Testing Tomorrow's Technology

**Application for**

**US Code Title 47, Part 2, Subpart J, Section 2.947**
**Certification Per**
**Part 15, Subpart C, for Intentional Radiators, Section 15.249, Intentional Radiator Operating within the Band 2400 MHz to 2483.5 MHz**
**And**
**Innovation, Science, and Economic Development Canada**
**Certification Per**
**IC RSS-Gen General Requirements for Radio Apparatus**
**And**
**RSS-210 Licence-Exempt Radio Apparatus: Category I Equipment**

**For the**

**Wink Labs, Inc.**

**Model: Wink Hub 2**
**(Bluetooth Radio Evaluation)**

**UST Project: 16-0220**
**Test Date(s): August 27 – August 29, 2016**
**Issue Date: September 1, 2016**

Total Number of Pages in this Report: 25

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I certify that I am authorized to sign for the test facility 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: Alan Ghasiani**

**Title: Consulting Engineer - President**

**Date: September 1, 2016**

NVLAP LAB CODE 200162-0



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# MEASUREMENT/TECHNICAL REPORT

**COMPANY NAME:** Wink Labs, Inc.
**MODEL(S):** Wink Hub 2
**FCC ID:** 2ACAJ-WHUB2
**IC:** 11938A-WHUB2
**DATE:** September 1, 2016

This report concerns (check one): Original grant_X
Class II change_____

Equipment type: Intentional Radiator Operating within the bands 2400-2483.5 MHz

Deferred grant requested per 47 CFR 0.457(d) (1) (ii)? yes_____ No_X

If yes, defer until:_____
date

__N.A.__ 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:

US Tech
3505 Francis Circle
Alpharetta, GA 30004

Phone Number: (770) 740-0717
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# SUMMARY OF TEST REQUIREMENTS

| FCC Requirement | Title | Disposition |
|---|---|---|
| 15.205 | Restricted Bands | Pass |
| 15.207 | Intentional Radiator Power Line Conducted Emissions | Pass |
| 15.209 | Intentional Radiator Radiated Emissions | Pass |
| 15.249(a) | Fundamental Field Strength | Pass |

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# 1 General Information

## 1.1 Purpose of this Report

This report is prepared as a means of presenting test data to be used by a Telecom Certification Body in determination of whether this product is permitted for unlicensed dissemination to the general public according to the FCC Rules and Regulations for RF Devices Intentional Radiators.

## 1.2 Product Description

The Equipment under Test (EUT) is the Wink Labs, Inc. home automation hub, model WINK HUB 2. The WINK HUB 2 has five transmitters, including: three 2.4 GHZ transmitters (Wifi (2.4/5GHz), Bluetooth, and Zigbee), one 431 MHz transmitter (Lutron), and one 915 MHz transmitter (Zwave). The circuit board uses four on-board transmitter antennas. The Bluetooth and Wifi radios share one antenna and the other transmitters each have their own antennas.

This report will cover in detail test results for the Bluetooth transmitter; test results for the other transmitters will be covered in separate reports.

The EUT used proprietary software to adjust frequency and power levels. The EUT was tested using the following parameters:

Maximum rated output power: +8.0 dBm
Symbol Rate: 1Mb/s
8-DPSK modulation (EDR)
Total data rate during testing= 3Mb/s

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

1.3.1 The EUT is subject to the following FCC authorizations:

a) Certification under section 15.249 as a transmitter.

b) Verification/Declaration of Conformity under 15.101 as a digital device and receiver.

1.3.2 Certification of the Transmitter

The EUT employs spread spectrum modulation, but is not being certified under CFR 15.247 because the field strength of the fundamental and its harmonics are within the limits specified in 47 CFR 15.249. Therefore the EUT is instead being presented under the requirements of CFR 15.249. The EUT will operate within the frequency band of 2402 MHz to 2480 MHz.

### 1.3.3 Verification of the Digital apparatus

The verification report is submitted separately.

# 2 Tests and Measurements

## 2.1 Configuration of Tested System

The sample was set up and tested per ANSI C63.4, Methods of Measurement from Low-Voltage Electrical and Electronic Equipment in the Frequency Range of 9 kHz to 40 GHz (2014) and ANSI C63.10 (2013). Conducted and radiated emissions data were taken with the EMC test receiver (or spectrum analyzer's) resolution bandwidth adjusted to 9 kHz and 120 kHz, respectively. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was off throughout the evaluation process. A Block diagram of the tested system is shown in Figure 1. A listing of the EUT and its test peripherals is found in Table 1 below. Test configuration photographs for spurious and fundamental emissions measurements are submitted as attachments.

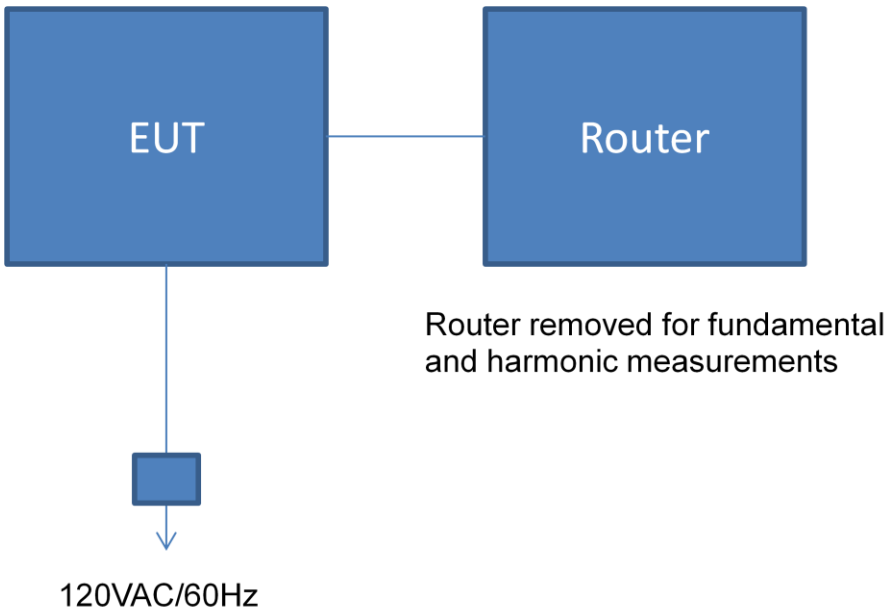


**Figure 1. Block Diagram of Test Configuration**

**Table 1. EUT and Peripherals**

| PERIPHERAL MANUFACTURER | MODEL NUMBER | SERIAL NUMBER | FCC/IC ID: | CABLES P/D |
|---|---|---|---|---|
| Gateway Wink Labs, Inc. (EUT) | WINK HUB 2 | Engineering Sample | Pending: FCC ID: 2ACAJ-WHUB2 IC:11938A-WHUB2 | 1.5 m U P<br>1.0 m U D |
| AC/DC Power Supply adapter Wink Labs, Inc | S012BEU1 200100 | None | None | 1.5 m U P |
| Router | Various | Various | Various | 1.5 m U P |
| Antenna See antenna details | -- | -- | -- | -- |

