FCC PART 15, SUBPART C
IC RSS-210, ISSUE 8, DECEMBER 2010

TEST AND MEASUREMENT REPORT

For

SmartThings, Inc.

1000 Potomac St NW, Suite 120,

Washington DC, 20007, USA

FCC ID: R3Y-STH-ETH200
IC: 10734A-STHETH200

Report Type:	**Product Type:**
Original Report	Home Automation Gateway

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Report Number:	R1412053-247 ZigBee
Report Date:	2015-02-10
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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1412053-247 Zigbee	Original Report	2015-02-10

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test and measurement report was prepared on behalf of *SmartThings Inc.* and their product, *FCC ID: **R3Y-STH-ETH200**, IC: **10734A-STHETH200,** model: STH-ETH-200*, or the "EUT" (Equipment Under Testing) as referred to in this report. The EUT is a home automation gateway with BLE 2402-2480 MHz and Zigbee 2405-2470 MHz.

1.2 Mechanical Description of EUT

The EUT measures approximately 10.7 cm (L) x 12.3 cm (W) x 3.4 cm (H) and weighs 300 g.

The test data gathered are from typical production sample, serial number: R1412053-01 assigned by BACL.

1.3 Objective

This report is prepared on behalf of *SmartThings* in accordance with Part 2, Subpart J, and Part 15, Subparts B and C of the Federal Communication Commission rules.

The objective is to determine compliance with FCC Part 15.247 rules and IC RSS-210 rules for Output Power, Antenna Requirements, 6 dB Bandwidth, and power spectral density, 100 kHz Bandwidth of Band Edges Measurement, Spurious Emissions, Conducted and Radiated Spurious Emissions.

1.4 Related Submittal(s)/Grant(s)

N/A

1.5 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI C63.4-2009, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz and FCC KDB 558074 D01 DTS Meas Guidance v03r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

1.6 Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in the field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

The following calculation follows the procedures as set forth in clause 7.2.3, ETSI TR 100 028-1 V1.4.1 (2001-12), the expression of Uncertainty in Radiated RF Testing is in accordance to ISO/IEC 17025 and TR 100 028-1 V1.4.1 (2001-12).

The expanded Measurement Uncertainty value having a confidence factor of 95%, is within a range of 5.48 dB. This means that the value of conducted RF carrier power test will be within +/- 2.74 dB of the measuring radiated emissions power versus the expected value.
The expected value is defined as the power at the antenna of the Transmitter under Test.

1.7 Test Facility

Bay area compliance Laboratories Corp. (BACL) is:
1- An independent Commercial Test Laboratory accredited to **ISO 17025: 2005** by **A2LA**, in the fields of: Electromagnetic Compatibility & Telecommunications covering Emissions, Immunity, Radio, RF Exposure, Safety and Telecom. This includes NEBS (Network Equipment Building System), Wireless RF, Telecommunications Terminal Equipment (TTE); Network Equipment; Information Technology Equipment (ITE); Medical Electrical Equipment; Industrial, Commercial, and Medical Test Equipment; Professional Audio and Video Equipment; Electronic (Digital) Products; Industrial and Scientific Instruments; Cabled Distribution Systems and Energy Efficiency Lighting.

2- An ENERGY STAR Recognized Laboratory, for the LM80 Testing, a wide variety of Luminares and Computers.

3- A NIST Designated Phase-I and Phase-II CAB including: ACMA (Australian Communication and Media Authority), BSMI (Bureau of Standards, Metrology and Inspection of Taiwan), IDA (Infocomm Development Authority of Singapore), IC(Industry Canada), Korea (Ministry of Communications Radio Research Laboratory), NCC (Formerly DGT; Directorate General of Telecommunication of Chinese Taipei) OFTA (Office of the Telecommunications Authority of Hong Kong), Vietnam, VCCI - Voluntary Control Council for Interference of Japan and a designated EU CAB (Conformity Assessment Body) (Notified Body) for the EMC and R&TTE Directives.

4- A Product Certification Body accredited to **ISO Guide 65: 1996** by **A2LA** to certify:
1- Unlicensed, Licensed radio frequency devices and Telephone Terminal Equipment for the FCC. Scope A1, A2, A3, A4, B1, B2, B3, B4 & C.
2. Radio Standards Specifications (RSS) in the Category I Equipment Standards List and All Broadcasting Technical Standards (BETS) in Category I Equipment Standards List for Industry Canada.
3. Radio Communication Equipment for Singapore.
4. Radio Equipment Specifications, GMDSS Marine Radio Equipment Specifications, and Fixed Network Equipment Specifications for Hong Kong.
5. Japan MIC Telecommunication Business Law (A1, A2) and Radio Law (B1, B2 and B3).
6. Audio/Video, Battery Charging Systems, Computers, Displays, Enterprise Servers, Imaging Equipment, Set-Top Boxes, Telephony, Televisions, Ceiling Fans, CFLs (Including GU24s),Decorative Light Strings, Integral LED Lamps, Luminaires, Residential Ventilating Fans.

The test site used by BACL Corp. to collect radiated and conducted emissions measurement data is located at its facility in Sunnyvale, California, USA.

The test site at BACL Corp. has been fully described in reports submitted to the Federal Communication Commission (FCC) and Voluntary Control Council for Interference (VCCI). The details of these reports have been found to be in compliance with the requirements of Section 2.948 of the FCC Rules on February 11 and December 10, 1997, and Article 8 of the VCCI regulations on December 25, 1997. The test site also complies with the test methods and procedures set forth in CISPR 22:2008 §10.4 for measurements below 1 GHz and §10.6 for measurements above 1 GHz as well as ANSI C63.4-2009, ANSI C63.4-2009, TIA/EIA-603 & CISPR 24:2010.

The Federal Communications Commission and Voluntary Control Council for Interference have the reports on file and they are listed under FCC registration number: 90464 and VCCI Registration No.: A-0027. The test site has been approved by the FCC and VCCI for public use and is listed in the FCC Public Access Link (PAL) database.

Additionally, BACL Corp. is an American Association for Laboratory Accreditation (A2LA) accredited laboratory (Lab Code 3297-02). The current scope of accreditations can be found at

http://www.a2la.org/scopepdf/3297-02.pdf?CFID=1132286&CFTOKEN=e42a3240dac3f6ba-6DE17DCB-1851-9E57-477422F667031258&jsessionid=8430d44f1f47cf2996124343c704b367816b

2 System Test Configuration

2.1 Justification

The EUT was configured by the manufacture in normal use or equivalent of normal use with the maximum allowable power .

The EUT was tested in accordance per ANSI C63.10-2009 and FCC KDB 558074 D01 DTS Meas Guidance v03r02.

The EUT was tested in a testing mode to represent worst-case results during the final qualification test.

The worst-case data rates are determined to be as follows for each mode based upon investigation by measuring the average power, peak power and PPSD across all data rates bandwidths, and modulations.

2.2 EUT Exercise Software

The software is HubCore Ver 0.2.0 provided by client and was verified by Rui Zhou.

2.3 Special Equipment

There were no special accessories required, included, or intended for use with EUT during these tests.

2.4 Equipment Modifications

No modifications were made to the EUT.

2.5 Local Support Equipment

Manufacturer	Description	Model	Serial Number
Dell	Laptop	Latitude E5420	CHZCMQ1

2.6 EUT Internal Configuration Details

Manufacturer	Description	Model	Serial Number
SmartThings	Main Board	PGC431-D	13

2.7 Interface Ports and Cables

Cable Description	Length (m)	From	To
Ethernet Cable	1m	Laptop	EUT

2.8 Power Supply List and Details

Manufacturer	Description	Model	Part Number
CUI	AC Power Supply	EPSA050200UH-P5P-DB-C1	4114HB

3 Summary of Test Results

Results reported relate only to the product tested.

