FCC PART 15, SUBPART C

TEST AND MEASUREMENT REPORT

For

iControl Incorporated

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Santa Clara, CA 95050, USA

FCC ID: W2E-ICHIME-M10

Report Type:	**Product Type:**
Original Report	Wireless Data Communication Module

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* This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "*" (Rev.2)

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1604252-247	Original Report	2016-06-10

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test and measurement report has been compiled on behalf of *iControl Incorporated*, and their product*, FCC ID: W2E-ICHIME-M10*, model number: *iCHIME-M1.0*, which henceforth is referred to as the EUT (Equipment under Test). The EUT is a 2.4GHz 802.15.4 radio equipped wireless data communications module for standalone use or integration into systems requiring remote data collection and dissemination.

1.2 Mechanical Description of EUT

The EUT measures approximately 4.25 cm (L) x 3.37 cm (W) x 0.79 cm (H) and weighs approximately 0.006 kg.

The data gathered are from a typical production sample provided by the manufacturer with serial number: R1604252-01, assigned by BACL.

1.3 Objective

This report is prepared on behalf of *iControl Incorporated,* 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 Output Power, Antenna Requirements, 6 dB Bandwidth, 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 C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices and FCC KDB 558074 D01 DTS Meas Guidance v03r05: 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.

Based on CISPR16-4-2:2011, The Treatment of Uncertainty in EMC Measurements, the values ranging from ±2.0 dB for Conducted Emissions tests and ±4.0 dB for Radiated Emissions tests are the most accurate estimates pertaining to uncertainty of EMC measurements at BACL Corp.

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:
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 C63.3-2013, ANSI C63.4-2014, 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 for testing according to ANSI C63.10-2013 and FCC KDB 558074 D01 DTS Meas Guidance v03r05.

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.

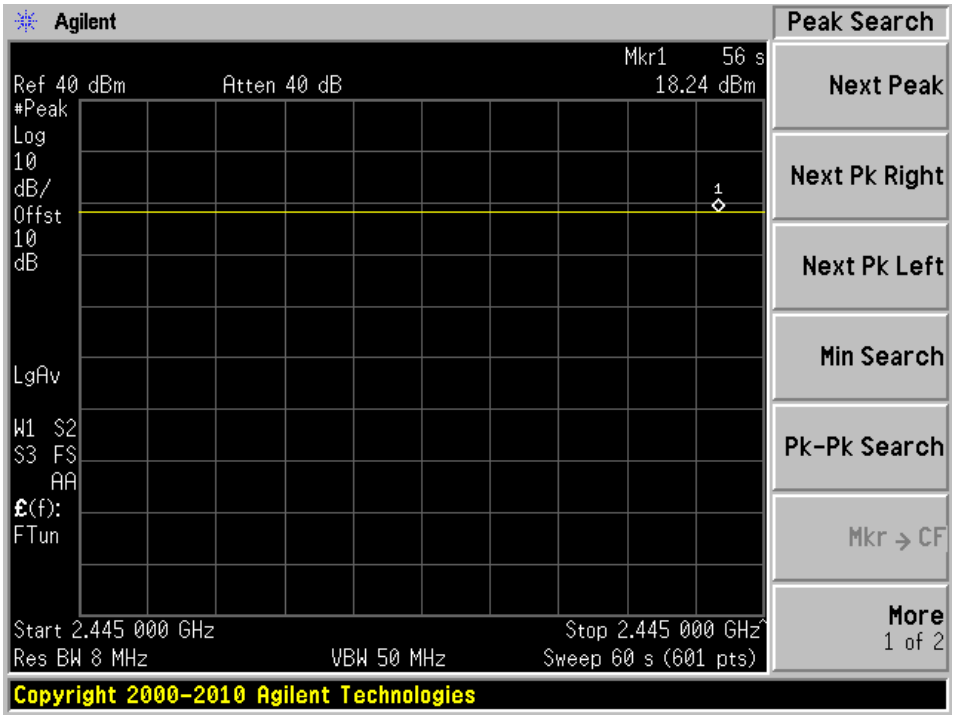
2.2 EUT Exercise Software

Channel	Frequency (MHz)
14.5 dBi Antenna Gain	
Low	2405
Middle	2445
High	2475
7 dBi Antenna Gain	
Low	2405
Middle	2445
High	2480
3.5 dBi Antenna Gain	
Low	2405
Middle	2445
High	2480

Note: for 14.5 dBi antenna, client will disable 2480MHz channel, please refers to the declaration letter for more details.

The software “icontrol.ht” was provided by customer. The worst case Duty cycle for the EUT was greater than 98%.

802.15.4 Middle Channel Duty Cycle



2.3 Equipment Modifications

No modifications were made to the EUT.

2.4 Local Support Equipment

Manufacturer	Description	Model	Serial Number
iControl, Inc.	miKIT Interface Board	-	-
SystemBase Co., Ltd.	Serial to USB Converter	Multi-1/USB RS232	-

2.5 EUT Internal Configuration Details

Manufacturer	Description	Model	Serial Number
Texas Instruments	Microcontroller	CC2530F256RHAT	-
Texas Instruments	Radio Front End	CC2592RGVR	-
Analog Devices	Linear Voltage Regulator	ADP160AUJZ-3.3-R7	-

2.6 Power Supply and Line Filter

Manufacturer	Description	Model	Serial Number
PHIHONG	Power Adapter	PSAA20R-033	-

2.7 Interface Ports and Cabling

Cable Description	Length (m)	To	From
USB-Serial	< 1m	EUT	Laptop

3 Summary of Test Results

Results reported relate only to the product tested.

FCC Rules	Description of Test	Results
§15.203	Antenna Requirement	Compliant
§2.1091, §15.247(i)	RF Exposure	Compliant
§15.207	AC Line conducted emission	Compliant
§15.247 (d)	Spurious Emissions at Antenna Port	Compliant
§15.209, §15.247 (d)	Radiated Spurious Emissions	Compliant
§15.247(a)(2)	6 dB&99% Emission Bandwidth	Compliant
§15.247(b)(3)	Maximum Peak Output Power	Compliant
§15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliant
§15.247(e)	Power Spectral Density	Compliant

4 FCC §2.1091 & §15.247(i) - RF Exposure

4.1 Applicable Standards

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

14.5 dBi antenna:

Maximum peak output power at antenna input terminal (dBm):	15.91
Maximum peak output power at antenna input terminal (mW):	38.9942
Prediction distance (cm):	20
Prediction frequency (MHz):	2445
Maximum Antenna Gain, typical (dBi):	14.5
Maximum Antenna Gain (numeric):	28.1838293
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.21864
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0

7 dBi antenna:

Maximum peak output power at antenna input terminal (dBm):	16.96
Maximum peak output power at antenna input terminal (mW):	49.659
Prediction distance (cm):	20
Prediction frequency (MHz):	2445
Maximum Antenna Gain, typical (dBi):	7
Maximum Antenna Gain (numeric):	5.012
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.0495
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0

3.5 dBi antenna:

Maximum peak output power at antenna input terminal (dBm):	17.78
Maximum peak output power at antenna input terminal (mW):	59.9791
Prediction distance (cm):	20
Prediction frequency (MHz):	2445
Maximum Antenna Gain, typical (dBi):	3.5
Maximum Antenna Gain (numeric):	2.23872
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.0267
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.22 mW/cm^2. Limit is 1.0 mW/cm^2.

4 FCC §15.207– AC Line Conducted Emissions

4.1 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 Note1	56 to 46 Note2
0.5-5	56	46
5-30	60	50

Note1: Decreases with the logarithm of the frequency.
Note2: A linear average detector is required

4.2 Test Setup

The measurement was performed at shield room, using the setup per ANSI C63.10-2013 measurement procedure. The specification used were 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 supported board was connected with LISN-1 which provided 120 V/60 Hz AC power.

4.3 Test Procedure

During the conducted emissions test, the power cord of the EUT host system was connected to the mains outlet of the LISN-1 and the power cords of support equipment were connected to LISN-2.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

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

4.4 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:

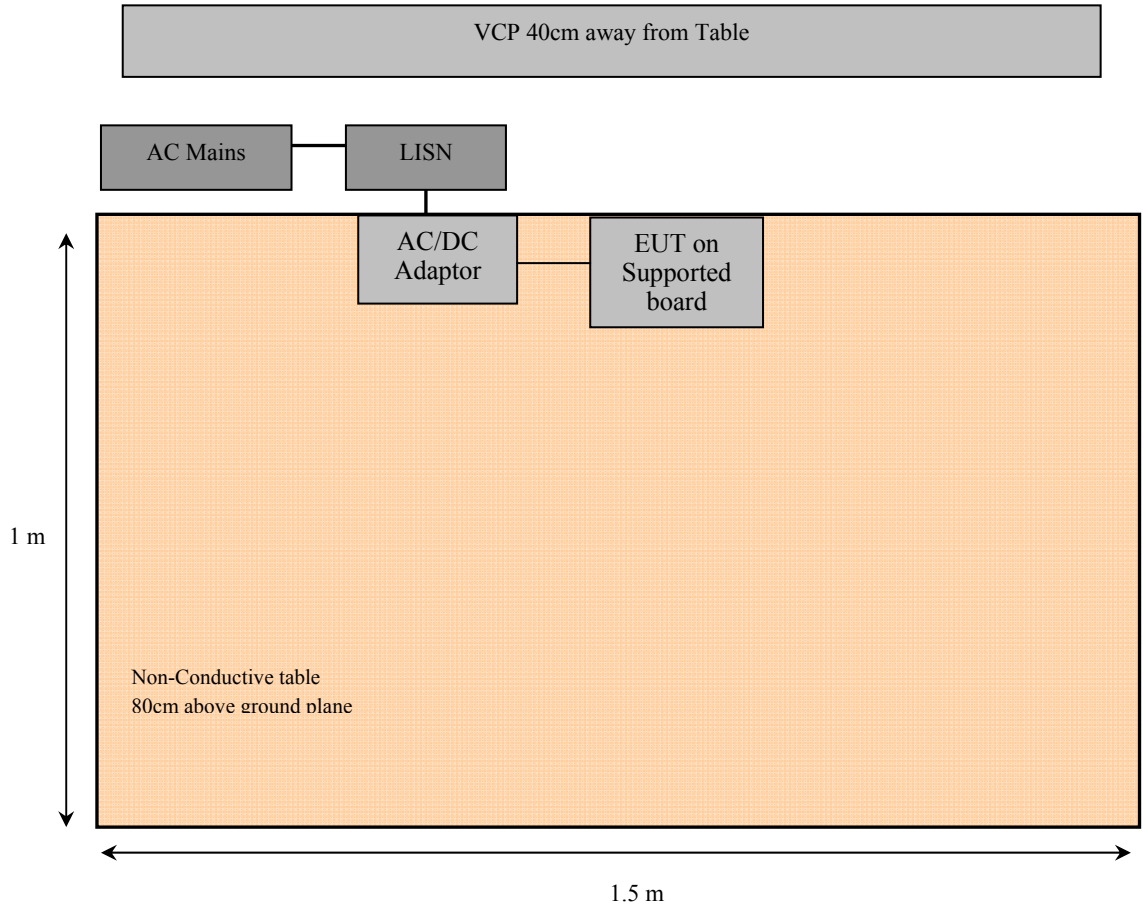
CA = Ai + CL + Atten

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

4.5 Test Setup Block Diagram



4.6 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950K03	100044	2015-07-23	1 year
Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101963	2015-07-15	1year
Keysight Technologies	RF Limiter	11867A	MY42242931	2015-12-15	1year
Solar Electronics Company	High Pass Filter	Type 7930-100	7930150204	2016-03-16	1 year
Suirong	30 ft conductive emission cable	LMR 400	-	2015-07-02	1 year
FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160129	2016-04-11	1year

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

4.7 Test Environmental Conditions

Temperature:	23º C
Relative Humidity:	44 %
ATM Pressure:	102.1 kPa

The testing was performed by Jin Yang on 2016-06-10.

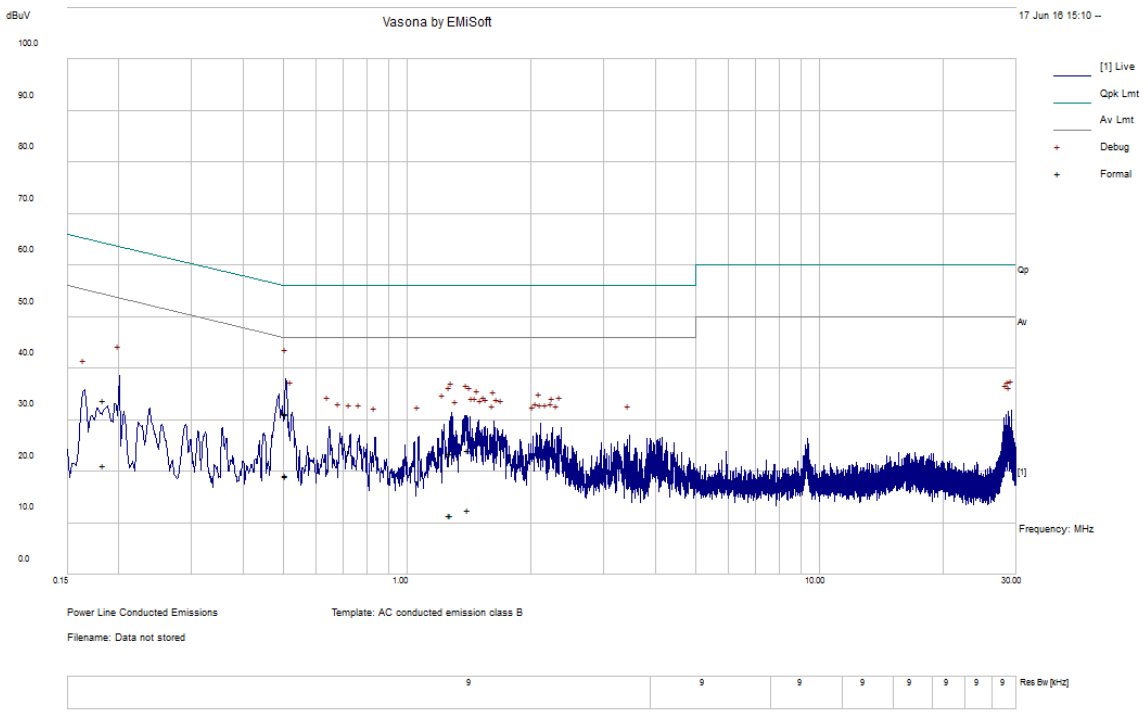
4.8 Summary of Test Results

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

Connection: AC/DC adaptor of Supported board connected to 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Live/Neutral)**	**Range (MHz)**
-21.54	0.498636	Neutral	0.15-30

4.9 Conducted Emissions Test Plots and Data

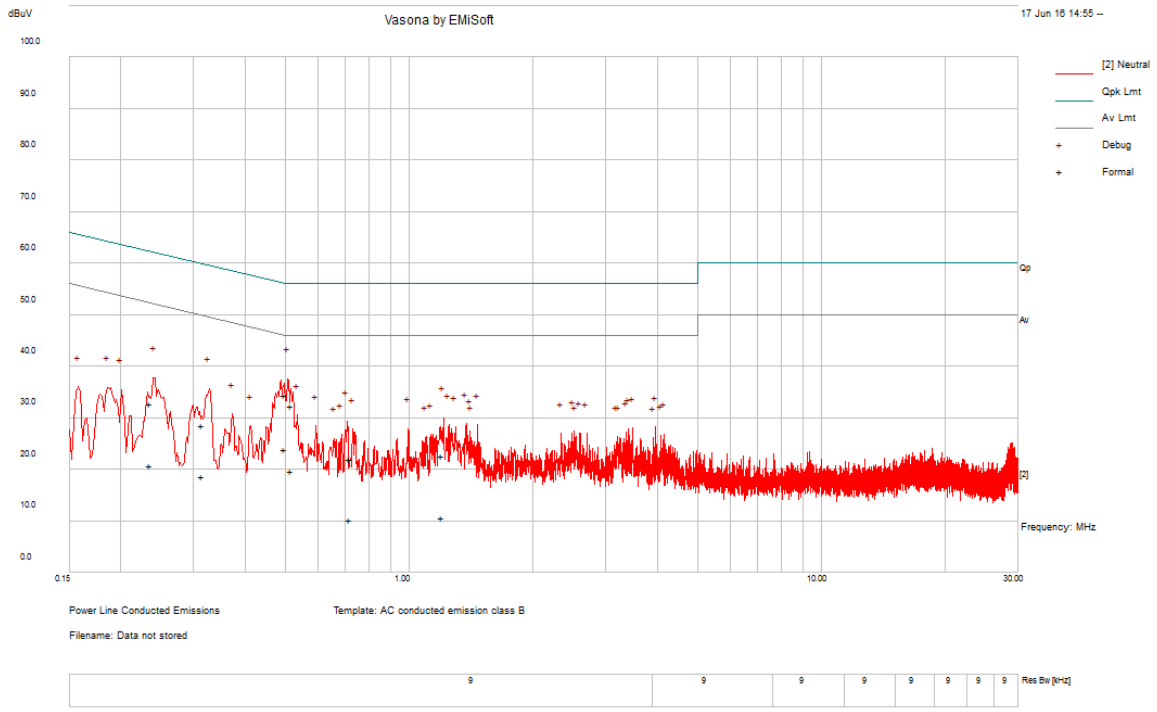
120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.508104	31.22	Line	56	-24.78	QP
0.506966	31.35	Line	56	-24.65	QP
1.271696	23.54	Line	56	-32.46	QP
0.183053	33.8	Line	64.35	-30.54	QP
1.404752	24.25	Line	56	-31.75	QP
1.273272	23.55	Line	56	-32.45	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.508104	19.17	Line	46	-26.83	Ave.
0.506966	19.47	Line	46	-26.53	Ave.
1.271696	11.67	Line	46	-34.33	Ave.
0.183053	21.27	Line	54.35	-33.08	Ave.
1.404752	12.72	Line	46	-33.28	Ave.
1.273272	11.67	Line	46	-34.33	Ave.

120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.498636	34.48	Neutral	56.02	-21.54	QP
0.314245	28.57	Neutral	59.86	-31.29	QP
0.235776	32.78	Neutral	62.24	-29.46	QP
0.518519	32.43	Neutral	56	-23.57	QP
1.204708	22.77	Neutral	56	-33.23	QP
0.718087	22.14	Neutral	56	-33.86	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.498636	23.92	Neutral	46.02	-22.1	Ave.
0.314245	18.77	Neutral	49.86	-31.09	Ave.
0.235776	20.83	Neutral	52.24	-31.41	Ave.
0.518519	19.76	Neutral	46	-26.24	Ave.
1.204708	10.68	Neutral	46	-35.32	Ave.
0.718087	10.31	Neutral	46	-35.69	Ave.

5 FCC §15.203 - Antenna Requirements

5.1 Applicable Standards

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 and Details

Frequency Range (MHz)	External/ Internal	Max Gain (dBi)	Antenna Type/Pattern
2400 - 2483.5	Integral PCB	3.5	OMNI
2400 - 2500	External	7	OMNI
24000 - 2500	External	14.5	Directional

6 FCC §15.209 & §15.247(d) - Spurious Radiated Emissions

6.1 Applicable Standards

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).

6.2 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.

6.3 Test Procedure

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

6.4 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

6.5 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4440A	US 42221851	2015-06-23	1 year
Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950K03	100044	2015-07-23	1 year
Sunol Science Corp	System Controller	SC99V	011003-1	N/R	N/R
Sunol Sciences	Antenna, Biconi-Log	JB1	A013105-3	2015-07-11	2 year
A.R.A	Antenna, Horn	DRG-118/A	1132	2015-09-21	2 year
HP	Pre-Amplifier	8447D	2944A06639	2015-06-08	1 year
Suirong	30 Ft Conducted Emission Cable	LMR 400	694	Cal. Not required	N/A
-	SMA cable	-	C0001	Each time[1]	N/A
IW Microwave	High Frequency Cable	DC-1531	KPS-1501A3960KPS	2015-08-10	1 year
Agilent	Pre-Amplifier	8449B	3008A01978	2015-09-02	1year

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

6.6 Test Environmental Conditions

Temperature:	20-25º C
Relative Humidity:	40-45 %
ATM Pressure:	101.2-103.5 kPa

The testing was performed by Leonard Gray on 2016-05-02 to 2016-05-18 in 5m chamber3.

