

FCC Part 15.247 Transmitter Certification

2.4 GHz ISM Band
Direct Sequence Spread Spectrum Transmitter

Test Report

FCC ID: TEB-HUNTTS764

FCC Rule Part: 15.247

Test Begin Date: 6/17/2009

Test End Date: 7/3/2009

Report Issue Date: August 11, 2009

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Additional Exhibits Included In Filing

External Photograph (Exhibit A)
Internal Photographs (Exhibit B)
Product Labeling (Exhibit C)
Users Manual Explanation (Exhibit D)
Test Setup Photos (Exhibit E)
Operational Statement (Exhibit F)
Radiated Emissions Sketch (Exhibit O)

Schematics (Exhibit G)
Block Diagram (Exhibit H)
Software Defined Radio Statement (Exhibit I)
Conducted Emissions Test Report (Exhibit J)
Radiated Emissions Test Report (Exhibit K)
Band Edge Plots (Exhibit L)
Cover Letter

1.0 GENERAL**1.1 Purpose**

The purpose of this report is to demonstrate compliance with Part 15, Subpart C of the FCC's Code of Federal Regulations.

1.2 Product Description**1.2.1 General**

Hunt Technologies' FOCUS AX Universal RF endpoint model 0764 and consists of a Landis & Gyr solid-state, single phase meter measuring electrical energy consumption integrated with a Hunt Technologies ZigBee transceiver on a single printed circuit board. The ZigBee circuit is a direct sequence spread spectrum transmitter operating in the 2400-2485.5 MHz unlicensed band and utilizing O-QPSK modulation.

Exhibits A and B are detailed external and internal photographs of the EUT. Exhibit A also indicates the location of the FCC label.

1.2.2 Intended Use

The FOCUS AX Universal RF endpoint model 0764 uses 2400-2485.5 MHz ISM band for in-home "Personal Energy Management" applications.

2.0 STATEMENT OF COMPLIANCE**§2.907 Certification**

This is an application for certification.

§2.911 Application

- a) This is an application and has been filed electronically with form 731.
- b) All information required has been supplied.
- c) The applicant has signed the application (electronically).
- d) The technical data has been signed.
- e) Applicant signature block on electronic form 731 completed by officer of the company or authorized company personnel.
- f) The appropriate fee has been paid.

§2.915 Grant

This application demonstrates that all applicable technical standards have been met and a grant of this application will serve the public interest.

§2.925 Label

Each piece of equipment for which authorization will be granted will be uniquely identified with "FCC ID: TEB-HUNTTTS764." The required statement will appear with the FCC ID on the outside

Hunt Technologies, LLC
6436 County Rd. 11
Pequot Lakes, MN 56472

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cover of the product. Exhibit C shows the external label. Exhibit D explains that although there is no User's Manual we do supply the meter manufacturer of the required statements that must be placed in the meter manual to meet the requirements of FCC CFR 47, Part 15, Paragraph 15.19(a)(3) and Industry Canada RSS-210 Paragraph 5.11.

§2.947 Measurement Procedure

- a) The scan of the restricted bands was made in a radiated manner. The radiated measurement procedure follows ANSI C63.4 procedure.
- b) All other RF measurements were made in a conducted manner.
- c) Procedural notes are contained in the laboratory report.
- d) A list of test equipment used is contained in the lab report.

§2.948 Description of Measurement Facilities

Measurements were performed at TÜV Testing Services Open Test Site. The FCC keeps a full description of the measurement facilities on file. TÜV's acceptance and approval is dated as December 5, 1993 in a letter received from the FCC.

The address of the test facility is:

TÜV Product Service
19035 Wild Mountain Road
Taylors Falls, MN 55084-1758

Phone: 651-638-0297
Contact: Joel Schneider
Test Engineer in Charge

See "Exhibit O Radiated Emissions Sketch.pdf" for a sketch of radiated measurement setup.

The radiated emissions, the power line conducted emissions, the RF conducted emissions above 1 GHz, and the RF conducted spurious emissions were tested at TÜV.

The RF conducted emissions tests (including 6-dB bandwidth, peak power output, spurious emissions from 30 MHz to 26 GHz, and power spectral density) were done at the following address:

Hunt Technologies
6436 County Rd. 11
Pequot Lakes, MN 56472

§2.1033 Application for Certification

- a) Form 731 has been electronically filed on 8/11/09. Items that did not apply were left blank.
- b) This technical report contains the following information where applicable.
 - 1. Full name and mailing address of manufacturer and applicant for certification:
Hunt Technologies, LLC
6436 County Rd. 11
Pequot Lakes, MN 56472
 - 2. FCC Identifier:
TEB-HUNTTTS764
 - 3. Brief Description of circuit functions and device operation:
See "Exhibit F Operational Description Statement.pdf" for operational description
See "Exhibit G Schematic.pdf" for schematic

4. Block Diagram:
See "Exhibit H Block Diagram Exhibit H.pdf"
 5. Report of the measurements of conducted and radiated emissions:
See figs. in section 6 and Exhibits J and K shown and discussed later in this report
 6. Photographs
External: See "Exhibit A External Photo ID Label Location Info.pdf"
Internal: See "Exhibit B Internal Photos.pdf"
Test Setup: See "Exhibit E Test Setup Photos.pdf"
 7. Peripheral or Accessory devices:
There are no peripheral or accessory devices designed to operate with this product.
 8. Transition Rules
This application is not pursuant to the transition rules of §15.37
 9. Application for scanning receivers:
Not applicable to this device.
 10. Application for operation within the 59-64GHz band:
Not applicable to this device.
- c) Composite Systems
Not applicable to this device.
- d) Software Defined Radio
Not applicable to this device. See "Exhibit I SDR Software Security Information Statement.pdf"

3.0 APPLICABLE STANDARD REFERENCES

The following standards were used:

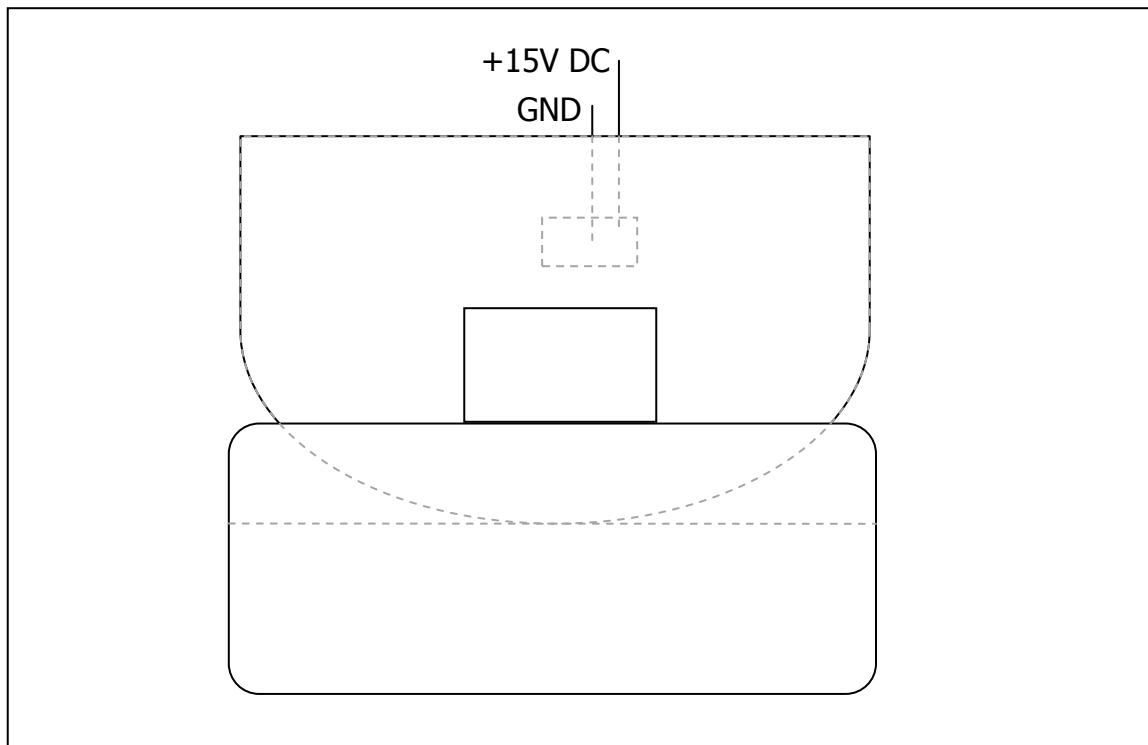
- ☐ ANSI C63.4-1992: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the 9KHz to 40GHz
- ☐ US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures (October 2004)
- ☐ US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators (October 2004)
- ☐ FCC OET Bulletin 65 Appendix C - Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields
- ☐ FCC KDB Publication No. 558074 - Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247), March 2005

4.0 LIST OF TEST EQUIPMENT

All test equipment used for regulatory testing is calibrated yearly or according to manufacturer's specifications. The equipment used to do all Radiated testing and Power Line Conducted Emissions is the property of TUV Product Services and is located at their Taylor's Falls facility. The FCC keeps a full description of TUV's measurement facilities on file. The equipment listed below was used at Hunt Technologies' Pequot Lakes, MN facility to do all RF conducted measurements.

Table 4.0-1: Test Equipment

Mfg.	Equip. Type	Model	S/N	Cal. Due
Agilent	Spectrum Analyzer	E4404B	MY41440735	7/15/2009
Agilent	Spectrum Analyzer	E4407B	MY45106578	7/21/2009
Agilent	DC Power Supply	E3646A	MY40008953	7/14/2009

5.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM**Figure 5.0-1 Radiated Emissions Test Setup**

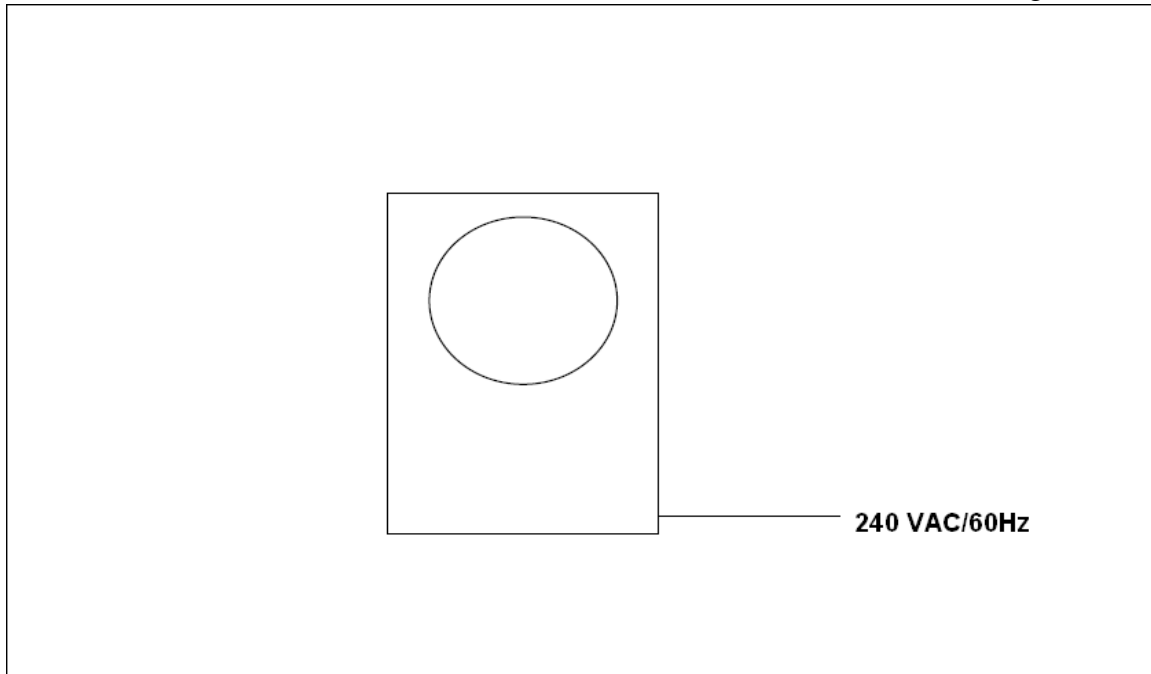


Figure 5.0-2 Power Line Conducted Emissions Test Setup

6.0 SUMMARY OF TESTS

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

6.1 Frequencies to be Examined [§15.31(m)]

In accordance with the guidelines of §15.31(m), all conducted and radiated measurements were performed at the lowest (2405 MHz), middle (2445 MHz), and highest (2480 MHz) frequencies that the product will transmit.

6.2 Antenna Requirement [§15.203]

The transmitter antennas are integral to the circuit board, and therefore comply with the requirement that no other antenna shall be used with the device.

6.3 Antenna Characteristics [§15.204]

There are only two antennas proposed for use with this device. These antennas have the following characteristics:

6.3.1 Antenna Type

The antenna is approximately a $\frac{1}{4}$ wave monopole at 2445 MHz.

6.3.2 Antenna Manufacturer

None; the antenna is part of the printed circuit board.

6.3.3 Antenna Gain

The $\frac{1}{4}$ wave monopole is a well-known antenna type. The theoretical gain of an ideal $\frac{1}{4}$ wave monopole is 5.15 dBi. The antenna on this transmitter has some non-ideal characteristics. The finite ground plane is the most significant non-ideal characteristic. Therefore, the antenna gain will be somewhat lower than the ideal number of 5.15 dBi.

