# Certification Test Report

## FCC ID: 2AMO4-JBRF-1

## FCC Rule Part: 15.519

## TÜV SÜD Report Number: RD72128962.100

## Manufacturer: Jigabot LLC
## Model: JBRF-1

## Test Begin Date: June 27, 2017
## Test End Date: August 22, 2017

## Report Issue Date: August 22, 2017

FOR THE SCOPE OF ACCREDITATION UNDER LAB Code AT-1921

This report must not be used by the client to claim product certification, approval, or endorsement by ANAB, ANSI, or any agency of the Federal Government.


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**TÜV SÜD America, Inc.**




**This report contains 27 pages**

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# 1 GENERAL

## 1.1 Purpose

The purpose of this report is to demonstrate compliance with Part 15 Subpart F (15.519) of the FCC's Code of Federal Regulations.

## 1.2 Product Description

The Jigabot RF product (model number: JBRF-1) is a hand held UWB system (FCC 15.519) product which is based upon the Decawave DW1000 UWB transceiver chip. Thus JBRF-1 is small, portable, and battery powered. It has no external antenna, but rather uses only an internal / PCB-mounted ceramic chip antenna. As a hand-held UWB system, it is intended for indoor and outdoor use (according to 15.519 provisions).

The Jigabot RF product is designed to locate moving objects. It uses the Decawave DW1000 UWB transceiver chip to transmit and receive UWB data over its chip antenna. The general radio characteristics are:
• Single channel (#2), operating from 3.774 GHz to 4.243 GHz. Carrier wave: 3.993 GHz.
• Pulse repetition frequency (PRF) of the modulated signal: 16Mhz.

Technical Information:

| Detail | Description |
|---|---|
| Frequency Range | Center Frequency 3993 GHz |
| Number of Channels | 1 |
| Modulation Format | BPM w/ BPSK |
| Data Rates | 110 kbps |
| Operating Voltage | 3.3 Vdc |
| Antenna Type / Gain | Ceramic Chip 2.73 dBi (Peak) |

Manufacturer Information:
Jigabot, LLC
230 South 1250 West
Lindon, UT 84042

Contact:
Rick Stout, CEO
801-369-6622
Rick@Jigabot.com

EUT Serial Numbers: TUV SUD 1

Test Sample Condition: The test samples were provided in good working order with no visible defects.

### 1.3 Test Methodology and Considerations

The device is physically small and can be used in many orientations. Therefore, the EUT was evaluated in the X, Y, and Z planes. The worst-case plane was X-Plane. The data in the report represents worst case.

The EUT Power setting was set to 38.

## 2 TEST FACILITIES

### 2.1 Location

The radiated and conducted emissions test sites are located at the following address:

TÜV SÜD America Inc.
2320 Presidential Drive, Suite 101
Durham, NC 27703
Phone: (919) 381-4235

### 2.2 Laboratory Accreditations/Recognitions/Certifications

TÜV SÜD America Inc. is accredited to ISO/IEC 17025 by ANSI-ASQ National Accreditation Board under their ANAB program and has been issued certificate number AT-1921 in recognition of this accreditation. Unless otherwise specified, all test methods described within this report are covered under the ISO/IEC 17025 scope of accreditation.

FCC Registered Test Site Number: 637011
ISED Canada Test Site Registration Number: 4175A

## 2.3 Radiated Emissions Test Site Description

### 2.3.1 Semi-Anechoic Chamber Test Site

The Semi-Anechoic Chamber Test Site consists of a 18' x 28' x 18' shielded enclosure. The chamber is lined with Samwha Electronics Co. LTD Ferrite Absorber, model number SFA300 (HSN-1). The ferrite tile is 10cm x 10 cm and weighs approximately 1.4lbs. These tiles are mounted on steel panels and installed directly on the inner walls of the chamber. On top of the ferrite tiles is DMAS HT-45 (Dutch Microwave Absorber Solutions) hybrid absorber on all walls except the wall behind the antenna mast which has a shorter DMAS HT-25 absorber.

The turntable is 1.50m in diameter and is located 150cm from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the ground plane using short #6 copper wire. The turntable is all steel, flush mounted table installed in an all steel frame. The table is remotely operated from inside the control room located 25' from the turntable. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane.

Behind the turntable is a 2' x 6' x 1.5' deep shielded pit used for support equipment if necessary. The pit is equipped with 2 - 4" PVC chase from the turntable to the pit that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit.

To comply with the requirements of the test methods given on page 4, RF absorbing foam was placed inside the chamber in a configuration that provided the best results. First, a 12ft X 12ft. patch of 10" tall absorber was placed on the floor between the turntable and the receiving antenna. This absorber meets the absorption requirements specified in ANSI C63.4:2009.

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3-1 below:

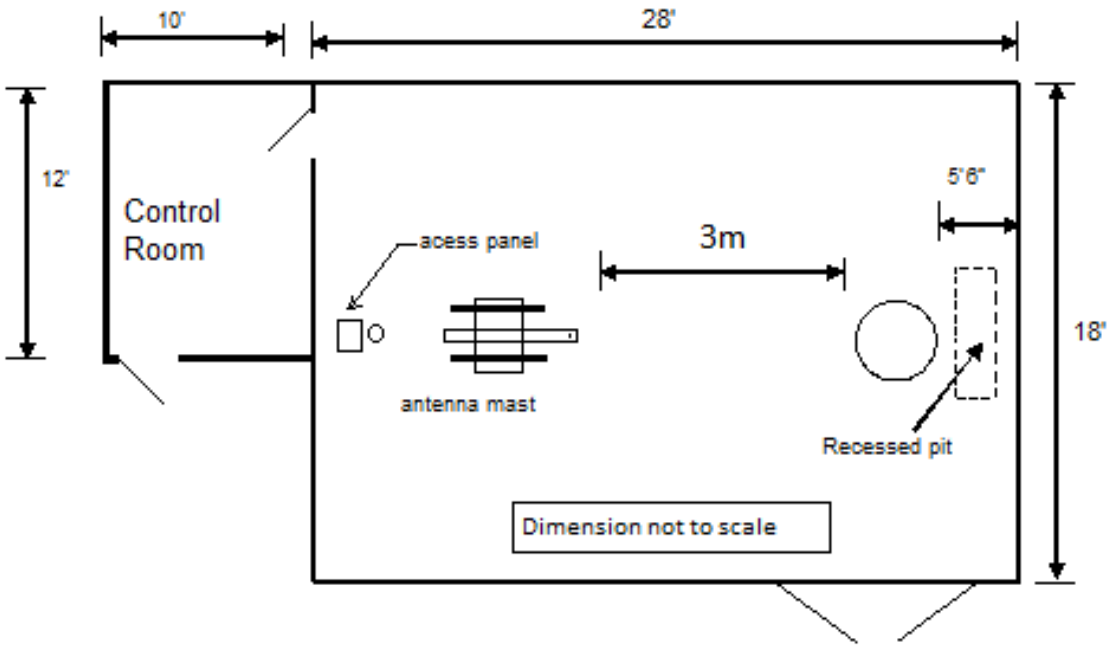


**Figure 2.3-1: Semi-Anechoic Chamber Test Site**

### 2.4 Conducted Emissions Test Site Description

The AC mains conducted EMI site is located in the main EMC lab. It consists of an 8’ x 10’ sheet galvanized steel horizontal ground reference plane (GRP) bonded every 6” to an 8’ X 8’ aluminum vertical ground plane.

A diagram of the room is shown below in figure 1.7-1:

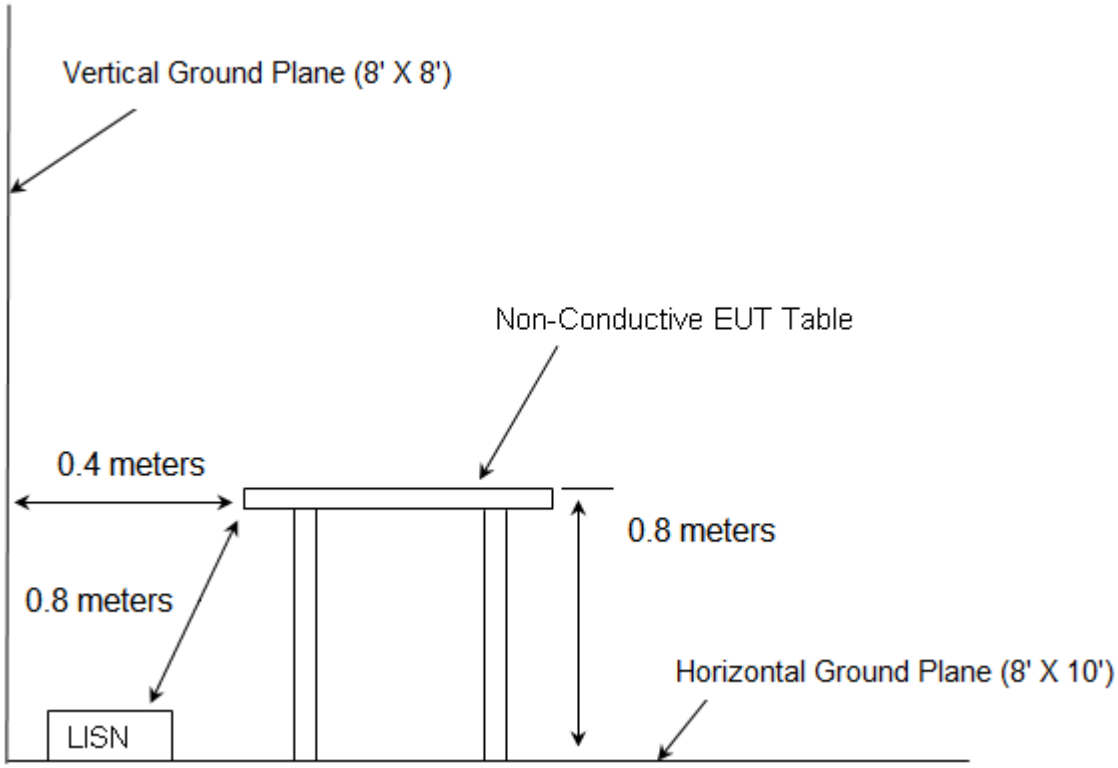


**Figure 2.4-1: AC Mains Conducted EMI Site**

## 3 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart F: Radio Frequency Devices, Ultra-Wideband Operation, 2017

## 4 LIST OF TEST EQUIPMENT

The calibration interval of test equipment is annually or the manufacturer's recommendations. Where the calibration interval deviates from the annual cycle based on the instrument manufacturer's recommendations, it shall be stated below.

