

TEST REPORT

Part 15 Subpart C 15.247

Equipment under test ALT

Model name BAGEL-003

FCC ID 2AJ8I-BAGEL003

Applicant BagelLabs co.,Ltd.

Manufacturer BagelLabs co.,Ltd.

Date of test(s) 2019.10.18 ~ 2019.10.25

Date of issue 2019.10.30

Issued to

BagelLabs co.,Ltd.

Suite 411, Startup Campus Bldg. 3, 289 St. Pangyo-ro, Bundang-Gu,
Seongnam-Si, Gyeonggi-do, Korea
Tel: +82-31-8039-5050 / Fax: +82-31-8039-5051

Issued by

KES Co., Ltd.

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

Test and report completed by :	Report approval by :
	
Seung-yeon, Lee Test engineer	Hyeon-Su, Jang Technical manager

This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact shchoi@kes.co.kr

**KES Co., Ltd.**

3701, 40, Simin-daero 365beon-gil,
Dongan-gu, Anyang-si, Gyeonggi-do, 14057, Korea
Tel: +82-31-425-6200 / Fax: +82-31-424-0450
www.kes.co.kr

Test report No.:
KES-RF-19T0163
Page (2) of (32)

Revision history

Revision	Date of issue	Test report No.	Description
-	2019.10.30	KES-RF-19T0163	Initial

This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact shchoi@kes.co.kr



TABLE OF CONTENTS

1.	General information	4
1.1.	EUT description	4
1.2.	Test configuration.....	4
1.3.	Device modifications.....	4
1.4.	Accessory information.....	5
1.5.	Software and Firmware description.....	5
1.6.	Measurement results explanation example.....	5
1.7.	Measurement Uncertainty	5
1.8.	Frequency/channel operations.....	6
2.	Summary of tests	7
3.	Test results.....	8
3.1.	6 dB bandwidth.....	8
3.2.	Output power.....	10
3.3.	Power spectral density.....	12
3.4.	Radiated restricted band and emissions.....	14
3.5.	Conducted spurious emissions & band edge	27
Appendix A.	Measurement equipment	31
Appendix B.	Test setup photos	32



KES Co., Ltd.

3701, 40, Simin-daero 365beon-gil,
Dongan-gu, Anyang-si, Gyeonggi-do, 14057, Korea
Tel: +82-31-425-6200 / Fax: +82-31-424-0450
www.kes.co.kr

Test report No.:
KES-RF-19T0163
Page (4) of (32)

1. General information

Applicant: BagelLabs co.,Ltd.
Applicant address: Suite 411, Startup Campus Bldg. 3, 289 St. Pangyo-ro, Bundang-Gu,
Seongnam-Si, Gyeonggi-do, Korea
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, Yeosu-si, Gyeonggi-do, Korea
Test Facility FCC Accreditation Designation No.: KR0100, Registration No.: 444148
FCC rule part(s): 15.247
FCC ID: 2AJ8I-BAGEL003
Test device serial No.: ☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test ALT
Frequency range 2 402 Mhz ~ 2 480 Mhz (BLE)
Model: BAGEL-003
Modulation technique GFSK
Number of channels 2 402 Mhz ~ 2 480 Mhz (BLE) : 40 ch
Antenna specification Antenna type : PCB Antenna, Peak gain : -4.89 dBi
Power source DC 3.7 V (Battery)

1.2. Test configuration

The **BagelLabs co.,Ltd. / BAGEL-003 / FCC ID: 2AJ8I-BAGEL003** was tested according to the specification of EUT, the EUT must comply with following standards and KDB documents.

FCC Part 15.247
KDB 558074 D01 v05r02
ANSI C63.10-2013

1.3. Device modifications

N/A



1.4. Accessory information

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

1.5. Software and Firmware description

The firmware installed in the EUT is ver1.0

1.6. Measurement results explanation example

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.

$$\begin{aligned}\text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)} \\ &= 1.71 + 10 = 11.71 \text{ (dB)}\end{aligned}$$

1.7. Measurement Uncertainty

Test Item		Uncertainty
Uncertainty for Conduction emission test		2.62 dB
Uncertainty for Radiation emission test (include Fundamental emission)	9kHz - 30MHz	4.54 dB
	30MHz - 1GHz	4.36 dB
	Above 1GHz	5.00 dB
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 (MHz)	Mode
00	2 402	BLE
.	.	.
20	2 442	BLE
.	.	.
39	2 480	BLE



2. Summary of tests

Reference	Parameter	Test results
15.247(a)(2)	6 dB bandwidth	Pass
15.247(b)(3)	Output power	Pass
15.247(e)	Power spectral density	Pass
15.205 15.209	Radiated restricted band and emission	Pass
15.247(d)	Conducted spurious emission and band edge	Pass
15.207(a)	AC conducted emissions	Pass

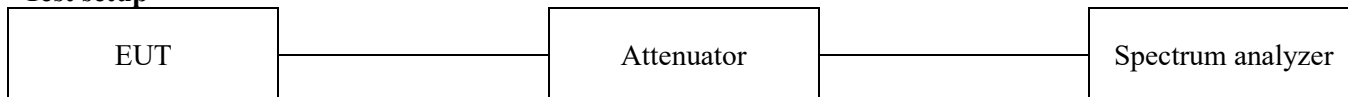
3. Test results

3.1. 6 dB bandwidth

Test procedure

ANSI C63.10 – section 11.8

Test setup



ANSI C63.10-2013 - Section 11.8.1

1. RBW = 100 kHz.
2. VBW $\geq 3 \times$ 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 dB relative to the maximum level measured in the fundamental emission.

ANSI C63.10-2013 - Section 11.8.2

The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described in 11.8.1 (i.e., RBW = 100 kHz, VBW $\geq 3 \times$ RBW, and peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB.

Limit

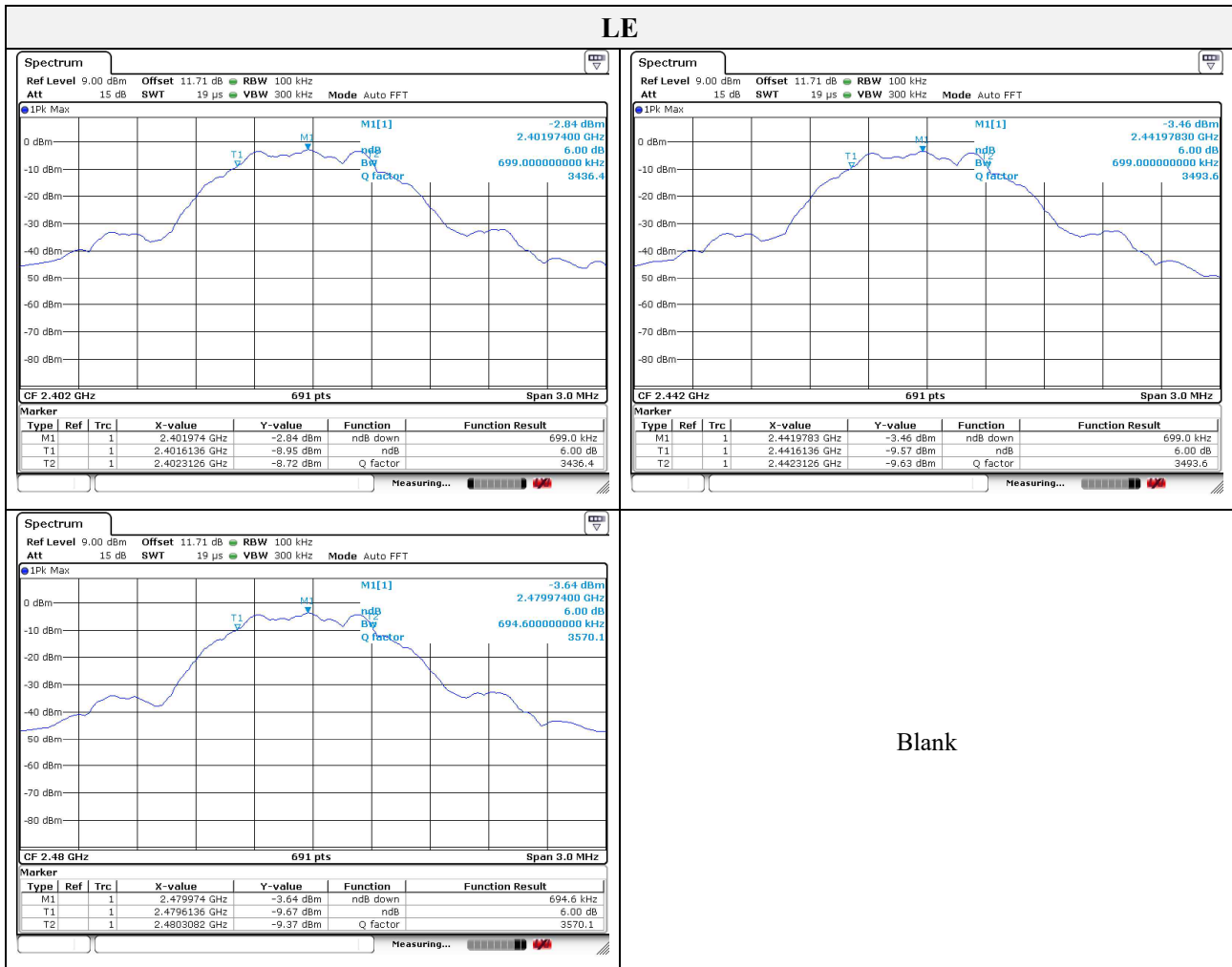
According to §15.247(a)(2), systems using digital modulation techniques may operate 902 ~ 928 MHz, 2 400 ~ 2 483.5 MHz, and 5 725 ~ 5 850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.



