FCC PART 15, SUBPART C

TEST AND MEASUREMENT REPORT

For

Cisco Systems, Inc.

125 West Tasman Drive,

San Jose, CA 95134, USA

FCC ID: LDK-IR509UWP

Report Type: CIIPC	**Product Type:** 915 MHz WPAN Router w/2 Serial, 1 FE LAN

Prepared By:	Frank Wang, Test Engineer
Report Number:	R1609051-509UWP
Report Date:	2016-11-28
Reviewed By:	Todd Moy, RF Engineer

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1609051-509UWP	Original Report	2016-11-28

1 General Description

1.1 General Statements

Bay area Compliance Laboratory Corp. [BACL] hereby makes the following Statements:

- The Unit(s) described in this Test Report were received at BACL's facilities on 8 September 2016 and was in working condition upon arrival. Testing was performed on the Unit(s) described in this Test Report during the period 18 September through 3 October 2016.
- The Test Results reported herein apply only to the Unit(s) actually tested, and to substantially identical Units.
- This Test Report must not be used to claim product endorsement by A2LA, or any agency of the U.S. Government, or by any other foreign government.
- This Test Report is the property of BACL, and shall not be reproduced, except in full, without prior written approval of BACL.

1.2 Objective

This report is prepared on behalf of *Cisco System, Inc.* and their product *FCC ID: LDK-IR509UWP*, Model number: IR509UWP-915/K9.in accordance with Part 2, Subpart J, and Part 15, Subparts B and C of the Federal Communication Commission's rules.

The objective is to determine compliance with FCC Part 15.247 rules for AC Line Conducted Emissions, Output Power, Antenna Requirements, 20 dB Channel Bandwidth, Hopping Channel Separation, Number of Hopping Frequency Used, Dwell Time, 100 kHz Bandwidth of Band Edges Measurement, and Conducted and Radiated Spurious Emissions.

1.3 Agent of responsible Party

None

1.4 Responsible Party

Company Name:	Cisco Systems, Inc.
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Country:	USA
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1.5 Product Description for Equipment Under Test (EUT)

The EUT is a WPAN Industrial Routers operate in 902-928 MHz.

1.6 Mechanical Description of EUT

The EUT measures approximately 10.2 cm (W) x 12.79 cm (L) x 3 cm (H). and weighs approximately 0.4kg.

The test data gathered are from typical production sample, S/N: JMX2027X01V assigned by Cisco, Inc.

1.7 Related Submittal(s)/Grant(s)

There are no related submittals or grants included.

1.8 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

1.9 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.

Parameter	Measurement uncertainty
Occupied Channel Bandwidth	±5 %
RF output power, conducted	±0.57 dB
Unwanted Emissions, conducted	±1.57 dB
All emissions, radiated	±4.0 dB
AC power line Conducted Emission	±2.0 dB
Temperature	±2 ºC
Humidity	±5 %
DC and low frequency voltages	±1 %
Time	±2 %
Duty Cycle	±3 %

1.10 Test Facility Registrations

BACLs test facilities that are used to perform Radiated and Conducted Emissions tests are currently recognized by the Federal Communications Commission as Accredited with NIST Designation Number US1129.

BACL's test facilities that are used to perform Radiated and Conducted Emissions tests are currently registered with Industry Canada under Registration Numbers: 3062A-1, 3062A-2, and 3062A-3.

BACL is a Chinese Taipei Bureau of Standards Metrology and Inspection (BSMI) validated Conformity Assessment Body (CAB), under Appendix B, Phase I Procedures of the APEC Mutual Recognition Arrangement (MRA). BACL's BSMI Lab Code Number is: SL2-IN-E-1002R

BACL's test facilities that are used to perform AC Line Conducted Emissions, Telecommunications Line Conducted Emissions, Radiated Emissions from 30 MHz to 1 GHz, and Radiated Emissions from 1 GHz to 6 GHz are currently recognized as Accredited in accordance with the Voluntary Control Council for Interference [VCCI] Article 15 procedures under Registration Number A-0027.

1.11 Test Facility Accreditations

Bay Area Compliance Laboratories Corp. (BACL) is:

A- ***An independent, 3rd-Party, Commercial Test Laboratory accredited to ISO/IEC 17025:2005 by A2LA (Test Laboratory Accreditation Certificate Number 3297.02),*** in the fields of: Electromagnetic Compatibility and Telecommunications. Unless noted by an Asterisk (*) in the Compliance Matrix (See Section 3 of this Test Report), BACL's ISO/IEC 17025:2005 Scope of Accreditation includes all of the Test Method Standards and/or the Product Family Standards detailed in this Test Report..

BACL's ISO/IEC 17025:2005 Scope of Accreditation includes a comprehensive suite of EMC Emissions, EMC Immunity, Radio, RF Exposure, Safety and wireline Telecommunications test methods applicable to a wide range of product categories. These product categories include Central Office Telecommunications Equipment [including NEBS - Network Equipment Building Systems], Unlicensed and Licensed Wireless and RF devices, Information Technology Equipment (ITE); Telecommunications Terminal Equipment (TTE); Medical Electrical Equipment; Industrial, Scientific and Medical Test Equipment; Professional Audio and Video Equipment; Industrial and Scientific Instruments and Laboratory Apparatus; Cable Distribution Systems, and Energy Efficient Lighting.

B- ***A Product Certification Body accredited to ISO/IEC 17065:2012 by A2LA (Product Certification Body Accreditation Certificate Number 3297.03)*** to certify

- For the USA (Federal Communications Commission):
    1- All Unlicensed radio frequency devices within FCC Scopes A1, A2, A3, and A4;
    2- All Licensed radio frequency devices within FCC Scopes B1, B2, B3, and B4;
    3- All Telephone Terminal Equipment within FCC Scope C.

- For the Canada (Industry Canada):
    1 All Scope 1-Licence-Exempt Radio Frequency Devices;
    2 All Scope 2-Licensed Personal Mobile Radio Services;
    3 All Scope 3-Licensed General Mobile & Fixed Radio Services;
    4 All Scope 4-Licensed Maritime & Aviation Radio Services;
    5 All Scope 5-Licensed Fixed Microwave Radio Services
    6 All Broadcasting Technical Standards (BETS) in the Category I Equipment Standards List.

- For Singapore (Info-Communications Development Authority (IDA)):
    1 All Line Terminal Equipment: All Technical Specifications for Line Terminal Equipment – Table 1 of IDA MRA Recognition Scheme: 2011, Annex 2
    2. All Radio-Communication Equipment: All Technical Specifications for Radio-Communication Equipment – Table 2 of IDA MRA Recognition Scheme: 2011, Annex 2
- For the Hong Kong Special Administrative Region:
    1 All Radio Equipment, per KHCA 10XX-series Specifications;
    2 All GMDSS Marine Radio Equipment, per HKCA 12XX-series Specifications;
    3 All Fixed Network Equipment, per HKCA 20XX-series Specifications.

- For Japan:
  1 MIC Telecommunication Business Law (Terminal Equipment):
    - All Scope A1 - Terminal Equipment for the Purpose of Calls;
    - All Scope A2 - Other Terminal Equipment
  2 Radio Law (Radio Equipment):
    - All Scope B1 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 1 of the Radio Law
    - All Scope B2 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 2 of the Radio Law
    - All Scope B3 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 3 of the Radio Law

C- ***A Product Certification Body accredited to ISO/IEC 17065:2012 by A2LA (Product Certification Body Accreditation Certificate Number 3297.01)*** to certify Products to USA's Environmental Protection Agency (EPA) ENERGY STAR Product Specifications for:

1 Electronics and Office Equipment:
- for Telephony (ver. 3.0)
- for Audio/Video (ver. 3.0)
- for Battery Charging Systems (ver. 1.1)
- for Set-top Boxes & Cable Boxes (ver. 4.1)
- for Televisions (ver. 6.1)
- for Computers (ver. 6.0)
- for Displays (ver. 6.0)
- for Imaging Equipment (ver. 2.0)
- for Computer Servers (ver. 2.0)

2 Commercial Food Service Equipment
- for Commercial Dishwashers (ver. 2.0)
- for Commercial Ice Machines (ver. 2.0)
- for Commercial Ovens (ver. 2.1)
- for Commercial Refrigerators and Freezers

3 Lighting Products
- For Decorative Light Strings (ver. 1.5)
- For Luminaires (including sub-components) and Lamps (ver. 1.2)
- For Compact Fluorescent Lamps (CFLs) (ver. 4.3)
- For Integral LED Lamps (ver. 1.4)

4 Heating, Ventilation, and AC Products
- for Residential Ceiling Fans (ver. 3.0)
- for Residential Ventilating Fans (ver. 3.2)

5 Other
- For Water Coolers (ver. 3.0)

D- ***A NIST Designated Phase-I and Phase-II Conformity Assessment Body (CAB) for the following economies and regulatory authorities under the terms of the stated MRAs/Treaties:***

- Australia: ACMA (Australian Communication and Media Authority) – APEC Tel MRA -Phase I;
- Canada: (Innovation, Science, and Economic Development Canada - ISEDC) Foreign Certification Body – FCB – APEC Tel MRA -Phase I & Phase II;
- Chinese Taipei (Republic of China – Taiwan):
  - BSMI (Bureau of Standards, Metrology and Inspection) APEC Tel MRA -Phase I;
  - NCC (National Communications Commission) APEC Tel MRA -Phase I;
- European Union:

  - Radio & Teleterminal Equipment (R&TTE) Directive 1995/5/EC
    US -EU EMC & Telecom MRA CAB
- Hong Kong Special Administrative Region: (Office of the Telecommunications Authority – OFTA)
  APEC Tel MRA -Phase I & Phase II
- Israel – US-Israel MRA Phase I
- Republic of Korea (Ministry of Communications - Radio Research Laboratory) APEC Tel MRA -Phase I
- Singapore: (Infocomm Development Authority - IDA) APEC Tel MRA -Phase I & Phase II;
- Japan: VCCI - Voluntary Control Council for Interference US-Japan Telecom Treaty VCCI Side Letter-
- USA:
  - ENERGY STAR Recognized Test Laboratory – US EPA
  - Telecommunications Certification Body (TCB) – US FCC;
- Vietnam: APEC Tel MRA -Phase I;

2 System Test Configuration

2.1 Justification

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 and peak power across all data rates, bandwidths, and modulations.

2.2 EUT Exercise Software

Tera Term was used to connect to the EUT and commands lines was used to control the EUT.

2.3 Special Equipment

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

2.4 Equipment Modifications

No modifications were made to the EUT.

2.5 Internal Configuration

Manufacturer	Description	Model	Serial Number
Cisco	Power Board	73-15682-03 01	-
Cisco	Main Board	73-15681-02 09	-

2.6 Local Support Equipment

Manufacturer	Description	Model	Serial Number
DELL	Laptop	Latitude E6530	-

2.7 External I/O Cabling List and Details

Cable Description	Length (m)	To	From
USB Cable	<1M	Laptop	EUT
RF Cable	<1M	EUT	PSA

2.8 Power Supply List and Details

Manufacturer	Description	Model	Part Number
Cisco	DC adapter	COM8910ARA	DTM170902A7

3 Summary of Test Results

Results reported relate only to the product tested.

