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EMC Test Report

Application for FCC Grant of Equipment Authorization
Canada Certification

FCC Part 15 Subpart C

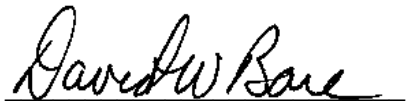
Model: ZFA-SK1

FCC ID:	2AT3BZFASK1
APPLICANT:	Zume, Inc. 250 Polaris Ave. Mountain View, CA 94043
TEST SITE(S):	National Technical Systems 41039 Boyce Road. Fremont, CA. 94538-2435
PROJECT NUMBER:	PR102060
REPORT DATE:	July 25, 2019
FINAL TEST DATES:	July 19 and 22, 2019
TOTAL NUMBER OF PAGES:	51

ACCREDITED
Testing Cert #0214.26

VALIDATING SIGNATORIES

PROGRAM MGR



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Chief Engineer

TECHNICAL REVIEWER:

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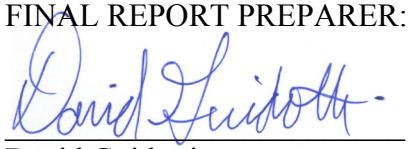
FINAL REPORT PREPARER:



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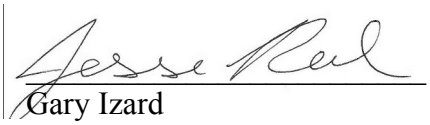

Gary Izard
Quality Assurance Representative

REVISION HISTORY

Rev#	Date	Comments	Modified By
-	July 25, 2019	First release	

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SCOPE

An electromagnetic emissions test has been performed on the Zume, Inc. model ZFA-SK1, 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 samples of Zume, Inc. model ZFA-SK1 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 Zume, Inc. model ZFA-SK1 and therefore apply only to the tested samples. The samples were selected and prepared by Daniel Paley of Zume, 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 GFSK modulation techniques	System must utilize a digital transmission technology	Complies
15.247 (a) (2)		6dB Bandwidth	0.727 MHz	>500kHz	Complies
15.247 (b) (3)		Output Power (multipoint systems)	0.0 dBm (0.001 Watts) EIRP = 0.0002 W Note 1	1Watt, EIRP limited to 4 Watts.	Complies
15.247(e)		Power Spectral Density	0 dBm / 3MHz	8dBm/3kHz	Complies
15.247(d) / 15.209		Radiated Spurious Emissions 30 MHz – 25 GHz	45.9 dBµV/m @ 7440.77 MHz (-8.1 dB)	Refer to the limits section (p20) for restricted bands, all others < -20dBc	Complies
15.247(d) / 15.209		Radiated Spurious Emissions 30 kHz – 30 MHz	No emissions observed above the noise floor	Refer to the limits section (p20) for restricted bands, all others < -20dBc	Complies
Note 1: EIRP calculated using antenna gains of -7.0 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	Integral antenna	Unique or integral antenna required	Complies
15.407 (b) (6)		AC Conducted Emissions	15.1 dBµV @ 2.953 MHz (-30.9 dB)	Refer to page 19	Complies
15.247 (i) 15.407 (f)		RF Exposure Requirements	Refer to SAR exclusion report	Refer to OET 65, FCC Part 1	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
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 Zume, Inc. model ZFA-SK1 is a sensor with a BLE Radio that is designed to send sensor data to mobile devices. 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 3.7 Volts supplied from a rechargeable battery.

The samples were received on July 19, 2019 and tested on July 19 and 22, 2019. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
Zume	ZFA-SK1	Sensor	0006	2AT3BZFASK1
Zume	ZFA-SK1	Sensor	0009	2AT3BZFASK1

ANTENNA SYSTEM

The antenna system consists of an integral MIFA.

ENCLOSURE

The EUT enclosure measures approximately 7 by 1.3 centimeters. It is primarily constructed of uncoated plastic.

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
Zume	XK 603529	3.7V Li-Battery	001	N/A
Sanyo	SCP-17ADT	AC Adapter	N/A	N/A

EUT INTERFACE PORTS

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

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
MicroUSB	AC Adapter	Multiwire	Shielded	2

EUT OPERATION

During testing, the EUT was set to transmit continuously at 0 dBm on selected channels using custom firmware.

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 6.2 of RSS-GEN, NTS has been recognized as an accredited test laboratory by the Commission and Innovation, Science and Economic Development Canada. A description of the facilities employed for testing is maintained by NTS.

Site	Company / Registration Numbers		Location
	FCC	Canada	
Chamber 7	US1031	2845B (Wireless test lab #US0027)	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.

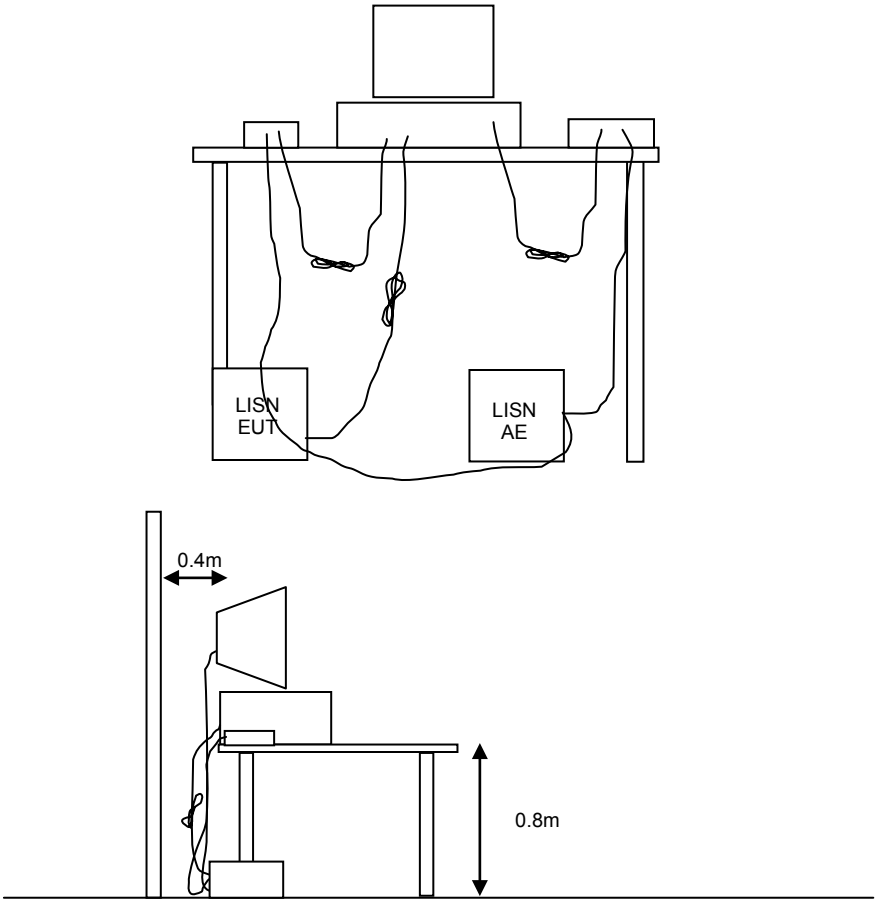


Figure 1 Typical Conducted Emissions Test Configuration

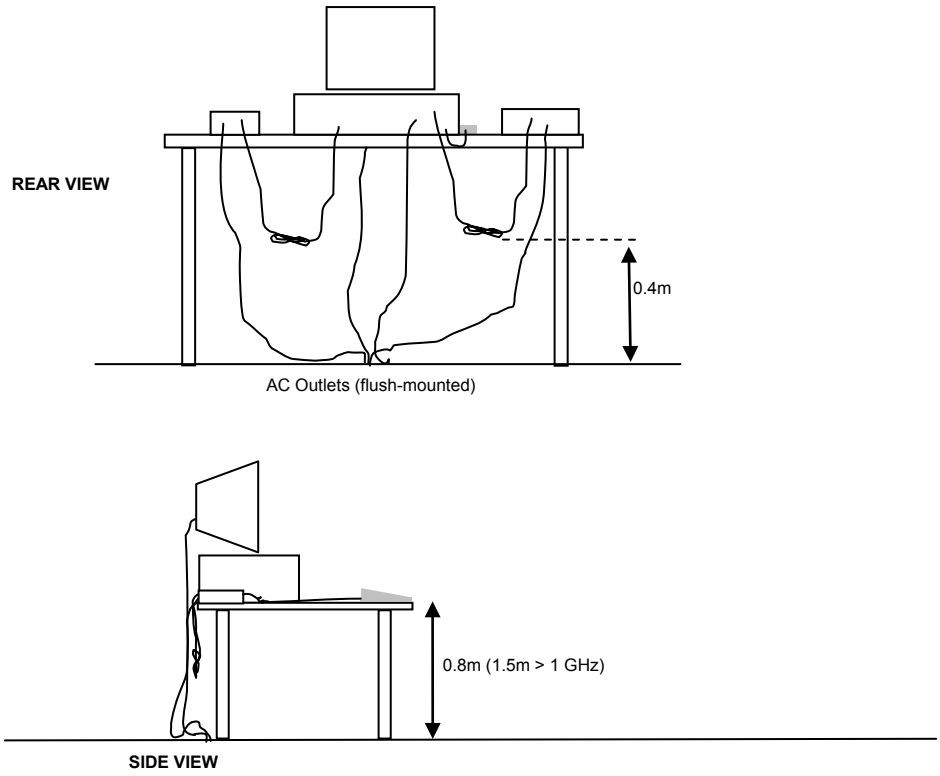
RADIATED EMISSIONS

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.

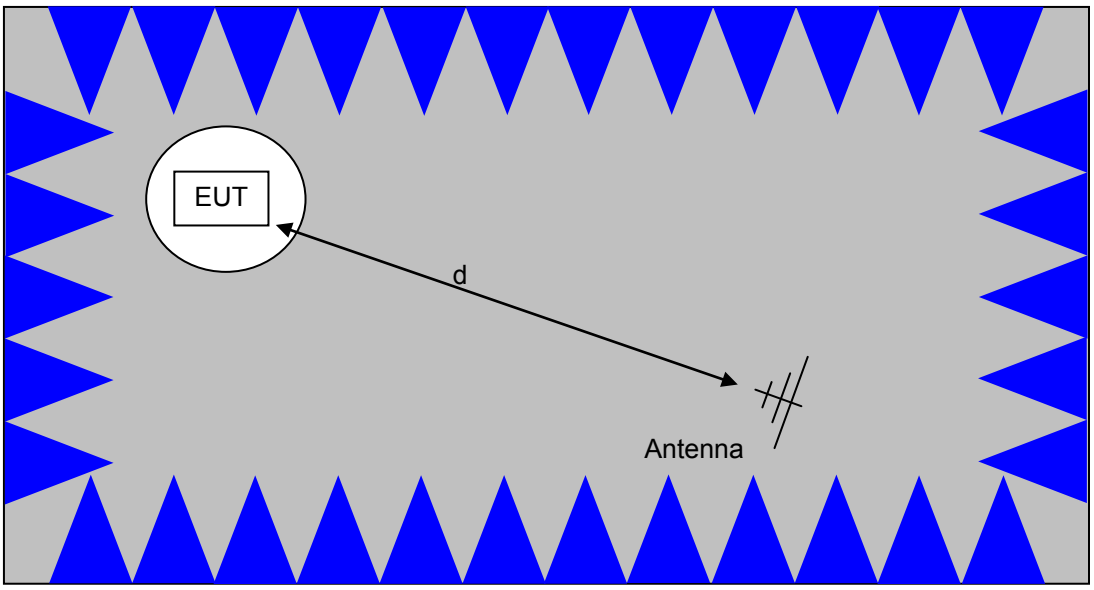
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

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.

