

TEST REPORT

Part 15 Subpart C 15.247

Equipment under test NUGU candle SE**Model name** NU110**FCC ID** 2A9KPNU110SE**Applicant** LISMA CO., LTD.**Manufacturer** DongGuan Hajen Electro-mechanics Co., Ltd.**Date of test(s)** 2022.12.01 ~ 2023.01.03**Date of issue** 2023.01.12**Issued to****LISMA CO., LTD.**358, Samil-daero, Jung-gu, Seoul,
Republic of Korea

Tel: +82-10-3107-0083 / Fax: +82-0508-918-3183

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 :
	
Gu-Bong, Kang Test engineer	Yeong-Jun Cho Technical manager

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

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 kes@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

Report No.:
KES-RF-23T0012
Page (2) of (55)

Revision history

Revision	Date of issue	Test report No.	Description
-	2023.01.12	KES-RF-23T0012	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 kes@kes.co.kr

TABLE OF CONTENTS

1.	General information.....	4
1.1.	EUT description	5
1.2.	Requirements for Bluetooth transmitter	6
1.3.	Test configuration.....	7
1.4.	Information about derivative model	7
1.5.	Accessory information.....	7
1.6.	Sample calculation	7
1.7.	Measurement Uncertainty	7
1.8.	Frequency/channel operations	8
2.	Summary of tests	10
3.	Test results	11
3.1.	20 dB bandwidth	11
3.2.	Output power.....	14
3.3.	Carrier frequency separation	16
3.4.	Number of hopping frequency.....	18
3.5.	Time of occupancy	20
3.6.	Radiated restricted band and emissions.....	24
3.7.	Conducted band edge and out of band emissions	45
3.8.	AC conducted emissions	51
3.9.	Antenna Requirement.....	53
Appendix A.	Measurement equipment	54
Appendix B.	Test setup photo.....	55

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 kes@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

Report No.:

KES-RF-23T0012

Page (4) of (55)

1. General information

Applicant: LISMA CO., LTD.
Applicant address: 358, Samil-daero, Jung-gu, Seoul, Republic of Korea
Test site: KES Co., Ltd.
Test site address: ☐ 3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si,
Gyeonggi-do, 14057, Korea
☒ 473-29, Gayeo-ro, Yeosu-si, Gyeonggi-do, Korea
Test Facility FCC Accreditation Designation No.: KR0100, Registration No.: 444148
FCC rule part(s): 15.247
FCC ID: 2A9KPNU110SE
Test device serial No.: ☒ Production ☐ Pre-production ☐ Engineering

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 kes@kes.co.kr

1.1. EUT description

Equipment under test	NUGU candle SE
Frequency range	2 402 MHz ~ 2 480 MHz (BDR / EDR) 2 402 MHz ~ 2 480 MHz (LE 1 Mbps) 2 412 MHz ~ 2 462 MHz (802.11b/g/n_HT20) 2 422 MHz ~ 2 452 MHz (802.11n_HT40) UNII-1 5 180 MHz ~ 5 240 MHz (802.11a/n_HT20) 5 190 MHz ~ 5 230 MHz (802.11n_HT40) UNII-2A 5 260 MHz ~ 5 320 MHz (802.11a/n_HT20) 5 270 MHz ~ 5 310 MHz (802.11n_HT40) UNII-2C 5 500 MHz ~ 5 720 MHz (802.11a/n_HT20) 5 510 MHz ~ 5 710 MHz (802.11n_HT40) UNII-3 5 745 MHz ~ 5 825 MHz (802.11a/n_HT20) 5 755 MHz ~ 5 795 MHz (802.11n_HT40)
Model	NU110
Modulation technique	GFSK, π/4QPSK, 8DPSK, DSSS, OFDM
Number of channels	2 402 MHz ~ 2 480 MHz (BDR / EDR) : 79 ch 2 402 MHz ~ 2 480 MHz (LE 1 Mbps) : 40 ch 2 412 MHz ~ 2 462 MHz (802.11b/g/n_HT20) : 11 ch 2 422 MHz ~ 2 452 MHz (802.11n_HT40) : 7 ch UNII-1 5 180 MHz ~ 5 240 MHz (802.11a/n_HT20) : 4 ch 5 190 MHz ~ 5 230 MHz (802.11n_HT40) : 2 ch UNII-2A 5 260 MHz ~ 5 320 MHz (802.11a/n_HT20) : 4 ch 5 270 MHz ~ 5 310 MHz (802.11n_HT40) : 2 ch UNII-2C 5 500 MHz ~ 5 720 MHz (802.11a/n_HT20) : 12 ch 5 510 MHz ~ 5 710 MHz (802.11n_HT40) : 6 ch UNII-3 5 745 MHz ~ 5 825 MHz (802.11a/n_HT20) : 5 ch 5 755 MHz ~ 5 795 MHz (802.11n_HT40) : 2 ch
Antenna specification	BDR/EDR : Chip Antenna // Peak gain: 3.0 dBi LE 1 Mbps : Chip Antenna // Peak gain: 3.0 dBi WLAN 2.4 GHz : Chip Antenna // Peak gain: 3.0 dBi WLAN 5 GHz : Chip Antenna // Peak gain: 3.3 dBi
Power source	AC 120 V (AC/DC adapter output 15 V)
H/W version	V0.2
S/W version	130020312

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:

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

System receiver input bandwidth

Each channel bandwidth is 1 MHz.

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 its 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 **LISMA CO., LTD. // NUGU candle SE // NU110 // FCC ID: 2A9KPNU110SE** was tested according to the specification of EUT, the EUT must comply with following standards and KDB documents.

FCC Subpart C 15.247
KDB 558074 D01 V05r02
ANSI C63.10-2013

1.4. Information about derivative model

N/A

1.5. Accessory information

Equipment	Manufacturer	Model	Serial No.	Power source
AC/DC adapter	Dongguan RuiHeng Electronic Technology Co.,LTD	RH-150200US	221010000111	AC 120 V input, DC 15 V, 2.0 A output

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.

$$\begin{aligned}\text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)} \\ &= 0.78 + 10 = 10.78 \text{ (dB)}\end{aligned}$$

For Radiation test :

Field strength level (dB μ V/m) = Measured level (dB μ V) + Antenna factor (dB) + Cable loss (dB) – Amplifier gain (dB)

1.7. Measurement Uncertainty

Test Item		Uncertainty
Uncertainty for Conduction emission test		2.38 dB (SHIELD ROOM #6)
Uncertainty for Radiation emission test (include Fundamental emission)	Below 1GHz	4.50 dB (SAC #6)
	Above 1GHz	4.90 dB (SAC #5)
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)	Rate(Mbps)
00	2 402	BDR 1 Mbps, EDR 2 Mbps, EDR 3 Mbps
.	.	.
40	2 442	BDR 1 Mbps, EDR 2 Mbps, EDR 3 Mbps
.	.	.
78	2 480	BDR 1 Mbps, EDR 2 Mbps, EDR 3 Mbps

Ch.	Frequency (MHz)	Rate(Mbps)
00	2 402	LE 1 Mbps
.	.	.
20	2 442	LE 1 Mbps
.	.	.
39	2 480	LE 1 Mbps

Ch.	Frequency (MHz)	Rate(Mbps)
01	2 412	802.11b/g/n_HT20
.	.	.
06	2 437	802.11b/g/n_HT20
.	.	.
11	2 462	802.11b/g/n_HT20

Ch.	Frequency (MHz)	Rate(Mbps)
03	2 422	802.11n_HT40
.	.	.
06	2 437	802.11n_HT40
.	.	.
09	2 452	802.11n_HT40

**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

Report No.:

KES-RF-23T0012

Page (9) of (55)

UNII-1

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

UNII-2A

Ch.	Frequency (MHz)
52	5 260
56	5 280
64	5 320

UNII-2C

Ch.	Frequency (MHz)
100	5 500
120	5 600
144	5 720

UNII-3

Ch.	Frequency (MHz)
149	5 745
157	5 785
165	5 825

802.11a/n_HT20 mode**UNII-1**

Ch.	Frequency (MHz)
38	5 190
46	5 230

UNII-2A

Ch.	Frequency (MHz)
54	5 270
62	5 310

UNII-2C

Ch.	Frequency (MHz)
102	5 510
118	5 590
142	5 710

UNII-3

Ch.	Frequency (MHz)
151	5 755
159	5 795

802.11n_HT40 mode

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 kes@kes.co.kr

2. Summary of tests

Reference	Test description	Test results
15.247(a)(1)(iii)	20 dB bandwidth	Pass
15.247(b)(1)	Output power	Pass
15.247(a)(1)	Channel separation	Pass
15.247(a)(1)(iii)	Number of channels	Pass
15.247(a)(1)(iii)	Time of occupancy	Pass
15.205, 15.209	Radiated restricted band and emission	Pass
15.207(a)	AC conducted emissions	Pass
15.207(d)	Conducted band edge and out of band emissions	Pass
15.203	Antenna Requirement	Pass

Note.

- Except for the list below, all tests were conducted with default output power.

2.4 GHz WLAN		
Mode	Frequency (MHz)	Setting value
802.11n_HT40	2 422	10
	2 437	10
	2 452	10
UNII-1		
802.11n_HT40	5 190	10
UNII-2A		
802.11n_HT40	5 310	10
UNII-2C		
802.11a	5 700	10
802.11n_HT20	5 700	10
802.11n_HT40	5 510	10
	5 670	10

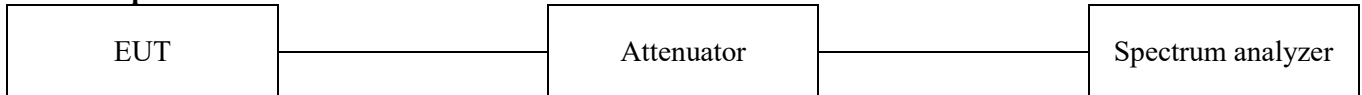
This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.

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

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

3. Test results**3.1. 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 $\geq 1\%$ to 5% of the OBW
3. VBW $\geq 3 * RBW$
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(MHz)	Channel no.	Data rate(Mbps)	Measured bandwidth(MHz)
2 402	00	BDR 1 Mbps	0.81
2 442	40		0.81
2 480	78		0.81
2 402	00	EDR 2 Mbps	1.33
2 442	40		1.32
2 480	78		1.32
2 402	00	EDR 3 Mbps	1.30
2 442	40		1.35
2 480	78		1.29

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 kes@kes.co.kr



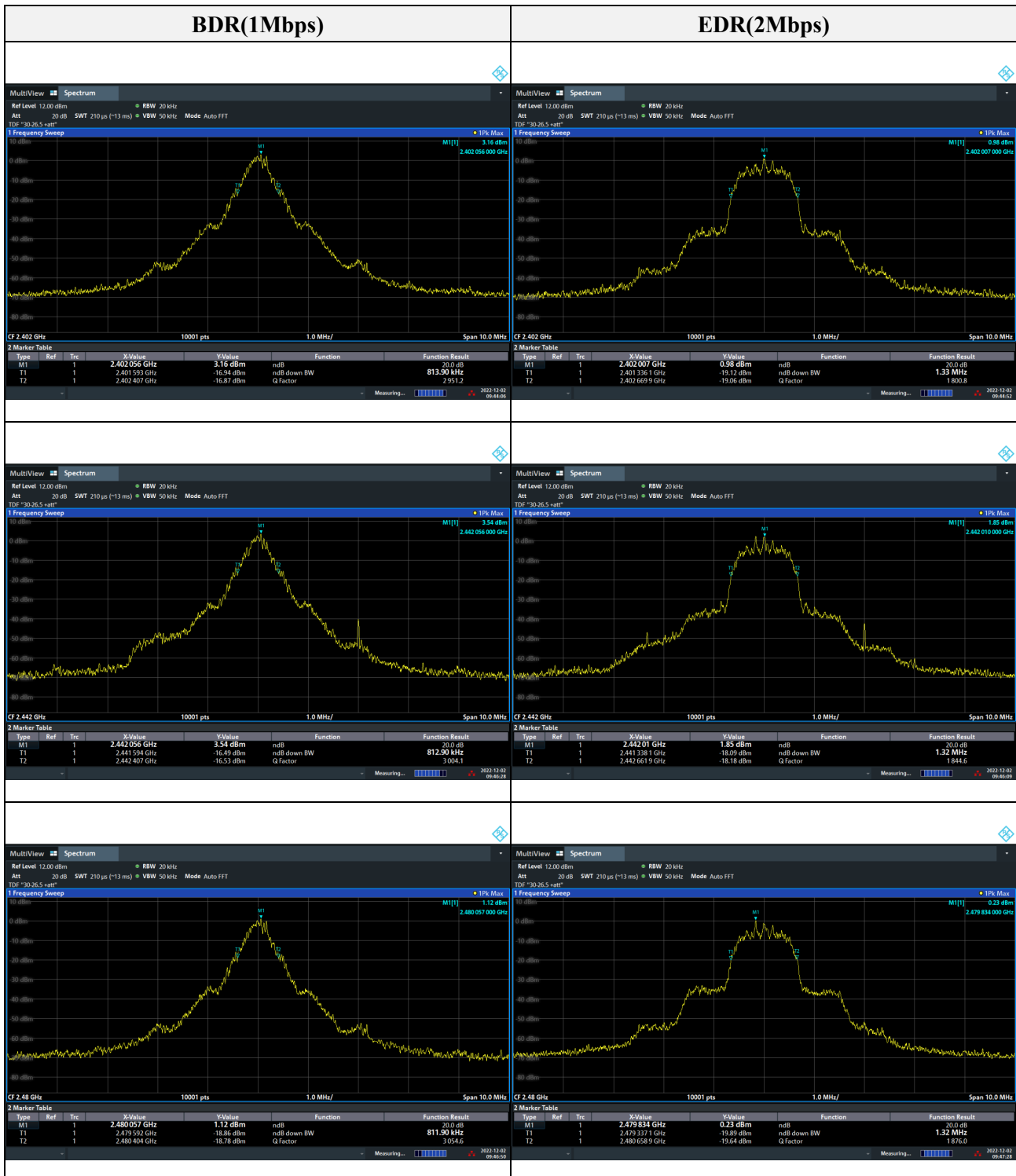
KES Co., Ltd.

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

Report No.:

KES-RF-23T0012

Page (12) of (55)



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 kes@kes.co.kr



KES Co., Ltd.

