FCC Part 15.247
Transmitter Certification

2.4 GHz ISM Band
Direct Sequence Spread Spectrum Transmitter

Test Report

FCC ID: HUNTSU825

FCC Rule Part: 15.247

Test Begin Date: 11/04/2009
Test End Date: 11/18/2009

Report Issue Date: 1/6/2010

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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' S4e Universal RF endpoint model 825 consists of a 900 MHz transceiver and a separate ZigBee transceiver on a single printed circuit board. The 900 MHz circuit, operating in the 902-928 MHz frequency band, is a frequency hopping spread spectrum transceiver utilizing GFSK modulation. The ZigBee circuit is a direct sequence spread spectrum transmitter operating in the 2400-2483.5 MHz unlicensed band and utilizing O-QPSK modulation. The 825 module will be assembled into a Landis+Gyr S4e meter before delivery to the customer. This report specifically addresses the testing of the ZigBee transceiver.

Exhibits A and B are detailed external and internal photographs of the EUT.

1.2.2 Intended Use
The S4e Universal RF endpoint model 825 will be transmitting and receiving over 2400-2483.5 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.

§2.925 Label
Each piece of equipment for which authorization will be granted will be uniquely identified with "TEB-HUNTSU825". The required statement will appear with the FCC ID on the outside cover of

the product. Exhibit C, "Exhibit C - FCC Label.pdf" shows the external label and Exhibit D, "Exhibit D - Product Ship Sheet.pdf" is the product's ship-sheet (pamphlet) provided to the end-user that contains the required compliance statement as defined by §15.19.

§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 this test report.
d) A list of test equipment used is contained in this test report.

§2.948 Description of Measurement Facilities

Measurements were performed at TUV Testing Services Open Test Site. The FCC keeps a full description of the measurement facilities on file. TUV's acceptance and approval is dated as December 5, 1993 in a letter received from the FCC. TUV FCC OATS #90983, IC OATS #2932L-1.

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 N, "Exhibit N - Radiated Emissions Sketch.pdf" for a sketch of radiated measurement setup.

The radiated emissions and the power line conducted emissions were tested at TUV.

The remainder of the RF conducted emissions tests (including all conducted emissions, 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 1/6/2010. 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-HUNTSU825
   3. Brief Description of circuit functions and device operation:
      See Exhibit F, "Exhibit F - Operational Statement.pdf" for operational description
      See Exhibit G, "Exhibit G - Schematic.pdf" for schematic
   4. Block Diagram:
      See Exhibit H, "Exhibit H - Block Diagram.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, "Exhibit A - External Photo.pdf"
   Internal: See Exhibit B, "Exhibit B - Internal Photos.pdf"
   Test Setup: See Exhibit E, "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, "Exhibit I - SDR 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	7/30/2010
Agilent	Spectrum Analyzer	E4407B	MY45106578	7/30/2010

