





TEST REPORT

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| <p>Eurofins KCTL Co.,Ltd. 65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea TEL: 82-70-5008-1021 FAX: 82-505-299-8311 www.kctl.co.kr</p> | <p>Report No.: KR23-SRF0236-A Page (1) of (34)</p> |   |
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1. Client

- Name : ITOFROM
- Address : 5F DS Building 8, Dogok-ro 7-gil Gangnam-gu, Seoul,06255, Korea
- Date of Receipt : 2023-08-23

2. Use of Report : Certification

3. Name of Product / Model : Data Terminal(Collection Device) / NDT23

4. Manufacturer / Country of Origin : ITOFROM / Korea



5. FCC ID : 2BC8U-I2F-NDT23

6. Date of Test : 2023-09-20 to 2023-11-03

7. Location of Test : Permanent Testing Lab On Site Testing
 (Address:65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea)

8. Test method used : FCC Part 15 Subpart C, 15.247


9. Test Result : Refer to the test result in the test report

| | | |
|-------------|---|--|
| Affirmation | Tested by | Technical Manager |
| | Name : Eunseong Lim (Signature)  | Name : Heesu Ahn (Signature)  |

2023-11-14

Eurofins KCTL Co.,Ltd.

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REPORT REVISION HISTORY

| Date | Revision | Page No |
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| 2023-11-08 | Originally issued | - |
| 2023-11-14 | Updated | 15 |
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Note. The report No. KR23-SRF0236 superseded by the report No. KR23-SRF0236-A.

General remarks for test reports

Statement concerning the uncertainty of the measurement systems used for the tests

(may be required by the product standard or client)

Internal procedure used for type testing through which traceability of the measuring uncertainty has been established:

Procedure number, issue date and title:

Calculations leading to the reported values are on file with the testing laboratory that conducted the testing.

Statement not required by the standard or client used for type testing

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1. General information

Client : ITOFROM
Address : 5F DS Building 8, Dogok-ro 7-gil Gangnam-gu, Seoul,06255, Korea
Manufacturer : ITOFROM
Address : 5F DS Building 8, Dogok-ro 7-gil Gangnam-gu, Seoul,06255, Korea
Laboratory : Eurofins KCTL Co.,Ltd.
Address : 65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea
Accreditations : FCC Site Designation No: KR0040, FCC Site Registration No: 687132
VCCI Registration No. : R-20080, G-20078, C-20059, T-20056
Industry Canada Registration No. : 8035A
KOLAS No.: KT231

2. Device information

Equipment under test : Data Terminal(Collection Device)
Model : NDT23
Modulation technique : O-QPSK (Zigbee)
Number of channels : 16 ch
Power source : DC 12 V
Antenna specification : Dipole Antenna
Antenna gain : 3.39 dBi
Frequency range : 2 405 MHz ~ 2 480 MHz
Software version : Linux am335x 4.4.36
Hardware version : 1.0
Test device serial No. : LTM2315NRL008
Operation temperature : 0 °C ~ 50 °C

2.1. Accessory information

| Equipment | Manufacturer | Model | Serial No. | Power source | FCC ID |
|---------------|--|----------------|------------|--|--------|
| AC/DC Adaptor | Shenzhen Perfect Gallant Tec Co., Ltd. | PG241-1202000I | - | Input: 110-240V ~ 50/60 Hz 0.8A Output: 12 V=2.0A 24.0W | - |

2.2. Frequency/channel operations

This device contains the following capabilities:

Bluetooth Low Energy, Zigbee

| Ch. | Frequency (MHz) |
|-----|-----------------|
| 15 | 2 405 |
| ⋮ | ⋮ |
| 20 | 2 440 |
| ⋮ | ⋮ |
| 25 | 2 480 |

Table 2.2.1. Zigbee mode

2.3 RF power setting in TEST SW

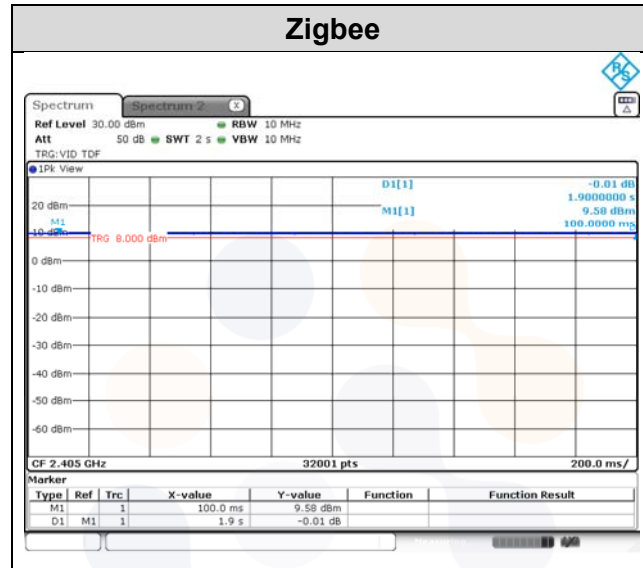
| Test Mode | Ch. | Frequency (MHz) | Power Setting | Test Program |
|-----------|-----|-----------------|---------------|------------------|
| Zigbee | 15 | 2 405 | -2 | Smart RF Studio7 |
| | 20 | 2 440 | | |
| | 25 | 2 480 | | |

2.4. Duty Cycle Factor

| Test mode | Period (ms) | T _{on} time (ms) | Duty cycle | | Duty Cycle Factor (dB) |
|------------|-------------|---------------------------|------------|-----|------------------------|
| | | | (Linear) | (%) | |
| Zigbee_ANT | 100.00 | 100.00 | 1.00 | 100 | 0.00 |

Notes.

1. Duty cycle (Linear) = T_{on} time / Period
2. DCF(Duty cycle factor) = 10log(1/duty cycle)
3. DCF is not compensated to average result if the duty cycle is more than 98%



3. Antenna requirement

Requirement of FCC part section 15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

- The transmitter has permanently attached Dipole Antenna (External antenna) on board.
- The E.U.T Complies with the requirement of §15.203, §15.247.



4. Summary of tests

| FCC Part section(s) | Parameter | Test Condition | Test results |
|-------------------------|------------------------------|----------------|--------------|
| 15.247(b)(3) | Maximum Peak Output Power | Conducted | Pass |
| 15.247(e) | Peak Power Spectral Density | | Pass |
| 15.247(a)(2) | 6 dB Channel Bandwidth | | Pass |
| 15.207(a) | AC Conducted Emissions | | Pass |
| 15.247(d) | Conducted Spurious Emissions | | Pass |
| 15.205(a), 15.209(a) | Spurious emission | Radiated | Pass |
| | Band-edge, restricted band | | Pass |

Notes:

1. All modes of operation and data rates were investigated. The test results shown in the following sections represent the worst case emissions.
2. 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.
3. 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.
4. The test procedure(s) in this report were performed in accordance as following.
 - ◆ ANSI C63.10-2013
 - ◆ KDB 558074 D01 v05r02

5. Measurement uncertainty

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of $k=2$ to indicated a 95 % level of confidence. The measurement data shown herein meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and thus, can be compared directly to specified limits to determine compliance.

| Parameter | Expanded uncertainty (\pm) | |
|------------------------------|--------------------------------|--------|
| Conducted RF power | 0.9 dB | |
| Conducted spurious emissions | 1.3 dB | |
| Radiated spurious emissions | Below 30 MHz | 2.3 dB |
| | 30 MHz to 1 000 MHz | 2.5 dB |
| | 1 000 MHz to 18 000 MHz | 4.7 dB |
| | Above 18 000 MHz | 4.8 dB |
| Conducted emissions | 150 kHz to 30 MHz | 2.7 dB |

6. Measurement results explanation example

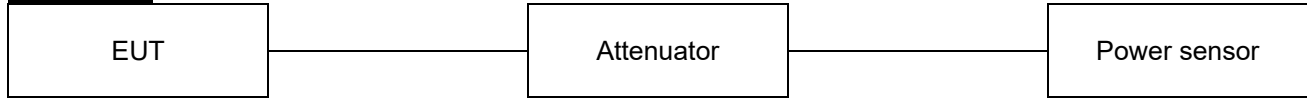
| Frequency (MHz) | Factor (dB) | Frequency (MHz) | Factor (dB) |
|-----------------|-------------|-----------------|-------------|
| 30 | 9.98 | 10 000 | 12.29 |
| 100 | 10.12 | 11 000 | 12.29 |
| 200 | 10.26 | 12 000 | 12.64 |
| 300 | 10.38 | 13 000 | 12.99 |
| 400 | 10.46 | 14 000 | 12.71 |
| 500 | 10.52 | 15 000 | 12.89 |
| 600 | 10.35 | 16 000 | 12.61 |
| 700 | 10.86 | 17 000 | 12.91 |
| 800 | 10.66 | 18 000 | 12.71 |
| 900 | 10.74 | 19 000 | 13.25 |
| 1000 | 10.69 | 20 000 | 13.35 |
| 2 000 | 10.86 | 21 000 | 13.36 |
| 3 000 | 11.35 | 22 000 | 13.34 |
| 4 000 | 11.41 | 23 000 | 14.21 |
| 5 000 | 11.56 | 24 000 | 14.51 |
| 6 000 | 11.63 | 25 000 | 13.76 |
| 7 000 | 12.26 | 26 000 | 13.78 |
| 8 000 | 12.53 | 26 500 | 14.13 |
| 9 000 | 12.31 | - | - |

Note : Offset(dB) = RF cable loss(dB) + Attenuator(dB)

7. Test results

7.1. Maximum peak output power

Test setup



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 output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

According to §15.247(b)(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Test procedure

ANSI C63.10 - Section 11.9

Used test method is section 11.9.1.3 and 11.9.2.3.1

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|--|---|---|

Test settings

General

Section 15.247 permits the maximum conducted (average) output power to be measured as an alternative to the maximum peak conducted output power for demonstrating compliance to the limit. When this option is exercised, the measured power is to be referenced to the OBW rather than the DTS bandwidth (see ANSI C63.10 for measurement guidance).