FCC/IC Rules	Description of Test	Results
FCC §15.247(i), §2.1091 IC RSS-102	RF Exposure	Compliant
FCC §15.203 IC RSS-Gen §8.3	Antenna Requirement	Compliant
FCC §15.207(a) IC RSS-Gen §8.8	AC Line Conducted Emissions	Compliant
FCC §15.205 IC RSS-210 §2.2	Restricted Bands	Compliant
FCC §15.209, §15.247 (d) IC RSS-210 §A8.5	Radiated Spurious Emissions	Compliant
FCC §15.247(a)(2) IC RSS-210 §A8.2	6 dB Emission Bandwidth	Compliant
FCC §15.247(b)(3) IC RSS-210 §A8.4	Maximum Peak Output Power	Compliant
FCC §15.247(d) IC RSS-210 §A8.5	100 kHz Bandwidth of Frequency Band Edge	Compliant
FCC §15.247(e) IC RSS-210 §A8.2(b)	Power Spectral Density	Compliant

4 FCC §15.247(i), §2.1091 & IC RSS-102 – RF Exposure

4.1 Applicable Standard

According to FCC §15.247(i) and §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	* (100)	30
1.34-30	824/f	2.19/f	* ($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

Before equipment certification is granted, the procedure of IC RSS-102 must be followed concerning the exposure of humans to RF field

According to IC RSS-102 Issue 2 section 4.1, RF limits used for general public will be applied to the EUT.

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Time Averaging (min)
0.003 - 1	280	2.19	-	6
1 - 10	280 / f	2.19 / f	-	6
10 - 30	28	2.19 / f	-	6
30 – 300	28	0.073	2*	6
300 – 1 500	$1.585\ f^{0.5}$	$0.0042\ f^{0.5}$	f / 150	6
1 500 – 15 000	61.4	0.163	10	6
15 000 – 150 000	61.4	0.163	10	$616000 / f^{1.2}$
150 000- 300 000	$0.158\ f^{0.5}$	$4.21 \times 10^{-4}\ f^{0.5}$	$6.67 \times 10^{-5}\ f$	$616000 / f^{1.2}$

Note: f is frequency in MHz
* = Power density limit is applicable at frequencies greater than 100 MHz

4.2 MPE Prediction

Predication of MPE limit at a given distance, Equation from OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

Where: S = power density
P = power input to antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

4.3 MPE Results

Zigbee:

Maximum peak output power at antenna input terminal (dBm):	13.57
Maximum peak output power at antenna input terminal (mW):	22.75
Prediction distance (cm):	20
Prediction frequency (MHz):	2440
Maximum Antenna Gain, typical (dBi):	3.3
Maximum Antenna Gain (numeric):	2.138
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.009677
Power density of prediction frequency at 20.0 cm (W/m^2):	0.09677
MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0
MPE limit for uncontrolled exposure at prediction frequency (W/m^2):	10

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.009677 mW/cm^2 (0.09677 W/m^2). Limit is 1.0 mW/cm^2 (10 W/m^2).

5 FCC §15.203 & IC RSS-Gen §8.3 – Antenna Requirements

5.1 Applicable Standard

According to FCC §15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

According to IC RSS-Gen §8.3: Transmitter Antenna

The applicant for equipment certification, as per RSP-100, must provide a list of all antenna types that may be used with the licence-exempt transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna.
Licence-exempt transmitters that have received equipment certification may operate with different types of antennas. However, it is not permissible to exceed the maximum equivalent isotropically radiated power (e.i.r.p.) limits specified in the applicable standard (RSS) for the licence-exempt apparatus.

5.2 Antenna Description

The antenna uses a unique coupling to the EUT, which complies with the antenna requirement. And the antenna gain is 3.3 dBi. Please refer to the internal photos.

6 FCC §15.207 & IC RSS-Gen §8.8 – AC Line Conducted Emissions

6.1 Applicable Standards

As per FCC §15.207 Conducted limits:

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

As per IC RSS-Gen §7.2.4 Conducted limits:

Except when the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply, either directly or indirectly (such as with abattery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in the table below. The more stringent limit applies at the frequency range boundaries. The conducted emissions shall be measured with a 50 ohm/50 microhenry line impedance stabilization network (LISN).

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 *	56 to 46 *
0.5-5	56	46
5-30	60	50

**Decreases with the logarithm of the frequency.*

6.2 Test Setup

The measurement was performed at shield room, using the setup per ANSI C63.4-2009 measurement procedure. The specification used was FCC §15.207 & IC RSS-Gen limits.

External I/O cables were draped along the edge of the test table and bundle when necessary.

The POE power adapter of the EUT was connected with LISN which provided 120 V / 60 Hz AC power.

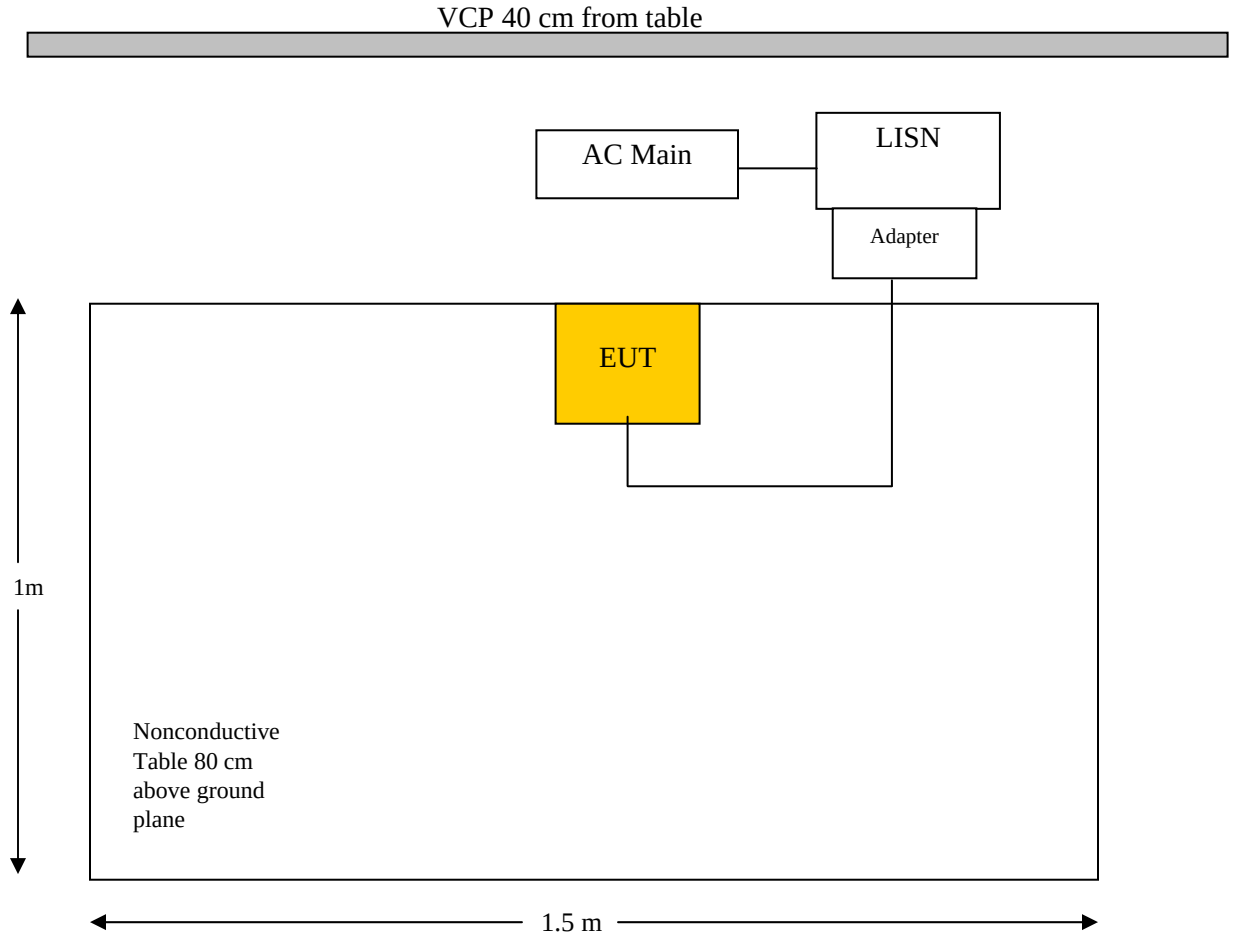
6.3 Test Procedure

Maximizing procedure was performed on the highest emissions of the EUT.

All data was recorded in the peak detection mode, quasi-peak and average. Quasi-Peak readings are distinguished with a “QP.” Average readings are distinguished with an “Ave”.