S= Shielded, U=Unshielded, P= Power line, D= Data line

## 2.2 EUT Characterization

The sample used for testing was received by US Tech on August 26, 2016 in good operating condition.

## 2.3 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA. This site has been fully described and registered with the FCC, under site registration number 186022. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1 and is also a NVLAP accredited test lab; lab code 200162-0.

## 2.4 Test Equipment

Table 2 describes test equipment used to evaluate this product.

**Table 2.Test Instruments**

| TEST INSTRUMENT | MODEL NUMBER | MANUFACTURER | SERIAL NUMBER | DATE OF LAST CALIBRATION |
|---|---|---|---|---|
| SPECTRUM ANALYZER | E4407B | AGILENT | US41442935 | 2/11/2016 |
| RF PREAMP 100 kHz to 1.3 GHz | 8447D | HEWLETT-PACKARD | 1937A02980 | 12/2/2015 |
| LOOP ANTENNA | SAS-200/562 | A. H. Systems | 142 | 9/28/2016 |
| BICONICAL ANTENNA | 3110B | EMCO | 9307-1431 | 8/25/2015 2 yr cycle |
| BICONICAL ANTENNA | 3110B | EMCO | 9306-1708 | 11/24/2014 2 yr cycle |
| LOG PERIODIC ANTENNA | 3146 | EMCO | 9110-3236 | 11/19/2014 2 yr cycle |
| LOG PERIODIC ANTENNA | 3146 | EMCO | 9305-3600 | 7/1/2014 2 yr cycle extended 90 days |
| HORN ANTENNA | 3115 | EMCO | 9107-3723 | 7/8/2014 2 yr cycle extended 90 days |
| PREAMP 1.0 GHz to 26.0 GHz | 8449B | HEWLETT-PACKARD | 3008A00480 | 12/1/2015 |
| HORN ANTENNA | 3116 | EMCO | 9505-2255 | 1/27/2015 2 yr cycle |
| CALCULATION PROGRAM | N/A | N/A | Ver. 6.0 | N/A |

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

## 2.5 Modifications to EUT

No modifications were made by US Tech to bring the EUT into compliance with FCC Part 15.249 or IC RSS-210 requirements.

## 2.6 Measurement Standards (CFR 15.31)

Intentional and unintentional radiators are to use the methods of ANSI C63.4: 2014 and ANSI C63.10: 2013. Measurements were made on an Open Area Test Site (OATS) wherever possible or in the Semi Anechoic Chamber. For battery powered equipment, new (or fully charged) batteries are used. Section 15.31(m) indicates that if the EUT System operates over the 2400 MHz to 2483.5 MHz ISM band, measurements must be made near the bottom of the band (around 2400 MHz for example) and in the middle of the band (2440 MHz for example) as well as near the top of the band (2483.5 MHz for example).

## 2.7 Frequency Range of Radiated Measurements (CFR 15.33)

The frequency range is detailed below for intentional and unintentional radiators.

### 2.7.1 Frequency Range for Intentional Radiators

The spectrum was investigated from the lowest RF signal generated without going below 9 kHz to the $10^{th}$ harmonic of the highest fundamental transmitter frequency.

### 2.7.2 Frequency Range for Unintentional Radiators

The spectrum was investigated from the lowest RF signal generated without going below the lowest frequency for which an emissions limit is specified (30 MHz) to the $5^{th}$ harmonic of the highest fundamental frequency of the digital device (12.5 GHz maximum).

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

On any frequency below 1000 MHz, the limits shown are based upon measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths. On frequencies above 1000 MHz, the radiation limits are based upon the use of measuring instrumentation employing an average detector function.

When average detector measurements are specified for use, including emission measurements below 1000 MHz, there is also a corresponding limit for Peak detector measurements having a limit of 20 dB above the corresponding average limit unless a different peak emission limit is specified. Measurements above 1000 MHz utilize a minimum resolution bandwidth of 1 MHz.

When radiated emissions limits are expressed in terms of the average value of the emission and pulsed operation is employed, the measurement field strength is determined by averaging over one complete pulse train (Duty Cycle) including blanking intervals for pulse trains up to 0.1 second in duration. The exact method of calculating the average field strength for this radio is expressed below.

1. Adaptive frequency hopping is turned on, then all 1600 timeslots are used, this requires 1 second
2. Each time slot is therefore 625uS
3. Each BT packet is 366uS
4. A unit is setup is a master or slave but not both
5. Master transmits on odd numbered timeslots, slave on even number time slots

Based on those specifications:

FCC 100mS window = 160 timeslots, if unit is master, then 80 timeslots are used so signal length = 80 x 366uS = 29mS

FCC window =100mS so duty cycle = 29/100 = 29% worst case, duty correction factor = 20 Log .29 =

-10.75dB,

**DUTY CYCLE= -10.75 dB**

**Figure 2. Duty Cycle Calculation**

Note: The transmitter was programmed to transmit at > 98% Duty cycle (the frequency sweeping/hopping was stopped and pulsed operation was disabled) for all testing; therefore throughout the test report the duty cycle factor calculated above was applied where applicable (to AVG detection measurements).

## 2.8 Antenna Requirement (CFR 15.203)

The EUT has an internal radiator; there are no external antenna ports.

