**F2 Labs**
**16740 Peters Road**
**Middlefield, Ohio 44062**
**United States of America**
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# CERTIFICATION TEST REPORT

| | |
|---|---|
| **Manufacturing Addresses:** | **Protran Technology**<br>**52 Paterson Avenue, Suite 4**<br>**Newton, New Jersey 07680 USA**<br><br>**Harsco Rail**<br>**2401 Edmund Road**<br>**West Columbia, South Carolina 29171 USA** |
| **Applicant:** | **Harsco Rail**<br>**2401 Edmund Road**<br>**West Columbia, South Carolina 29171 USA** |
| **Product Name:** | **Ranging Module** |
| **Product Description:** | **Module with a ranging radio to be used in distance monitoring and reporting systems.** |
| **Model:** | **Swarm Bee** |
| **FCC ID:** | **2AEO5PT-000320** |
| **Testing Commenced:** | **July 20, 2015** |
| **Testing Ended:** | **July 22, 2015** |
| **Summary of Test Results:** | **In Compliance, with Modifications**<br><br>The EUT complies with the EMC requirements when manufactured identically as the unit tested in this report, including any required modifications. Any changes to the design or build of this unit subsequent to this testing may deem it non-compliant. |

**Standards**:

- **FCC Part 15 Subpart C, Section 15.247**
- **FCC Part 15, Subpart C, Section 15.207**
- **FCC Part 15, Subpart C, Section 15.209**

**Evaluation Conducted by:**

Joe Knepper, EMC Proj. Eng.

**Report Reviewed by:**

Ken Littell, EMC Tech. Mgr.

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# 1 ADMINISTRATIVE INFORMATION

## 1.1 Measurement Location:

F2 Labs in Middlefield, Ohio. Site description and attenuation data are on file with the FCC's Sampling and Measurement Branch at the FCC Laboratory in Columbia, MD**.**

## 1.2 Measurement Procedure:

All measurements were performed according to ANSI C63.4 and recommended FCC procedure of measurement of DTS operating under Section 15.247 and in KDB558074. A list of the measurement equipment can be found in Section 6.

## 1.3 Uncertainty Budget:

Radiated Emission

- Combined Uncertainty (+ or -) 2.24 dB
- Expanded Uncertainty (+ or -) 4.48 dB

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

## 1.4 Document History

| Document Number | Description | Issue Date | Approved By |
|---|---|---|---|
| F2LQ7230B-01E | First Issue | Aug. 5, 2015 | K. Littell |
| | | | |
| | | | |

## 2 SUMMARY OF TEST RESULTS

| Test Name | Standard(s) | Results |
|---|---|---|
| -6dB Occupied Bandwidth | CFR 47 Part 15.247(a)(2) / KDB558074 | Complies |
| Conducted Output Power | CFR 47 Part 15.247(b)(3) / KDB558074 | Complies |
| Conducted Spurious Emissions | CFR 47 Part 15.247(d) / Part 15.209 / KDB558074 | Complies |
| Radiated Spurious Emission with 12dBi Whip Antenna | CFR 47 Part 15.247(d) / Part 15.209 / KDB558074 | Complies |
| Radiated Spurious Emission with 15dBi Whip Antenna | CFR 47 Part 15.247(d) / Part 15.209 / KDB558074 | Complies |
| Radiated Spurious Emission with 18Bi Integral Antenna | CFR 47 Part 15.247(d) / Part 15.209 / KDB558074 | Complies, with Modifications* |
| Peak Power Spectral Density | CFR 47 Part 15.247(e) / KDB558074 | Complies |
| Voltage Variations | CFR 47 Part 15.31 / KDB558074 | Complies |
| Conducted Emissions | CFR 47 Part 15.207(a) | Complies |

| Modifications Made to the Equipment |
|---|
| *Output power changed only for 18dBi Whip Antenna to Output Power setting 52 (from 63). |

## 3 TABLES OF MEASURED RESULTS

| Test | 2.44GHz |
|---|---|
| Conducted Output Power for use with 12 or 15dBi Whip Antennas | 119.7mW (20.78dBm) |
| Conducted Output Power Limit when using the 12dBi whip antenna | .251W (24dBm) |
| Conducted Output Power Limit when using the 15dBi whip antenna | .126W (21dBm) |
| E.I.R.P. with 12dBi Whip Antenna | 1.897W (32.78dBm) |
| E.I.R.P. with 15dBi Whip Antenna | 3.784W (35.78dBm) |
| Conducted Output Power when used with18dBi Whip Antenna | 0.058W* (17.67dBm) |
| Conducted Output Power Limit, 18dBi Whip Antenna | 0.063 Watt, (18dBm) |
| E.I.R.P. with 18dBi Whip Antenna | 3.689W (35.67dBm) |
| E.I.R.P. Limit | 4 Watts, (36.02dBm) |
| Peak Power Spectral Density | -20.96 dBm |
| Peak Power Spectral Density Limit | 8 dBm |
| -6dB Occupied bandwidth | 57.21MHz |
| -6dB Occupied Bandwidth Limit | ≥ 500KHz |

**Results with modifications noted in Section 2 of this Test Report.*

## FCC PART 15.31 – VOLTAGE VARIATIONS

| Test | Full Output (dBm) | Power (mW) | Limit |
|---|---|---|---|
| When used with 15dBi Whip Antenna @100V | 20.53dBm | 113mW | .126W (21dBm) |
| When used with 15dBi Whip Antenna @ 140V | 20.46dBm | 111.2mW | .126W (21dBm) |
| When used with 12dBi Whip Antenna @100V | 20.53dBm | 113mW | .251W (24dBm) |
| When used with 12dBi Whip Antenna @ 140V | 20.46dBm | 111.2mW | .251W (24dBm) |
| When used with18dBi Whip Antenna @100V | 17.34dBm | 54.2mW | 63mW (18dBm) |
| When used with18dBi Whip Antenna @ 140V | 17.29dBm | 53.6mW | 63mW (18dBm) |

## 4 ENGINEERING STATEMENT

This report has been prepared on behalf of Harsco Rail to provide documentation for the testing described herein. This equipment has been tested and found to comply with Part 15.247 of the FCC Rules using ANSI C63.4 and KDB558074 standards. The test results found in this test report relate only to the items tested.

# 5 EUT INFORMATION AND DATA

## 5.1 Equipment Under Test:

Product: Ranging Module
Model: Swarm Bee
Serial No.: 333447133737313333B0045000
FCC ID: 2AEO5PT-000320

## 5.2 Trade Name:

Harsco Rail

## 5.3 Power Supply:

AC/DC Adapter – Lenovo 42T5276

## 5.4 Applicable Rules:

CFR 47, Part 15.247, subpart C

## 5.5 Equipment Category:

Radio Transmitter-DTS

## 5.6 Antenna:

12dBi Whip, 15dBi Whip, 18dBi Whip

## 5.7 Accessories:

**N/A**

## 5.8 Test Item Condition:

The equipment to be tested was received in good condition.

## 5.9 Testing Algorithm:

EUT was set up in a normal operating manner, powered at 120V, 60 Hz. EUT transmitted at 2.44GHz with one channel. The highest emissions were recorded in the data tables.

## 6 LIST OF MEASUREMENT INSTRUMENTATION

| Equipment Type | Asset Number | Manufacturer | Model | Serial Number | Calibration Due Date |
|---|---|---|---|---|---|
| Shielded Chamber | CL166 | AlbatrossProjects | B83117-DF435-T261 | US140023 | Jan. 1, 2016 |
| Shield Room | 0175 | Ray Proof | N/A | 11645 | Verified |
| Receiver | CL151 | Rohde & Schwarz | ESU40 | 100319 | Nov. 12, 2015 |
| Antenna 1-Chamber | 0142 | ETS/EMCO | 3142B | 9811-1330 | Verified |
| Antenna, JB3 Combination | CL175 | Sunol Sciences | JB3 | A030315 | Mar. 12, 2016 |
| Horn Antenna | CL098 | Emco | 3115 | 9809-5580 | Dec. 3, 2015 |
| Horn, Antenna | CL114 | A.H. Systems | SAS-572 | 237 | Oct. 16, 2016 |
| Pre-Amplifier | CL153 | Agilent | 83006-69007 | MY39500791 | May 6, 2016 |
| Pre-Amplifier | CL136 | Hewlett Packard | 8447E | 1937A01894 | Apr. 1, 2016 |
| Software: | Tile Version 1.0 | | Software Verified: July 20, 2015 | | |
| Software: | EMC 32, Version 5.20.2 | | Software Verified: July 20, 2015 | | |

# 7 FCC PART 15.247(a)(2) – OCCUPIED BANDWIDTH

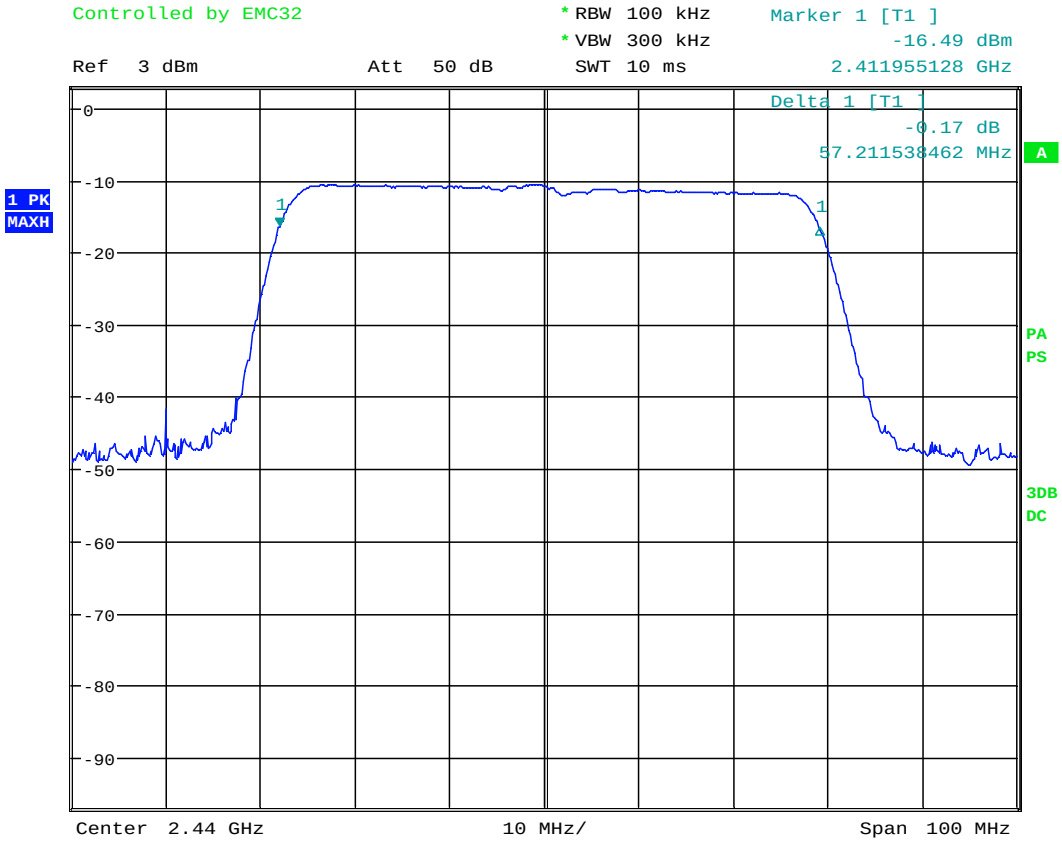
## 7.1 Requirements:

The 6dB bandwidth shall be greater than 500 kHz.

Bandwidth measurements were made at the one (2.44 GHz) frequency with the resolution Bandwidth set at 100 kHz (video bandwidth set at 300 kHz) while the span was set at 100 MHz. The bandwidth was measured using the analyzer's marker function.

## 7.2 Occupied Bandwidth Test Data

| | | | |
|---|---|---|---|
| **Test Date:** | July 21, 2015 | **Test Engineer:** | J. Knepper |
| **Standards:** | CFR 47 Part 15.247(a)(2); KDB558074 | **Air Temperature:** | 21.7ºC |
| | | **Relative Humidity:** | 49% |




Date: 21.JUL.2015 10:26:49

# 8 FCC PART 15.247(b)(3) – CONDUCTED OUTPUT POWER

The EUT antenna port was fitted with an SMA connector and directly connected to the input of the receiver. The peak power output was measured.

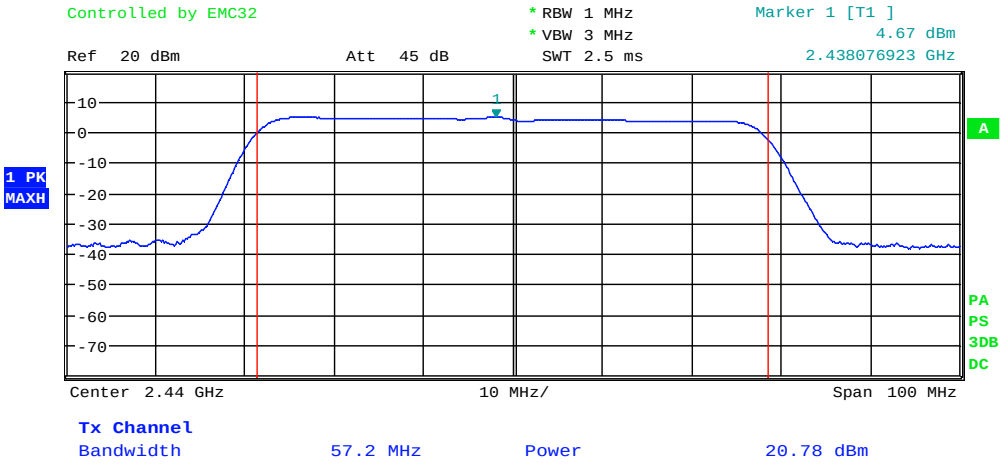
## 8.1 Requirements:

The peak power output shall be 1 watt (30 dBm) or less when using an antenna with a gain of less than 6dBi. For antennas having a gain of more than 6dBi, the limit is reduced by 1dB for every dB the antenna gain is over 6dBi.

## 8.2 Conducted Output Power Test Data

| | | | |
|---|---|---|---|
| **Test Date:** | July 21, 2015 | **Test Engineer:** | J. Knepper |
| **Standards:** | CFR 47 Part 15.247(b)(3); KDB558074 | **Air Temperature:** | 21.9ºC |
| | | **Relative Humidity:** | 42% |

### 12/15dBi Whip Antennas

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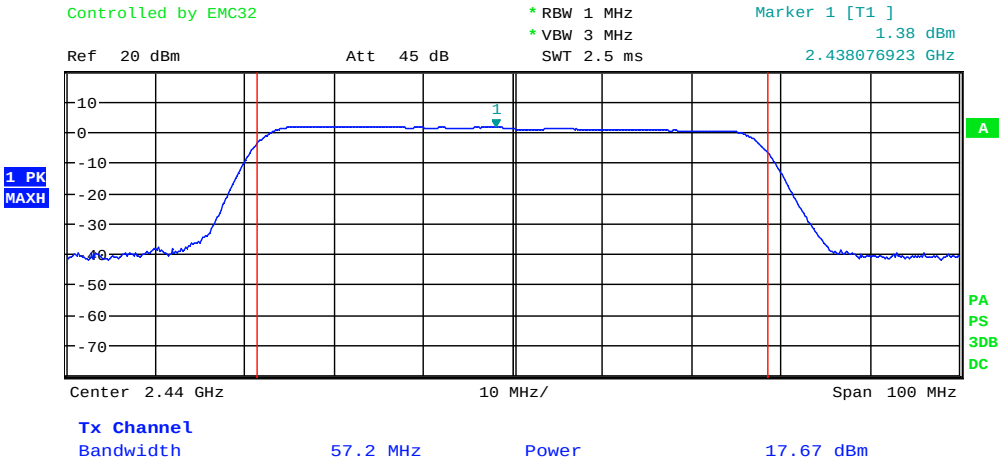
## 18dBi Whip Antenna

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# 9 FCC Part 15.247(c) – CONDUCTED SPURIOUS EMISSIONS

The following tests were performed to demonstrate compliance.

**RF Antenna Conducted Test**
The EUT antenna port was fitted with an SMA connector and directly connected to the input of the spectrum analyzer.

## 9.1 Requirements:

All Spurious Emissions must be at least 20dB down from the highest emission level measured within the authorized band up through the tenth harmonic.

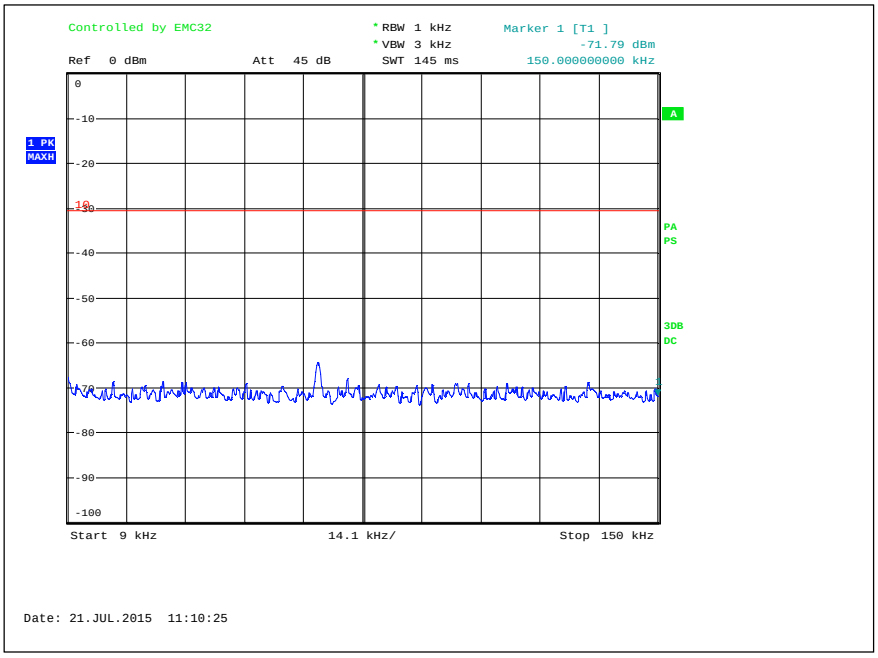
Spurious emissions measurements were made with the appropriate spectrum analyzer impulse bandwidth. Additionally, 20dB down points were measured for the channel to verify band edge compliance.

## 9.2 Test Data – Conducted Spurious Emissions

| Test Date: | July 21, 2015 | Test Engineer: | J. Knepper |
|---|---|---|---|
| Standards: | CFR 47 Part 15.247(d) / Part 15.209; KDB558074 | Air Temperature: | 21.9ºC |
| | | Relative Humidity: | 49% |

**9kHz to 150kHz**

.




