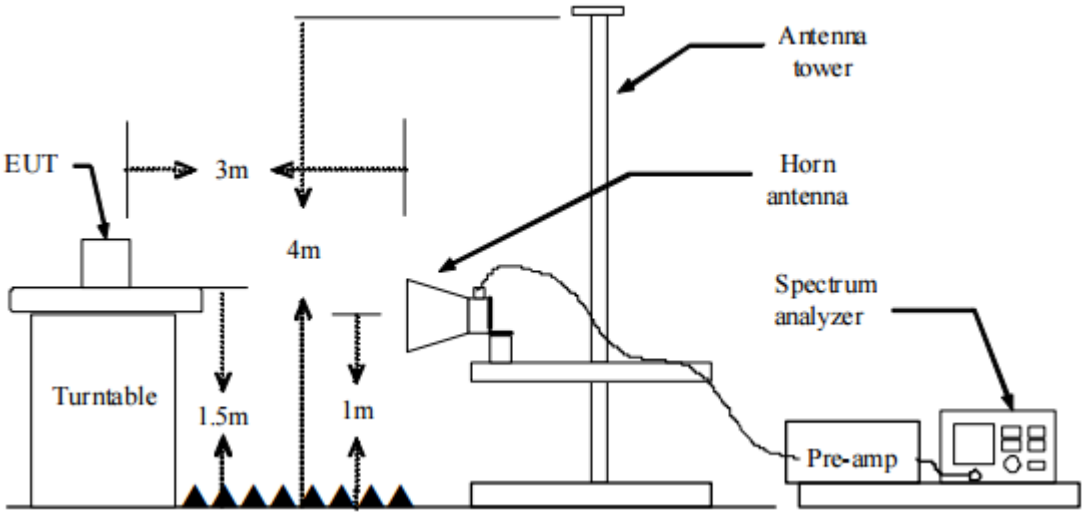
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 ㎑ to 30 ㎒ Emissions.



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 1.5 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. 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.

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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 ≥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 ≥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.

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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.
5. 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.**
6. The worst-case emissions are reported however emissions whose levels were not within 20 ㏈ of respective limits were not reported.
7. 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.

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According to RSS-Gen, Except when the requirements applicable to a given device state otherwise, emissions from licence-exempt transmitters shall comply with the field strength limits：

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

* Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

Note: Transmitting devices are not permitted in restricted frequency bands unless stated otherwise in the specific RSS.

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Duty cycle

Regarding to KDB 558074 D01_v05 r02, 6. Measurements of duty cycle and transmission duration shall be performed using one of the following techniques:

a) A diode detector and an oscilloscope that together have sufficiently short response time to permit accurate measurements of the on- and off-times of the transmitted signal.

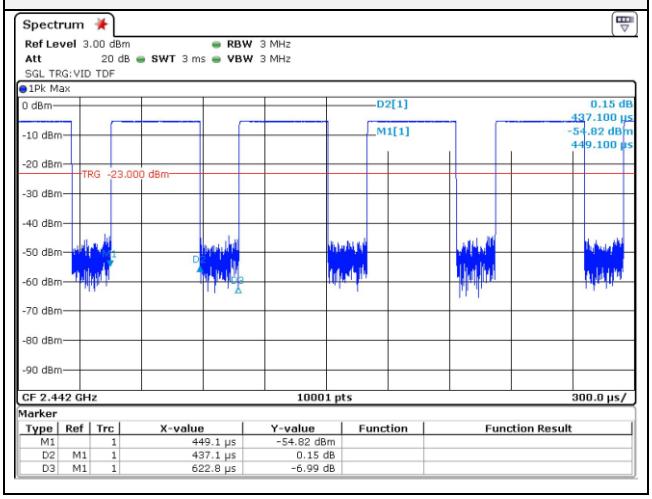
b) The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the on- and off-times of the transmitted signal.

T_{on} time (㎳)	Period (㎳)	Duty cycle (Linear)	Duty cycle (%)	Duty cycle correction factor (㏈)
0.615	3.967	0.155	15.503	8.10

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

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

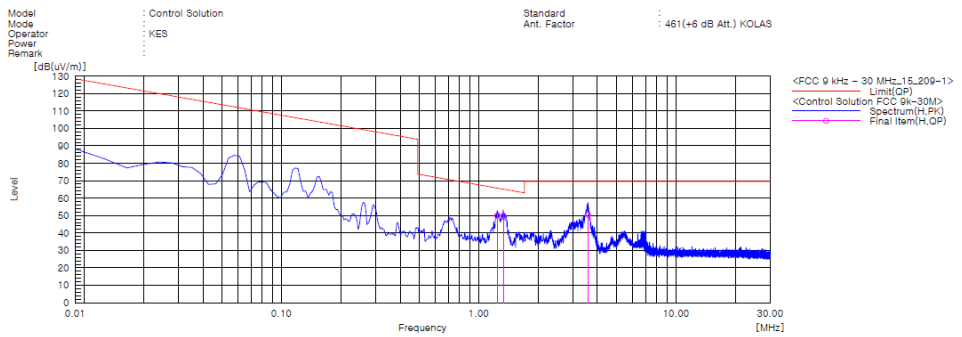
Middle channel



Test results (Below 30 ㎒)

Mode:	ZigBee
Distance of measurement:	3 meter
Channel:	00 (Worst case)

Parallel



Final Result

No.	Frequency [MHz]	(P)	Reading QP [dB(uV)]	c.f [dB(1/m)]	Result QP [dB(uV/m)]	Limit QP [dB(uV/m)]	Margin QP [dB]	Height [cm]	Angle [deg]	Remark
1	1.242	H	29.1	20.7	49.8	65.7	15.9	100.0	38.7	
2	1.332	H	29.2	20.7	49.9	65.1	15.2	99.8	0.8	
3	3.578	H	30.4	19.9	50.3	69.5	19.2	99.8	67.2	

