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EMC Test Report

Application for FCC Grant of Equipment Authorization
Canada Certification

Innovation, Science and Economic Development Canada
RSS-Gen Issue 4 / RSS 247 Issue 1
FCC Part 15 Subpart C

Model: ApexZ family of products

FCC ID:	2AL8XAPEXZ
APPLICANT:	Lighthouse Worldwide Solutions 47300 Kato Road Fremont, CA 94538
TEST SITE(S):	National Technical Systems - Silicon Valley 41039 Boyce Road. Fremont, CA. 94538-2435
IC SITE REGISTRATION #:	2845B-5
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Testing Cert #0214.26

VALIDATING SIGNATORIES

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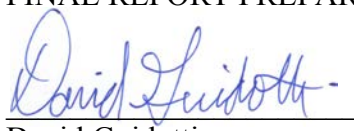

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REVISION HISTORY

Rev#	Date	Comments	Modified By
-	August 21, 2017	First release	
1	September 7, 2017	Revised report to correct Reviewer Name and Title	David Guidotti
2	September 18, 2017	Revised to correct EUT height	David Bare

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SCOPE

An electromagnetic emissions test has been performed on the Lighthouse Worldwide Solutions model ApexZ family of products, pursuant to the following rules:

RSS-Gen Issue 4 " General Requirements for Compliance of Radio Apparatus"
RSS 247 Issue 1 "Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices"
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 - Silicon Valley test procedures:

FHSS test procedure DA 00-0705A1

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.

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.

Prior to marketing in Canada, Class I transmitters, receivers and transceivers require certification. Class II devices are required to meet the appropriate technical requirements but are exempt from certification 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.).

Testing was performed only on model ApexZ family of products.

STATEMENT OF COMPLIANCE

The tested sample of Lighthouse Worldwide Solutions model ApexZ family of products complied with the requirements of the following regulations:

RSS-Gen Issue 4 " General Requirements for Compliance of Radio Apparatus"
RSS 247 Issue 1 "Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices"
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 Lighthouse Worldwide Solutions model ApexZ family of products and therefore apply only to the tested sample. The sample was selected and prepared by Charley Abboud of Lighthouse Worldwide Solutions.

DEVIATIONS FROM THE STANDARDS

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

TEST RESULTS SUMMARY

FREQUENCY HOPPING SPREAD SPECTRUM (2400 – 2483.5 MHz, Less Than 75 Hopping Channels)

FCC Rule Part	RSS Rule Part	Description	Measured Value / Comments	Limit / Requirement	Result
15.247 (a) (1)	RSS 247 5.1 (1)	20 dB Bandwidth	Basic Rate: 1015 kHz EDR: 1318 kHz	Channel spacing > 2/3rds 20 dB BW (minimum 25 kHz)	Complies
		Channel Separation	1000 kHz		Complies
15.247 (a) (1) (iii)	RSS 247 5.1 (4) & 5.4 (2)	Number of Channels	Bluetooth device minimum 20	15 or more	Complies
15.247 (a) (1) (iii) & (b) (1)	RSS 247 5.1 (4)	Channel Dwell Time (*average time of occupancy)*	Max. 3.125 ms	<0.4 second within a period of 0.4 x number of channels	Complies
15.247 (a) (1)	RSS 247 5.1 (1)	Channel Utilization	All channels are used equally - refer to the operational description for full explanation The system uses the Bluetooth algorithm and, therefore, meets all requirements for channel utilization.	All channels shall, on average, be used equally	Complies
15.247 (b) (3)	RSS 247 5.4 (2)	Output Power	Basic Rate: -7.5 dBm (0.18 mW) EDR: -8.5 dBm (0.14 mW)	*0.125 Watts*	Complies
15.247(d)	RSS 247 5.5	Spurious Emissions 30 MHz – 25 GHz	All spurious emissions < -20 dBc	< -20 dBc	Complies
15.247(d) / 15.209	RSS 247 5.5	Radiated Spurious Emissions 30 MHz – 25 GHz	32.5 dBµV/m @ 2379.280 MHz (-21.5 dB)	Refer to the limits section (p21) for restricted bands, all others < -20 dBc	Complies
15.247 (a) (1)	RSS 247 5.1(2)	Receiver bandwidth	Refer to operational description	Shall match the channel bandwidth	Complies
Note 1: EIRP, if stated was calculated using maximum antenna gain of 1 dBi.					

GENERAL REQUIREMENTS APPLICABLE TO ALL BANDS

FCC Rule Part	RSS Rule part	Description	Measured Value / Comments	Limit / Requirement	Result (margin)
15.203	-	RF Connector	Integral antenna	Unique or integral antenna required	Complies
15.407 (b) (6)	RSS-Gen Table 3	AC Conducted Emissions	37.1 dBµV @ 0.327 MHz (-12.4 dB)	Refer to page 20	Complies
15.247 (i) 15.407 (f)	RSS 102	RF Exposure Requirements	Refer to MPE calculations in separate exhibit, RSS 102 declaration and User Manual statements.	Refer to OET 65, FCC Part 1 and RSS 102	Complies
-	RSS-Gen 8.3	User Manual	Integral antenna	Statement for products with detachable antenna	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
Conducted emission of receiver	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 Lighthouse Worldwide Solutions model ApexZ family of products is a particle counter that is designed to detect air born particles. In addition, it incorporates Wi-Fi and Bluetooth radios. Since the EUT would be placed on a tabletop during operation, the EUT was treated as tabletop equipment during testing to simulate the end-user environment. The electrical rating of the EUT is 24 Vdc, 5.0 Amps. An AC Adapter (GST120A24-P1M) is provided with the product. The electrical rating is 100-240 Volts ,50,60 Hz,1.4 Amps Input. Output is 24Vdc, 5.0 Amps.
The sample was received on July 3, 2017 and tested on July 11 and 27 and August 5, 2017. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
Lighthouse Worldwide Solutions	ApexZ3	Particle Counter	1704141003	2AL8XAPEXZ

OTHER EUT DETAILS

The following EUT details should be noted: Wi-Fi radio is 2.4 GHz b/g/n20 single antenna. Wi-Fi and BT radios cannot transmit simultaneously.

ANTENNA SYSTEM

Integral antenna

ENCLOSURE

The EUT enclosure is primarily constructed of molded plastic. It measures approximately 32.41 cm wide by 15.82 cm deep by 22.55 cm high.

MODIFICATIONS

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

SUPPORT EQUIPMENT

Manufacturer	Model	Description	Serial Number	FCC ID
Mean Well	GST120A24	Power Supply	EB6BP05875	-

EUT INTERFACE PORTS

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

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
DC power	AC/DC power supply	Power cable	Unshielded	1.8
Ethernet 10/100 Base T	Router	CAT5	Shielded	10.0
Serial	Not connected	-	-	-
USB	Flash drive	USB	Shielded	3.0
Smart	Not connected	-	-	-
Micro USB	Not connected	-	-	-

EUT OPERATION

During testing, the EUT was transmitting with the highest RF power, with required modes and frequencies for each test case.

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. 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 20 Hz, 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 50 µH Line Impedance Stabilization Network as the monitoring point. The LISN used also contains a 250 µH 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 tests below 1 GHz and 1.5 meters for tests 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.

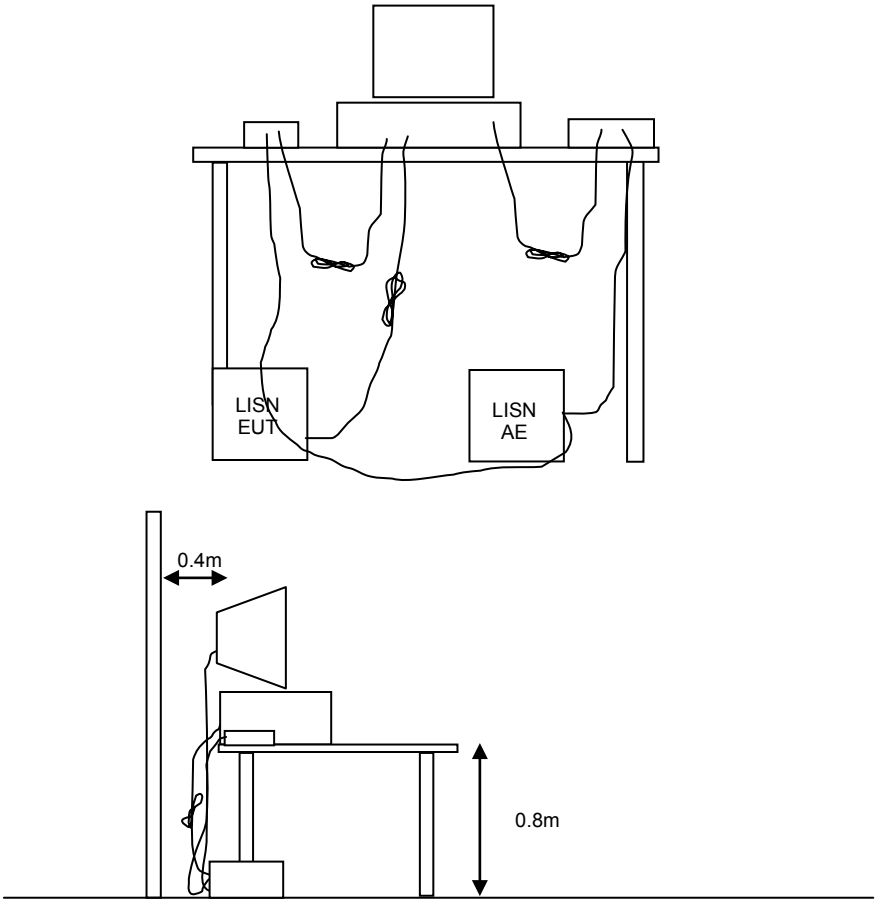


Figure 1 Typical Conducted Emissions Test Configuration

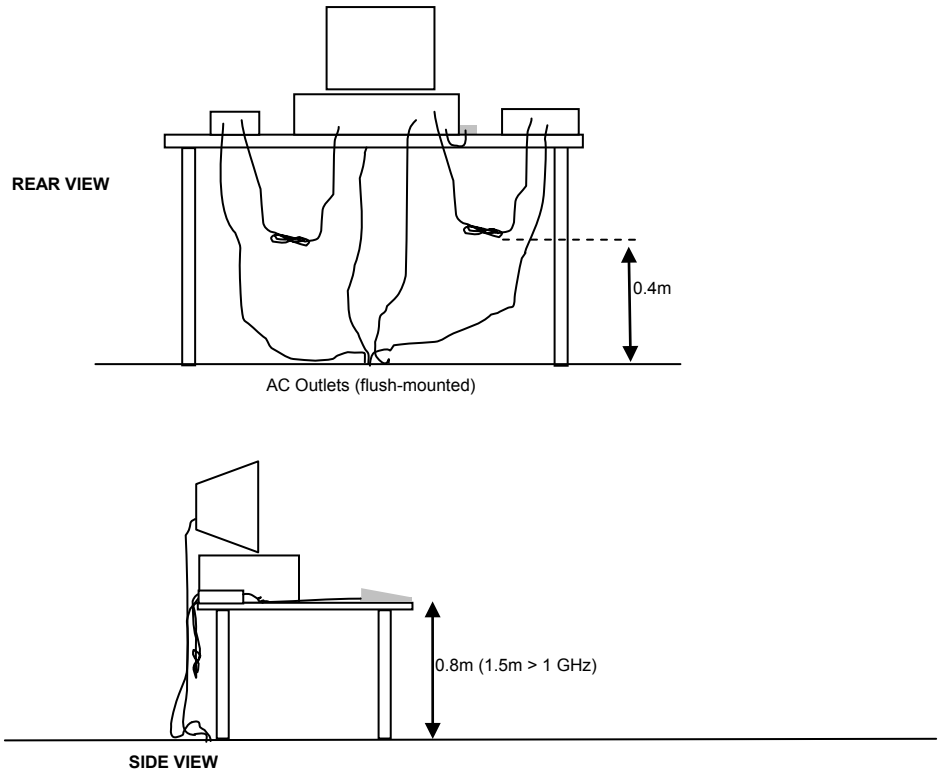
RADIATED EMISSIONS

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.

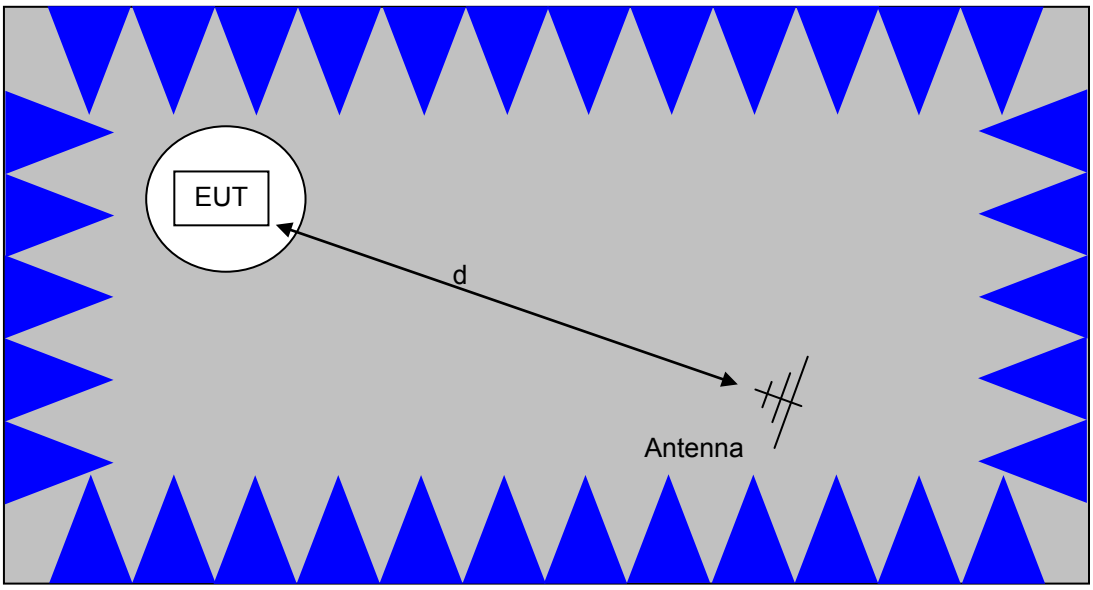
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

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.

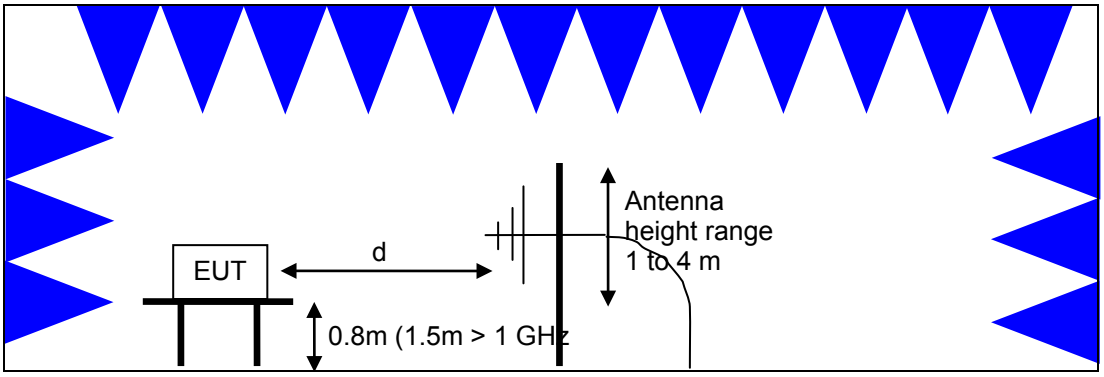


Typical Test Configuration for Radiated Field Strength Measurements



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.

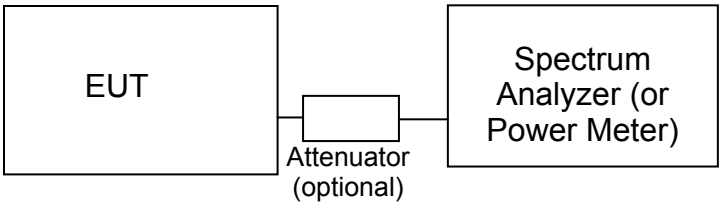
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



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 6 dB, 20 dB, 26 dB 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 (dBµV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBµV/m). The results are then converted to the linear forms of µV and µV/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 (dBµV)	Quasi Peak Limit (dBµV)
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 (µV/m)	Limit (dBµV/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

OUTPUT POWER LIMITS – FHSS SYSTEMS

The table below shows the limits for output power based on the number of channels available for the hopping system.

