



TEST REPORT



Report No. : KES-RF-23T0153
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KES Co., Ltd.
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■ FCC&IC TEST REPORT

1. Client

- Name : THINKWARE CORPORATION
- Address : A, 9FL., Samwhan Hipex, 240, Pangyoyeok-ro, Bundang-gu, Seongnam-si,
Gyeonggi-do, South Korea

2. Sample Description

- Product item : CAR BLACK BOX
- Model name : ARC
- Manufacturer etc. : THINKWARE CORPORATION

3. Date of test : 2023.10.31 ~ 2023.11.06

4. Location of Test : ☒ Permanent Testing Lab ☐ On Site Testing

- Address : 473-29, Gayeo-ro, Yeosu-si, Gyeonggi-do, Korea

5. Test method used : Part 15.247 & RSS-247 (Issue 3)

6. Test result : PASS

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
This laboratory is not accredited for the test results marked*.

This test report is not related to KOLAS accreditation.

Affirmation	Tested by		Technical Manager	
	Name : Bong-Seok Kim	(Signature)	Name : Yeong-Jun Cho	(Signature)

2023 . 11. 30.

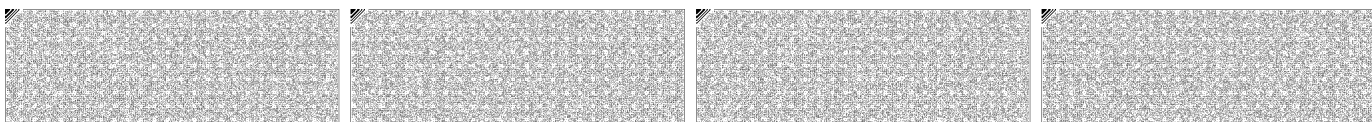
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Accredited by KOLAS, Republic of KOREA

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REPORT REVISION HISTORY

Date	Test Report No.	Revision History
2023.11.30	KES-RF-23T0153	Initial

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Use of uncertainty of measurement for decisions on conformity (decision rule):

☒ No decision rule is specified by the standard, when comparing the measurement result with the applicable limit according to the specification in that standard. The decisions on conformity are made without applying the measurement uncertainty("simple acceptance" decision rule, previously known as "accuracy method").

☐ Other (to be specified, for example when required by the standard or client)

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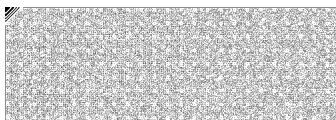
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1. General information

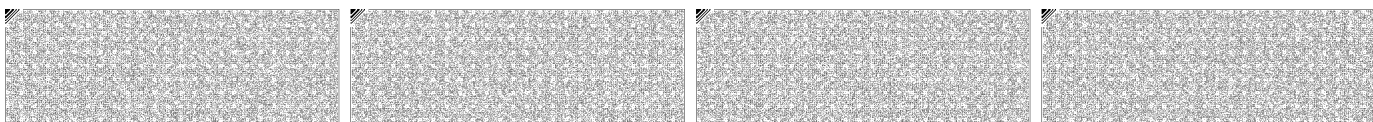
Applicant: THINKWARE CORPORATION
 Applicant address: A, 9FL., Samwhan Hipex, 240, Pangyoyeok-ro, Bundang-gu, Seongnam-si, Gyeonggi-do, South Korea
 Test site: KES Co., Ltd.
 Test site address: ☐ 3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, 14057, Korea
☒ 473-21, Gayeo-ro, Yeoju-si, Gyeonggi-do, Korea
 Test Facility: FCC Accreditation Designation No.: KR0100, Registration No.: 444148
 ISED Registration No.: 23298
 FCC rule part(s): FCC: 15.247
 IC rule part(s): IC : RSS-247
 FCC ID: 2ADTG-ARC
 IC ID: 12594A-ARC
 Test device serial No.: ☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test: CAR BLACK BOX
 Frequency range: 2 412 MHz ~ 2 462 MHz (802.11b,g,n_HT20)
 2 422 MHz ~ 2 452 MHz (802.11n_HT40)
 Model: ARC
 Variant Model: -
 Modulation technique: DSSS, OFDM
 Number of channels: 2 412 MHz ~ 2 462 MHz (802.11b,g,n_HT20) : 11 ch
 2 422 MHz ~ 2 452 MHz (802.11n_HT40) : 7 ch
 Antenna specification: Chip Antenna // Peak gain: 1.99 dBi
 Power source: DC 12 V / 24 V
 H/W Version: V4.0
 S/W Version: V1.00.00
 S/N: 6QAN9A008841A

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1.2. Test configuration

The **THINKWARE CORPORATION // CAR BLACK BOX // ARC // FCC ID: 2ADTG-ARC //**

IC ID: 12594A-ARC was tested according to the specification of EUT, the EUT must comply with following standards and KDB documents.

FCC Part 15.247

ISED RSS-247 Issue 3 and RSS-Gen Issue 5

KDB 558074 D01 v05 r02

ANSI C63.10-2013

1.3. Information about derivative model

N/A

1.4. Accessory information

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

1.5. Sample calculation

Where relevant, the following sample calculation is provided

For all conducted test items :

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor

between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

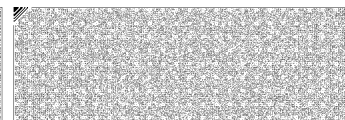
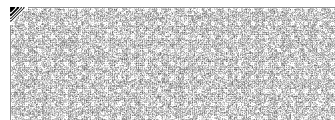
$$\begin{aligned}\text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)} \\ &= 0.72 + 10 = 10.72 \text{ (dB)}\end{aligned}$$

For Radiation test :

$$\text{Field strength level (dB}\mu\text{V/m)} = \text{Measured level (dB}\mu\text{V)} + \text{Antenna factor (dB)} + \text{Cable loss (dB)} - \text{Amplifier gain (dB)}$$

1.6. Measurement Uncertainty

Test Item		Uncertainty
Uncertainty for Conduction emission test		2.22 dB (SHIELD ROOM #6)
Uncertainty for Radiation emission test (include Fundamental emission)	Below 1GHz	4.04 dB (SAC #6)
	Above 1GHz	5.32 dB (SAC #5)
Note. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.		