6.7 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:

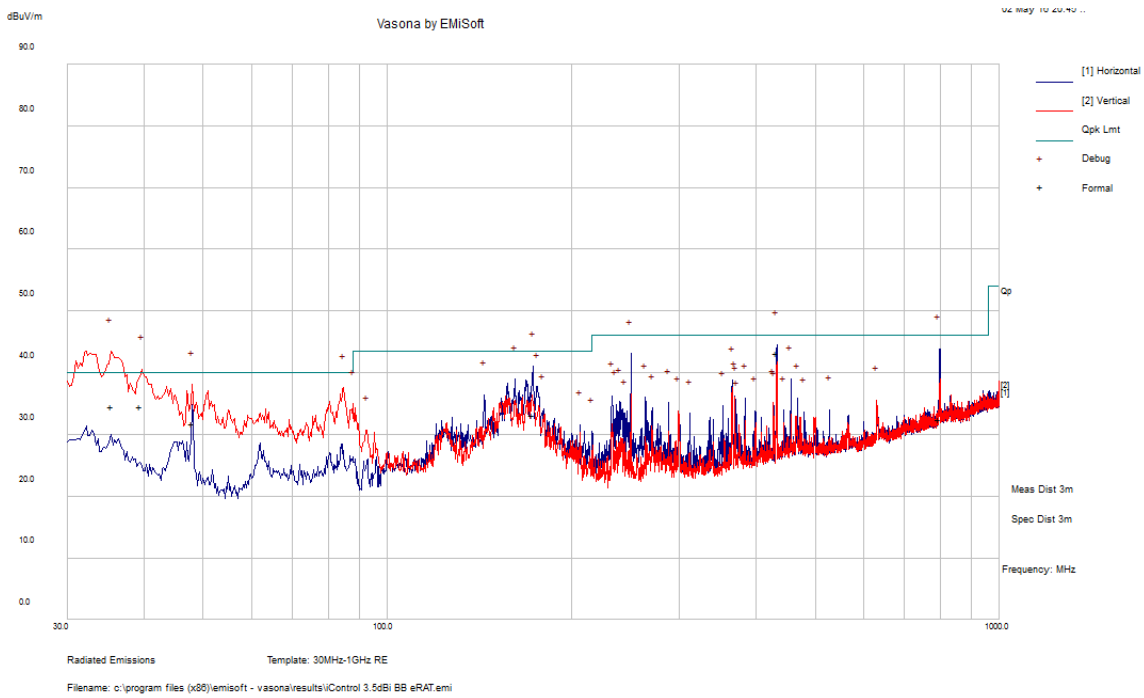
Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Mode, Channel**
-0.10	2483.5	Horizontal	3.5 dBi, High CH

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

6.8 Radiated Emissions Test Data and Plots

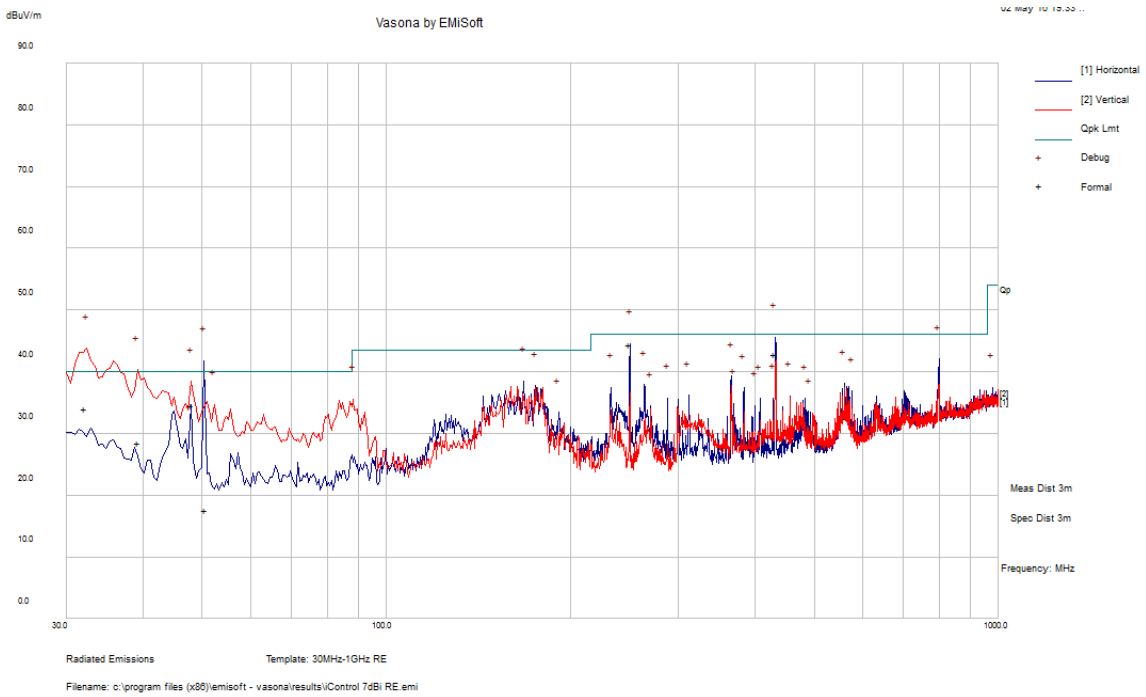
1) 30 MHz – 1 GHz, Measured at 3 meters

3.5 dBi Antenna



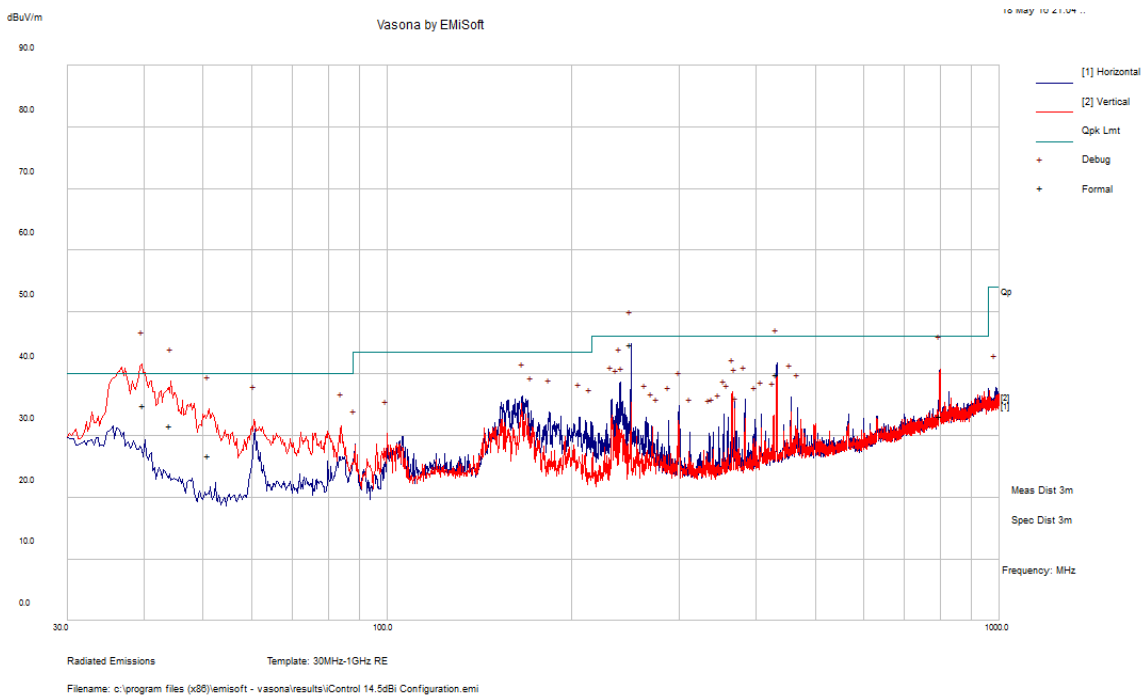
Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comments (PK/QP/Ave.)
35.401	34.61	136	V	170	40	-5.39	QP
39.49175	34.64	101	V	160	40	-5.36	QP
433.124	43.22	180	H	102	46	-2.78	QP
48.0245	31.78	109	V	99	40	-8.22	QP
796.2908	32.47	239	H	58	46	-13.53	QP
172.8385	33.14	185	H	99	43.5	-10.36	QP

7 dBi Antenna



Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comments (PK/QP/Ave.)
32.19275	33.99	212	V	93	40	-6.01	QP
50.56475	17.58	256	H	122	40	-22.42	QP
39.2975	28.59	220	V	34	40	-11.41	QP
431.368	42.82	174	H	110	46	-3.18	QP
249.9858	44.44	116	H	161	46	-1.56	QP
47.97825	34.59	143	V	76	40	-5.41	QP

14.5 dBi Antenna



Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comments (PK/QP/Ave.)
39.86325	34.95	102	V	125	40	-5.05	QP
249.9973	44.71	119	H	177	46	-1.29	QP
44.15	31.55	119	V	121	40	-8.45	QP
433.136	39.88	164	H	97	46	-6.12	QP
799.4895	33.1	116	V	150	46	-12.9	QP
50.94175	26.77	178	V	47	40	-13.23	QP

2) Above 1 GHz, Measured at 3 meters

3.5 dBi Antenna

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 2405 MHz											
2405	74.05	27	263	V	28.45	3.43	0.00	105.93	-	-	Peak
2405	74.31	43	290	H	29.04	3.43	0.00	106.78	-	-	Peak
2405	71.88	27	263	V	28.45	3.43	0.00	103.76	-	-	Ave
2405	72.13	43	290	H	29.04	3.43	0.00	104.60	-	-	Ave
2390	26.41	27	263	V	28.45	3.43	0.00	58.29	74.00	-15.71	Peak
2390	26.34	43	290	H	29.04	3.43	0.00	58.81	74.00	-15.19	Peak
2390	14.61	27	263	V	28.45	3.43	0.00	46.49	54.00	-7.51	Ave
2390	14.56	43	290	H	29.04	3.43	0.00	47.03	54.00	-6.97	Ave
4810	60.070	345	146	V	32.42	6.73	38.02	61.20	74.00	-12.80	Peak
4810	59.080	64	100	H	32.47	6.73	38.02	60.26	74.00	-13.74	Peak
4810	52.550	345	146	V	32.42	6.73	38.02	53.68	54.00	-0.32	Ave
4810	50.330	64	100	H	32.47	6.73	38.02	51.51	54.00	-2.49	Ave
7215	53.570	17	268	V	36.16	8.14	37.53	60.34	74.00	-13.66	Peak
7215	50.870	296	299	H	36.69	8.14	37.53	58.17	74.00	-15.83	Peak
7215	44.840	17	268	V	36.16	8.14	37.53	51.61	54.00	-2.39	Ave
7215	40.180	296	299	H	36.69	8.14	37.53	47.48	54.00	-6.52	Ave
9620	50.840	0	100	V	37.17	11.48	38.00	61.49	74.00	-12.51	Peak
9620	46.750	0	100	H	37.77	11.48	38.00	58.00	74.00	-16.00	Peak
9620	40.570	0	100	V	37.17	11.48	38.00	51.22	54.00	-2.78	Ave
9620	33.190	0	100	H	37.77	11.48	38.00	44.44	54.00	-9.56	Ave
Middle Channel 2445 MHz											
2445	75.11	31	273	V	28.448	3.43	0.00	106.99	-	-	Peak
2445	74.42	3	271	H	29.042	3.43	0.00	106.89	-	-	Peak
2445	72.88	31	273	V	28.448	3.43	0.00	104.76	-	-	Ave
2445	72.1	3	271	H	29.042	3.43	0.00	104.57	-	-	Ave
4890	61.97	277	100	V	32.608	6.73	37.92	63.39	74.00	-10.61	Peak
4890	59.71	75	100	H	32.638	6.73	37.92	61.16	74.00	-12.84	Peak
4890	51.92	277	100	V	32.608	6.73	37.92	53.34	54.00	-0.66	Ave
4890	49.73	75	100	H	32.638	6.73	37.92	51.18	54.00	-2.82	Ave
7335	51.5	0	113	V	36.406	8.14	37.53	58.52	74.00	-15.48	Peak
7335	49.12	320	110	H	37.148	8.14	37.53	56.88	74.00	-17.12	Peak
7335	42.17	0	113	V	36.406	8.14	37.53	49.19	54.00	-4.81	Ave
7335	38.52	320	110	H	37.148	8.14	37.53	46.28	54.00	-7.72	Ave
9780	46.99	0	100	V	37.101	11.48	38.27	57.30	74.00	-16.70	Peak
9780	46.9	0	100	H	37.923	11.48	38.27	58.03	74.00	-15.97	Peak
9780	33.8	0	100	V	37.101	11.48	38.27	44.11	54.00	-9.89	Ave
9780	33.31	0	100	H	37.923	11.48	38.27	44.44	54.00	-9.56	Ave

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)	
High Channel 2480 MHz											
2480	63.13	357	200	V	28.91	3.43	0.00	95.47	-	-	Peak
2480	65.14	33	279	H	29.41	3.43	0.00	97.98	-	-	Peak
2480	60.63	357	200	V	28.91	3.43	0.00	92.97	-	-	Ave
2480	62.76	33	279	H	29.41	3.43	0.00	95.60	-	-	Ave
2483.5	29.26	357	200	V	28.91	3.43	0.00	61.60	74.00	-12.40	Peak
2483.5	30.47	33	279	H	29.41	3.43	0.00	63.31	74.00	-10.69	Peak
2483.5	19.39	357	200	V	28.91	3.43	0.00	51.73	54.00	-2.27	Ave
2483.5	21.06	33	279	H	29.41	3.43	0.00	53.90	54.00	-0.10	Ave
4960	48.430	196	100	V	32.61	6.62	37.85	49.81	74.00	-24.19	Peak
4960	51.480	132	229	H	32.99	6.62	37.85	53.24	74.00	-20.77	Peak
4960	36.790	196	100	V	32.61	6.62	37.85	38.17	54.00	-15.83	Ave
4960	37.500	132	229	H	32.99	6.62	37.85	39.26	54.00	-14.75	Ave
7440	47.610	0	100	V	36.31	8.14	37.62	54.44	74.00	-19.56	Peak
7440	47.530	0	100	H	37.14	8.14	37.62	55.19	74.00	-18.81	Peak
7440	33.950	0	100	V	36.31	8.14	37.62	40.78	54.00	-13.22	Ave
7440	33.900	0	100	H	37.14	8.14	37.62	41.56	54.00	-12.44	Ave
9920	47.380	0	100	V	37.18	11.48	38.38	57.67	74.00	-16.33	Peak
9920	47.240	0	100	H	37.99	11.48	38.38	58.33	74.00	-15.67	Peak
9920	34.180	0	100	V	37.18	11.48	38.38	44.47	54.00	-9.53	Ave
9920	34.190	0	100	H	37.99	11.48	38.38	45.28	54.00	-8.72	Ave

7 dBi Antenna Gain

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 2405 MHz											
2405	78.5	38	100	V	28.45	3.43	0.00	110.38	-	-	Peak
2405	68.63	281	105	H	29.04	3.43	0.00	101.10	-	-	Peak
2405	76.26	38	100	V	28.45	3.43	0.00	108.14	-	-	Ave
2405	66.2	281	105	H	29.04	3.43	0.00	98.67	-	-	Ave
2390	28.02	38	100	V	28.45	3.43	0.00	59.90	74.00	-14.10	Peak
2390	27.71	281	105	H	29.04	3.43	0.00	60.18	74.00	-13.82	Peak
2390	16.53	38	100	V	28.45	3.43	0.00	48.41	54.00	-5.59	Ave
2390	15.73	281	105	H	29.04	3.43	0.00	48.20	54.00	-5.80	Ave
4810	60.040	356	310	V	32.42	5.47	38.02	59.91	74.00	-14.09	Peak
4810	59.410	60	259	H	32.47	5.47	38.02	59.33	74.00	-14.67	Peak
4810	53.650	356	310	V	32.42	5.47	38.02	53.52	54.00	-0.48	Ave
4810	52.900	60	259	H	32.47	5.47	38.02	52.82	54.00	-1.18	Ave
7215	49.990	281	127	V	36.16	8.14	37.53	56.76	74.00	-17.24	Peak
7215	50.600	228	100	H	36.69	8.14	37.53	57.90	74.00	-16.10	Peak
7215	38.840	281	127	V	36.16	8.14	37.53	45.61	54.00	-8.39	Ave
7215	41.660	228	100	H	36.69	8.14	37.53	48.96	54.00	-5.04	Ave
9620	50.690	193	100	V	37.17	11.48	38.00	61.34	74.00	-12.66	Peak
9620	47.170	0	100	H	37.77	11.48	38.00	58.42	74.00	-15.58	Peak
9620	40.720	193	100	V	37.17	11.48	38.00	51.37	54.00	-2.63	Ave
9620	33.130	0	100	H	37.77	11.48	38.00	44.38	54.00	-9.62	Ave
Middle Channel 2445 MHz											
2445	78.49	58	134	V	28.448	3.43	0.00	110.37	-	-	Peak
2445	68.61	286	291	H	29.042	3.43	0.00	101.08	-	-	Peak
2445	76.36	58	134	V	28.448	3.43	0.00	108.24	-	-	Ave
2445	66.37	286	291	H	29.042	3.43	0.00	98.84	-	-	Ave
4890	59.92	0	100	V	32.608	5.45	37.92	60.06	74.00	-13.94	Peak
4890	58.9	62	310	H	32.638	5.45	37.92	59.07	74.00	-14.93	Peak
4890	53.43	0	100	V	32.608	5.45	37.92	53.57	54.00	-0.43	Ave
4890	51.98	62	310	H	32.638	5.45	37.92	52.15	54.00	-1.85	Ave
7335	51.89	19	100	V	36.406	8.14	37.53	58.91	74.00	-15.09	Peak
7335	51.55	229	100	H	37.148	8.14	37.53	59.31	74.00	-14.69	Peak
7335	43.17	19	100	V	36.406	8.14	37.53	50.19	54.00	-3.81	Ave
7335	43.07	229	100	H	37.148	8.14	37.53	50.83	54.00	-3.17	Ave
9780	50.11	0	100	V	37.101	11.48	38.27	60.42	74.00	-13.58	Peak
9780	47.03	0	100	H	37.923	11.48	38.27	58.16	74.00	-15.84	Peak
9780	39.18	0	100	V	37.101	11.48	38.27	49.49	54.00	-4.51	Ave
9780	33.2	0	100	H	37.923	11.48	38.27	44.33	54.00	-9.67	Ave

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)	
High Channel 2480 MHz											
2480	64.82	64	147	V	28.91	3.43	0.00	97.16	-	-	Peak
2480	53.75	286	100	H	29.41	3.43	0.00	86.59	-	-	Peak
2480	60.55	64	147	V	28.91	3.43	0.00	92.89	-	-	Ave
2480	51.16	286	100	H	29.41	3.43	0.00	84.00	-	-	Ave
2483.5	30.87	64	147	V	28.91	3.43	0.00	63.21	74.00	-10.79	Peak
2483.5	27.74	286	100	H	29.41	3.43	0.00	60.58	74.00	-13.42	Peak
2483.5	21.31	64	147	V	28.91	3.43	0.00	53.65	54.00	-0.35	Ave
2483.5	15.69	286	100	H	29.41	3.43	0.00	48.53	54.00	-5.47	Ave
4960	47.840	298	225	V	32.61	6.62	37.85	49.22	74.00	-24.78	Peak
4960	48.770	40	183	H	32.99	6.62	37.85	50.53	74.00	-23.48	Peak
4960	37.650	298	225	V	32.61	6.62	37.85	39.03	54.00	-14.97	Ave
4960	37.760	40	183	H	32.99	6.62	37.85	39.52	54.00	-14.49	Ave
7440	46.220	0	100	V	36.31	8.14	37.62	53.05	74.00	-20.95	Peak
7440	46.320	0	100	H	37.14	8.14	37.62	53.98	74.00	-20.02	Peak
7440	32.650	0	100	V	36.31	8.14	37.62	39.48	54.00	-14.52	Ave
7440	32.640	0	100	H	37.14	8.14	37.62	40.30	54.00	-13.70	Ave
9920	45.690	0	100	V	37.18	11.48	38.38	55.98	74.00	-18.02	Peak
9920	43.960	0	100	H	37.99	11.48	38.38	55.05	74.00	-18.95	Peak
9920	33.010	0	100	V	37.18	11.48	38.38	43.30	54.00	-10.70	Ave
9920	32.990	0	100	H	37.99	11.48	38.38	44.08	54.00	-9.92	Ave