**Table 4-1: Test Equipment**

| Asset ID | Manufacturer | Model # | Equipment Type | Serial # | Last Calibration Date | Calibration Due Date |
|---|---|---|---|---|---|---|
| 277 | EMCO | 93146 | Antennas | 9904-5199 | 9/12/2016 | 9/12/2018 |
| 332 | Rohde & Schwarz | TS-PR40 | Amplifiers | 100021 | 3/14/2016 | 3/14/2018 |
| 333 | Rohde & Schwarz | 3160-10 | Antennas | 00045576 | NCR | NCR |
| 335* | Suhner | SF-102A | Cables | 882/2A | 7/12/2016 | 7/12/2017 |
| 626 | EMCO | 3110B | Antennas | 9411-1945 | 3/21/2017 | 3/21/2019 |
| 3002 | Rohde & Schwarz | ESU40 | Receiver | 100346 | 1/12/2017 | 1/12/2018 |
| 3006 | Rohde & Schwarz | TS-PR18 | Amplifiers | 122006 | 1/11/2017 | 1/11/2018 |
| 3007 | Rohde & Schwarz | TS-PR26 | Amplifiers | 100051 | 1/11/2017 | 1/11/2018 |
| 3011 | Rohde & Schwarz | ENV216 | LISN | 3011 | 1/12/2017 | 1/12/2018 |
| 3012 | Rohde & Schwarz | EMC32-EB | Software | 100731 | NCR | NCR |
| 3016 | Fei Teng Wireless Technology | HA-07M18G-NF | Antennas | 2013120203 | 1/26/2016 | 1/26/2018 |
| 3032 | Hasco, Inc. | HLL142-S1-S1-192/WA | Cables | 3075 | 1/11/2017 | 1/11/2018 |
| 3038 | Florida RF Labs | NMSE-290AW-60.0-NMSE | Cable Set | 1448 | 1/3/2017 | 1/3/2018 |
| 3039 | Florida RF Labs | NMSE-290AW-396.0-NMSE | Cable Set | 1447 | 1/3/2017 | 1/3/2018 |
| 3042 | Aeroflex Inmet | 18N10W-10 | Attenuator | 1444 | 1/16/2017 | 1/16/2018 |
| 3051 | Mountain View Cable | BMS-RG400-264.0-BMS | Cables | 3051 | 1/3/2017 | 1/3/2018 |
| 3055 | Rohde & Schwarz | 3005 | Cables | 3055 | 1/3/2017 | 1/3/2018 |
| 3057 | Advanced Technical Materials | 42-441-6/BR | Antennas | R110602 | NCR | NCR |
| 3059 | Mountain View Cable | A | Cables | 3059 | 1/11/2017 | 1/11/2018 |
| 3085 | Rohde & Schwarz | FSW43 | Spectrum Analyzer | 103997 | 6/9/2017 | 6/9/2018 |

*Note: Asset 335 was used prior to the calibration due date to support test testing and was not used after 7/12/2017.
NCR = No Calibration Required
DMAS MT-25 RF absorber material was used on the floor for all final measurements above 1GHz.
Asset 3002: Firmware Version: ESU40 is 4.73 SP4
Asset 3012: Software Version: EMC32-B is 9.15Asset 3085: Instrument Firmware 2.41 SP1

## 5 SUPPORT EQUIPMENT

**Table 5-1: EUT and Support Equipment**

| Item # | Type Device | Manufacturer | Model/Part # | Serial # |
|---|---|---|---|---|
| 1 | EUT | Jigabot | JBRF-1 | TUV SUD 1 |
| 2 | Laptop | Dell | Latitude D630 | G03F3F1 |
| 3 | Power Supply | Targus | APM62US | 0812002836 |

**Table 5-2: Cable Description**

| Cable # | Cable Type | Length | Shield | Termination |
|---|---|---|---|---|
| A | USB | 125cm | No | 1 to 2 |
| B | DC Power | 180cm | No | 2 to 3 |
| C | AC Power | 180cm | No | 3 to AC |

## 6 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

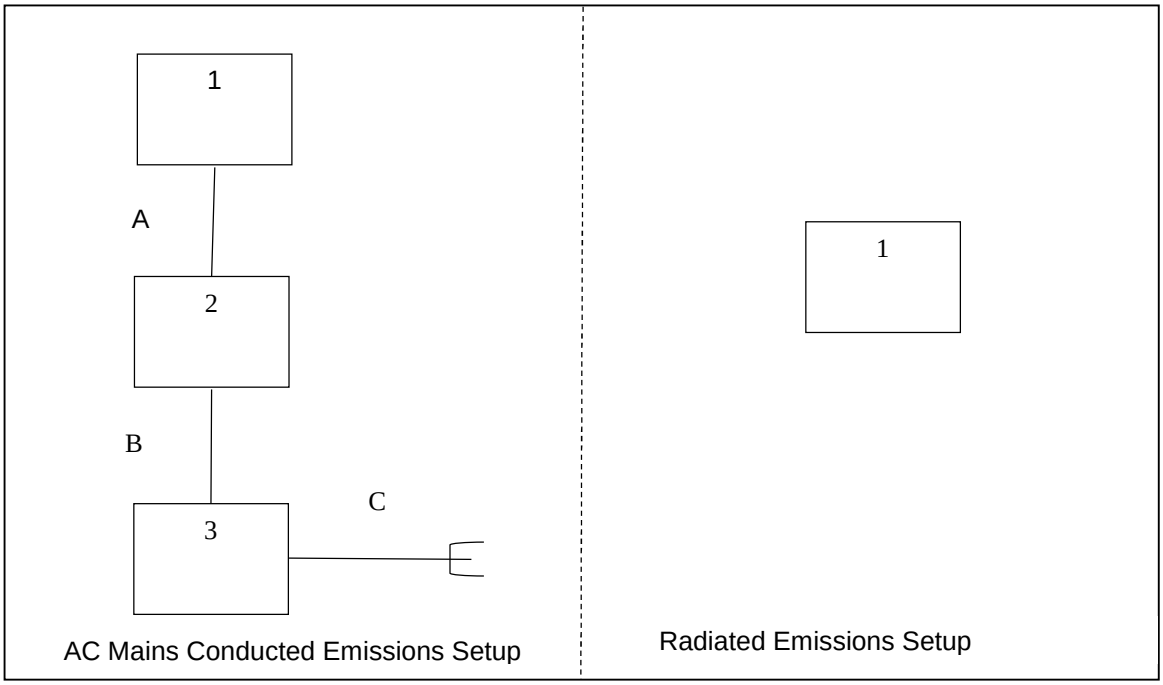


**Figure 6-1: EUT Test Setup Block Diagram**

# 7 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

## 7.1 Antenna Requirement – FCC 15.203

The antenna is integrated into the device.

## 7.2 Power Line Conducted Emissions – FCC 15.207

### 7.2.1 Measurement Procedure

ANSI C63.10 section 6.2 was the guiding document for this evaluation. Conducted emissions were performed from 150 kHz to 30 MHz with the spectrum analyzer's resolution bandwidth set to 9 kHz and the video bandwidth set to 30 kHz. The calculation for the conducted emissions is as follows:

**Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss**
**Margin = Applicable Limit - Corrected Reading**

### 7.2.2 Measurement Results

Measurement Performed By: Randy Sherian

The equipment under test is a module and compliance for conducted emissions was tested in a representative configuration of a final product.

**Table 7.2.2-1 - Line**

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Filter | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.158000 | --- | 21.19 | 55.53 | 34.34 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 0.158000 | 43.79 | --- | 65.53 | 21.74 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 0.176000 | --- | 19.65 | 54.56 | 34.91 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 0.176000 | 41.93 | --- | 64.58 | 22.65 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 0.412000 | --- | 11.95 | 47.48 | 35.53 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 0.412000 | 27.04 | --- | 57.50 | 30.46 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 0.648000 | --- | 9.57 | 46.00 | 36.43 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 0.648000 | 20.90 | --- | 56.00 | 35.10 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 1.932000 | --- | 11.80 | 46.00 | 34.20 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 1.932000 | 17.24 | --- | 56.00 | 38.76 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 3.340000 | --- | 15.84 | 46.00 | 30.16 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 3.340000 | 22.13 | --- | 56.00 | 33.87 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 4.896000 | --- | 15.22 | 46.00 | 30.78 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 4.896000 | 20.48 | --- | 56.00 | 35.52 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 7.890000 | --- | 19.85 | 50.00 | 30.15 | 2000.0 | 9.000 | L1 | OFF | 9.9 |
| 7.890000 | 26.46 | --- | 60.00 | 33.54 | 2000.0 | 9.000 | L1 | OFF | 9.9 |
| 9.094000 | --- | 17.86 | 50.00 | 32.14 | 2000.0 | 9.000 | L1 | OFF | 9.9 |
| 9.094000 | 23.16 | --- | 60.00 | 36.84 | 2000.0 | 9.000 | L1 | OFF | 9.9 |
| 22.922000 | --- | 18.74 | 50.00 | 31.26 | 2000.0 | 9.000 | L1 | OFF | 10.1 |
| 22.922000 | 26.71 | --- | 60.00 | 33.29 | 2000.0 | 9.000 | L1 | OFF | 10.1 |