5.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

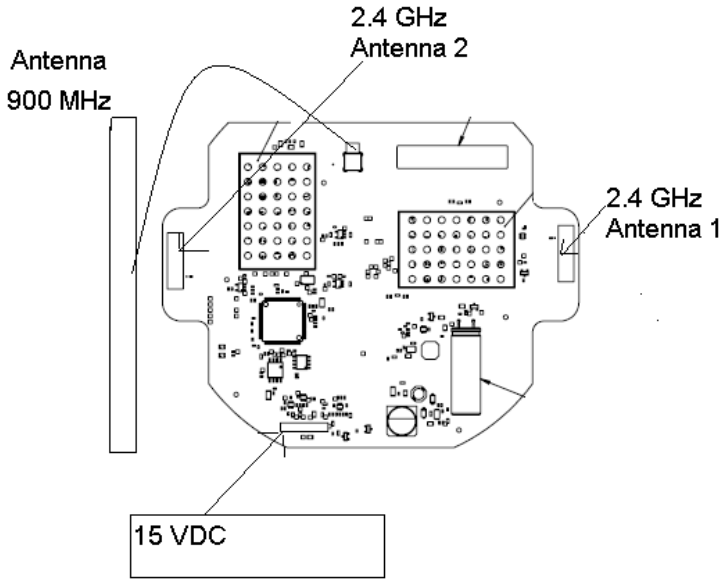

Figure 5.0-1: Radiated Emissions Test Setup

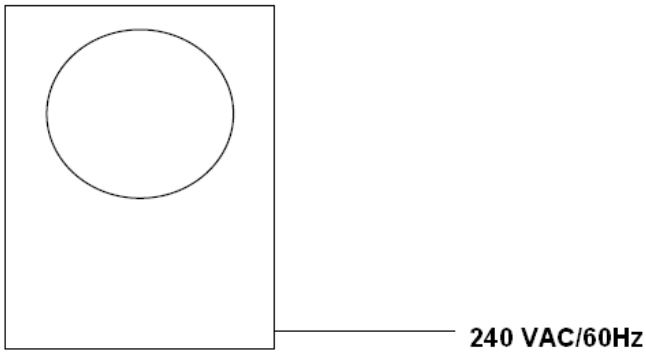

Figure 5.0-2: Power Line Conducted Emissions Test Setup

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 ¼ 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 ¼ wave monopole is a well-known antenna type. The theoretical gain of an ideal ¼ 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 figure 6.4-1. For the complete test report, see Exhibit J, "Exhibit J - Conducted Emissions.pdf"

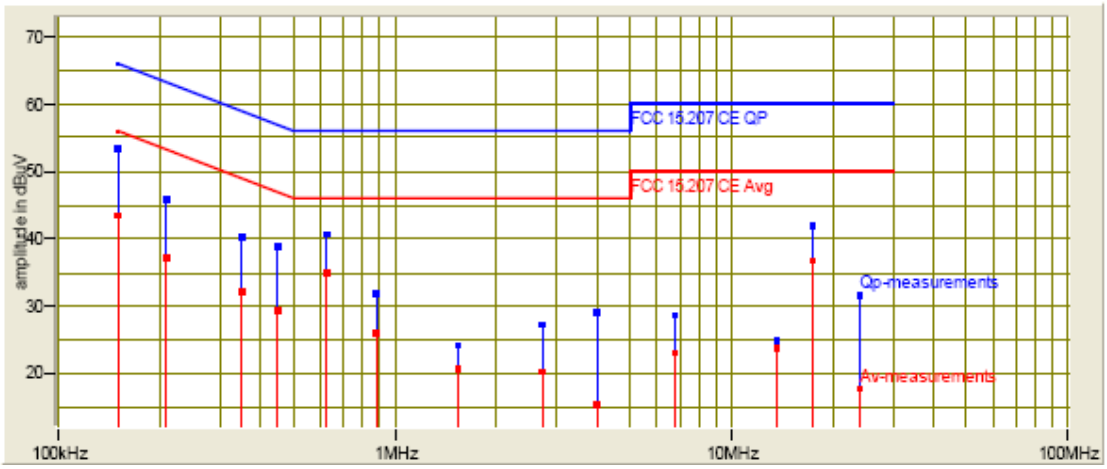

Figure 6.4-1: Power Line Conducted Emissions Summary

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 N, "Exhibit N - 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: -20log (42/100) = 7.53dB.

Transmit Time		# bytes
TX Time (Packet)	0.004256	133
Total TX Time (sec)	0.004256	

NOT Transmit time (RX or Idle)		
Wait for ACK (tack)	0.000192	
RX Time (ACK)	0.000352	
Backoff Time (tbo)	0.0048	(Backoff Time * Backoff Period)
CPU Processing (tcpu)	0.0002	(0.2ms average on EM2xx running EmberZNet)
CCA Assessment (tcca)	0.000128	(averaged over 8 symbols in RX Mode)
Turn Around Time (RX to TX)	0.000192	(After CCA, Radio turns over to TX in 12 symbols)
Total Off Time (sec)	0.005864	

Total Time (ttotal)	0.01012
Number of RX / TX cycles in 100ms	9.88142292

Worse Case (100ms window)

TX Frame 10 times	0.04256
RX or IDLE 10 Times	0.05864
Sum	0.1012

MAC TX Duty Cycle (On /total)	42.06%	Represents theoretical ZigBee / MAC performance
		(This number should be used for FCC compliance testing.)

6.5.3 Test Results

Radiated spurious emissions found in the band of 30 MHz to 25 GHz 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, "Exhibit K - Radiated Emissions 30 MHz to 1 GHz.pdf" and Exhibit L, "Exhibit L - Restricted Band (Antenna 1).pdf". The highest signal in the restricted bands portion of the test was the 7.334 GHz harmonic produced by the Mid channel transmission. This signal was 2.83 dB down from the average limit of 54 dBuV/m after the duty cycle correction factor of 7.53 dB was applied. The unit contains two antennas. Antenna 2 was maximized on the low, mid, and high channels, with results shown in Exhibit M, "Exhibit M - Restricted Band (Antenna 2).pdf". It was found that Antenna 1 produced the most gain, in that its maximized levels were greater than those of Antenna 2. Results are summarized in table 6.5-1.