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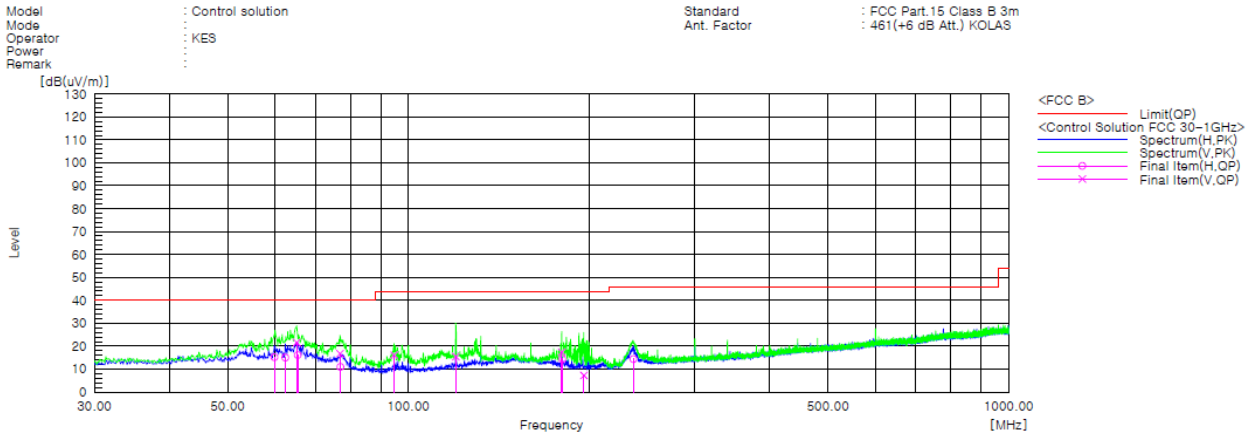
Test results (Below 1 000 ㎒)

Mode:	ZigBee
Distance of measurement:	3 meter
Channel:	00 (Worst case)

Horizontal // Vertical



Final Result

No.	Frequency [MHz]	(P)	Reading QP [dB(uV)]	c.f [dB(1/m)]	Result QP [dB(uV/m)]	Limit QP [dB(uV/m)]	Margin QP [dB]	Height [cm]	Angle [deg]	Remark
1	59.828	H	28.1	-12.9	15.2	40.0	24.8	226.0	4.0	
2	62.374	H	28.2	-13.2	15.0	40.0	25.0	207.0	110.0	
3	65.163	V	35.2	-13.6	21.6	40.0	18.4	103.0	45.5	
4	65.405	H	29.7	-13.6	16.1	40.0	23.9	158.0	256.5	
5	76.924	V	33.0	-16.3	16.7	40.0	23.3	102.0	228.2	
6	77.045	H	27.3	-16.4	10.9	40.0	29.1	159.0	205.5	
7	94.626	V	34.2	-18.1	16.1	43.5	27.4	108.0	65.0	
8	119.968	V	30.7	-15.3	15.4	43.5	28.1	119.0	265.1	
9	179.986	V	31.8	-14.4	17.4	43.5	26.1	109.0	324.7	
10	180.471	H	28.8	-14.5	14.3	43.5	29.2	328.0	84.0	
11	195.870	V	22.8	-15.5	7.3	43.5	36.2	115.0	14.9	
12	236.974	H	28.7	-14.4	14.3	46.0	31.7	341.0	287.6	

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Test results (Above 1 000 ㎒)

Mode: ZigBee

Distance of measurement: 3 meter

Channel: 00

- **Spurious**

Frequency (㎒)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 174.96	49.61	Peak	H	-10.23	-	39.38	74.00	34.62
1 216.46	49.00	Peak	V	-10.01	-	38.99	74.00	35.01
1 386.83	49.06	Peak	V	-9.10	-	39.96	74.00	34.04
2 282.24	49.31	Peak	H	-3.23		46.08	74.00	27.92

- **Band edge**

Frequency (㎒)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 314.54	47.94	Peak	V	-3.09	-	44.85	74.00	29.15
2 315.29	48.15	Peak	V	-3.09	-	45.06	74.00	28.94
2 372.69	52.04	Peak	H	-2.84	-	49.20	74.00	24.80
2 385.70	49.11	Peak	H	-2.78	-	46.33	74.00	27.67

