

TEST REPORT

Report No: KST-FCR-150004

| | | |
|----------------------|---|--|
| Applicant | Name | YL Co., Ltd. |
| | Address | #85404 Sungkyunkwan University 2066, Seobu-ro, Jangan-gu, Suwon-si, Gyeonggi-do, Korea |
| Manufacturer | Name | YL Co., Ltd. |
| | Address | #85404 Sungkyunkwan University 2066, Seobu-ro, Jangan-gu, Suwon-si, Gyeonggi-do, Korea |
| | | |
| Equipment | Name | LED Engine for HBE |
| | Model No | YLRK120_HBE_Engine-130W |
| | Brand | None |
| | FCC ID | 2AGMP-YLRK120-130 |
| | | |
| Test Standard | FCC CFR 47, Part 15. Subpart C-15.247 558074 D01 DTS Meas. Guidance v03r03 | |
| Test Date(s) | 2015. 11. 19 - 2015. 11. 20 | |
| Issue Date | 2015. 11. 23 | |
| Test Result | Compliance | |
| Note | None | |

Supplementary Information

The device bearing the brand name and FCC ID specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with measurement procedures specified in ANSI C 63.10-2013.

We attest to the accuracy of data and all measurements reported herein were performed by KOSTEC Co., Ltd. and were made under Chief Engineer's supervision. We assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

Tested by Mi Young, Lee

Approved by Gyeong Hyeon, Park

Signature



Signature

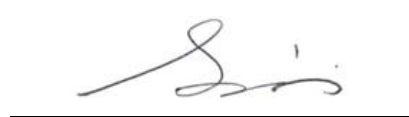


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1. GENERAL INFORMATION

1.1 Test Facility

Test laboratory and address

KOSTEC Co., Ltd.

128(175-20,Annyeong-dong)406-gil sejaro, Hwaseong-si Gyeonggi-do, Korea

The open area field test site and conducted measurement facility are used for these testing. This site at was fully described in a reports submitted to the Federal Communications Commission (FCC).

The details of these reports have been found to be in complies with the requirements of Section 2.948 of the FCC Rules on November 14, 2002. The facility also complies with the radiated and conducted test site criteria set forth in ANSI C 63.10-2013.

The Federal Communications Commission (FCC) has the reports on file and KOSTEC Co., Ltd. is listed under FCC Registration No.525762. The test site has been approved by the FCC for public use and is List in the FCC Public Access Link CORES (Commission Registration System)

Registration information

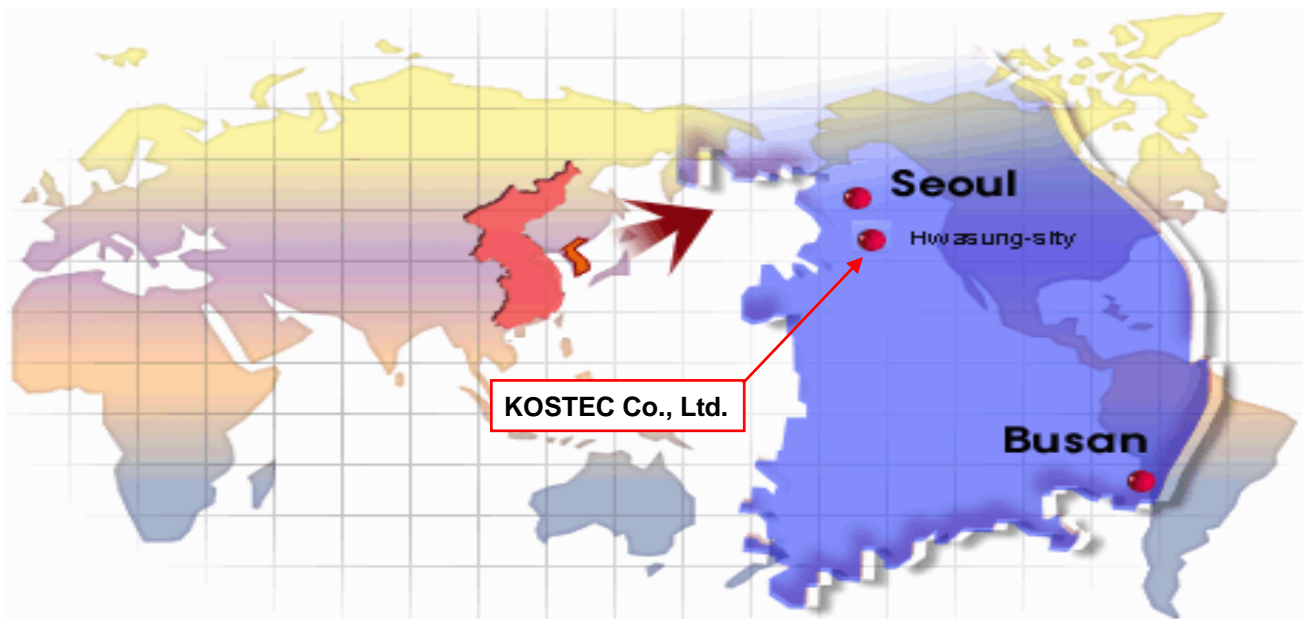
KCC (Korea Communications Commission) Number : KR0041

KOLAS(Korea Laboratory Accreditation Scheme) Number : 232

FCC Registration Number(FRN) : 525762

IC Registration Site Number : 8305A

1.2 Location



Revision History of test report

| Rev. | Revisions | Effect page | Reviewed | Date |
|------|--------------------|-------------|--------------------|--------------|
| - | Initial issue | All | Gyeong Hyeon, Park | 2015. 11. 23 |
| 1 | Add spurious graph | 22 - 26 | Gyeong Hyeon, Park | 2015. 11. 26 |

2. EQUIPMENT DESCRIPTION

The product specification described herein was declared by manufacturer. And refer to user's manual for the details.

| | |
|-----------------------|--|
| Equipment Name | LED Engine for HBE |
| Model No | YLRK120_HBE_Engine-130W |
| Usage | BT LED light |
| Serial Number | Proto type |
| Modulation type | GFSK |
| Emission Type | F1D |
| Maximum output power | -2.56 dBm |
| Operated Frequency | 2 402 MHz - 2 480 MHz |
| Channel Number | 40 |
| Operation temperature | 0 °C ~ + 40 °C |
| Power Source | DC 39.5 V |
| Antenna Description | Internal chip Antenna, Max gain: 1.99 dBi |
| Remark | <p>1. The data rates used when evaluating the EUT were the lowest data rates. The device was operating at its maximum output power at the lowest data rate for all measurements.</p> <p>2. Regarding to the operation frequency, the lowest, middle and highest frequency are selected to perform the test.</p> <p>3. The radiation measurements are performed in X, Y, Z axis positioning. Only the worst case (X) is shown in the report.</p> <p>4. The above DUT's information was declared by manufacturer. Please refer to the specifications or user manual for more detailed description.</p> |
| FCC ID | 2AGMP-YLRK120-130 |

3. SYSTEM CONFIGURATION FOR TEST

3.1 Characteristics of equipment

The equipment under test was an wireless LED controller with the functions of bluetooth operating in the 2.4 GHz bands.

3.2 Used peripherals list

| Description | Model No. | Serial No. | Manufacture | Remark |
|-------------|--------------|------------|-------------|--------------|
| Notebook | BCM-1063 | 2Z7S1Z1 | Dell Inc | |
| Adapter | DA65NM111-00 | None | Dell Inc | For notebook |

3.3 Product Modification

N/A

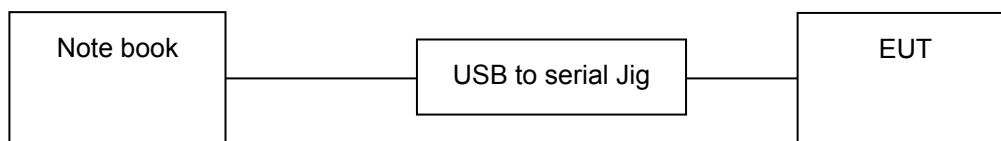
3.4 Operating Mode

* Constantly transmitting with a modulated carrier at maximum power on the bottom, middle and top channels.

3.5 Test Setup of EUT

The measurements were taken in continuous transmit / receive mode using the TEST MODE.

For controlling the EUT as TEST MODE, the test program and the test Jig and cables were provided by the applicant.