**150kHz to 30 MHz**

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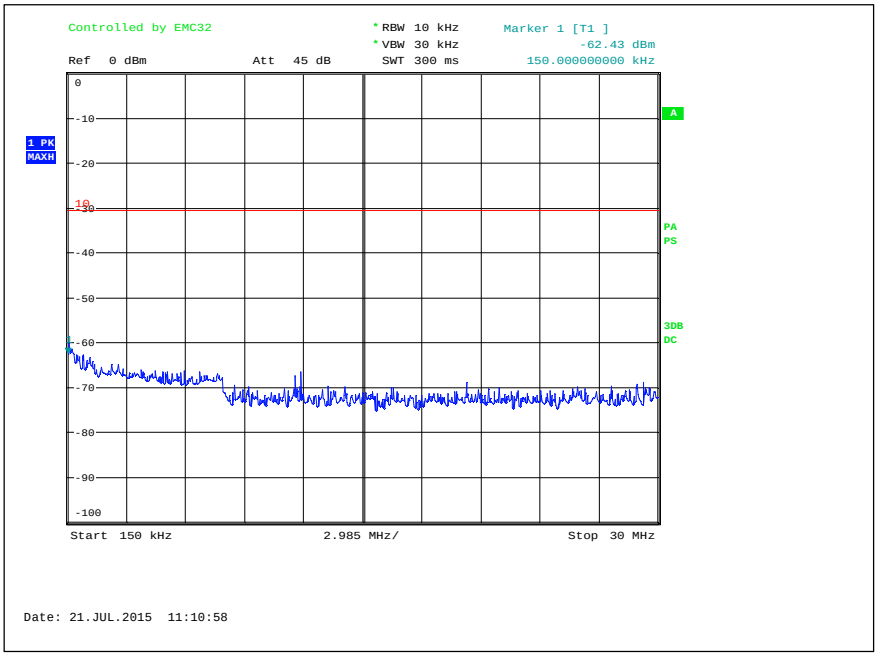
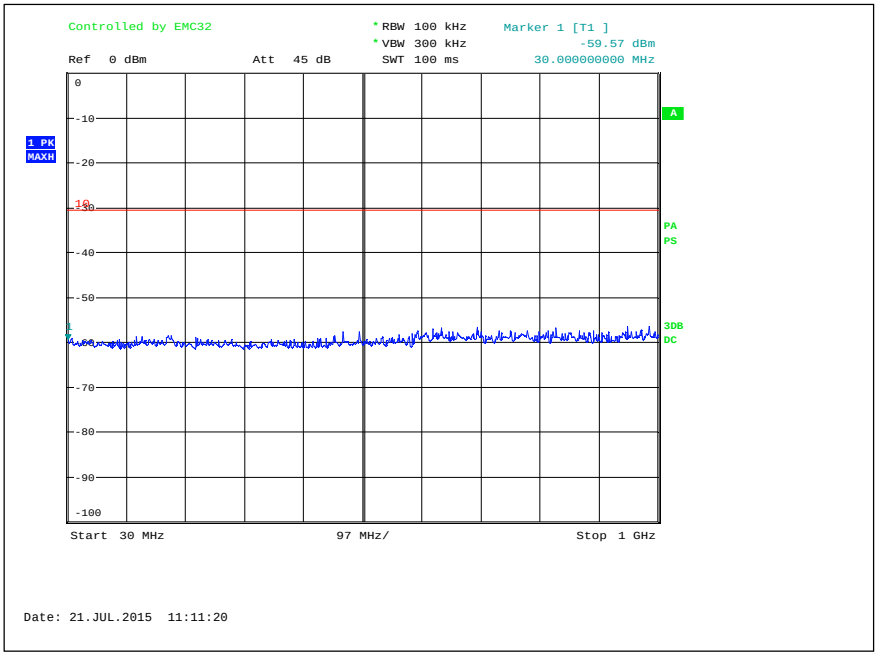


## 30 MHz to 1 GHz

.




## 1 GHz to 2.3 GHz

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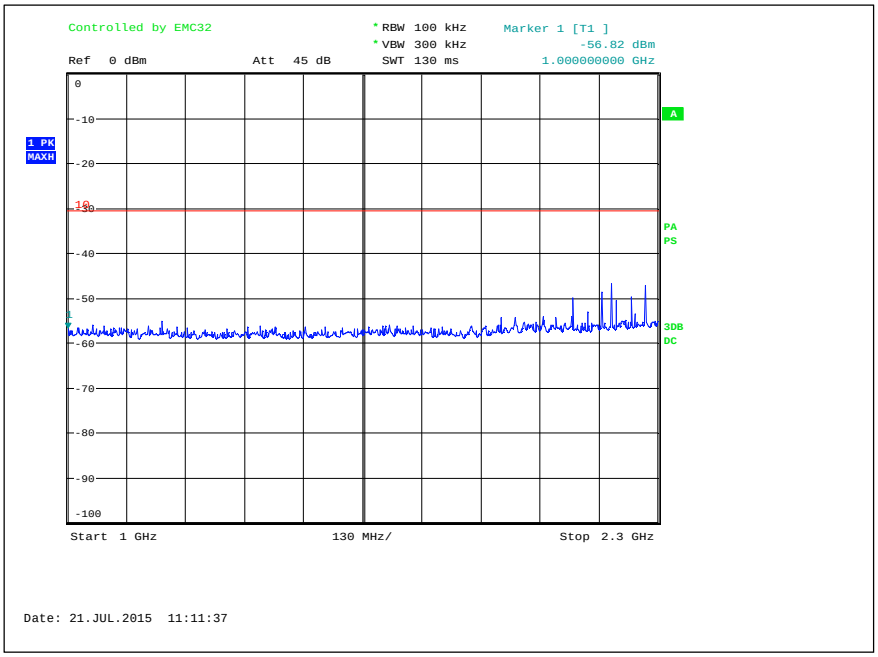

## 2.3 GHz to 2.6 GHz

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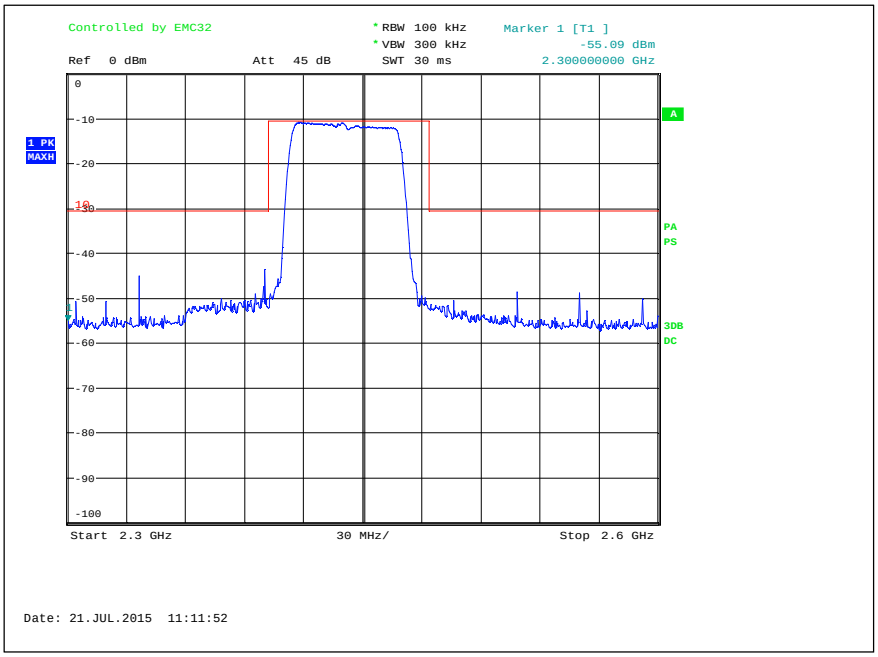


## 2.6 GHz to 6 GHz

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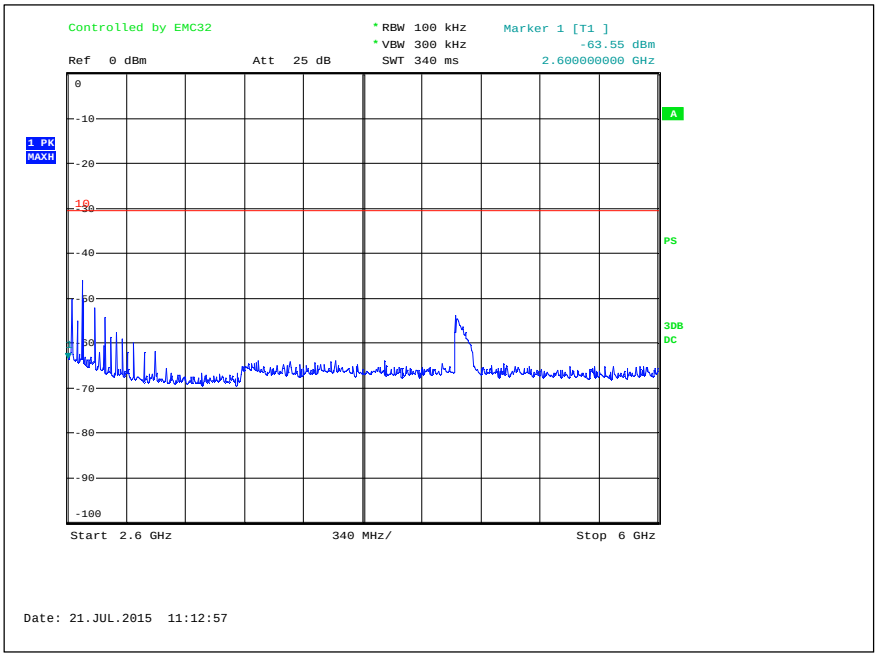

## 6 GHz to 18 GHz

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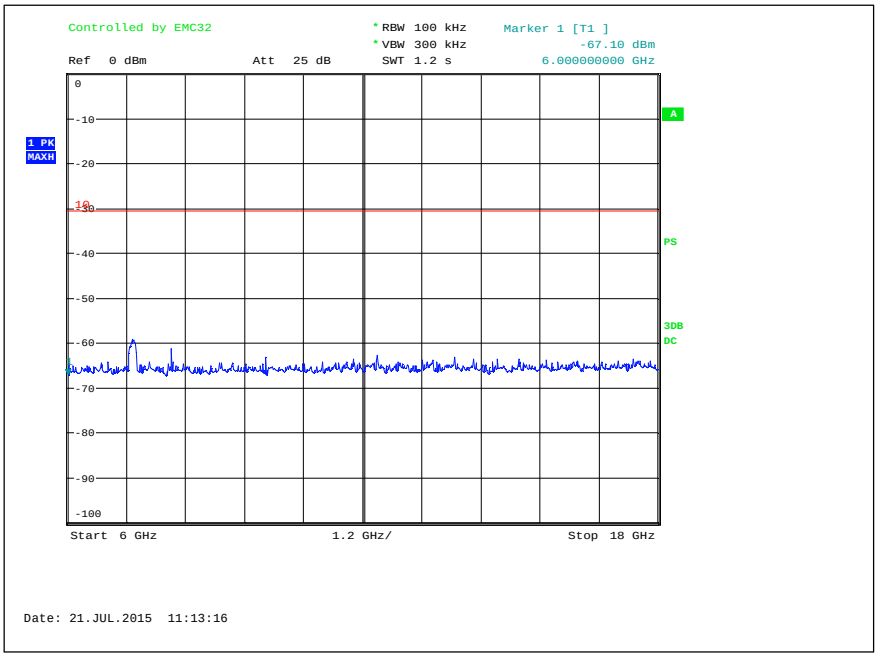


## 18 GHz to 25 GHz

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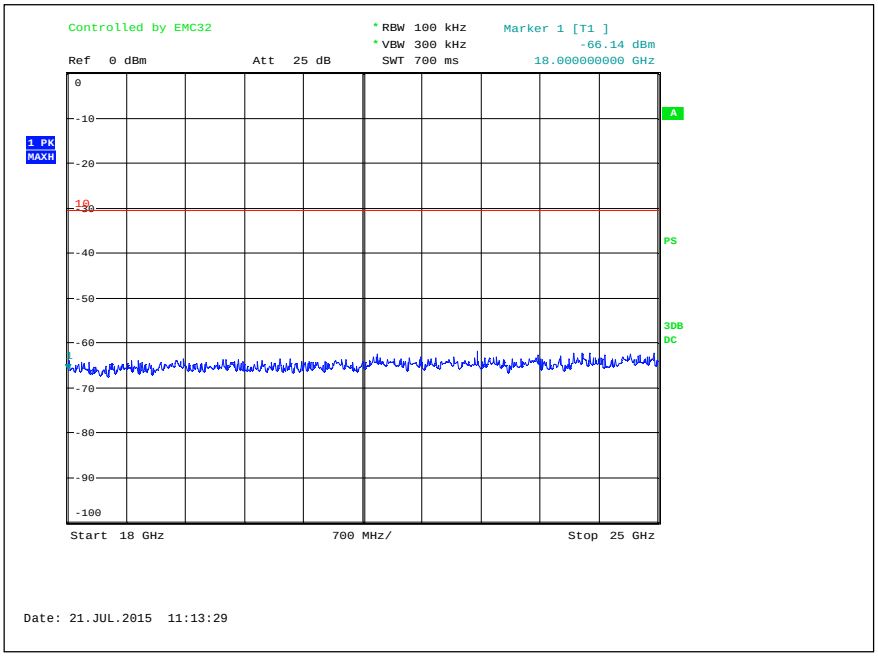


## 10 RADIATED SPURIOUS EMISSIONs

The EUT antenna port was fitted with its 12/15/18 Whip antennas. Radiated emissions were measured on the Open Area Test Site (OATS). All emissions generated that fall in the restricted bands per FCC Part 15.205 were examined.

### 10.1 Requirements:

All emissions that fall in the restricted bands defined in FCC Part 15.205 shall not exceed the maximum field strength listed in FCC Part 15.209(a).

## 10.2 Radiated Spurious Emission Test Data

| | | | |
|---|---|---|---|
| **Test Date(s):** | July 20-22, 2015 | **Test Engineer:** | J. Knepper |
| **Standards:** | CFR 47 Part 15.247(d); Part 15.209 / KDB558074 | **Air Temperature:** | 20.3ºC |
| | | **Relative Humidity:** | 48% |

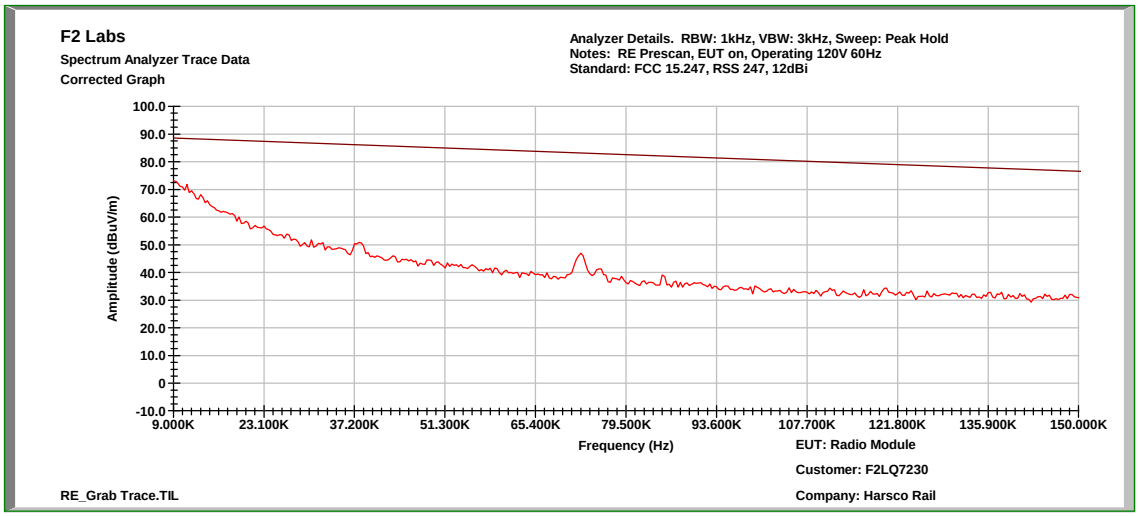
Notes: Plots are peak, max hold prescan data included only to determine what frequencies to investigate and measure. The EUT was initially placed in a semi-anechoic chamber, and rotated in all three orthogonal positions to maximize the emissions. Characterization measurements were then performed to determine at which frequencies significant emissions occurred. These graphs are shown below.

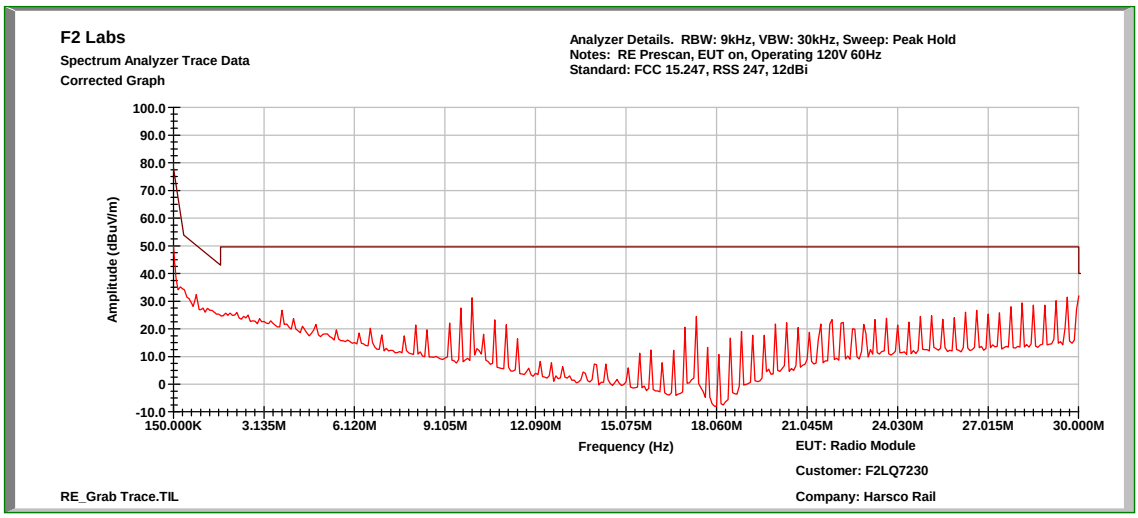
The equipment was fully exercised with all cabling attached to the EUT and was positioned on the OATS for maximum emissions. While the equipment was energized, the receiving antenna was scanned from 1.0 meter to 4.0 meters in both vertical and horizontal polarities while the turntable was adjusted 360 degrees to determine the maximum field strength. The tables of measured results can be found below.

Some of the frequencies did not change with the EUT on or off. At those frequencies, the test distance was shortened to 1 meter and still no emissions from the EUT were visible or over the ambient or limit.

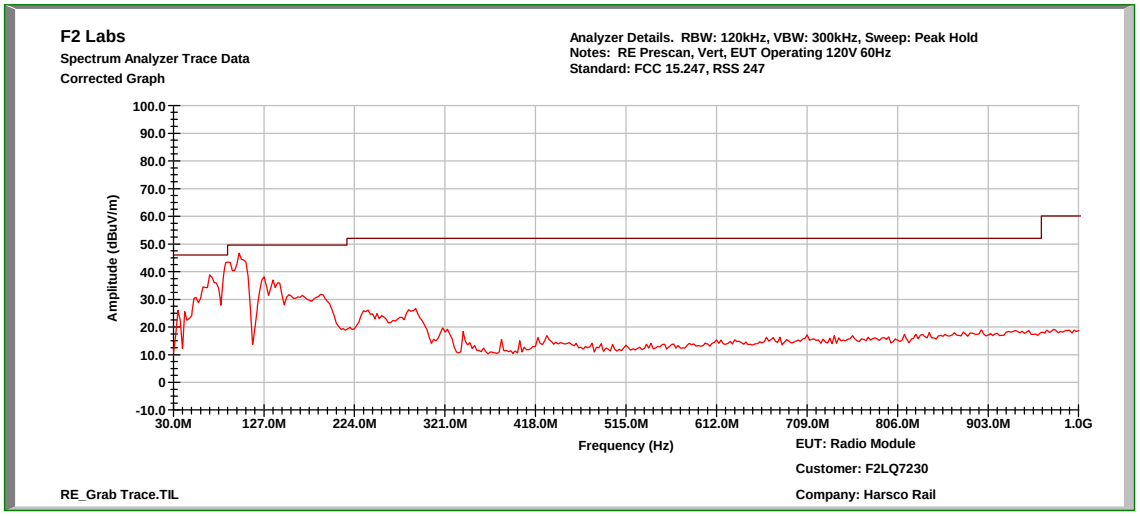
In the following plots, the black line indicates ambient noise and the red line indicates the measurement with the EUT on. Emissions to be found by the EUT were measured and listed in tables. The plots are for reference only and the limit lines are not actual limit lines but merely a guide.