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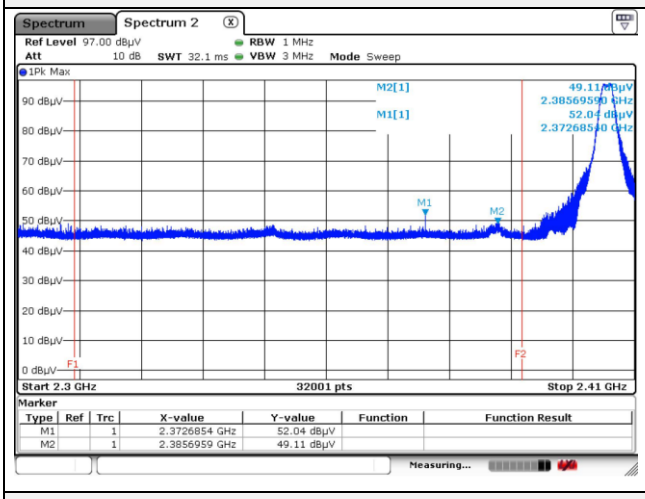
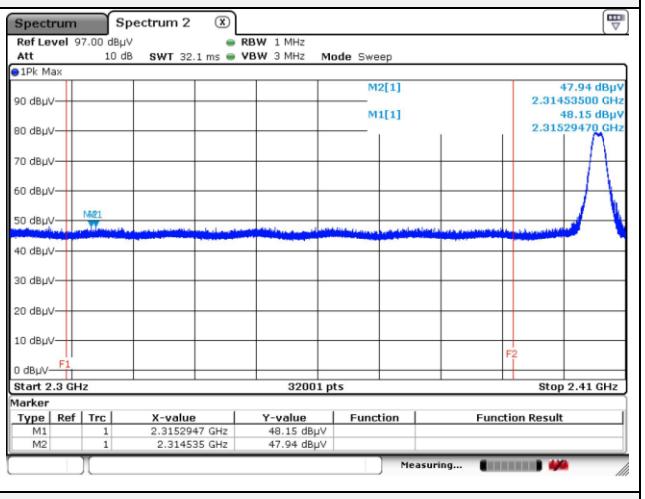
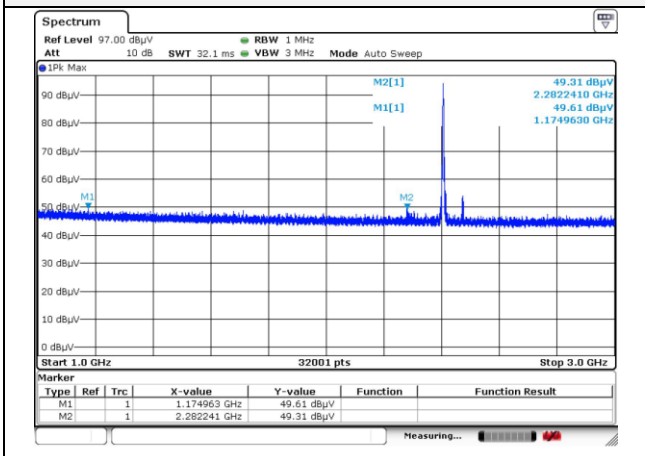
Restricted band // Horizontal // Peak