6.4 Test Setup Block Diagram

AC/DC Adaptor:



6.5 Corrected Amplitude & Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the Cable Loss (CL), the Attenuator Factor (Atten) to indicated Amplitude (Ai) reading. The basic equation is as follows:

CA = Ai + CL + Atten

For example, a corrected amplitude of 46.2 dBuV = Indicated Reading (32.5 dBuV) + Cable Loss (3.7 dB) + Attenuator (10 dB)

The "**Margin**" column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

Margin = Corrected Amplitude - Limit

6.6 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	EMI Test Receiver	ESCI 1166.5950K03	100337	2014-03-28	1 year
Solar Electronics	LISN	9252-50-R-24-N	511213	2014-07-14	1 year
TTE	Filter, High Pass	H962-150K-50-21378	K7133	2014-06-13	1 year

Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

6.7 Test Environmental Conditions

Temperature:	22-24º C
Relative Humidity:	40-41 %
ATM Pressure:	103.1-104.1 kPa

The testing was performed by Rui Zhou on 2014-12-19 in 5m chamber3.

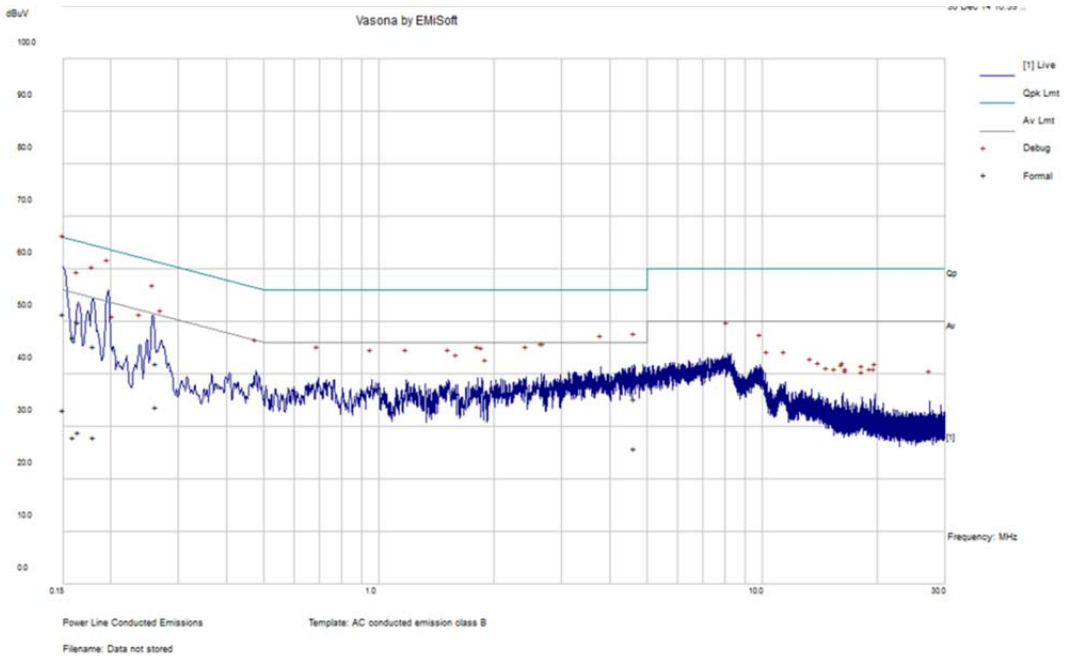
6.8 Summary of Test Results

According to the recorded data in following table, the EUT complied with the FCC 15C and IC RSS-Gen standard's conducted emissions limits, with the margin reading of:

Connection: AC/DC adapter connected to 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Line/Neutral)**	**Range (MHz)**
-13.87	0.157452	Neutral	0.15-30

6.9 Conducted Emissions Test Plots and Data

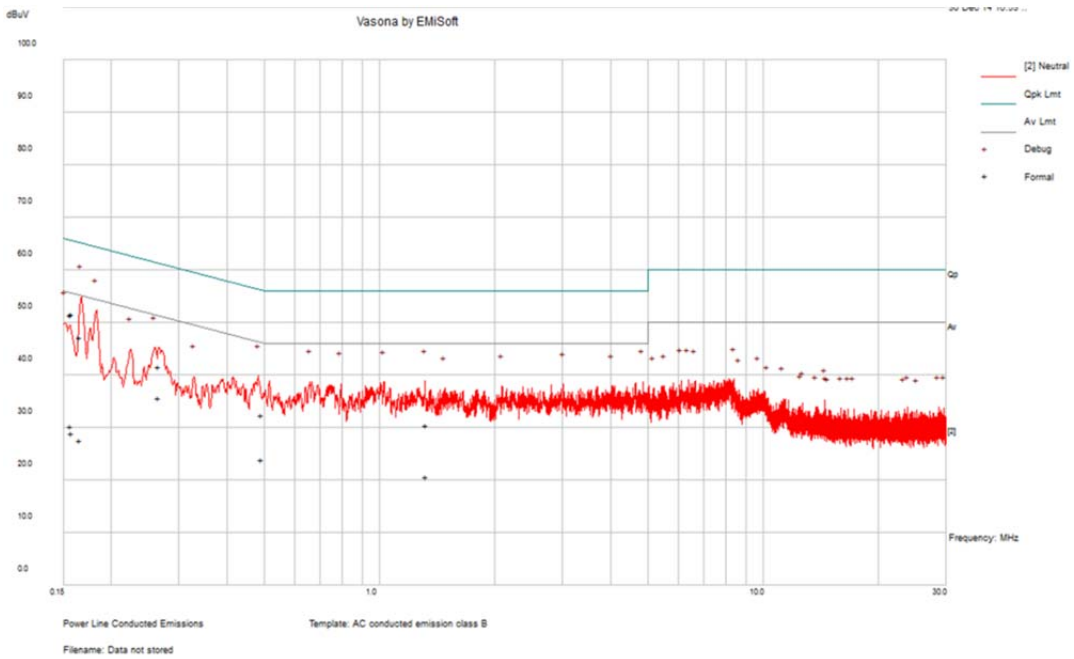
120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.150313	51.38	Line	65.98	-14.61	QP
0.18072	45.33	Line	64.45	-19.12	QP
0.164235	49.93	Line	65.25	-15.31	QP
0.262281	41.97	Line	61.36	-19.39	QP
0.159729	46.99	Line	65.48	-18.49	QP
4.646438	35.28	Line	56	-20.72	QP

Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.150313	33.22	Line	55.98	-22.76	Ave.
0.18072	27.99	Line	54.45	-26.46	Ave.
0.164235	29.02	Line	55.25	-26.23	Ave.
0.262281	33.82	Line	51.36	-17.53	Ave.
0.159729	28.04	Line	55.48	-27.43	Ave.
4.646438	25.99	Line	46	-20.01	Ave.

120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.157452	51.73	Neutral	65.6	-13.87	QP
0.165627	47.2	Neutral	65.18	-17.97	QP
0.156855	51.52	Neutral	65.63	-14.11	QP
0.265908	41.74	Neutral	61.24	-19.51	QP
0.494223	32.36	Neutral	56.1	-23.74	QP
1.324143	30.61	Neutral	56	-25.39	QP

Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.157452	28.96	Neutral	55.6	-26.64	Ave.
0.165627	27.59	Neutral	55.18	-27.59	Ave.
0.156855	30.28	Neutral	55.63	-25.35	Ave.
0.265908	35.75	Neutral	51.24	-15.49	Ave.
0.494223	23.93	Neutral	46.1	-22.16	Ave.
1.324143	20.79	Neutral	46	-25.21	Ave.

7 FCC §15.209, §15.247(d) & IC RSS-210 §A8.5 – Spurious Radiated Emissions

7.1 Applicable Standard

As per FCC §15.35(d): Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz.

As per FCC §15.209(a) and RSS-210: Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table

Frequency (MHz)	Field Strength (micro volts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

As Per FCC §15.205(a) except as show in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	960 – 1240	4. 5 – 5. 15
0.495 – 0.505	16.69475 – 16.69525	1300 – 1427	5. 35 – 5. 46
2.1735 – 2.1905	25.5 – 25.67	1435 – 1626.5	7.25 – 7.75
4.125 – 4.128	37.5 – 38.25	1645.5 – 1646.5	8.025 – 8.5
4.17725 – 4.17775	73 – 74.6	1660 – 1710	9.0 – 9.2
4.20725 – 4.20775	74.8 – 75.2	1718.8 – 1722.2	9.3 – 9.5
6.215 – 6.218	108 – 121.94	2200 – 2300	10.6 – 12.7
6.26775 – 6.26825	123 – 138	2310 – 2390	13.25 – 13.4
6.31175 – 6.31225	149.9 – 150.05	2483.5 – 2500	14.47 – 14.5
8.291 – 8.294	156.52475 – 156.52525	2690 – 2900	15.35 – 16.2
8.362 – 8.366	156.7 – 156.9	3260 – 3267	17.7 – 21.4
8.37625 – 8.38675	162.0125 –167.17	3.332 – 3.339	22.01 – 23.12
8.41425 – 8.41475	167.72 – 173.2	3 3458 – 3 358	23.6 – 24.0
12.29 – 12.293	240 – 285	3.600 – 4.400	31.2 – 31.8
12.51975 – 12.52025	322 – 335.4		36.43 – 36.5
12.57675 – 12.57725	399.9 – 410		Above 38.6
13.36 – 13.41	608 – 614		

As per FCC §15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c).