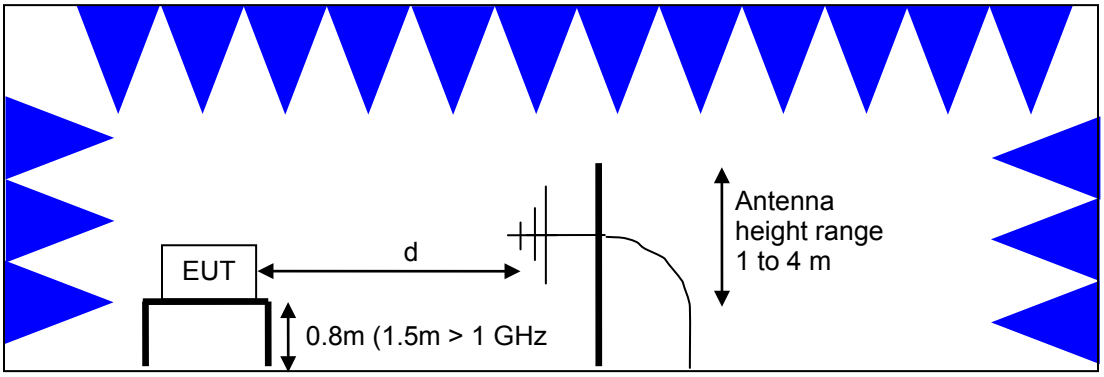


Typical Test Configuration for Radiated Field Strength Measurements



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.

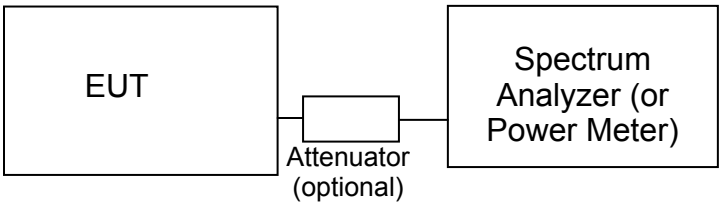
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



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
Conducted Emissions - AC Power Ports, 19-Jul-19					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
EMCO	LISN, 10 kHz-100 MHz	3825/2	1292	8/16/2018	8/16/2019
Rohde & Schwarz	Pulse Limiter	ESH3 Z2	1401	12/26/2018	12/26/2019
Rohde & Schwarz	EMI Test Receiver, 20 Hz-40 GHz	ESI 40	2493	3/15/2019	3/15/2020
Radiated Emissions, 1000 - 25000 MHz, 19-Jul-19					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
EMCO	Antenna, Horn, 1-18 GHz (SA40-Blu)	3115	1386	10/8/2018	10/8/2020
Hewlett Packard	Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz	8564E (84125C)	1393	12/8/2018	12/8/2019
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	1683	4/25/2019	4/25/2020
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	1780	7/18/2019	7/18/2020
Radiated Spurious Emission 18~26GHz, 22-Jul-19					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
HP / Miteq	SA40 B Head HF preAmplifier, 18-40 GHz (w/1393)	TTA1840-45-5P-HG-S	1620	1/9/2019	1/9/2020
A. H. Systems	Blue System Horn, 18-40GHz	SAS-574, p/n: 2581	2159	9/5/2017	8/8/2020
Radiated Emissions, 0.030 - 1,000 MHz, 22-Jul-19					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	2237	7/3/2018	7/3/2020
Com-Power	Preamplifier, 30-1000 MHz	PA-103	2465	5/2/2019	5/2/2020
Rohde & Schwarz	EMI Test Receiver, 20 Hz-40 GHz	ESI 40	2493	3/15/2019	3/15/2020
Rohde & Schwarz	Antenna (Loop)	HFH2-Z2	WC062 457	1/5/2018	1/5/2020

Appendix B Test Data

TL102060-RA Pages 26 – 50

Client:	Zume, Inc.	PR Number:	PR102060
Product	ZFK-SK1	T-Log Number:	TL102060-RA
System Configuration:		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Emissions Standard(s):	FCC §15.247	Class:	-
Immunity Standard(s):		Environment:	Radio

EMC Test Data

For The

Zume, Inc.

Product

ZFK-SK1

Date of Last Test: 7/23/2019

Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A

FCC §15.247 (DTS) Radiated Emissions, Power and Bandwidth

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: 25 °C
Rel. Humidity: 43 %

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

Run #	Mode	Channel	Power Setting		Test Performed	Limit	Result / Margin
1a		low	0		Restricted Band Edge (2390 MHz)	FCC Part 15.209 / 15.247(c)	34.8 dBµV/m @ 2357.3 MHz (-19.2 dB)
			0		Radiated Emissions, 30 MHz - 26 GHz	FCC Part 15.209 / 15.247(c)	43.7 dBµV/m @ 10819.2 MHz (-10.3 dB)
1b		center	0		Radiated Emissions, 30 MHz - 26 GHz	FCC Part 15.209 / 15.247(c)	44.9 dBµV/m @ 7319.44 MHz (-9.1 dB)
1c		high	0		Restricted Band Edge (2483.5 MHz)	FCC Part 15.209 / 15.247(c)	35.7 dBµV/m @ 2483.6 MHz (-18.3 dB)
			0		Radiated Emissions, 30 MHz - 26 GHz	FCC Part 15.209 / 15.247(c)	45.9 dBµV/m @ 7440.77 MHz (-8.1 dB)
2		Low, center, high	0		Output Power	15.247(b)	0.0 dBm
3					Minimum 6dB	15.247(a)	0.727 MHz
3					99% Bandwidth	-	1.08 MHz

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

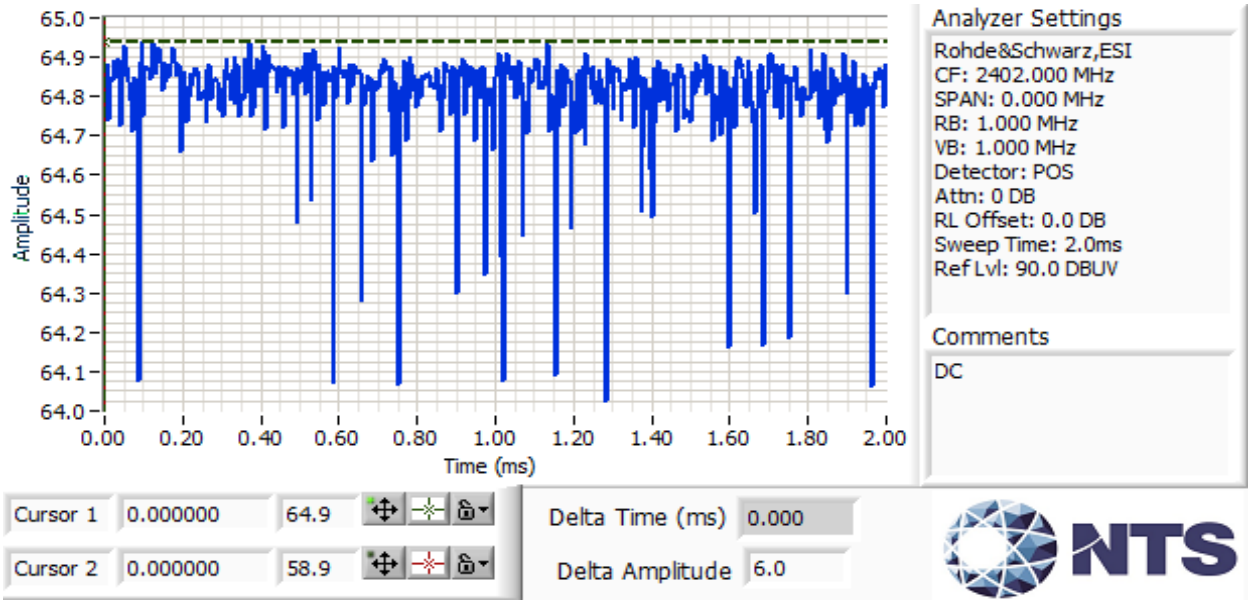
No deviations were made from the requirements of the standard.

Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A

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
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.

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
BLE	1 Mb/s	1.00	Yes	1.82	0.0	0.0	10



Sample Notes

Sample S/N: Rev B Board
Driver: Test Version 1.0

Client:	Zume, Inc.	PR Number:	PR102060
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		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	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 20dB 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

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Standard:	FCC §15.247	Class:	N/A

Fundamental 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	
Flat Orientation								
2401.470	86.4	H			PK	290	1.4	RB 3 MHz;VB 3 MHz;Peak
2401.750	72.9	V			PK	29	1.0	RB 3 MHz;VB 3 MHz;Peak
2440.370	73.5	V			PK	151	2.4	RB 3 MHz;VB 3 MHz;Peak
2440.270	86.1	H			PK	105	1.0	RB 3 MHz;VB 3 MHz;Peak
2479.750	72.3	V			PK	360	1.1	RB 3 MHz;VB 3 MHz;Peak
2480.020	84.8	H			PK	289	1.3	RB 3 MHz;VB 3 MHz;Peak
Side Orientation								
2401.350	80.2	V			PK	272	1.6	RB 3 MHz;VB 3 MHz;Peak
2401.500	88.3	H			PK	208	1.0	RB 3 MHz;VB 3 MHz;Peak
2439.800	80.1	V			PK	266	2.2	RB 3 MHz;VB 3 MHz;Peak
2439.900	87.7	H			PK	203	1.3	RB 3 MHz;VB 3 MHz;Peak
2480.320	78.9	V			PK	282	1.6	RB 3 MHz;VB 3 MHz;Peak
2479.800	85.5	H			PK	208	1.3	RB 3 MHz;VB 3 MHz;Peak
Upright Orientation								
2401.610	86.3	V			PK	183	1.7	RB 3 MHz;VB 3 MHz;Peak
2401.440	80.1	H			PK	178	2.2	RB 3 MHz;VB 3 MHz;Peak
2439.870	83.9	V			PK	205	1.5	RB 3 MHz;VB 3 MHz;Peak
2439.830	75.4	H			PK	336	2.1	RB 3 MHz;VB 3 MHz;Peak
2480.280	81.0	H			PK	178	2.1	RB 3 MHz;VB 3 MHz;Peak
2480.250	81.8	V			PK	334	1.2	RB 3 MHz;VB 3 MHz;Peak

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Standard:	FCC §15.247	Class:	N/A