FCC Rules	Description of Test	Results
§15.247(i), §2.1091	RF Exposure	Compliant
§15.203	Antenna Requirements	Compliant
§15.207(a)	AC Line Conducted Emissions	Compliant
§15.205, §15.209, §15.247(d)	Spurious Radiated Emissions	Compliant
§15.247(a)(1)	20 dB Channel Bandwidth	Compliant
§15.247(b)(2)	Maximum Peak Output Power	Compliant
§15.247(d)	Band Edge	Compliant
§15.247(a)(1)	Hopping Channel Separation	Compliant
§15.247(a)(1)(i)	Dwell Time	Compliant
§15.247(a)(1)(i)	Number of Hopping Channels	Compliant

4 FCC §2.1091 & §15.247 (i) – 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

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

Maximum peak output power at antenna input terminal (dBm):	29.86
Maximum peak output power at antenna input terminal (mW):	968.28
Prediction distance (cm):	20
Prediction frequency (MHz):	915
Maximum Antenna Gain, typical (dBi):	5.00
Maximum Antenna Gain (numeric):	3.162
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.609
MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	0.610

The device is compliant with the requirement MPE limit for uncontrolled exposure.

5 FCC §15.203 – 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.

And according to FCC §15.247 (b) (4), if transmitting antennas of directional gain greater than 6 dBi are used the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

5.2 Antenna List

Antenna Type/Pattern	Antenna Gain (dBi)
directional multi-beam steerable dipole antenna array, Chassis-mounted, Integrated directly onto the chassis without any external coaxial connections	5

The EUT used an external antenna; therefore it complies with the antenna requirement.

6 FCC §15.207– 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.

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 C63.10-2013 measurement procedure. The specification used was FCC §15.207 limits.

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

The AC/DC power adapter of the EUT was connected with LISN-1 which provided 120 V/60 Hz AC power.

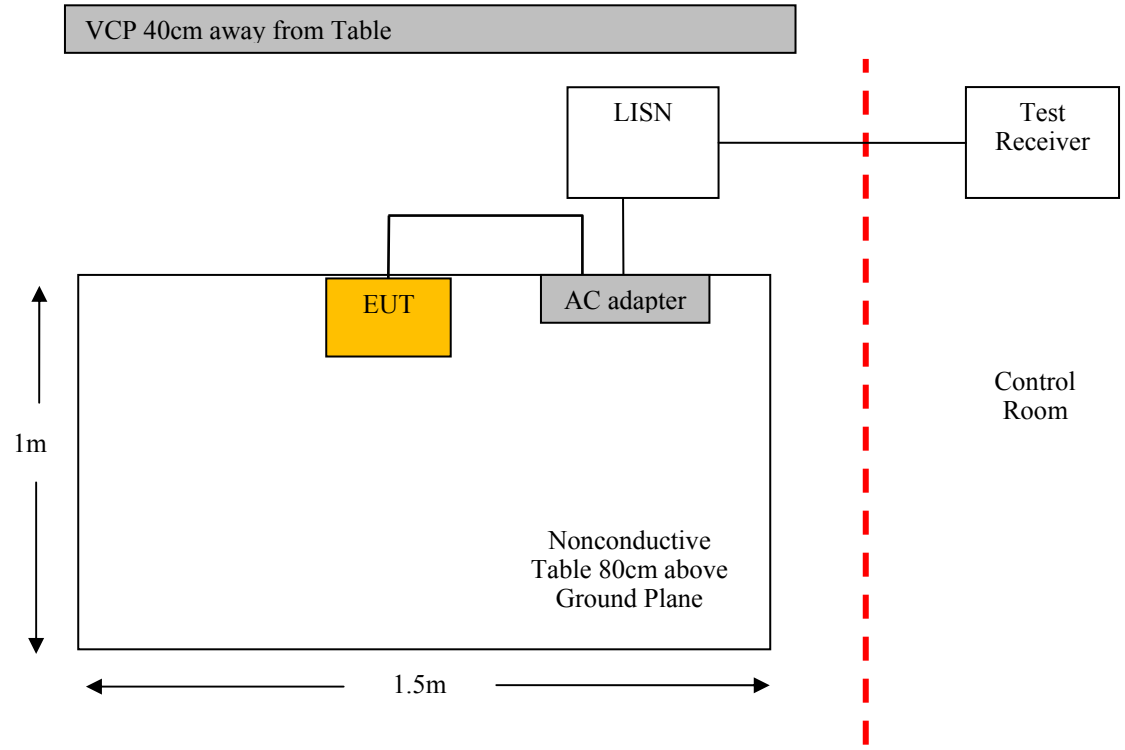
6.3 Test Procedure

During the conducted emissions test, the power adapter of the EUT was connected to a power strip on the table which is then connected to the LISN.

Maximizing procedure was performed on the six (6) 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



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	100044	2016-06-24	1 year
Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101963	2016-07-14	1year
Keysight Technologies	RF Limiter	11867A	MY42242931	2015-12-15	1year
Solar Electronics Company	High Pass Filter	Type 7930-100	7930150204	2016-03-09	1 year
Wireless Solutions	Conducted Emission Cable	LMR 400	691	2016-06-29	1year
FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160129	2016-04-11	1year
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

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:	20° C
Relative Humidity:	45 %
ATM Pressure:	101.94 kPa

The testing was performed by Frank Wang on 2016-11-10 at 5m 3.

6.8 Summary of Test Results

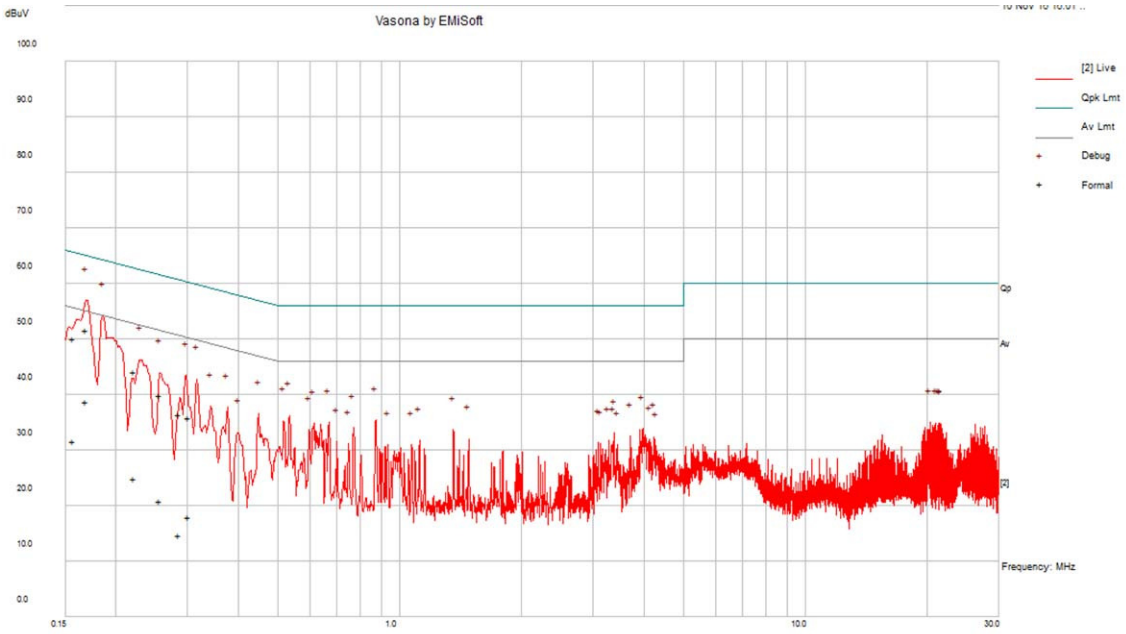
According to the recorded data in following table, the EUT complied with the FCC Part 15 standard's conducted emissions limits, with the margin reading of:

Connection: AC/DC adapter connected to 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Line/Neutral)**	**Range (MHz)**
13.44	0.168453	Line	0.15-30

6.9 Conducted Emissions Test Plots and Data

Worst case – Middle channel

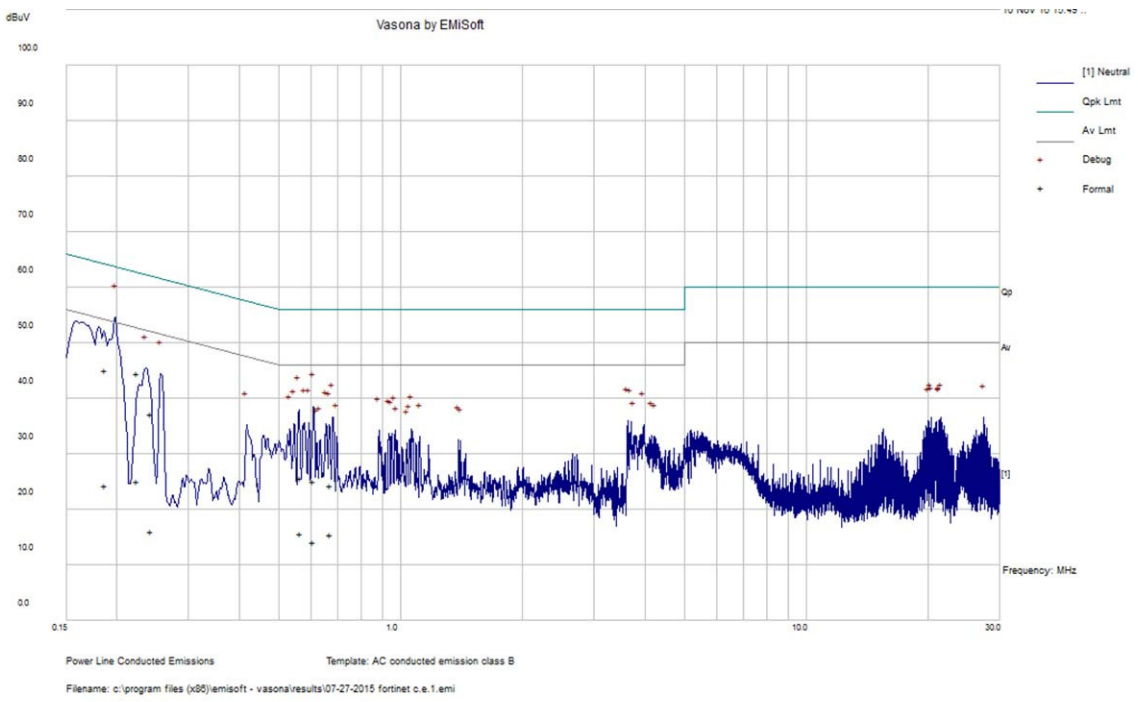
120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.156361	50.14	Line	65.66	-15.51	QP
0.168453	51.59	Line	65.04	-13.44	QP
0.221883	44.15	Line	62.75	-18.60	QP
0.286359	36.53	Line	60.63	-24.10	QP
0.301432	35.96	Line	60.20	-24.24	QP
0.256442	39.98	Line	61.55	-21.56	QP

Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.156361	31.72	Line	55.66	-23.94	Ave.
0.168453	38.81	Line	55.04	-16.23	Ave.
0.221883	24.95	Line	52.75	-27.80	Ave.
0.286359	14.81	Line	50.63	-35.81	Ave.
0.301432	17.99	Line	50.20	-32.22	Ave.
0.256442	20.91	Line	51.55	-30.64	Ave.

120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.187451	45.20	Neutral	64.15	-18.95	QP
0.224239	44.47	Neutral	62.66	-18.19	QP
0.242474	37.26	Neutral	62.01	-24.75	QP
0.608427	25.18	Neutral	56	-30.82	QP
0.568348	25.79	Neutral	56	-30.21	QP
0.67139	24.43	Neutral	56	-31.57	QP

Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.187451	24.38	Neutral	54.15	-29.77	Ave.
0.224239	25.06	Neutral	52.66	-27.60	Ave.
0.242474	16.17	Neutral	52.01	-35.84	Ave.
0.608427	14.18	Neutral	46	-31.82	Ave.
0.568348	15.67	Neutral	46	-30.33	Ave.
0.67139	15.58	Neutral	46	-30.42	Ave.