Test results

Frequency(MHz)	6 dB bandwidth(MHz)	Limit(MHz)
2 402	0.699	0.5
2 442	0.699	
2 480	0.695	

Test plots



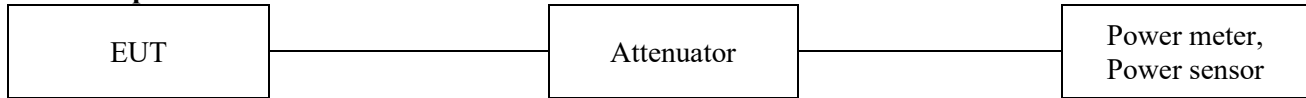
This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact shchoi@kes.co.kr

3.2. Output power

Test procedure

ANSI C63.10 – section 11.9.1.3 and 11.9.2.3.2

Test setup



ANSI C63.10 - 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 bandwidth and shall utilize a fast-responding diode detector.

ANSI C63.10 - 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. Since this 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 MHz, 2 400~2 483.5 MHz, and 5 725~5 850 MHz 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 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi 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 dBi.

**KES Co., Ltd.**

3701, 40, Simin-daero 365beon-gil,
Dongan-gu, Anyang-si, Gyeonggi-do, 14057, Korea
Tel: +82-31-425-6200 / Fax: +82-31-424-0450
www.kes.co.kr

Test report No.:
KES-RF-19T0163
Page (11) of (32)

Test results

Frequency(MHz)	Peak output power(dBm)	Average output power(dBm)	Limit(dBm)
2 402	-1.79	-2.12	30
2 442	-2.24	-2.81	
2 480	-2.58	-2.96	

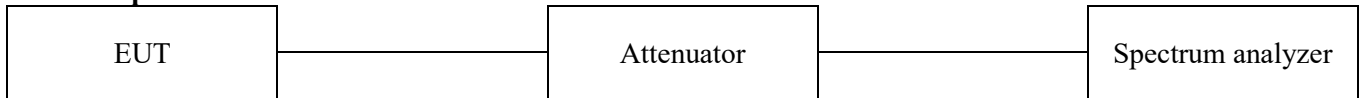
This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact shchoi@kes.co.kr

3.3. Power spectral density

Test procedure

ANSI C63.10 – section 11.10.2

Test setup



ANSI C63.10 – section 11.10.2

1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the DTS channel bandwidth.
3. Set the RBW : $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
4. Set the VBW $\geq 3 \times \text{RBW}$.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds requirement, than reduce RBW(but no less than 3 kHz) and repeat.

Limit

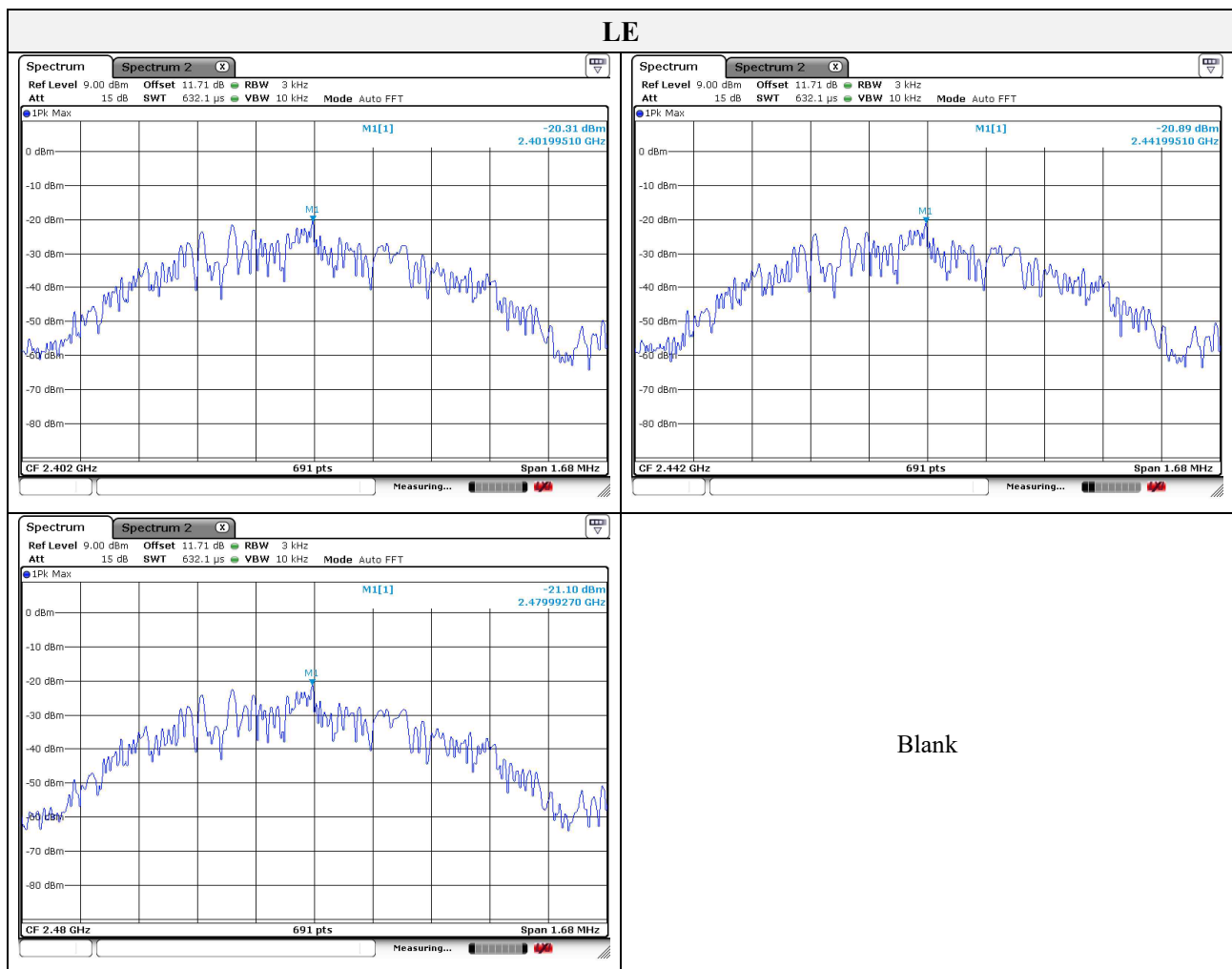
According to §15.247(e), For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.