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As per IC RSS-210 A8.5 Out-of-band Emissions, In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section A8.4 (4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

7.2 Test Setup

The radiated emissions tests were performed in the 5-meter Chamber, using the setup in accordance with ANSI C63.4-2009. The specification used was the FCC 15 Subpart C and IC RSS-210 limits.

The spacing between the peripherals was 10 centimeters.

External I/O cables were draped along the edge of the test table and bundle when necessary.

7.3 Test Procedure

The measurements are base on FCC KDB 558074 D01 DTS Meas Guidance v03r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 11: Emissions in non-restricted frequency bands and section 12: Emissions in restricted frequency bands. As well as ANSI C63.4: 2009 as described below:

For the radiated emissions test, the EUT host, and all support equipment power cords was connected to the AC floor outlet.

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

The EUT is set 3 meter away from the testing antenna, which is varied from 1-4 meter, and the EUT is placed on a turntable, which is 0.8 meter above ground plane, the table shall be rotated for 360 degrees to find out the highest emission. The receiving antenna should be changed the polarization both of horizontal and vertical.

The spectrum analyzer or receiver is set as:

Below 1000 MHz:

RBW = 100 kHz / VBW = 300 kHz / Sweep = Auto

Above 1000 MHz:

(1) Peak: RBW = 1MHz / VBW = 3MHz / Sweep = Auto
(2) Average: RBW = 1MHz / VBW = 10Hz / Sweep = Auto

7.4 Corrected Amplitude & Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the Antenna Factor (AF), the Cable Loss (CL), the Attenuator Factor (Atten) and subtracting the Amplifier Gain (Ga) to indicated Amplitude (Ai) reading. The basic equation is as follows:

CA = Ai + AF + CL + Atten – Ga

For example, a corrected amplitude of 40.3 dBuV/m = Indicated Reading (32.5 dBuV) + Antenna Factor (+23.5dB) + Cable Loss (3.7 dB) + Attenuator (10 dB) - Amplifier Gain (29.4 dB)

The "**Margin**" column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

Margin = Corrected Amplitude - Limit

7.5 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Sunol Science	System Controller	SC99V	122303-1	N/R	N/R
Sunol Science	Combination Antenna	JB3	A020106-3	2014-07-24	1 year
Hewlett Packard	Pre-amplifier 1-26.5 GHz	8447D	2944A10187	2014-03-20	1 year
Agilent	Spectrum Analyzer	E4440A	MY44303352	2014-11-13	1 year
EMCO	Horn Antenna	3115	9511-4627	2014-01-06	1 year
Rohde & Schwarz	EMI Test Receiver	ESCI 1166.5950K03	100337	2014-05-28	1 year

Statement of Traceability: BACL *attests that all calibrations have been performed per the A2LA requirements, traceable to NIST.*

7.6 Test Environmental Conditions

Temperature:	22 º C
Relative Humidity:	52 %
ATM Pressure:	101.9 kPa

The testing was performed by Rui Zhou on 2014-12-19 in 5 m chamber 3.

7.7 Summary of Test Results

Maximizing procedure was performed on the six (6) highest emissions readings to ensure the EUT is compliant with all installation combinations.

According to the data hereinafter, the EUT complied with the FCC Title 47, Part 15C/IC RSS-210 standard's radiated emissions limits, and had the worst margin of:

30-1000 MHz:

Mode: Transmitting				
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Operating Channel**	**Operating Frequency**
-4.4	58.7305	Vertical	18	2440

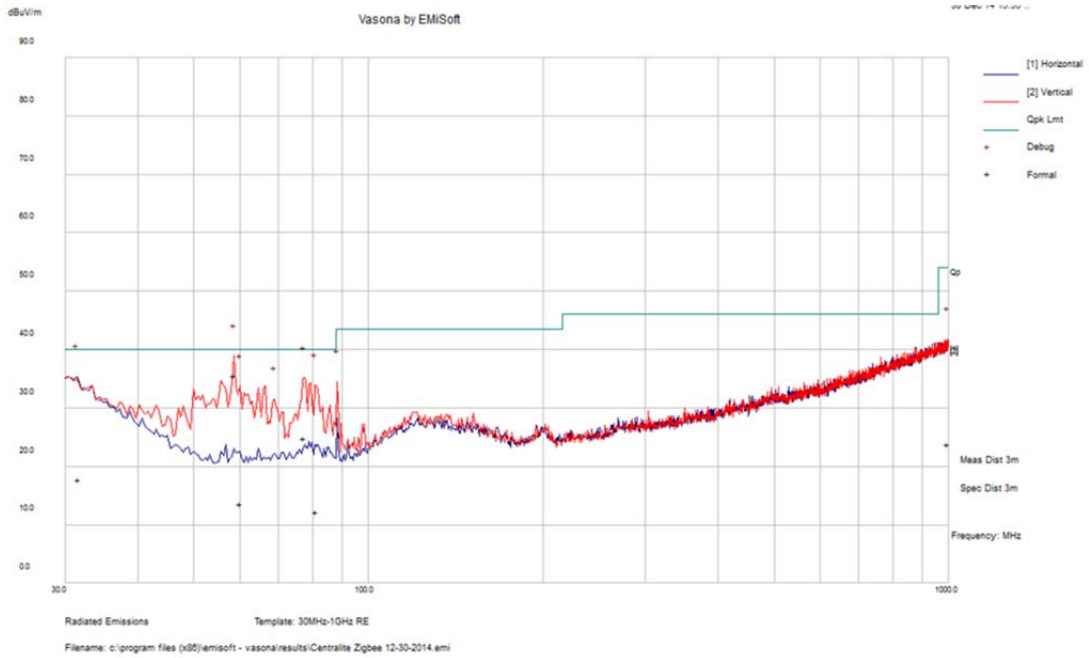
1–26 GHz:

Mode: Transmitting				
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Channel**	**Operating Frequency**
-0.92	4940	Vertical	24	2470

Please refer to the following table and plots for specific test result details

7.8 Radiated Emissions Test Results

1) 30 MHz–1 GHz, Measured at 3 meters



Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Detector (PK/QP/Ave)
58.7305	35.6	100	V	338	40	-4.4	QP
31.64175	17.74	352	H	232	40	-22.26	QP
77.49475	24.85	190	V	217	40	-15.15	QP
81.1665	12.31	101	V	290	40	-27.69	QP
60.04525	13.7	163	V	196	40	-26.3	QP
995.0053	23.84	399	V	174	54	-30.16	QP