7 FCC §15.205, §15.209 & §15.247(d) – 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): 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 0.495 – 0.505 2.1735 – 2.1905 4.125 – 4.128 4.17725 – 4.17775 4.20725 – 4.20775 6.215 – 6.218 6.26775 – 6.26825 6.31175 – 6.31225 8.291 – 8.294 8.362 – 8.366 8.37625 – 8.38675 8.41425 – 8.41475 12.29 – 12.293 12.51975 – 12.52025 12.57675 – 12.57725 13.36 – 13.41	16.42 – 16.423 16.69475 – 16.69525 25.5 – 25.67 37.5 – 38.25 73 – 74.6 74.8 – 75.2 108 – 121.94 123 – 138 149.9 – 150.05 156.52475 – 156.52525 156.7 – 156.9 162.0125 –167.17 167.72 – 173.2 240 – 285 322 – 335.4 399.9 – 410 608 – 614	960 – 1240 1300 – 1427 1435 – 1626.5 1645.5 – 1646.5 1660 – 1710 1718.8 – 1722.2 2200 – 2300 2310 – 2390 2483.5 – 2500 2690 – 2900 3260 – 3267 3.332 – 3.339 3 3458 – 3 358 3.600 – 4.400	4. 5 – 5. 15 5. 35 – 5. 46 7.25 – 7.75 8.025 – 8.5 9.0 – 9.2 9.3 – 9.5 10.6 – 12.7 13.25 – 13.4 14.47 – 14.5 15.35 – 16.2 17.7 – 21.4 22.01 – 23.12 23.6 – 24.0 31.2 – 31.8 36.43 – 36.5 Above 38.6

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).

7.2 Test Setup

The radiated emissions tests were performed in the 5-meter Chamber, using the setup in accordance with ANSI C63.10-2013. The specification used was the FCC 15 Subpart C 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 based on ANSI C63.10: 2013 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 or 1.5 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 = 1MHz / 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
Agilent	Analyzer, Spectrum	E4440A	US45303156	2016-01-19	16 months
Sunol Sciences	Controller, System	SC104V	122303-1	Cal. Not required	Cal. Not required
Sunol Sciences	Antenna, Biconi-Log	JB3	A020106-2	2015-07-11	2 years
Agilent	Pre-amplifier	8447D	2944A10187	2016-03-23	1 year
HP/ Agilant	Pre-amplifier	8449B OPT HO2	3008A0113	2016-05-23	1 year
Sunol Sciences	Antenna, Horn	DRH-118	A052704	2015-03-09	2 years
Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950K03	100044	2015-07-23	2 years
IW	Armored High Frequency Cable	DC 1531	KPS-1501A3960KPS	2016-08-05	1 year
-	SMA cable	-	C0005	Each Time[1]	-
-	N-Type Cable	-	C00013	2016-04-28	1 year
-	N-Type Cable	-	C00014	2016-05-28	1 year
Wainwright Instruments	Wainwright Instruments	Band Reject Filter	1	Each Time[1]	-
Vasona	Test software	V6.0 build 11	10400213	Cal. Not required	Cal. Not required

Note 1: cable and attenuator included in the test set-up will be calibrated each time before testing.
Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

7.6 Test Environmental Conditions

Temperature:	21 °C
Relative Humidity:	42 %
ATM Pressure:	101.44 kPa

The testing was performed by Frank Wang on 2016-11-10 at chamber 3.

7.7 Summary of Test Results

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

30-1000 MHz:

Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Range (MHz)**
-0.33	970.787	Vertical	30-1000

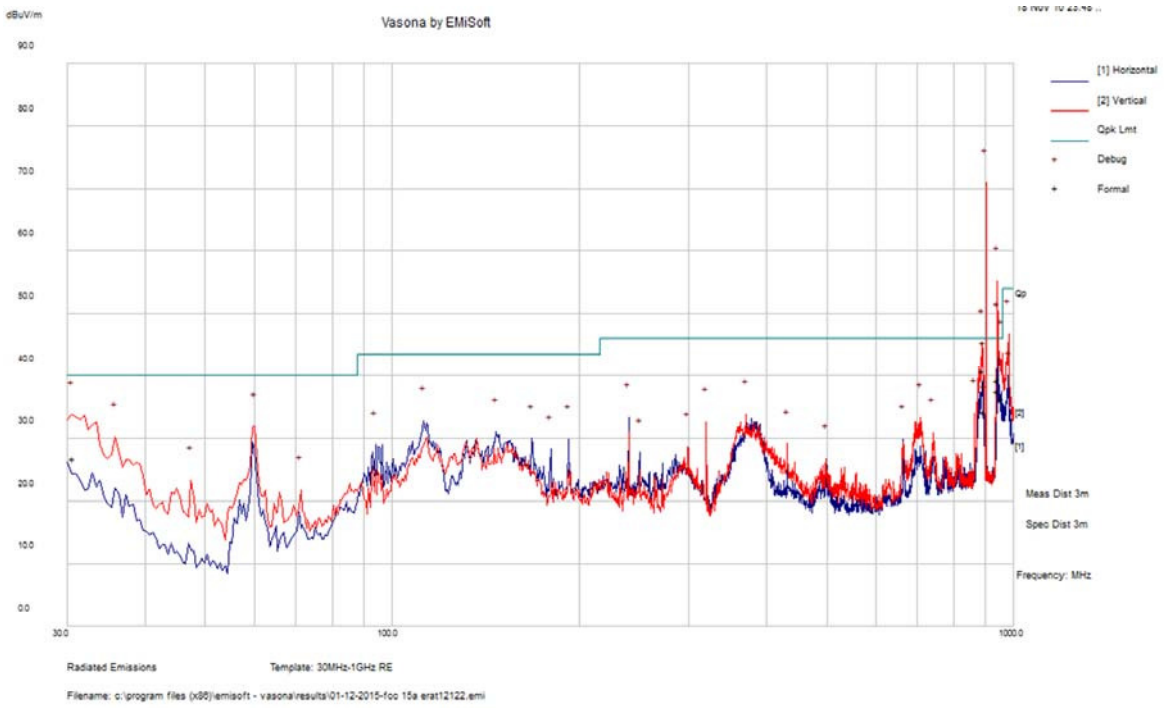
1 – 10 GHz:

Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Range (GHz)**
-12.403	2707.90	Vertical	1-10

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

7.8 Radiated Emissions Test Data and Plots

1) 30 MHz – 1 GHz, Measured at 3 meters



Frequency (MHz)	Cord. Reading (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Detector (PK/QP/Ave.)
941.5505	37.51	113	V	187	46	-8.49	QP
942.842	39.18	106	V	133	46	-6.82	QP
890.3075	40.76	100	V	162	46	-5.24	QP
957.4443	36.37	137	V	147	46	-9.63	QP
894.7255	34.18	109	V	151	46	-11.82	QP
30.622	26.76	111	V	63	40	-13.24	QP

2) 1 GHz–10 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		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel: 902.5 MHz											
1805.18	58.97	40	191	H	27.218	4.39	30.75	59.828	89.65[1]	-29.822	Peak
1805.20	69.93	143	143	V	27.218	4.39	30.75	70.788	99.60[1]	-28.812	Peak
2707.42	53.87	249	193	H	29.077	5.73	39.46	49.217	74	-24.783	Peak
2707.42	42.56	249	196	H	29.077	5.73	39.46	37.907	54	-16.093	Ave
2707.90	54.83	0	300	V	29.077	5.73	39.46	50.177	74	-23.823	Peak
2707.90	46.25	0	300	V	29.077	5.73	39.46	41.597	54	-12.403	Ave
3610	45.80	0	100	H	31.431	6.7	39.2	44.731	74	-29.269	Peak
3610	33.30	0	100	H	31.431	6.7	39.2	32.231	54	-21.769	Ave
3609.40	45.97	0	100	V	31.431	6.7	39.2	44.901	74	-29.099	Peak
3609.40	33.31	0	100	V	31.431	6.7	39.2	32.241	54	-21.759	Ave
Middle Channel: 915 MHz											
1829.76	59.43	360	100	H	27.218	4.39	30.75	60.288	94.67[1]	-34.382	Peak
1830.18	69.59	193	300	V	27.218	4.39	30.75	70.448	102.67[1]	-32.222	Peak
2742.32	48.31	0	100	H	29.077	5.73	39.46	43.657	74	-30.343	Peak
2742.32	34.33	0	100	H	29.077	5.73	39.46	29.677	54	-24.323	Ave
2742.45	47.51	0	100	V	29.077	5.73	39.46	42.857	74	-31.143	Peak
2742.45	35.95	0	100	V	29.077	5.73	39.46	31.297	54	-22.703	Ave
4575.08	47.56	0	100	H	31.431	6.7	39.2	46.491	74	-27.509	Peak
4575.08	33.67	0	100	H	31.431	6.7	39.2	32.601	54	-21.399	Ave
4574.23	46.18	0	100	V	31.431	6.7	39.2	45.111	74	-28.889	Peak
4574.23	33.66	0	100	V	31.431	6.7	39.2	32.591	54	-21.409	Ave
High Channel: 927.5 MHz											
1854.73	68.26	0	108	H	27.218	4.39	30.75	69.118	91.63[1]	-22.512	Peak
1854.71	78.14	218	290	V	27.218	4.39	30.75	78.998	101.55[1]	-22.552	Peak
2780.9	50.65	0	100	H	28.969	5.73	39.46	45.889	74	-28.111	Peak
2780.9	36.81	0	100	H	28.969	5.73	39.46	32.049	54	-21.951	Ave
2780.13	50.38	0	100	V	28.969	5.73	39.46	45.619	74	-28.381	Peak
2780.13	36.81	0	100	V	28.969	5.73	39.46	32.049	54	-21.951	Ave
3710.23	47.03	0	100	H	31.892	6.7	39.2	46.422	74	-27.578	Peak
3710.23	34.83	0	100	H	31.892	6.7	39.2	34.222	54	-19.778	Ave
3709.55	47.54	0	100	V	31.892	6.7	39.2	46.932	74	-27.068	Peak
3709.55	35.44	0	100	V	31.892	6.7	39.2	34.832	54	-19.168	Ave

Note[1]: The peak limit for the twice harmonic channel (1800 MHz) is 20dB lower than the fundamental signal which is list in the following form.
Note[2]: Fundamental signal can been seen in the following form.