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1.7. Frequency/channel operations

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

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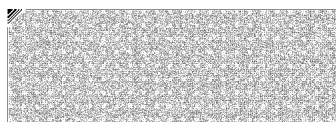
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2. Summary of tests

Section in FCC Part 15	Section in RSS-247 & Gen	Test description	Test results
-	RSS-Gen 6.7	99% Occupied bandwidth	N/T ^{note1}
15.247(a)(2)	RSS-247 5.2(a)	6 dB bandwidth	N/T ^{note1}
15.247(b)(3)	RSS-247 5.4(d)	Output power	Pass
15.247(e)	RSS-247 5.2(b)	Power spectral density	N/T ^{note1}
15.205 15.209	RSS-247 5.5 RSS-Gen 8.9,8,10	Radiated restricted band and emission	Pass
15.247(d)	RSS-247 5.5	Conducted spurious emission and band edge	N/T ^{note1}
15.207(a)	RSS-Gen 8.8	AC Conducted emissions	N/T ^{note3}
15.203	-	Antenna Requirement	Pass ^{note4}

N/T: Not Tested**Note**

1. This product is equipped with an approved module, please refer to Module Report below for details.
Report No.
FCC : AGC13525220401FE05
IC : AGC13525220301CE05
2. Tested in Worst Case mode.
3. This EUT is a product that operates using only DC power.
4. Please check the antenna spec. for the Antenna Requirement.



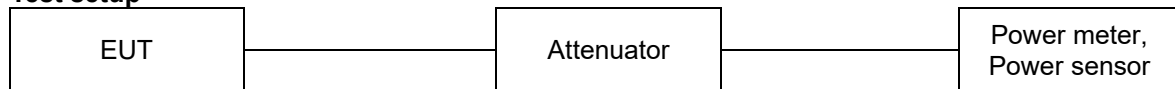
3. Test results

3.1. Output power

Test procedure

ANSI C63.10-2013 - Section 11.9.1.3 and 11.9.2.3.2

Test setup



ANSI C63.10-2013 - Section 11.9.1.3

The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall use a fast-responding diode detector.

ANSI C63.10-2013 - Section 11.9.2.3.2

Alternatively, measurements may be performed using a wideband gated RF power meter provided that the gate parameters are adjusted such that the power is measured only when the EUT is transmitting at its maximum power control level. Because the measurement is made only during the ON time of the transmitter, no duty cycle correction is required.

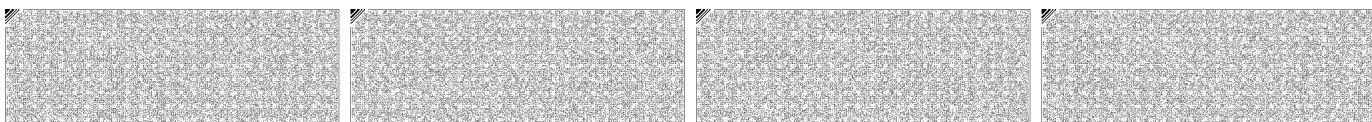
Limit

According to §15.247(b)(3), For systems using digital modulation in the 902~928 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.

Limit

According to RSS-247 5.4 (d), For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.



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Test results**DC 12 V**

Mode	2 412 MHz		2 437 MHz		2 462 MHz	
	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)
802.11b	14.39	16.79	14.92	17.33	14.61	17.04
802.11g	12.99	22.34	13.38	22.71	11.19	20.93
802.11n_HT20	12.93	21.47	12.17	20.68	13.58	22.95

Mode	2 422 MHz		2 437 MHz		2 452 MHz	
	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)
802.11n_HT40	13.67	22.14	11.88	20.51	12.61	21.22

DC 24 V

Mode	2 412 MHz		2 437 MHz		2 462 MHz	
	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)
802.11b	14.98	17.39	15.26	17.63	14.91	17.38
802.11g	13.45	22.82	13.79	23.19	11.68	21.44
802.11n_HT20	13.41	22.52	11.45	20.86	14.03	23.07

Mode	2 422 MHz		2 437 MHz		2 452 MHz	
	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)
802.11n_HT40	14.25	22.59	12.43	21.18	13.28	21.56

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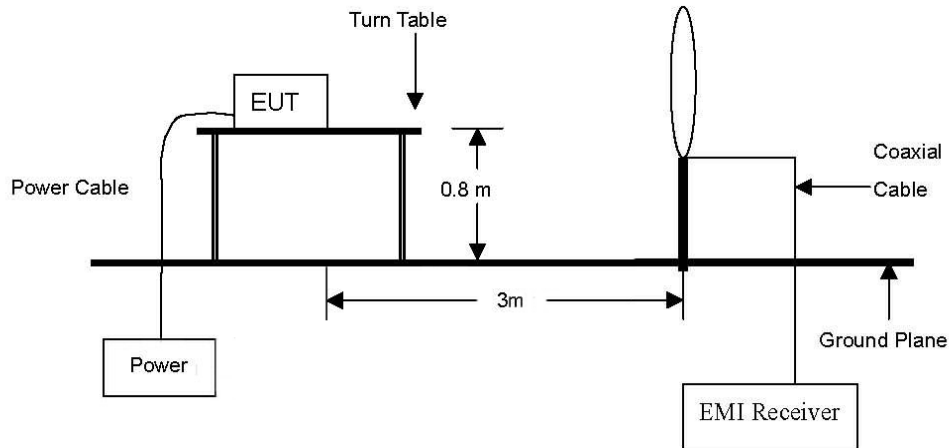
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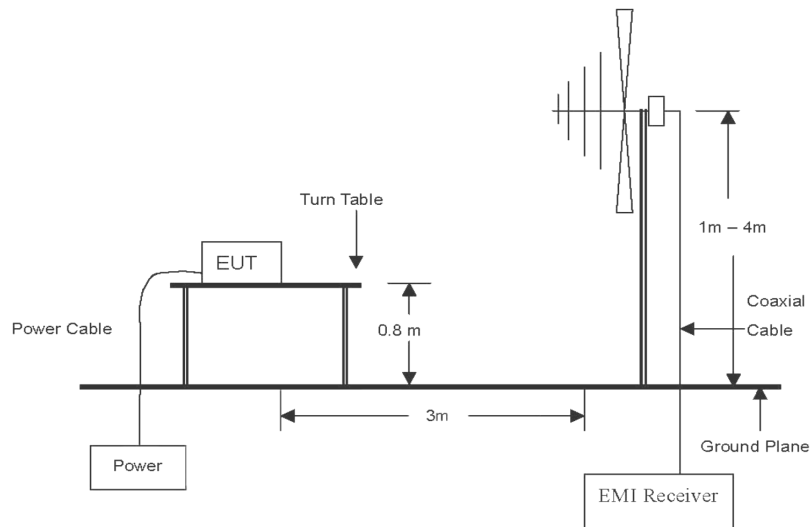
3.2. Radiated restricted band and emissions

Test setup

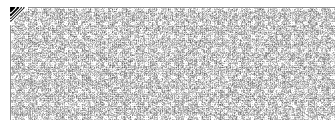
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions.