**Table 7.2.2-2 - Neutral**

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Filter | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.150000 | --- | 21.23 | 56.00 | 34.77 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.150000 | 44.61 | --- | 66.00 | 21.39 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.176000 | --- | 18.73 | 54.56 | 35.83 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.176000 | 41.51 | --- | 64.58 | 23.07 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.396000 | --- | 14.39 | 47.79 | 33.40 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 0.396000 | 27.38 | --- | 57.81 | 30.43 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 0.712000 | --- | 13.21 | 46.00 | 32.79 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 0.712000 | 20.46 | --- | 56.00 | 35.54 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.352000 | --- | 17.62 | 46.00 | 28.38 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.352000 | 22.54 | --- | 56.00 | 33.46 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.648000 | --- | 17.35 | 46.00 | 28.65 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 3.648000 | 22.46 | --- | 56.00 | 33.54 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 7.862000 | --- | 21.79 | 50.00 | 28.21 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 7.862000 | 27.40 | --- | 60.00 | 32.60 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 8.126000 | --- | 23.91 | 50.00 | 26.09 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 8.126000 | 29.17 | --- | 60.00 | 30.83 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 8.394000 | --- | 24.01 | 50.00 | 25.99 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 8.394000 | 28.99 | --- | 60.00 | 31.01 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 22.846000 | --- | 19.80 | 50.00 | 30.20 | 2000.0 | 9.000 | N | OFF | 10.1 |
| 22.846000 | 26.83 | --- | 60.00 | 33.17 | 2000.0 | 9.000 | N | OFF | 10.1 |

## 7.3 10 dB Bandwidth – FCC 15.519(b)

### 7.3.1 Measurement Procedure

The 10 dB bandwidth was measured in accordance with the ANSI C63.10: 2013 Section 10.1. The resolution bandwidth (RBW) of the spectrum analyzer was set to 1MHz. The video bandwidth (VBW) was set to ≥ 1 to 3 times the RBW. The trace was set to max hold with a Peak detector active.

### 7.3.2 Measurement Results

Measurement Performed By: Randy Sherian

**Table 7.3.2-1 – Frequency Bounds**

| Frequency Bounds | Frequency [MHz] |
|---|---|
| $F_m$ | 3993.476 |
| $F_l$ | 3743.300 |
| $F_h$ | 4243.564 |

**Table 7.3.2-2: 10 dB Bandwidth**

| Frequency fc [MHz] | 10 dB Bandwidth [MHz] |
|---|---|
| 3993.432 | 500.264 |

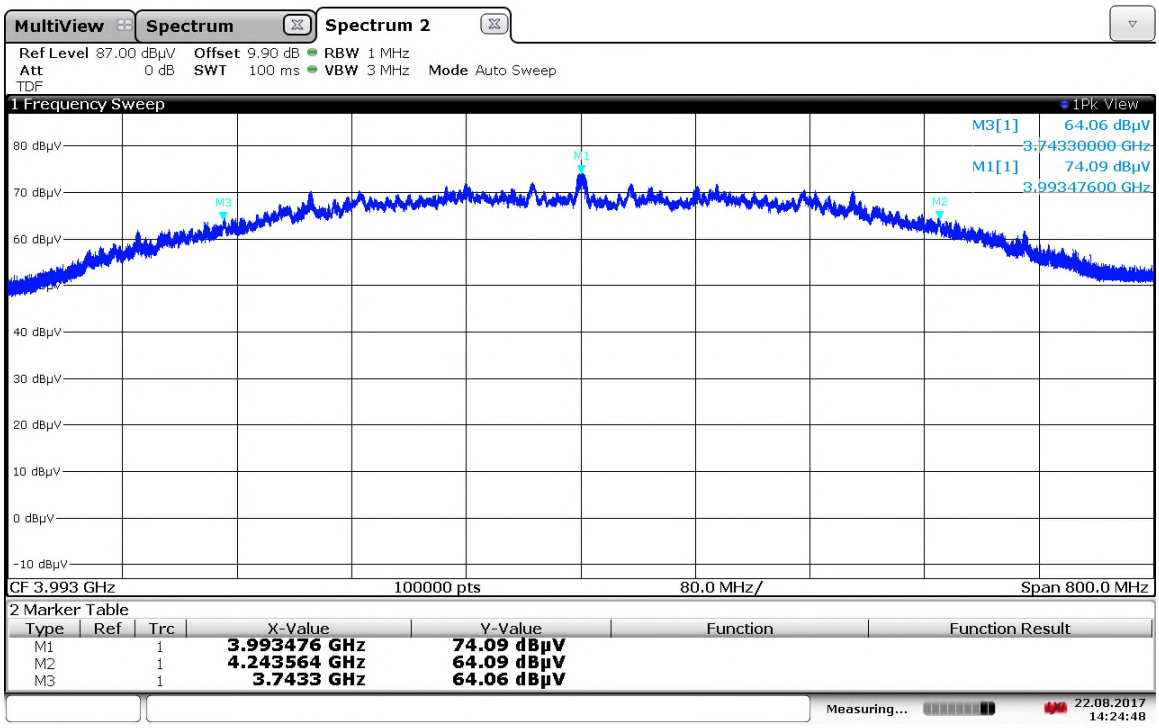


**Figure 7.3.2-1: 10 dB Bandwidth**

## 7.4 Fundamental Emission Peak Power – FCC 15.519(e)

### 7.4.1 Measurement Procedure

The maximum peak radiated output power was measured in accordance with ANSI C63.10: 2013 Section 10.3.5. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 50MHz. The Video Bandwidth (VBW) was set to its maximum 80MHz. The trace was set to max hold with a peak detector active.

### 7.4.2 Measurement Results

Measurement Performed By: Randy Sherian

Field Strength: Data (from plot) + antenna CF = Field Strength
91.6 dBµV/m + 2.18 dB/m = 93.78 dBµV/m

Field Strength to EIRP (dBm): Field Strength – 95.3 = EIRP (dBm)
93.78dBuV/m - 95.3dB = -1.52 dBm EIRP
Per 15.519(e) the peak limit on the fundamental is 0 dBm EIRP.

**Table 7.4.2-1: Maximum Peak Radiated Output Power**

| Frequency (MHz) | Output Power (EIRP) (dBm) |
|---|---|
| 3997 | -1.52 |

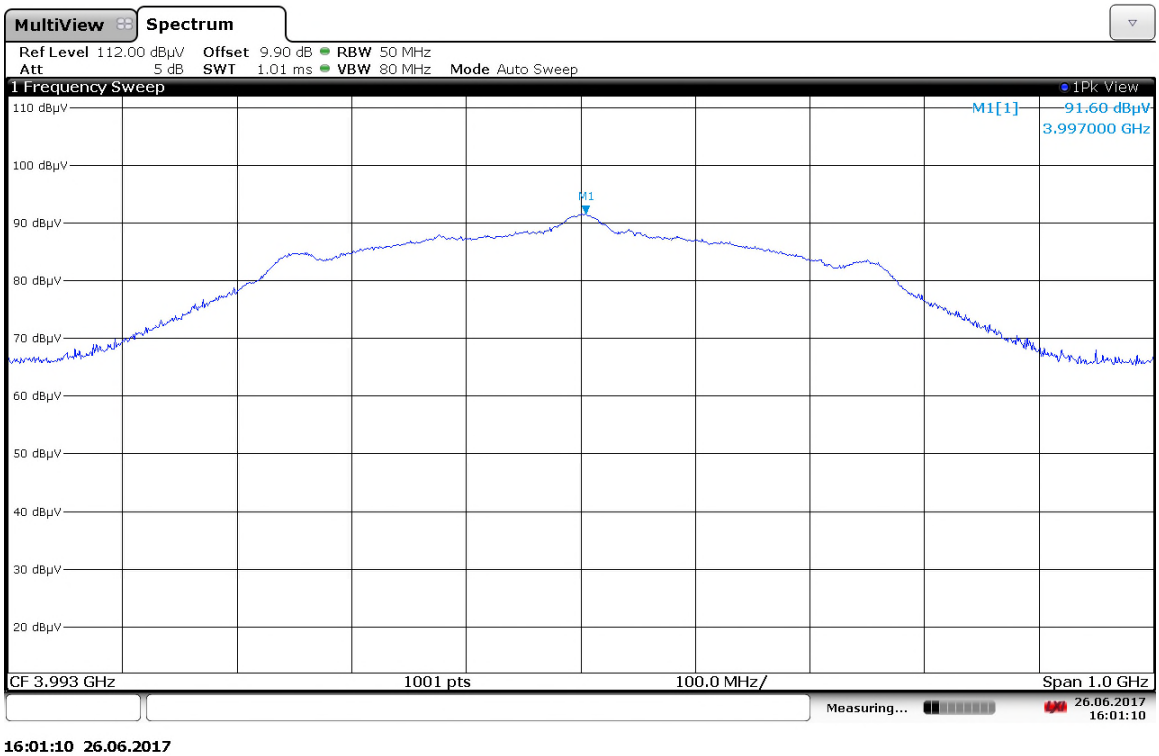


**Figure 7.4.2-1: Peak Power Plot**

## 7.5 Power Spectral Density in the Fundamental Emission – FCC 15.519(c).

### 7.5.1 Measurement Procedure

The power spectral density was measured in accordance with the ANSI C63.10 Section 10.3.7. The equipment under test was tested radiated. The resolution bandwidth (RBW) of the spectrum analyzer was set to 1 MHz. The video bandwidth (VBW) was set to ≥1 MHz. Span was set to a convenient frequency segment. The trace was set to max hold with a RMS detector active. The sweep time did not exceed 1ms per bin. For the 600 bins used a 600 ms sweep time was used.

### 7.5.2 Measurement Results

Measurement Performed By: Randy Sherian

Field Strength: Data (from plot) + antenna CF = Field Strength
51.37 dBµV/m + 2.17 dB/m = 53.54 dBµV/m

Field Strength to EIRP (dBm): Field Strength – 95.3 = EIRP (dBm)
53.54dBuV/m - 95.3 = -41.76 dBm EIRP
Per 15.519(c) the limit on the fundamental is -41.3 dBm EIRP.

