# ENGINEERING TEST REPORT

**BR-RFX100**
**Model: BR-RFX100**
**FCC ID: 2AHHP-X100**

*Applicant:*

**Bluerover Inc.**
151 Charles Street West, Suite 117
Kitchener, Ontario
Canada N2G 1H6

***In Accordance With***

**Federal Communications Commission (FCC)**
**Part 15, Subpart C, Section 15.247 Frequency Hopping Spread Spectrum (FHSS)**

**UltraTech's File No.: 16BLRO006_FCC15247_DSS**

| | |
|---|---|
| This Test report is Issued under the Authority of<br>Tri M. Luu<br>Vice President of Engineering<br>UltraTech Group of Labs<br><br>Date: June 17, 2016 | |
| Report Prepared by: Dharmajit Solanki<br><br>Issued Date: June 17, 2016 | Tested by: Hung Trinh<br><br>Test Dates: January 19 - March 12, 2016 |

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
- *This report must not be used by the client to claim product endorsement by NVLAP or any agency of the US Government.*

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# EXHIBIT 1. INTRODUCTION

## 1.1. SCOPE

| | |
|---|---|
| **Reference:** | FCC Part 15, Subpart C, Section 15.247 |
| **Title:** | Code of Federal Regulations (CFR), Title 47 – Telecommunication, Part 15 |
| **Purpose of Test:** | Equipment Certification for Part 15C Spread Spectrum Transmitter Module |
| **Test Procedures:** | ▪ ANSI C63.4<br>▪ ANSI C63.10<br>▪ FCC Public Notice DA 00-705 |
| **Environmental Classification:** | [ x ] Commercial, industrial or business environment<br>[ ] Residential environment |

## 1.2. RELATED SUBMITTAL(S)/GRANT(S)

None

## 1.3. NORMATIVE REFERENCES

| Publication | Year | Title |
|---|---|---|
| 47 CFR Parts 0-19 | 2016 | Code of Federal Regulations (CFR), Title 47 – Telecommunication |
| ANSI C63.4 | 2014 | American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 KHz to 40 GHz |
| ANSI C63.10 | 2013 | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices |
| CISPR 22 &<br>EN 55022 | 2008-09, Edition 6.0<br>2006 | Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement |
| CISPR 16-1-1<br>+A1<br>+A2 | 2006<br>2006<br>2007 | Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus |
| CISPR 16-1-2<br>+A1<br>+A2 | 2003<br>2004<br>2006 | Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-2: Conducted disturbances |
| FCC Public Notice DA 00-705 | 2000 | Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems |
| FCC ET Docket No. 99-231 | 2002 | Amendment to FCC Part 15 of the Commission's Rules Regarding to Spread Spectrum Devices |

# EXHIBIT 2. PERFORMANCE ASSESSMENT

## 2.1. CLIENT INFORMATION

| APPLICANT | |
|---|---|
| **Name:** | Bluerover Inc. |
| **Address:** | 151 Charles Street West, Suite 117<br>Kitchener, Ontario<br>Canada N2G 1H6 |
| **Contact Person:** | Harminder Banwait<br>Phone #: 855-682-2874<br>Fax #: N/A<br>Email Address: hbanwait@bluerover.ca |

| MANUFACTURER | |
|---|---|
| **Name:** | Urtech Manufacturing Inc. |
| **Address:** | 835 Harrington Court, Unit 1<br>Burlington, Ontario<br>Canada L7N 3P3 |
| **Contact Person:** | Jamal Qureshi<br>Phone #: 905-667-2310 ext 405<br>Fax #: N/A<br>Email Address: jamal@urtechmfg.com |

## 2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

| | |
|---|---|
| **Brand Name:** | Bluerover Inc. |
| **Product Name:** | BR-RFX100 |
| **Model Name or Number:** | BR-RFX100 |
| **Serial Number:** | Test Sample |
| **Type of Equipment:** | FH Spread Spectrum Transmitter, Radio Module |
| **Input Power Supply Type:** | External Regulated DC Sources |
| **Primary User Functions of EUT:** | Transmit and receive sensory data to the Gateway |

## 2.3. EUT'S TECHNICAL SPECIFICATIONS

| Transmitter | |
|---|---|
| **Equipment Type:** | ▪ Mobile<br>▪ Base Station (fixed use) |
| **Intended Operating Environment:** | Commercial, industrial or business environment |
| **Power Supply Requirement:** | 3.0-3.6VDC @ 50mA |
| **RF Output Power Rating:** | 13.98 dBm |
| **Operating Frequency Range:** | 902.5 – 927.5 MHz |
| **RF Output Impedance:** | 50 Ω |
| **Duty Cycle:** | Continuous |
| **Modulation Type:** | 2GFSK |
| **Antenna Connector Type:** | U.FL/PCB |

## 2.4. ASSOCIATED ANTENNA DESCRIPTIONS

| Manufacturer | Type | Model/Part Number | Gain |
|---|---|---|---|
| Pulse Electronics | Dipole | W1063 | 3 dBi |
| Texas Instruments | Helical PCB | DN038 | 2.33 dBi |

## 2.5. LIST OF EUT'S PORTS

| Port Number | EUT's Port Description | Number of Identical Ports | Connector Type | Cable Type (Shielded/Non-shielded) |
|---|---|---|---|---|
| [1]1 | RF IN/OUT Port | 1 | U.FL | Shielded coaxial cable with unique coupling connectors |
| 2 | External Sensor (J3) | 1 | Header | 4" non-shielded |
| 3 | Power | 1 | Header | Non-shielded |
| 4 | [2]JTAG (J4) | 1 | Header | Non-shielded |

[1]Optional U.FL connector for an external dipole antenna
[2]Factory use only

## 2.6. ANCILLARY EQUIPMENT

The EUT was tested while connected to the following representative configuration of ancillary equipment necessary to exercise the ports during tests:

| Ancillary Equipment # 1 | |
|---|---|
| Description: | Switching Power Supply |
| Brand name: | Tenma |
| Model Name or Number: | 72-7295 |
| Connected to EUT's Port: | Power |

# EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

## 3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

| | |
|---|---|
| Temperature: | 21°C |
| Humidity: | 51% |
| Pressure: | 102 kPa |
| Power Input Source: | 3.3VDC |

## 3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

| | |
|---|---|
| **Operating Modes:** | ▪ Each of lowest, middle and highest channel frequencies transmits continuously for emissions measurements.<br>▪ The EUT operates in normal Frequency Hopping mode for occupancy duration, and frequency separation. |
| **Special Test Software & Hardware:** | Test software provided by the Applicant is installed to allow the EUT to operate in hopping mode or at each channel frequency continuously. For example, the transmitter will be operated at each of lowest, middle and highest frequencies individually continuously during testing. |
| **Transmitter Test Antenna:** | The EUT is tested with the antenna fitted in a manner typical of normal intended use as non-integral/integral antenna equipment as described with the test results. |

| **Transmitter Test Signals** | |
|---|---|
| **Frequency Band(s):** | 902.5 - 927.5 MHz |
| **Frequency(ies) Tested:**<br>(Near lowest, near middle & near highest frequencies in the frequency range of operation.) | 902.5 MHz, 915.0 MHz and 927.5 MHz |
| **RF Power Output:**<br>(measured maximum output power at antenna terminals) | 13.98 dBm, 25 mW (conducted) |
| **Normal Test Modulation:** | 2GFSK |
| **Modulating Signal Source:** | Internal |

# EXHIBIT 4. SUMMARY OF TEST RESULTS

## 4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).
- Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with FCC office (FCC File No.: 91038) and Industry Canada office (Industry Canada File No.: 2049A-3). Expiry Date: 2017-04-02.

## 4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

| FCC Section(s) | Test Requirements | Compliance (Yes/No) |
|---|---|---|
| 15.203 | Antenna requirements | Yes |
| 15.207(a) | AC Power Line Conducted Emissions | Yes |
| 15.247(a) | Provisions for Frequency Hopping Systems | Yes |
| 15.247(b)(2) | Peak Conducted Output Power | Yes |
| 15.247(d), 15.209 & 15.205 | Transmitter Spurious Radiated Emissions | Yes |
| 15.247(i), 1.1307, 1.1310, 2.1091 | RF Exposure | Yes |

## 4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

# EXHIBIT 5. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR EMC EMISSIONS

## 5.1. POWER LINE CONDUCTED EMISSIONS [§15.207(a)]

### 5.1.1. Limit(s)

The equipment shall meet the limits of the following table:

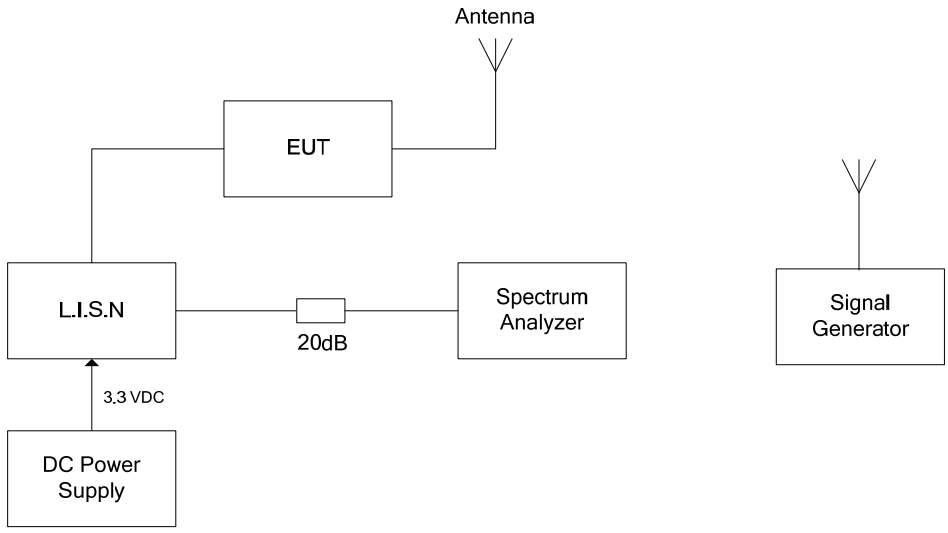
| Frequency of emission (MHz) | Conducted Limits (dBμV) | |
|---|---|---|
| | Quasi-peak | Average |
| 0.15–0.5 .....…….. | 66 to 56* ..... | 56 to 46* |
| 0.5–5 .....…….. | 56 ..... | 46 |
| 5-30 …….. | 60 ...…….. | 50 |

