Testing Tomorrow's Technology

**Application**
**For**

**Title 47 USC, Part 2, Subpart J, Paragraph 2.902, Equipment Authorization of Verification for an Unintentional Radiator per Part 15, Subpart B, Paragraphs 15.107 and 15.109**

**And**

**Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart C, paragraphs 15.207, 15.209 and 15.247**

**For the**

**Inventek Systems**

**Model Number: ISM2531-USB-F**

**FCC ID: O7P-2531F**
**IC: 10147A-2531F**

**UST Project: 14-0212**
**Issue Date: November 7, 2014**

Total Pages: 55

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Testing Tomorrow's Technology

I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: 

Name: George Yang

Title: Laboratory Manager

Date November 7, 2014



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# MEASUREMENT TECHNICAL REPORT

**COMPANY NAME**: INVENTEK SYSTEMS
**MODEL:** ISM2531-USB-F
**FCC ID:** O7P-2531F
**IC:** 10147A-2351F
**DATE:** November 7, 2014

This report concerns (check one): Original grant [X]
Class II change

Equipment type: 2.4 GHz ZigBee Transmitter Module

Modulation type: DSSS, O-QPSK

Deferred grant requested per 47 CFR 0.457(d)(1)(ii)? yes_____ No X

If yes, defer until: _____N/A_____
date
agrees to notify the Commission by N/A
date
of the intended date of announcement of the product so that the grant can be issued on that date.

Report prepared by:

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# 1 General Information

## 1.1 Purpose of this Report

This report is prepared as a means of conveying test results and information concerning the suitability of this exact product for public distribution according to the FCC Rules and Regulations Part 15, Section 247.

## 1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on September 9, 2014 in good operating condition.

## 1.3 Product Description

The Equipment under Test (EUT) is the Inventek Systems model ISM2531-USB-F. The EUT is a USB dongle with Texas Instruments System-On-Chip solution for 2.4 GHz IEEE 802.15.4 and Zigbee, for use in commercial/industrial communications environments. This device is USB powered and receives its power from the USB port of the host PC.

During this evaluation the EUT was programmed using proprietary customer software. The EUT was set with the following registry configuration:

| Settings desired for Inventek Dongle RevB | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SE2438T Pin | CPS | CSD | CRX | CTX | | | | |
| Inventek Dongle Port | P0_1 | P0_7 | P1_4 | P1_1 | P0DIR | P1DIR | P0 | P1 |
| All Off | 0 | 0 | 0 | 0 | FF | FF | 0 | 0 |
| Rx Bypass | 0 | 1 | 1 | 0 | FF | FF | 80 | 10 |
| Rx High Gain | 1 | 1 | 1 | 0 | FF | FF | 82 | 10 |
| Rx Low Gain | 1 | 1 | 0 | 0 | FF | FF | 82 | 0 |
| Tx Bypass | 0 | 1 | 0 | 1 | FF | FF | 80 | 2 |
| Tx High Power | 1 | 1 | 0 | 1 | FF | FF | 82 | 2 |

These settings were in place throughout testing. Additional settings included programming the EUT to sweep through each of the 16 channels. There is a tab on the software that allows for modulated channel sweeping. So each channel was turned on and modulated for 50ms at a time. There are 16 channels so a full sweep took 0.8 seconds.

For conducted radio measurements an SMA pigtail was soldered on the EUT before the trace antenna. The trace antenna was electrically disconnected from the circuit.

## 1.4 Configuration of Tested System

The EUT was tested per *ANSI C63.4:2003, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2003)* for FCC subpart B Digital equipment Verification requirements and per FCC KDB Publication number 558074 for Digital Transmission Systems Operating Under section 15.247. Also, FCC, KDB Publication No. 558074 was used as a test procedure guide.

Digital RF conducted and radiated verification emissions data (FCC 15.107 and 109) below 1 GHz was taken with the measuring receiver (or spectrum analyzer's) resolution bandwidth adjusted to 9 kHz and 120 kHz, respectively. All measurements performed above 1.0 GHz were made with a RBW of 1 MHz. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was off throughout the evaluation process.

A list of EUT and Peripherals is found in Table 1 below. A block diagram of the tested system is shown in Figure 1. Test configuration photographs for spurious and fundamental emissions are provided in separate Appendices.

## 1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC. Its designation number is 186022. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

## 1.6 Related Submittal(s)/Grant(s)

The EUT is subject to the following FCC Equipment Authorizations:

a) Certification of the transmitter, see test data presented herein.
b) Verification as a class B digital device.

## Table 1. EUT and Peripherals

| PERIPHERAL MANUFACTURER. | MODEL NUMBER | SERIAL NUMBER | FCC ID/IC Number | CABLES P/D |
|---|---|---|---|---|
| Dongle<br>Inventek System<br>(EUT) | ISM2531-USB-F | Engineering Sample | Pending:<br>FCC ID: O7P-2531F<br>IC: 10147A-2531F | 1.5 m SD<br>USB cable |
| CC Debugger<br>Texas Instruments | CC Debugger | Engineering Sample | None | 10 cm D<br>1.0 m SD |
| Antenna<br>See antenna details | -- | -- | -- | -- |
| Laptop<br>ASUS | Eee PC 1005HA | CND | CND | 1.5 m SD<br>USB Cable |

**D** **Data Cable**
**P** **Power Cable**
**S** **Shielded**
**CND** **Could Not Determine**

# 2 Tests and Measurements

## 2.1 Test Equipment

The table below lists test equipment used to evaluate this product. Model numbers, serial numbers and their calibration status are included herein.

**Table 2. Test Instruments**

| TEST INSTRUMENT | MODEL NUMBER | MANUFACTURER | SERIAL NUMBER | DATE OF LAST CALIBRATION |
|---|---|---|---|---|
| SPECTRUM ANALYZER | E4407B | AGILENT | US41442935 | 11/8/2013 |
| SPECTRUM ANALYZER | 8566B | HEWLETT-PACKARD | 2410A00109 | 2/03/2014 |
| RF PREAMP 100 kHz to 1.3 GHz | 8447D | HEWLETT-PACKARD | 1937A02980 | 2/6/2014 |
| LOOP ANTENNA | SAS-200/562 | A. H. Systems | 142 | 9/12/2013 2 yr cycle |
| BICONICAL ANTENNA | 3110B | EMCO | 9307-1431 | 2/11/2013 2 yr cycle |
| LOG PERIODIC ANTENNA | 3146 | EMCO | 9305-3600 | 7/1/2013 2 yr cycle |
| HORN ANTENNA | SAS-571 | A. H. Systems | 9107-3723 | 7/8/2014 2 yr cycle |
| HORN ANTENNA | 3116 | EMCO | 9505-2255 | 8/08/2012 2 yr cycle with 90 day extension |
| PREAMP 1.0 GHz to 26.0 GHz | 8449B | HEWLETT-PACKARD | 3008A00480 | 2/06/14 |
| LISN | 9247-50-TS-50-N | Solar Electronics | 955824 & 955826 | 3/20/2014 |
| CALCULATION PROGRAM | N/A | N/A | Ver. 6.0 | N/A |

**Note: The calibration interval of the above test instruments are 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.**

## 2.2 Modifications to EUT Hardware

No modifications were made by US Tech in order to bring the EUT into compliance with FCC Part 15, Subpart C Intentional Radiator Limits for the transmitter portion of the EUT or the Subpart B Unintentional Radiator Limits (Receiver and Digital Device) Requirements.

## 2.3 Number of Measurements for Intentional Radiators (15.31(m))

Measurements of intentional radiators or receivers shall be performed and reported for each band in which the device can be operated, with the device operating at the number of frequencies in each band specified in Table 3 below.

**Table 3. Number of Test Frequencies for Intentional Radiators**

| Frequency Range over which the device operates | Number of Frequencies | Location in the Range of operation |
|---|---|---|
| 1 MHz or less | 1 | Middle |
| 1 to 10 MHz | 2 | 1 near the top<br>1 near the bottom |
| Greater than 10 MHz | 3 | 1 near top<br>1 near middle<br>1 near bottom |

Because the EUT operates over 2.4 GHz to 2.4835 GHz, 3 test frequencies will be used.

## 2.4 Frequency Range of Radiated Measurements (Part 15.33)

### 2.4.1 Intentional Radiator

The spectrum shall be investigated for the intentional radiator from the lowest RF signal generated in the EUT, without going below 9 kHz to the 10$^{th}$ harmonic of the highest fundamental frequency generated or 40 GHz, whichever is the lowest.

### 2.4.2 Unintentional Radiator

For the digital device, an unintentional radiator, the frequency range shall be investigated from 30 MHz to 1000 MHz, and per the table in 15.33 (b)(1) which cites a maximum range of up to the 5$^{th}$ harmonic of the highest clock frequency used by the product but not greater than 40 GHz.

## 2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the parameters described below.

### 2.5.1 Detector Function and Associated Bandwidth

For frequencies below 1000 MHz, the limits herein are based upon measurement equipment employing a CISPR quasi-peak detector function and related measurement bandwidths (i.e. 9 kHz from 150 kHz to 30 MHz and 120 kHz from 30 MHz to 1000 MHz). Alternatively, measurements may be made with equipment employing a peak detector function as long as the same bandwidths specified for the Quasi-peak device are used.

### 2.5.2 Corresponding Peak and Average Requirements

Above 1000 MHz, radiated limits are based on measuring instrumentation employing an average detector function. When average radiated emissions are specified there is also a corresponding Peak requirement, as measured using a peak detector, of 20 dB greater than the average limit. For all measurements above 1000 MHz the Resolution Bandwidth shall be at least 1 MHz.

### 2.5.3 Pulsed Transmitter Averaging

When the radiated emissions limit is expressed as an average value, and the transmitter is pulsed, the measured field strength shall be determined by applying a Duty Cycle Correction Factor based upon dividing the total ON time during the first 100 ms period by 100 ms (or by the period if greater than 100 ms). The duty cycle may also be expressed logarithmically in dB. Please section 2.8 herein for details.

## 2.6 EUT Antenna Requirements (CFR 15.203)

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. Only the antenna(s) listed in Table 4 will be used with this module.

**Table 4. Allowed Antenna(s)**

| REPORT REFERENCE | MANUFACTURER | TYPE OF ANTENNA | MODEL | GAIN $dB_i$ | TYPE OF CONNECTOR |
|---|---|---|---|---|---|
| Antenna 1 | INVENTEK SYSTEMS | Trace | N/A | 4.35 | PCB Trace |

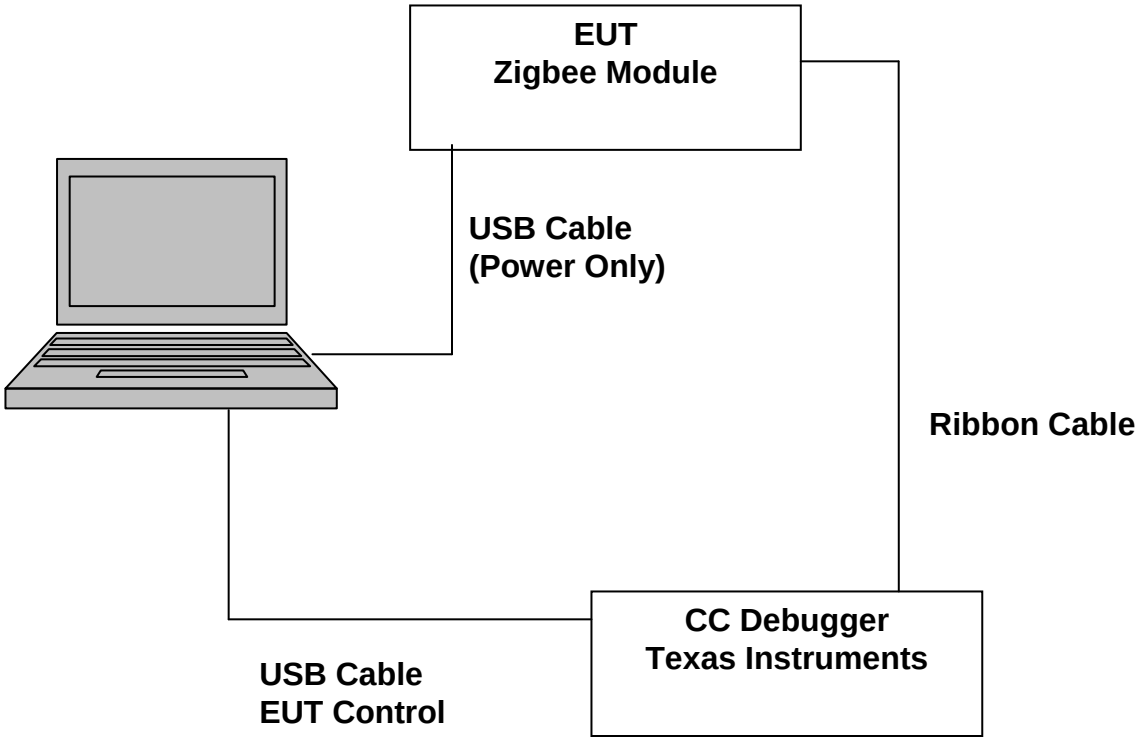



**Figure 1. Block Diagram of Test Configuration**

## 2.7 Restricted Bands of Operation (Part 15.205)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these spurious cannot exceed the limits of 15.209. Radiated harmonics and other Spurious are examined for this requirement see paragraph 2.10.