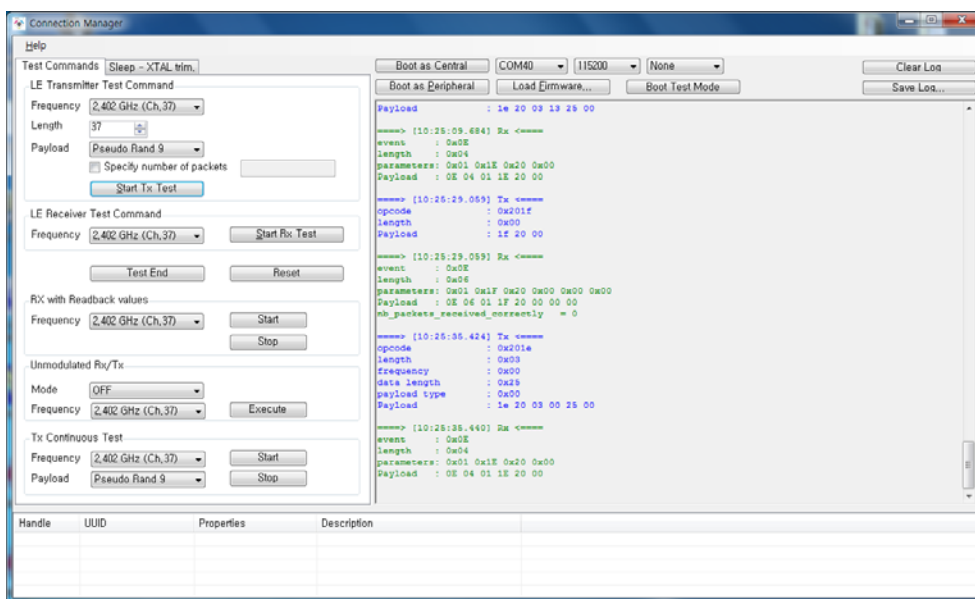
3.6 Parameters of Test Software Setting

During testing, Channel & Power Controlling Software provided by the customer was used to control the operating channel as well as the output power level. The RF output power selection is for the setting of RF output power expected by the customer and is going to be fixed on the firmware of the final end product.

■ TX Power setting value during test

| Band | Rate | TX Power setting value | | |
|--------------|--------|------------------------|-----------|---------|
| | | Low CH | Middle CH | High CH |
| 2.4 GHz band | 1 Byte | 0 | 0 | 0 |

■ Test Program



■ Test Program Version



3.7 Table for Carrier Frequencies

| Channel | Frequency (MHz) | Channel | Frequency (MHz) | Channel | Frequency (MHz) | Channel | Frequency (MHz) |
|---------|-----------------|---------|-----------------|---------|-----------------|---------|-----------------|
| 0 | 2 402 | 10 | 2 422 | 20 | 2 442 | 30 | 2 462 |
| 1 | 2 404 | 11 | 2 424 | 21 | 2 444 | 31 | 2 464 |
| 2 | 2 406 | 12 | 2 426 | 22 | 2 446 | 32 | 2 466 |
| 3 | 2 408 | 13 | 2 428 | 23 | 2 448 | 33 | 2 468 |
| 4 | 2 410 | 14 | 2 430 | 24 | 2 450 | 34 | 2 470 |
| 5 | 2 412 | 15 | 2 432 | 25 | 2 452 | 35 | 2 472 |
| 6 | 2 414 | 16 | 2 434 | 26 | 2 454 | 36 | 2 474 |
| 7 | 2 416 | 17 | 2 436 | 27 | 2 456 | 37 | 2 476 |
| 8 | 2 418 | 18 | 2 438 | 28 | 2 458 | 38 | 2 478 |
| 9 | 2 420 | 19 | 2 440 | 29 | 2 460 | 39 | 2 480 |

3.8 Used Test Equipment List

| No. | Instrument | Model | S/N | Manufacturer | Due to cal date | Cal interval | used |
|-----|-------------------------------------|------------------|--------------|----------------------------|-----------------|--------------|-------------------------------------|
| 1 | T & H Chamber | EY-101 | 90E14260 | TABAI ESPEC | 2016.09.17 | 1 year | <input type="checkbox"/> |
| 2 | Constant switch Tester | DS-COT | None | Dong sung Ele. | N/A | N/A | <input type="checkbox"/> |
| 3 | Vibration Tester | 70UA | L90016 | IDEX Co.,Ltd | N/A | N/A | <input type="checkbox"/> |
| 4 | Vibration Meter | VM-6360 | N225098 | LANDTEK | 2016.04.07 | 1 year | <input type="checkbox"/> |
| 5 | Falling Tester | SWD-8000 | None | Sinwoo | N/A | N/A | <input type="checkbox"/> |
| 6 | Spectrum Analyzer | 8563E | 3846A10662 | Agilent Technology | 2016.02.05 | 1 year | <input type="checkbox"/> |
| 7 | Spectrum Analyzer | 8593E | 3710A02859 | Agilent Technology | 2016.02.05 | 1 year | <input type="checkbox"/> |
| 8 | Spectrum Analyzer | FSV30 | 20-353063 | Rohde& Schwarz | 2016.02.05 | 1 year | <input checked="" type="checkbox"/> |
| 9 | EMI Test Receiver | ESCI7 | 100823 | Rohde& Schwarz | 2016.02.02 | 1 year | <input checked="" type="checkbox"/> |
| 10 | EMI Test Receiver | ESI | 834000/002 | Rohde& Schwarz | 2016.02.05 | 1 year | <input checked="" type="checkbox"/> |
| 11 | Vector Signal Analyzer | 89441A | 3416A02620 | Agilent Technology | 2016.02.05 | 1 year | <input type="checkbox"/> |
| 12 | Network Analyzer | 8753ES | US39172348 | AGILENT | 2016.09.16 | 1 year | <input type="checkbox"/> |
| 13 | EPM Series Power meter | E4418B | GB39512547 | Agilent Technology | 2016.02.05 | 1 year | <input type="checkbox"/> |
| 14 | RF Power Sensor | E9300A | MY41496631 | Agilent Technology | 2016.02.05 | 1 year | <input type="checkbox"/> |
| 15 | Microwave Frequency Counter | 5352B | 2908A00480 | Agilent Technology | 2016.02.02 | 1 year | <input type="checkbox"/> |
| 16 | Modulation Analyzer | 8901A | 3538A07071 | Agilent Technology | 2016.02.05 | 1 year | <input type="checkbox"/> |
| 17 | Audio Analyzer | 8903B | 3514A16919 | Agilent Technology | 2016.02.02 | 1 year | <input type="checkbox"/> |
| 18 | Audio Telephone Analyzer | DD-5601CID | 520010281 | CREDIX | 2016.02.02 | 1 year | <input type="checkbox"/> |
| 19 | Digital storage Oscilloscope | TDS3052 | B015962 | Tektronix | 2016.09.16 | 1 year | <input type="checkbox"/> |
| 20 | ESG-D Series Signal Generator | E4436B | US39260458 | Agilent Technology | 2016.02.04 | 1 year | <input checked="" type="checkbox"/> |
| 21 | ESG Vector Signal Generator | E4438C | MY42083133 | Agilent Technology | 2016.09.16 | 1 year | <input checked="" type="checkbox"/> |
| 22 | Vector Signal Generator | SMBV100A | 257557 | Rohde & Schwarz | 2016.01.10 | 1 year | <input type="checkbox"/> |
| 23 | Tracking Source | 85645A | 070521-A1 | Agilent Technology | 2016.02.05 | 1 year | <input type="checkbox"/> |
| 24 | SLIDAC | None | 0207-4 | Myoung sung Ele. | 2016.02.02 | 1 year | <input type="checkbox"/> |
| 25 | DC Power supply | DRP-5030 | 9028029 | Digital Electronic Co.,Ltd | 2016.02.03 | 1 year | <input type="checkbox"/> |
| 26 | DC Power supply | 6038A | 3440A12674 | Agilent Technology | 2016.02.02 | 1 year | <input checked="" type="checkbox"/> |
| 27 | DC Power supply | E3610A | KR24104505 | Agilent Technology | 2016.02.02 | 1 year | <input type="checkbox"/> |
| 28 | DC Power supply | UP-3005T | 68 | Unicon Co.,Ltd | 2016.02.02 | 1 year | <input type="checkbox"/> |
| 29 | DC Power Supply | SM 3004-D | 114701000117 | DELTAELEKTRONIKA | 2016.02.02 | 1 year | <input type="checkbox"/> |
| 30 | Dummy Load | 8173 | 3780 | Bird Electronic Co., Corp | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 31 | Attenuator | 50FH-030-500 | 140410 9433 | JEW Industries Inc. | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 32 | Attenuator | 765-20 | 9703 | Narda | 2016.09.16 | 1 year | <input type="checkbox"/> |
| 33 | Attenuator | 8498A | 3318A09485 | HP | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 34 | Step Attenuator | 8494B | 3308A32809 | HP | 2016.02.05 | 1 year | <input type="checkbox"/> |
| 35 | Step Attenuator | 8495D | 3308A01464 | HP | 2016.02.05 | 1 year | <input checked="" type="checkbox"/> |
| 36 | Power divider | 11636B | 51212 | HP | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 37 | 3Way Power divider | KPDSU3W | 00070365 | KMW | 2016.09.16 | 1 year | <input type="checkbox"/> |
| 38 | Band rejection filter | WTR-BRF2442-84NN | 09020001 | WAVE TECH Co.,LTD | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 39 | White noise audio filter | ST31EQ | 101902 | SoundTech | 2016.09.16 | 1 year | <input type="checkbox"/> |
| 40 | Dual directional coupler | 778D | 17693 | HEWLETT PACKARD | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 41 | Dual directional coupler | 772D | 2839A00924 | HEWLETT PACKARD | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 42 | Band rejection filter | 3TNF-0006 | 26 | DOVER Tech | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 43 | Band rejection filter | 3TNF-0008 | 317 | DOVER Tech | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 44 | Band rejection filter | 3TNF-0007 | 311 | DOVER Tech | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 45 | Highpass Filter | WHJS1100-10EF | 1 | WAINWRIGHT | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 46 | Highpass Filter | WHJS3000-10EF | 1 | WAINWRIGHT | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 47 | Radio Communication Alalyzer | MT8815A | 6200429622 | ANRITSU | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 48 | CDMA Mobile Station Test Set | E8285A | US40081298 | AGILENT | 2016.02.05 | 1 year | <input type="checkbox"/> |
| 49 | WideBand Radio Communication Tester | CMW500 | 102276 | Rohde & Schwarz | 2016.04.02 | 1 year | <input type="checkbox"/> |