When using a spectrum analyzer or EMI receiver to perform these measurements, it shall be capable of utilizing a number of measurement points in each sweep that is greater than or equal to twice the span/RBW to set a bin-to-bin spacing of \leq RBW/2 so that narrowband signals are not lost between frequency bins.

If possible, configure or modify the operation of the EUT so that it transmits continuously at its maximum power control level. The intent is to test at 100 % duty cycle; however a small reduction in duty cycle (to no lower than 98 %) is permitted, if required by the EUT for amplitude control purposes. Manufacturers are expected to provide software to the test lab to permit such continuous operation.

If continuous transmission (or at least 98 % duty cycle) cannot be achieved due to hardware limitations (e.g., overheating), the EUT shall be operated at its maximum power control level, with the transmit duration as long as possible, and the duty cycle as high as possible during which sweep triggering/signal gating techniques may be used to perform the measurement over the transmission duration.

11.9.1. Maximum peak conducted output power

One of the following procedures may be used to determine the maximum peak conducted output power of a DTS EUT.

11.9.1.1. RBW \geq DTS bandwidth

The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the DTS bandwidth is available to perform the measurement:

- a) Set the RBW \geq DTS bandwidth.
- b) Set VBW \geq [3 \times RBW].
- c) Set span \geq [3 \times RBW].
- d) Sweep time = auto couple.
- e) Detector = peak.
- f) Trace mode = max hold.
- g) Allow trace to fully stabilize.
- h) Use peak marker function to determine the peak amplitude level.

11.9.1.3. PKPM1 Peak power meter method

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.

11.9.2.3.1. Measurement using a power meter (PM)

Method AVGP is a measurement using an RF average power meter, as follows:

- a) As an alternative to spectrum analyzer or EMI receiver measurements, 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:
 - 1) The EUT is configured to transmit continuously, or to transmit with a constant duty cycle.
 - 2) At all times when the EUT is transmitting, it shall be transmitting at its maximum power control level.
 - 3) The integration period of the power meter exceeds the repetition period of the transmitted signal by at least a factor of five.
- b) If the transmitter does not transmit continuously, measure the duty cycle, D, of the transmitter output signal as described in 11.6.
- c) Measure the average power of the transmitter. This measurement is an average over both the ON and OFF periods of the transmitter.
- d) Adjust the measurement in dBm by adding $[10 \log(1/D)]$, where D is the duty cycle

Notes:

A peak responding power sensor is used, where the power sensor system video bandwidth is greater than the occupied bandwidth of the EUT.

Test results

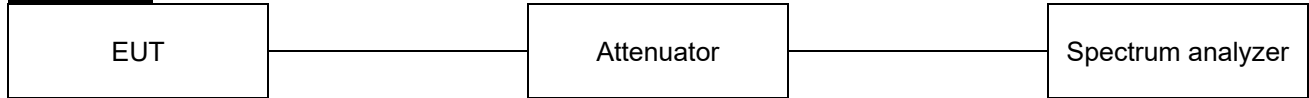
| Test mode | Frequency(MHz) | Measured output power (dBm) | | Limit(dBm) |
|-----------|----------------|-----------------------------|---------|------------|
| | | Peak | Average | |
| Zigbee | 2 405 | 1.64 | 0.95 | 30.00 |
| | 2 440 | 0.85 | 0.21 | |
| | 2 480 | 0.07 | -0.60 | |

Notes:

- 1. Conducted output power(Average) = reading value of average power + D.C.F

7.2. Peak Power Spectral Density

Test setup



Limit

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

Test procedure

ANSI C63.10 - Section 11.10.2

Test settings

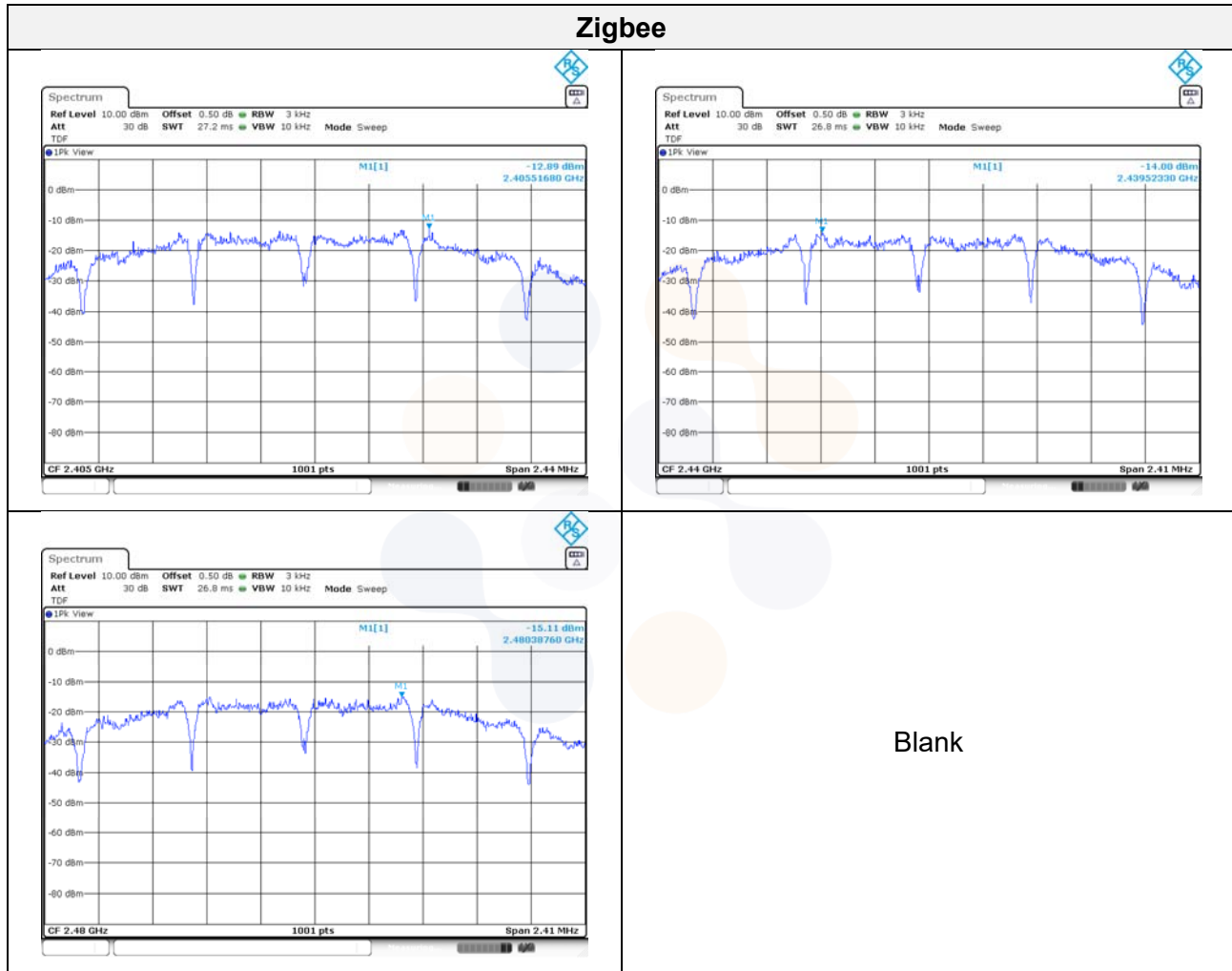
Method PKPSD (peak PSD)

The following procedure shall be used if maximum peak conducted output power was used to determine compliance, and it is optional if the maximum conducted (average) output power was used to determine compliance:

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

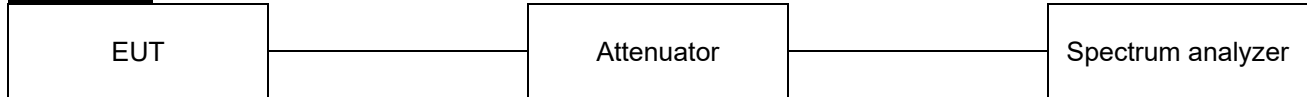
Test results

| Test mode | Frequency (MHz) | Reading (dBm/ 3kHz) | Limit (dBm/ 3kHz) |
|-----------|-----------------|---------------------|-------------------|
| Zigbee | 2 405 | -12.89 | 8.00 |
| | 2 440 | -14.00 | |
| | 2 480 | -15.11 | |



7.3. 6 dB Bandwidth(DTS Channel Bandwidth) & 99% Bandwidth

Test setup



Limit

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

Test procedure

ANSI C63.10 – Section 11.8.2

Test settings

DTS bandwidth

One of the following procedures may be used to determine the modulated DTS bandwidth.

