# FCC/IC REPORT

| | |
|---|---|
| **Applicant:** | Horizon Hobby, LLC |
| **Address of Applicant(FCC):** | 2904 Research Rd., Champaign, IL 61822 USA |
| **Address of Applicant(IC):** | 4105 Fieldstone Rd.Champaign IL 61822 United States Of America |

Equipment Under Test (EUT)

| | |
|---|---|
| Product Name: | Waco RF Module |
| Model No.: | Waco |
| FCC ID: | BRWWACO1T |
| IC: | 6157A-WACO1T |
| **Applicable standards:** | FCC CFR Title 47 Part 15 Subpart C Section 15.249<br>RSS-210 Issue 9 August 2016 Annex B Section B10<br>RSS-Gen Issue 5 April 2018 |
| **Date of sample receipt:** | 24 Apr., 2019 |
| **Date of Test:** | 25 Apr., to 14 May., 2019 |
| **Date of report issued:** | 14 May., 2019 |
| **Test Result:** | PASS* |

* In the configuration tested, the EUT complied with the standards specified above.

Authorized Signature:

Bruce Zhang
Laboratory Manager

This report details the results of the testing carried out on one sample. The results contained in this test report do not relate to other samples of the same product and does not permit the use of the CCIS product certification mark. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

This report may only be reproduced and distributed in full. If the product in this report is used in any configuration other than that detailed in the report, the manufacturer must ensure the new system complies with all relevant standards.

# 2 Version

| Version No. | Date | Description |
|---|---|---|
| *00* | *14 May, 2019* | *Original* |
| *01* | *31 May, 2019* | *Update page 1, 4~11, 25, 26, 28* |
| | | |
| | | |
| | | |

***Prepared By:*** Mike.ou ***Date:*** *14 May, 2019*

***Project Engineer***

***Check By:*** Wimer Zhang ***Date:*** *14 May, 2019*

***Reviewer***

# 3 Contents

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# 4 Test Summary

| Test Item | Section in CFR 47 | | Result |
|---|---|---|---|
| | FCC | IC | |
| Antenna requirement | 15.203 | RSS-GEN Section 6.8 | Pass |
| Conducted Emission | 15.207 | RSS-GEN Section 8.8 | Pass |
| Field strength of the fundamental signal | 15.249 (a)(e) | RSS-210 Annex B Section B.10(a) | Pass |
| Spurious emissions | 15.249 (d)/15.209 | RSS-210 Annex B Section B.10(b) / RSS-GEN Section 8.9 | Pass |
| 20dB Occupy Bandwidth | 15.215 | RSS-GEN Section 6.7 | Pass |
| 99% Occupy Bandwidth | N/A | RSS-GEN Section 6.7 | Pass |
| Frequency stability | / | RSS-210 RSS-GEN Section 8.11 | Pass |

*Pass: The EUT comply with the essential requirements in the standard.*

# 5 General Information

## 5.1 Client Information

| | |
|---|---|
| Applicant: | Horizon Hobby, LLC |
| Address of Applicant: | 2904 Research Rd., Champaign, IL 61822 USA |
| Manufacturer: | Horizon Hobby, LLC |
| Address: | 2904 Research Rd., Champaign, IL 61822 USA |

## 5.2 General Description of E.U.T.

| | |
|---|---|
| Product Name: | Waco RF Module |
| Model No.: | Waco |
| Operation Frequency: | 2404MHz~2476MHz |
| Channel numbers: | 23 |
| Hardware version: | A |
| Software version: | 1.0 |
| Modulation type: | GFSK |
| Antenna Type: | Integral antenna |
| Antenna gain: | 1.3 dBi |
| Power supply: | DC 3.3V |
| Test Sample Condition: | The test samples were provided in good working order with no visible defects. |

| **Operation Frequency each of channel** | | | | | |
|---|---|---|---|---|---|
| Channel | Frequency | Channel | Frequency | Channel | Frequency |
| 0 | 2404MHz | 9 | 2433MHz | 18 | 2463MHz |
| 1 | 2407MHz | 10 | 2437MHz | 19 | 2466MHz |
| 2 | 2411MHz | 11 | 2440MHz | 20 | 2469MHz |
| 3 | 2414MHz | 12 | 2443MHz | 21 | 2473MHz |
| 4 | 2417MHz | 13 | 2446MHz | 22 | 2476 MHz |
| 5 | 2420MHz | 14 | 2450MHz | | |
| 6 | 2424MHz | 15 | 2453MHz | | |
| 7 | 2427MHz | 16 | 2456MHz | | |
| 8 | 2430MHz | 17 | 2459MHz | | |

*Note:*
*In section 15.31(m), regards to the operating frequency range over 10 MHz, the Lowest frequency, the middle frequency, and the highest frequency of channel were selected to perform the test. Channel No. 0, 11 & 22 were selected as Lowest, Middle and Highest channel.*

## 5.3 Test mode

| Transmitting mode: | Keep the EUT in transmitting mode with modulation. |
|---|---|

**Pre-Test Mode:** (highest channel=2404MHz)

CCIS has verified the construction and function in typical operation, The EUT was placed on three different polar directions; i.e. X axis, Y axis, Z axis. which was shown in this test report and defined as follows:

| Axis | X | Y | Z |
|---|---|---|---|
| Field Strength(dBuV/m) | 95.13 | 94.37 | 93.89 |

**Final Test Mode:**

According to ANSI C63.4 standards, the test results are both the “worst case” and “worst setup”:
Z axis (see the test setup photo)

## 5.4 Description of Support Units

| Manufacturer | Description | Model | S/N | FCC ID/DoC |
|---|---|---|---|---|
| LENOVO | Laptop | SL510 | 2847A65 | DoC |
| ROKIT | Adapter | TPA-46B050055UU | N/A | N/A |
| Horizon Hobby, LCC | Test suite | WCAO DEV KIT X0 | N/A | N/A |

## 5.5 Laboritory Facility

The test facility is recognized, certified, or accredited by the following organizations:

- **FCC - Registration No.: 727551**

Shenzhen Zhongjian Nanfang Testing Co., Ltd. has been accredited as a testing laboratory by FCC (Federal Communications Commission). The Registration No. is 727551.

- **IC - Registration No.: 10106A-1**

The 3m Semi-anechoic chamber of Shenzhen Zhongjian Nanfang Testing Co., Ltd. has been Registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No.: 10106A-1.

- **CNAS - Registration No.: CNAS L6048**

Shenzhen Zhongjian Nanfang Testing Co., Ltd. is accredited to ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration laboratories for the competence of testing. The Registration No. is CNAS L6048.

- **A2LA - Registration No.: 4346.01**

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories. The test scope can be found as below link: https://portal.a2la.org/scopepdf/4346-01.pdf

## 5.6 Laboritory Location

Shenzhen Zhongjian Nanfang Testing Co., Ltd.
Address: No. B-C, 1/F., Building 2, Laodong No.2 Industrial Park, Xixiang Road,
Bao’an District, Shenzhen, Guangdong, China
Tel: +86-755-23118282, Fax: +86-755-23116366
Email: info@ccis-cb.com, Website: http://www.ccis-cb.com