14.5 dBi Antenna

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 2405 MHz											
2405	85.94	0	175	V	28.45	3.43	0.00	117.82	-	-	Peak
2405	61.69	20	133	H	29.04	3.43	0.00	94.16	-	-	Peak
2405	83.57	0	175	V	28.45	3.43	0.00	115.45	-	-	Ave
2405	59.27	20	133	H	29.04	3.43	0.00	91.74	-	-	Ave
2390	31.38	0	175	V	28.45	3.43	0.00	63.26	74.00	-10.74	Peak
2390	26.73	20	133	H	29.04	3.43	0.00	59.20	74.00	-14.80	Peak
2390	19.67	0	175	V	28.45	3.43	0.00	51.55	54.00	-2.45	Ave
2390	13.62	20	133	H	29.04	3.43	0.00	46.09	54.00	-7.91	Ave
4810	58.240	248	205	V	32.42	6.73	38.02	59.37	74.00	-14.63	Peak
4810	53.590	0	100	H	32.47	6.73	38.02	54.77	74.00	-19.23	Peak
4810	52.550	248	205	V	32.42	6.73	38.02	53.68	54.00	-0.32	Ave
4810	45.640	0	100	H	32.47	6.73	38.02	46.82	54.00	-7.18	Ave
7215	53.410	354	295	V	36.16	8.14	37.53	60.18	74.00	-13.82	Peak
7215	52.050	129	301	H	36.69	8.14	37.53	59.35	74.00	-14.65	Peak
7215	45.250	354	295	V	36.16	8.14	37.53	52.02	54.00	-1.98	Ave
7215	42.900	129	301	H	36.69	8.14	37.53	50.20	54.00	-3.80	Ave
9620	52.230	91	100	V	37.17	11.48	38.00	62.88	74.00	-11.12	Peak
9620	47.060	228	100	H	37.77	11.48	38.00	58.31	74.00	-15.69	Peak
9620	42.560	91	100	V	37.17	11.48	38.00	53.21	54.00	-0.79	Ave
9620	34.470	228	100	H	37.77	11.48	38.00	45.72	54.00	-8.28	Ave
Middle Channel 2445 MHz											
2445	84.28	37	173	V	28.448	3.43	0.00	116.16	-	-	Peak
2445	62.19	324	100	H	29.042	3.43	0.00	94.66	-	-	Peak
2445	81.88	37	173	V	28.448	3.43	0.00	113.76	-	-	Ave
2445	59.87	324	100	H	29.042	3.43	0.00	92.34	-	-	Ave
4890	58.3	244	191	V	32.608	6.73	37.92	59.72	74.00	-14.28	Peak
4890	54.38	0	256	H	32.638	6.73	37.92	55.83	74.00	-18.17	Peak
4890	52.4	244	191	V	32.608	6.73	37.92	53.82	54.00	-0.18	Ave
4890	46.53	0	256	H	32.638	6.73	37.92	47.98	54.00	-6.02	Ave
7335	48.48	202	100	V	36.406	8.14	37.53	55.50	74.00	-18.50	Peak
7335	47.6	124	186	H	37.148	8.14	37.53	55.36	74.00	-18.64	Peak
7335	37.89	202	100	V	36.406	8.14	37.53	44.91	54.00	-9.09	Ave
7335	35.65	124	186	H	37.148	8.14	37.53	43.41	54.00	-10.59	Ave
9780	50.32	109	300	V	37.101	11.48	38.27	60.63	74.00	-13.37	Peak
9780	46.98	224	293	H	37.923	11.48	38.27	58.11	74.00	-15.89	Peak
9780	40.91	109	300	V	37.101	11.48	38.27	51.22	54.00	-2.78	Ave
9780	35.04	224	293	H	37.923	11.48	38.27	46.17	54.00	-7.83	Ave

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)	
High Channel 2475 MHz											
2475	76.97	107	148	V	29.32	5.22	-	111.51	-	-	Peak
2475	56.67	114	167	H	29.32	5.22	-	91.21	-	-	Peak
2475	74.69	107	148	V	29.32	5.22	-	109.23	-	-	Ave
2475	54.72	114	167	H	29.32	5.22	-	89.26	-	-	Ave
2483.5	28.16	107	148	V	29.35	5.83	-	63.34	74	-10.66	Peak
2483.5	26.43	114	167	H	29.35	5.83	-	61.61	74	-12.39	Peak
2483.5	16.38	107	148	V	29.35	5.83	-	51.56	54	-2.44	Ave
2483.5	16.02	114	167	H	29.35	5.83	-	51.2	54	-2.8	Ave
4950	47.88	99	102	V	32.81	7.97	36.59	52.07	74	-21.93	Peak
4950	48.82	334	260	H	32.81	7.97	36.59	53.01	74	-20.99	Peak
4950	38.71	99	102	V	32.81	7.97	36.59	42.9	54	-11.1	Ave
4950	38.69	334	260	H	32.81	7.97	36.59	42.88	54	-11.12	Ave
7425	46.13	72	106	V	37.08	10.82	36.45	57.58	74	-16.42	Peak
7425	33.88	72	106	V	37.08	10.82	36.45	45.33	54	-8.67	Ave
9900	46.47	76	112	V	37.99	11.53	36.70	59.29	74	-14.71	Peak
9900	34.27	76	112	V	37.99	11.53	36.70	47.09	54	-6.91	Ave

7 FCC §15.247(a) (2) - 6 dB & 99% Emission Bandwidth

7.1 Applicable Standards

According to FCC §15.247(a)(2), 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

7.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v03r05: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 8: DTS bandwidth

7.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4440A	US42221851	2015-06-23	1 year
-	SMA Cable	-	C0001	Each Time[1]	N/A
Mini-Circuits	Attenuator	BW-S10W5	1430	Each Time[1]	N/A

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

7.4 Test Environmental Conditions

Temperature:	22º C
Relative Humidity:	42 %
ATM Pressure:	102.7 kPa

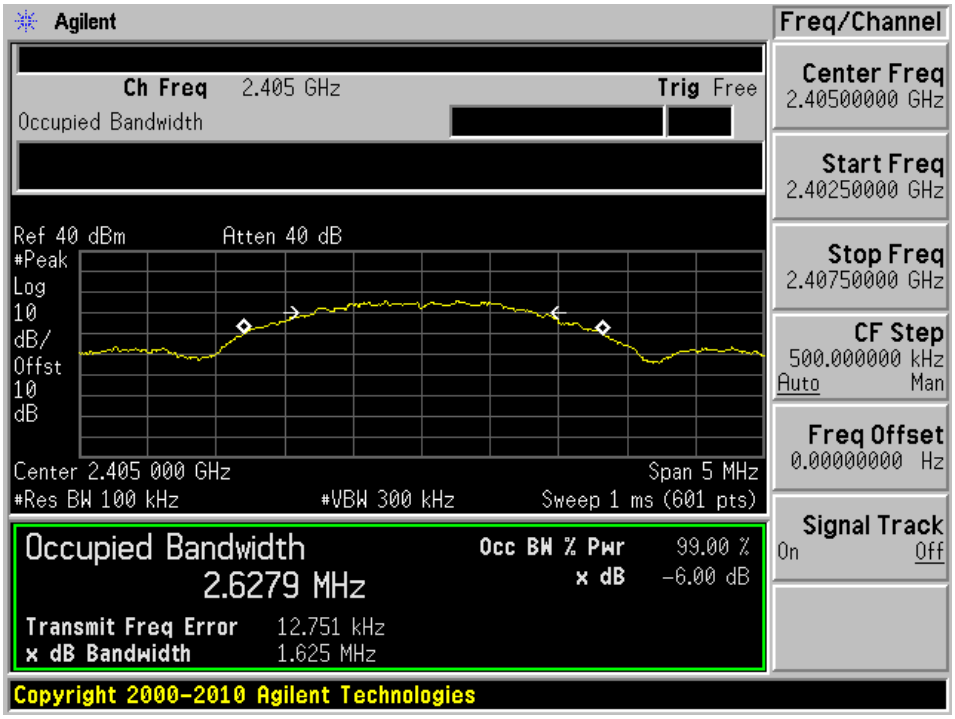
The testing was performed by Leonard Gray on 2016-04-29 to 2016-05-18 in RF site.

7.5 Test Results

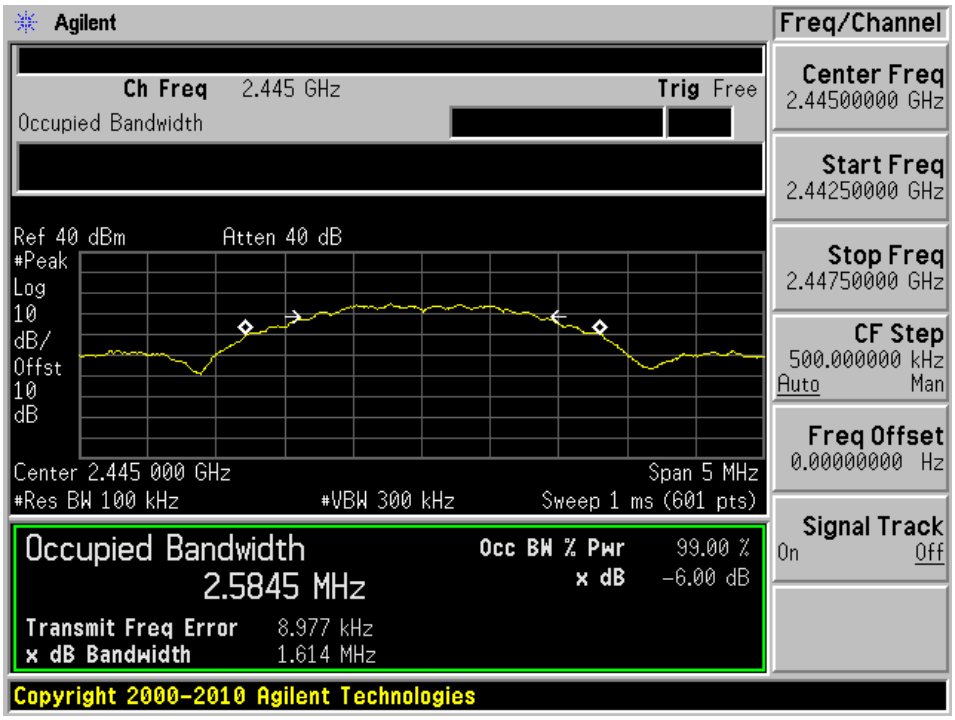
Channel	Frequency (MHz)	99 % OBW (MHz)	6 dB OBW (MHz)	6 dB OBW Limit (kHz)	Result
Low	2405	2.6279	1.625	≥ 500	Pass
Middle	2445	2.5845	1.614	≥ 500	Pass
High	2480	2.5880	1.621	≥ 500	Pass

Please refer to the following plots for detailed test results

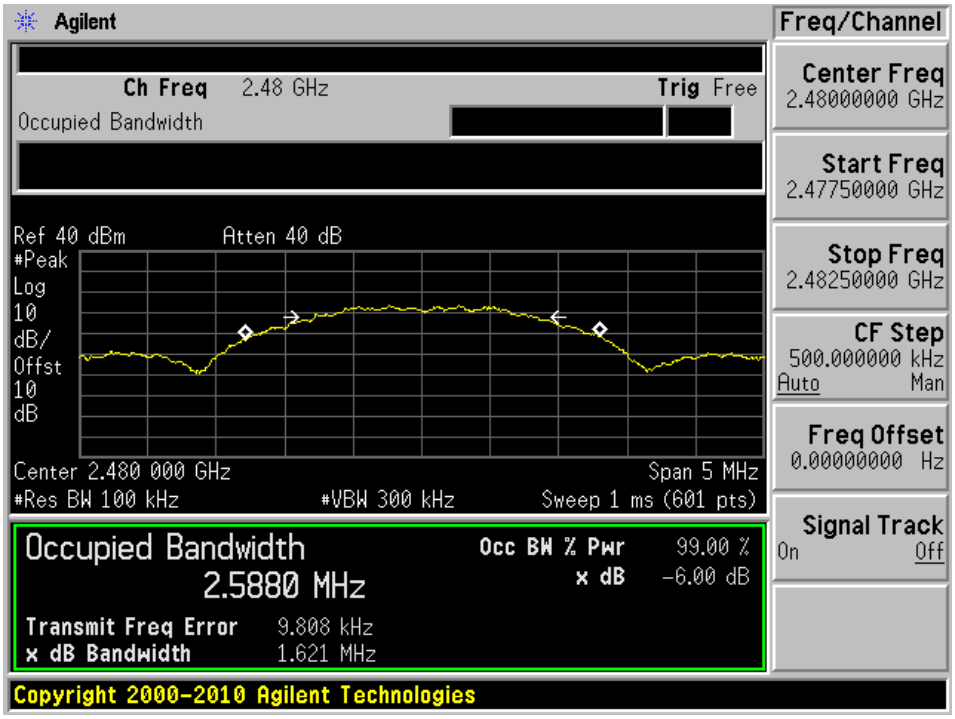
802.15.4 - 2405 MHz



802.15.4 - 2445 MHz



802.15.4 - 2480 MHz



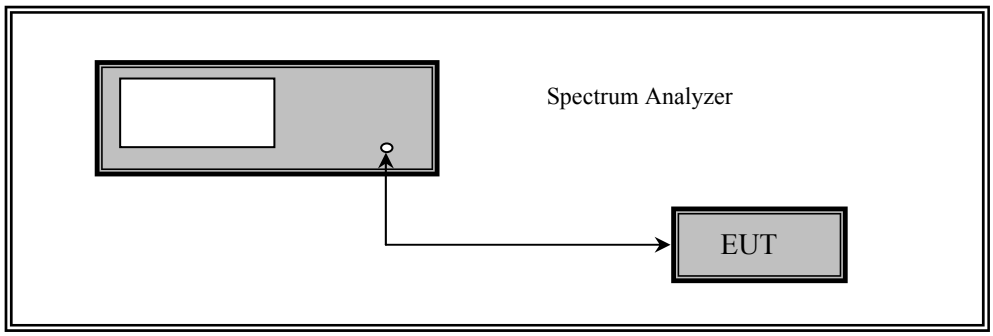
8 FCC §15.247(b) - Output Power Measurement

8.1 Applicable Standards

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.

8.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v03r05: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 9: Fundamental emission output power



8.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4440A	US42221851	2015-06-23	1 year
-	SMA Cable	-	C0001	Each Time[1]	N/A
Mini-Circuits	Attenuator	BW-S10W5	1430	Each Time[1]	N/A

Note [1] cable and attenuator included in the test set-up will be checked each time before testing.
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:	21-24º C
Relative Humidity:	40-44 %
ATM Pressure:	102.1-103.5 kPa

The testing was performed by Leonard Gray on 2016-04-29 to 2016-05-18 in RF site.

8.5 Test Results

Channel	Frequency (MHz)	Average Conducted Output Power (dBm)	Limit (dBm)	Margin (dB)
14.5 dBi Antenna Gain				
Low	2405	15.9	21.5	-5.6
Middle	2445	15.91	21.5	-5.59
-	2470	13.64	21.5	-7.86
High	2475	6.36	21.5	-15.14
7 dBi Antenna Gain				
Low	2405	16.33	29	-12.67
Middle	2445	16.96	29	-12.04
-	2475	15.48	29	-13.52
High	2480	-2.85	29	-31.85
3.5 dBi Antenna Gain				
Low	2405	17.34	30	-12.66
Middle	2445	17.78	30	-12.22
-	2475	16.19	30	-13.81
High	2480	6.7	30	-23.3

Note: $P_{OUT} = P_{Limit} - (G_{TX} - 6)$

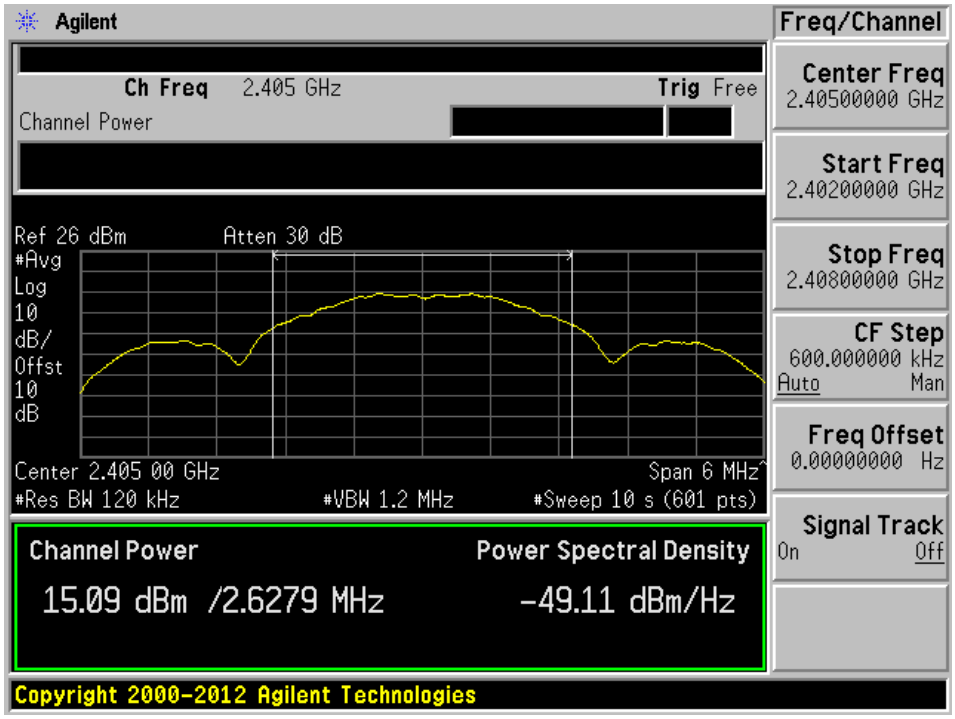
Where:
P_{OUT} *is the maximum conducted output power in dBm,*
P_{Limit} *is the output power limit in dBm,*
G_{TX} *is the maximum transmitting antenna directional gain in dBi.*

The P_{Limit} *is 30dBm, and* G_{TX} *is 14.5dBi, thus the maximum conducted output power limit is 21.5dBm*

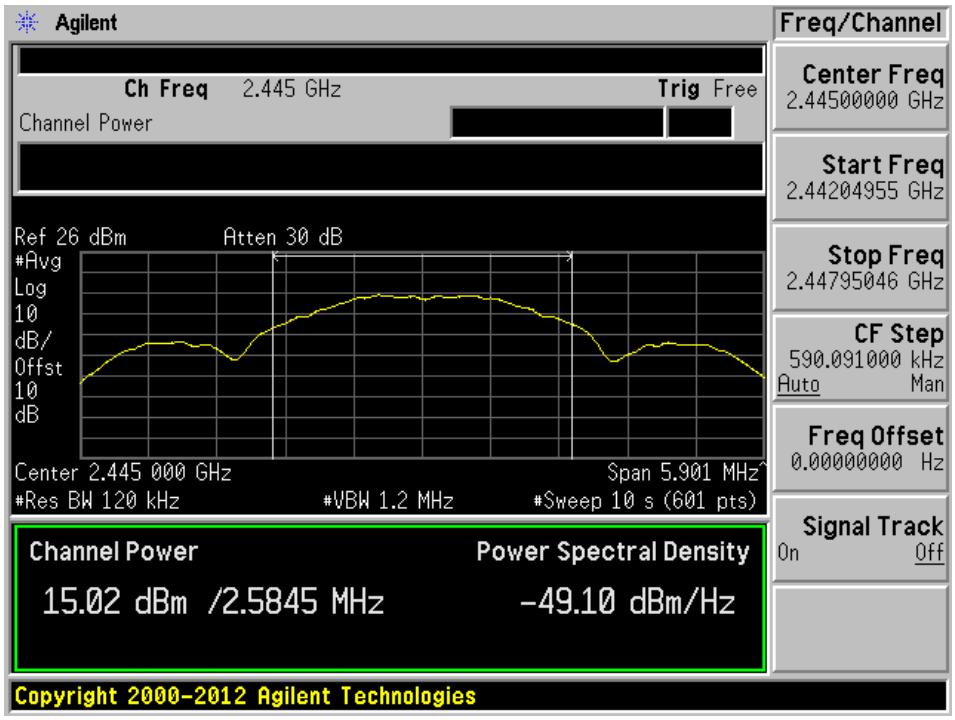
Note: Cable Loss is not included in the plots, 2405 MHz: 0.81dB, 2445 MHz: 0.89 dB, 2470 MHz: 1.2 dB, 2475MHz: 1.18, 2480 MHz: 1.30 dB