Option 1

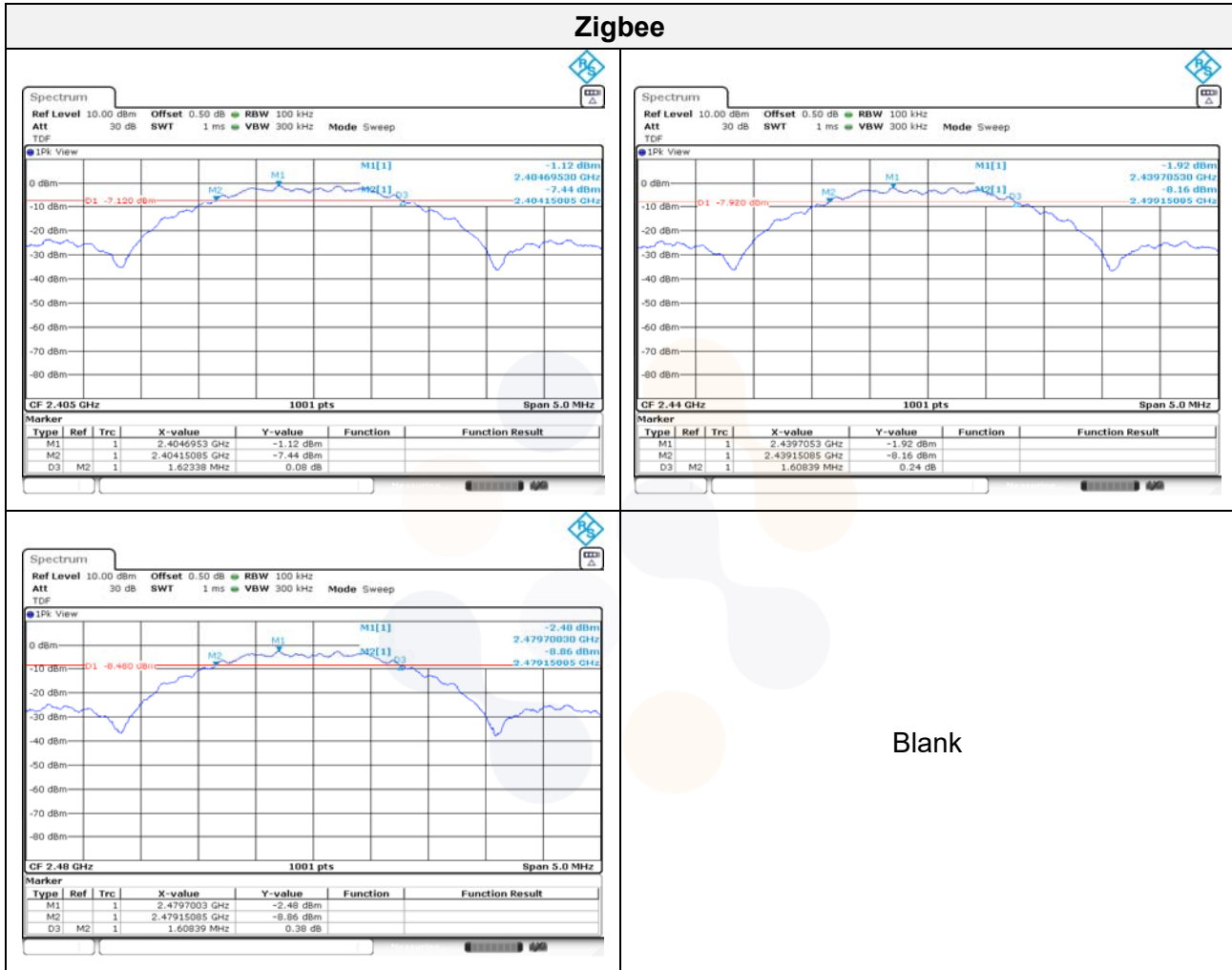
- 1) Set RBW = 100 kHz.
- 2) Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
- 3) Detector = Peak.
- 4) Trace mode = max hold.
- 5) Sweep = auto couple.
- 6) Allow the trace to stabilize.
- 7) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

Option 2

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

Test results

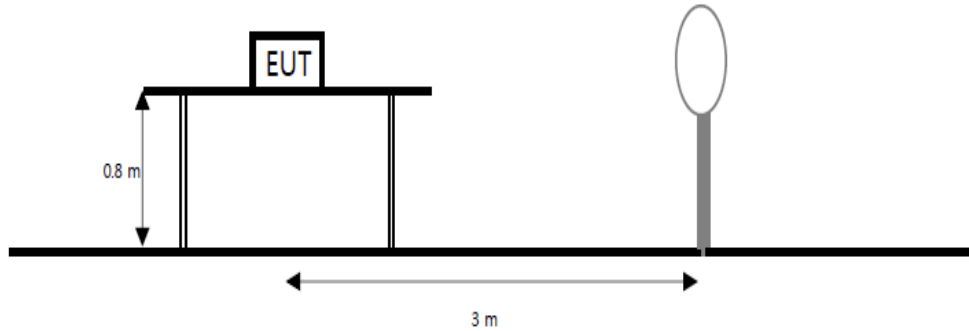
| Test mode | Frequency(MHz) | 6 dB bandwidth(MHz) |
|-----------|----------------|---------------------|
| Zigbee | 2 405 | 1.623 |
| | 2 440 | 1.608 |
| | 2 480 | 1.608 |



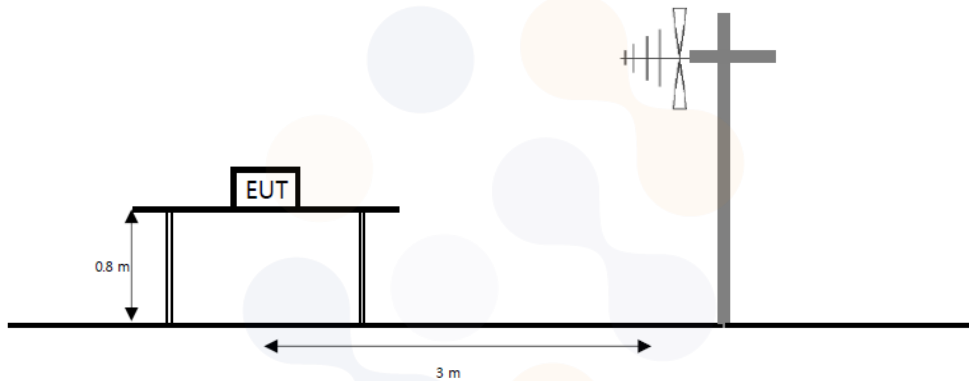
7.4. Spurious Emission, Band Edge and Restricted bands

Test setup

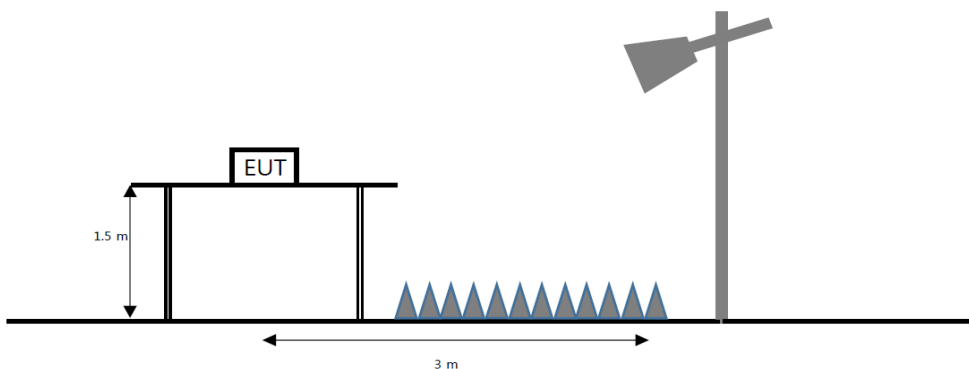
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions



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.



Limit

According to section 15.209(a), except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

| Frequency (MHz) | Field strength ($\mu V/m$) | Measurement distance (m) |
|-----------------|------------------------------|--------------------------|
| 0.009 - 0.490 | 2 400/F(kHz) | 300 |
| 0.490 - 1.705 | 24 000/F(kHz) | 30 |
| 1.705 - 30 | 30 | 30 |
| 30 - 88 | 100** | 3 |
| 88 - 216 | 150** | 3 |
| 216 - 960 | 200** | 3 |
| Above 960 | 500 | 3 |

**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., Section 15.231 and 15.241.

According to section 15.205(a) and (b), only spurious emissions are permitted in any of the frequency bands listed below:

| MHz | MHz | MHz | GHz |
|-----------------------|-----------------------|-------------------|---------------|
| 0.009 - 0.110 | 16.42 - 16.423 | 399.9 - 410 | 4.5 - 5.15 |
| 0.495 - 0.505 | 16.694 75 - 16.695 25 | 608 - 614 | 5.35 - 5.46 |
| 2.173 5 - 2.190 5 | 16.804 25 - 16.804 75 | 960 - 1 240 | 7.25 - 7.75 |
| 4.125 - 4.128 | 25.5 - 25.67 | 1 300 - 1 427 | 8.025 - 8.5 |
| 4.177 25 - 4.177 75 | 37.5 - 38.25 | 1 435 - 1 626.5 | 9.0 - 9.2 |
| 4.207 25 - 4.207 75 | 73 - 74.6 | 1 645.5 - 1 646.5 | 9.3 - 9.5 |
| 6.215 - 6.218 | 74.8 - 75.2 | 1 660 - 1 710 | 10.6 - 12.7 |
| 6.267 75 - 6.268 25 | 108 - 121.94 | 1 718.8 - 1 722.2 | 13.25 - 13.4 |
| 6.311 75 - 6.312 25 | 123 - 138 | 2 200 - 2 300 | 14.47 - 14.5 |
| 8.291 - 8.294 | 149.9 - 150.05 | 2 310 - 2 390 | 15.35 - 16.2 |
| 8.362 - 8.366 | 156.524 75 - 156.525 | 2 483.5 - 2 500 | 17.7 - 21.4 |
| 8.376 25 - 8.386 75 | 25 | 2 690 - 2 900 | 22.01 - 23.12 |
| 8.414 25 - 8.414 75 | 156.7 - 156.9 | 3 260 - 3 267 | 23.6 - 24.0 |
| 12.29 - 12.293 | 162.012 5 - 167.17 | 3 332 - 3 339 | 31.2 - 31.8 |
| 12.519 75 - 12.520 25 | 167.72 - 173.2 | 3 345.8 - 3 358 | 36.43 - 36.5 |
| 12.576 75 - 12.577 25 | 240 - 285 | 3 600 - 4 400 | Above 38.6 |
| 13.36 - 13.41 | 322 - 335.4 | | |

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in section 15.209. At frequencies equal to or less than 1 000 MHz, compliance with the limits in section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1 000 MHz, compliance with the emission limits in section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in section 15.35 apply to these measurements.