**Table 3. Allowed Antenna(s)**

| MANUFACTURER | TYPE OF ANTENNA | MODEL | REPORT REFERENCE | GAIN $dB_i$ | TYPE OF CONNECTOR |
|---|---|---|---|---|---|
| Johanson Technology | Dual Band Chip antenna | 2450AD46A 5400 | None | -2.5 | soldered |

## 2.9 Intentional Radiator, Power Line Conducted Emissions (CFR 15.207)

The EUT requires 12.0 VDC to operate; this power is supplied by a switching power supply that is plugged into the AC Mains. The EUT is not intended to be operated without this power supply.

## 2.10 Intentional Radiator, Radiated Emissions (CFR 15.249 (a), (e))

The EUT was placed into a continuous transmit mode of operation. A preliminary scan was performed on the EUT to find signal frequencies that were caused by the transmitter part of the product and to obtain the worse case result the EUT tested in all X, Y and Z axis. Radiated measurements below 30 MHz were tested with a RBW = 9 kHz; emissions below 1 GHz were tested with a RBW = 120 kHz and radiated measurements above 1 GHz were measured using a RBW =1 MHz and VBW = 3 MHz.

Test data is found in the tables below.

## 2.11 Restricted Bands of Operation (CFR 15.205)

Only radiated harmonics and other spurious signals can be permitted to fall into the restricted bands of 15.205. All signals found in paragraph 2.7 above shall be examined for this requirement. Limits are based upon the limits of paragraph 15.209. Above 1 GHz, the limits are for Average value. See Table 4 and Table 5 below for peak and Average measurements. According to CFR 15.35, the peak limits can exceed the average limits by 20 dB.

## Table 4. Peak Measurements (CFR15.249 (a))

| Tested By: RKM | Test: FCC Part 15, Para 15.249(a) and (e) | | | | Client: Wink Labs, Inc. | | | |
|---|---|---|---|---|---|---|---|---|
| | Project: 16-0220 | | | | Model: WINK HUB 2 | | | |
| **Frequency (MHz)** | **Test Data (dBuV)** | **AF+CL-PA (dB/m)** | **Additional factor (dB)** | **Corrected Results (dBuV/m)** | **Limits (dBuV/m)** | **Distance / Polarization** | **Margin (dB)** | **Detection Mode** |
| Low Channel - Peak | | | | | | | | |
| 2402.43 | 58.53 | 28.70 | | 87.23 | 114.0 | 3m/Vert. | 26.8 | **PK** |
| 4806.05 | 50.31 | 0.42 | 2.5 | 53.23 | 74.0 | 3m/Vert. | 20.8 | **PK** |
| 7205.22 | 51.05 | 5.12 | 2.5 | 58.67 | 74.0 | 3m/Vert. | 15.3 | **PK** |
| Mid Channel - Peak | | | | | | | | |
| 2442.20 | 59.00 | 28.75 | | 87.75 | 114.0 | 3m/Vert. | 26.3 | **PK** |
| 4883.65 | 49.96 | 0.98 | 2.5 | 53.44 | 74.0 | 3m/Vert. | 20.6 | **PK** |
| 7322.37 | 50.28 | 5.85 | 2.5 | 58.63 | 74.0 | 3m/Vert. | 15.4 | **PK** |
| High Channel – Peak | | | | | | | | |
| 2479.80 | 58.57 | 28.75 | | 87.32 | 114.0 | 3m/Vert. | 26.7 | **PK** |
| 4951.83 | 45.56 | 0.06 | 2.5 | 48.12 | 74.0 | 3m/Vert. | 25.9 | **PK** |
| 7434.22 | 44.21 | 5.08 | 2.5 | 51.79 | 74.0 | 3m/Vert. | 22.2 | **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. Harmonics investigated up to the 10th harmonic (25GHz using EMCO 3116 Horn Antenna)
4. Additional factor of 2.5 dB added to final results for used of filter.
3. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 2402.43 MHz:

| | | |
|---|---|---|
| Magnitude of Measured Frequency | 58.53 | dBuV |
| +Antenna Factor + Cable Loss+ Amplifier Gain | 28.70 | dBVm |
| Corrected Result | 87.23 | dBuV/m |

Test Date: August 27, 2016
Tested By
Signature: _____ Name: Robert K. Mills

**Table 5. Average Measurements (CFR 15.35(b), 15.249(a))**

| Tested By: RKM | | | Test: FCC Part 15, Para<br>Project: 16-0220 | | Client: Wink Labs, Inc.<br>Model: WINK HUB 2 | | | |
|---|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **Test Data (dBuV)** | **AF+CL-PA (dB/m)** | **Additional factor (dB)** | **Corrected Results (dBuV/m)** | **Limits (dBuV/m)** | **Distance / Polarization** | **Margin (dB)** | **Detection mode** |
| | | Low Channel - Average | | | | | | |
| 2402.43 | 53.83 | 28.70 | | 82.53 | 94.0 | 3m/Vert. | 11.5 | **AVG** |
| 4806.05 | 29.38 | 0.42 | 2.5 | 32.30 | 54.0 | 3m/Vert. | 21.7 | **AVG** |
| 7205.22 | 30.21 | 5.12 | 2.5 | 37.83 | 54.0 | 3m/Vert. | 16.2 | **AVG** |
| | | Mid Channel - Average | | | | | | |
| 2442.20 | 55.55 | 28.75 | | 84.30 | 94.0 | 3m/Vert. | 9.7 | **AVG** |
| 4883.65 | 29.62 | 0.98 | 2.5 | 33.10 | 54.0 | 3m/Vert. | 20.9 | **AVG** |
| 7322.37 | 30.28 | 5.85 | 2.5 | 38.63 | 54.0 | 3m/Vert. | 15.4 | **AVG** |
| | | High Channel – Average | | | | | | |
| 2479.80 | 54.54 | 28.75 | | 83.29 | 94.0 | 3m/Vert. | 10.7 | **AVG** |
| 4951.83 | 30.51 | 0.06 | 2.5 | 33.07 | 54.0 | 3m/Vert. | 20.9 | **AVG** |
| 7434.22 | 29.47 | 5.08 | 2.5 | 37.05 | 54.0 | 3m/Vert. | 16.9 | **AVG** |

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. Harmonics investigated up to the 10th harmonic (25 GHz using EMCO 3116 Horn Antenna)
3. Additional factor of 2.5 dB was added for use of High Frequency band pass filter.
4. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.
5. Duty cycle reduction was not applied to the average measurements.

