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EMC Test Report

Application for Grant of Equipment Authorization

FCC Part 15 Subpart C

Model: Reduced Sensor 1A

FCC ID:	2AFKHTTRACKS1
APPLICANT:	Lab Sensor Solutions 831 Jefferson Blvd Redwood City, CA 94063
TEST SITE(S):	National Technical Systems - Silicon Valley 41039 Boyce Road. Fremont, CA. 94538-2435
IC SITE REGISTRATION #:	2845B-7
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Testing Cert #0214.26

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REVISION HISTORY

Rev#	Date	Comments	Modified By
-	August 20, 2015	First release	
1	September 10, 2015	Updated the procedure used for power measurement	David Guidotti

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SCOPE

An electromagnetic emissions test has been performed on the Lab Sensor Solutions model Reduced Sensor 1A, 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 - Silicon Valley 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.

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.).

STATEMENT OF COMPLIANCE

The tested sample of Lab Sensor Solutions model Reduced Sensor 1A 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 Lab Sensor Solutions model Reduced Sensor 1A and therefore apply only to the tested sample. The sample was selected and prepared by Daniel Paley of Lab Sensor Solutions.

DEVIATIONS FROM THE STANDARDS

The following deviation was made from the published requirements listed in the scope of this report.

1. Power measurements were performed using RBW=1MHz instead of 1-5% of the OBW.

TEST RESULTS SUMMARY

DIGITAL TRANSMISSION SYSTEMS (2400 – 2483.5MHz)

FCC Rule Part	RSS Rule Part	Description	Measured Value / Comments	Limit / Requirement	Result
15.247(a)	-	Digital Modulation	Systems uses DSSS techniques	System must utilize a digital transmission technology	Complies
15.247 (a) (2)	-	6dB Bandwidth	665 kHz	>500kHz	Complies
15.247 (b) (3)	-	Output Power (multipoint systems)	-2.4 dBm (0.6mWatts) EIRP = 0.74mW Note 1	1Watt, EIRP limited to 4 Watts.	Complies
15.247(e)	-	Power Spectral Density	-16.9 dBm/3kHz	8dBm/3kHz	Complies
15.247(d)	-	Antenna Port Spurious Emissions 30MHz – 25 GHz	> 30dBc below limit	< -30dBc Note 2	Complies
15.247(d) / 15.209	-	Radiated Spurious Emissions 30MHz – 25 GHz	20.7dBµV/m @ 182.53MHz (-9.3 dB)	15.207 in restricted bands, all others <-30dBc Note 2	Complies

Note 1: EIRP calculated using antenna gain of 1.1 dBi for the highest EIRP system.
Note 2: Limit of -30dBc used because the power was measured using the UNII test procedure (maximum power averaged over a transmission burst).

GENERAL REQUIREMENTS APPLICABLE TO ALL BANDS

FCC Rule Part	RSS Rule part	Description	Measured Value / Comments	Limit / Requirement	Result (margin)
15.203	-	RF Connector	Antenna is integral to the device	Unique or integral antenna required	Complies
15.207	-	AC Conducted Emissions	N/A – the device uses a non-rechargeable battery		
15.247 (b) (5) 15.407 (f)	-	RF Exposure Requirements	Refer to SAR Exclusion calculations in separate exhibit	Refer to OET 65, FCC Part 1 and RSS 102	Complies

MEASUREMENT UNCERTAINTIES

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

Measurement Type	Measurement Unit	Frequency Range	Expanded Uncertainty
RF power, conducted (power meter)	dBm	25 to 7000 MHz	± 0.52 dB
RF power, conducted (Spectrum analyzer)	dBm	25 to 7000 MHz	± 0.7 dB
Conducted emission of transmitter	dBm	25 to 26500 MHz	± 0.7 dB
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 Lab Sensor Solutions model Reduced Sensor 1A is a Bluetooth Low Energy device that is designed to monitor temperature of biological samples during transportation. Since the EUT would be placed in a cooler during normal operations and is not sensitive to location, it can be treated as a tabletop device during testing. The device is powered from a non-rechargeable battery. The electrical rating of the EUT is 3.3Volts, 12.5 mAmps. The device operates at Bluetooth Low Energy frequencies at 2.4GHz.

The sample was received on August 4, 2015 and tested on August 4 and 7, 2015. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
Lab Sensor Solutions Inc	Reduced Sensor	Bluetooth Low Energy Temperature Sensor	A1	2AFKHTTRACKS1

ANTENNA SYSTEM

The antenna is an integral PCB trace antenna.

ENCLOSURE

The EUT enclosure is primarily constructed of ABS Plastic. It measures approximately 5.08 cm wide by 2.54 cm deep by 1.27 cm high.

Note – the enclosure was not present during testing. The enclosure would not adversely affect the results.

MODIFICATIONS

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

SUPPORT EQUIPMENT

No equipment was used as support equipment for testing.

A laptop was used to configure the EUT to the desired channel over the BLE connection. The laptop was removed after the EUT was configured.

EUT INTERFACE PORTS

The EUT has no interface ports.

EUT OPERATION

During testing, the EUT was configured for continuous transmission on the noted channel.

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 7	US0027	2845B-7	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.

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

The receivers utilize either a Rohde & Schwarz EZM Spectrum Monitor/Controller or contain an internal Spectrum Monitor/Controller to view and convert the 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 Spectrum Monitor provides a visual display of the signal being measured. In addition, the controller or a personal computer run automated data collection programs which control the receivers. This provides added accuracy since all site correction factors, such as cable loss and antenna factors are added automatically.

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. 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.

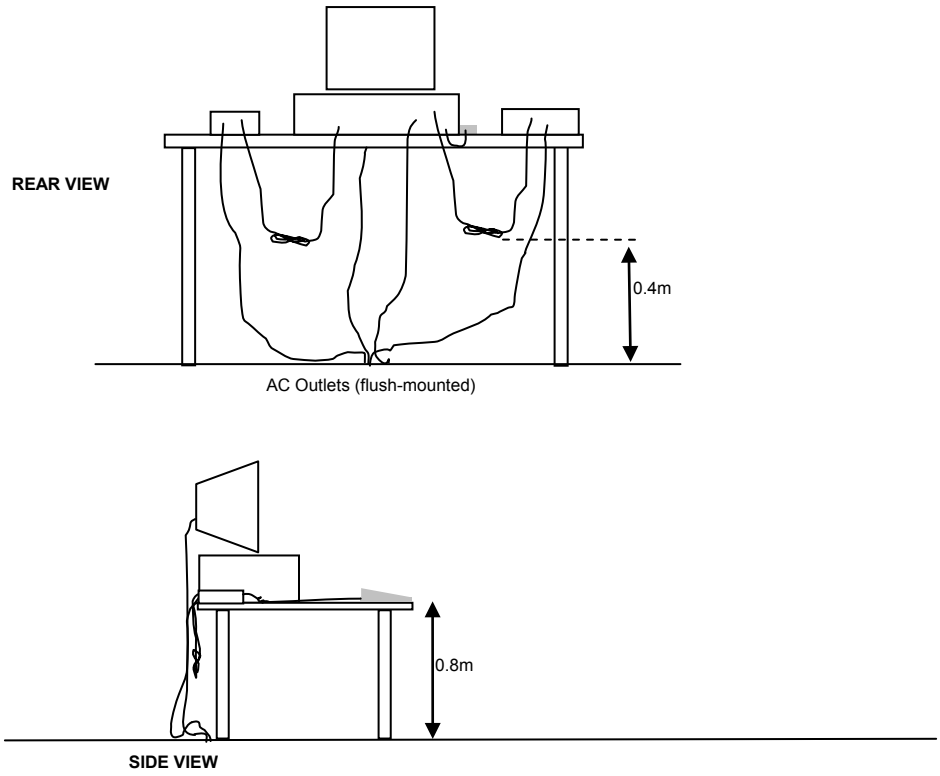
RADIATED EMISSIONS

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.