Table 6.5-1: Antenna Comparison

Frequency (GHz)	Antenna 1 (dBuV/m)	Antenna 2 (dBuV/m)	Delta (dBuV/m)
2.405	123.68	114.94	8.74
2.445	121.87	114.44	7.43
2.480	60.33	53.33	7.00

The radiated emissions within the restricted band, beginning at 2483.5 MHz, were found to be below the peak limit of 74 dBuV/m and below the average limit of 54 dBuV/m. See results in Figure 6.5-1 and 6.5-2.

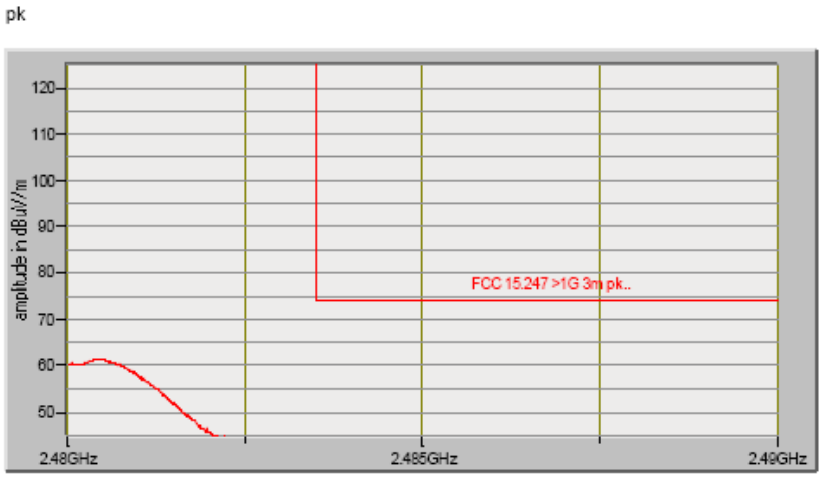

Figure 6.5-1: Restricted Band Starting at 2483.5 MHz (Radiated Peak)

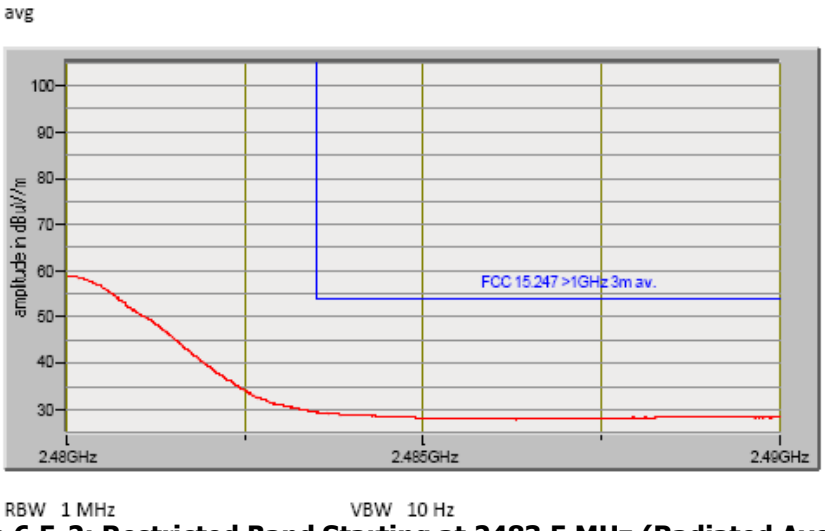

Figure 6.5-2: Restricted Band Starting at 2483.5 MHz (Radiated Average)

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. The output power of the high channel is transmitting at reduced power in order to

demonstate compliance with radiated emissions limits in sections 15.249 or 15.205 when a restricted band is located adjacent to 15.247 band (beginning at 2483.5 MHz). All manufactured production units will operate at a reduced power level on Ch26.