Operating Frequency (MHz)	Number of Channels	Output Power
902 – 928	≥ 50	1 Watt (30 dBm)
902 – 928	25 to 49	0.25 Watts (24 dBm)
2400 – 2483.5	≥ 75	1 Watt (30 dBm)
2400 – 2483.5	< 75	0.125 Watts (21 dBm)
5725 – 5850	75	1 Watt (30 dBm)

The maximum permitted output power is reduced by 1dB for every dB the antenna gain exceeds 6 dBi. 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).

[1] The restricted bands are detailed in FCC 15.205 and RSS-Gen Table 6

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 dBµV
S = Specification Limit in dBµV
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 30 MHz, 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 dBµV/m
F_d = Distance Factor in dB
R_c = Corrected Reading in dBµV/m
L_s = Specification Limit in dBµV/m
M = Margin in dB Relative to Spec

Appendix A Test Equipment Calibration Data

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Radiated Emissions, BE, 1,000 - 6,500 MHz, 03-Jul-17					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
EMCO	Antenna, Horn, 1-18 GHz (SA40-Red)	3115	1142	9/29/2016	9/29/2018
Rohde & Schwarz	EMI Test Receiver, 20 Hz-40 GHz	ESI 40	2493	3/17/2017	3/17/2018
Radiated Emissions, 1,000 - 26,500 MHz, 03-Jul-17					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
EMCO	Antenna, Horn, 1-18 GHz (SA40-Red)	3115	1142	9/29/2016	9/29/2018
Hewlett Packard	Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz	8564E (84125C)	1393	4/10/2017	4/10/2018
HP / Miteq	SA40 B Head HF preAmplifier, 18-40 GHz (w/1393)	TTA1840-45-5P-HG-S	1620	2/13/2017	2/13/2018
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	1780	9/30/2016	9/30/2017
A. H. Systems	Spare System Horn, 18-40GHz	SAS-574, p/n: 2581	2162	7/29/2015	7/29/2017
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	2249	5/17/2017	5/17/2018
Radiated Emissions, 1,000 - 26,500 MHz, 06-Jul-17					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
Hewlett Packard	Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz	8564E (84125C)	1393	4/10/2017	4/10/2018
EMCO	Antenna, Horn, 1-18 GHz	3115	1561	7/8/2016	7/8/2018
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	1780	9/30/2016	9/30/2017
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	2249	5/17/2017	5/17/2018
Radiated Emissions, 30 - 26,500 MHz, 10-Jul-17					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
Hewlett Packard	Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz	8564E (84125C)	1393	4/10/2017	4/10/2018
EMCO	Antenna, Horn, 1-18 GHz	3115	1561	7/8/2016	7/8/2018
HP / Miteq	SA40 B Head HF preAmplifier, 18-40 GHz (w/1393)	TTA1840-45-5P-HG-S	1620	2/13/2017	2/13/2018
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	1780	9/30/2016	9/30/2017
A. H. Systems	Blue System Horn, 18-40GHz	SAS-574, p/n: 2581	2159	9/9/2015	9/9/2017
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	2197	9/9/2015	9/9/2017
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	2249	5/17/2017	5/17/2018
Rohde & Schwarz	EMI Test Receiver, 20 Hz-40 GHz	ESI 40	2493	3/17/2017	3/17/2018

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Com-Power	Preamplifier, 1-1000 MHz	PAM-103	2885	9/16/2016	9/16/2017
Radiated Emissions, 1000 - 18,000 MHz, 11-Jul-17					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
Hewlett Packard	Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz	8564E (84125C)	1393	4/10/2017	4/10/2018
EMCO	Antenna, Horn, 1-18 GHz	3115	1561	7/8/2016	7/8/2018
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	1683	5/17/2017	5/17/2018
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	1780	9/30/2016	9/30/2017
BE measurements for BT Basic & EDR, 12-Jul-17					
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	1538	2/11/2017	2/11/2018
EMCO	Antenna, Horn, 1-18 GHz	3115	1561	7/8/2016	7/8/2018
Radiated Emissions, 18,000 - 25,000 MHz, 12-Jul-17					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
Hewlett Packard	Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz	8564E (84125C)	1393	4/10/2017	4/10/2018
HP / Miteq	SA40 B Head HF preAmplifier, 18-40 GHz (w/1393)	TTA1840-45-5P-HG-S	1620	2/13/2017	2/13/2018
A. H. Systems	Red System Horn, 18-40GHz	SAS-574, p/n: 2581	2161	7/16/2015	7/16/2017
Radiated Emissions, 30 - 1,000 MHz, 12-Jul-17					
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	1538	2/11/2017	2/11/2018
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	2197	9/9/2015	9/9/2017
Com-Power	Preamplifier, 1-1000 MHz	PAM-103	2885	9/16/2016	9/16/2017
Conducted Emissions - AC Power Ports, 27-Jul-17					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
Rohde & Schwarz	Pulse Limiter	ESH3 Z2	1401	2/3/2017	2/3/2018
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	1538	2/11/2017	2/11/2018
Fischer Custom Comm	LISN, 25A, 150kHz to 30MHz, 25 Amp,	FCC-LISN-50-25-2-09	2000	9/26/2016	9/26/2017
Radiated Emissions, 30 - 1,000 MHz, 27-Jul-17					
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	1538	2/11/2017	2/11/2018
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	2197	9/9/2015	9/9/2017
Com-Power	Preamplifier, 1-1000 MHz	PAM-103	2885	9/16/2016	9/16/2017

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Radio Antenna Port (Power and Spurious Emissions), 04-Aug-17 & 05-Aug-17					
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	5/22/2017	5/22/2018

Appendix B Test Data

T105297 Pages 27 – 61

Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Product	ApexZ3	T-Log Number:	T105297
System Configuration:		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Emissions Standard(s):	FCC Part 15	Class:	B
Immunity Standard(s):		Environment:	Radio

EMC Test Data

For The

Lighthouse Worldwide Solutions

Product

ApexZ3

Date of Last Test: 8/17/2017

Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

RSS-247 and FCC 15.247 (FHSS) Measurements

Power, 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: 8/5/2017
Test Engineer: Yew-Kwong Soo
Test Location: FT Lab#4A

Config. Used: 1
Config Change: -
EUT Voltage: 120V/60Hz

General Test Configuration

When measuring the conducted emissions from the EUT's antenna port, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators used.

Unless stated otherwise the EUT was operating such that it constantly hopped on either the low, center or high channels.

Ambient Conditions:

Temperature: 27 °C
Rel. Humidity: 44 %

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1	Output Power	15.247(b)	Pass	Basic Rate: -7.5 dBm (0.18mW) EDR: -8.5 dBm (0.14mW)
2	20dB Bandwidth	15.247(a)	Pass	Basic Rate: 1015 kHz EDR: 1318 kHz
3	30 - 25,000 MHz - Transmitter Conducted Spurious Emissions	FCC Part 15.247(c)	Pass	All spurious < -20 dBc.
4	Channel Occupancy	15.247(a)	Pass	Bluetooth device
4	Number of Channels	15.247(a)	Pass	Bluetooth device minimum 20

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:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

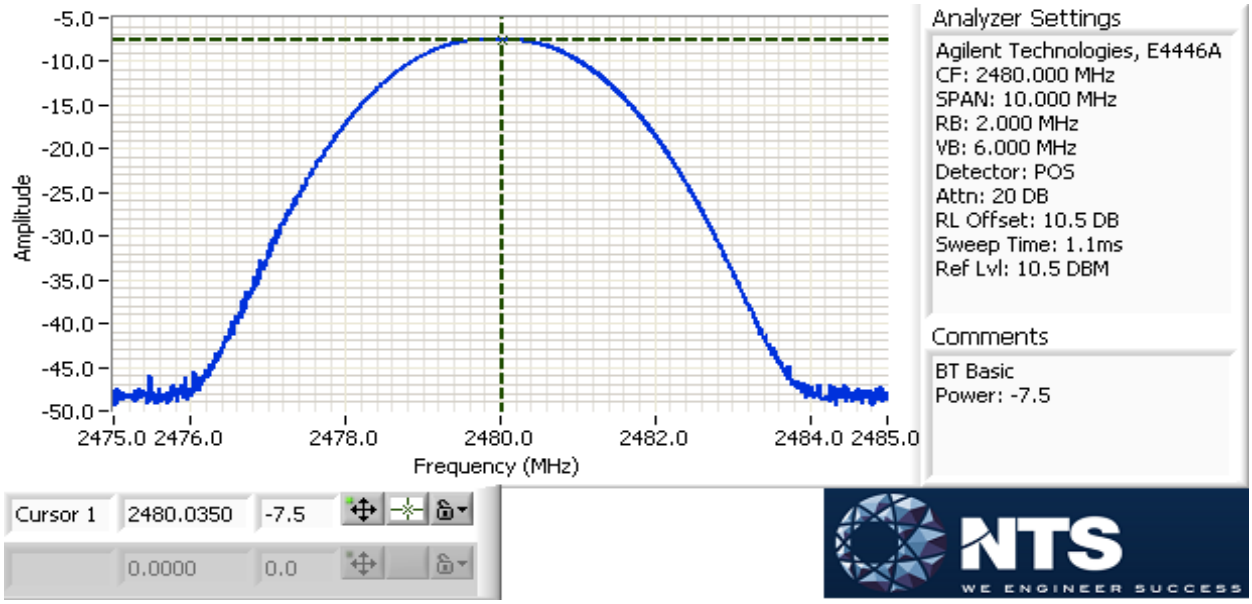
Run #1: Output Power

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels: 1 watt.
For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

Maximum antenna gain: 1 dBi

Mode	Channel	Frequency (MHz)	Res BW	Output Power (dBm)	Output Power (W)	EIRP (W)
Basic	Low	2402	2.0	-8.4	0.00014	0.00018
Basic	Mid	2441	2.0	-7.8	0.00017	0.00021
Basic	High	2480	2.0	-7.5	0.00018	0.00022
EDR	Low	2402	2.0	-8.7	0.00013	0.00017
EDR	Mid	2441	2.0	-8.6	0.00014	0.00017
EDR	High	2480	2.0	-8.5	0.00014	0.00018

Note 1:	Output power measured using a spectrum analyzer with RBW > OBW and VB ≥3* RBW, Span ≥ 1.5 of OBW, auto sweep time, Peak detector and max hold. Spurious limit becomes -20dBc.

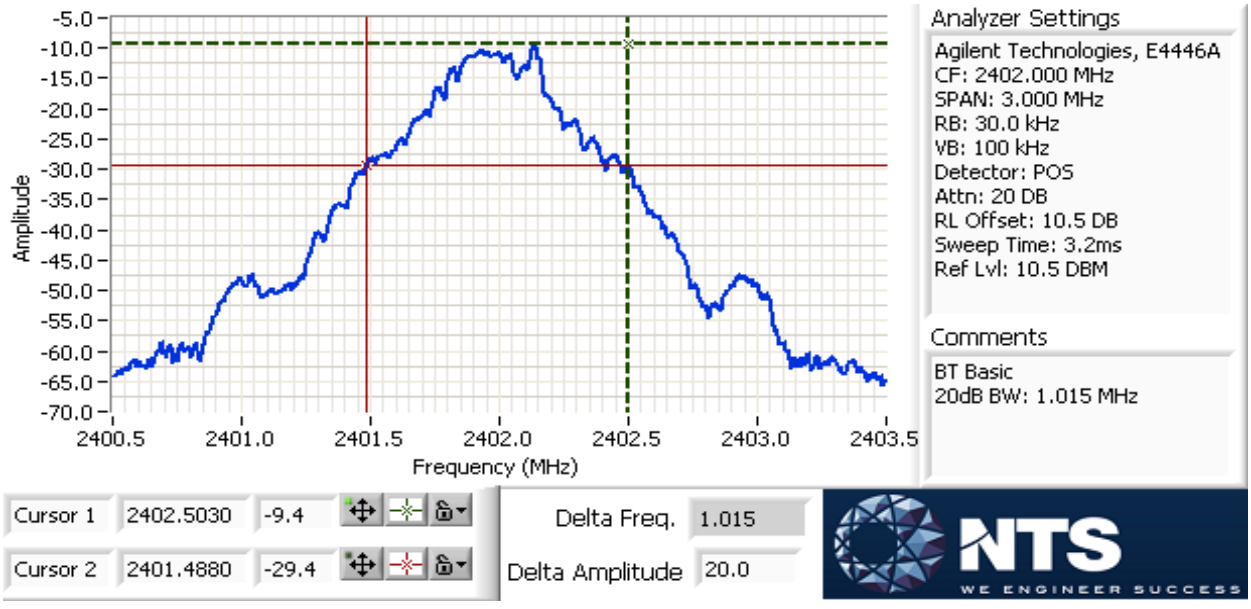


Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

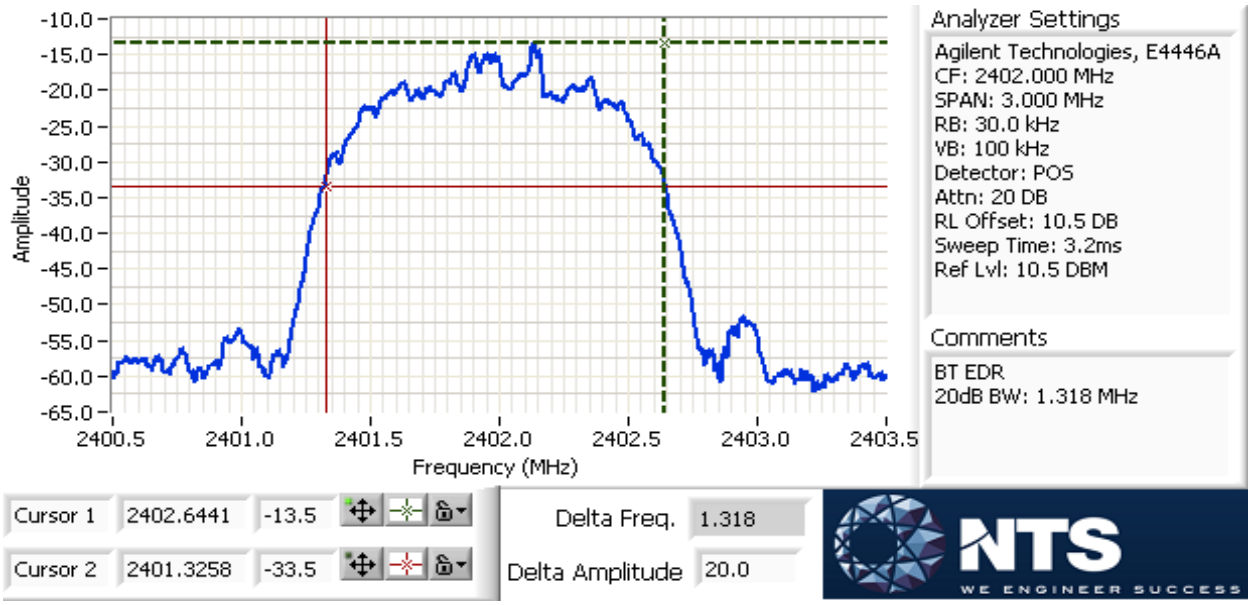
Run #2: Occupied Bandwidth

Mode	Channel	Frequency (MHz)	Resolution Bandwidth (kHz)	20dB Bandwidth (kHz)
Basic	Low	2402	30	1015
Basic	Mid	2441	30	1009
Basic	High	2480	30	976
EDR	Low	2402	30	1318
EDR	Mid	2441	30	1318
EDR	High	2480	30	1315

Note 1:	20dB bandwidth measured using RB = 30 kHz, VB = 100 kHz (VB > RB)



