Test Report

Part 15 Subpart C 15.247

Equipment under test Bluetooth Earbud (Cradle)

Model name TONE-T90QC

HVINs TONE-T90QC, TONE-UF90QC, TONE-DF90QC

FVIN 1.0

FCC ID ZNFTONET90QC

Applicant LG Electronics USA, Inc.

Manufacturer LG Electronics Inc.

Date of test(s) 2022.06.09 ~ 2022.06.13

Date of issue 2022.06.14

Issued to

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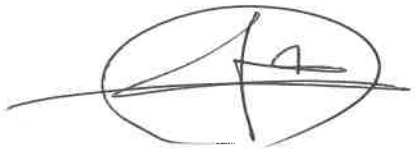
Test and report completed by :	**Report approval by :**
	
Bong-Seok, Kim Test engineer	Yeong-Jun Cho Technical manager

Revision history

Revision	Date of issue	Test report No.	Description
-	2022.06.14	KES-RF1-22T0055	Initial

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1. General information

Applicant:	LG Electronics Inc USA, Inc.
Applicant address:	111 Sylvan Avem North Building, Englewood Cliffs, New Jersey, United States
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 ISED Registration No.: 23298
FCC,IC rule part(s):	FCC : 15.247 / IC : RSS-247
FCC ID:	ZNFTONET90QC 2703C-TONET90QC
Test device serial No.:	☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test	Bluetooth Earbud (Cradle)
Frequency range	**2 402 ㎒ ~ 2 480 ㎒ (BDR/EDR)**
Model	TONE-T90QC
Modulation technique	GFSK, π/4DQPSK, 8DPSK
Number of channels	**2 402 ㎒ ~ 2 480 ㎒ (BDR / EDR) : 79ch**
Antenna specification	PCB Antenna // Peak gain: -3.0 ㏈i
Power source	DC 3.70 V (Battery)
H/W version	1.0
S/W version	1.0

1.2. Requirements for Bluetooth transmitter

15.247(a)(1) that the rx input bandwidths shift frequencies in synchronization with the transmitted signals.

Pseudorandom frequency hopping sequence
The channel is represented by a pseudo-random hopping sequence hopping through the 79 RF channels. The hopping sequence is unique for the piconet and is determined by the Bluetooth device address of the master; the phase in the hopping sequence is determined by the Bluetooth clock of the master. The channel is divided into time slots where each slot corresponds to an RF hop frequency. Consecutive hops correspond to different RF hop frequencies. The nominal hop rate is 1 600 hops/s.

Equal hopping frequency use
The channels of this system will be used equally over the long-term distribution of the hopsets.

Example of a 79 hopping sequence in data mode:
67, 41, 2, 34, 4, 8, 73, 22, 50, 3, 56, 11, 77, 54, 7, 35, 27, 40, 62, 42, 29, 14, 72, 53, 36, 13, 12, 17, 48, 70, 26, 16, 19, 31, 18, 25, 60, 23, 30, 45, 46, 6, 52, 44, 75, 74, 55, 65, 00, 68, 57, 63, 1, 37, 38, 33, 64, 78, 47, 51, 20, 15, 32, 76, 49, 21, 61, 71, 69, 10, 5, 39, 66, 58, 43, 59, 9, 28, 24, 72, 50, 18, 25, 54, 22, 23, 39, 33, 37, 29, 13, 56, 74, 78, 49, 40, 1, 7, 63, 6, 46, 57, 15, 36, 16, 5, 28, 4, 69, 26, 30, 77, 9, 3, 52, 67, 47, 68, 73, 44, 64, 45, 42, 41, 70, 8, 31, 34, 00, 58, 35, 43, 24, 61, 76, 11, 27, 38, 71, 66, 32, 60, 20, 55, 21, 48, 12, 65, 10, 51, 53, 17, 75, 14, 59, 62, 19, 2

System receiver input bandwidth
Each channel bandwidth is 1 ㎒.
The system receivers have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

15.247(g): In accordance with the Bluetooth Industry Standard, the system is designed to comply with all of the regulations in Section 15.247 when the transmitter is presented with a continuous data (or information) system.

15.247(h): In accordance with the Bluetooth Industry Standard, the system does not coordinate it channels selection/ hopping sequence with other frequency hopping systems for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters.

1.3. Test configuration

The **LG Electronics USA, Inc. // Bluetooth Earbud (Cradle) // TONE-T90QC //**

FCC ID: ZNFTONET90QC // IC ID: 2703C-TONET90QC 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

1.4. Information about derivative model

N/A

1.5. Accessory information

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

1.6. 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(㏈).
= 0.72 + 10 = 10.72 (㏈)

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

1.7. 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.		

1.8. Frequency/channel operations

Ch.	Frequency (㎒)	Rate(Mbps)
00	2402	BDR 1 Mbps, EDR 2 Mbps, EDR 3 Mbps
. .	. .	. .
40	2442	BDR 1 Mbps, EDR 2 Mbps, EDR 3 Mbps
. .	. .	. .
78	2480	BDR 1 Mbps, EDR 2 Mbps, EDR 3 Mbps

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)(1)(iii)	RSS-247 5.1(a)	20 dB bandwidth	Pass
15.247(b)(1)	RSS-247 5.4(b)	Output power	Pass
15.247(a)(1)	RSS-247 5.1(b)	Channel separation	Pass
15.247(a)(1)(iii)	RSS-247 5.1(d)	Number of channels	Pass
15.247(a)(1)(iii)	RSS-247 5.1(d)	Time of occupancy	Pass
15.205, 15.209	RSS-247 5.5 RSS-Gen 8.9,8,10	Radiated restricted band and emission	Pass
15.207(a)	RSS-Gen 8.8	AC Conducted emissions	Pass
15.207(d)	RSS-247 5.5	Conducted spurious emission and band edge	Pass

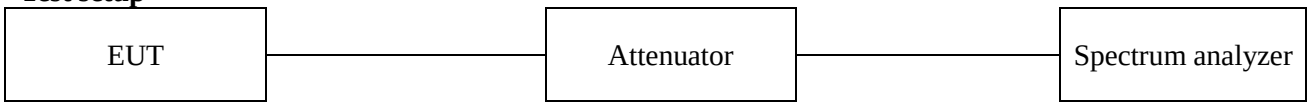
3. Test results

3.1. 99% Occupied Bandwidth

Test procedure

ANSI C63.10-2013 clause 6.9.2 and 6.9.3

Test setup



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.

Mode : BDR 1Mbps

Frequency(㎒)	99% occupied bandwidth(㎒)	Limit(㎒)
2 402	0.864	-
2 442	0.879	
2 480	0.867	

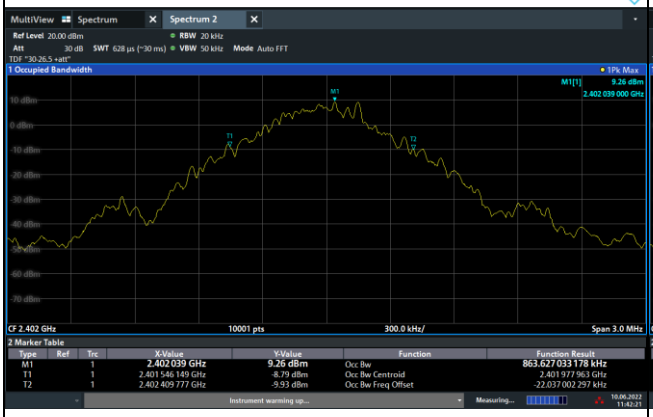
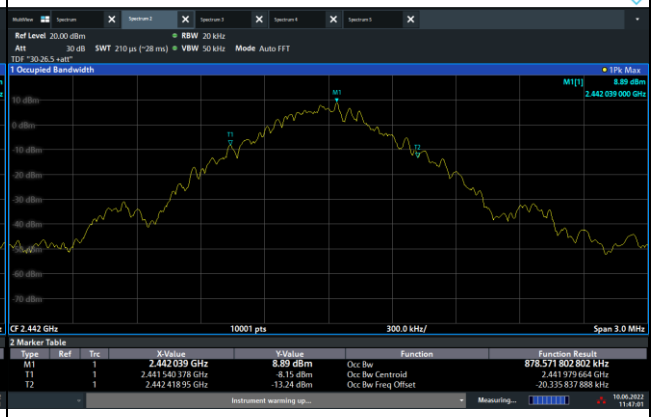
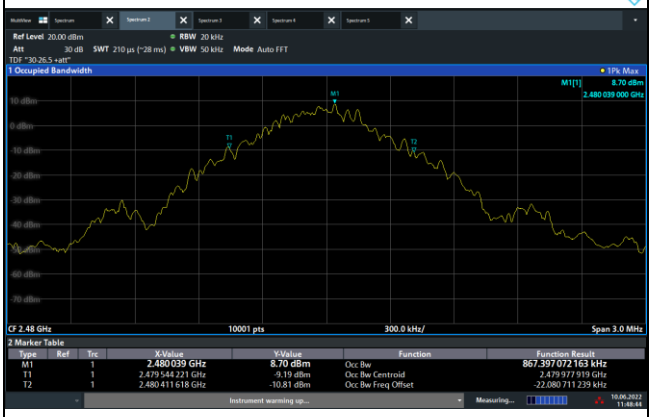
Mode : EDR 2Mbps

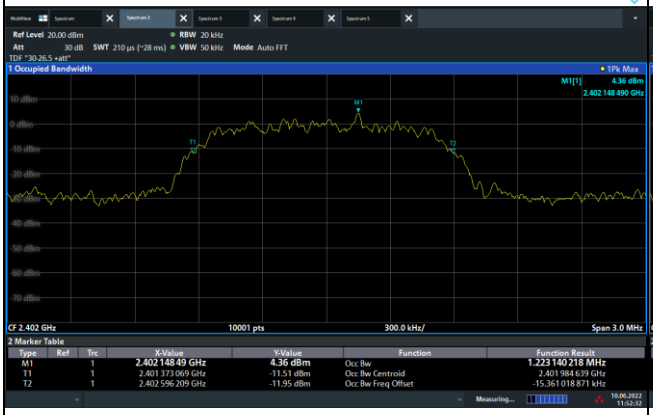
Frequency(㎒)	99% occupied bandwidth(㎒)	Limit(㎒)
2 402	1.223	-
2 442	1.226	
2 480	1.216	

Mode : EDR 3Mbps

Frequency(㎒)	99% occupied bandwidth(㎒)	Limit(㎒)
2 402	1.218	-
2 442	1.220	
2 480	1.213	

Test plots

BDR 1Mbps	
	
	N/A

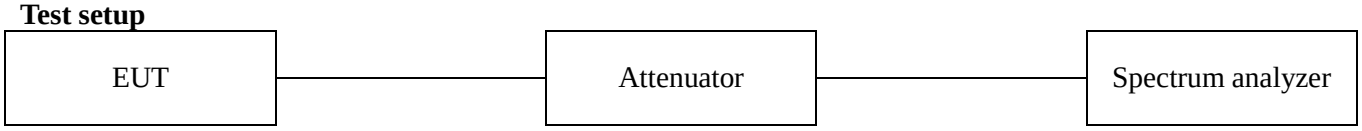
EDR 2Mbps	
	
	N/A

EDR 3Mbps	
	
	N/A

3.2. 20 dB bandwidth

Test procedure
ANSI 63.10-2013

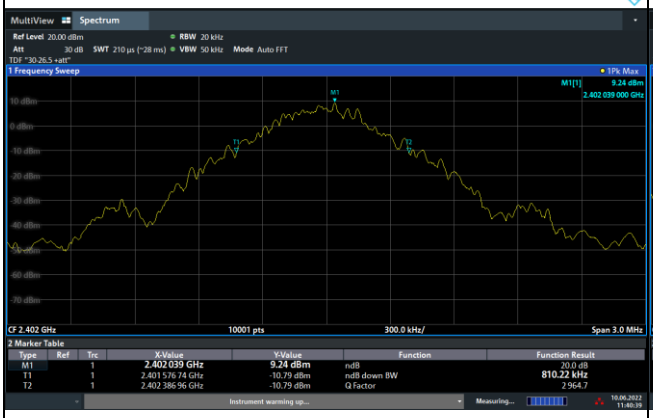
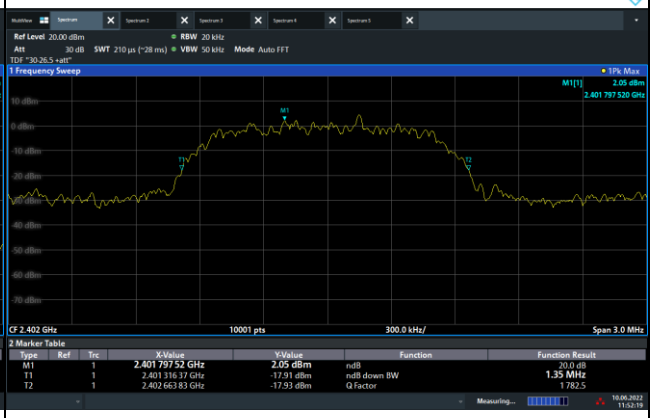
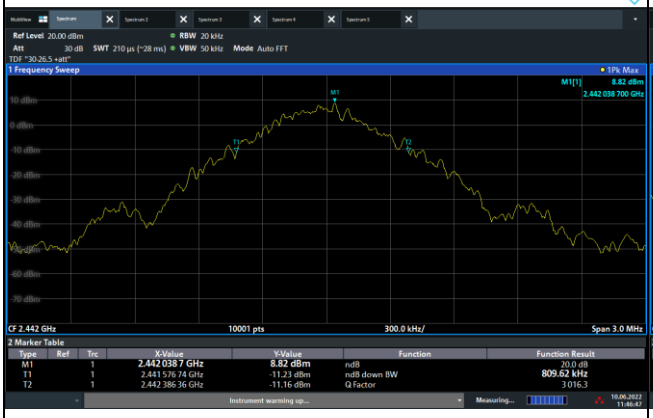
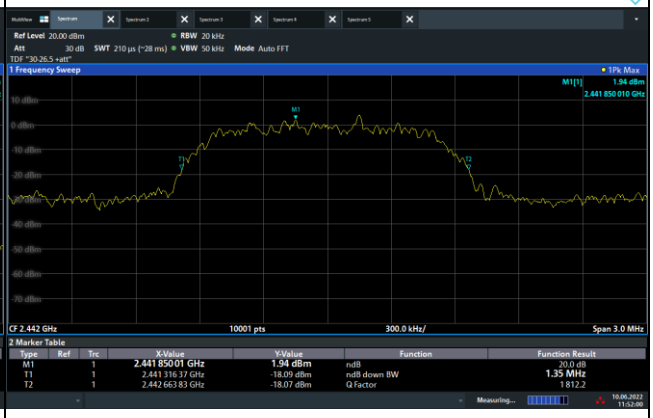
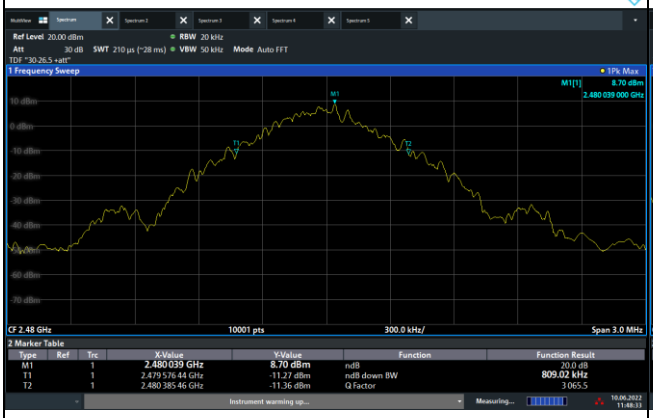
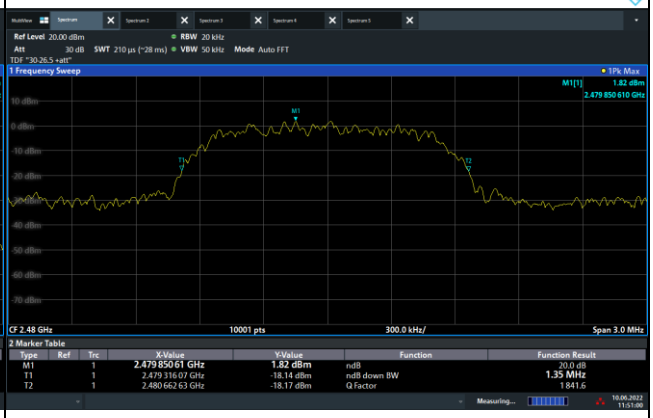
Test setup



