41039 Boyce Road
Fremont, CA. 94538

510-578-3500 Phone
510-440-9525 Fax

EMC Test Report

Application for FCC Grant of Equipment Authorization

FCC Part 15 Subpart C

Model: WL-TINGM1

FCC ID:	2AQNW-TINGM1
APPLICANT:	Whisker Labs, Inc. 12410 Milestone Center Dr, Suite 300 Germantown, MD 20876
TEST SITE(S):	National Technical Systems 41039 Boyce Road. Fremont, CA. 94538-2435
IC SITE REGISTRATION #:	2845B-5
PROJECT NUMBER:	PR082203
REPORT DATE:	July 30, 2018
RE_ISSUED DATE:	August 3, 2018
FINAL TEST DATES:	July 6, 11, 12, 16, 24 and 27, 2018
TOTAL NUMBER OF PAGES:	78

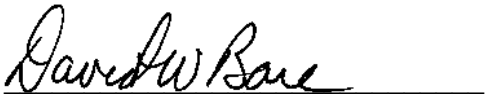
A2LA ACCREDITED
Testing Cert #0214.26

VALIDATING SIGNATORIES

PROGRAM MGR

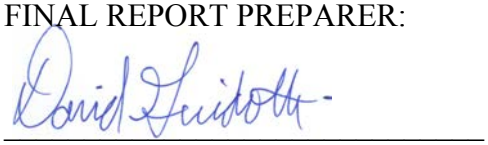
David W. Bare
Chief Engineer

TECHNICAL REVIEWER:



David W. Bare
Chief Engineer

FINAL REPORT PREPARER:



David Guidotti
Senior Technical Writer

QUALITY ASSURANCE DELEGATE

Gary Izard
Technical Writer

REVISION HISTORY

Rev#	Date	Comments	Modified By
-	July 30, 2018	First release	
1	August 3, 2018	Added statement concerning correlation of results below 30 MHz	dwb

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SCOPE

An electromagnetic emissions test has been performed on the Whisker Labs, Inc. model WL-TINGM1, pursuant to the following rules:

FCC Part 15 Subpart C

Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in the following reference standards and as outlined in National Technical Systems test procedures:

ANSI C63.10-2013
FCC DTS Measurement Guidance KDB558074

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant Industry Canada performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

National Technical Systems is accredited by the A2LA, certificate number 0214.26, to perform the test(s) listed in this report, except where noted otherwise.

OBJECTIVE

The primary objective of the manufacturer is compliance with the regulations outlined in the previous section.

Prior to marketing in the USA, all unlicensed transmitters and transceivers require certification. Receive-only devices operating between 30 MHz and 960 MHz are subject to either certification or a manufacturer's declaration of conformity, with all other receive-only devices exempt from the technical requirements.

Certification is a procedure where the manufacturer submits test data and technical information to a certification body and receives a certificate or grant of equipment authorization upon successful completion of the certification body's review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units, which are subsequently manufactured.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

STATEMENT OF COMPLIANCE

The tested sample of Whisker Labs, Inc. model WL-TINGM1 complied with the requirements of the following regulations:

FCC Part 15 Subpart C

Maintenance of compliance is the responsibility of the manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the device with respect to the standards detailed in this test report.

The test results recorded herein are based on a single type test of Whisker Labs, Inc. model WL-TINGM1 and therefore apply only to the tested sample. The sample was selected and prepared by Donnie Bixler of Whisker Labs, Inc.

DEVIATIONS FROM THE STANDARDS

No deviations were made from the published requirements listed in the scope of this report.

TEST RESULTS SUMMARY

DIGITAL TRANSMISSION SYSTEMS (2400 – 2483.5MHz)

FCC Rule Part		Description	Measured Value / Comments	Limit / Requirement	Result
15.247(a)		Digital Modulation	Systems uses OFDM / DSSS techniques	System must utilize a digital transmission technology	Complies
15.247 (a) (2)		Minimum 6dB Bandwidth	8.6 MHz	>500kHz	Complies
15.247 (b) (3)		Output Power (multipoint systems)	20.2 dBm (0.105 Watts) EIRP = 0.132 W Note 1	1Watt, EIRP limited to 4 Watts.	Complies
15.247(e)		Power Spectral Density	0.1 dBm/10kHz	8dBm/3kHz	Complies
15.247(d)		Antenna Port Spurious Emissions 30 kHz – 25 GHz	All emissions below -20dBc limit	< -20dBc	Complies
15.247(d) / 15.209		Radiated Spurious Emissions 30 kHz – 25 GHz	53.0 dBµV/m @ 4874.0 MHz (-1.0 dB)	Refer to the limits section (p20) for restricted bands, all others < -20dBc	Complies
Note 1: EIRP calculated using antenna gain of 1.0 dBi for the highest EIRP system.					

GENERAL REQUIREMENTS APPLICABLE TO ALL BANDS

FCC Rule Part		Description	Measured Value / Comments	Limit / Requirement	Result (margin)
15.203		RF Connector	U.FL connector	Unique or integral antenna required	Complies
15.407 (b) (6)		AC Conducted Emissions	52.6 dBµV @ 3.083 MHz (-3.4 dB)	Refer to page 19	Complies
15.247 (i) 15.407 (f)		RF Exposure Requirements	Refer to MPE calculations in separate exhibit	Refer to OET 65, FCC Part 1 and RSS 102	Complies

MEASUREMENT UNCERTAINTIES

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level and were calculated in accordance with UKAS document LAB 34.

Measurement Type	Measurement Unit	Frequency Range	Expanded Uncertainty
RF power, conducted (power meter)	dBm	25 to 7000 MHz	± 0.52 dB
RF power, conducted (Spectrum analyzer)	dBm	25 to 7000 MHz	± 0.7 dB
Conducted emission of transmitter	dBm	25 to 26500 MHz	± 0.7 dB
Radiated emission (substitution method)	dBm	25 to 26500 MHz	± 2.5 dB
Radiated emission (field strength)	dBµV/m	25 to 1000 MHz	± 3.6 dB
		1000 to 40000 MHz	± 6.0 dB
Conducted Emissions (AC Power)	dBµV	0.15 to 30 MHz	± 2.4 dB

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The Whisker Labs, Inc. model WL-TINGM1 is a Wi-Fi modular radio that is designed for use in sensors that measure arcs in electrical systems. Since the EUT could be placed in any position during operation, the EUT was treated as tabletop equipment during testing to simulate the end-user environment. The electrical rating of the EUT is 5 Volts.

The sample was received on July 6, 2018 and tested on July 6, 11, 12, 16, 24 and 27, 2018. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
Whisker Labs, Inc.	WL-TINGM1	Radio module	B854567AD010	2AQNW-TINGM1

OTHER EUT DETAILS

The following EUT details should be noted: The EUT uses a 1.0 dBi Pulse Electronics W3921 PCB antenna that connects to the module via an integral RF cable.

ENCLOSURE

The EUT has no enclosure.

MODIFICATIONS

No modifications were made to the EUT during the time the product was at NTS Silicon Valley.

SUPPORT EQUIPMENT

The following equipment was used as support equipment for testing:

Company	Model	Description	Serial Number	FCC ID
Whisker Labs	Ting	Sensor	-	-
Lenovo	ThnkCentre M700	PC	MJ04RB9Y	-
Dell	E2010Hc	Monitor	CN-01PTX3-64180-022-0YAM	-
Logitech	K120	Keyboard	1602MR001FD8	-
Lenovo	MOEUUOA	Mouse	44YX827	-

The Ting sensor was used to support the antenna during testing.

EUT INTERFACE PORTS

The I/O cabling configuration during testing was as follows:

EUT

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
3pin serial adapter	PC	3pin to USB	Shielded	1
USB power	EUT	USB	Shielded	1
AC\DC Wall mount adapter	Mains	Direct	-	-
Antenna	EUT	Coax (part of the antenna)	Unshielded	0.1

Additional on Support Equipment

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
USB Keyboard	PC	USB	Shielded	1
USB Mouse	PC	USB	Shielded	1
Monitor VGA	PC	VGA	Shielded	1
PC DC input	AC/DC adapter Output	2Wire	Unshielded	1
PC AC/DC adapter input	Mains	3Wire	Unshielded	1
Monitor AC input	Mains	3Wire	Unshielded	1

EUT OPERATION

During emissions testing the EUT was configured to transmit continuously on the selected channel at maximum power level.

TEST SITE

GENERAL INFORMATION

Final test measurements were taken at the test sites listed below. Pursuant to section 2.948 of the FCC's Rules and section 3.3 of RSP-100, construction, calibration, and equipment data has been filed with the Commission and with industry Canada.

Site	Designation / Registration Numbers		Location
	FCC	Canada	
Chamber 5	US0027	2845B-5	41039 Boyce Road Fremont, CA 94538-2435

ANSI C63.4 recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement. The test site(s) contain separate areas for radiated and conducted emissions testing. Results from testing performed in this chamber have been correlated with results from an open area test site. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent requirements of ANSI C63.4.

CONDUCTED EMISSIONS CONSIDERATIONS

Conducted emissions testing is performed in conformance with ANSI C63.10. Measurements are made with the EUT connected to the public power network through a nominal, standardized RF impedance, which is provided by a line impedance stabilization network, known as a LISN. A LISN is inserted in series with each current-carrying conductor in the EUT power cord.

RADIATED EMISSIONS CONSIDERATIONS

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated measurements are performed in an open field environment or in a semi-anechoic chamber. The test sites are maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4 guidelines and meet the Normalized Site Attenuation (NSA) requirements of ANSI C63.4.

MEASUREMENT INSTRUMENTATION

RECEIVER SYSTEM

An EMI receiver as specified in CISPR 16-1-1 is used for emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 2000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the CISPR detector used during measurements. If the repetition frequency of the signal being measured is below 20Hz, peak measurements are made in lieu of Quasi-Peak measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. Average measurements above 1000MHz are performed on the spectrum analyzer using the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz, unless the signal is pulsed in which case the average (or video) bandwidth of the measuring instrument is reduced to onset of pulse desensitization and then increased.

INSTRUMENT CONTROL COMPUTER

Software is used to view and convert receiver measurements to the field strength at an antenna or voltage developed at the LISN measurement port, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate. A personal computer is used to record all measurements made with the receivers. The software used for radiated and conducted emissions measurements is NTS EMI Test Software (rev 2.10)

LINE IMPEDANCE STABILIZATION NETWORK (LISN)

Line conducted measurements utilize a fifty microhenry Line Impedance Stabilization Network as the monitoring point. The LISN used also contains a 250 uH CISPR adapter. This network provides for calibrated radio frequency noise measurements by the design of the internal low pass and high pass filters on the EUT and measurement ports, respectively.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or LISN and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A loop antenna is used below 30 MHz. For the measurement range 30 MHz to 1000 MHz either a combination of a biconical antenna and a log periodic or a bi-log antenna is used. Above 1000 MHz, horn antennas are used. The antenna calibration factors to convert the received voltage to an electric field strength are included with appropriate cable loss and amplifier gain factors to determine an overall site factor, which is then programmed into the test receivers or incorporated into the test software.

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height. Measurements below 30 MHz are made with the loop antenna at a fixed height of 1m above the ground plane.

ANSI C63.10 specifies that the test height above ground for table mounted devices shall be 80 centimeters for testing below 1 GHz and 1.5m for testing above 1 GHz. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor as specified in ANSI C63.4. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An exhibit of this report contains the list of test equipment used and calibration information.

TEST PROCEDURES

EUT AND CABLE PLACEMENT

The regulations require that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.10, and the worst-case orientation is used for final measurements.

CONDUCTED EMISSIONS

Conducted emissions are measured at the plug end of the power cord supplied with the EUT. Excess power cord length is wrapped in a bundle between 30 and 40 centimeters in length near the center of the cord. Preliminary measurements are made to determine the highest amplitude emission relative to the specification limit for all the modes of operation. Placement of system components and varying of cable positions are performed in each mode. A final peak mode scan is then performed in the position and mode for which the highest emission was noted on all current carrying conductors of the power cord.

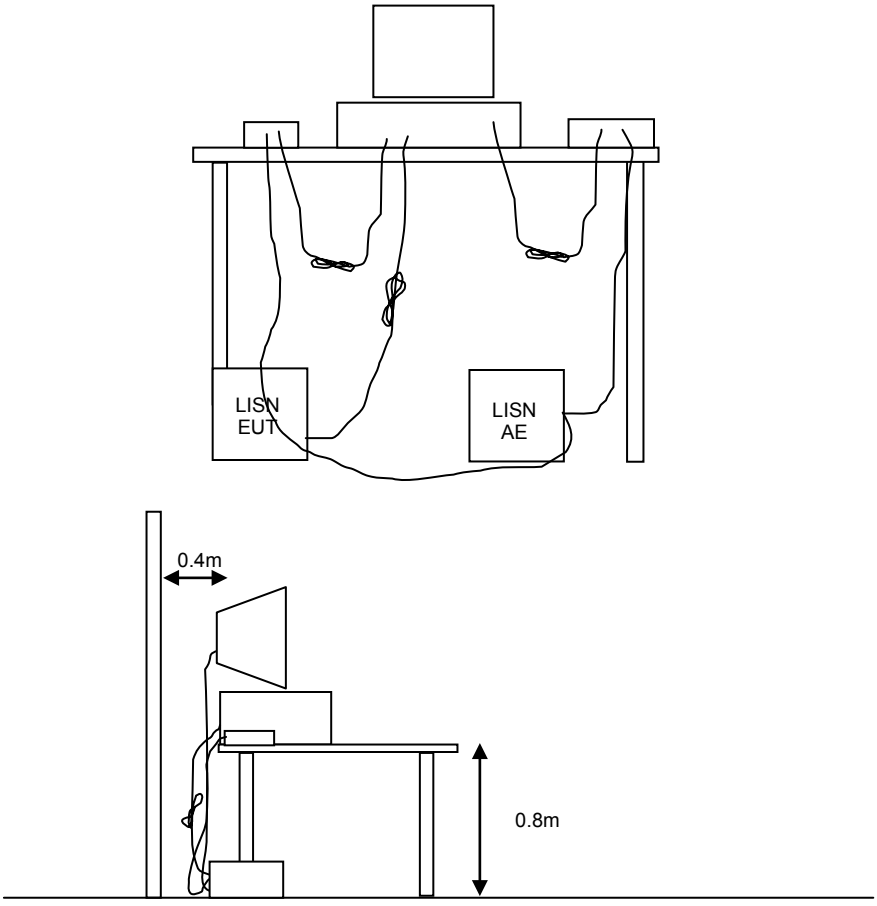


Figure 1 Typical Conducted Emissions Test Configuration

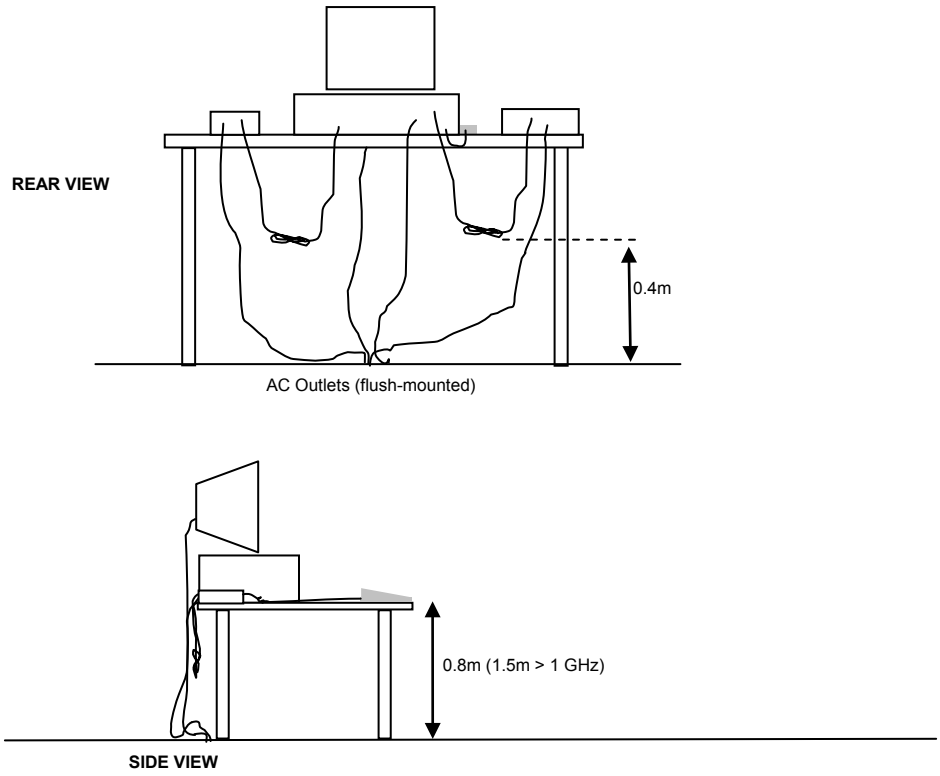
RADIATED EMISSIONS

A preliminary scan of the radiated emissions is performed in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed, one scan for each antenna polarization (horizontal and vertical; loop parallel and perpendicular to the EUT). During the preliminary scans, the EUT is rotated through 360˚, the antenna height is varied (for measurements above 30 MHz) and cable positions are varied to determine the highest emission relative to the limit. Preliminary scans may be performed in a fully anechoic chamber for the purposes of identifying the frequencies of the highest emissions from the EUT.

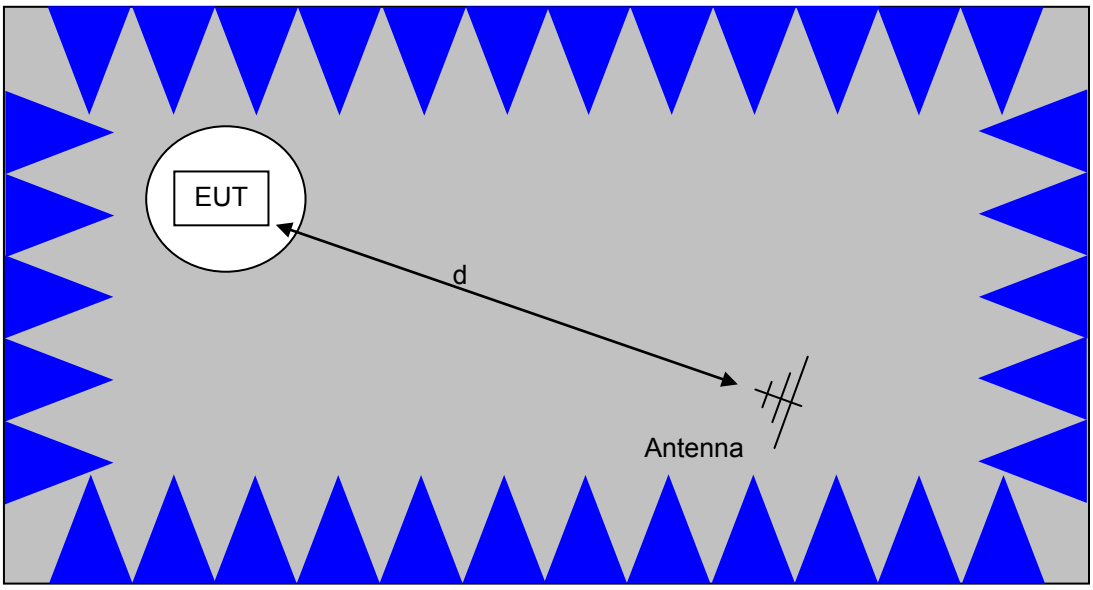
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth, which results in the highest emission is then maintained while varying the antenna height from one to four meters (for measurements above 30 MHz, measurements below 30 MHz are made with the loop antenna at a fixed height of 1m). The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain.

When testing above 18 GHz, the receive antenna is located at 1meter from the EUT and the antenna height is restricted to a maximum of 2.5 meters.

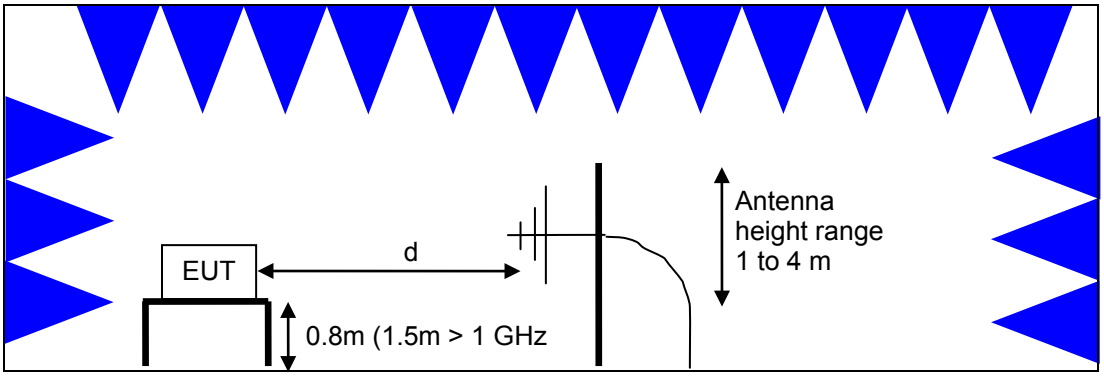


Typical Test Configuration for Radiated Field Strength Measurements



The anechoic materials on the walls and ceiling ensure compliance with the normalized site attenuation requirements of CISPR 16 / CISPR 22 / ANSI C63.4 for an alternate test site at the measurement distances used.

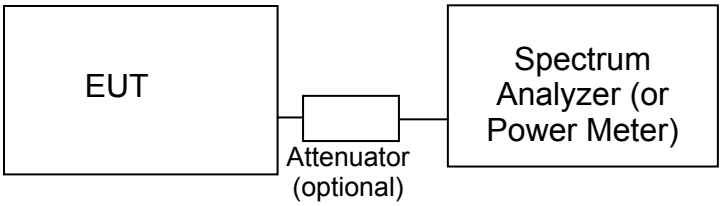
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



Test Configuration for Radiated Field Strength Measurements
Semi-Anechoic Chamber, Plan and Side Views

CONDUCTED EMISSIONS FROM ANTENNA PORT

Direct measurements of power, bandwidth and power spectral density are performed, where possible, with the antenna port of the EUT connected to either the power meter or spectrum analyzer via a suitable attenuator and/or filter. These are used to ensure that the front end of the measurement instrument is not overloaded by the fundamental transmission.