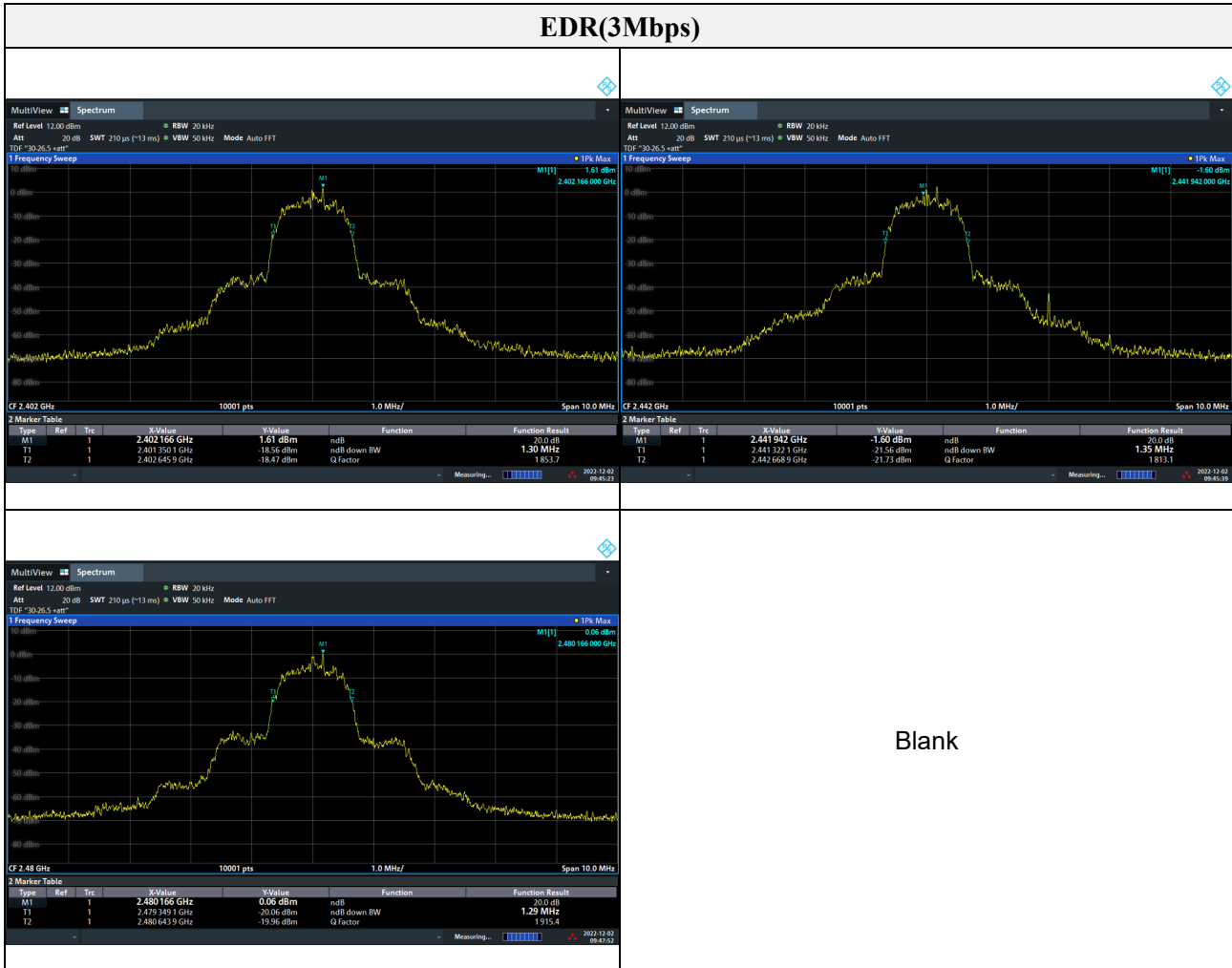
3701, 40, Simin-daero 365beon-gil,
Dongan-gu, Anyang-si, Gyeonggi-do, 14057, Korea
Tel: +82-31-425-6200 / Fax: +82-31-424-0450
www.kes.co.kr

Report No.:

KES-RF-23T0012

Page (13) of (55)

EDR(3Mbps)



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 kes@kes.co.kr

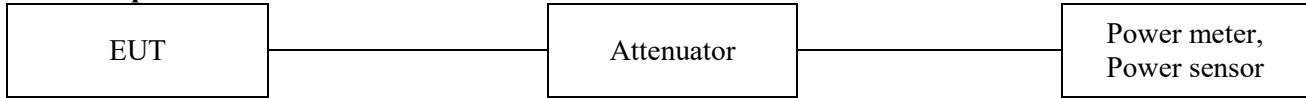
KES-QP16-F01(00-23-01-01)

3.2. 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 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

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

**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

Report No.:

KES-RF-23T0012

Page (15) of (55)

Test results

Frequency(MHz)	Channel no.	Data rate(Mbps)	Average Power (dBm)	Peak Power (dBm)	Power Limit (dBm)
2 402	00	BDR 1 Mbps	5.47	6.08	20.97
2 442	40		5.99	6.62	20.97
2 480	78		3.68	4.26	20.97
2 402	00	EDR 2 Mbps	4.72	7.01	20.97
2 442	40		4.98	7.45	20.97
2 480	78		2.74	4.87	20.97
2 402	00	EDR 3 Mbps	4.67	7.32	20.97
2 442	40		4.90	7.81	20.97
2 480	78		2.68	5.24	20.97

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.

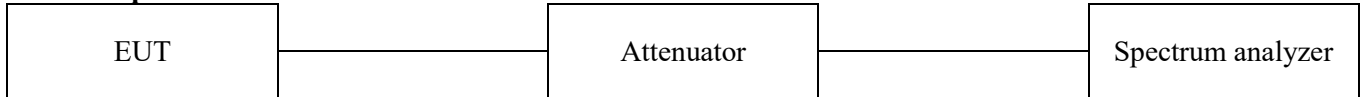
The authenticity of the test report, contact kes@kes.co.kr

3.3. 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) $\geq$ 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 MHz. Band may have hopping channel carrier frequencies that are separated by 25 kHz or two-third of 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.



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

Report No.:

KES-RF-23T0012

Page (17) of (55)

Test results

Frequency(MHz)	Channel no.	Data rate(Mbps)	Channel Separation (MHz)	Limit (MHz)
2 442	40	BDR 1 Mbps	1.000	≥ 0.54
2 442	40	EDR 3 Mbps	1.000	≥ 0.90



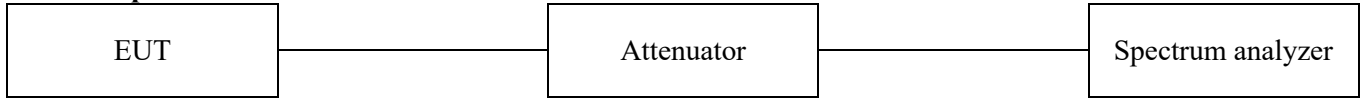
This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact kes@kes.co.kr

3.4. 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 $\geq$ 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 MHz bands shall use at least 15 hopping frequencies.