Test setting
1. Span = Set between two times and five times the OBW
2. RBW ≥ 1 % to 5 %of the OBW
3. VBW ≥ 3 * RBW
4. Sweep = Auto
5. Detector function = Peak
6. Sweep = Auto couple
7. Trace mode = Max hold
8. All the trace to stabilize

Limit
Not applicable

Frequency(㎒)	Channel no.	Data rate(Mbps)	Measured bandwidth(㎒)
2 402	00	BDR 1 Mbps	0.81
2 442	40		0.81
2 480	78		0.81
2 402	00	EDR 2 Mbps	1.35
2 442	40		1.35
2 480	78		1.35
2 402	00	EDR 3 Mbps	1.35
2 442	40		1.35
2 480	78		1.35

BDR(1Mbps)	EDR(2Mbps)
	
	
	

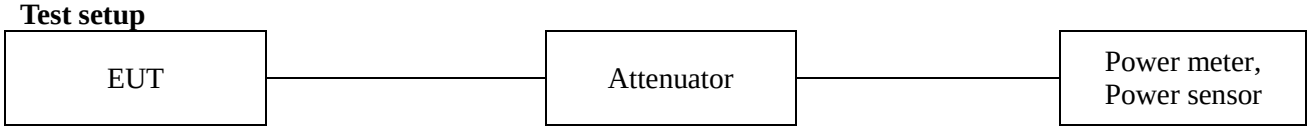
EDR(3Mbps)	
	
	Blank

3.3. Output power

Test procedure

KDB 558074 v05r02 & ANSI 63.10-2013 – Section 11.9.2.1 and 11.9.2.3.2

Test setup



Test setting

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 factor is required.

Limit

According to §15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 ㎑ or the 20 ㏈ bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 ㎽.

According to §15.247(b)(1), For frequency hopping systems operating in the 2 400 ~ 2 483.5 ㎒ employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 ~ 5 805 ㎒ band: 1 Watt.

According to §15.247(a)(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 dBi.

Limit

For FHSs operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e)

Test results

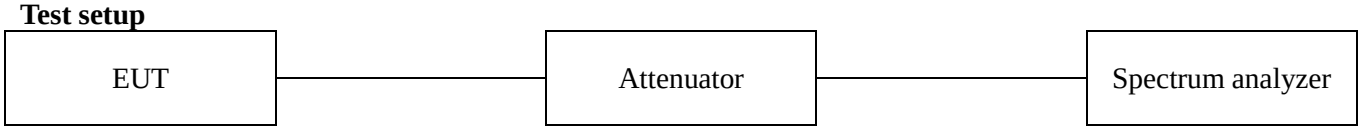
Frequency(㎒)	Channel no.	Data rate(Mbps)	Average Power (dBm)	Peak Power (dBm)	Power Limit (dBm)
2 402	00	BDR 1 Mbps	13.91	13.95	20.97
2 442	40		13.87	13.92	20.97
2 480	78		13.82	13.86	20.97
2 402	00	EDR 2 Mbps	10.34	11.87	20.97
2 442	40		10.32	11.88	20.97
2 480	78		10.24	11.93	20.97
2 402	00	EDR 3 Mbps	10.24	12.20	20.97
2 442	40		10.41	12.45	20.97
2 480	78		10.31	12.37	20.97

3.4. Carrier frequency separation

Test procedure

KDB 558074 v05r02 & ANSI 63.10-2013

Test setup



Test Setting

1. The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:
2. Span = wide enough to capture the peaks of two adjacent channels
3. RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
4. Video (or Average) Bandwidth (VBW) ≥ RBW
5. Sweep = auto
6. Detector function = peak
7. Trace = max hold
8. Allow the trace to stabilize.

Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.

Limit

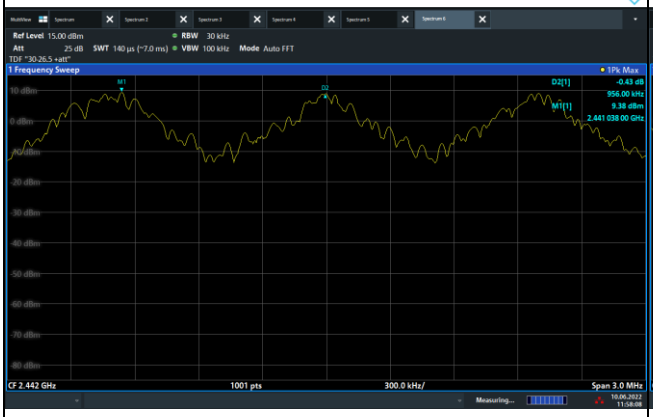
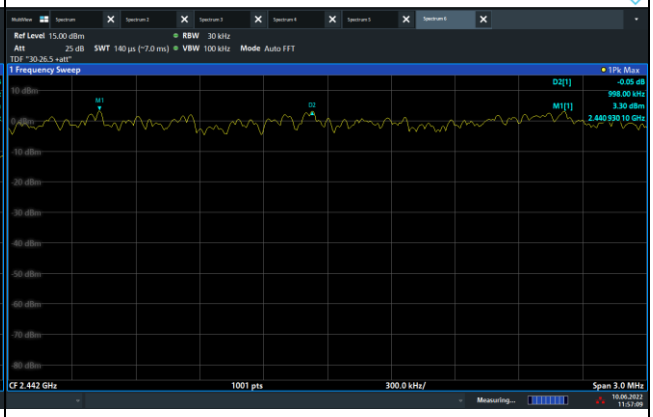
According to 15.247(a)(1), frequency hopping system operating in 2 400 ~ 2 483.5 ㎒. Band may have hopping channel carrier frequencies that are separated by 25 ㎑ or two-third of 20 ㏈ bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 ㎽.

Limit

FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W

Test results

Frequency(㎒)	Channel no.	Data rate(Mbps)	Channel Separation (㎒)	Limit (㎒)
2 442	40	BDR 1 Mbps	**0.956**	≥ 0.540
2 442	40	EDR 3 Mbps	**0.998**	≥ 0.900

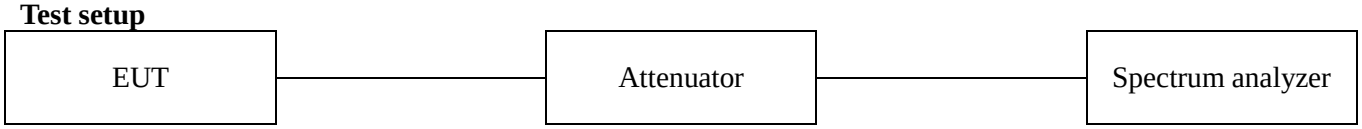
Hopping mode_BDR(1Mbps)	Hopping mode_EDR(3Mbps)
	

3.5. Number of hopping frequency

Test procedure

KDB 558074 v05r02 & ANSI 63.10-2013

Test setup



Test setting

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings.

1. Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
2. RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
3. VBW ≥ RBW.
4. Sweep = auto
5. Detector function = peak
6. Trace = max hold

All the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

Limit

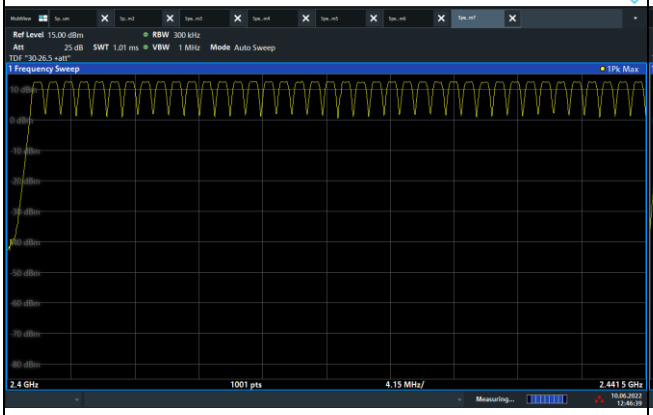
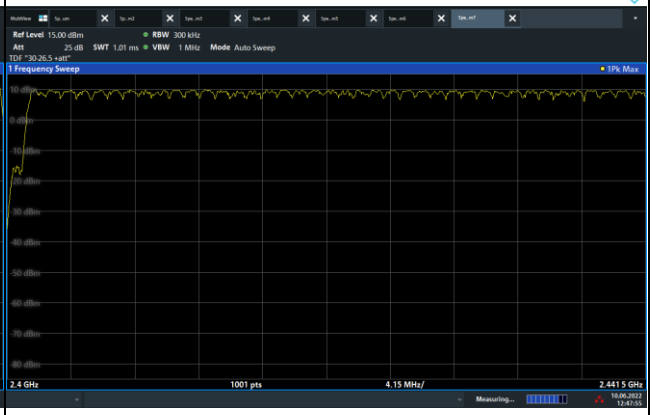
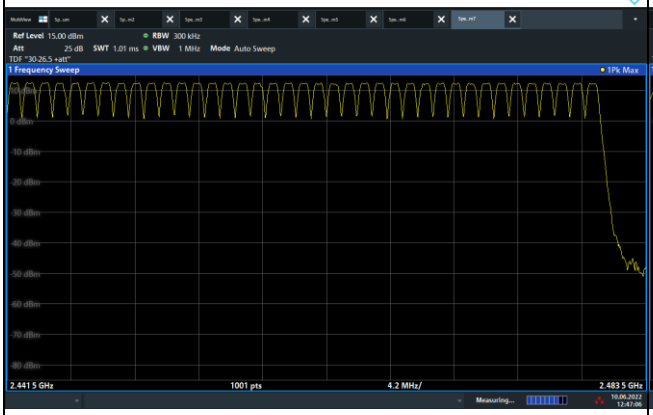
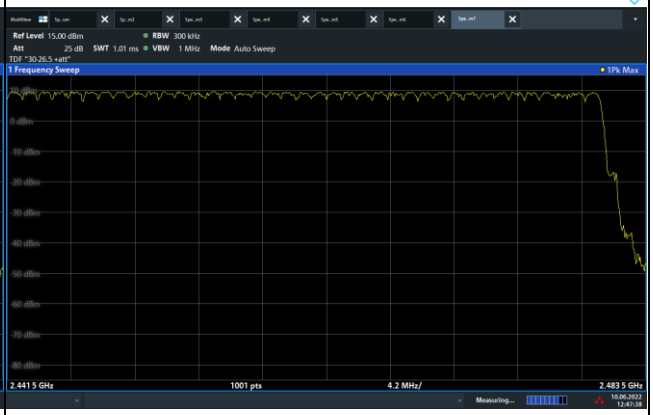
According to 15.247(a)(1)(iii), for frequency hopping system operating in the 2 400 ~ 2 483.5 ㎒ bands shall use at least 15 hopping frequencies.

Limit

FHSs operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

Test results

Frequency	Data rate(Mbps)	Number of hopping frequency	Limit
2 402 ~ 2 480 ㎒	BDR 1 Mbps	79	≥ 15
2 402 ~ 2 480 ㎒	EDR 3 Mbps	79	≥ 15

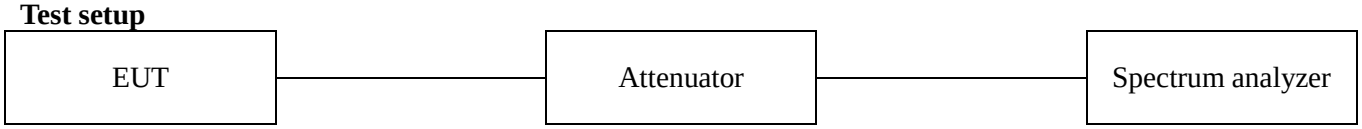
Hopping mode_BDR(1 Mbps)	Hopping mode_EDR(3 Mbps)
	
	

3.6. Time of occupancy

Test procedure

KDB 558074 v05r02 & ANSI 63.10-2013

Test setup



Test setting

1. The EUT must have its hopping function enabled.
2. Span = zero span, centered on a hopping channel
3. RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
4. Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
5. Detector function = peak
6. Trace = max hold

Limit

According to 15.247(a)(1)(iii), for frequency hopping system operating in the 2 400 ~ 2 483.5 ㎒ band, the average time of occupancy on any frequency shall not be greater than 0.4 second within a 31.6 second period.

A period time = 0.4(s) × 79 = 31.6(s)

Time of occupancy on the TX channel in 31.6 sec
= time domain slot length × (hop rate ÷ number of hop per channel) × 31.6

Limit

According to RSS-247 5.1(d), for frequency hopping system operating in the 2 400 ~ 2 483.5 ㎒ band, the average time of occupancy on any frequency shall not be greater than 0.4 second within a 31.6 second period.