Sample Calculation at 2402.43 MHz:

| | | |
|---|---|---|
| Magnitude of Measured Frequency | 53.83 | dBuV |
| +Antenna Factor + Cable Loss+ Amplifier Gain +Duty Cycle | 28.70 | dB/m |
| Corrected Result | 82.53 | dBuV/m |

Test Date: August 27, 2016
Tested By
Signature: _____ Name: Robert K. Mills

## 2.12 Band Edge and Restricted Band Measurements (CFR15.249(d))

Band Edge measurements were made with the EUT operating at its lowest channel and highest channel of operation. These plots are recorded and provide below. A Resolution Bandwidth of $>$ 1% of the emission bandwidth was used.

Any emissions found, the limit per section 15.249(d) is 50 dB below the fundamental or the value expressed by CFR 15.209 (54 dBuV/m), whichever is the lesser attenuation.

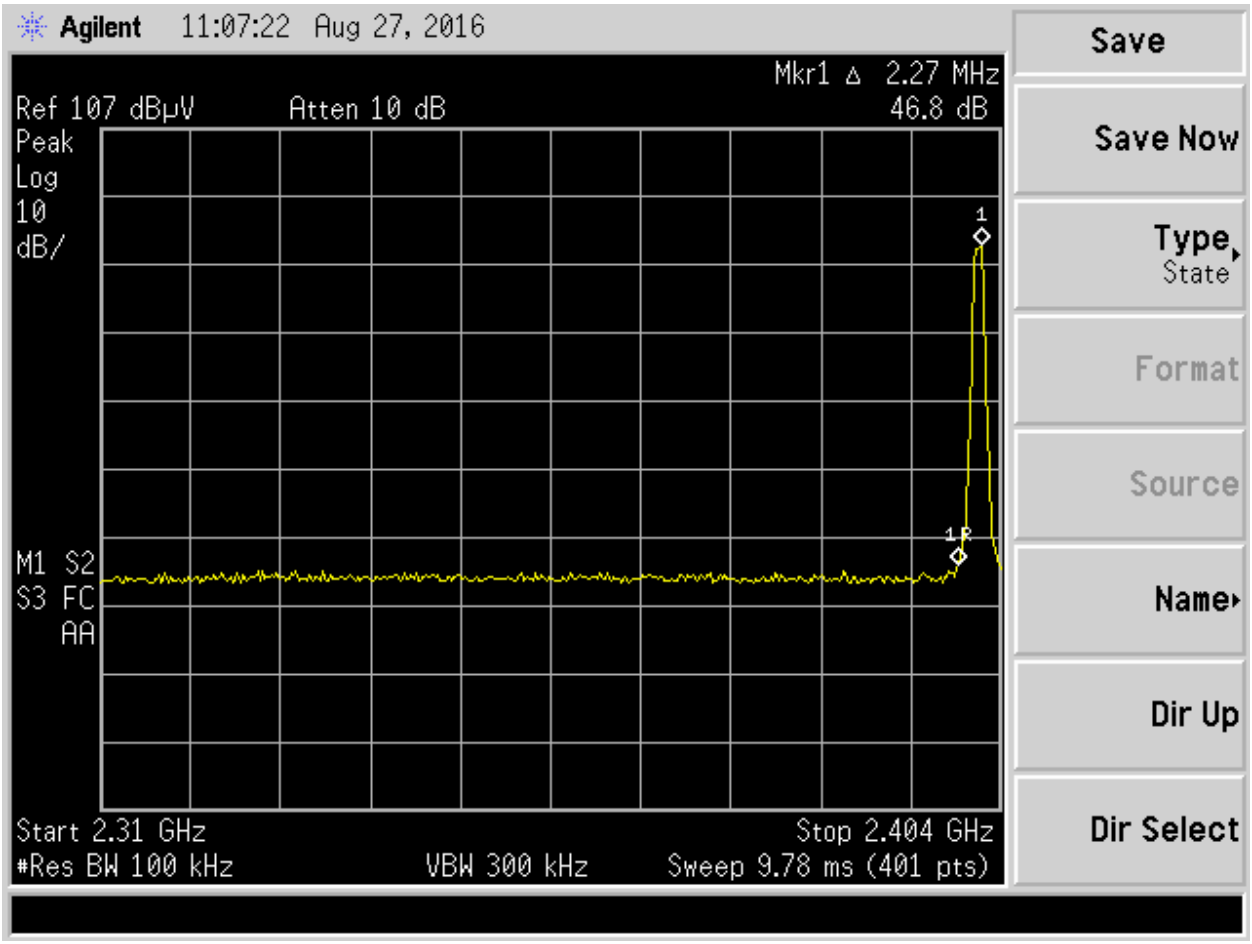


**Figure 3. Radiated Band Edge – Low Channel Delta – Peak**

Calculation of worst case PEAK upper band edge measurement:

| | | |
|---|---|---|
| Low Channel Corrected Measured Value from Table 4 | 87.23 | dBuV |
| Low Channel Band Edge Delta from Figure 3 | -46.80 | dB |
| Calculated Result | 40.43 | dBuV/m |
| | | |
| Average Limit + 20dB Relaxation for PEAK | 74.00 | dBuV/m |
| Calculated Result | -40.43 | dBuV/m |
| Band Edge Margin | 33.57 | dBuV/m |