14 dBi Antenna

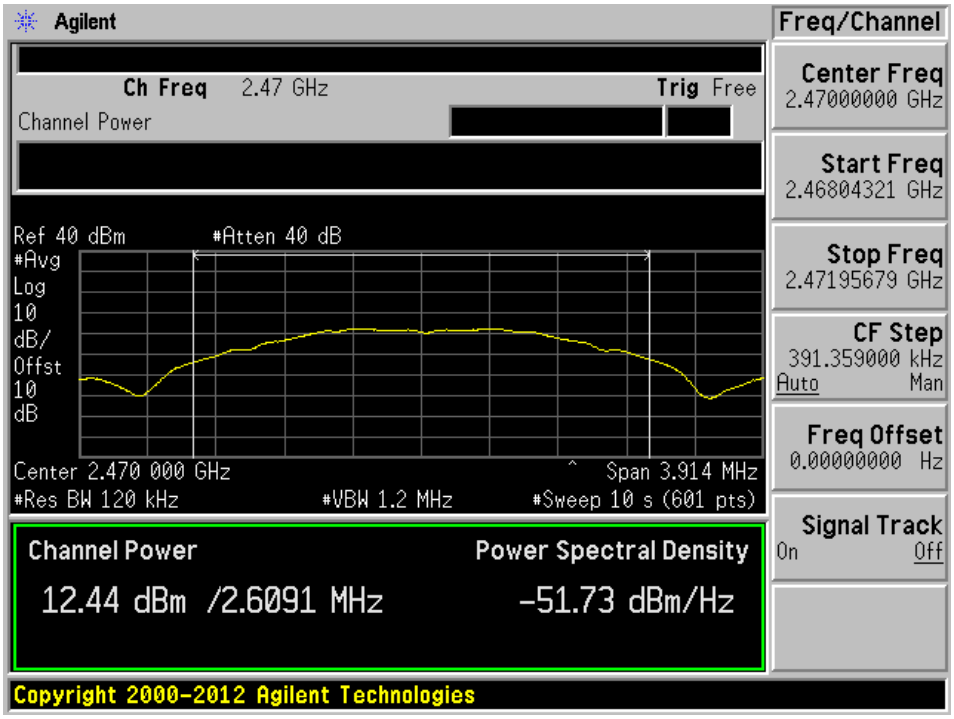
802.15.4 - 2405 MHz



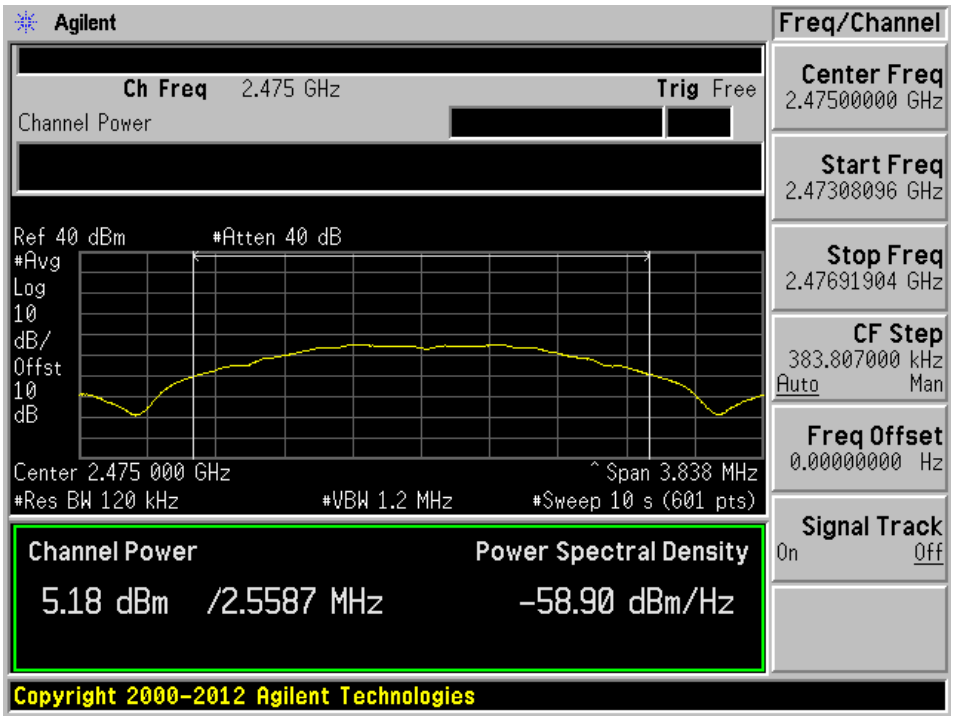
802.15.4 - 2445 MHz



802.15.4 - 2470 MHz

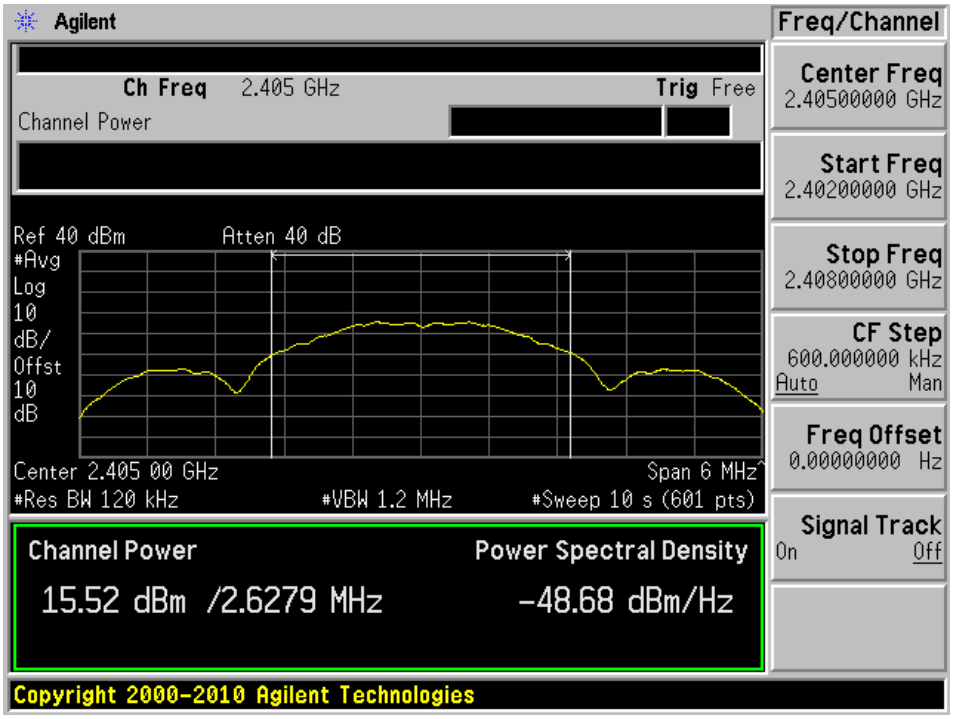


802.15.4 - 2475 MHz

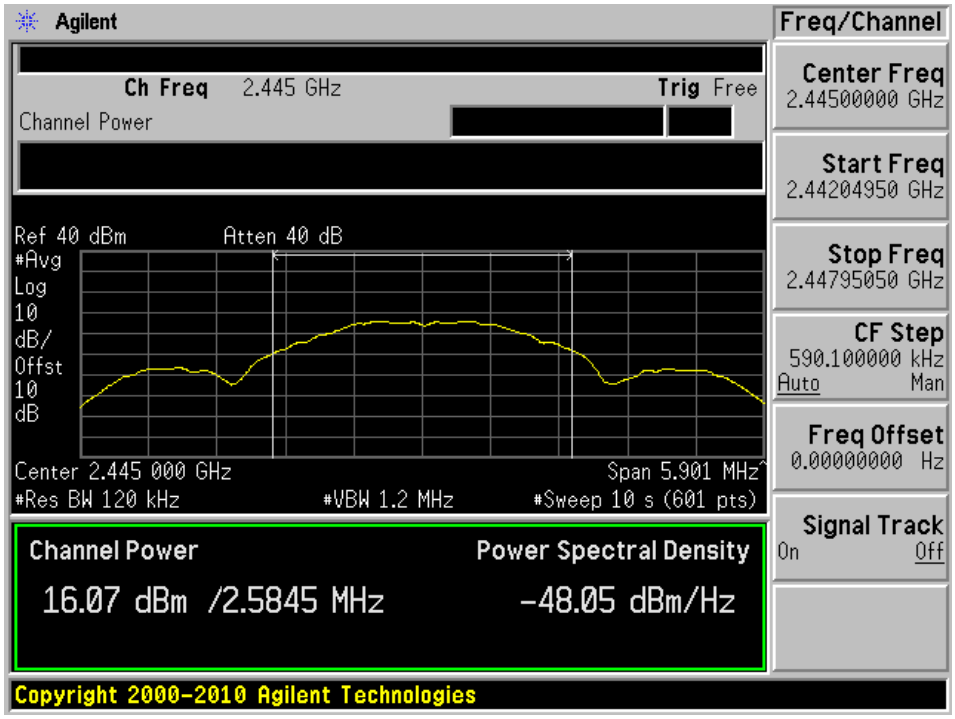


7 dBi Antenna

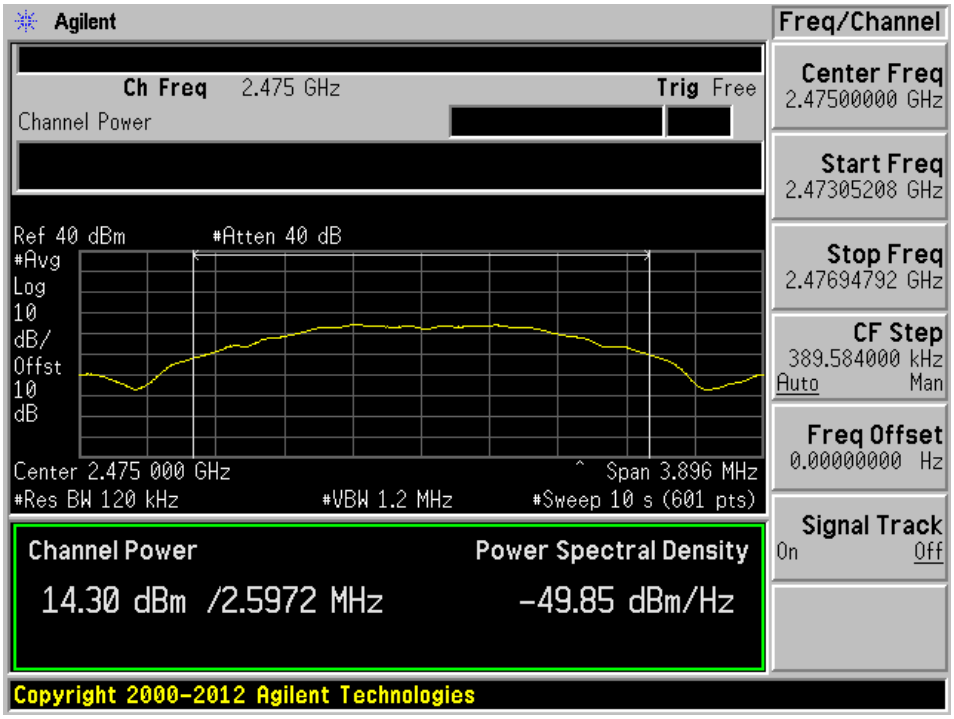
802.15.4 - 2405 MHz



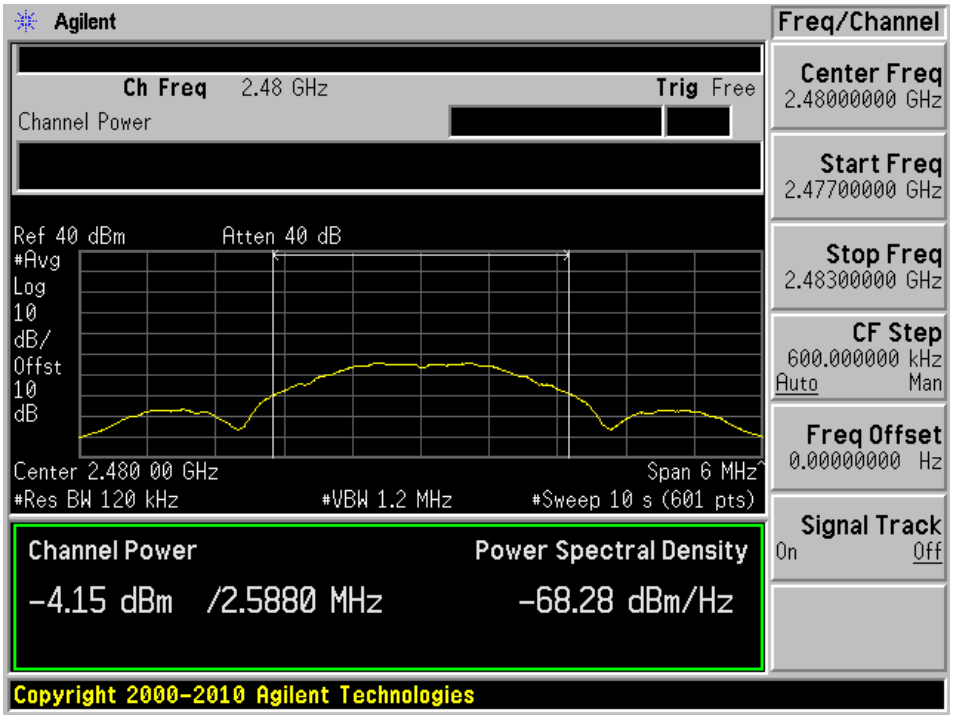
802.15.4 - 2445 MHz



802.15.4 - 2475 MHz

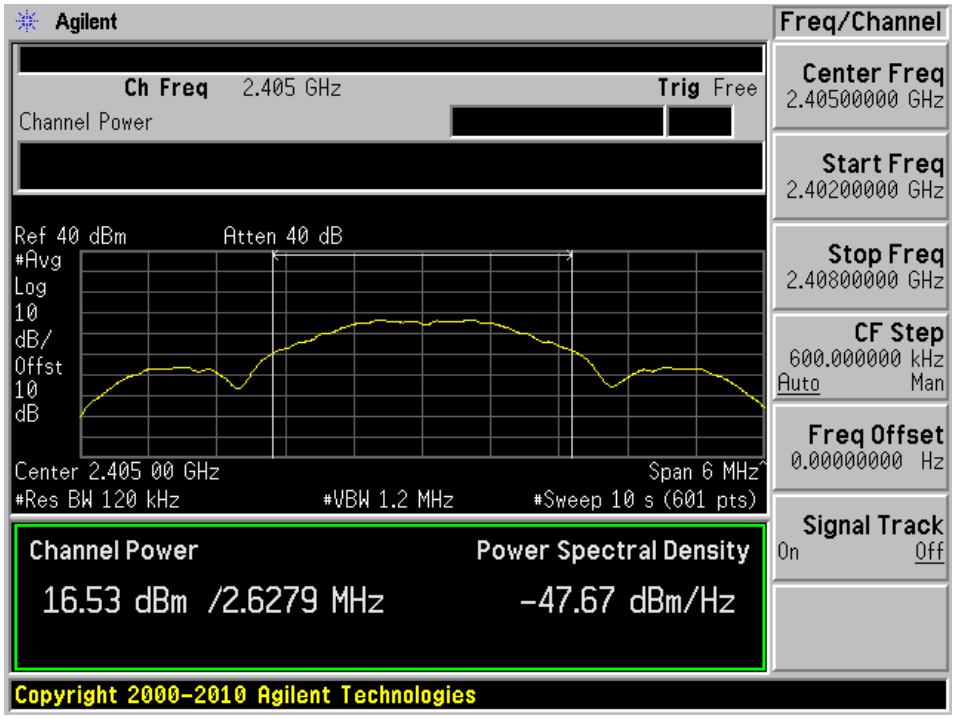


802.15.4 - 2480 MHz

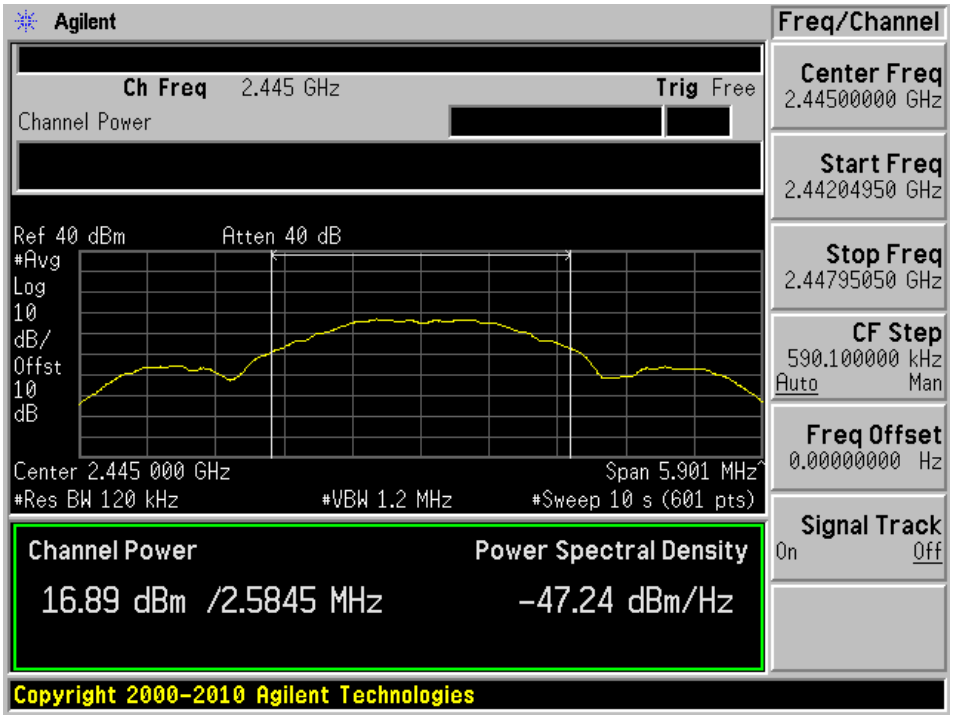


3.5 dBi Antenna

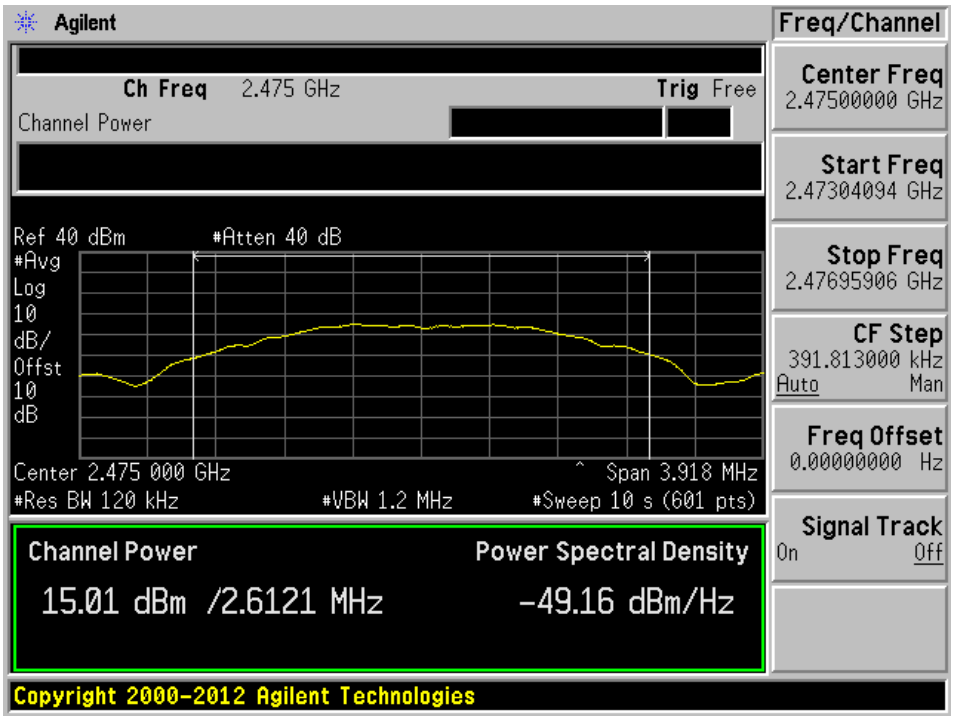
802.15.4 - 2405 MHz



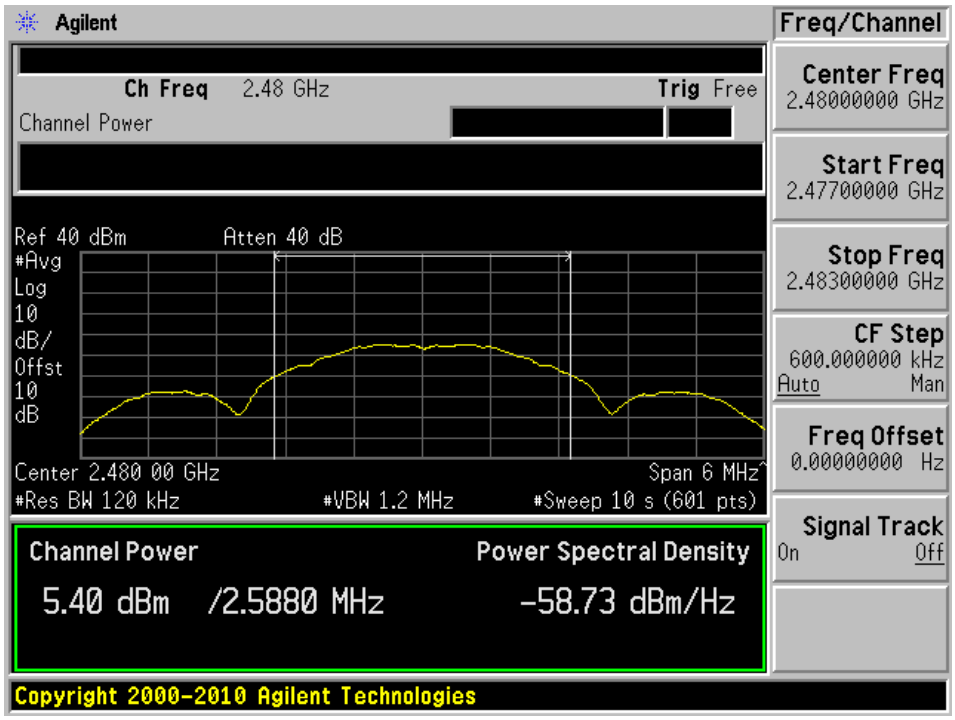
802.15.4 - 2445 MHz



802.15.4 - 2475 MHz



802.15.4 - 2480 MHz



9 FCC §15.247(d) - Spurious Emissions at Antenna Port & Band Edges

9.1 Applicable Standards

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).

9.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v03r05: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 13: Band-edge measurements

9.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4440A	US42221851	2015-06-23	1 year
-	SMA Cable	-	C0001	Each Time[1]	N/A
Mini-Circuits	Attenuator	BW-S10W5	1430	Each Time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
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:	22º C
Relative Humidity:	42 %
ATM Pressure:	102.7 kPa

The testing was performed by Leonard Gray on 2016-04-29 to 2016-05-18 in RF site.

