

TEST REPORT

Part 15 Subpart E 15.407

Equipment under test ASM

Model name ASM

FCC ID XYCASM

Applicant Aram Huvis Co., LTD.

Manufacturer Aram Huvis Co., LTD.

Date of test(s) 2019.11.04 ~ 2019.11.08

Date of issue 2019.11.13

Issued to

Aram Huvis Co., LTD.

Jung-Ja Dong-Rm401-402, Seoul National University Hospital's
Health Care Innovation Park, 172, Dolma-ro, Bundang-gu,
Seongnam-si, Gyeonggi-do, South Korea
Tel: +82-70-4687-1712 / Fax: +82-31-732-6330

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 :
	
Jun-Su Jeong 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-19T0178
Page (2) of (39)

Revision history

Revision	Date of issue	Test report No.	Description
-	2019.11.13	KES-RF-19T0178	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.	Frequency/channel operations.....	5
1.5.	Maximum average output power	5
1.6.	Accessory information.....	5
1.7.	Software and Firmware description.....	5
1.8.	Measurement results explanation example.....	5
1.9.	Measurement Uncertainty	5
2.	Summary of tests	6
3.	Test results.....	7
3.1.	26 dB bandwidth & 99% Occupied Bandwidth	7
3.2.	Maximum conducted output power	11
3.4.	Maximum Power spectral density	13
3.5.	Frequency Stability.....	16
3.6.	Radiated restricted band and emissions.....	18
3.7.	AC conducted emissions	36
Appendix A.	Measurement equipment	38
Appendix B.	Test setup photos	39

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

1. General information

Applicant: Aram Huvis Co., LTD.
Applicant address: Jung-Ja Dong-Rm401-402, Seoul National University Hospital's
Health Care Innovation Park, 172, Dolma-ro, Bundang-gu,
Seongnam-si, Gyeonggi-do, South Korea
Test site: KES Co., Ltd.
Test site address: 3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si,
Gyeonggi-do, 14057, Korea
473-29, Gayeo-ro, Yeoju-si, Gyeonggi-do, Korea
Test Facility FCC Accreditation Designation No.: KR0100, Registration No.: 444148
FCC rule part(s): 15.407
FCC ID: XYCASM
Test device serial No.: ☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test ASM
Frequency range 2 402 MHz ~ 2 480 MHz (BDR/EDR)
2 402 MHz ~ 2 480 MHz (LE)
2 412 MHz ~ 2 462 MHz (11b/g/n_HT20)
UNII-1 5 180 MHz ~ 5 240 MHz (11a/an_HT20)
Model: ASM
Modulation technique WIFI : DSSS, OFDM
BT : GFSK, $\pi/4$ DQPSK, 8DPSK
Number of channels 2 402 MHz ~ 2 480 MHz (BDR/EDR) : 79 ch
2 402 MHz ~ 2 480 MHz (LE) : 40 ch
2 412 MHz ~ 2 462 MHz (11b/g/n_HT20) : 11 ch
5 180 MHz ~ 5 240 MHz (11a/an_HT20) : 4 ch
Antenna specification 2.4 GHz Antenna type : Chip antenna, Peak gain : 1.99 dBi
5 GHz Antenna type : Chip antenna, Peak gain(UNII-1) : 4.72 dBi
Power source DC 3.85 V (Internal Rechargeable Battery)

1.2. Test configuration

The **Aram Huvis Co., LTD. // ASM // FCC ID: XYCASM** was tested per the guidance of KDB 789033 D02 v02r01. ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing.

1.3. Device modifications

N/A

1.4. Frequency/channel operations

UNII-1

Ch.	Frequency (MHz)
36	5 180
44	5 220
48	5 240

Table 1.4-1. 802.11a/an_HT20 mode

1.5. Maximum average output power

Refer to the average output power.

Note.

1. Radiated emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.
2. Worst-case data rates as provided by the client were:
UNII-1 a : 6 Mbps , an_HT 20 : MCS 0

1.6. Accessory information

Equipment	Manufacturer	Model	Serial No.	Power source
Smart Cradle	Aram Huvis Co., LTD.	ASM	-	DC 5 V

1.7. Software and Firmware description

The software and firmware installed in the EUT is version 5.6

1.8. 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.

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

- UNII-1 : 1.01 + 10 = 11.01 (dB)

1.9 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.		

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

2. Summary of tests

Reference	Parameter	Test results
15.407(a)	26 dB bandwidth & 99 % Occupied Bandwidth	Pass
15.407(a)	Maximum conducted output power	Pass
15.407(a)	Power spectral density	Pass
15.407(g)	Frequency stability	Pass
15.205 15.209	Radiated restricted band and emission	Pass
15.407(d)	General field strength limit (Restricted bands and radiated emission limit)	Pass
15.207	AC power line conducted emissions	Pass

3. Test results

3.1. 26 dB bandwidth & 99% Occupied Bandwidth

Test procedure

KDB 789033 D02 v02r01– Section C.1

Test setup



Section C.1

1. Set RBW = approximately 1% of the emission bandwidth.
2. Set the VBW > RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Measure the maximum width of the emission that is 26 dB down from the peak of the emission. Compare this with the RBW setting of the analyzer. Readjust RBW and repeat measurement as needed until the RBW/EBW ratio is approximately 1%.

Limit

N/A

99 % bandwidth

KDB 789033 D02 v02r01– Section D

1. Set span = 1.5 times to 5.0 times the OBW.
2. Set RBW = 1% to 5% of the OBW
3. Set the VBW > 3 x RBW.
4. Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak bandwidth function of the instrument (if available).
5. Use the 99% power bandwidth function of the instrument (if available).
6. If the instrument does not have a 99% power bandwidth function, the trace data points are recovered and directly summed in power units. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% occupied bandwidth is the difference between these two frequencies.

In the result,

-DFS requirements are not applicable in the 5 150 MHz ~ 5 250 MHz.



Test results

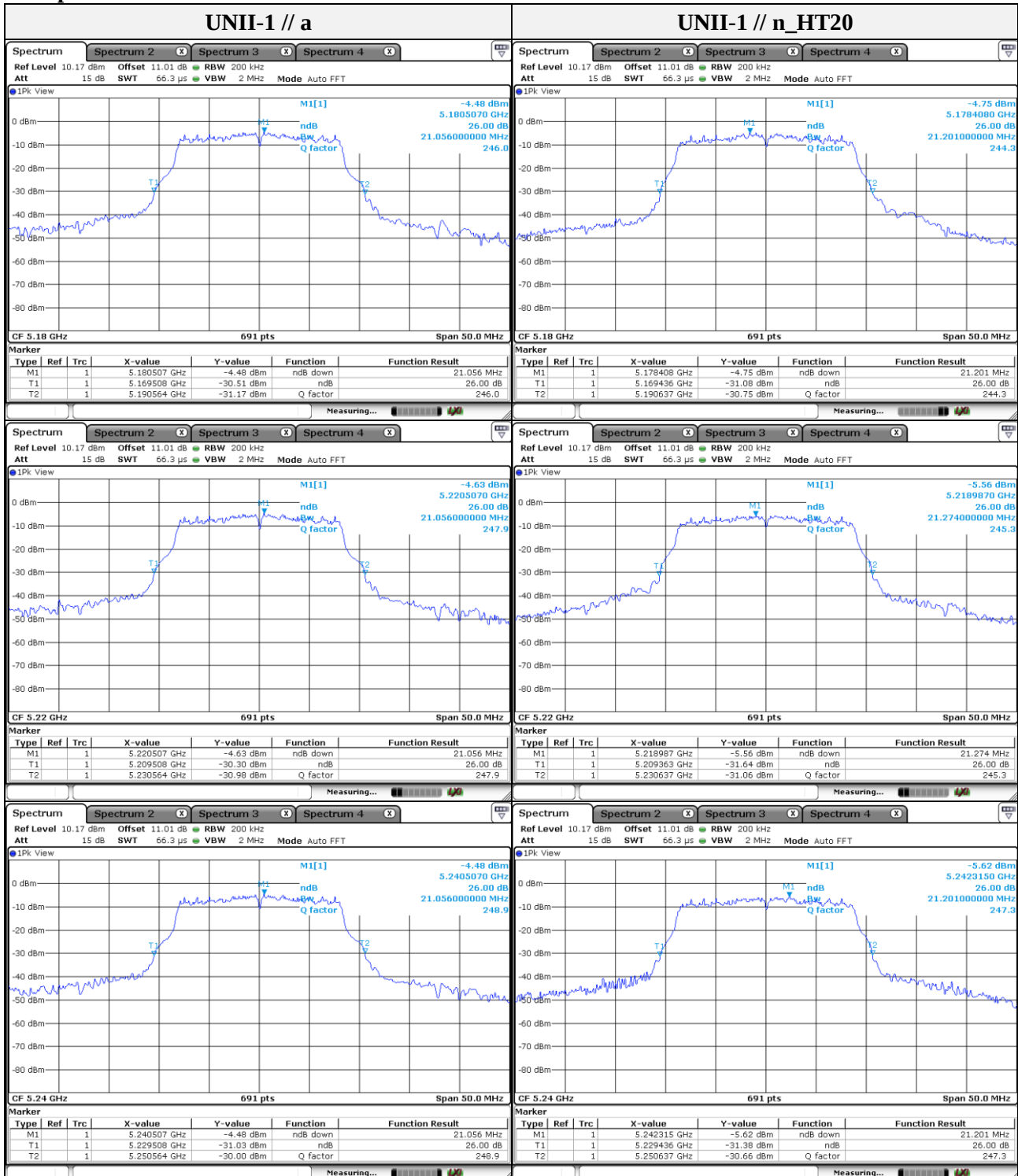
Band	Frequency(MHz)	Mode	26 dB bandwidth(MHz)
UNII-1	5 180	a	21.06
	5 220		21.06
	5 240		21.06
	5 180	HT20	21.20
	5 220		21.27
	5 240		21.20