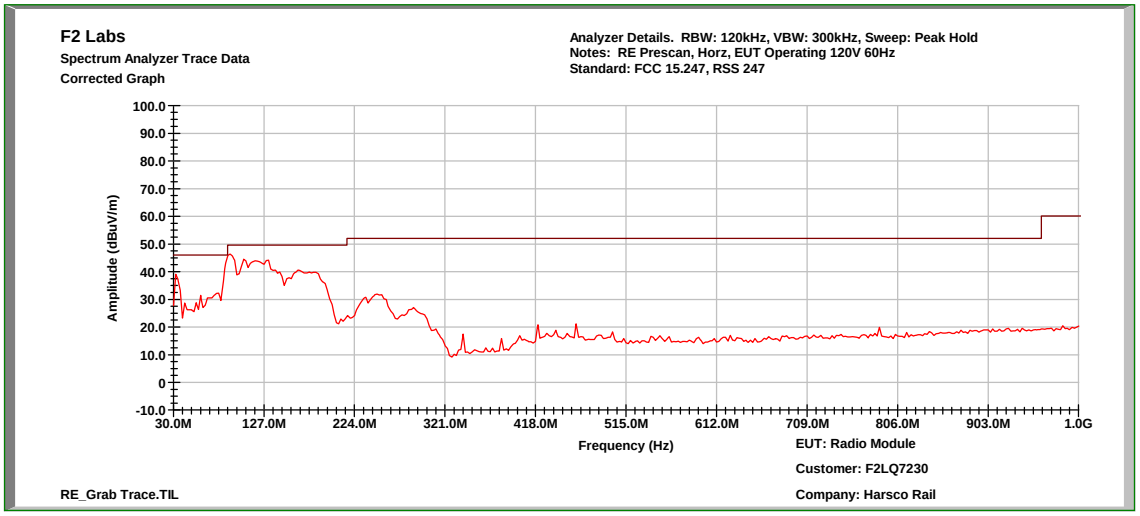
## Radiated Spurious Emission with 12dBi Whip Antenna



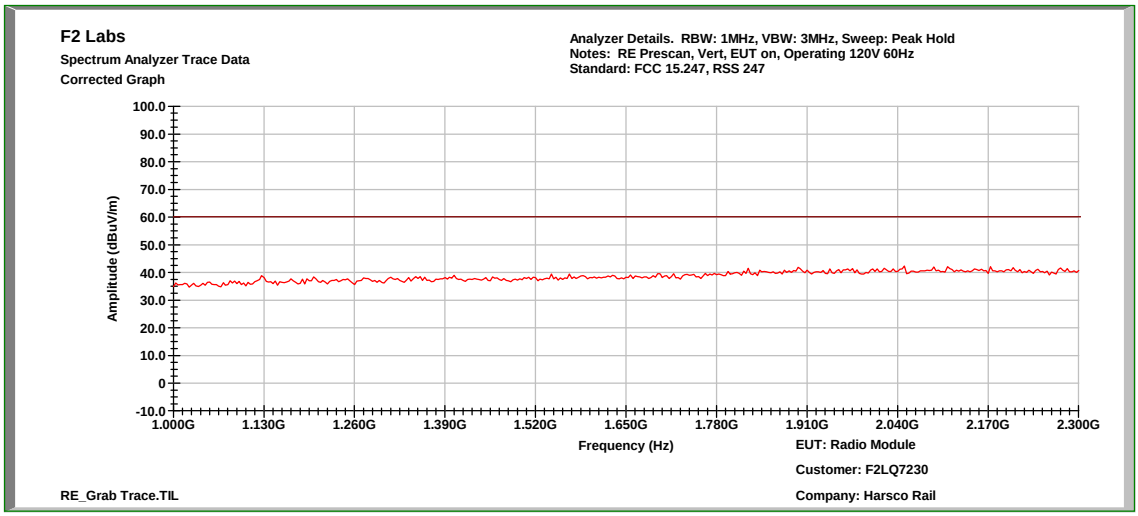



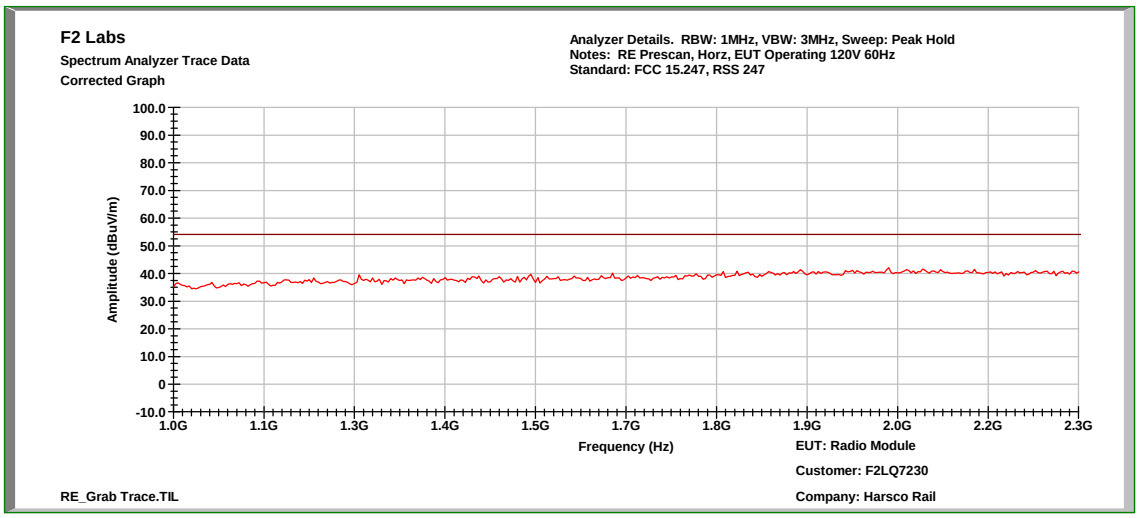
## Radiated Spurious Emission with 12dBi Whip Antenna, cont'd



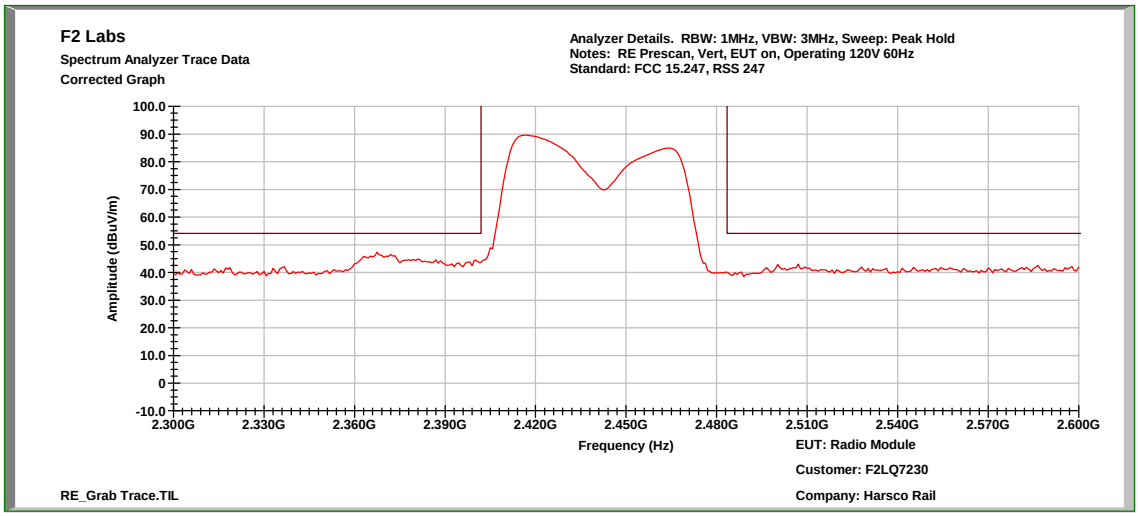



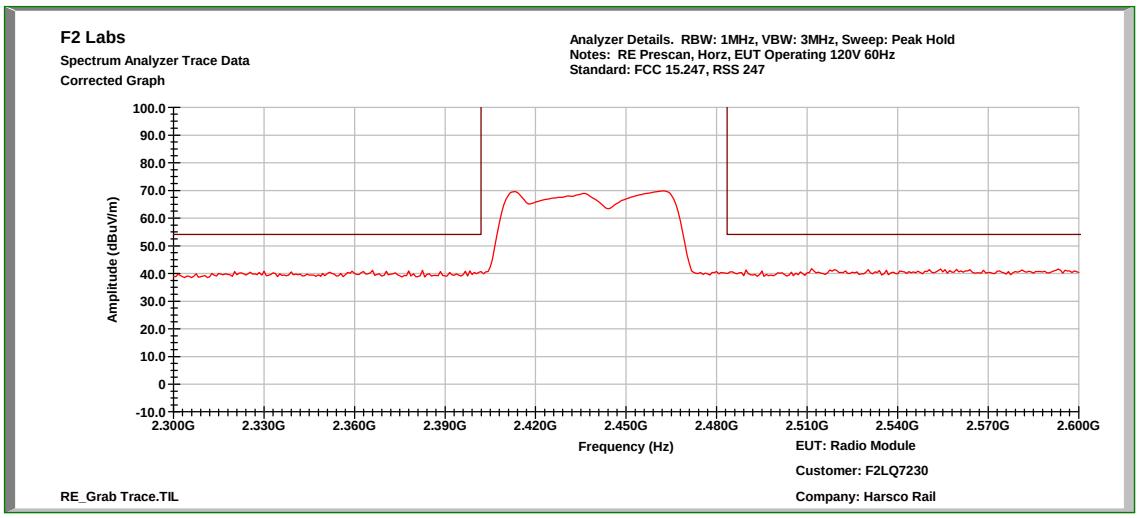
## Radiated Spurious Emission with 12dBi Whip Antenna, cont'd



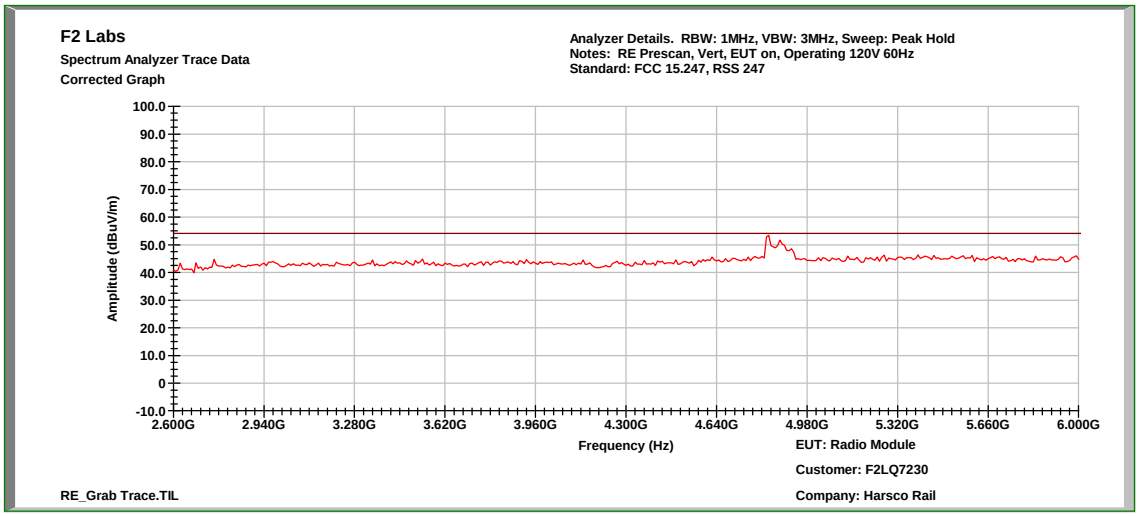



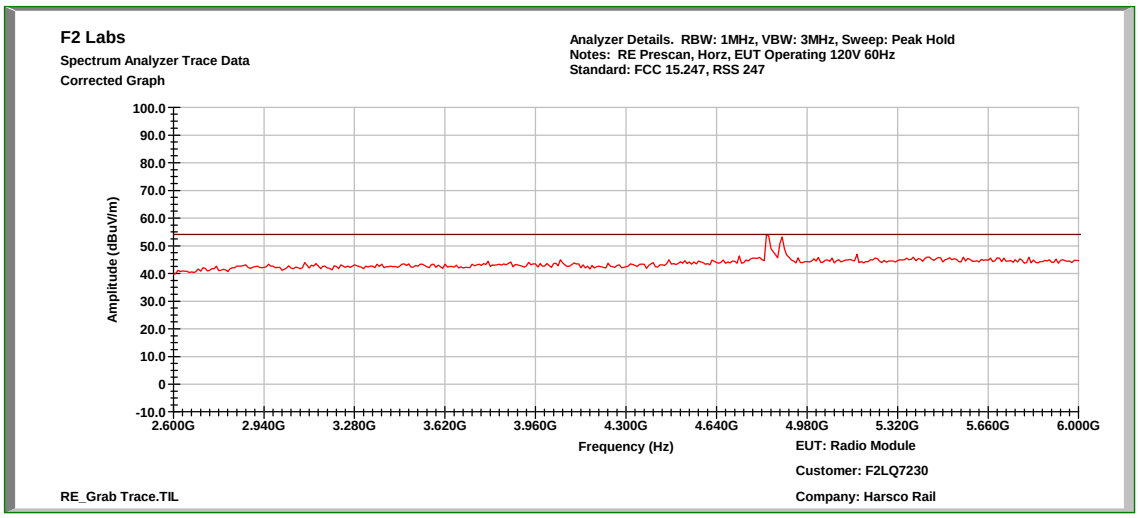
## Radiated Spurious Emission with 12dBi Whip Antenna, cont'd



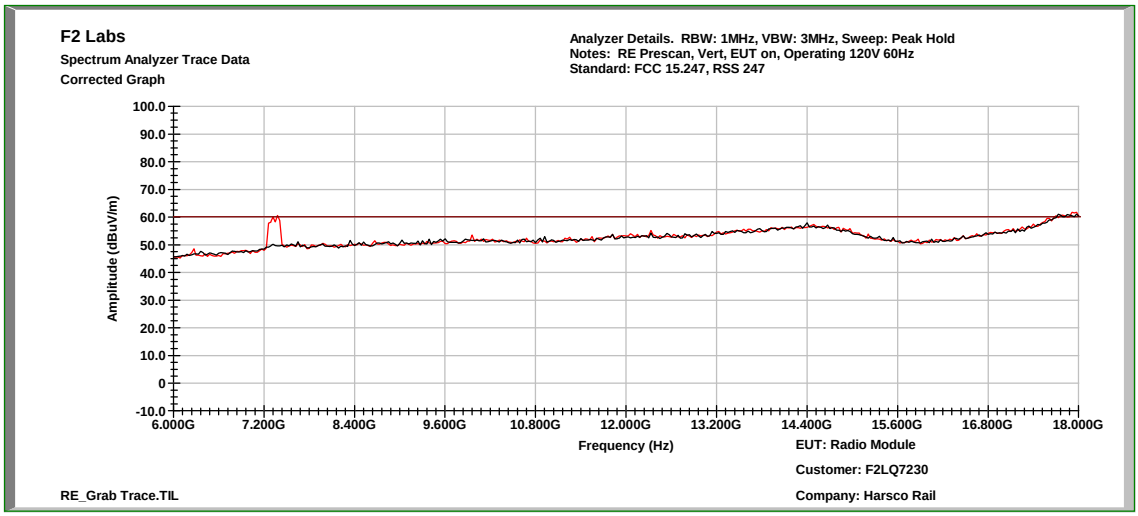



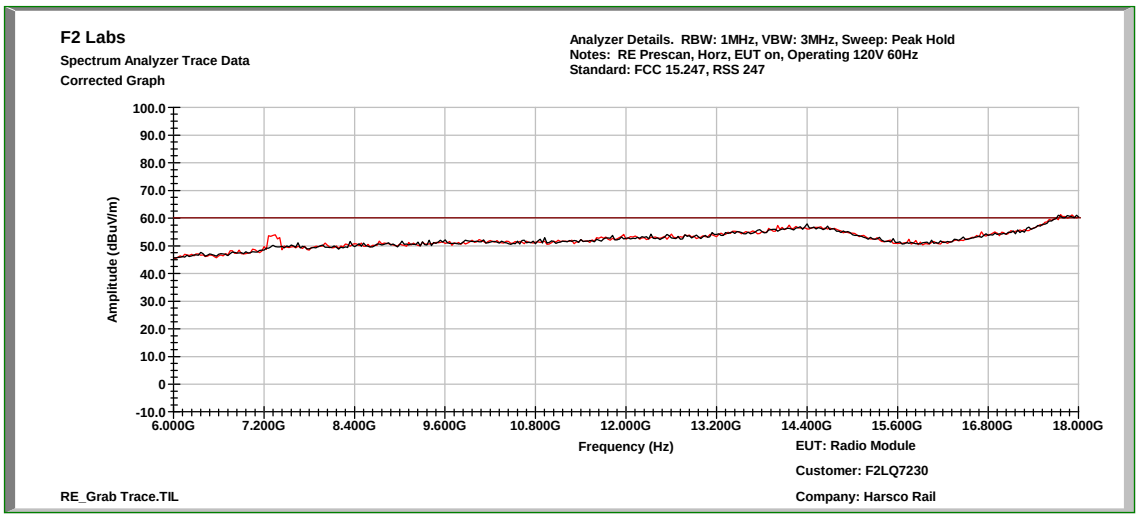
## Radiated Spurious Emission with 12dBi Whip Antenna, cont'd



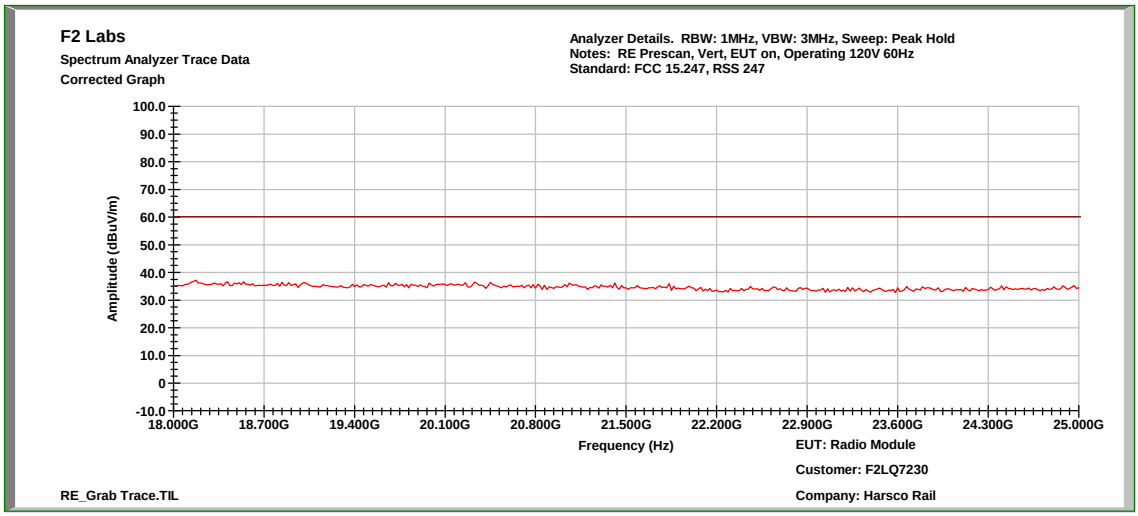



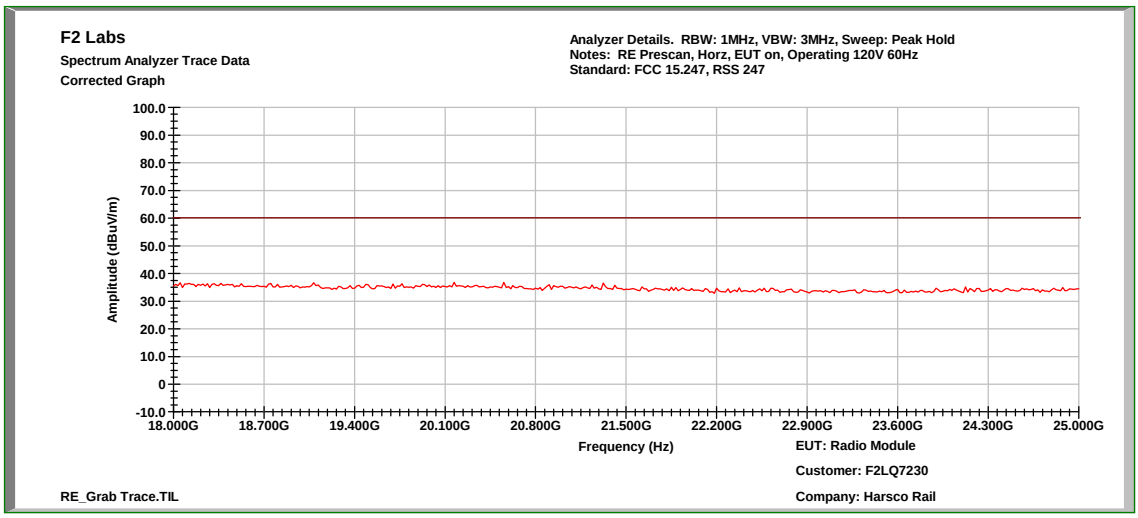
## Radiated Spurious Emission with 12dBi Whip Antenna, cont'd



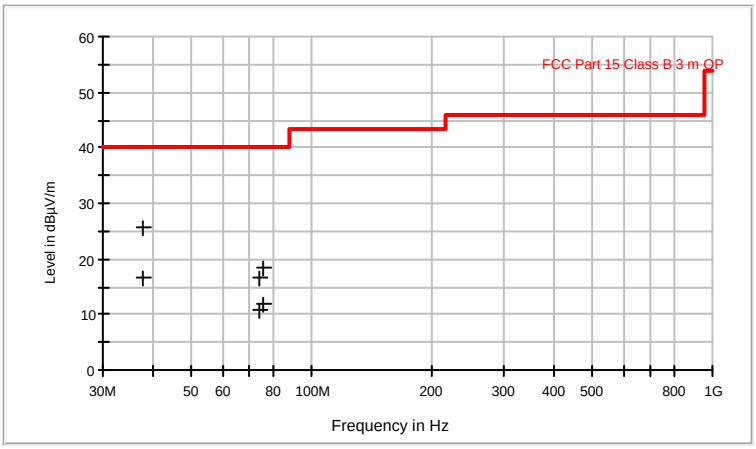
## Radiated Spurious Emission with 12dBi Whip Antenna, cont'd