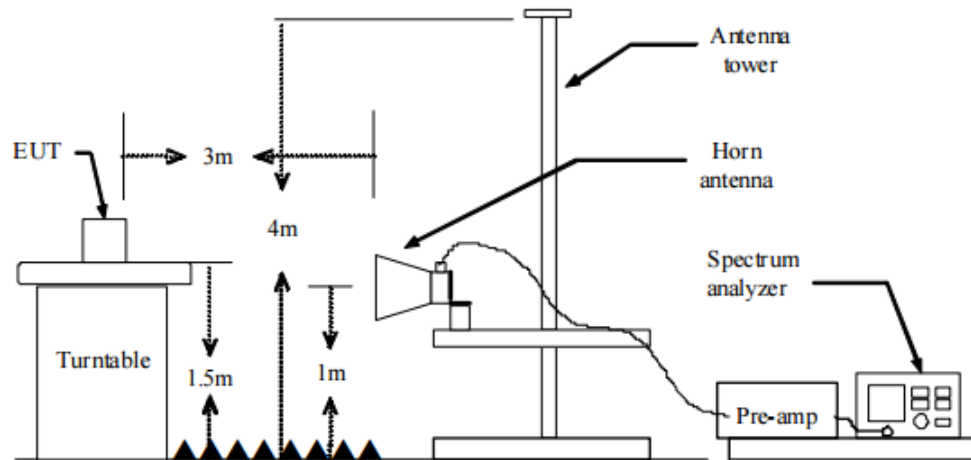


The diagram below shows the test setup that is utilized to make the measurements for emission from 30 MHz to 1 GHz emissions.



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.

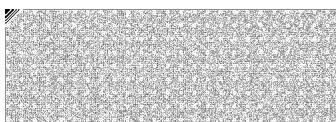
Test procedure above 30 MHz ~ 1 000 MHz

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. 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.



Test procedure above 1 000 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 $\geq$ 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. 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.

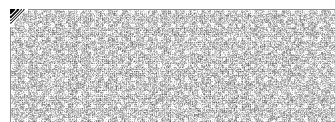
1. $f < 30$ MHz, extrapolation factor of 40 dB/decade of distance. $F_d = 40\log(D_m/D_s)$
 $f \geq 30$ MHz, extrapolation factor of 20 dB/decade of distance. $F_d = 20\log(D_m/D_s)$
 Where:
 F_d = Distance factor in dB
 D_m = Measurement distance in meters
 D_s = Specification distance in meters
2. 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.
5. The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z, it was determined that **X orientation** was worst-case orientation; therefore, all final radiated testing was performed with the EUT in **X orientation**.
6. The worst-case emissions are reported however emissions whose levels were not within 20 dB of respective limits were not reported.
7. 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	2 400/F(kHz)
0.490 ~ 1.705	30	24 000/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.



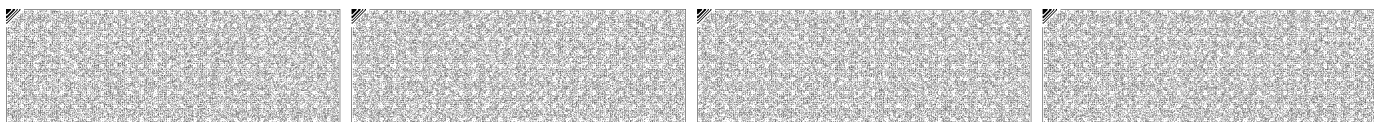
Limit

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

Frequency (MHz)	Distance (Meters)	Radiated ($\mu\text{V/m}$)
0.009 ~ 0.490	300	2 400 / F(kHz)
0.490 ~ 1.705	30	24 000 / F(kHz)
1.705 ~ 30.0	30	30
30 ~ 88	3	100
88 ~ 216	3	150
216 ~ 960	3	200
Above 960*	3	500

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

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



Duty cycle

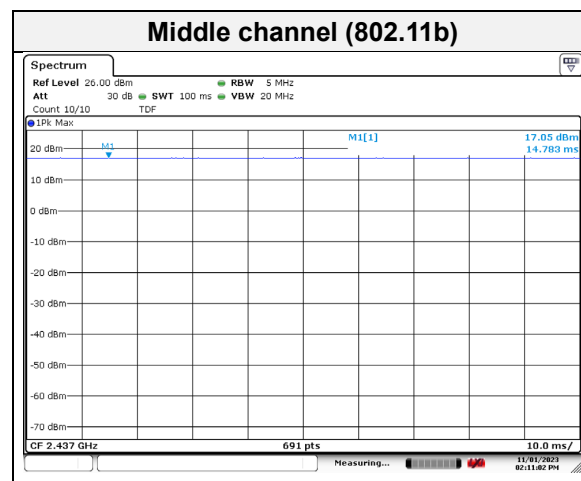
Regarding to KDB 558074 D01_v05 r02, 6. Measurements of duty cycle and transmission duration shall be performed using one of the following techniques:

- A 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)
802.11b	100	100	1.00	100.00	0.00