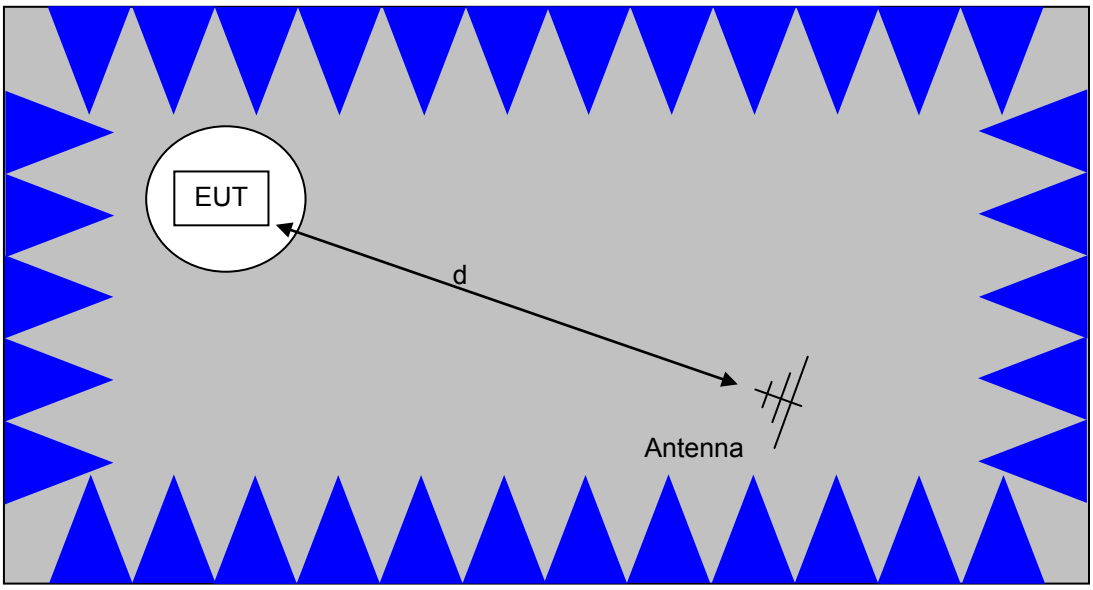
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

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.

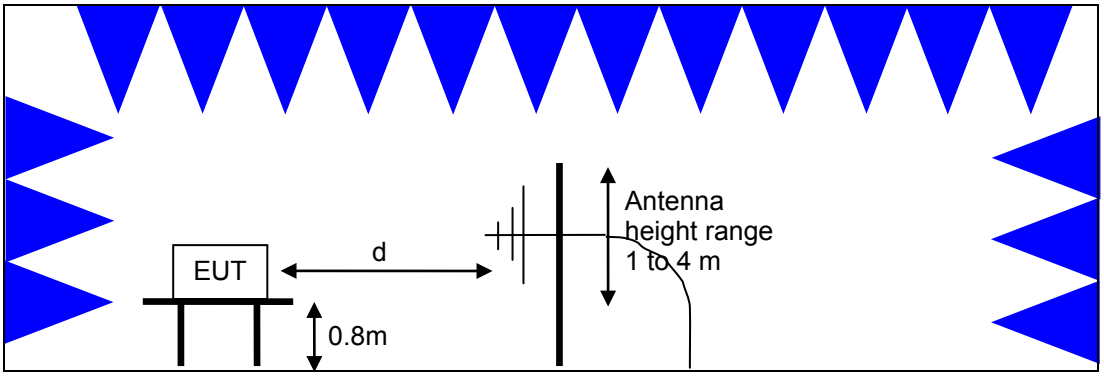


Typical Test Configuration for Radiated Field Strength Measurements



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.

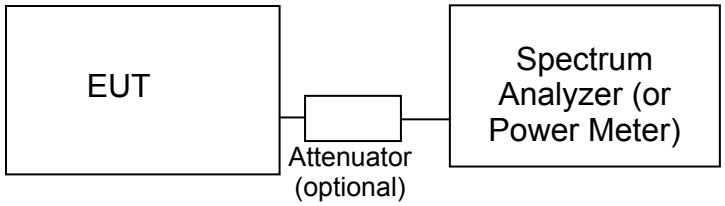
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



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:

GENERAL TRANSMITTER RADIATED EMISSIONS SPECIFICATION LIMITS

The table below shows the limits for the spurious emissions from transmitters that fall in restricted bands[1] (with the exception of transmitters operating under FCC Part 15 Subpart D), the limits for all emissions from a low power device operating under the general rules of FCC Part 15 Subpart C section 15.209.

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

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

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

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. 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 15.203, RSS 210 Table 1 and RSS 310 Table 2

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

Radiated Emissions, 1,000 - 6,500 MHz, 07-Aug-15

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
EMCO	Antenna, Horn, 1-18 GHz	3115	487	7/29/2014	7/29/2016
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/20/2014	12/20/2015

Radiated Emissions, 30 - 25,000 MHz, 18-Aug-15

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
EMCO	Antenna, Horn, 1-18 GHz	3115	487	7/29/2014	7/29/2016
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	870	2/20/2015	2/20/2016
Hewlett Packard	SpecAn 30 Hz -40 GHz, SV (SA40) Red	8564E (84125C)	1148	9/20/2014	9/20/2015
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/20/2014	12/20/2015
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	2249	10/3/2014	10/3/2015

Radiated Emissions, 30 - 1,000 MHz, 18-Aug-15

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/20/2014	12/20/2015
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	1549	6/2/2015	6/2/2017
Hewlett Packard	9KHz-1300MHz pre-amp	8447F	2777	3/4/2015	3/5/2016

Appendix B Test Data

T98995 Pages 23 – 43

Client:	Lab Sensor Solutions	Job Number:	JD98970
Product	Reducted Sensor 1A	T-Log Number:	T98995
System Configuration:	-	Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Engineer:	Mark Hill
Emissions Standard(s):	FCC 15.247	Class:	-
Immunity Standard(s):	-	Environment:	-

EMC Test Data

For The

Lab Sensor Solutions

Product

Reducted Sensor 1A

Date of Last Test: 8/18/2015

Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	-

Radiated 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: 8/18/2015
Test Engineer: M. Birgani
Test Location: Fremont Chamber #7

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

General Test Configuration

The EUT was located on the turntable for radiated emissions testing.

The test distance and extrapolation factor (if applicable) are detailed under each run description.

Note, preliminary testing indicates that the emissions were maximized by orientation of the EUT and elevation of the measurement antenna. Maximized testing indicated that the emissions were maximized by orientation of the EUT, elevation of the measurement antenna, and manipulation of the EUT's interface cables.

Ambient Conditions:

Temperature: 22-24 °C
Rel. Humidity: 30-35 %

Summary of Results (ANSI C63.4:2009)

Run #	Test Performed	Limit	Result	Margin
2	Radiated Emissions 30 - 1000 MHz, Maximized	Class B	Pass	20.7 dBµV/m @ 182.53 MHz (Margin: -9.3 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

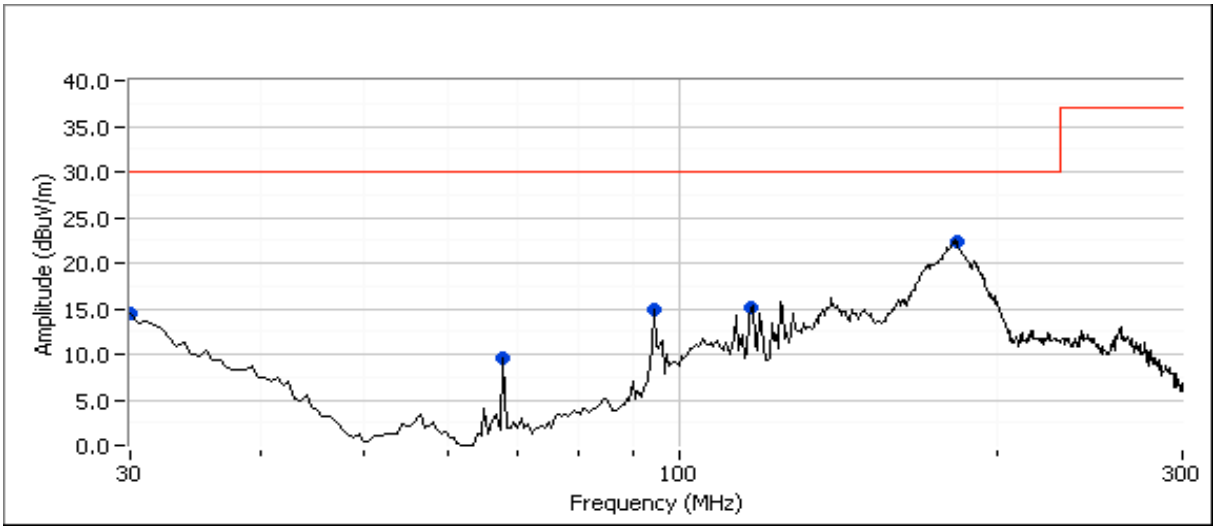
No deviations were made from the requirements of the standard.