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

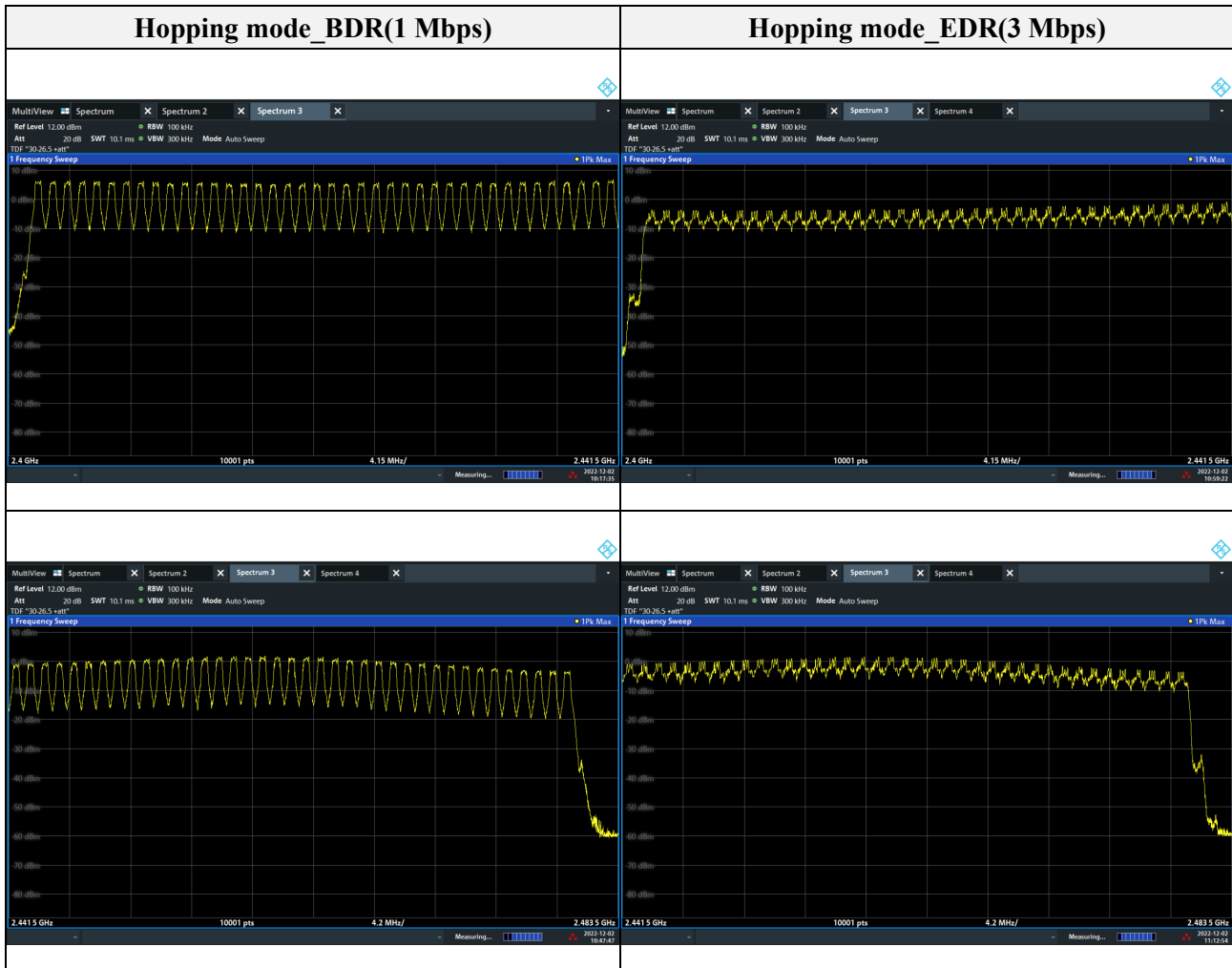
Report No.:

KES-RF-23T0012

Page (19) of (55)

Test results

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



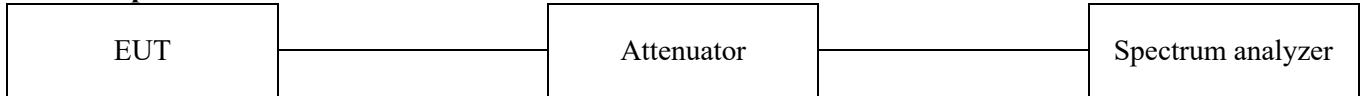
This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
The authenticity of the test report, contact kes@kes.co.kr

3.5. 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 $\leq$ channel spacing and where possible RBW should be set $\gg 1 / T$, 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 MHz band, the average time of occupancy on any frequency shall not be greater than 0.4 second within a 31.6 second period.

$$\text{A period time} = 0.4(\text{s}) \times 79 = 31.6(\text{s})$$

Time of occupancy on the TX channel in 31.6 sec

$$= \text{time domain slot length} \times (\text{hop rate} \div \text{number of hop per channel}) \times 31.6$$

**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

Report No.:

KES-RF-23T0012

Page (21) of (55)

Operation mode: GFSK , $\pi/4$ -DQPSK, 8DPSK

Packet type	Frequency (MHz)	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	0.403	128.8	400
DH3	2 442	1.659	265.5	400
DH5	2 442	2.910	310.4	400
2-DH1	2 442	0.413	132.2	400
2-DH3	2 442	1.664	266.3	400
2-DH5	2 442	2.916	311.0	400
3-DH1	2 442	0.414	132.5	400
3-DH3	2 442	1.665	266.4	400
3-DH5	2 442	2.916	311.0	400

Note:**Normal Mode**DH1: Dwell time (ms) $\times [(1\ 600 \div 2) \div 79] \times 31.6(\text{s}) = 128.8 \text{ (ms)}$ DH3: Dwell time (ms) $\times [(1\ 600 \div 4) \div 79] \times 31.6(\text{s}) = 265.5 \text{ (ms)}$ DH5: Dwell time (ms) $\times [(1\ 600 \div 6) \div 79] \times 31.6(\text{s}) = 310.4 \text{ (ms)}$ 2-DH1: Dwell time (ms) $\times [(1\ 600 \div 2) \div 79] \times 31.6(\text{s}) = 132.2 \text{ (ms)}$ 2-DH3: Dwell time (ms) $\times [(1\ 600 \div 4) \div 79] \times 31.6(\text{s}) = 266.3 \text{ (ms)}$ 2-DH5: Dwell time (ms) $\times [(1\ 600 \div 6) \div 79] \times 31.6(\text{s}) = 311.0 \text{ (ms)}$ 3-DH1: Dwell time (ms) $\times [(1\ 600 \div 2) \div 79] \times 31.6(\text{s}) = 132.5 \text{ (ms)}$ 3-DH3: Dwell time (ms) $\times [(1\ 600 \div 4) \div 79] \times 31.6(\text{s}) = 266.4 \text{ (ms)}$ 3-DH5: Dwell time (ms) $\times [(1\ 600 \div 6) \div 79] \times 31.6(\text{s}) = 311.0 \text{ (ms)}$

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 kes@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