2) Above 1 GHz, Measured at 3 meters

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC/IC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2405 MHz, measured at 3 meters											
2405	79.92	183	100	V	28.688	2.87	0	111.48	-	-	Peak
2405	80.18	249	100	H	28.688	2.87	0	111.74	-	-	Peak
2405	77.07	183	100	V	28.688	2.87	0	108.63	-	-	Ave
2405	77.85	249	100	H	28.688	2.87	0	109.41	-	-	Ave
4810	54.44	162	124	V	33.5	4.23	34.29	57.88	74	-16.12	Peak
4810	52	88	100	H	33.5	4.23	34.29	55.44	74	-18.56	Peak
4810	46.64	162	124	V	33.5	4.23	34.29	50.08	54	-3.92	Ave
4810	43.95	88	100	H	33.5	4.23	34.29	47.39	54	-6.61	Ave
7215	46.39	0	100	V	36.7	5.69	34.61	54.17	74	-19.83	Peak
7215	46.06	0	100	H	36.7	5.69	34.61	53.84	74	-20.16	Peak
7215	35.31	0	100	V	36.7	5.69	34.61	43.09	54	-10.91	Ave
7215	35.38	0	100	H	36.7	5.69	34.61	43.16	54	-10.84	Ave
9620	47.01	0	100	V	38.2	8.55	34	59.76	74	-14.24	Peak
9620	46.86	0	100	H	38.2	8.55	34	59.61	74	-14.39	Peak
9620	36.38	0	100	V	38.2	8.55	34	49.13	54	-4.87	Ave
9620	36.49	0	100	H	38.2	8.55	34	49.24	54	-4.76	Ave
2390	27.36	183	100	V	28.51	2.85	0	58.72	74	-15.28	Peak
2390	27.58	249	100	H	28.51	2.85	0	58.94	74	-15.06	Peak
2390	17.43	183	100	V	28.51	2.85	0	48.79	54	-5.21	Ave
2390	17.86	249	100	H	28.51	2.85	0	49.22	54	-4.78	Ave
Middle Channel 2440 MHz, measured at 3 meters											
2440	77.79	183	100	V	28.7	2.88	0	109.37	-	-	Peak
2440	80.45	249	100	H	28.7	2.88	0	112.03	-	-	Peak
2440	75.55	183	100	V	28.7	2.88	0	107.13	-	-	Ave
2440	78.33	249	100	H	28.7	2.88	0	109.91	-	-	Ave
4880	55.97	165	119	V	33.6	4.38	38.1	55.85	74	-18.15	Peak
4880	53.14	271	100	H	33.6	4.38	38.1	53.02	74	-20.98	Peak
4880	50.05	162	119	V	33.6	4.38	38.1	49.93	54	-4.07	Ave
4880	41.84	271	100	H	33.6	4.38	38.1	41.72	54	-12.28	Ave
7320	50.69	2	174	V	37.2	5.81	38.6	55.10	74	-18.90	Peak
7320	48.83	305	177	H	37.2	5.81	38.6	53.24	74	-20.76	Peak
7320	42.84	2	174	V	37.2	5.81	38.6	47.25	54	-6.75	Ave
7320	38.30	305	177	H	37.2	5.81	38.6	42.71	54	-11.29	Ave
9760	46.85	0	100	V	38.4	8.16	39.7	53.71	74	-20.29	Peak
9760	46.76	0	100	H	38.4	8.16	39.7	53.62	74	-20.38	Peak
9760	36.13	0	100	V	38.4	8.16	39.7	42.99	54	-11.01	Ave
9760	35.95	0	100	H	38.4	8.16	39.7	42.81	54	-11.19	Ave

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC/IC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
High Channel 2470 MHz, measured at 3 meters											
2470	79.93	183	100	V	28.73	2.92	0	111.58	-	-	Peak
2470	80.25	249	100	H	28.73	2.92	0	111.90	-	-	Peak
2470	77.85	183	100	V	28.73	2.92	0	109.50	-	-	Ave
2470	77.95	249	100	H	28.73	2.92	0	109.60	-	-	Ave
4940	58.31	173	116	V	33.8	4.45	37.98	58.58	74	-15.42	Peak
4940	54.58	272	100	H	33.8	4.45	37.98	54.85	74	-19.15	Peak
4940	52.81	173	116	V	33.8	4.45	37.98	53.08	54	-0.92	Ave
4940	44.64	272	100	H	33.8	4.45	37.98	44.91	54	-9.09	Ave
7410	48.66	310	189	V	37.3	5.87	34.61	57.22	74	-16.78	Peak
7410	49.11	131	154	H	37.3	5.87	34.61	57.67	74	-16.33	Peak
7410	38.74	310	189	V	37.3	5.87	34.61	47.30	54	-6.70	Ave
7410	40.04	131	154	H	37.3	5.87	34.61	48.60	54	-5.40	Ave
9880	47.57	0	100	V	38.7	7.44	34	59.71	74	-14.29	Peak
9880	46.94	0	100	H	38.7	7.44	34	59.08	74	-14.92	Peak
9880	36.01	0	100	V	38.7	7.44	34	48.15	54	-5.85	Ave
9880	35.63	0	100	H	38.7	7.44	34	47.77	54	-6.23	Ave
2483.5	28.83	183	100	V	28.51	2.93	0	60.27	74	-13.73	Peak
2483.5	30.21	249	100	H	28.51	2.93	0	61.65	74	-12.35	Peak
2483.5	19.62	183	100	V	28.51	2.93	0	51.06	54	-2.94	Ave
2483.5	19.51	249	100	H	28.51	2.93	0	50.95	54	-3.05	Ave

8 FCC§15.247(a)(2) & IC RSS-210 §A8.2 – 6 dB & 99% Emission Bandwidth

8.1 Applicable Standard

According to FCC §15.247(a)(2) and IC RSS-210 A8.2 (a), systems using digital modulation techniques may operate in the 902~928 MHz, 2400~2483.5 MHz, and 5725~5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz

8.2 Measurement Procedure

The measurements are base on FCC KDB 558074 D01 DTS Meas Guidance v03r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 8: DTS bandwidth

8.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Sunol Science	System Controller	SC99V	122303-1	N/R	N/R
Agilent	Spectrum Analyzer	E4440A	MY44303352	2014-11-13	1 year
EMCO	Horn Antenna	3115	9511-4627	2014-01-06	1 year

Statement of Traceability: BACL *attests that all calibrations have been performed per the A2LA requirements, traceable to NIST.*

8.4 Test Environmental Conditions

Temperature:	22º C
Relative Humidity:	52 %
ATM Pressure:	101.9 kPa

The testing was performed by Rui Zhou on 2014-12-19 in 5 m chamber 3.

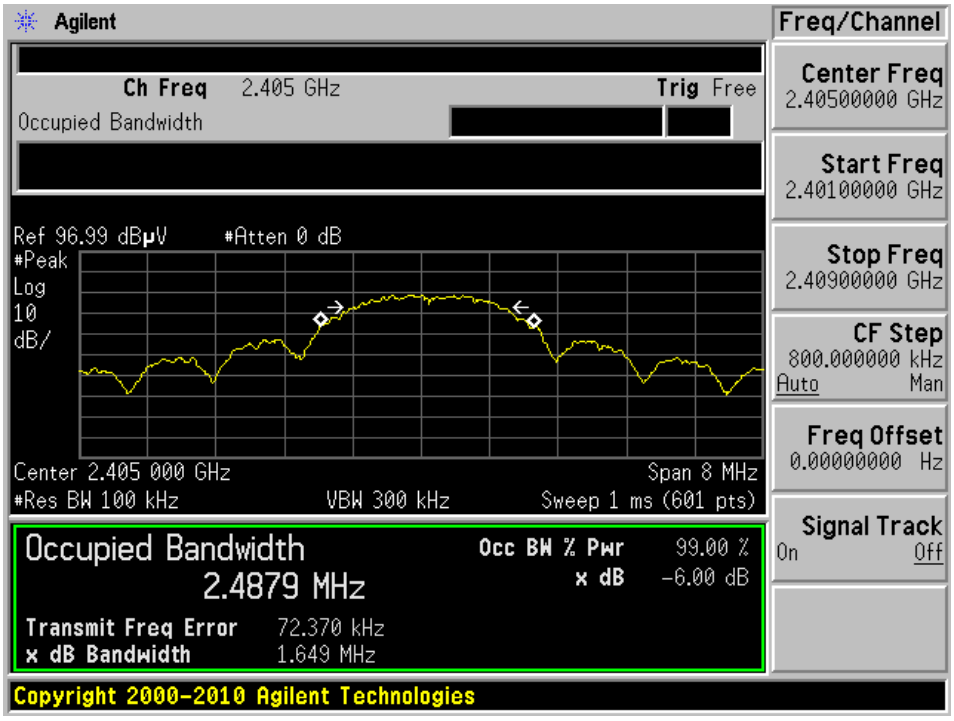
8.5 Test Results and Plots

Peak Output Power:

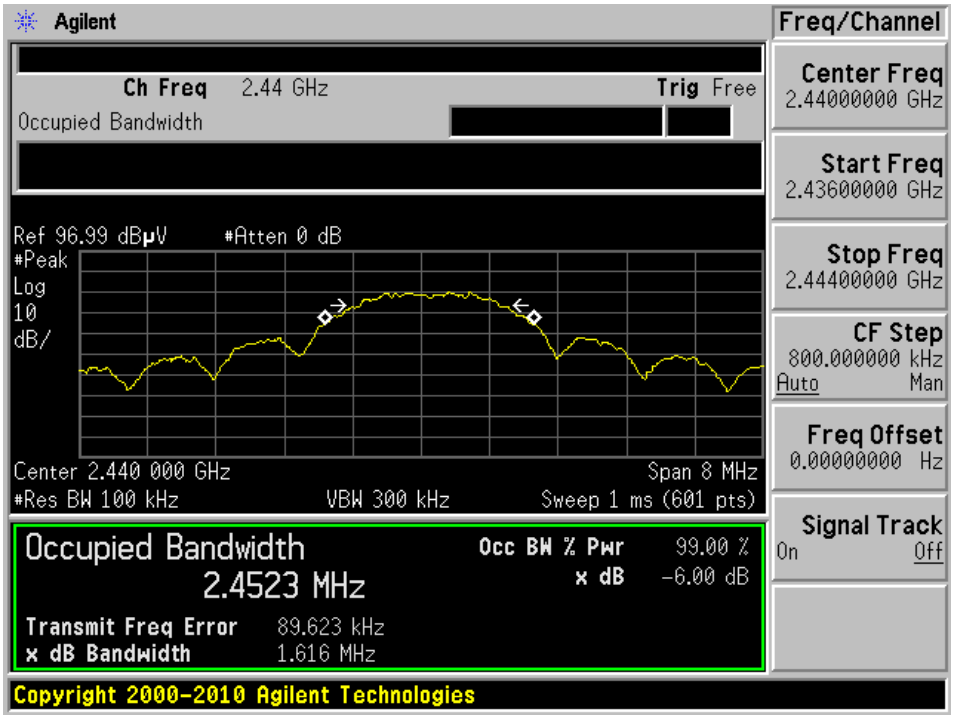
Channel	Frequency (MHz)	6 dB Emission Bandwidth (MHz)	99% Emission Bandwidth (MHz)	Limit (MHz)	Results
Low	2405	1.649	2.4879	> 0.5	Compliant
Middle	2440	1.616	2.4523	> 0.5	Compliant
High	2470	1.622	2.4771	> 0.5	Compliant

Please refer to the following plots for detailed test results

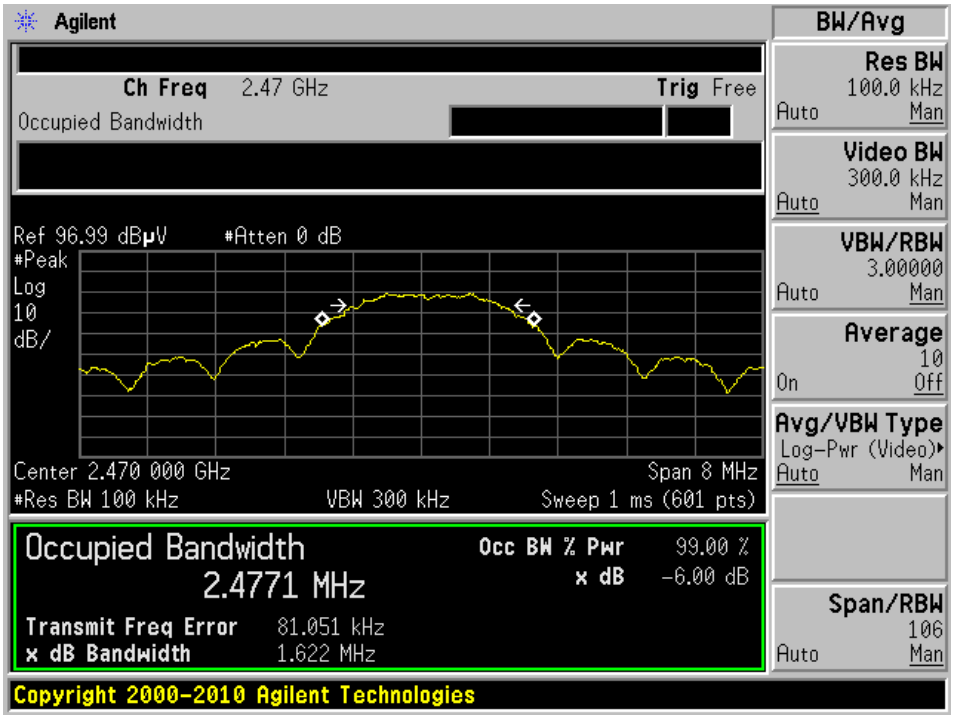
Low Channel: 2405 MHz



Middle Channel: 2440 MHz



High Channel 2470 MHz



9 FCC §15.247(b) & IC RSS-210 §A8.4 – Peak Output Power Measurement

9.1 Applicable Standard

According to FCC §15.247(b) and IC RSS-210 §A8.4 (4) for systems using digital modulation in the 902~928 MHz, 2400~2483.5 MHz, and 5725~5850 MHz bands: 1 Watt.

9.2 Measurement Procedure

The measurements are base on FCC KDB 558074 D01 DTS Meas Guidance v03r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 9: Fundamental emission output power

9.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Sunol Science	System Controller	SC99V	122303-1	N/R	N/R
Agilent	Spectrum Analyzer	E4440A	MY44303352	2014-11-13	1 year
EMCO	Horn Antenna	3115	9511-4627	2014-01-06	1 year

Statement of Traceability: BACL *attests that all calibrations have been performed per the A2LA requirements, traceable to NIST.*

9.4 Test Environmental Conditions

Temperature:	22 ºC
Relative Humidity:	52 %
ATM Pressure:	101.9 kPa

The testing was performed by Rui Zhou on 2014-12-19 in 5 m chamber 3.

9.5 Test Results

The field strength and

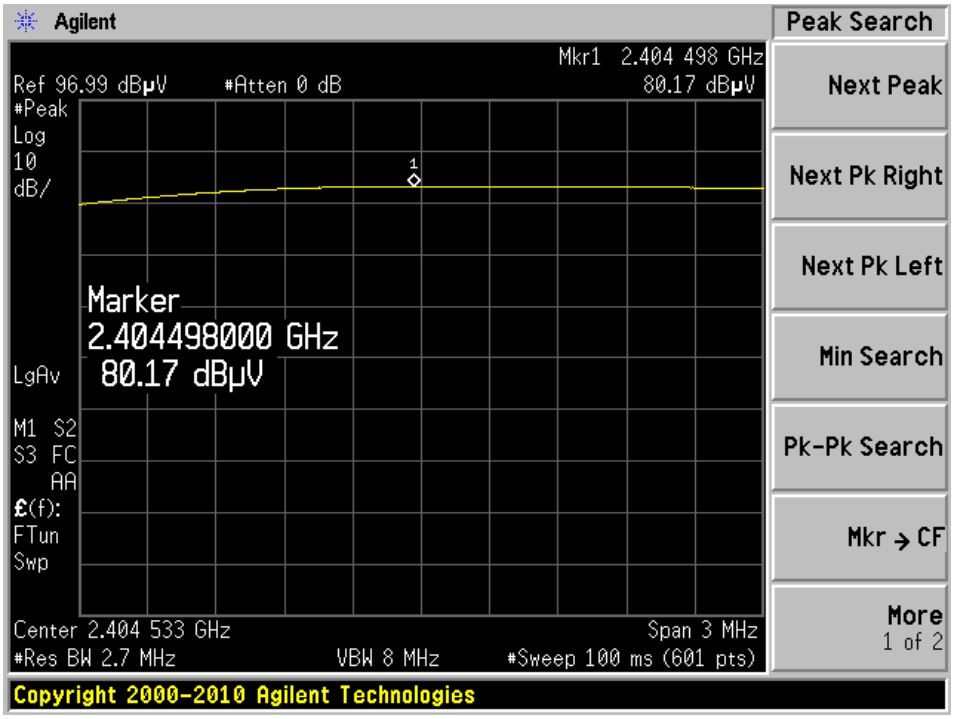
Frequency (MHz)	S.A. Reading (dBµV)	Test Antenna Factor (dB/m)	Cable Loss (dB)	Cord. Reading (dBµV/m)	EIRP (dBm)	Antenna Gain (dBi)	Output Power (dBm)	Limit (dBm)	Power Setting
2405	80.17	28.688	2.87	111.73	16.53	3.3	13.23	30	-6
2440	80.52	28.7	2.88	112.1	16.9	3.3	13.57	30	-6
2470	80.15	28.73	2.92	111.8	16.6	3.3	13.27	30	-6

The field strength converts to conducted power should be as following:

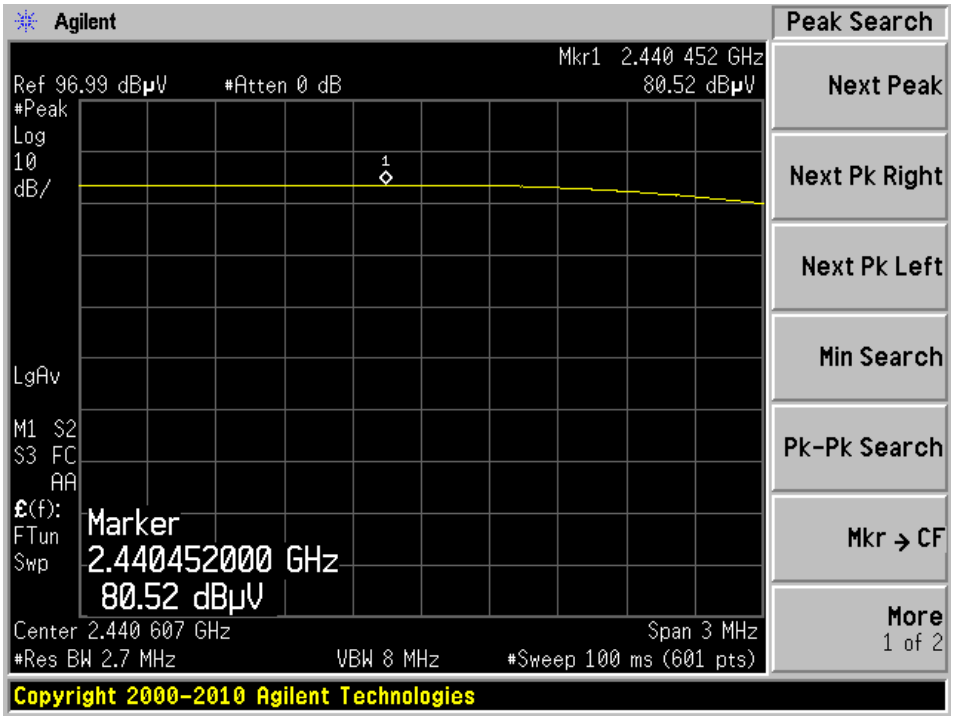
E (dBµV/m)= EIRP [dBm] + 95.2 for the distance at 3 meters.

Please refer to the following plots:

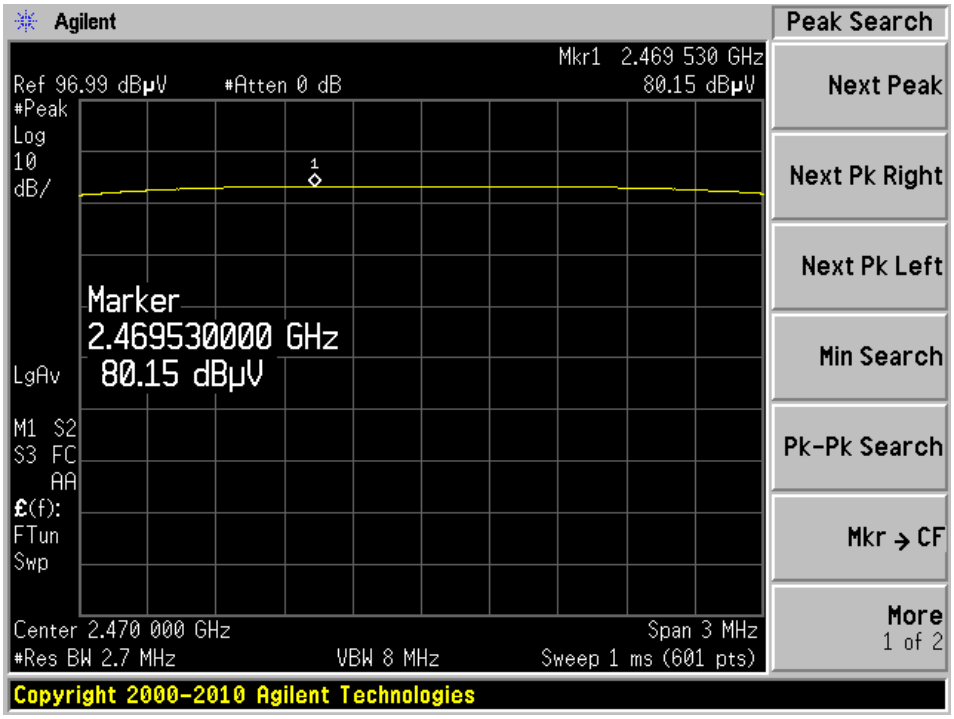
Low Channel: 2405 MHz



Middle Channel: 2440 MHz



High Channel 2470 MHz



10 FCC §15.247(d) & IC RSS-210 §A8.5 – 100 kHz Bandwidth of Band Edges

10.1 Applicable Standard

According to FCC §15.247(d), in any 100 kHz bandwidth outside the frequency bands in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emissions limits specified in §15.209(a) see §15.205(c).

According to IC Rss-210 §A8.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the radio frequency power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Tables 2 and 3 is not required.

10.2 Measurement Procedure

The measurements are base on FCC KDB 558074 D01 DTS Meas Guidance v03r01: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 13: Band-edge measurements

10.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Sunol Science	System Controller	SC99V	122303-1	N/R	N/R
Agilent	Spectrum Analyzer	E4440A	MY44303352	2014-11-13	1 year
EMCO	Horn Antenna	3115	9511-4627	2014-01-06	1 year

Statement of Traceability: BACL *attests that all calibrations have been performed per the A2LA requirements, traceable to NIST.*

10.4 Test Environmental Conditions

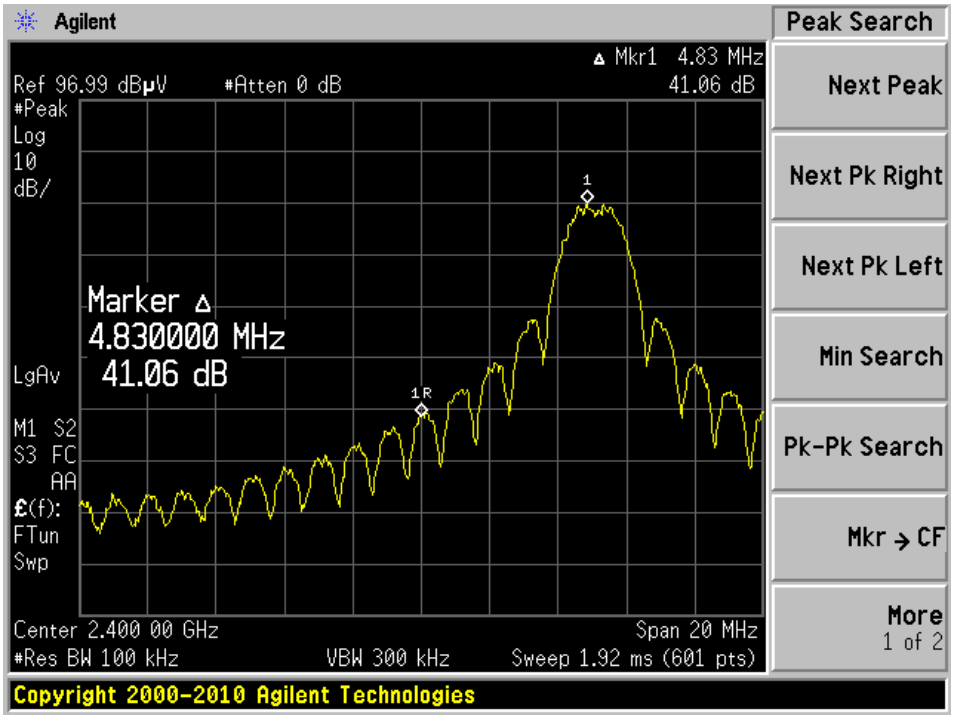
Temperature:	22 ºC
Relative Humidity:	52 %
ATM Pressure:	101.9 kPa

The testing was performed by Rui Zhou on 2014-12-19 in 5 m chamber 3.