Fundamental signal Field Strength

Channel	Frequency (MHz)	S.A. Reading (dBµV)	Antenna Factor (dB/m)	Cable Loss (dB)	Cord. Reading (dBµV/m)	Ant. Polarity (H/V)
Low	902.5	85.42	22.46	1.77	109.65	H
Low	902.5	95.37	22.46	1.77	119.60	V
Middle	915	90.44	22.46	1.77	114.67	H
Middle	915	98.44	22.46	1.77	122.67	V
High	927.5	87.47	22.39	1.77	111.63	H
High	927.5	97.39	22.39	1.77	121.55	V

8 FCC §15.247(a) – Hopping Channel Bandwidth

8.1 Applicable Standard

According to FCC §15.247(a) (1): frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

8.2 Measurement Procedure

Span = approximately 2 to 5 times the 99% occupied bandwidth, centered on a hopping channel

RBW = 1% to 5 % of the 99% occupied bandwidth

VBW = 3RBW

Sweep = auto

Detector function = peak

Trace = max hold

8.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US45303156	2016-01-19	1 year
-	SMA cable	-	C0001	Each Time[1]	N/A
-	10 dB attenuator	-	-	Each time[1]	N/A

Note[1]: These items shall be calibrated before every test.
***Statement of Traceability: BACL Corp.** attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

8.4 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	33 %
ATM Pressure:	101.2 kPa

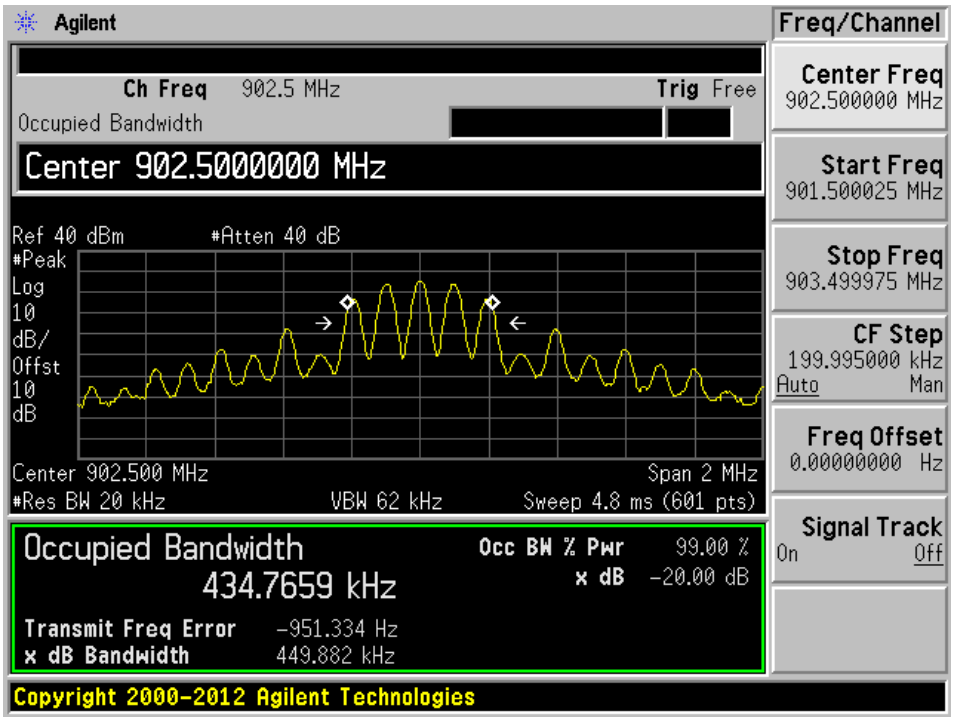
The testing was performed by Frank Wang on 2016-09-19 at the RF site.

8.5 Test Results

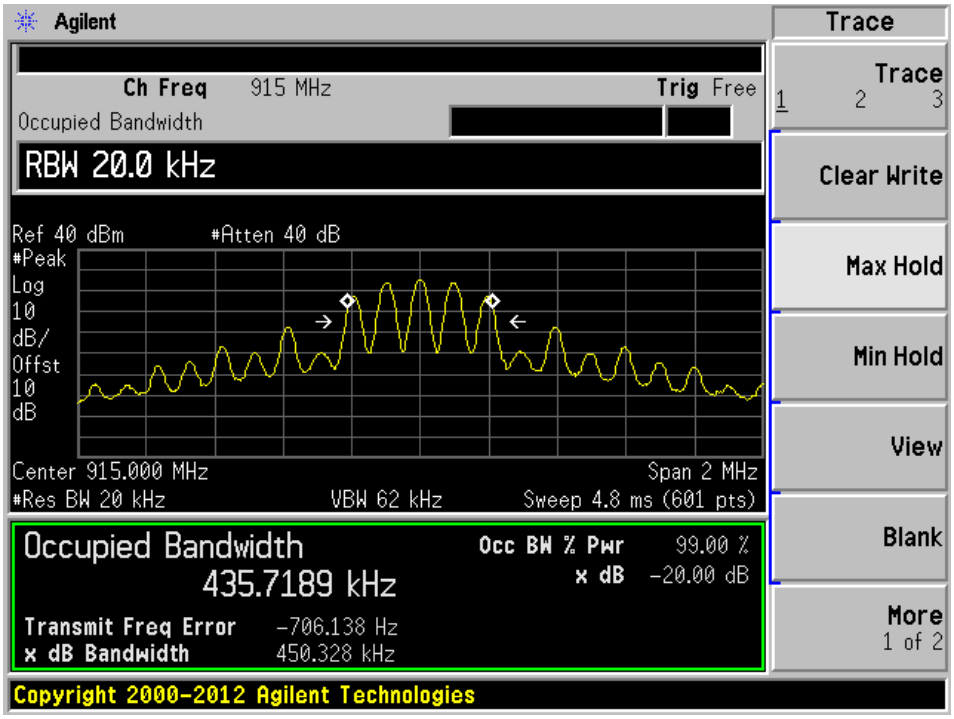
Channel	Frequency (MHz)	20 dB Emission Bandwidth (kHz)	99% Emission Bandwidth (kHz)	Results
Low	902.5	449.88	434.77	Compliant
Middle	915	450.33	435.72	Compliant
High	927.5	449.98	434.62	Compliant

Please refer to the following plots for detailed test results.

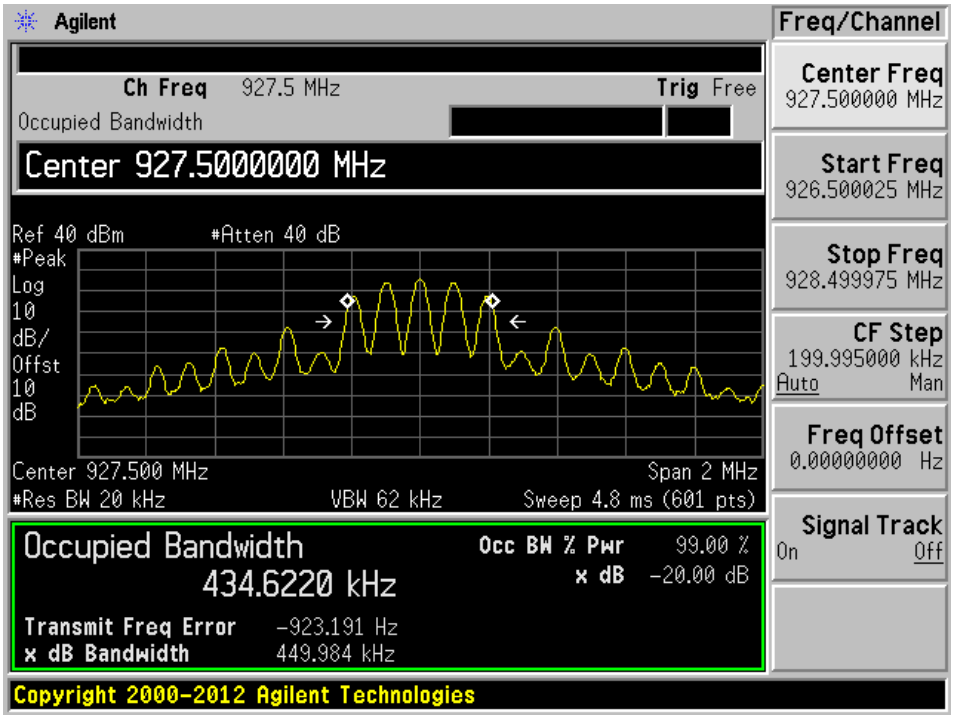
Low channel



Middle channel



High channel



9 FCC §15.247(a) – Hopping Channel Separation

9.1 Applicable Standard

According to FCC §15.247(a)(1): Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

9.2 Measurement Procedure

Span = wide enough to capture the peaks of two adjacent channels

RBW = 30 % of the channel spacing; adjust as necessary to best identify the center of each individual channel

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

9.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US45303156	2016-01-19	1 year
-	SMA cable	-	C0001	Each Time[1]	N/A
-	10dB attenuator	-	-	Each time[1]	N/A

Note[1]: These items shall be calibrated before every test.
Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

9.4 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	33 %
ATM Pressure:	101.2 kPa

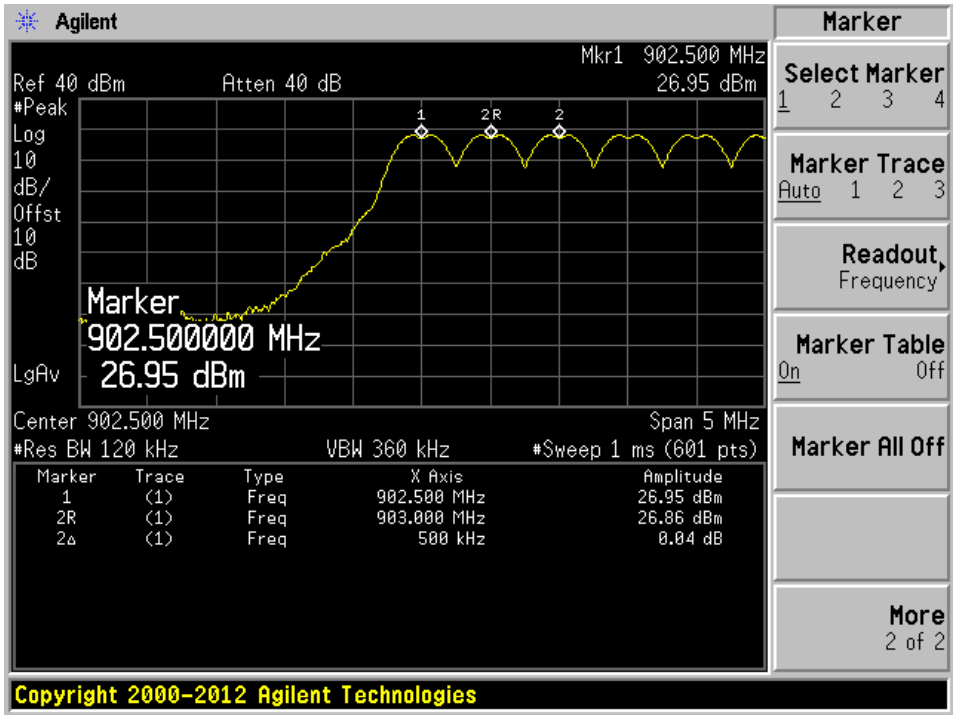
The testing was performed by Frank Wang on 2016-9-20 at the RF site.

9.5 Test Results

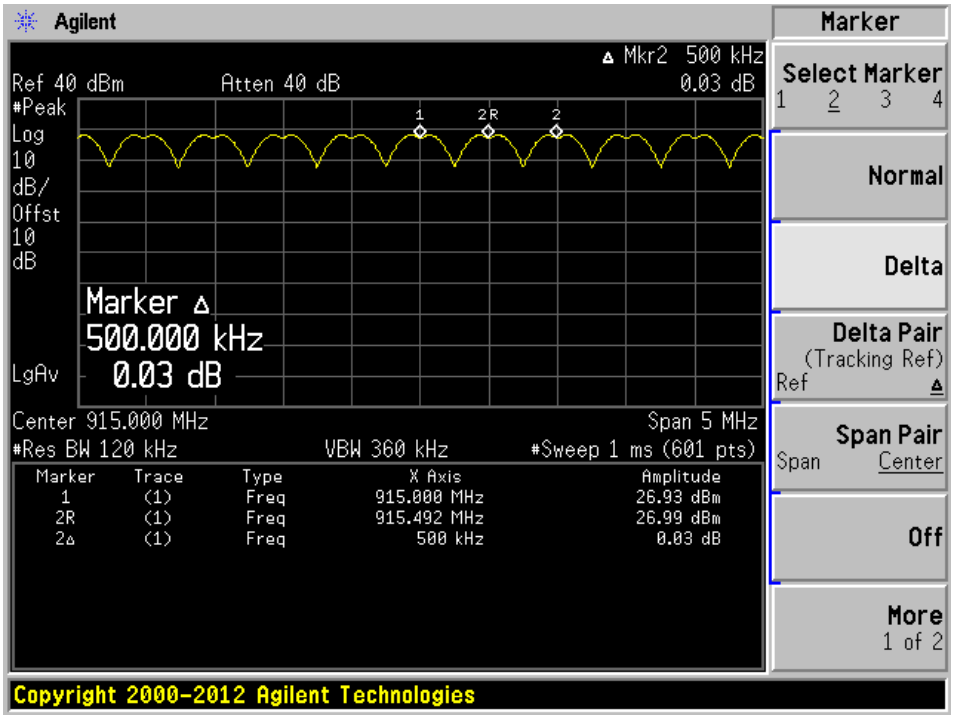
Channel	Frequency (MHz)	Channel Separation (kHz)	Limit > 20 dB OBW (kHz)	Result
Low	902.5	500	449.88	Pass
Middle	915	500	450.33	Pass
High	927.5	500	449.98	Pass

Please refer to the following plots.