## 2.8 Transmitter Duty Cycle (CFR 15.35 (c))

The plots below were captured using the zero span test method as detailed by FCC KDB Publication 558074, DTS Measurement Guidance. The EUT was programmed to transmit at >98% ON time during all tests except for this one.

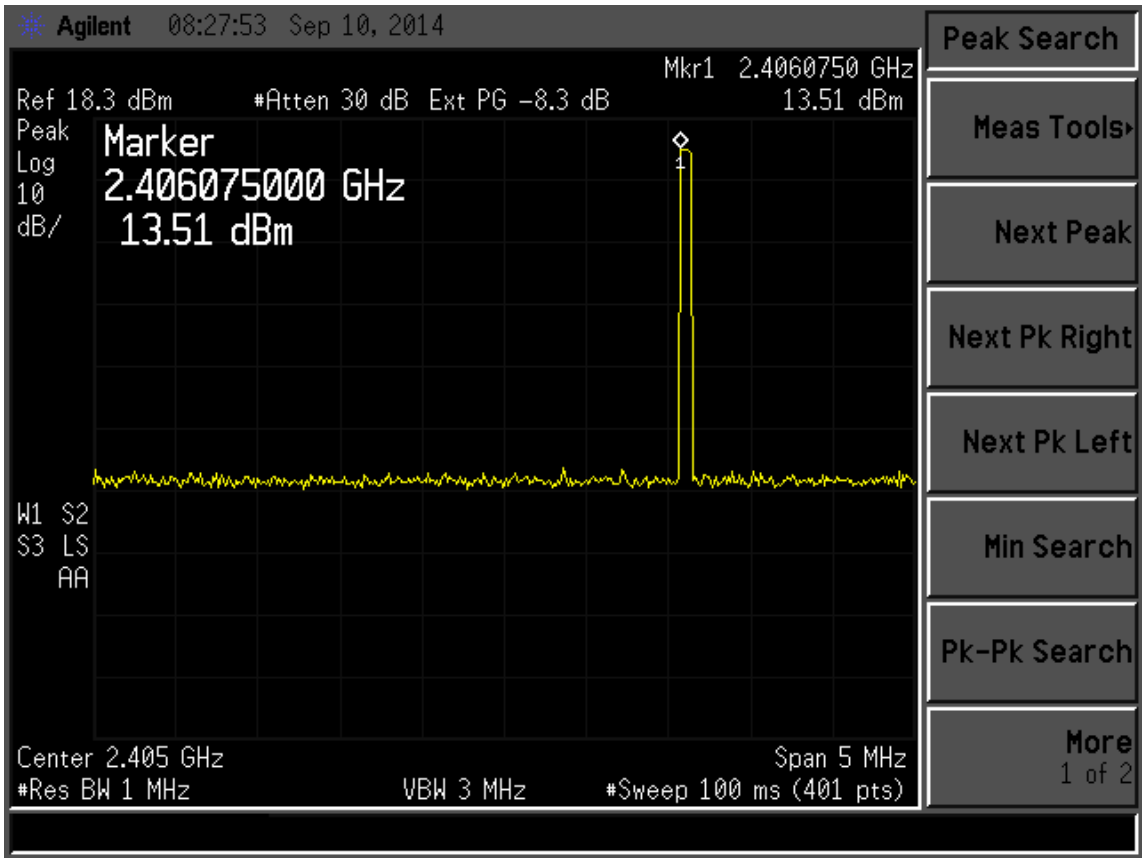



**Figure 2. Duty Cycle Data**

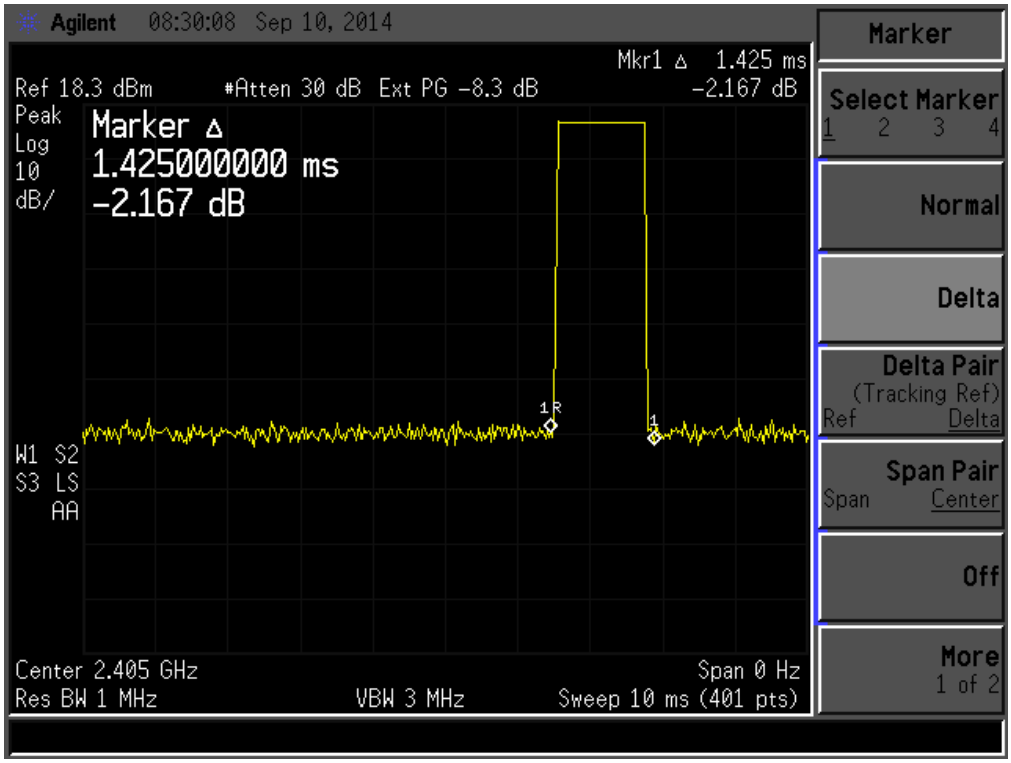



**Figure 3. Duty Cycle Data – Pulse Width**

**Total Time On from Figure 3 = 1.425mS**

**(1.425mS Total Time On)/(100mS FCC Standard) = 0.01425 Numeric Duty Cycle**
**Duty Cycle = 20 Log (0.01425) = -36.92dB**

For the purposes of this report and accompanying submittal documents a -20dB factor will be used for all average measurements.

## 2.9 Antenna Conducted Intentional and Spurious Emissions (CFR 15.209, 15.247(d)) (IC RSS 210, A2.9 (a))

The EUT was put into a continuous-transmit mode of operation and tested per FCC KDB Publication 558074 for conducted out of band emissions emanating from the antenna port over the frequency range of 30 MHz to 25 GHz. A conducted scan was performed on the EUT to identify and record spurious signals that were related to the transmitter. Antenna Conducted Emissions of a significant magnitude that fell within restricted bands were then measured as radiated emissions on the OATS. The conducted emissions graphs are found in Figures 4 through 12 below. The limit for antenna conducted power is 1 Watt (30 dBm) per 15.247 (b)(3).

For radiated measurements, the EUT was set into a continuous transmission mode. Below 1 GHz, the RBW of the measuring instrument was set equal to 120 kHz. Peak measurements above 1 GHz were measured using a RBW = 1 MHz, with a VBW ≥ RBW. The results of peak radiated spurious emissions falling within restricted bands are given in Table 5 below.

For Average Voltage measurements above 1 GHz, the emissions were measured using RBW = 1 MHz and VBW = 10 Hz. For a pulse-modulated transmitter, the EUT's average emissions are further modified by adding to them the worst-case duty cycle, determined by adding the EUT's total pulse widths (on time) over a 100 ms period and dividing by 100 ms.

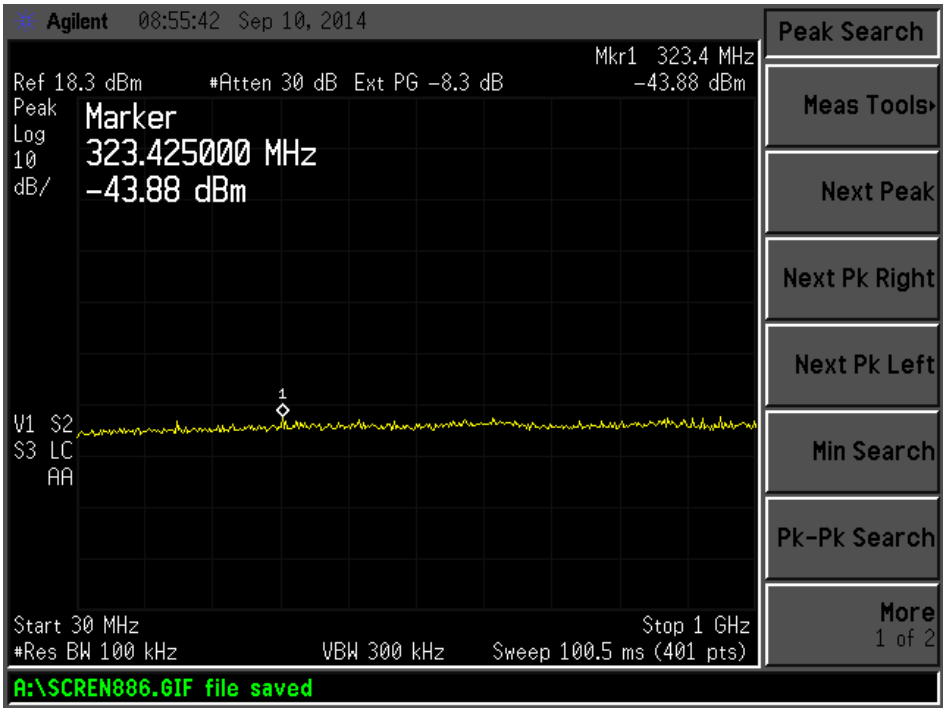



**Figure 4. Antenna Conducted Spurious Emissions – Low Channel, Part 1**

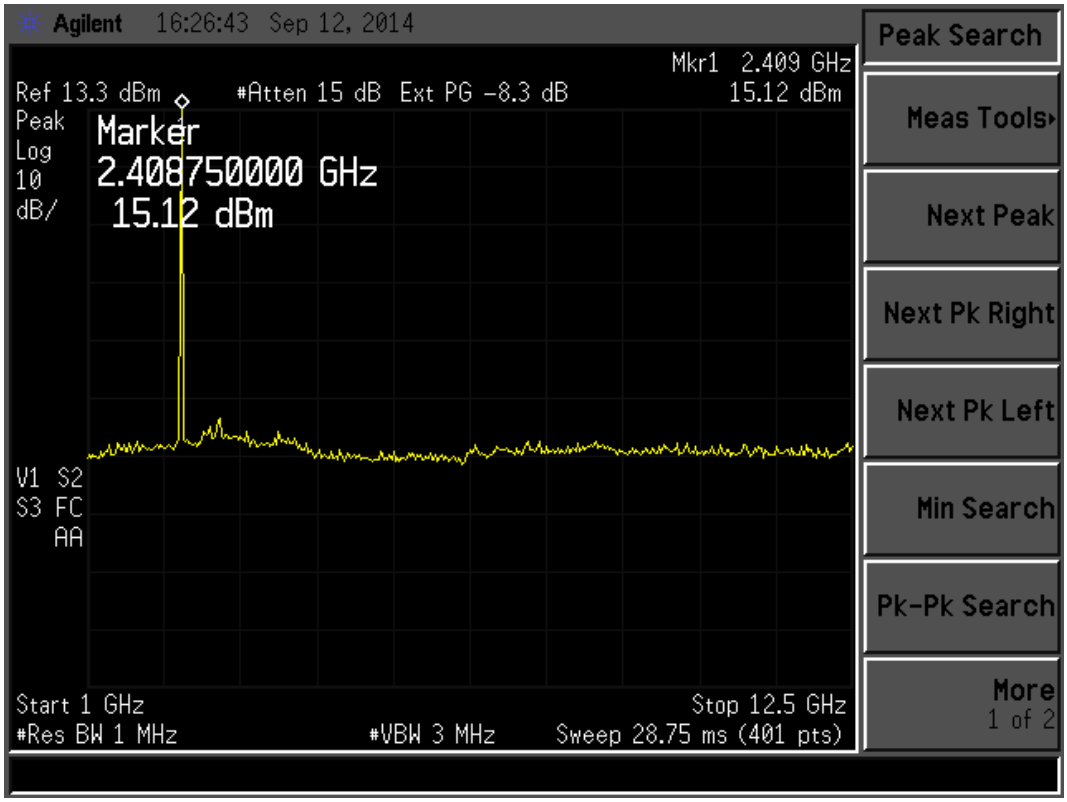



**Figure 5. Antenna Conducted Spurious Emissions – Low Channel, Part 2**

Note: Large Signal shown is Fundamental Frequency

Magnitude of Fundamental Frequency is less than 30 dBm.