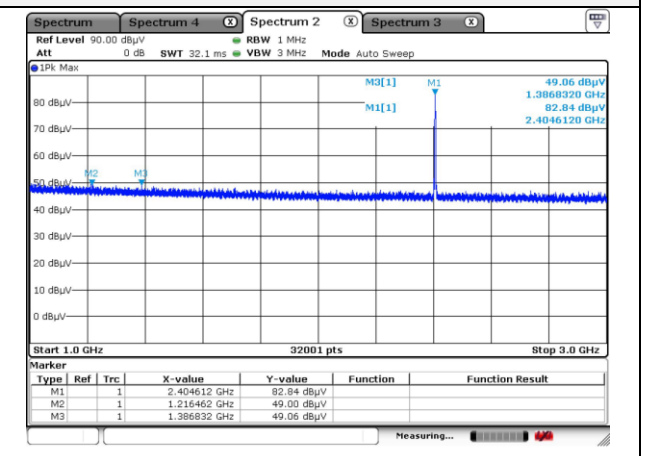
Restricted band // Vertical // Peak



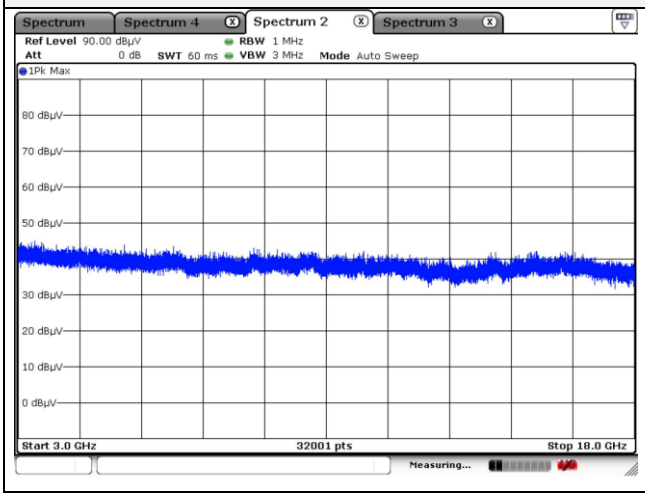
Horizontal // Peak for 1 ㎓ to 3 ㎓



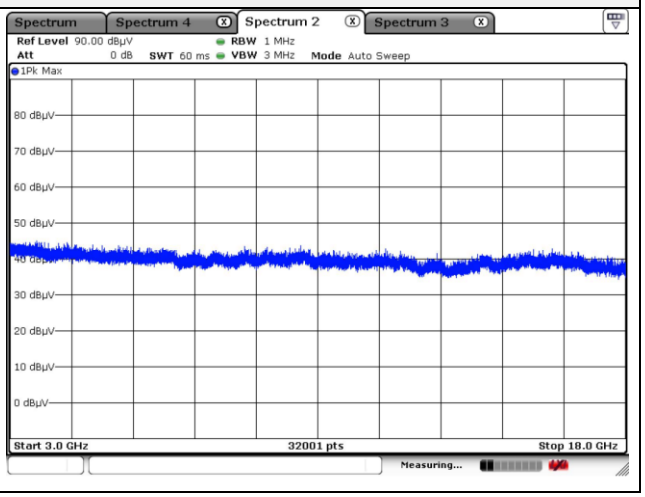
Vertical // Peak for 1 ㎓ to 3 ㎓



Horizontal // Peak for 3 ㎓ to 18 ㎓



Vertical // Peak for 3 ㎓ to 18 ㎓



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

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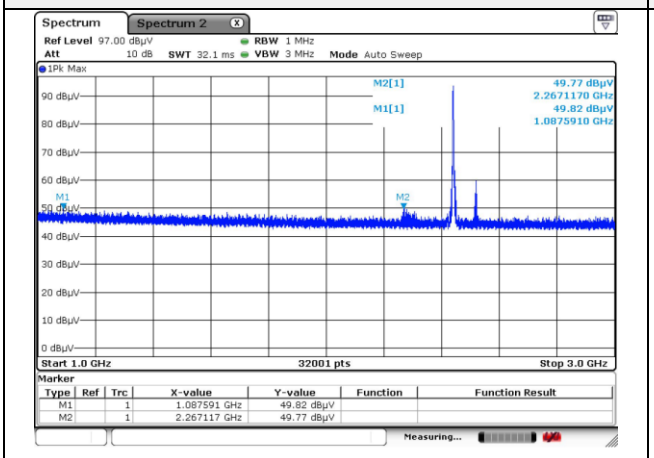
Mode: ZigBee
Distance of measurement: 3 meter
Channel: 07

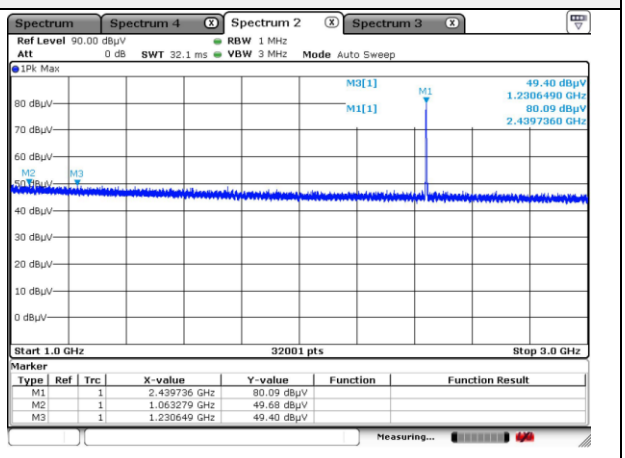
- **Spurious**

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
1 063.28	49.68	Peak	V	-10.82	-	38.86	74.00	35.14
1 087.59	49.82	Peak	H	-10.69	-	39.13	74.00	34.87
1 230.65	49.40	Peak	V	-9.93	-	39.47	74.00	34.53
2 267.12	49.77	Peak	H	-3.30	-	46.47	74.00	27.53

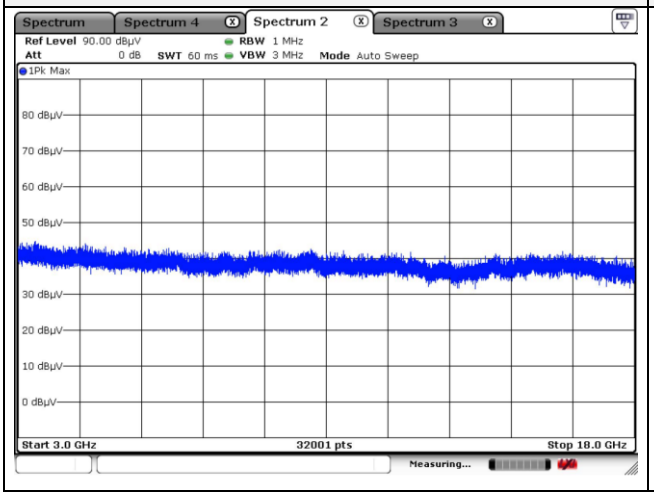
Horizontal // Peak for 1 ㎓ to 3 ㎓



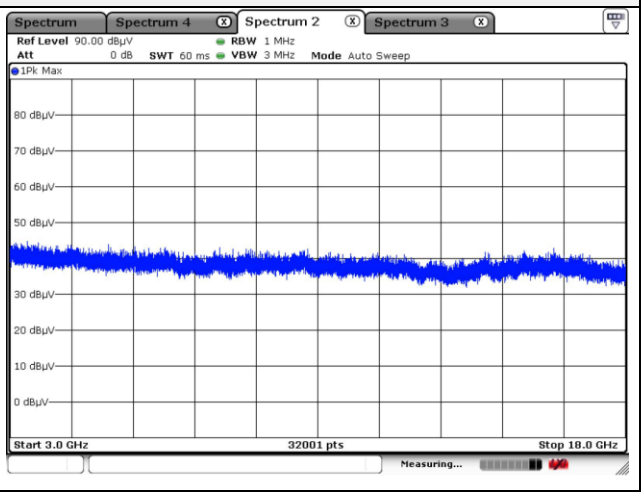
Vertical // Peak for 1 ㎓ to 3 ㎓



Horizontal // Peak for 3 ㎓ to 18 ㎓



Vertical // Peak for 3 ㎓ to 18 ㎓



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

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Mode: ZigBee

Distance of measurement: 3 meter

Channel: 15

- **Spurious**

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 051.72	49.34	Peak	V	-10.89	-	38.45	74.00	35.55
1 447.21	48.56	Peak	V	-8.77	-	39.79	74.00	34.21
2 267.99	50.55	Peak	H	-3.29	-	47.26	74.00	26.74
2 275.93	50.67	Peak	H	-3.26	-	47.41	74.00	26.59

- **Band edge**

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 483.51	71.81	Peak	H	-2.40	-	69.41	74.00	4.59
2 483.51	38.98	Average	H	-2.40	8.10	44.68	54.00	9.32
2 483.52	53.62	Peak	V	-2.40	-	51.22	74.00	22.78
2 483.58	71.37	Peak	H	-2.40	-	68.97	74.00	5.03
2 483.58	38.74	Average	H	-2.40	8.10	44.44	54.00	-9.56
2 483.74	53.07	Peak	V	-2.40	-	50.67	74.00	23.33