9.5 Test Results

Please refer to the following plots for detailed test results

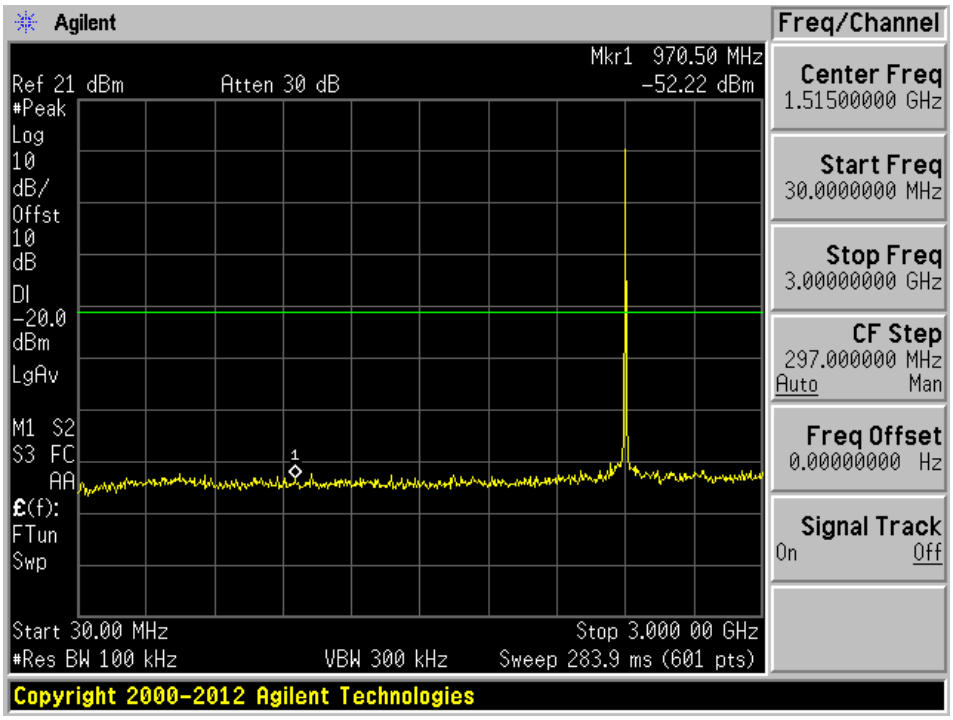
Note: Cable Loss is not included in the plots, 2405 MHz: 0.81dB, 2445 MHz: 0.89dB, 2480 MHz: 1.30dB

Note: Based on KDB 558074 D01, for average power measurement, the conducted emission level should be 30dB below the fundamental, the test result shows all the emission is 30dB below the fundamental.

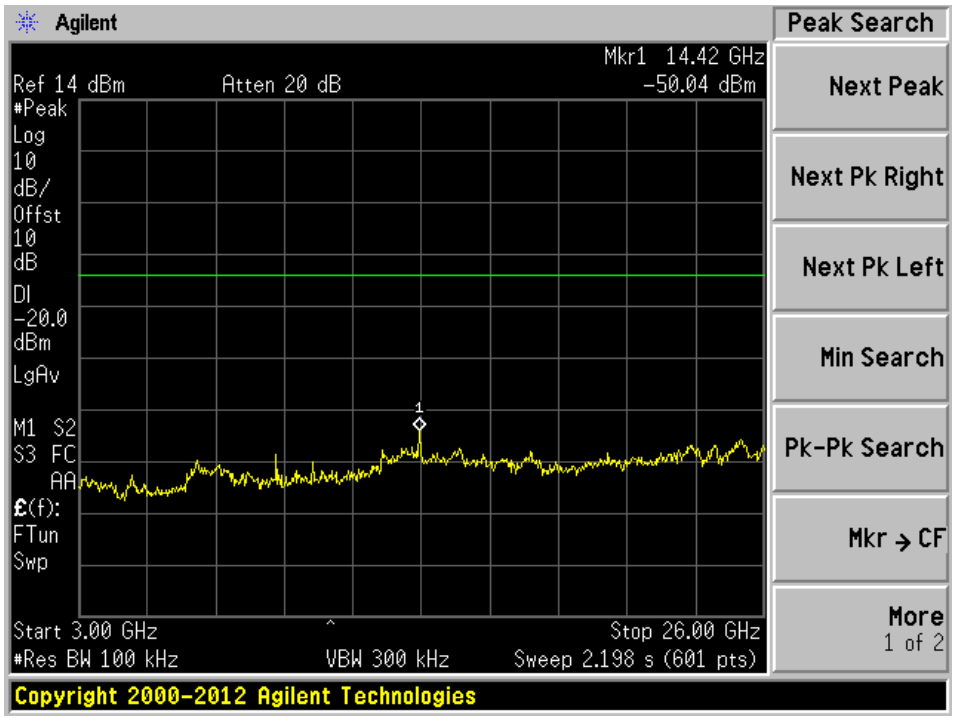
Conducted Spurious Emissions

14 dBi Antenna

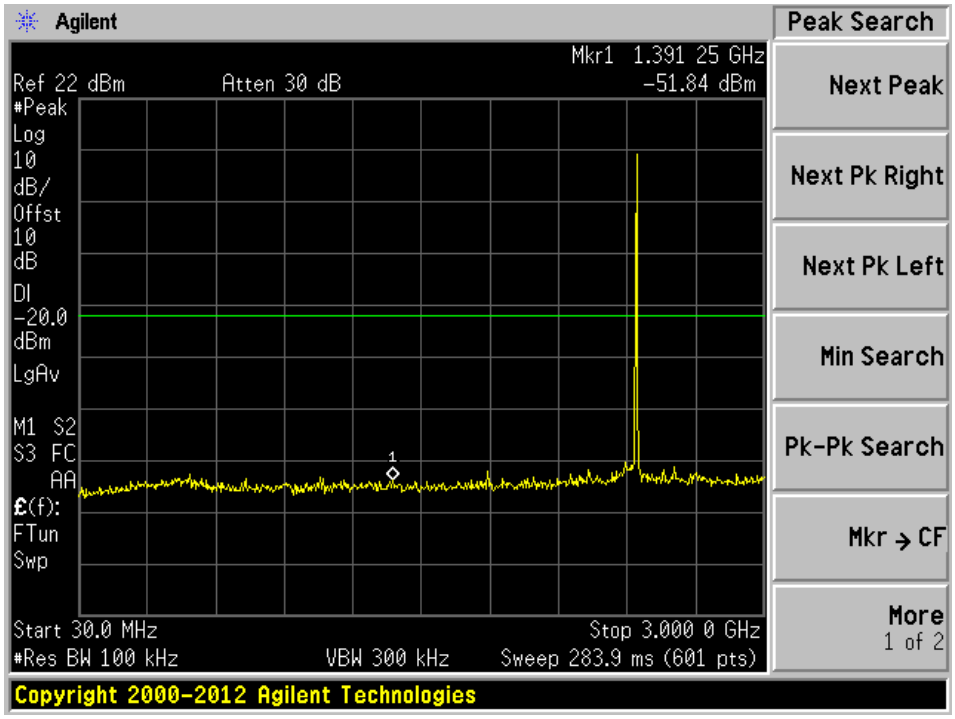
802.15.4-2405 MHz (30 MHz-3 GHz)



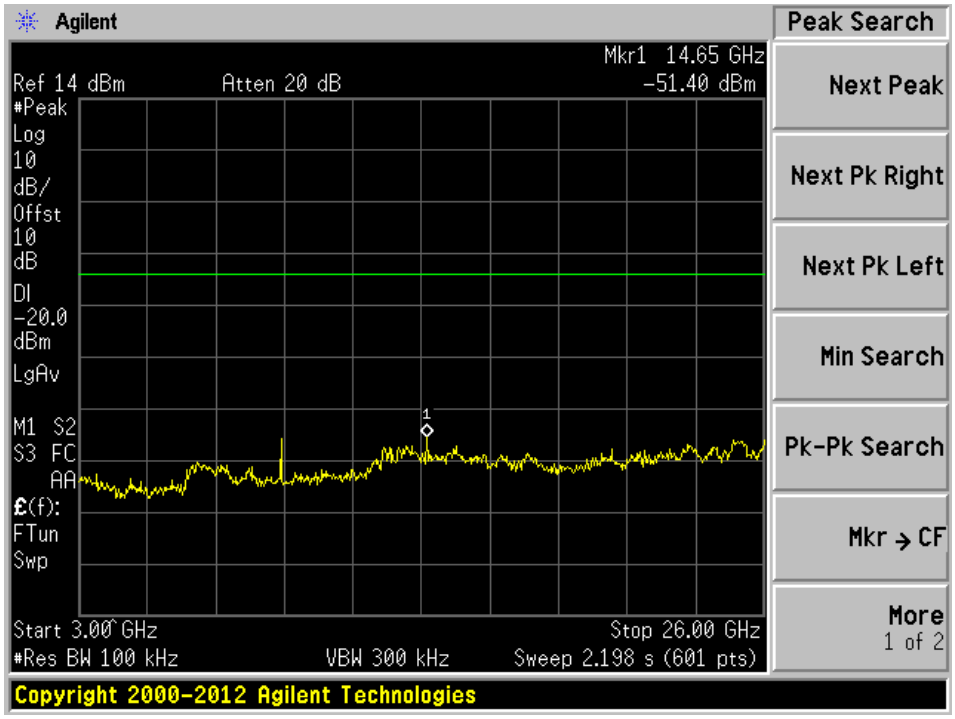
802.15.4-2405 MHz (3-26 GHz)



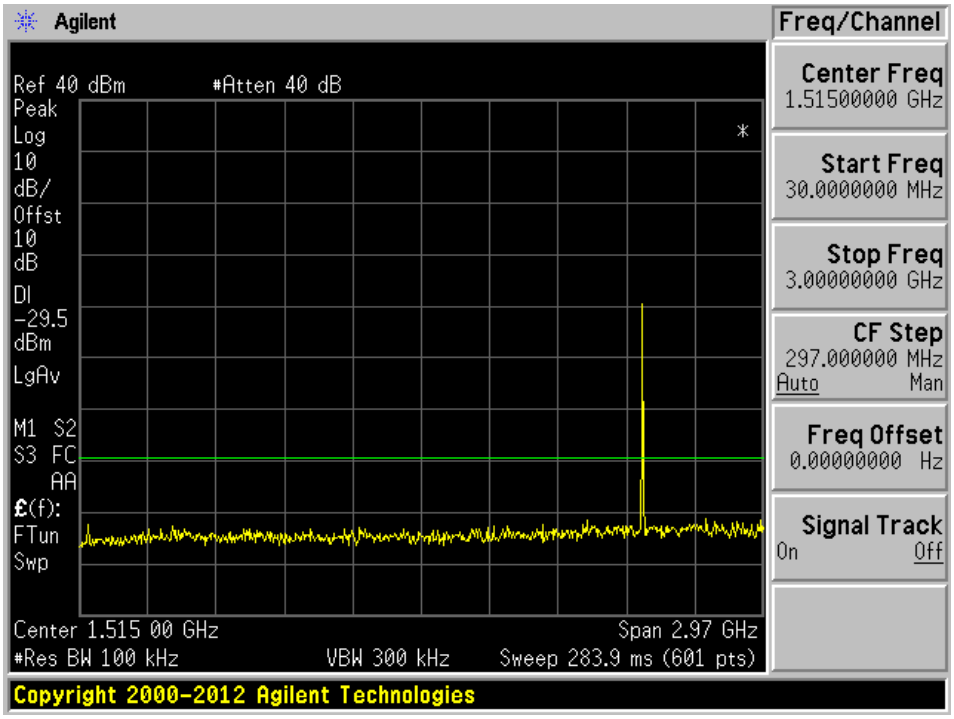
802.15.4-2445 MHz (30 MHz-3 GHz)



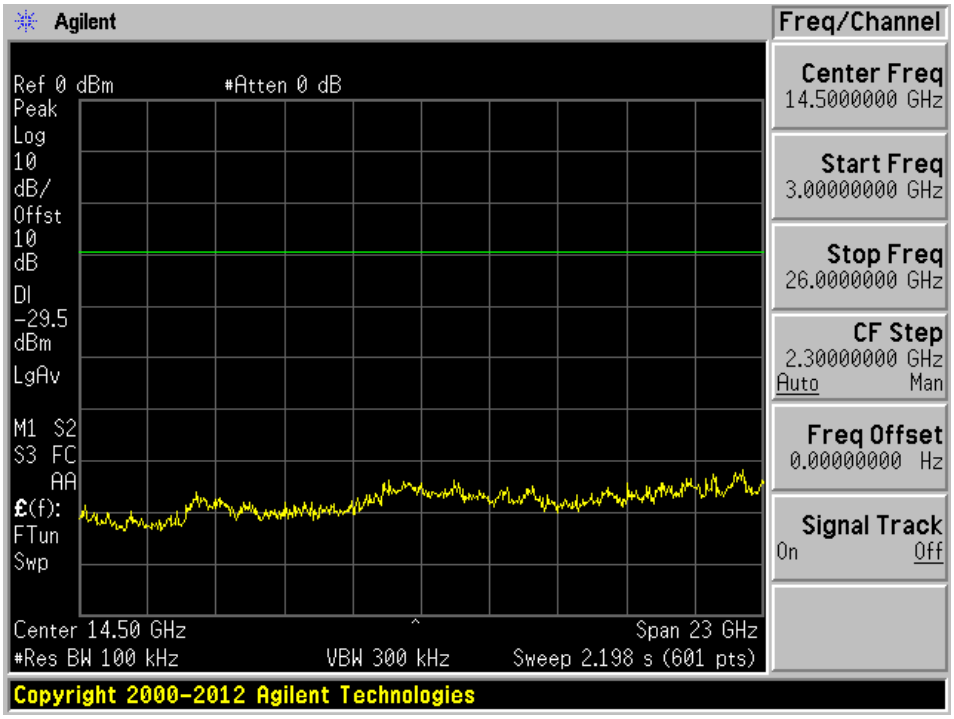
802.15.4-2445 MHz (3-26 GHz)



802.15.4-2475 MHz (30 MHz-3 GHz)

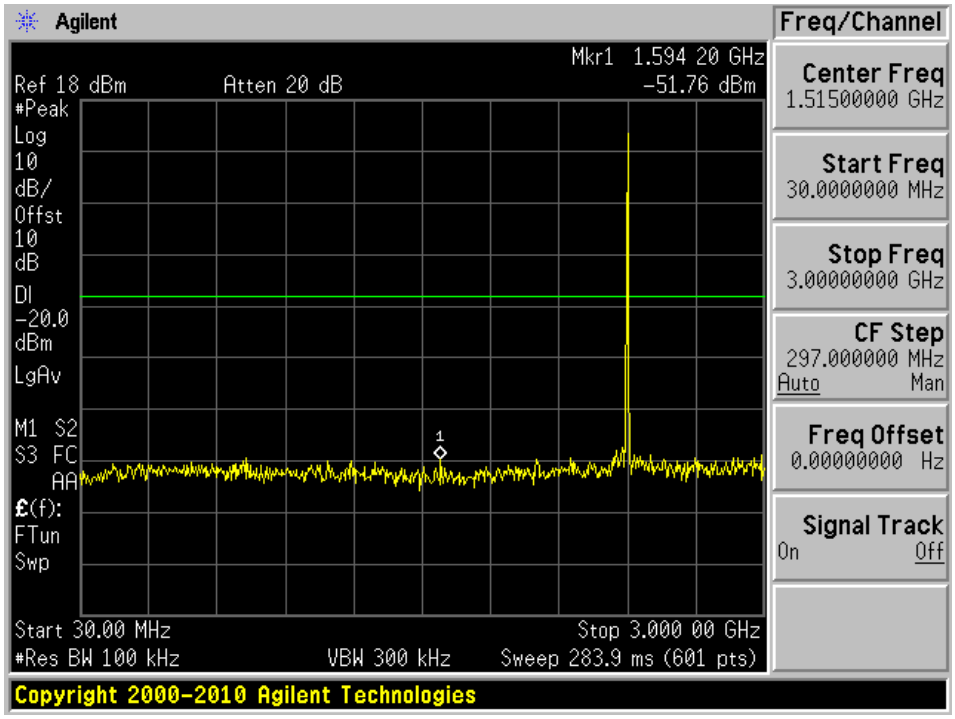


802.15.4-2475 MHz (3-26 GHz)

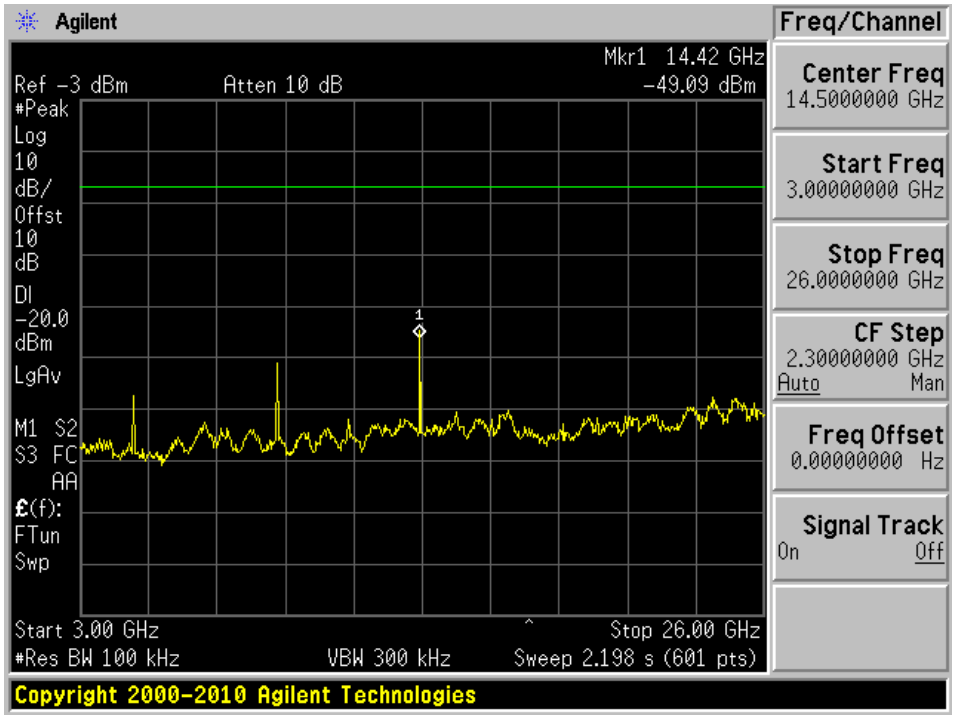


7 dBi Antenna

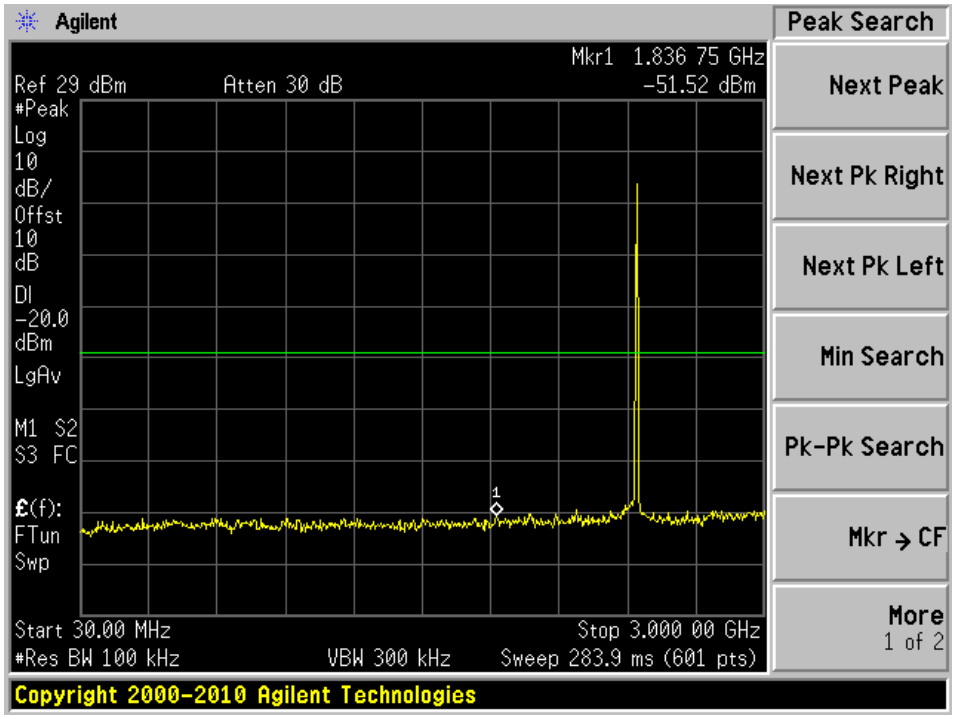
802.15.4-2405 MHz (30 MHz-3 GHz)