Test procedure

ANSI C63.10-2013

Test settings

Peak field strength measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = as specified in table
3. VBW \geq (3 \times RBW)
4. Detector = peak
5. Sweep time = auto
6. Trace mode = max hold
7. Allow sweeps to continue until the trace stabilizes

Table. RBW as a function of frequency

| Frequency | RBW |
|---------------------|--------------------|
| 9 kHz to 150 kHz | 200 Hz to 300 Hz |
| 0.15 MHz to 30 MHz | 9 kHz to 10 kHz |
| 30 MHz to 1 000 MHz | 100 kHz to 120 kHz |
| > 1 000 MHz | 1 MHz |

Average field strength measurements

Trace averaging with continuous EUT transmission at full power


If the EUT can be configured or modified to transmit continuously ($D \geq 98\%$), then the average emission levels shall be measured using the following method (with EUT transmitting continuously):

1. RBW = 1 MHz (unless otherwise specified).
2. VBW \geq (3 \times RBW).
3. Detector = RMS (power averaging), if $[\text{span} / (\# \text{ of points in sweep})] \leq (\text{RBW} / 2)$. 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.
4. 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 to use linear voltage averaging. Log or dB averaging shall not be used.
5. Sweep time = auto.
6. Perform a trace average of at least 100 traces.

Trace averaging across ON and OFF times of the EUT transmissions followed by duty cycle correction

If continuous transmission of the EUT ($D \geq 98\%$) cannot be achieved and the duty cycle is constant (duty cycle variations are less than $\pm 2\%$), then the following procedure shall be used:

1. The EUT shall be configured to operate at the maximum achievable duty cycle.
2. Measure the duty cycle D of the transmitter output signal as described in 11.6.
3. RBW = 1 MHz (unless otherwise specified).
4. VBW \geq [3 \times RBW].
5. Detector = RMS (power averaging), if $[\text{span} / (\# \text{ of points in sweep})] \leq (\text{RBW} / 2)$. 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.

| | | |
|---|--|---|
| <p align="center">Eurofins KCTL Co.,Ltd. 65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea TEL: 82-70-5008-1021 FAX: 82-505-299-8311 www.kctl.co.kr</p> | <p align="center">Report No.: KR23-SRF0236-A Page (21) of (34)</p> |  |
|---|--|---|

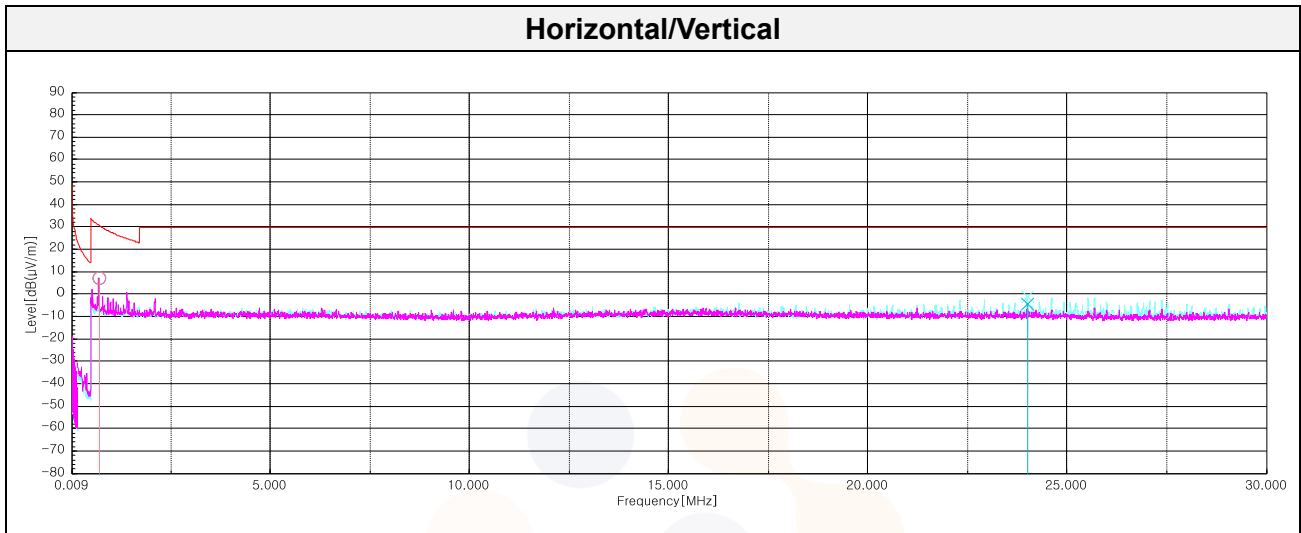
6. Averaging type = power (i.e., rms):
 - 1) As an alternative, the detector and averaging type may be set for linear voltage averaging.
 - 2) Some instruments require linear display mode to use linear voltage averaging. Log or dB averaging shall not be used.
7. Sweep time = auto.
8. Perform a trace average of at least 100 traces.
9. A correction factor shall be added to the measurement results prior to comparing with the emission limit to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as follows:
 - 1) If power averaging (rms) mode was used in step f), then the applicable correction factor is $[10 \log (1 / D)]$, where D is the duty cycle.
 - 2) If linear voltage averaging mode was used in step f), then the applicable correction factor is $[20 \log (1 / D)]$, where D is the duty cycle.
 - 3) If a specific emission is demonstrated to be continuous ($D \geq 98\%$) rather than turning ON and OFF with with the transmit cycle, then no duty cycle correction is required for that emission.

Notes:

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. Factors(dB) = Antenna factor(dB/m) + Cable loss(dB) + or Amp. gain(dB) + or F_d (dB)
3. The worst-case emissions are reported however emissions whose levels were not within 20 dB of respective limits were not reported.
4. Average test would be performed if the peak result were greater than the average limit.
5. ¹⁾ means restricted band.

Test results (Below 30 MHz) –Worst case: Zigbee_2 405 MHz

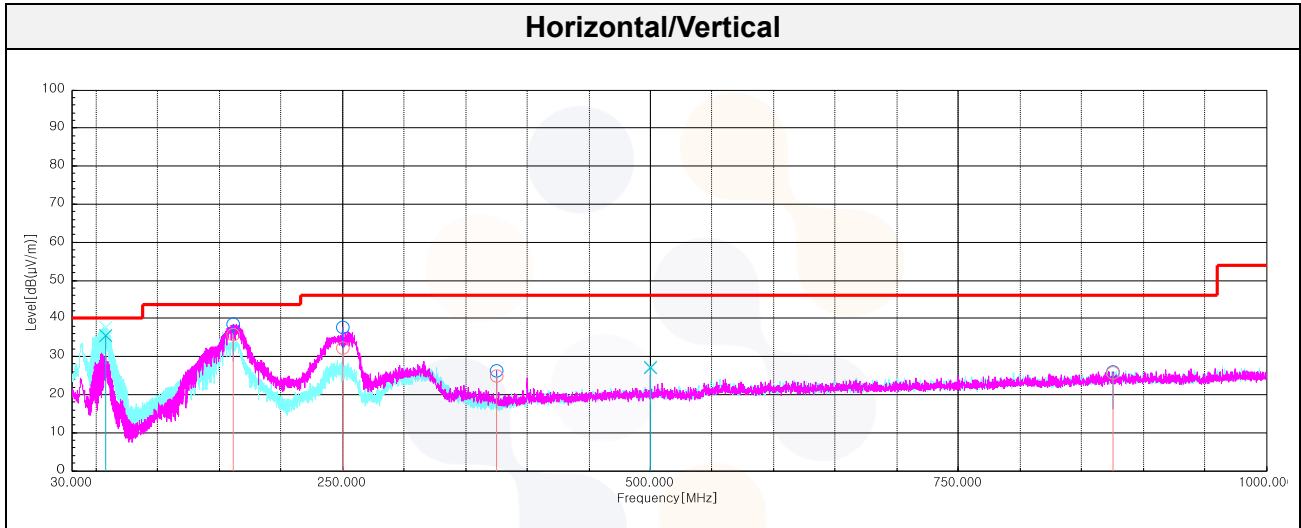
| Frequency | Pol. | Reading | Cable Loss | Amp Gain | Antenna Factor | DCF | Result | Limit | Margin |
|--|-------|----------|------------|----------|----------------|------|------------|------------|--------|
| [MHz] | [V/H] | [dB(μV)] | [dB] | [dB] | [dB] | [dB] | [dB(μV/m)] | [dB(μV/m)] | [dB] |
| No spurious emissions were detected within 20 dB of the limit. | | | | | | | | | |



Test results (Below 1 000 MHz) –Worst case: Zigbee_2 405 MHz

| Frequency (MHz) | Pol. (V/H) | Reading (dB(μV)) | Antenna Factor (dB) | Amp. + Cable (dB) | DCF (dB) | Result (dB(μV/m)) | Limit (dB(μV/m)) | Margin (dB) |
|------------------------|---------------|---------------------|---------------------------|----------------------|-------------|----------------------|---------------------|----------------|
| Quasi peak data | | | | | | | | |
| 55.95 | V | 54.60 | 12.51 | -31.57 | - | 35.54 | 40.00 | 4.46 |
| 165.68 ¹⁾ | H | 54.00 | 15.60 | -31.13 | - | 38.47 | 43.50 | 5.03 |
| 249.95 ¹⁾ | H | 46.50 | 18.49 | -30.87 | - | 34.12 | 46.00 | 11.88 |
| 374.96 | H | 35.00 | 20.70 | -30.91 | - | 24.79 | 46.00 | 21.21 |
| 499.97 | V | 35.00 | 23.20 | -30.74 | - | 27.46 | 46.00 | 18.54 |
| 911.97 | V | 33.40 | 26.40 | -28.92 | - | 30.88 | 46.00 | 15.12 |