| No. | Instrument | Model | S/N | Manufacturer | Due to cal date | Cal interval | used |
|-----|----------------------|-----------|-------------|----------------------|-----------------|--------------|-------------------------------------|
| 50 | RF Up/Down Converter | DCP-1780 | 980901003 | CREDIX | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 51 | DECT Test set | 8923B | 3829U00364 | HP | 2016.02.05 | 1 year | <input type="checkbox"/> |
| 52 | DECT Test set | CMD60 | 840677/005 | Rohde & Schwarz | 2016.09.16 | 1 year | <input type="checkbox"/> |
| 53 | Loop Antenna | 6502 | 9203-0493 | EMCO | 2017.06.04 | 2 year | <input checked="" type="checkbox"/> |
| 54 | Dipole Antenna | HZ-12 | 100005 | Rohde & Schwarz | 2016.07.01 | 2 year | <input type="checkbox"/> |
| 55 | Dipole Antenna | HZ-13 | 100007 | Rohde & Schwarz | 2016.07.01 | 2 year | <input type="checkbox"/> |
| 56 | BiconiLog Antenna | 3142B | 1745 | EMCO | 2016.06.16 | 2 year | <input checked="" type="checkbox"/> |
| 57 | Horn Antenna | 3115 | 9605-4834 | EMCO | 2016.06.16 | 2 year | <input checked="" type="checkbox"/> |
| 58 | Horn Antenna | 3115 | 2996 | EMCO | 2016.02.26 | 2 year | <input type="checkbox"/> |
| 59 | Horn Antenna | BBHA9170 | BBHA9170152 | SCHWARZBECK | 2017.04.10 | 2 year | <input type="checkbox"/> |
| 60 | Signal Generator | SMT-06 | 100552 | Rohde & Schwarz | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 61 | HYGRO-Thermograph | NSII-Q | 1611545 | SATO | 2016.09.21 | 1 year | <input type="checkbox"/> |
| 62 | Barometer | 7612 | 81134 | SATO | 2016.01.20 | 2 year | <input type="checkbox"/> |
| 63 | Multi meter | DM-313 | S60901832 | LG Precision Co.,Ltd | 2016.02.02 | 1 year | <input type="checkbox"/> |
| 64 | Antenna Mast(OSA) | AT14 | None | Daeil EMC | N/A | N/A | <input type="checkbox"/> |
| 65 | Turn table(OSA) | None | None | Daeil EMC | N/A | N/A | <input type="checkbox"/> |
| 66 | RF Amplifier(OSA) | 8447D | 2944A07881 | AGILENT | 2016.02.04 | 1 year | <input type="checkbox"/> |
| 67 | Antenna Master(3) | AT13 | None | AUDIX | N/A | N/A | <input checked="" type="checkbox"/> |
| 68 | Turn Table(3) | None | None | AUDIX | N/A | N/A | <input checked="" type="checkbox"/> |
| 69 | PREAMPLIFIER(3) | 8449B | 3008A02577 | Agilent | 2016.02.05 | 1 year | <input checked="" type="checkbox"/> |
| 70 | Antenna Master(10) | MA4000-EP | None | inno systems GmbH | N/A | N/A | <input checked="" type="checkbox"/> |
| 71 | Turn Table(10) | None | None | inno systems GmbH | N/A | N/A | <input checked="" type="checkbox"/> |
| 72 | AMPLIFIER(10) | TK-PA6S | 120009 | TESTEK | 2016.02.02 | 1 year | <input checked="" type="checkbox"/> |
| 73 | Vernier Calipers | None | 8280373 | Mitutoyo | 2016.09.17 | 1 year | <input type="checkbox"/> |

4. SUMMARY TEST RESULTS

| Description of Test | FCC Rule | Reference Clause | Used | Test Result |
|---|-------------------|------------------|-------------------------------------|-------------|
| Max. Conducted output power | 15.247(b)(3) | Clause 5.1 | <input checked="" type="checkbox"/> | Compliance |
| Power spectral density | 15.247(e) | Clause 5.2 | <input checked="" type="checkbox"/> | Compliance |
| 6 dB spectrum Bandwidth | 15.247(a)(2) | Clause 5.3 | <input checked="" type="checkbox"/> | Compliance |
| Band edge of RF conducted emissions | 15.247(d) | Clause 5.4 | <input checked="" type="checkbox"/> | Compliance |
| Spurious RF radiated emissions | 15.247(d), 15.209 | Clause 5.5 | <input checked="" type="checkbox"/> | Compliance |
| Antenna requirement | 15.203, 15.247 | Clause 5.6 | <input checked="" type="checkbox"/> | Compliance |
| <p>Compliance/pass : The EUT complies with the essential requirements in the standard.</p> <p>Not Compliance : The EUT does not comply with the essential requirements in the standard.</p> <p>N/A : The test was not applicable in the standard.</p> | | | | |

5. MEASUREMENT RESULTS

5.1 Max. Conducted output power

5.1.1 Standard Applicable [FCC §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.

5.1.2 Test Environment conditions

- Ambient temperature : (20 - 22) °C
- Relative Humidity : (55 - 57) % R.H.

5.1.3 Measurement Procedure

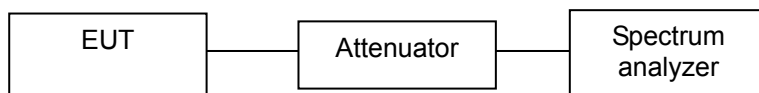
The transmitter output was connected to the spectrum analyzer with an attenuator. The maximum peak output power was measured and recorded with the spectrum analyzer. EUT was programmed to be in continuously transmitting mode.

All conducted power tests were performed using a test receiver in accordance with FCC KDB 558074 v03r03 Section 9.1.1 Measurement Procedure $RBW \geq DTS$ bandwidth

The spectrum analyzer is set to the as follows :

- Set $RBW \geq DTS$ bandwidth
- Set the $VBW \geq 3 \times RBW$.
- Set the span $3 \times RBW$.
- Sweep time = auto couple.
- Detector = peak.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level.