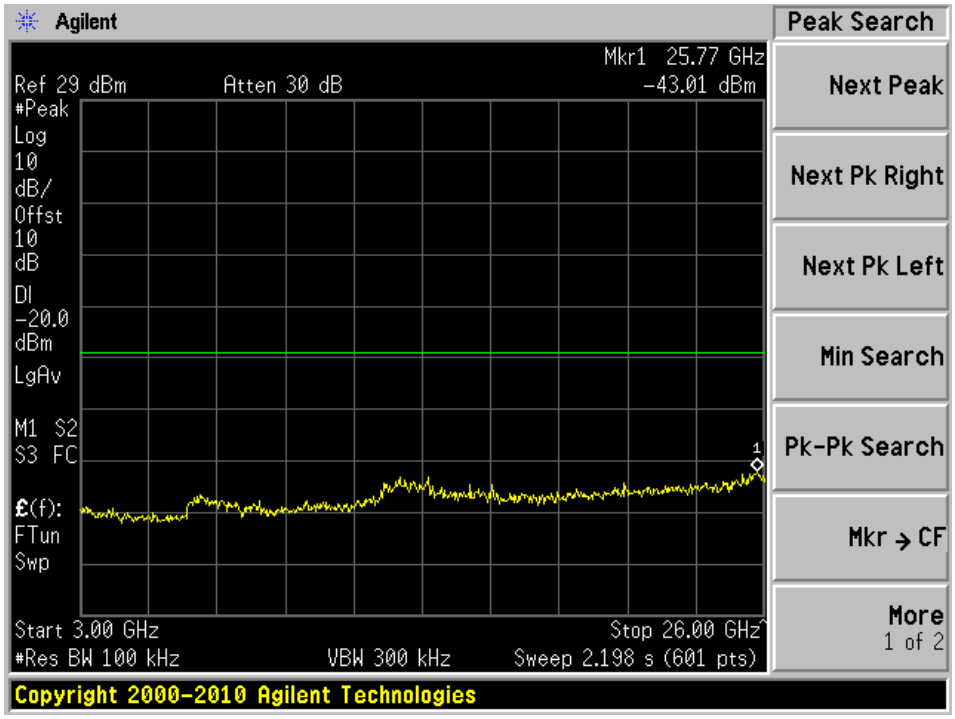
802.15.4-2405 MHz (3-26 GHz)



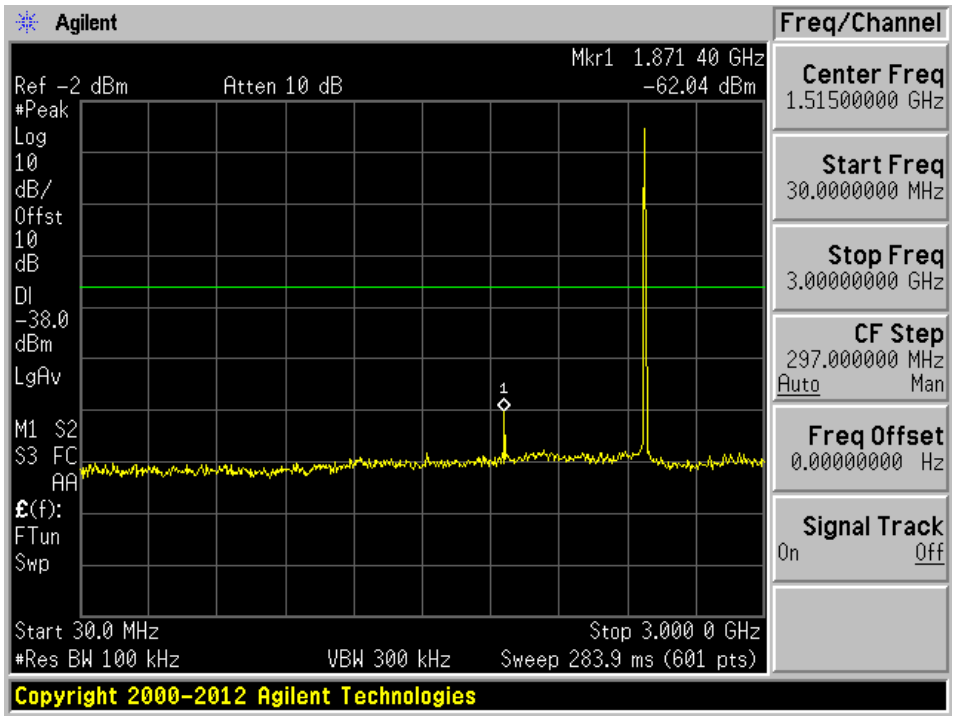
802.15.4-2445 MHz (30 MHz-3 GHz)



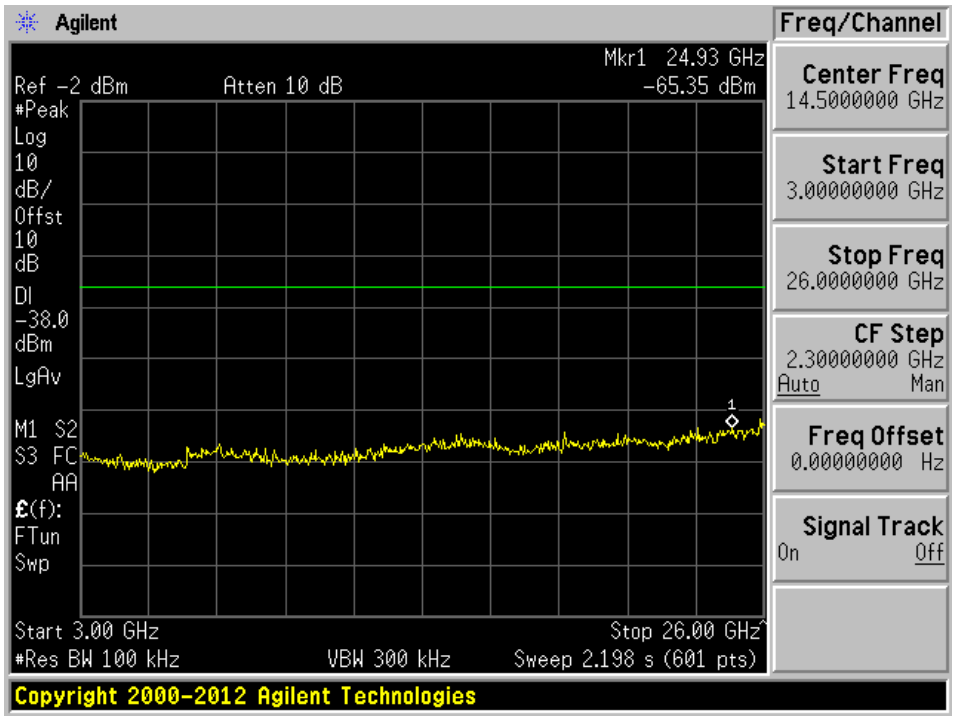
802.15.4-2445 MHz (3-26 GHz)



802.15.4-2480 MHz (30 MHz-3 GHz)

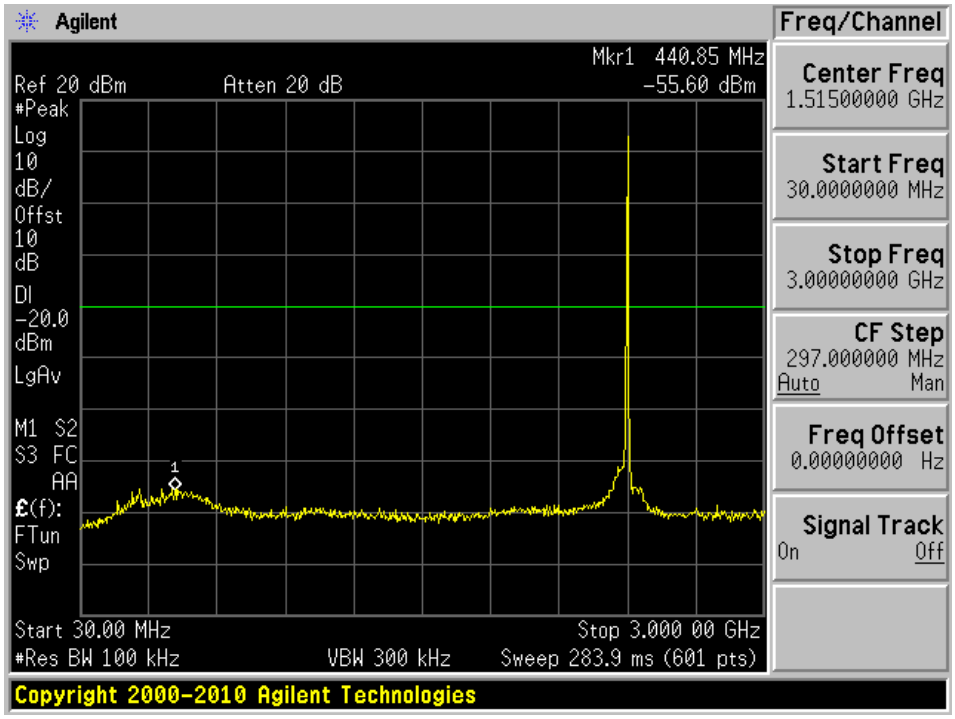


802.15.4-2480 MHz (3-26 GHz)

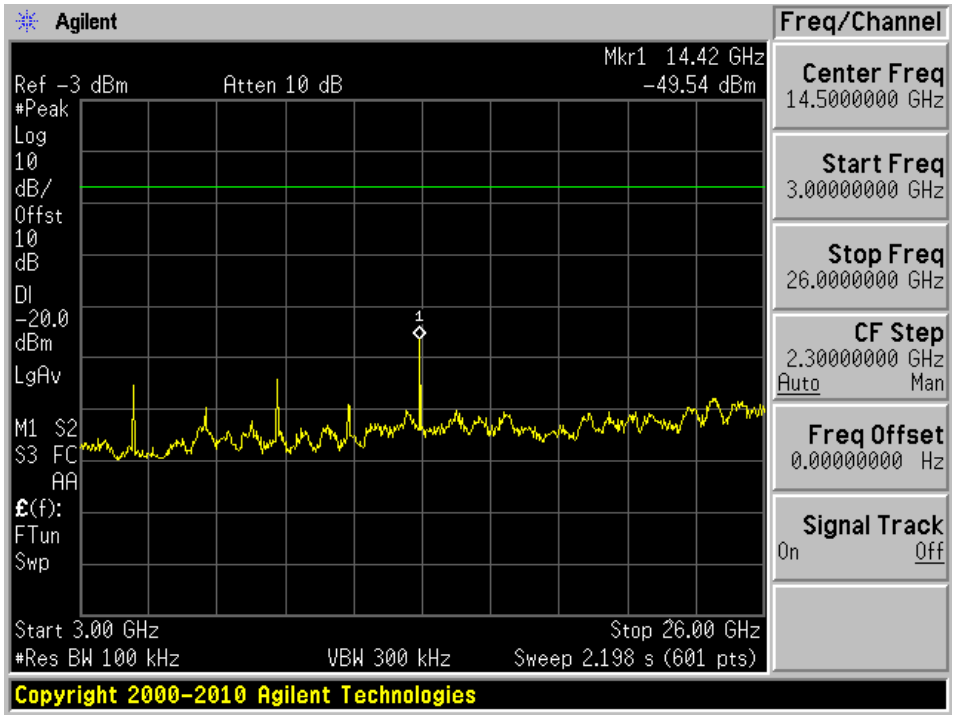


3.5 dBi Antenna

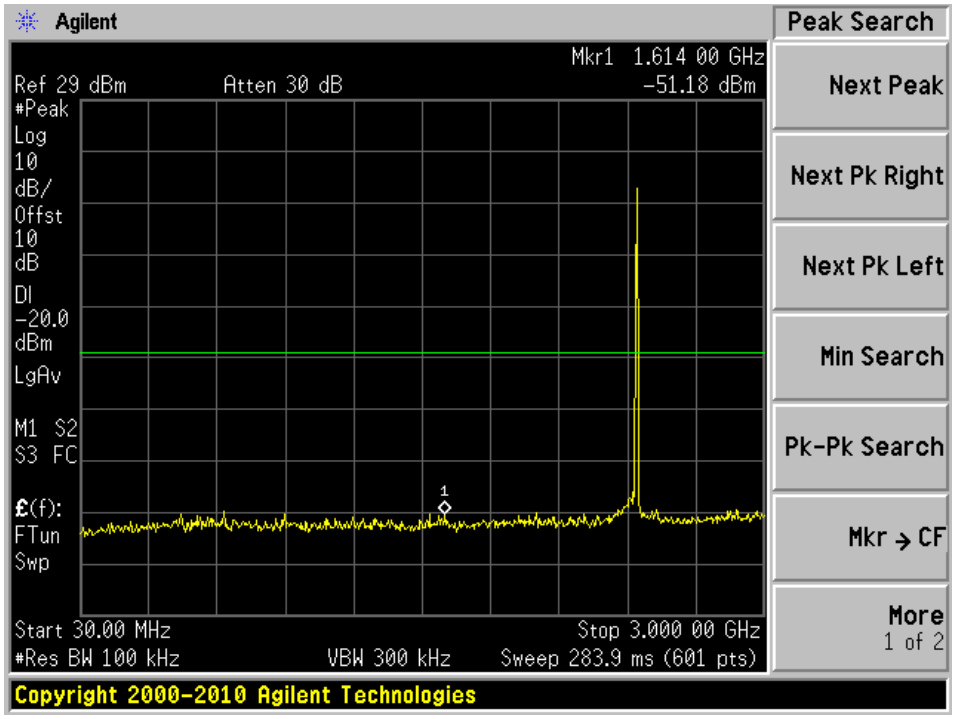
802.15.4-2405 MHz (30 MHz-3 GHz)



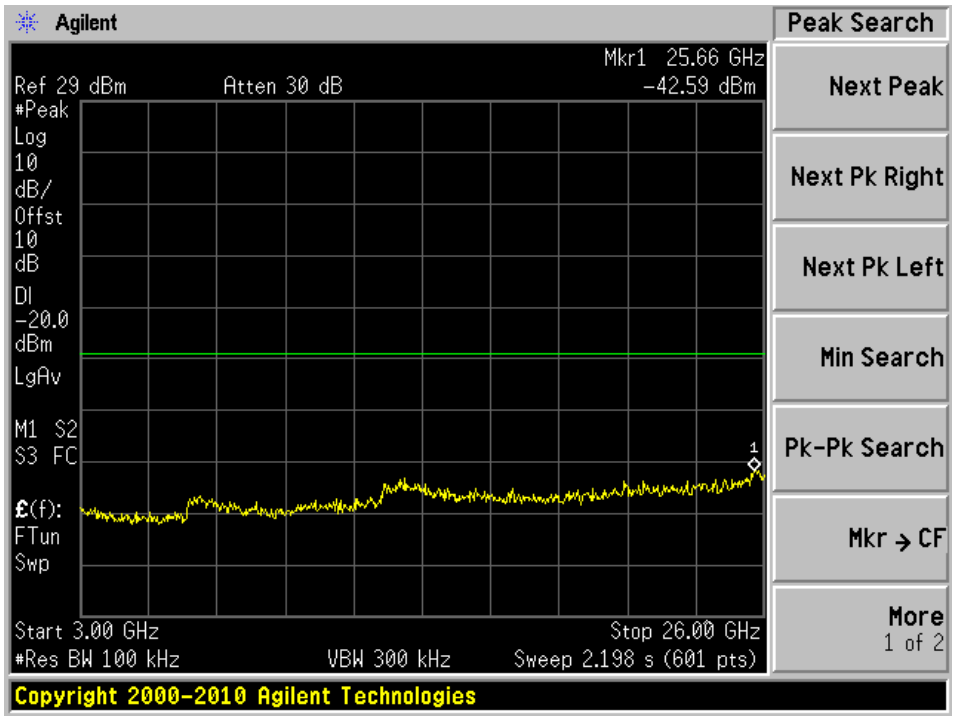
802.15.4-2405 MHz (3-26 GHz)



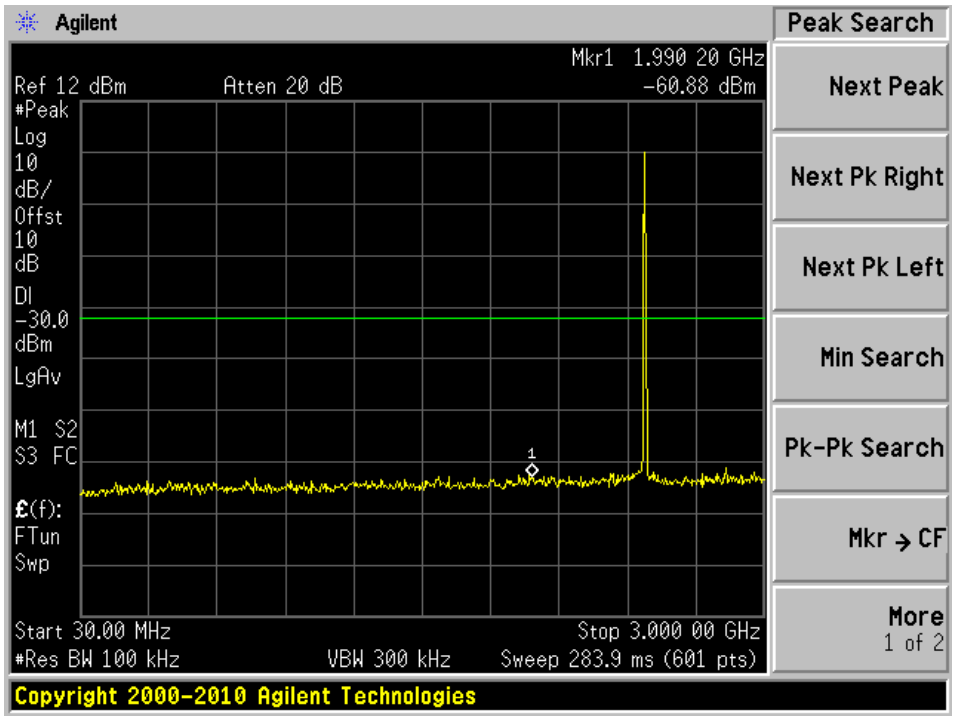
802.15.4-2445 MHz (30 MHz-3 GHz)



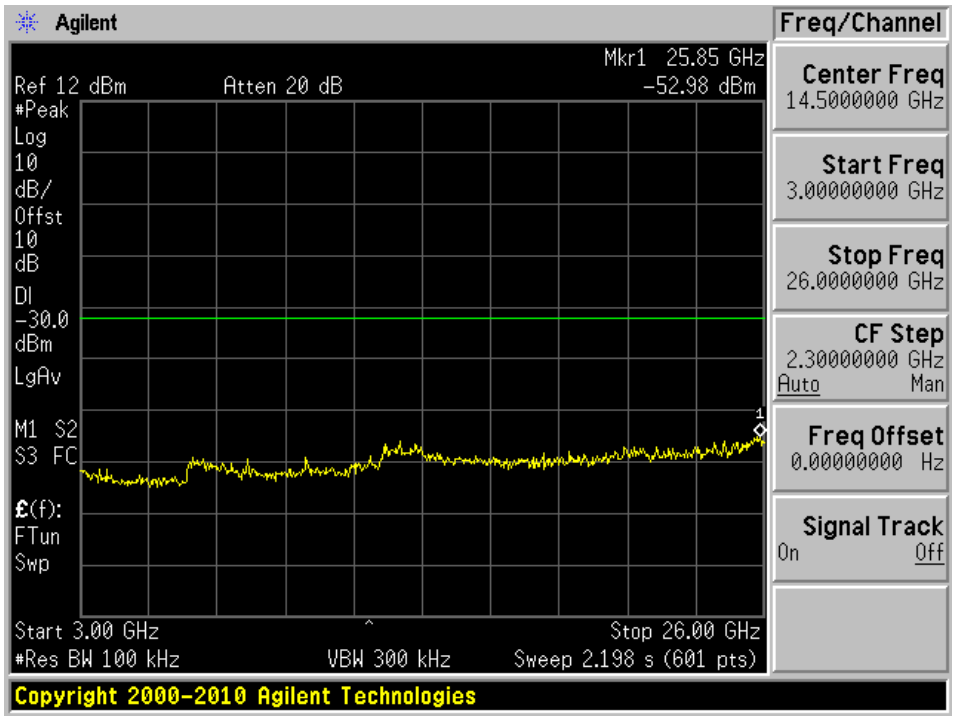
802.15.4-2445 MHz (3-26 GHz)



802.15.4-2480 MHz (30 MHz-3 GHz)