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

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

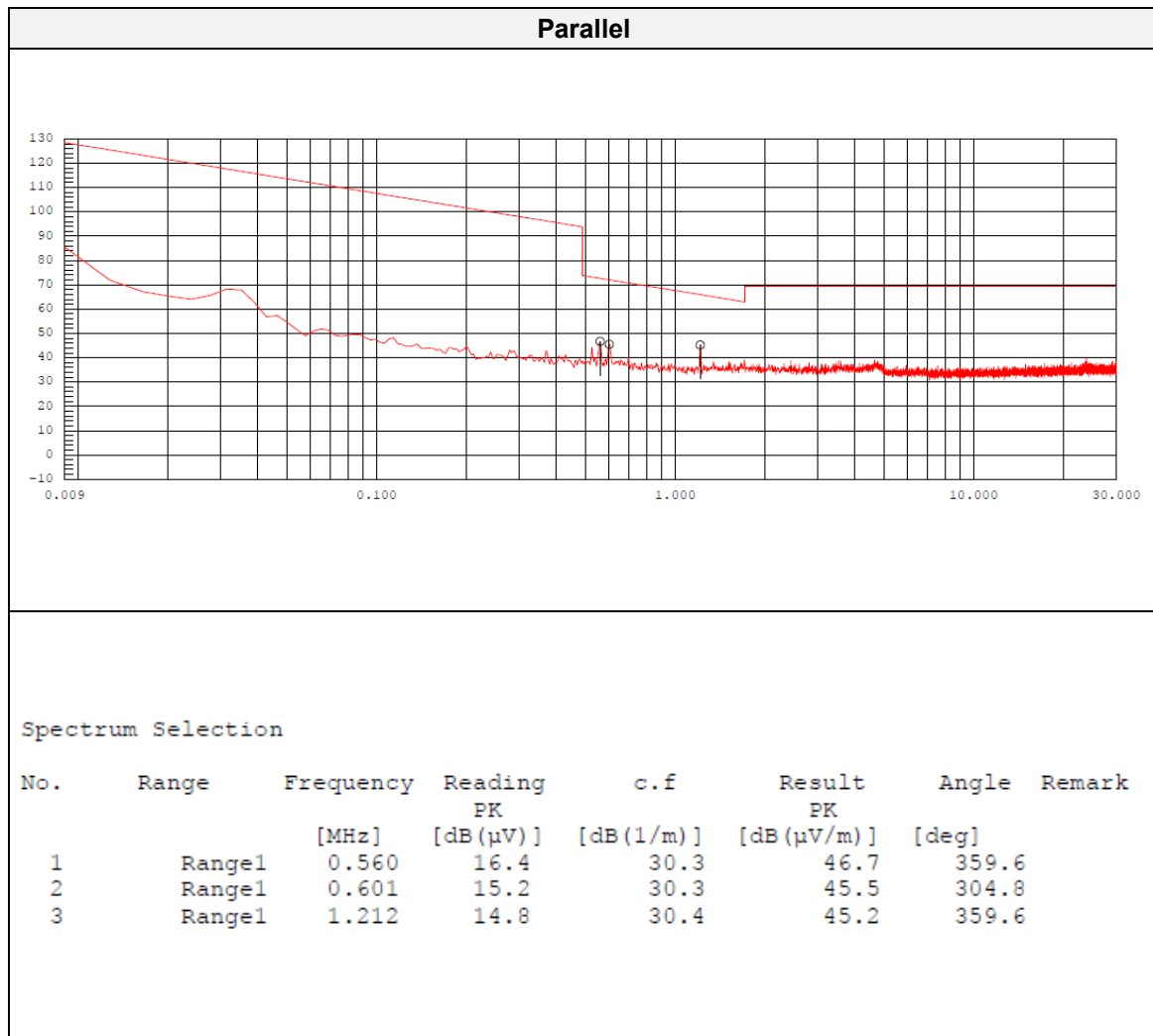


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Test results (Below 30 MHz)

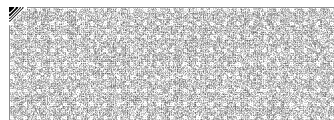
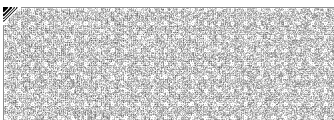
Mode: 802.11b_DC 12V
Distance of measurement: 3 meter
Channel: 06 (Worst case)



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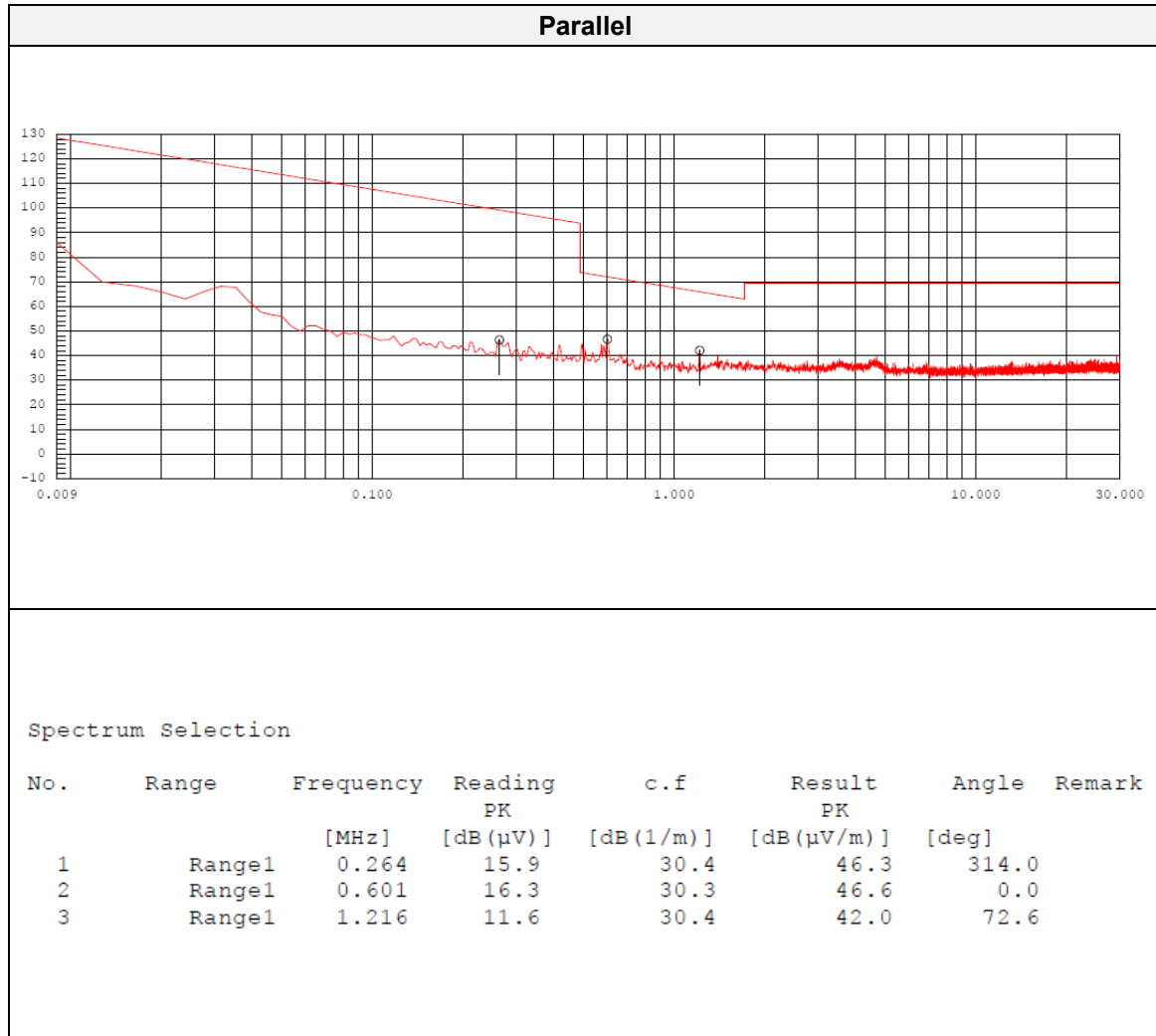
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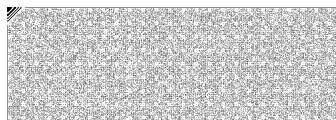
Mode: 802.11b_DC 24V
Distance of measurement: 3 meter
Channel: 06 (Worst case)