## 5.7 Test Instruments list

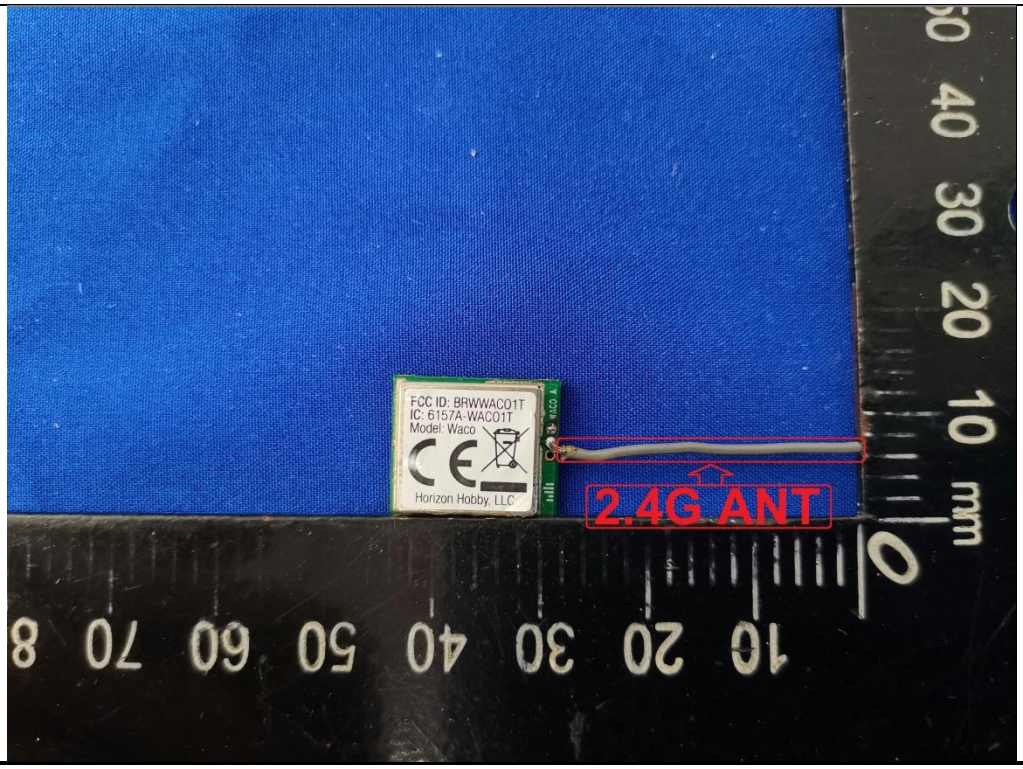
| Radiated Emission: | | | | | |
|---|---|---|---|---|---|
| **Test Equipment** | **Manufacturer** | **Model No.** | **Serial No.** | **Cal. Date (mm-dd-yy)** | **Cal. Due date (mm-dd-yy)** |
| 3m SAC | SAEMC | 9m*6m*6m | 966 | 07-22-2017 | 07-21-2020 |
| BiConiLog Antenna | SCHWARZBECK | VULB9163 | 497 | 03-18-2019 | 03-17-2020 |
| Horn Antenna | SCHWARZBECK | BBHA9120D | 916 | 03-18-2019 | 03-17-2020 |
| Horn Antenna | SCHWARZBECK | BBHA9120D | 1805 | 06-22-2017 | 06-21-2020 |
| Horn Antenna | SCHWARZBECK | BBHA 9170 | BBHA9170582 | 11-21-2018 | 11-20-2019 |
| Loop Antenna | SCHWARZBECK | FMZB 1519 B | 00044 | 03-18-2019 | 03-17-2020 |
| EMI Test Software | AUDIX | E3 | Version: 6.110919b | | |
| Pre-amplifier | HP | 8447D | 2944A09358 | 03-18-2019 | 03-17-2020 |
| Pre-amplifier | CD | PAP-1G18 | 11804 | 03-18-2019 | 03-17-2020 |
| Spectrum analyzer | Rohde & Schwarz | FSP30 | 101454 | 03-18-2019 | 03-17-2020 |
| Spectrum analyzer | Rohde & Schwarz | FSP40 | 100363 | 11-21-2018 | 11-20-2019 |
| EMI Test Receiver | Rohde & Schwarz | ESRP7 | 101070 | 03-18-2019 | 03-17-2020 |
| Simulated Station | Anritsu | MT8820C | 6201026545 | 03-18-2019 | 03-17-2020 |
| Cable | ZDECL | Z108-NJ-NJ-81 | 1608458 | 03-18-2019 | 03-17-2020 |
| Cable | MICRO-COAX | MFR64639 | K10742-5 | 03-18-2019 | 03-17-2020 |
| Cable | SUHNER | SUCOFLEX100 | 58193/4PE | 03-18-2019 | 03-17-2020 |

| Conducted Emission: | | | | | |
|---|---|---|---|---|---|
| **Test Equipment** | **Manufacturer** | **Model No.** | **Serial No.** | **Cal. Date (mm-dd-yy)** | **Cal. Due date (mm-dd-yy)** |
| EMI Test Receiver | Rohde & Schwarz | ESCI | 101189 | 03-18-2019 | 03-17-2020 |
| Pulse Limiter | SCHWARZBECK | OSRAM 2306 | 9731 | 03-18-2019 | 03-17-2020 |
| LISN | CHASE | MN2050D | 1447 | 03-18-2019 | 03-17-2020 |
| LISN | Rohde & Schwarz | ESH3-Z5 | 8438621/010 | 07-21-2018 | 07-20-2019 |
| Cable | HP | 10503A | N/A | 03-18-2019 | 03-17-2020 |
| EMI Test Software | AUDIX | E3 | Version: 6.110919b | | |

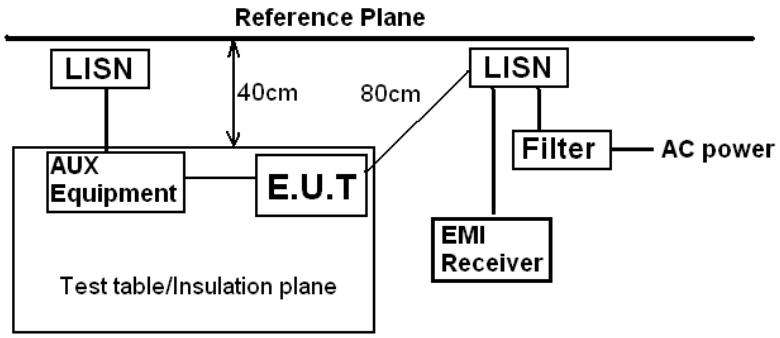
# 6 Test results and Measurement Data

## 6.1 Antenna requirement:

| Standard requirement: | FCC Part15 C Section 15.203 |
|---|---|
| 15.203 requirement:<br>*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, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.* | |
| **E.U.T Antenna:** | |
| *The antenna is Solder 1/4 Wave Antenna which cannot detachable . The best case gain of the antenna is 1.3 dBi.* | |



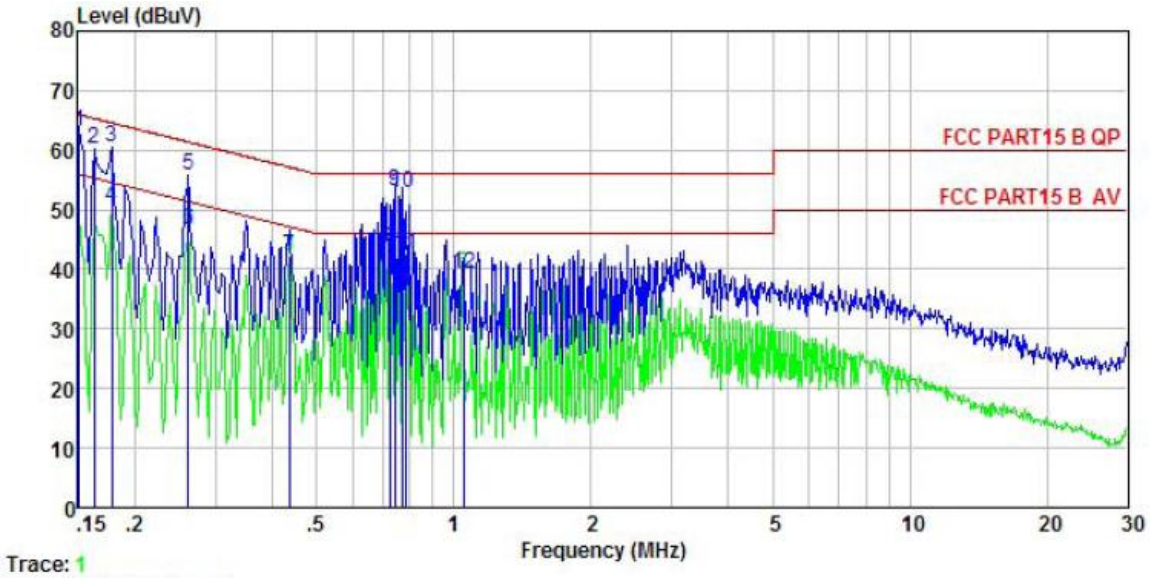
## 6.2 Conducted Emission

<table>
<tr><td>Test Requirement:</td><td colspan="3">FCC Part 15 C Section 15.207</td></tr>
<tr><td>Test Method:</td><td colspan="3">ANSI C63.10: 2013</td></tr>
<tr><td>Test Frequency Range:</td><td colspan="3">150 kHz to 30 MHz</td></tr>
<tr><td>Class / Severity:</td><td colspan="3">Class B</td></tr>
<tr><td>Receiver setup:</td><td colspan="3">RBW=9kHz, VBW=30kHz</td></tr>
<tr><td>Limit:</td><td rowspan="2">Frequency range (MHz)</td><td colspan="2">Limit (dBuV)</td></tr>
<tr><td></td><td>Quasi-peak</td><td>Average</td></tr>
<tr><td></td><td>0.15-0.5</td><td>66 to 56*</td><td>56 to 46*</td></tr>
<tr><td></td><td>0.5-5</td><td>56</td><td>46</td></tr>
<tr><td></td><td>5-30</td><td>60</td><td>50</td></tr>
<tr><td></td><td colspan="3">* Decreases with the logarithm of the frequency.</td></tr>
<tr><td>Test procedure</td><td colspan="3">1. The E.U.T and simulators are connected to the main power through a line impedance stabilization network (L.I.S.N.), which provides a 50ohm/50uH coupling impedance for the measuring equipment.<br>2. The peripheral devices are also connected to the main power through a LISN that provides a 50ohm/50uH coupling impedance with 50ohm termination. (Please refer to the block diagram of the test setup and photographs).<br>3. Both sides of A.C. line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.4: 2014 on conducted measurement.</td></tr>
<tr><td>Test setup:</td><td colspan="3"> 