## 12dBi Antenna, 30 MHz to 1 GHz, QuasiPeak

| Frequency (MHz) | Antenna Polarization | Reading (dBµV) | Cable Loss & Antenna Factor (dB) | Emission (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 37.728000 | V | 10.1 | 15.7 | 25.80 | 40.0 | -14.2 |
| 37.728000 | H | -0.5 | 17.1 | 16.60 | 40.0 | -23.4 |
| 73.958000 | V | 7.8 | 8.9 | 16.70 | 40.0 | -23.3 |
| 73.958000 | H | 1.1 | 9.9 | 11.00 | 40.0 | -29.0 |
| 75.066000 | V | 9.8 | 8.8 | 18.60 | 40.0 | -21.4 |
| 75.066000 | H | 2.0 | 9.8 | 11.80 | 40.0 | -28.2 |

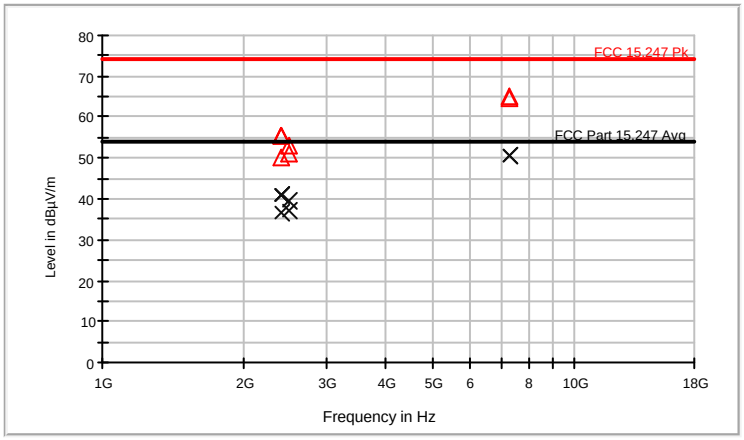


## 12dBi Antenna, 1 GHz to 18 GHz, MaxPeak

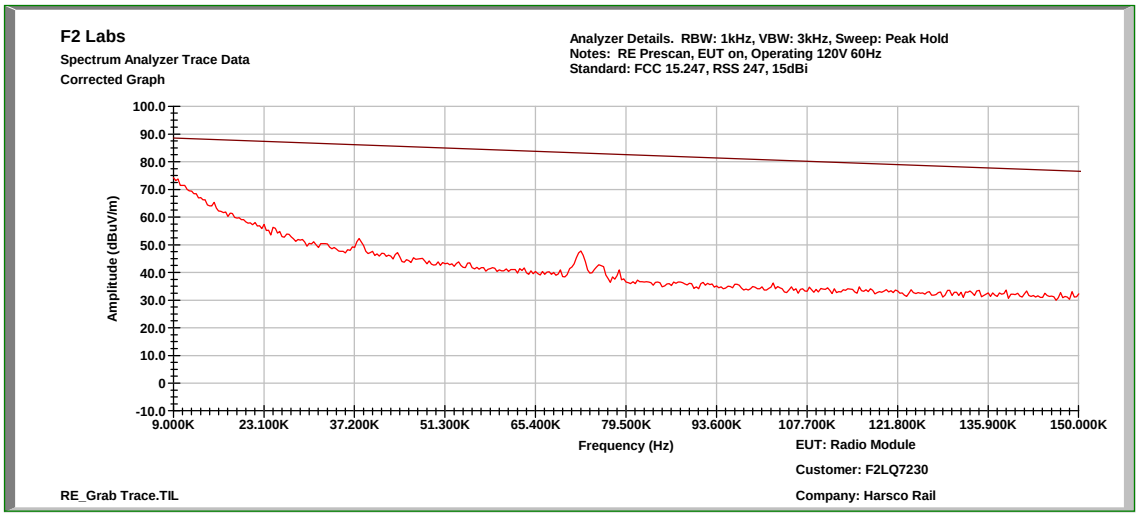
| Frequency (MHz) | Antenna Polarization | Reading (dBµV) | Cable Loss & Antenna Factor (dB) | Emission (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2390.000000 | V | 44.3 | 11.2 | 55.50 | 74.0 | -18.5 |
| 2390.000000 | V | 44.3 | 11.2 | 55.50 | 74.0 | -18.5 |
| 2390.000000 | V | 44.3 | 11.2 | 55.50 | 74.0 | -18.5 |
| 2390.000000 | H | 38.8 | 11.2 | 50.00 | 74.0 | -24.0 |
| 2483.500000 | V | 41.3 | 11.5 | 52.80 | 74.0 | -21.2 |
| 2483.500000 | H | 39.5 | 11.5 | 51.00 | 74.0 | -23.0 |
| 7320.000000 | H | 41.3 | 23.2 | 64.50 | 74.0 | -9.5 |
| 7320.000000 | V | 41.8 | 23.2 | 65.00 | 74.0 | -9.0 |

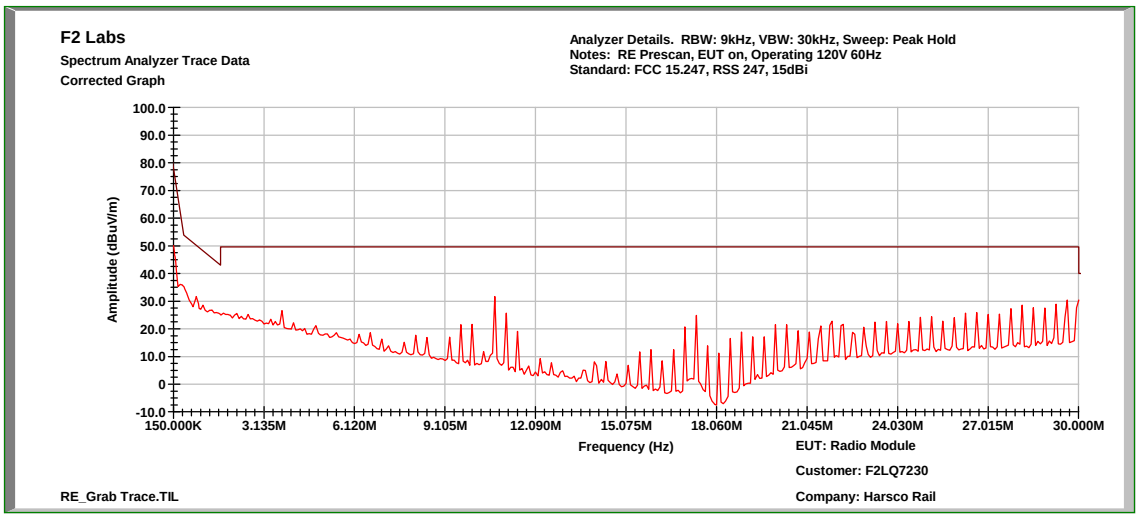
## 12dBi Antenna, 1 GHz to 18 GHz, Average

| Frequency (MHz) | Antenna Polarization | Reading (dBµV) | Cable Loss & Antenna Factor (dB) | Emission (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2390.000000 | V | 29.9 | 11.2 | 41.10 | 54.0 | -12.9 |
| 2390.000000 | V | 29.9 | 11.2 | 41.10 | 54.0 | -12.9 |
| 2390.000000 | V | 29.9 | 11.2 | 41.10 | 54.0 | -12.9 |
| 2390.000000 | H | 25.3 | 11.2 | 36.50 | 54.0 | -17.5 |
| 2483.500000 | V | 27.8 | 11.5 | 39.30 | 54.0 | -14.7 |
| 2483.500000 | H | 25.4 | 11.5 | 36.90 | 54.0 | -17.1 |
| 7320.000000 | H | 27.5 | 23.2 | 50.70 | 54.0 | -3.3 |
| 7320.000000 | V | 27.5 | 23.2 | 50.70 | 54.0 | -3.3 |

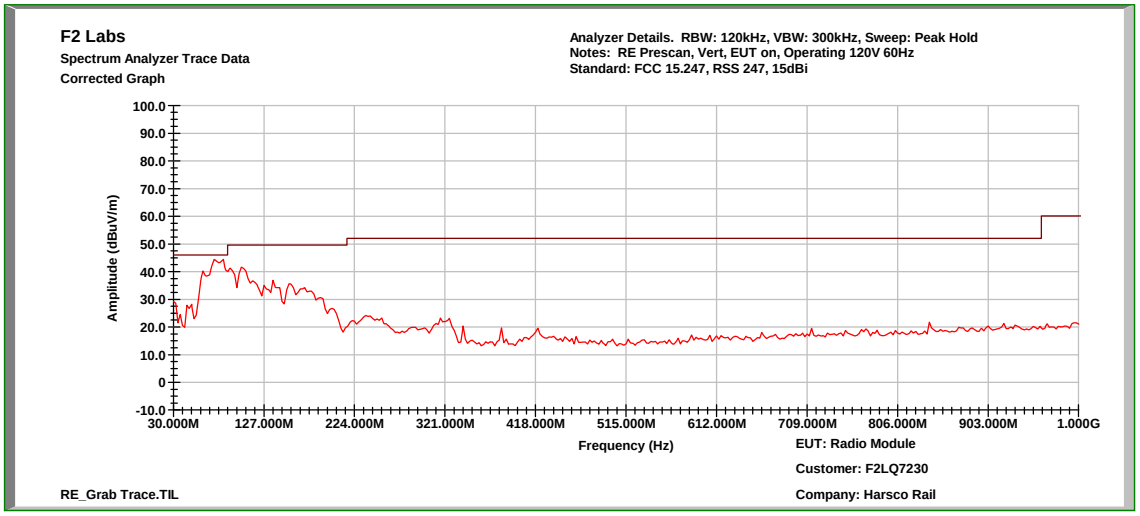


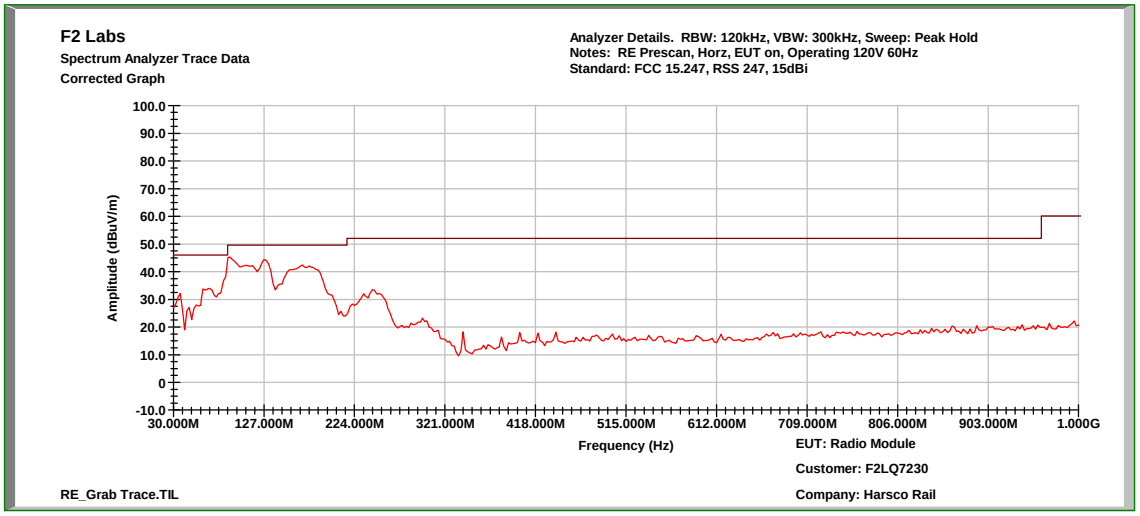
## Radiated Spurious Emission with 15dBi Whip Antenna



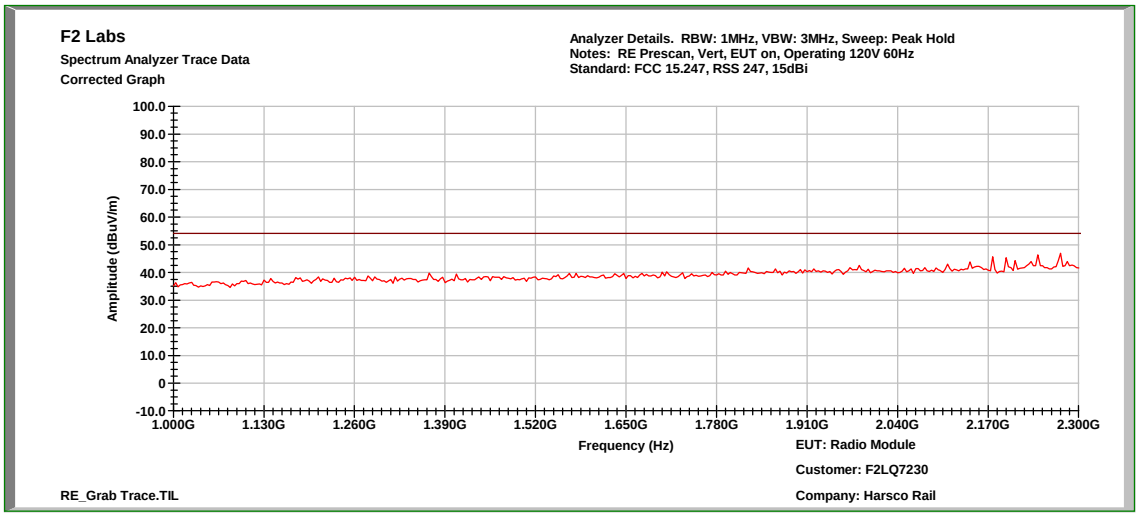



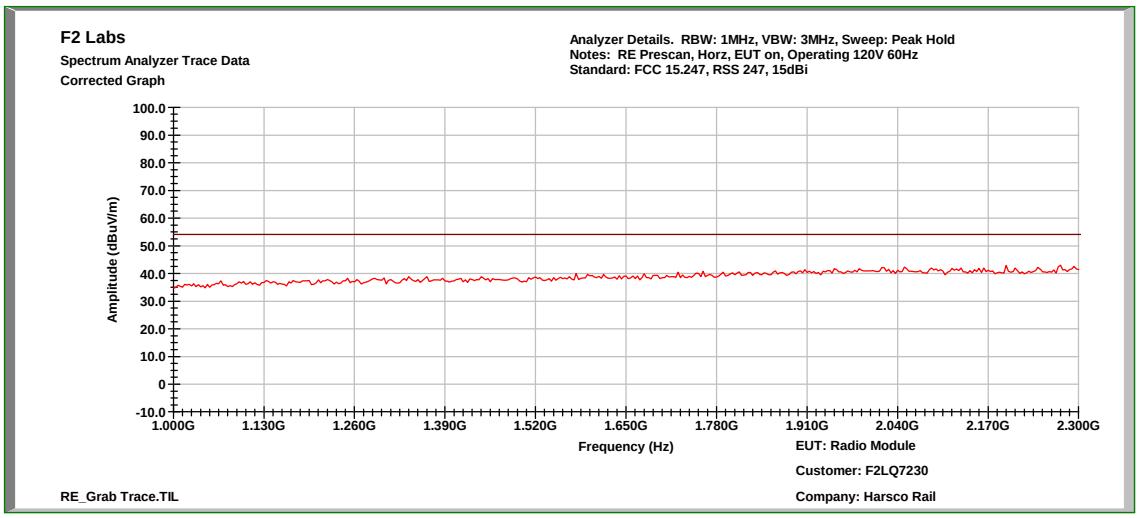
## Radiated Spurious Emission with 15dBi Whip Antenna, cont'd



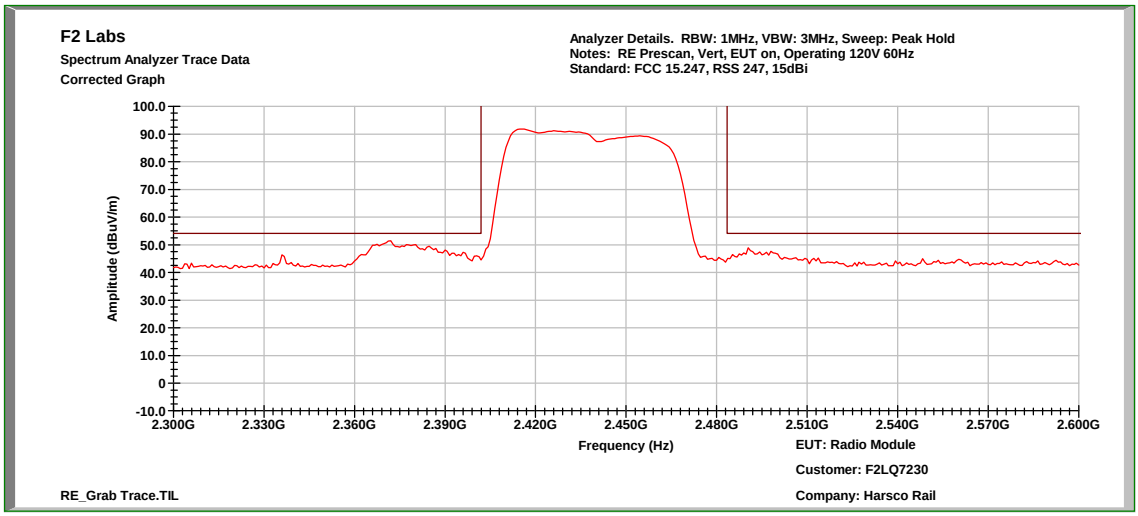



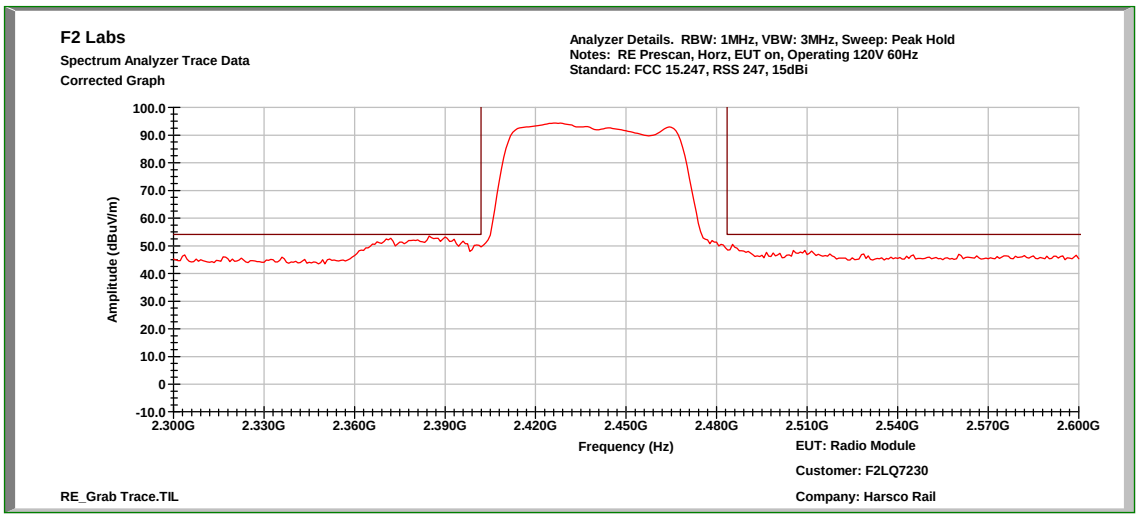
## Radiated Spurious Emission with 15dBi Whip Antenna, cont'd