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	20.03
2445	19.73
2480	-39.49

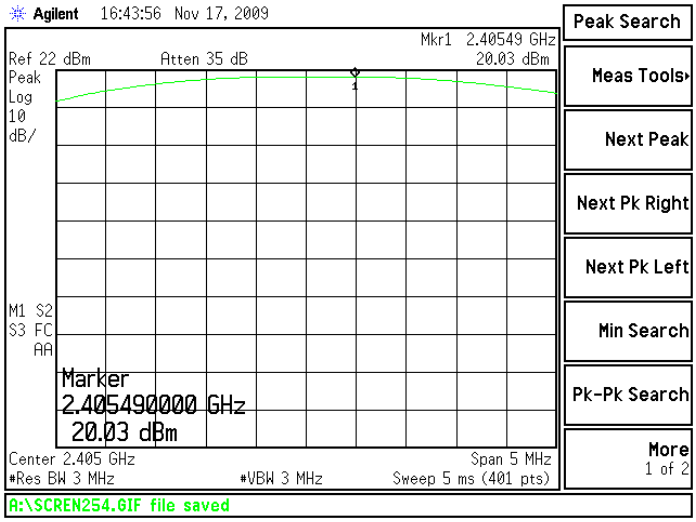

Figure 6.6-1: Output Power – Low Channel

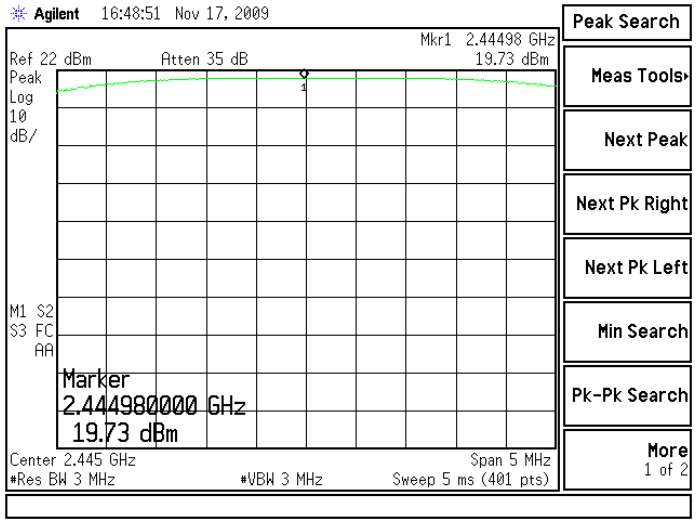

Figure 6.6-2: Output Power – Mid Channel

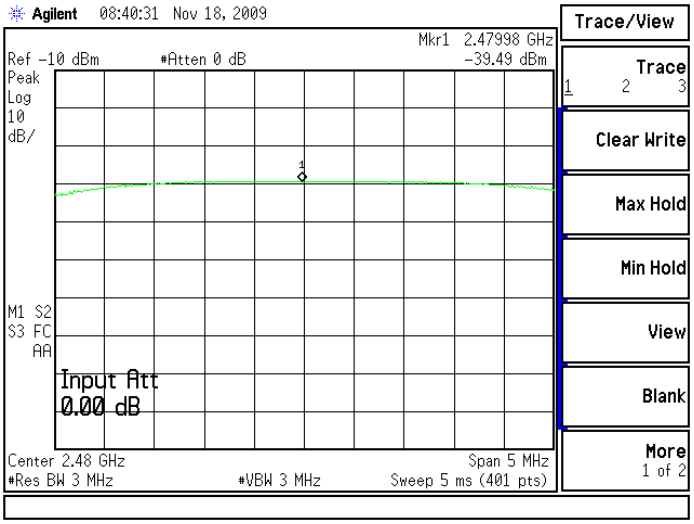

Figure 6.6-3: Output Power – High Channel

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	1.882
2445	1.983
2480	1.949