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 plots



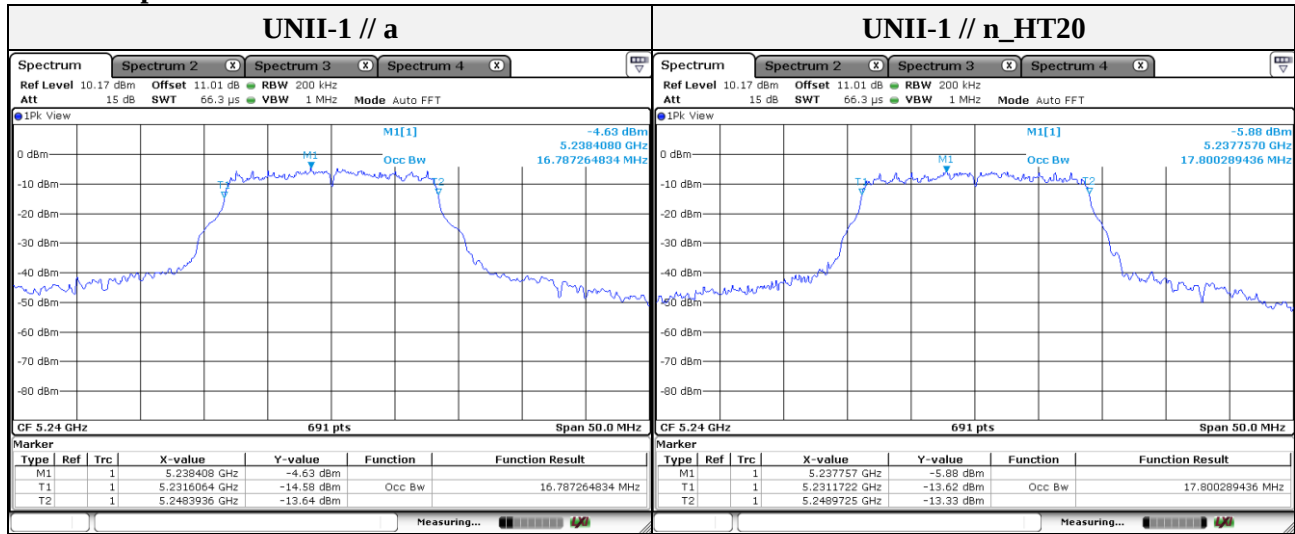
This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.

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



99% Occupied Bandwidth-5240 MHz



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. Maximum conducted output power

Test procedure

KDB 789033 D02 v02r01– Section E.3.a) or b)

Used test method is Section E.3.b)

Test setup



Section E.3.a)

Method PM (Measurement using an RF average power meter):

- i. Measurements may be performed using a wideband RF power meter with a thermocouple detector or equivalent if all of the conditions listed below are satisfied.
 - The EUT is configured to transmit continuously or to transmit with a constant duty cycle.
 - At all times when the EUT is transmitting, it must be transmitting at its maximum power control level.
 - The integration period of the power meter exceeds the repetition period of the transmitted signal by at least a factor of five.
- ii. If the transmitter does not transmit continuously, measure the duty cycle, x, of the transmitter output signal as described in section II.B.
- iii. Measure the average power of the transmitter. This measurement is an average over both the on and off periods of the transmitter.
- iv. Adjust the measurement in dBm by adding $10 \log (1/x)$ where x is the duty cycle (e.g., $10 \log (1/0.25)$ if the duty cycle is 25 %).
- v. In case of band crossing channels 138, 142 and 144, the measurement is complied with section E.2.d of KDB 644545_D03 v01

Section E.3.b)

Method PM-G (Measurement using a gated RF average power meter):

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 the measurement is made only during the ON time of the transmitter, no duty cycle correction factor is required.

Limit

Band	EUT Category		Limit
UNII-1		Outdoor access point	1 W (30 dBm)
		Indoor access point	
		Fixed point-to-point access point	
	✓	Mobile and portable client device	250 mW (24 dBm)
UNII-2A			250 mW or 11 dBm + $10 \log B^*$
UNII-2C			250 mW or 11 dBm + $10 \log B^*$
UNII-3			1 W (30 dBm)

Note.

1. B is the 26 dB emission bandwidth.

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-19T0178
Page (12) of (39)

Test results

Band	mode	Frequency (MHz)	Detector mode	Output power(dBm)	Limit (dBm)
UNII-1	a	5 180	AV	4.55	24.00
		5 220		4.48	
		5 240		4.49	
	HT20	5 180		4.24	
		5 220		4.23	
		5 240		4.32	

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.

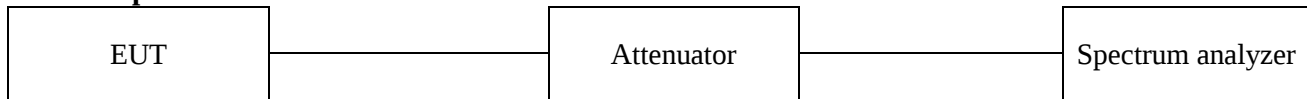
The authenticity of the test report, contact shchoi@kes.co.kr

3.4. Maximum Power spectral density

Test procedure

KDB 789033 D02 v02r01 – Section F

Test setup



Section F

1. Create an average power spectrum for the EUT operating mode being tested by following the instructions in section II.E.2. for measuring maximum conducted output power using a spectrum analyzer or EMI receiver: select the appropriate test method (SA-1, SA-2, SA-3, or alternatives to each) and apply it up to, but not including, the step labeled, “Compute power...” (This procedure is required even if the maximum conducted output power measurement was performed using a power meter, method PM.)
2. Use the peak search function on the instrument to find the peak of the spectrum and record its value.
3. Make the following adjustments to the peak value of the spectrum, if applicable:
 - a) If Method SA-2 or SA-2 Alternative was used, add $10 \log(1/x)$, where x is the duty cycle, to the peak of the spectrum.
 - b) If Method SA-3 Alternative was used and the linear mode was used in step II.E.2.g)(viii), add 1 dB to the final result to compensate for the difference between linear averaging and power averaging.
4. The result is the Maximum PSD over 1 MHz reference bandwidth.
5. For devices operating in the bands 5.15-5.25 GHz, 5.25-5.35 GHz, and 5.47-5.725 GHz, the preceding procedures make use of 1 MHz RBW to satisfy directly the 1 MHz reference bandwidth specified in § 15.407(a)(5). For devices operating in the band 5.725-5.85 GHz, the rules specify a measurement bandwidth of 500 kHz. Many spectrum analyzers do not have 500 kHz RBW, thus a narrower RBW may need to be used. The rules permit the use of a RBWs less than 1 MHz, or 500 kHz, “provided that the measured power is integrated over the full reference bandwidth” to show the total power over the specified measurement bandwidth (i.e., 1 MHz, or 500 kHz). If measurements are performed using a reduced resolution bandwidth (< 1 MHz, or < 500 kHz) and integrated over 1 MHz, or 500 kHz bandwidth, the following adjustments to the procedures apply:
 - a) Set $RBW \geq 1/T$, where T is defined in section II.B.1.a)
 - b) Set $VBW \geq 3$ RBW.
 - c) If measurement bandwidth of Maximum PSD is specified in 500 kHz, add $10 \log(500 \text{ kHz}/RBW)$ to the measured result, whereas $RBW (< 500 \text{ kHz})$ is the reduced resolution bandwidth of the spectrum analyzer set during measurement.
 - d) If measurement bandwidth of Maximum PSD is specified in 1 MHz, add $10 \log(1 \text{ MHz}/RBW)$ to the measured result, whereas $RBW (< 1 \text{ MHz})$ is the reduced resolution bandwidth of spectrum analyzer set during measurement.
 - e) Care must be taken to ensure that the measurements are performed during a period of continuous transmission or are corrected upward for duty cycle.

Note.

As a practical matter, it is recommended to use reduced RBW of 100 kHz for the II.F.5.c) and II.F.5.d), since $RBW=100 \text{ kHz}$ is available on nearly all spectrum analyzers.

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

Band	EUT Category		Limit
UNII-1		Outdoor access point	17 dBm/MHz
		Indoor access point	
		Fixed point-to-point access point	
	✓	Mobile and portable client device	11 dBm/MHz
UNII-2A			11 dBm/MHz
UNII-2C			11 dBm/MHz
UNII-3			30 dBm/500 kHz

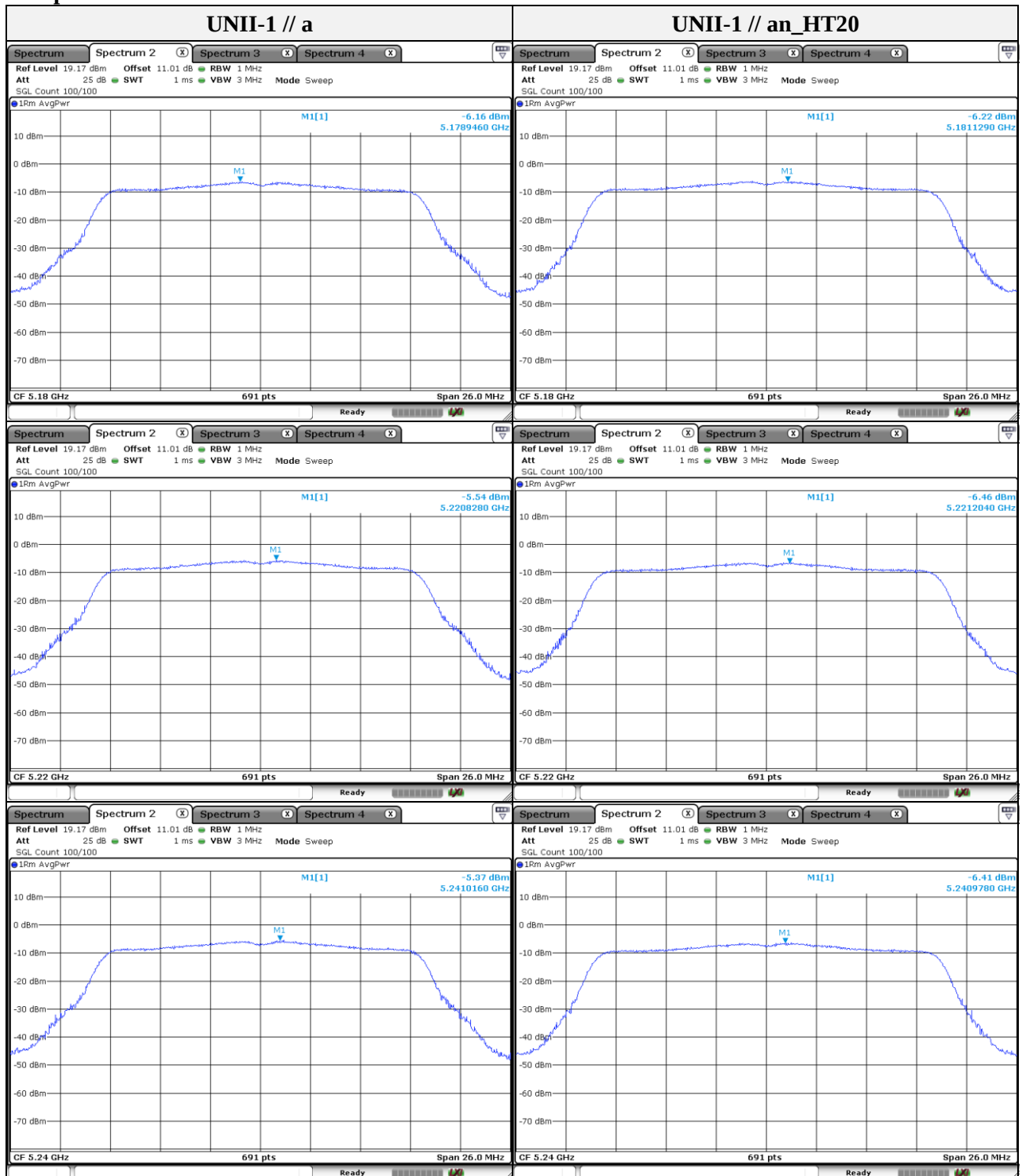
Test results

Band	mode	Frequency (MHz)	DCF ^{Note1}	Measured PSD (dBm/MHz) ^{Note2}	Limit (dBm/MHz)
UNII-1	a	5 180	0.21	-5.95	11.00
		5 220		-5.33	
		5 240		-5.16	
	HT20	5 180	0.17	-6.05	
		5 220		-6.29	
		5 240		-6.24	

Note.