6.4 Power Line Conducted Emissions [§15.207]

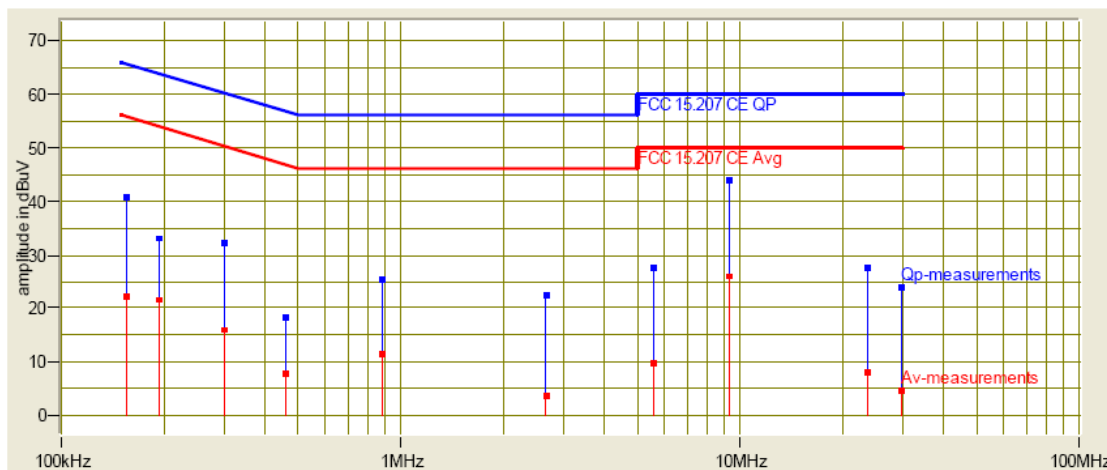
6.4.1 Test Methodology

ANSI C63.4 sections 6 and 7 were the guiding documents for this evaluation. Conducted emissions were performed from 150 kHz to 30 MHz.

6.4.2 Test Results

The summary of the results are shown below in table 6.4-1. For the complete test report, see "Exhibit J Conducted Emissions.pdf"

Table 6.4-1: Power Line Conducted Emissions Summary



6.5 Radiated Emissions [§15.109] and Radiated Spurious Emissions (Restricted Bands) [§15.205]

6.5.1 Test Methodology

Radiated emissions tests were performed over the frequency range of 30MHz to 1 GHz and in the restricted bands up to 25 GHz, greater than 10 times the highest fundamental frequency. The restricted band tests were done at the lowest, middle, and highest transmit frequencies. Measurements of the radiated field strength were made at a distance of 3m from the boundary of the equipment under test (EUT) and the receiving antenna. The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000MHz, quasi-peak measurements were made using a resolution bandwidth (RBW) of 120 kHz and a video bandwidth (VBW) of 300 kHz. For frequencies above 1000MHz, peak measurements were made using an RBW of 1 MHz and a VBW of 1 MHz. Average values were determined by subtracting the duty cycle correction factor stated in 6.5.2 from the peak measurements. See "Exhibit O Radiated Emissions Sketch.pdf," for a sketch of the test setup.

6.5.2 Calculation of allowed limit for Radiated Spurious Emissions

For spurs above 1000 MHz, §15.205(b) allows duty cycle averaging per §15.35. This device transmits packets for no longer than 42ms in any 100ms period; therefore, 7.53dB of duty cycle correction applies. The duty cycle correction factor is determined using the formula: $-20\log(42/100) = 7.53\text{dB}$.

6.5.3 Test Results

Radiated spurious emissions found in the band of 30MHz to 25GHz are all below the applicable limits. Each emission found to be in a restricted band as defined by section 15.205, was compared to the radiated emission limits as defined in section 15.209. Results are shown in "Exhibit K Radiated Emissions.pdf" and "Exhibit N Restricted Bands.pdf". The highest signal in the restricted bands portion of the test was the 4.809 GHz harmonic produced by the Low channel transmission on the First antenna. This signal was 0.76 dB down from the average limit of 54 dBuV/m.

6.6 Peak Output Power – [§15.247(b)(3)]

6.6.1 Test Methodology (Conducted Method)

The Peak Output Power was measured in accordance with the FCC KDB Publication No. 558074 "Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)" Power Option 1. The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer.

6.6.2 Test Results

Results are shown below in table 6.6-1 and the worst case was plotted and shown in figure 6.6-1 to 6.6-3 below:

Table 6.6-1: RF Output Power

Frequency (MHz)	Level (dBm)
2405	18.21
2445	19.01
2480	-0.305

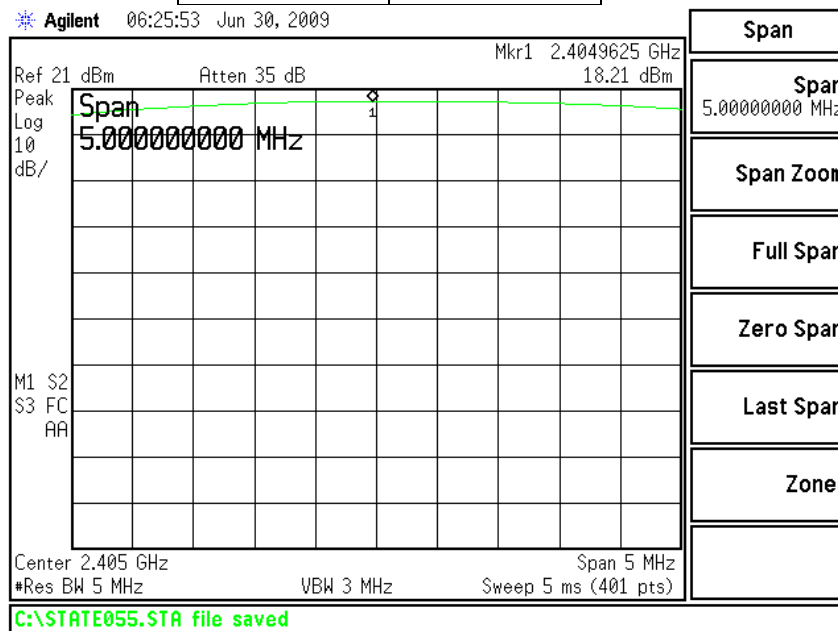


Figure 6.6-1: Output Power – Low Channel

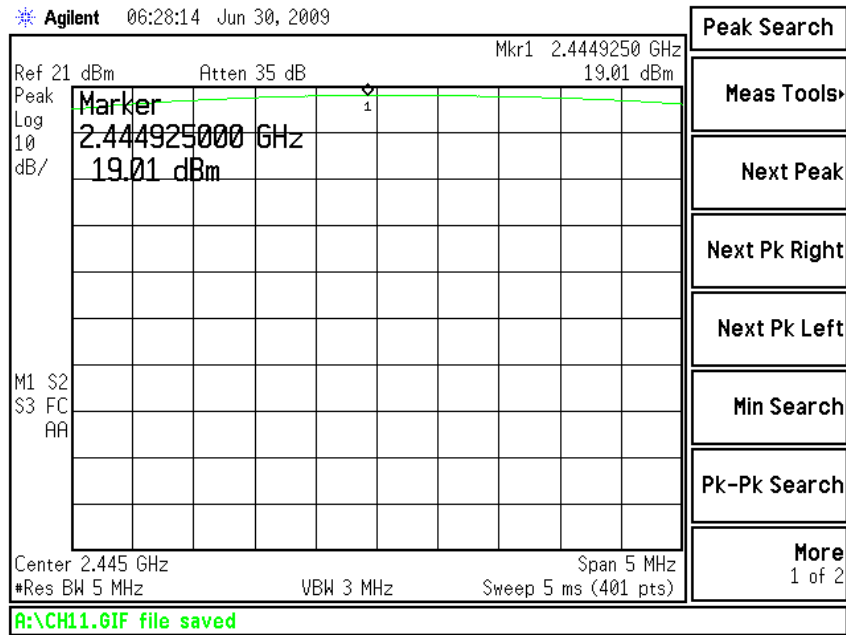


Figure 6.6-2: Output Power – Mid Channel

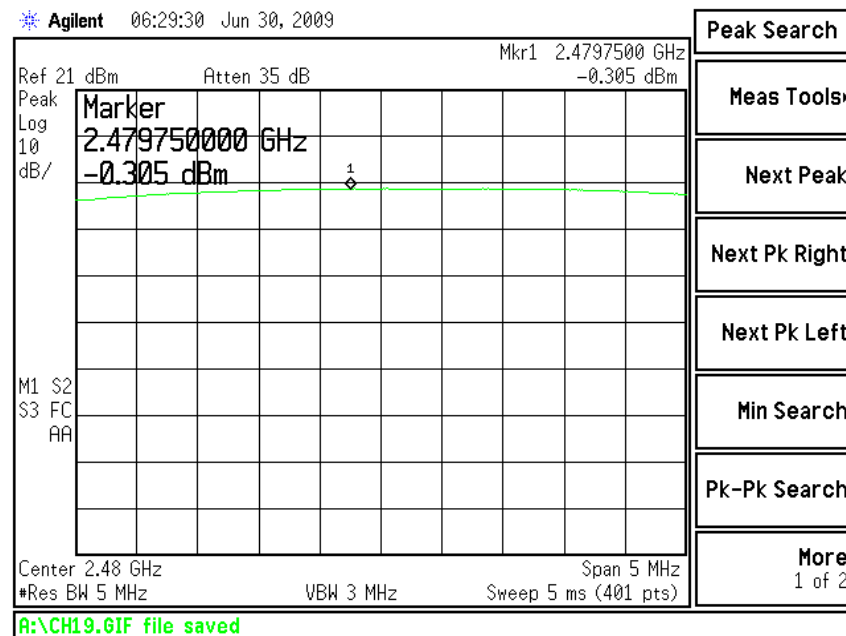


Figure 6.6-3: Output Power – High Channel

6.6.3 De Facto EIRP Limit

The gain of the transmit antenna is given earlier in this report. Because the gain of the antenna is less than 6 dBi, the peak output power need not be reduced to comply with this requirement.

6.6.4 RF Exposure Compliance Requirements

This device is not intended to operate within 20 cm of a person's body. Therefore, RF exposure requirements are not applicable to this application for certification.

6.7 6-dB Bandwidth [§15.247(a)(2)]

15.247(a)(2): Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

6.7.1 Test Methodology

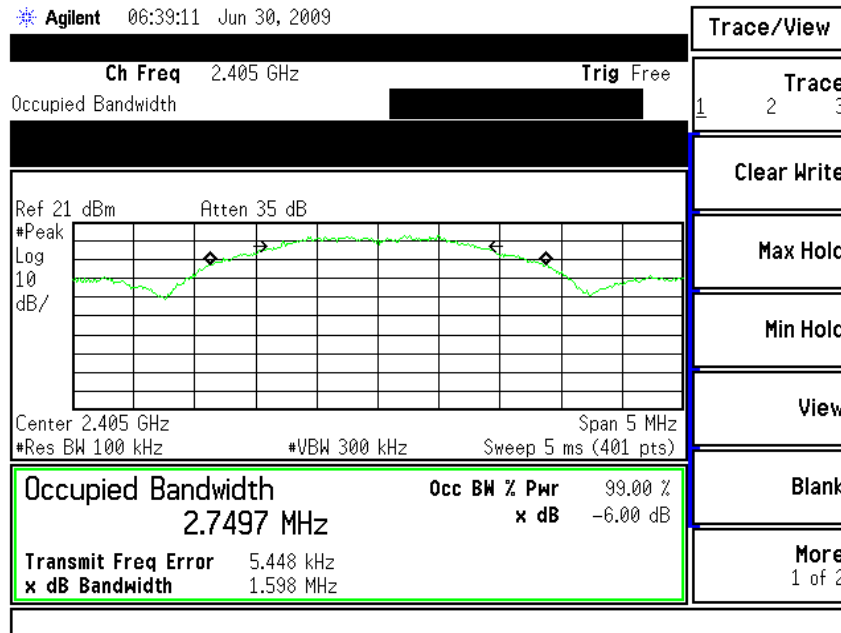
The 6dB bandwidth was measured in accordance with the FCC KDB Publication No. 558074 "Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)". The RBW of the spectrum analyzer was set to 100 kHz and VBW 300 kHz. Span was set large enough to capture the entire emissions and >> RBW.

6.7.2 Test Results

Results are shown below in table 6.7-1 and plotted in figures 6.7-1 to 6.7-3 below:

Table 6.7-1: 6-dB Bandwidth

Frequency (MHz)	Bandwidth (MHz)
2405	1.598
2445	1.585
2480	1.611

**Figure 6.7-1: 6-dB Bandwidth Plot – Low Channel**

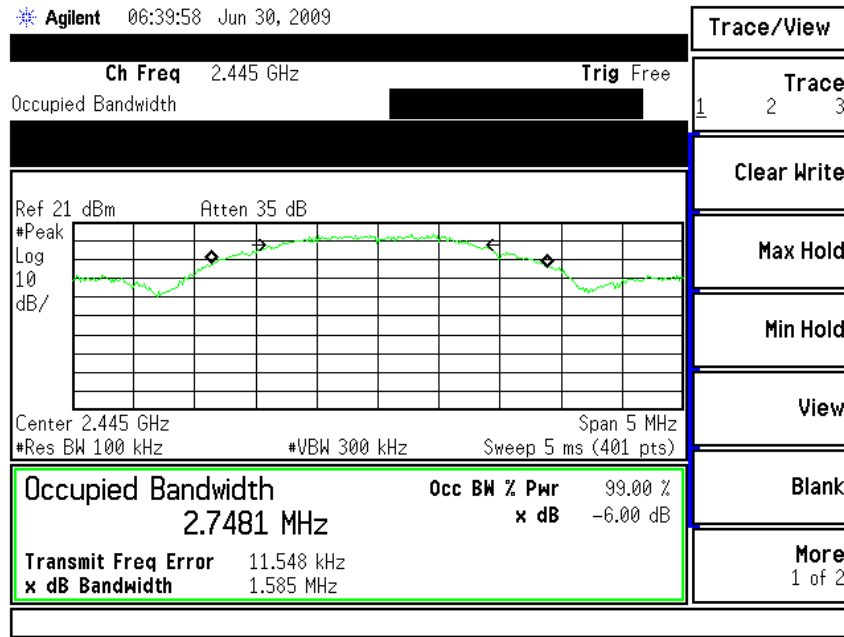


Figure 6.7-2: 6-dB Bandwidth Plot – Mid Channel

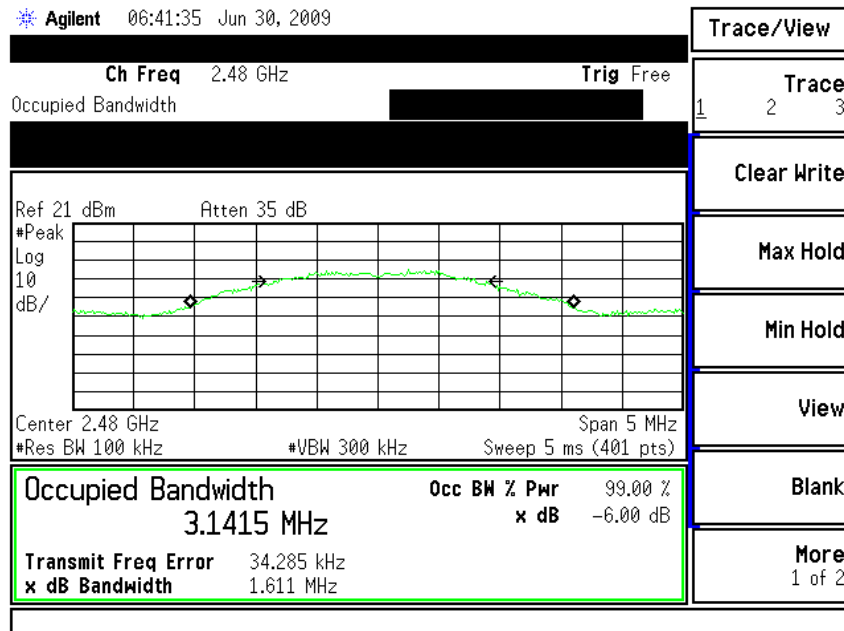


Figure 6.7-3: 6-dB Bandwidth Plot – High Channel

6.8 Peak Power Spectral Density [§15.247(e)]

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

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6.8.1 Test Methodology

The power spectral density was measured in accordance with the FCC KDB Publication No. 558074 "Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)". The emission peaks within the pass band were located and zoomed in on. The spectrum analyzer RBW was set to 3 kHz and VBW 10 kHz. Span was adjusted to 100 kHz and the sweep time was calculated to be 34s (Span/3 kHz).

6.8.2 Test Results

Results are shown below in table 6.8-1 and figures 6.8-1 – 6.8-3:

Table 6.8-1: Peak Power Spectral Density

Frequency (MHz)	Level (dBm)
2405	2.076
2445	4.334
2480	-14.12

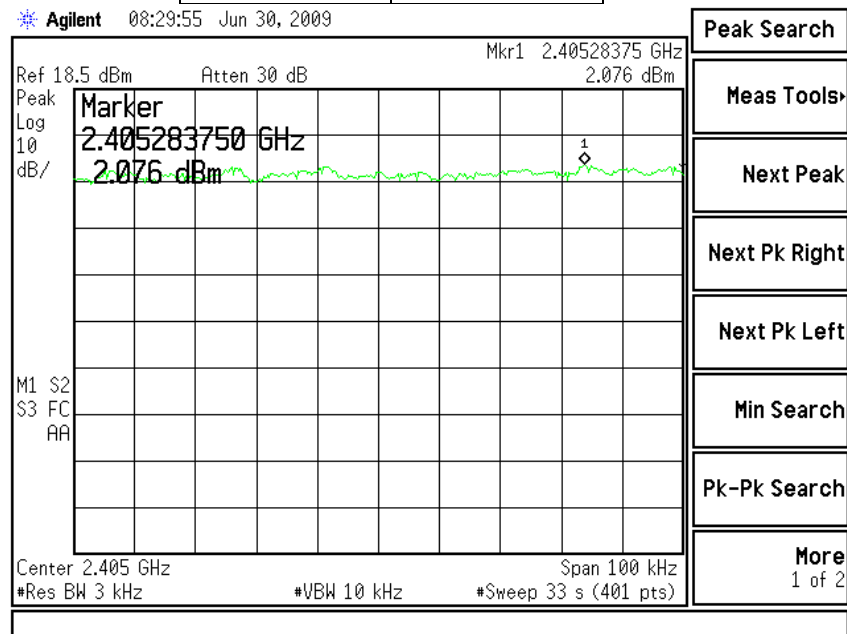
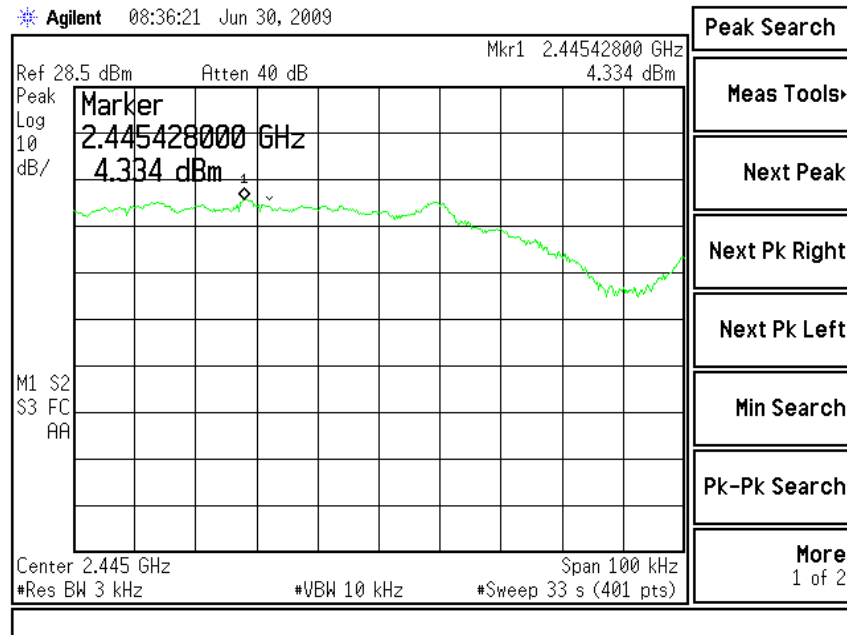
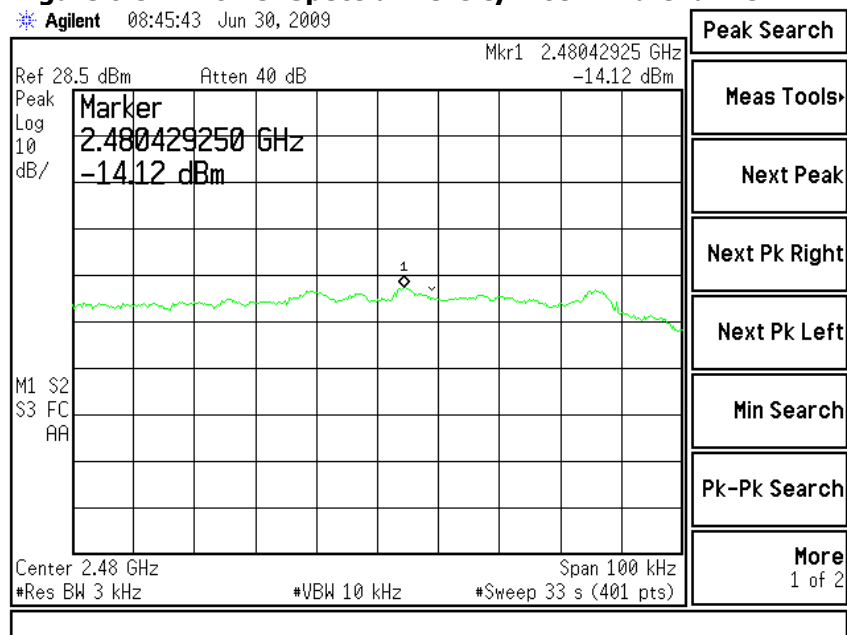