Test Configuration for Antenna Port Measurements

Measurement bandwidths (video and resolution) are set in accordance with the relevant standards and NTS Silicon Valley's test procedures for the type of radio being tested. When power measurements are made using a resolution bandwidth less than the signal bandwidth the power is calculated by summing the power across the signal bandwidth using either the analyzer channel power function or by capturing the trace data and calculating the power using software. In both cases the summed power is corrected to account for the equivalent noise bandwidth (ENBW) of the resolution bandwidth used.

If power averaging is used (typically for certain digital modulation techniques), the EUT is configured to transmit continuously. Power averaging is performed using either the built-in function of the analyzer or, if the analyzer does not feature power averaging, using external software. In both cases the average power is calculated over a number of sweeps (typically 100). When the EUT cannot be configured to continuously transmit then either the analyzer is configured to perform a gated sweep to ensure that the power is averaged over periods that the device is transmitting or power averaging is disabled and a max-hold feature is used.

If a power meter is used to make output power measurements the sensor head type (peak or average) is stated in the test data table.

BANDWIDTH MEASUREMENTS

The 6dB, 20dB, 26dB and/or 99% signal bandwidth are measured using the bandwidths recommended by ANSI C63.10 and RSS GEN.

SPECIFICATION LIMITS AND SAMPLE CALCULATIONS

The limits for conducted emissions are given in units of microvolts, and the limits for radiated emissions are given in units of microvolts per meter at a specified test distance. Data is measured in the logarithmic form of decibels relative to one microvolt, or dB microvolts (dBuV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBuV/m). The results are then converted to the linear forms of uV and uV/m for comparison to published specifications.

For reference, converting the specification limits from linear to decibel form is accomplished by taking the base ten logarithm, then multiplying by 20. These limits in both linear and logarithmic form are as follows:

CONDUCTED EMISSIONS SPECIFICATION LIMITS: FCC 15.207; FCC 15.107(a), RSS GEN

The table below shows the limits for the emissions on the AC power line from an intentional radiator and a receiver.

Frequency (MHz)	Average Limit (dBuV)	Quasi Peak Limit (dBuV)
0.150 to 0.500	Linear decrease on logarithmic frequency axis between 56.0 and 46.0	Linear decrease on logarithmic frequency axis between 66.0 and 56.0
0.500 to 5.000	46.0	56.0
5.000 to 30.000	50.0	60.0

GENERAL TRANSMITTER RADIATED EMISSIONS SPECIFICATION LIMITS

The table below shows the limits for the spurious emissions from transmitters that fall in restricted bands[1].

Frequency Range (MHz)	Limit (uV/m)	Limit (dBuV/m @ 3m)
0.009-0.490	$2400/F_{KHz}$ @ 300m	$67.6-20*\log_{10}(F_{KHz})$ @ 300m
0.490-1.705	$24000/F_{KHz}$ @ 30m	$87.6-20*\log_{10}(F_{KHz})$ @ 30m
1.705 to 30	30 @ 30m	29.5 @ 30m
30 to 88	100 @ 3m	40 @ 3m
88 to 216	150 @ 3m	43.5 @ 3m
216 to 960	200 @ 3m	46.0 @ 3m
Above 960	500 @ 3m	54.0 @ 3m

[1] The restricted bands are detailed in FCC 15.205 and RSS-Gen Table 7

OUTPUT POWER LIMITS – DIGITAL TRANSMISSION SYSTEMS

The table below shows the limits for output power and output power density. Where the signal bandwidth is less than 20 MHz the maximum output power is reduced to the power spectral density limit plus 10 times the log of the bandwidth (in MHz).

Operating Frequency (MHz)	Output Power	Power Spectral Density
902 – 928	1 Watt (30 dBm)	8 dBm/3kHz
2400 – 2483.5	1 Watt (30 dBm)	8 dBm/3kHz
5725 – 5850	1 Watt (30 dBm)	8 dBm/3kHz

The maximum permitted output power is reduced by 1dB for every dB the antenna gain exceeds 6dBi. Fixed point-to-point applications using the 5725 – 5850 MHz band are not subject to this restriction.

TRANSMIT MODE SPURIOUS RADIATED EMISSIONS LIMITS – FHSS and DTS SYSTEMS

The limits for unwanted (spurious) emissions from the transmitter falling in the restricted bands are those specified in the general limits sections of FCC Part 15 and RSS 210. All other unwanted (spurious) emissions shall be at least 20dB below the level of the highest in-band signal level (30dB if the power is measured using the sample detector/power averaging method).

SAMPLE CALCULATIONS - CONDUCTED EMISSIONS

Receiver readings are compared directly to the conducted emissions specification limit (decibel form) as follows:

$$R_r - S = M$$

where:
R_r = Receiver Reading in dBuV
S = Specification Limit in dBuV
M = Margin to Specification in +/- dB

SAMPLE CALCULATIONS - RADIATED EMISSIONS

Receiver readings are compared directly to the specification limit (decibel form). The receiver internally corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

A distance factor, when used for electric field measurements above 30MHz, is calculated by using the following formula:

$$F_d = 20*LOG_{10} (D_m/D_s)$$

where:
F_d = Distance Factor in dB
D_m = Measurement Distance in meters
D_s = Specification Distance in meters

For electric field measurements below 30MHz the extrapolation factor is either determined by making measurements at multiple distances or a theoretical value is calculated using the formula:

$$F_d = 40*LOG_{10} (D_m/D_s)$$

Measurement Distance is the distance at which the measurements were taken and Specification Distance is the distance at which the specification limits are based. The antenna factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:
R_r = Receiver Reading in dBuV/m
F_d = Distance Factor in dB
R_c = Corrected Reading in dBuV/m
L_s = Specification Limit in dBuV/m
M = Margin in dB Relative to Spec

SAMPLE CALCULATIONS - FIELD STRENGTH TO EIRP CONVERSION

Where the radiated electric field strength is expressed in terms of the equivalent isotropic radiated power (eirp), or where a field strength measurement of output power is made in lieu of a direct measurement, the following formula is used to convert between eirp and field strength at a distance of d (meters) from the equipment under test:

$$E = \frac{1000000 \sqrt{30 P}}{d} \quad \text{microvolts per meter}$$

where P is the eirp (Watts)

For a measurement at 3m the conversion from a logarithmic value for field strength (dBuV/m) to an eirp power (dBm) is -95.3dB.

Appendix A Test Equipment Calibration Data

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Power and Duty Cycle, 06-Jul-18					
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	5/31/2018	5/31/2019
Radiated Emissions, 1000 - 25,000 MHz, 11-Jul-18					
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	785	9/8/2017	9/8/2018
Hewlett Packard	Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz	8564E (84125C)	1393	12/8/2017	12/8/2018
HP / Miteq	SA40 B Head HF preAmplifier, 18-40 GHz (w/1393)	TTA1840-45-5P-HG-S	1620	1/9/2018	1/9/2019
A. H. Systems	Purple System Horn, 18-40GHz	SAS-574, p/n: 2581	2160	8/18/2017	8/18/2018
Micro-Tronics	Band Reject Filter, 2400-2500 MHz 18GHz	BRM50702-02	2238	5/1/2018	5/1/2019
EMCO	Antenna, Horn, 1-18 GHz	3115	2870	8/24/2017	8/24/2019
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	9482	10/28/2016	10/28/2018
Radiated Emissions, 1000 - 18,000 MHz, 12-Jul-18					
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	785	9/8/2017	9/8/2018
Hewlett Packard	Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz	8564E (84125C)	1393	12/8/2017	12/8/2018
Micro-Tronics	Band Reject Filter, 2400-2500 MHz 18GHz	BRM50702-02	2238	5/1/2018	5/1/2019
EMCO	Antenna, Horn, 1-18 GHz	3115	2870	8/24/2017	8/24/2019
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	9482	10/28/2016	10/28/2018
Radiated Emissions, 25 - 1,000 MHz, 12-Jul-18					
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	1549	5/30/2017	5/30/2019
Com-Power	Preamplifier, 1-1000 MHz	PAM-103	2885	8/30/2017	8/30/2018
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	9482	10/28/2016	10/28/2018
Radio Antenna Port (Power and Spurious Emissions), 12-Jul-18					
Rohde & Schwarz	Power Meter, Single Channel	NRVS	1422	2/6/2018	2/6/2019
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	5/31/2018	5/31/2019
Rohde & Schwarz	Peak Power Sensor 100 uW - 2 Watts use with 20dB attenuator sn:1031.6959.00 only	NRV-Z32	3225	11/5/2017	11/5/2018
Rohde & Schwarz	20dB attenuator sn:1031.6959.00 only for Peak Power Sensor 100 uW - 2 Watts	NRV-Z32 atten	3226	11/5/2017	11/5/2018

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Conducted Emissions - AC Power Ports, 16-Jul-18					
EMCO	LISN, 10 kHz-100 MHz	3825/2	1292	8/8/2017	8/8/2018
EMCO	LISN, 10 kHz-100 MHz	3825/2	1293	6/19/2018	6/19/2019
Rohde & Schwarz	Pulse Limiter	ESH3 Z2	1401	1/8/2018	1/8/2019
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	9482	10/28/2016	10/28/2018
Radiated Emissions, 30KHz-30MHz, 24-Jul-18					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	1756	7/7/2018	7/7/2019
Compower	Magnetic Loop Antenna, 9 kHz-30 MHz	AL-130	3003	8/9/2016	8/9/2018
Radio Antenna Port (Spurious Emissions), 27-Jul-18					
Rohde & Schwarz	Signal Analyzer 20 Hz - 26.5 GHz	FSQ26	2327	6/25/2018	6/25/2019

Appendix B Test Data

TL082203-RA Pages 27 – 77

Client:	Whisker Labs, Inc.	PR Number:	PR082203
Product	Ting Radio	T-Log Number:	TL082203-RA
System Configuration:	-	Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Engineer:	David Bare
Emissions Standard(s):	FCC part 15	Class:	-
Immunity Standard(s):		Environment:	Radio

EMC Test Data

For The

Whisker Labs, Inc.

Product

Ting Radio

Date of Last Test: 7/27/2018

Client:	Whisker Labs, Inc.	PR Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Engineer:	David Bare
Standard:	FCC part 15	Class:	-

Conducted Emissions

(NTS Silicon Valley, Fremont Facility, Semi-Anechoic Chamber)

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 7/16/2018
Test Engineer: Rafael Varelas
Test Location: Fremont Chamber #5

Config. Used: 1
Config Change: None
Host Unit Voltage 120V/60Hz

General Test Configuration

For tabletop equipment, the EUT and power adapter were located on a support inside the semi-anechoic chamber, 40 cm from a vertical coupling plane and 80cm from the LISN. A second LISN was used for all local support equipment. Remote support equipment was located outside of the semi-anechoic chamber. Any cables running to remote support equipment where routed through metal conduit and when possible passed through a ferrite clamp upon exiting the chamber.

Ambient Conditions:

Temperature: 23.7 °C
Rel. Humidity: 41 %

Summary of Results

Run #	Test Performed	Limit	Result	Margin
1	CE, AC Power,120V/60Hz	FCC 15.207	Pass	52.6 dBµV @ 3.083 MHz (-3.4 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

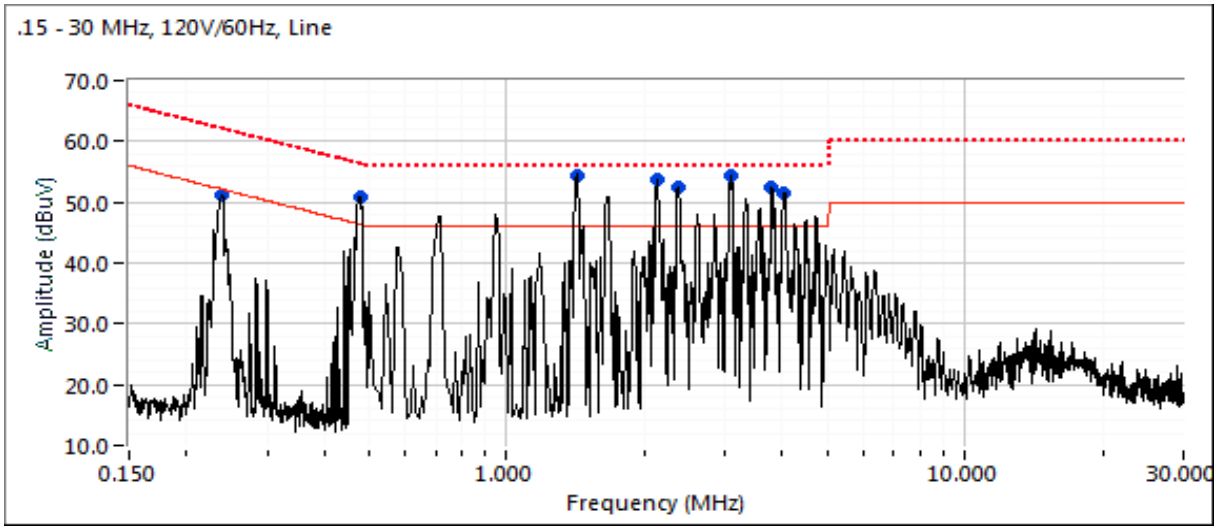
No deviations were made from the requirements of the standard.

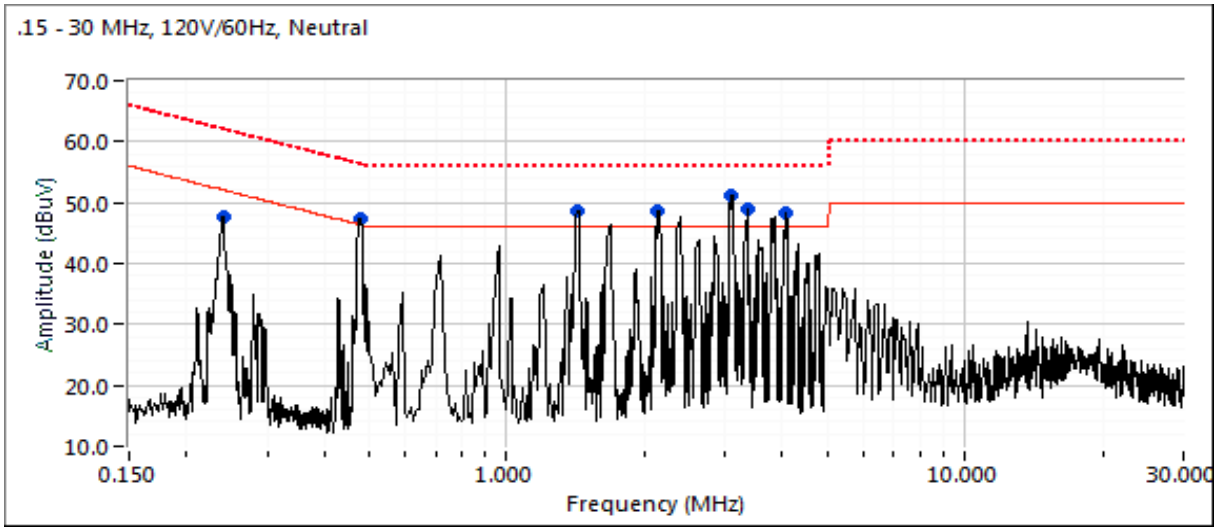
Sample Notes

Sample S/N: B854567AD010
Antenna: Inventek W2.4-5P-U

Client:	Whisker Labs, Inc.	PR Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Engineer:	David Bare
Standard:	FCC part 15	Class:	-

Run #1: AC Power Port Conducted Emissions, 0.15 - 30MHz, 120V/60Hz
Wi-Fi transmitting on channel 6 in 802.11b mode





Client:	Whisker Labs, Inc.	PR Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Engineer:	David Bare
Standard:	FCC part 15	Class:	-

Preliminary peak readings captured during pre-scan (peak readings vs. average limit)

Frequency	Level	AC	FCC 15.207		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
0.051	*29.4*	*Open*	*33.8*	*-4.4*	*Peak*	
0.238	51.1	Line 1	52.1	-1.0	Peak	
0.476	51.0	Line 1	46.4	4.6	Peak	
1.432	54.3	Line 1	46.0	8.3	Peak	
2.134	53.7	Line 1	46.0	7.7	Peak	
2.378	52.3	Line 1	46.0	6.3	Peak	
3.083	54.4	Line 1	46.0	8.4	Peak	
3.777	52.4	Line 1	46.0	6.4	Peak	
4.030	51.4	Line 1	46.0	5.4	Peak	
0.239	47.8	Neutral	52.1	-4.3	Peak	
0.480	47.2	Neutral	46.4	0.8	Peak	
1.436	48.6	Neutral	46.0	2.6	Peak	
2.127	48.6	Neutral	46.0	2.6	Peak	
3.115	51.2	Neutral	46.0	5.2	Peak	
3.353	48.9	Neutral	46.0	2.9	Peak	
4.086	48.2	Neutral	46.0	2.2	Peak	

Final quasi-peak and average readings

Frequency	Level	AC	FCC 15.207		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
3.083	52.6	Line 1	56.0	-3.4	QP	QP (1.00s)
0.476	42.9	Line 1	46.4	-3.5	AVG	AVG (0.10s)
2.134	52.5	Line 1	56.0	-3.5	QP	QP (1.00s)
2.134	41.9	Line 1	46.0	-4.1	AVG	AVG (0.10s)
1.432	50.8	Line 1	56.0	-5.2	QP	QP (1.00s)
0.476	50.3	Line 1	56.4	-6.1	QP	QP (1.00s)
3.115	49.8	Neutral	56.0	-6.2	QP	QP (1.00s)
3.083	39.5	Line 1	46.0	-6.5	AVG	AVG (0.10s)
4.030	49.4	Line 1	56.0	-6.6	QP	QP (1.00s)
3.777	49.3	Line 1	56.0	-6.7	QP	QP (1.00s)
1.432	38.9	Line 1	46.0	-7.1	AVG	AVG (0.10s)
2.378	48.7	Line 1	56.0	-7.3	QP	QP (1.00s)
1.436	47.3	Neutral	56.0	-8.7	QP	QP (1.00s)
2.127	45.7	Neutral	56.0	-10.3	QP	QP (1.00s)
3.353	45.7	Neutral	56.0	-10.3	QP	QP (1.00s)
0.480	35.6	Neutral	46.3	-10.7	AVG	AVG (0.10s)
0.480	45.2	Neutral	56.3	-11.1	QP	QP (1.00s)

Client:	Whisker Labs, Inc.	PR Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Engineer:	David Bare
Standard:	FCC part 15	Class:	-

4.030	34.4	Line 1	46.0	-11.6	AVG	AVG (0.10s)
0.238	39.8	Line 1	52.2	-12.4	AVG	AVG (0.10s)
0.238	49.3	Line 1	62.2	-12.9	QP	QP (1.00s)
1.436	32.9	Neutral	46.0	-13.1	AVG	AVG (0.10s)
3.777	32.0	Line 1	46.0	-14.0	AVG	AVG (0.10s)
0.239	37.6	Neutral	52.1	-14.5	AVG	AVG (0.10s)
0.239	47.2	Neutral	62.1	-14.9	QP	QP (1.00s)
4.086	41.1	Neutral	56.0	-14.9	QP	QP (1.00s)
2.378	29.1	Line 1	46.0	-16.9	AVG	AVG (0.10s)
3.115	25.8	Neutral	46.0	-20.2	AVG	AVG (0.10s)
2.127	22.7	Neutral	46.0	-23.3	AVG	AVG (0.10s)
3.353	21.1	Neutral	46.0	-24.9	AVG	AVG (0.10s)
4.086	18.9	Neutral	46.0	-27.1	AVG	AVG (0.10s)

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

RSS-247 and FCC 15.247 (DTS) Antenna Port Measurements

Power, PSD, Bandwidth and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 7/12 & 7/27/2018
Test Engineer: Rafael Varelas
Test Location: Fremont EMC Lab #4A

Config. Used: 1
Config Change: None
Host Unit Voltage 120V/60Hz

General Test Configuration

The EUT was connected to the spectrum analyzer or power meter via a suitable attenuator. All measurements were made on a single chain.

All measurements have been corrected to allow for the external attenuators used.

Ambient Conditions:

Temperature: 23 - 25 °C
Rel. Humidity: 41 - 44 %

Summary of Results

Run #	Pwr setting	Avg Pwr	Test Performed	Limit	Pass / Fail	Result / Margin
1			Output Power	15.247(b)	Pass	20.2 dBm
2			Power spectral Density (PSD)	15.247(d)	Pass	0.1 dBm/10kHz
3			Minimum 6dB Bandwidth	15.247(a)	Pass	8.6 MHz
3			99% Bandwidth	RSS GEN	-	17.7 MHz
4			Spurious emissions	15.247(b)	Pass	All emissions below -20dBc limit

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Procedure Comments:

Measurements performed in accordance with FCC KDB 558074

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
11b	1 Mb/s	1.00	Yes	8.41	0.0	0.0	10
11g	6 Mb/s	0.97	Yes	1.4	0.1	0.2	714
n20	MCS 0	0.97	Yes	1.31	0.1	0.3	763

Sample Notes

Sample S/N: B854567AD010

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Run #1: Output Power

Mode: 11b

Power Setting[2]	Frequency (MHz)	Output Power (dBm)[1]	Output Power mW	Antenna Gain (dBi)	Result	EIRP dBm	EIRP W	Output Power (dBm)[3]	Output Power mW
FW	2412	17.5	56.2	1.0	Pass	18.5	0.071		
FW	2437	17.7	58.9	1.0	Pass	18.7	0.074		
FW	2462	17.9	61.7	1.0	Pass	18.9	0.078		

Mode: 11g

Power Setting[2]	Frequency (MHz)	Output Power (dBm)[1]	Output Power mW	Antenna Gain (dBi)	Result	EIRP dBm	EIRP W	Output Power (dBm)[3]	Output Power mW
FW	2412	19.7	93.3	1.0	Pass	20.7	0.117		
FW	2437	19.9	97.7	1.0	Pass	20.9	0.123		
FW	2462	20.2	104.7	1.0	Pass	21.2	0.132		

Mode: n20

Power Setting[2]	Frequency (MHz)	Output Power (dBm)[1]	Output Power mW	Antenna Gain (dBi)	Result	EIRP dBm	EIRP W	Output Power (dBm)[3]	Output Power mW
FW	2412	19.7	93.3	1.0	Pass	20.7	0.117		
FW	2437	19.9	97.7	1.0	Pass	20.9	0.123		
FW	2462	20.1	102.3	1.0	Pass	21.1	0.129		

Note 1:	Output power measured using a peak power meter, spurious limit is -20dBc.
Note 2:	Power setting - the software power setting used during testing, included for reference only. FW = Firmware setting.
Note 3:	Power measured using average power meter (non-gated) and is included for reference only.