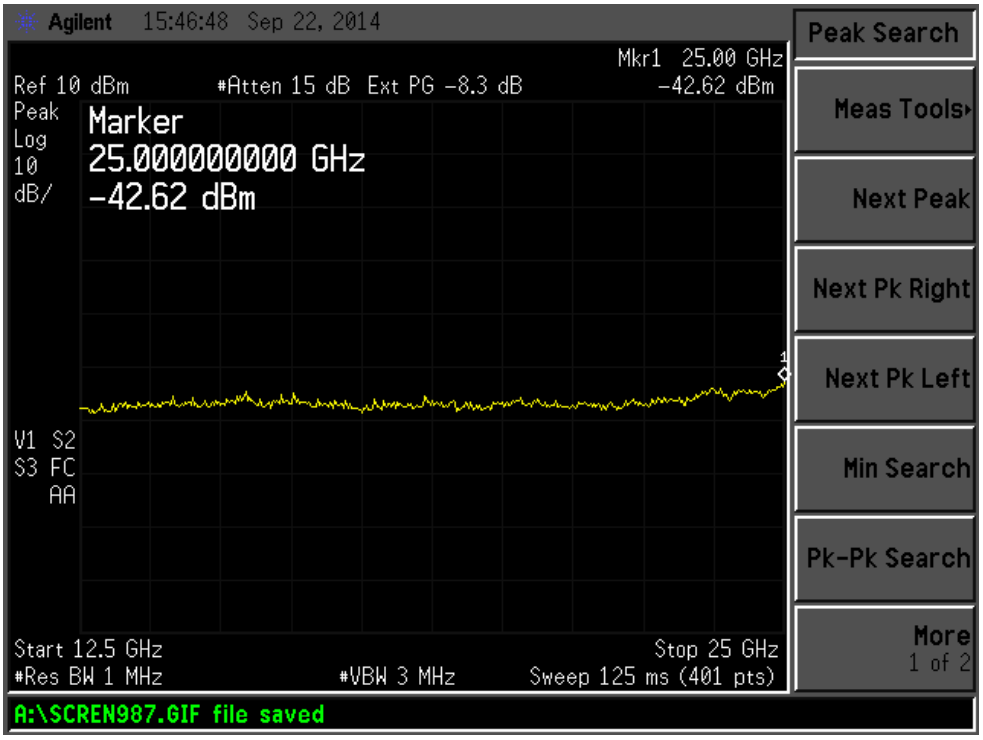



**Figure 6. Antenna Conducted Spurious Emissions – Low Channel, Part 3**

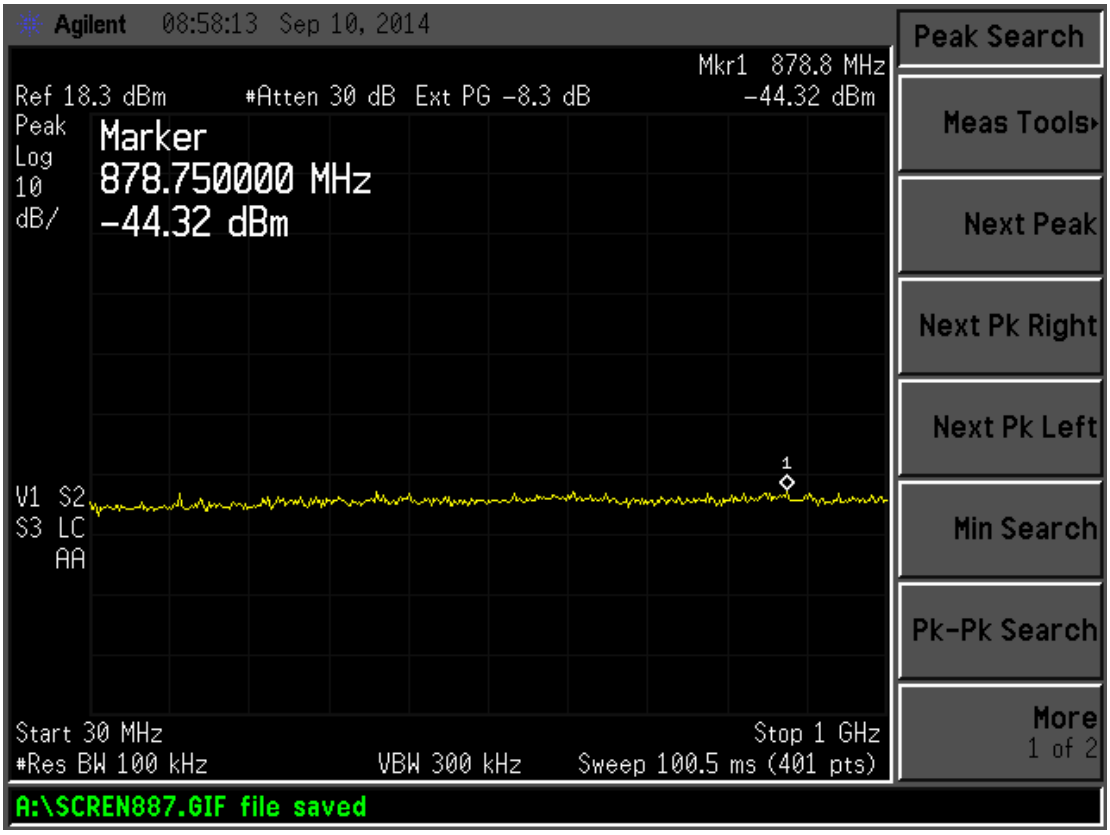



**Figure 7. Antenna Conducted Spurious Emissions – Mid Channel, Part 1**

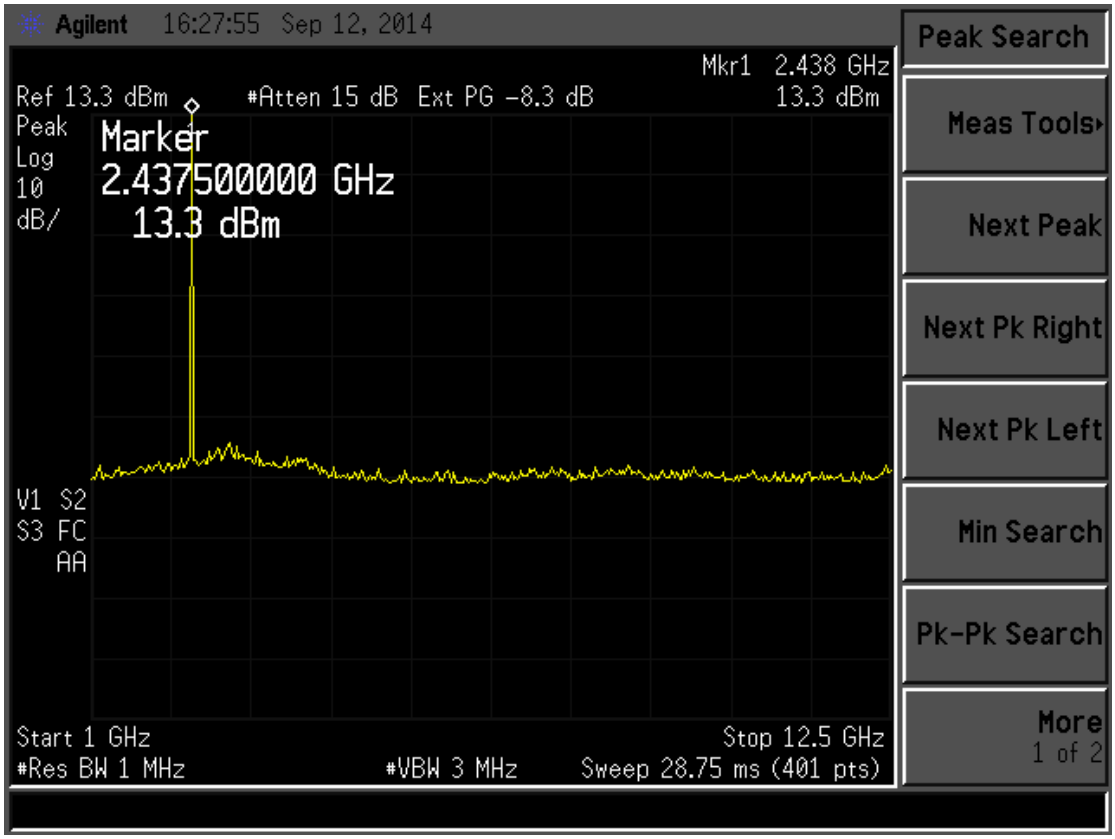



**Figure 8. Antenna Conducted Spurious Emissions – Mid Channel, Part 2**

Note: Large Signal shown is Fundamental Frequency

Magnitude of Fundamental Frequency is less than 30 dBm.