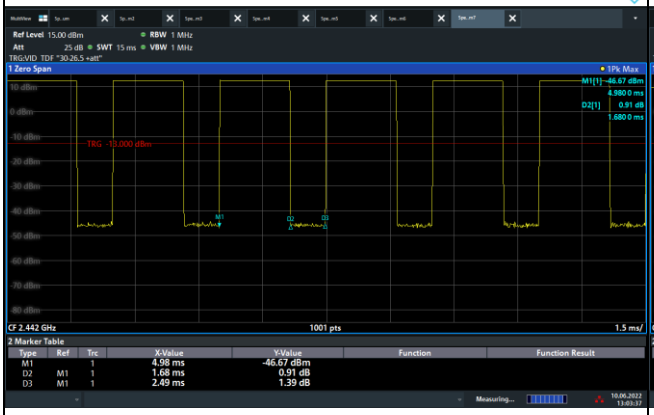
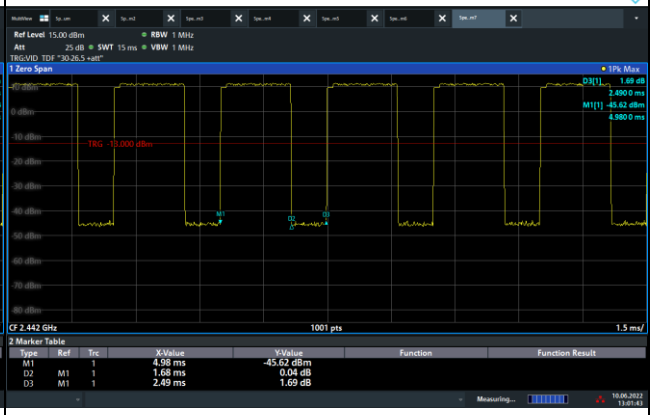
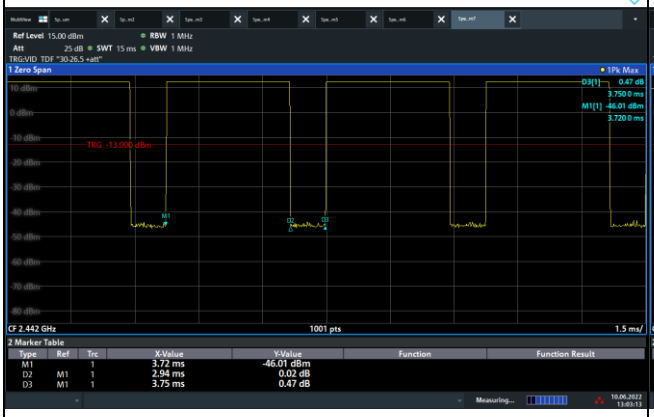
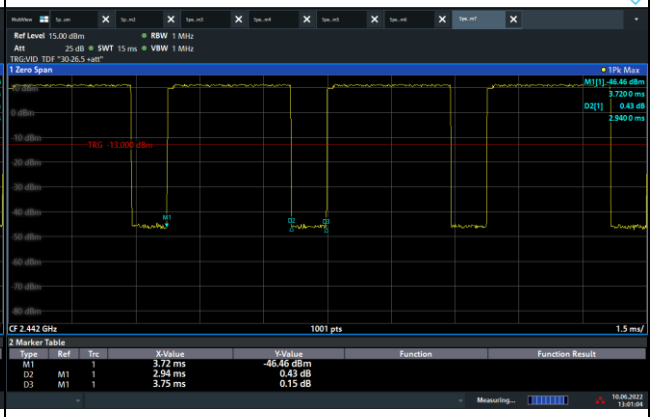
A period time = 0.4(s) × 79 = 31.6(s)

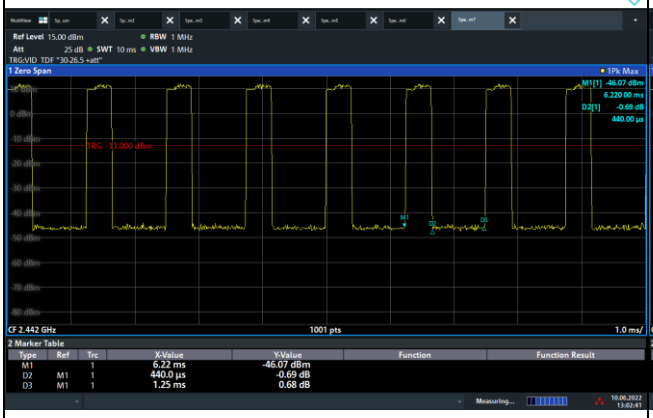
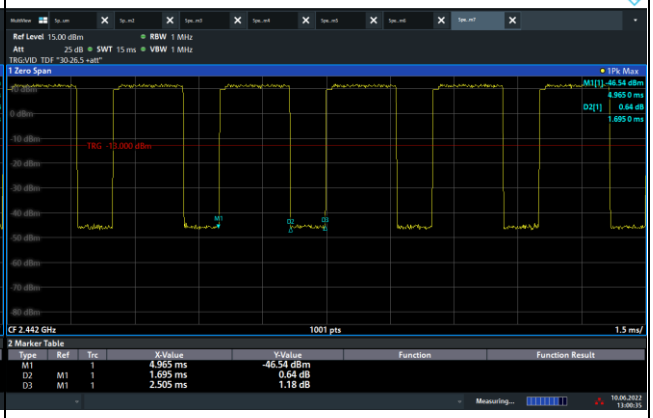
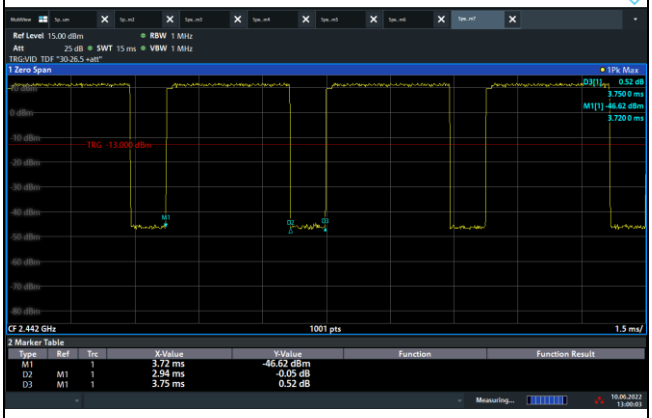
Time of occupancy on the TX channel in 31.6 sec
= time domain slot length × (hop rate ÷ number of hop per channel) × 31.6

Operation mode: GFSK , π/4-DQPSK, 8DPSK

Packet type	Frequency (㎒)	Dwell time (ms)	Time of occupancy on the Tx channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx channel in 31.6 sec (ms)
DH1	2 442	0.44	140.80	400
DH3	2 442	1.68	268.80	400
DH5	2 442	2.94	313.60	400
2-DH1	2 442	0.44	140.80	400
2-DH3	2 442	1.68	268.80	400
2-DH5	2 442	2.94	313.60	400
3-DH1	2 442	0.44	140.80	400
3-DH3	2 442	1.70	271.20	400
3-DH5	2 442	2.94	313.60	400

Note:
Normal Mode
DH1: Dwell time (ms) × [(1 600 ÷ 2) ÷ 79] × 31.6(s) = 140.80 (ms)
DH3: Dwell time (ms) × [(1 600 ÷ 4) ÷ 79] × 31.6(s) = 268.80 (ms)
DH5: Dwell time (ms) × [(1 600 ÷ 6) ÷ 79] × 31.6(s) = 313.60 (ms)
2-DH1: Dwell time (ms) × [(1 600 ÷ 2) ÷ 79] × 31.6(s) = 140.80 (ms)
2-DH3: Dwell time (ms) × [(1 600 ÷ 4) ÷ 79] × 31.6(s) = 268.80 (ms)
2-DH5: Dwell time (ms) × [(1 600 ÷ 6) ÷ 79] × 31.6(s) = 313.60 (ms)
3-DH1: Dwell time (ms) × [(1 600 ÷ 2) ÷ 79] × 31.6(s) = 140.80 (ms)
3-DH3: Dwell time (ms) × [(1 600 ÷ 4) ÷ 79] × 31.6(s) = 271.20 (ms)
3-DH5: Dwell time (ms) × [(1 600 ÷ 6) ÷ 79] × 31.6(s) = 313.60 (ms)

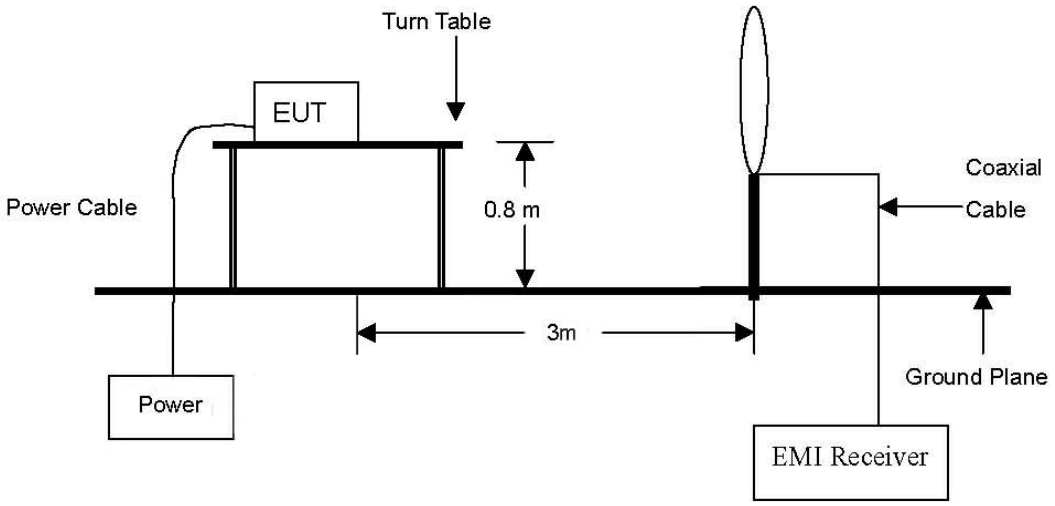
BDR(1Mbps)	EDR(2Mbps)
	
	
	

EDR(3Mbps)	
	
	Blank

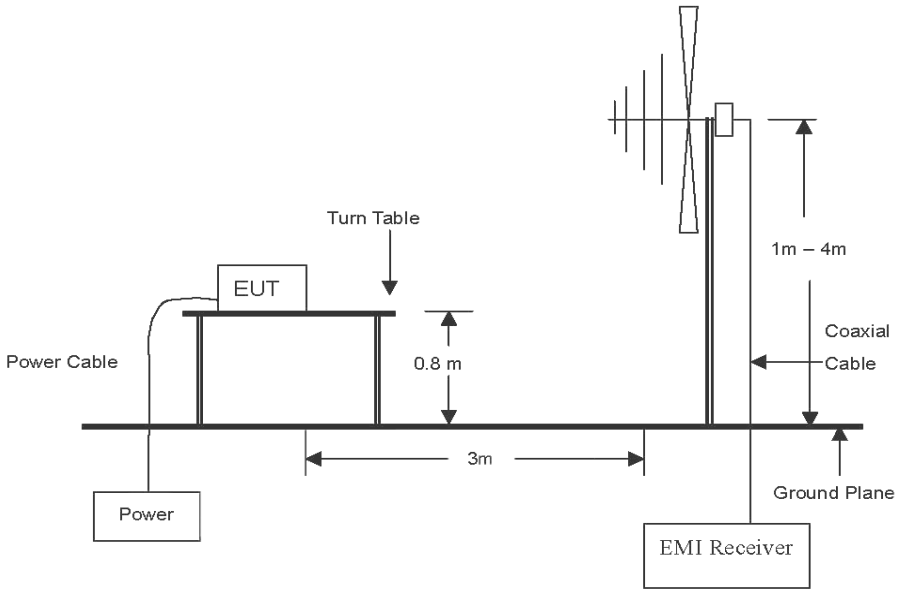
3.7. Radiated restricted band and emissions

Test setup

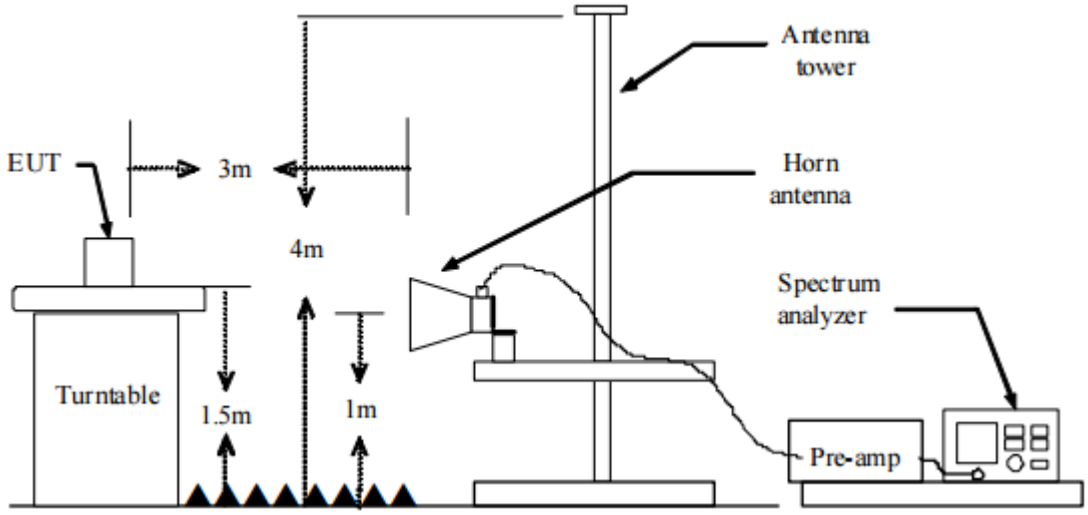
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 ㎑ to 30 ㎒ Emissions.



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.

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.

Limit

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.

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.