*Decreases linearly with the logarithm of the frequency

### 5.1.2. Method of Measurements

ANSI C63.4

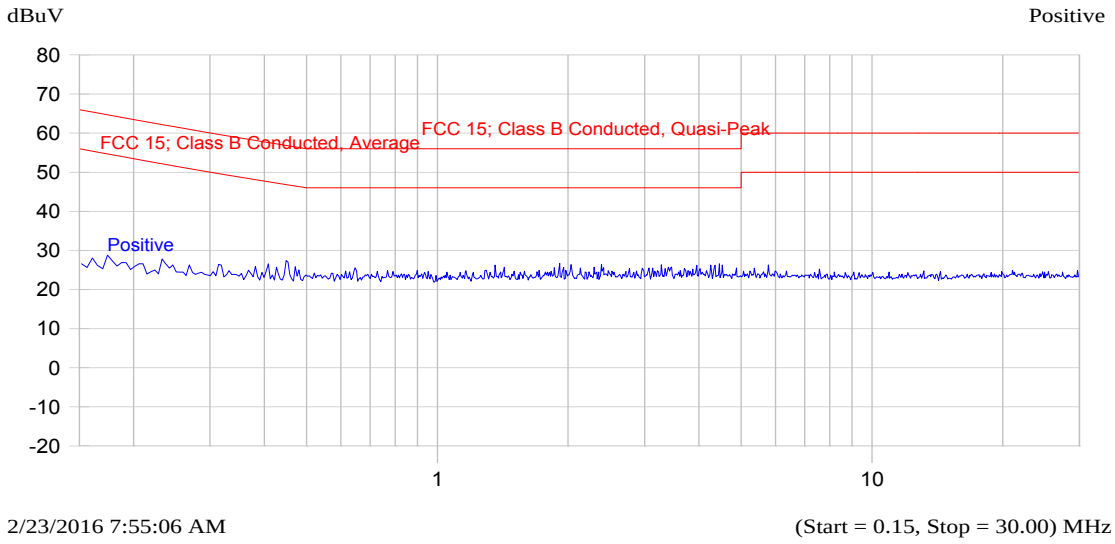
### 5.1.3. Test Arrangement



### 5.1.4. Test Data

**Plot 5.1.4.1.** Power Line Conducted Emissions (Tx Mode)
Line Voltage: 3.3 VDC; Line Tested: Positive

**Current Graph**

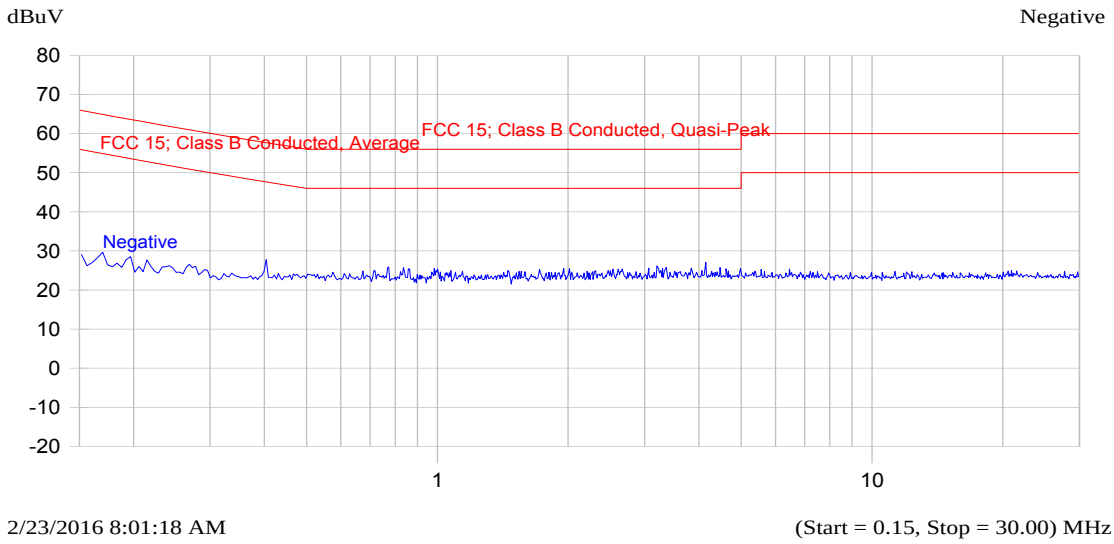



**Current List**

| Frequency MHz | Peak dBuV | QP dBuV | Delta QP-QP Limit dB | Avg dBuV | Delta Avg-Avg Limit dB | Trace Name |
|---|---|---|---|---|---|---|
| 0.174 | 41.7 | 36.2 | -28.5 | 31.1 | -23.6 | Positive |
| 0.441 | 36.0 | 29.8 | -27.2 | 24.2 | -22.8 | Positive |

**Plot 5.1.4.2.** Power Line Conducted Emissions (Tx Mode)
Line Voltage: 3.3 VDC; Line Tested: Negative

## Current Graph

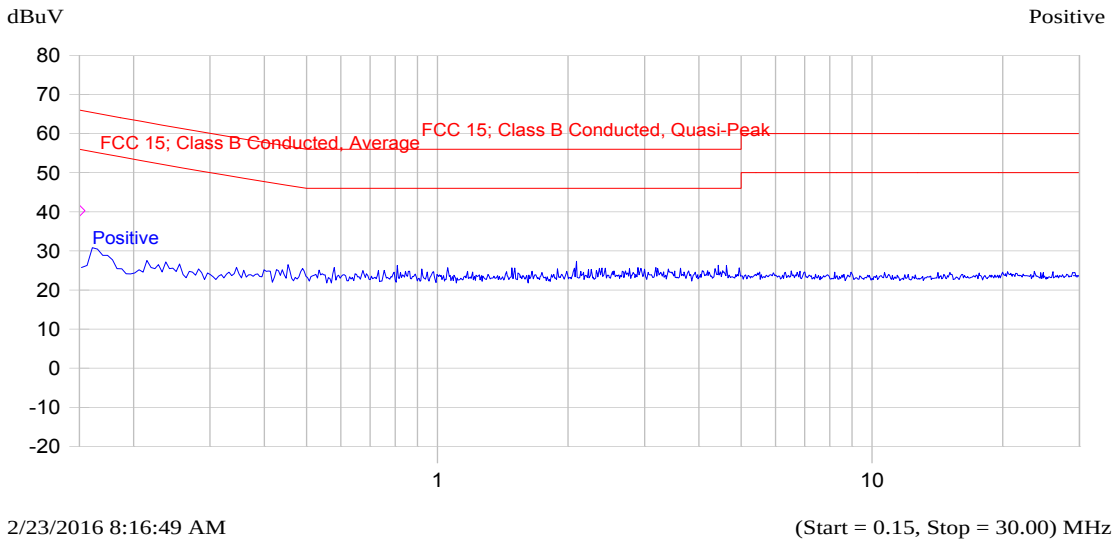



## Current List

| Frequency MHz | Peak dBuV | QP dBuV | Delta QP-QP Limit dB | Avg dBuV | Delta Avg-Avg Limit dB | Trace Name |
|---|---|---|---|---|---|---|
| 0.165 | 39.0 | 34.2 | -31.1 | 28.4 | -26.8 | Negative |
| 0.395 | 35.9 | 30.2 | -27.7 | 24.5 | -23.4 | Negative |

**Plot 5.1.4.3.** Power Line Conducted Emissions (Rx Mode)
Line Voltage: 3.3 VDC; Line Tested: Positive

## Current Graph

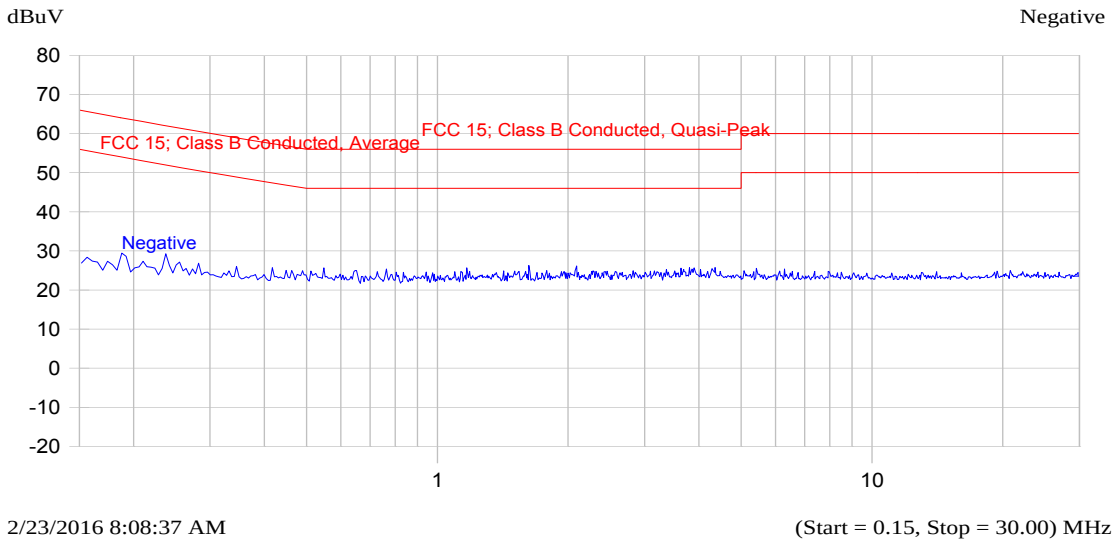



## Current List

| Frequency MHz | Peak dBuV | QP dBuV | Delta QP-QP Limit dB | Avg dBuV | Delta Avg-Avg Limit dB | Trace Name |
|---|---|---|---|---|---|---|
| 0.150 | 40.3 | 34.9 | -31.1 | 29.2 | -26.8 | Positive |

**Plot 5.1.4.4.** Power Line Conducted Emissions (Rx Mode)
Line Voltage: 3.3 VDC; Line Tested: Negative

## Current Graph




## Current List

| Frequency MHz | Peak dBuV | QP dBuV | Delta QP-QP Limit dB | Avg dBuV | Delta Avg-Avg Limit dB | Trace Name |
|---|---|---|---|---|---|---|
| 0.189 | 40.2 | 35.6 | -28.4 | 30.6 | -23.4 | Negative |
| 0.240 | 38.5 | 32.0 | -30.0 | 26.6 | -25.5 | Negative |

## 5.2. COMPLIANCE WITH FCC PART 15 – GENERAL TECHNICAL REQUIREMENTS

| FCC Section | FCC Rules | Manufacturer's Clarification |
|---|---|---|
| 15.203 | Described how the EUT complies with the requirement that either its antenna is permanently attached, or that it employs a unique antenna connector, for every antenna proposed for use with the EUT.<br><br>The exception is in those cases where EUT must be professionally installed. In order to demonstrate that professional installation is required, the following 3 points must be addressed:<br>➢ The application (or intended use) of the EUT<br>➢ The installation requirements of the EUT<br>➢ The method by which the EUT will be marketed | The antenna employs a unique/integral antenna connector. |
| 15.204 | Provided the information for every antenna proposed for use with the EUT:<br>➢ type (e.g. Yagi, patch, grid, dish, etc…),<br>➢ manufacturer and model number<br>➢ gain with reference to an isotropic radiator | See proposed antenna listed in user manual. |
| 15.247(a) | Description of how the EUT meets the definition of a frequency hopping spread spectrum, found in Section 2.1. Based on the technical description. | See Operational Description |
| 15.247(a) | Pseudo Frequency Hopping Sequence:<br>Describe how the hopping sequence is generated. Provide an example of the hopping sequence channels, in order to demonstrate that the sequence meets the requirements specified in the definition of a frequency hopping spread spectrum system, found in Section 2.1 | See Operational Description |
| 15.247(a) | Equal Hopping Frequency Use:<br>Describe how each individual EUT meets the requirement that each of its hopping channels is used equally on average (e.g. that each new transmission event begins on the next channel in the hopping sequence after final channel used in the previous transmission events). | See Operational Description |
| 15.247(a) | System Receiver Input Bandwidth:<br>Describe how the associated receiver(s) complies with the requirement that its input bandwidth (either RF or IF) matches the bandwidth of the transmitted signal. | See Operational Description |

| FCC Section | FCC Rules | Manufacturer's Clarification |
|---|---|---|
| 15.247(a) | System Receiver Hopping Capability:<br>Describe how the associated receiver(s) has the ability to shift frequencies in synchronization with the transmitted signals | See Operational Description |
| 15.247(g) | Describe how the EUT complies with the requirement that it be designed to be capable of operating as a true frequency hopping system | See Operational Description |
| 15.247(h) | Describe how the EUT complies with the requirement that it not have the ability to coordinated with other FHSS is an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitters | See Operational Description |