**Table 7.5.2-1: Power Spectral Density**

| Frequency (MHz) | PSD Level EIRP(dBm) |
|---|---|
| 3993.5 | -41.76 |

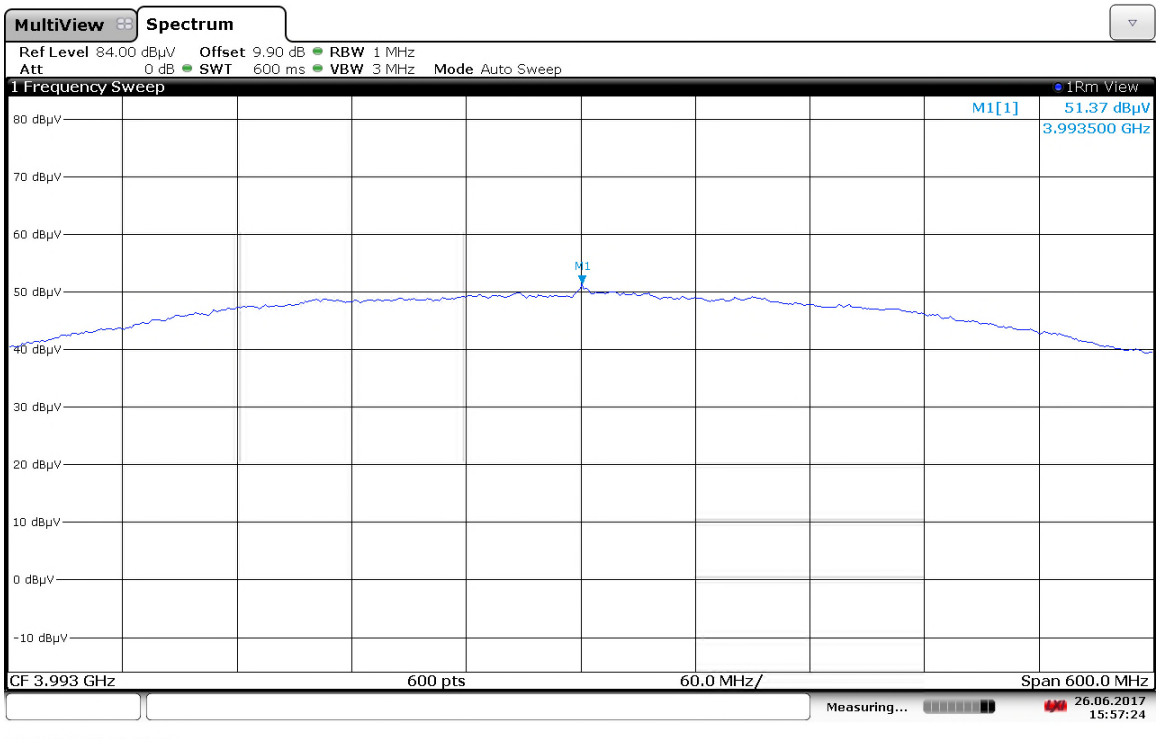


**Figure 7.5.2-1: PSD Plot**

## 7.6 Radiated Emissions – FCC 15.519(c)

### 7.6.1 Emissions into Frequency Bands above 960 MHz

#### 7.6.1.1 Measurement Procedure

The unwanted emissions above 960 MHz were measured radiated in accordance with ANSI 63.10: 2013 Section 10.3. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 1 MHz. The Video Bandwidth (VBW) was set to ≥ 1MHz. The trace was set to max hold with a RMS detector active. The sweep time did not exceed 1ms per bin. Below 1.99GHz, 600 bins were used with a sweep time of 600 ms. Above 1.99GHz, 1000 bins were used with a 1000 ms sweep time.

The correction factor is a combination of coax cable loss, preamp gain, antenna factor, and a measurement distance correction factor (when needed).

#### 7.6.1.2 Sample Calculation:

$R_C = R_U + CF_T$

Where:

| | | |
|---|---|---|
| $CF_T$ | = | Total Correction Factor (AF+CA+AG)+DCF |
| $R_U$ | = | Uncorrected Reading |
| $R_C$ | = | Corrected Level |
| AF | = | Antenna Factor |
| CA | = | Cable Attenuation |
| AG | = | Amplifier Gain |
| DCF | = | Distance Correction Factor |

**Example Calculation: RMS**
Corrected Level: 18.34 + -7.07 = 11.27dBµV/m
Limit Conversion to dBµV/m: EIRP (dBm) + 95.3 = dBµV/m

**Table 7.6.1.2-1 Limits from 15.519(c):**

| Frequency MHz | EIRP dBm | Limit dBµV/m @3m |
|---|---|---|
| 960 to 1610 | -75.3 | 20 |
| 1610 to 1990 | -63.3 | 32 |
| 1990 to 3100 | -61.3 | 34 |
| 3100 to 10600 | -41.3 | 54 |
| Above 10600 | -61.3 | 34 |

Measurement Performed By: Randy Sherian

### 7.6.1.3 Measurement Results

Measurement Performed By: Randy Sherian

| Emission Frequency MHz | Reading From plot dBµV | Antenna Polarity | Measurement Distance meter | Correction Factors dB/m | Field Strength dBµV/m | Limit dBµV/m @3m |
|---|---|---|---|---|---|---|
| 1257.4 | 18.34* | H | 1 | -7.07 | 11.27 | 20 |
| 1776.9 | 27.33 | H | 3 | -5.63 | 21.70 | 32 |
| 2460.1 | 27.64 | H | 3 | -3.52 | 24.12 | 34 |
| 4697 | 26.13 | H | 3 | 3.61 | 29.74 | 54 |
| 7987.6 | 27.83 | H | 3 | 9.08 | 36.91 | 54 |
| 13859.7 | 17.70* | H | 1 | 12.35 | 30.05 | 34 |
| 18973.3 | 19.45* | H | 1 | 8.19 | 27.64 | 34 |
| 39197.0 | 32.19* | H | 1 | -0.09 | 32.10 | 34 |

*Measurements were made at 1 meter. The reading from the plot was corrected to a 3-meter measurement distance using the extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements) (9.54 dB).

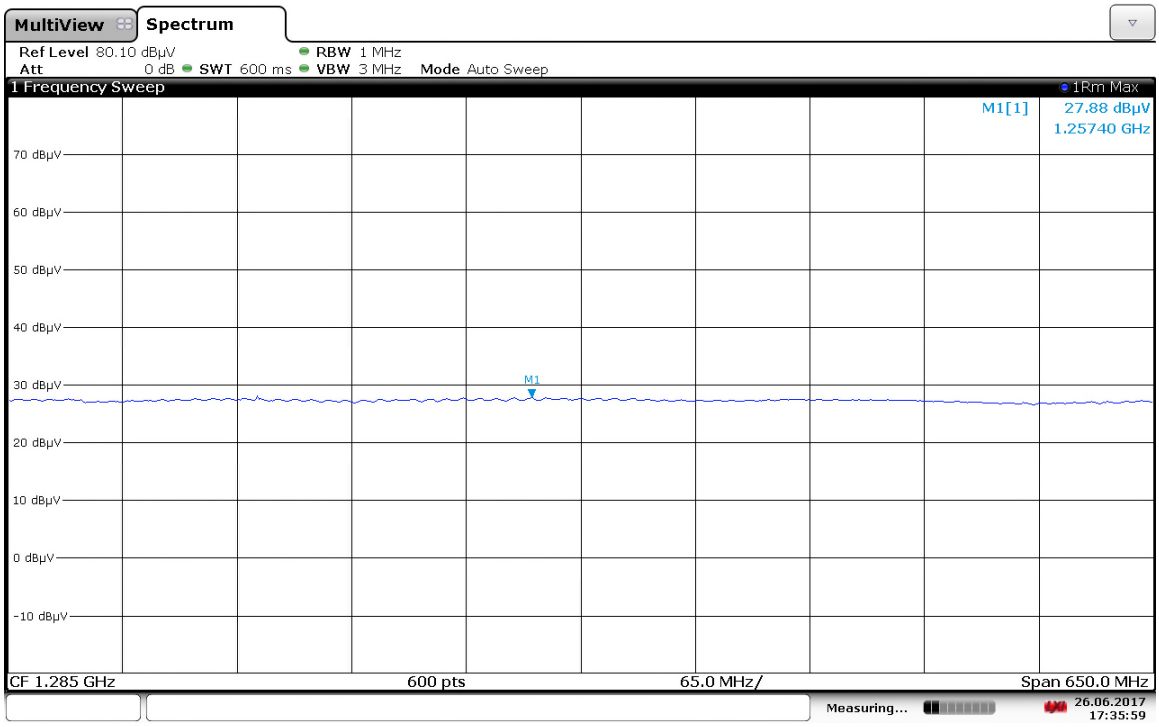


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**Figure 7.6.1.3-1: 960 MHz – 1.61 GHz**