Mode	T_{on} time (㎳)	Period (㎳)	Duty cycle (Linear)	Duty cycle (%)	Duty cycle correction factor (㏈)
BDR(1 Mbps)	2.94	3.75	0.78	78.40	1.06
EDR(3 Mbps)	2.94	3.75	0.78	78.40	1.06

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

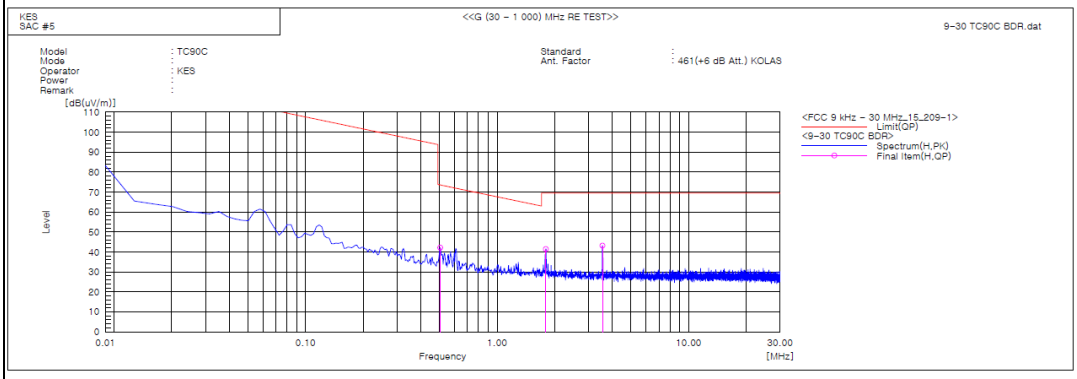
DCF(Duty cycle correction factor (㏈)) = 10log(1/duty cycle)

BDR (1 Mbps)	EDR (3 Mbps)
	

Test results (Below 30 ㎒)

Mode:	BDR
Distance of measurement:	3 meter
Channel:	0 (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	0.504	H	22.5	19.7	42.2	73.6	31.4	99.7	143.4	
2	1.797	H	21.2	20.3	41.5	69.5	28.0	99.7	22.2	
3	3.548	H	23.3	19.9	43.2	69.5	26.3	99.7	95.8	

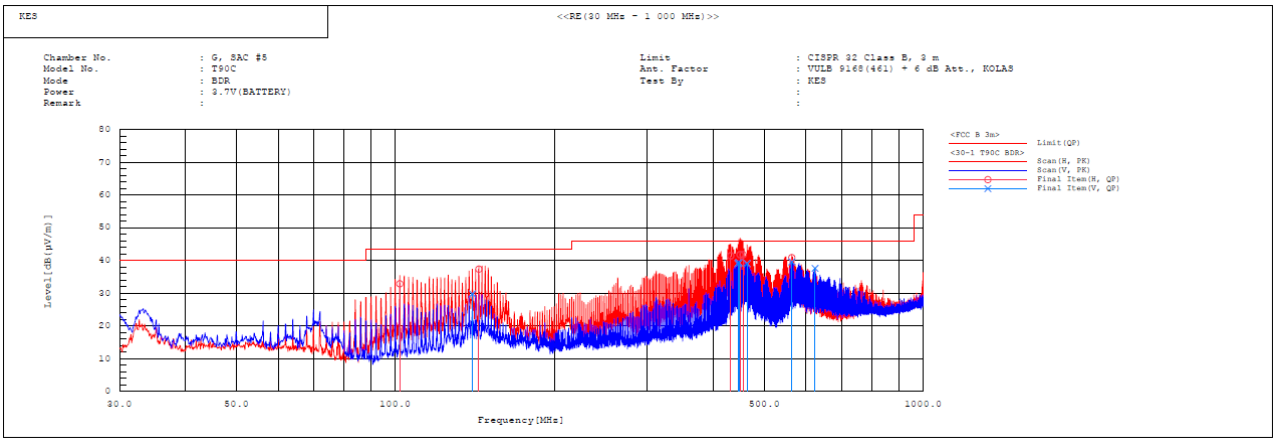
Note.

1. No spurious emission were detected under 30 ㎒, the above test result is the peak result.

Test results (Below 1 000 ㎒) – Worst case

Mode:	BDR
Distance of measurement:	3 meter
Channel:	0 (Worst case)

Horizontal // Vertical



Final Result

No.	Range	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	Range1	101.974	H	50.1	-17.2	32.9	43.5	10.6	200.0	158.0	
2	Range1	139.998	V	43.0	-13.2	29.8	43.5	13.7	130.0	299.7	
3	Range1	143.975	H	50.4	-13.0	37.4	43.5	6.1	200.0	9.5	
4	Range1	431.968	H	50.4	-8.9	41.5	46.0	4.5	208.0	56.8	
5	Range1	446.033	V	47.6	-8.5	39.1	46.0	6.9	100.0	217.1	
6	Range1	447.973	V	47.9	-8.5	39.4	46.0	6.6	147.0	205.5	
7	Range1	450.010	H	50.2	-8.4	41.8	46.0	4.2	100.0	60.4	
8	Range1	456.024	H	50.1	-8.3	41.8	46.0	4.2	100.0	72.4	
9	Range1	463.978	V	47.3	-8.2	39.1	46.0	6.9	110.0	203.7	
10	Range1	563.985	H	47.3	-6.4	40.9	46.0	5.1	198.0	331.8	
11	Range1	563.985	V	46.0	-6.4	39.6	46.0	6.4	100.0	247.3	
12	Range1	624.028	V	42.6	-5.0	37.6	46.0	8.4	100.0	158.8	

Test results (Above 1 000 ㎒)

Mode: BDR

Distance of measurement: 3 meter

Channel: 00

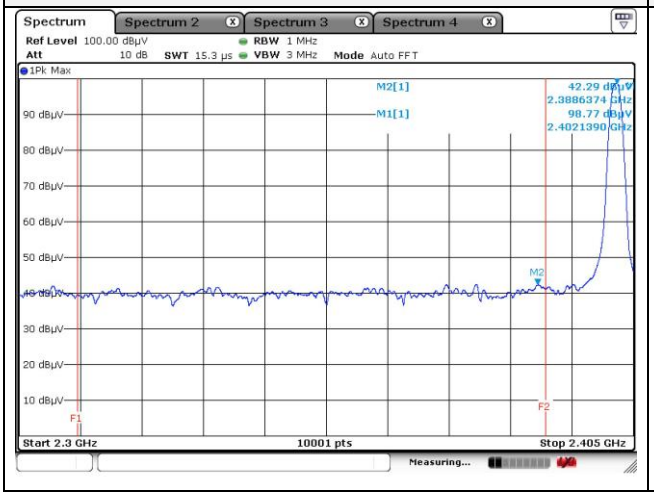
- **Spurious**

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
1 332.27	49.45	Peak	H	-7.47	-	41.98	74.00	32.02
1 332.67	45.90	Peak	V	-7.47	-	38.43	74.00	35.57

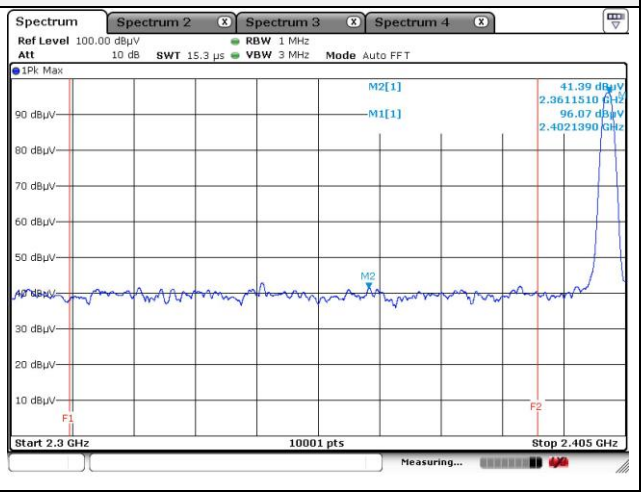
- **Band edge**

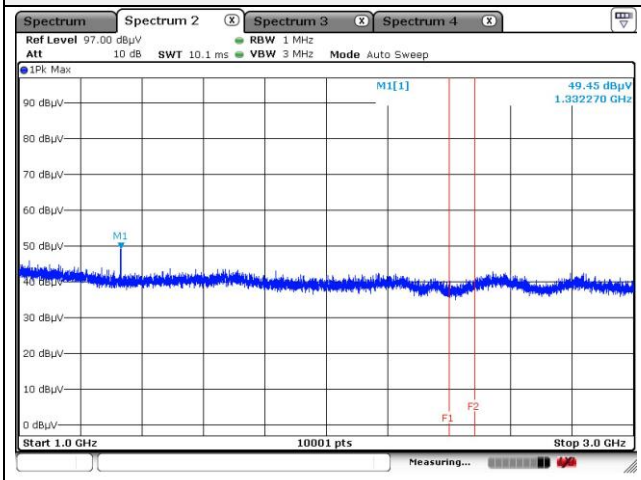
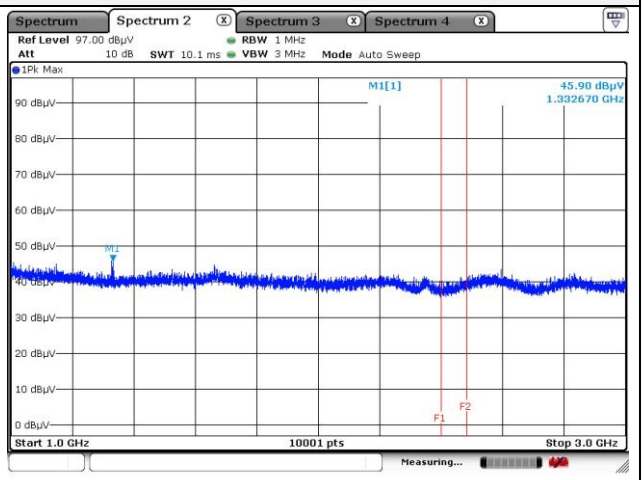
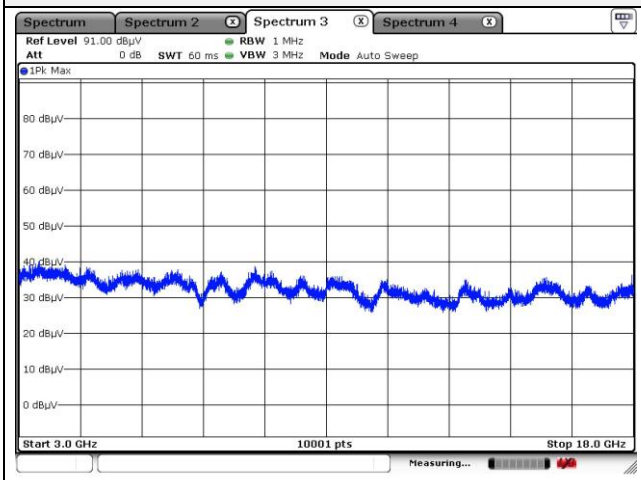
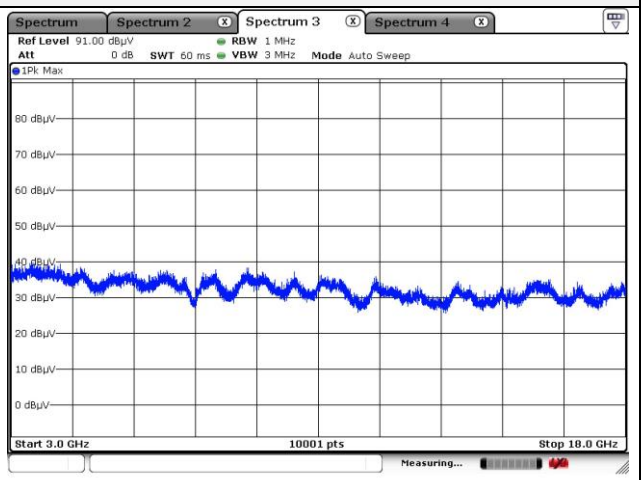
Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 361.15	41.39	Peak	V	-0.85	-	40.54	74.00	33.46
2 388.64	42.29	Peak	H	-0.83	-	41.46	74.00	32.54

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.

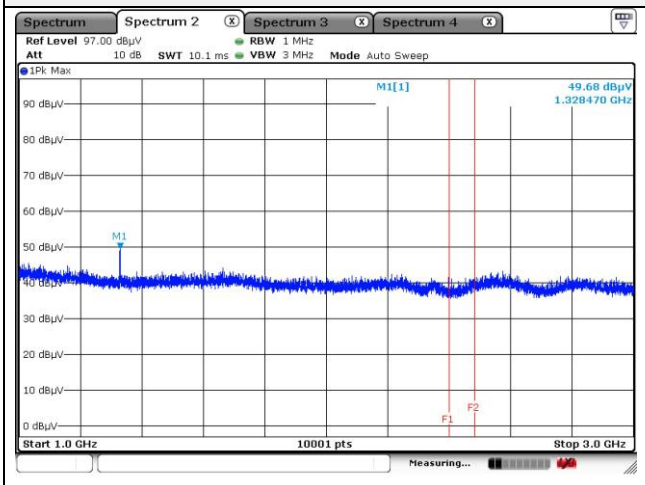
Mode: BDR

Distance of measurement: 3 meter

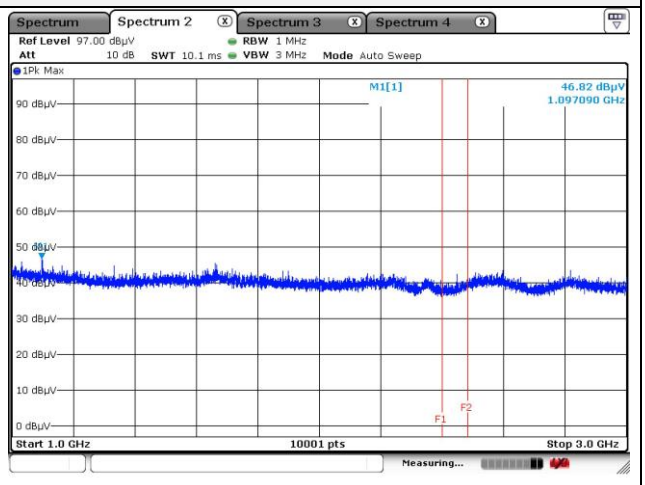
Channel: 40

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
1 097.09	46.82	Peak	V	-8.88	-	37.94	74.00	36.06
1 328.47	49.68	Peak	V	-7.49	-	42.19	74.00	31.81

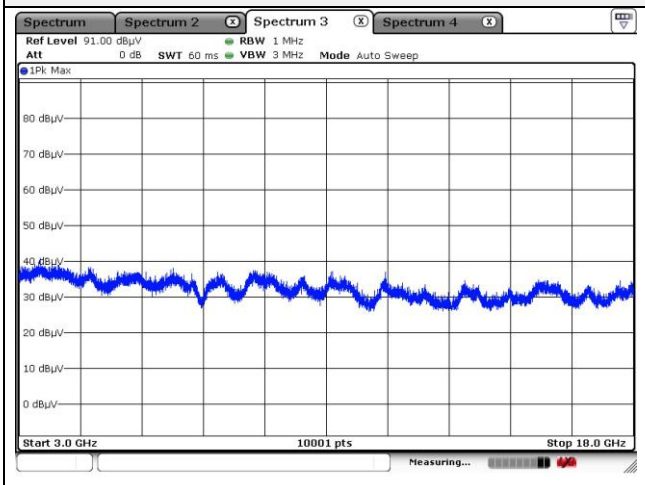
Horizontal // Peak for 1 ㎓ to 3 ㎓



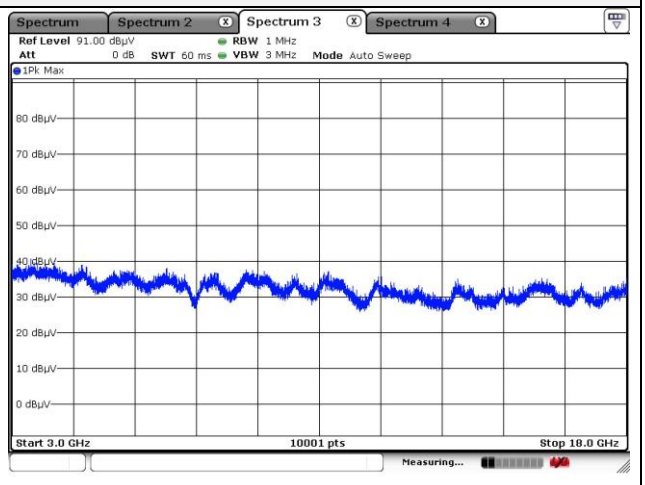
Vertical // Peak for 1 ㎓ to 3 ㎓



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.