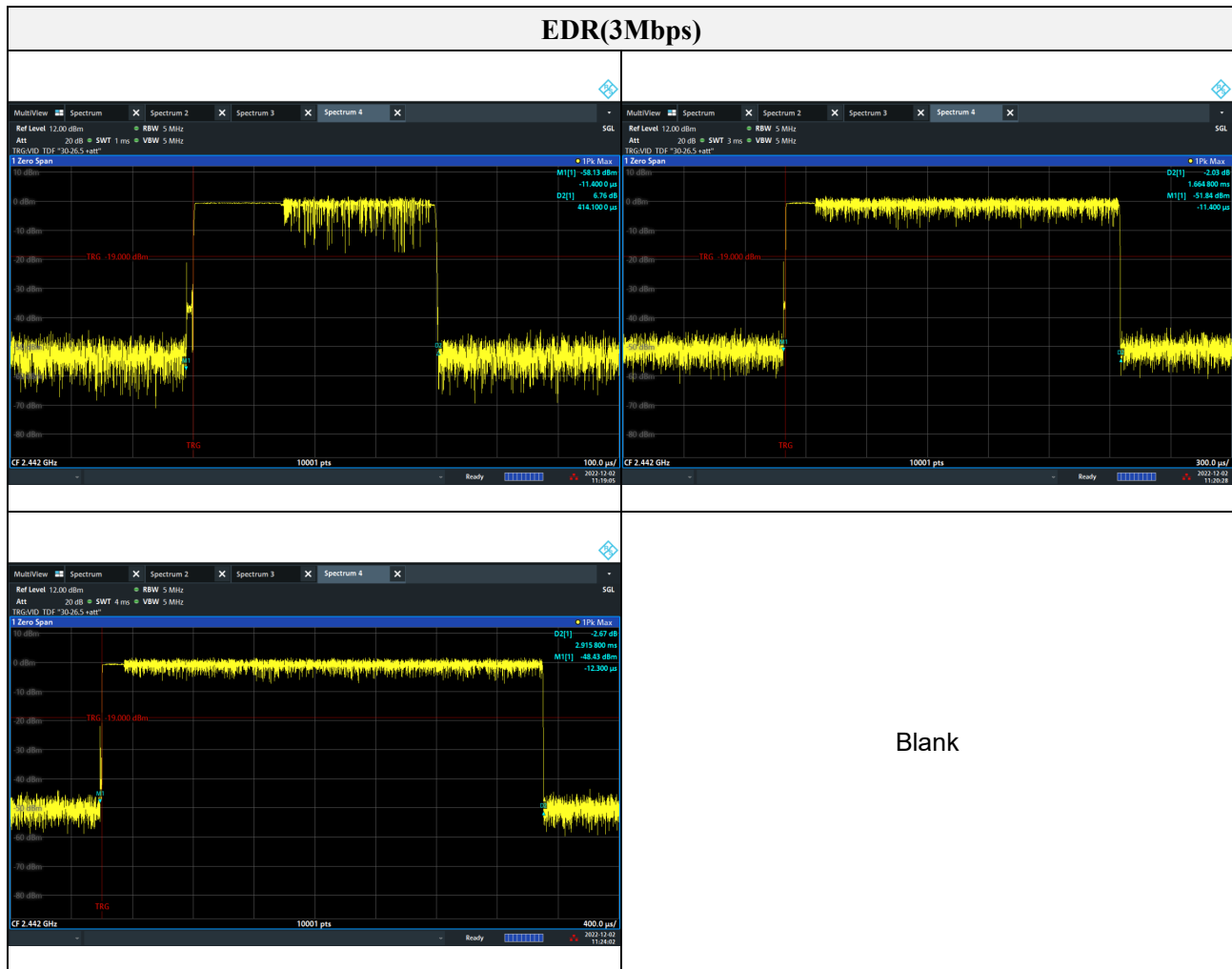
Report No.:

KES-RF-23T0012

Page (22) of (55)



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 kes@kes.co.kr

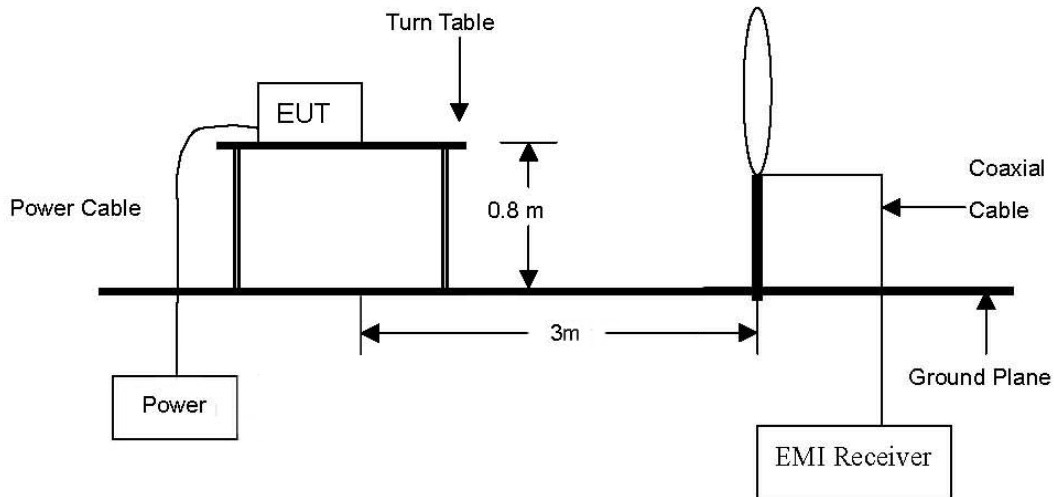


This report shall not be reproduced except in full, without the written approval of KES Co., Ltd.
 The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
 The authenticity of the test report, contact kes@kes.co.kr

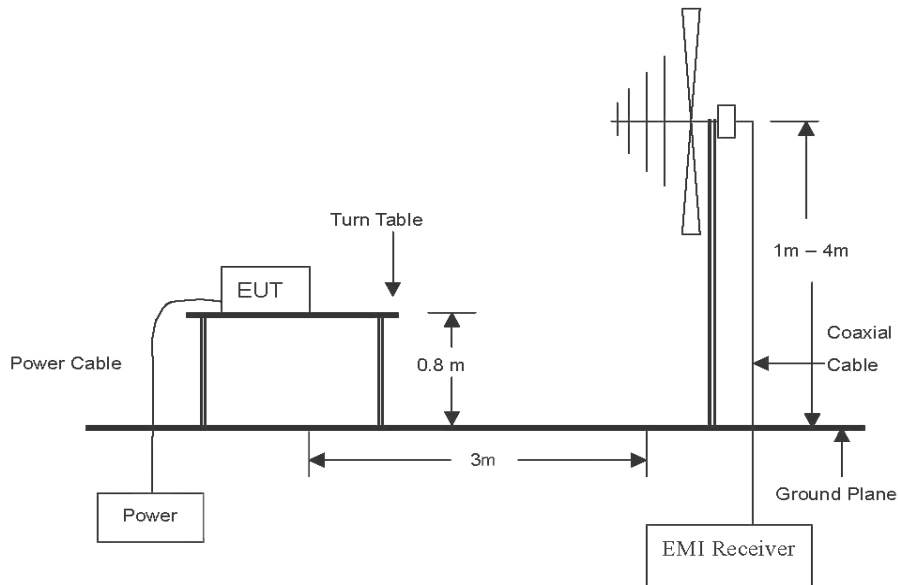
3.6. Radiated restricted band and emissions

Test setup

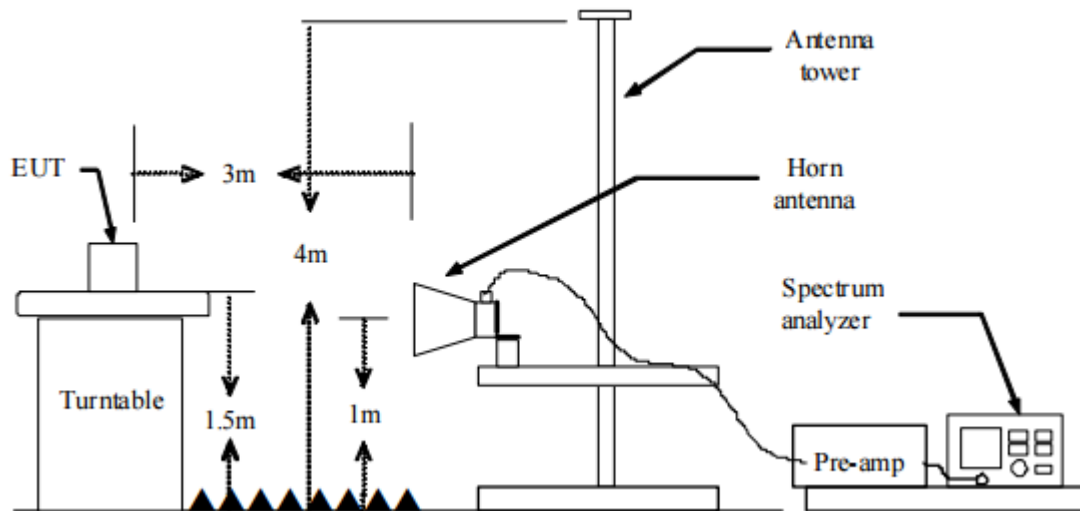
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions.