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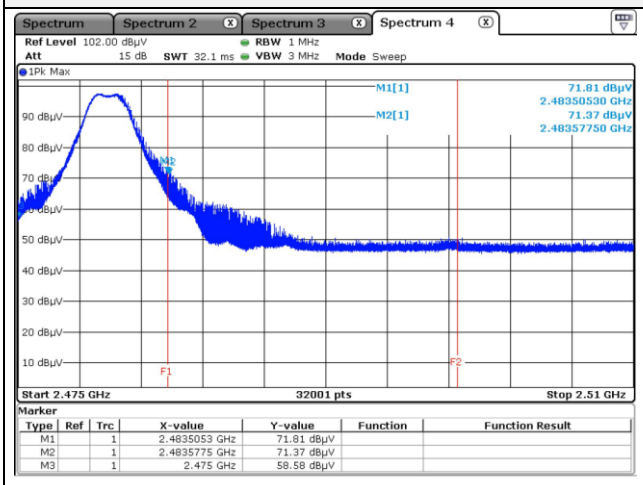
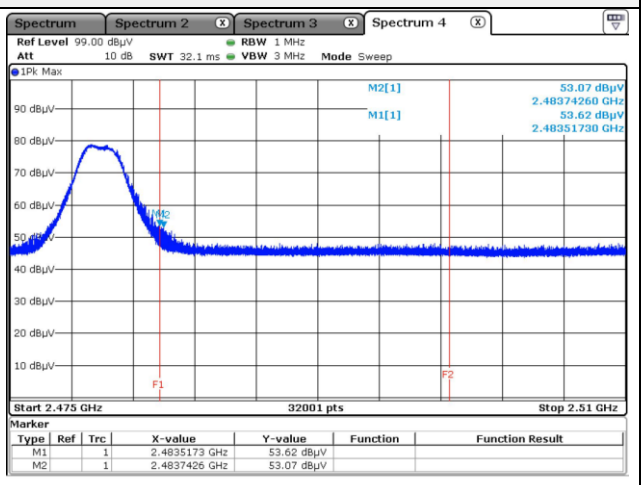
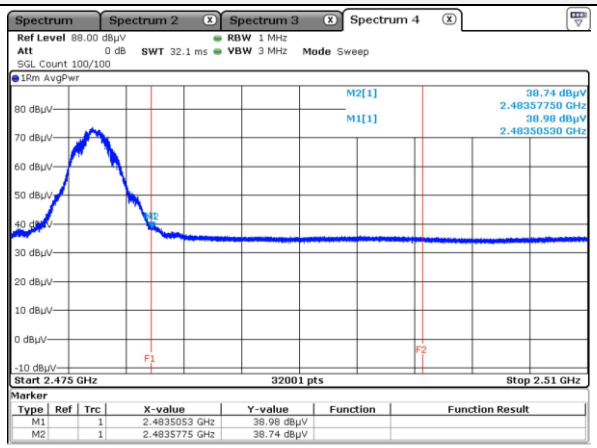
Restricted band // Horizontal // Peak



Restricted band // Vertical // Peak



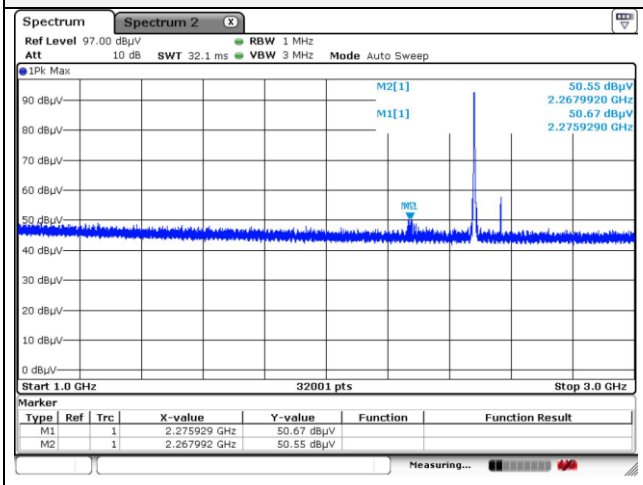
Restricted band // Horizontal // Average