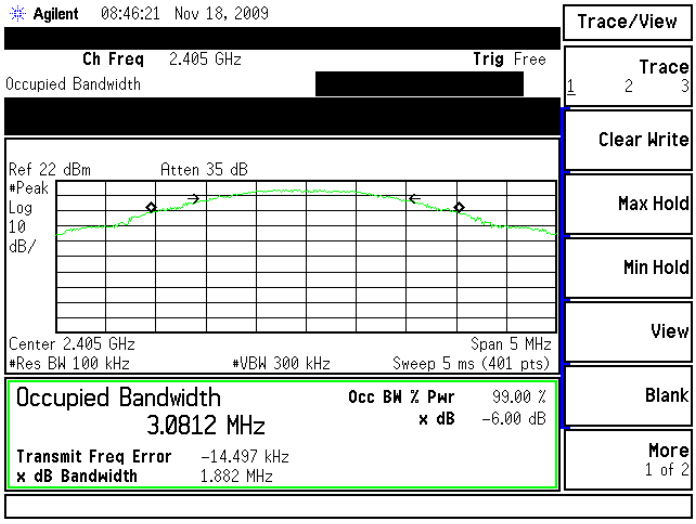

Figure 6.7-1: 6-dB Bandwidth Plot – Low Channel

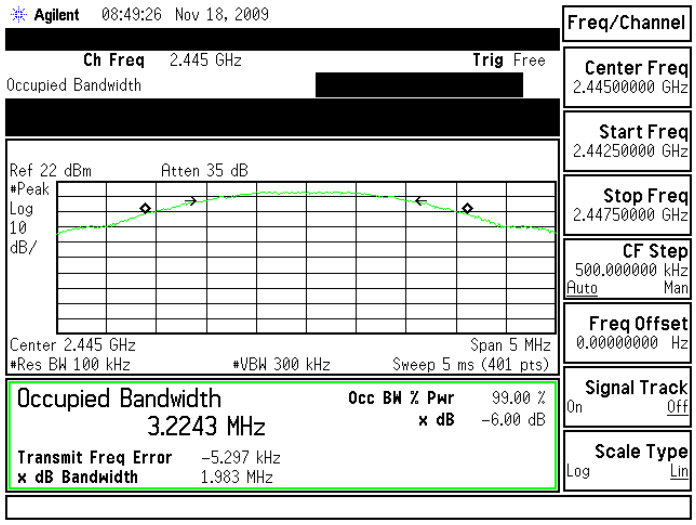

Figure 6.7-2: 6-dB Bandwidth Plot – Mid Channel

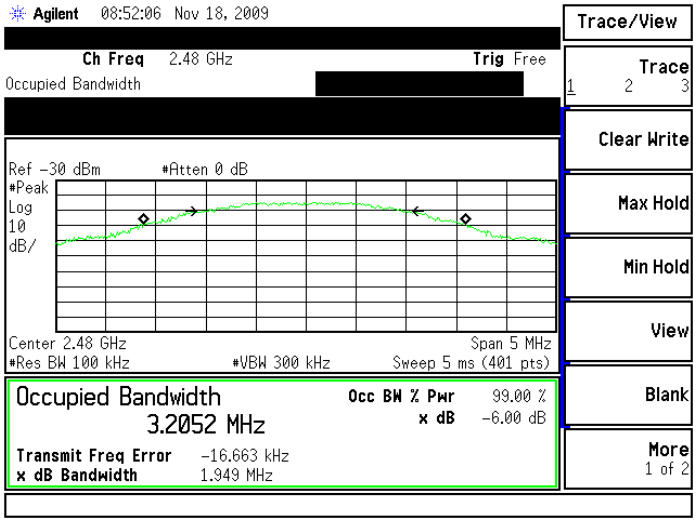

Figure 6.7-3: 6-dB Bandwidth Plot – High Channel

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.

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	4.408
2445	3.297
2480	-56.44