5.1.4 Test setup

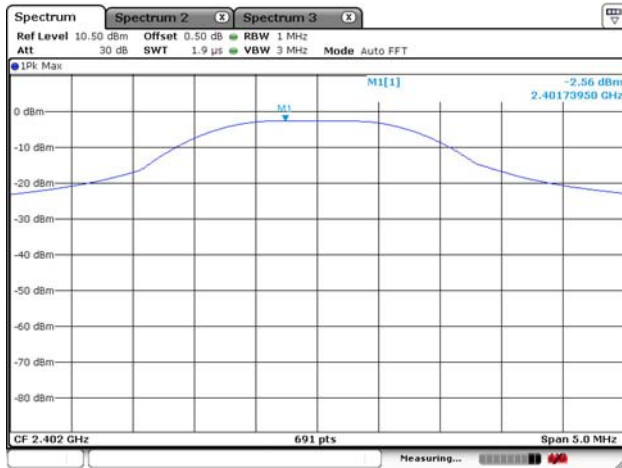


5.1.5 Measurement Result

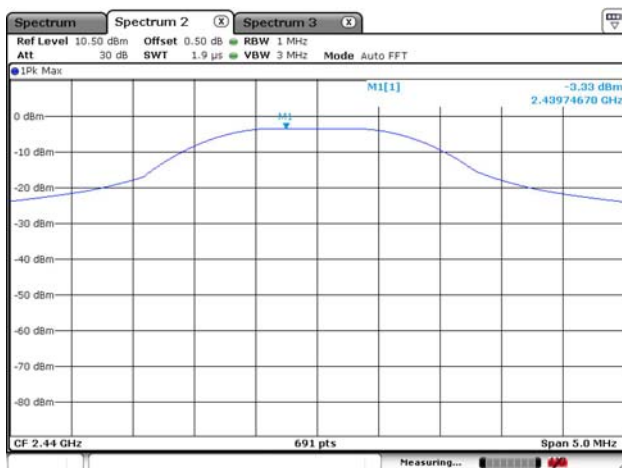
| Channel | Frequency [MHz] | Conducted Power | | Limit [dBm] | Test Results |
|---------|--------------------|-----------------|------|----------------|--------------|
| | | [dBm] | [mW] | | |
| 0 | 2 402 | -2.56 | 0.56 | 30 | Compliance |
| 19 | 2 440 | -3.33 | 0.47 | 30 | Compliance |
| 39 | 2 480 | -3.02 | 0.50 | 30 | Compliance |

5.1.6 Test Plot

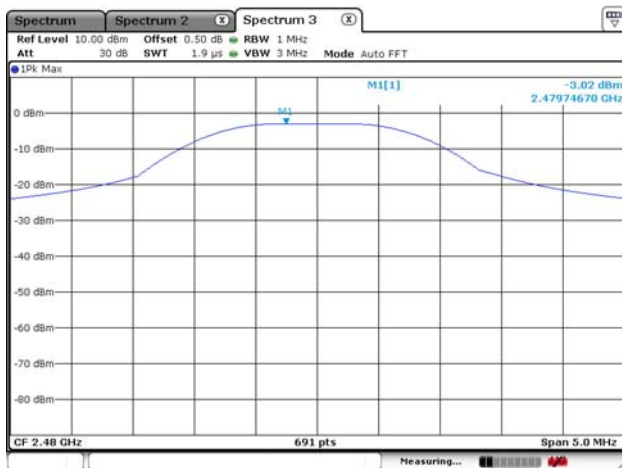
CH Low



CH Middle



CH High



5.2 Power spectral density

5.2.1 Standard Applicable [FCC §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 transmit

5.2.2 Test Environment conditions

- Ambient temperature : (20 - 22) °C
- Relative Humidity : (55 - 57) % R.H.

5.2.3 Measurement Procedure

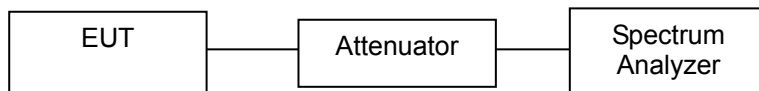
The power spectral density conducted from the intentional radiator was measured with a spectrum analyzer connected to the antenna terminal, while EUT had the highest, middle and the lowest available channels. After the trace being stable, Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak power spectral density.

All conducted power tests were performed using a test receiver in accordance with FCC KDB 558074 v03r03 Section 10.1

The spectrum analyzer is set to the as follows :

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

5.2.4 Test setup

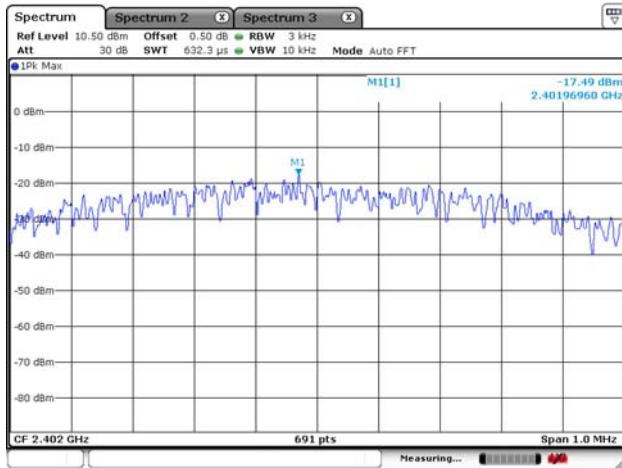


5.2.5 Measurement Result

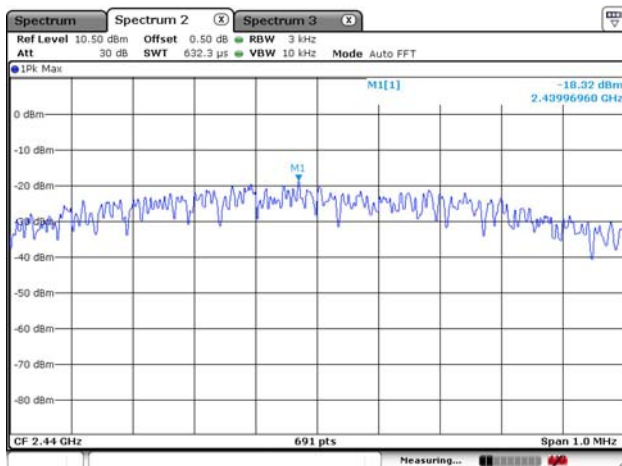
| Channel | Frequency [MHz] | Result Value [dBm] | Limit [dBm] | Test Results |
|---------|-----------------|--------------------|-------------|--------------|
| 0 | 2 402 | -17.49 | 8 | Compliance |
| 19 | 2 440 | -18.32 | 8 | Compliance |
| 39 | 2 480 | -17.86 | 8 | Compliance |

5.2.6 Test Plot

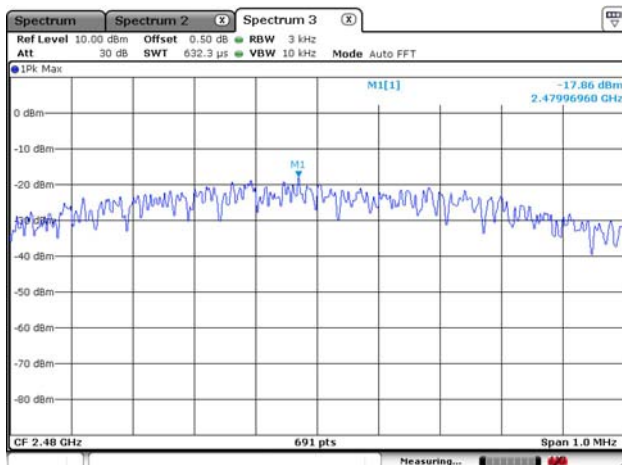
CH Low



CH Middle



CH High



5.3 6 dB spectrum Bandwidth

5.3.1 Standard Applicable [FCC §15.247(a)(2)]

Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

5.3.2 Test Environment conditions

- Ambient temperature : (20 - 22) °C
- Relative Humidity : (55 - 57) % R.H.

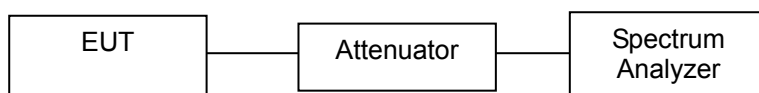
5.3.3 Measurement Procedure

1. The transmitter output (antenna port) was connected to the spectrum analyzer in peak hold mode.
2. The resolution bandwidth of 100 kHz and the video bandwidth of 100 kHz were used.
3. Measured the spectrum width with power higher than 6 dB below carrier.