1. Refer to the page 27 on this report.
2. UNII-1 = $10\log(1 \text{ MHz}/1 \text{ MHz})$
3. $\text{PSD(dBm)} = \text{RBWF} + \text{Duty correction factor (dB)}$

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.

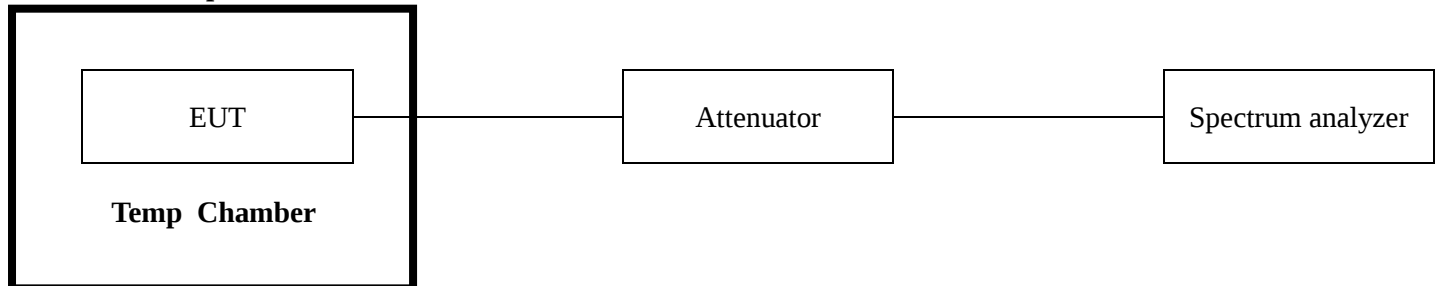
The authenticity of the test report, contact shchoi@kes.co.kr

3.5. Frequency Stability

Test procedure

ANSI C63.10-2013, clause 6.8.1

Test setup



1. The EUT was placed inside the environmental test chamber and powered by nominal DC voltage.
2. Turn the EUT on and couple its output to a spectrum analyzer.
3. Turn the EUT off and set the chamber to the highest temperature specified.
4. Allow sufficient time (approximately 30 min) for the temperature of the chamber to stabilize, turn the EUT on and measure the operating frequency.
5. Repeat step 2 and 3 with the temperature chamber set to the lowest temperature.
6. The test chamber was allowed to stabilize at +20 degree C for a minimum of 30 minutes. The supply voltage was then adjusted on the EUT from 85% to 115% and the frequency record.
7. While maintaining a constant temperature inside the environmental chamber, turn the EUT on and record the operating frequency at startup, and at 2 minutes, 5 minutes, and 10 minutes after the EUT is energized. Four measurements in total are made.

Limit

N/A

Test results

Mode: UNII-1
Operating frequency: 5 180 MHz

Test voltage (%)	Test voltage (V)	Temperature (℃)	Maintaining time	Measure frequency (MHz)	Frequency deviation (Hz)	Deviation (%)
100 %	DC 3.85	-10	Startup	5 180.083 825	83 825	0.016 182
			2 minutes	5 180.083 912	83 912	0.016 199
			5 minutes	5 180.083 997	83 997	0.016 216
			10 minutes	5 180.084 024	84 024	0.016 221
100 %		0	Startup	5 180.077 671	77 671	0.014 994
			2 minutes	5 180.077 932	77 932	0.015 045
			5 minutes	5 180.078 102	78 102	0.015 078
			10 minutes	5 180.078 286	78 286	0.015 113
100 %		10	Startup	5 180.070 214	70 214	0.013 555
			2 minutes	5 180.070 589	70 589	0.013 627
			5 minutes	5 180.070 721	70 721	0.013 653
			10 minutes	5 180.071 042	71 042	0.013 715
100 %		20	Startup	5 180.064 243	64 243	0.012 402
			2 minutes	5 180.064 473	64 473	0.012 447
			5 minutes	5 180.064 714	64 714	0.012 493
			10 minutes	5 180.064 992	64 992	0.012 547
100 %		21.8	Startup	5 180.058 684	58 684	0.011 329
			2 minutes	5 180.060 847	60 847	0.011 747
			5 minutes	5 180.061 241	61 241	0.011 823
			10 minutes	5 180.061 789	61 789	0.011 928
100 %		30	Startup	5 180.052 352	52 352	0.010 107
			2 minutes	5 180.052 414	52 514	0.010 138
			5 minutes	5 180.052 403	52 603	0.010 155
			10 minutes	5 180.052 391	52 711	0.010 176
100 %		40	Startup	5 180.045 495	45 495	0.008 783
			2 minutes	5 180.045 312	45 312	0.008 747
			5 minutes	5 180.045 173	45 173	0.008 721
			10 minutes	5 180.044 922	44 922	0.008 672
100 %		50	Startup	5 180.039 783	39 783	0.007 680
			2 minutes	5 180.039 571	39 571	0.007 639
			5 minutes	5 180.039 274	39 274	0.007 582
			10 minutes	5 180.039 003	39 003	0.007 530
85 %	DC 3.47	21.8	Startup	5 180.060 241	60 241	0.011 630
			2 minutes	5 180.061 997	61 997	0.011 969
			5 minutes	5 180.062 741	62 741	0.012 112
			10 minutes	5 180.063 065	63 065	0.012 175
115 %	DC 4.24	21.8	Startup	5 180.061 007	61 007	0.011 777
			2 minutes	5 180.061 931	61 931	0.011 956
			5 minutes	5 180.062 469	62 469	0.012 060
			10 minutes	5 180.062 966	62 996	0.012 161

This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.

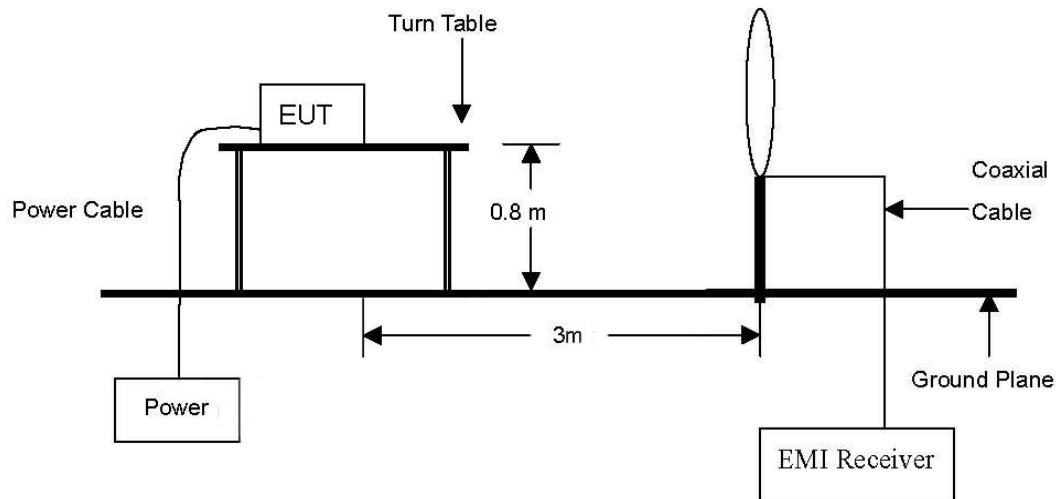
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.

The authenticity of the test report, contact shchoi@kes.co.kr

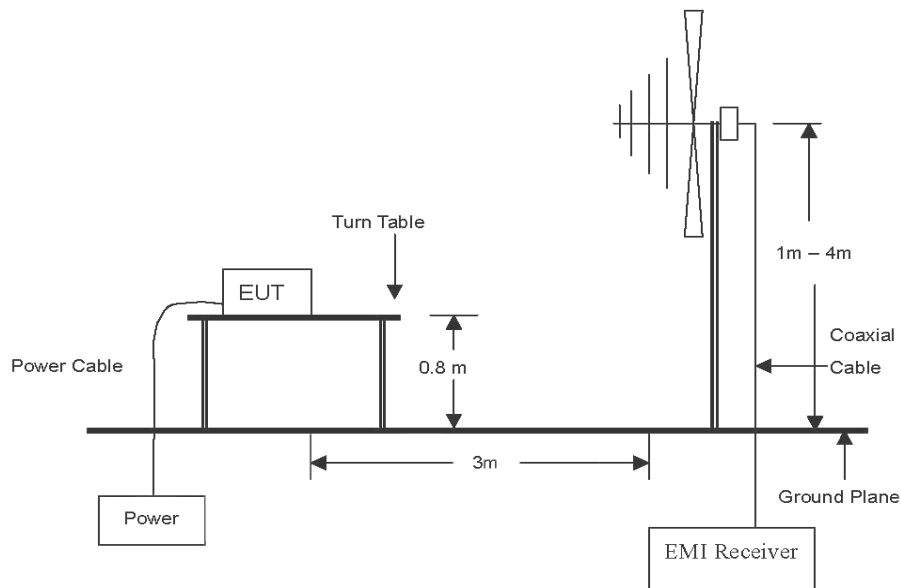
3.6. Radiated restricted band and emissions

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.