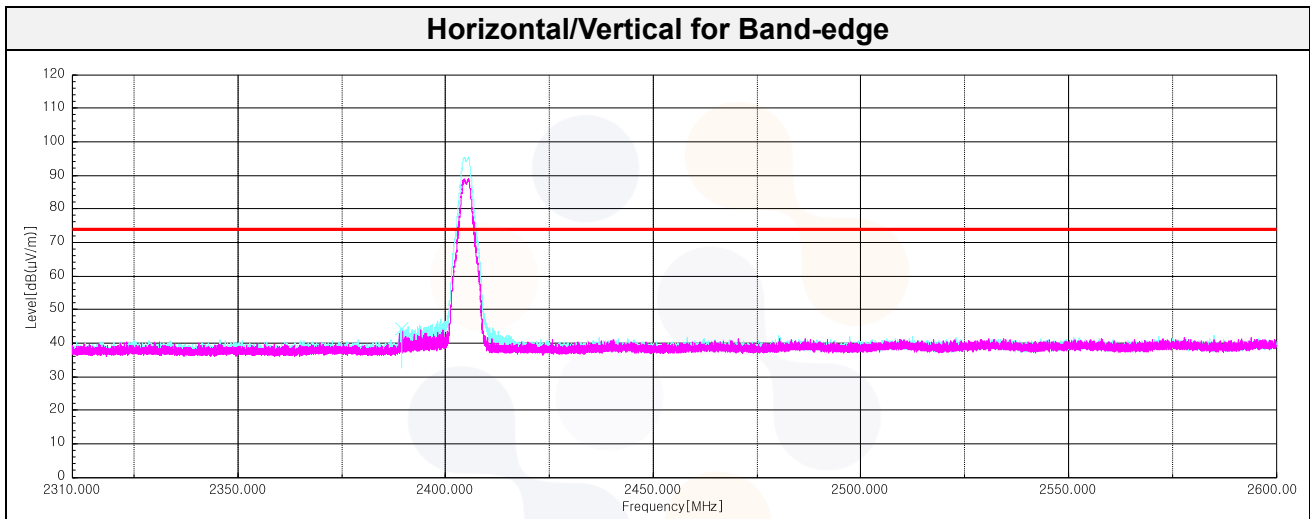
Horizontal/Vertical



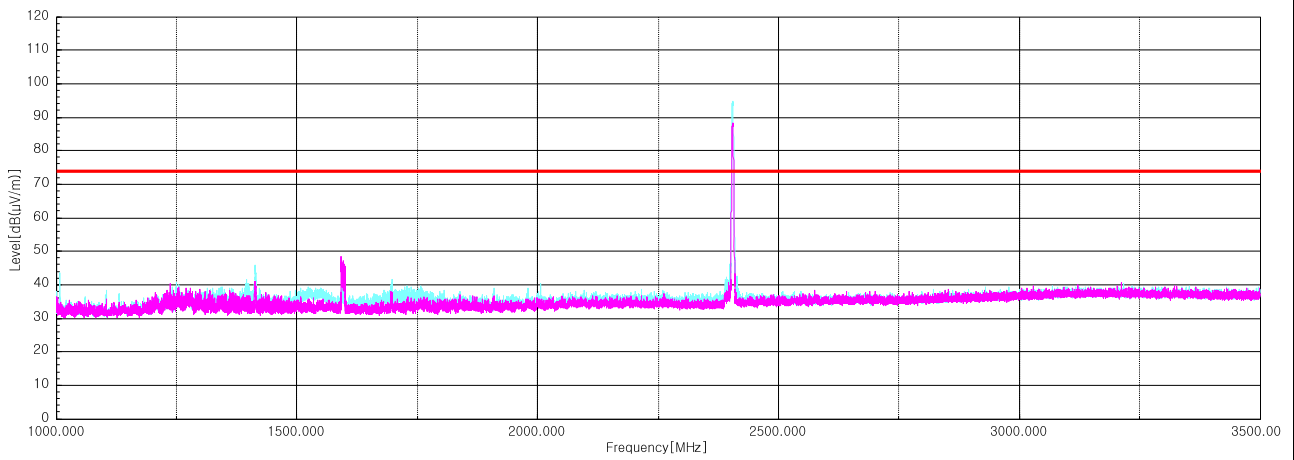
Test results (Above 1 000 MHz)

2 405 MHz

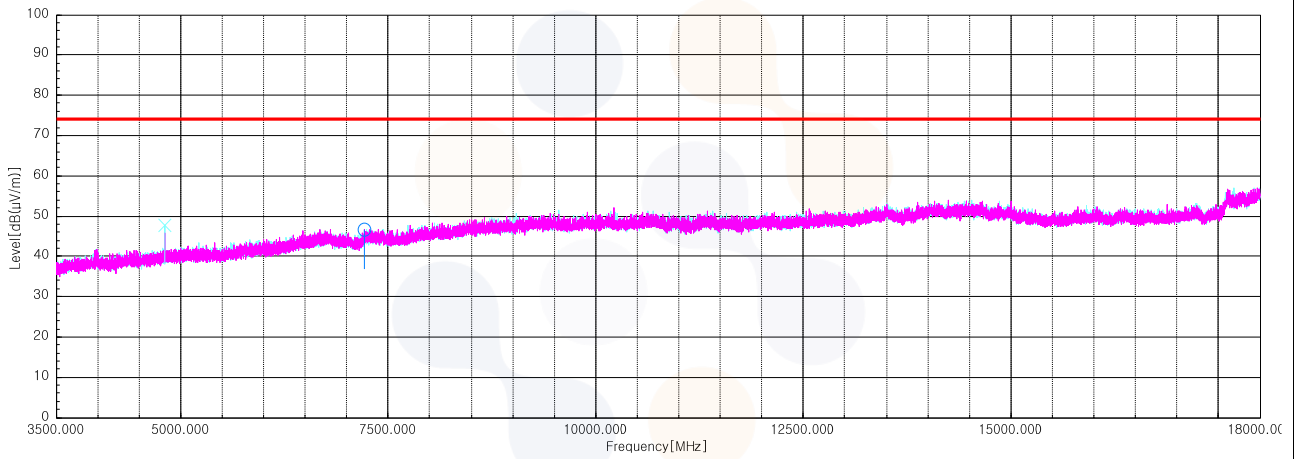
| Frequency | Pol. | Reading | Antenna Factor | Amp. + Cable | DCF | Result | Limit | Margin |
|--|-------|----------|----------------|--------------|------|------------|------------|--------|
| [MHz] | [V/H] | [dB(μV)] | [dB] | [dB] | [dB] | [dB(μV/m)] | [dB(μV/m)] | [dB] |
| Peak data | | | | | | | | |
| 2 389.43 ¹⁾ | V | 47.60 | 27.10 | -30.59 | - | 44.11 | 74.00 | 29.89 |
| 4 809.83 ¹⁾ | V | 61.20 | 32.36 | -45.82 | - | 47.74 | 74.00 | 26.26 |
| 7 215.38 | H | 53.60 | 37.13 | -44.25 | - | 46.48 | 74.00 | 27.52 |
| Average Data | | | | | | | | |
| No spurious emissions were detected within 20 dB of the limit. | | | | | | | | |



Horizontal/Vertical for 1 GHz ~ 3.5 GHz



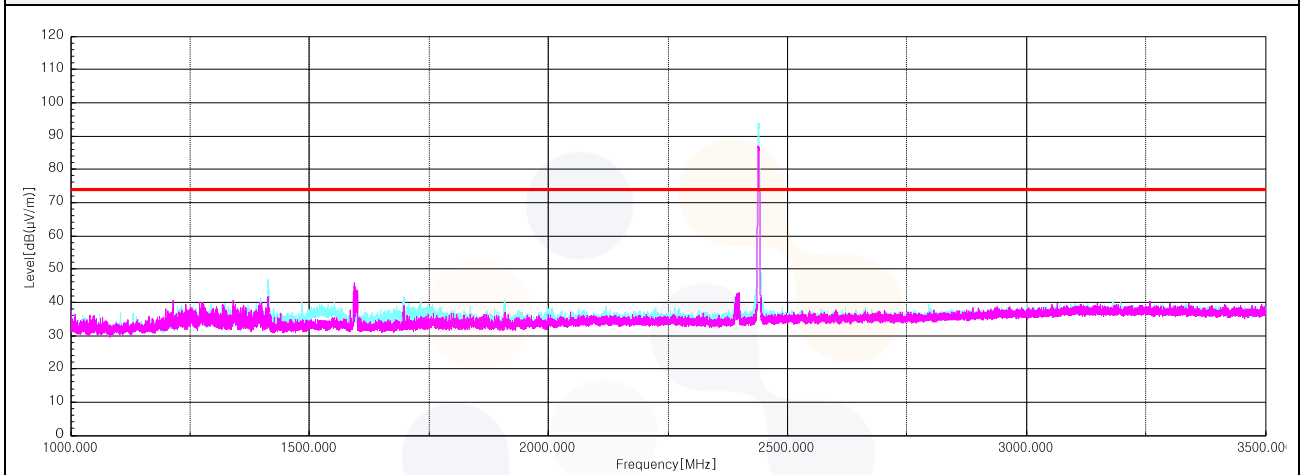
Horizontal/Vertical for 3.5 GHz ~ 18 GHz