Mode:	BDR
Transfer rate:	1 Mbps
Distance of measurement:	3 meter
Channel:	78

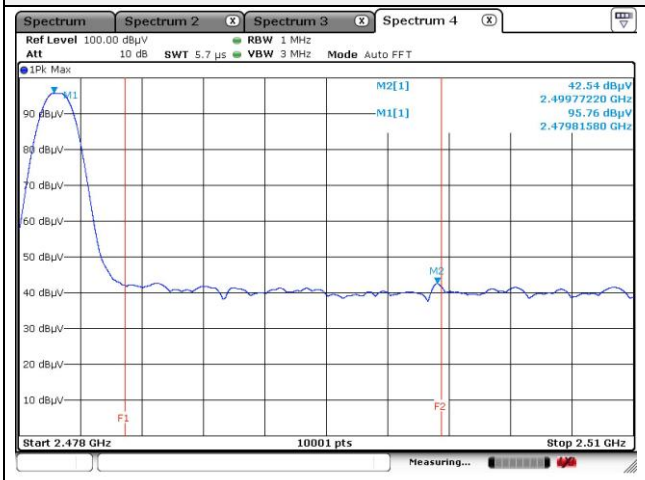
- **Spurious**

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
1 328.47	45.83	Peak	H	-7.49	-	38.34	74.00	35.66
1 666.23	46.73	Peak	V	-4.82	-	41.91	74.00	32.09

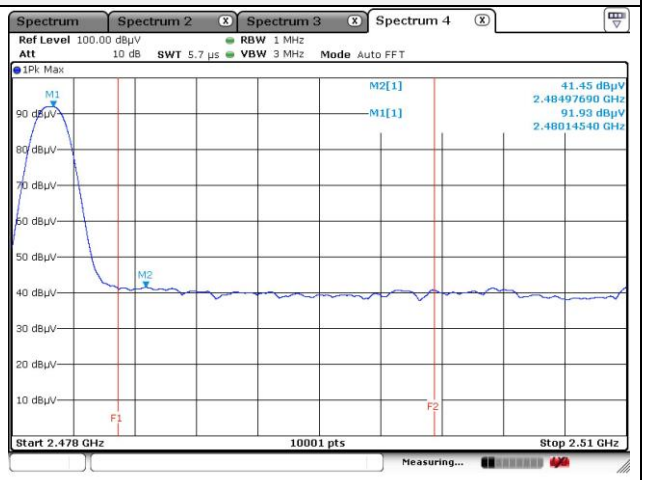
- **Band edge**

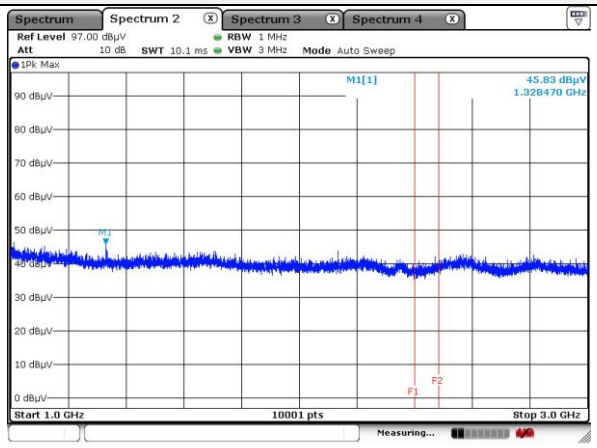
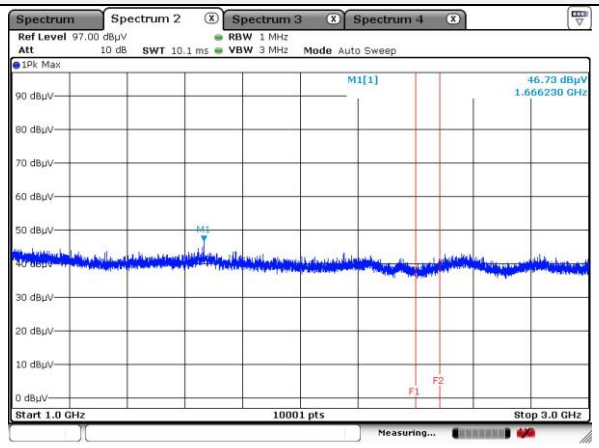
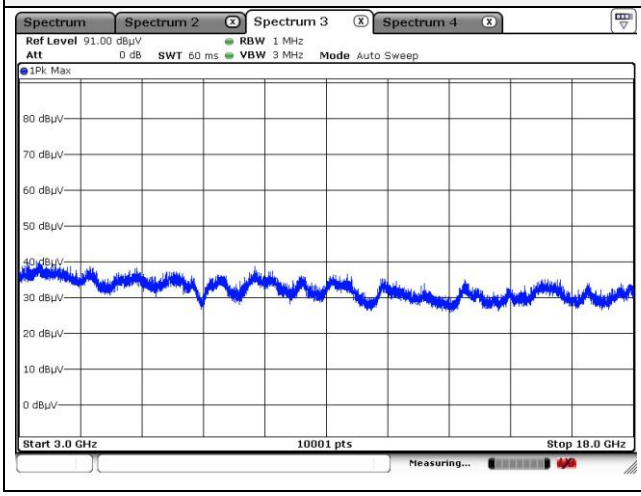
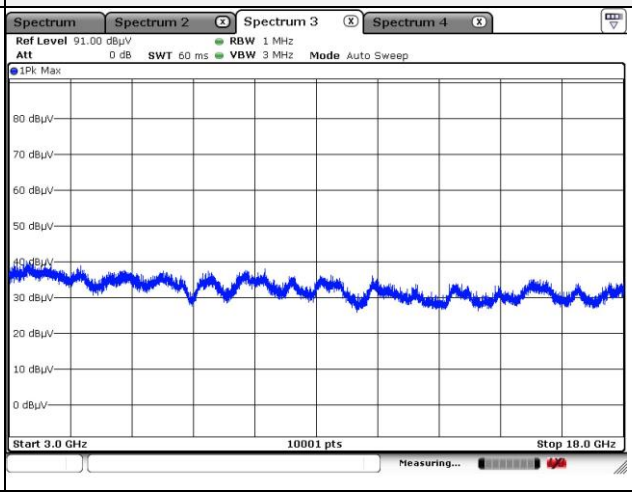
Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 484.98	41.45	Peak	V	-0.77	-	40.68	74.00	33.32
2 499.77	42.54	Peak	H	-0.76	-	41.78	74.00	32.22

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.

Mode:	EDR
Transfer rate:	3 Mbps(Worst case)
Distance of measurement:	3 meter
Channel:	00

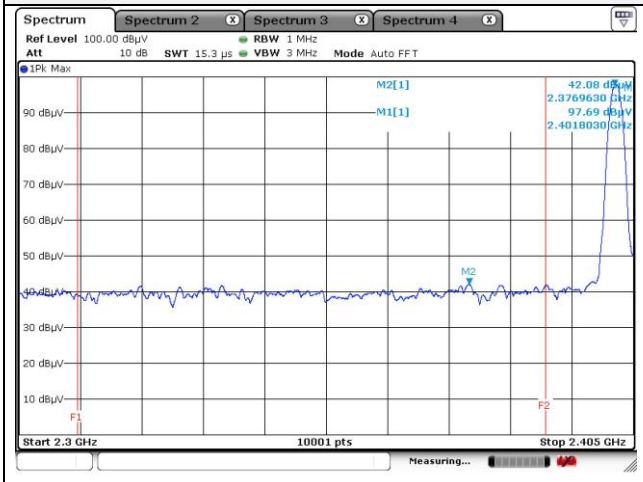
- **Spurious**

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
1 329.27	48.28	Peak	H	-7.49	-	40.79	74.00	33.21
1 330.67	45.92	Peak	V	-7.48	-	38.44	74.00	35.56

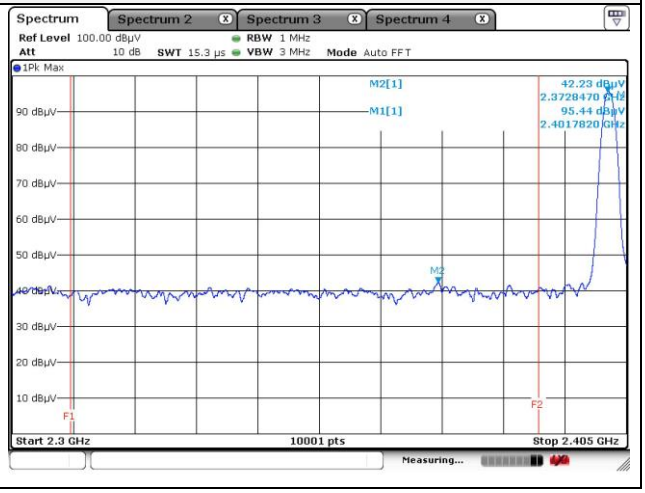
- **Band edge**

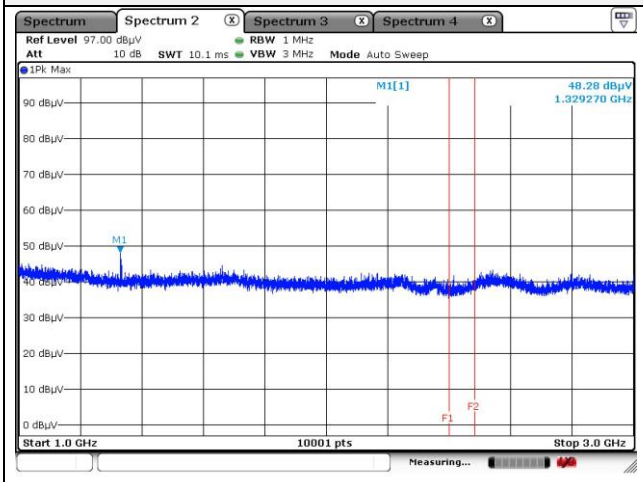
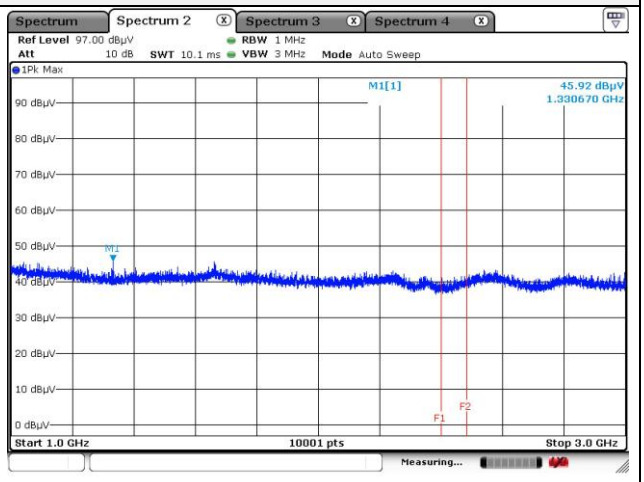
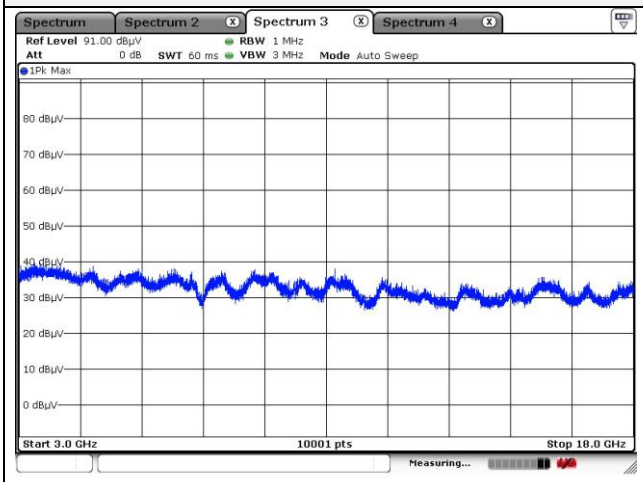
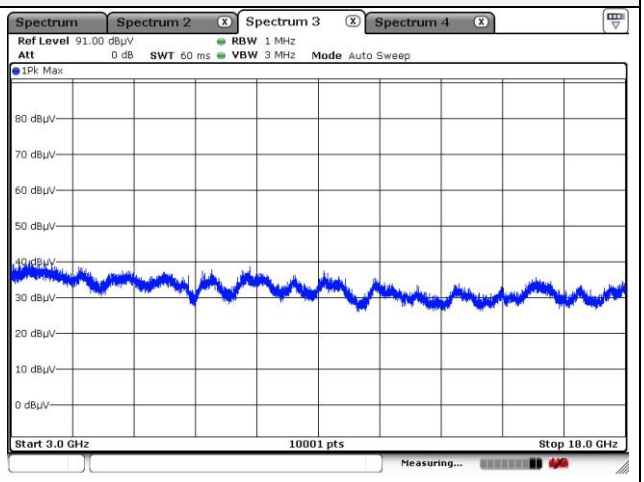
Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 372.85	42.23	Peak	V	-0.84	-	41.39	74.00	32.61
2 376.96	42,08	Peak	H	-0.84	-	41.24	74.00	32.76

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 ㎓**
	

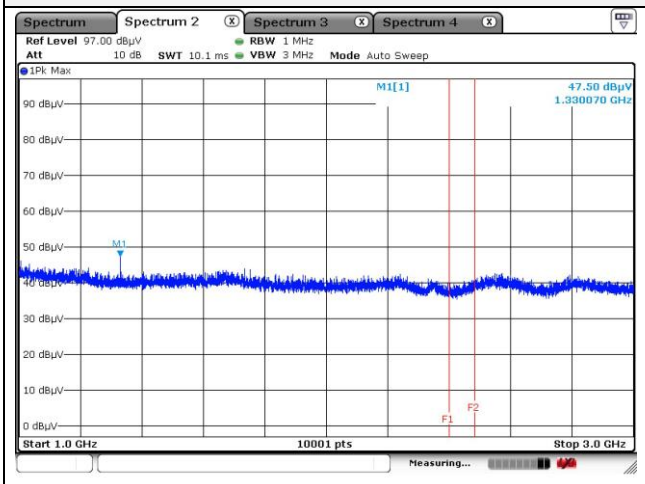
Note.
1. Average test would be performed if the peak result were greater than the average limit.