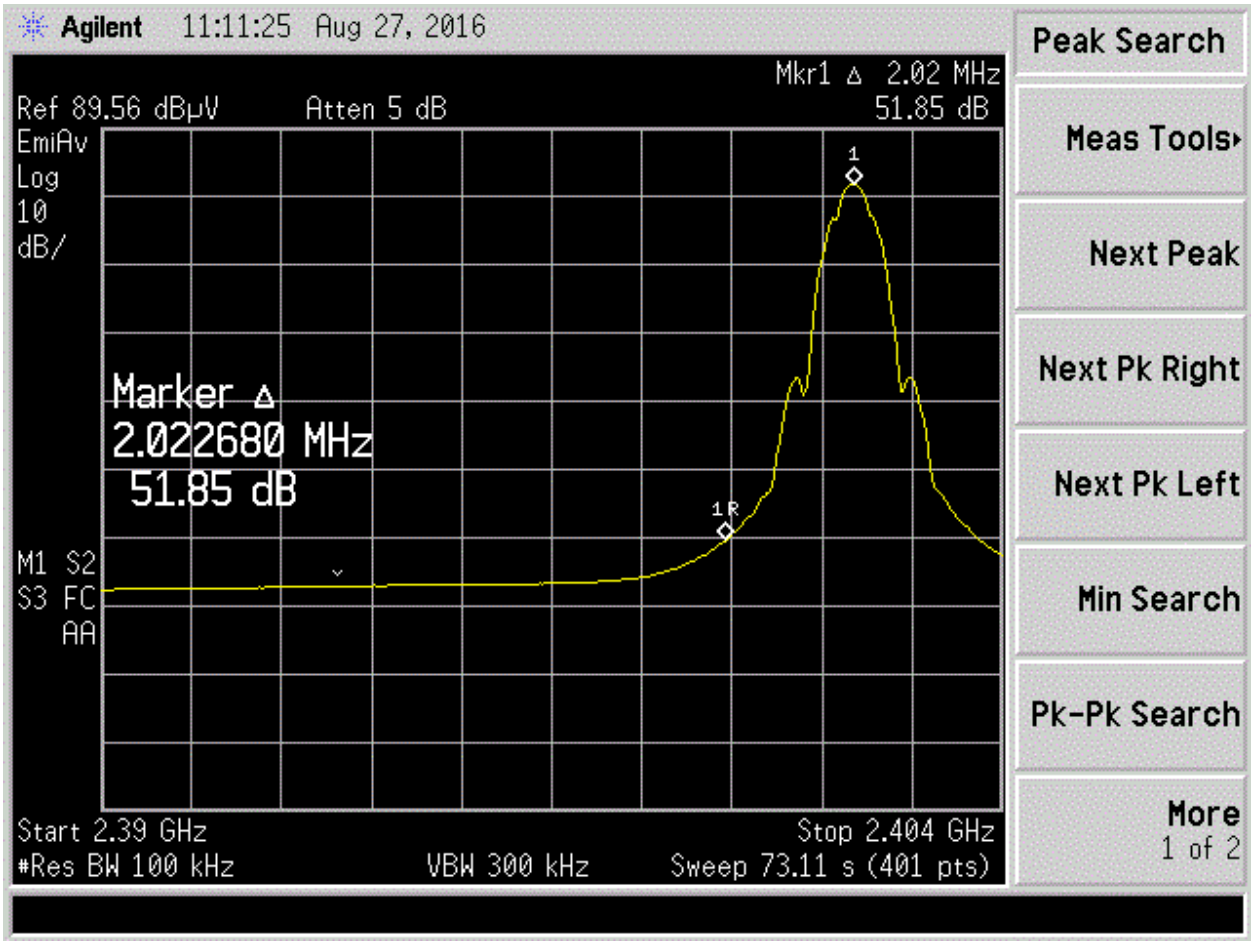


**Figure 4. Radiated Band Edge – Low Channel Delta – Average**

Calculation of worst case AVERAGE upper band edge measurement:

| | | |
|---|---|---|
| Low Channel Corrected Measured Value from Table 5 | 82.53 | dBuV |
| Low Channel Band Edge Delta from Figure 4 | -51.85 | dB |
| Calculated Result | 30.68 | dBuV/m |
| | | |
| Peak Limit | 54.00 | dBuV/m |
| Calculated Result | 30.68 | dBuV/m |
| Band Edge Margin | 23.32 | dBuV/m |