Remark:<br>E.U.T: Equipment Under Test<br>LISN: Line Impedence Stabilization Network<br>Test table height=0.8m</td></tr>
<tr><td>Test Instruments:</td><td colspan="3">Refer to section 5.8 for details</td></tr>
<tr><td>Test mode:</td><td colspan="3">Refer to section 5.3 for details</td></tr>
<tr><td>Test results:</td><td colspan="3">Passed</td></tr>
</table>

**Measurement Data:**

| Product name: | Waco RF Module | Product model: | Waco |
|---|---|---|---|
| Test by: | Mike | Test mode: | 2.4G Tx mode |
| Test frequency: | 150 kHz ~ 30 MHz | Phase: | Line |
| Test voltage: | AC 120 V/60 Hz | Environment: | Temp: 22.5℃ Huni: 55% |

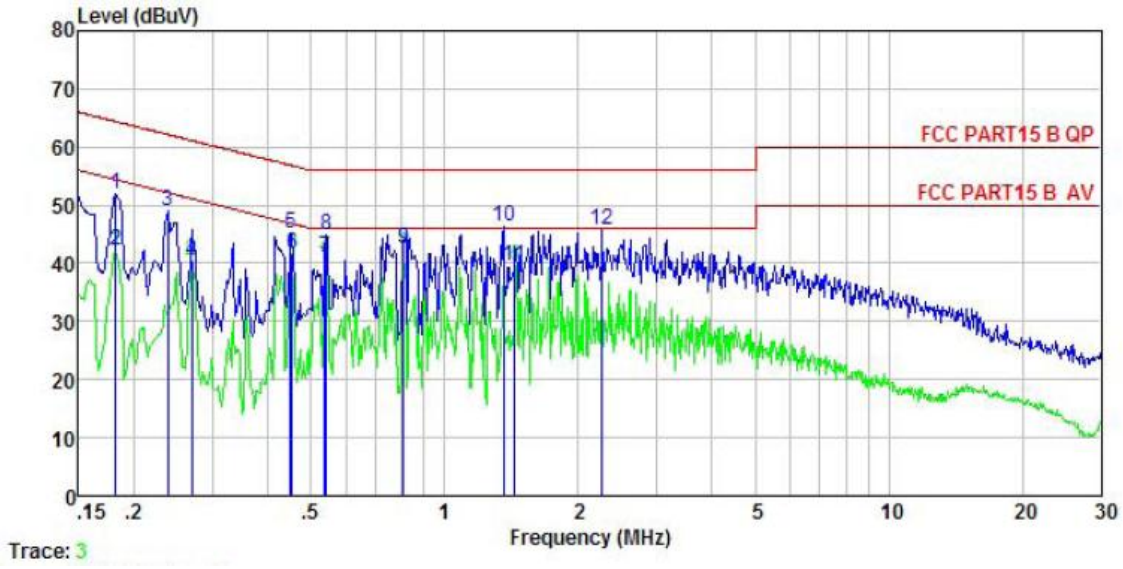



| | Freq | Read Level | LISN Factor | Cable Loss | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB | dB | dBuV | dBuV | dB | |
| 1 | 0.151 | 52.74 | -0.45 | 10.78 | 63.07 | 65.96 | -2.89 | QP |
| 2 | 0.162 | 49.86 | -0.44 | 10.77 | 60.19 | 65.34 | -5.15 | QP |
| 3 | 0.178 | 50.31 | -0.43 | 10.77 | 60.65 | 64.59 | -3.94 | QP |
| 4 | 0.178 | 40.14 | -0.43 | 10.77 | 50.48 | 54.59 | -4.11 | Average |
| 5 | 0.262 | 45.50 | -0.39 | 10.75 | 55.86 | 61.38 | -5.52 | QP |
| 6 | 0.262 | 36.38 | -0.39 | 10.75 | 46.74 | 51.38 | -4.64 | Average |
| 7 | 0.435 | 31.78 | -0.38 | 10.73 | 42.13 | 47.15 | -5.02 | Average |
| 8 | 0.727 | 32.94 | -0.38 | 10.78 | 43.34 | 46.00 | -2.66 | Average |
| 9 | 0.743 | 42.69 | -0.38 | 10.79 | 53.10 | 56.00 | -2.90 | QP |
| 10 | 0.771 | 42.43 | -0.38 | 10.80 | 52.85 | 56.00 | -3.15 | QP |
| 11 | 0.788 | 31.96 | -0.38 | 10.81 | 42.39 | 46.00 | -3.61 | Average |
| 12 | 1.049 | 28.89 | -0.38 | 10.88 | 39.39 | 46.00 | -6.61 | Average |

*Notes:*

1. *An initial pre-scan was performed on the line and neutral lines with peak detector.*
2. *Quasi-Peak and Average measurement were performed at the frequencies with maximized peak emission.*
3. *Final Level =Receiver Read level + LISN Factor + Cable Loss.*

| Product name: | Waco RF Module | Product model: | Waco |
|---|---|---|---|
| Test by: | Mike | Test mode: | 2.4G Tx mode |
| Test frequency: | 150 kHz ~ 30 MHz | Phase: | Neutral |
| Test voltage: | AC 120 V/60 Hz | Environment: | Temp: 22.5℃ Huni: 55% |



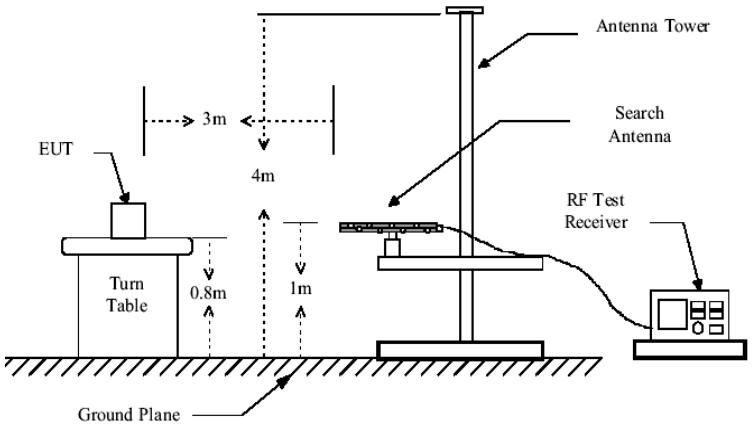
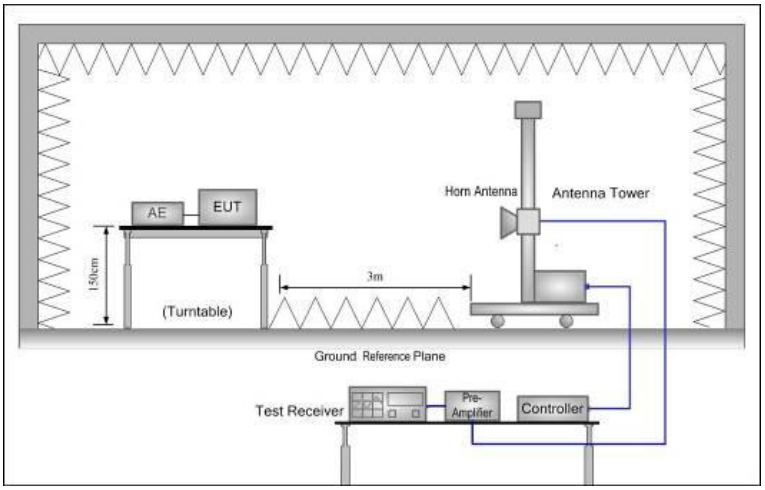

| | Freq | Read Level | LISN Factor | Cable Loss | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB | dB | dBuV | dBuV | dB | |
| 1 | 0.182 | 41.84 | -0.69 | 10.77 | 51.92 | 64.42 | -12.50 | QP |
| 2 | 0.182 | 32.24 | -0.69 | 10.77 | 42.32 | 54.42 | -12.10 | Average |
| 3 | 0.238 | 38.77 | -0.66 | 10.75 | 48.86 | 62.17 | -13.31 | QP |
| 4 | 0.270 | 30.46 | -0.65 | 10.75 | 40.56 | 51.12 | -10.56 | Average |
| 5 | 0.449 | 35.20 | -0.65 | 10.74 | 45.29 | 56.89 | -11.60 | QP |
| 6 | 0.454 | 31.43 | -0.65 | 10.74 | 41.52 | 46.80 | -5.28 | Average |
| 7 | 0.538 | 31.05 | -0.65 | 10.76 | 41.16 | 46.00 | -4.84 | Average |
| 8 | 0.541 | 34.88 | -0.65 | 10.76 | 44.99 | 56.00 | -11.01 | QP |
| 9 | 0.809 | 32.25 | -0.64 | 10.81 | 42.42 | 46.00 | -3.58 | Average |
| 10 | 1.359 | 36.00 | -0.65 | 10.91 | 46.26 | 56.00 | -9.74 | QP |
| 11 | 1.441 | 29.37 | -0.65 | 10.92 | 39.64 | 46.00 | -6.36 | Average |
| 12 | 2.261 | 35.55 | -0.67 | 10.95 | 45.83 | 56.00 | -10.17 | QP |