Figure 6.8-1: Power Spectral Density Plot – Low Channel

**Figure 6.8-2: Power Spectral Density Plot – Mid Channel****Figure 6.8-3: Power Spectral Density Plot – High Channel**

6.9 Band-Edge Compliance and Spurious Emissions [§15.247(d)]

6.9.1 Band-Edge Compliance of RF Emissions

6.9.1.1 Test Methodology

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The EUT was investigated at the lowest and highest channel available to determine band-edge compliance. At the lower band-edge, a conducted measurement was used to determine compliance. The lower band-edge measurement was performed with the spectrum analyzer's RBW set to 100 kHz, which is $\geq 1\%$ of the span, and VBW set to 300 kHz.

Because the upper band-edge coincides with a restricted band, band-edge compliance was determined using the radiated marker-delta method, as outlined in FCC DA 00-705. The radiated field strength of the fundamental emission was first determined; then the marker-delta method was used to determine the field strength of the band-edge emissions.

6.9.1.2 Test Results

In a 100 kHz bandwidth at the lower band-edge, the radio frequency power that was produced by the EUT is at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power. Lower band-edge compliance is displayed in Figure 6.9-1.

Using the marker-delta method, the radiated emissions within the restricted band, beginning at 2483.5 MHz, were found to be 14.43 dB below the peak limit of 74 dBuV/m and 1.66 dB below the average limit of 54 dBuV/m. The peak emission within the restricted band was determined by subtracting the amplitude delta from the peak in-band field strength.

[Peak Restricted Band Emission] = [Peak In-Band Field Strength] - [Amplitude Delta]

The average emission was determined from the peak emission with an additional 7.53 dB subtraction due to the duty-cycle correction factor as stated in 6.5.2.

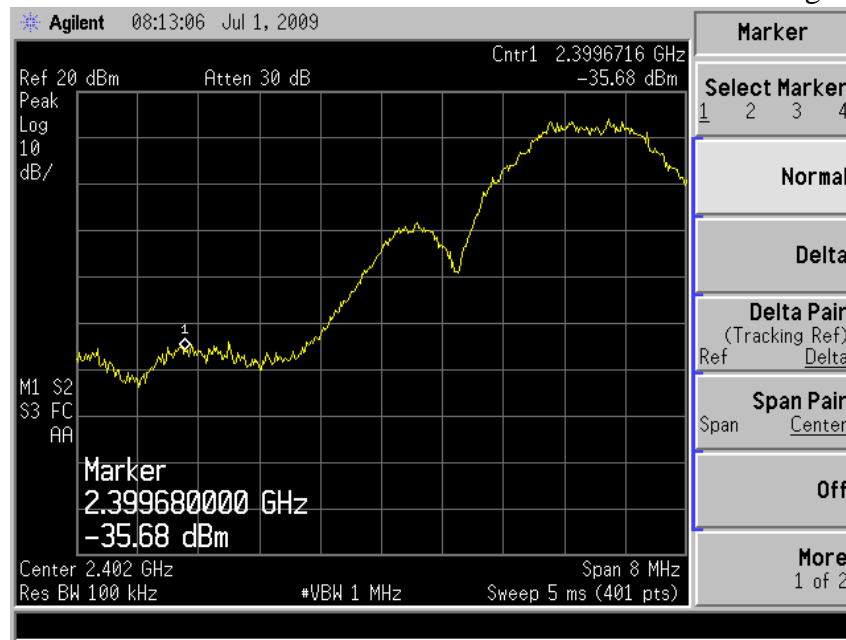
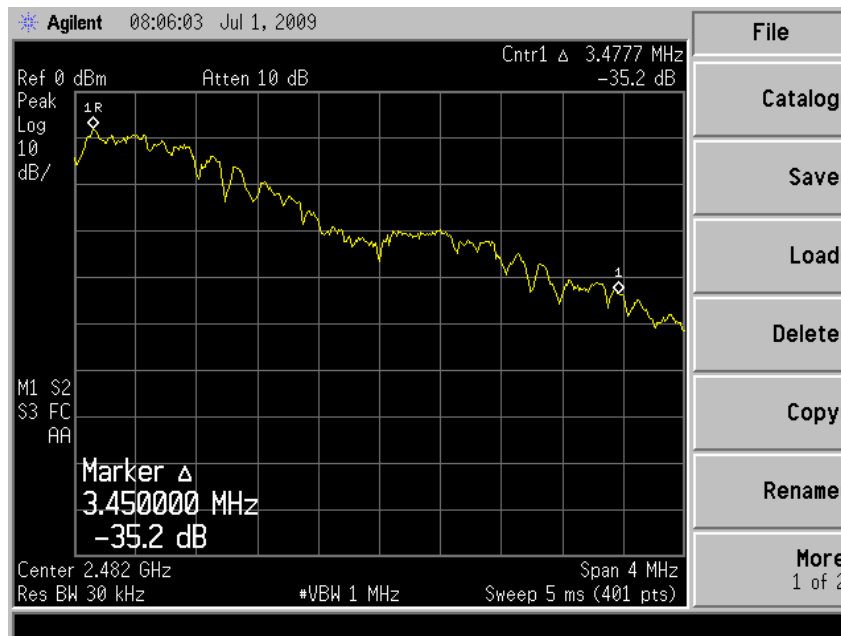
[Average Restricted Band Emission] = [Peak In-Band Field Strength] - [Amplitude Delta] - [Duty Cycle Correction Factor]

These results are shown in Table 6.9-1 and Figure 6.9-2. See "Exhibit L Band Edge Plots.PDF" for more detail.