Test results

Frequency(MHz)	PSD (dBm)	Limit(dBm)
2 402	-20.31	8
2 442	-20.89	
2 480	-21.10	

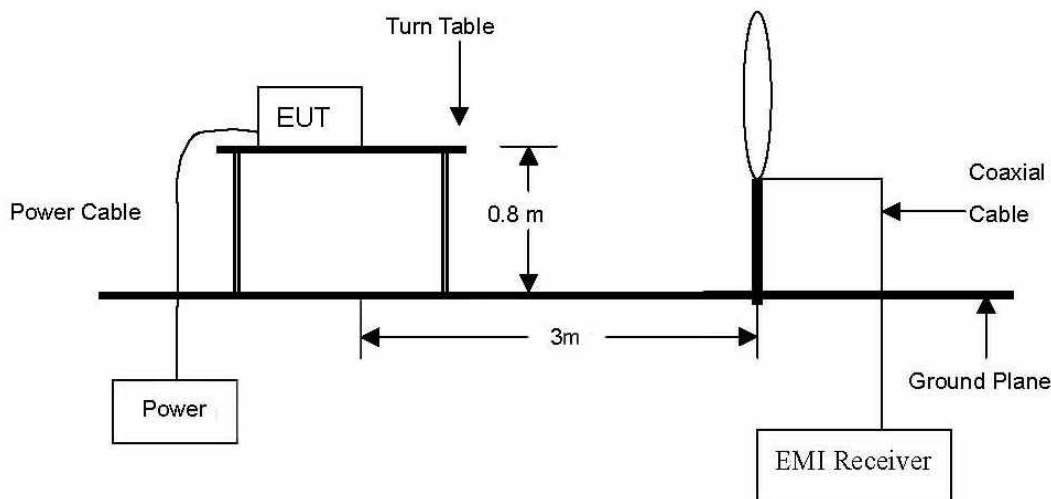
Test plots



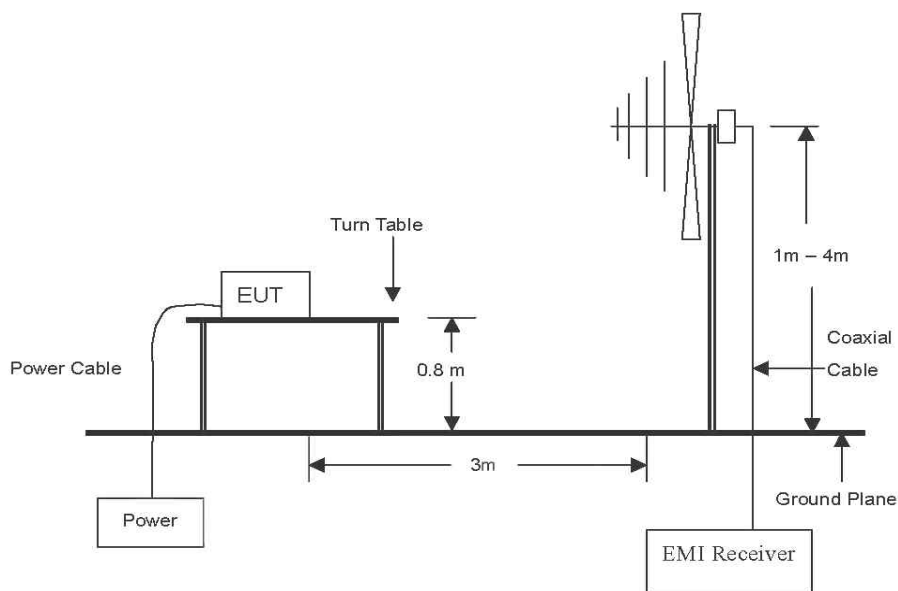
3.4. Radiated restricted band and emissions

Test setup

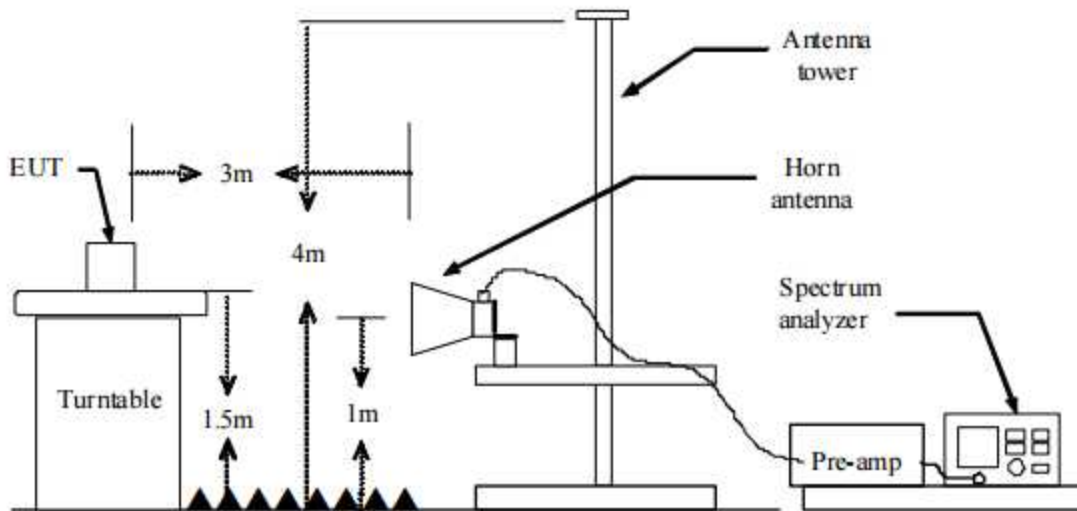
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 30 MHz to 1 GHz emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 1 GHz to the tenth harmonic of the highest fundamental frequency or to 40 GHz emissions, whichever is lower.



Test procedure below 30 MHz

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 and perpendicular of the antenna are set to make the measurement.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization and Parallel to the ground plane in detecting antenna.
4. 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.
5. The test-receiver system was set to average or quasi peak detect function and Specified Bandwidth with Maximum hold mode.

Test procedure above 30 MHz

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

3. Spectrum analyzer settings for $f \geq 1$ GHz: Average

- ① Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
- ② RBW = 1 MHz
- ③ VBW $\geq 3 \times$ RBW
- ④ Detector = RMS, if span/(# of points in sweep) $\leq$ (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 dB 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. The loop antenna was investigated with three polarizations, and vertical polarizations were reported as the worst case.
2. $f < 30$ MHz, extrapolation factor of 40 dB/decade of distance. $F_d = 40 \log(D_m/D_s)$
 $f \geq 30$ MHz, extrapolation factor of 20 dB/decade of distance. $F_d = 20 \log(D_m/D_s)$
Where:
 F_d = Distance factor in dB
 D_m = Measurement distance in meters
 D_s = Specification distance in meters
3. CF(Correction factors(dB)) = Antenna factor(dB/m) + Cable loss(dB) + or Amp. gain(dB) + or F_d (dB)
4. Field strength(dB μ V/m) = Level(dB μ V) + CF (dB) + or DCF(dB)
5. Margin(dB) = Limit(dB μ V/m) - Field strength(dB μ V/m)
6. Emissions below 18 GHz were measured at a 3 meter test distance while emissions above 18 GHz 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 dB of respective limits were not reported.
9. According to exploratory test no any obvious emission were detected from 9kHz to 30MHz. Although these tests were performed other than open area test site, adequate comparison measurements were confirmed against 30 m open area test 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.

This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact shchoi@kes.co.kr



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 (MHz)	Distance (Meters)	Radiated ($\mu\text{V/m}$)
0.009 ~ 0.490	300	2400/F(kHz)
0.490 ~ 1.705	30	24000/F(kHz)
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 MHz, 76 ~ 88 MHz, 174 ~ 216 MHz or 470 ~ 806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.



KES Co., Ltd.

3701, 40, Simin-daero 365beon-gil,
Dongan-gu, Anyang-si, Gyeonggi-do, 14057, Korea
Tel: +82-31-425-6200 / Fax: +82-31-424-0450
www.kes.co.kr

Test report No.:
KES-RF-19T0163
Page (18) of (32)

Duty cycle

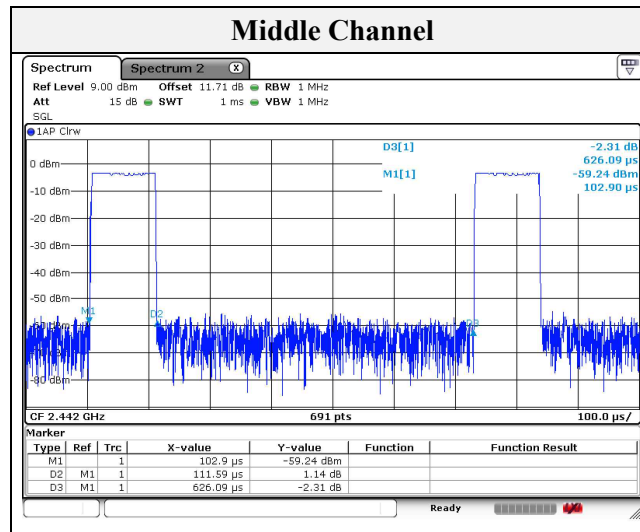
Regarding to KDB 558074 D01_v05r02, 6.0, the maximum duty cycles of all modes were investigated and set the spectrum analyzer as below.