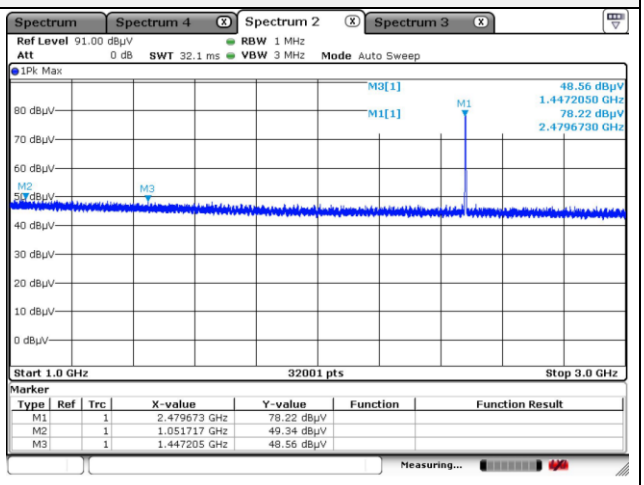
Restricted band // Vertical // Average

N/A

Horizontal // Peak for 1 ㎓ to 3 ㎓



Vertical // Peak for 1 ㎓ to 3 ㎓



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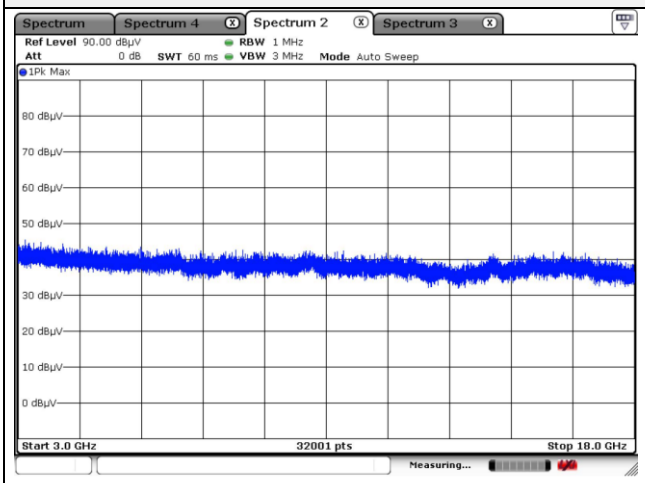
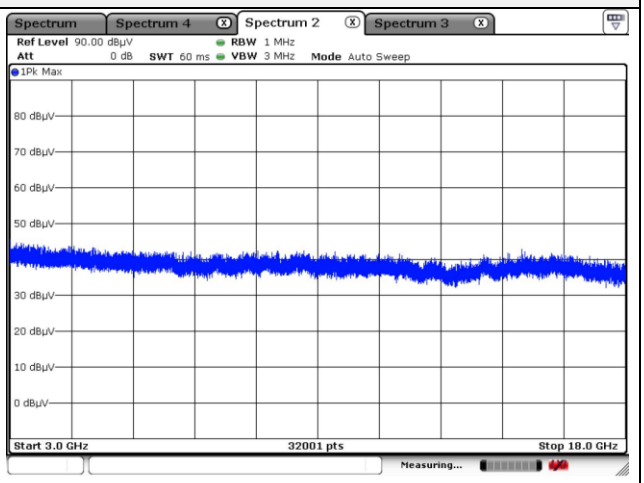
Horizontal // Peak for 3 ㎓ to 18 ㎓	Vertical // Peak for 3 ㎓ to 18 ㎓
	

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

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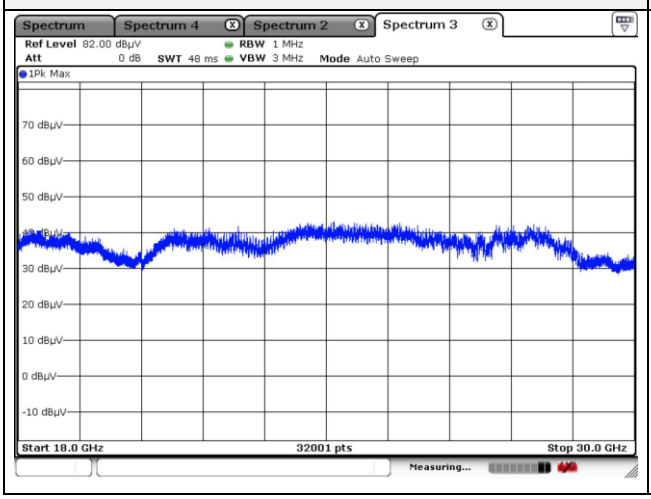
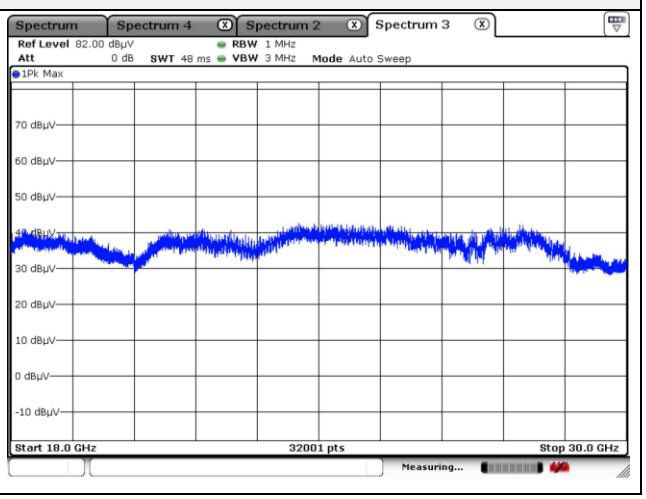
Test results (18 ㎓ to 30 ㎓) – Worst case

Mode:	ZigBee
Distance of measurement:	3 meter
Channel:	00 (Worst case)

Horizontal Peak	Vertical Peak
	

Note.
No spurious emission were detected above 18 ㎓.

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3.6. Conducted spurious emissions & band edge

Test setup

EUT	—	Attenuator	—	Spectrum analyzer

Test procedure

Band edge

ANSI C63.10-2013 - Section 11.11

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. Set the RBW = 100 ㎑
4. Set the VBW = [3 × RBW].
5. Detector = Peak
6. Sweep time = auto
7. Trace mode = max hold
8. Allow trace to fully stabilize.

Out of band emissions

ANSI C63.10-2013 - Section 11.11

1. Start frequency was set to 30 ㎒ and stop frequency was set to 25 ㎓ for 2.4 ㎓ frequencies and 40 ㎓ for 5 ㎓ frequencies
2. Set the RBW = 100 ㎑
3. Set the VBW = [3 × RBW].
4. Detector = Peak
5. Sweep time = auto
6. Trace mode = max hold
7. Allow trace to fully stabilize.

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))

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According to RSS-247 5.5, In any 100 kHz bandwidth outside the frequency band in which the spr ead spectrum or digitally modulated device is operating, the RF power that is produced 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 that the t ransmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time inter val, as permitted under Section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. At tenuation below the general field strength limits specified in RSS-Gen is not required.