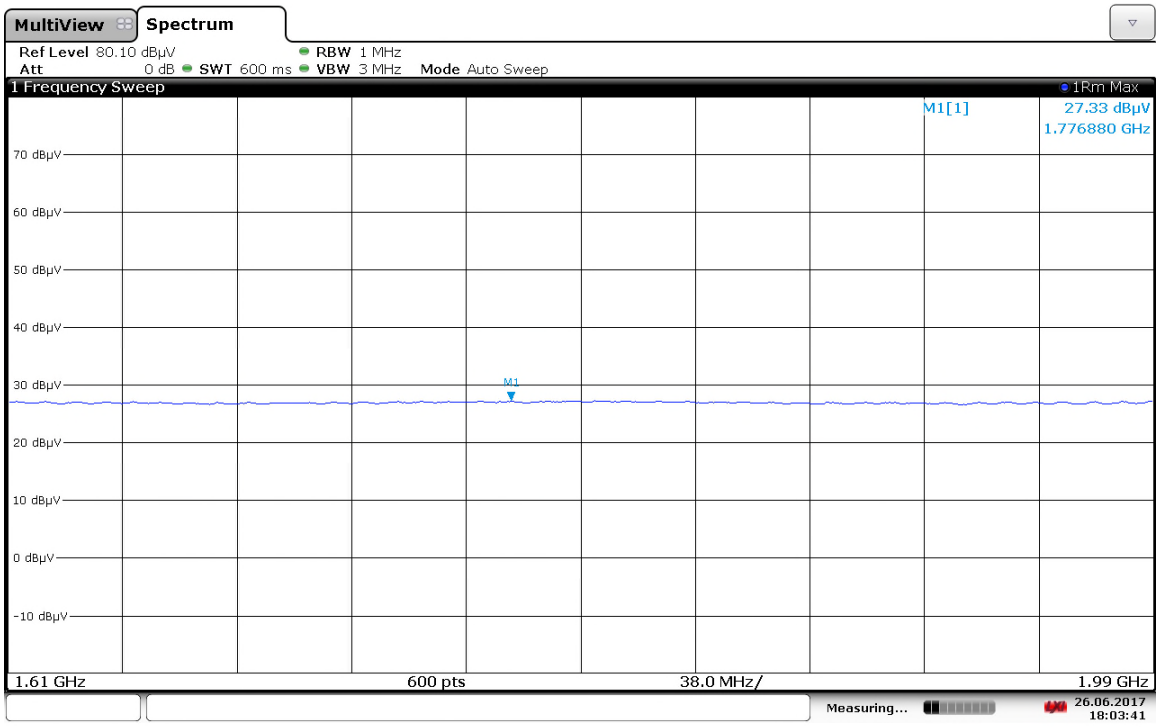


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**Figure 7.6.1.3-2: 1.61 GHz – 1.99 GHz**

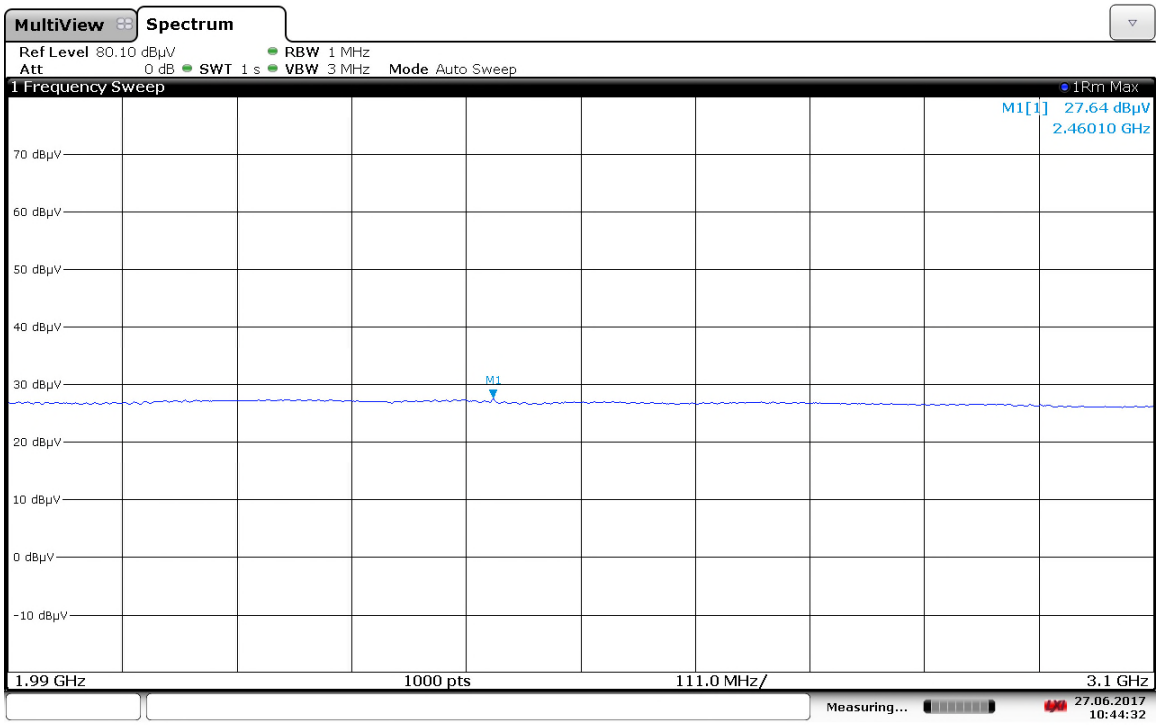


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**Figure 7.6.1.3-3: 1.99 GHz – 3.1 GHz**

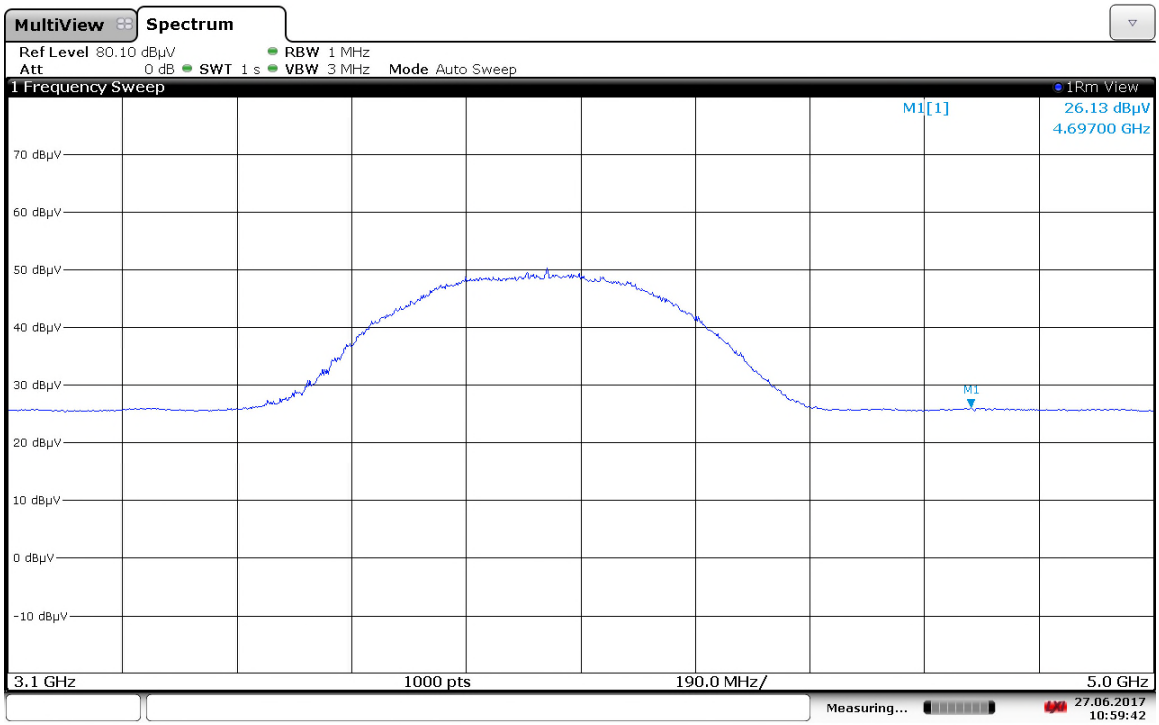


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**Figure 7.6.1.3-4: 3.1 GHz – 5 GHz**