The spectrum analyzer is set to the as follows :

- Set RBW = 100 kHz.
- Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
- Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize.
- 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.

5.3.4 Test setup

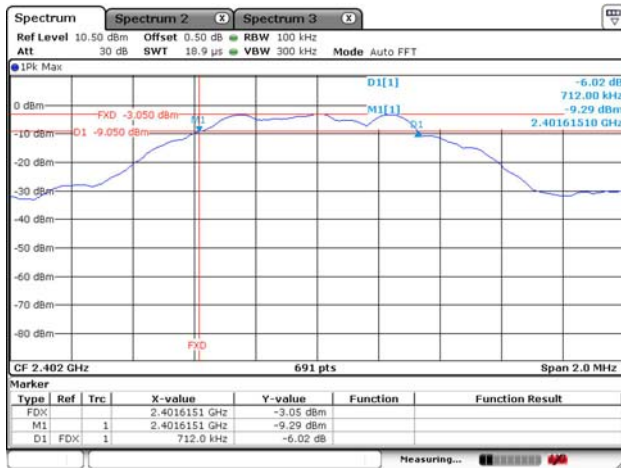


5.3.5 Measurement Result

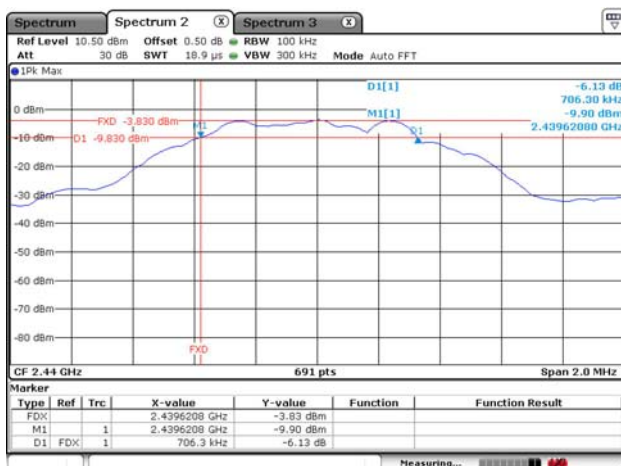
| Channel | Frequency [MHz] | 6 dB Bandwidth [MHz] | 99% Bandwidth [MHz] | Limit [MHz] | Test Results |
|---------|-----------------|----------------------|---------------------|-------------|--------------|
| 0 | 2 402 | 0.712 | 1.12 | >0.5 | Compliance |
| 19 | 2 440 | 0.706 | 1.12 | >0.5 | Compliance |
| 39 | 2 480 | 0.705 | 1.12 | >0.5 | Compliance |

5.3.6 Test Plot (6 dB bandwidth)

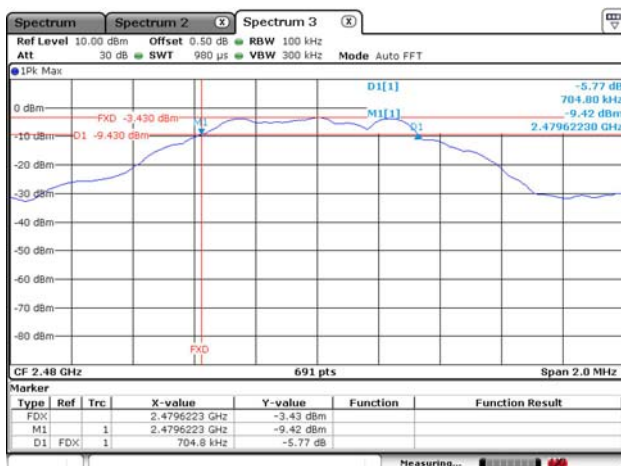
CH Low



CH Middle

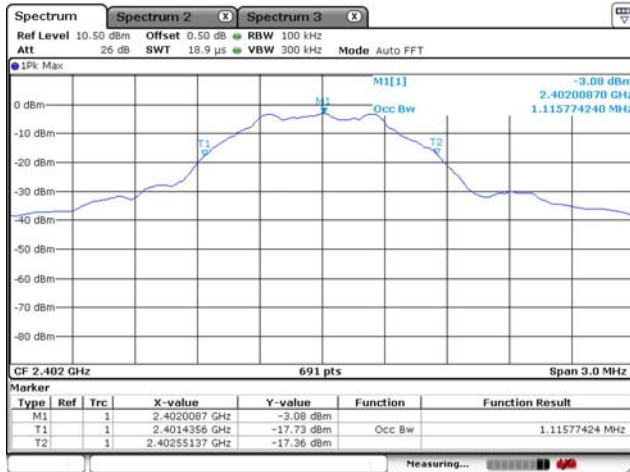


CH High

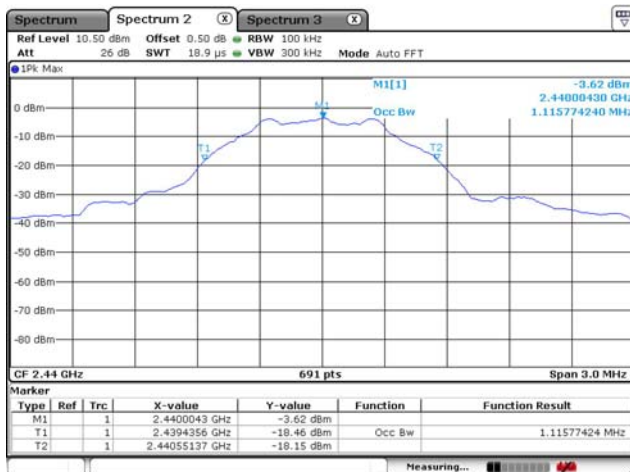


Test Plot (99 % band width)

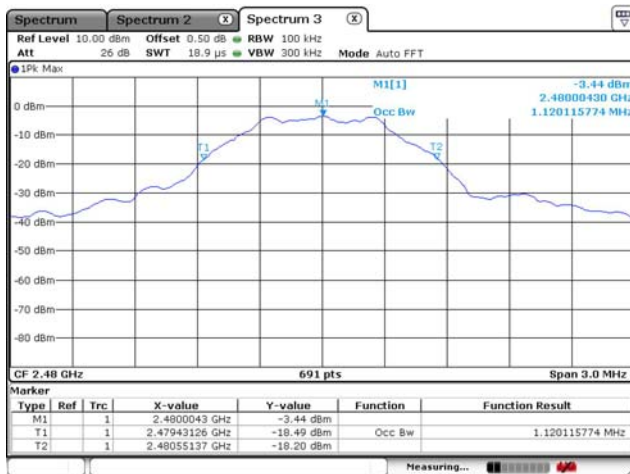
CH Low



CH Middle



CH High



5.4 Band-edge Compliance of RF Conducted emissions

5.4.1 Standard Applicable [FCC §15.247(d)]

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on RF conducted.

5.4.2 Test Environment conditions

- Ambient temperature : (20 - 22) °C
- Relative Humidity : (55 - 57) % R.H.

5.4.3 Measurement Procedure

- ① Pre-calibration for the spectrum analyzer has to be done first through a reference CW signal from signal generator.
- ② Reference frequency generated from the signal generator is supply to spectrum analyzer input port via RF cable and attenuator, and then, it's apply to offset value on spectrum analyzer.
- ③ Remove the antenna from the EUT and then, connected to spectrum analyzer via a dc Block, suitable low loss RF cable and attenuator.
- ④ Place the EUT on the table and set on the emission at the band-edge,
- ⑤ After the trace being stable, Use the marker-to-peak function to move the marker to the peak of the in-band emission.
- ⑥ The marker-delta value now displayed must comply with the limit specified in above standard.
- ⑦ please refer to the detailed procedure method KDB 558074 v03r03.