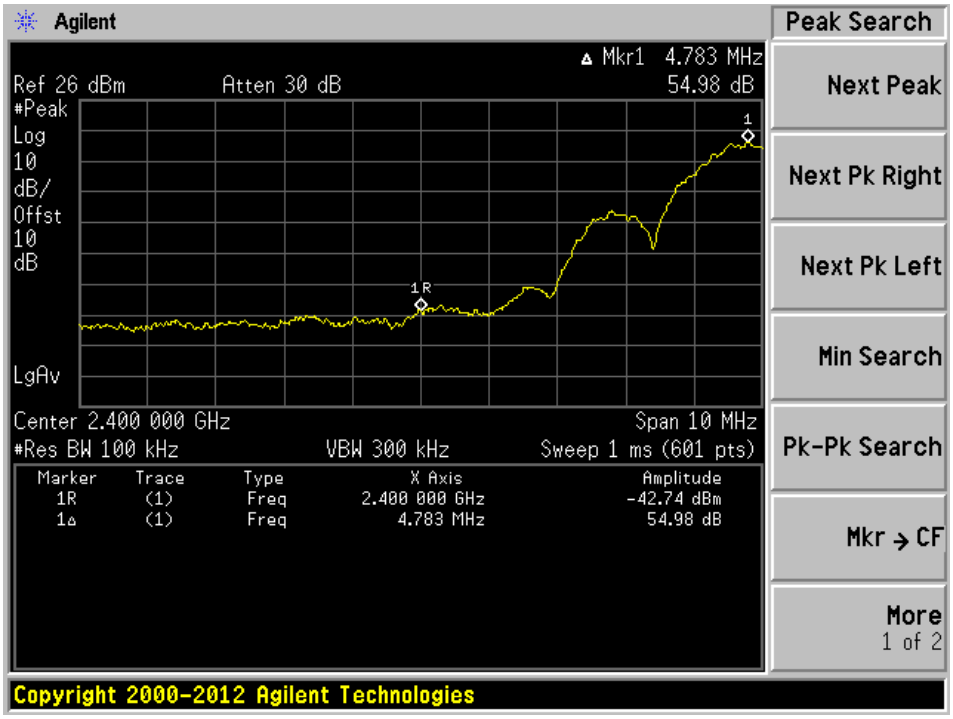
802.15.4-2480 MHz (3-26 GHz)



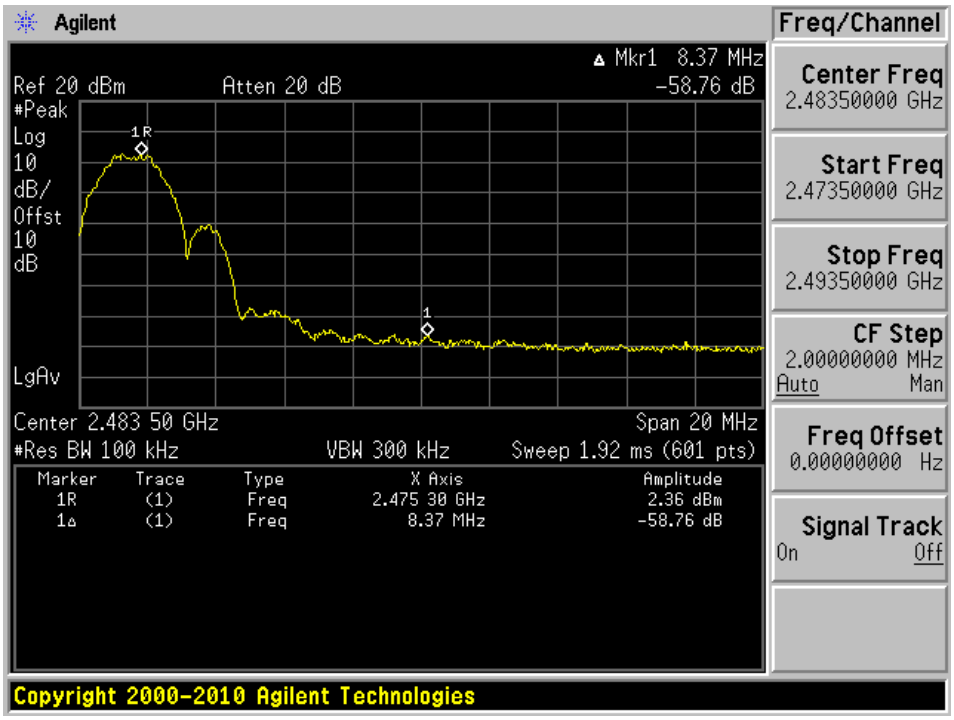
Band Edge

14 dBi Antenna

802.15.4-2405 MHz - Low Band Edge

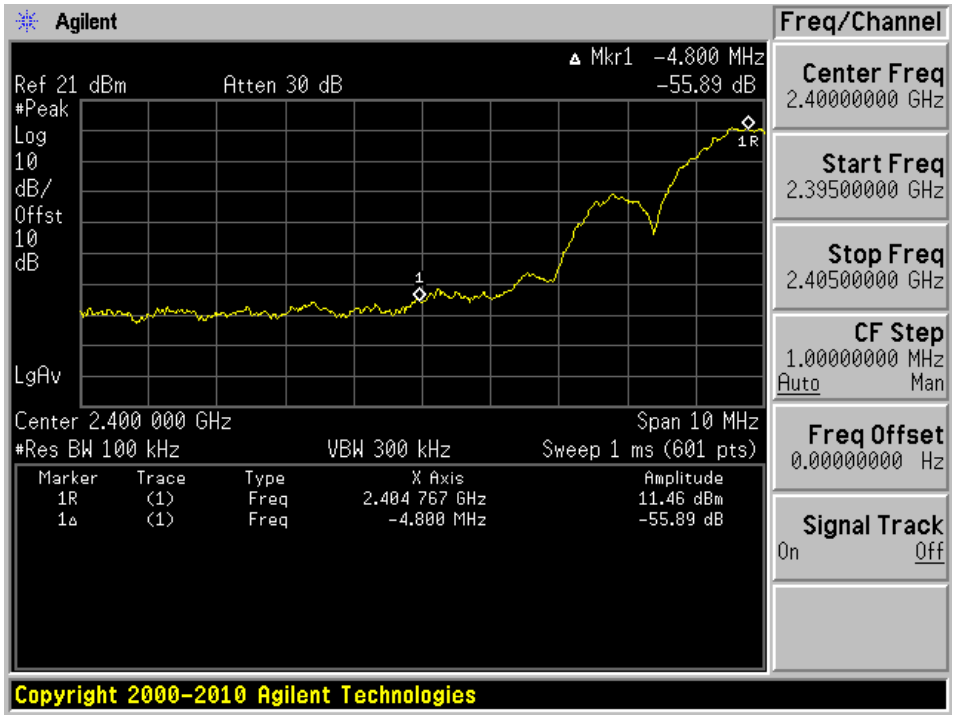


802.15.4-2475 MHz - High Band Edge

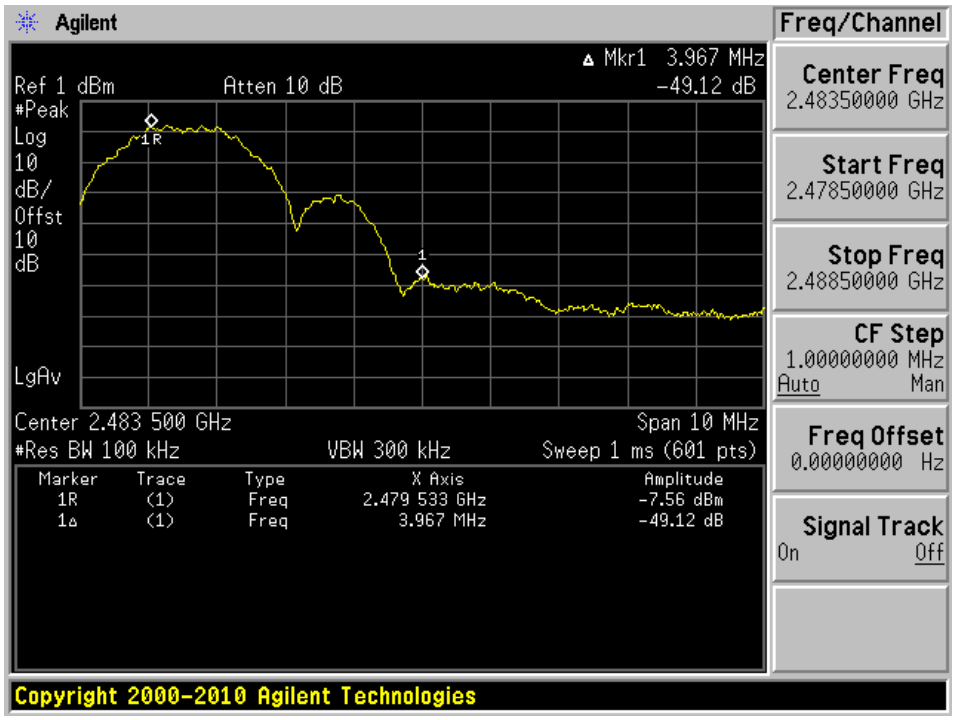


7 dBi Antenna

802.15.4-2405 MHz - Low Band Edge

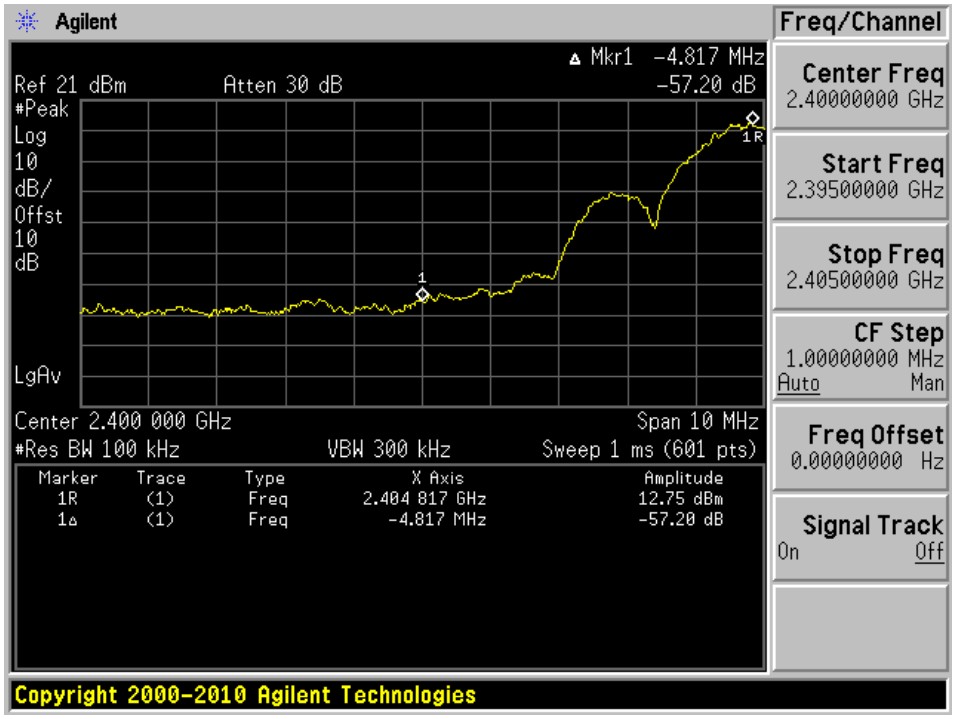


802.15.4-2480 MHz - High Band Edge

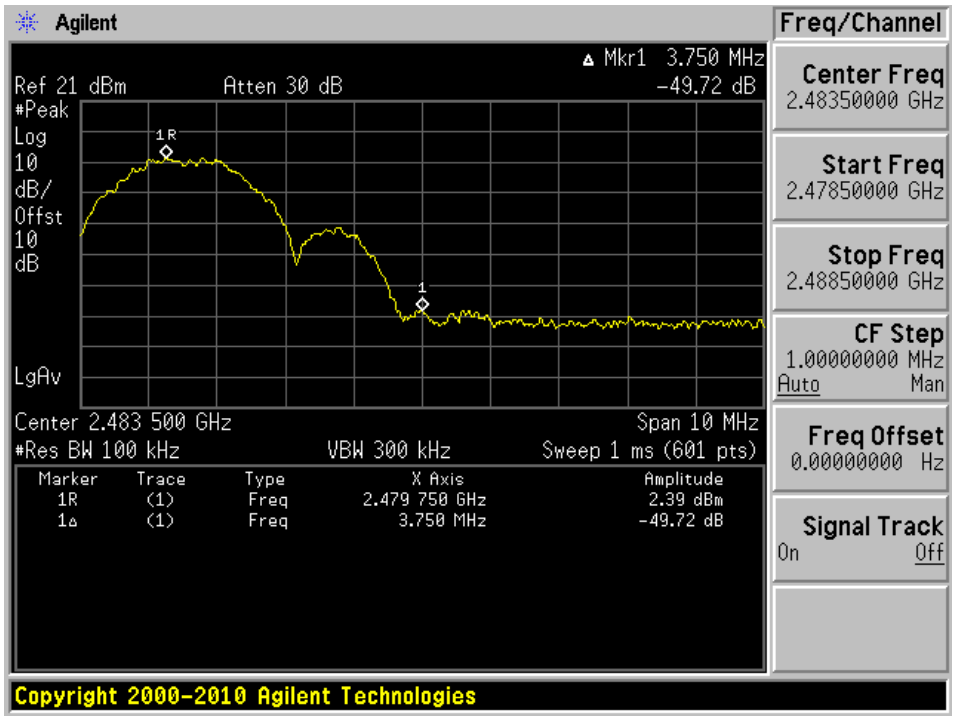


3.5 dBi Antenna

802.15.4-2405 MHz - Low Band Edge



802.15.4-2480 MHz - High Band Edge



10 FCC §15.247(e) - Power Spectral Density

10.1 Applicable Standards

According to FCC §15.247(e), 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.

10.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v03r05: 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

10.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4440A	US42221851	2015-06-23	1 year
-	SMA Cable	-	C0001	Each Time[1]	N/A
Mini-Circuits	Attenuator	BW-S10W5	1430	Each Time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
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:	21-25º C
Relative Humidity:	42-45 %
ATM Pressure:	102.1-103.7 kPa

The testing was performed by Leonard Gray on 2016-04-29 to 2016-05-18 in RF site.

10.5 Test Results

Channel	Frequency (MHz)	Power Spectral Density (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
14.5 dBi Antenna				
Low	2405	-6.57	-0.5	-6.07
Middle	2445	-9.34	-0.5	-8.84
-	2470	-7.97	-0.5	-7.47
High	2475	-15.62	-0.5	-15.12
7 dBi Antenna				
Low	2405	-6.2	7	-13.2
Middle	2445	-6.04	7	-13.04
-	2475	-7.21	7	-14.21
High	2480	-24.23	7	-31.23
3.5 dBi Antenna				
Low	2405	-0.99	8	-8.99
Middle	2445	-5.12	8	-13.12
-	2475	-5.4	8	-13.4
High	2480	-16.07	8	-24.07

Note: $PSD_{OUT} = PSD_{Limit} - (G_{TX} - 6)$

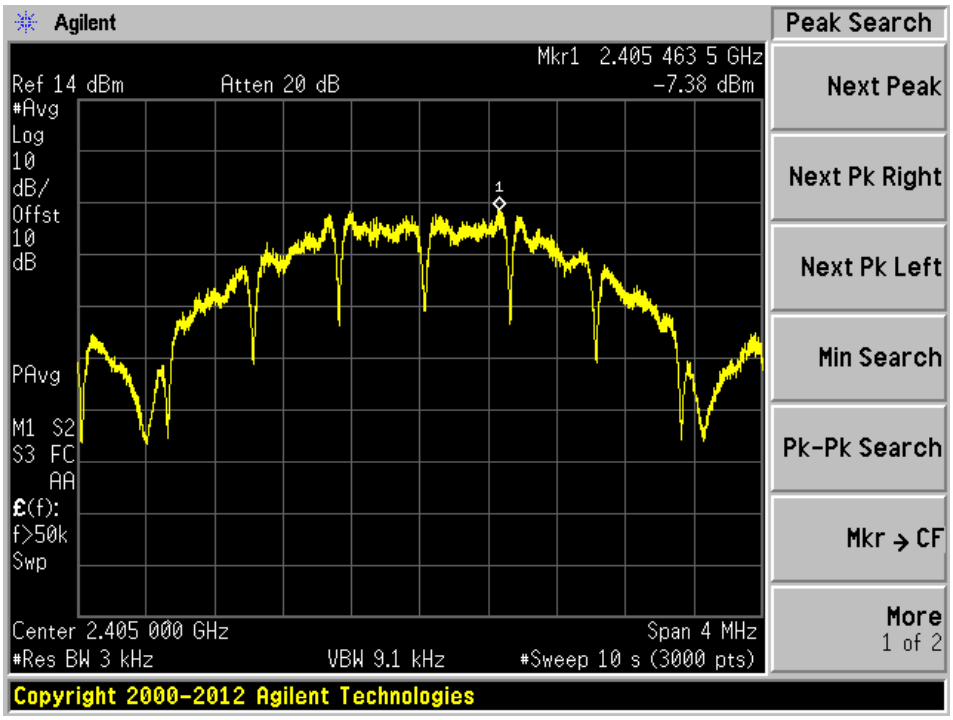
Where:
PSD_{OUT} *is the maximum conducted power spectral density in dBm/3kHz,*
PSD_{Limit} *is the power spectral density limit in dBm/3kHz,*
G_{TX} *is the maximum transmitting antenna directional gain in dBi.*

The PSD_{Limit} *is 8dBm/3kHz, and* G_{TX} *is 14.5dBi, thus the maximum PSD limit is -0.5dBm/3kHz*

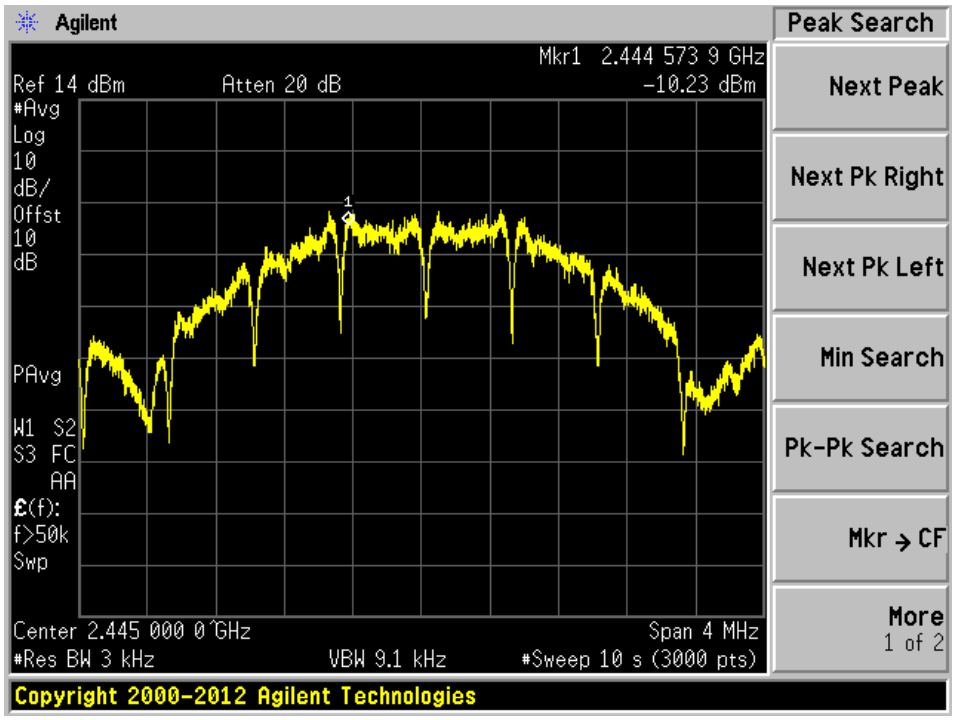
Note: Cable Loss is not included in the plots, 2405 MHz: 0.81dB, 2445 MHz: 0.89 dB, 2470 MHz: 1.2 dB, 2475 MHz: 1.18, 2480 MHz: 1.30 dB