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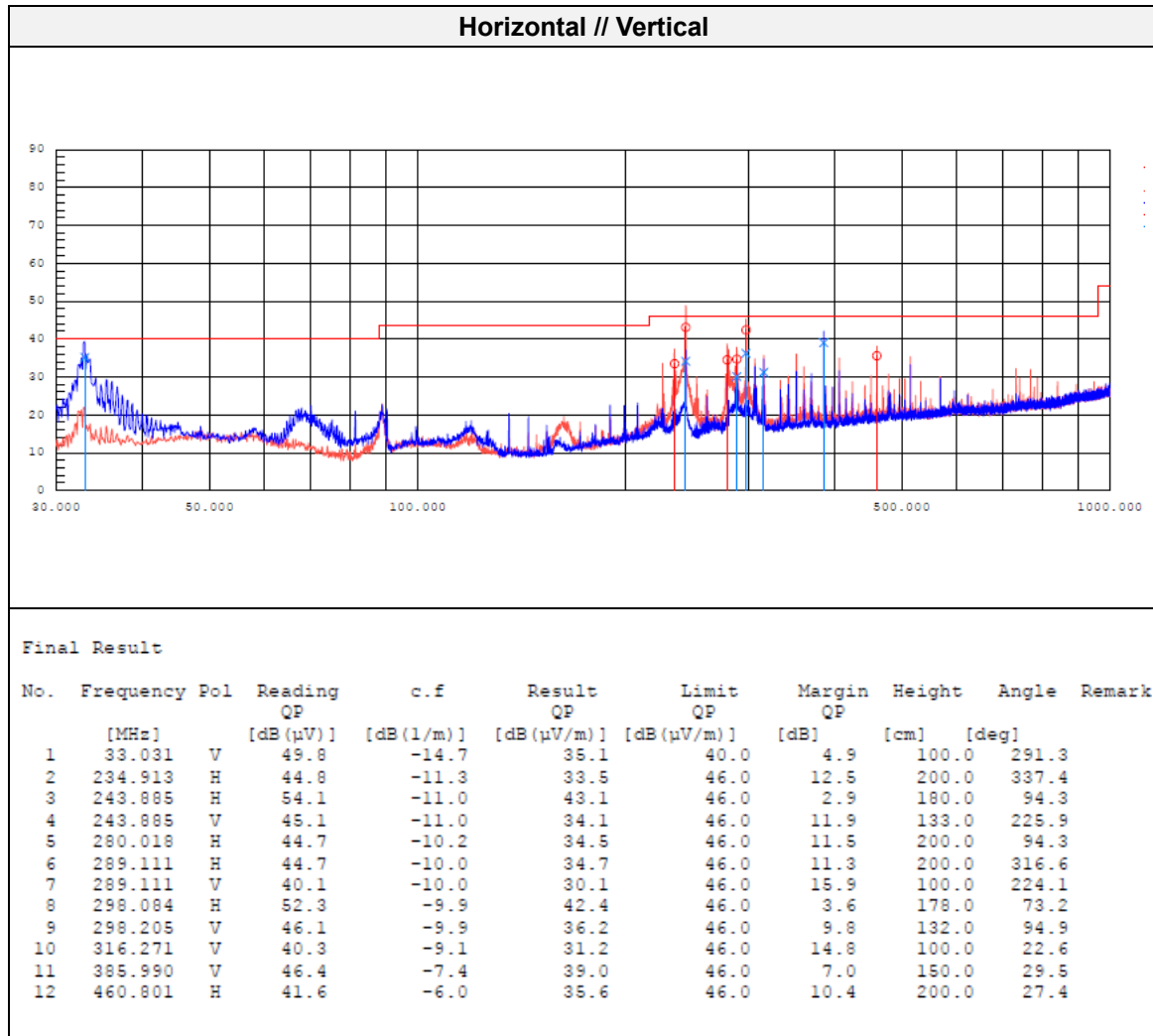


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Test results (Below 1 000 MHz)

Mode: 802.11b_DC 12V
 Distance of measurement: 3 meter
 Channel: 06 (Worst case)



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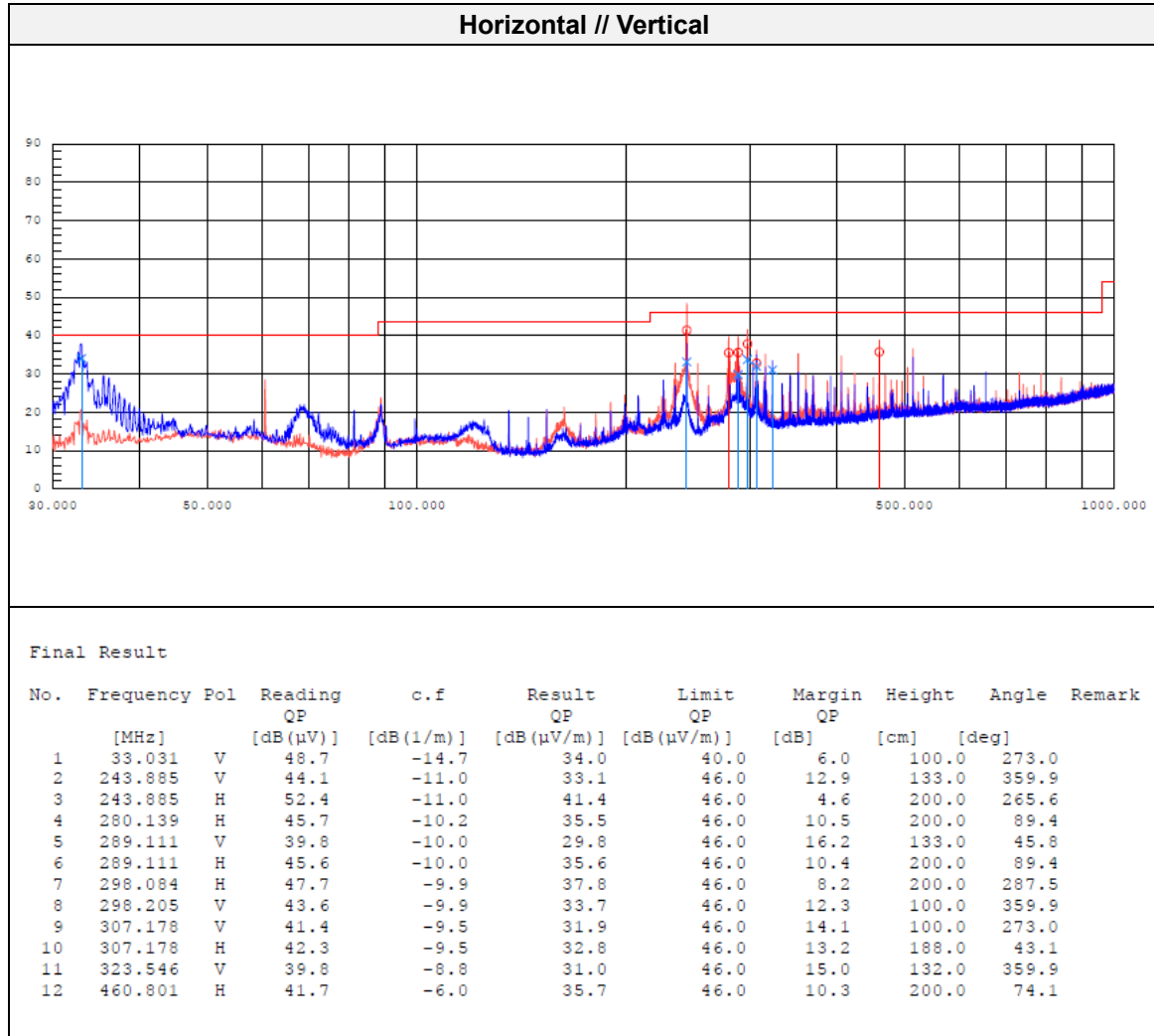
The authenticity of the test report, contact kes@kes.co.kr