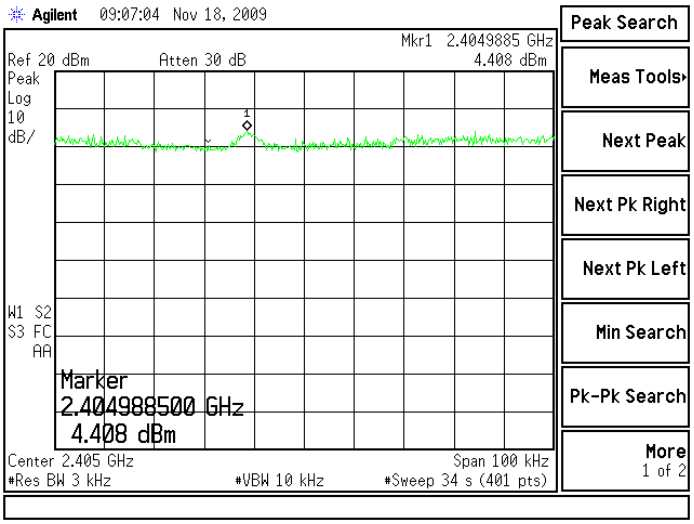

Figure 6.8-1: Power Spectral Density Plot – Low Channel

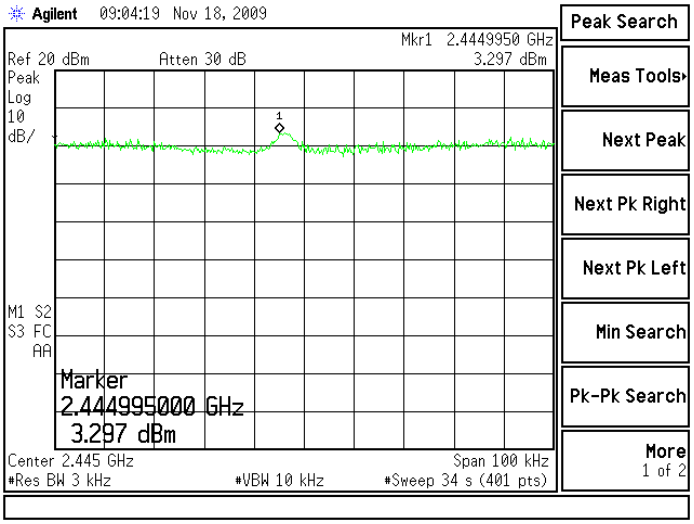

Figure 6.8-2: Power Spectral Density Plot – Mid Channel

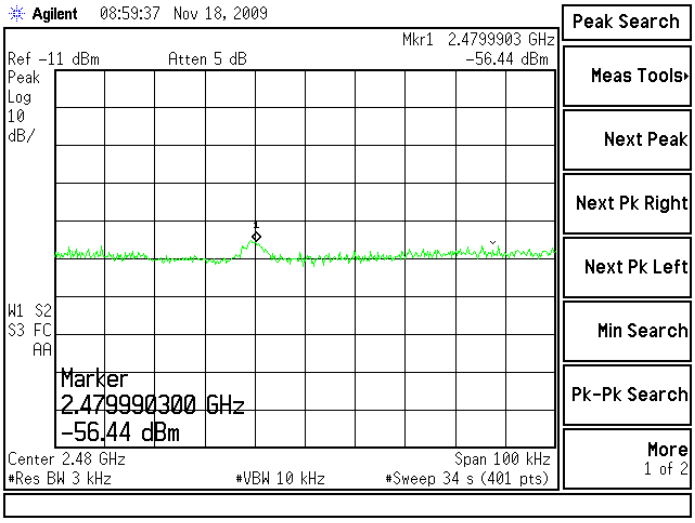

Figure 6.8-3: Power Spectral Density Plot – High Channel

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

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

6.9.1.2 Test Results

In the 100 kHz bandwidth at the lower and upper band-edges, the radio frequency power that is 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 the desired power. Band-edge compliance is displayed in Figure 6.9-1 and 6.9-2.

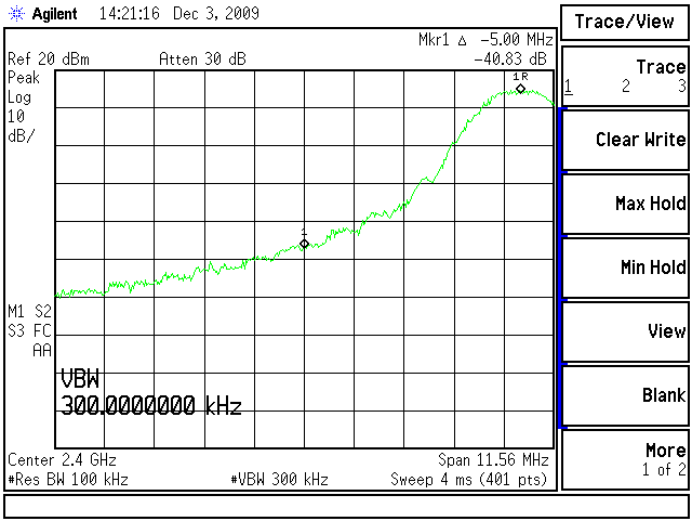

Figure 6.9-1: Lower Band-Edge (Conducted)