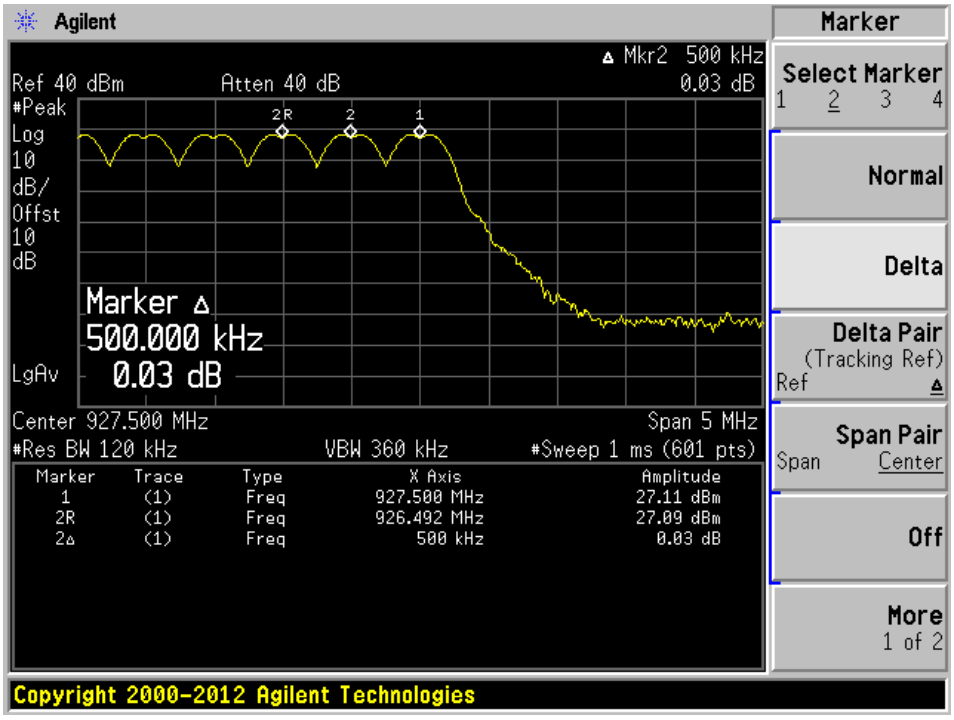
Low channel



Middle Channel



High Channel



10 FCC §15.247(a)(1)(i) - Number of Hopping Channels

10.1 Applicable Standard

According to FCC §15.247(a)(1)(i), for frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

10.2 Measurement Procedure

Span = the frequency band of operation

RBW < 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

10.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US45303156	2016-01-19	1 year
-	SMA cable	-	C0001	Each Time[1]	N/A
-	10 dB attenuator	-	-	Each time[1]	N/A

Note[1]: These items shall be calibrated before every test.
Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

10.4 Test Environmental Conditions

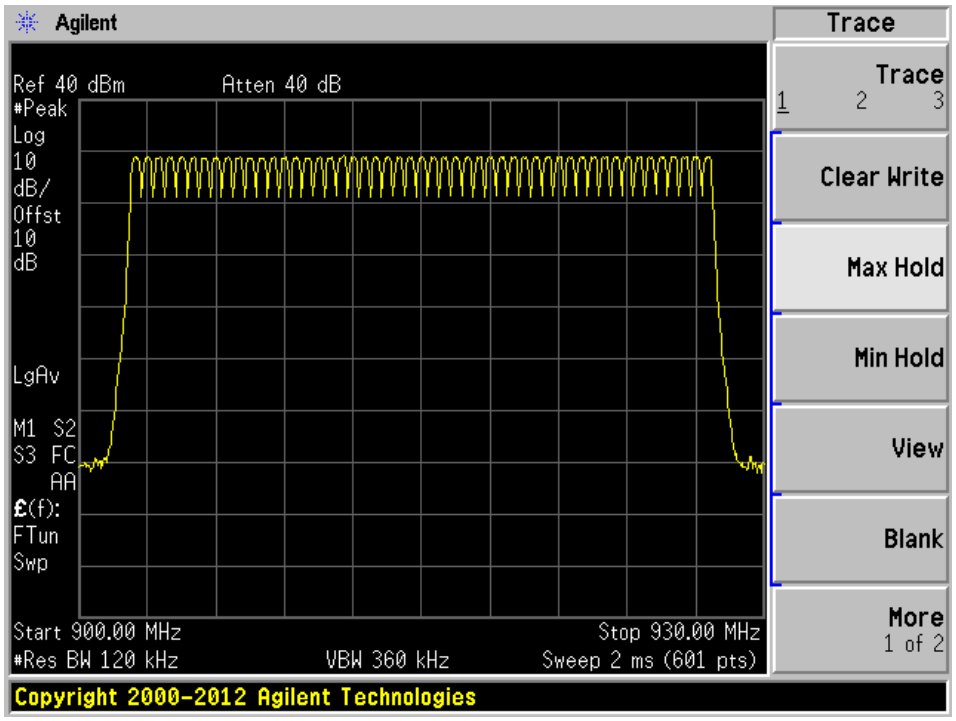
Temperature:	23° C
Relative Humidity:	33 %
ATM Pressure:	101.2 kPa

The testing was performed by Frank Wang on 2016-09-20 at the RF site.

10.5 Test Results

Total 51 channels; please refer to the plots hereinafter.

Hopping Channel Number: Total 51 Channels



11 FCC §15.247(a) - Dwell Time

11.1 Applicable Standard

According to FCC §15.247 (a)(1)(i), for frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

11.2 Measurement Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

Span: Zero span, centered on a hopping channel.

RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / *T*, where *T* is the expected dwell time per channel.

Sweep: As necessary to capture the entire dwell time per hopping channel

Detector function: Peak.

Trace: Max hold.

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

(Number of hops in the period specified in the requirements) =
(number of hops on spectrum analyzer) × (period specified in the requirements / analyzer sweep time)

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirements. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.

The measured transmit time and time between hops shall be consistent with the values described in the operational description for the EUT.

11.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US45303156	2016-01-19	1 year
-	SMA cable	-	C0001	Each Time[1]	N/A
-	10 dB attenuator	-	-	Each time[1]	N/A

Note[1]: These items shall be calibrated before every test.
***Statement of Traceability: BACL Corp.** attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

11.4 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	33 %
ATM Pressure:	101.2 kPa

The testing was performed by Frank Wang on 2016-09-20 at the RF site.

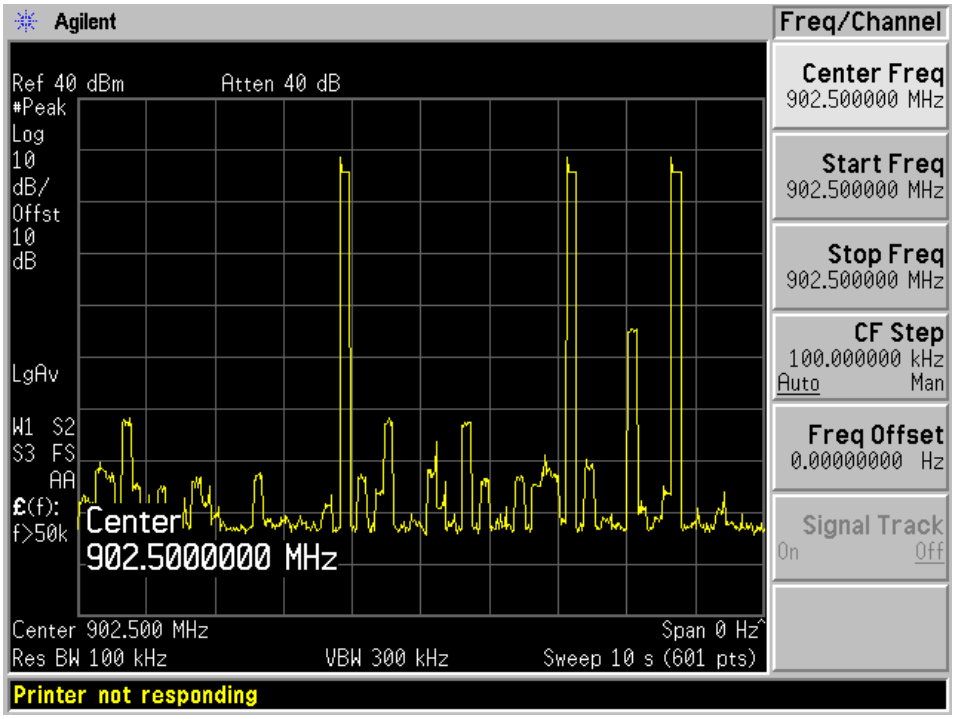
11.5 Test Results

Channel	Pulse Width (ms)	Dwell Time (sec)	Limit (sec)	Results
Low	125	0.375	0.4	Compliant
Middle	125.8	0.3774	0.4	Compliant
High	126.7	0.3801	0.4	Compliant

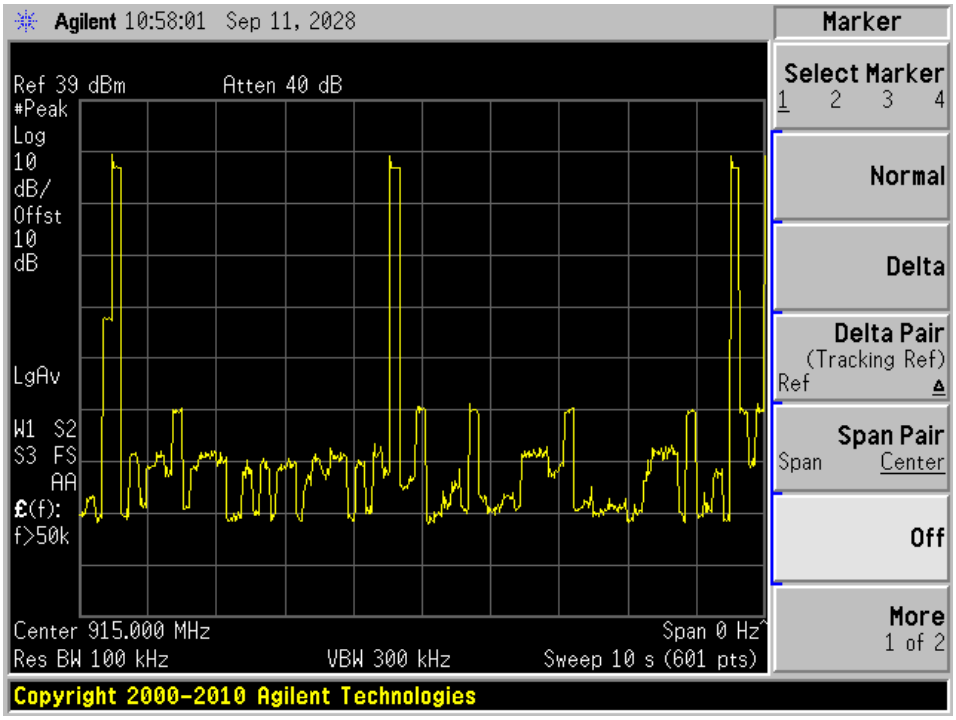
Note: There are 3 pulses in each 10 seconds.