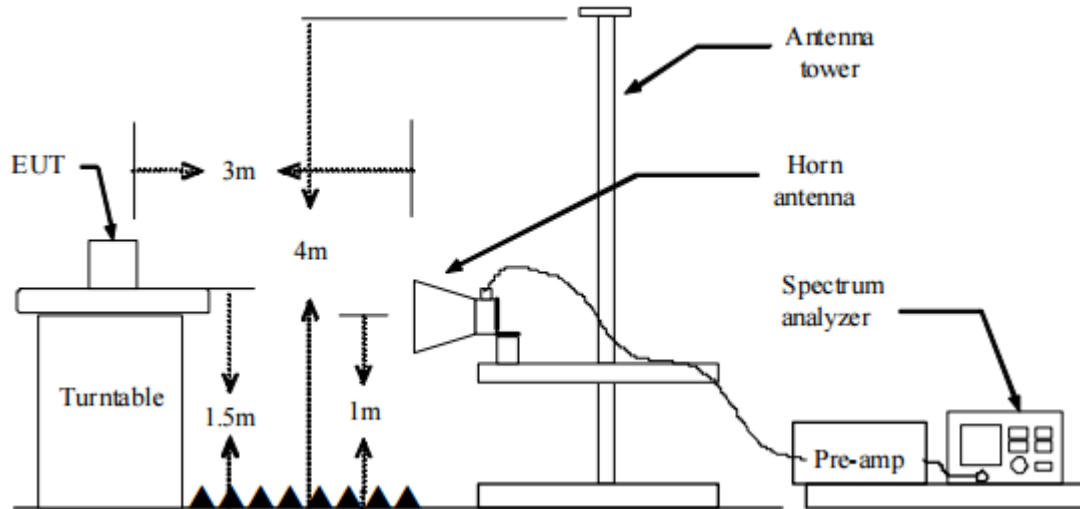


This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.

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

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 = 120 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 = 3 MHz ($\geq 3 \times$ RBW)
 - ④ Detector = peak
 - ⑤ Sweep time = auto
 - ⑥ Trace = max hold
 - ⑦ Trace was allowed to stabilize

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. 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. $f < 30$ 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
2. CF(Correction factors(dB)) = Antenna factor(dB/m) + Cable loss(dB) + or Amp. gain(dB) + or F_d (dB)
4. Field strength(dBμV/m) = Level(dBμV) + CF (dB) + or DCF(dB)
5. Margin(dB) = Limit(dBμV/m) - Field strength(dBμV/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 9 kHz to 30 MHz. 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.

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 ($\mu V/m$)
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.

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

According to 15.407(b), (b) Undesirable emission limits: Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

- (1) For transmitters operating in the 5.15–5.25 GHz band: all emissions outside of the 5.15–5.35 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.
- (2) For transmitters operating in the 5.25–5.35 GHz band: All emissions outside of the 5.15–5.35 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.
- (3) For transmitters operating in the 5.47–5.725 GHz band: All emissions outside of the 5.47–5.725 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.
- (4) For transmitters operating in the 5.725–5.85 GHz band:
 - i) All emissions shall be limited to a level of -27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.
 - ii) Devices certified before March 2, 2017 with antenna gain greater than 10 dBi may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease by March 2, 2018. Devices certified before March 2, 2018 with antenna gain of 10 dBi or less may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease before March 2, 2020.
- (5) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.
- (6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in § 15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in § 15.207.
- (7) The provisions of §15.205 apply to intentional radiators operating under this section.
- (8) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

Duty cycle

Regarding to KDB 789033 D02 v02r01, B)2)b), 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 $> 50/T$, where T is defined in II.B.1.a), and the number of sweep points across duration T exceeds 100.

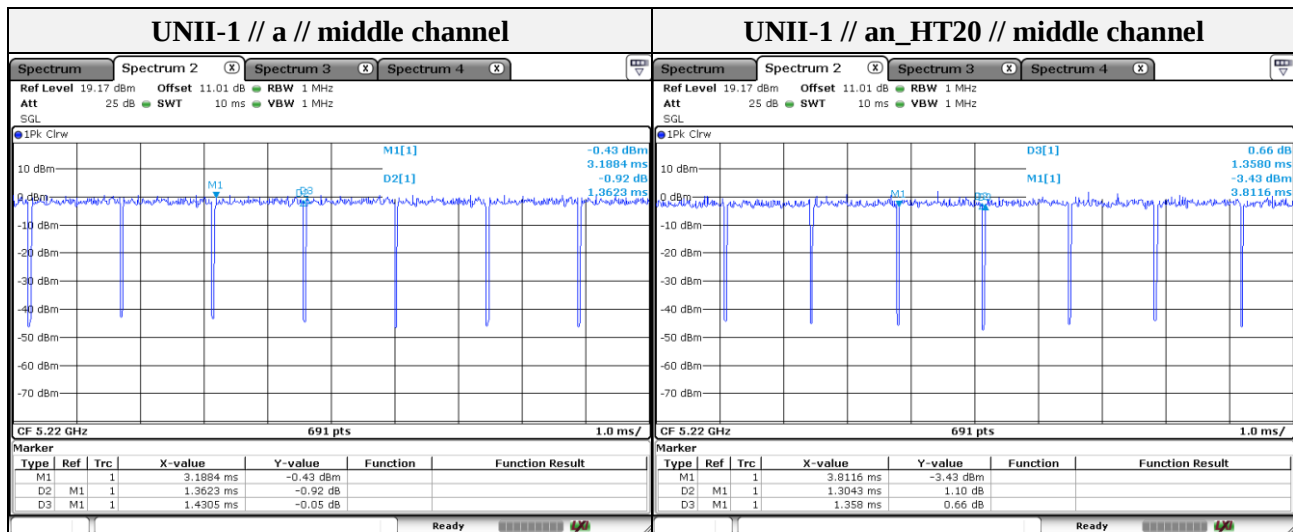
For the band 5.15-5.25 GHz

Test mode	T _{on} time (ms)	Period (ms)	Duty cycle (Linear)	Duty cycle (%)	Duty cycle correction factor (dB)
802.11a	1.362 3	1.430 5	0.952 3	95.23	0.21
802.11n_HT20	1.304 3	1.358 0	0.960 4	96.04	0.17

Note:

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

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



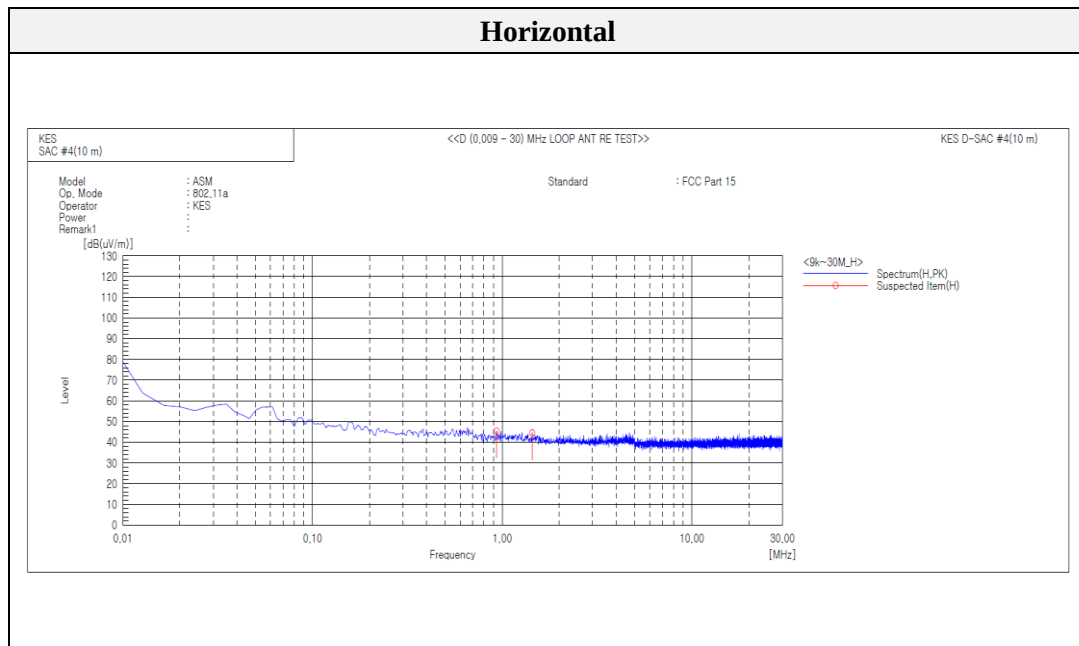
This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.

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) – Worst case

Mode: UNII-1_a
 Distance of measurement: 3 meter
 Channel: 36 (Worst case)



This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.

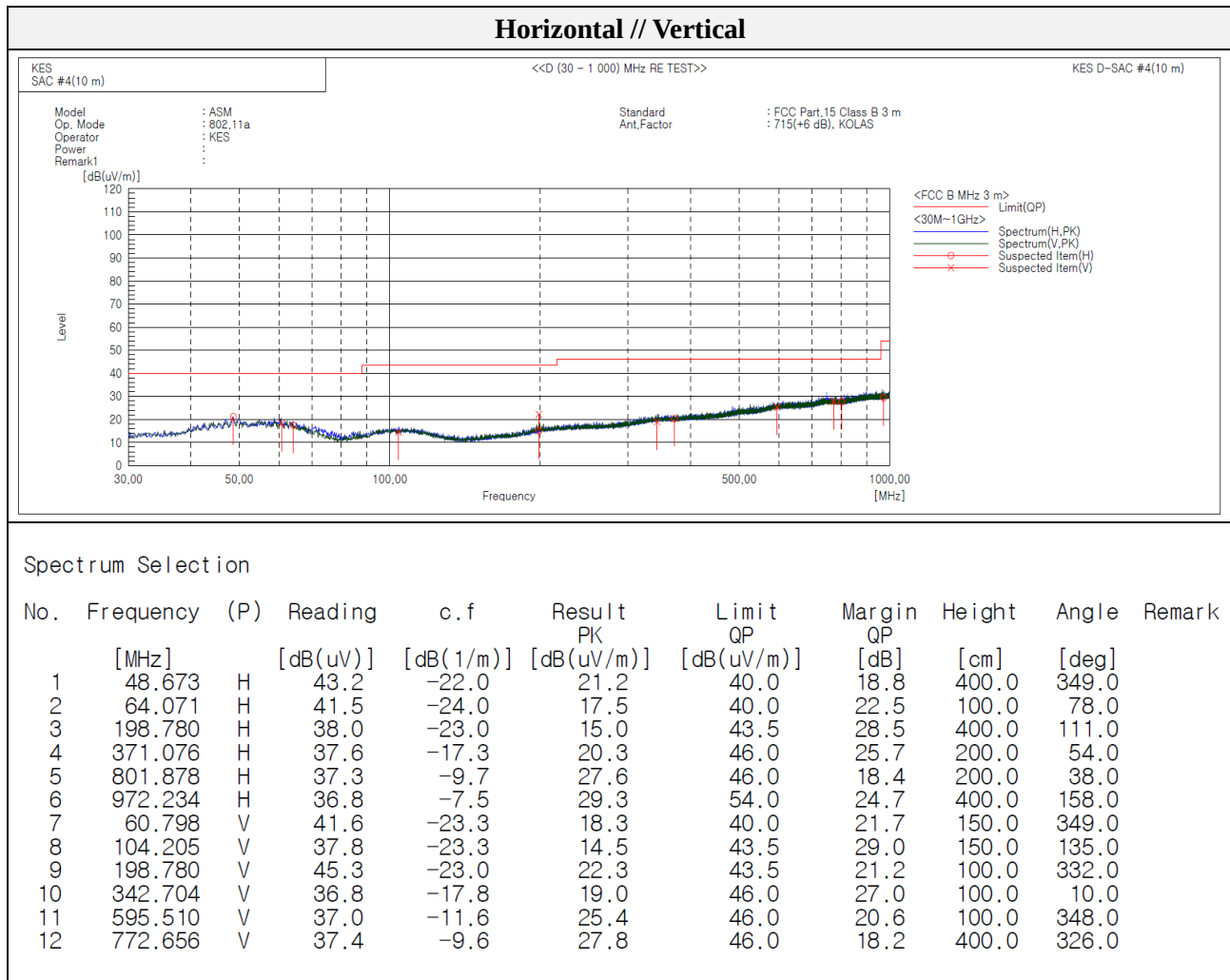
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.