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

Test mode	T _{on} time (ms)	Period (ms)	Duty cycle (Linear)	Duty cycle (%)	Duty cycle correction factor (dB)
BLE	0.111 6	0.626 1	0.178 2	17.82	7.49

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

DCF(Duty cycle correction factor (dB)) = $10\log(1/\text{duty cycle})$



This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact shchoi@kes.co.kr

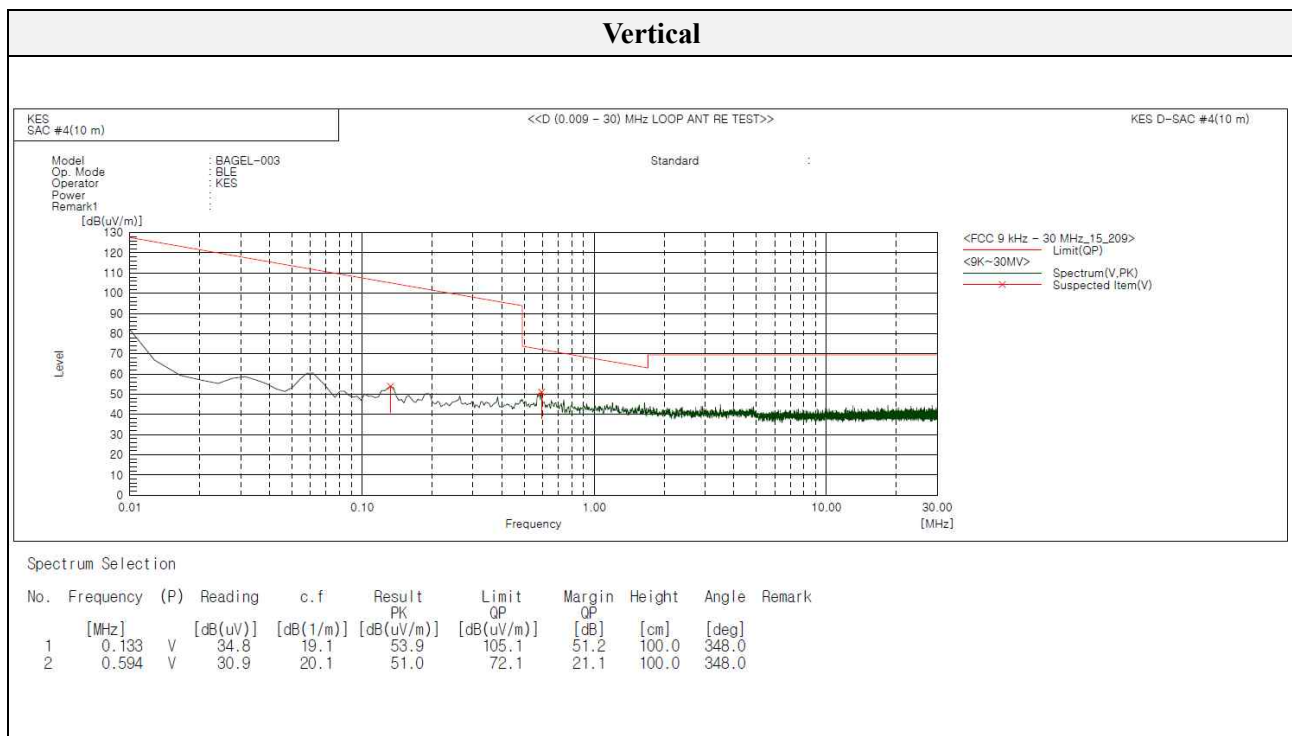


Test results (Below 30 MHz)

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

Frequency (MHz)	Level (dBμV)	Ant. Pol. (H/V)	CF (dB)	Distance factor (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
0.133	34.80	V	19.10	-80.00	-26.10	25.10	51.20
0.594	30.90	V	20.10	-40.00	11.00	32.10	21.10

Vertical

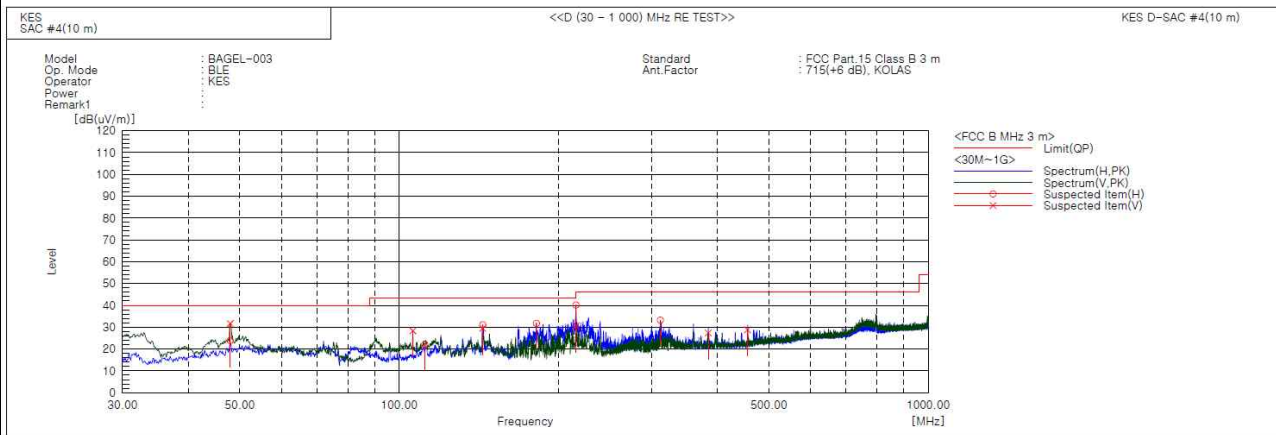




Test results (Below 1 000 MHz) – Worst case

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

Horizontal // Vertical



Spectrum Selection

No.	Frequency [MHz]	(P)	Reading [dB(uV)]	c.f [dB(1/m)]	Result PK [dB(uV/m)]	Limit OP [dB(uV/m)]	Margin OP [dB]	Height [cm]	Angle [deg]	Remark
1	47.945	H	46.0	-22.1	23.9	40.0	16.1	200.0	354.0	
2	111.844	H	45.9	-23.7	22.2	43.5	21.3	200.0	352.0	
3	143.975	H	58.0	-26.9	31.1	43.5	12.4	200.0	166.0	
4	181.805	H	56.4	-24.7	31.7	43.5	11.8	100.0	264.0	
5	215.998	H	62.0	-21.9	40.1	43.5	3.4	100.0	256.0	
6	311.785	H	52.5	-19.3	33.2	46.0	12.8	100.0	81.0	
7	47.945	V	53.7	-22.1	31.6	40.0	8.4	150.0	4.0	
8	106.145	V	51.6	-23.3	28.3	43.5	15.2	100.0	10.0	
9	143.854	V	56.5	-27.0	29.5	43.5	14.0	100.0	208.0	
10	215.998	V	52.5	-21.9	30.6	43.5	12.9	100.0	18.0	
11	384.050	V	44.4	-17.0	27.4	46.0	18.6	150.0	341.0	
12	455.951	V	43.6	-15.9	27.7	47.0	19.3	150.0	162.0	



Test results (Above 1 000 MHz)