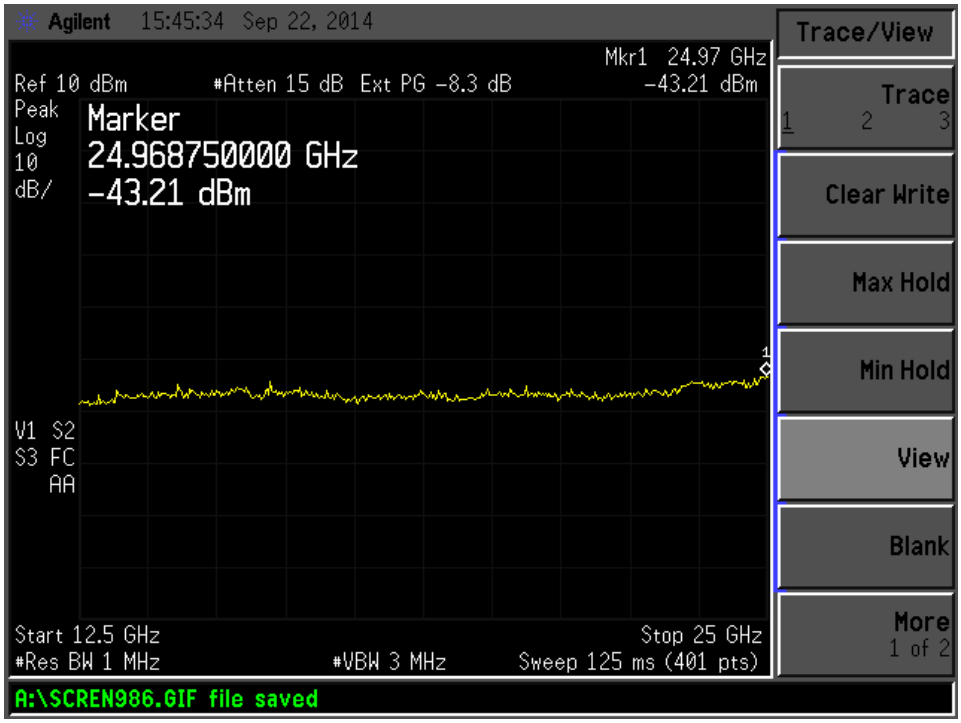



**Figure 9. Antenna Conducted Spurious Emissions – Mid Channel, Part 3**

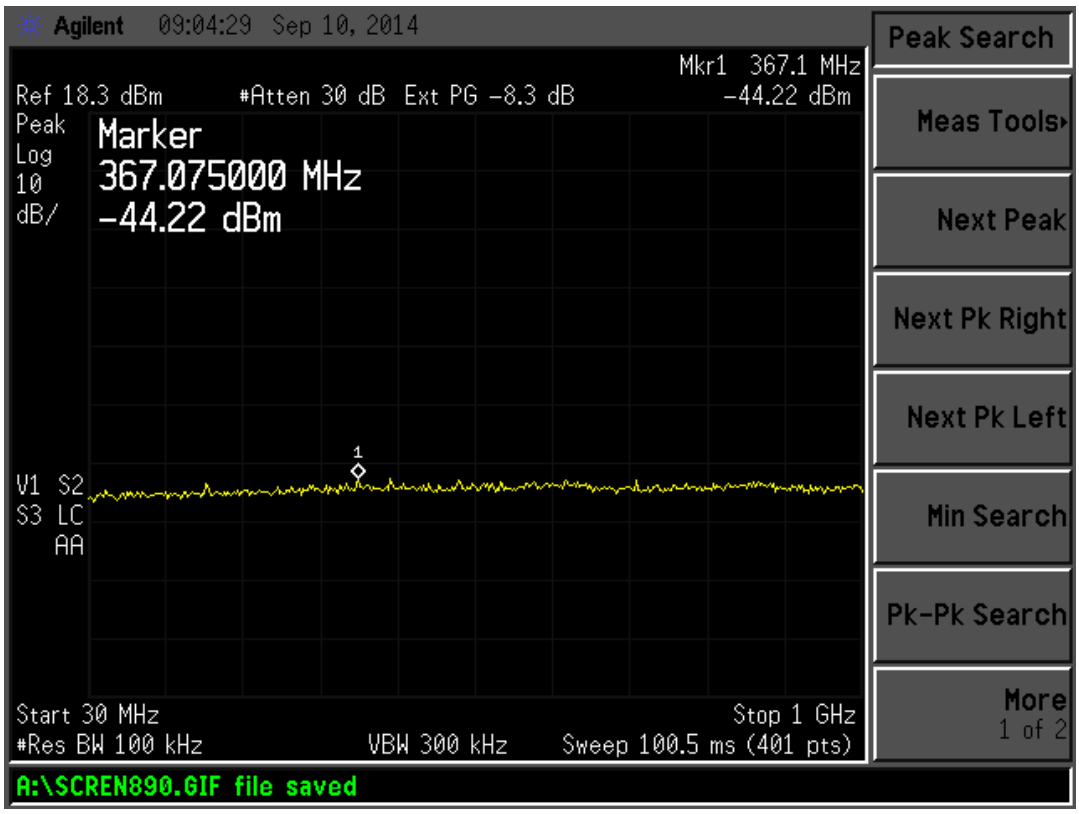



**Figure 10. Antenna Conducted Spurious Emissions – High Channel, Part 1**

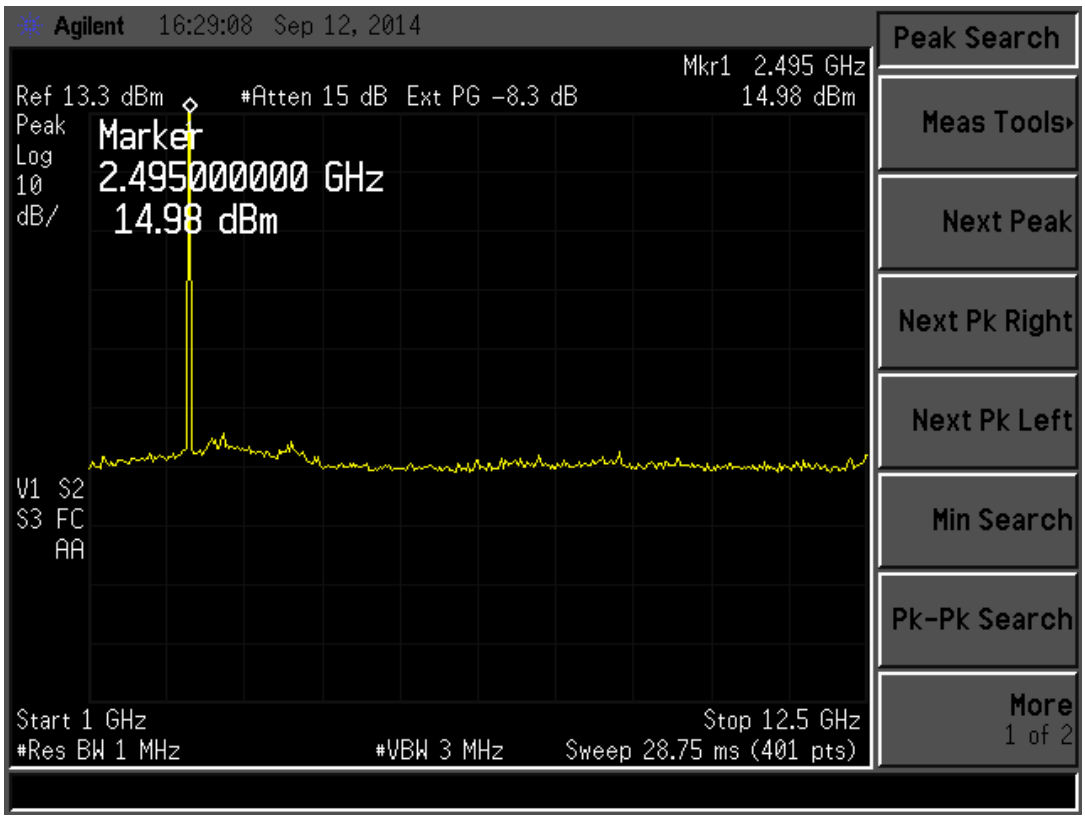



**Figure 11. Antenna Conducted Spurious Emissions – High Channel, Part 2**

Note: Large Signal shown is Fundamental Frequency

Magnitude of Fundamental Frequency is less than 30 dBm.

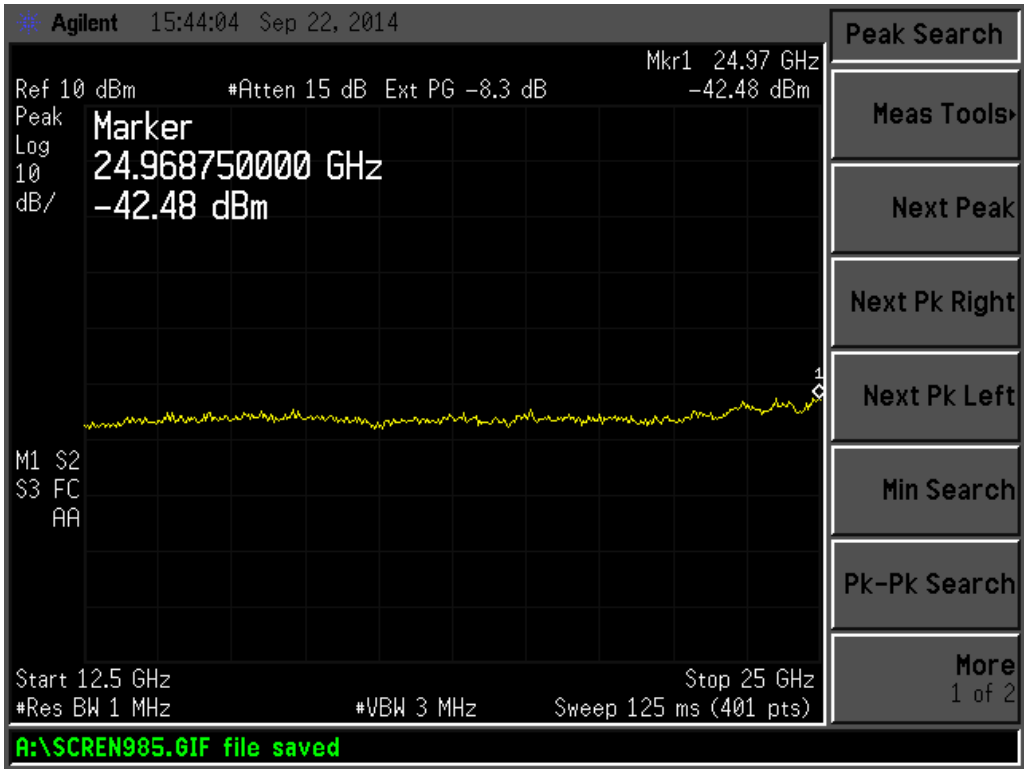



**Figure 12. Antenna Conducted Spurious Emissions – High Channel, Part 3**

## 2.10 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d))

On the OATS, the EUT was mounted on top of a non-conductive table, 80 cm above the floor, by placing it in the X-Y-Z plane along the Z axis with its bottom cover in parallel with the ground. The front of the EUT faced the measurement antenna located 3 meters away. Each signal measured was maximized by raising and lowering the receive antenna between 1 and 4 meters in height while monitoring the ever changing spectrum analyzer display (with channel A in the Clear-Write mode and channel B in the Max-Hold mode) for the largest signal visible. That exact antenna height where the signal was maximized was recorded for reproducibility purposes. Also, the EUT was rotated about its Y-axis while monitoring the Spectrum Analyzer display for maximum. The EUT azimuth was recorded for reproducibility purposes. The EUT was measured when both maxima were simultaneously satisfied.

The test data is detailed below for this section. Several radiated emissions above 1 GHz were measured at a distance of 1 meter. The measured value at 1 meter was then extrapolated to the resultant at 3 meters using an inverse distance extrapolation factor of -20 dB/decade. There were no test failures.

## Table 5. Zigbee - Peak Radiated Fundamental & Harmonic Emissions

| **Tested By:** SM | **Test:** FCC Part 15,247(d) | | | **Client:** Inventek Systems | | | |
|---|---|---|---|---|---|---|---|
| | **Project:** 14-0215 | | | **Model:** ISM2531-USB-F | | | |
| **Frequency (MHz)** | **Test Data (dBuV)** | **AF+CL-PA (dB/m)** | **Corrected Results (dBuV/m)** | **Limits (dBuV/m)** | **Distance / Polarization** | **Margin (dB)** | **DET** |
| **Low Channel - Peak** | | | | | | | |
| 2405.47 | 77.27 | 32.11 | 109.38 | | 3M/Hor. | | **PK** |
| ~4808.97 | 54.81 | 3.50 | 49.81 | 74.0 | ~1M/Hor. | 25.2 | **PK** |
| ~7216.36 | 55.71 | 10.63 | 56.84 | 74.0 | ~1M/Hor. | 17.2 | **PK** |
| **Mid Channel – Peak** | | | | | | | |
| 2439.50 | 73.57 | 32.11 | 105.68 | | 3M/Hor. | | **PK** |
| ~4881.00 | 51.88 | 3.62 | 46.00 | 74.0 | ~1M/Hor. | 28.0 | **PK** |
| ~7321.20 | 59.52 | 10.89 | 60.91 | 74.0 | ~1M/Hor. | 13.1 | **PK** |
| **High Channel – Peak** | | | | | | | |
| 2480.50 | 75.61 | 32.01 | 107.62 | | 3M/Hor. | | **PK** |
| ~4950.10 | 53.42 | 4.09 | 48.01 | 74.0 | ~1M/Hor. | 26.0 | **PK** |
| ~7442.00 | 52.00 | 10.75 | 53.25 | 74.0 | ~1M/Hor. | 20.7 | **PK** |

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. No harmonics present beyond those presented above.
3. (~)Measurements taken at 1 meter were extrapolated to 3 meters using a factor of (-9.5 dB).
4. Sample Calculation at 2440.72:

| | | |
|---|---|---|
| Magnitude of Measured Frequency (at 2405.47 MHz) | 77.27 | dBuV |
| +Antenna Factor + Cable Loss+ Amplifier Gain | 32.11 | dB/m |
| Corrected Result | 109.38 | dBuV/m |

Test Date: September 10, 2014
Tested By
Signature: Stephen Miller Name: Stephen Miller

## Table 6. Zigbee - Average Radiated Fundamental & Harmonic Emissions

| **Tested By:** SM | **Test:** FCC Part 15,247(d) | | | **Client:** Inventek Systems | | | |
|---|---|---|---|---|---|---|---|
| | **Project:** 14-0215 | | | **Model:** ISM2531-USB-F | | | |
| **Frequency (MHz)** | **Test Data (dBuV)** | **AF+CL-PA (dB/m)** | **Corrected Results (dBuV/m)** | **Limits (dBuV/m)** | **Distance / Polarization** | **Margin (dB)** | **DET** |
| **Low Channel - Average** | | | | | | | |
| 2405.47 | 74.62 | 32.11 | 86.73 | | 3M/Hor. | | **AVG** |
| ~4808.97 | 45.09 | 3.50 | 19.09 | 54.0 | 1M/Hor. | 34.9 | **AVG** |
| ~7216.36 | 46.68 | 10.63 | 27.81 | 54.0 | 1M/Hor. | 26.2 | **AVG** |
| **Mid Channel – Average** | | | | | | | |
| 2439.50 | 69.37 | 32.11 | 81.48 | | 3M/Hor. | | **AVG** |
| ~4881.00 | 41.56 | 3.62 | 15.68 | 74.0 | ~1M/Hor. | 38.3 | **AVG** |
| ~7321.20 | 49.75 | 10.89 | 31.14 | 74.0 | ~1M/Hor. | 22.8 | **AVG** |
| **High Channel – Average** | | | | | | | |
| 2480.50 | 72.49 | 32.01 | 84.5 | | 3M/Hor. | | **AVG** |
| ~4960.90 | 44.26 | 4.09 | 18.85 | 54.0 | 3M/Hor. | 35.1 | **AVG** |
| ~7442.00 | 40.61 | 10.75 | 21.86 | 54.0 | 3M/Hor. | 32.1 | **AVG** |

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 CFR 15.35.
2. No other signals detected within 20 dB of specification limit. No harmonics present beyond those presented above.
3. (~)Measurements taken at 1 meter were extrapolated to 3 meters using a factor of (-9.5 dB).
4. All measurements are corrected with a -20 dB duty cycle. See section 2.8
5. Sample Calculation at 2405.47 MHz:

| | | |
|---|---|---|
| Magnitude of Measured Frequency (at 2405.47 MHz) | 74.62 | dBuV |
| +Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle | 32.11 | dB/m |
| Corrected Result | 86.73 | dBuV/m |

Test Date: September 10, 2014
Tested By
Signature: Stephen Miller Name: Stephen Miller

## 2.11 Band Edge Measurements – (CFR 15.247 (d))

Band Edge measurements are made following the guidelines in FCC KDB Publication No. 558074 with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Antenna port conducted measurements are performed to demonstrate compliance with the requirement of 15.247(d) that all emissions outside of the band edges be attenuated by at least 20 dB when compared to its highest in-band value (contained in a 100 kHz band). Because these frequencies occur above 1000 MHz they have both a peak and average requirement.

To capture the band edge, set the Spectrum Analyzer frequency span large enough (usually around 10 MHz) to capture the peak level of the emission operating on the channel closest to the band edge as well as any modulation products falling outside of the authorized band of operation. Conducted measurements are performed with RBW ≥1% of the frequency span. In all cases, the VBW is set ≥ RBW. See figures and calculations below for more detail.

The limit for the average value of radiated emissions in a Restricted Band is 54 dBuV/m. To compute the average values of the band edge emissions, the duty cycle correction factor of -20.00 dB is applied to the values in the Corrected Results column. After this correction the EUT is found to have met the restrictions placed on average radiated emissions in Restricted Bands. The worst-case measurement is computed below.