Mode:	EDR
Transfer rate:	3 Mbps(Worst case)
Distance of measurement:	3 meter
Channel:	40

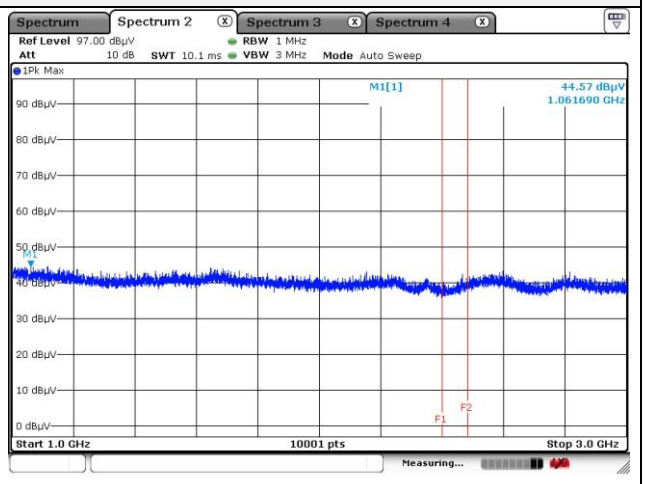
- **Spurious**

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
1 061.69	44.57	Peak	V	-9.08	-	35.49	74.00	38.51
1 330.07	47.50	Peak	H	-7.48	-	40.02	74.00	33.98

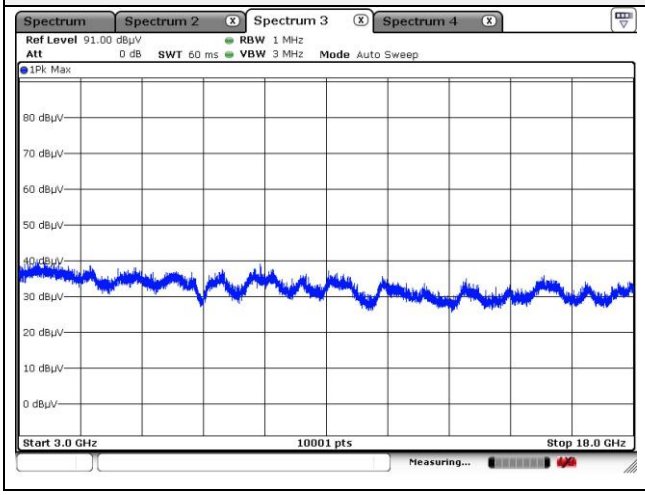
Horizontal // Peak for 1 ㎓ to 3 ㎓



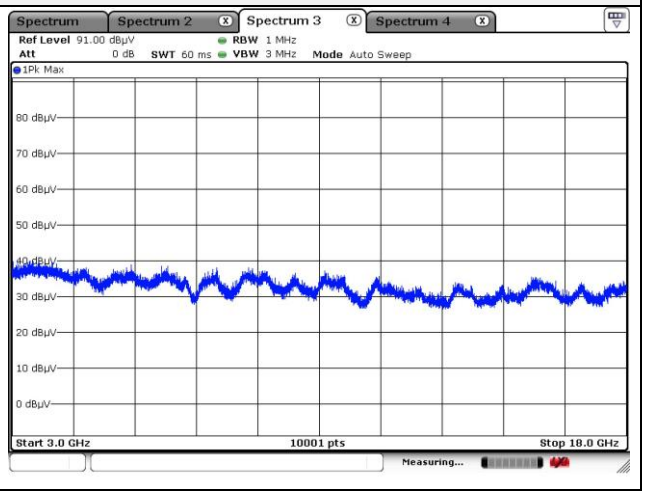
Vertical // Peak for 1 ㎓ to 3 ㎓



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.

Mode:	EDR
Transfer rate:	3 Mbps(Worst case)
Distance of measurement:	3 meter
Channel:	78

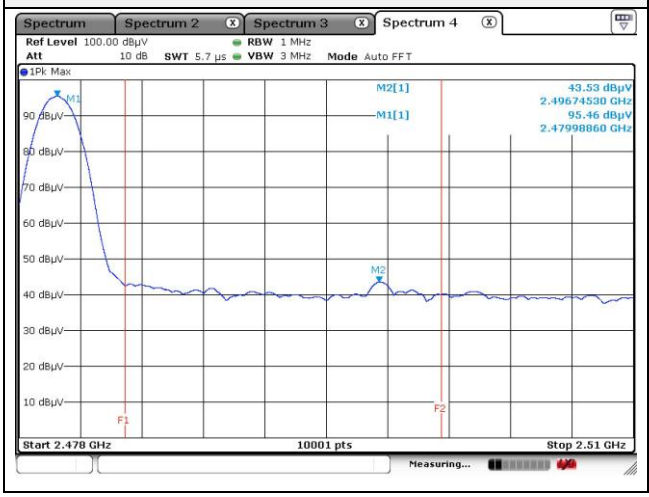
- **Spurious**

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
1 329.47	49.11	Peak	H	-7.49	-	41.62	74.00	32.38
1 661.23	45.16	Peak	V	-4.88	-	40.28	74.00	33.72

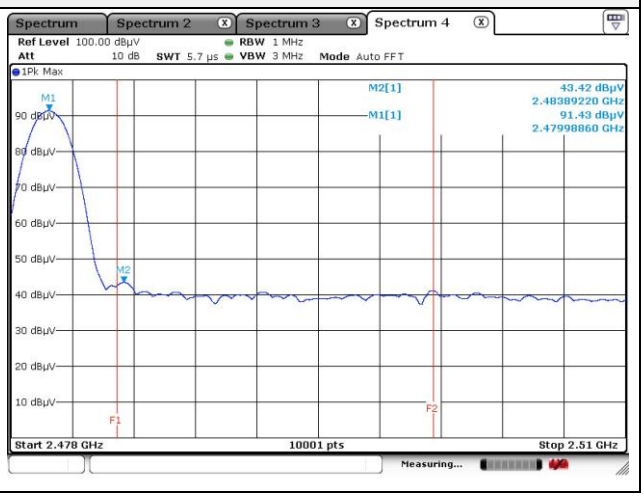
- **Band edge**

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 483.89	43.42	Peak	V	-0.77	-	42.65	74.00	31.35
2 496.75	43.53	Peak	H	-0.76	-	42.77	74.00	31.23

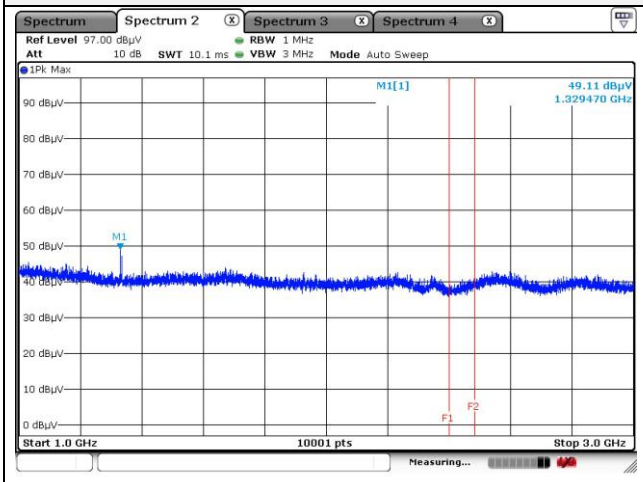
Restricted band // Horizontal // Peak



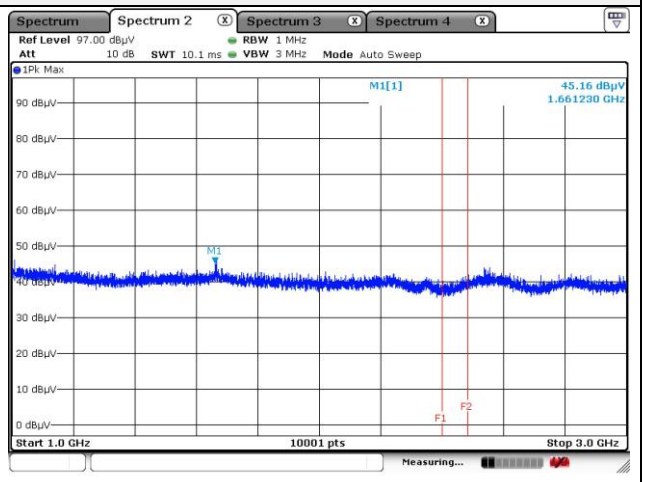
Restricted band // Vertical // Peak



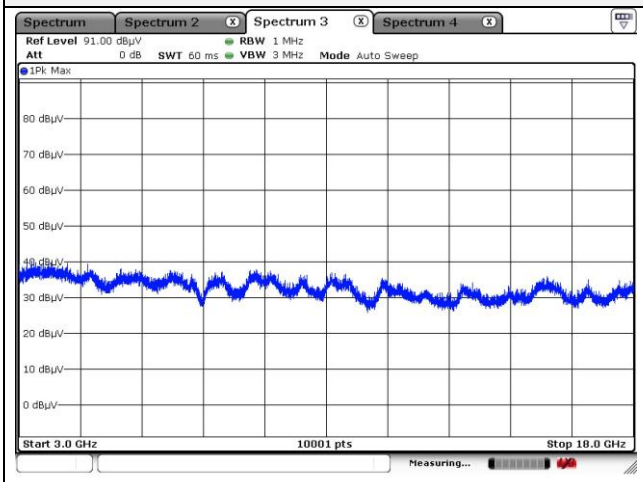
Horizontal // Peak for 1 ㎓ to 3 ㎓



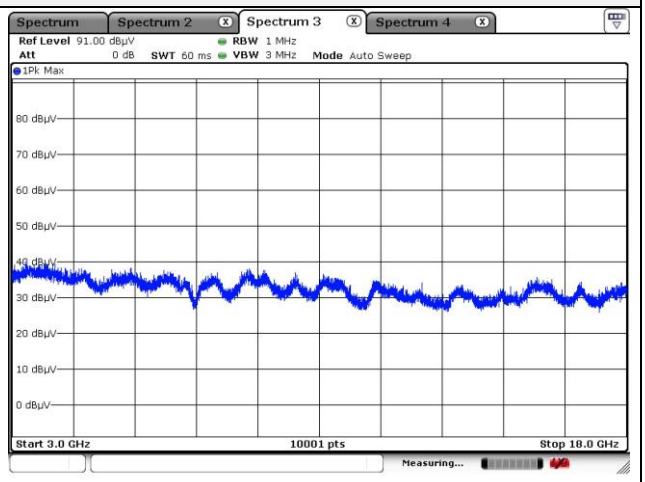
Vertical // Peak for 1 ㎓ to 3 ㎓



Horizontal // Peak for 3 ㎓ to 18 ㎓



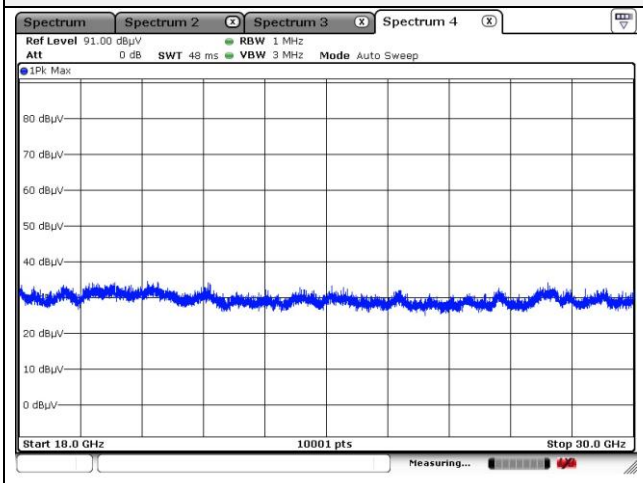
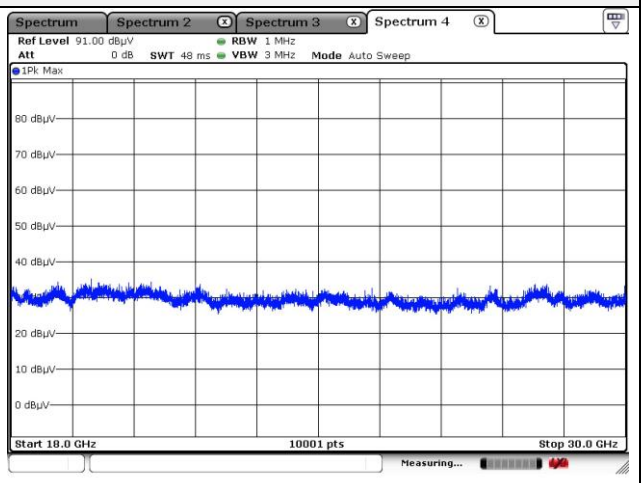
Vertical // Peak for 3 ㎓ to 18 ㎓



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.

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

Mode:	BDR
Transfer rate:	1 Mbps
Distance of measurement:	3 meter
Channel:	0 (Worst case)

Horizontal	Vertical
	

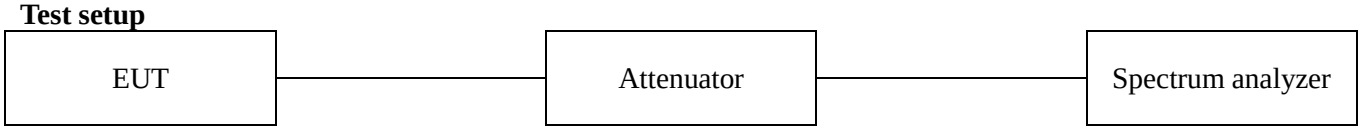
Note.
1. No spurious emission were detected above 18 ㎓.