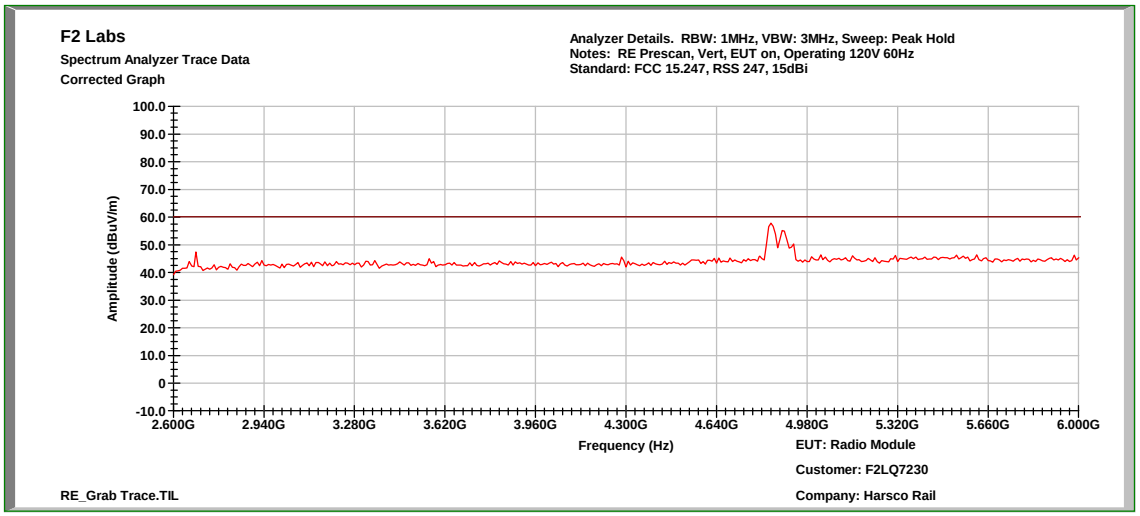



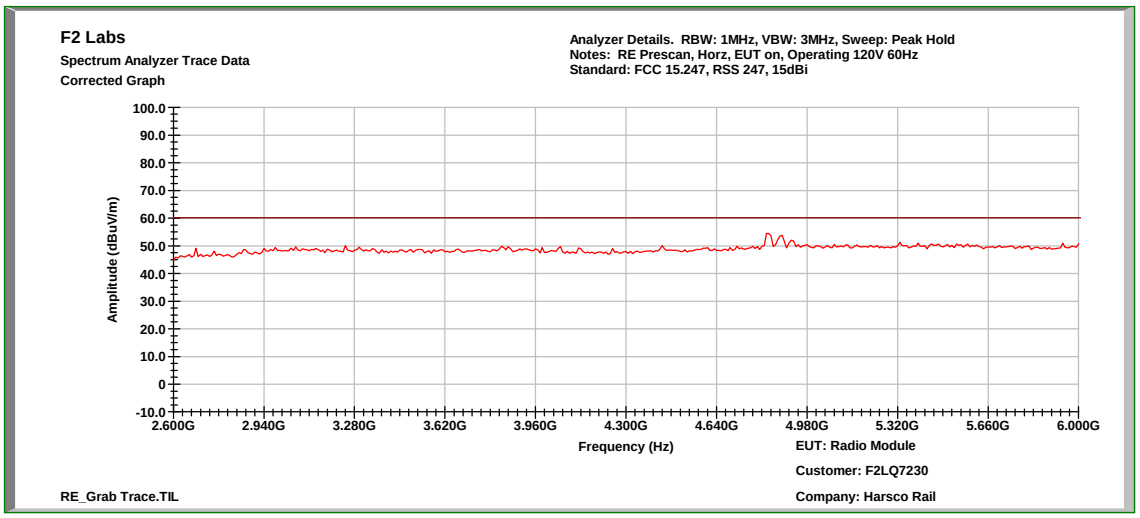
## Radiated Spurious Emission with 15dBi Whip Antenna, cont'd



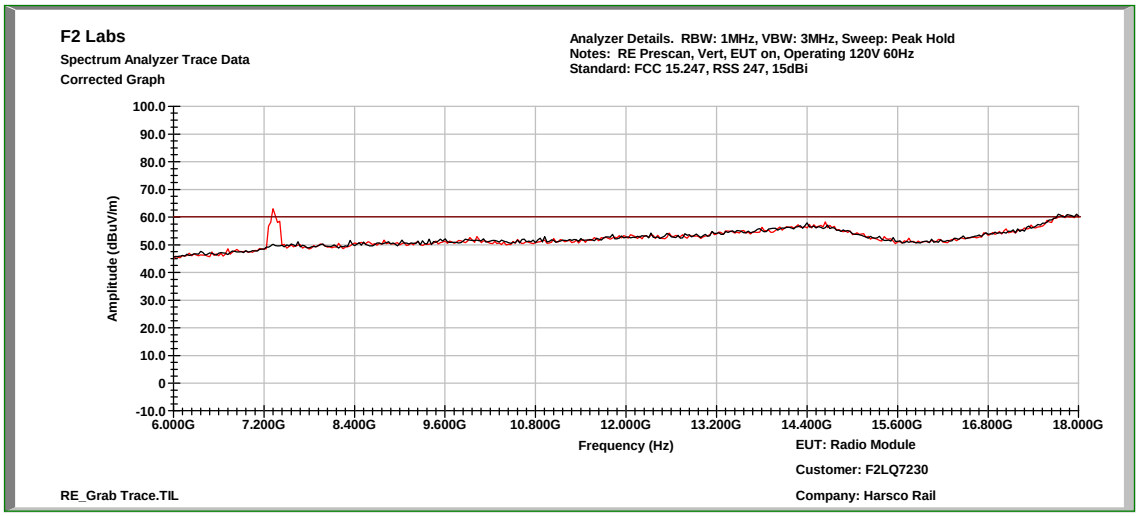



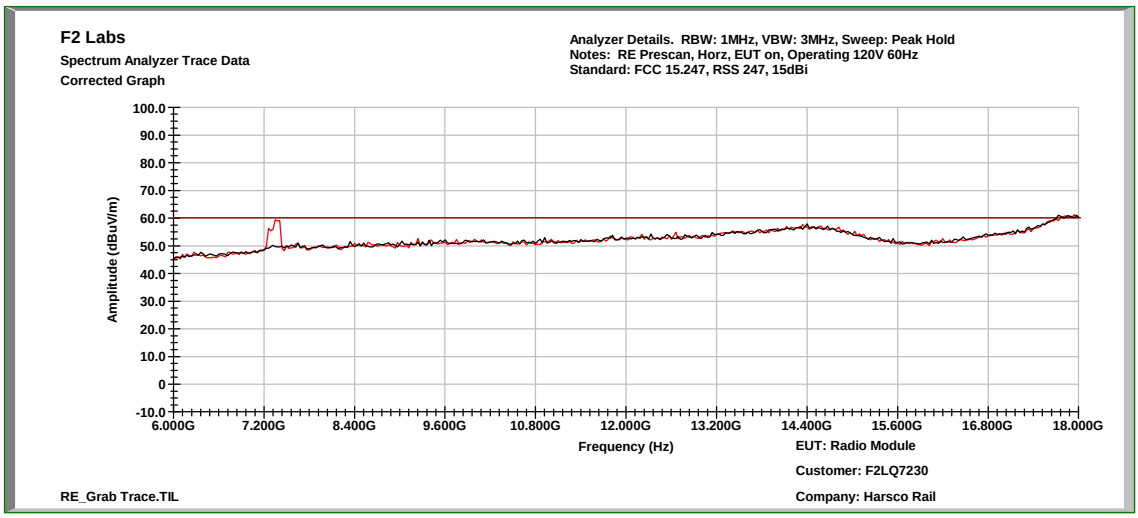
## Radiated Spurious Emission with 15dBi Whip Antenna, cont'd



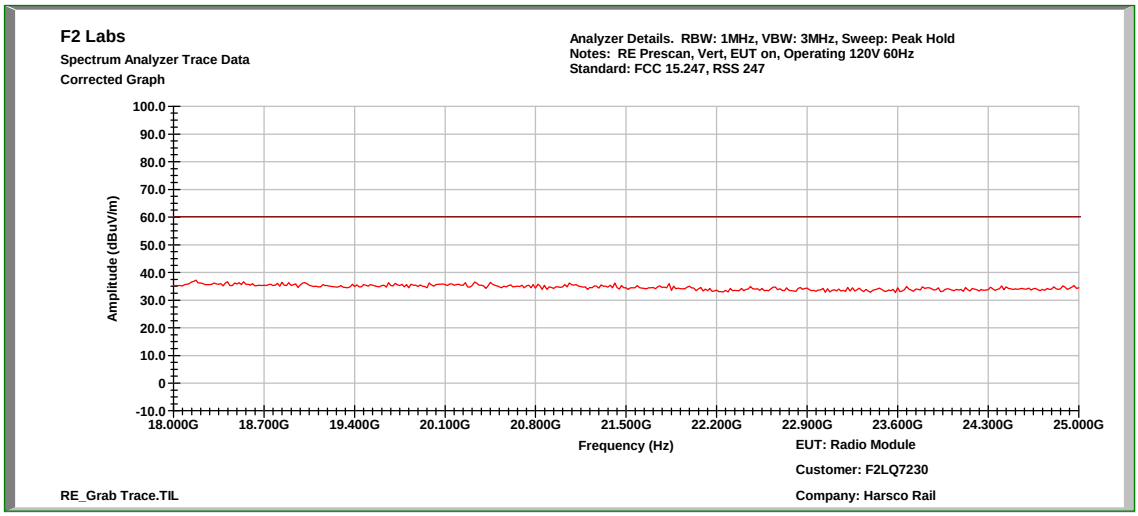



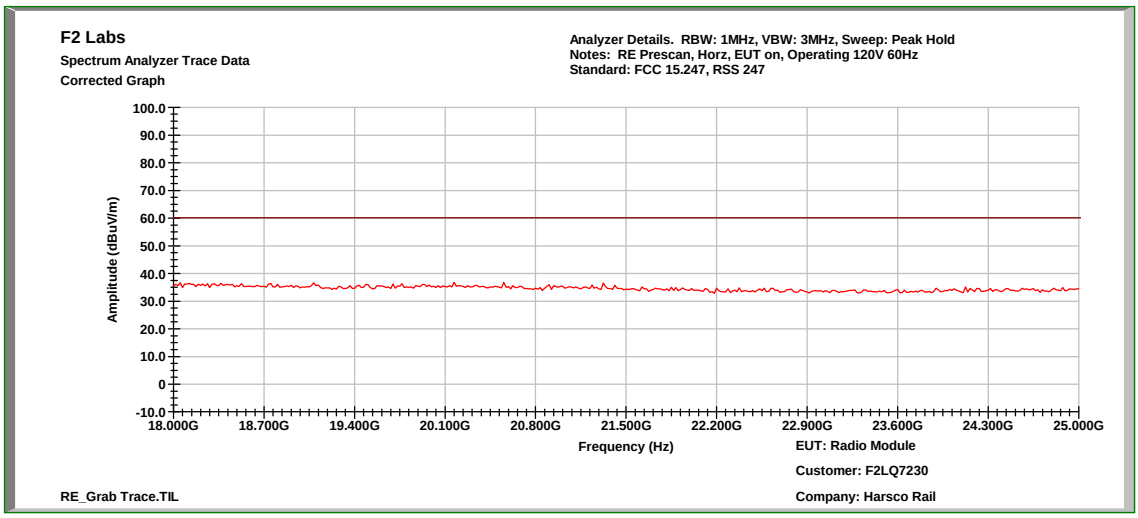
## Radiated Spurious Emission with 15dBi Whip Antenna, cont'd



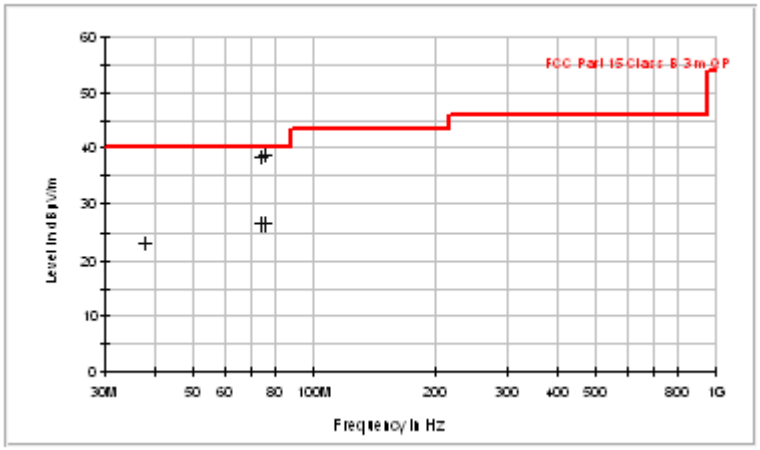
## Radiated Spurious Emission with 15dBi Whip Antenna, cont'd



## 15dBi Antenna, 30 MHz to 1 GHz, QuasiPeak

| Frequency (MHz) | Antenna Polarization | Reading (dBµV) | Cable Loss & Antenna Factor (dB) | Emission (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 37.732000 | V | 7.3 | 15.7 | 23.00 | 40.0 | -17.0 |
| 37.732000 | H | 7.4 | 15.7 | 23.10 | 40.0 | -16.9 |
| 74.000000 | V | 29.3 | 8.9 | 38.20 | 40.0 | -1.8 |
| 74.000000 | H | 17.6 | 8.9 | 26.50 | 40.0 | -13.5 |
| 75.110000 | V | 30.0 | 8.8 | 38.80 | 40.0 | -1.2 |
| 75.110000 | H | 17.4 | 8.8 | 26.20 | 40.0 | -13.8 |

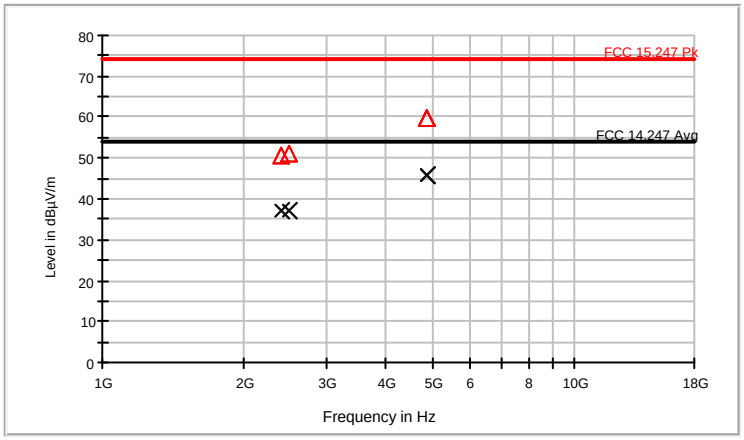


## 15dBi Antenna, 1 GHz to 18 GHz, MaxPeak

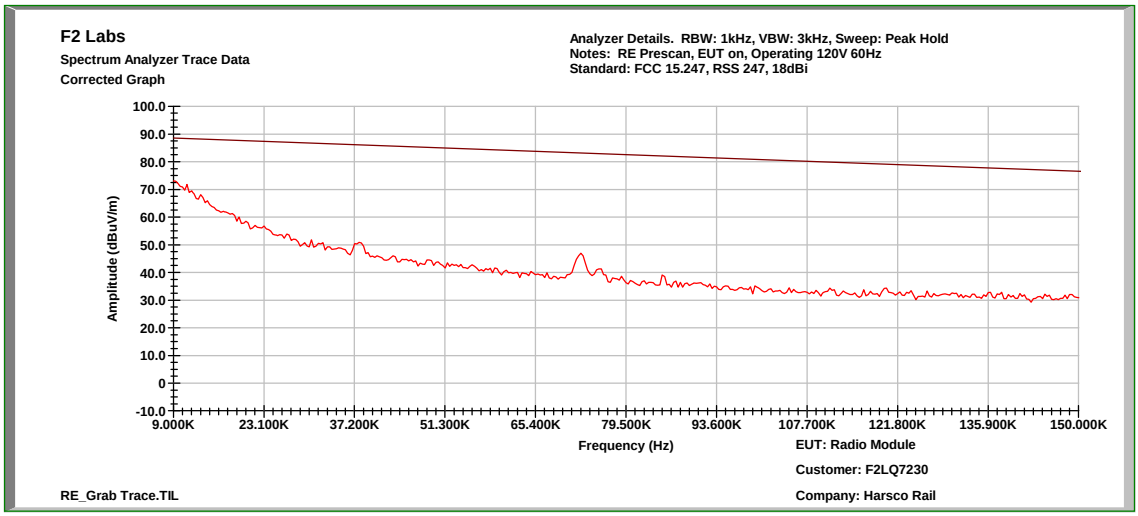
| Frequency (MHz) | Antenna Polarization | Reading (dBµV) | Cable Loss & Antenna Factor (dB) | Emission (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2390.000000 | H | 39.5 | 11.2 | 50.70 | 74.0 | -23.3 |
| 2390.000000 | V | 39.2 | 11.2 | 50.40 | 74.0 | -23.6 |
| 2483.500000 | H | 39.5 | 11.5 | 51.00 | 74.0 | -23.0 |
| 2483.500000 | V | 39.5 | 11.5 | 51.00 | 74.0 | -23.0 |
| 4880.000000 | H | 41.9 | 17.9 | 59.80 | 74.0 | -14.2 |
| 4880.000000 | H | 41.9 | 17.9 | 59.80 | 74.0 | -14.2 |
| 4880.000000 | V | 41.7 | 17.9 | 59.60 | 74.0 | -14.4 |
| 4880.000000 | H | 41.9 | 17.9 | 59.80 | 74.0 | -14.2 |

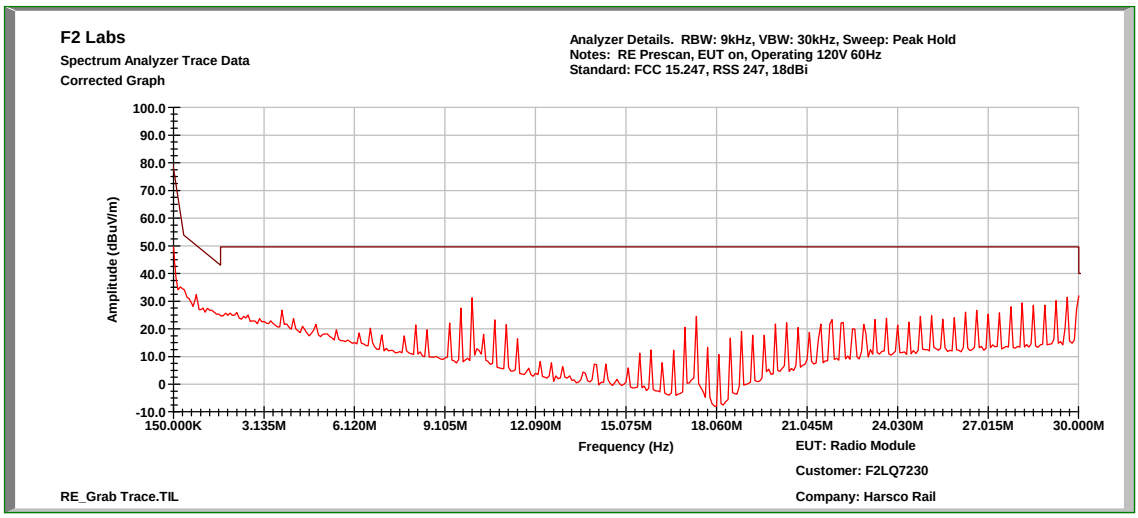
## 15dBi Antenna, >1 GHz to 18 GHz, Average

| Frequency (MHz) | Antenna Polarization | Reading (dBµV) | Cable Loss & Antenna Factor (dB) | Emission (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2390.000000 | H | 26.0 | 11.2 | 37.20 | 54.0 | -16.8 |
| 2390.000000 | V | 25.9 | 11.2 | 37.10 | 54.0 | -16.9 |
| 2483.500000 | H | 25.7 | 11.5 | 37.20 | 54.0 | -16.8 |
| 2483.500000 | V | 25.6 | 11.5 | 37.10 | 54.0 | -16.9 |
| 4880.000000 | H | 28.0 | 17.9 | 45.90 | 54.0 | -8.1 |
| 4880.000000 | H | 28.0 | 17.9 | 45.90 | 54.0 | -8.1 |
| 4880.000000 | V | 28.0 | 17.9 | 45.90 | 54.0 | -8.1 |
| 4880.000000 | H | 28.0 | 17.9 | 45.90 | 54.0 | -8.1 |