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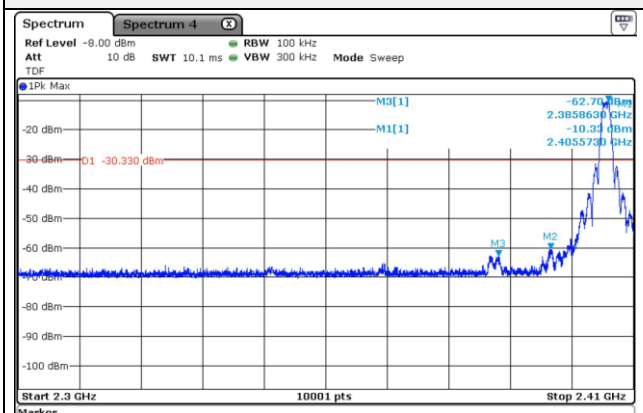
Test results

ZigBee

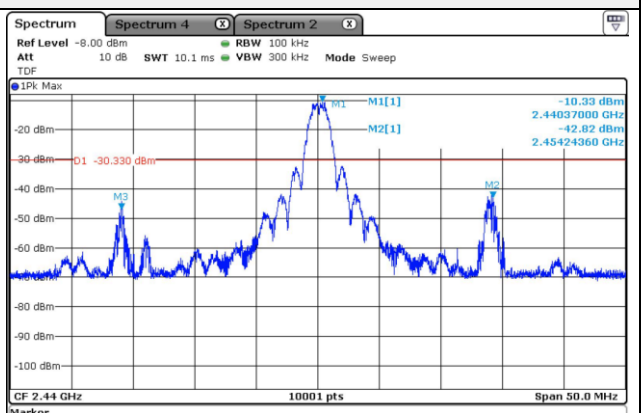
2405 MHz



Marker

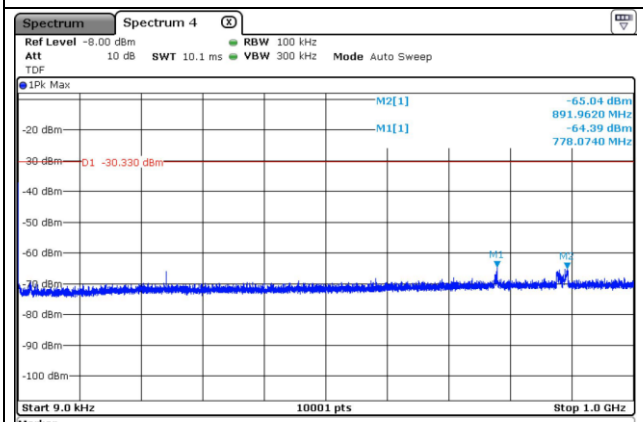
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.405573 GHz	-10.33 dBm		
M2		1	2.3953 GHz	-60.50 dBm		
M3		1	2.385863 GHz	-62.70 dBm		

2440 MHz



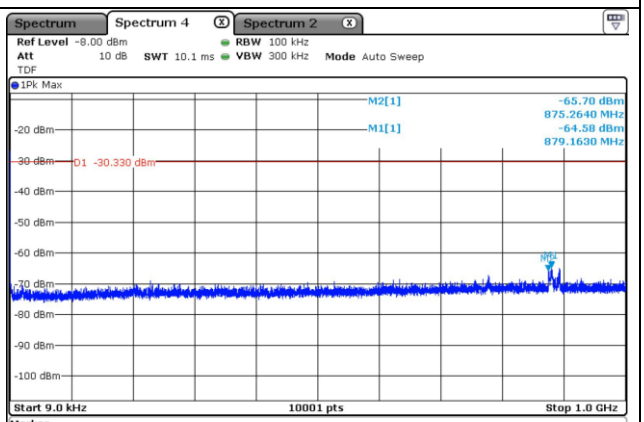
Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.44037 GHz	-10.33 dBm		
M2		1	2.4542436 GHz	-42.82 dBm		
M3		1	2.4240216 GHz	-46.89 dBm		



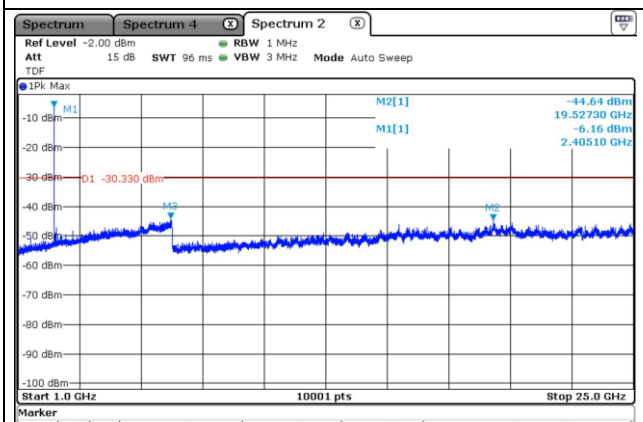
Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	778.074 MHz	-64.39 dBm		
M2		1	891.962 MHz	-65.04 dBm		



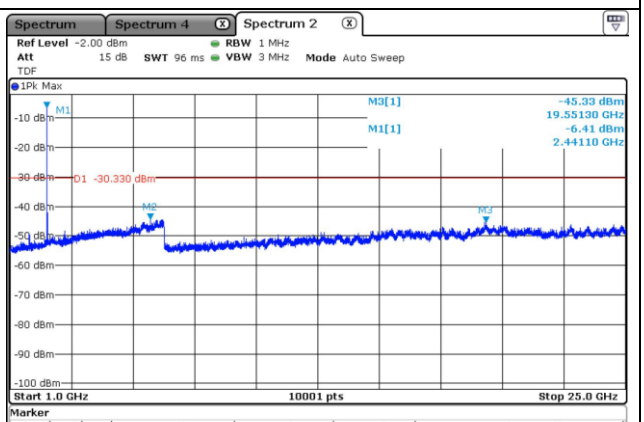
Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	879.163 MHz	-64.58 dBm		
M2		1	875.264 MHz	-65.70 dBm		