3.8. Conducted band edge and out of band emissions

Test procedure

KDB 558074 v05r02 & ANSI 63.10-2013

Test setup



Test setting

1. Span = wide enough to capture the peak level of the in-band emission and all spurious emissions(e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic.
2. RBW = 100 ㎑
3. VBW ≥ 300 ㎑
4. Detector = Peak
5. Number of sweep points ≥ 2 × Span/RBW
7. Trace mode = max hold
8. Sweep time = auto couple
9. The trace was allowed to stabilize

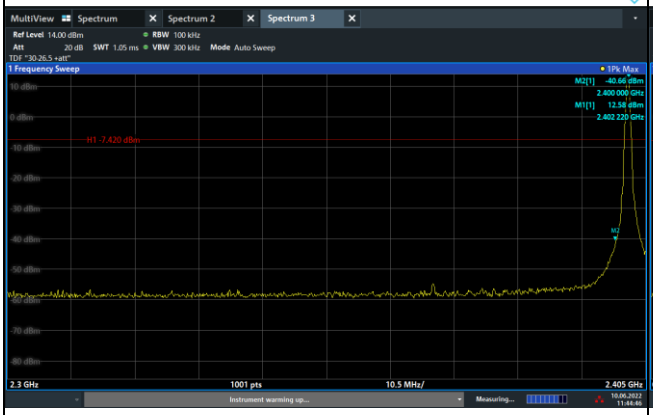
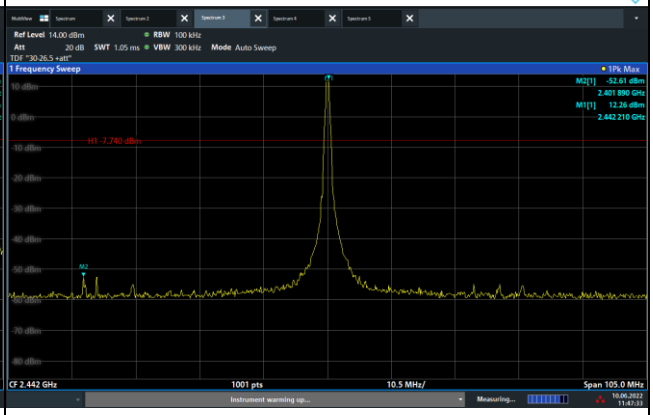
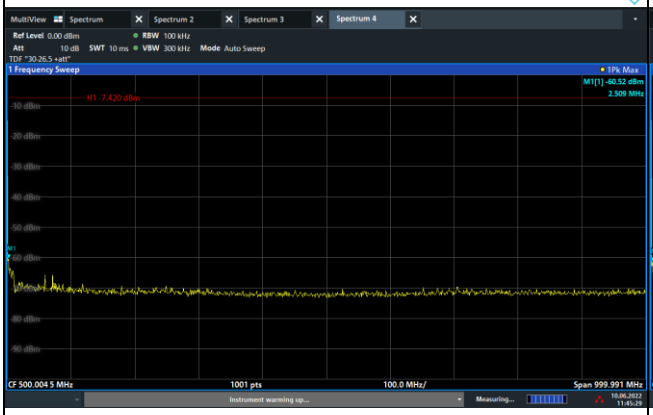
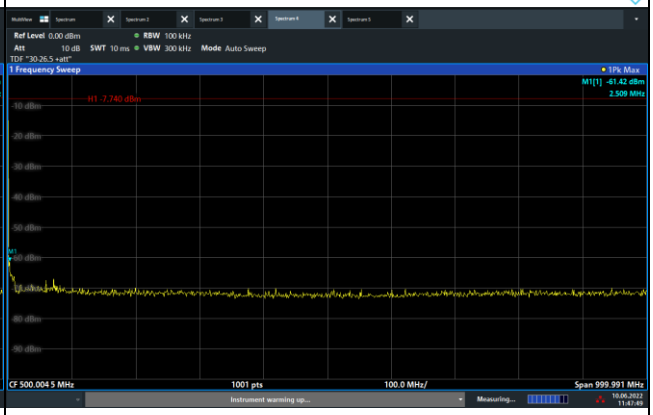
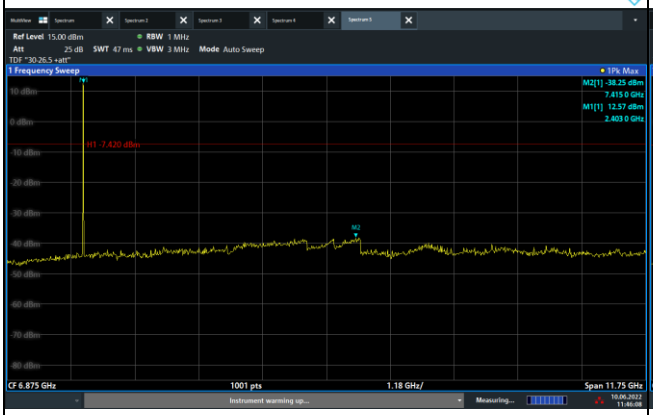
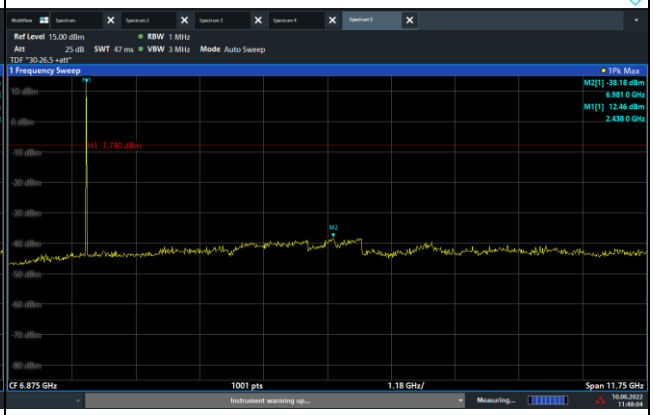
Limit

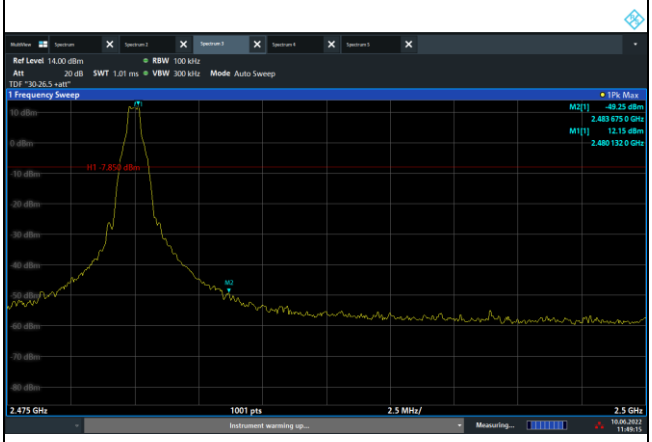
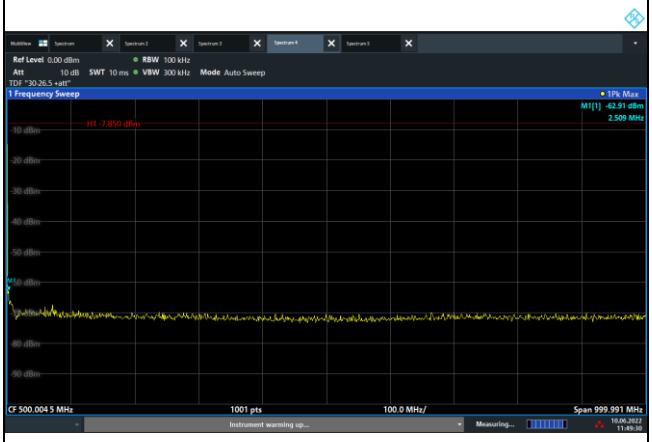
According to 15.247(d), in any 100 ㎑ bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 ㏈ below that in the 100 ㎑ bandwidth within the band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

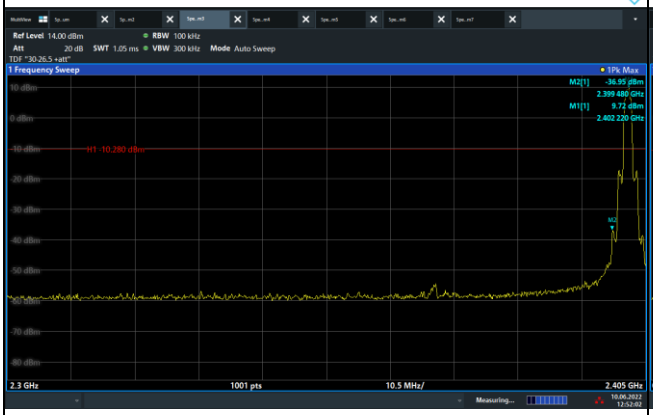
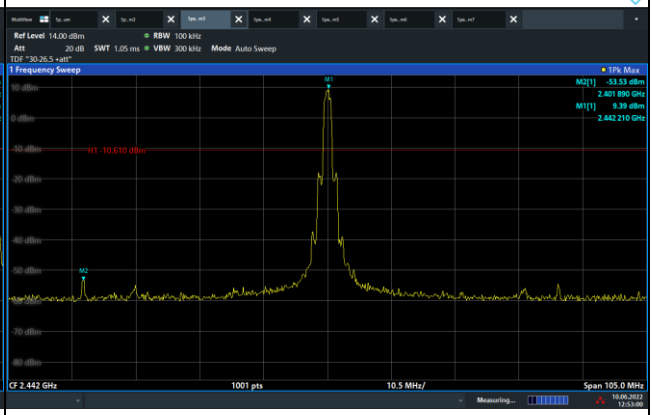
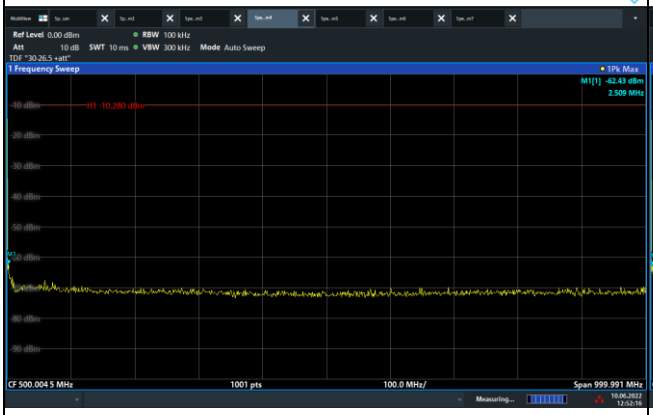
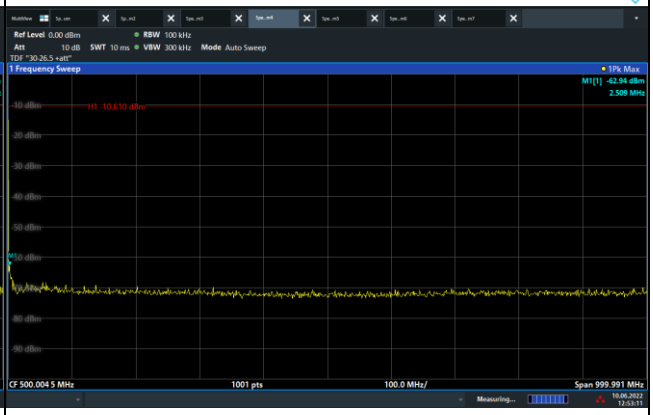
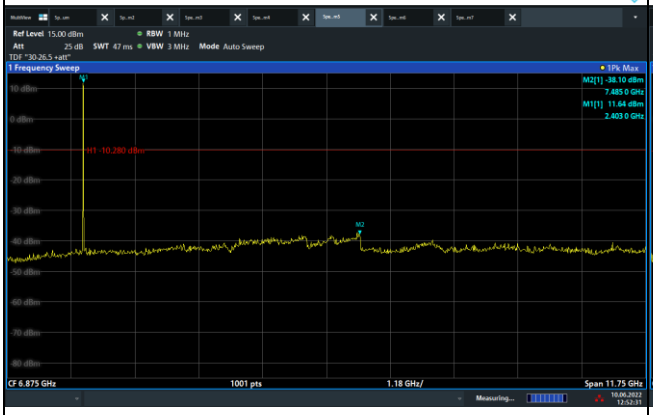
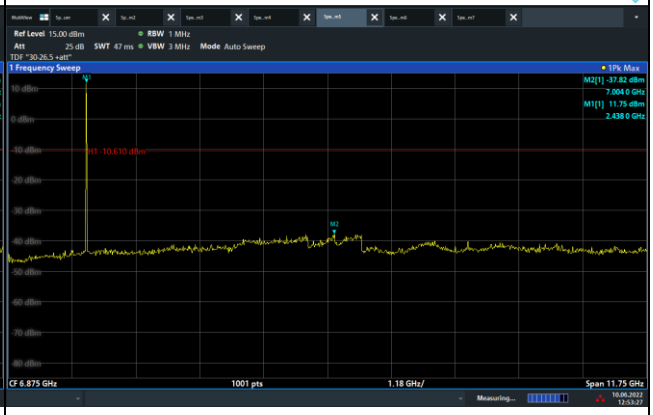
Limit