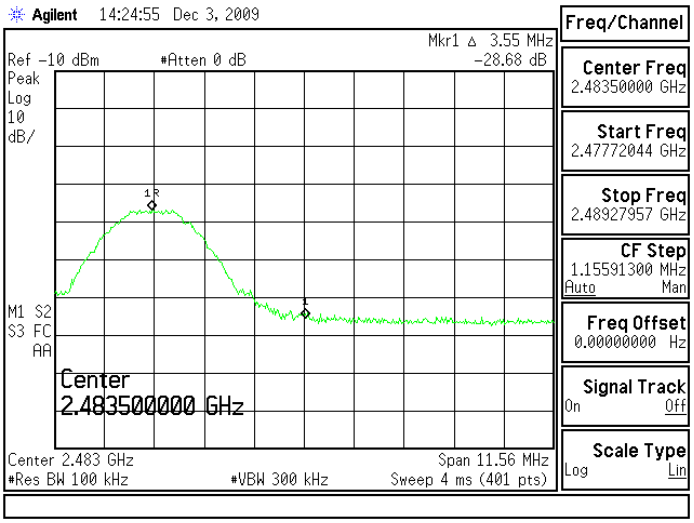

Figure 6.9-2: Upper Band-Edge (Conducted)

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.

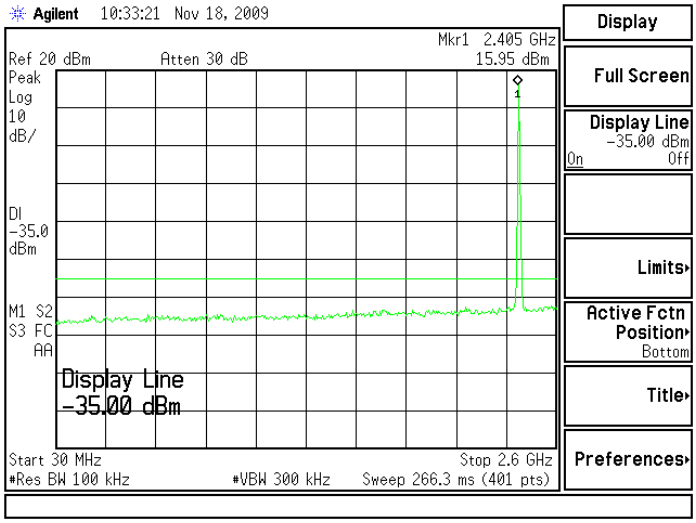

Figure 6.9-3: RF Conducted Spurious Emissions – Low Channel

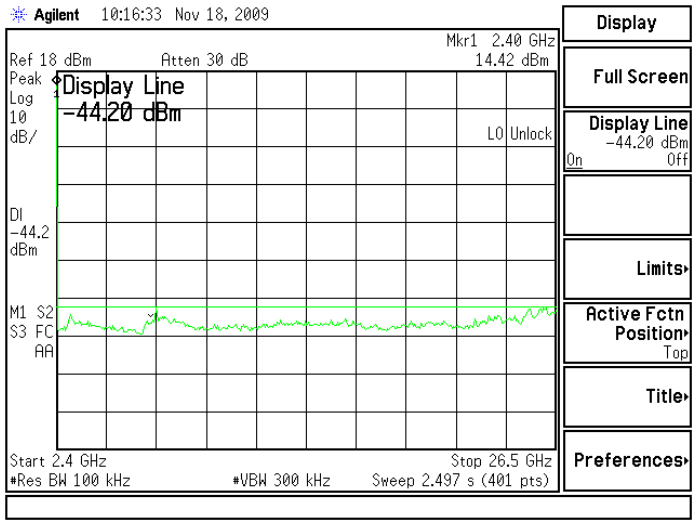

Figure 6.9-4: RF Conducted Spurious Emissions – Low Channel

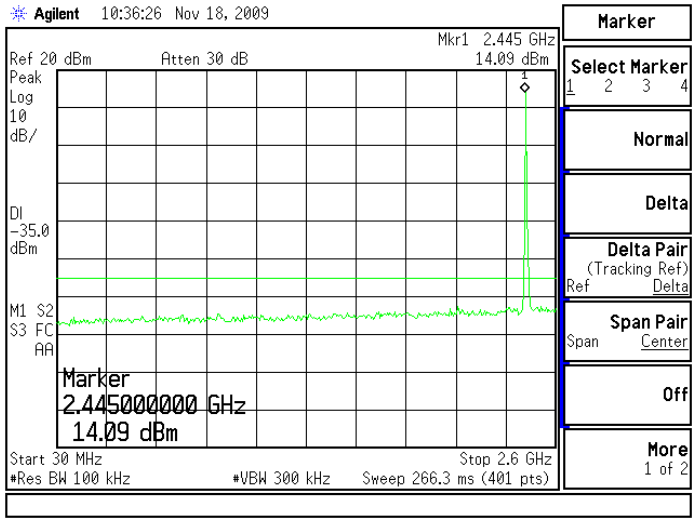

Figure 6.9-5: RF Conducted Spurious Emissions – Mid Channel