The authenticity of the test report, contact shchoi@kes.co.kr



Test results (Below 1 000 MHz) – Worst case

Mode: UNII-1_a
Distance of measurement: 3 meter
Channel: 36 (Worst case)



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 (Above 1 000 MHz)

Mode: UNII-1_a
Distance of measurement: 3 meter
Channel: 36

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 850.20	46.90	Peak	H	-2.35	-	44.55	68.20	23.65
1 083.20	47.44	Peak	H	-8.17	-	39.27	74.00	34.73
1 828.50	47.15	Peak	V	-2.55	-	44.60	68.20	23.60

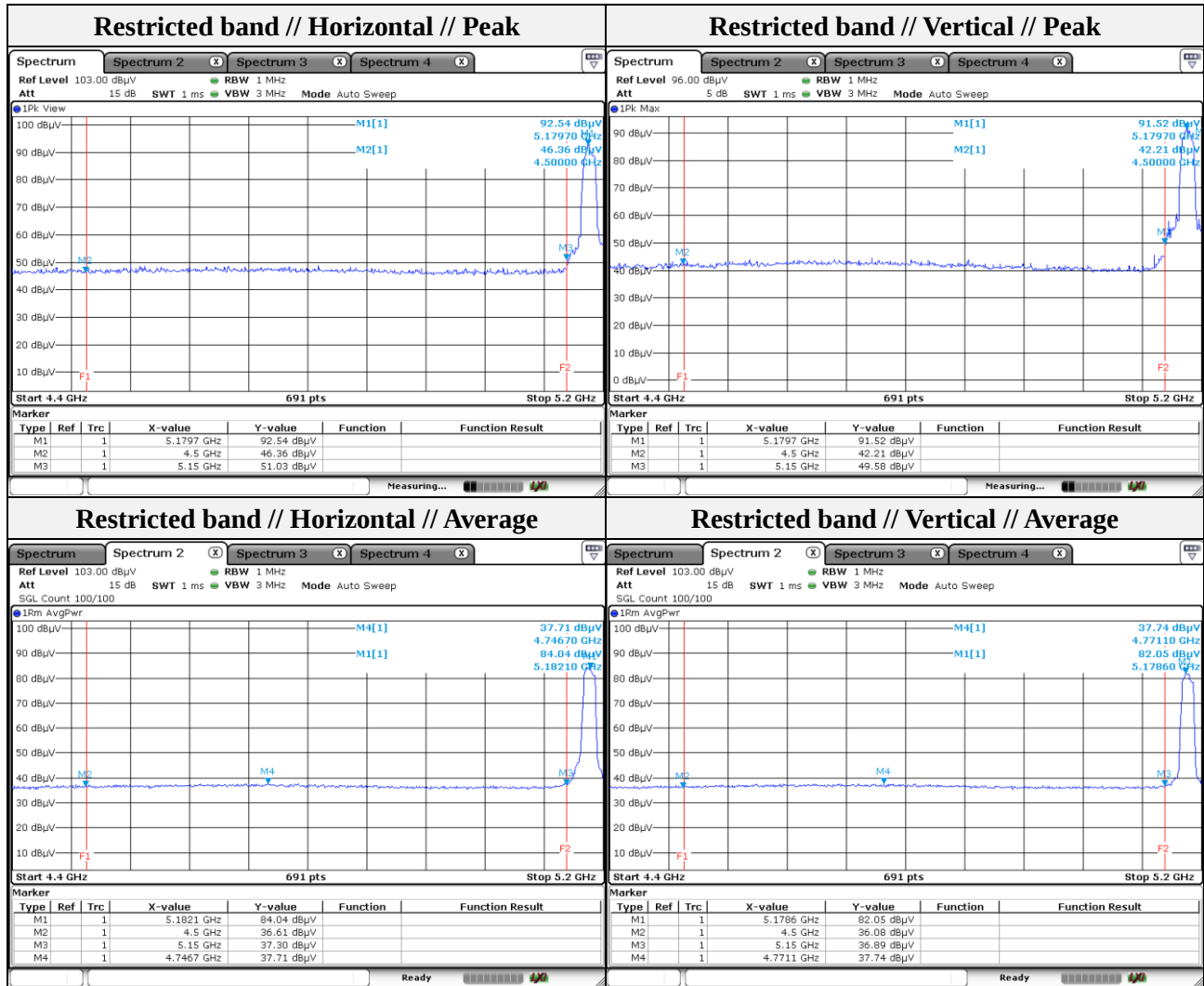
- Band edge

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
5 150.00	48.14	Peak	H	8.22	-	56.36	74.00	17.64
4 746.70	37.71	Average	H	6.56	0.21	44.48	54.00	9.52
5 150.00	49.58	Peak	V	8.22	-	57.80	74.00	16.20
4 771.10	37.74	Average	V	6.74	0.21	44.69	54.00	9.31

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.

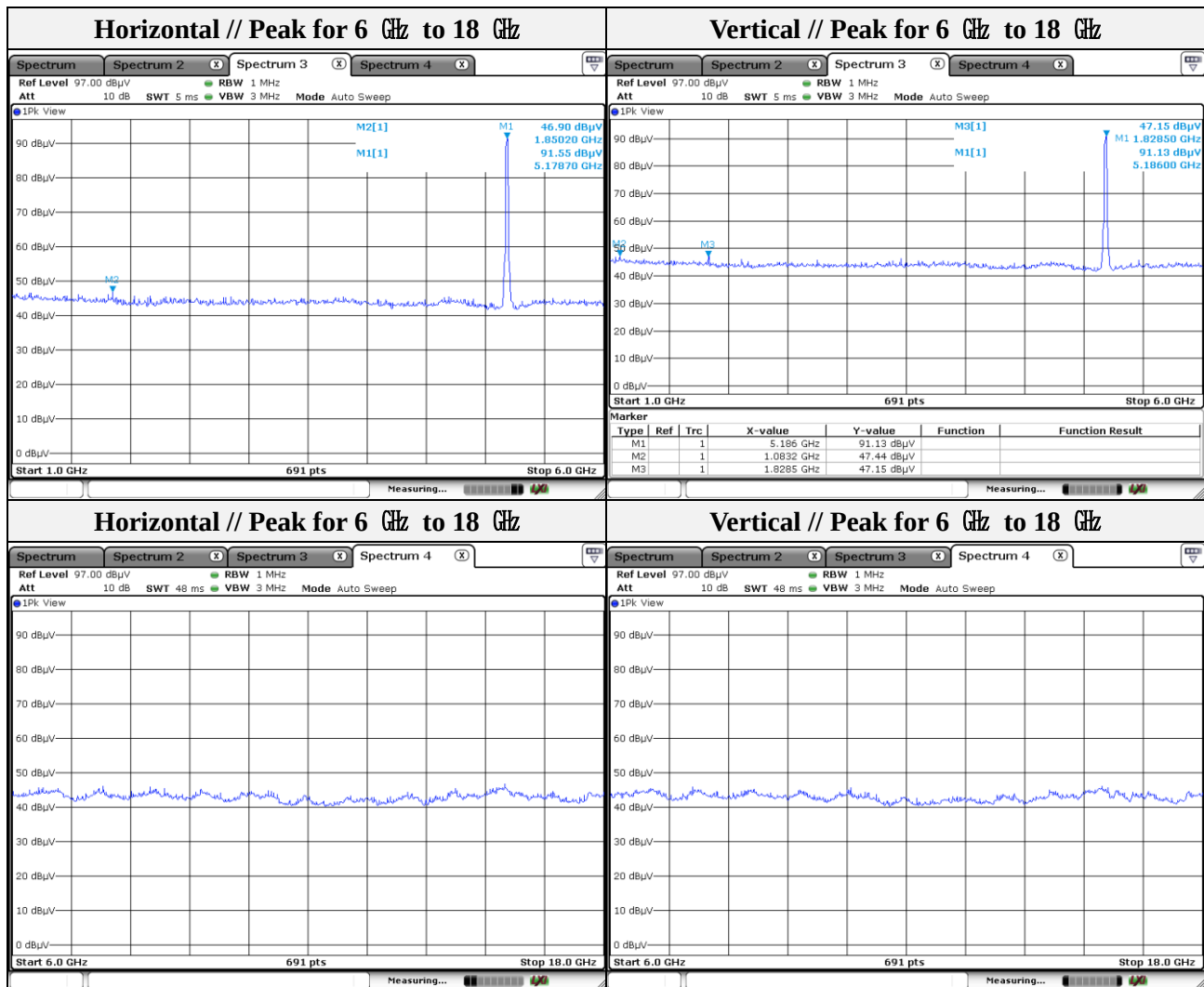
The authenticity of the test report, contact shchoi@kes.co.kr



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



Note.