## 5.3. PROVISIONS FOR FREQUENCY HOPPING SYSTEMS [§ 15.247(a)(1)]

### 5.3.1. Limits

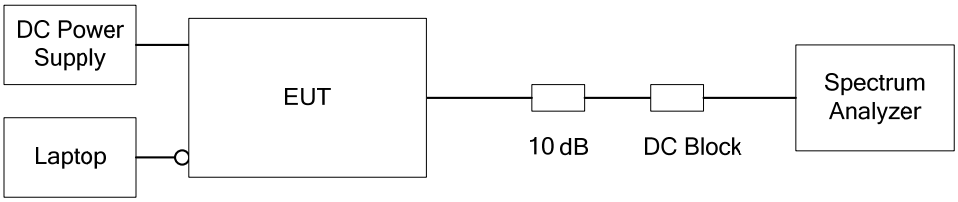
**§ 15.247(a)(1)**: Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

**§ 15.247(a)(1)(i)**: For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

### 5.3.2. Method of Measurements

FCC Public Notice DA 00-705 and ANSI C63.10

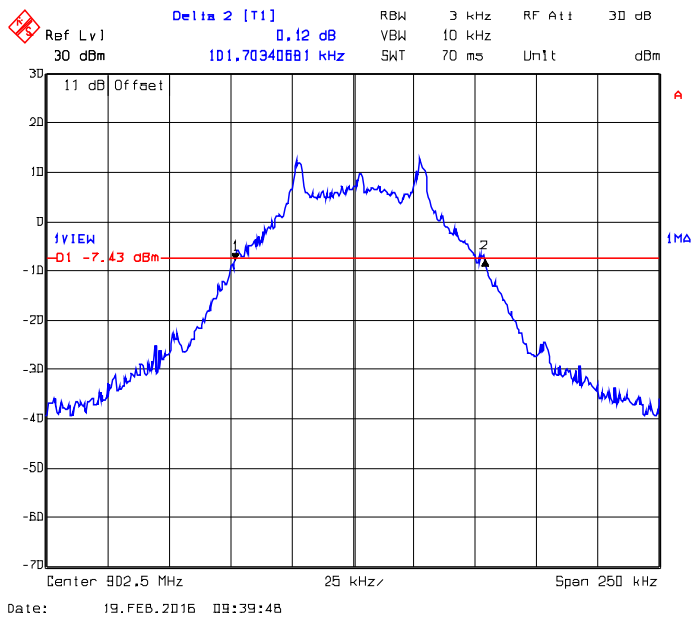
### 5.3.3. Test Arrangement



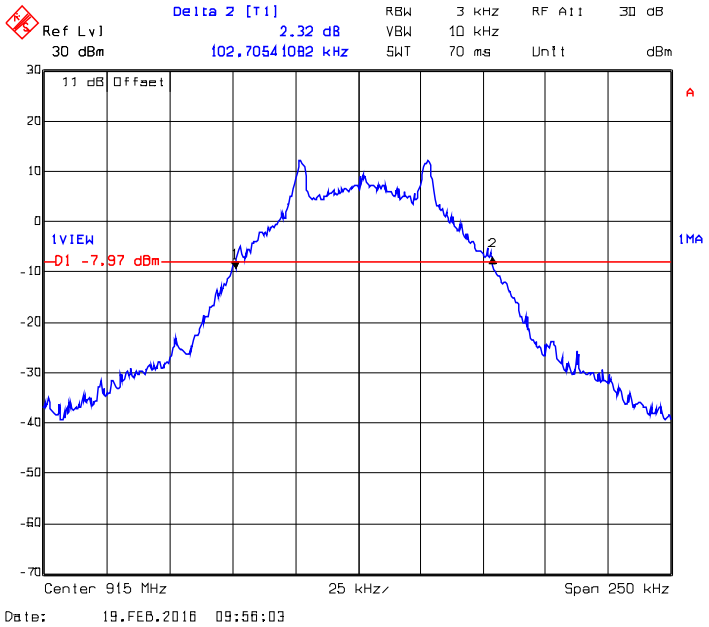
### 5.3.4. Test Data

| Test Description | FCC Specification | Measured Values | | Comments |
|---|---|---|---|---|
| Frequency Hopping Systems Requirements | The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals. | -- | | See Note 1 |
| 20 dB BW of the hopping channel | The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz | **Frequency** | **20 dB Bandwidth** | See Note 2 |
| | | 902.5 MHz | 101.70 kHz | |
| | | 915.0 MHz | 102.71 kHz | |
| | | 927.5 MHz | 101.70 kHz | |
| Channel Hopping Frequency Separation | Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. | 503 kHz | | See Note 2 |
| Number hopping frequencies | If the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies.<br><br>If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies. | 50 hopping frequencies | | See Note 1 and 2 |
| Average Time of Occupancy | If the 20 dB bandwidth of the hopping channel is less than 250 kHz, the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.<br><br>If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. | **Frequency** | **Dwell time in 20 second period** | See Note 2 |
| | | 902.5 MHz | 24.85 ms | |
| | | 915.0 MHz | 37.27 ms | |
| | | 927.5 MHz | 31.06 ms | |
| **Note 1**: See operational description exhibit for details.<br>**Note 2**: See the following plots for details. | | | | |

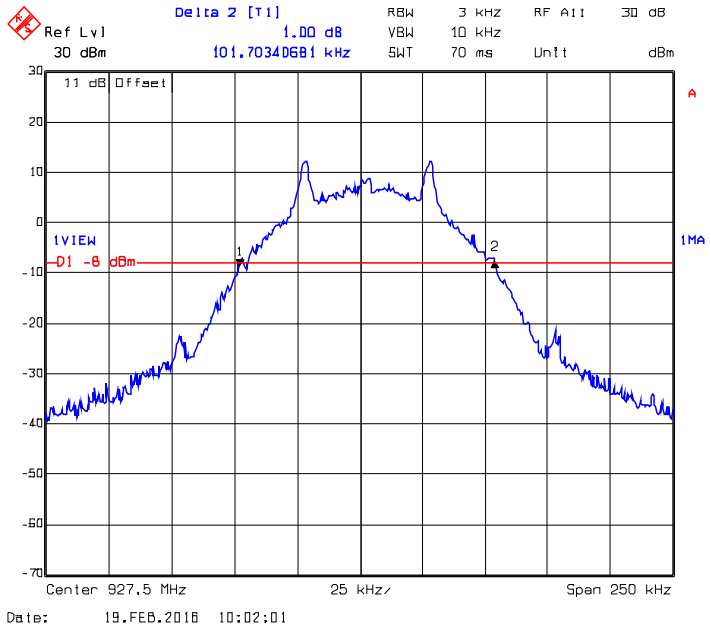
**Plot 5.3.4.1.** 20 dB Bandwidth, 902.5 MHz, 2GFSK



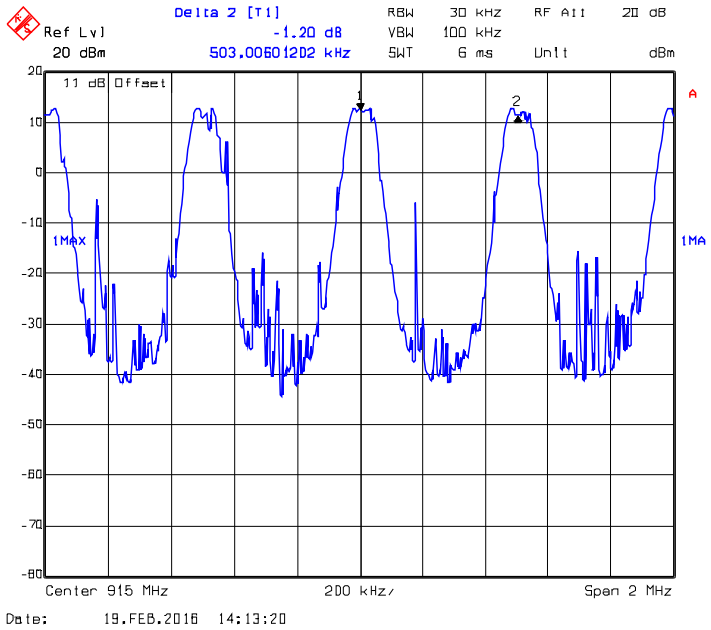

**Plot 5.3.4.2.** 20 dB Bandwidth, 915.0 MHz, 2GFSK



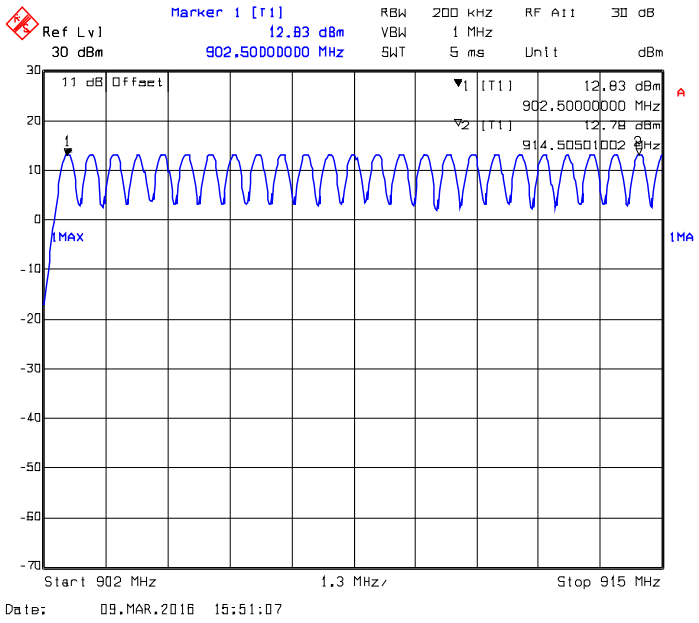
**Plot 5.3.4.3.** 20 dB Bandwidth, 927.5 MHz, 2GFSK