*Notes:*

1. *An initial pre-scan was performed on the line and neutral lines with peak detector.*
2. *Quasi-Peak and Average measurement were performed at the frequencies with maximized peak emission.*
3. *Final Level =Receiver Read level + LISN Factor + Cable Loss.*

## 6.3 Radiated Emission

<table>
<tr><td>Test Requirement:</td><td colspan="5">FCC Part15 C Section 15.249 and 15.209<br>RSS-210 Annex B Section B.10 and RSS-GEN Section 8.9</td></tr>
<tr><td>Test Method:</td><td colspan="5">ANSI C63.10:2013</td></tr>
<tr><td>Test Frequency Range:</td><td colspan="5">30MHz to 25000MHz</td></tr>
<tr><td>Test site:</td><td colspan="5">Measurement Distance: 3m</td></tr>
<tr><td rowspan="4">Receiver setup:</td><td>Frequency</td><td>Detector</td><td>RBW</td><td>VBW</td><td>Remark</td></tr>
<tr><td>30MHz-1GHz</td><td>Quasi-peak</td><td>120kHz</td><td>300kHz</td><td>Quasi-peak Value</td></tr>
<tr><td rowspan="2">Above 1GHz</td><td>Peak</td><td>1MHz</td><td>3MHz</td><td>Peak Value</td></tr>
<tr><td>RMS</td><td>1MHz</td><td>3MHz</td><td>Average Value</td></tr>
<tr><td rowspan="3">Limit:<br>(Field strength of the fundamental signal)</td><td colspan="2">Frequency</td><td colspan="2">Limit (dBuV/m @3m)</td><td>Remark</td></tr>
<tr><td colspan="2" rowspan="2">2400-2483.5MHz</td><td colspan="2">94.00</td><td>Average Value</td></tr>
<tr><td colspan="2">114.00</td><td>Peak Value</td></tr>
<tr><td rowspan="7">Limit:<br>(Spurious Emissions)</td><td colspan="2">Frequency</td><td colspan="2">Limit (dBuV/m @3m)</td><td>Remark</td></tr>
<tr><td colspan="2">30MHz-88MHz</td><td colspan="2">40.00</td><td>Quasi-peak Value</td></tr>
<tr><td colspan="2">88MHz-216MHz</td><td colspan="2">43.50</td><td>Quasi-peak Value</td></tr>
<tr><td colspan="2">216MHz-960MHz</td><td colspan="2">46.00</td><td>Quasi-peak Value</td></tr>
<tr><td colspan="2">960MHz-1GHz</td><td colspan="2">54.00</td><td>Quasi-peak Value</td></tr>
<tr><td colspan="2" rowspan="2">Above 1GHz</td><td colspan="2">54.00</td><td>Average Value</td></tr>
<tr><td colspan="2">74.00</td><td>Peak Value</td></tr>
<tr><td>Limit:<br>(outside of the specified frequency band)</td><td colspan="5">Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in Section 15.209, whichever is the lesser attenuation.</td></tr>
<tr><td>Test Procedure:</td><td colspan="5">1. The EUT was placed on the top of a rotating table 0.8m(below 1GHz)/1.5m(above 1GHz) above the ground at a 3 meter camber. The table was rotated 360 degrees to determine the position of the highest radiation.<br>2. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.<br>3. The antenna height is 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.<br>4. 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 rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.<br>5. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.<br>6. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.</td></tr>
</table>

| | |
|---|---|
| Test setup: | Below 1GHz<br>  <br><br>Above 1GHz<br>  <br> |
| Test Instruments: | Refer to section 5.7 |
| Test mode: | Refer to section 5.3 |
| Test results: | Passed |

### 6.3.1 Field Strength Of The Fundamental Signal

| Peak value | | | | | | | |
|---|---|---|---|---|---|---|---|
| Frequency (MHz) | Read Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Level (dBuV/m) | Limit Line (dBuV/m) | Over Limit (dB) | Polarization |
| 2404 | 55.00 | 27.11 | 4.70 | 86.81 | 114.00 | -27.19 | Vertical |
| | 62.77 | 27.56 | 4.80 | 95.13 | 114.00 | -18.87 | Horizontoal |
| 2440 | 55.33 | 27.22 | 4.75 | 87.3 | 114.00 | -26.70 | Vertical |
| | 61.71 | 27.22 | 4.75 | 93.68 | 114.00 | -20.32 | Horizontoal |
| 2476 | 54.59 | 27.33 | 4.80 | 86.72 | 114.00 | -27.28 | Vertical |
| | 59.48 | 27.33 | 4.80 | 91.61 | 114.00 | -22.39 | Horizontoal |
| **Average value** | | | | | | | |
| Frequency (MHz) | Read Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Level (dBuV/m) | Limit Line (dBuV/m) | Over Limit (dB) | Polarization |
| 2404 | 54.26 | 27.11 | 4.7 | 86.07 | 94.00 | -7.93 | Vertical |
| | 61.37 | 27.11 | 4.7 | 93.18 | 94.00 | -0.82 | Horizontoal |
| 2440 | 52.31 | 27.22 | 4.75 | 84.28 | 94.00 | -9.72 | Vertical |
| | 61.4 | 27.22 | 4.75 | 93.37 | 94.00 | -0.63 | Horizontoal |
| 2476 | 53.39 | 27.33 | 4.8 | 85.52 | 94.00 | -8.48 | Vertical |
| | 58.93 | 27.33 | 4.8 | 91.06 | 94.00 | -2.94 | Horizontoal |

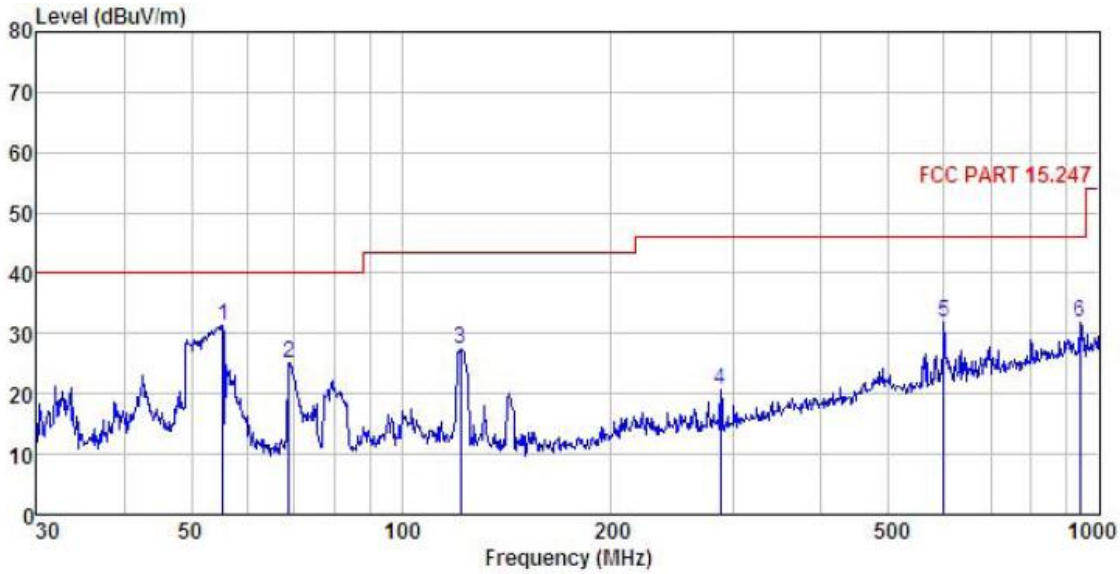
*NOTE: Field strength of the fundamental signal test, RBW >20dB BW, VBW>=3XRBW.*