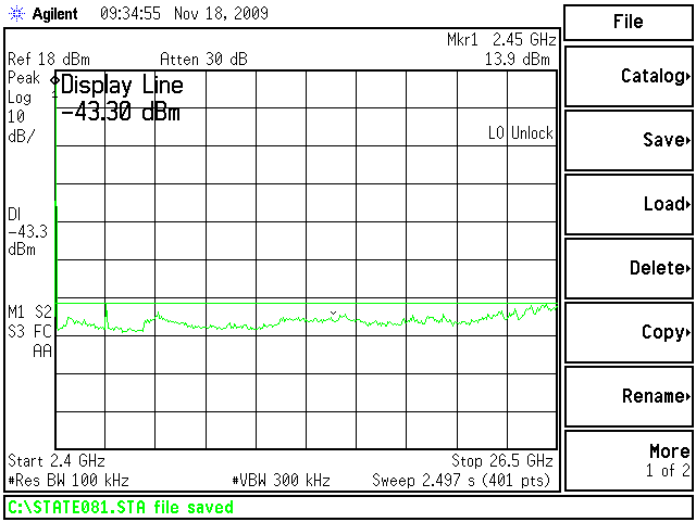

Figure 6.9-6: RF Conducted Spurious Emissions – Mid Channel

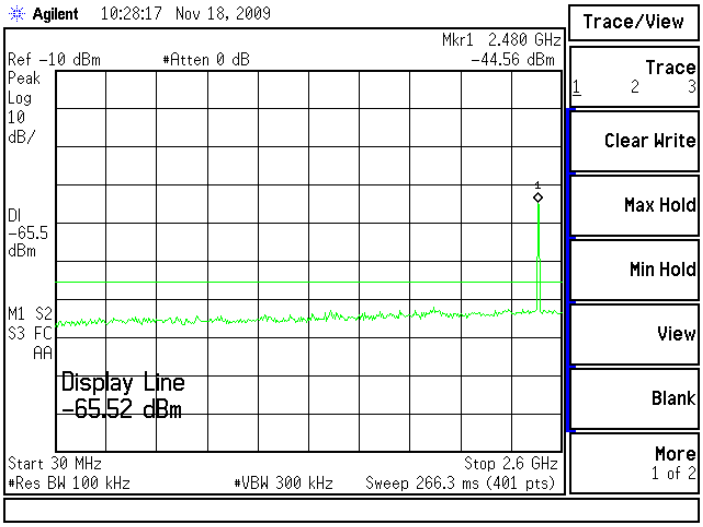

Figure 6.9-7: RF Conducted Spurious Emissions – High Channel

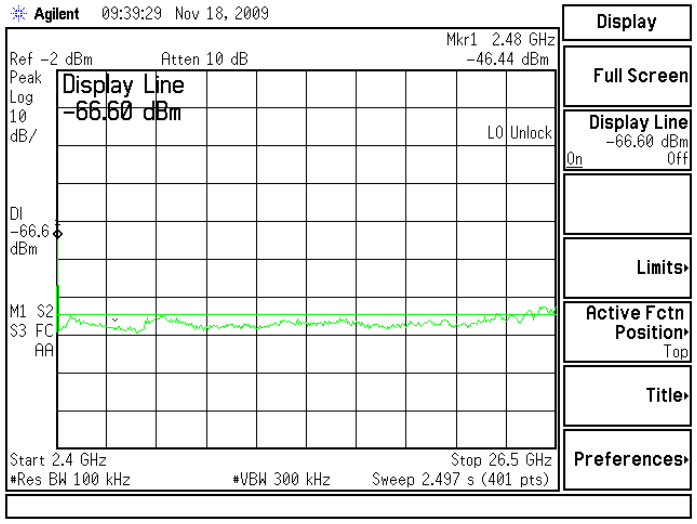

Figure 6.9-8: RF Conducted Spurious Emissions – High Channel

7.0 CONCLUSION

The S4e Universal RF endpoint model 825, manufactured by Hunt Technologies, LLC, meets the requirements of FCC Part 15 subpart C.