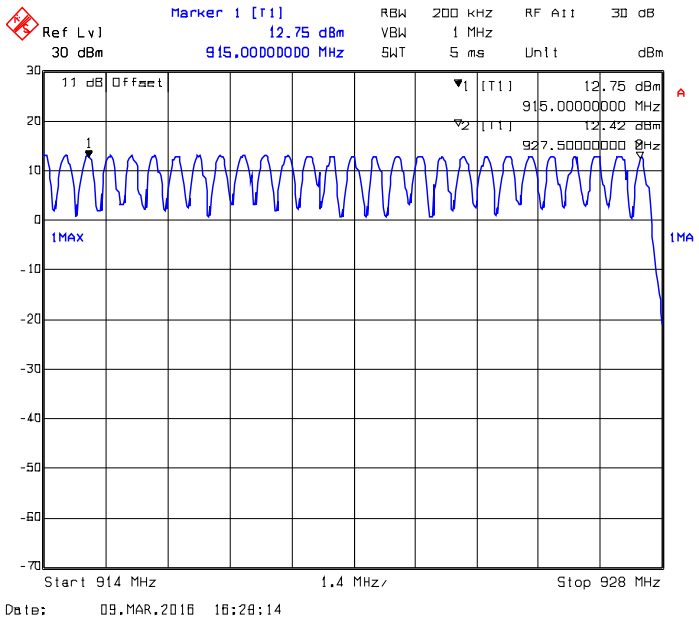

**Plot 5.3.4.4.** Carrier Frequency Separation, 915.0 MHz, 2GFSK, Random Hopping



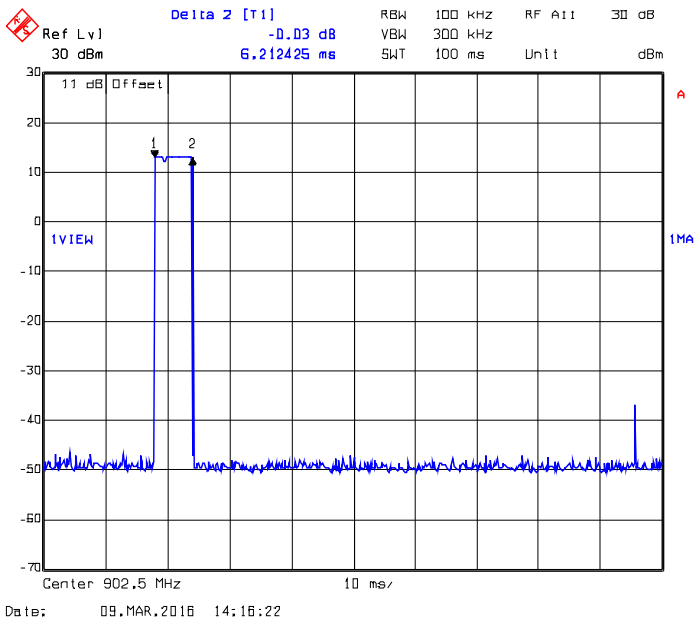
**Plot 5.3.4.5.** Number of Hopping Frequencies
25 Hopping Channels from 902.5 – 914.5 MHz



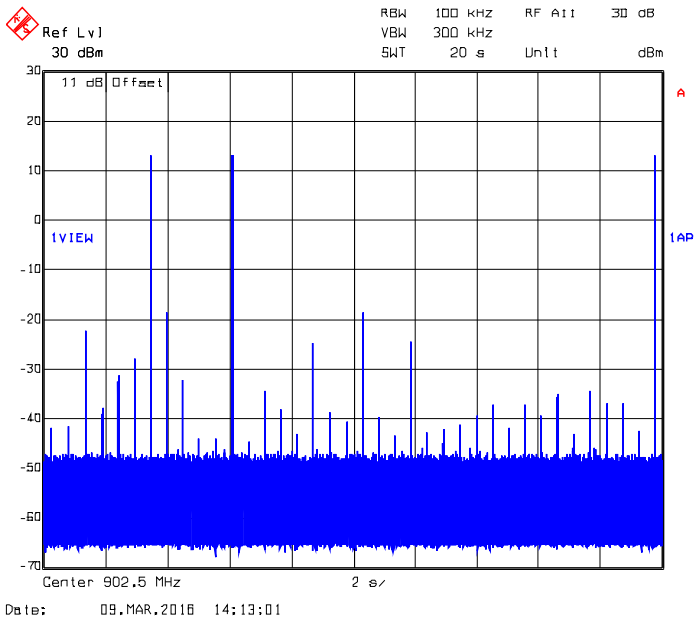

**Plot 5.3.4.6.** Number of Hopping Frequencies
25 Hopping Channels from 914.5 – 927.5 MHz



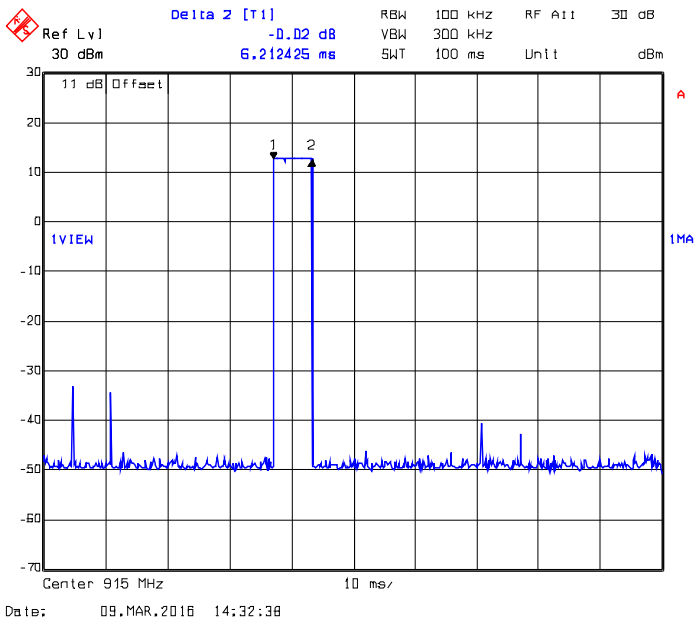
**Plot 5.3.4.7.** Time of Occupancy, 902.5 MHz
Dwell Time @ 902.5 MHz = 6.212425 ms



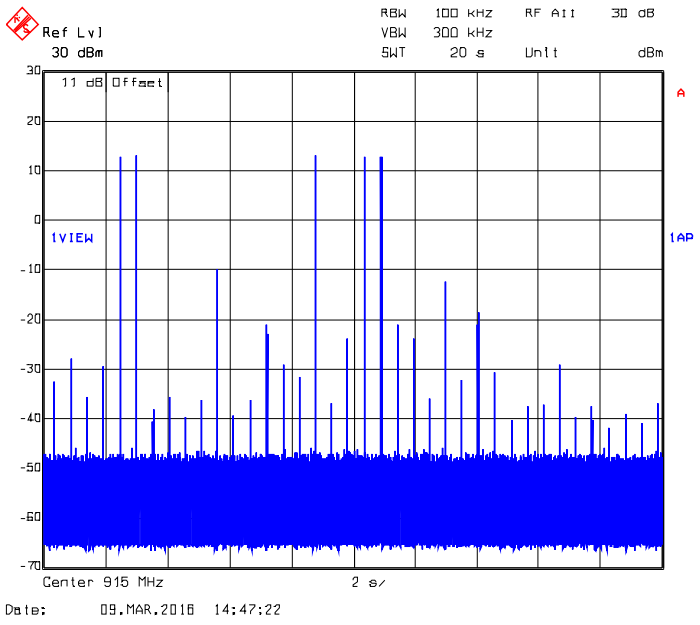

**Plot 5.3.4.8.** Time of Occupancy, 902.5 MHz
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 6.212425 ms x 4 = 24.85 ms



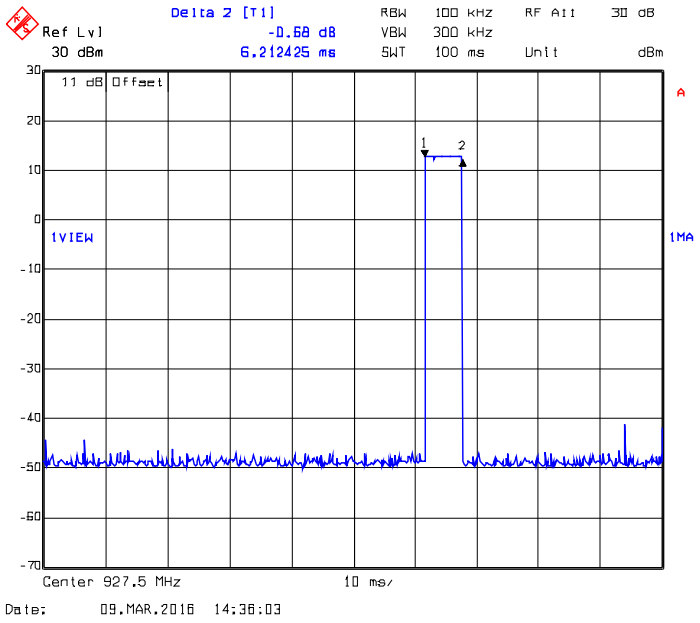
**Plot 5.3.4.9.** Time of Occupancy, 915.0 MHz
Dwell Time @ 915.0 MHz = 6.212425 ms



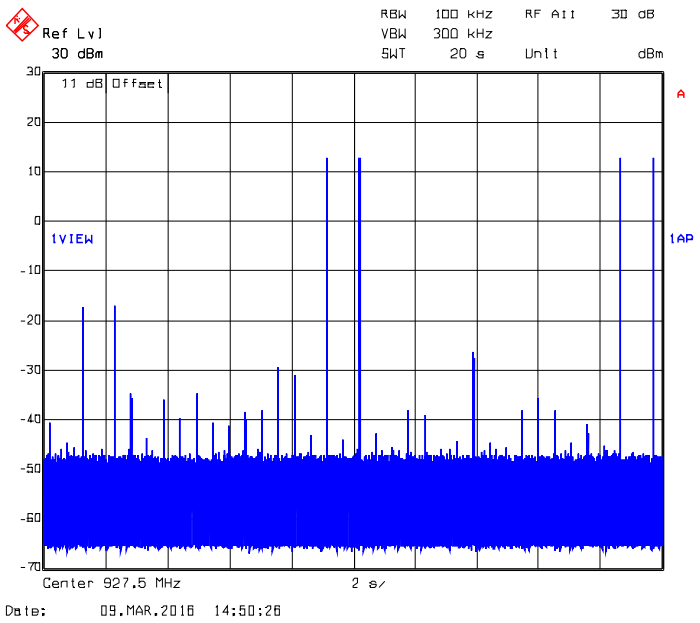

**Plot 5.3.4.10.** Time of Occupancy, 915.0 MHz
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 6.212425 ms x 6 = 37.27 ms



**Plot 5.3.4.11.** Time of Occupancy, 927.5 MHz
Dwell Time @ 927.5 MHz = 6.212425 ms




**Plot 5.3.4.12.** Time of Occupancy, 927.5 MHz
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 6.212425 ms x 5 = 31.06 ms



## 5.4. PEAK CONDUCTED OUTPUT POWER [§ 15.247(b)(2)]

### 5.4.1. Limits

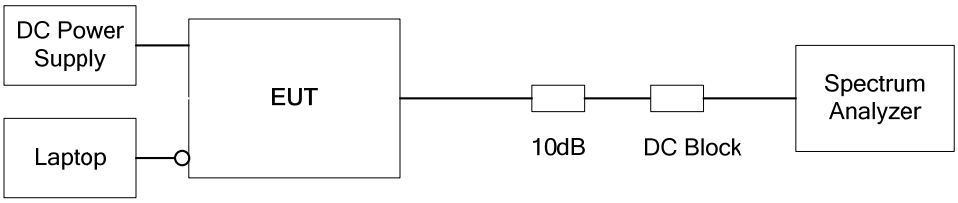
**§15.247(b)(2):** For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

**§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.

### 5.4.2. Method of Measurements

FCC Public Notice DA 00-705 and ANSI C63.10.