14 dBi Antenna

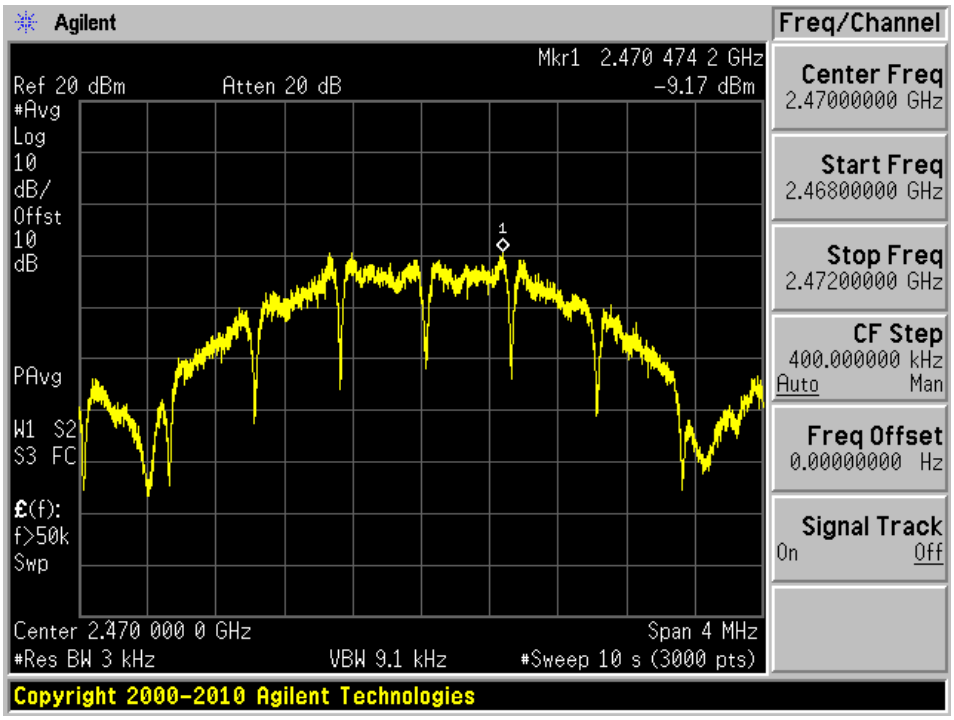
802.15.4-2405 MHz



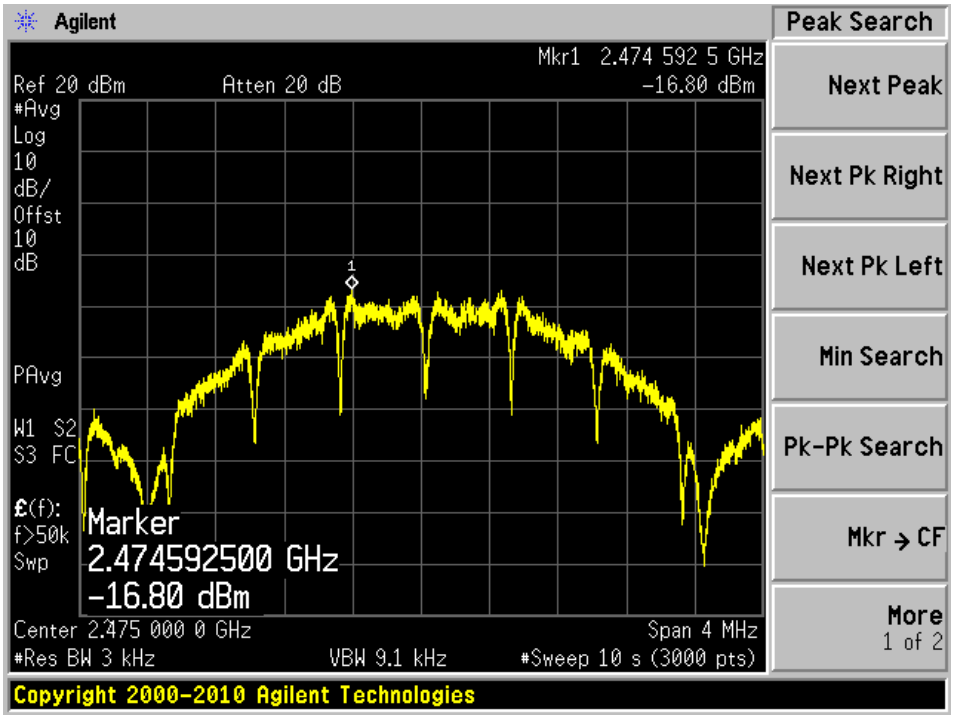
802.15.4-2445 MHz



802.15.4-2470 MHz

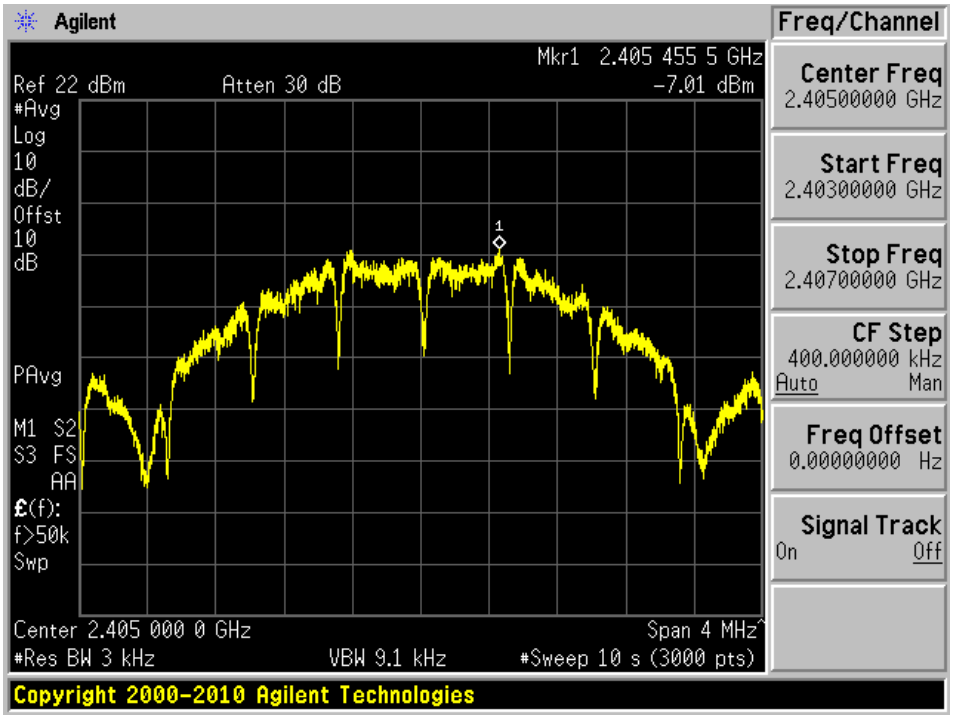


802.15.4-2475 MHz

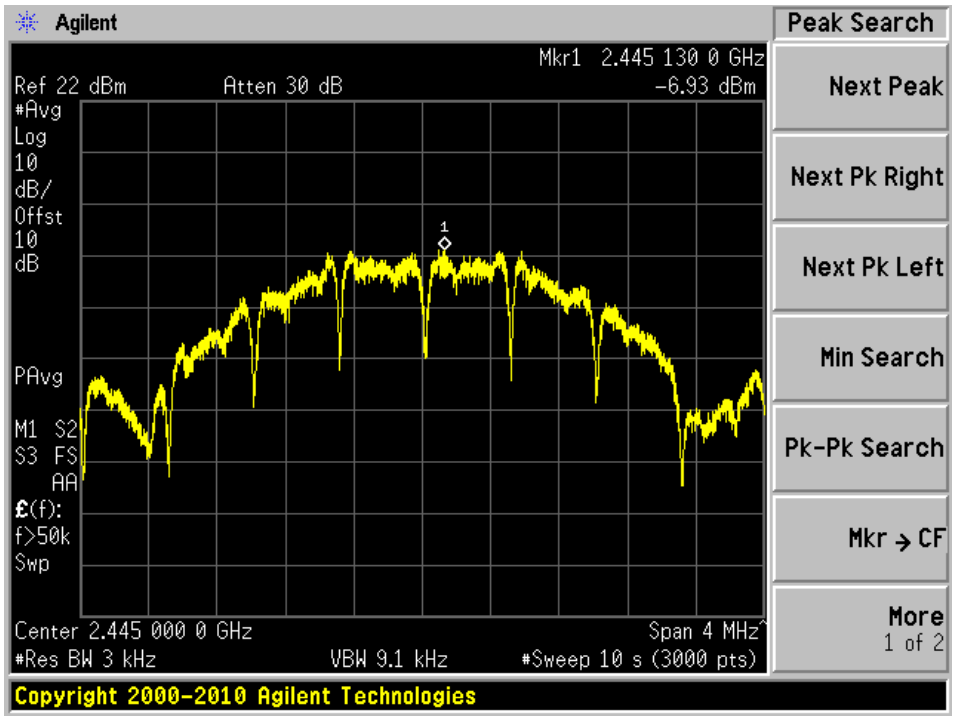


7 dBi Antenna Gain

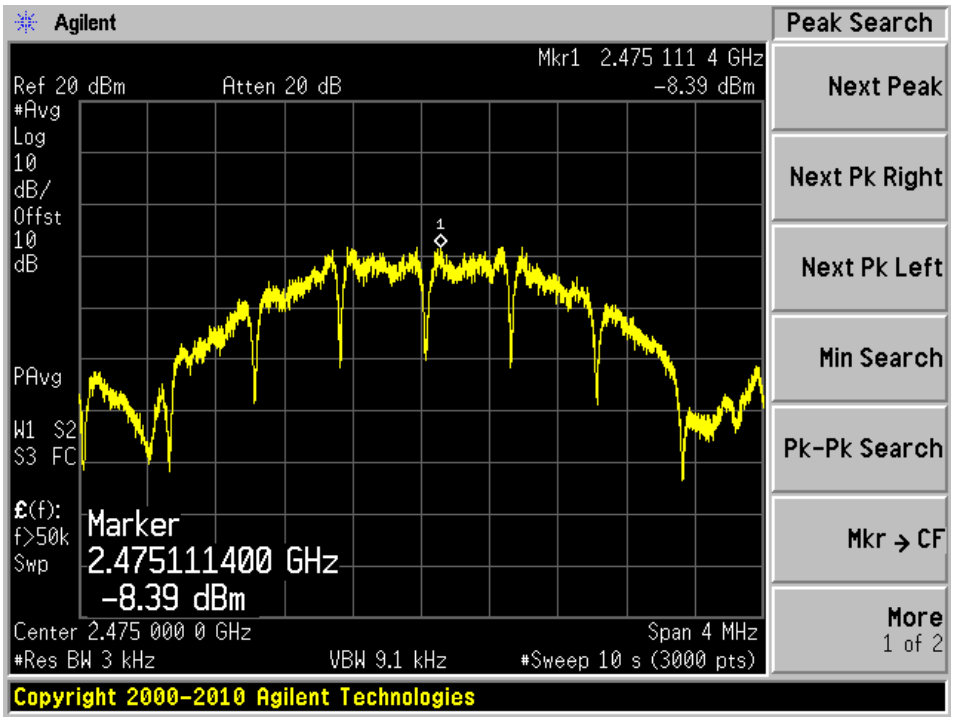
802.15.4-2405 MHz



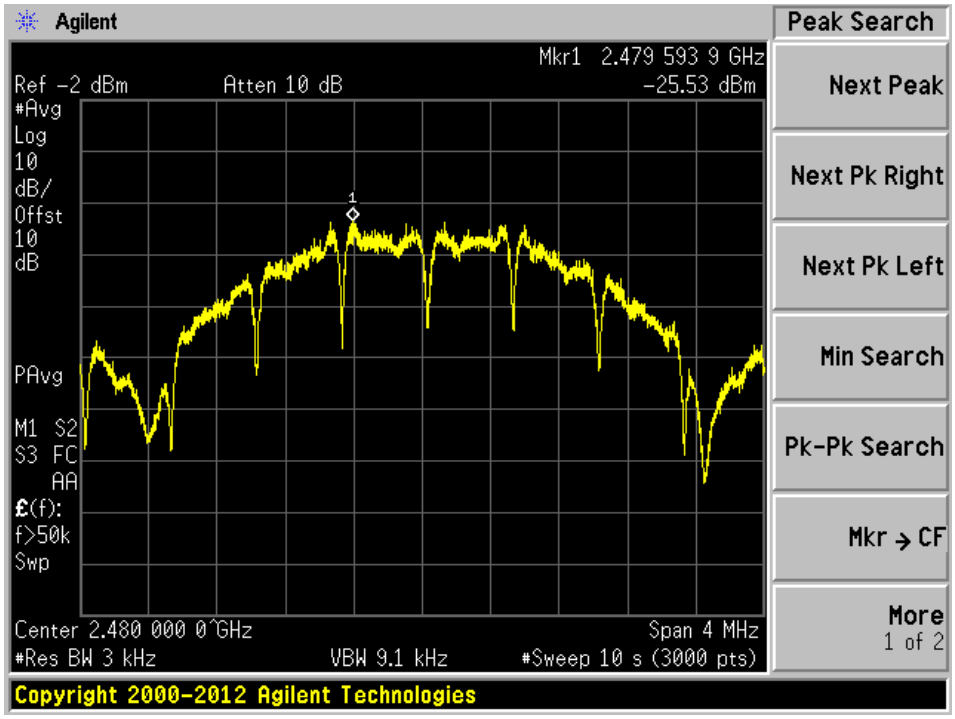
802.15.4-2445 MHz



802.15.4-2475 MHz

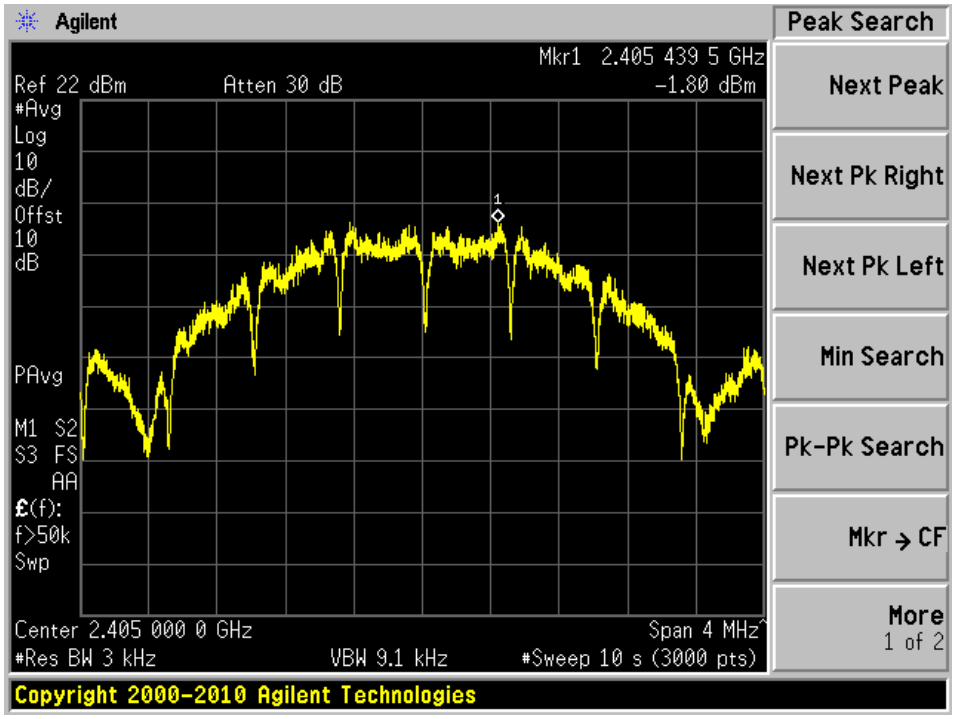


802.15.4-2480 MHz

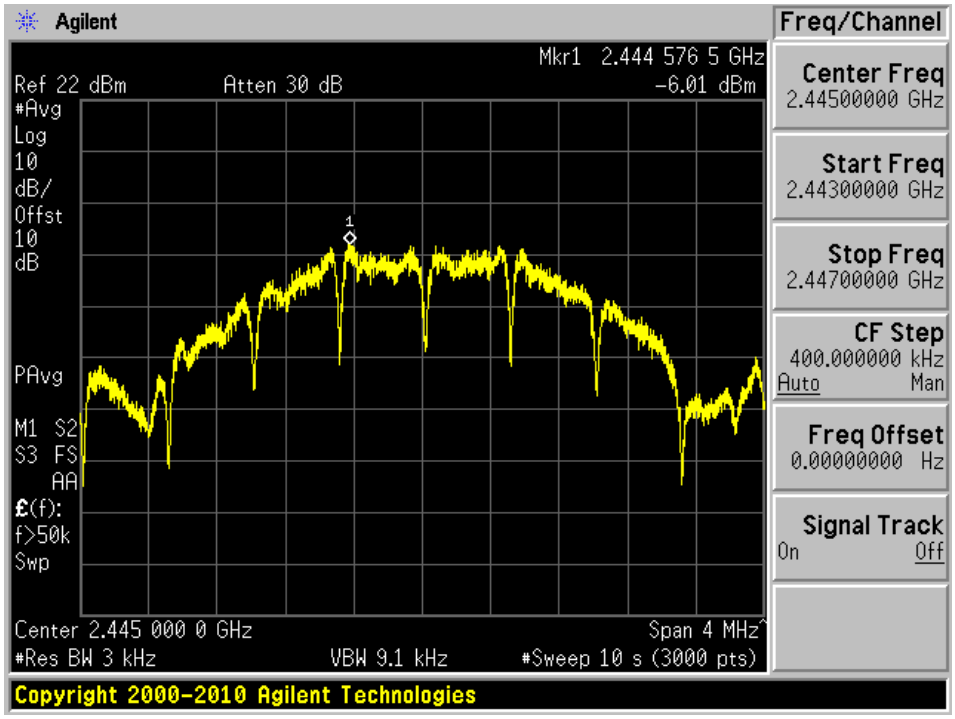


3.5 dBi Antenna

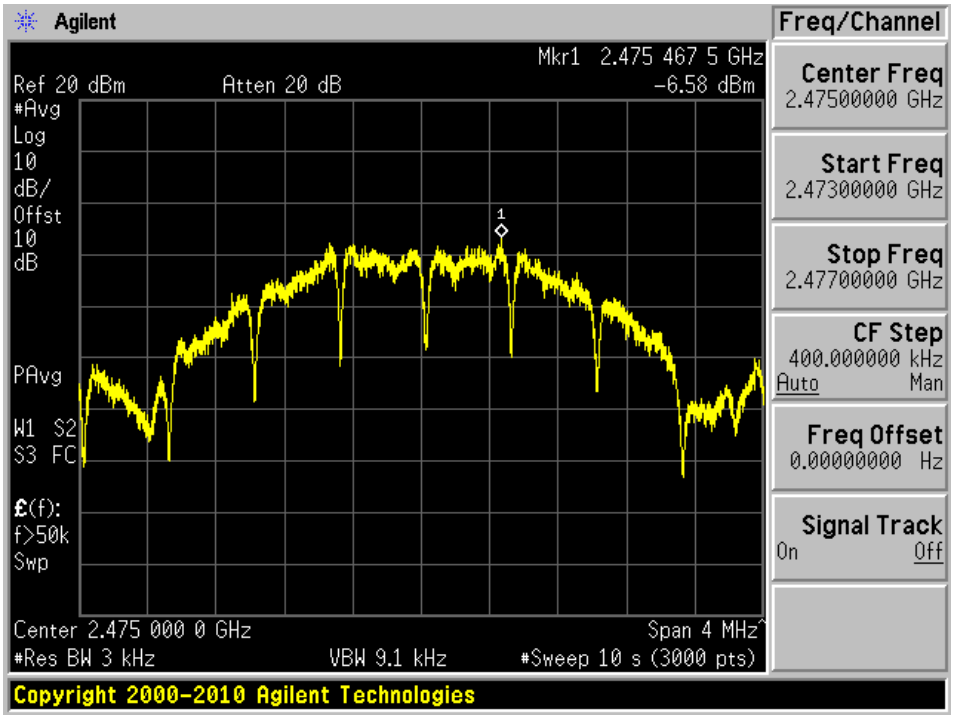
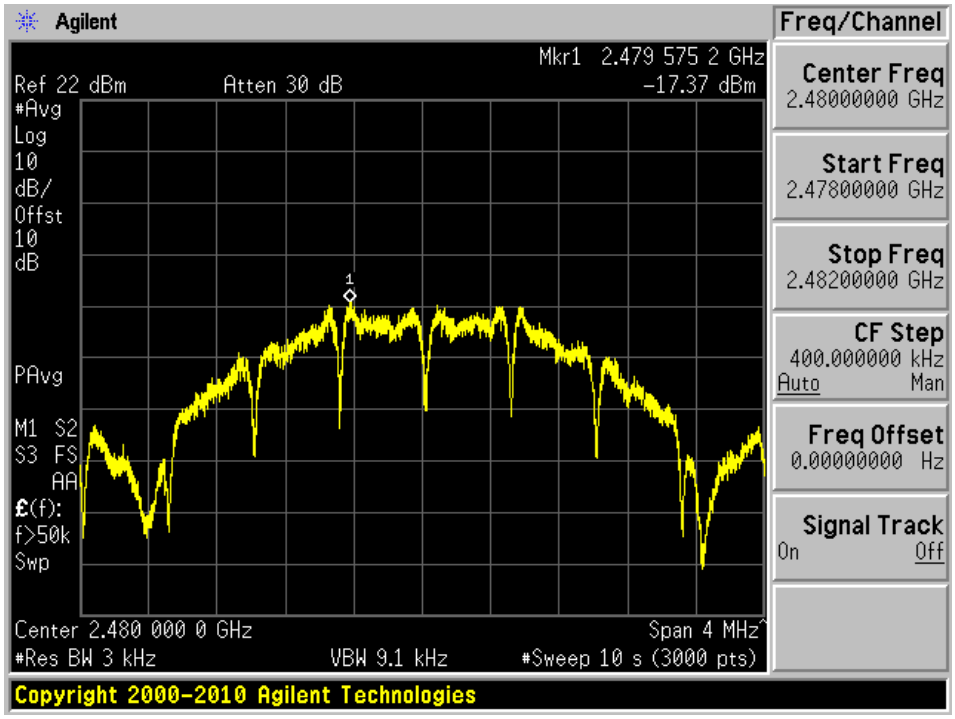
802.15.4-2405 MHz



802.15.4-2445 MHz



802.15.4-2475 MHz



802.15.4-2480 MHz