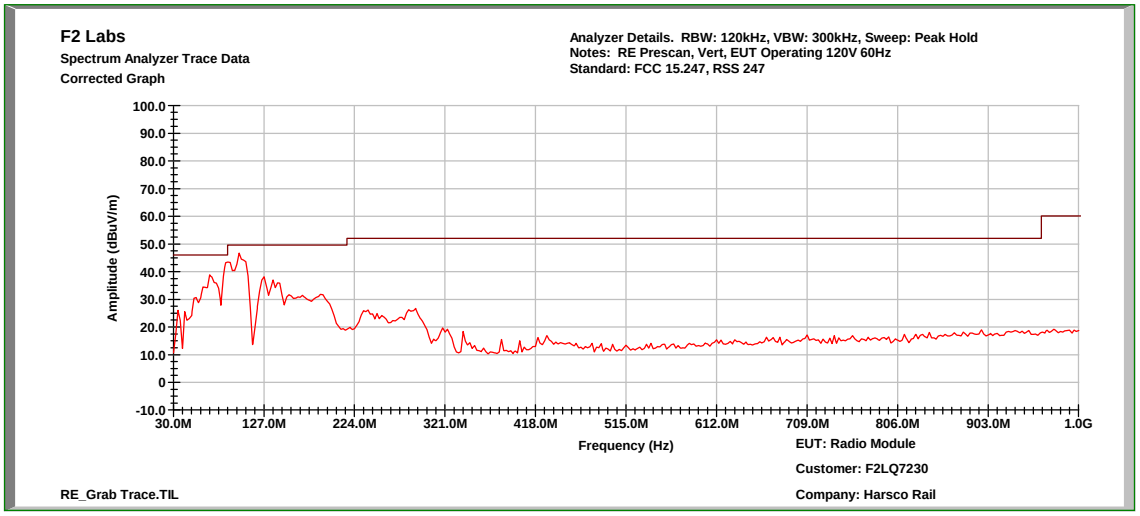


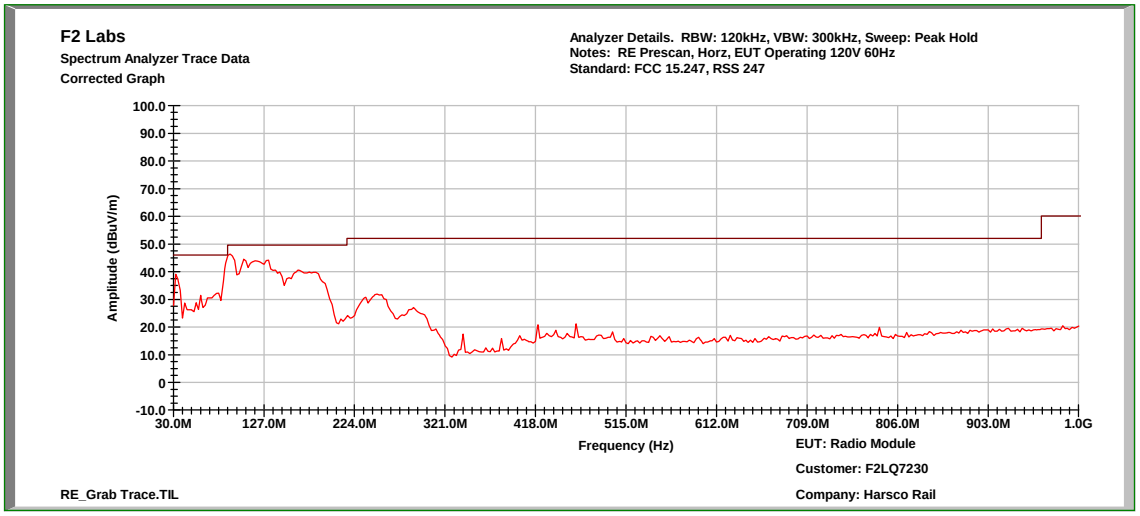
## Radiated Spurious Emission with 18dBi Whip Antenna



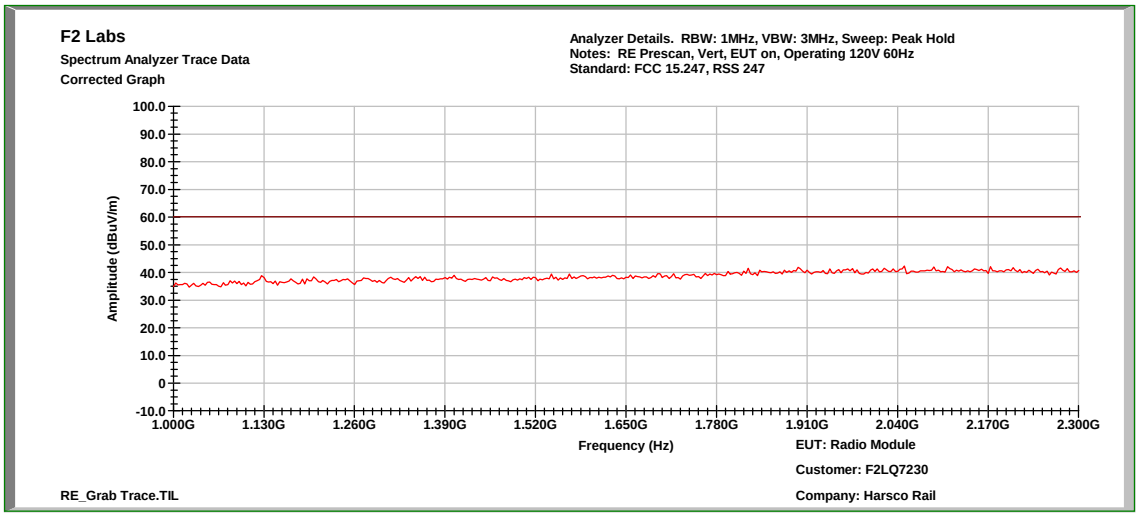



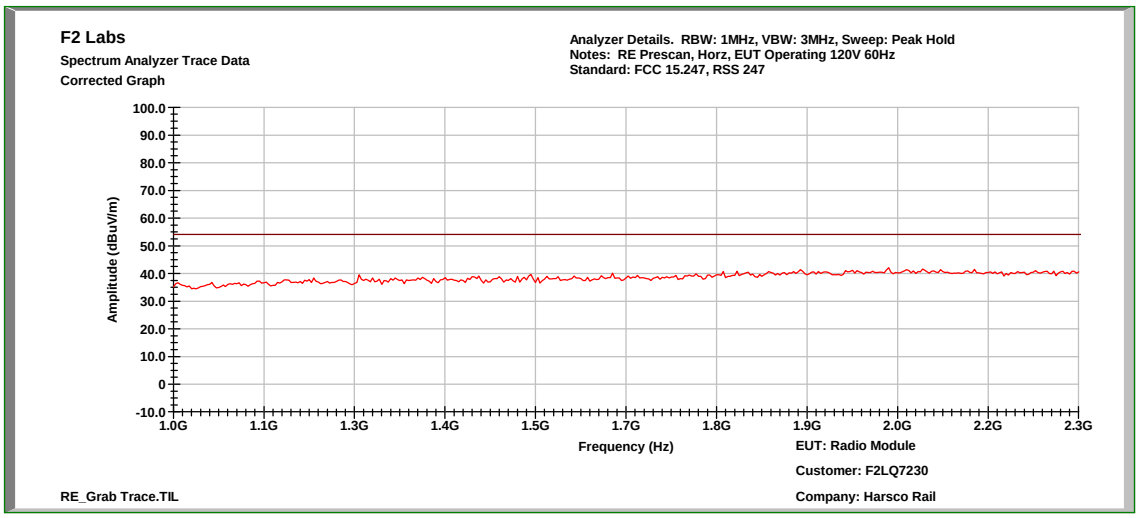
## Radiated Spurious Emission with 18dBi Whip Antenna, cont'd



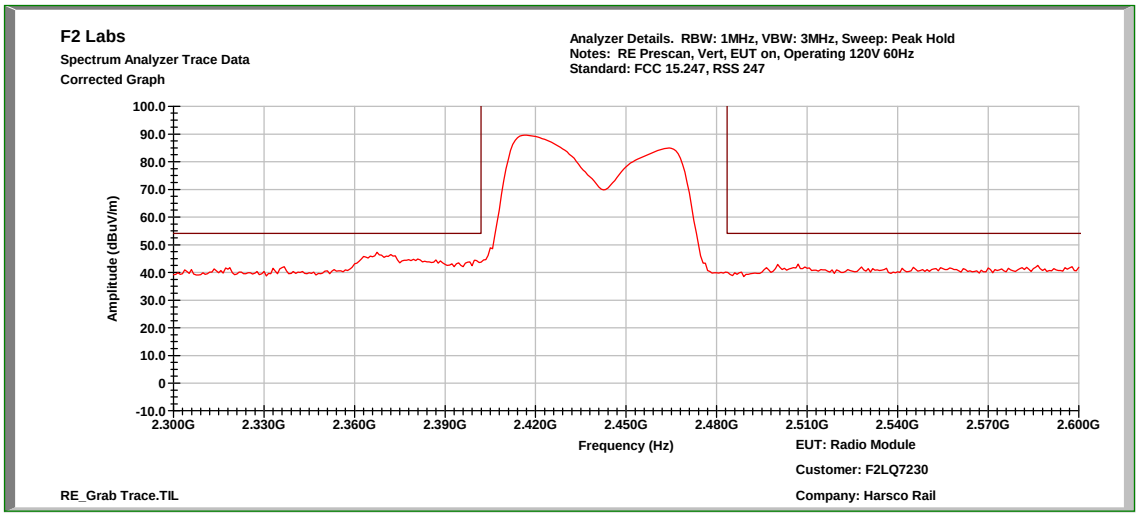



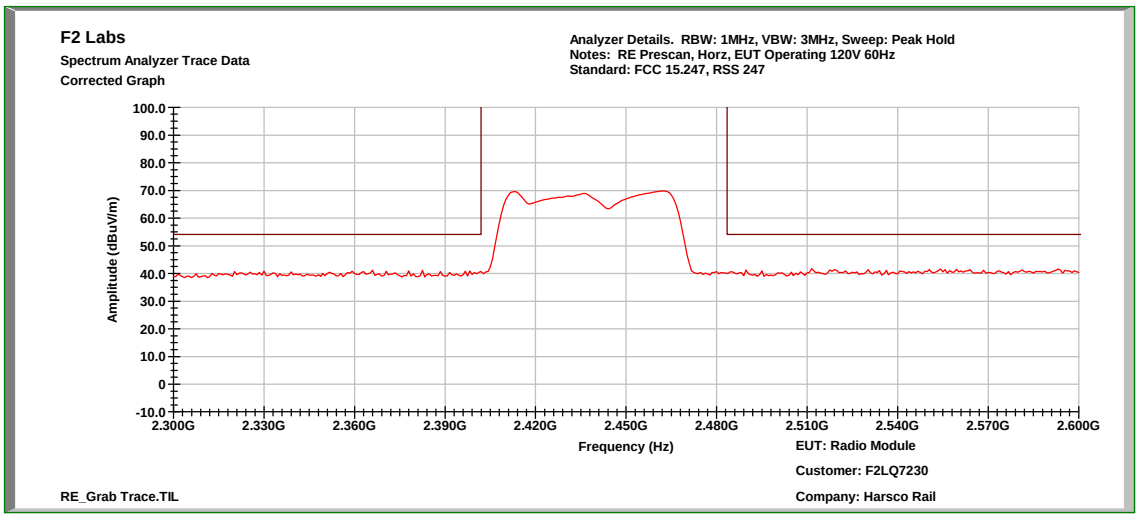
## Radiated Spurious Emission with 18dBi Whip Antenna, cont'd



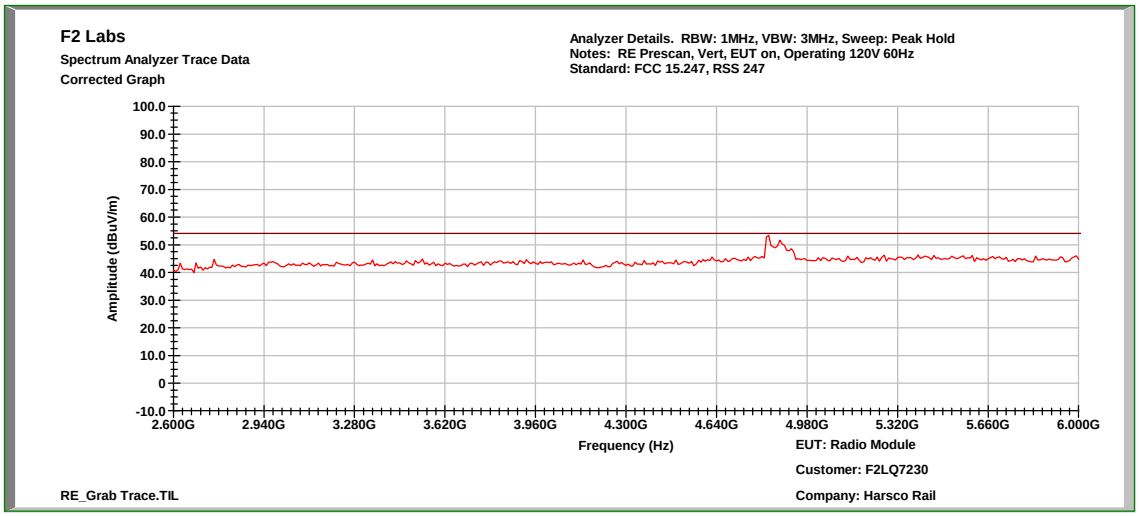



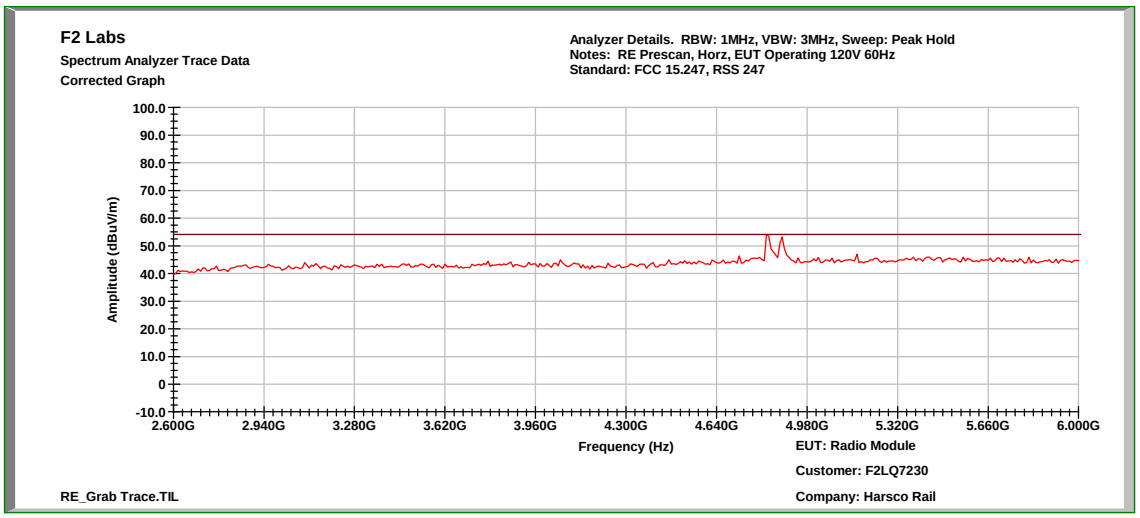
## Radiated Spurious Emission with 18dBi Whip Antenna, cont'd



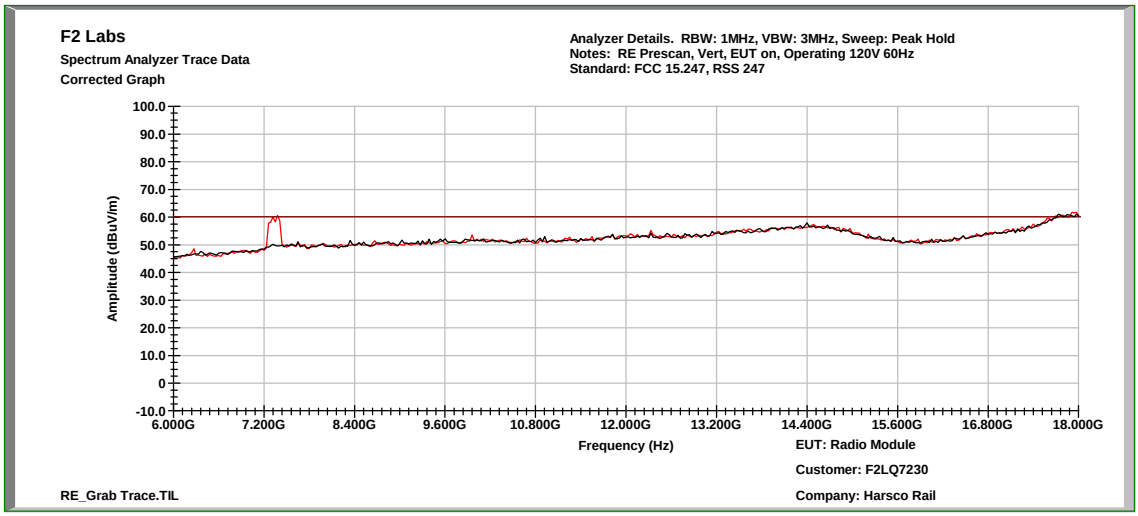



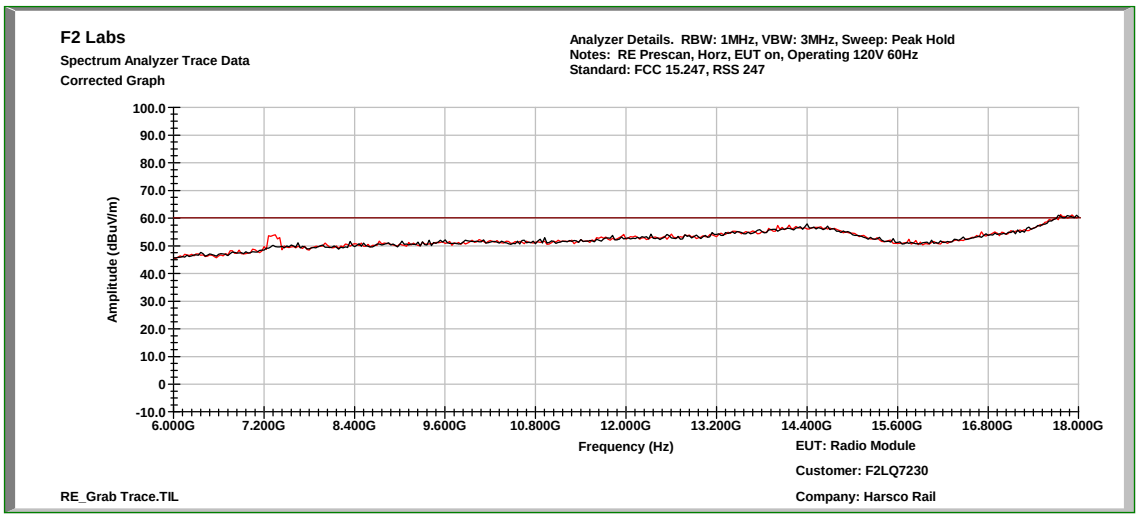
## Radiated Spurious Emission with 18dBi Whip Antenna, cont'd



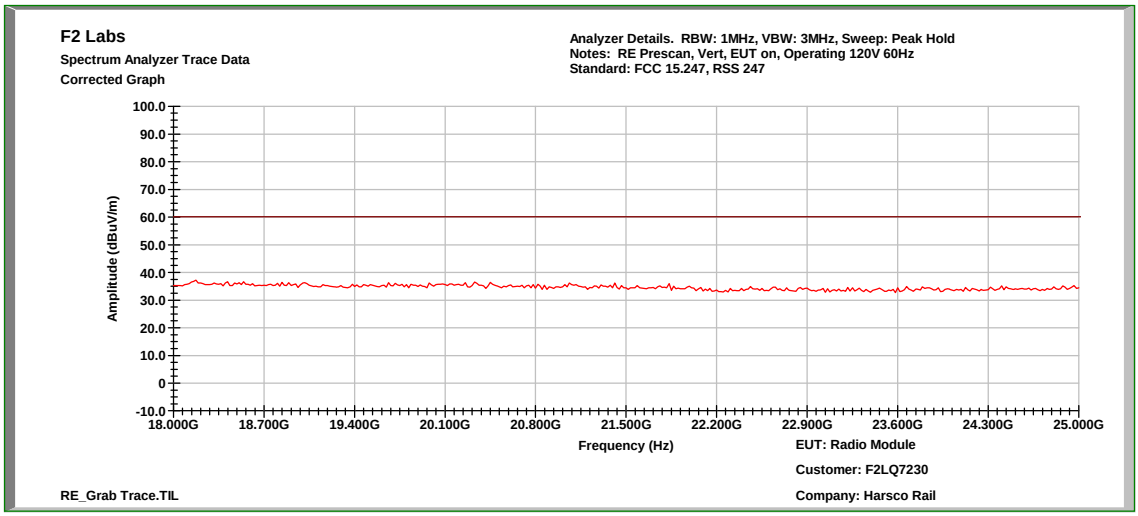



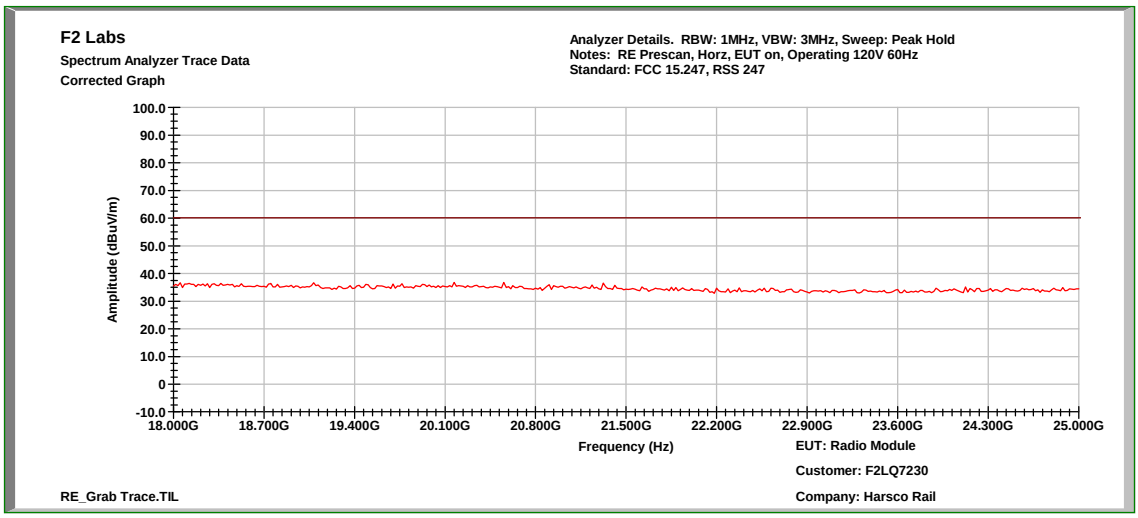
## Radiated Spurious Emission with 18dBi Whip Antenna, cont'd