### 5.4.3. Test Arrangement




### 5.4.4. Test Data

| Frequency (MHz) | Peak Output Power at Antenna Terminal (dBm) | Max. Antenna Gain (dBi) | EIRP (dBm) | Peak Conducted Output Power Limit (dBm) | EIRP Limit (dBm) |
|---|---|---|---|---|---|
| 902.5 | 13.98 | 3 | 16.98 | 30 | 36 |
| 915.0 | 13.93 | 3 | 16.93 | 30 | 36 |
| 927.5 | 13.79 | 3 | 16.79 | 30 | 36 |

## 5.5. TRANSMITTER SPURIOUS RADIATED EMISSIONS AT 3 METERS [§§ 15.247(d), 15.209 & 15.205]

### 5.5.1. Limit

**§ 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 either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

**Section 15.205(a) - Restricted Bands of Operation**

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090–0.110 | 16.42–16.423 | 399.9–410 | 4.5–5.15 |
| [1] 0.495–0.505 | 16.69475–16.69525 | 608–614 | 5.35–5.46 |
| 2.1735–2.1905 | 16.80425–16.80475 | 960–1240 | 7.25–7.75 |
| 4.125–4.128 | 25.5–25.67 | 1300–1427 | 8.025–8.5 |
| 4.17725–4.17775 | 37.5–38.25 | 1435–1626.5 | 9.0–9.2 |
| 4.20725–4.20775 | 73–74.6 | 1645.5–1646.5 | 9.3–9.5 |
| 6.215–6.218 | 74.8–75.2 | 1660–1710 | 10.6–12.7 |
| 6.26775–6.26825 | 108–121.94 | 1718.8–1722.2 | 13.25–13.4 |
| 6.31175–6.31225 | 123–138 | 2200–2300 | 14.47–14.5 |
| 8.291–8.294 | 149.9–150.05 | 2310–2390 | 15.35–16.2 |
| 8.362–8.366 | 156.52475–156.52525 | 2483.5–2500 | 17.7–21.4 |
| 8.37625–8.38675 | 156.7–156.9 | 2655–2900 | 22.01–23.12 |
| 8.41425–8.41475 | 162.0125–167.17 | 3260–3267 | 23.6–24.0 |
| 12.29–12.293 | 167.72–173.2 | 3332–3339 | 31.2–31.8 |
| 12.51975–12.52025 | 240–285 | 3345.8–3358 | 36.43–36.5 |
| 12.57675–12.57725 | 322–335.4 | 3600–4400 | ([2]) |
| 13.36–13.41. | | | |

[1] Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.
[2] Above 38.6

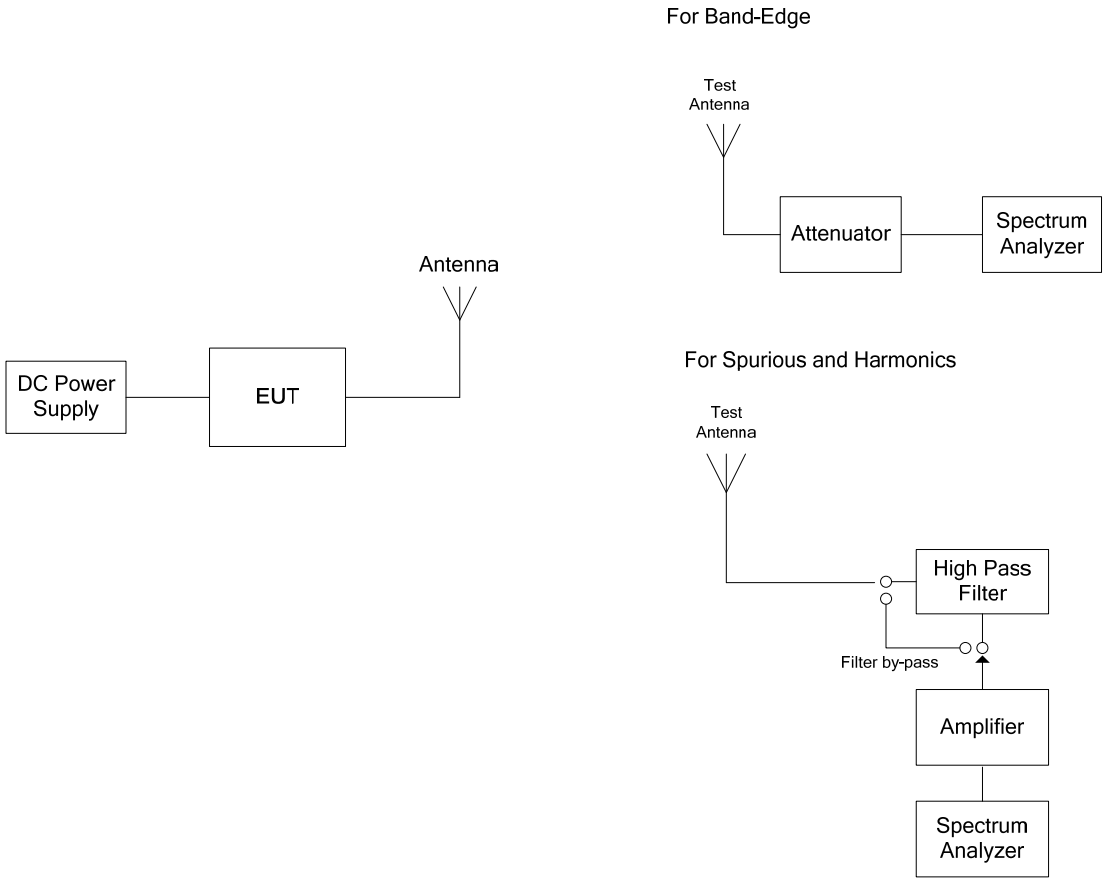
**Section 15.209(a) - Field Strength Limits within Restricted Frequency Bands**

| Frequency (MHz) | Field Strength (microvolts/meter) | Measurement Distance (meters) |
|---|---|---|
| 0.009 - 0.490 | 2,400 / F (kHz) | 300 |
| 0.490 - 1.705 | 24,000 / F (kHz) | 30 |
| 1.705 - 30.0 | 30 | 30 |
| 30 – 88 | 100 | 3 |
| 88 – 216 | 150 | 3 |
| 216 – 960 | 200 | 3 |
| Above 960 | 500 | 3 |

### 5.5.2. Method of Measurements

FCC Public Notice DA 00-705, ANSI C63.10 and ANSI 63.4 procedures.

### 5.5.3. Test Arrangement



### 5.5.4. Test Data

**Remark(s):**

- All spurious emissions that are in excess of 20 dB below the specified limit shall be recorded.
- EUT shall be tested in three orthogonal positions.

#### 5.5.4.1. EUT with 3 dBi Dipole Antenna

##### 5.5.4.1.1. Spurious Radiated Emissions

| | |
|---|---|
| Fundamental Frequency: | 902.5 MHz |
| Measured Conducted Power: | 13.98 dBm |
| Frequency Test Range: | 30 MHz – 10 GHz |

| Frequency (MHz) | RF Peak Level (dBµV/m) | RF Avg Level (dBµV/m) | Antenna Plane (H/V) | Limit 15.209 (dBµV/m) | Limit 15.247 (dBµV/m) | Margin (dB) | Pass/ Fail |
|---|---|---|---|---|---|---|---|
| 902.5 | 113.10 | -- | V | -- | -- | -- | -- |
| 902.5 | 114.54 | -- | H | -- | -- | -- | -- |
| 2707.5 | 46.62 | 36.66 | V | 54.0 | 94.5 | -17.3 | Pass* |
| 2707.5 | 48.52 | 40.59 | H | 54.0 | 94.5 | -13.4 | Pass* |
| 3610.0 | 48.23 | 36.40 | V | 54.0 | 94.5 | -17.6 | Pass* |
| 3610.0 | 48.16 | 35.32 | H | 54.0 | 94.5 | -18.7 | Pass* |
| 4512.5 | 50.47 | 39.32 | V | 54.0 | 94.5 | -14.7 | Pass* |
| 4512.5 | 50.25 | 40.16 | H | 54.0 | 94.5 | -13.8 | Pass* |
| 8122.5 | 57.44 | 47.95 | V | 54.0 | 94.5 | -6.1 | Pass* |
| 8122.5 | 56.76 | 45.37 | H | 54.0 | 94.5 | -8.6 | Pass* |
| 9025.0 | 57.08 | 43.87 | V | 54.0 | 94.5 | -10.1 | Pass* |

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

| | |
|---|---|
| Fundamental Frequency: | 915.0 MHz |
| Measured Conducted Power: | 13.93 dBm |
| Frequency Test Range: | 30 MHz – 10 GHz |

| Frequency (MHz) | RF Peak Level (dBµV/m) | RF Avg Level (dBµV/m) | Antenna Plane (H/V) | Limit 15.209 (dBµV/m) | Limit 15.247 (dBµV/m) | Margin (dB) | Pass/ Fail |
|---|---|---|---|---|---|---|---|
| 915.0 | 112.87 | -- | V | -- | -- | -- | -- |
| 915.0 | 113.69 | -- | H | -- | -- | -- | -- |
| 2745.0 | 46.99 | 38.18 | V | 54.0 | 93.7 | -15.8 | Pass* |
| 2745.0 | 48.32 | 39.19 | H | 54.0 | 93.7 | -14.8 | Pass* |
| 3660.0 | 48.98 | 35.50 | V | 54.0 | 93.7 | -18.5 | Pass* |
| 3660.0 | 47.23 | 34.22 | H | 54.0 | 93.7 | -19.8 | Pass* |
| 4575.0 | 51.42 | 44.79 | V | 54.0 | 93.7 | -9.2 | Pass* |
| 4575.0 | 50.55 | 39.98 | H | 54.0 | 93.7 | -14.0 | Pass* |
| 8235.0 | 56.91 | 47.75 | V | 54.0 | 93.7 | -6.3 | Pass* |
| 8235.0 | 54.33 | 41.98 | H | 54.0 | 93.7 | -12.0 | Pass* |
| 9150.0 | 58.04 | 46.13 | V | 54.0 | 93.7 | -7.9 | Pass* |
| 9150.0 | 55.87 | 42.66 | H | 54.0 | 93.7 | -11.3 | Pass* |

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

| | |
|---|---|
| Fundamental Frequency: | 927.5 MHz |
| Measured Conducted Power: | 13.79 dBm |
| Frequency Test Range: | 30 MHz – 10 GHz |