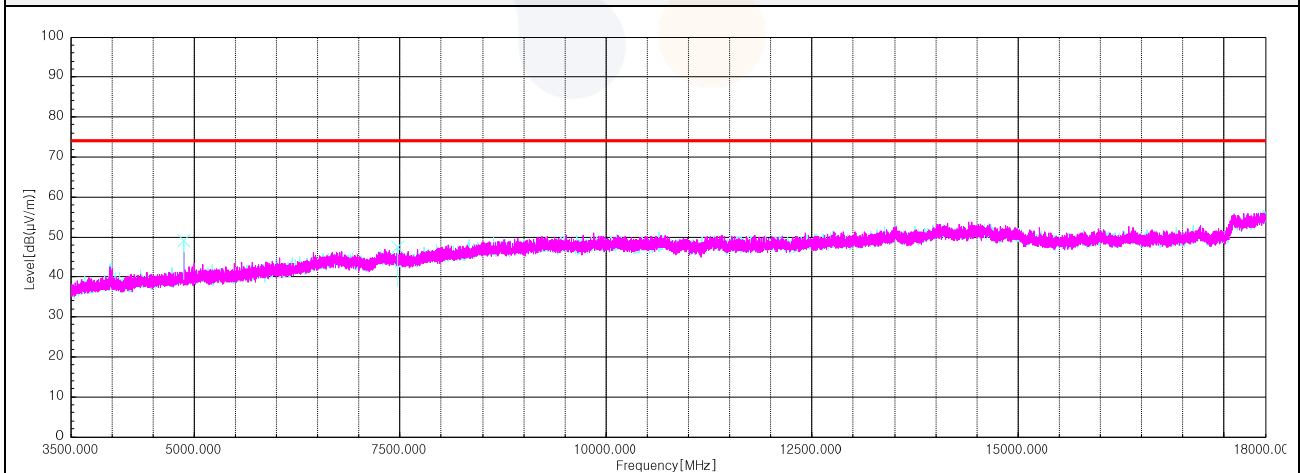
2 440 MHz

| Frequency | Pol. | Reading | Antenna Factor | Amp. + Cable | DCF | Result | Limit | Margin |
|--|-------|----------|----------------|--------------|------|------------|------------|--------|
| [MHz] | [V/H] | [dB(μV)] | [dB] | [dB] | [dB] | [dB(μV/m)] | [dB(μV/m)] | [dB] |
| Peak data | | | | | | | | |
| 4 879.92 ¹⁾ | V | 61.80 | 32.78 | -45.51 | - | 49.07 | 74.00 | 24.93 |
| 7 473.00 ¹⁾ | V | 54.60 | 36.61 | -43.79 | - | 47.42 | 74.00 | 26.58 |
| Average Data | | | | | | | | |
| No spurious emissions were detected within 20 dB of the limit. | | | | | | | | |

Horizontal/Vertical for 1 GHz ~ 3.5 GHz



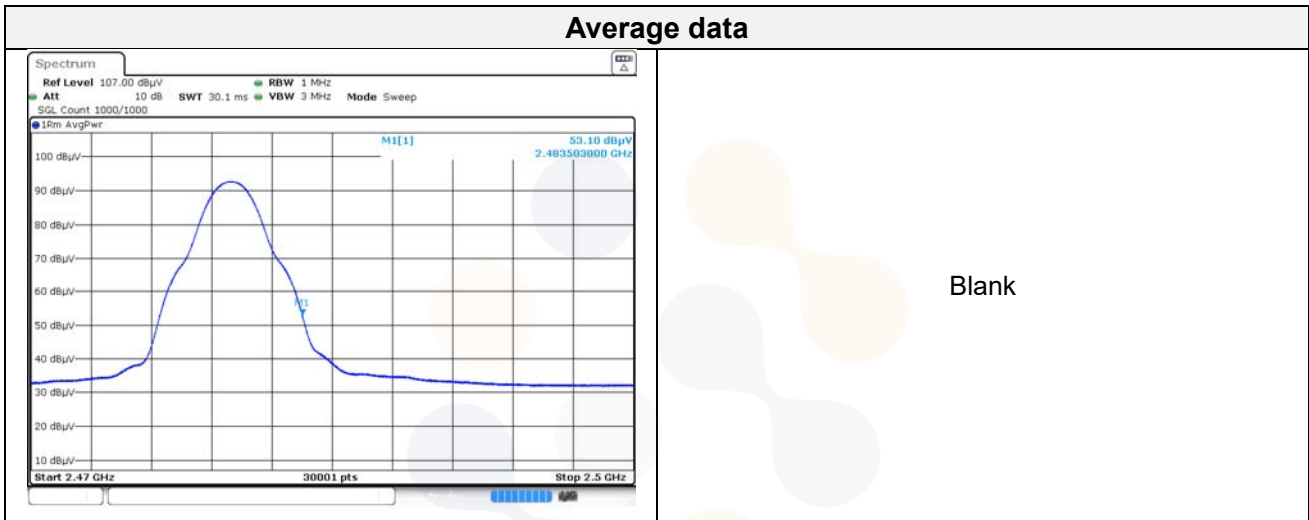
Horizontal/Vertical for 3.5 GHz ~ 18 GHz



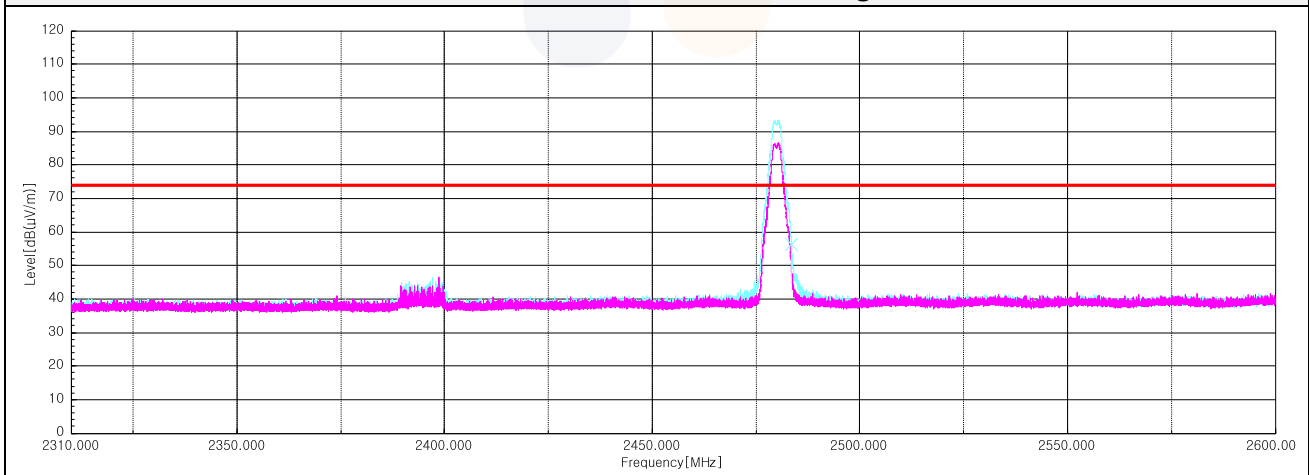
2 480 MHz

| Frequency | Pol. | Reading | Antenna Factor | Amp. + Cable | DCF | Result | Limit | Margin |
|------------------------|-------|----------|----------------|--------------|------|------------|------------|--------|
| [MHz] | [V/H] | [dB(μV)] | [dB] | [dB] | [dB] | [dB(μV/m)] | [dB(μV/m)] | [dB] |
| Peak data | | | | | | | | |
| 2 483.51 ¹⁾ | V | 59.00 | 27.70 | -30.48 | - | 56.22 | 74.00 | 17.78 |
| 4 959.67 ¹⁾ | V | 61.40 | 32.82 | -45.16 | - | 49.06 | 74.00 | 24.94 |
| 7 432.88 ¹⁾ | H | 52.80 | 36.83 | -43.89 | - | 45.74 | 74.00 | 28.26 |
| Average Data | | | | | | | | |
| 2 483.50 ¹⁾ | V | 53.10 | 27.70 | -30.48 | - | 50.32 | 54.00 | 3.68 |