## 6.3.2 Spurious Emissions

**Measurement Data (worst case):**

**Below 1GHz:**

| Product Name: | Waco RF Module | Product Model: | WACO |
|---|---|---|---|
| Test By: | Mike | Test mode: | 2.4G Tx mode |
| Test Frequency: | 30 MHz ~ 1 GHz | Polarization: | Vertical |
| Test Voltage: | DC 3.3V | Environment: | Temp: 24℃ Huni: 57% |

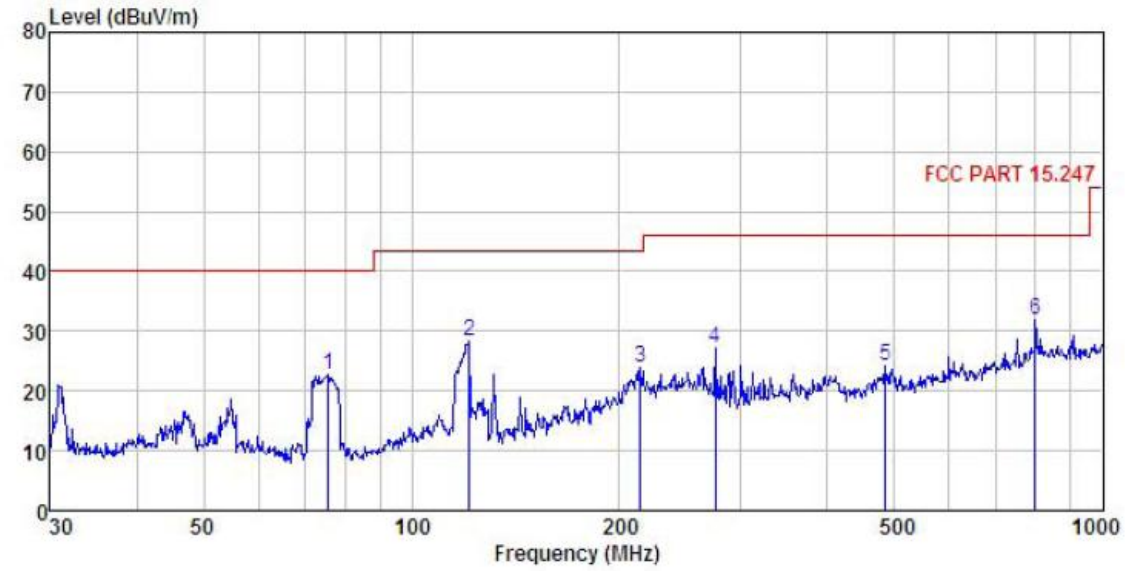



| | Freq | Read Level | Antenna Factor | Cable Loss | Preamp Factor | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB/m | dB | dB | dBuV/m | dBuV/m | dB | |
| 1 | 55.415 | 48.13 | 11.58 | 1.36 | 29.80 | 31.27 | 40.00 | -8.73 | QP |
| 2 | 68.872 | 44.64 | 8.74 | 1.49 | 29.73 | 25.14 | 40.00 | -14.86 | QP |
| 3 | 121.549 | 44.02 | 10.77 | 2.19 | 29.38 | 27.60 | 43.50 | -15.90 | QP |
| 4 | 286.982 | 32.89 | 13.39 | 2.90 | 28.47 | 20.71 | 46.00 | -25.29 | QP |
| 5 | 599.321 | 37.47 | 19.50 | 3.94 | 28.94 | 31.97 | 46.00 | -14.03 | QP |
| 6 | 938.833 | 33.00 | 22.65 | 4.10 | 27.76 | 31.99 | 46.00 | -14.01 | QP |

*Remark:*

1. *Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.*
2. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

| Product Name: | Waco RF Module | Product Model: | WACO |
|---|---|---|---|
| Test By: | Mike | Test mode: | 2.4G Tx mode |
| Test Frequency: | 30 MHz ~ 1 GHz | Polarization: | Horizontal |
| Test Voltage: | DC 3.3V | Environment: | Temp: 24℃ Huni: 57% |




| | Freq | Read Level | Antenna Factor | Cable Loss | Preamp Factor | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB/m | dB | dB | dBuV/m | dBuV/m | dB | |
| 1 | 75.711 | 42.99 | 7.78 | 1.63 | 29.67 | 22.73 | 40.00 | -17.27 | QP |
| 2 | 121.123 | 44.74 | 10.81 | 2.18 | 29.38 | 28.35 | 43.50 | -15.15 | QP |
| 3 | 214.514 | 38.60 | 11.23 | 2.85 | 28.74 | 23.94 | 43.50 | -19.56 | QP |
| 4 | 275.157 | 39.66 | 13.18 | 2.87 | 28.49 | 27.22 | 46.00 | -18.78 | QP |
| 5 | 485.609 | 31.97 | 17.72 | 3.50 | 28.93 | 24.26 | 46.00 | -21.74 | QP |
| 6 | 798.980 | 34.17 | 21.50 | 4.35 | 28.20 | 31.82 | 46.00 | -14.18 | QP |

*Remark:*

1. *Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.*
2. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

**Above 1GHz**

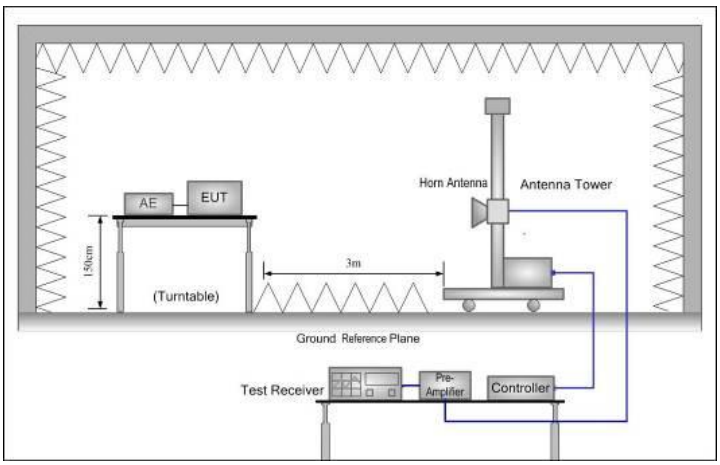
| Test channel: Lowest channel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Detector: Peak Value | | | | | | | | |
| Frequency (MHz) | Read Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Preamp Factor (dB) | Level (dBuV/m) | Limit Line (dBuV/m) | Over Limit (dB) | Polarization |
| 4808.00 | 46.72 | 31.62 | 6.81 | 41.82 | 43.33 | 74.00 | -30.67 | Vertical |
| 4808.00 | 49.96 | 31.62 | 6.81 | 41.82 | 46.57 | 74.00 | -27.43 | Horizontal |
| Detector: Average Value | | | | | | | | |
| Frequency (MHz) | Read Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Preamp Factor (dB) | Level (dBuV/m) | Limit Line (dBuV/m) | Over Limit (dB) | Polarization |
| 4808.00 | 38.54 | 31.62 | 6.81 | 41.82 | 35.15 | 54.00 | -18.85 | Vertical |
| 4808.00 | 39.75 | 31.62 | 6.81 | 41.82 | 36.36 | 54.00 | -17.64 | Horizontal |
| | | | | | | | | |
| Test channel: Middle channel | | | | | | | | |
| Detector: Peak Value | | | | | | | | |
| Frequency (MHz) | Read Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Preamp Factor (dB) | Level (dBuV/m) | Limit Line (dBuV/m) | Over Limit (dB) | Polarization |
| 4880.00 | 47.26 | 31.72 | 6.86 | 41.84 | 44.00 | 74.00 | -30.00 | Vertical |
| 4880.00 | 48.83 | 31.72 | 6.86 | 41.84 | 45.57 | 74.00 | -28.43 | Horizontal |
| Detector: Average Value | | | | | | | | |
| Frequency (MHz) | Read Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Preamp Factor (dB) | Level (dBuV/m) | Limit Line (dBuV/m) | Over Limit (dB) | Polarization |
| 4880.00 | 38.67 | 31.72 | 6.86 | 41.84 | 35.41 | 54.00 | -18.59 | Vertical |
| 4880.00 | 38.91 | 31.72 | 6.86 | 41.84 | 35.65 | 54.00 | -18.35 | Horizontal |
| | | | | | | | | |
| Test channel: Highest channel | | | | | | | | |
| Detector: Peak Value | | | | | | | | |
| Frequency (MHz) | Read Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Preamp Factor (dB) | Level (dBuV/m) | Limit Line (dBuV/m) | Over Limit (dB) | Polarization |
| 4952.00 | 46.86 | 31.84 | 6.91 | 41.87 | 43.74 | 74.00 | -30.26 | Vertical |
| 4952.00 | 47.49 | 31.84 | 6.91 | 41.87 | 44.37 | 74.00 | -29.63 | Horizontal |
| Detector: Average Value | | | | | | | | |
| Frequency (MHz) | Read Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Preamp Factor (dB) | Level (dBuV/m) | Limit Line (dBuV/m) | Over Limit (dB) | Polarization |
| 4952.00 | 38.44 | 31.84 | 6.91 | 41.87 | 35.32 | 54.00 | -18.68 | Vertical |
| 4952.00 | 38.62 | 31.84 | 6.91 | 41.87 | 35.50 | 54.00 | -18.50 | Horizontal |