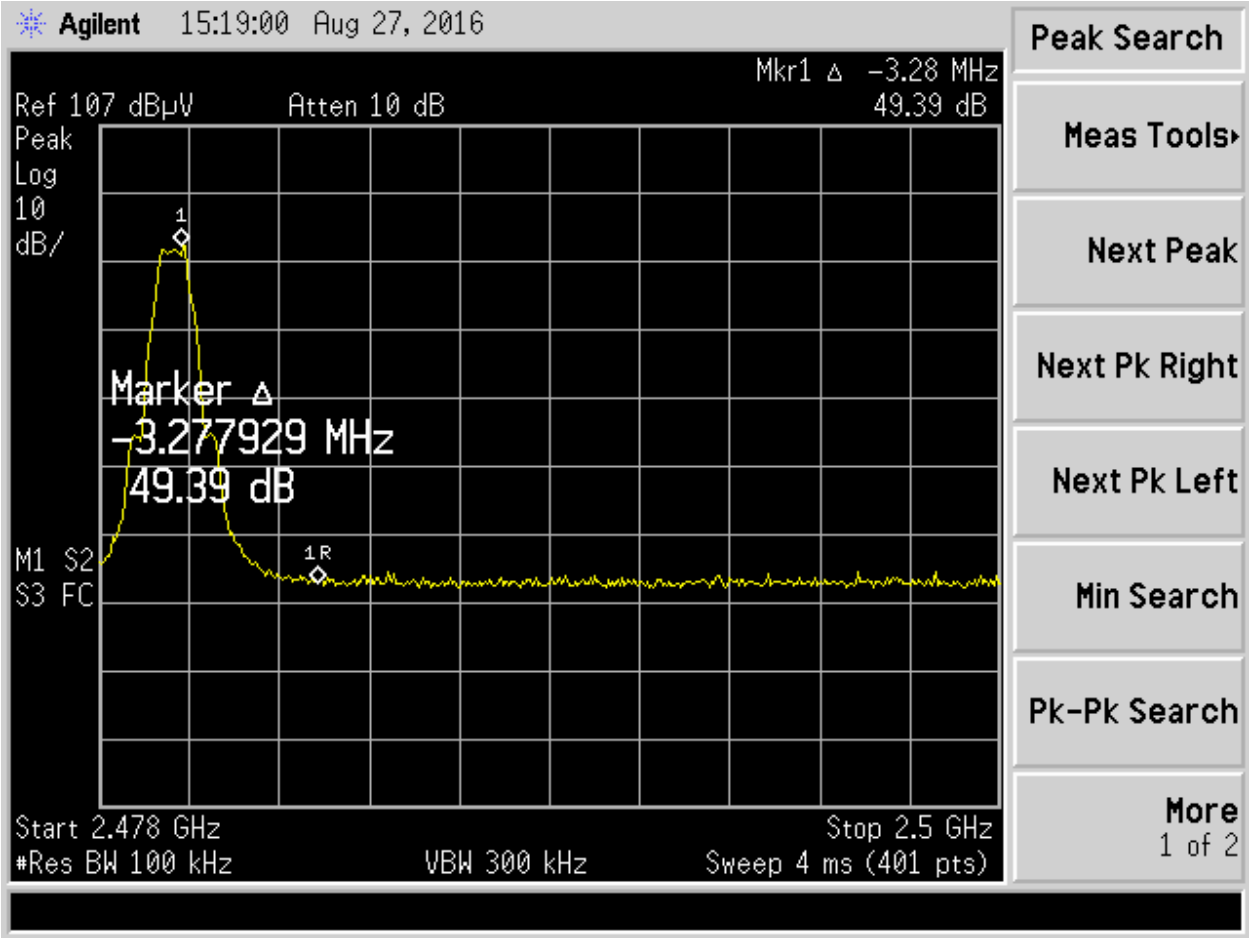


**Figure 5. Radiated Band Edge – High Channel Delta – Peak**

Calculation of worst case PEAK upper band edge measurement:

| | | |
|---|---|---|
| High Channel Corrected Measured Value from Table 4 | 87.32 | dBuV |
| High Channel Band Edge Delta from Figure 5 | -49.39 | dB |
| Calculated Result | 37.93 | dBuV/m |
| | | |
| Average Limit + 20dB Relaxation for PEAK | 74.00 | dBuV/m |
| Calculated Result | -37.93 | dBuV/m |
| Band Edge Margin | 36.07 | dBuV/m |

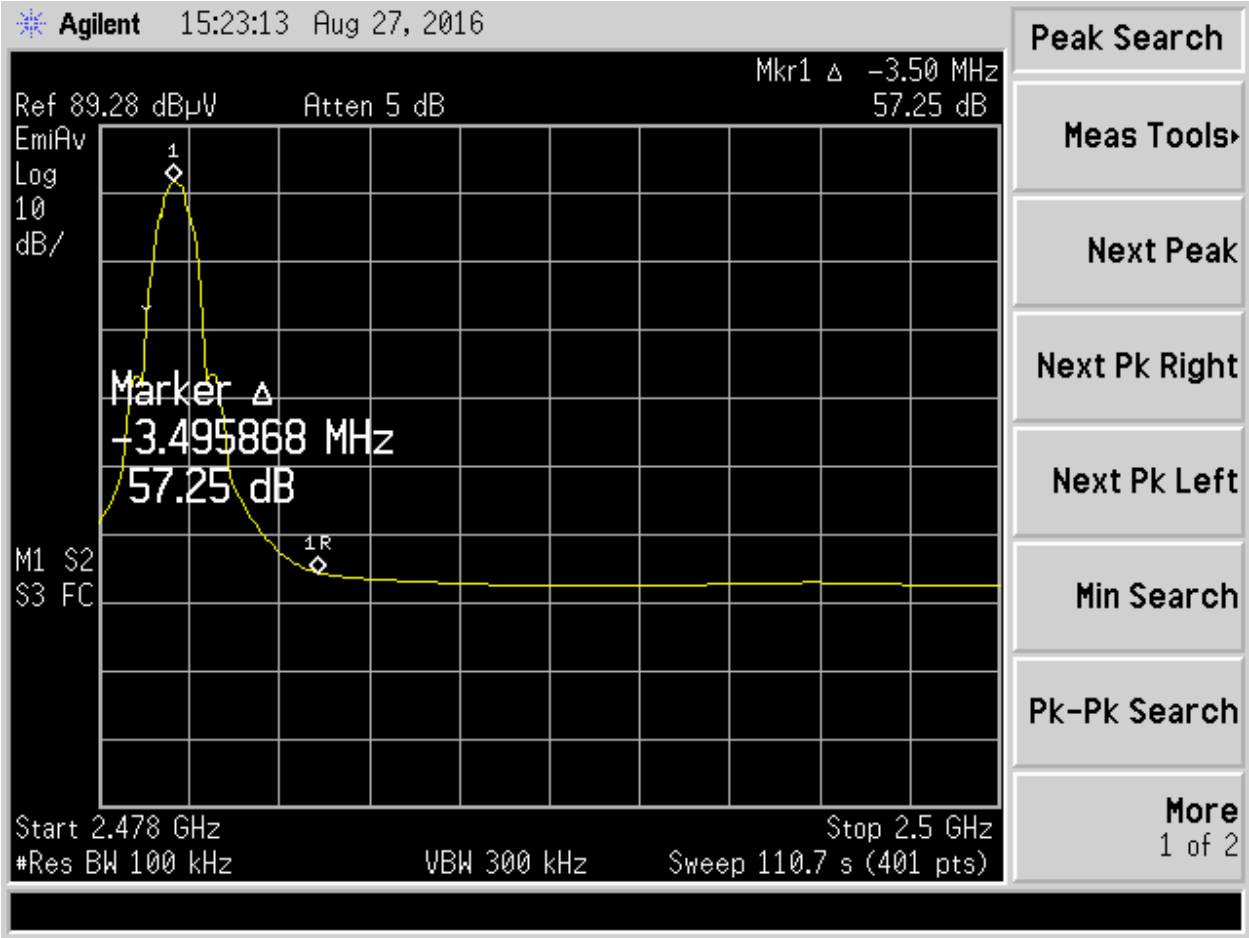


**Figure 6. Radiated Band Edge – High Channel Delta - Average**

Calculation of worst case AVERAGE upper band edge measurement:

| | | |
|---|---|---|
| High Channel Corrected Measured Value from Table 5 | 83.29 | dBuV |
| High Channel Band Edge Delta from Figure 6 | -57.25 | dB |
| Calculated Result | 26.04 | dBuV/m |
| | | |
| Peak Limit | 54.00 | dBuV/m |
| Calculated Result | 26.04 | dBuV/m |
| Band Edge Margin | 27.96 | dBuV/m |

Test Date: August 27, 2016
Tested By
Signature: _____ Name: Robert K. Mills

## 2.13 Occupied Bandwidth Measurements (RSS-Gen 6.6)

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance. Measurements were performed following the procedures described in RSS-Gen Issue 4 (2014) clause 6.6.