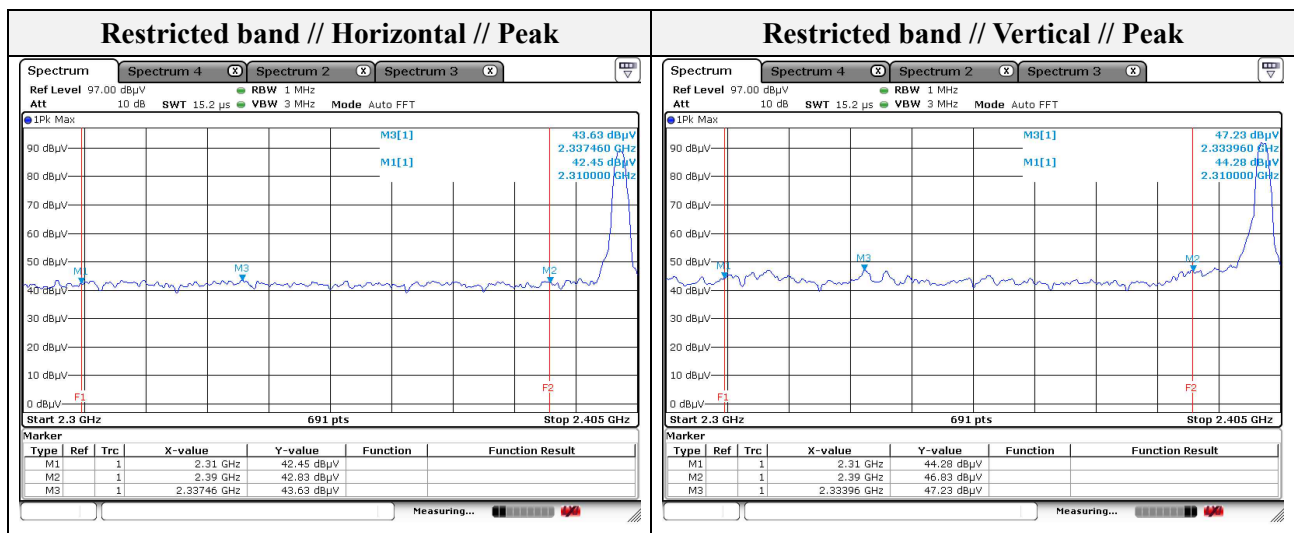
Mode: BLE
Distance of measurement: 3 meter
Channel: 00

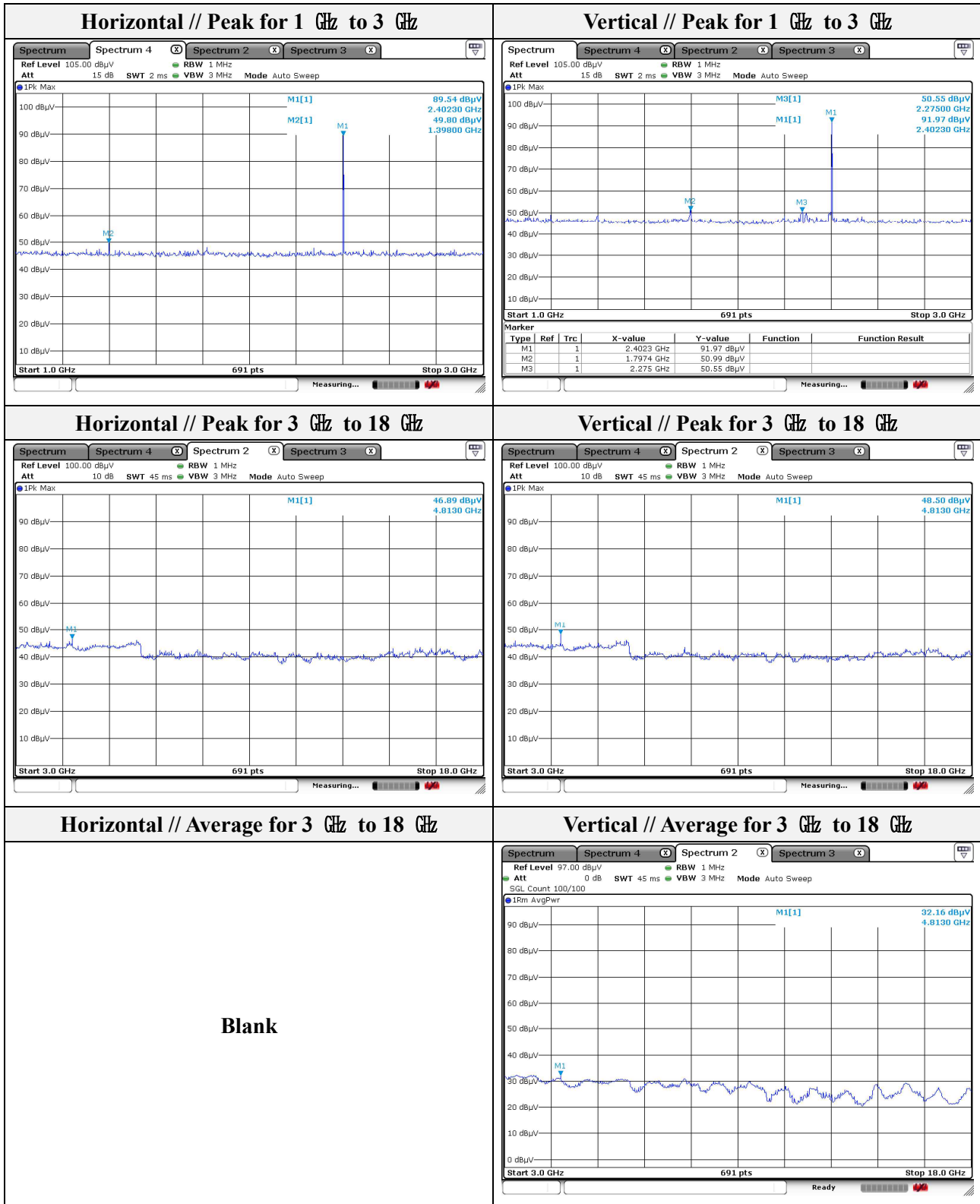
- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1398.00	49.80	Peak	H	-6.24	-	43.56	74.00	30.44
4813.00	46.89	Peak	H	7.06	-	53.95	74.00	20.05
1797.40	50.99	Peak	V	-2.84	-	48.15	74.00	25.85
2275.00	50.55	Peak	V	-0.36	-	50.19	74.00	23.81
4813.00	48.50	Peak	V	7.06	-	55.56	74.00	18.44
4813.00	32.16	average	V	7.06	7.49	46.71	54.00	7.29

- 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)
2337.46	43.63	Peak	H	-0.24	-	43.39	74.00	30.61
2333.96	47.23	Peak	V	-0.24	-	46.99	74.00	27.01





Note.

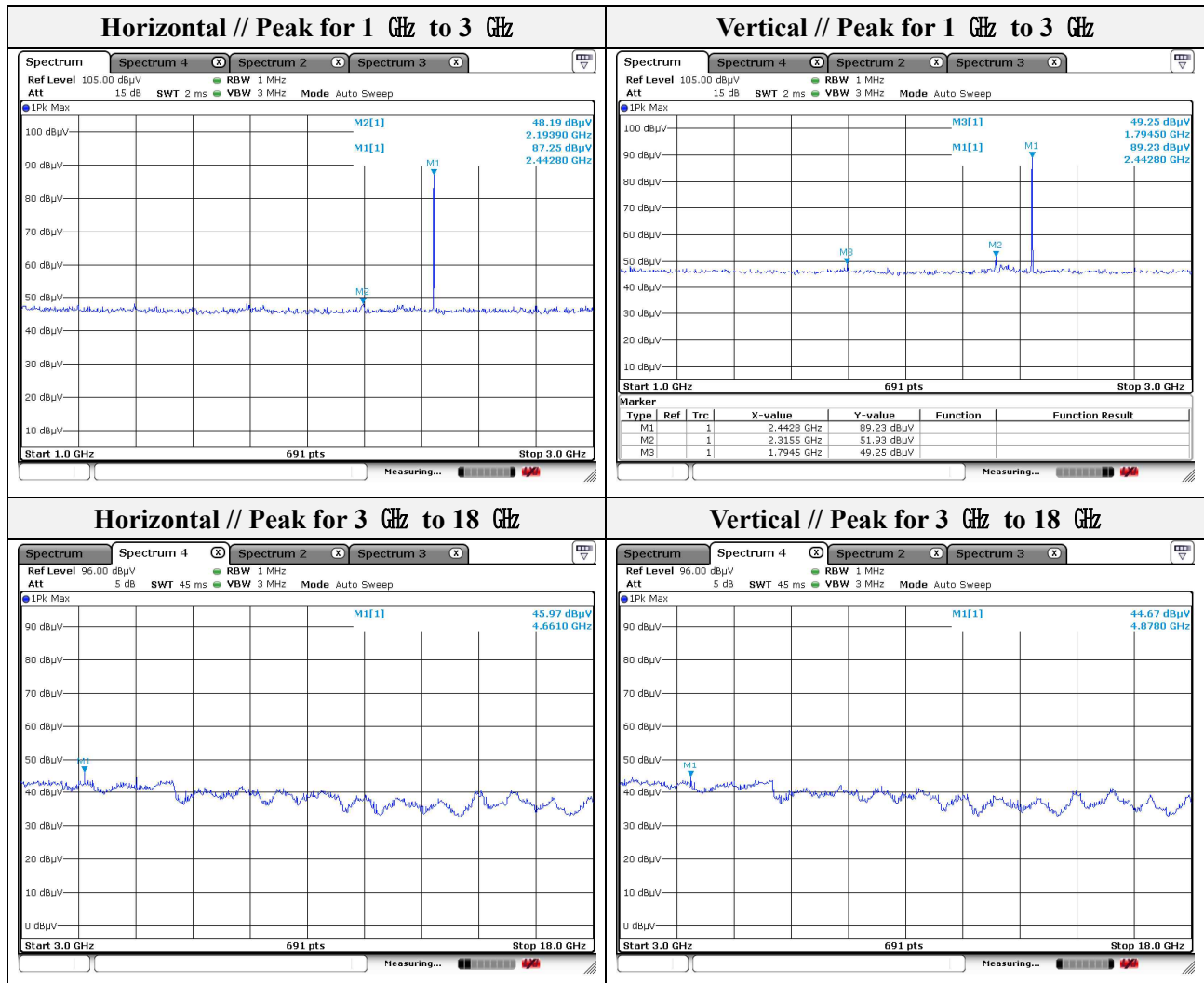
1. Average test would be performed if the peak result were greater than the average limit.