1. No spurious emission were detected above 6 GHz.
2. 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.

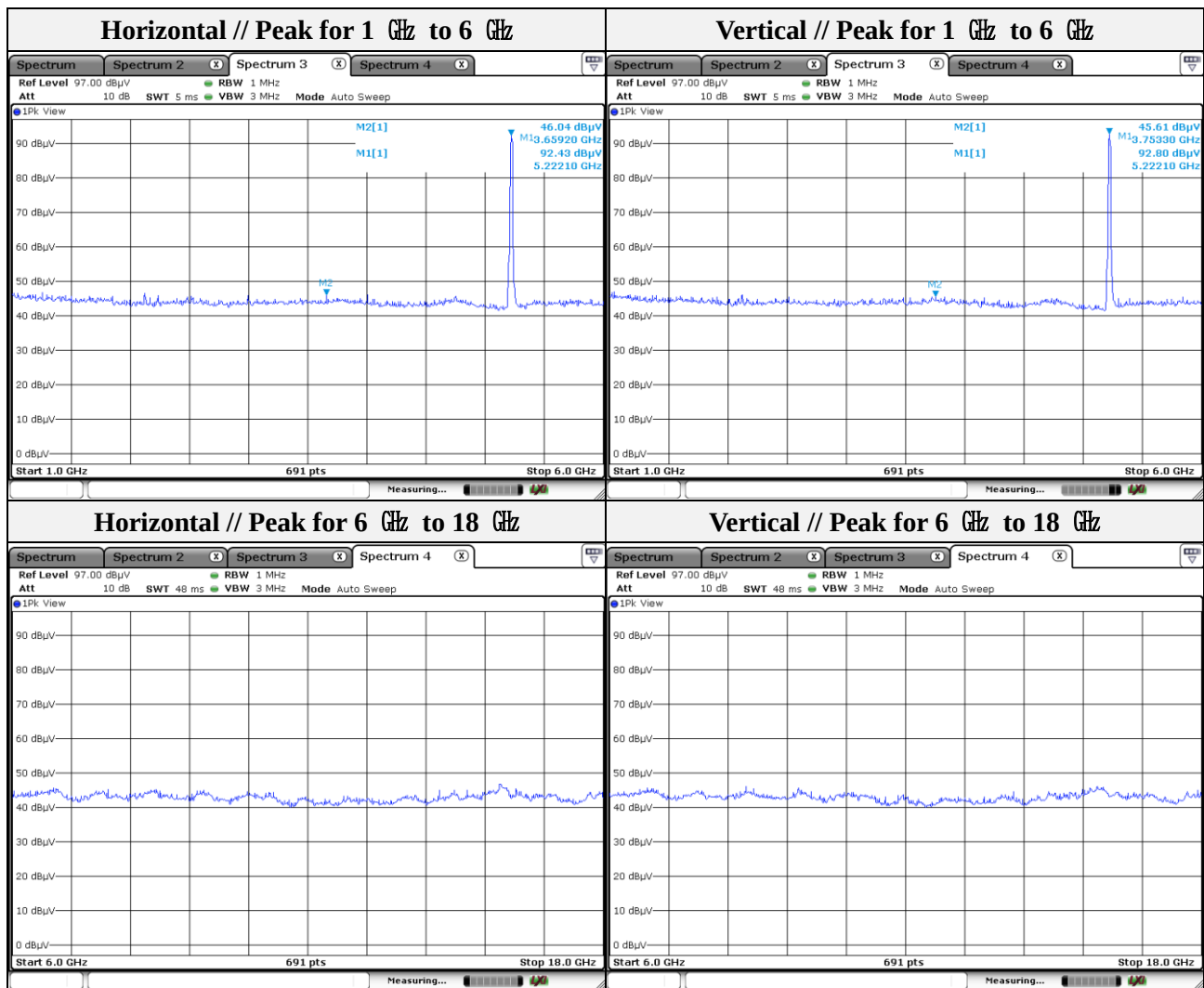
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.

The authenticity of the test report, contact shchoi@kes.co.kr

Mode: UNII-1_a
Distance of measurement: 3 meter
Channel: 44

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
3 659.20	46.04	Peak	H	2.39	-	48.43	74.00	25.57
3 753.30	45.61	Peak	V	2.81	-	48.42	74.00	25.58



Note.

1. No spurious emission were detected above 6 GHz.
2. 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.

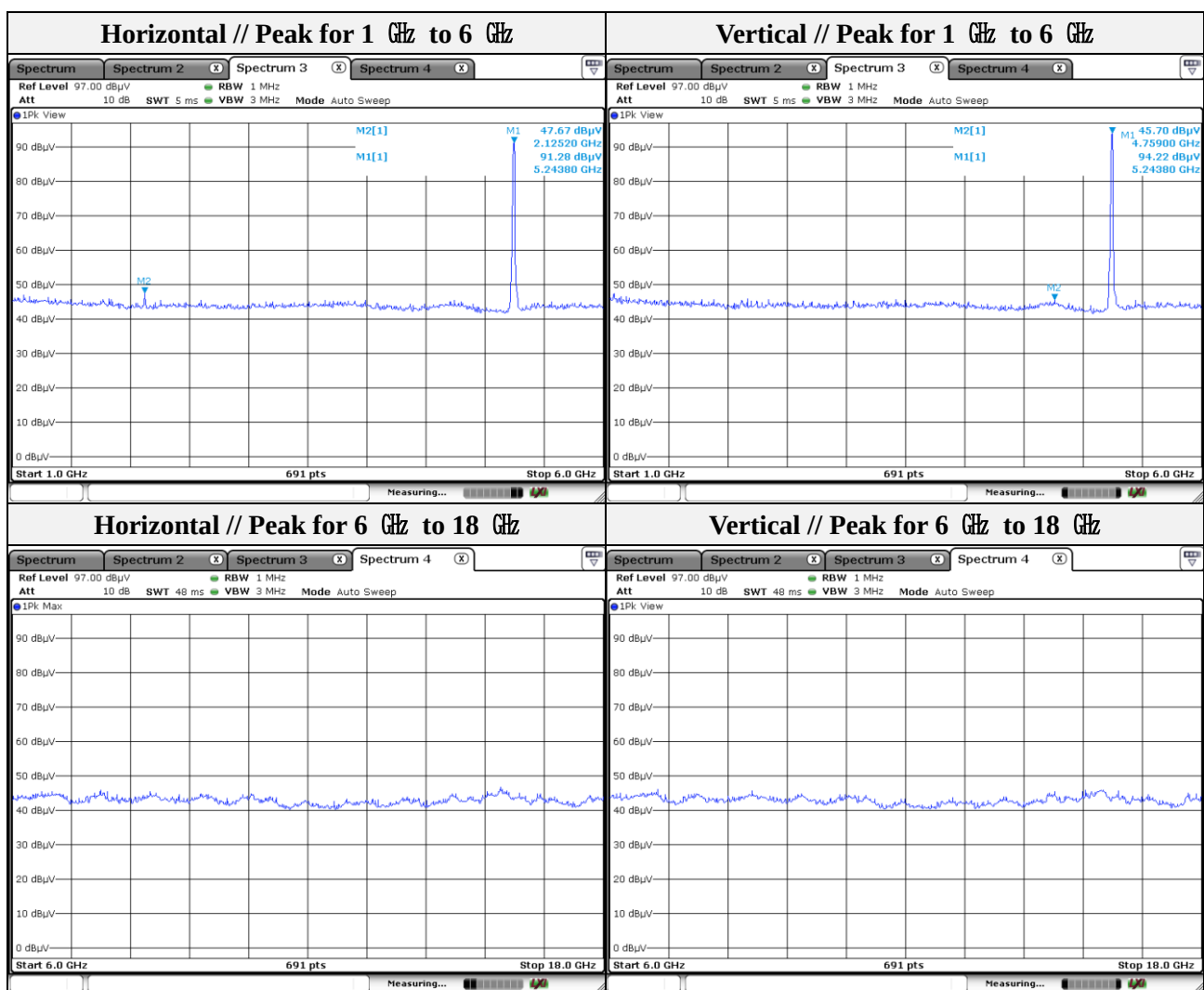
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.

The authenticity of the test report, contact shchoi@kes.co.kr

Mode: UNII-1_a
Distance of measurement: 3 meter
Channel: 48

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 125.20	47.67	Peak	H	-0.67	-	47.00	68.20	21.20
4 759.00	45.70	Peak	V	6.65	-	52.35	74.00	21.65



Note.

1. No spurious emission were detected above 6 GHz.
2. 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: UNII-1_n(HT20)

Distance of measurement: 3 meter

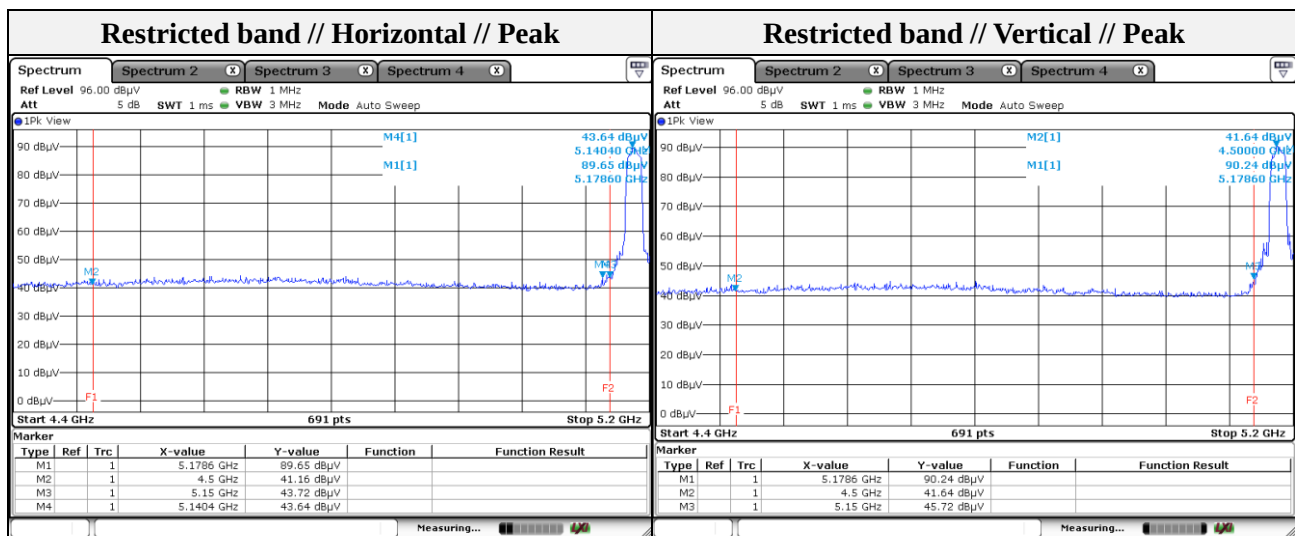
Channel: 36

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 125.20	46.90	Peak	H	-0.67	-	46.23	68.20	21.97
3 550.70	46.32	Peak	H	1.88	-	48.20	68.20	20.00
2 117.90	46.19	Peak	V	-0.69	-	45.50	68.20	22.70
3 847.30	45.71	Peak	V	3.24	-	48.95	74.00	25.05