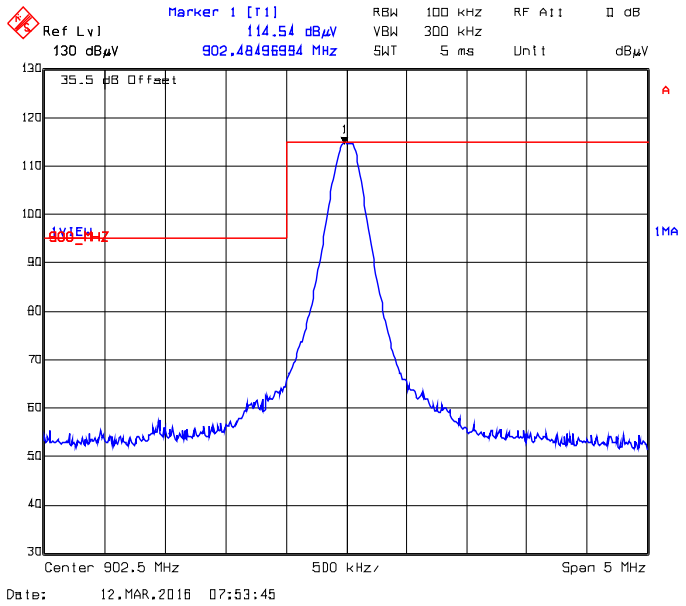
| Frequency (MHz) | RF Peak Level (dBµV/m) | RF Avg Level (dBµV/m) | Antenna Plane (H/V) | Limit 15.209 (dBµV/m) | Limit 15.247 (dBµV/m) | Margin (dB) | Pass/ Fail |
|---|---|---|---|---|---|---|---|
| 927.5 | 112.21 | -- | V | -- | -- | -- | -- |
| 927.5 | 113.80 | -- | H | -- | -- | -- | -- |
| 2782.5 | 46.55 | 38.2 | V | 54.0 | 93.8 | -15.8 | Pass* |
| 2782.5 | 46.78 | 39.02 | H | 54.0 | 93.8 | -15.0 | Pass* |
| 3710.0 | 47.14 | 34.51 | V | 54.0 | 93.8 | -19.5 | Pass* |
| 3710.0 | 47.22 | 34.05 | H | 54.0 | 93.8 | -20.0 | Pass* |
| 4637.5 | 51.91 | 43.68 | V | 54.0 | 93.8 | -10.3 | Pass* |
| 4637.5 | 51.1 | 42.26 | H | 54.0 | 93.8 | -11.7 | Pass* |
| 8347.5 | 57.3 | 47.03 | V | 54.0 | 93.8 | -7.0 | Pass* |
| 8347.5 | 54.94 | 41.97 | H | 54.0 | 93.8 | -12.0 | Pass* |

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

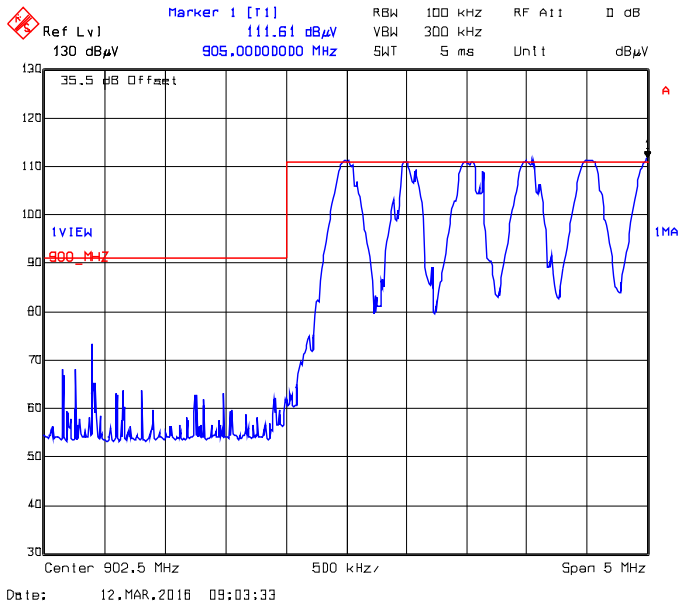
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

### 5.5.4.1.2. Band –Edge RF Radiated Emissions

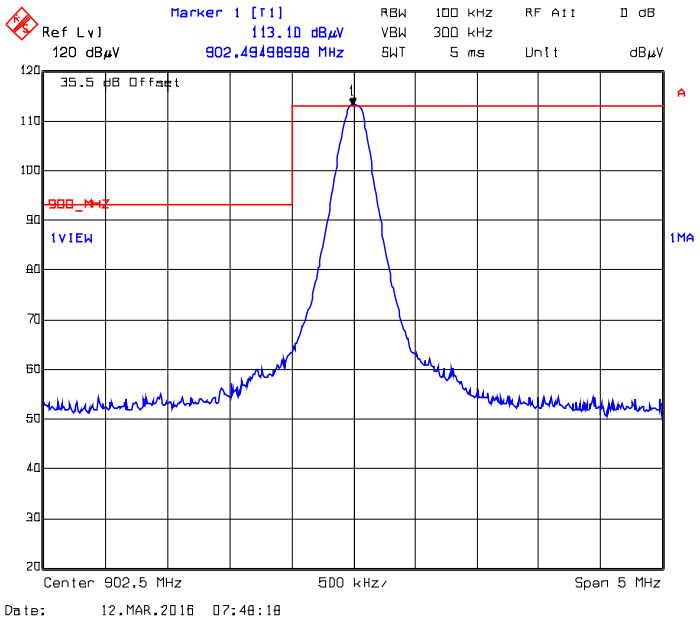
**Plot 5.5.4.1.2.1.** Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, Low End of Frequency Band



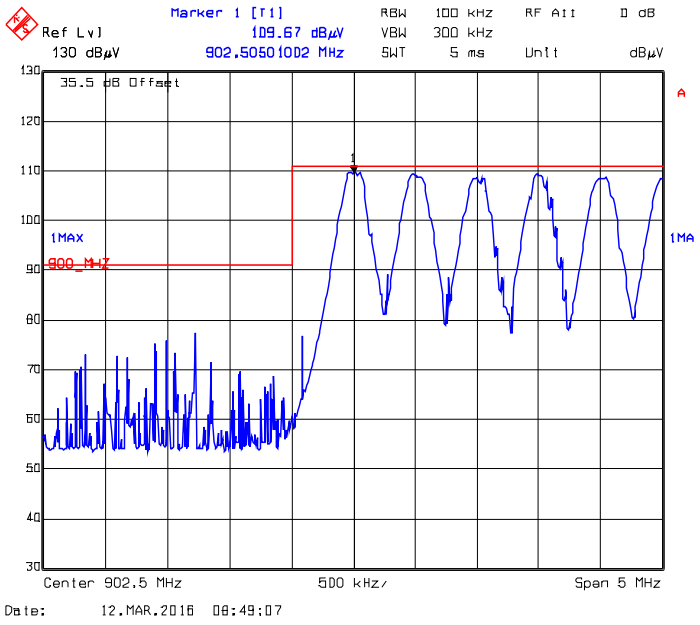

**Plot 5.5.4.1.2.2.** Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



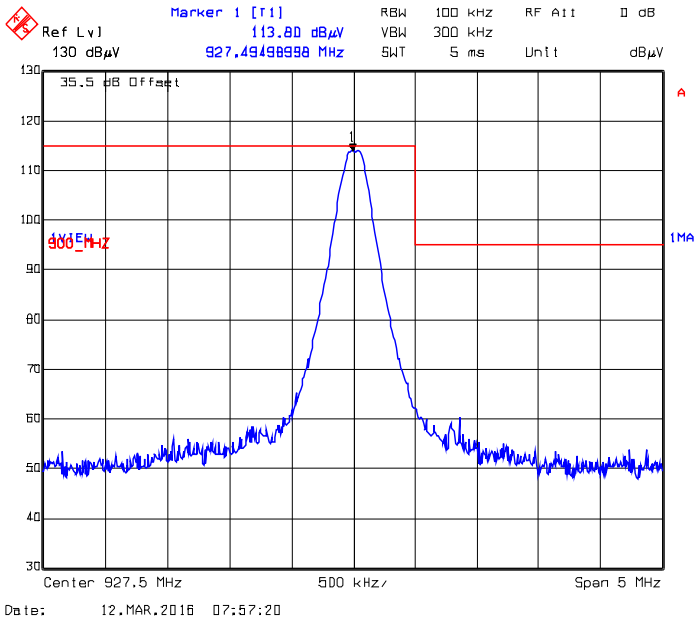
**Plot 5.5.4.1.2.3.** Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, Low End of Frequency Band



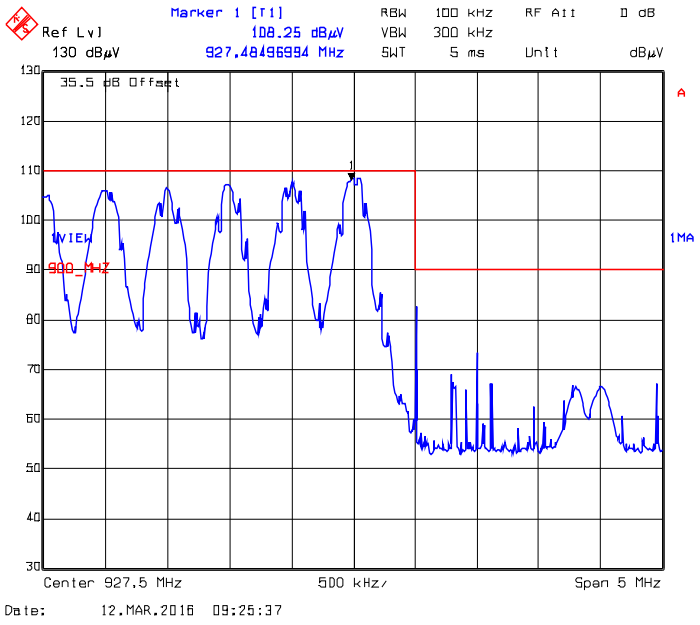

**Plot 5.5.4.1.2.4.** Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



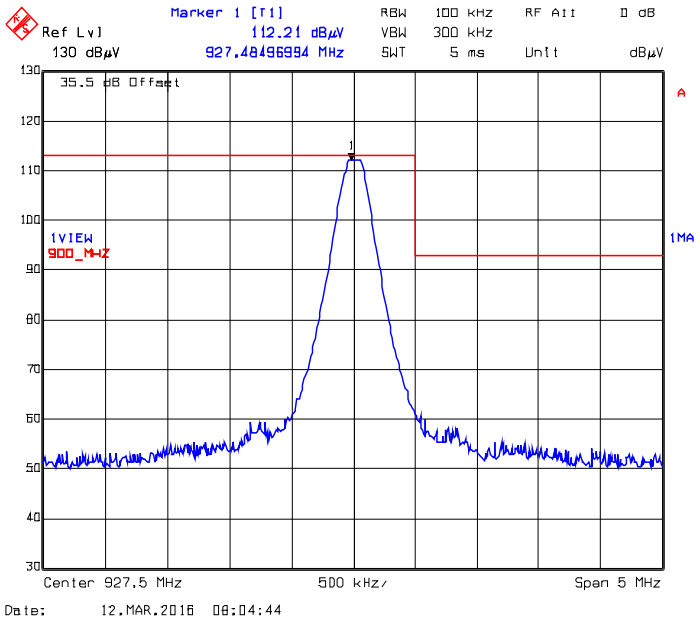
**Plot 5.5.4.1.2.5.** Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, High End of Frequency Band