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Run #2: Power spectral Density

Mode: 11b

Power Setting	Frequency (MHz)	PSD (dBm/10kHz) Note 1	Limit dBm/3kHz	Result
FW	2411.50	-0.2	8.0	Pass
FW	2437.60	-0.4	8.0	Pass
FW	2461.47	0.1	8.0	Pass

Mode: 11g

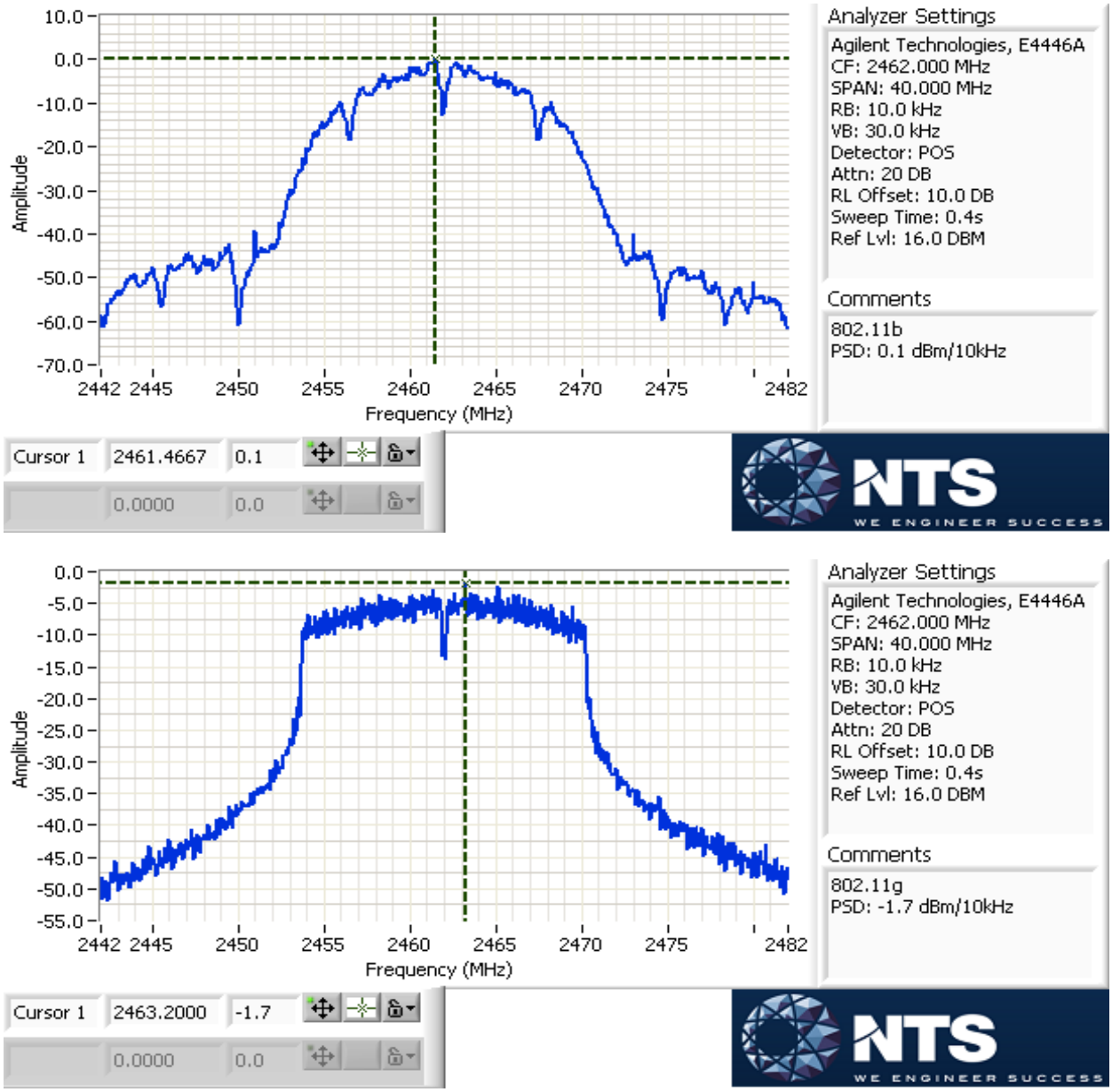
Power Setting	Frequency (MHz)	PSD (dBm/10kHz) Note 1	Limit dBm/3kHz	Result
FW	2408.87	-3.1	8.0	Pass
FW	2433.87	-2.5	8.0	Pass
FW	2463.20	-1.7	8.0	Pass

Mode: n20

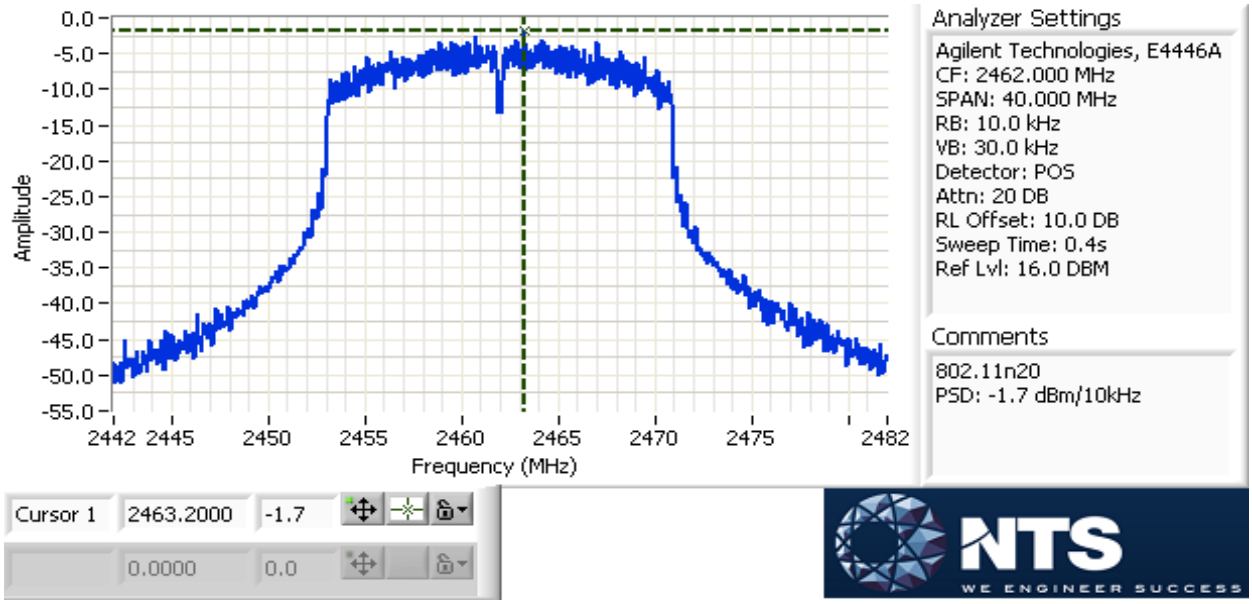
Power Setting	Frequency (MHz)	PSD (dBm/10kHz) Note 1	Limit dBm/3kHz	Result
FW	2410.73	-3.5	8.0	Pass
FW	2437.20	-2.4	8.0	Pass
FW	2463.20	-1.7	8.0	Pass

Note 1:	Test performed per method PKSPD, in KDB 558074. Power spectral density measured using: 3kHz ≤ RBW ≤ 100kHz, VBW=3*RBW, peak detector, span = 1.5*DTS BW, auto sweep time, max hold.

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A



Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A



Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Run #3: Signal Bandwidth

Mode: 11b

Power Setting	Frequency (MHz)	Bandwidth (MHz)		RBW Setting (MHz)	
		6dB	99%	6dB	99%
FW	2412	8.6	14.04	100	300
FW	2437	9.0	14.04	100	300
FW	2462	9.1	14.04	100	300

Mode: 11g

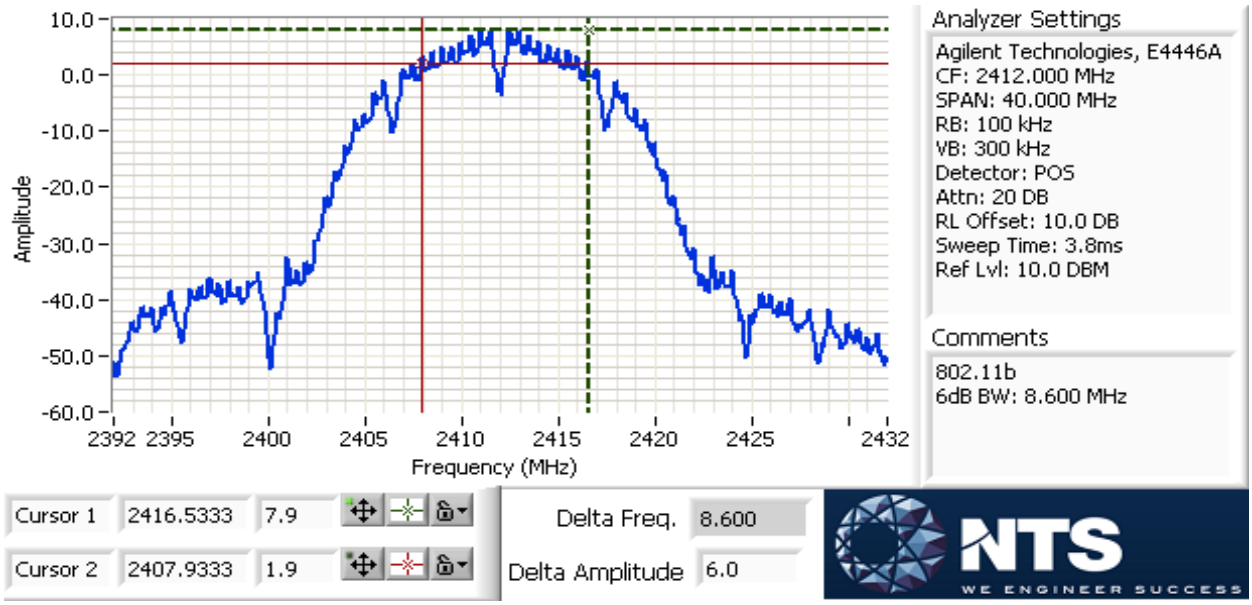
Power Setting	Frequency (MHz)	Bandwidth (MHz)		RBW Setting (MHz)	
		6dB	99%	6dB	99%
FW	2412	15.1	16.6	100	300
FW	2437	15.1	16.6	100	300
FW	2462	15.1	16.6	100	300

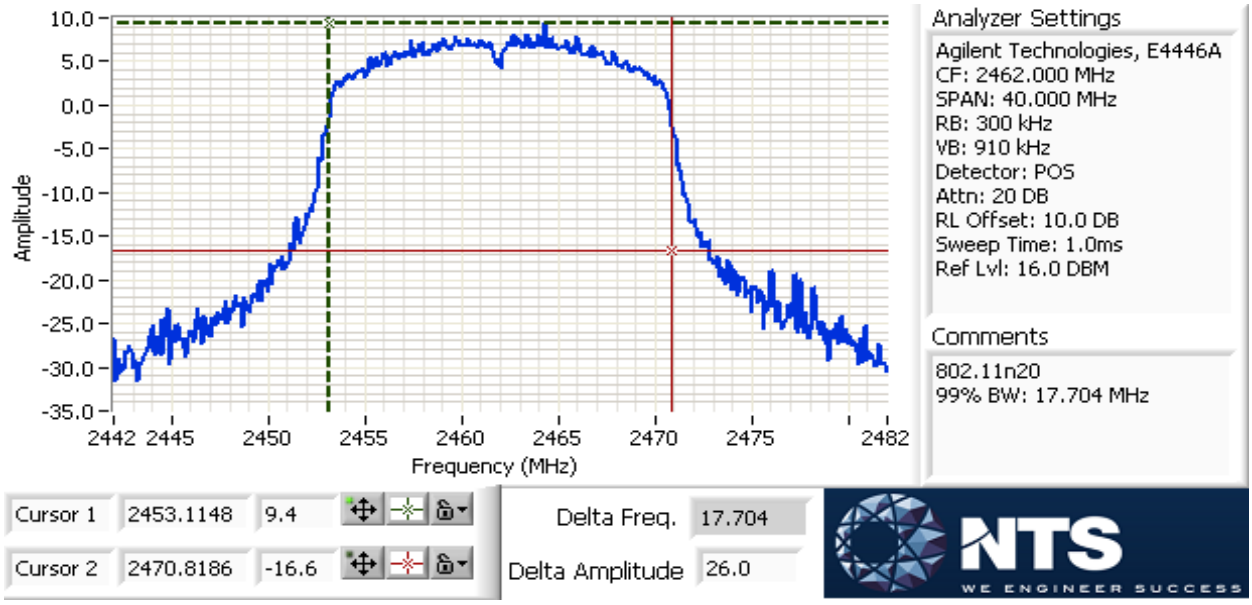
Mode: n20

Power Setting	Frequency (MHz)	Bandwidth (MHz)		RBW Setting (MHz)	
		6dB	99%	6dB	99%
FW	2412	15.1	17.7	100	300
FW	2437	15.1	17.6	100	300
FW	2462	15.1	17.7	100	300

Note 1:	DTS BW: RBW=100kHz, VBW ≥ 3*RBW, peak detector, max hold, auto sweep time, Span 2-5 times measured BW. 99% BW: RBW=1-5% of 99%BW, VBW ≥ 3*RBW, peak detector, max hold, auto sweep time. Span 1.5-5 times OBW.

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A





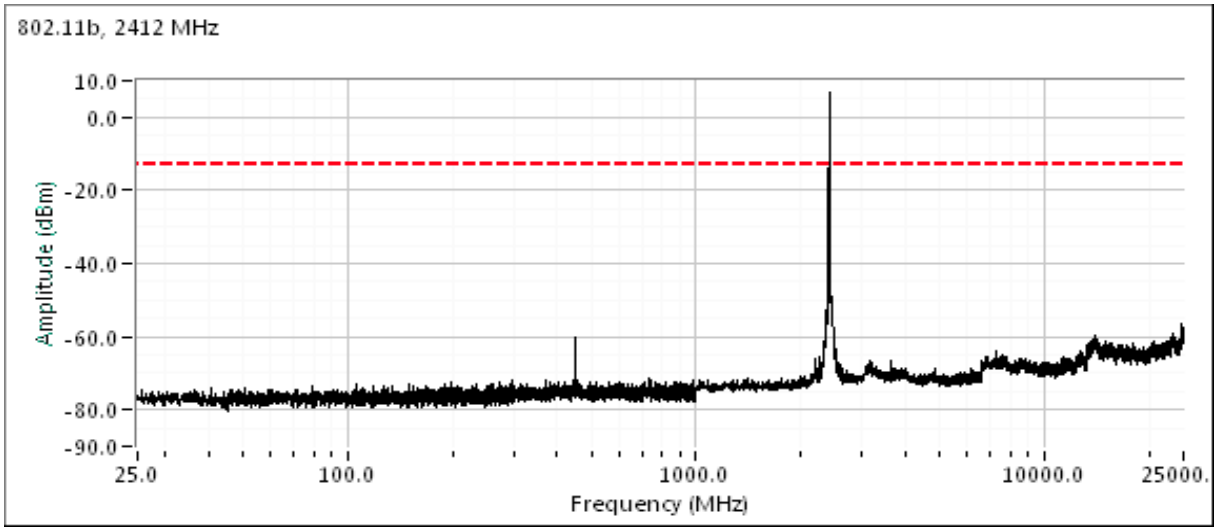
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Run #4a: Out of Band Spurious Emissions

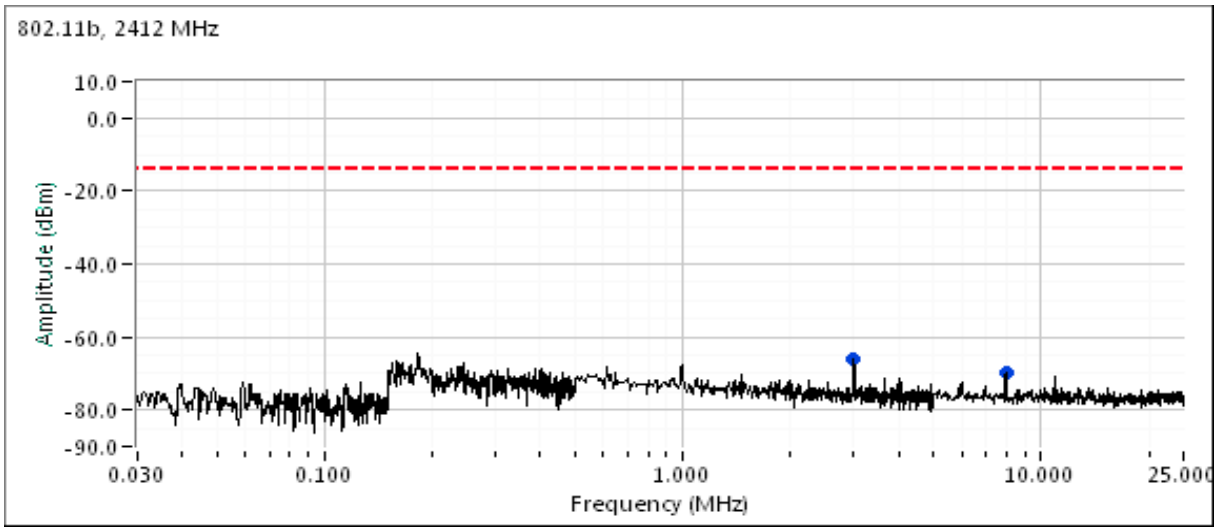
Frequency (MHz)	Power Setting	Mode	Limit	Result
2412	FW	b	-20dBc	Pass
2437	FW	b	-20dBc	Pass
2462	FW	b	-20dBc	Pass
2412	FW	g	-20dBc	Pass
2437	FW	g	-20dBc	Pass
2462	FW	g	-20dBc	Pass
2412	FW	n20	-20dBc	Pass
2437	FW	n20	-20dBc	Pass
2462	FW	n20	-20dBc	Pass

RBW = 100 kHz and VBW = 300 kHz for all plots except those below 30 MHz where RBW = 9 kHz and VBW = 30 kHz.

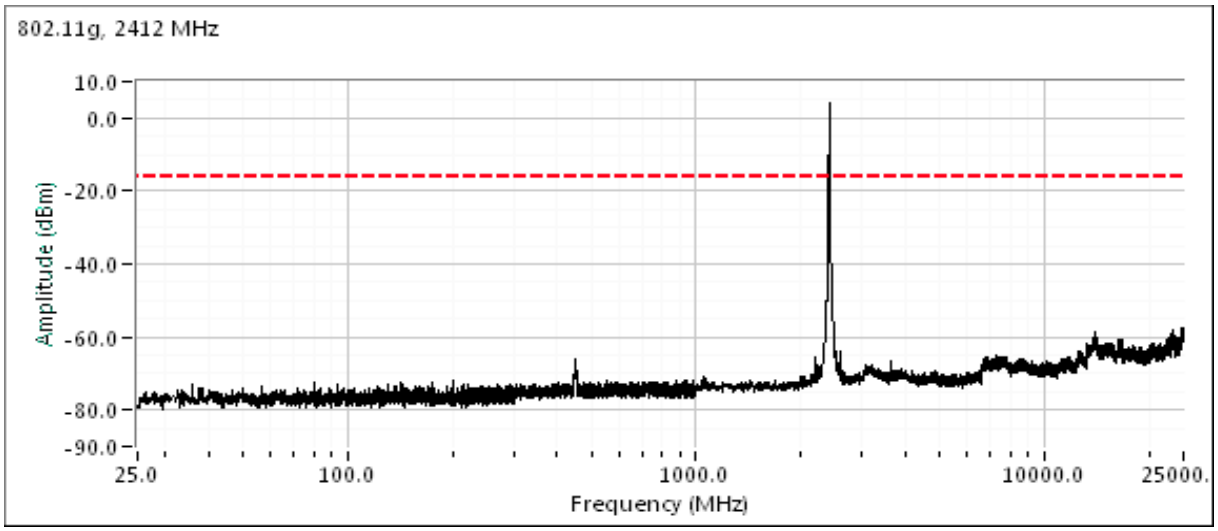
Plots for low channel

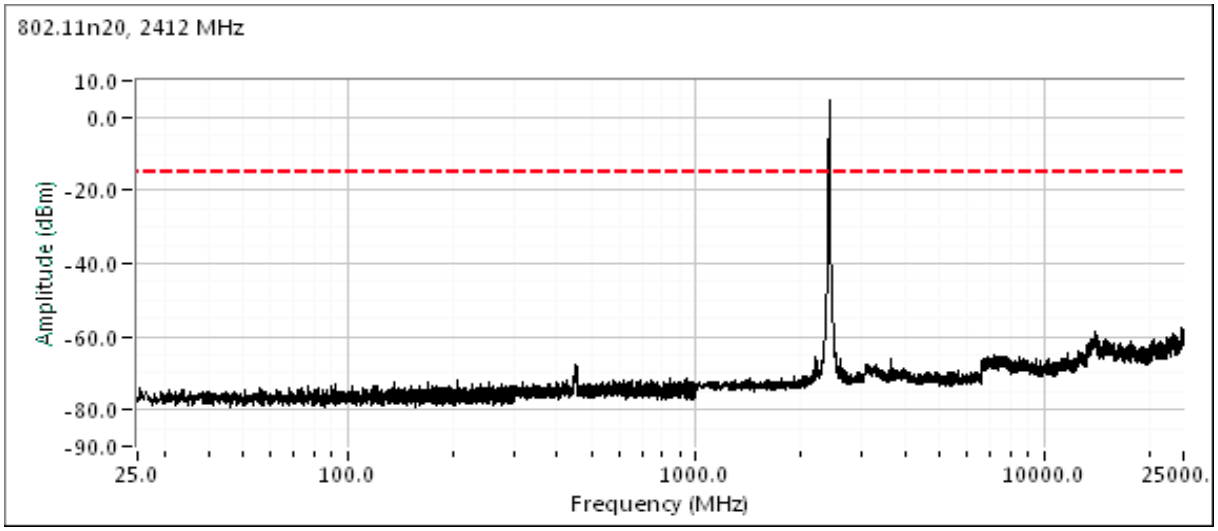


Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A



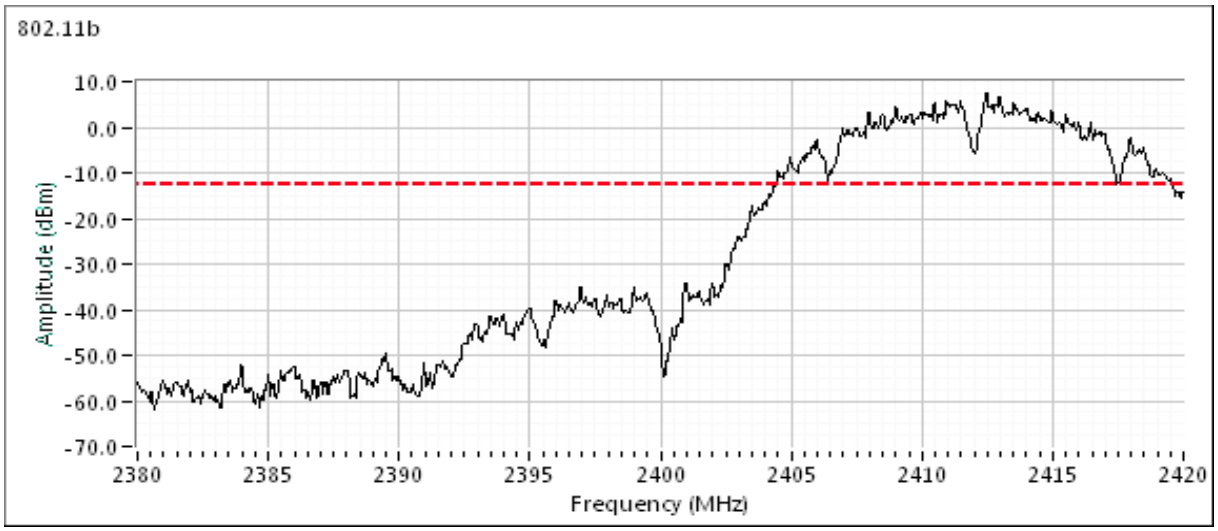
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