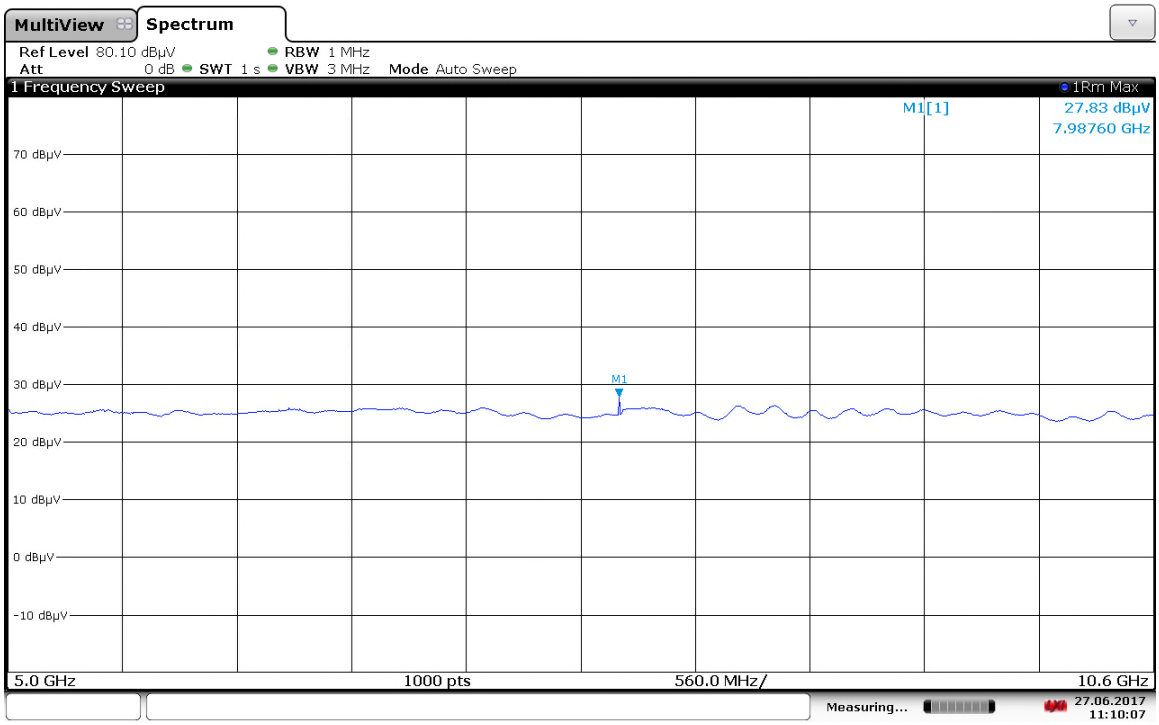


**Figure 7.6.1.3-5: 45 GHz – 10.6 GHz**

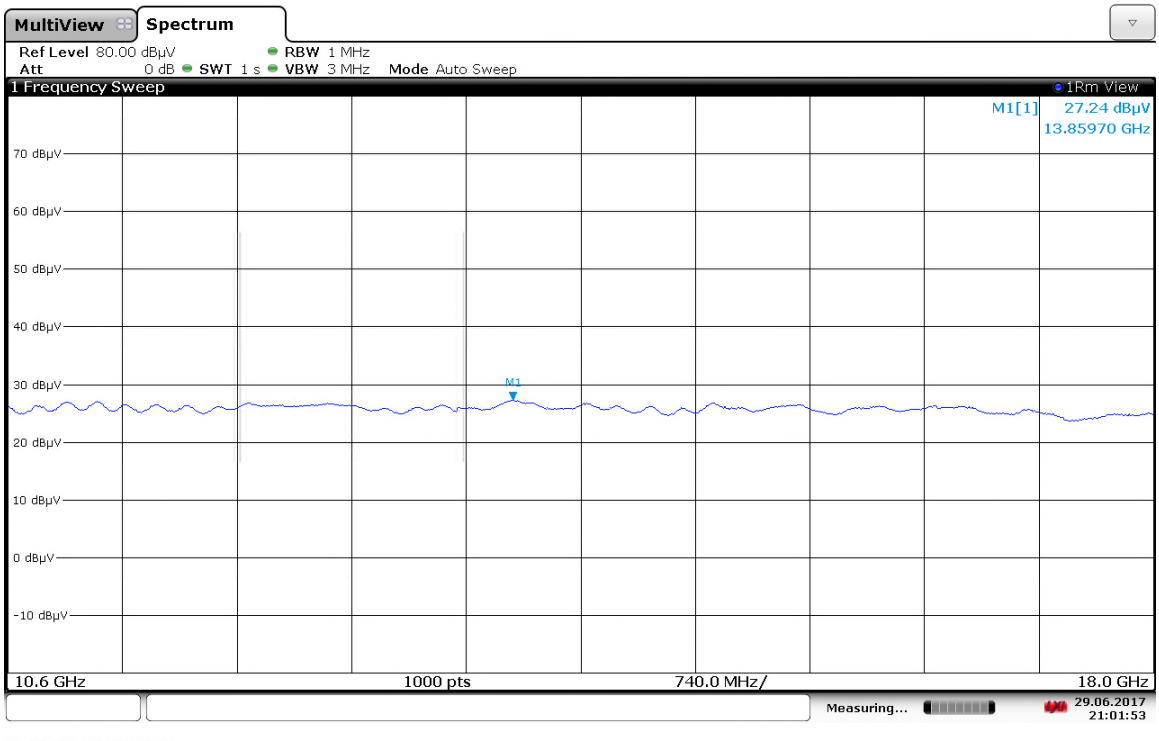


**Figure 7.6.1.3-6: 10.6 GHz – 18 GHz**

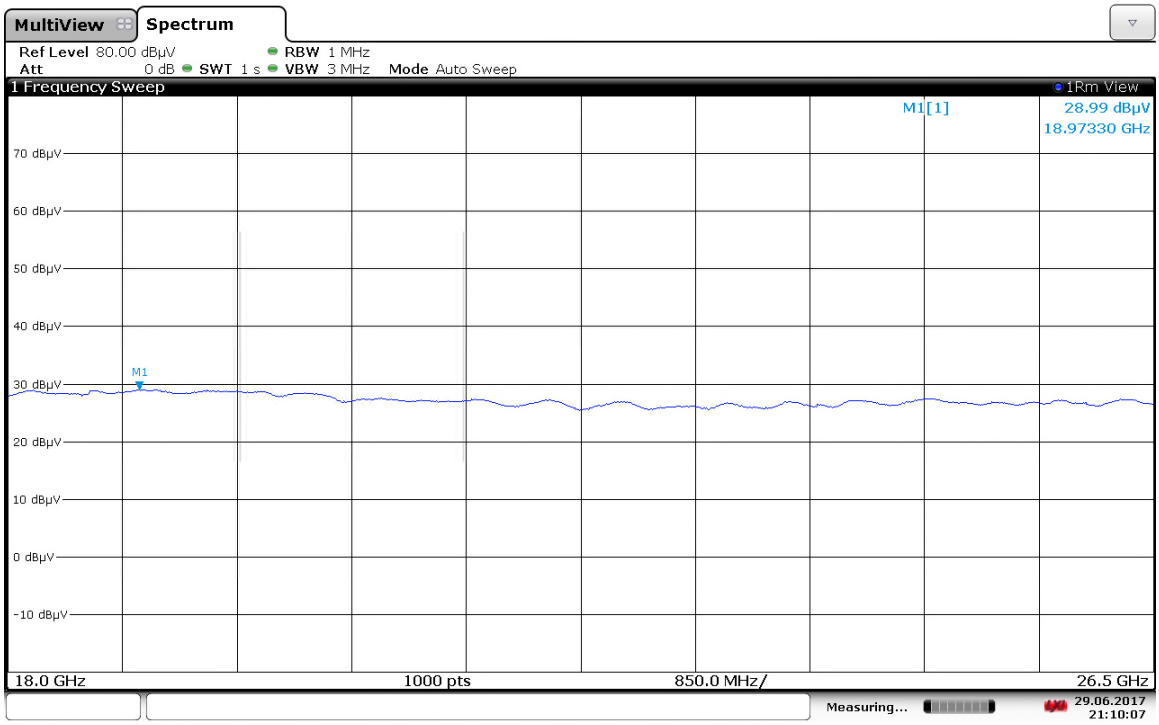


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**Figure 7.6.1.3-7: 18 GHz – 26.5 GHz**

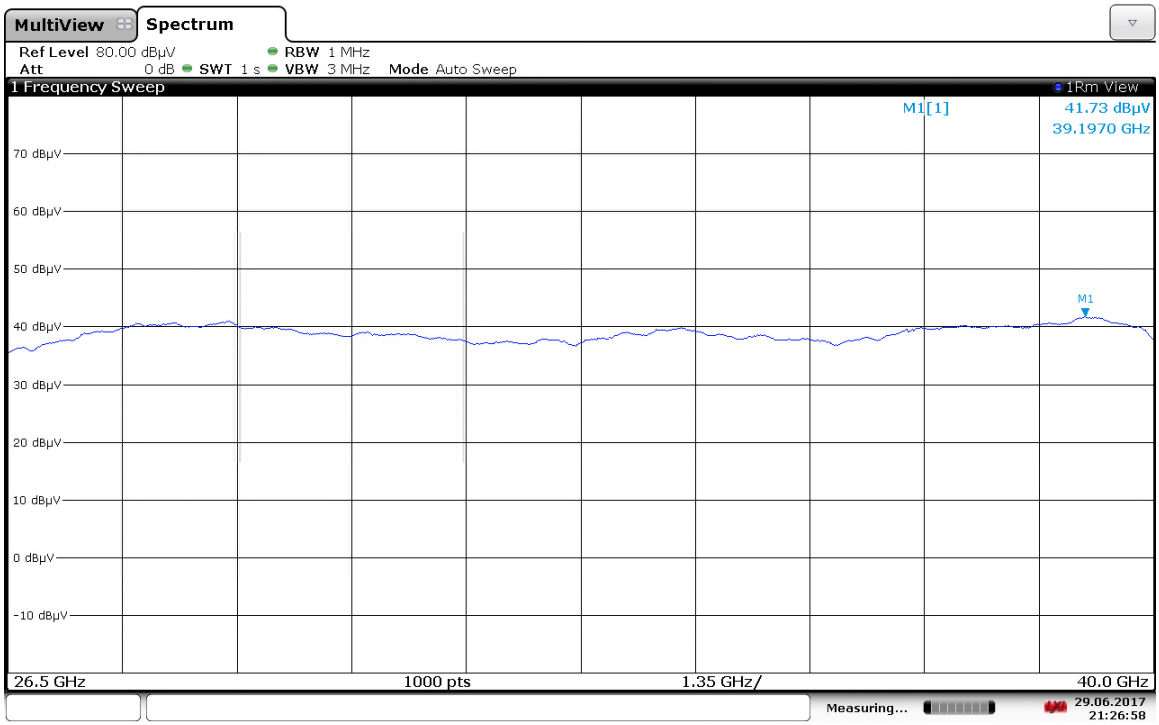


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**Figure 7.6.1.3-8: 26.5 GHz – 40 GHz**

### 7.6.2 Emissions into Frequency Bands below 960 MHz FCC 15.209

#### 7.6.2.1 Measurement Procedure

The unwanted emissions from the lowest frequency generated or 9 kHz to 960 MHz in accordance with ANSI 63.10: 2013 Section 10.2. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 100 kHz. The Video Bandwidth (VBW) was set to ≥ 100 kHz. The trace was set to max hold with a Q-P detector active.

The correction factor is a combination of coax cable loss, preamp gain, antenna factor, and a distance correction factor (if needed).