Table 6.9-1

Final=Peak-Amlitude Delta-Duty Cycle

Antenna 1 Peak 94.77 dBuV/M	Limit 74 dBuV/M	Final 52.05 dBuV/M
AvG 90.86 dBuV/M	Limit 54 dBuV/M	Final 48.16 dBuV/M
Antenna 2 Peak 90.87 dBuV/M	Limit 74 dBuV/M	Final 52.91 dBuV/M
AvG 87.32 dBuV/M	Limit 54dBuV/M	Final 49.36 dBuV/M

**Figure 6.9-1: Lower Band-Edge (Conducted)****Figure 6.9-2: Upper Band-Edge (Marker-Delta, Radiated, Maximized)**

6.9.2 RF Conducted Spurious Emissions

6.9.2.1 Test Methodology

The EUT was investigated for conducted spurious emissions from 30MHz to 26GHz, 10 times the highest fundamental frequency. Measurements were made at the low, center and high channels of the EUT. For each measurement, the spectrum analyzer's VBW was set to 100kHz and the RBW was set to 300kHz. A peak detector function was used with the trace set to max hold.

6.9.2.2 Test Results

All emission found were greater than 20dB down from the fundamental carrier. The RF conducted spurious emissions were measured in the band of 30MHz to 26GHz. Results are shown below in Figure 6.9-3 through 6.9-8.

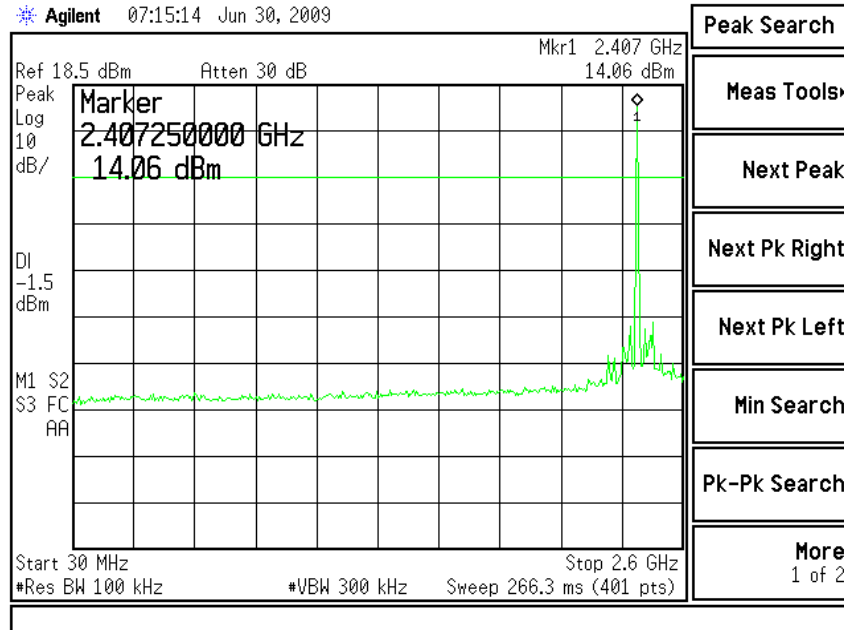
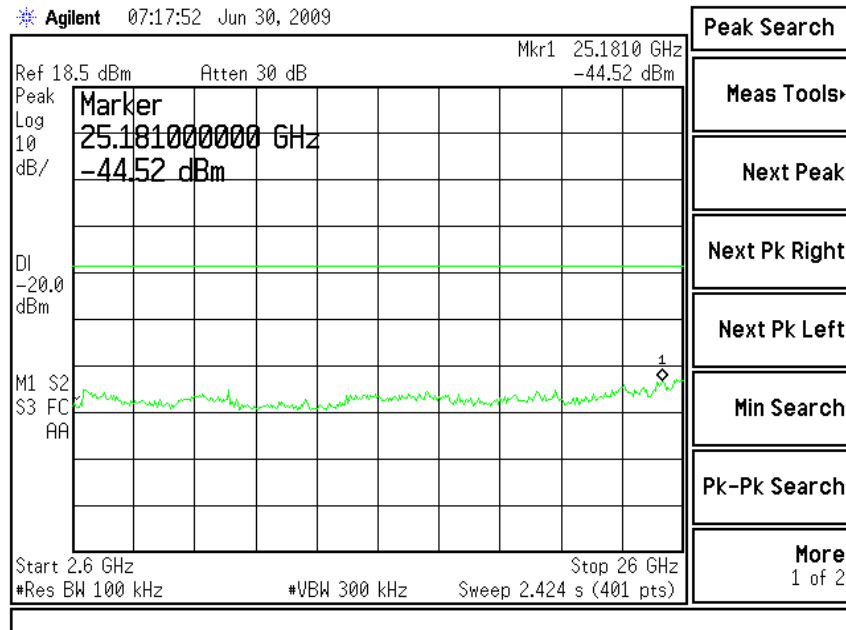
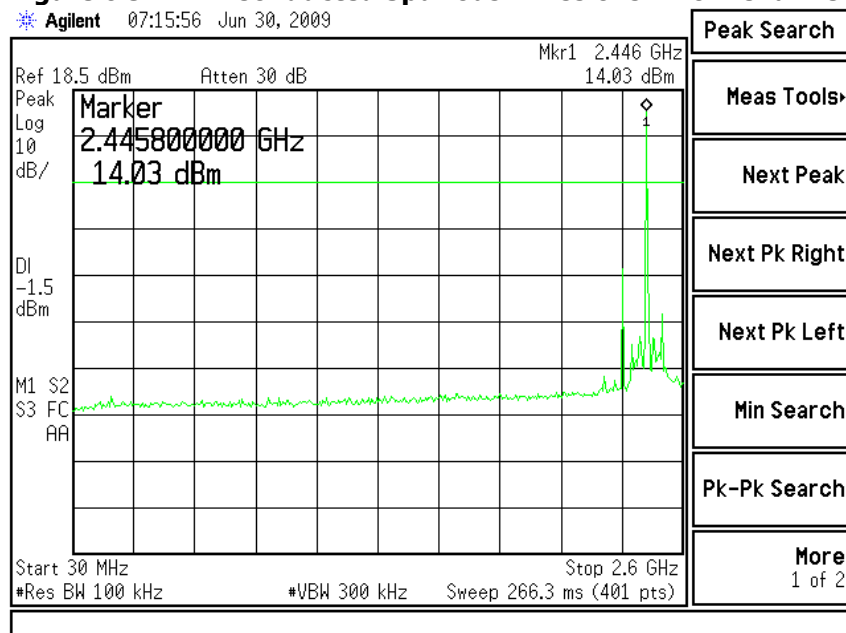
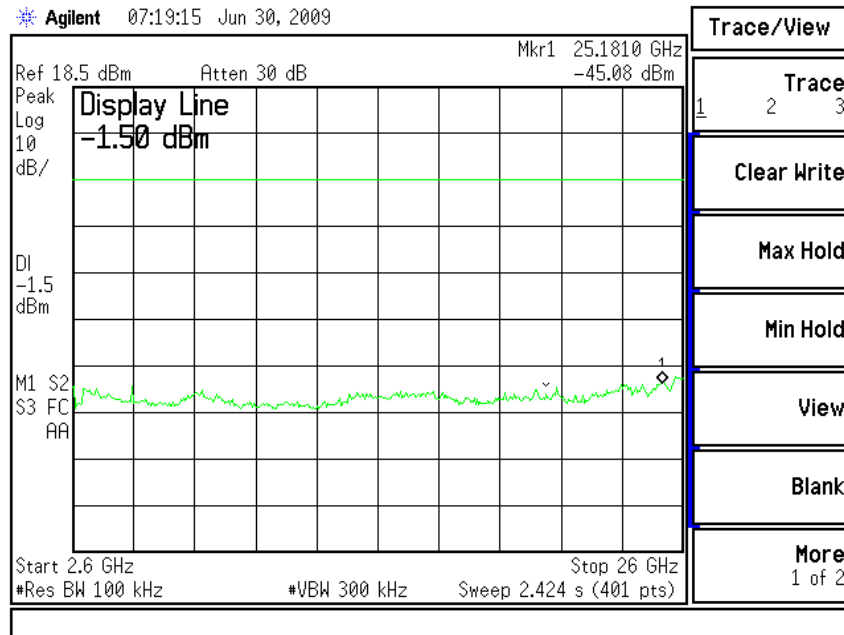
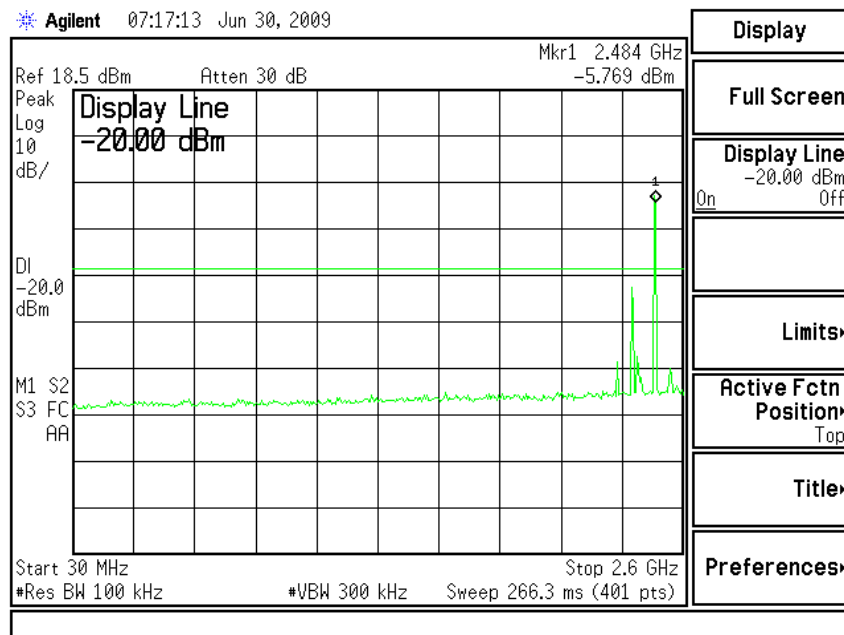