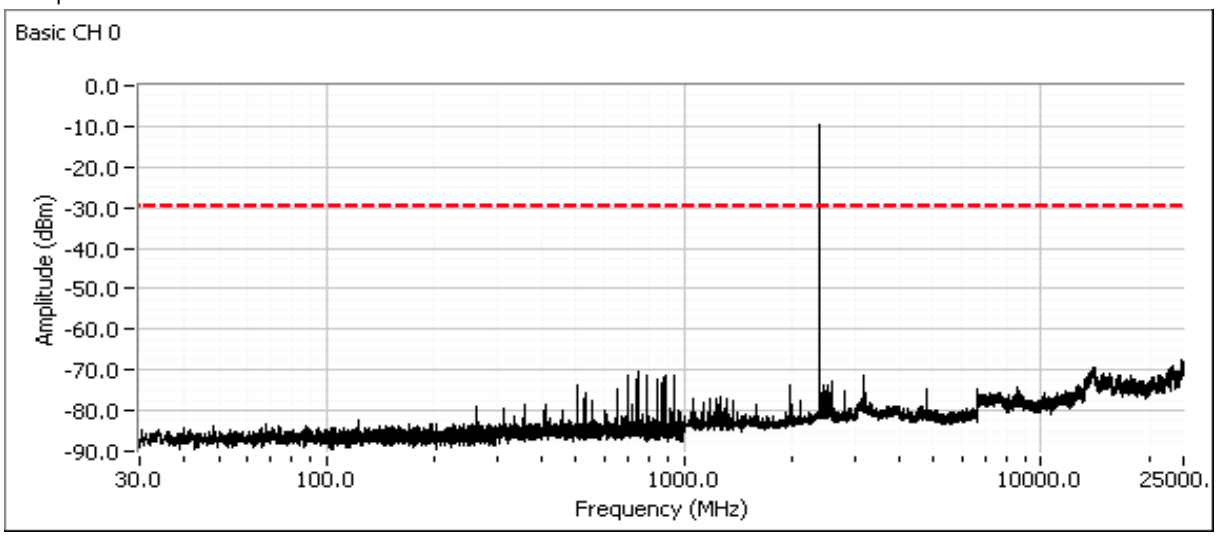
Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

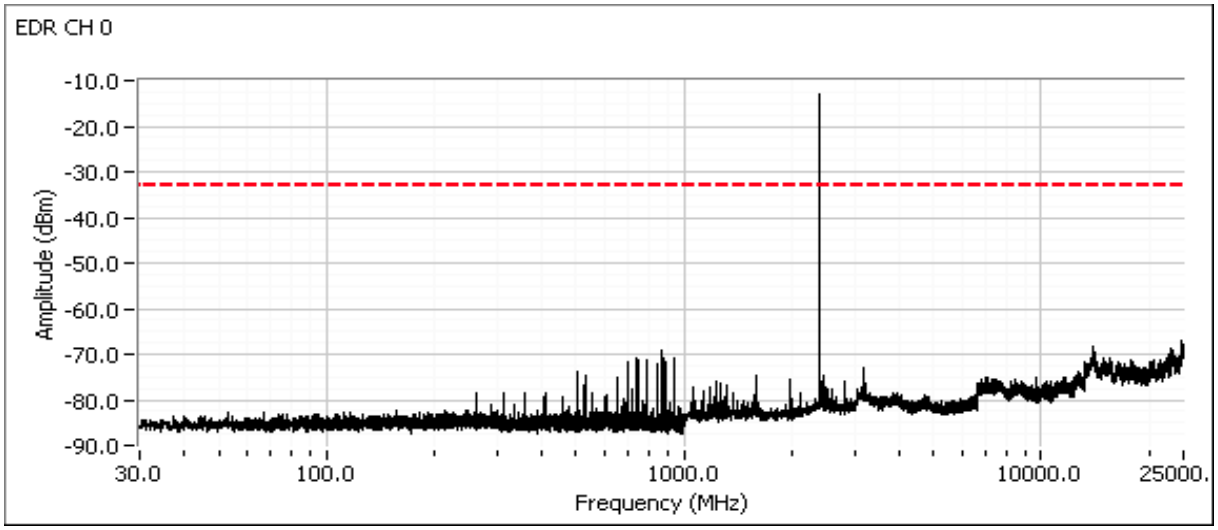


Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

Run #3: Antenna Conducted Spurious Emissions, 30 - 25,000 MHz.
Refer to plots below. Scans made using RBW=VB=100 KHz with the limit line set at 20dB below the highest in-band signal level with the hopping feature disabled.
Basic and EDR modes

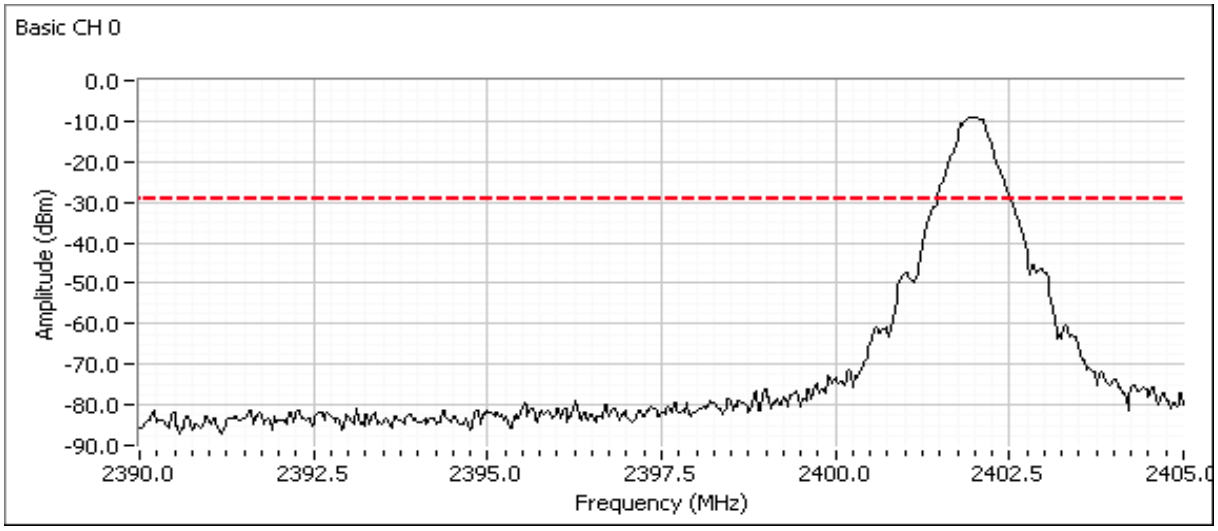
Low channel
Broadband plot

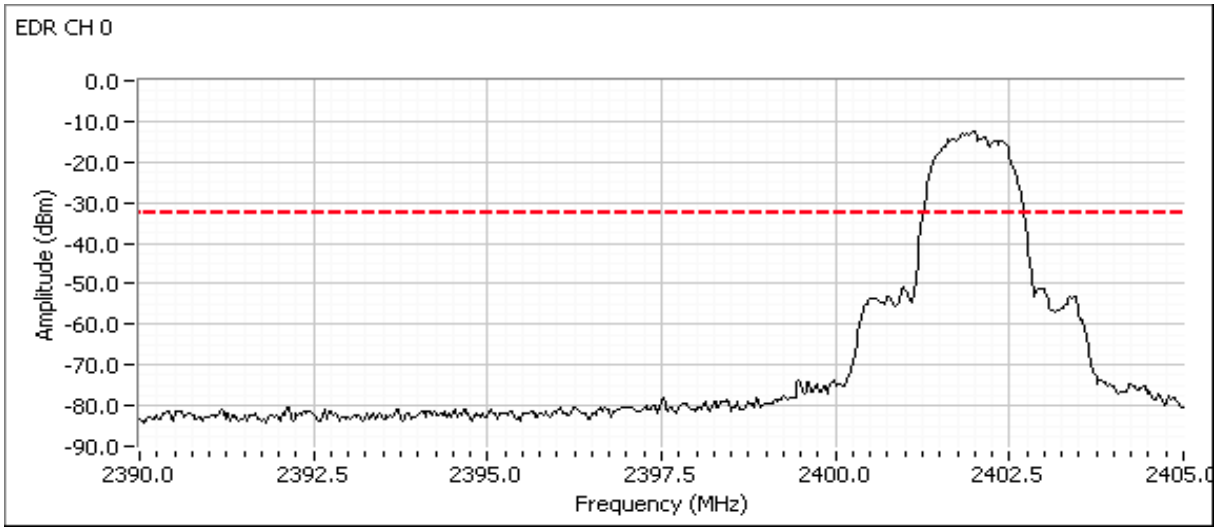




Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

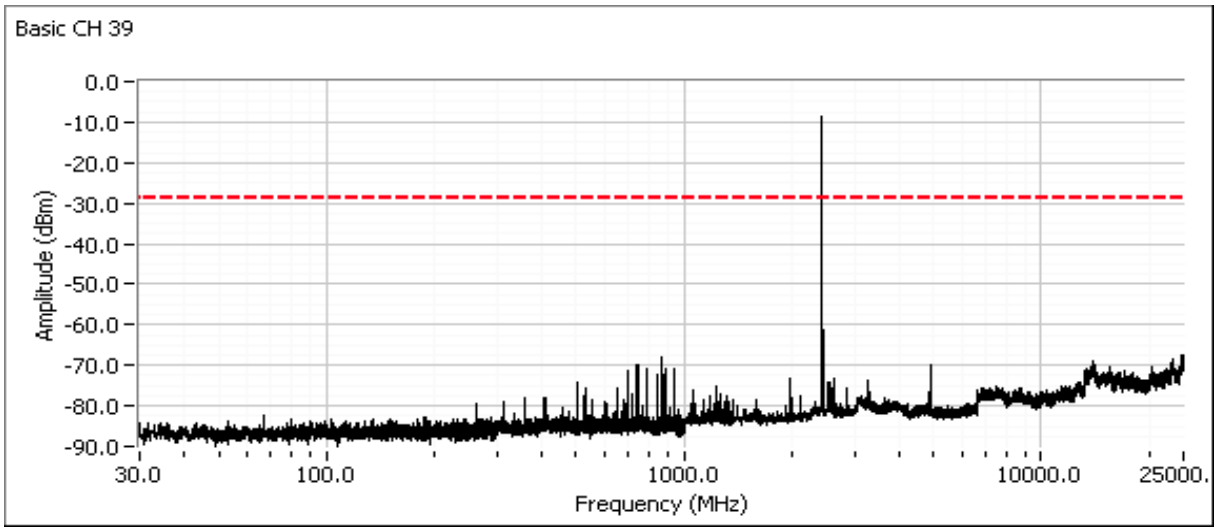
Plot showing -20dBc at the lower band edge