Mode: BLE
Distance of measurement: 3 meter
Channel: 20

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 193.90	48.19	Peak	H	-0.52	-	47.67	74.00	26.33
4 661.00	45.97	Peak	H	5.90	-	51.87	74.00	22.13
1 794.50	49.25	Peak	V	-2.87	-	46.38	74.00	27.62
2 315.50	51.93	Peak	V	-0.28	-	51.65	74.00	22.35
4 878.00	44.67	Peak	V	7.54	-	52.21	74.00	21.79



Note.

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

This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact shchoi@kes.co.kr



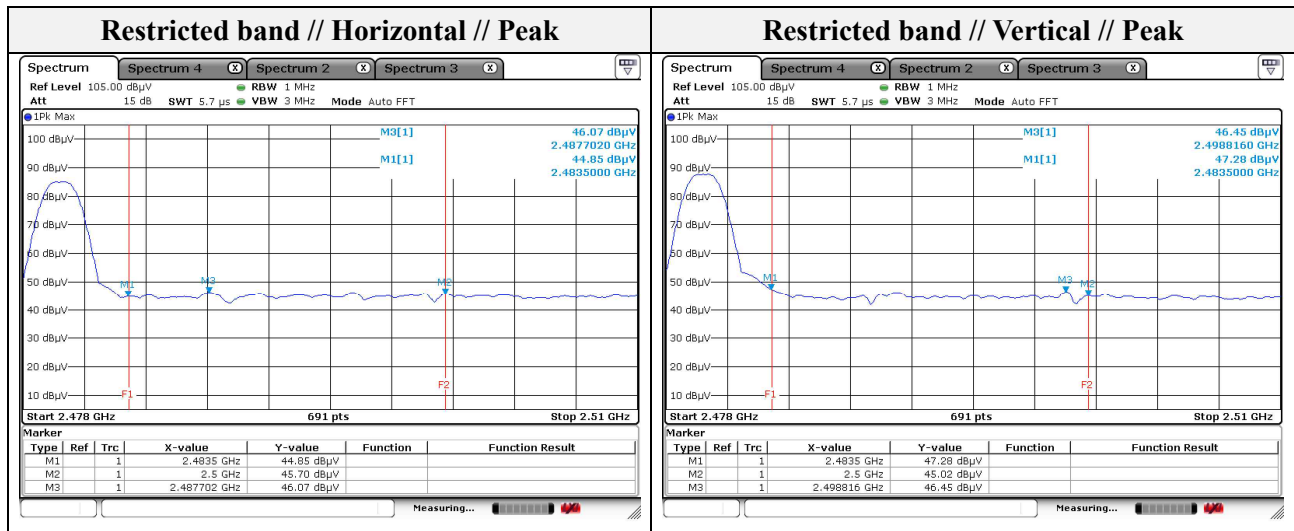
Mode: BLE
Distance of measurement: 3 meter
Channel: 39

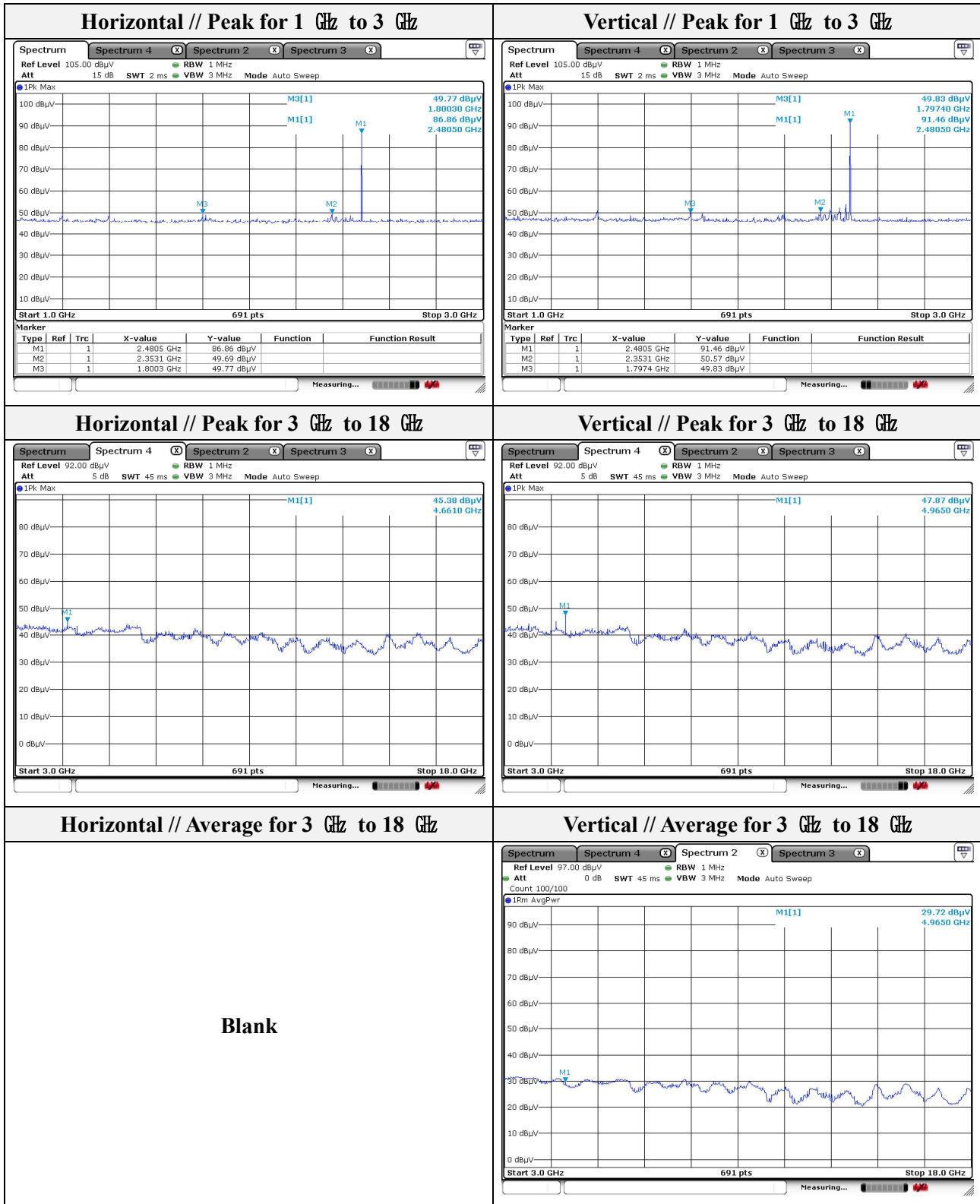
- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 800.30	49.77	Peak	H	-2.81	-	46.96	74.00	27.04
2 353.10	49.69	Peak	H	-0.20	-	49.49	74.00	24.51
4 661.00	45.38	Peak	H	5.90	-	51.28	74.00	22.72
1797.40	49.83	Peak	V	-2.84	-	46.99	74.00	27.01
2353.10	50.57	Peak	V	-0.20	-	50.37	74.00	23.63
4965.00	47.87	Peak	V	8.18	-	56.05	74.00	17.95
4965.00	29.72	Average	V	8.18	7.49	45.39	54.00	8.61

- 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)
2 487.70	46.07	Peak	H	0.08	-	46.15	74.00	27.85
2 483.50	47.28	Peak	V	0.07	-	47.35	74.00	26.65
2 498.82	46.45	Peak	V	0.11	-	46.56	74.00	27.44





Note.