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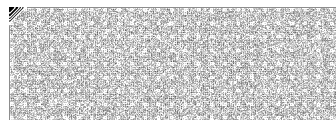
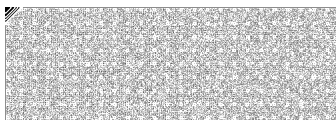
Mode: 802.11b_ DC 24V
Distance of measurement: 3 meter
Channel: 06 (Worst case)



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Test results (Above 1 000 MHz)

Mode: 802.11b(Worst Case)_ DC 12V

Distance of measurement: 3 meter

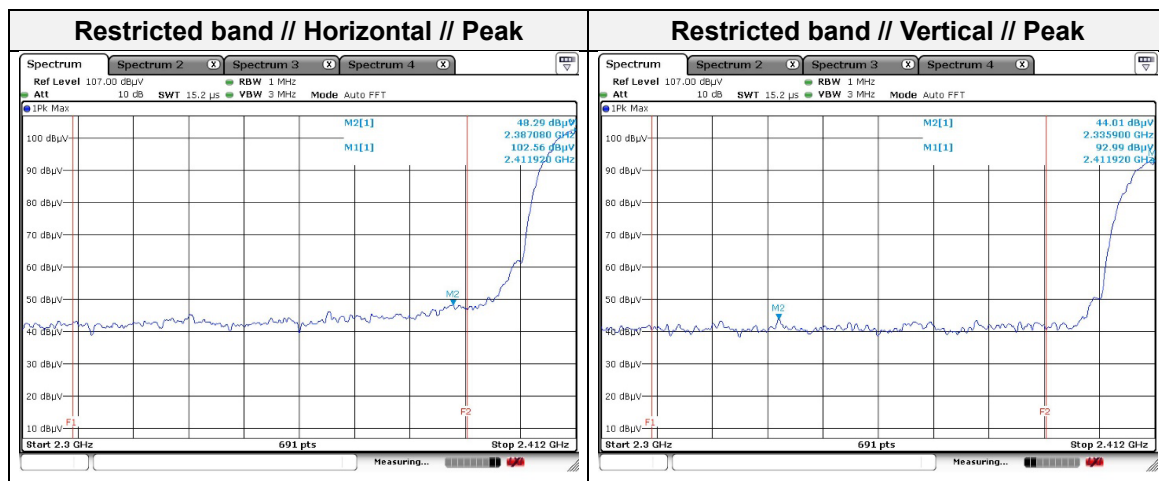
Channel: 00

- Spurious

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)
1 102.70	45.80	Peak	H	-8.89	-	36.91	74.00	37.09
1 328.50	47.59	Peak	V	-7.34	-	40.25	74.00	33.75

- Band edge

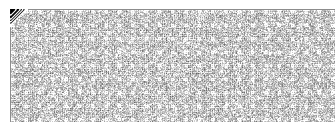
Frequency (MHz)	Level (dB μ V)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2 335.90	44.01	Peak	V	-0.83	-	43.18	74.00	30.82
2 387.08	48.29	Peak	H	-0.73	-	47.56	74.00	26.44