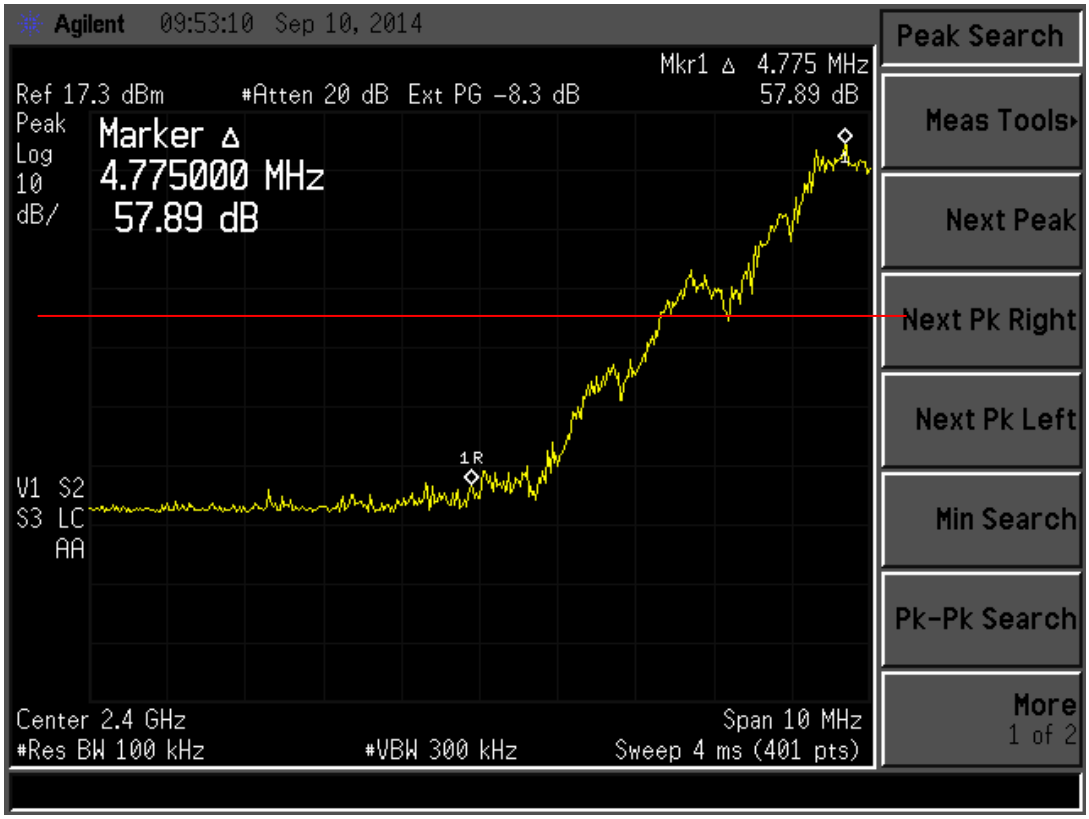



**Figure 13. Band Edge Compliance – Low Channel Delta - Peak**

Lower band edge must be 20 dB below the fundamental.

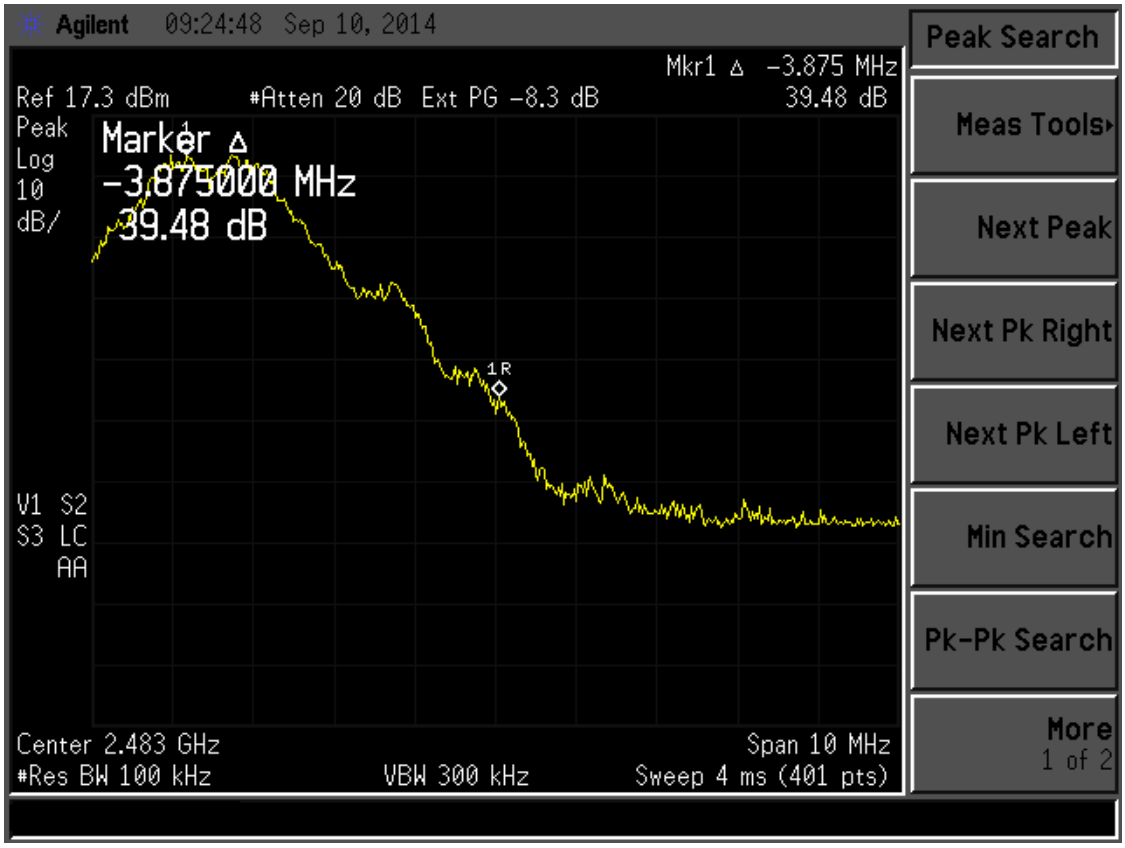



**Figure 14. Band Edge Compliance – High Channel Delta - Peak**

Calculation of worst case PEAK upper band edge measurement:

| | | |
|---|---|---|
| High Channel Corrected Measured Value from Table 5 | 107.62 | dBuV |
| High Channel Band Edge Delta from Figure 11 | -39.48 | dB |
| Calculated Result | 68.14 | dBuV/m |
| | | |
| Average Limit + 20 dB relaxation | 74.00 | dBuV/m |
| Calculated Result | -68.14 | dBuV/m |
| Band Edge Margin (PEAK) | 5.86 | dBuV/m |

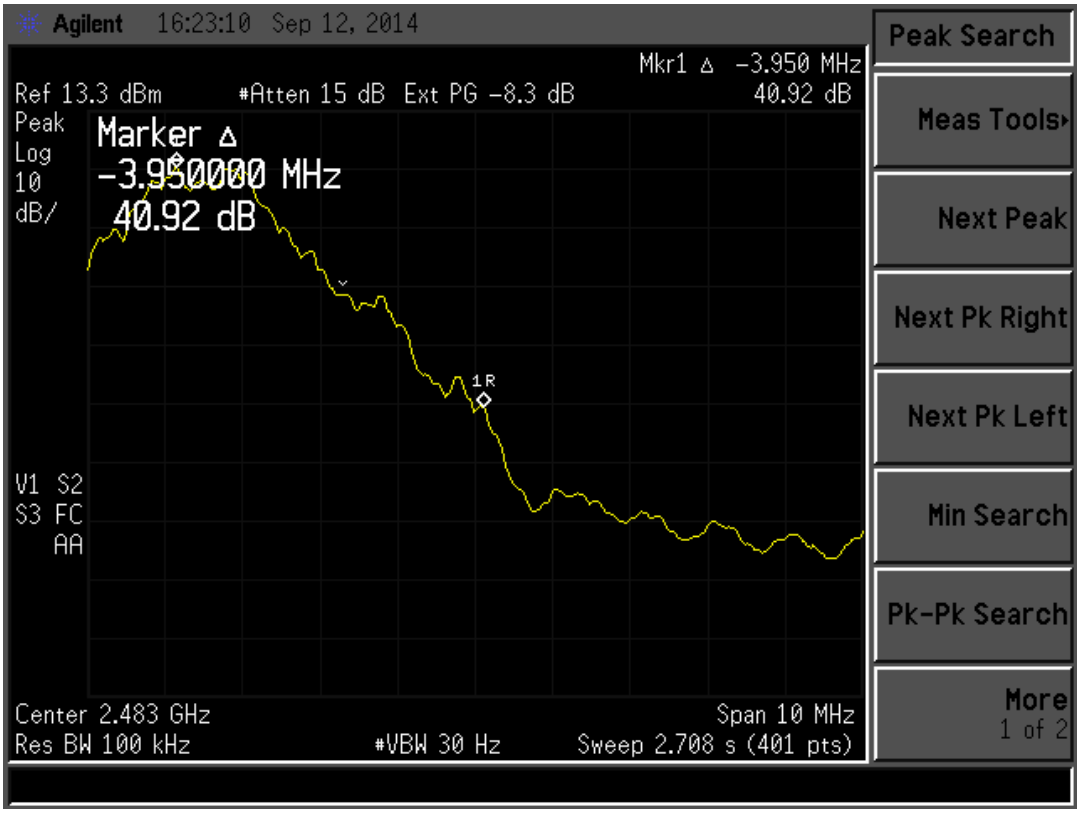



**Figure 15. Band Edge Compliance – High Channel Delta - Average**

Calculation of worst case AVERAGE upper band edge measurement:

| | | |
|---|---|---|
| High Channel Corrected Measured Value from Table 6 | 84.50 | dBuV |
| High Channel Band Edge Delta from Figure 12 | -40.92 | dB |
| Calculated Result | 43.58 | dBuV/m |
| | | |
| AVG Limit | 54.00 | dBuV/m |
| Calculated Result | -43.58 | dBuV/m |
| Band Edge Margin (AVG) | 10.42 | dBuV/m |

## 2.12 Six (6) dB Bandwidth per CFR 15.247(a)(2)

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance. Measurements were performed per the method of FCC, KDB Publication No. 558074 for a bandwidth of 6 dB. The RBW was set to approximately 1/100 of the manufacturers claimed RBW and with the VBW ≥ RBW. The results of this test are given in the table below and figures below.

**Table 7. Six (6) dB Bandwidth**

| Frequency (MHz) | 6 dB Bandwidth (MHz) | Minimum FCC Bandwidth (MHz) |
|---|---|---|
| 2405 | 1.575 | 0.5 |
| 2440 | 1.600 | 0.5 |
| 2480 | 1.525 | 0.5 |