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

Date of Test: 7/19/2019 0:00 Config. Used: 1

Test Engineer: Roy Zheng Config Change: -

Test Location: Fremont Chamber #7 EUT Voltage: Battery

Run #1a: Low Channel @ 2402 MHz

Fundamental Signal Field Strength: Peak value measured in 100kHz

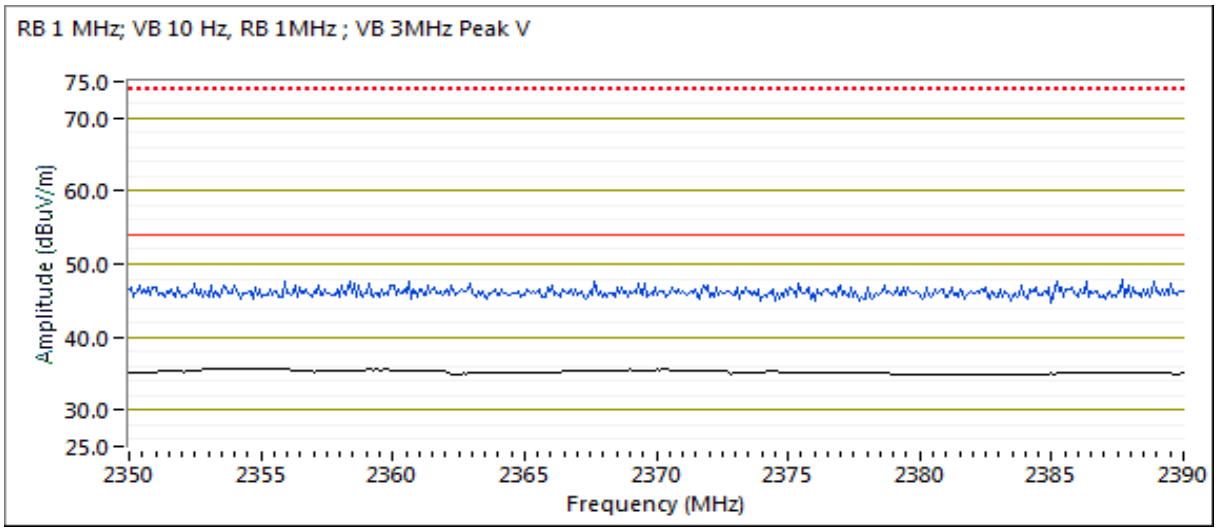
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2401.770	74.9	V			PK	271	1.6	RB 100 kHz;VB 300 kHz;Peak
2402.020	83.4	H			PK	184	1.8	RB 100 kHz;VB 300 kHz;Peak

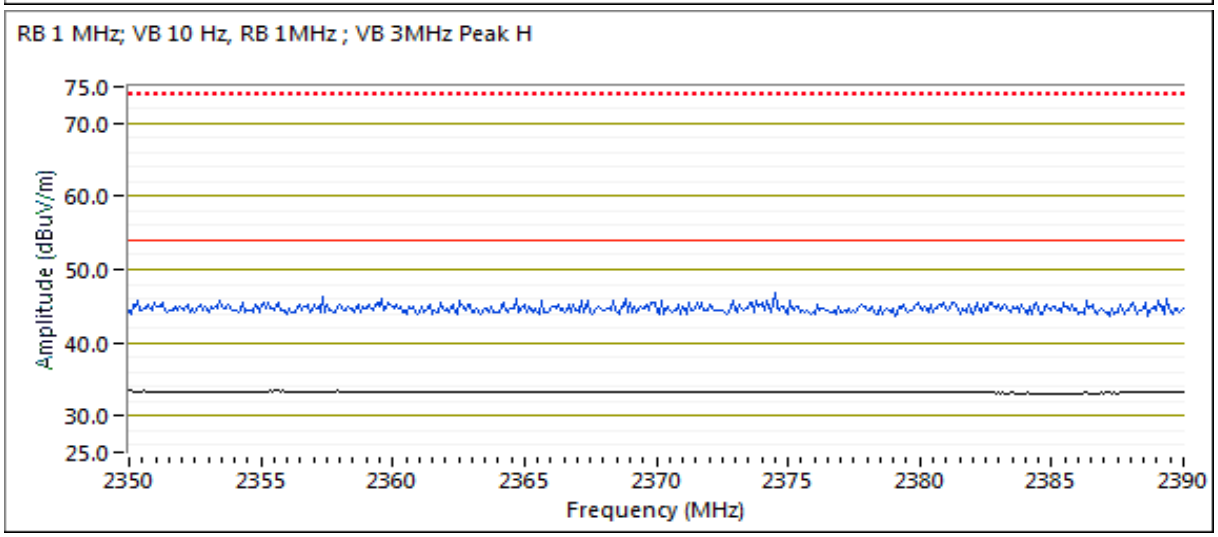
Fundamental emission level @ 3m in 100kHz RBW:	83.4	dBµV/m	
Limit for emissions outside of restricted bands:	63.4	dBµV/m	Limit is -20dBc (Peak power measurement)

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	
2357.290	34.8	V	54.0	-19.2	AVG	145	2.0	POS; RB 1 MHz; VB: 10 Hz
2357.370	33.4	H	54.0	-20.6	AVG	29	1.2	POS; RB 1 MHz; VB: 10 Hz
2387.350	52.0	V	74.0	-22.0	PK	145	2.0	POS; RB 1 MHz; VB: 3 MHz
2350.400	46.8	H	74.0	-27.2	PK	29	1.2	POS; RB 1 MHz; VB: 3 MHz

Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A

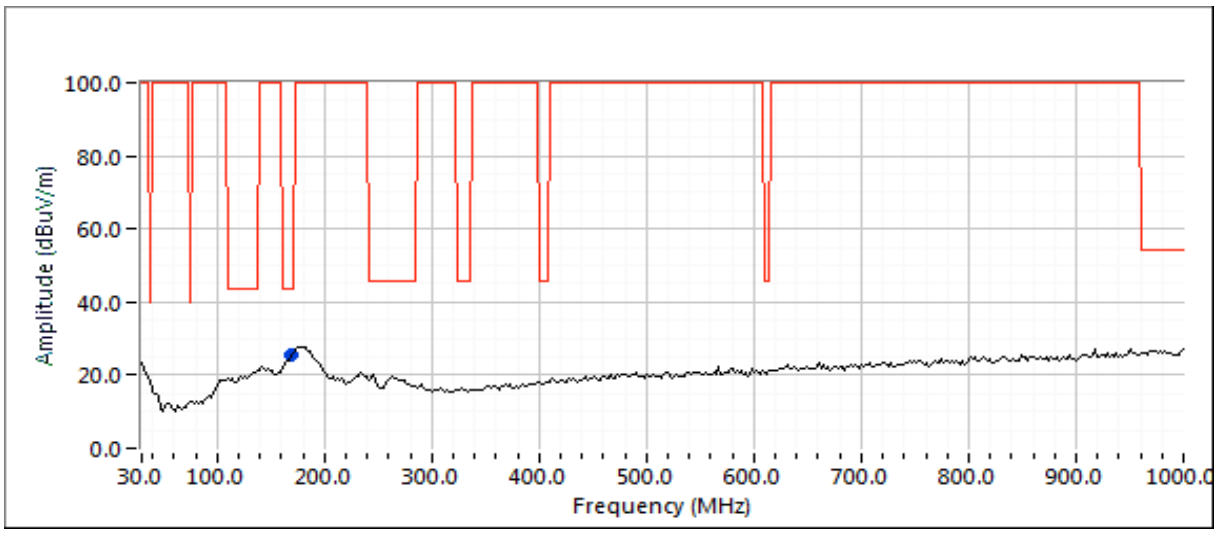




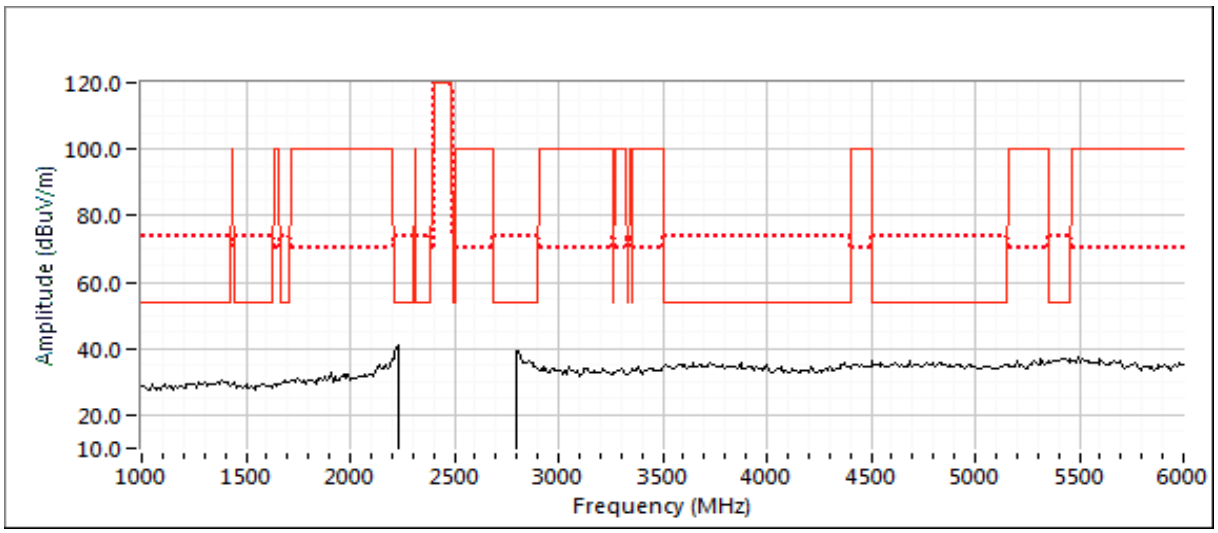
Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A

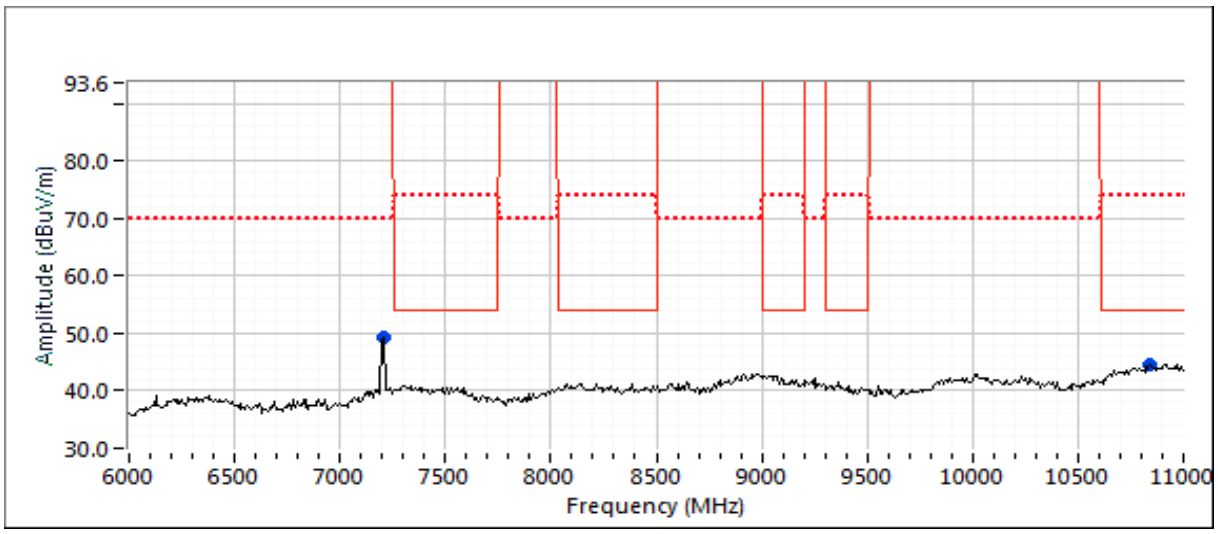
Other Spurious Emissions (upright)