Figure 6.9-3: RF Conducted Spurious Emissions – Low Channel

**Figure 6.9-4: RF Conducted Spurious Emissions – Low Channel****Figure 6.9-5: RF Conducted Spurious Emissions – Mid Channel**

**Figure 6.9-6: RF Conducted Spurious Emissions – Mid Channel****Figure 6.9-7: RF Conducted Spurious Emissions – High Channel**

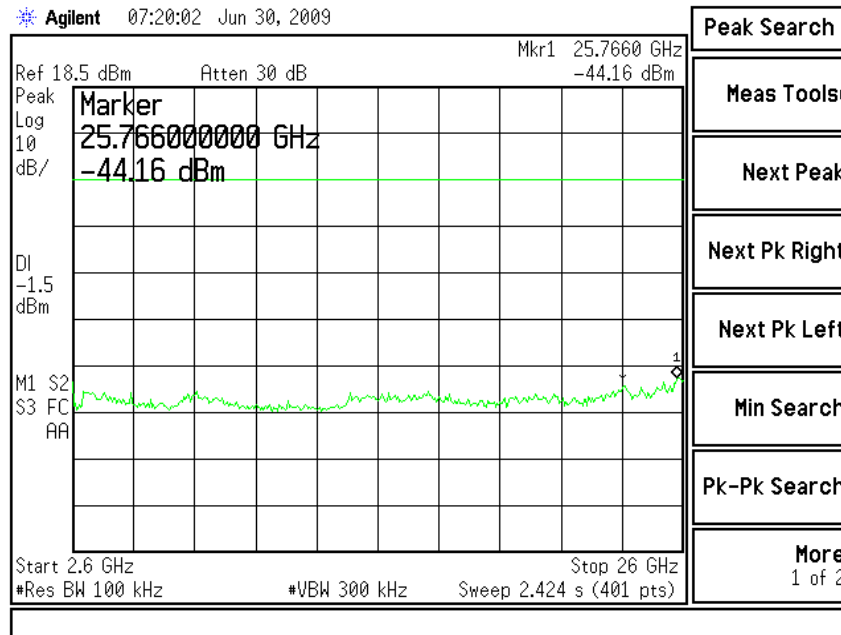


Figure 6.9-8: RF Conducted Spurious Emissions – High Channel

7.0 CONCLUSION

The FOCUS AX Universal RF endpoint model 0764, manufactured by Hunt Technologies, LLC, meets the requirements of FCC Part 15 subpart C.