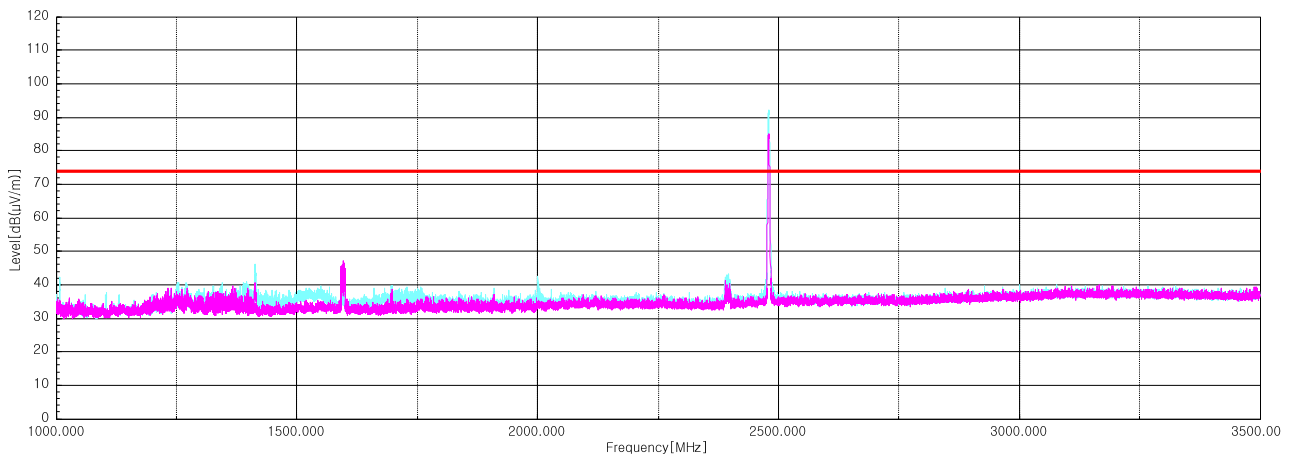
Average data



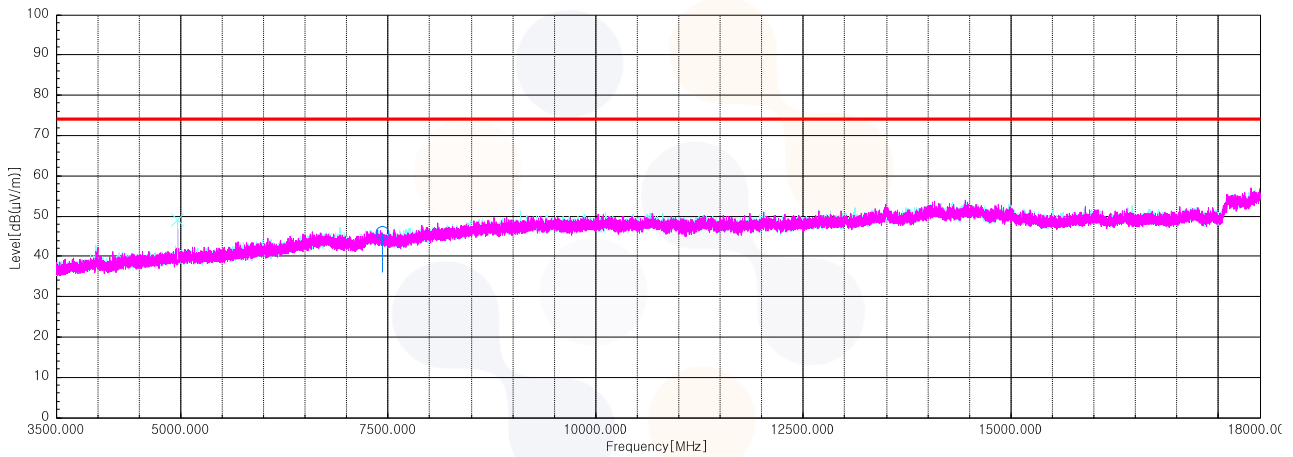
Horizontal/Vertical for Band-edge



Horizontal/Vertical for 1 GHz ~ 3.5 GHz

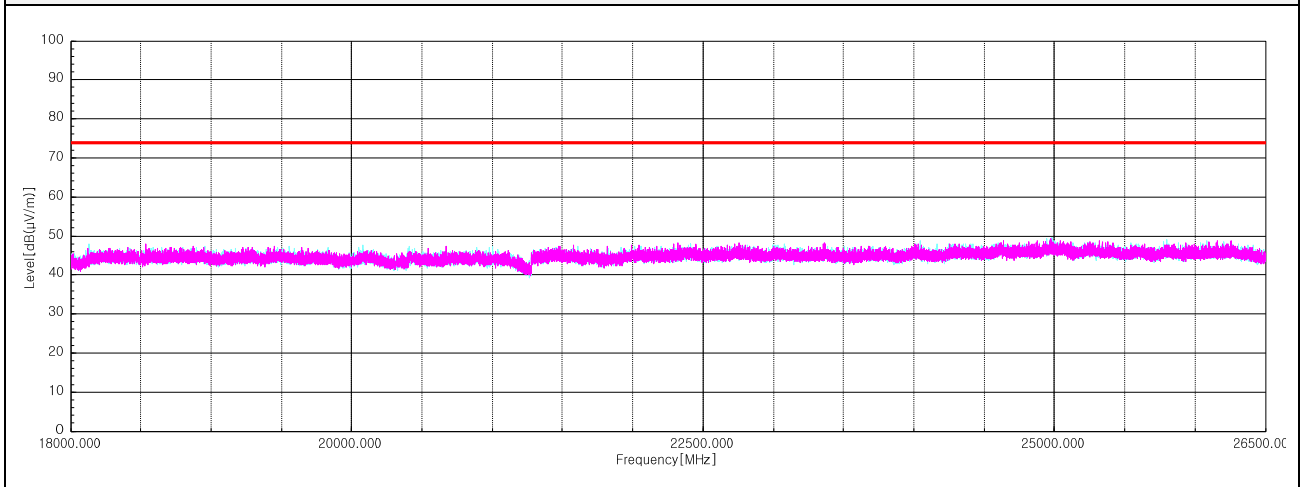


Horizontal/Vertical for 3.5 GHz ~ 18 GHz

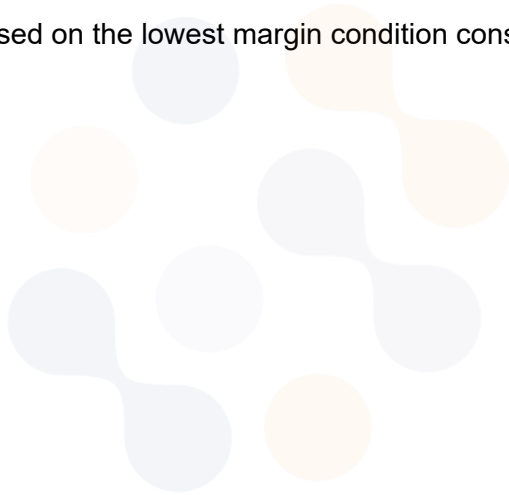


Test results (Above 18 GHz) – Worst case: Zigbee_2 405 MHz

Horizontal/Vertical for 18 GHz ~ 26.5 GHz

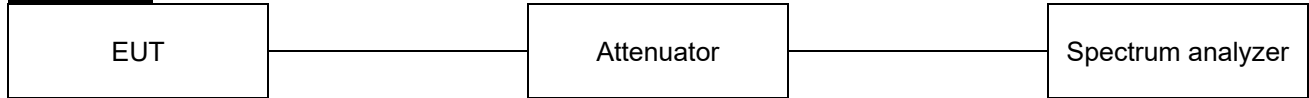


Note: The Worst case was based on the lowest margin condition considering Harmonic and Spurious Emission



7.5. Conducted Spurious Emission

Test setup



Limit

According to §15.247(d), In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operation, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation specified in §15.209(a) is not required. In addition, radiated emission limits specified in §15.209(a) (see §15.205(c)).

Limit : 20 dBc

Test procedure

ANSI C63.10-2013 - Section 11.11.3
KDB 558074 D01 v05 - Section 8.5
KDB 662911 D01 v02r01 – section (E)(3)(b)

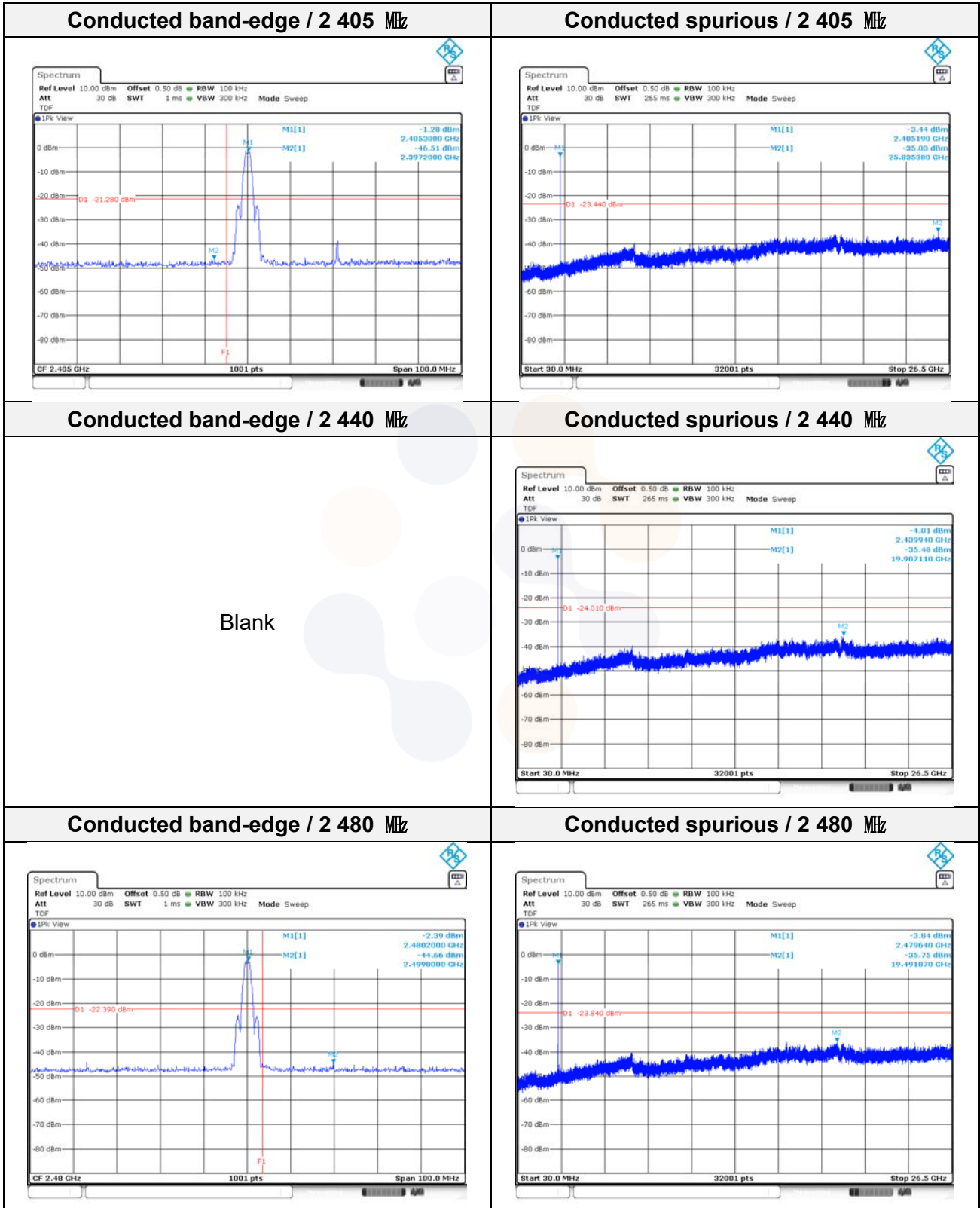
Test settings

Establish an emission level by using the following procedure:

- 1) Set the center frequency and span to encompass frequency range to be measured.
- 2) Set the RBW = 100 kHz
- 3) Set the VBW $\geq [3 \times \text{RBW}]$
- 4) Detector = peak
- 5) Sweep time = auto couple
- 6) Trace mode = max hold
- 7) Allow trace to fully stabilize.
- 8) Use the peak marker function to determine the maximum amplitude level.