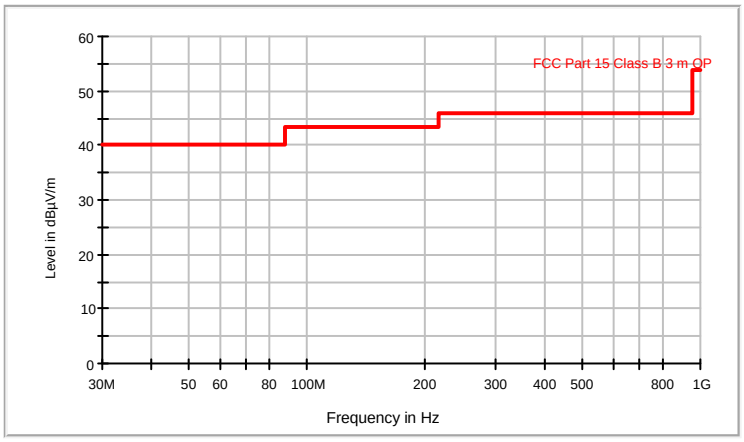
## Radiated Spurious Emission with 18dBi Whip Antenna, cont'd



## 18dBi Antenna, 30 MHz to 1 GHz, QuasiPeak

| Frequency (MHz) | Antenna Polarization | Reading (dBµV) | Cable Loss & Antenna Factor (dB) | Emission (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 37.500000 | V | 13.9 | 15.8 | 29.70 | 40.0 | -10.3 |
| 38.000000 | H | -2.2 | 16.9 | 14.70 | 40.0 | -25.3 |
| 74.000000 | V | 17.6 | 9.9 | 27.50 | 40.0 | -12.5 |
| 75.000000 | H | 21.4 | 8.8 | 30.20 | 40.0 | -9.8 |
| 120.000000 | V | 13.8 | 16.1 | 29.90 | 43.5 | -13.6 |
| 128.164000 | H | 14.1 | 16.7 | 30.80 | 43.5 | -12.7 |
| 136.312000 | H | 12.7 | 15.7 | 28.40 | 43.5 | -15.1 |
| 150.000000 | H | 0.8 | 15.0 | 15.80 | 43.5 | -27.7 |

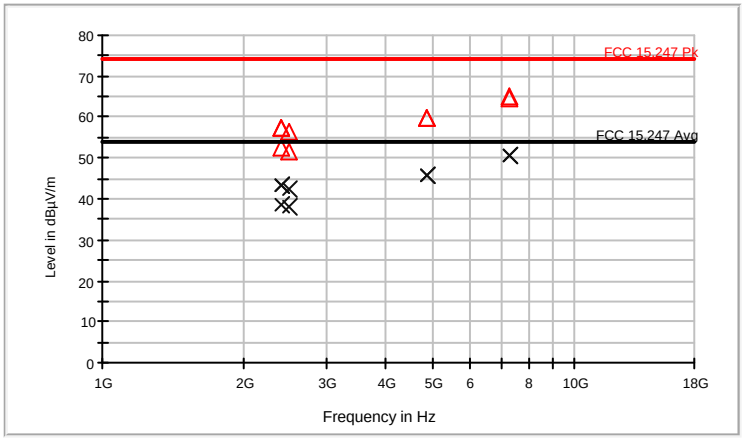


## 18dBi Antenna, 1 GHz to 18 GHz, MaxPeak

| Frequency (MHz) | Antenna Polarization | Reading (dBµV) | Cable Loss & Antenna Factor (dB) | Emission (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2390.000000 | V | 46.1 | 11.2 | 57.30 | 74.0 | -16.7 |
| 2390.000000 | V | 46.1 | 11.2 | 57.30 | 74.0 | -16.7 |
| 2390.000000 | H | 41.2 | 11.2 | 52.40 | 74.0 | -21.6 |
| 2483.500000 | V | 44.9 | 11.5 | 56.40 | 74.0 | -17.6 |
| 2483.500000 | H | 40.0 | 11.5 | 51.50 | 74.0 | -22.5 |
| 4880.000000 | V | 41.8 | 17.9 | 59.70 | 74.0 | -14.3 |
| 4880.000000 | H | 41.7 | 17.9 | 59.60 | 74.0 | -14.4 |
| 7320.000000 | H | 41.8 | 23.2 | 65.00 | 74.0 | -9.0 |
| 7320.000000 | V | 41.6 | 23.2 | 64.80 | 74.0 | -9.2 |

## 18dBi Antenna, >1 GHz to 18 GHz, Average

| Frequency (MHz) | Antenna Polarization | Reading (dBµV) | Cable Loss & Antenna Factor (dB) | Emission (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2390.000000 | V | 32.2 | 11.2 | 43.40 | 54.0 | -10.6 |
| 2390.000000 | V | 32.3 | 11.2 | 43.50 | 54.0 | -10.5 |
| 2390.000000 | H | 27.4 | 11.2 | 38.60 | 54.0 | -15.4 |
| 2483.500000 | V | 30.9 | 11.5 | 42.40 | 54.0 | -11.6 |
| 2483.500000 | H | 26.7 | 11.5 | 38.20 | 54.0 | -15.8 |
| 4880.000000 | V | 28.1 | 17.9 | 46.00 | 54.0 | -8.0 |
| 4880.000000 | H | 28.0 | 17.9 | 45.90 | 54.0 | -8.1 |
| 7320.000000 | H | 27.5 | 23.2 | 50.70 | 54.0 | -3.3 |
| 7320.000000 | V | 27.5 | 23.2 | 50.70 | 54.0 | -3.3 |



## 11 FCC PART 15.247 – PEAK POWER SPECTRAL DENSITY (PSD)

Peak power spectral density measurements were performed.

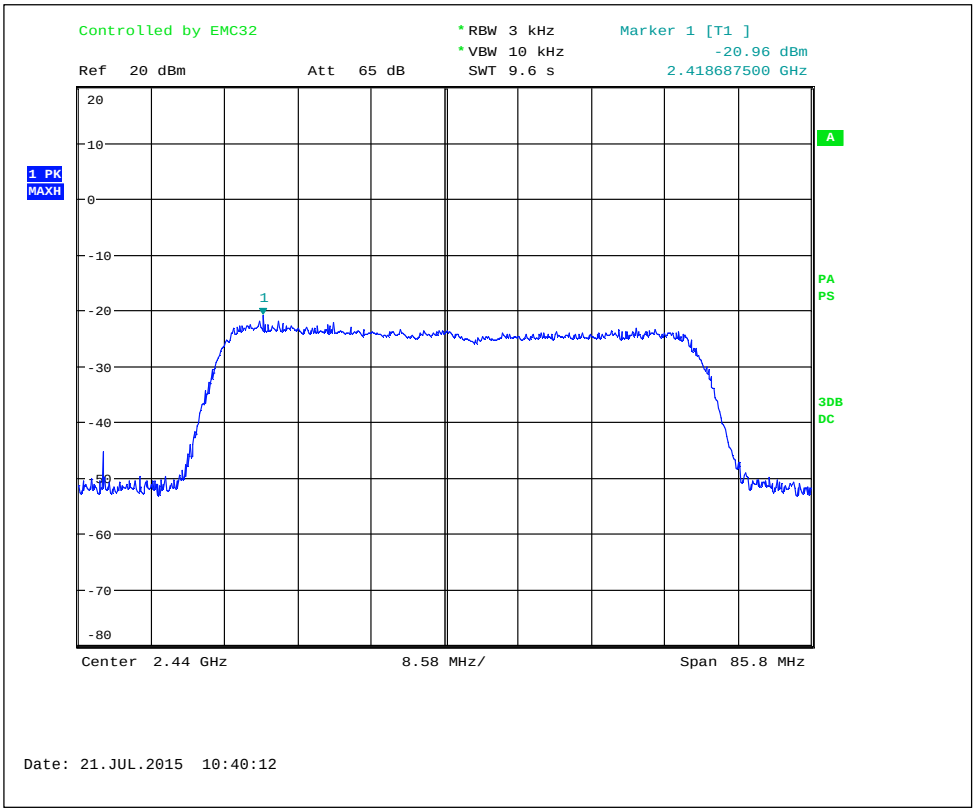
### 11.1 Requirements:

The peak power spectral density shall not exceed +8dBm in any 3 kHz band during any time interval of continuous transmission.

Power spectral density measurements were performed at a resolution bandwidth of 3 kHz (video bandwidth set at 10 KHz). The peak spectral densities were measured at 2.44 GHz.

## 11.2 Peak Power Spectral Density Test Data

| Test Date(s): | July 21, 2015 | Test Engineer: | J. Knepper |
|---|---|---|---|
| Standards: | CFR 47 Part 15.247; KDB558074 | Air Temperature: | 21.5ºC |
| | | Relative Humidity: | 43% |



## 12 FCC PART 15.31 – VOLTAGE VARIATIONS

The EUT was fitted with a SMA connector and was measured directly from the output of the radio.

The nominal voltage was varied by ±15% and the output power was measured to ensure that there was not an increase or shift of the fundamental frequency.

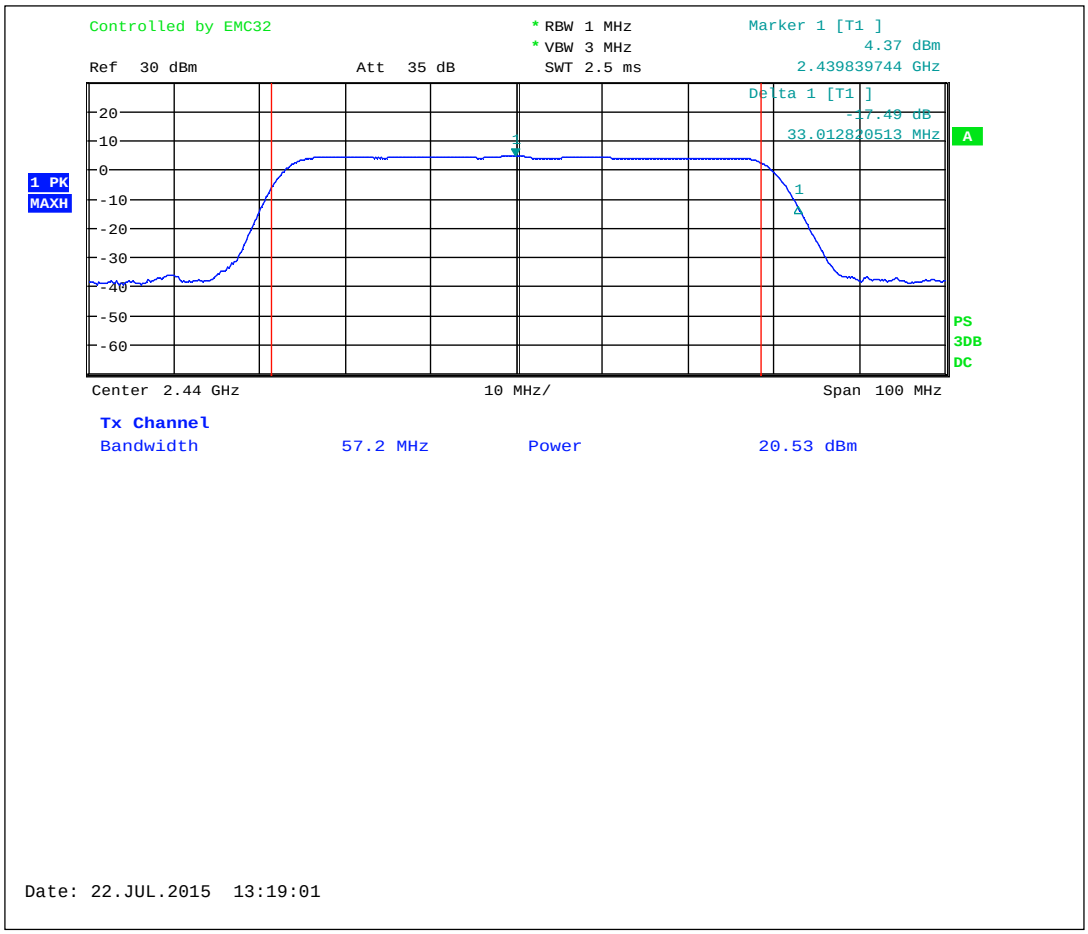
For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery. A nominal voltage of 120VAC was used and then 100VAC and 138VAC were used as the 85% and 115% variations.

**RESULTS:** The results showed that the fundamental frequency did not move outside the frequency band and the field strength did not increase above the limit during the variations.

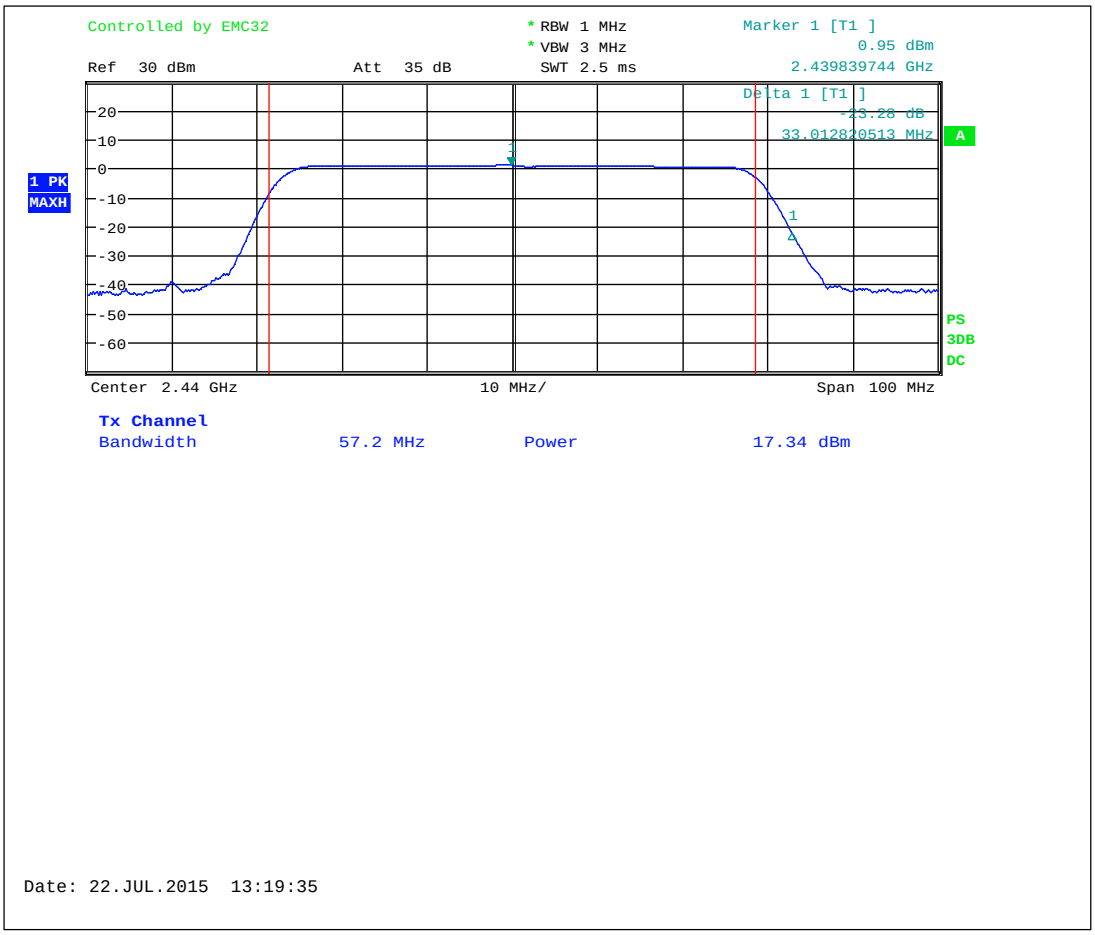
## 12.1 FCC PART 15.31 – VOLTAGE VARIATIONS

| | | | |
|---|---|---|---|
| **Test Date(s):** | July 22, 2015 | **Test Engineer:** | J. Knepper |
| **Standards:** | CFR 47 Part 15.247; KDB558074 | **Air Temperature:** | 21.2ºC |