*Remark:*

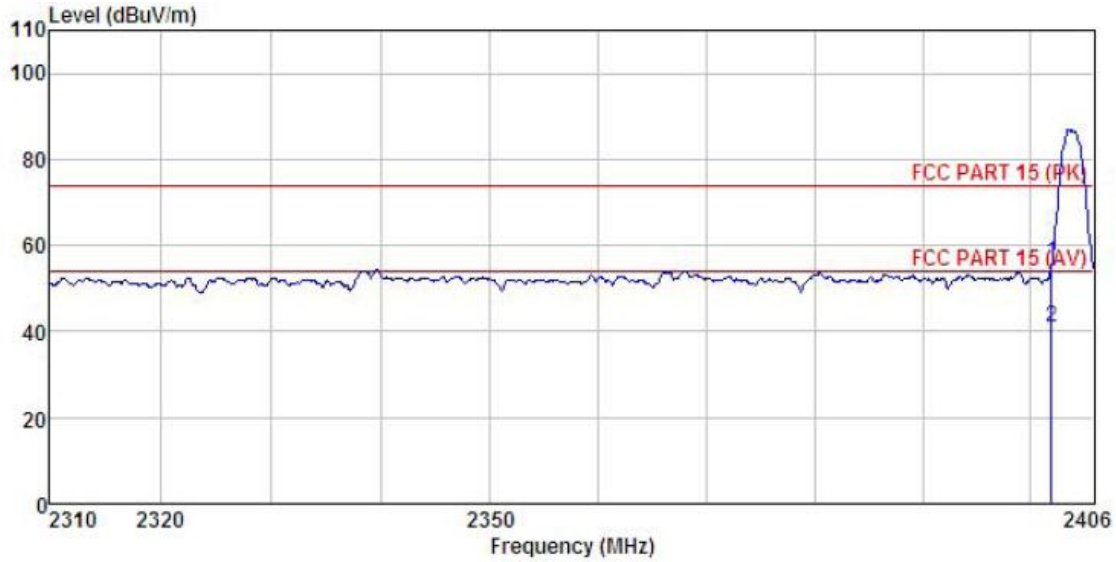
1. *Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.*
2. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

### 6.3.3 Band Edge

**Radiated Emission Method**

<table>
<tr><td>Test Requirement:</td><td colspan="5">FCC Part 15 C Section 15.205 and 15.209<br>RSS-GEN Section 8.9 and RSS-GEN Section 8.10</td></tr>
<tr><td>Test Method:</td><td colspan="5">ANSI C63.10:2013</td></tr>
<tr><td>Test Frequency Range:</td><td colspan="5">2.3GHz to 2.5GHz</td></tr>
<tr><td>Test Distance:</td><td colspan="5">3m</td></tr>
<tr><td rowspan="3">Receiver setup:</td><td>Frequency</td><td>Detector</td><td>RBW</td><td>VBW</td><td>Remark</td></tr>
<tr><td rowspan="2">Above 1GHz</td><td>Peak</td><td>1MHz</td><td>3MHz</td><td>Peak Value</td></tr>
<tr><td>RMS</td><td>1MHz</td><td>3MHz</td><td>Average Value</td></tr>
<tr><td rowspan="3">Limit:</td><td colspan="2">Frequency</td><td colspan="2">Limit (dBuV/m @3m)</td><td>Remark</td></tr>
<tr><td colspan="2" rowspan="2">Above 1GHz</td><td colspan="2">54.00</td><td>Average Value</td></tr>
<tr><td colspan="2">74.00</td><td>Peak Value</td></tr>
<tr><td>Test Procedure:</td><td colspan="5">7. The EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter camber. The table was rotated 360 degrees to determine the position of the highest radiation.<br>8. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.<br>9. The antenna height is 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.<br>10. 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 rota table was turned from 0 degrees to 360 degrees to find the maximum reading.<br>11. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.<br>12. If the emission level of the EUT in peak mode was 10 dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.</td></tr>
<tr><td>Test setup:</td><td colspan="5"> 
</td></tr>
<tr><td>Test Instruments:</td><td colspan="5">Refer to section 5.7 for details</td></tr>
<tr><td>Test mode:</td><td colspan="5">Refer to section 5.3 for details</td></tr>
<tr><td>Test results:</td><td colspan="5">Passed</td></tr>
</table>

| Product Name: | Waco RF Module | Product Model: | WACO |
|---|---|---|---|
| Test By: | Mike | Test mode: | 2.4G-Tx mode |
| Test Channel: | Lowest channel | Polarization: | Vertical |
| Test Voltage: | DC 3.3V | Environment: | Temp: 24℃ Huni: 57% |

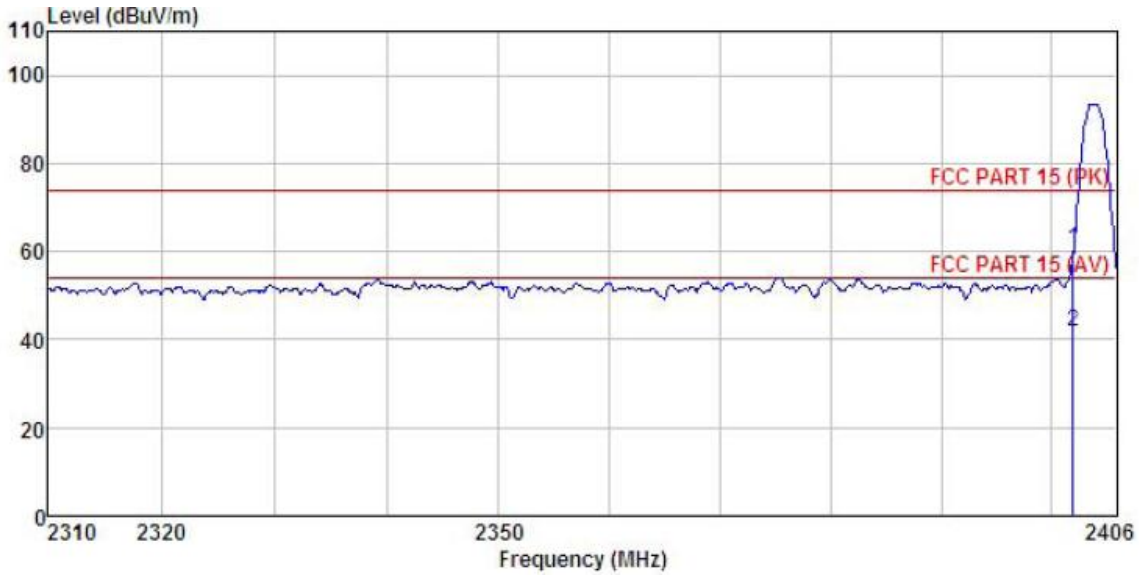



| | Freq | Read Level | Antenna Factor | Cable Loss | Preamp Factor | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB/m | dB | dB | dBuV/m | dBuV/m | dB | |
| 1 | 2402.000 | 24.30 | 27.11 | 4.70 | 0.00 | 56.11 | 74.00 | -17.89 | Peak |
| 2 | 2402.000 | 9.24 | 27.11 | 4.70 | 0.00 | 41.05 | 54.00 | -12.95 | Average |

*Remark:*

1. *Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.*
2. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

| Product Name: | Waco RF Module | Product Model: | WACO |
|---|---|---|---|
| Test By: | Mike | Test mode: | 2.4G-Tx mode |
| Test Channel: | Lowest channel | Polarization: | Horizontal |
| Test Voltage: | DC 3.3V | Environment: | Temp: 24℃ Huni: 57% |