**Table 7.6.2.1-1 Limits from 15.109:**

| Emission Type | Frequency Range (MHz) | Voltage limits (dBµV/m) |
|---|---|---|
| Radiated Class B @ 3 meters | 0.009 to 0.490 | 20log(2400/F(kHz)) @300m |
| | 0.490 to 1.705 | 20log(24000/F(kHz)) @30m |
| | 30.0 to 88.0 | 40.0 |
| | 88.0 to 216.0 | 43.5 |
| | 216.0 to 960.0 | 46.0 |

#### 7.6.2.2 Measurement Results

Measurement Performed By: Randy Sherian

| Frequency (MHz) | Level (dBuV) | | Antenna Polarity | Correction Factors | Corrected Level (dBuV/m) | | Limit (dBuV/m) | | Margin (dB) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pk | Qpk/Avg | (H/V) | (dB) | pk | Qpk/Avg | pk | Qpk/Avg | pk | Qpk/Avg |
| **31.64** | | -3.00 | H | 13.81 | --------- | 10.81 | -------- | 40.0 | --------- | 29.2 |
| **31.64** | | -2.70 | V | 13.81 | --------- | 11.11 | -------- | 40.0 | --------- | 28.9 |
| **134.44** | | -3.00 | H | 12.49 | --------- | 9.49 | -------- | 43.5 | --------- | 34.0 |
| **134.44** | | -2.70 | V | 12.49 | --------- | 9.79 | -------- | 43.5 | --------- | 33.7 |
| **193.8** | | -1.80 | H | 15.25 | --------- | 13.45 | -------- | 43.5 | --------- | 30.0 |
| **193.8** | | -2.00 | V | 15.25 | --------- | 13.25 | -------- | 43.5 | --------- | 30.2 |
| **293.4** | | -2.30 | H | 14.40 | --------- | 12.10 | -------- | 46.0 | --------- | 33.9 |
| **293.4** | | -2.60 | V | 14.40 | --------- | 11.80 | -------- | 46.0 | --------- | 34.2 |
| **512.04** | | -1.70 | H | 19.26 | --------- | 17.56 | -------- | 46.0 | --------- | 28.4 |
| **512.04** | | -1.80 | V | 19.26 | --------- | 17.46 | -------- | 46.0 | --------- | 28.5 |
| **931** | | -0.80 | H | 24.45 | --------- | 23.65 | -------- | 46.0 | --------- | 22.4 |
| **931** | | -0.90 | V | 24.45 | --------- | 23.55 | -------- | 46.0 | --------- | 22.5 |

### 7.6.3 Radiated Emissions in the GPS bands FCC 15.519(d)

#### 7.6.3.1 Measurement Procedure

Unwanted emissions in the above bands were measured radiated in accordance with ANSI 63.10: 2013 Section 10.3.10 and 10.3.7 and the FCC rules. The resolution bandwidth (RBW) of the spectrum analyzer was set to 30 kHz with the minimum allowed being 1 kHz. The ratio of the RBW to Video Bandwidth (VBW) was set to ≥ 3 where possible. The trace was set to max hold with a RMS detector active. The sweep time did not exceed 1ms per bin. For the 600 bins used, a 600 ms sweep time was used.

#### 7.6.3.2 Sample Calculation:

$R_C = R_U + CF_T$

Where:

| | | |
|---|---|---|
| $CF_T$ | = | Total Correction Factor (AF+CA+AG)+DCF |
| $R_U$ | = | Uncorrected Reading |
| $R_C$ | = | Corrected Level |
| AF | = | Antenna Factor |
| CA | = | Cable Attenuation |
| AG | = | Amplifier Gain |
| DCF | = | Distance Correction Factor |

**Example Calculation: RMS**
Corrected Level: 14.37 + -7.10 = 7.27dBµV/m
Limit Conversion to dBµV/m: EIRP (dBm) + 95.3 = dBµV/m

The frequency bands to be investigated and the associated limits are:

**Table 7.6.3.1-1 Frequency Bands**

| Frequency MHz | EIRP dBm | Field Strength @3m dBµV/m |
|---|---|---|
| 1164 to 1240 | -85.3 | 10 |
| 1559 to 1610 | -85.3 | 10 |

#### 7.6.3.3 Measurement Results:

Measurement Performed By: Randy Sherian

| Emission Frequency MHz | Reading From plot dBµV | Antenna Polarity | Measurement Distance m | Correction Factors dB/m | Field Strength dBµV/m | Limit dBµV/m @3m |
|---|---|---|---|---|---|---|
| 1238.67 | 14.37 | H | 3 | -7.10 | 7.27 | 10 |
| 1604.26 | 14.44 | H | 3 | -6.33 | 8.11 | 10 |

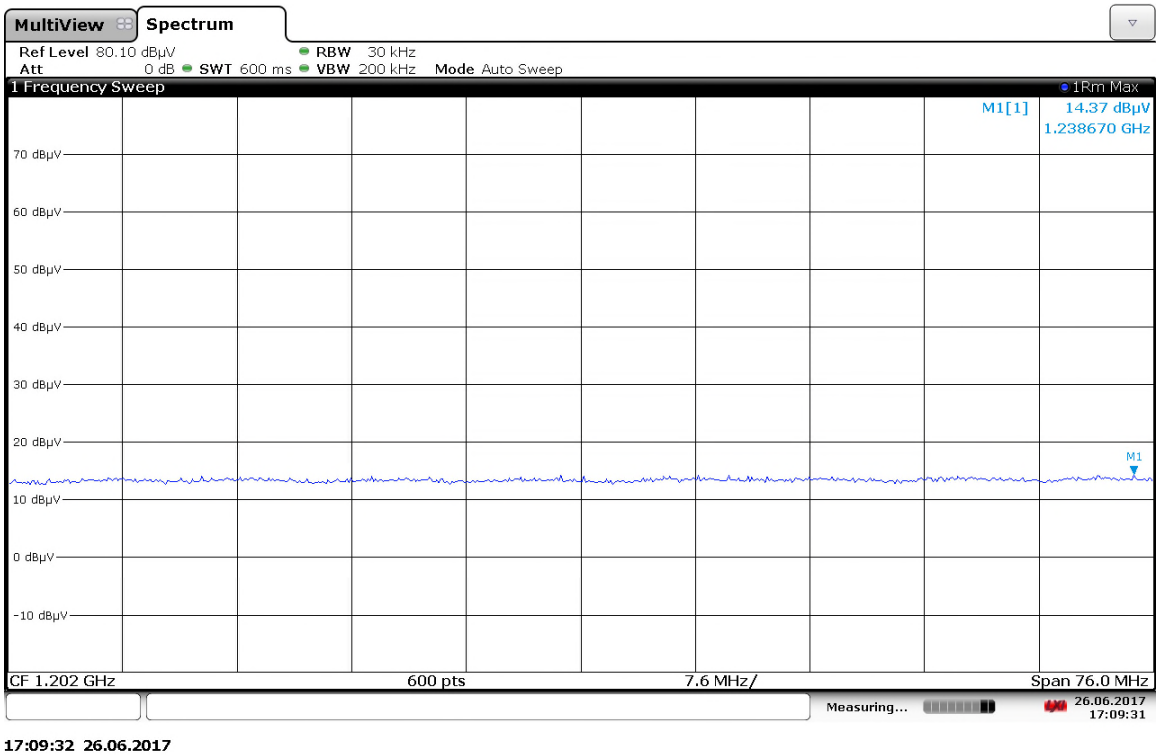


**Figure 7.6.3.2-1: 1.164 GHz – 1.24 GHz**

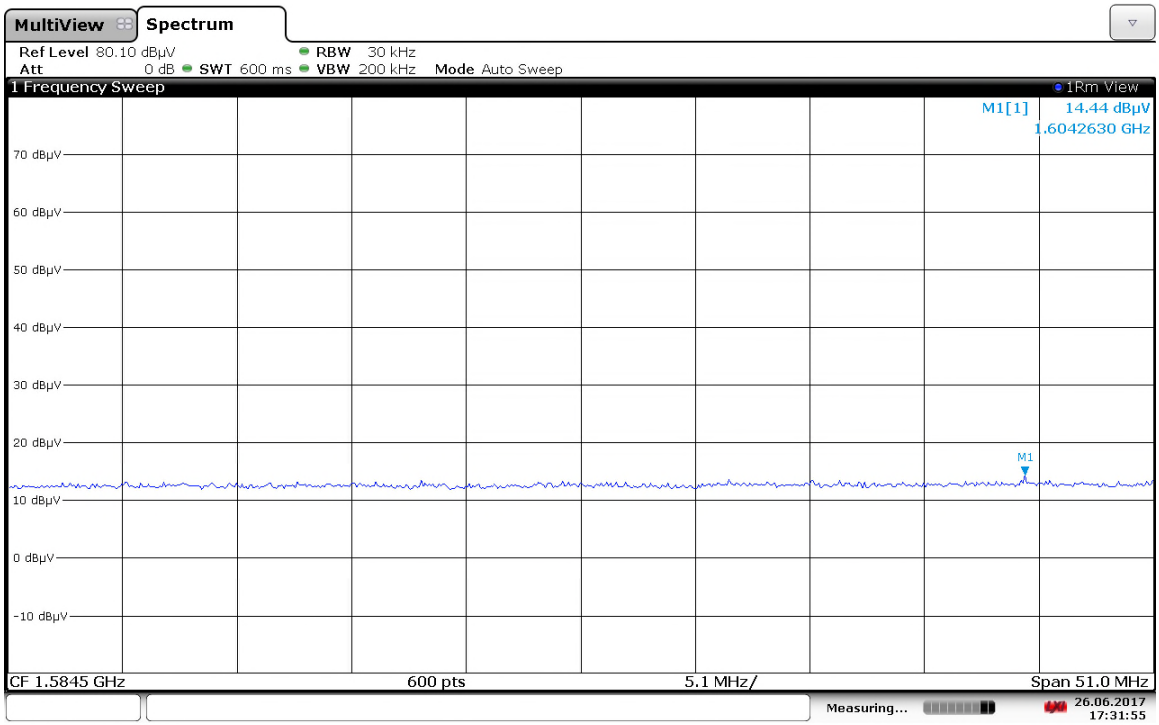


**Figure 7.6.3.2-2: 1.559 GHz – 1.610 GHz**

## 7.7 Transmit On/Off Requirements – FCC 15.519(a)(1)

### 7.7.1 Handheld Transmitter On/Off Requirements FCC 15.519(a)(1)

A UWB device operating under the provisions of this section shall transmit only when it is sending information to an associated receiver. The UWB intentional radiator shall cease transmission within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgment of reception must continue to be received by the UWB intentional radiator at least every 10 seconds or the UWB device must cease transmitting. The Theory of Operation, provided under a separate cover, contains detailed information supporting the transmission time of the device.