Please refer to following plots:

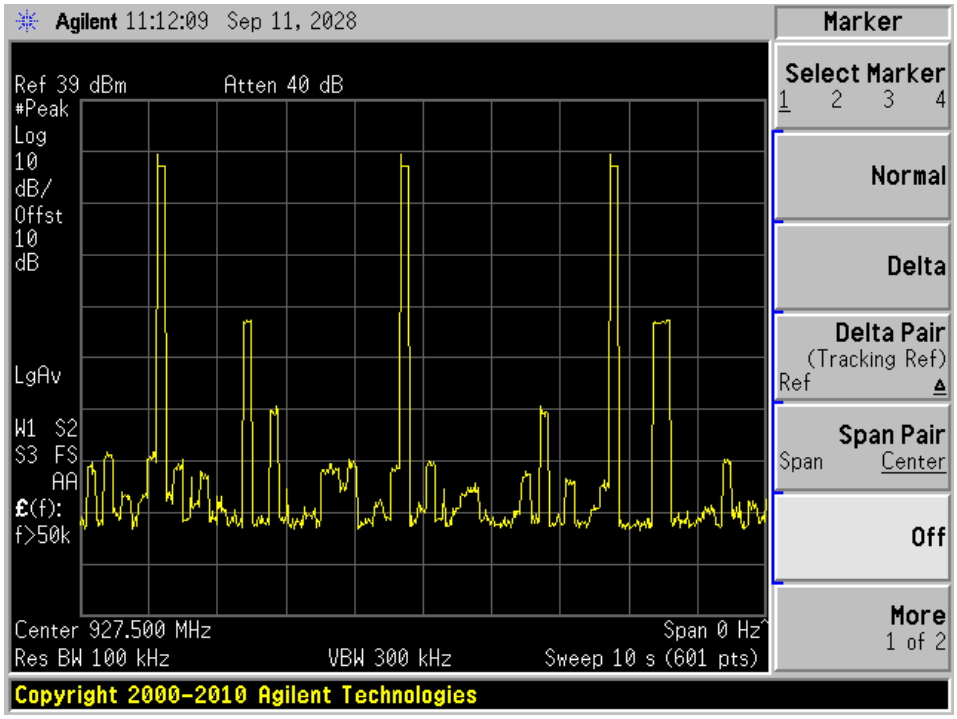
Low channel



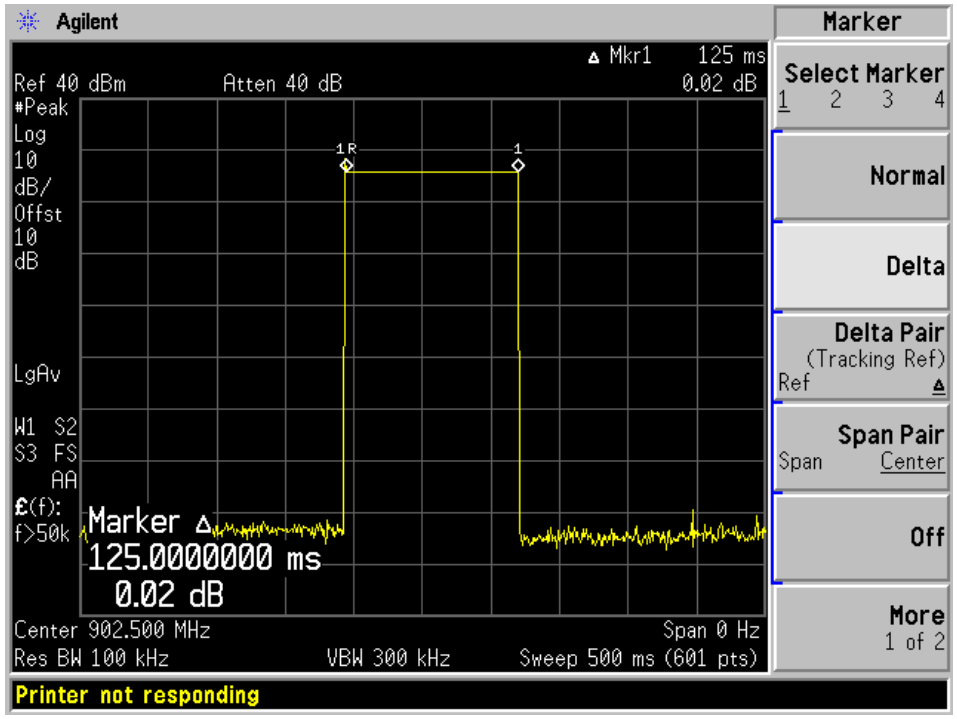
Middle channel



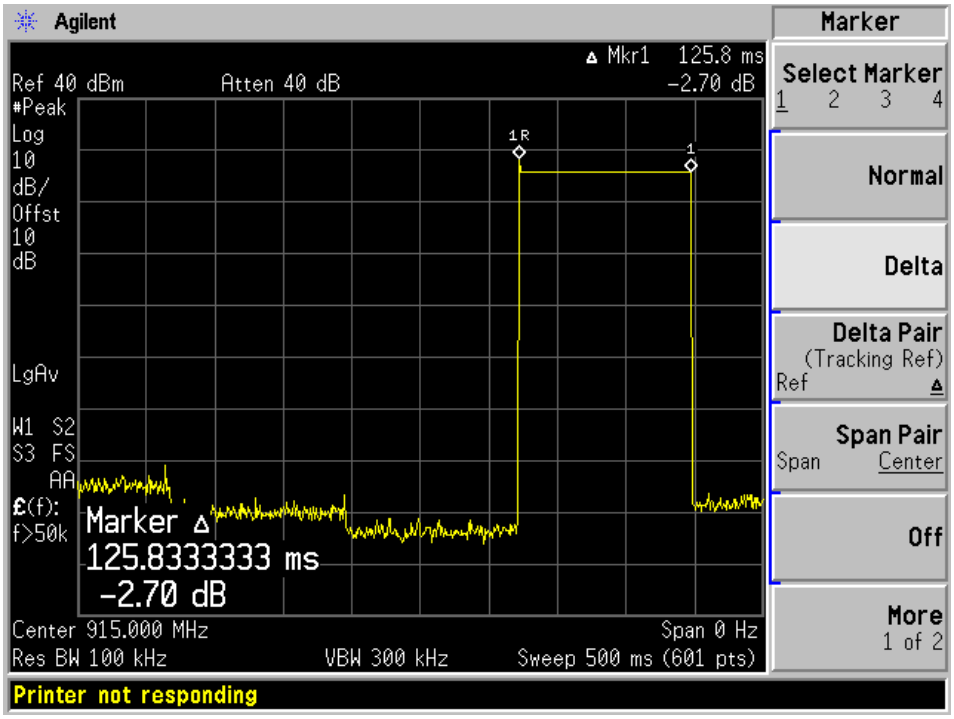
High channel



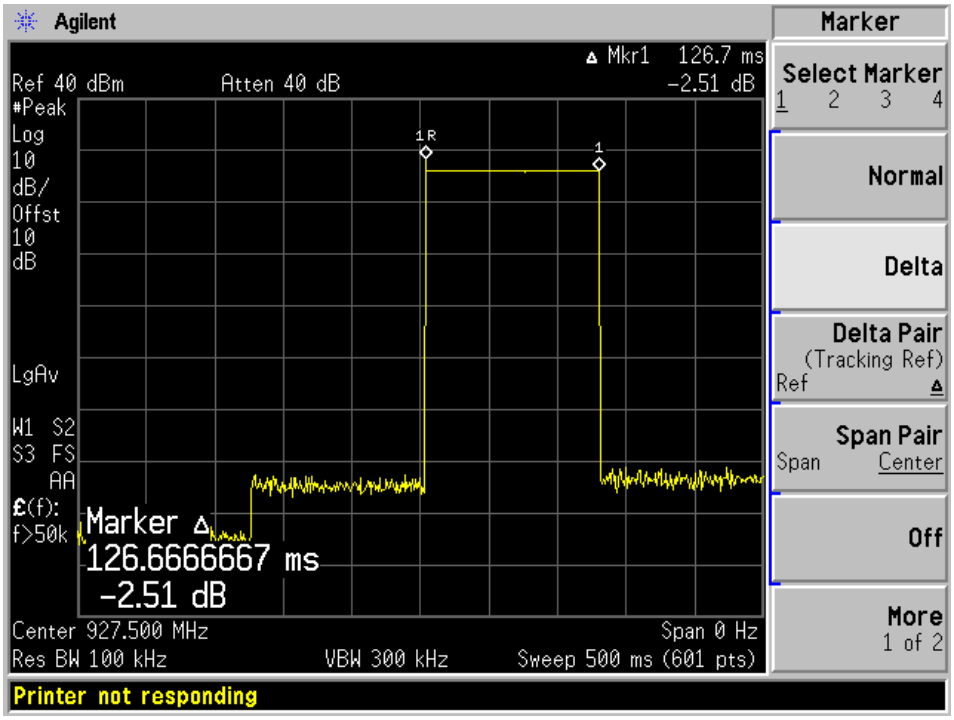
Low channel



Middle channel



High channel



12 FCC §15.247(b) – Peak Output Power Measurement

12.1 Applicable Standard

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

12.2 Measurement Procedure

Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel

RBW > the 20 dB bandwidth of the emission being measured

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

12.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US45303156	2016-01-19	1 year
-	SMA cable	-	C0001	Each Time[1]	N/A
-	10 dB attenuator	-	-	Each time[1]	N/A

Note[1]: These items shall be calibrated before every test.
***Statement of Traceability: BACL Corp.** attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

12.4 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	33 %
ATM Pressure:	101.2 kPa

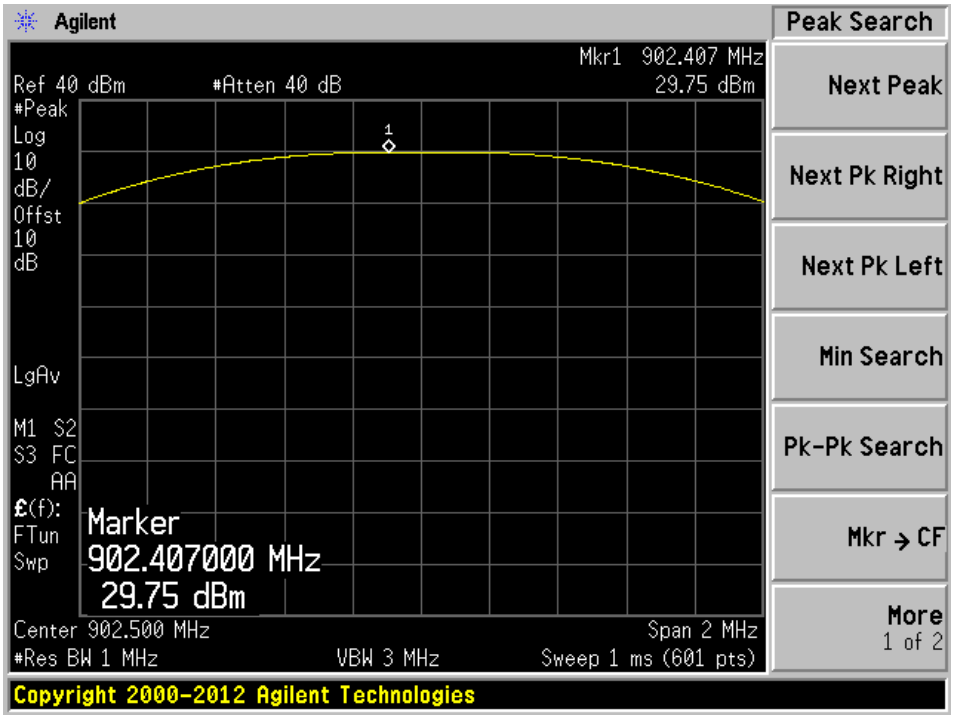
The testing was performed by Frank Wang on 2016-09-21 at the RF site.