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
169.960	23.0	H	43.5	-20.5	QP	228	3.5	QP (1.00s)
7206.620	39.3	H	63.4	-24.1	PK	49	1.6	RB 100 kHz;VB 300 kHz;Peak
10819.230	43.7	V	54.0	-10.3	AVG	238	1.0	RB 1 MHz;VB 10 Hz;Peak
10822.200	54.0	V	74.0	-20.0	PK	238	1.0	RB 1 MHz;VB 3 MHz;Peak
14340.340	49.7	V	63.4	-13.7	PK	117	1.9	RB 100 kHz;VB 300 kHz;Peak

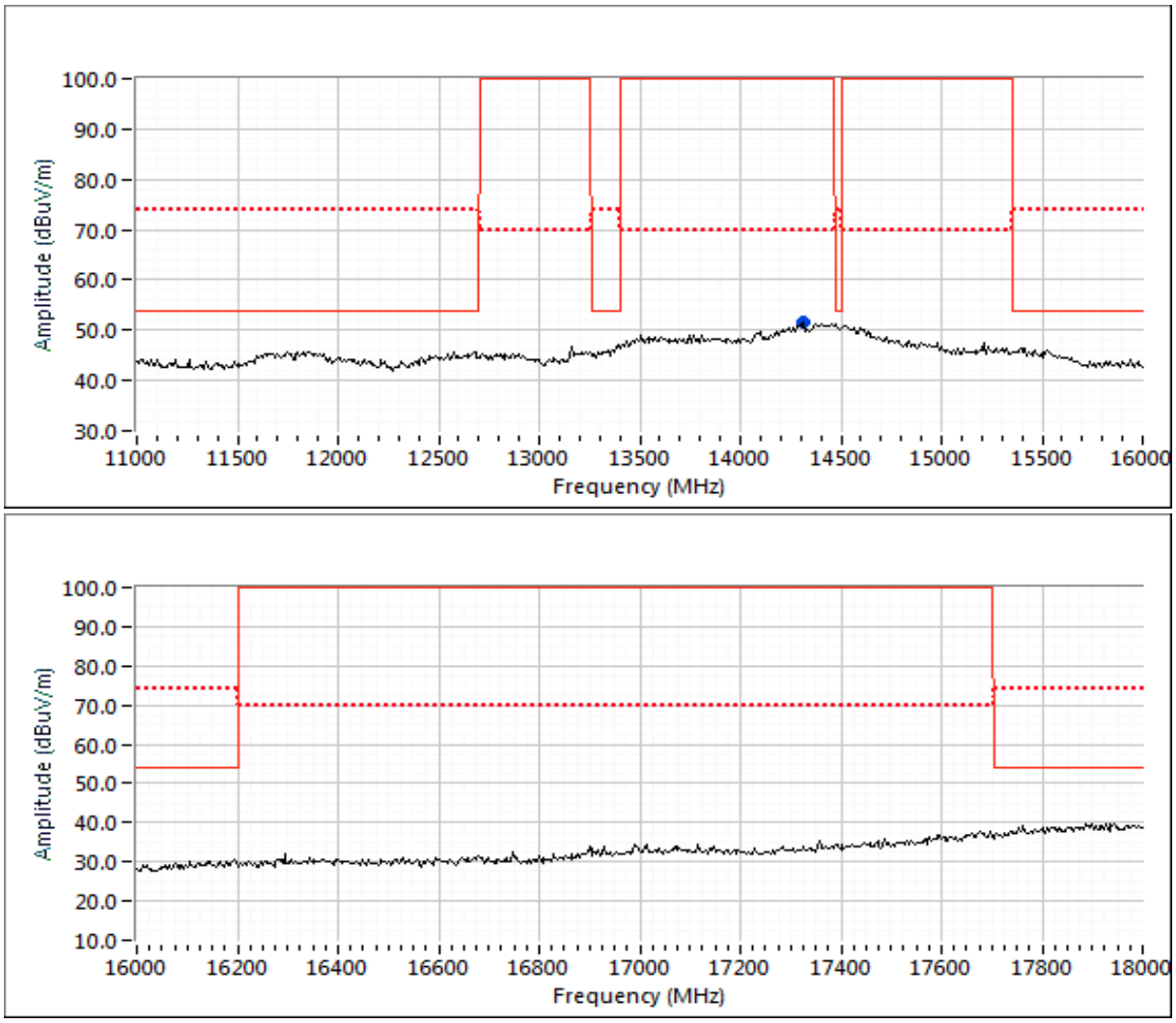


Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A

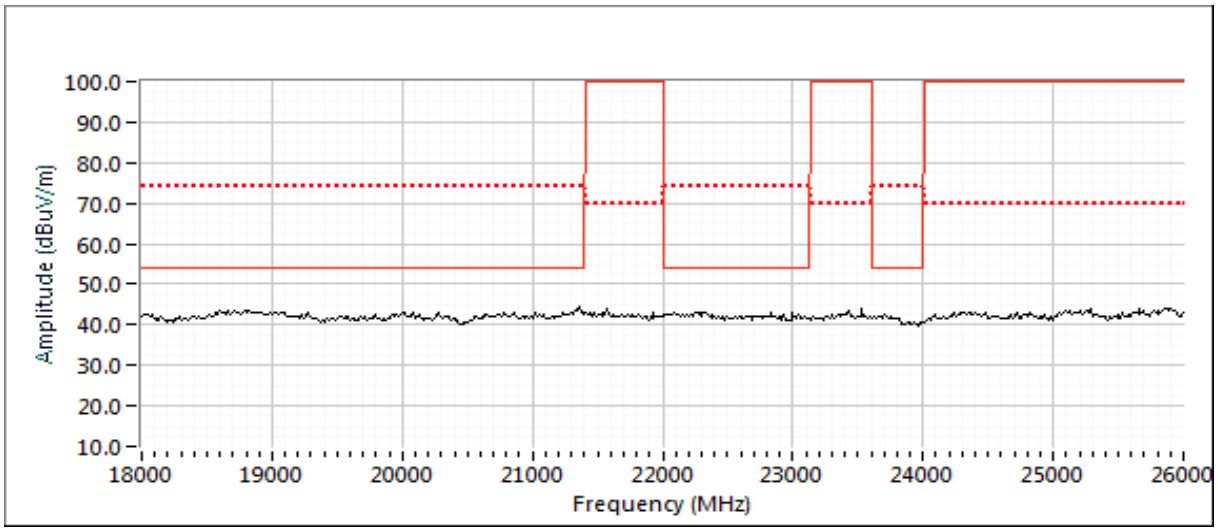




Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A



Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A



Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A

Run #1b: Center Channel @ 2440 MHz

Fundamental Signal Field Strength: Peak value measured in 100kHz

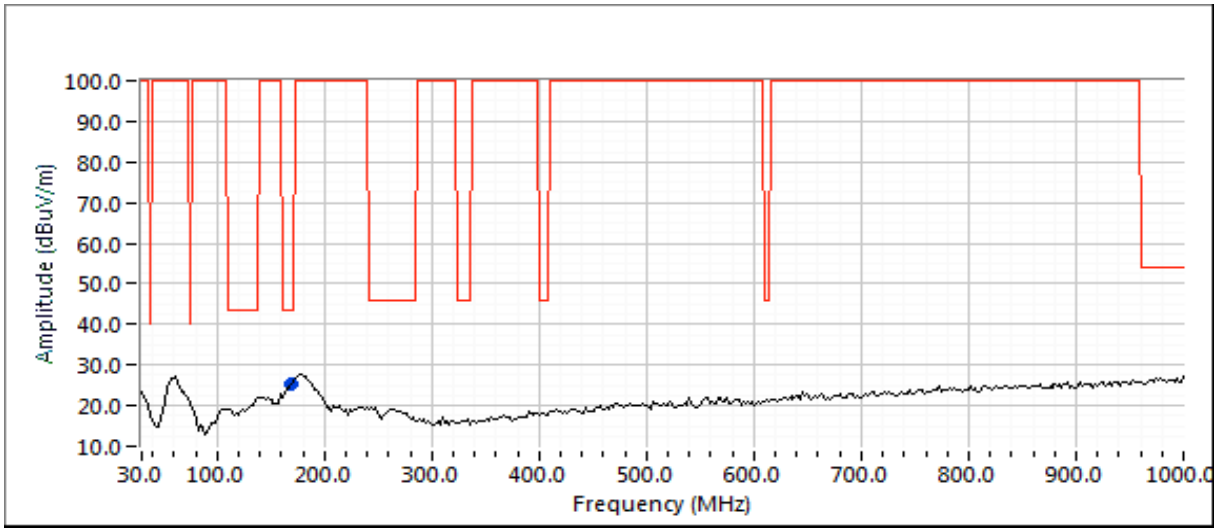
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2440.120	79.3	V			PK	90	1.8	RB 100 kHz;VB 300 kHz;Peak
2440.060	84.7	H			PK	24	1.3	RB 100 kHz;VB 300 kHz;Peak

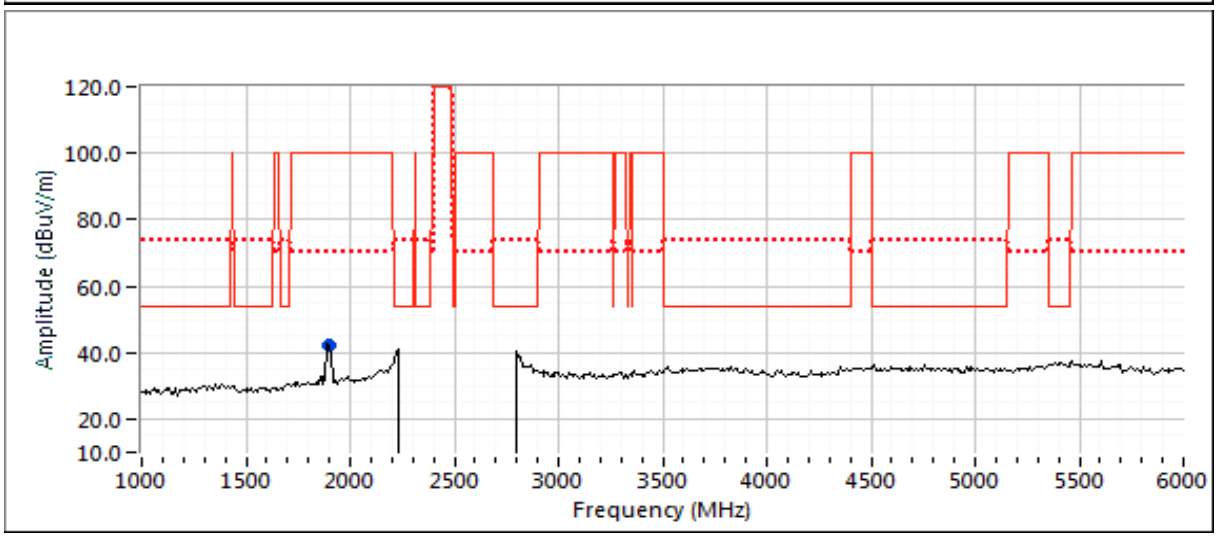
Fundamental emission level @ 3m in 100kHz RBW:	84.7	dBµV/m	
Limit for emissions outside of restricted bands:	64.7	dBµV/m	Limit is -20dBc (Peak power measurement)