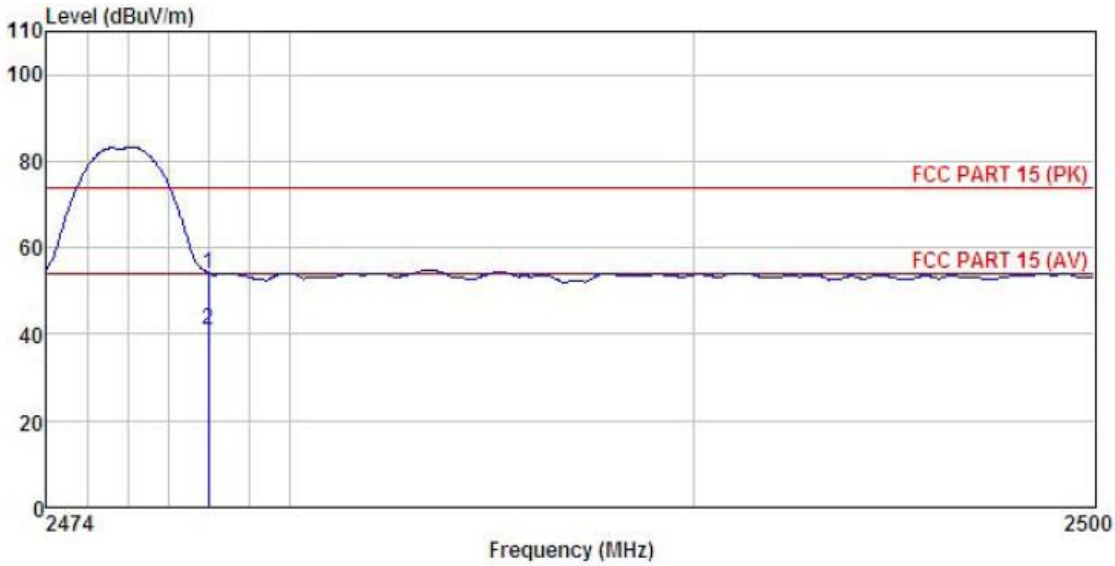



| | Freq | Read Level | Antenna Factor | Cable Loss | Preamp Factor | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB/m | dB | dB | dBuV/m | dBuV/m | dB | |
| 1 | 2402.000 | 28.60 | 27.11 | 4.70 | 0.00 | 60.41 | 74.00 | -13.59 | Peak |
| 2 | 2402.000 | 10.09 | 27.11 | 4.70 | 0.00 | 41.90 | 54.00 | -12.10 | Average |

*Remark:*

1. *Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.*
2. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

| Product Name: | Waco RF Module | Product Model: | WACO |
|---|---|---|---|
| Test By: | Mike | Test mode: | 2.4G-Tx mode |
| Test Channel: | Highest channel | Polarization: | Vertical |
| Test Voltage: | DC 3.3V | Environment: | Temp: 24℃ Huni: 57% |

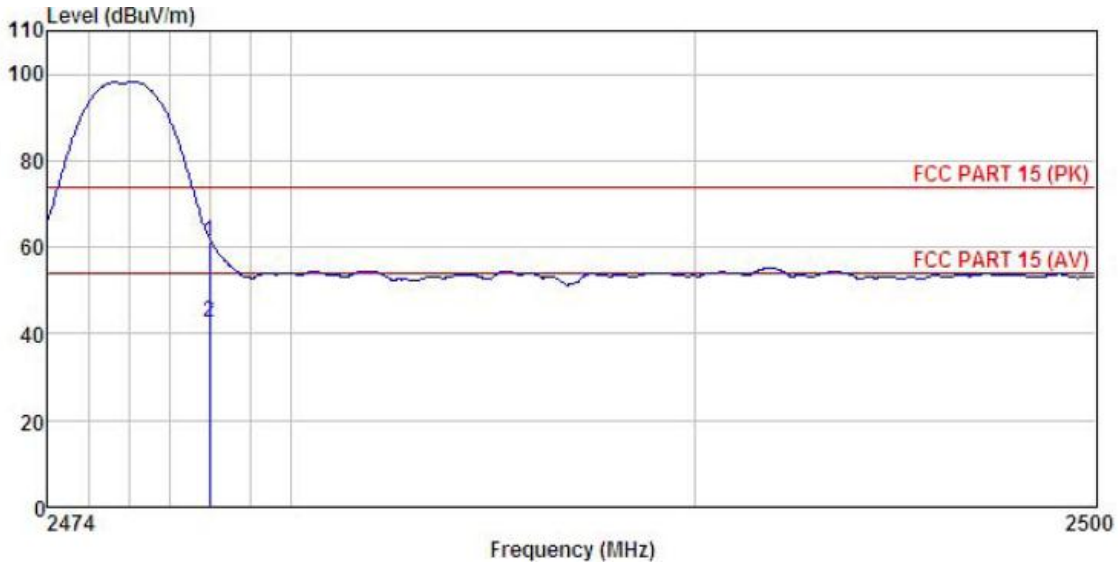



| | Freq | Read Level | Antenna Factor | Cable Loss | Preamp Factor | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB/m | dB | dB | dBuV/m | dBuV/m | dB | |
| 1 | 2478.000 | 21.88 | 27.34 | 4.80 | 0.00 | 54.02 | 74.00 | -19.98 | Peak |
| 2 | 2478.000 | 9.04 | 27.34 | 4.80 | 0.00 | 41.18 | 54.00 | -12.82 | Average |

*Remark:*

1. *Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.*
2. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

| Product Name: | Waco RF Module | Product Model: | WACO |
|---|---|---|---|
| Test By: | Mike | Test mode: | 2.4G-Tx mode |
| Test Channel: | Highest channel | Polarization: | Horizontal |
| Test Voltage: | DC 3.3V | Environment: | Temp: 24℃ Huni: 57% |

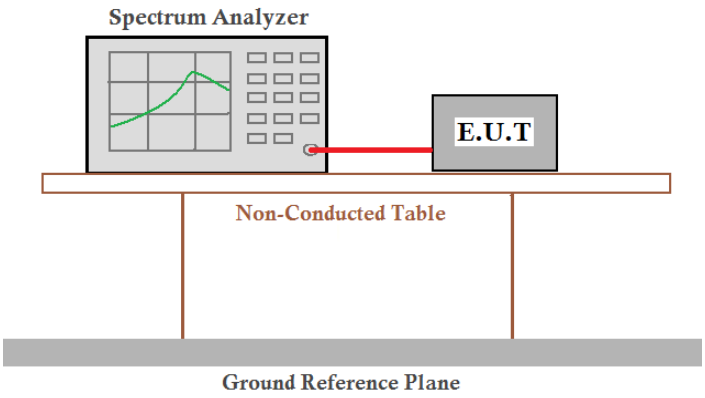



| | Freq | Read Level | Antenna Factor | Cable Loss | Preamp Factor | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB/m | dB | dB | dBuV/m | dBuV/m | dB | |
| 1 | 2478.000 | 29.20 | 27.34 | 4.80 | 0.00 | 61.34 | 74.00 | -12.66 | Peak |
| 2 | 2478.000 | 10.57 | 27.34 | 4.80 | 0.00 | 42.71 | 54.00 | -11.29 | Average |

*Remark:*

1. *Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.*
2. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

## 6.4 Occupy Bandwidth

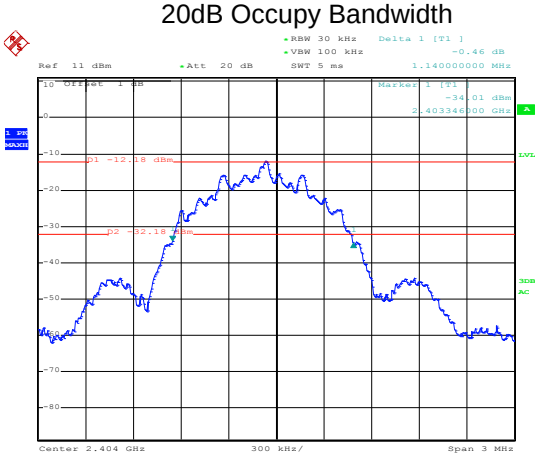
| | |
|---|---|
| Test Requirement: | FCC Part 15 C Section 15.215<br>RSS-GEN Section 6.7 |
| Test Method: | ANSI C63.10:2013 |
| Receiver setup: | RBW=30 kHz, VBW=100 kHz, detector=Peak |
| Limit: | N/A |
| Test setup: |  |
| Test Instruments: | Refer to section 5.7 for details |
| Test mode: | Transmitting mode |
| Test results: | Pass |

**Measurement Data:**

| 20dB Occupy Bandwidth (MHz) | | |
|---|---|---|
| Lowest channel | Middle channel | Highest Highest |
| 1.140 | 1.188 | 1.176 |
| 99% Occupy Bandwidth (MHz) | | |
| Lowest channel | Middle channel | Highest Highest |
| 1.038 | 1.056 | 1.050 |