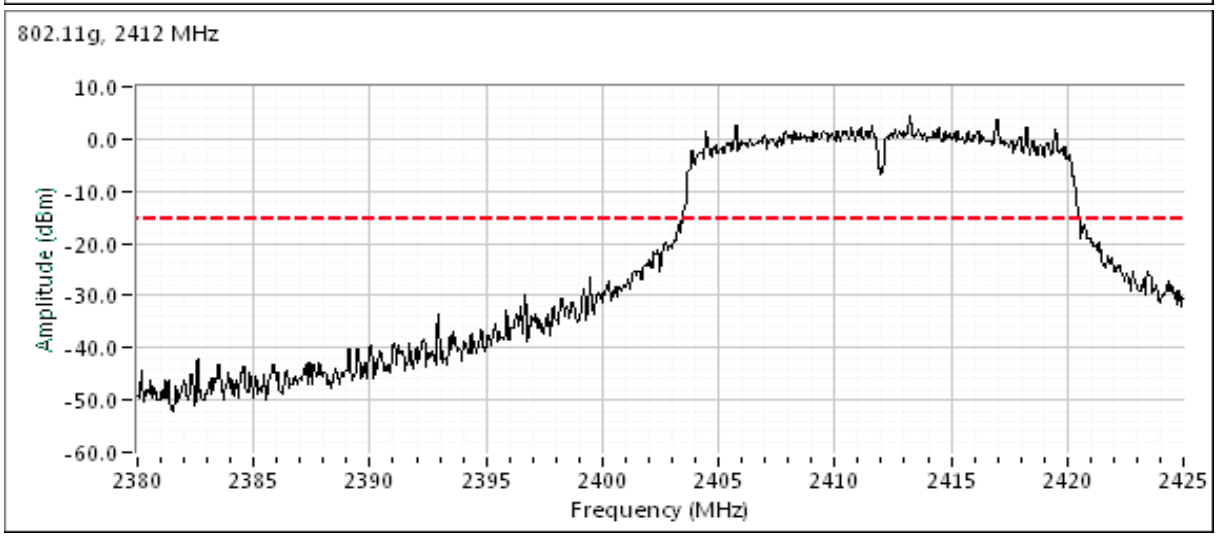




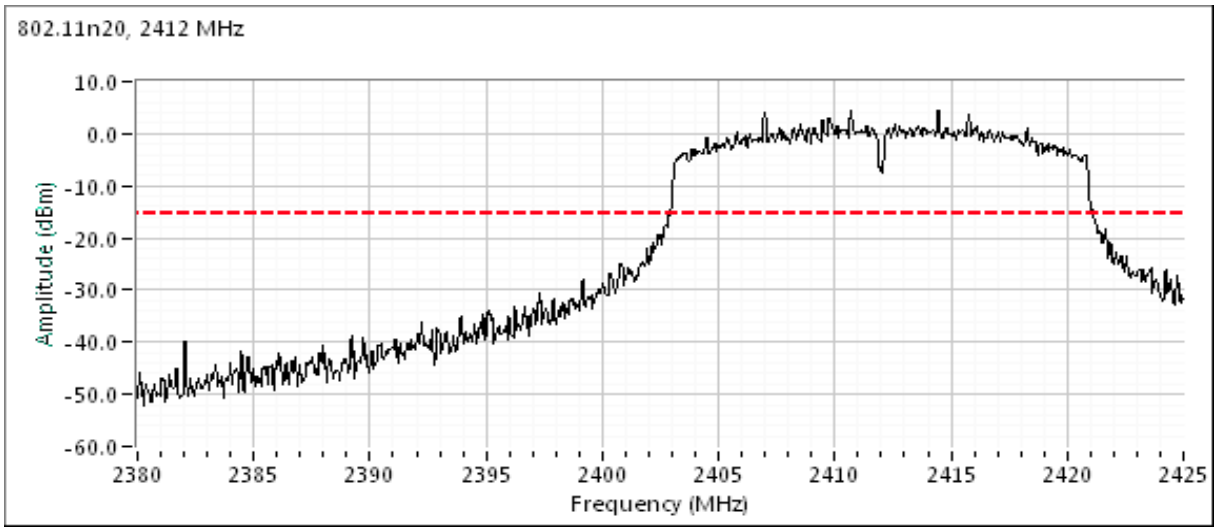
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Additional plot showing compliance with -20dBc limit from 2390 MHz to 2400 MHz. Radiated measurements used to show compliance with the limits in the restricted band below 2390 MHz.

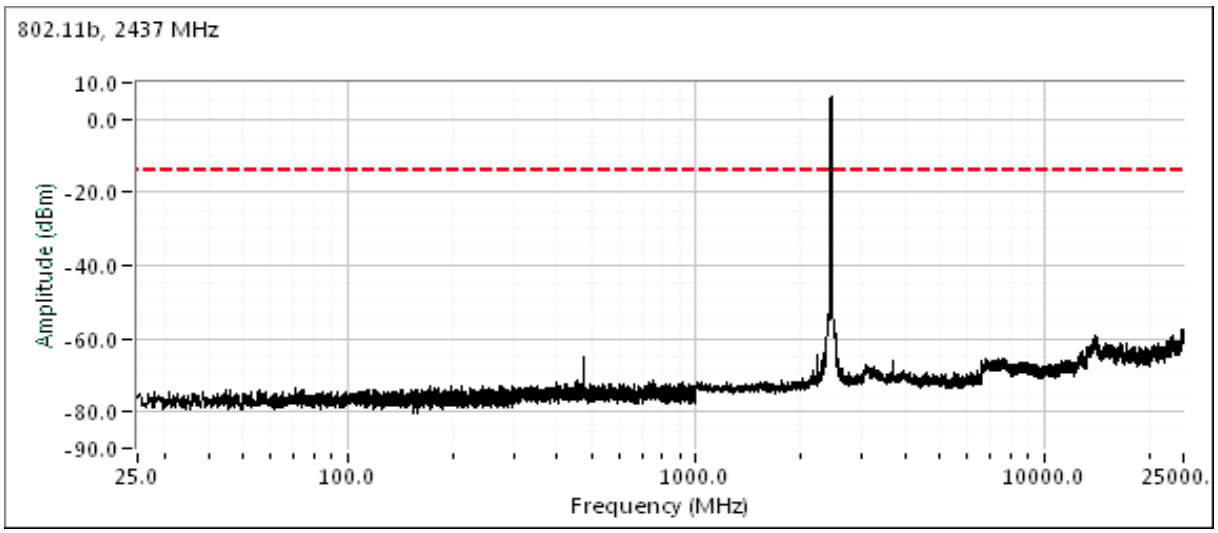




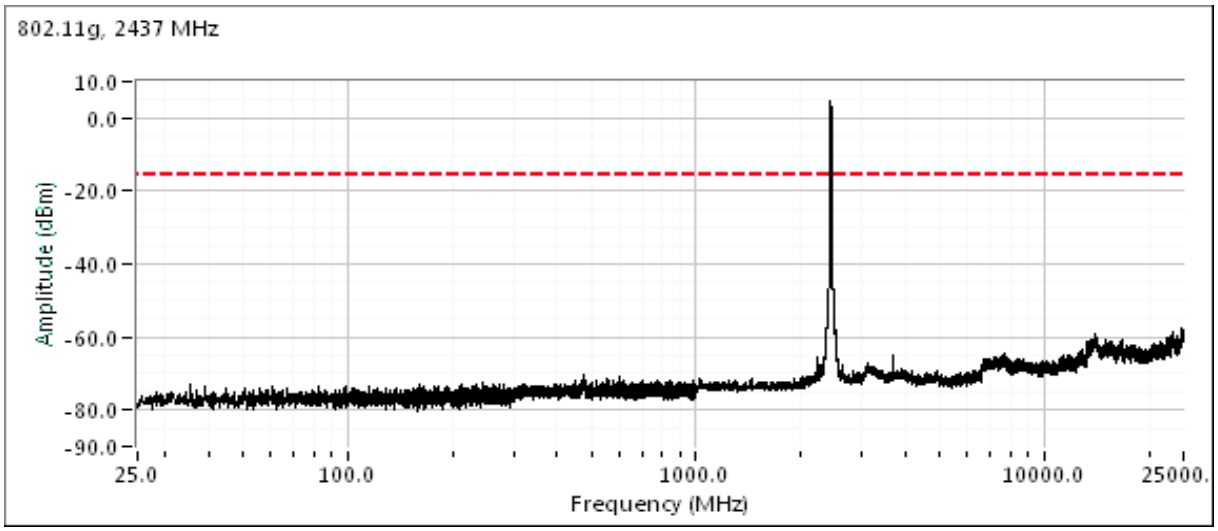
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

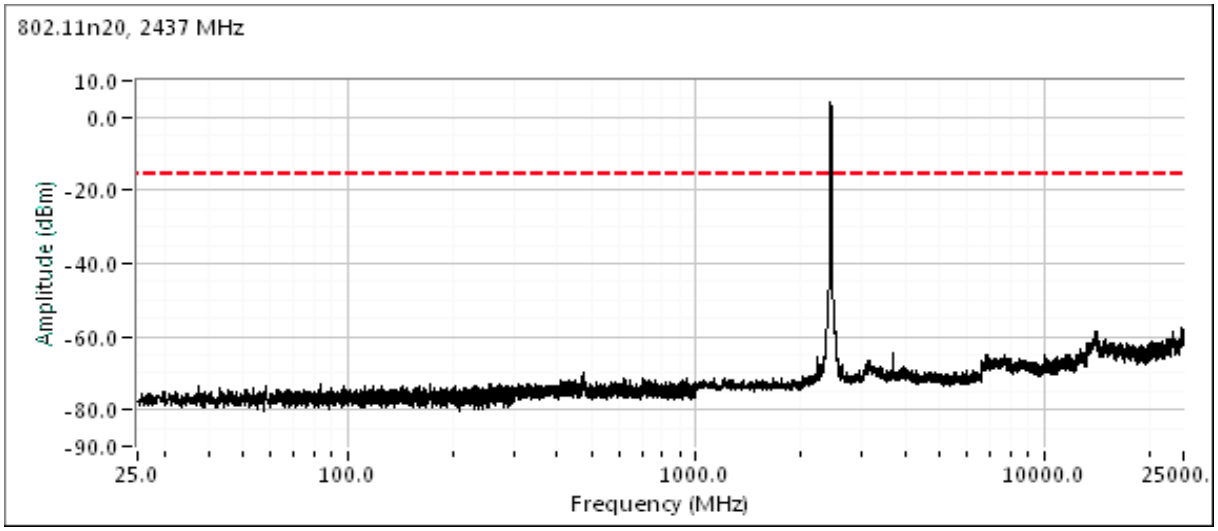


Plots for center channel



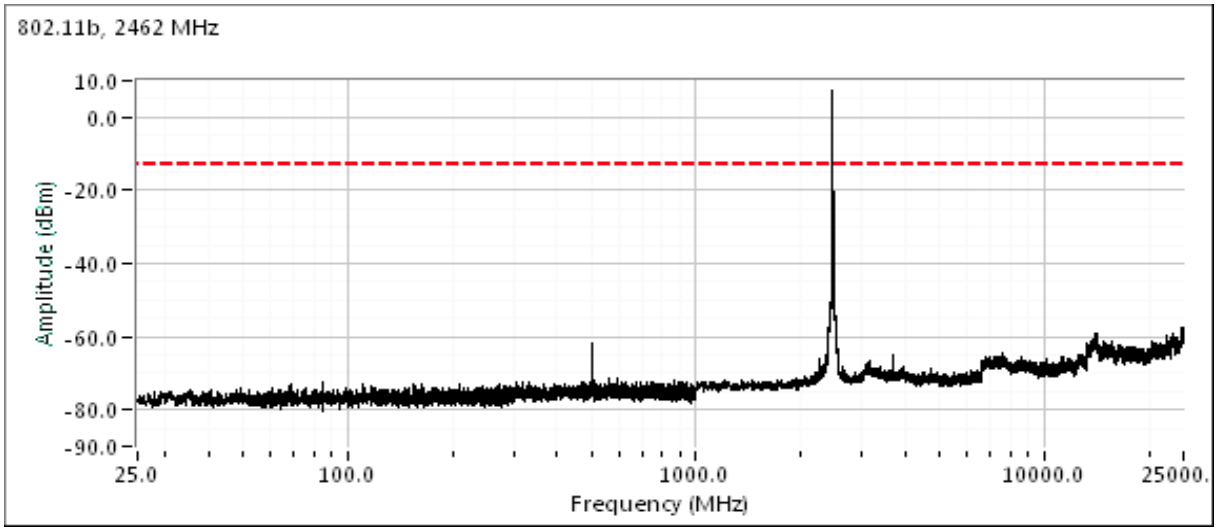
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

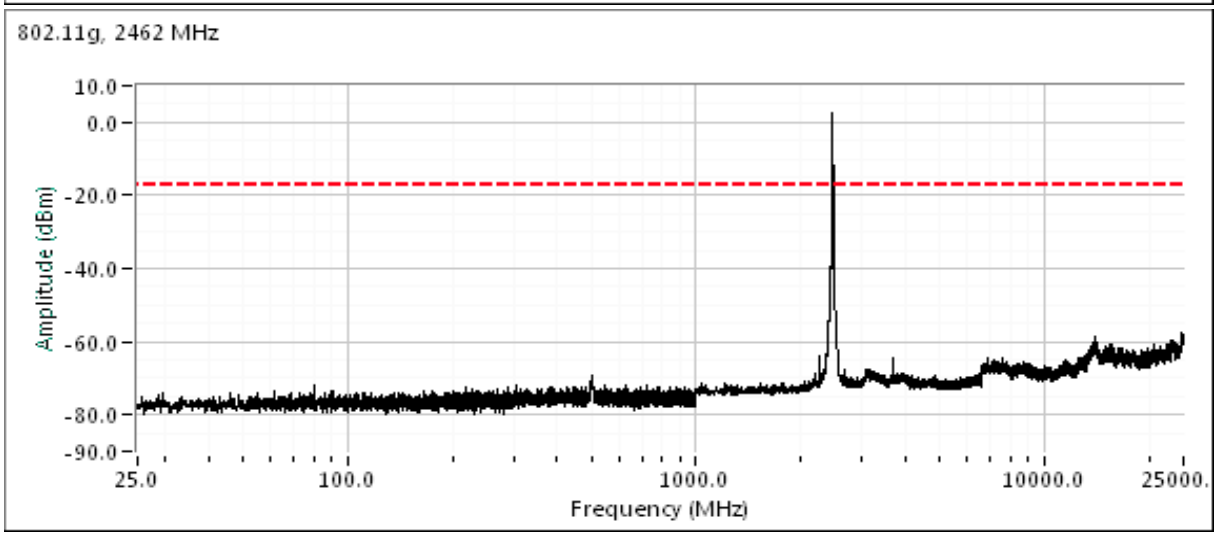




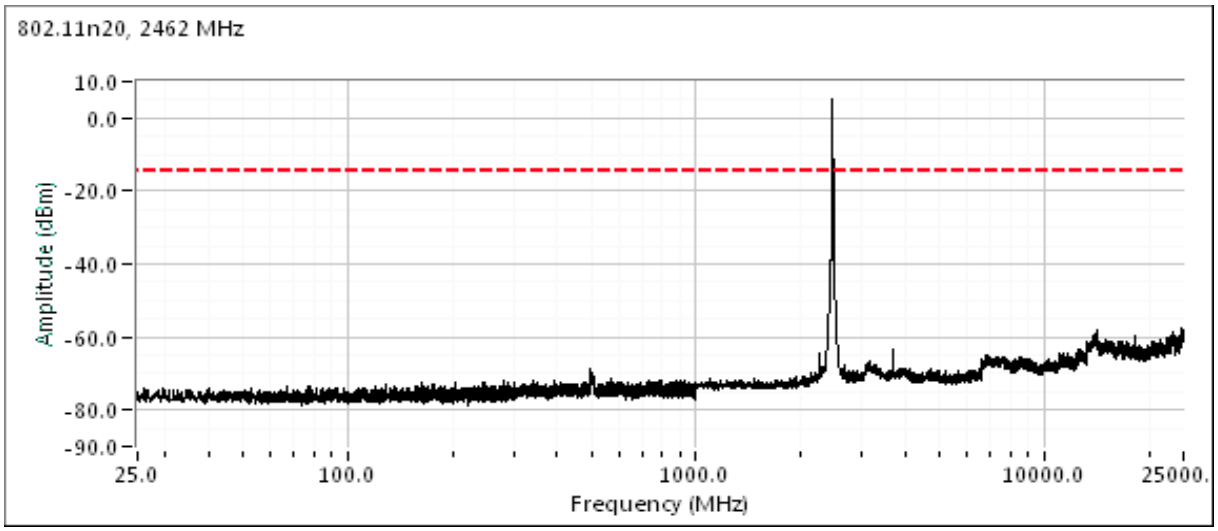
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

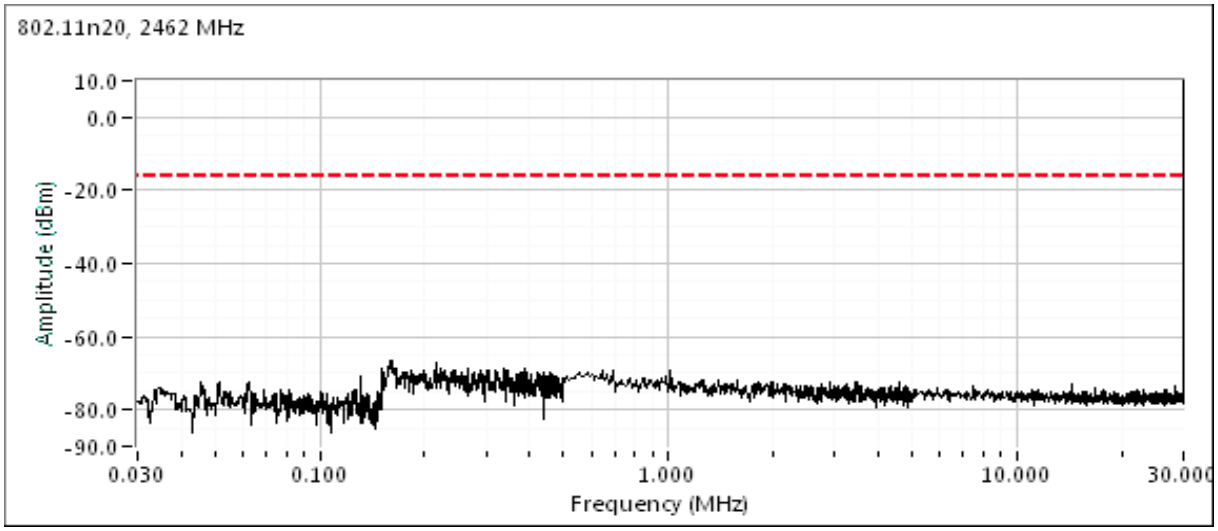
Plots for high channel





Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A





Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

RSS-247 and FCC 15.247 (DTS) Radiated Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.
For radiated emissions testing the measurement antenna was located 3 meters from the EUT, unless otherwise noted.

Ambient Conditions:

Temperature: 27 °C
Rel. Humidity: 34 %

Summary of Results - Device Operating in the 2400-2483.5 MHz Band

Run #	Mode	Channel	Target Power	Power Setting	Test Performed	Limit	Result / Margin
1	b	1 - 2412MHz	-	-	Restricted Band Edge (2390 MHz)	FCC Part 15.209 / 15.247(c)	37.5 dBµV/m @ 2379.7 MHz (-16.5 dB)
	b	11 - 2462MHz	-	-	Restricted Band Edge (2483.5 MHz)	FCC Part 15.209 / 15.247(c)	38.8 dBµV/m @ 2485.3 MHz (-15.2 dB)
2	g	1 - 2412MHz	-	-	Restricted Band Edge (2390 MHz)	FCC Part 15.209 / 15.247(c)	62.9 dBµV/m @ 2384.9 MHz (-11.1 dB)
	g	11 - 2462MHz	-	-	Restricted Band Edge (2483.5 MHz)	FCC Part 15.209 / 15.247(c)	66.1 dBµV/m @ 2483.7 MHz (-7.9 dB)
3	n20	1 - 2412MHz	-	-	Restricted Band Edge (2390 MHz)	FCC Part 15.209 / 15.247(c)	65.5 dBµV/m @ 2388.6 MHz (-8.5 dB)
	n20	11 - 2462MHz	-	-	Restricted Band Edge (2483.5 MHz)	FCC Part 15.209 / 15.247(c)	66.3 dBµV/m @ 2486.3 MHz (-7.7 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Sample Notes

Sample S/N: B854567AD010
Antenna: Pulse Electronics W3921

Procedure Comments:

Measurements performed in accordance with FCC KDB 558074
Peak measurements performed with: RBW=1MHz, VBW=3MHz, peak detector, max hold, auto sweep time
Unless otherwise stated/noted, emission has a duty cycle ≥ 98% and was measured using RBW=1MHz, VBW=10Hz, peak detector, linear average mode, auto sweep time, max hold.