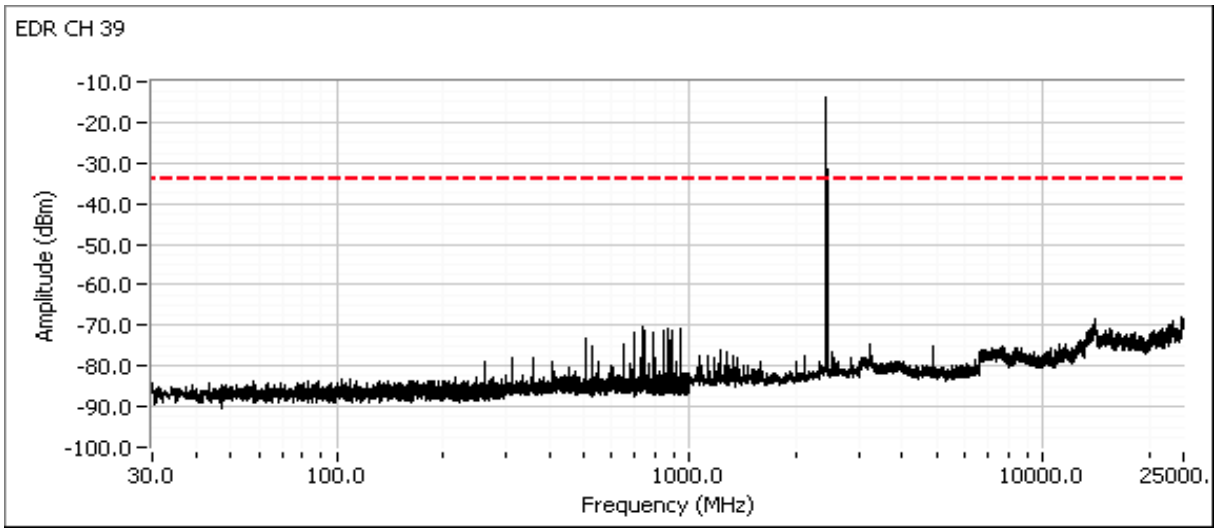




Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

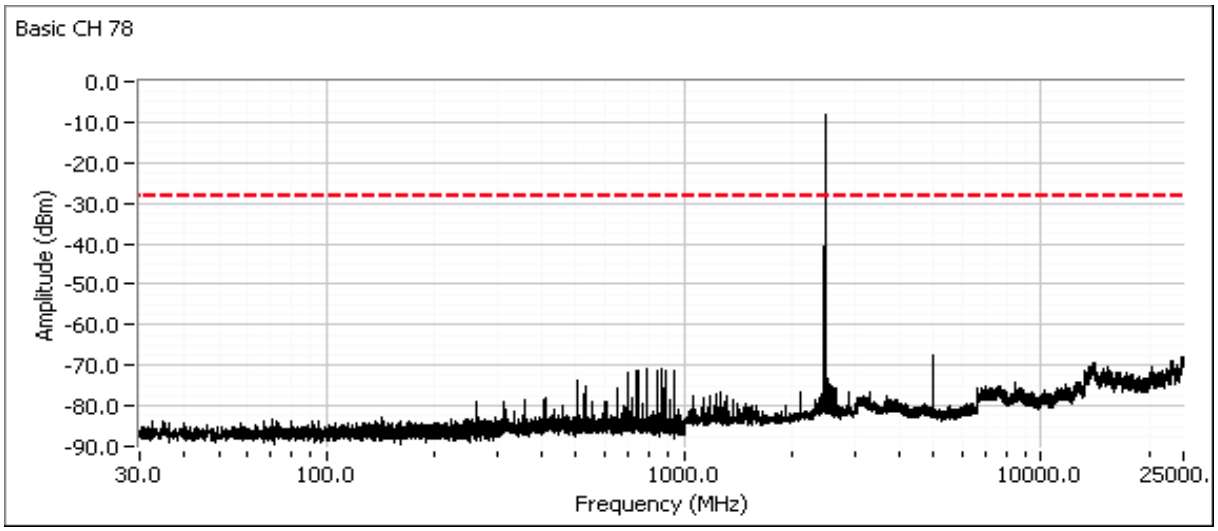
Center channel
Broadband plot

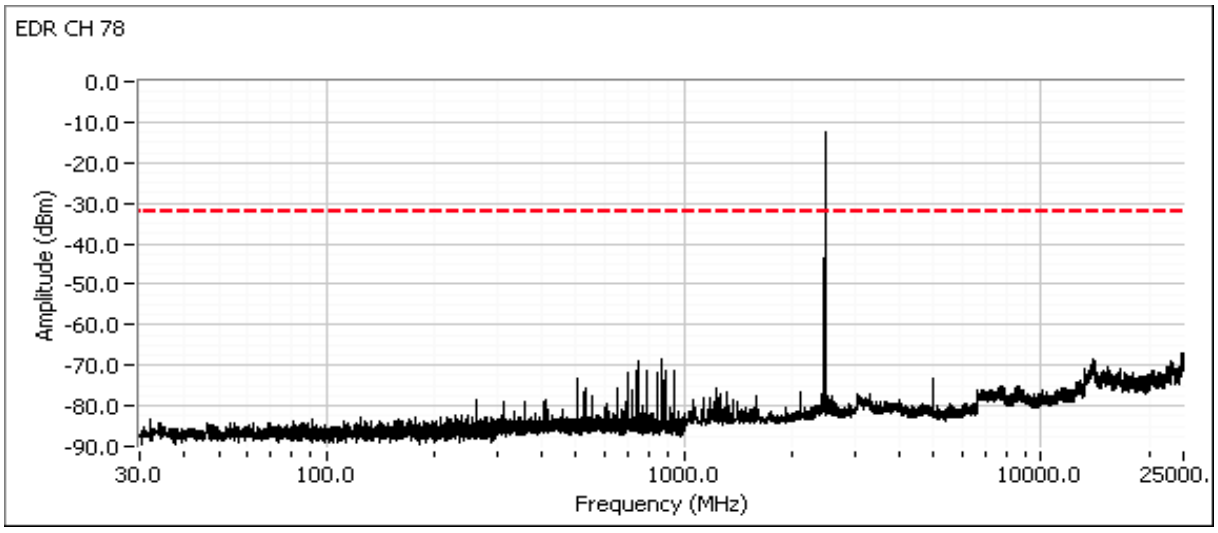




Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

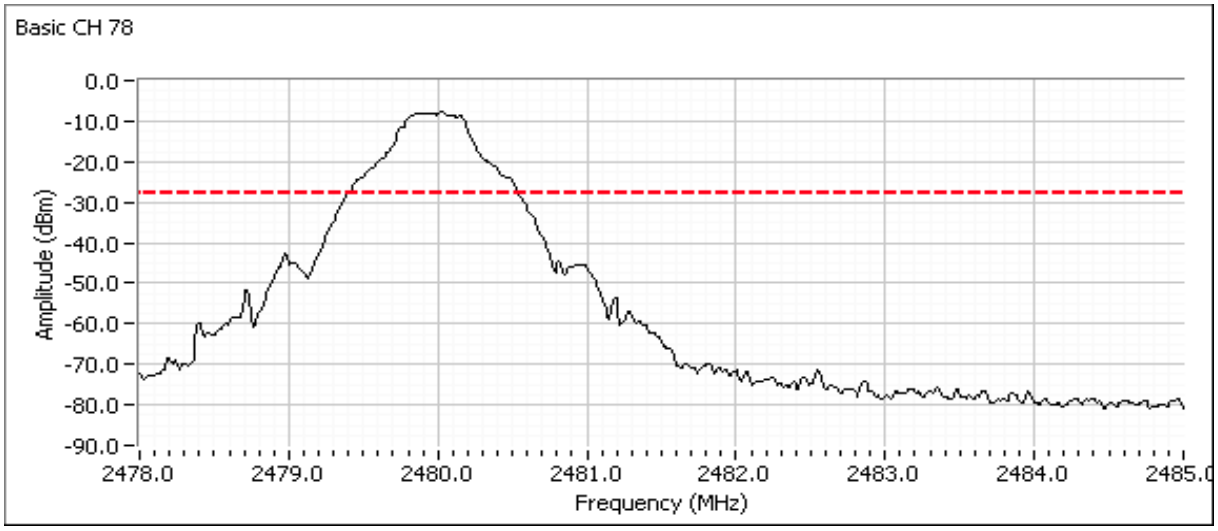
High channel
Broadband plot

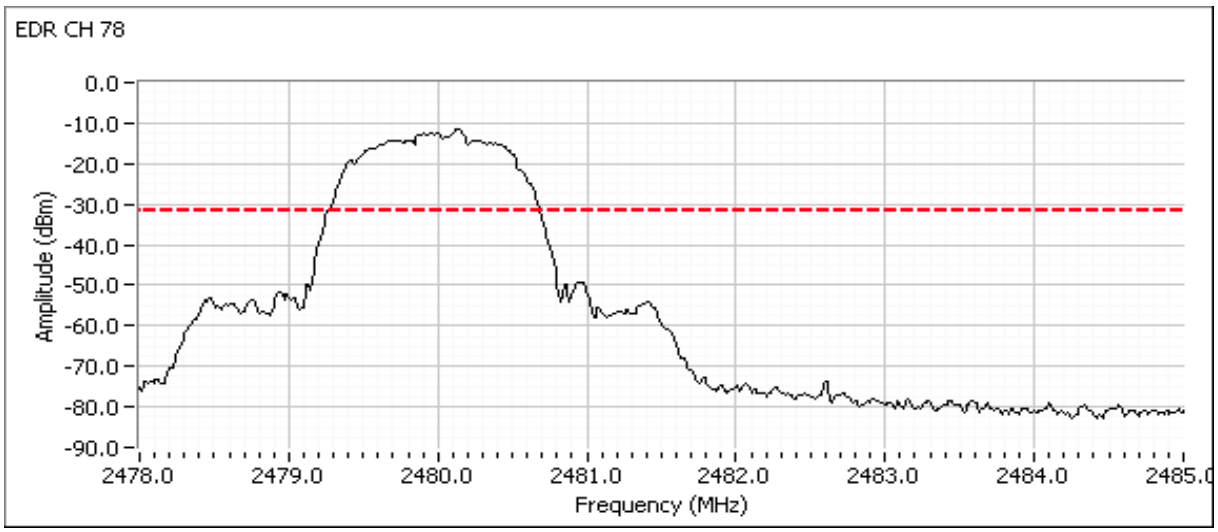




Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

Plot showing -20dBc at the upper band edge

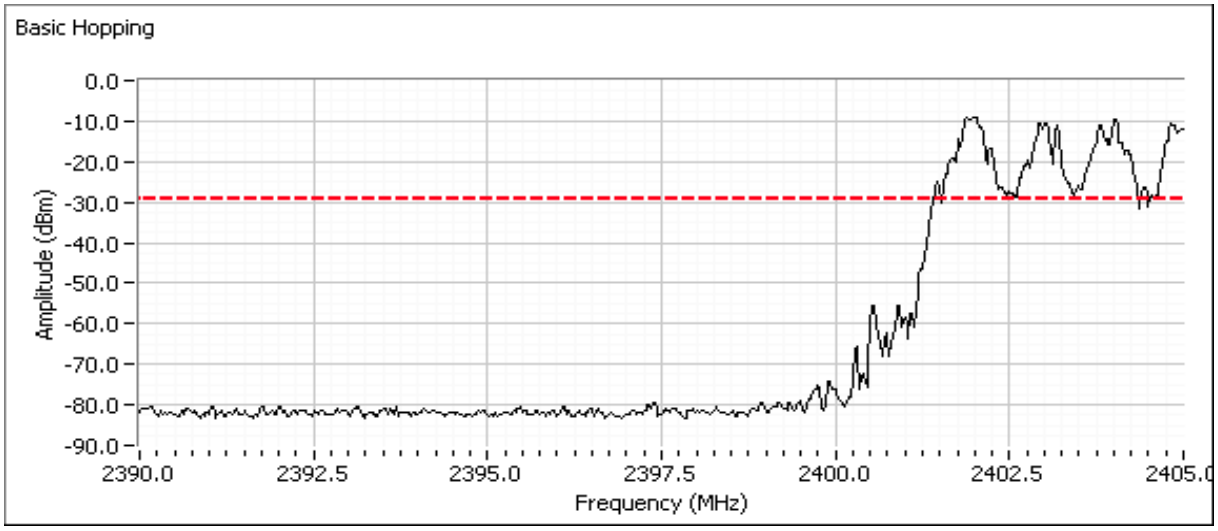


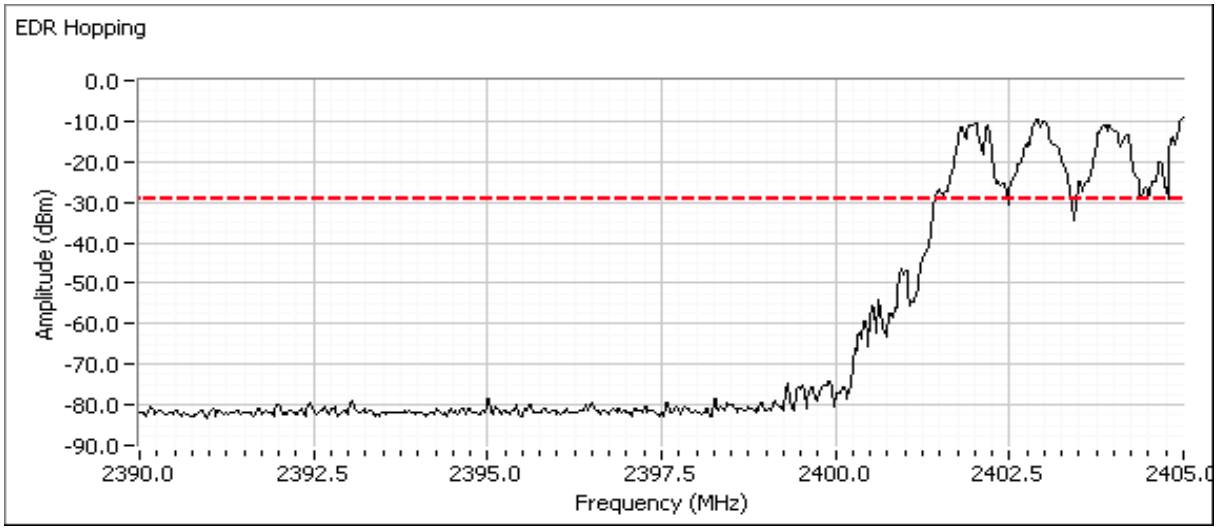


Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

Refer to plots below. Scans made using RBW=VB=100 KHz with the limit line set at 20dB below the highest in-band signal level with the hopping feature enabled to show compliance with the -20dBc requirement at the allocated band edge. The spectrum analyzer is left in max hold mode until the trace stabilizes.

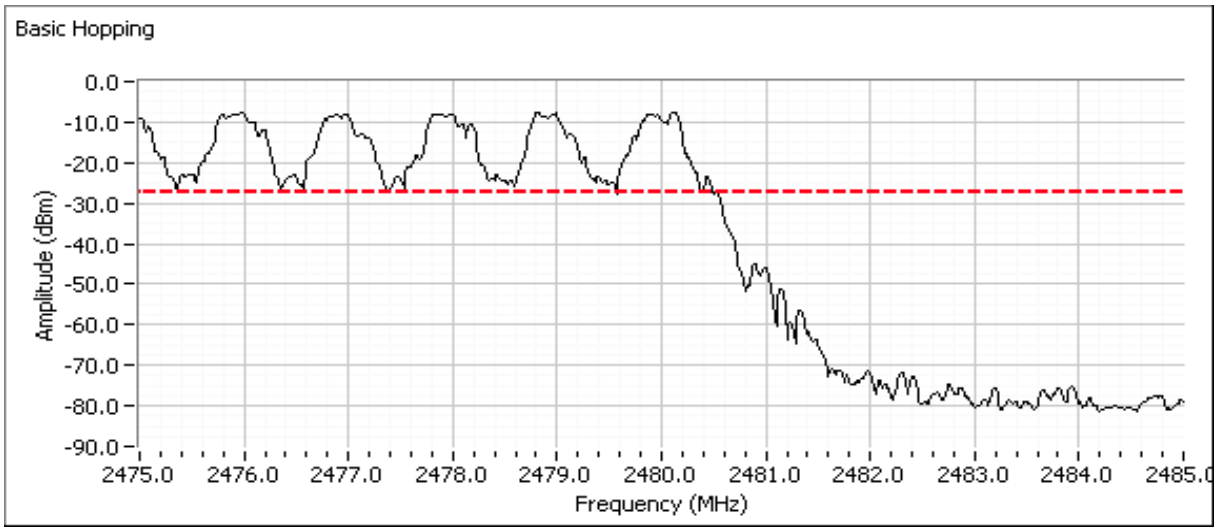
Low channel, hopping enabled
Plot showing -20dBc at the lower band edge

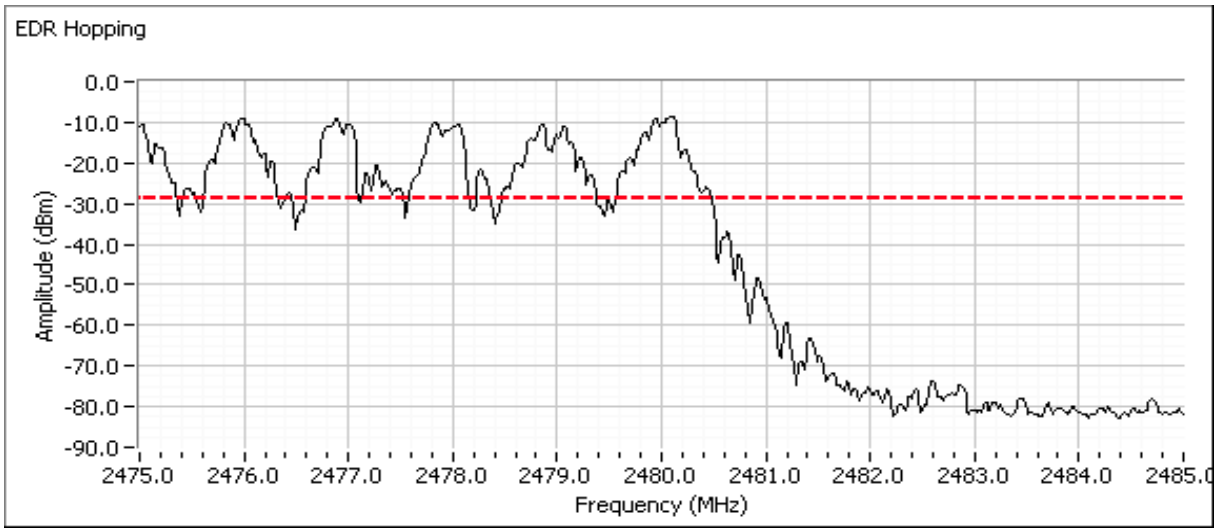




Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

High channel, hopping enabled
Plot showing -20dBc at the upper band edge





Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

Run #4: Channel Occupancy, Spacing and Number of Channels

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. (Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.)

The device complies with the Bluetooth protocol and employs a minimum of 20 of the available 79 hopping channels when employing adaptive frequency hopping and all 79 channels when not. Channels are selected in a pseudo random manner to ensure, on average, all channels are used equally.

The hopping rate is 1600 hops per second although any new channel may be used for a single hop slot, 3 hop slots or 5 hop slots. The dwell time per channel is, therefore either 0.625ms (single slot), 1.875ms (three slot) or 3.125ms (five slot). The average time of occupancy will not exceed 0.4s in any time interval of 0.4s multiplied by the number of channels being used.

Requirement: The channel spacing shall be greater than 2/3 of the highest 20dB bandwidth as the ouput power is < 0.125 W.

			2/3 of 20dB BW	
Channel Spacing:	1000 kHz			
20dB Bandwidth:	1015 kHz	Basic	676.7 kHz	Basic
20dB Bandwidth:	1318 kHz	EDR	878.7 kHz	EDR

The channel spacing for Bluetooth is 1 MHz.

Requirement: The system shall employ a minimum of 15 hopping channels.

The minimum number of channels is 20 for Bluetooth.

Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

RSS-247 and FCC 15.247 (FHSS) Measurements

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. All remote support equipment was located approximately 30 meters from the EUT with all I/O connections running on top of the ground plane or routed in overhead in the GR-1089 test configuration.

For radiated emissions testing the measurement antenna was located 3 meters from the EUT.

Unless stated otherwise the EUT was operating such that it constantly hopped on either the low, center or high channels.

Ambient Conditions:

Temperature: 26-29 °C
Rel. Humidity: 36-40 %

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1, Basic	30 - 25,000 MHz - Transmitter Radiated Spurious Emissions	FCC Part 15.209 / 15.247(c)	Pass	Refer to individual runs
2, EDR3	30 - 25,000 MHz - Transmitter Radiated Spurious Emissions	FCC Part 15.209 / 15.247(c)	Pass	Refer to individual runs

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:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

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 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

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)	
Basic	1 Mb/s	0.77	Yes	2.906	1.1	2.3	344	64.935065
EDR	1 Mb/s	0.77	Yes	2.932	1.1	2.2	341	

Sample Notes

Sample S/N: 1704141003
Driver:
Antenna: internal

Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

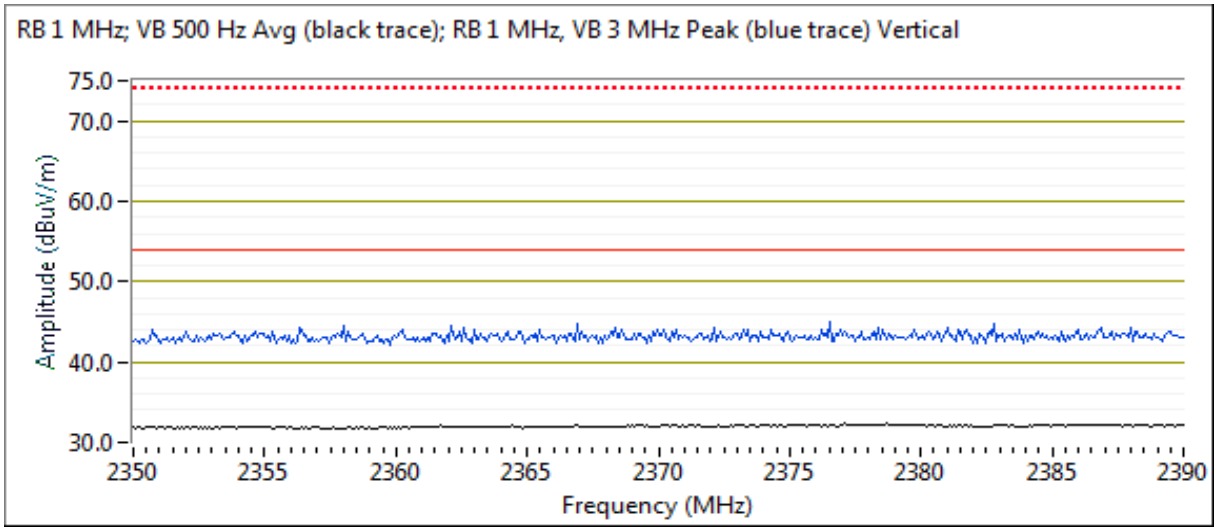
Run #1: Radiated Spurious Emissions, 30 - 25,000 MHz.