The spectrum analyzer is set to the as follows :

- Span : Wide enough to capture the peak level of the emission operating on the channel closet to the Band-edge, as well as any modulation products which fall outside of the authorized band of operation
- RBW : 100 kHz (≥ 1 % of the span)
- VBW : \geq RBW
- Sweep : auto
- Detector function : peak
- Trace : Max hold

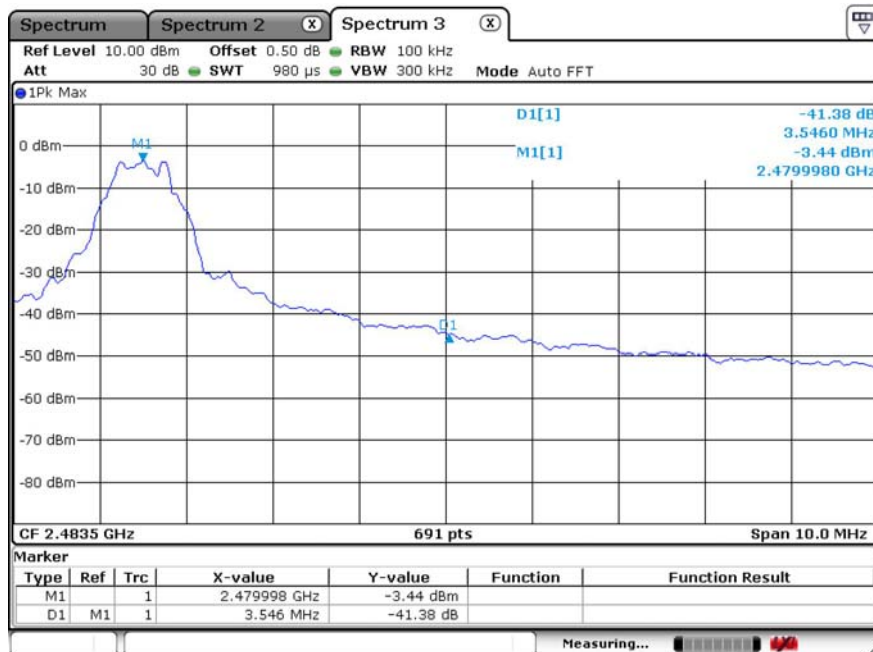
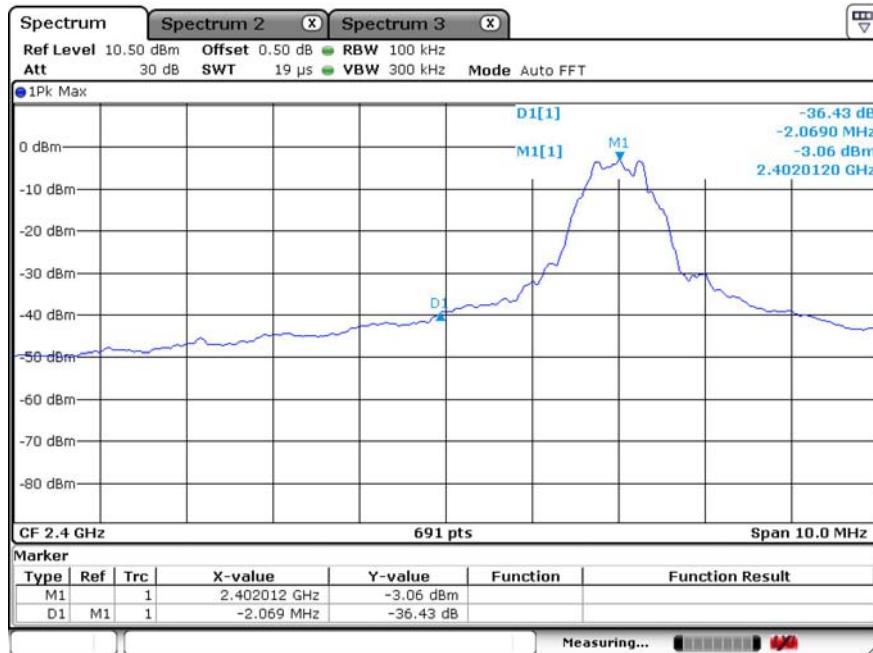
5.4.4 Test setup

Please refer 5.3.4

5.4.5 Measurement Result

| Setting Channel | | Test Results | | |
|-----------------|---------------|---------------------|--------------------------|------------|
| | | Measured value [dB] | Limit [dB] | Result |
| 0 | ~ 2 400 MHz | -36.43 | ≤ 20 than PSD level | Compliance |
| 39 | 2 483.5 MHz ~ | -41.38 | | Compliance |

5.4.6 Test Plot (Band-edge)



5.5 Spurious RF Radiated emissions

5.5.1 Standard Applicable [FCC §15.247(d)]

All other emissions outside these bands shall not exceed the general radiated emission limits specified in §15.209(a). And according to §15.33(a)(1), for an intentional radiator operates below 10 GHz, the frequency Range of measurements: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, Whichever is lower. In addition, radiated emissions which fall in the restricted bands, as defined in Sec.15.205(a), must also comply with the radiated emission limits specified in Sec. 15.209(a)

§15.209. [Table 1] limits for radiated emissions measurements (distance at 3 m)

| Frequency Band [MHz] | DISTANCE[Meters] | Limit [$\mu V/m$] | Limit [dB $\mu V/m$] | Detector |
|----------------------|------------------|---|-----------------------|------------|
| 0.009 ~ 0.490 | 300 | 2400/F(kHz) | 67.6-20log(F) | Peak |
| 0.490 ~ 1.705 | 30 | 24000/F(kHz) | 87.6-20log(F) | Peak |
| 1.705 ~ 30.0 | 30 | 30 | 29.54 | Peak |
| 30 - 88 | 3 | 100 ** | 40.00 | Quasi peak |
| 88 - 216 | 3 | 150 ** | 43.52 | Quasi peak |
| 216 - 960 | 3 | 200 ** | 46.02 | Quasi peak |
| Above 960 | 3 | 500 | 54.00 | Average |
| Above 1000 | 3 | 74.0 dB(μV)/m (Peak), 54.0 dB(μV)/m (Average) | | |

** fundamental emissions from intentional radiators operation 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 Section 15.231 and 15.241

§15.205. [Table 2] Restrict Band of Operation

| Only spurious emissions are permitted in any of the frequency bands listed below ; | | | |
|--|-------------------------|-------------------|---------------|
| [MHz] | [MHz] | [MHz] | [GHz] |
| 0.090 - 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. |
| 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. |
| 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 25 | 2 483.5 - 2 500 | 17.7 - 21.4 |
| 8.376 25 - 8.38 6 75 | 156.7 - 156.9 | 2 690 - 2 900 | 22.01 - 23.12 |
| 8.414 25 - 8.414 75 | 162.012 5 - 167.17 | 3 260 - 3 267 | 23.6 - 24.0 |
| 12.29 - 12.293 | 167.72 - 173.2 | 3 332 - 3 339 | 31.2 - 31.8 |
| 12.519 75 - 12.520 25 | 240 - 285 | 3 345.8 - 3 358 | 36.43 - 36.5 |
| 12.576 75 - 12.577 25 | 322 - 335.4 | 3 600 - 4 400 | Above 38.6 |

** Until February 1, 1999, this restricted band shall be 0.490-0.510

5.5.2 Test Environment conditions

- Ambient temperature : (20 - 22) °C
- Relative Humidity : (55 - 57) % R.H.

5.5.3 Measurement Procedure

The measurements procedure of the transmitter radiated E-field is as following describe method.

The test is performed in a Shield chamber to determine the accurate frequencies, after maximum emissions level will be checked on a test chamber and measuring distance is 3 m from EUT to test antenna.