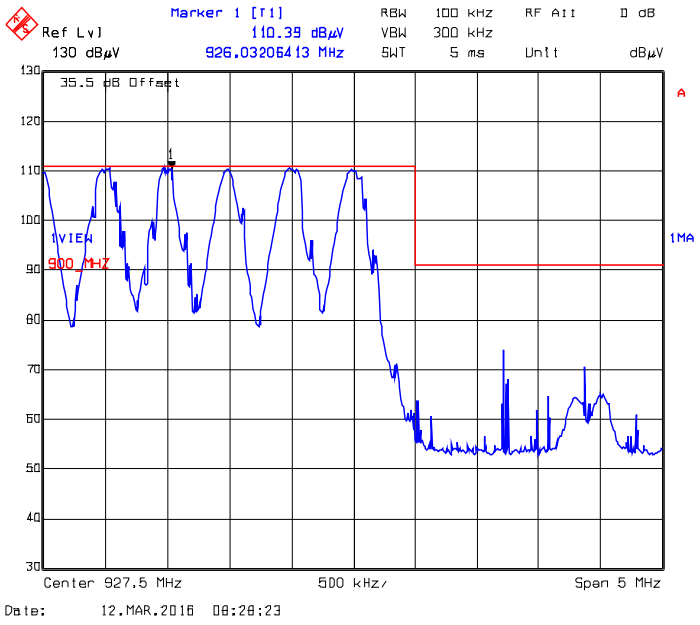

**Plot 5.5.4.1.2.6.** Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



**Plot 5.5.4.1.2.7.** Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, High of Frequency Band




**Plot 5.5.4.1.2.8.** Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



### 5.5.4.2. EUT with 2.3 dBi PCB Antenna

#### 5.5.4.2.1. Spurious Radiated Emissions

| | |
|---|---|
| Fundamental Frequency: | 902.5 MHz |
| Measured Conducted Power: | 13.98 dBm |
| Frequency Test Range: | 30 MHz – 10 GHz |

| Frequency (MHz) | RF Peak Level (dBµV/m) | RF Avg Level (dBµV/m) | Antenna Plane (H/V) | Limit 15.209 (dBµV/m) | Limit 15.247 (dBµV/m) | Margin (dB) | Pass/ Fail |
|---|---|---|---|---|---|---|---|
| 902.5 | 108.57 | -- | V | -- | -- | -- | -- |
| 902.5 | 115.85 | -- | H | -- | -- | -- | -- |
| 2707.5 | 54.02 | 50.91 | V | 54.0 | 95.9 | -3.1 | Pass* |
| 2707.5 | 51.43 | 47.59 | H | 54.0 | 95.9 | -6.4 | Pass* |
| 3610.0 | 53.26 | 48.16 | V | 54.0 | 95.9 | -5.8 | Pass* |
| 3610.0 | 49.82 | 41.39 | H | 54.0 | 95.9 | -12.6 | Pass* |
| 4512.5 | 50.85 | 41.75 | V | 54.0 | 95.9 | -12.3 | Pass* |
| 4512.5 | 49.96 | 39.61 | H | 54.0 | 95.9 | -14.4 | Pass* |

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

| | |
|---|---|
| Fundamental Frequency: | 915.0 MHz |
| Measured Conducted Power: | 13.93 dBm |
| Frequency Test Range: | 30 MHz – 10 GHz |

| Frequency (MHz) | RF Peak Level (dBµV/m) | RF Avg Level (dBµV/m) | Antenna Plane (H/V) | Limit 15.209 (dBµV/m) | Limit 15.247 (dBµV/m) | Margin (dB) | Pass/ Fail |
|---|---|---|---|---|---|---|---|
| 915.0 | 109.33 | -- | V | -- | -- | -- | -- |
| 915.0 | 114.22 | -- | H | -- | -- | -- | -- |
| 2745.0 | 48.62 | 42.52 | V | 54.0 | 94.2 | -11.5 | Pass* |
| 2745.0 | 48.34 | 39.94 | H | 54.0 | 94.2 | -14.1 | Pass* |
| 4575.0 | 52.39 | 45.24 | V | 54.0 | 94.2 | -8.8 | Pass* |
| 4575.0 | 49.87 | 40.8 | H | 54.0 | 94.2 | -13.2 | Pass* |

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

| | |
|---|---|
| Fundamental Frequency: | 927.5 MHz |
| Measured Conducted Power: | 13.79 dBm |
| Frequency Test Range: | 30 MHz – 10 GHz |

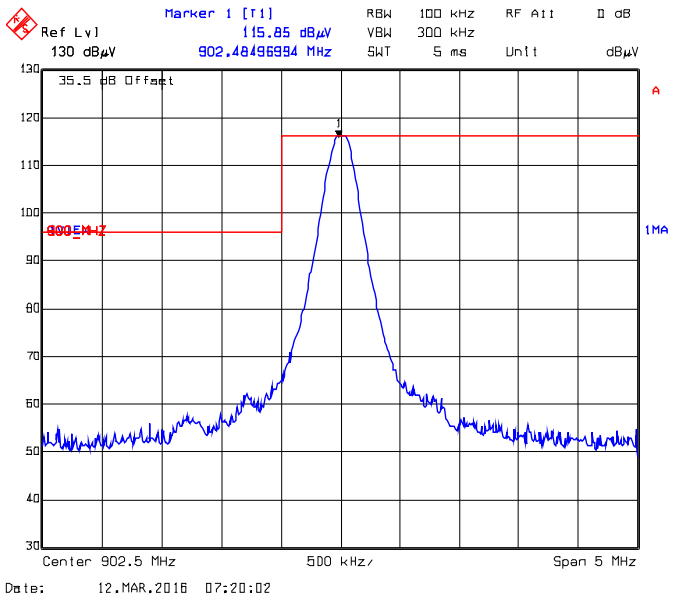
| Frequency (MHz) | RF Peak Level (dBµV/m) | RF Avg Level (dBµV/m) | Antenna Plane (H/V) | Limit 15.209 (dBµV/m) | Limit 15.247 (dBµV/m) | Margin (dB) | Pass/ Fail |
|---|---|---|---|---|---|---|---|
| 927.5 | 110.55 | -- | V | -- | -- | -- | -- |
| 927.5 | 113.90 | -- | H | -- | -- | -- | -- |
| 2782.5 | 48.52 | 41.97 | V | 54.0 | 93.9 | -12.0 | Pass* |
| 2782.5 | 47.47 | 38.43 | H | 54.0 | 93.9 | -15.6 | Pass* |
| 4637.5 | 51.84 | 42.45 | V | 54.0 | 93.9 | -11.6 | Pass* |
| 4637.5 | 50.58 | 38.23 | H | 54.0 | 93.9 | -15.8 | Pass* |

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

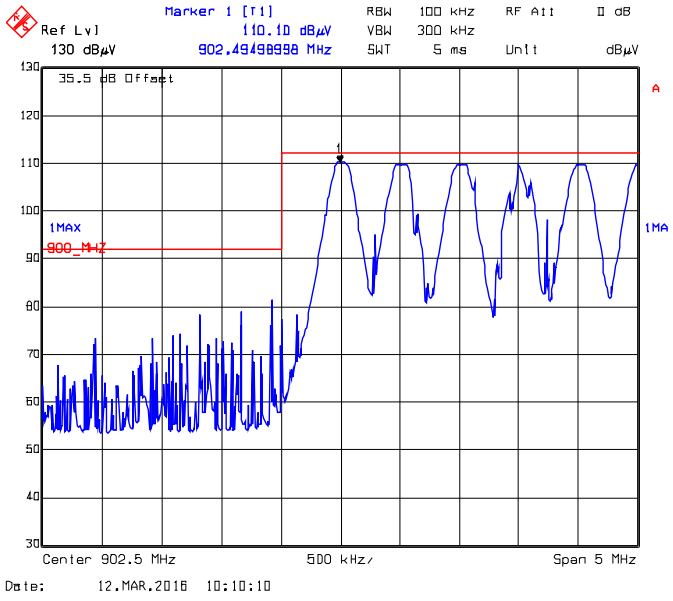
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

### 5.5.4.2.2. Band-Edge RF Radiated Emissions

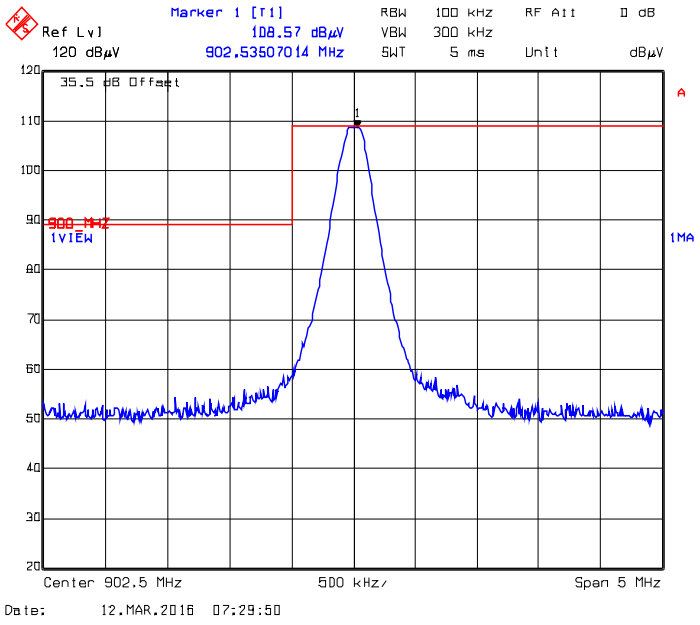
**Plot 5.5.4.2.2.1.** Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, Low End of Frequency Band



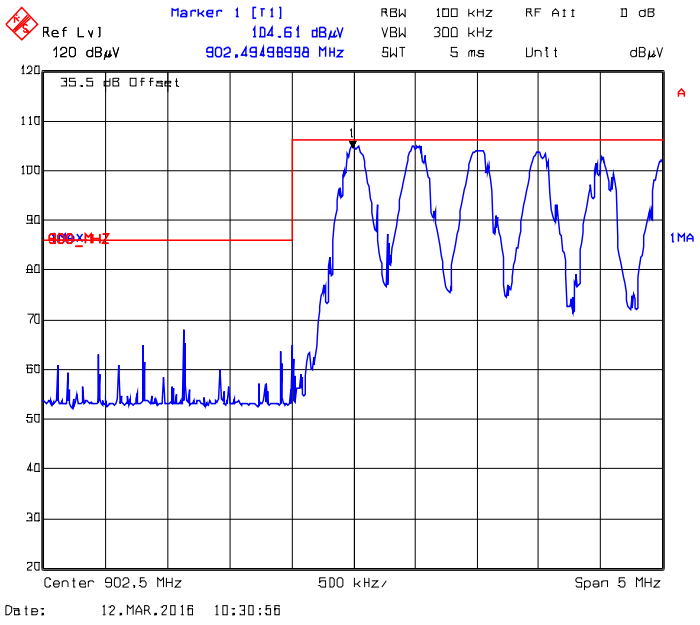

**Plot 5.5.4.2.2.2.** Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



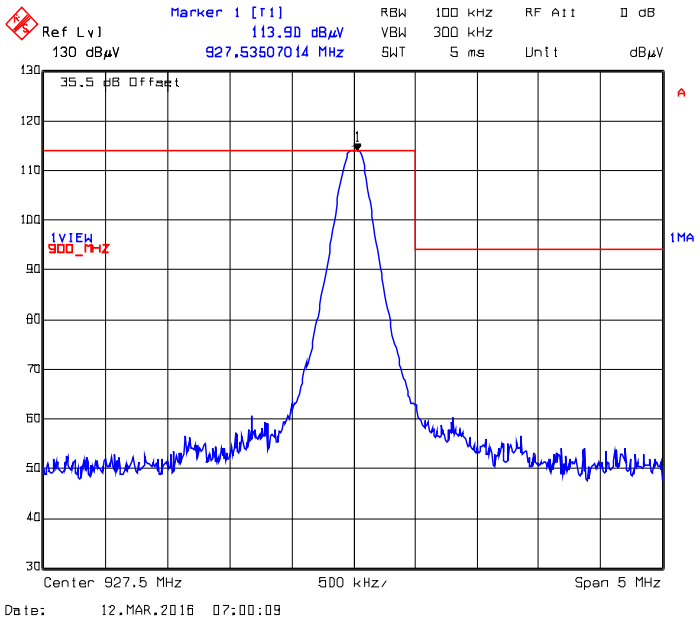
**Plot 5.5.4.2.2.3.** Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, Low End of Frequency Band