Date of Test: 7/11/2017, 7/27/217
Test Engineer: John Caizzi, Joseph Cadigal
Test Location: Chamber 5

Run #1a: Radiated Spurious Emissions, 30 - 25,000 MHz. Low Channel @ 2402 MHz

Band Edge Signal 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	
2379.280	32.5	V	54.0	-21.5	Avg	217	1.6	POS; RB 1 MHz; VB: 500 Hz
2379.070	44.8	V	74.0	-29.2	PK	217	1.6	POS; RB 1 MHz; VB: 3 MHz
2371.980	32.2	H	54.0	-21.8	Avg	62	1.2	POS; RB 1 MHz; VB: 500 Hz
2370.040	44.7	H	74.0	-29.3	PK	62	1.2	POS; RB 1 MHz; VB: 3 MHz

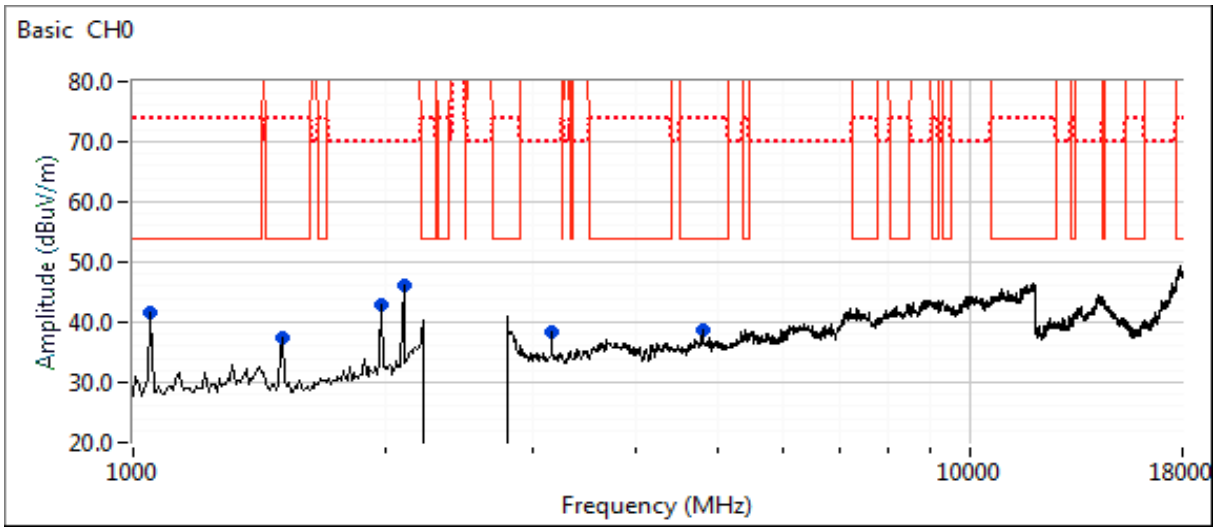


Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

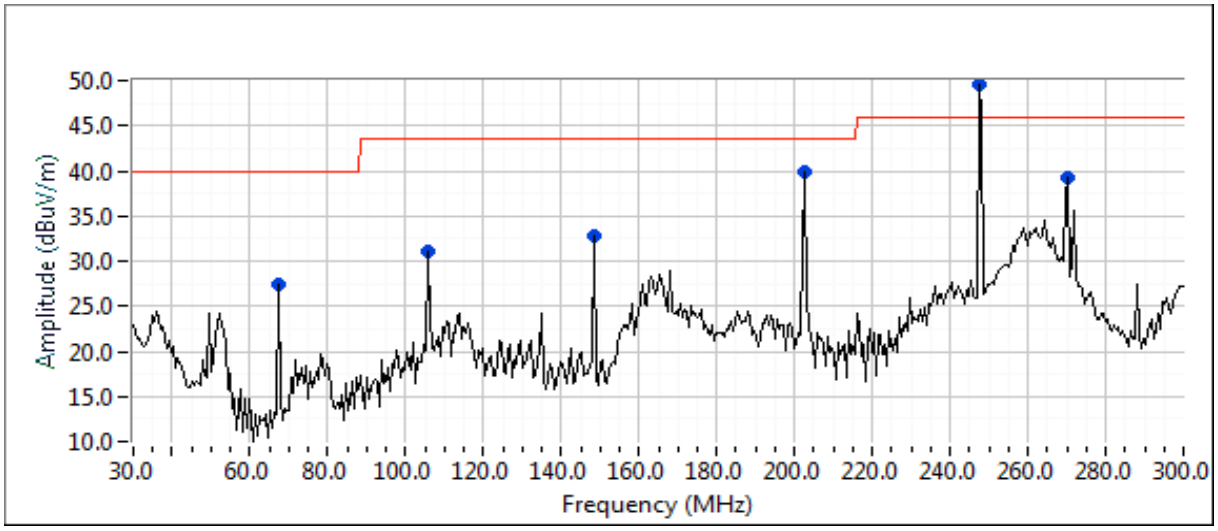
Other Spurious Emissions

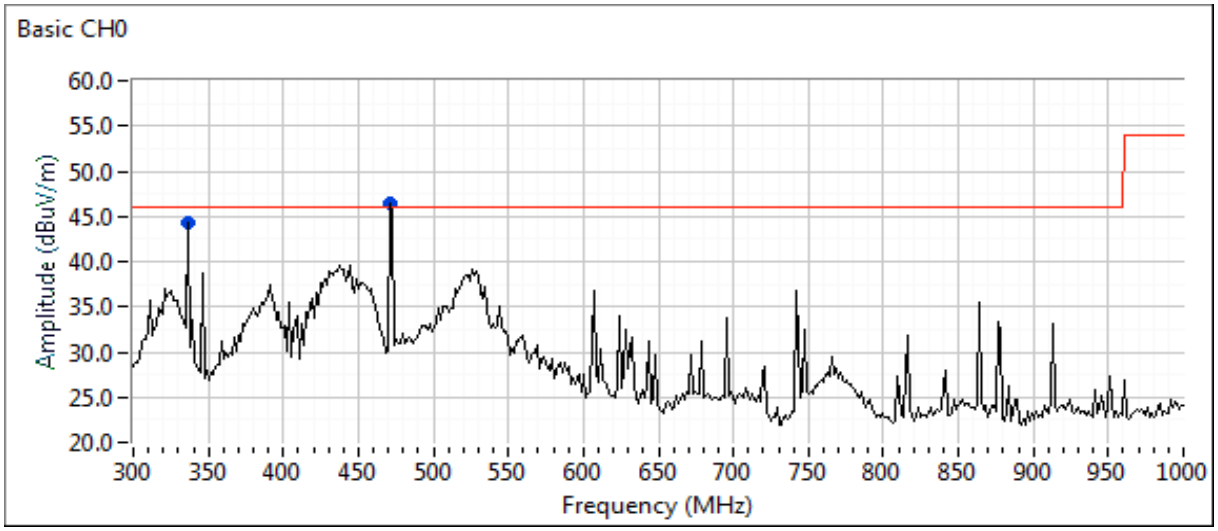
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
472.121	45.9	H	-	N/A	QP	26	1.0	*Note 4*
202.338	40.7	V	-	N/A	QP	49	1.0	*Note 4*
269.778	38.2	V	-	N/A	QP	191	1.0	*Note 4*
247.603	18.7	H	-	N/A	QP	215	1.0	*Note 4*
148.621	14.9	V	-	N/A	QP	266	1.5	*Note 4*
105.532	16.3	V	-	N/A	QP	274	1.0	*Note 4*
67.453	26.1	V	-	N/A	QP	274	1.0	*Note 4*
337.239	40.5	H	-	N/A	QP	327	1.0	*Note 4*
1011.870	28.5	V	54.0	-25.5	Avg	280	2.50	RB 1 MHz, VB 1 kHz, note 6
1011.530	37.5	V	74.0	-36.5	PK	280	2.50	
1050.000	*41.5*	*V*	*54.0*	*-12.5*	*Peak*	*286*	*2.0*	*Not a radio signal; from display.*
1508.330	*37.3*	*V*	*54.0*	*-16.7*	*Peak*	*133*	*1.5*	
1983.330	*42.9*	*H*	*54.0*	*-11.1*	*Peak*	*48*	*1.0*	*Not a radio signal. Note 1*
2108.330	*46.2*	*H*	*54.0*	*-7.8*	*Peak*	*132*	*2.5*	*Not a radio signal; 2nd harmonic of display signal. Note 1.*
3166.670	*38.3*	*H*	*54.0*	*-15.7*	*Peak*	*91*	*1.5*	

Note 3:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 4:	These emissons are not from the radio. These emissions must meet the limits for commerical non radio equipment.



Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A





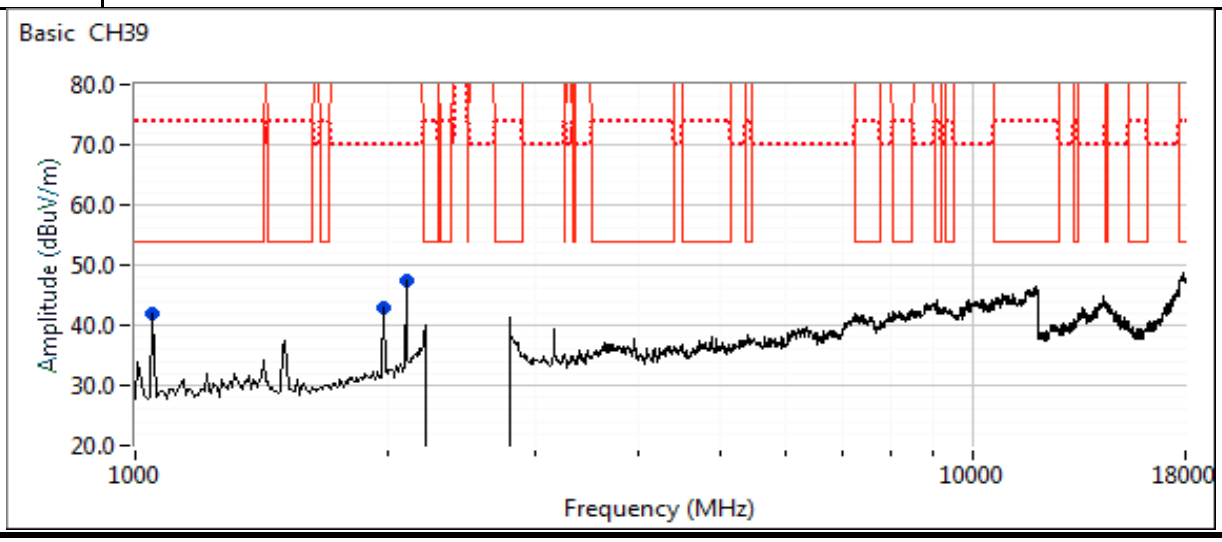
Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

Run #1b: Radiated Spurious Emissions, 30 - 25,000 MHz. Center Channel @ 2441 MHz

Spurious Emissions

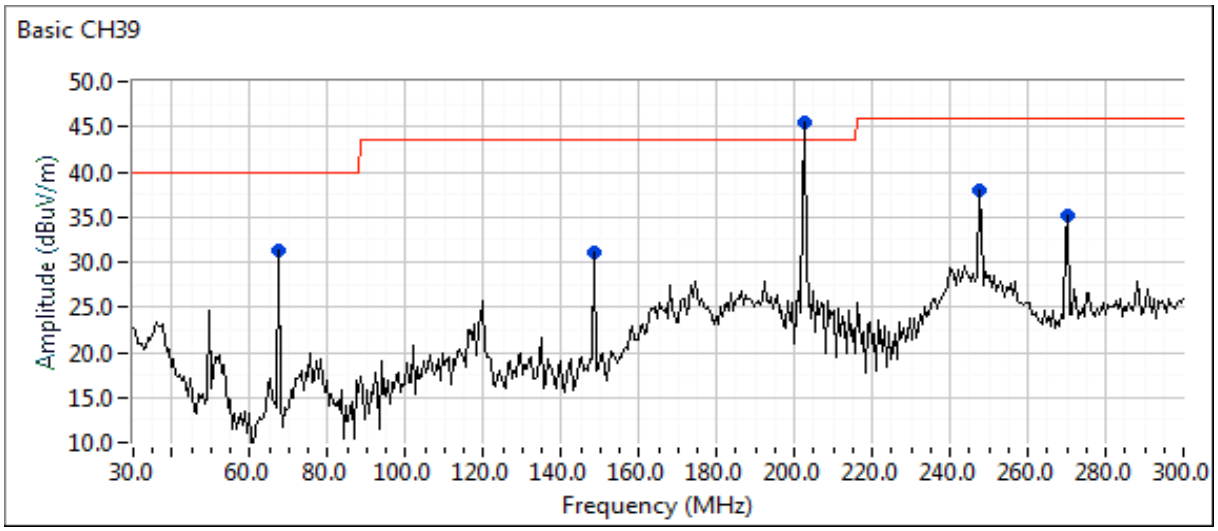
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
337.222	47.6	V	-	N/A	QP	0	1.5	*Note 4*
247.611	21.7	V	-	N/A	QP	13	2.0	*Note 4*
202.342	44.5	V	-	N/A	QP	76	1.0	*Note 4*
269.780	35.0	V	-	N/A	QP	100	1.0	*Note 4*
148.632	9.1	V	-	N/A	QP	114	1.5	*Note 4*
472.110	45.9	V	-	N/A	QP	148	1.5	*Note 4*
67.453	28.7	V	-	N/A	QP	259	1.0	*Note 4*
443.695	36.2	V	-	N/A	QP	305	1.5	*Note 4*
430.717	35.6	V	-	N/A	QP	320	1.5	*Note 4*
337.222	26.1	V	-	N/A	QP	0	1.5	*Note 4*
202.342	35.9	V	-	N/A	QP	76	1.0	*Note 4*
472.110	42.0	V	-	N/A	QP	148	1.5	*Note 4*
2108.330	*47.4*	*V*	*54.0*	-6.6	*Peak*	*131*	*2.5*	*Not a radio signal; 2nd harmonic of display signal. Note 1.*
1050.000	*41.8*	*V*	*54.0*	*-12.2*	*Peak*	*261*	*2.0*	*Not a radio signal; from display.*
1983.330	*42.8*	*H*	*54.0*	-11.2	*Peak*	*62*	*1.0*	*Not a radio signal. Note 1*

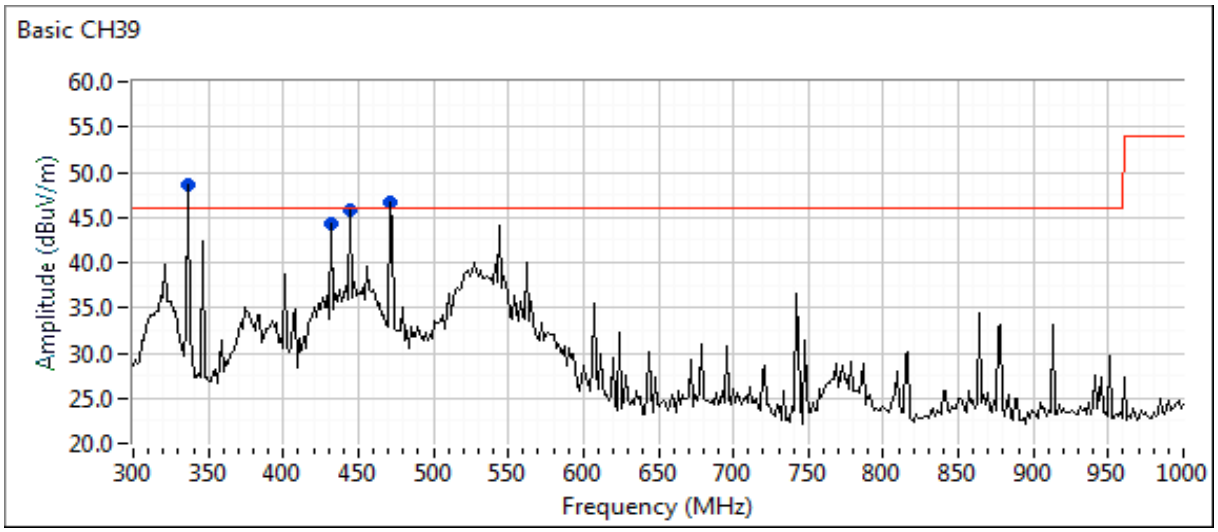
Note 3:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 4:	These emissons are not from the radio. These emissions must meet the limits for commerical non radio equipment.



Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

Note 5:	*Scans made between 18 - 25 GHz with the measurement antenna moved around the card and its antennas 20-50cm from the device indicated there were no significant emissions in this frequency range*



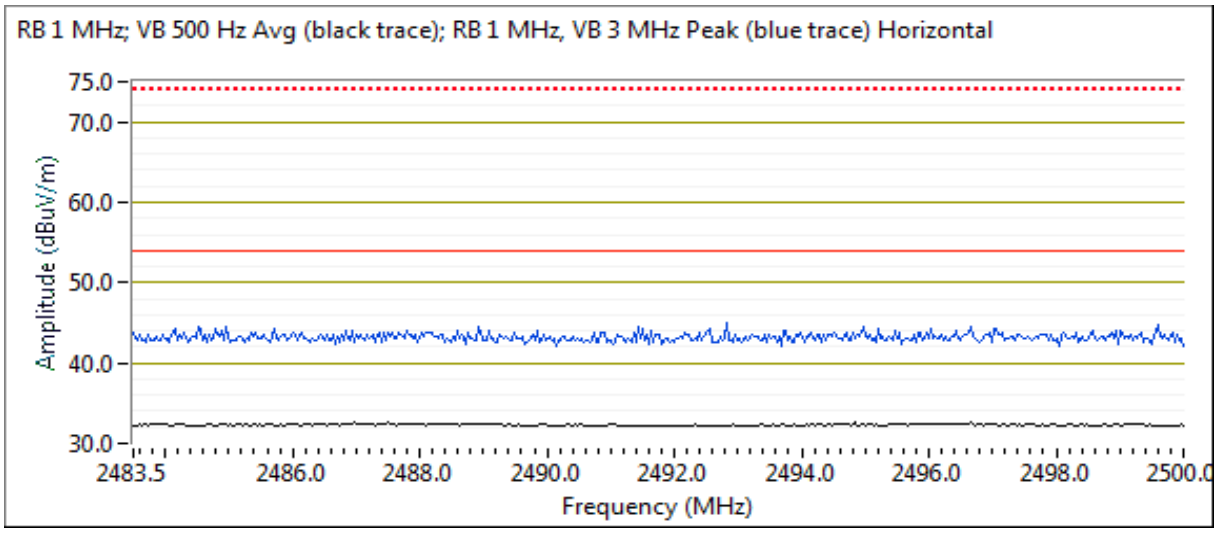


Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

Run #1c: Radiated Spurious Emissions, 30 - 25,000 MHz. High Channel @ 2480 MHz

Band Edge Signal 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	
2487.180	32.5	V	54.0	-21.5	Avg	82	1.4	POS; RB 1 MHz; VB: 500 Hz
2484.930	44.9	V	74.0	-29.1	PK	82	1.4	POS; RB 1 MHz; VB: 3 MHz
2493.540	32.5	H	54.0	-21.5	Avg	77	1.0	POS; RB 1 MHz; VB: 500 Hz
2492.250	45.2	H	74.0	-28.8	PK	77	1.0	POS; RB 1 MHz; VB: 3 MHz

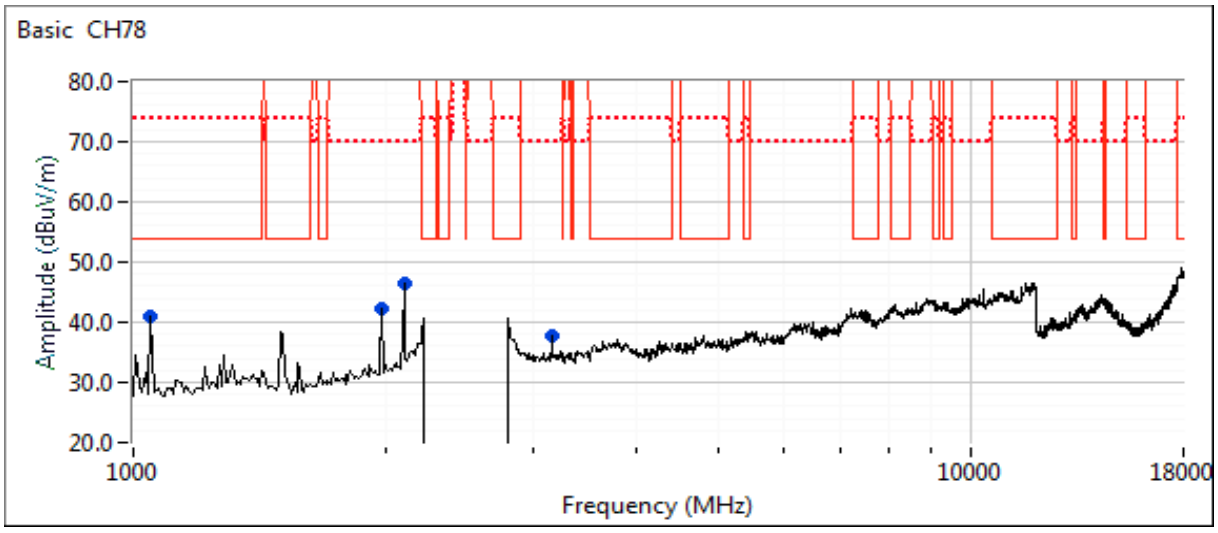


Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

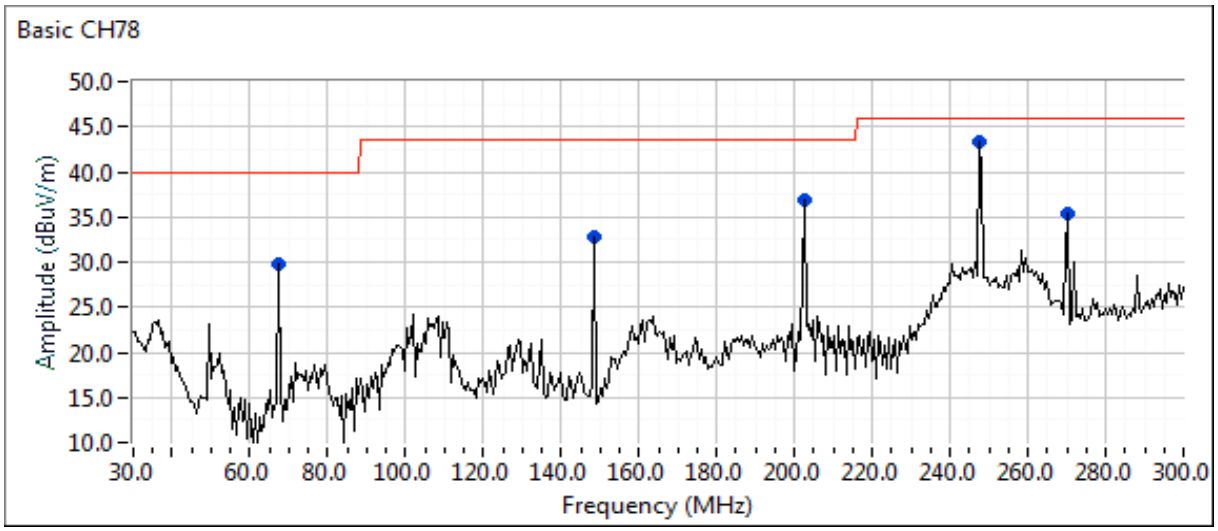
Other Spurious Emissions

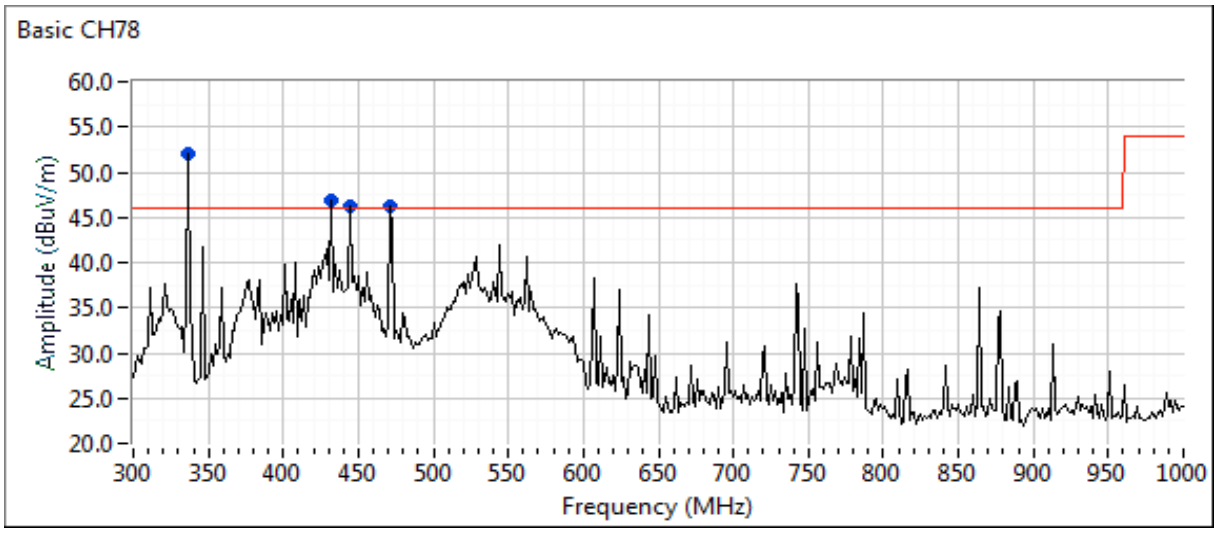
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
472.116	40.8	H	-	N/A	QP	19	1.0	*Note 4*
148.632	12.5	V	-	N/A	QP	318	1.0	*Note 4*
337.222	40.1	H	-	N/A	QP	196	1.0	*Note 4*
202.340	37.4	V	-	N/A	QP	74	1.0	*Note 4*
430.789	39.1	H	-	N/A	QP	37	1.0	*Note 4*
443.813	37.9	V	-	N/A	QP	161	1.5	*Note 4*
269.789	35.2	H	-	N/A	QP	206	1.0	*Note 4*
247.497	19.3	H	-	N/A	QP	197	1.0	*Note 4*
67.453	28.5	V	-	N/A	QP	273	1.0	*Note 4*
1050.000	*41.1*	*V*	*54.0*	*-12.9*	*Peak*	*288*	*2.5*	*Not a radio signal; from display.*
1983.330	*42.3*	*H*	*54.0*	-11.7	*Peak*	*170*	*1.0*	*Not a radio signal. Note 1*
2108.330	*46.6*	*V*	*54.0*	-7.4	*Peak*	*165*	*2.0*	*Not a radio signal; 2nd harmonic of display signal. Note 1.*
3166.670	*37.8*	*H*	*54.0*	-16.2	*Peak*	*70*	*2.0*	*Not a radio signal; from display.*

Note 3:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 4:	These emissons are not from the radio. These emissions must meet the limits for commerical non radio equipment.



Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A





Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

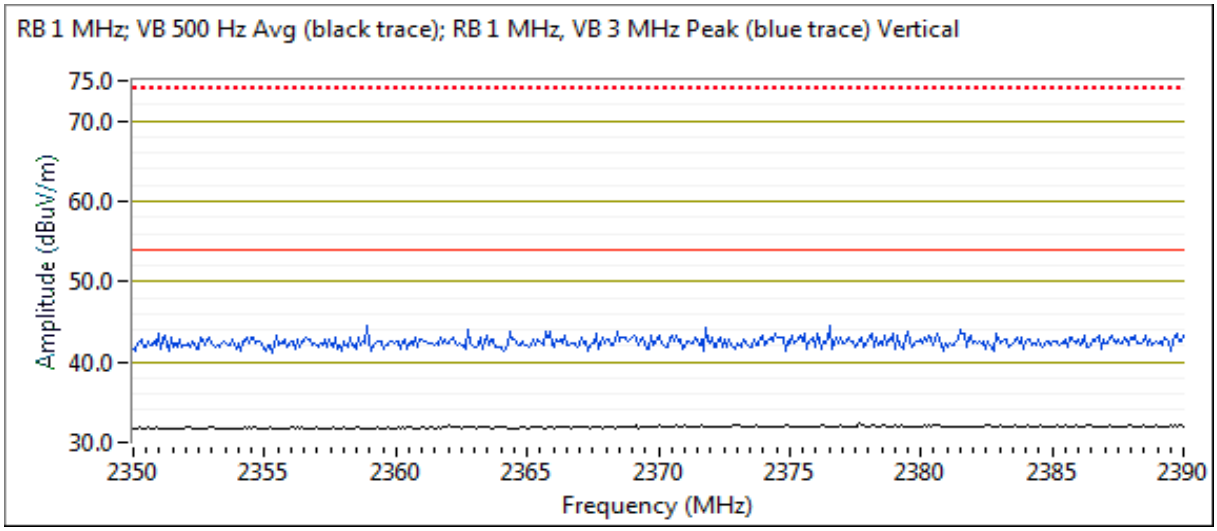
Run #2: Radiated Spurious Emissions, 30 - 25,000 MHz.