**Test plot as follows:**

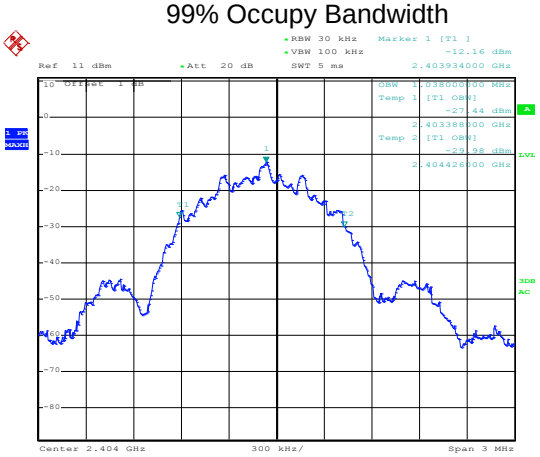
20dB Occupy Bandwidth




Date: 13.MAY.2019 16:04:02

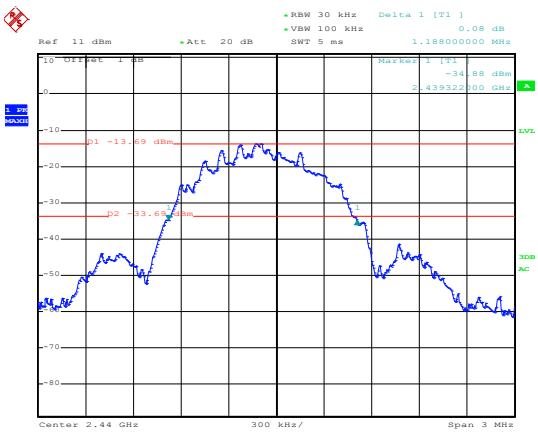
Lowest channel

99% Occupy Bandwidth



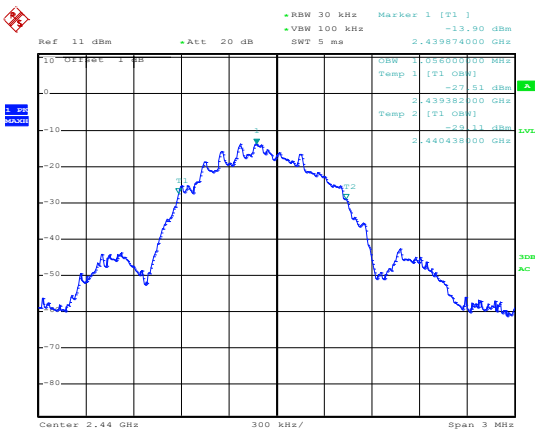

Date: 13.MAY.2019 16:02:36

Lowest channel



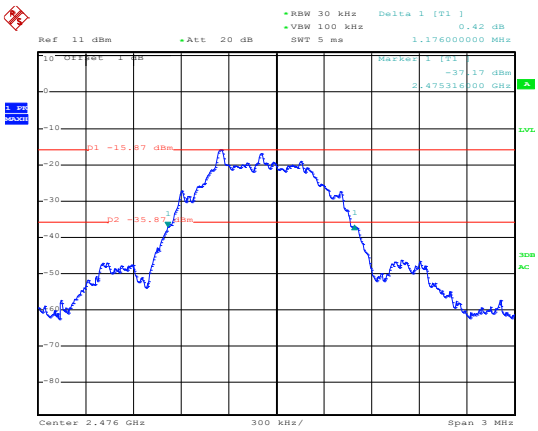

Date: 13.MAY.2019 15:59:14

Middle channel



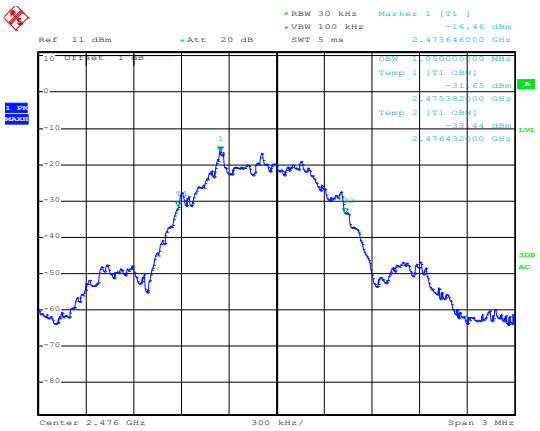

Date: 13.MAY.2019 16:00:59

Middle channel




Date: 13.MAY.2019 16:17:47

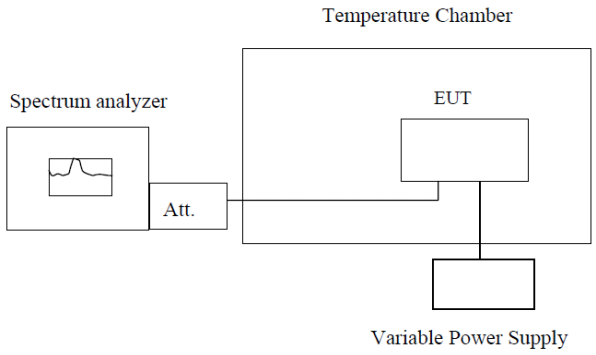
Highest channel




Date: 13.MAY.2019 16:18:42

Highest channel

## 6.5 Frequency stability

| | |
|---|---|
| Test Requirement: | RSS-GEN Section 8.11 |
| Test Method: | RSS-GEN Section 6.11 |
| Limit: | 2400MHz~2483.5MHz |
| Test setup: |  <br>**Note :** Measurement setup for testing on Antenna connector |
| Test procedure: | 1. The EUT is installed in an environment test chamber with external power source.<br>2. Set the chamber to operate at 50 centigrade and external power source to output at nominal voltage of EUT.<br>3. A sufficient stabilization period at each temperature is used prior to each frequency measurement.<br>4. When temperature is stabled, measure the frequency stability.<br>5. The test shall be performed under -20 to 50 centigrade and 85 to 115 percent of the nominal voltage. Change setting of chamber and external power source to complete all conditions. |
| Test Instruments: | Refer to section 5.7 for details |
| Test mode: | Refer to section 5.3 for details |
| Test results: | Passed |

## Measurement Data (worst case):

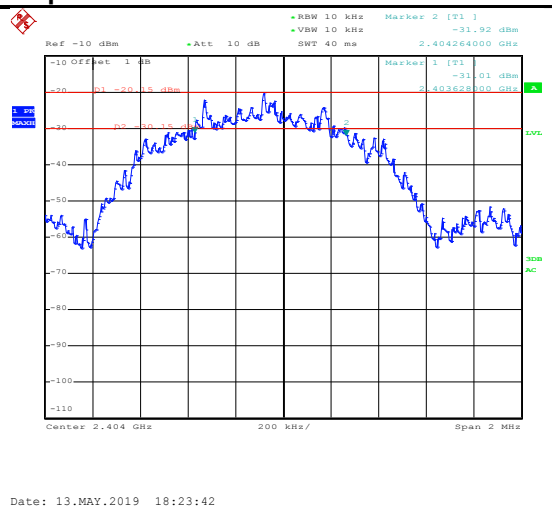
Voltage vs. Frequency Stability

| Test conditions | | Measurement Frequency (MHz) | | Limit (MHz) |
|---|---|---|---|---|
| Temp(℃) | Voltage(ac) | Lowest channel | Highest Highest | |
| 20 | 5.0V | 2403.946 | 2475.942 | 2400MHz~2483.5 |
| | 3.3V | 2403.947 | 2475.943 | |
| | 3.0V | 2403.945 | 2475.940 | |
| *Note: EUT stops working when the supply voltage is lower than DC 3V.* | | | | |

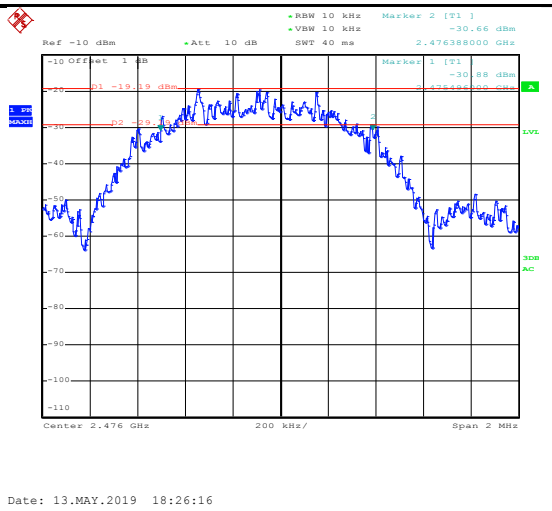
Temperature vs. Frequency Stability

| Test conditions | | Frequency(MHz) | | Limit (MHz) |
|---|---|---|---|---|
| Voltage(dc) | Temp(℃) | Lowest channel | Highest channel | |
| 3.3 V | -20 | 2403.945 | 2475.947 | 2400MHz~2483.5 |
| | -10 | 2403.946 | 2475.946 | |
| | 0 | 2403.947 | 2475.948 | |
| | 10 | 2403.945 | 2475.945 | |
| | 20 | 2403.946 | 2475.944 | |
| | 30 | 2403.944 | 2475.942 | |
| | 40 | 2403.947 | 2475.943 | |
| | 50 | 2403.945 | 2475.9449 | |

**Test plot as follows:**




Lowest channel




Highest channel