Test Date: September 10, 2014
Tested By
Signature: _____ Name: John Wynn

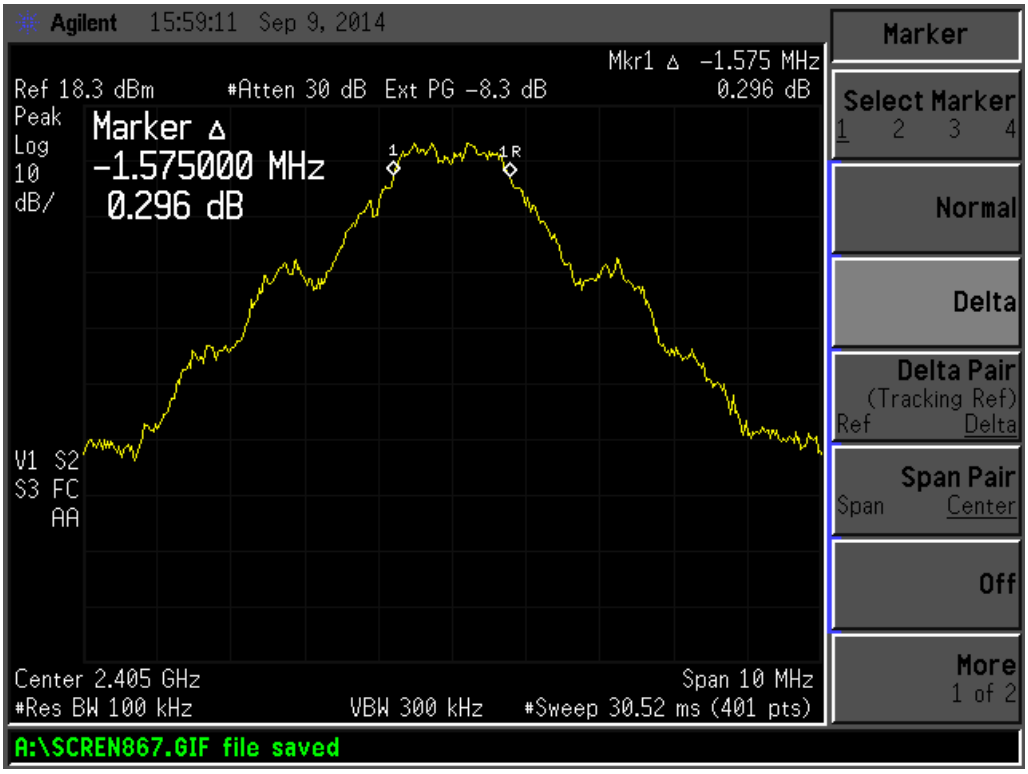



**Figure 16. Low Channel 6dB Bandwidth**

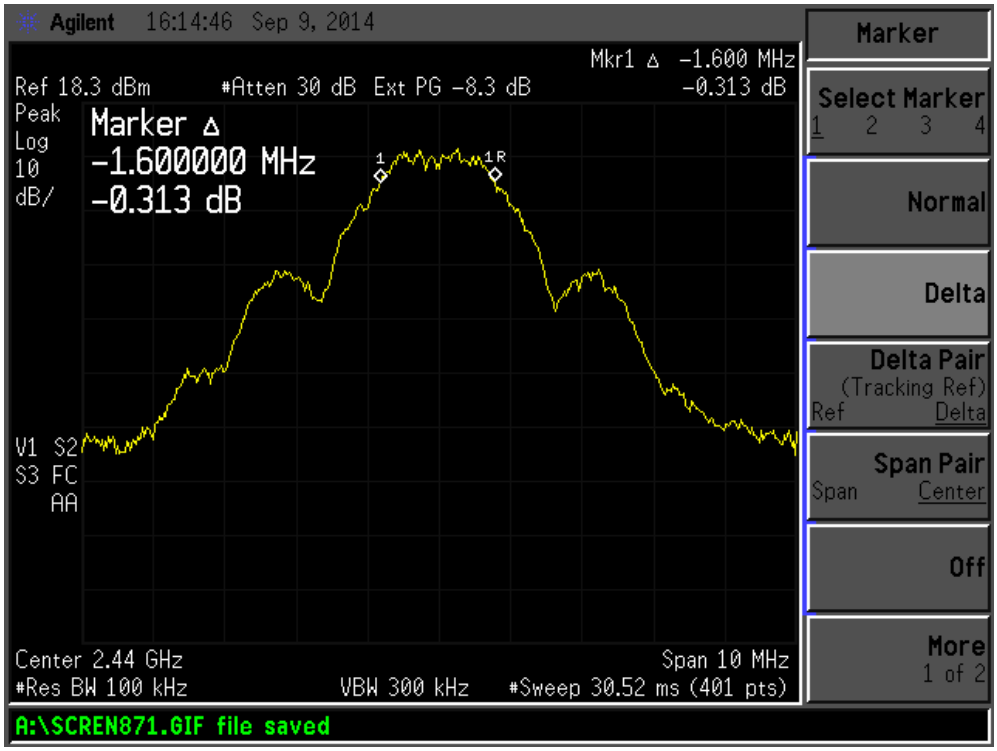



**Figure 17. Mid Channel 6dB Bandwidth**

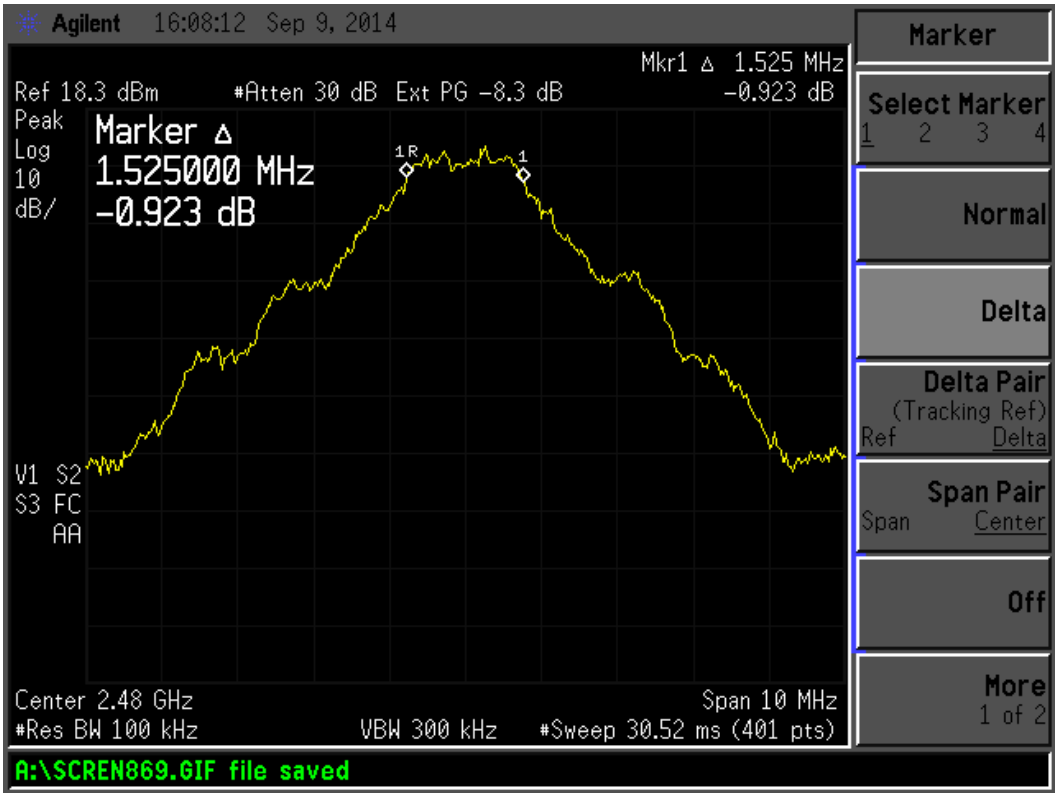



**Figure 18. High Channel 6dB Bandwidth**

## 2.13 Occupied Bandwidth, 99%

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance. The spectrum analyzer was set to have a span that was greater than the occupied bandwidth. The RBW was set to approximately 1/100 of the manufacturers claimed occupied bandwidth and the VBW ≥ RBW. The results of this test are displayed in the following figures and tabulated below.

**Table 8. 99% Occupied Bandwidth**

| Frequency (MHz) | 99% Occupied Bandwidth (MHz) |
|---|---|
| 2405.0 | 3.05 |
| 2440.0 | 2.88 |
| 2480.0 | 3.30 |

Test Date: September 9, 2014
Tested By
Signature: _____ Name: John Wynn

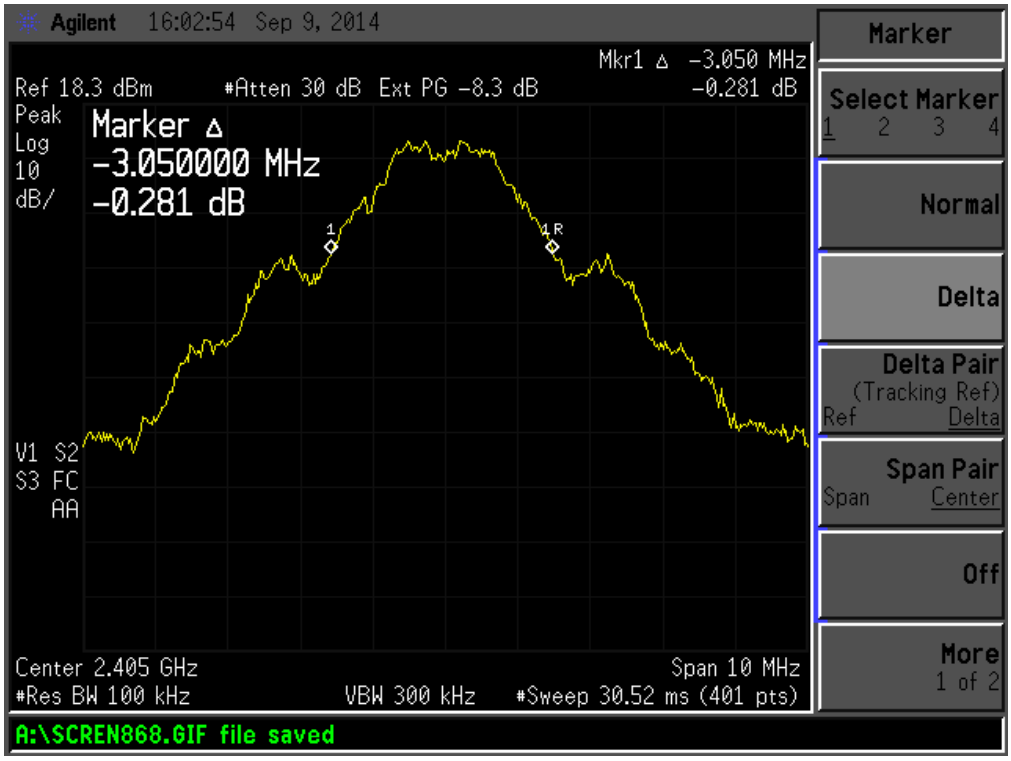



**Figure 19. Bandwidth - Low Channel**

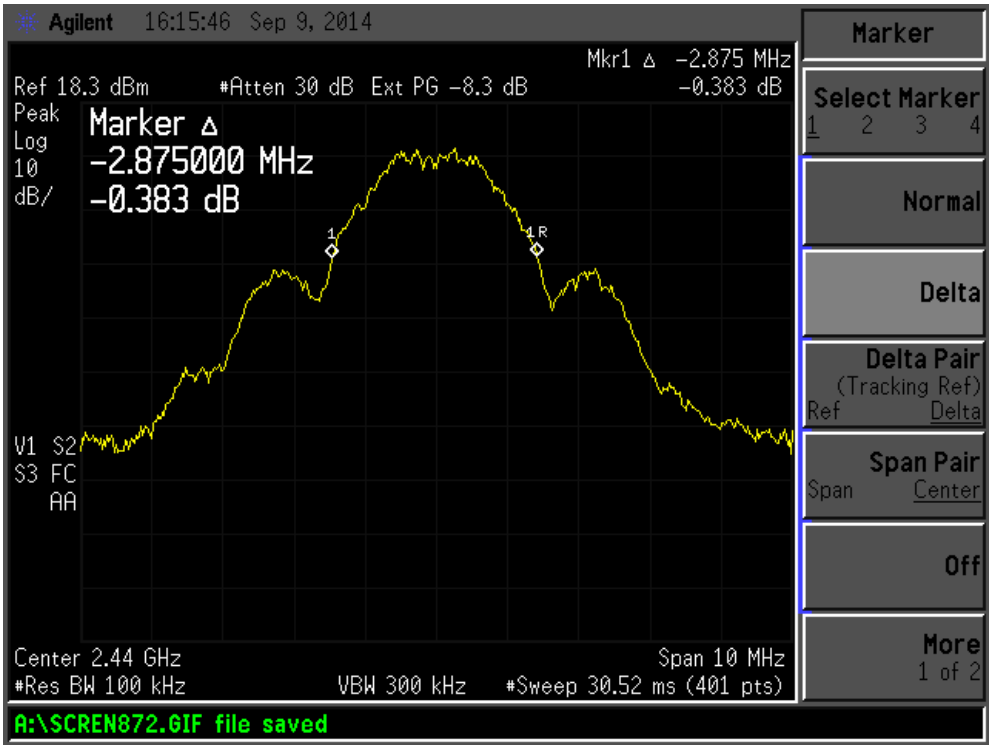



**Figure 20. Bandwidth - Mid Channel**

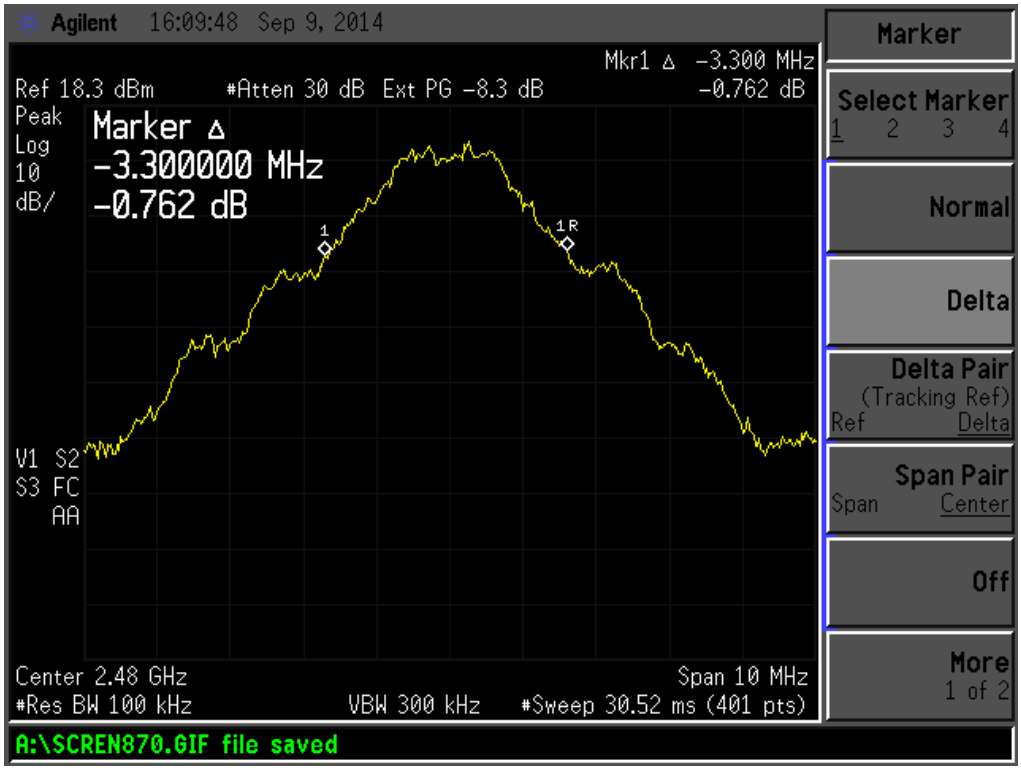



**Figure 21. Bandwidth - High Channel**

## 2.14 Maximum Peak Conducted Output Power (CFR 15.247 (b) (3))

For the EUT, the transmitter was programmed to operate at a maximum output power across the bandwidth. For this test the output power of the radio was set to the highest level. See the product description section above for details on the exact settings.