Date of Test: 7/11/2017
Test Engineer: John Caizzi
Test Location: Chamber 5

Run #2a: Radiated Spurious Emissions, 30 - 25,000 MHz. Low Channel @ 2402 MHz

Band Edge Signal 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	
2356.470	31.9	V	54.0	-22.1	Avg	337	1.7	POS; RB 1 MHz; VB: 500 Hz
2362.280	31.9	H	54.0	-22.1	Avg	257	2.3	POS; RB 1 MHz; VB: 500 Hz
2359.680	44.6	V	74.0	-29.4	PK	337	1.7	POS; RB 1 MHz; VB: 3 MHz
2363.650	44.5	H	74.0	-29.5	PK	257	2.3	POS; RB 1 MHz; VB: 3 MHz

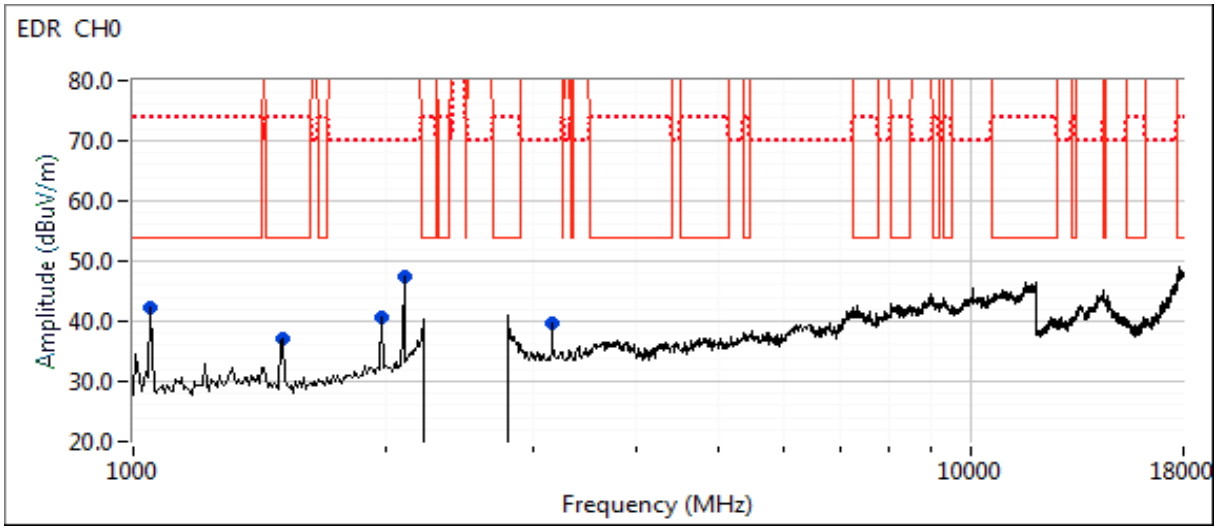


Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

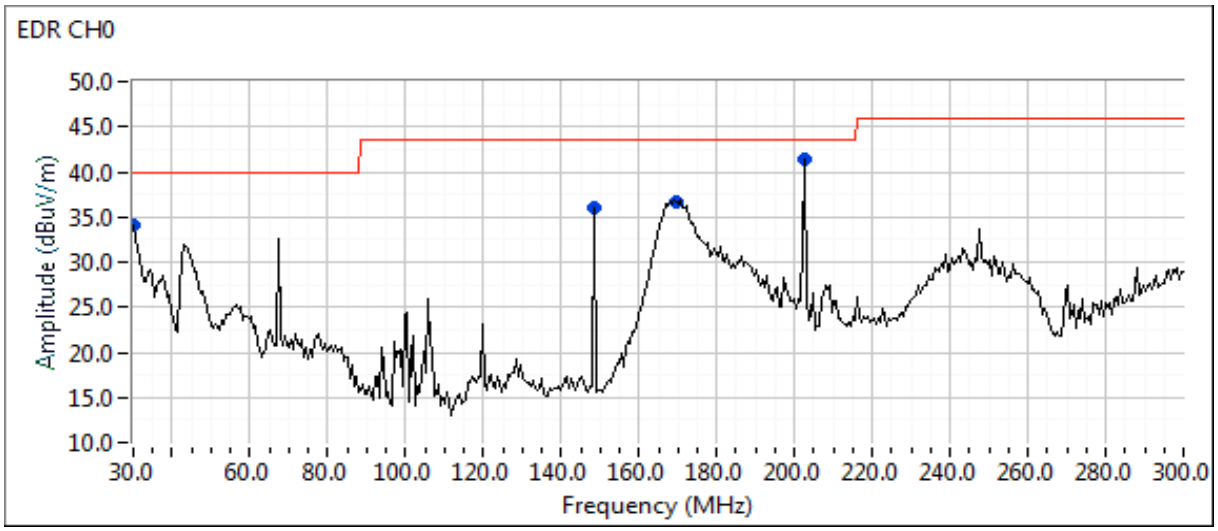
Other Spurious Emissions

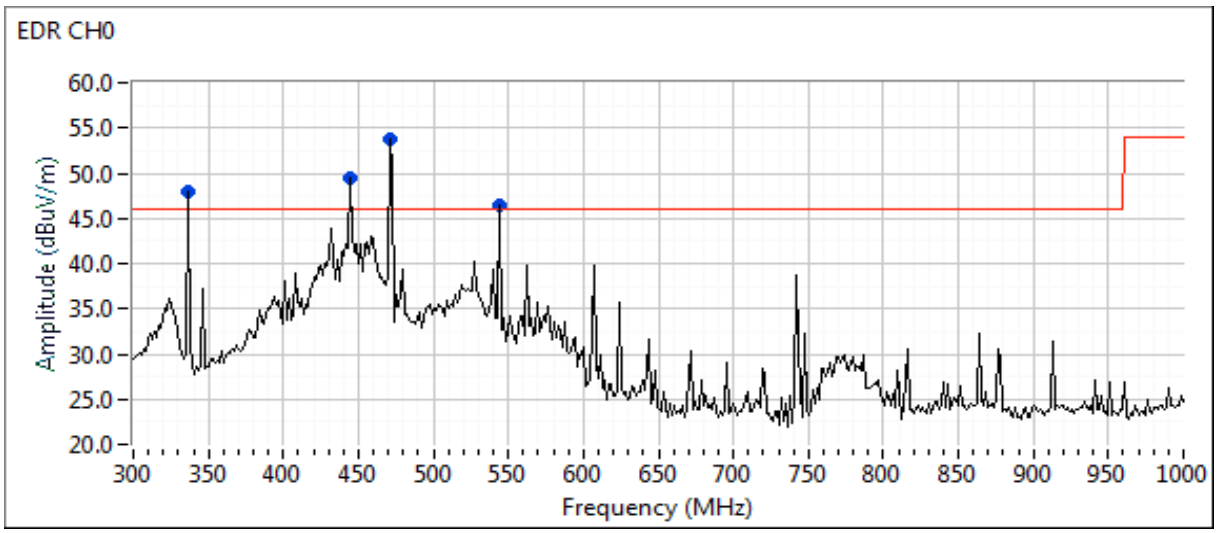
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
202.340	38.2	H	-	N/A	QP	37	1.0	*Note 4*
148.678	13.1	H	-	N/A	QP	53	1.0	*Note 4*
30.173	29.9	V	-	N/A	QP	121	1.0	*Note 4*
337.211	46.3	H	-	N/A	QP	149	1.5	*Note 4*
472.054	51.4	H	-	N/A	QP	218	1.0	*Note 4*
443.942	38.2	H	-	N/A	QP	245	2.0	*Note 4*
543.098	22.6	H	-	N/A	QP	245	2.5	*Note 4*
169.806	14.6	V	-	N/A	QP	284	1.0	*Note 4*
2108.330	*47.4*	*V*	*54.0*	-6.6	*Peak*	*170*	*1.5*	*Not a radio signal; 2nd harmonic of display signal. Note 1.*
1050.000	*42.1*	*V*	*54.0*	*-11.9*	*Peak*	*276*	*2.0*	*Not a radio signal; from display.*
1983.330	*40.8*	*H*	*54.0*	-13.2	*Peak*	*177*	*1.5*	*Not a radio signal. Note 1.*
3166.670	*39.8*	*H*	*54.0*	-14.2	*Peak*	*96*	*2.0*	*Not a radio signal; from display.*
1509.200	38.0	V	54.0	-16.0	Avg	80	1.10	RB 1 MHz, VB 1 kHz, note 6.
1509.330	46.0	V	74.0	-28.0	PK	80	1.10	

Note 3:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 4:	These emissons are not from the radio. These emissions must meet the limits for commerical non radio equipment.



Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A





Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

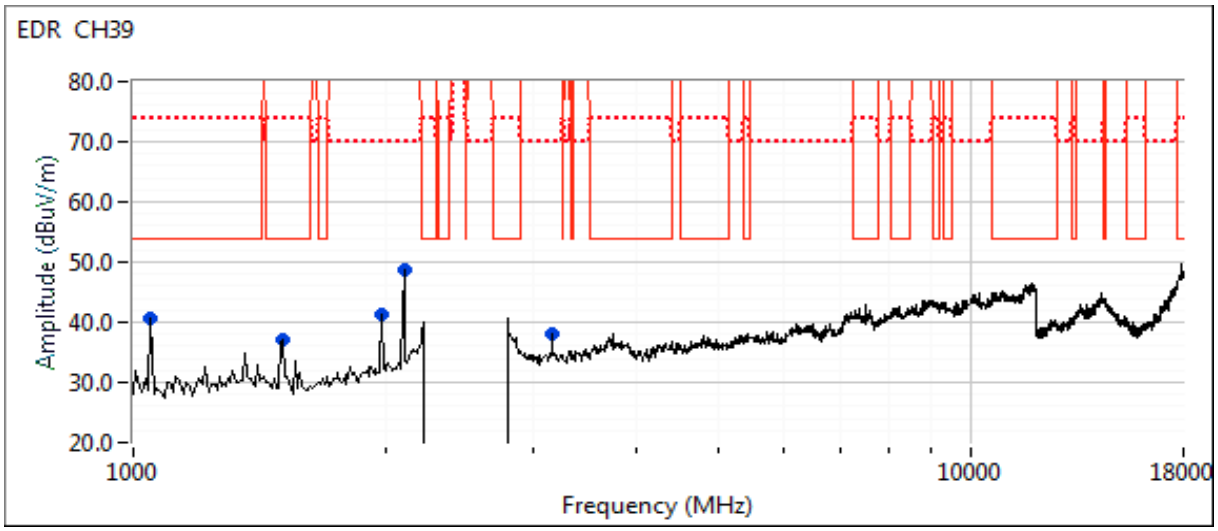
Run #2b: Radiated Spurious Emissions, 30 - 25,000 MHz. Center Channel @ 2441 MHz

Spurious Emissions

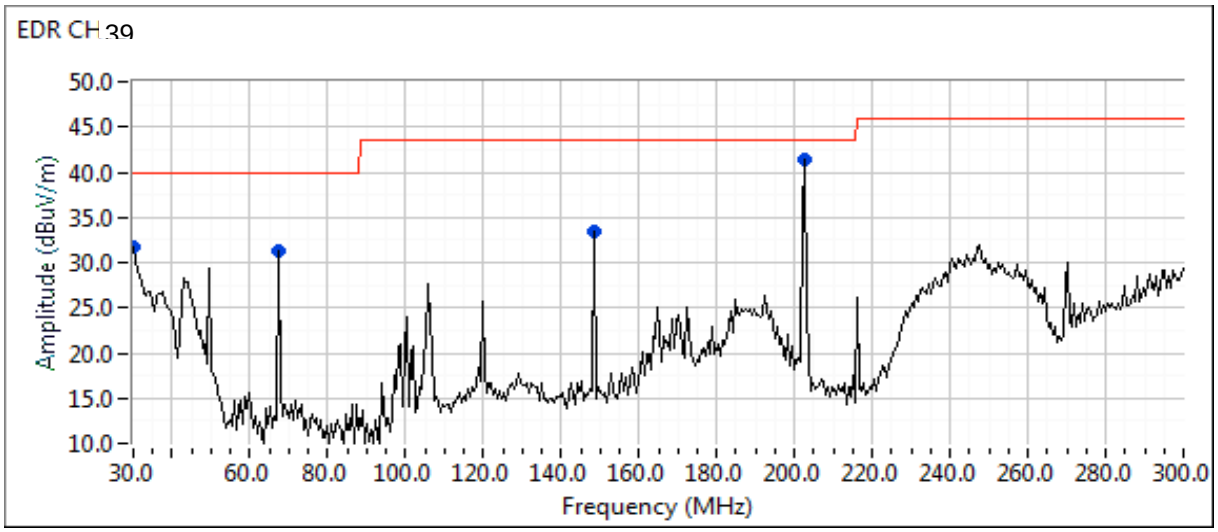
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
202.323	41.2	H	-	N/A	QP	52	1.0	*Note 4*
337.194	46.8	H	-	N/A	QP	139	1.5	*Note 4*
563.630	27.4	H	-	N/A	QP	209	1.5	*Note 4*
472.059	51.7	H	-	N/A	QP	224	1.0	*Note 4*
443.858	39.6	H	-	N/A	QP	224	1.0	*Note 4*
543.042	28.5	H	-	N/A	QP	224	1.0	*Note 4*
528.487	32.3	H	-	N/A	QP	231	1.0	*Note 4*
30.050	30.3	V	-	N/A	QP	356	1.0	*Note 4*
148.619	10.7	H	-	N/A	QP	360	1.0	*Note 4*
67.449	23.0	H	-	N/A	QP	360	1.5	*Note 4*
1050.000	*40.5*	*V*	*54.0*	*-13.5*	*Peak*	*0*	*2.0*	*Not a radio signal; from display.*
1512.400	36.1	V	54.0	-17.9	Avg	137	1.49	RB 1 MHZ, VB 1 kHz, note 6.
1512.260	44.4	V	74.0	-29.6	PK	137	1.49	
1983.330	*41.3*	*V*	*54.0*	*-12.7*	*Peak*	*172*	*1.0*	*Not a radio signal. Note 1.*
2108.330	*48.6*	*V*	*54.0*	*-5.4*	*Peak*	*164*	*1.5*	*Not a radio signal; 2nd harmonic of display signal. Note 1.*
3166.670	*38.1*	*H*	*54.0*	*-15.9*	*Peak*	*98*	*1.5*	*Not a radio signal; from display.*

Note 3:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 4:	These emissons are not from the radio. These emissions must meet the limits for commerical non radio equipment.

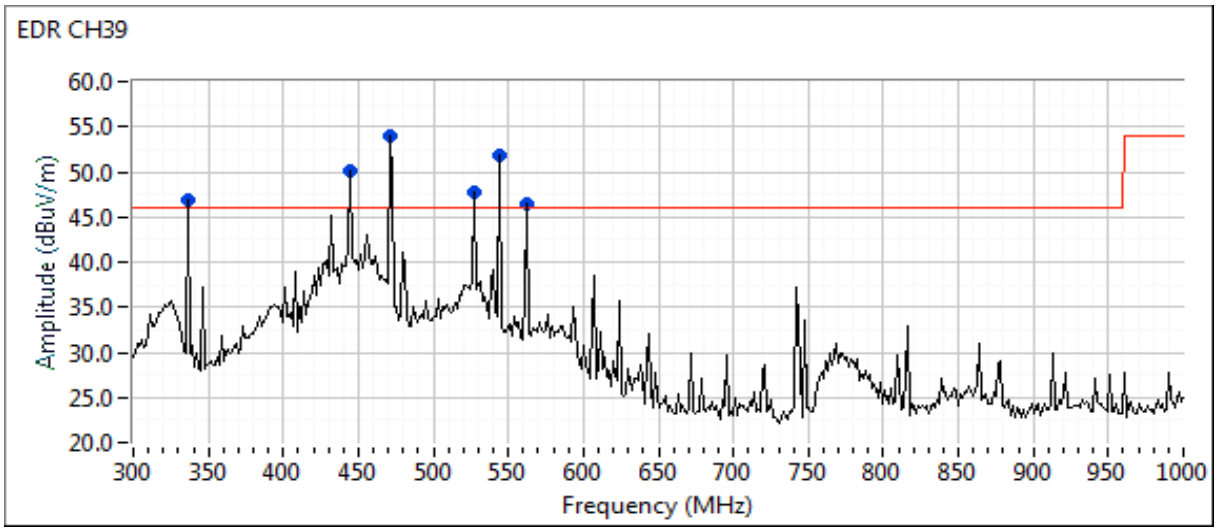
Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A



Note 5:	*Scans made between 18 - 25 GHz with the measurement antenna moved around the card and its antennas 20-50cm from the device indicated there were no significant emissions in this frequency range*



Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

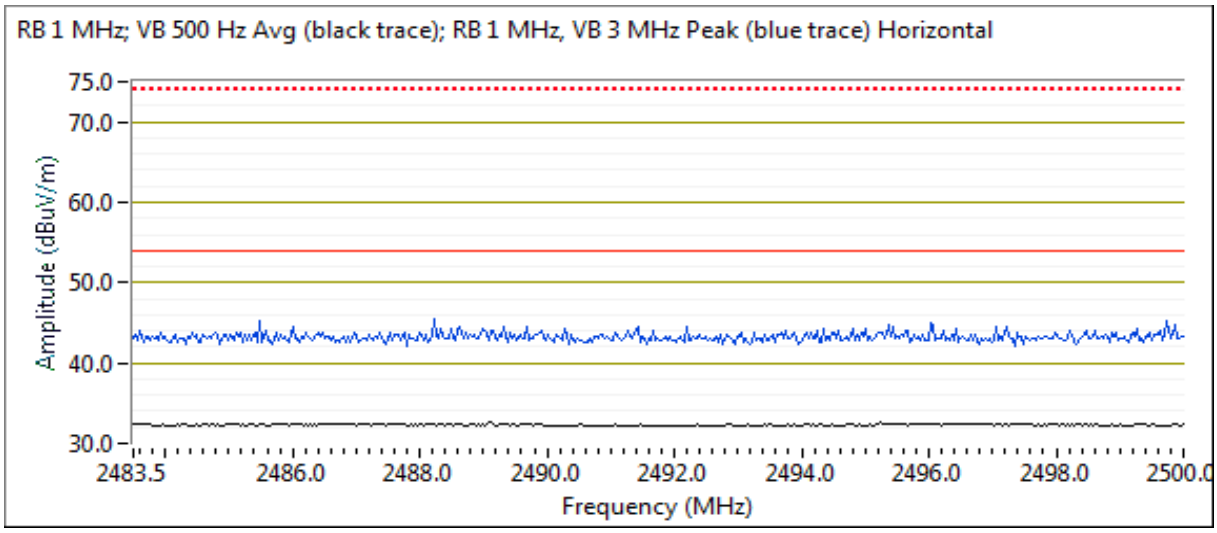


Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

Run #2c: Radiated Spurious Emissions, 30 - 25,000 MHz. High Channel @ 2480 MHz

Band Edge Signal 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	
2489.630	32.6	H	54.0	-21.4	Avg	63	2.5	POS; RB 1 MHz; VB: 500 Hz
2489.070	44.5	H	74.0	-29.5	PK	63	2.5	POS; RB 1 MHz; VB: 3 MHz
2489.980	32.5	V	54.0	-21.5	Avg	0	1.7	POS; RB 1 MHz; VB: 500 Hz
2489.490	44.7	V	74.0	-29.3	PK	0	1.7	POS; RB 1 MHz; VB: 3 MHz