12.5 Test Results

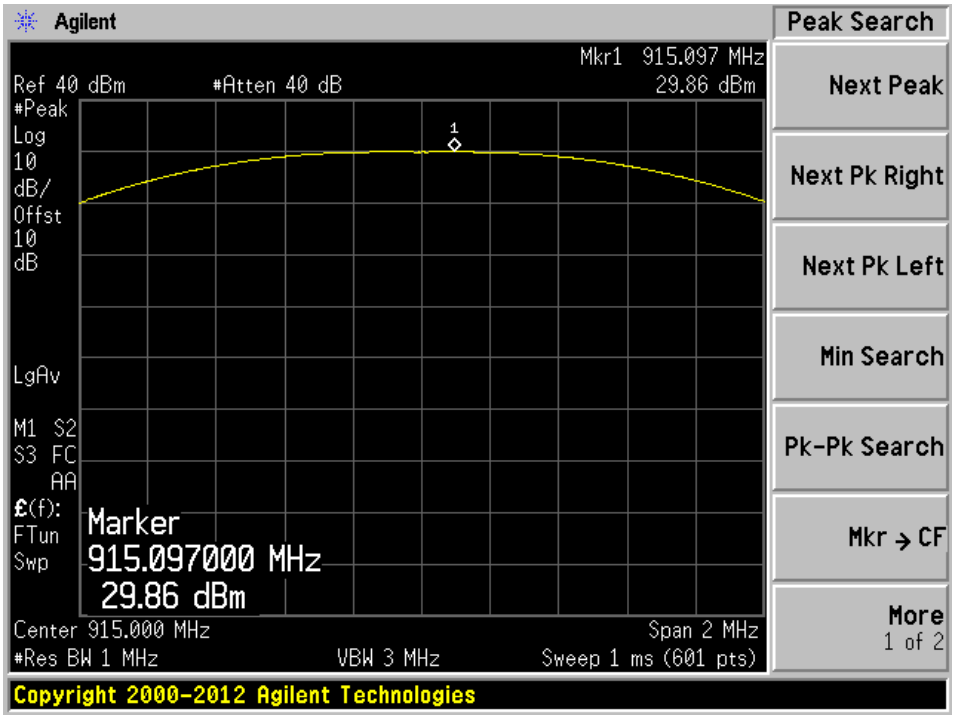
Channel	Frequency (MHz)	Conducted Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	902.5	29.75	30	-0.25
Middle	915	29.86	30	-0.14
High	927.5	29.79	30	-0.21

Please refer to the following plots for detailed test results.

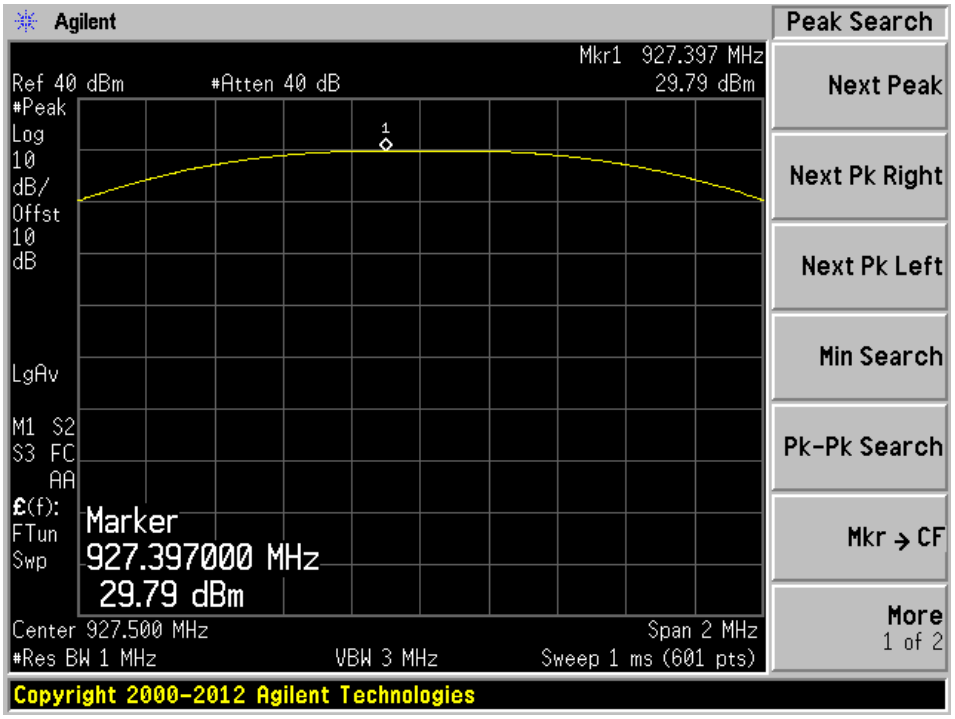
Low channel



Middle channel



High channel



13 FCC §15.247(d) – 100 kHz Bandwidth of Band Edges

13.1 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).

13.2 Measurement Procedure

Span = wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation

RBW = 100 kHz
VBW = 300 kHz
Sweep = coupled
Detector function = peak
Trace = max hold

13.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US45303156	2016-01-19	1 year
-	SMA cable	-	C0001	Each Time[1]	N/A
-	10 dB attenuator	-	-	Each time[1]	N/A

Note[1]: These items shall be calibrated before every test.
Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

13.4 Test Environmental Conditions

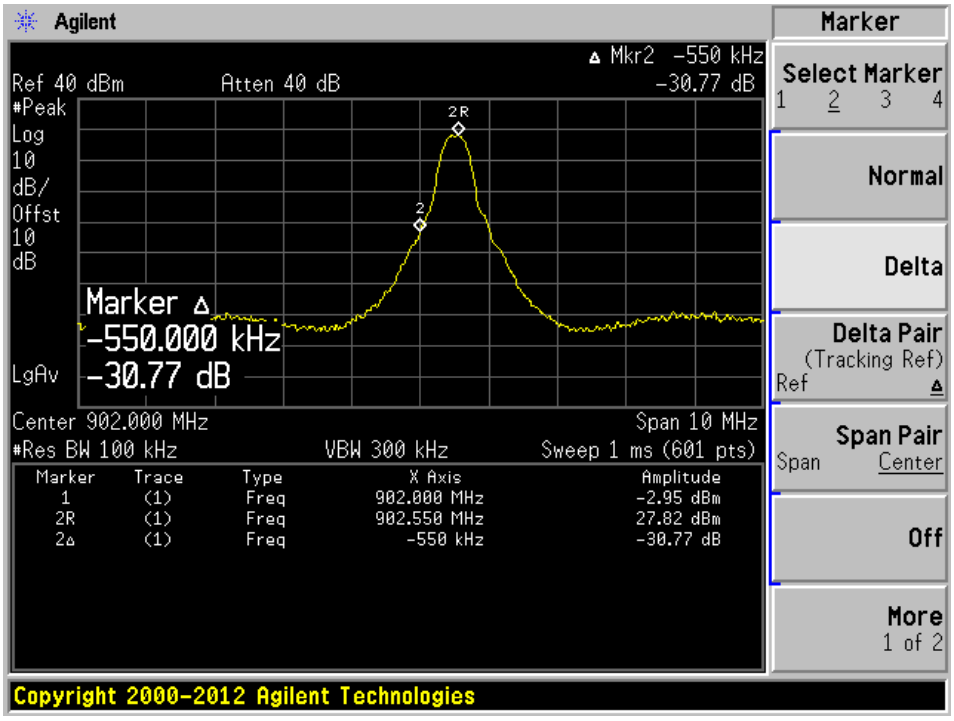
Temperature:	23° C
Relative Humidity:	33 %
ATM Pressure:	101.2 kPa

The testing was performed by Frank Wang on 2016-09-21 at the RF site.

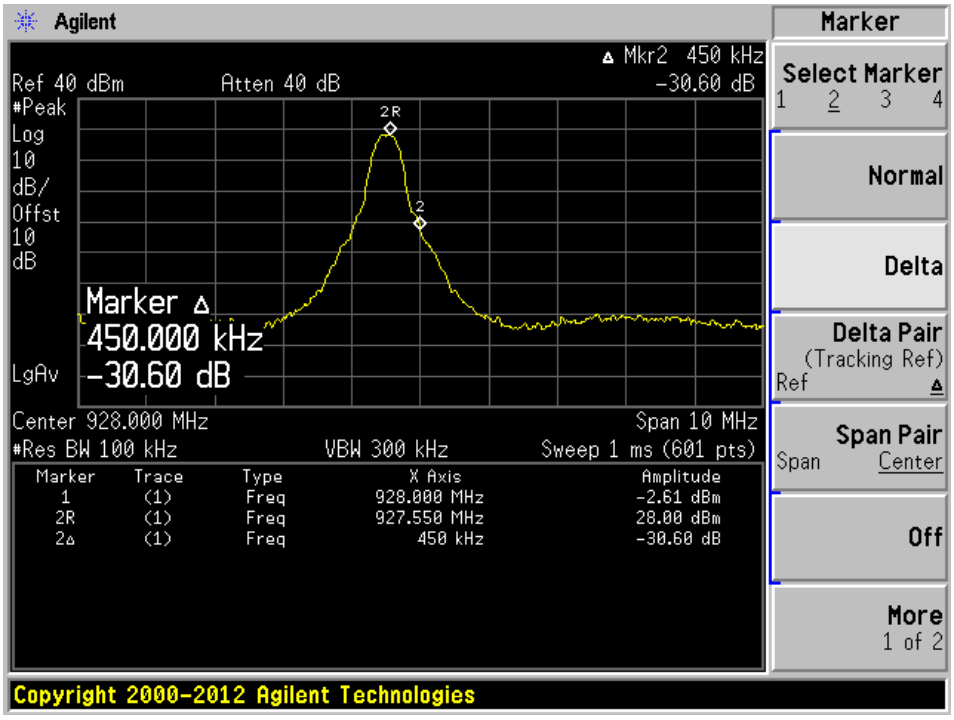
13.5 Test Results

Please refer to following pages for plots of band edge.

Low CH at Band Edge



High CH at Band Edge



14 FCC §15.247(d) - Spurious Emissions at Antenna Terminals

14.1 Applicable Standard

For 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.

14.2 Measurement Procedure

The RF output of the EUT was connected to a spectrum analyzer through appropriate attenuation. The resolution bandwidth of the spectrum analyzer was set at 100 kHz. Sufficient scans were taken to show any out of band emissions up to 10th harmonic.