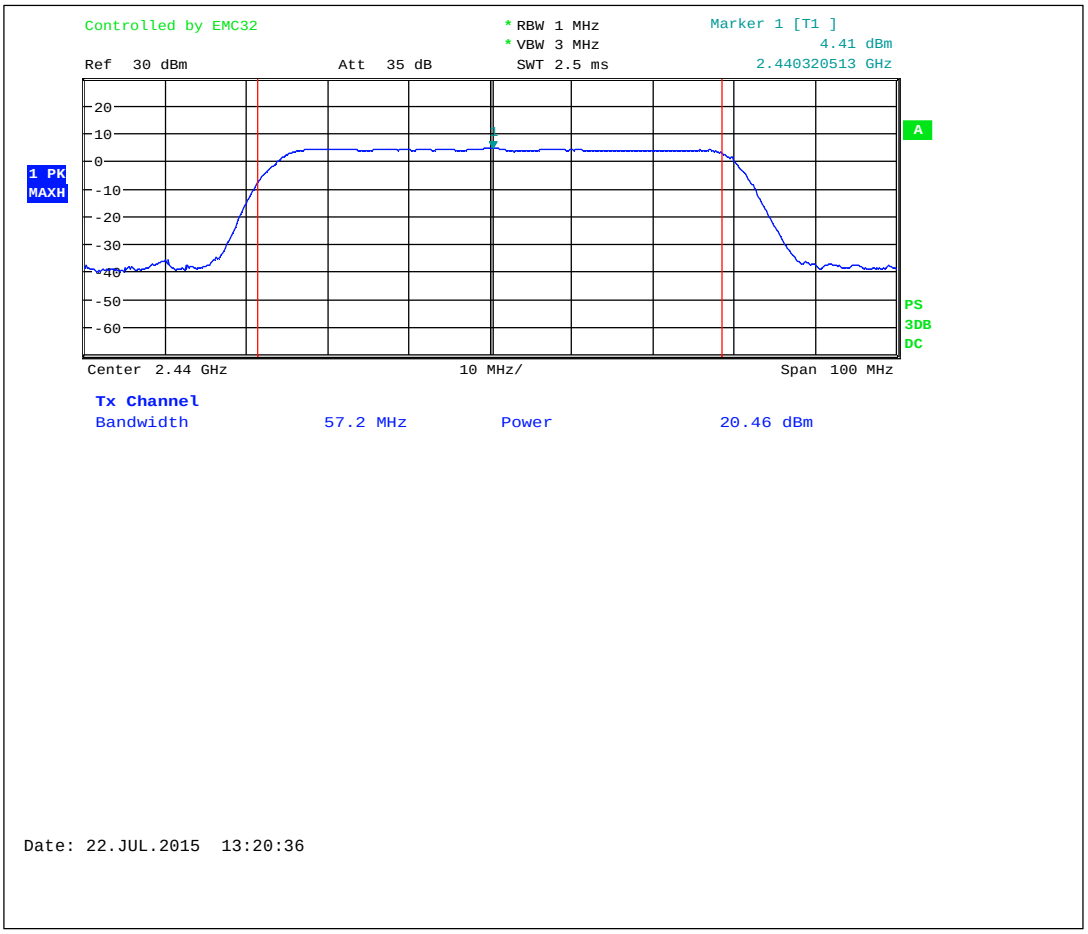
### Full Output, 100V



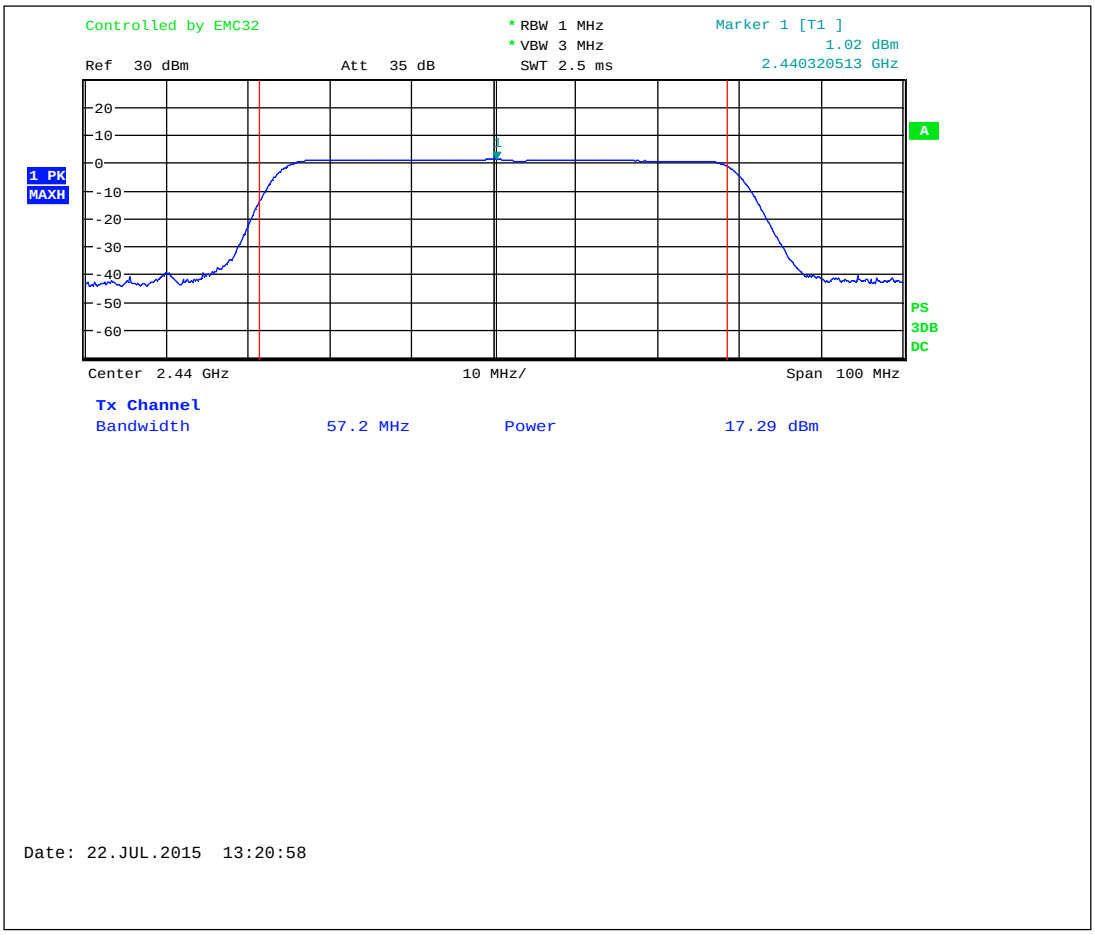
## Reduced Output, 100V



## Full Output, 140V



## Reduced Output, 140V



## 13 CONDUCTED EMISSIONS TEST

In accordance with FCC CFR 47 Part 15.207(a), “Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

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

*Decreases with the logarithm of the frequency.

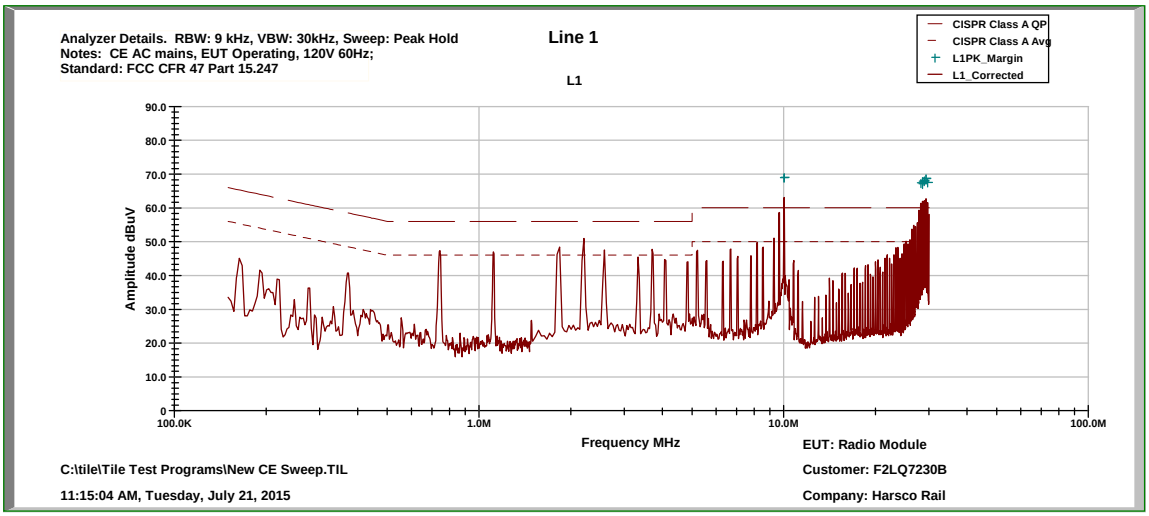
### 12.2 Procedure

The EUT was placed on a 1.0 x 1.5 meter non-conductive table, 0.8 meter above a horizontal ground plane and 0.4 meter from a vertical ground plane. Power was provided to the EUT through a LISN bonded to a 3 x 2 meter ground plane. The LISN and peripherals were supplied power through a filtered AC power source. The output of the LISN was connected to the input of the receiver via a transient limiter, and emissions in the range 150 kHz to 30 MHz were measured. The measurements were recorded using the quasi-peak and average detectors as directed by the standard, and the resolution bandwidth during testing was 9 kHz. The raw measurements were corrected to allow for attenuation from the LISN, transient limiter and cables.

## 13.1 Conducted Emissions Test Data

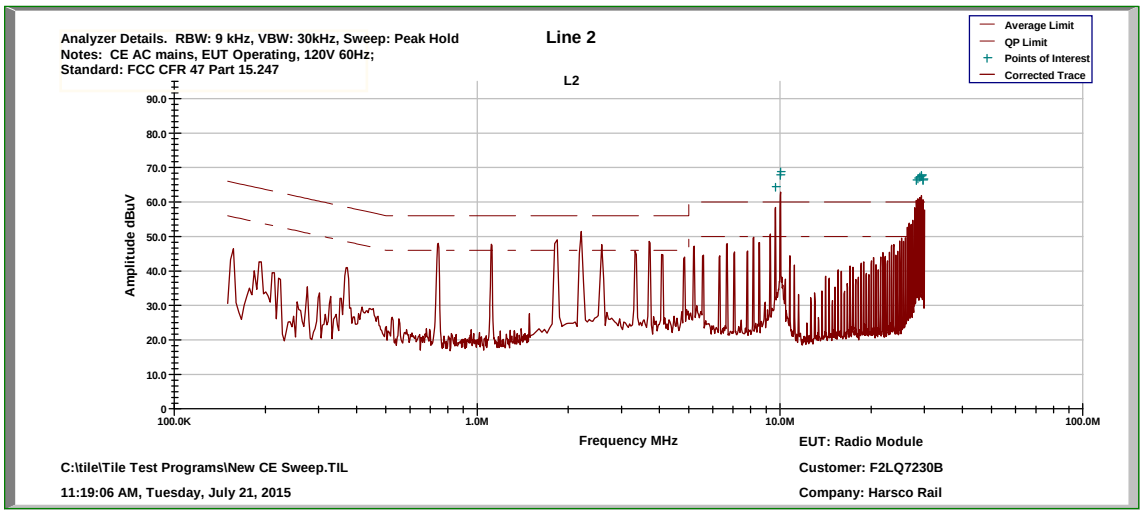
| | | | |
|---|---|---|---|
| **Test Date:** | July 21, 2015 | **Test Engineer:** | J. Knepper |
| **Rule:** | FCC CFR 47, Part 15, subpart B:2007, Part 15.107(a), Class B | **Air Temperature:** | 21.9º C |
| **Test Results:** | Pass | **Relative Humidity:** | 47% |

### Conducted Test – Line 1: 0.15 MHz to 30.0 MHz




| Top Discrete Measurements | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **No.** | **Conductor** | **Frequency (MHz)** | **Detector** | **Level (dBµV)** | **Adjustment (dB)** | **Results (dBµV)** | **Limit (dBµV)** | **Margin (dB)** |
| 1 | Line 1 | 10.005 | Quasi-Peak | 23.49 | 10.14 | 33.63 | 60.0 | -26.37 |
| | | 10.005 | Average | 19.883 | 10.14 | 30.023 | 50.0 | -19.977 |
| 2 | Line 1 | 10.0387 | Quasi-Peak | 22.61 | 10.139 | 32.749 | 60.0 | -27.251 |
| | | 10.0387 | Average | 15.757 | 10.139 | 25.896 | 50.0 | -24.104 |
| 3 | Line 1 | 28.1625 | Quasi-Peak | 21.66 | 10.288 | 31.948 | 60.0 | -28.052 |
| | | 28.1625 | Average | 13.938 | 10.288 | 24.226 | 50.0 | -25.774 |
| 4 | Line 1 | 28.5 | Quasi-Peak | 31.56 | 10.305 | 41.865 | 60.0 | -18.135 |
| | | 28.5 | Average | 26.373 | 10.305 | 36.678 | 50.0 | -13.322 |
| 5 | Line 1 | 28.5375 | Quasi-Peak | 21.71 | 10.307 | 32.017 | 60.0 | -27.983 |
| | | 28.5375 | Average | 15.04 | 10.307 | 25.347 | 50.0 | -24.653 |
| 6 | Line 1 | 28.875 | Quasi-Peak | 27.74 | 10.324 | 38.064 | 60.0 | -21.936 |
| | | 28.875 | Average | 21.917 | 10.324 | 32.241 | 50.0 | -17.759 |
| 7 | Line 1 | 28.9125 | Quasi-Peak | 22.09 | 10.326 | 32.416 | 60.0 | -27.584 |
| | | 28.9125 | Average | 14.693 | 10.326 | 25.019 | 50.0 | -24.981 |
| 8 | Line 1 | 29.25 | Quasi-Peak | 26.68 | 10.318 | 36.998 | 60.0 | -23.002 |
| | | 29.25 | Average | 20.142 | 10.318 | 30.460 | 50.0 | -19.54 |
| 9 | Line 1 | 29.2875 | Quasi-Peak | 22.45 | 10.316 | 32.766 | 60.0 | -27.234 |
| | | 29.2875 | Average | 14.533 | 10.316 | 24.849 | 50.0 | -25.151 |
| 10 | Line 1 | 29.6625 | Quasi-Peak | 20.1 | 10.297 | 30.397 | 60.0 | -29.603 |
| | | 29.6625 | Average | 13.705 | 10.297 | 24.002 | 50.0 | -25.998 |

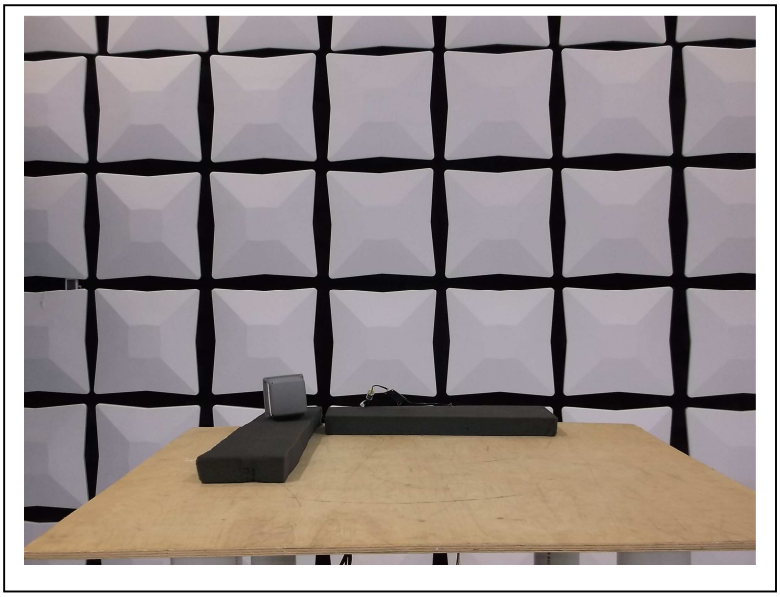
## Conducted Test – Line 2: 0.15 MHz to 30.0 MHz



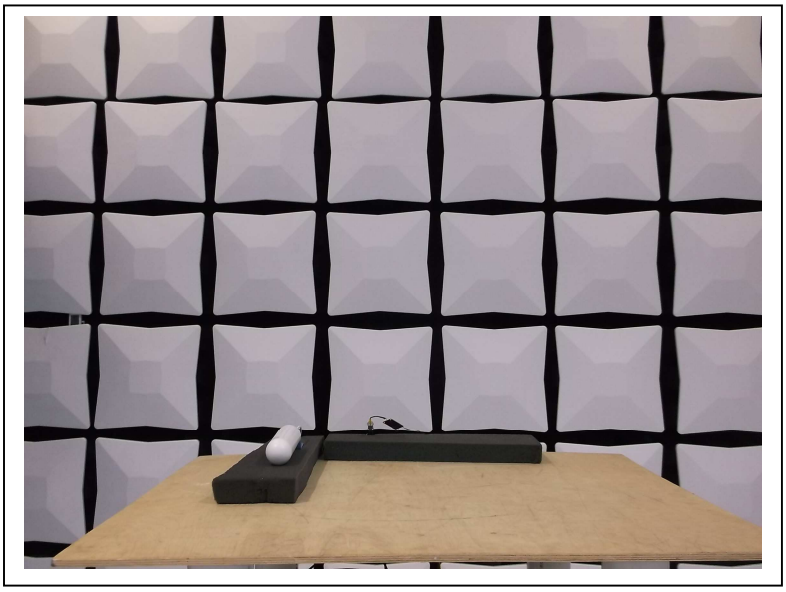

| Top Discrete Measurements | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **No.** | **Conductor** | **Frequency (MHz)** | **Detector** | **Level (dBµV)** | **Adjustment (dB)** | **Results (dBµV)** | **Limit (dBµV)** | **Margin (dB)** |
| 1 | Line 2 | 9.6675 | Quasi-Peak | 17.04 | 10.127 | 27.167 | 60.0 | -32.833 |
| | | 9.6675 | Average | 9.93 | 10.127 | 20.057 | 50.0 | -29.943 |
| 2 | Line 2 | 10.005 | Quasi-Peak | 25.03 | 10.140 | 35.17 | 60.0 | -24.83 |
| | | 10.005 | Average | 22.44 | 10.140 | 32.58 | 50.0 | -17.42 |
| 3 | Line 2 | 10.0387 | Quasi-Peak | 21.83 | 10.139 | 31.969 | 60.0 | -28.031 |
| | | 10.0387 | Average | 15.528 | 10.139 | 25.667 | 50.0 | -24.333 |
| 4 | Line 2 | 28.1625 | Quasi-Peak | 40.48 | 10.288 | 50.768 | 60.0 | -9.232 |
| | | 28.1625 | Average | 12.715 | 10.288 | 23.003 | 50.0 | -26.997 |
| 5 | Line 2 | 28.5375 | Quasi-Peak | 20.28 | 10.307 | 30.587 | 60.0 | -29.41 |
| | | 28.5375 | Average | 13.595 | 10.307 | 23.902 | 50.0 | -26.098 |
| 6 | Line 2 | 28.9125 | Quasi-Peak | 20.26 | 10.326 | 30.586 | 60.0 | -29.414 |
| | | 28.9125 | Average | 13.488 | 10.326 | 23.814 | 50.0 | -26.186 |
| 7 | Line 2 | 29.25 | Quasi-Peak | 26.86 | 10.318 | 37.178 | 60.0 | -22.822 |
| | | 29.25 | Average | 20.325 | 10.318 | 30.643 | 50.0 | -19.357 |
| 8 | Line 2 | 29.2875 | Quasi-Peak | 20.7 | 10.316 | 31.016 | 60.0 | -28.984 |
| | | 29.2875 | Average | 13.4 | 10.316 | 23.716 | 50.0 | -26.284 |

## 14 PHOTOGRAPHS/EXHIBITS – PRODUCT PHOTOS, TEST SETUPS

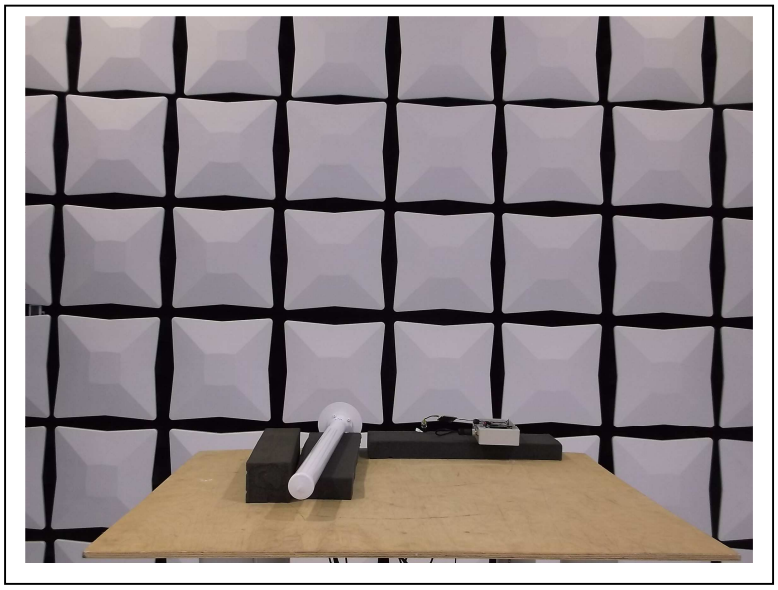
### Radiated Spurious Emission with 12dBi Whip Antenna



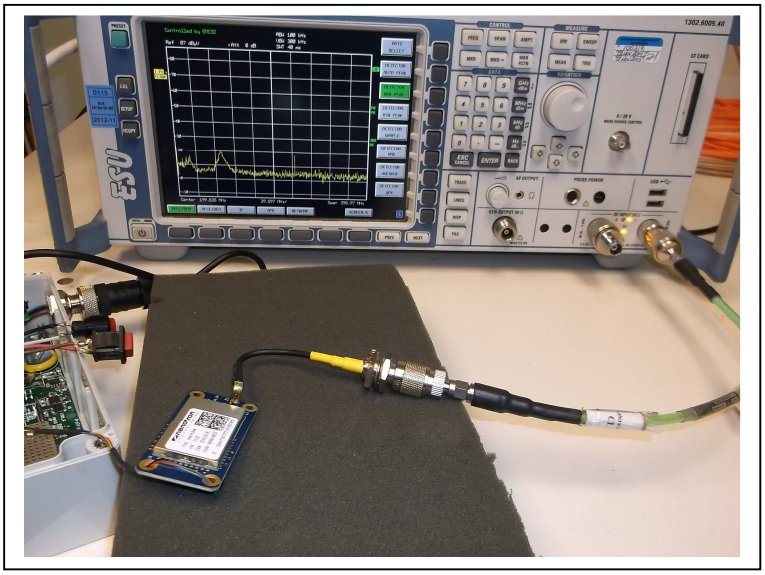
### Radiated Spurious Emission with 15dBi Whip Antenna



## Radiated Spurious Emission with 18dBi Whip Antenna



## Conducted Output Power, Peak Power Spectral Density, -6dB Occupied Bandwidth, Conducted Spurious Emissions & Voltage Variations



## Conducted Emissions