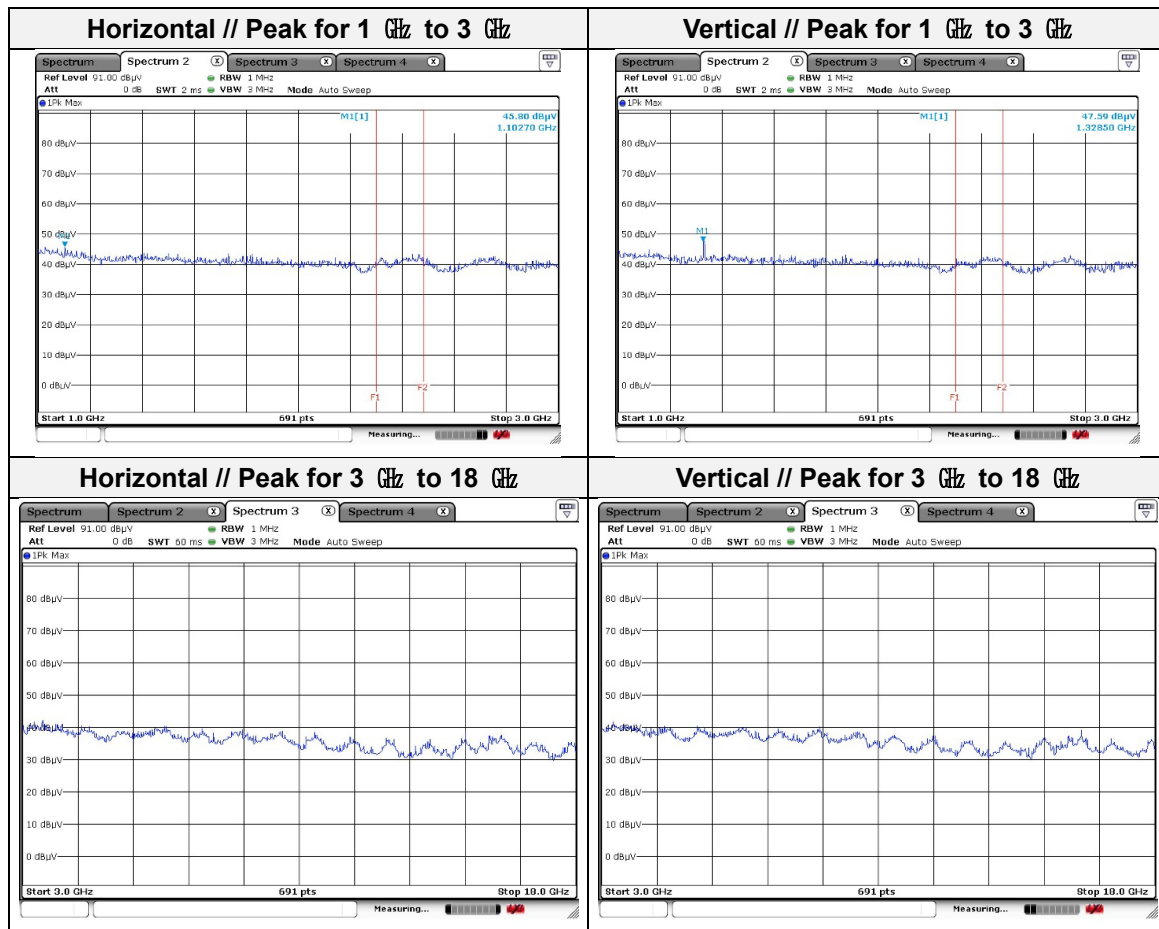


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Note.

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



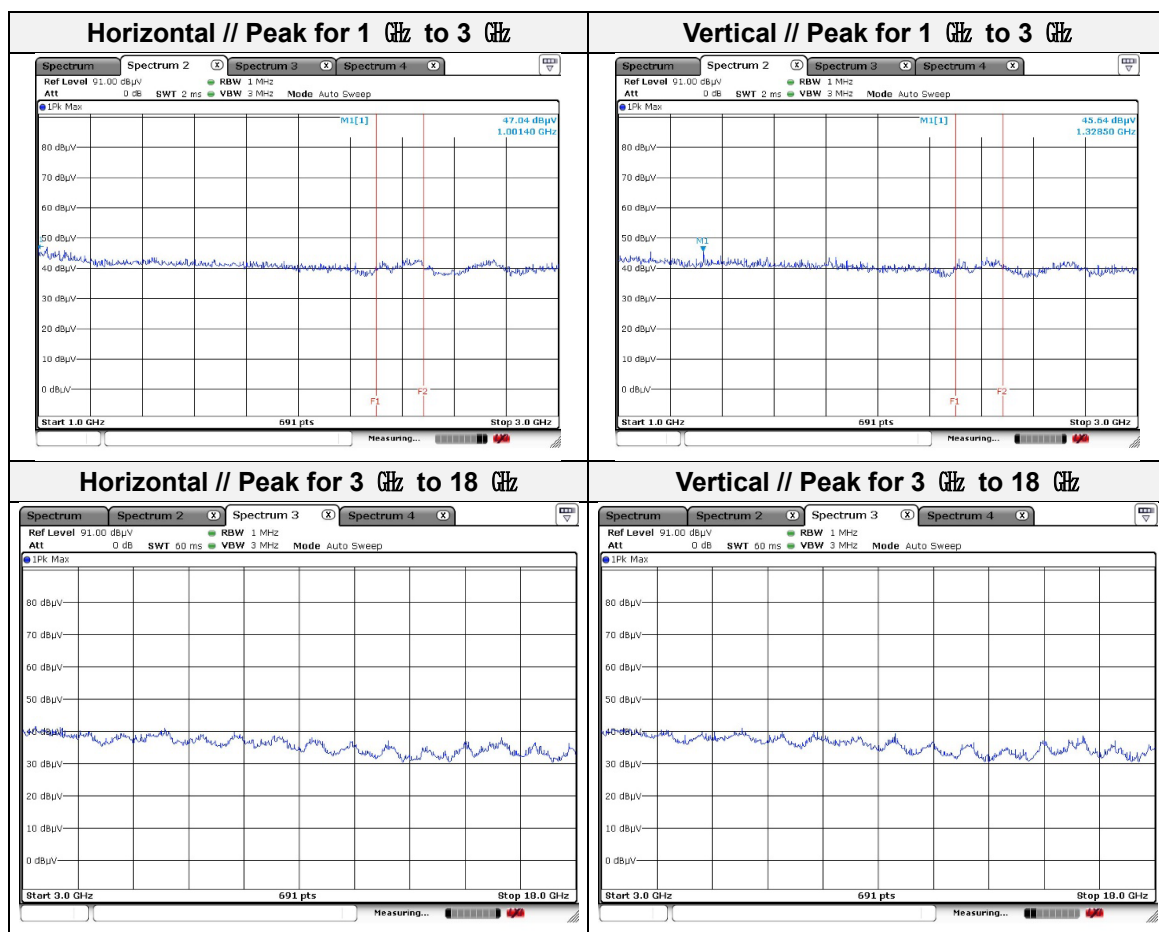
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Mode: 802.11b(Worst Case)_ DC 12V
 Distance of measurement: 3 meter
 Channel: 06

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 001.40	47.04	Peak	H	-9.59	-	37.45	74.00	36.55
1 328.50	45.64	Peak	V	-7.34	-	38.30	74.00	35.70



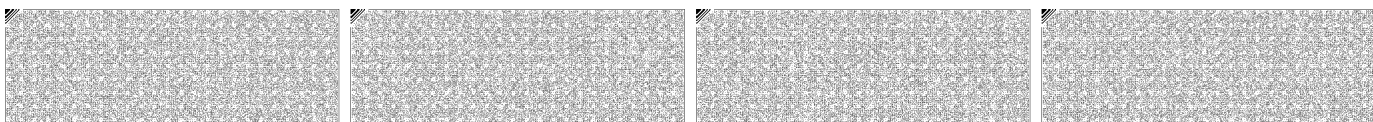
Note.