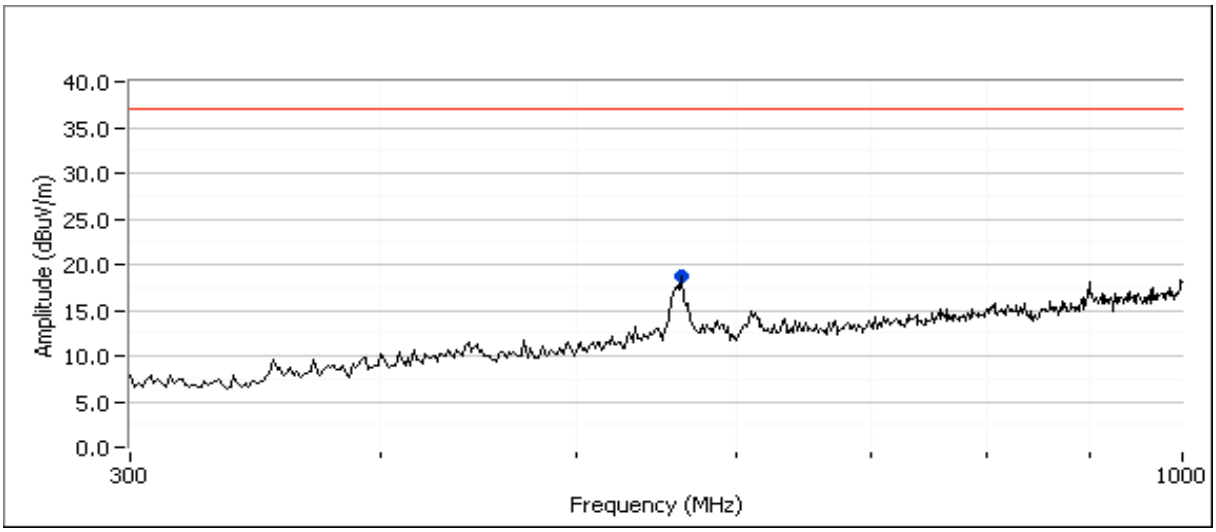
Note 1:	The EUT was transmitting continuously at 2440 MHz.

Test Parameters for Preliminary Scan(s)			
Frequency Range (MHz)	Prescan Distance (meters)	Limit Distance (meters)	Extrapolation Factor (dB, applied to data)
30 - 1000	5	10	-6.0

Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	-

Run #1: Preliminary Radiated Emissions, 30 - 1000 MHz





Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	-

Run #1: Preliminary Radiated Emissions, 30 - 1000 MHz

Preliminary peak readings captured during pre-scan

Frequency	Level	Pol	Class B		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
182.531	22.4	H	30.0	-7.6	Peak	352	2.0	
115.395	15.2	V	30.0	-14.8	Peak	46	1.0	
94.446	15.0	V	30.0	-15.0	Peak	4	1.5	
30.496	14.5	H	30.0	-15.5	Peak	11	3.0	
559.593	18.8	H	37.0	-18.2	Peak	147	1.5	
68.054	9.5	H	30.0	-20.5	Peak	88	3.5	

Preliminary quasi-peak readings (no manipulation of EUT interface cables)

Frequency	Level	Pol	Class B		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
182.531	20.7	H	30.0	-9.3	QP	352	2.0	QP (1.00s)
30.496	9.8	H	30.0	-20.2	QP	11	3.0	QP (1.00s)
559.593	15.0	H	37.0	-22.0	QP	147	1.5	QP (1.00s)
115.395	3.0	V	30.0	-27.0	QP	46	1.0	QP (1.00s)
94.446	-1.6	V	30.0	-31.6	QP	4	1.5	QP (1.00s)
68.054	-2.4	H	30.0	-32.4	QP	88	3.5	QP (1.00s)

Run #2: Maximized Readings From Run #1

Maximized quasi-peak readings (includes manipulation of EUT interface cables)

Frequency	Level	Pol	Class B		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
182.531	20.7	H	30.0	-9.3	QP	352	2.0	
30.496	9.8	H	30.0	-20.2	QP	11	3.0	
559.593	15.0	H	37.0	-22.0	QP	147	1.5	
115.395	3.0	V	30.0	-27.0	QP	46	1.0	
94.446	-1.6	V	30.0	-31.6	QP	4	1.5	
68.054	-2.4	H	30.0	-32.4	QP	88	3.5	

Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

RSS 210 and FCC 15.247 (DTS) Radiated Spurious Emissions

Test Specific Details

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

General Test Configuration

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

Ambient Conditions:

Temperature: 25 °C
Rel. Humidity: 32 %

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

Run #	Mode	Channel	Power Setting	Measured Power	Test Performed	Limit	Result / Margin
1a	BLE	2402MHz	Default		Restricted Band Edge (2390 MHz)	FCC Part 15.209 / 15.247(c)	33.0 dBµV/m @ 2370.0 MHz (-21.0 dB)
			Default		Radiated Emissions 1 - 25 GHz	FCC Part 15.209 / 15.247(c)	41.2 dBµV/m @ 4806.1 MHz (-12.8 dB)
1b	BLE	2440MHz	Default		Radiated Emissions 1 - 25 GHz	FCC Part 15.209 / 15.247(c)	40.7 dBµV/m @ 4882.0 MHz (-13.3 dB)
1c	BLE	2480MHz	Default		Restricted Band Edge (2483.5 MHz)	FCC Part 15.209 / 15.247(c)	36.5 dBµV/m @ 2483.5 MHz (-17.5 dB)
			Default		Radiated Emissions 1 - 25 GHz	FCC Part 15.209 / 15.247(c)	41.3 dBµV/m @ 4958.0 MHz (-12.7 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Date of Test: 08/18/15
Test Engineer: Mehran Birgani
Test Location: FTChamber #7

Config. Used: 1
Config Change: none
EUT Voltage: Battery

Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
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/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	-	100.0%	Yes	1	0	0	-

Sample Notes

Sample S/N: A1

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:	Plots of the average and peak bandedge do not account for any duty cycle correction. Refer to the tabular results for final measurements.