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
11b	1 Mb/s	1.00	Yes	8.41	0	0	10
11g	6 Mb/s	0.97	Yes	1.4	0.1	0.2	714
n20	MCS 0	0.97	Yes	1.31	0.1	0.3	763
BLE	1 Mb/s	#DIV/0!			#DIV/0!	#DIV/0!	#DIV/0!

Measurement Specific Notes:

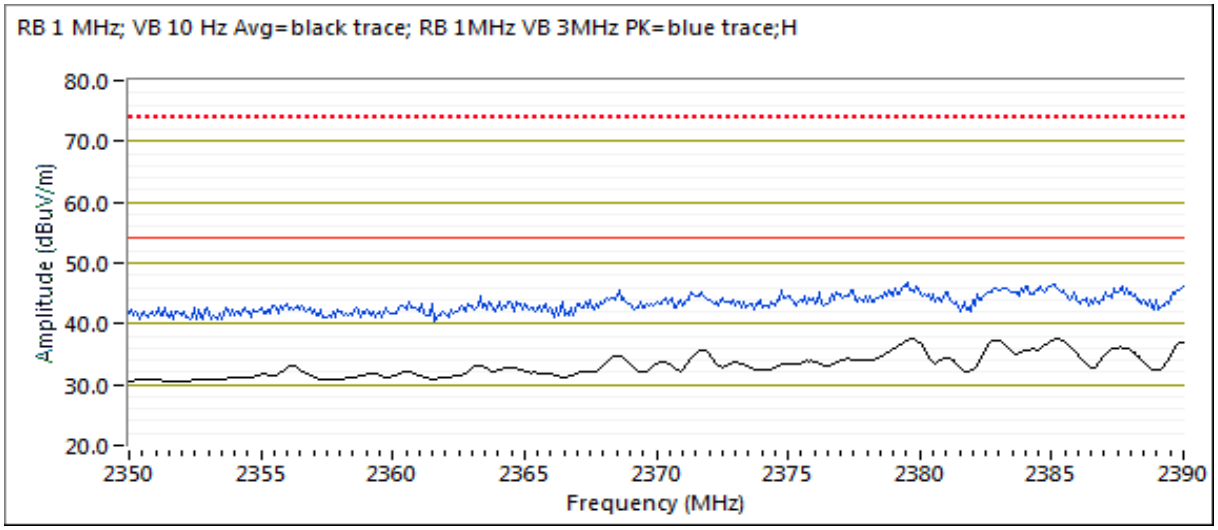
Note 1:	Emission in non-restricted band, but limit of 15.209 used.
Note 2:	Emission in non-restricted band, the limit was set 30dB below the level of the fundamental and measured in 100kHz.
Note 3:	Emission has a duty cycle ≥ 98%, average measurement performed: RBW=1MHz, VBW=3MHz, RMS, Power averaging, auto sweep, trace average 100 traces
Note 4:	Emission has constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW>1/T but not less than 10Hz, peak detector, linear averaging, auto sweep, trace average 100 traces, measurement corrected by Linear voltage correction factor
Note 5:	Emission has constatnt duty cycle < 98%, average measurement performed: RBW=1MHz, VBW=3MHz, RMS, Power averaging, auto sweep, trace average 100 traces, measurement corrected by Pwr correction factor
Note 6:	Emission has non constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW> 1/T, peak detector, linear average mode, sweep time auto, max hold. Max hold for 50*(1/DC) traces
Note 7:	Emission has non constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW> 1/T, RMS detector, sweep time auto, max hold. Max hold for 50*(1/DC) traces
Note 8:	Plots of the average and peak bandedge do not account for any duty cycle correction. Refer to the tabular results for final measurements.

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Run #1: Radiated Bandedge Measurements

Date of Test: 7/11/2018 0:00 Config. Used: 1
Test Engineer: Jude Semana / R. Varelas Config Change: None
Test Location: FT Chamber 5 EUT Voltage:

Channel: 1 Mode: b
Data Rate: 1 Mb/s

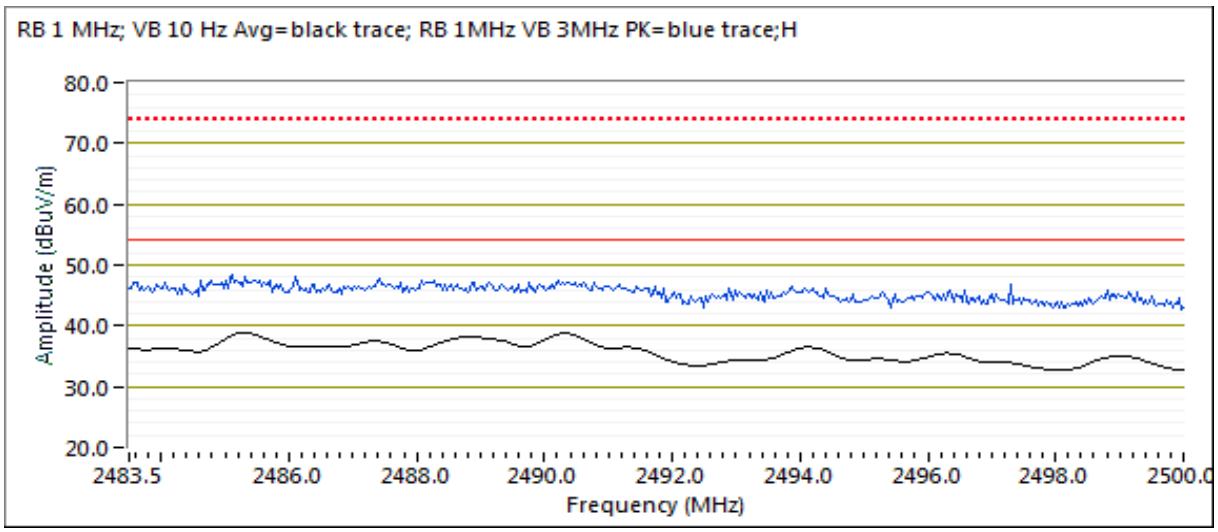


Band Edge Signal Field Strength - Direct measurement of field strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2379.740	37.5	H	54.0	-16.5	AVG	10	1.0	POS; RB 1 MHz; VB: 10 Hz
2384.950	46.6	H	74.0	-27.4	PK	10	1.0	POS; RB 1 MHz; VB: 3 MHz
2382.820	35.1	V	54.0	-18.9	AVG	322	1.3	POS; RB 1 MHz; VB: 10 Hz
2382.880	45.5	V	74.0	-28.5	PK	322	1.3	POS; RB 1 MHz; VB: 3 MHz

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Channel: 11 Mode: b
Data Rate: 1 Mb/s



Band Edge Signal Field Strength - Direct measurement of field strength

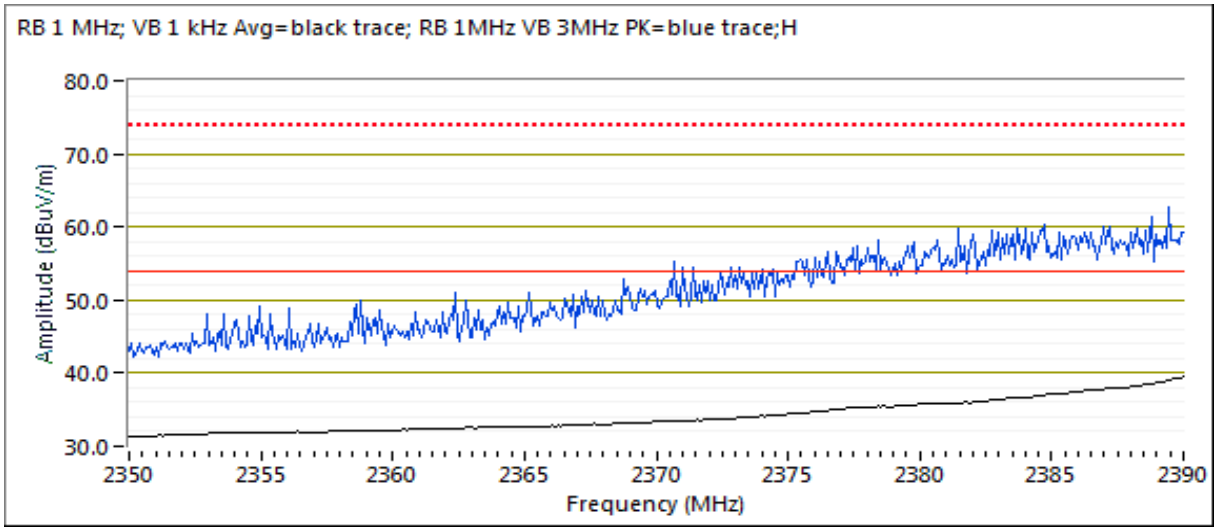
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2485.250	38.8	H	54.0	-15.2	AVG	350	1.8	POS; RB 1 MHz; VB: 10 Hz
2485.420	47.7	H	74.0	-26.3	PK	350	1.8	POS; RB 1 MHz; VB: 3 MHz
2485.350	35.5	V	54.0	-18.5	AVG	224	1.0	POS; RB 1 MHz; VB: 10 Hz
2490.640	46.3	V	74.0	-27.7	PK	224	1.0	POS; RB 1 MHz; VB: 3 MHz

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Run #2: Radiated Bandedge Measurements

Date of Test: 7/11/2018 0:00 Config. Used: 1
Test Engineer: Jude Semana Config Change: None
Test Location: FT Chamber 5 EUT Voltage:

Channel: 1 Mode: g
Data Rate: 6 Mb/s

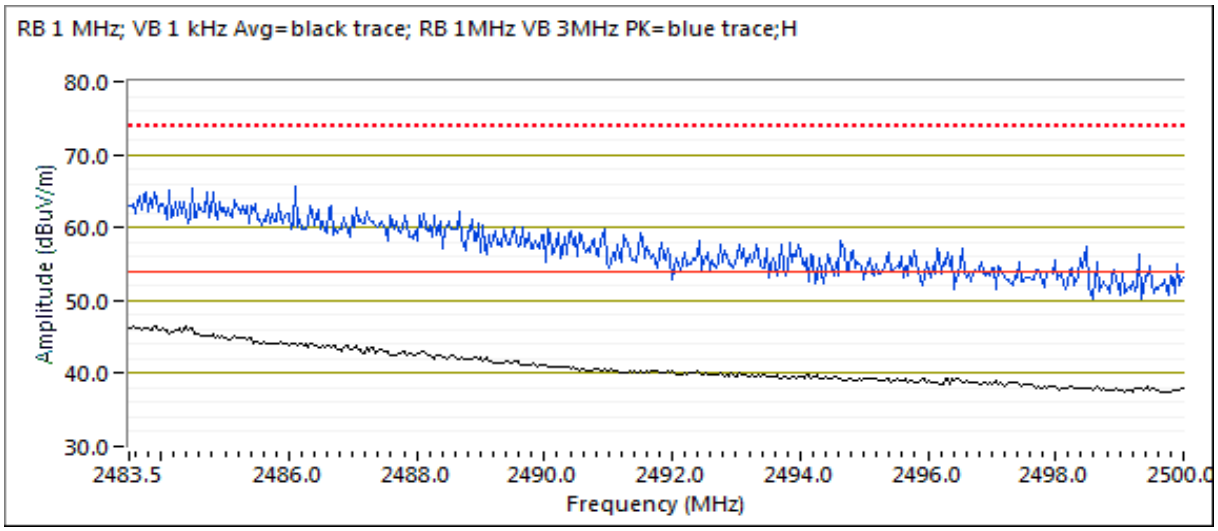


Band Edge Signal Field Strength - Direct measurement of field strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2389.980	39.6	H	54.0	-14.4	Avg	345	2.2	Note 4,POS Vavg:100; RB 1 MHz; VB
2384.850	62.9	H	74.0	-11.1	PK	345	2.2	POS; RB 1 MHz; VB: 3 MHz
2389.960	35.6	V	54.0	-18.4	Avg	323	1.0	Note 4,POS Vavg:100; RB 1 MHz; VB
2389.980	55.9	V	74.0	-18.1	PK	323	1.0	POS; RB 1 MHz; VB: 3 MHz

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Channel: 11 Mode: g
Data Rate: 6 Mb/s



Band Edge Signal Field Strength - Direct measurement of field strength

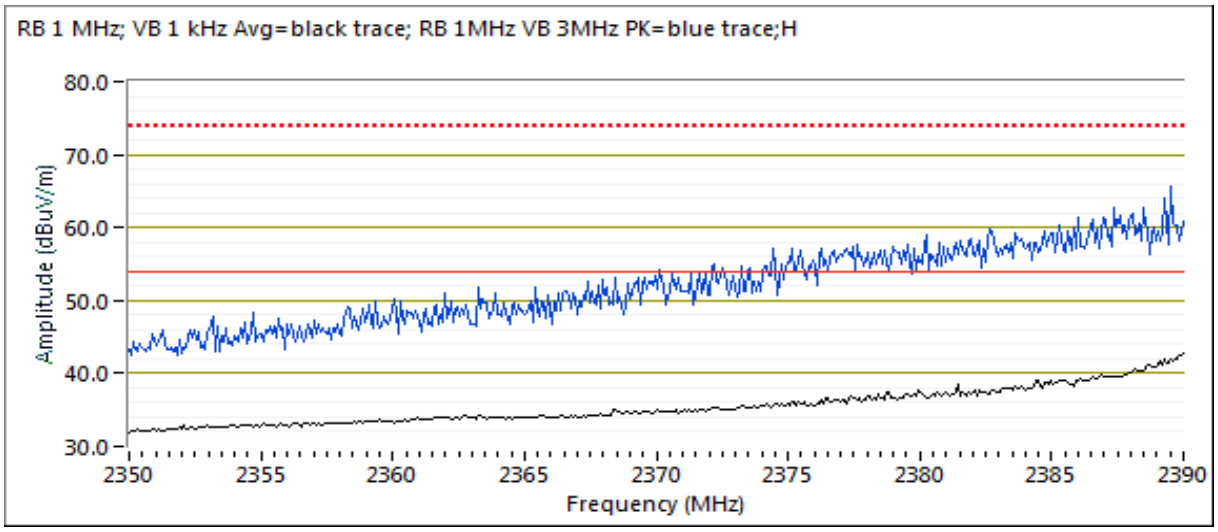
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2483.550	45.1	H	54.0	-8.9	Avg	344	2.1	Note 4,POS Vavg:100; RB 1 MHz; VB
2483.730	66.1	H	74.0	-7.9	PK	344	2.1	POS; RB 1 MHz; VB: 3 MHz
2483.540	42.6	V	54.0	-11.4	Avg	316	1.6	Note 4,POS Vavg:100; RB 1 MHz; VB
2484.820	63.2	V	74.0	-10.8	PK	316	1.6	POS; RB 1 MHz; VB: 3 MHz

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Run #3: Radiated Bandedge Measurements

Date of Test: 7/11/2018 0:00 Config. Used: 1
Test Engineer: Jude Semana / R. Varelas Config Change: None
Test Location: FT Chamber 5 EUT Voltage:

Channel: 1 Mode: n20
Data Rate: MCS 0

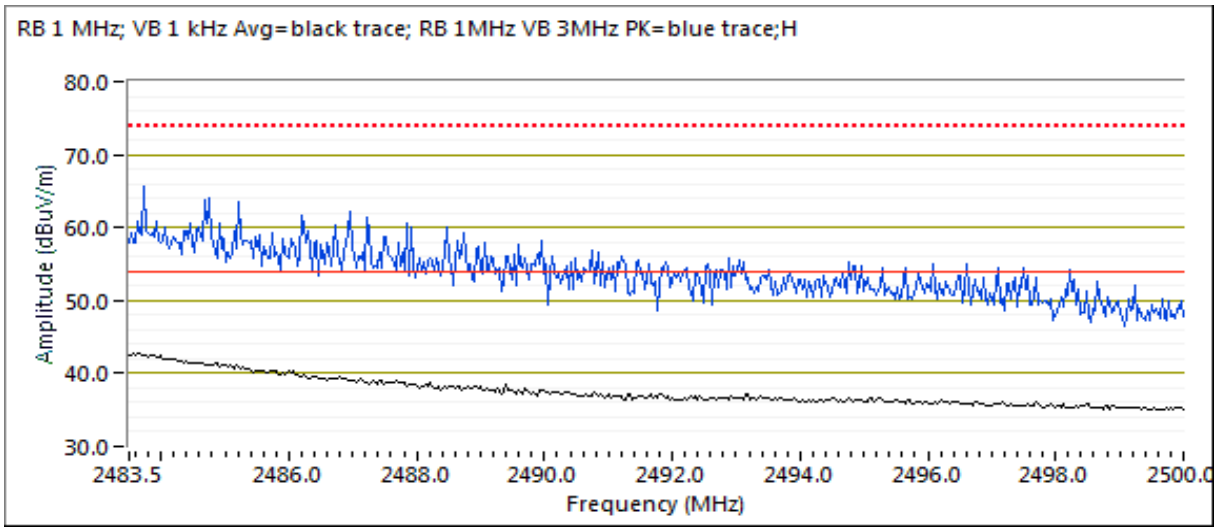


Band Edge Signal Field Strength - Direct measurement of field strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2390.000	41.5	H	54.0	-12.5	Avg	358	1.8	Note 4,POS Vavg:100; RB 1 MHz; VB
2388.560	65.5	H	74.0	-8.5	PK	358	1.8	POS; RB 1 MHz; VB: 3 MHz
2390.000	36.9	V	54.0	-17.1	Avg	325	1.5	Note 4,POS Vavg:100; RB 1 MHz; VB
2382.870	59.1	V	74.0	-14.9	PK	325	1.5	POS; RB 1 MHz; VB: 3 MHz

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Channel: 11 Mode: n20
Data Rate: MCS 0



Band Edge Signal Field Strength - Direct measurement of field strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2483.510	41.9	H	54.0	-12.1	Avg	349	2.1	Note 4,POS Vavg:100; RB 1 MHz; VB
2486.290	66.3	H	74.0	-7.7	PK	349	2.1	POS; RB 1 MHz; VB: 3 MHz
2483.510	38.9	V	54.0	-15.1	Avg	312	1.5	Note 4,POS Vavg:100; RB 1 MHz; VB
2487.360	59.5	V	74.0	-14.5	PK	312	1.5	POS; RB 1 MHz; VB: 3 MHz

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

RSS-247 and FCC 15.247 (DTS) Radiated Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.

For radiated emissions testing the measurement antenna was located 3 meters from the EUT, unless otherwise noted.

Ambient Conditions:

Temperature: 23.4 °C

Rel. Humidity: 41 %

Summary of Results - Device Operating in the 2400-2483.5 MHz Band

Run #	Mode	Channel	Target Power	Power Setting	Test Performed	Limit	Result / Margin
2	b	1 - 2412MHz	-	-	Radiated Emissions, 30 kHz - 25 GHz	FCC Part 15.209 / 15.247(c)	51.5 dBµV/m @ 4823.9 MHz (-2.5 dB)
	b	6 - 2437MHz	-	-	Radiated Emissions, 25 MHz - 25 GHz	FCC Part 15.209 / 15.247(c)	53.0 dBµV/m @ 4874.0 MHz (-1.0 dB)
	b	11 - 2462MHz	-	-	Radiated Emissions, 25 MHz - 25 GHz	FCC Part 15.209 / 15.247(c)	52.9 dBµV/m @ 4924.0 MHz (-1.1 dB)
Scans on center channel in both OFDM modes to determine the worst case mode.							
3	g	6 - 2437MHz	-	-	Radiated Emissions, 25 MHz - 25 GHz	FCC Part 15.209 / 15.247(c)	48.7 dBµV/m @ 4048.7 MHz (-5.3 dB)
	n20	6 - 2437MHz	-	-	Radiated Emissions, 25 MHz - 25 GHz	FCC Part 15.209 / 15.247(c)	47.8 dBµV/m @ 3655.4 MHz (-6.2 dB)
Measurements on low and high channels in worst-case OFDM mode.							
4	g	1 - 2412MHz	-	-	Radiated Emissions, 25 MHz - 25 GHz	FCC Part 15.209 / 15.247(c)	47.0 dBµV/m @ 3618.0 MHz (-7.0 dB)
	g	11 - 2462MHz	-	-	Radiated Emissions, 30 kHz - 25 GHz	FCC Part 15.209 / 15.247(c)	48.9 dBµV/m @ 4921.9 MHz (-5.1 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Sample Notes

Sample S/N: B854567AD010
Antenna: Pulse Electronics W3921

Procedure Comments:

Measurements performed in accordance with FCC KDB 558074
Peak measurements performed with: RBW=1MHz, VBW=3MHz, peak detector, max hold, auto sweep time
Unless otherwise stated/noted, emission has duty cycle ≥ 98% and was measured using RBW=1MHz, VBW=10Hz, peak detector, linear average mode, auto sweep time, max hold.
2.4GHz band reject filter used

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
11b	1 Mb/s	1.00	Yes	8.41	0.0	0.0	10
11g	6 Mb/s	0.97	Yes	1.4	0.1	0.2	714
n20	MCS 0	0.97	Yes	1.31	0.1	0.3	763
BLE	1 Mb/s	#DIV/0!			#DIV/0!	#DIV/0!	#DIV/0!