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



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

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 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, 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 MHz

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 $f < 1$ 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

6. 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
- ④ Detector = peak
- ⑤ Sweep time = auto
- ⑥ Trace = max hold
- ⑦ Trace was allowed to stabilize

7. Spectrum analyzer settings for $f \geq 1$ 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. Field strength(dB μ V/m) = Level(dB μ V) + CF (dB) + or DCF(dB)
3. Margin(dB) = Limit(dB μ V/m) - Field strength(dB μ V/m)
4. 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.

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 (μ 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.

Duty cycle

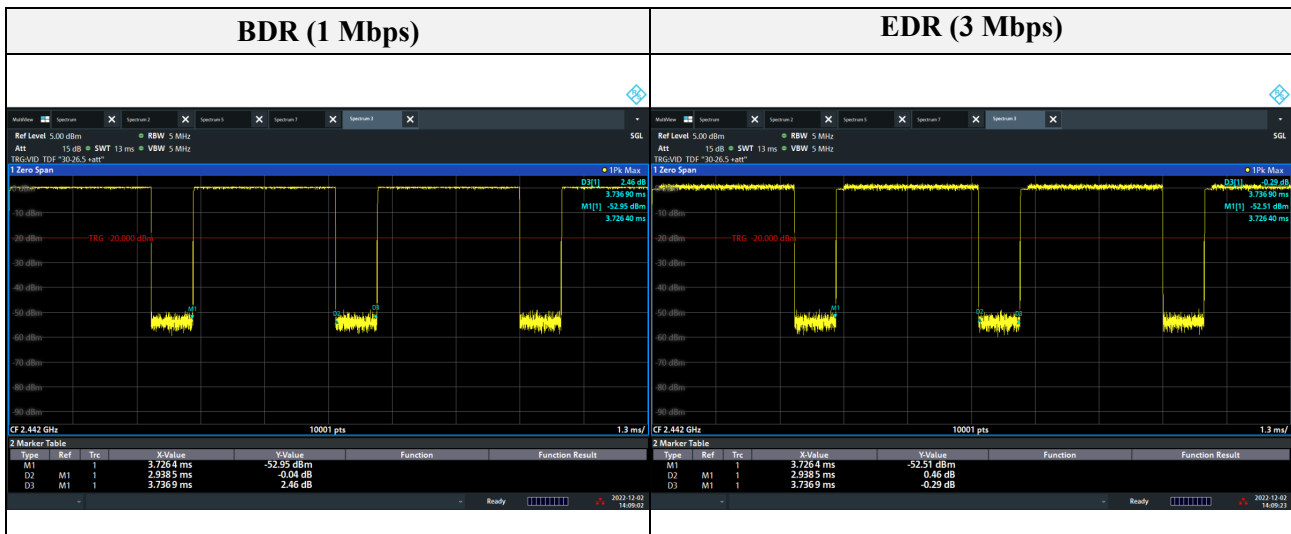
Regarding to KDB 558074 D01_v05 r02, 6. Measurements of duty cycle and transmission duration shall be performed using one of the following techniques:

- A 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.
- 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 (ms)	Period (ms)	Duty cycle (Linear)	Duty cycle (%)	Duty cycle correction factor (dB)
BDR(1 Mbps)	2.94	3.74	0.79	78.63	1.04
EDR(3 Mbps)	2.94	3.74	0.79	78.63	1.04

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

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





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

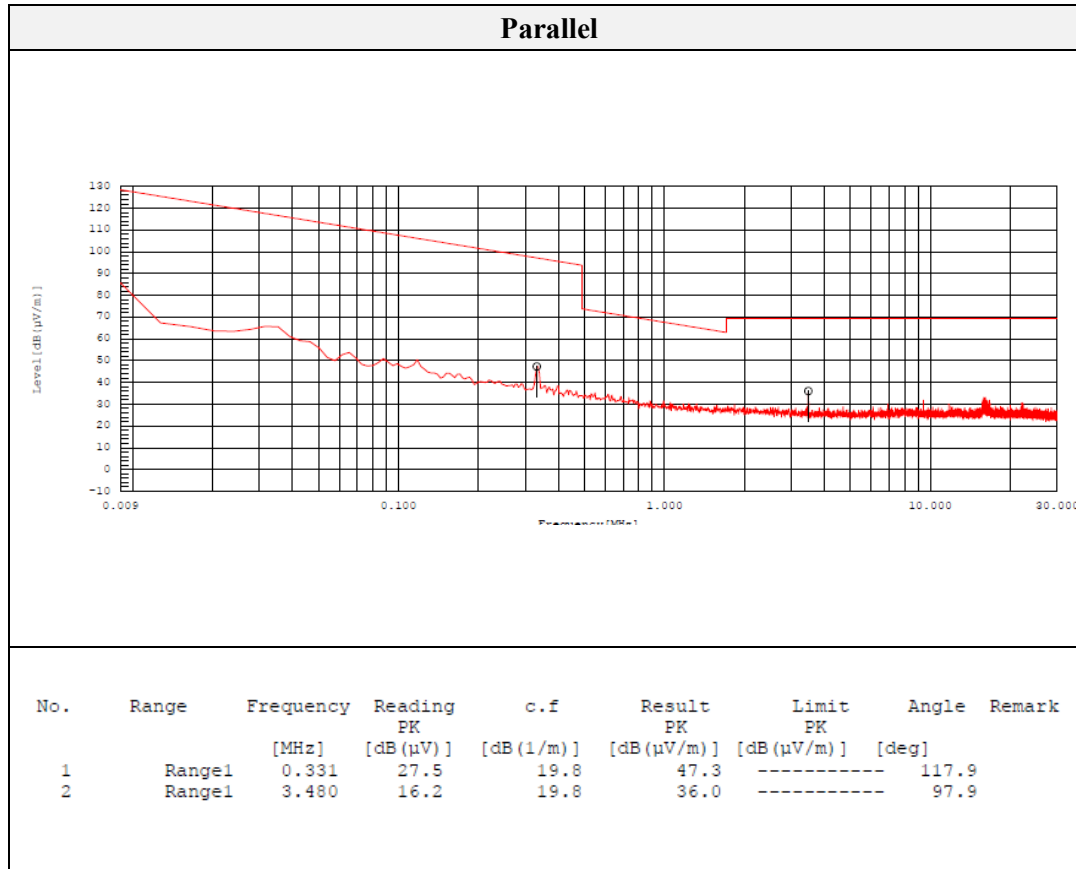
Report No.:

KES-RF-23T0012

Page (29) of (55)

Test results (Below 30 MHz)

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



Note.