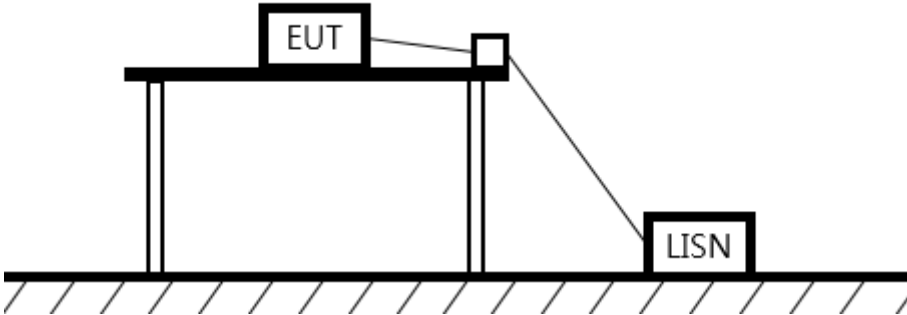
Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) is attenuated by at least the minimum requirements specified in 11.11. Report the three highest emissions relative to the limit.

Test results



7.6. AC Conducted emission

Test setup



Limit

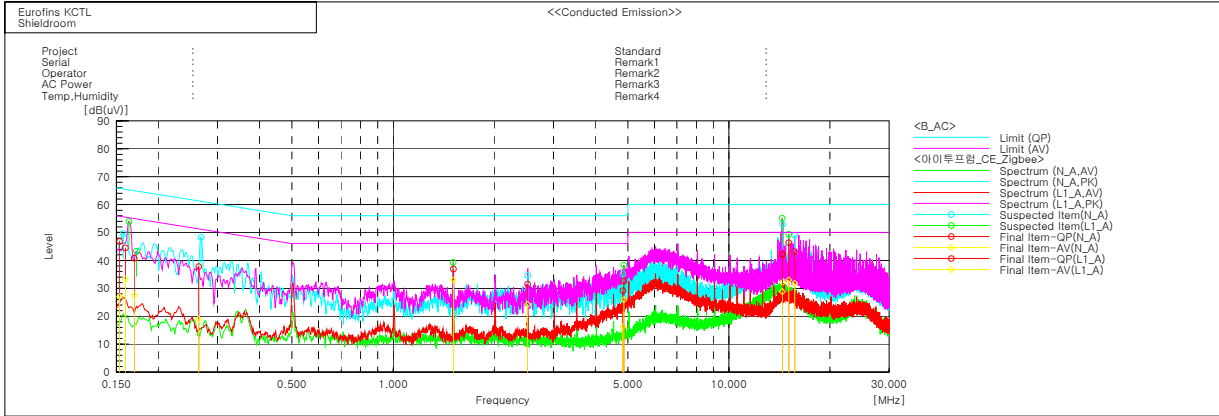
According to 15.207(a), for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/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 (dB μ V/m) | |
|-----------------------------|--------------------------------|----------|
| | Quasi-peak | Average |
| 0.15 – 0.50 | 66 - 56* | 56 - 46* |
| 0.50 – 5.00 | 56 | 46 |
| 5.00 – 30.0 | 60 | 50 |

Measurement procedure

1. The EUT was placed on a wooden table of size, 1 m by 1.5 m, raised 80 cm in which is located 40 cm away from the vertical wall and 1.5m away from the side wall of the shielded room.
2. Each current-carrying conductor of the EUT power cord was individually connected through a 50 Ω /50 μ H LISN, which is an input transducer to a spectrum analyzer or an EMI/Field Intensity Meter, to the input power source.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment is the system) was then performed over the frequency range of 0.15 MHz to 30 MHz.
5. The measurements were made with the detector set to peak amplitude within a bandwidth of 10 kHz or to quasi-peak and average within a bandwidth of 9 kHz. The EUT was in transmitting mode during the measurements.

Test results-Worst case: Zigbee_2 405 MHz



Final Result

--- L2 Phase ---

| No. | Frequency [MHz] | Reading QP [dB(uV)] | Reading CAV [dB(uV)] | c.f [dB] | Result QP [dB(uV)] | Result CAV [dB(uV)] | Limit QP [dB(uV)] | Limit AV [dB(uV)] | Margin QP [dB] | Margin CAV [dB] |
|-----|-----------------|---------------------|----------------------|----------|--------------------|---------------------|-------------------|-------------------|----------------|-----------------|
| 1 | 0.15341 | 36.8 | 17.1 | 10.0 | 46.8 | 27.1 | 65.8 | 55.8 | 19.0 | 28.7 |
| 2 | 0.26389 | 27.9 | 9.2 | 9.9 | 37.8 | 19.1 | 61.3 | 51.3 | 23.5 | 32.2 |
| 3 | 2.51655 | 21.5 | 14.3 | 10.0 | 31.5 | 24.3 | 56.0 | 46.0 | 24.5 | 21.7 |
| 4 | 4.83506 | 19.1 | 6.2 | 10.1 | 29.2 | 16.3 | 56.0 | 46.0 | 26.8 | 29.7 |
| 5 | 14.45838 | 31.4 | 21.2 | 10.9 | 42.3 | 32.1 | 60.0 | 50.0 | 17.7 | 17.9 |
| 6 | 15.69108 | 32.1 | 20.8 | 11.0 | 43.1 | 31.8 | 60.0 | 50.0 | 16.9 | 18.2 |

--- L3 Phase ---

| No. | Frequency [MHz] | Reading QP [dB(uV)] | Reading CAV [dB(uV)] | c.f [dB] | Result QP [dB(uV)] | Result CAV [dB(uV)] | Limit QP [dB(uV)] | Limit AV [dB(uV)] | Margin QP [dB] | Margin CAV [dB] |
|-----|-----------------|---------------------|----------------------|----------|--------------------|---------------------|-------------------|-------------------|----------------|-----------------|
| 1 | 0.15965 | 34.4 | 23.2 | 10.1 | 44.5 | 33.3 | 65.5 | 55.5 | 21.0 | 22.2 |
| 2 | 0.16936 | 30.5 | 17.3 | 10.3 | 40.8 | 27.6 | 65.0 | 55.0 | 24.2 | 27.4 |
| 3 | 1.51192 | 26.9 | 23.0 | 10.0 | 36.9 | 33.0 | 56.0 | 46.0 | 19.1 | 13.0 |
| 4 | 4.86947 | 22.5 | 15.8 | 10.1 | 32.6 | 25.9 | 56.0 | 46.0 | 23.4 | 20.1 |
| 5 | 14.40603 | 31.2 | 17.9 | 10.9 | 42.1 | 28.8 | 60.0 | 50.0 | 17.9 | 21.2 |
| 6 | 15.07375 | 35.3 | 22.0 | 11.0 | 46.3 | 33.0 | 60.0 | 50.0 | 13.7 | 17.0 |

8. Measurement equipment

| Equipment Name | Manufacturer | Model No. | Serial No. | Next Cal. Date |
|------------------------|-----------------------------|---|------------------------|----------------|
| Controller | INNCO SYSTEMS | CO3000 | 1441/54370322/P | - |
| Antenna Mast | INNCO SYSTEMS | MA4640-XP-ET | - | - |
| Turn Device | INNCO SYSTEMS | DS1200-S-1t | - | - |
| Spectrum Analyzer | R&S | FSVA40 | 101575 | 24.06.19 |
| PSA Spectrum Analyzer | Agilent | E4440A | MY46186407 | 24.03.22 |
| Broadband PreAmplifier | SCHWARZBECK | BBV9718D | 57 | 24.03.17 |
| Low Noise Amplifier | TESTEK | TK-PA18H | 220124-L | 24.10.12 |
| Low Noise Amplifier | TESTEK | TK-PA1840H | 220133-L | 24.10.17 |
| Amplifier | SONOMA INSTRUMENT | 310N | 421821 | 24.10.12 |
| Horn Antenna | SCHWARZBECK | BBHA9120D | 2763 | 24.10.18 |
| Horn Antenna | SCHWARZBECK | BBHA9170 | 1267 | 24.10.16 |
| Bilog Antenna | Teseq GmbH | CBL 6112D | 63756 | 24.11.17 |
| Loop Antenna | R&S | HFH2-Z2 | 100355 | 24.08.10 |
| High Pass Filter | Wainwright Instruments GmbH | WHKX12-2805-3000-18000-40SS | SN58 | 24.10.16 |
| High Pass Filter | QOTANA TECHNOLOGIES | DBHF0508004000A | 23041800061 | 24.07.10 |
| TWO-LINE V -NETWORK | R&S | ENV216 | 101584 | 24.03.28 |
| EMI TEST RECEIVER | R&S | ESCI3 | 101428 | 24.08.18 |
| Signal Generator | R&S | SMB100A | 176206 | 24.01.19 |
| Spectrum Analyzer | R&S | FSV40 | 100989 | *24.10.12 |
| Attenuator | API Inmet | 40AH2W-10 | 11 | 24.05.03 |
| Attenuator | R&S | DNF Dämpfungsglied 10 dB in N-50 Ohm | 0007 | 24.01.09 |
| Power Sensor | R&S | NRP-Z81 | 1137.9009.02-106225-JM | 24.04.25 |

End of test report