Measurement Specific Notes:

Note 1:	Emission in non-restricted band, but limit of 15.209 used.
Note 2:	Emission in non-restricted band, the limit was set 30dB below the level of the fundamental and measured in 100kHz.
Note 3:	Emission has a duty cycle ≥ 98%, average measurement performed: RBW=1MHz, VBW=3MHz, RMS, Power averaging, auto sweep, trace average 100 traces
Note 4:	Emission has constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW>1/T but not less than 10Hz, peak detector, linear averaging, auto sweep, trace average 100 traces, measurement corrected by Linear voltage correction factor
Note 5:	Emission has constatnt duty cycle < 98%, average measurement performed: RBW=1MHz, VBW=3MHz, RMS, Power averaging, auto sweep, trace average 100 traces, measurement corrected by Pwr correction factor
Note 6:	Emission has non constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW> 1/T, peak detector, linear average mode, sweep time auto, max hold. Max hold for 50*(1/DC) traces
Note 7:	Emission has non constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW> 1/T, RMS detector, sweep time auto, max hold. Max hold for 50*(1/DC) traces

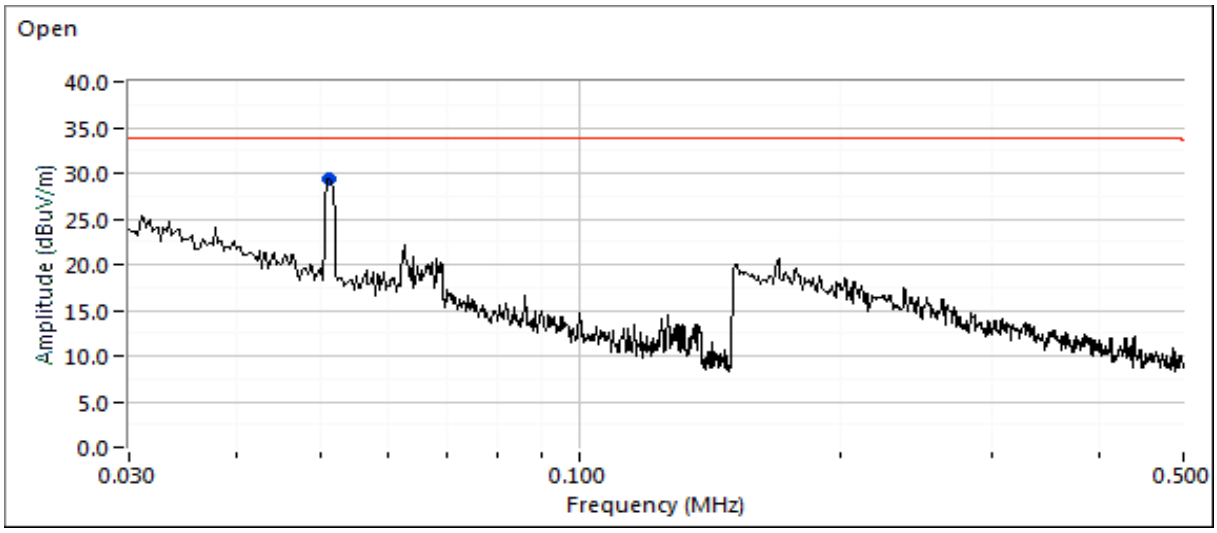
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

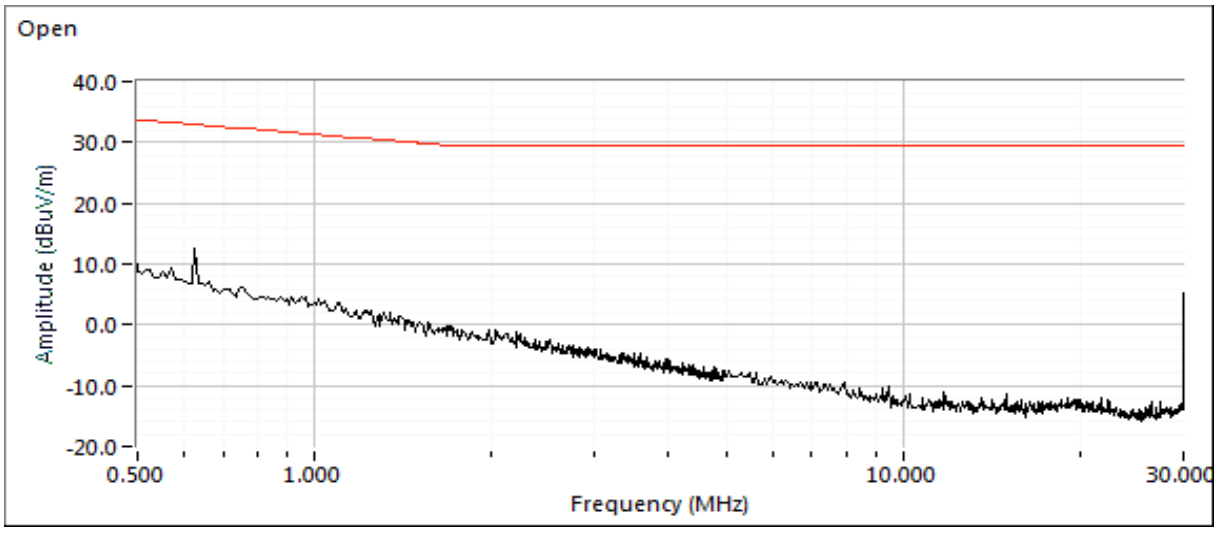
Run #2: Radiated Spurious Emissions, 30 kHz - 25 GHz. Operating Mode: 802.11b

Date of Test: 7/11 & 7/24/2018 Config. Used: 1
Test Engineer: Jude Semana / R. Varelas Config Change: None
Test Location: FT Chamber 5 EUT Voltage: 120V/60Hz

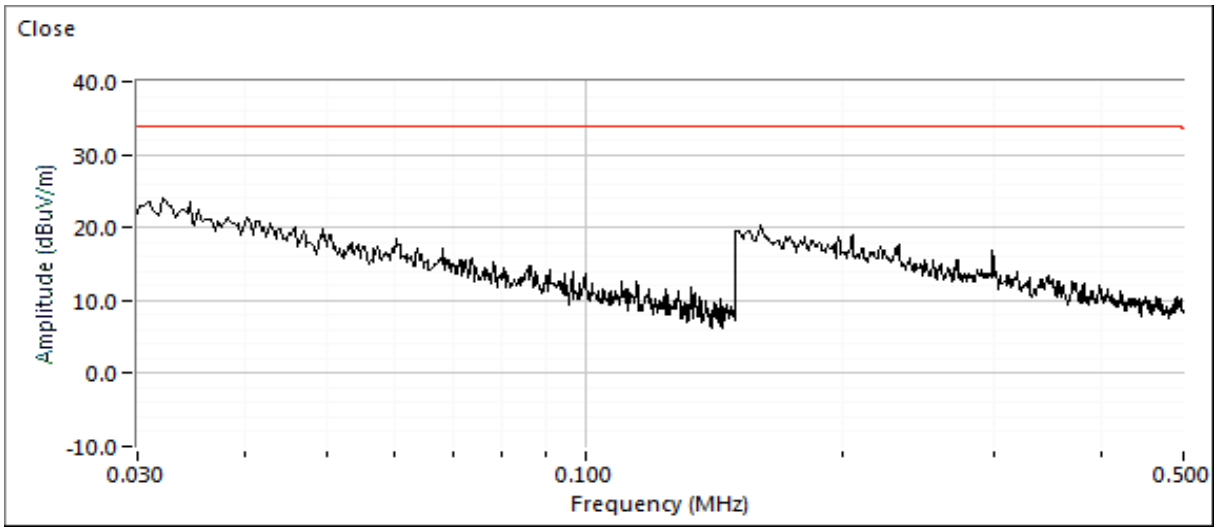
Run #2a: Low Channel

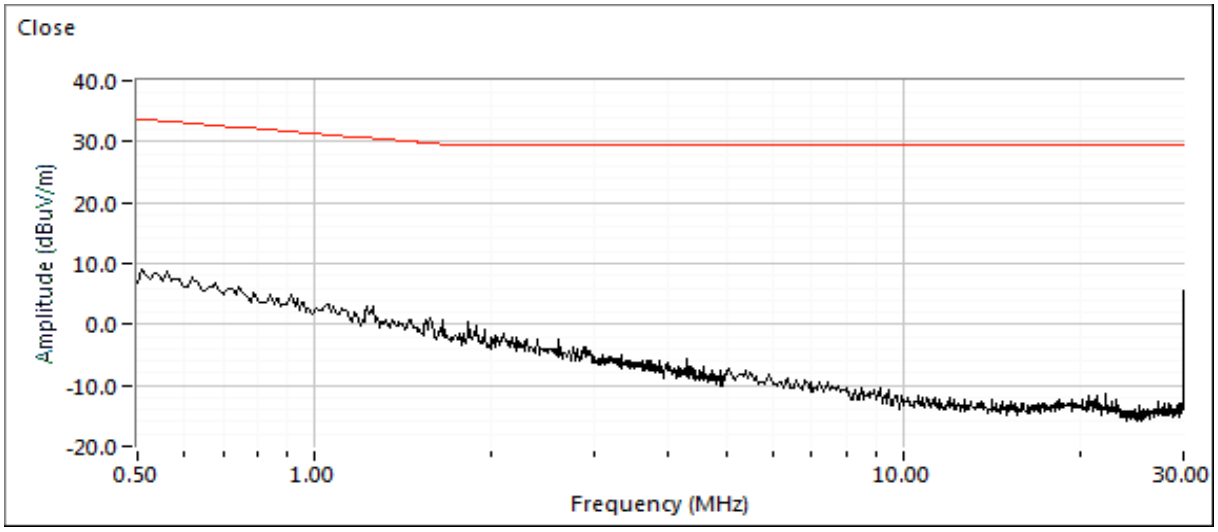
Channel: 1 Mode: b
Data Rate: 1 Mb/s



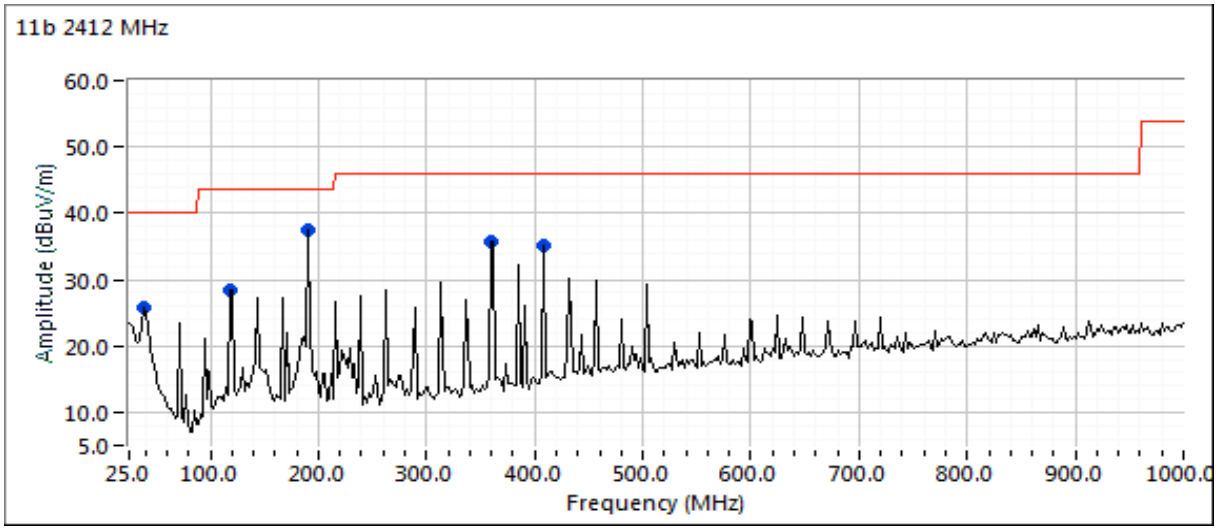


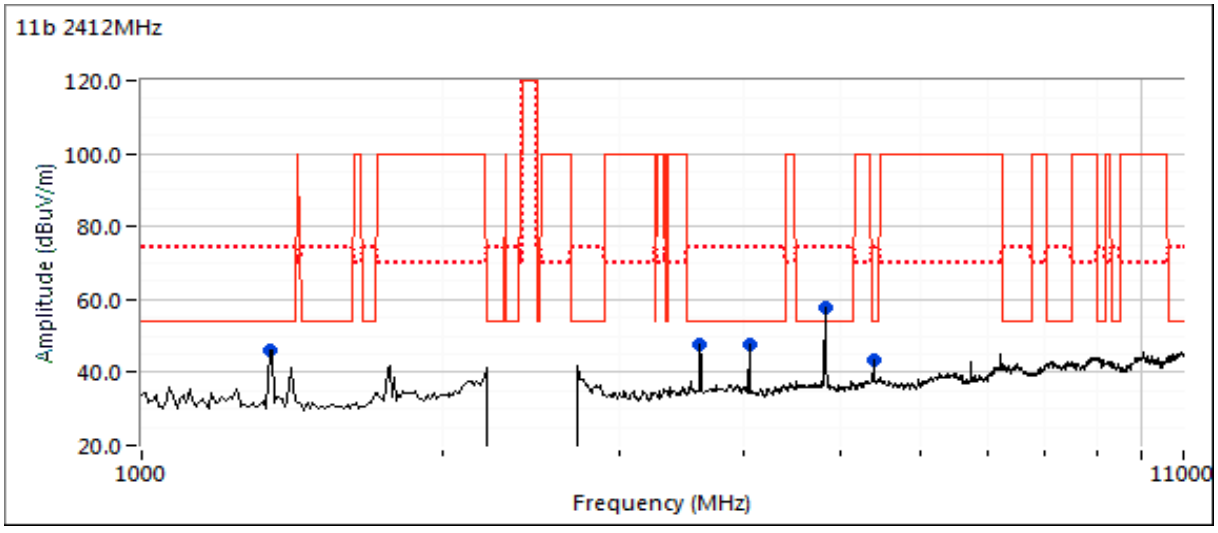
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A



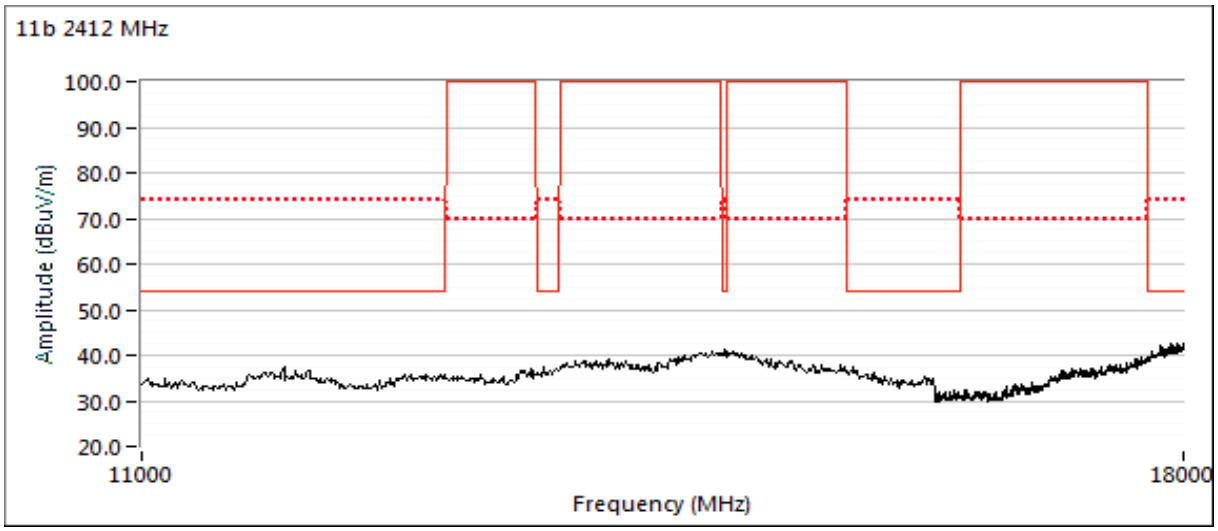


Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A





Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A



Note:	*Emisisons observed below 1 GHz are not related to the 2.4 GHz radio in the product but are from the digital electronics.*

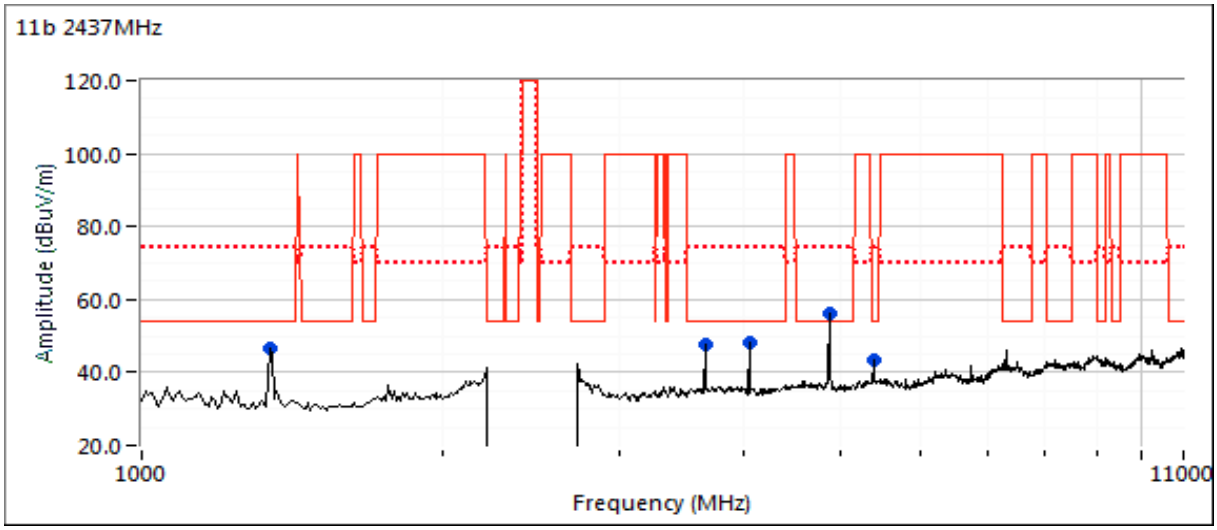
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

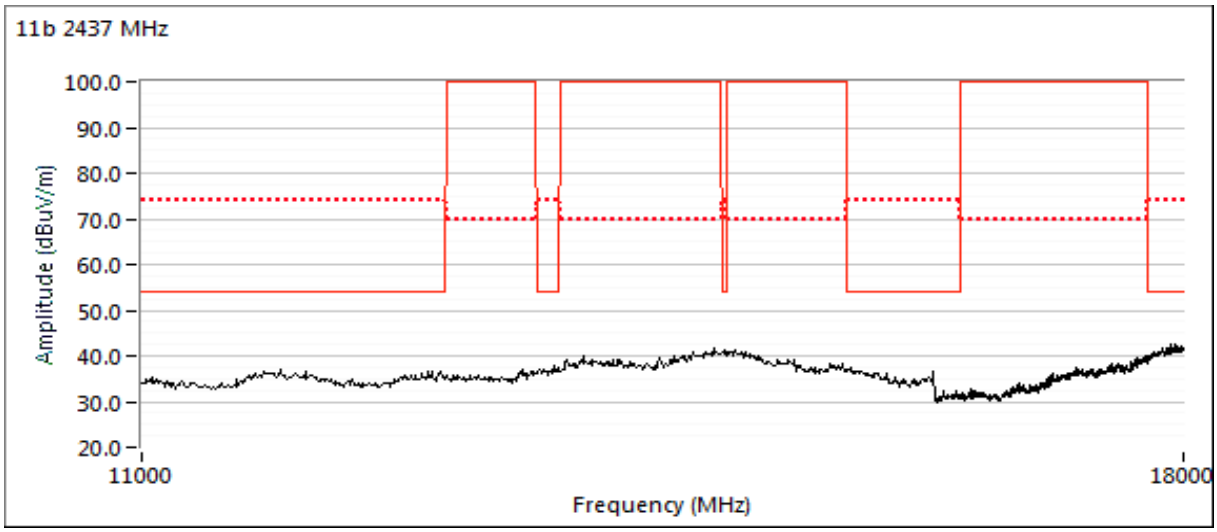
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
38.677	25.9	V	40.0	-14.1	Peak	234	1.5	
118.788	28.4	V	43.5	-15.1	Peak	193	1.0	
191.082	37.6	V	43.5	-5.9	Peak	88	1.5	
359.118	35.6	V	46.0	-10.4	Peak	129	1.5	
407.966	35.1	V	46.0	-10.9	Peak	102	1.0	
1350.010	38.4	V	54.0	-15.6	AVG	99	2.2	RB 1 MHz;VB 10 Hz;Peak
1349.990	43.4	V	74.0	-30.6	PK	99	2.2	RB 1 MHz;VB 3 MHz;Peak
3617.940	43.0	V	54.0	-11.0	AVG	198	1.3	RB 1 MHz;VB 10 Hz;Peak
3617.840	47.6	V	74.0	-26.4	PK	198	1.3	RB 1 MHz;VB 3 MHz;Peak
4050.020	46.0	V	54.0	-8.0	AVG	98	1.5	RB 1 MHz;VB 10 Hz;Peak
4050.060	49.4	V	74.0	-24.6	PK	98	1.5	RB 1 MHz;VB 3 MHz;Peak
5400.000	40.5	V	54.0	-13.5	AVG	99	1.0	RB 1 MHz;VB 10 Hz;Peak
5400.000	47.5	V	74.0	-26.5	PK	99	1.0	RB 1 MHz;VB 3 MHz;Peak
4823.940	51.5	H	54.0	-2.5	AVG	33	1.0	RB 1 MHz;VB 10 Hz;Peak
4823.900	53.9	H	74.0	-20.1	PK	33	1.0	RB 1 MHz;VB 3 MHz;Peak