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

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Mode: 802.11b(Worst Case)_ DC 12V

Distance of measurement: 3 meter

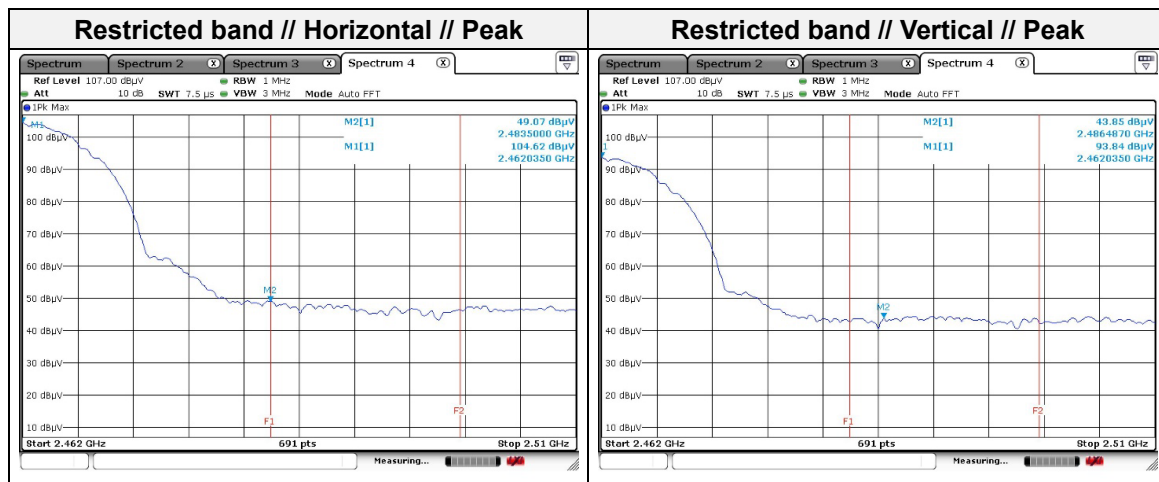
Channel: 11

- Spurious

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)
1 001.40	47.23	Peak	H	-9.59	-	37.64	74.00	36.36
1 328.50	46.47	Peak	V	-7.34	-	39.13	74.00	34.87

- Band edge

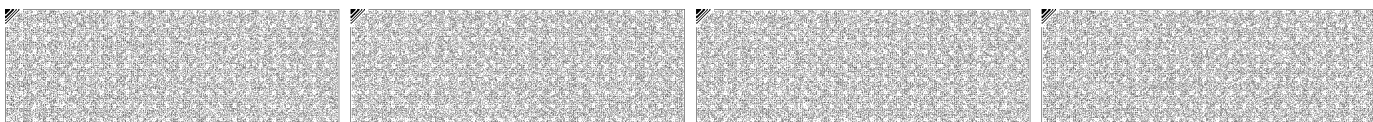
Frequency (MHz)	Level (dB μ V)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2 483.50	49.07	Peak	H	-0.57	-	48.50	74.00	25.50
2 486.49	43.85	Peak	V	-0.57	-	43.95	74.00	30.05

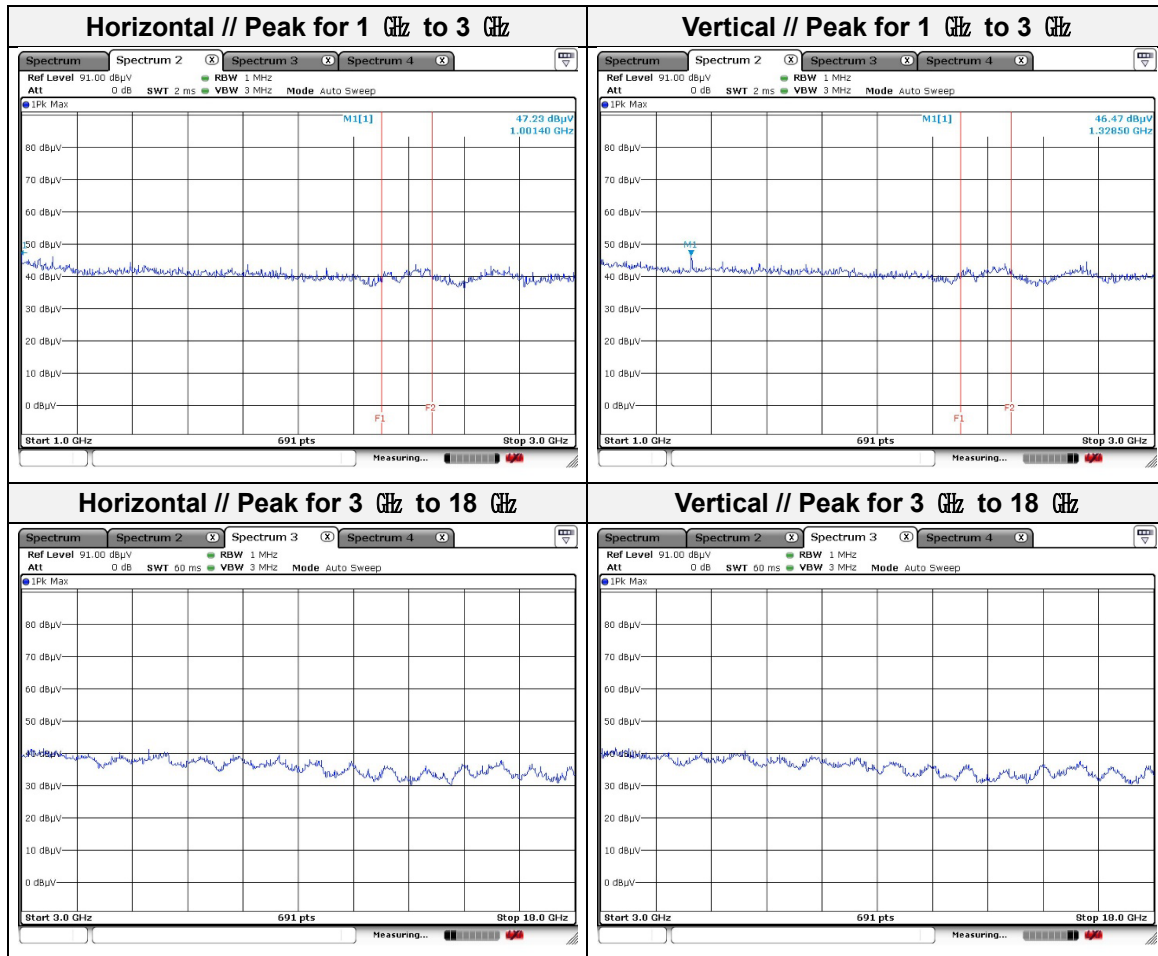


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Note.

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



Report No. : KES-RF-23T0153

Test results (18 GHz to 30 GHz)

Mode: 802.11b(Worst Case)_ DC 12V
Distance of measurement: 3 meter
Channel: 06 (Worst case)