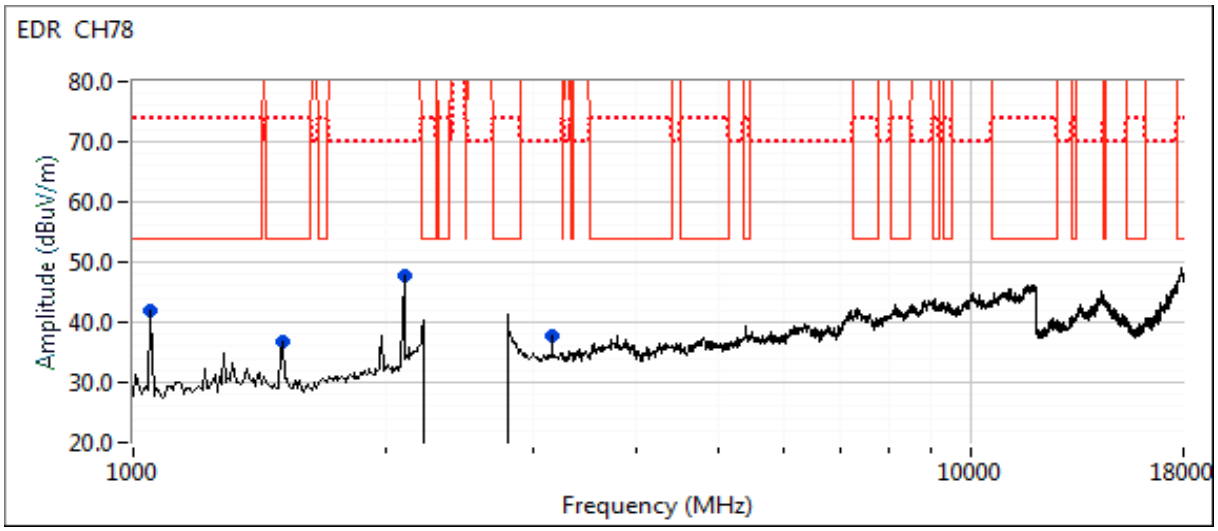


Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A

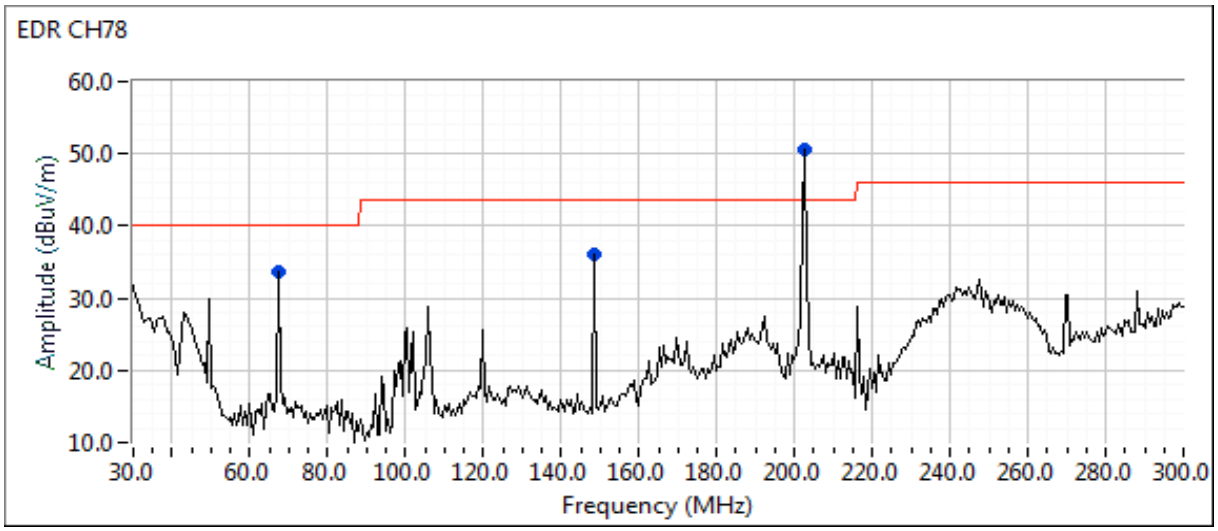
Other Spurious Emissions

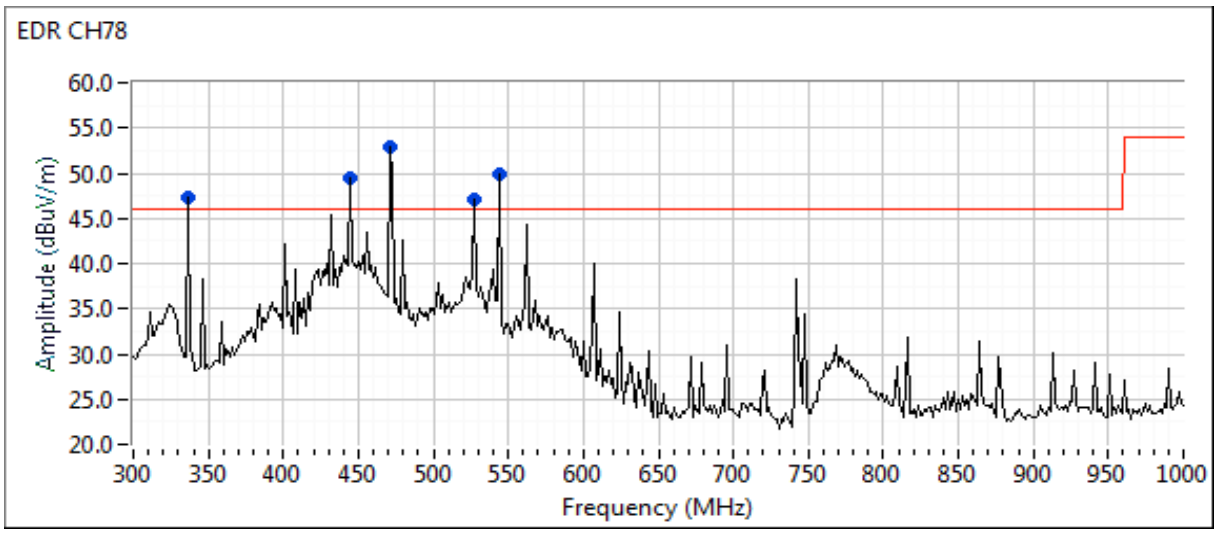
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
337.183	47.8	H	-	N/A	QP	120	1.5	*Note 4*
472.076	52.6	H	-	N/A	QP	214	1.0	*Note 4*
527.999	32.1	H	-	N/A	QP	225	1.0	*Note 4*
542.907	29.4	H	-	N/A	QP	231	1.0	*Note 4*
443.914	40.0	H	-	N/A	QP	258	1.0	*Note 4*
202.329	36.8	H	-	N/A	QP	263	3.5	*Note 4*
148.660	12.3	H	-	N/A	QP	276	1.5	*Note 4*
67.446	24.5	H	-	N/A	QP	354	2.5	*Note 4*
1050.000	*42.0*	*V*	*54.0*	*-12.0*	*Peak*	*284*	*2.0*	
1510.530	35.0	V	54.0	-19.0	Avg	163	1.48	RB 1 MHz, VB 1 kHz, note 6.
1510.400	43.9	V	74.0	-30.1	PK	163	1.48	
2108.330	*47.6*	*V*	*54.0*	*-6.4*	*Peak*	*167*	*1.5*	*Not a radio signal; 2nd harmonic of display signal. Note 1.*
3166.670	*37.8*	*V*	*54.0*	*-16.2*	*Peak*	*341*	*1.5*	*Not a radio signal; from display.*

Note 3:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 4:	These emissons are not from the radio. These emissions must meet the limits for commerical non radio equipment.



Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	N/A





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Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	B

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: 7/27/2017
Test Engineer: Joseph Cadigal
Test Location: FT Chamber#5

Config. Used: 1
Config Change: none
EUT Voltage: 120V/60Hz

General Test Configuration

For tabletop equipment, the EUT was located on a wooden table 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 °C
Rel. Humidity: 38 %

Summary of Results

Run #	Test Performed	Limit	Result	Margin
1	CE, AC Power,120V/60Hz	15.207	Pass	37.1 dBµV @ 0.327 MHz (-12.4 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.

Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
Model:	ApexZ3	T-Log Number:	T105297
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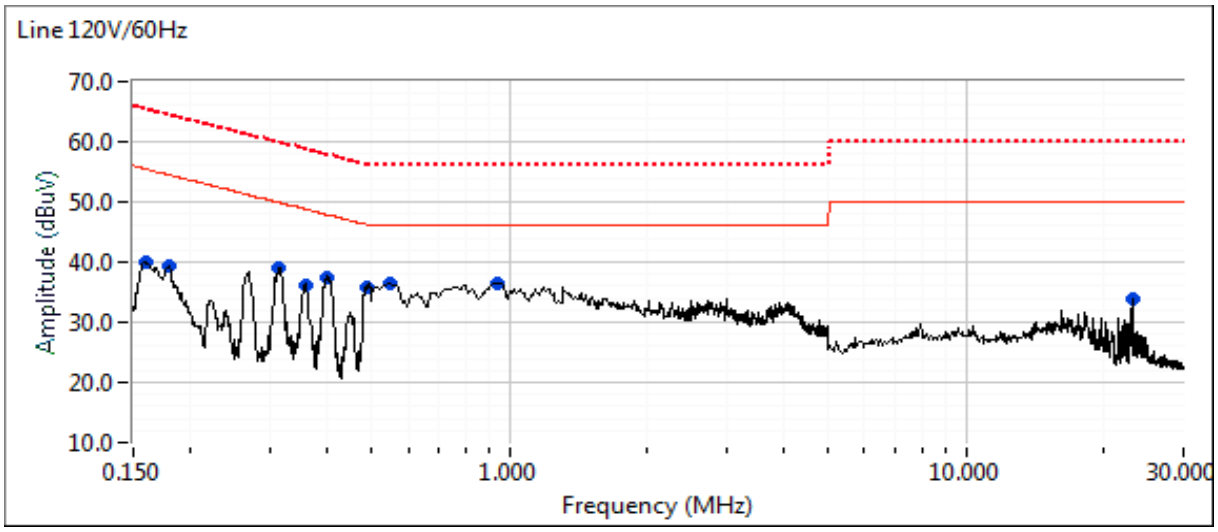
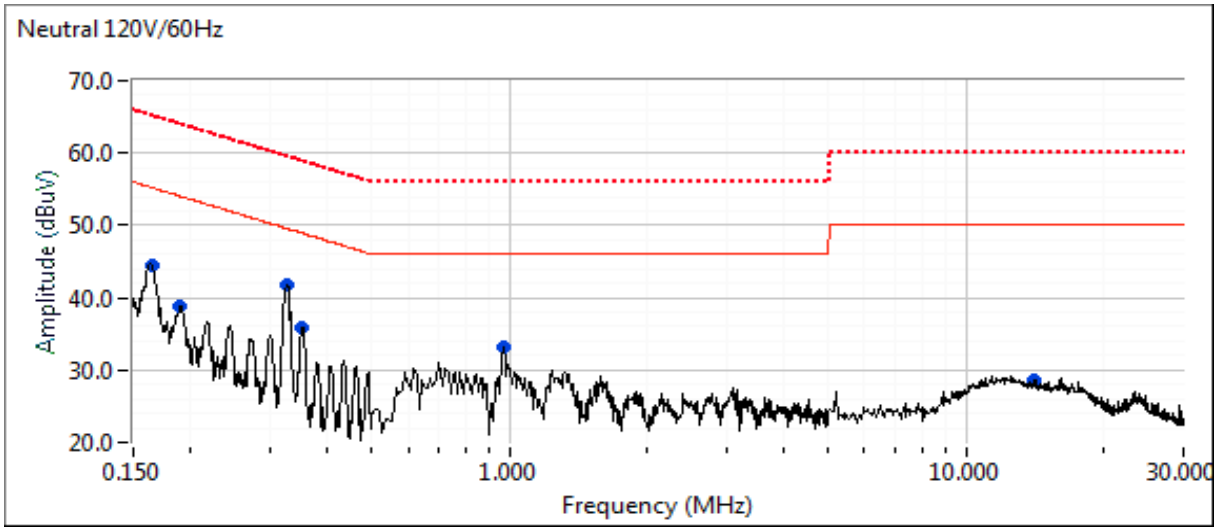
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	B

Run #1: AC Power Port Conducted Emissions, 0.15 - 30MHz, 120V/60Hz
WiFi radio operating





Client:	Lighthouse Worldwide Solutions	Job Number:	JD105241
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		Project Manager:	Irene Radamacher
Contact:	Charley Abboud	Project Coordinator:	-
Standard:	FCC Part 15	Class:	B

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

Frequency	Level	AC	Class B		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
0.401	37.5	Line 1	47.8	-10.3	Peak	
0.357	36.0	Line 1	48.8	-12.8	Peak	
0.313	38.9	Line 1	49.9	-11.0	Peak	
0.489	35.9	Line 1	46.2	-10.3	Peak	
0.160	40.0	Line 1	55.5	-15.5	Peak	
0.179	39.2	Line 1	54.5	-15.3	Peak	
0.938	36.5	Line 1	46.0	-9.5	Peak	
0.536	36.4	Line 1	46.0	-9.6	Peak	
23.128	33.8	Line 1	50.0	-16.2	Peak	
0.327	41.7	Neutral	49.5	-7.8	Peak	
0.165	44.5	Neutral	55.2	-10.7	Peak	
0.190	38.7	Neutral	54.0	-15.3	Peak	
0.352	35.9	Neutral	48.9	-13.0	Peak	
0.968	33.2	Neutral	46.0	-12.8	Peak	
14.082	28.7	Neutral	50.0	-21.3	Peak	

Final quasi-peak and average readings

Frequency	Level	AC	Class B		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
0.327	37.1	Neutral	49.5	-12.4	AVG	AVG (0.10s)
0.352	31.9	Neutral	48.9	-17.0	AVG	AVG (0.10s)
0.160	38.3	Line 1	55.5	-17.2	AVG	AVG (0.10s)
0.968	28.4	Neutral	46.0	-17.6	AVG	AVG (0.10s)
0.165	37.4	Neutral	55.2	-17.8	AVG	AVG (0.10s)
0.327	39.2	Neutral	59.5	-20.3	QP	QP (1.00s)
0.938	24.4	Line 1	46.0	-21.6	AVG	AVG (0.10s)
0.401	25.9	Line 1	47.8	-21.9	AVG	AVG (0.10s)
0.190	31.1	Neutral	54.1	-23.0	AVG	AVG (0.10s)
0.160	42.0	Line 1	65.5	-23.5	QP	QP (1.00s)
0.165	41.3	Neutral	65.2	-23.9	QP	QP (1.00s)
0.968	31.2	Neutral	56.0	-24.8	QP	QP (1.00s)
0.352	33.0	Neutral	58.9	-25.9	QP	QP (1.00s)
0.190	37.1	Neutral	64.1	-27.0	QP	QP (1.00s)
0.938	27.3	Line 1	56.0	-28.7	QP	QP (1.00s)
0.357	19.3	Line 1	48.8	-29.5	AVG	AVG (0.10s)
0.489	16.7	Line 1	46.2	-29.5	AVG	AVG (0.10s)
0.401	28.0	Line 1	57.8	-29.8	QP	QP (1.00s)
0.313	19.6	Line 1	49.9	-30.3	AVG	AVG (0.10s)

End of Report

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