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

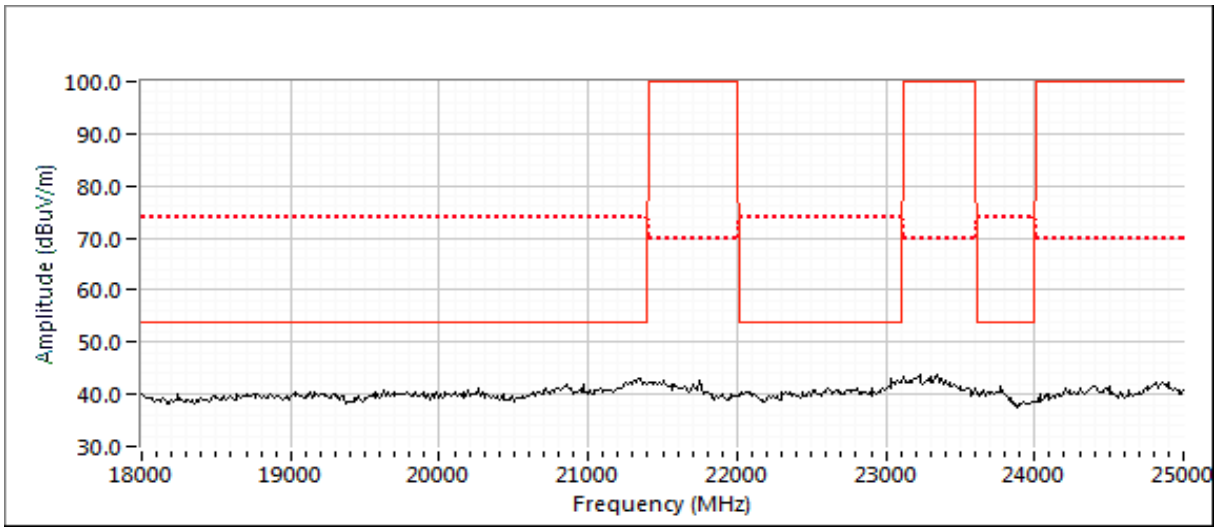
Run #2b: Center Channel

Channel: 6 Mode: b
Data Rate: 1 Mb/s





Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A



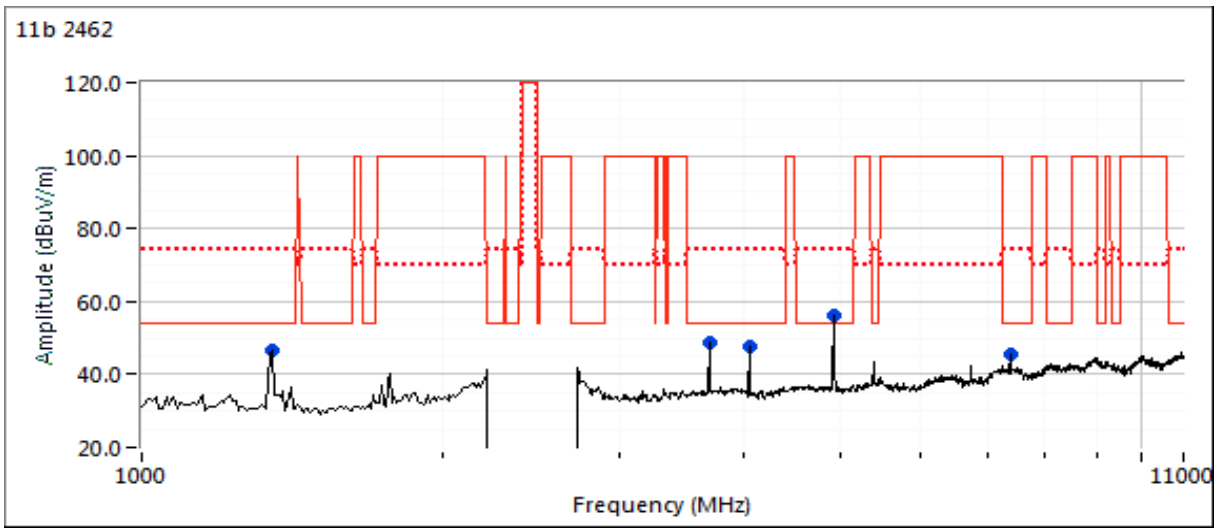
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
3655.450	44.9	V	54.0	-9.1	AVG	91	1.2	RB 1 MHz;VB 10 Hz;Peak
3655.470	49.2	V	74.0	-24.8	PK	91	1.2	RB 1 MHz;VB 3 MHz;Peak
4049.990	49.0	V	54.0	-5.0	AVG	95	1.0	RB 1 MHz;VB 10 Hz;Peak
4050.050	51.0	V	74.0	-23.0	PK	95	1.0	RB 1 MHz;VB 3 MHz;Peak
5400.000	40.9	V	54.0	-13.1	AVG	76	1.0	RB 1 MHz;VB 10 Hz;Peak
5400.110	48.0	V	74.0	-26.0	PK	76	1.0	RB 1 MHz;VB 3 MHz;Peak
1349.950	45.7	V	54.0	-8.3	AVG	112	1.0	RB 1 MHz;VB 10 Hz;Peak
1349.980	48.3	V	74.0	-25.7	PK	112	1.0	RB 1 MHz;VB 3 MHz;Peak
4873.960	53.0	H	54.0	-1.0	AVG	38	1.0	RB 1 MHz;VB 10 Hz;Peak
4873.940	55.3	H	74.0	-18.7	PK	38	1.0	RB 1 MHz;VB 3 MHz;Peak

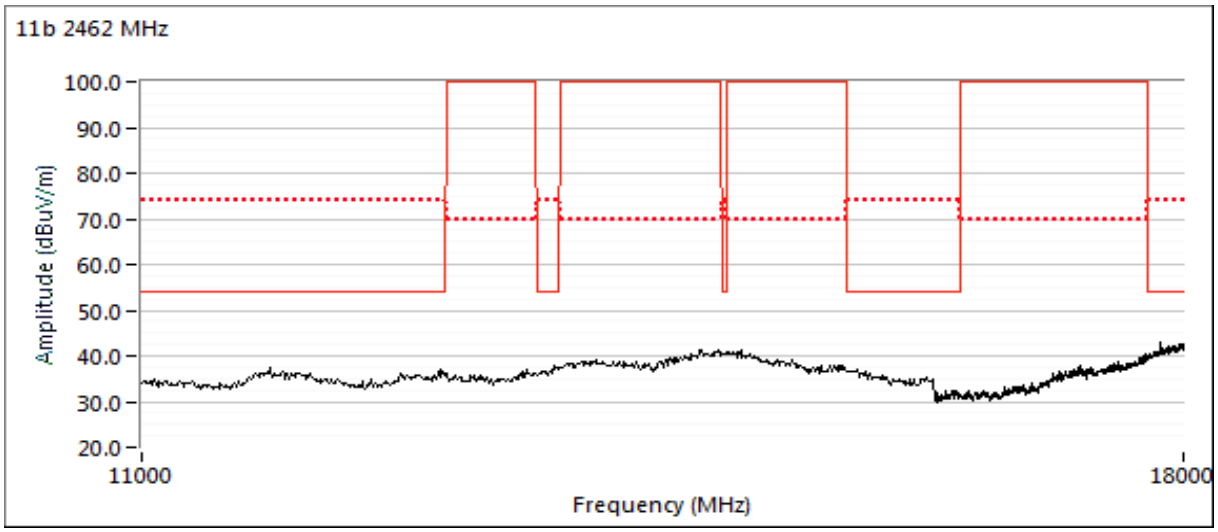
Note:	Scans made between 18 - 25 GHz with the measurement antenna at 3m from device indicated there were no significant emissions in this frequency range

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Run #2c: High Channel

Channel: 11 Mode: b
Tx Chain: Data Rate: 1 Mb/s





Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
1349.980	44.2	H	54.0	-9.8	AVG	94	1.0	RB 1 MHz;VB 10 Hz;Peak
1349.980	47.4	H	74.0	-26.6	PK	94	1.0	RB 1 MHz;VB 3 MHz;Peak
3692.910	39.9	H	54.0	-14.1	AVG	198	1.4	RB 1 MHz;VB 10 Hz;Peak
3693.040	45.8	H	74.0	-28.2	PK	198	1.4	RB 1 MHz;VB 3 MHz;Peak
4050.030	46.4	H	54.0	-7.6	AVG	105	1.0	RB 1 MHz;VB 10 Hz;Peak
4049.980	49.4	H	74.0	-24.6	PK	105	1.0	RB 1 MHz;VB 3 MHz;Peak
7385.990	38.4	H	54.0	-15.6	AVG	328	2.0	RB 1 MHz;VB 10 Hz;Peak
7385.560	48.7	H	74.0	-25.3	PK	328	2.0	RB 1 MHz;VB 3 MHz;Peak
4923.960	52.9	H	54.0	-1.1	AVG	33	1.0	RB 1 MHz;VB 10 Hz;Peak
4924.030	55.2	H	74.0	-18.8	PK	33	1.0	RB 1 MHz;VB 3 MHz;Peak

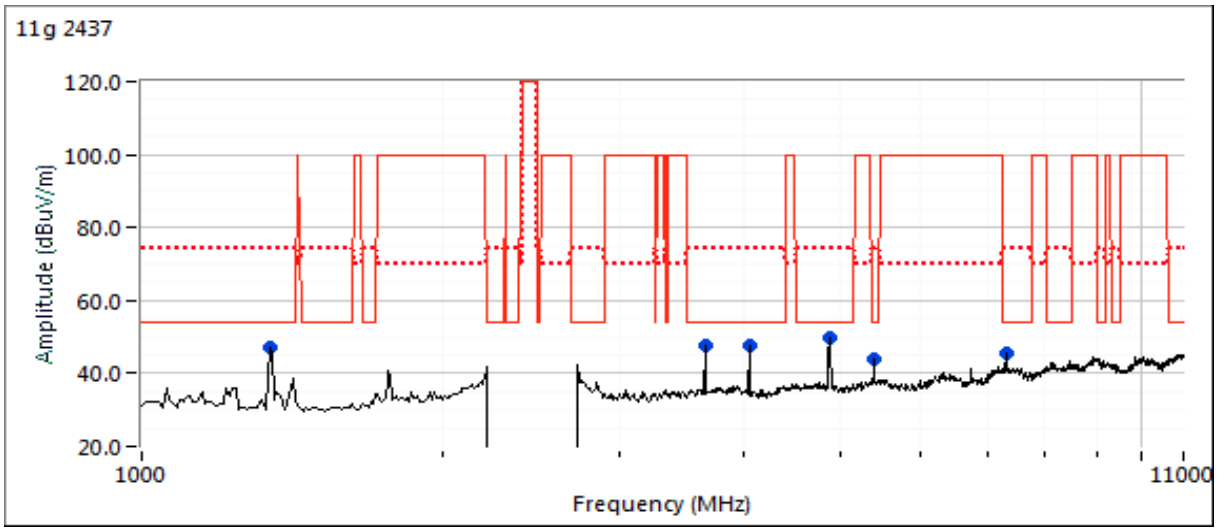
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

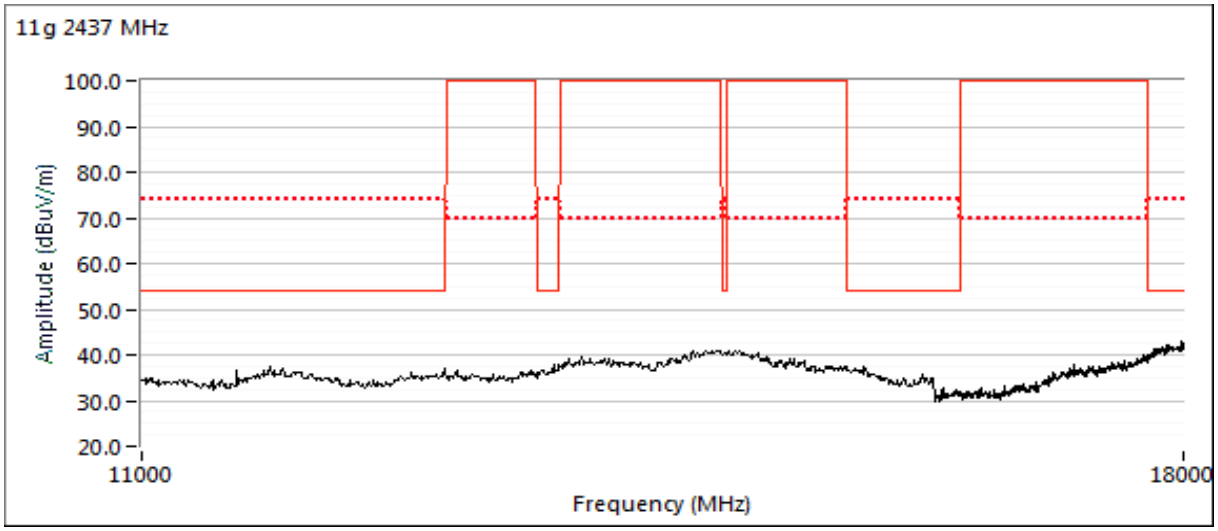
Run #3: Radiated Spurious Emissions, 25 - 25000 MHz. Operating Mode: OFDM

Date of Test: 7/11/2018 0:00 Config. Used: 1
Test Engineer: Jude Semana / R. Varelas Config Change: None
Test Location: FT Chamber 5 EUT Voltage: 120V/60Hz

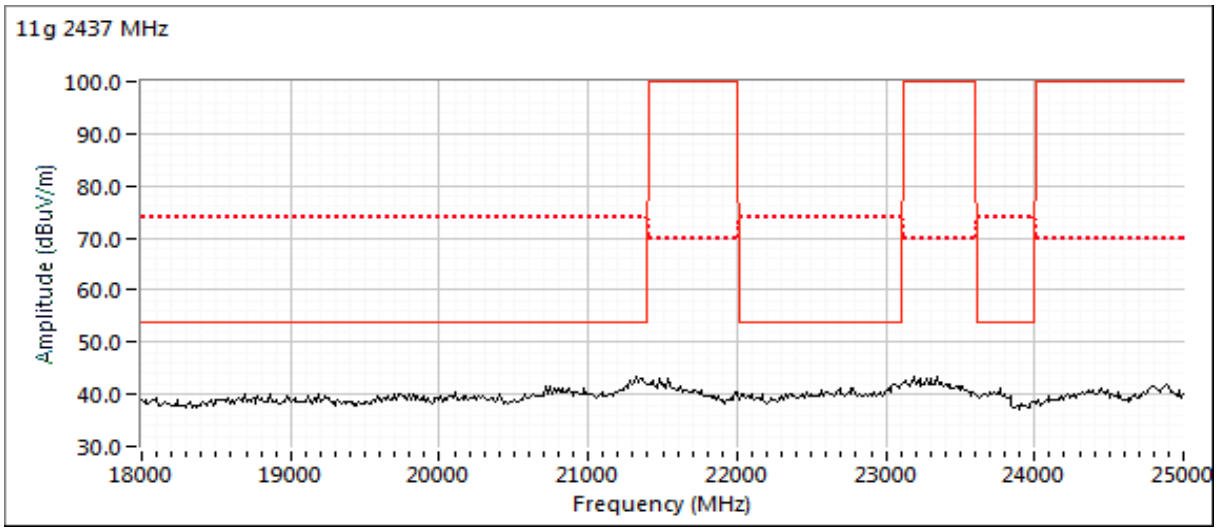
Run #3a: Center Channel

Channel: 6 Mode: g
Data Rate: 6 Mb/s





Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A



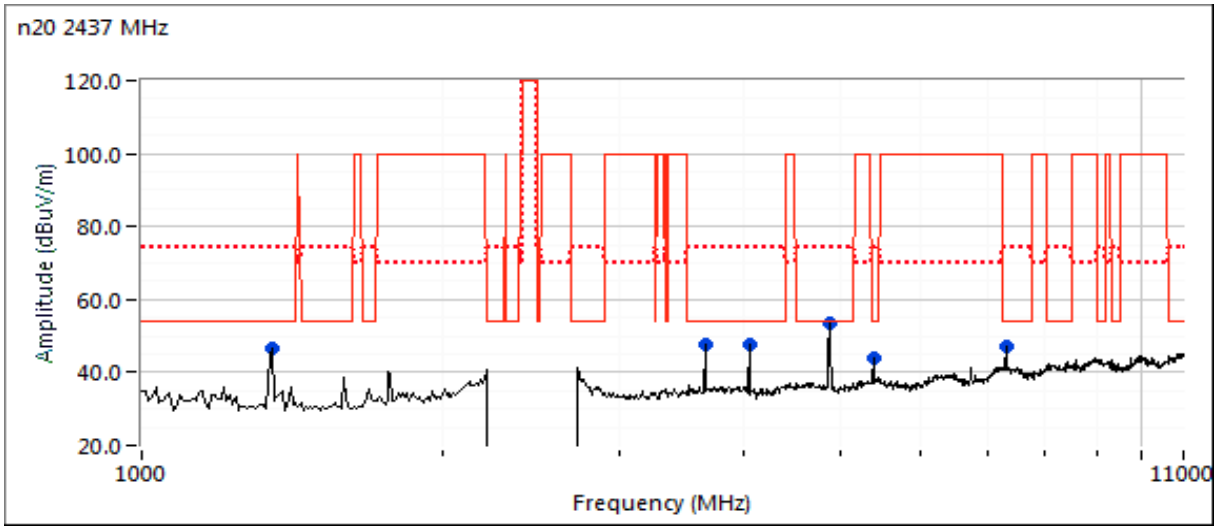
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
1348.570	46.1	V	54.0	-7.9	Avg	112	1.0	RB 1 MHz;VB 1 kHz;Peak VAVG 100
1349.090	38.0	V	74.0	-36.0	PK	112	1.0	RB 1 MHz;VB 3 MHz;Peak
4048.730	48.7	V	54.0	-5.3	Avg	94	1.0	RB 1 MHz;VB 1 kHz;Peak VAVG 100
4050.680	41.2	V	74.0	-32.8	PK	94	1.0	RB 1 MHz;VB 3 MHz;Peak
5399.520	42.0	V	54.0	-12.0	Avg	72	1.0	RB 1 MHz;VB 1 kHz;Peak VAVG 100
5399.550	45.0	V	74.0	-29.0	PK	72	1.0	RB 1 MHz;VB 3 MHz;Peak
7311.000	45.9	V	54.0	-8.1	Avg	3	1.1	RB 1 MHz;VB 1 kHz;Peak VAVG 100
7311.020	53.1	V	74.0	-20.9	PK	3	1.1	RB 1 MHz;VB 3 MHz;Peak
4873.550	45.9	V	54.0	-8.1	Avg	306	1.2	RB 1 MHz;VB 1 kHz;Peak VAVG 100
4873.300	61.7	V	74.0	-12.3	PK	306	1.2	RB 1 MHz;VB 3 MHz;Peak
3655.440	47.7	V	54.0	-6.3	Avg	337	1.0	RB 1 MHz;VB 1 kHz;Peak VAVG 100
3655.330	50.5	V	74.0	-23.5	PK	337	1.0	RB 1 MHz;VB 3 MHz;Peak

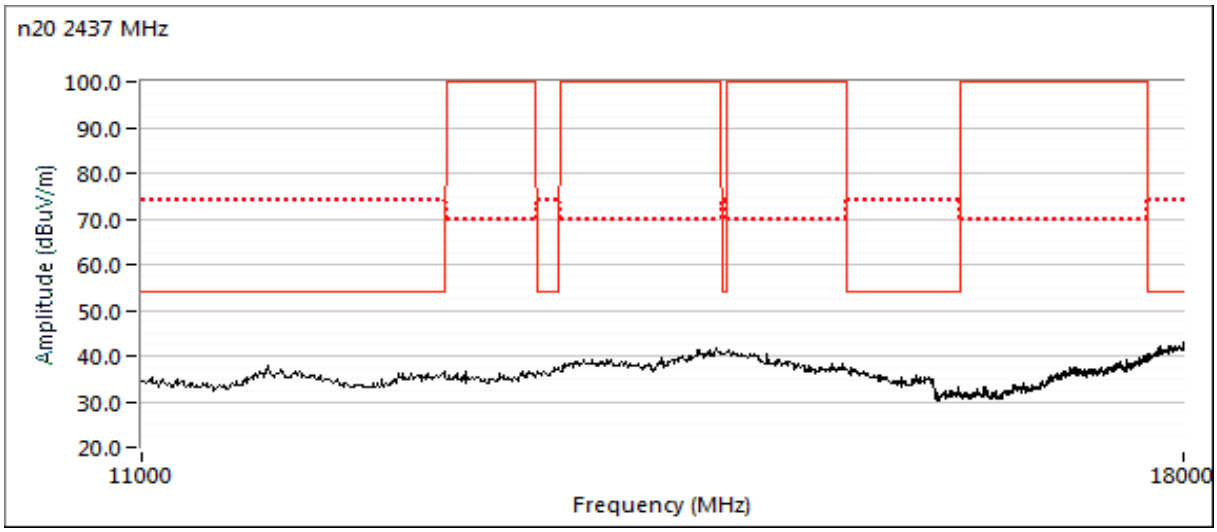
Note:	Scans made between 18 - 25 GHz with the measurement antenna at 3m from device indicated there were no significant emissions in this frequency range

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

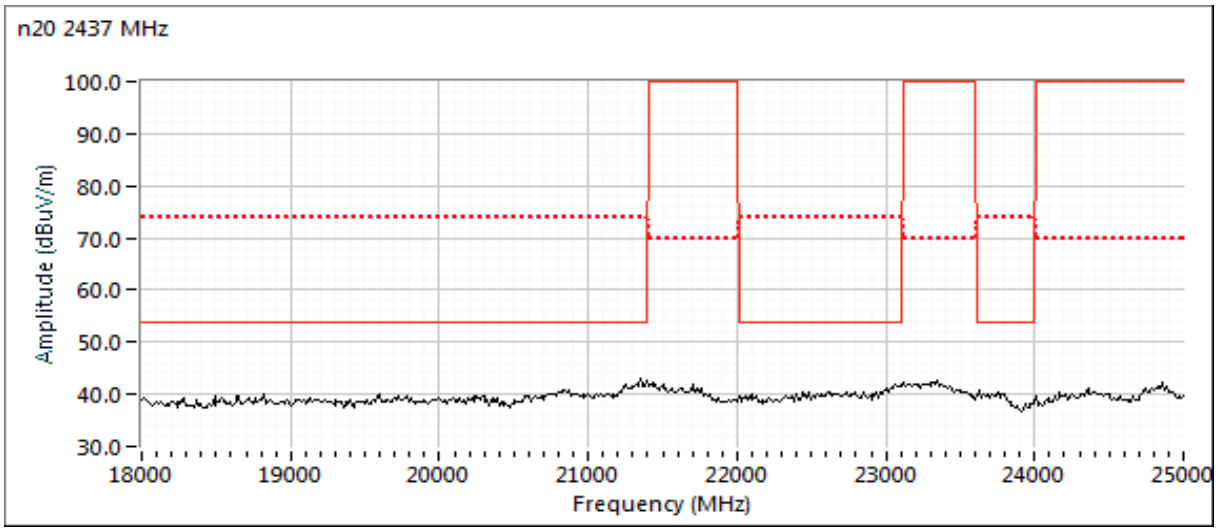
Run #3b: Center Channel

Channel: 6 Mode: n20
Data Rate: MCS 0





Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A



Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
7310.960	44.5	V	54.0	-9.5	Avg	360	1.0	Note 4,RB 1 MHz;VB 1 kHz;Peak VA
7311.060	50.7	V	74.0	-23.3	PK	360	1.0	RB 1 MHz;VB 3 MHz;Peak
3655.440	47.8	V	54.0	-6.2	Avg	338	1.0	Note 4,RB 1 MHz;VB 1 kHz;Peak VA
3655.410	50.8	V	74.0	-23.2	PK	338	1.0	RB 1 MHz;VB 3 MHz;Peak
4873.270	46.1	V	54.0	-7.9	Avg	320	1.0	Note 4,RB 1 MHz;VB 1 kHz;Peak VA
4872.680	62.1	V	74.0	-11.9	PK	320	1.0	RB 1 MHz;VB 3 MHz;Peak

Note:	Scans made between 18 - 25 GHz with the measurement antenna at 3m from device indicated there were no significant emissions in this frequency range

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Run #4: Radiated Spurious Emissions, 25 - 25000 MHz. Operating Mode: Worse case from Run #3