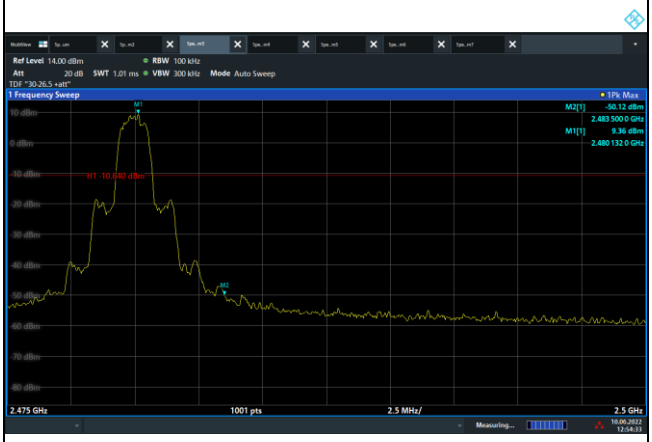
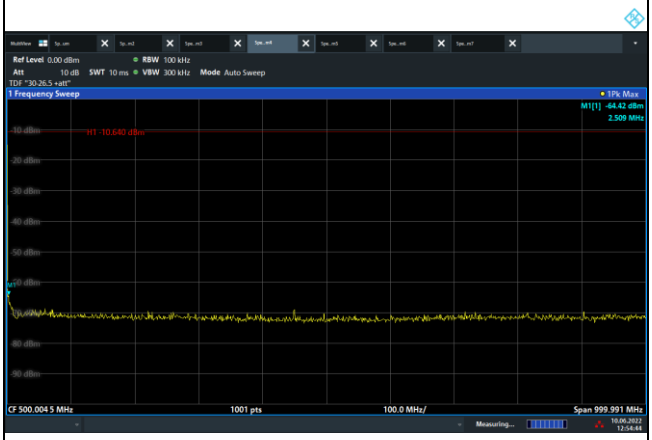
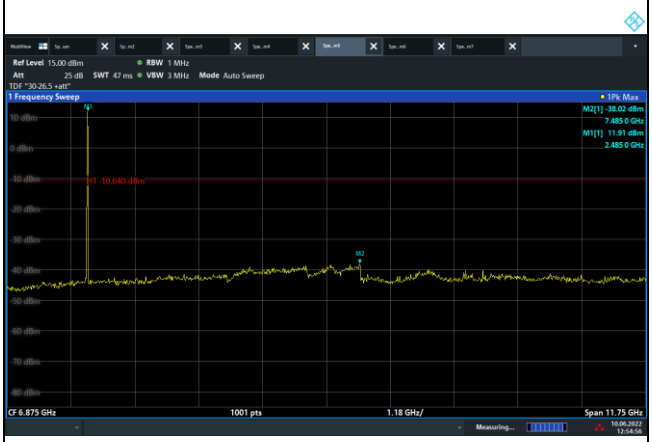
According to RSS-247 5.5, In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter 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 interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

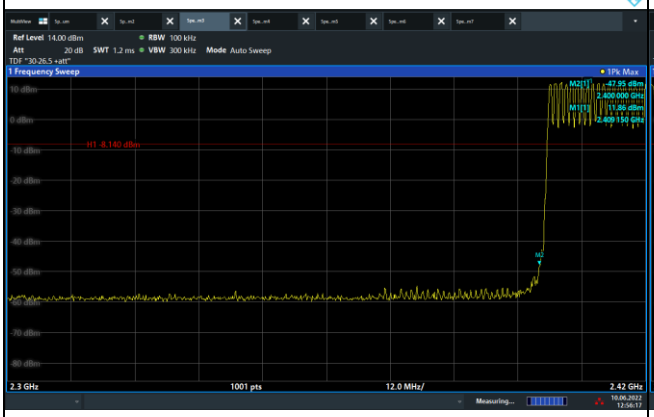
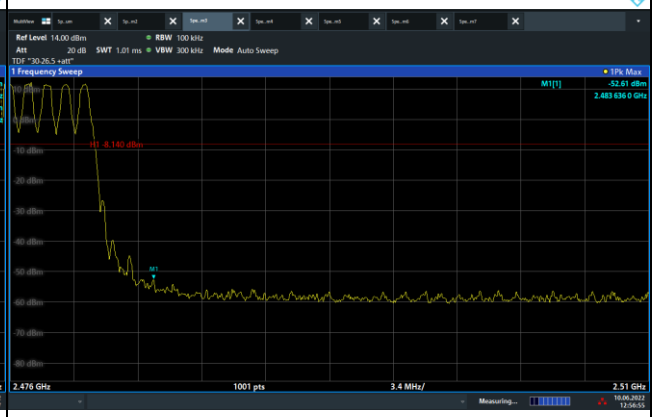
Test results

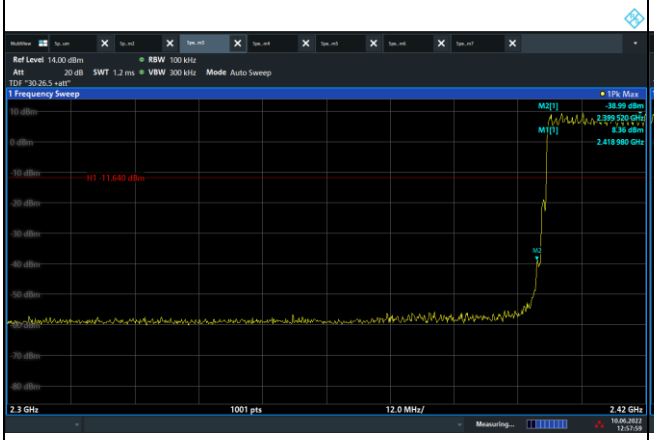
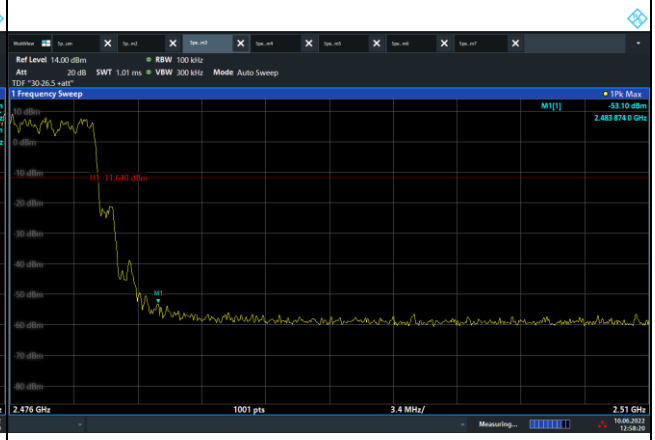
BDR(1Mbps)	
2402 ㎒	2442 ㎒
	
	
	

BDR(1Mbps)	
2480 ㎒	-
	BLANK
	BLANK
	BLANK

EDR(3Mbps)	
2402 MHz	2442 MHz
	
	
	

EDR(3Mbps)	
2480 ㎒	-
	BLANK
	BLANK
	BLANK

Hopping mode_BDR(1Mbps)	
	

Hopping mode_EDR(3Mbps)	
	

3.8. AC conducted emissions

Limit

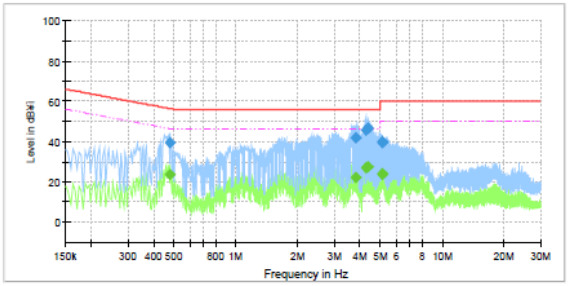
According to 15.207(a), for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 ㎑ to 30 ㎒, shall not exceed the limits in the following table, as measured using a 50uH/50 ohm line impedance stabilization network (LISN). Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequencies ranges.

Frequency of Emission (㎒)	Conducted limit (dB㎶/m)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

Test results

Mode:	BDR
Transfer rate:	1 Mbps
Distance of measurement:	3 meter
Channel:	0 (Worst case)

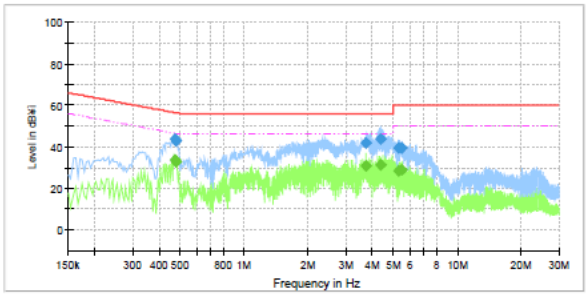
Hot Line



Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.482000	39.54	---	56.30	16.76	1000.0	9.000	N	19.8
0.482000	---	23.75	46.30	22.55	1000.0	9.000	N	19.8
3.814000	---	22.21	46.00	23.79	1000.0	9.000	N	20.1
3.814000	42.07	---	56.00	13.93	1000.0	9.000	N	20.1
4.254000	---	26.81	46.00	19.19	1000.0	9.000	N	20.0
4.254000	45.79	---	56.00	10.21	1000.0	9.000	N	20.0
4.358000	---	27.31	46.00	18.69	1000.0	9.000	N	20.0
4.358000	46.60	---	56.00	9.40	1000.0	9.000	N	20.0
5.130000	---	24.10	50.00	25.90	1000.0	9.000	N	19.9
5.130000	39.97	---	60.00	20.03	1000.0	9.000	N	19.9
5.158000	---	23.82	50.00	26.18	1000.0	9.000	N	19.8
5.158000	39.50	---	60.00	20.50	1000.0	9.000	N	19.8

Neutral Line



Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.474000	---	33.67	46.44	12.77	1000.0	9.000	L1	19.9
0.474000	43.61	---	56.44	12.83	1000.0	9.000	L1	19.9
0.482000	---	32.82	46.30	13.48	1000.0	9.000	L1	19.9
0.482000	42.69	---	56.30	13.61	1000.0	9.000	L1	19.9
3.738000	---	30.98	46.00	15.02	1000.0	9.000	L1	20.2
3.738000	41.82	---	56.00	14.18	1000.0	9.000	L1	20.2
4.366000	---	31.28	46.00	14.72	1000.0	9.000	L1	20.1
4.366000	43.87	---	56.00	12.13	1000.0	9.000	L1	20.1
5.334000	---	28.56	50.00	21.44	1000.0	9.000	L1	19.9
5.334000	39.61	---	60.00	20.39	1000.0	9.000	L1	19.9
5.490000	---	29.09	50.00	20.91	1000.0	9.000	L1	19.9
5.490000	39.32	---	60.00	20.68	1000.0	9.000	L1	19.9

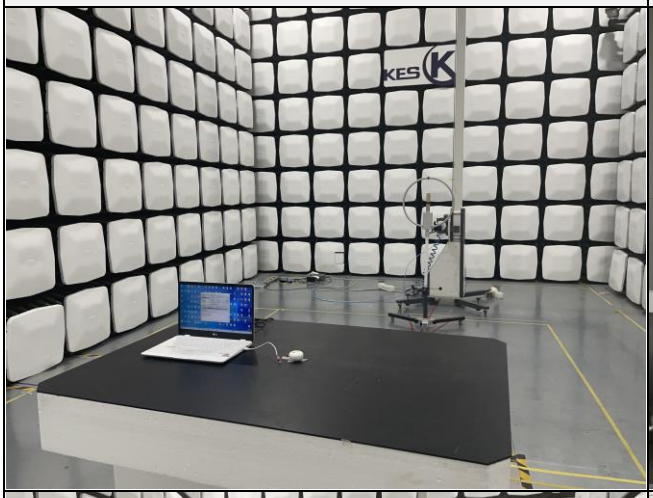
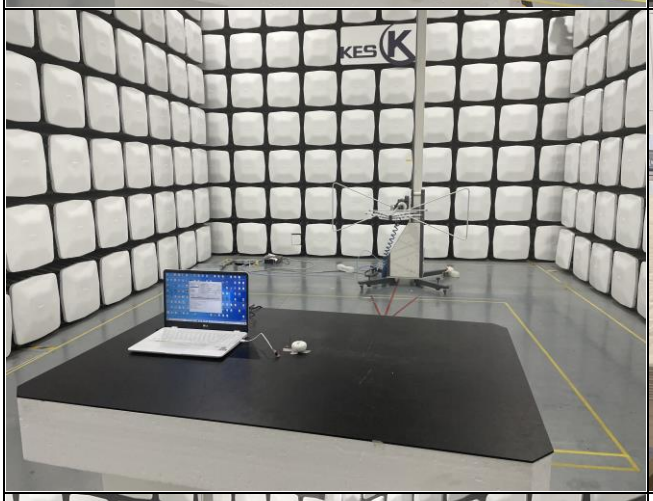
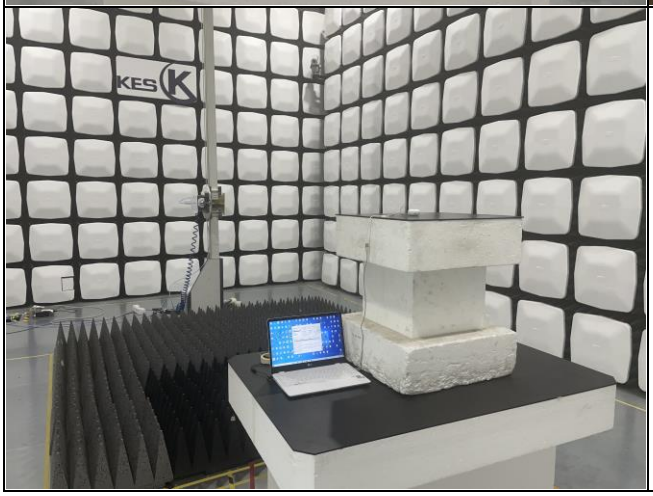
Appendix A. Measurement equipment

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due.
Spectrum analyzer	R&S	FSV3044	101272	1 year	2023.03.14
SIGNAL GENERATOR	KEYSIGHT	N5182B	MY59100115	1 year	2023.04.27
SIGNAL GENERATOR	Anritsu	68369B	002118	1 year	2023.05.13
Power Meter	Anritsu	ML2495A	2010001	1 year	2023.04.27
Pulse Power Sensor	Anritsu	MA2411B	1911111	1 year	2023.04.27
Attenuator	Mini-Circuits	BW-S10-2W263+	3	1 year	2023.01.17
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 year	2023.01.18
Horn Antenna	SCHWARZBECK	BBHA9170	BBHA 9170550	1 year	2023.01.18
Amplifier	SONOMA INSTRUMENT	310N	401123	1 year	2023.06.02
PREAMPLIFIER	HP	8449B	3008A00538	1 year	2023.06.02
BROADBAND AMPLIFIER	SCHWARZBECK	BBV9721	PS9721-003	1 year	2023.01.17
Attenuator	HUBER+SHHNER	6806.17.A	NONE	1 year	2023.04.01
DC POWER SUPPLY	AGILENT	6632B	MY43004090	1 year	2022.06.21
EMI Test Receiver	R&S	ESU26	100552	1 year	2023.03.31
LISN	ENV216	R & S	101787	1 year	2022.12.27
EMI TEST RECEIVER	ESR3	R & S	101783	1 year	2022.12.28
PULSE LIMITER	ESH3-Z2	R & S	101915	1 year	2022.12.27

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
Notebook computer	LG Electronics Inc.,	LGS53	306QCZP560949

Appendix B. Test setup photo

Radiated test	AC Conducted test
	
	
	BLANK

The end of test report.