- Band edge

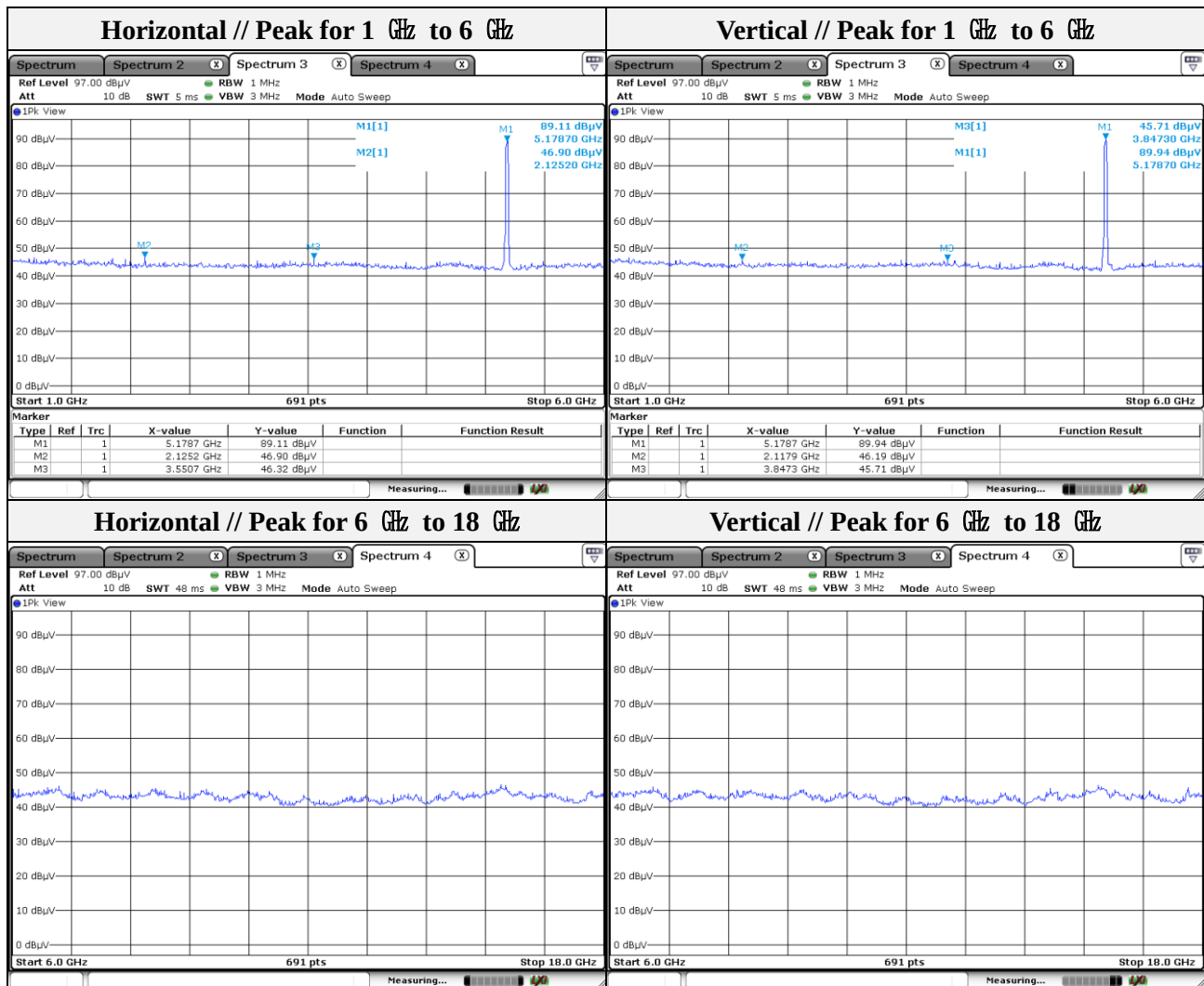
Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
5 150.00	43.72	Peak	H	8.22	-	51.94	74.00	22.06
5 140.40	43.64	Peak	H	8.24	-	51.88	74.00	22.12
5 150.00	45.72	Peak	V	8.22	-	53.94	74.00	20.06



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



Note.

1. No spurious emission were detected above 6 GHz.
2. 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

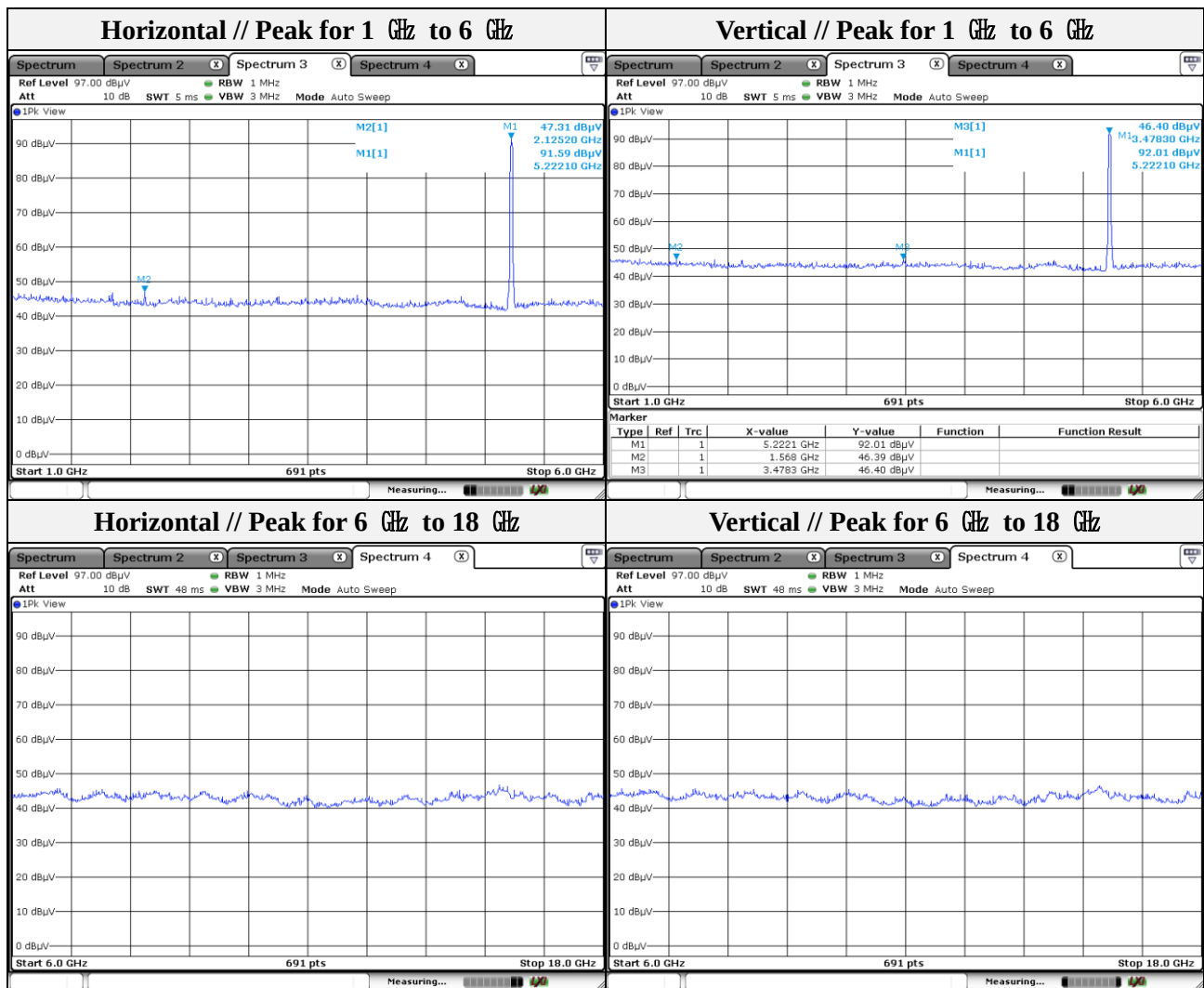
Mode: UNII-1_n(HT20)

Distance of measurement: 3 meter

Channel: 44

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 125.20	47.31	Peak	H	-0.67	-	46.64	68.20	21.56
1 568.00	46.39	Peak	V	-5.05	-	41.34	74.00	32.66
3 478.30	46.40	Peak	V	1.63	-	48.03	68.20	20.17



Note.

1. No spurious emission were detected above 6 GHz.
2. 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.

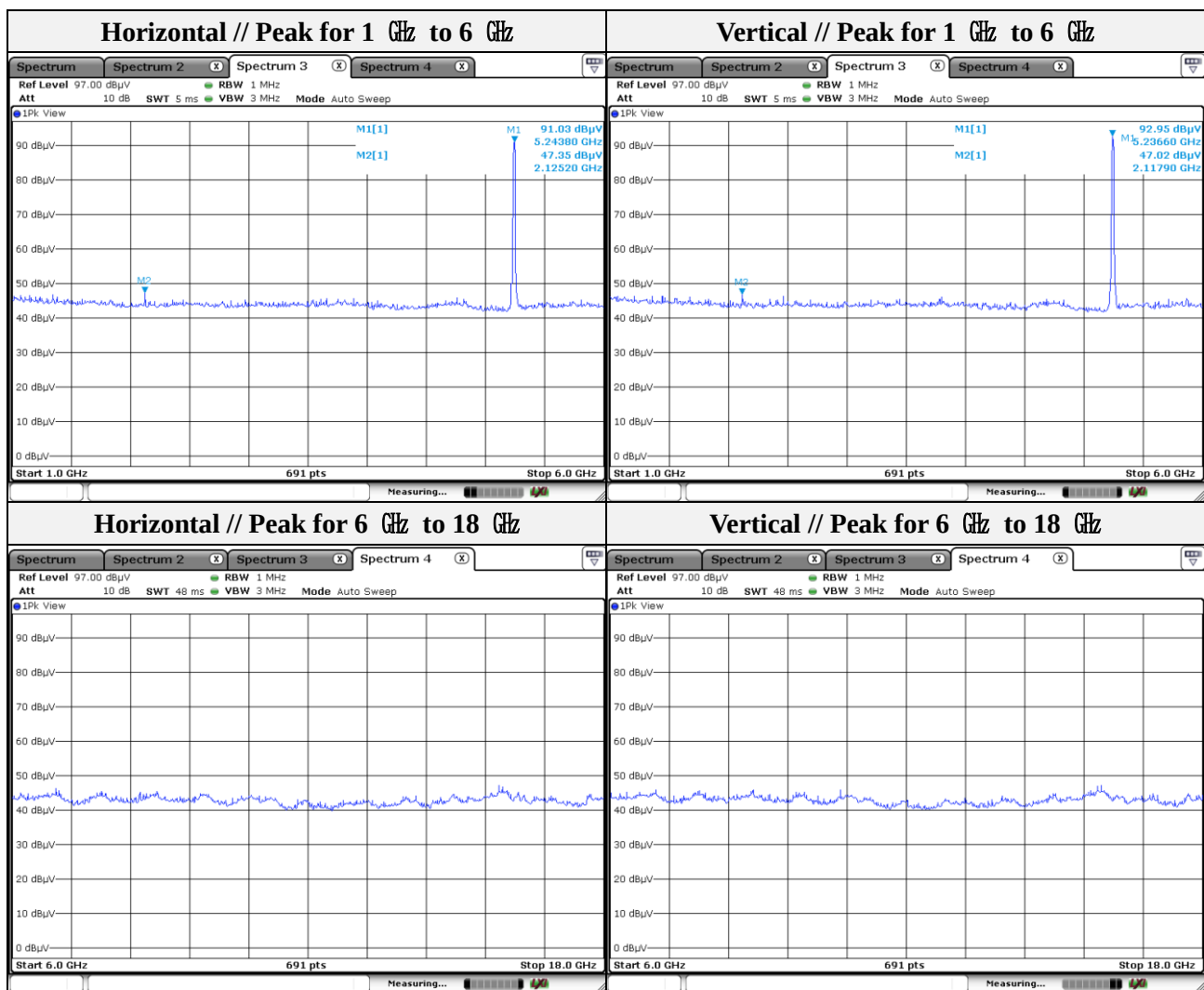
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.