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

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 kes@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

Report No.:

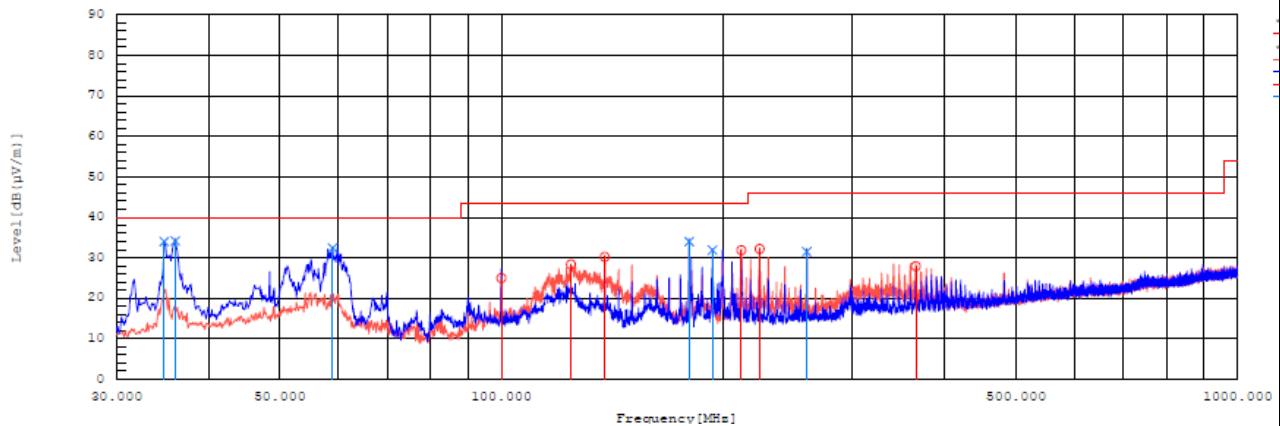
KES-RF-23T0012

Page (30) of (55)

Test results (Below 1 000 MHz) – Worst case

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

Horizontal // Vertical



Final Result

No.	Frequency	Pol	Reading	c.f	Result	Limit	Margin	Height	Angle	Remark
	[MHz]		QP		QP	QP	QP			
			[dB (μV)]	[dB (1/m)]	[dB (μV/m)]	[dB (μV/m)]	[dB]	[cm]	[deg]	
1	34.850	V	48.1	-14.1	34.0	40.0	6.0	112.0	269.0	
2	36.063	V	48.0	-13.8	34.2	40.0	5.8	124.0	337.2	
3	58.979	V	44.8	-12.4	32.4	40.0	7.6	132.0	0.0	
4	99.961	H	38.2	-13.2	25.0	43.5	18.5	325.0	222.6	
5	124.333	H	43.8	-15.4	28.4	43.5	15.1	242.0	114.5	
6	138.155	H	46.2	-16.0	30.2	43.5	13.3	156.0	224.7	
7	179.986	V	48.2	-14.2	34.0	43.5	9.5	117.0	72.2	
8	193.445	V	45.1	-13.2	31.9	43.5	11.6	111.0	225.8	
9	211.875	H	44.3	-12.4	31.9	43.5	11.6	226.0	26.9	
10	224.243	H	44.2	-12.0	32.2	46.0	13.8	100.0	45.3	
11	260.011	V	42.5	-11.0	31.5	46.0	14.5	134.0	345.2	
12	365.499	H	36.1	-8.2	27.9	46.0	18.1	105.0	22.8	

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 kes@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

Report No.:

KES-RF-23T0012

Page (31) of (55)

Test results (Above 1 000 MHz)

Mode: BDR

Distance of measurement: 3 meter

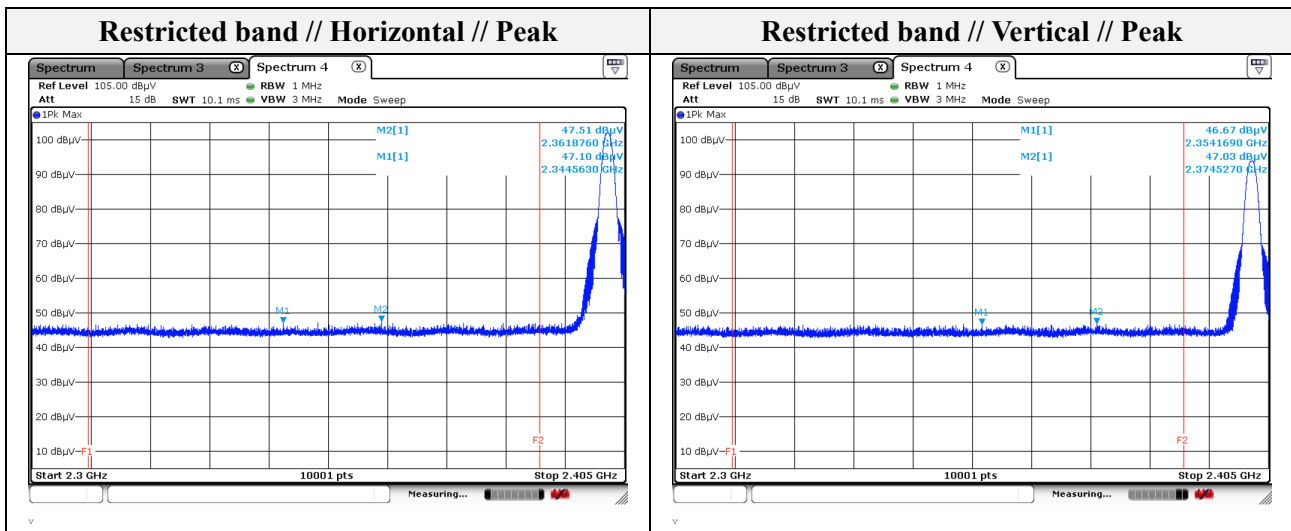
Channel: 00

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 117.09	46.63	Peak	V	-9.70	-	36.93	74.00	37.07
1 121.29	44.64	Peak	H	-9.68	-	34.96	74.00	39.04
1 416.86	44.76	Peak	H	-7.88	-	36.88	74.00	37.12
1 709.03	45.40	Peak	V	-5.16	-	40.24	74.00	33.76
4 803.60	46.90	Peak	H	4.70	-	51.60	74.00	22.40

- 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)
2 344.56	47.10	Peak	H	-1.75	-	45.35	74.00	28.65
2 354.17	46.67	Peak	V	-1.73	-	44.94	74.00	29.06
2 361.88	47.51	Peak	H	-1.72	-	45.79	74.00	28.21
2 374.53	47.03	Peak	V	-1.71	-	45.32	74.00	28.68



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 kes@kes.co.kr



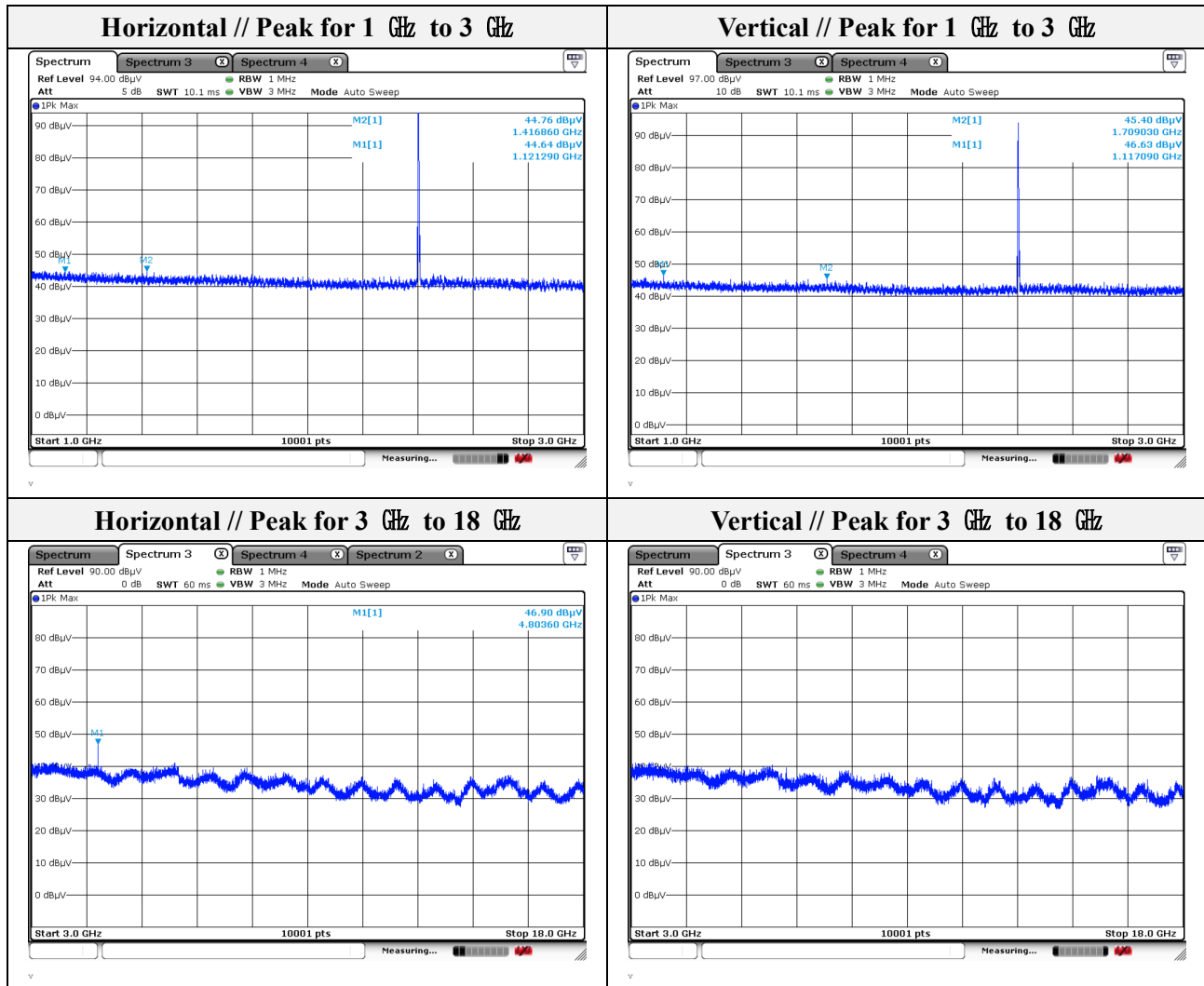
KES Co., Ltd.