14.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US45303156	2016-01-19	1 year
-	SMA cable	-	C0001	Each Time[1]	N/A
-	10 dB attenuator	-	-	Each time[1]	N/A

Note[1]: These items shall be calibrated before every test.
***Statement of Traceability: BACL Corp.** attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

14.4 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	33 %
ATM Pressure:	101.2 kPa

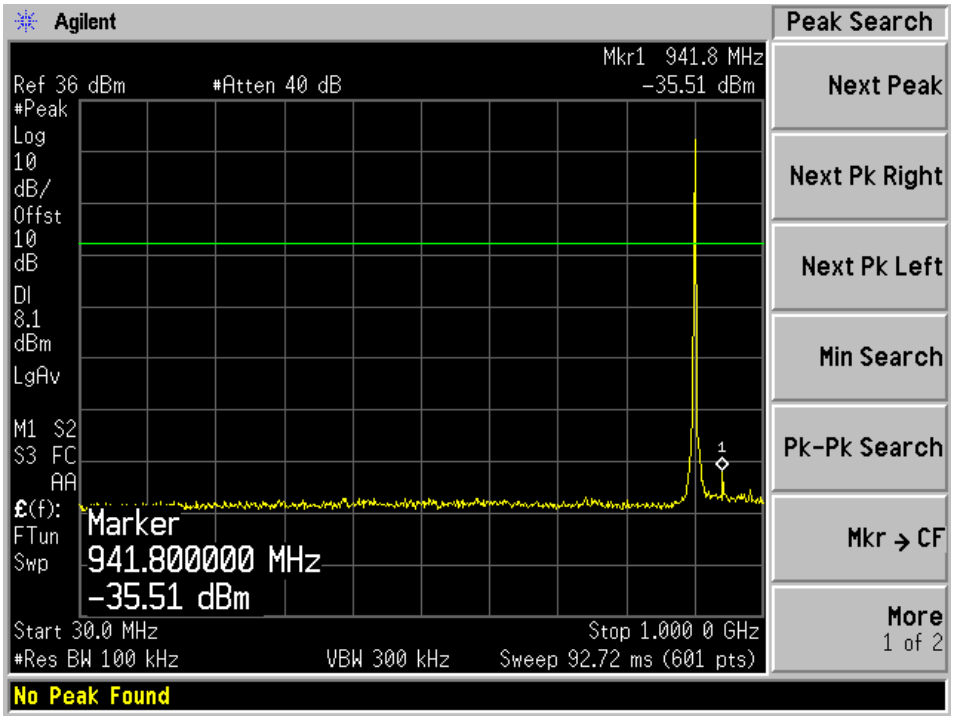
The testing was performed by Frank Wang on 2016-09-22 at the RF site.

14.5 Test Results

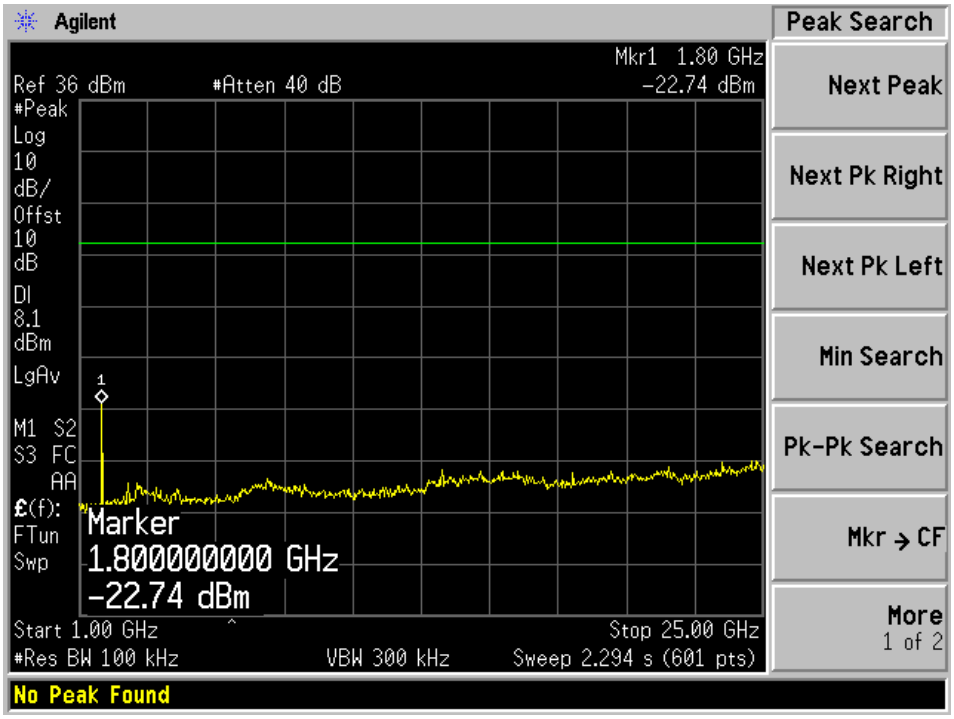
Please refer to following plots.

Low Channel

30 MHz to 1 GHz

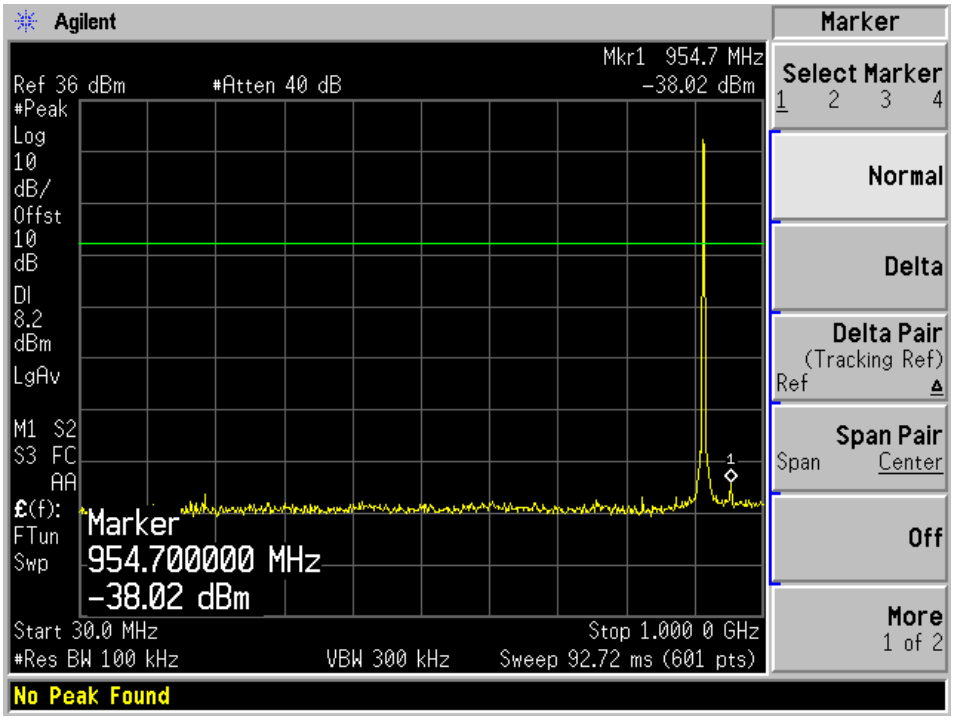


1 GHz to 25 GHz

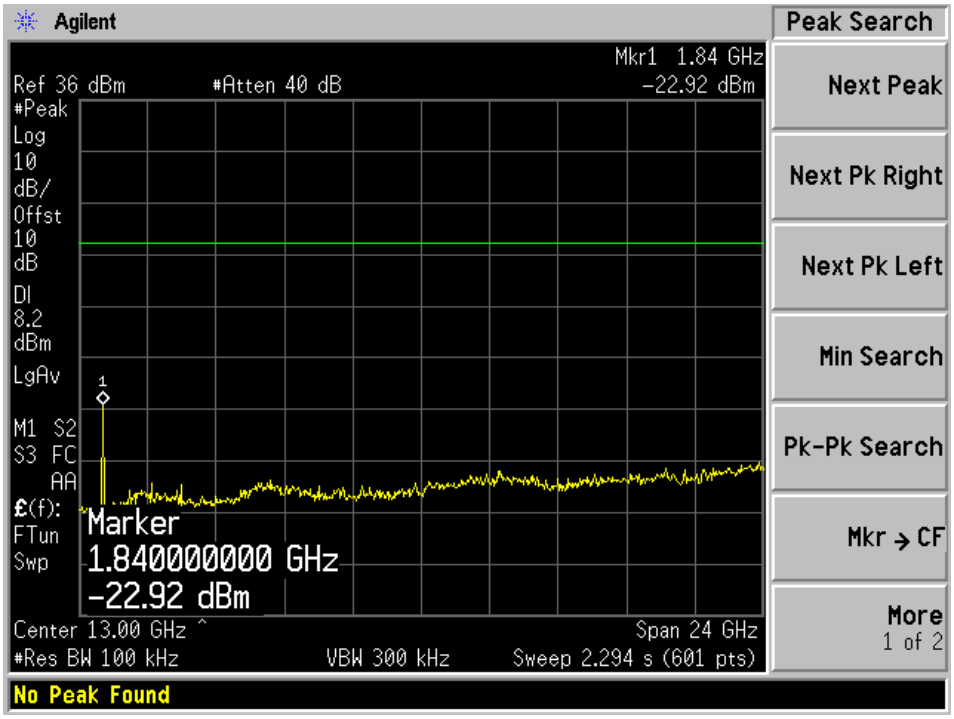


Middle Channel

30 MHz to 1 GHz

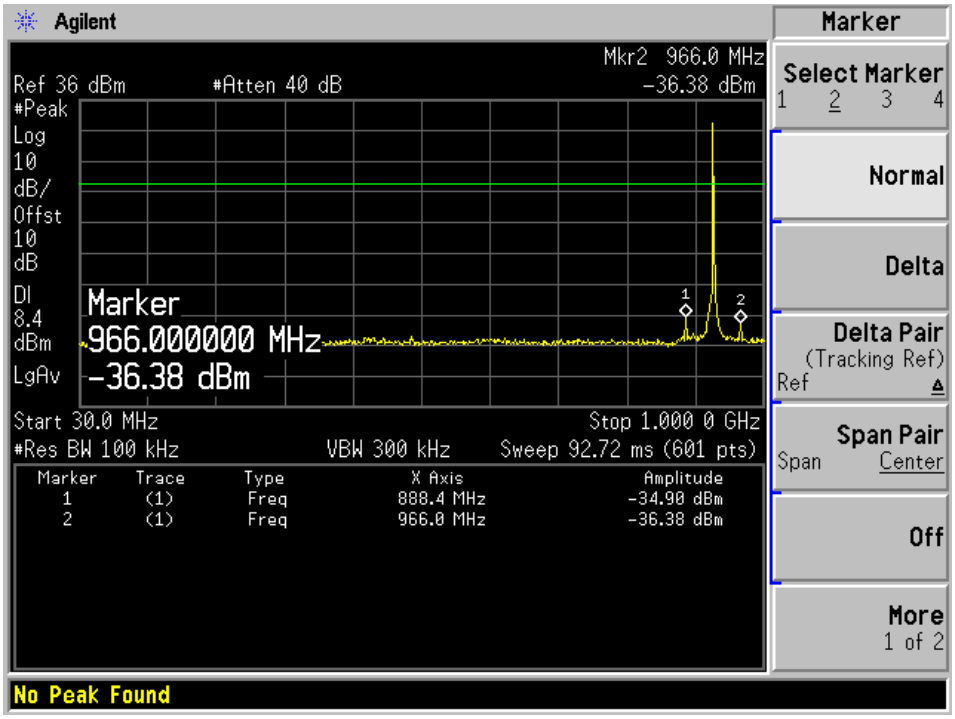


1 GHz to 25 GHz



High Channel

30 MHz to 1 GHz



1 GHz to 25 GHz