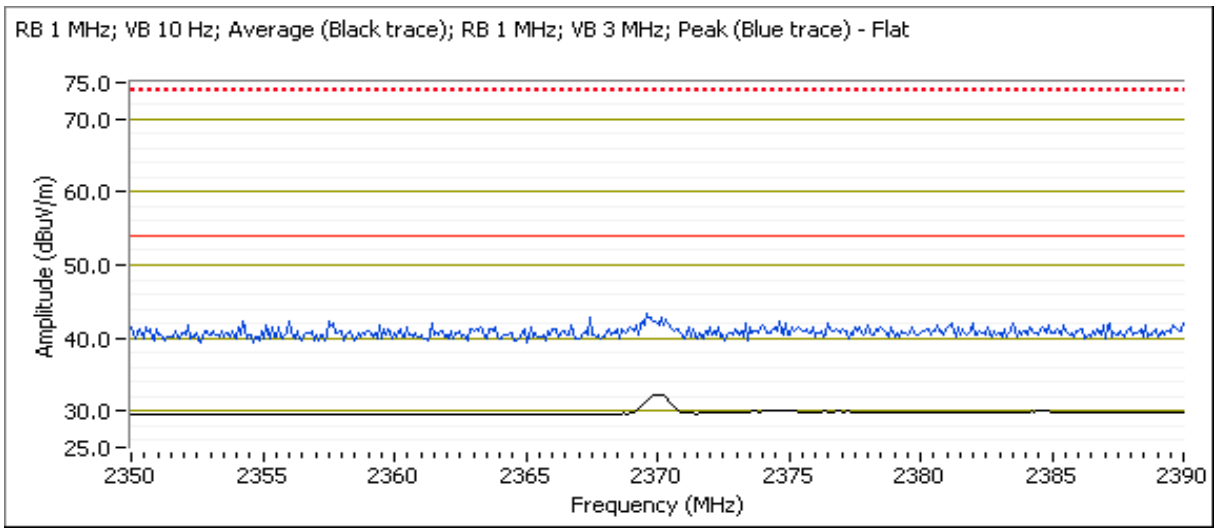
Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

Run #1: Radiated Spurious Emissions, 30 - 25000 MHz. Operating Mode: BLE

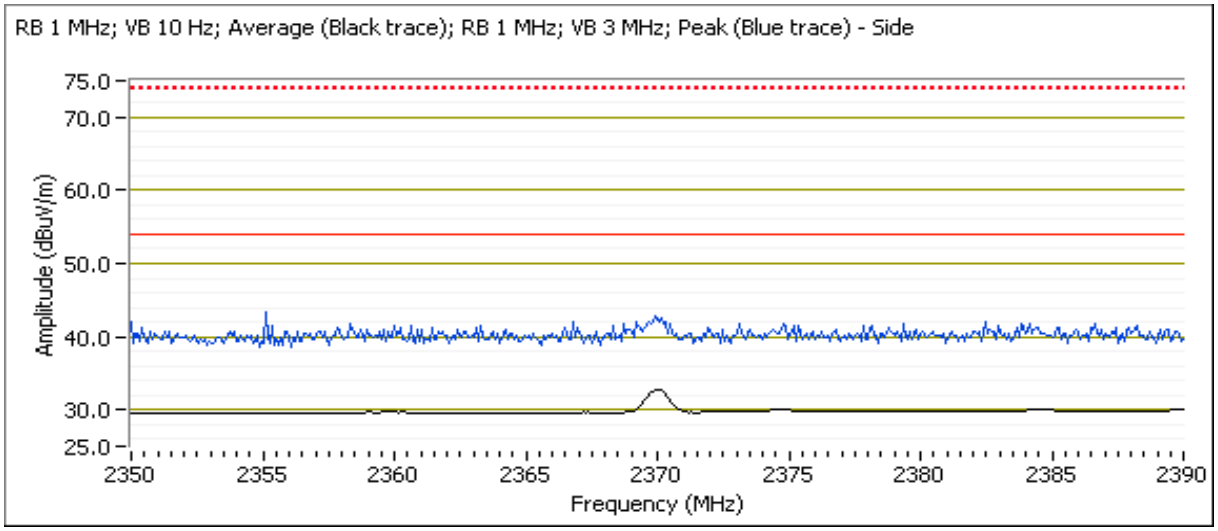
Run #1a: Low Channel @ 2402 MHz

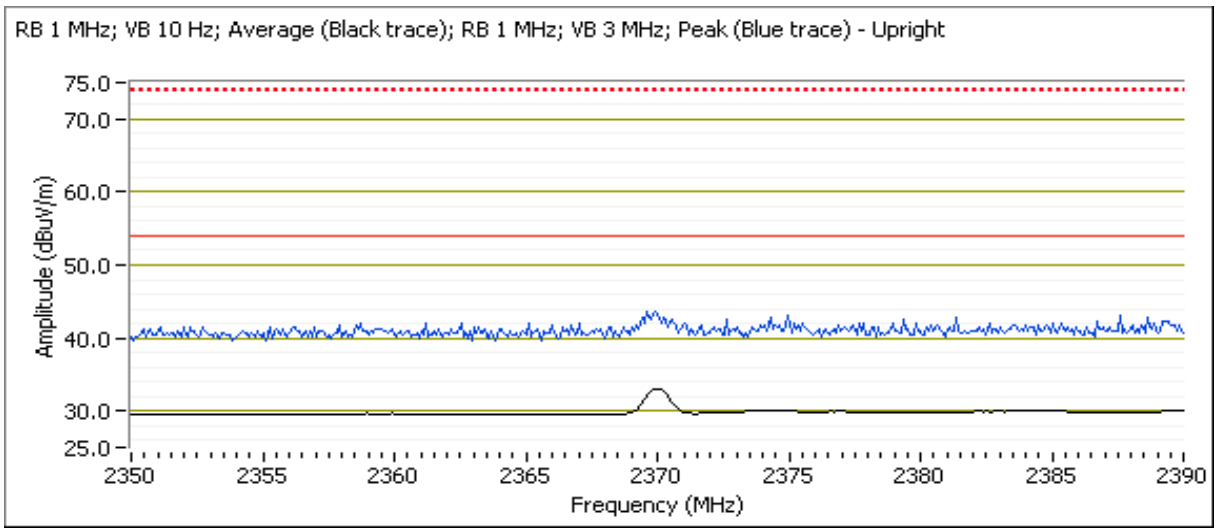
Band Edge Signal Field Strength - Direct measurement of field strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2376.210	29.8	V	54.0	-24.2	AVG	136	2.3	POS; RB 1 MHz; VB: 10 Hz; Flat
2381.740	41.7	V	74.0	-32.3	PK	136	2.3	POS; RB 1 MHz; VB: 3 MHz; Flat
2369.960	32.3	H	54.0	-21.7	AVG	201	1.0	POS; RB 1 MHz; VB: 10 Hz; Flat
2369.560	42.9	H	74.0	-31.1	PK	201	1.0	POS; RB 1 MHz; VB: 3 MHz; Flat
2370.040	30.6	V	54.0	-23.4	AVG	176	2.4	POS; RB 1 MHz; VB: 10 Hz; Side
2384.790	41.6	V	74.0	-32.4	PK	176	2.4	POS; RB 1 MHz; VB: 3 MHz; Side
2370.040	32.6	H	54.0	-21.4	AVG	71	2.7	POS; RB 1 MHz; VB: 10 Hz; Side
2356.570	42.5	H	74.0	-31.5	PK	71	2.7	POS; RB 1 MHz; VB: 3 MHz; Side
2370.040	33.0	V	54.0	-21.0	AVG	130	1.8	POS; RB 1 MHz; VB: 10 Hz; Upright
2369.800	42.5	V	74.0	-31.5	PK	130	1.8	POS; RB 1 MHz; VB: 3 MHz; Upright
2370.040	30.4	H	54.0	-23.6	AVG	106	1.0	POS; RB 1 MHz; VB: 10 Hz; Upright
2377.010	41.9	H	74.0	-32.1	PK	106	1.0	POS; RB 1 MHz; VB: 3 MHz; Upright



Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A



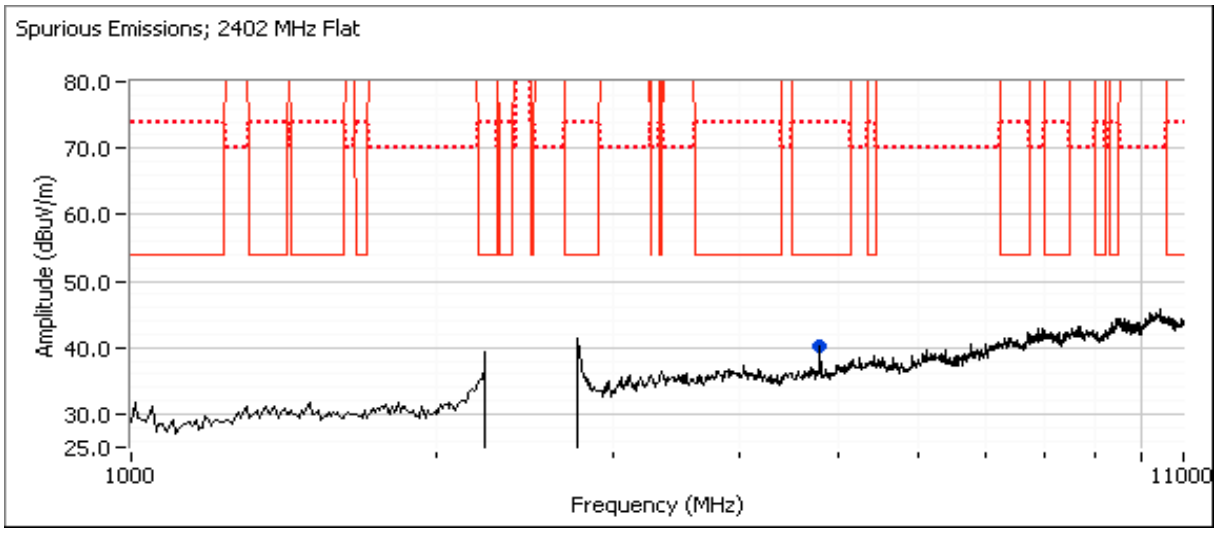


Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

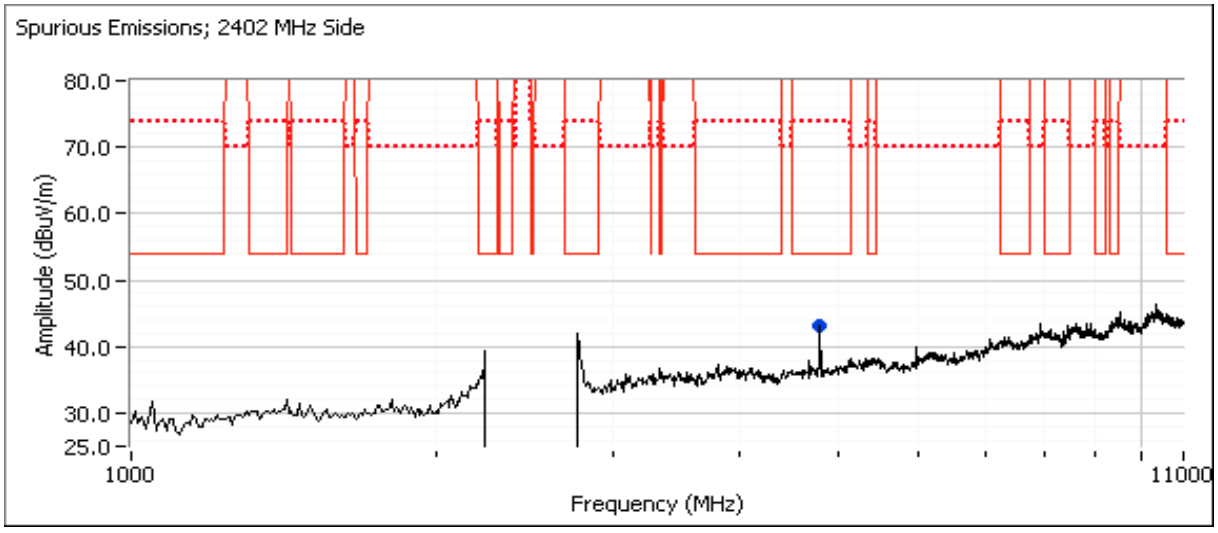
Other Spurious Emissions

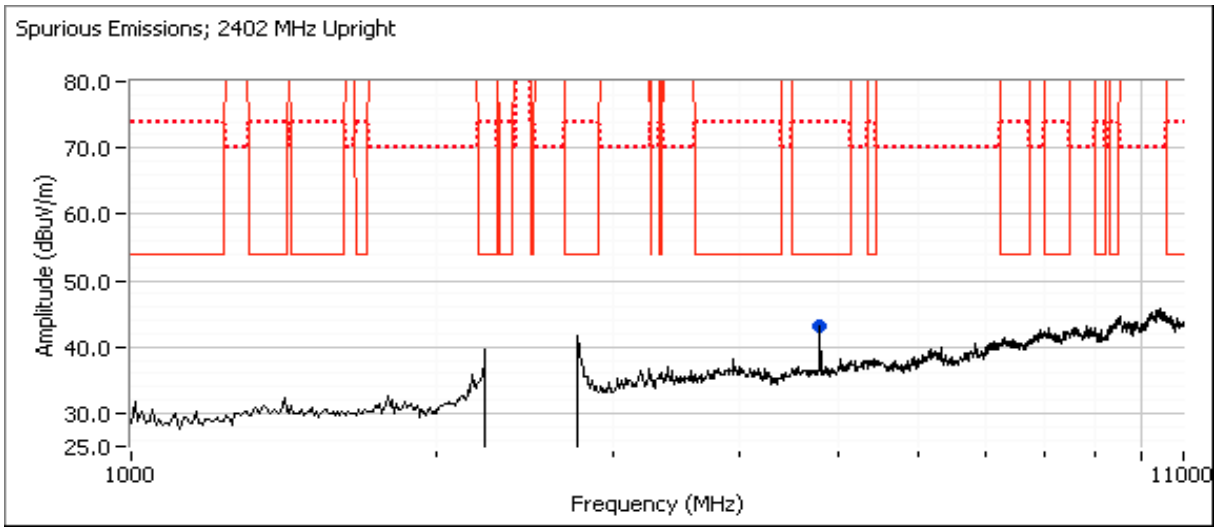
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
4806.130	38.7	H	54.0	-15.3	AVG	126	1.5	POS; RB 1 MHz; VB: 10 Hz; Flat
4806.350	46.4	H	74.0	-27.6	PK	126	1.5	POS; RB 1 MHz; VB: 3 MHz; Flat
4806.080	41.2	V	54.0	-12.8	AVG	16	1.2	POS; RB 1 MHz; VB: 10 Hz; Side
4806.150	47.8	V	74.0	-26.2	PK	16	1.2	POS; RB 1 MHz; VB: 3 MHz; Side
4806.110	40.8	H	54.0	-13.2	AVG	360	1.6	POS; RB 1 MHz; VB: 10 Hz; Upright
4806.160	47.5	H	74.0	-26.5	PK	360	1.6	POS; RB 1 MHz; VB: 3 MHz; Upright

Note A:	Scans made between 11 - 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:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A



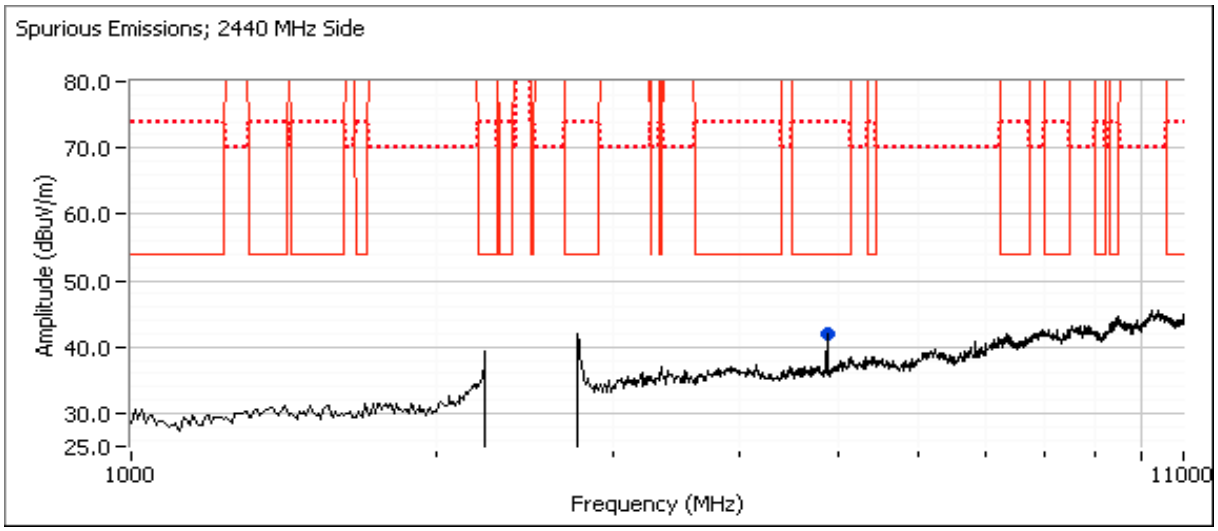


Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

Run #1b: Center Channel @ 2440 MHz
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	
4882.000	40.7	V	54.0	-13.3	AVG	10	1.0	POS; RB 1 MHz; VB: 10 Hz; Side
4882.030	46.5	V	74.0	-27.5	PK	10	1.0	POS; RB 1 MHz; VB: 3 MHz; Side

Note A:	Scans made between 11 - 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
Note B:	Preliminary testing showed Side orientation has the highest reading.