(The chamber is ensured that comply with at least 6 dB above the ambient noise level)

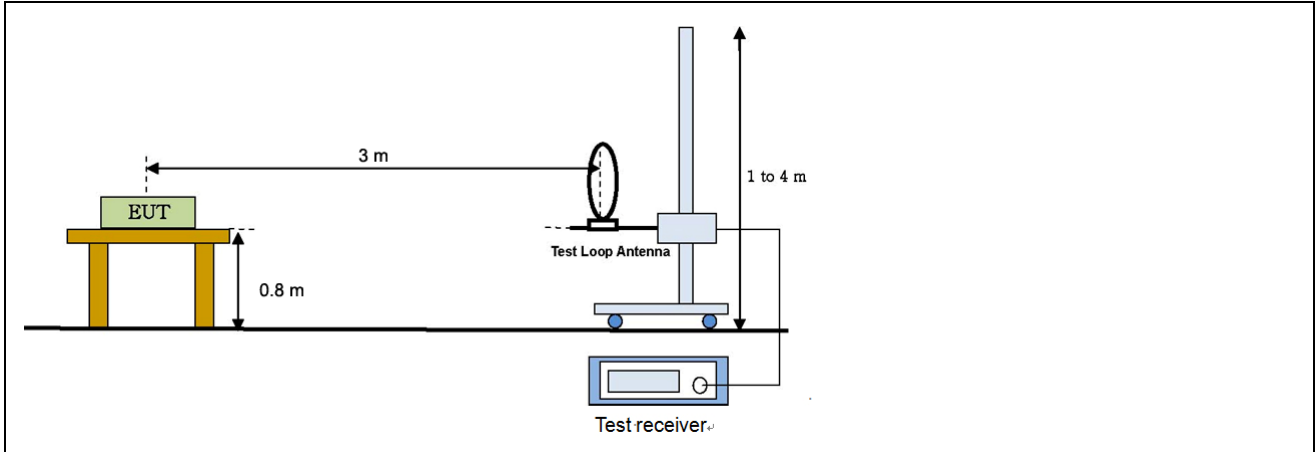
- ① The EUT was powered ON with continuously operating mode and placed on a 0.8 meter for below 1 GHz and a 1.5 m for above 1 GHz high non-conductive table on the reference ground plane.
 - ② The test antenna was used on Horn antenna for above 1 GHz, and if the below 1 GHz, broad-band antenna and Loop antenna were used for below 30 MHz and it's antenna positioned in both the horizontal and vertical plane was location at EUT during the test for maximized the emission measurement.
 - ③ The output of the test antenna will be connected to a measuring receiver, and it is set to tuned over the frequency range according to required standard
 - ④ The resolution bandwidth below 30 MHz setting on the field strength meter is 9 kHz and 30 MHz ~ 1 GHz is 120 kHz and above 1 GHz, both Peak and Average level were measured with Spectrum Analyzer, and the RBW is set at 1 MHz, VBW is set at 3 MHz for Peak measure; RBW is set at 1 MHz, VBW is set at 10 Hz for Average measure(according ANSI C63.10:2013 clause 4.2.3.2.3 procedure for average measure). Both PK and AV level test, PK detector is used.
 - ⑤ The fundamental frequency at which a relevant radiated signal component is detected, the test antenna will be raised and lowered through the specified range of heights in horizontal and vertical polarized orientation, until an maximum signal level is detected on the measuring receiver.
 - ⑥ The transmitter is position x, y, z axis on rotating through 360 degrees, until the maximum signal level is detected by the measuring receiver.
 - ⑦ The receiver is scanned from requested measuring frequency band and then the maximum meter reading is recorded. The radiated emissions were measured with required standard.
- The measurement results are obtained as described below:
$$\text{Result(dB } \mu\text{V/m)} = \text{Reading(dB } \mu\text{V)} + \text{Antenna factor(dB/m)} + \text{CL(dB)} + \text{other applicable factor (dB)}$$
 - According to §15.33 (a)(1), Frequency range of radiated measurement is performed the tenth harmonic.

5.5.4 Measurement Uncertainty

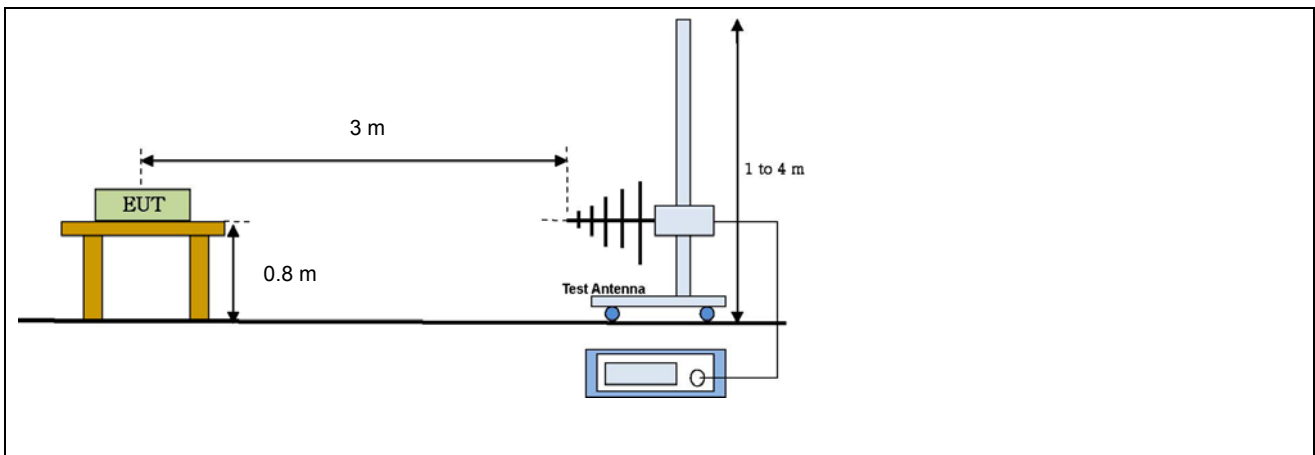
All measurements involve certain levels of uncertainties. The factors contributing to uncertainties are test receiver, Cable loss, Antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, Antenna frequency interpolation, measurement distance variation, Site imperfection, mismatch, and system repeatability based on NIS 80.81, The measurement uncertainty level with a 95 % confidence level were apply to Uncertainty of a radiation emissions measurement at Chamber of KOSTEC is ± 6.0 dB

5.5.5 Test Configuration

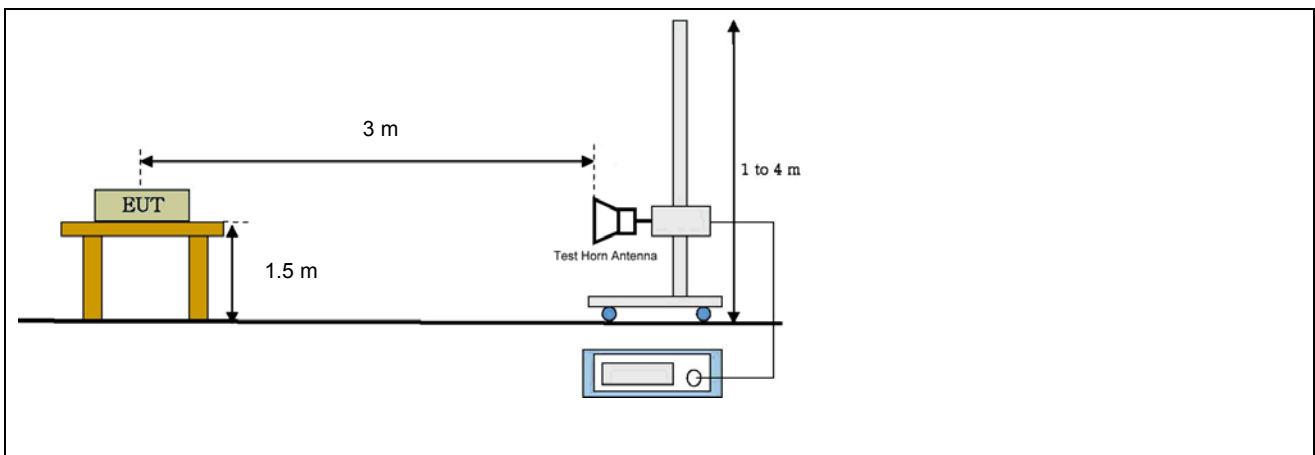
Radiated emission setup, Below 30 MHz



Radiated emission setup, Below 1 000 MHz



Radiated emission setup, Above 1 GHz



5.5.6 Measurement Result

Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available data rates. Following channel(s) was (were) selected for the final test as listed below.

| Band | Tested channel | Modulation | Data rate | Tested frequency band |
|---------|----------------|------------|-----------|-----------------------|
| 2.4 GHz | 0, 19, 39 | GFSK | 1 Byte | Above 1 GHz |
| | 19 | GFSK | 1 Byte | Below 1 GHz |

Above 1 GHz

CH 0(2 402 MHz)

| Freq. (GHz) | Reading (dB μ V/m) | | Table (Deg) | Antenna | | | CL+AMP (dB) | Meas Result (dB μ V/m) | | Limit (dB μ V/m) | | Mgn. (dB) | | Result |
|----------------|---------------------------|-------|----------------|---------------|---------------|-----------------|----------------|-------------------------------|-------|-------------------------|----|--------------|-------|------------|
| | PK | AV | | Height (m) | Pol. (H/V) | Fctr. (dB/m) | | PK | AV | PK | AV | PK | AV | |
| 2.142 | 48.32 | 38.00 | 170 | 1.5 | H | 27.88 | -32.05 | 44.15 | 33.83 | 74 | 54 | 29.85 | 20.17 | Compliance |

There are no emissions above 2.142 GHz.