The authenticity of the test report, contact shchoi@kes.co.kr

Mode: UNII-1_n(HT20)
Distance of measurement: 3 meter
Channel: 48

- **Spurious**

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 125.20	47.35	Peak	H	-0.67	-	46.68	68.20	21.52
2 117.90	47.02	Peak	V	-0.69	-	46.33	68.20	21.87



Note.

1. No spurious emission were detected above 6 GHz.
2. Average test would be performed if the peak result were greater than the average limit.

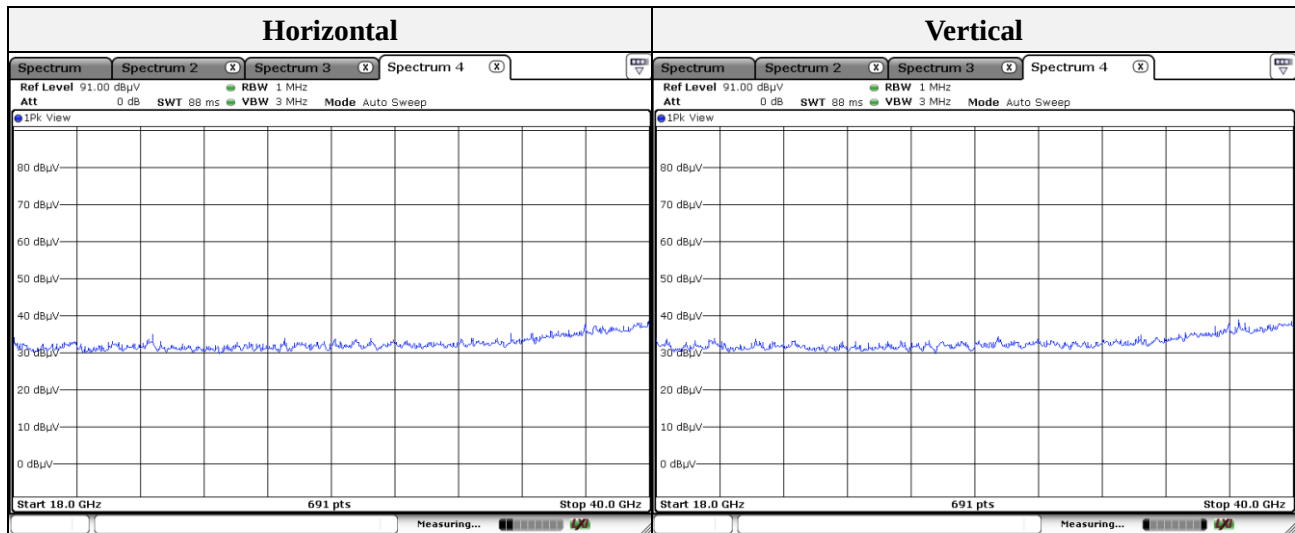
This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.

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 40 GHz) – Worst case

Mode: UNII-1_a
 Distance of measurement: 3 meter
 Channel: 36 (Worst case)



Note.

1. No spurious emission were detected above 18 GHz.

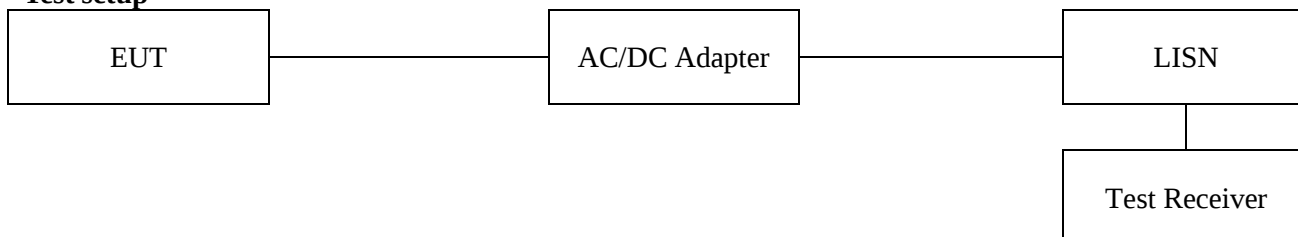
This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.

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

3.7 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.

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 across a frequency range from 150k to 30M Hz. The y-axis ranges from 0 to 100 dBμV. Two limit lines are shown: a solid red line for FCC Part 15 Class B Voltage on Mains QP and a dashed purple line for FCC Part 15 Class B Voltage on Mains AV. The signal is represented by a blue line with diamond markers, and the background is filled with green and blue noise. The signal level is generally below the QP limit, with some peaks reaching up to 60 dBμV.

Final Result

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.265000	44.83	---	61.27	16.44	1000.0	9.000	L1	10.2
0.265000	---	27.90	51.27	23.37	1000.0	9.000	L1	10.2
0.690000	41.10	---	56.00	14.90	1000.0	9.000	L1	11.3
0.690000	---	27.86	46.00	18.14	1000.0	9.000	L1	11.3
0.880000	39.19	---	56.00	16.81	1000.0	9.000	L1	11.4
0.880000	---	25.85	46.00	20.15	1000.0	9.000	L1	11.4
0.970000	37.78	---	56.00	18.22	1000.0	9.000	L1	11.4
0.970000	---	25.14	46.00	20.86	1000.0	9.000	L1	11.4
3.595000	31.84	---	56.00	24.16	1000.0	9.000	L1	10.2
3.595000	---	20.29	46.00	25.71	1000.0	9.000	L1	10.2
10.650000	32.38	---	60.00	27.62	1000.0	9.000	L1	10.4
10.710000	---	25.78	50.00	24.22	1000.0	9.000	L1	10.5

Neutral Line

The spectrum plot for the Neutral Line shows the signal level in dBμV across a frequency range from 150k to 30M Hz. The y-axis ranges from 0 to 100 dBμV. Two limit lines are shown: a solid red line for FCC Part 15 Class B Voltage on Mains QP and a dashed purple line for FCC Part 15 Class B Voltage on Mains AV. The signal is represented by a blue line with diamond markers, and the background is filled with green and blue noise. The signal level is generally below the QP limit, with some peaks reaching up to 60 dBμV.

Final Result

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.280000	38.37	---	60.82	22.45	1000.0	9.000	N	10.3
0.280000	---	22.06	50.82	28.76	1000.0	9.000	N	10.3
0.520000	---	21.19	46.00	24.81	1000.0	9.000	N	11.0
0.520000	33.64	---	56.00	22.36	1000.0	9.000	N	11.0
0.630000	---	23.60	46.00	22.40	1000.0	9.000	N	11.2
0.630000	36.25	---	56.00	19.75	1000.0	9.000	N	11.2
1.540000	28.77	---	56.00	27.23	1000.0	9.000	N	10.3
1.540000	---	14.97	46.00	31.03	1000.0	9.000	N	10.3
3.175000	28.99	---	56.00	27.01	1000.0	9.000	N	10.3
3.175000	---	17.22	46.00	28.78	1000.0	9.000	N	10.3
10.890000	28.05	---	60.00	31.95	1000.0	9.000	N	10.5
10.890000	---	20.73	50.00	29.27	1000.0	9.000	N	10.5

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 due.
Spectrum Analyzer	R&S	FSV40	100736	1 year	2020.01.09
8360B Series Swept Signal Generator	HP	83630B	3844A00786	1 year	2020.01.15
Power Meter	Anritsu	ML2495A	1438001	1 year	2020.01.15
Pulse Power Sensor	Anritsu	MA2411B	1339205	1 year	2020.01.15
DC Power Supply	Agilent	6632B	MY43004130	1 year	2020.06.24
Attenuator	Agilent	8493C	82506	1 year	2020.01.15
Loop Antenna	Schwarzbeck	FMZB1513	225	2 years	2021.02.15
Trilog-broadband antenna	SCHWARZBECK	VULB 9163	714	2 years	2020.11.26
Horn Antenna	A.H	SAS-571	414	2 years	2021.02.11
Horn Antenna	SCHWARZBECK	BBHA9170	BBHA 9170550	2 years	2021.02.19
High Pass Filter	Wainwright Instrument Gmbh	WHJS3000-10TT	1	1 year	2020.06.24
Low Pass Filter	Wainwright Instrument Gmbh	WLK1.0/18G-10TT	1	1 year	2020.06.24
Broadband Amplifier	Schwarzbeck	BBV9721	PS9721-003	1 year	2020.01.16
Preamplifier	R&S	SCU01	100603	1 year	2019.11.26
Preamplifier	AGILENT	8449B	3008A01742	1 year	2020.06.24
EMI Test Receiver	R&S	ESR3	101781	1 year	2020.04.22
EMI Test Receiver	R&S	ESU26	100552	1 year	2020.04.09
Pulse Limiter	R&S	ESH3-Z2	101915	1 year	2019.11.26
LISN	R&S	ENV216	101787	1 year	2020.01.04

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
-	-	-	-

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