Spurious Emissions

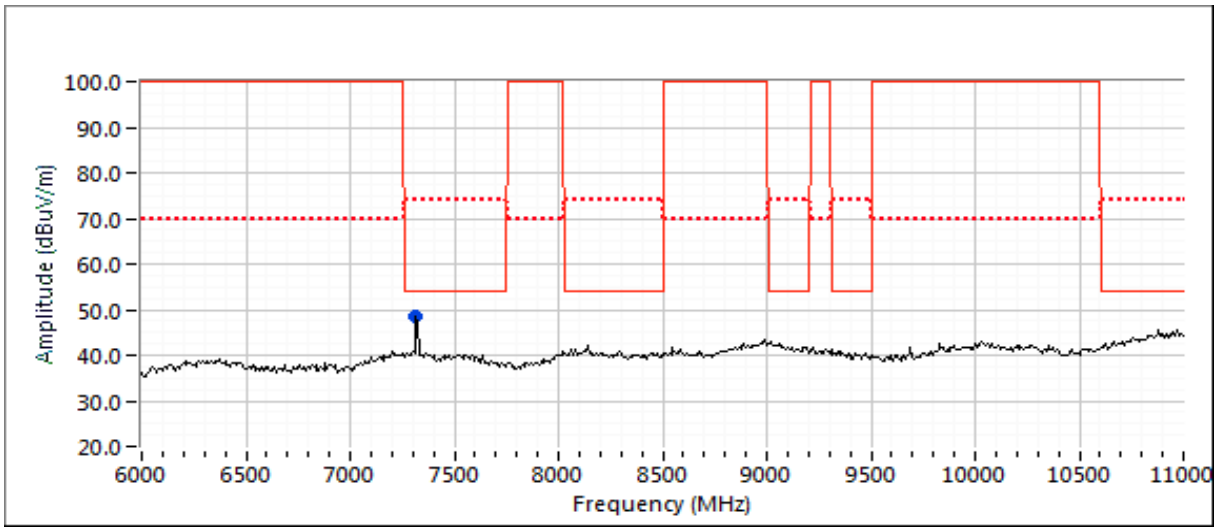
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
169.960	20.0	H	43.5	-23.5	QP	360	1.0	QP (1.00s)
1894.620	38.0	V	64.7	-26.7	PK	21	1.6	RB 1 MHz;VB 3 MHz;Peak
14459.390	52.4	H	64.7	-12.3	PK	39	1.6	RB 1 MHz;VB 3 MHz;Peak
Side								
7319.440	44.9	H	54.0	-9.1	AVG	32	1.0	RB 1 MHz;VB 10 Hz;Peak
7320.850	54.2	H	74.0	-19.8	PK	32	1.0	RB 1 MHz;VB 3 MHz;Peak
Upright								
7319.460	41.0	H	54.0	-13.0	AVG	66	1.2	RB 1 MHz;VB 10 Hz;Peak
7320.250	52.5	H	74.0	-21.5	PK	66	1.2	RB 1 MHz;VB 3 MHz;Peak
Flat								
7319.410	42.7	H	54.0	-11.3	AVG	336	1.0	RB 1 MHz;VB 10 Hz;Peak
7320.750	53.4	H	74.0	-20.6	PK	336	1.0	RB 1 MHz;VB 3 MHz;Peak

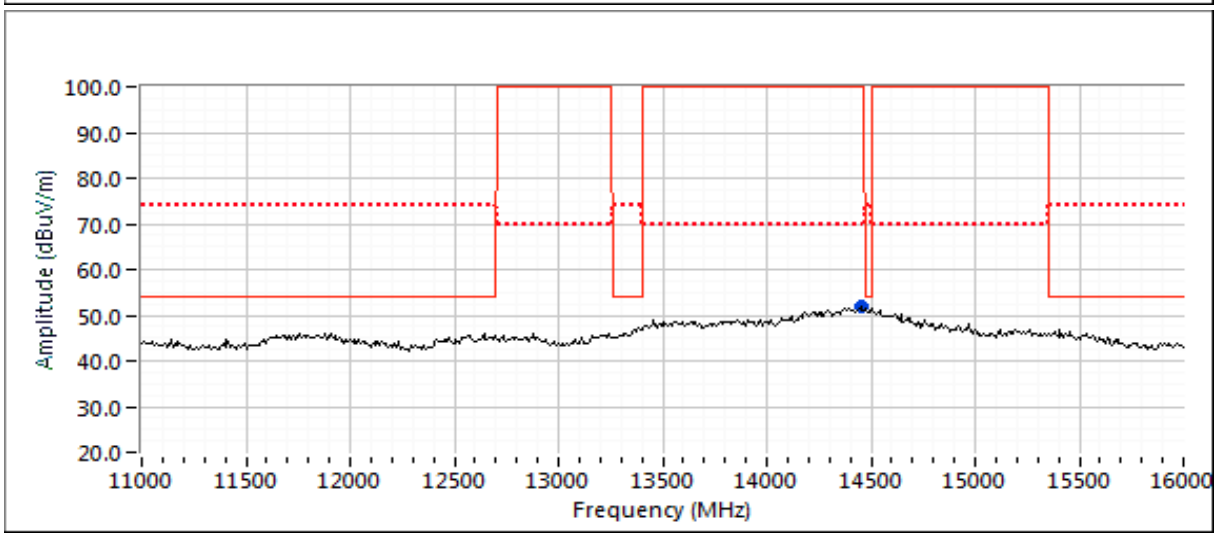
Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A





Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A





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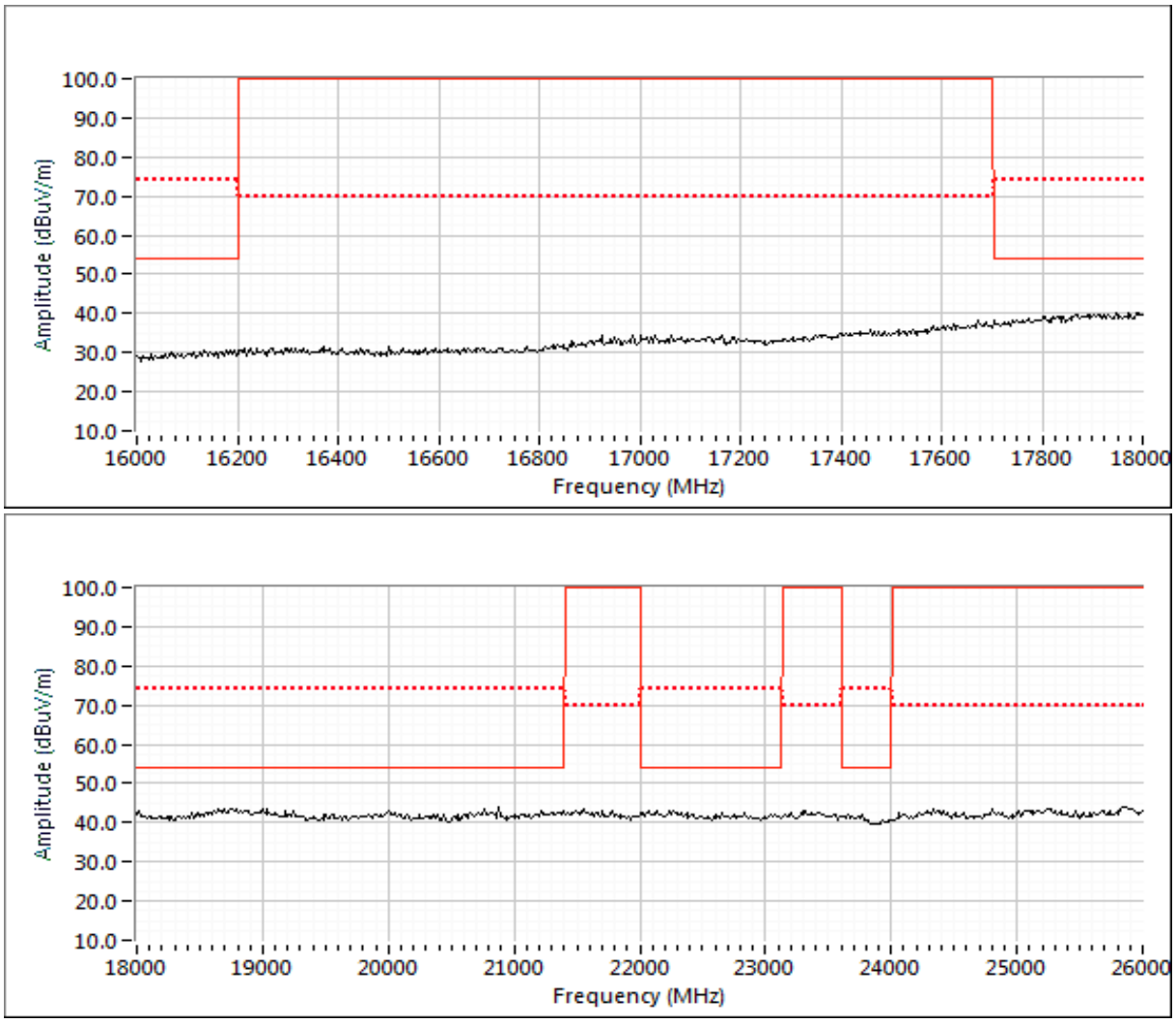
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A



Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A

Run #1c: High Channel @ 2480 MHz

Fundamental Signal Field Strength: Peak value measured in 100kHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2479.780	78.6	V			PK	140	2.0	RB 100 kHz;VB 300 kHz;Peak
2479.830	82.0	H			PK	166	1.8	RB 100 kHz;VB 300 kHz;Peak