CH 19(2 440 MHz)

| Freq. (GHz) | Reading (dB μ V/m) | | Table (Deg) | Antenna | | | CL+AMP (dB) | Meas Result (dB μ V/m) | | Limit (dB μ V/m) | | Mgn. (dB) | | Result |
|----------------|---------------------------|-------|----------------|---------------|---------------|-----------------|----------------|-------------------------------|-------|-------------------------|----|--------------|-------|------------|
| | PK | AV | | Height (m) | Pol. (H/V) | Fctr. (dB/m) | | PK | AV | PK | AV | PK | AV | |
| 2.142 | 47.54 | 35.87 | 170 | 1.5 | H | 27.88 | -32.05 | 43.37 | 31.70 | 74 | 54 | 30.63 | 22.30 | Compliance |

There are no emissions above 2.142 GHz.

CH 39(2 480 MHz)

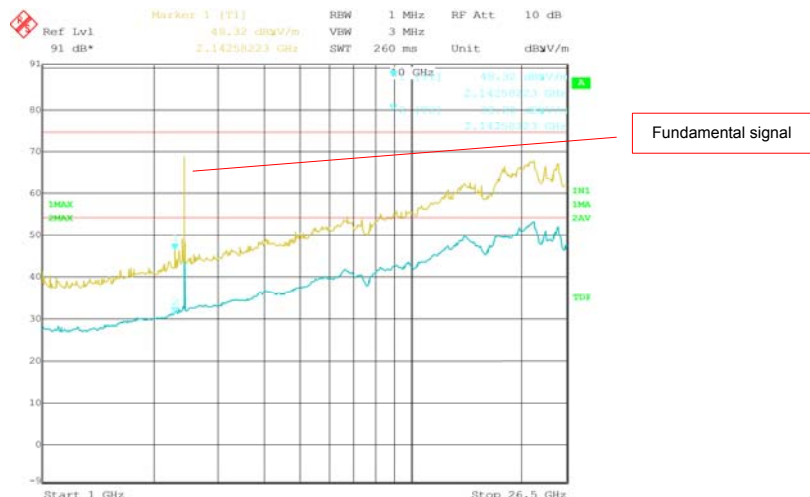
| Freq. (GHz) | Reading (dB μ V/m) | | Table (Deg) | Antenna | | | CL+AMP (dB) | Meas Result (dB μ V/m) | | Limit (dB μ V/m) | | Mgn. (dB) | | Result |
|----------------|---------------------------|-------|----------------|---------------|---------------|-----------------|----------------|-------------------------------|-------|-------------------------|----|--------------|-------|------------|
| | PK | AV | | Height (m) | Pol. (H/V) | Fctr. (dB/m) | | PK | AV | PK | AV | PK | AV | |
| 2.142 | 48.00 | 36.13 | 170 | 1.5 | H | 27.88 | -32.05 | 43.83 | 31.96 | 74 | 54 | 30.17 | 22.04 | Compliance |

There are no emissions above 2.142 GHz.

*Note

- Above 1 GHz is measured average and peak detector mode on Spectrum analyzer in accordance with FCC Rule15.35
- Limit: 54 dB μ V/m(Average), 74 dB μ V/m(Peak), Attenuated more than 20 dB below the permissible value.
- It is not recorded on the report that the reading of emissions are attenuated more than 20 dB below the permissible limits or the field strength is too small to be measured.
- For the below 30 MHz and above 2.142 GHz, measured any other signal is not detected on test receiver
- The transmitter radiated spectrum was investigated from 9 kHz to 26.5 GHz.

* Worst case only.

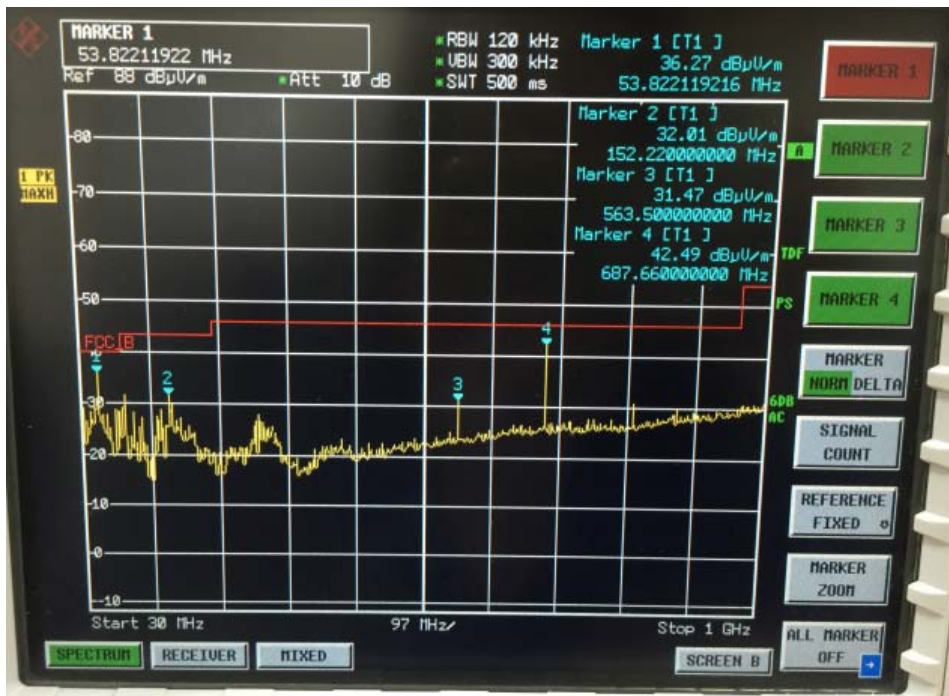


Below 1 GHz

CH 19(2 440 MHz)

| Freq. (MHz) | Reading (dB μ V/m) | Table (Deg) | Antenna | | | CL (dB) | AMP (dB) | Meas Result (dB μ V/m) | Limit (dB μ V/m) | Mgn (dB) | Result |
|----------------|---------------------------|----------------|---------------|---------------|-----------------|------------|-------------|----------------------------------|-------------------------|-------------|------------|
| | | | Height (m) | Pol. (H/V) | Fctr. (dB/m) | | | | | | |
| 53.82 | 3.77 | 160 | 1.5 | V | 20.96 | 0.49 | 8.01 | 33.23 | 40.00 | 6.77 | Compliance |
| 152.22 | 6.10 | 160 | 1.5 | V | 14.17 | 1.15 | 8.44 | 29.86 | 43.52 | 13.66 | Compliance |
| 563.50 | -10.34 | 170 | 1.5 | V | 18.16 | 2.65 | 19.79 | 30.25 | 46.02 | 15.77 | Compliance |
| 687.66 | -5.75 | 160 | 1.5 | V | 19.73 | 2.94 | 21.93 | 38.85 | 46.02 | 7.17 | Compliance |

Freq.(MHz) : Measurement frequency, Reading(dB μ V/m) : Indicated value for test receiver, Table (Deg) : Directional degree of Turn table
Antenna (Height, Pol, Fctr) : Antenna Height, Polarization and Factor, Cbl(dB) : Cable loss, Pre AMP(dB) : Preamplicifier gain(dB)
Meas Result (dB μ V/m) : Reading(dB μ V/m)+ Antenna factor.(dB/m) + CL(dB) - Pre AMP(dB)
Limit(dB μ V/m): Limit value specified with FCC Rule, Mgn(dB) : FCC Limit (dB μ V/m) – Meas Result(dB μ V/m)



5.6 Antenna requirement

5.6.1 Standard applicable [FCC §15.203, §15.247(4)(1)]

For intentional device, according to §15.203, an intentional radiator shall be designed to ensure that no antenna other than furnished by responsible party shall be used with the device.

The use of a permanently attached antenna or of an antenna that user a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

The manufacturer may design the unit So that broken antenna can be replaced by the user, but the Use of a standard antenna jack or electrical connector is prohibited.

And according to §15.247(4)(1), 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.

5.6.2 Antenna gain

| Frequency Band | Antenna Type | Gain [dBi] | Limit [dBi] | Results |
|----------------|--|------------|-------------|------------|
| 2.4 GHz | Chip Antenna (Permanently attached antenna) | 1.99 | ≤ 6 | Compliance |