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

Report No.:

KES-RF-23T0012

Page (32) of (55)



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 kes@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

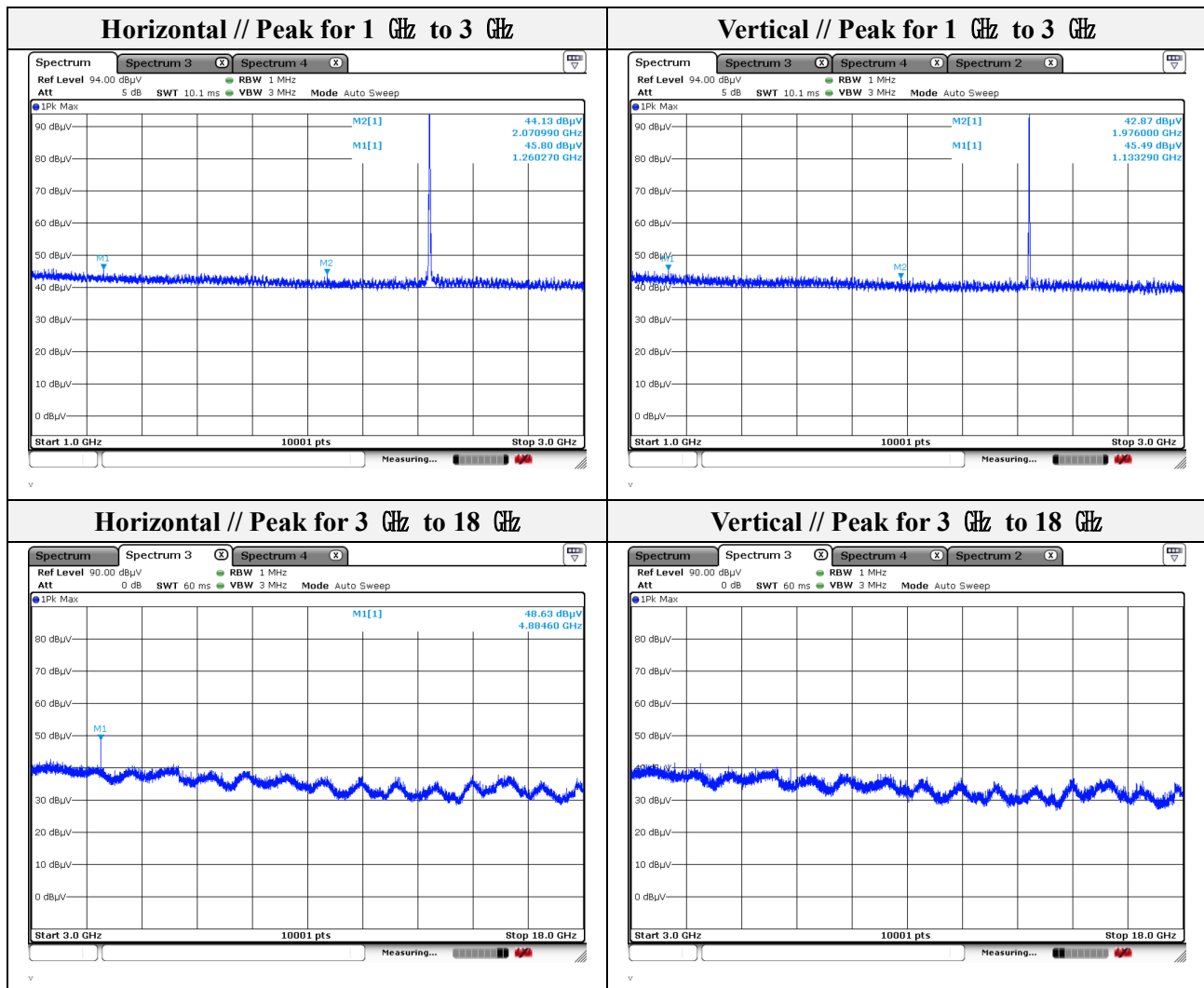
Report No.:

KES-RF-23T0012

Page (33) of (55)

Mode: BDR
Distance of measurement: 3 meter
Channel: 40

Frequency (MHz)	Level (dB μ V)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
1 133.29	45.49	Peak	V	-9.61	-	35.88	74.00	38.12
1 260.27	45.80	Peak	H	-8.83	-	36.97	74.00	37.03
1 976.00	42.87	Peak	V	-2.29	-	40.58	74.00	33.42
2 070.99	44.13	Peak	H	-2.01	-	42.12	74.00	31.88
4 884.60	48.63	Peak	H	5.32	-	53.95	74.00	20.05



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 kes@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

Report No.:

KES-RF-23T0012

Page (34) of (55)

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

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 012.10	44.50	Peak	V	-10.35	-	34.15	74.00	39.85
1 242.28	45.41	Peak	H	-8.94	-	36.47	74.00	37.53
1 895.01	44.37	Peak	V	-3.12	-	41.25	74.00	32.75
1 966.00	43.91	Peak	H	-2.39	-	41.52	74.00	32.48
4 961.10	45.61	Peak	H	5.91	-	51.52	74.00	22.48

- Band edge

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 483.52	67.05	Peak	H	-1.67	-	65.38	74.00	8.62
2 483.52	43.99	Average	H	-1.67	1.04	43.36	54.00	10.64
2 483.55	58.89	Peak	V	-1.67	-	57.89	74.00	16.11
2 483.55	37.72	Average	V	-1.67	1.04	37.09	54.00	16.91
2 483.65	57.86	Peak	V	-1.67	-	56.19	74.00	17.81
2 483.65	36.83	Average	V	-1.67	1.04	36.2	54.00	17.80
2 483.72	65.46	Peak	H	-1.67	-	63.79	74.00	10.21
2 483.72	43.20	Average	H	-1.67	1.04	42.57	54.00	11.43

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 kes@kes.co.kr