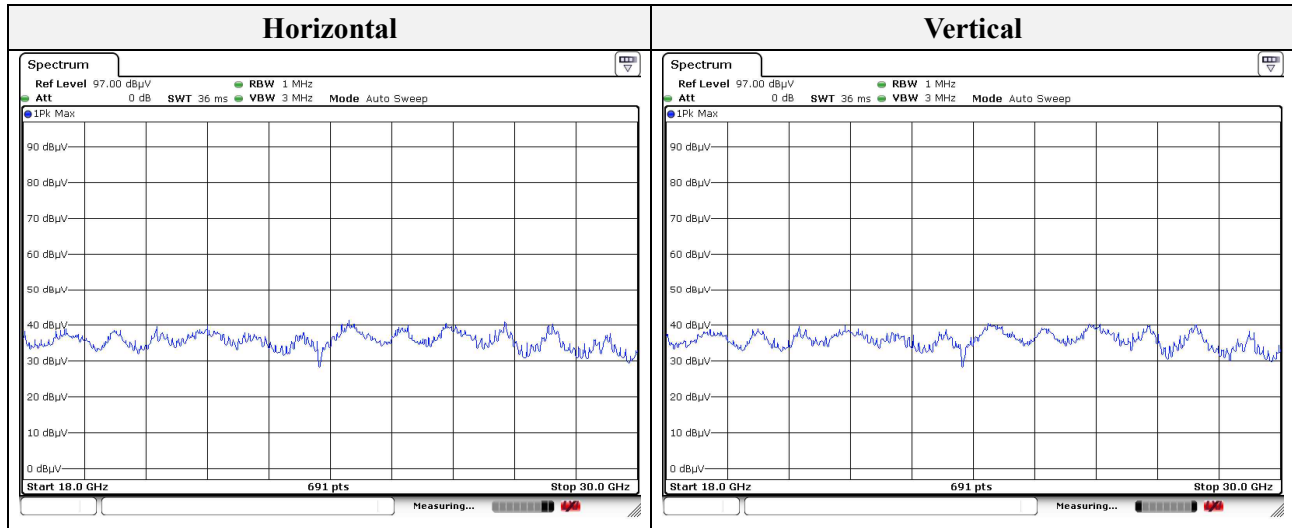
1. Average test would be performed if the peak result were greater than the average limit.

This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact shchoi@kes.co.kr



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

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

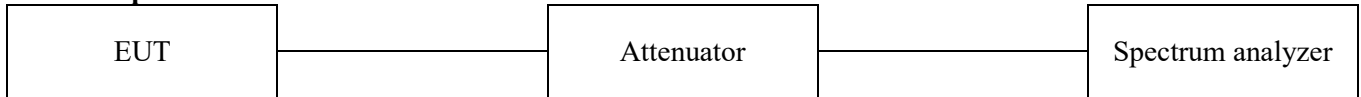


Note.

1. No spurious emission were detected above 18 GHz.

3.5 Conducted spurious emissions & band edge

Test setup



Test procedure

Band edge

ANSI C63.10 – 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. RBW = 100 kHz
4. VBW = 300 kHz
5. Detector = Peak
6. Trace mode = max hold
7. Sweep time = auto
8. The trace was allowed to stabilize

Out of band emissions

ANSI C63.10 – Section 11.11

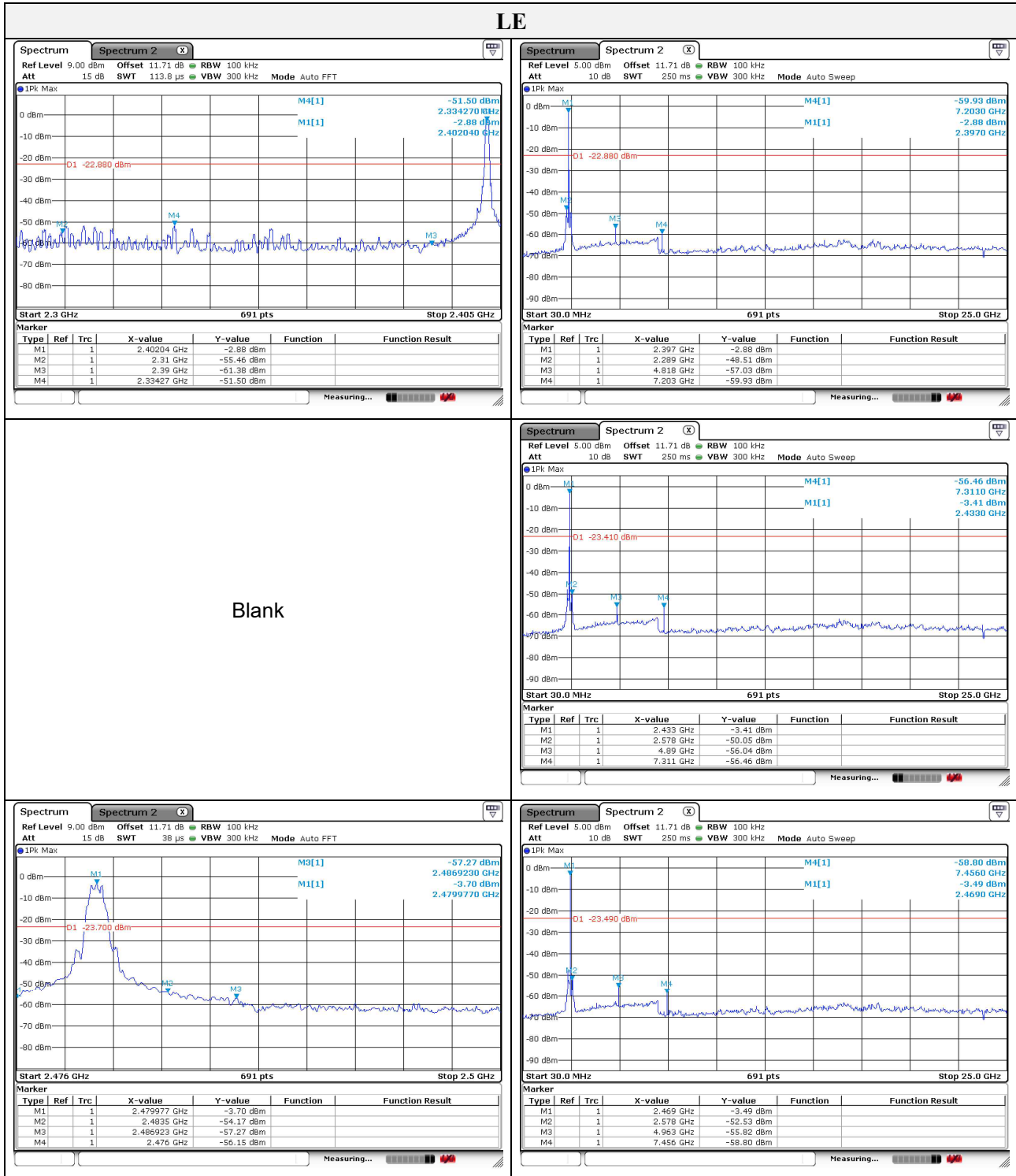
1. Start frequency was set to 30 MHz and stop frequency was set to 25 GHz for 2.4 GHz frequencies and 40 GHz for 5 GHz frequencies
2. RBW = 100 kHz
3. VBW = 300 kHz
4. Detector = Peak
5. Trace mode = max hold
6. Sweep time = auto couple
7. The trace was allowed to stabilize

Limit

According to 15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph(b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in 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))



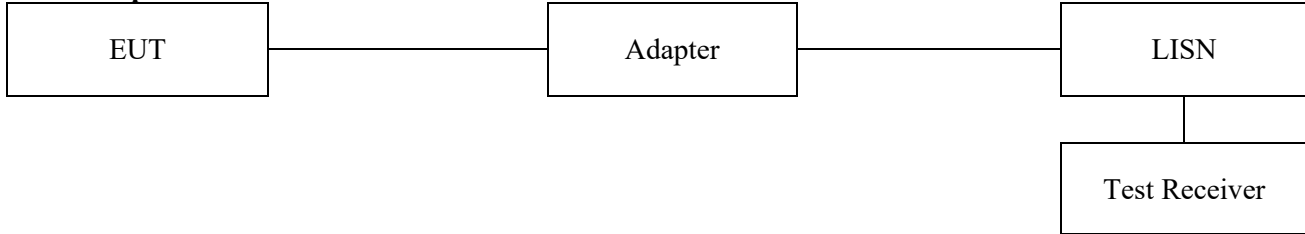
Test results



This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact shchoi@kes.co.kr

3.6 AC conducted emissions

Test setup



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 kHz to 30 MHz, 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.