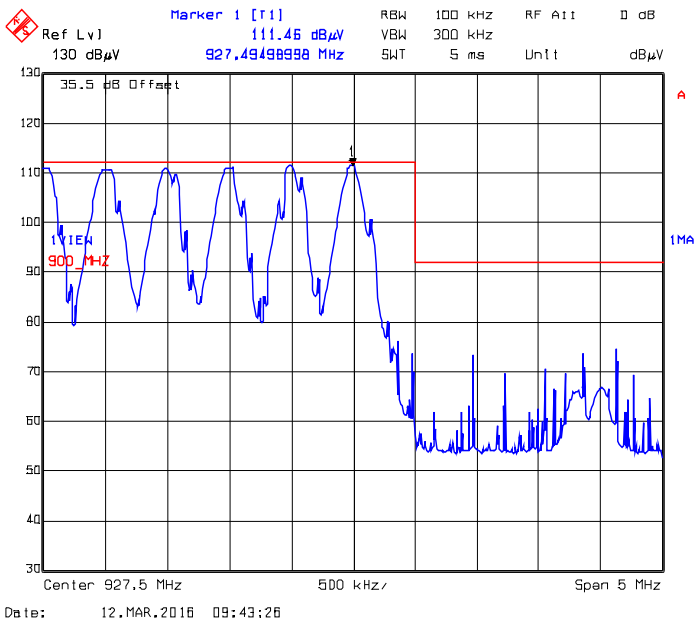

**Plot 5.5.4.2.2.4.** Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



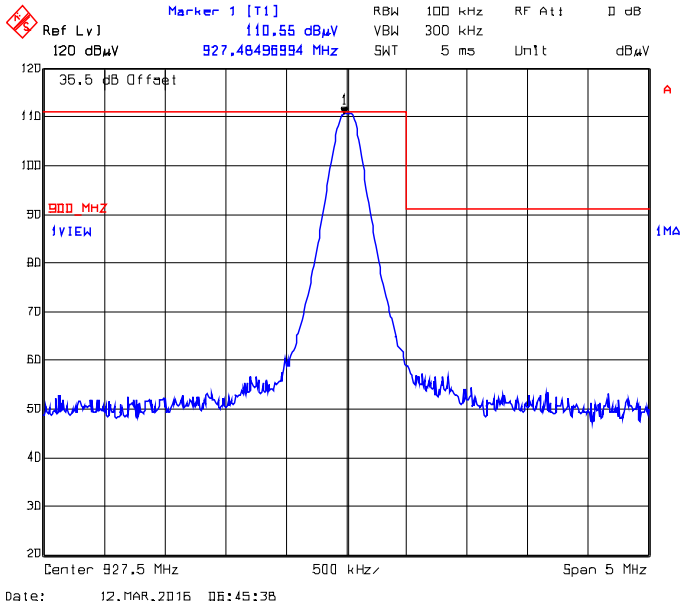
**Plot 5.5.4.2.2.5.** Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, High End of Frequency Band



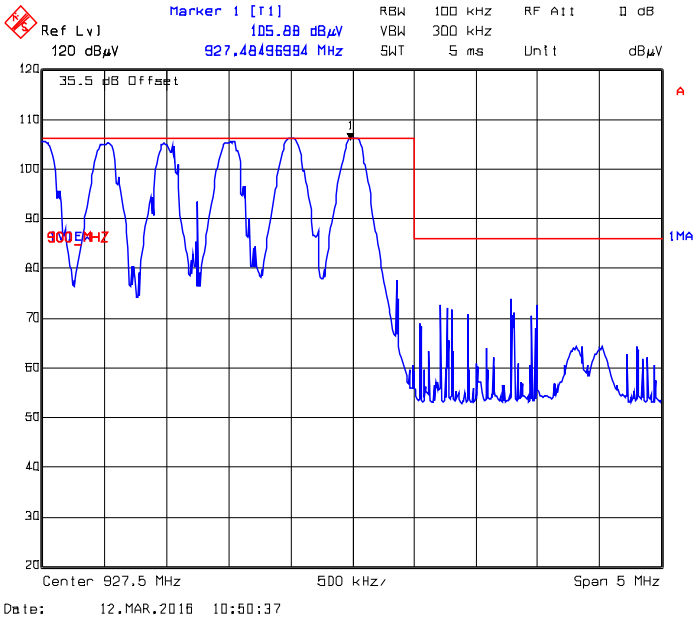

**Plot 5.5.4.2.2.6.** Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



**Plot 5.5.4.2.2.7.** Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, High of Frequency Band




**Plot 5.5.4.2.2.8.** Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



## 5.6. RF EXPOSURE REQUIRMENTS [§§ 15.247(i), 1.1310 & 2.1091]

§ **1.1310:** The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

**Limits for Maximum Permissible Exposure (MPE)**

| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density ($mW/cm^2$) | Averaging time (minutes) |
|---|---|---|---|---|
| **(A) Limits for Occupational/Controlled Exposures** | | | | |
| 0.3-3.0 | 614 | 1.63 | *(100) | 6 |
| 3.0-30 | 1842/f | 4.89/f | *($900/f^2$) | 6 |
| 30-300 | 61.4 | 0.163 | 1.0 | 6 |
| 300-1500 | | | f/300 | 6 |
| 1500-100,000 | | | 5 | 6 |
| **(B) Limits for General Population/Uncontrolled Exposure** | | | | |
| 0.3-1.34 | 614 | 1.63 | *(100) | 30 |
| 1.34-30 | 824/f | 2.19/f | *($180/f^2$) | 30 |
| 30-300 | 27.5 | 0.073 | 0.2 | 30 |
| 300-1500 | | | f/1500 | 30 |
| 1500-100,000 | | | 1.0 | 30 |

f = frequency in MHz
* = Plane-wave equivalent power density

Note 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Note 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

### 5.6.1. Method of Measurements

**Calculation Method of Power Density/RF Safety Distance**:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where, P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm$^2$
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

### 5.6.2. RF Evaluation

#### 5.6.2.1. Standalone

| Frequency (MHz) | EIRP (dBm) | EIRP (mW) | Evaluation Distance, r (cm) | Power Density, S (mW/cm$^2$) | MPE Limit (mW/cm$^2$) | Margin (mW/cm$^2$) |
|---|---|---|---|---|---|---|
| 902.5 | 17 | 50.119 | 20 | 0.010 | 0.602 | -0.592 |

#### 5.6.2.2. Co-location

Pursuant to KDB 447498 D01 General RF Exposure Guidance v06, Section 7.2:

*Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density.*

**The maximum calculated MPE ratio of the EUT with 3 dBi Dipole Antenna**

| Frequency (MHz) | EUT EIRP (dBm) | EUT EIRP (mW) | Evaluation Distance (cm) | Power Density (mW/cm$^2$) | FCC MPE Limit (mW/cm$^2$) | MPE Ratio |
|---|---|---|---|---|---|---|
| 902.5 | 17 | 50.119 | 20 | 0.010 | 0.602 | 0.017 |

The maximum calculated MPE ratio for the EUT with 3 dBi dipole antenna is 0.017, this configuration can be co-located with other transmitting antennas provided the sum of the MPE ratios for all the other simultaneous transmitting antennas incorporated in a host device is **≤ 1.0 - 0.017 ≤ 0.983**

# EXHIBIT 6. TEST EQUIPMENT LIST

| Test Instruments | Manufacturer | Model No. | Serial No. | Frequency Range | Cal. Due Date |
|---|---|---|---|---|---|
| Spectrum Analyzer | Hewlett Packard | HP 8593EM | 3412A00103 | 9 kHz–26.5 GHz | 09 Apr 2017 |
| Attenuator | Pasternack | PE7010-20 | - | DC–2 GHz | 03 Feb 2017 |
| L.I.S.N | EMCO | 3825/2 | 2209 | 0.10 -100 MHz | 29 Sep 2016 |
| Spectrum Analyzer | Rohde & Schwarz | FSEK30 | 100077 | 20Hz–40 GHz | 21 Nov 2016 |
| Attenuator | Pasternack | 7024-10 | 4 | DC–26.5 GHz | Cal on use |
| DC Block | Hewlett Packard | 11742A | 12460 | 0.045 – 26.5 GHz | Cal on use |
| EMI Receiver | Rohde & Schwarz | ESU40 | 100037 | 20Hz–40 GHz | 08 May 2017 |
| RF Amplifier | Com-Power | PAM-0118A | 551052 | 0.5 – 18 GHz | 13 Jul 2016 |
| RF Amplifier | Hewlett Packard | 84498 | 3008A00769 | 1 – 26.5 GHz | 20 Aug 2016 |
| Biconilog | EMCO | 3142C | 26873 | 26-3000 MHz | 14 Apr 2016 |
| Horn Antenna | EMCO | 3155 | 6570 | 1 – 18 GHz | 11 Sep 2016 |
| High Pass Filter | K & L | 11SH10-1500/T8000 | 2 | Cut off 900 MHz | Cal on use |
| Band Reject Filter | Micro-Tronics | BRM50701 | 105 | Cut off 2.4-2.483 GHz | Cal on use |
| Log Periodic | ETS-Lindgren | 3148 | 23845 | 200 – 2000 MHz | 14 Apr 2016 |

# EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

## 7.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

| | **Line Conducted Emission Measurement Uncertainty (9 kHz – 30 MHz):** | **Measured** | **Limit** |
|---|---|---|---|
| **$u_c$** | **Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$ | **± 1.44** | **± 1.8** |
| **U** | **Expanded uncertainty U:** $U = 2u_c(y)$ | **± 2.89** | **± 3.6** |

## 7.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

| | **Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):** | **Measured (dB)** | **Limit (dB)** |
|---|---|---|---|
| **$u_c$** | **Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$ | **± 2.39** | **± 2.6** |
| **U** | **Expanded uncertainty U:** $U = 2u_c(y)$ | **± 4.79** | **± 5.2** |

| | **Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):** | **Measured (dB)** | **Limit (dB)** |
|---|---|---|---|
| **$u_c$** | **Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$ | **± 2.39** | **± 2.6** |
| **U** | **Expanded uncertainty U:** $U = 2u_c(y)$ | **± 4.78** | **± 5.2** |

| | **Radiated Emission Measurement Uncertainty @ 3 m, Horizontal & Vertical (1 – 18 GHz):** | **Measured (dB)** | **Limit (dB)** |
|---|---|---|---|
| **$u_c$** | **Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$ | **± 1.87** | **Under consideration** |
| **U** | **Expanded uncertainty U:** $U = 2u_c(y)$ | **± 3.75** | **Under consideration** |