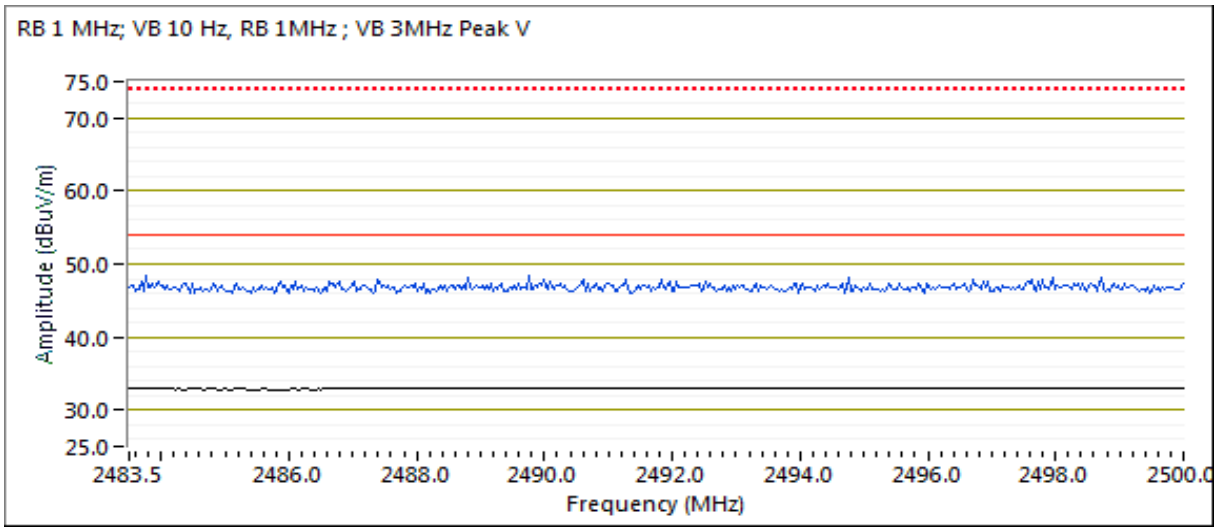
Fundamental emission level @ 3m in 100kHz RBW:	82.0	dBµV/m
Limit for emissions outside of restricted bands:	62	dBµV/m

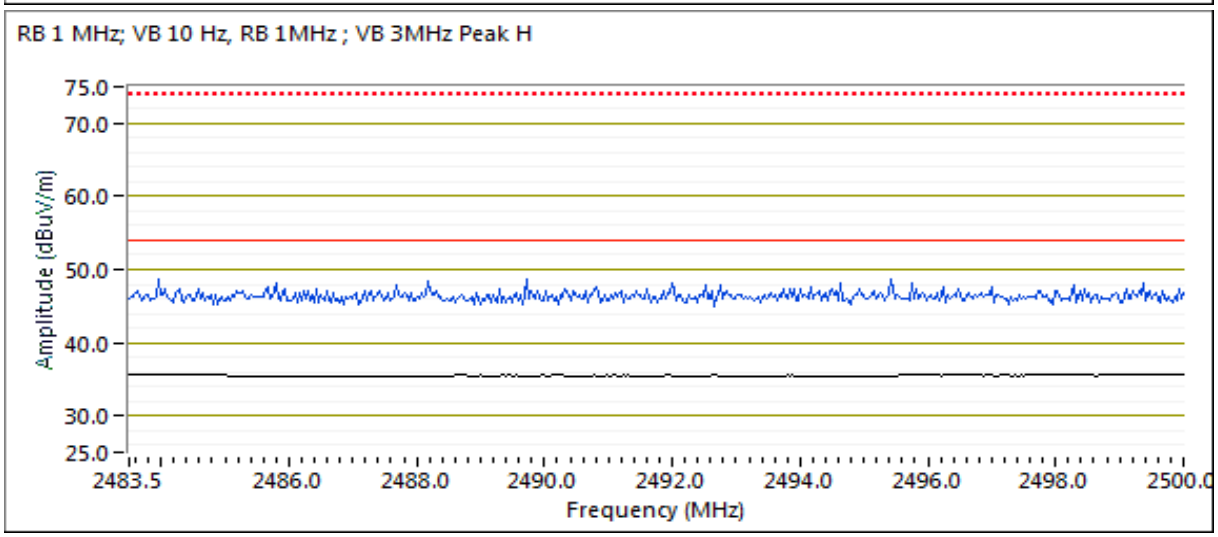
Limit is -20dBc (Peak power measurement)

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	
2483.630	35.7	H	54.0	-18.3	AVG	164	1.4	POS; RB 1 MHz; VB: 10 Hz
2483.500	35.1	V	54.0	-18.9	AVG	166	2.0	POS; RB 1 MHz; VB: 10 Hz
2491.670	48.8	H	74.0	-25.2	PK	164	1.4	POS; RB 1 MHz; VB: 3 MHz
2497.650	48.2	V	74.0	-25.8	PK	166	2.0	POS; RB 1 MHz; VB: 3 MHz

Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A





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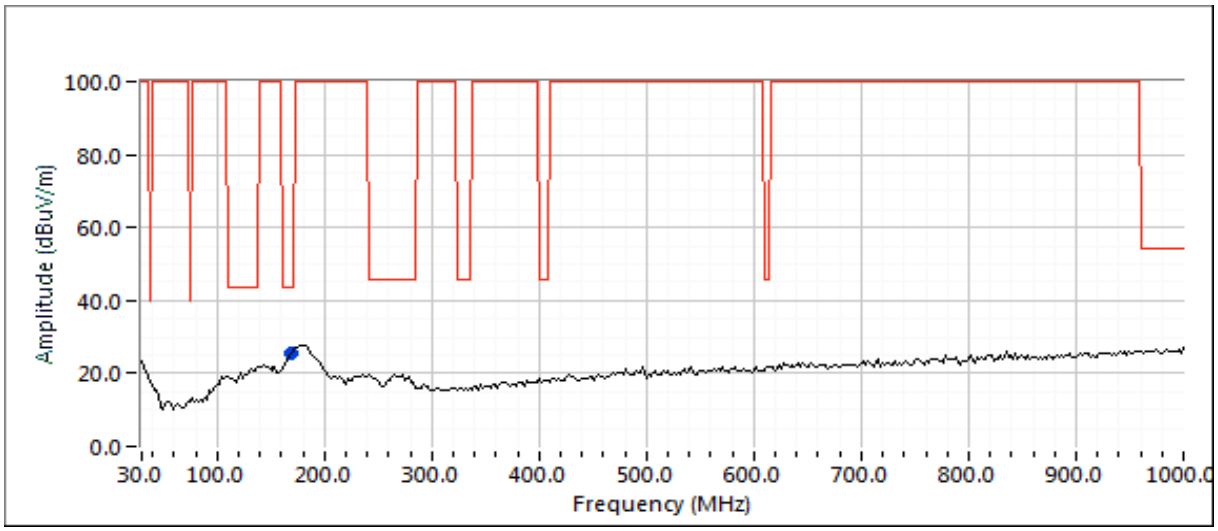
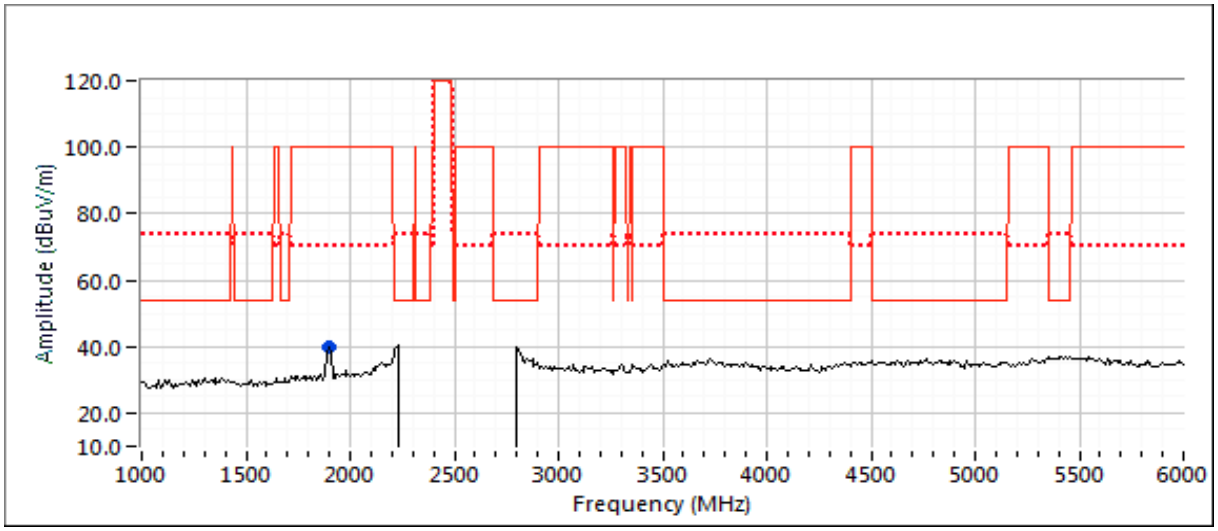
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A

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	
169.960	22.9	H	43.5	-20.6	QP	132	3.5	QP (1.00s)
1886.360	39.0	V	62.0	-23.0	PK	332	1.6	RB 100 kHz;VB 300 kHz;Peak
14465.320	51.9	H	62.0	-10.1	PK	292	2.2	RB 1 MHz;VB 3 MHz;Peak
side								
7440.770	45.9	H	54.0	-8.1	AVG	234	1.3	RB 1 MHz;VB 10 Hz;Peak
7439.370	55.3	H	74.0	-18.7	PK	234	1.3	RB 1 MHz;VB 3 MHz;Peak
upright								
7440.740	40.4	H	54.0	-13.6	AVG	67	1.0	RB 1 MHz;VB 10 Hz;Peak
7439.150	52.3	H	74.0	-21.7	PK	67	1.0	RB 1 MHz;VB 3 MHz;Peak
Flat								
7440.710	42.1	H	54.0	-11.9	AVG	333	1.2	RB 1 MHz;VB 10 Hz;Peak
7441.000	52.8	H	74.0	-21.2	PK	333	1.2	RB 1 MHz;VB 3 MHz;Peak

Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A





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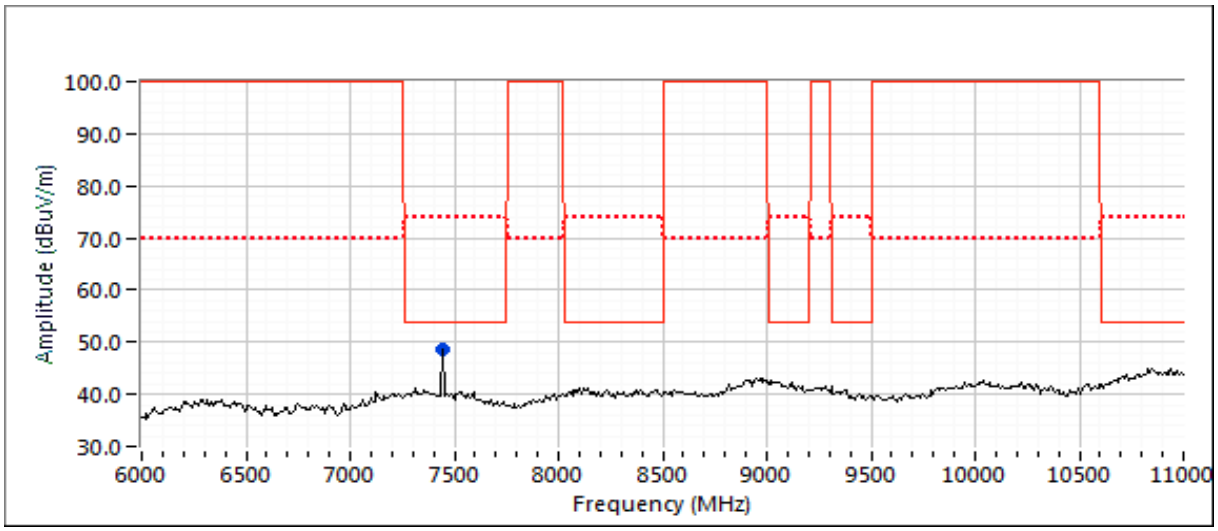
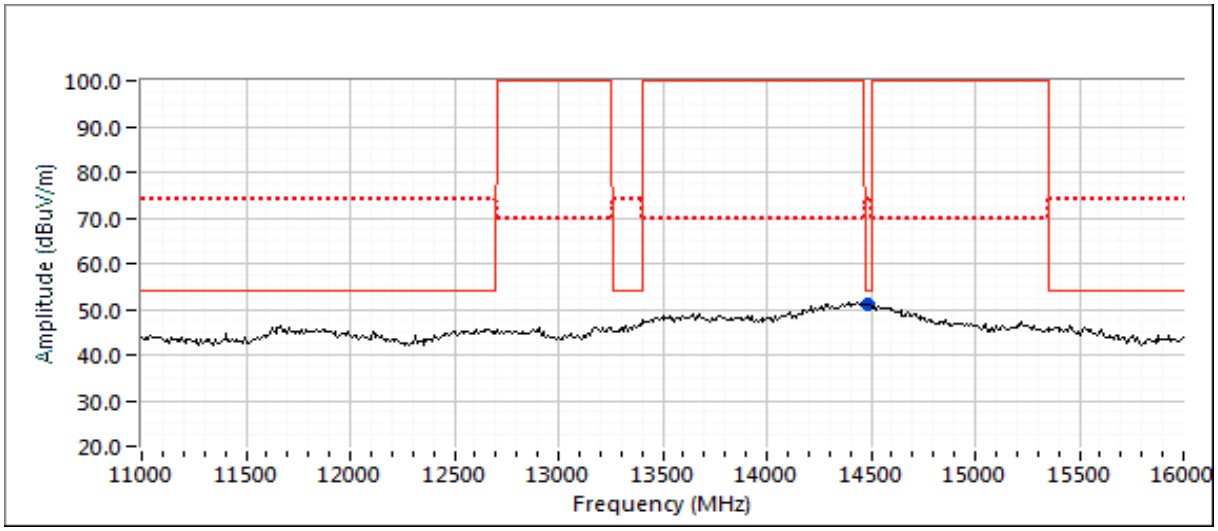
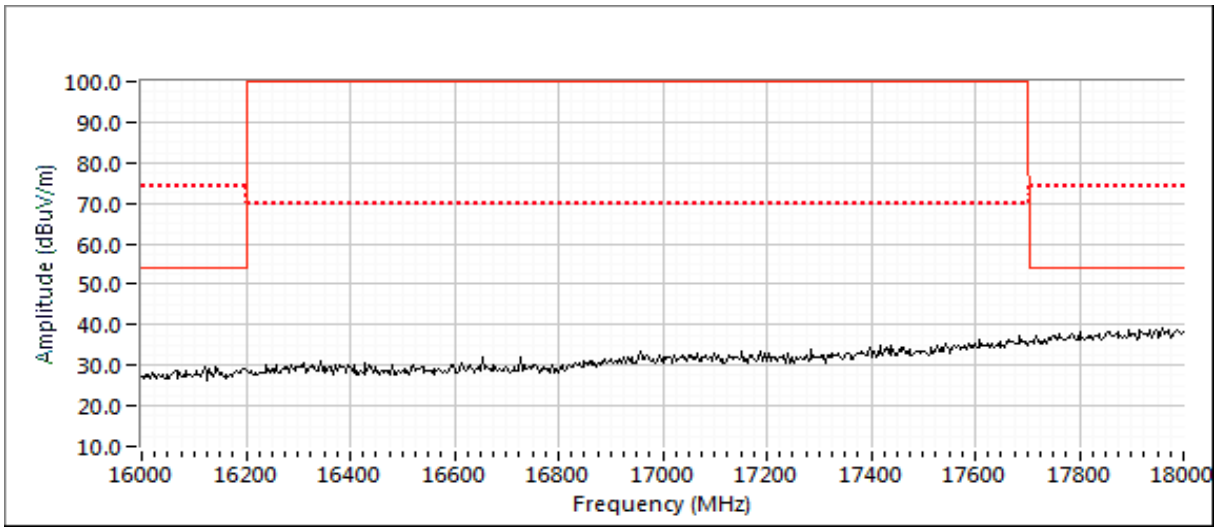
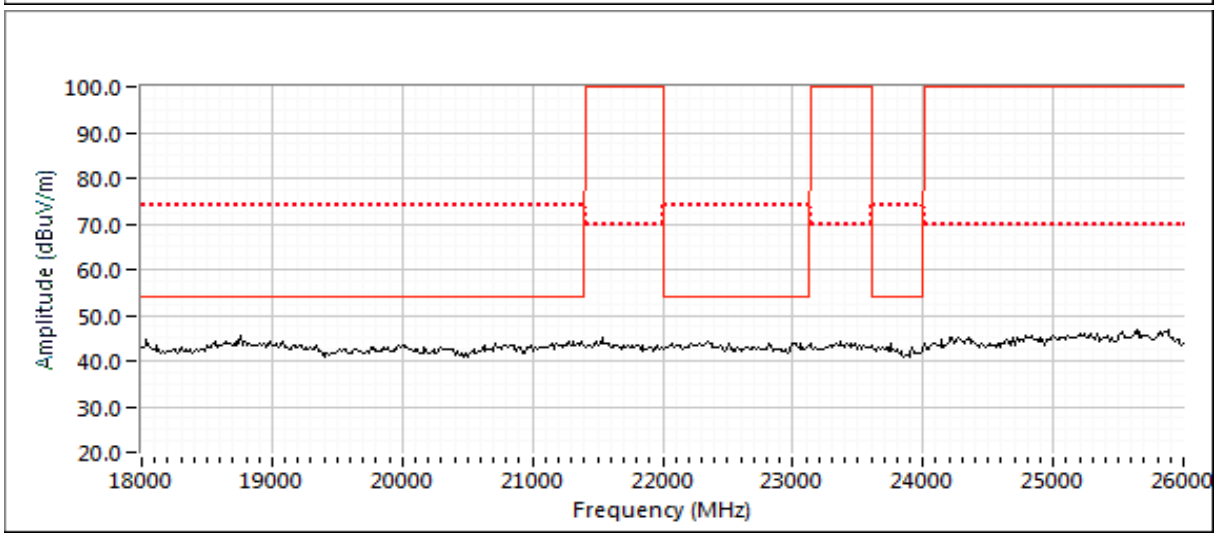




Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A





Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A

Run #2: Power and PSD

Calculated EIRP and output power from peak fundamental field strengths

Frequency (MHz)	Output Power		Limit	Antenna	Result	calculated EIRP	
	(dBm)	mW	dBm	Gain (dBi)		dBm	W
2402	0.0	1.0	30.0	-7.0	Pass	-7.0	0.0002
2440	-0.6	0.9	30.0	-7.0	Pass	-7.6	0.000
2480	-2.8	0.5	30.0	-7.0	Pass	-9.8	0.000

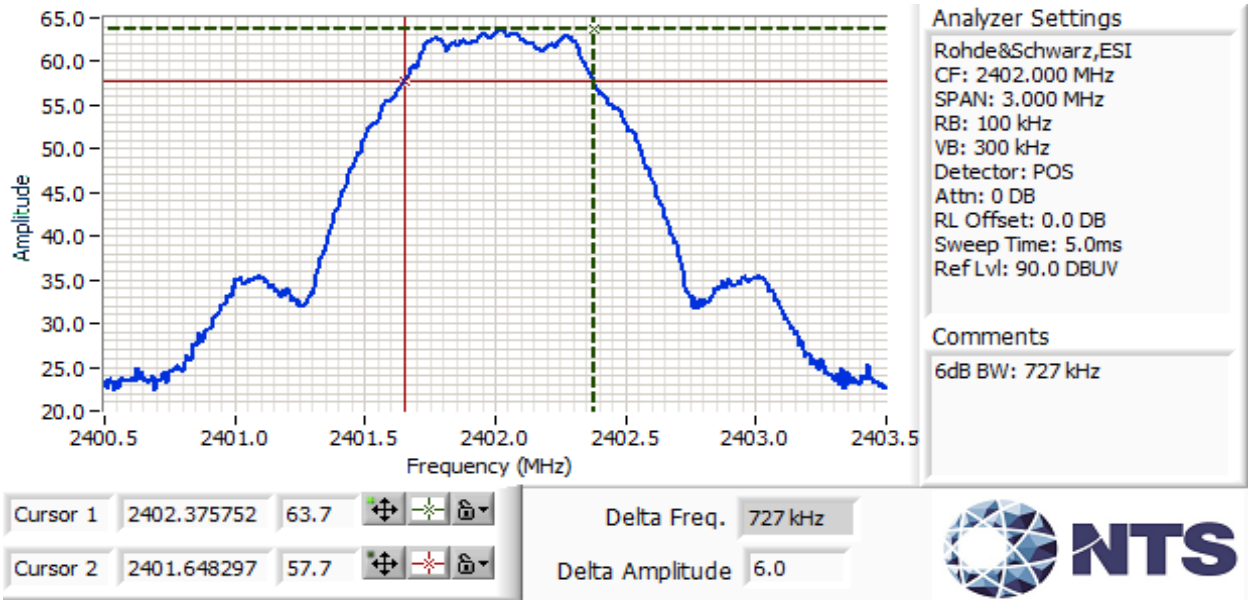
Run #3: Signal Bandwidth

Date of Test: 7/22/2019 16:00
Test Engineer: Roy Zheng
Test Location: Fremont Chamber #7

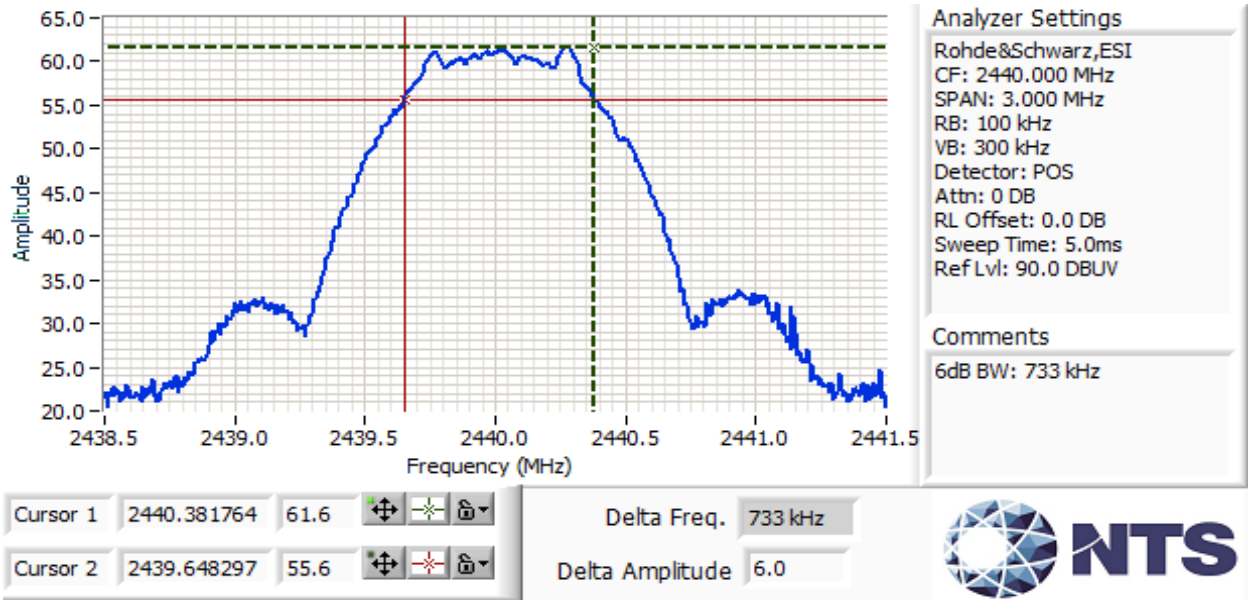
Config. Used: 1
Config Change: -
EUT Voltage: Battery