Date of Test: 7/12 & 7/24/2018 Config. Used: 1

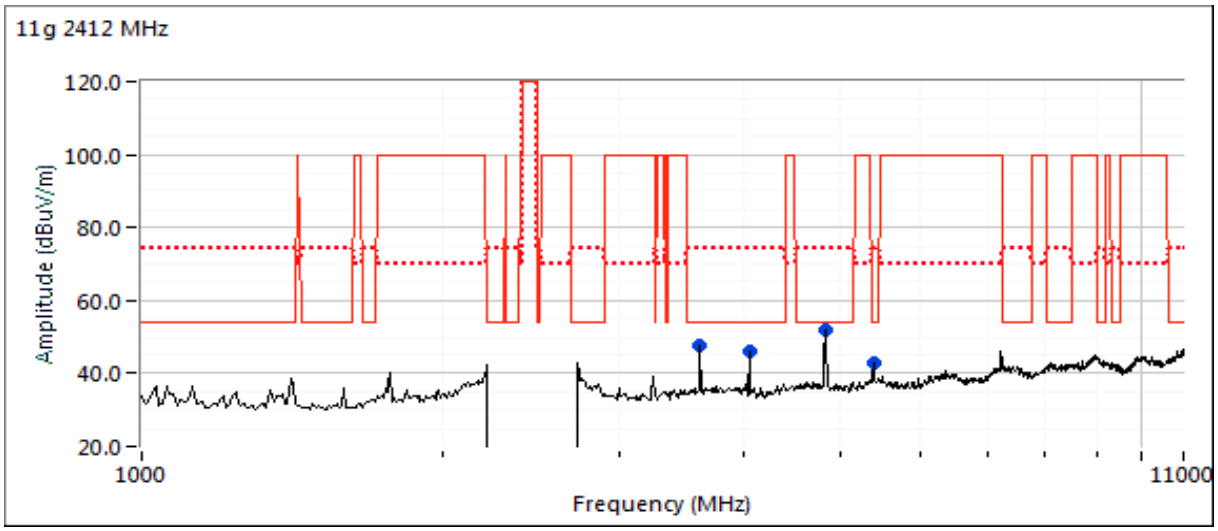
Test Engineer: Jude Semana Config Change: None

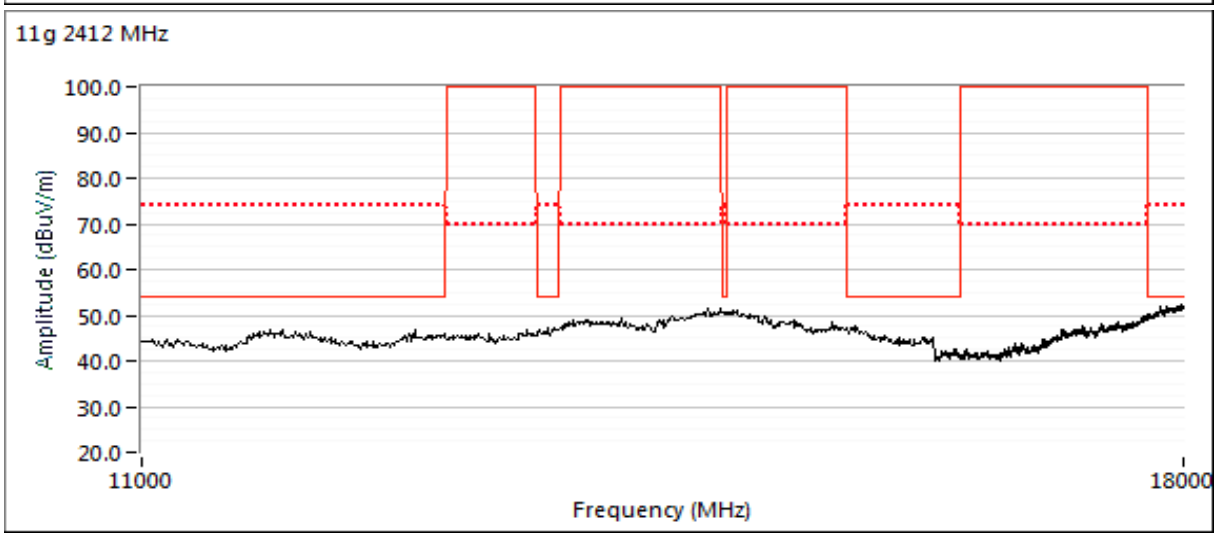
Test Location: FT Chamber 5 EUT Voltage: 120V/60Hz

Run #4a: Low Channel

Channel: 1 Mode: g

Data Rate: 6 Mb/s





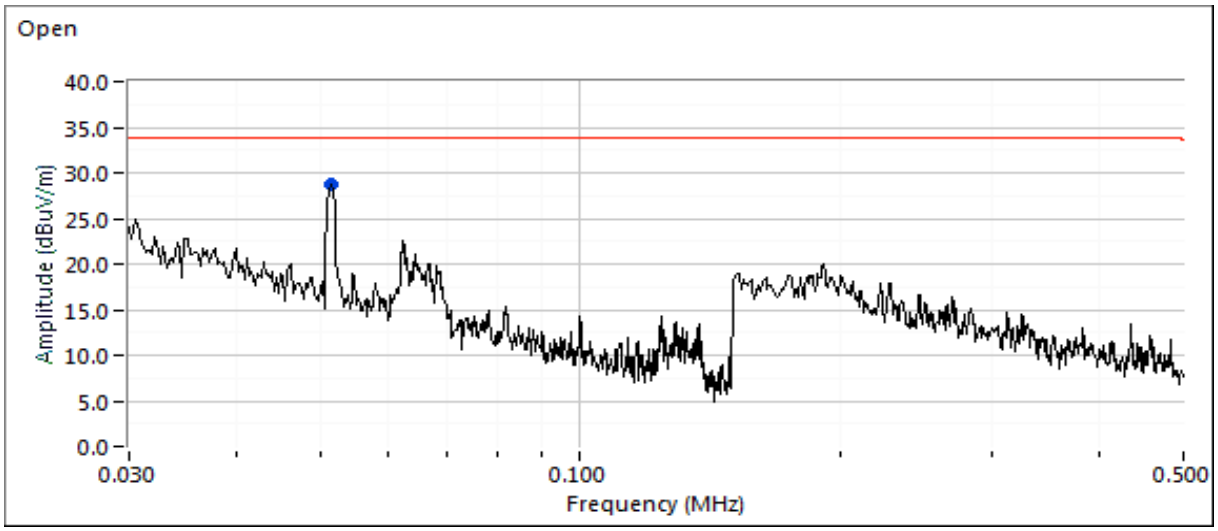
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

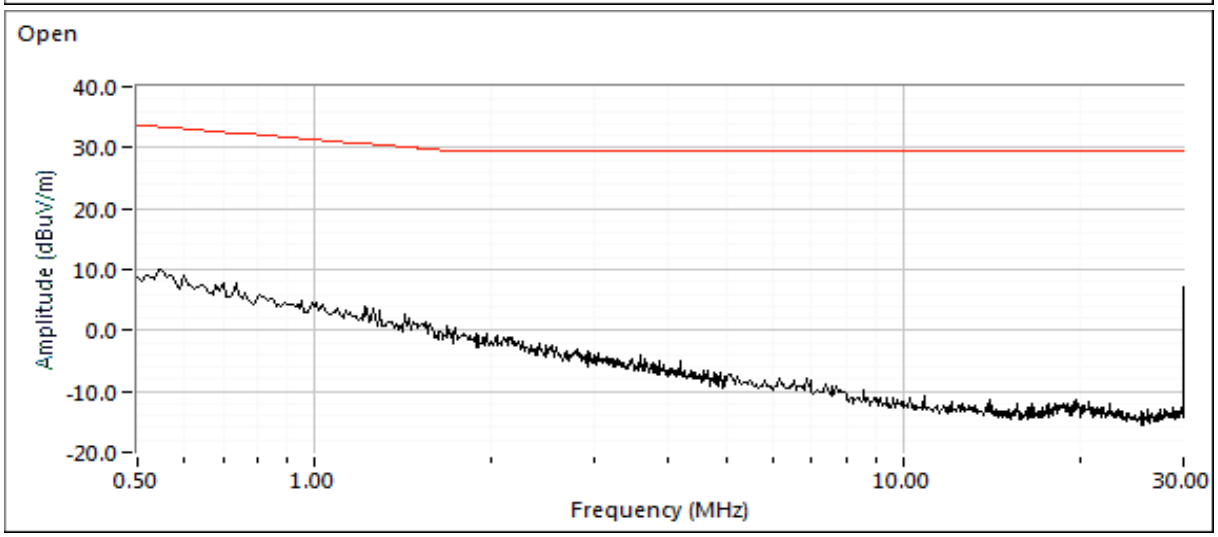
3617.950	47.0	V	54.0	-7.0	Avg	337	1.5	RB 1 MHz;VB 1 kHz;Peak VAVG 100
3617.950	50.2	V	74.0	-23.8	PK	337	1.5	RB 1 MHz;VB 3 MHz;Peak
4017.330	30.2	V	54.0	-23.8	Avg	92	1.3	RB 1 MHz;VB 1 kHz;Peak VAVG 100
4026.230	42.2	V	74.0	-31.8	PK	92	1.3	RB 1 MHz;VB 3 MHz;Peak
4824.900	46.7	V	54.0	-7.3	Avg	307	1.0	RB 1 MHz;VB 1 kHz;Peak VAVG 100
4826.470	61.0	V	74.0	-13.0	PK	307	1.0	RB 1 MHz;VB 3 MHz;Peak
5369.120	32.5	V	54.0	-21.5	Avg	67	1.0	RB 1 MHz;VB 1 kHz;Peak VAVG 100
5366.200	45.4	V	74.0	-28.6	PK	67	1.0	RB 1 MHz;VB 3 MHz;Peak

Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

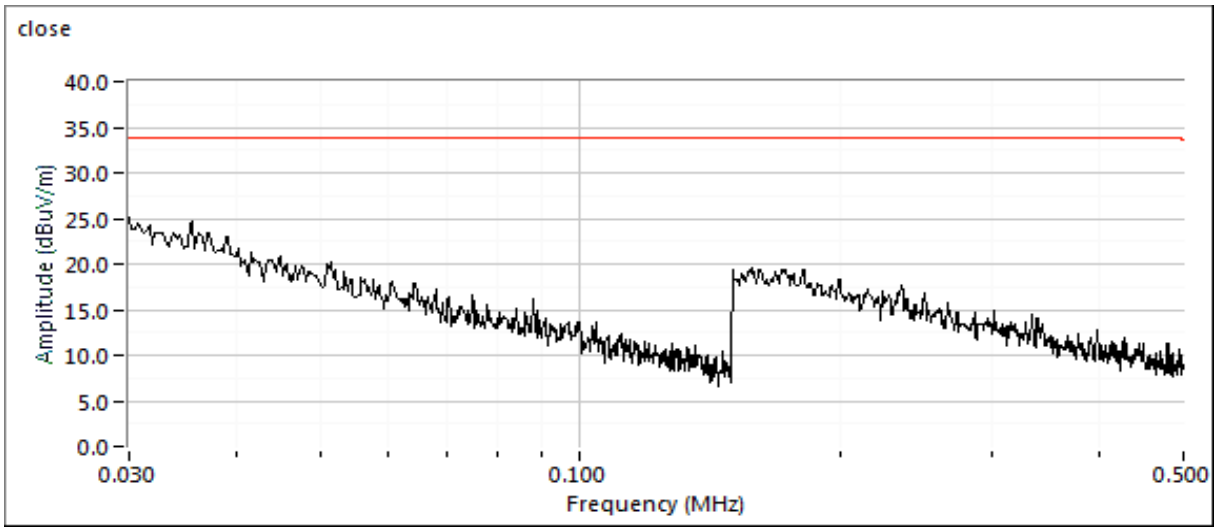
Run #4b: High Channel

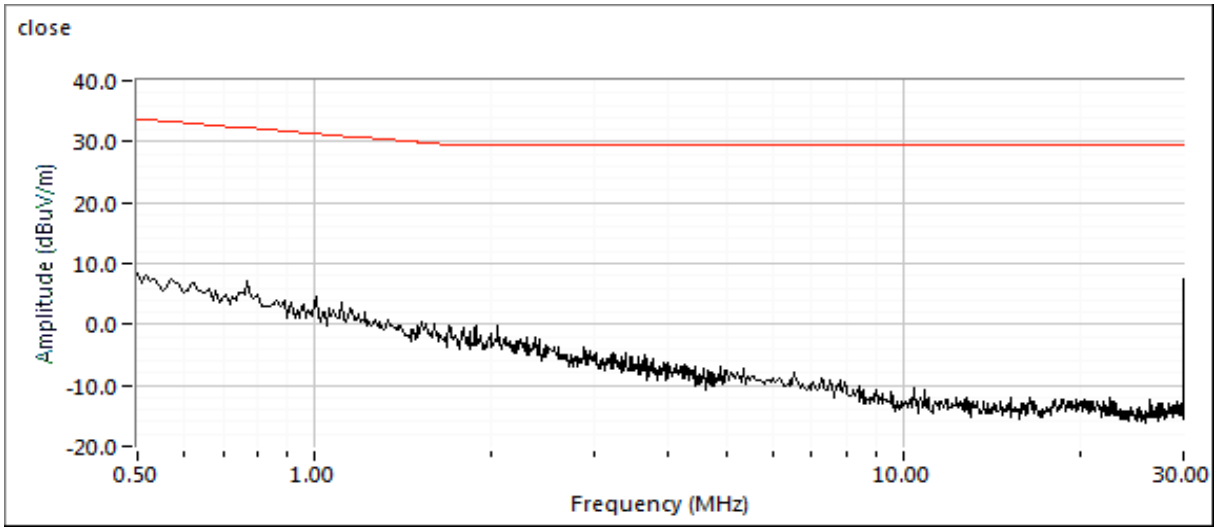
Channel: 11 Mode: g
Data Rate: 6 Mb/s



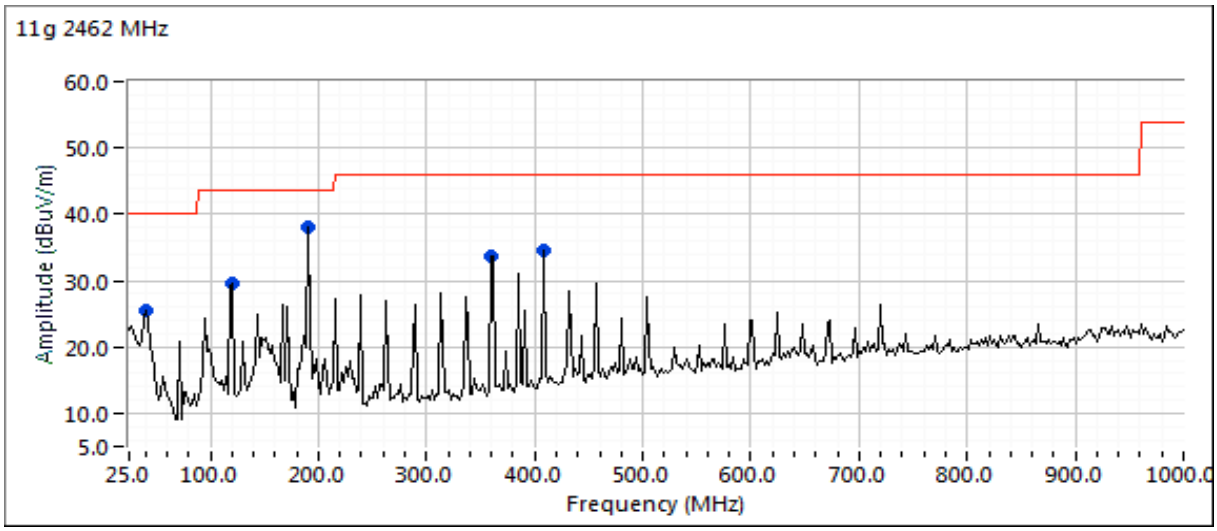


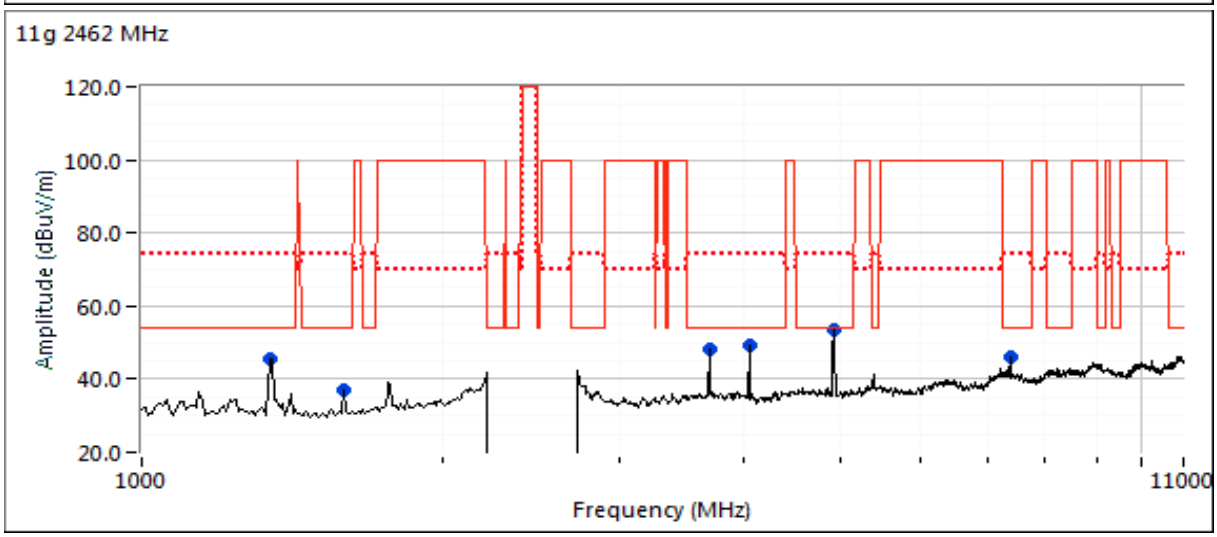
Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A



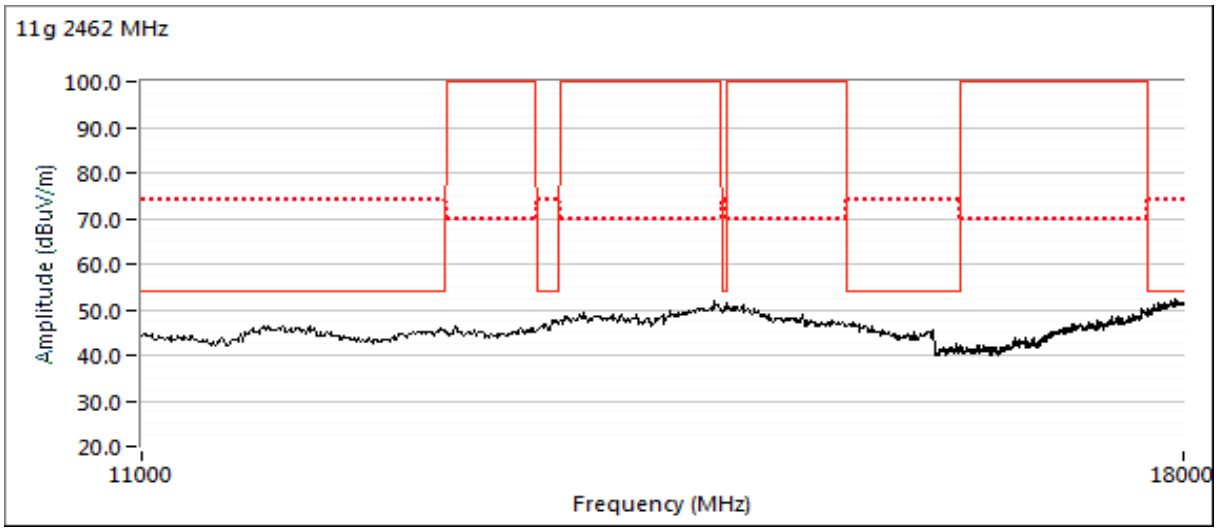


Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A





Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A



Client:	Whisker Labs, Inc.	Job Number:	PR082203
Model:	Ting Radio	T-Log Number:	TL082203-RA
		Project Manager:	Christine Krebill
Contact:	Chris Sloop	Project Coordinator:	David Bare
Standard:	FCC part 15	Class:	N/A

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
0.051	*28.8*	*V*	*33.8*	*-5.0*	*Peak*	*51*	*1.0*	
38.631	25.4	V	40.0	-14.6	Peak	222	1.0	
118.741	29.6	V	43.5	-13.9	Peak	85	1.0	
191.082	38.1	V	43.5	-5.4	Peak	95	1.0	
359.118	33.6	V	46.0	-12.4	Peak	90	1.0	
407.966	34.5	V	46.0	-11.5	Peak	111	1.0	
1348.700	25.6	V	54.0	-28.4	Avg	108	1.0	RB 1 MHz;VB 1 kHz;Peak VAVG 100
1349.820	38.2	V	74.0	-35.8	PK	108	1.0	RB 1 MHz;VB 3 MHz;Peak
3692.960	48.8	V	54.0	-5.2	Avg	335	1.0	RB 1 MHz;VB 1 kHz;Peak VAVG 100
3692.910	51.6	V	74.0	-22.4	PK	335	1.0	RB 1 MHz;VB 3 MHz;Peak
4019.330	30.2	V	54.0	-23.8	Avg	84	1.0	RB 1 MHz;VB 1 kHz;Peak VAVG 100
4021.170	43.3	V	74.0	-30.7	PK	84	1.0	RB 1 MHz;VB 3 MHz;Peak
4921.870	48.9	V	54.0	-5.1	Avg	302	1.2	RB 1 MHz;VB 1 kHz;Peak VAVG 100
4923.000	63.4	V	74.0	-10.6	PK	302	1.2	RB 1 MHz;VB 3 MHz;Peak
1578.310	25.3	V	54.0	-28.7	Avg	261	1.9	RB 1 MHz;VB 1 kHz;Peak VAVG 100
1579.920	37.6	V	74.0	-36.4	PK	261	1.9	RB 1 MHz;VB 3 MHz;Peak
7385.970	45.2	V	54.0	-8.8	Avg	360	1.3	RB 1 MHz;VB 1 kHz;Peak VAVG 100
7385.830	52.5	V	74.0	-21.5	PK	360	1.3	RB 1 MHz;VB 3 MHz;Peak

End of Report

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