According to RSS-Gen Issue 5, 8.8, a radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in Table 3. Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in Table 3 below. The more stringent limit applies at the frequency range boundaries.

The conducted emissions shall be measured in accordance with the reference publication mentioned in Section 3.

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

Note:

1. All AC line conducted spurious emission are measured with a receiver connected to a grounded LISN while the EUT is operating at its maximum duty cycle, at maximum power, and the appropriate frequencies. All data rates and modes were investigated for conducted spurious emission. Only the conducted emissions of the configuration that produced the worst case emissions are reported in this section.
2. Both Cable loss and LISN factor are included in measurement level(QP Level or AV Level).



Test results

Hot Line

The spectrum plot for the Hot Line shows the signal level in dBµV on the y-axis (0 to 100) against frequency in Hz on a logarithmic x-axis (150k to 30M). Two limit lines are shown: a red line for 'FCC Part 15 Class B Voltage on Mains QP' and a magenta line for 'FCC Part 15 Class B Voltage on Mains AV'. The measured signal is represented by a blue line with diamond markers and a green line with diamond markers. The blue signal is significantly higher than the green signal, especially at lower frequencies, and remains below the red limit line.

Final Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.170000	---	18.61	54.96	36.35	1000.0	9.000	L1	9.9
0.170000	32.56	---	64.96	32.40	1000.0	9.000	L1	9.9
0.210000	---	15.88	53.21	37.33	1000.0	9.000	L1	10.0
0.210000	29.49	---	63.21	33.72	1000.0	9.000	L1	10.0
1.260000	---	4.17	46.00	41.83	1000.0	9.000	L1	10.8
1.260000	14.09	---	56.00	41.91	1000.0	9.000	L1	10.8
4.950000	---	0.72	46.00	45.28	1000.0	9.000	L1	10.0
4.950000	16.19	---	56.00	39.81	1000.0	9.000	L1	10.0
23.980000	---	17.38	50.00	32.62	1000.0	9.000	L1	11.0
23.980000	34.58	---	60.00	25.42	1000.0	9.000	L1	11.0

Neutral Line

The spectrum plot for the Neutral Line shows the signal level in dBµV on the y-axis (0 to 100) against frequency in Hz on a logarithmic x-axis (150k to 30M). Two limit lines are shown: a red line for 'FCC Part 15 Class B Voltage on Mains QP' and a magenta line for 'FCC Part 15 Class B Voltage on Mains AV'. The measured signal is represented by a blue line with diamond markers and a green line with diamond markers. The blue signal is significantly higher than the green signal, especially at lower frequencies, and remains below the red limit line.

Final Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.185000	---	20.09	54.26	34.17	1000.0	9.000	N	10.0
0.185000	34.92	---	64.26	29.34	1000.0	9.000	N	10.0
1.270000	---	3.37	46.00	42.63	1000.0	9.000	N	10.7
1.270000	10.95	---	56.00	45.05	1000.0	9.000	N	10.7
4.885000	---	-2.21	46.00	48.21	1000.0	9.000	N	10.0
4.885000	7.65	---	56.00	48.35	1000.0	9.000	N	10.0
8.565000	---	1.00	50.00	49.00	1000.0	9.000	N	10.4
8.565000	25.61	---	60.00	34.39	1000.0	9.000	N	10.4
24.055000	---	5.09	50.00	44.91	1000.0	9.000	N	11.0
24.055000	24.19	---	60.00	35.81	1000.0	9.000	N	11.0

This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact shchoi@kes.co.kr



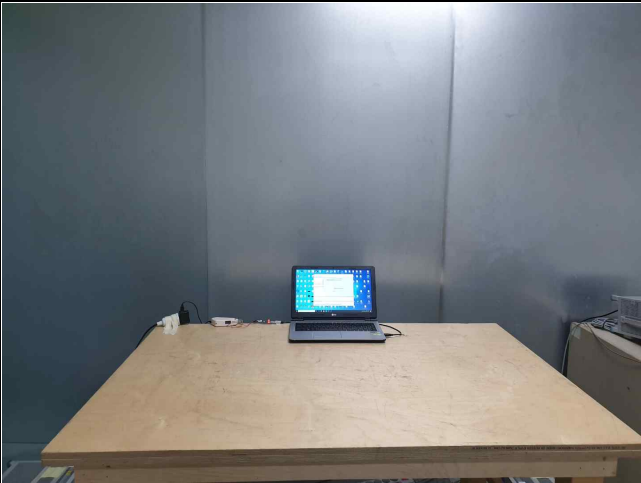
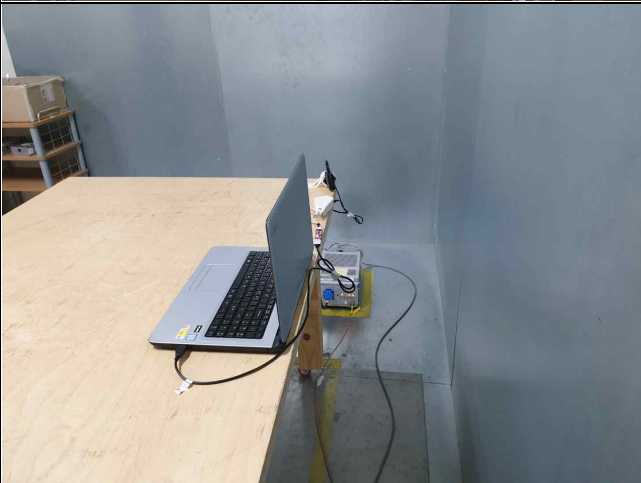
Appendix A. Measurement equipment

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration date	Calibration due.
Spectrum Analyzer	R&S	FSV30	101389	1 year	2019.01.16	2020.01.16
Spectrum Analyzer	R&S	FSV30	100736	1 year	2019.01.09	2020.01.09
8360B Series Swept Signal Generator	HP	83630B	3844A00786	1 year	2019.01.15	2020.01.15
Power Meter	Anritsu	ML2495A	1438001	1 year	2019.01.15	2020.01.15
Pulse Power Sensor	Anritsu	MA2411B	1339205	1 year	2019.01.15	2020.01.15
DC Power Supply	Agilent	6632B	MY43004130	1 year	2019.06.24	2020.06.24
Attenuator	KEYSIGHT	8495B	110504721	1 year	2019.01.15	2020.01.15
Loop Antenna	Schwarzbeck	FMZB1513	225	2 years	2019.02.15	2021.02.15
Trilog-broadband antenna	S/B	VULB 9163	714	2 years	2018.11.26	2020.11.26
Horn Antenna	A.H	SAS-571	414	2 years	2019.02.11	2021.02.11
Horn Antenna	SCHWARZBECK	BBHA9170	BBHA 9170550	2 years	2019.02.19	2021.02.19
High Pass Filter	Wainwright Instrument Gmbh	WHJS3000-10TT	1	1 year	2019.06.25	2020.06.25
Low Pass Filter	Wainwright Instrument Gmbh	WLK1.0/18 G-10TT	1	1 year	2019.06.24	2020.06.24
Preamplifier	R&S	SCU01	100603	1 year	2018.11.26	2019.11.26
Preamplifier	AGILENT	8449B	3008A01742	1 year	2019.01.08	2020.01.08
EMI Test Receiver	R&S	ESR3	101781	1 year	2019.04.22	2020.04.22
EMI Test Receiver	R&S	ESU26	100552	1 year	2019.04.19	2020.04.19
Pulse Limiter	R&S	ESH3-Z2	101915	1 year	2018.11.26	2019.11.26
LISN	R&S	ENV216	101787	1 year	2019.01.04	2020.01.04

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
Notebook Computer	LG Electronics, Inc.	LG15N365	607QCUK558542
Test board	N/A	N/A	N/A

Appendix B. Test setup photos

Radiated	AC conducted
	
	
	Blank

The end of test report.