### 7.7.2 Measurement Results:

Measurement Performed By: Jean Tezil

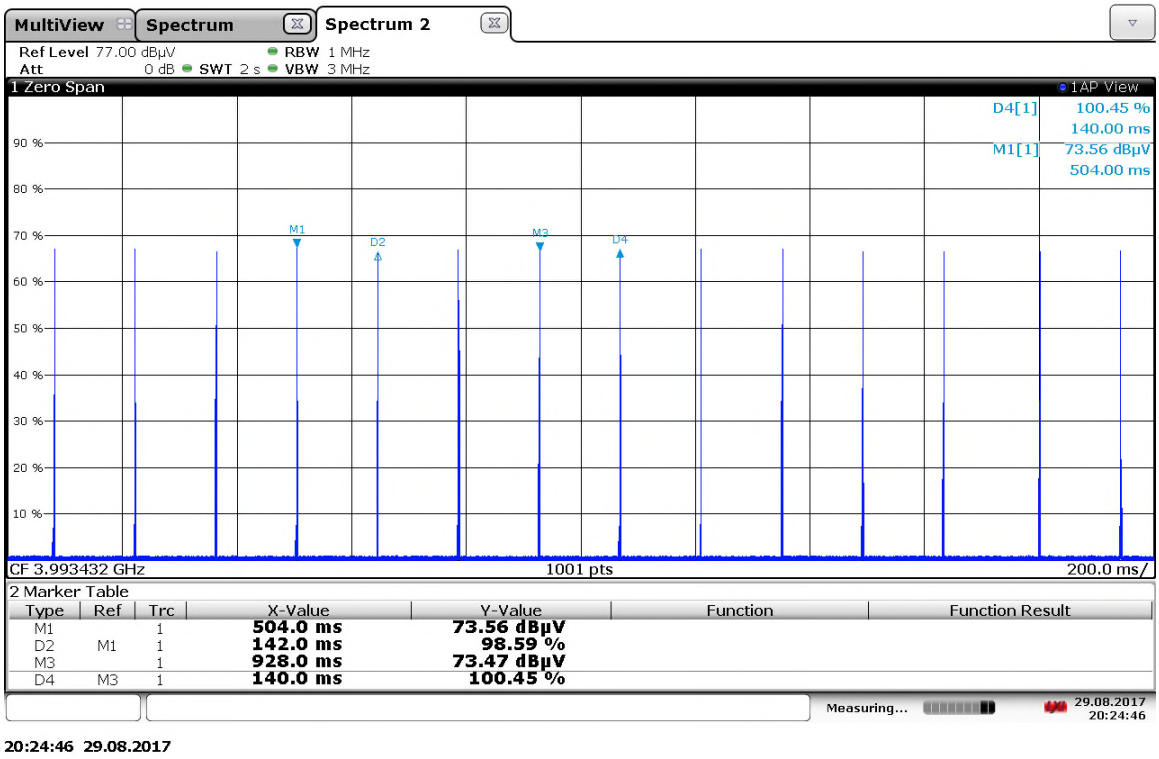


**Figure 7.7.2-1: Transmitter (Tag) On/Off Time With No Receiver (Anchor) Available**

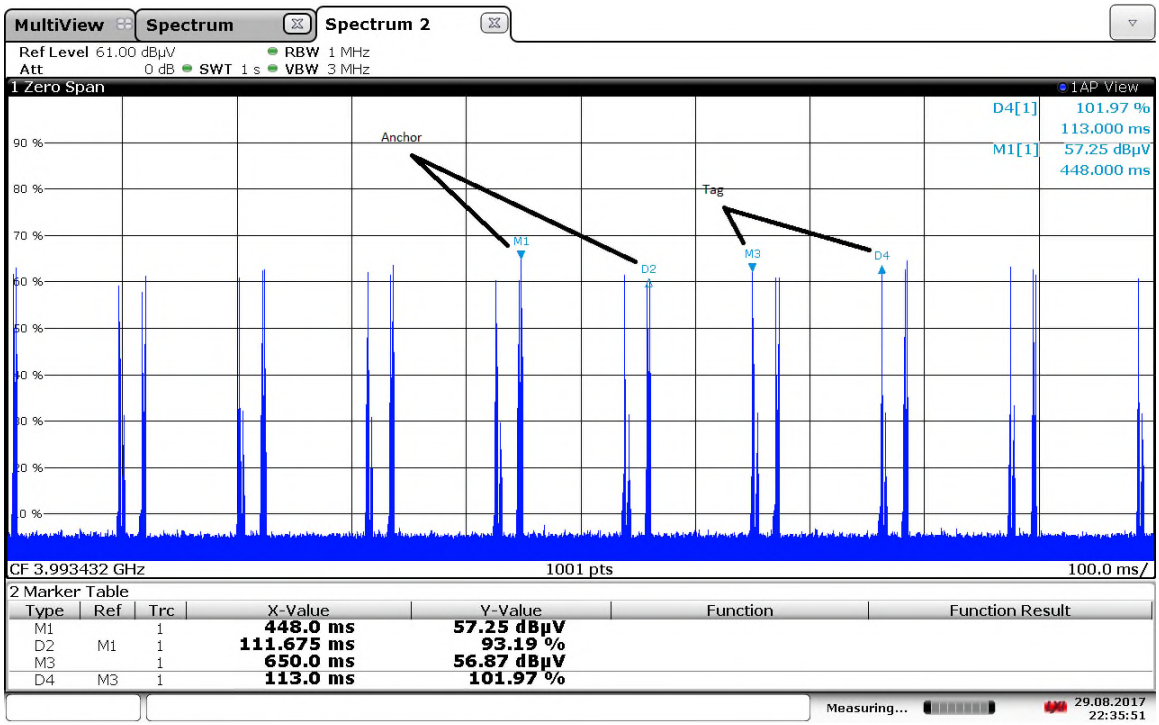


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**Figure 7.7.2-2: Transmitter (Tag) On/Off Time With Receiver (Anchor) Available**

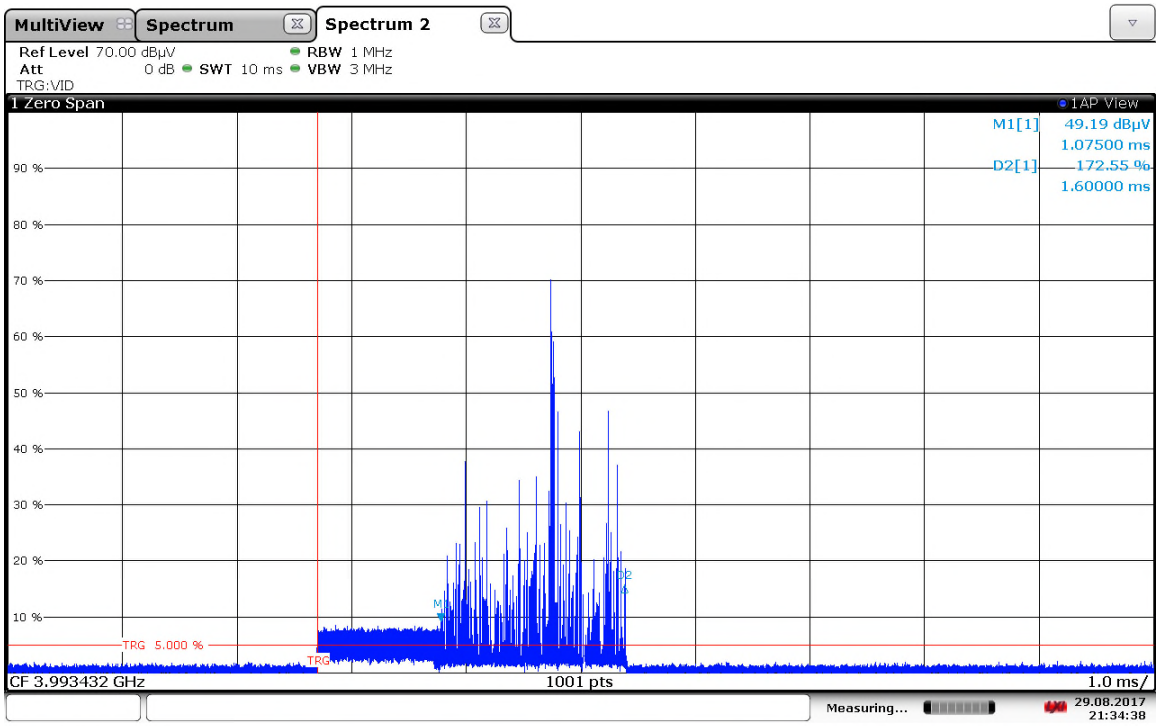


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**Figure 7.7.2-3: Transmitter (Tag) Exchange Time With Receiver (Anchor) Available**

## 8 MEASUREMENT UNCERTAINTY

The expanded laboratory measurement uncertainty figures ($U_{Lab}$) provided below correspond to an expansion factor (coverage factor) k = 1.96 which provide confidence levels of 95%.

| Parameter | $U_{lab}$ |
|---|---|
| Occupied Channel Bandwidth | ± 0.004% |
| RF Conducted Output Power | ± 0.689 dB |
| Power Spectral Density | ±0.5 dB |
| Antenna Port Conducted Emissions | ± 2.717 dB |
| Radiated Emissions | ± 5.877 dB |
| Temperature | ± 0.860 °C |
| Radio Frequency | ±2.832 x 10-8 |
| AC Power Line Conducted Emissions | ±2.85 dB |

## 9 CONCLUSION

In the opinion of TÜV SÜD America Inc. the JBRF-1, manufactured by Jigabot LLC meets the requirements of FCC Part 15 subpart F.

# END REPORT