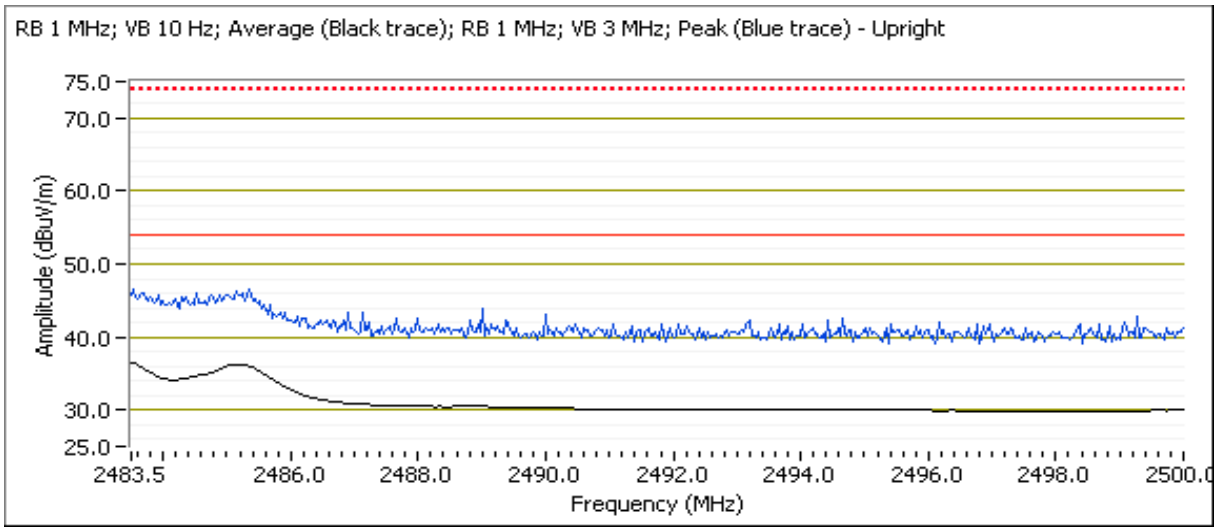
Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

Run #1c: High Channel @ 2480 MHz

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	
2483.500	36.5	V	54.0	-17.5	AVG	21	1.1	POS; RB 1 MHz; VB: 10 Hz; Upright
2483.600	45.9	V	74.0	-28.1	PK	21	1.1	POS; RB 1 MHz; VB: 3 MHz; Upright
2485.250	31.6	H	54.0	-22.4	AVG	13	1.2	POS; RB 1 MHz; VB: 10 Hz; Upright
2484.260	42.5	H	74.0	-31.5	PK	13	1.2	POS; RB 1 MHz; VB: 3 MHz; Upright

Note B:	Preliminary testing showed Upright orientation has the highest reading.

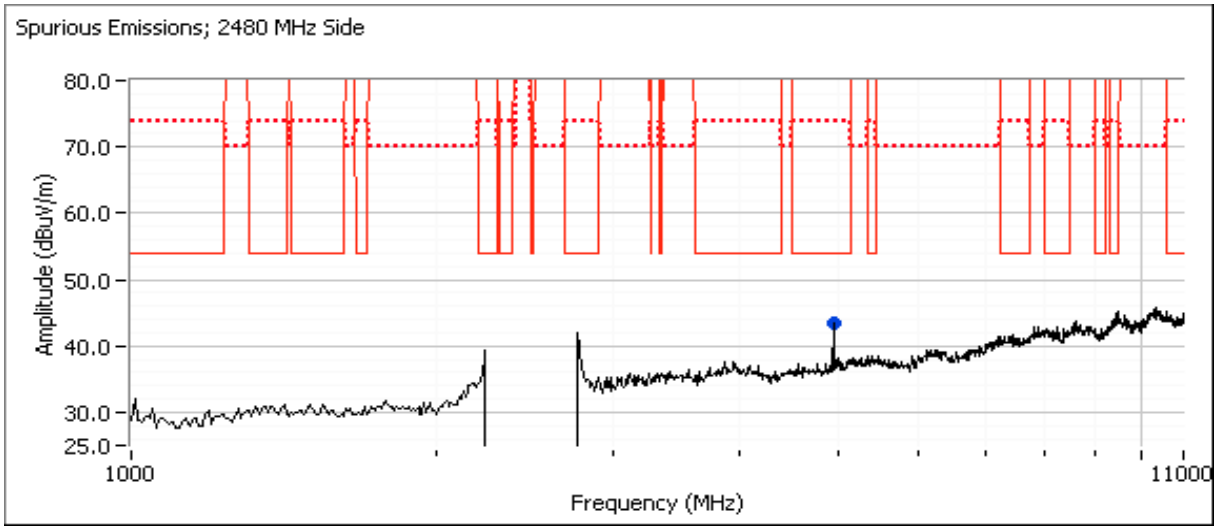


Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

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	
4958.030	41.3	V	54.0	-12.7	AVG	346	1.3	RB 1 MHz;VB 10 Hz;Peak
4958.310	47.7	V	74.0	-26.3	PK	346	1.3	RB 1 MHz;VB 3 MHz;Peak

Note A:	Scans made between 11 - 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
Note B:	Preliminary testing showed Side orientation has the highest reading.



Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

RSS 247 and FCC 15.247 (DTS) Antenna Port Measurements

Power, PSD, Bandwidth and Spurious Emissions

Test Specific Details

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

General Test Configuration

All measurements were performed radiated at 3m distance from the measurement antenna.

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

Ambient Conditions:

Temperature: 20-23 °C

Rel. Humidity: 35-40 %

Summary of Results

Run #	Pwr setting	Avg Pwr	Test Performed	Limit	Pass / Fail	Result / Margin
1	Max		Output Power	15.247(b)	Pass	-2.4dBm (0.6mW)
2	Max		Power spectral Density (PSD)	15.247(d)	Pass	-16.9dBm/3kHz
3	Max		Minimum 6dB Bandwidth	15.247(a)	Pass	665 kHz
3	Max		99% Bandwidth	RSS GEN	-	1.07 MHz
4	Max		Spurious emissions	15.247(b)	Pass	> 30dBc below limit

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

Power was measured using RBW=1MHz.

Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

Procedure Comments:

Measurements performed in accordance with FCC KDB 558074

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
BLE	-	100.0%	Yes	1	0	0	-

Sample Notes

Sample S/N: A1
Driver: -

Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

Run #1: Output Power

Date of Test: 8/7/2015 Config. Used: -

Test Engineer: M. Birgani Config Change: -

Test Location: Chamber #7 EUT Voltage: Battery Powered

Mode: BLE Orientation: All 3 orientation

EUT Orientation	Frequency (MHz)	Output Power (EIRP) (dBm) [1]	mW	Antenna Gain (dBi)	Result	Power dBm	W	Output Power (dBm)	mW
Vertical									
Flat	2402	-14.0	0.04	1.1	Pass	-15.1	0.0000		
Side	2402	-6.6	0.22	1.1	Pass	-7.7	0.0002		
Upright	2402	-3.1	0.49	1.1	Pass	-4.2	0.0004		
Horizontal									
Flat	2402	-1.3	0.74	1.1	Pass	-2.4	0.0006		
Side	2402	-3.3	0.47	1.1	Pass	-4.4	0.0004		
Upright	2402	-14.6	0.03	1.1	Pass	-15.7	0.0000		

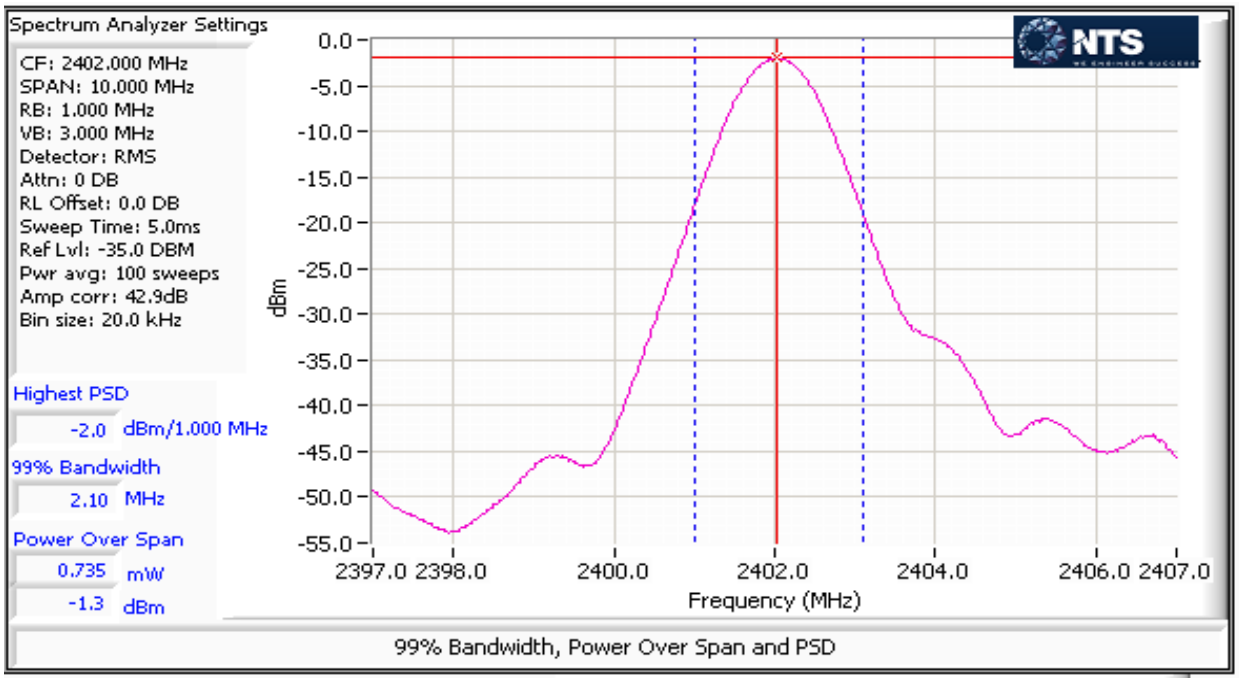
Note: Preliminary testing showed Flat orientation and Horizontal has the highest power and PSD level. All power and PSD measurements were performed at that orientation.

Mode: BLE Orientation: Flat

Power Setting [2]	Frequency (MHz)	Output Power (EIRP) (dBm) [1]	mW	Antenna Gain (dBi)	Result	Power dBm	W	Output Power (dBm)	mW
Vertical									
Max	2402	-14.0	0.04	1.1	Pass	-15.1	0.0000		
Max	2440	-11.3	0.07	0.0	Pass	-11.3	0.0001		
Max	2480	-17.0	0.02	-1.5	Pass	-15.5	0.0000		
Horizontal									
Max	2402	-1.3	0.74	1.1	Pass	-2.4	0.0006		
Max	2440	-5.4	0.29	0.0	Pass	-5.4	0.0003		
Max	2480	-6.5	0.22	-1.5	Pass	-5.0	0.0003		

Note 1:	Duty Cycle ≥ 98%. Output power measured using a spectrum analyzer (see plots below) with RBW= 1MHz, VB≥3* RBW, RMS detector, power averaging on, and power integration over the OBW, trace average 100 traces. Spurious limit becomes -30dBc.

Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A



Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

Run #2: Power spectral Density

Date of Test: 8/7/2015 Config. Used: -

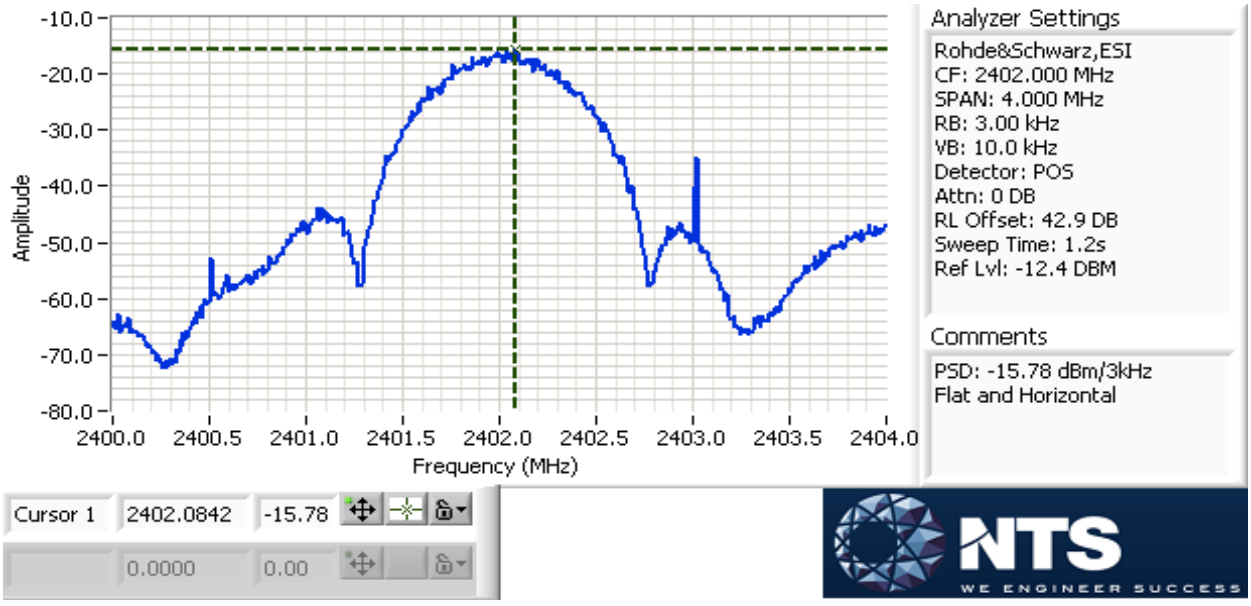
Test Engineer: M. Birgani Config Change: -

Test Location: Chamber #7 EUT Voltage: Battery Powered

Mode: BLE Orientation: Flat

Power Setting	Frequency (MHz)	PSD (eirp) (dBm/3kHz) Note 1	Ant Gain (dBi)	PSD (dBm/3kHz) Note 1	Limit dBm/3kHz	Result
Max	2402	-15.8	1.1	-16.9	8.0	Pass
Max	2440	-17.7	0	-17.7	8.0	Pass
Max	2480	-19.8	-1.5	-18.3	8.0	Pass