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4051 GHz	-6.16 dBm		
M2		1	19.5273 GHz	-44.64 dBm		
M3		1	6.9622 GHz	-44.17 dBm		



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4411 GHz	-6.41 dBm		
M2		1	6.4751 GHz	-44.32 dBm		
M3		1	19.5513 GHz	-45.33 dBm		

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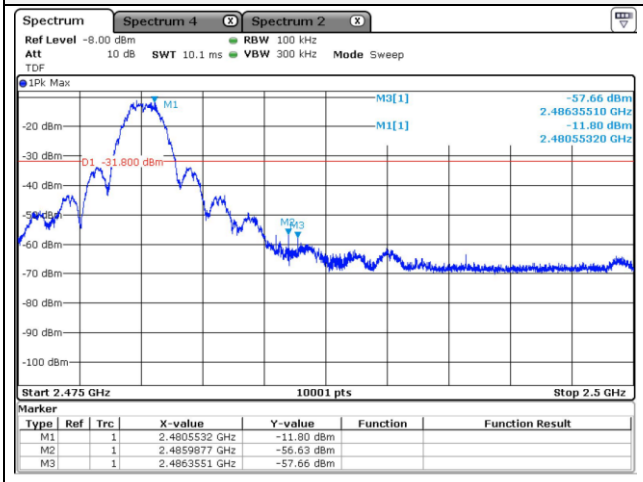
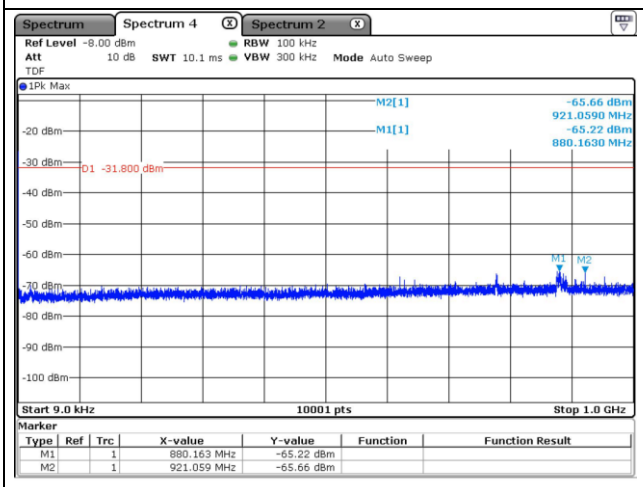
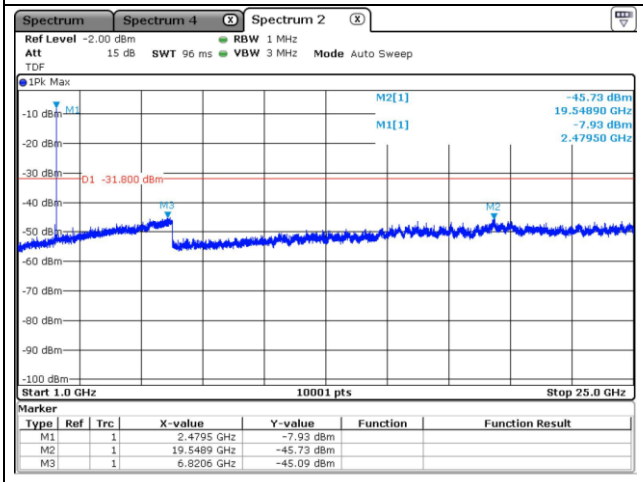
LE 1M	
2480 MHz	-
	BLANK
	BLANK
	BLANK

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Appendix A. Measurement equipment

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due.
Spectrum Analyzer	R&S	FSV40-N	102194	1 year	2021.07.02
8360B Series Swept Signal Generator	HP	83630B	3844A00786	1 year	2022.01.15
SYNTHESIZED SIGNAL GENERATOR	KEYSIGHT	N5182B	MY59100115	1 year	2021.05.12
Power Meter	Anritsu	ML2495A	2010001	1 year	2021.05.12
Pulse Power Sensor	Anritsu	MA2411B	1911111	1 year	2021.05.12
Attenuator	Mini-Circuits	BW-S10-2W263+	1	1 year	2022.01.18
Attenuator	F04-C1206-01	SRT	20022403	1 year	2022.01.15
Loop Antenna	Schwarzbeck	FMZB1513	225	2 years	2023.01.18
BILOG ANTENNA	Schwarzbeck	VULB 9168	9168-461	2 years	2022.12.22
Horn Antenna	A.H	SAS-571	414	1 years	2022.01.22
Horn Antenna	SCHWARZBECK	BBHA9170	BBHA 9170550	1 years	2022.01.18
Amplifier	SONOMA INSTRUMENT	310N	401123	1 year	2021.06.08
PREAMPLIFIER	Agilent	8449B	8008A01640	1 year	2021.04.01
BROADBAND AMPLIFIER	SCHWARZBECK	BBV9721	PS9721-003	1 year	2022.01.19
EMI Test Receiver	R&S	ESU26	100552	1 year	2021.04.01
DC Power supply	Agilent	6632B	MY43004090	1 year	2021.06.22

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
Notebook computer	LG Electronics Inc.,	15ND530-GX50K	311QCFT567147

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