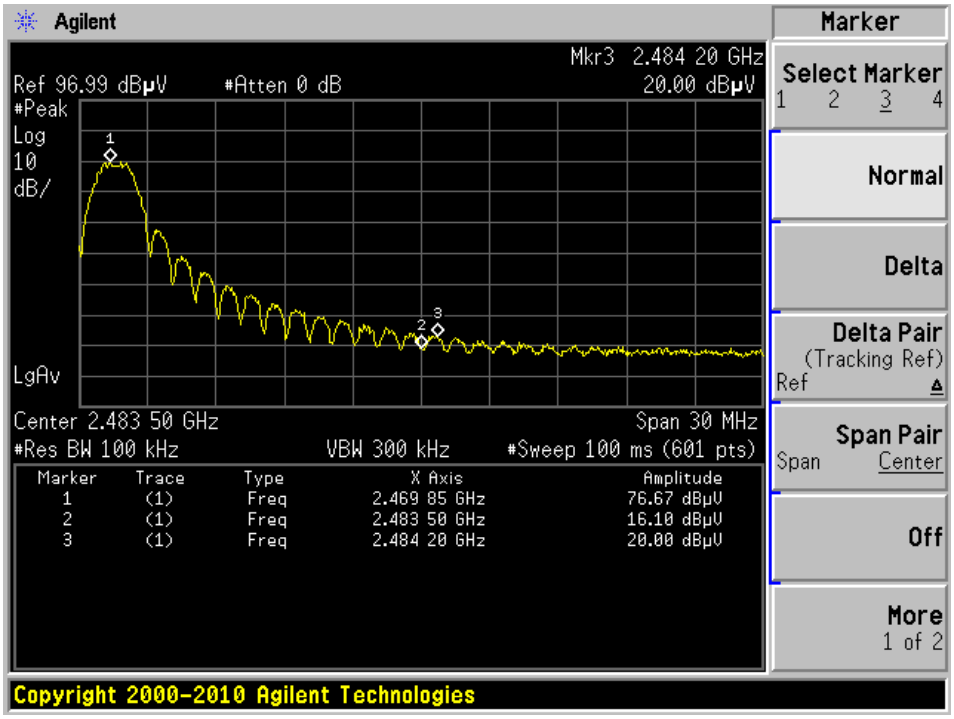
10.5 Test Results

Please refer to following pages for plots of band edge.

Low Channel 2405 MHz



High Channel 2470 MHz



11 FCC §15.247(e) & IC RSS-210 §A8.2 (b) – Power Spectral Density

11.1 Applicable Standard

According to FCC §15.247(e) and RSS-210 §A8.2 (b), for digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

11.2 Measurement Procedure

The measurements are base on FCC KDB 558074 D01 DTS Meas Guidance v03r01: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 10: Maximum power spectral density level in the fundamental emission

11.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Sunol Science	System Controller	SC99V	122303-1	N/R	N/R
Agilent	Spectrum Analyzer	E4440A	MY44303352	2014-11-13	1 year
EMCO	Horn Antenna	3115	9511-4627	2014-01-06	1 year

Statement of Traceability: BACL *attests that all calibrations have been performed per the A2LA requirements, traceable to NIST.*

11.4 Test Environmental Conditions

Temperature:	22 º C
Relative Humidity:	52 %
ATM Pressure:	101.9 kPa

The testing was performed by Rui Zhou on 2014-12-19 in 5 m chamber 3.

11.5 Test Results

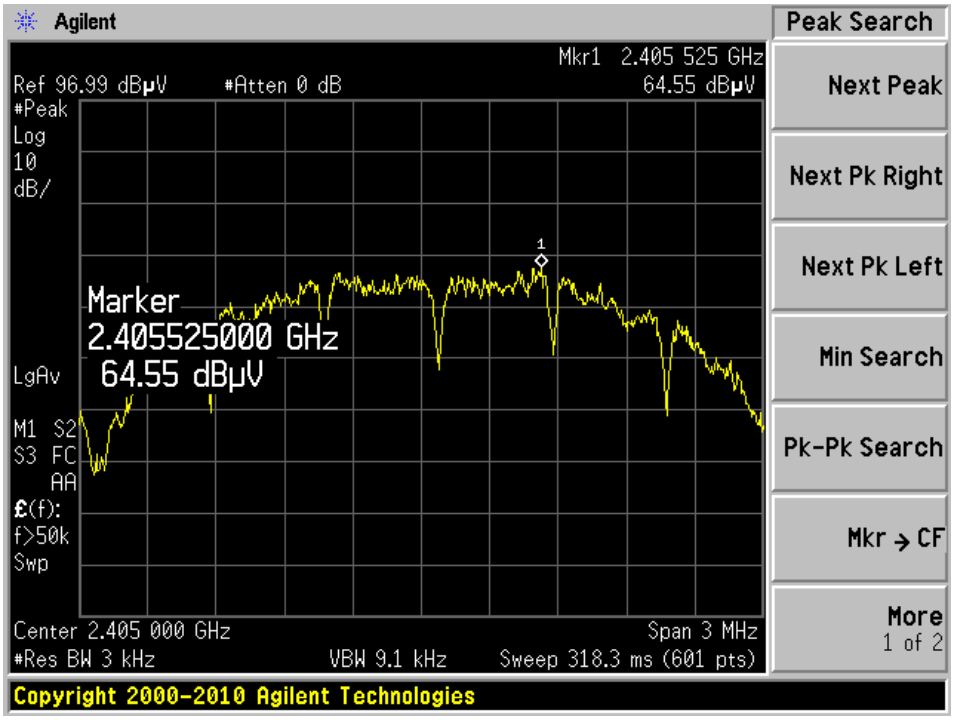
Frequency (MHz)	S.A. Reading (dBµV)	Test Antenna Factor (dB/m)	Cable Loss (dB)	Cord. Reading (dBµV/m)	EIRP (dBm/3kHz)	Antenna Gain (dBi)	Power Density (dBm/3kHz)	Limit
2405	64.55	28.688	2.87	96.11	0.91	3.3	-2.39	8
2440	64.9	28.7	2.88	96.48	1.28	3.3	-2.02	8
2470	64.28	28.73	2.92	95.93	0.73	3.3	-2.57	8

The field strength converts to conducted power should be as following:

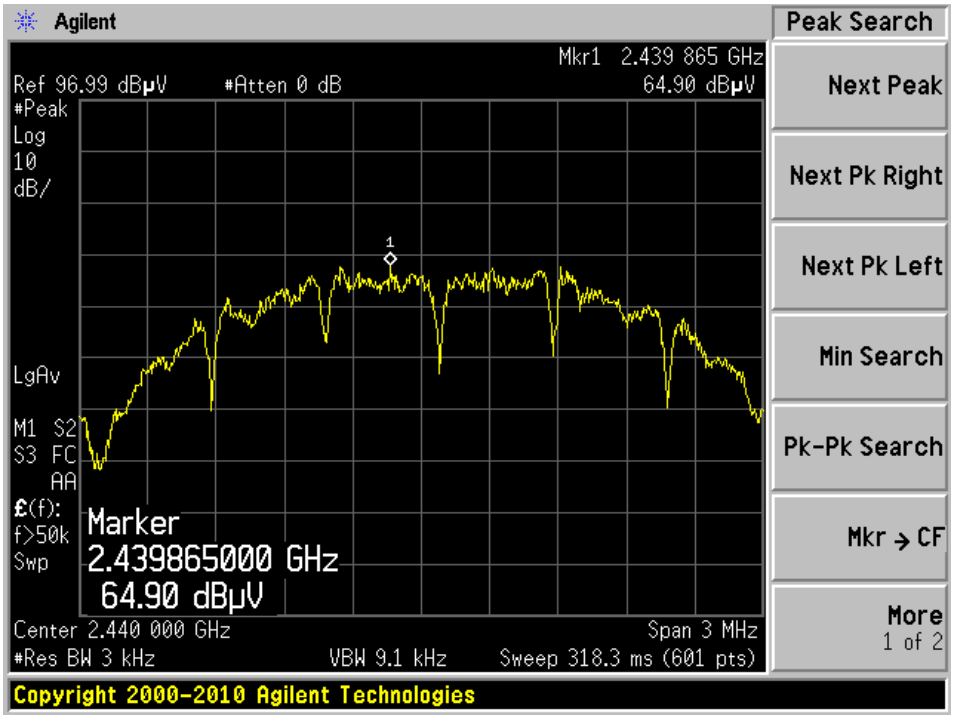
E (dBµV/m) = EIRP [dBm] + 95.2 for the distance at 3 meters.

Please refer to the following plots for detailed test results:

Low Channel: 2405 MHz



Middle Channel: 2440 MHz



High Channel 2470MHz