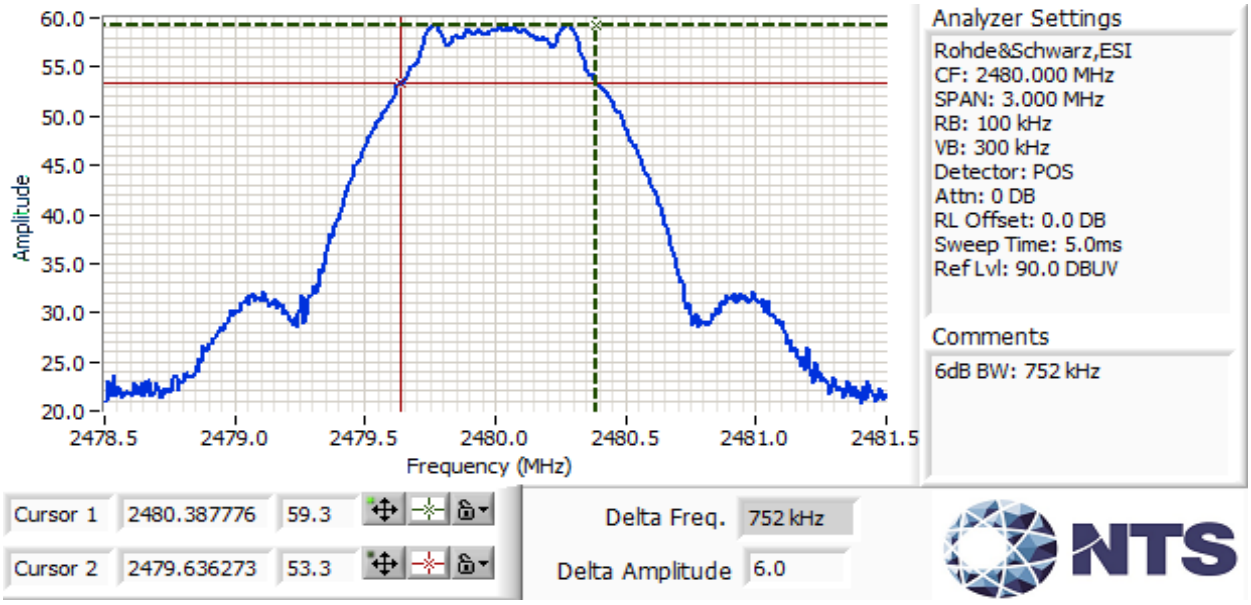
Note: VBW is set to >= 3 times the RBW

Frequency (MHz)	Bandwidth (MHz)		RBW Setting (MHz)	
	6dB	99%	6dB	99%
2402	0.727	1.068	0.1	0.03
2440	0.733	1.062	0.1	0.03
2480	0.752	1.08	0.1	0.03

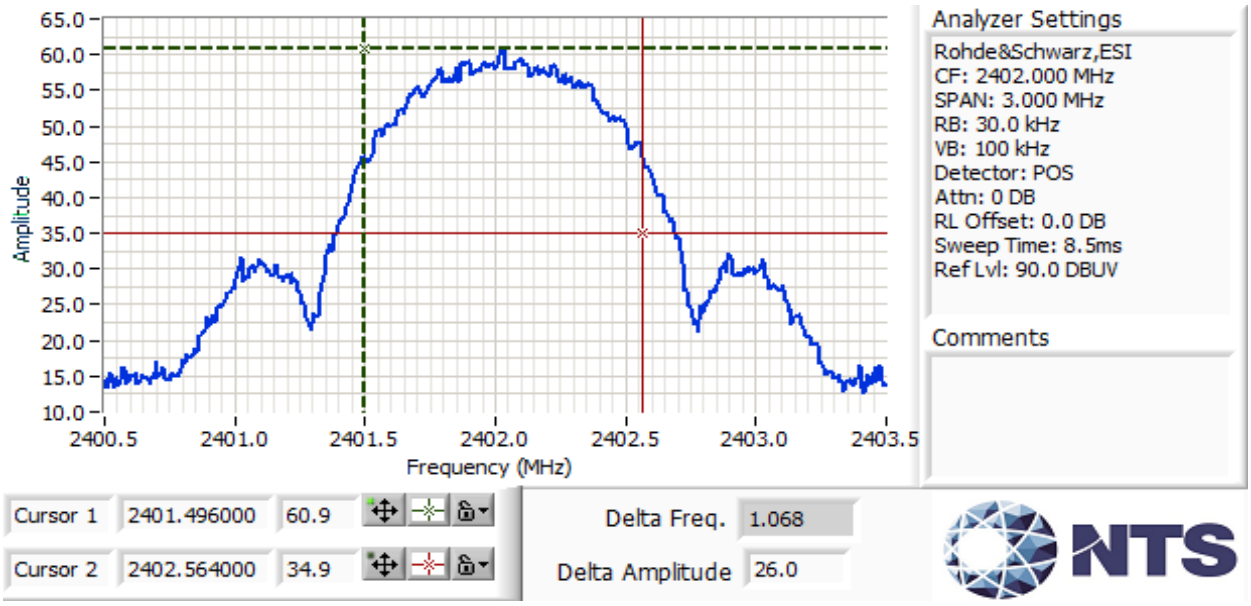


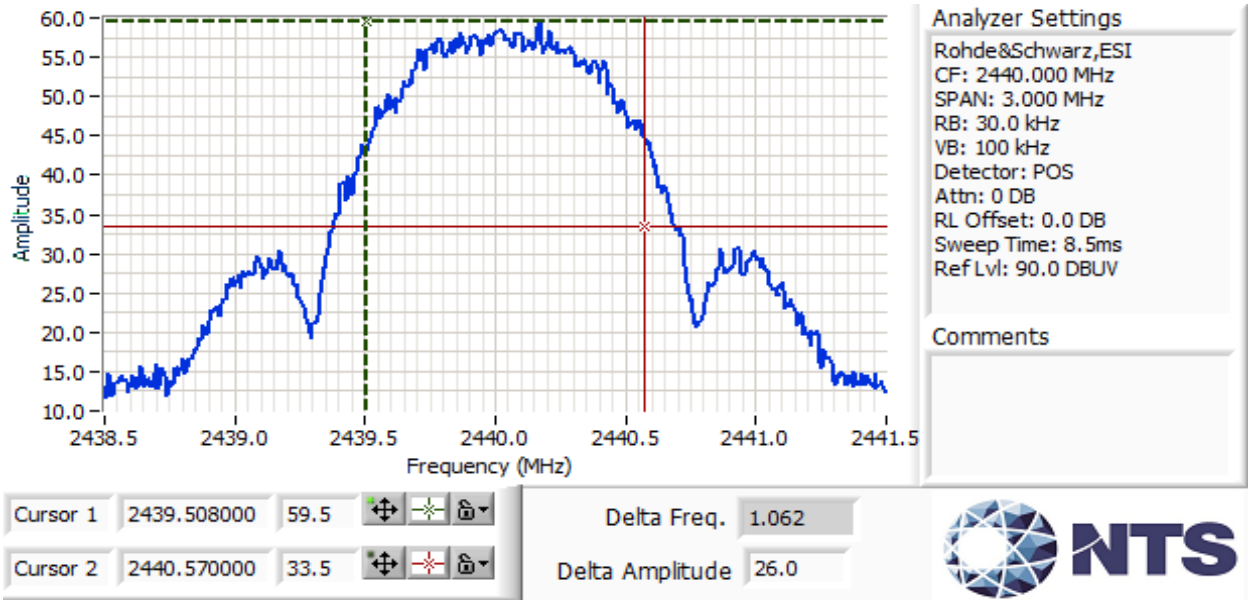
Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A



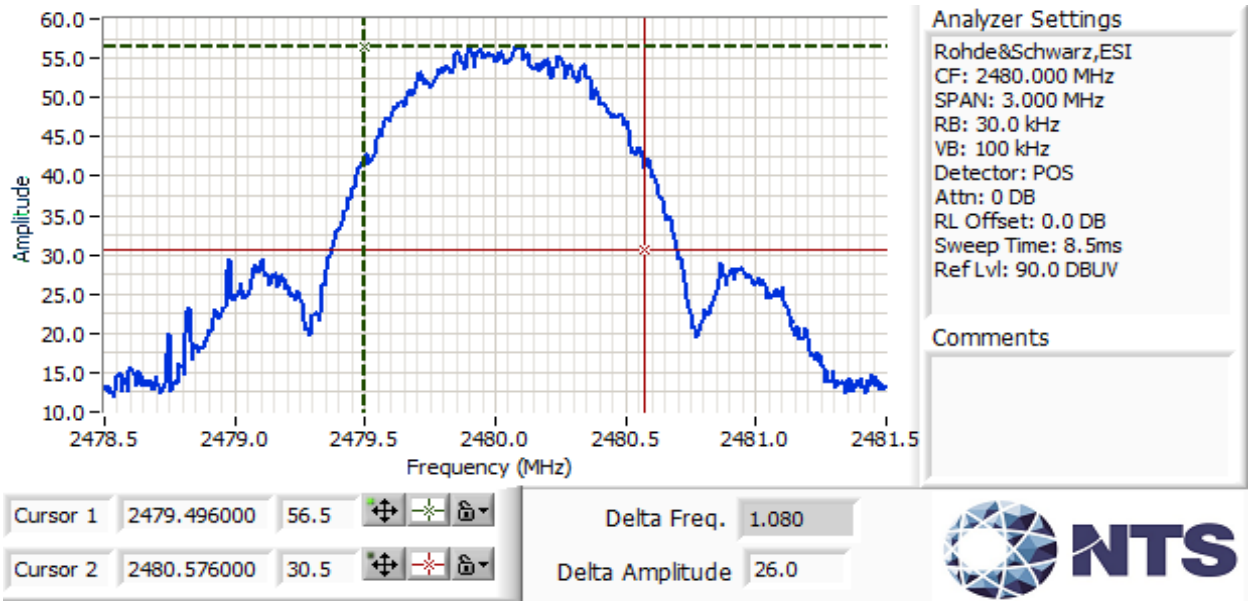


Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A





Client:	Zume, Inc.	PR Number:	PR102060
Model:	ZFK-SK1	T-Log Number:	TL102060-RA
		Project Manager:	Christine Krebill
Contact:	Daniel Paley / Josh Goldberg	Project Engineer:	David Bare
Standard:	FCC §15.247	Class:	N/A



End of Report

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