**Table 6. Bandwidth Measurements, 99% Occupied Bandwidth**

| Frequency (MHz) | 99% Occupied Bandwidth (MHz) |
|---|---|
| 2402 | 1.107 |
| 2440 | 1.010 |
| 2480 | 1.010 |

**Test Date: August 27, 2016**
**Tested By**
**Signature:**  **Name: Robert K. Mills**

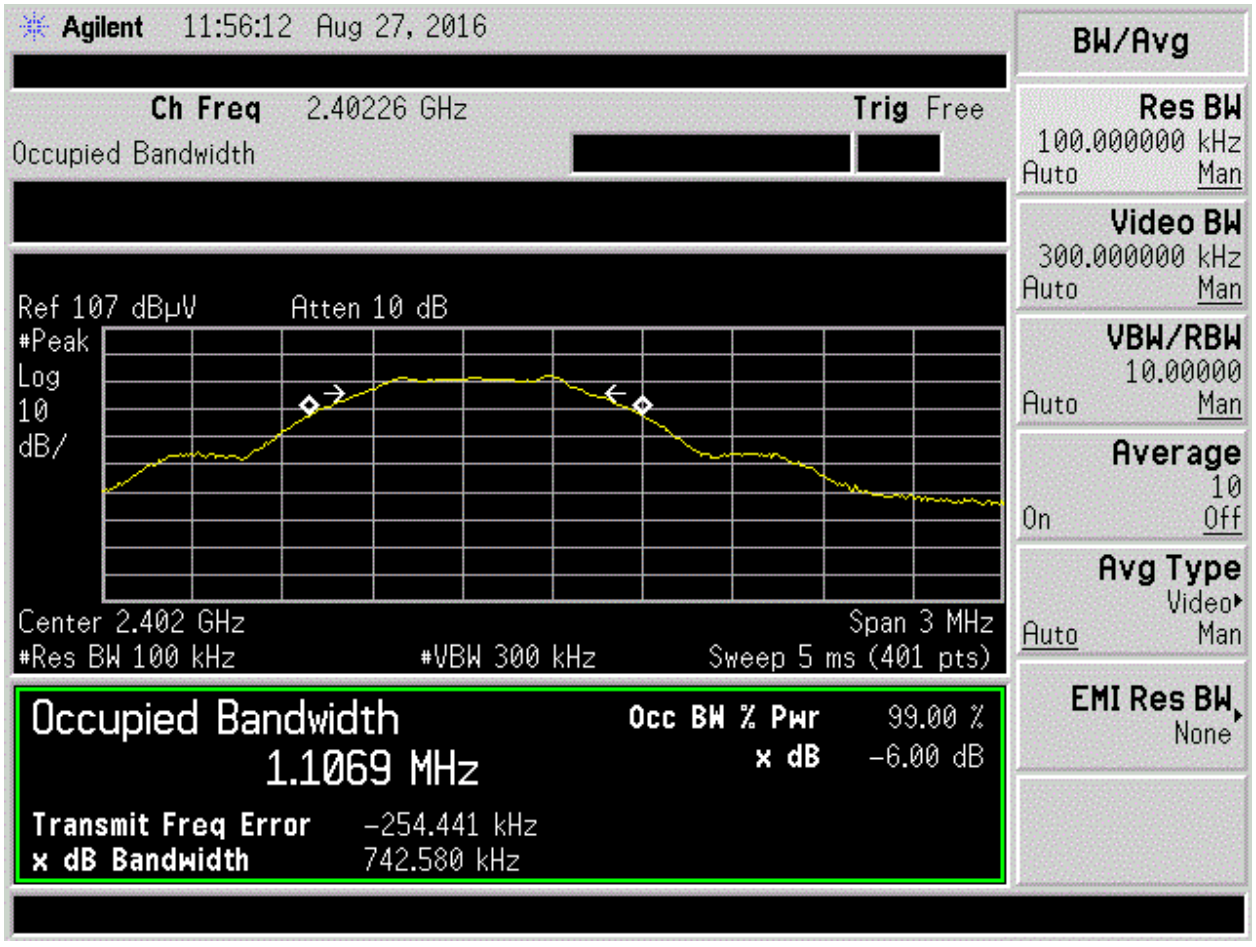


**Figure 7. Low Channel 99% OCCP Bandwidth**

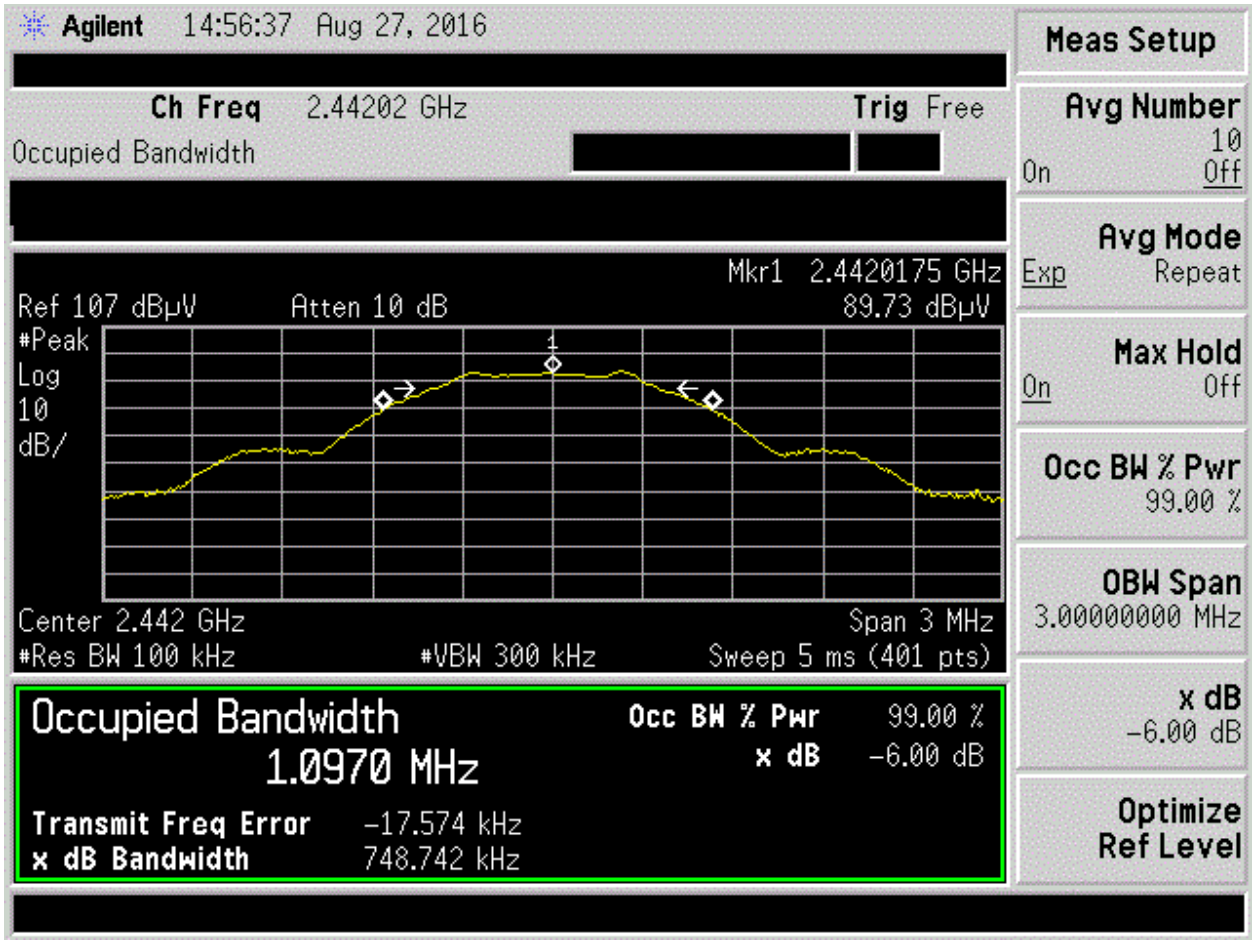


**Figure 8. Mid Channel 99% OCCP Bandwidth**

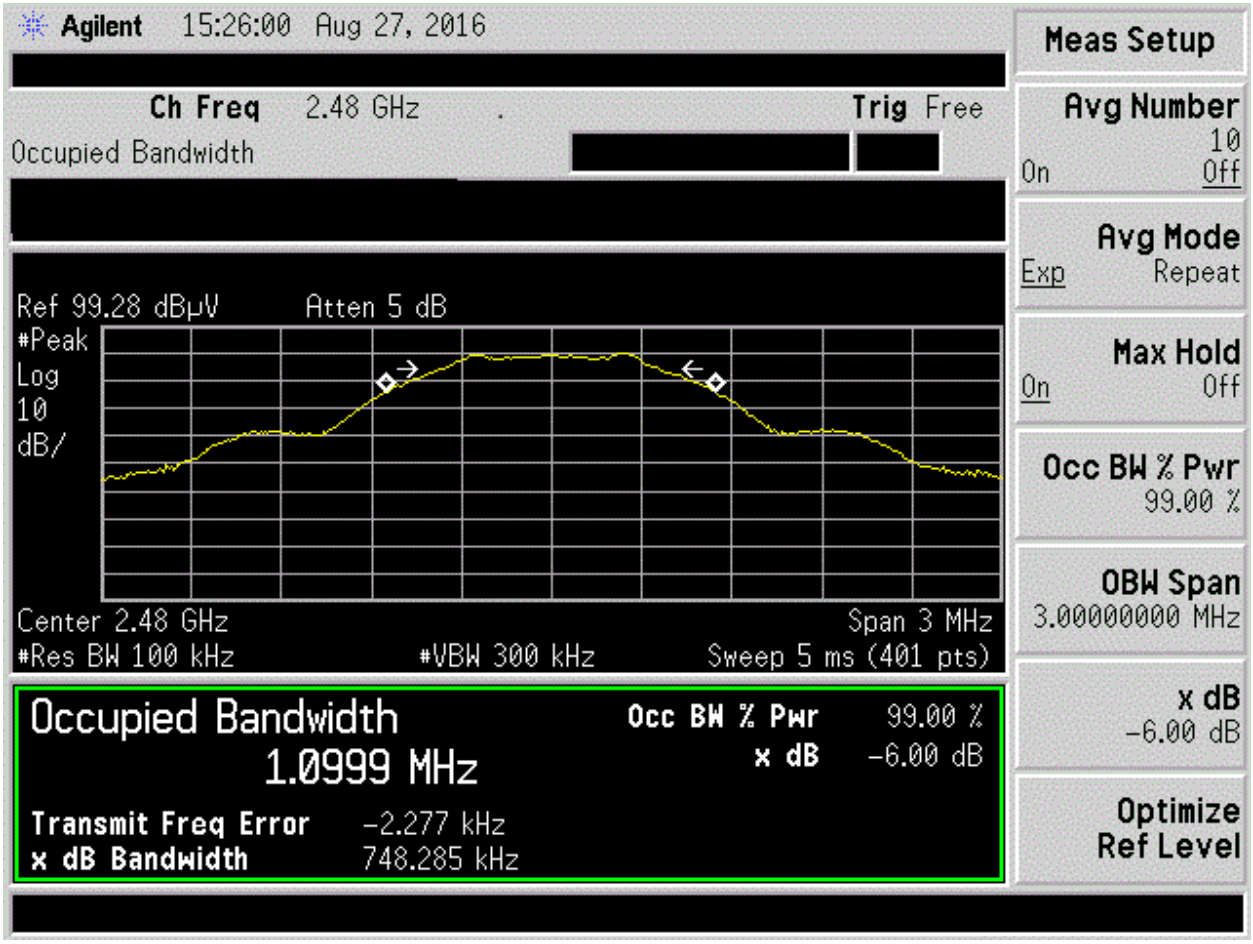


**Figure 9. High Channel 99% OCCP Bandwidth**