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



Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

Run #3: Signal Bandwidth

Date of Test: 8/7/2015 Config. Used: -

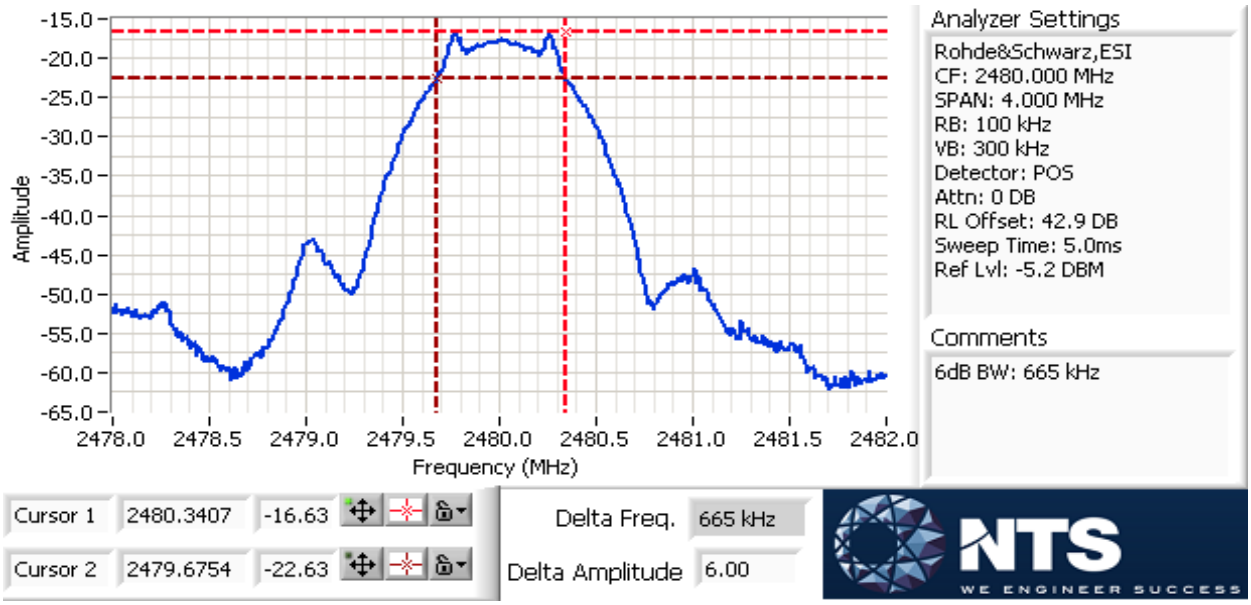
Test Engineer: M. Birgani Config Change: -

Test Location: Chamber #7 EUT Voltage: Battery Powered

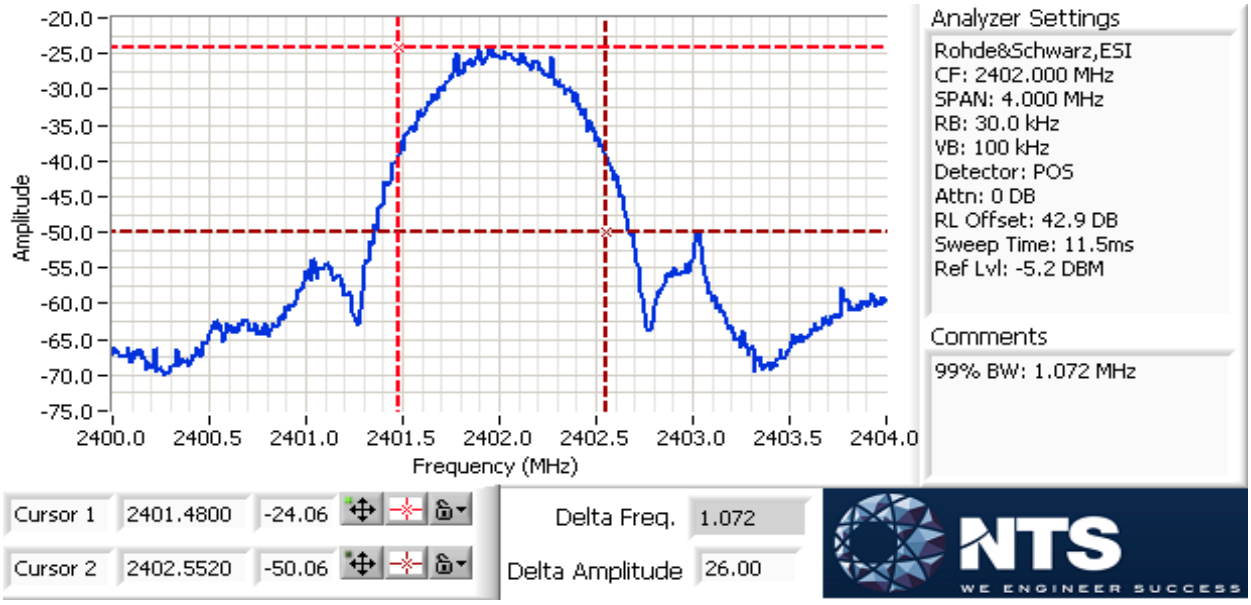
Mode: BLE

Power Setting	Frequency (MHz)	Bandwidth (kHz)		RBW Setting (kHz)	
		6dB	99%	6dB	99%
Max	2402	697	1072	100	30
Max	2440	697	1080	100	30
Max	2480	665	1072	100	30

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



Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A



Client:	Lab Sensor Solutions	Job Number:	JD98970
Model:	Reducted Sensor 1A	T-Log Number:	T98995
		Project Manager:	Irene Rademacher
Contact:	Daniel Paley	Project Coordinator:	Mark Hill
Standard:	FCC 15.247	Class:	N/A

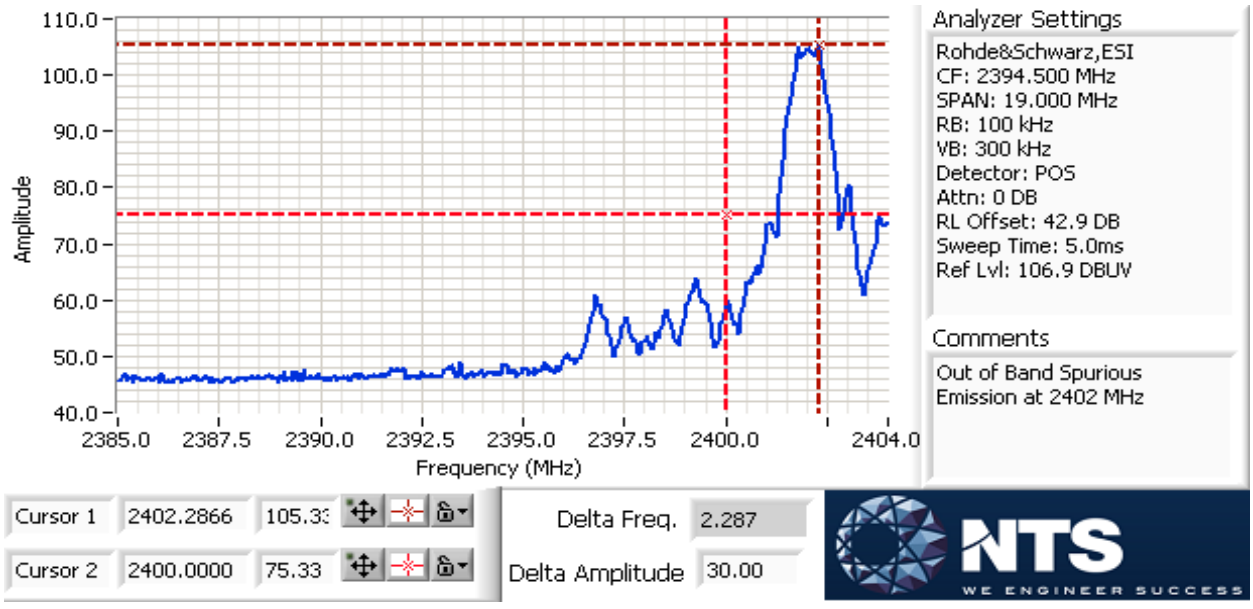
Run #4a: Out of Band Spurious Emissions

Frequency (MHz)	Power Setting	Mode	Limit	Result
2402	Max	BLE	-30dBc	Pass

Measurement performed RBW=100kHz, VBW=300kHz, peak detector, max hold

Plots for low channel

Additional plot showing compliance with -30dBc limit from 2390 MHz to 2400 MHz. Radiated measurements used to show compliance with the limits in the restricted band below 2390 MHz.



End of Report

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