Peak power within the band 2400 MHz to 2483.5 MHz was measured per FCC KDB Publication 558074 as an Antenna Conducted test with a spectrum analyzer by connecting the spectrum analyzer directly, via a short RF cable, and attenuators to the antenna output terminals on the EUT. The spectrum analyzer was set for an impedance of 50 Ω with the RBW set greater than the 6 dB bandwidth of the EUT, and the VBW ≥ RBW. Peak antenna conducted output power is tabulated in the table below.

**Table 9. Peak Antenna Conducted Output Power per Part 15.247 (b)(3)**

| Frequency of Fundamental (MHz) | Raw Test Data dBm | Converted Data (mW) | FCC Limit (mW Maximum) |
|---|---|---|---|
| 2405 | 15.51 | 35.56 | 1000 |
| 2440 | 13.62 | 23.01 | 1000 |
| 2480 | 15.06 | 32.06 | 1000 |

Test Date: September 9, 2014
Tested By
Signature: _____ Name: John Wynn

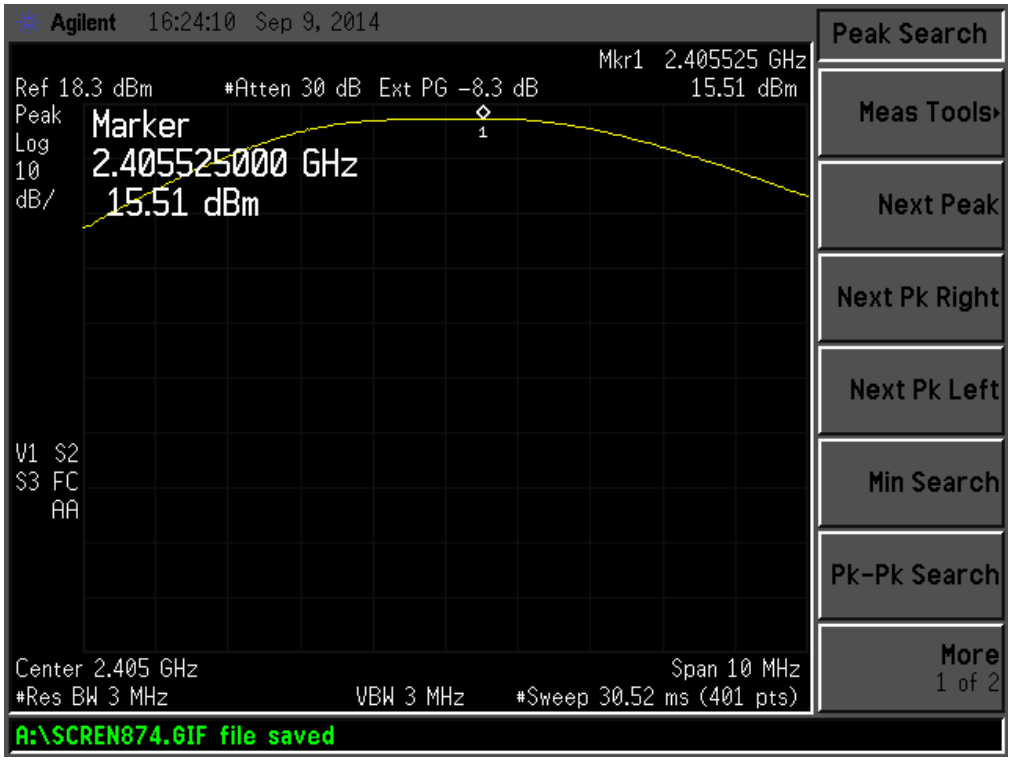



**Figure 22. Peak Antenna Conducted Output Power, Low Channel**

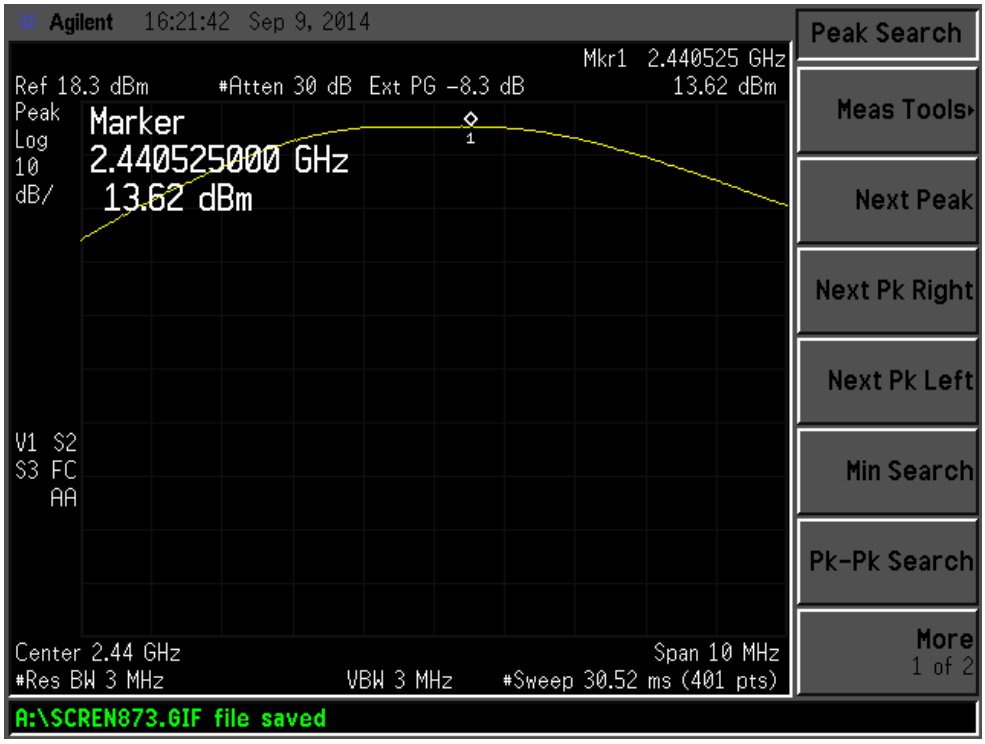



**Figure 23. Peak Antenna Conducted Output Power, Mid Channel**

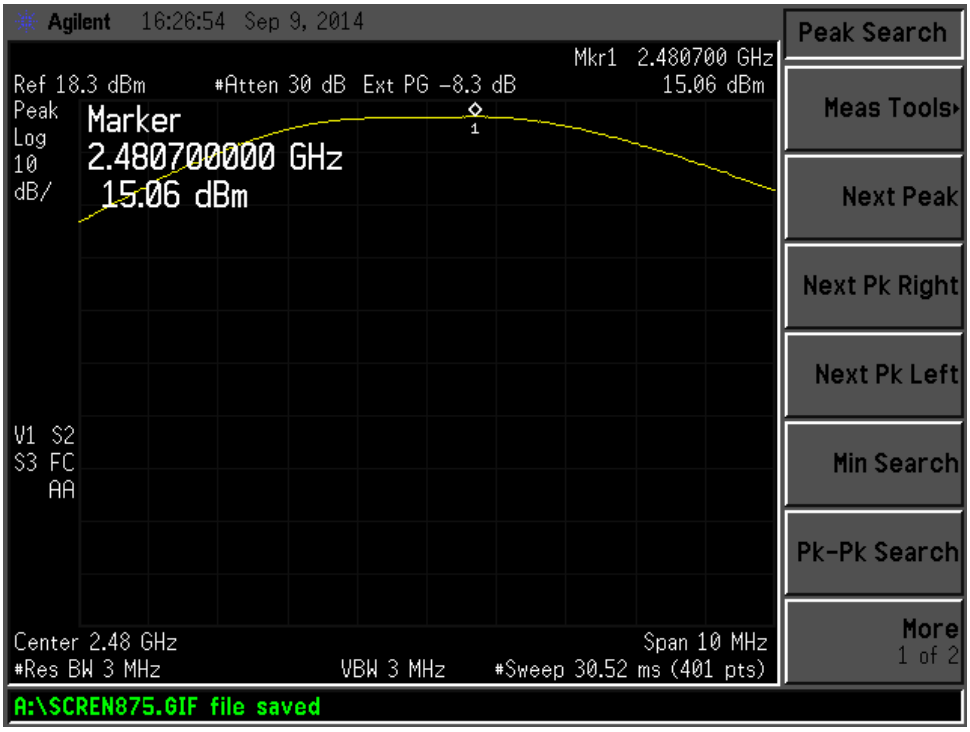



**Figure 24. Peak Antenna Conducted Output Power, High Channel**

## 2.15 Power Spectral Density (CFR 15.247(e))

The transmitter was placed into a continuous mode of operation at all applicable frequencies. The measurements were performed per the procedures of FCC KDB Procedure 558074. The RBW was set to 3 kHz and the Video Bandwidth was set to ≥ RBW. The trace capture time was set to (Span/3 kHz).

In accordance with 15.247 (e), the power spectral density shall be no greater than +8 dBm per any 3 kHz band.

Results are shown in the table and figures below. All are less than +8 dBm per 3 kHz band.

**Table 10. Power Spectral Density for Low, Mid and High Bands**

| Frequency (MHz) | Results (dBm/3 kHz) | FCC Limit (dBm/3 kHz) |
|---|---|---|
| Low-2405 | 2.346 | +8.0 |
| Mid-2480 | -0.391 | +8.0 |
| High-2480 | 0.988 | +8.0 |

Test Date: September 9, 2014
Tested By
Signature: _____ Name: John Wynn

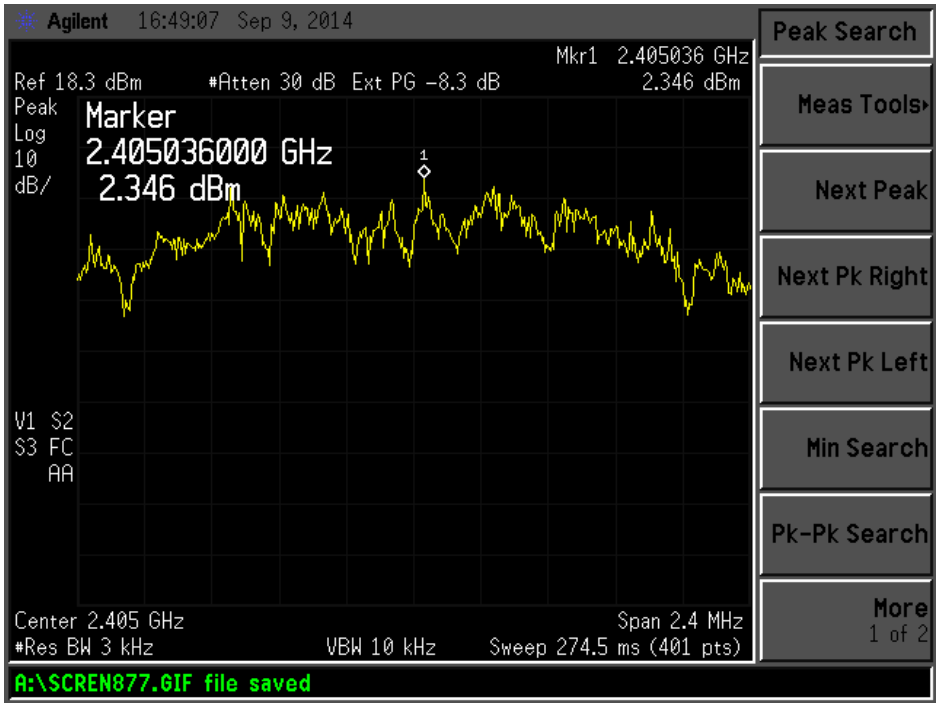



**Figure 25. Peak Power Spectral Density - Part 15.247 (e) - Low Channel**

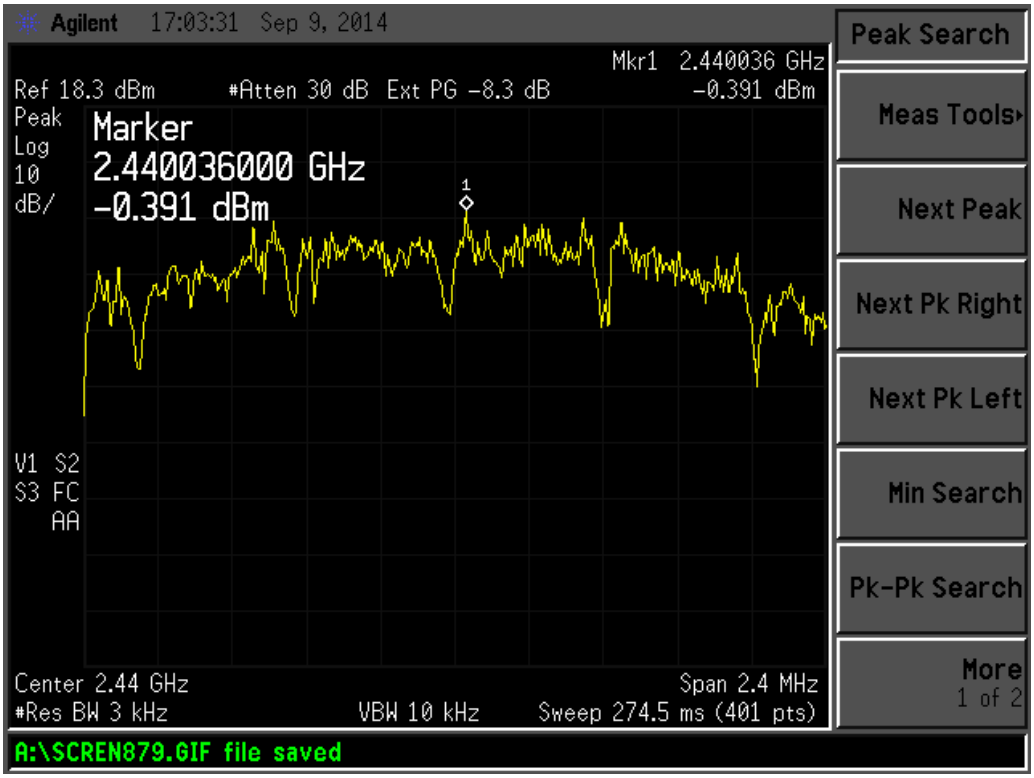



**Figure 26. Power Spectral Density - Part 15.247 (e) - Mid Channel**

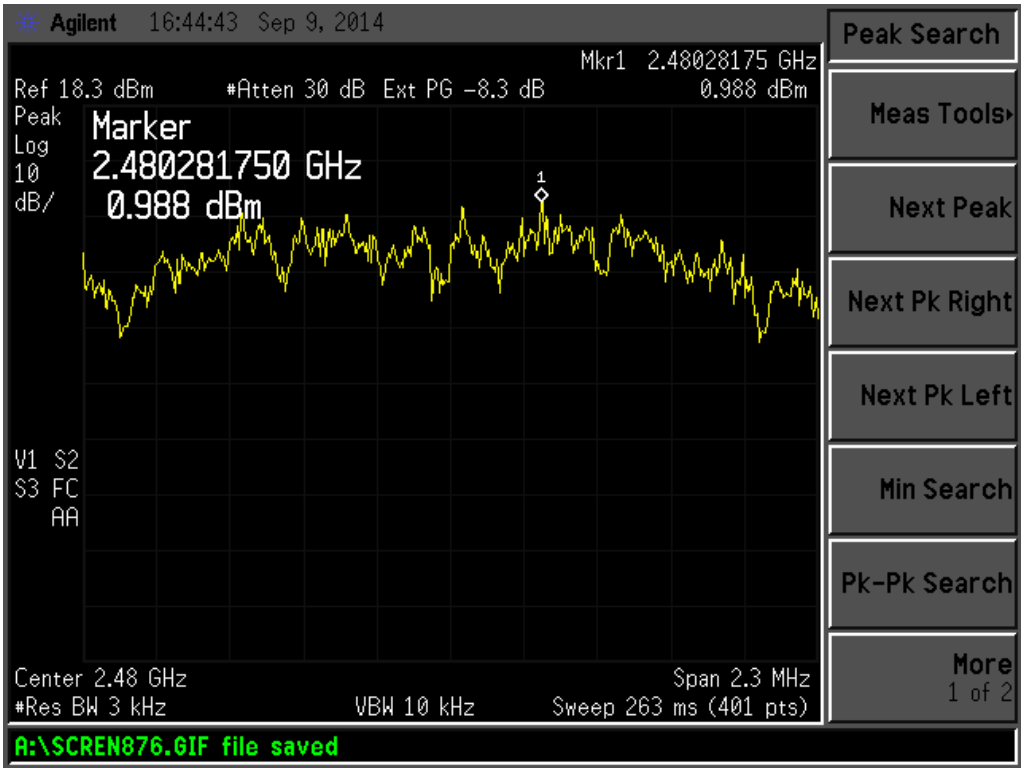



**Figure 27. Peak Power Spectral Density - Part 15.247 (e) - High Channel**

## 2.16 Unintentional Radiator and Intentional Radiator Power Lines Conducted Emissions (CFR 15.107, 15.207)

The test data provided in this section is to support the Verification requirement for the digital apparatus. The power line conducted voltage measurements for Receiver and Digital Devices have been carried out in accordance with CFR 15.107 and ANSI C63.4:2003, Paragraph 7, with a spectrum analyzer connected to an LISN and the EUT placed into an idle condition or a continuous mode of receive (non-transmitting). Please refer to the results as shown in the table below.

The power line conducted voltage emission measurements have been carried out in accordance with CFR 15.207, per ANSI C63.4:2003, Paragraph 7, with a spectrum analyzer connected to an LISN and the EUT placed into a continuous mode of transmission.

The worst-case results for conducted emissions were determined to be produced when the EUT was operating under continuous transmission. The worst case measurement occurred on the neutral line at 15.76MHz. The emission level was 3.3 dB from the applicable limit. All other emissions were at least 4.6 dB from the limit. Those results are given in the table below.

**NOTE: The test data provided in this section is to support the unintentional and intentional requirement for the digital apparatus and the radios within.**

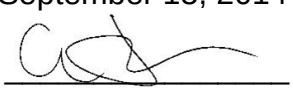
## Table 11. Power Line Conducted Emissions Data, Class B

| CONDUCTED EMISSIONS 150 kHz to 30 MHz | | | | | | |
|---|---|---|---|---|---|---|
| **Tested By:** CF | **Specification Requirement:** FCC Part 15.207 FCC Part 15.107 Class B | | **Project No.:** 14-0212 | **Manufacturer:** INVENTEK SYSTEMS **Model:** ISM2531-USB-F | | |
| **Frequency (MHz)** | **Test Data (dBuV)** | **LISN+CL-PA (dB)** | **Corrected Results (dBuV)** | **Avg Limits (dBuV)** | **Margin (dB)** | **Detector** |
| **120 VAC, 60 Hz, Phase Line** | | | | | | |
| 0.1500 | 57.80 | 1.44 | 59.24 | *66.0 | 6.8 | PK |
| 0.1500 | 38.60 | 1.44 | 40.04 | 56.0 | 16.0 | AVG |
| 0.6100 | 44.10 | 0.37 | 44.47 | *56.0 | 11.5 | PK |
| 0.6100 | 38.70 | 0.37 | 39.07 | 46.0 | 6.9 | AVG |
| 3.6920 | 44.50 | 0.37 | 44.87 | *56.0 | 11.1 | PK |
| 3.6920 | 35.40 | 0.37 | 35.77 | 46.0 | 10.2 | AVG |
| 8.1700 | 44.10 | 0.43 | 44.53 | 50.0 | 5.5 | PK |
| 11.6400 | 44.90 | 0.46 | 45.36 | 50.0 | 4.6 | PK |
| 21.8400 | 42.70 | 0.58 | 43.28 | 50.0 | 6.7 | PK |
| **120 VAC, 60 Hz, Neutral Line** | | | | | | |
| 0.1540 | 52.80 | 1.42 | 54.22 | *65.8 | 11.6 | PK |
| 0.1540 | 38.70 | 1.42 | 40.12 | 55.8 | 15.7 | AVG |
| 0.6120 | 46.20 | 0.60 | 46.80 | *56.0 | 9.2 | PK |
| 0.6120 | 42.10 | 0.60 | 42.70 | 46.0 | 3.3 | AVG |
| 2.9280 | 43.20 | 0.76 | 43.96 | *56.0 | 12.0 | PK |
| 2.9280 | 34.40 | 0.76 | 35.16 | 46.0 | 10.8 | AVG |
| 9.2500 | 41.60 | 0.90 | 42.50 | 50.0 | 7.5 | PK |
| 15.7600 | 42.60 | 1.00 | 43.60 | 50.0 | 6.4 | PK |
| 21.0800 | 42.00 | 0.98 | 42.98 | 50.0 | 7.0 | PK |

(*)= Quasi-Peak limit used

SAMPLE CALCULATION At 0.1500 MHz:

| | | |
|---|---|---|
| Magnitude of Measured Frequency | 57.80 | dBuV |
| + Cable Loss+ LISN Loss | 1.44 | dB |
| Corrected Result | 59.24 | dBuV |

Test Date: September 15, 2014
Tested By
Signature:  Name: Carrie Fincannon

## 2.17 Unintentional Radiator and Intentional Radiator, Radiated Emissions (CFR 15.109 and 15.209)

The test data provided herein is to support the verification requirement for digital devices. Radiated emissions coming from the EUT in a non-transmit state per 15.109 were evaluated from 30 MHz to 12.5 GHz as well as radiated emission coming for the EUT in a transmitting state per 15.209 and were investigated from 9kHz or the lowest operating clock frequency to 25 GHz and tested as detailed in ANSI C63.4:2003, Paragraph 8. The worst case is presented in Table 12 below.

Radiated emissions within the band of 9 kHz to 30 MHz were investigated using a calibrated Loop Antenna and per the requirements of ANSI C63.4:2003.

Measurements were made with the analyzer's resolution bandwidth set to 120 kHz for measurements made below 1 GHz and 1 MHz for measurements made above 1 GHz. The video bandwidth was set to three times the resolution bandwidth; 1 MHz RBW and 3 MHz VBW. The test data were maximized for magnitude by rotating the turn-table through 360 degrees and raising and lowering the receiving antenna between 1 to 4 meters in height as a part of the measurement procedure.

The worst-case radiated emission was 4.8 dB below the specification limit at 142.75 Mhz. All other measured signals were at least 6.0 dB below the specification limit. The results are shown in the table below. These results are meant to show that this EUT's digital device portion has met the verification requirements for an unintentional radiator under CFR Part 15.109 as well as the intentional transmitter requirements of CFR Part 15.209.

**NOTE: The test data provided in this section is to support the unintentional and intentional requirement for the digital apparatus and the radios within.**

## Table 12. Unintentional Radiator, Radiated Emissions (150 kHz – 25 GHz)

| **Test By:** JW | **Test:** FCC Part 15.109/15.209 | | | **Client:** INVENTEK SYSTEMS | | | |
|---|---|---|---|---|---|---|---|
| | **Project:** 14-0212 Class B | | | **Model:** ISM2531-USB-F | | | |
| **Frequency (MHz)** | **Test Data (dBuV)** | **AF+CL-PA (dB)** | **Results (dBuV/m)** | **Limits (dBuV/m)** | **Distance / Polarization** | **Margin (dB)** | **DETECTOR PK / QP/AVG** |
| **Tested from 150 kHz to 1 GHz, Quasi Peak Limits** | | | | | | | |
| 140.49 | 45.60 | -12.61 | 32.99 | 43.5 | 3m./VERT | 10.5 | **QP** |
| 142.75 | 51.30 | -12.61 | 38.69 | 43.5 | 3m./HORZ | 4.8 | **QP** |
| 158.93 | 47.20 | -11.10 | 36.10 | 43.5 | 3m./VERT | 7.4 | **QP** |
| 216.00 | 52.40 | -12.42 | 39.98 | 46.0 | 3m./VERT | 6.0 | **PK** |
| 220.30 | 50.90 | -12.37 | 38.53 | 46.0 | 3m./HORZ | 7.5 | **PK** |
| 261.10 | 46.70 | -10.28 | 36.42 | 46.0 | 3m./HORZ | 9.6 | **QP** |
| 324.50 | 44.80 | -8.25 | 36.55 | 46.0 | 3m./HORZ | 9.5 | **PK** |
| **Tested from 1 GHz to 25 GHz, Average Limits** | | | | | | | |
| 2010.00 | 43.45 | -5.58 | 37.87 | 54.0 | 3.0m./HORZ | 16.1 | **PK** |
| 5347.50 | 40.50 | 3.38 | 43.88 | 54.0 | 3.0m./HORZ | 10.1 | **PK** |
| 7154.40 | 40.66 | 7.03 | 47.69 | 54.0 | 3.0m./HORZ | 6.3 | **PK** |

No other emissions detected other than those presented in this table and the tables in section 2.10 above.
AF is antenna factor. CL is cable loss. PA is preamplifier gain.

SAMPLE CALCULATION at 140.49 MHz:

| | | |
|---|---|---|
| Magnitude of Measured Frequency | 45.60 | dBuV |
| +Antenna Factor + Cable Loss+ Amplifier Gain | -12.61 | dB |
| Corrected Result | 32.99 | dBuV/m |

Test Date: September 10, 2014

Tested By Signature: John C Wynn Name: John Wynn

## 2.18 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4. A coverage factor of k=2 was used to give a level of confidence of approximately 95%.

### 2.18.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ±2.8 dB.

The data listed in this test report does have sufficient margin to negate the effects of uncertainty, therefore, the EUT unconditionally passes this requirement.

### 2.18.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ±5.3 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ±5.1 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ±5.2 dB.

The data listed in this test report does not have sufficient margin to negate the effects of uncertainty, therefore, the EUT conditionally passes this requirement.